MALAWI CLIMATE CHANGE VULNERABILITY ASSESSMENT: ANNEX A. PARTICIPATORY RURAL APPRAISAL TOOLKIT

African and Latin American Resilience to Climate Change (ARCC)

SEPTEMBER 2013

CONTENTS

ACRONYMS AND ABBREVIATIONS

ARCC	African and Latin American Resilience to Climate Change
CC	Climate Change
CC/V	Climate Change/Variability
CIESIN	Center for International Earth Science Information Network
DRR/M	Disaster Risk Reduction/Management
EPA	Environmental Protection Agency
FS	Food Security
FtF	Feed the Future (USAID)
GFDRR	Global Facility for Disaster Reduction and Recovery
GoM	Government of Malawi
HHLD	Household
IGA	Income Generating Activity
KII	Key Informant Interview
PRA	Participatory Rural Appraisal
TA	Traditional Authority
TT	Team Triangulation
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
VA	Vulnerability Assessment
VAC	Vulnerability Assessment Committee
WALA	Wellness and Agriculture for Life Advancement (USAID)
WB	World Bank
XLS	MS Excel software, best used for the triangulation matrix

1.0 INTRODUCTION

The Malawi component of the African and Latin American Resilience to Climate Change (ARCC) project includes an in-depth participatory rural appraisal (PRA) to understand community vulnerability and resilience to climate change. This PRA toolkit is available upon request. The approach suggested here is appropriate for a five-to-six day PRA to be carried out in each targeted community by a team of five researchers representing a variety of disciplines (i.e., agriculture/food and livelihood security, fisheries, hydrology, forestry, anthropology). These notes assume that the reader/user has some experience with the PRA methodology and knows how to use the standard toolkit. More specific guidelines for using the tools are provided primarily when they fall outside the usual practice, or as special reminders. Readers/users less familiar with the methodological principles and standard toolkit may wish to consult http://www.crsprogramquality.org/storage/pubs/me/RRAPRA.pdf.

The suggestions below should NEVER be blindly followed; they are neither a road map nor a recipe. Indeed, each PRA should be different, even if the overall objectives remain the same. The field teams should have the flexibility to adapt the tools based on the information that arises, allowing the tools and checklists to evolve (undirected by time constraints, but by genuine need and desire to expand the understanding of the field researchers). The changes made, however, do need to be communicated to the other teams, allowing them to make the same or similar changes to keep the results comparable across the full set of targeted villages. Similarly, the sequencing of the activities will depend on many factors including the availability of participants and the depth and breadth of information that comes out of each activity and its logical progression.

It is very important to remember that in PRA, the tools are not ends in themselves. They are rather a means of encouraging participation, organizing discussions, and desensitizing issues that may otherwise be awkward. It is therefore essential to encourage and capture the knowledge that is offered by respondents during each activity: explanations of **why** X number of beans were placed in a given category by the respondents are generally more important and vastly more insightful and revealing than the actual number of beans. ***Why?*** **is a word that should constantly be at the tip of the tongue of every qualitative researcher. If you do not have this reflex, you need to cultivate it.**

Checklists (also known as Topical Outlines) are provided below as an indication of the types of information that can reasonably be expected to come out of each activity. They are not exhaustive. Teams can and should refine the checklists as they go along and are encouraged to add additional topics to the extent that they are well suited to the tool being used. For all the checklist items, it is important to remember that the best information comes from digging more deeply, trying to understand the nuances, and getting to the logic behind the practices. This requires sensitive questioning and excellent listening. Almost every checklist issue can be probed with who, what, where, when, and why questions to get to more detailed and complete information. To avoid endless repetition, we have not listed these sub-questions under each issue.

It is critical that teams take the time at some point each day to digest the information they are gathering. The proposed format for this digestion is to conduct a triangulation session each day (see table below). Teams (pairs) having conducted a given activity need to report to the rest of the team using a structured format depicting the information that the Vulnerability Assessment (VA) needs to determine (here, called a triangulation matrix). Even if the whole team was involved, it is very common for members to have "heard", observed, or even understood very different versions of the story. Discussing these in the context of the main objectives and information needs will enable a lively debate and stronger understanding. This activity will ensure that information is fully shared among team members and help to organize and analyze information as the work proceeds, allowing for time to probe further the next day or session to get an even stronger understanding.

The processing discussions, called Team Triangulations (TTs) among team members, are vital on a daily basis—often it even makes sense twice a day—before the information gleaned from one session is jumbled with another. Triangulation sessions should be an event that genuine researchers look forward to, not a chore that is dreaded.

Contemporary technology enables more and more often the use of a laptop and a delegated scribe to record the debates that occur during the triangulation sessions. Even if the scribe is a very fast typist or writer, it is often useful to digitally record the debates and discussions. The scribe should record them in the XLS format provided, one separate triangulation matrix file per village studied. When technology is no longer feasible, a backup plan using flipcharts is extremely helpful in preparing the final feedback session to the community as well as for doing the analysis and write-up. The flipcharts and discussions organized around them, however, need to be inserted with the appropriate level of detail into the Triangulation Matrix and updated at every possible moment. The individual(s) responsible for recording into the Triangulation Matrices need to be able to write in a language and tone that analysts not present in the village will rapidly and clearly understand. It is crucial that someone who was not in that village with you can read the Triangulation Matrix and feel as if they had been there alongside you. It is vital to insert "quoted text" that captures the feeling, the local color—even exact phrasing—of important explanations offered by the respondents.

TABLE 1.1. ARCC TRIANGULATION MATRIX, SIMPLIFIED DRAFT

To be completed for each case study village by the entire field team as they process their results each day	PRA Tool 1	PRA Tool 2	PRA Tool 3…
EXPOSURE Record in each cell, how exposure to climate-related hazards, threats and changes in the natural resource base is perceived today and how it has changed…DISCUSS: frequency, intensity, coverage, and differentiated impact on vulnerable groups…see sub-categories in XLS file			
VULNERABILITY: In each cell, describe how vulnerability (socioeconomic well-being, wealth, education, health, services, markets, etc.) is perceived today AND how it has evolved over past x years?…see sub-categories in XLS file			
ADAPTATION OPTIONS: What strategies/options have already been employed as a response to evolving climate change exposure? Which are most successful, why? Which would be feasible and/or ideal under x conditions? …see sub-categories in XLS file			

2.0 PRA GOAL AND OBJECTIVES

Every PRA requires a set of clear and comprehensive study objectives that will guide the research/collection of information in the field. The objectives proposed here are the same that will help guide the summary of PRA results.

GOAL

To understand the impact of climate change on rural communities in Malawi and the adaptation strategies they have or could employ to build resilience

NB: ALL issues addressed in the study should be explored through the lenses of (1) socioeconomic differentiation and (2) historical evolution (past, present and future)

2.1 OBJECTIVES

I. Profile communities with a particular focus on aspects that will illuminate the impact of climate change and people's ability/agency to adapt or respond.

a. Historical context (e.g., access to natural resources, exposure to hazards and threats; general changes in well-being, food & livelihood security);

b. Socio-cultural context (e.g., ethnicity, age, gender, wealth ranking) and services/partnerships and relations within and with other communities;

c. Economic context (e.g., markets, transport, credit); and

d. Climatic context (e.g., rainfall and temperature changes, hazard profiles, community risk analysis).

II. Understand the impact of climate change on livelihood portfolio(s) and general well-being.

a. To what extent has the composition of livelihood portfolios shifted over time?

- Here, more general livelihoods include fishing, livestock, and cash crops/income-generating activities (IGAs).

b. What pressures, constraints, and opportunities caused the shifts?

- What role has climate change played in motivating/necessitating these shifts?

c. To what extent are people better or worse off as a result of the livelihood changes?

d. To what extent are elements of climate perceived to impact general well-being: health, culture, etc.?

III. Understand the impact of climate change on agricultural production systems.

a. What are the perceived impacts of climate change on agricultural systems?

- i.e., seed selection, cropping patterns, methods/techniques, timing, etc.

b. Attribution: to what extent does the community genuinely attribute noted changes in production to the climate?

c. What impacts have *not* been adequately mitigated producing a negative impact on individual, household, or community well-being?

- What subgroups of the population have been most affected and why?
  - Who are the winners? Losers?

IV. Identify adaptation strategies that build resilience in the face of climate change.

a. What strategies have individuals, households, and communities already started to employ to attenuate the impacts of climate change?

- Why was this mix chosen?
- How have their chosen strategies evolved?
- How effective have they been?

b. Which climate impacts do they perceive to require adaptation but for which they have not yet identified solutions?

- What do they perceive to be the most feasible, effective, and sustainable adaptation strategies for these?

3.0 SAMPLING FRAME

The PRA component of the ARCC Malawi Vulnerability Assessment aims to capture existing perceptions of climate change and adaptation measures that are already used and/or feasible to attenuate the impact. This knowledge must be gleaned from a set of villages and households that are representative of the diversity of dynamics in Malawi. To this end, criteria to consider in the sampling strategy and potential sources of geo-referenced information permitting selection are portrayed in Table 3.1.

TABLE 3.1. CRITERIA FOR SAMPLING STRATEGY AND SOUCES OF DATA AVAILABILITY

Criteria	Assumptions	**Data availability**, with georeferenced data
Climate change and variability (projected and/or observations).	HHLDs most exposed to CC/V already will have developed or be considering a greater variety or number of adaptation strategies.	UNDP's 2007 study is the only one found with sub-national climate projections: UNDP CC Country Profile, Malawi (McSweeney, et al., 2010). However, insufficient resolution to be useful.
Livelihood strategies and agricultural production.	• Adaptation varies by livelihood type (farmers, fishers, pastoral, hunters). • High dependence on singular livelihoods and/or particular crops may increase vulnerability.	• Livelihood zones: Sep 2005, VAC profiles • Crop production: total area cropped for 2010 can be found at: http://www.countrystat.org/mwi/cont/pxwebquery/ma/130agr002/en. • Specific crops: some available by EPA from Malawi Atlas of Social Statistics, 2005.
Major threats: prices (77%[1]), impact of drought/floods on yield (63%), and illness/death of family members (46/41%) are the major threats reported by Malawian HHLDs.	Adaptation varies by variety, frequency and intensity of exposure to hazards/threats.	• Price/purchasing power: Malawi's PVA (GoM and WB, 2006) has a TA-level map of poverty headcount. • Drought/flood maps from CIESIN (GFDRR), but these appear to include impact, not just exposure/risk.
Socioeconomics and demographics: population density, index of remoteness, prevalence of female-headed households, dependency ratio, literacy.	Socioeconomic and demographic factors influence the need, decision and capacity to adapt.	Most of these variables could be sourced from the Malawi Atlas of Social Statistics, 2005.

Drawing on the combination of data compiled (described in Table 3.1 above), districts that are relatively more exposed to climate-related shocks appear to include Balaka, Chikwawa, Zomba, Machinga and Nsanje. In a parallel manner, districts that appear to be relatively more vulnerable include Machinga, Dedza, Thyolo, Mangochi, Ntcheu and Lilongwe.

Based on a very limited and partial analysis of these variables and guidance from the client, the following staged sampling has been used:

[1] This indicator is the only of 15 threats that reportedly increased in step with poverty (using quintiles).

	What is selected	What it is representative of
Strata A	Districts	USAID FtF/WALA Focus Areas
Strata B	Livelihoods (VAC)	All livelihoods existing in Strata A
Primary sampling unit	Villages (N=9)	Livelihood/District Pairs (Area common to both Strata A and B, "zones")
Secondary sampling unit	Participants for Focus Groups & PRA Activities	*Depends on activity,* Livelihood or socioeconomic, age, etc.

3.1 STAGE 1: SELECTION OF DISTRICTS

The starting point for the sampling strategy is the set of 13 districts targeted by the Feed the Future Program (7 districts) and the WALA Program (8 districts, Machinga and Balaka are included in both) (see list and map portraying names and total population). The majority of these districts are in the Southern Region; among the 13, FtF features four from the Central Region and WALA, none.

3.2 STAGE 2: CHOICE OF VILLAGES (N=25,540 NATIONWIDE)

Within the selected 'zones' above, it was important to choose villages that capture each of the nine livelihood systems reportedly present within the 13 districts. They are described below in order of relative risk level (*9 zones: livelihoods within 8 districts)* and one village is chosen from each. This combination of livelihood zones covered by the VA/PRA indicates that the study may represent approximately 77% of Malawi's total population (2003).

1. **Chilwa—Phalombe Plain Livelihood and Machinga District (cross-section)**: greatest combined risk, and a livelihood system representing up to 10% national population. Unique characteristics: rain-shadow; flooding.

2. **Shire Highlands Livelihood and Zomba District (cross-section)**: second most at-risk and 9% population. Greatest proportion of income sources in a normal year comes from animal sales (poor and middle); greatest also from trade. Unique characteristics: most densely populated area of Malawi.

3. **Thyolo-Mulanje Tea Estate Livelihood and Mulanje District (cross-section)**: unique livelihood representing 5.6% of national population. The greatest proportion of food sources in a normal year comes from purchasing (poorest HHLDs). Unique characteristics: small land holdings, food-production deficits and proximity to Mozambique.

4. **Southern Lakeshore Livelihood and Mangochi District (cross-section)**: unique livelihood representing up to 4.2% of national population. Greatest proportion of income sources coming from ganyu (poorest and middle). Unique characteristics: fishing is the major livelihood.

5. **Kasungu-Lilongwe Plain Livelihood and Dedza District (cross-section)**: high relative vulnerability and a livelihood system representing 27% of national population. Greatest proportion of food sources in a normal year coming from maize, same for *ganyu* (poor and middle). Unique characteristics: greatest proportion of income sources from tobacco (poorest and middle income households).

6. **Rift Valley Escarpment Livelihood and Ntcheu District (cross-section)**: moderate risk profile and 10% pop, very rarely studied. (No livelihood profiling data available). Projected for high increases in temperature, high proportion of female headed households. High dependency ration, high poverty, relatively strong production of pulses.

7. **Lower Shire Livelihood and Nsanje District (cross-section)**: hot, dry zone but relatively productive and major cotton-growing area. Livelihood income sourced from food, cotton and livestock.

Mozambique exerts strong influence with ganyu and maize trade. Expected to suffer the greatest changes in rising temperatures and decreasing rainfall.

8. **Middle Shire Livelihood and Balaka District (cross-section)**: relatively dry mid lowland area, with fishing on Shire river. Woodlands finance charcoal and firewood IGAs destined for nearby urban centers. High exposure to flooding and malaria, susceptible to volatile prices (highly dependent on maize).

9. **Phirilongwe Hills Livelihood and Mangochi District (cross-section)**: highly agricultural (especially maize, groundnuts and cassava), low literacy rates. Not well studied (not included in VAC 2005).

3.3 STAGE 3: CHOICE OF PARTICIPANTS (FOCUS, KII, ETC.)

Within each of the selected villages, it is important to chose participants keeping in mind the power/ agency dynamics among various leaders and traditional institutions. The toolkit details the purposive and random socioeconomic sampling required for each tool.

4.0 PRA TEAM COMPOSITION

Scott McCormick, *Malawi Team Leader*

Lezlie Moriniere, *Field Coordinator & Trainer*

Anna Farmer, *Technology & Asst. Trainer*

Susan Qashu, *Fisheries & Asst. Trainer*

Jason Agar, Kadale Consultants, Malawi

Kadale Coordinators

- Don Kalonga, Project
- Richard Kusseni, Field

Kadale Team Supervisors (3)

Kadale Qualitative Researchers (3 teams * 4 = 12)

Malawi Dept. of Meteorology: 1 Representative within each PRA team (to be confirmed)

5.0 VILLAGE CASE STUDIES

A total of nine villages will be studied in this PRA. They have been chosen to represent nine distinct livelihood zones that cover eight different districts of Malawi (see sampling above). Each case study entails one week spent in each village. The purpose of the case studies is to gain an in-depth understanding of each community in a meaningful way that can be compared with the other cases, grounded in the objectives detailed above.

6.0 SCHEDULING AND SEQUENCING OF ACTIVITIES

6.1 PRA SCHEDULE

Training (everyone)**:** 3-7 Sep 2012, *Blantyre*

Case study 1 (for each of 3 teams): 10-15 Sep 2012, *x, y and z*

1-day Rehash (everyone): 17 Sep 2012, *Blantyre*

Case studies 2 and 3 (for each of 3 teams): *2 weeks immediately following*

Complete and submit all field notes to Kadale: first week October

6.2 CASE STUDY SCHEDULE (REPEATED FOR EACH)

The Case Study schedule is purposefully extended over six days to allow the requisite time for each activity to be completed appropriately, without haste and to give time to the research team to *process* the information (especially but not constrained to the TT session).

The generic flow of activities per case study is depicted below. Qualitative research is not rigid; if, for any reason, one of the activities below cannot be held in the timeslot/order listed, the others can be shuffled around to replace it. It is urgent for the team to "think on their feet", providing creative solutions and never rushing through an activity "just to get it done". As a rule of thumb for scheduling purposes, each activity can be estimated to require approximately 2 hours of time (in reality, experienced researchers may achieve the required understanding between 45 minutes and 3 hours, depending on the dynamic among the respondents).

Given a team of five researchers working in pairs (the fifth is always observing, taking notes, or supervising), many of the activities are to be run simultaneously. Those noted below with a * are to be conducted with at least two sub-groups of the community (i.e., men and women separately), so multiple versions of the same activity are going on at the same time. Typically the more intensive activities are scheduled in the morning sessions. The evening sessions are reserved for one simple (non-repeated) session thereby leaving ample time for processing and the TT. The TT sessions each day are ideal with the presence of the entire team.

TABLE 6.1. PRA ACTIVITY FLOW (5-6 DAYS FOR EACH VILLAGE)

	AM	PM
Day 1	a. Protocol/introduction b. Hazard & Vulnerability Mapping*	c. Zigzag Diagram: FS/Rainfall *Team Triangulation (TT)*
Day 2	a. Transect Walks* b. Field Profiles*	c. Wealth Ranking *Team Triangulation (TT)*
Day 3	a. Livelihood Portfolio Evolution* b. Household Portfolio Management*	c. Seasonal Calendar *Team Triangulation (TT)*
Day 4	a. Key Informant Interviews* (KII: community level)	b. Climate Impact *Team Triangulation (TT)*
Day 5	a. Village History & Hope	*Final Team Triangulation (TT)* b. Give Back to the Community

	AM	PM
Day 6	Reserved to catch up or further triangulate before leaving the zone	

7.0 MATERIALS NEEDED

For each PRA activity (there are often two organized at the same time), the facilitators must have the following materials ready to use:

- **PRA Manual & Toolkit** (refer to pages dedicated to each activity) (available upon request)
- **Notebook and pencils/pens**
- **Recorder** (if possible, to refer back later when processing the information)
- **Ipad/Camera:** to take photos of process and results (or for respondents to take photos)
- **Bag of beans:** dry, multiple colors, amount of beans roughly equivalent to number of households in the village
- **Flip chart paper and markers**
- **Sheets of colored paper** (for Household Portfolio Management activity only)
- **Also:** desire to understand *why* ,strong ears, open-mindedness, creative thinking, teamwork, concentration and patience

8.0 TOOLKIT

See pages 1-39 of the PRA Toolkit (not included) for all PRA activities to be conducted in each village, along with instructions on the process and the checklist of questions not to forget.

Also included in the toolkit are worksheets—tabular templates that will be revised during the training session, especially after the trial run in a nearby village. The worksheets are not to assist with taking notes; there is no space included for this. They are meant to highlight the guiding pieces of knowledge that should be extracted from the PRA activity. In summary:

- Matrices are to record the summary results (in synthetic format) that lends themselves to cross-village comparison with a quick glance. The most important results of the PRA, however, are not the numbers or codes you write on the matrices, but how intricately they are understood and explained.
- Hand-written notes, digital recordings and eventually the triangulation matrix records all the learning, understanding and full sets of explanations that help someone to fully understand the *who*, *why*, *when*, and *how* behind the matrices and pulls them into a larger knowledge platform that will help the PRA meet its research objectives.

Final versions of the template package will need to be prepared, and reproduced for at least 3 copies per researcher (total 45 copies of each page), upon which they can better follow and track results as they move from activity to activity and village to village.

At the end of the toolkit, more detail on the Triangulation Matrix (to be made available in XLS digital format to each team) and the checklist of items to prepare to give Kadale after each Case Study is complete. Teams are requested to have their scribes record all discussions in this digital framework during the TT, as it allows three sheets per file to be cross-checked and compared.

On the last "sheet" inside the triangulation matrix, there is a reference tool, named the "InfoMap." This tool indicates which of the PRA activities should provide parts of each PRA information requirement.

MALAWI CLIMATE CHANGE VULNERABILITY ASSESSMENT: ANNEX B. DETAILED PARTICIPATORY RURAL APPRAISAL REPORT

African and Latin American Resilience to Climate Change (ARCC)

SEPTEMBER 2013

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ACRONYMS AND ABBREVIATIONS

ARCC	African and Latin American Resilience to Climate Change (Project)
ADMARC	Agriculture Development Marketing Corporation
AIDS	Acquired Immunodeficiency Syndrome
ASF	African Swine Fever
CVA	Community Vulnerability Assessment
DPD	Directorate of Planning and Development (at District Level)
ECF	East Coast Fever
GoM	Government of Malawi
FISP	Farm Input Subsidy Program
FMD	Foot and Mouth Disease
GVH	Group Village Headman
HEA	Household Economy Analysis
HH	Household
HIV	Human Immunodeficiency Virus
IGA	Income-Generating Activity
KII	Key Informant Interviews
LLW	Lilongwe
LZ	Livelihood Zone
LDF	Local Development Fund
OPV	Open Pollinated Variety
MVA	Malawi Vulnerability Assessment
MVAC	Malawi Vulnerability Assessment Committee
ND	Newcastle Disease
NGO	Nongovernmental Organization
PRA	Participatory Rural Appraisal
SA	South Africa
SoW	Scope of Work
TA	Traditional Authority
TT	Team Triangulation

USAID	United States Agency for International Development
VH	Village Head
WALA	Wellness and Agriculture for Life Advancement

GLOSSARY

This section contains a glossary of some of the English and Chichewa terms that are included in the report:

(The) **Average**: People with moderate wealth in the communities, between the 'Better-off' and the 'Poorer' as categorized in each of the PRA villages—this is a relative definition. Typically, they have some livestock, one or two alternative sources of income to farming, produce or can buy food for most of the year, but still have to reduce the number of meals taken during the 'hunger season'. Because of the high levels of poverty in Malawi, many of The Average would be considered as Poor based on absolute definitions.

(The) **Better-off**: People who are considered wealthy in their communities, in relative terms, with multiple sources of income and so are not dependent on their agricultural livelihoods. They own a range of livestock, and have enough food throughout the year.

Chambo: A large tilapia fish that reach up to 30 cm, that was very common and popular with consumers.

Chigodola: Chichewa name for Foot and Mouth Disease.

Chikumbasuchi: Chichewa name for rains that usually come in October that soak the ground ready for planting.

Chimanga: Chichewa name for the dried kernels of maize. This is the product that is commonly traded in markets for consumers to buy and have it milled into flour (*ufa*) ready for cooking into *nsima* (dry porridge) that accompanies many meals.

Chisanu: Frost.

Chizimalupsa: Chichewa name for rains which usually come in September, which are an early warning of the coming rainy season.

Dambo: Chichewa name for an area of land that has moisture all year round.

Ganyu: Chichewa name for casual labor. Most of the time it is associated with working in other people's fields or 'gardens' like making ridges or weeding, but it could be any kind of work depending on the livelihood and job opportunities of the area.

Hungry months/hunger period: this refers to the period prior to the next harvest period when household stocks of maize from the previous harvest season are exhausted. This period is normally considered to be January to March, but for Poorer and some Average households, it starts much earlier. In the report, the term refers to the January to March period when a substantial number of households have little or no residual food stocks.

Kapenta: Chichewa name for a small, fingerlike fish which lives in muddy water, such as rivers, marshes and ponds rather than in Lake Malawi. Lake Chirwa is a main habitat of this small fish.

Matemba: Chichewa name for a small cyprinid fish, which is slightly big.

Mvula ya moto: Chichewa name for acidic rain. Literally, rain that burns.

Mphembezu: Chichewa name for large ants.

Mandasi: Chichewa name for a fried dough fritter, like a solid donut.

Mangoni: Chichewa name for winds from the north.

Mphepo yakuangoni: Chichewa name for a wind that comes from the north.

Msangu: Chichewa name for a tree that is promoted to bring back soil fertility.

Nanthambwe: Chichewa name for a bird whose song is a precursor to rains (some call it *Mkoka*).

Mwera: Chichewa name for a wind that comes from the south.

Napolo: Chichewa name for a flash flood.

Nsima: Chichewa name for the traditional boiled maize flour component that accompanies, and in many ways 'defines', meals. An eating occasion without *nsima* is not regarded by many as a meal, so when Malawians talk of hunger and going without meals, it can (but not always) mean that they have not eaten *nsima* that day or on that eating occasion.

Njasi: Chichewa name for a plant whose flowering and production of fruits indicates that the rains are near (reported in Nkasala).

Ntuluko: Chichewa name for rains that are the actual onset of the rainy season, which usually come in November.

(The) **Poorer**: This group are the poorest group in a community defined in relative terms. Typically, although they do have land, they persistently have low yields due to lack of inputs and having to spend time doing ganyu for others. Their land may be rented out or sold in dire times. If they have livestock then it is only poultry. They have inadequate food every year and cope by reducing the number of meals per day and missing meals altogether during lean periods and by doing ganyu for payment in maize.

Summer: This season runs from around November to April. It is the rainy season and is characterised by relatively warm/hot weather.

Thuku: Chichewa name for a common bacterial wilt found in Irish potato plants. It attacks leaves and tubers.

Ufa: Chichewa name for pounded maize flour ready for preparing into nsima and other products (animal feed, ready to use therapeutic foods etc.).

Usipa: Chichewa name for a common small non-cichlid fish that swims near the surface of Lake Malawi. Since usipa like light, they are usually active in the daytime and can be attracted to fishermen's lights at night.

Winter: This is the dry season that runs from around May to October. June to August are relatively the coldest months of the year, with temperatures rising to their peak in October immediately prior to the rains.

Zitumbuwa: Chichewa name for banana flitters.

Ziphwita: Chichewa name for a type of flying biting insect.

1.0 BACKGROUND AND SCOPE

This report summarizes the findings of the Community Vulnerability Assessment (CVA) conducted in September 2012 in nine communities across nine livelihood zones (the 'Zones') of Malawi.

The Zones are defined by the Malawi Vulnerability Assessment Committee (MVAC) (2005) study, which utilized a Household Economy Analysis (HEA) to define how households access food and income. This enabled each livelihood zone to be characterized based on the predominant means through which households access food and income. Based on these predominant characteristics, the Zones are demarcated geographically. Within the Zones, households are characterized so as to demarcate wealthy, middle and poor groups, based on relative wealth. Livelihood responses of households are therefore a function of both their location and their relative wealth. The MVAC (2005) study identified 17 Zones for Malawi, of which 11 were profiled.[1]

Understanding the outcomes for households is related to identified '*hazards*', '*vulnerabilities*' and '*responses*'. *Hazards*, sometimes referred to as '*shocks*', are events that impact on potential food and income availability. *Vulnerability* is the extent to which a particular household is affected by a particular event—it is context specific. *Responses*, also termed '*adaptations*', are how particular households find alternatives following events that change their food and income access.

The purpose of this assignment is to conduct community vulnerability assessments (in Malawi) using appropriate participatory tools to identify the impacts of climate change on agriculture in nine of the 17 Zones, as part of the wider African and Latin American Resilience to Climate Change (ARCC) Project, funded by USAID, which is the ultimate client for this report.

From the SoW:

The African and Latin American Resilience to Climate Change project represents an important vehicle for USAID to invest more effectually and consistently in adaptation programming and activities that support economic growth, democratic governance, health, human rights, and education. Tetra Tech ARD is implementing the ARCC, a USAID/Washington D.C.-based PLACE IQC Task Order. ARCC will supply technical services for developing, testing, standardizing and replicating vulnerability assessment frameworks in order to assist USAID missions assess real climate change threats and their impacts on vulnerable populations and ecosystems, prepare adaptation strategies, and program critical USG funds for efforts that address economic growth, especially the agriculture sector under the Feed the Future program. ARCC will build on climate adaptation resources that have been developed to bring improved science, methodologies and tools, and shared learning on adaptation into the mainstream of USAID and development partner programming. Four tasks comprise ARCC—developing vulnerability assessment methodologies; providing outreach, training and meeting support; developing and managing knowledge; and providing technical support to USAID missions.

Tetra Tech ARD will be assisted by partners ACDI/VOCA, the World Resources Institute, Cadmus Group, and Center for International Earth Science Information Network, Earth Institute, Columbia University.

The Malawi Vulnerability Assessment (MVA) will determine the impact of climate change on four key sectors within Malawi—agriculture and food security, water resources, forestry, and fisheries. Because of the importance of agriculture and food security within the Feed the Future program for USAID Malawi, complementary community PRA surveys, crop modeling, and value chain analyses will be conducted for that sector. For the other three sectors, literature reviews will be conducted to reflect the

[1] This was due to resource limitations at the time. Although there was an intention to complete the work, this has not been done.

conclusions of existing research of climate change impacts on forests, water resources and fisheries and results of these reviews will be used to project future impacts on these respective sectors.

The report structure is Section 1, Background and Scope; Section 2, Methodology; Section 3, Climate Change and Rural Malawi; and Section 4, Conclusions and Recommendations.

2.0 METHODOLOGY

This study utilized an intensive Participatory Rural Appraisal (PRA) approach, developed by Lezlie Moriniere, the Field Coordinator, from material prepared by Karen Freudenberger. The approach is documented in Annex A to the Malawi VA Preliminary Results report; individual tools can be made available upon request to the office of the African and Latin American Resilience to Climate Change (ARCC) or the ARCC USAID Contracting Officer's Representative.

The goal of the PRA was:

To understand the impact of climate change on rural communities in Malawi and the adaptation strategies they have or could employ to build resilience.

The PRA was undertaken through the dual lenses of socio-economic differentiation and historical evolution. Its four objectives were to:

1. *Profile the community, with a particular focus on aspects that will illuminate the impact of climate change and people's ability/agency to adapt or respond.*
2. *Understand the impact of climate change on livelihood portfolio(s) and general well-being.*
3. *Understand the impact of climate change on agricultural production system.*
4. *Identify adaptation strategies that build resilience in the face of climate change.*

2.1 TOOLS, TEAM, AND COMMUNITY SELECTION

In essence, three teams of researchers, including staff of the Directorate of Meteorology, trained in PRA and qualitative methods, spent six days in each of three communities (nine communities in total) that were typical of the livelihood zones within which they were located. The teams spent the nights in the village using the time to engage in more informal discussions when opportunities arose. In the day, the teams implemented a series of PRA tools,[2] being:

1. Hazard and vulnerability mapping;
2. Zigzag diagrams;
3. Transect walks & field profiles;
4. Seasonal calendars;
5. Wealth ranking;
6. Climate impact;
7. Key informant interviews (KIIs) with weather forecaster, health person, trader, conflict resolver, community organization representative and others;
8. Livelihood portfolio evolution and household portfolio management; and
9. Village history and hope.

In addition, there were protocol and introductory, and community feedback sessions.

[2] Full details of the tools are contained in the PRA toolkit manuals previously referenced.

The research sought to use technology where possible including iPads for recording, photos and marking transect walks.

In terms of selection, the nine Livelihood Zones (LZ) were identified by the Field Coordinator based on their relative exposure to climate related shocks. Within these nine LZs, which in some cases span several Districts, target Districts were selected by the Field Coordinator for their relative vulnerability. It was intended that the selective communities should be 'typical' of communities in that LZ, as defined in the MVAC (2005) report.

Prior to the research, the Kadale Field Research Manager visited each target District to meet District officials, explain the research and seek their assistance in selection of typical communities for that LZ. These discussions typically involved the District Planning and Development (DPD) Directors/Staff within each District, as well as Agricultural and Meteorological staff where possible.

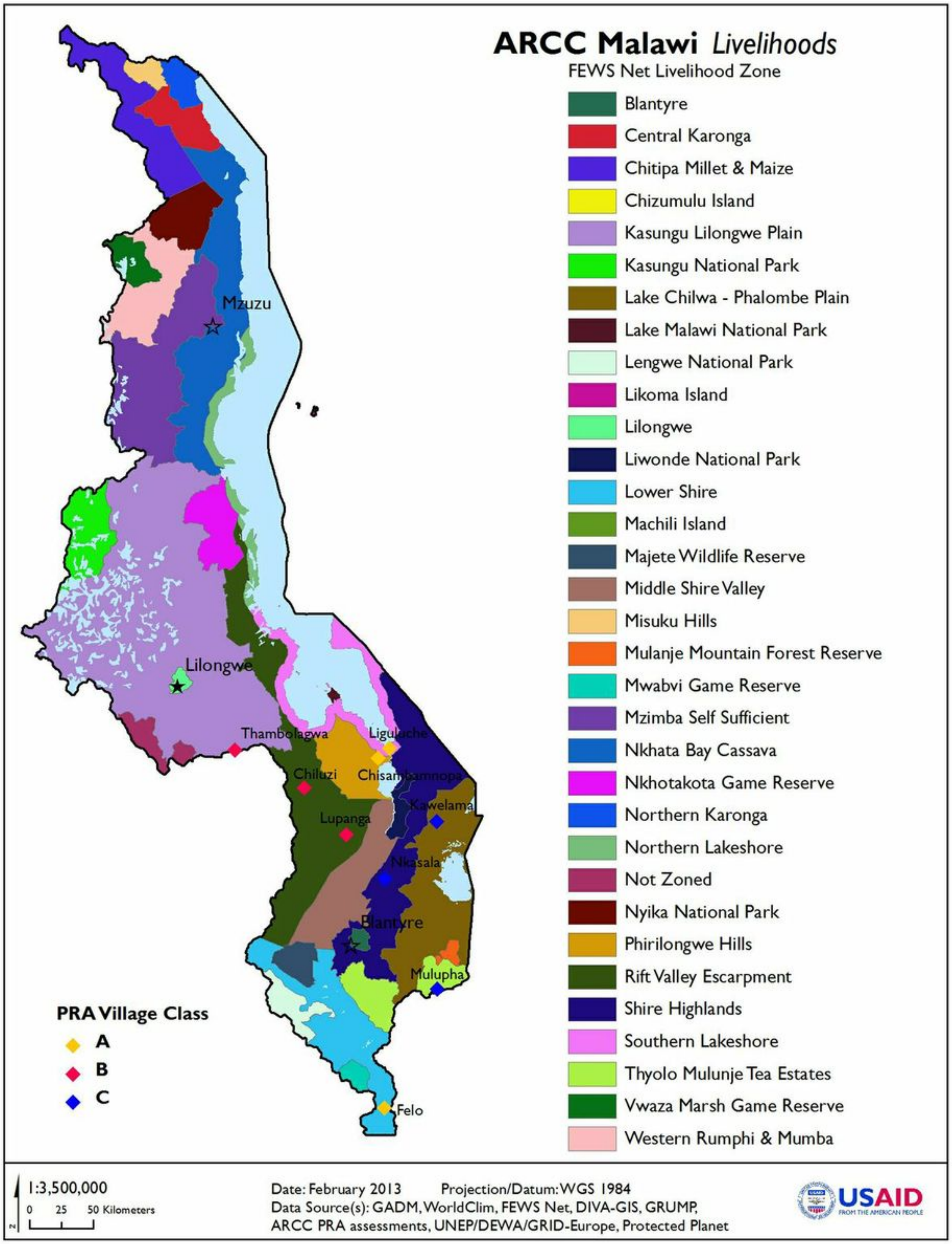
With the involvement of District personnel, a shortlist of up to 10 communities was drawn up using a screening tool with 11 criteria. These criteria included proximity to a weather station, livelihood characteristics, size as well as disqualifying factors, such as being the home of a prominent politician or close to a major town. The Kadale Field Manager visited the relevant Traditional Authority (TA) and then met Group Village Heads (GVHs)/Village Heads (VHs) of the shortlisted communities to check if the communities were suitable and if the communities were willing to be part of a highly intensive research process. Logistical arrangements (accommodation, etc.) were checked at the time of a visit to ensure the team could stay in the community safely and securely.

The final selection was made from a summary of the shortlisted communities by Kadale. The communities selected were:

1. Chiluzi, Ntcheu District, Rift Valley Escarpment LZ;
2. Chisambamnopa, Mangochi District, Phirilongwe Hills LZ;
3. Felo, Nsanje District, Lower Shire LZ;
4. Kawelama, Machinga District, Lake Chilwa Phalombe Plain LZ;
5. Liguluche, Mangochi District, Southern Lakeshore LZ;
6. Lupanga, Balaka District, Middle Shire Valley LZ;
7. Mulupha, Mulanje District, Mulanje/Thyolo LZ;
8. Nkasala, Zomba District, Shire Highlands LZ; and
9. Thambolagwa, Dedza District, Kasungu-Lilongwe Plain LZ

The nine LZs are highlighted on the map below:

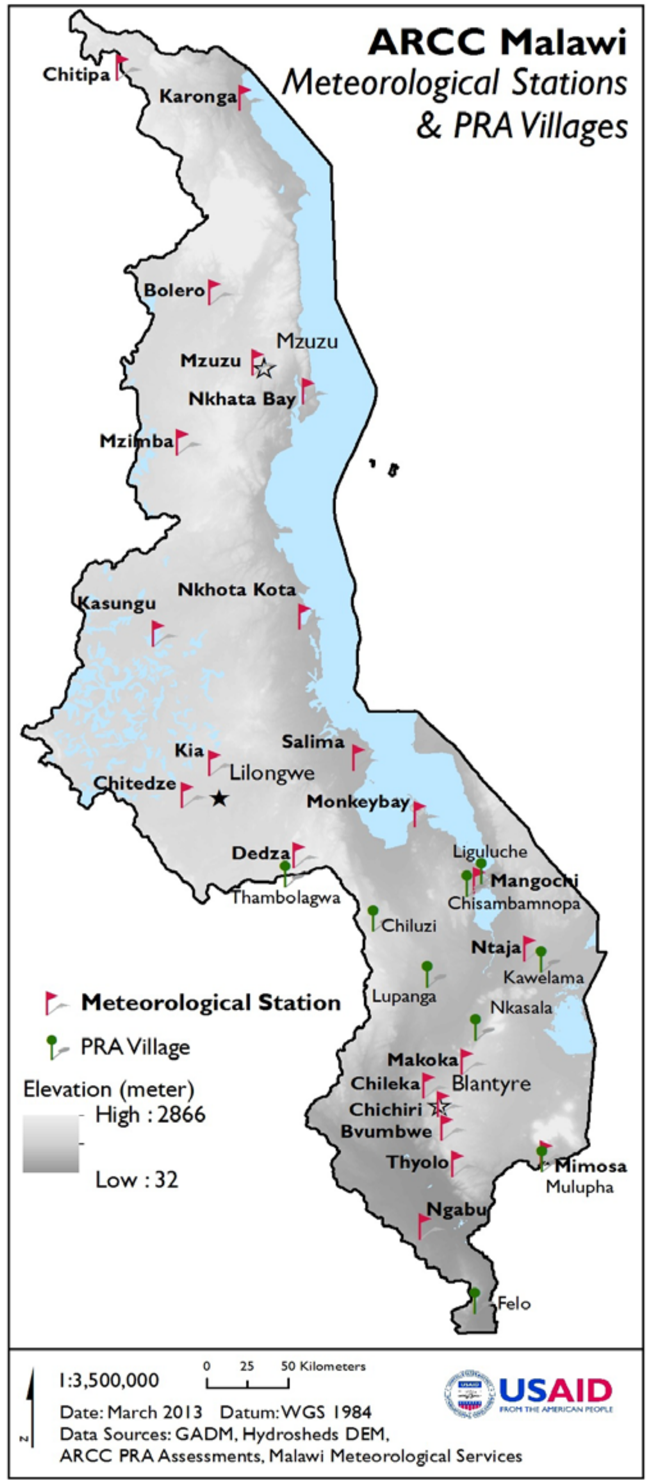
FIGURE 1. MAP OF MALAWI'S LIVELIHOOD ZONES



Source: Malawi Vulnerability Assessment Committee Report (2005)

The nine communities for the research are identified in Figure 2.

FIGURE 2. MAP OF THE NINE COMMUNITIES IN THE PRA



The composition of the research teams ensured that at least two out of six/seven researchers were female, and that the team had a mix of language speakers appropriate for the particular communities. Each team included one Department of Meteorology representative, who was also fully trained in the techniques. The intention was that they should contribute valuable climate insights to the process, particularly during the review. The teams were also composed to include a mix of technical experience including agriculture, environment and social areas. With so many factors to balance, it was not possible to get a perfect mix of experience, but the team compositions were judged to be sufficient for the tasks required of them.

The teams underwent an intensive five-day training, including two days of supervised field practice applying the techniques in two rural communities (near Blantyre). After the first round of PRAs, the three teams came together for a review day to address issues that arose in the field.

The teams were accompanied for the first round by the Field Coordinator, two other Tetra-Tech ARD staff, the Kadale Field Manager and the Kadale Data Manager to provide in-field support to address issues as they arose, including the daily recording and analysis of the findings in a Team Triangulation (TT) session. The TT sessions included planning for the next days' activities, with adjustments to the program due to people's availability. Roles were assigned to individual team members based on the plan for the next day.

At the end of each week in a community, the teams usually undertook additional time to further consolidate TT findings. However, as the teams were moving between three communities in a three-week period, there was insufficient time to finalize the TT matrices and other summary matrices, as well as the data ordering and labeling of files. As a result, the teams spent an additional 5-10 days at the end of the three week field research period completing the TT matrices, other summary matrices and data ordering. This process was followed by a prolonged period where data was reviewed by the Kadale team for accuracy, consistency gaps and clarifications. Again, due to the large amount of data, this process took almost two months as there were delays in getting response from the field team that had by then dispersed.

The analysis for the report required the handling, management and ordering of a substantial amount of data from the nine communities. The Kadale team focused on getting the TT matrices and summary matrices in good order, as well as preparing summary profiles for each of the nine communities (see separate report 'Community Profiles').

After consideration of the best ways to handle so much qualitative data, the team produced a TT summary matrix from the nine community TT matrices to enable comparisons to be more apparent through this further aggregating of the data. From this, the level of aggregation, it was possible to produce highly summarized tables that are contained in this report. It is important for the reader to recognize this multi-tiered aggregation process and that there is considerable qualitative data behind each statement. As the tables contained in this report are summarized from the TT summary, and behind them, the nine community TT summaries, the specific tool or tools from which the data are drawn are not identified. In most cases, the data come from a mixture of tools, as well as researcher observations making it difficult to attribute to one specific tool. The PRA methodology gives researchers a set of tools and an extended period of time to identify the community's perceptions, views and actions.

2.2 METHODOLOGICAL CHALLENGES

As with any research study in physically difficult circumstances, there were challenges in implementing the methodology.

Logistics: in general, the logistics of having three teams fully equipped for six days/five nights in the communities worked well. The biggest logistical challenge was access to electricity to enable the iPads, phones and laptops to be utilized in the research. Teams generally found the nearest market with power and sent items for recharging regularly, though in some cases the equipment could not be fully utilized all of the time. The other logistical issue was with late arrival of the teams on some occasions for a mix of reasons. This contributed to compressed timescales and in one case, the villagers were very concerned at the arrival of outsiders after dark. These were resolved in each case.

Village selection/politics: in one case, the team arrived, but found that the GVH wanted the team to research his village, not the selected one, partly due to his poor relationship with the VH of the selected village. This was also because there was an expectation of some material outcome from the research process, even though that issue had been discussed prior to arrival. This was resolved, but contributed to a delay in the fieldwork in that case. There were expectations of immediate and future support in many of the communities either stated or unstated. This required the teams to emphasize the research purpose and progressively overcome the expectations through engaging the communities in the process. Once community members became involved in the activities, the issue of expectations fell away as the focus had changed.

Day-to-Day village life: research was conducted in the period prior to planting, so in most of the communities, people went to their fields early in the morning returning late morning to prepare food for the day. This meant that in general the team could not conduct those activities involving farmers prior to 11.00 a.m. except when the team accompanied farmers to their fields for research tasks. The teams adapted by undertaking what activities they could, including spillover 'internal' discussions from the previous evening's TT session (see below). In several of the communities, the program was interrupted by funerals, visits by nongovernmental organization (NGO) teams undertaking their activities, registration for the Farm Input Subsidy Program (FISP) and Mosque. The latter made Fridays a difficult day to conduct research, particularly in the four Yao and predominantly Muslim communities. All these 'ongoing' activities, particular in a period of relatively intense farming activity made some activities more difficult to complete in the sequence and timescale intended, compressing the overall program. However, in the end almost all the activities in all cases were completed.

Analytical capacity, time and tools: at the end of each day, the teams met to undertake a TT analysis and recording session. With delays encountered in the day, lack of power and inappropriate space within which to work, such as being in the Chief's house or having people/visitors interrupting or listening in, the TT sessions proved very challenging. This was contributed to by the unfamiliarity with the TT matrices and the size of the three matrices to be completed, with around 840 boxes of data to enter[3] as well as narrative analytical tools to complete. As a result, the teams generally took at least two additional days per community to complete the TT matrices, maps, photo-records and other narrative tools.

The teams were able to record information, but their ability to undertake analysis was limited, partly to do with their capacity, but also because there was so much data to handle and the tools did not enable them to narrow this down to a manageable number of key analytical points, while in the field. Teams were tasked to reconcile contradictory findings from different sources; this was mostly possible, as well as to see through false or misleading information from the community that was intended to give an incorrect/ misleading impression, mainly in the hope of getting something or to cover-up certain activities. It is not possible to state that all misleading information has been addressed, but several issues were further investigated and resolved.

The analysis was undertaken by the Kadale team utilizing data from the PRAs. The analysis required seeking many clarifications and additional information from the field teams. Overall, it is worth noting that conducting the TTs in the field at the end of the research day with large amounts of data to handle in physically challenging conditions, particularly the lack of power, is demanding for the field teams. The research team's conclusion is that much more time is required in the field specifically to capture data and undertake the immediate post fieldwork analysis. This would be more efficient in more physically conducive conditions, and ideally done before moving to the next community.

[3] Some of the entries were the same or similar and some boxes only needed entry of a 'nil' result.

3.0 CLIMATE CHANGE AND RURAL MALAWI

The following section addresses the questions set out in section 2, namely to:

1. Profile the community, with a particular focus on aspects that will illuminate the impact of climate change and people's ability/agency to adapt or respond.
2. Understand the impact of climate change on livelihood portfolio(s) and general well-being
3. Understand the impact of climate change on agricultural production system
4. Identify adaptation strategies that build resilience in the face of climate change

Each of these areas is addressed in turn in Sections 3.1 to 3.4.

3.1 COMMUNITY SOCIAL, ECONOMIC AND CLIMATIC PROFILE

Detailed community profiles for each of the nine communities are included in a separate report. In this section, the historical, social, economic and climatic profiles for the nine communities are set out.

3.1.1 HISTORICAL CONTEXT

The profiles of the nine communities highlight historical data that ultimately has an impact on the hazards and vulnerabilities of the communities in the present day.

First of all, many of these communities were able to trace their history to a time when they migrated to the area, for example, the Ngoni people at Chiluzi originally came from Swaziland, and passed to the area via Mozambique. The Yao people at Kawelama initially came from Mozambique, feeing from the Portuguese wars. Most of the Yao communities, such as Liguluche and Chisambamnopa, originally came from Mozambique, but settled in different areas due to the timing of the migration.

Secondly, the selection of the actual location of the community within a locality generally required available unsettled land,[4] but also access to key natural resources, such as water/dambo/rivers,[5] forest, game/wildlife and cultivatable land. For example, the Yao community of Liguluche settled in Mangochi near the lake to have access to good fishing grounds. Chief Kawelama and his people chose the present location of Kawelama village because of abundance of water (Lake Chilwa) and plenty of game animals. In Mulupha, the people had originally settleted on one side of Chingozi hills, but moved to the present location in search of more cultivatable land.

The final location of the village may have moved more than once, due to hazards in the past, such as flooding, for example flooding of Lake Malawi in 1978 led the people of Liguluche to move to the present location. The other driver was to move to a more attractive location; for example, the people in Lupanga came from Mozambique and initially went to Tanzania before they came to Chimbiya area, Malawi. As the

4 In the case of Chisambamnopa, land was won by conquest.

5 A dambo is a wetland area that can be used for 'winter' crop cultivation, but may be too wet in the rainy season for 'summer' cultivation.

demand for farm land increased they later settled at the present place to the West of Chimbiya due to the availability of farm land.

TABLE 1. HISTORICAL REASONS FOR LOCATION, BY COMMUNITY

Community / Zone	Migrated in	Key attractions	Final location moved
Chiluzi - Rift Valley	✓	Fertile, dambo, unsettled, water for cattle	✓Closer to the road
Chisambamnopa - Phirilongwe Hills	✓ circa 1880	Fertile, river, won by conquest	✓Land allocated by Sultan
Felo - Lower Shire	✓	Close to Shire River	Maintained original location
Kawelama - Phalombe-Lake Chilwa	✓1915	Abundance of Water and plenty of game	Maintained original location
Liguluche - Southern Lakeshore	✓	Close to the Lake	✓Further from flood prone area
Lupanga - Middle Shire	✓1847	Close to the river	✓Area with more farm land
Mulupha - Mulanje-Thyolo Tea Estate	✓1930s	Land was uninhabited and good for farming	✓Area with better cultivation land
Nkasala - Shire Highlands	✓1912	Heavy and reliable rains	Maintained original location
Thambolagwa - Kasungu-LLW[6] Plain	✓1962-75	Land uninhabited - close to river & dambo for grazing	Maintained original location

Source: PRAs, Kadale Consultants

Access to natural features and resources were reported as key factors in the particular decisions on location. The four main reported features/resources were fertile land, dambo, forest and river/lake. The attractions of each are:

- Fertile land for crops and livestock pasture
- Dambo land[7] to enable all year cropping through winter as well as summer planting
- Forest areas as a source of timber for construction, firewood, fruits/herbs etc., and wild game
- Rivers/Lakes for fish, water for drinking/bathing and for farming

The table below summarizes these by community:

TABLE 2. KEY NATURAL FEATURES AND RESOURCES, BY COMMUNITY

Community / Zone	Fertile Land	Dambo	Forest	River/ Lake
Chiluzi - Rift Valley	✓	✓	✓	✓river
Chisambamnopa - Phirilongwe Hills	✓	✓	✓	✓river
Felo - Lower Shire	✓	✓	x	✓river
Kawelama - Phalombe-Lake Chilwa	✓	✓	x	✓river & lake
Liguluche - Southern Lakeshore	x	x	x	✓lake
Lupanga - Middle Shire	✓	✓	x	✓river
Mulupha - Mulanje-Thyolo Tea Estate	✓	x	x	✓rivers

[6] Lilongwe

[7] A dambo is a wetland area that has water all year round. In dry season it can be too wet to use, being prone to water accumulation/flooding, but in the rainy season, it can enable planting of 'winter" crops providing a second harvest in the year. Dambos are increasingly used, even though it is illegal to cultivate them. Traditionally they are used for grazing and as a source of fodder and sometimes housing materials, so cultivation often brings conflicts between users.

Community / Zone	Fertile Land	Dambo	Forest	River/ Lake
Nkasala - Shire Highlands	✓	✓	✓	✓rivers
Thambolagwa - Kasungu-LLW Plain	✓	✓	x	✓rivers

Source: PRAs, Kadale Consultants

Although these natural attractions provided a historical reason for the location, as noted later, the depletion of the natural resources and changes to the climate have undermined the benefits of the location at this current point in time. Historically, the response to newly arising or persistent hazards and depletion of resources has been to move location, but the pressure on land area makes that much more difficult now than in the past.

3.1.2 SOCIO-CULTURAL CONTEXT

It was not possible to get complete **age and gender profiles** for the communities from the PRA, though it was possible to get general indications on gender and age profiles. Usually, the gender and age profiles were affected by outward-migration, typically, but not exclusively of young men. In Lupanga, older men were reported to be working in the Boma in retail shops.

TABLE 3. GENDER AND AGE PROFILE, BY COMMUNITY

Community / Zone	Age Profile	Sex Profile	Migration
Chiluzi - Rift Valley	Majority are youth & children	More females than males	Youth migrate to cities and South Africa (SA)
Chisambamnopa - Phirilongwe Hills	More elderly and 16-35 age group	More females than males	Young men migrate to SA for work
Felo - Lower Shire	Not clearly captured in PRAs	More females than males	Many men migrate to Mozambique or Nchalo[8]
Kawelama—Phalombe-Lake Chilwa	More middle aged & young 15-49	No differences identified	Adults go to Mozambique for ganyu.[9] Male in-migration for marriage/land
Liguluche - Southern Lakeshore	Majority are youth & children	More females than males	Middle aged men migrate to SA for work
Lupanga - Middle Shire	High proportion of youth & children	More females than males	15-28 age group migrate to cities & SA
Mulupha - Mulanje-Thyolo Tea Estate	No differences identified	More females than males	Men migrate to Mozambique for work
Nkasala - Shire Highlands	Majority are elderly & children	More females than males	Some migrate to SA or Malawi's cities for work
Thambolagwa - Kasungu-LLW Plain	No differences identified	No differences identified	Migrate to Mozambique & other parts of Malawi for marriage & work

Source: PRAs, Kadale Consultants

Most of the communities started as single **ethnic groups**, typically clans within a tribal group that originally migrated in and settled the land.

Subsequent to the original settlement, several communities reported subsequent inward migration by other groups into the community; for example, in Thambolagwa, another group of refugees that fled the Mozambique civil war came and settled in the area in 1985. These people inter-married with the Chewa and Ngoni people already in the village. Inter-marriage with subsequent inward migrants also occurred at Nkasala.

TABLE 4. SOCIO CULTURAL PROFILE, BY COMMUNITY

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[8] There is a large sugar estate at Nchalo, Chikhwawa District.

[9] Ganyu is the Chichewa name for casual employment, usually based on a task, such as an area of land to ridge or weed. Payment is either in cash or in maize. As is discussed later, ganyu is an important means though which the Poorer can access maize.

Community / Zone	Main ethnic	Other ethnic	Subsequent in-migration
Chiluzi - Rift Valley	Ngoni	Chewa	Tonga/Tumbuka
Chisambamnopa - Phirilongwe Hills	Yao	None	None
Felo - Lower Shire	Sena	Mang'anja	None
Kawelama - Phalombe-Lake Chilwa	Yao	Lomwe/Ngoni	Tumbuka
Liguluche - Southern Lakeshore	Yao	Lomwe	Ngoni
Lupanga - Middle Shire	Yao	Ngoni/Lomwe	None
Mulupha - Mulanje-Thyolo Tea Estate	Lomwe	Mang'anja	Mozambicans (not specified as to which tribe)
Nkasala - Shire Highlands	Yao	Lomwe	Ngoni/Tumbuka
Thambolagwa - Kasungu-LLW Plain	Ngoni	Chewa	Mozambicans

Source: PRAs, Kadale Consultants

There are links between some tribes and the predominant **religions**. For example, the Yao are predominantly Muslim, while the Lomwe and Ngonis are predominantly Christian. There are other cultural-religious beliefs, such as the Mbona cult among the Sena people of Felo, Lower Shire LZ that could be classed as animist. These religio-cultural factors can affect use of the natural resource base; the best example of this is Felo, where people believe that cutting the trees has angered Mbona, compounded by failure to follow the proper rituals and appease Mbona, so he has withheld the rains. The elderly believe that no matter what interventions are made to mitigate the effects of climate, things will not get any better unless the rituals start being followed again.

Some communities report being assisted by religious institutions to mitigate climate change impacts. In Chisambamnopa, the most vulnerable families get help from the local Islamic Association in food and money taken from contributions from members. However, some religious institutions were however reported not to have assisted community members in times of hardship when approached, such as the Bilal trust in Liguluche and the Roman Catholic in Thambolagwa.

The influx of **migrants** from Mozambique in the 1990s, who left to avoid the war, was a source of conflicts in Thambolagwa and Chisambamnopa. These people subsequently mainly returned to Mozambique at the end of the war. In Chisambamnopa, the way this was discussed, referring to the migrants as *akadzigulire malo*,[10] suggested a degree of hostility and a desire to blame outsiders for problems like deforestation. In Chiluzi and Nkasala, there were also references to community members who had engaged in acts of deforestation, but there was no element of hostility to these 'insiders' compared to the attitude if 'migrants' were responsible.

[10] Those that buy land for themselves through a Government of Malawi program.

TABLE 5. INTRA-COMMUNITY CONFLICTS, BY COMMUNITY

Community / Zone	Land	Water	Grazing	Other Conflicts
Chiluzi - Rift Valley	✓	✓HH use & Agric.	x	✓ Gender-based violence ✓ Drunkenness ✓ Indebtedness
Chisambamnopa - Phirilongwe Hills	✓	✓HH use	✓	✓ Access to forest - ethnic basis
Felo - Lower Shire	✓	✓HH use		✓ FISP
Kawelama - Phalombe-Lake Chirwa	✓	✓HH use	x	✓ Finances
Liguluche - Southern Lakeshore	✓	✓HH use	✓	✓ Cutting trees at graveyards
Lupanga - Middle Shire	x	✓HH use and Agric	x	✓ Rich exploit the poor ✓ Indebtedness
Mulupha -Mulanje-Thyolo Tea Estate	✓	x	x	✓ Husband 'grabbing' due to shortage of men
Nkasala - Shire Highlands	✓	✓HH use and Agric.	x	✓ FISP ✓Witchcraft
Thambolagwa - Kasungu-LLW Plain	✓	x	✓	✓ Political power ✓ Drunkenness ✓ FISP coupon distribution

Source: PRAs, Kadale Consultants

The cutting of trees from communal land might have been expected to generate **conflicts over the use of communal forest resources**. However, in most other places, the view appeared to be that those who were not able to feed themselves in a poor agricultural season had no choice other than to make use of the natural resource base, particularly trees to be cut for firewood and timber to be sold. For those that cut trees for charcoal and brick-making, it was identified that these were often young men who had no alternative livelihood, so they had little choice. In Liguluche, the community reported that letters from "government" had been brought by various people giving permission for them to cut the trees for boat building, so they had no choice but to allow it. However, only in Chiluzi was there no acceptance that people could just cut trees for their own reasons, including food insecurity. In this case, the female VH strictly enforced the rules on no removal of wood from the forest area, other than for sanctioned community projects. This stance was strongly supported by the community, in contrast to the passivity and almost helplessness of the other communities.

Although the use of communal forest resources by parts of the community was not a cause of open conflict, there was conflict over access to the forest areas for firewood in Chisambamnopa, where it had an explicitly an ethnic dimension. The established Yao community members said that the (more recent) Lomwe migrants put snares in the forest to "injure" Yao people collecting firewood. This was not reported by Lomwe community members.

There were other examples of **negative attitudes towards foreigners**; in Thambolagwa and Mulupha, Malawians cross the border with Mozambique as the prices for their produce are higher than in their local markets, and there is more ganyu available in Mozambique for those that rely upon it for their livelihoods. These cross-border travelers reported poor treatment by Mozambique border staff and police, such as being forced to work for them or receiving humiliating treatment:

They command us to climb into a tree and make noise like an owl; sometimes they tell us to mop their filthy toilets.
Community member, Thambolagwa

Although unpleasant, these livelihood strategies appear to be sufficiently valuable (trade), or people sufficiently dependent on them (ganyu) that community members are willing to risk such treatment. That partly reflected the limited opportunities for trade and ganyu in Malawi, and party the economic strain on the households that meant they felt it necessary to pursue this livelihood.

There were strains in the communities **between the wealth groups** that were explicitly identified and stated by the communities, such as in Felo, Liguluche and Lupanga. In Liguluche and Lupanga, the Better-off, and to some extent the Average, used strong terms about the Poorer, such as being "lazy". For the Poorer in Felo, they felt that they were exploited by the Better-off and the Average as they were forced to rent out their land at low rates and that when they did ganyu for the Average group, they were paid less than when the Average group did ganyu for the Better-off. In Felo, the Poorer felt that the other groups were able to bribe the Chief's Court to get the result they wanted.

The strains between the different wealth groups also appeared over the issue of the eligibility for the Farm Input Subsidy Program (FISP). The FISP is not targeted at the very poorest, as they do not have land and resources to make use of it, but there is sufficient subsidized inputs for a majority of rural households. However, there were particularly strong complaints about who was on the list to receive coupons at Felo, Nkasala and Thambolagwa, with the Poorer stating that the Better-off were being registered and many of them were excluded. In addition, when it came to redeeming the vouchers, the Better-off were reportedly able to make deals with the Agricultural Development Marketing Corporation (ADMARC)[11] officials to actually get the fertilizer, whereas the poor waited and left empty-handed. This led to feelings and statements of powerlessness:

A poor person is like a stone (meaning 'they can be treated in any way the Better-off desire). Poorer person, Felo

Land was one of the common areas of conflicts within communities. This was both a function of a relative shortage of land, such as in Felo and Mulupha, and loss of land due to flooding, such as in Kawelama. In Felo, the shortage was also stated in terms of population pressure, as it was in Mulupha and Liguluche where new settlement was blamed for taking up available land.

Land settlement disputes are on the increase because of population pressure. This is also affecting the fields as people have to share the same field perimeter thereby shortening the fields. Community member, Liguluche

There were tensions about land boundaries, which appeared to relate to falling productivity, where some community members tried to take better quality land from others, as they were no longer able to produce enough on their current land, such as at Kawelama. In Liguluche, witchcraft was used as part of the land conflicts to protect oneself and one's land from the witchcraft of others.

Another commonly reported was **conflict over water for household use**. This was mainly about women fighting due to the long waiting times at water points, such as at Chiluzi, Chisambamnopa, Kawelama and Nkasala. The long waiting times were a function of relatively few water sources, but also low water tables meaning that water flows were slow, thereby increasing the waiting times such as at Lupanga, Chisambamnopa and Kawelama

(There are conflicts between women) up to the extent of breaking each other's buckets. A month does not lapse before this happens. Some even fight. Community member, Chisambamnopa

A second dimension to the **conflicts is over water for agriculture**. In Nkasala, there were conflicts over shared use of water for irrigation. In Chiluzi, tobacco farmers upstream were blamed for drawing off too much water from the streams, resulting in conflict.

Another major source of **conflict was the free grazing of animals**, particularly goats, as reported in Chisambamnopa and Thambolagwa. This is a problem in the summer season when crops are in the field, and particularly for those that are winter cropping in dambos, as there is so little alternative pasture for the animals that they are attracted by the crops in the dambos, such as at Thambolagwa. In some cases, the livestock were killed and in others the livestock owner was taken to the Chief's Court for judgment. In

[11] A parastatal that has been involved in FISP input distribution.

mitigation, livestock owners argue that the availability of pasture is now more limited particularly in the dry season, such as at Chisambamnopa. A major part of the problem is that dambo land, which was previously for communal grazing, is now used for cultivation due to the pressure to produce more. Cultivating in the dambo was not allowed in the time of President Kamuzu Banda and the rule was strictly enforced.

There were other reasons for conflicts, around **borrowing and handling finance** (Chiluzi and Kawelama), **politics** (Thambolagwa) and **distribution of development items** (Thambolagwa and Felo). In Chiluzi, a grocery store owner said:

"As a business man people borrow bags of maize from me and they don't want to pay back so we end up having fights."

Conflicts around **gender-based violence** were also reported in some communities. For example, in Chiluzi, gender based violence was reported to be perpetrated by both men and women in marriages. In Thambolagwa, such conflicts were attributed to excessive drinking.

In a few communities, there were **strains between community members and their leaders**, such as in Felo. This was due to perceived favoritism in selection of beneficiaries of aid programs when NGOs, such as WALA, involve the chiefs. However, in some communities, there was strong support for the leadership. In Chiluzi, the VH strictly enforced the ban on extracting timber and firewood from the protected areas. Community members appreciated this, as they still had their forest areas while other communities had lost theirs.

There were examples of **positive co-existence with other communities**, particularly over water for household use. Members of Lupanga and Felo reported that due to the location and relative shortage of water sources in the community, some women went to neighboring villages to access water for domestic use. This did not appear to generate the same frictions as were reported at communities' own water sources. Possibly the other communities had relatively good water sources, so queuing was more limited, or the conflicts may not be reported by those who go to other communities, as they would be more likely to be the subject of complaint and conflict.

3.1.3 ECONOMIC CONTEXT

In this section, the focus is on describing the economic context specifically the current main livelihoods (farm and non-farm), the main economic groups (from the wealth-ranking), their economic conditions and threats to their livelihoods. Changes to livelihoods, in particular to agriculture resulting from climatic variations and changes, are discussed in section 3.2.1.

One criterion for selection of the nine communities was that they were not close to the Boma. This selection criterion did not mean that the communities were necessarily very remote. The intention was to select communities that could be regarded as typical of their particular Livelihood Zone. In the economic context, this meant a community that was not overly influenced by proximity to the Boma, which tends to be the dominant economic focal point for a District. The exception to this was Lupanga (Middle Shire), which was chosen to have one community that had proximity to a major market.

3.1.3.1 CURRENT LIVELIHOODS – FARM AND NON-FARM

In all the communities, agriculture was the main livelihood for the majority of people, even in Liguluche (Southern Lakeshore), where fishing was an important, but no longer a predominant activity. The type of agriculture varied between crops and livestock, with crops predominant. Within crops, there were variations according to the agro-ecological conditions. Most people in the communities could be classed as poor and so most production was subsistence. As a result, food crops were prominent, particularly maize, though food crops were also sold when required to raise cash for necessary expenditures, such as medical costs, school fees and inputs for farming. There was dedicated cash crop production, particularly cotton in hotter drier areas, though cotton was generally being grown and sold in order to buy maize, such as in Chisambamnopa, Phirilongwe Hills LZ.

TABLE 6. CURRENT CASH CROPS, FOOD CROPS, LIVESTOCK AND FISHING, BY COMMUNITY

Community / Zone	Food crops	Cash crops	Livestock	Fishing/ Fish Farm
Chiluzi - Rift Valley	✓Maize, cassava, millet, soybean, groundnuts	✓Tobacco, sweet potatoes, groundnuts, cotton and soybean	✓Cattle, poultry goats & pigs	x
Chisambamnopa – Phirilongwe Hills	✓Maize & sorghum	✓Cotton, & cassava	✓Goats & chickens	x
Felo – Lower Shire	✓Maize, sorghum & millet	✓Cotton & sweet potato	✓Goats	✓From Shire River
Kawelama – Phalombe-Lake Chilwa	✓Maize, cassava, beans & pigeon peas	✓Rice, cassava, some tobacco & chilies	✓Sheep & goats - reducing	✓Lake Chilwa
Liguluche – Southern Lakeshore	✓Maize; cassava stopped due to pests;	✓Sweet potato; rice decreased	✓Goats, sheep & poultry; many more cattle	✓Lake Malawi
Lupanga – Middle Shire	✓Maize & cassava	✓Cotton, beans, groundnuts & tobacco	✓Goats & chickens	x
Mulupha –Mulanje-Thyolo Tea Estate	✓Maize, cassava, & pigeon peas;	✓Cassava, tea & pigeon peas	✓Goats & chickens	✓3 households
Nkasala – Shire Highlands	✓Maize, cassava, sorghum, beans, millet, pigeon peas & groundnuts	✓Cotton & rice	✓Goats, chicken & pigs	✓2 households
Thambolagwa - Kasungu-LLW Plain	✓Maize, beans & Irish potato	✓Maize, beans, Irish potato & soybean	✓Cattle, poultry, goats & pigs	x

Source: PRAs, Kadale Consultants

The table above sets out the current agricultural/fishing livelihood portfolio. Changes in production are discussed in section 3.2, through a comparison with the historic situation.

As would be expected, the nine communities are all predominantly agricultural communities[12] that depend on crop production combined with livestock and/or fishing for food and incomes.

Maize is the predominant food crop in all cases, though cassava is also important; other crops mainly for consumption include pigeon peas, millet and sorghum. All these could and were also being sold for cash, as required. There were some food crops that were grown mainly for cash being: sweet potatoes, vegetables, tomatoes, groundnuts, rice and Irish potatoes.

Livestock was important in Liguluche, particularly cattle, and Nkasala (chickens and goats), but in most communities livestock keeping was not a significant livelihood and was in decline.

Fishing was still important in Liguluche, a lakeshore community, but was mainly for small 'usipa' fish due to the lack of larger fish, such as mcheni and chambo. In Kawelama, there was still fishing on Lake Chilwa. In other communities, there was river fishing, such as Felo, but it was insignificant elsewhere. There were fishponds in Mulupha and Nkasala only.

For non-food cash crops, cotton is grown in several of the communities that have drier climates, such as at Lupanga (Middle Shire), Chisambamnopa (Phirilongwe Hills) and Felo (Lower Shire). Other non-food cash crops include tobacco, tea (Mulupha only) and peppers/capsicum (Kawelama only). In addition to agricultural/fish production, there were other livelihoods identified as set out in Table 7 below.

TABLE 7. CURRENT MAIN LIVELIHOODS, BY COMMUNITY

[12] The only partial exception is Liguluche (Southern Lakeshore) which was predominantly a fishing community, but is now more diversified with a considerable emphasis on livestock.

Community / Zone	Employment	Ganyu	Business/IGA	Remittances
Chiluzi - Rift Valley	x	✓Work in other's gardens[13]	✓Sell beer and thobwa[14] sell mice; Poorer engage more in firewood & charcoal	x
Chisambamnopa – Phirilongwe Hills	x	✓Work in other's gardens	✓ Sell fish, mandasi, vegetables & mats; brick making, firewood/ charcoal	✓Relatives in SA
Felo – Lower Shire	☐✓Some in shops at Boma & sugar estate[15]	✓Work in other's gardens	✓Sell tomato and vegetables (increasing); Poorer engage more in firewood & charcoal	✓Relatives in SA and cities
Kawelama – Phalombe-Lake Chilwa	x	✓Work in other's gardens, public works	✓Sell fish and rice, baskets/mats, firewood & hunting finished	x
Liguluche – Southern Lakeshore	x	✓Work in other's gardens, public works	✓ Fish trading declining, brick making, mats	✓Relatives in SA
Lupanga – Middle Shire	✓Seasonal at cotton ginnery	✓Washing in town & work in gardens	✓Sell vegetables, mandasi, fish (declining), grocery; firewood finished	✓Relatives in SA
Mulupha –Mulanje-Thyolo Tea Estate	✓Tea estates	✓Work in other's gardens	✓Brew beer	✓Relatives in Moz and SA
Nkasala – Shire Highlands	x	✓Work in other's gardens	✓Charcoal, firewood & timber, mats	✓Relatives in SA
Thambolagwa - Kasungu-LLW Plain	x	✓Work in other's gardens	✓Brew beer	x

Source: PRAs, Kadale Consultants

Employment was not common, unless there was a major employer in the area, such as the sugar estate and factory at Nchalo (Felo), close to a cotton ginnery (Lupanga), or at the surrounding tea estates (Mulupha). In contrast, all communities had ganyu opportunities to work in the gardens of those with more land and resources in their communities. There were also ganyu opportunities outside the community, notably in Mozambique where the low population density means land area is not such a constraint as in Malawi.

People operated small-scale businesses[16] or Income Generating Activities (IGAs) in all the communities; the main ones are listed in the table. These were typically small trading activities such as selling fish and vegetables, basic processing such as beer brewing and making mandasi[17] and African cakes, and natural resource exploitation such as gathering firewood for sale or making charcoal and making bricks. Many of these small-scale businesses are seasonal to reflect that the owners need to concentrate on farming in the farming season, and that this also coincides with the period when income is most scarce.

3.1.3.2 WEALTH RANKING

A key aspect of the socioeconomic profile is the **wealth ranking**. All the communities defined and labeled key groupings in their own community based on wealth. The research team guided the community respondents to think about families who were 'Average'. They were then asked to consider who was 'Better-

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13 Gardens refers to agricultural land, but is the common term used in Malawi.

14 Thobwa is a non-alcoholic brew from maize flour. Maize grain is soaked in water to germinate, then pounded and used to brew the Thobwa. It is similar to sorghum beer (Chibuku), but without yeast.

15 This is the Illovo sugar plantation and factory at Nchalo, about 60-70 kms from Felo.

16 Sale of own farm produce is not classed as a business, but rather where there is buying in of produce to sell on, or making something from own resources to sell.

17 These are shallow fried dough balls like donuts.

off' and who was 'Poorer'. Given the widespread nature and depth of rural poverty in Malawi, the Average group was commonly labeled by communities as 'the Poor', alongside the rich/ very rich[18] who were 'the Better-offs' and the very poor who were 'the Poorer'. The use of relative terms was considered to be more appropriate than terms such as 'rich' and 'poor' as these require complex definition, whereas relative terms give a sense of the place of the person within the community not necessarily their absolute wealth or poverty.

Overall, a substantial majority of households were labeled Average/Poor or Poorer/Very Poor by the communities, with relatively few as Better-off/Rich. Communities were asked to provide their key differentiators for each category and the responses are set out in Table 8 below.[19]

TABLE 8. WEALTH RANKING CATEGORIES, PROPORTIONS[20] AND DIFFERENTIATORS, BY COMMUNITY

Community / Zone	Better Off / Rich	Average / Poor	Poorer / Very Poor	Key differentiators
Chiluzi - Rift Valley	1%	29%	70%	Food adequacy, livestock ownership, housing (iron sheet, burnt brick), household assets & ability to pay school fees
Chisambamnopa – Phirilongwe Hills	10%	40%	50%	Food adequacy, housing (durability) diverse income sources, remittances from SA & cash cropping,
Felo – Lower Shire	13%	27%	60%	Livestock ownership, housing & cultivated land ownership.
Kawelama – Phalombe-Lake Chilwa	15%	25%	60%	Food adequacy, livestock ownership, business operation, mode of transport owned, land ownership
Liguluche – Southern Lakeshore	10%	20%	70%	Food adequacy, livestock ownership, housing structures, ownership of nets & boats
Lupanga – Middle Shire	20%	80%		Diversity of diet, livestock ownership/sales, housing, business operation & reliability of income source
Mulupha –Mulanje-Thyolo Tea Estate	20%	30%	50%	Food adequacy & diet diversity, livestock ownership, business operation, employment, & clothing
Nkasala – Shire Highlands	10%	30%	60%	Food adequacy, housing, asset ownership & using modern farming techniques
Thambolagwa - Kasungu-LLW Plain	40%	60%		Amount of farm produce, livestock ownership, housing & toilet type, income sources, clothing & ability to buy farm inputs

Source: PRAs, Kadale Consultants

Food adequacy was a major differentiator, with the Better-off generally having enough food all year with dietary diversity, the Average having food for the majority of the year with limited dietary diversity, and the Poorer having insufficient food and very limited diversity. For example, in Nkasala, the Better-off group were defined as having enough food for the year, the Average group as having short hungry seasons of up to three months and the Poorer as having long hungry seasons of up to six months. In all nine communities, even those in areas where maize does not grow well (Mulupha and Liguluche), maize is the staple food as is the case throughout Malawi; and hunger is often defined in relation to having eaten maize or not. Only in Felo was food adequacy not explicitly stated as a differentiator of wealth, though the focus on the amount of land owned could reasonably be taken to be a proxy for crop production and food availability, suggesting that even here, food availability was an important differentiator.

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18 One community split the Better-off into rich and very rich, but otherwise the communities just had a single category for the rich/very rich

19 In Lupanga and Thambolagwa, the communities only distinguished the Better-off and the rest, whom they regarded as Poor/Very Poor without much to differentiate them.

20 Note that the researchers were asked communities to give proportions, rather than undertake actual measurement to give a sense of the size of the wealth categories than actually determine their size.

A further reinforcement of the importance of maize in community definitions of wealth ranking is highlighted later in the adaptation section in that households respond to difficult times by reducing the number of meals involving maize and talk about substitutes for maize in the meal.

Livestock ownership was also a common differentiator. Only in Nkasala was livestock ownership not explicitly stated at all as a means to differentiate wealth within the community, as it has been adopted by many as a strategy for food security.[21] In Chisambamnopa, it was stated in relation to the Average group, but not the other groups, though it might be inferred that more or less livestock would be a characteristic of the Better-off and Poorer groups respectively.

The type of livestock held, as well as the number, was part of the differentiation. For example, in Chiluzi, cattle were owned by the Better-off groups,[22] while the Average and the Poorer did not own cattle. The Better-off and Average groups both owned pigs, poultry and pigeons, while the Poorer had no livestock.

Generally reported problems with livestock were theft, disease and access to grazing, which in some cases had led to a reduction in livestock keeping.

Theft is linked by communities to a mixture of being near the border with Mozambique where it is easy for robbers to steal and make off (Thambolagwa and Felo), and due to poverty within their own community and locality, such that theft has become more prevalent. Theft of free-ranging goats has become such an issue in Kawelama, that it has reduced people's motivation to keep them. This was also reported as an issue in Thambolagwa, Chisambamnopa and Lupanga. In Chisambamnopa, the community reported that theft became a problem from 2000.

"Three of five homes are victims of theft and not in the far future, goats will be extinct in our village." Community member, Chisambamnopa.

Livestock disease was commonly reported and often linked to climate as having increased, particularly that higher temperatures were promoting disease. Cattle were commonly reported to be affected by Foot and Mouth Disease (FMD) or 'chigodola' in Chichewa, as well as by ticks and related to this, by East Coast Fever (ECF). Pigs were reportedly affected by African Swine Fever (ASF) and high temperatures. Goats were reportedly affected by ECF, ticks and worms. Chickens were mainly affected by Newcastle Disease (ND), particularly in hot weather. It was reported that access to veterinary services and dip tanks was problematic. However, the Better-off can afford treatments, but the other groups cannot, so they slaughter diseased animals and eat them, as reported at Thambolagwa. In Lupanga, the community reports that the cattle population was lost to FMD and there were heavy losses of chickens to ND. In Felo, the community reports that ECF has affected the pig population and ND the poultry.

Access to grazing was a problematic issue in some communities, particularly Mulupha, where there is little available land due to the village being surrounded mainly by tea estates. Scarcity of pasture was also reported at Chiluzi and Lupanga. Part of this loss of pasture is due to cultivation of the dambos, such as at Thambolagwa where all dambos which were used for livestock grazing have been turned into cultivation land. As noted earlier, the free grazing of goats and pigs has created conflicts with crop farmers, particularly those that are growing in the dambos during the winter dry season, as this is the time and area that traditionally has been available for free-grazing of livestock.

It is clear from the PRAs that livestock is typically seen as a means to store accumulated wealth. A farmer in Chisambamnopa said that his father advised him to buy the goats and chickens:

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21 Have enough livestock to sell in order to buy food, and breeding more to replace those sold.

22 In Chiluzi, four groups were differentiated, including "the rich" and the "fairly rich".

"So that I can be selling them during times of need." Farmer, Chisambamnopa

Selling of livestock in times of need has been a long standing adaptation strategy. However, the pressures on food production and poor harvests in recent years have resulted in a decline in livestock numbers, such as in Kawelama and Nkasala.

In Liguluche, a community that previously benefited from fishing as a major source of income, there has been a major shift over the last ten years by households from fishing to keeping cattle, such that cattle numbers are increasing. It was stated that households that did not have any cattle ten years ago, now have twenty or more.

"The lake is no longer what is used to be and cattle now help a lot when you are in problems." Community member, Liguluche.

"*Cattle are now our wealth and when a cow dies I cry as if a person has died." Community member, Liguluche. (underlining added by consultants)*

It is important to note that the cattle are not being reared in a commercial manner, but rather for a mixture of status and food security reasons.

This increase in cattle is being fuelled by funds from migrants to SA, and is encouraging households to send more young men to SA to what they call 'Liguluche 2', which is a community consisting mainly of migrant men from Liguluche.

Other than Liguluche where there is livelihood strategy to increase cattle numbers, and Chiluzi, where the numbers of goats and pigs were increasing though cattle and chickens were decreasing, most communities reported overall decreases in livestock in recent years due to the problems discussed above. There were also reported problems with hyenas in Kawelama, Lupanga and Chisambamnopa. This is possibly a consequence of loss of forest and wild animals, such that hyenas are increasingly seeking out domesticated livestock.

TABLE 9. FACTORS AFFECTING LIVESTOCK

Community / Zone	Theft	Disease	Access to grazing	Sale to buy food
Chiluzi - Rift Valley	✓Cattle theft rising	✓ND & FMD more frequent	✓Free grazing, though it is discouraged	✓Livestock sales or exchange for maize
Chisambamnopa – Phirilongwe Hills	✓Theft of goats has worsened	No disease reported	✓Goats graze freely in dry season	✓Livestock sales in hunger periods
Felo – Lower Shire	✓Livestock theft common	No disease reported	✓Free grazing occurs	✓Livestock sales in hunger period and to pay school fees
Kawelama – Phalombe-Lake Chilwa	✓ Sheep & goats theft rising	✓Seasonal infection of goats	✓Grazing on crop fields in dry season	✓Livestock sales (mostly goats) to buy food and seeds
Liguluche – Southern Lakeshore	No theft reported	✓ND more frequent	✓Grazing dambos along Shire River and Lake Malawi	✓Livestock sales to buy maize – very common strategy
Lupanga – Middle Shire	✓Livestock theft rising forced people to sell	✓FMD & ND very common	✓Mostly free range grazing; farmers guard their fields	✓Livestock sales to buy maize
Mulupha – Mulanje-Thyolo Tea Estate	No theft reported	No disease reported	✓Lack of grazing land due to estates, so gather feed	✓Sale of goats, chickens and pigs to buy maize
Nkasala – Shire Highlands	No theft reported	✓Livestock more prone to diseases	✓Reduced forage resulted in fewer livestock	✓Livestock sales to buy inputs and food
Thambolagwa - Kasungu-LLW Plain	✓Theft of all types; now keep goats & chickens in houses	✓ASF for pigs Chickens get ND	✓Free grazing on dambo where crops are grown; brings conflict	✓Cattle and pig sales to buy food; but also due to insufficient grazing

Source: PRAs, Kadale Consultants

Housing was a common differentiator of wealth, explicitly stated as such, except in Kawelama and Mulupha. The main differentiating features were the nature of materials used, the facilities (such as toilets) and how well the housing structure was maintained. In Chiluzi, the differentiation of materials was iron sheets and burnt brick being for the better off as opposed to mud and grass thatch for the Poorer. In Thambolagwa, the better off were distinguished by having safe latrines with cement slabs, while the Poorer were identified by their poorly constructed houses and absence of latrines.

Operating businesses, **employment, access to remittances** and **diversity of income sources** were related indicators of wealth given in Chisambamnopa (diverse income), Kawelama (business operation), Liguluche (ownership of fishing boat and equipment), Lupanga (business operation and reliability of income, Mulupha (business operation and employment), Thambolagwa (income sources). All these indicate a capacity to generate cash incomes other than from farming. Although businesses might be farm-related, such as trading, or dependent on the success of farming, such as a grocery businesses, they do offer some degree of downside protection if farming is negatively affected in the locality. This is partly why the diversity and the reliability of income sources were given as differentiators, as was employment, which was highly valued.

In contrast, the Average and the Poorer households were identified by the degree of reliance on ganyu. While the Average may have to engage in ganyu at particular times to get food or money, the Poorer are highly dependent on it for considerable periods of the year, notably in the second half and particularly the final quarter being the hungry season.

There were **farming-related** differentiators, including **land ownership**, engaging in **cash cropping,** use of **modern farming techniques**[23] and **ability to afford farm inputs**. These differentiated people's ability to generate incomes from farming. Those that have high land ownership, engage in cash cropping and have access to inputs offer ganyu opportunities to the Average and Poorer groups. These Better-off households are able to pay for the ganyu out of accumulated surplus maize production from previous seasons, or cash generated by crop sales, business or employment. In a related manner, it was the ownership of boats and fishing gear that differentiated the Better-off in Liguluche, on the Southern Lakeshore. In that case, the Better-off hired the Poorer to do the fishing for them.

Other differentiators included **ownership of household assets**, **transport means** and clothing that are the product of greater wealth, as well as having the **capacity to pay for school fees.**

Overall, it is the ability to produce more during good agricultural seasons and to manage in poor agricultural seasons[24] that means the better off can improve their position relative to the others, the Average can manage, but are vulnerable to individual problems and the Poorer constantly struggle.

Beyond the wealth ranking which differentiated within the community, communities identified **access to markets** as important, as it has a direct influence on the selling prices of farm produce. For example, In Kawelama it was reported that the distance from the market where people can go and sell their produce is long, so people sell their produce within the village at a reduced price.

"When you have a steady market for your product, it determines your decision to plant and go to sell the product." Community member, Kawelama

"Selling produce to middlemen and cotton buyers has become a problem as we lack latest information about fixed buying prices at the Boma." Community member, Chisambamnopa.

[23] This included Sasakawa, which relies heavily on purchased inputs to deliver productivity gains.

[24] For example being able to buy seeds for re-planting.

In Chisambamnopa, the community members stated that the long distance to the market forces vegetable traders to sell their produce cheaply to return home in good time.

Access to markets affects the prices that farmers can get for farm produce, increases the cost of transport for taking produce to market and increases the price of items that the community needs to buy.

Part of the problem with access was the **poor condition of bridges and roads**, particularly in the rainy season, which exacerbated the relative remoteness of these communities. Poor access to markets was highlighted by people in Chiluzi, Chisambamnopa, Liguluche, Lupanga, Mulupha and Thambolagwa. In contrast, people at Nkasala reported that their access to the things they need, including farm inputs has improved.

A number of economic threats were identified by communities, which are set out in Table 10.

TABLE 10. IDENTIFIED ECONOMIC THREATS, BY COMMUNITY

Community / Zone	Production related	Market related	Other economic threats
Chiluzi - Rift Valley	• Pest attacks on livestock • Theft of livestock	• Low prices at ADMARC[25] Devaluation and rising prices	• None identified
Chisambamnopa – Phirilongwe Hills	• Theft of livestock	• Cotton prices fixed; • Poor HHs sell produce cheaply as market is far	• Hyenas kill goats
Felo – Lower Shire	• FISP benefits a few • Theft of livestock	• No market in village • Maize expensive & all prices rising • Business is seasonal	• Robbery of business people
Kawelama – Phalombe-Lake Chilwa	• Fertilizer & pesticide are expensive • FISP is insufficient • Theft of livestock • River/Lake drying affects fishing	• No market in village so sell cheaply	• Ganyu pricing is different for Average versus the Poorer
Liguluche – Southern Lakeshore	• Dwindling fish stocks • Cassava disease	• High transport costs to the far off market • Price of goods to buy	• Hippo/Croc attacks limit use of dambo
Lupanga – Middle Shire	• Poor soil fertility • Livestock theft	• High interest on loans • Rising price of goods	• Work at ginnery can be short if low production
Mulupha –Mulanje-Thyolo Tea Estate	• Insufficient land due to tea estates and population rise	• Higher maize price • Low prices from tea buyers	• Seasonal jobs at tea estates, but limited income off-season
Nkasala – Shire Highlands	• High fertilizer price so use manure only	• Volatile cotton prices High prices for food and other items	• Fewer trees affects charcoal making • Officials confiscate charcoal
Thambolagwa - Kasungu-LLW Plain	• Livestock theft • High costs of farm inputs	• Low prices set for farm produce	• Unstable market for selling e.g., opaque beer

Source: PRAs, Kadale Consultants

Economic hazards given were classified into production-related, market-related and other threats. This section does not include climate related threats that clearly have considerable impacts on production and livelihoods, as these are considered later.

[25] The Agricultural Development and Marketing Corporation, a parastatal charged with buying farmer produce through its rural markets.

Production related economic threats include theft, diseases and pests for crops and livestock, high cost of inputs combined with inability to access the FISP inputs, limited access to sufficient land and decline in fish stocks.

Of these threats, theft, particularly of livestock but also crops is a major problem. Referring to keeping food in granaries rather than in the house, a farmer from Nkasala said:

"You don't keep your life outside." Farmer, Nkasala

Livestock are relatively valuable and can be easily transported and sold quickly. In some communities, theft was linked to the onset of the hungry season as well as a breakdown of livelihoods and opportunities, such that stealing becomes a (partial) livelihood in its own right. Some of the theft problems are with communities near the border with Mozambique, such as Thambolagwa, Mulupha and Felo, which appears to contribute to insecurity combined with the ineffectiveness of the police to pursue and find robbers. It was noted in Chisambamnopa that people are abandoning livestock due to the pressures on their livelihoods resulting in the need to sell livestock to get food, but also explicitly because theft deprives them of a key asset and form of saving against difficult times.

The second major production related threat is the cost of inputs, particularly fertilizer, but (hybrid) seeds and pesticides were also mentioned.

"Farming these days has become very expensive as the farmer has to rent land if he does not have it and purchase seed and fertilizer whose prices have gone up tremendously."

The farmers highlighted that the market price of fertilizer in particular had increased substantially relative to the price a farmer received for selling maize. Selling maize from the previous season to buy fertilizer for the current season is a common strategy by farmers, but this is being undermined by the relative prices of fertilizer and maize.

"In the past they would buy 50kg of fertilizer by selling 2x50kg of maize but now they have to sell 6-7 bags of maize." Community member, Thambolagwa

The situation of high input prices can be eased if there is access to the FISP subsidized inputs, but this was reported to be problematic in most of the communities. It is difficult to determine if the actual distribution is unfair or if the allocated number of coupons does reach the communities; however, the community perceptions are that not many member of the community benefit, and that the Better-off seem to be able to get or buy coupons and/or bribe ADMARC officials to provide them with the inputs. So, even if some community members do manage to get coupons, they are unable to get the fertilizer.

In the communities, this was framed as a wealth-based issue, such as:

"The FISP does not reach any needy person so many still cultivate without the necessary inputs." All from Community Members, Mulupha

"Farming today is favoring the rich because they are the ones who can afford to purchase inputs, during free input distribution they rush to ADMARC and purchase all the fertilizer so that even if we have our coupons we cannot access any fertilizer, as a result most of us do not harvest much as we cannot afford fertilizer at (MK) 14,000 (US $ 40) per bag, its just as good as buying the maize from Mozambique."

The consequence is that the Average and Poorer households do not use fertilizer and so have lower yields. These groups are also unable to utilize the higher yielding, shorter maturing hybrid varieties, as these are more dependent on fertilizer than the traditional varieties. This means they cannot adapt to shorter rainfall seasons by changing varieties to hybrids, further compounding their vulnerability. The lack of access to inputs is a major threat to livelihoods, particularly if rainfall seasons are shortening.

One issue of significance for communities that have fishing as part of their livelihood (Liguluche, Southern Lakeshore and Kawelama, Lake Chilwa Phalombe Plain) is the depletion of fish stocks in the Lakes and rivers, but also the drying up of Lake Chilwa. The response has a mixture of abandoning fishing, intensifying fishing activity by spending more time to maintain fishing income and catching smaller, more readily available fish, notably usipa. The depletion of stocks has resulted in breaking the rules to try to maintain catch value.

"Fisheries department prohibits the use of nets with small holes. Seeing that we have problems, we still use them." Community member, Liguluche

It was also noted that the GoM officials are implicated in the problem of overfishing by reportedly tipping off the larger boats as to when the patrols are taking place in particular areas so that these boats can continue to fish in the closed season.

Market-related economic threats were rising prices of goods particularly after the devaluation of the Malawi Kwacha (MK), low crop prices from traders and at markets, the long distances to market and related high costs of transport, and the certainty of markets for farm produce.

The two most important market related threats are inflation and low crop prices. The rise in prices has accelerated following the devaluation[26] and is presenting households with problems of affording what are termed necessities. For example:

"Those who are managing to have sugar in their households are white men." Community member, Mulupha

The second major issue is the prices paid for farm produce, particularly cotton. This is related to the fall in cotton prices in the 2011-12 growing season compared to the 2010-11 season, when prices were high due to world demand factors. The Poorer relative prices in the last market season are contrasted with the higher input prices for the 2012-13, hence the comments about price for (last year's) crop relative to the price of inputs for the next crop.

A related issue is that farmers feel they are being taken advantage of by traders, mainly because of their poor access to markets, which is a function of relative remoteness.

The volatility of prices was also an issue:

"Last week I bought usipa at K600/5 liters at the lake and sold it at M'baluku at just K650. Yesterday it was selling at K600 and today it has even going down to K450 and I cannot do business. There is too much supply of usipa at the market."

Other economic threats include robbery, limited employment opportunities and attacks by wild animals on livestock (hyenas) and people in the dambos (crocodiles and hippos).

As well as theft of livestock and crops, there were reports of robbery, including with violence. One boy on his way to market have been robbed and killed. These challenges with rural security undermine economic activity.

"Thugs beat people and snatch bicycles: some do have their private parts[27] removed especially during the rainy season." Community member, Chisambamnopa

Three communities have access to work opportunities from agro-businesses, being Felo where men travel to the sugar estate and factory at Nchalo, Mulupha which is surrounded by tea estates and Lupanga which is close to a cotton ginnery, but also not far from the Boma where there are employment opportunities in

[26] This has also pushed up the buying prices of some (export-related) crops, but this was not mentioned by communities, rather that produce prices were volatile and they felt exploited by buyers.

[27] This refers to removal of male genitals that are used in witchcraft-related activities, often from boys.

shops. All of these agro-businesses are seasonal to some extent, particularly cotton. As a result, although the employment opportunities and regular cash income is highly appreciated, the employment is also seasonal.

There were reported attacks by hyenas on livestock. This is not a new problem, but the loss of habitat and of wild game could be contributing to hyenas visiting populated areas looking for food. The problem of hippos and crocodiles in the dambo area was reported. The cultivation of the lakeside and dambo areas means that the hippos are more likely to graze on crops, particularly in the dry season when other vegetation is sparse. The communities said that the reduction in fish stocks may be affecting crocodiles' behaviour and encouraging them to come to the dambo where there are humans and livestock.

3.1.4 CLIMATIC CONTEXT

The PRAs highlighted a series of climatic effects related to rainfall, temperature and wind. Although there is merit in separating the past from the current situation, this is more difficult in practice as the climate effects are to some extent blurred so that there is not necessarily clarity over when a change has occurred and to what extent it has changed. Communities spoke a lot about how things were more predictable in the past, but also that the same sorts of events did occur in the past, only that these are now more the norm. It is difficult to determine in a qualitative analysis the previous norm, the transitional period and the new norm, without also bringing in formally recorded climate data, which is beyond this study's scope. Therefore, this section focuses on changes the communities described as being part of their current reality.

3.1.4.1 CHANGES IN RAINFALL

The effects of variations in rainfall were the most commonly reported climatic effects and most complex, with several inter-related variations and impacts.

The identified rainfall variations were:

1. Late onset of the rains
2. Unclear start to the rains
3. Extended dry periods
4. Early cessation of the rains
5. Heavier rains than normal during the rains and at the end of the season

TABLE 11. REPORTED RAINFALL EFFECTS, BY COMMUNITY

Community / Zone	Late Onset	Unclear Start	Extended Dry Periods	Early Cessation	Heavier Rains
Chiluzi - Rift Valley	✓Late onset	✓Stop & start	✓Prolonged dry spells since 2008	✓Early cessation is common	✓Too much in 2009
Chisambamnopa – Phirilongwe Hills	✓Late onset	✓Has made people replant several times	✓Prolonged dry spells after first rains	✓Shorter season	✓Heavy from 2000-2007 causing flooding
Felo – Lower Shire	✓Used to start in Oct. Now Dec. or Jan.	✓Unclear start has confused planting time	✓Withering of crops reported	✓Short rains	✓Heavy rains in 2001-2002 washed away crops
Kawelama – Phalombe-Lake Chilwa	✓Been starting late	✓Rains have unclear start	✓Extended dry spells reported	✓Unclear end & short duration	✓Heavy rains in a short period
Liguluche – Southern Lakeshore	✓Sometimes started late	✓Rains have been very erratic at the start	✓Have been long periods when rain is scarce	✓Have been very low with frequent cuts	✓Create logging conditions - submerge crops, leach soil & wash away fertilizers

Community / Zone	Late Onset	Unclear Start	Extended Dry Periods	Early Cessation	Heavier Rains
Lupanga – Middle Shire	✓Late onset	✓Unclear start	✓More prolonged dry spells	✓Early cessation	✓Destructive heavy rains
Mulupha –Mulanje-Thyolo Tea Estate	✓Sometimes come very late	✓Very random with no clear start	✓Prolonged dry spells	✓Have been very low and erratic	✓Been periodic heavy rains
Nkasala – Shire Highlands	None reported	✓Very unpredictable - start Oct. & can break to Dec.	✓A long dry period in 1999 & 2001	✓Experience low rainfall	✓Heavy rains, especially near the mountain; people cannot plan
Thambolagwa - Kasungu-LLW Plain	✓Late onset - was Sep now Nov	✓Increasing uncertainty of season onset	✓Dry spells in Oct to Dec (unclear onset)	✓Shorter rainfall – was May, now Mar.	✓Too much rainfall towards season end

Source: PRAs, Kadale Consultants

Communities typically described the rains as 'erratic' compared to the more predictable patterns that they had previously experienced. All communities except Nkasala reported all the effects. Nkasala reported unpredictable start, lower rainfall, dry spells (but not recent) and heavy rains near the mountain. In addition, they did report hailstones combined with heavy rain and what they called *"mvula ya moto"* like an acidic rain that damaged crops.

Inevitably, in agricultural communities that depend on rainfed cropping, the rains were a major topic of discussion in which several effects were highlighted:

"Rains are playing games with us as they are not predictable" Community member, Chisambamnopa

"The atmosphere has lost its memory." Community member, Chisambamnopa

"In the times of our forefathers we were assured that planting rains will come in October" Community members, Felo

"We are not sure which rains are the planting rains and even the meteorological department seems not to know what they are saying unlike in the past" Community members, Felo

"The rains have been crooked and tricky." Community member, Kawelama

"These days there is no proper distinction between chizimalupsa and the main rainfall for planting. In the past we were experiencing chizimalupsa (rains) in September, chikumbasuchi (rains) in October, ntuluko (rains) in November. These days the rains are unreliable because you can tell which is which." Community member, Liguluche

"Nobody can trust the rains anymore these days. 10 to 15 years ago we were sure that rains which came late October or early November were for planting; but these days planting rains are coming as late as December" Community member, Mulupha

"It is risky these days to rely on rain fed agriculture because you are not sure of how the rains will be in a particular year" Community member, Mulupha

"These days maize survives on dew" Community member, Thambolagwa

The above statements and others from the PRAs bring out the following key points:

1. The rains were until 10-15 years ago perceived to be more predictable
2. Rainfall onset has reportedly come later and is more blurred—several communities referred to the three rains that heralded the start, but that these are now not so distinct.
3. Dry spells are more common and longer—these can occur after the first rains as well as in the January/February
4. There are more reported incidences of heavy rains, especially at the end of the season

5. Rainfall season duration is shorter, which is also expressed as lower rainfall, though this might be confusing duration with volume

Communities explained the different methods they had for predicting rainfall onset and how good the season would be:

"When there is a lot of flowering of mangoes then there is good rain. When Nanthambwe (a bird) is jovial (sings a lot of songs) then there are good rains." Community member, Chisambamnopa

"Over the years we have learnt that the rain calendar has been coming in three years; three years of good rains and followed by three years of bad rain. We hope that this year we are going to have good rains." Community member, Kawelama

"The jovial singing of Mkoka bird (Nanthambwe) and also increase in whirlwinds in September and October are good indicators for a good rainfall season. Increased occurrence of south easterly winds in May, June and July are also good indicators of good rainfall season." Community Member, Liguluche

"In the 1940s-60s the land was rich with vegetation and birds, which we could use for forecasting, the flowering of some specific plants like Njasi could indicate the rain pattern, when this flower grew on its own and produced a flower and a fruit it meant that rainfall was near and would come in a weeks time." Community member, Nkasala

"Before we used to know that rains are close when trees starts to develop fresh leaves" Community member, Thambolagwa

In Mulupha, the community referred to an early warning sign of the rains being the sound of a bird called 'mvula chochocho'. A black cloud in dawn hours from Mulanje Mountain was another symbol they will be receiving rains, but now these are reported to be missing.

The key point emerging is that as well as a change in timing, the early warning signs for the arrival of rains appear to have also been affected which makes predicting the timing of planting very difficult, one of the key decisions that a farmer has to make.

Droughts were reported by communities. There was an unclear distinction between dry spells, prolonged dry spells and droughts. These can be seen as a continuum, so what communities were referring to were a mixture of prolonged dry spells and droughts; however, what is important to note is that these prolonged dry spells are characterized by significant damage to crops, which is what differentiates them from the 'normal' dry spells that occur mid-season, often in January of February.

Recent 'droughts' were reported as follows. In 2007-08 there was drought in Felo. In 2009, there was drought in Kawelama. The 2010-11 season was also very bad in Felo, with reports that only millet and sorghum survived; in Lupanga, the river dried up in 2011. The 2011-12 growing season was reportedly a 'drought' in Chisambamnopa, Liguluche and Kawelama.

"Since 1990 we have been experiencing the incidence of droughts in other years. It doesn't take two or three years without experiencing droughts in this area . We don't really know the cause but I think it is due to the destruction of trees in the upland areas". Community member, Felo

The drying of rivers and dambo areas were consequences of periods of reduced rainfall:

"Madzimbayera dambos never dried up during droughts, but now it dries up." Community member, Chiluzi

"In the dambo areas it was wet all year round unlike these days where it dries up so quickly soon after the rains stop" Community member, Lupanga

Drying of water sources affects winter production, but also makes everyday life more difficult through reduced access to water for washing and other domestic uses.

In contrast to drought, although not a climatic effect, one of the key intermediate effects of the rainfall pattern was **flooding**.

TABLE 12. REPORTED FLOODING EFFECTS, BY COMMUNITY

Community / Zone	Historic Vulnerability	Current Vulnerability	Comments
Chiluzi - Rift Valley	High	High	Whenever there are heavy rains there is flooding in fields & dambos
Chisambamnopa – Phirilongwe Hills	Medium	High	Nansenga River floods almost every year, as people cut reeds and trees on its banks to make gardens for irrigation. Previously it used to flood seasonally when there were heavy rains
Felo – Lower Shire	Low	High	From 1990-96, water used to flow within river courses as many trees on the banks. From 1997, these trees were cut and rivers filled with sand. Now waters flow without following the river course and so flood fields
Kawelama – Phalombe-Lake Chilwa	High	Low	Flooding that is "not forgotten" (i.e., serious) in 1968, 1991, 1996, 2006 and 2010, forcing relocation. Now rains are erratic; do not fill river.
Liguluche – Southern Lakeshore	Medium	Low	Water levels in Lake have reduced, but Chikomo Valley and Chigumukile Gully affected by flooding. Relocation took place in 1993 and 1995, moving the village further from the Lake.
Lupanga – Middle Shire	High	Low	Last major floods occurred in 2003
Mulupha –Mulanje-Thyolo Tea Estate	Low	High	Deforestation by Mulli Brothers' tea estate has increased flooding downstream
Nkasala – Shire Highlands	Low	High	Chilawe River experiences river bank erosion when it rains heavily, causing flooding downstream
Thambolagwa - Kasungu-LLW Plain	High	High	Every year the dambo area experiences floods

Source: PRAs, Kadale Consultants

All the communities reported some incidences of recent flooding, except Lupanga where the last flood was in 2003. The communities indicated that this occurred mainly with rivers breaching their courses, but also in the dambo areas. The community responses suggest that flooding has worsened, such as at Chisambamnopa, Felo, Mulupha and Nkasala. In other places, flooding continues to be a regular occurrence, such as at Thambolagwa and Chiluzi, and a periodic problem at Liguluche and Kawelama. However, it is noteworthy from the comments of community members at Kawelama that serious flooding is not a new phenomenon and that in their case, they are seeing more of a shortfall in water volume.

Although the messages from the communities were consistent in describing the rainfall effects, it is important to note that the community members could recall previous years where there had been 'erratic' rainfall. For example:

"We experienced less rainfall in the following growing seasons: 1980, 1989, 1991, 1995, 2009, and 2011-12." Community Member, Liguluche

Therefore the erratic rainfall patterns described by communities in recent years are not new, only that the incidences are reported to be more frequent with less predictability.

3.1.4.2 CHANGES IN TEMPERATURE

After rainfall changes, the most commonly reported set of changes was in temperature, which can be categorized into three:

1. More variable temperatures in winter, both higher and lower
2. Higher temperatures in an extended dry season, immediately prior to the rains
3. Higher temperatures in within the rainy season, particularly during dry spells

TABLE 13. TEMPERATURE CHANGES, BY COMMUNITY

Community / Zone	More Variable Winter Temperatures	Higher Temperatures pre-Rainy Season	Higher Temperatures in the Rainy Season
Chiluzi - Rift Valley	June has become hotter	Very high temperatures in Oct	High temperatures from Aug to Dec even when rains have started
Chisambamnopa – Phirilongwe Hills	May to Jun are cold most days, but warmer & very hot some days	High temperatures reported	High temperatures especially in dry spells
Felo – Lower Shire	Winters getting warmer from Apr to Jul, when it was cold	Very high temperatures Sep to Oct	High temperatures in early rainy season, Dec to Jan
Kawelama – Phalombe-Lake Chilwa	Generally longer winters	Colder summer than expected	High temperatures coupled with dry spells
Liguluche – Southern Lakeshore	No clear variations reported	High temperatures Oct to Dec	High temperatures in early part of the rainy season Dec to Jan
Lupanga – Middle Shire	Warmer winters	High temperatures before rains start. Makes people end work in fields earlier	High temperatures in rainy season coupled with dry spells
Mulupha –Mulanje-Thyolo Tea Estate	Warmer winters	Generally higher temperatures than in the past	High temperatures results in drying of maize and cassava
Nkasala – Shire Highlands	Warm late winters with high temperatures Jul to Nov	High temperatures in summer before the rains	Very high temperatures resulting in drying up of crops
Thambolagwa - Kasungu-LLW Plain	Very cold winters May to Jul	High temperatures, but cooler than in the past	High temperatures in rainy season

Source: PRAs, Kadale Consultants

The higher temperatures pre-commencement of the rainy season appear to be linked to delayed rainfall onset, as the rains normally have a cooling effect. Higher temperatures were not universal, as community members in Thambolagwa reported cooler winters, including frosts in August.

The implications of higher temperatures were that people could not work for as along in the fields before it became too hot. There were also incidences of pest development that seemed to thrive on the longer hotter period prior to the onset of rains, such as elegant grasshoppers and locusts reported at Mulupha. Finally, high temperatures were blamed for increases in livestock diseases, particularly Newcastle Disease in poultry, e.g., at Felo.

3.1.4.3 CHANGES IN WIND

The final climatic changes observed by the communities were in winds. This included the intensity, the frequency and direction of winds. These were of less significance to the communities than rainfall and temperatures.

TABLE 14. REPORTED WINDS, BY COMMUNITY

Community / Zone	Change in Intensity	Change in Frequency	Change in Direction
Chiluzi - Rift Valley	Stronger winds, including whirlwinds	Strong winds usually from Aug to Oct	More wind storms from the south
Chisambamnopa – Phirilongwe Hills	Increased intensity of whirlwinds affects grass thatching	Increased frequency of whirl winds	No changes observed
Felo – Lower Shire	Stronger winds than in the past	No observable changes	More easterly winds
Kawelama – Phalombe-Lake Chilwa	Increased intensity of south-easterly winds	Strong winds are more persistent	More south-easterly winds

Community / Zone	Change in Intensity	Change in Frequency	Change in Direction
Ligulwiche – Southern Lakeshore	Strong winds	Not changes observed	South-easterly & northerly winds accompany heavy rains
Lupanga – Middle Shire	Strong whirlwinds that destroy houses	Increased frequency of southeasterly winds	More south-easterly winds
Mulupha –Mulanje-Thyolo Tea Estate	No changes observed	No changes observed	No changes observed
Nkasala – Shire Highlands	Strong winds that can break maize and housing	No changes observed	Mwera winds from south herald damaging heavy rain & hailstones. Mphepo yakuangoni from north destroys maize & houses
Thambolagwa - Kasungu-LLW Plain	Strong winds blowing off roofs	No changes observed	More south-easterly winds

Source: PRAs, Kadale Consultants

There has been a general increase in wind intensity, frequency and destructiveness, such as at Felo, Lupanga and Kawelama. The effect of winds is reported to be on both crops and buildings. In Nkasala, they called it *napolo wa mwamba* meaning "atmospheric flash floods" to describe the suddenness and damaging nature of the winds, which have removed roofs in central parts of the village. Houses with thatch and iron sheets were reportedly damaged in other several communities. Roof repair/replacement is a major and urgent cost for the families affected. In Kawelama, winds removed the roof of the school, and in Liguluche they removed the roof of the mosque. The loss of trees is reported to have exacerbated the impacts of wind on housing structures and crops, leading some communities to start replanting, at least near their houses.

"Continuous blowing of Mwera winds during January and February is an indicator for a bad season." Community member, Liguluche

Winds also affect the rainfall patterns. In Nkasala the community said that the rains do not come when there are strong winds. In Liguluche, winds bringing rain from the North in December to February were bad for crops, as has occurred periodically since 2002. In contrast, reliable rains were associated with winds from the north in October, and easterly and north-westerly winds after that. In Nkasala, the Mangoni winds (heavy winds from the north) are attributed to bring pests like stalk borers (Kapuchi) which destroy the maize.

The whirlwinds was reported to be damaging in Chisambamnopa, due to more bare ground and late rains resulting in dust being taken up and spread. Dust storms were also reported at Felo.

Winds play a critical role for fishing communities at the Lake, as they can enable or limit fishing. Fishing communities report that they are less able to predict the winds by seasons and other indicators that were previously reliable, making fishing more hazardous and less effective.

3.2 IMPACT OF CLIMATE CHANGE ON LIVELIHOOD AND WELL-BEING

This section reviews the impact of the climate changes identified in the previous section (3.1.4) on livelihoods in the communities and the well-being of community members.

3.2.1 CHANGES IN LIVELIHOODS

The changes to livelihood are separated into changes to households' agricultural/fishing activities and changes to households' other livelihood activities. Although separated for the analysis, in practice the responses are integrated as households respond to pressures from climate change that require adjustments to their 'portfolio' of agricultural/fishing and other livelihood activities.

3.2.1.1 CHANGES TO AGRICULTURAL AND FISHING LIVELIHOOD ACTIVITIES

The details of changes in the specific agricultural production systems are set out in section 3.3. This section sets out the changes within households' **agricultural/fishing portfolios**.

The PRAs established the predominant agricultural/fishing livelihoods historically and currently. The current position for food crops, cash crops, livestock and fish production was given in Table 6. This table is adapted as Table 16, to highlight the changes mainly over the last 10 years compared to the historic position, which is set out in Table 15 immediately below.

TABLE 15. HISTORIC FOOD CROPS, CASH CROPS, LIVESTOCK & FISH PRODUCTION, BY COMMUNITY

Community / Zone	Food crops	Cash crops	Livestock	Fishing/Fish Farming
Chiluzi - Rift Valley	✓Maize, cassava, beans	✓Maize, cassava, tobacco, sweet potatoes & groundnuts	✓Cattle, poultry, goats & pigs	✓River fishing
Chisambamnopa – Phirilongwe Hills	✓Maize & sorghum	✓Maize & cotton	✓Goats & chickens	x
Felo – Lower Shire	✓Maize, sorghum & millet	✓Maize, cotton, & sweet potato	✓Goats	✓From Shire River
Kawelama – Phalombe-Lake Chilwa	✓Maize dominant	✓Rice & cassava	✓Cattle, sheep & goats	✓From Lake Chirwa
Liguluche – Southern Lakeshore	✓Maize, cassava, sweet potato	✓Sweet potato, & rice	✓Goats & chickens, some cattle	✓From Lake Malawi – main livelihood
Lupanga – Middle Shire	✓Maize, cassava, beans & groundnuts	✓Maize, cassava, beans, tobacco & groundnuts	✓Cattle, goats, pigs & chickens	x
Mulupha –Mulanje-Thyolo Tea Estate	✓Cassava, maize, beans & pigeon peas	✓Cassava, tea & pigeon peas	✓Goats & chickens	✓Fish farming
Nkasala – Shire Highlands	✓Maize, cassava, beans, sorghum, pigeon peas, millet & groundnuts	✓Maize, rice, tobacco, cassava & groundnuts	✓Goats, rabbits & chickens	✓Fish farming
Thambolagwa - Kasungu-LLW Plain	✓Maize, beans & Irish potato	✓Maize, beans, Irish potato & soybean	✓Cattle, poultry, goats & pigs	x

Source: PRAs, Kadale Consultants

TABLE 16. CURRENT CASH CROPS, FOOD CROPS, LIVESTOCK & FISH PRODUCTION, BY COMMUNITY

Community / Zone	Food crops	Cash crops	Livestock	Fishing/ Fish Farm
Chiluzi - Rift Valley	✓Maize, cassava (reducing), millet, soybean, groundnuts	✓Tobacco decreased; sweet potatoes & groundnuts (reduced), added cotton and soybean	✓Cattle & poultry reducing, goats & pigs increasing	x
Chisambamnopa – Phirilongwe Hills	✓Maize & sorghum	✓Cotton, cassava & vegetables	✓Goats & chickens	x
Felo – Lower Shire	✓Maize, sorghum & millet	✓Cotton & sweet potato	✓Goats	✓From Shire River but dwindling
Kawelama – Phalombe-Lake Chilwa	✓Maize, cassava, beans & pigeon peas	✓Rice, cassava, some tobacco & chilies	✓Sheep & goats - reducing	✓Lake Chilwa, Jan-Mar only
Liguluche – Southern Lakeshore	✓Maize; cassava stopped due to pests;	✓Sweet potato; rice decreased	✓Goats, sheep & poultry; many more cattle	✓Lake Malawi, dwindling

Community / Zone	Food crops	Cash crops	Livestock	Fishing/ Fish Farm
Lupanga – Middle Shire	✓Maize & cassava	✓Cotton increased considerably; beans, groundnuts and tobacco mainly stopped	✓Goats and chickens, but much reduced	x
Mulupha –Mulanje-Thyolo Tea Estate	✓Maize (reduced), cassava (increased), & pigeon peas; beans no longer grow well	✓Cassava, tea & pigeon peas	✓Goats & chickens	✓3 households
Nkasala – Shire Highlands	✓Maize, cassava, sorghum; less beans, millet, pigeon peas & groundnuts	✓Cotton production has increased; rice doing poorly & tobacco stopped	✓Goats & chicken; rabbits dropped, but added pigs	✓2 households
Thambolagwa - Kasungu-LLW Plain	✓Maize, beans & Irish potato	✓Maize, beans, Irish potato & soybean	✓Cattle (but decreased a lot), poultry, goats & pigs	x

Source: PRAs, Kadale Consultants

Overall, the significant changes were shifts between traditional and improved varieties, a shift to more drought resistant food crops, a shift from food crops to cotton, reductions in livestock numbers in most places, and a decline in fishing and fish farming.

The issue of changes between traditional/local ('traditional') varieties of maize and 'improved varieties' such as Open Pollinated (OPVs) and hybrid maize varieties is complex. This is dealt with in more detail in the maize value-chain report. In essence, improved varieties of maize have long been promoted by GoM, private sector (seed companies) and NGOs because of their superior yields as a key step towards household food security. A further advantage of improved varieties that has become more important is that they are mostly early maturing, which means they can yield a successful harvest even when the season is shortened by late onset or early cessation of rains. These qualities attracted households in these communities to grow more improved varieties, as reported at Kawelama, Lupanga and Thambolagwa.

However, improved varieties also have some disadvantages. Notably, they do not perform as well compared to traditional without the application of fertilizer. Improved varieties are also more susceptible to dry spells, as commonly occur in January and February, even in a normal season. Although they can survive the 'normal' up to 10 day dry spell, yields are affected by prolonged dry spells, particularly at the crucial tasselling stage. Traditional varieties cope better with more prolonged moisture shortage, though they too lose yield if the period is prolonged. A further problem with improved varieties is that they are more susceptible to pest damage in storage, as the grains are less dense and easier to 'bore'. There is a strong preference for traditional maize varieties when it comes to consumption. Traditional varieties yield a higher percentage of flour and the taste of that flour is preferred by many Malawians, such they will try to keep chimanga from traditional varieties and sell chimanga from hybrid, if they have that option. Finally, hybrid seeds need to be purchased each year, which is problematic for Poorer households. OPVs can be replanted for several years, but after three to four plantings need to be replaced with fresh seed.

Although the research found a shift to improved seed to address the shortened season and low productivity of traditional varieties, it was also noted that there had been a swing back towards traditional varieties, because of the disadvantages of improved varieties. The outcome is that households that can afford to buy seed and fertilizer do grow improved varieties, but they also plant traditional varieties both because they prefer it for home consumption and because the seasonal conditions might better suit the traditional varieties, such as if there is a normal period of rains, but with a prolonged dry spell during the season. Thus, where they can afford to, households are generally pursuing a dual production strategy of traditional and improved maize, such as at Chiluzi,

However, for Poorer households, the option of buying improved seed and applying fertilizer is not possible as they do not have the resources. The substantial rise in fertilizer prices over recent years, particularly in

2012-13 means that it is out of reach for a majority of households in these communities. Unless they have access to the Farm Input Subsidy Program (FISP) inputs, then many Average and most Poorer households can only grow traditional relatively low yielding varieties that may not mature if the season is shortened. The late onset of rains in particular is resulting in shortened seasons, and very poor maize yields for these households in general. This is one of the most significant issues for Poorer households in that they cannot adopt a mixed planting strategy and are impacted substantially by the late onset and/or early cessation because they are growing mostly traditional varieties.

The second major change has been a general shift from maize to more drought resistant food crops, such as cassava, for example at Felo where maize growing is very difficult and Mulupha, again because maize has not been doing well. Some of the more moisture sensitive crops like beans, groundnuts, rice and pigeon peas have reduced or been abandoned, such as at Mulupha and Nkasala.

By contrast, in Liguluche, households used to grow cassava, but have now mostly stopped due to pest infestation that resulted in poisoning of the livestock when fed the cassava. Livestock is very important in this community, and has been the production activity into which households have switched as fishing dwindled as a livelihood.

A related shift has occurred due to the drier conditions from maize into cotton. For example, at Lupanga the maize to cotton production ratio use to be 50:50, but has now changed to 20:80. People in Nkasala used to grow cotton in the 1960s, but abandoned it for other crops, such as tobacco. However, due to low tobacco prices, they moved back to producing cotton in the 2010-11 season. Tobacco production is also reported to have decreased at Chiluzi for the same reason of low prices.

Although cotton production has increased in recent years, and it is better suited to the drier conditions, it is not without problems notably pests:

"Last year cotton was attacked by worms but we didn't do anything as we didn't have money to buy pesticides." Community member, Lupanga

There was a reduction in other more moisture-sensitive crops such as groundnuts, beans, rice, sweet potatoes and pigeon peas in Chiluzi, Liguluche, Mulupha and Nkasala.

For livestock, the general decrease has been discussed and attributed to disease, theft and selling in order to get money for food, but not being able to replace, such as reported at Lupanga. The exceptions are Liguluche where cattle is now seen as a major livelihood source, and Nkasala where there is a strategy to increase pigs and goats. In both communities, the intention is to use livestock sales to meet cash requirements for the households.

The final production area is fishing and fish farming. Significant falls in fish stocks in Lake Malawi are attributed to overfishing:

"The ones who steal are from government. They link up with owners of nets. When they are not going to patrol the Lake on that day they ring them, telling them that they can go on the Lake since there won't be anyone patrolling it." Community member, Liguluche

"There is fear that tomorrow we will no longer have fish and the Lake will just be for bathing."

There were some suggestions that the fish in Lake Malawi may have moved due to lower rainfall, affecting the currents and the temperatures of the Lake. The loss of plant habitat was partly attributed to this:

"In the past the lake had some plants and it is in those places where the fish used to breed. Now those plants are not there and when the fish moves it finds that the place is bare." Community members, Liguluche

In Lake Chilwa, the loss of fishing livelihood was attributed to the drying of the lake and siltation, which mean there is only fishing from January to March during the rainy season.

"People have fishing equipment which they no longer use - what remains is seasonal fishing of cat fish." Community member, Kawelama

For river and dambo fishing, reduced rainfall and hotter temperatures compound the overfishing:

"It has been almost 20 years since their dambos and the rivers stopped having amounts of water to sustain fishing livelihoods." Community member, Chiluzi.

In Felo, the range of fish in the rivers has reduced, and is now just 'mud' fish (catfish), attributed to drying of rivers, though this may also be a consequence of overfishing. Siltation of the river was reported in Mulupha, resulting in only catfish surviving.

Climate has affected fishponds, which have been in decline, as these dry up. However, another identified cause was the cost of feeding fish, which has been affected by other pressures on their livelihoods, such as at Nkasala:

"Fish production is going down because we cannot feed the fish adequately as we cannot afford to feed madeya to the fish. We also cannot afford to use the usual wrappers (nets)to harvest the fish but rather use a ladies wrapping cloth to harvest." Community member, Nkasala

Overall, there were a complex set of changes that were not all in the same direction of change, such as in the use of improved maize varieties and livestock, though the reduction in fishing/farming was all pointing to decline where it was practiced. Communities were trying different crops and livestock combinations, which fitted their resources and their local climate. The shift in crops was mostly towards more drought tolerant options, such as cotton and cassava.

3.2.1.2 CHANGES TO OTHER (NON-AGRICULTURAL) LIVELIHOODS

This section focuses on other (non-agricultural) livelihoods categorized as employment, ganyu, operating businesses/ income generating activities (IGA) and remittances.

The historic and current non-agricultural livelihoods were established in the PRAs.

TABLE 17. HISTORIC OTHER LIVELIHOODS, BY COMMUNITY

Community / Zone	Employment	Ganyu	Business/IGA	Remittances
Chiluzi - Rift Valley	x	✓Work in other's gardens	✓Sell beer & thobwa, collect forest products, sell mice	x
Chisambamnopa – Phirilongwe Hills	x	✓Work in other's gardens	✓Sell fish, mandasi & vegetables, brick-making, sell mats, collect firewood	✓Relatives in SA
Felo – Lower Shire	✓Some people work at the Boma or sugar factory	✓Work in other's gardens	✓Sell tomato & vegetables	✓Relatives in SA & Malawi
Kawelama – Phalombe-Lake Chilwa	x	✓Work in other's gardens	✓Sell fish & rice, collect firewood & hunting	x
Liguluche – Southern Lakeshore	x	✓Work in other's gardens	✓Fish trading, Brick-making, mats	✓Relatives in SA
Lupanga – Middle Shire	✓Seasonal employment at ginnery factory	✓Work in town - washing	✓Sell vegetables/ mandasi, fish, grocery, firewood	✓Relatives in SA
Mulupha –Mulanje-Thyolo Tea Estate	✓Seasonal employment in Tea estates	✓Work in other's gardens	✓Beer brewing	✓Relatives in Mozambique and SA
Nkasala – Shire Highlands	x	✓Work in other's gardens	✓Charcoal, firewood & timber, hunting & collect forest products, mats	✓Relatives in SA

Thambolagwa - Kasungu-LLW Plain	x	✓Work in other's gardens	✓Beer brewing	x

Source: PRAs, Kadale Consultants

This compares to the current situation.

TABLE 18. CURRENT OTHER LIVELIHOODS, BY COMMUNITY

Community / Zone	Employment	Ganyu	Business/IGA	Remittances
Chiluzi - Rift Valley	x	Work in other's gardens	Sell beer & thobwa; sell mice; Poorer engage more in firewood & charcoal	x
Chisambamnopa – Phirilongwe Hills	x	Work in other's gardens	Sell fish, mandasi & vegetables, brick making, sell mats, firewood/charcoal increased	Relatives in SA
Felo – Lower Shire	☐Some in shops at Boma & sugar estate	Work in other's gardens	Sell tomato and vegetables (increasing); Poorer engage more in firewood & charcoal	Relatives in SA and cities
Kawelama – Phalombe-Lake Chilwa	x	Work in other's gardens, public works	Sell fish and rice, baskets/mats, firewood & hunting finished	x
Liguluche – Southern Lakeshore	x	Work in other's gardens, public works	Fish trading has declined, Brick making, mats,	Relatives in SA
Lupanga – Middle Shire	Seasonal at cotton ginnery	Washing in town & work in gardens	Sell vegetables, mandasi, fish (declining), grocery; firewood finished	Relatives in SA
Mulupha –Mulanje-Thyolo Tea Estate	Tea estates	Work in other's gardens	Brew beer	Relatives in Moz and SA
Nkasala – Shire Highlands	x	Work in other's gardens	Charcoal, firewood & timber, mats	Relatives in SA
Thambolagwa - Kasungu-LLW Plain	x	Work in other's gardens	Brew beer	x

Source: PRAs, Kadale Consultants

Overall, the key changes were a reduction in reliance on agriculture by more emphasis on businesses and IGAs, an increased reliance on ganyu and timber, firewood, charcoal and brick making, and the further development of remittances as a strategy to improve livelihoods.

There appears to have been some shift to a more diverse range of livelihoods, as agriculture is not regarded as reliable any more, as sentiment that was expressed at Felo and Mulupha. There were differences according to wealth groups, with the Better-off engaging in businesses, such as grocery, trading and brewing, as well as benefiting from more regular employment and supporting relatives to travel to South Africa and other places in Malawi to find work and develop a remittances stream.

"Every household here has one or two (members) in South Africa with the aim of buying cattle." Community member, Liguluche[28]

The Poorer had many fewer options, being much more agriculture dependent with few alternative income sources. The Poorer may already have rented out part or all of their land in order to raise cash and lack the resources to invest in a business or even a small IGA. The main strategy for the Poorer when agriculture was not doing well, was to undertake ganyu, mainly working on the land of others:

[28] As they previously had fishing as a main livelihood, the community was relatively Better-off than, so had resources to invest, including in sending young men to SA, from where they could send remittances.

"In the old days ganyu was done by children to raise money for Christmas festivities but these days it is done by everybody in the family for survival (food security)." Community member, Lupanga.

There were opportunities for GoM run public works through the Local Development Fund (LDF), at Kawelama and Liguluche.

Historically, the other alternative was to utilize forest and other natural products. This includes hunting game, collecting mushrooms and fruits, wild honey, collecting reeds for weaving into mats, collecting firewood for sale, making charcoal, burning bricks and cutting trees for timber. It appears that the loss of forest to over-harvesting of its trees/resources and to settlement/farming, and pressure on other communal natural resource areas, like river banks/dambos, has resulted in loss of the related livelihood opportunities. There are still forest resources, but these are now limited and further away:

"I used to mould small clay pots and bigger ones for sale and I could provide for my household, but I stopped as I am now old and not physically fit to travel longer distances to collect firewood, grass and clay soil as these days these materials are scarce to find due to change in climate." Elderly community member, Felo

These continue to be exploited at a seemingly unsustainable rate:

"As you can see on the road those people with firewood are going to sell it and buy maize on their return." Community member, Chisambamnopa

The development of remittances has been mentioned. This was a core strategy for Liguluche, and to a lesser extent in Chisambamnopa, Felo, Lupanga, Mulupha and Nkasala. Arguably, these are some of the communities with the most significant problems agriculturally, resulting in people moving away in search of alternatives. Sadly, in addition to the mainly male migration, the women who were left behind turned to casual prostitution to raise money when it was needed, as reported at Felo & Nkasala. This was not a permanent or full time livelihood, but rather a means to supplement family income sources at times of pressure.

3.2.2 PRESSURES, CONSTRAINTS AND OPPORTUNITIES

This section sets out the underlying pressures, constraints and opportunities that have led to the livelihood changes in section 3.2.1 split into climate and non-climate related.

TABLE 19. PRESSURES, CONSTRAINTS & OPPORTUNITIES, BY COMMUNITY

Community / Zone	Pressures	Constraints	Opportunities
Chiluzi - Rift Valley	**Climate Related** • Erratic rainfall onset & end • Higher temps Aug to Feb • Prolonged dry spells • Strong winds more common that damage maize & property **Non-climate related** • Population pressure on land – dambo is cultivated • Free grazing of livestock • Loss of unprotected forest • More livestock & crop theft	**Climate Related** • Low rainfall constrains beans & maize • Land degraded • Animal diseases (ECF and ND) common **Non-climate related** • Long distance to Boma (22 km) for market and health access • 15km from firewood source	**Climate Related** • Increased irrigation & water conservation • Changed to drought resistant & early maturing varieties • Used organic fertilizer & husbandry to improve soil fertility • Planted trees & sisal for wind breaks and harvesting **Non-climate related** • Establish woodlots • Enforced strict access to protected area
Chisambamnopa – Phirilongwe Hills	**Climate Related** • Erratic short rainy season with prolonged dry spells. **Non-climate related** • Theft of goats common • Deforestation rampant due to relocation of people from Mulanje • Increased frequency of malaria.	**Climate Related** • Climate not conducive for maize production • Soil fertility is poor **Non-climate related** • Population pressure • High cost of farm inputs	**Climate Related** • Switch to cotton production • Irrigated along the river • Switch to hybrid maize as short maturing • Used organic fertilizer & husbandry to improve soil fertility • Planted Msangu and other fertility restoring trees **Non-climate related** • Sell firewood & burn bricks
Felo – Lower Shire	**Climate Related** • Extreme temps – Sep to Feb • Erratic rains since 2001 **Non-climate related** • Deforestation by refugees for houses • Poor sanitation so prone to cholera and diarrhea.	**Climate Related** • Maize and other crops dry up due to high temps/low rainfall • Flooding common • Sandy soil due to flooding **Non-climate related** • Only one borehole so using unsafe sources • Reduced available land for cultivation	**Climate Related** • Increased cultivation of drought resistant e.g., millet and sorghum • Irrigated from the rivers • Restoring soil fertility with help of WALA • Plant trees in upland and channel water away **Non-climate related** • Some brew Kachasu (traditional spirit from maize) • Poorer supplement income by ganyu

Community / Zone	Pressures	Constraints	Opportunities
Kawelama – Phalombe-Lake Chilwa	**Climate Related** • Erratic rains with unpredictable start & end • Strong winds Aug to Nov destroy houses & structures **Non-climate related** • High prevalence of malaria • Over population has depleted cultivation land	**Climate Related** • Maize production constrained • Still gets flooding • Land degradation • Partly on a bare slope **Non-climate related** • Livestock theft • Village has no market & poor transport • Ntaja is 10km away	**Climate Related** • Early planting and hybrid adoption Used manure & fertilizer combined • Adopted conservation methods • Crop diversification into low input drought resistant - cow peas, cassava and legumes generally • Developing woodlots **Non-climate related** • None
Liguluche – Southern Lakeshore	**Climate Related** • Strong winds remove soil • Low rainfall amounts **Non-climate related** • Hippos destroys crops • Population increase reduces cultivation land Declining fish stock	**Climate Related** • Poor soils and climate not conducive to crops **Non-climate related** • Nearest market at M'baluku 10km away • Attacks by hippos & crocs reduce dambo cultivation	**Climate Related** • Increased water can based irrigation • Increase dambo cultivation for sweet potatoes **Non-climate related** • Outward male migration for remittances • Sell livestock to buy food • More ganyu to buy maize • Making mats for sale
Lupanga – Middle Shire	**Climate Related** • Shortened rainy season • Erratic rains since 2003 **Non-climate related** • High rate of deforestation • High prevalence of HIV/AIDS • Population pressure	**Climate Related** • Soil erosion • High temperatures • Changing river course **Non-climate related** • HIV/AIDS infected/ affected cannot work • Long distances to collect firewood	**Climate Related** • Increased cotton cultivation • Used riverbanks for irrigated crops • Adopted conservation measures Shallow wells for irrigation **Non-climate related** • Employment in Boma and ginnery Dig • Sell, vegetables, bananas
Mulupha –Mulanje-Thyolo Tea Estate	**Climate Related** • Increased frequency of droughts • High temperatures **Non-climate related** • Instant dismissal from estates when rains stop • Deforestation	**Climate Related** • Very limited land area - no fodder or land to cultivate • Removal of mountain forest results in fast run off and flooding **Non-climate related** • Far from Markets	**Climate Related** • Increased cultivation of vegetables & tomatoes for sale in dambo • Adopted drought resistant crops: cassava, sorghum • Practicing conservation farming to conserve moisture **Non-climate related** • Work opportunities in the estates Sell in Mozambique

Community / Zone	Pressures	Constraints	Opportunities
Nkasala – Shire Highlands	**Climate Related** • Heavy winds Aug to Oct • Droughts & erratic rains • Falling rocks from the mountain **Non- climate related** • Population pressure results in land conflicts	**Climate Related** • Reduced crop production • Flooding **Non-climate related** • Forest product opportunities are reducing fruits/herbs. • Corruption surrounding FISP so poor access	**Climate Related** • Increased irrigation & crop diversify • All shifted to hybrid maize • Adopted livestock strategy to sell when need money • Fish farming and private woodlots • Crop rotation & other new techniques **Non-climate related** • Engaged in ganyu. • Brewing local beer
Thambolagwa - Kasungu-LLW Plain	**Climate Related** • Variable temperatures – hotter and colder • Increased frequency of frost **Non-climate related** • Theft of livestock, crops or money • Free range livestock destroy crops in dambo	**Climate Related** • Main crop of Irish potato is vulnerable to frost • Livestock and crops vulnerable to pests and disease promoted by hotter temperatures **Non-climate related** • Harassment in Mozambique when selling/collecting wood	**Climate Related** • Cultivation of hybrid crops has increased • Sale of crops in Mozambique has increased • Used the dambo for winter cropping • Developed alternative IGAs like beer brewing • Adopted conservation measures • Livestock sales to realize income so that people can buy food **Non-climate related** • Individual woodlots planted

Source: PRAs, Kadale Consultants

The above table illustrates the pressures and constraints affecting households, as well as the opportunities so far taken to mitigate the pressures they face within the constraints they have.

Common **climate-related pressures** were identified as:

1. Erratic rainfall resulting in low yields on moisture sensitive crops
2. Heavier rainfall resulting in more common and more extensive flooding, particularly due to siltation in rivers and removal of trees (due to cultivation of the riverbanks) that result in rivers not staying within their courses.
3. Higher temperatures and prolonged dry spells promoting crop pest development and livestock disease development, with colder temperatures in one place resulting in frost damage to potatoes (Thambolagwa)
4. Stronger winds damaging crops and structures

The climate-related pressures are detailed in section 3.1.4, relating to changes in rainfall (3.1.4.1), temperature (3.1.4.2) and wind (3.1.4.3). The particular effects are felt in both agricultural activity and other livelihoods more generally, as these are interlinked.

The common **non-climate-related pressures** were identified as:

1. Population pressure reducing farm land availability, combined with falling productivity and need for more/new land to increase production
2. Uncontrolled use of shared resources such as dambo and forest areas resulting in conflicts over use (with grazing animals) and depletion of the resource (forest)

3. Declining fish stocks in the lakes and rivers due to over fishing, but also drying and siltation of some lakes and rivers
4. Increased incidence of theft of crops and livestock, as well as robbery of persons
5. Increased human disease incidence, such as malaria related to increased flooding but also inability to protect through buying nets and treat, and cholera due to poor sanitation and dirty water from flooding. Increase in HIV/AIDs partly related to need for some women to raise money through casual prostitution
6. Employment opportunities are mostly seasonal and uncertain

The main constraints faced are set out in detail in Section 3.2.1, but are summarized in the table to enable them to be linked to the particular climate pressures and the responses of communities in the opportunities they have taken.

Common **climate-related constraints** were identified as:

1. Erratic rainfall constrains crop choices, with beans, sweet potato and, most significantly, maize particularly affected
2. Land has been degraded through poor previous husbandry, lack of access to inorganic and organic fertilizer and leaching of soils by heavy rain/floods. Floods have also brought sandy soils that do not retain moisture
3. Land area is constrained in many communities due to settlement/population pressures that have taken up both available farmland and resulted in cultivation/settlement in shared-resource areas like dambos and forests

The common **non-climate-related constraints** were identified as:

1. Long distances to markets, particularly the main ones at the Boma mean unable to getter better prices for produce or cheaper prices for inputs
2. Long distance to access health facilities (hospitals at the Boma) for those that are sick, compounding the increased health pressures and adding high cost for transport which is hard for the Poorer to afford. Health facilities do not function well and of poor quality
3. Loss of forest and dambo areas results in fewer natural resource products that can harvested for consumption or sale, notably firewood/timber, fruits, mushrooms, wild game, herbs (for medicine). This has occurred when more households are seeking other sources of income due to poor agricultural performance
4. Longer distances to firewood sources, taking considerable amounts of (women's) time and energy. Women are vulnerable to harassment when collecting
5. Clean water points are relatively few resulting in queuing and loss of time (for women), as well as conflicts
6. Access to inputs is constrained due to higher cost of getting to markets, limited availability of FISP and lack of affordability for many Average and most Poorer households

Details of the community responses at the time of the research are covered in more depth in the adaptation sections that follow in section 3.4, but are outlined in brief in the table to illustrate the links with pressures and constraints.

The common **climate-related responses/opportunities** taken by communities were identified as:

1. Cultivating along riverbanks and dambo. Increased small-scale irrigation by watering can and stream diversion, combined with water conservation measures in the way land is cultivated. These activities can lead to conflicts with livestock owners and those that harvest reeds for weaving/roofs and other materials.
2. Change in cropping to more drought resistant crops (cassava, millet, sweet potato and sorghum) and early maturing improved varieties of maize, where household resources allow that, so limited to Better-off and

some Average. This has also included a switch to cotton, which is explicitly grown for sale in order to buy maize.

3. Improving husbandry methods, such as use of organic vegetative and animal manure as fertilizer to improve soil fertility. Planting of appropriate trees (Msangu) to help restore soil fertility. This has been promoted by GoM and several NGOs working in these communities, such as WALA and Emmanuel International
4. Planting trees and sisal near structures, field boundaries and riverbanks to reduce wind and flooding damage

The common **non-climate-related responses/opportunities** taken by communities were identified as:

1. Establishing communal and private woodlots for harvesting firewood and timber
2. Selling livestock in order to buy food—mostly this is running down existing stocks, but in Liguluche and Nkasala it was a deliberate strategy to increase livestock for sale to improve food and livelihood security.
3. Poorer households undertaking more ganyu, including travel to Mozambique and Malawi's cities and towns
4. Poorer households intensifying collection of firewood, charcoal making and brick making even though forest resources are more scarce and as a result of this activity, become even scarcer
5. Migrating to cities and South Africa for employment. Remittances come back in some cases, but not others.
6. Engaging in casual prostitution to raise cash when needed
7. Engaging in small scale businesses if have the resources, such as brewing, trading and baking/cooking

3.2.3 RESULTS OF LIVELIHOOD CHANGES

This section sets out how livelihood changes have affected the economic well-being of people split according to the wealth groups identified in section 3.1.3 and characterized in relative terms as Better-off, Average and Poorer.

It is clear from the PRAs that some impacts differ by wealth group though many are the same, such as changes in rainfall, temperature and winds; however, the distinguishing element is mainly in the ability of the different groups to mitigate the impacts.

TABLE 20. AGRICULTURAL/FISHING & LIVELIHOOD EFFECTS BY WEALTH GROUP, BY COMMUNITY

<table>
<tr><th>Community / Zone</th><th>Better-off</th><th>Average</th><th>The Poorer</th></tr>
<tr><td>Chiluzi - Rift Valley</td><td>• Grow tobacco & hybrid maize as other income to buy inputs
• Hire the Poorer at low rates to cultivate for them
• Sell livestock when in need
• Have diversified income with business in village & Boma</td><td>• Farming output constrained by lack of inputs
• Have income from some businesses/IGAs</td><td>• Heavily dependent on farming for livelihoods
• Rely on ganyu for food/money
• Rent out land to others
• Reports that Poorer steal food from fields of others</td></tr>
<tr><td>Chisambamnopa – Phirilongwe Hills</td><td>• Cash cropping cotton and hybrid maize
• Trade cotton, maize & fish bought from other groups
• Can do katapila lending</td><td>• Irrigate land
• Rear goats and sell when need food
• Does brick making</td><td>• Heavily depend on farming
• Rent out fields
• Do ganyu when need food
• Collect firewood when no food</td></tr>
<tr><td>Felo – Lower Shire</td><td>• Grow hybrid maize with irrigation and inputs
• Own cattle and other livestock to sell if in need
• Do trading businesses</td><td>• Own goats, chickens to sell if need money
• Borrow from Better-off
• Does ganyu for Better-off at higher rates Poorer get
• Some do fishing</td><td>• Sell few remaining chickens for food
• Mostly do ganyu for Average
• Do fishing if possible</td></tr>
<tr><td>Kawelama – Phalombe-Lake Chilwa</td><td>• Own cattle and other livestock to sell as needed
• Own businesses - hardware shops, grocery shops & secondhand clothes
• Still rely on agriculture</td><td>• Can sell some livestock
• Operate own bicycle taxis and do mat weaving
• Use money from IGAs to buy fertilizer for crops as still rely on agriculture</td><td>• Rely on ganyu for food and neglect own fields
• Rent out their land
• No livestock to sell</td></tr>
<tr><td>Liguluche – Southern Lakeshore</td><td>• Cultivate large areas by ganyu
• Plant hybrid - buy fertilizer
• Move to cattle rearing paid by sending men to SA
• Get others to fish for them using their boats/nets
• Have businesses in the Boma</td><td>• Rely on farming
• Have livestock
• Have small businesses in the village – canteens and trading</td><td>• Do ganyu for the Better-off in fields and hauling nets
• Rent out their fields</td></tr>
<tr><td>Lupanga – Middle Shire</td><td>• Farming maize and cotton – can afford inputs
• Reliable income from businesses (groceries)
• Not much difference with the other group as may do ganyu at times
• Adopt conservation farming
• Some irrigate</td><td colspan="2">• Do a lot of ganyu on other people's farms
• Do casual work at cotton ginnery close to the village</td></tr>
<tr><td>Mulupha –Mulanje-Thyolo Tea Estate</td><td>• Have permanent jobs as civil servants, higher salaried staff of tea estates
• Get land cultivated by ganyu
• Plant hybrid maize with inputs and drought tolerant crops
• Use conservation farming Some have woodlots
• Do not need to sell livestock</td><td>• Jobs with tea estates with lower salaries
• Sell livestock when needed
• Some adopt conservation farming</td><td>• Do ganyu for middle and upper class
• Do ganyu in tea estates
• Sell livestock when need food</td></tr>
</table>

Community / Zone	Better-off	Average	The Poorer
Nkasala – Shire Highlands	• Use conservation farming, irrigation & inputs so high yield • Some fish farming • Rear livestock to sell as needed • Have brewing businesses and shops at the local market	• Have small-scale businesses in brewing & trading fish. • Do charcoal making and trading • Rear livestock to sell	• Depend more on ganyu in fields and carrying charcoal • Rear chickens to sell
Thambolagwa - Kasungu-LLW Plain	• Farm using ganyu –adopted conservation methods & hybrid maize • Brew beer, trade locally & in Mozambique (groceries, oil, fish) • Diversified cash cropping – soybean & Irish potatoes • Some woodlots	• Rely on ganyu for the Better-off • Sell beer for the Better-off	

Source: PRAs, Kadale Consultants

The key points from the above are:

1. **The Better-off have sufficient resources and diverse income sources to overcome climate changes effects**, including making investments in agriculture such as adopting conservation methods, irrigating, using hybrid maize, buying inputs and diversifying into cash crops. They have invested in businesses that enables them to maintain income when agriculture is affected. They benefit from better employment opportunities and remittances. They have livestock to sell if required either to get food in poor crop years or to invest in other activities; livestock is a store of wealth and for prestige.
2. **The Average**, who are poor under many definitions, **struggle to cope with changes, as they have limited resources to invest in agriculture or their other livelihoods**. They have some resilience, but their position is generally worsening, mainly through poor productivity and livestock losses with each poor agricultural season. Livestock is sold for food and in some places rearing it is a strategy to store up assets for sale. They have some alternatives, such as casual employment in the tea estates and cotton ginnery, but these are limited and not available to all. They also have some small-scale businesses that require low capital and give some alternative income.
3. **The Poorer are heavily agriculture dependent and face significant negative impacts from declining productivity**, particularly for vulnerable crops like maize, which is critical to their food supply. They are unable to invest in hybrid maize production, as they cannot afford the fertilizer. Many have resorted to renting out their land and most engage in ganyu in the fields of the Better-off and Average to get immediate food or money for food, thereby neglecting their remaining fields. When they need money, they also resort to firewood collection and tree cutting, due to lack of other alternatives. This includes ganyu for the other groups to make charcoal and bricks.

There is tension between the wealth groups. For example in Chiluzi, the Poorer say they are mocked by the Better-off when they are doing ganyu and complain at the low rates, because the Poorer have had to rent out their fields by saying: *"Go and cultivate in your own (fields)"*

3.2.4 CLIMATE IMPACT ON GENERAL WELL-BEING

This section reviews how changing climatic elements affect general community and household well-being. The PRAs identified impacts in relation to health, education and housing.

TABLE 21. CLIMATE IMPACT ON GENERAL WELL-BEING, BY WEALTH GROUP

Community / Zone	Health	Education	Housing
Chiluzi - Rift Valley	• High rate of malaria & cholera in rainy season • Colds/flu when strong winds	• Some classes close in rainy season, as too few classroom blocks	• Strong winds blow off roofs
Chisambamnopa – Phirilongwe Hills	• High rate of malaria and cholera in rainy season	• No significant impacts	• More whirlwinds from August to onset of rains damage grass thatched houses
Felo – Lower Shire	• Malaria worsening due to high temperatures & more breeding areas from flooding	• When it rains heavily, children cannot cross the river to get to school	• In 2011 heavy rainfall damaged houses
Kawelama – Phalombe-Lake Chilwa	• Cholera is a major problem in the rainy season	• Roofs on some school blocks were blown off forcing school to close	• Strong winds blow off roofs for houses
Liguluche – Southern Lakeshore	• Rising cases of malaria, cholera, pneumonia and anemia in rainy season	• Poorer families send kids to do ganyu when there is need and opportunity • Flooding in gullies prevents access to school for some	• Lake has flooded & affected housing on the western side; no significant effects on housing since they moved
Lupanga – Middle Shire	• Increased casual prostitution has increased prevalence of HIV/AIDS	• Early marriages for cultural and poverty reasons increase girl drop outs	• Increased intensity of whirlwinds blows away roofs
Mulupha –Mulanje-Thyolo Tea Estate	• Outbreak of stinging insects that cause sores • Increase in diarrhea cases from poor sanitation following floods	• Gullies created due to heavy rains and floods. Can be impassable by children going to school	• Increased flash floods from the mountain destroy housing structures
Nkasala – Shire Highlands	• More coughs due to strong winds that raise dust • Water logging contributes to rise in malaria cases	• No significant impacts	• Flooding of Mtunguludzi river destroys housing
Thambolagwa - Kasungu-LLW Plain	• Malaria & diarrhea are common health problems in especially in rainy season	• Early marriages of girls due to poverty • Absenteeism due to food shortages in rainy season • Standard 3 classroom roof blown off by wind & not yet repaired • Do not attend in rainy season due to flooding & no bridges	• No significant impacts

Source: PRAs, Kadale Consultants

The key impacts on general well-being are:

1. **Health** has been significantly affected, with a wide range of climate-related affects. There were reported increases in water-borne disease (cholera & diarrhea) from more flooding combined with poor sanitation, and increases in malaria from more flooded areas and inability to afford bednets. The health situation is exacerbated by long distances to get to hospitals—the Average and Poorer are less able to afford transport and are not in good physical condition to travel, so they do not get treated early or at all. It should be noted that it was not possible to verify if the incidences were increasing, but KIIs with District Health Officials support that there were high incidences, some of which was due to poor sanitation practices and facilities at homes and schools

2. The main effects on **education** were damage to school blocks due to flooding and high winds leading to inability to operate classes, insufficient classrooms so that classes that meet outside in the dry season

could not operate in rainy season, and difficulties getting to school due to flooding and swollen rivers. It is difficult to attribute these necessarily to a change in climate, as these are not new problems, but the increase in damage is more directly attributed to the reported increase in winds. The problem of early marriage is a long standing problem; however, the decline in production in poor seasons for Poorer households could be a direct pressure from the resulting poverty to push girls into early marriage, which leads to dropping out of school.

3. For **housing**, the main effect is the loss of roofs due to high winds and damage through flooding. The high winds are potentially a direct attribution to changes in climate, as is some of the flooding.

3.3 IMPACT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION SYSTEMS

This section focuses on the effect of climate change on the agricultural production systems and how these have changed. The change to the agricultural and livelihood portfolio was covered in section 3.2.1. This section focuses on the changing practices, rather than changes between crops, livestock and fishing.

3.3.1 IMPACTS ON AGRICULTURAL PRODUCTION

The impacts identified in the PRAs are split between maize and other food crops, main cash crops, livestock and fishing/fisheries. Maize is of predominant importance to all communities, so is considered in its own right, whereas other crops are grouped together.

TABLE 22. IMPACTS ON MAIZE PRODUCTION, BY COMMUNITY

Community / Zone	Seed/Variety	Husbandry Methods	Use of Inputs	Harvesting/ Storage
Chiluzi - Rift Valley	• Return to a mix of improved and traditional maize due to pest & disease resistant in storage	• Sasakawa narrow ridge spacing & box ridging to conserve water & prevent soil erosion • More intercropping	• Use animal manure to supplement fertilizer • Bury maize stalks • Plant Msasa, Mtangatanga & Msangu • Sisal around fields to conserve soil	• Guard crops • Shift to local due to pest problems • Store indoors due to theft
Chisambamnopa – Phirilongwe Hills	• Plant more improved maize	• Adopt box ridges, zero tillage & crop rotation	• Use compost manure & inorganic fertilizer	• None identified
Felo – Lower Shire	• None identified, but planting less maize as shift to more drought resistant	• Adopt winter cropping, conservation farming, box ridges	• None identified	• Mix seed maize for next season with neem, ash & cow dung to stop them eating it
Kawelama – Phalombe-Lake Chilwa	• More hybrid (MH18 and MH41) than traditional maize variety, but plant both to have a dual strategy	• Adopt Sasakawa& conservation farming, intercrop with pigeon peas • Plant near river & develop water ways for gravity irrigation	• Use more compost manure	• None identified
Liguluche – Southern Lakeshore	• Plant improved & traditional variety in a dual planting strategy	• More winter cropping • More irrigation	• Apply cow & compost manure • Bury maize stalks to retain moisture	• None identified

Community / Zone	Seed/Variety	Husbandry Methods	Use of Inputs	Harvesting/ Storage
Lupanga – Middle Shire	• More improved variety, but generally less maize and more cotton	• Box ridges & crop rotation • Plant near water sources • Use stalk-borer ritual	• Use fertilizer with hybrid • Use manure for fertility & more water retention • Conserve trees for fertility and erosion	• Cover cobs with plastic bags to protect from bird attack
Mulupha –Mulanje-Thyolo Tea Estate	• More improved, but still some traditional varieties	• Chain plant maize & cassava on alternate ridges, contour ridges, inter-cropping, pit planting, minimum tillage & Sasakawa	• Not identified	• None identified
Nkasala – Shire Highlands	• More improved, but still some traditional varieties	• Conservation farming with box ridges, irrigation since 1999	• More manure & crop rotate with legumes (groundnuts)	• None identified
Thambolagwa - Kasungu-LLW Plain	• More improved, but still some traditional varieties	• Box ridges, winter cropping, crop rotation and inter cropping, early preparation • Dig channels to reduce/ prevent water logging	• More fertilizer & compost manure • Plant Jerejere to restore fertility • Plant on heaps that cover ashes • Buy fertilizer in advance so cannot spend on other things	• Using actellic & Jerejere in fields to kill stalk borers. • Guard fields from animal grazing • Early harvest when heavy rains & water logging at season end

Source: PRAs, Kadale Consultants

The key changes identified are:

1. **Shifts between traditional and improved varieties**—this is discussed in section 3.2.1.1. There has been a general shift to improved maize for those that can afford the necessary accompanying fertilizer, but also a deliberate balancing between improved and traditional varieties. This diversifies risk, so that if one fails due to climatic effects, the conditions for the other might be sufficient to get some production e.g., traditional varieties of maize may survive dry spells or heavy end of season rains better than improved, but if it is a short rainy season, then hybrid will do yield, while traditional will not reach maturity.

2. **Limited availability of FISP combined with inability of Average and Poorer to afford inorganic fertilizer**, means they cannot adopt improved varieties and improved methods, such as Sasakawa due to the requirement for fertilizer.

3. **Adoption of water and soil conservation** through a range of methods grouped under 'conservation farming', such as box ridging, minimum tillage and compost manure making and use, has increased. These are promoted by GoM and NGOs, but there are still many farmers yet to adopt methods that could help improve soil fertility, moisture retention and thereby improve the chances of better yields.

4. **A shift towards more irrigated and dambo winter cropping** where this is physically possible, but some areas that could adopt have not done so.

5. **More fertilizer use when accompanying improved varieties**, for those that can afford it, supplemented or substituted (depending on poverty) by more use of animal and vegetative compost.

Other methods to improve fertility include selective planting of trees and burying crop residues rather than the normal practice of burning. These help improve soil texture and water retention.

6. **Notably few harvesting and storage changes to protect the crop in the field** when mature. There were measures to address pest and bird losses, as well as from thieves and grazing animals, but these are not very effective in the main.

One extreme method that highlights the pressure on food and importance of maintaining seed for the next season was in Felo:

"After harvesting the little that we manage to get we mix ash, powder from neem leaves or cow dung so that we might not get tempted to eat the maize." Community member, Felo

Table 23 focuses on crops other than maize. Much of the content on methods and inputs is the same as for maize, so this table only gives additional methods, inputs and harvesting points.

TABLE 23. IMPACTS ON OTHER CROPS, BY COMMUNITY

Community / Zone	Crop Choice/ Seed/Variety	Husbandry Methods	Use of Inputs	Harvesting
Chiluzi - Rift Valley	• Shift to hybrid groundnut variety (CG7) • Shift to cassava and sweet potato	• Mulching for tobacco seed beds • Intercrop cabbage and pumpkin	• Give goats msangu pods – use droppings to pass high fertility to the soil	• Smear veg leaves with dung to prevent goats eating • Cassava theft in field
Chisambamnopa – Phirilongwe Hills	• More cotton. • Added tomato & other vegetables	• Irrigate vegetables	• Same as maize	• Few cassava because of theft
Felo – Lower Shire	• Added millet, sorghum, cotton, sweet potato and vegetables	• Winter cropping, conservation farming, box ridges • Started pesticides - cypermethyline on cotton	• Same as maize	• Millet and sorghum less easy to steal in the field
Kawelama – Phalombe-Lake Chilwa	• Continue with rice • More cassava, peppers, legumes and pigeon peas	• Inter-cropping and conservation farming • Planting groundnuts on least fertile parts to boost fertility	• Same as maize	• None identified
Liguluche – Southern Lakeshore	• From maize and rice to more sweet potato and tomato • Stopped cassava as was poisoning animals	• More winter cropping of vegetables	• Same as maize	• None identified
Lupanga – Middle Shire	• More cassava and g/nuts than maize	• Sugar cane and bananas at edge of irrigated fields	• Put diluted boom soap on cotton pests, but failed	• None identified
Mulupha –Mulanje-Thyolo Tea Estate	• From maize & cassava to pigeon peas, buffalo beans & paprika, sorghum, millet	• Plant sugar cane and bananas to prevent soil wash away	• Use aloe vera, turmeric and garlic to improve soil fertility	• None identified
Nkasala – Shire Highlands	• More cassava, and cotton and less maize	• Same as maize	• Same as maize	• None identified

Community / Zone	Crop Choice/ Seed/Variety	Husbandry Methods	Use of Inputs	Harvesting
Thambolagwa - Kasungu-LLW Plain	• More soybeans & cassava	• Plant sugar cane & bananas to prevent soil wash away • Soybeans to help soil fertility	• Apply Karate to soybean • Uproot affected potatoes	• None identified

Source: PRAs, Kadale Consultants

The key points in relation to other food crops were identified as:

1. **A shift to more drought resistant crops like cassava, sorghum, sweet potato and millet** that serve as both food and cash crops, and to cotton which is seen as a cash crop to be sold in order to buy maize in the market
2. **A diversification of crops to spread risks through intensification** of farming and irrigation. This includes the addition of vegetables.
3. **Irrigation has been accompanied by planting sugar cane and bananas at field edges** to benefit from spare water, reduce wash away, and as a food/income source
4. **Planting crops that fix nitrogen, such as soybean and groundnuts**. As noted earlier, the generally dryer conditions have reduced bean planting that might otherwise have had the same impact

The next table looks at effects of changes in the climate on livestock and fishing

TABLE 24. IMPACTS ON LIVESTOCK PRODUCTION, BY COMMUNITY

Community / Zone	Changes to livestock	Changes to Fishing
Chiluzi - Rift Valley	• Livestock decreased due to theft; goats and pigs now kept in houses at night • Free grazing during summer causes problems • Goats taken to grazing trees while on hind legs	• Not fishing
Chisambamnopa – Phirilongwe Hills	• Few goats left due to theft, kept by the Better-off • Keep livestock in the house for protection	• No longer fishing, since 20 years ago
Felo – Lower Shire	• No impacts on production methods	• Fishing from Shire River for food & income been constant over the years
Kawelama – Phalombe-Lake Chilwa	• Better-off and Average HHs have livestock - goats & pigs • Free grazing during summer • Let animals from other villages feed on their fields	• Fishing has decreased due to drying of Lake Chirwa & other major rivers
Liguluche – Southern Lakeshore	• Better-off and Average have shifted to keeping cattle in large numbers.	• Fishing decreased; boat owners rent to others • Use nets with small holes to catch smaller fish: mkacha, ogo, kandwindwi, chafi and ngwelele • Want GoM to enforce rules with trawlers
Lupanga – Middle Shire	• Keep their livestock in houses due to theft • Allow them to graze freely in summer – other farmers fence & guard fields • They slaughter and eat ND infected poultry	• Not fishing
Mulupha –Mulanje-Thyolo Tea Estate	• Keep goats, chicken, pigs, ducks and pigeons bought with money from tea estates • Lend hens to the Poorer so that they hatch eggs for them to have their own • Restrictions on pasture limits livestock keeping	• Only a few people practice fish farming

Community / Zone	Changes to livestock	Changes to Fishing
Nkasala – Shire Highlands	• Now rear livestock as an alternative to crops	• Some have fishponds to generate income, but other ponds have dried up
Thambolagwa - Kasungu-LLW Plain	• Some have sold their cattle due to lack of pasture – dambo now cultivated • Livestock found eating crops can be killed • Use herbs for treatment, like aloe vera for ND in poultry. If fail, then slaughter and eat	• Not fishing

Source: PRAs, Kadale Consultants

The key changes in livestock and fishing that were identified were:

1. A **general reductions in large ruminants,** particularly cattle due to theft, pressure on pasture, disease (FMD) and pressure on food supply leading to sale of animals to buy food. However, in Liguluche cattle have become the alternative source of income to fishing, so numbers have increased dramatically in the last 10 years, funded by existing wealth from fishing and remittances from SA. In Nkasala, there has also been an increase in goat keeping as a deliberate food security strategy of rearing in order to sell.

2. **A general depletion of other livestock numbers from sale** due to a relatively poor production decade. There are disease problems in all locations, but it is unclear if these are more prevalent even if reported to be. ND in chickens is reported to be directly connected to higher temperatures.

3. Though still practiced, **free grazing is more restricted due to cultivation of dambos** and conflicts with crop farmers. Cultivation of dambos and other common land has reduced available grazing areas considerably, notably at Thambolagwa. Grazing at Mulupha has always been restricted by surrounding tea estates, but increased populations are removing any spare land. The high incidence of theft also discourages free-grazing (unsupervised), so there is more tethering of goats and fodder collection.

4. There are **large gaps in prevention and treatment of livestock from disease and pests**. Where livestock is diseased, there can be use of traditional remedies. Where these fail, livestock is slaughtered to reduce spread of infection and consumed.

5. **Fish stocks of large fish, like chambo, have been depleted in Lake Malawi, Lake Chilwa and rivers**, so that fishing has declined in all communities that practice it. In Liguluche, which had fishing as the main livelihood ten years ago, there has been both more intensive fishing 'effort' to seek to maintain income through fishing for smaller fish and spending more time fishing (using hired labor) and switching to other income sources such as livestock and remittances.

There are considerable tensions between livestock owners and crop farmers. The latter take steps to protect their crops, particularly winter crops in the dambos, where traditionally the livestock could free graze in this season. This has led to conflicts when livestock enter the dambo, killing of livestock, destruction of crops and related conflicts. Crop farmers put up barriers/fences (sticks, sisal etc.) and maize stalks around vulnerable plants to deter animals. They also keep guard to drive off the animals.

"As much as we report the free range livestock that destroys our crops, the owners do not take action so we kill them and they end up suing us" Community member, Thambolagwa

3.3.2 ATTRIBUTION OF IMPACTS TO CLIMATE CHANGE

This section reviews to what extent communities attribute changes in production to climate.

The communities spoke a great deal about climate (or rather 'weather') changes, which is inevitable in farming/fishing communities, as rainfall is so central to the their livelihoods. This was often stated to be climate change, when, according to the Department of Meteorology staff that accompanied the teams, they were more describing climate variations as the trends are not necessarily sufficiently established to call it a change. From the PRA discussions, the strong message from the communities is that Malawi appears to have moved from a relatively settled and generally predictable pattern to a much less predictable pattern from around 2000.

TABLE 25. ATTRIBUTION OF PRODUCTION CHANGES TO CLIMATE

Community / Zone	Level of Attribution to Climate Change	Comments/Details
Chiluzi - Rift Valley	• High attribution of damage to maize crop to strong winds • High attribution of reduced yield to dry spells & short rainy season • Very high attribution of increase in ND (poultry) to high temperatures • Very high attribution of dambo drying in Oct to high temperatures • Very high attribution of reduction in maize and sugarcane production due to flooding	• Impact of strong winds worsened by reduced tree cover • Late rainfall onset, shorter season & dry spells increasing since 2000 • ND common in Oct, a hot month • Drying of river quickly due to high temperatures • Flooding in Madzimbayera dambo area sweeps away crops
Chisambamnopa – Phirilongwe Hills	• High attribution of poor maize yields due to flooding • High attribution of lower yields (groundnuts, maize and cotton) to high temperatures • High attribution of low maize production to increased frequency of droughts	• Flooding of Nansenga River in Jan/Feb results in washing away riverbank crops. Access to fields reduced as people cannot cross it; • Very high temperatures result in withering of crops • Long periods of drought occurred since 1981 & more frequent dry spells in rainy season
Felo – Lower Shire	• Very high attribution of poor maize harvest to flooding, • Very high attribution of drying up of maize, sesame and rice to high temperatures	• Sand from the mountains is replacing good soils – 'mphumbu' - resulting in poor moisture retention • Too much sun Nov to Jan causes crops, mostly maize, to dry up
Kawelama – Phalombe-Lake Chilwa	• Medium attribution of damage to maize and other crops in the field from prolonged dry spells that promote pests • High attribution of poor maize harvests to erratic rains • Very high attribution of poor crop harvests to flooding that destroys gardens	• Prolonged dry spells are frequent promoting pests like include locusts, crickets and army worms • Erratic rain comes early in Dec but cuts abruptly in Jan results in poor maize harvests • Flooding occurs Dec to Feb
Liguluche – Southern Lakeshore	• Medium attribution of poor harvests to strong winds that remove rain clouds & also damage crops • Medium attribution of poor maize harvest to increased pests due to high temperatures • High attribution of death of chickens related to high temperatures • Very high attribution of reduced harvests to water logging conditions	• SE winds bring little rainfall; heavy dusty storms damaging crops • Dry spells associated with very high temps in Jan & Feb have increased in last 15 years. Pests such as termites destroy crops when before the rains come • ND has killed chickens in the last four 'hot' years • Flash floods from Chikomo Valley in Jan & Feb make it inaccessible & waterlog fields
Lupanga – Middle Shire	• Medium attribution of poor maize & other crop harvests to whirlwinds • High attribution of low maize yields to late onset, long dry spells and early cessation • High attribution of poultry deaths to increased prevalence of diseases linked to high temperatures	• Increased frequency of high-speed south-easterly winds flatten crops • Long dry spells & shorter rainy seasons led to diversifying into cotton and vegetable cultivation • Long dry spells with very high temperatures occur in Jan • Changes observed over 10 years

Community / Zone	Level of Attribution to Climate Change	Comments/Details
Mulupha –Mulanje-Thyolo Tea Estate	• High attribution of maize & rice damage in the field due to floods that occur every year • High attribution of high temperatures to withering of crops, especially maize • Very high attribution of poor health of people to insects due to high temp and diarrhea cases promoted by floods • Very high attribution of increased pests such as ants attacks on crops to increased temperatures promoting their reproduction	• High areas deforested for a new tea estate result in river overflows in rainy season destroying crops. • There were high temps in 2011-12 season. Maize and cassava dried up and only pigeon peas survived • "Msungu" sores caused by fly-like insects locally called "Ziphwita". • Most crops attacked by ants and worms, particularly maize.
Nkasala – Shire Highlands	• High attribution of poor maize yields due to flooding of Mtunguludzi River • High attribution of crop destruction from heavy rain close to mountain in late season • Very high attribution of dwindling fish production in ponds to low & erratic rainfall • Very high attribution of poor maize yields to acidic rains	• Flash floods in 1981-82 & 1990-93 from Mtunguludzi River washed away some fields • If there are heavy rains, there are low yields as crops rot while in the field especially hybrid maize. • Since 2001, experienced low & erratic rain; fishponds dry up. • Experienced "mvula ya moto" (acidic rain); all crops dry up after such rains
Thambolagwa - Kasungu-LLW Plain	• Medium attribution of poor maize yields to increased frequency of frost • Medium attribution of low production in soya & Irish potatoes to increased pests attacks & diseases • High attribution of poor maize and bean harvests to prolonged dry spells • High attribution of low maize & Irish potato productivity among other crops to more frequent south-easterly winds & flooding	• Since 2009 frost occurs every year • Warm temperatures promote pests. Beans attacked by *mphembezu* (big ants) while Irish potatoes attacked by *thuku (bacterial wilt)* • Increased frequency of dry spells Oct to Dec results in wilting of • South-easterly winds more frequent and intense; destroy crops in the field • Increased flooding from the river

Source: PRAs, Kadale Consultants

The key areas of attribution identified were:

1. Erratic rains and accompanying high temperatures in dry spells clearly linked to low productivity of maize, beans and other crops

2. Flooding and intense winds (south-easterlies) can completely destroy crops—maize is susceptible due to its height and that it is intolerant to too much water, as when there is flooding or water logging, especially improved varieties

3. Increase in pests and disease for crops and livestock is highly attributed to high temperatures and dry spells in the pre-onset period. ND is known to be temperature related

4. Drying of fishponds attributed to lower rainfall and shorter seasons

Overall, the impact of climate-related events on crop, livestock and fish production is highly attributed.

3.3.3 IMPACTS NOT YET FULLY MITIGATED

The PRAs revealed climate-related and non-climate related production impacts that communities had not yet mitigated.

TABLE 26. CLIMATE & NON CLIMATE-RELATED PRODUCTION IMPACTS NOT YET MITIGATED, BY COMMUNITY

Community / Zone	Impacts not Mitigated	Comments/Details
Chiluzi - Rift Valley	**Climate-related** • Low rainfall has not been fully mitigated **Non Climate-related** • Poor harvests from traditional maize due to lack of fertilizer and inability to use improved for same reason	**Climate-related** • When rivers dry up, there is no water for irrigation to supplement rains affecting yields **Non Climate-related** • Though people can & do grow improved maize to mitigate poor yields of traditional varieties, the absence of affordable fertilizer prevents higher yields
Chisambamnopa – Phirilongwe Hills	**Climate-related** • Prolonged dry spells & high temperatures reduce cropping options and yields **Non Climate-related** • As cotton is a cash crop only, then the pricing is more important than for maize, but it is volatile and can be below cost of production	**Climate-related** • Have been prolonged dry spells for the past 10 years; people have switched more to cotton, but continue to grow maize even though the yields are low • High temperatures and delayed rains promote termites which they cannot afford to pay for pesticides against **Non Climate-related** • Cotton prices are dictated by the market and have gone from good to poor from 2011-12 to 2012-13.
Felo – Lower Shire	**Climate-related** • Flooding of Ngoni & Chikunkha Rivers in rainy season covers the whole village in water, destroying crops & property • High temperatures bring discomfort and scorch crops in the field	**Climate-related** • Not much done to mitigate flooding other than the community just constructed a drainage system to divert water; the effectiveness is yet to be established • No solution to the high temperatures; some community members believe the situation will not change unless M'bona cult rituals are respected while others believe afforestation is the solution
Kawelama – Phalombe-Lake Chilwa	**Climate-related** • Late onset of rains & high temps promote locust & army worms that destroy crops • Strong south-easterly winds continue to destroy crops • Dry spells within the rainy season are a major problem to crop production as crops need regular rains **Non Climate-related** • Poor harvests from traditional maize due to lack of fertilizer and inability to use improved for same reason	**Climate-related** • Locusts are endemic, but increased due to low & erratic rains which give them time to multiply. • South easterly winds are very strong and damage crops. No mitigation, other than trees as wind breaks • Dry spells within the rainy season have are more frequent over the past 10 years. Irrigation is limited along the river. The problem is compounded by drying up of the Lake and rivers **Non Climate-related** • Though people can & do grow improved maize to mitigate poor yields of traditional varieties, the absence of affordable fertilizer prevents higher yields
Ligulwiche – Southern Lakeshore	**Climate-related** • Erratic rains (late onset & early cessation plus dry spells): impacts are not fully addressed	**Climate-related** Some have tried to plant on the shores of the Lake but risk Hippos destroying their crops or crocodile attacks

Community / Zone	Impacts not Mitigated	Comments/Details
Lupanga – Middle Shire	**Climate-related** • High temperatures continue to lower maize production for farmers • A shortened rain season has reduced crop produce **Non Climate-related** • Cotton prices are not high enough and farmers feel exploited	**Climate-related** • High temperatures have not had a solution yet. Community seems to have lost hope. Cotton has been grown more than maize so that people would buy maize from the proceeds of cotton, but cotton has also suffered due to reduced moisture caused by high temperatures • Some have tried to mitigate the short rain season with early planting but still face challenges due to dry spells **Non Climate-related** • Cotton prices are volatile and can be below cost of production
Mulupha –Mulanje-Thyolo Tea Estate	**Climate-related** • Flooding attributed to heavy rains from the mountain coupled with deforestation continues to have heavy impacts on crop production	**Climate-related** • The community has not found a solution to flash flooding. They indicated that one solution would be to plant trees in the village to give some protection, but not sufficient
Nkasala – Shire Highlands	**Climate-related** • High temperatures coupled with low rains have resulted in fish ponds dry up	**Climate-related** • 15 fish ponds in the south of the village had dried up attributed to low rains and high temperatures causing high evaporation rates. No solution has yet been found
Thambolagwa - Kasungu-LLW Plain	• Increased impact of frost in the cold season especially in June-August	• Frost (chisanu) affects crops, mainly Irish potatoes & beans during Aug and no solution has yet been found

Source: PRAs, Kadale Consultants

The outstanding production impacts are mainly climate related. The main impacts not yet mitigated were identified as:

1. Although there has been a switching to more drought resistant food (cassava, millet, sorghum) and cash crops (cotton), **prolonged dry spells and drought still overwhelm these crops**

2. Water conservation and irrigation can help mitigate, but **there are not enough water sources to meet the needs of all the land**

3. Flooding has been exacerbated by loss of forests resulting in fast and destructive run-off, such as at Mulupha. Although **there are efforts to deflect flash floods and to keep rivers within their banks, the cultivation of so many areas means this has not been successful**

4. The **increased prevalence of pests attributed to high temperatures and late onset of rains has not been mitigated**. Pest control through chemical means is beyond the affordability of most households and crops are not sufficiently pest resistant

5. The **main non-climate-related impact is the high cost of fertilizer and inputs that is beyond most households; based on the PRAs, FISP is not effectively addressing this shortfall for many Average and Poorer households**. The increase in the price of inputs this current season has been a major challenge. **Mitigation through improved husbandry, soil conservation and soil fertility measures such as crop rotation with legumes, planting certain types of trees, adding animal and vegetative compost/manure are all useful, but insufficient in the absence or limited application of inorganic fertilizer**

6. A second important **non-climate-related impact is volatility of prices for cash crops** like cotton. This can take it to below the cost of production and is challenging when there is high inflation between the sale of last year's crop and buying inputs for the next year's crop. At present there is no mitigation activity.

3.3.4 DIFFERENTIAL IMPACTS

This section reviews how **production-related** impacts that have not yet been mitigated differ by wealth groups. This is split by impacts that are climate-related, indirectly climate related and non-climate-related.

TABLE 27. DIFFERENTIAL PRODUCTION IMPACTS ACCORDING TO WEALTH, BY COMMUNITY

Community / Zone	Impacts not yet Mitigated	Comments/Details
Chiluzi - Rift Valley	**Climatic direct impacts:** • The Poorer produce less maize and groundnuts than other groups due to short rainy season • The Poorer are more vulnerable to impacts from strong winds	• The Poorer cannot afford fertilizer or to practice irrigation; other groups use income from other sources to buy inputs for improved varieties that cope with a short rain season • The Poorer have weak houses that lose roofs in strong winds. The housing for the other groups is more permanent and can withstand strong winds
	Climatic indirect impacts: • The Poorer are more affected by prevalence of malaria due to conducive conditions for mosquitoes	• Malaria mostly attacks the poorest groups as they do not use nets correctly (e.g., use them as sheets) or do not have them
	Non climatic impacts: • The Poorer suffer more from devaluation & increased commodity prices especially for farm inputs	• The Poorer are more affected as they depend on farming and do not have diversified income sources
Chisambamnopa – Phirilongwe Hills	**Climatic direct impacts:** • The Poorer have lower maize production from erratic rainfall onset than other groups	• Erratic rain onset forces replanting. The Poorer cannot afford more seeds; the Average and Better-off can buy more inputs and respond very quickly
	Climatic Indirect Impacts: • The Poorer are affected more by cholera & malaria in the rainy season; this affects their ability to produce and do ganyu	• The Poorer cannot protect themselves form mosquitoes as they cannot afford nets and when they get sick, they cannot easily travel to the hospital for lack of funds. The sick fail to attend to their fields & so produce less maize, weakening them further
	Non Climatic Impacts: • The Poorer sell cotton to the Better-off and Average who buy it at very low prices as they need to get cash	• The Poorer are fail to grow cotton due to low price but have no alternative but to sell, particularly if they need cash early • Prices are not responsive to an increase in price of pesticides due to season end and start time differences
Felo – Lower Shire	**Climatic direct impacts:** • The Poorer are more vulnerable to heavy rains and floods which affects their fields (and housing) than other groups	• The Poorer's houses are more vulnerable to heavy rains as the structure is mud and grass thatched; the other Better-off and some Average have stronger structures of burnt bricks and iron roofs
	Climatic Indirect Impacts: • The Poorer produce less than other groups as more affected by malaria in rainy season	• The Poorer suffer more from malaria compared to other groups who can afford mosquito nets and treatment; as a result they produce less
	Non Climatic impact: • The Poorer have less land to cultivate and so produce less	• The Poorer rent out some of their land to the other groups to raise money for fertilizer and food following a poor season; this is a downward spiral.
Kawelama – Phalombe-Lake Chilwa	**Climatic direct impacts:** • The Poorer have poor soil fertility and lower production • Poorer fishing households are more affected by dwindling fish stock and drying of Lake Chilwa	• Sasakawa and conservation farming are intensive requiring labor, fertilizer and pesticides, which the Poorer cannot afford, but the Better-off can. • Dwindling fish population, which the Poorer sell and consume, leave few alternative income sources for the Poorer

Community / Zone	Impacts not yet Mitigated	Comments/Details
	Climatic indirect impacts: • No notable differential impacts	• No notable differential impacts over the wealth groups
	Non Climatic impacts: • The Poorer rent out or sell their land and so produce less on their small fields	• The Poorer cannot afford fertilizer and other inputs so they sell or rent out their land to the other groups to raise money for inputs
Liguluche – Southern Lakeshore	**Climatic direct impacts:** • The Poorer have lower yields of maize, beans and sweet potatoes compared to other groups	• The Poorer cannot afford fertilizer to improve the nutrient content of the sandy soils and pesticides to deal with pests promoted by the high temperatures. FISP inputs are insufficient for the Poorer
	Climatic production impacts: • The Poorer suffer more from malaria than other groups	• Malaria prevalence gets worse in the rainy season; the Poorer cannot afford nets & transport, affecting household health status & capacity to work
	Non climatic impacts: • The Poorer suffer more from population increase reducing their production land	• Poorer have insufficient land, so the loss of any land or access to common land has more impact. Also they cannot supplement their own produce by buying using income from other sources
Lupanga – Middle Shire	**Climatic direct impacts:** • The Poorer harvest less maize & cotton as cannot replant and cannot treat pests	• The Poorer cannot afford extra seeds for replanting when rains are erratic at onset or inputs to protect cotton from pests. The Better-off can afford inputs and so harvest more.
	Climatic indirect impacts: • No clear differential impacts	• No clear differential impacts over the wealth groups
	Non climatic impacts: • The Poorer do not have land with access to water from the river compared to the Better-off	• The Poorer do not have land on the riverbanks for hereditary reasons (compounding wealth differences over time) or have had to rent land with river access out to the Better-off to get cash for food, inputs or emergencies. As a result, in dry spells, the Better-off combine access to fields along the river with inputs leading to high production.
Mulupha – Mulanje-Thyolo Tea Estate	**Climatic direct impacts:** • The Poorer have low maize productivity due to erratic rains and floods compared to other groups	• The other groups can use their other income sources to buy fertilizer resulting in higher productivity than the Poorer
	Climatic indirect impacts: • No clear differential impacts	• No clear differential impacts over the wealth groups
	Non climatic impacts: • The Poorer have less land than other groups, so produce less	• The Poorer rent out some of their land to other groups leaving a small cultivation land. The Poorer have an Average land holding of 0.5 ha
Nkasala – Shire Highlands	**Climatic direct impacts:** • The Poorer are more vulnerable to erratic rains/droughts as they cannot afford fertilizer and crop protection	• The Poorer cannot afford fertilizer & pesticides; the FISP fertilizer & seeds provided are insufficient. The Better-off and Average can buy fertilizer, seeds and pesticides, so can cope better with erratic rains
	Climatic indirect impacts: • No differential impacts	• No differential impacts over the wealth groups
	Non climatic impacts: • No differential impacts	• No differential impacts over the wealth groups

Community / Zone	Impacts not yet Mitigated	Comments/Details
Thambolagwa - Kasungu-LLW Plain	**Climatic direct impacts:** • The Poorer are affected more by heavy rains as they cannot replace lost production • The Poorer suffer more from the consequences of lower yields when rains are erratic rains	• Maize rots in the field when there are heavy rains at rainy season. The effect on crops is the same for all wealth groups; however, the Poorer have limited alternative income sources so resort to ganyu, while Better-off cope through businesses and selling in Mozambique at high prices • The Better-off have enough fertilizer so use sasakawa, while the Poorer have insufficient fertilizer for sasakawa so have less to harvest
	Climatic indirect impacts: No differential impacts	• No differential impacts over the wealth groups
	Non climatic impacts: • No differential impacts	• No differential impacts over the wealth groups

Source: PRAs, Kadale Consultants

The key points relating to the differential impacts on wealth groups from the above are:

1. The Poorer are more vulnerable to erratic rains and high temperatures, as they do not have alternative sources of income to replant or buy food if they lose their crop
2. The Poorer cannot plant high-input improved higher yielding early maturing maize varieties, as they cannot afford the additional inputs, so they can only grow the traditional variety that is vulnerable to shorter rains. Nor can they adopt the dual planting strategy of improved and traditional varieties to benefit from whichever is best suited to the coming season
3. The Poorer cannot diversify or intensify, as they do not have resources for irrigation and alternative crops
4. The Poorer are more affected by the indirect impacts of disease, as they do not have the resources to prevent or to travel to get treatment or to pay for treatment. They are more prone to illness and so lose more productive time
5. The Poorer have to do ganyu to meet immediate food needs and so neglect their own crops. They also rent out their land to raise money for food, often resulting in insufficient land to feed themselves

The table that follows looks at **non-production**-related impacts that are not yet mitigated as they differ by wealth category.

TABLE 28: DIFFERENTIAL NON-PRODUCTION IMPACTS ACCORDING TO WEALTH, BY COMMUNITY

Community / Zone	Differential Impacts not yet Mitigated	Comments/Details
Chiluzi - Rift Valley	• The Poorer are stigmatized or excluded from development activities • Children from the Poorer are at higher risk of school dropout and generally perform worse at school than those from the other groups • The Poorer sell their agricultural produce (e.g., tobacco and livestock) at low prices to the other groups who sell on at higher prices	• The Poorest, including Child- and Female-headed households are left out of LDF road rehabilitation projects on which participants are paid MK 200/day (US $0.60) • The Poorer are at a high risk of school dropouts due to lack of fees. Performance is affected by hunger • In lean periods, the Better-off take advantage of the Poorer's need for cash by buying at low prices.
Chisambamnopa – Phirilongwe Hills	• The Poorer and Average have limited access to lower cost loans • The Poorer are the most affected by malaria than the other groups	• The Poorer and Average pile up debts from (katapila) loans at high interest from Better-off • The Poorer cannot afford mosquito nets and transport to the hospital 10 Kms away

Community / Zone	Differential Impacts not yet Mitigated	Comments/Details
Felo – Lower Shire	• The Poorer have less land to cultivate than the other groups • The Poorer suffer more from malaria compared to the other groups • The Poorer have limited access to loans than the other groups • The Poorer have undiversified sources of income and heavily depend on agriculture than the Better-off and the Average	• The Poorer have up to 0.25 ha, the Average have 0.25-2 ha. The Better-off have at least 2 ha • The Poorer cannot afford mosquito nets while the Average the Better-off do • There is more trust in lending each other money between the Average and Better-off than when the Poorer want loans from the other two classes • The Better-off and Average have small scale businesses with diversified incomes and so less susceptible to agricultural problems
Kawelama – Phalombe-Lake Chilwa	• The Poorer have little land to cultivate compared to the other groups • The Poorer have less diversified sources of income • The Poorer are more affected by malaria than other groups	• The Poorer rent out their land to the others • The Better-off have businesses, while the Average have IGAs (making pots & mats); the Poorer mostly rely on their own produce and ganyu, so hard to cope in a poor farming season • The Poorer fail to travel for medical help as they cannot afford transport and medical costs
Liguluche – Southern Lakeshore	• The Poorer have less access to FISP coupons than other groups • The Poorer are more affected by dwindling fishing activities • The Poorer are more vulnerable to food insecurity than the other groups	• There are allegations of favoritism in coupon distribution for the other groups over the Poorer • Dwindling fishing activities mean less ganyu for the Poorer • The Poorer groups rent out their fields to the other groups so more prone to food insecurity.
Lupanga – Middle Shire	• The Poorer have no alternative income sources to agriculture • The Poorer have lower production of maize than the Better-off • The Poorer are more prone to diseases than the Better-off • The Poorer have more difficulty to access medical services than the Better-off	• The Better-off have more diverse income from livestock sales, cash cropping and small business while the Poorer mostly rely on ganyu • The Poorer do ganyu from the Better-off so do not attend their fields • The Poorer are more prone to diseases due to lack of food and lack of diverse diet • The Poorer rely on well-wishers to get to hospital; the Better-off can sell livestock to buy medicine
Mulupha – Mulanje-Thyolo Tea Estate	• The Poorer have unstable non-farm related sources of income compared to other groups • The Poorer have insufficient land for food insecurity than the other groups	• The Poorer do ganyu in tea estates, while other groups are employed with regular salaries at higher rates • The Better-off have more land to cultivate and rent land from the Poorer. Some of the Better-off also go to Mozambique to buy food (maize)
Nkasala – Shire Highlands	• The Poorer have limited alternative income sources making them more vulnerable in poor agricultural seasons • The Poorer lose out cases involving land or coupons at the village chief's court compared to the other groups	• The Poorer opt for charcoal making when farming is affected, which does not give as much income as businesses that other run • The Poorer mostly lose cases when referred to the village chief's courts as they cannot bribe officials compared to the other groups
Thambolagwa - Kasungu-LLW Plain	• The Poorer are exploited by the Better-off in low pay for ganyu	• The Poorer are exploited, especially in the hungry season when they are desperate

Source: PRAs, Kadale Consultants

The key points on non-production-related impacts not yet mitigated from the above are:

1. The **Poorer are easily excluded from development activities and benefits**, including FISP as they are more powerless within their communities because of their poverty

2. **Children of Poorer households are more likely to drop out of school or not perform well** due to lack of fees and food. This impacts their overall life outcomes.
3. The **Poorer are more dependent on agriculture so are more affected in all aspects of their well-being by a poor season** than those with alternative income sources.
4. The **Poorer may sell their produce cheaply to pay debts/loans accumulated in the production season, or to meet other urgent needs**. They are exploited for their labor through low payment as they are desperate for food/money in the production season.
5. The **Poorer are more affected by disease, as they can only earn a living if they are working for others (ganyu) or contributing to their own food production**.

This was summed up by a Poorer person in Felo:

"A poor person is like a stone." Meaning that there is nothing we can say when things are discussed. Poorer community member, Felo

3.4 ADAPTATION STRATEGIES

This section focuses on the adaptation strategies adopted to address the impacts identified in the previous section and on impacts that have not yet been addressed.

This section reviews strategies adopted for their effectiveness covering crop production, livestock, other livelihoods and food security.

3.4.1 ADAPTATION STRATEGIES – CROP PRODUCTION

A variety of crop production strategies were reviewed and their effectiveness determined based on the views from the PRAs.

TABLE 29. CROP PRODUCTION STRATEGIES ADOPTED TO MITIGATE IMPACTS, BY COMMUNITY

Community / Zone	Strategies adopted	Effectiveness of Strategies
Chiluzi - Rift Valley	1. Use fertilizer and manure to increase crop production 2. Adopt narrow ridge spacing and planting (Sasakawa). 3. Intercrop maize with drought resistant crops e.g., cassava & sweet potato 4. Use hybrid maize & g/nuts to increase production. 5. Use of box ridges to conserve water and reduce soil erosion.	1. Using manure to supplement fertilizer helps a lot, especially the Better-off with livestock than those who rely on compost manure 2. Sasakawa has effectively increased maize production. Can harvest more on small land area 3. Intercropping has to some extent improved food security as they can now rely on another crop like cassava when maize has failed 4. Hybrid maize & groundnuts has effectively increased production 5. Box ridges to some extent help conserve water during dry spells.
Chisambamnopa – Phirilongwe Hills	1. Shift from traditional to hybrid maize 2. Adopt irrigation farming 3. Use fertilizer to increase maize yields 4. Practice zero tillage to restore soil fertility 5. Practice agro-forestry (some). 6. Practice crop rotation (most) 7. Adopt cotton farming for income	1. Hybrid has increased production to some extent, although yields affected by limited FISP and rainfall. 2. Irrigation has improved production for households with gardens close to rivers as can grow vegetables for income. However, using watering cans limits area for vegetables 3. Few Better-off & Poorer who get FISP fertilizer have improved yields. However, less than a quarter of the village benefit 4. Zero tillage restores soil fertility to some extent 5. Planting trees like Msangu restores soil fertility, improves yields & adds tree cover 6. Crop rotation has improved yields as legumes like g/nuts help maize 7. Cotton farming effectively improves income although market is volatile and can be low relative to costs
Felo – Lower Shire	1. More irrigation for maize & vegetables 2. Grow traditional & improved maize and diversify crops into pigeon peas & groundnuts 3. Adopt 'zero tillage' conservation farming, box ridges, plant vetiver grass in contours – taught by WALA	1. Irrigate gardens from Ngoni, Chikunkha & Nyamatudzi rivers. Some dig shallow wells – effective overall 2. When one fails they can rely on the other – it is more effective except in very bad seasons. 3. This has reduced soil erosion & improved soil fertility.
Kawelama – Phalombe-Lake Chilwa	1. Shift from only traditional maize to plant traditional and improved 2. Use compost manure 3. Some irrigate 4. Grow more g/nuts to bring back soil fertility and sell for income 5. Shift from inter-crop to Sasakawa and conservation farming	1. Plant early maturing high yielding hybrid maize like MH-18 and MH-41. Complement the low yielding but disease resistant traditional – more effective 2. Compost manure complements fertilizer and has improved production 3. Irrigation has improved food security for those with fields close to water sources. 4. Agric extension worker (Govt) advised them to plant more g/nuts to fix nitrogen 5. Sasakawa & conservation farming has effectively improved crop yield
Liguluche – Southern Lakeshore	1. 1.Shift from plant only traditional maize to adding improved varieties 2. Use compost manure to improve soil fertility 3. Intensified winter cropping & irrigation	1. Cultivate both to maximize yield depending on advantages of each crop 2. Manure has improved soil fertility 3. Winter cropping & irrigation have improved crop yields. Diversified into sweet potatoes & tomatoes.

Community / Zone	Strategies adopted	Effectiveness of Strategies
Lupanga – Middle Shire	1. Adopt improved maize 2. Increase cotton production to improve food security 3. Use of diluted boom soap as insecticide for cotton 4. Some people undertake stalk borer ritual to control attacks on maize 5. Adopt conservation farming – use of box ridges to reduce soil erosion 6. Grow cotton to increase income	1. Shift from traditional to improved variety has effectively improved crop yields 2. Cotton farming has effectively improved income, though market prices vary and can be relatively low compared to cost 3. Use of diluted soap was not effective 4. It is no longer effective. People just practice from tradition. 5. Conservation farming has significantly helped to conserve water, reduce soil erosion & restore soil fertility to increase crop yield 6. Cotton production has improved food security as the area is conducive
Mulupha –Mulanje-Thyolo Tea Estate	1. Shift from maize & cassava to pigeon peas, buffalo beans & paprika 2. Adopt tea growing for income 3. Adopt conservation farming - box ridge, plant vetiver grass & sugarcane in contours 4. Adopt pit planting for bananas 5. Shift from traditional maize to improved 6. Intercrop to improve crop yields 7. Plant drought tolerant crops - sorghum, pigeon peas & cassava.	1. These complement poor maize & cassava production 2. Those growing tea have effectively mitigated decrease in food production 3. Modern farming techniques have effectively improved crop yields. 4. Pit planting has effectively improved banana production as pits retain moisture 5. Hybrid maize has effectively improved crop yield, as early maturing & high yielding 6. As most people have small landholdings, more intensive means they harvest more 7. Drought tolerant crops have effectively improved production & food security
Nkasala – Shire Highlands	1. Plant crops according to soil types 2. Adopt conservation farming to retain moisture & reduce soil erosion 3. Since 1999, some farmers irrigate 4. Grow more cotton for income. 5. Since 2004, most farmers rotate crops to bring back soil fertility. 6. Shift from traditional to improved maize	1. Has effectively improved production as taught which crop suits a particular soil type 2. Reduced soil erosion helps restore fertility & improve production 3. Irrigation has improved production as can harvest two or three times per year 4. Cotton production has improved food security as the area is conducive for cotton farming 5. Rotation to some extent improves production 6. Improved maize to some extent improves production but is prone to weevils in storage
Thambolagwa - Kasungu-LLW Plain	1. Adopt conservation farming - zero tillage, sasakawa, crop rotate & box ridges 2. Apply fertilizer (most HHs) 3. Shift to improved maize 4. Increase use of pesticides to fight pests 5. Increase winter cropping 6. Use of compost manure 7. Shift from maize to more Irish potatoes	1. Conservation agriculture has effectively improved production 2. Fertilizer has effectively improved production 3. Use of improved maize has effectively increased maize yield 4. Pesticide has partially improved production 5. Winter cropping has significantly assisted as plant maize & other crops more than once a year 6. Manure to supplement fertilizer has effectively improved production 7. Irish potato can be a food & cash crop

Source: PRAs, Kadale Consultants

The key points relating to the effectiveness of crop production strategies from the above are:

1. **The dual strategy of planting traditional and improved maize is effective** for when the rains are of normal length or shortened due to late onset and/or early cessation. The proviso is that this strategy cannot mitigate against prolonged dry spells mid-season or drought conditions

2. The strategy of **moving from traditional or mixed to all improved maize varieties can be effective, if the farmer has sufficient inputs and, ideally, has irrigation or sufficient residual moisture such as in a dambo**. However, the unresolved problem with hybrid is its vulnerability to pests in storage

3. Adopting **improved husbandry methods such as conservation farming, zero tillage, and Sasakawa has proven effective,** except in extreme conditions

4. Increasing **irrigation and winter cropping is very effective through enabling more than one crop and a high degree of certainty of success**

5. Adopting **measures to improve soil fertility and reduce erosion, such as inter-cropping with legumes, crop rotation, planting vetiver, adding compost/animal manure, have been effective**, though access to inorganic inputs and animal manure is constrained.

3.4.2 ADAPTATION STRATEGIES – LIVESTOCK PRODUCTION

A variety of livestock production strategies were reviewed and their effectiveness determined based on the views from the PRAs.

TABLE 30. LIVESTOCK STRATEGIES ADOPTED TO MITIGATE IMPACTS, BY COMMUNITY

Community / Zone	Strategies adopted	Effectiveness of Strategies
Chiluzi - Rift Valley	• The Poorer sell goats to Better-off to buy maize in the hunger season	• Effectively helped minimize hunger, but resulted in depletion of livestock levels & so not a sustainable strategy, more a food security immediate response
Chisambamnopa – Phirilongwe Hills	• The Poorer and Average sell livestock (goats & chickens) in the hunger season to the Better-off & traders from Mangochi Boma.	• Livestock sale has not been effective as most people have sold all their goats & do not plan to keep again due to theft. Most sold cheaply to traders from Mangochi. • Number of goats has reduced
Felo – Lower Shire	• People keep diverse range of livestock (cattle, goats, chickens, pigs, ducks & guinea fowls). Poorer and Average keep livestock to sell to buy maize in hunger periods; Better-off keep for prestige.	• Keeping livestock as a strategy has reduced the number of people who face hunger.
Kawelama – Phalombe-Lake Chilwa	• The Average keep goats & chickens to sell and buy hybrid seeds & maintain houses. They buy more goats when they sell their crops	• This is a deliberate strategy to rear livestock for sale & has been effective to meet farming & housing needs
Liguluche – Southern Lakeshore	• Cattle and (some) goat-keeping has increased among Better-off & Average as an alternative income & form of wealth to fishing, which was their major livelihood	• Cattle keeping has effectively substituted fishing as a livelihood. Animals are sold to start businesses, buy farm inputs or for transport for migrants to SA. They sell the little milk they produce to buy necessities
Lupanga – Middle Shire	• The Poorer sell their livestock at Balaka Boma to buy fertilizer, seeds & consumer goods. • The Poorer barter livestock for maize with the Better-off	• This is a very effective way of getting money for farm inputs as the livestock acts as savings and capital • Prices are higher for goats at the Boma than selling to Better-off in the village
Mulupha –Mulanje-Thyolo Tea Estate	• A few of the Average keep goats, chickens and pigs to sell when they do not have money	• This is an effective strategy for when tea picking season is closed. However, very few people keep livestock due to limited land area & scarcity of fodder

Community / Zone	Strategies adopted	Effectiveness of Strategies
Nkasala – Shire Highlands	• The Poorer keep chickens or goats to sell them and buy maize in case of a poor crop season.	• This is very effective as the area has experienced frequent dry spells. However, frequency of dry spells depletes livestock as the Poorer sell without replacing
Thambolagwa - Kasungu-LLW Plain	• The Poorer sell goats to Better-off in times of food shortages	• This is very effective to get cash when there is hunger

Source: PRAs, Kadale Consultants

The key points relating to the effectiveness of livestock strategies are:

1. Livestock is a useful form of saving for times when food is short and there is no other means to buy it.
2. Livestock numbers are depleted if there are multiple poor years in close succession, as has occurred in recent years
3. Adopting a deliberate strategy to buy livestock with available funds, such as immediately post-harvest, can be effective.
4. Disease and theft risks still exist and can set back livestock numbers and production, as these are not yet mitigated fully

3.4.3 ADAPTATION STRATEGIES – OTHER SOURCES OF LIVELIHOOD

A variety of other livelihood strategies were reviewed and their effectiveness determined based on the views from the PRAs.

TABLE 31. OTHER LIVELIHOOD STRATEGIES ADOPTED TO MITIGATE IMPACTS, BY COMMUNITY

Community / Zone	Strategies adopted	Effectiveness of Strategies
Chiluzi - Rift Valley	1. Tree planting program initiated by GoM's forestry & agriculture depts.. Some (Better-off) people established private woodlots. 2. Some men, especially Average, seek permanent or temporary employment in Blantyre, Lilongwe or Dwangwa 3. The Poorer do more work in gardens of Better-off for income to buy food or are paid in maize 4. The Poorer hunt and sell mice to find money to buy maize 5. The Better-off and Average brew and sell beer	1. Tree planting has to some extent effectively restored vegetation cover; Mswaswa and Mtangatanga trees improve soil fertility. Potential for income from firewood sales over time 2. Employment is an effective strategy, but poses social and health risks from extra marital affairs 3. Ganyu is quite effective in short term, as get money or maize. However, they remain poor as spend most of their time in other people's gardens instead of their own fields 4. Hunting mice is not very effective as they fetch low prices & hard to catch 5. Selling beer is very effective, as heavy drinking is part of the culture

Community / Zone	Strategies adopted	Effectiveness of Strategies
Chisambamnopa – Phirilongwe Hills	1. Men and women engage in afforestation promoted by Malawi Lake Basin Project 2. Some men within the Poorer and the Average wealth group seek permanent or temporary employment in Blantyre, Lilongwe and SA 3. Do more ganyu in the hungry months (Dec-Feb), including going to the Lake to pull nets 4. Make bricks and sell them 5. Poorer engage in IGAs like mat making, sell vegetables, fish zitumbuwa & mandasi 6. Better off & Average do bicycle taxi & charging phones using solar energy	1. Acacia, Msangu and Mgosais restore tree cover and soil fertility 2. Employment is an effective strategy for remittances and income. However it can lead to permanent or long term migration and impact on marriages 3. Poorer work in Better-off's gardens – effective short term for maize or cash but neglect own gardens 4. Some men especially Poorer, burn bricks for income resulting in deforestation. Generates income but not sustainable 5. These do generate small incomes as some items bought daily 6. Charging phones has been effective as many of the Poorer and some Average do not have electricity
Felo – Lower Shire	1. Poorer fish at Shire, Ngoni & Chikunkha Rivers 2. The Poorer and Average seek permanent or temporary employment in sugar plantations in Nchalo, Blantyre & Lilongwe. Also in Mozambique and SA. 3. Men & women planting trees along river banks & places which are bare - GOAL Malawi program 4. Poorer & young men have increased charcoal production	1. Fishing is effective as anyone can catch & sell fish 2. Employment is effective as it can give regular cash income. Nchalo is less than 70 km away so men can return home at weekends. 3. Planting trees is not effective - as some people plant, others cut established trees for charcoal 4. Charcoal production is quite effective as good prices in town
Kawelama – Phalombe-Lake Chilwa	1. Tree planting initiated by Emmanuel International & WALA including wood lots 2. Poorer engage in IGAs like make & sell mats; Better-off run small shops/stalls 3. Poorer go for ganyu in Mozambique for income to buy food in the hunger months 4. Poorer work on public work projects, such as the LDF projects 5. Poorer and elderly benefit from GoM's social cash transfer 6. Poorer & Average mold & sell bricks when agriculture is not performing 7. Better off go to Lake Chilwa to trade fish	1. Men and women benefit from woodlot products. Msangu & Acacia in fields restore soil fertility 2. IGAs are a very effective strategy 3. Ganyu within the village and in Mozambique has effectively helped the Poorer sustain families in hungry season, but at cost of own farming 4. Daily pay is very effective for buying food and necessities. In some cases they can buy FISP fertilizer, but neglect own farms 5. The social cash transfer program enables them to buy food 6. Brick selling effectively helped Poorer and Average household get money for food in poor crop years 7. Trading fish is quite profitable
Liguluche – Southern Lakeshore	1. Fishing was the main livelihood, but declining due to overfishing. They use smaller nets & sell small fish *(usipa)* 2. Youth and younger married men migrate to SA to find jobs 3. Some Average and Poorer people have permanently migrated to areas like TA Mponda where there is land for farming 4. The Poorer rely on ganyu in the Better-off gardens or pulling fish nets at the lake.	1. Fishing is no longer effective as fish stock is now small due to poor regulation of seasonal fishing & nets 2. This is an effective adaptation as they remit money, which is partly invested in cattle – however, it results in semi-permanent migration, with the establishment of 'Liguluche 2' in SA. 3. Migrating has helped to some extent, as they cultivate a larger piece of land with higher yields than before. 4. Pulling fishnets is no longer a reliable option as fishing has decreased.

Community / Zone	Strategies adopted	Effectiveness of Strategies
Lupanga – Middle Shire	1. Better-off rent land in neighboring village 2. Poorer gather & sell firewood 3. Middle aged men and youth migrate to SA to find work 4. The Poorer rely on ganyu to find money for food. Women do laundry in Better-off houses, while men work in the fields 5. Seasonal employment at cotton ginnery	1. Extra land to some extent helps mitigate climate change effects as they have increased crop yield 2. Firewood is no longer very effective as most trees have been cut for charcoal & farming land. 3. When in SA they remit money. Very effective as the MK is weak so Rands can buy fertilizer & iron sheets 4. This is less effective now as casual labor opportunities are scarce 5. Jobs depend on level of cotton production which varies
Mulupha –Mulanje-Thyolo Tea Estate	1. Three HHs were fish farming 2. A few Better-off established woodlots to use & sell wood 3. Poorer do ganyu in tea estates to buy food and firewood 4. Middle aged men & youth migrate to Moz & SA for jobs 5. Beer brewing as an IGA among Better off and Average who have surplus maize needed for brewing 6. The Poorer benefit from public work projects by GoM 7. Better-off do small groceries	1. Fish farming is helping, but harvest only twice a year, mostly for food 2. Woodlot is not very effective, as land is very scarce due to tea plantations. People buy poles for houses; woodlot reduces erosion 3. Ganyu in tea estate is effective as is it reliable source of income 4. Migration is effective as the migrants send remittances 5. Beer brewing business is effective as drinking beer occurs all year round even in hungry months 6. Public works has to some extent improved livelihoods as can afford food and FISP fertilizer, but neglect own land 7. This is effective as it gives a steady income
Nkasala – Shire Highlands	1. Some Better-off farm fish 2. Established a communal woodlot with help of forestry & agriculture depts. Some Better-off & Average have own woodlots 3. Charcoal making remains a popular IGA even though there is a tree protection committee 4. The Poorer make & sell baskets from bamboos 5. Some, especially women collect and sell firewood 6. Average & Poorer people make & sell bricks	1. Fish farming has not been effective as most ponds dry up at some point 2. Woodlots are quite effective as there is a market for wood to burn brick & build/maintain houses 3. This is an effective livelihood especially for Poorer as there is a ready market at Zomba Boma 4. Basket making is to some extent effective, but affected by forest protection policy from getting bamboo from Zomba mountain 5. Firewood is no longer an effective strategy as now few trees in the area. 6. Brick making is effective to make a lot of money in a short time
Thambolagwa - Kasungu-LLW Plain	1. Beer brewing 2. Women do ganyu in Moz to buy firewood & food 3. Poorer do ganyu in Better-off gardens in hungry months 4. Bake and sell African cakes	1. Beer brewing is effective as Ngoni have beer drinking is their culture 2. Strategy is not effective, as they are abused by unfriendly locals 3. This is effective as they are paid with maize or cash, but neglect their gardens 4. People eat cakes for breakfast. This helps, but is not effective as it is rare

Source: PRAs, Kadale Consultants

The key points relating to the effectiveness of other livelihoods from the above are:

1. Business and IGA opportunities can generate income, though some are not sustained all year round and some are unsustainable in nature, such as those involving use of forestry products for firewood, charcoal, brick burning and timber,. The latter category are one of the few options for the Poorer

2. The Poorer have few other livelihood options, the most significant being ganyu. Ganyu is effective up to a point at generating immediate income or food, but the Poorer are easily exploited by those who offer work and pay/food. The strategy is not effective in the short to medium term as it results in neglect of their own gardens. This may also be a down side to doing work for food/cash under a GoM scheme

3. Establishing woodlots has multiple benefits for the communities, bringing in a source of firewood and timber, given that many now have to travel long distances to collect, but the current scale is small and the time to establish them is relatively long

4. Migration to towns, factories and outside Malawi can be effective at generating income, but this is not always remitted. The downside is that migration may become (semi-) permanent, and migrants may establish second families, while the wives left behind can also find a new husband or engage in casual prostitution for cash when needed

5. Although beer brewing is an effective business to earn income, the PRAs reported problems with drunkenness, leading to fights and indolence among those that drink. This can be a significant cause of poverty, leading to debts, neglect of livelihoods and loss of productive capacity of the persons.

3.4.4 ADAPTATION STRATEGIES – FOOD SECURITY

A variety of food security strategies were reviewed and their effectiveness determined based on the views from the PRAs. These are inter-related with livelihood strategy. Strategies already mentioned such as seeking ganyu, selling firewood etc. are not repeated.

TABLE 32. FOOD SECURITY STRATEGIES ADOPTED TO MITIGATE IMPACTS, BY COMMUNITIES

Community / Zone	Food Security Strategies	Effectiveness of Strategies
Chiluzi - Rift Valley	• Poorer reduce meals from three to two or one/day • Poorer eat wild yams • The Poorer also use maize husks to make flour for food	• Reducing meal intake helps to survive but weakens the person in the time of maximum production effort • Yams are hard to find • The flour from maize husks are very effective as they are nutritious and very cheap
Chisambamnopa – Phirilongwe Hills	• The Poorer reduce number of meals from three to two or one per day	• Reducing meals is effective as Poorer survive the hunger months, but weakens them in time of maximum production
Felo – Lower Shire	• Eat water lilies from the Shire River in a really poor season	• Not effective as very poor nutritional qualities and have made some people ill
Kawelama – Phalombe-Lake Chilwa	• The Poorer & Average mix cassava & maize flours when cooking nsima • The Poorer reduce number of meals from three to two or one per day	• Mixing maize and cassava flour is effective as it complement each other during the hunger months • Reducing meals is effective as Poorer survive the hunger months, but weakens them in time of maximum production
Liguluche – Southern Lakeshore	• The Poorer reduce meal intake from three to two or even one. • The Average and the Poorer shifted from eating communal to eating at family level	• Reducing meals is partly effective as Poorer survive hunger months, but it weakens them in time of maximum production • This is effective as they are able to regulate quantity and number of meals per day

Community / Zone	Food Security Strategies	Effectiveness of Strategies
Lupanga – Middle Shire	• Poorer and Average reduce number of meals per day. Poorer from three to one; Average from three to two • The Poorer substitute maize flour with maize husks • The Poorer gather wild roots for food	• This is quite effective as they can supplement the meal with porridge. • This is very effective as it helps to survive the hunger months. They buy maize husks at the market and make flour • Gathering tubers is not effective as they hard to find and poisonous if not cooked properly
Mulupha –Mulanje-Thyolo Tea Estate	• The Poorer reduce meals per day from three to one in hunger months • During hungry months, the Poorer and Average combine maize & dry cassava to make flour. • The Poorer and the Average people also eat cooked peeled dry cassava together with pigeon peas	• Reducing meals is partly effective as Poorer survive hunger months, but it weakens them in time of maximum production • Mixing maize and cassava flour is effective as it complement each other during the hunger months. • This is very effective as it is cheap and locally grown.
Nkasala – Shire Highlands	• The Poorer and Average shift from using maize flour for nsima to cassava flour for their meals during hunger months	• This is very effective as cassava is drought tolerant & commonly grown in the area.
Thambolagwa - Kasungu-LLW Plain	• The Poorer reduce their number of meals per day from the usual three to two or one during lean periods. • The Poorer consume chithegere plant during hungry months	• Reducing meals is partly effective as Poorer survive hunger months, but it weakens them in time of maximum production • This is quite effective as the tree is commonly found in the area. The leaves of the tree looks like the leaves of cassava plant. The leaves are used as relish during hunger months.

Source: PRAs, Kadale Consultants

The key points in relation to the effectiveness of food security strategies from the above are:

1. **One very common method is to reduce daily calorific intake**. This enables the HH to get through to the end of the hunger period, but it weakens them at the time when their production effort is greatest. Shortage of food can also contribute to and exacerbate poor health. As noted earlier, the Poorer are already the most vulnerable in relation to their health

2. A second method is to **change from maize to other foods, such as cassava, or dilute maize flour with bran or cassava flour.** These have similar calorific and nutritional content, but for Malawians it is a major psychological blow not to be able to eat maize at least once a day. The PRA found some shifting of the deeply entrenched adherence to maize

3. A third method was to **search for alternative foods, such as wild tubers/yams, wild fruits and even water lilies.** These have limited effectiveness either because they are rare and in demand by others, or have limited nutritional value or can make the person ill if not properly prepared

Overall, aside for points 1 and 2 above, the main strategies for food security are those described earlier relating to ganyu and utilization of wood from the dwindling forests.

4.0 GAPS AND POTENTIAL SOLUTIONS

The immediate foregoing sections have highlighted ways in which farmers have adapted to climate and non-climate impacts. As noted, some of these strategies are very effective, some are moderately effective and some are not at all effective. In addition, there are some impacts that have not had any adaptations by households and that remain as yet not mitigated.

This concluding section sets out the impacts that are partially and not yet mitigated ('gaps'), split by climate-related (direct and indirect) and non-climate-related, though it should be recognized that these are interlinked. This section also provides potential actions to mitigate these impacts.

TABLE 33. CLIMATE-RELATED IMPACTS THAT REQUIRE MITIGATION, ALL COMMUNITIES

Impact	Degree that it has been mitigated	Potential Actions to Mitigate
Blurred onset of the rains resulting in need to replant and late planting	• For Better-off & those Average that can afford to replant, this can be mitigated fully by replanting, but at a cost • For Poorer and those Average that cannot afford to replant, they have not been able to mitigate fully other than to switch to drought resistant crops	• Improved early warning monitoring, modeling and work at Meteorology Dept • Promote good planting practices such as the best methods to assess soil moisture ready for planting, land preparation and other key planting extension measures • Develop and promote seed insurance schemes, such as Kilimo Salama from Kenya, where farmers get an insurance policy to cover new seed and inputs if replanting conditions apply. • Further development of more drought resistant varieties of maize and other key crops • Promote drought resistant varieties and more drought resistant alternative crops to Poorer/Average HHS • Promote small-scale irrigation and appropriate water conservation measures • Develop and promote input financing schemes, though caution is required while FISP is in operation
Prolonged dry spells and drought	• These impact all wealth categories. They are not well mitigated, except for those with irrigation	• Promote drought resistant varieties and more drought resistant alternative crops to all HHS • Promote small-scale irrigation and appropriate water conservation measures • Support development of weather insurance models, such as Micro-Insurer's Dry Day insurance that is crop and area specific.

Impact	Degree that it has been mitigated	Potential Actions to Mitigate
High temperatures	• High temperatures are related to late onset & dry spells, as well as overall drought conditions. These impact all wealth categories. They are not well mitigated, except for those with irrigation. • High temperatures are associated with promoting certain crop and animal pests. These are not well mitigated, except for the Better-off that can access and pay for crop protection and veterinary services. Even then, it adds to cost of production and affects market competitiveness.	• Promote drought resistant varieties and more drought resistant alternative crops to all HHS • Promote small-scale irrigation and appropriate water conservation measures • Research into pest and disease prevention and control measures for targeted crops, particularly maize, cotton and cassava as three key livelihood crops for the Average and Poorer • Research into pest and disease prevention and control measures for targeted livestock, particularly goats, pigs and poultry as three key livelihood livestock for the Average and Poorer • Promote effective pest and disease prevention for targeted crops through the combination of government, private sector (suppliers), NGOs and farmer organizations • Promote effective pest and disease prevention for targeted livestock through the combination of government, private sector (suppliers), NGOs and farmer organizations • Fund by public-private partnerships to research and develop new drought resistant varieties and/or pest/disease resistance/treatment of the particular crops that the partnership is interested in, for example groundnuts, tea, millet, sweet potato etc. This could be via a challenge fund/bid model • Development and promotion of low cost appropriate livestock and crop insurances
Low temperatures	• Low temperatures were only reported at Thambolagwa, which is a high altitude important potato growing area. The effect of resulting more frequent frost has not been mitigate and is catastrophic to Irish potato production	• Research into more frost resistant varieties and related husbandry practices for Irish potatoes as a key livelihood crops for the Average and Poorer in selected areas prone to frost. • Development and promotion of low cost crop insurances
Excessive rainfall during the season	• High rainfall is linked to localized flooding which is particularly damaging to those with fields and housing in flood prone areas across all wealth categories. • The Better-off can often 'bounce back' due to access to resources, but the Average and Poorer often cannot do so without help	• Support for mapping of flood-prone areas and planning for relief through GoM National and District level Disaster Relief Management structures, including NGO and community partners. • Support for flood protection measures that could mitigate impacts in areas where the risk can be reduced by appropriate measures (as not all areas can be). This could include both policy and enforcement work (cultivation of riverbank, lakeshore and dambo) to get appropriate policies that can be realistically enforced. It can also include actual construction and mitigation (tree planting, localized works, improved drainage etc.) measures at community, district and national levels as appropriate.
Excessive rainfall at season end	• Excessive rainfall at season end is particularly damaging to improved varieties of maize and other maturing crops. This results in water-logging of fields. Some communities have partially mitigated via drainage action or sub-optimal early harvesting, but not effectively mitigated • Related flooding impacts are discussed in 'high rainfall during the season'	• Support consolidation of good practices on how to deal with water-logging and promotion of those good practices in areas prone to this problem through GoM and NGO extension staff • Develop and promote low cost crop insurances

Impact	Degree that it has been mitigated	Potential Actions to Mitigate
Early cessation of rains	• Early cessation of rains results in some crops, particularly traditional maize varieties not maturing properly. This is mitigated by those who use dual planting strategies or plant improved maize, but the Poorer and many of the Average cannot afford the inputs. (measures are similar to late onset).	• Improved early warning monitoring, modeling and work at Meteorology Department • Promote timely planting to maximize season length. • Further development of more drought resistant varieties of maize and other key crops • Promote drought resistant varieties and more drought resistant alternative crops to Poorer/Average HHS • Promote small-scale irrigation and appropriate water conservation measures
Destructive Winds	• Destructive winds affect all wealth groups and are not well mitigated for damage to crops	• Develop and promote low cost crop insurances

The next table sets out indirect climate-related impacts that have not been mitigated and potential actions to mitigate.

TABLE 34. INDIRECT CLIMATE IMPACTS NOT YET MITIGATED

Impact	Degree that it has been mitigated	Potential Actions to Mitigate
Higher incidence of climate related disease	• This includes malaria, diarrhea, cholera, as noted by the communities	• Support for preventative measures on sanitation, water sources and mosquito breeding in vulnerable communities • Support for improved access to basic treatments
Flooding and damage to houses	• Flooding and damage to houses and other community buildings has not been mitigated	• See measures concerning flooding under excessive rainfall during the season • Develop and promote financing and related insurances for improving, maintaining and repairing rural housing
Poorer attendance and higher dropouts by the poor, particularly girls	• Poorer attendance and higher dropouts by the poor, particularly girls is not yet mitigated to any extent.	• Support for measures to promote participation of the children of Poorer households in education, particularly girls

The final table sets out non-climate-related production impacts that have not yet been mitigated and potential actions to mitigate.

TABLE 35. NON CLIMATE-RELATED PRODUCTION IMPACTS NOT YET MITIGATED

Impact	Degree that it has been mitigated	Potential Actions to Mitigate
Volatile crop pricing	• This has not been mitigated for the key livelihood crops of maize, cotton and cassava.	• Support development of contract farming models for cotton and any other key livelihood crops identified
Access to affordable farm inputs	• Access to farm inputs has not been mitigated, and is substantially affected by effectiveness of FISP.	• Support reform of the FISP to ensure better targeting and effectiveness of delivery.
Access to markets	• Physical access to markets is problematic for many rural communities and not yet mitigated.	• Support for rural roads programs • Support establishment of more weekly/fortnightly/ monthly rural markets as has been promoted in Mozambique by Progressio
Limited alternative livelihood opportunities for the Poorer	• When production is insufficient, Poorer and Average HHs do ganyu for others, neglecting their gardens or engage in damaging harvesting of 'free' natural resources. There are few alternatives for these HHs	• Support development of rural livelihood programs for developing small-scale rural enterprises, including finance where appropriate.

MALAWI CLIMATE CHANGE VULNERABILITY ASSESSMENT: ANNEX C. CLIMATE CHANGE PROJECTIONS

African and Latin American Resilience to Climate Change (ARCC)

SEPTEMBER 2013

CONTENTS

INTRODUCTION

Please note that this annex is composed to two appendices to previous reports. Section 1.0 comprises “Appendix A: Historical Climate Summaries,” and Section 2.0 comprises “Appendix B: Future Projections.”

Appendix A:

Historic Climate Summaries

Climate Summary Report for BOLERO

Figure A.1.1: Map showing location of BOLERO observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).
Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

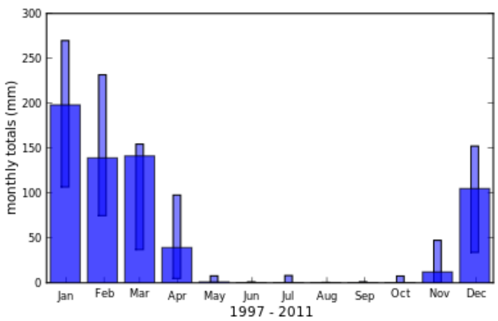

Figure A.1.2: Annual cycle of monthly rainfall (mm) for BOLERO station.

Observed seasonal mean dry spell duration

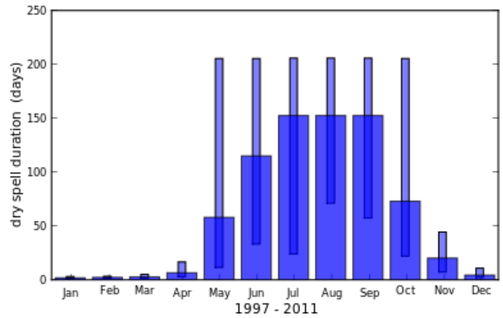

Figure A.1.3: Annual cycle of monthly mean dry spell duration for BOLERO station (> 0.3mm).

Observed seasonal mean dry spell duration

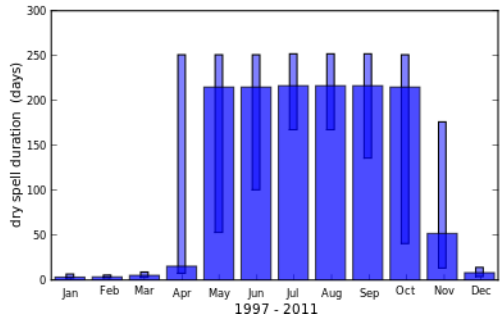

Figure A.1.4: Annual cycle of monthly mean dry spell duration for BOLERO station (> 5mm).

Observed monthly mean rain day frequency

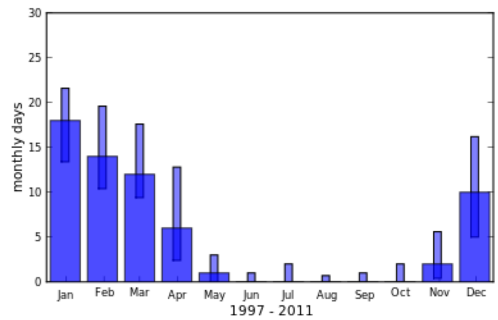

Figure A.1.5: Annual cycle of monthly rain days > 0.3 mm (days) for BOLERO station.

Observed monthly mean rain day frequency

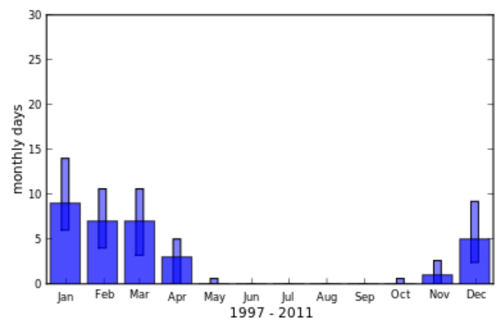

Figure A.1.6: Annual cycle of monthly rain days > 5 mm (days) for BOLERO station.

Observed monthly mean rain day frequency

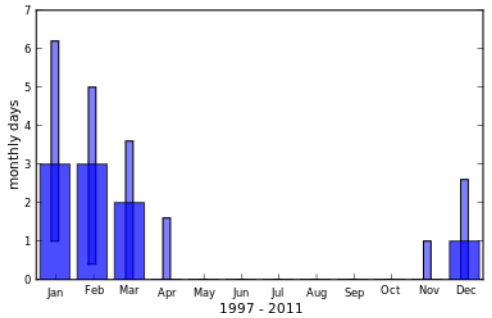

Figure A.1.7: Annual cycle of monthly rain days > 20 mm (days) for BOLERO station.

Observed monthly mean extreme rain day frequency

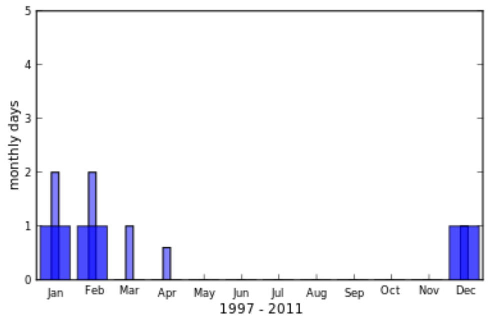

Figure A.1.8: Annual cycle of monthly rain days > 95th percentile (31.6 mm) (days) for BOLERO station.

Observed seasonal daily maximum temperatures

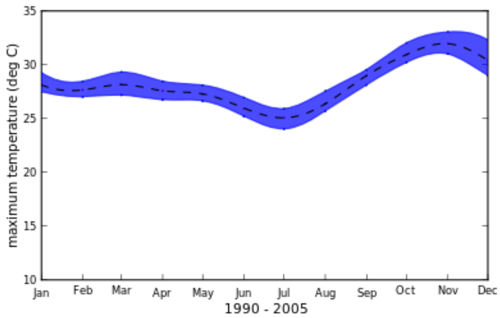

Figure A.1.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for BOLERO station.

Observed seasonal days/month exceeding 36 deg C

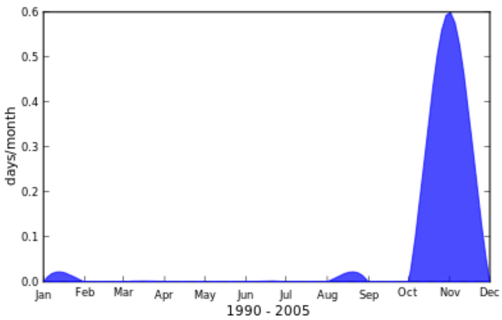

Figure A.1.10: Annual cycle days/month exceeding 36 deg C for BOLERO station.

Observed seasonal days/month exceeding 95th percentile

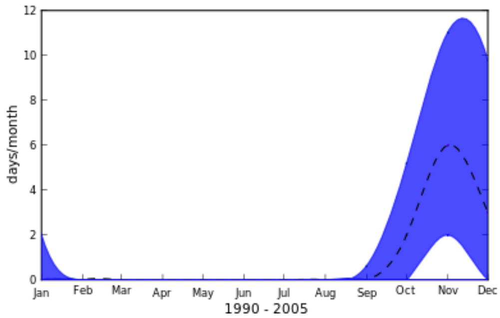

Figure A.1.11: Annual cycle days/month exceeding 33.5 deg C for BOLERO station.

Observed seasonal heat spell length

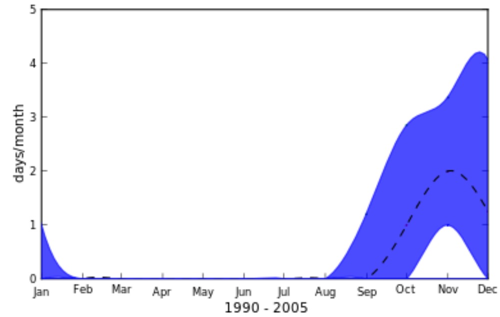

Figure A.1.12: Annual cycle of monthly mean heat spell duration (33.5 deg C) for BOLERO station.

Observed seasonal daily minimum temperatures

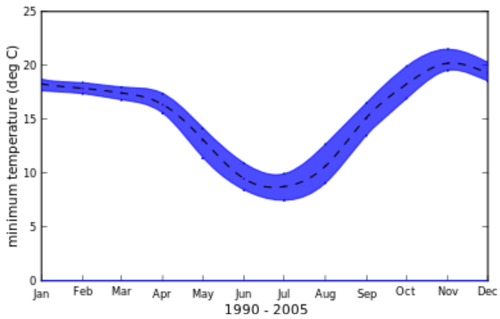

Figure A.1.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for BOLERO station.

Climate Summary Report for BVUMBWE

BVUMBWE

Figure A.2.1: Map showing location of BVUMBWE observation station

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Observed climate

Observed seasonal rainfall

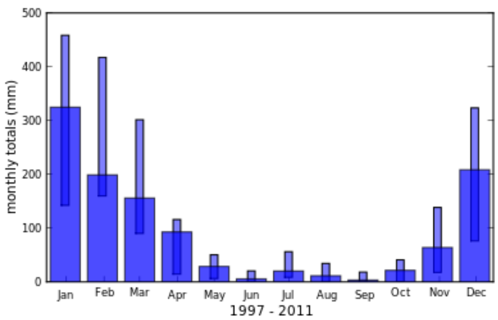

Figure A.2.2: Annual cycle of monthly rainfall (mm) for BVUMBWE station

Observed seasonal mean dry spell duration

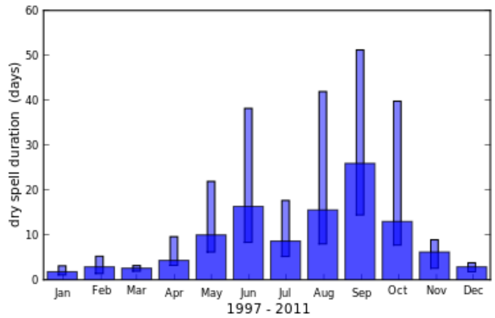

Figure A.2.3: Annual cycle of monthly mean dry spell duration for BVUMBWE station (> 0.3mm).

Observed seasonal mean dry spell duration

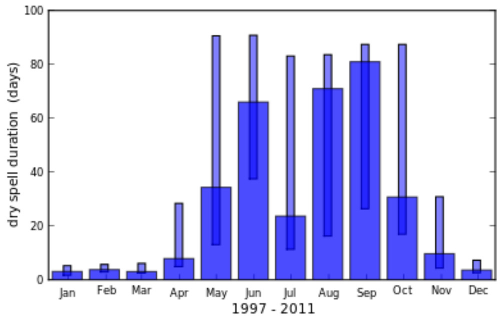

Figure A.2.4: Annual cycle of monthly mean dry spell duration for BVUMBWE station (> 5mm).

Observed monthly mean rain day frequency

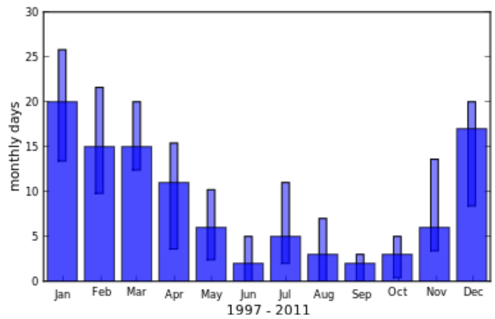

Figure A.2.5: Annual cycle of monthly rain days > 0.3 mm (days) for BVUMBWE station.

Observed monthly mean rain day frequency

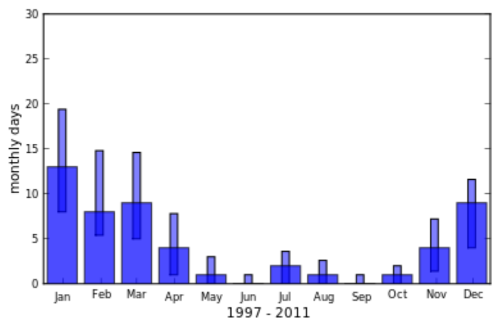

Figure A.2.6: Annual cycle of monthly rain days > 5 mm (days) for BVUMBWE station.

Observed monthly mean rain day frequency

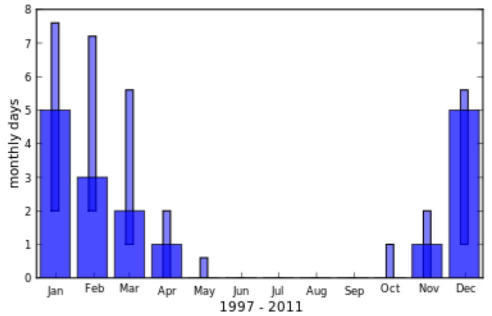

Figure A.2.7: Annual cycle of monthly rain days > 20 mm (days) for BVUMBWE station.

Observed monthly mean extreme rain day frequency

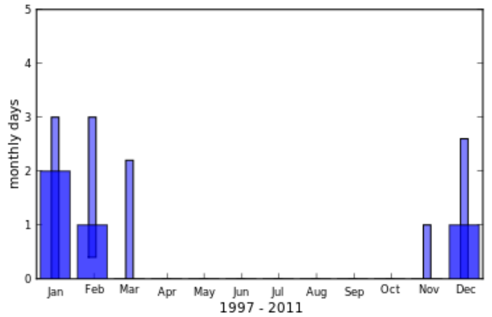

Figure A.2.8: Annual cycle of monthly rain days > 95th percentile (45 mm) (days) for BVUMBWE station.

Observed seasonal daily maximum temperatures

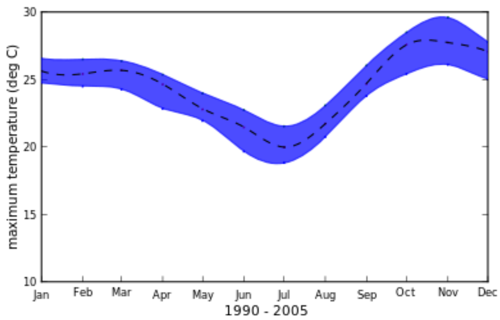

Figure A.2.9: Annual cycle of monthly mean maximum daily temperatures (degC) for BVUMBWE station.

Observed seasonal days/month exceeding 36 degC

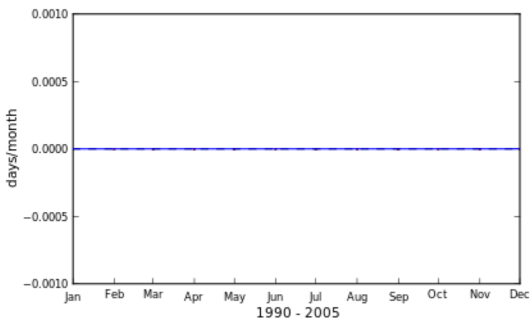

Figure A.2.10: Annual cycle days/month exceeding 36 deg C for BVUMBWE station.

Observed seasonal days/month exceeding 95th percentile

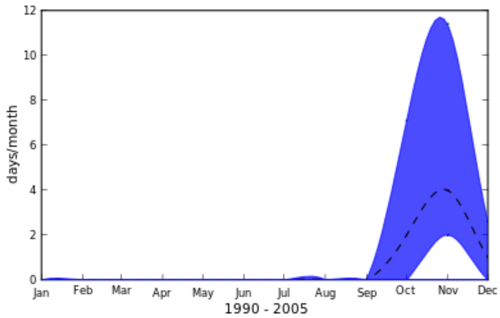

Figure A.2.11: Annual cycle days/month exceeding 31.2 deg C for BVUMBWE station.

Observed seasonal heat spell length

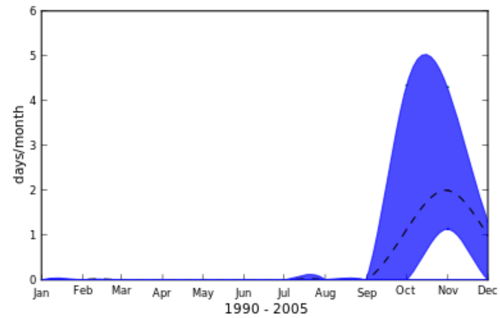

Figure A.2.12: Annual cycle of monthly mean heat spell duration (31.2 deg C) for BVUMBWE station.

Observed seasonal daily minimum temperatures

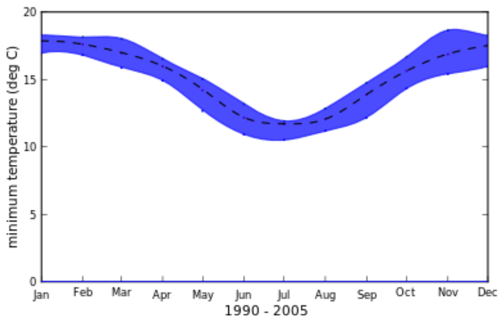

Figure A.2.13: Annual cycle of monthly mean minimum daily temperatures (degC) for BVUMBWE station.

Climate Summary Report for CHICHIRI

CHICHIRI

Figure A.3.1: Map showing location of CHICHIRI observation station

Observed climate

Observed seasonal rainfall

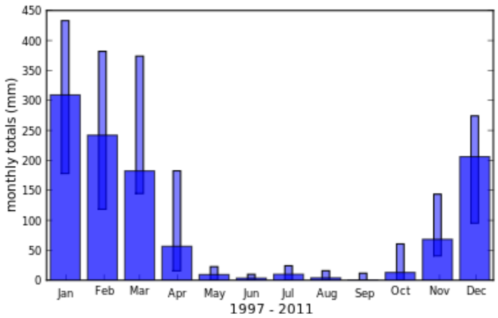

Figure A.3.2: Annual cycle of monthly rainfall (mm) for CHICHIRI station.

Observed seasonal mean dry spell duration

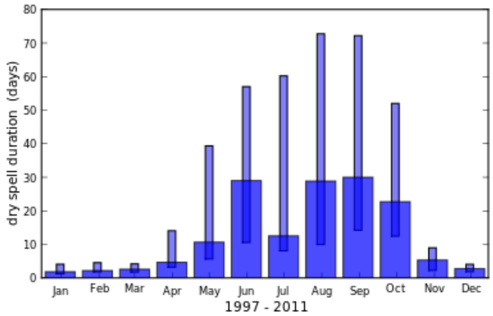

Figure A.3.3: Annual cycle of monthly mean dry spell duration for CHICHIRI station (> 0.3mm).

Observed seasonal mean dry spell duration

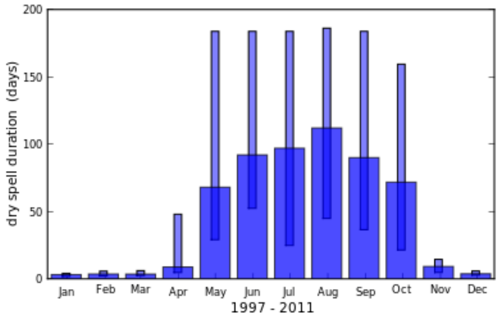

Figure A.3.4: Annual cycle of monthly mean dry spell duration for CHICHIRI station (> 5mm).

Observed monthly mean rain day frequency

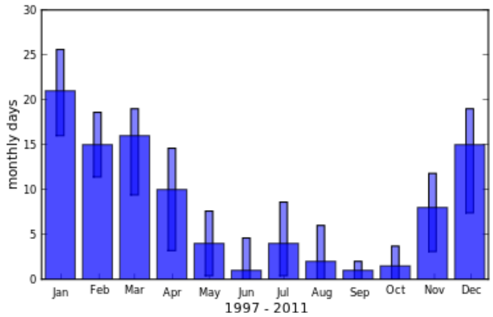

Figure A.3.5: Annual cycle of monthly rain days > 0.3 mm (days) for CHICHIRI station.

Observed monthly mean rain day frequency

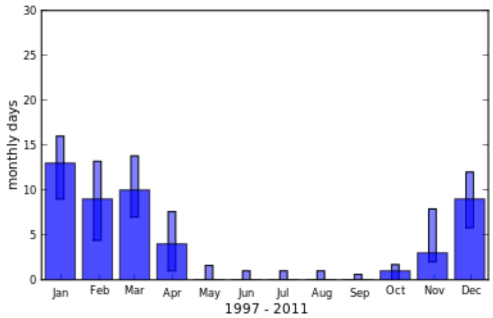

Figure A.3.6: Annual cycle of monthly rain days > 5 mm (days) for CHICHIRI station.

Observed monthly mean rain day frequency

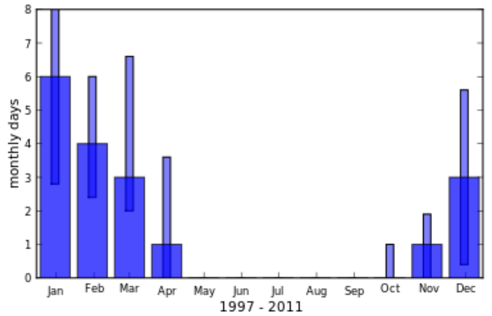

Figure A.3.7: Annual cycle of monthly rain days > 20 mm (days) for CHICHIRI station.

Observed monthly mean extreme rain day frequency

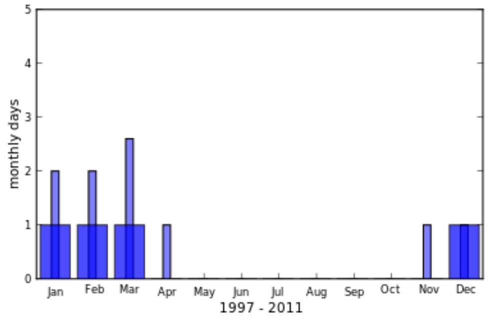

Figure A.3.8: Annual cycle of monthly rain days > 95th percentile (46 mm) (days) for CHICHIRI station.

Observed seasonal daily maximum temperatures

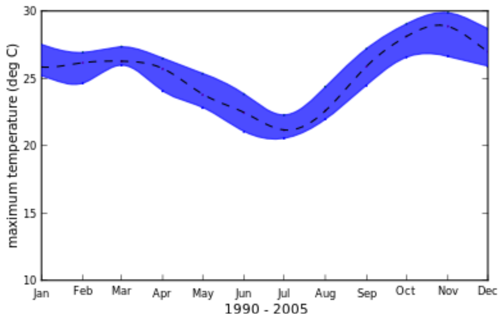

Figure A.3.9: Annual cycle of monthly mean maximum daily temperatures (degC) for CHICHIRI station.

Observed seasonal days/month exceeding 36 degC

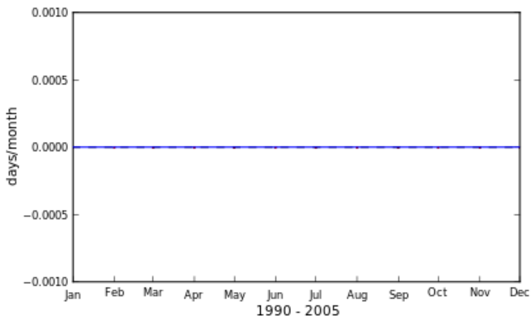

Figure A.3.10: Annual cycle days/month exceeding 36 deg C for CHICHIRI station.

Observed seasonal days/month exceeding 95th percentile

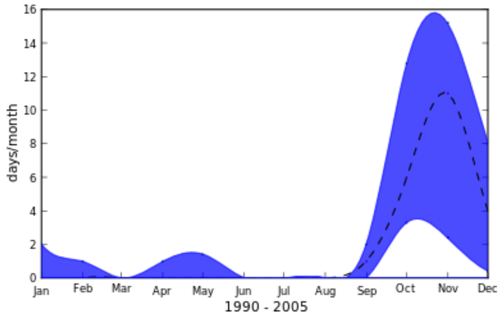

Figure A.3.11: Annual cycle days/month exceeding 30.5 deg C for CHICHIRI station.

Observed seasonal heat spell length

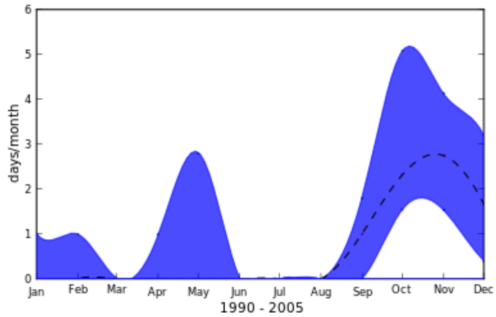

Figure A.3.12: Annual cycle of monthly mean heat spell duration (30.5 deg C) for CHICHIRI station.

Observed seasonal daily minimum temperatures

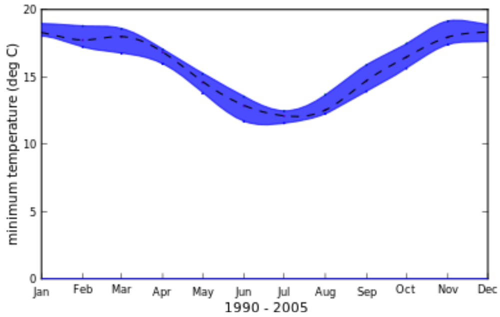

Figure A.3.13: Annual cycle of monthly mean minimum daily temperatures (degC) for CHICHIRI station.

Climate Summary Report for CHILEKA

CHILEKA

Figure A.4.1: Map showing location of CHILEKA observation station

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Observed climate

Observed seasonal rainfall

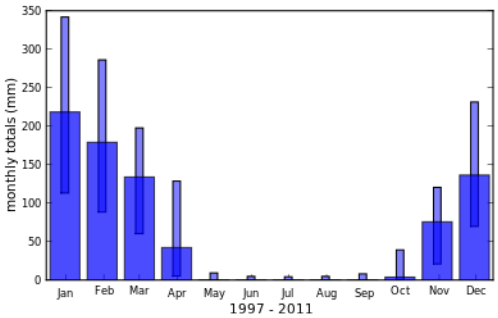

Figure A.4.2: Annual cycle of monthly rainfall (mm) for CHILEKA station.

Observed seasonal mean dry spell duration

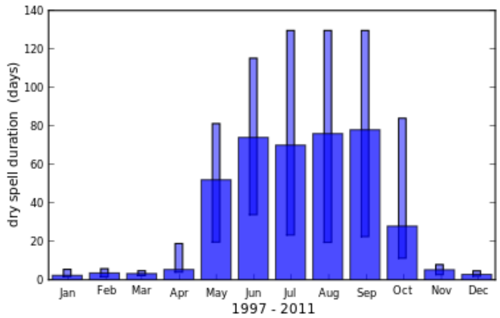

Figure A.4.3: Annual cycle of monthly mean dry spell duration for CHILEKA station (> 0.3mm).

Observed seasonal mean dry spell duration

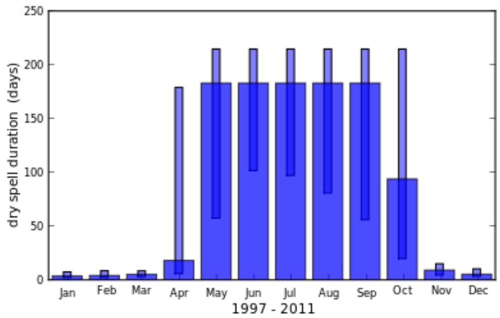

Figure A.4.4: Annual cycle of monthly mean dry spell duration for CHILEKA station (> 5mm).

Observed monthly mean rain day frequency

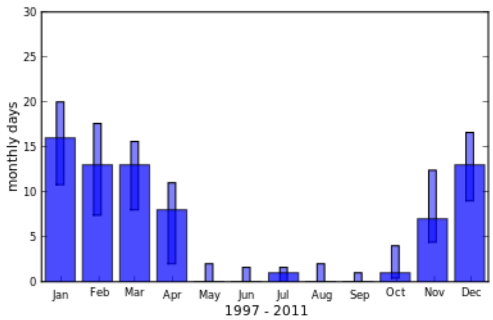

Figure A.4.5: Annual cycle of monthly rain days > 0.3 mm (days) for CHILEKA station.

Observed monthly mean rain day frequency

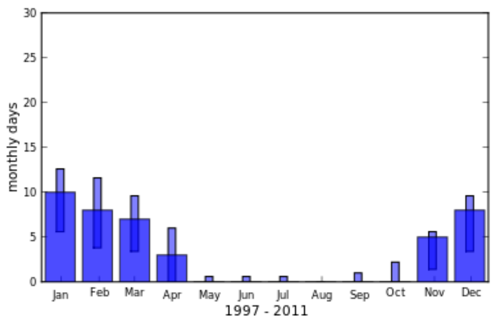

Figure A.4.6: Annual cycle of monthly rain days > 5 mm (days) for CHILEKA station.

Observed monthly mean rain day frequency

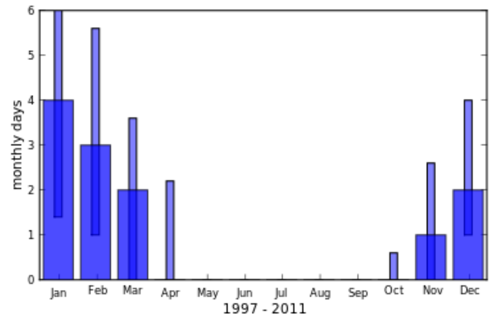

Figure A.4.7: Annual cycle of monthly rain days > 20 mm (days) for CHILEKA station.

Observed monthly mean extreme rain day frequency

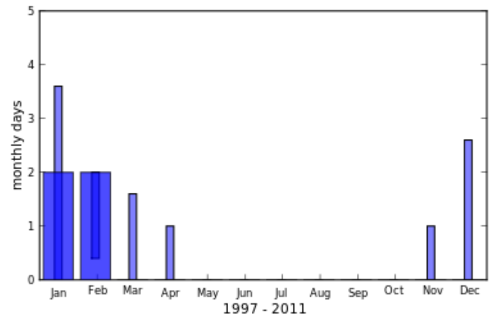

Figure A.4.8: Annual cycle of monthly rain days > 95th percentile (36.8 mm) (days) for CHILEKA station.

Observed seasonal daily maximum temperatures

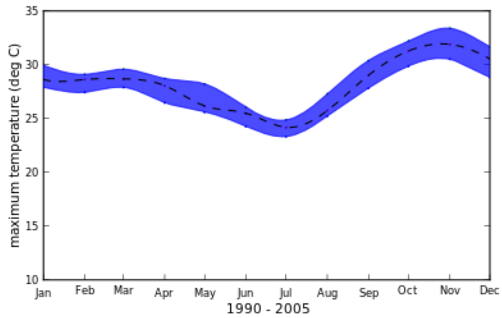

Figure A.4.9: Annual cycle of monthly mean maximum daily temperatures (degC) for CHILEKA station.

Observed seasonal days/month exceeding 36 degC

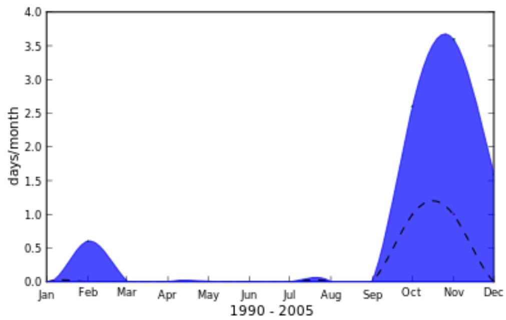

Figure A.4.10: Annual cycle days/month exceeding 36 deg C for CHILEKA station.

Observed seasonal days/month exceeding 95th percentile

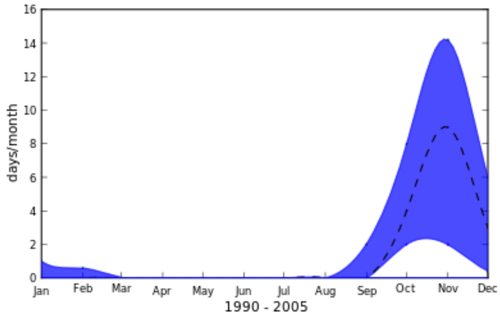

Figure A.4.11: Annual cycle days/month exceeding 34.2 deg C for CHILEKA station.

Observed seasonal heat spell length

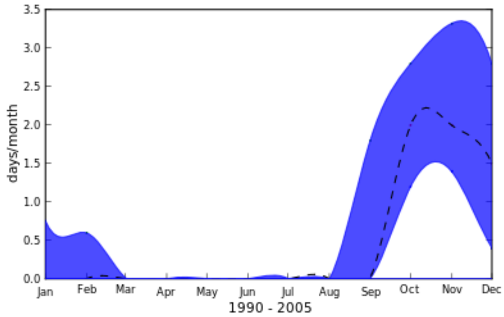

Figure A.4.12: Annual cycle of monthly mean heat spell duration (34.2 deg C) for CHILEKA station.

Observed seasonal daily minimum temperatures

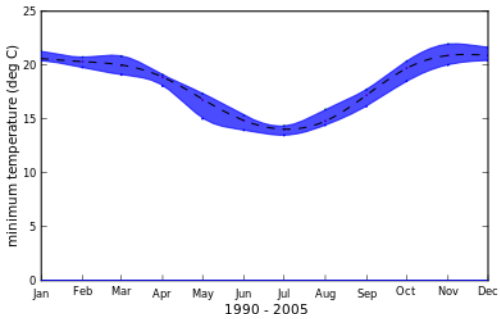

Figure A.4.13: Annual cycle of monthly mean minimum daily temperatures (degC) for CHILEKA station.

Climate Summary Report for CHITEDZE

Figure A.5.1: Map showing location of CHITEDZE observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).
Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

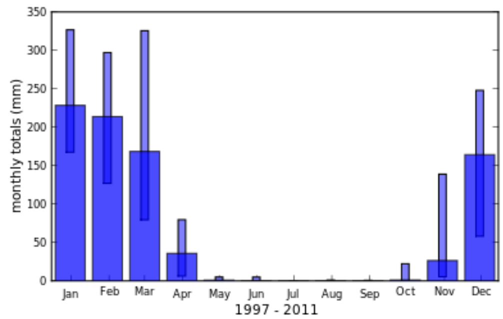

Figure A.5.2: Annual cycle of monthly rainfall (mm) for CHITEDZE station.

Observed seasonal mean dry spell duration

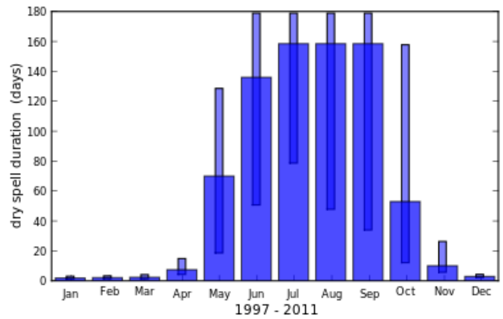

Figure A.5.3: Annual cycle of monthly mean dry spell duration for CHITEDZE station (> 0.3mm).

Observed seasonal mean dry spell duration

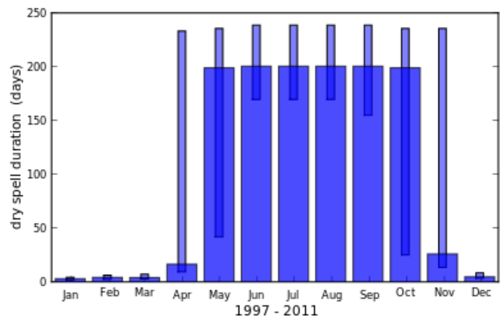

Figure A.5.4: Annual cycle of monthly mean dry spell duration for CHITEDZE station (> 5mm).

Observed monthly mean rain day frequency

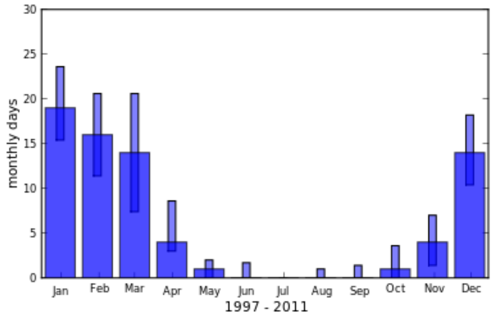

Figure A.5.5: Annual cycle of monthly rain days > 0.3 mm (days) for CHITEDZE station.

Observed monthly mean rain day frequency

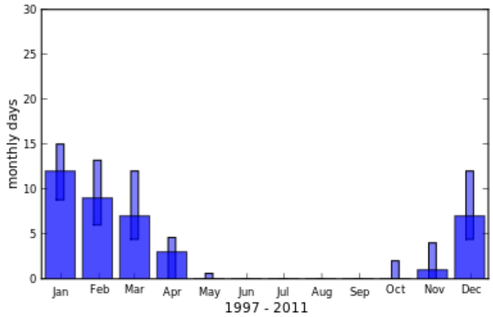

Figure A.5.6: Annual cycle of monthly rain days > 5 mm (days) for CHITEDZE station.

Observed monthly mean rain day frequency

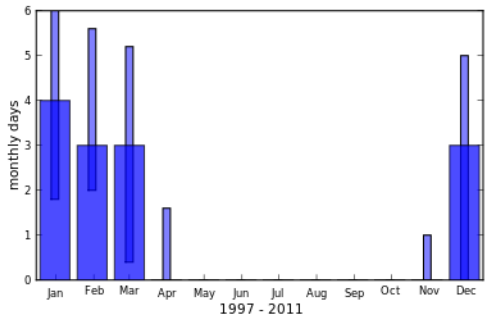

Figure A.5.7: Annual cycle of monthly rain days > 20 mm (days) for CHITEDZE station.

Observed monthly mean extreme rain day frequency

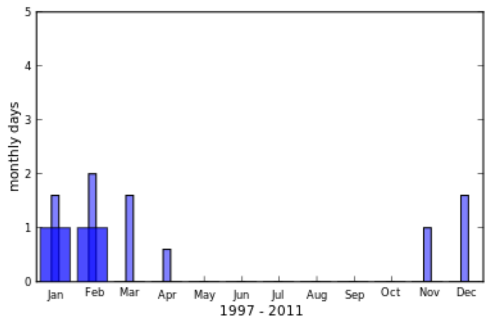

Figure A.5.8: Annual cycle of monthly rain days > 95th percentile (45.5 mm) (days) for CHITEDZE station.

Observed seasonal daily maximum temperatures

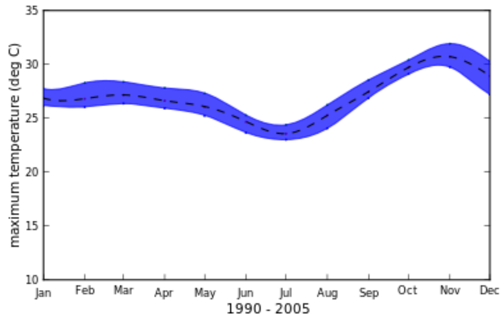

Figure A.5.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for CHITEDZE station.

Observed seasonal days/month exceeding 36 deg C

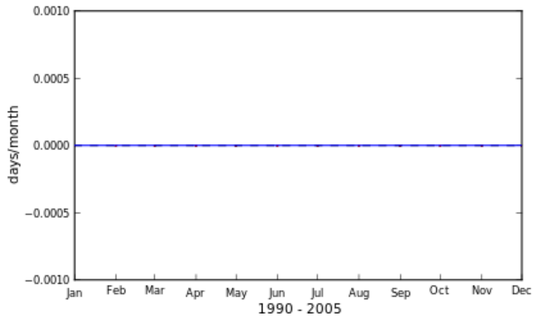

Figure A.5.10: Annual cycle days/month exceeding 36 deg C for CHITEDZE station.

Observed seasonal days/month exceeding 95th percentile

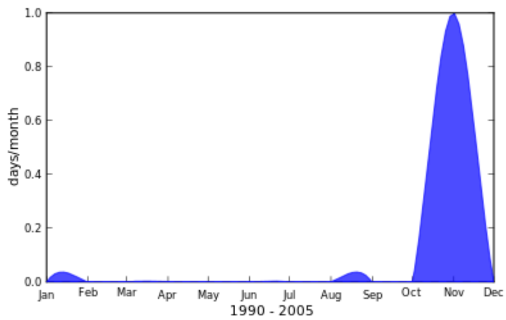

Figure A.5.11: Annual cycle days/month exceeding 34.3 deg C for CHITEDZE station.

Observed seasonal heat spell length

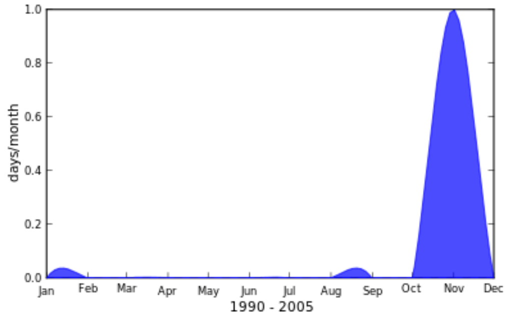

Figure A.5.12: Annual cycle of monthly mean heat spell duration (34.3 deg C) for CHITEDZE station.

Observed seasonal daily minimum temperatures

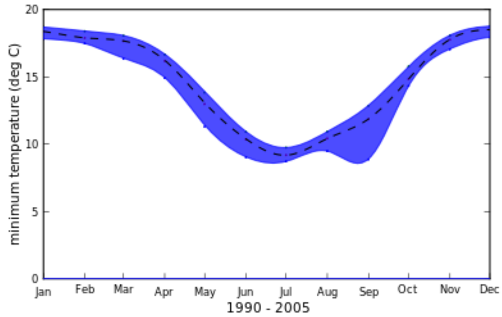

Figure A.5.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for CHITEDZE station.

Climate Summary Report for CHITIPA

Figure A.6.1: Map showing location of CHITIPA observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).
Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

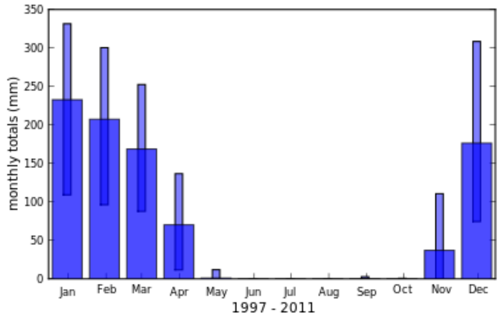

Figure A.6.2: Annual cycle of monthly rainfall (mm) for CHITIPA station.

Observed seasonal mean dry spell duration

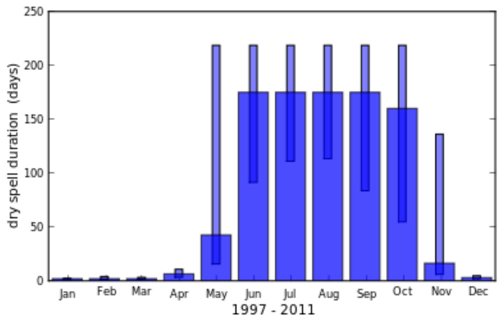

Figure A.6.3: Annual cycle of monthly mean dry spell duration for CHITIPA station (> 0.3mm).

Observed seasonal mean dry spell duration

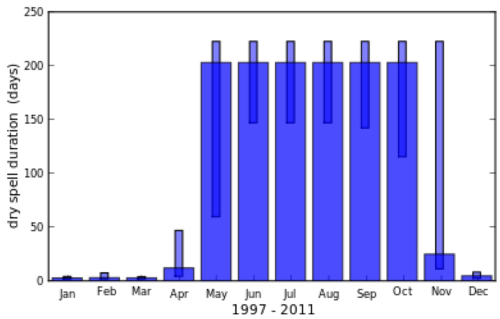

Figure A.6.4: Annual cycle of monthly mean dry spell duration for CHITIPA station (> 5mm).

Observed monthly mean rain day frequency

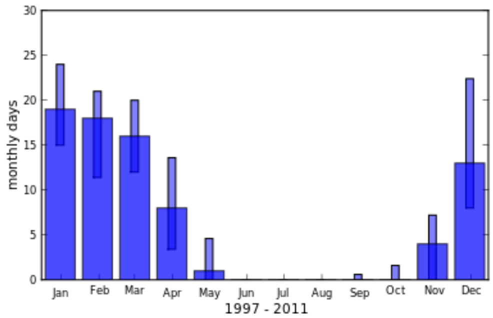

Figure A.6.5: Annual cycle of monthly rain days > 0.3 mm (days) for CHITIPA station.

Observed monthly mean rain day frequency

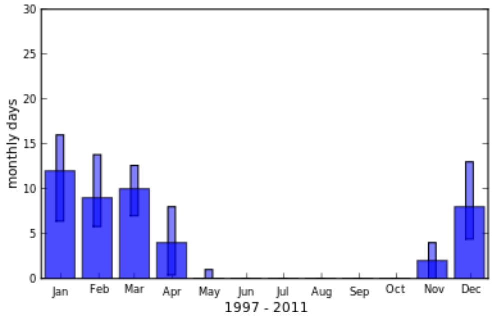

Figure A.6.6: Annual cycle of monthly rain days > 5 mm (days) for CHITIPA station.

Observed monthly mean rain day frequency

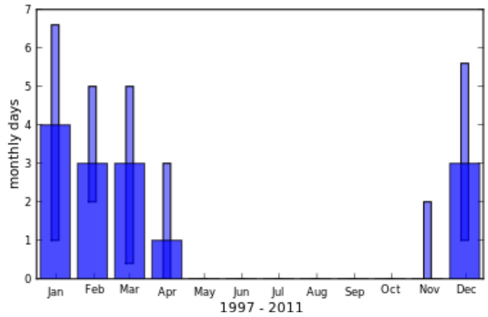

Figure A.6.7: Annual cycle of monthly rain days > 20 mm (days) for CHITIPA station.

Observed monthly mean extreme rain day frequency

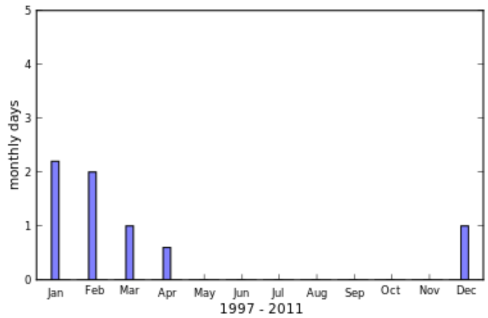

Figure A.6.8: Annual cycle of monthly rain days > 95th percentile (43.4 mm) (days) for CHITIPA station.

Observed seasonal daily maximum temperatures

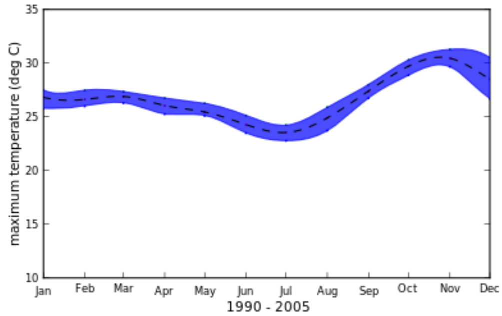

Figure A.6.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for CHITIPA station.

Observed seasonal days/month exceeding 36 deg C

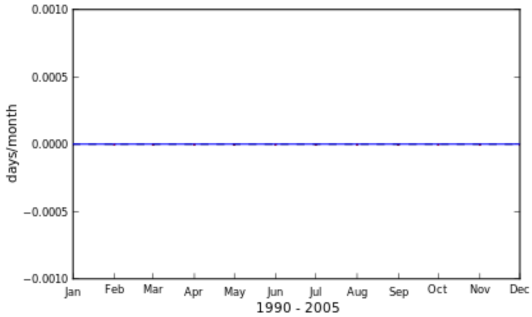

Figure A.6.10: Annual cycle days/month exceeding 36 deg C for CHITIPA station.

Observed seasonal days/month exceeding 95th percentile

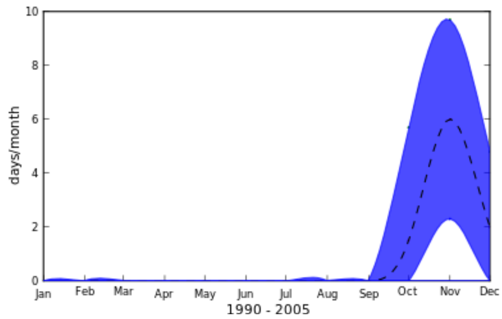

Figure A.6.11: Annual cycle days/month exceeding 31.9 deg C for CHITIPA station.

Observed seasonal heat spell length

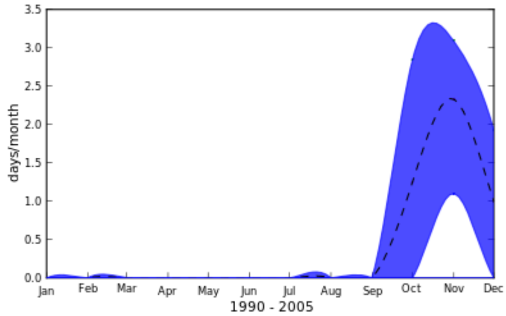

Figure A.6.12: Annual cycle of monthly mean heat spell duration (31.9 deg C) for CHITIPA station.

Observed seasonal daily minimum temperatures

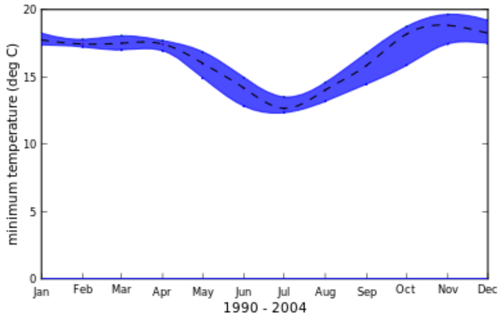

Figure A.6.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for CHITIPA station.

Climate Summary Report for DEDZA

DEDZA

Figure A.7.1: Map showing location of DEDZA observation station

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Observed climate

Observed seasonal rainfall

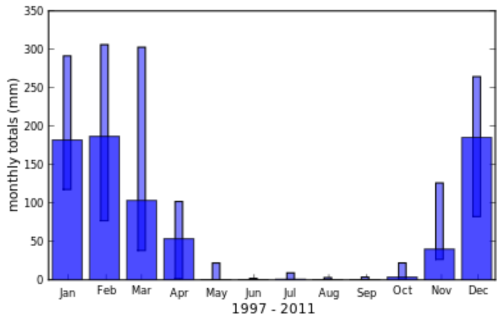

Figure A.7.2: Annual cycle of monthly rainfall (mm) for DEDZA station.

Observed seasonal mean dry spell duration

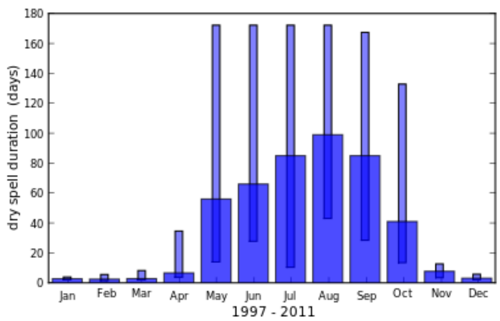

Figure A.7.3: Annual cycle of monthly mean dry spell duration for DEDZA station (> 0.3mm).

Observed seasonal mean dry spell duration

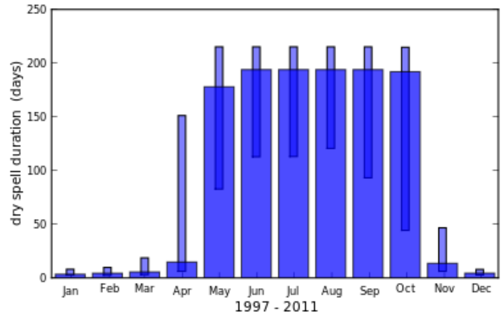

Figure A.7.4: Annual cycle of monthly mean dry spell duration for DEDZA station (> 5mm).

Observed monthly mean rain day frequency

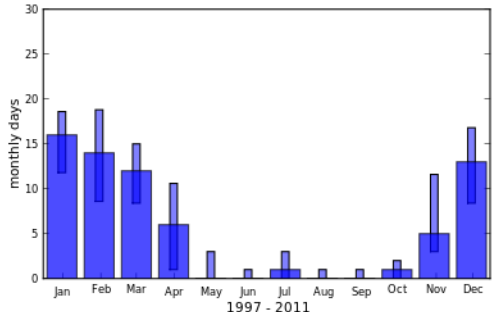

Figure A.7.5: Annual cycle of monthly rain days > 0.3 mm (days) for DEDZA station.

Observed monthly mean rain day frequency

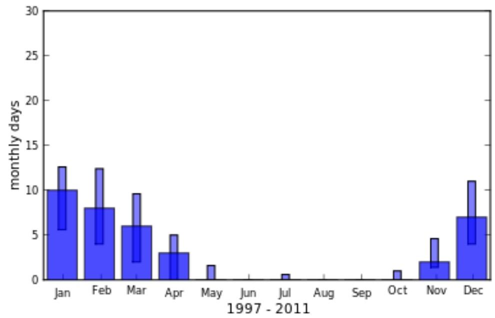

Figure A.7.6: Annual cycle of monthly rain days > 5 mm (days) for DEDZA station.

Observed monthly mean rain day frequency

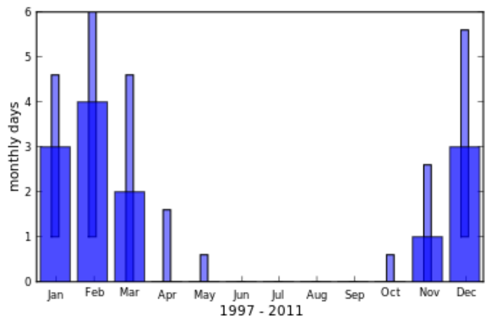

Figure A.7.7: Annual cycle of monthly rain days > 20 mm (days) for DEDZA station.

Observed monthly mean extreme rain day frequency

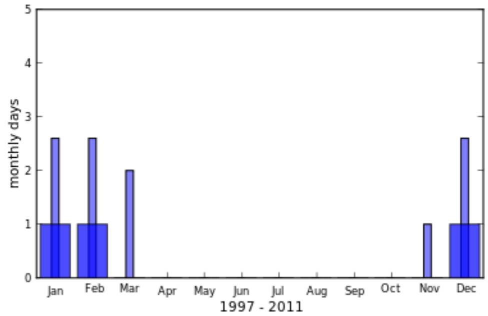

Figure A.7.8: Annual cycle of monthly rain days > 95th percentile (37.7 mm) (days) for DEDZA station.

Observed seasonal daily maximum temperatures

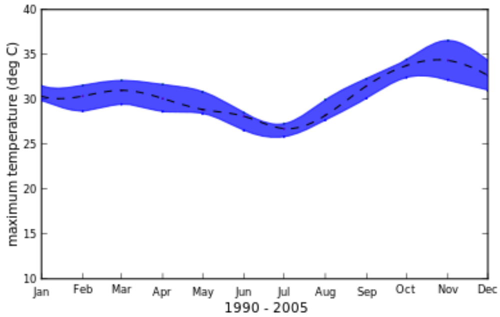

Figure A.7.9: Annual cycle of monthly mean maximum daily temperatures (degC) for DEDZA station.

Observed seasonal days/month exceeding 36 degC

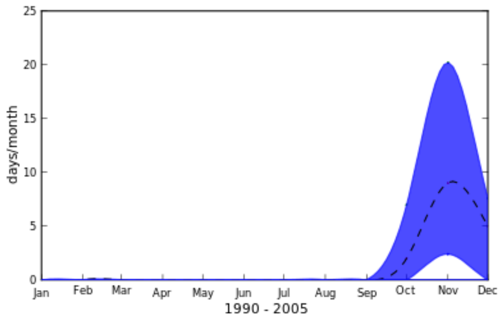

Figure A.7.10: Annual cycle days/month exceeding 36 deg C for DEDZA station.

Observed seasonal days/month exceeding 95th percentile

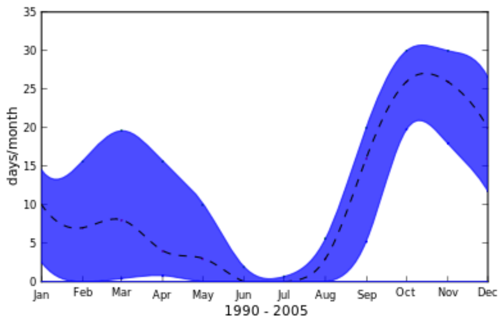

Figure A.7.11: Annual cycle days/month exceeding 31.6 deg C for DEDZA station.

Observed seasonal heat spell length

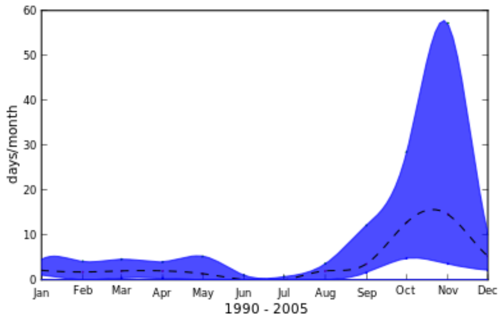

Figure A.7.12: Annual cycle of monthly mean heat spell duration (31.6 deg C) for DEDZA station.

Observed seasonal daily minimum temperatures

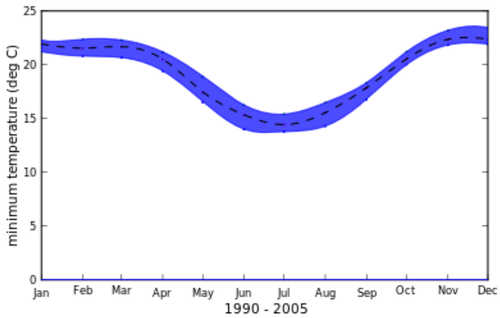

Figure A.7.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for DEDZA station.

Climate Summary Report for KARONGA

Figure A.8.1: Map showing location of KARONGA observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).
Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

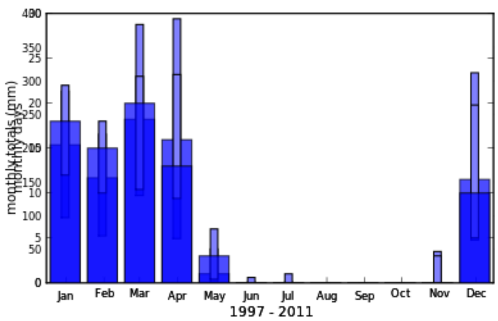

Figure A.8.2: Annual cycle of monthly rainfall (mm) for KARONGA station.

Observed seasonal mean dry spell duration

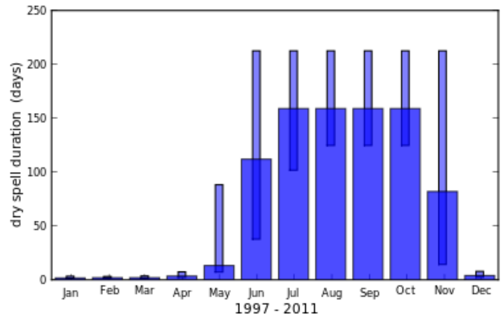

Figure A.8.3: Annual cycle of monthly mean dry spell duration for KARONGA station (> 0.3mm).

Observed seasonal mean dry spell duration

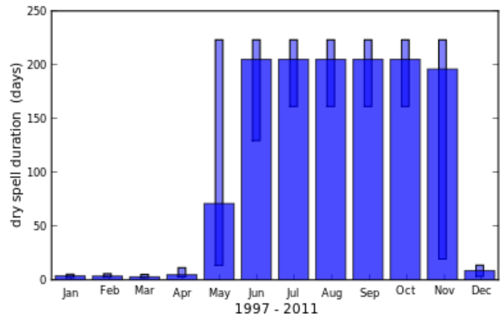

Figure A.8.4: Annual cycle of monthly mean dry spell duration for KARONGA station (> 5mm).

Observed monthly mean rain day frequency

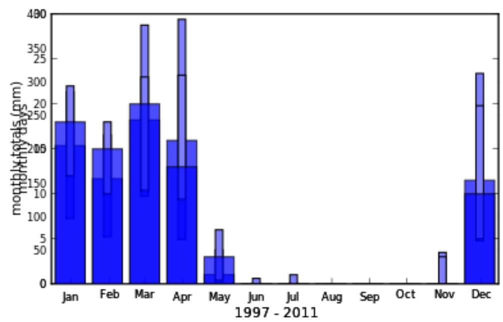

Figure A.8.5: Annual cycle of monthly rain days > 0.3 mm (days) for KARONGA station.

Observed monthly mean rain day frequency

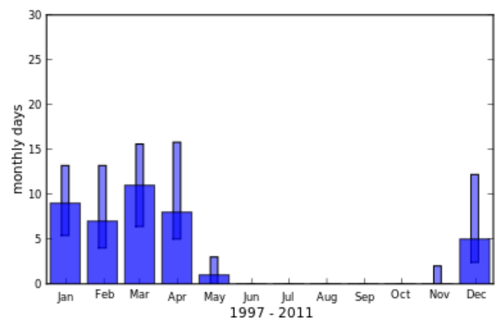

Figure A.8.6: Annual cycle of monthly rain days > 5 mm (days) for KARONGA station.

Observed monthly mean rain day frequency

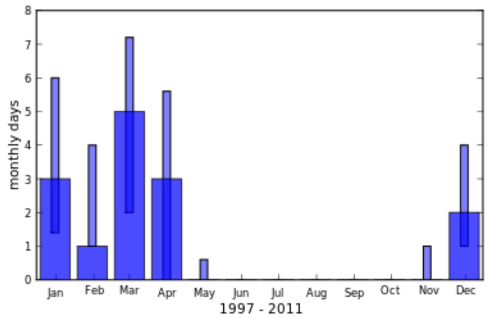

Figure A.8.7: Annual cycle of monthly rain days > 20 mm (days) for KARONGA station.

Observed monthly mean extreme rain day frequency

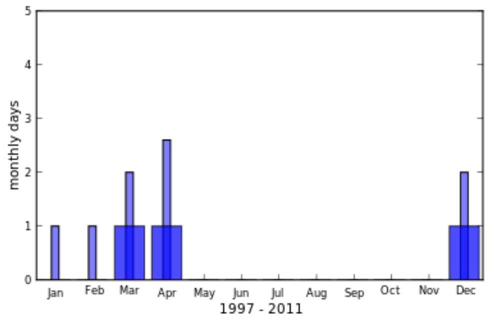

Figure A.8.8: Annual cycle of monthly rain days > 95th percentile (46 mm) (days) for KARONGA station.

Observed seasonal daily maximum temperatures

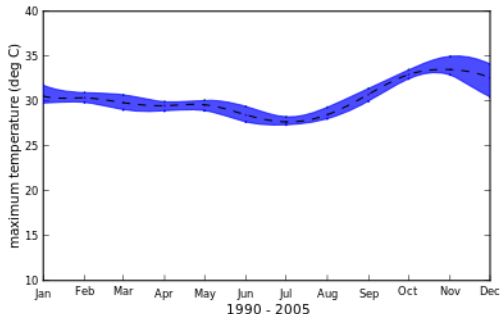

Figure A.8.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for KARONGA station.

Observed seasonal days/month exceeding 36 deg C

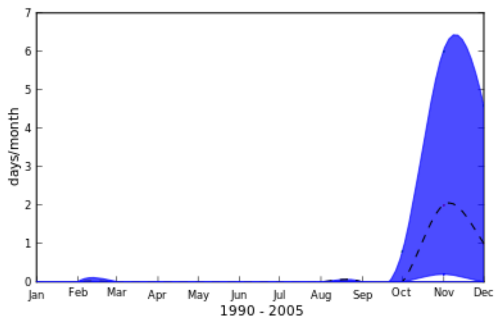

Figure A.8.10: Annual cycle days/month exceeding 36 deg C for KARONGA station.

Observed seasonal days/month exceeding 95th percentile

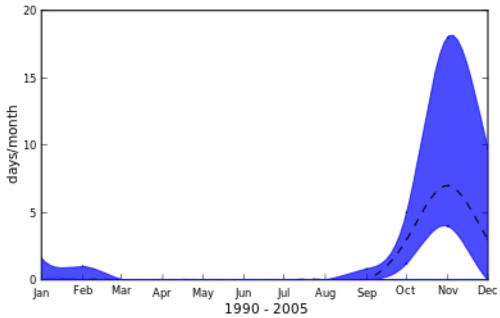

Figure A.8.11: Annual cycle days/month exceeding 34.8 deg C for KARONGA station.

Observed seasonal heat spell length

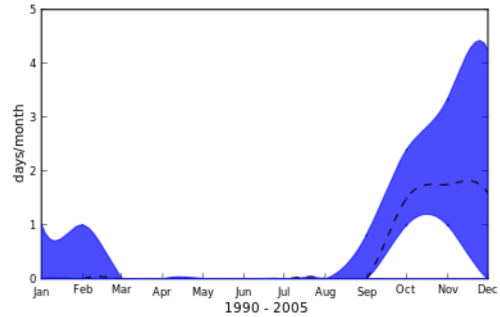

Figure A.8.12: Annual cycle of monthly mean heat spell duration (34.8 deg C) for KARONGA station.

Observed seasonal daily minimum temperatures

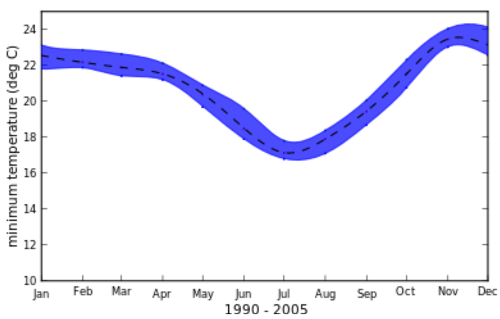

Figure A.8.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for KARONGA station.

Climate Summary Report for KASUNGU

Figure A.9.1: Map showing location of KASUNGU observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).
Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

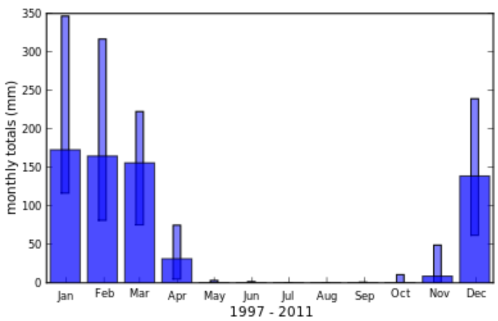

Figure A.9.2: Annual cycle of monthly rainfall (mm) for KASUNGU station.

Observed seasonal mean dry spell duration

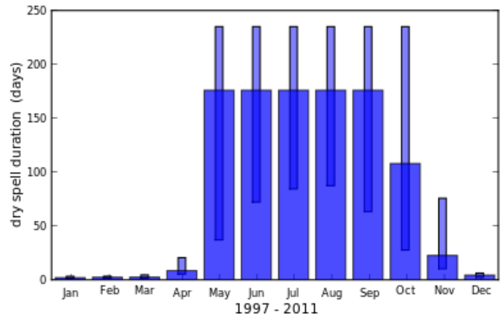

Figure A.9.3: Annual cycle of monthly mean dry spell duration for KASUNGU station (> 0.3mm).

Observed seasonal mean dry spell duration

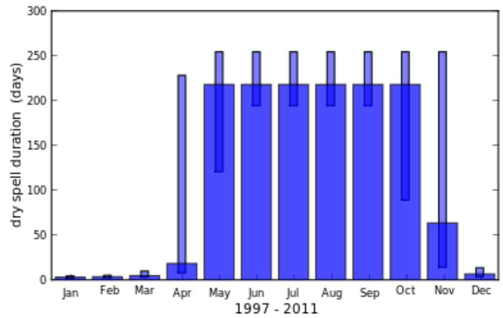

Figure A.9.4: Annual cycle of monthly mean dry spell duration for KASUNGU station (> 5mm).

Observed monthly mean rain day frequency

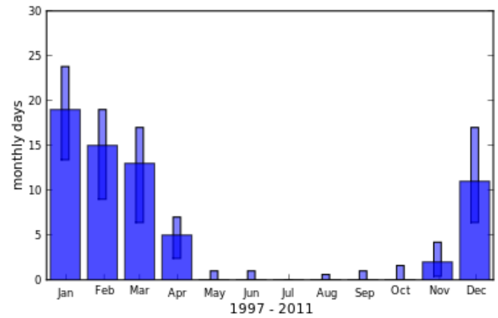

Figure A.9.5: Annual cycle of monthly rain days > 0.3 mm (days) for KASUNGU station.

Observed monthly mean rain day frequency

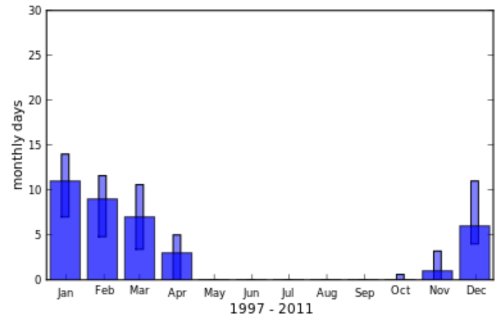

Figure A.9.6: Annual cycle of monthly rain days > 5 mm (days) for KASUNGU station.

Observed monthly mean rain day frequency

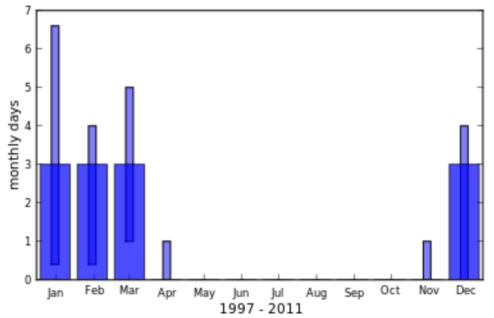

Figure A.9.7: Annual cycle of monthly rain days > 20 mm (days) for KASUNGU station.

Observed monthly mean extreme rain day frequency

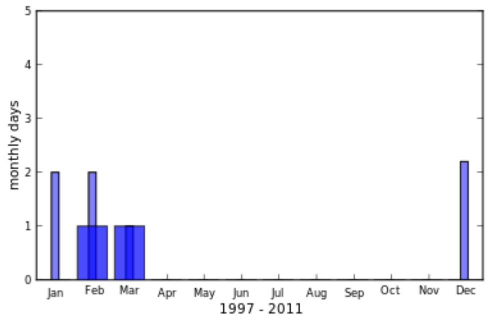

Figure A.9.8: Annual cycle of monthly rain days > 95th percentile (40 mm) (days) for KASUNGU station.

Observed seasonal daily maximum temperatures

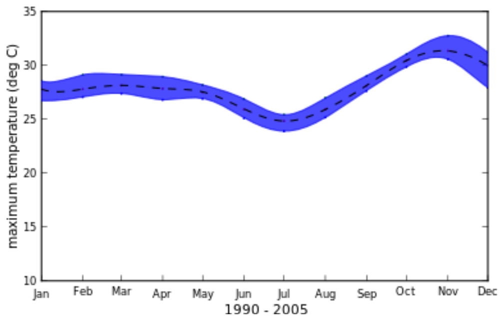

Figure A.9.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for KASUNGU station.

Observed seasonal days/month exceeding 36 deg C

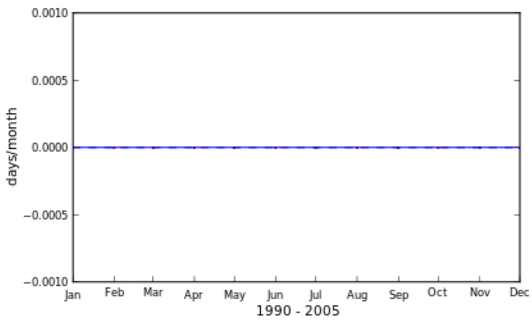

Figure A.9.10: Annual cycle days/month exceeding 36 deg C for KASUNGU station.

Observed seasonal days/month exceeding 95th percentile

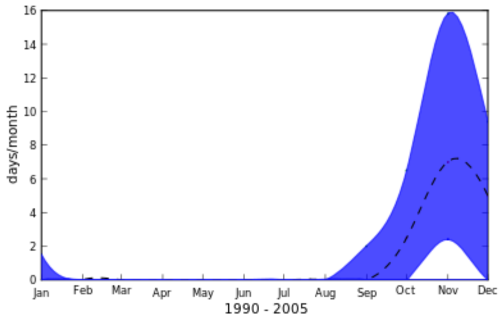

Figure A.9.11: Annual cycle days/month exceeding 32.6 deg C for KASUNGU station.

Observed seasonal heat spell length

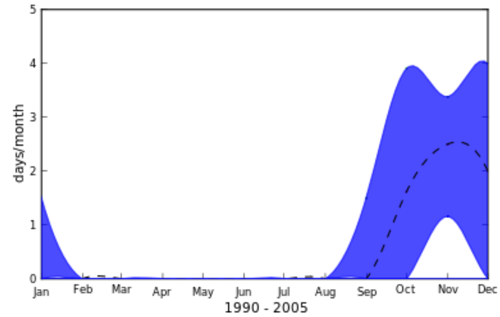

Figure A.9.12: Annual cycle of monthly mean heat spell duration (32.6 deg C) for KASUNGU station.

Observed seasonal daily minimum temperatures

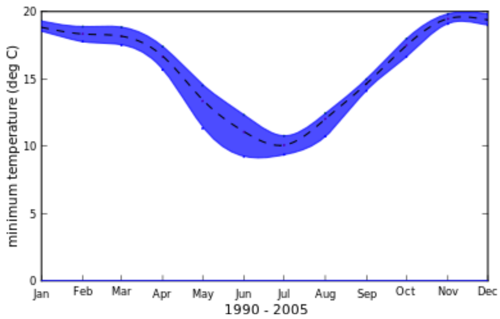

Figure A.9.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for KASUNGU station.

Climate Summary Report for KIA

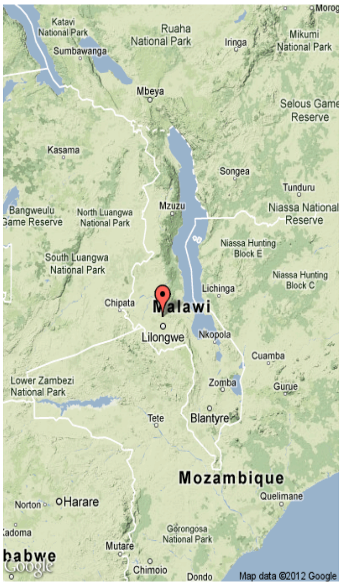

Figure A.10.1: Map showing location of KIA observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).
Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

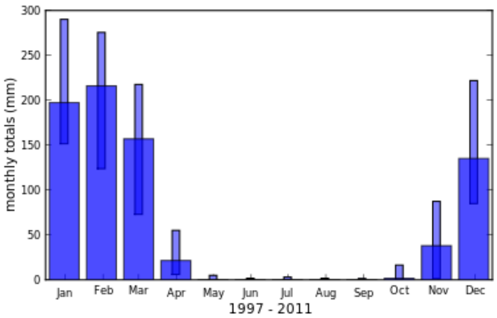

Figure A.10.2: Annual cycle of monthly rainfall (mm) for KIA station.

Observed seasonal mean dry spell duration

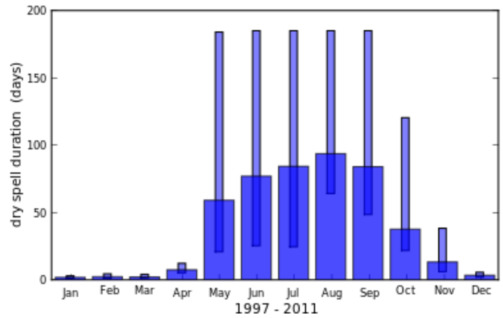

Figure A.10.3: Annual cycle of monthly mean dry spell duration for KIA station (> 0.3mm).

Observed seasonal mean dry spell duration

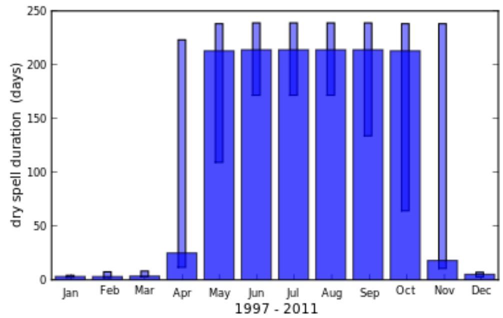

Figure A.10.4: Annual cycle of monthly mean dry spell duration for KIA station (> 5mm).

Observed monthly mean rain day frequency

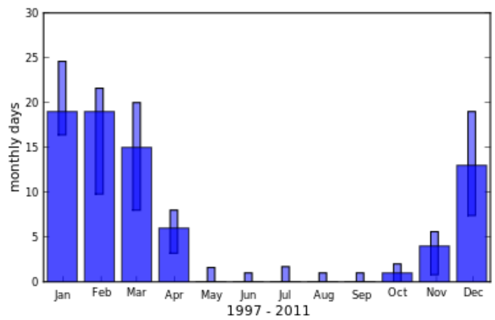

Figure A.10.5: Annual cycle of monthly rain days > 0.3 mm (days) for KIA station.

Observed monthly mean rain day frequency

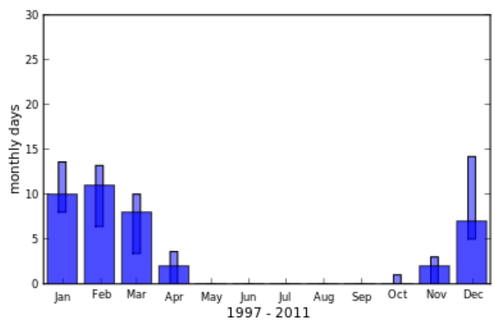

Figure A.10.6: Annual cycle of monthly rain days > 5 mm (days) for KIA station.

Observed monthly mean rain day frequency

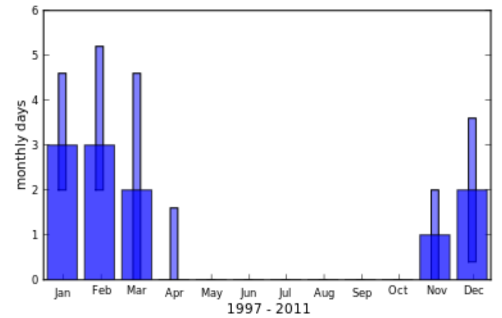

Figure A.10.7: Annual cycle of monthly rain days > 20 mm (days) for KIA station.

Observed monthly mean extreme rain day frequency

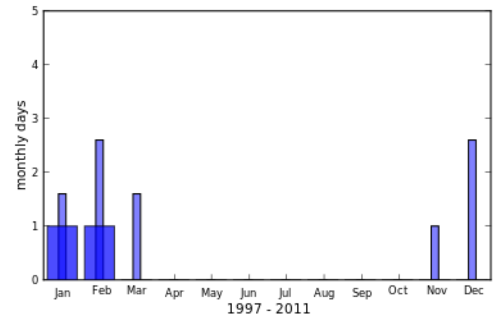

Figure A.10.8: Annual cycle of monthly rain days > 95th percentile (36.8 mm) (days) for KIA station.

Observed seasonal daily maximum temperatures

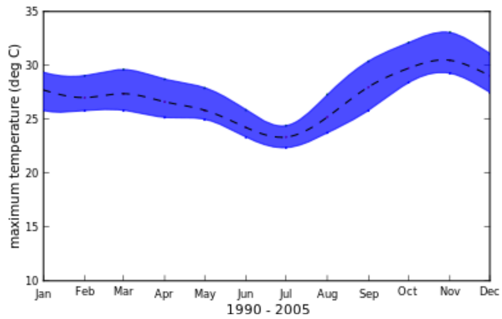

Figure A.10.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for KIA station.

Observed seasonal days/month exceeding 36 deg C

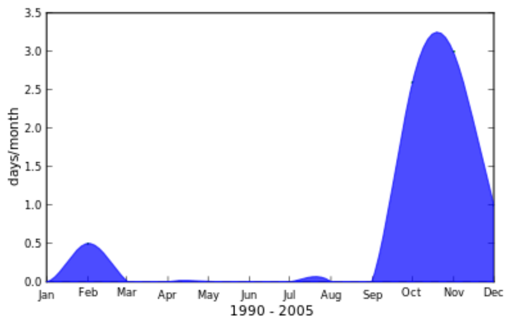

Figure A.10.10: Annual cycle days/month exceeding 36 deg C for KIA station.

Observed seasonal days/month exceeding 95th percentile

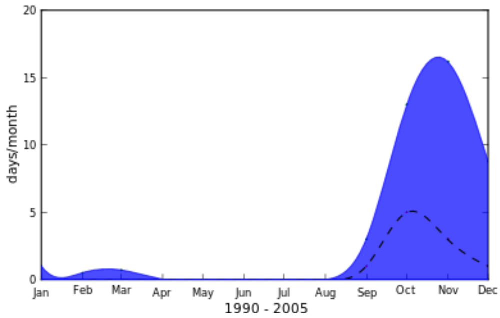

Figure A.10.11: Annual cycle days/month exceeding 33.4 deg C for KIA station.

Observed seasonal heat spell length

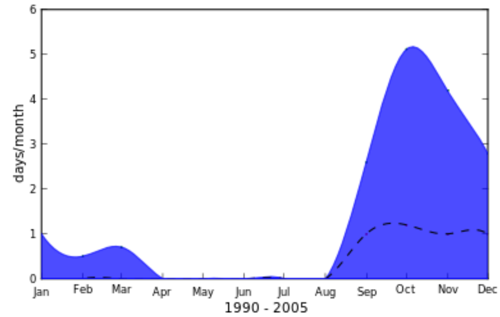

Figure A.10.12: Annual cycle of monthly mean heat spell duration (33.4 deg C) for KIA station.

Observed seasonal daily minimum temperatures

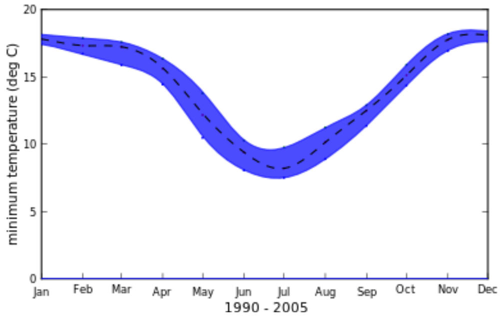

Figure A.10.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for KIA station.

Climate Summary Report for MAKOKA

MAKOKA

Figure A.11.1: Map showing location of MAKOKA observation station

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Observed climate

Observed seasonal rainfall

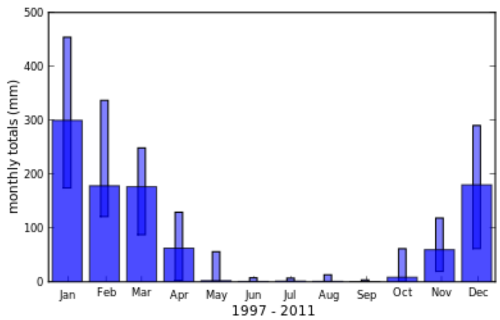

Figure A.11.2: Annual cycle of monthly rainfall (mm) for MAKOKA station.

Observed seasonal mean dry spell duration

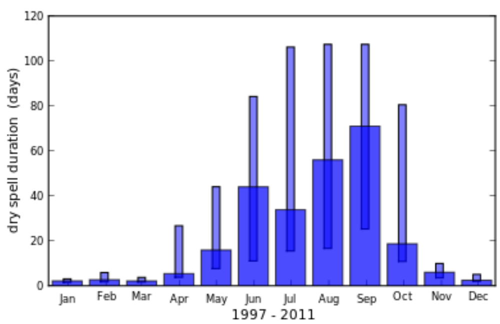

Figure A.11.3: Annual cycle of monthly mean dry spell duration for MAKOKA station (> 0.3mm).

Observed seasonal mean dry spell duration

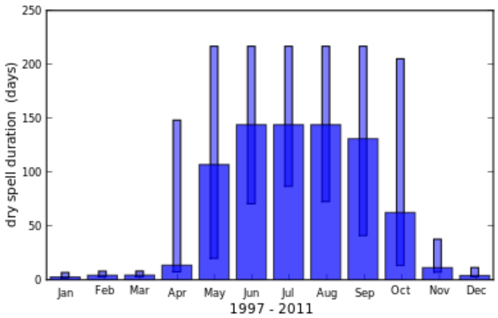

Figure A.11.4: Annual cycle of monthly mean dry spell duration for MAKOKA station (> 5mm).

Observed monthly mean rain day frequency

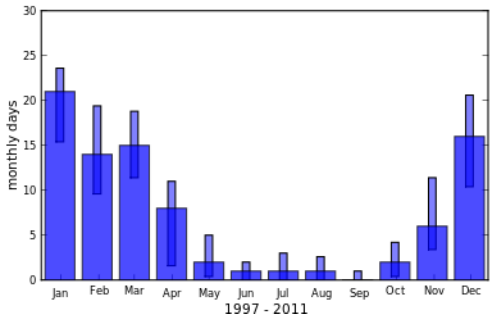

Figure A.11.5: Annual cycle of monthly rain days > 0.3 mm (days) for MAKOKA station.

Observed monthly mean rain day frequency

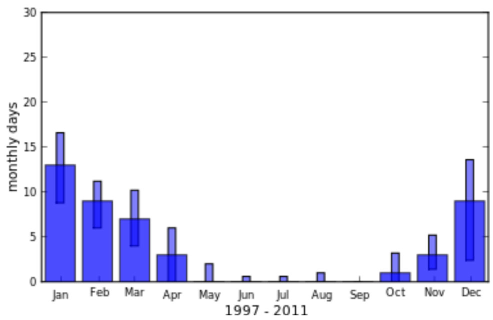

Figure A.11.6: Annual cycle of monthly rain days > 5 mm (days) for MAKOKA station.

Observed monthly mean rain day frequency

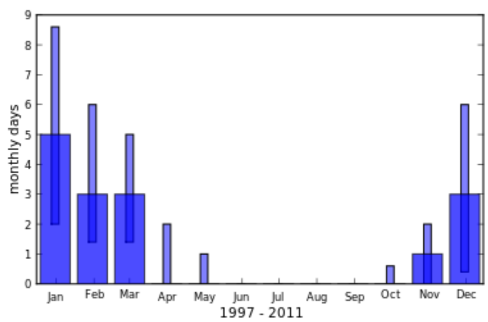

Figure A.11.7: Annual cycle of monthly rain days > 20 mm (days) for MAKOKA station.

Observed monthly mean extreme rain day frequency

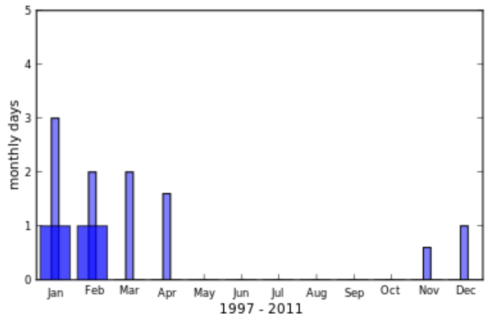

Figure A.11.8: Annual cycle of monthly rain days > 95th percentile (44.7 mm) (days) for MAKOKA station.

Observed seasonal daily maximum temperatures

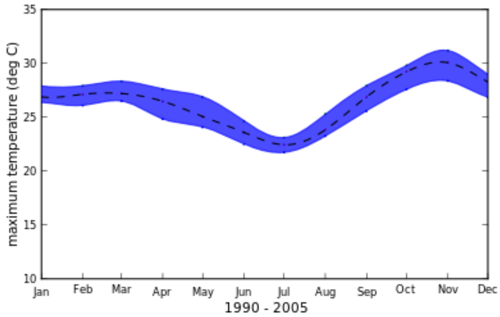

Figure A.11.9: Annual cycle of monthly mean maximum daily temperatures (degC) for MAKOKA station.

Observed seasonal days/month exceeding 36 degC

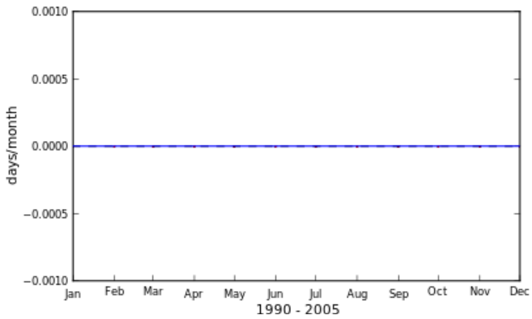

Figure A.11.10: Annual cycle days/month exceeding 36 deg C for MAKOKA station.

Observed seasonal days/month exceeding 95th percentile

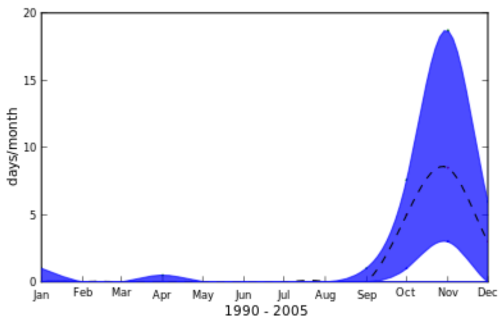

Figure A.11.11: Annual cycle days/month exceeding 31.5 deg C for MAKOKA station.

Observed seasonal heat spell length

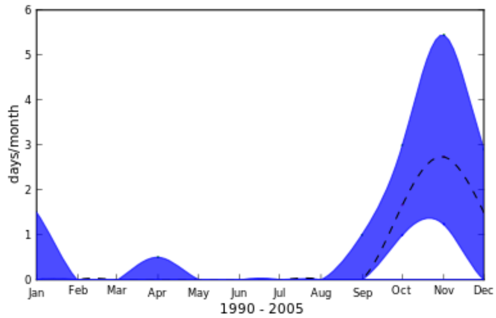

Figure A.11.12: Annual cycle of monthly mean heat spell duration (31.5 deg C) for MAKOKA station.

Observed seasonal daily minimum temperatures

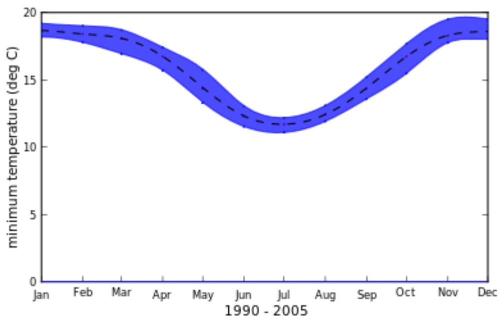

Figure A.11.13: Annual cycle of monthly mean minimum daily temperatures (degC) for MAKOKA station.

Climate Summary Report for MANGOCHI

MANGOCHI

Figure A.12.1: Map showing location of MANGOCHI observation station

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Observed climate

Observed seasonal rainfall

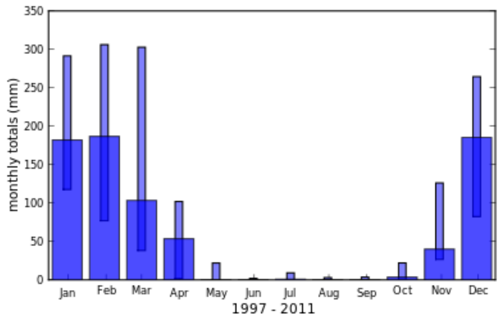

Figure A.12.2: Annual cycle of monthly rainfall (mm) for MANGOCHI station.

Observed seasonal mean dry spell duration

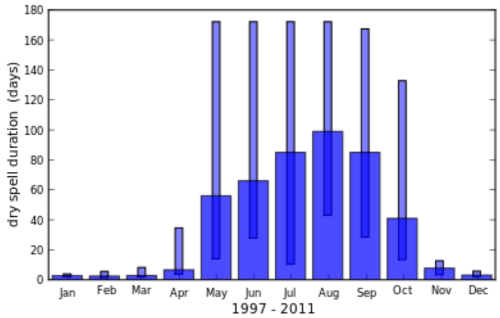

Figure A.12.3: Annual cycle of monthly mean dry spell duration for MANGOCHI station (> 0.3mm).

Observed seasonal mean dry spell duration

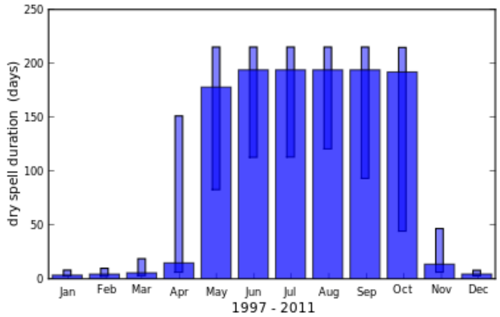

Figure A.12.4: Annual cycle of monthly mean dry spell duration for MANGOCHI station (> 5mm).

Observed monthly mean rain day frequency

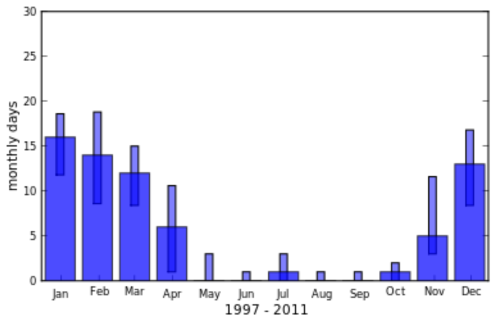

Figure A.12.5: Annual cycle of monthly rain days > 0.3 mm (days) for MANGOCHI station.

Observed monthly mean rain day frequency

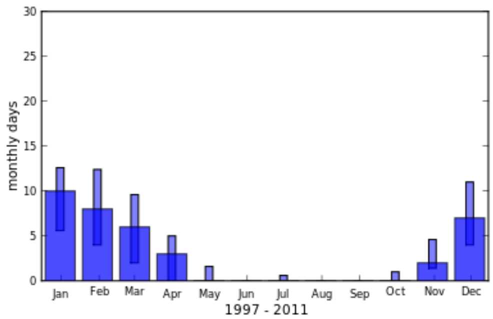

Figure A.12.6: Annual cycle of monthly rain days > 5 mm (days) for MANGOCHI station.

Observed monthly mean rain day frequency

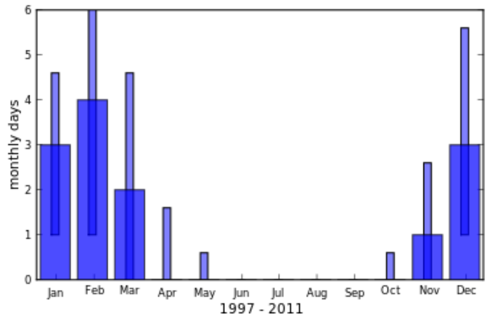

Figure A.12.7: Annual cycle of monthly rain days > 20 mm (days) for MANGOCHI station.

Observed monthly mean extreme rain day frequency

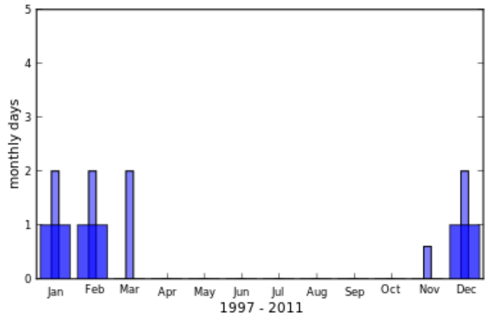

Figure A.12.8: Annual cycle of monthly rain days > 95th percentile (41.7 mm) (days) for MANGOCHI station.

Observed seasonal daily maximum temperatures

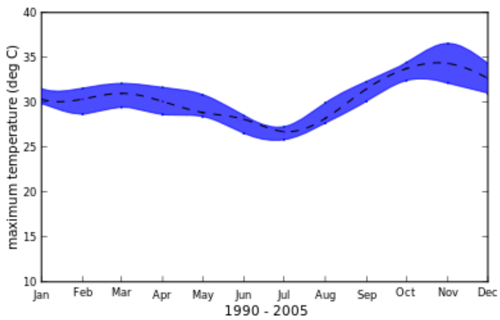

Figure A.12.9: Annual cycle of monthly mean maximum daily temperatures (degC) for MANGOCHI station.

Observed seasonal days/month exceeding 36 degC

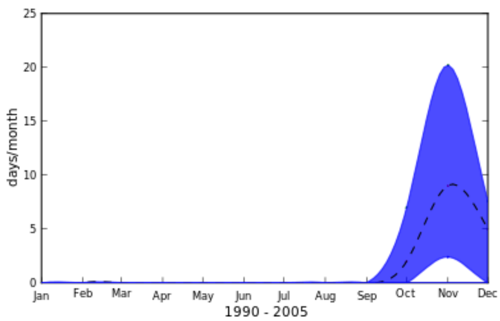

Figure A.12.10: Annual cycle days/month exceeding 36 deg C for MANGOCHI station.

Observed seasonal days/month exceeding 95th percentile

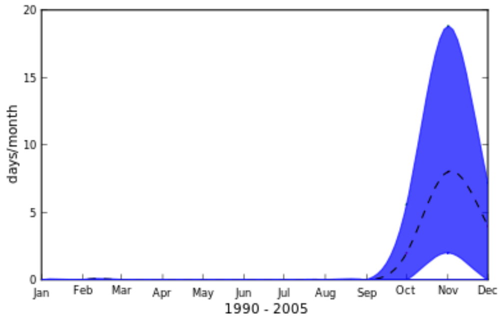

Figure A.12.11: Annual cycle days/month exceeding 36.3 deg C for MANGOCHI station.

Observed seasonal heat spell length

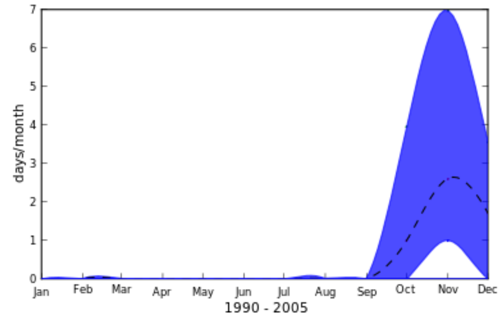

Figure A.12.12: Annual cycle of monthly mean heat spell duration (36.3 deg C) for MANGOCHI station.

Observed seasonal daily minimum temperatures

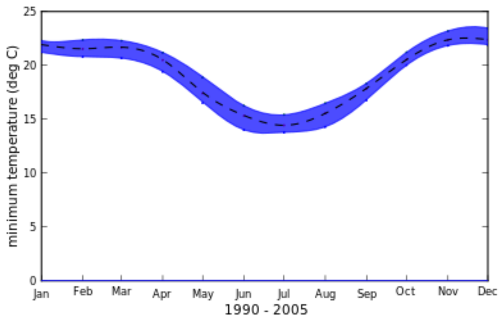

Figure A.12.13: Annual cycle of monthly mean minimum daily temperatures (degC) for MANGOCHI station.

Climate Summary Report for MONKEYBAY

Figure A.14.1: Map showing location of MONKEYBAY observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).

Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

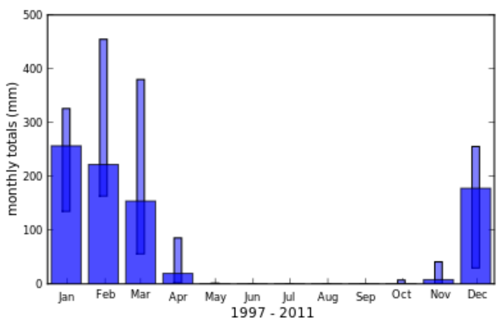

Figure A.14.2: Annual cycle of monthly rainfall (mm) for MONKEYBAY station.

Observed seasonal mean dry spell duration

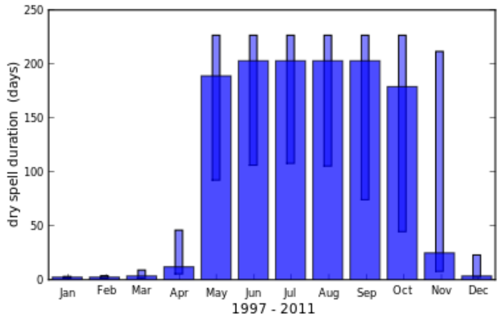

Figure A.14.3: Annual cycle of monthly mean dry spell duration for MONKEYBAY station (> 0.3mm).

Observed seasonal mean dry spell duration

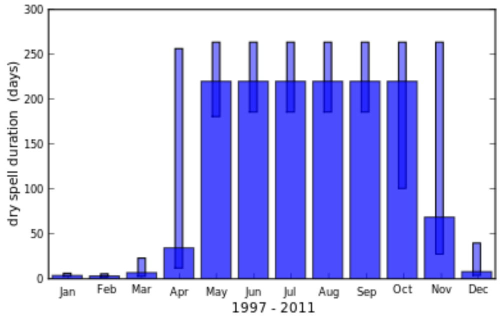

Figure A.14.4: Annual cycle of monthly mean dry spell duration for MONKEYBAY station (> 5mm).

Observed monthly mean rain day frequency

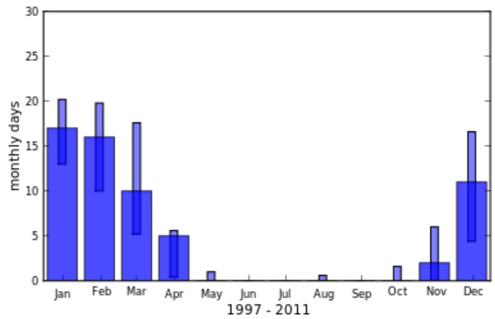

Figure A.14.5: Annual cycle of monthly rain days > 0.3 mm (days) for MONKEYBAY station.

Observed monthly mean rain day frequency

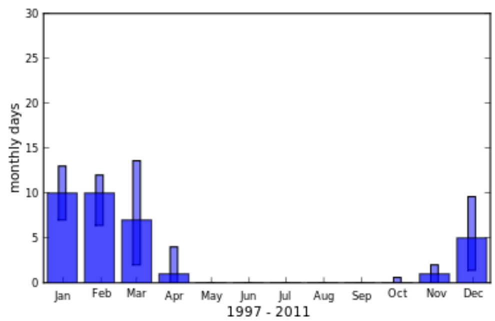

Figure A.14.6: Annual cycle of monthly rain days > 5 mm (days) for MONKEYBAY station.

Observed monthly mean rain day frequency

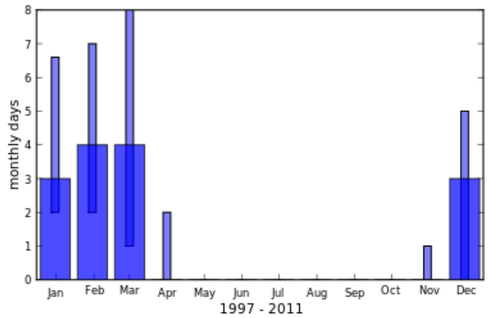

Figure A.14.7: Annual cycle of monthly rain days > 20 mm (days) for MONKEYBAY station.

Observed monthly mean extreme rain day frequency

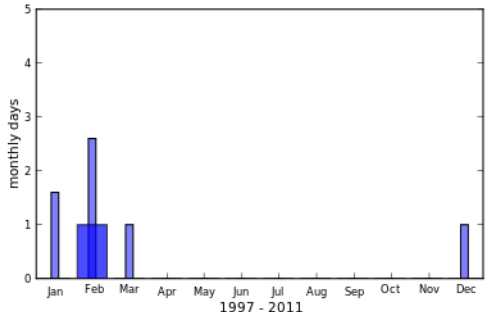

Figure A.14.8: Annual cycle of monthly rain days > 95th percentile (57.2 mm) (days) for MONKEYBAY station.

Observed seasonal daily maximum temperatures

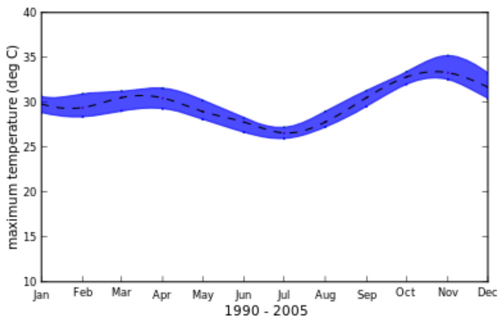

Figure A.14.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for MONKEYBAY station.

Observed seasonal days/month exceeding 36 deg C

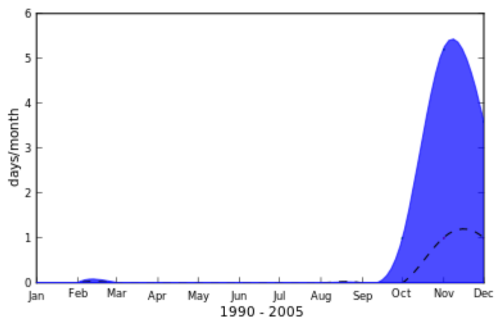

Figure A.14.10: Annual cycle days/month exceeding 36 deg C for MONKEYBAY station.

Observed seasonal days/month exceeding 95th percentile

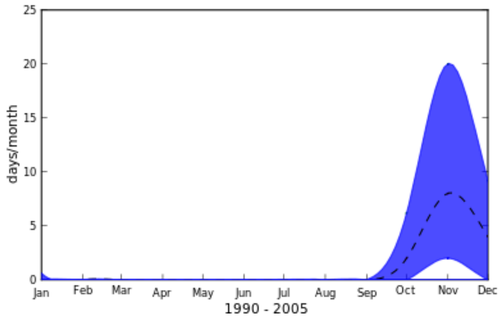

Figure A.14.11: Annual cycle days/month exceeding 34.7 deg C for MONKEYBAY station.

Observed seasonal heat spell length

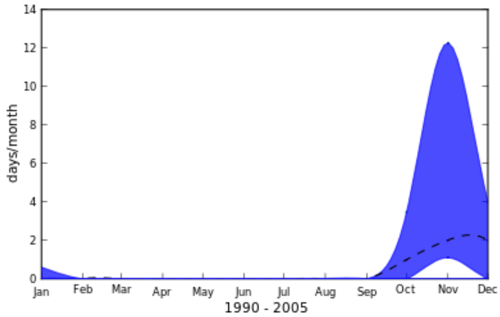

Figure A.14.12: Annual cycle of monthly mean heat spell duration (34.7 deg C) for MONKEYBAY station.

Observed seasonal daily minimum temperatures

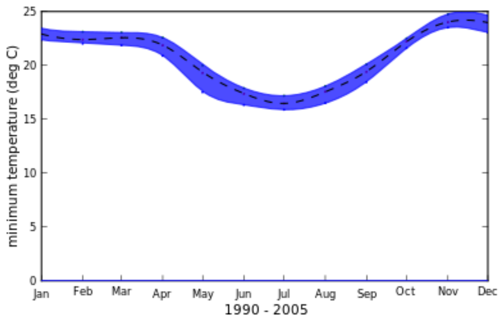

Figure A.14.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for MONKEYBAY station.

Climate Summary Report for MZIMBA

Figure A.15.1: Map showing location of MZIMBA observation station

Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).

Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

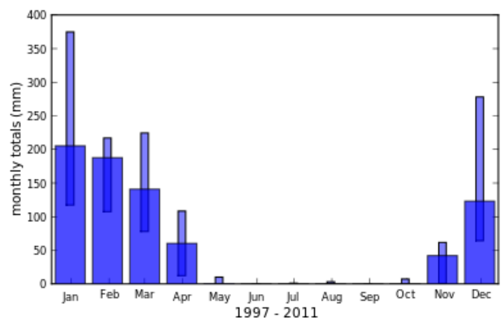

Figure A.15.2: Annual cycle of monthly rainfall (mm) for MZIMBA station.

Observed seasonal mean dry spell duration

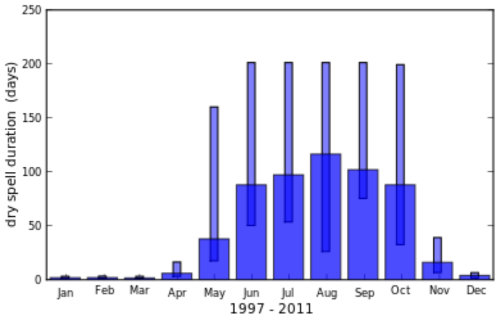

Figure A.15.3: Annual cycle of monthly mean dry spell duration for MZIMBA station (> 0.3mm).

Observed seasonal mean dry spell duration

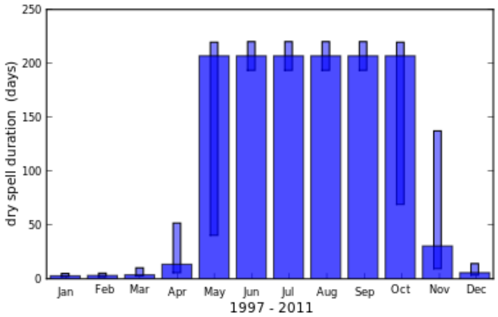

Figure A.15.4: Annual cycle of monthly mean dry spell duration for MZIMBA station (> 5mm).

Observed monthly mean rain day frequency

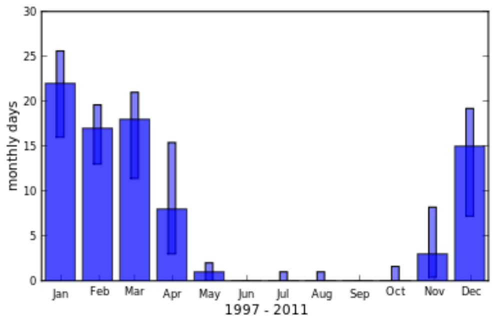

Figure A.15.5: Annual cycle of monthly rain days > 0.3 mm (days) for MZIMBA station.

Observed monthly mean rain day frequency

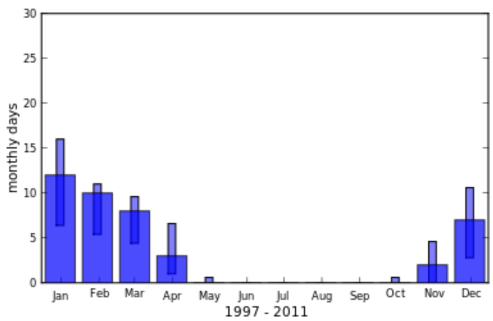

Figure A.15.6: Annual cycle of monthly rain days > 5 mm (days) for MZIMBA station.

Observed monthly mean rain day frequency

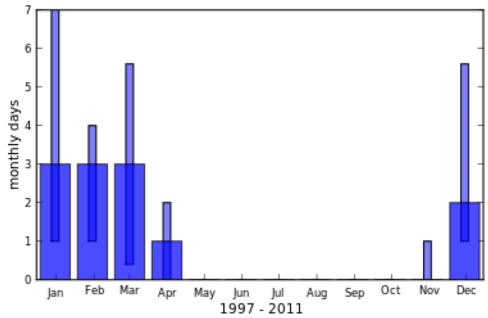

Figure A.15.7: Annual cycle of monthly rain days > 20 mm (days) for MZIMBA station.

Observed monthly mean extreme rain day frequency

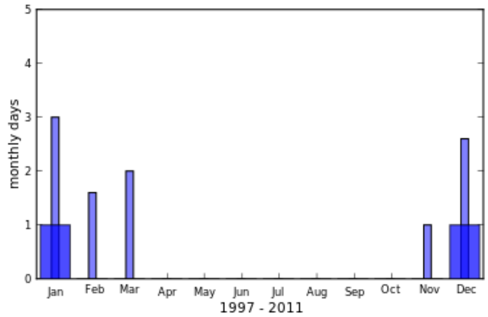

Figure A.15.8: Annual cycle of monthly rain days > 95th percentile (35.6 mm) (days) for MZIMBA station.

Observed seasonal daily maximum temperatures

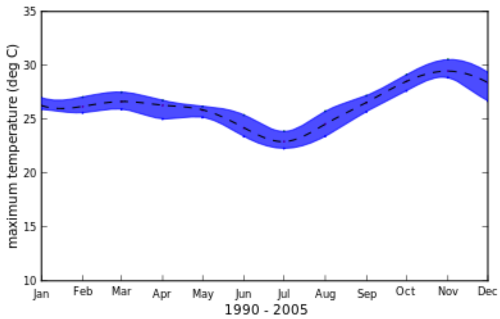

Figure A.15.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for MZIMBA station.

Observed seasonal days/month exceeding 36 deg C

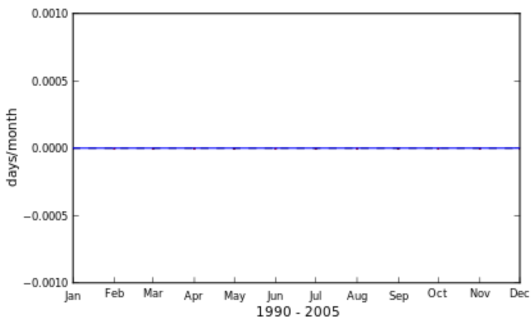

Figure A.15.10: Annual cycle days/month exceeding 36 deg C for MZIMBA station.

Observed seasonal days/month exceeding 95th percentile

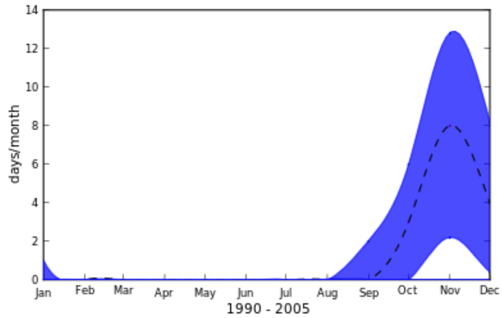

Figure A.15.11: Annual cycle days/month exceeding 30.5 deg C for MZIMBA station.

Observed seasonal heat spell length

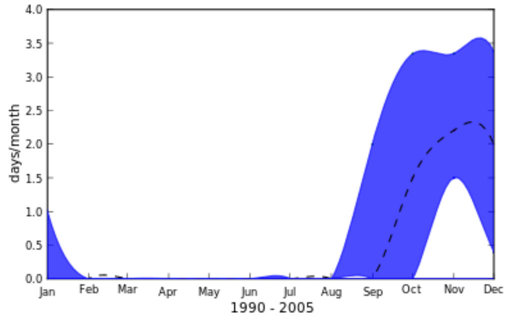

Figure A.15.12: Annual cycle of monthly mean heat spell duration (30.5 deg C) for MZIMBA station.

Observed seasonal daily minimum temperatures

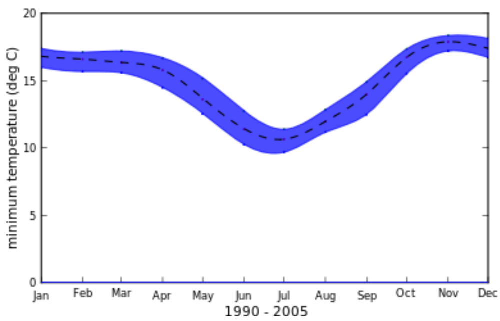

Figure A.15.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for MZIMBA station.

Climate Summary Report for MZUZU

Figure A.16.1: Map showing location of MZUZU observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).

Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

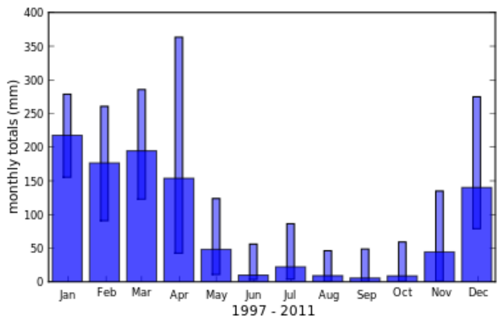

Figure A.16.2: Annual cycle of monthly rainfall (mm) for MZUZU station.

Observed seasonal mean dry spell duration

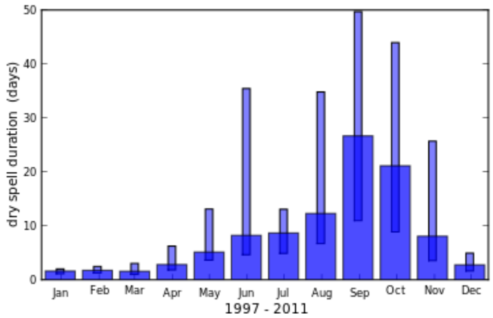

Figure A.16.3: Annual cycle of monthly mean dry spell duration for MZUZU station (> 0.3mm).

Observed seasonal mean dry spell duration

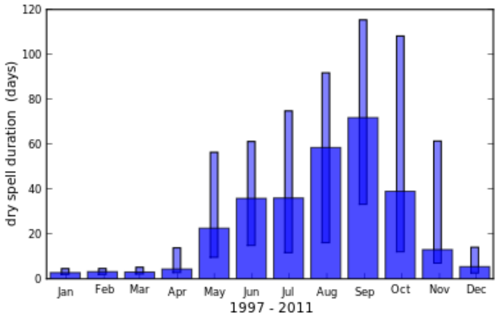

Figure A.16.4: Annual cycle of monthly mean dry spell duration for MZUZU station (> 5mm).

Observed monthly mean rain day frequency

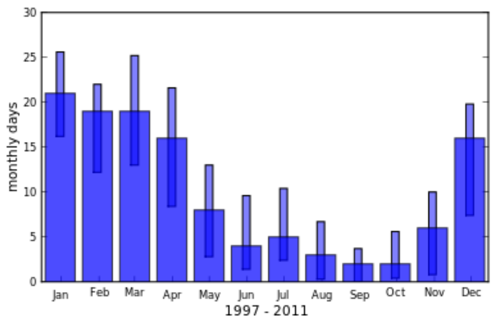

Figure A.16.5: Annual cycle of monthly rain days > 0.3 mm (days) for MZUZU station.

Observed monthly mean rain day frequency

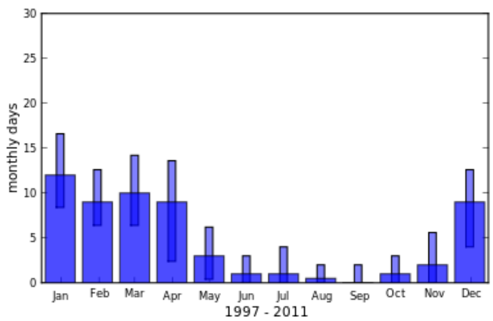

Figure A.16.6: Annual cycle of monthly rain days > 5 mm (days) for MZUZU station.

Observed monthly mean rain day frequency

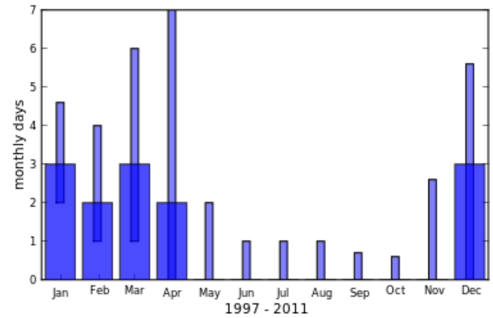

Figure A.16.7: Annual cycle of monthly rain days > 20 mm (days) for MZUZU station.

Observed monthly mean extreme rain day frequency

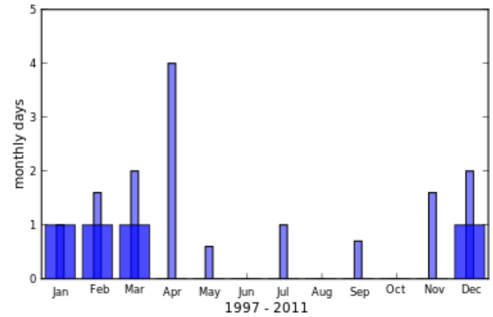

Figure A.16.8: Annual cycle of monthly rain days > 95th percentile (35.7 mm) (days) for MZUZU station.

Observed seasonal daily maximum temperatures

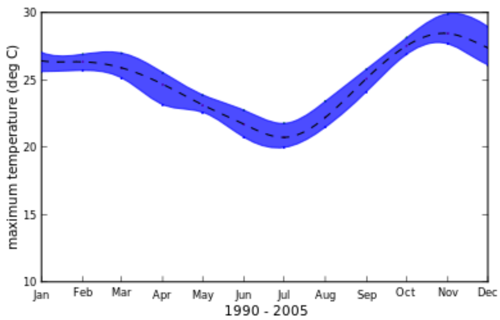

Figure A.16.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for MZUZU station.

Observed seasonal days/month exceeding 36 deg C

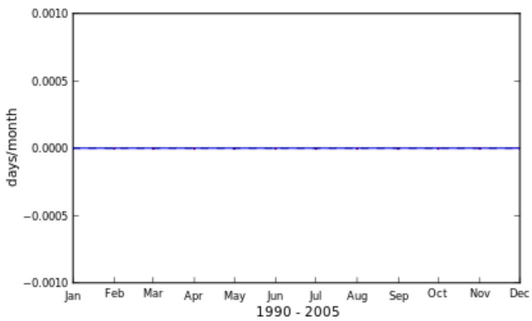

Figure A.16.10: Annual cycle days/month exceeding 36 deg C for MZUZU station.

Observed seasonal days/month exceeding 95th percentile

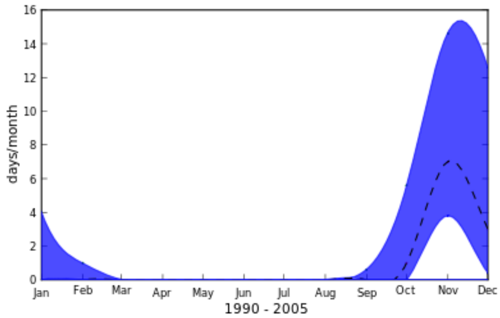

Figure A.16.11: Annual cycle days/month exceeding 30 deg C for MZUZU station.

Observed seasonal heat spell length

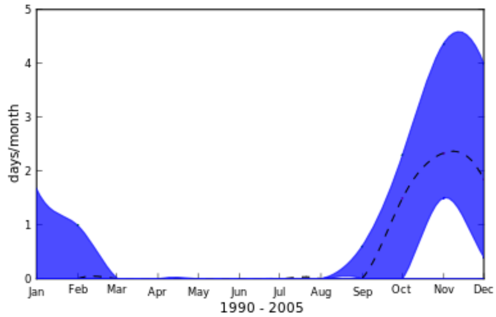

Figure A.16.12: Annual cycle of monthly mean heat spell duration (30 deg C) for MZUZU station.

Observed seasonal daily minimum temperatures

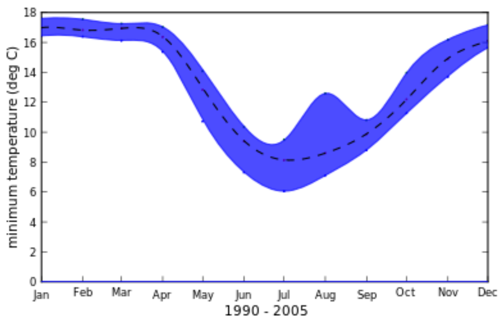

Figure A.16.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for MZUZU station.

Climate Summary Report for NGABU

NGABU

Figure A.17.1: Map showing location of NGABU observation station

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Observed climate

Observed seasonal rainfall

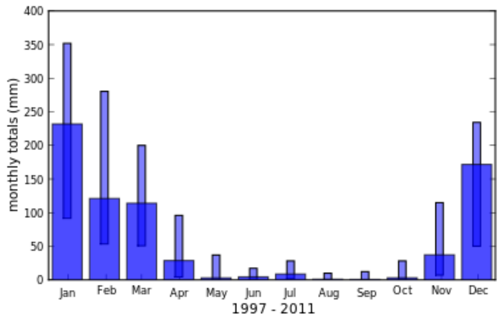

Figure A.17.2: Annual cycle of monthly rainfall (mm) for NGABU station.

Observed seasonal mean dry spell duration

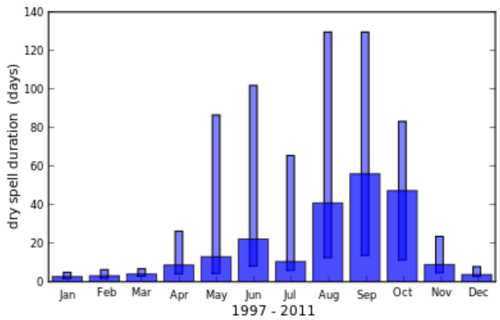

Figure A.17.3: Annual cycle of monthly mean dry spell duration for NGABU station (> 0.3mm).

Observed seasonal mean dry spell duration

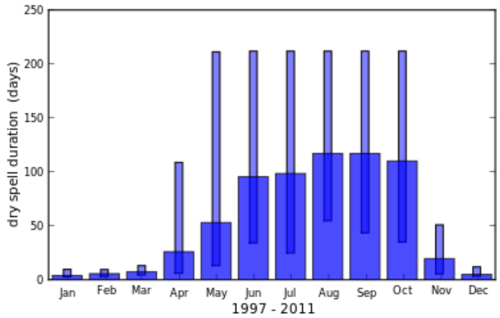

Figure A.17.4: Annual cycle of monthly mean dry spell duration for NGABU station (> 5mm).

Observed monthly mean rain day frequency

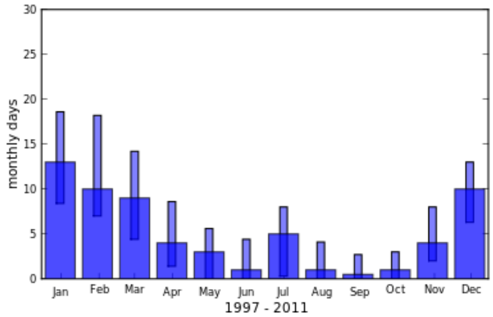

Figure A.17.5: Annual cycle of monthly rain days > 0.3 mm (days) for NGABU station.

Observed monthly mean rain day frequency

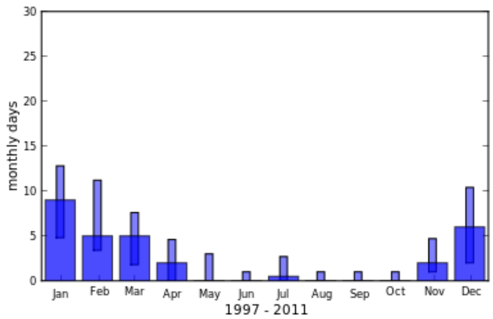

Figure A.17.6: Annual cycle of monthly rain days > 5 mm (days) for NGABU station.

Observed monthly mean rain day frequency

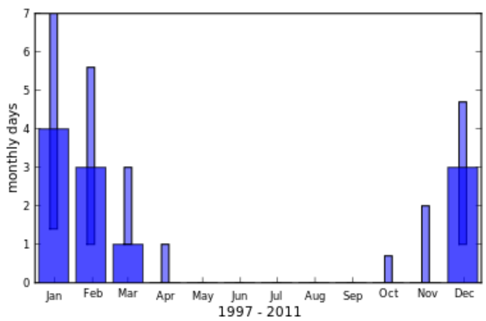

Figure A.17.7: Annual cycle of monthly rain days > 20 mm (days) for NGABU station.

Observed monthly mean extreme rain day frequency

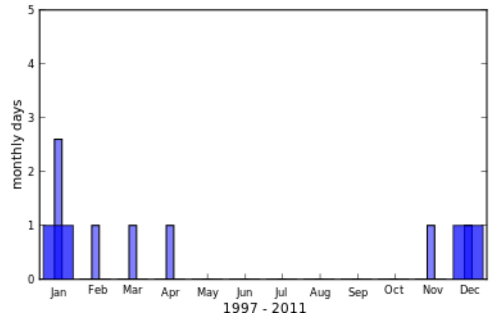

Figure A.17.8: Annual cycle of monthly rain days > 95th percentile (48.2 mm) (days) for NGABU station.

Observed seasonal daily maximum temperatures

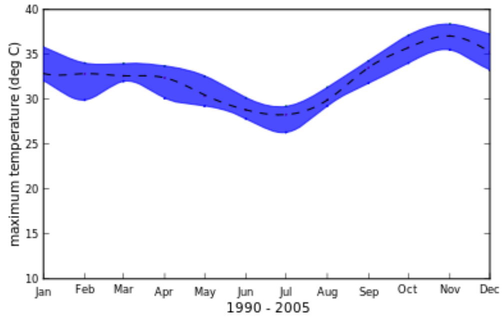

Figure A.17.9: Annual cycle of monthly mean maximum daily temperatures (degC) for NGABU station.

Observed seasonal days/month exceeding 36 degC

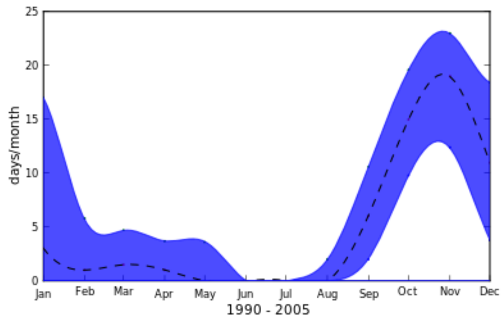

Figure A.17.10: Annual cycle days/month exceeding 36 deg C for NGABU station.

Observed seasonal days/month exceeding 95th percentile

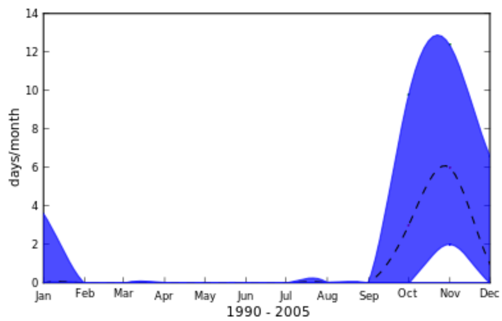

Figure A.17.11: Annual cycle days/month exceeding 39.5 deg C for NGABU station.

Observed seasonal heat spell length

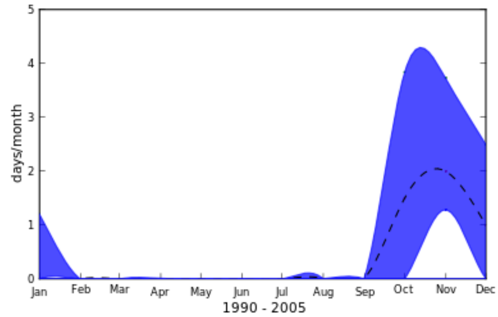

Figure A.17.12: Annual cycle of monthly mean heat spell duration (39.5 deg C) for NGABU station.

Observed seasonal daily minimum temperatures

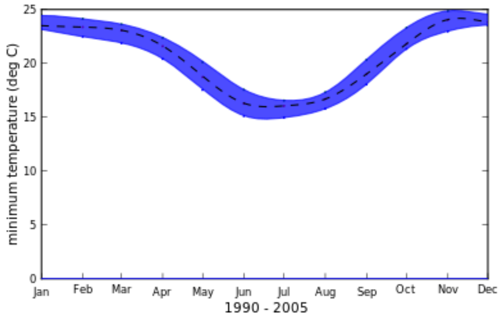

Figure A.17.13: Annual cycle of monthly mean minimum daily temperatures (degC) for NGABU station.

Climate Summary Report for NKHATA BAY

Figure A.18.1: Map showing location of NKHATA BAY observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).

Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

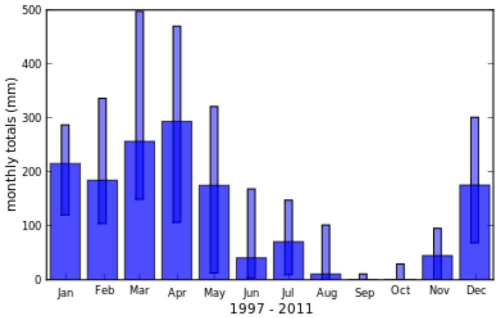

Figure A.18.2: Annual cycle of monthly rainfall (mm) for NKHATA BAY station.

Observed seasonal mean dry spell duration

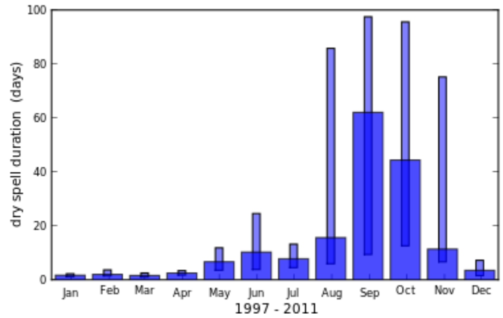

Figure A.18.3: Annual cycle of monthly mean dry spell duration for NKHATA BAY station (> 0.3mm).

Observed seasonal mean dry spell duration

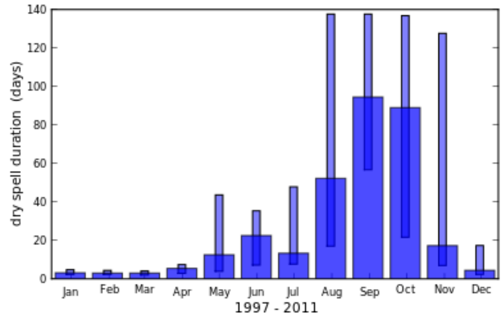

Figure A.18.4: Annual cycle of monthly mean dry spell duration for NKHATA BAY station (> 5mm).

Observed monthly mean rain day frequency

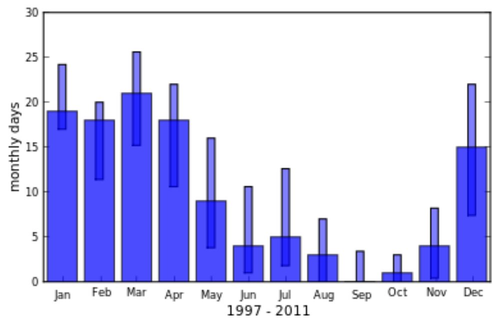

Figure A.18.5: Annual cycle of monthly rain days > 0.3 mm (days) for NKHATA BAY station.

Observed monthly mean rain day frequency

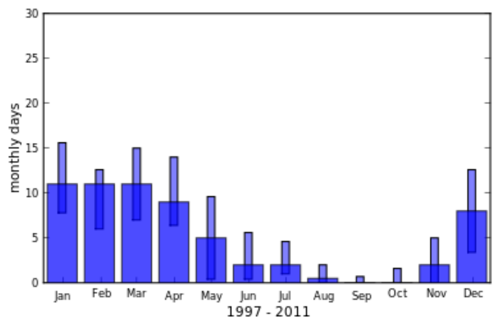

Figure A.18.6: Annual cycle of monthly rain days > 5 mm (days) for NKHATA BAY station.

Observed monthly mean rain day frequency

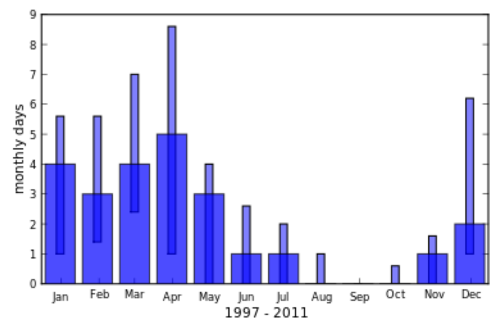

Figure A.18.7: Annual cycle of monthly rain days > 20 mm (days) for NKHATA BAY station.

Observed monthly mean extreme rain day frequency

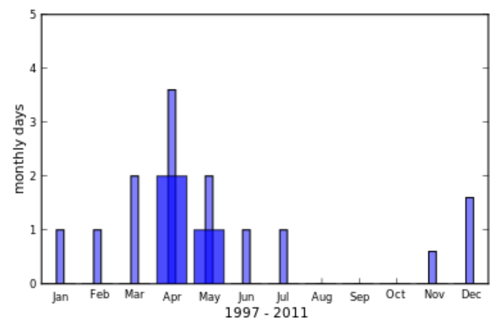

Figure A.18.8: Annual cycle of monthly rain days > 95th percentile (55 mm) (days) for NKHATA BAY station.

Observed seasonal daily maximum temperatures

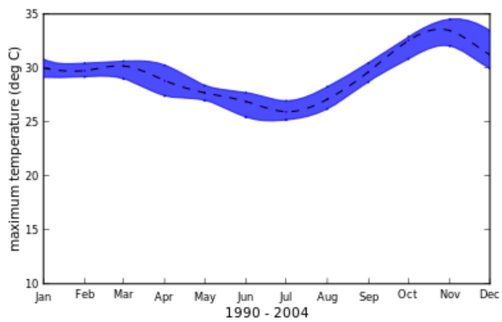

Figure A.18.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for NKHATA BAY station.

Observed seasonal days/month exceeding 36 deg C

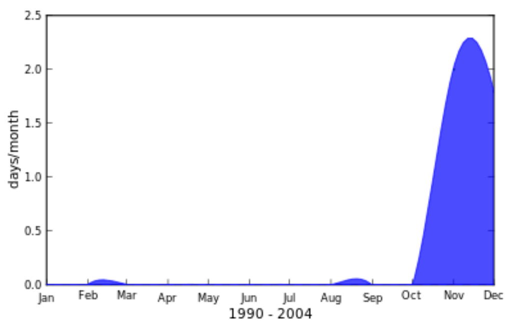

Figure A.18.10: Annual cycle days/month exceeding 36 deg C for NKHATA BAY station.

Observed seasonal days/month exceeding 95th percentile

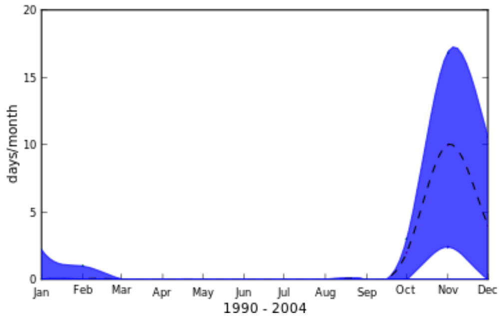

Figure A.18.11: Annual cycle days/month exceeding 34.3 deg C for NKHATA BAY station.

Observed seasonal heat spell length

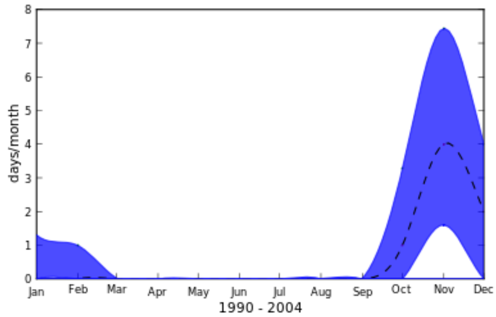

Figure A.18.12: Annual cycle of monthly mean heat spell duration (34.3 deg C) for NKHATA BAY station.

Observed seasonal daily minimum temperatures

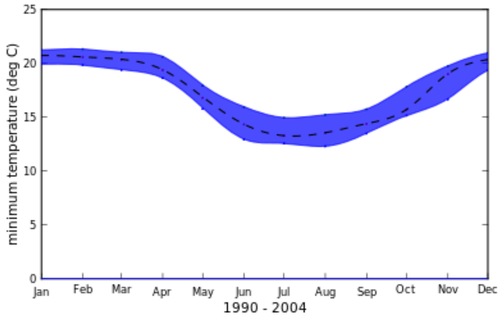

Figure A.18.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for NKHATA BAY station.

Climate Summary Report for NKHOTA KOTA

Figure A.19.1: Map showing location of NKHOTA KOTA observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).

Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

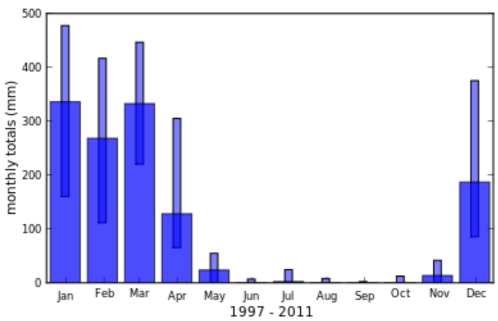

Figure A.19.2: Annual cycle of monthly rainfall (mm) for NKHOTA KOTA station.

Observed seasonal mean dry spell duration

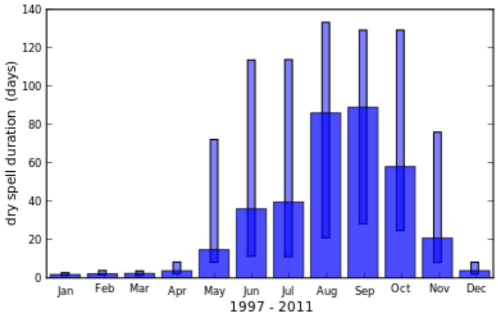

Figure A.19.3: Annual cycle of monthly mean dry spell duration for NKHOTA KOTA station (> 0.3mm).

Observed seasonal mean dry spell duration

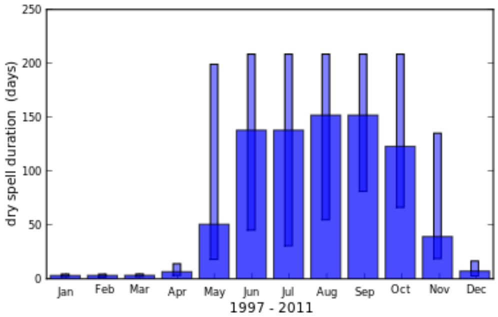

Figure A.19.4: Annual cycle of monthly mean dry spell duration for NKHOTA KOTA station (> 5mm).

Observed monthly mean rain day frequency

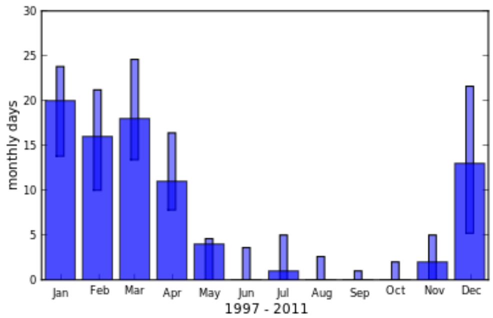

Figure A.19.5: Annual cycle of monthly rain days > 0.3 mm (days) for NKHOTA KOTA station.

Observed monthly mean rain day frequency

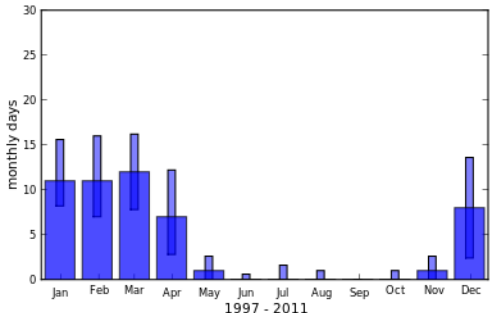

Figure A.19.6: Annual cycle of monthly rain days > 5 mm (days) for NKHOTA KOTA station.

Observed monthly mean rain day frequency

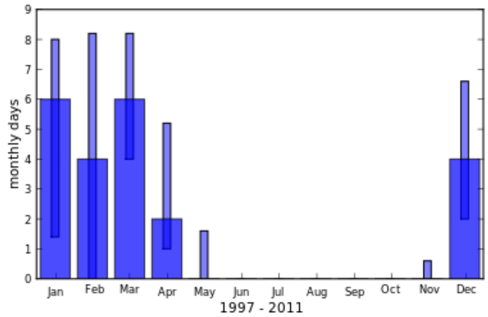

Figure A.19.7: Annual cycle of monthly rain days > 20 mm (days) for NKHOTA KOTA station.

Observed monthly mean extreme rain day frequency

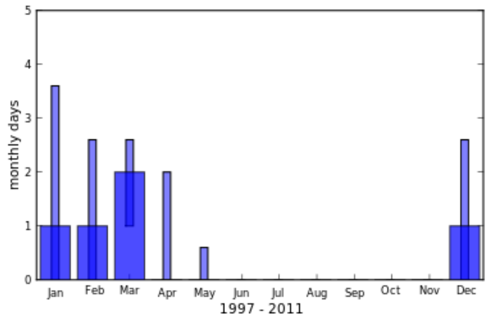

Figure A.19.8: Annual cycle of monthly rain days > 95th percentile (47.5 mm) (days) for NKHOTA KOTA station.

Observed seasonal daily maximum temperatures

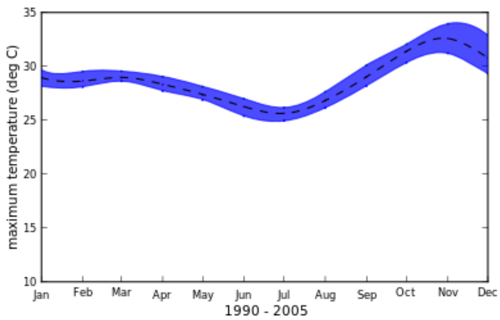

Figure A.19.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for NKHOTA KOTA station.

Observed seasonal days/month exceeding 36 deg C

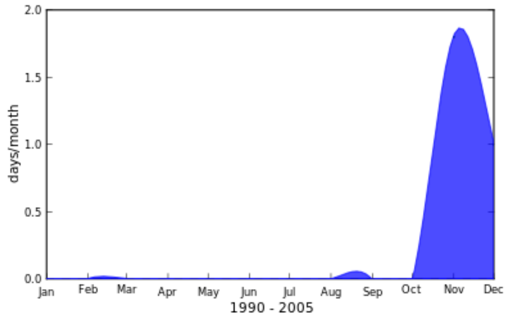

Figure A.19.10: Annual cycle days/month exceeding 36 deg C for NKHOTA KOTA station.

Observed seasonal days/month exceeding 95th percentile

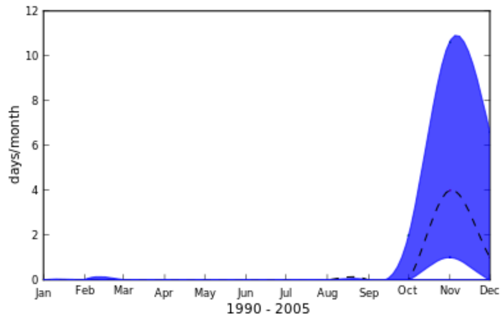

Figure A.19.11: Annual cycle days/month exceeding 34.5 deg C for NKHOTA KOTA station.

Observed seasonal heat spell length

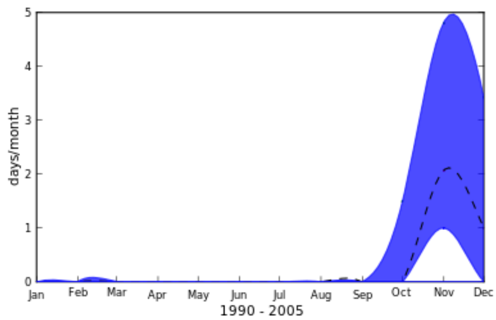

Figure A.19.12: Annual cycle of monthly mean heat spell duration (34.5 deg C) for NKHOTA KOTA station.

Observed seasonal daily minimum temperatures

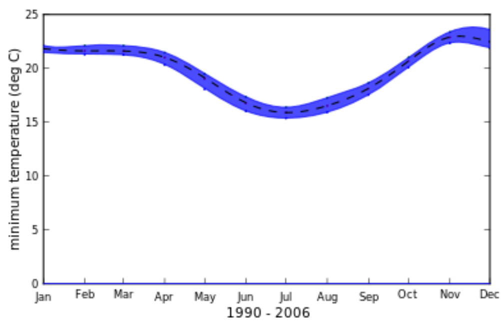

Figure A.19.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for NKHOTA KOTA station.

Climate Summary Report for NTAJA

NTAJA

Figure A.20.1: Map showing location of NTAJA observation station

Observed climate

Observed seasonal rainfall

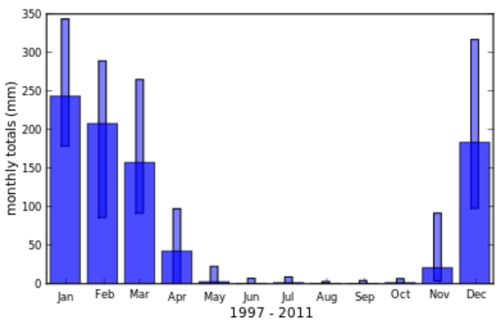

Figure A.20.2: Annual cycle of monthly rainfall (mm) for NTAJA station.

Observed seasonal mean dry spell duration

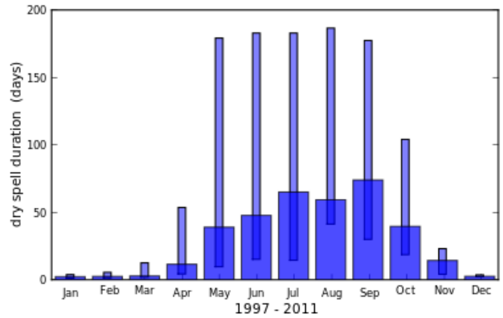

Figure A.20.3: Annual cycle of monthly mean dry spell duration for NTAJA station (> 0.3mm).

Observed seasonal mean dry spell duration

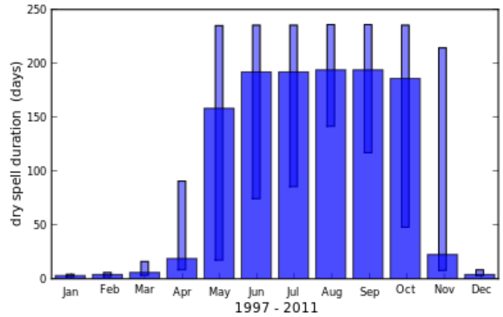

Figure A.20.4: Annual cycle of monthly mean dry spell duration for NTAJA station (> 5mm).

Observed monthly mean rain day frequency

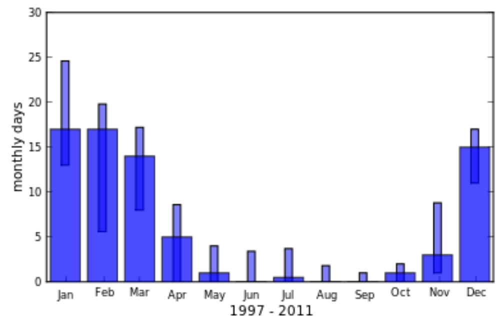

Figure A.20.5: Annual cycle of monthly rain days > 0.3 mm (days) for NTAJA station.

Observed monthly mean rain day frequency

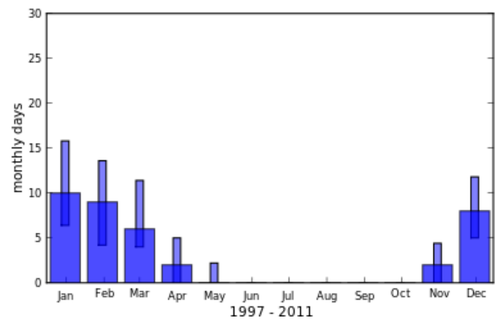

Figure A.20.6: Annual cycle of monthly rain days > 5 mm (days) for NTAJA station.

Observed monthly mean rain day frequency

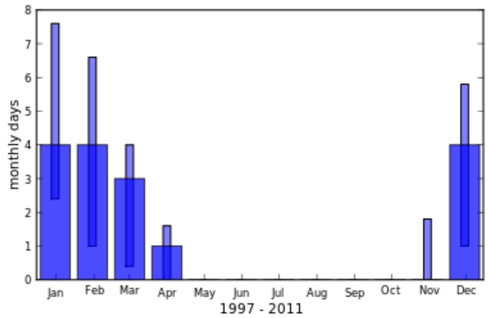

Figure A.20.7: Annual cycle of monthly rain days > 20 mm (days) for NTAJA station.

Observed monthly mean extreme rain day frequency

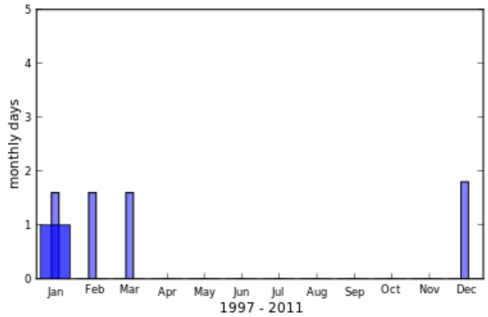

Figure A.20.8: Annual cycle of monthly rain days > 95th percentile (55.3 mm) (days) for NTAJA station.

Observed seasonal daily maximum temperatures

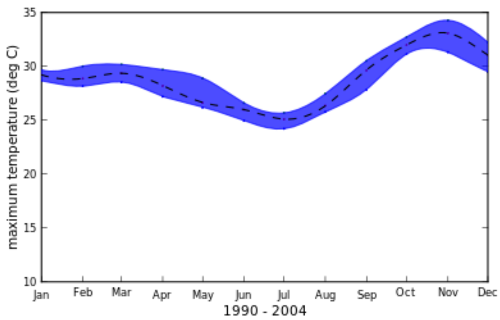

Figure A.20.9: Annual cycle of monthly mean maximum daily temperatures (degC) for NTAJA station.

Observed seasonal days/month exceeding 36 degC

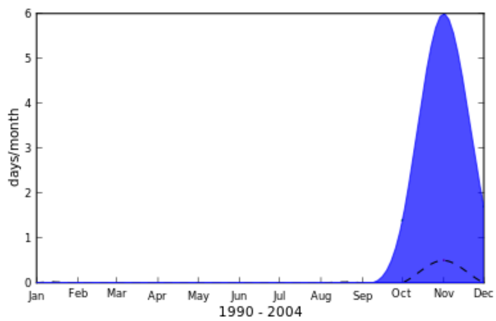

Figure A.20.10: Annual cycle days/month exceeding 36 deg C for NTAJA station.

Observed seasonal days/month exceeding 95th percentile

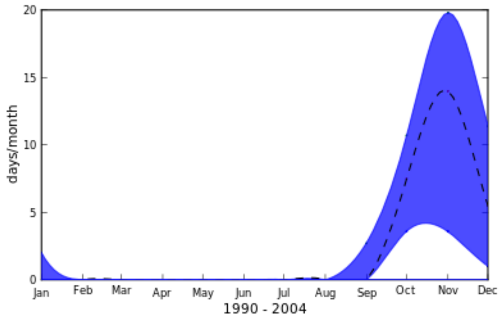

Figure A.20.11: Annual cycle days/month exceeding 33.6 deg C for NTAJA station.

Observed seasonal heat spell length

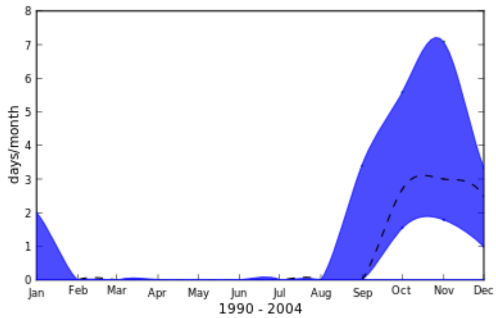

Figure A.20.12: Annual cycle of monthly mean heat spell duration (33.6 deg C) for NTAJA station.

Observed seasonal daily minimum temperatures

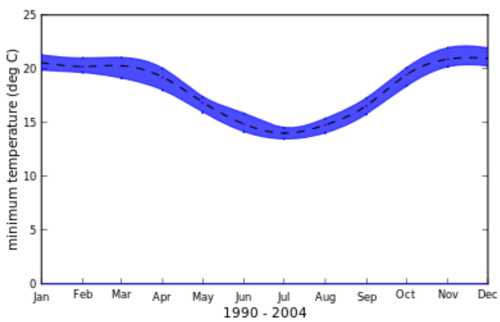

Figure A.20.13: Annual cycle of monthly mean minimum daily temperatures (degC) for NTAJA station.

Climate Summary Report for SALIMA

Figure A.21.1: Map showing location of SALIMA observation station

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Observed climate

Explanation of Historic Observation Plots -

Precipitation: Observed monthly median climatology (wide bars) with the 10th to 90th percentile inter-annual range (narrow bars).

Temperature: Observed monthly median climatology for the observed period (dashed line). Blue envelope represents the 10th to 90th percentile range of inter-annual variability.

Observed seasonal rainfall

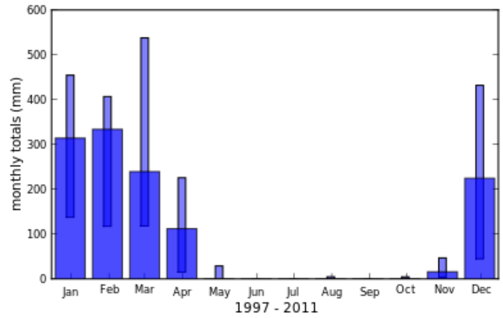

Figure A.21.2: Annual cycle of monthly rainfall (mm) for SALIMA station.

Observed seasonal mean dry spell duration

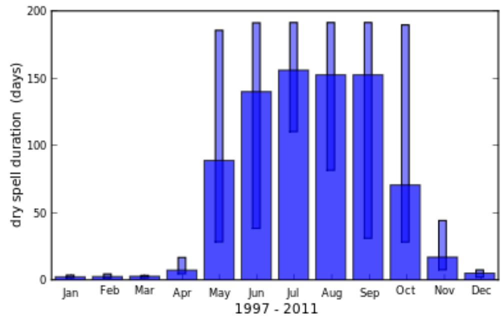

Figure A.21.3: Annual cycle of monthly mean dry spell duration for SALIMA station (> 0.3mm).

Observed seasonal mean dry spell duration

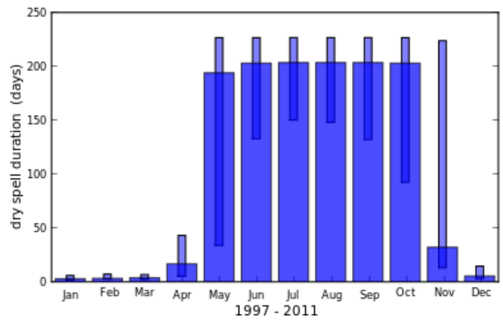

Figure A.21.4: Annual cycle of monthly mean dry spell duration for SALIMA station (> 5mm).

Observed monthly mean rain day frequency

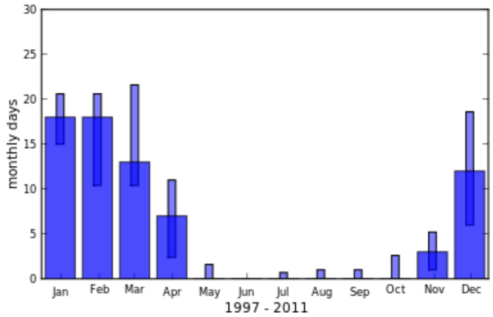

Figure A.21.5: Annual cycle of monthly rain days > 0.3 mm (days) for SALIMA station.

Observed monthly mean rain day frequency

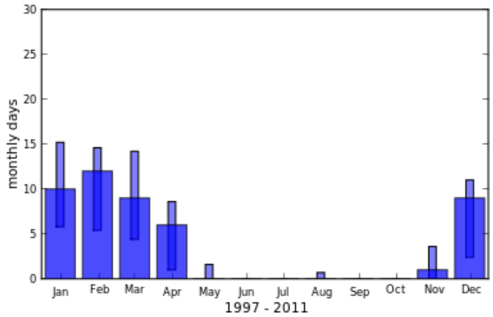

Figure A.21.6: Annual cycle of monthly rain days > 5 mm (days) for SALIMA station.

Observed monthly mean rain day frequency

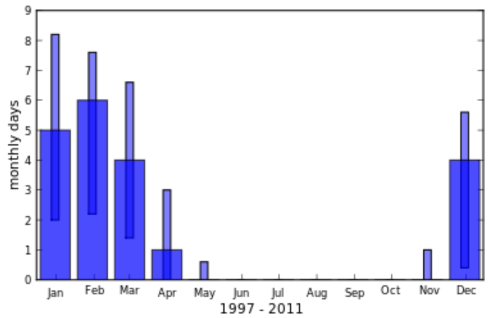

Figure A.21.7: Annual cycle of monthly rain days > 20 mm (days) for SALIMA station.

Observed monthly mean extreme rain day frequency

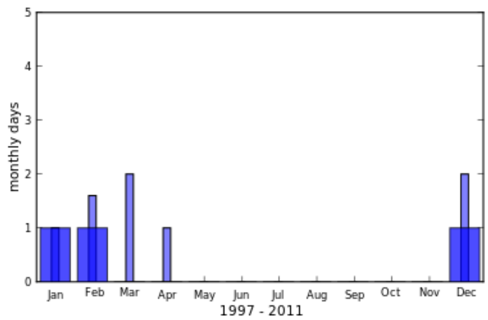

Figure A.21.8: Annual cycle of monthly rain days > 95th percentile (66.9 mm) (days) for SALIMA station.

Observed seasonal daily maximum temperatures

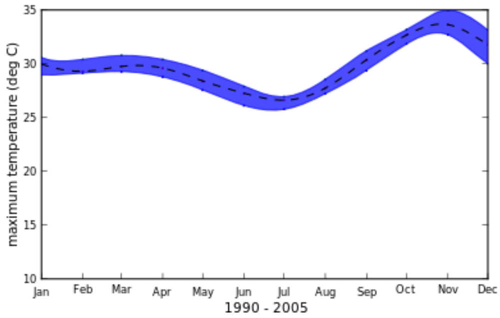

Figure A.21.9: Annual cycle of monthly mean maximum daily temperatures (deg C) for SALIMA station.

Observed seasonal days/month exceeding 36 deg C

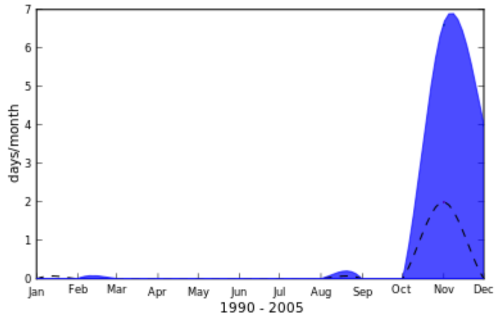

Figure A.21.10: Annual cycle days/month exceeding 36 deg C for SALIMA station.

Observed seasonal days/month exceeding 95th percentile

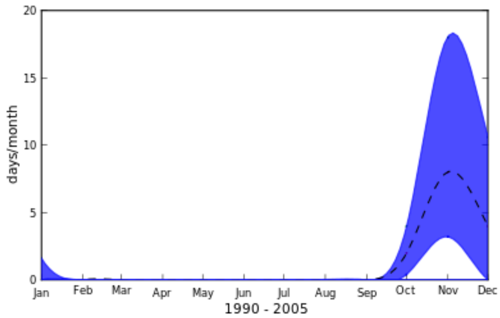

Figure A.21.11: Annual cycle days/month exceeding 34.8 deg C for SALIMA station.

Observed seasonal heat spell length

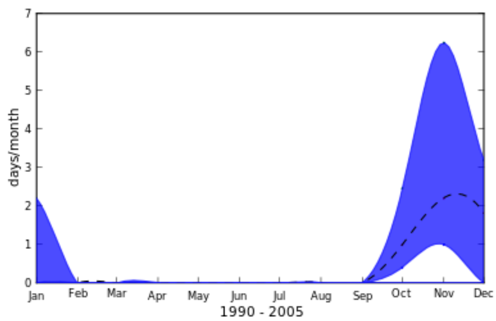

Figure A.21.12: Annual cycle of monthly mean heat spell duration (34.8 deg C) for SALIMA station.

Observed seasonal daily minimum temperatures

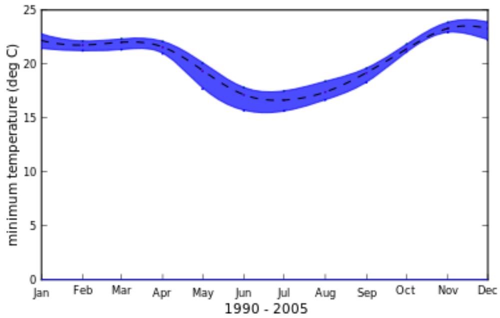

Figure A.21.13: Annual cycle of monthly mean minimum daily temperatures (deg C) for SALIMA station.

Climate Summary Report for THYOLO

THYOLO

Figure A.22.1: Map showing location of THYOLO observation station

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Observed climate

Observed seasonal rainfall

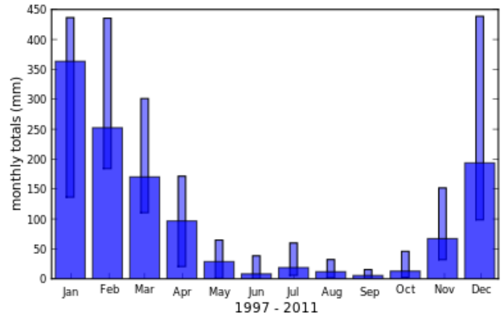


Figure A.22.2: Annual cycle of monthly rainfall (mm) for THYOLO station.

Observed seasonal mean dry spell duration

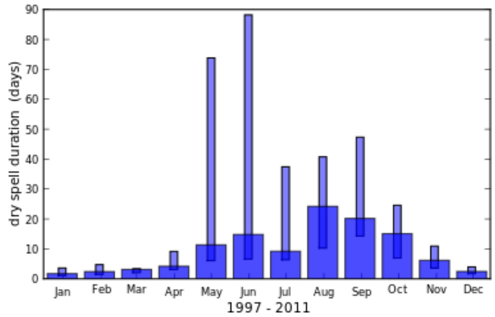


Figure A.22.3: Annual cycle of monthly mean dry spell duration for THYOLO station (> 0.3mm).

Observed seasonal mean dry spell duration

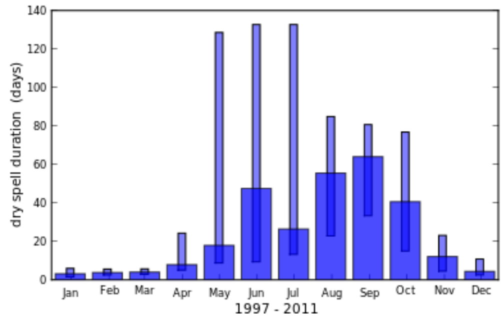


Figure A.22.4: Annual cycle of monthly mean dry spell duration for THYOLO station (> 5mm).

Observed monthly mean rain day frequency

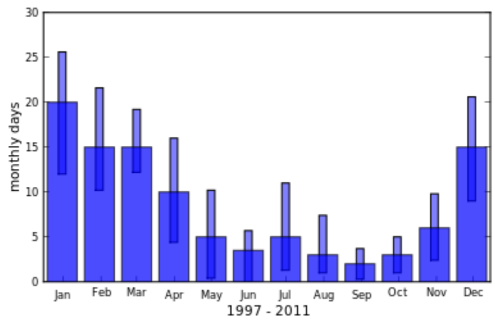


Figure A.22.5: Annual cycle of monthly rain days > 0.3 mm (days) for THYOLO station.

Observed monthly mean rain day frequency

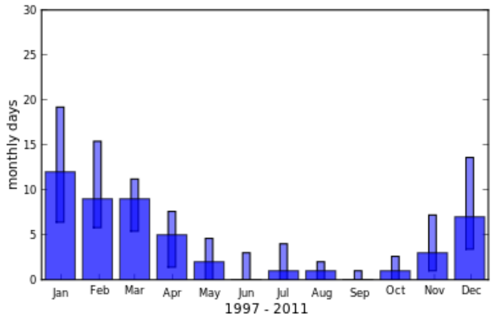


Figure A.22.6: Annual cycle of monthly rain days > 5 mm (days) for THYOLO station.

Observed monthly mean rain day frequency

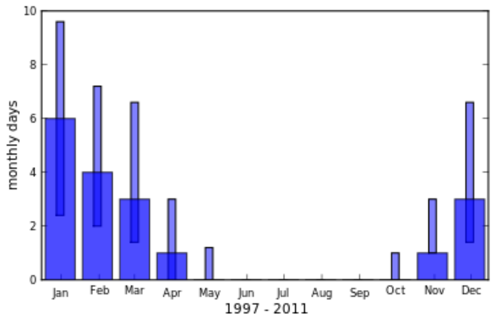


Figure A.22.7: Annual cycle of monthly rain days > 20 mm (days) for THYOLO station.

Observed monthly mean extreme rain day frequency

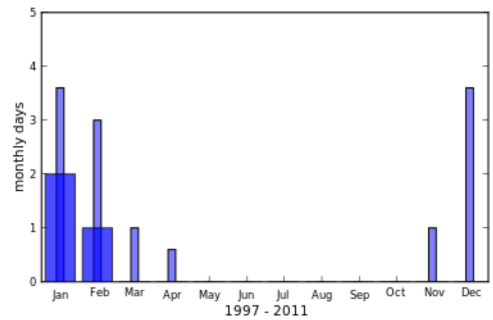


Figure A.22.8: Annual cycle of monthly rain days > 95th percentile (48.7 mm) (days) for THYOLO station.

Observed seasonal daily maximum temperatures

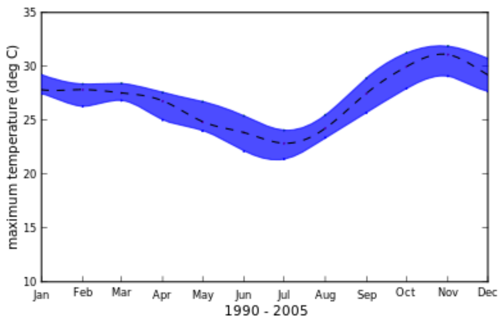


Figure A.22.9: Annual cycle of monthly mean maximum daily temperatures (degC) for THYOLO station.

Observed seasonal days/month exceeding 36 degC

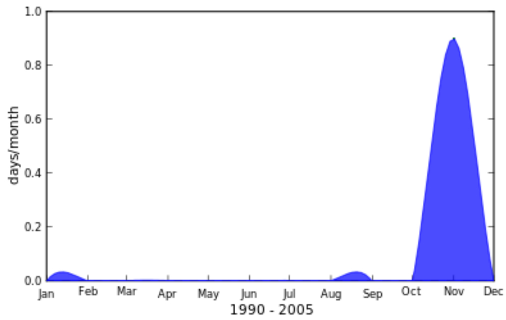


Figure A.22.10: Annual cycle days/month exceeding 36 deg C for THYOLO station.

Observed seasonal days/month exceeding 95th percentile

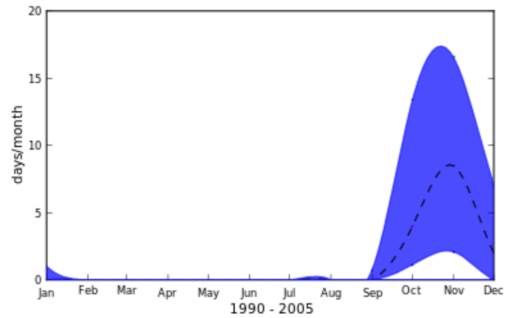


Figure A.22.11: Annual cycle days/month exceeding 32.9 deg C for THYOLO station

Observed seasonal heat spell length

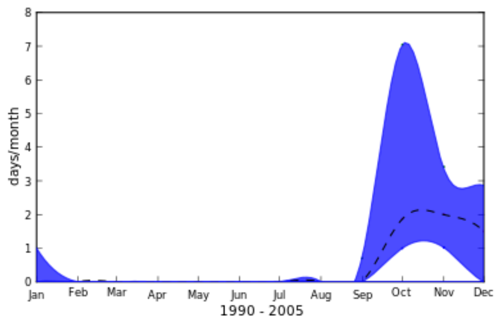


Figure A.22.12: Annual cycle of monthly mean heat spell duration (32.9 deg C) for THYOLO station.

Observed seasonal daily minimum temperatures

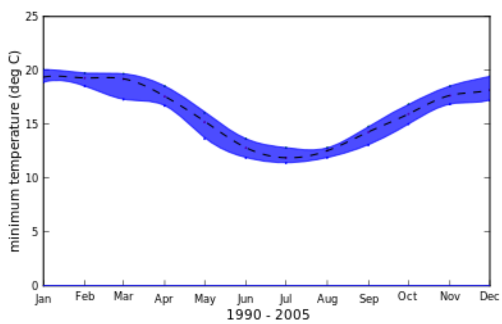


Figure A.22.13: Annual cycle of monthly mean minimum daily temperatures (degC) for THYOLO station.

APPENDIX *E– HISTORICAL TRENDS*

E.1: BVUMBWE

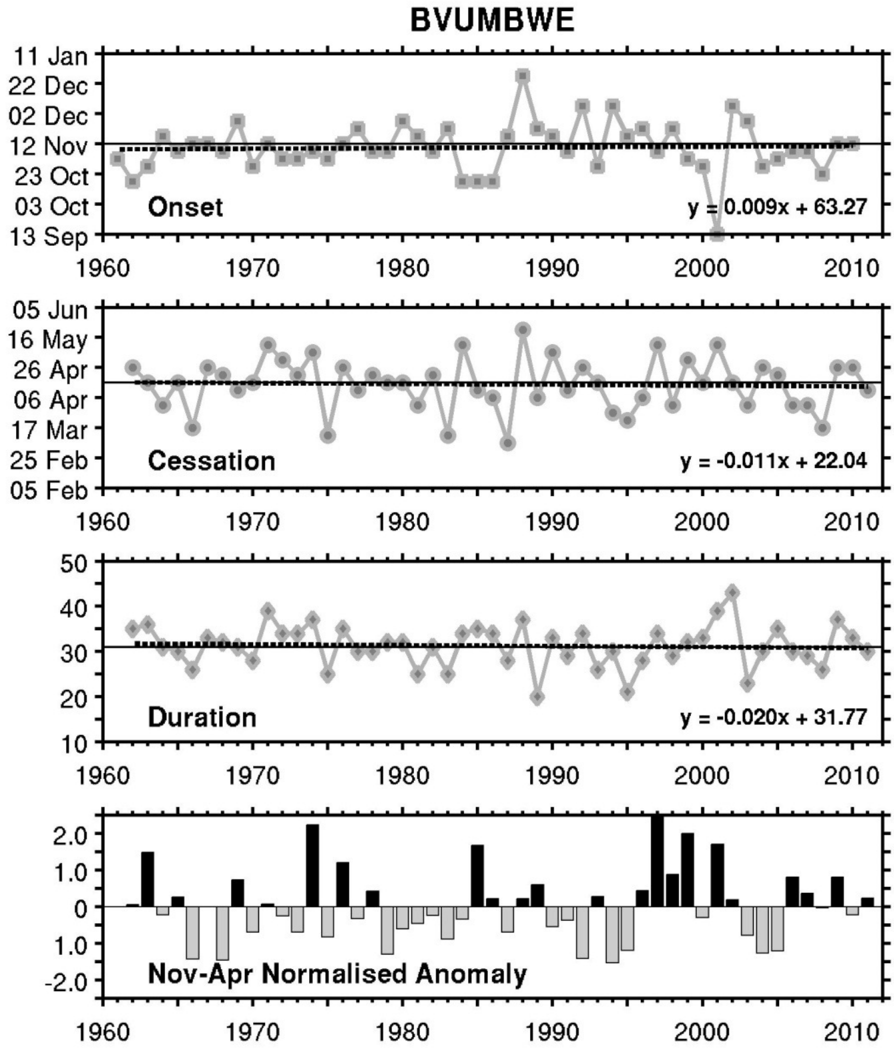


Figure E.1.1: The onset, cessation, duration (given in number of pentads) of the rainfall at BVUMBWE. The grey lines show the actual values, the solid black line shows the mean, while the dashed black line shows the trend (also shown is the trend equation). Trends that are significant at the 95% confidence level are highlighted with an asterisk (*) at the end of the equation. The bottom panel shows the normalised anomaly of the November – April rainfall. The year on the x-axis refers to the January-April of the given summer for the bottom three panels (e.g. the 1961 / 1962 summer will be shown as 1962), while the x-axis for onset refers to the November-December (e.g. the 1961 / 1962 summer will be shown as 1961).

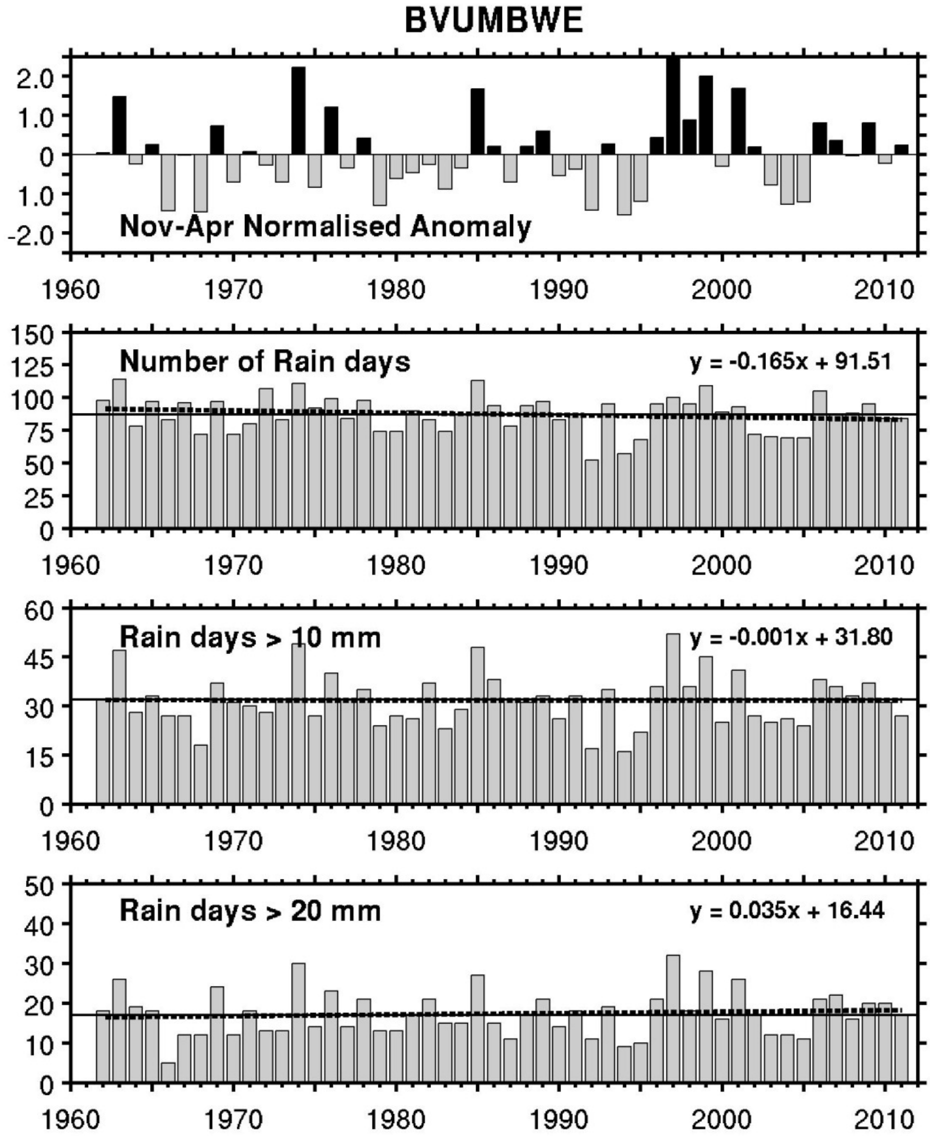


Figure E.1.2: The top panel shows the November – April normalised rainfall anomalies, while the bottom three panels show the number of days exceeding different thresholds (0.3 mm, 10 mm and 20 mm). All panels are for BVUMBWE. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962), while the y-axis for the top panel has no units and the other three are in days. Trends and equations are given (an '*' at the end of the equation signifies the trend is significant at the 95% confidence level).

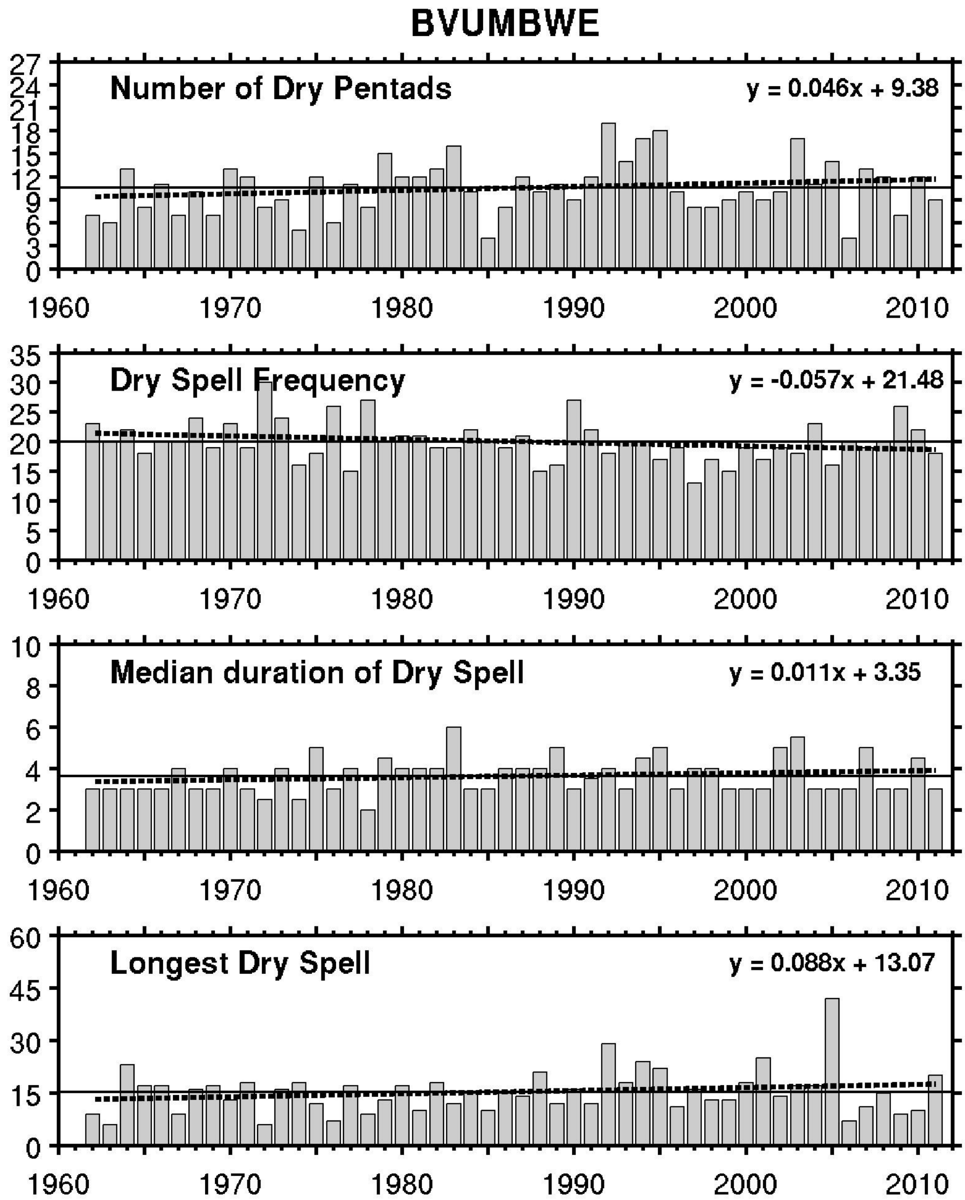


Figure E.1.3: Changes in the dry spells at BVUMBWE. The top panel shows the number of dry pentads (refer to the text to what this is), while the *Dry Spell Frequency* shows the number of times a dry spell (refer to the text to what this is) occurred per season. Also shown is the median duration of the dry spells as well as the longest dry spell during the season. Note that these are for the November – April period only. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962). The x-axis on the top panel has no units, while the bottom two panels are days. Trends and equations are given (an '*' at the end of the equation signifies the trend is significant at the 95% confidence level).

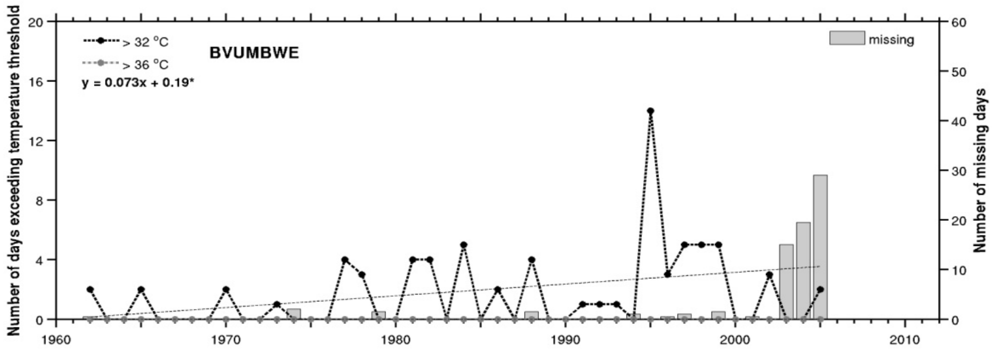


Figure E.1.4: The number of days exceeding 32°C (black dotted line) and 36°C (grey dotted line) at BVUMBWE during November - April. Also shown is the trend line (grey dashed) and equation (if significant at the 95% confidence level it is denoted with a '*') for the 32°C threshold only. The number of days with missing data are shown in grey bars (right y-axis). The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962).

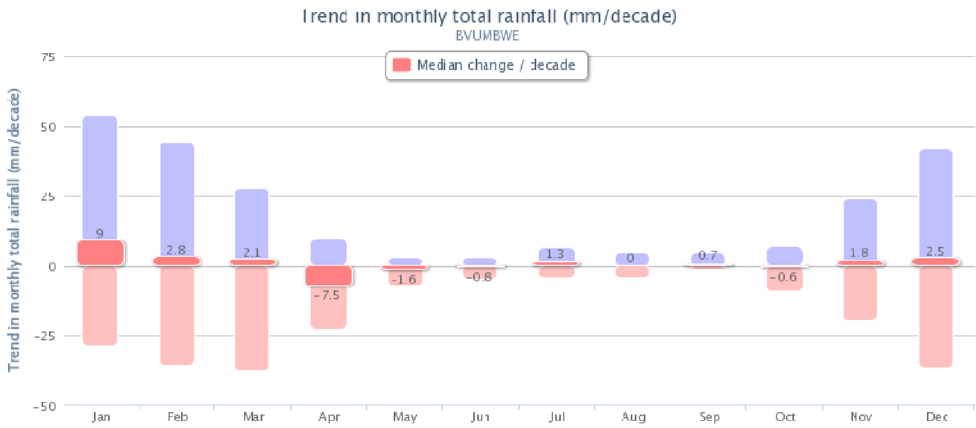


Figure E.1.5: Monthly change in total rainfall at BVUMBWE (illustrated as changes in mm per decade).

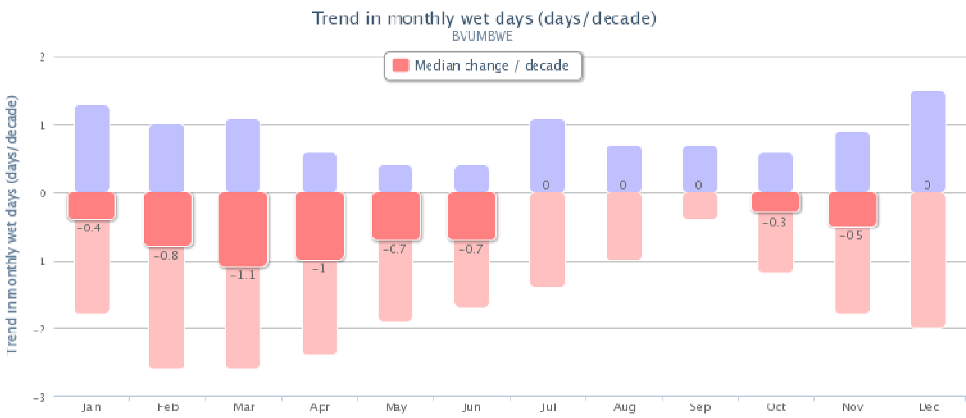


Figure E.1.6: Monthly change in the number of wet days at BVUMBWE (illustrated as changes in days per decade).

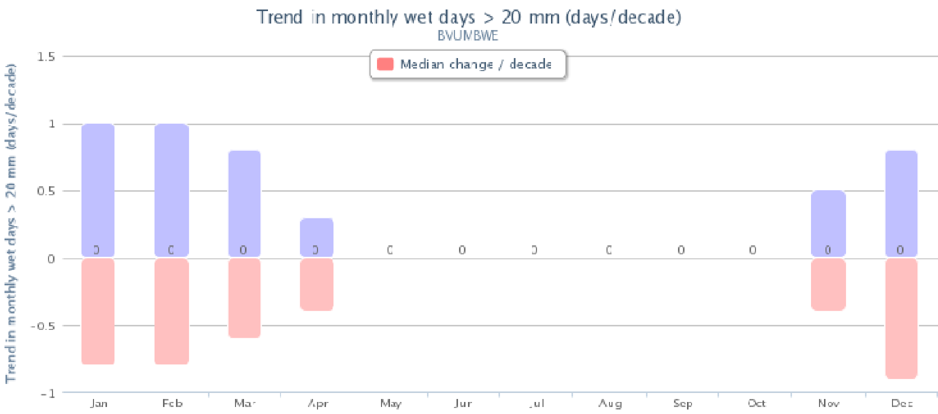


Figure E.1.7: Monthly change in the number of days exceeding 20 mm of rainfall at BVUMBWE (illustrated as changes in days per decade).

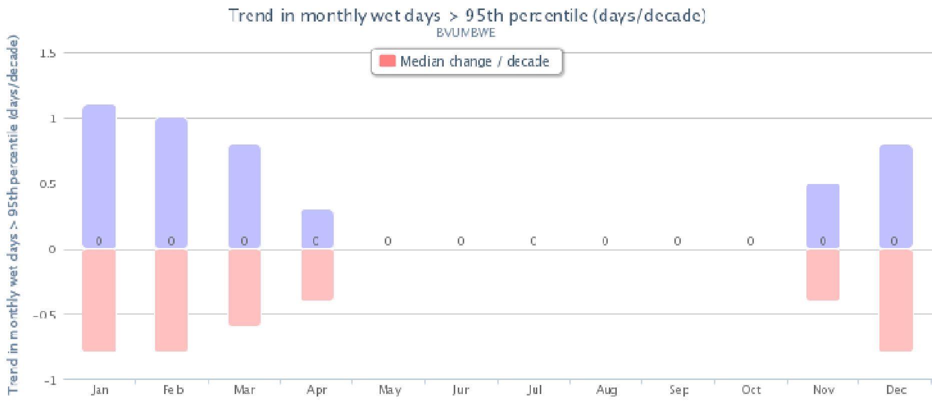


Figure E.1.8: Monthly change in the number of rain days exceeding the 95% percentile at BVUMBWE (illustrated as changes in days per decade).

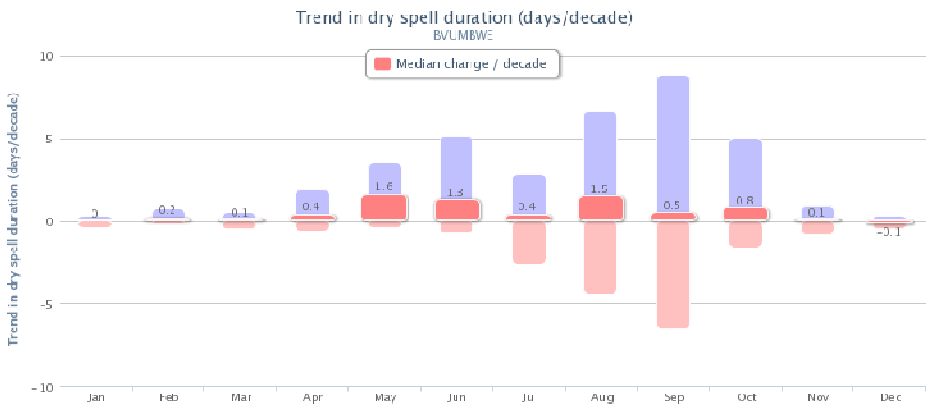


Figure E.1.9: Monthly change in the mean dry spell duration at BVUMBWE (illustrated as changes in days per decade).

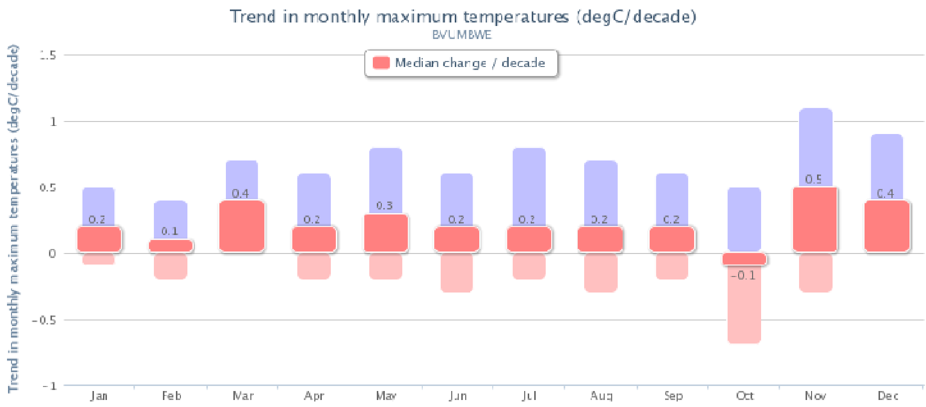


Figure E.1.10: Monthly change in the maximum temperature at BVUMBWE (illustrated as changes in °C per decade).

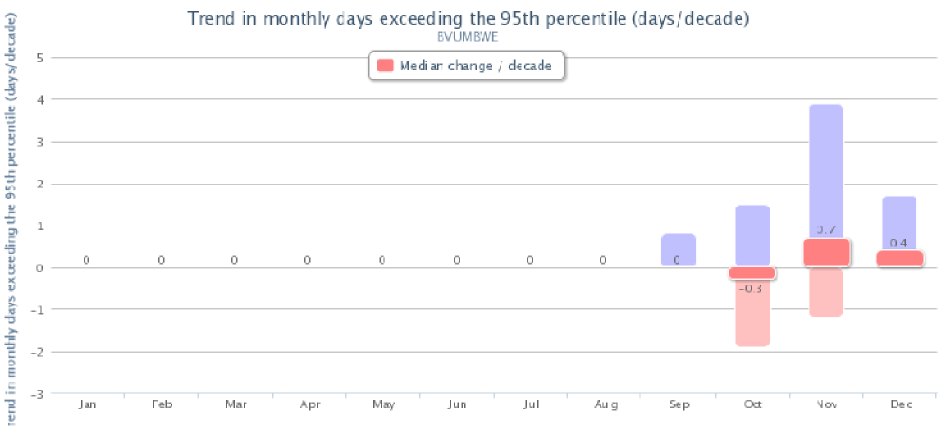


Figure E.1.11: Monthly change in the number of days exceeding the 95th percentile (temperature) at BVUMBWE (illustrated as changes in days per decade).

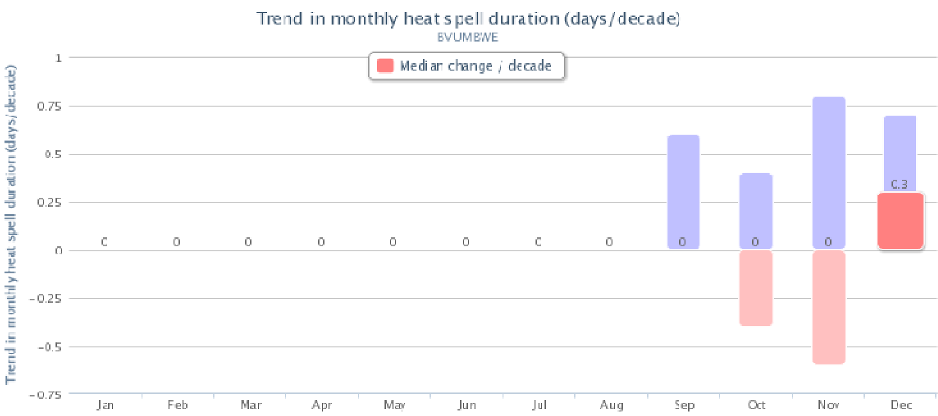


Figure E.1.12: Monthly change in the mean heat spell duration at BVUMBWE (illustrated as changes in days per decade).

E.2: KIA

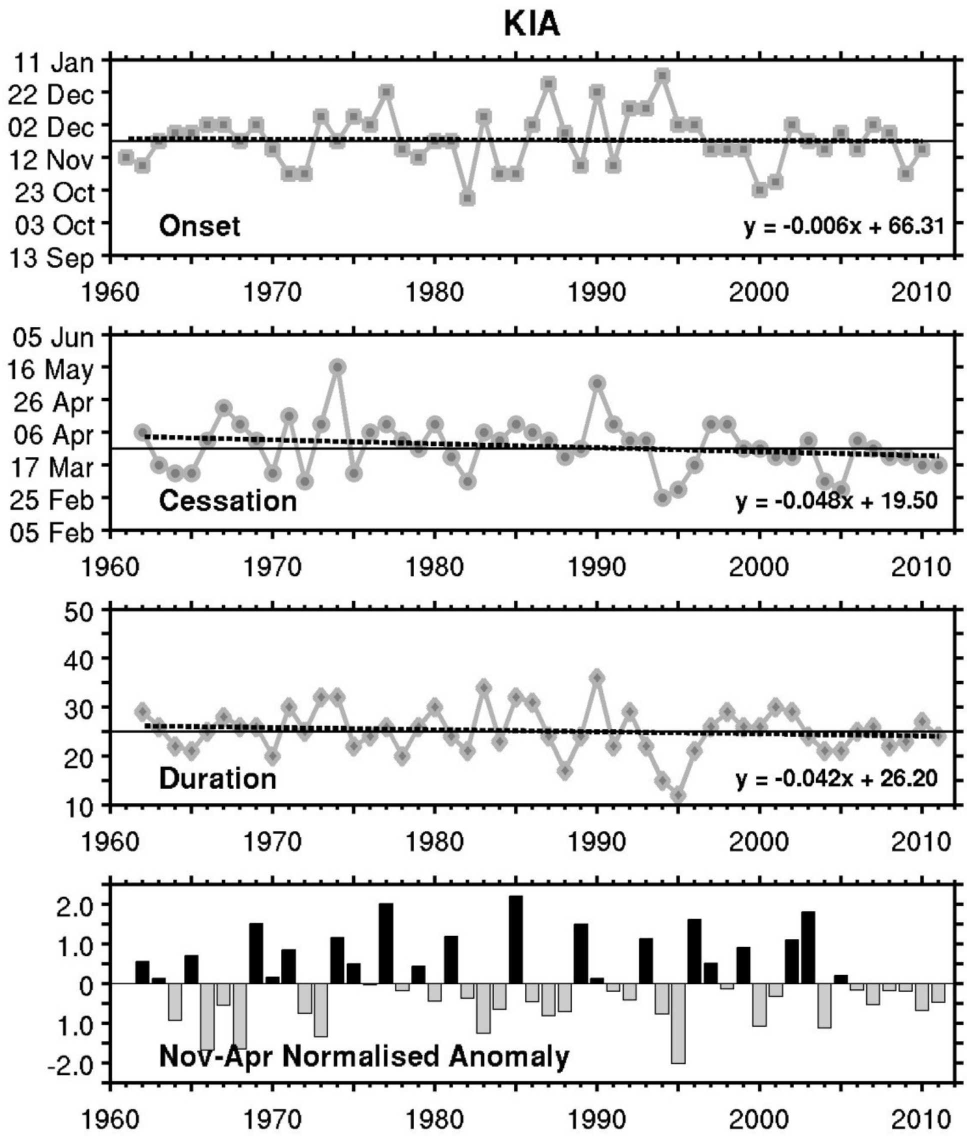


Figure E.2.1: The onset, cessation, duration (given in number of pentads) of the rainfall at KIA. The grey lines show the actual values, the solid black line shows the mean, while the dashed black line shows the trend (also shown is the trend equation). Trends that are significant at the 95% confidence level are highlighted with an asterisk (*) at the end of the equation.. The bottom panel shows the normalised anomaly of the November – April rainfall. The year on the x-axis refers to the January-April of the given summer for the bottom three panels (e.g. the 1961 / 1962 summer will be shown as 1962), while the x-axis for onset refers to the November-December (e.g. the 1961 / 1962 summer will be shown as 1961).

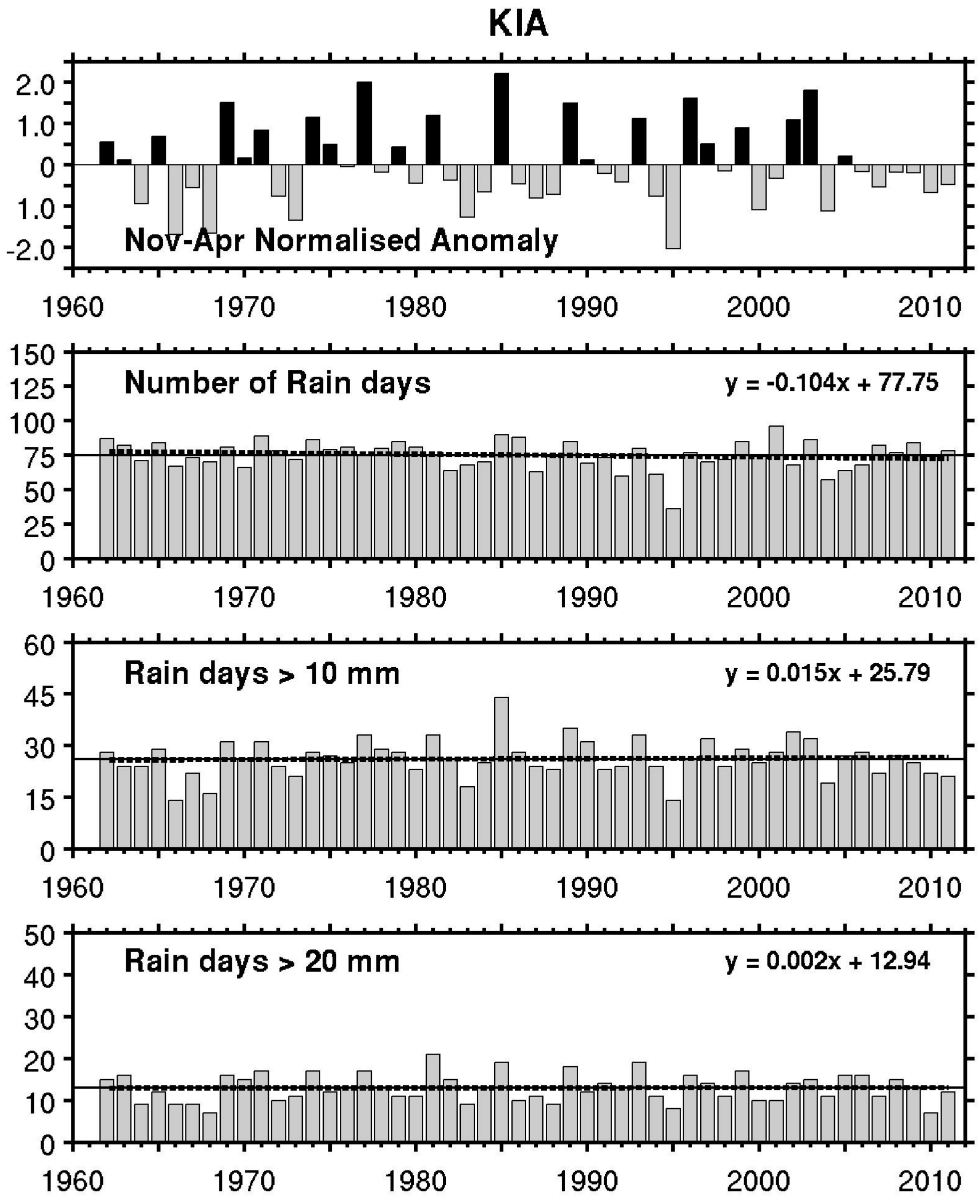


Figure E.2.2: The top panel shows the November – April normalised rainfall anomalies, while the bottom three panels show the number of days exceeding different thresholds (0.3 mm, 10 mm and 20 mm). All panels are for KIA. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962), while the y-axis for the top panel has no units and the other three are in days. Trends and equations are given (an '*' at the end of the equation signifies the trend is significant at the 95% confidence level).

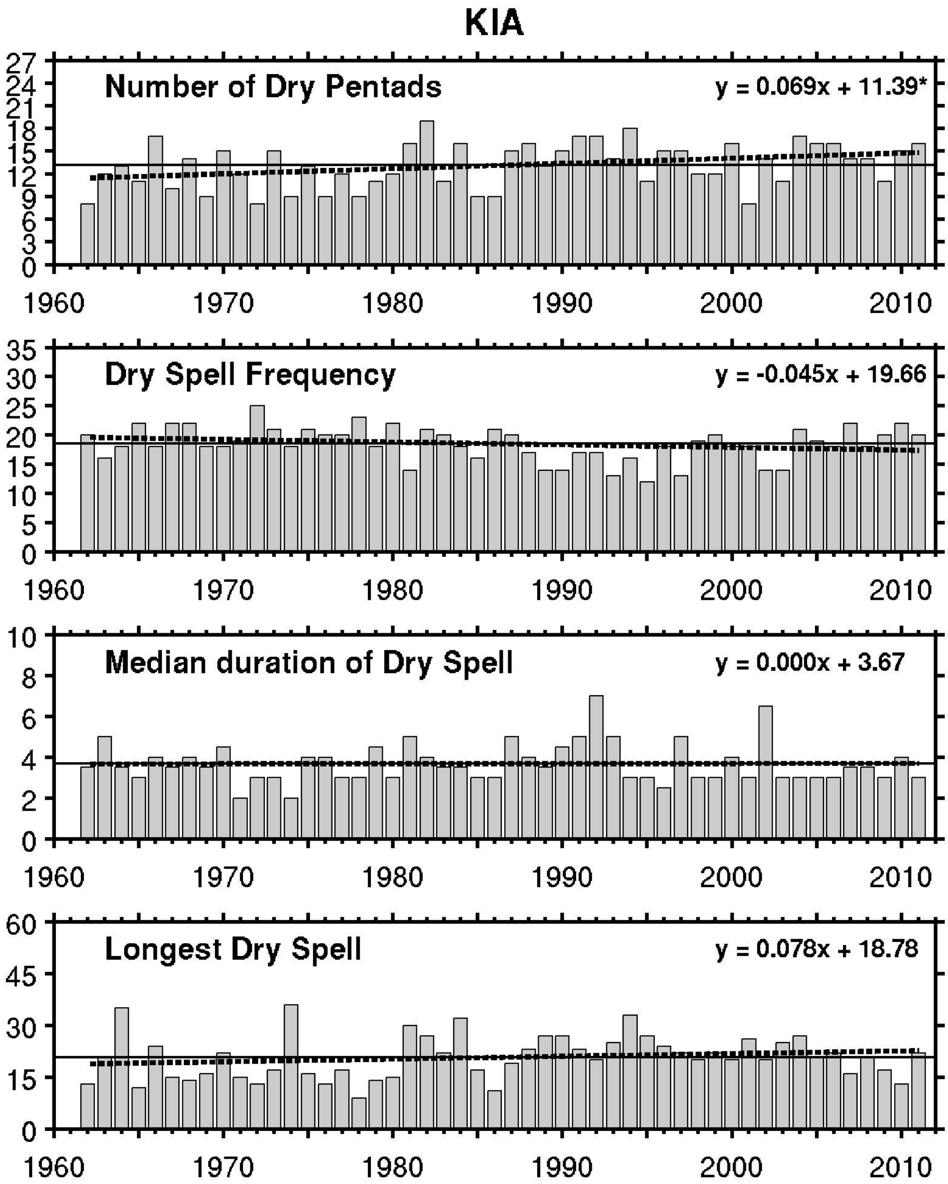


Figure E.2.3: Changes in the dry spells at KIA. The top panel shows the number of dry pentads (refer to the text to what this is), while the *Dry Spell Frequency* shows the number of times a dry spell (refer to the text to what this is) occurred per season. Also shown is the median duration of the dry spells as well as the longest dry spell during the season. Note that these are for the November – April period only. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962). The x-axis on the top panel has no units, while the bottom two panels are days. Trends and equations are given (an '*' at the end of the equation signifies the trend is significant at the 95% confidence level).

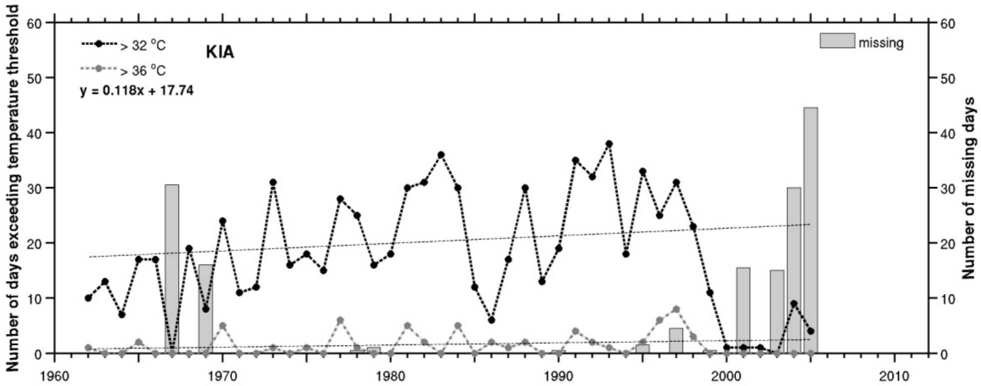


Figure E.2.4: The number of days exceeding 32°C (black dotted line) and 36°C (grey dotted line) at KIA during November - April. Also shown is the trend line (grey dashed) and equation (if significant at the 95% confidence level it is denoted with a '*') for the 32°C threshold only. The number of days with missing data are shown in grey bars (right y-axis). The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962).

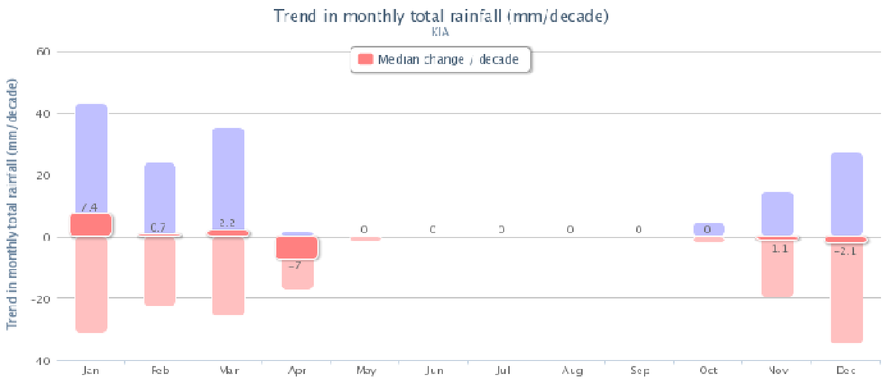


Figure E.2.5: Monthly changes in total rainfall at KIA (illustrated as changes in mm per decade).

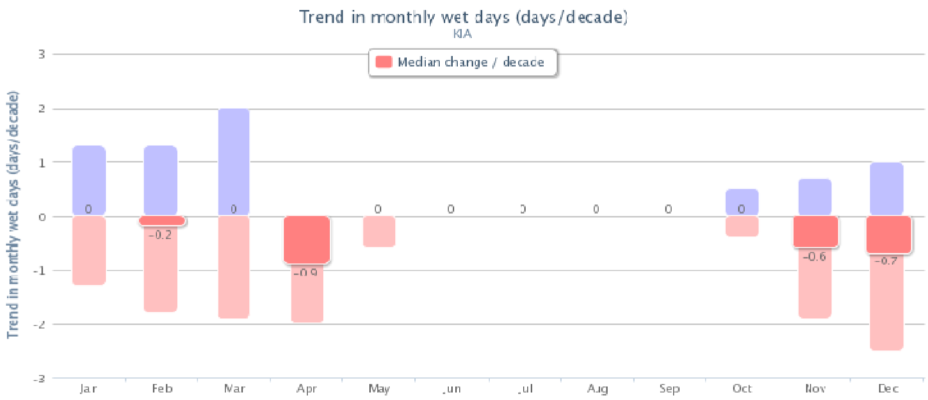


Figure E.2.6: Monthly change in the number of wet days at KIA (illustrated as changes in days per decade).

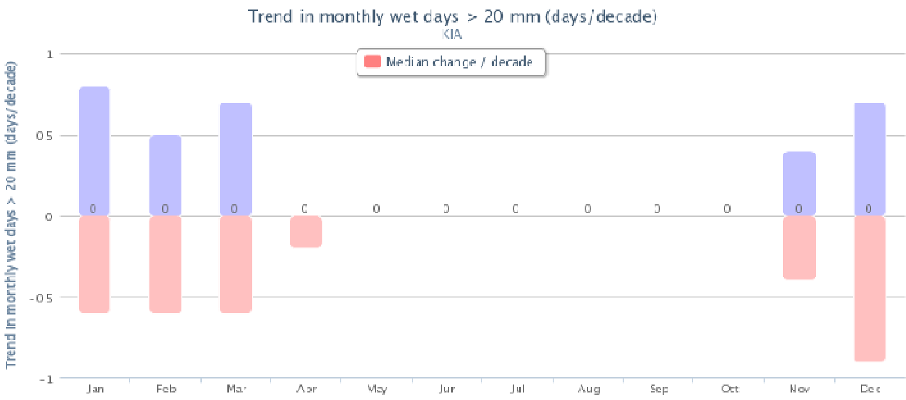


Figure E.2.7: Monthly change in the number of days exceeding 20 mm of rainfall at KIA (illustrated as changes in days per decade).

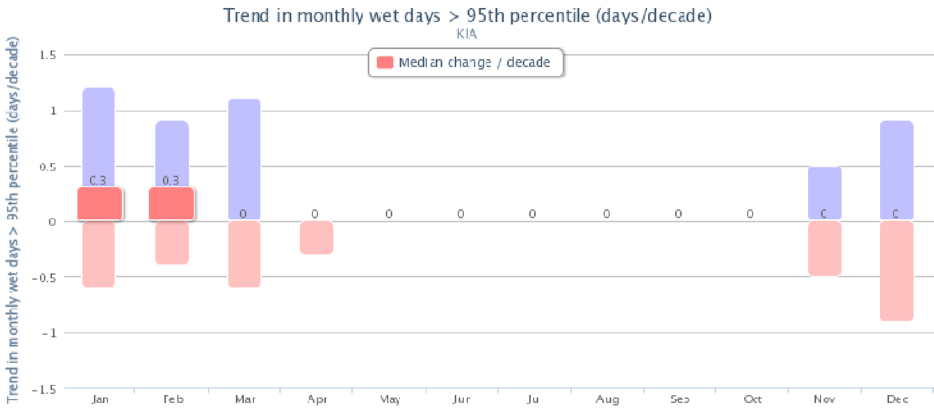


Figure E.2.8: Monthly change in the number of rain days exceeding the 95% percentile at KIA (illustrated as changes in days per decade).

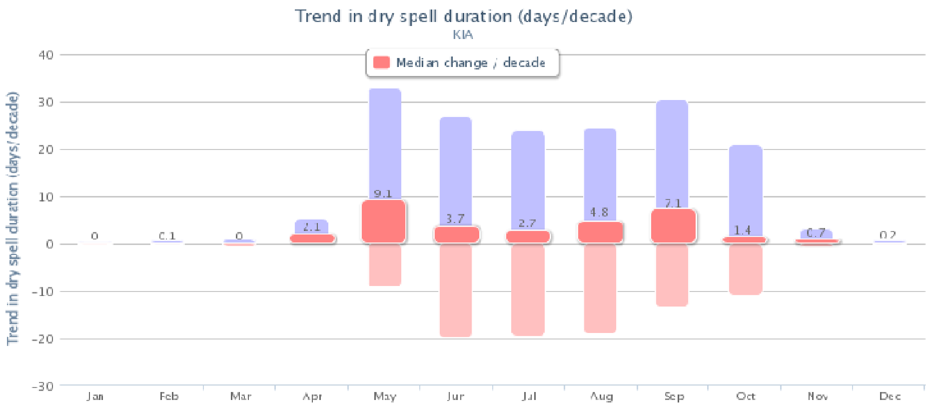


Figure E.2.9: Monthly change in the mean dry spell duration at KIA (illustrated as changes in days per decade).

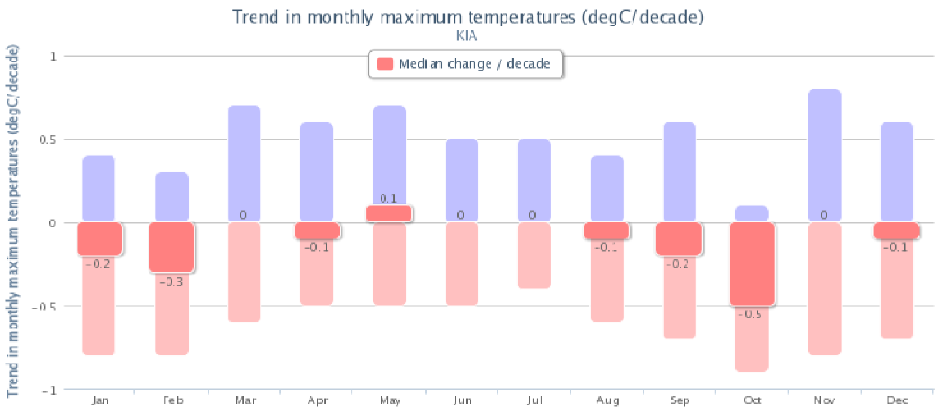


Figure E.2.10: Monthly change in the maximum temperature at KIA (illustrated as changes in °C per decade).

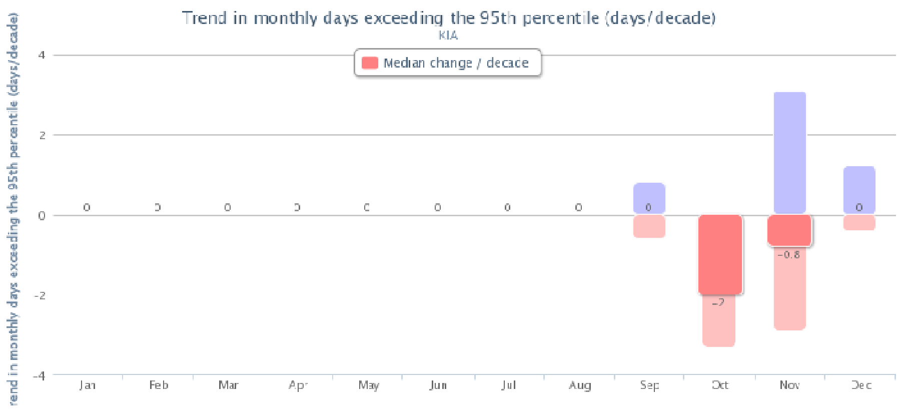


Figure E.2.11: Monthly change in the number of days exceeding the 95th percentile (temperature) at KIA (illustrated as changes in days per decade).

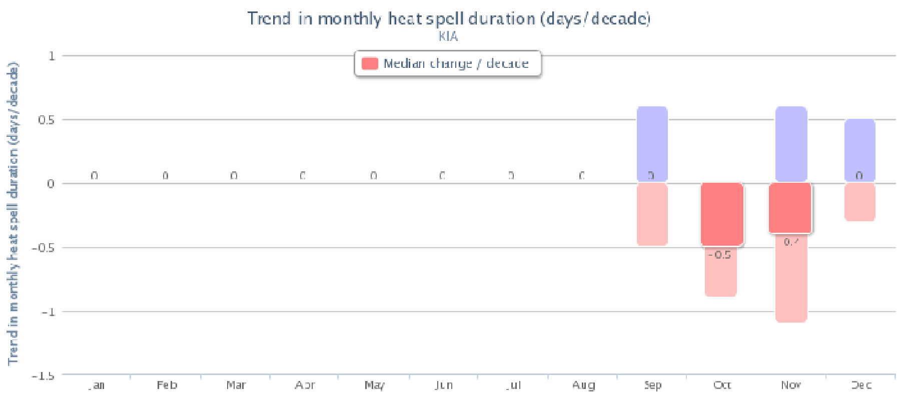


Figure E.2.12: Monthly change in the mean heat spell duration at KIA (illustrated as changes in days per decade).

E.3: MANGOCHI

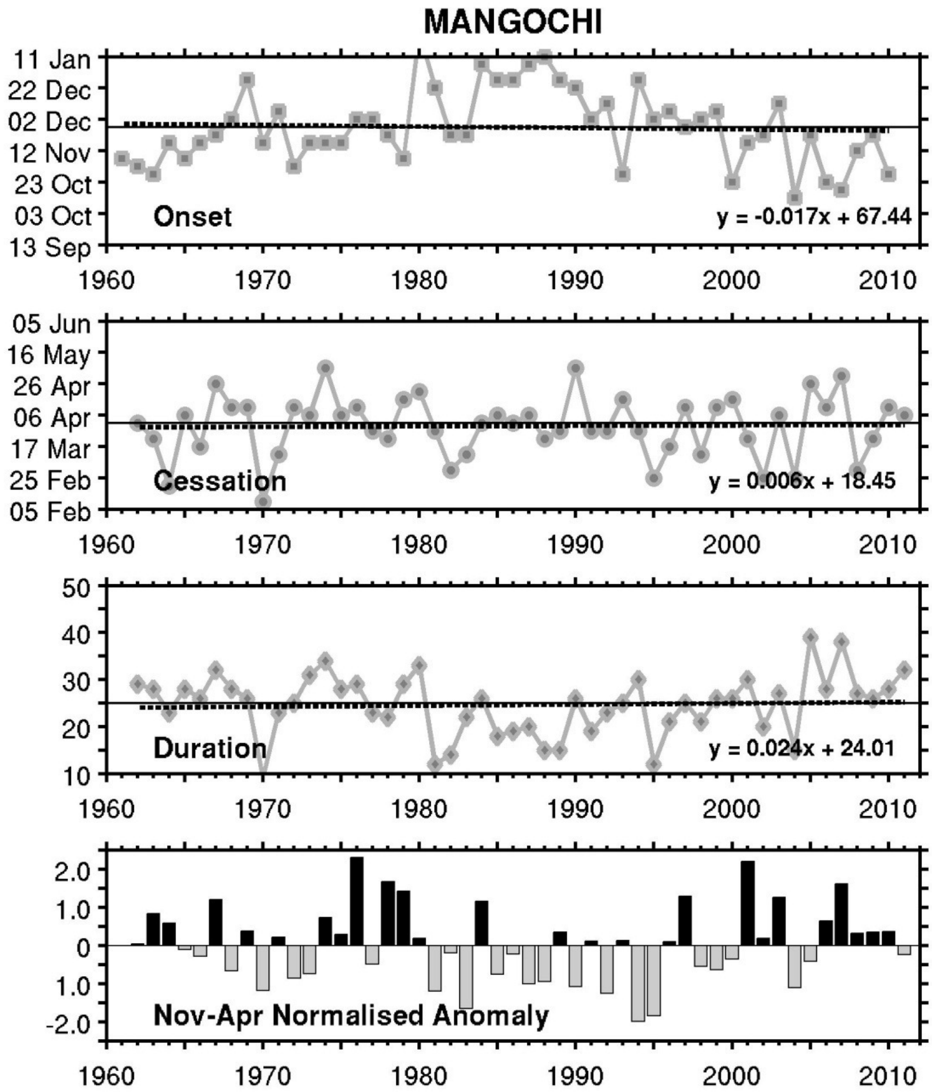


Figure E.3.1: The onset, cessation, duration (given in number of pentads) of the rainfall at MANGOCHI. The grey lines show the actual values, the solid black line shows the mean, while the dashed black line shows the trend (also shown is the trend equation). Trends that are significant at the 95% confidence level are highlighted with an asterisk (*) at the end of the equation. The bottom panel shows the normalised anomaly of the November – April rainfall. The year on the x-axis refers to the January-April of the given summer for the bottom three panels (e.g. the 1961 / 1962 summer will be shown as 1962), while the x-axis for onset refers to the November-December (e.g. the 1961 / 1962 summer will be shown as 1961).

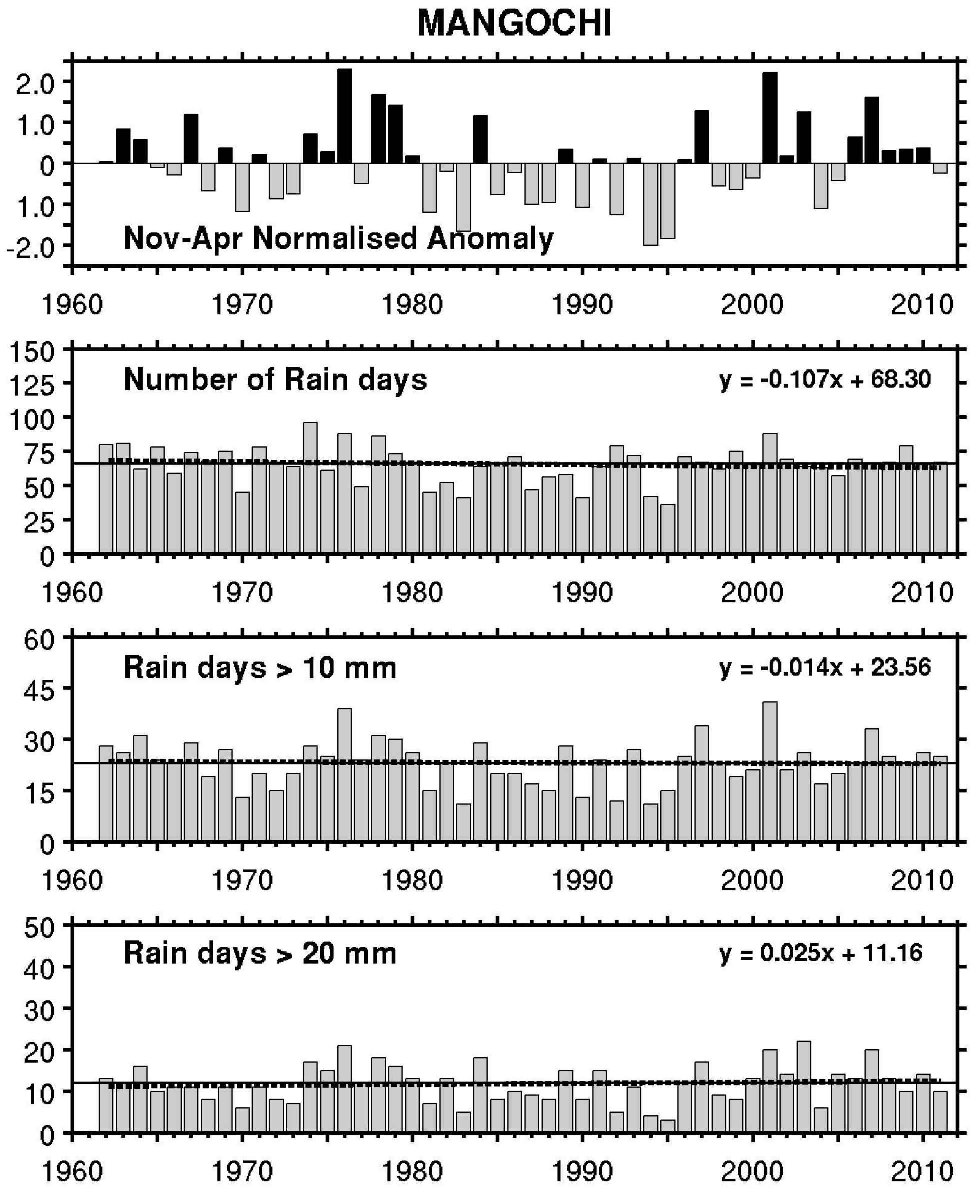


Figure E.3.2: The top panel shows the November – April normalised rainfall anomalies, while the bottom three panels show the number of days exceeding different thresholds (0.3 mm, 10 mm and 20 mm). All panels are for MANGOCHI. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962), while the y-axis for the top panel has no units and the other three are in days. Trends and equations are given (an '*' at the end of the equation signifies the trend is significant at the 95% confidence level).

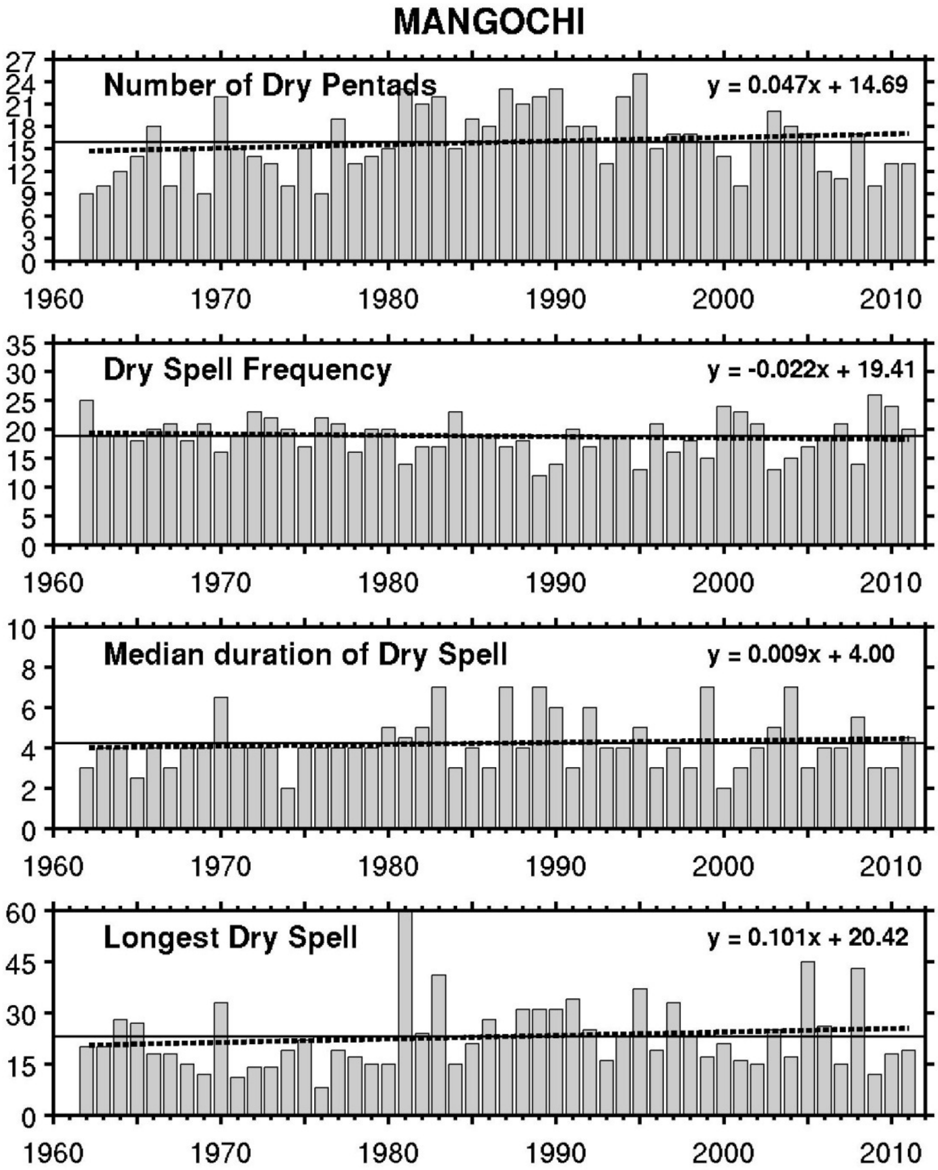


Figure E.3.3: Changes in the dry spells at MANGOCHI. The top panel shows the number of dry pentads (refer to the text to what this is), while the *Dry Spell Frequency* shows the number of times a dry spell (refer to the text to what this is) occurred per season. Also shown is the median duration of the dry spells as well as the longest dry spell during the season. Note that these are for the November – April period only. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962). The x-axis on the top panel has no units, while the bottom two panels are days. Trends and equations are given (an '*' at the end of the equation signifies the trend is significant at the 95% confidence level).

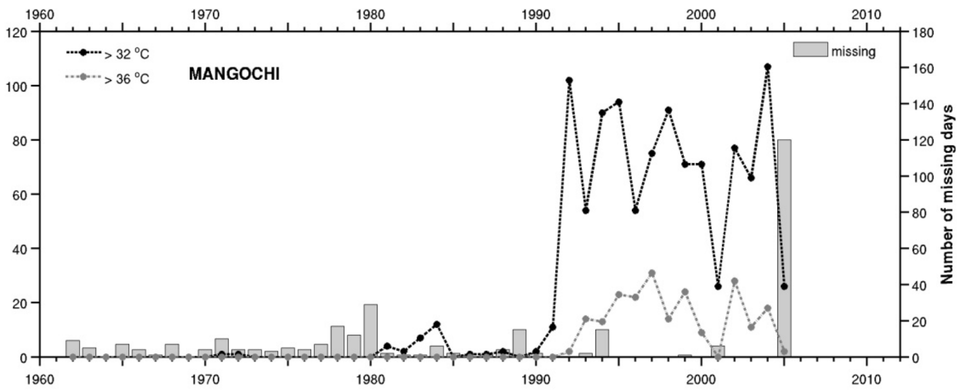


Figure E.3.4: The number of days exceeding 32°C (black dotted line) and 36°C (grey dotted line) at MANGOCHI during November - April. Also shown is the number of days with missing data (grey bars), corresponding with the right y-axis. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962), while y-axis is number of days.

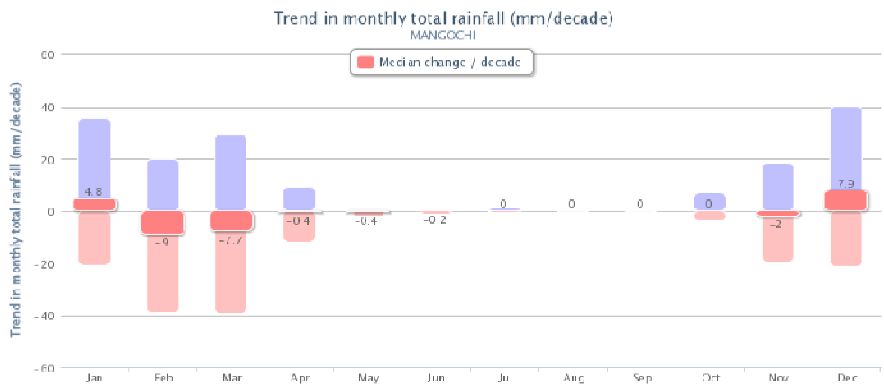


Figure E.3.5: Monthly changes in total rainfall at MANGOCHI (illustrated as changes in mm per decade).

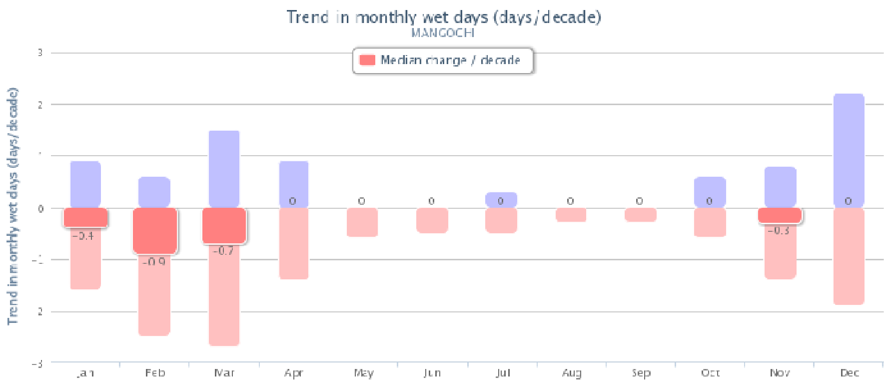


Figure E.3.6: Monthly change in the number of wet days at MANGOCHI (illustrated as changes in days per decade).

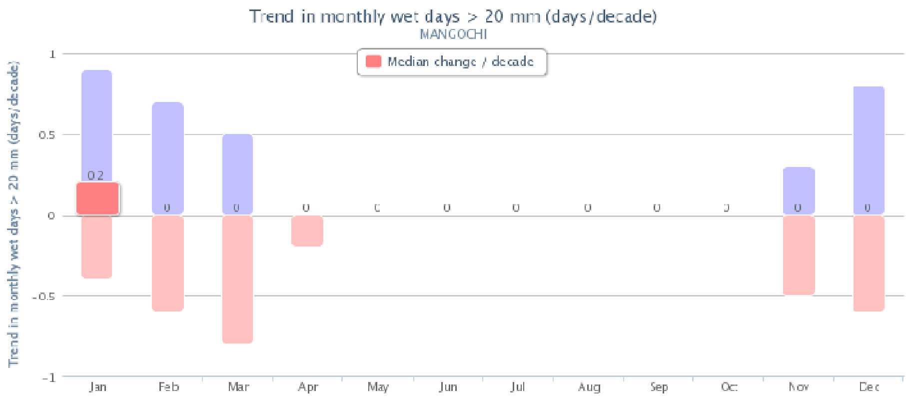


Figure E.3.7: Monthly change in the number of days exceeding 20 mm of rainfall at MANGOCHI (illustrated as changes in days per decade).

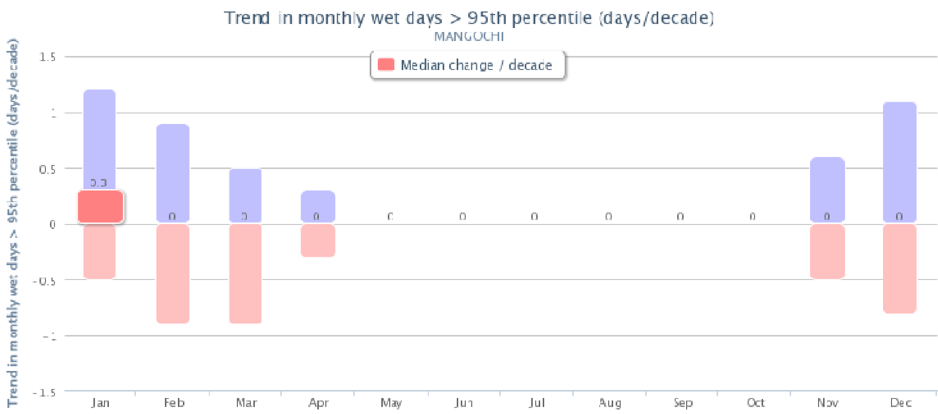


Figure E.3.8: Monthly change in the number of rain days exceeding the 95% percentile at MANGOCHI (illustrated as changes in days per decade).

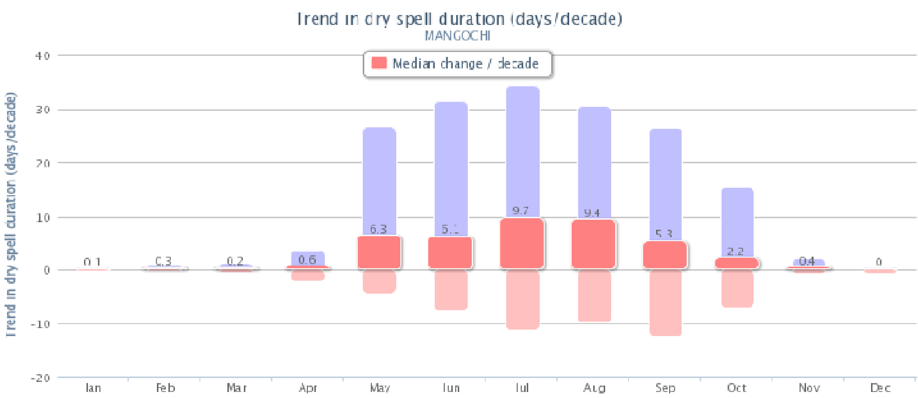


Figure E.3.9: Monthly change in the mean dry spell duration at MANGOCHI (illustrated as changes in days per decade).

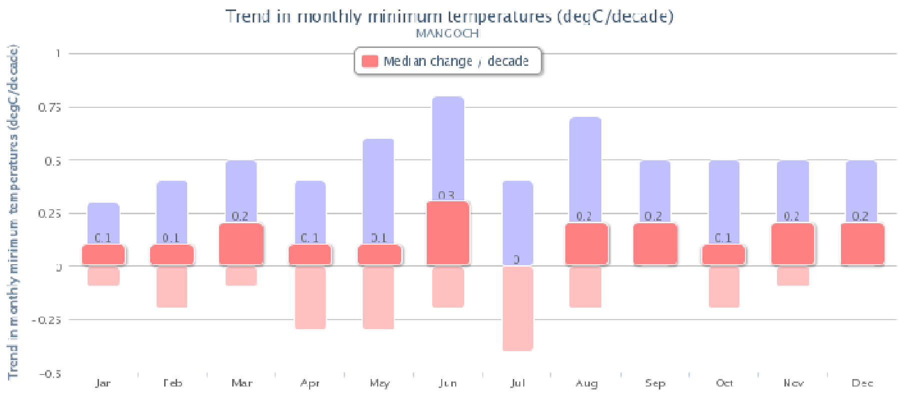


Figure E.3.10: Monthly change in the minimum temperature at BVUMBWE (illustrated as changes in °C per decade).

E.4: NGABU

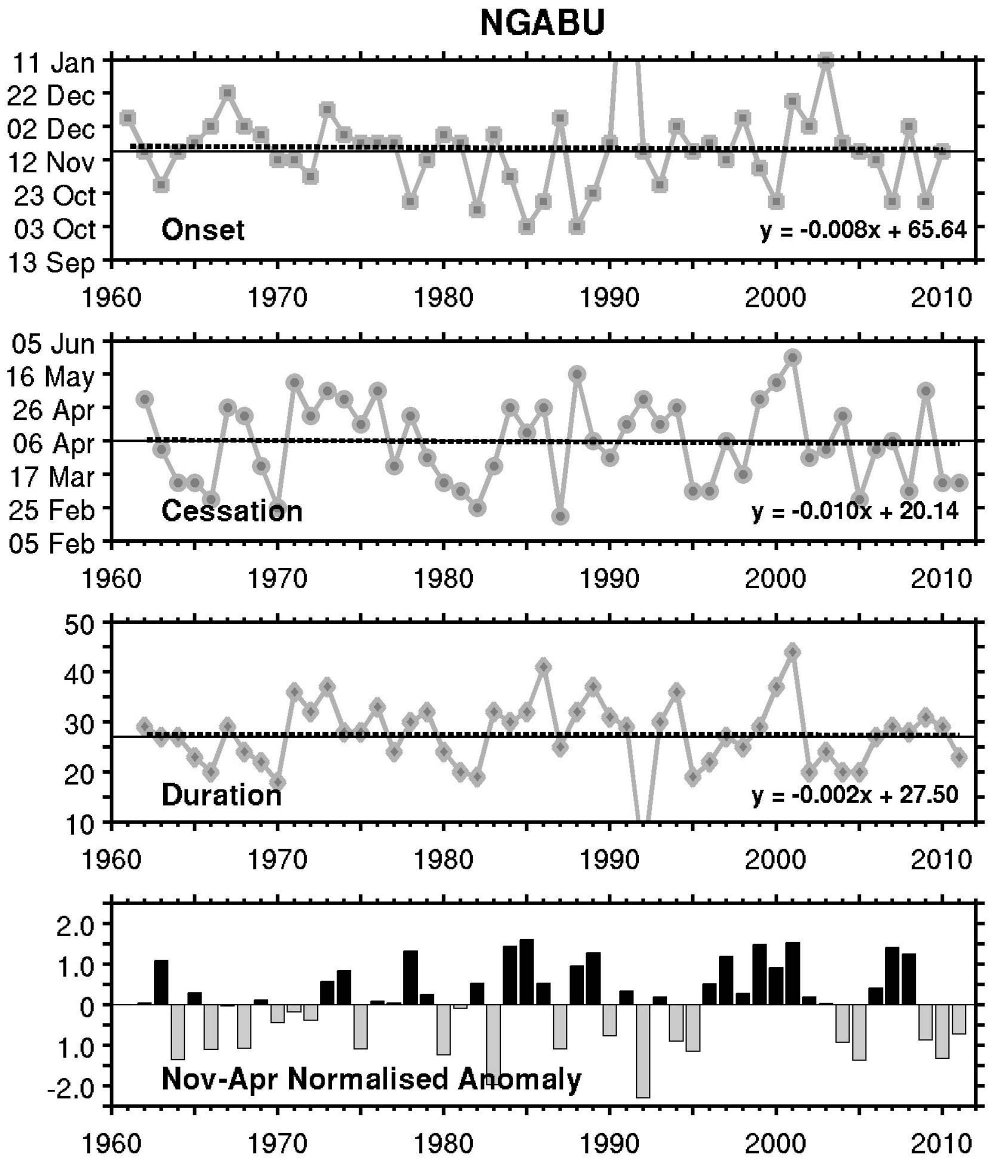


Figure E.4.1: The onset, cessation, duration (given in number of pentads) of the rainfall at NGABU. The grey lines show the actual values, the solid black line shows the mean, while the dashed black line shows the trend (also shown is the trend equation). Trends that are significant at the 95% confidence level are highlighted with an asterisk (*) at the end of the equation. The bottom panel shows the normalised anomaly of the November – April rainfall. The year on the x-axis refers to the January-April of the given summer for the bottom three panels (e.g. the 1961 / 1962 summer will be shown as 1962), while the x-axis for onset refers to the November-December (e.g. the 1961 / 1962 summer will be shown as 1961).

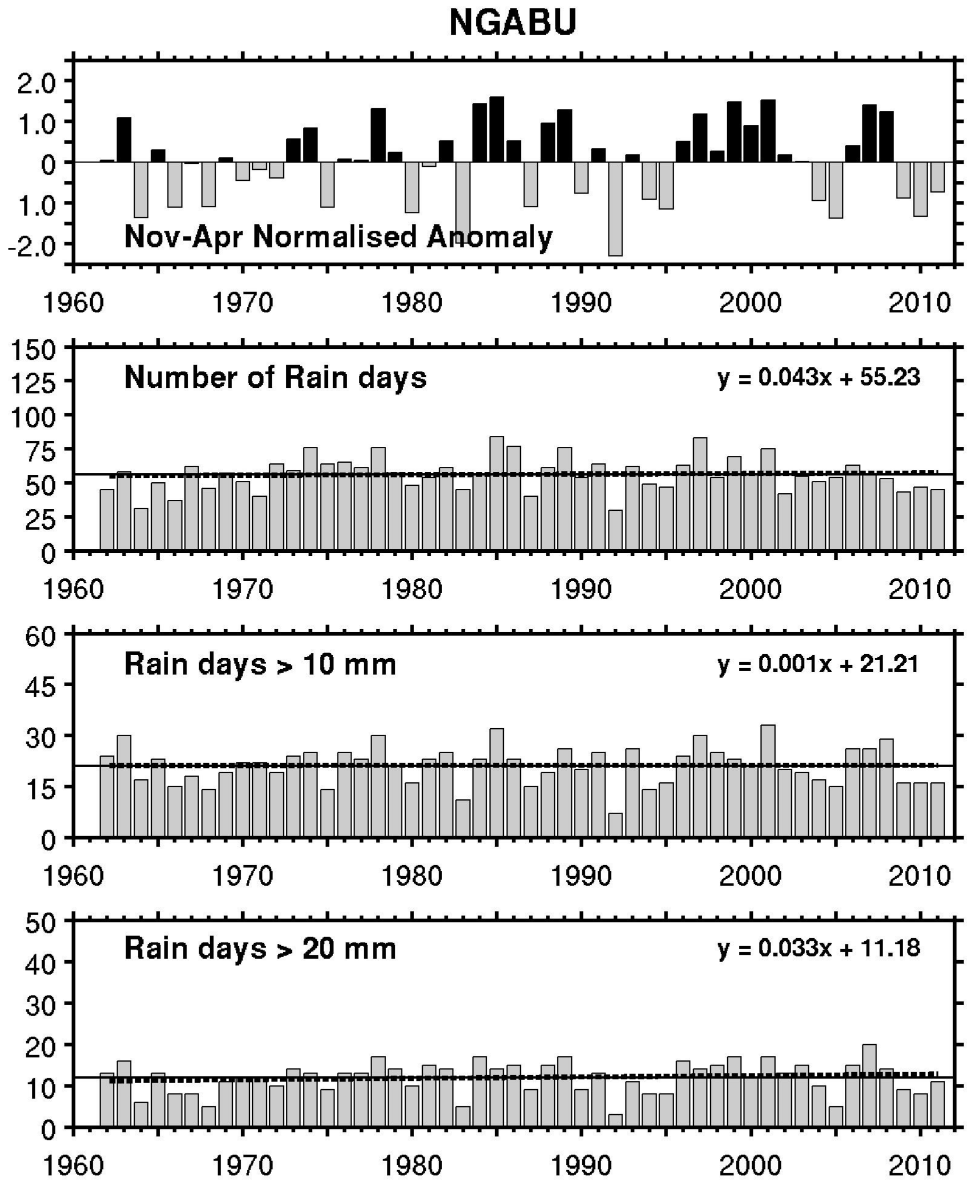


Figure E.4.2: The top panel shows the November – April normalised rainfall anomalies, while the bottom three panels show the number of days exceeding different thresholds (0.3 mm, 10 mm and 20 mm). All panels are for NGABU. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962), while the y-axis for the top panel has no units and the other three are in days. Trends and equations are given (an '*' at the end of the equation signifies the trend is significant at the 95% confidence level).

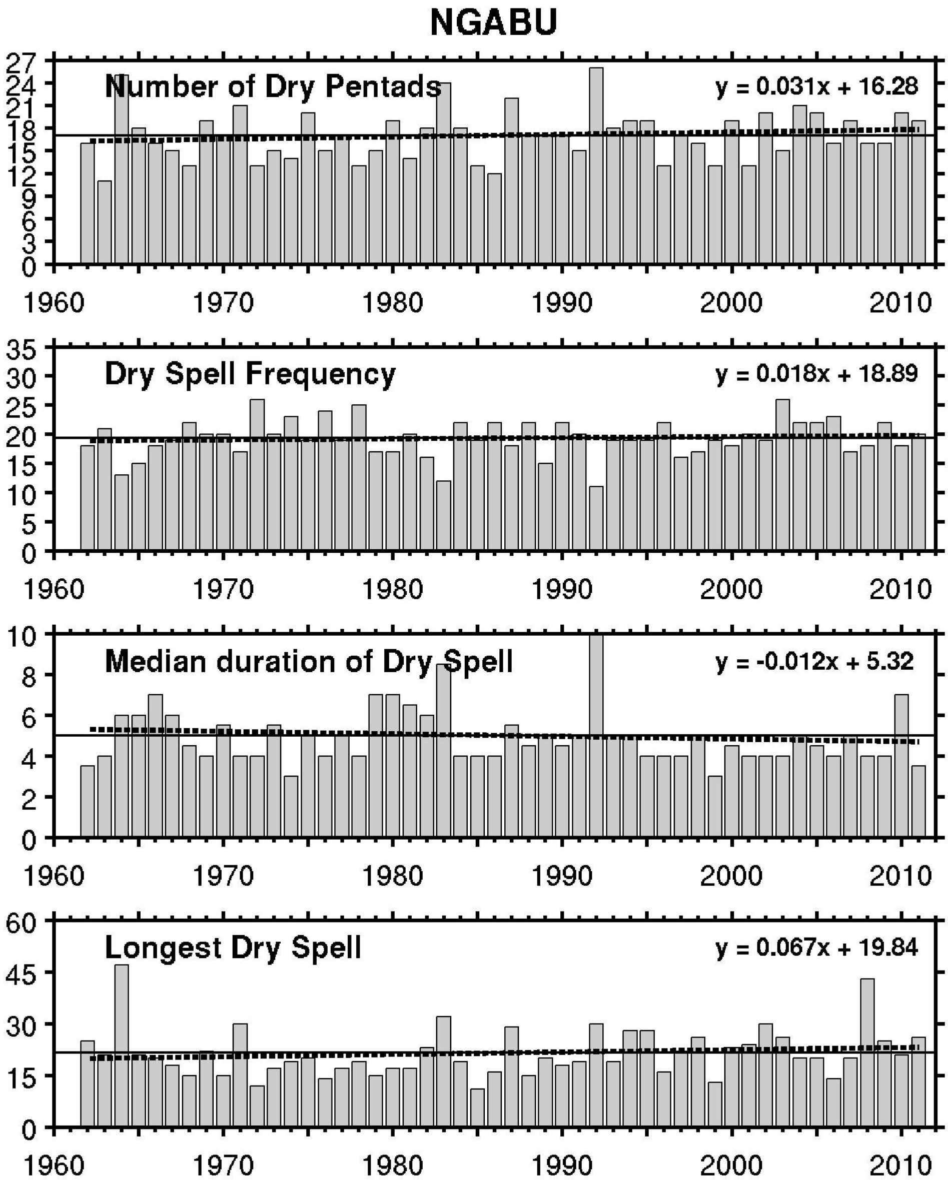


Figure E.4.3: Changes in the dry spells at NGABU. The top panel shows the number of dry pentads (refer to the text to what this is), while the *Dry Spell Frequency* shows the number of times a dry spell (refer to the text to what this is) occurred per season. Also shown is the median duration of the dry spells as well as the longest dry spell during the season. Note that these are for the November – April period only. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962). The x-axis on the top panel has no units, while the bottom two panels are days. Trends and equations are given (an '*' at the end of the equation signifies the trend is significant at the 95% confidence level).

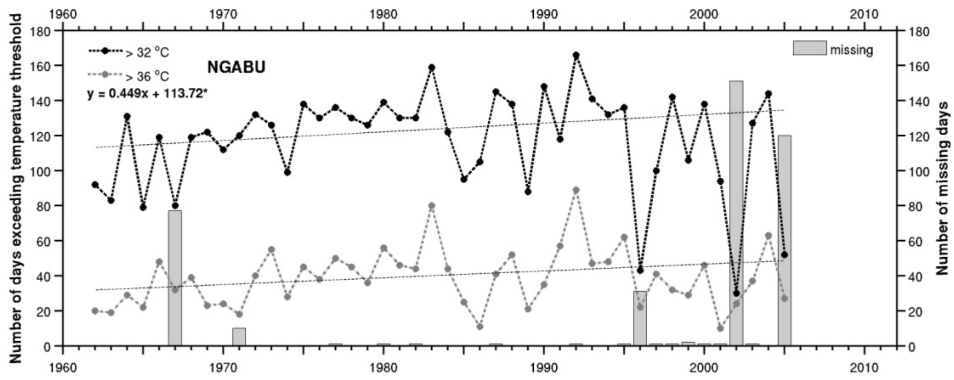


Figure E.4.4: The number of days exceeding 32°C (black dotted line) and 36°C (grey dotted line) at NGABU during November - April. Also shown is the trend line (grey dashed) and equation (if significant at the 95% confidence level it is denoted with a '*') for the 32°C threshold only. The number of days with missing data are shown in grey bars (right y-axis). The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962).

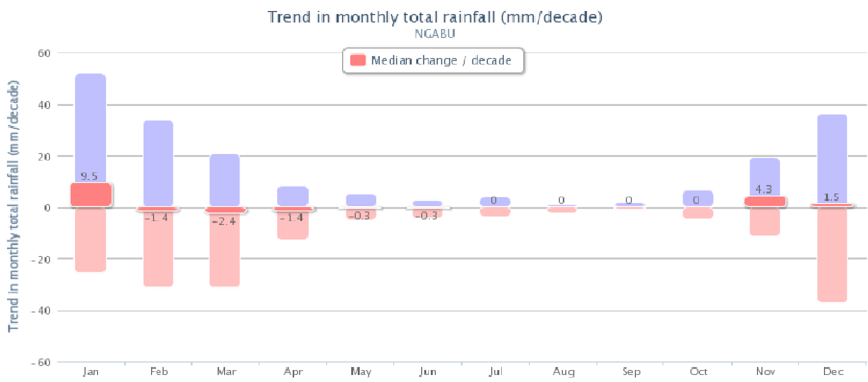


Figure E.4.5: Monthly changes in total rainfall at NGABU (illustrated as changes in mm per decade).

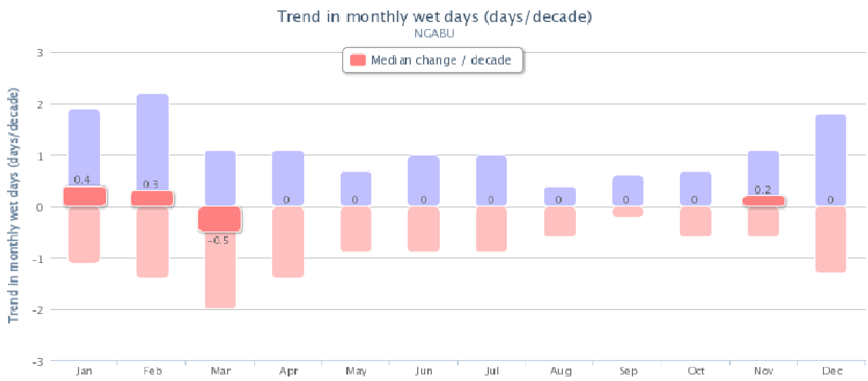


Figure E.4.6: Monthly change in the number of wet days at NGABU (illustrated as changes in days per decade).

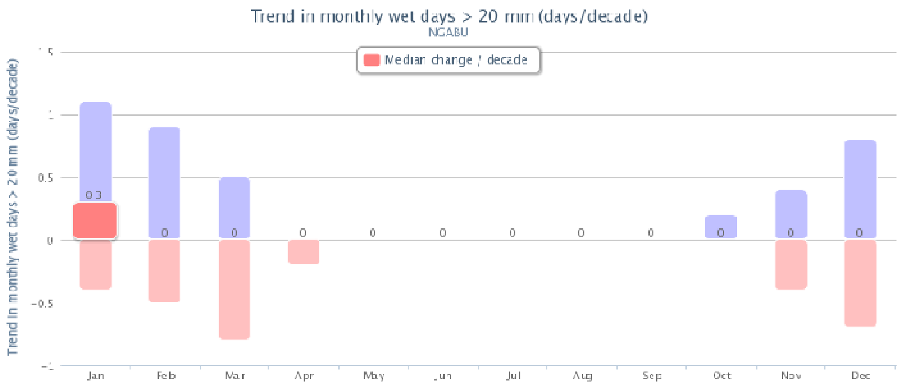


Figure E.4.7: Monthly change in the number of days exceeding 20 mm of rainfall at NGABU (illustrated as changes in days per decade).

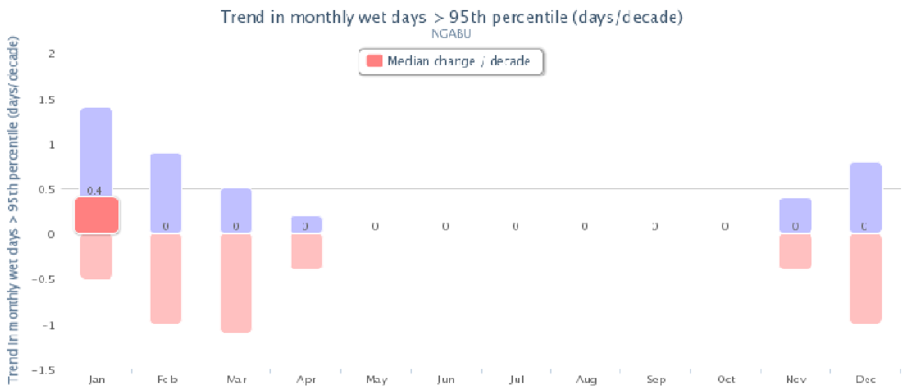


Figure E.4.8: Monthly change in the number of rain days exceeding the 95% percentile at NGABU (illustrated as changes in days per decade).

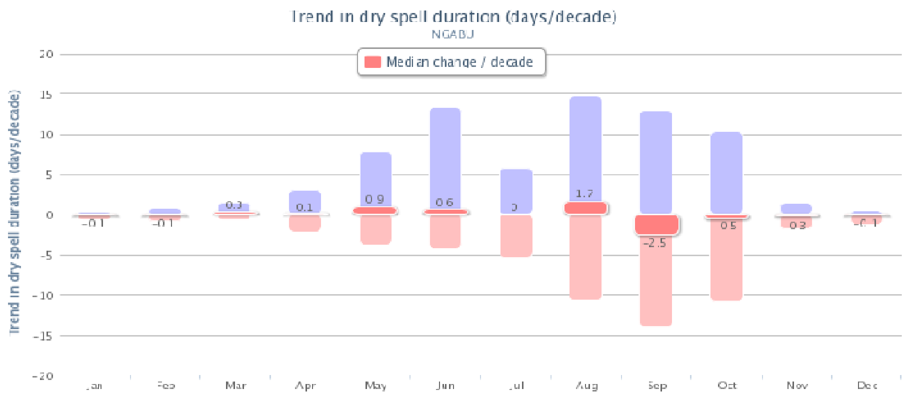


Figure E.4.9: Monthly change in the mean dry spell duration at NGABU (illustrated as changes in days per decade).

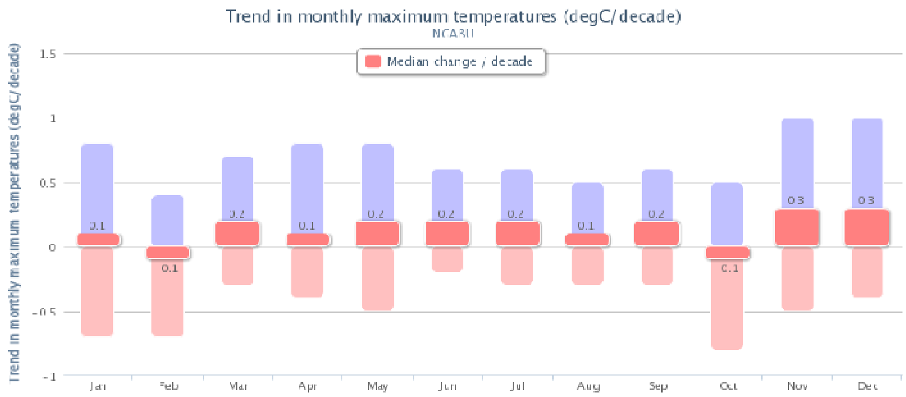


Figure E.4.10: Monthly change in the maximum temperature at NGABU (illustrated as changes in °C per decade).

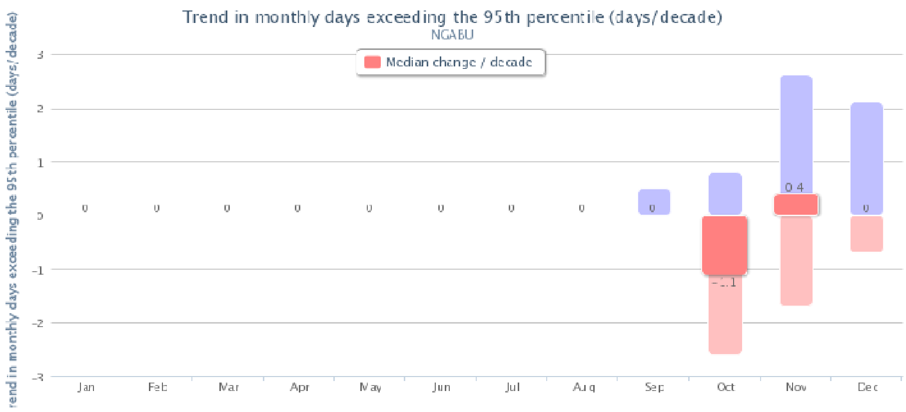


Figure E.4.11: Monthly change in the number of days exceeding the 95th percentile (temperature) at NGABU (illustrated as changes in days per decade).

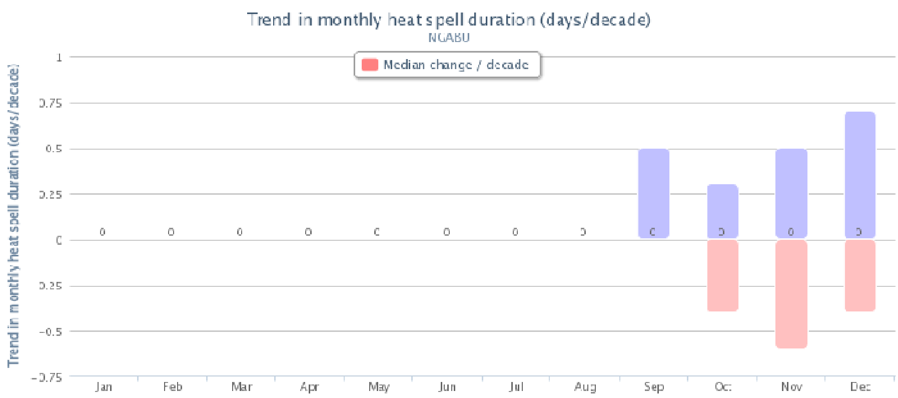


Figure E.4.12: Monthly change in the mean heat spell duration at NGABU (illustrated as changes in days per decade).

E.5: NKHOTA-KOTA

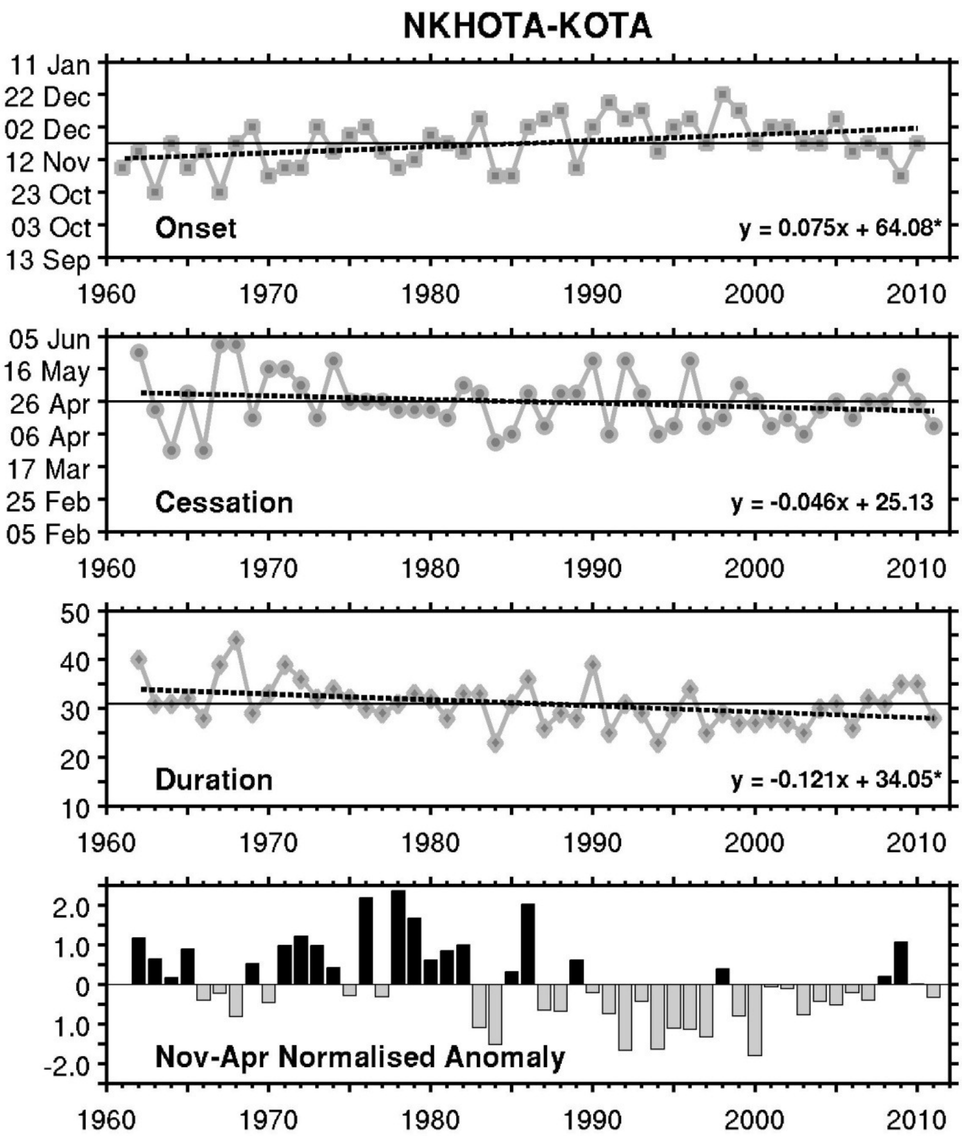


Figure E.5.1: The onset, cessation, duration (given in number of pentads) of the rainfall at NKHOTA-KOTA. The grey lines show the actual values, the solid black line shows the mean, while the dashed black line shows the trend (also shown is the trend equation). Trends that are significant at the 95% confidence level are highlighted with an asterisk (*) at the end of the equation. The bottom panel shows the normalised anomaly of the November – April rainfall. The year on the x-axis refers to the January-April of the given summer for the bottom three panels (e.g. the 1961 / 1962 summer will be shown as 1962), while the x-axis for onset refers to the November-December (e.g. the 1961 / 1962 summer will be shown as 1961).

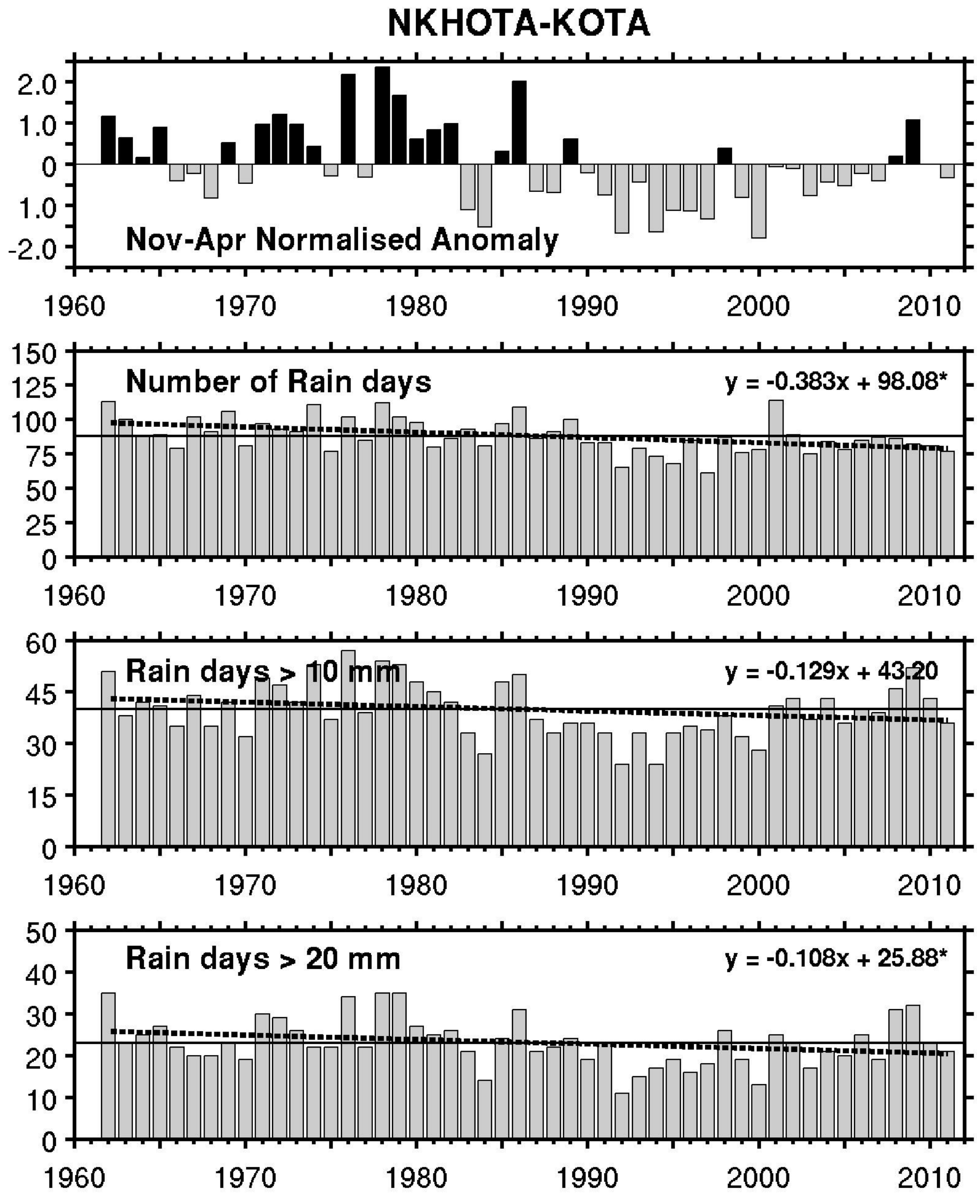


Figure E.5.2: The top panel shows the November – April normalised rainfall anomalies, while the bottom three panels show the number of days exceeding different thresholds (0.3 mm, 10 mm and 20 mm). All panels are for NKHOTA-KOTA. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962), while the y-axis for the top panel has no units and the other three are in days. Trends and equations are given (an '*' at the end of the equation signifies the trend is significant at the 95% confidence level).

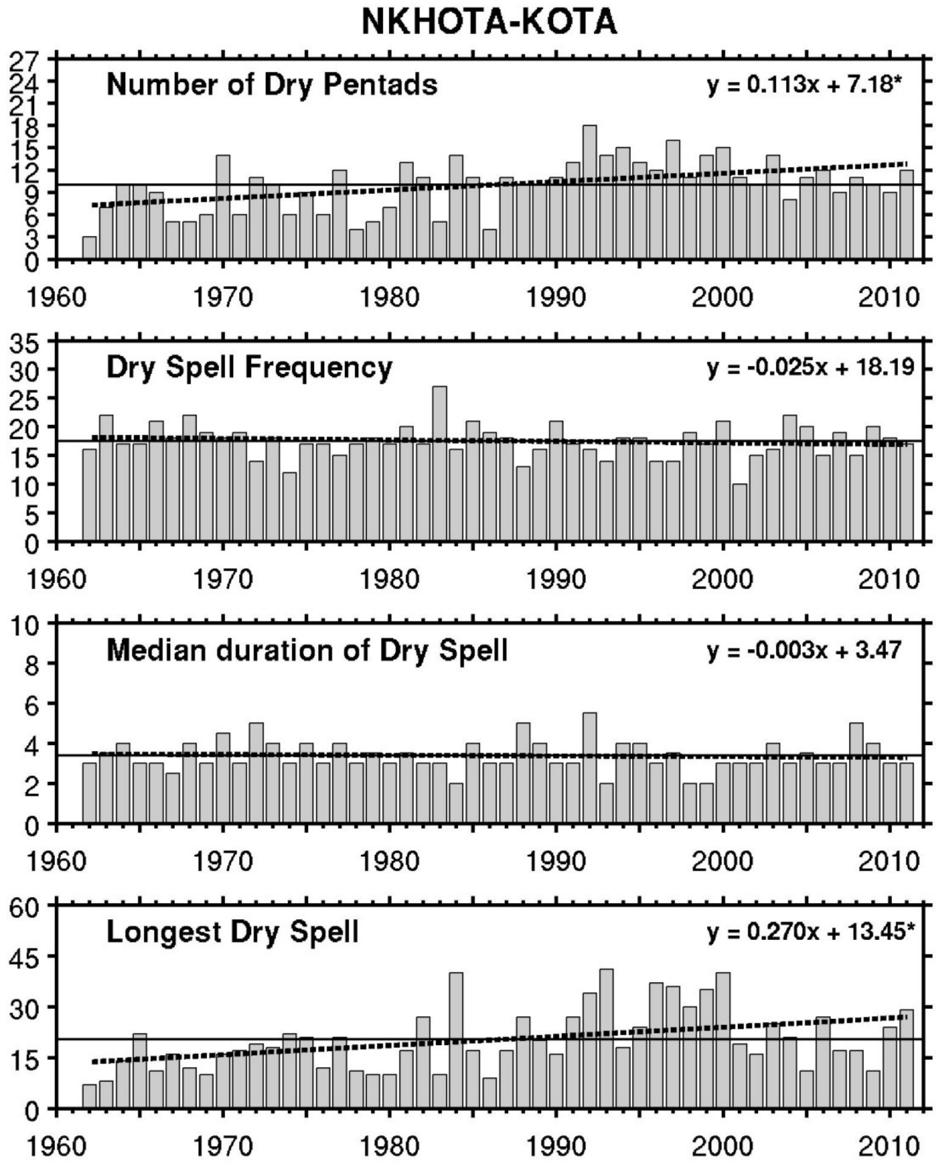


Figure E.5.3: Changes in the dry spells at NKHOTA-KOTA. The top panel shows the number of dry pentads (refer to the text to what this is), while the *Dry Spell Frequency* shows the number of times a dry spell (refer to the text to what this is) occurred per season. Also shown is the median duration of the dry spells as well as the longest dry spell during the season. Note that these are for the November – April period only. The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962). The x-axis on the top panel has no units, while the bottom two panels are days. Trends and equations are given (an '*' at the end of the equation signifies the trend is significant at the 95% confidence level).

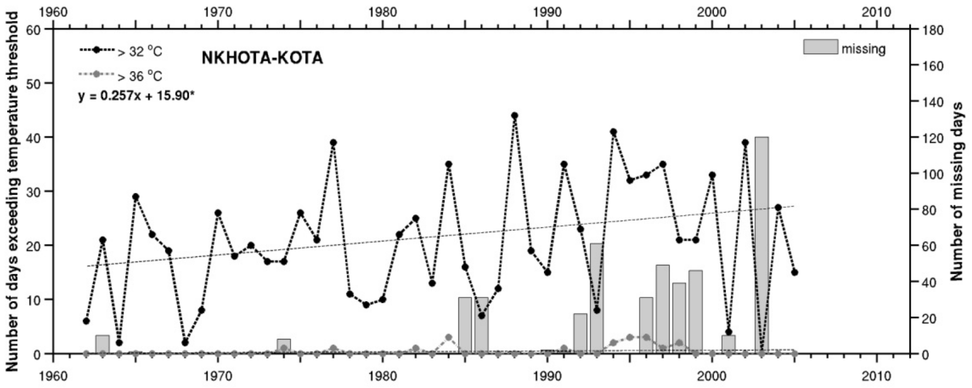


Figure E.5.4: The number of days exceeding 32°C (black dotted line) and 36°C (grey dotted line) at NKHOTA-KOTA during November - April. Also shown is the trend line (grey dashed) and equation (if significant at the 95% confidence level it is denoted with a '*') for the 32°C threshold only. The number of days with missing data are shown in grey bars (right y-axis). The year on the x-axis refers to the January-April of the given summer (e.g. the 1961/1962 summer will be shown as 1962).

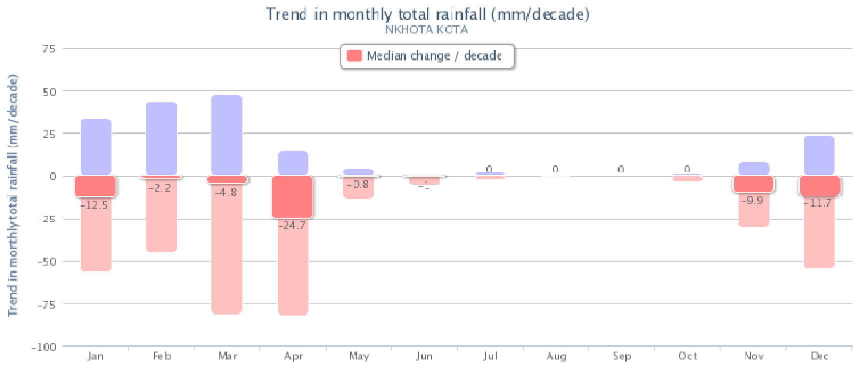


Figure E.5.5: Monthly changes in total rainfall at NKHOTA-KOTA (illustrated as changes in mm per decade).

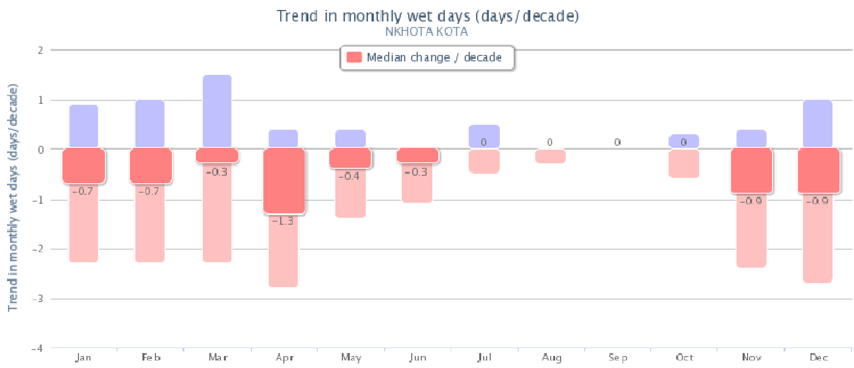


Figure E.5.6: Monthly change in the number of wet days at NKHOTA-KOTA (illustrated as changes in days per decade).

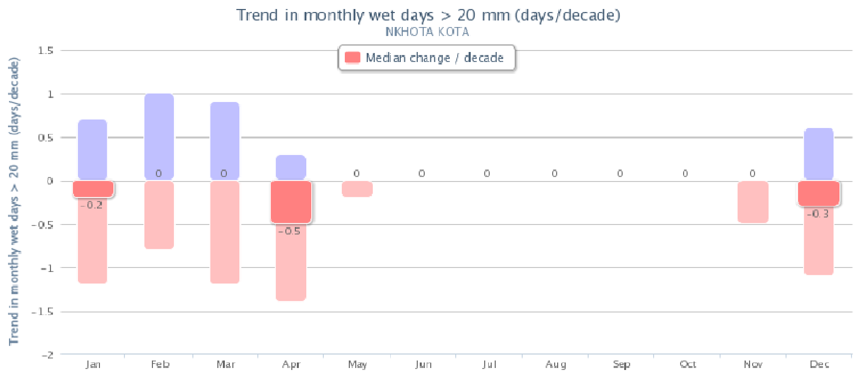


Figure E.5.7: Monthly change in the number of days exceeding 20 mm of rainfall at NKHOTA-KOTA (illustrated as changes in days per decade).

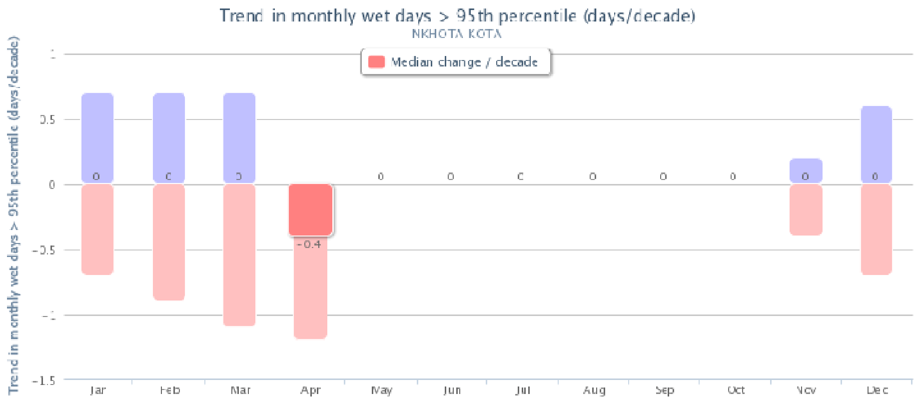


Figure E.5.8: Monthly change in the number of rain days exceeding the 95% percentile at NKHOTA-KOTA (illustrated as changes in days per decade).

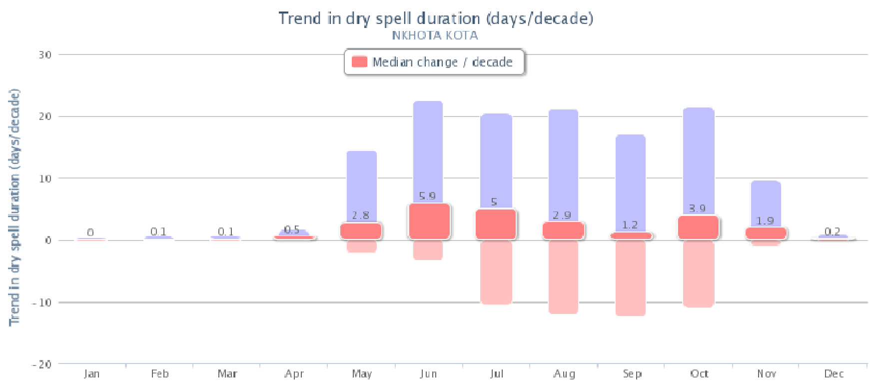


Figure E.5.9: Monthly change in the mean dry spell duration at NKHOTA-KOTA (illustrated as changes in days per decade).

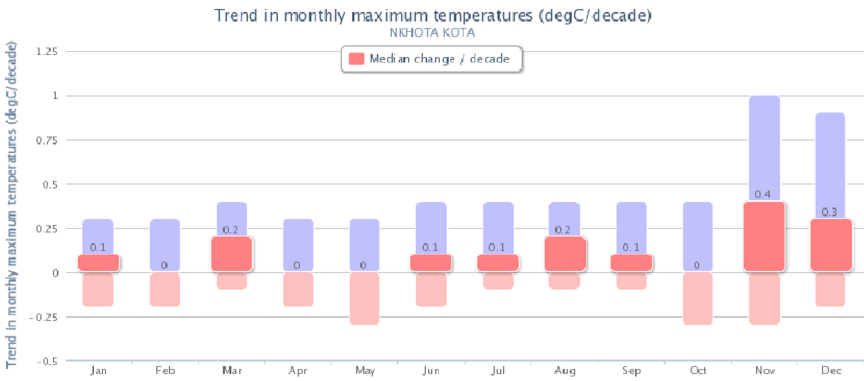


Figure E.5.10: Monthly change in the maximum temperature at NKHOTA-KOTA (illustrated as changes in °C per decade).

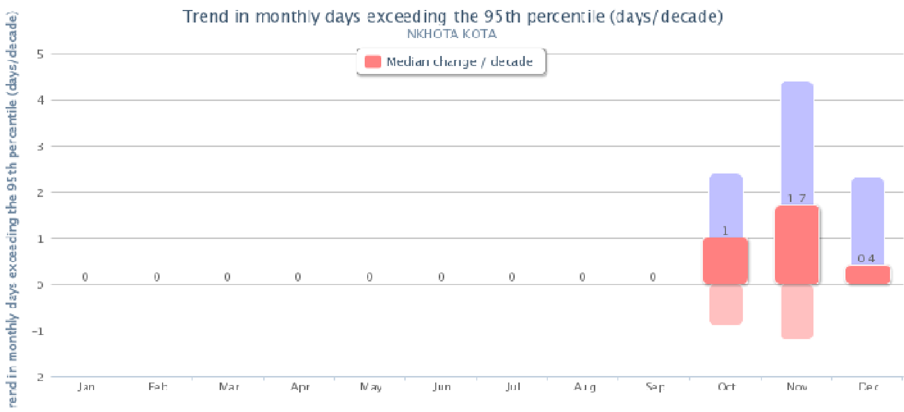


Figure E.5.11: Monthly change in the number of days exceeding the 95th percentile (temperature) at NKHOTA-KOTA (illustrated as changes in days per decade).

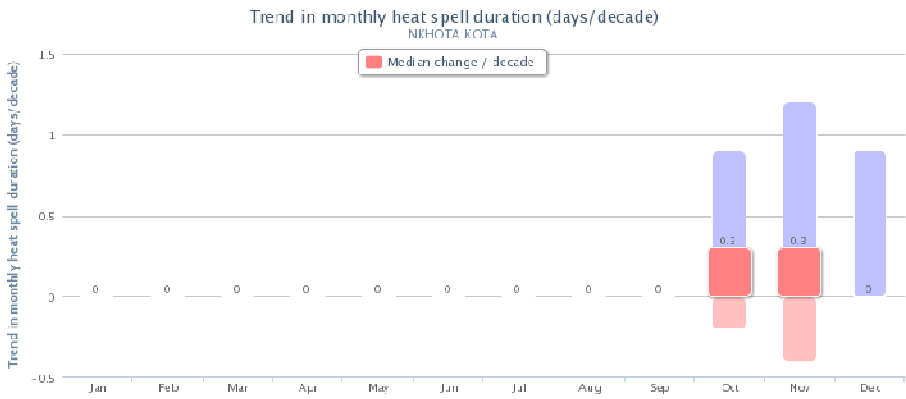


Figure E.5.12: Monthly change in the mean heat spell duration at NKHOTA-KOTA (illustrated as changes in days per decade).

APPENDIX B – FUTURE PROJECTIONS (PERIOD 2020-2040)

B.1: Climate Summary for BOLERO

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

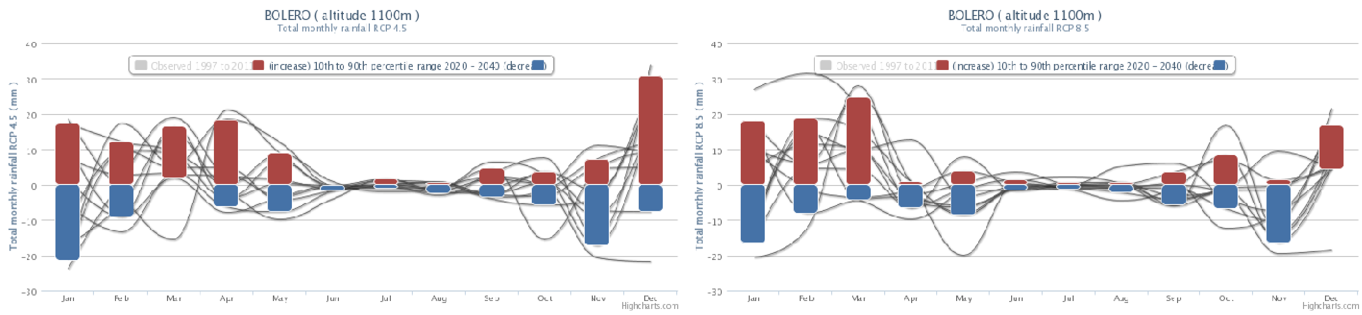


Figure B.1.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Projected change in monthly mean dry spell duration change

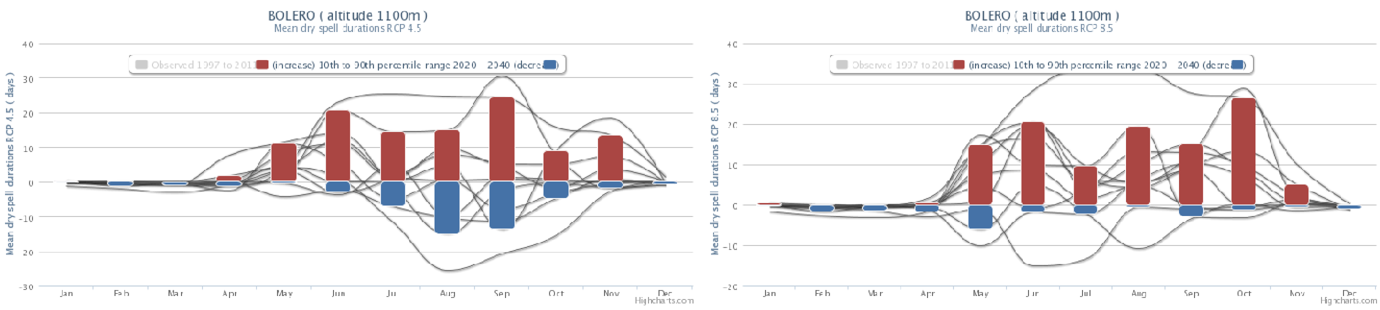


Figure B.1.2: Change in monthly mean dry spell duration (< 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Projected change in monthly mean rain day frequency

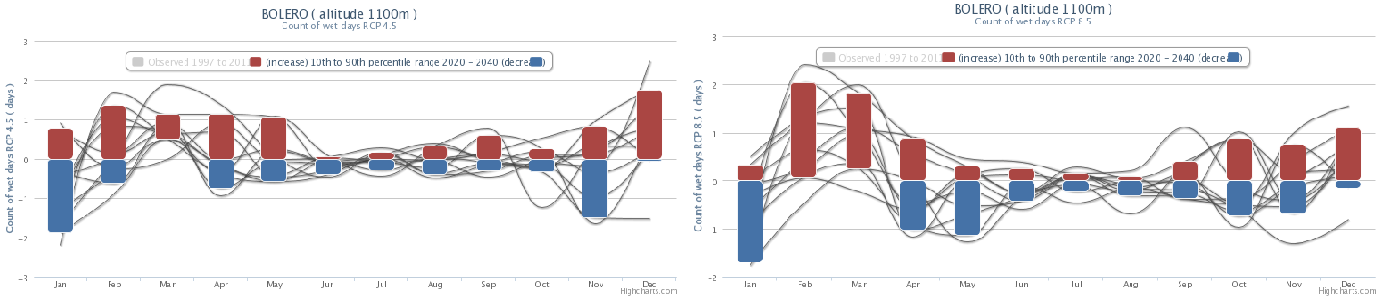


Figure B.1.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Projected change in monthly mean rain day frequency (> 20mm)

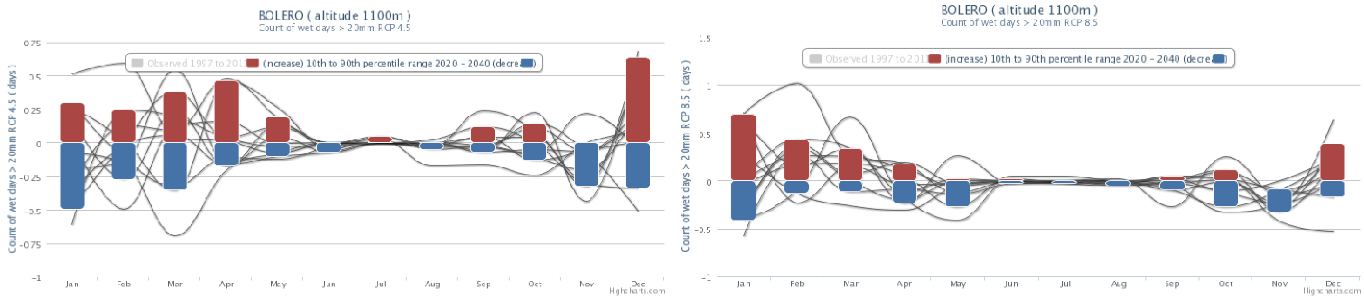
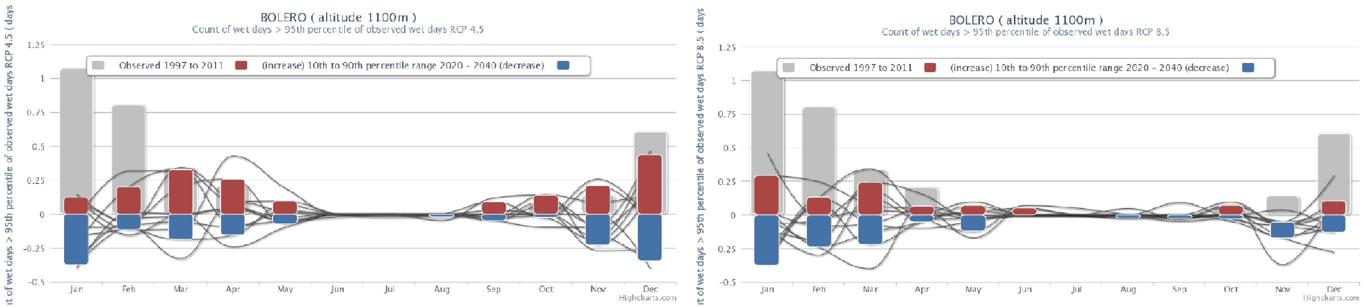


Figure B.1.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Projected change in monthly extreme rain day frequency (> 95th percentile)



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igure B.1.5: Change in monthly rain day frequency > 31.6 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

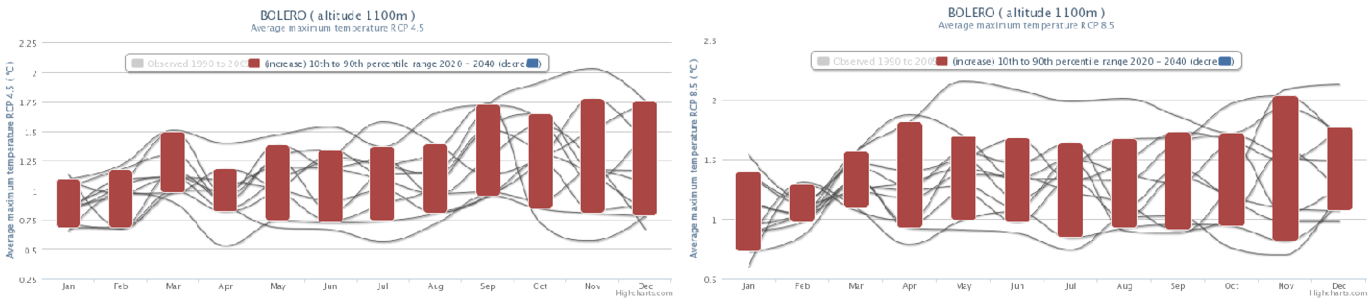


Figure B.1.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Monthly mean maximum days above 36 degree C

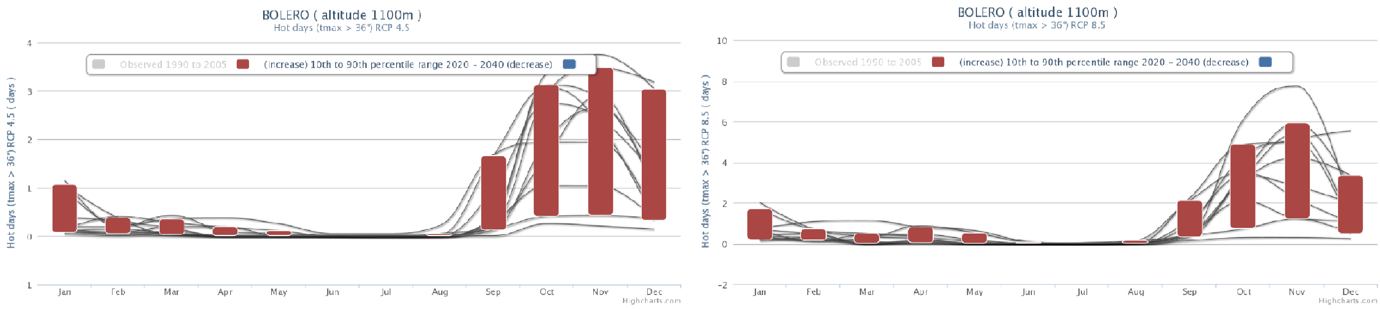


Figure B.1.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Monthly mean maximum days above 95th percentile

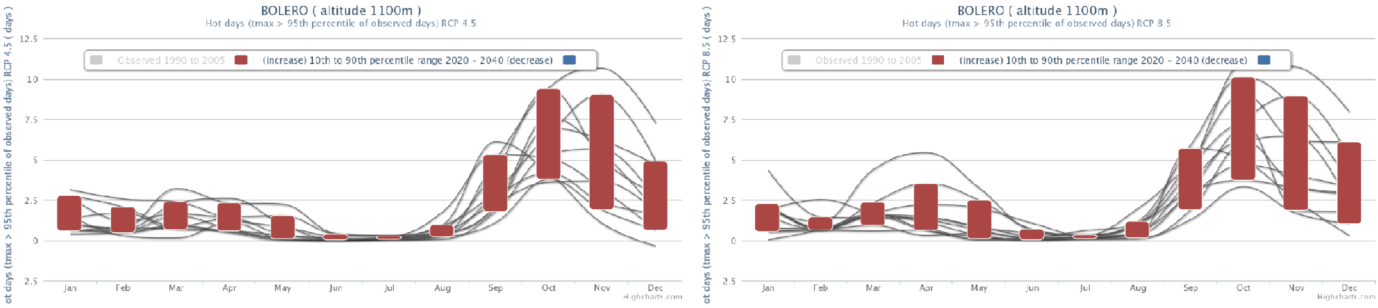


Figure B.1.8: Change in days above 33.2 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Monthly mean heat spell duration

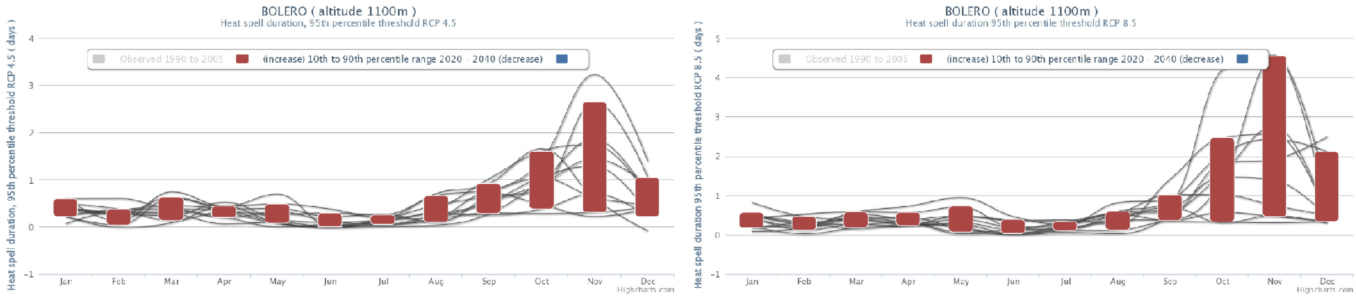


Figure B.1.9: Change in heat spell duration (33.2 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Monthly mean minimum daily temperature change

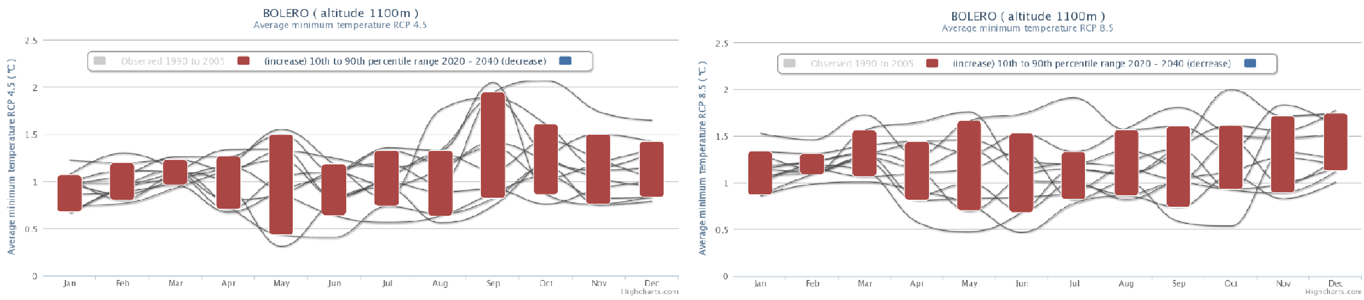


Figure B.1.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

B.2: Climate Summary for BVUMBWE 20-40

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

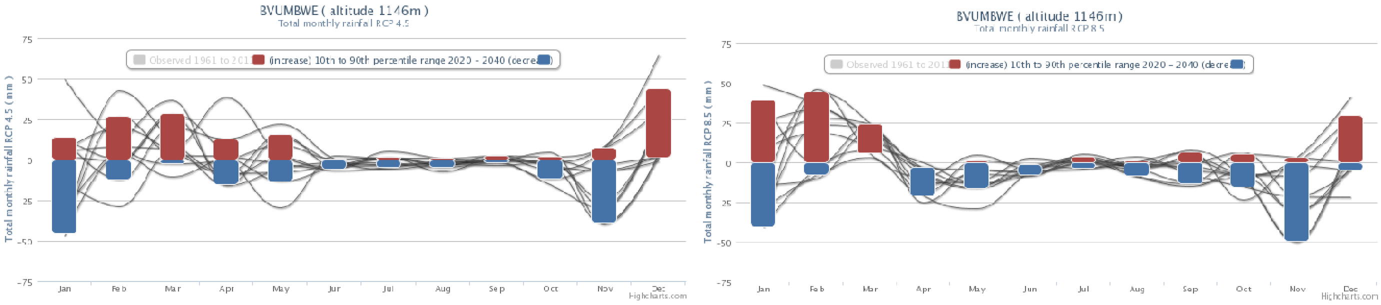


Figure B.2.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station

Projected change in monthly mean dry spell duration change

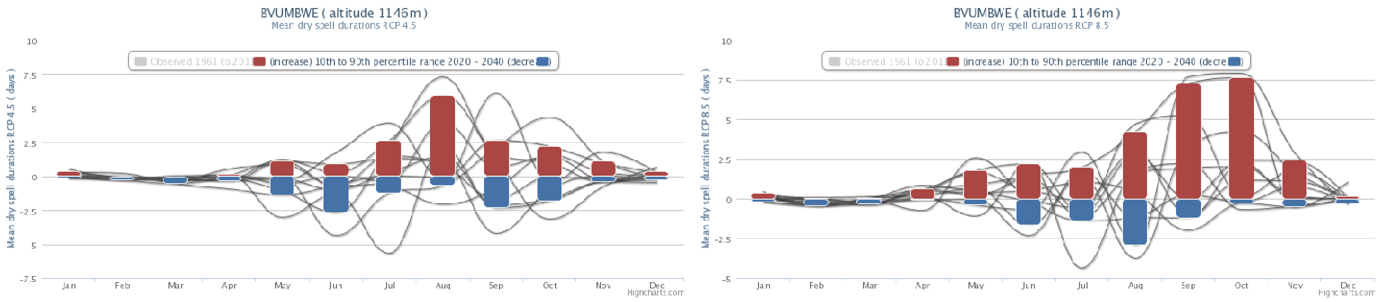


Figure B.2.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Projected change in monthly mean rain day frequency

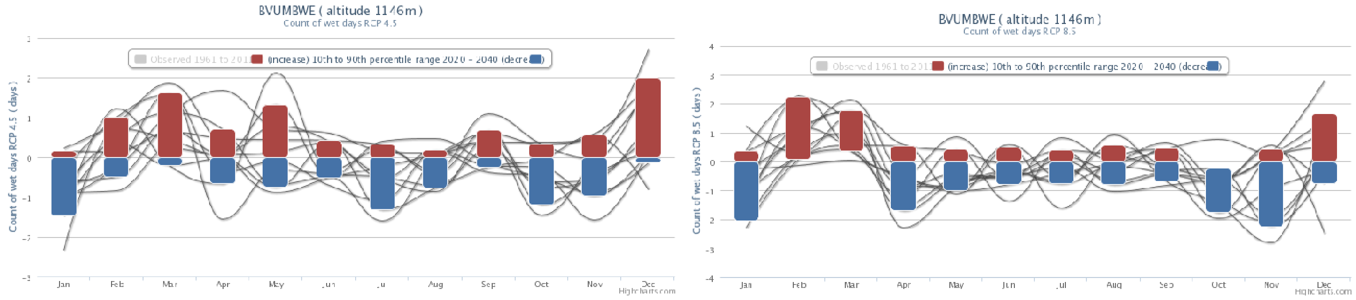


Figure B.2.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Projected change in monthly mean rain day frequency (> 20mm)

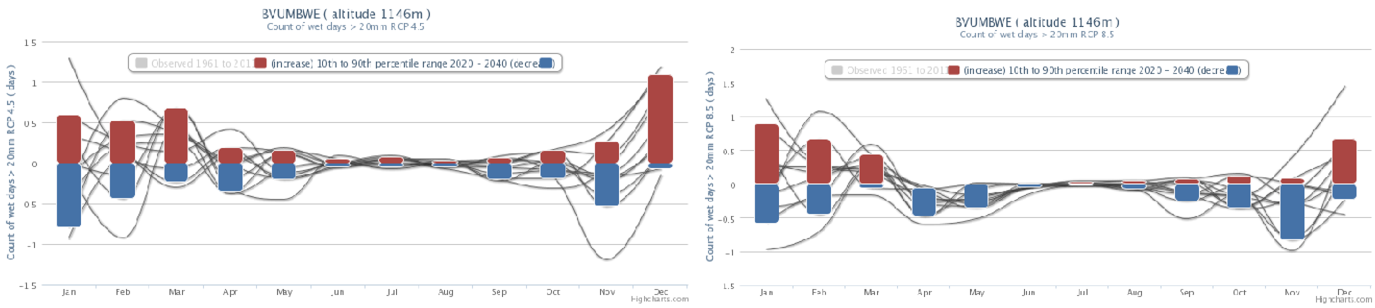
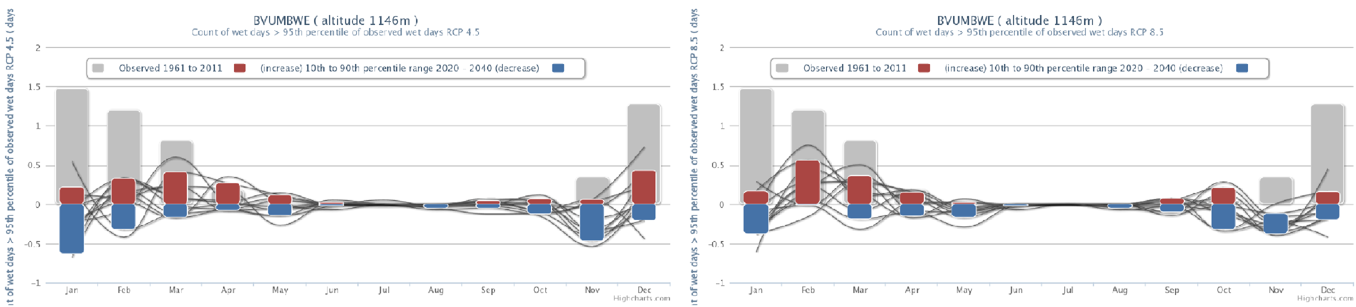


Figure B.2.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Projected change in monthly extreme rain day frequency (> 95th percentile)



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igure B.2.5: Change in monthly rain day frequency > 45 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

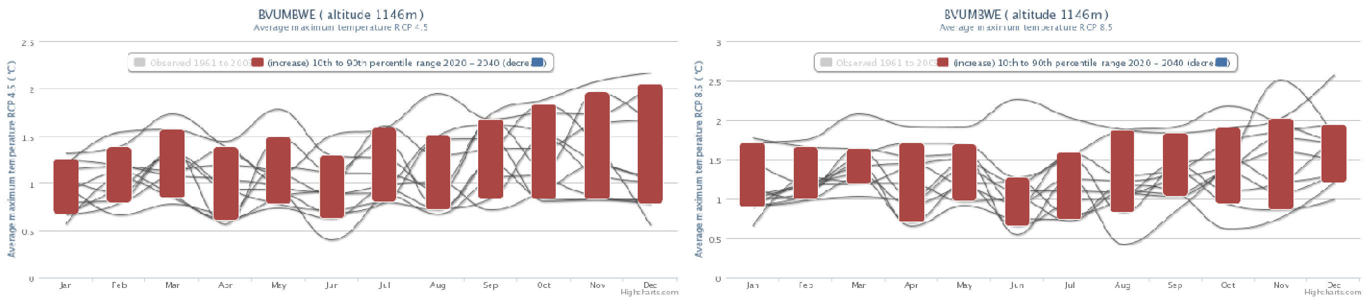


Figure B.2.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Monthly mean maximum days above 36 degree C

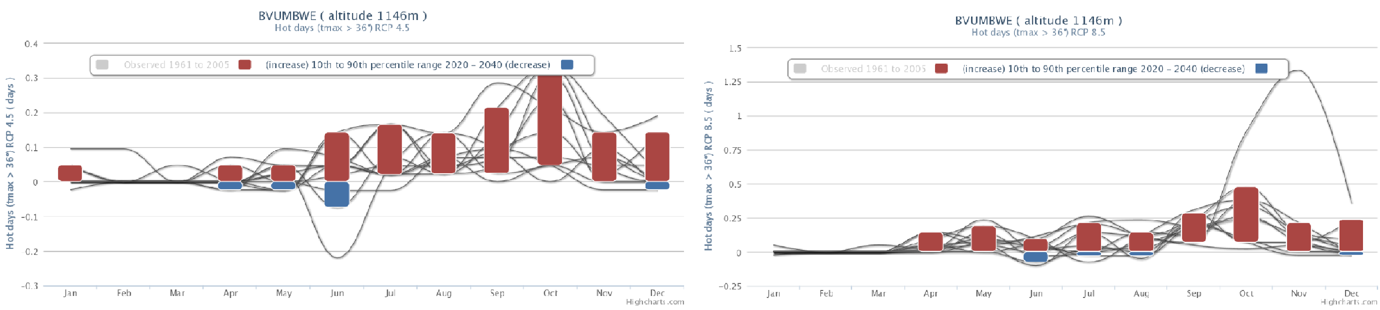


Figure B.2.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Monthly mean maximum days above 95th percentile

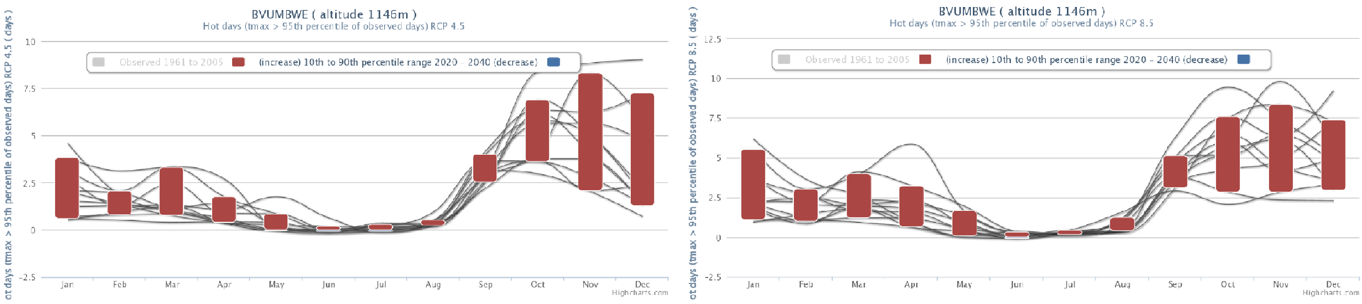


Figure B.2.8: Change in days above 31.2 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Monthly mean heat spell duration

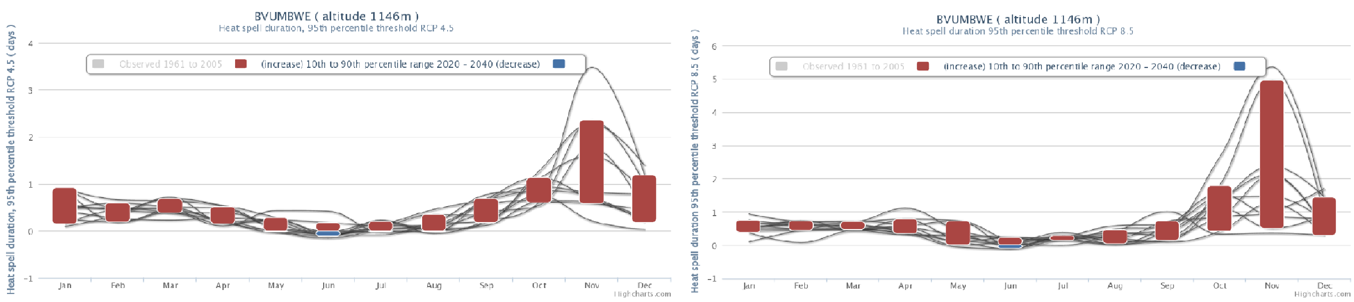


Figure B.2.9: Change in heat spell duration (31.2 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Monthly mean minimum daily temperature change

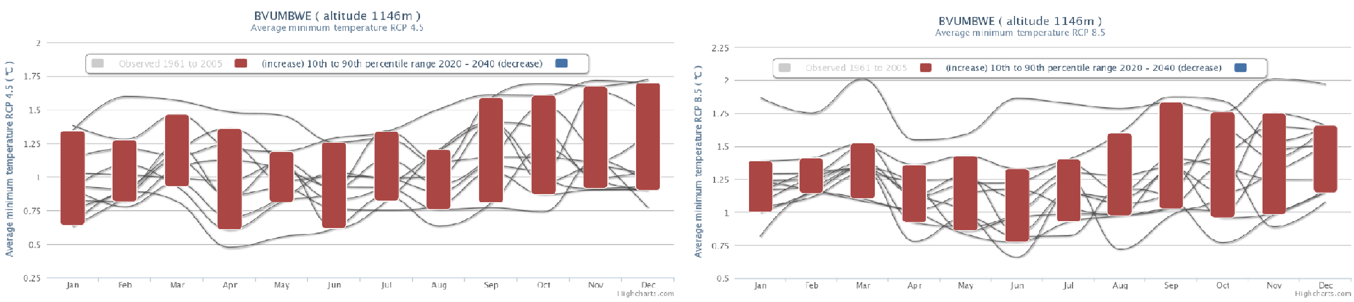


Figure B.2.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

B.3: Climate Summary for CHICHIRI 20-40

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

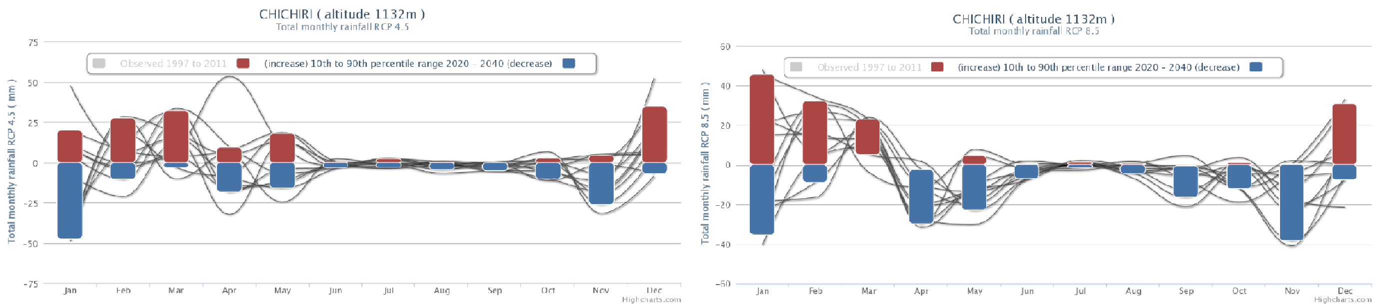


Figure B.3.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Projected change in monthly mean dry spell duration change

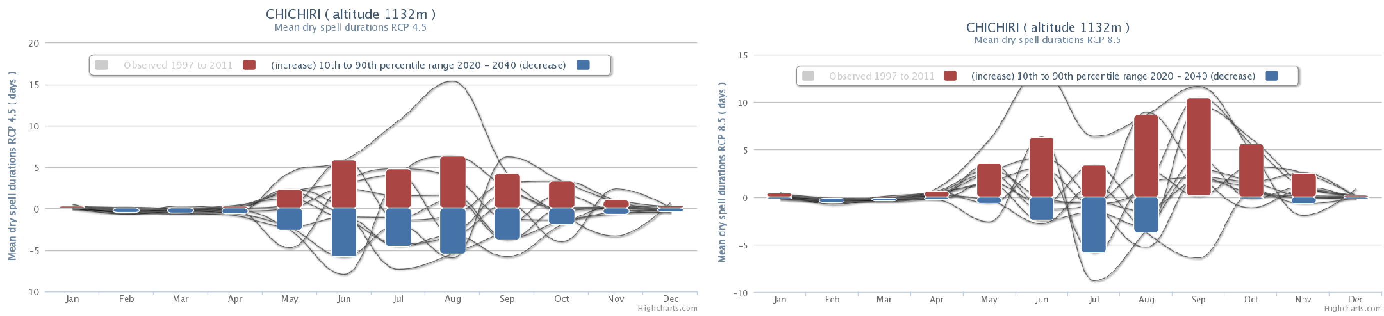


Figure B.3.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Projected change in monthly mean rain day frequency

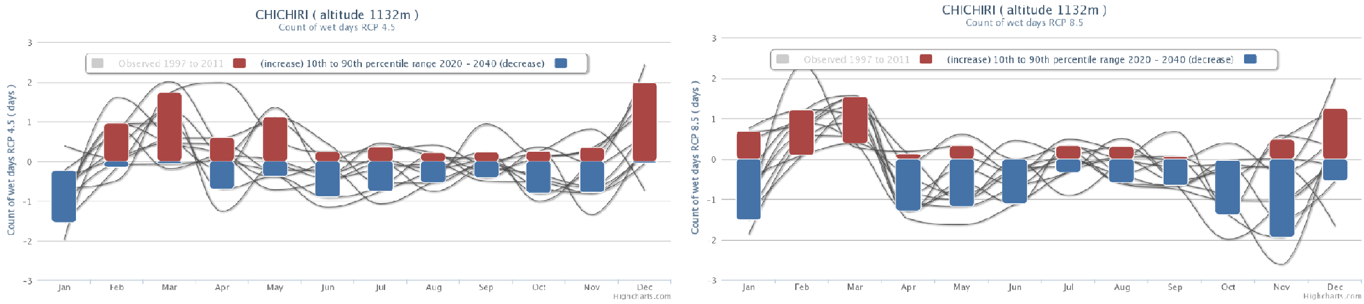


Figure B.3.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Projected change in monthly mean rain day frequency (> 20mm)

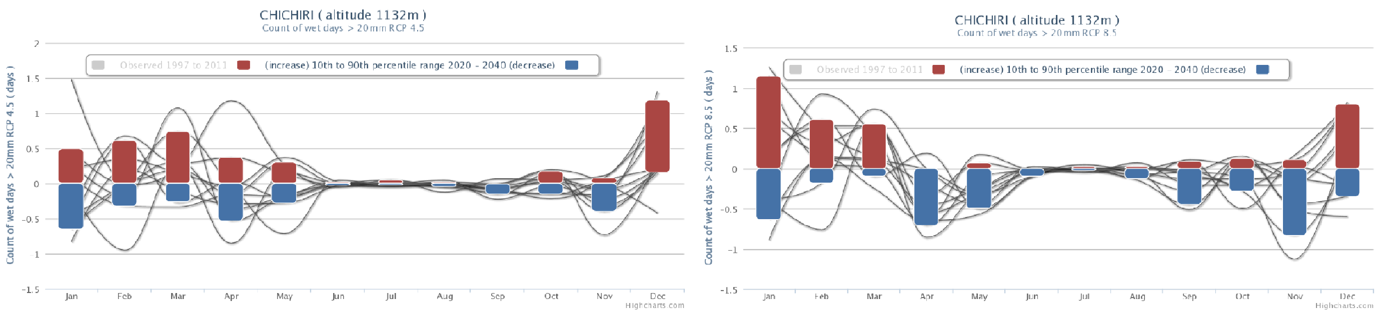


Figure B.3.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

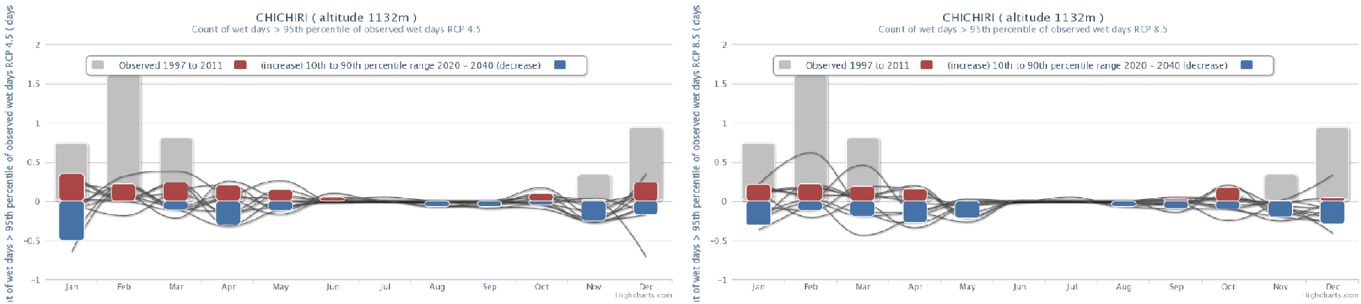


Figure B.3.5: Change in monthly rain day frequency > 46 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

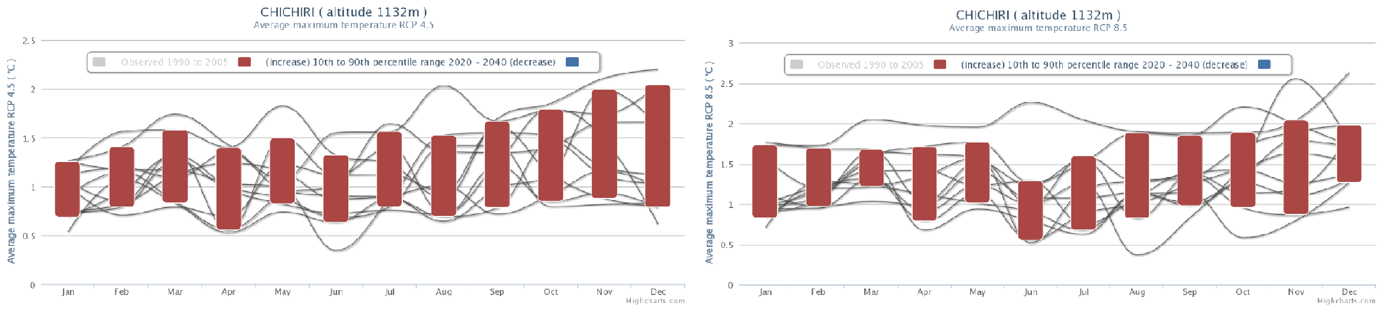


Figure B.3.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Monthly mean maximum days above 36 degree C

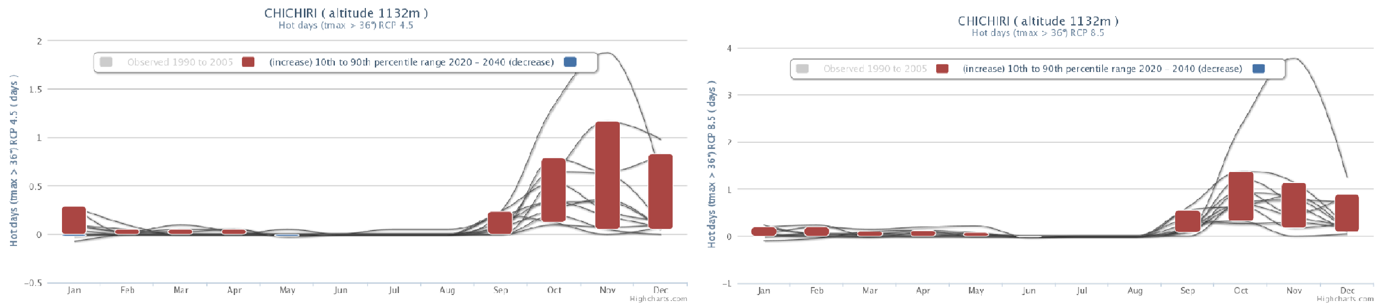


Figure B.3.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Monthly mean maximum days above 95th percentile

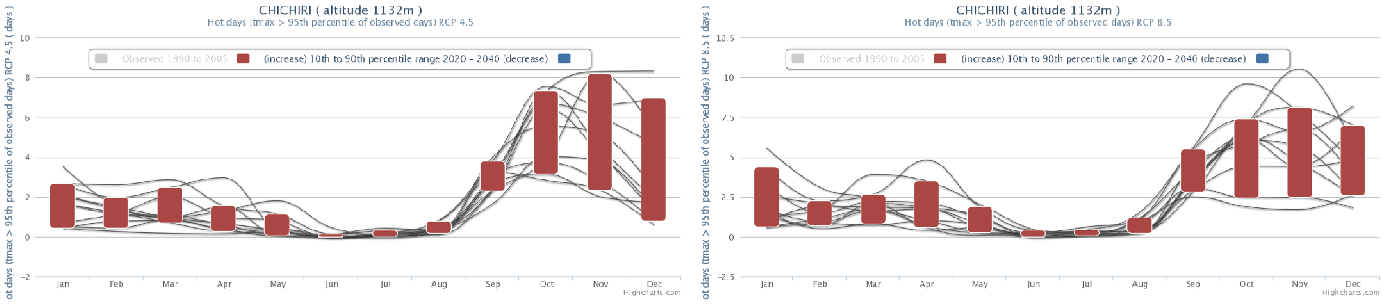


Figure B.3.8: Change in days above 30.5 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Monthly mean heat spell duration

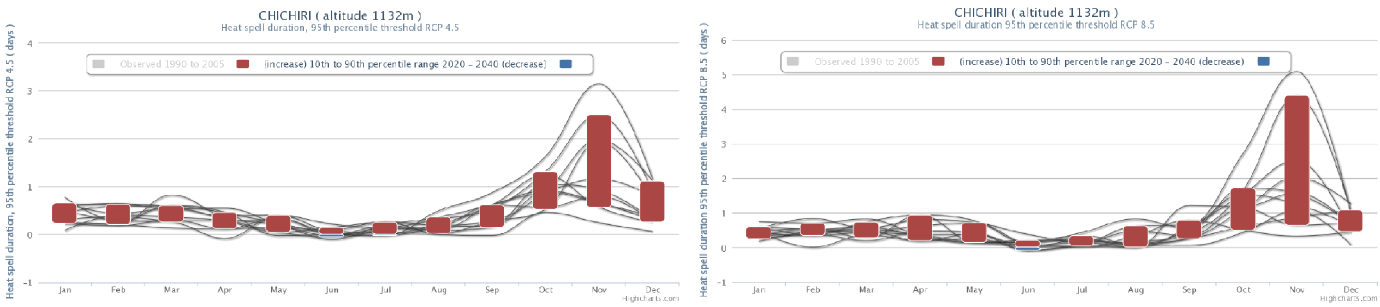


Figure B.3.9: Change in heat spell duration (30.5 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Monthly mean minimum daily temperature change

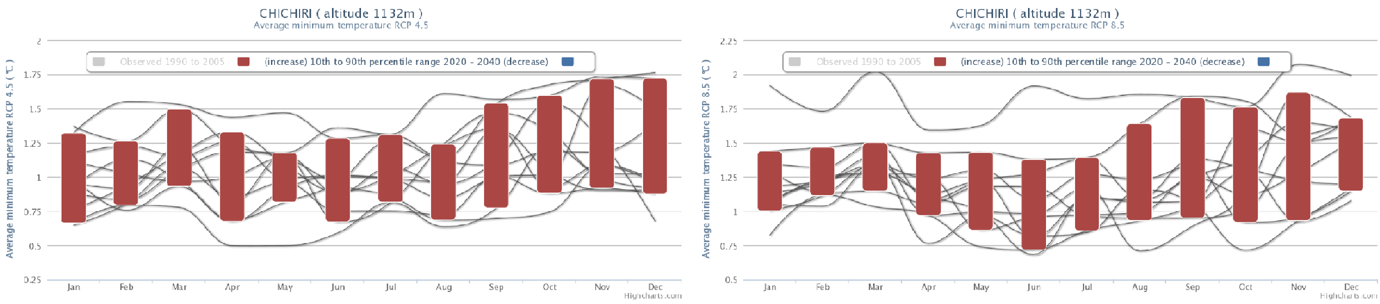


Figure B.3.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

B.4: Climate Summary for CHILEKA 20-40

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

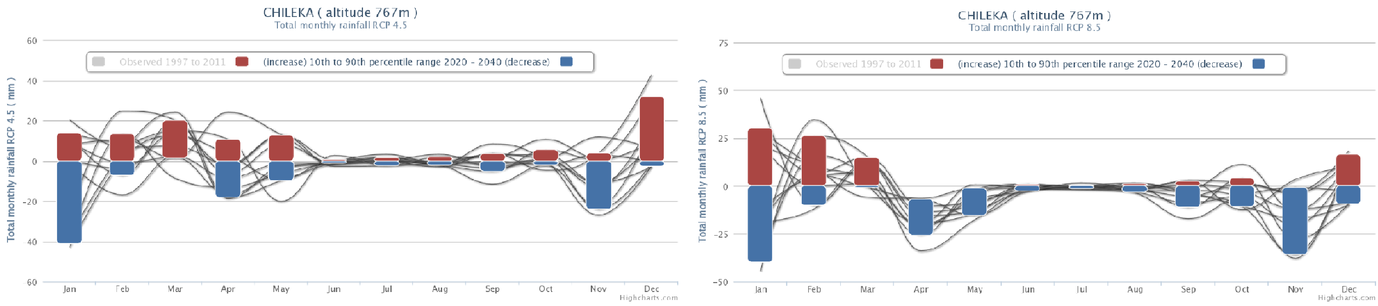


Figure B.4.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Projected change in monthly mean dry spell duration change

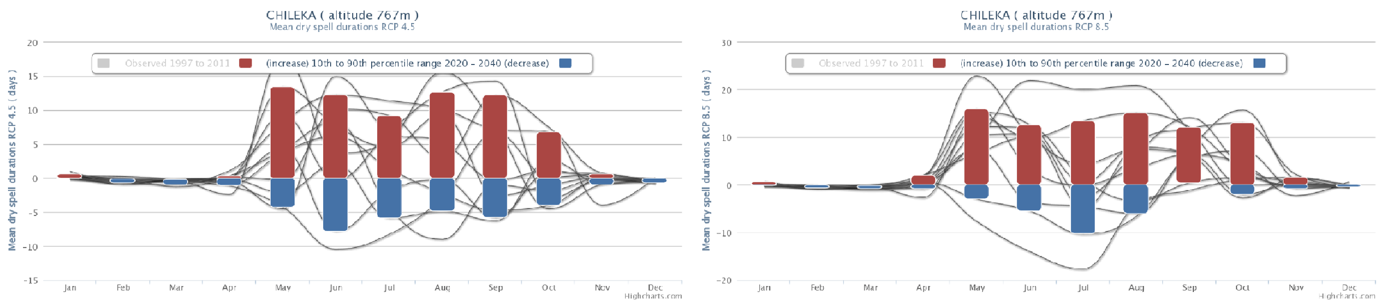


Figure B.4.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Projected change in monthly mean rain day frequency

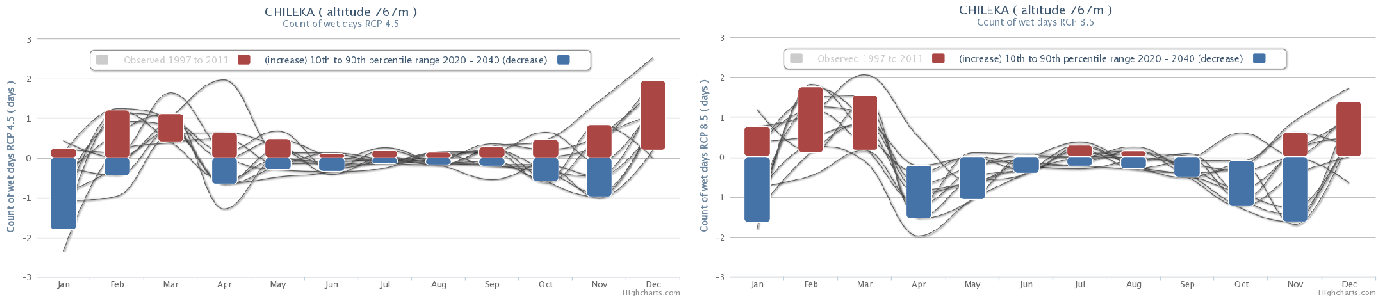


Figure B.4.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Projected change in monthly mean rain day frequency (> 20mm)

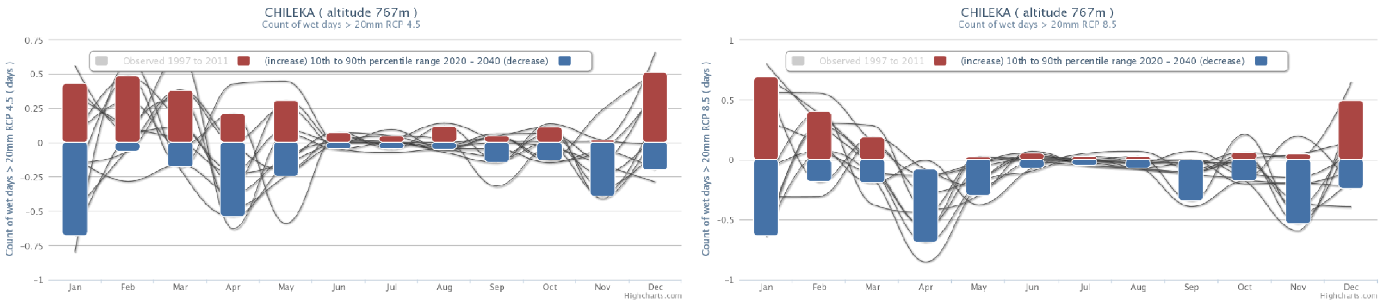


Figure B.4.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

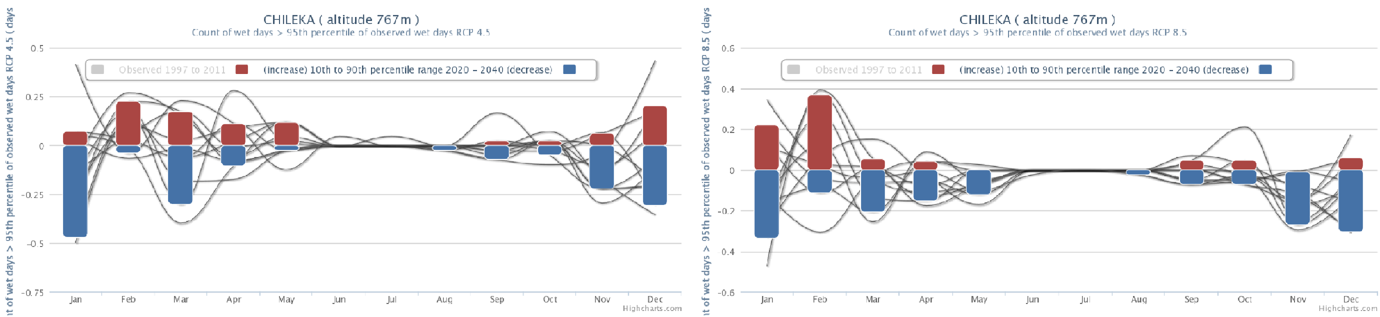


Figure B.4.5: Change in monthly rain day frequency > 36.8 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

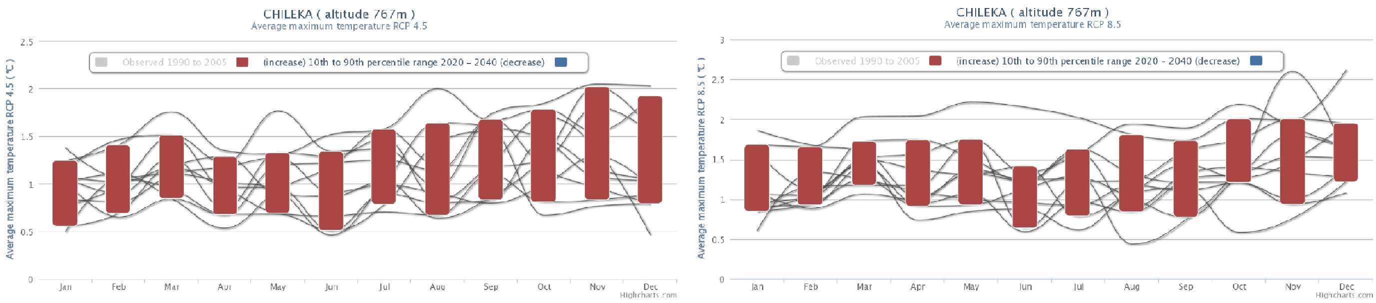


Figure B.4.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Monthly mean maximum days above 36 degree C

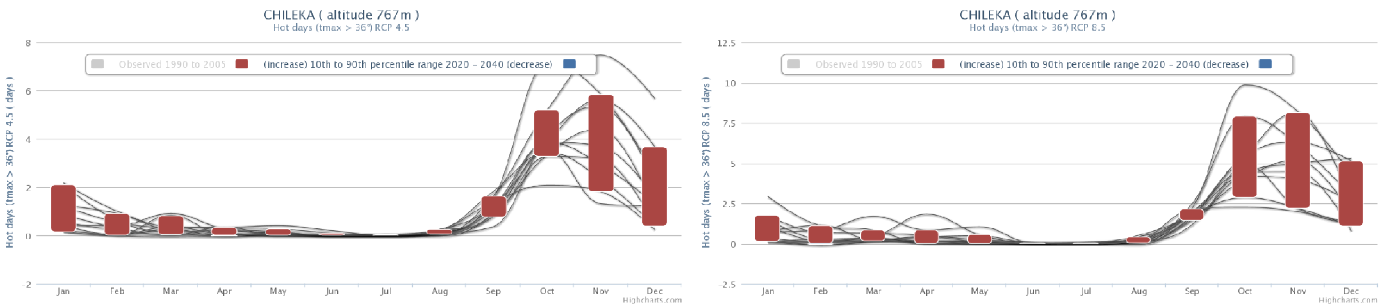


Figure B.4.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Monthly mean maximum days above 95th percentile

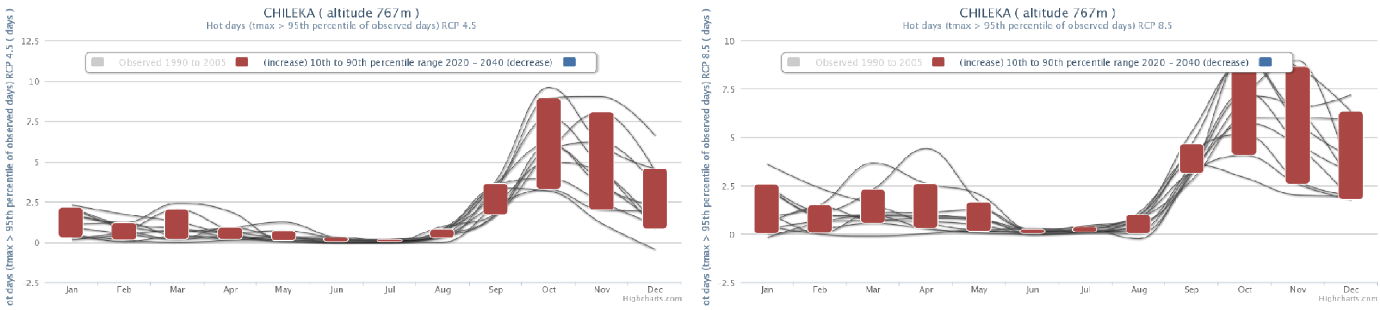


Figure B.4.8: Change in days above 34.2 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Monthly mean heat spell duration

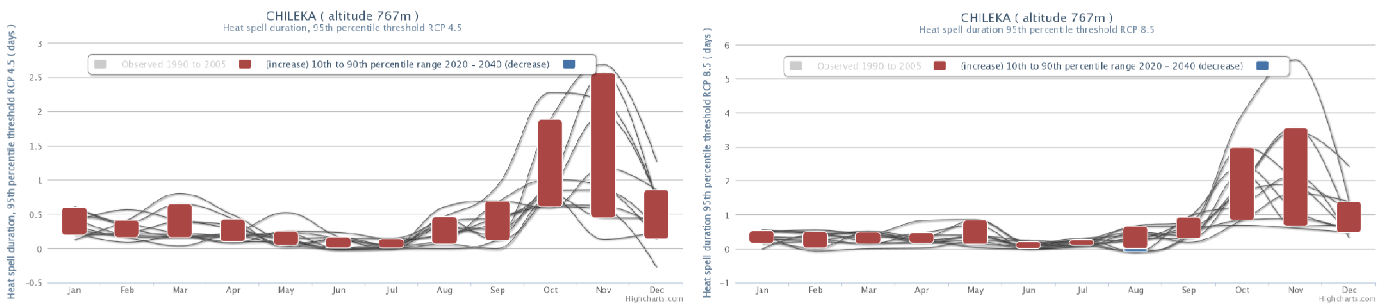


Figure B.4.9: Change in heat spell duration (34.2 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Monthly mean minimum daily temperature change

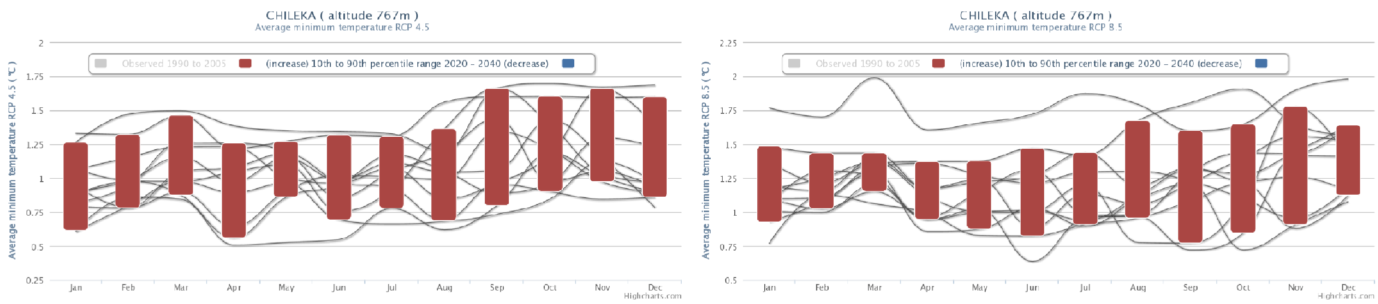


Figure B.4.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

B.5: Climate Summary for CHITEDZE

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

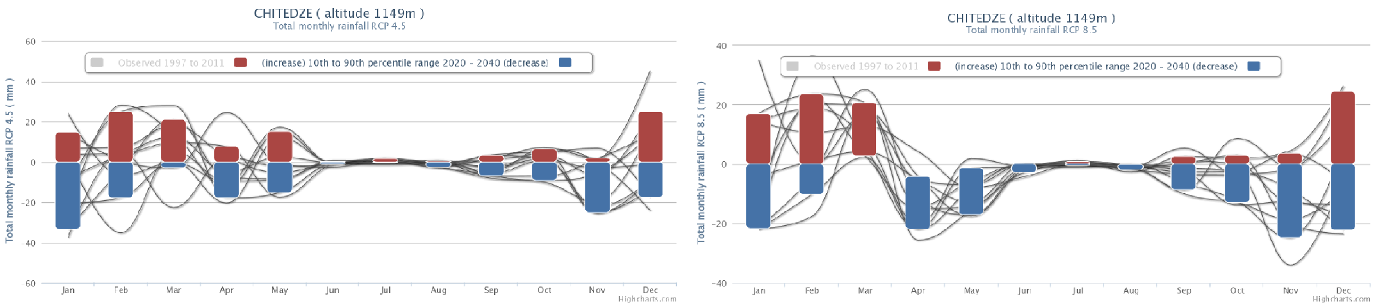


Figure B.5.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Projected change in monthly mean dry spell duration change

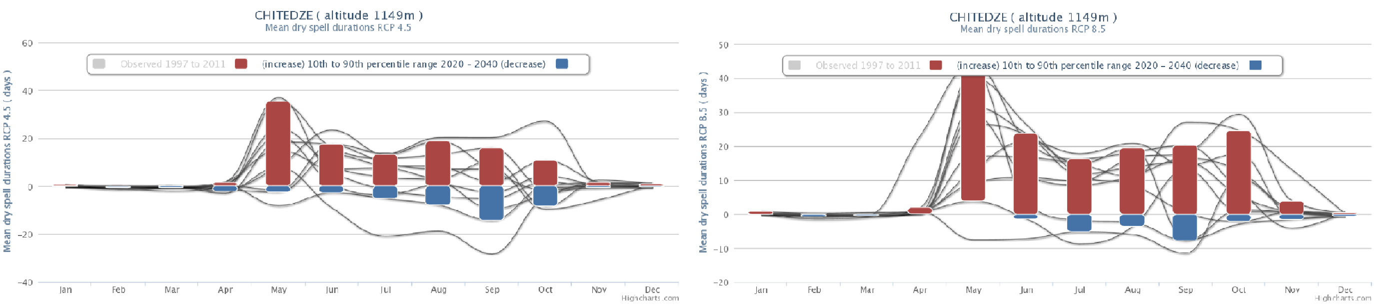


Figure B.5.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Projected change in monthly mean rain day frequency

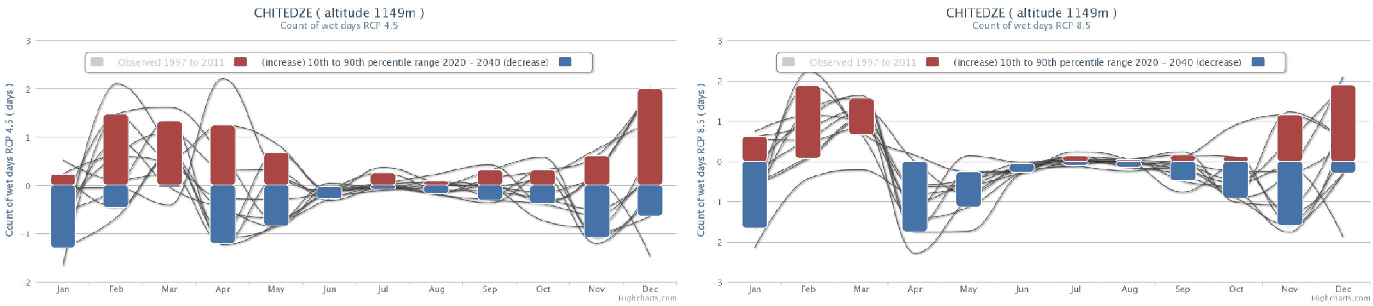


Figure B.5.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Projected change in monthly mean rain day frequency (> 20mm)

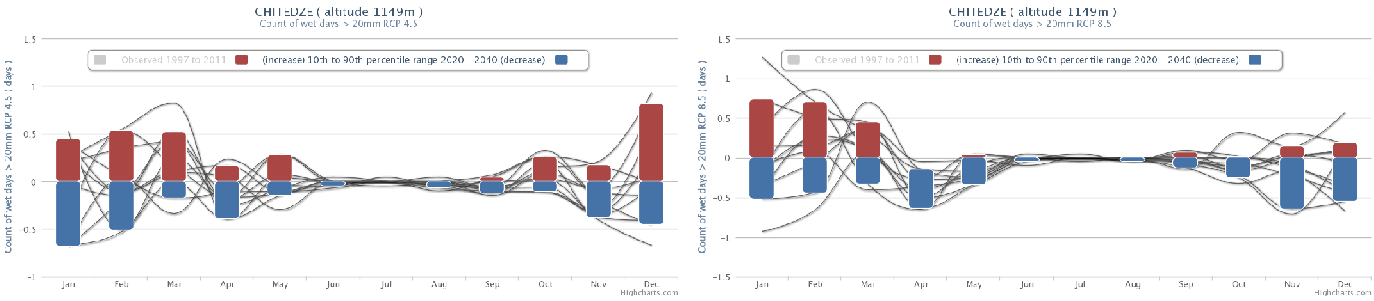


Figure B.5.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

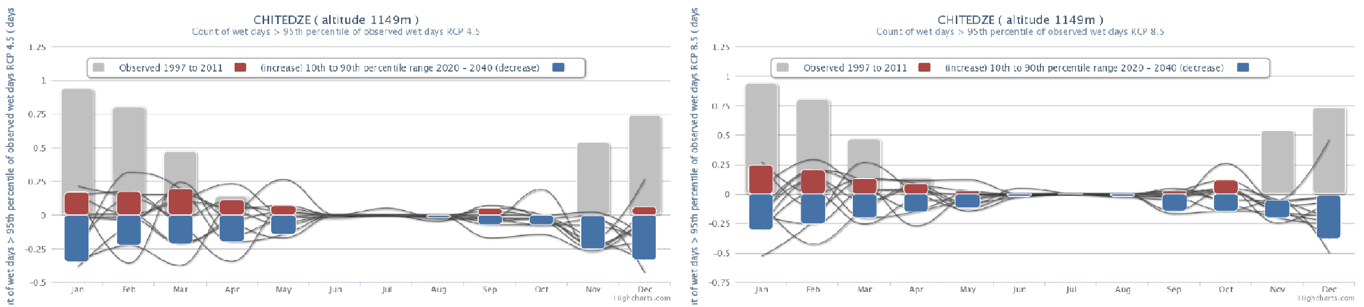


Figure B.5.5: Change in monthly rain day frequency > 45.5 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

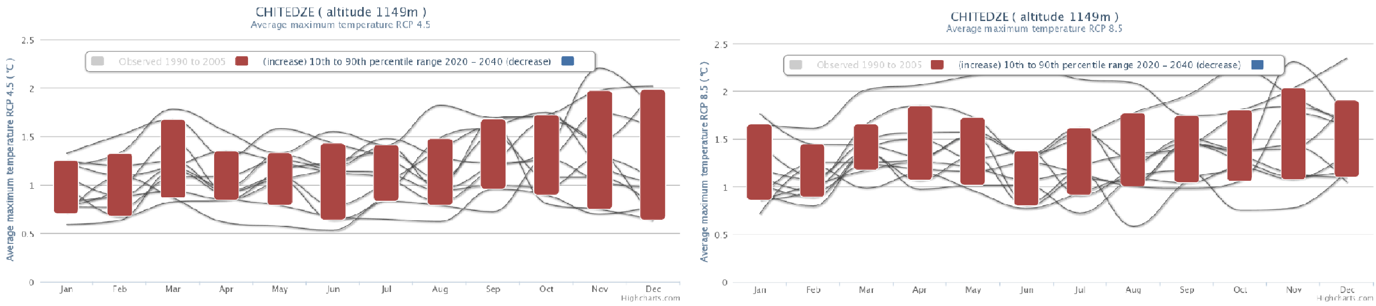


Figure B.5.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Monthly mean maximum days above 36 degree C

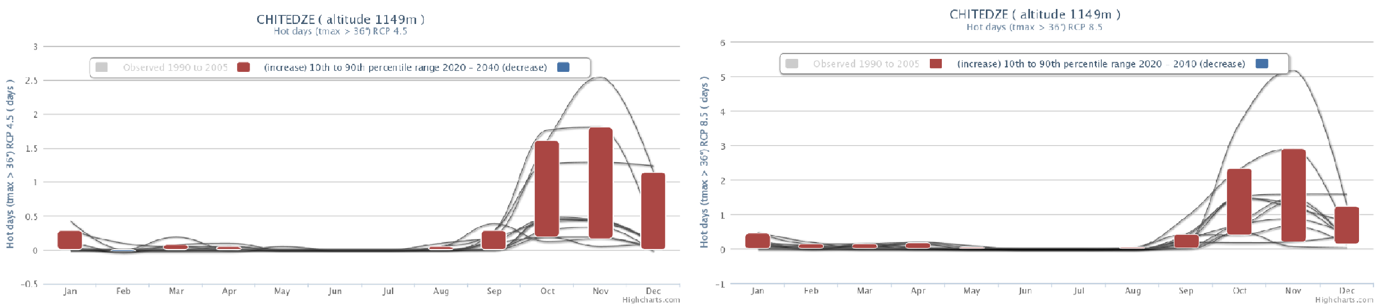


Figure B.5.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Monthly mean maximum days above 95th percentile

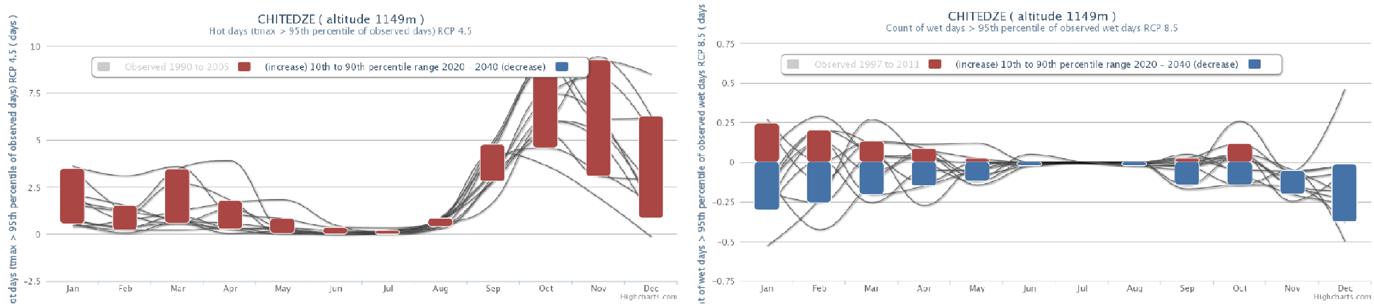


Figure B.5.8: Change in days above 34.3 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Monthly mean heat spell duration

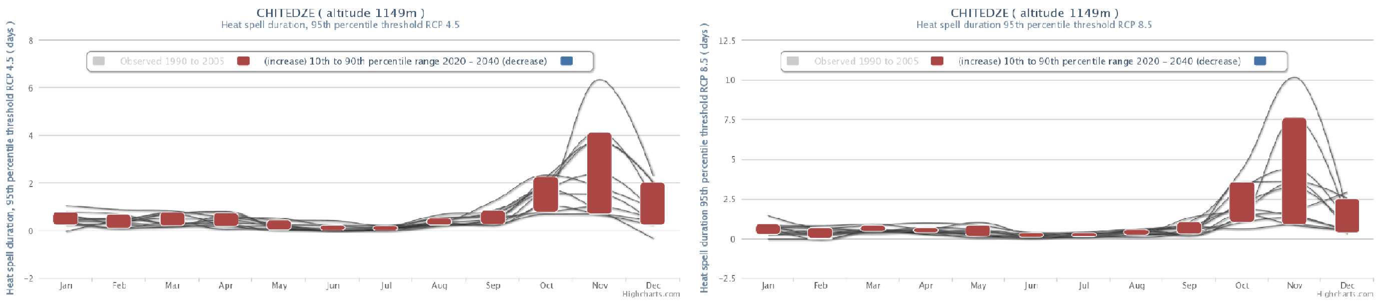


Figure B.5.9: Change in heat spell duration (34.3 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Monthly mean minimum daily temperature change

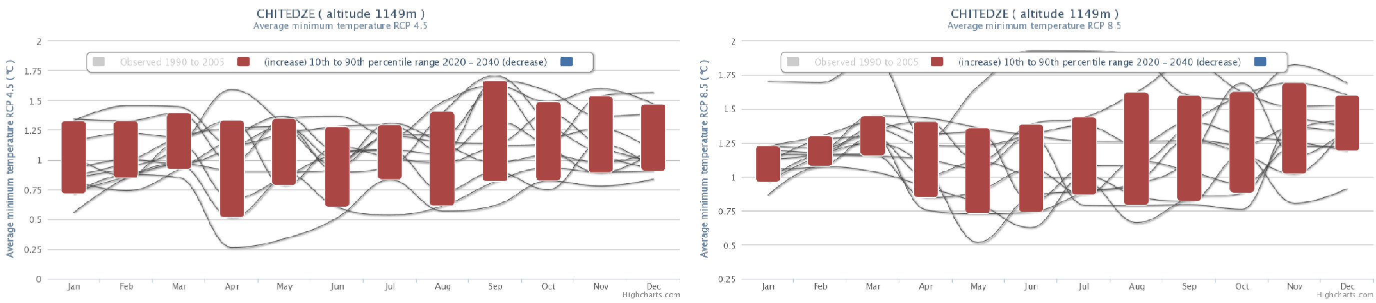


Figure B.5.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

B.6: Climate Summary for CHITIPA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

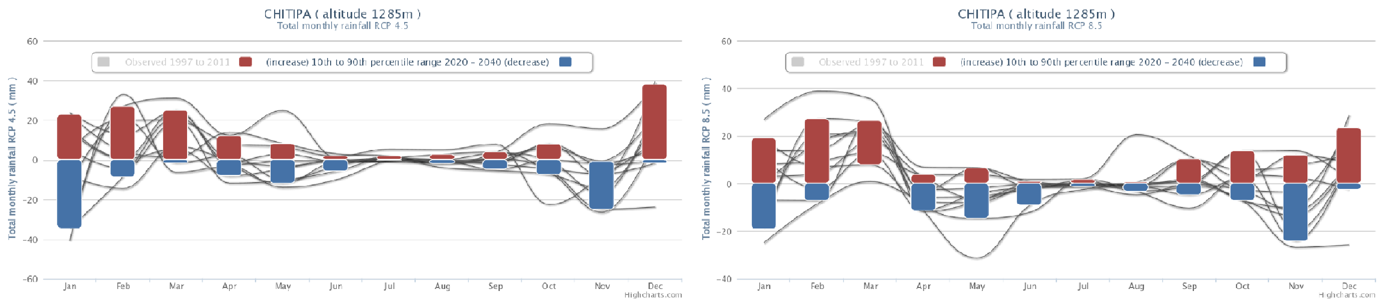


Figure B.6.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Projected change in monthly mean dry spell duration change

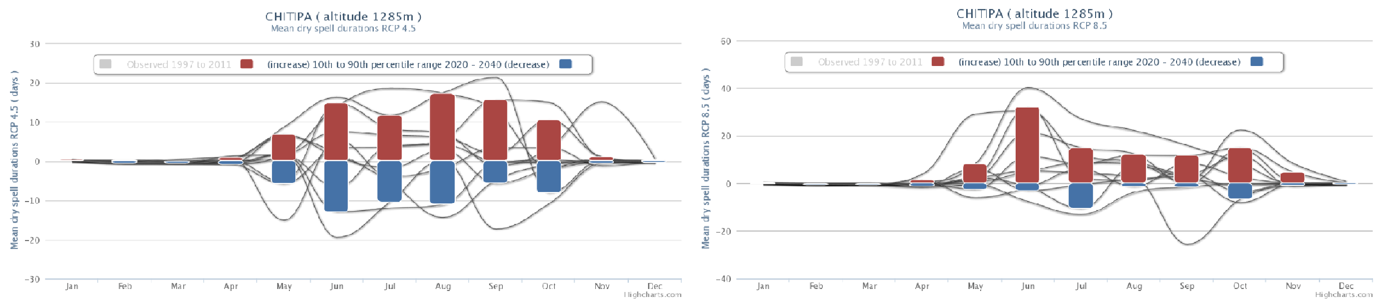


Figure B.6.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Projected change in monthly mean rain day frequency

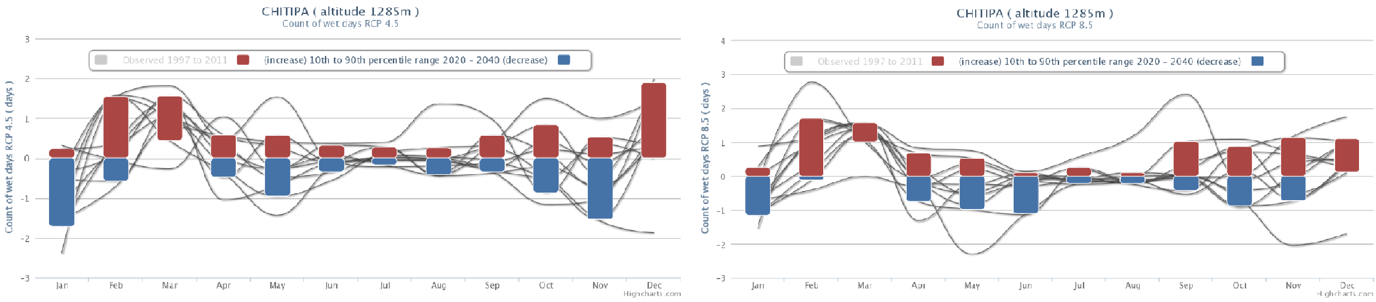


Figure B.6.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Projected change in monthly mean rain day frequency (> 20mm)

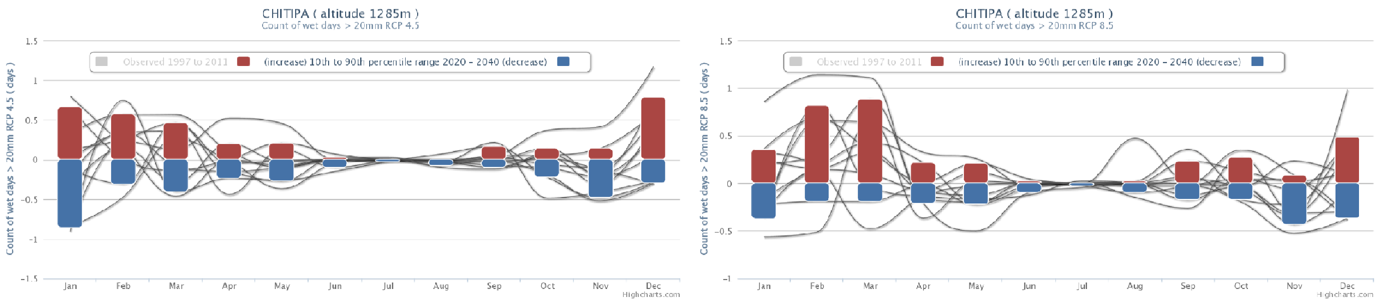


Figure B.6.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

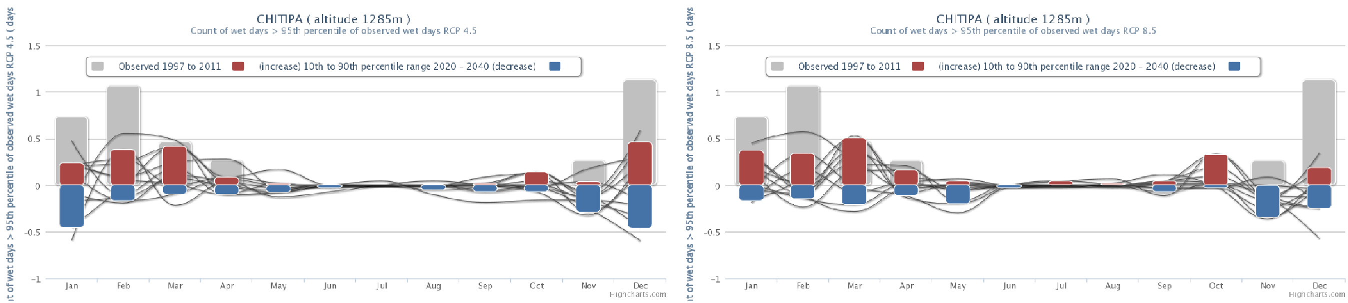


Figure B.6.5: Change in monthly rain day frequency > 43.4 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Climate Projections - Temperature

CLIMATE SYSTEM ANALYSIS GROUP (2013)

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

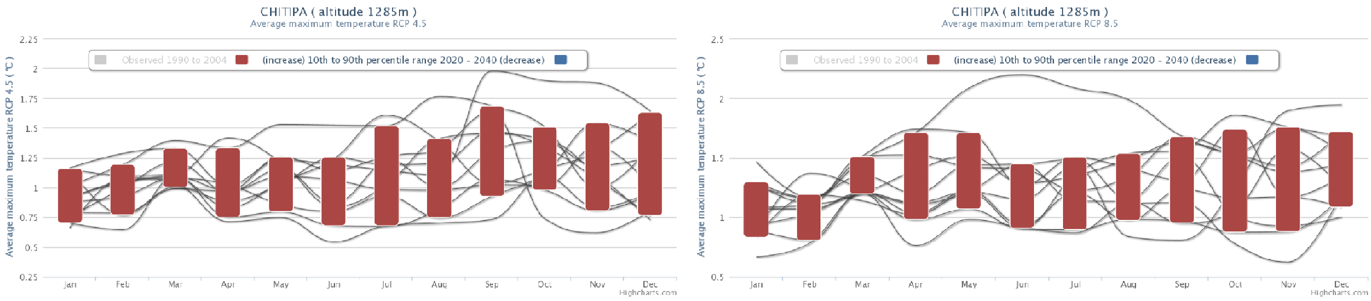


Figure B.6.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Monthly mean maximum days above 36 degree C

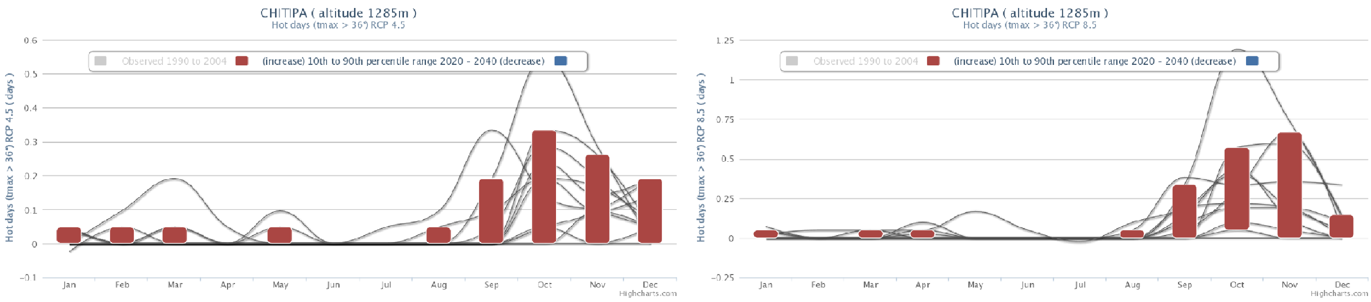


Figure B.6.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Monthly mean maximum days above 95th percentile

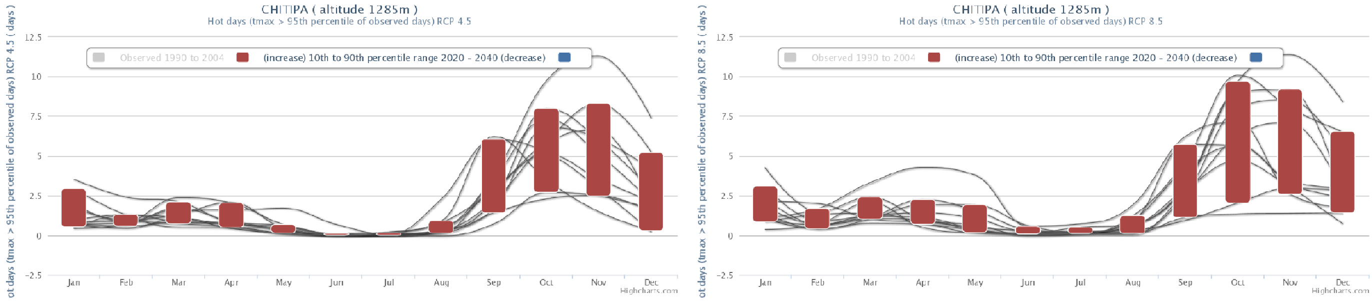


Figure B.6.8: Change in days above 31.9 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Monthly mean heat spell duration

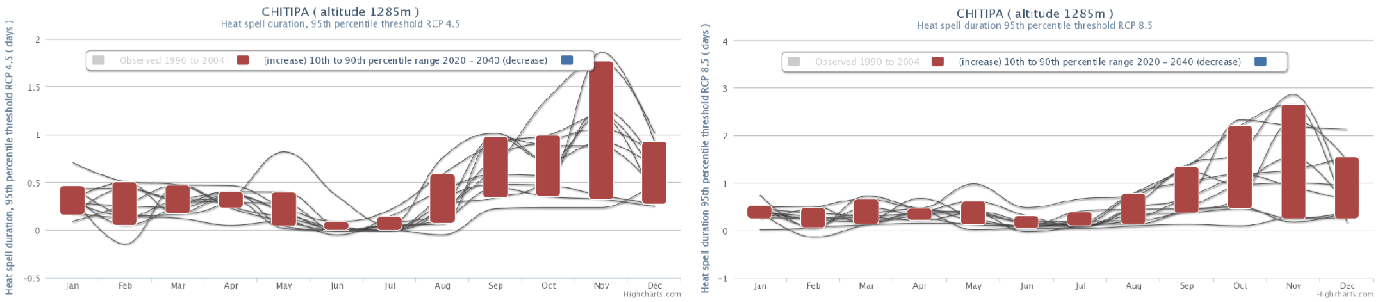


Figure B.6.9: Change in heat spell duration (31.9 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Monthly mean minimum daily temperature change

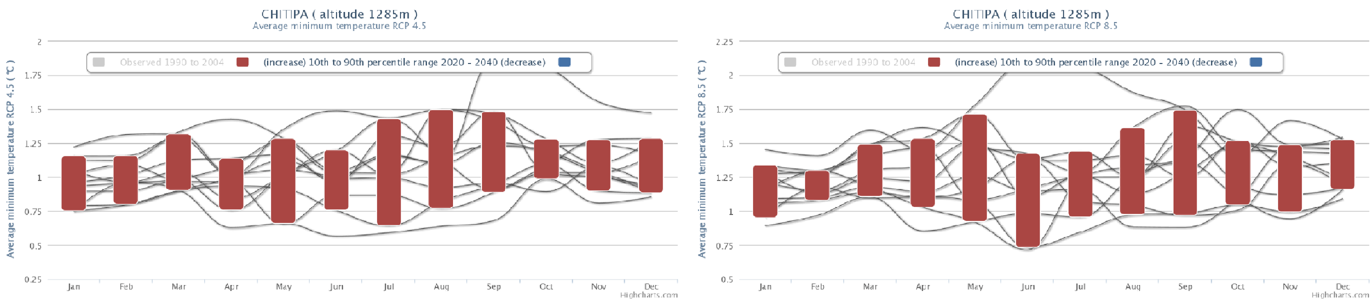


Figure B.6.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

B.7: Climate Summary for DEDZA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

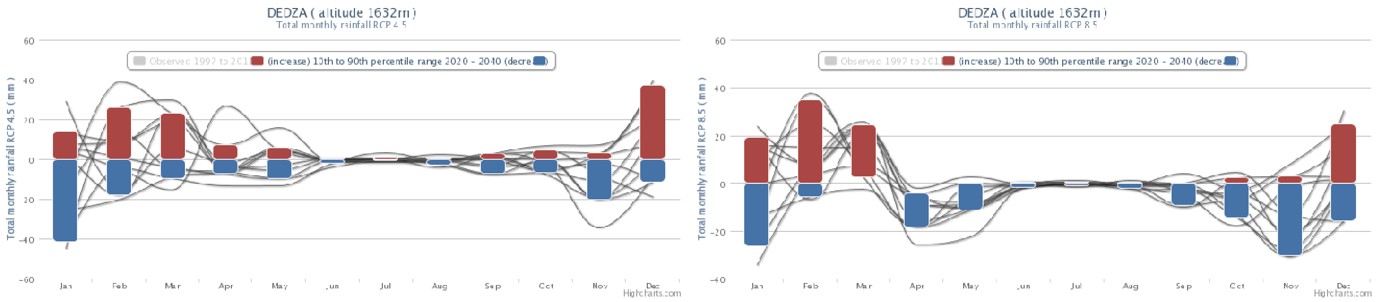


Figure B.7.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Projected change in monthly mean dry spell duration change

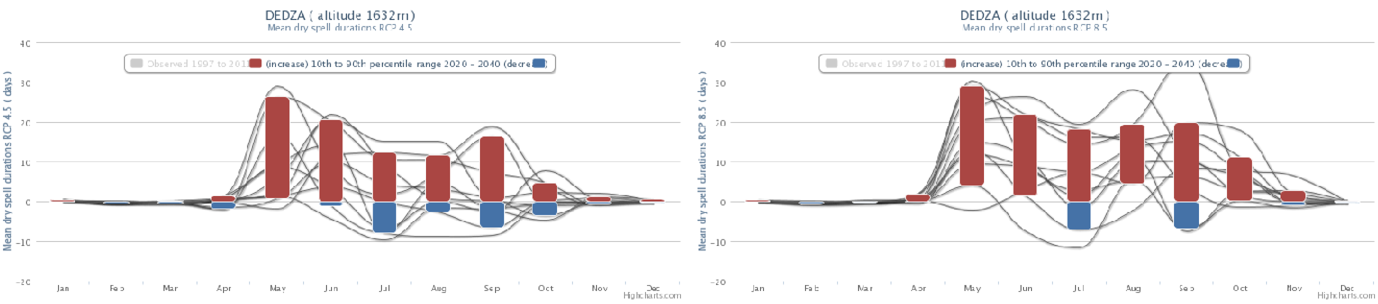


Figure B.7.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Projected change in monthly mean rain day frequency

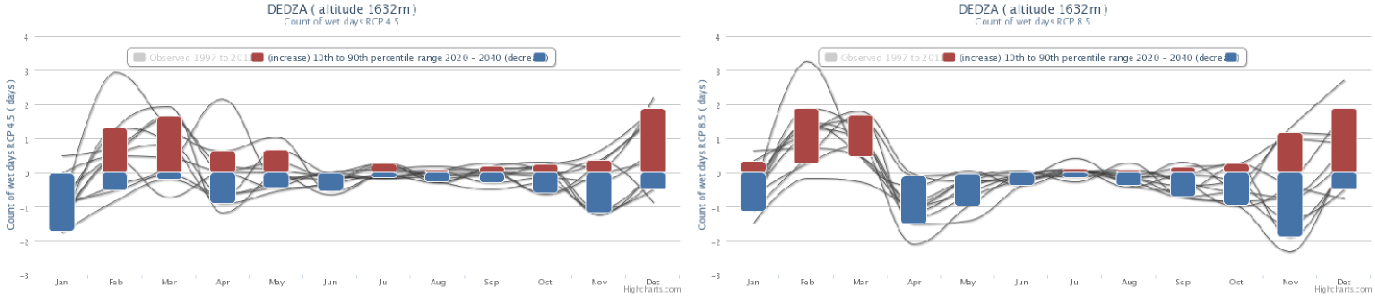


Figure B.7.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Projected change in monthly mean rain day frequency (> 20mm)

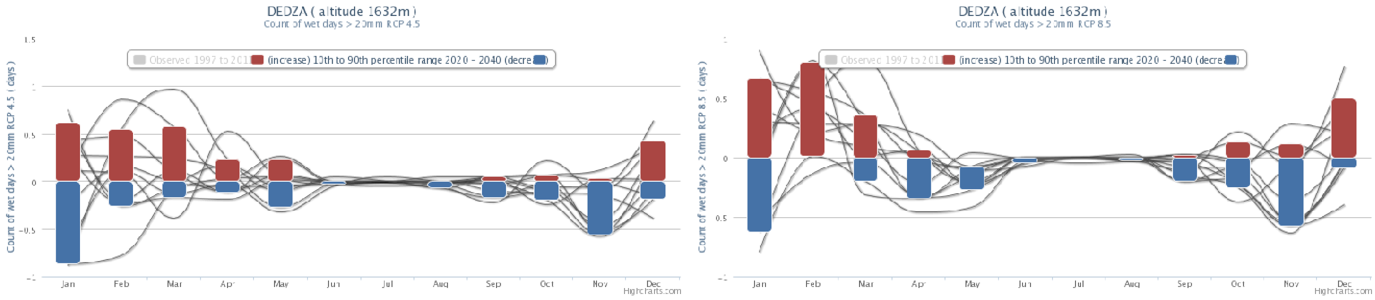


Figure B.7.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

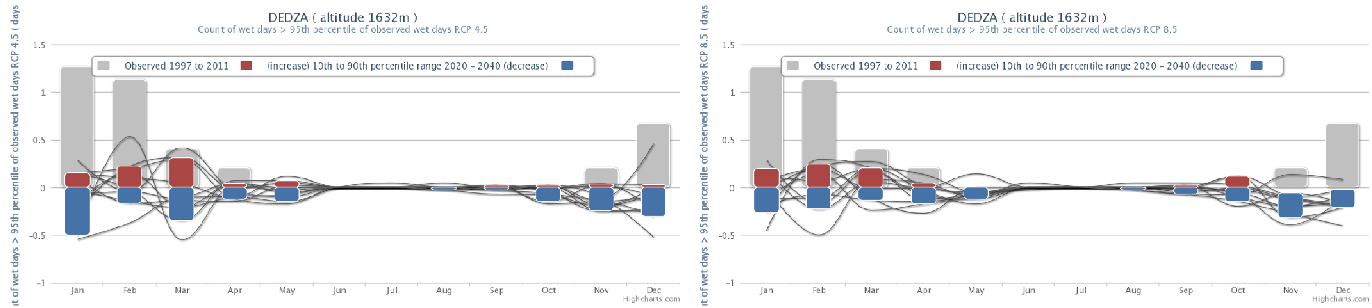


Figure B.7.5: Change in monthly rain day frequency > 37.7 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

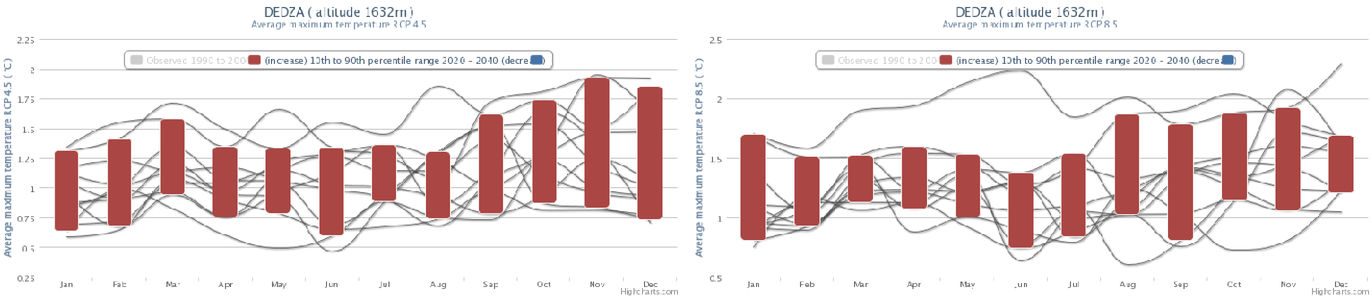


Figure B.7.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Monthly mean maximum days above 36 degree C

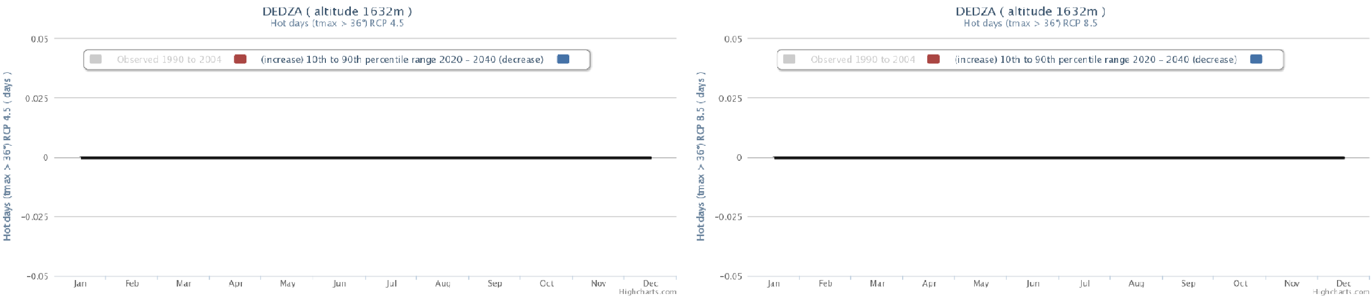


Figure B.7.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Monthly mean maximum days above 95th percentile

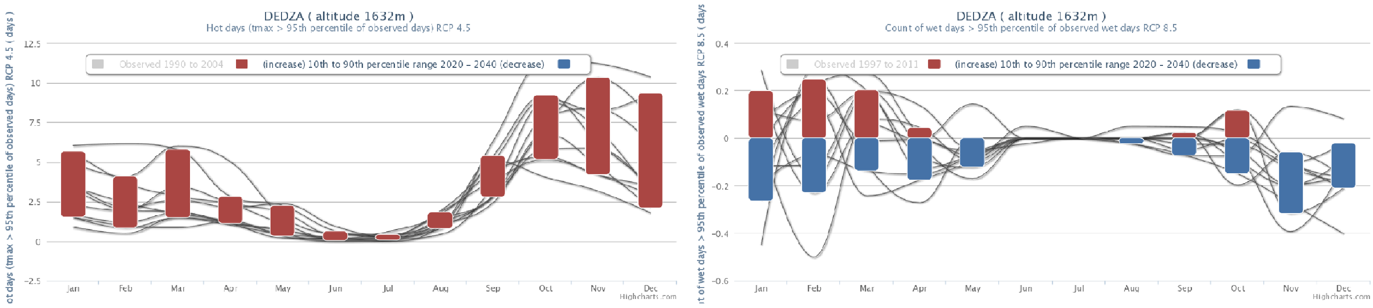


Figure B.7.8: Change in days above 31.6 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Monthly mean heat spell duration

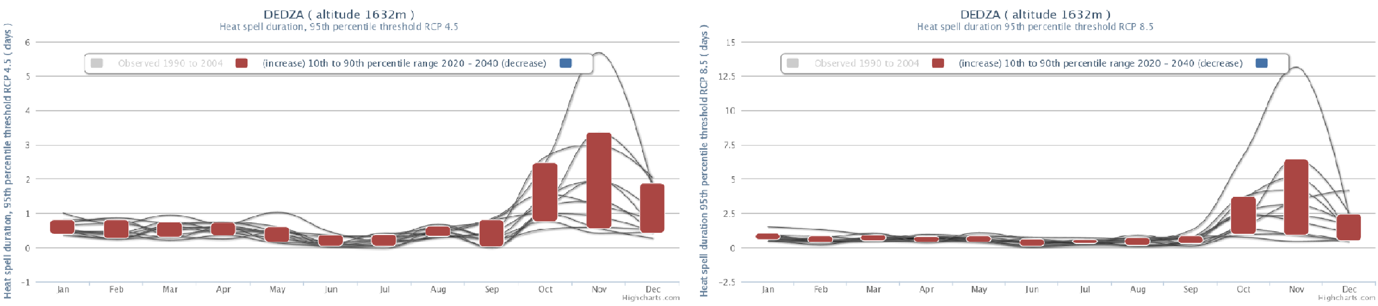


Figure B.7.9: Change in heat spell duration (31.6 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Monthly mean minimum daily temperature change

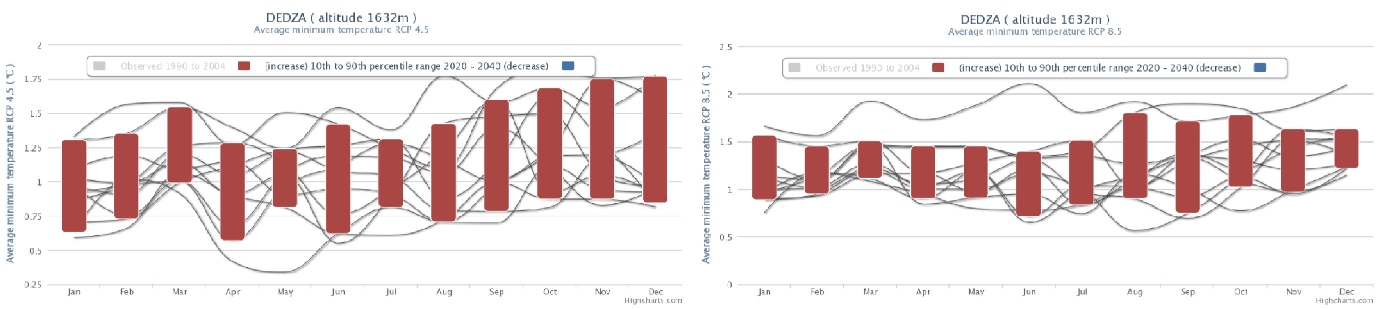


Figure B.7.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

B.8: Climate Summary for KARONGA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

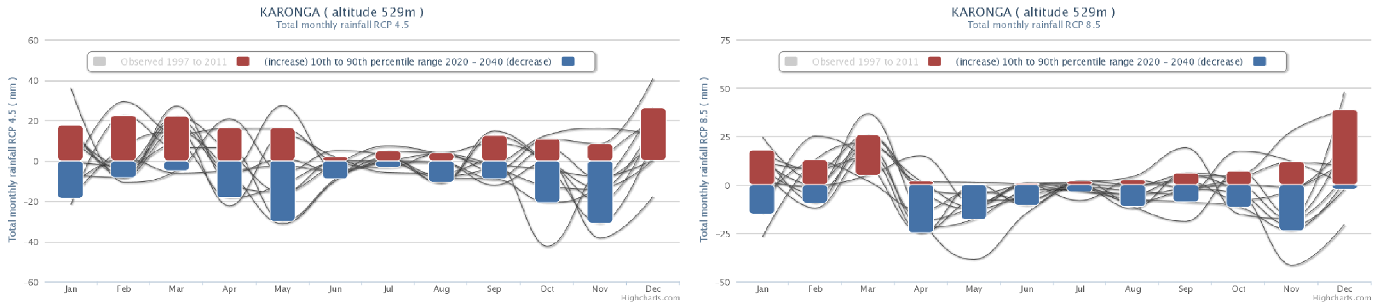


Figure B.8.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station

Projected change in monthly mean dry spell duration change

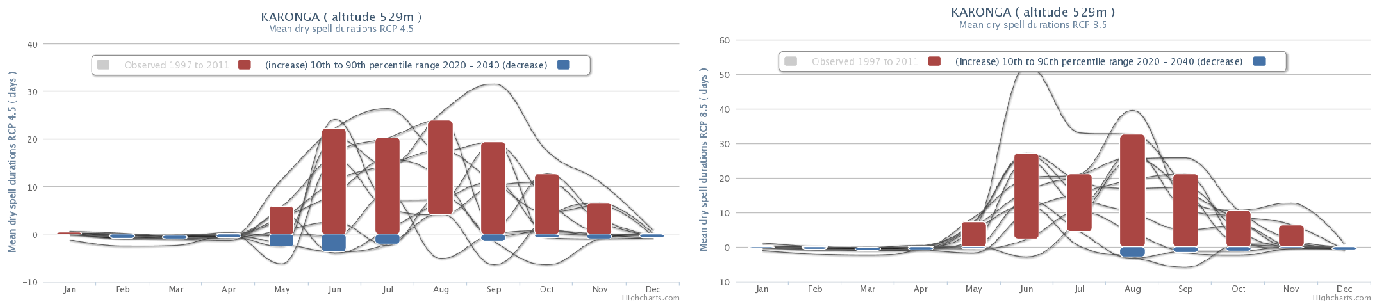


Figure B.8.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Projected change in monthly mean rain day frequency

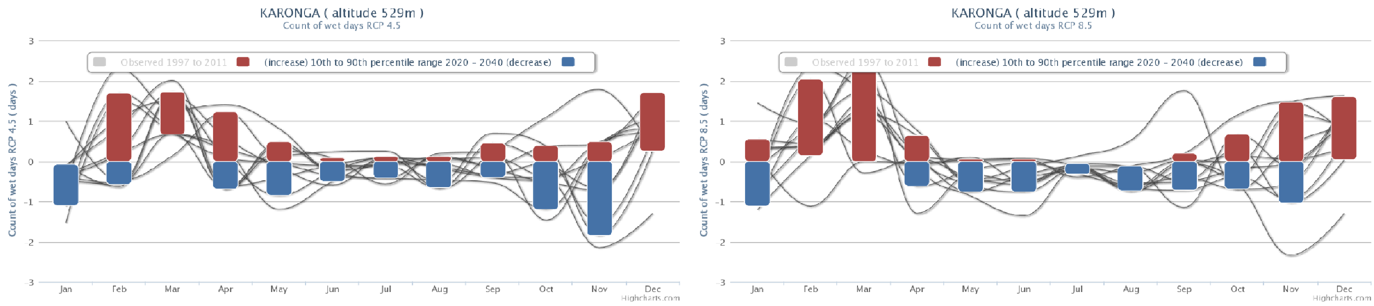


Figure B.8.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Projected change in monthly mean rain day frequency (> 20mm)

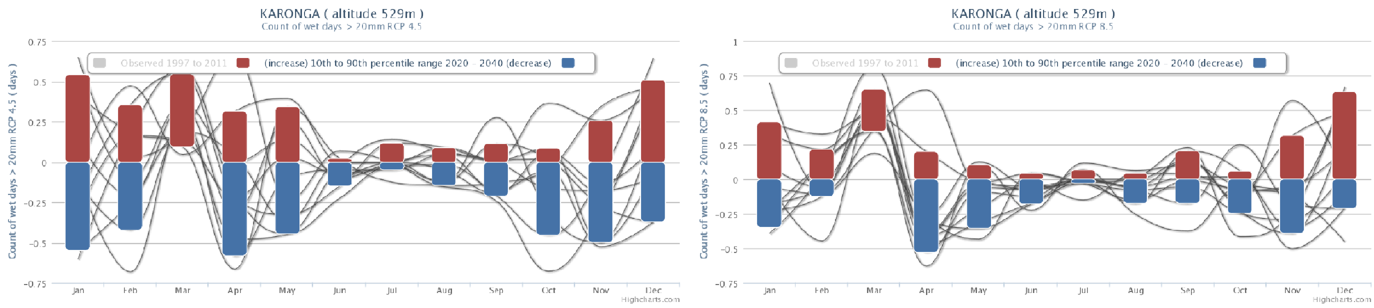


Figure B.8.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

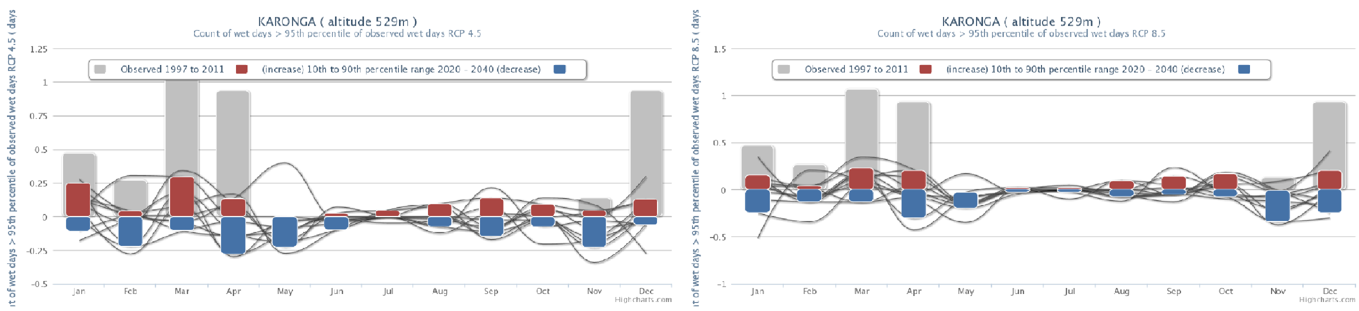


Figure B.8.5: Change in monthly rain day frequency > 46 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

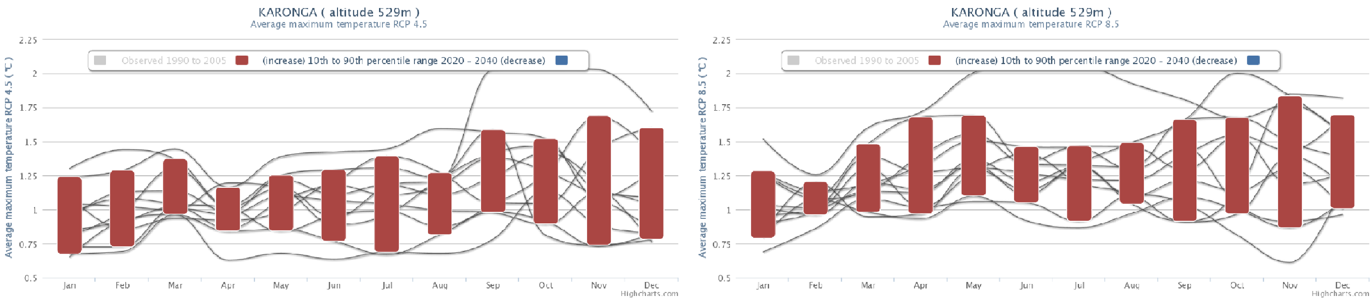


Figure B.8.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Monthly mean maximum days above 36 degree C

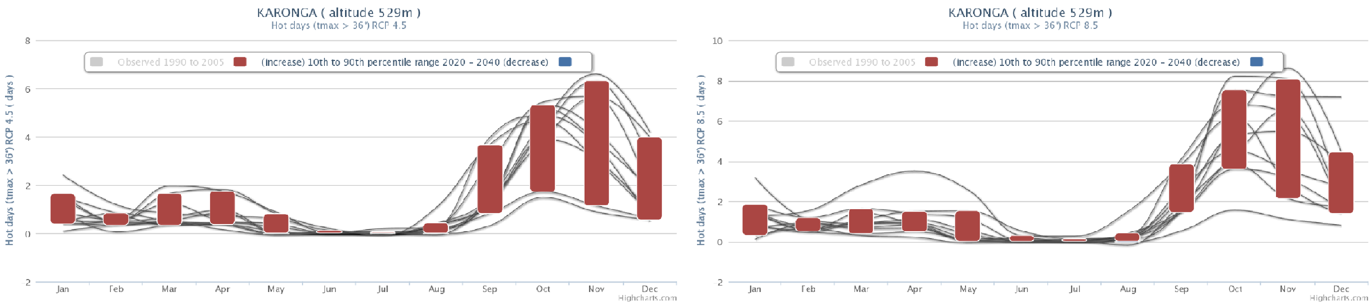


Figure B.8.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Monthly mean maximum days above 95th percentile

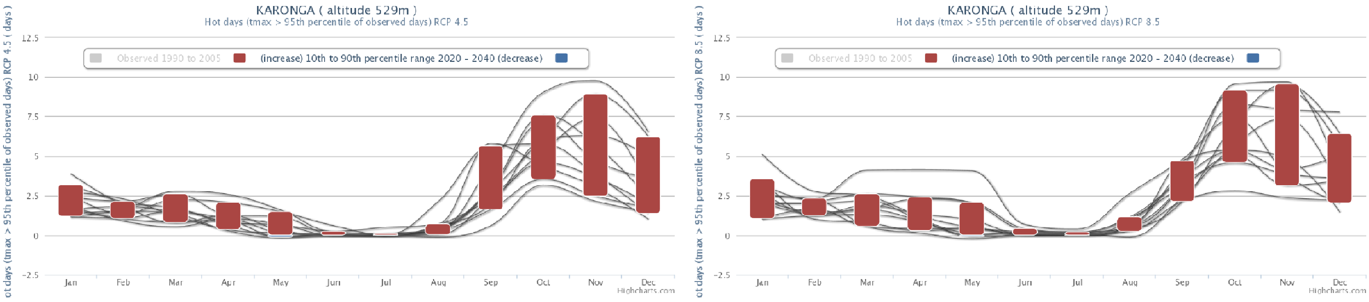


Figure B.8.8: Change in days above 34.8 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Monthly mean heat spell duration

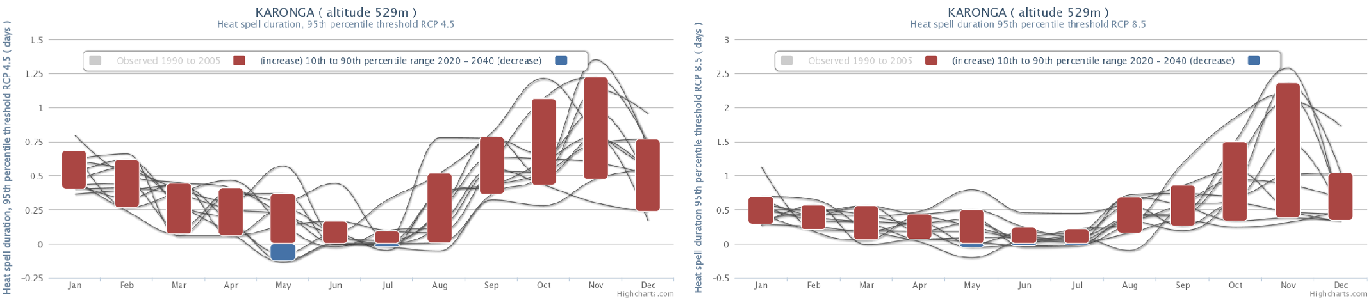


Figure B.8.9: Change in heat spell duration (34.8 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Monthly mean minimum daily temperature change

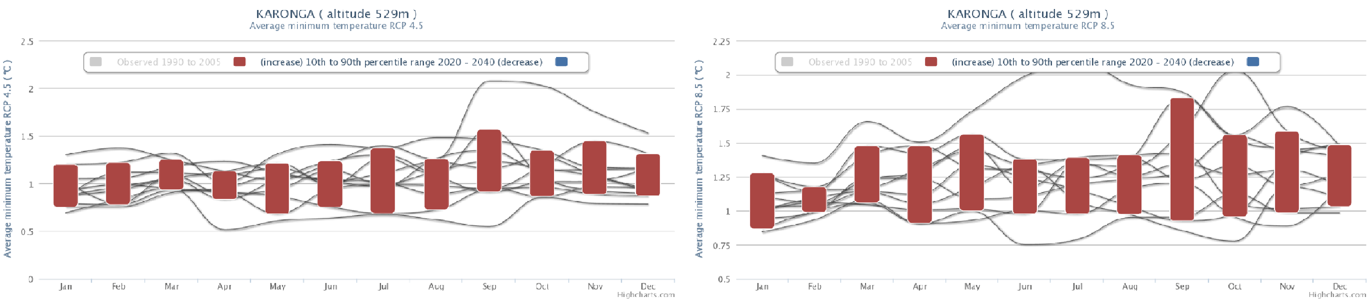


Figure B.8.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

B.9: Climate Summary for KASUNGU

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

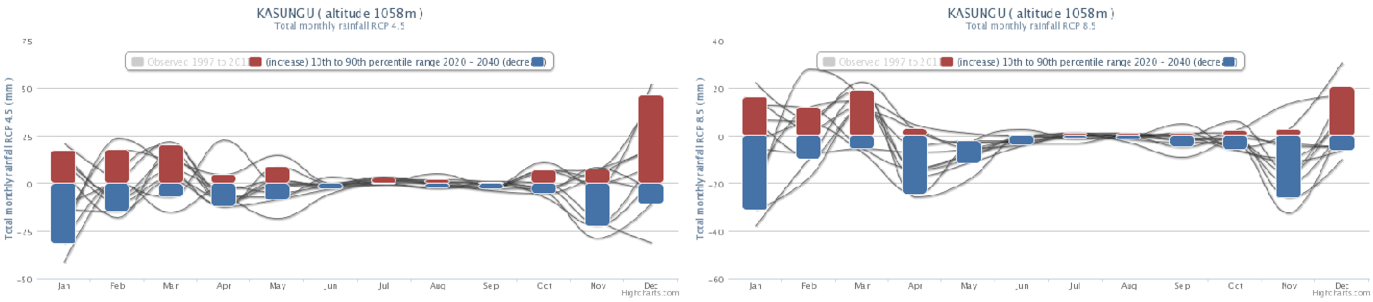


Figure B.9.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station

Projected change in monthly mean dry spell duration change

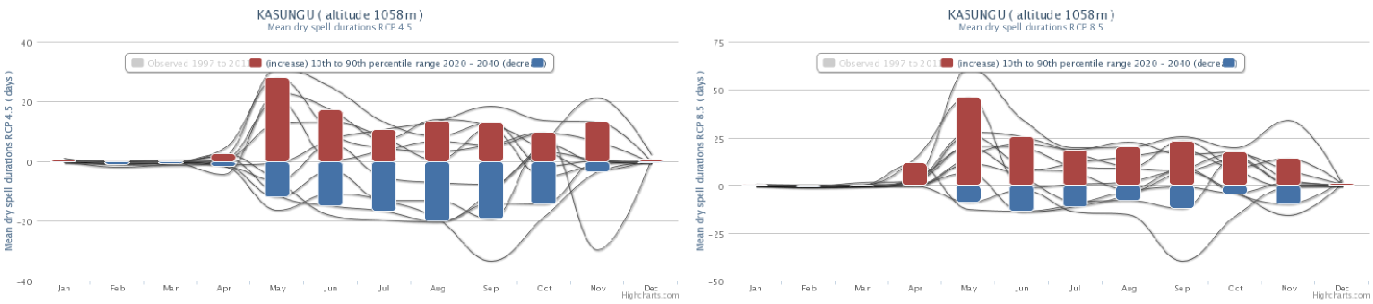


Figure B.9.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Projected change in monthly mean rain day frequency

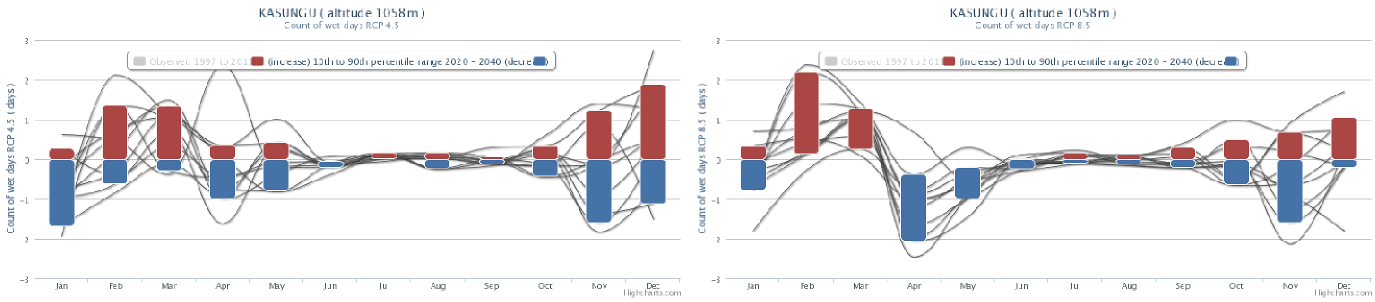


Figure B.9.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Projected change in monthly mean rain day frequency (> 20mm)

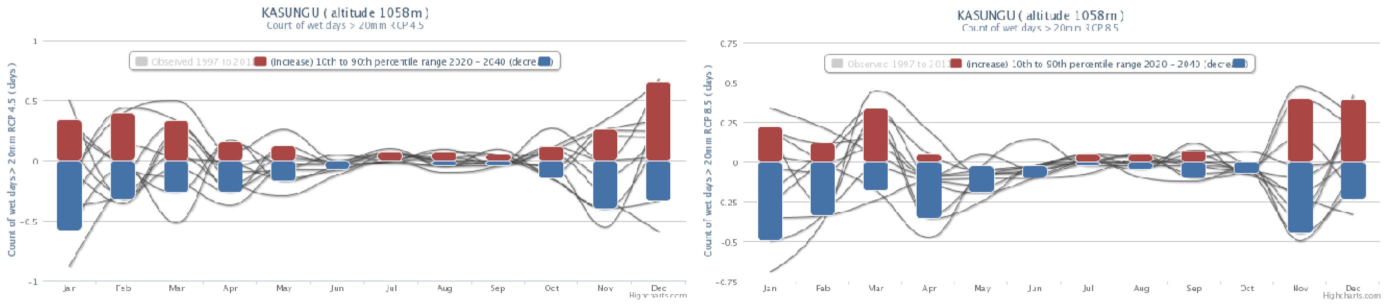


Figure B.9.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

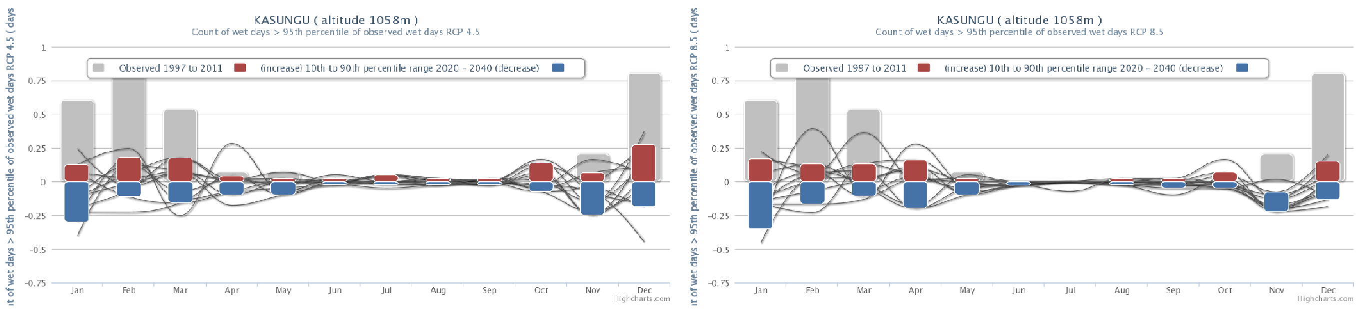


Figure B.9.5: Change in monthly rain day frequency > 40 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

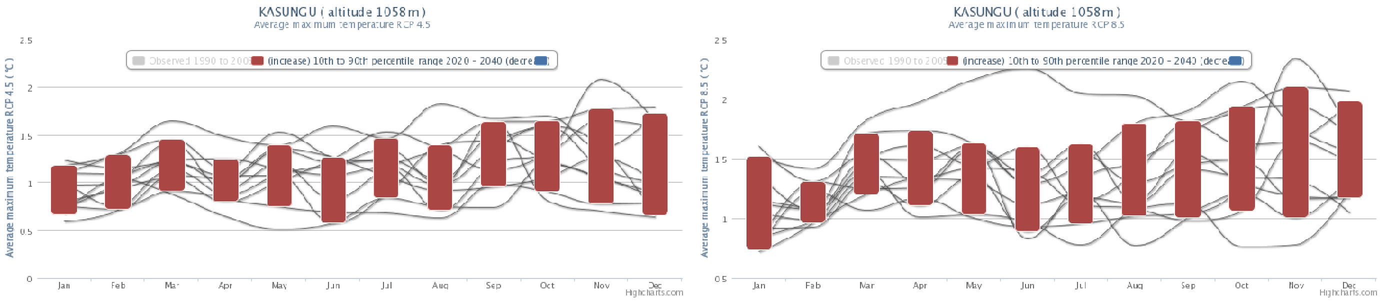


Figure B.9.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Monthly mean maximum days above 36 degree C

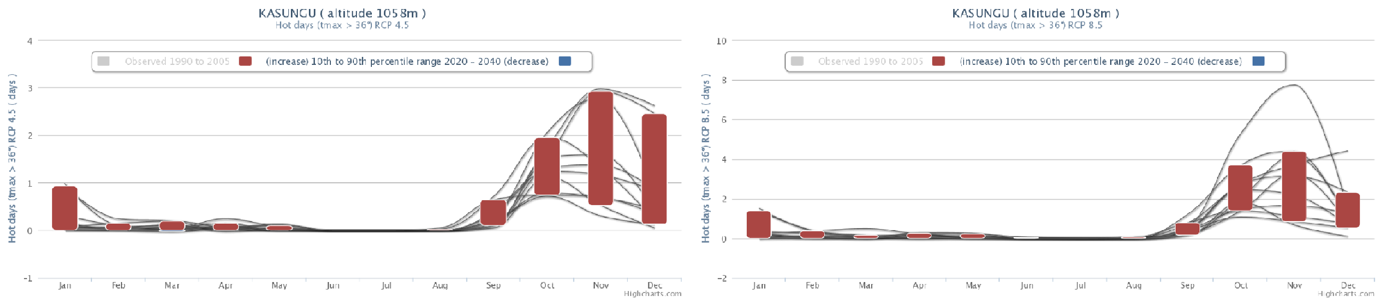


Figure B.9.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Monthly mean maximum days above 95th percentile

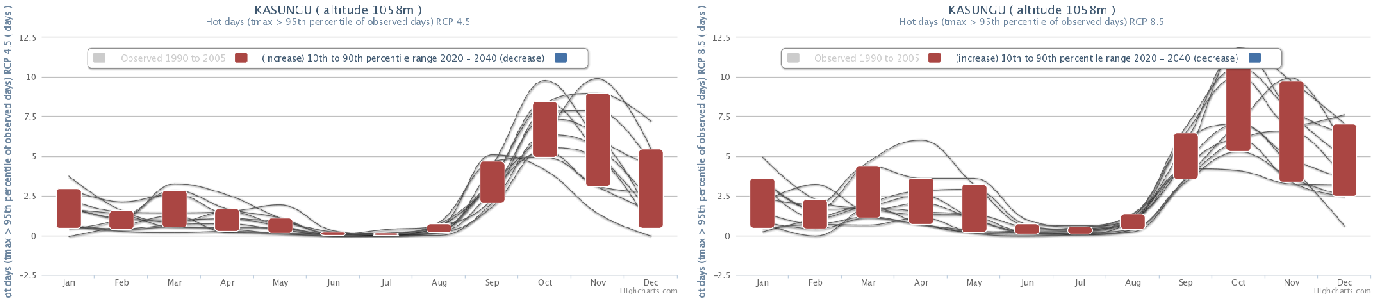


Figure B.9.8: Change in days above 32.6 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Monthly mean heat spell duration

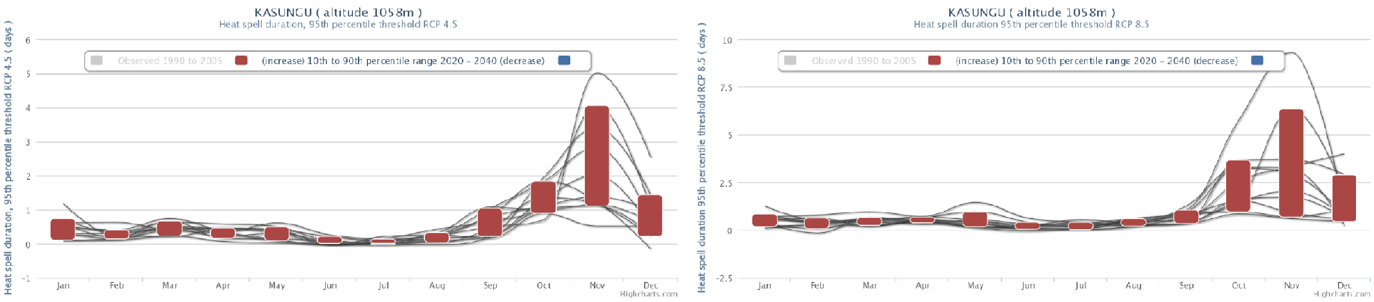


Figure B.9.9: Change in heat spell duration (32.6 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Monthly mean minimum daily temperature change

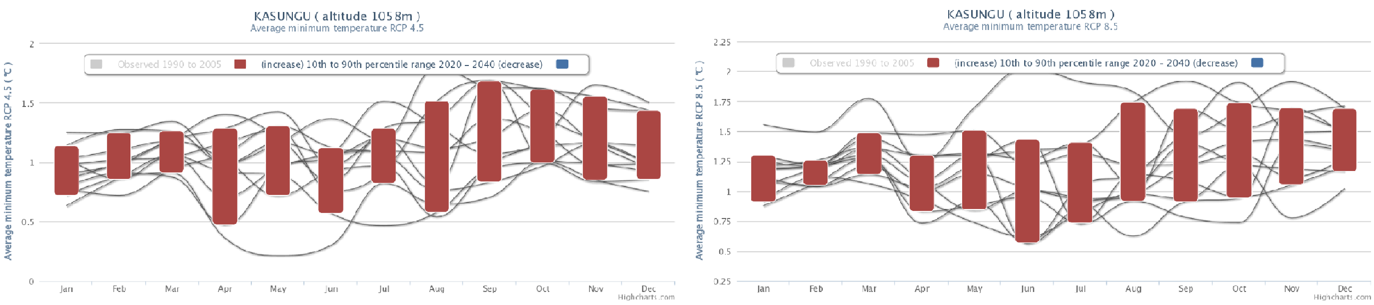


Figure B.9.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

B.10: Climate Summary for KIA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

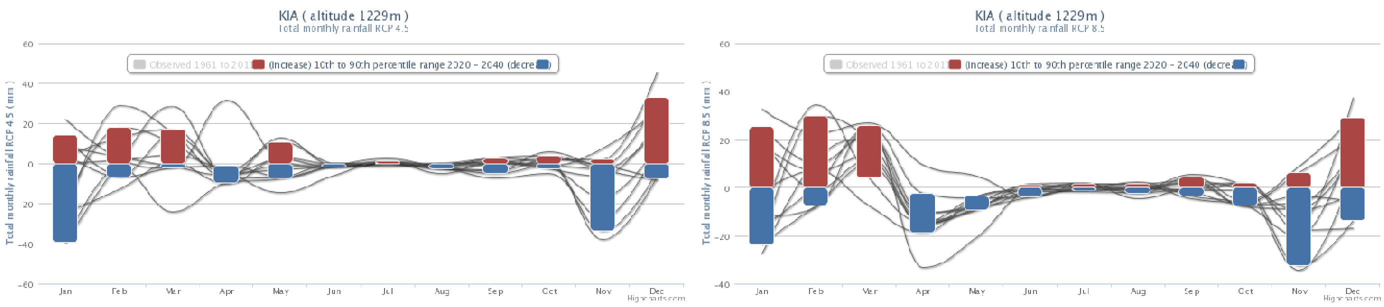


Figure B.10.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station

Projected change in monthly mean dry spell duration change

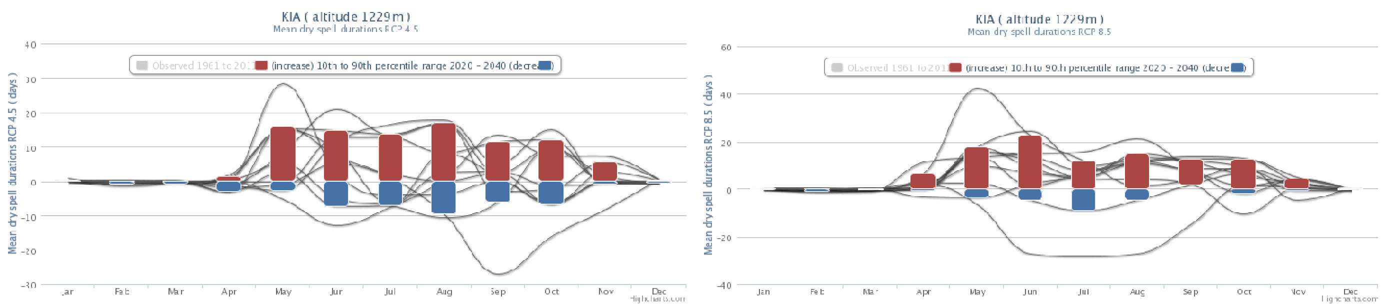


Figure B.10.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Projected change in monthly mean rain day frequency

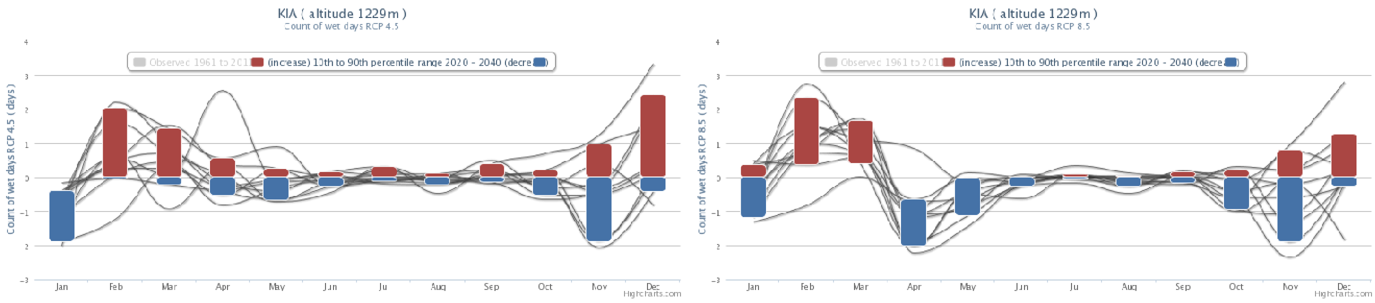


Figure B.10.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Projected change in monthly mean rain day frequency (> 20mm)

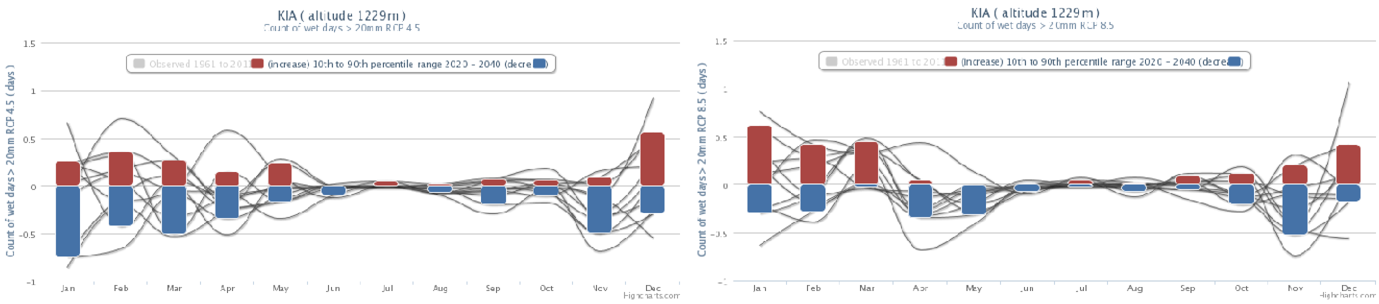


Figure B.10.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

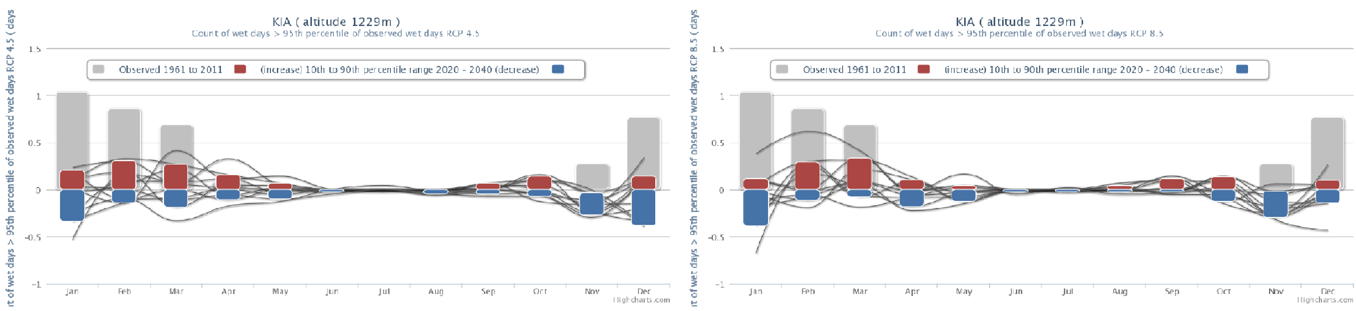


Figure B.10.5: Change in monthly rain day frequency > 36.8 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

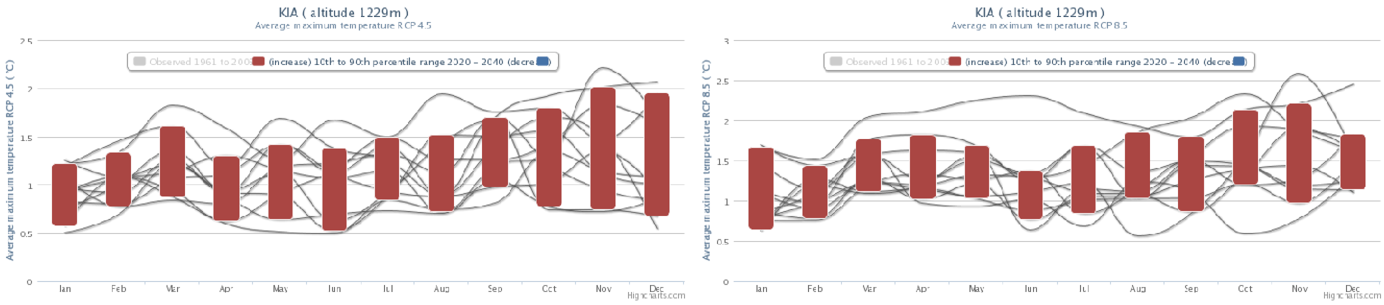


Figure B.10.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Monthly mean maximum days above 36 degree C

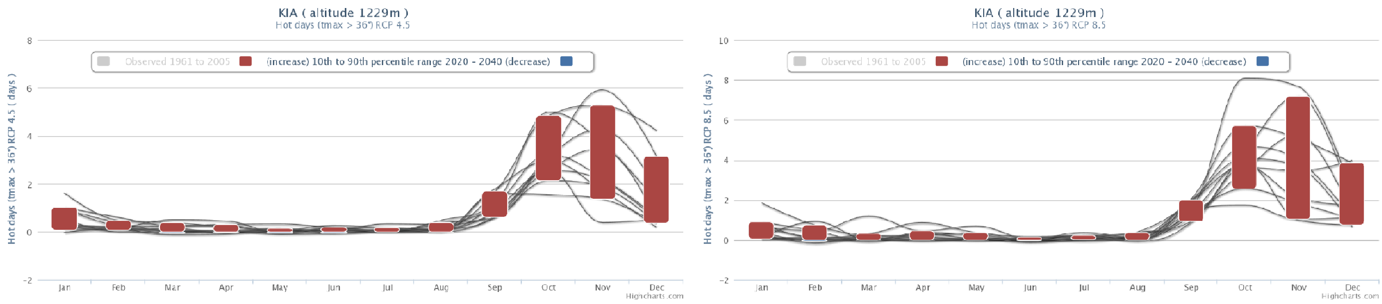


Figure B.10.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Monthly mean maximum days above 95th percentile

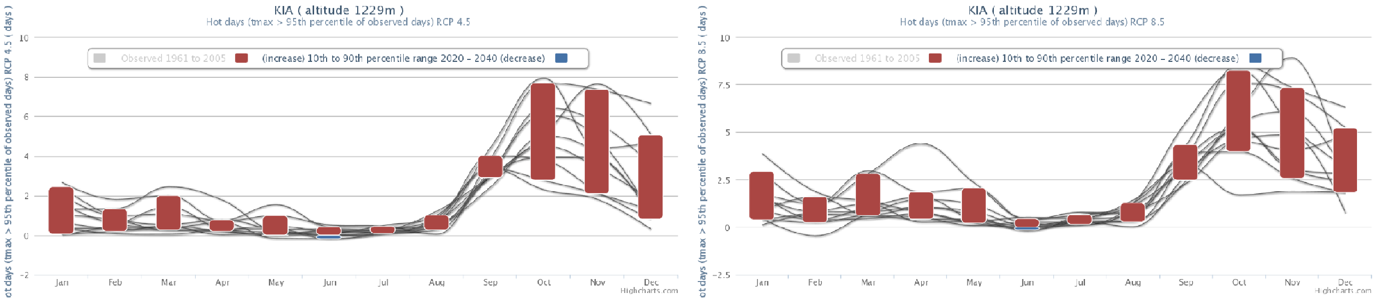


Figure B.10.8: Change in days above 33.4 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Monthly mean heat spell duration

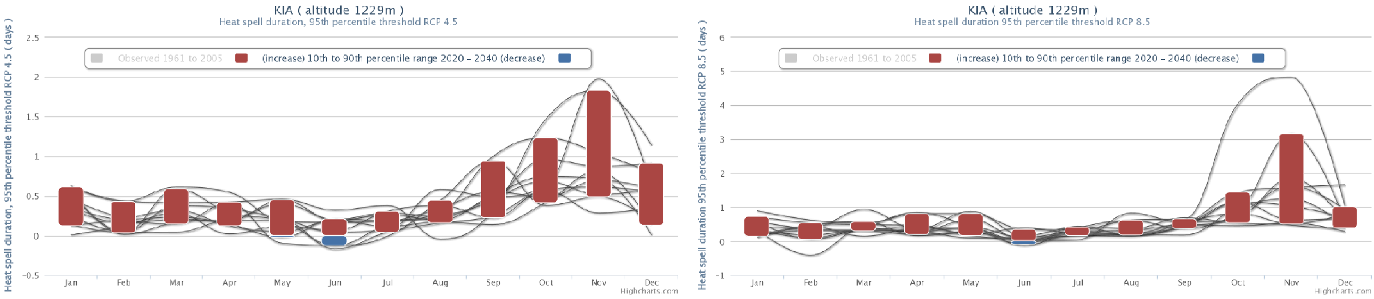


Figure B.10.9: Change in heat spell duration (33.4 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Monthly mean minimum daily temperature change

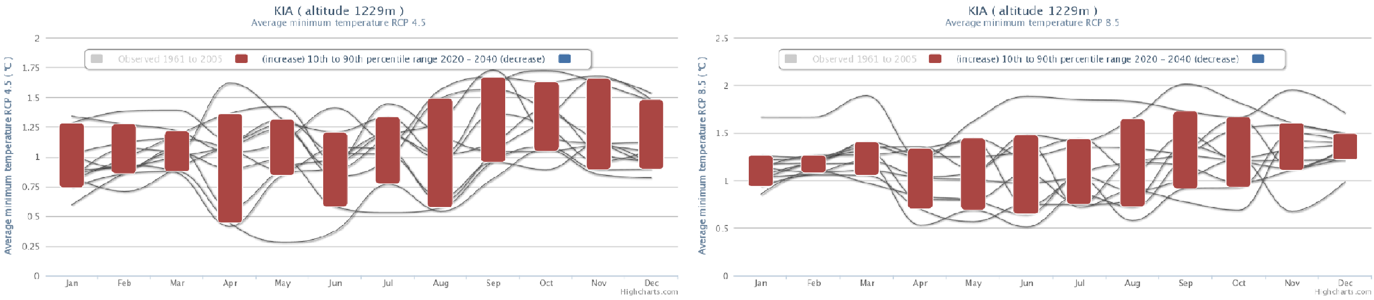


Figure B.10.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

B.11: Climate Summary for MAKOKA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

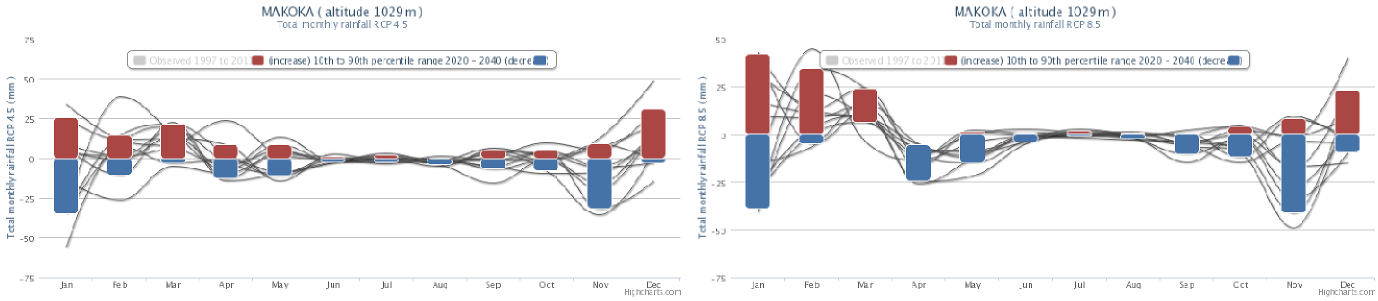


Figure B.11.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Projected change in monthly mean dry spell duration change

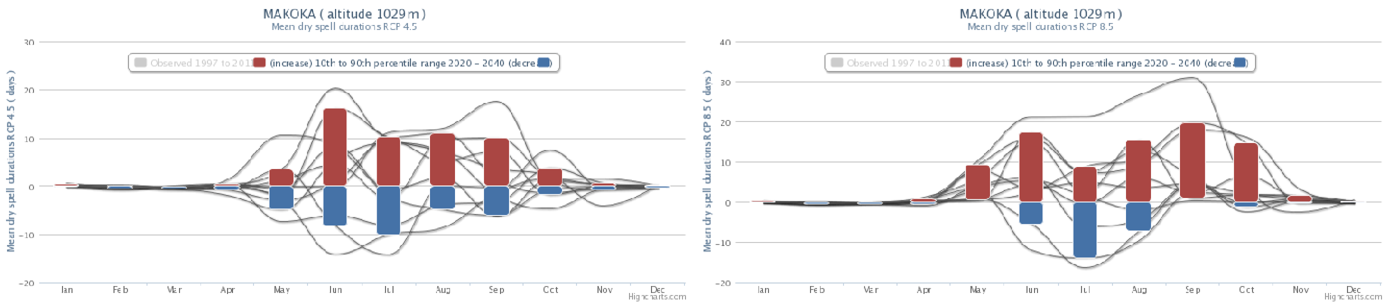


Figure B.11.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Projected change in monthly mean rain day frequency

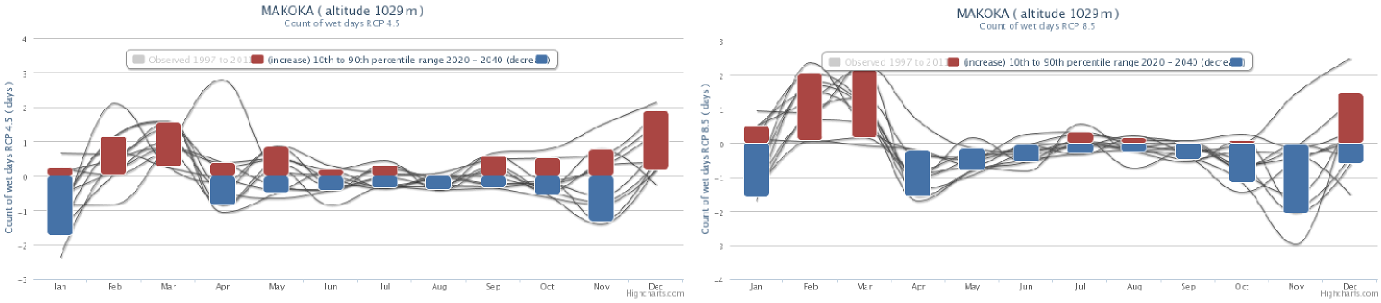


Figure B.11.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Projected change in monthly mean rain day frequency (> 20mm)

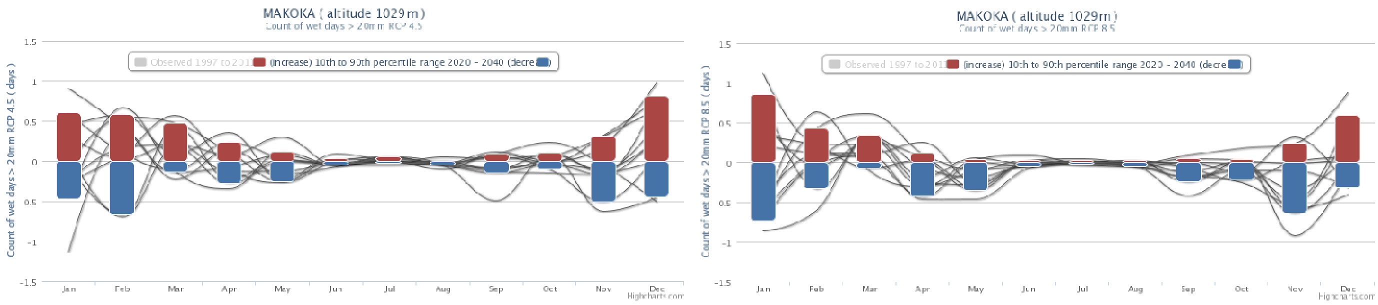


Figure B.11.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

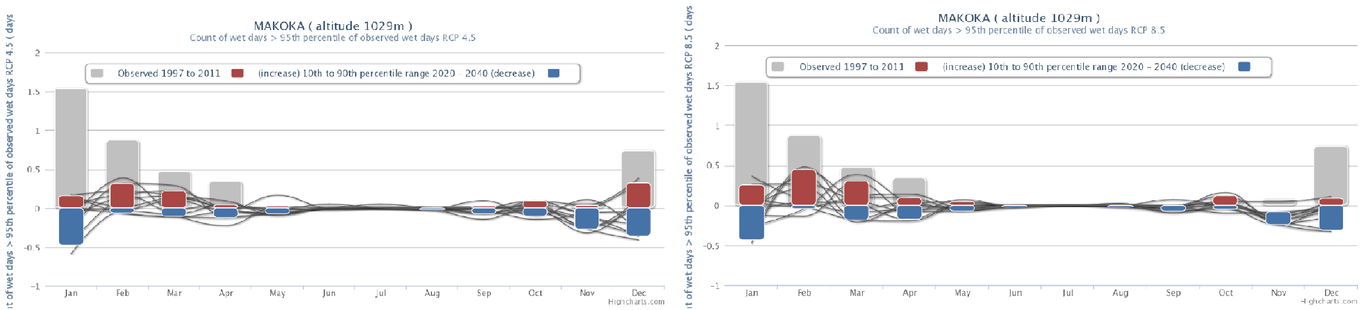


Figure B.11.5: Change in monthly rain day frequency > 44.7 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

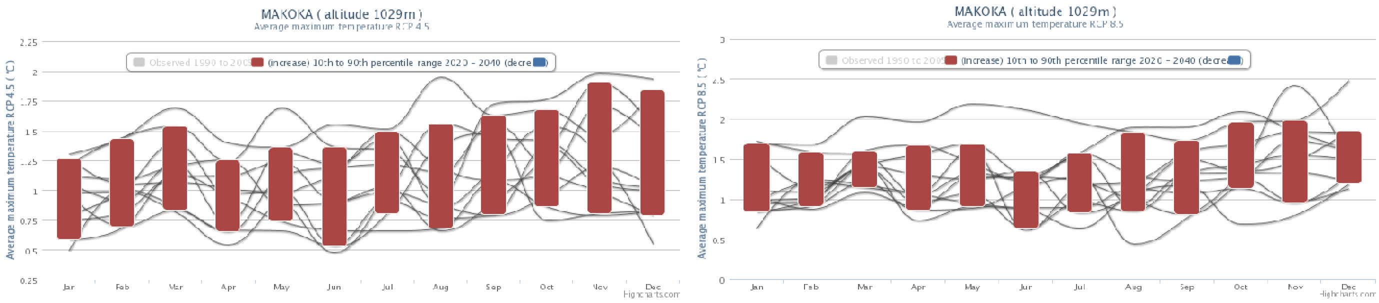


Figure B.11.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Monthly mean maximum days above 36 degree C

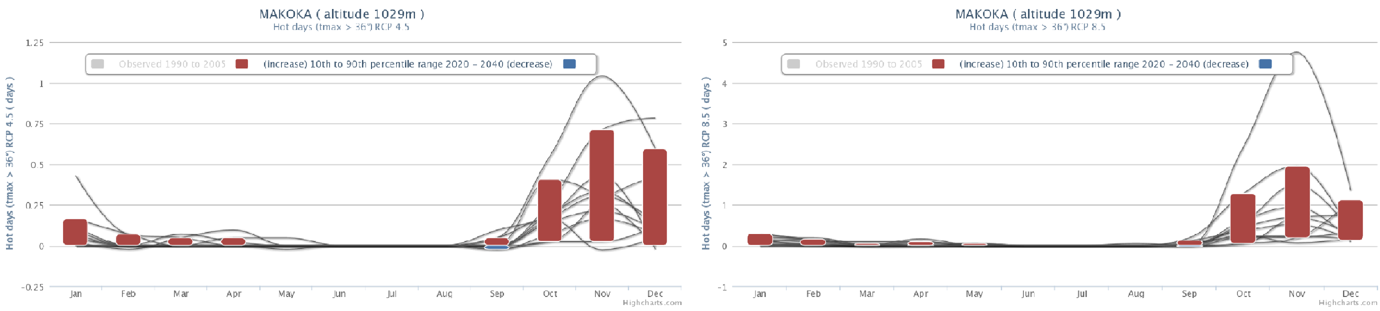


Figure B.11.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Monthly mean maximum days above 95th percentile

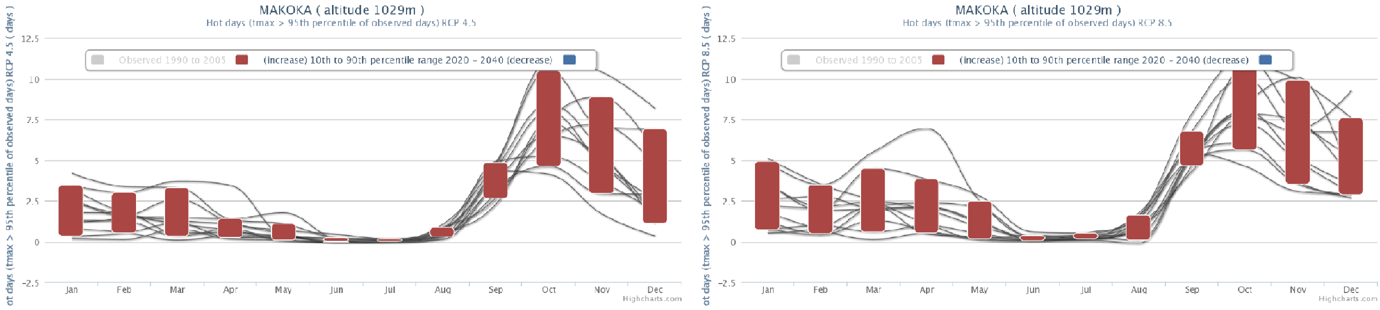


Figure B.11.8: Change in days above 31.5 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Monthly mean heat spell duration

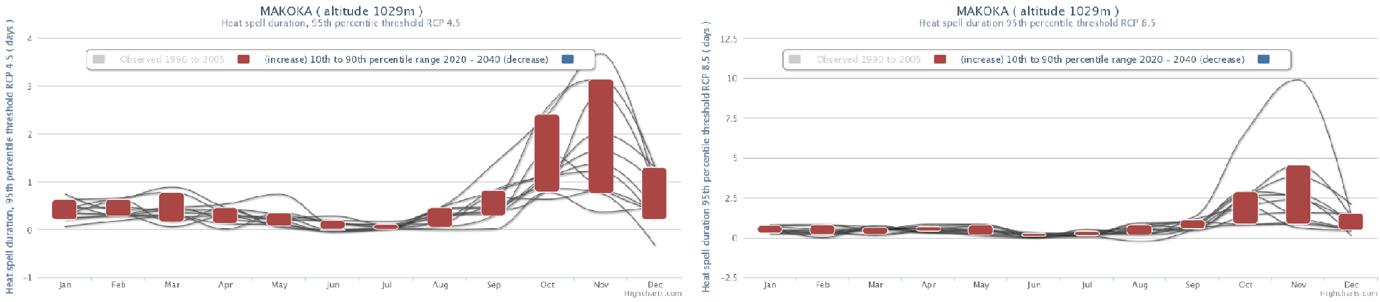


Figure B.11.9: Change in heat spell duration (31.5 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Monthly mean minimum daily temperature change

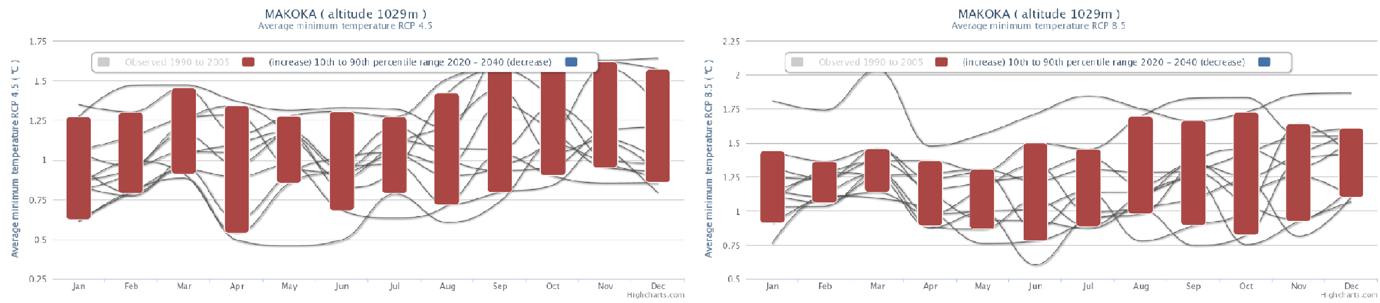


Figure B.11.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

B.12: Climate Summary for MANGOCHI

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

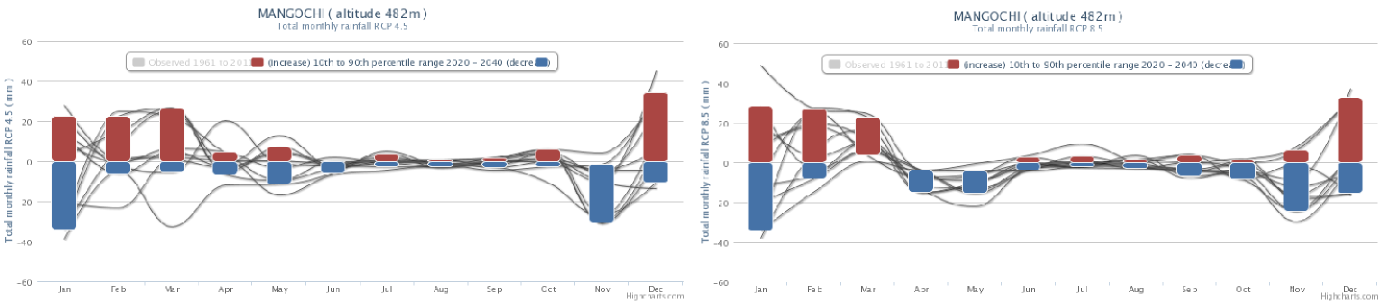


Figure B.12.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Projected change in monthly mean dry spell duration change

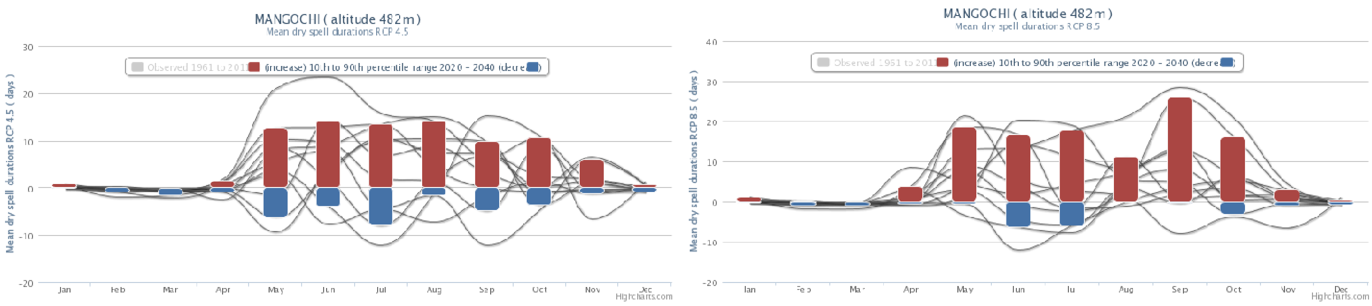


Figure B.12.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Projected change in monthly mean rain day frequency

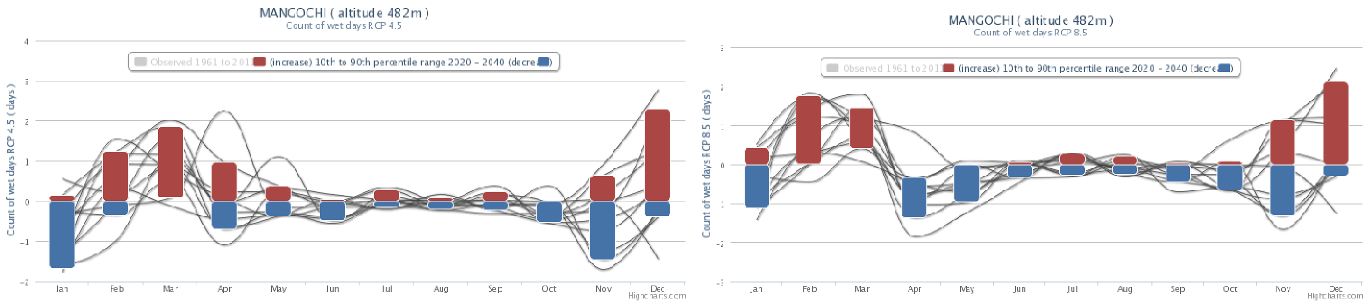


Figure B.12.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Projected change in monthly mean rain day frequency (> 20mm)

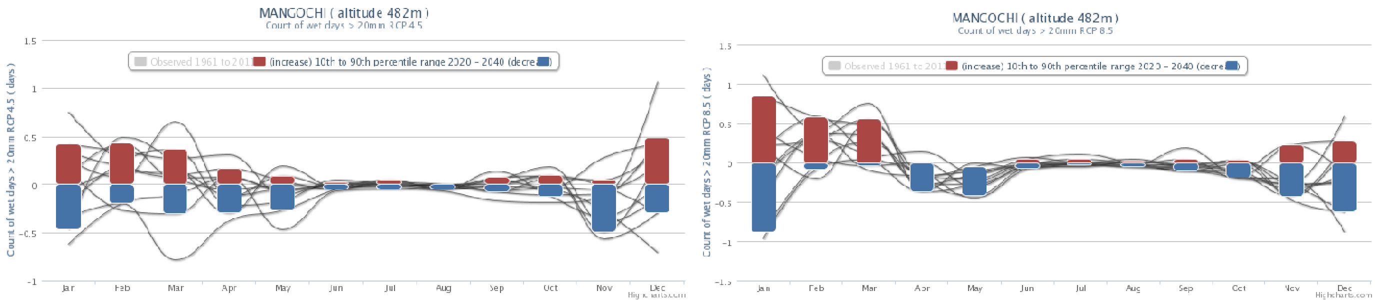


Figure B.12.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

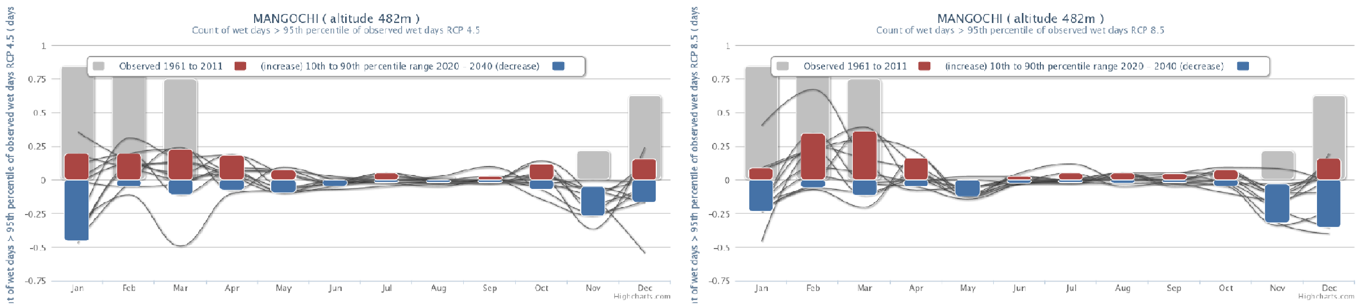


Figure B.12.5: Change in monthly rain day frequency > 41.7 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

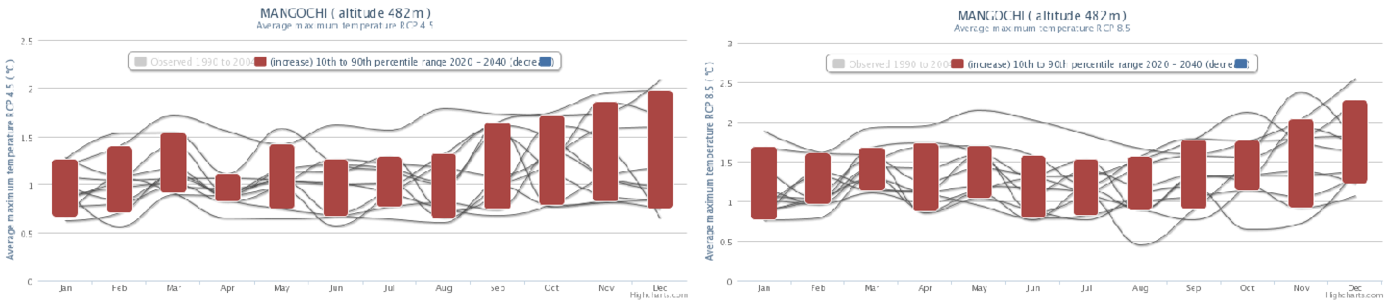


Figure B.12.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Monthly mean maximum days above 36 degree C

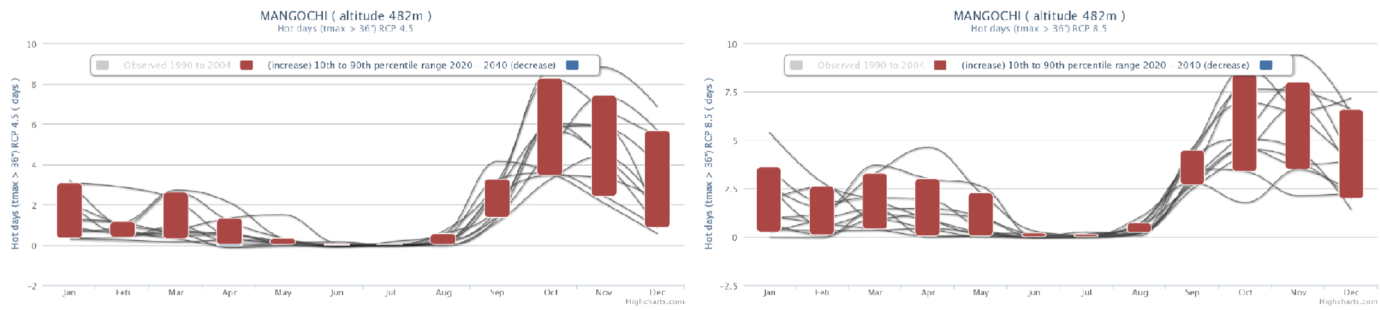


Figure B.12.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Monthly mean maximum days above 95th percentile

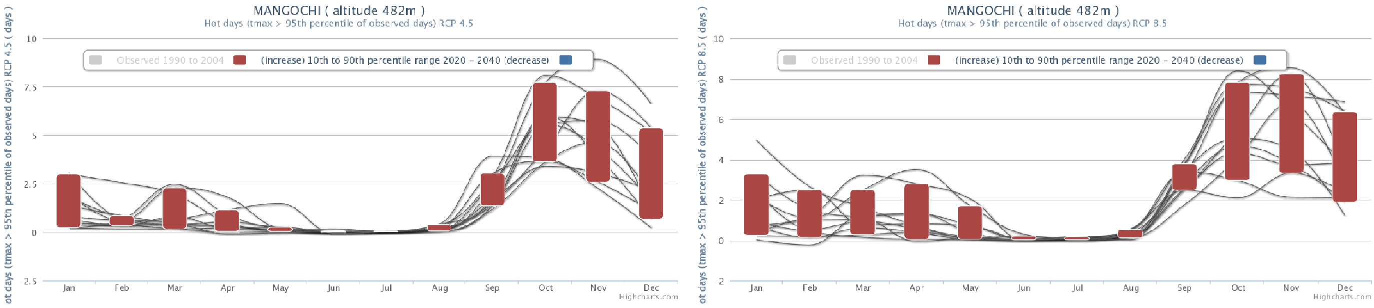


Figure B.12.8: Change in days above 36.3 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Monthly mean heat spell duration

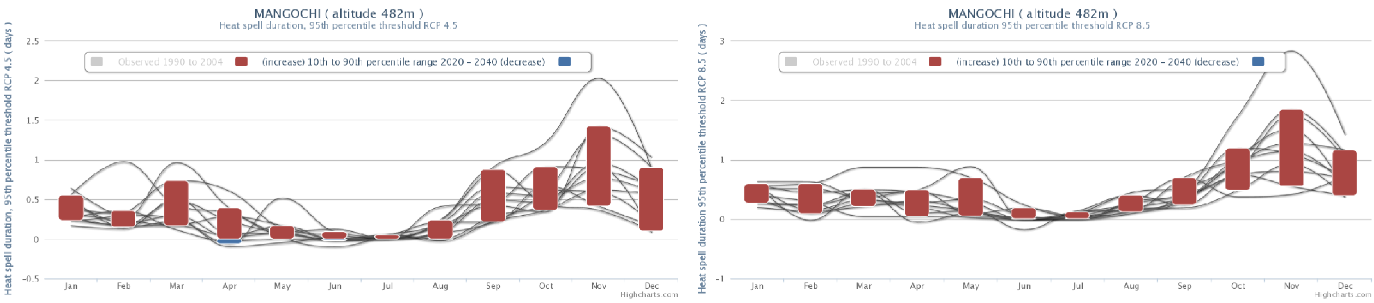


Figure B.12.9: Change in heat spell duration (36.3 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Monthly mean minimum daily temperature change

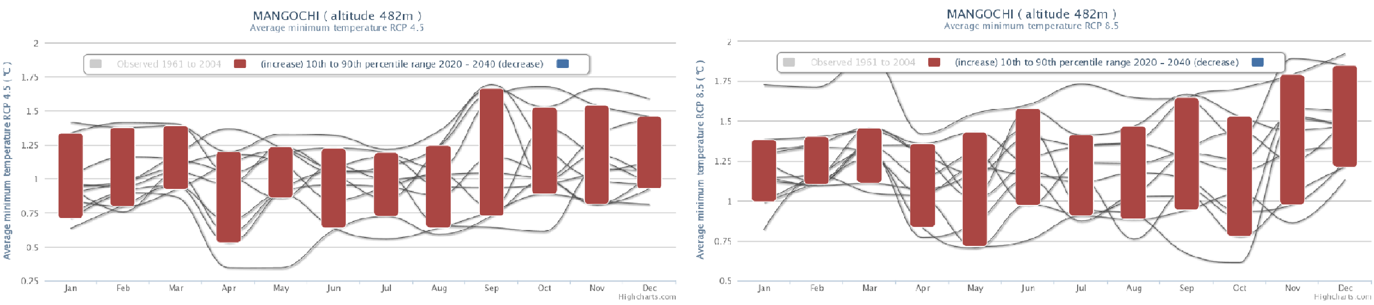


Figure B.12.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

B.13: Climate Summary for MIMOSA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

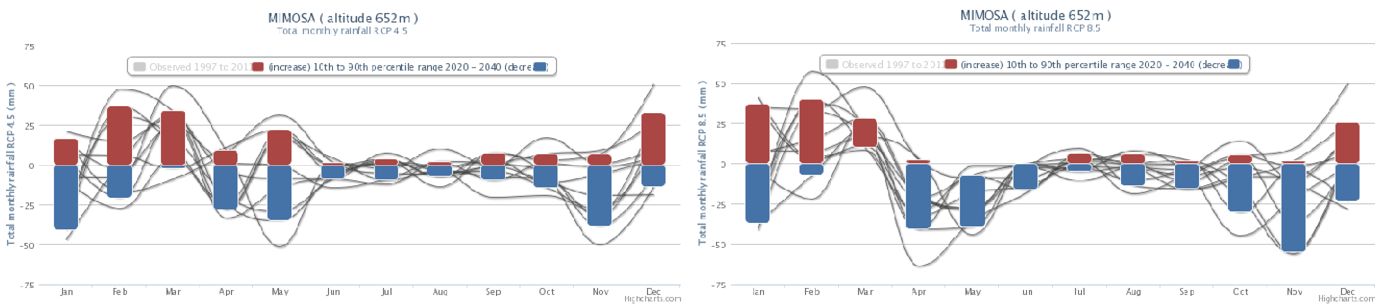


Figure B.13.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Projected change in monthly mean dry spell duration change

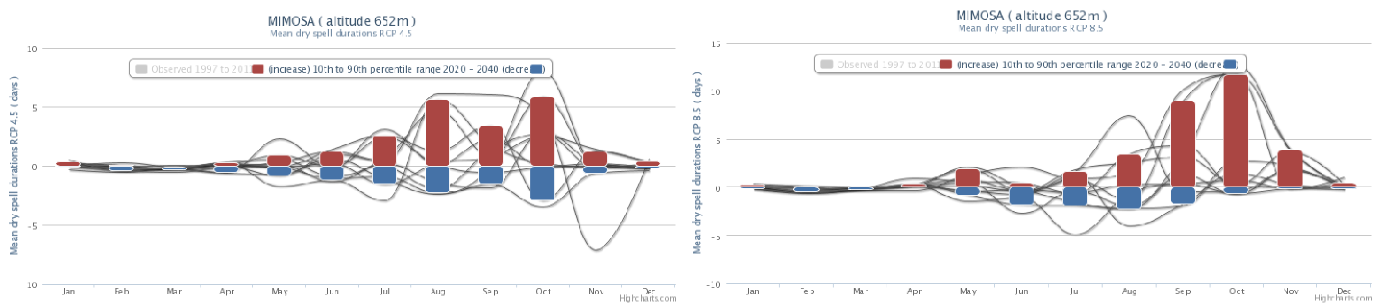


Figure B.13.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Projected change in monthly mean rain day frequency

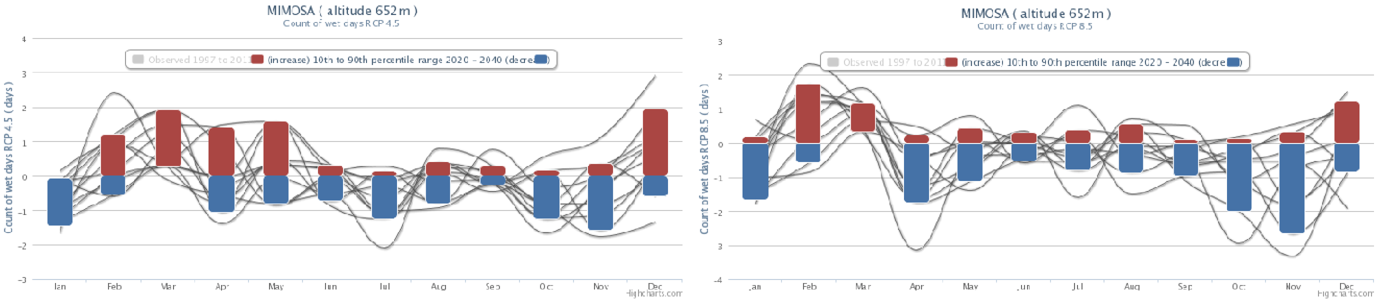


Figure B.13.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Projected change in monthly mean rain day frequency (> 20mm)

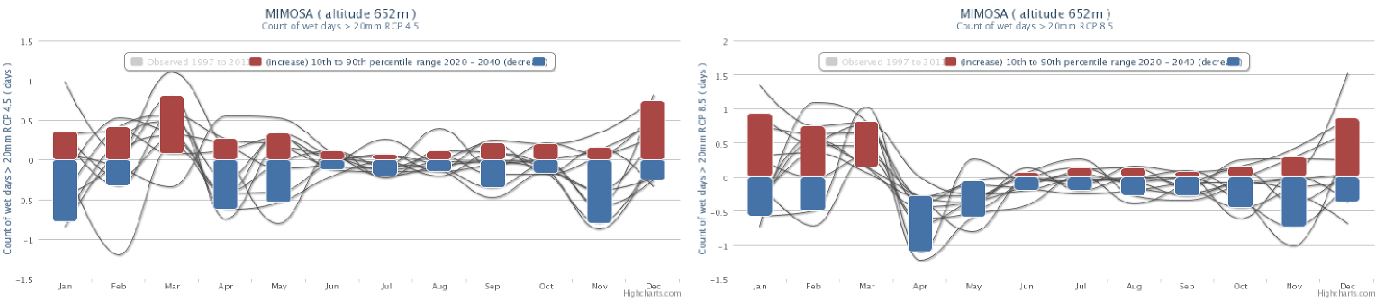


Figure B.13.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

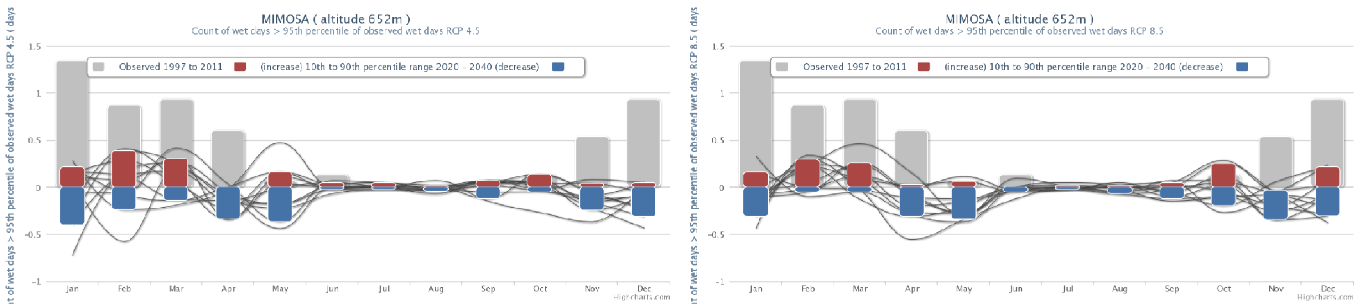


Figure B.13.5: Change in monthly rain day frequency > 49.3 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

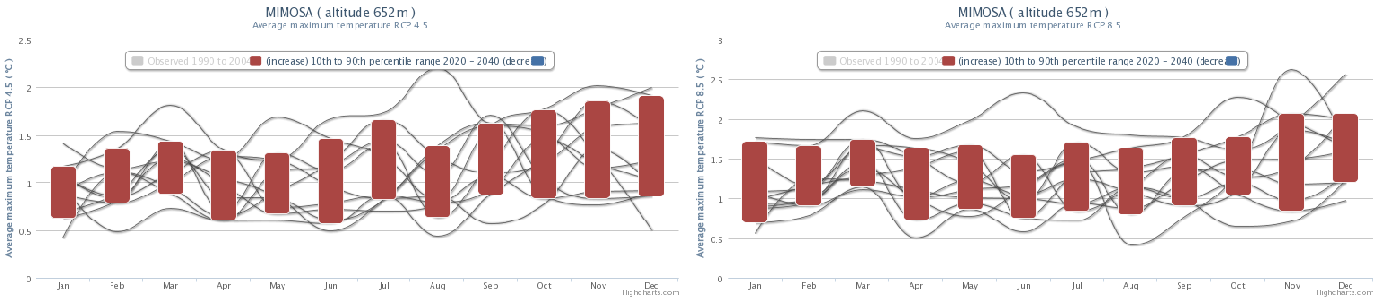


Figure B.13.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Monthly mean maximum days above 36 degree C

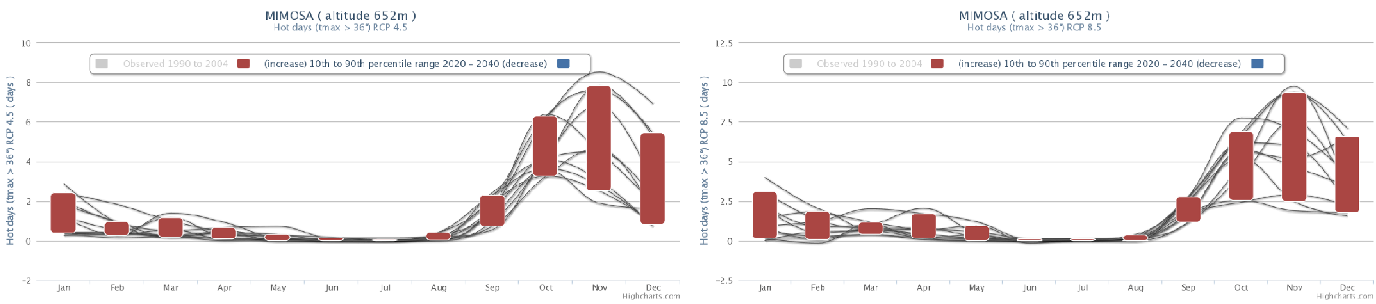


Figure B.13.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Monthly mean maximum days above 95th percentile

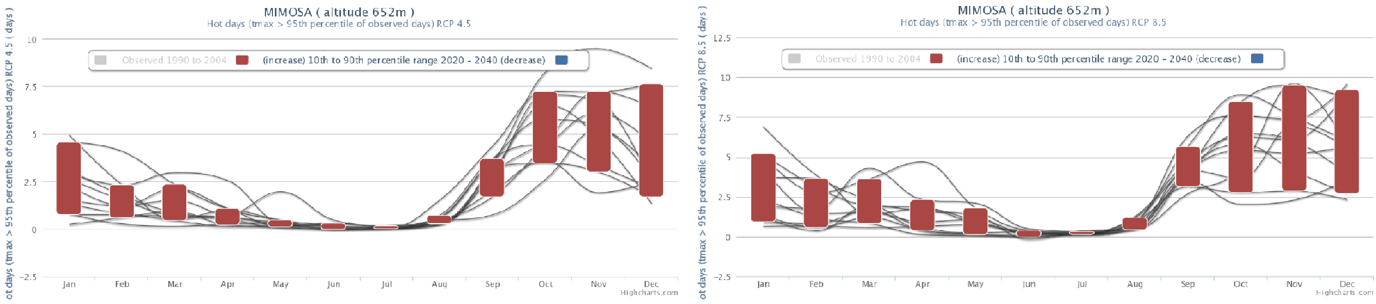


Figure B.13.8: Change in days above 34.7 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Monthly mean heat spell duration

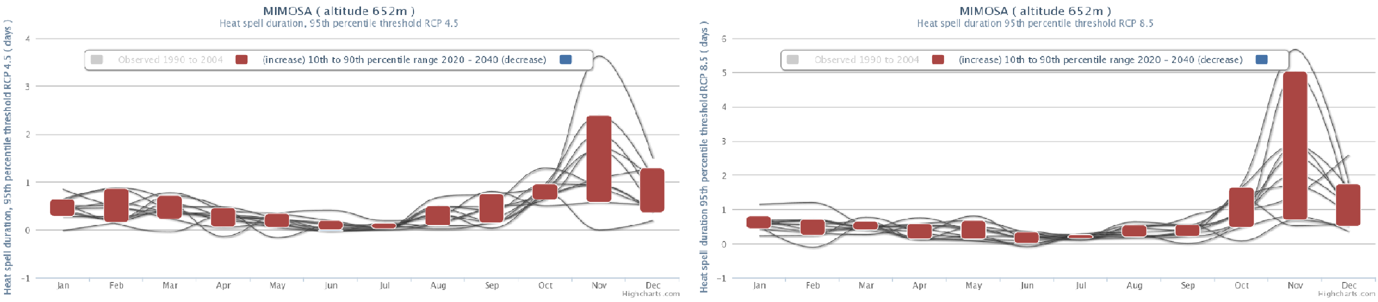


Figure B.13.9: Change in heat spell duration (34.7 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Monthly mean minimum daily temperature change

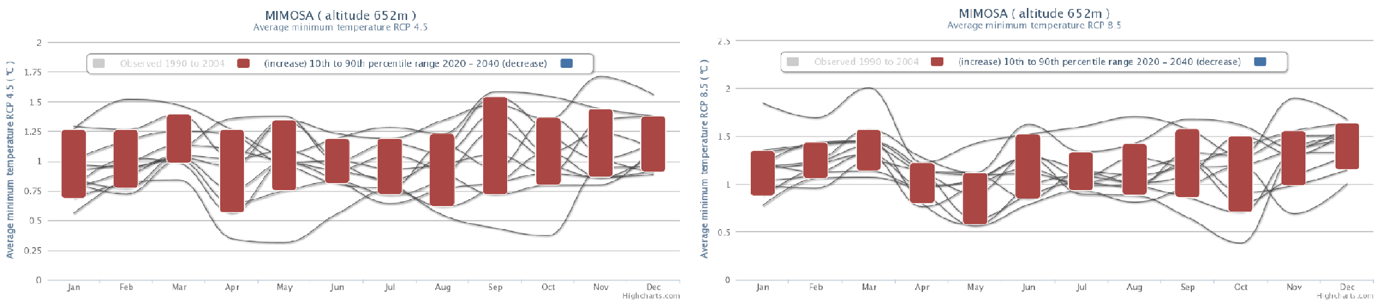


Figure B.13.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

B.14: Climate Summary for MONKEYBAY

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

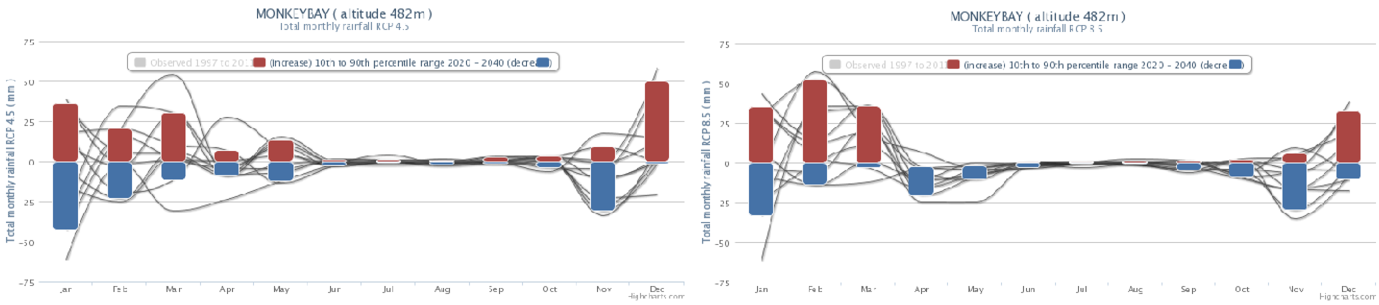


Figure B.14.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Projected change in monthly mean dry spell duration change

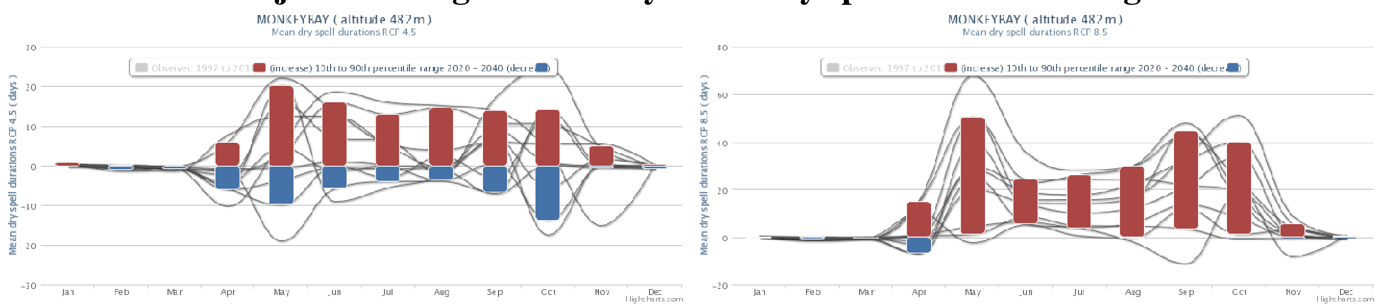


Figure B.14.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Projected change in monthly mean rain day frequency

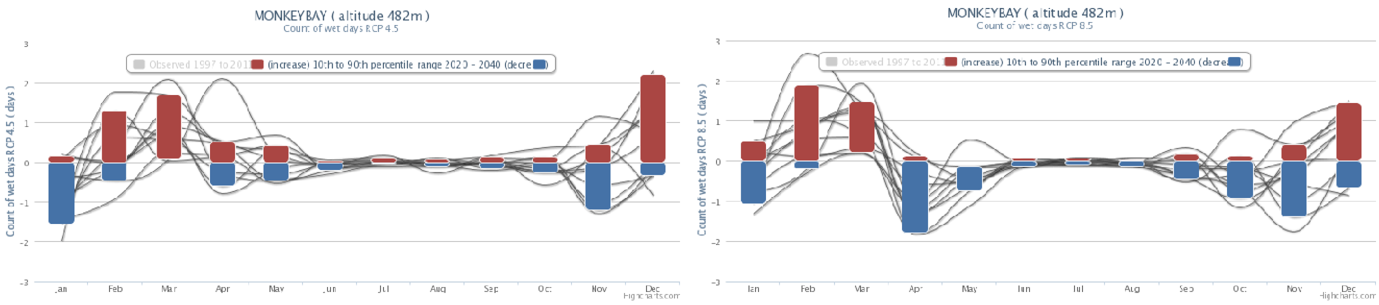


Figure B.14.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Projected change in monthly mean rain day frequency (> 20mm)

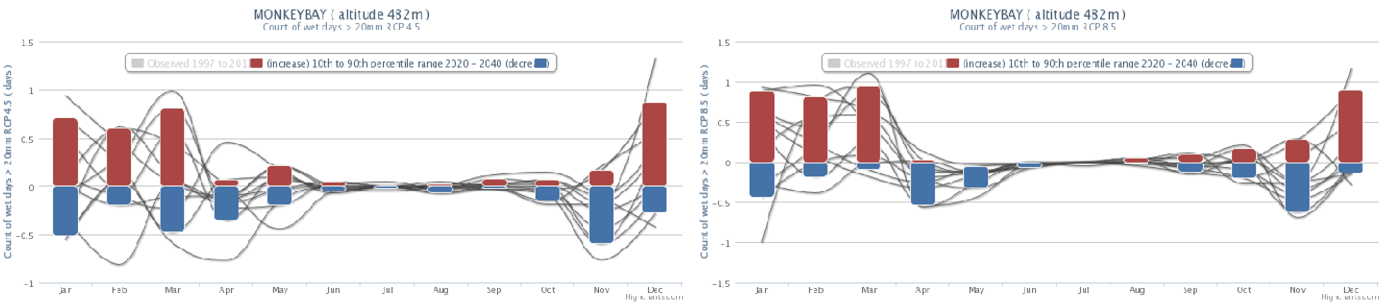


Figure B.14.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

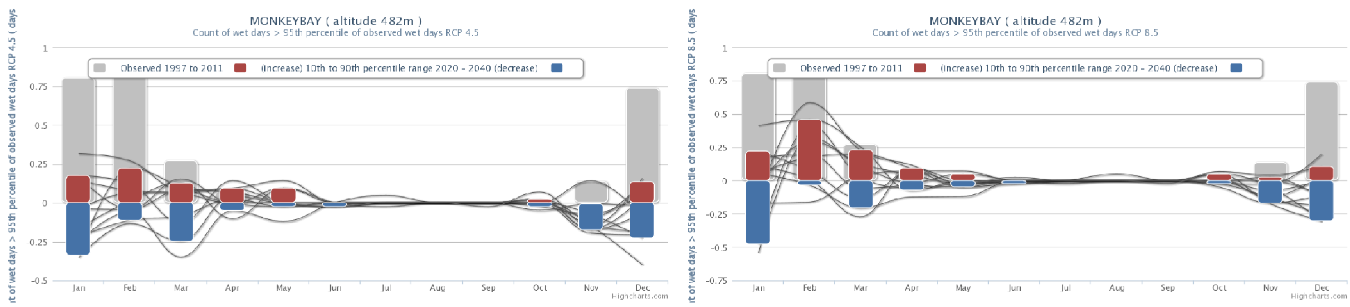


Figure B.14.5: Change in monthly rain day frequency > 57.2 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

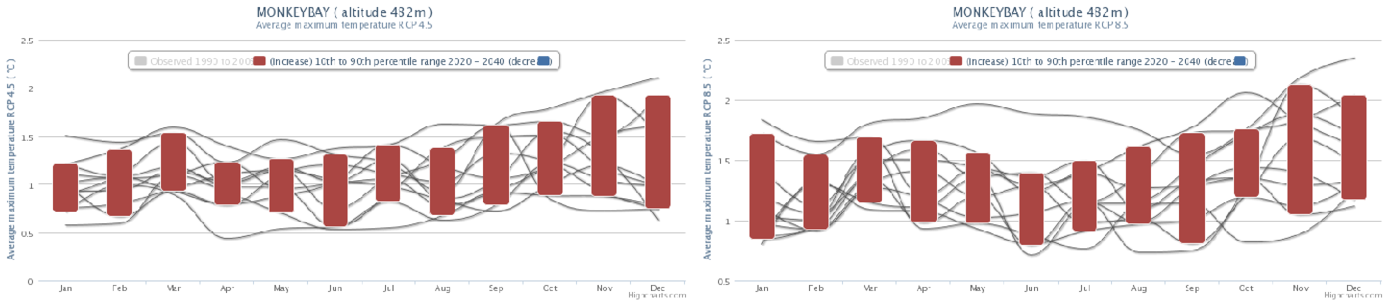


Figure B.14.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Monthly mean maximum days above 36 degree C

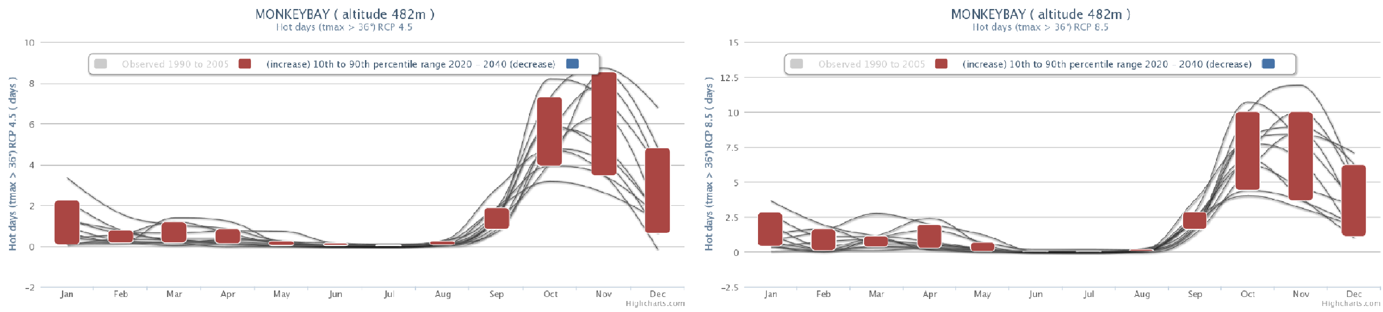


Figure B.14.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Monthly mean maximum days above 95th percentile

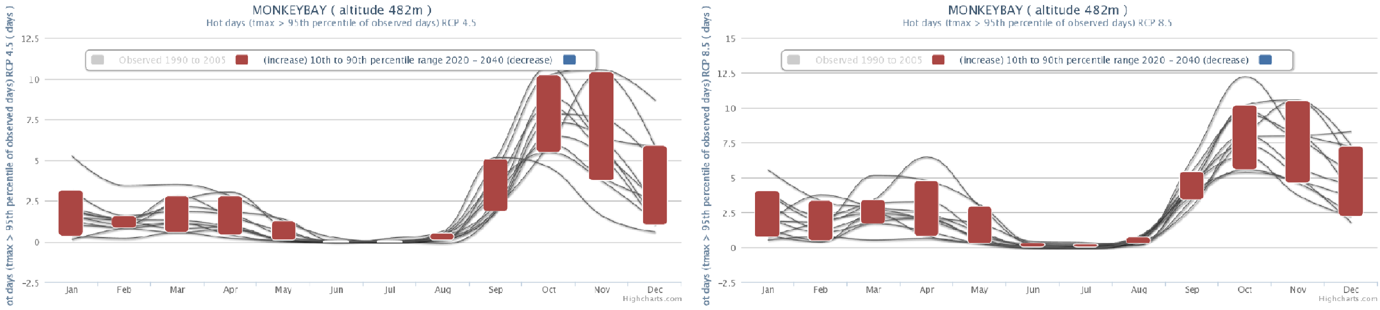


Figure B.14.8: Change in days above 34.7 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Monthly mean heat spell duration

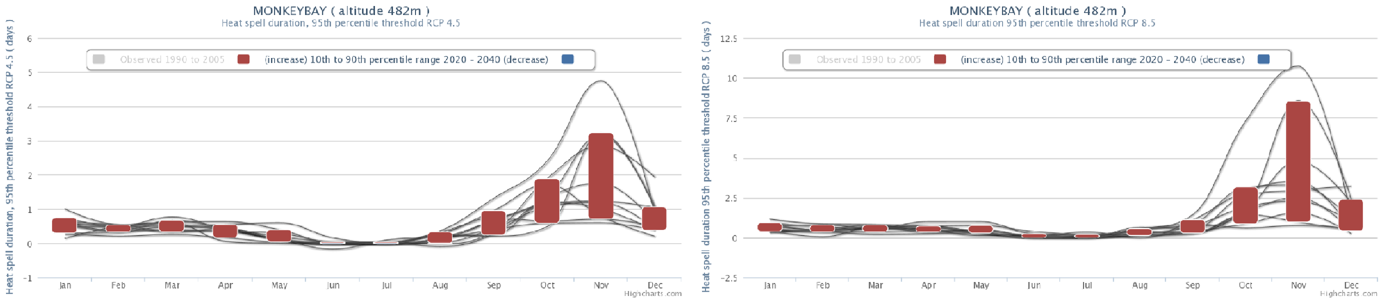


Figure B.14.9: Change in heat spell duration (34.7 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Monthly mean minimum daily temperature change

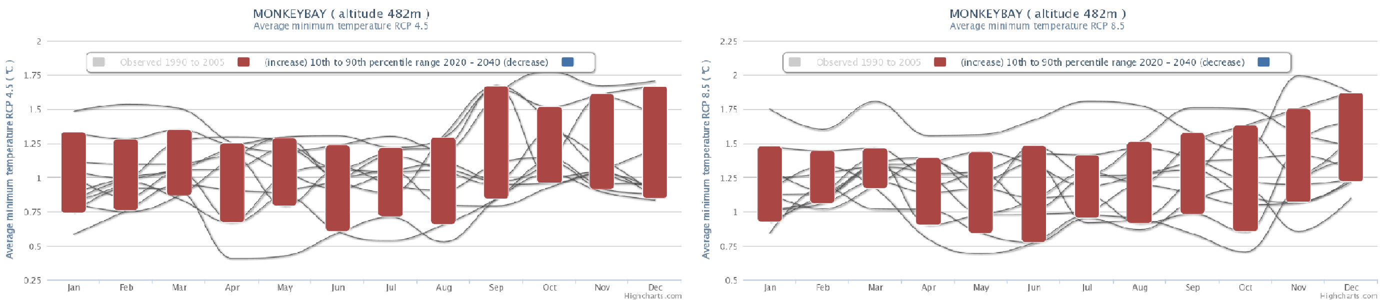


Figure B.14.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

B. 15: Climate Summary for MZIMBA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

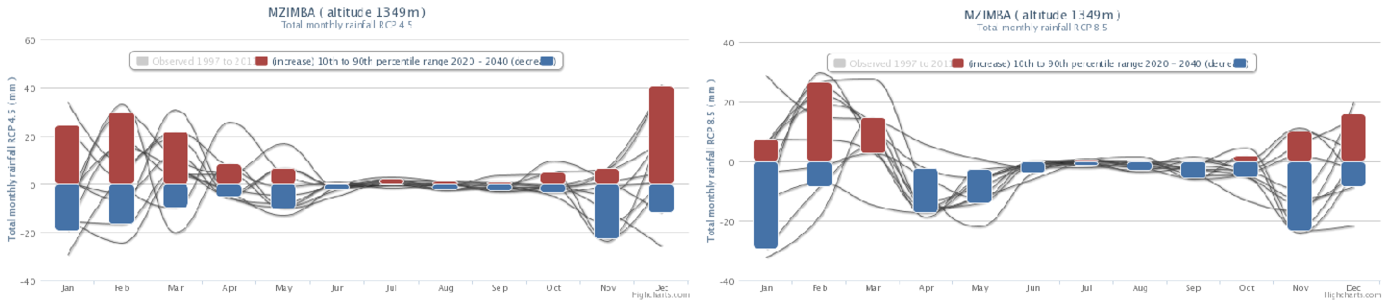


Figure B.15.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station

Projected change in monthly mean dry spell duration change

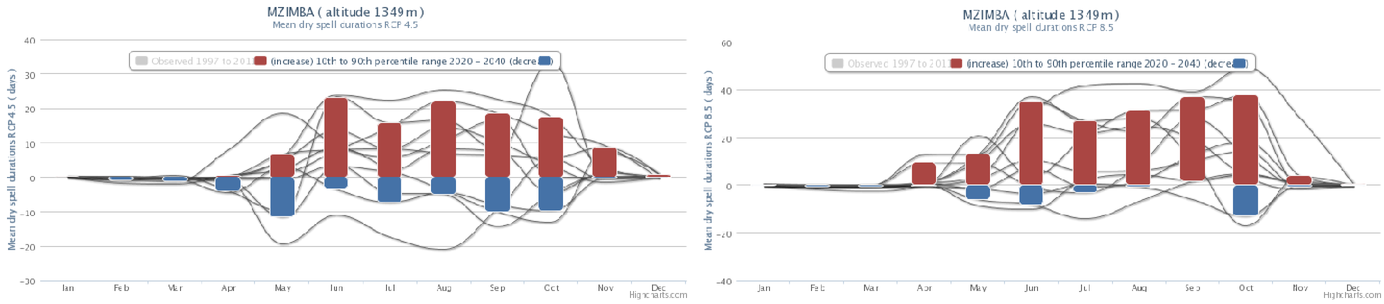
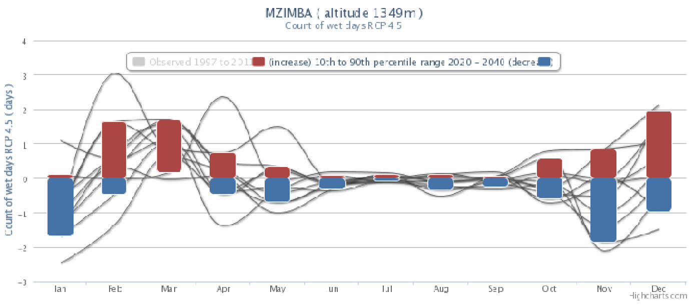


Figure B.15.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Projected change in monthly mean rain day frequency



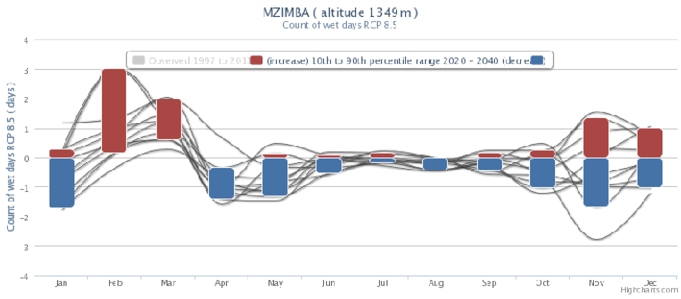
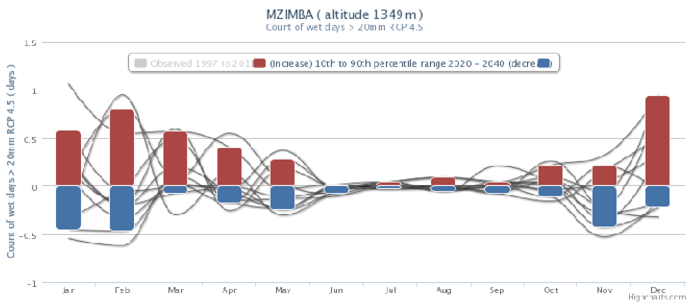


Figure B.15.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Projected change in monthly mean rain day frequency (> 20mm)



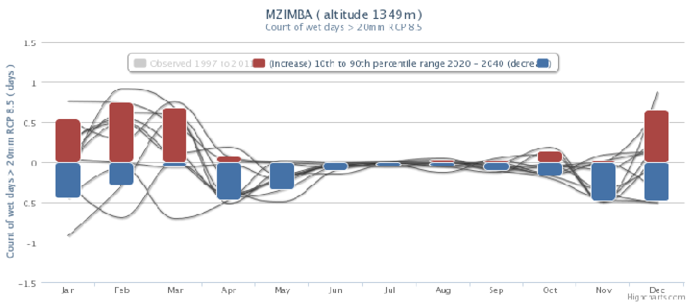
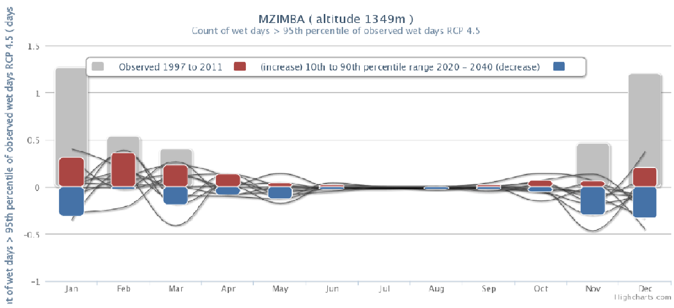


Figure B.15.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)



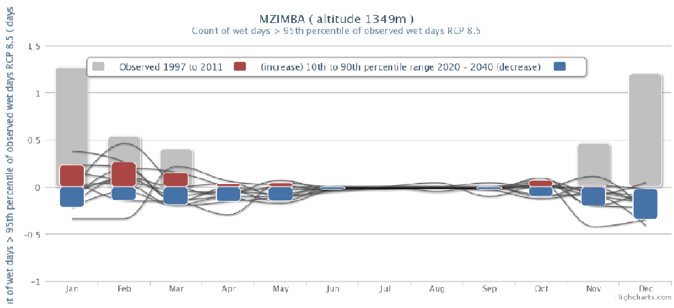


Figure B.15.5: Change in monthly rain day frequency > 35.6 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

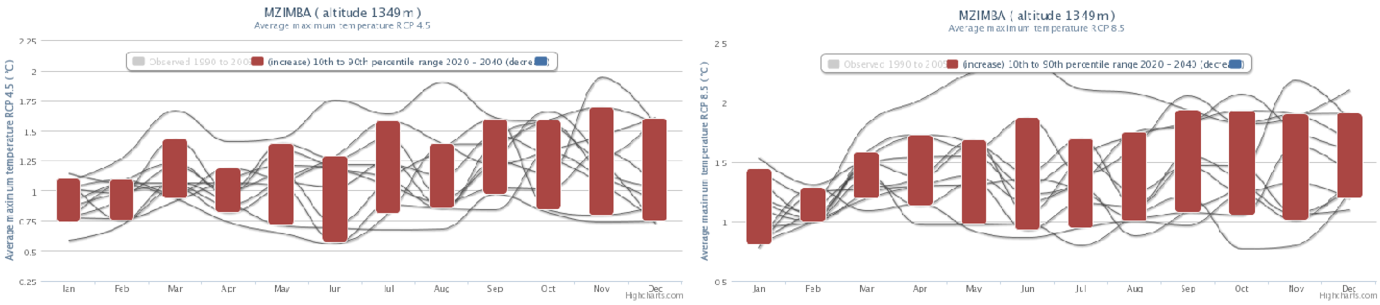


Figure B.15.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Monthly mean maximum days above 36 degree C

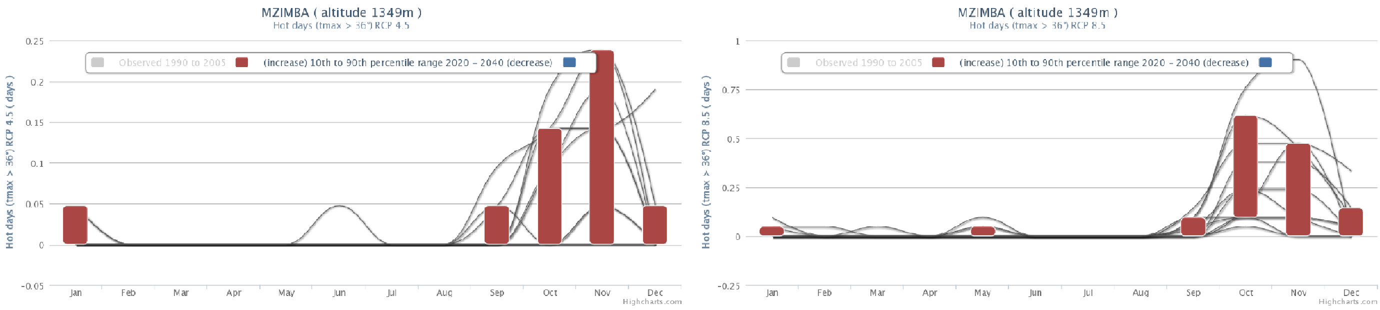


Figure B.15.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Monthly mean maximum days above 95th percentile

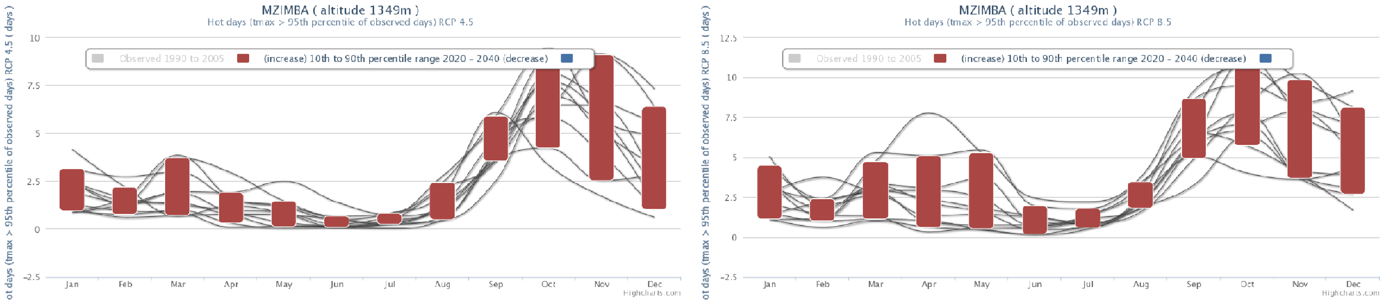


Figure B.15.8: Change in days above 30.5 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Monthly mean heat spell duration

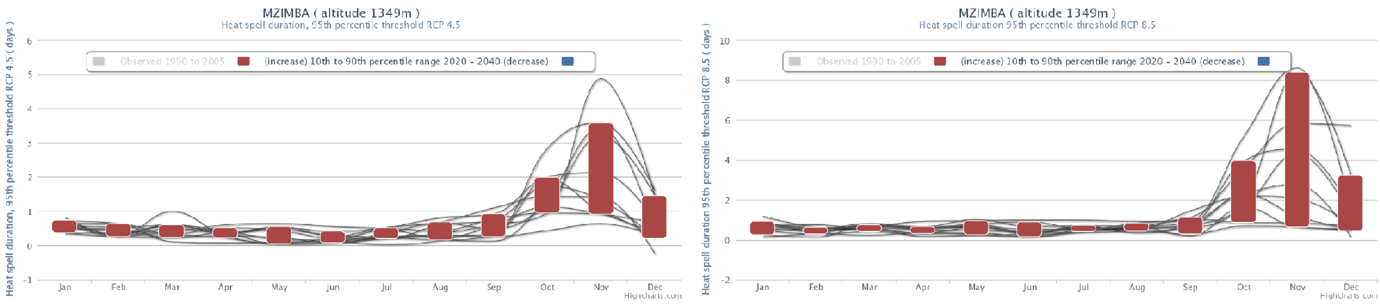


Figure B.15.9: Change in heat spell duration (30.5 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Monthly mean minimum daily temperature change

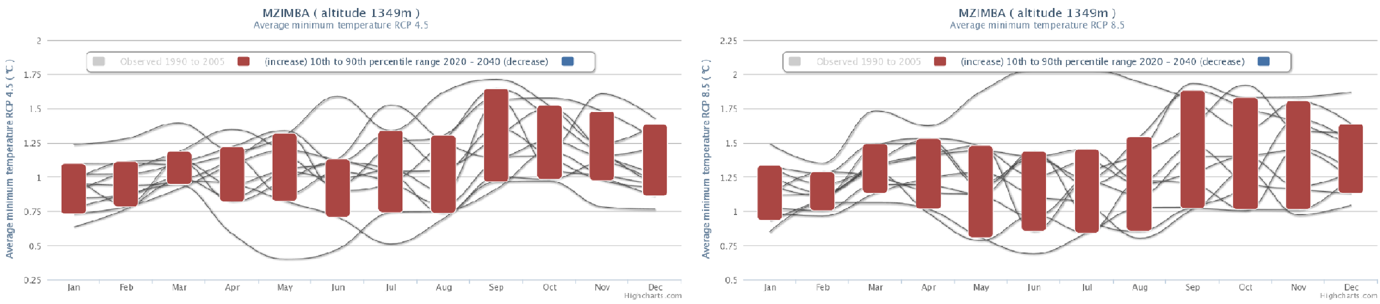


Figure B.15.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

B.16: Climate Summary for MZUZU

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

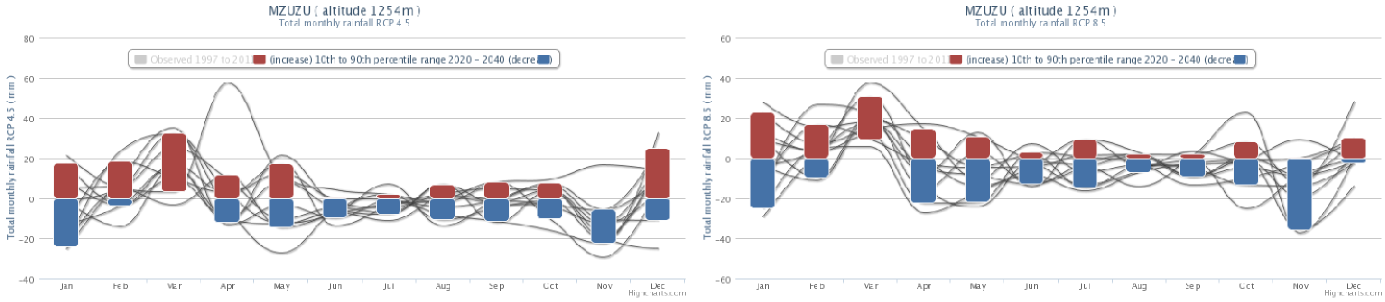


Figure B.16.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station

Projected change in monthly mean dry spell duration change

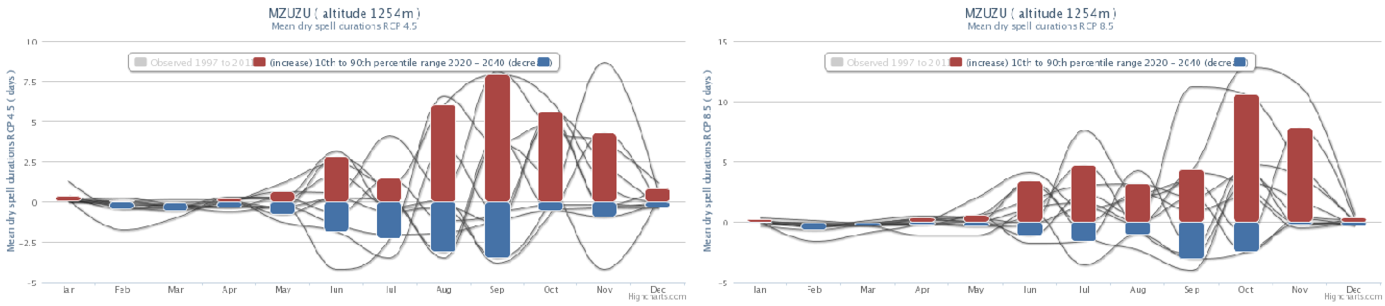


Figure B.16.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Projected change in monthly mean rain day frequency

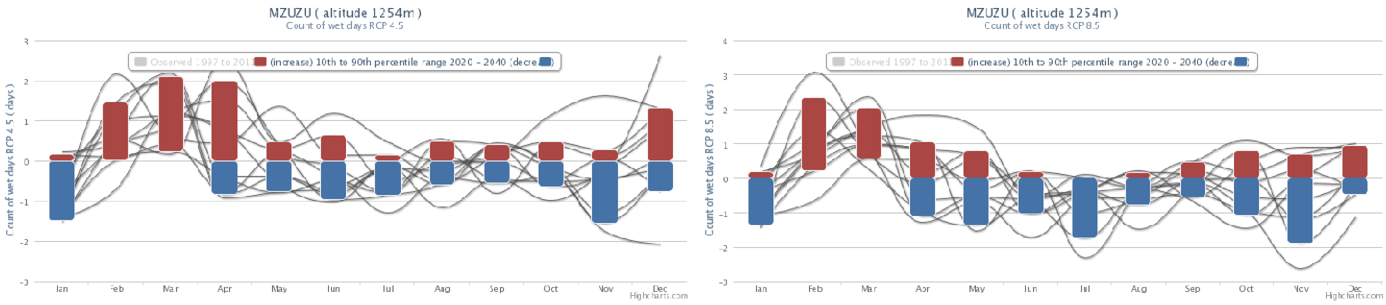


Figure B.16.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Projected change in monthly mean rain day frequency (> 20mm)

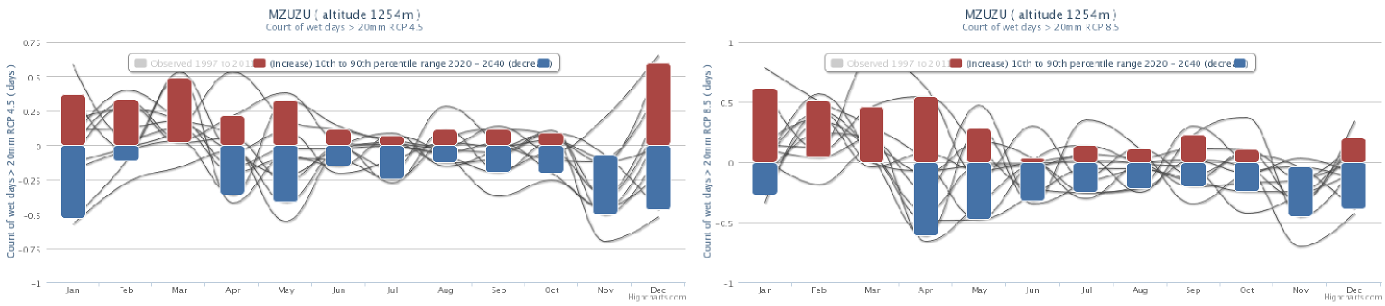


Figure B.16.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

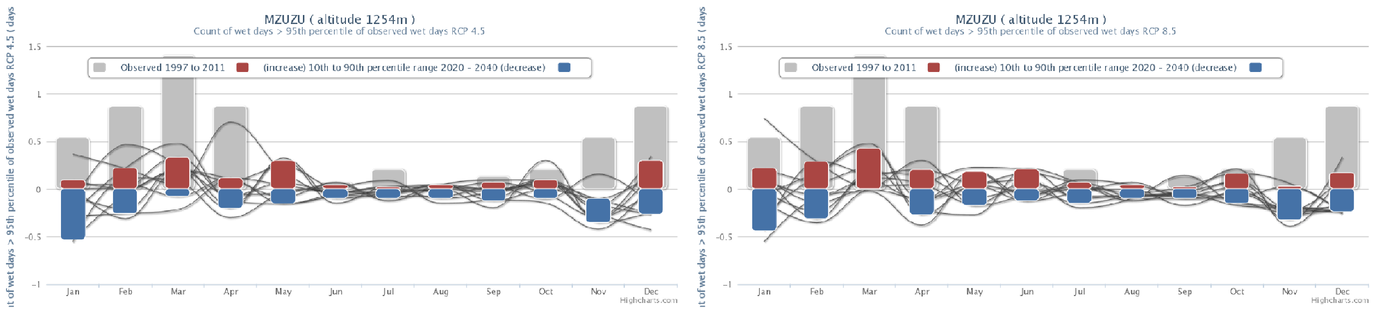


Figure B.16.5: Change in monthly rain day frequency > 35.7 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

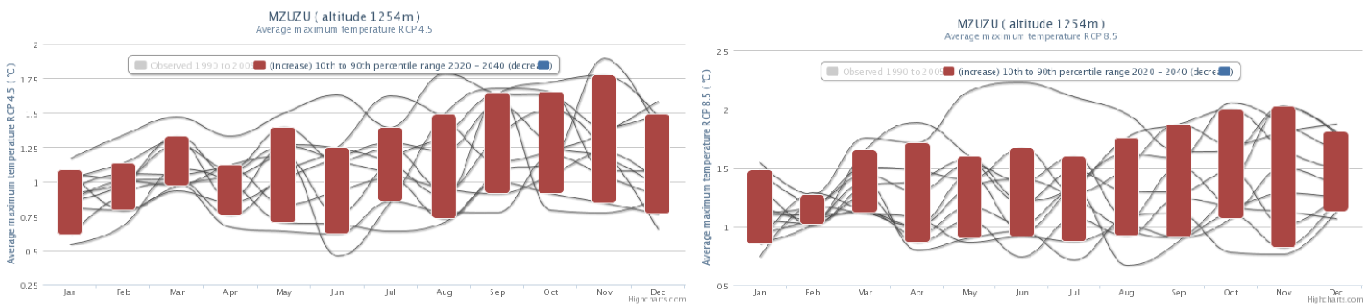


Figure B.16.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Monthly mean maximum days above 36 degree C

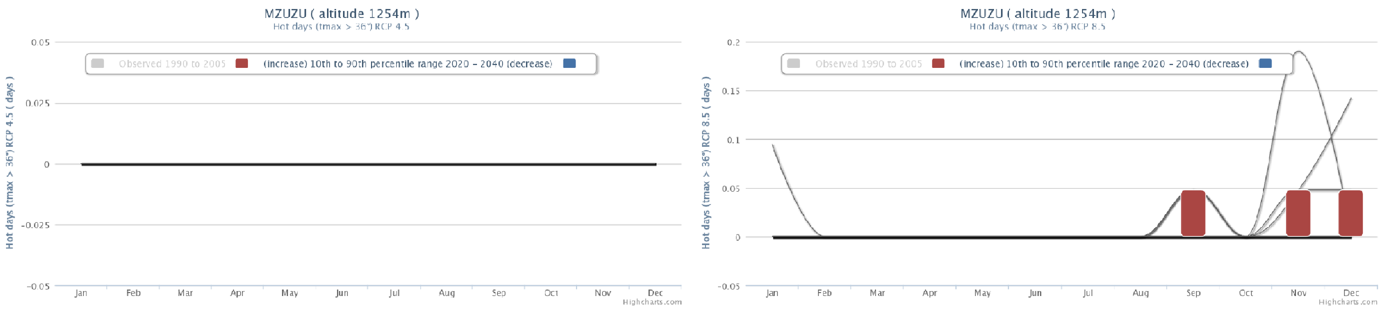


Figure B.16.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Monthly mean maximum days above 95th percentile

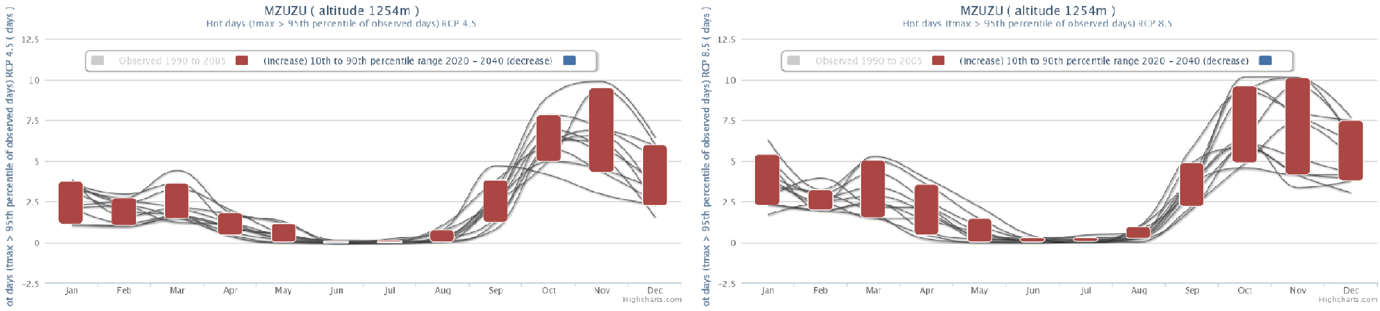


Figure B.16.8: Change in days above 30 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Monthly mean heat spell duration

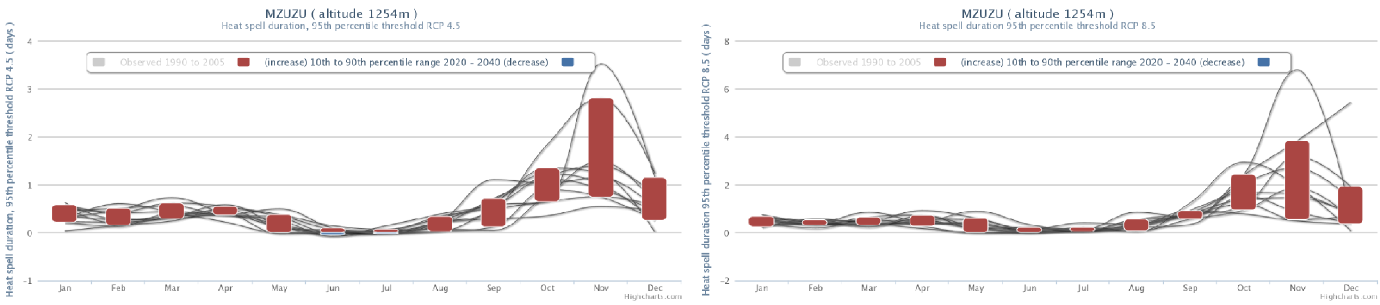


Figure B.16.9: Change in heat spell duration (30 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Monthly mean minimum daily temperature change

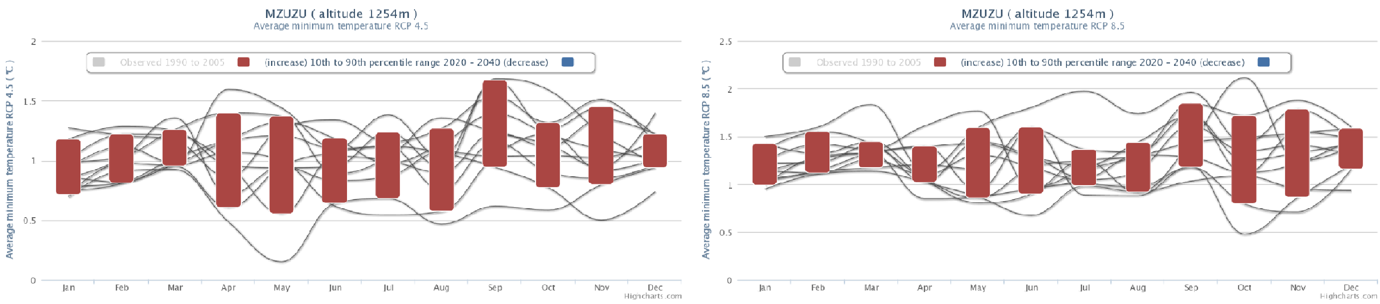


Figure B.16.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

B.17: Climate Summary for NGABU

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

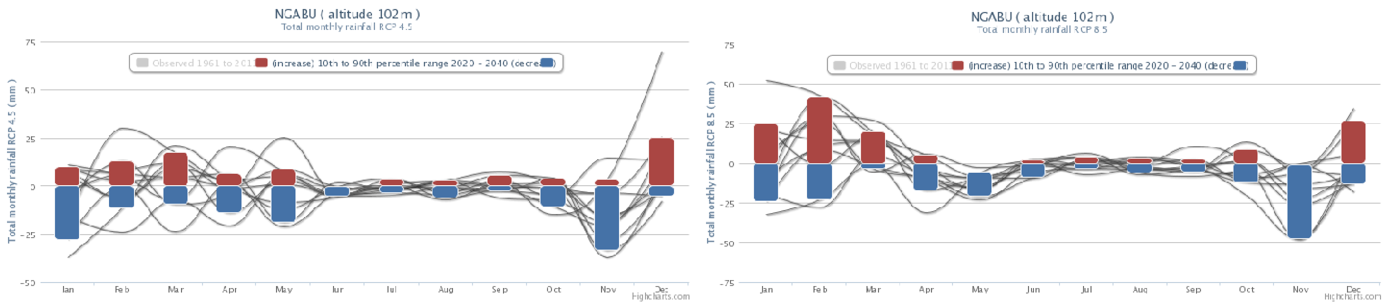


Figure B.17.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station

Projected change in monthly mean dry spell duration change

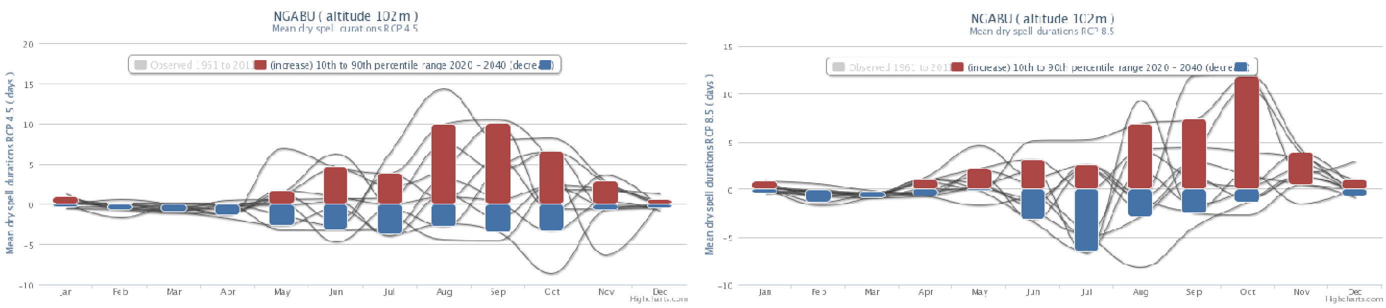


Figure B.17.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Projected change in monthly mean rain day frequency

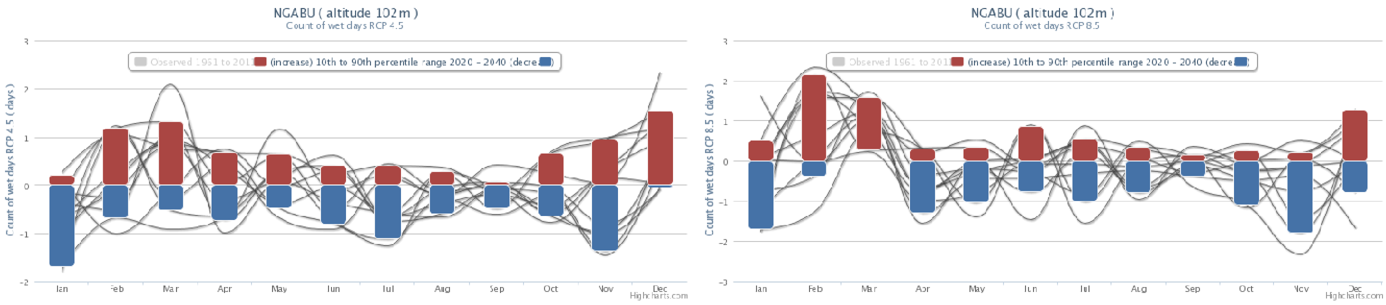


Figure B.17.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Projected change in monthly mean rain day frequency (> 20mm)

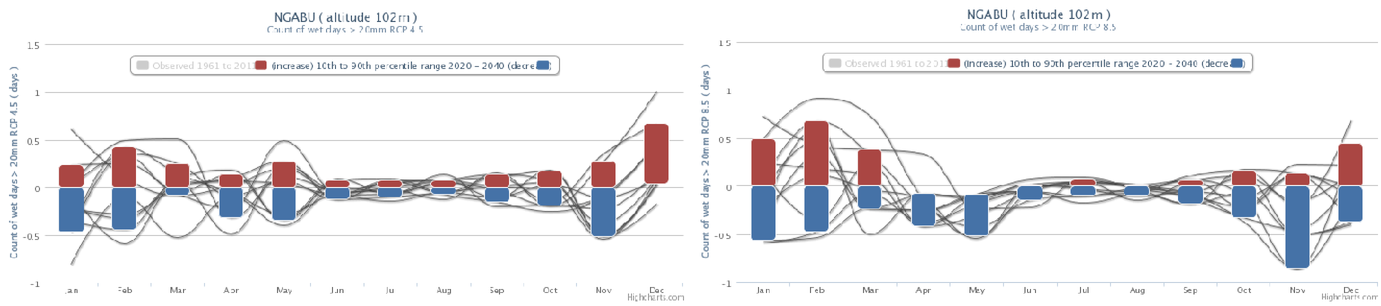


Figure B.17.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

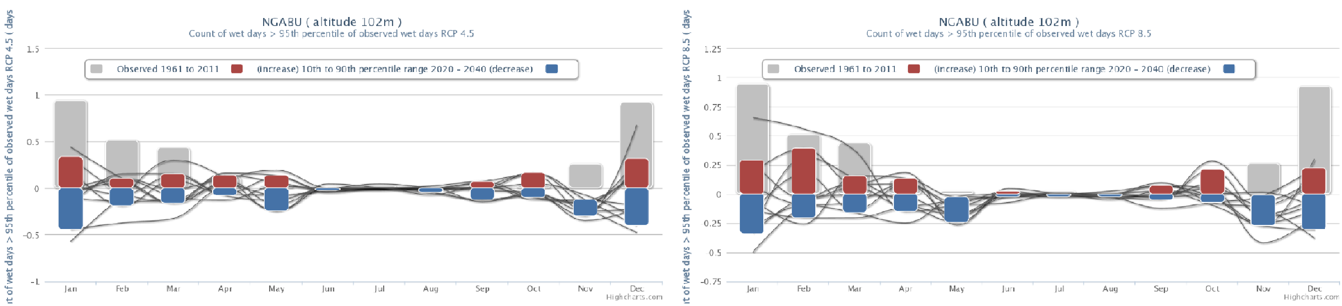


Figure B.17.5: Change in monthly rain day frequency > 48.2 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

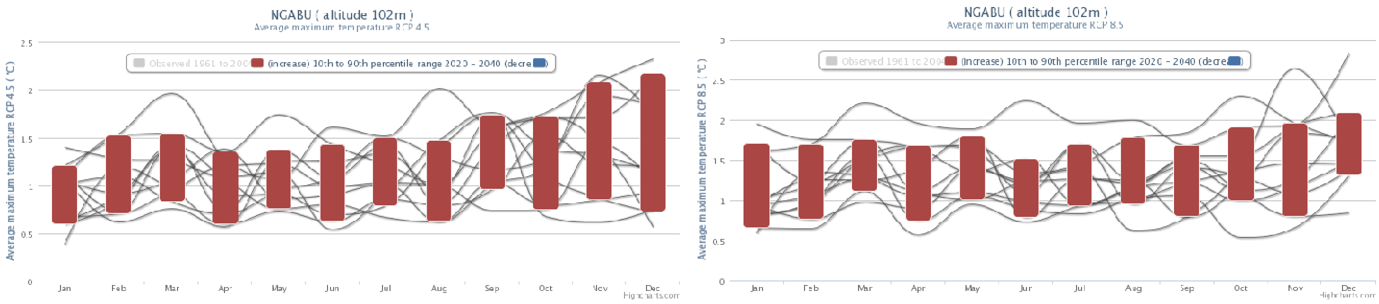


Figure B.17.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Monthly mean maximum days above 36 degree C

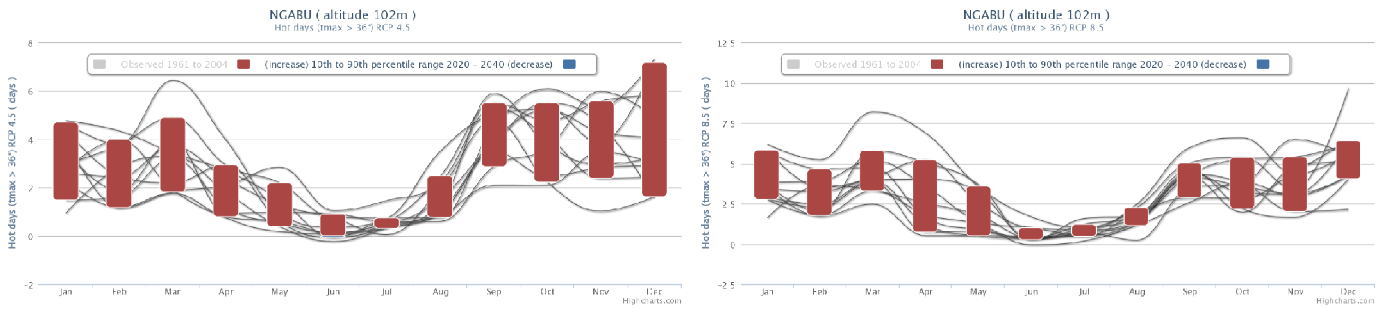


Figure B.17.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Monthly mean maximum days above 95th percentile

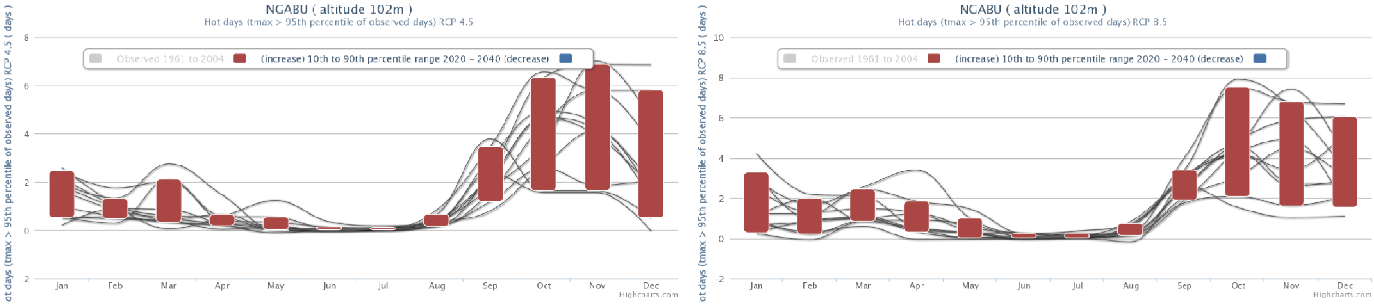


Figure B.17.8: Change in days above 39.5 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Monthly mean heat spell duration

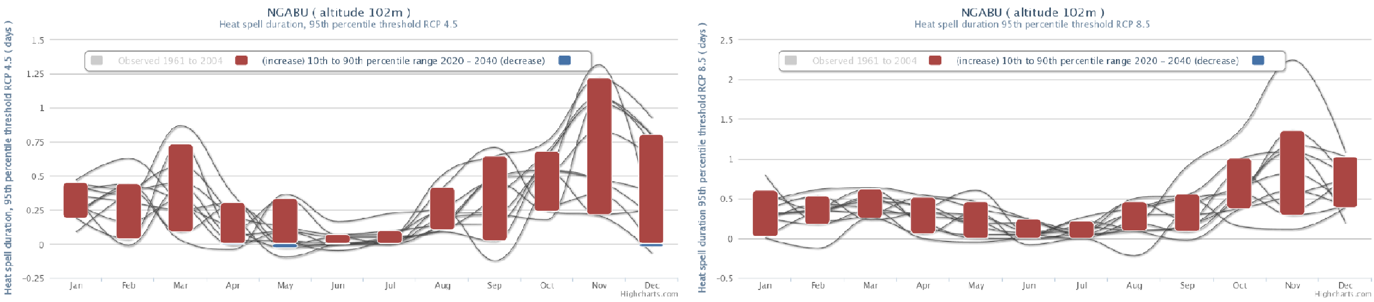


Figure B.17.9: Change in heat spell duration (39.5 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Monthly mean minimum daily temperature change

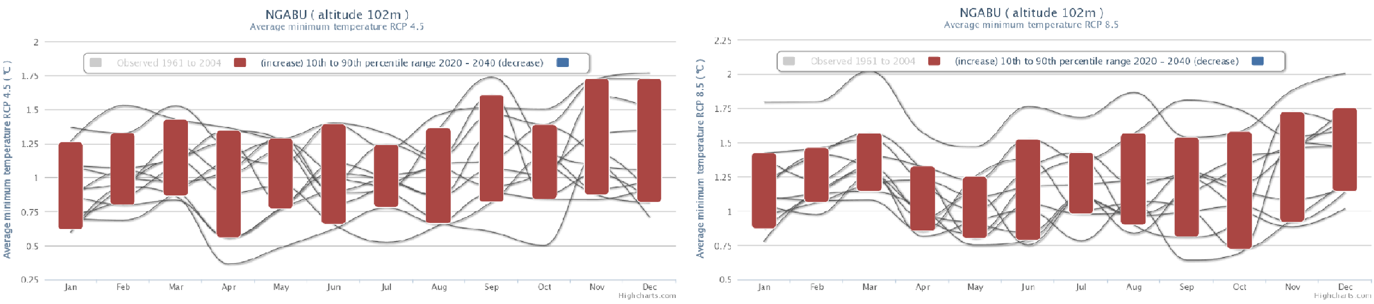


Figure B.17.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

B.18: Climate Summary for NKHATA BAY

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

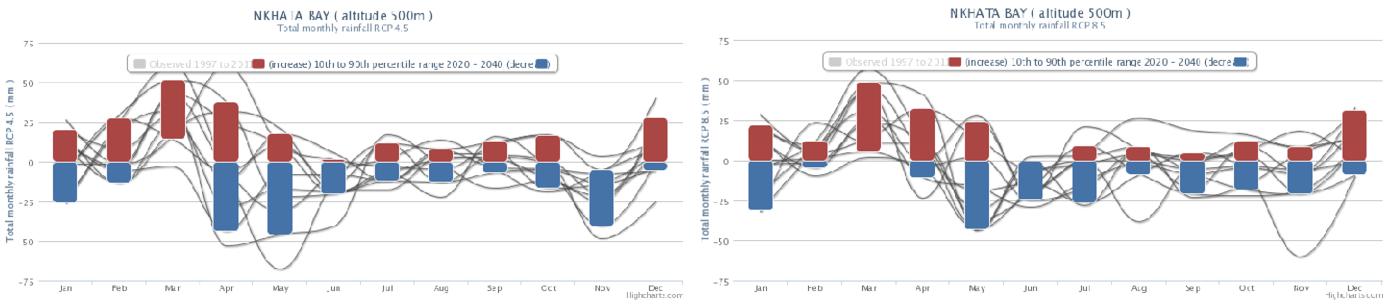


Figure B.18.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station

Projected change in monthly mean dry spell duration change

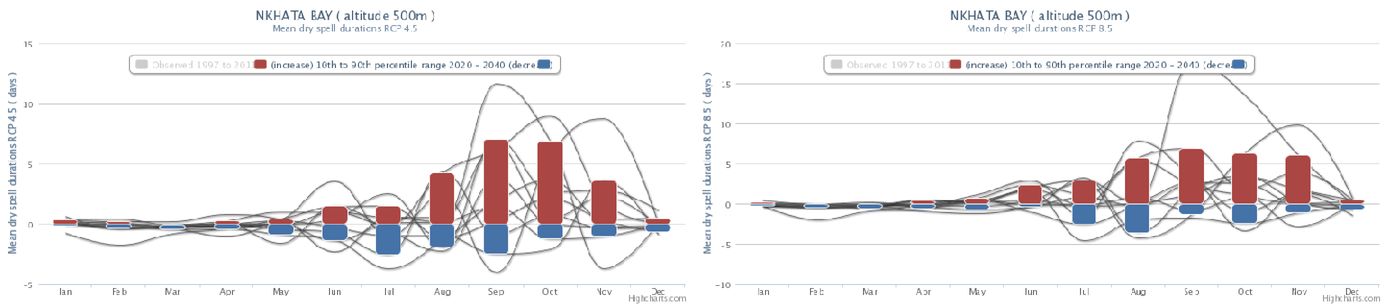


Figure B.18.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Projected change in monthly mean rain day frequency

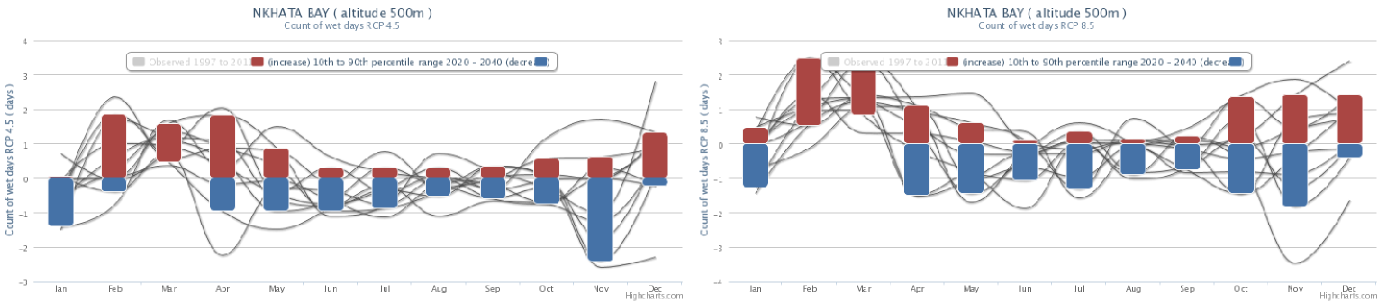


Figure B.18.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Projected change in monthly mean rain day frequency (> 20mm)

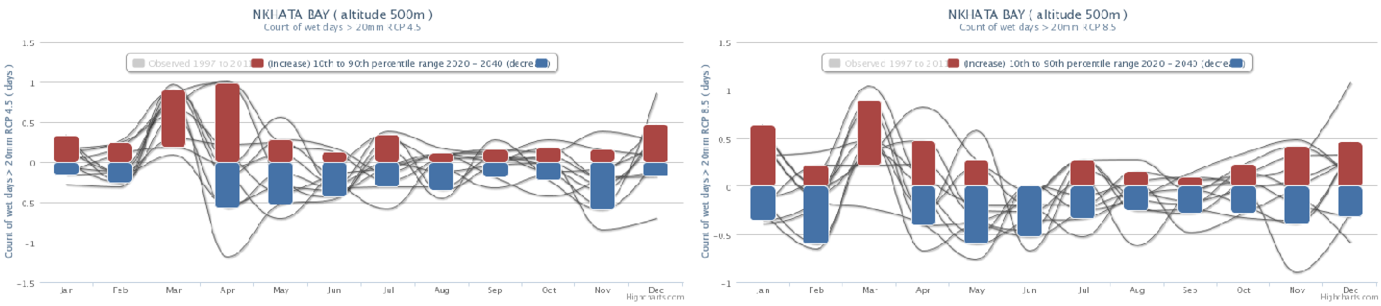


Figure B.18.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

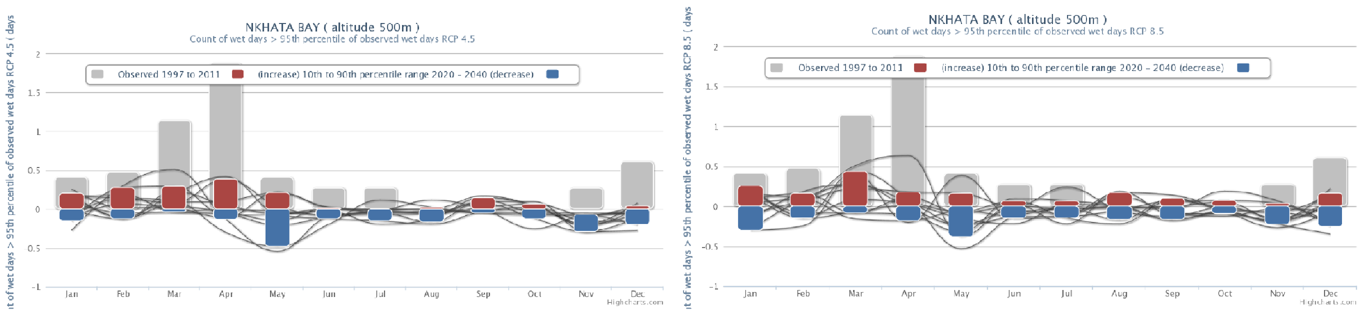


Figure B.18.5: Change in monthly rain day frequency > 55 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

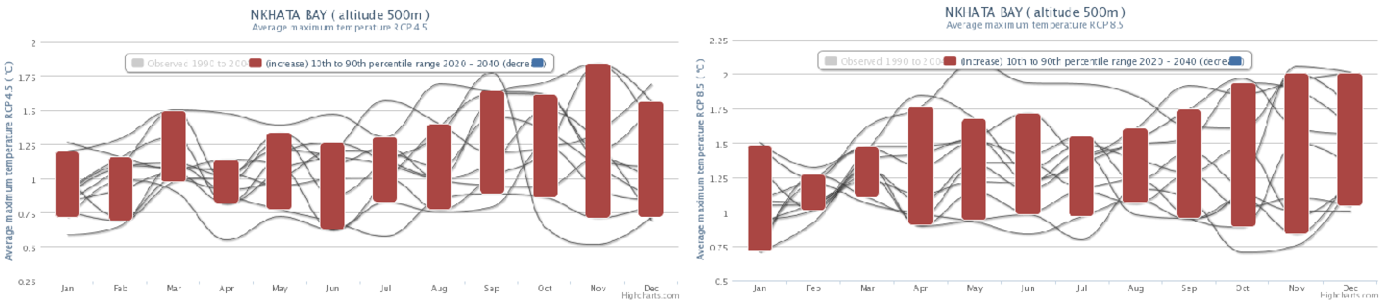


Figure B.18.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Monthly mean maximum days above 36 degree C

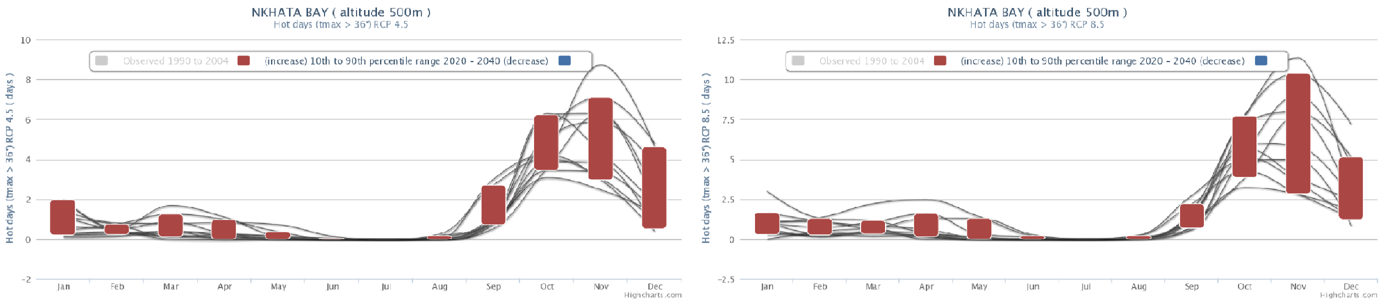


Figure B.18.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Monthly mean maximum days above 95th percentile

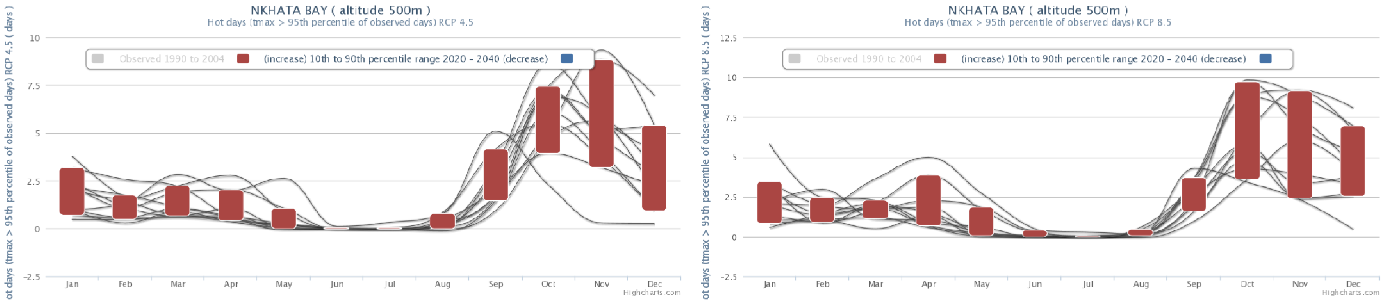


Figure B.18.8: Change in days above 34.3 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Monthly mean heat spell duration

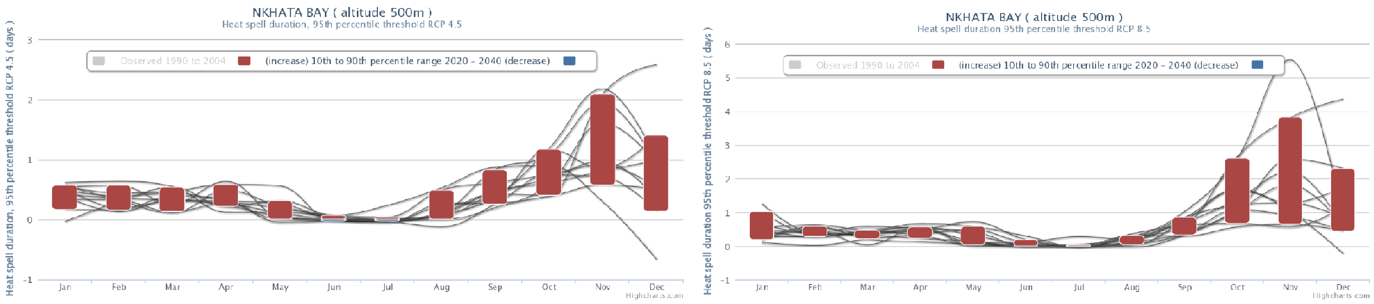


Figure B.18.9: Change in heat spell duration (34.3 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Monthly mean minimum daily temperature change

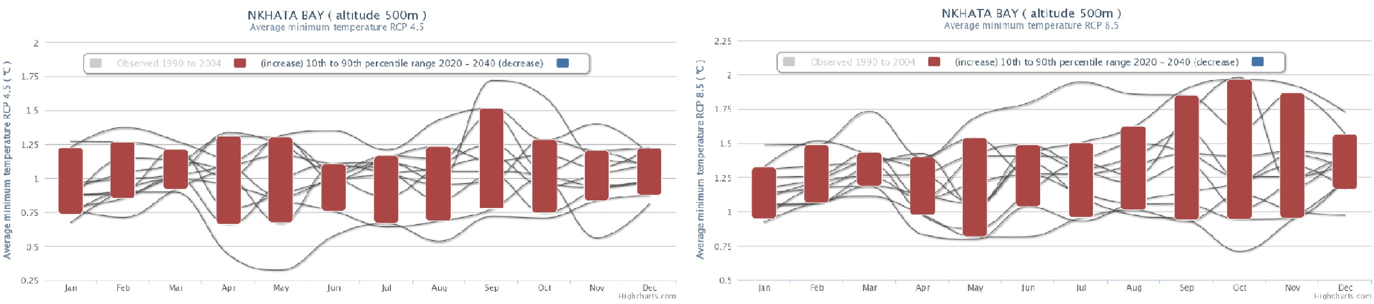


Figure B.18.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

B. 19: Climate Summary for NKHOTA KOTA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

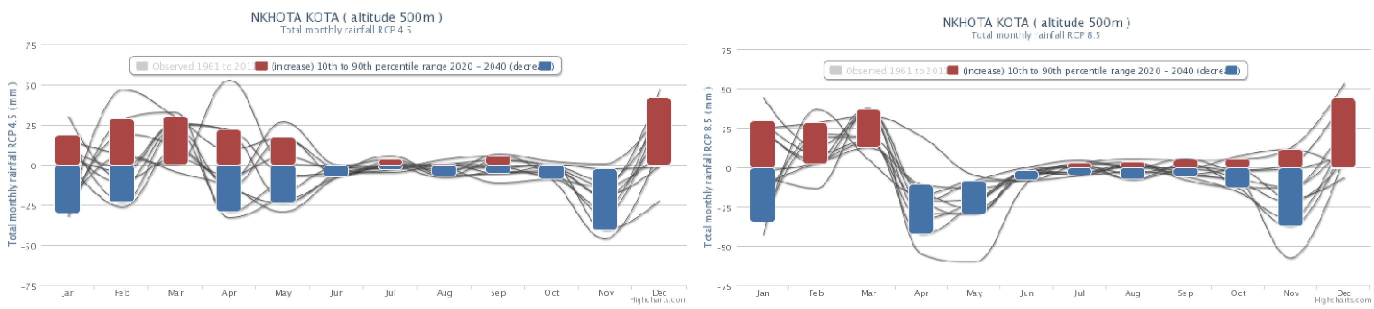


Figure B.19.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station

Projected change in monthly mean dry spell duration change

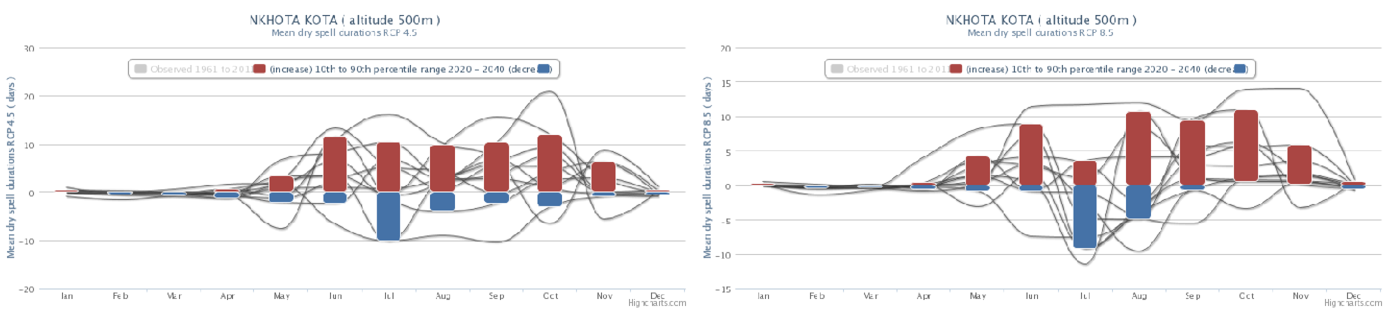


Figure B.19.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Projected change in monthly mean rain day frequency

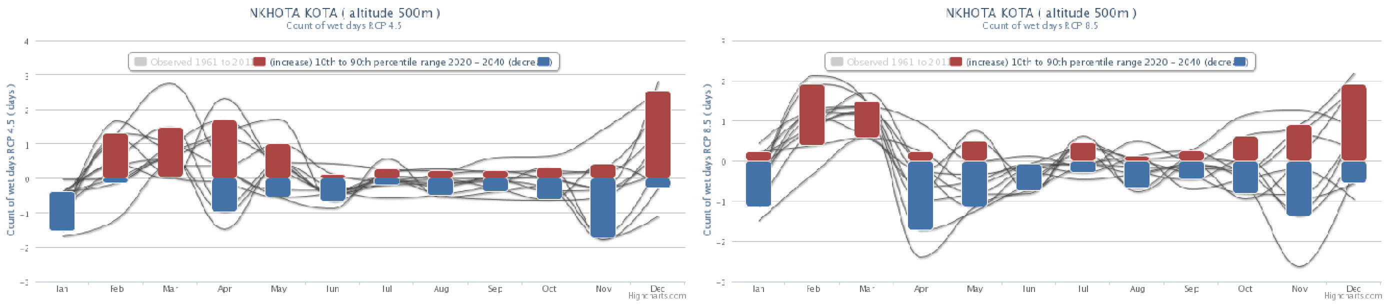


Figure B.19.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Projected change in monthly mean rain day frequency (> 20mm)

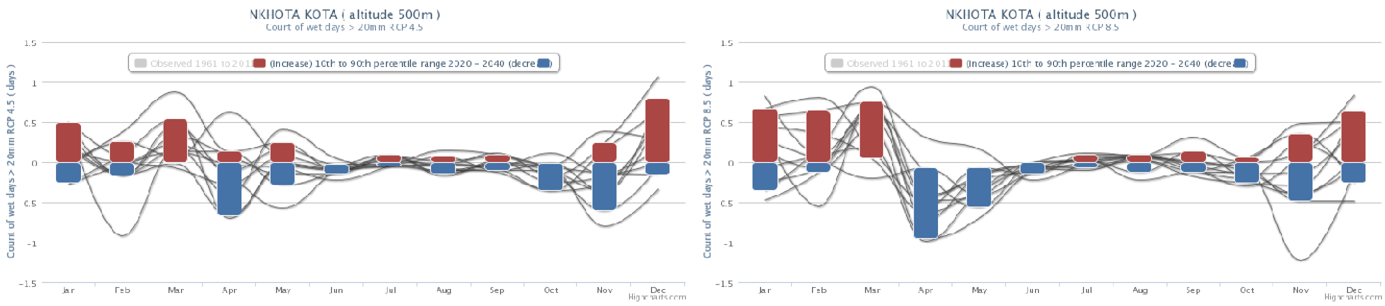


Figure B.19.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

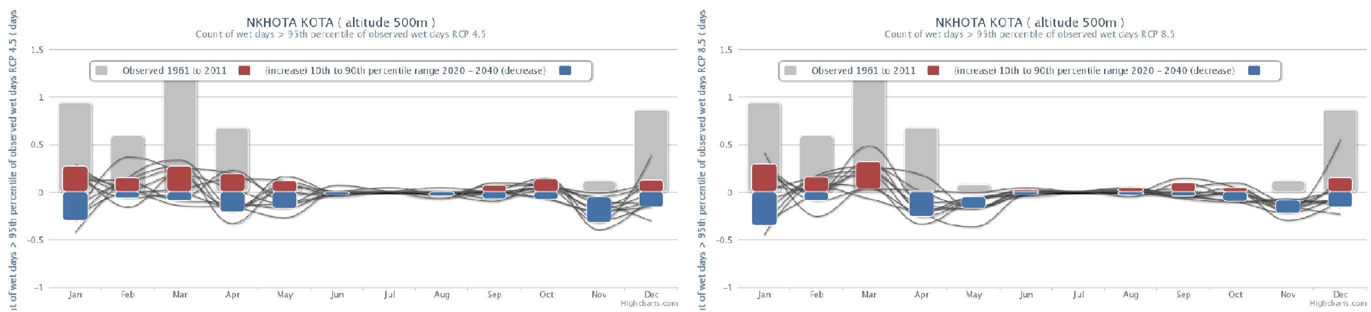


Figure B.19.5: Change in monthly rain day frequency > 47.5 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

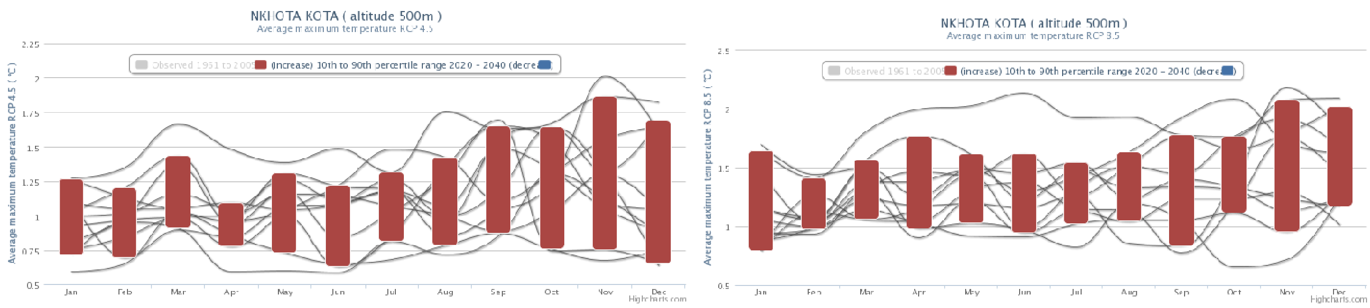


Figure B.19.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Monthly mean maximum days above 36 degree C

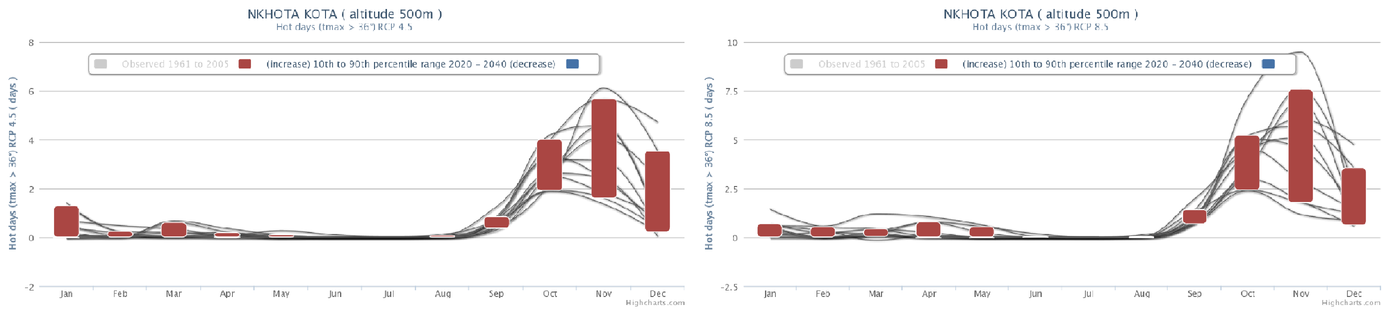


Figure B.19.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Monthly mean maximum days above 95th percentile

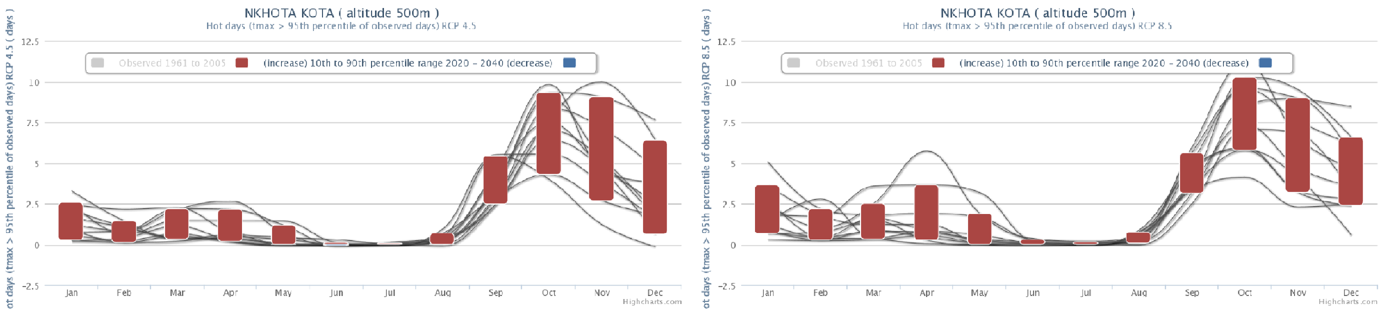


Figure B.19.8: Change in days above 34.5 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Monthly mean heat spell duration

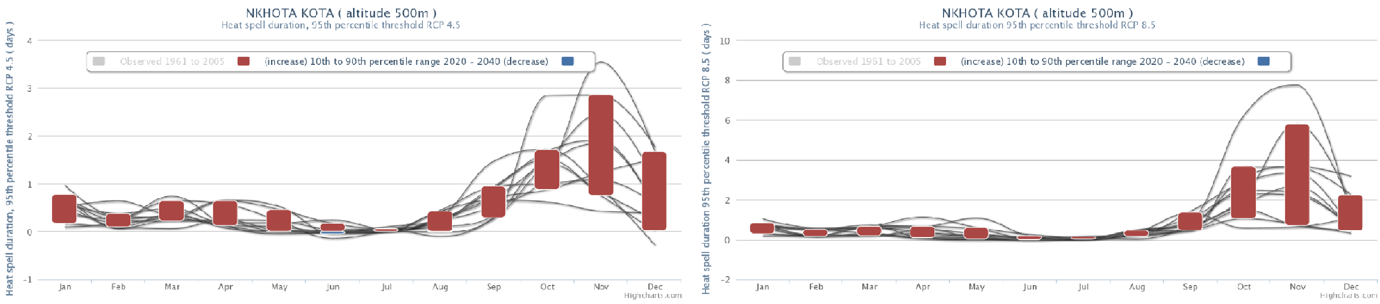


Figure B.19.9: Change in heat spell duration (34.5 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Monthly mean minimum daily temperature change

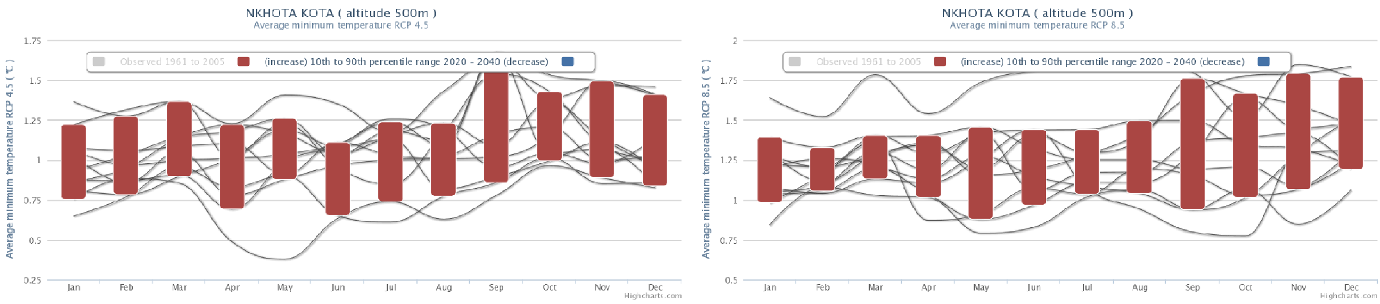


Figure B.19.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

B.20: Climate Summary for NTAJA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

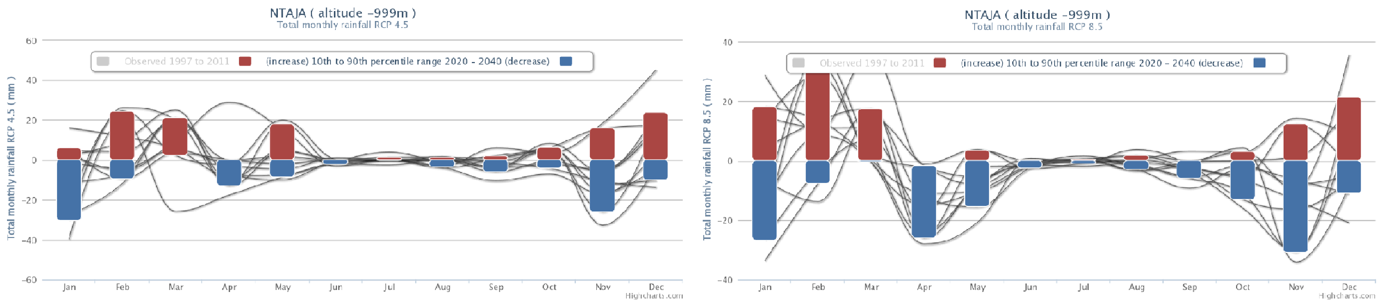


Figure B.20.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Projected change in monthly mean dry spell duration change

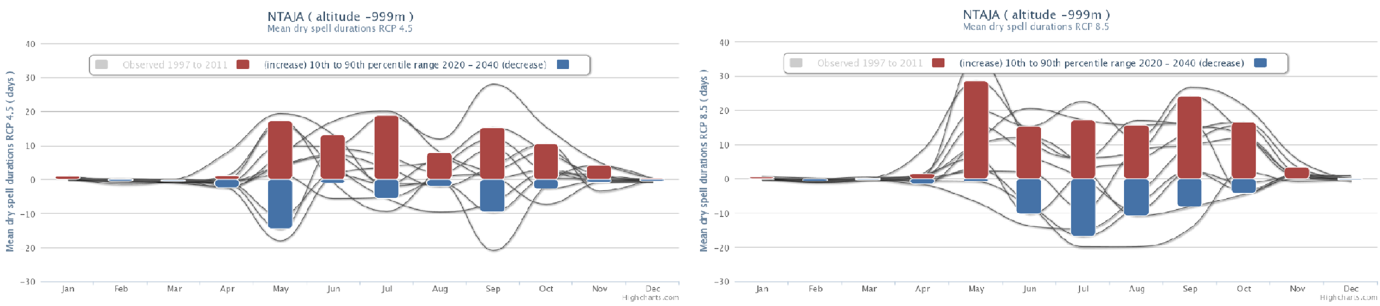


Figure B.20.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Projected change in monthly mean rain day frequency

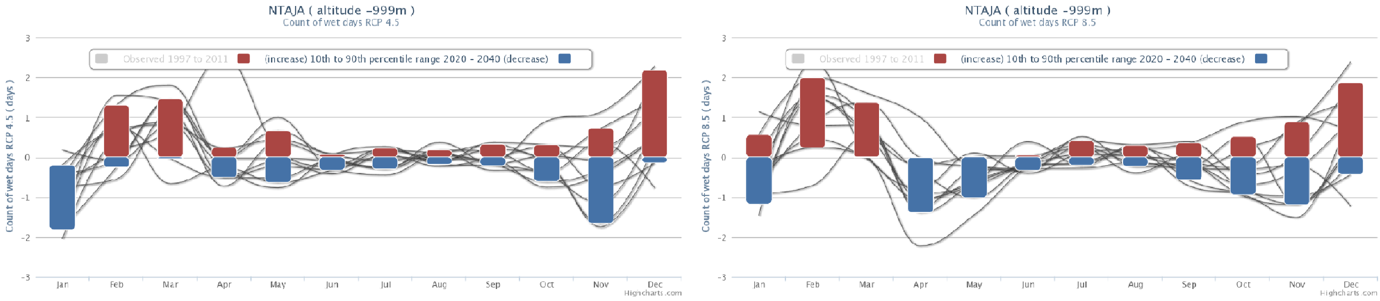


Figure B.20.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Projected change in monthly mean rain day frequency (> 20mm)

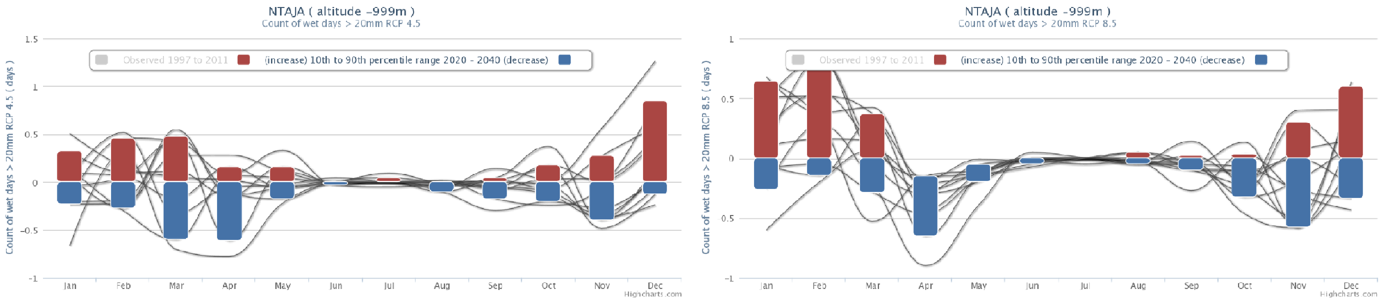


Figure B.20.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

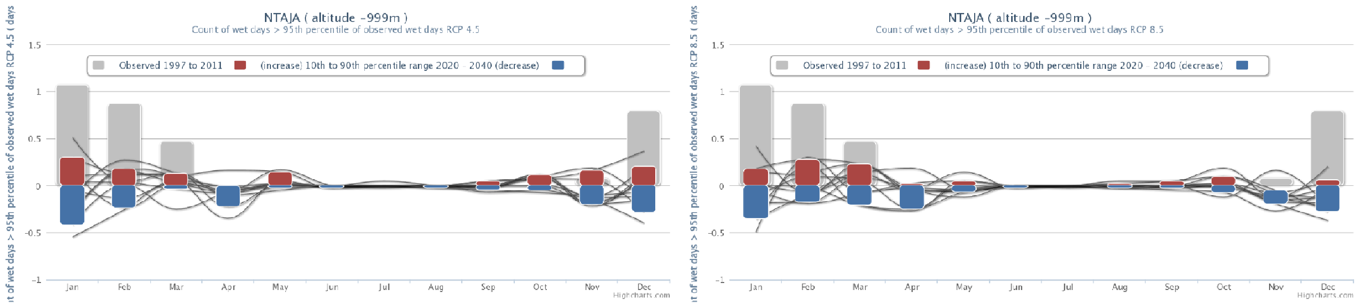


Figure B.20.5: Change in monthly rain day frequency > 55.3 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

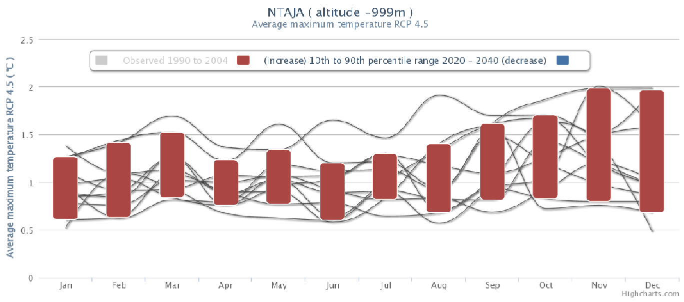


Figure B.20.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Monthly mean maximum days above 36 degree C

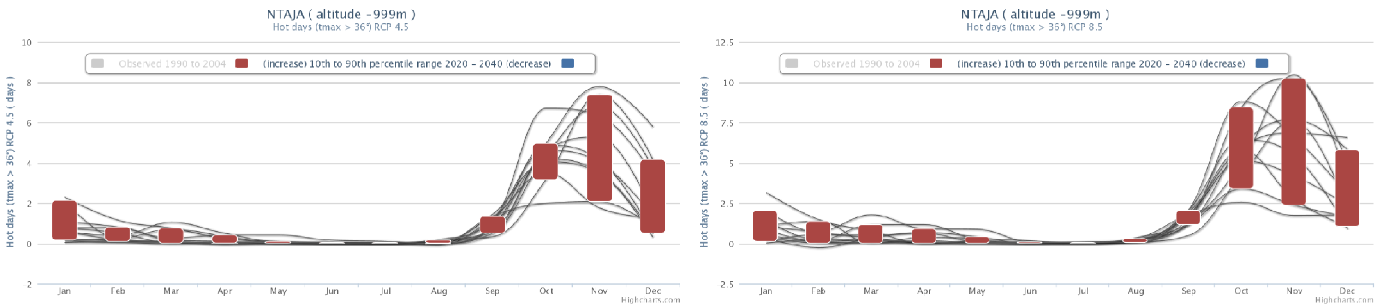


Figure B.20.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Monthly mean maximum days above 95th percentile

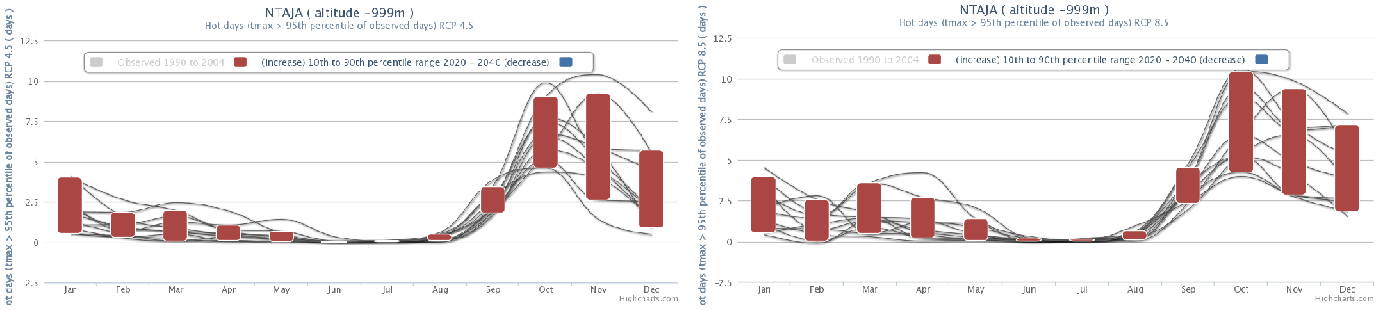


Figure B.20.8: Change in days above 33.6 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Monthly mean heat spell duration

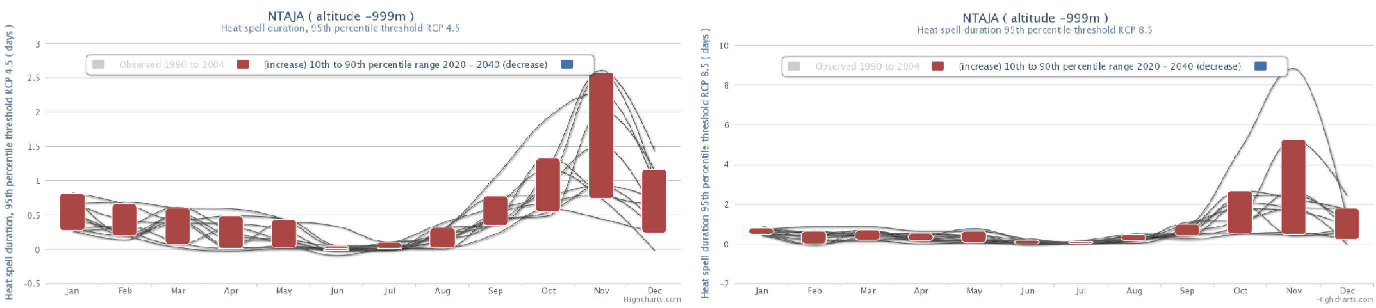


Figure B.20.9: Change in heat spell duration (33.6 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Monthly mean minimum daily temperature change

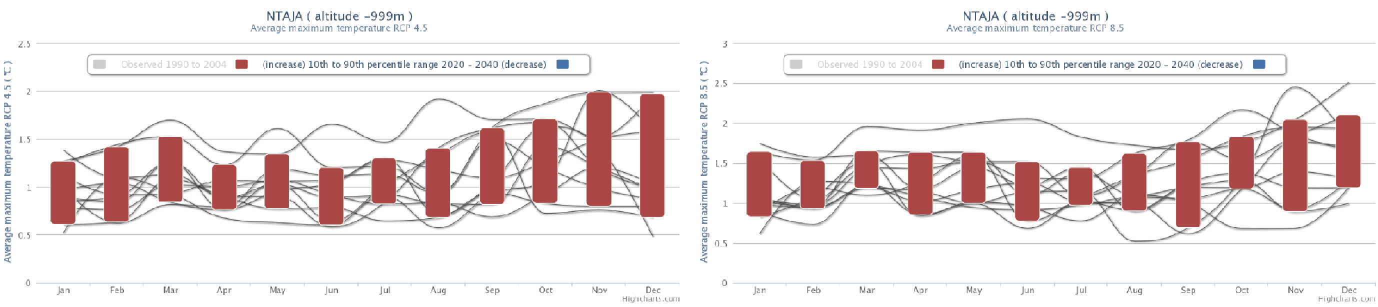


Figure B.20.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

B.21: Climate Summary for SALIMA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

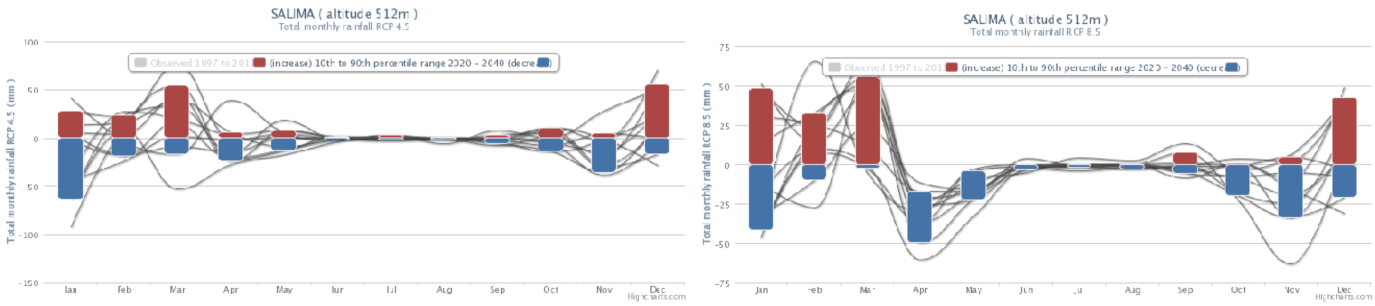


Figure B.21.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station

Projected change in monthly mean dry spell duration change

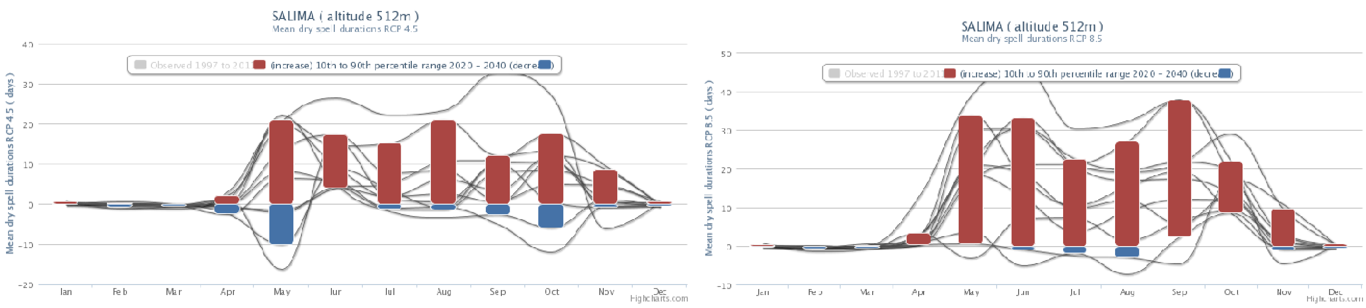


Figure B.21.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Projected change in monthly mean rain day frequency

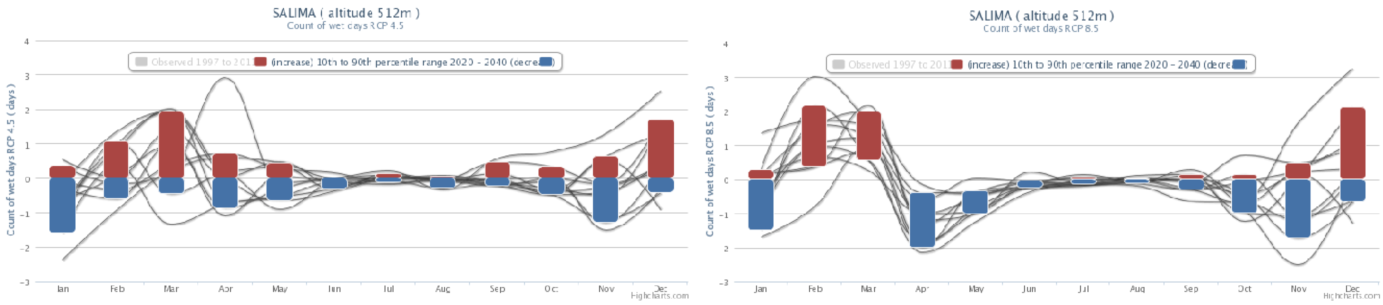


Figure B.21.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Projected change in monthly mean rain day frequency (> 20mm)

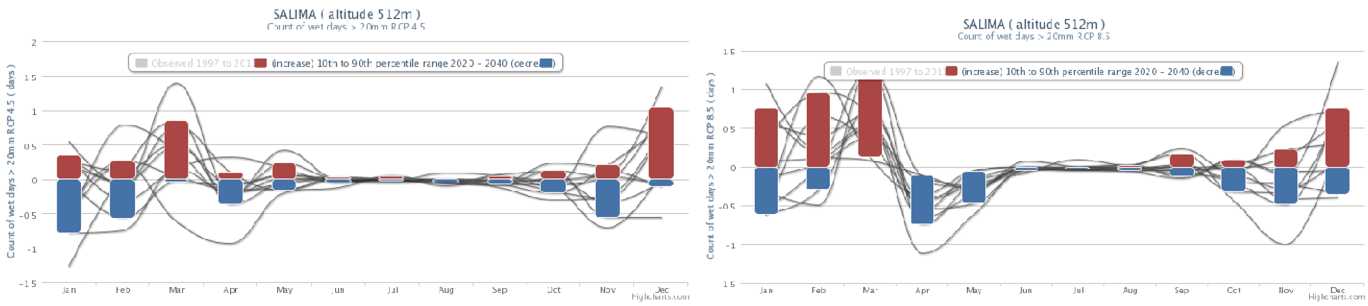


Figure B.21.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

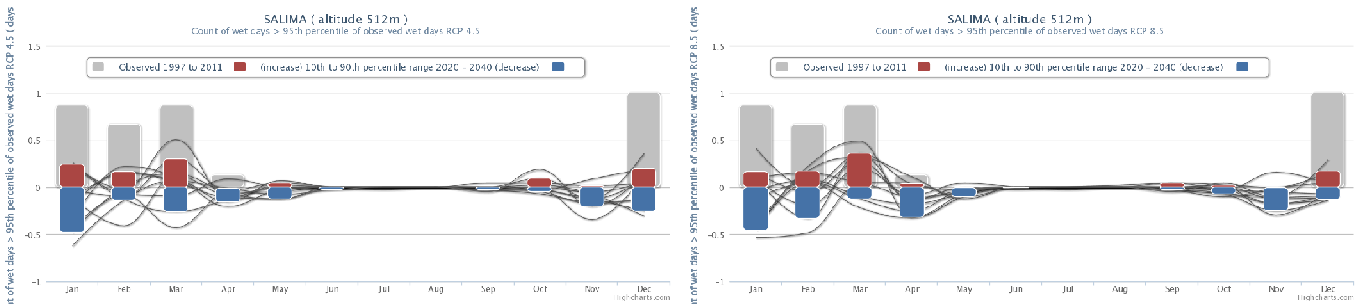


Figure B.21.5: Change in monthly rain day frequency > 66.9 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

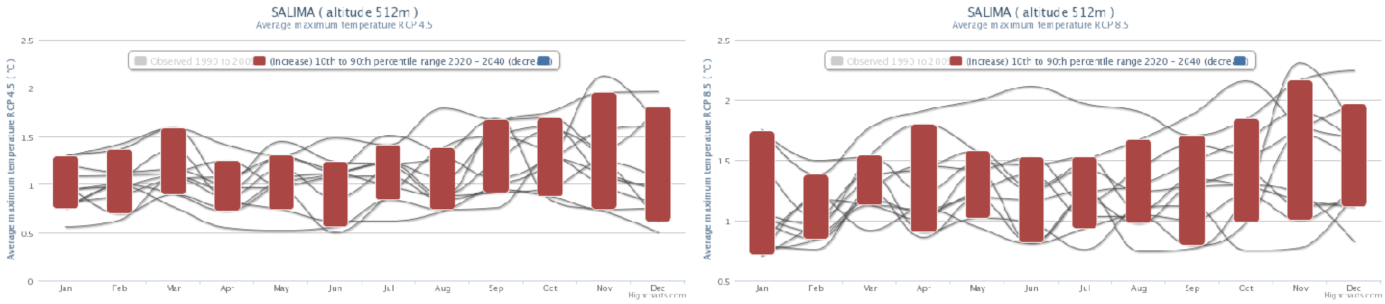


Figure B.21.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Monthly mean maximum days above 36 degree C

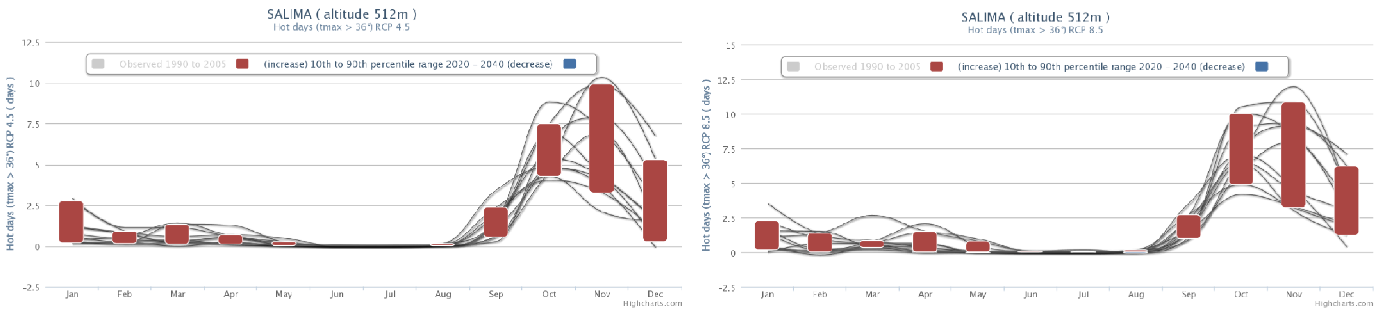


Figure B.21.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Monthly mean maximum days above 95th percentile

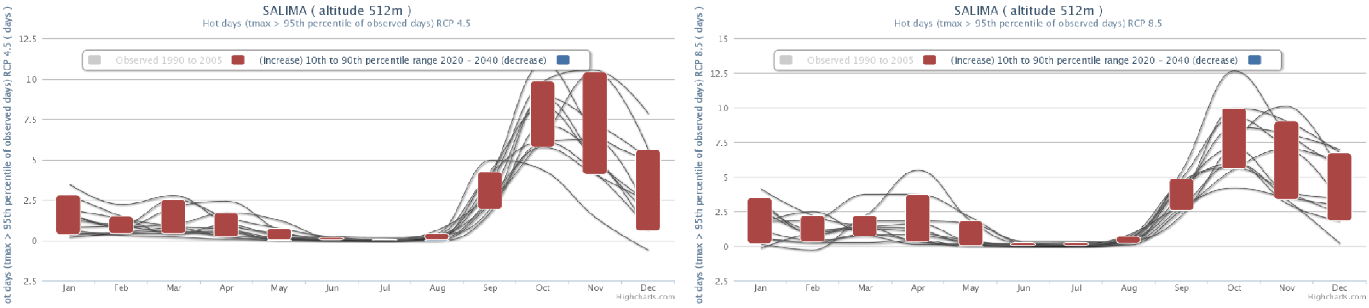


Figure B.21.8: Change in days above 34.8 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Monthly mean heat spell duration

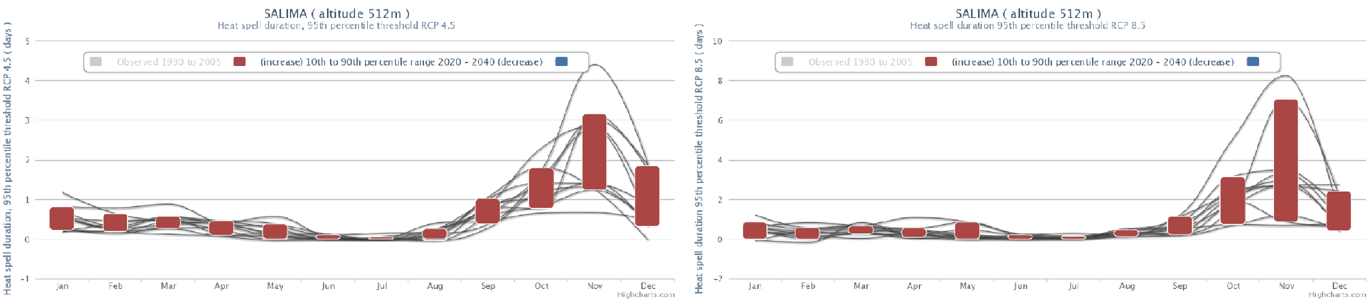


Figure B.21.9: Change in heat spell duration (34.8 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Monthly mean minimum daily temperature change

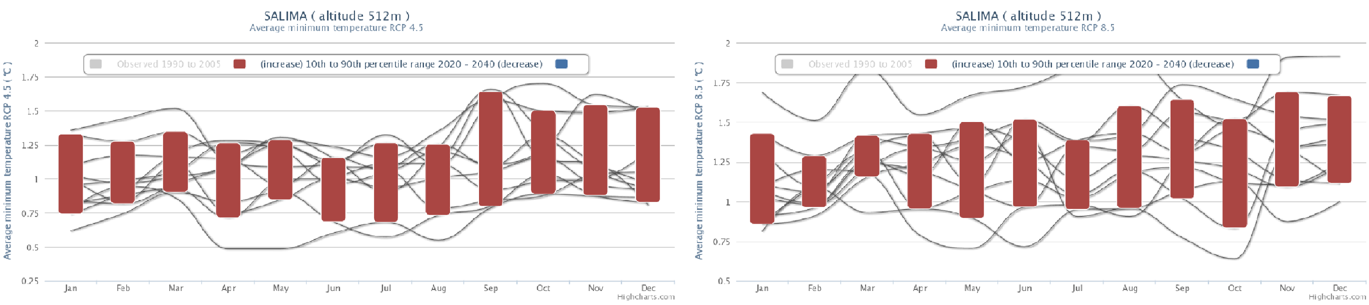


Figure B.21.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

B.22: Climate Summary for THYOLO

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

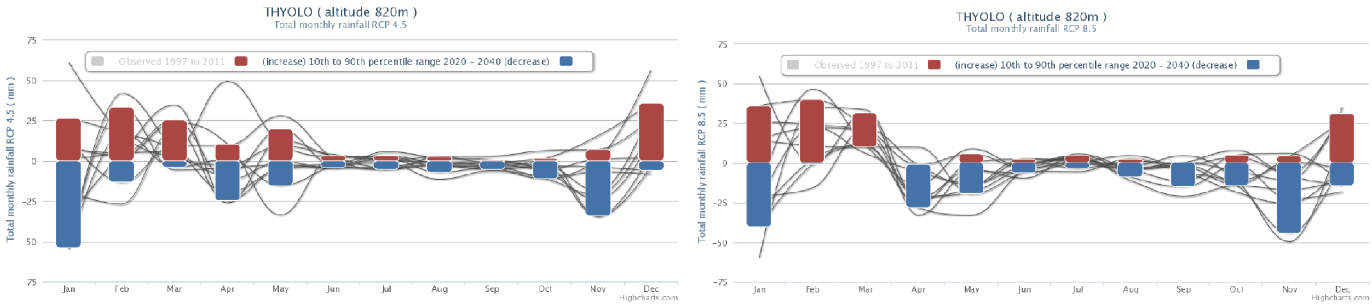


Figure B.22.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station

Projected change in monthly mean dry spell duration change

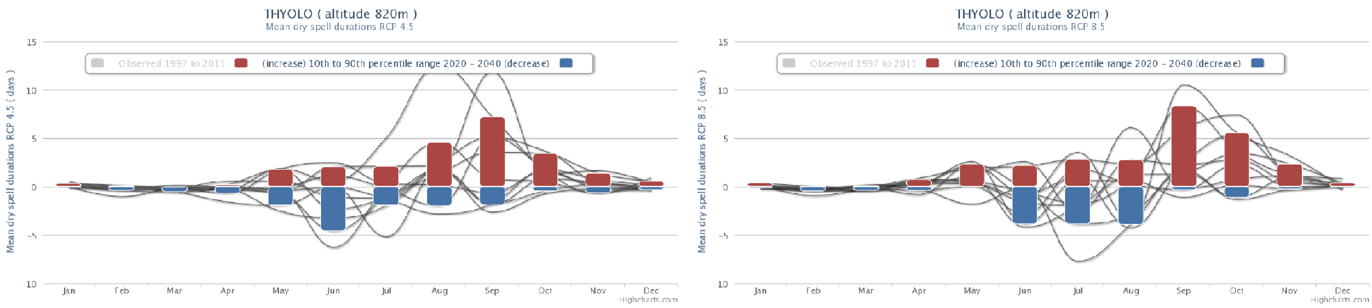


Figure B.22.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Projected change in monthly mean rain day frequency

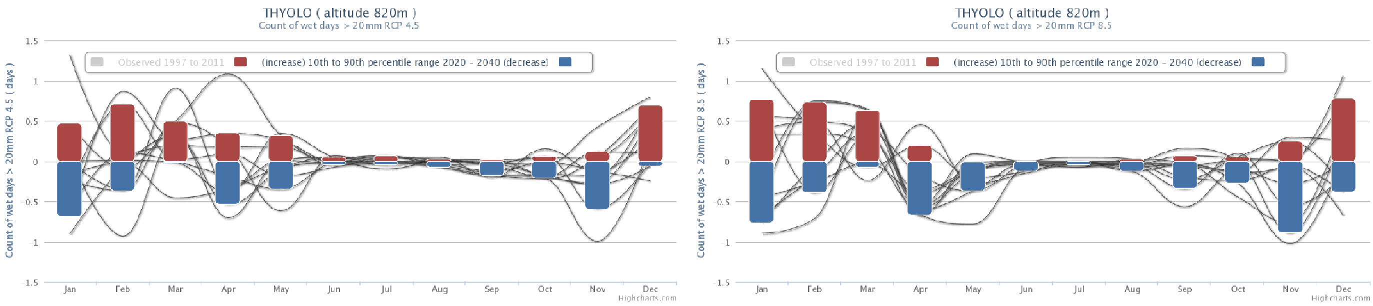


Figure B.22.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Projected change in monthly mean rain day frequency (> 20mm)

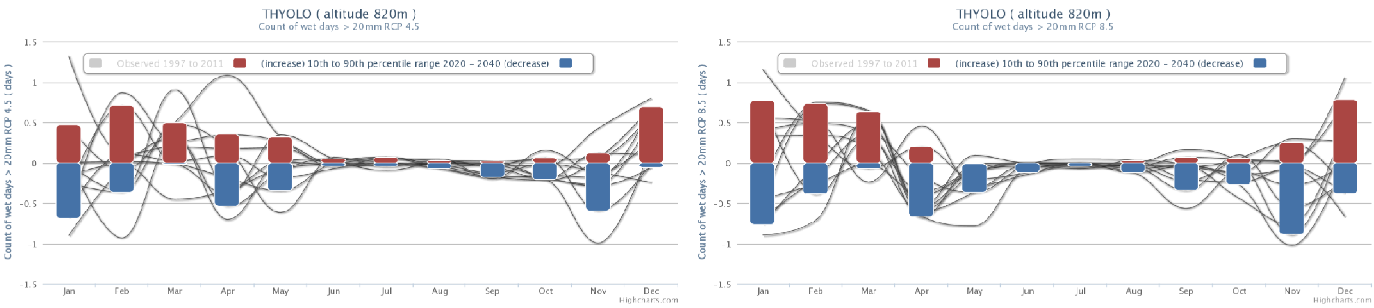


Figure B.22.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

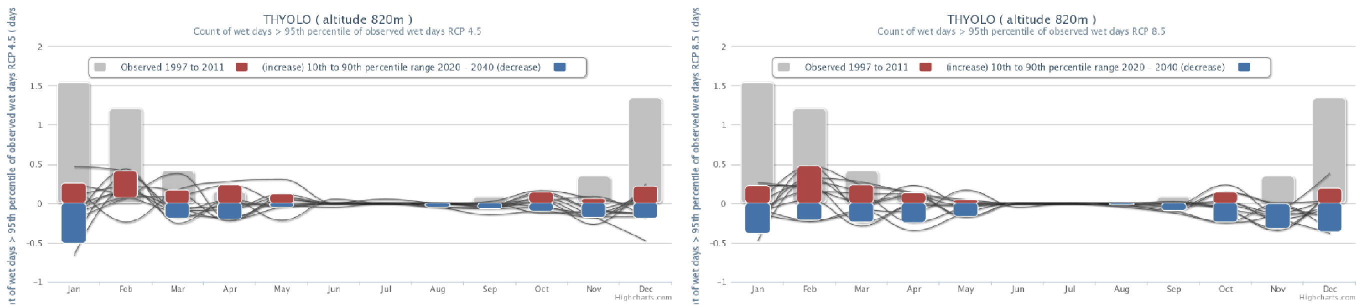


Figure B.22.5: Change in monthly rain day frequency > 48.7 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

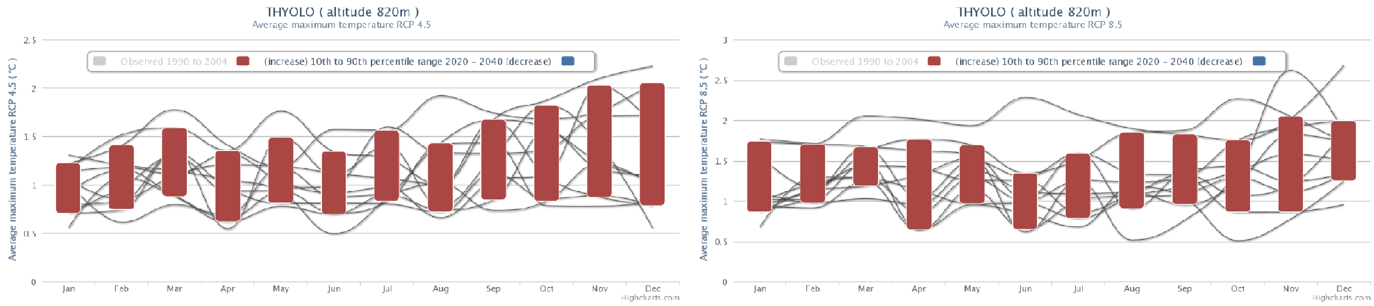


Figure B.22.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Monthly mean maximum days above 36 degree C

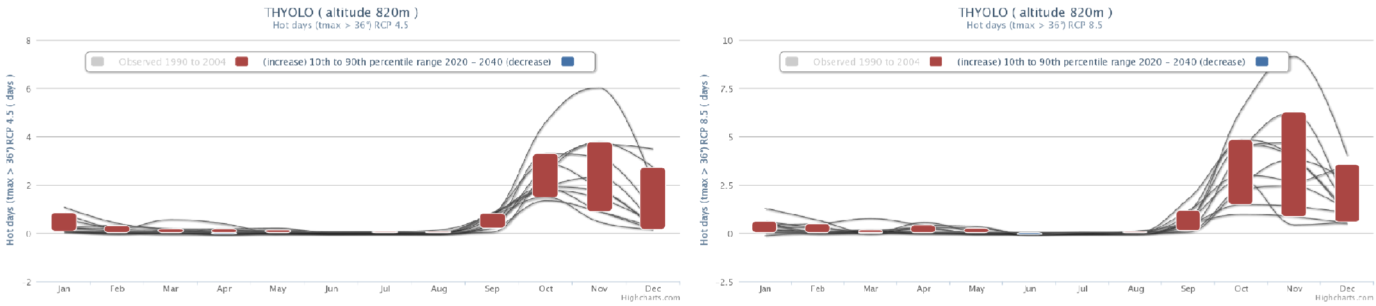


Figure B.22.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Monthly mean maximum days above 95th percentile

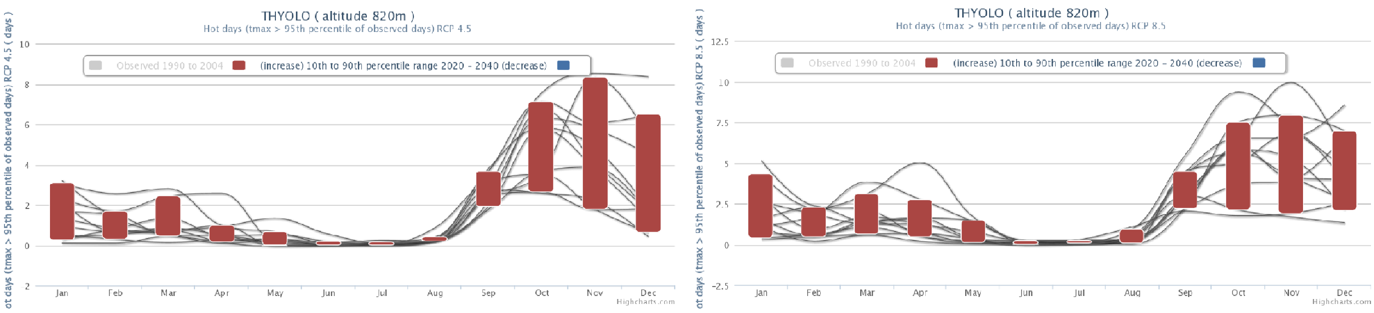


Figure B.22.8: Change in days above 32.9 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Monthly mean heat spell duration

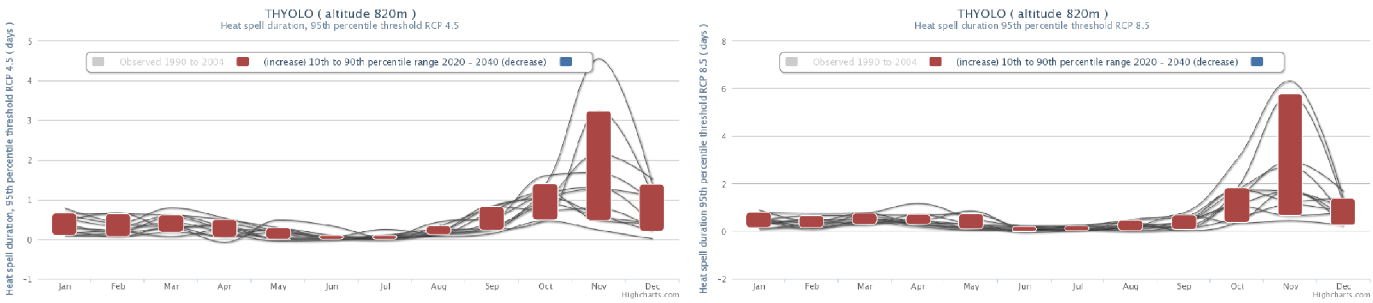


Figure B.22.9: Change in heat spell duration (32.9 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Monthly mean minimum daily temperature change

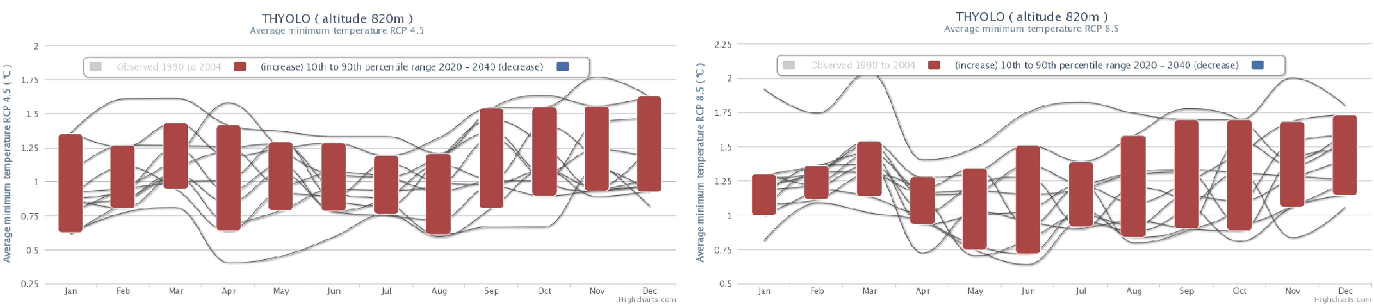


Figure B.22.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

APPENDIX B CONTINUED – FUTURE PROJECTIONS (PERIOD 2040-2060)

B.23: Climate Summary for BOLERO

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

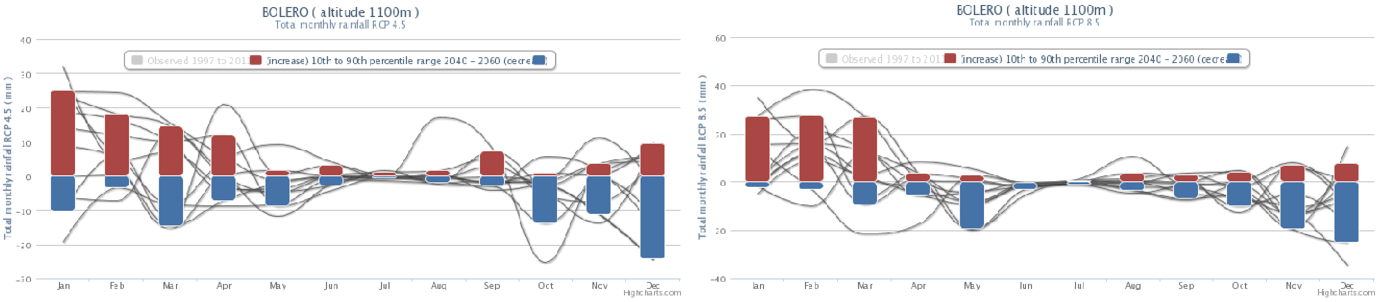


Figure B.23.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Projected change in monthly mean dry spell duration

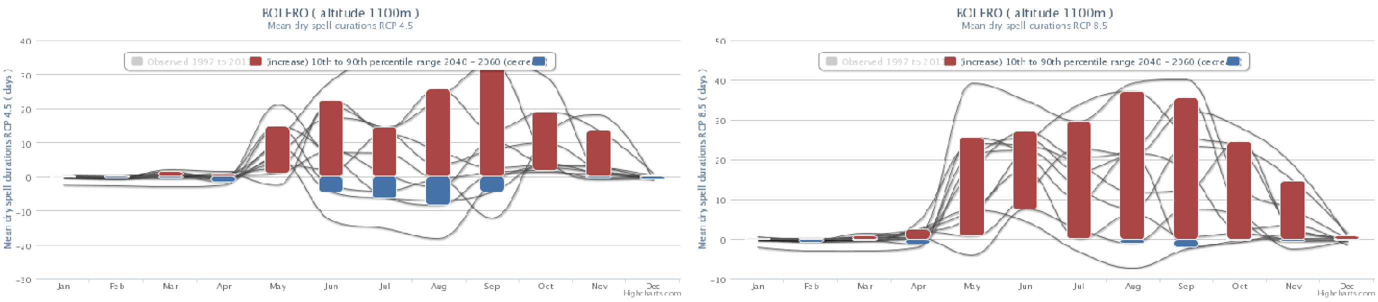


Figure B.23.2: Change in monthly mean dry spell duration (< 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Projected change in monthly mean rain day frequency

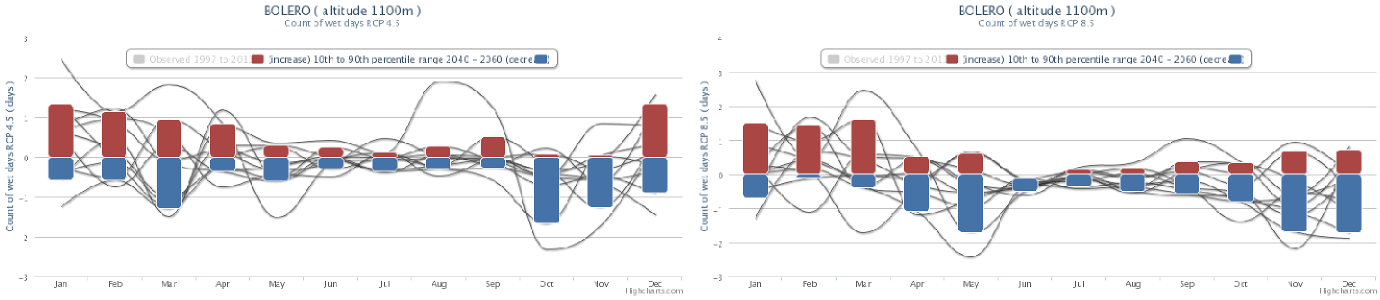


Figure B.23.3: Change in monthly rain day frequency (rain day = rain > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Projected change in monthly mean rain day frequency (> 20mm)

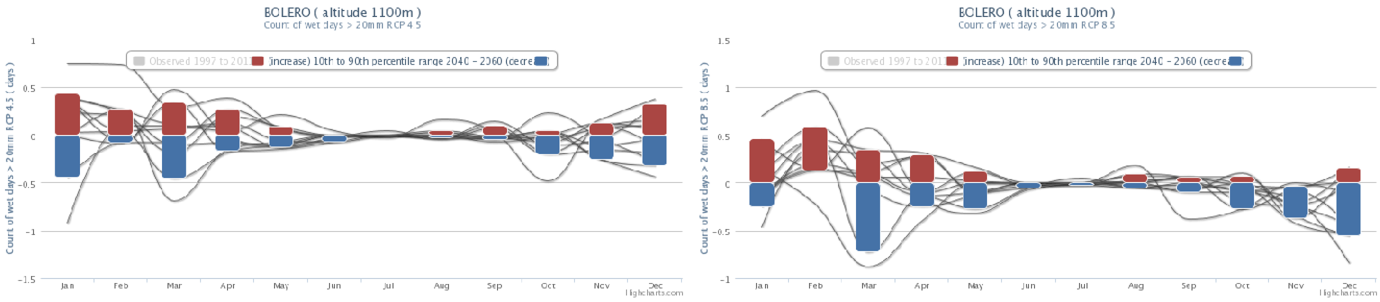


Figure B.23.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

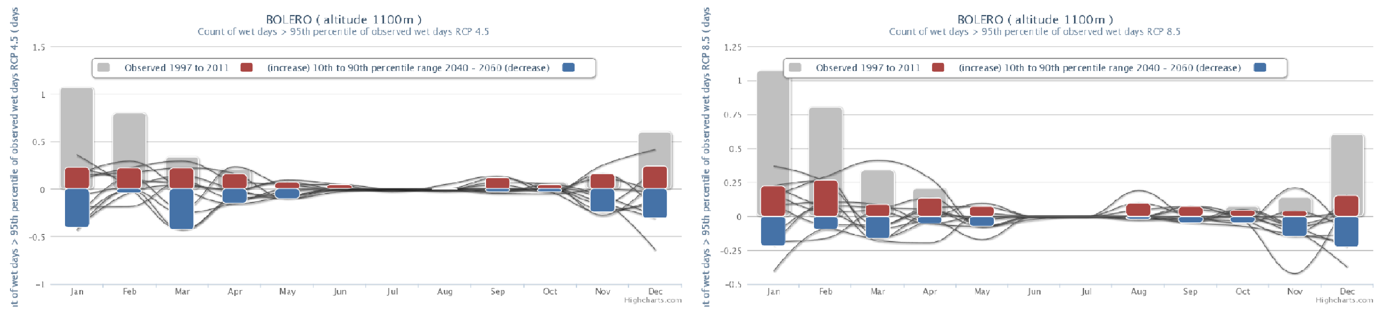


Figure B.23.5: Change in monthly rain day frequency > 31.6 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

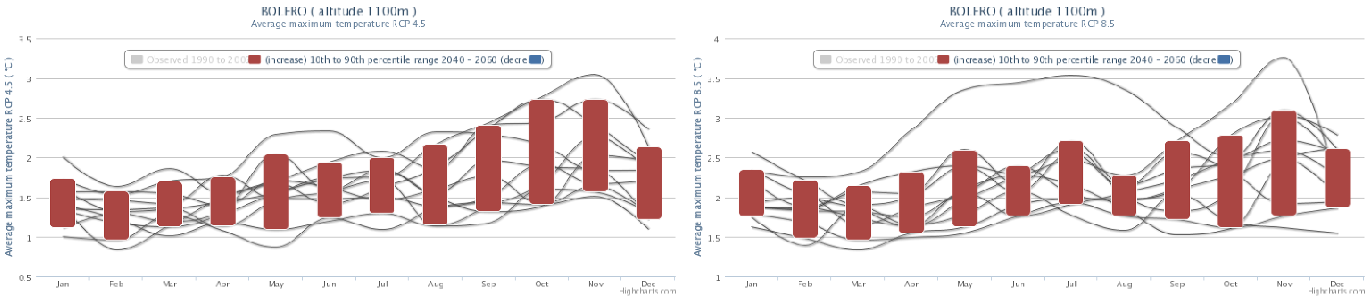


Figure B.23.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Monthly mean maximum days above 36 degree C

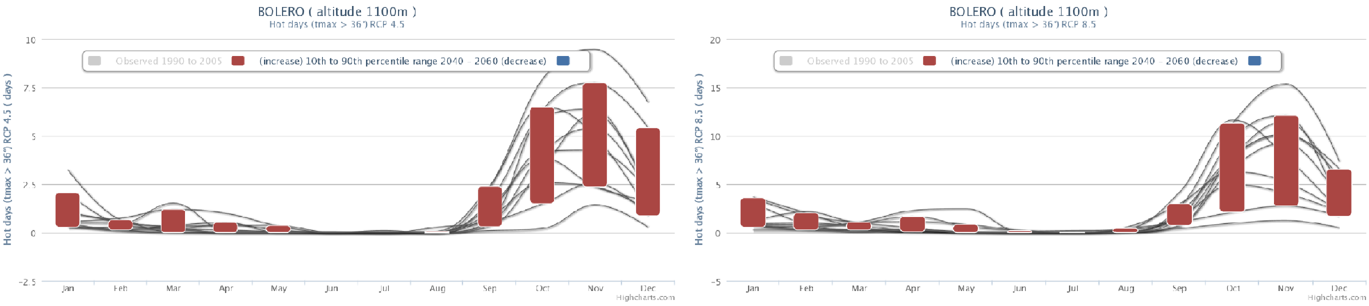


Figure B.23.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Monthly mean maximum days above 95th percentile

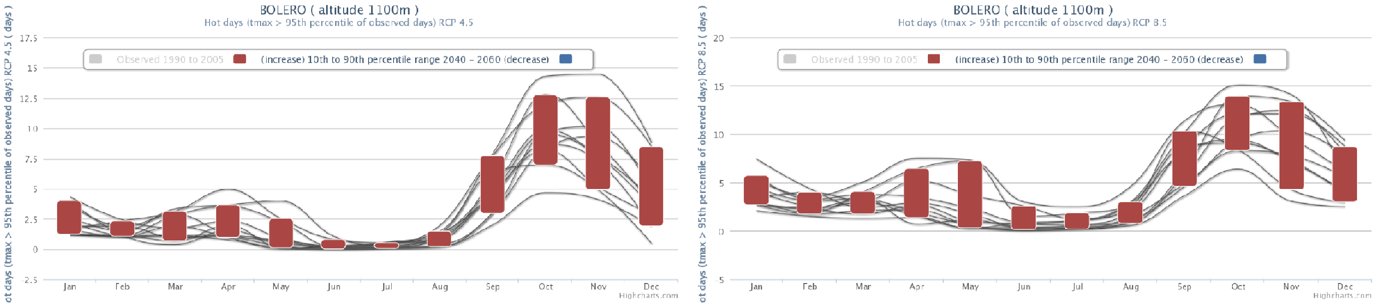


Figure B.23.8: Change in days above 33.2 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Monthly mean heat spell duration

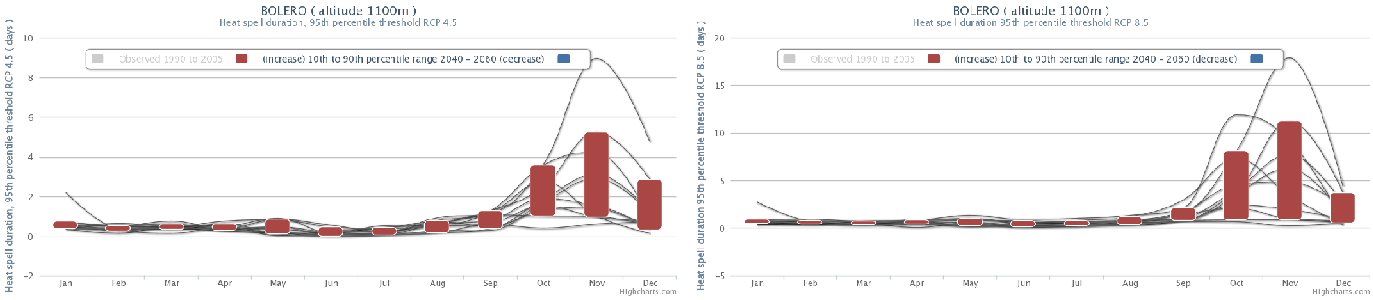


Figure B.23.9: Change in heat spell duration (33.2 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

Monthly mean minimum daily temperature change

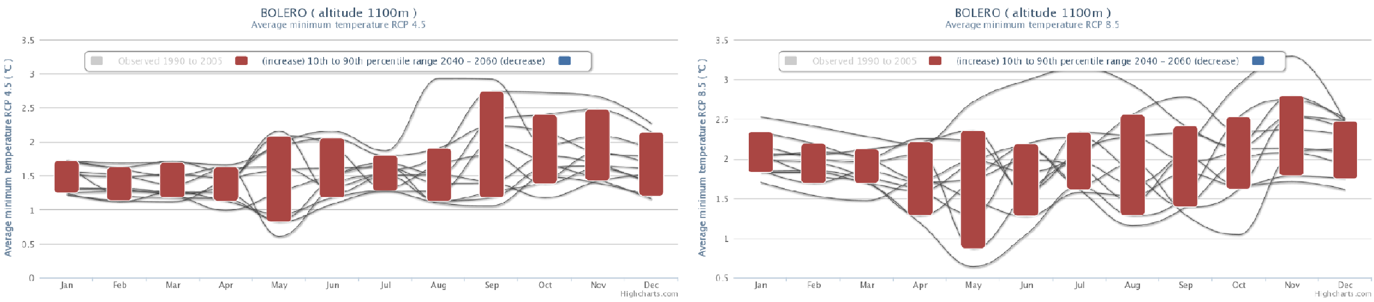


Figure B.23.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BOLERO station.

B.24: Climate Summary for BVUMBWE

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

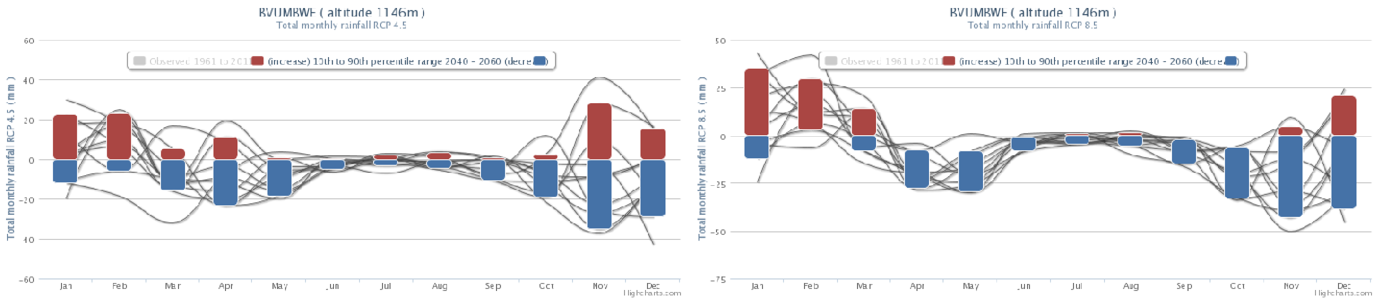


Figure B.24.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station

Projected change in monthly mean dry spell duration

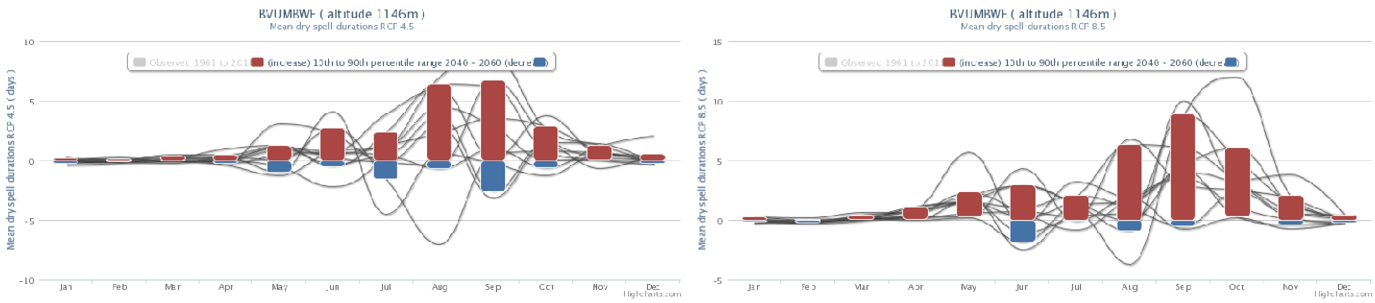


Figure B.24.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Projected change in monthly mean rain day frequency

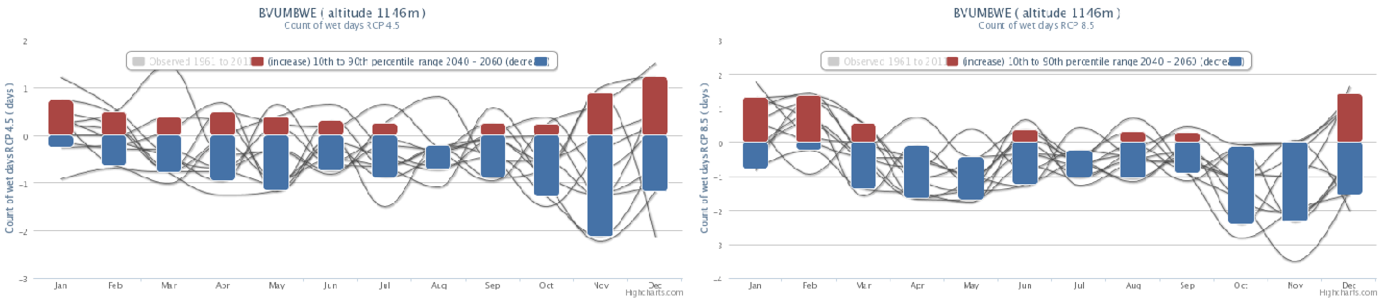


Figure B.24.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Projected change in monthly mean rain day frequency (> 20mm)

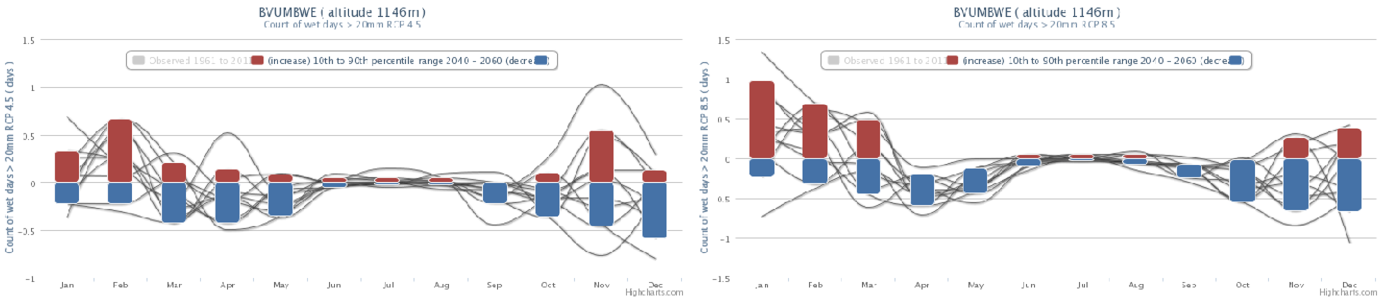


Figure B.24.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

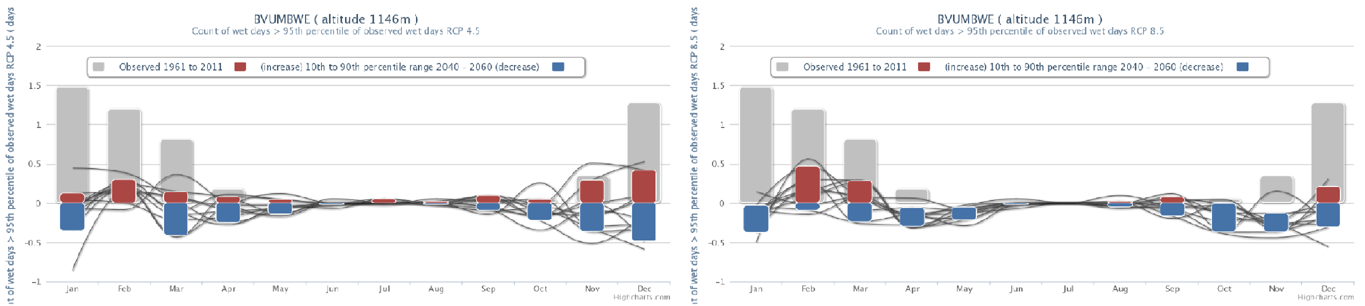


Figure B.24.5: Change in monthly rain day frequency > 45 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

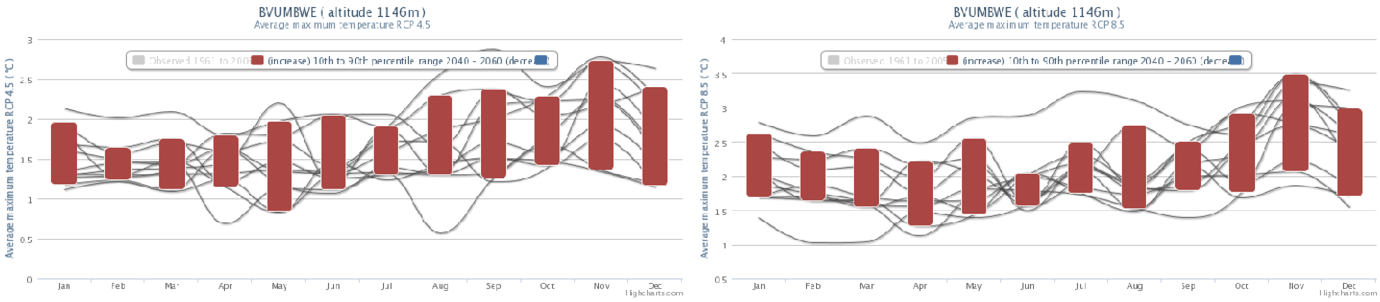


Figure B.24.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Monthly mean maximum days above 36 degree C

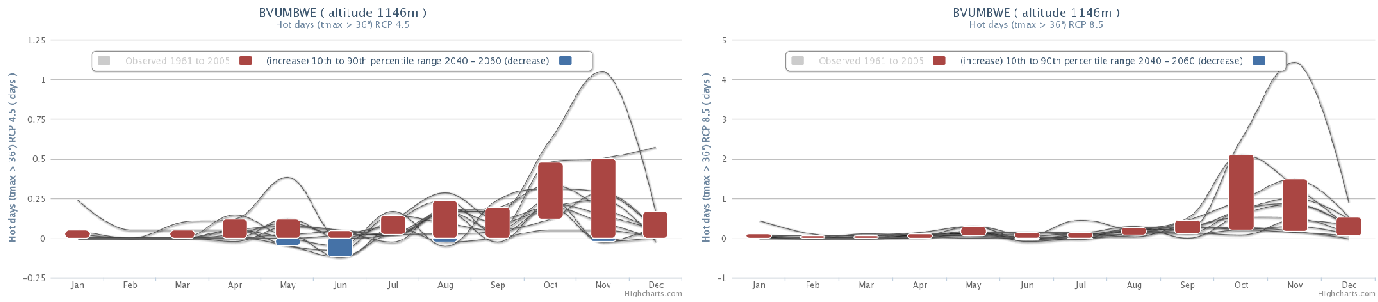


Figure B.24.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Monthly mean maximum days above 95th percentile

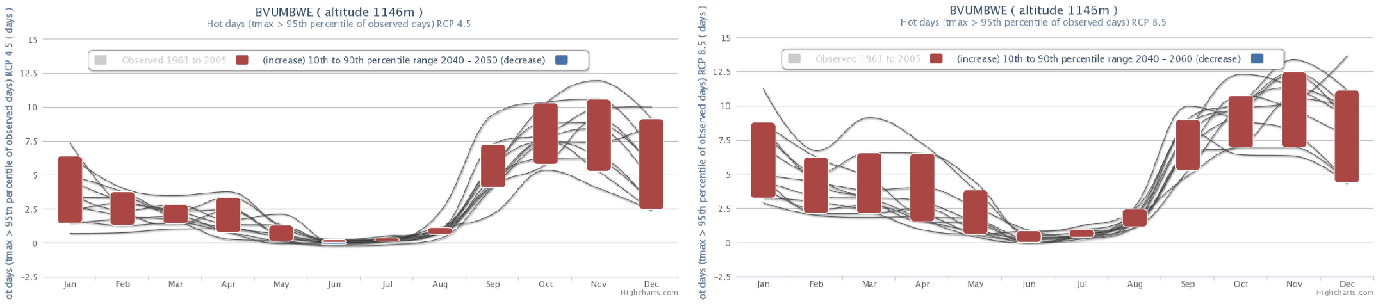


Figure B.24.8: Change in days above 31.2 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Monthly mean heat spell duration

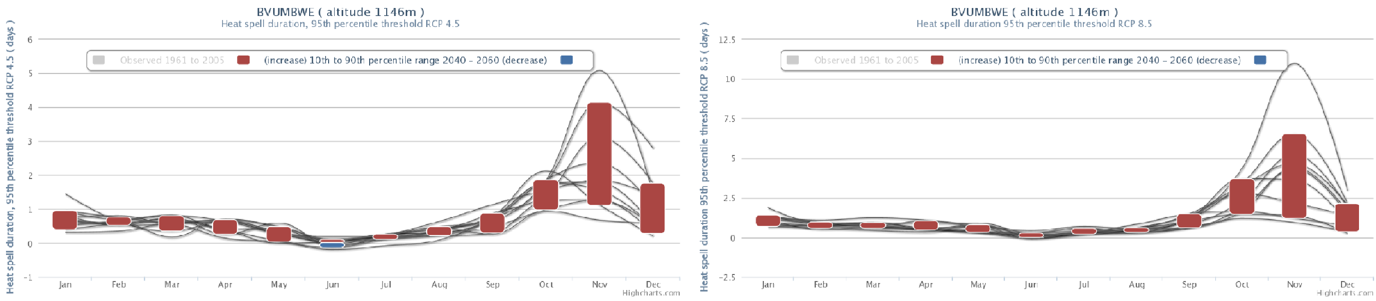


Figure B.24.9: Change in heat spell duration (31.2 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

Monthly mean minimum daily temperature change

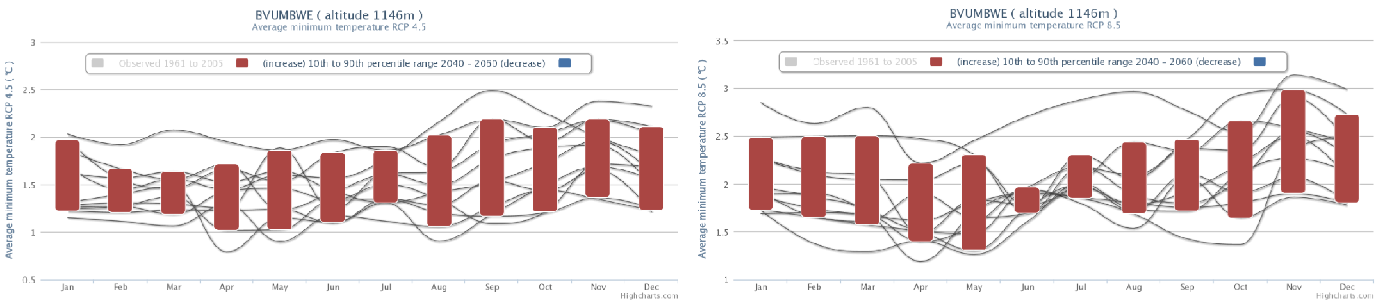


Figure B.24.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for BVUMBWE station.

B.25: Climate Summary for CHICHIRI

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

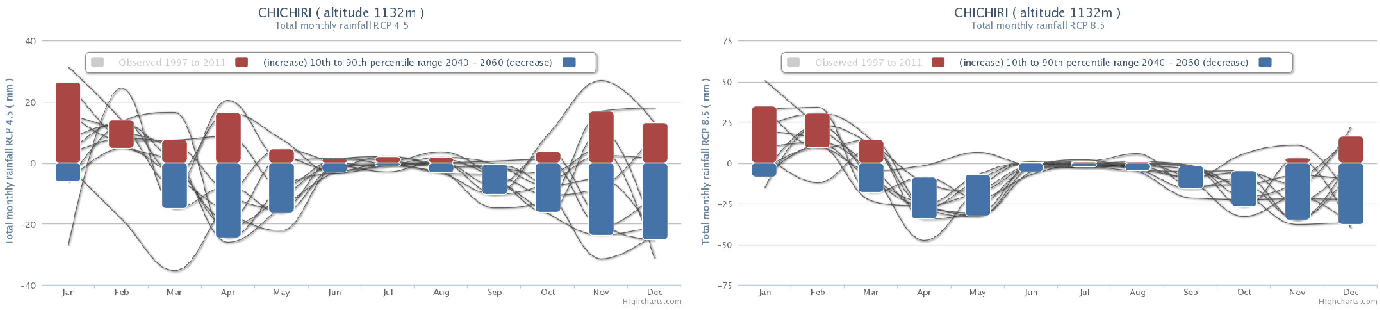


Figure B.25.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Projected change in monthly mean dry spell duration

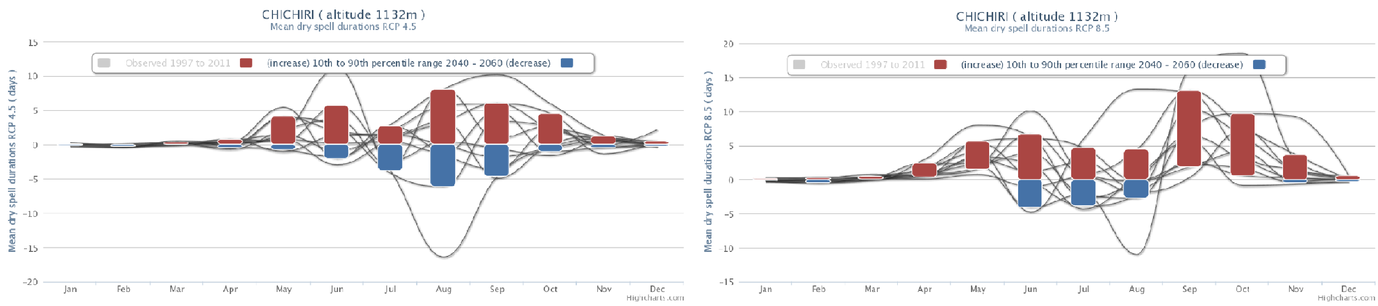


Figure B.25.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Projected change in monthly mean rain day frequency

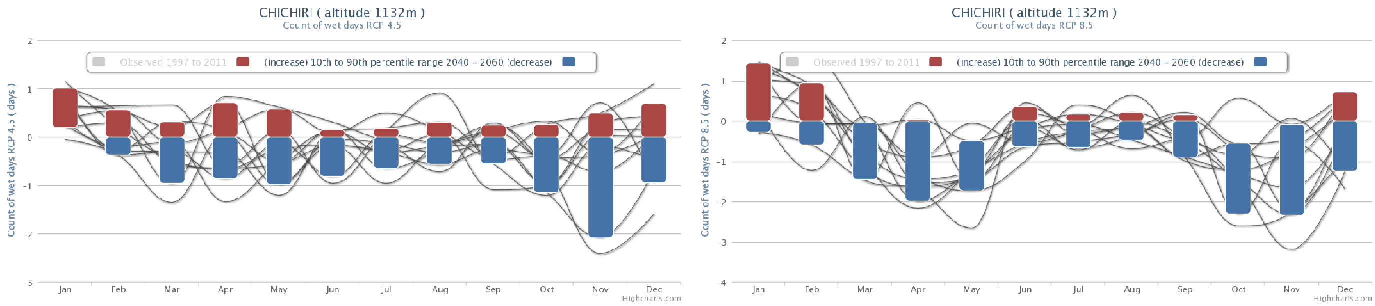


Figure B.25.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Projected change in monthly mean rain day frequency (> 20mm)

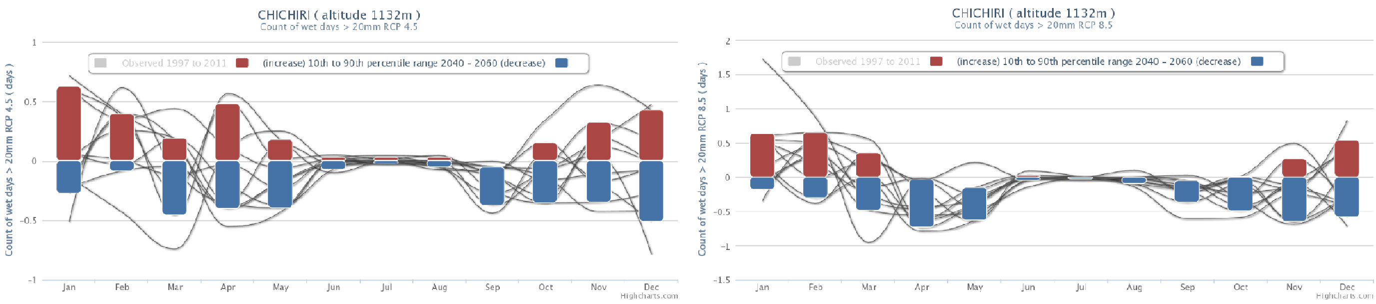


Figure B.25.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

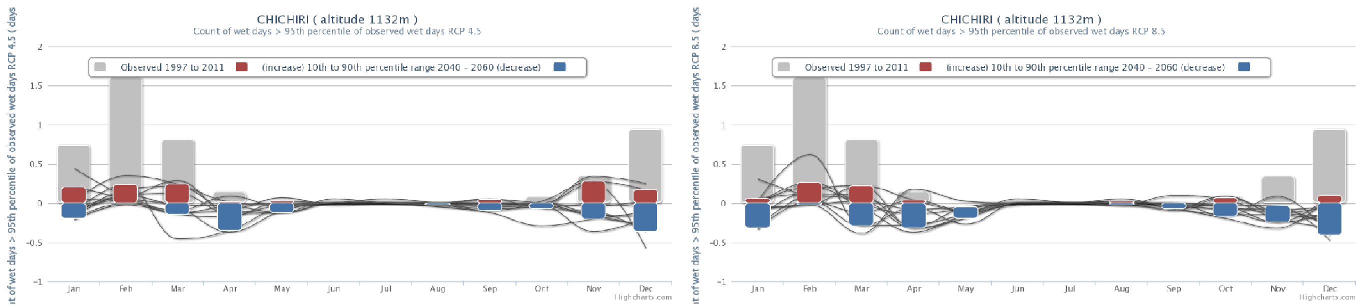


Figure B.25.5: Change in monthly rain day frequency > 46 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model

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Monthly mean maximum daily temperature change

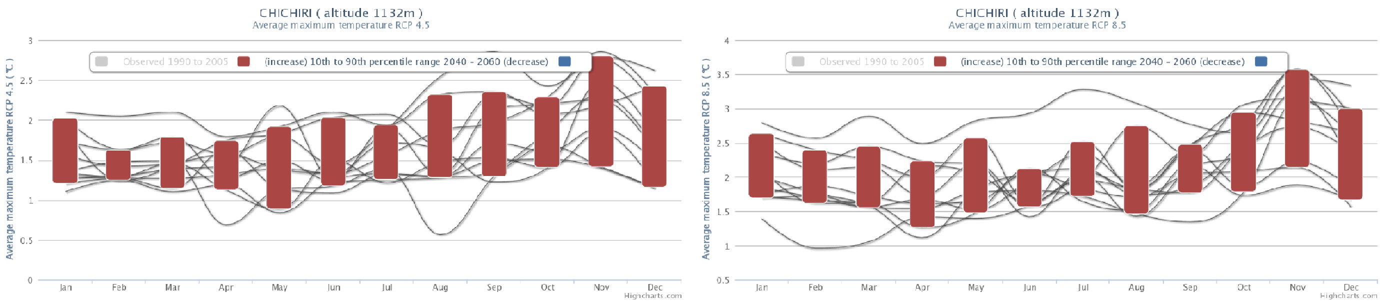


Figure B.25.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Monthly mean maximum days above 36 degree C

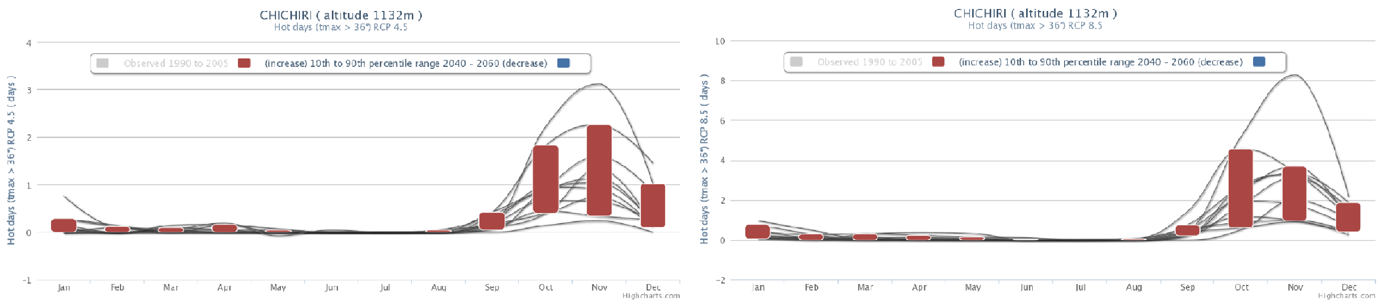


Figure B.25.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Monthly mean maximum days above 95th percentile

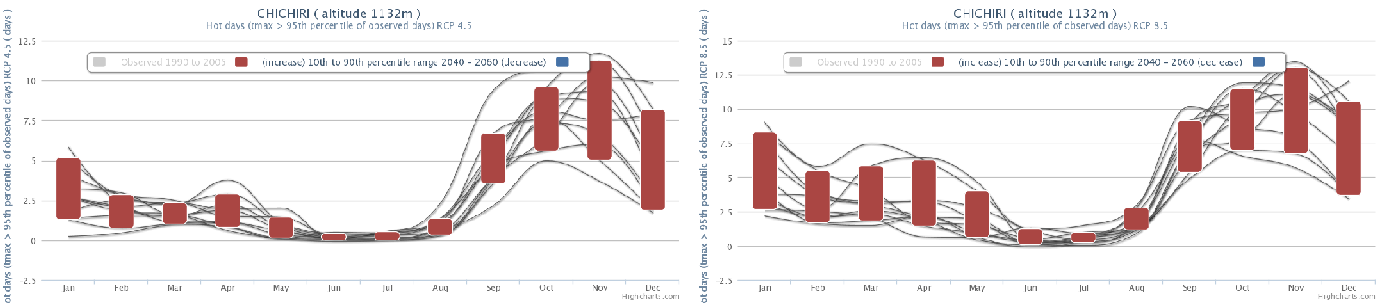


Figure B.25.8: Change in days above 30.5 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Monthly mean heat spell duration

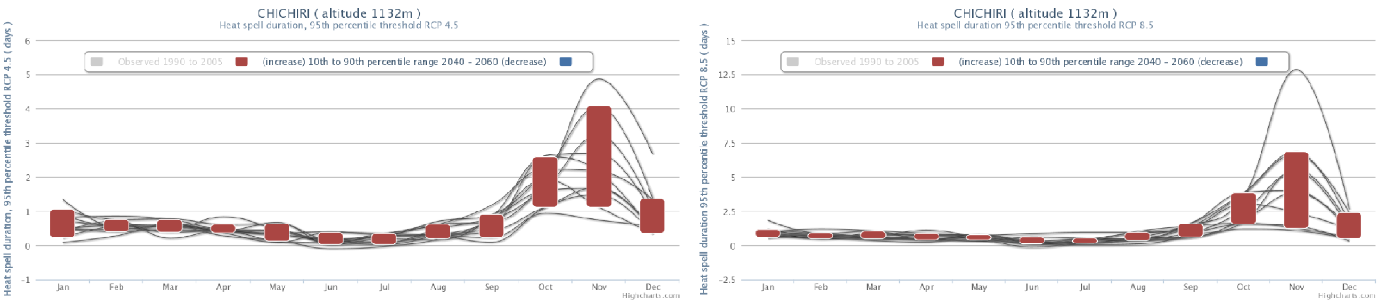


Figure B.25.9: Change in heat spell duration (30.5 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

Monthly mean minimum daily temperature change

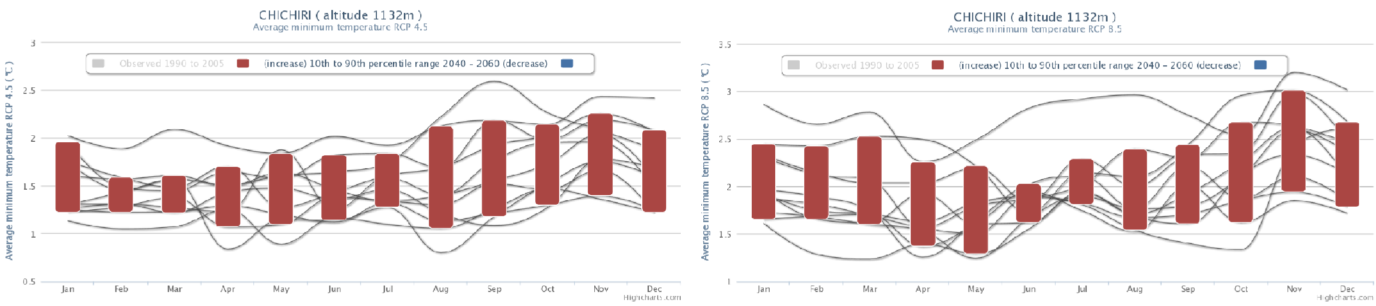


Figure B.25.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHICHIRI station.

B.26: Climate Summary for CHILEKA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

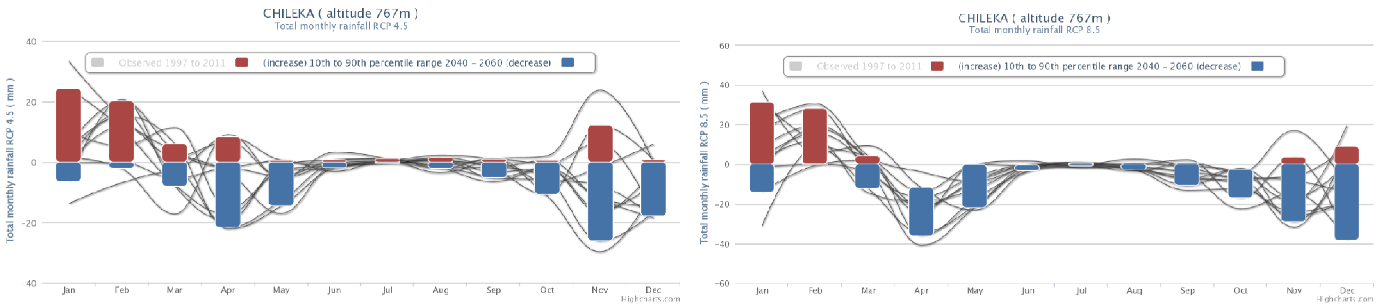


Figure B.26.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Projected change in monthly mean dry spell duration

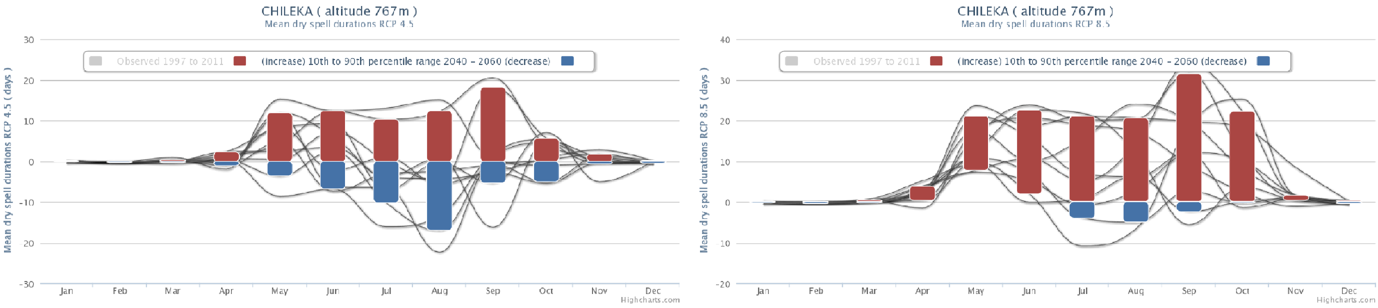


Figure B.26.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Projected change in monthly mean rain day frequency

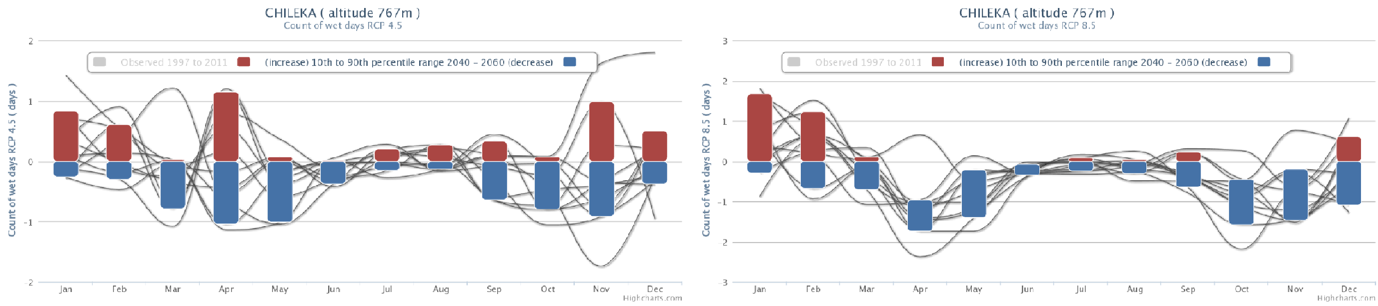


Figure B.26.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Projected change in monthly mean rain day frequency (> 20mm)

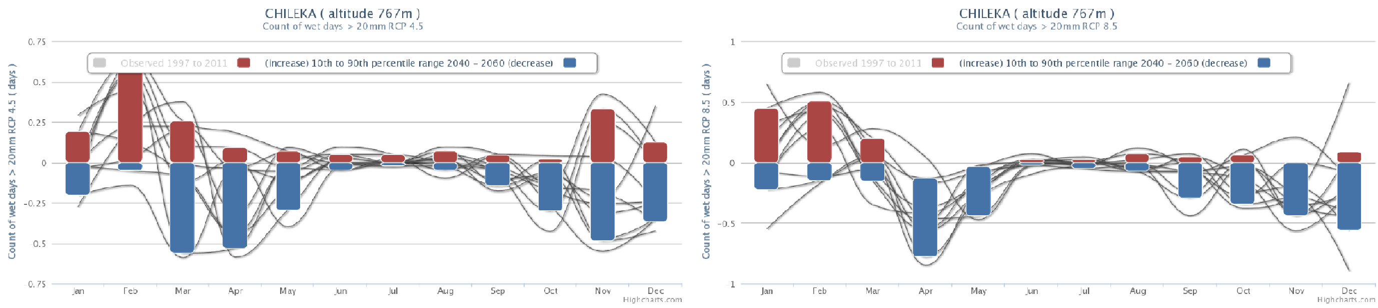


Figure B.26.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

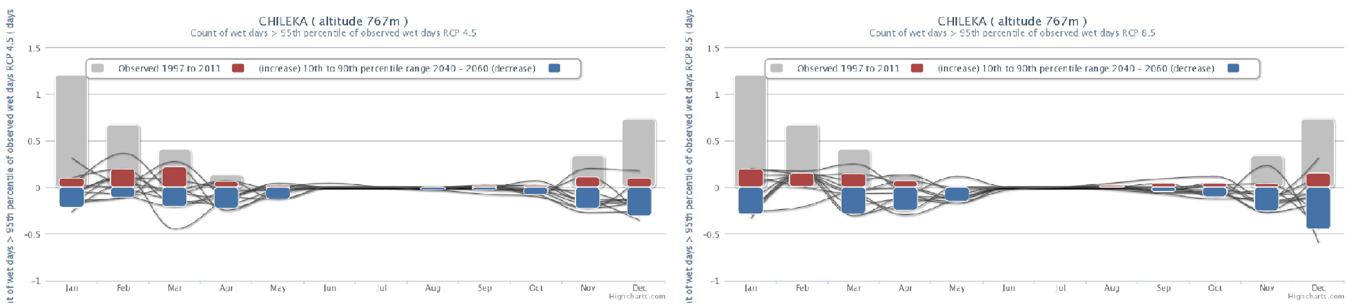


Figure B.26.5: Change in monthly rain day frequency > 36.8 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

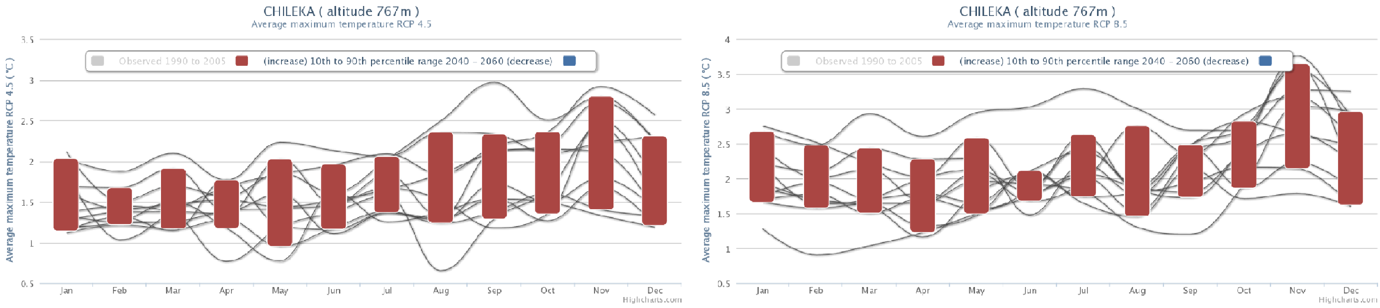


Figure B.26.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Monthly mean maximum days above 36 degree C

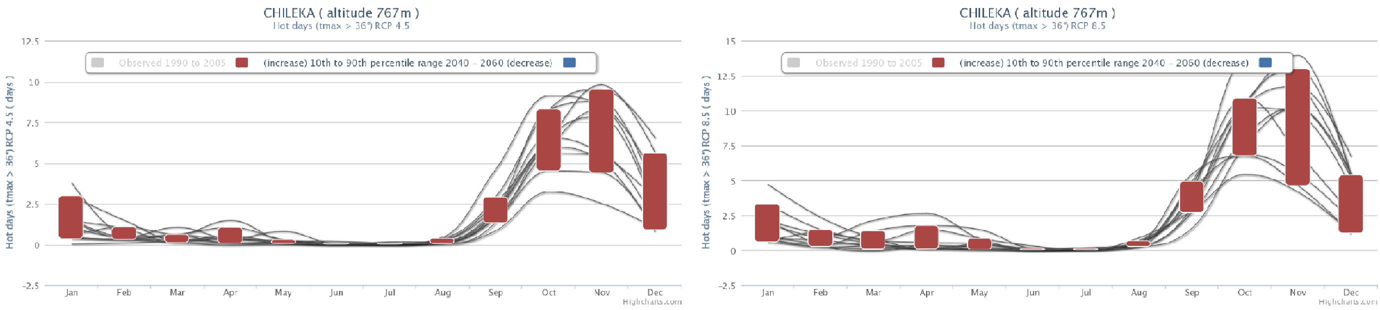


Figure B.26.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Monthly mean maximum days above 95th percentile

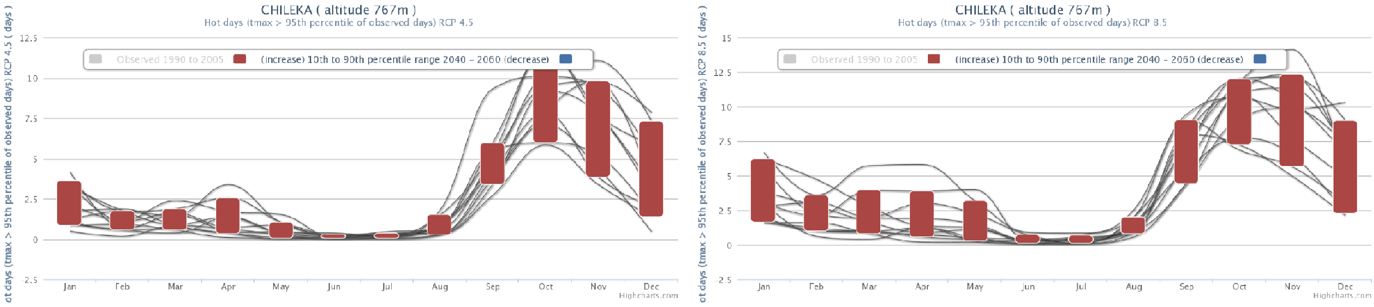


Figure B.26.8: Change in days above 34.2 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Monthly mean heat spell duration

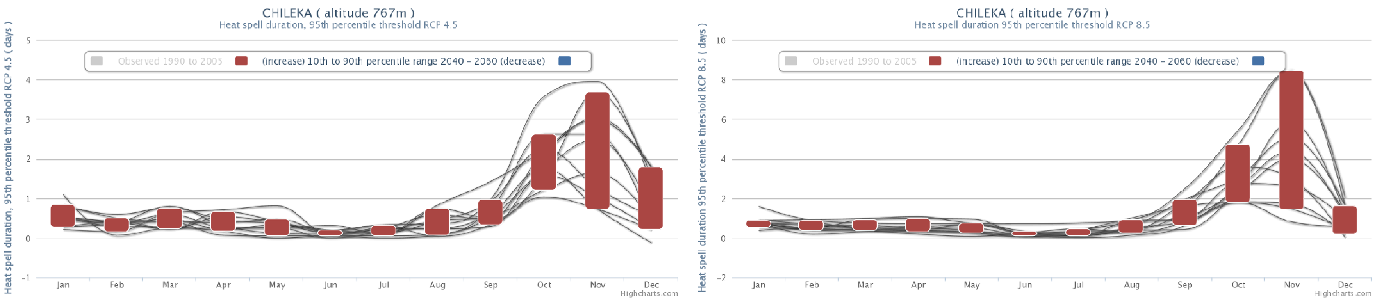


Figure B.26.9: Change in heat spell duration (34.2 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

Monthly mean minimum daily temperature change

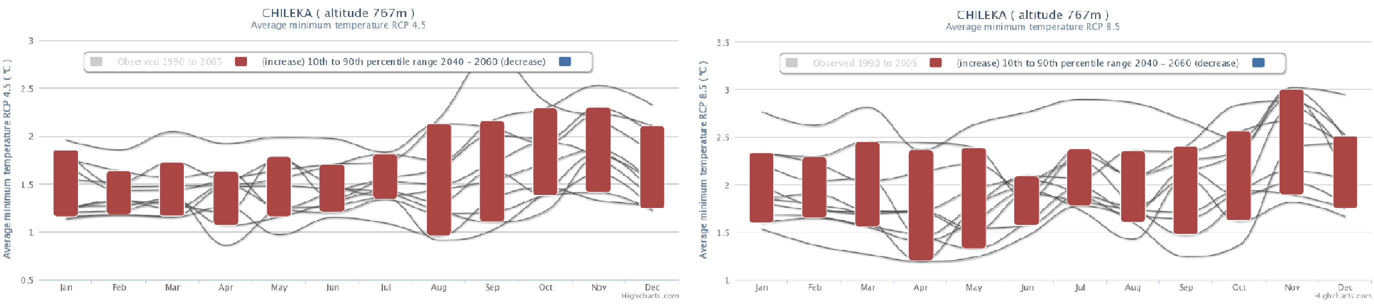


Figure B.26.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHILEKA station.

B.27: Climate Summary for CHITEDZE

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

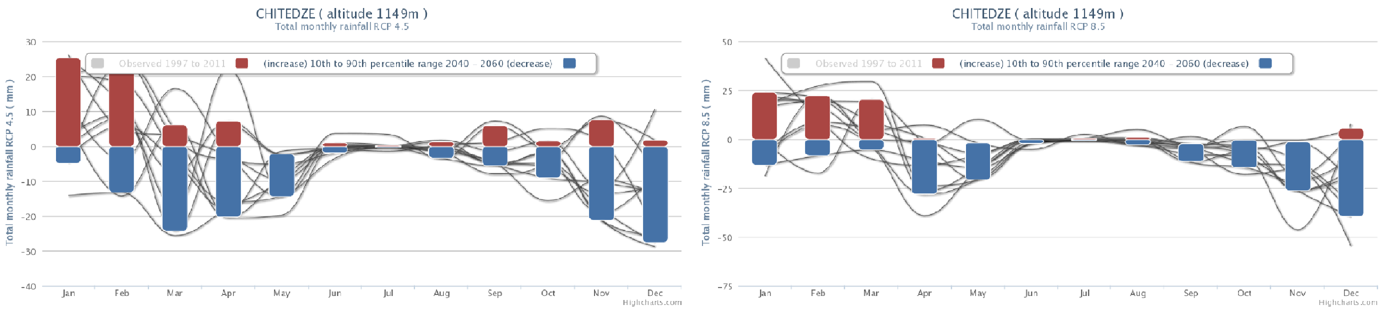


Figure B.27.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Projected change in monthly mean dry spell duration

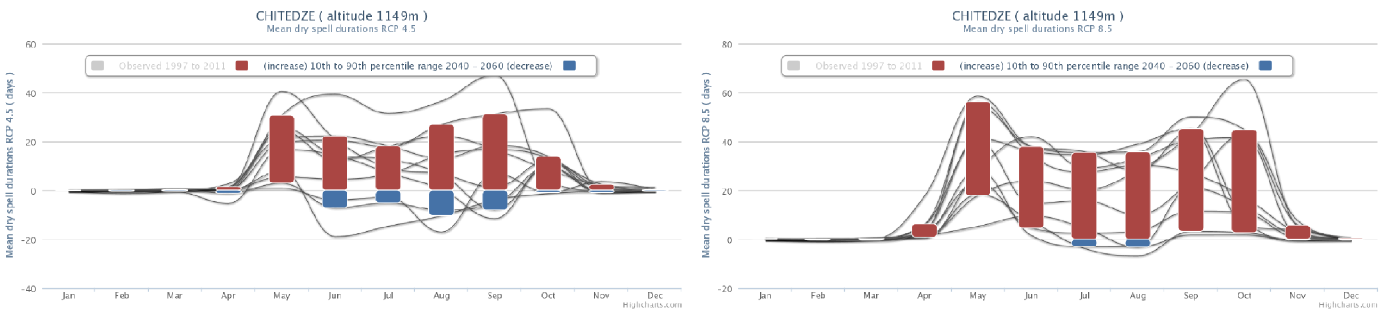


Figure B.27.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Projected change in monthly mean rain day frequency

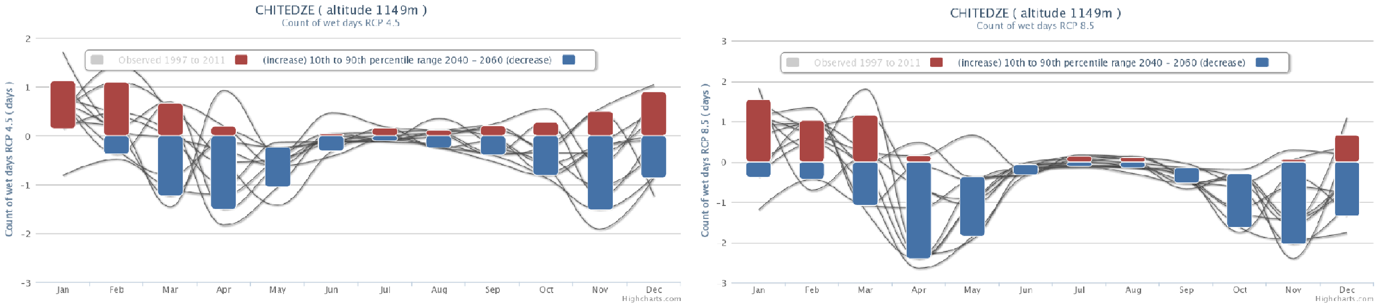


Figure B.5.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Projected change in monthly mean rain day frequency (> 20mm)

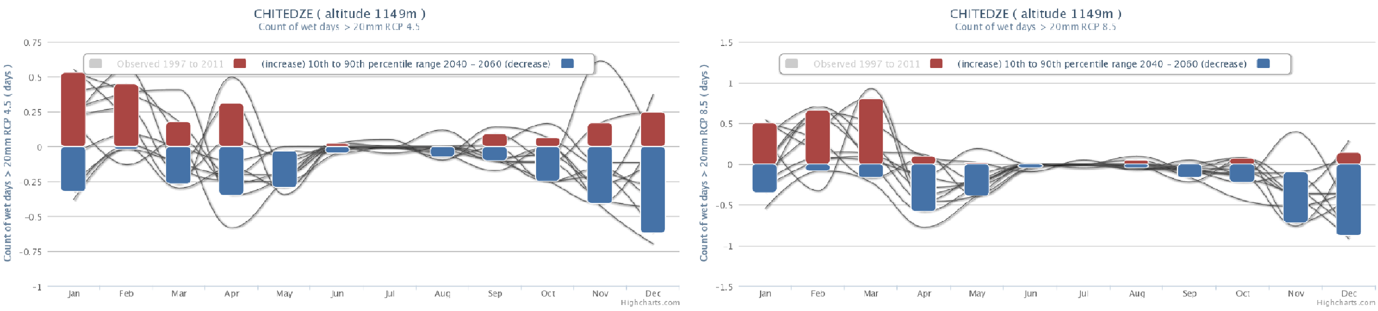
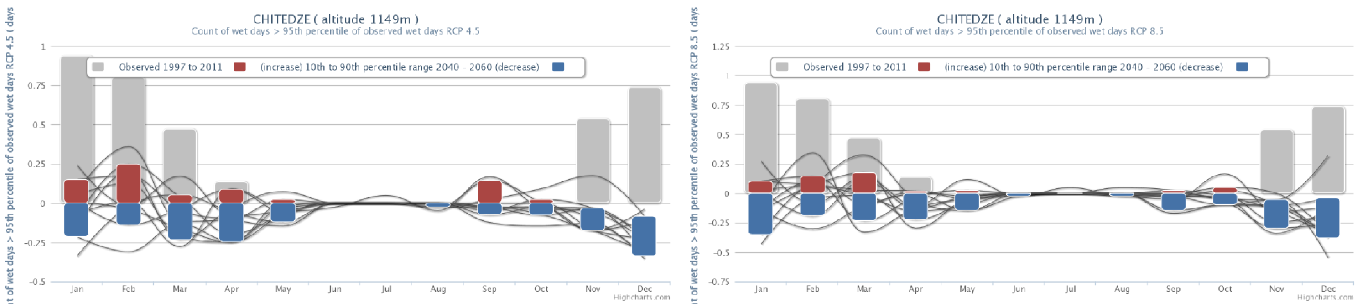


Figure B.27.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Projected change in monthly extreme rain day frequency (> 95th percentile)



F

igure B.27.5: Change in monthly rain day frequency > 45.5 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

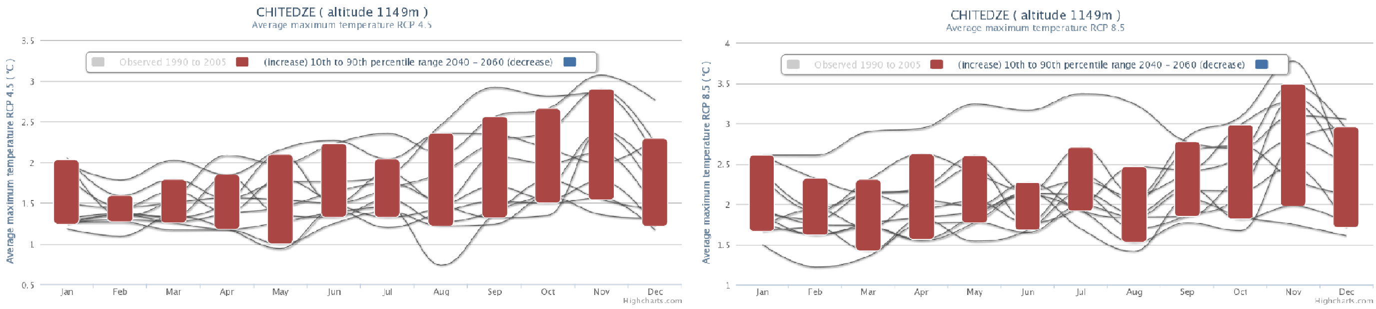


Figure B.27.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Monthly mean maximum days above 36 degree C

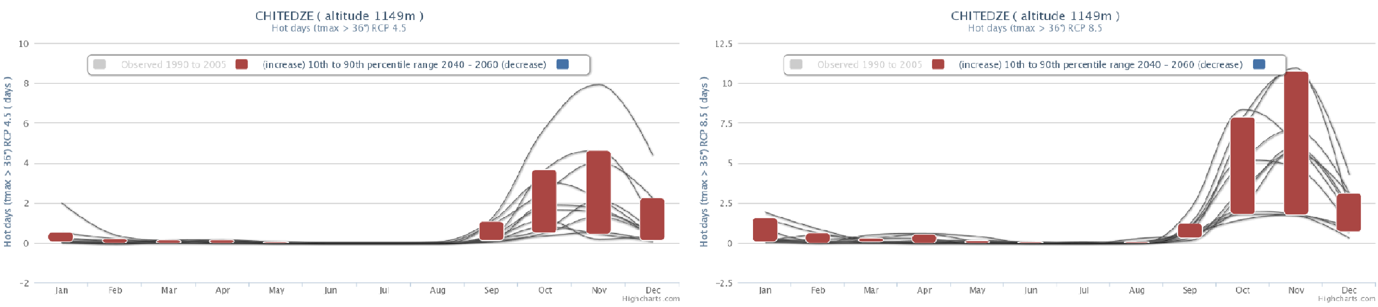


Figure B.27.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Monthly mean maximum days above 95th percentile

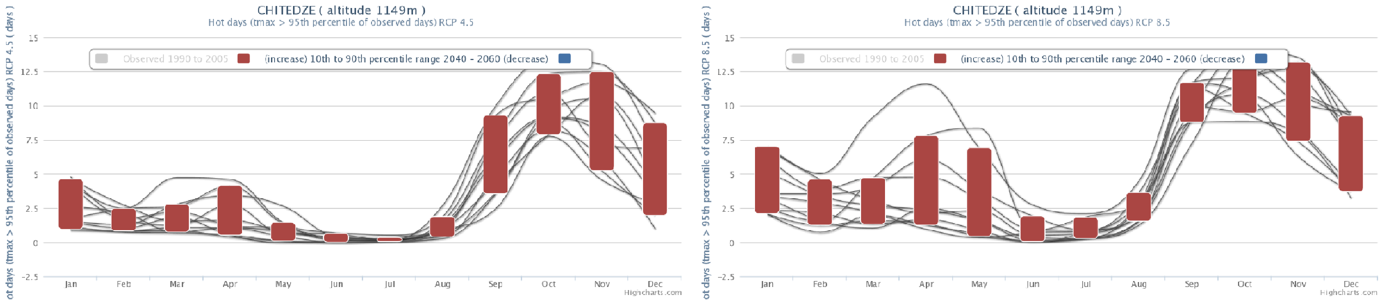


Figure B.27.8: Change in days above 34.3 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Monthly mean heat spell duration

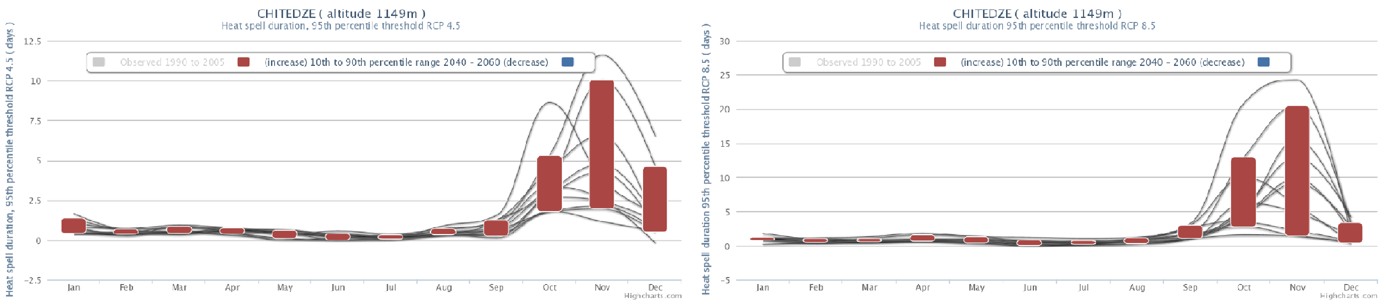


Figure B.27.9: Change in heat spell duration (34.3 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

Monthly mean minimum daily temperature change

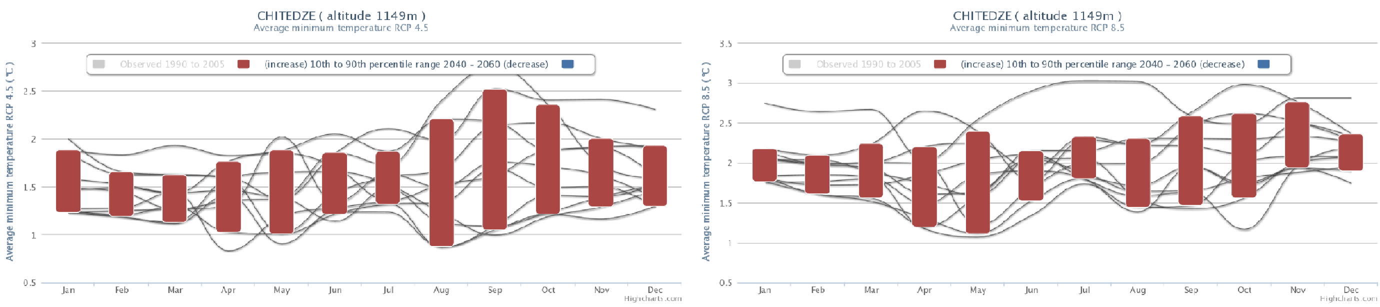


Figure B.27.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITEDZE station.

B.28: Climate Summary for CHITIPA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

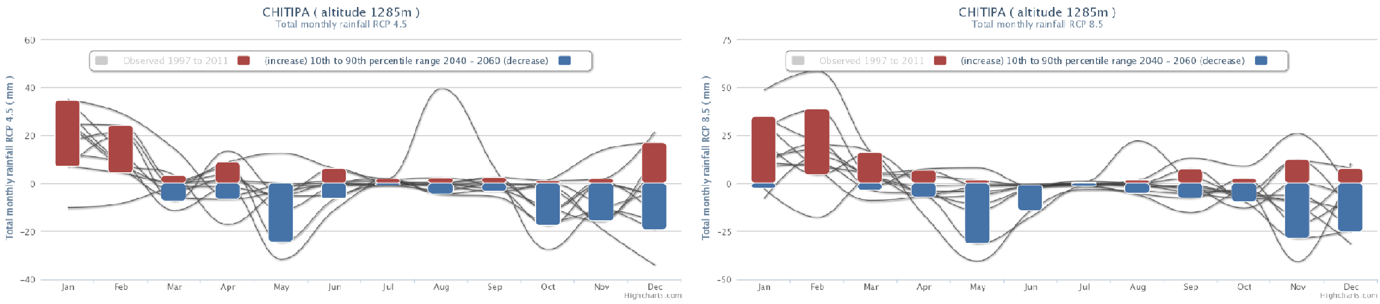


Figure B.28.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Projected change in monthly mean dry spell duration

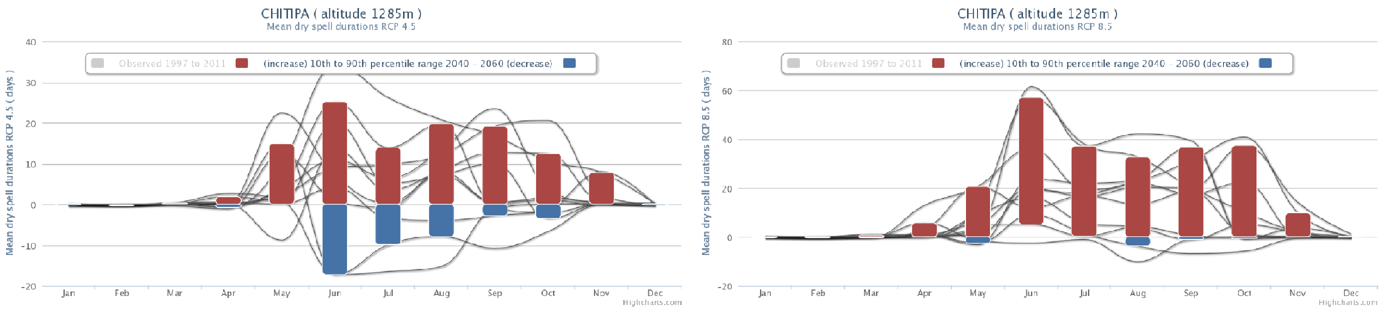


Figure B.28.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Projected change in monthly mean rain day frequency

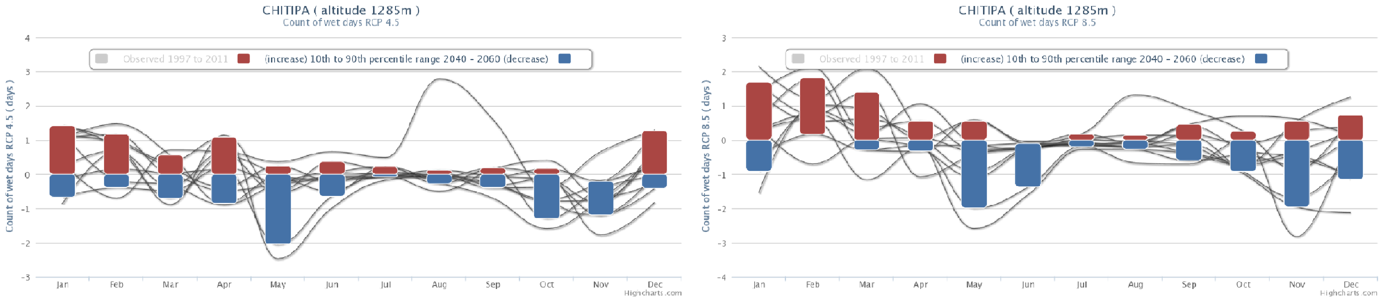


Figure B.28.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Projected change in monthly mean rain day frequency (> 20mm)

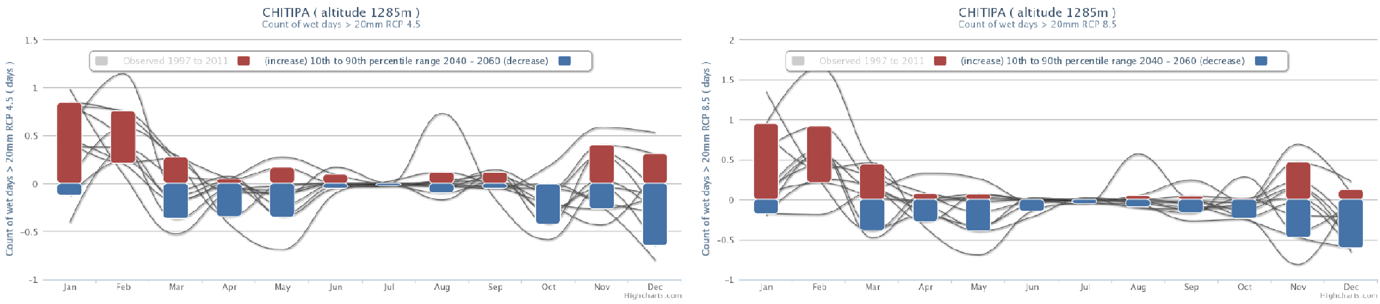


Figure B.28.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

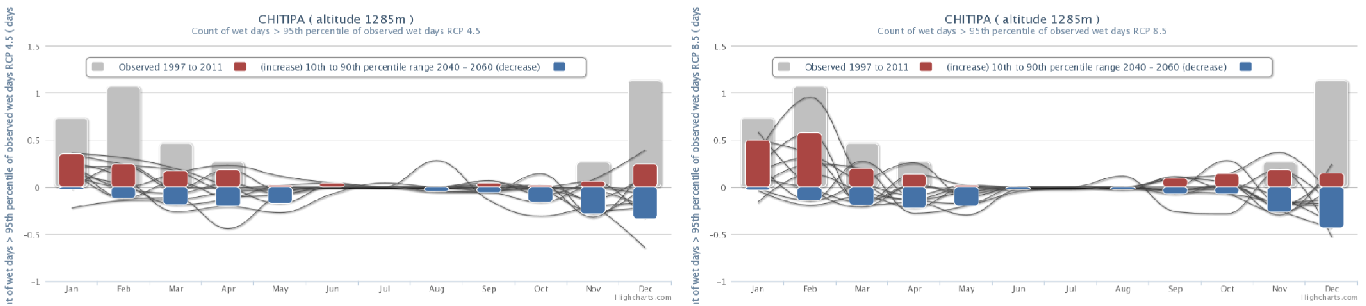


Figure B.28.5: Change in monthly rain day frequency > 43.4 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model

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Monthly mean maximum daily temperature change

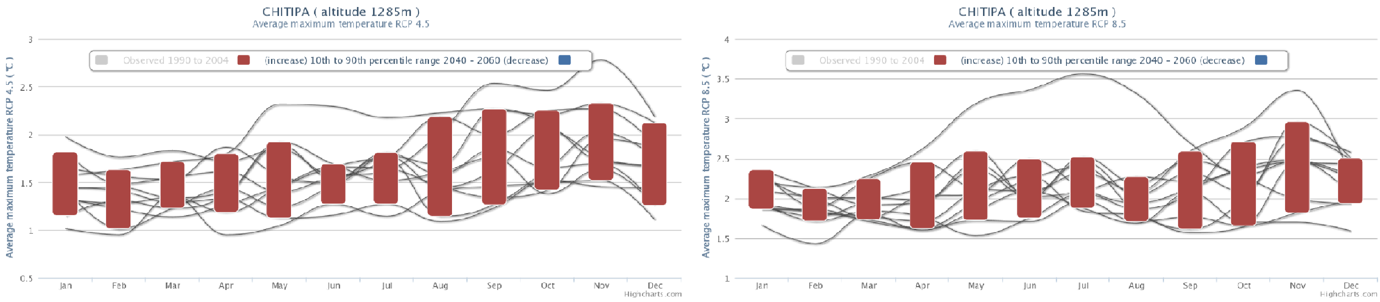


Figure B.28.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Monthly mean maximum days above 36 degree C

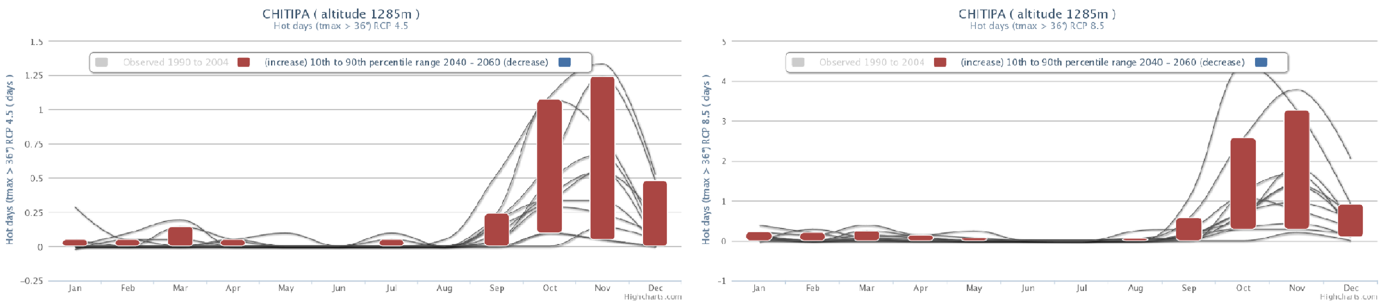


Figure B.28.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Monthly mean maximum days above 95th percentile

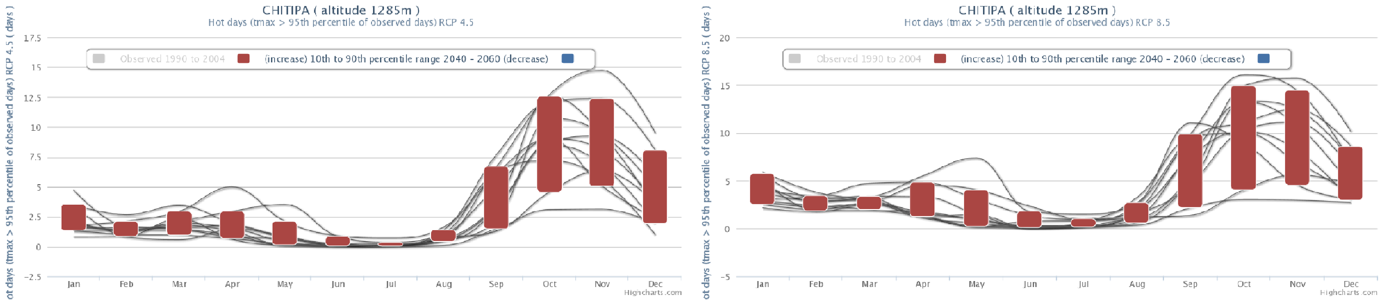


Figure B.28.8: Change in days above 31.9 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Monthly mean heat spell duration

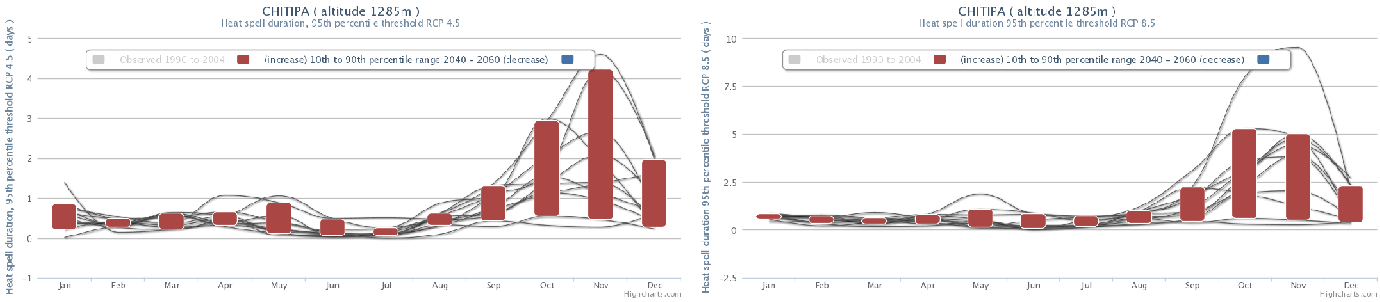


Figure B.28.9: Change in heat spell duration (31.9 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

Monthly mean minimum daily temperature change

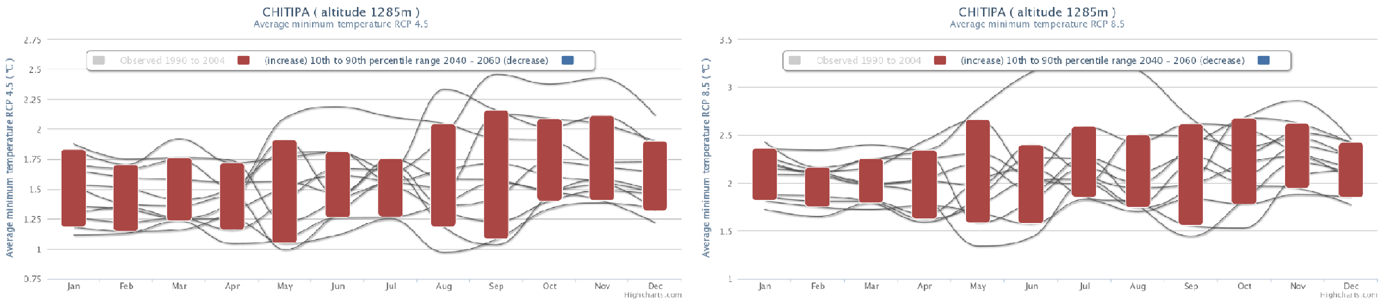


Figure B.28.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for CHITIPA station.

B.29: Climate Summary for DEDZA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

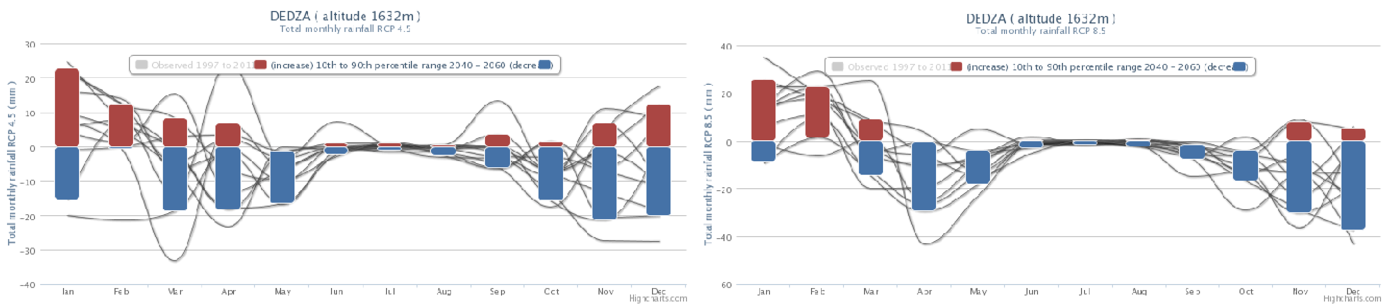


Figure B.29.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Projected change in monthly mean dry spell duration

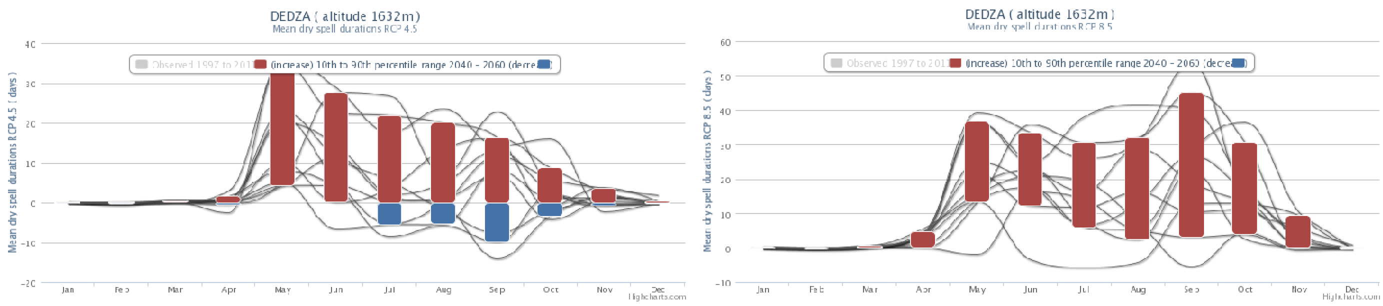


Figure B.29.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Projected change in monthly mean rain day frequency

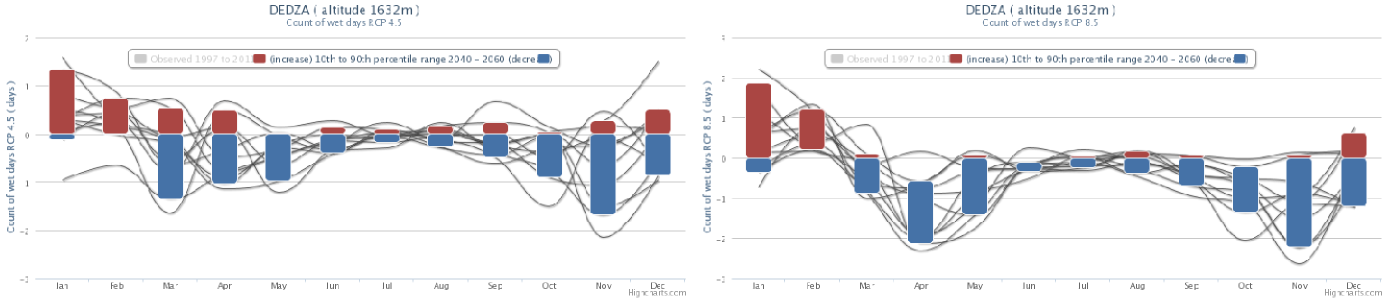


Figure B.29.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Projected change in monthly mean rain day frequency (> 20mm)

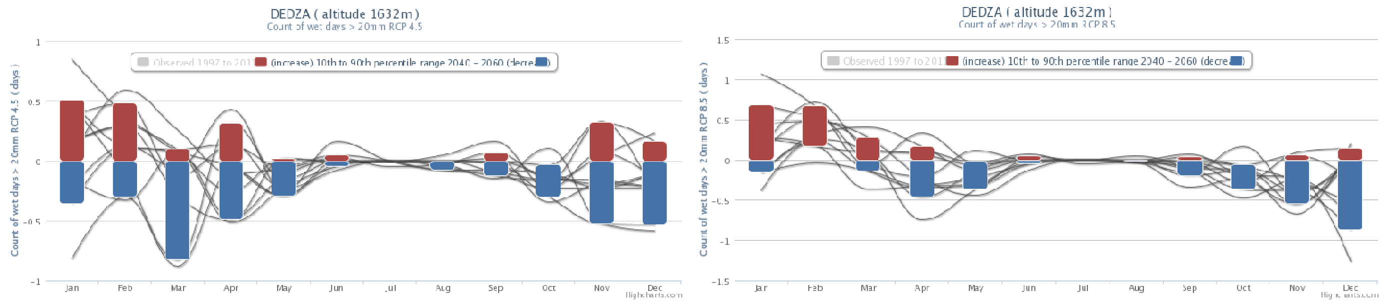


Figure B.29.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

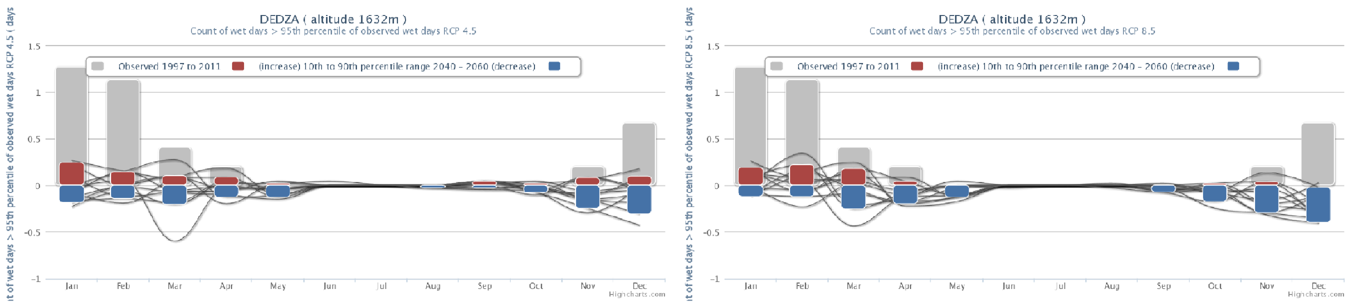


Figure B.29.5: Change in monthly rain day frequency > 37.7 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

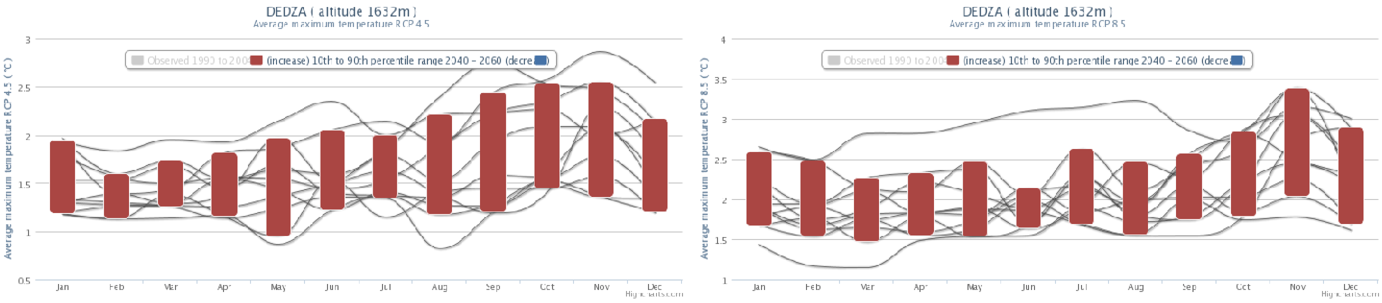


Figure B.29.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Monthly mean maximum days above 36 degree C

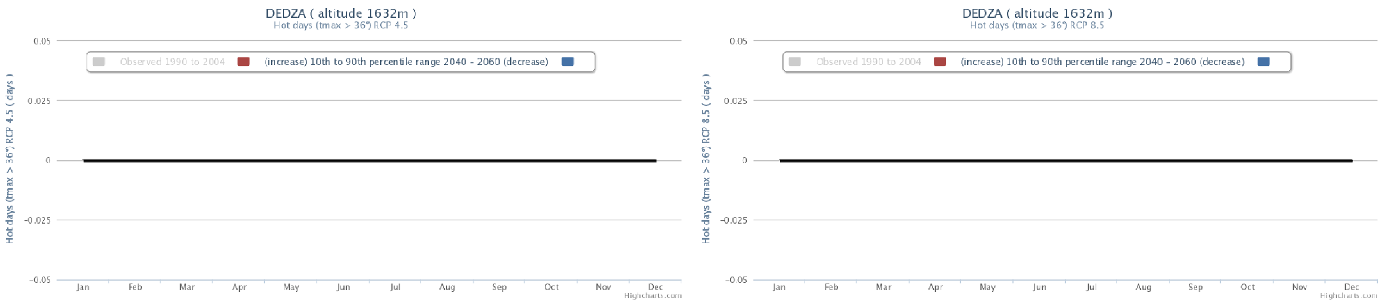


Figure B.29.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Monthly mean maximum days above 95th percentile

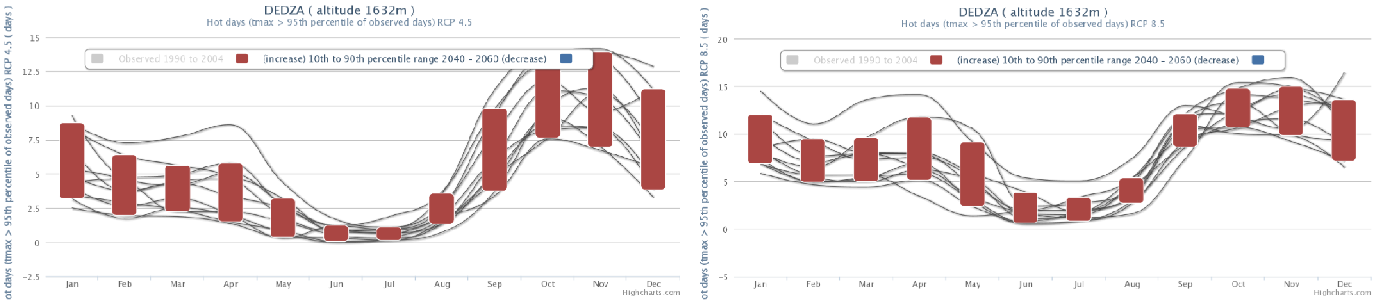


Figure B.29.8: Change in days above 31.6 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Monthly mean heat spell duration

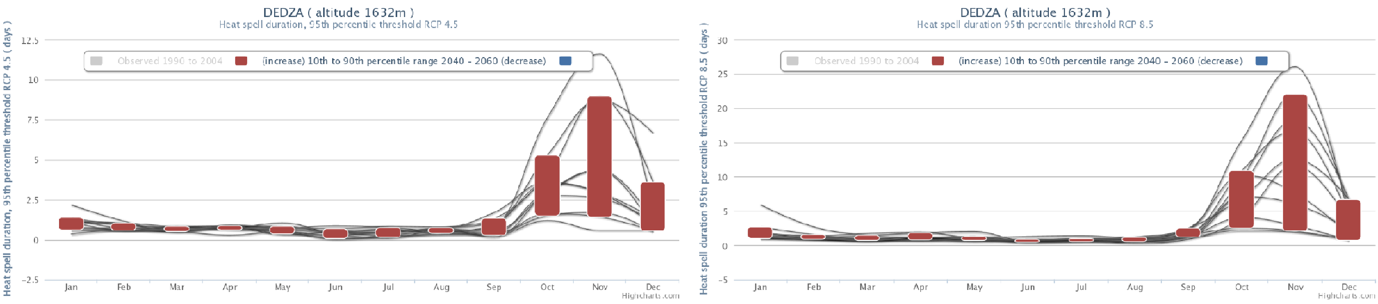


Figure B.29.9: Change in heat spell duration (31.6 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

Monthly mean minimum daily temperature change

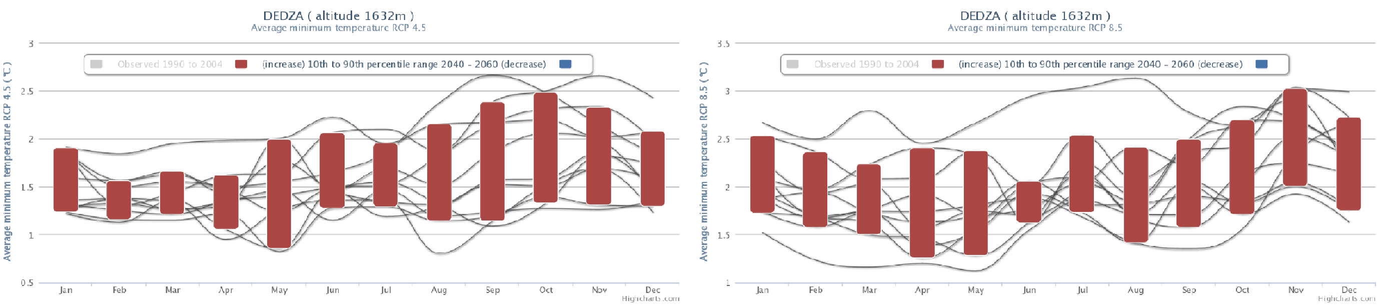


Figure B.29.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for DEDZA station.

B.30: Climate Summary for KARONGA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

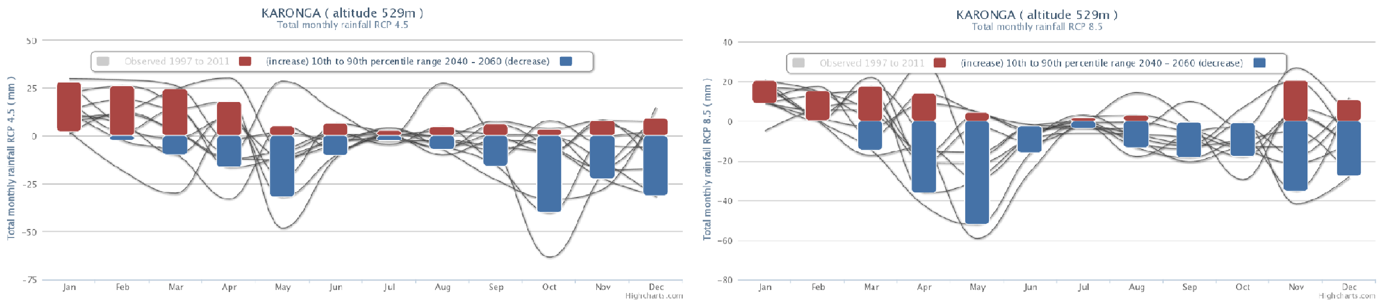


Figure B.30.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Projected change in monthly mean dry spell duration

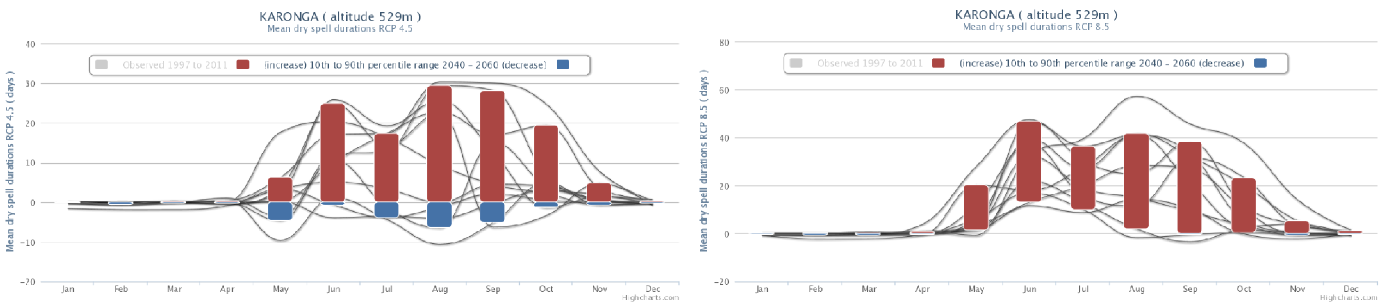


Figure B.30.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Projected change in monthly mean rain day frequency

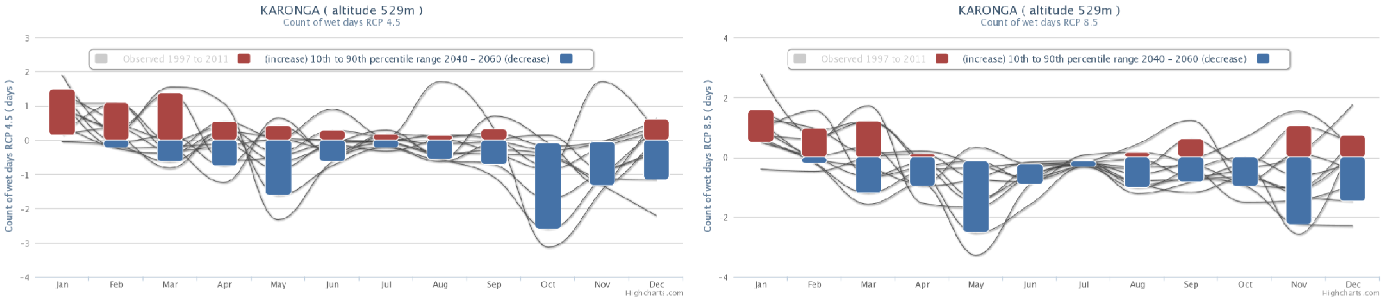


Figure B.30.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Projected change in monthly mean rain day frequency (> 20mm)

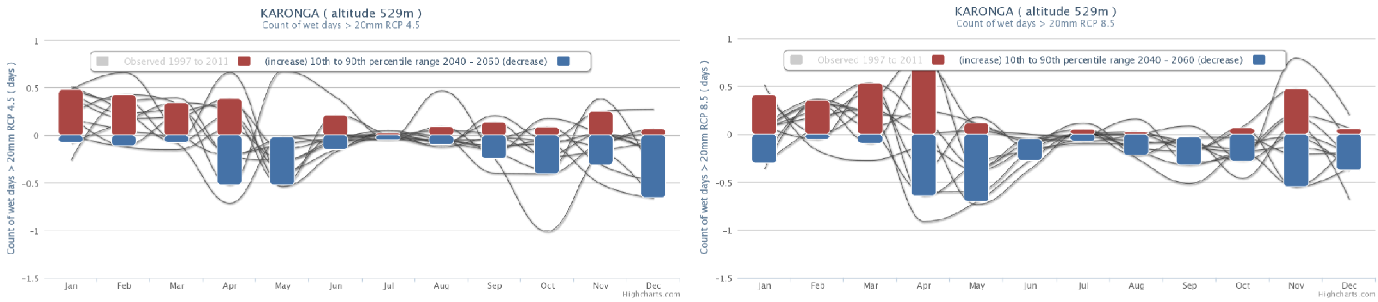


Figure B.30.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

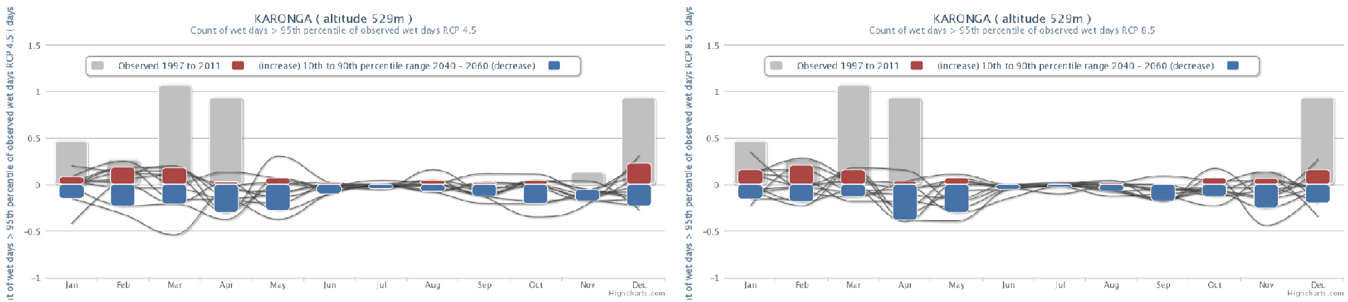


Figure B.30.5: Change in monthly rain day frequency > 46 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

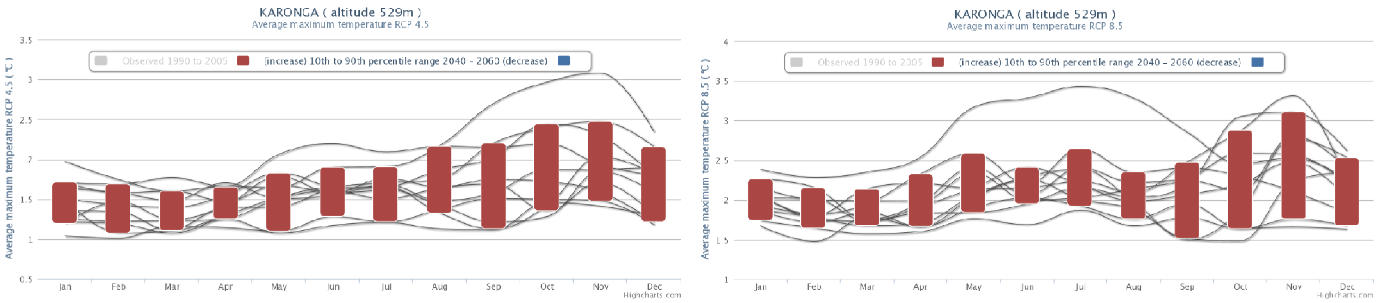


Figure B.30.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Monthly mean maximum days above 36 degree C

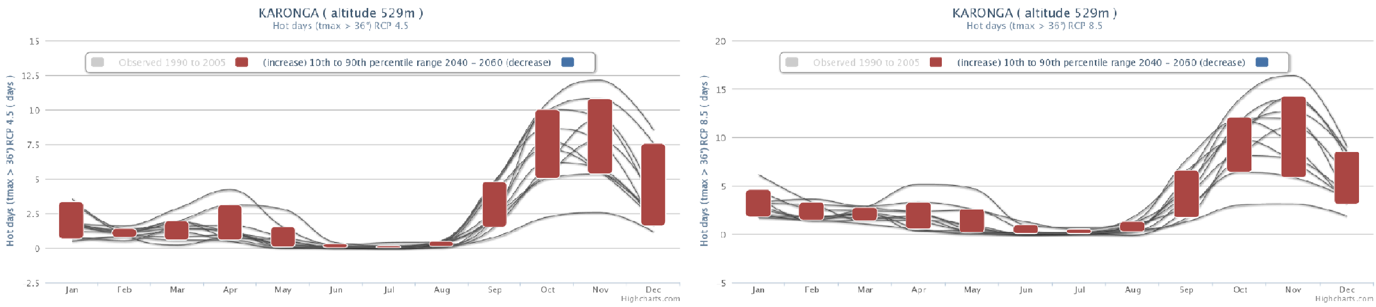


Figure B.30.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Monthly mean maximum days above 95th percentile

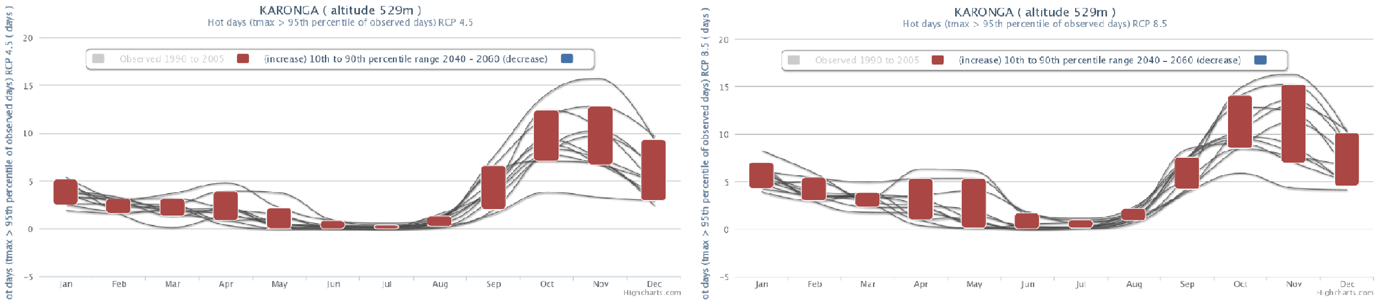


Figure B.30.8: Change in days above 34.8 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Monthly mean heat spell duration

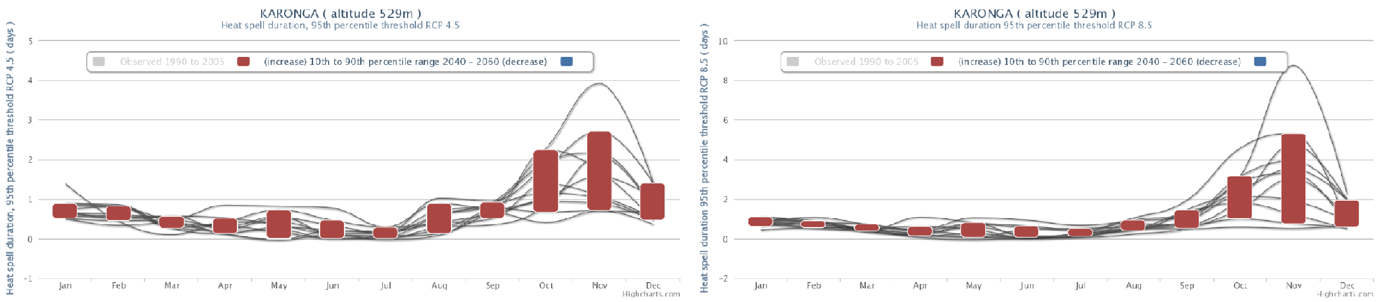


Figure B.30.9: Change in heat spell duration (34.8 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

Monthly mean minimum daily temperature change

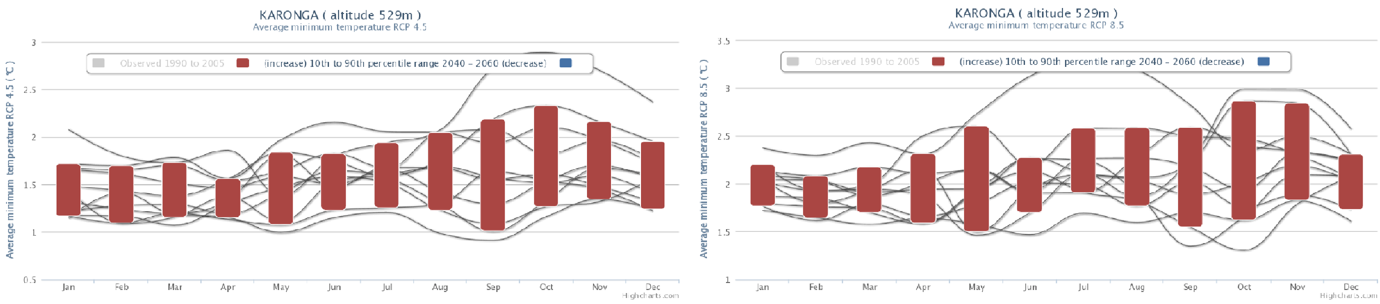


Figure B.30.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KARONGA station.

B.31: Climate Summary for KASUNGU

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

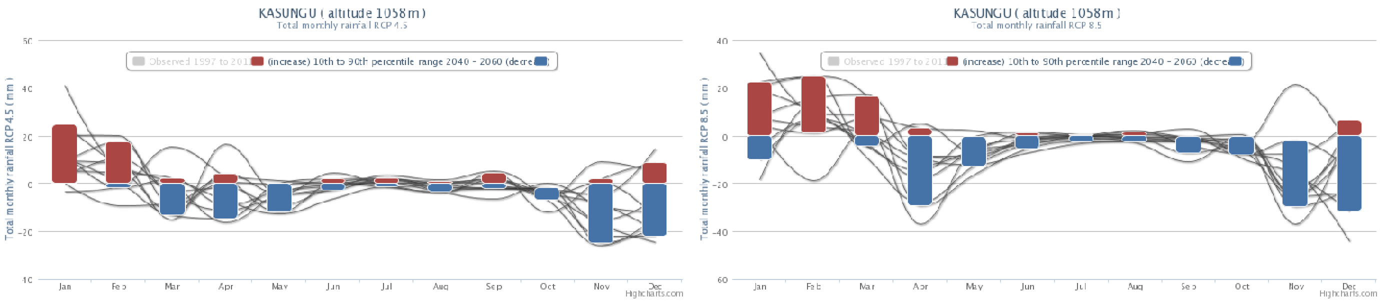


Figure B.31.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station

Projected change in monthly mean dry spell duration

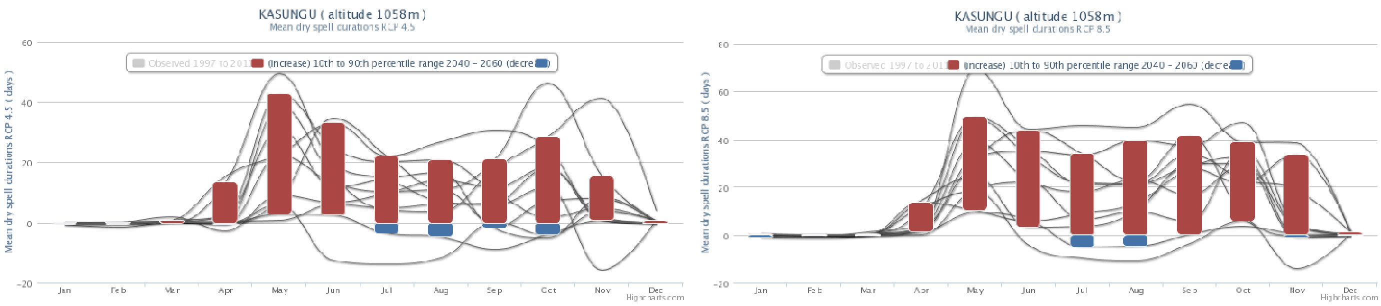


Figure B.31.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Projected change in monthly mean rain day frequency

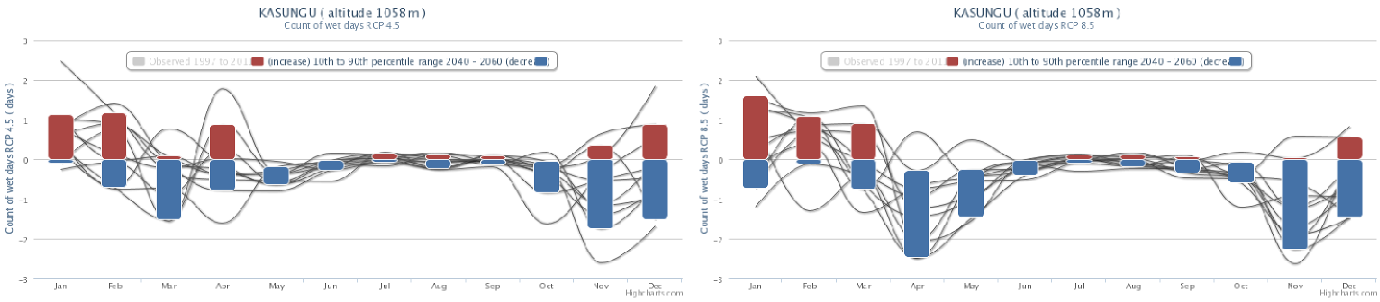


Figure B.31.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Projected change in monthly mean rain day frequency (> 20mm)

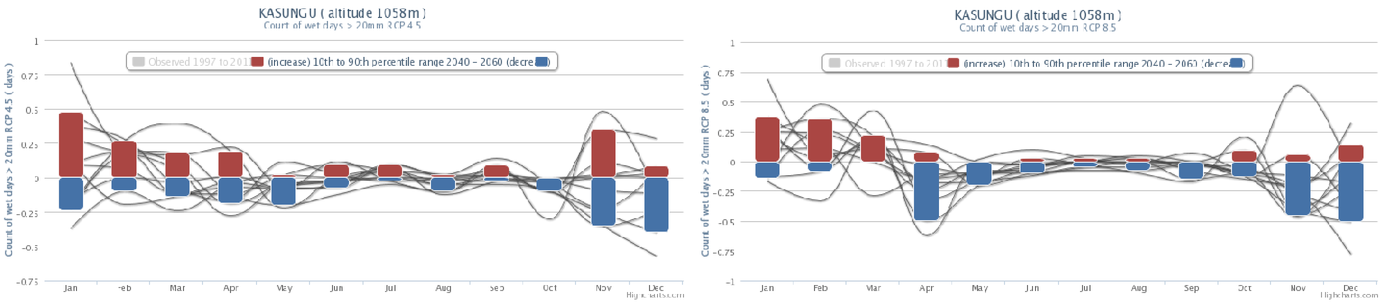


Figure B.31.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

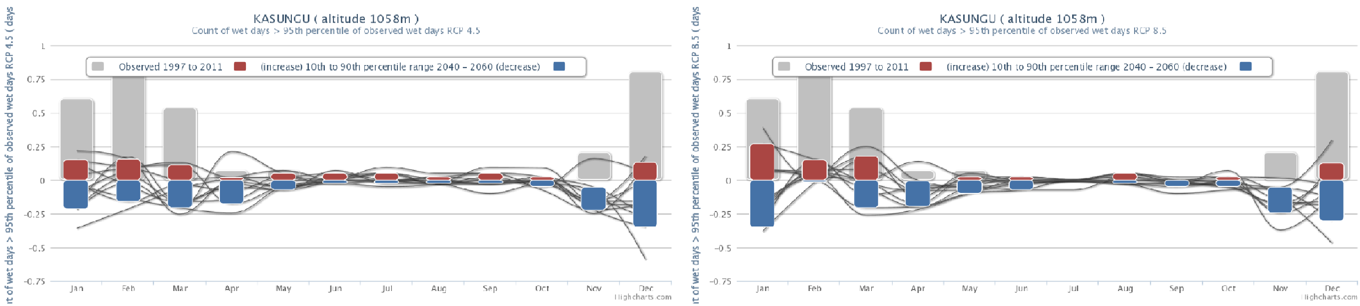


Figure B.31.5: Change in monthly rain day frequency > 40 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

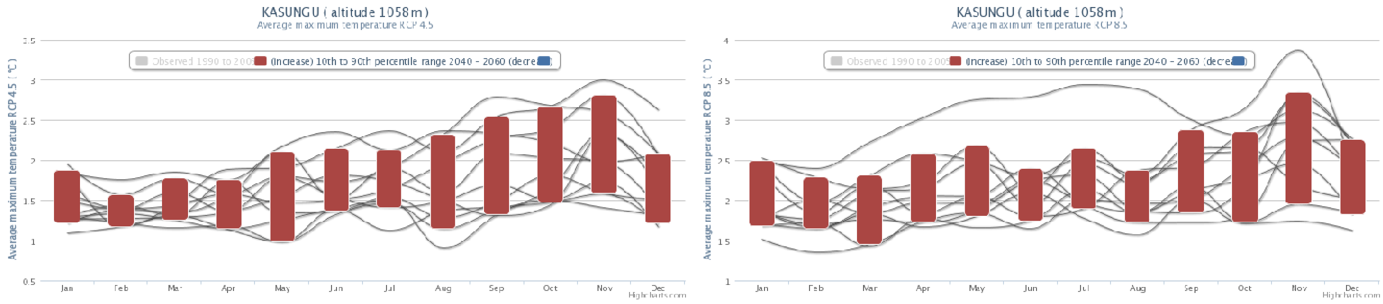


Figure B.31.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Monthly mean maximum days above 36 degree C

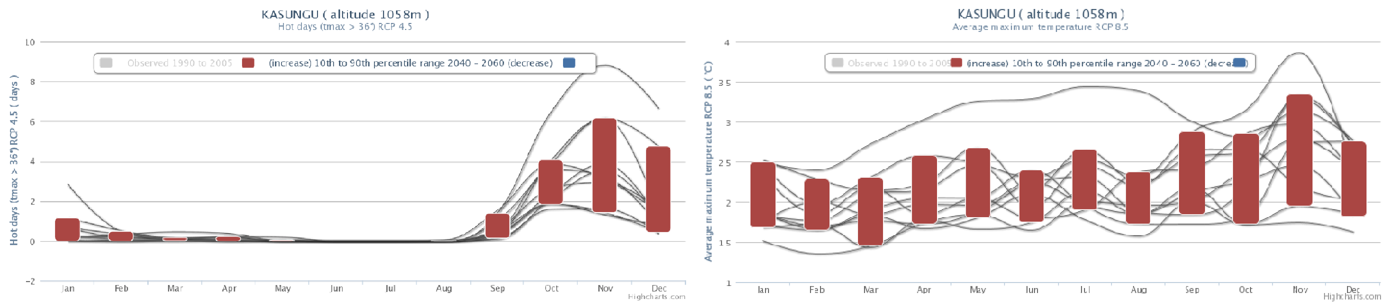


Figure B.31.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Monthly mean maximum days above 95th percentile

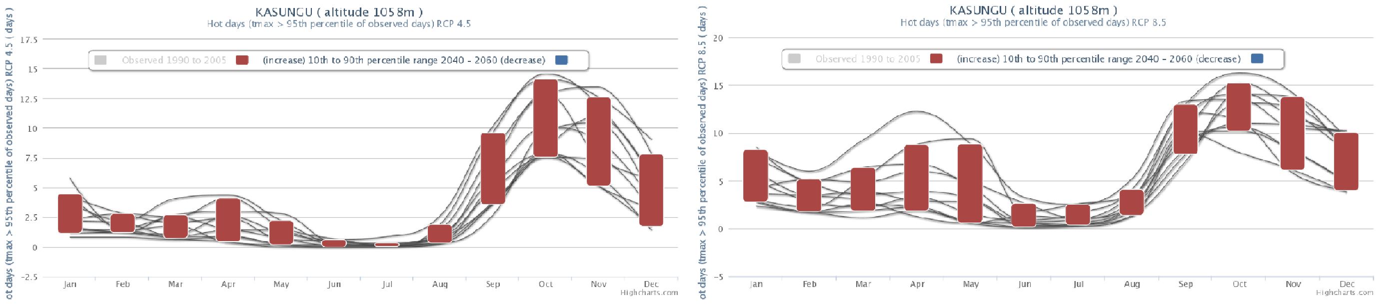


Figure B.31.8: Change in days above 32.6 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Monthly mean heat spell duration

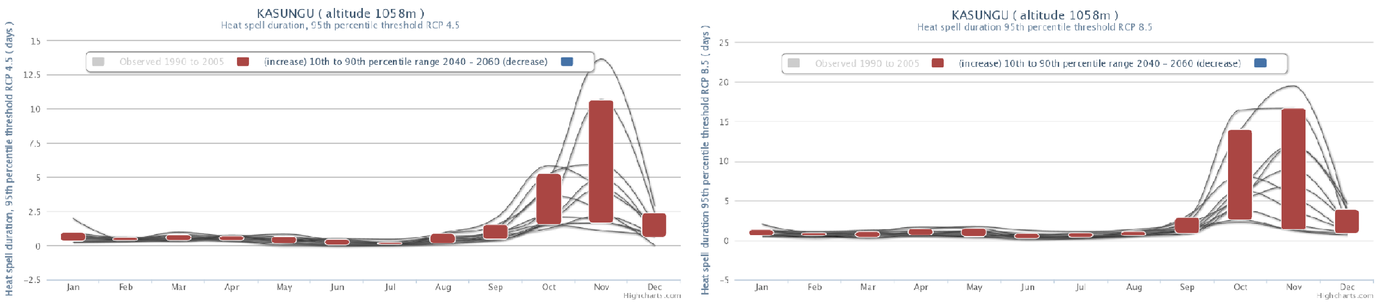


Figure B.31.9: Change in heat spell duration (32.6 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

Monthly mean minimum daily temperature change

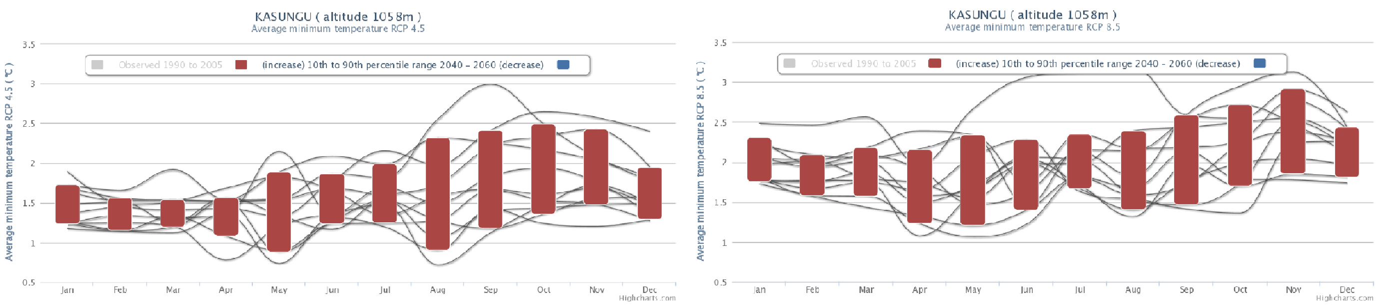


Figure B.31.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KASUNGU station.

B.32: Climate Summary for KIA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

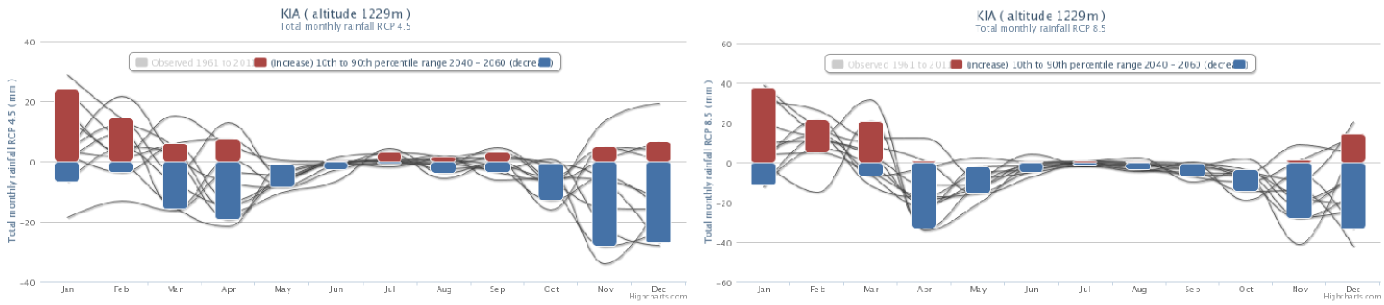


Figure B.32.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station

Projected change in monthly mean dry spell duration

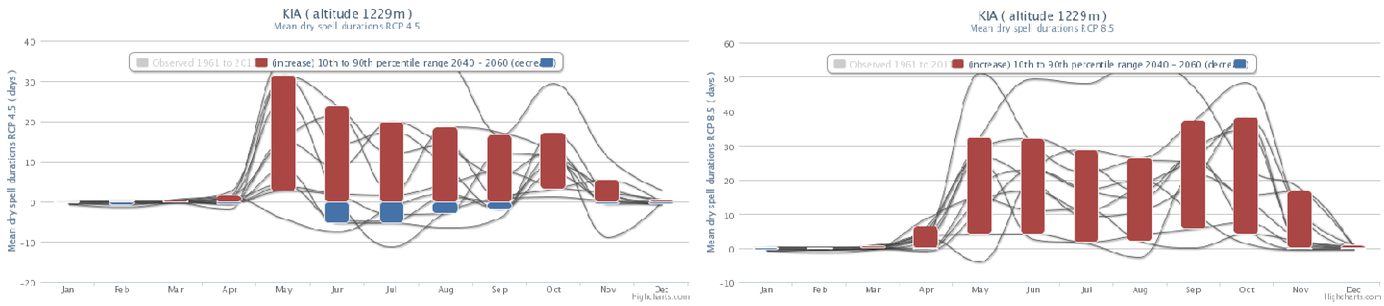


Figure B.32.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Projected change in monthly mean rain day frequency

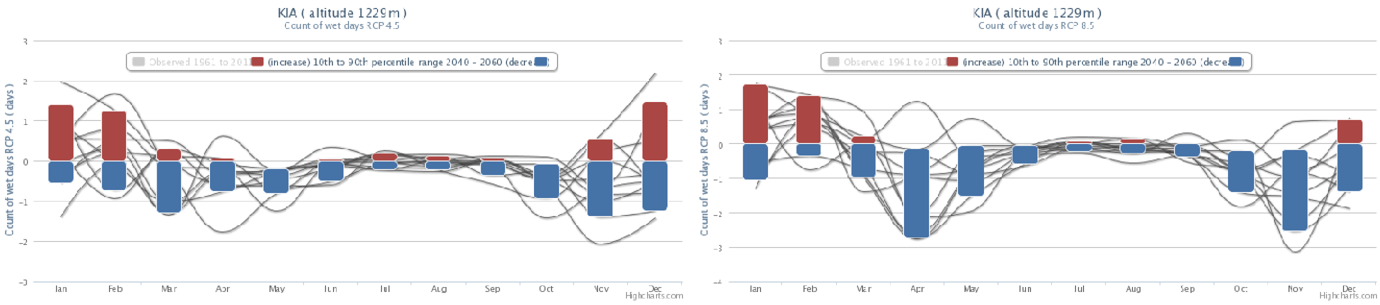


Figure B.32.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Projected change in monthly mean rain day frequency (> 20mm)

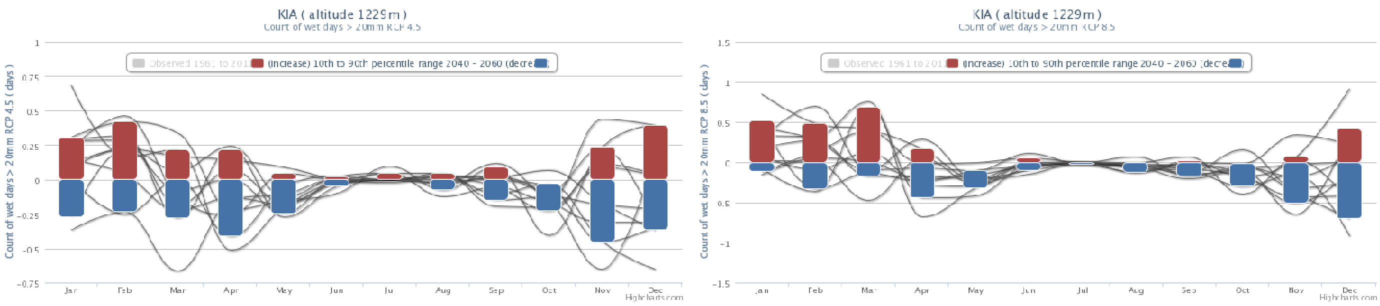


Figure B.32.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

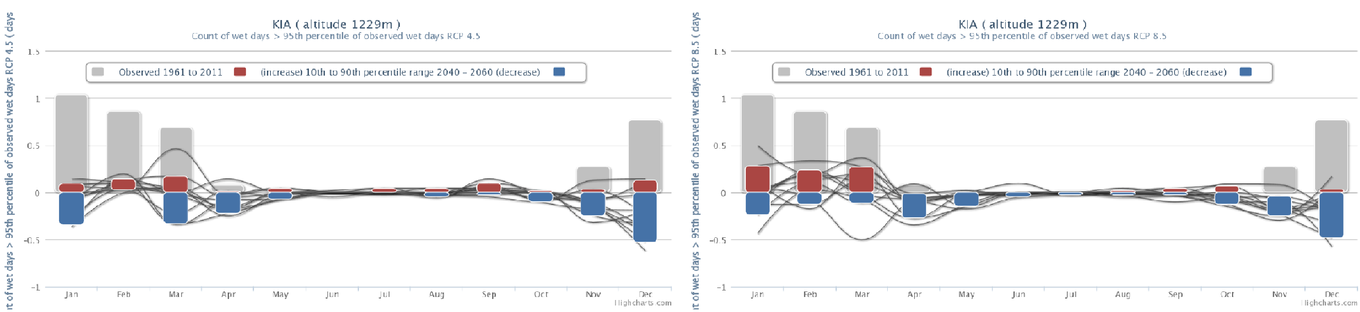


Figure B.32.5: Change in monthly rain day frequency > 36.8 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

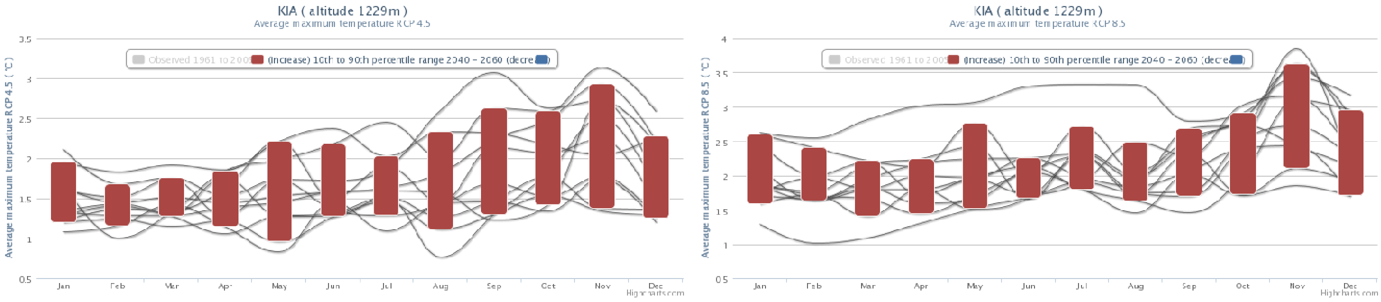


Figure B.32.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Monthly mean maximum days above 36 degree C

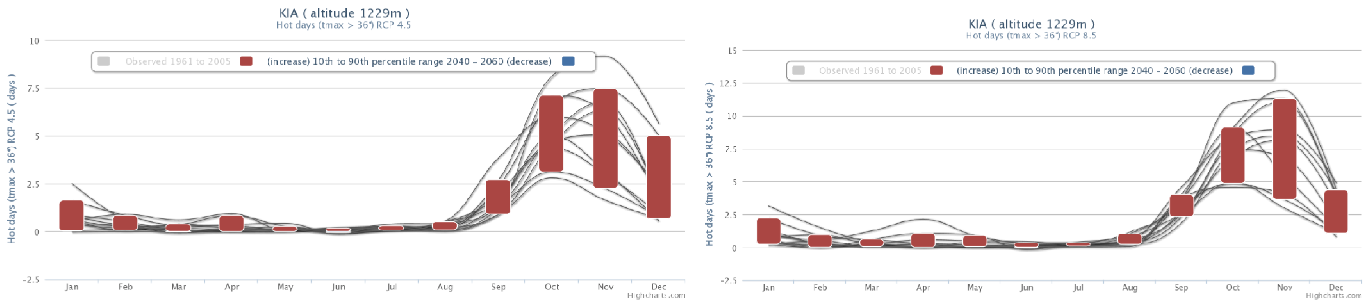


Figure B.32.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Monthly mean maximum days above 95th percentile

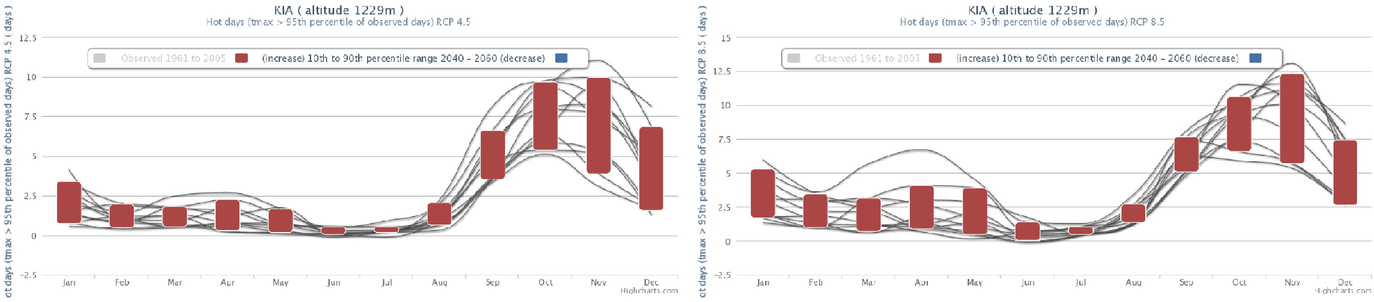


Figure B.32.8: Change in days above 33.4 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Monthly mean heat spell duration

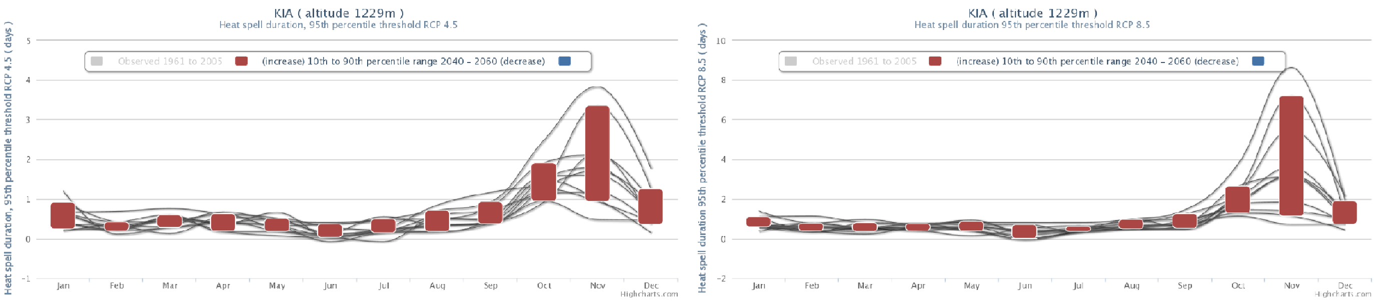


Figure B.32.9: Change in heat spell duration (33.4 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

Monthly mean minimum daily temperature change

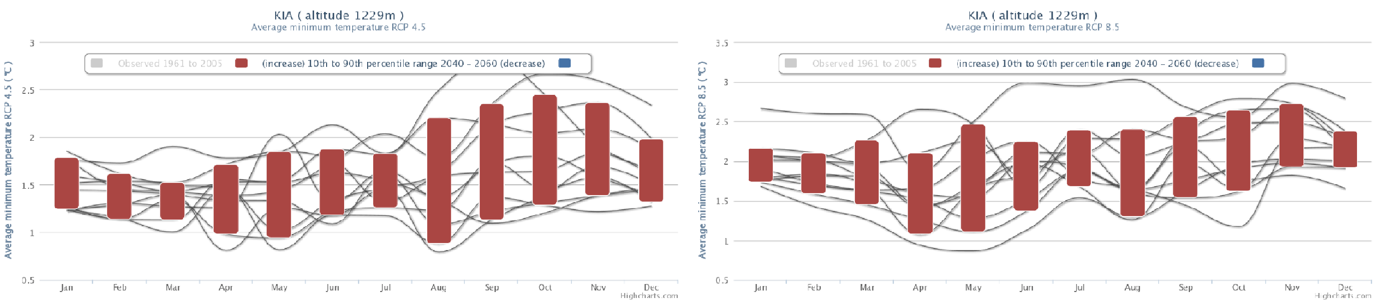


Figure B.32.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for KIA station.

B.33: Climate Summary for MAKOKA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

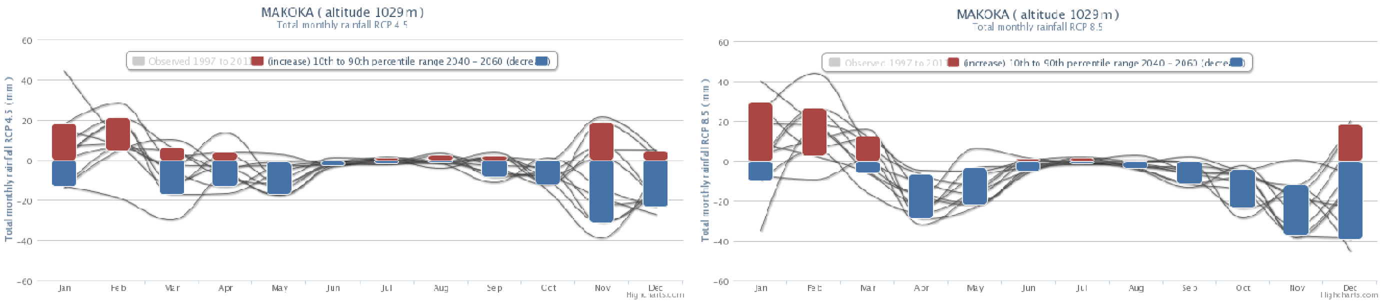


Figure B.33.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Projected change in monthly mean dry spell duration

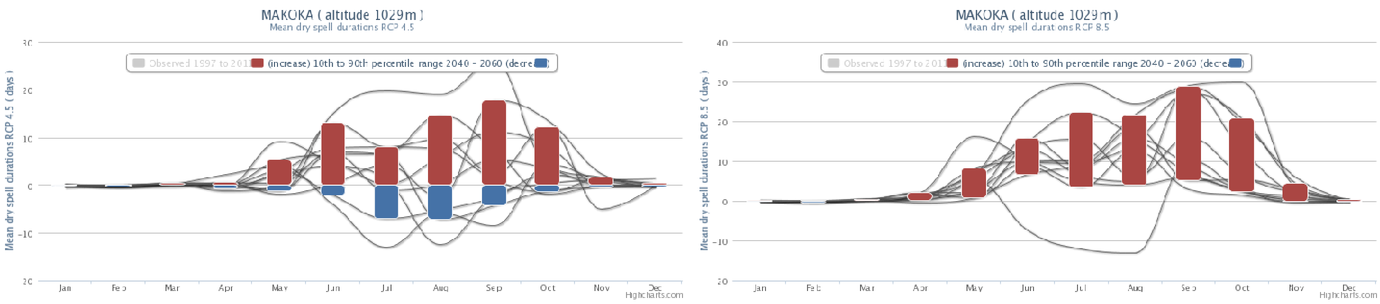


Figure B.33.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Projected change in monthly mean rain day frequency

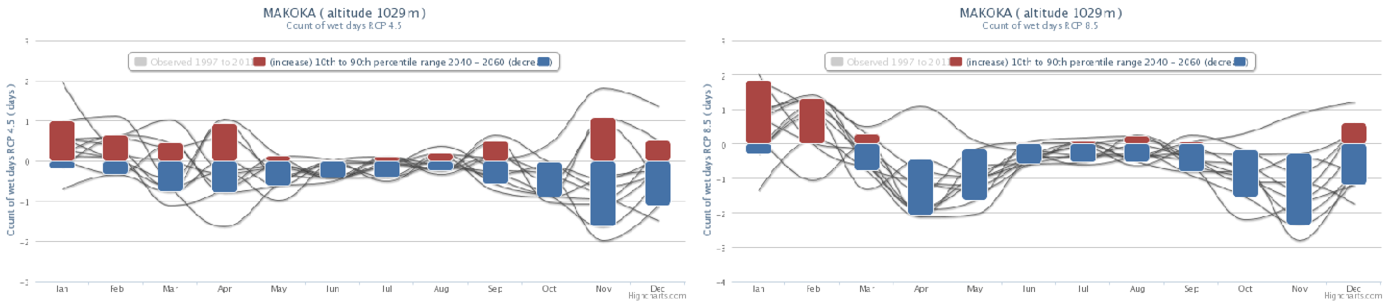


Figure B.33.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Projected change in monthly mean rain day frequency (> 20mm)

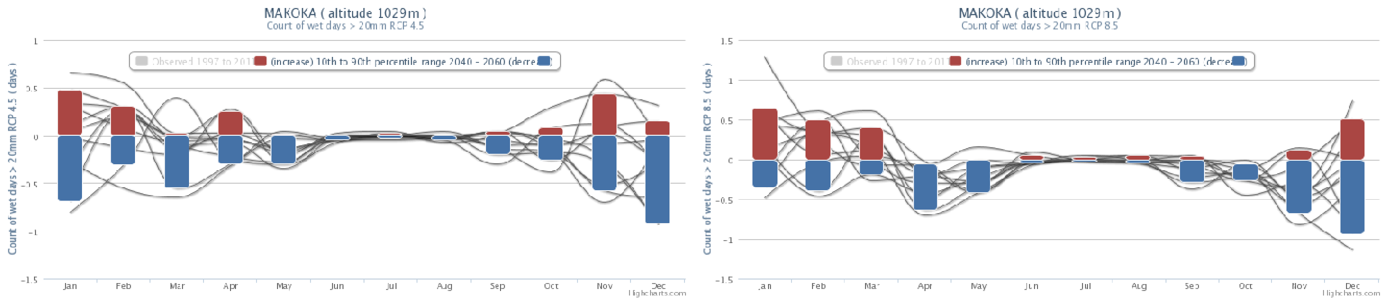


Figure B.33.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

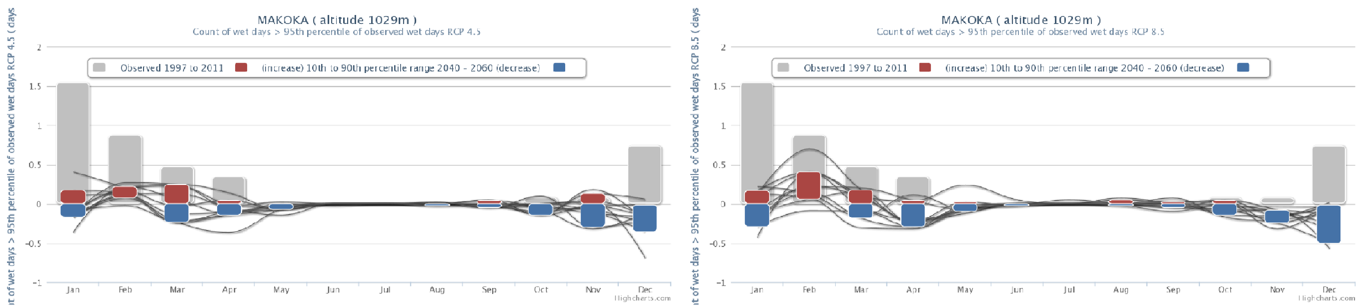


Figure B.33.5: Change in monthly rain day frequency > 44.7 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

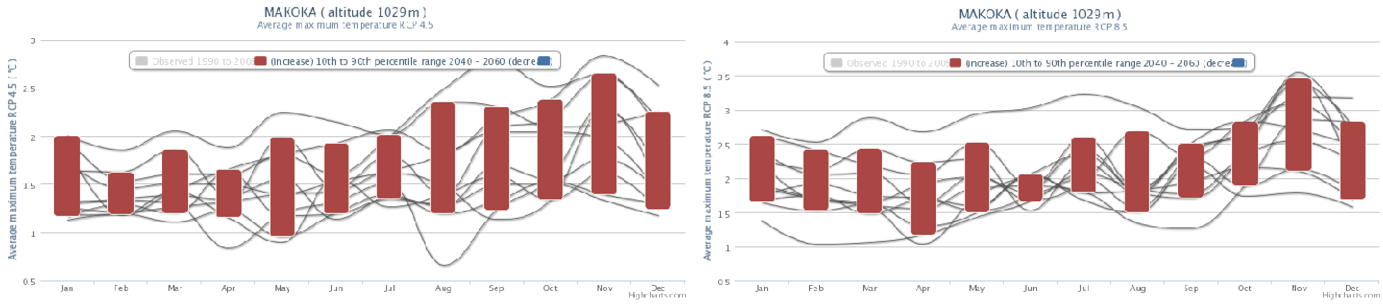


Figure B.33.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Monthly mean maximum days above 36 degree C

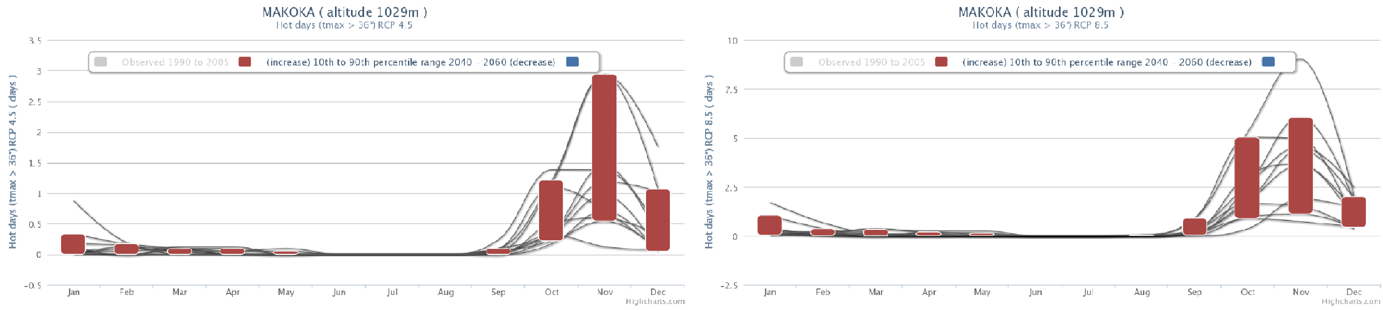


Figure B.33.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Monthly mean maximum days above 95th percentile

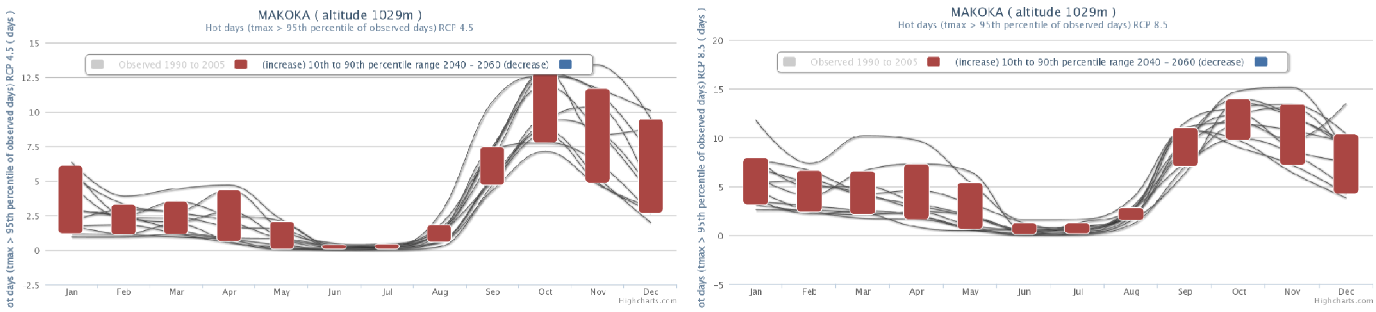


Figure B.33.8: Change in days above 31.5 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Monthly mean heat spell duration

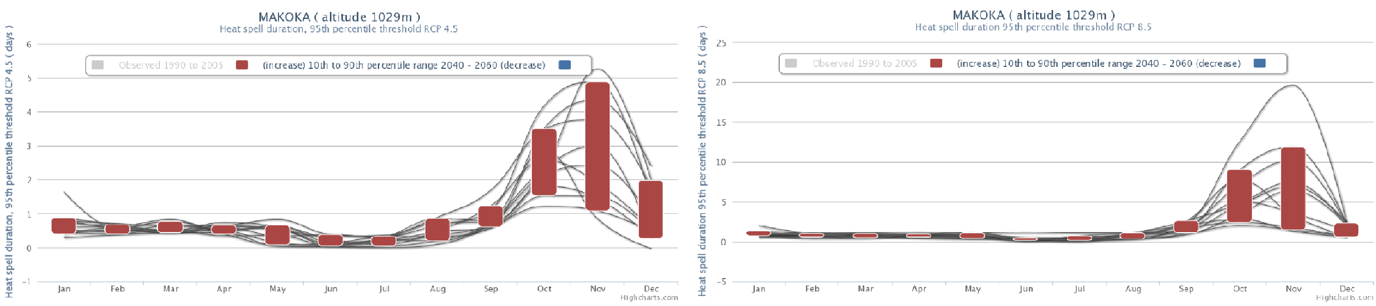


Figure B.33.9: Change in heat spell duration (31.5 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

Monthly mean minimum daily temperature change

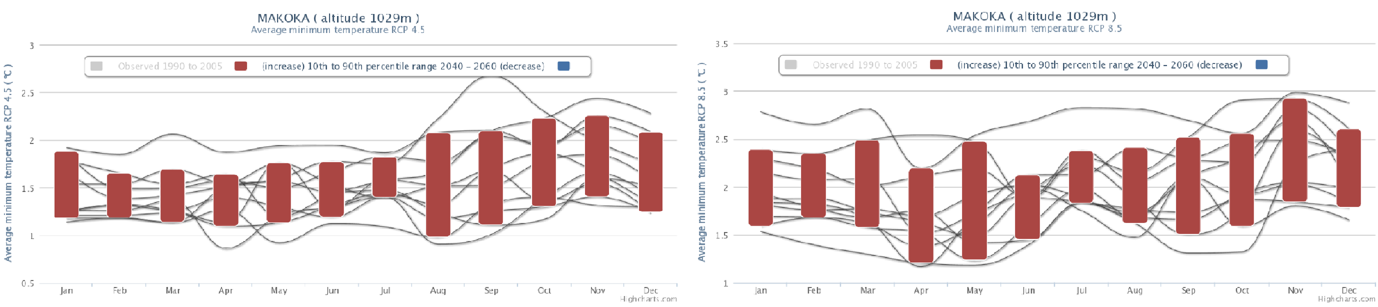


Figure B.33.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MAKOKA station.

B.34: Climate Summary for MANGOCHI

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

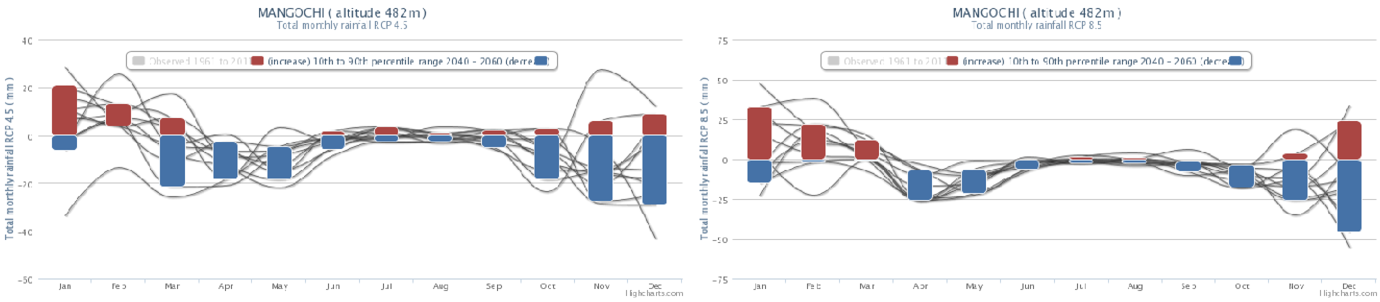


Figure B.34.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Projected change in monthly mean dry spell duration

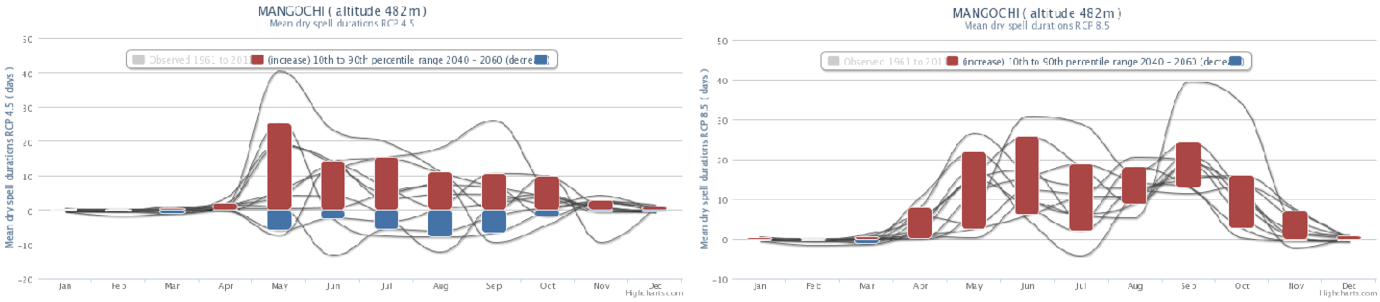


Figure B.34.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Projected change in monthly mean rain day frequency

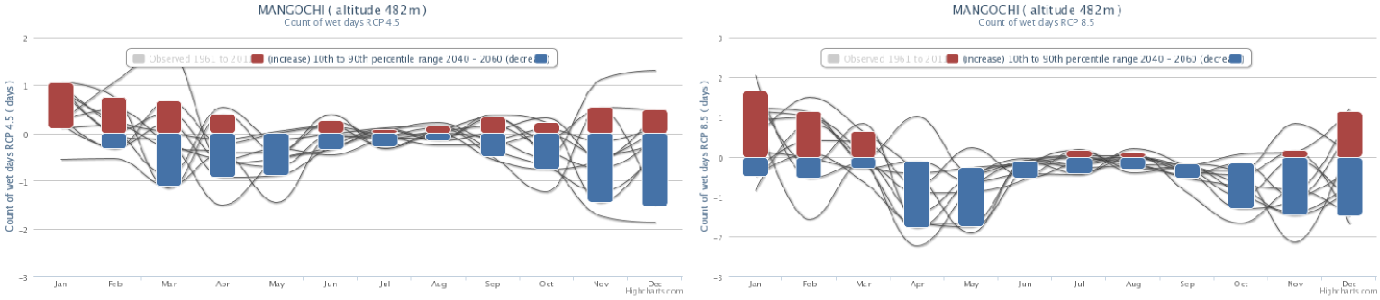


Figure B.34.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Projected change in monthly mean rain day frequency (> 20mm)

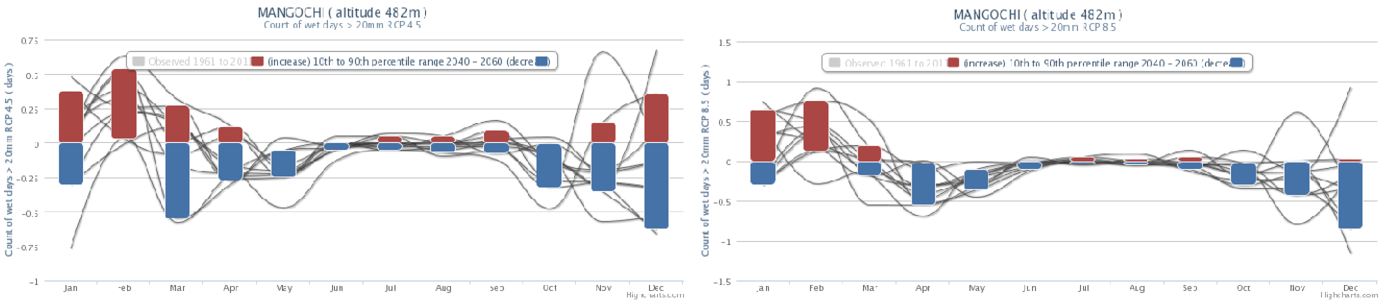


Figure B.34.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

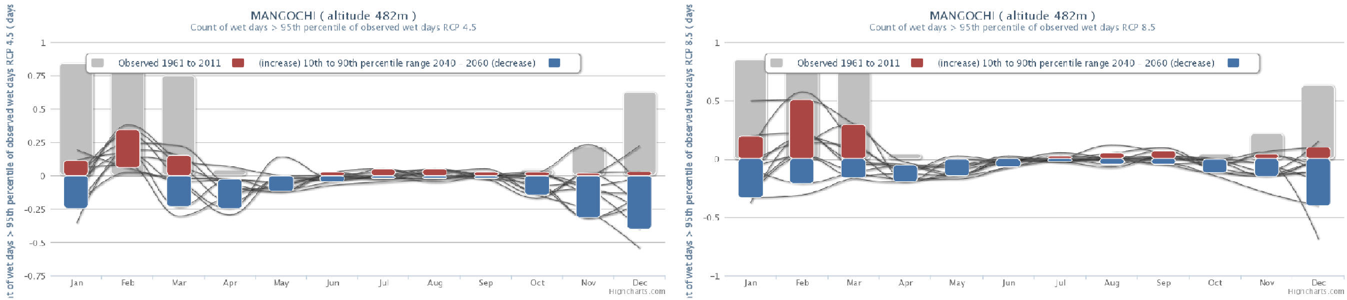


Figure B.34.5: Change in monthly rain day frequency > 41.7 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

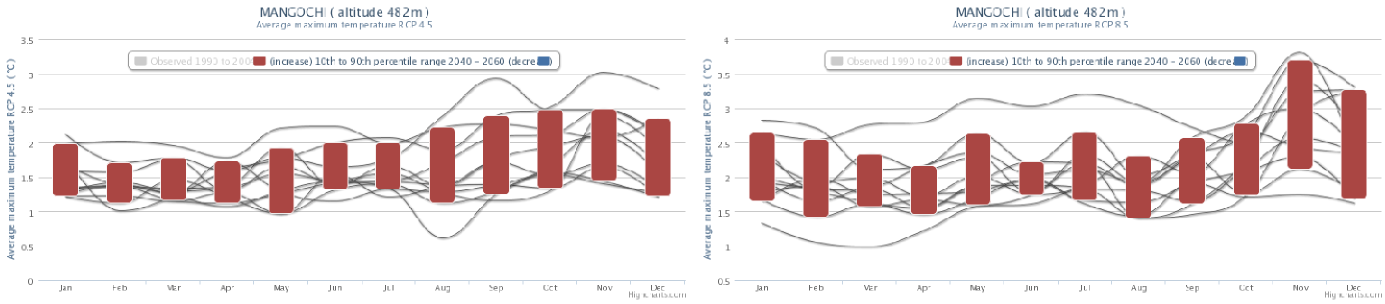


Figure B.34.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Monthly mean maximum days above 36 degree C

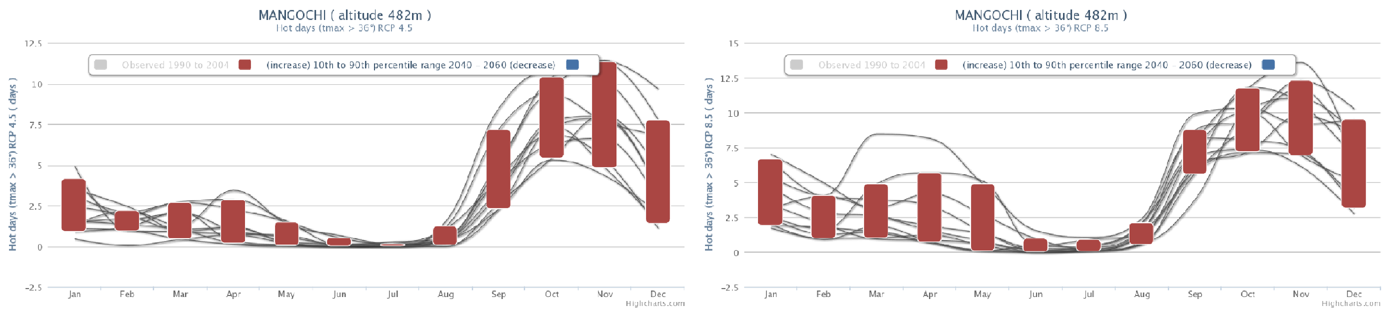


Figure B.34.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Monthly mean maximum days above 95th percentile

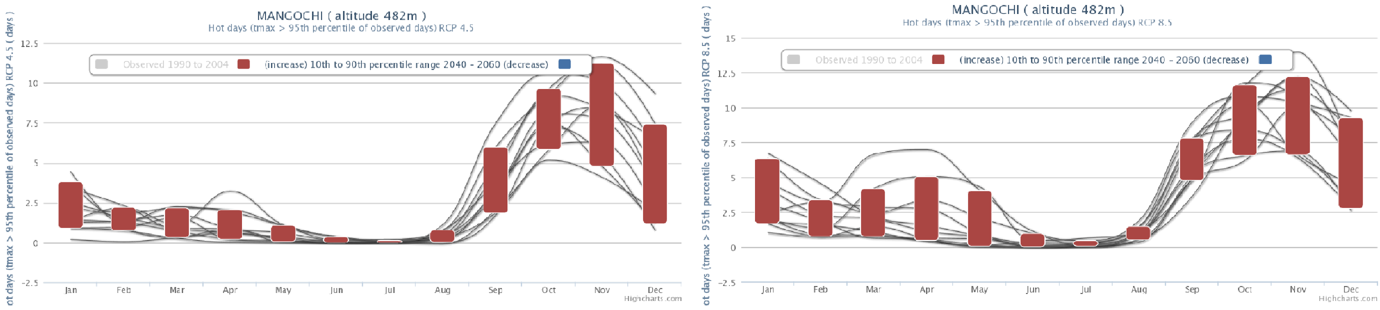


Figure B.34.8: Change in days above 36.3 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Monthly mean heat spell duration

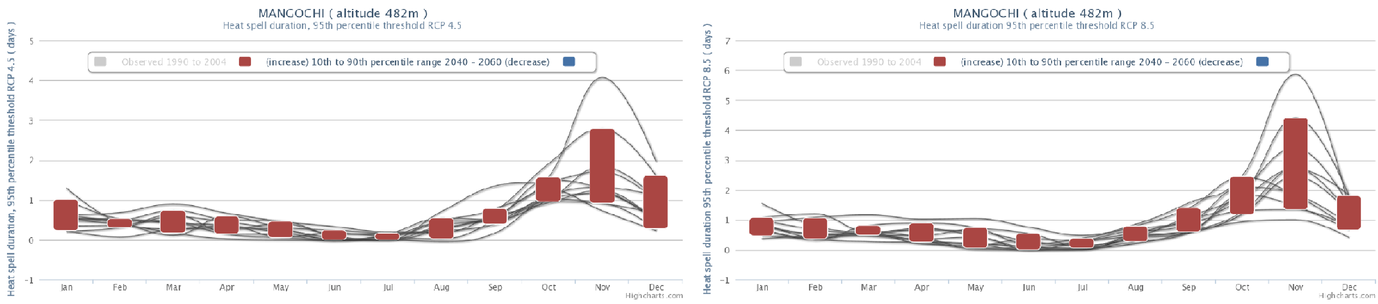


Figure B.34.9: Change in heat spell duration (36.3 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

Monthly mean minimum daily temperature change

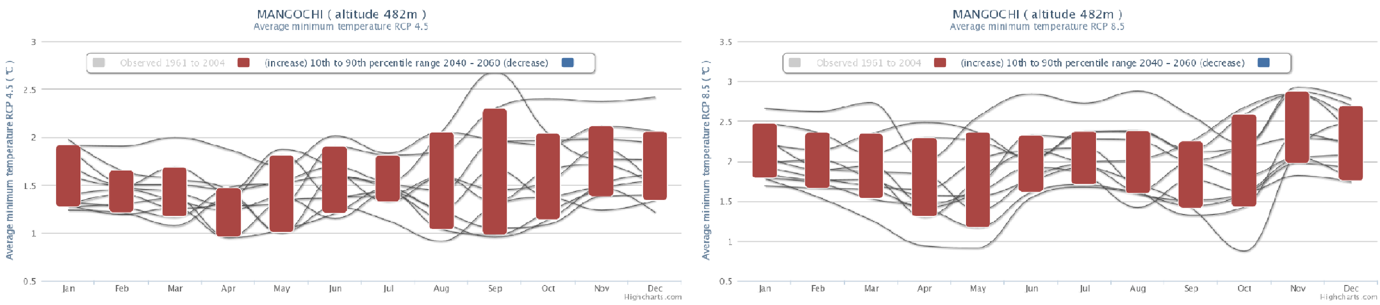


Figure B.34.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MANGOCHI station.

B.35: Climate Summary for MIMOSA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

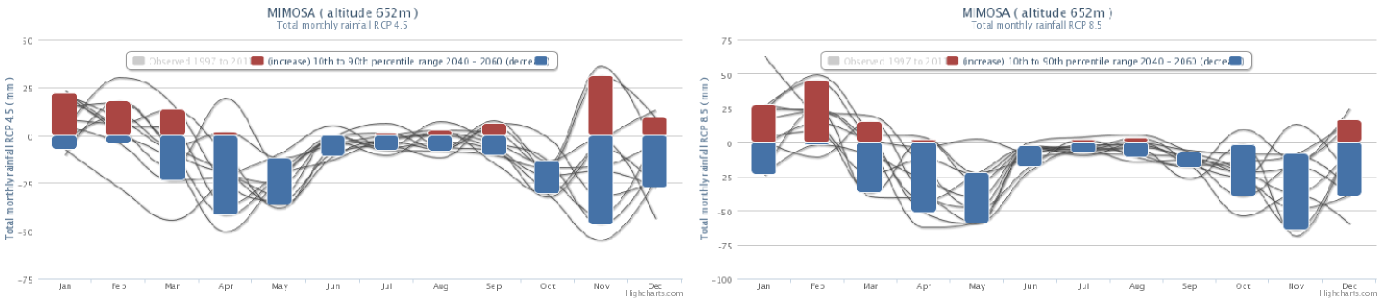


Figure B.35.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Projected change in monthly mean dry spell duration

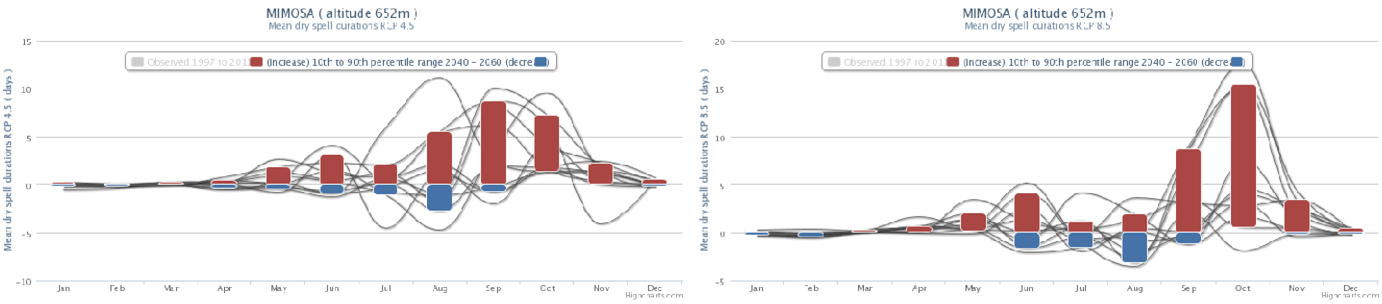


Figure B.35.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Projected change in monthly mean rain day frequency

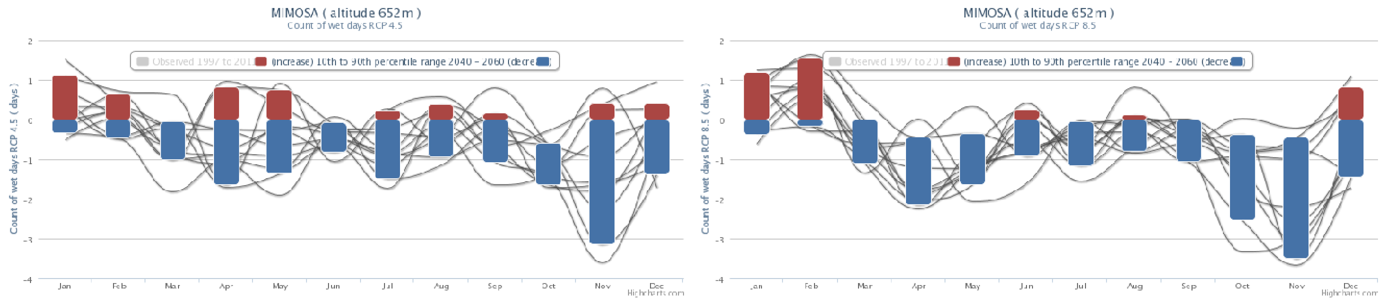


Figure B.35.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Projected change in monthly mean rain day frequency (> 20mm)

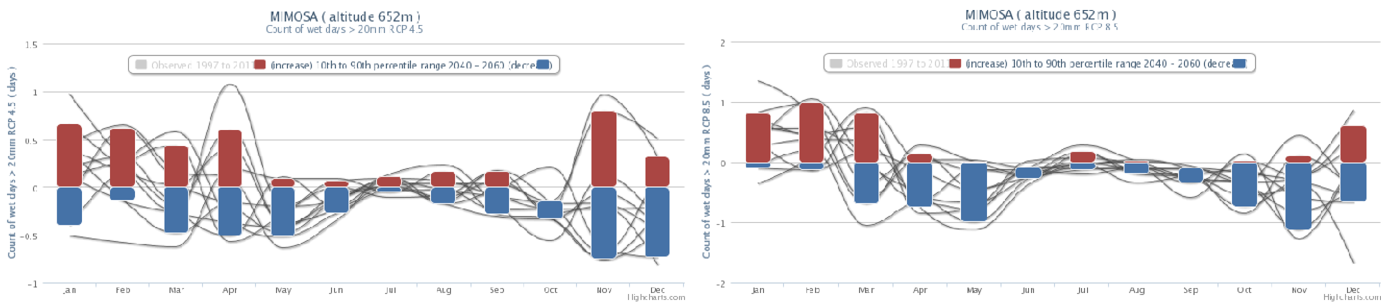


Figure B.35.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

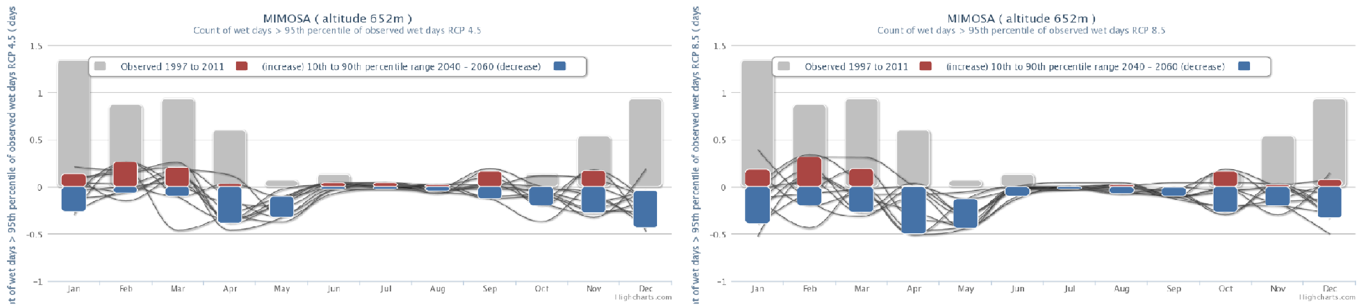


Figure B.35.5: Change in monthly rain day frequency > 49.3 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

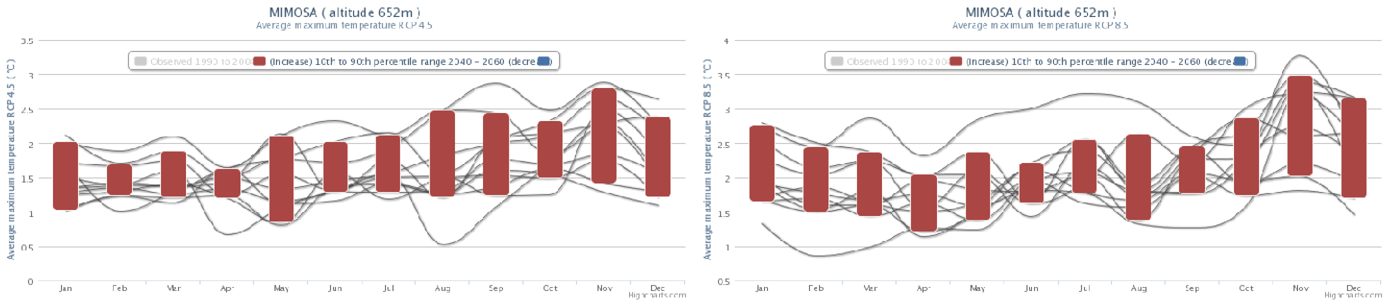


Figure B.35.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Monthly mean maximum days above 36 degree C

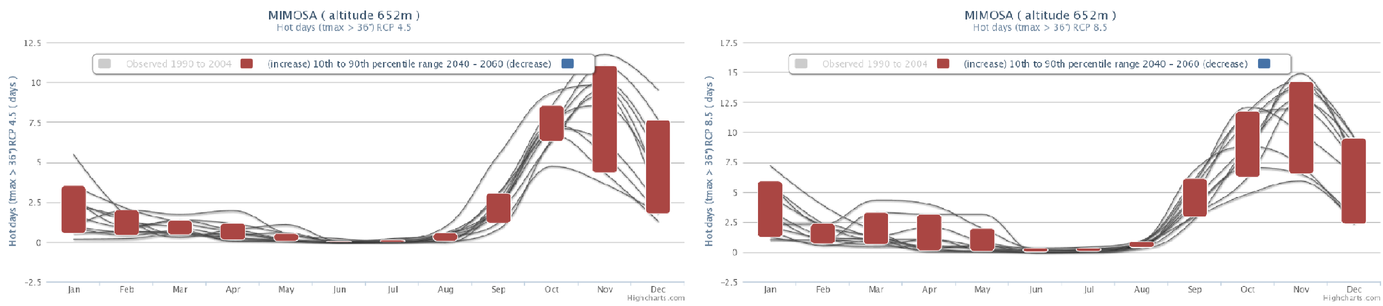


Figure B.35.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Monthly mean maximum days above 95th percentile

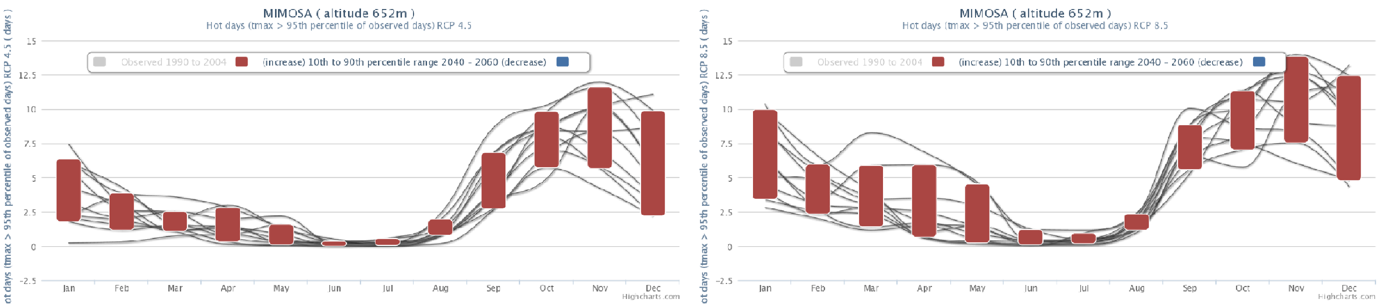


Figure B.35.8: Change in days above 34.7 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Monthly mean heat spell duration

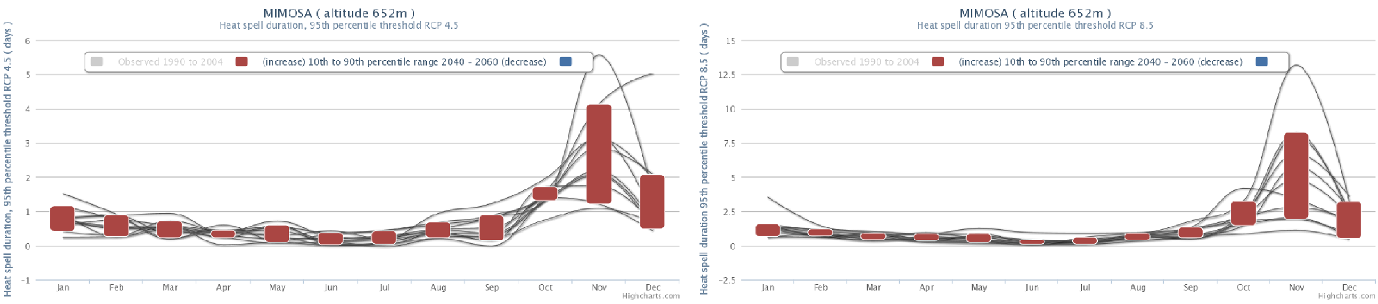


Figure B.35.9: Change in heat spell duration (34.7 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

Monthly mean minimum daily temperature change

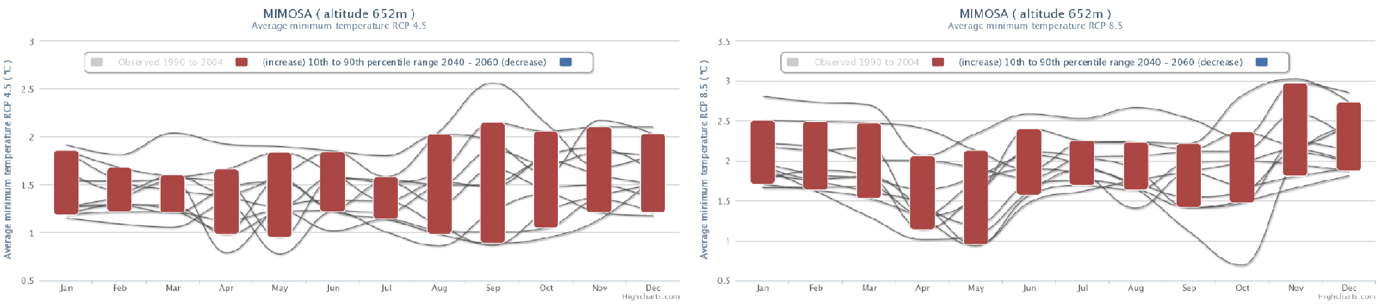


Figure B.35.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MIMOSA station.

B.36: Climate Summary for MONKEYBAY

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

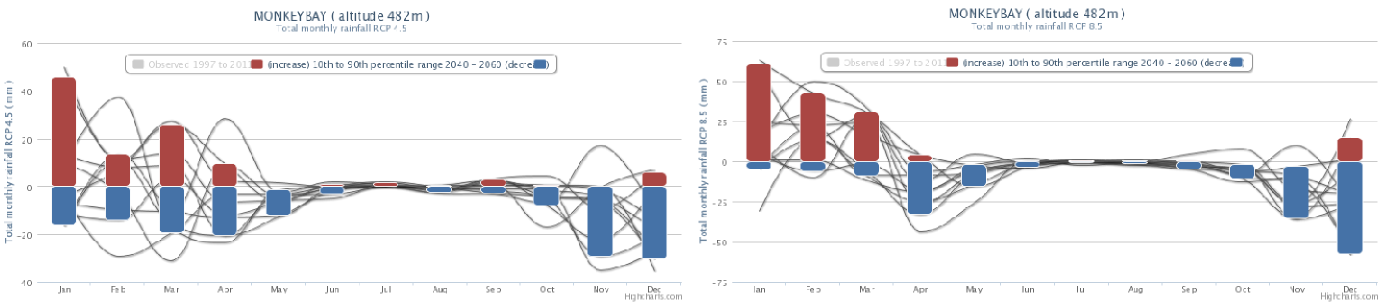


Figure B.36.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Projected change in monthly mean dry spell duration

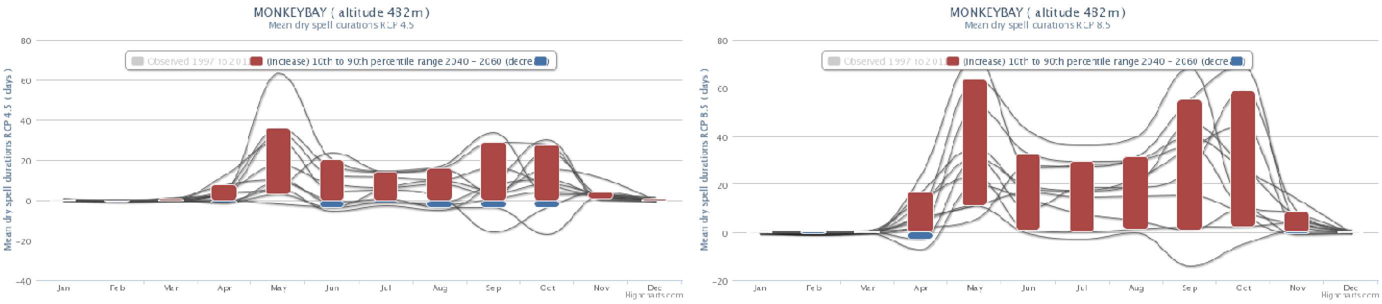


Figure B.36.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Projected change in monthly mean rain day frequency

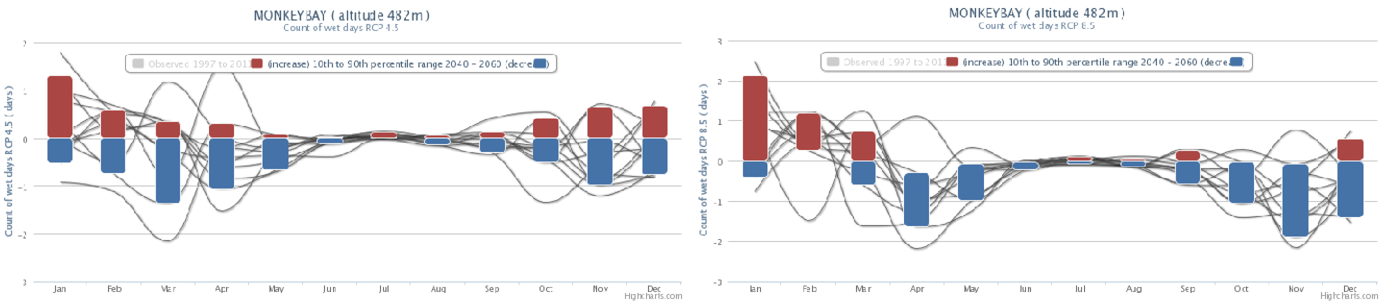


Figure B.36.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Projected change in monthly mean rain day frequency (> 20mm)

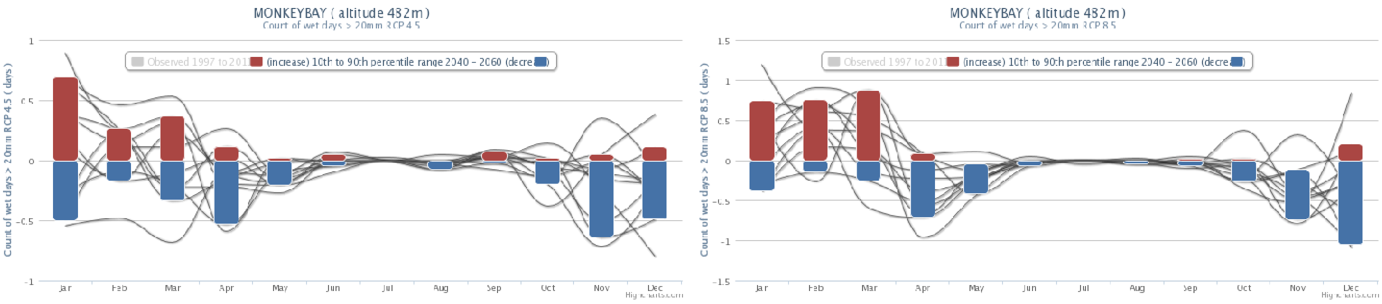


Figure B.36.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

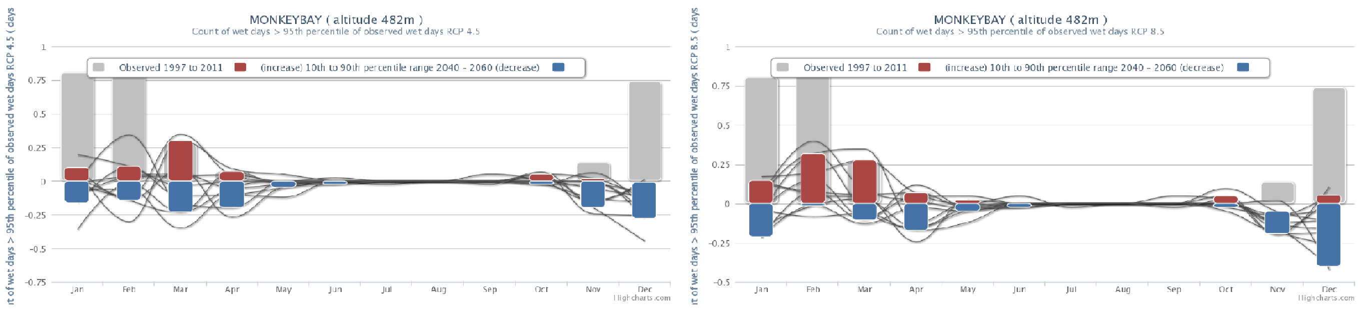


Figure B.36.5: Change in monthly rain day frequency > 57.2 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

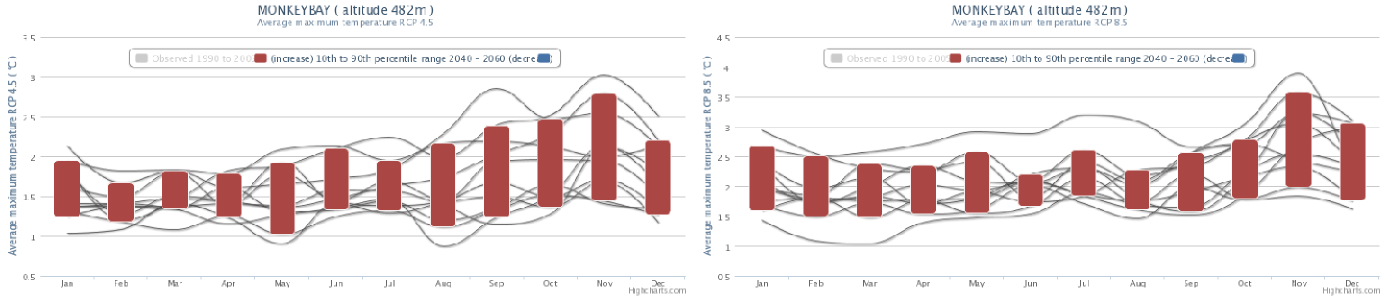


Figure B.36.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Monthly mean maximum days above 36 degree C

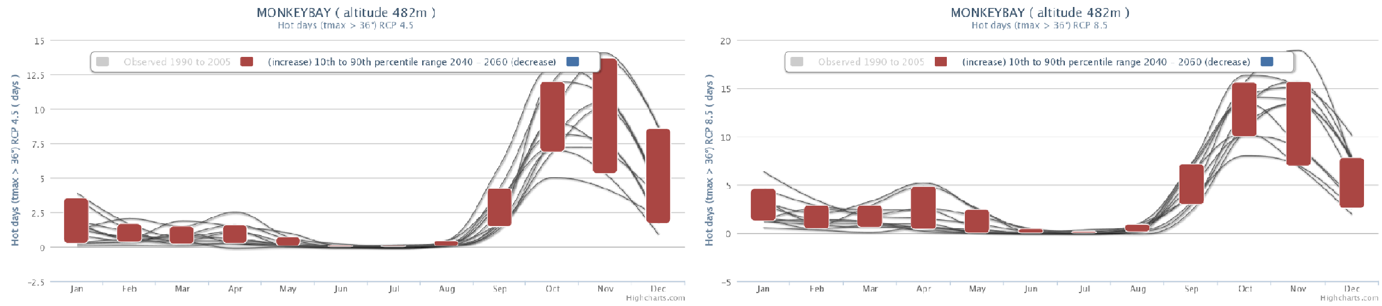


Figure B.36.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Monthly mean maximum days above 95th percentile

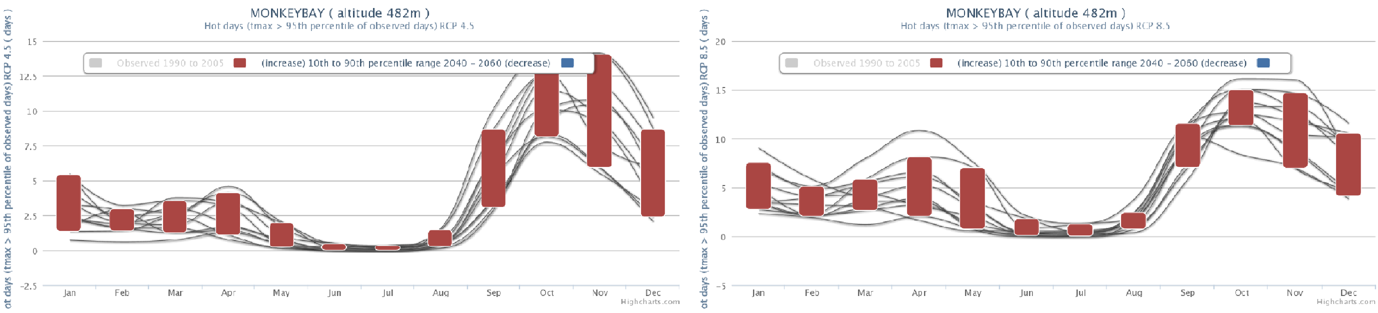


Figure B.36.8: Change in days above 34.7 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Monthly mean heat spell duration

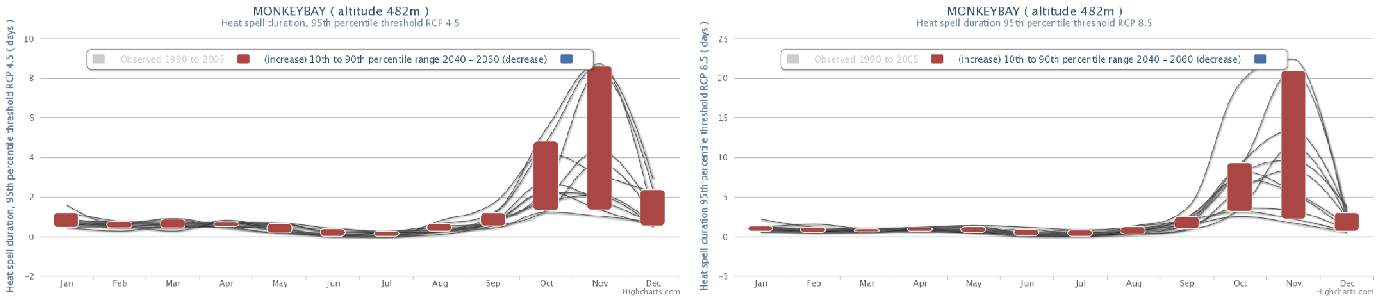


Figure B.36.9: Change in heat spell duration (34.7 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

Monthly mean minimum daily temperature change

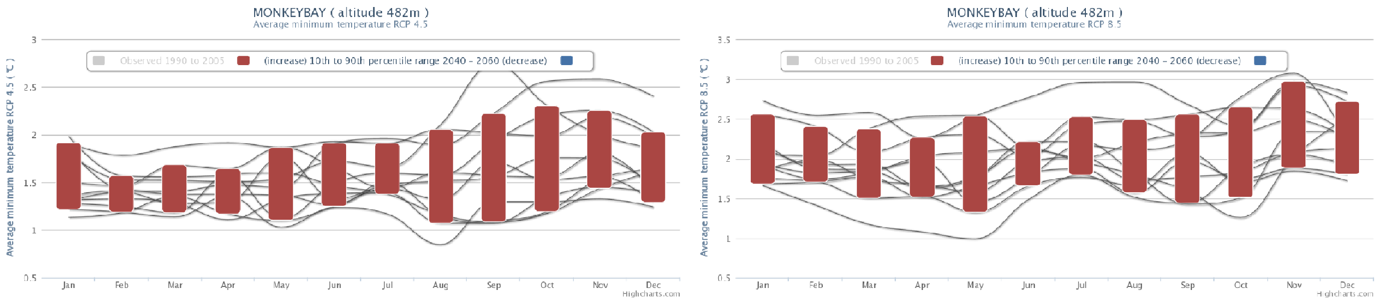


Figure B.36.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MONKEYBAY station.

B. 37: Climate Summary for MZIMBA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

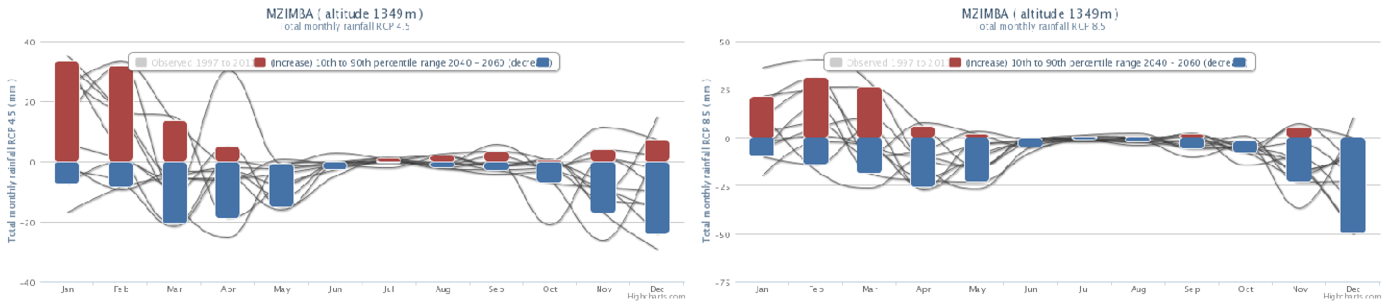


Figure B.37.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station

Projected change in monthly mean dry spell duration

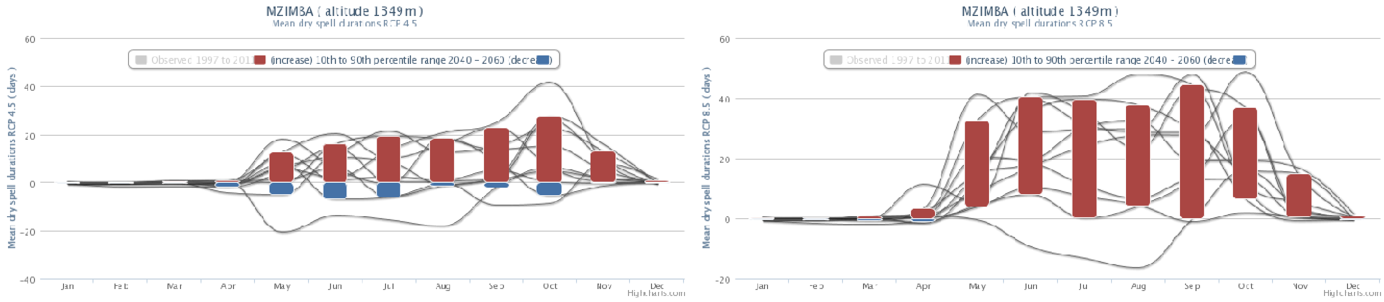


Figure B.37.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Projected change in monthly mean rain day frequency

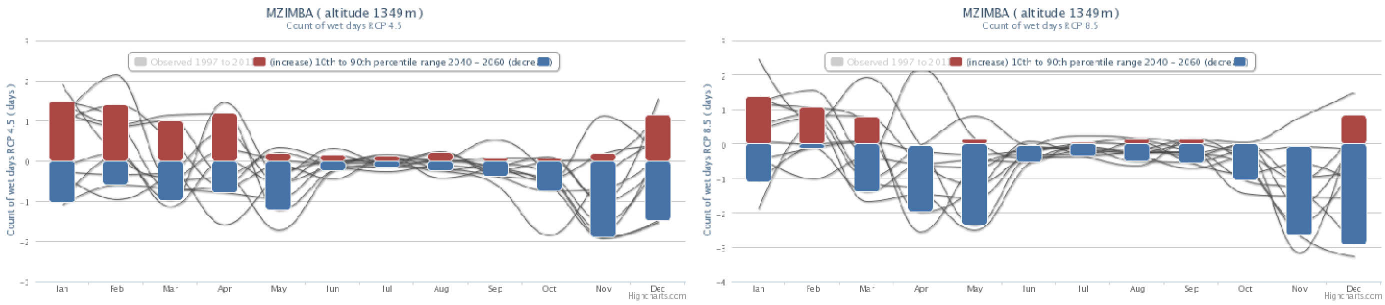


Figure B.37.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Projected change in monthly mean rain day frequency (> 20mm)

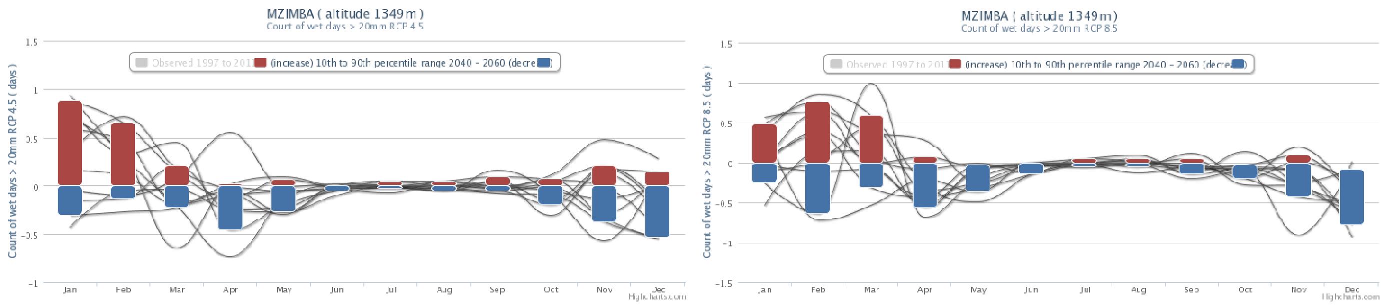


Figure B.37.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

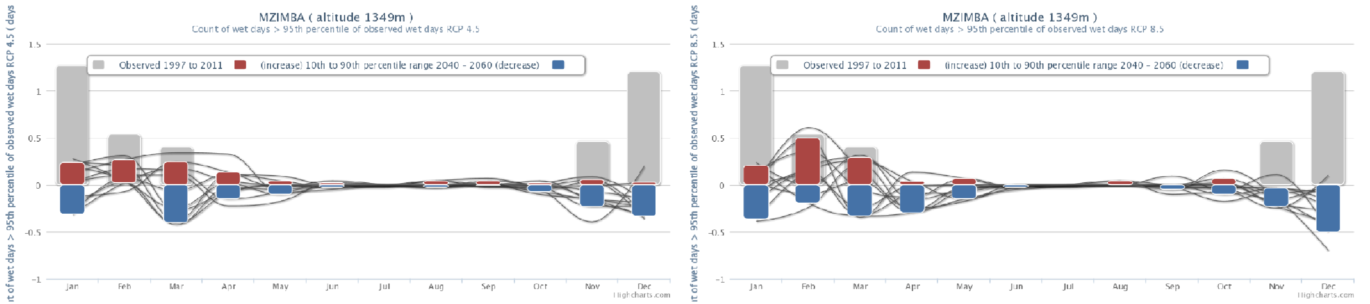


Figure B.37.5: Change in monthly rain day frequency > 35.6 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

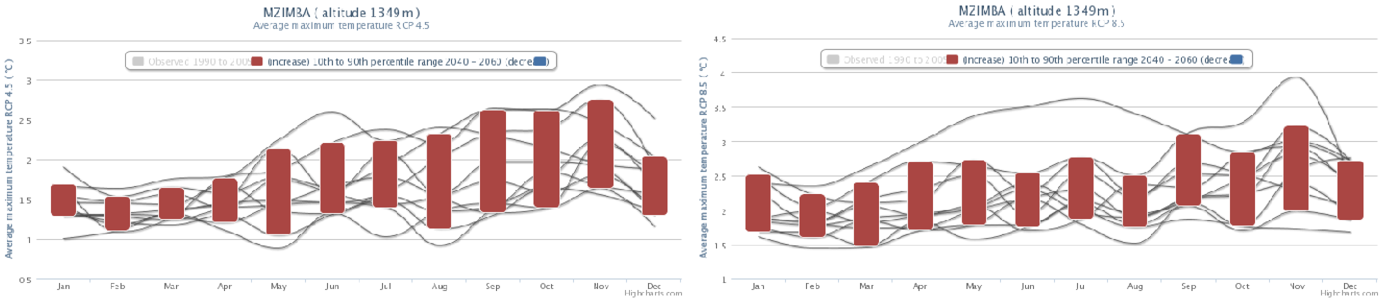


Figure B.37.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Monthly mean maximum days above 36 degree C

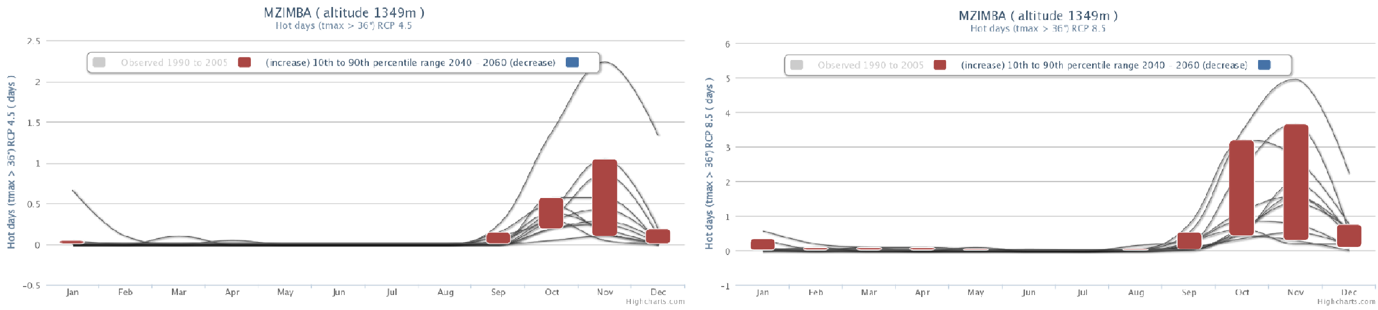


Figure B.37.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Monthly mean maximum days above 95th percentile

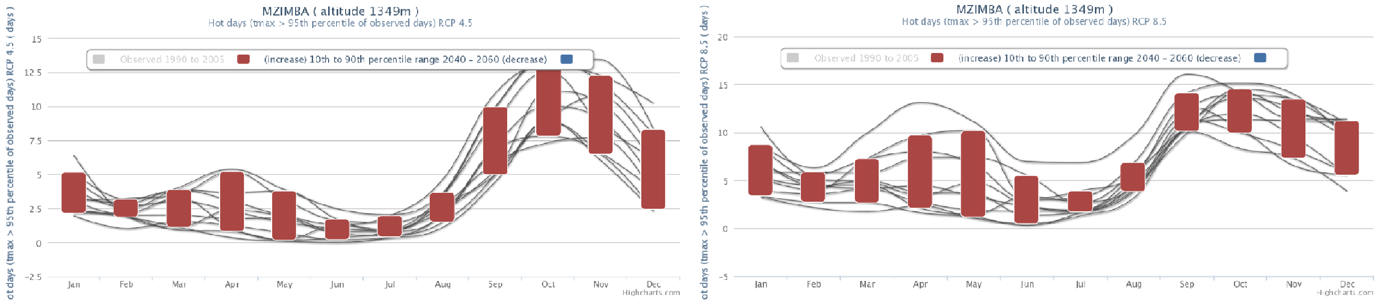


Figure B.37.8: Change in days above 30.5 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Monthly mean heat spell duration

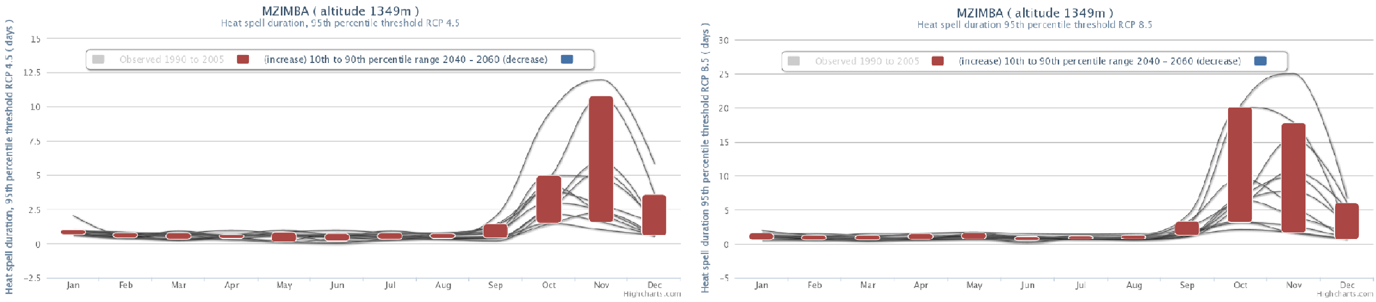


Figure B.37.9: Change in heat spell duration (30.5 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

Monthly mean minimum daily temperature change

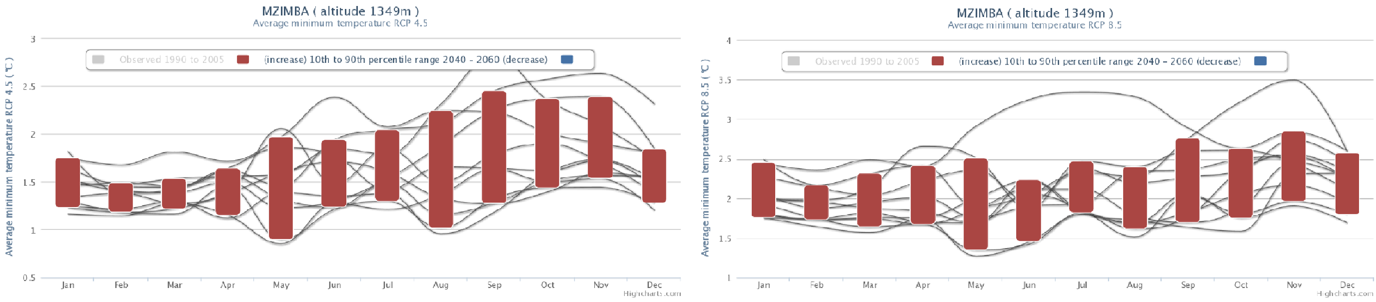


Figure B.37.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZIMBA station.

B.38: Climate Summary for MZUZU

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

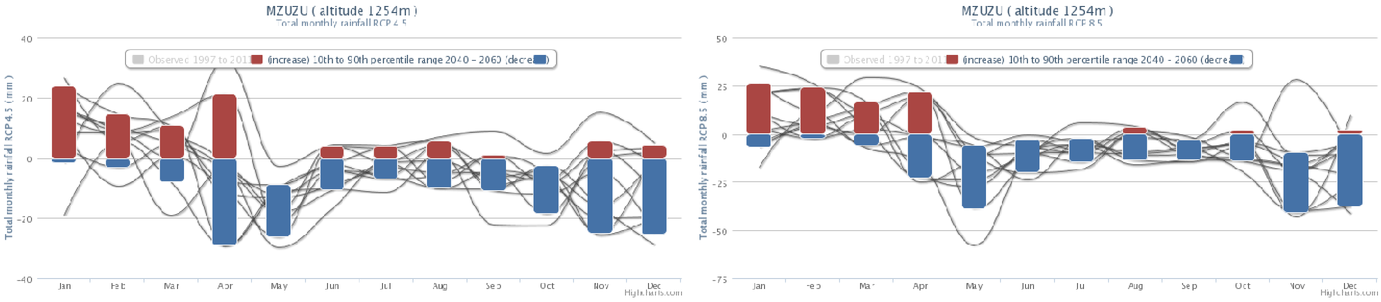


Figure B.38.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station

Projected change in monthly mean dry spell duration

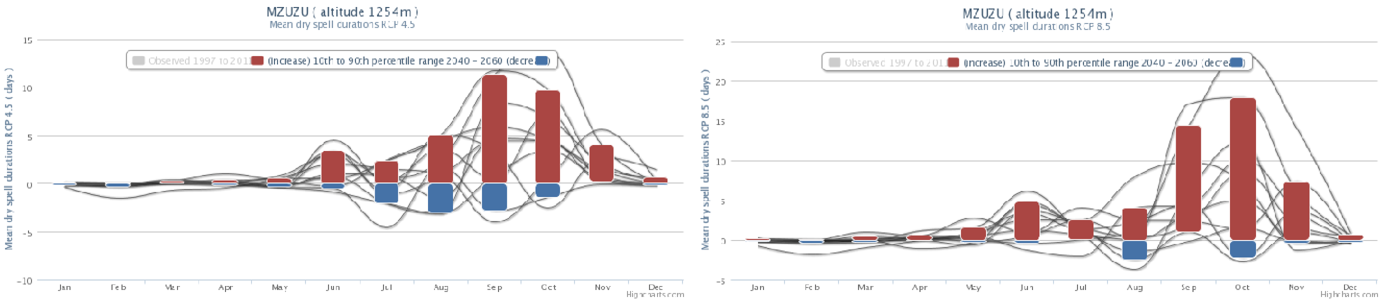


Figure B.38.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Projected change in monthly mean rain day frequency

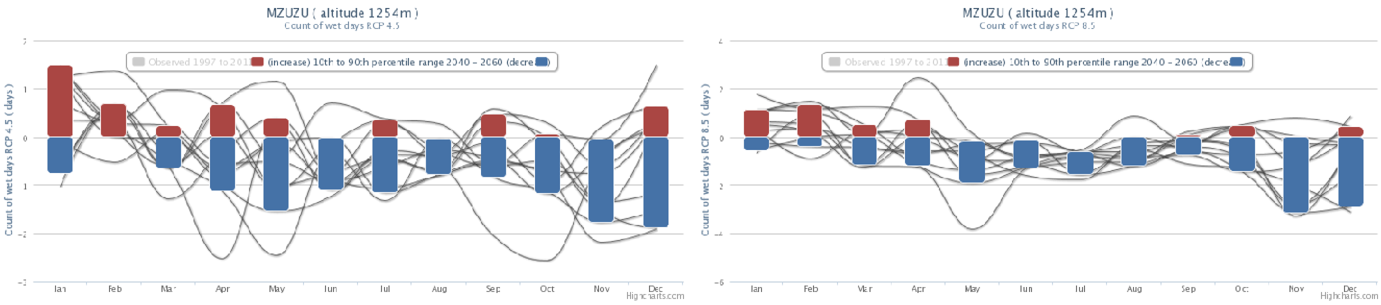


Figure B.38.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Projected change in monthly mean rain day frequency (> 20mm)

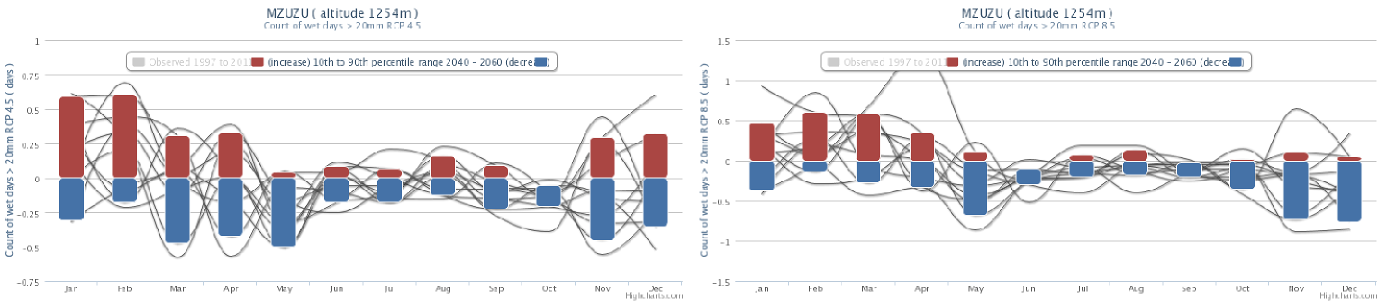


Figure B.38.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

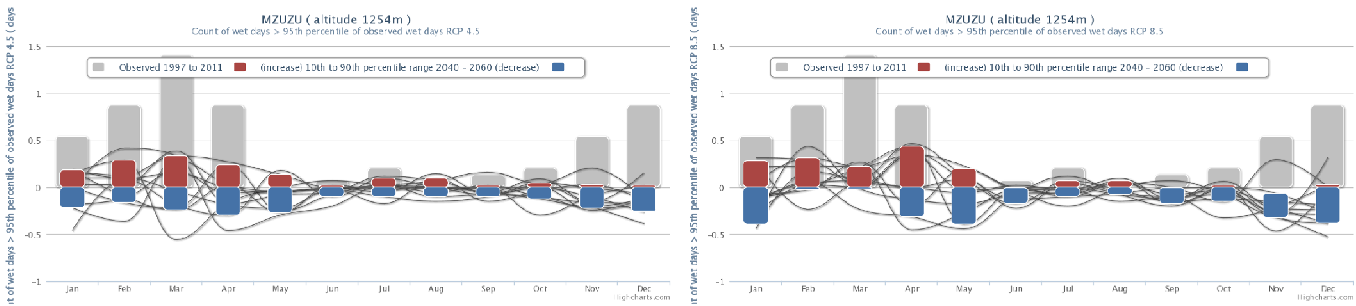


Figure B.38.5: Change in monthly rain day frequency > 35.7 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

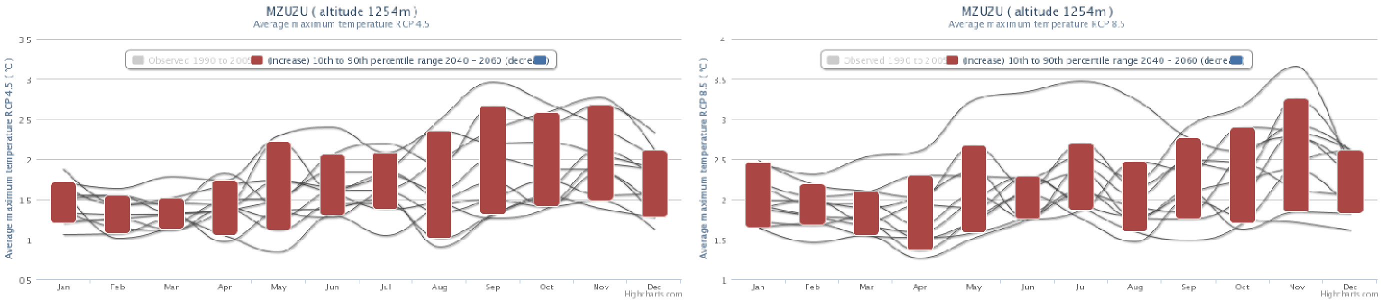


Figure B.38.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Monthly mean maximum days above 36 degree C

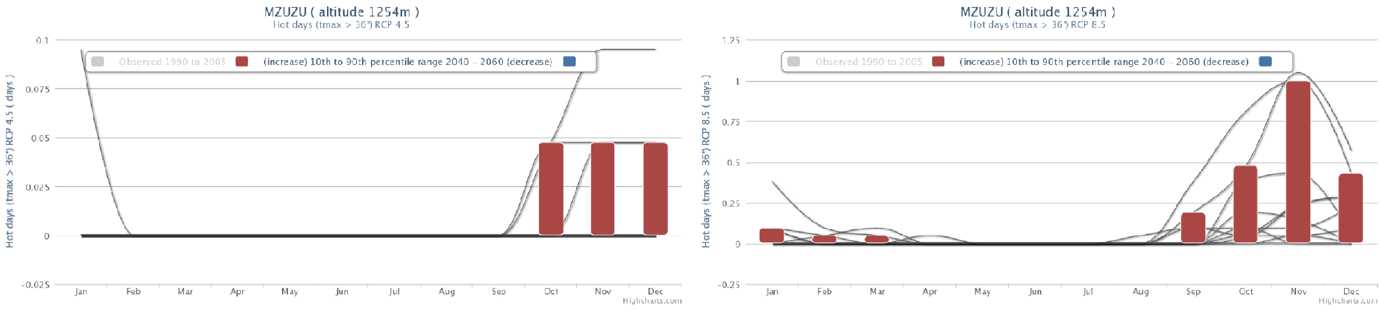


Figure B.38.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Monthly mean maximum days above 95th percentile

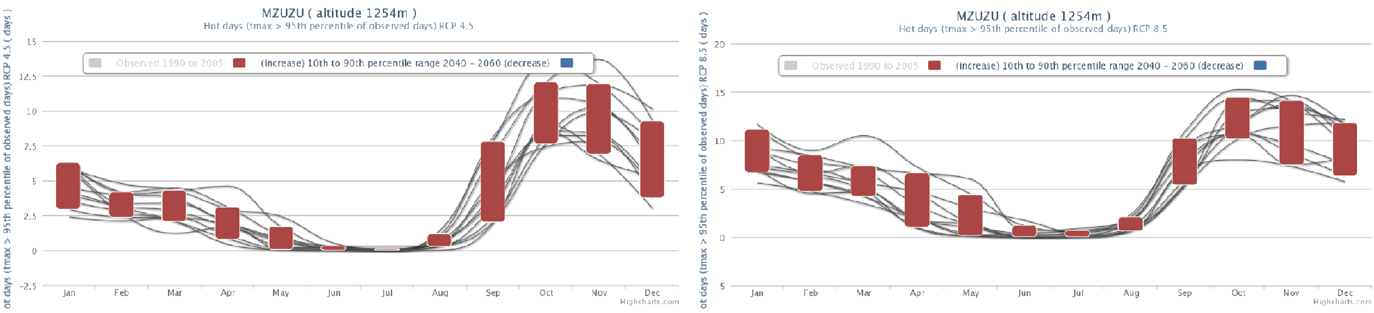


Figure B.38.8: Change in days above 30 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Monthly mean heat spell duration

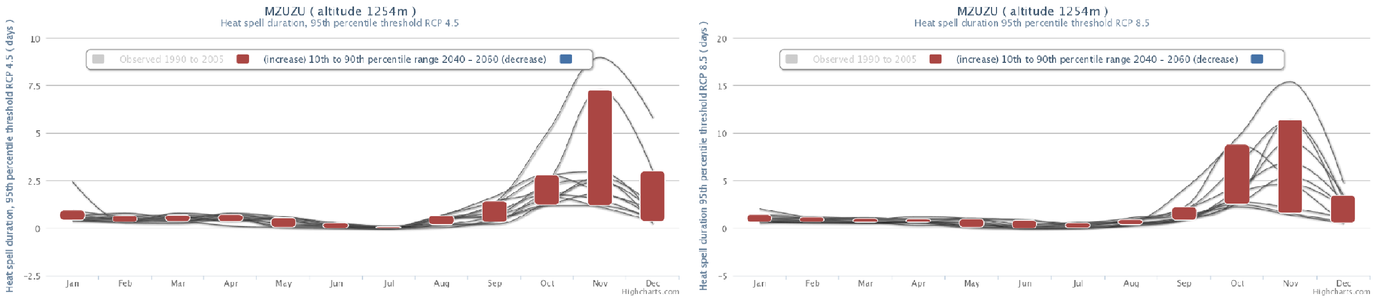


Figure B.38.9: Change in heat spell duration (30 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

Monthly mean minimum daily temperature change

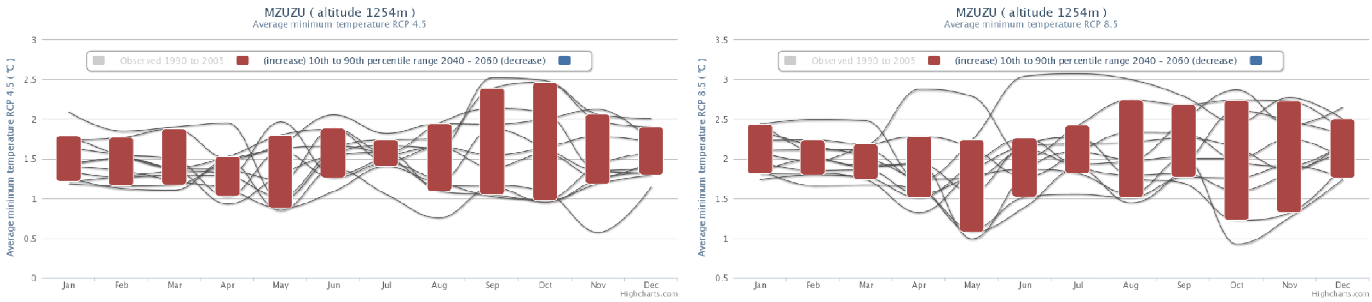


Figure B.38.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for MZUZU station.

B.39: Climate Summary for NGABU

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

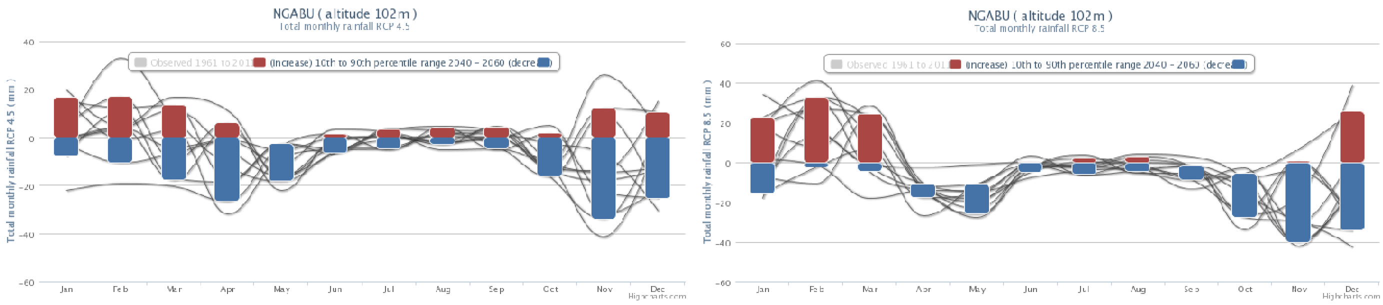


Figure B.39.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station

Projected change in monthly mean dry spell duration

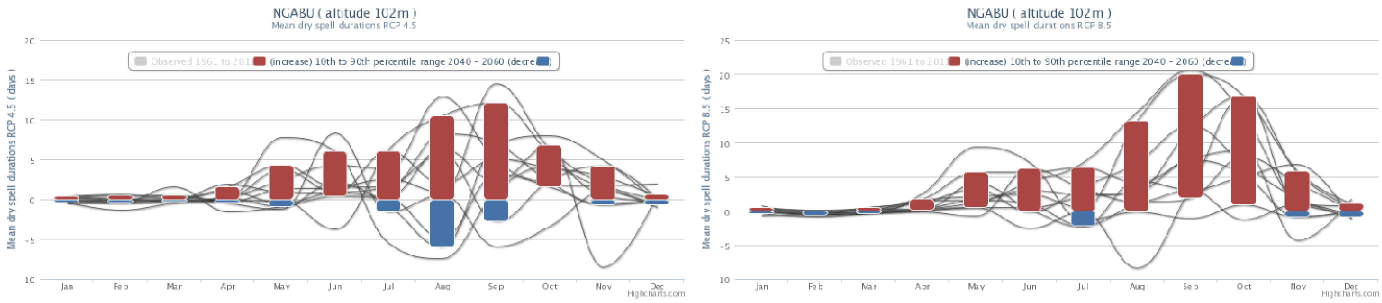


Figure B.39.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Projected change in monthly mean rain day frequency

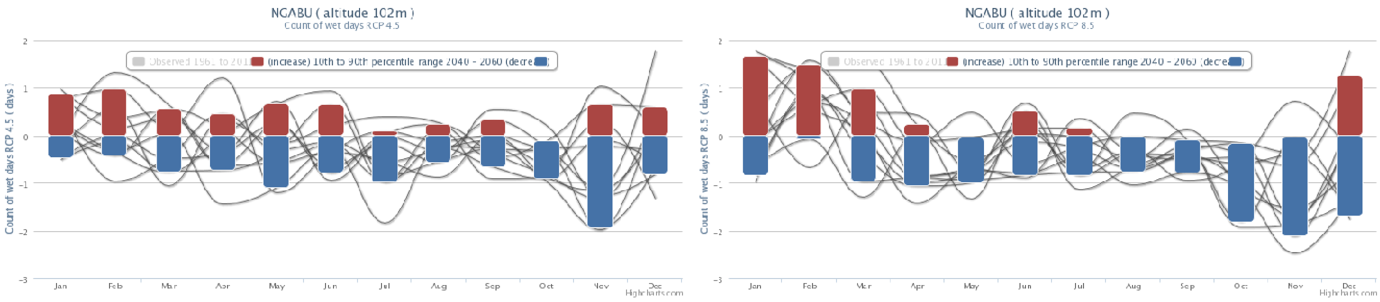


Figure B.39.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Projected change in monthly mean rain day frequency (> 20mm)

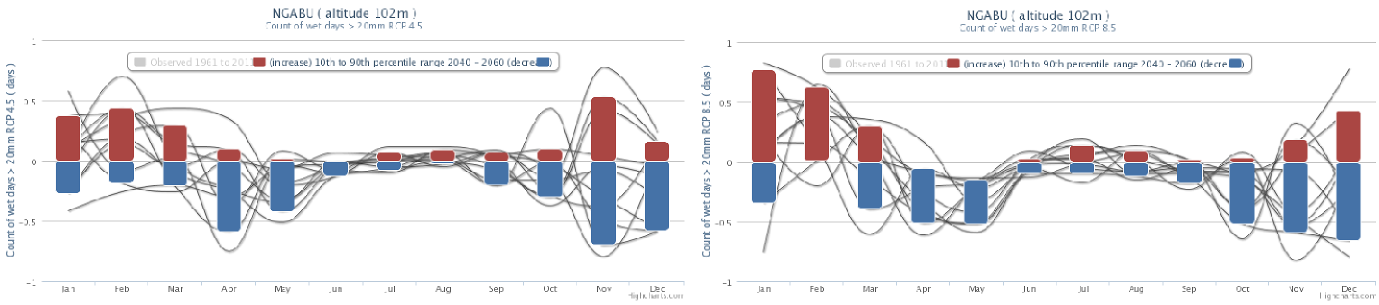


Figure B.39.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

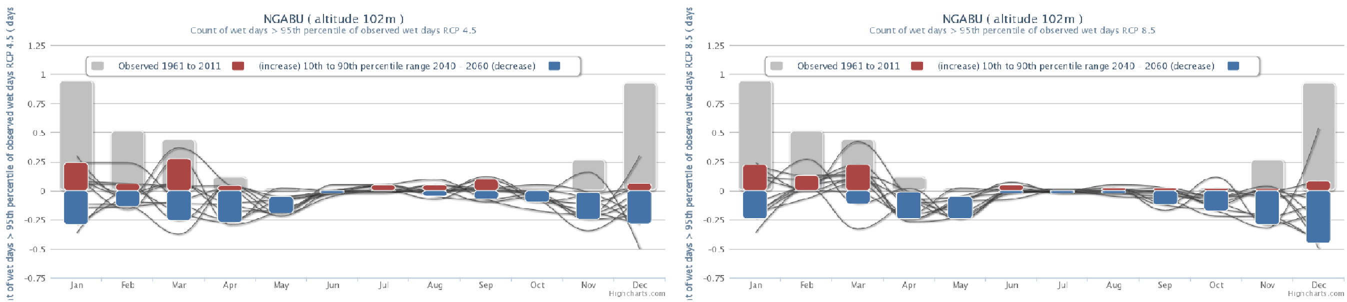


Figure B.39.5: Change in monthly rain day frequency > 48.2 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

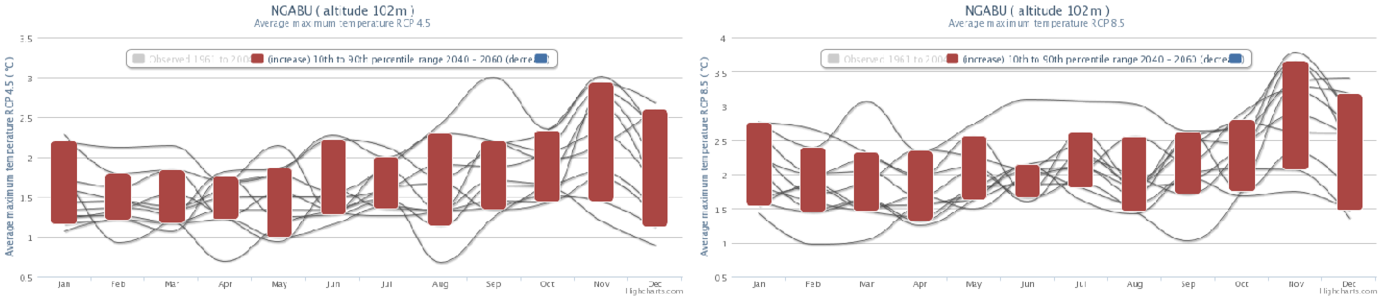


Figure B.39.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Monthly mean maximum days above 36 degree C

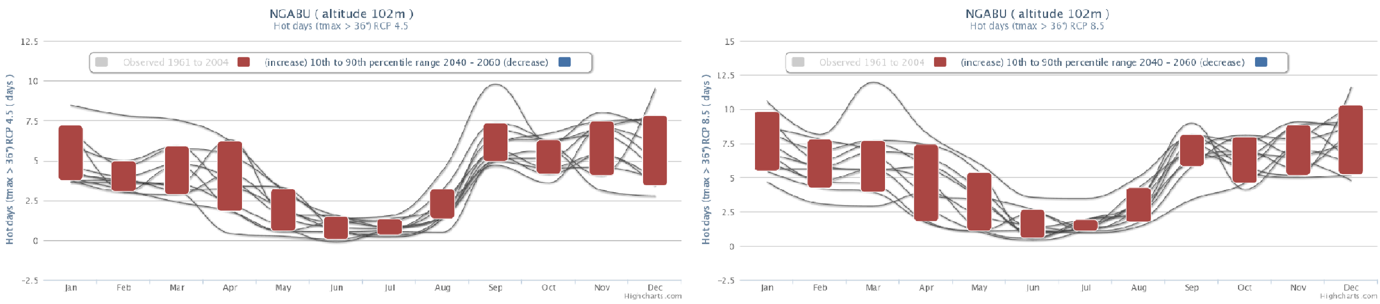


Figure B.39.6: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Monthly mean maximum days above 95th percentile

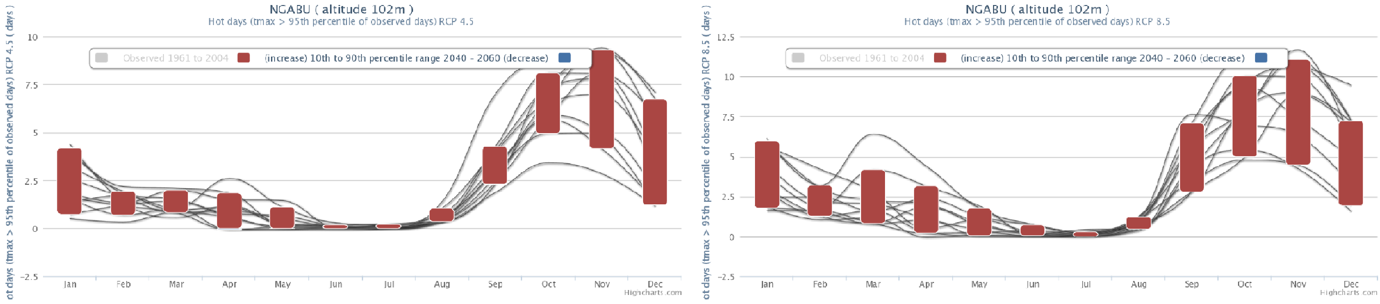


Figure B.39.7: Change in days above 39.5 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Monthly mean heat spell duration

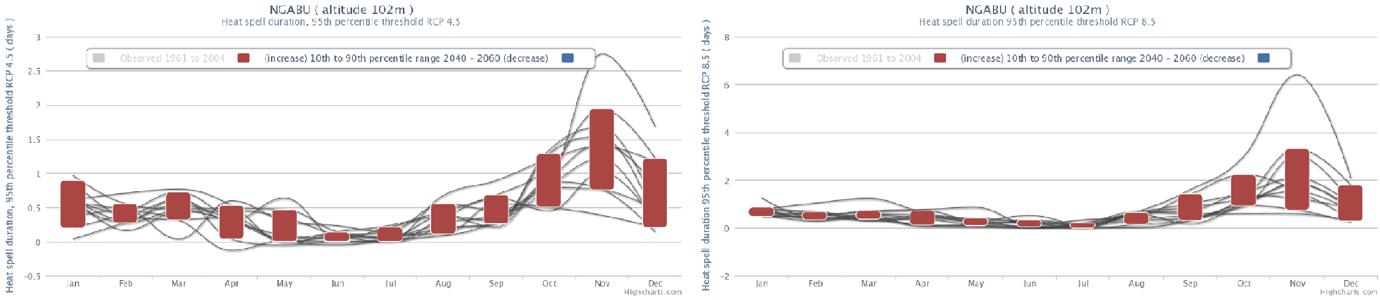


Figure B.39.9: Change in heat spell duration (39.5 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

Monthly mean minimum daily temperature change

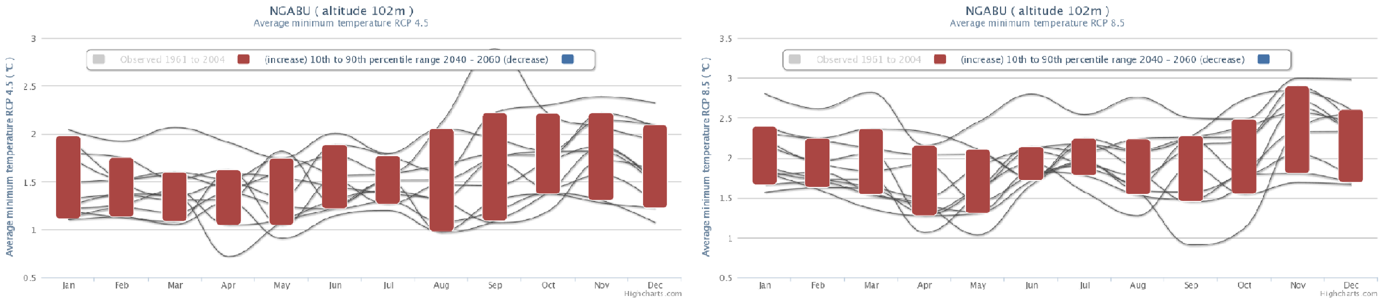


Figure B.39.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NGABU station.

B.40: Climate Summary for NKHATA BAY

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

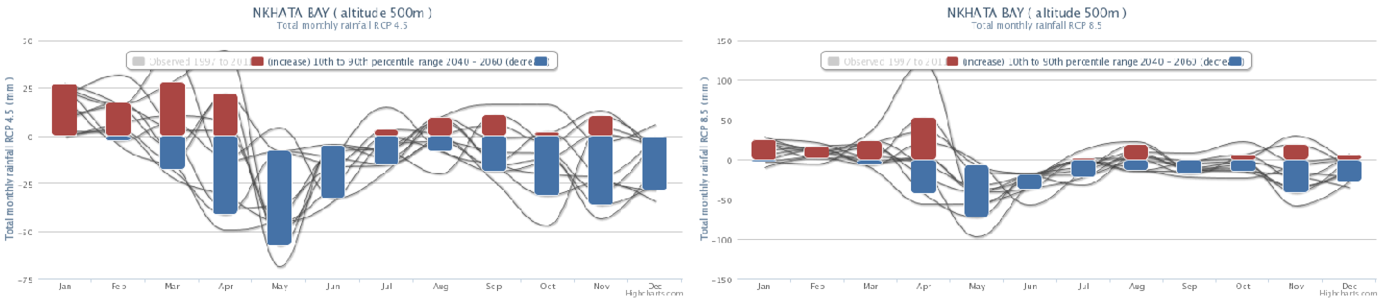


Figure B.40.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station

Projected change in monthly mean dry spell duration

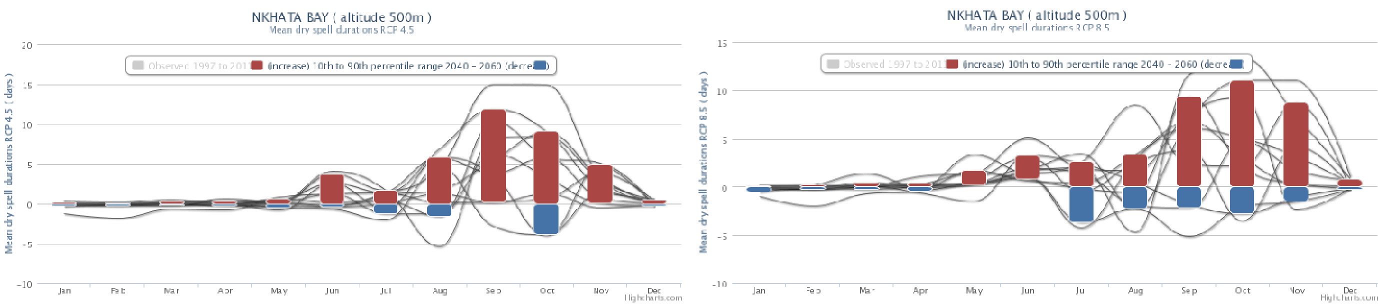


Figure B.40.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Projected change in monthly mean rain day frequency

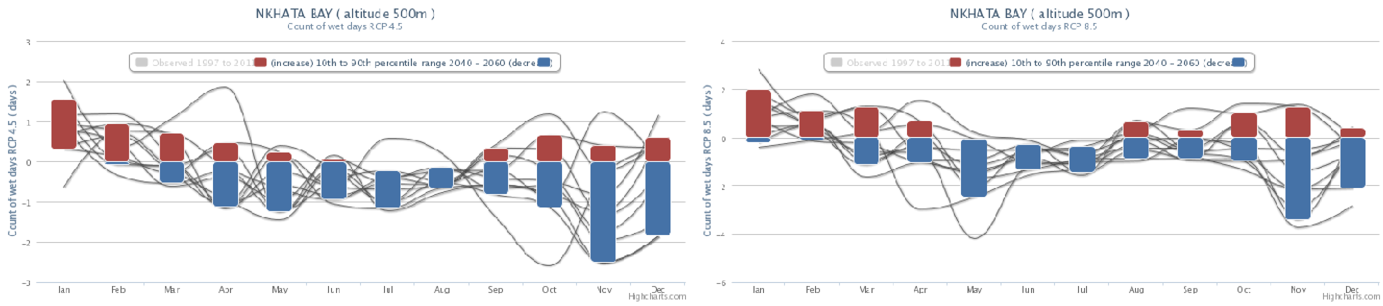


Figure B.40.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Projected change in monthly mean rain day frequency (> 20mm)

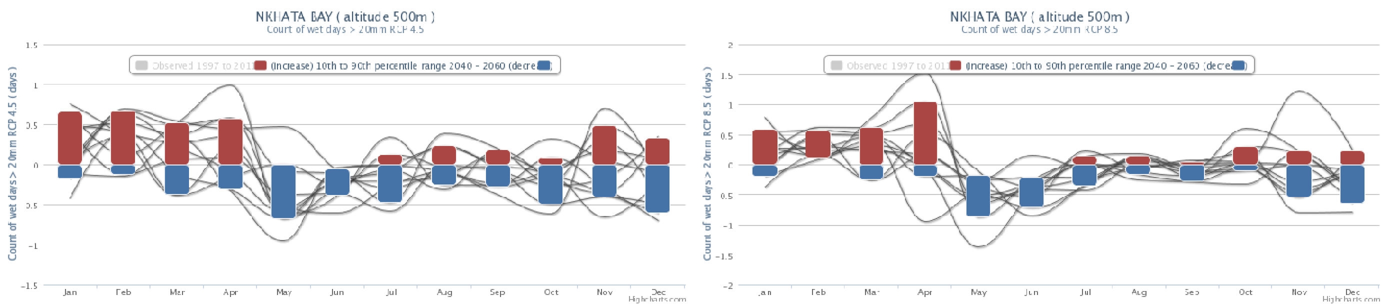


Figure B.40.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

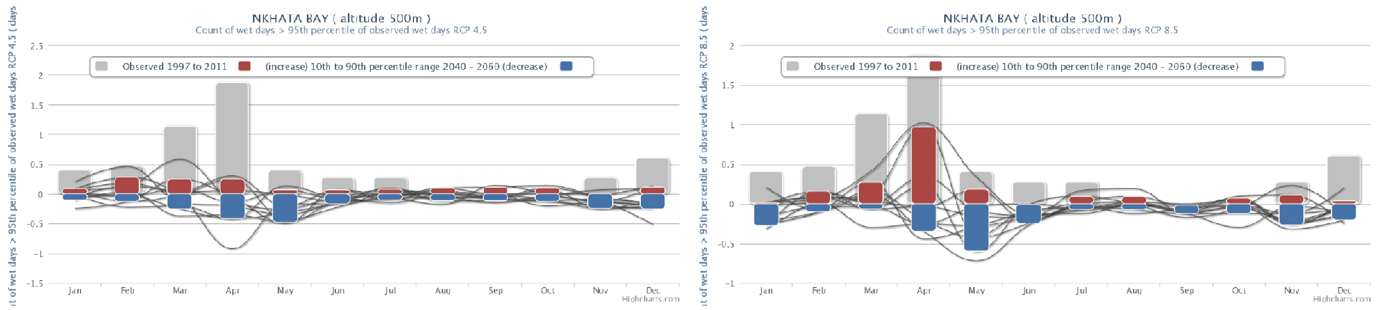


Figure B.40.5: Change in monthly rain day frequency > 55 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Climate Projections - Temperature

CLIMATE SYSTEM ANALYSIS GROUP (2013)

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

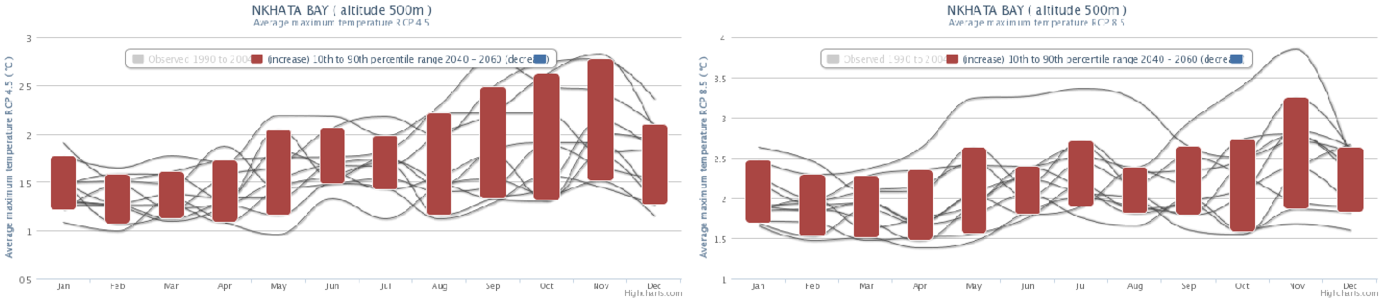


Figure B.40.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Monthly mean maximum days above 36 degree C

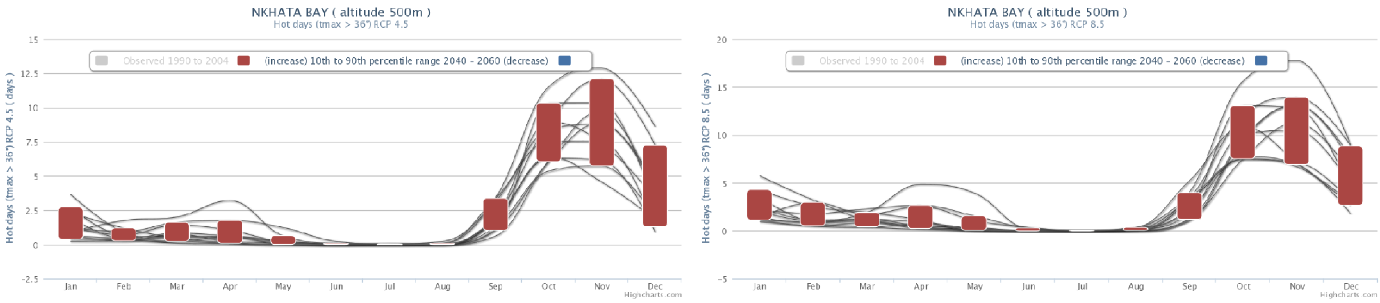


Figure B.40.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Monthly mean maximum days above 95th percentile

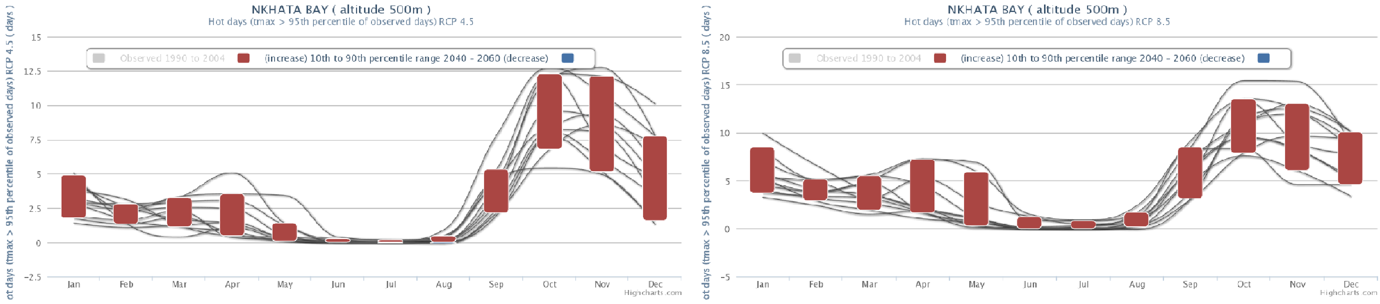


Figure B.40.8: Change in days above 34.3 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Monthly mean heat spell duration

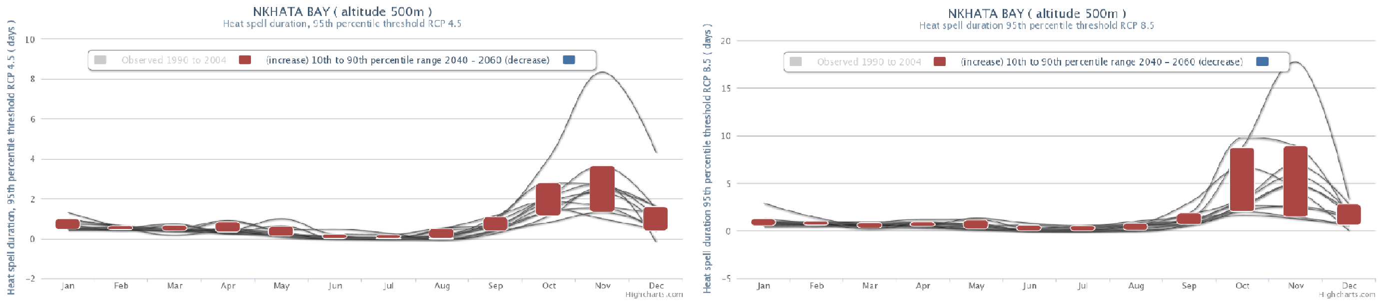


Figure B.40.9: Change in heat spell duration (34.3 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

Monthly mean minimum daily temperature change

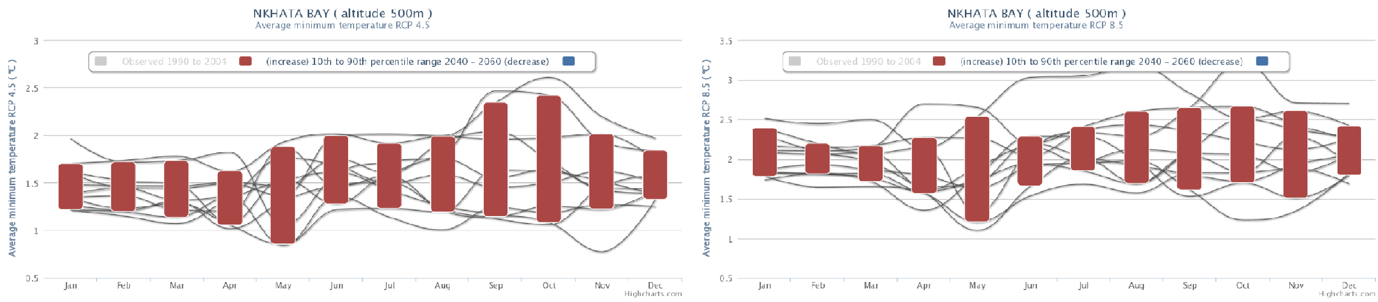


Figure B.40.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHATA BAY station.

B. 41: Climate Summary for NKHOTA KOTA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

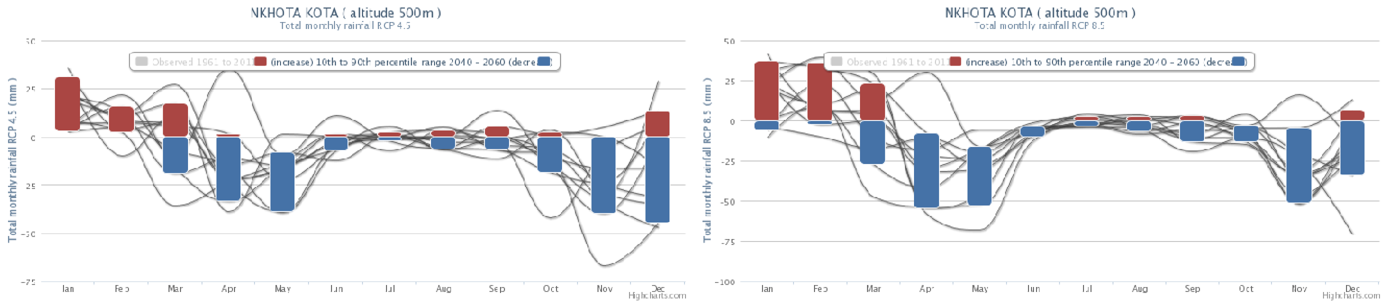


Figure B.41.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Projected change in monthly mean dry spell duration

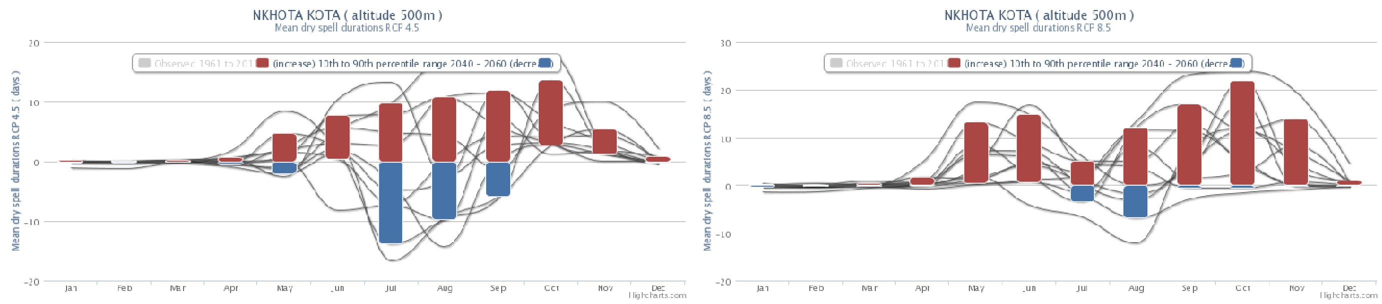


Figure B.41.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Projected change in monthly mean rain day frequency

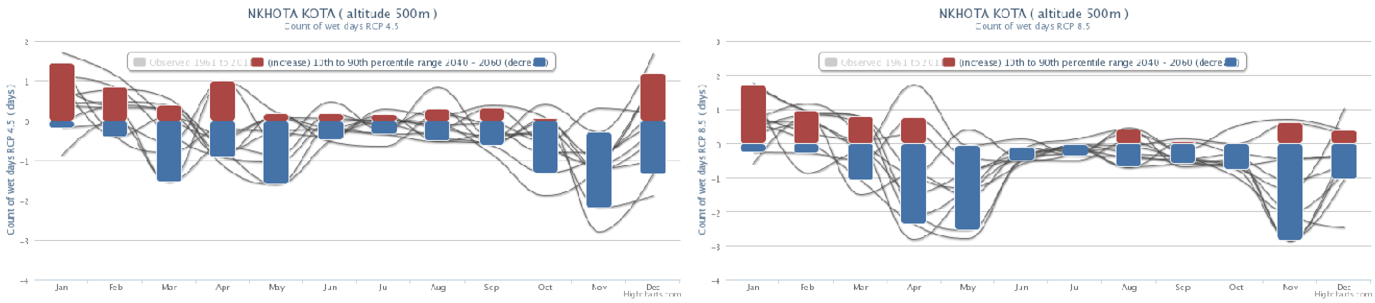


Figure B.41.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Projected change in monthly mean rain day frequency (> 20mm)

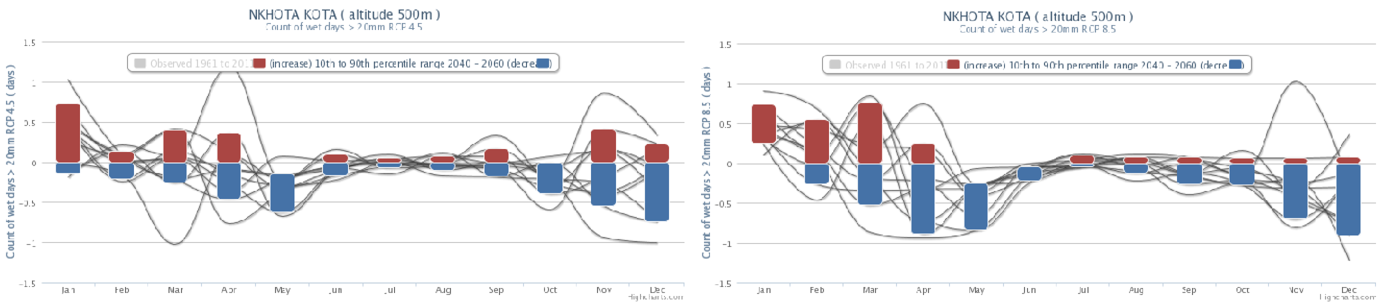


Figure B.41.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

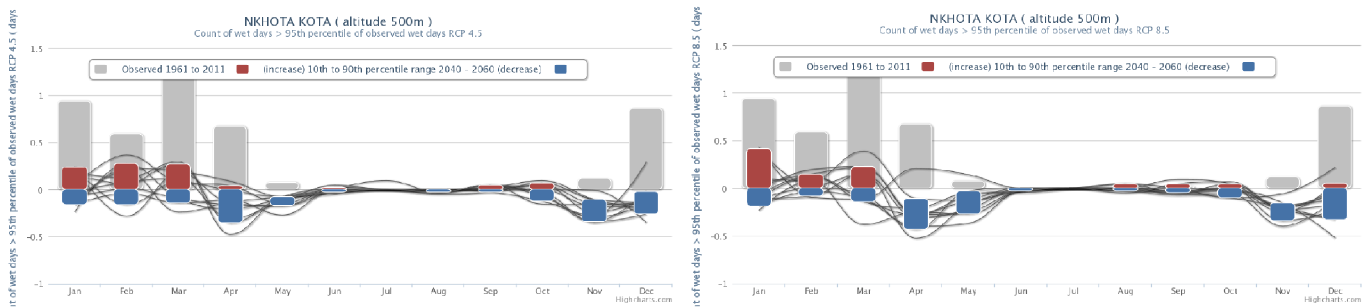


Figure B.41.5: Change in monthly rain day frequency > 47.5 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

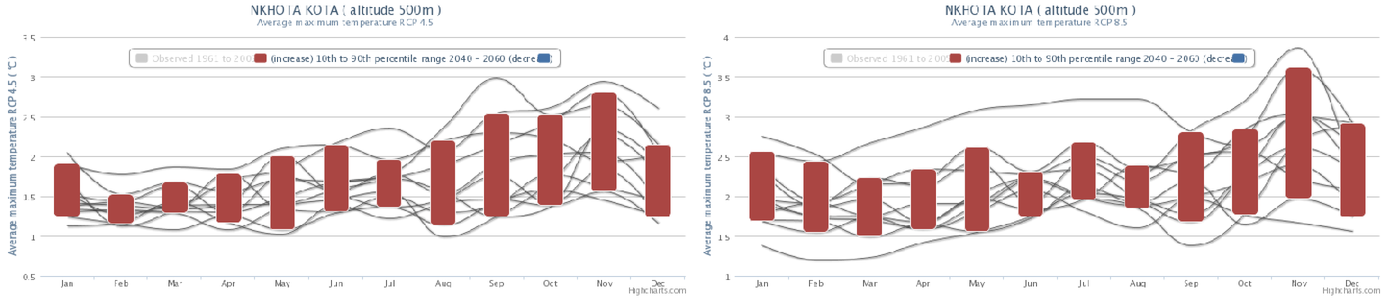


Figure B.41.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Monthly mean maximum days above 36 degree C

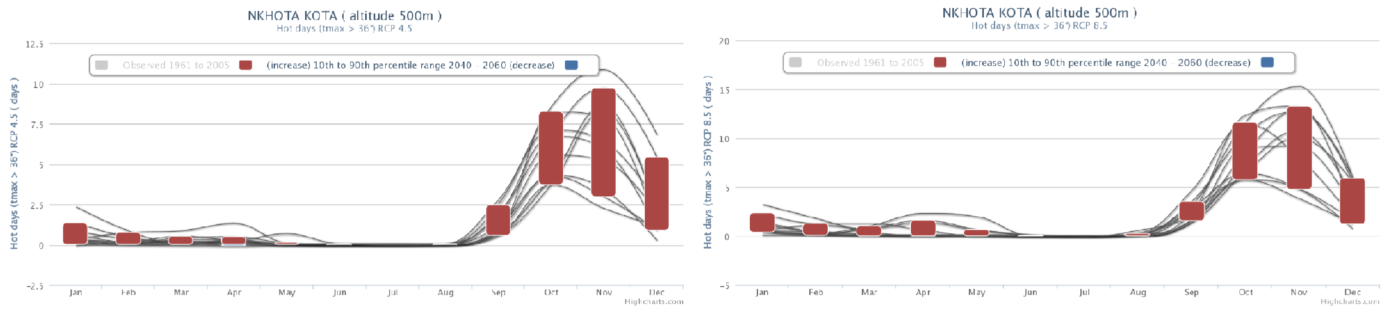


Figure B.41.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Monthly mean maximum days above 95th percentile

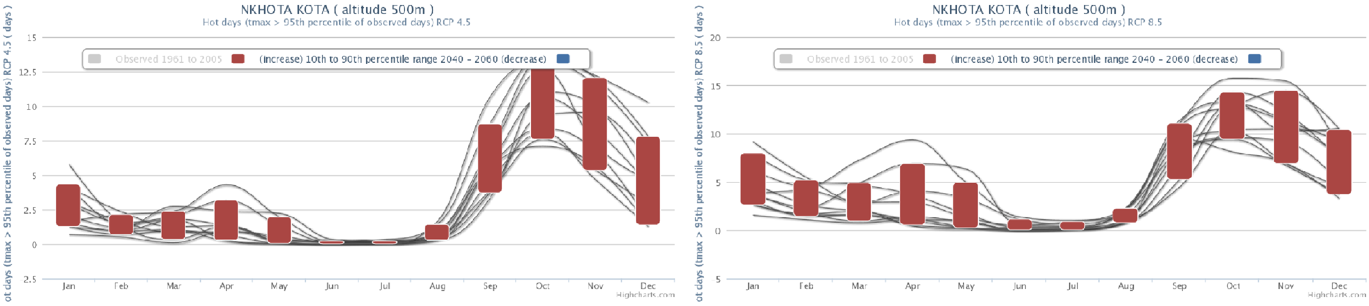


Figure B.41.8: Change in days above 34.5 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Monthly mean heat spell duration

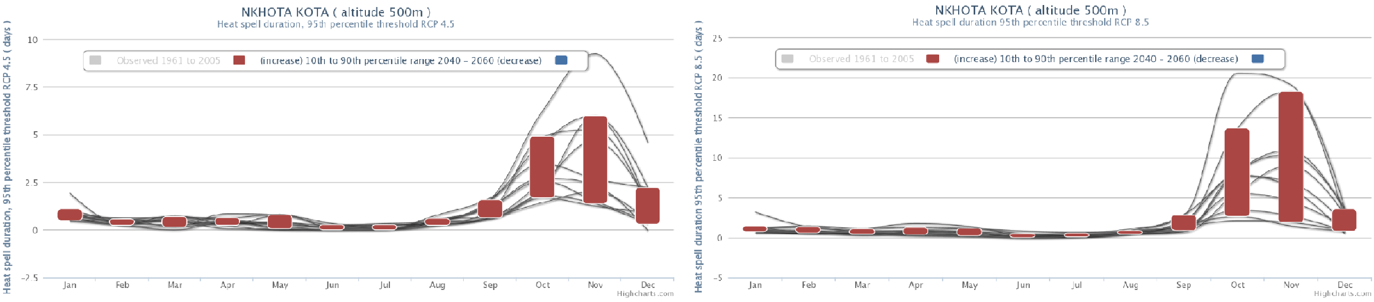


Figure B.41.9: Change in heat spell duration (34.5 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

Monthly mean minimum daily temperature change

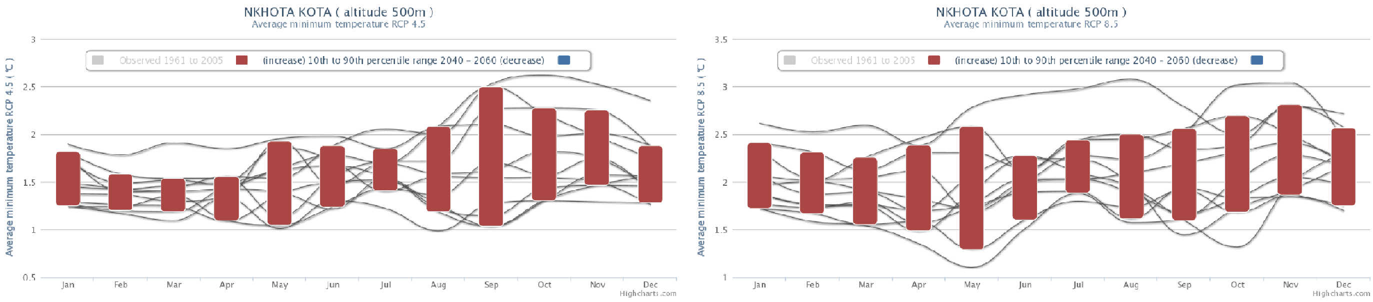


Figure B.41.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NKHOTA KOTA station.

B.42: Climate Summary for NTAJA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

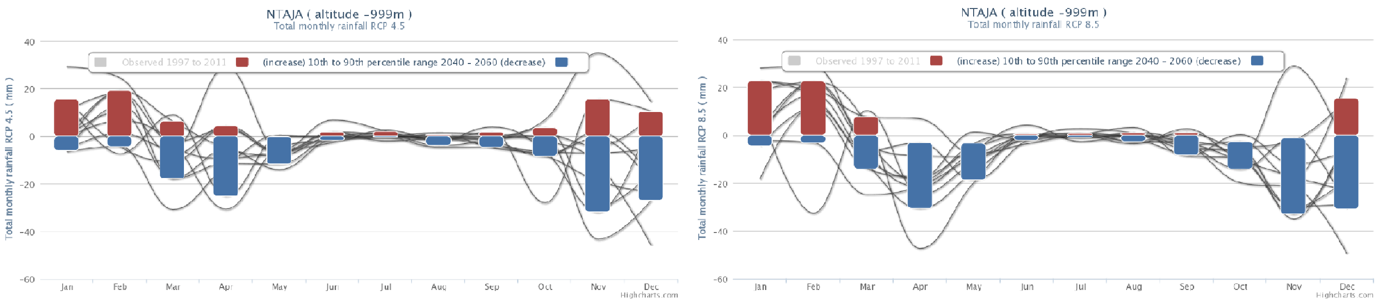


Figure B.42.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Projected change in monthly mean dry spell duration

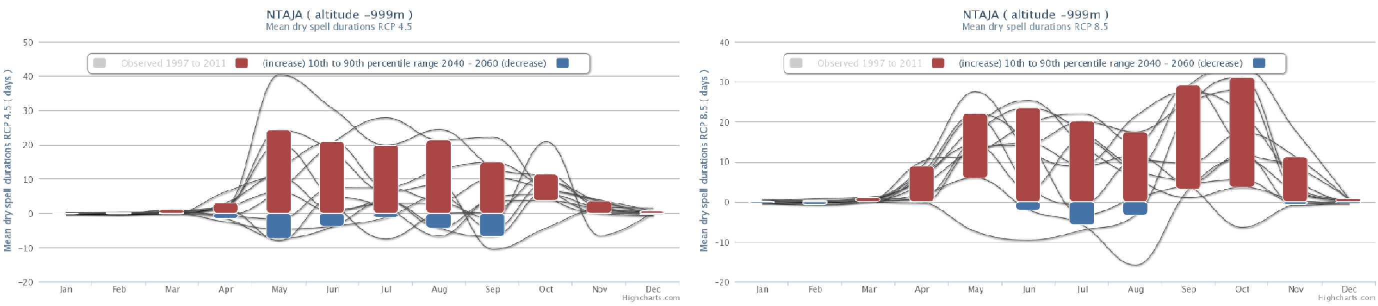


Figure B.42.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Projected change in monthly mean rain day frequency

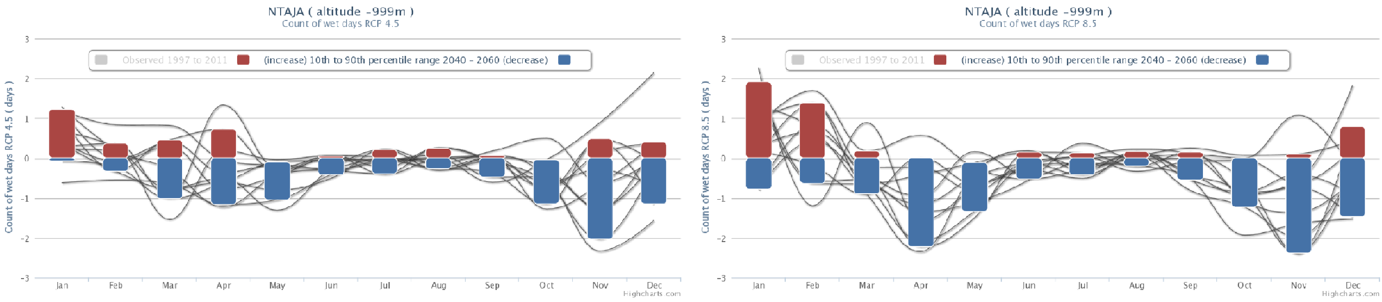


Figure B.42.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Projected change in monthly mean rain day frequency (> 20mm)

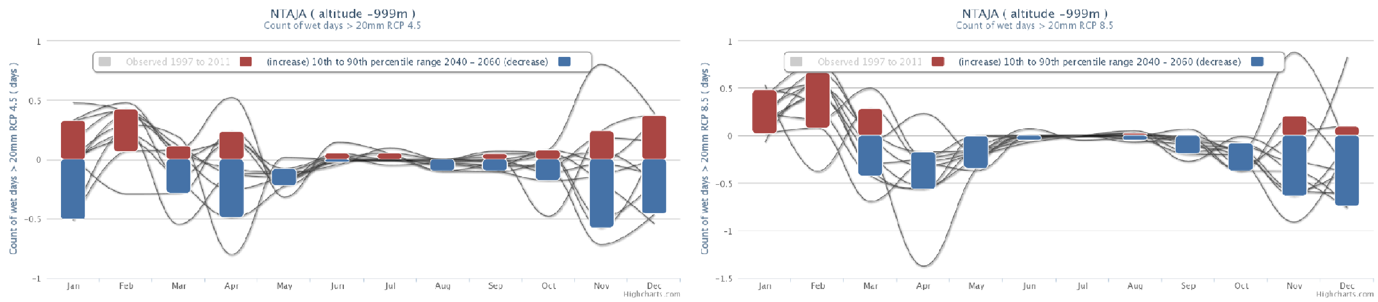


Figure B.42.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

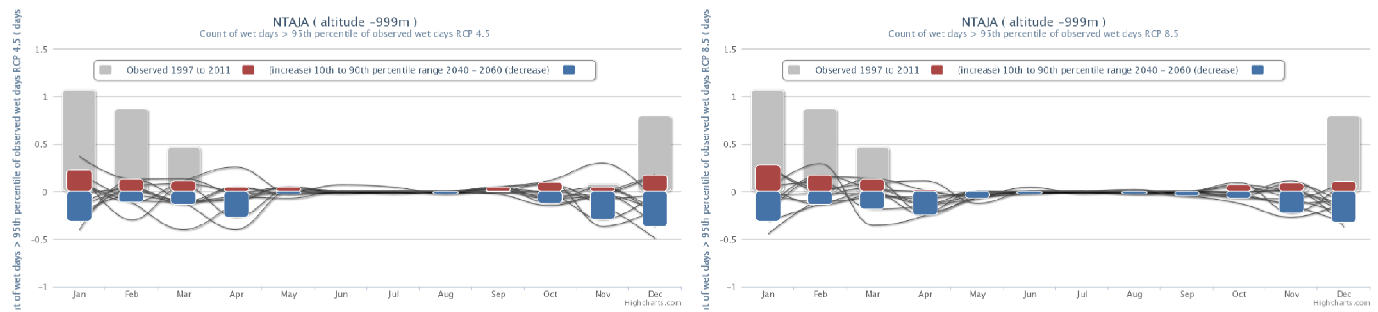


Figure B.42.5: Change in monthly rain day frequency > 55.3 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

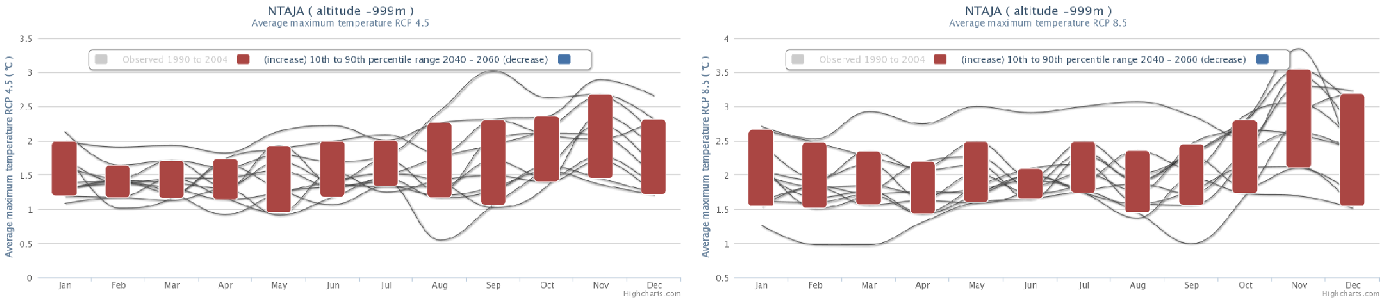


Figure B.42.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Monthly mean maximum days above 36 degree C

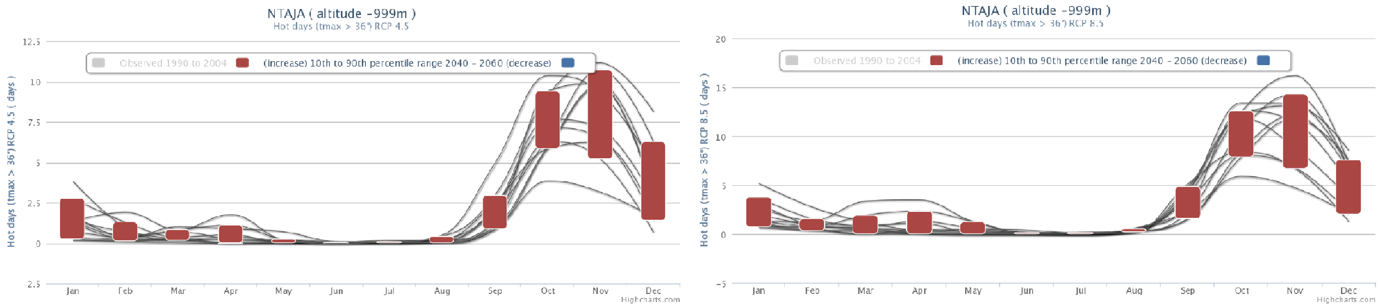


Figure B.42.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Monthly mean maximum days above 95th percentile

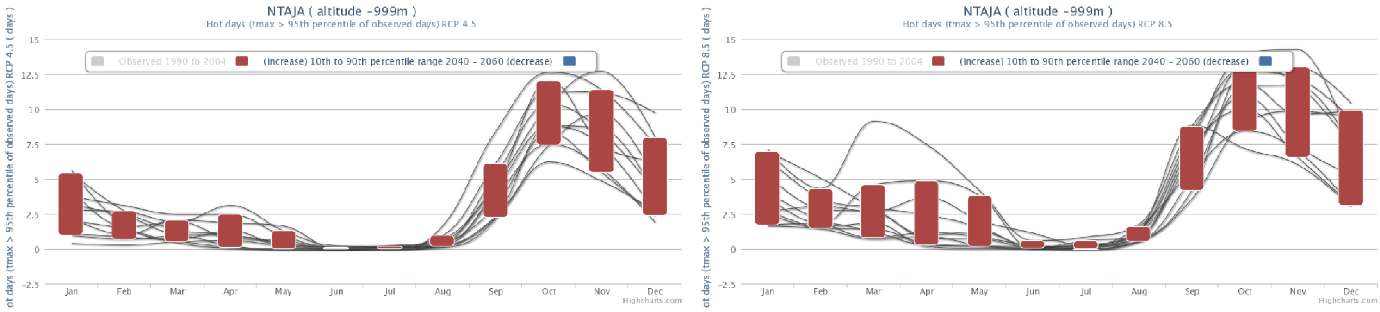


Figure B.42.8: Change in days above 33.6 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Monthly mean heat spell duration

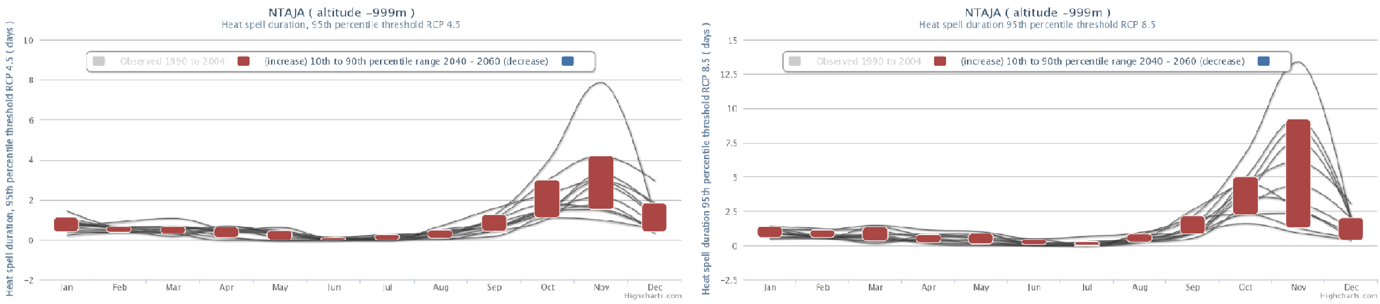


Figure B.42.9: Change in heat spell duration (33.6 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

Monthly mean minimum daily temperature change

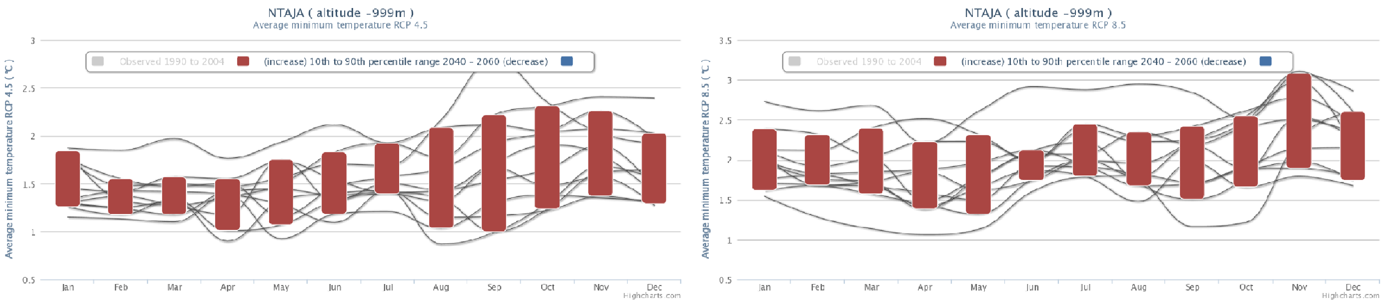


Figure B.42.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for NTAJA station.

B.43: Climate Summary for SALIMA

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

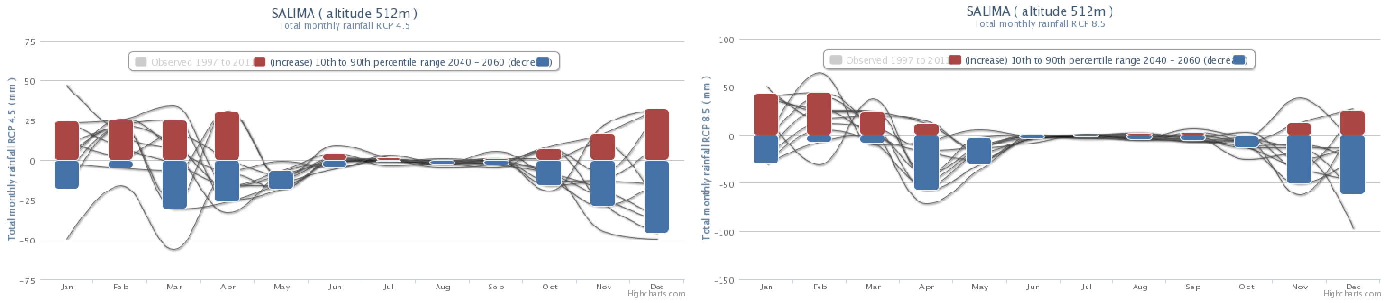


Figure B.43.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station

Projected change in monthly mean dry spell duration

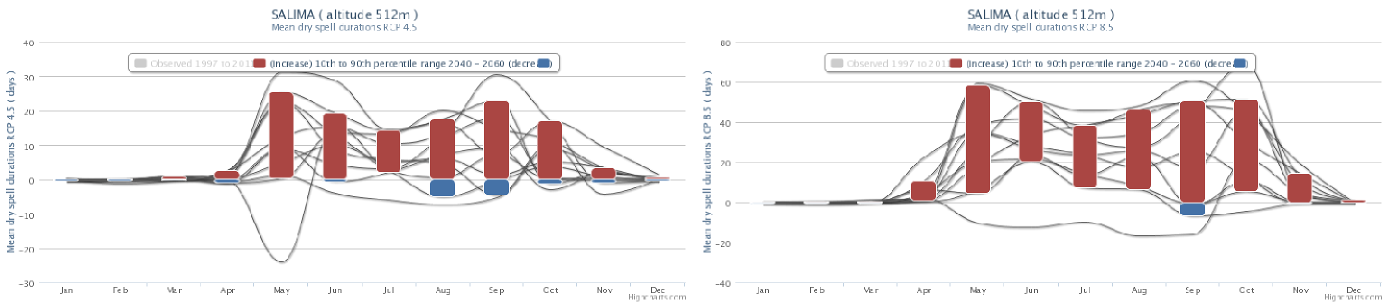


Figure B.43.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Projected change in monthly mean rain day frequency

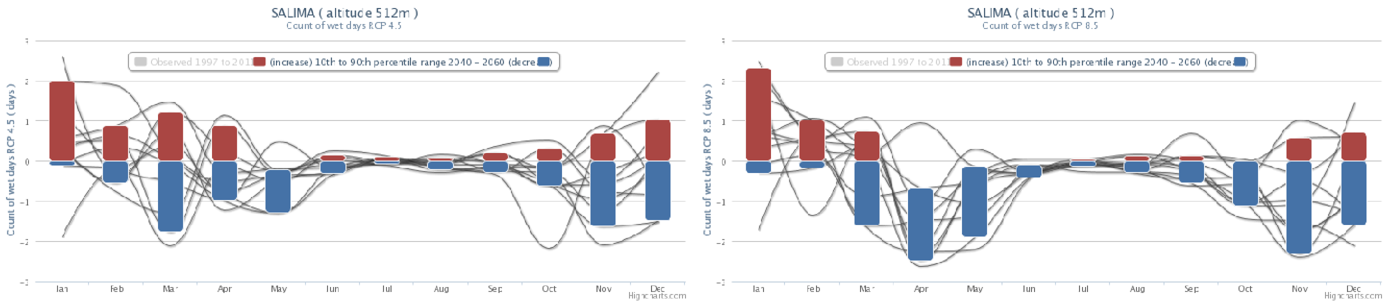


Figure B.43.3: Change in monthly rain day frequency (rain day => 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Projected change in monthly mean rain day frequency (> 20mm)

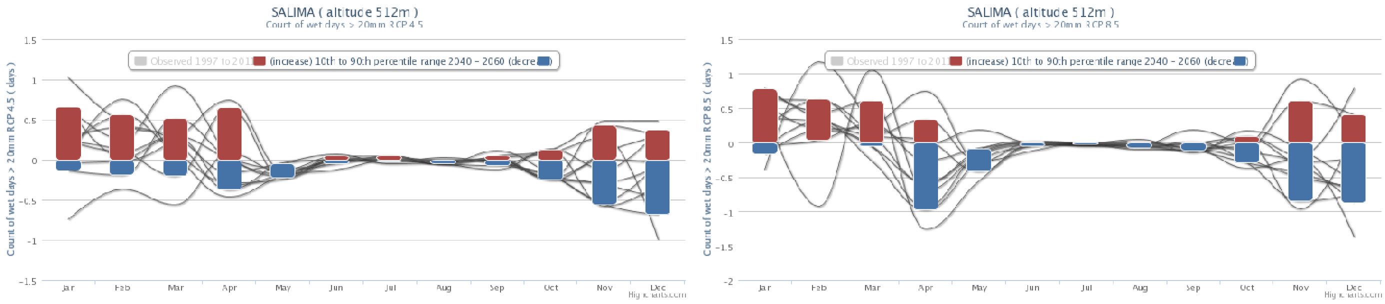


Figure B.43.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

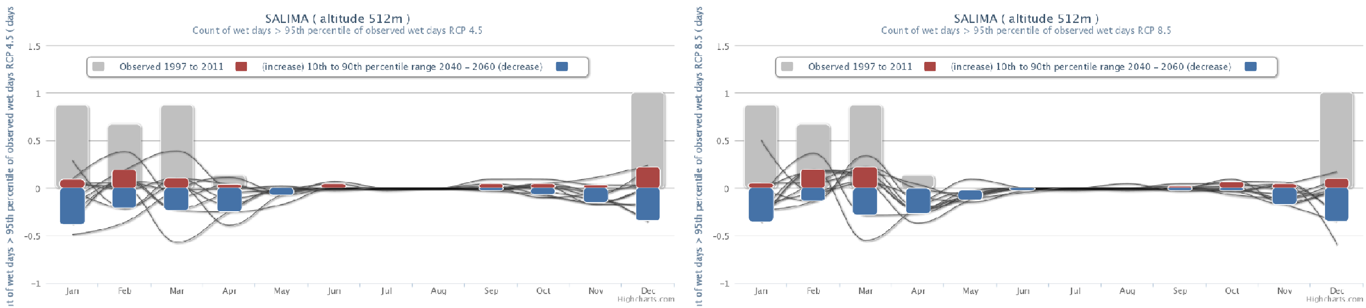


Figure B.43.5: Change in monthly rain day frequency > 66.9 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

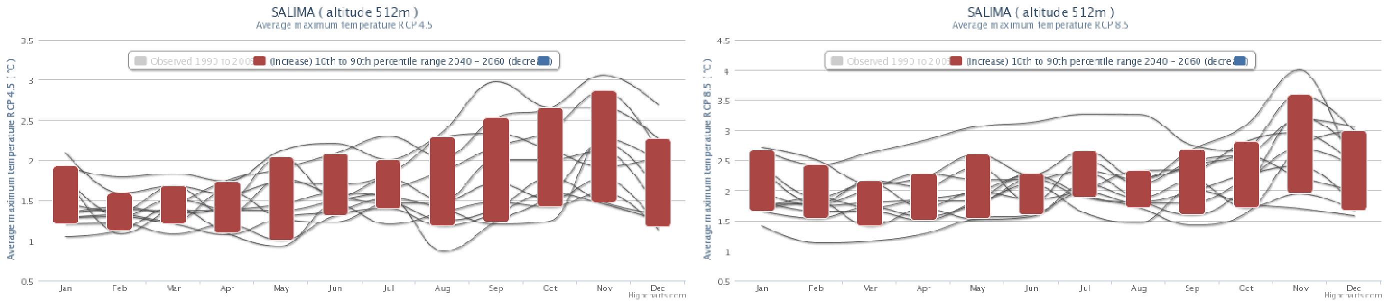


Figure B.43.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Monthly mean maximum days above 36 degree C

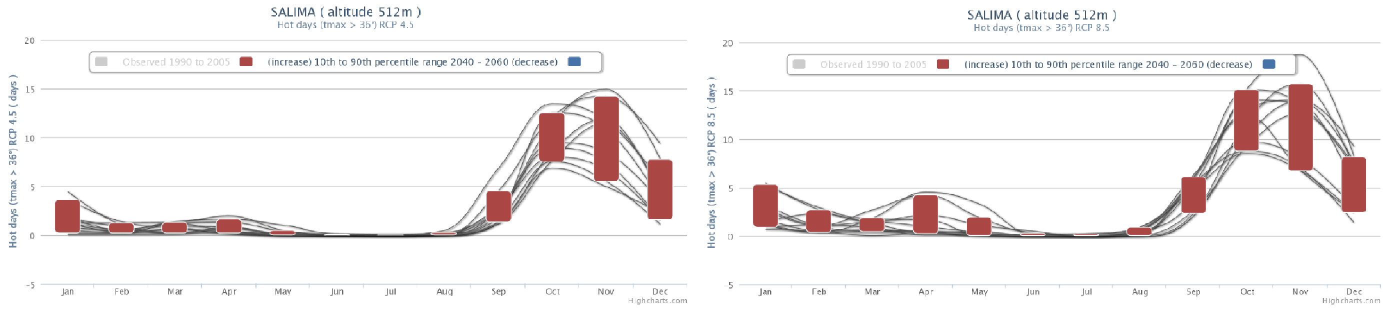


Figure B.43.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Monthly mean maximum days above 95th percentile

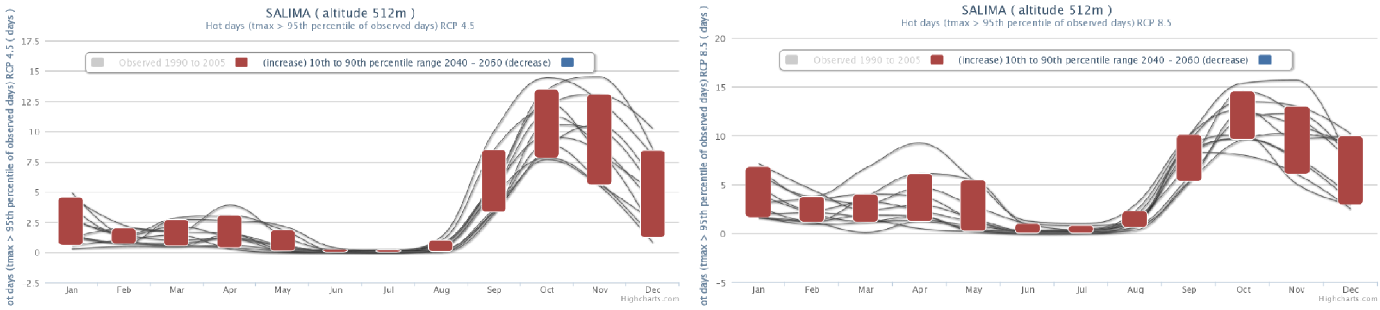


Figure B.43.8: Change in days above 34.8 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Monthly mean heat spell duration

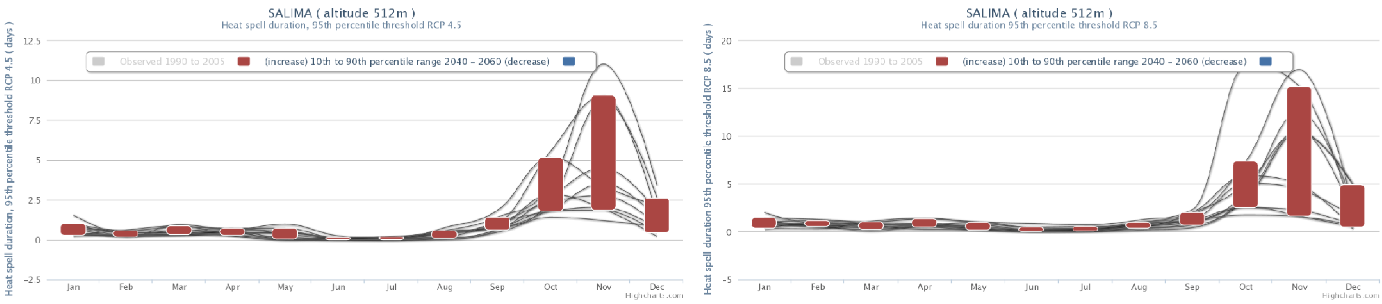


Figure B.43.9: Change in heat spell duration (34.8 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

Monthly mean minimum daily temperature change

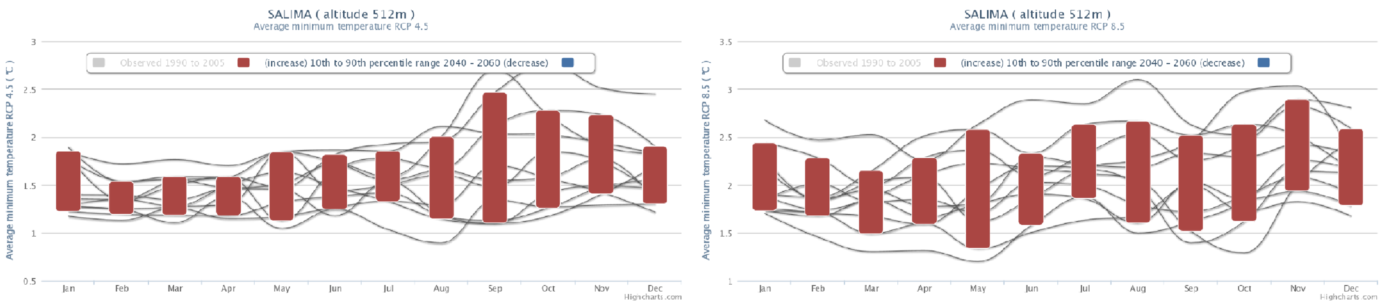


Figure B.43.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for SALIMA station.

B.44: Climate Summary for THYOLO

Climate Projections - Precipitation

Explanation of Climate Projection Plots - Precipitation Anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or mm). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Projected change in monthly total rainfall

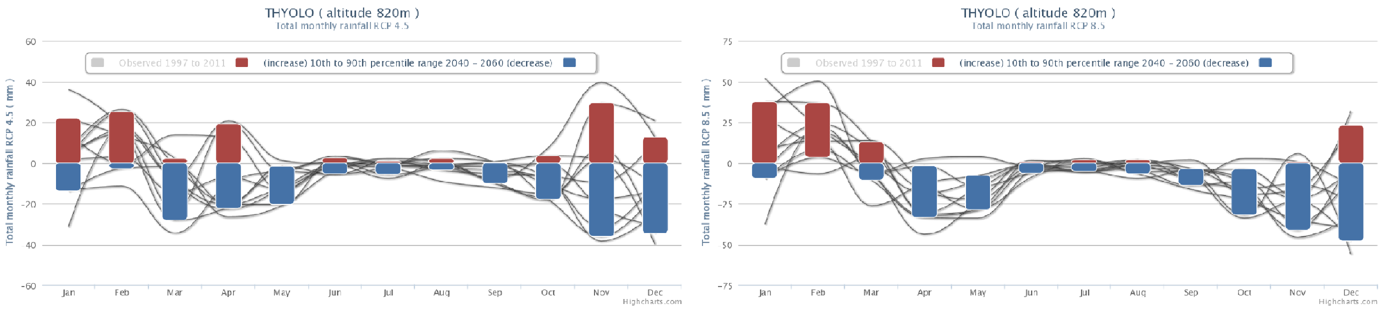


Figure B.44.1: Change in monthly total rainfall using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Projected change in monthly mean dry spell duration

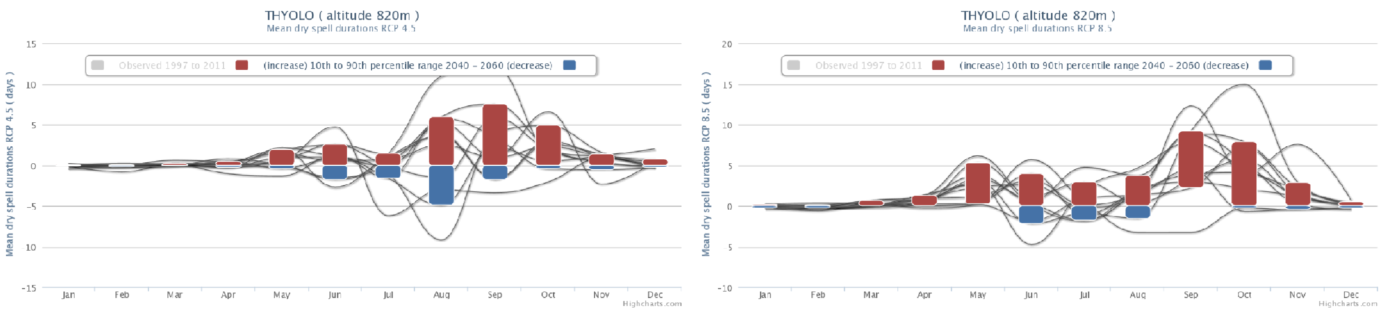


Figure B.44.2: Change in monthly mean dry spell duration (> 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Projected change in monthly mean rain day frequency

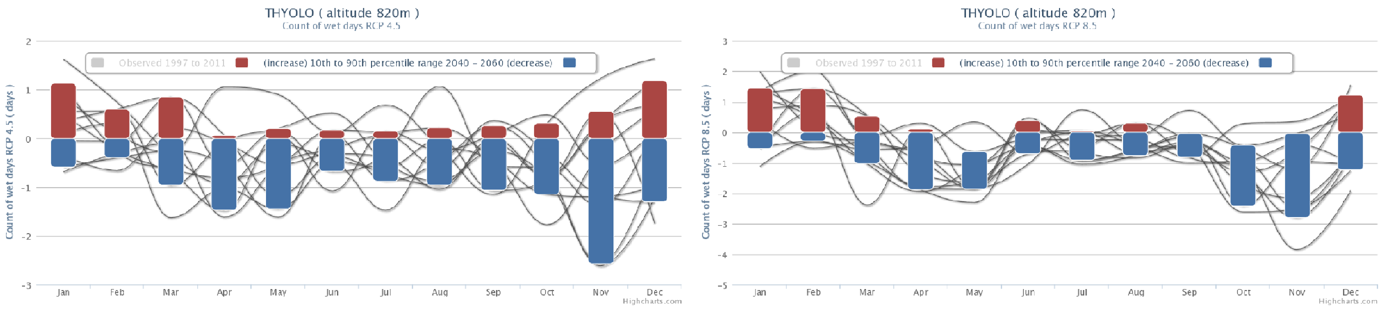


Figure B.44.3: Change in monthly rain day frequency (rain day = > 0.3 mm) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Projected change in monthly mean rain day frequency (> 20mm)

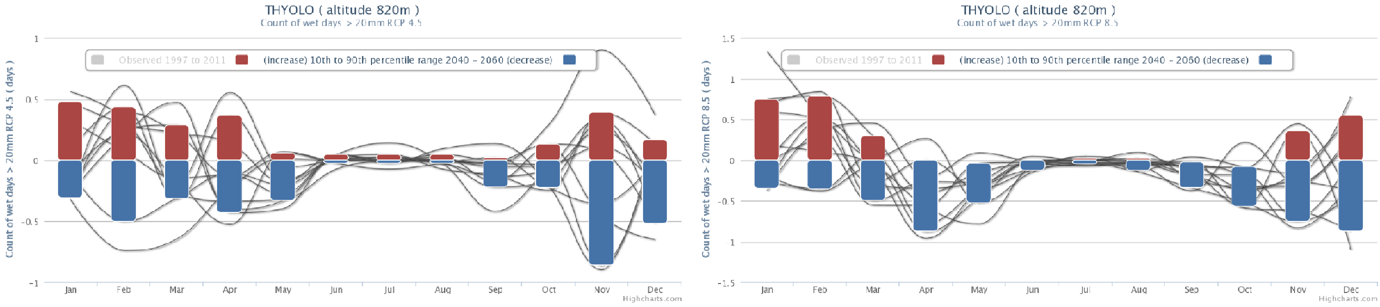


Figure B.44.4: Change in monthly rain day frequency > 20 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Projected change in monthly extreme rain day frequency (> 95th percentile)

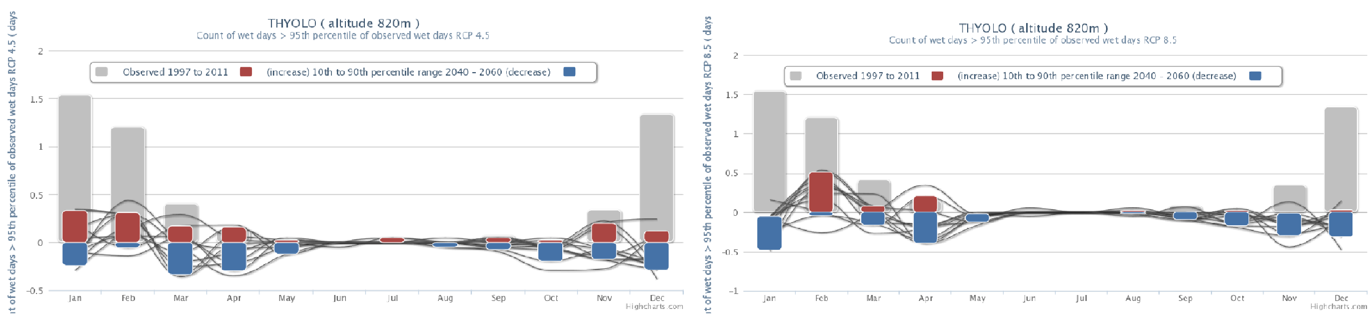


Figure B.44.5: Change in monthly rain day frequency > 48.7 mm using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Climate Projections - Temperature

Explanation of Climate Projection Plots - Temperature anomalies: Bars represent the range between the middle 80 percent of the projected change. They are presented as monthly mean change (either in days or degrees Celsius). Blue represents below the zero line, while red represents above the zero line. The grey lines show the projected change for each individual model.

Monthly mean maximum daily temperature change

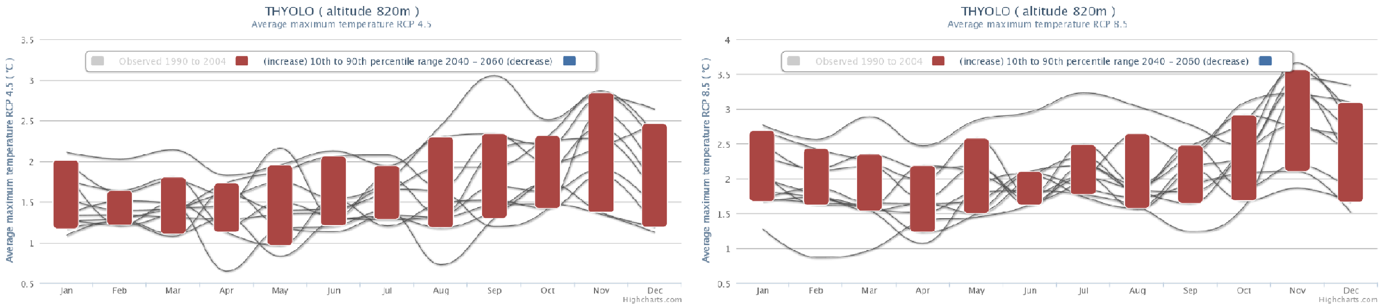


Figure B.44.6: Change in monthly mean maximum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Monthly mean maximum days above 36 degree C

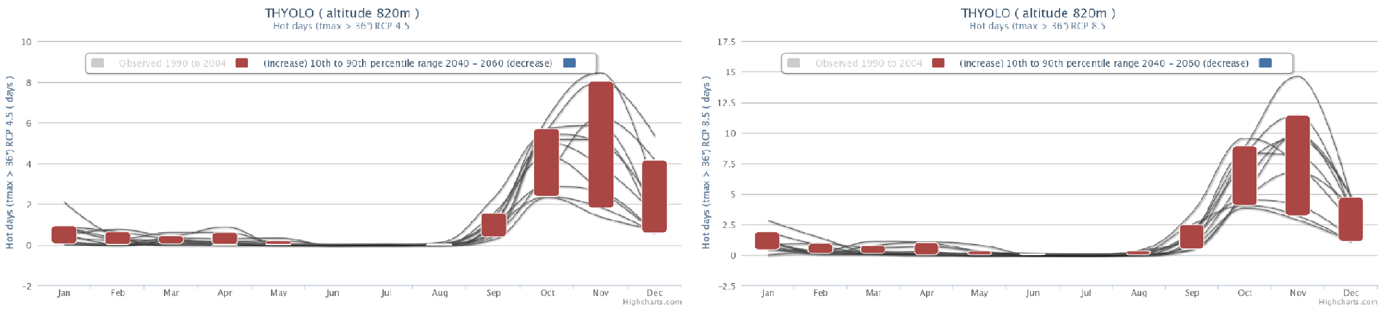


Figure B.44.7: Change in days above 36 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Monthly mean maximum days above 95th percentile

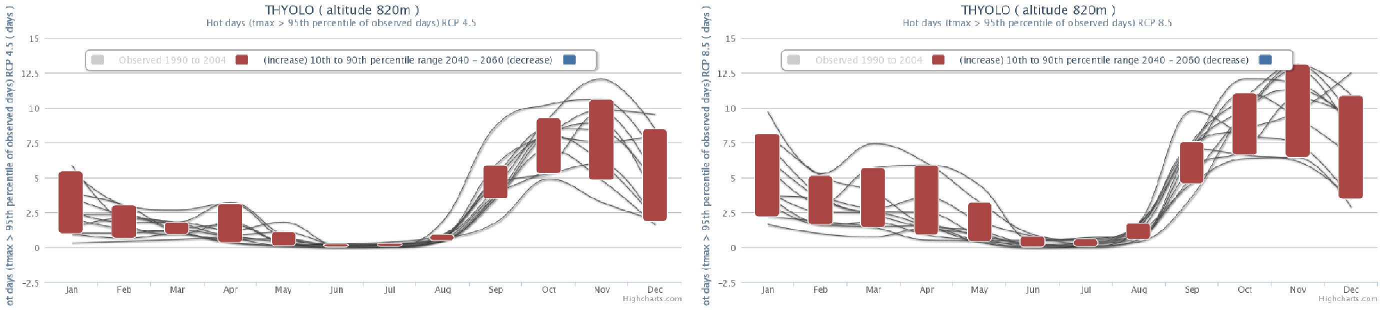


Figure B.44.8: Change in days above 32.9 deg C using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Monthly mean heat spell duration

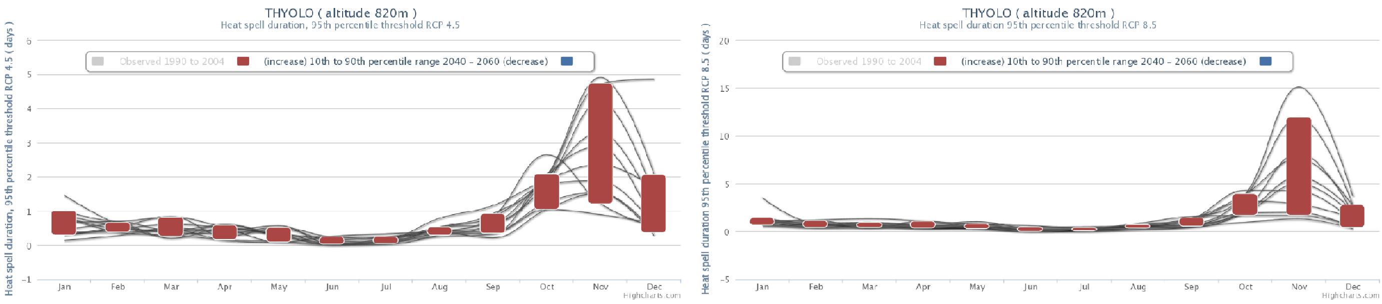


Figure B.44.9: Change in heat spell duration (32.9 deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

Monthly mean minimum daily temperature change

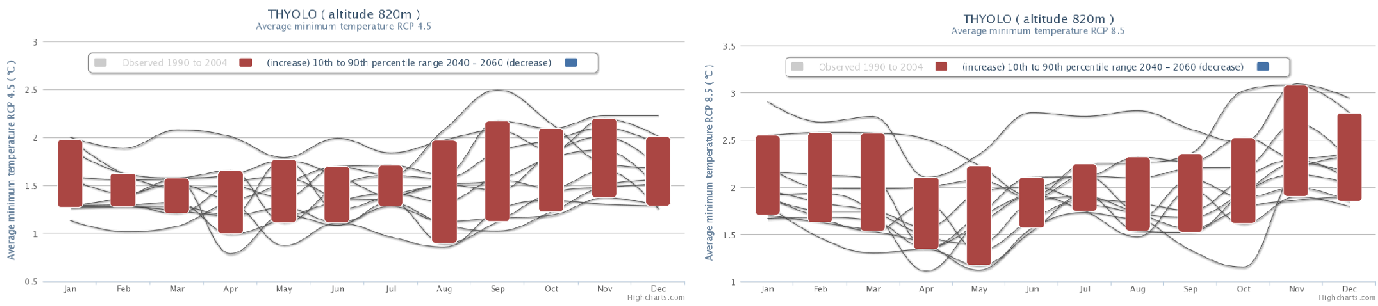


Figure B.44.10: Change in monthly mean minimum daily temperature (deg C) using the RCP 4.5 (left) and RCP 8.5 (right) emission scenarios for THYOLO station.

MALAWI CLIMATE CHANGE VULNERABILITY ASSESSMENT: ANNEX D. CROP PHENOLOGY

African and Latin American Resilience to Climate Change (ARCC)

SEPTEMBER 2013

CONTENTS

1.0 INTRODUCTION

This annex examines in detail potential impacts of projected climate variations on phenological stages of six crops currently cultivated in Malawi. With a climate commonly described as tropical, the temperatures in the mountain regions of the country are moderately cool.

Climate projections described in other sections of this report suggest that average annual temperatures in Malawi will increase between 1.2 and 3.5°C by the year 2060. The range of projections for changed in mean rainfall is large–projections from different models includes both negative and positive changes; but seasonally, the projections tend towards decreases in dry season rainfall and increases in wet season rainfall. Specifically, climate projections carried out under this Malawi Vulnerability Assessment (VA) project reduced average monthly rainfall during the months of December and January, and increased average monthly rainfall during the months between February and April. As discussed in other portions of this report, inter-annual unpredictability in the levels of rainfall is high, and is related to fluctuations in temperatures of the Indian Ocean, which can be different from one year to another.

This annex provides a detailed analysis of the vulnerability of the responses of the phenological stages of six crops to projected temperature and rainfall variations. As in most parts of Africa, crops utilized in Malawi are adapted to the limited fertility of the soils and unpredictable sources of water. In general, agriculture and crop production in Malawi rarely reach full potential and, rather that they are substandard and poor. The analyses described in this annex indicate that the impact of changes in temperature and rainfall can be more significant in the early stages of the plant development, especially at the stages of germination and early emergence. These are phases in development where water availability plays a substantial role in plant health and plant viability. Any damage at these early phenological stages can be very important because even if the plant recovers, the damage can be carried on to later stages and affect growth, flowering, fruiting, and yield.

That said, an excess of water can also be a serious constraint under a scenario of excessive rainfall. The problem is exacerbated in fields with poor drainage which can create a prolonged exposure of the crops to water logging stress. The most vulnerable areas to floods in Malawi are the river valleys, the lakeshore plain, and the Upper Middle and Lower Shire Valleys. Recent floods have occurred in some of these areas from 2000 to 2004.

As with all second-degree impacts (as defined in the Malawi VA study), the potential impacts of climate change and climate variability can be at least partially addressed by adaptation actions taken by local farmers and breeders, such as modifications in planting dates, breeding efforts, and/or use of different cultivars. Because these human-driven actions are difficult to predict, potential options to counter negative impacts on plant development and productivity in the face of climate change are not captured by this analysis, which is focused only on phonological responses to climate change and climate variability.

1.1 METHODOLOGY, ASSUMPTIONS, AND CONSTRAINTS

The climate analysis conducted as part of the Malawi VA clearly demonstrated how weather in Malawi is strongly influenced by surface temperatures originated in the Indian Ocean, which can vary considerably from one year to another due to deviations in the patterns of atmospheric and oceanic circulation. The country is situated in a location of influences by the Niño Southern Oscillation (ENSO) , an Indo-Pacific phenomenon that may modulate circulation in the Indian and Atlantic oceans; the Indian Ocean Dipole, (IOD), an equatorial pattern that affects rainfall primarily over equatorial Africa, but which may also impact subtropical southern Africa; and the Subtropical Indian Ocean Dipole (SIOD), a pattern further south of the IOD that may be linked to higher than normal rainfall in southern Africa. Recent evidence indicates that weather in Malawi may also be significantly influenced by Atlantic Ocean sea surface temperatures. This situation cause mixed climate responses in Malawi, contributing to considerable uncertainty in climate projections for the region. In addition to the climate analysis conducted under the Malawi VA, two other climate models were used to predict the potential impacts of changes in climate conditions on different phenological stages of select crops grown in the study zone. These were the climate model created by the United Nations Development Programme (UNDP) for Malawi (McSweeney et al. 2010) and the National Center for Atmospheric Research (NCAR) Community Climate Model (CCM3) climate model (Christensen et al. 2007; Govindasamy et al. 2003; Kiehl et al. 1996; Meehl et al 2007). The findings from these studies were combined to determine the climate parameters that would be considered for this phonological study: A mean increase of averaged annual temperature between 1.2 and 2.5°C and between 1.1 to 3.0℃ by the year 2060, and projections of rainfall that include both negative and positive changes (-13 percent to +32 percent).

The phenological study was carried out through a review the scientific and technical literature to identify how climate conditions impact different phenological stages of select crops grown in the study zone, and also how climate can influence the occurrence and outbreak of common pests and diseases observed in Malawi. The conclusions on the impacts are relative to vulnerability to climate change within optimal plant growth ranges, and indicators of impact are extrapolated from existing literature and do not necessarily obtain a high level of confidence.

The available scientific and technical literature sources relevant to Malawi were limited and the information in them was sometimes contradictory. For the more commonly studied crops, such as maize, cassava, and sorghum, there were more sources of information than for minor crops. Even for the major crops, the sources of information specific to Malawi were limited. Thus, the study complemented with findings from other areas of Africa or even other areas of the world with similar climate conditions.

Contradictory information–such as one report finding a negative correlation between a pest and temperature, and another finding a positive correlation between them–was resolved by reviewing additional information that would corroborate the sources.

1.2 SUMMARY OF CLIMATE IMPACTS ON SIX KEY CROPS

The six crops studied were those of the Malawi VA: Maize, sorghum, pigeon peas, groundnuts, cowpeas, and soybeans. This section provides a brief overview of these six crops. The next section presents a detailed analysis of the climate change impacts on the six crops.

1.2.1 MAIZE

Maize is considered to be the most important food staple in Malawi. Consumption reaches up to 133 kg per capita and accounts for about 54 percent of the caloric intake of rural households. It is the most broadly grown cereal, covering 76 percent of farmlands. However, drought episodes occurring regularly since 1990 have critically hurt maize production. The dependence on rain-fed maize has also resulted in food shortages taking place every two or three years. Traditional varieties in Malawi can produce well under high temperature conditions. However, production and yield are highly susceptible to water stress and poor levels of micro-nutrients in soil.

1.2.2 SORGHUM

Sorghum was a very important staple before the introduction of maize in Malawi and is still regularly grown by local farmers. Sorghum is mainly grown in the Central and Northern regions of the country: Salima, Machinga, and Karonga for lowlands and Shire Valley district for highland regions. The primary uses of sorghum are for food ("*nsima"*) and for brewing beer. Sorghum production is limited by a number of factors such as the lack of better cultivars, inadequate crop production practices, drought, pests, and diseases. Recently, production has been increasingly affected by poor and unpredictable rainfall.

1.2.3 GROUNDNUTS

Malawi is one of the most important groundnut-producing countries in southern Africa. Groundnuts account for 25 percent of household-level agricultural income in the country. Moreover, groundnuts help fix atmospheric nitrogen in soils, enhancing soil fertility. Groundnuts are cultivated as a rain-fed crop either alone or in association with cereals such as maize and sorghum, millet, or grain legumes such as pigeon peas. Apart from the infrequent utilization of improved varieties, low productivity can be attributed to biotic and abiotic stresses and low soil fertility. Average yields in Malawi are poor (700kg/ha) compared to yield over 2500 kg/ha obtained in the developed world. Groundnut hulls are also valuable as fodder for animals and fuel. Groundnuts grow in a range of altitude of 200–1,500 meters with the majority grown in the Central region (Lilongwe and Kasungu districts) at around 1,200 meters.

1.2.4 PIGEON PEAS

Pigeon peas rank as the third-most important legume crop after groundnuts and beans; an estimated 65 percent of the pigeon peas produced in Malawi are consumed by the farm households. Poor production practices make this crop susceptible to insect and other pest damage. Lack of crop rotation is the leading cause of a high incidence of wilt caused by *Fusarium*. Another negative factor is the presence of aflatoxin which makes the product unhealthy for human and animal consumption. Pigeon pea cultivation is heavily concentrated in the Blantyre, Machinga, and Shire Valley districts. This crop can withstand low moisture condition and performs well in areas with low levels of rainfall. Pigeon peas can be planted with crops such as maize, sorghum, or groundnuts without significantly reducing the yield of the main crop. Intercropping with maize and groundnuts is very common in Malawi.

1.2.5 COWPEAS

Cowpeas (*Vigna unguiculata)* are important for poor rural regions throughout the semi-arid and sub-humid areas of East and Southern Africa. Cowpeas are widely known as "the crop of the poor" because the plant's green pods and leaves are the earliest food available before cereals mature so serving as "insurance" against food shortages during the "hungry season." The areas in which cowpeas are cultivated are often inappropriate for the production of other crops such as beans or peanuts, but cowpea yields in these farmer-managed fields are low, averaging only 388 kg/ha in Malawi. Different abiotic and biotic stresses keep productivity low. The most significant of these are drought; heat; poor soil fertility; inappropriate agronomic practices; fungal, viral, and bacterial diseases; and parasitic weeds (*Striga* and *Alectra*). Cowpeas are particularly susceptible to infestation by several insects with devastating effects on plants in the field and seeds in storage.

1.2.6 SOYBEANS

Soybeans can grow from sea level up to 2,000 meters and under a broad range of temperature; however the most favorable temperature for growth and development is around 30°C, whereas for appropriate seed emergence the optimal temperature is between 25–33°C. Soybeans require low water input; rainfall levels of 500–850 mm during the growing season are good. Depending on the variety and growing conditions, soybeans can mature between 65 and 150 days after planting. This crop that offers an important source of proteins and oil (an average protein content of 40 percent and oil content of 20 percent). Like most food crops grown in Africa, the production of soybeans is mainly rain-fed and often grown by small-scale farmers on small land areas and in various mixed cropping systems. The lack of varieties with tolerance to water stress and high yielding varieties tolerant to low phosphorus in soil are among the most significant abiotic constraints.

Table1on the following page provides a summary of climate change impacts on the six key crops. Section 2.0 provides detailed information on potential climate change impacts on crop yield and the prevalence of pests and diseases. The potential climate change impact on each crop is described in two parts: The first describes the potential influence of posited changes in rainfall and temperature on the success of each vegetative and reproductive stage; the second shows the how the same changes in climate may influence the ability of diverse pests and diseases to infest or infect select crops at their different phenological stages.

It is noted that the conclusions are subject to the limitations described in Section 1.1 "Methodology, Assumptions, and Constraints."

TABLE 1. SUMMARY OF CLIMATE CHANGE IMPACTS ON SIX CROPS

Maize	
Impact on maize productivity	High to very high potential for decrease in productivity, both reproductive and vegetative stages can be impacted by extreme temperature and rainfall variations. Combination of extreme heat and long droughts can significantly impact plant development.
Termites *Microtermes sp. and others*	Moderate to high potential for increase in prevalence, particularly under warmer than normal temperatures and decreased rainfall scenarios.
Gray Leaf Spot *Cercospora zeae-maydis*	High potential for increased prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
Turcicum Leaf Blight *Exserohilum turcicum*	Moderate to high potential for increased prevalence, particularly under increased rainfall and cooler than normal temperature scenarios.
Maize Streak Virus	Moderate to high potential for increase in prevalence, particularly under decreased rainfall scenarios and warmer than normal temperatures which promotes higher vector incidence. Outbreaks of maize streak have been associated with drought and irregular rain.
Sorghum	
Impact on sorghum productivity	Moderate potential for decrease in productivity, particularly during seed germination and initiation as well as 3-and 5-leaf stages and root growth. It shows good adaptability in later reproductive stages.
Covered smut (*Sphacelotheca sorghi*) and loose smut (*S. cruenta*)	Moderate potential for increased prevalence, particularly sensitive to water availability and will possibly decrease in prevalence under warmer than normal conditions
Spotted Stemborer *Chilo partellus*	Moderate to high potential for increased prevalence, particularly under decreased rainfall and warmer than normal temperature scenarios.
Rust *Puccinia purpurea*	Moderate to high potential for increased prevalence, particularly in vegetative stages and under increased rainfall and warmer than normal temperature scenarios.
Sorghum Aphid *Melanaphis saccari*	Moderate potential for increased prevalence, particularly sensitive to water availability and will possibly decrease in prevalence under warmer than normal conditions.
Anthracnose *Colletotrichum graminicola*	High potential for increased prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
Groundnuts	
Impact on groundnut productivity	High potential for decrease in productivity under variable precipitation and temperature scenarios. Different developmental stages at both vegetative and reproductive phases can be affected.
Yellow Witchweed *Alectra vogeli*	Moderate to high potential for increase in prevalence, particularly under warmer than normal temperatures and decreased rainfall scenarios. Yield losses may range from 41% to total crop lost.
Groundnut rosette virus (GRV)	Moderate to high potential for increase in prevalence, particularly under decreased rainfall scenarios and warmer than normal temperatures which promotes higher vector incidence. It can cause losses of up to 90%.
Web Blotch *Phoma arachidicola*	Moderate to high potential for increased prevalence, particularly under increased rainfall and cooler than normal temperature scenarios.

Pigeon peas	
Impact on pigeon pea productivity	Slight to moderate potential for decrease in productivity. Seed yield that includes grain filling, maturity and ripening are reported to be sensitive to drought.
Root-Knot Nematode *Meloidogyne javanica*	Moderate to high potential for increased prevalence, particularly under decreased rainfall and warmer than normal temperature scenarios. Nematodes are found in warmer and drier soils.
Fusarium Wilt *Fusarium udum*	Moderate potential for increased prevalence, particularly under increased rainfall and warmer than normal temperature scenarios. This is the most prevalent and destructive disease of pigeon pea, affects reproductive and vegetative stages.
Leaf spots, stem canker *Xanthomonas campestris pv cajani*	High potential for increased prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
Cowpeas	
Impact on cowpea productivity	Slight to moderate potential for decrease in productivity, critical stages are emergence, seedling growth and root development. Cowpea displays good adaptability in reproductive stages.
Pod Borer, Cowpea Caterpillar *Maruca vitrata*	Moderate to high potential for increased prevalence, particularly under increased rainfall and warmer than normal temperature scenarios. Adults are most active during the rainy season.
Root-Knot Nematode *Meloidogyne javanica*	Moderate to high potential for increased prevalence, particularly under decreased rainfall and warmer than normal temperature scenarios. Nematodes are found in warmer and drier soils.
Soybeans	
Impact on soybean productivity	Slight to very slight potential for decrease in productivity. Most stages in both reproductive and vegetative phases appear to have enough adaptability for changes in temperature and rainfall. Inflorescence and floral development can be critical stages.
Soybean Rust *Phakopsora pachyrhizi*	High potential for increased prevalence, particularly under increased rainfall and warmer than normal temperature scenarios. It is the most destructive foliar disease of soybean; affects all stages of crop development.
Root-Knot Nematode *Meloidogyne mayaguensis*	High potential for increased prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.

2.0 POTENTIAL IMPACTS ON YIELD AND THE PREVALENCE OF PESTS AND DISEASES

Please use the following legend for each of the Phenological Stages tables in this section.

LEGEND

+	Favorable conditions expected to increase productivity of crops; increase pest/disease attacks on crops
0	Little or no influence or impact expected
-	Non-favorable conditions expected to decrease productivity of crops; decrease pest/disease attacks on crops

2.1 MAIZE

MAIZE																								
	Vegetative Stages								Reproductive Stages															
Phenological Stages	Germination and emergence				Leaf development, stem elongation				Inflorescence development				Flowering, anthesis				Development of fruit, grain development, milking				Ripening, Senescence and Harvesting			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal condition	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
Impact on maize productivity [1]	+	-	-	-	+	-	-	+	+	-	-	0	-	-	-	0	+	-	-	-	+	-	-	0

[1] Climate projections indicate that mean annual temperature is projected to increase by between 1.2 and 2.5°C or between 1.1 to 3.0°C by the 2060s (using two different climate models). Projections of mean rainfall do not indicate substantial changes in annual rainfall. However, the range of projections from different models is large and includes both negative and positive changes (-13% to +32%). Seasonally, the projections tend towards decreases in dry season rainfall and increases in wet season rainfall.

MAIZE PESTS AND DISEASES																								
	Germination and emergence				Leaf development, stem elongation				Inflorescence development				Flowering, anthesis				Development of fruit, grain development, milking				Ripening, Senescence and Harvesting			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal condition	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
MAIZE PESTS																								
Larger Grain Borer *Prostephanus truncatus*[2]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0	+	+	0
Spotted stemborer *Chilo partellus*	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0
Maize weevil *Sitophilus zeamais*[3]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	+	+	-	-	+	+	-
Angoumois Grain Moth *Sitotroga cerealella*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0

2 Both adults and larvae feed internally on maize grains and an infestation can start in the field.

3 Breeding conditions require temperatures between 15 and 34° C and 40% relative humidity.

Stem Borer *Busseola fusca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	+	+	-	-	+	+	-
Pink Stem Borer *Sesamia calamistis*[4]	0	0	0	0	0	0	0	0	-	+	+	-	-	+	+	-	-	+	+	-	-	+	+	-
Termites *Microtermes sp., Macrotermes sp., Allodontermes spp.,Odontotermes spp)*[5]	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0
Striga Weed *Striga asiatica*	+	0	+	0	+	-	+	0	+	0	+	0	0	+	+	0	0	+	+	0	+	0	0	+
VIRAL DISEASSES																								
Maize Streak Virus[6]	+	-	+	0	+	-	+	0	+	-	+	-	+	-	0	0	+	-	0	0	+	0	+	0
FUNGAL DISEASES																								
Sorghum downy mildew *Peronosclerospora sorghi*	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Turcicum Leaf Blight *Exserohilum turcicum*	+	-	0	+	+	-	0	+	+	-	0	+	+	-	0	+	+	-	0	+	+	-	0	+
Gray Leaf Spot *Cercospora zeae-maydis*	0	0	0	0	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0

[4] This species is found in sub-Saharan Africa.

[5] Twenty-seven species of termites are known for attacking crops in Malawi. The most frequently crop attacked is maize.

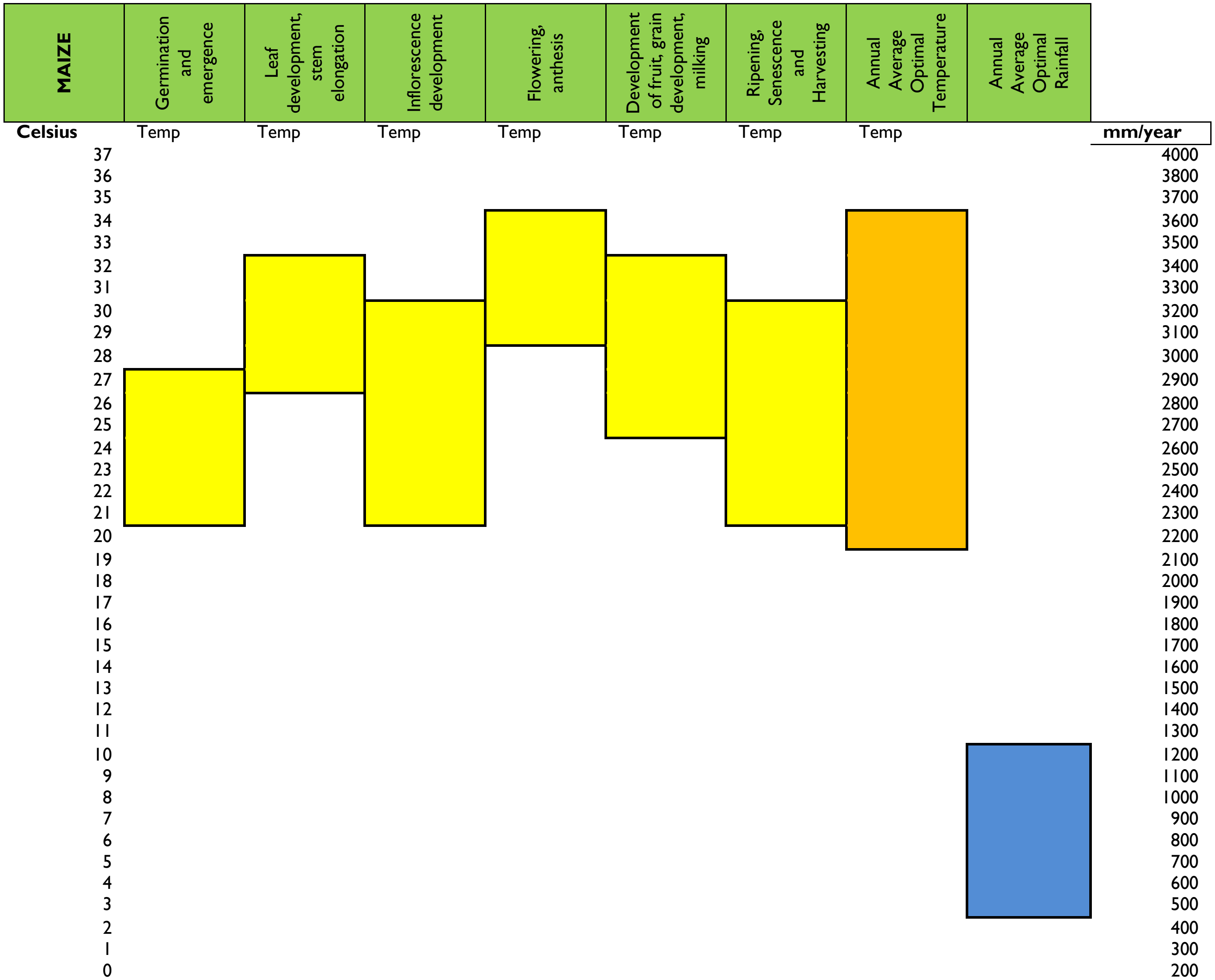
[6] Outbreaks of maize streak have been associated with drought and irregular rain.

Southern Corn Leaf Blight *Bipolaris maydis*[7]	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	0	+	0	+	0	+	0
Rust *Puccinia sorghi*[8]	0	0	0	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	0	0	0	0

[7] Seedlings from seeds infected often wilt and die within 3 to 4 weeks.

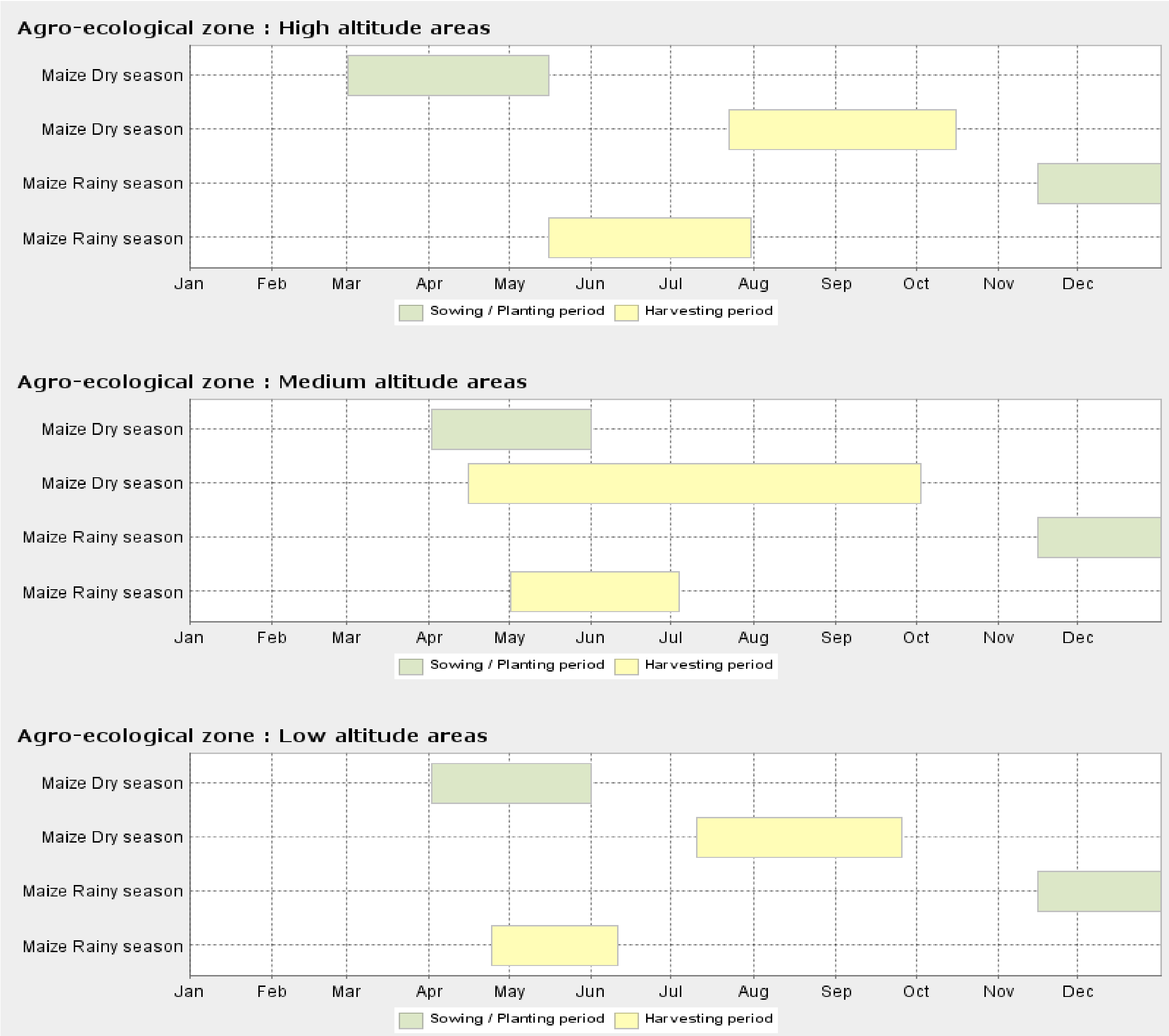
[8] Late planted maize is particularly vulnerable to rust.

2.1.1 TABLE OF OPTIMAL RANGES OF TEMPERATURES AND RAINFALL REQUIRED AT PHENOLOGICAL STAGES OF MAIZE



- Riley (1981) Planta 151: 68-74
- Ellis RH et al (1992) Crop Science 32:1225-1232.
- Greaves (1996) Journal of Experimental Botany 47 (296): 307-323
- Brown DM (1977) . Agrometeorology of the Maize . World Met Org, Switzerland. No. 481, pp. 15--26

2.1.2 MAIZE: AGRONOMIC CALENDAR FOR PLANTING AND HARVESTING IN MALAWI



Source: FAO Crop Calendar - http://www.fao.org/agriculture/seed/cropcalendar/welcome.do

2.2 SORGHUM

SORGHUM[9]																								
	Vegetative Stages												Reproductive Stages											
	Seed Germination and Initiation				Emergence and Seedling Growth.				3-and 5-leaf Stages. Root Growth				Growing Point Differentiation and Floral initiation				Culm elongation, bloom stage and Soft-Dough Stage				Hard-Dough Stage and Physiological Maturity			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal condition[10,11]	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
Impact on sorghum productivity[12,13]	+	0	-	-	+	0	-	0	0	-	-	0	+	0	0	0	0	0	-	0	0	0	-	0

9 Lower Shire Valley (in Southern Malawi) is the main sorghum producing area in Malawi. In that region the rainfall is lower than the rest of the country. Though its production is not significant, sorghum has a high value in drought-prone areas as it can grow in areas that receive less than 650 mm of annual rainfall.

10 Climate projections indicate that mean annual temperature is projected to increase by between 1.2 and 2.5°C or between 1.1 to 3.0℃ by the 2060s (using two different climate models). Projections of mean rainfall do not indicate substantial changes in annual rainfall. However, the range of projections from different models is large and includes both negative and positive changes (-13% to +32%). Seasonally, the projections tend towards decreases in dry season rainfall and increases in wet season rainfall.

11 In past two decades the Shire Valley has experienced significant weather fluctuations ranging from severe drought conditions (1991-1992) to severe flooding conditions (2000-2001)

12 Sorghum is a low yielding crop in Malawi, almost one third of that of maize.

13 It is not a favorite staple crop, falls behind maize and rice.

SORGHUM PESTS AND DISEASES																								
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal condition	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
SORGHUM PESTS																								
Spotted Stemborer *Chilo partellus*[14]	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0
Striga Purple witchweed *Striga hermonthica*[15]	+	0	+	0	+	-	+	0	+	0	+	0	0	+	+	0	0	+	+	0	+	0	0	+
Sorghum Aphid *Melanaphis saccari*[16]	0	0	0	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0
Lesser Grain Borer *Rhyzopertha dominica*[17]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0
Angoumois Grain Moth *Sitotroga cerealella*[18]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0

14 Wind velocity has significant positive correlation with infestation.

15 hermonthica occurs in general under conditions of low fertility.

16 Heavy infestations on sorghum at the booting and heading stages critically reduce both grain quality and yield.

17 Infestations of *R. dominica* adversely affects quantity and quality of stored seed.

18 It can cause losses of up to 50% during storage.

FUNGAL DISEASES																								
Sorghum downy mildew *Peronosclerospora sorghi*[19]	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0
Anthracnose *Colletotrichum graminicola*[20]	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0
Covered kernel smut *Sporisorium sorghi*[21,22]	+	-	+	-	0	0	0	0	0	0	0	0	+	-	+	0	+	-	+	0	+	-	+	0
Rust *Puccinia purpurea*[23]	0	0	0	0	0	0	0	0	0	0	0	0	+	-	+	0	+	-	+	0	+	-	+	0
Leaf blight *Helminthosporm turcicum*[24]	+	-	+	0	+	-	+	0	+	0	+	0	+	0	+	0	0	0	0	0	0	0	0	0
Grey Leaf Spot Cercospora sorghi[25]	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0
Sooty stripe *Ramulispora sorghi*	+	-	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0

19 Require warm temperatures and high humidity to develop. Found at all stages of growing.

20 Rain splash can disperse spores within crop canopy. Pathogen persists on and in seed, crop residues. Not as prevalent as mildew.

21 Caution must be taken at harvest time since galls are broken and spores can contaminate the outer surface of other kernels.

22 Once inside the seedling, the fungus grows systemically, apparently without damaging the plant until heading development.

23 Rust control is achieved primarily by cultivating resistant varieties.

24 Under warm, humid conditions disease may cause serious damage by killing all leaves before plants have matured.

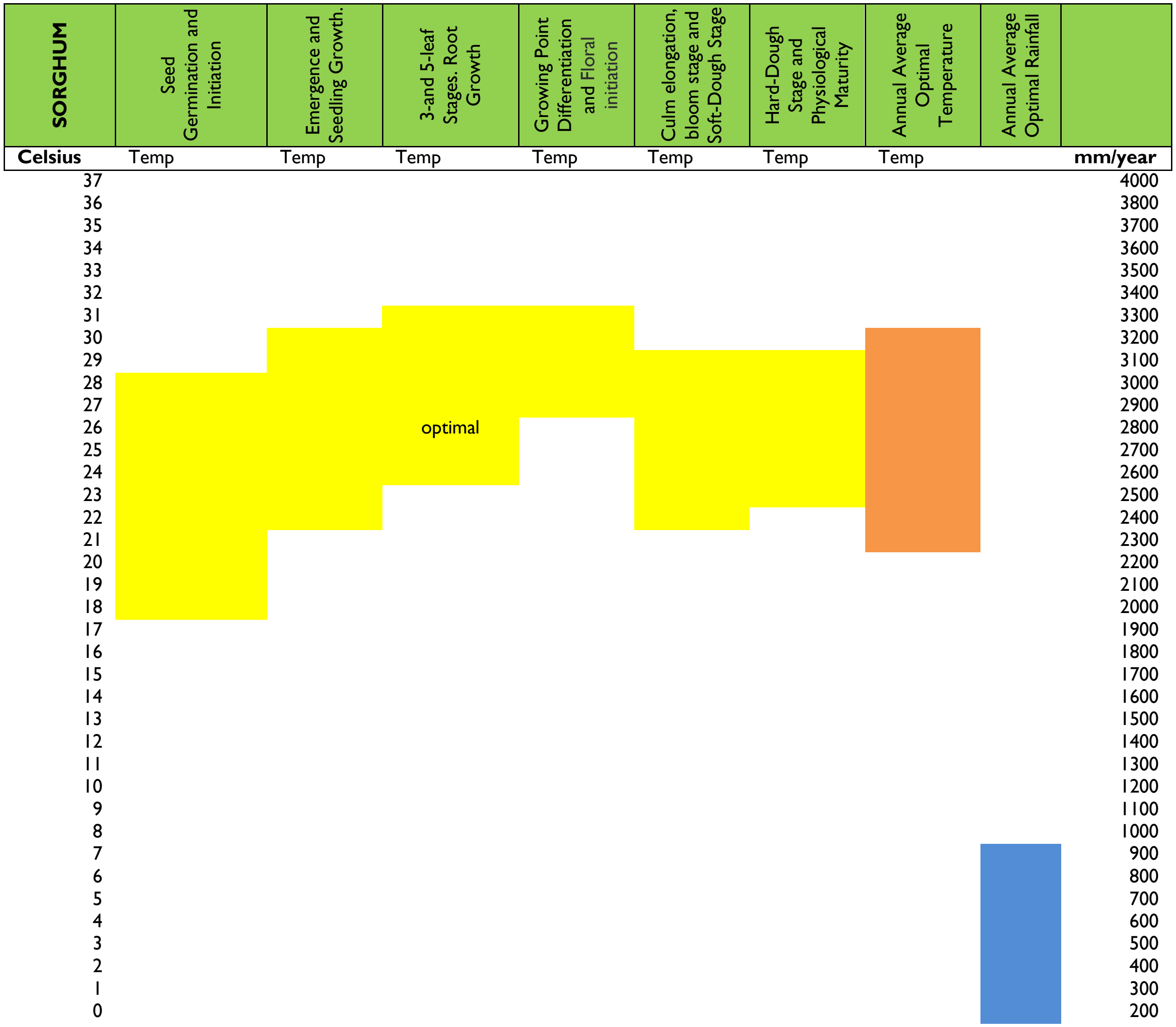
25 Yield losses of up to 67% have been recorded in some susceptible cultivars.

Zonate Leaf Spot *Gloecercospora sorghi*[26]	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0
Rough Leaf Spot *Ascochyta sorghi*[27]	0	0	0	0	+	-	+	-	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0
Oval Leaf Spot *Ramulispora sorghicola*	+	-	+	-	+	-	+	-	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0

[26] Temperatures ranging from 28 to 32^{0}C are ideal.

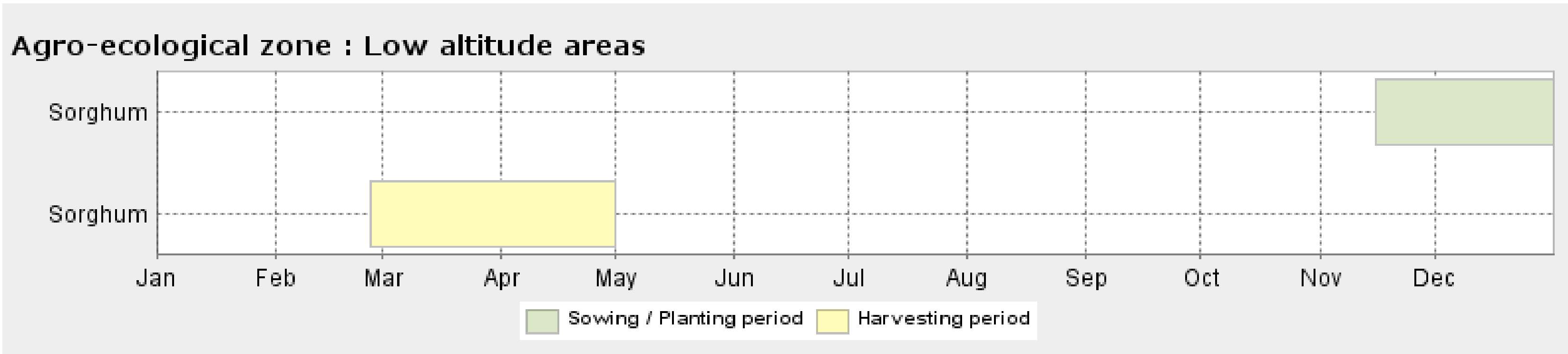
[27] This is more important on sweet sorghum varieties.

2.2.1 TABLE OF OPTIMAL RANGES OF TEMPERATURES AND RAINFALL REQUIRED AT PHENOLOGICAL STAGES OF SORGHUM



- du Plessis J (2008) Sorghum Production. Republic of South Africa, Dept. of Agriculture
- Prasad et al. (2008) Crop Sci. 48:1911–1917.
- Peacock (1982) ICRISAT Sorghum in the Eighties: Proc of the International Symposium on Sorghum. 2-7 Nov 81.
- Wortman et al (2008) The Atlas of Sorghum Production in Eastern and Southern Africa. PR189, USAID

2.2.2 SORGHUM: AGRONOMIC CALENDAR FOR PLANTING AND HARVESTING IN MALAWI



Source: FAO Crop Calendar - http://www.fao.org/agriculture/seed/cropcalendar/welcome.do

2.3 GROUNDNUTS

GROUNDNUTS[28,29]																								
	Vegetative Stages												Reproductive Stages											
	Germination and Seedling Emergence				Stem elongation and Root Development				Stem Growth and Leaf Development				Inflorescence Emergence				Flowering				Pod/Seed Ripening and Harvest			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal condition	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased[30]	Warmer than normal[31]	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
Impact on groundnut productivity [32]	+	-	0	0	0	-	-	-	0	-	-	0	-	0	-	-	0	-	-	-	0	-	-	-

28 Groundnuts are grown in all parts of Malawi. Rainfall is quite important since many of the areas of cultivation for this crop are rainfed.

29 Ong CK (1986) Agrometereology of Groundnuts. Proc of an Internat Symp. Aug 21-26, 1985. ICRISAT, India.

30 Severe water deficit can delay onset of flowering and rapid pod growth.

31 Pollen death is reported to occur at 33°C.

32 Climate projections indicate that mean annual temperature is projected to increase by between 1.2 and 2.5°C or between 1.1 to 3.0 ̊C by the 2060s (using two different climate models). Projections of mean rainfall do not indicate substantial changes in annual rainfall. However, the range of projections from different models is large and includes both negative and positive changes (-13% to +32%). Seasonally, the projections tend towards decreases in dry season rainfall and increases in wet season rainfall.

GROUNDNUTS PESTS AND DISEASES																								
	Germination and Seedling Emergence				Stem elongation and Root Development				Stem Growth and Leaf Development				Inflorescence Emergence				Flowering				Pod/Seed Ripening and Harvest			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal condition	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
Yellow Witchweed *Alectra vogelii*[33]	+	-	+	-	+	-	+	-	+	-	+	-	+	0	+	0	0	0	0	0	0	0	0	0
Peanut Pod Nematode *Ditylenchus africanus*[34]	+	0	+	0	+	0	+	0	0	0	+	0	0	0	+	0	0	0	+	0	0	0	0	0
FUNGAL DISEASES																								
Aspergillus flavus[35]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	+	+	0	0	+
Late Leafspot *Cercosporidium personatum*[36] [37]	0	0	0	0	0	0	0	0	+	-	+	-	+	-	+	-	+	0	+	0	0	0	0	0

33 Yield losses may range from 41% to total crop lost.

34 Affects the yield of peanut seeds by increasing premature germination.

35 *A. flavus* is likely to thrive in hot and dry climates. Drought and high temperatures increase severity of the disease.

36 Cause defoliation, reduced yield, and increased incidence of certain soilborne diseases.

37 Environmental conditions required for both types of leafspot are warm temperatures and long periods of high humidity or leaf wetness.

Groundnut Rust *Puccinia arachidis*[38]	0	0	0	0	+	-	+	-	+	-	+	-	+	-	+	-	0	0	0	0	0	0	0	0
Leaf Scorch *Leptosphaerulina crassiaca*[39]	0	0	0	0	+	-	-	+	+	-	-	+	+	0	0	+	+	0	0	+	+	0	0	+
Web Blotch *Phoma arachidicola* [40]	0	0	0	0	+	-	-	+	+	-	-	+	+	0	0	+	+	0	0	+	+	0	0	+
Anthracnose *Colletotrichum sp.*[41]	0	0	0	0	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	0	0	0	0
Early Leaf Spot *Cercospora arachidicola*[42]	0	0	0	0	0	0	0	0	+	-	+	-	+	-	+	-	+	0	+	0	0	0	0	0
VIRAL DISEASES																								
Groundnut rosette virus (GRV)[43]	0	0	0	0	0	0	0	0	-	+	+	-	-	+	+	-	-	+	+	-	0	0	0	0
Sunflower Yellow Blotch Umbravirus[44]	0	0	0	0	0	0	0	0	-	+	+	-	-	+	+	-	-	+	+	-	0	0	0	0

38 Rain promotes infection of this pathogen.

39 Common during late growing season when air temperatures are cooler.

40 Sometimes develops interaction with *Cercospora.*

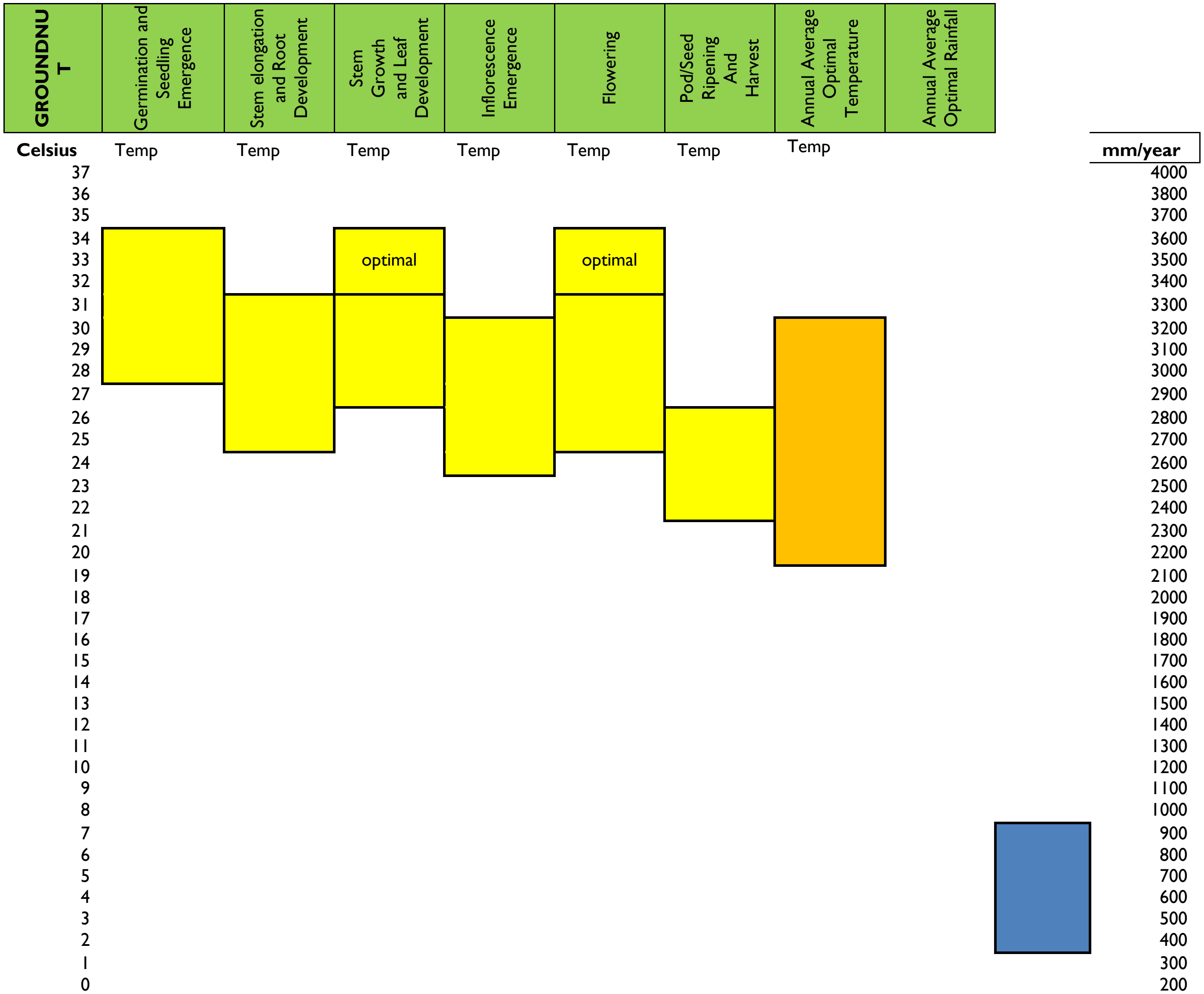
41 *Colletotrichum* can affect stem tips causing die back and stem lesions.

42 Spots first appear on the upper surface of lower leaves.

43 Groundnut Rosette is the most serious virus disease in Malawi, it can cause losses of up to 90%.

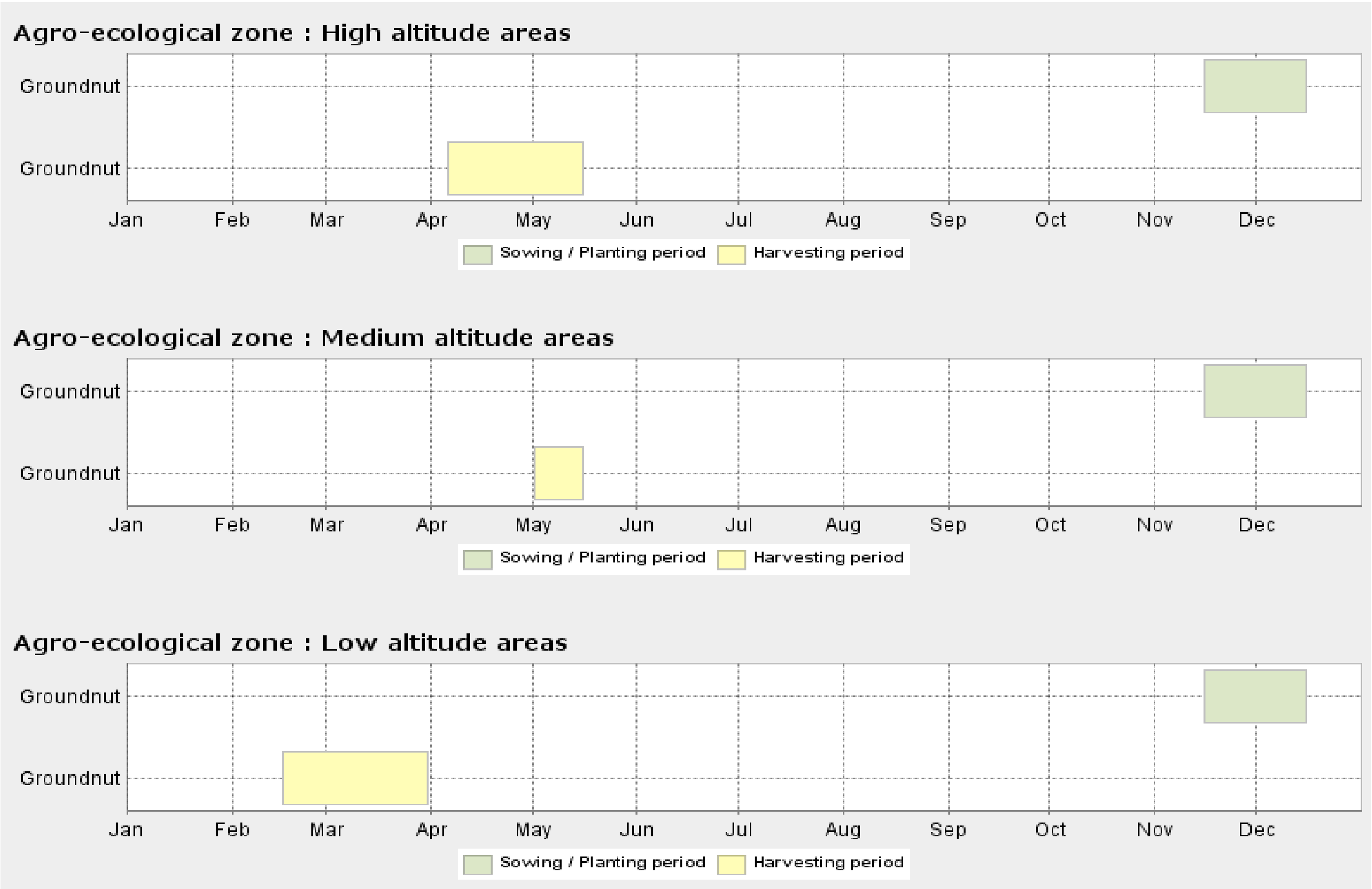
44 Infestation of aphids correlates with virus infection.

2.3.1 TABLE OF OPTIMAL RANGES OF TEMPERATURES AND RAINFALL REQUIRED AT PHENOLOGICAL STAGES OF GROUNDNUTS



- Ong (1986) Agriclimatological factors affecting phenology of groundnuts. ICRISAT, India
- AJ Cilliers Groundnut Production. A concise guide. ARC Grain Crops Institute
- Ketring and Wheless (1989) Agronomy Journal 81 (6): 910-917.

2.3.2 GROUNDNUTS: AGRONOMIC CALENDAR FOR PLANTING AND HARVESTING IN MALAWI



Source: FAO Crop Calendar - http://www.fao.org/agriculture/seed/cropcalendar/welcome.do

2.4 PIGEON PEAS

PIGEON PEAS

	Vegetative Stages											
	Sowing and Germination				Emergence				Plant growth and maturation			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal conditions [46]	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
Impact on pigeon pea productivity	+	0	+	-	+	0	+	-	+	0	0	0

	Reproductive Stages											
	Floral Initiation and Flowering				Grain Filling				Maturity and Harvest Ripe[45]			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal conditions [46]	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
Impact on pigeon pea productivity	0	0	0	0	0	-	0	-	0	-	0	-

[45] Seed yield is more sensitive to drought during the reproductive compared to the vegetative growth stage.

[46] Climate projections indicate that mean annual temperature is projected to increase by between 1.2 and 2.5°C or between 1.1 to 3.0℃ by the 2060s (using two different climate models). Projections of mean rainfall do not indicate substantial changes in annual rainfall. However, the range of projections from different models is large and includes both negative and positive changes (-13% to +32%). Seasonally, the projections tend towards decreases in dry season rainfall and increases in wet season rainfall.

PIGEON PEA PESTS AND DISEASES																								
	Sowing and Germination				Emergence				Plant growth and maturation				Floral Initiation and Flowering				Grain Filling				Maturity and Harvest Ripe			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal condition	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
PIGEON PEA PESTS																								
Pod Borer *Helicoverpa armigera* [47]	-	+	+	0	-	+	+	0	-	+	+	0	-	+	+	0	-	+	+	0	-	+	+	0
Bean Pod Borer, Legume Pod Borer, Spotted Pod Borer *Maruca testularis*[48]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	+	0	+	0	+	0
Pea Blue Butterfly *Lampides boeticus, Catochrysops strado*[49]	0	0	0	0	0	0	0	0	0	0	0	0	+	0	+	0	+	0	+	0	+	0	+	0
Thrips Megalurothrips spp[50]	0	0	0	0	0	0	0	0	0	0	0	0	-	+	+	0	-	+	+	0	-	+	+	0

[47] It is the most important biotic constrain for pigeon peas worldwide.

[48] The borer can infest many alternate hosts.

[49] Risk of infestation is higher in long droughts.

[50] It causes extensive destruction before flowers are produced by feeding on floral buds.

Blister beetle, orange blister beetle [51] *Mylabris pustulata*	0	0	0	0	0	0	0	0	0	0	0	0	-	+	-	-	-	+	-	-	-	+	-	-
Pod Fly *Melanagromyza obtuse*[52]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	+	-	+	-	+	-	+
Sucking Bugs [53, 54]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	0
Cutworms *Agrotis spp*[55]	0	+	-	-	0	+	-	-	0	+	-	-	0	+	-	-	0	+	-	-	0	+	-	-
Jassid Leafhopers *Empoasca kerri*[56]	+	-	-	+	+	-	-	+	+	-	-	+	+	-	-	+	+	-	-	+	+	-	-	+
Aphids *Aphis craccivora*[57]	0	0	0	0	0	0	0	0	-	+	0	+	-	+	0	+	-	+	0	+	-	+	0	+
Mites *Aceria cajani*	0	0	0	0	-	+	+	0	-	+	+	0	-	+	+	0	-	+	+	0	0	0	0	0
***Bemisia* whitefly** *Bemisia tabaci*[58]	0	0	0	0	0	0	0	0	-	+	+	0	-	+	+	0	-	+	+	0	0	0	0	0

51 Rainfall may wash some insects from the plants. Temperature and light intensity influence flight.

52 Responsible for some of the major damage to the pods.

53 Sucking bugs include Anoplocnemis spp, Clavigralla spp), Riptortus spp and Nezara viridula.

54 Periods of drought can trigger infestation by these bugs.

55 Eaton Eat plants soon after germination at ground levels.

56 Damage signs include yellowing at the edges of leaves.

57 They transmit viral mosaic diseases.

58 Responsible of transmitting viral diseases.

Root-Knot Nematode *Meloidogyne javanica*[59]	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0
Root knot nematodes *Meloidogyne spp*	-	+	+	-	0	+	+	-	0	+	+	-	0	+	+	-	0	+	+	0	0	+	+	0
Scales *Icerya purchasi*[60]	-	0	+	-	-	0	+	-	-	0	+	-	-	0	+	-	-	0	+	-	0	0	0	0
Weevils [61] *Myllocerus undecimpustulatus*	0	0	0	0	0	0	0	0	-	+	+	-	-	+	+	-	-	+	+	-	0	0	0	0
Termites[62] *Microtermes., Ancistrotermes, Trinervitermes Macrotermes Odontotermes*	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0
FUNGAL DISEASES																								
Fusarium wilt *Fusarium udum*[63]	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	0	0	0	0
BACTERIAL DISEASES																								

[59] In Malawi, *M. javanica* is the predominant nematode and is found in warmer and drier soils.

[60] Scales suck fluids in the stems.

[61] The larvae of this weevil burrow in the soil.

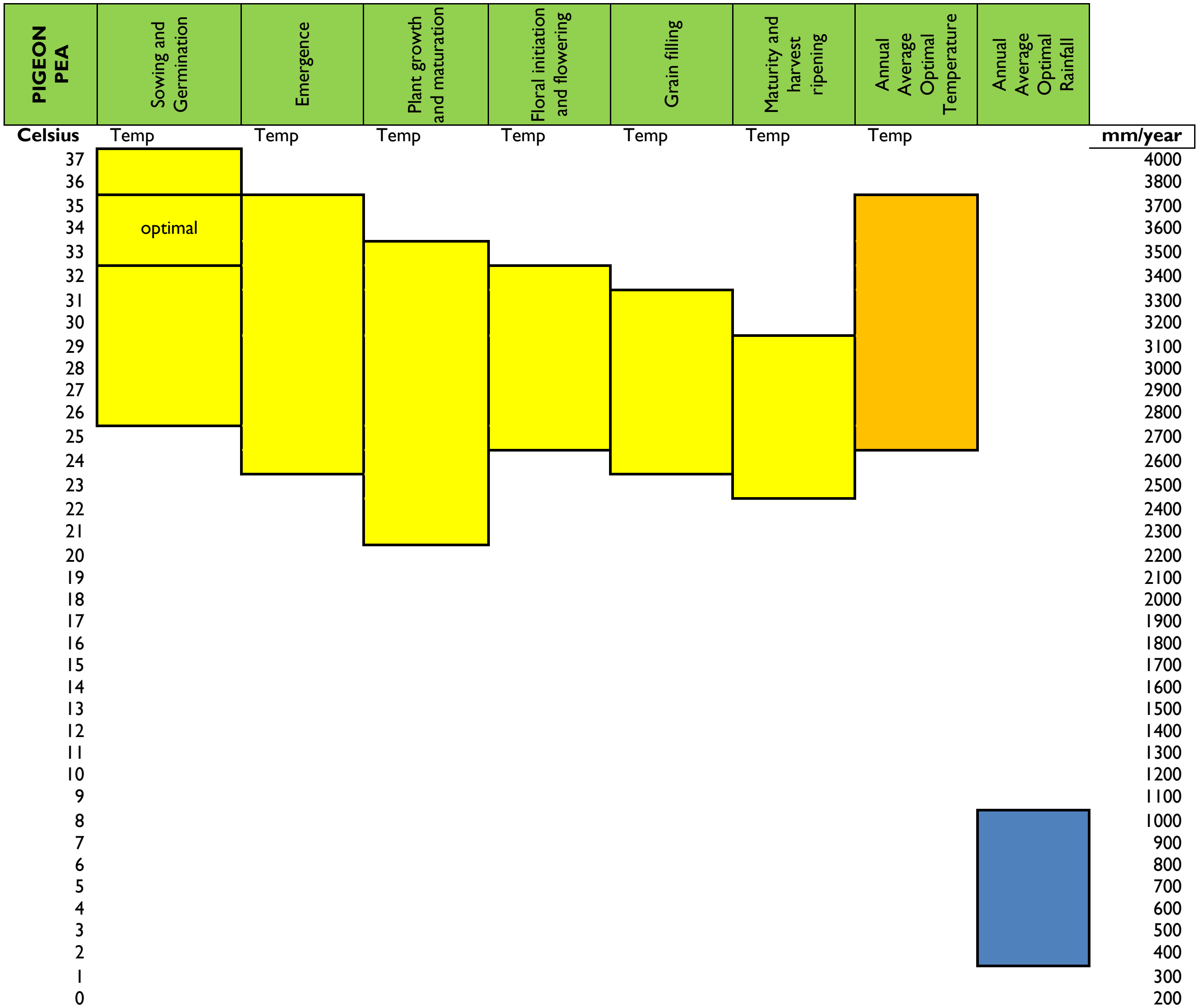
[62] Serious damage is sometimes seen during dry periods or low humidity.

[63] The most prevalent and destructive disease of pigeon pea, yield losses as high as 50-100%.

Leaf spots, stem canker Xanthomonas campestris pv cajani[64]	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-

64 Incidence is higher in low-lying areas

2.4.1 TABLE OF OPTIMAL RANGES OF TEMPERATURES AND RAINFALL REQUIRED AT PHENOLOGICAL STAGES OF PIGEON PEAS



- Nene et al (Eds) (1990) The Pigeonpea. (CAB International Crops Research Institute for Semi-Arid Tropics, India).
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- Agrawal SC (2003) Disease of Pigeonpeas. AK Mittal (ed). Concept Pub Company. India
- Omanga and Summerfield (1995) Field Crops Research 41: 25-34.

2.4.2 PIGEON PEAS: AGRONOMIC CALENDAR FOR PLANTING AND HARVESTING IN MALAWI

Source: FAO Crop Calendar - http://www.fao.org/agriculture/seed/cropcalendar/welcome.do

2.5 COWPEAS

COWPEAS[65, 66]																								
	Vegetative Stages												Reproductive Stages											
	Emergence and Seedling Growth. Root Development				Leaf development and vine growth				Primary branches development				Inflorescence Development, pre-flowering and Flowering				Pod formation				Grain maturation and harvest			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal condition[67]	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal[68]	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
Impact on cowpea productivity	+	-	-	0	0	0	0	0	+	0	-	0	+	0	-	0	+	0	-	0	0	0	-	+

65 Cowpea has nfootitrogen-fixing properties for improving fertility of soil, so it is good for intercropping. A mean temperature of 27^0C is optimum for good pod formation and seed yield. It performs better in regions with annual rainfall of 250-1000 mm (Marfo and Hall, *Crop Science* 3: 912-918, 1992).

66 Seed shape is a major characteristic correlated with seed development in the pod.

67 Climate projections indicate that mean annual temperature is projected to increase by between 1.2 and 2.5°C or between 1.1 to 3.0°C by the 2060s (using two different climate models). Projections of mean rainfall do not indicate substantial changes in annual rainfall. However, the range of projections from different models is large and includes both negative and positive changes (-13% to +32%). Seasonally, the projections tend towards decreases in dry season rainfall and increases in wet season rainfall.

68 Many cowpea genotypes exhibit heat-induced suppression of floral bud development. This damage reduces pod set, number of seeds per pod, and thus seed yield.

COWPEA PESTS AND DISEASES																								
	Emergence and Seedling Growth. Root Development				Leaf development and vine growth				Primary branches development				Inflorescence Development, pre-flowering and Flowering				Pod formation				Grain maturation and harvest			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal condition	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
COWPEA PESTS																								
Yellow Witchweed *Alectra vogelii*[69]	+	-	+	-	+	-	+	-	+	-	+	-	+	0	+	0	0	0	0	0	0	0	0	0
Cowpea aphids *Aphis craccivora*[70, 71]	0	0	0	0	0	0	0	0	+	0	+	-	+	0	+	-	+	0	+	0	0	0	0	0
White Grubs Coleoptera: Scarabaeidae[72]	+	0	0	+	+	0	0	0	+	0	0	0	+	0	0	0	+	0	0	0	+	0	0	0

69 Striga witchweed (*S. hermonthica)* is more adaptive to adverse climatic conditions of increased osmotic potential and extreme temperatures than *A. vogelii*.

70 Cowpea aphid injects a powerful toxin into the plant while feeding and, when populations are large, this can stunt or kill plants.

71 Cowpea aphids are known to transmit a number of plant viruses.

72 Infestation is more severe when relatively higher annual rainfall.

Legume Pod Borer, Cowpea Caterpillar *Maruca vitrata*[73,74]	0	0	0	0	+	-	+	-	+	-	+	-	+	-	+	-	+	0	+	0	+	0	+	0
Cowpea weevil *Callosobruchus maculatus*[75]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0	+	+	0
Root-Knot Nematode *Meloidogyne javanica*[76]	+	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0	0	+	+	0
FUNGAL DISEASES																								
Scab *Sphaceloma* **sp.**[77]	0	0	0	0	0	0	0	0	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0
Cercospora Leaf Spot *Cercospora canescens*[78]	0	0	0	0	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0
Ascochyta blight *Ascochyta phaseolorum*[79]	0	0	0	0	+	-	+	-	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0
VIRAL DISEASES																								

73 Adults are most active during the rainy season.

74 This is the most important pod borer pest, causing severe damage to cowpeas.

75 It is the most common and widespread insect pests in storage.

76 In Malawi, M. javanica is predominant and is found in warmer and drier soils.

77 Many successive days of wet weather are ideal for the disease.

78 It is widespread in regions with warmer subtropical and tropical climate.

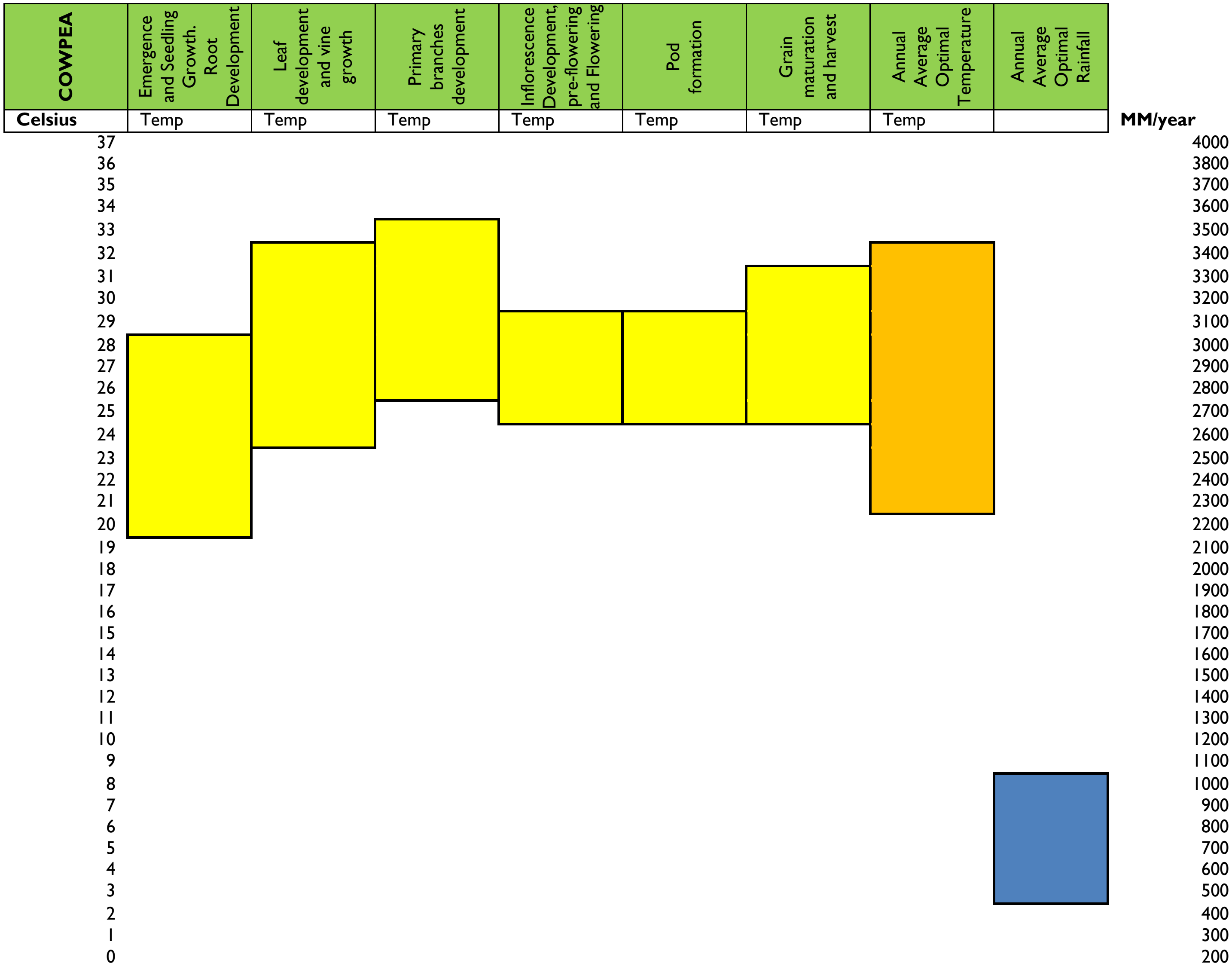
79 Severe epidemics occur mostly at medium elevations (500-1200 m).

Cowpea Aphid-Borne Mosaic Virus (CABMV) Potyvirus[80,81]	0	0	0	0	0	0	0	0	+	0	+	-	+	0	+	-	+	0	+	0	0	0	0	0

80 The virus has worldwide distribution and it is considered to be a major and widespread disease of cowpea in sub-Saharan Africa.

81 *Aphis craccivora* is the most efficient vector.

2.5.1 TABLE OF OPTIMAL RANGES OF TEMPERATURES AND RAINFALL REQUIRED AT PHENOLOGICAL STAGES OF COWPEAS



- Stewart KA and RJ Summerfield (1978) Plant and Soil49: 443-448
- Warrag (1984) Field Crops Research 8: 3--16
- Ahmed et al (1992) Am Journal of Botany 79(7): 784-791
- Hall AE (1992) Plant Breeding Rev 10: 129–168.

2.5.2 COWPEAS: AGRONOMIC CALENDAR FOR PLANTING AND HARVESTING IN MALAWI

No agronomic calendar was found for cowpeas in Malawi.

2.6 SOYBEANS

SOYBEANS																								
	Vegetative Stages												Reproductive Stages											
	Seed Germination				Emergence and Seedling Growth				Plant growth and maturation				Inflorescence Development				Flowering				Pod Development and Seed Set			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature[82]		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal conditions[83]	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
Impact on soybean productivity	+	0	0	0	+	0	0	0	0	0	0	0	0	0	-	-	0	0	-	0	0	0	0	0

82 Low and high temperatures can delay flowering. Photoperiod and temperature control the duration of both pre- and post-flowering phases.

83 Climate projections indicate that mean annual temperature is projected to increase by between 1.2 and 2.5°C or between 1.1 to 3.0 ̊C by the 2060s (using two different climate models). Projections of mean rainfall do not indicate substantial changes in annual rainfall. However, the range of projections from different models is large and includes both negative and positive changes (-13% to +32%). Seasonally, the projections tend towards decreases in dry season rainfall and increases in wet season rainfall.

SOYBEAN PESTS AND DISEASES																								
	Seed Germination				Emergence and Seedling Growth				Plant growth and maturation				Inflorescence Development				Flowering				Pod Development and Seed Set			
Climatic variables	Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature		Rainfall		Temperature	
Assumed change from normal condition	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal	Increased	Decreased	Warmer than normal	Cooler than normal
Root-Knot Nematode *Meloidogyne mayaguensis*[84]	+	-	+	-	+	-	+	-	+	0	+	0	+	0	+	0	+	0	+	0	+	0	+	0
Soybean Rust *Phakopsora pachyrhizi*[85, 86]	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Soybean Mosaic Virus Gemini Virus [87]	0	0	0	0	0	0	0	0	-	+	+	-	-	+	+	-	0	0	0	0	0	0	0	0

84 Rammah, A. and H. Hirschmann (1988) Journal of Nematology20: 58-69.

85 Ramteke R et al. (2003) J Oilseeds Res 20:195–203.

86 Soybean rust is the most destructive foliar disease of soybean in recent times.

87 Symptoms can be difficult to see when temperatures are above 30°C.

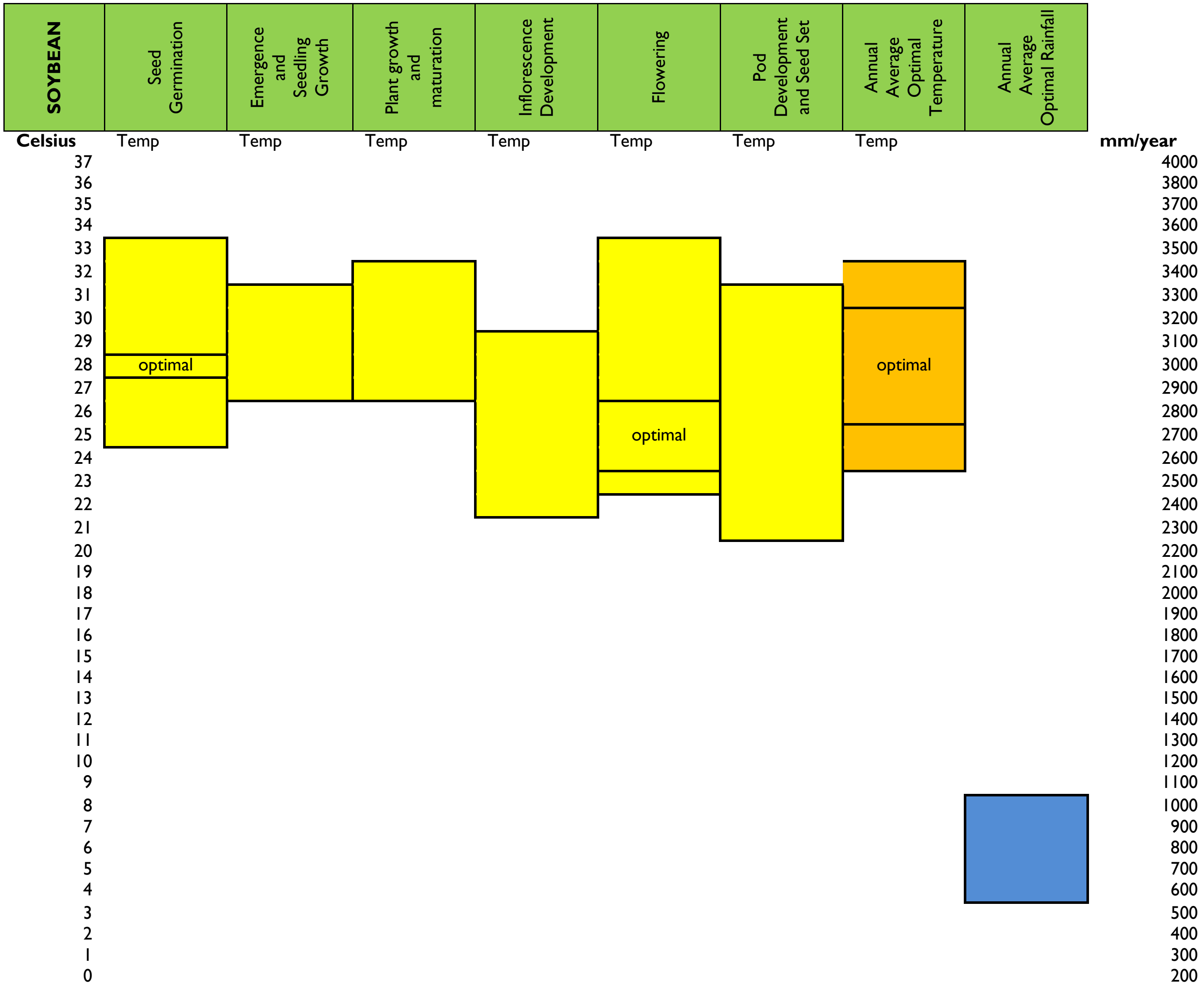
Soybean Red Leaf Blotch *Phoma glycinicola* [88,89]	0	0	0	0	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Soybean Witches-Broom Disease 16SrII Phytoplasma*[90]	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

88 Sinclair JB (1989) Plant Disease/73(7): 604-606.

89 Spread occurs when rain showers, water splash, and/or animal or human activities transport the fungal propagules between plants and fields.

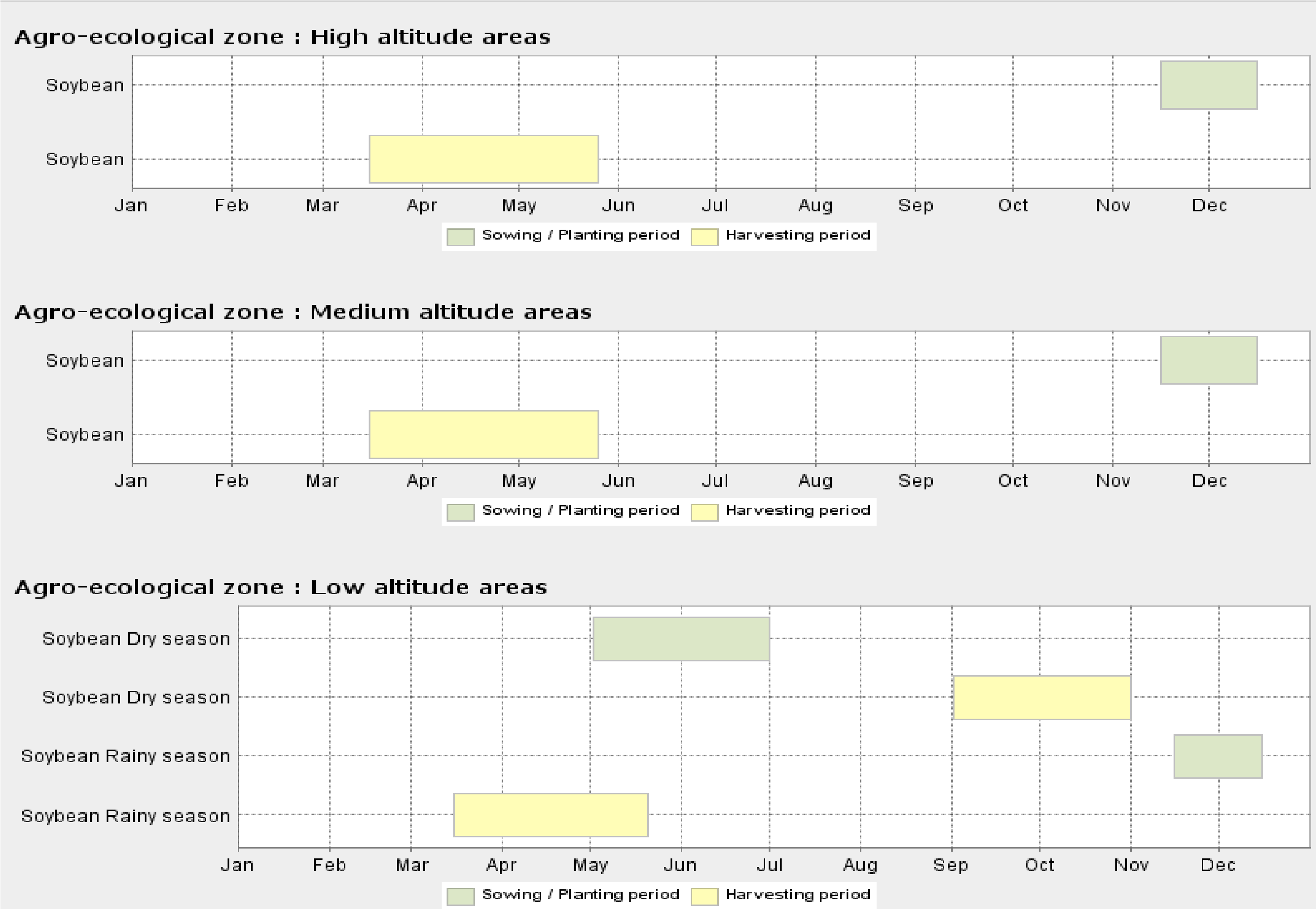
90 First time reported in Malawi, no information on factors conditioning transmission. Reported in Lava Kumar P and Sharma K (2011) Plant Disease 95(4): 492-493.

2.6.1 TABLE OF OPTIMAL RANGES OF TEMPERATURES AND RAINFALL REQUIRED AT PHENOLOGICAL STAGES OF SOYBEANS



- Kumar A et al. (2008) American-Eurasian Journal of Agronomy 1 (2): 45-50
- SK Tyagi and RP Tripathi (1983) Plant and Soil 74(2): 273-280

2.6.2 SOYBEANS: AGRONOMIC CALENDAR FOR PLANTING AND HARVESTING IN MALAWI



Source: FAO Crop Calendar - http://www.fao.org/agriculture/seed/cropcalendar/welcome.do