Urban Africa
Risk Knowledge

Karonga Climate Profile: Full Technical Version

Prepared by:

University of Cape Town

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

ACDI African Climate & Development Initiative

CSAG CLIMATE SYSTEM ANALYSIS GROUP

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

UKaid from the British people

Department for International Development

November 2017

For enquiries regarding this Climate Profile, please contact Lisa van Aardenne (lisa@csag.uct.ac.za) or Lorena Pasquini (lorena.pasquini@gmail.com)

Karonga Climate Profile

This document provides a summary of the historic climate at Karonga and how it is projected to change into the future due to anthropogenic climate change. This document is intended to be used by members of the Urban ARK project working in Karonga, another version has been created for use by stakeholders in Karonga and for dissemination to the wider community.

Historic Climate

Karonga has a sub-tropical climate, which is relatively dry and the rainfall is strongly seasonal in nature. Rainfall occurs in a single season from November - April totalling on average 1300mm/year - and there is a well-defined dry season from May to October. Temperatures are lowest during the austral winter season (May – August) with daily maximum and minimum temperatures averaging 28 °C and 17 °C respectively in July. The warmest time of the year occurs just before the core rainy season starts with average daily maximum and minimum temperatures reaching 32 °C and 21 °C respectively. Daily maximum and minimum temperatures remain relatively constant during the rainy season averaging around 30 °C and 21 °C before dropping again during winter. More details are provided Figure 1 below and Table 4 in the supplementary section.

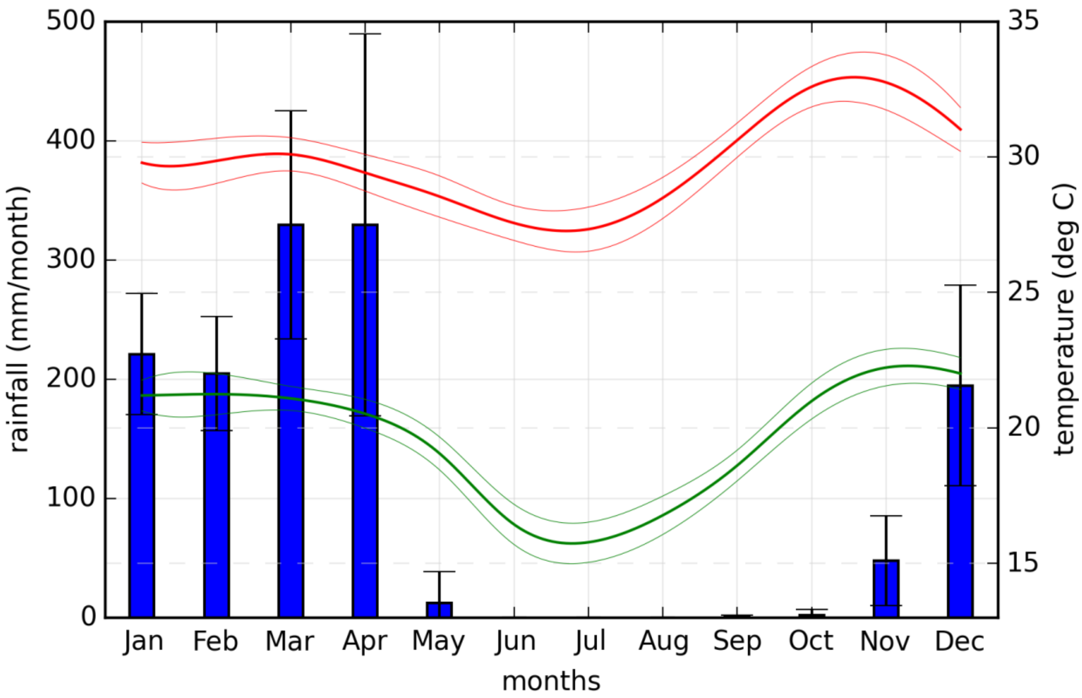

Figure 1: 1981 to 2010 Historical Average Seasonality for gridcell over Karonga. Mean monthly total rainfall (mm/month) from the CHIRPS dataset depicted as blue bars, whiskers show +- 2 standard deviations. Monthly mean daily maximum and minimum temperature from the WFDEI dataset presented by the red and green lines respectively. Dashed lines represent the +- 2 standard deviation around these means.

The climate is not static and rainfall and temperature display variability on a number of different time scales from daily to decadal. On top of this there may also be evidence of long-term trends in the climate; however it can sometimes be difficult to distinguish between a trend and variability at a longer timescale especially when only using a relatively short dataset.

Rainfall

Rainfall varies on a number of time scales from sub-daily to decadal:

Rainfall over this region shows clear diurnal variability since it is predominantly convective in nature. It occurs mostly during the late afternoon to early evening, however the lake may have an effect on the timing of the rainfall since rainfall over large water bodies often exhibit a peak during the early hours of the morning (we do not have suitable sub-daily data to explore this in this report).

The seasonal cycle of rainfall at Karonga is strong with a clearly defined wet season from December to April the following year and a dry season from July to October (Figure 1). Rainfall varies from a maximum of almost 300mm/month in March to less than 1mm/month in August and September.

Year-to-year or interannual variability is evident for rainfall (figure 2) with many years recording more than 200mm above or below the long-term average annual total amount (1300mm/season). The 1999/2000 season was dry and received just under 1000mm while a wet seasons like and 1997/98 recorded around 1900mm/season.

On multi-year to decadal time scales Karonga also experiences variability. Some of this is related to large scale remote forcings such as the El Nino Southern Oscillation (ENSO) with El Nino conditions generally being associated with below average rainfall and La Nina conditions to above average rainfall (figure 3). However the 35 years of CHIRPS data is not long enough to really explore decadal variability. Trends in rainfall statistics, such as annual total rainfall, average daily rainfall intensity, rainfall frequency, dry-spell duration etc., are not evident in the CHIRPS data over the last 35 years (figure 4).

Temperature

Temperature also shows clear variability on a range of time scales:

The diurnal temperature range – or difference between the maximum and minimum temperature within a 24-hour period – is an important mode of variability. For Karonga it averages just over 10 °C, but varies between seasons, with largest differences occurring at the end of the dry season, especially September (12 °C) and smallest differences occurring during the core rainy season (8-9 °C).

The seasonal cycles of daily maximum and minimum temperature are relatively small averaging 5.5° and 5.5 C° respectively. The warmest temperatures occur during October – November (~32.5 C°) for maximum temperature and from December – March (~21 °C) for minimum temperature. The coolest daily maximum and minimum temperatures occur during the dry winter season (~27 C° and 16 °C) (figure 1).

Temperatures show little interannual variability, with annual average daily maximum and minimum temperatures generally varying by less than half a degree from year to year. The variability for a specific month or season is generally larger than that for annual average temperature varying by as much as 1 °C from the long term mean. This is often linked to the ENSO signal with warmer temperatures generally being associated with El Nino conditions and cooler temperatures being associated with La Nina conditions. See figure 3 for further details.

Focussing on the longer-term multi-decadal timescale, Karonga shows a slight positive trend in daily maximum temperature throughout the year, but the trend is only statistically significant during the cooler dry season (May-August) and the hottest time of year (September-December) (+0.2 °C per decade)(figure 5). Extreme hot days (days where the temperature exceeds 33.2 °C) generally occur from October through to December. These daytime hot events have seen a clear and statistically significant increase in their frequency (+7.9 days/decade) and duration (0.1 days/decade), especially during the 1990s, though this increasing trend is not seen in the last 10 years (figure 6).

Average night-time temperatures also show a similar warming trend to that of day-time temperatures. Again the trends are strongest and are statistically significant outside of the rainy season (figure 7). Extreme warm nights (tmin>23.4°) generally occur from November – January and there has been a very clear increase in the frequency (+9 days per decade) and duration (+0.2 days per decade) and these events occur later within the season (figure 8).

Table 1 below provides a summary of the trends in key temperature and rainfall attributes for Karonga.

Table 1: Summary of the mean and trends in temperature and rainfall attributes, Karonga. The long-term mean value or threshold (1981-2010) is provided along with the Theil-Sen linear trend slope (per decade) (in brackets). The rainfall is from the CHIRPS dataset and the temperatures are from the WFDEI dataset. Values in bold indicate a statistically significant change.

Temperature	**Jan – Apr**	**May - Aug**	**Sep - Dec**
Tmax / [°C/decade]	29.8 (no trend)	28.0 (**+0.2**)	31.7 (**+0.2**)
Tmin / [°C/decade]	21.0 (**+0.1**)	17.0 (**+0.2**)	21.0 (**+0.2**)
	Annual (July – June)		
Tmax extreme hot events [days]	Threshold: 33.6°C (Frequency: **+7.9** Duration: **+0.1**)		
Tmin extreme hot events [days]	Threshold: 22.5°C (Frequency: **+9.1** Duration: **+0.2**)		
Rainfall	**Annual (July – June)**		
Total rainfall [mm/decade]	1327 (-3.6)		
Rain intensity [mm/day]	14.7 (+0.7)		
Rain day frequency [days/decade]	99 (no trend)		
Heavy rain day frequency [days/decade]	48 (-0.9)		
Wet spell [consecutive days]	2.3 (+0.1)		
Dry spell [consecutive days]	89.6 (+2.7)		

Climate change projections

Global Climate Models

Projections of future climate, based on 15 CMIP5 GCM simulations[1] under the RCP8.5 pathway[2] show a clear and statistically significant increase in both minimum and maximum temperature into the future (figure 9 - 12). By 2040 the mean daily maximum temperatures may be between 0.5 - 1.5 °C warmer than the current climate, while daily minimum temperatures are projected to warm even more (+1 °C to +2 °C by 2040). The models suggest that the warming due to anthropogenic climate change may begin to be distinguished from that of natural variability within this current decade. This is supported by the observations which already show evidence of record breaking warming.

Total annual rainfall is projected to remain within the historic range of variability, or to decrease slightly in the second half of the century (figure13). However two outlier models disagree with the rest projected a significant increase in rainfall into the future. The change in rainfall is not projected to be discernable from that of natural variability until at least the middle of the century. The current drying trend seen in the observations, may be early evidence of the projected drying, but could very likely be due to decadal variability. Other rainfall attributes show different results. Rainfall daily intensity show either no change or an increase into the future. Rain day frequency shows no change or a decrease in the second half of the century. The frequency of higher intensity rainfall events (days with rainfall over 10mm and over the 90th percentile) show mixed results with no clear agreement on the direction of change (Table 2 below provides a summary and information is presented in Figure 13 - 17 in the supplementary section).

---

1 The fifth iteration of the Couple Model Inter-comparison Project (CMIP) is a coordinate activity amongst international modeling centers to produce a suite of climate simulations using common experimental parameters. CMIP5 is currently the primary source of global to regional scale climate projections and extensively informed the IPCC Fifth Assessment Report (AR5)

2 Although this emissions/development pathway represents the "worst-case scenario" amongst the pathways simulated by the IPCC CMIP5 models, at this stage it is the most realistic reflection of the recent progression of anthropogenic emissions. It is presented here, in spite of the Paris agreement, as effects of its commitments remain to be shown.

Table 2: Summary of CMIP5 GCM projected climate changes messages for key temperature and rainfall attributes, Karonga.

Statistic	Annual
Average Tmax [°C]	**Increasing:** +0.5 °C to +1.5 °C by 2040s, and by +2.5° to + 6.5°C by the end of the century. Warming becomes distinct from natural variability in the current decade.
Average Tmin [°C]	**Increasing:** +1 °C to +2 °C by 2040s and by +2.5° to +6 °C by the end of the century. Warming should already have started to become distinct from natural variability from the beginning of this decade.
Frequency of daytime heat spells (days)	**Increasing:** +10 to +40 days by 2040, and by +60 to 150 days by the end of the century. Increase in frequency discernable from that of natural variability within this decade.
Frequency of nighttime heat spells (days)	**Increasing:** +20 to +120 days by 2040, and by +100 to 300 days by the end of the century. Increase in frequency discernable from that of natural variability from the beginning of this decade. Note: nighttime heat spells increasing much more than daytime heat spells
Rainfall Totals [mm/year]	**Normal to decreasing rainfall**, ranging from no change to significant decrease from 2070 (with 2 outlying models showing strong increase).
Rainfall daily intensity [mm/day]	**No change to strong positive change:** most models project no clear change into the future, with the exception of 3 models which project a strong increase in intensity especially towards the end of the century.
Rainfall frequency [days]	**No change to decreasing frequency:** most models show a decrease in frequency from the middle of the century, though some a few show no change and 1 shows an increase in frequency into the future.
Heavy rainfall frequency (over 10 mm) [days]	**No change to increasing or decreasing frequency:** Most models show no change in frequency, though 3 models show an increase while 3 models show a decrease in frequency of heavy rainfall events into the future.
Extreme rainfall frequency (over 90^{th} percentile) [days]	**No change to increasing or decreasing frequency:** Most models show no change in frequency, though 4 models show a strong increase while a few models show a small decrease in frequency of extreme rainfall events into the future.

Statistically downscaled projections

Projections of future climate, based on 11 statistically downscaled CMIP5 GCM simulations under the RCP8.5 pathway show a clear and statistically significant increase in both minimum and maximum temperature into the future (figure 18 – 21). By 2040 the temperatures may be between 1 - 2 °C warmer than the current climate, depending on the model selected. The frequency of days exceeding the historical extreme temperature threshold (90th percentile) is projected to increase and to occur during more than just the hot September – November season. Rainfall is projected to remain within the historic range of variability, or to decrease in the second half of the century. This decrease is primarily seen in a decrease in the frequency of rain events rather than a decrease in the intensity of rainfall which shows no change. However there is one model which disagrees with the rest and projects a significant increase in rainfall into the future. (Table 3 below provides a summary and information is presented in Figure 22 - 26 in the supplementary section.

Table 3: Summary of statistically downscaled GCMs projected climate change messages for key temperature and rainfall attributes.

Statistic	Annual
Average Tmax [°C]	**Increasing** +1 to +2 °C by 2040, and between 3.5 to 5.5 °C by the end of the century. Warming trend already discernable from that of natural variability.
Average Tmin [°C]	**Increasing** +1 °C to +2 °C by 2040s, and between 3.5 and 5 °C by the end of the century. Warming trend already discernable from that of natural variability.
Daytime extreme heat events [days]	**Increasing**, +20 to 50 extra days by 2040, and between +100 to 200 extra days by the end of the century. Warming trend already discernable from that of natural variability in this decade.
Nighttime extreme heat events [days]	**Increasing**, +70 to 110 extra nights by 2040, and between +190 to 260 extra nights by the end of the century. Warming trend already discernable from that of natural variability.
Total rainfall [mm/year]	**Normal to decreasing rainfall**, ranging from slight wetting to significant drying from 2050 onwards (1 models shows extreme wetting).
Rain intensity [mm/day]	**No change in daily intensity.**
Rain day frequency [days]	**No change to decreasing rain day frequency**, ranging from no change to significant decrease from 2050 onwards (1 outlying model shows extreme increase).
Heavy rain day frequency [days]	**No change to decreasing rain day frequency**, ranging from no change to significant decrease from 2050 onwards (1 outlying model shows extreme increase).
Extreme rain day frequency [days]	**No change to decreasing extreme rain day frequency**, ranging from no change to significant decrease from 2050 onwards (1 outlying model shows extreme increase).

Supporting evidence

The above summary information is supported by rigorous analysis of observed and model projections data. More details of this analysis and supporting figures can be found below.

Data

This study focuses on how the climate for Karonga has changed in the past and how it may change in the future due to anthropogenic climate change. Ideally one would like to base the historical analysis on data from weather stations to obtain a detailed understanding of the local climates within the city. Karonga has a weather station which records daily weather conditions, unfortunately we were unable to obtain recent data for this station and the records we have cover the period 1961-2011 for rainfall and 1971-2005 for minimum and maximum temperature and therefore provides no information on how the climate has changed over the last decade. Instead this analysis relies on temperature data from a gridded product call the WATCH Forcing Data ERA-Interim (WFDEI)[3] where the WATCH Forcing Data methodology is applied to ERA-Interim data (Weedon et.al. 2014). It provides data for the global land surface at 0.5° x 0.5° Covering the period 1979-2014. The daily rainfall data used in the historical analysis is obtained from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)[4] (Funk et al 2015). CHIRPS incorporates 0.05° resolution satellite imagery with station data to create a gridded rainfall time series for most of the globe. The version 2.0 is used in this analysis which provides data on a 0.05° grid.

Two different sets of climate change data are used to explore the possible future changes in the climate due to anthropogenic climate change. The first set is an ensemble of 15 Global Climate Models (GCMs) from the Climate Model Intercomparison Projection version 5 (CMIP5) (a list of the models and modelling groups is provided in table 4 below). Daily rainfall, maximum and minimum temperature from the historical experiment (1960-2005) and the RCP8.5 future emission experiment (2006-2100) were used to explore how these variables are projected to change into the future. The second set of climate change data is an ensemble of 11 statistically downscaled CMIP5 GCMs. Circulation fields from the GCMs were used as predictor variables, while the WFDEI daily rainfall, maximum and minimum temperature data were used as predictant datasets in a statistical downscaling methodology called Self-Organising Map based Downscaling (SOMD) developed by the Climate System Analysis Group (CSAG) (Hewitson and Crane 2006). The downscaling provides daily rainfall, maximum and minimum temperature for each GCM for the historical (1960-2005) and RCP8.5 future (2006-2100) experiment at a 0.5° resolution.

A time series for the gridcell covering Karonga was extracted from each of the observed datasets and also from all of the GCM and statistically downscaled data. These data were used in all the analyses.

[3] EU WATCH – Data for Researchers: http://www.eu-watch.org/data_availability
[4] CHG – Data – CHIRPS: http://chg.geog.ucsb.edu/data/chirps/

Table 4: CMIP5 modelling centres and models used in the analysis (those models in italics are also used in the statistical downscaling)

MODELING CENTRE (OR GROUP)	INSTITUTE ID	MODEL NAME
Beijing Climate Center, China Meteorological Administration	BCC	*BCC-CSM1.1*
College of Global Change and Earth System Science, Beijing Normal University	GCESS	*BNU-ESM*
Canadian Centre for Climate Modelling and Analysis	CCCMA	*CanESM2*
Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en CalculScientifique	CNRM- CERFACS	*CNRM-CM5*
LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences	LASG-IAP	*FGOALS-s2*
NOAA Geophysical Fluid Dynamics Laboratory	NOAA GFDL	*GFDL-ESM2G* *GFDL-ESM2M*
Institut Pierre-Simon Laplace	IPSL	IPSL-CM5A-MR IPSL-CM5B-LR
Institute for Numerical Mathematics	INM	INM-CM4
Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	MIROC	*MIROC5*
Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies	MIROC	*MIROC-ESM* *MIROC-ESM-CHEM*
Max Planck Institute for Meteorology (MPI-M)	MPI_M	MPI-ESM-LR
Meteorological Research Institute	MRI	*MRI-CGCM3*

Historical trends and variability analysis

The analysis of historical trends and variability of key climate variables is presented below. This analysis uses daily maximum and minimum temperature data obtained from the WATCH which covers the period 1979 - 2014. The rainfall dataset used is the CHIRPS dataset covers the period January 1981 – December 2016. Derived statistics were calculated at the monthly, seasonal and annual time scale. These were used to explore the long term trends and variability of the climate at Karonga.

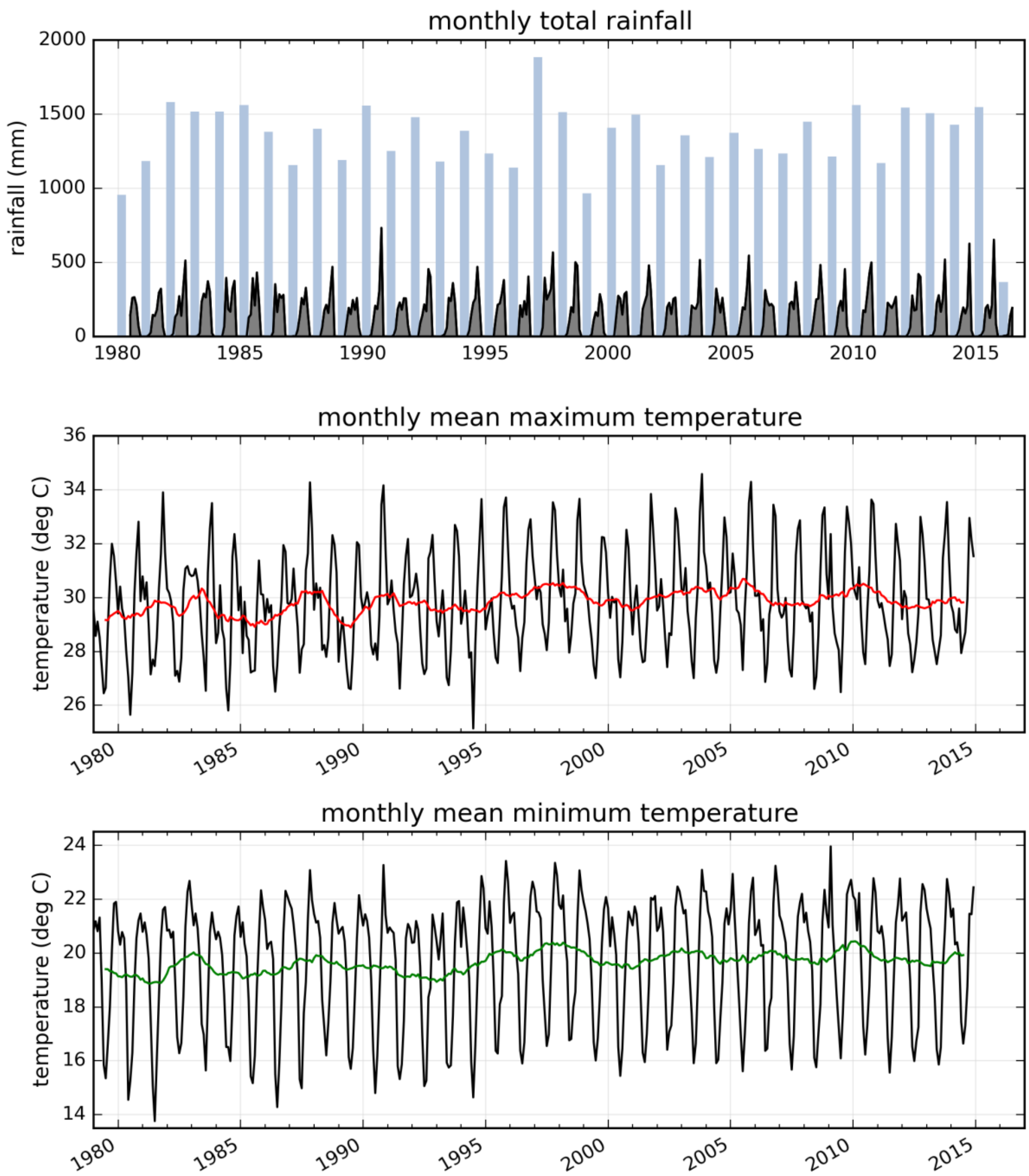

Figure 2: Time series of monthly mean maximum and minimum temperature and total rainfall for the gridcell over Karonga, red and green coloured lines represent a 12 month running average for maximum and minimum temperature respectively from the WFDEI dataset. Light blue bars present the annual (July – June) total rainfall from the CHIRPS dataset.

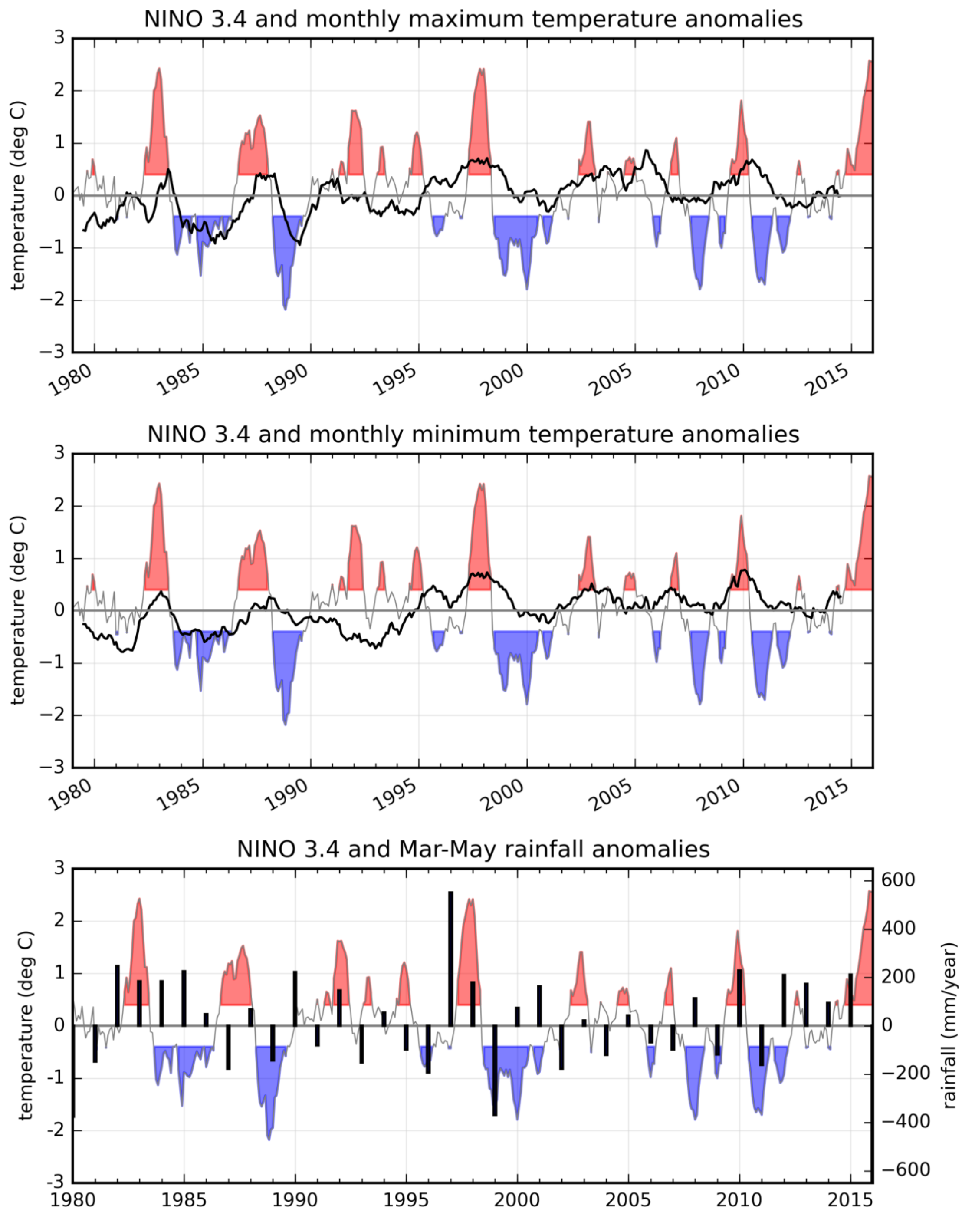

Figure 3: Association between ENSO and the climate at Karonga through time. Time series of the NINO 3.4 SST monthly anomalies is presented as the grey line; positive (El Nino) phases are coloured red, while negative (La Nina) phases are shaded in blue. Black line in top panel shows the monthly mean maximum temperature anomalies smoothed with a 12-value running mean from the WFDEI dataset. The second panel shows the same as above, but for minimum temperature. The black bars in the bottom two panels show the March to May and October – December seasonal total rainfall anomalies (mm/season) from the CHIRPS dataset.

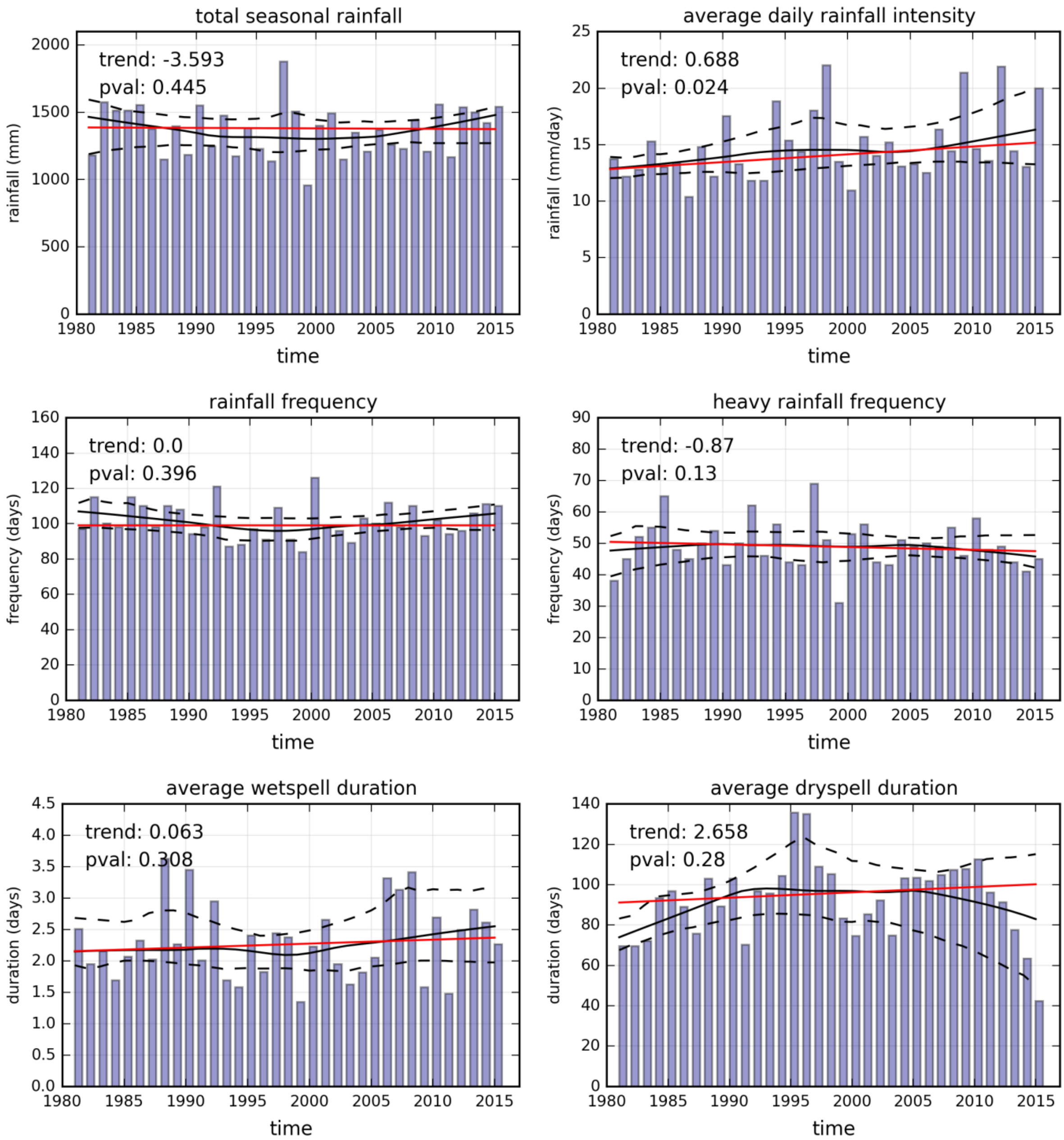

Figure 4: Time series and trend in July - June seasonal rainfall statistics for the gridcell over Karonga from the CHIRPS dataset. Each panel shows that statistic as a blue bars along with the Theil-Sen trend (red line) and the Lowess smooth mean (black line) and 95th confidence interval (dashed line). The bottom panel shows the same as above but for the annual (July-June) frequency of rain days.

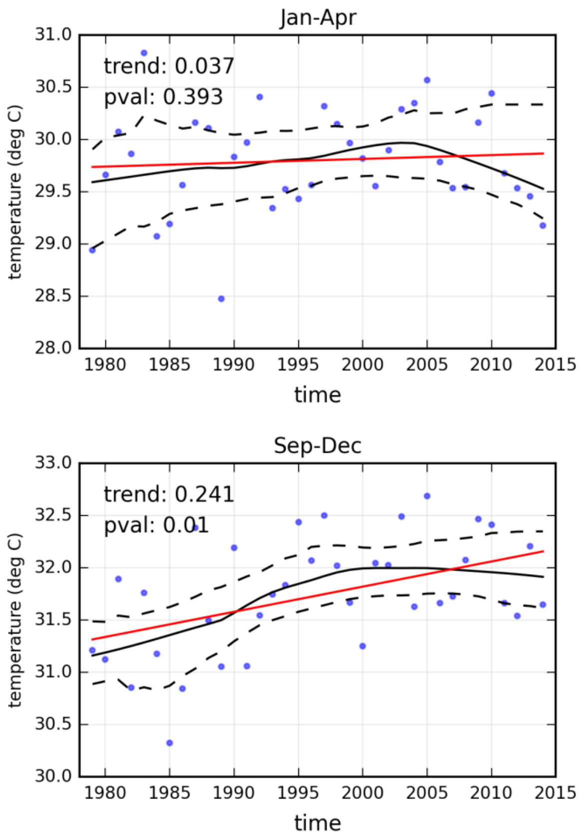

Figure 5: Time series and trend in seasonal average maximum temperature for the gridcell over Karonga from the WFDEI dataset. Time series of seasonal mean maximum temperature (blue dots). Theil-Sen trend (red line) and the Lowess smooth (black line) and 95th confidence interval (dashed lines)

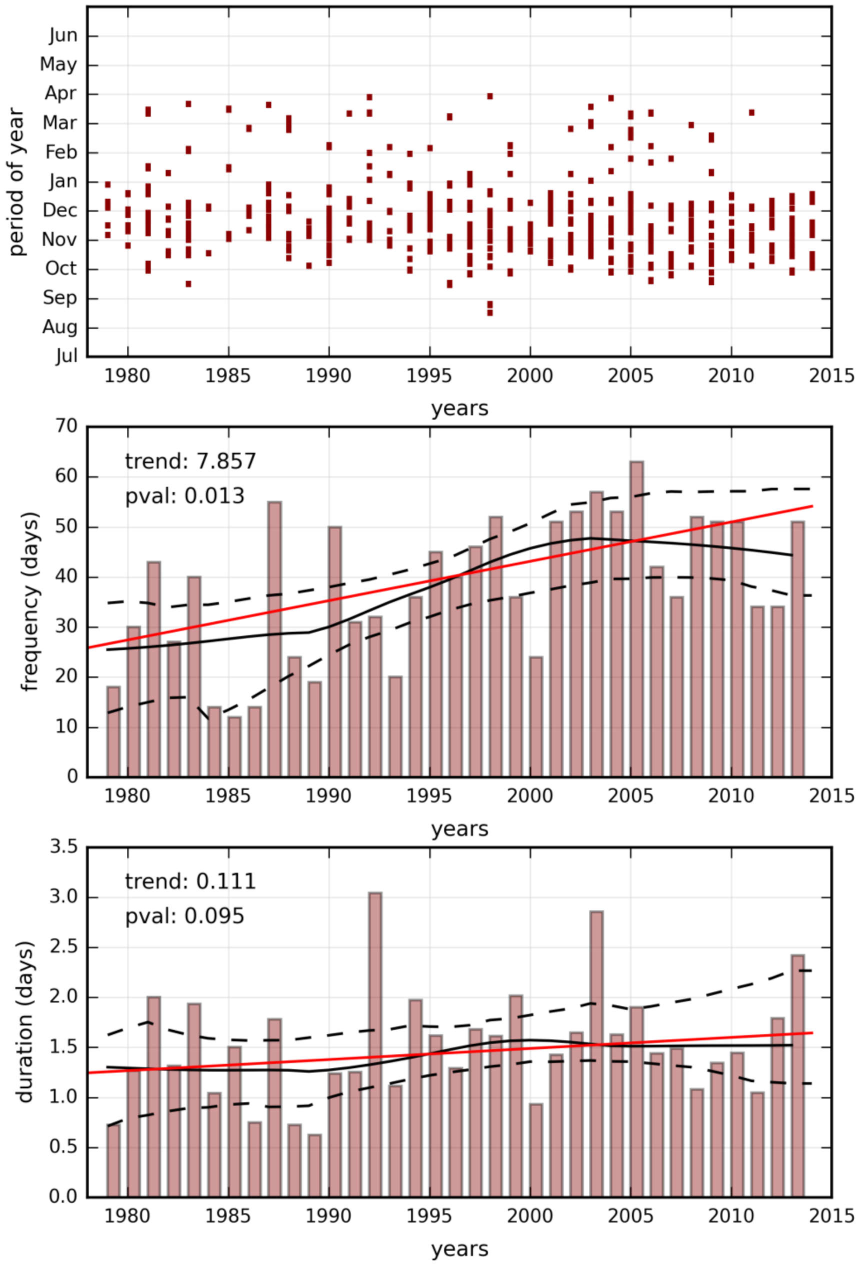

Figure 6: Time series and trend in the frequency of hot days (tmax > 34.5) for the gridcell over Karonga from the WFDEI dataset. The top panel shows the timing and duration of these events in each year (July-June) of the record. The middle panel shows the heat spell frequency or number of days per year (July – June) in the red bars along with the Theil-Sen trend (red line) and the Lowess smooth (black line) and 95th confidence interval (dashed lines). The bottom panel shows the same as above but for the average spell duration or number of consecutive days per year (July-June).

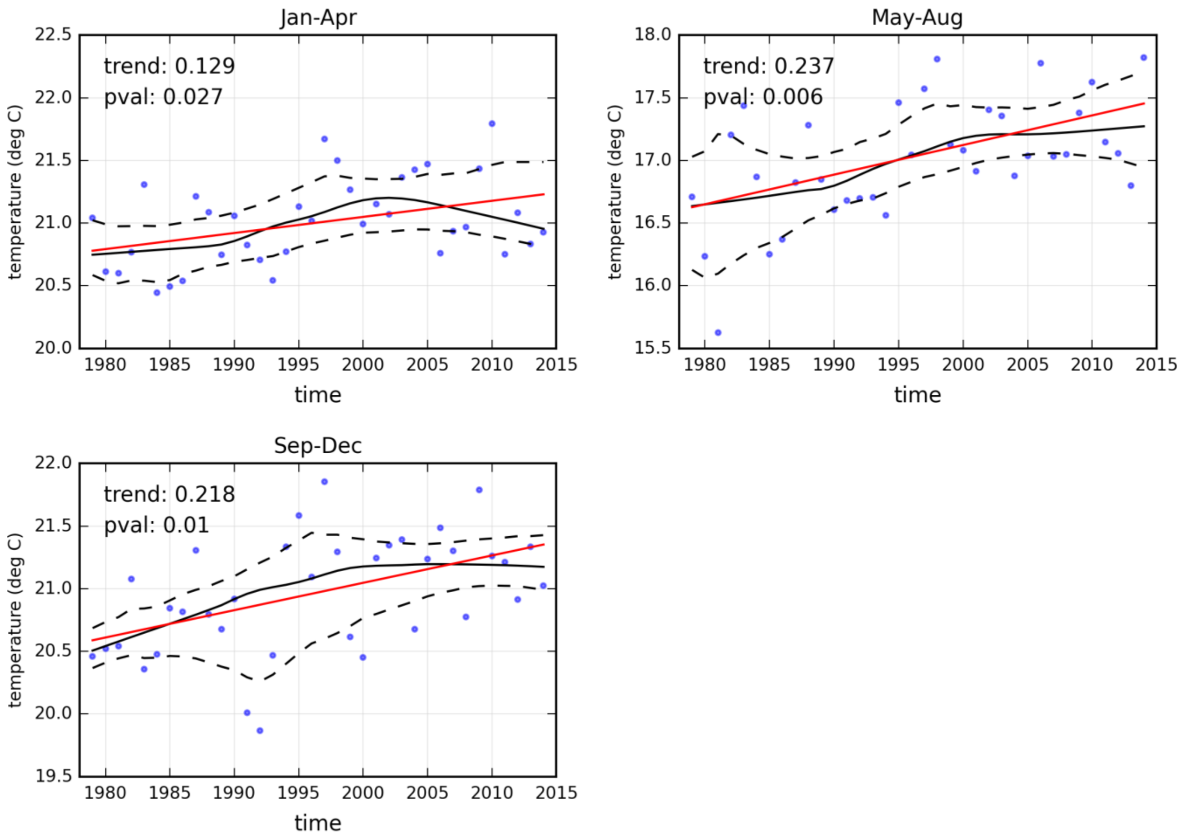

Figure 7: Time series and trend in seasonal average minimum temperature for the gridcell over Karonga from the WFDEI dataset. Time series of seasonal mean minimum temperature (blue dots). Theil-Sen trend (red line) and the Lowess smooth (black line) and 95th confidence interval (dashed lines)

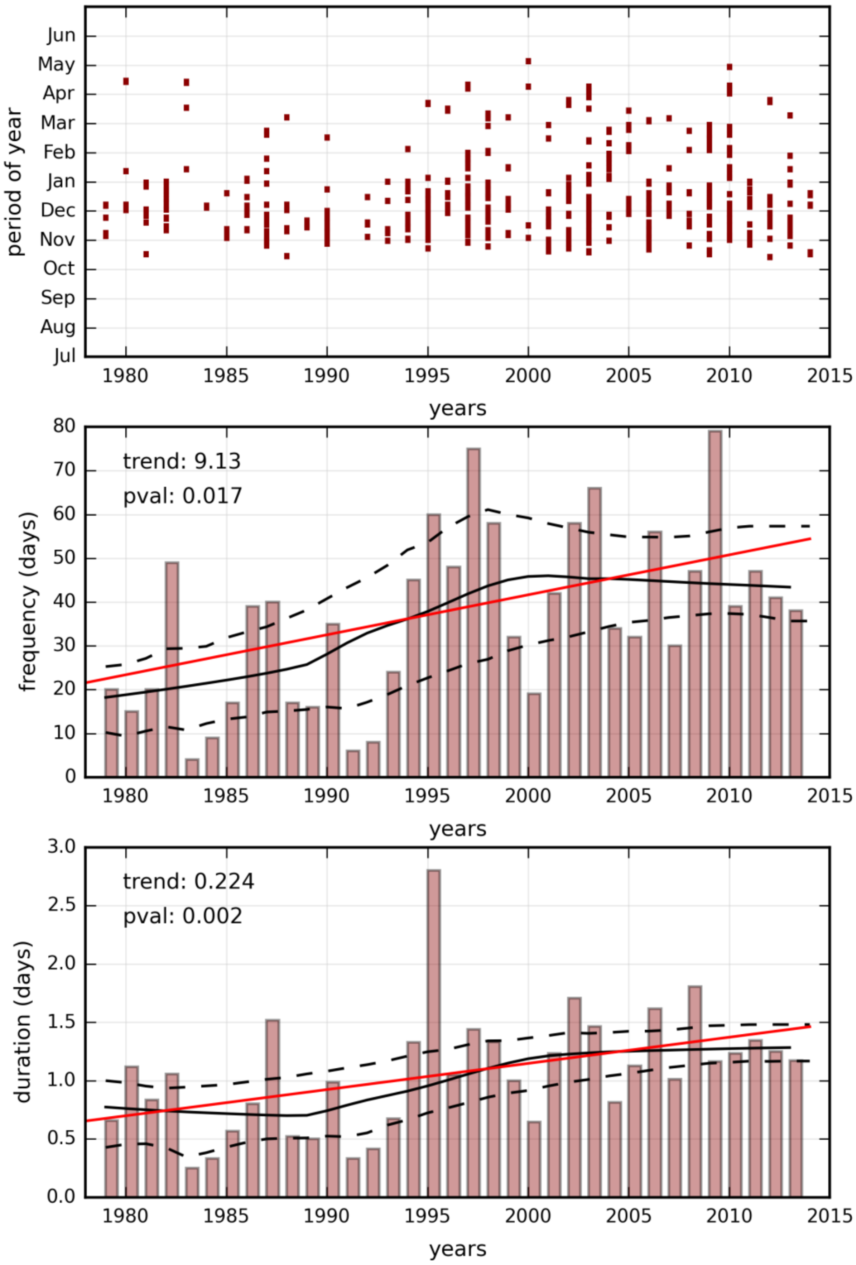

Figure 8: Time series and trend in the frequency of hot nights (tmax > 24.5) for the gridcell over Karonga from the WFDEI dataset. The top panel shows the timing and duration of these events in each year (July-June) of the record. The middle panel shows the heat spell frequency or number of days per year (July – June) in the red bars along with the Theil-Sen trend (red line) and the Lowess smooth (black line) and 95th confidence interval (dashed lines). The bottom panel shows the same as above but for the average spell duration or number of consecutive days per year (July-June).

Climate projections visualizations

Global Climate Models

The plots below (Figures 9 to 17) are called plume plots and they are used to represent the different long term projections across the multiple climate models in the CMIP5 model archive used to inform the IPCC AR5 report. The plots show projected variations in different variables for the gridcell over Karonga produces by an ensemble of 15 models. The blue colours indicate variations that would be considered within the range of natural variability, so in other words, not necessarily the result of climate change. The orange colours indicate projection time series where the changes would be considered outside of the range of natural variability and so likely a response to climate change.

It is important to note that these are Global Climate Model (GCM) projections and so likely do not capture local scale features such as topography and land ocean boundary dynamics. They also may not capture small scale features such as severe thunderstorms that can have important societal impacts. Finally, these projections are averages over relatively large spatial area which differs between GCMs and it is possible that different messages would be obtained at smaller spatial scales and if various forms of downscaling are performed.

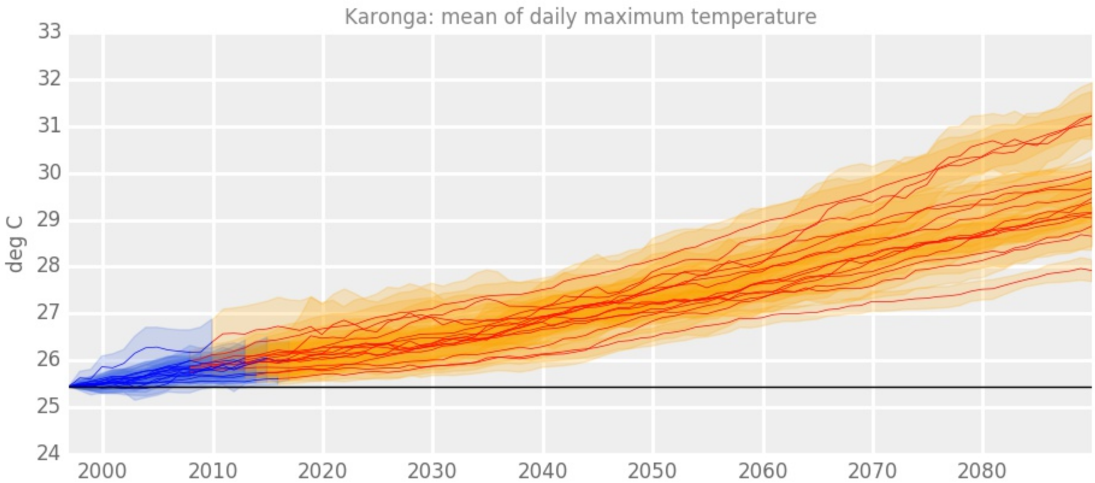

Figure 9: CMIP5 projected changes in seasonal mean daily maximum temperature under the RCP 8.5 concentration pathway for Karonga. The black line shows the multi-model mean value across all models in the reference period 1986-2005. The coloured lines show the 20-year moving average of results from each model and the shading around each line shows the 95% confidence range around those model results. Where the line and associated shading changes from blue to red/orange indicates when 20-year moving average moves outside of the 95% confidence range of the reference period.

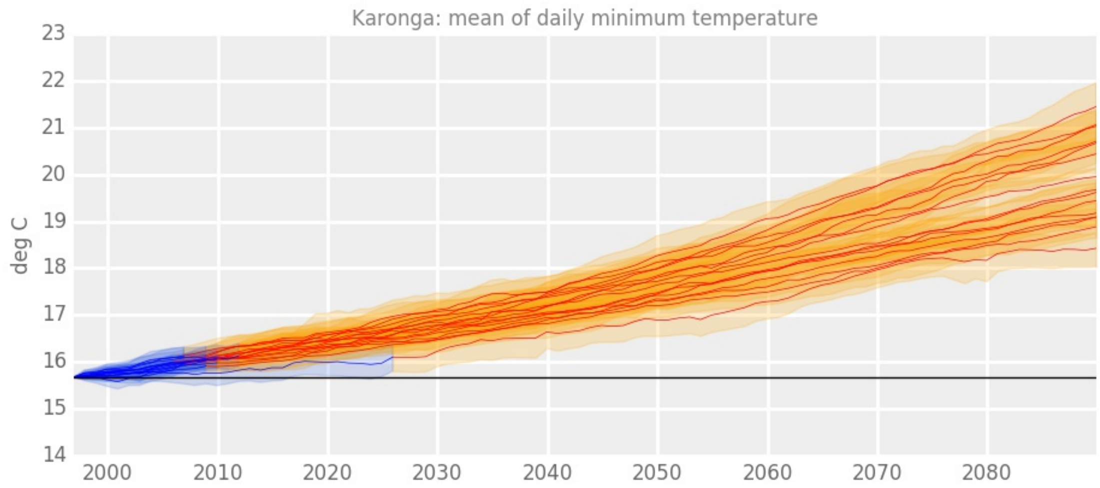

Figure 10: CMIP5 projected changes in annual mean daily minimum temperature under the RCP 8.5 concentration pathway for Karonga.

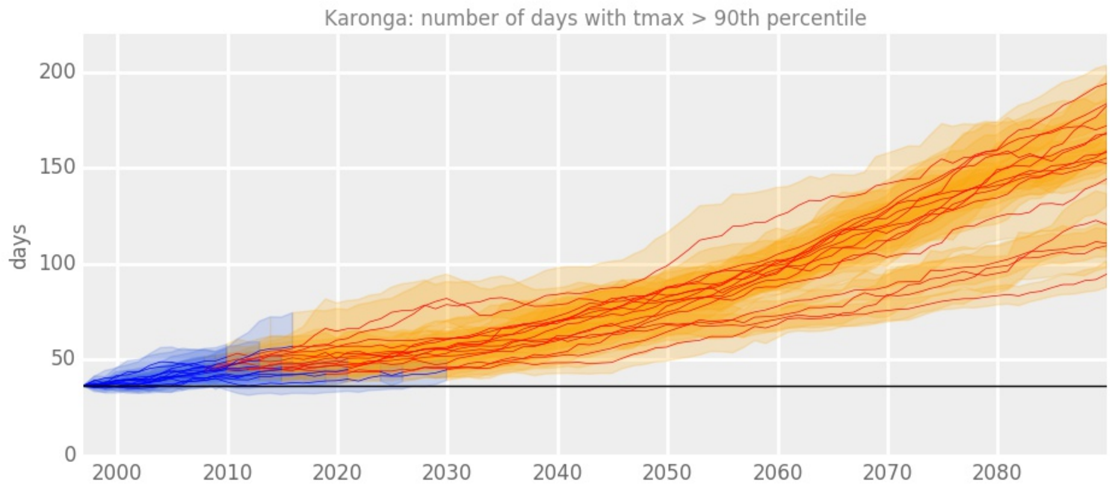

Figure 11: CMIP5 projected changes in annual frequency of days exceeding the 90th percentile for maximum temperature under the RCP 8.5 concentration pathway for Karonga.

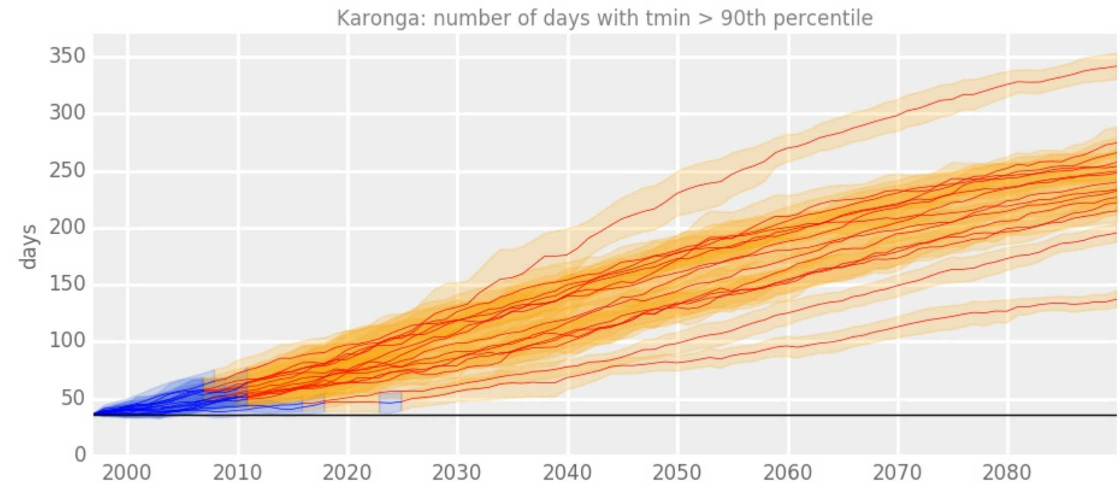

Figure 12: CMIP5 projected changes in annual frequency of days exceeding the 90th percentile for minimum temperature under the RCP 8.5 concentration pathway for Karonga.

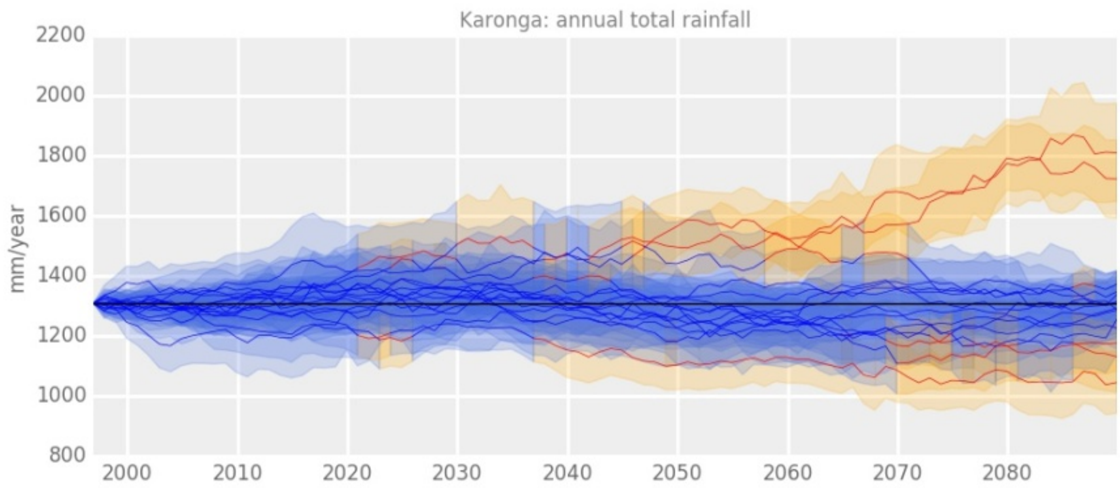

Figure 13: CMIP5 projected changes in annual total rainfall under the RCP 8.5 concentration pathway for Karonga.

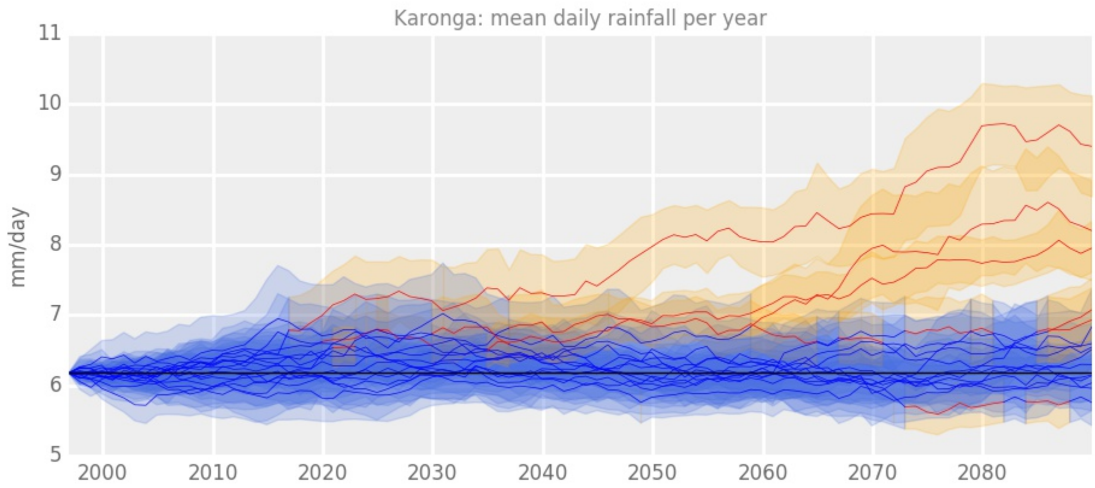

Figure 14: CMIP5 projected changes in annual average daily rainfall intensity under the RCP 8.5 concentration pathway for Karonga.

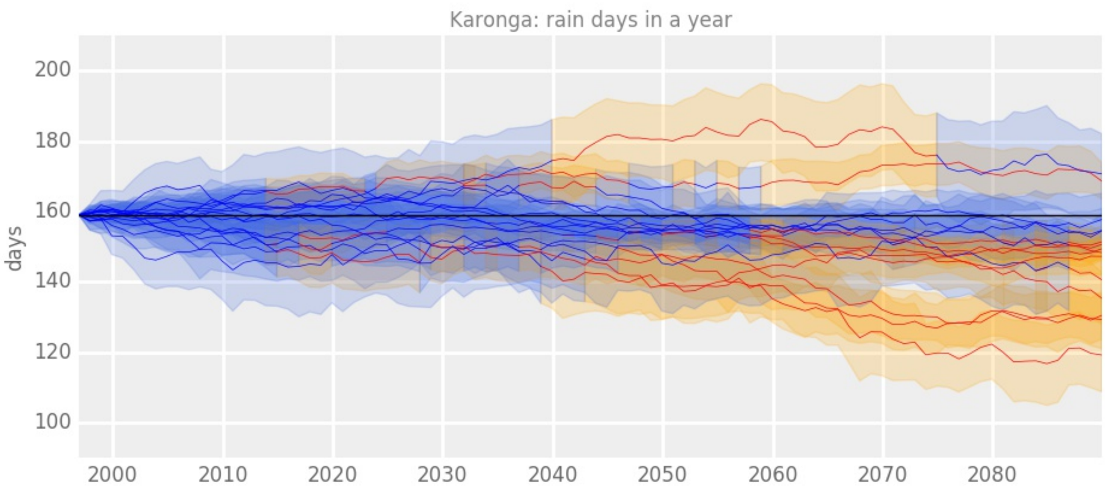

Figure 15: CMIP5 projected changes in annual rainfall frequency under the RCP 8.5 concentration pathway for Karonga.

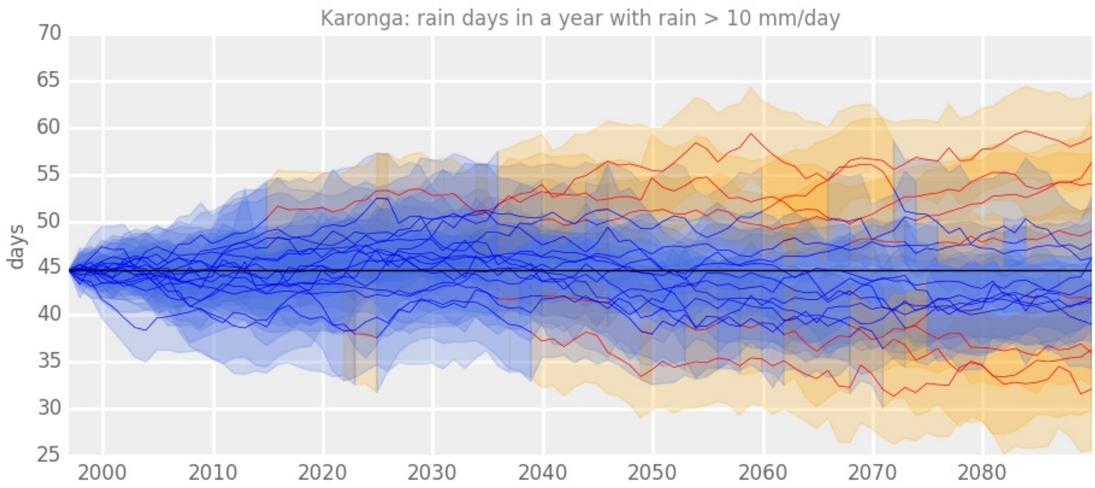

Figure 16: CMIP5 projected changes in annual heavy (pr>10mm) rainfall frequency under the RCP 8.5 concentration pathway for Karonga.

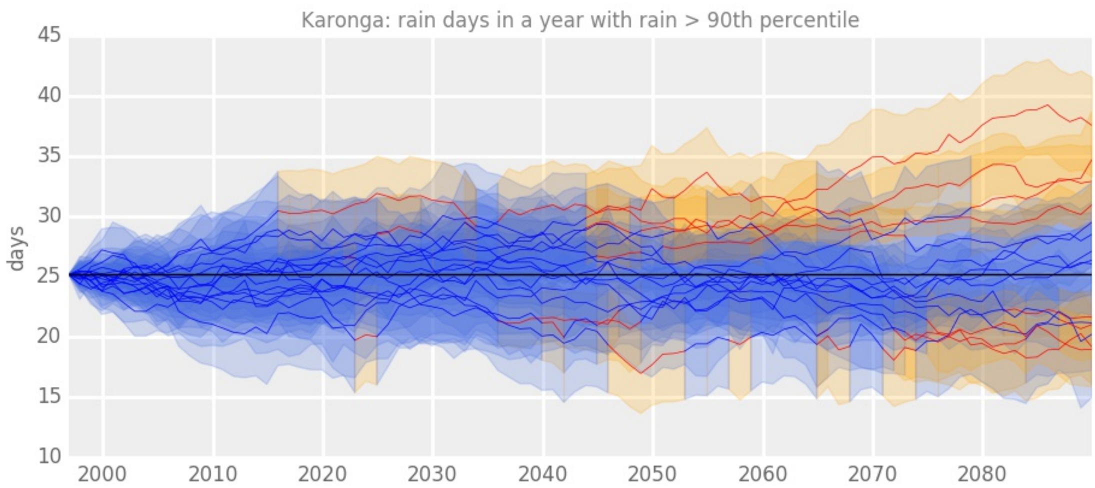

Figure 17: CMIP5 projected changes in annual extreme rainfall frequency under the RCP 8.5 concentration pathway for Karonga.

Statistical downscaling

The plots below (Figures 18 to 26) are called plume plots and they are used to represent the different long term projections across the multiple statistically downscaled climate models in the CMIP5 model archive used to inform the IPCC AR5 report. The plots show projected variations in different variables for the gridcell over Karonga produces by an ensemble of 11 models. The blue colours indicate variations that would be considered within the range of natural variability, so in other words, not necessarily the result of climate change. The orange colours indicate projection time series where the changes would be considered outside of the range of natural variability and so likely a response to climate change.

It is important to note that these are downscaled GCM projections, which have a spatial resolution of roughly 50 km. They provide higher resolution output than the raw GCM and depict the first order response to anthropogenic response. However they are unlikely to accurately capture local scale features such as topography and land ocean boundary dynamics. They also may not capture small scale features such as severe thunderstorms that can have important societal impacts.

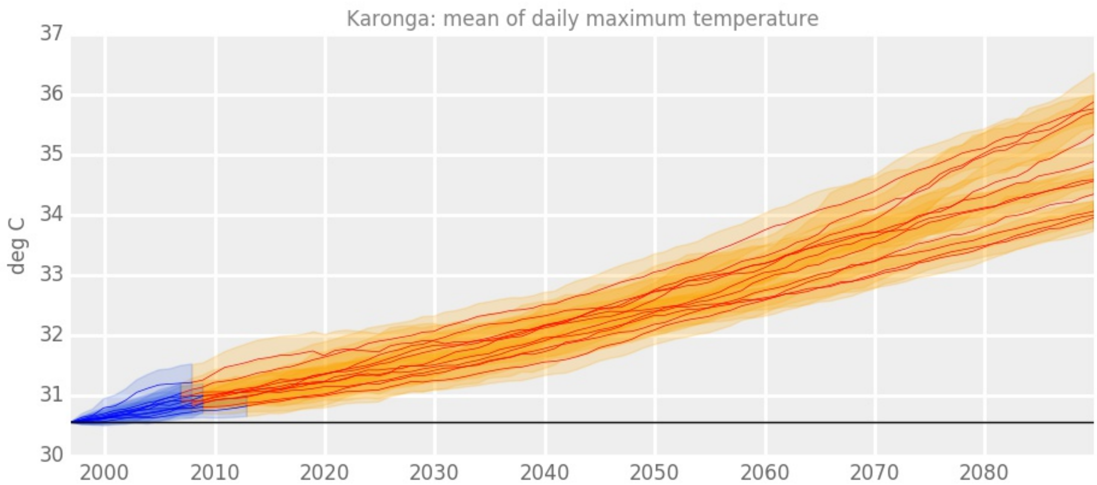

Figure 18: Statistically downscaled projected changes in seasonal mean daily maximum temperature under the RCP 8.5 concentration pathway for Karonga. The black line shows the multi-model mean value across all models in the reference period 1986-2005. The coloured lines show the 20-year moving average of results from each model and the shading around each line shows the 95% confidence range around those model results. Where the line and associated shading changes from blue to red/orange indicates when 20-year moving average moves outside of the 95% confidence range of the reference period.

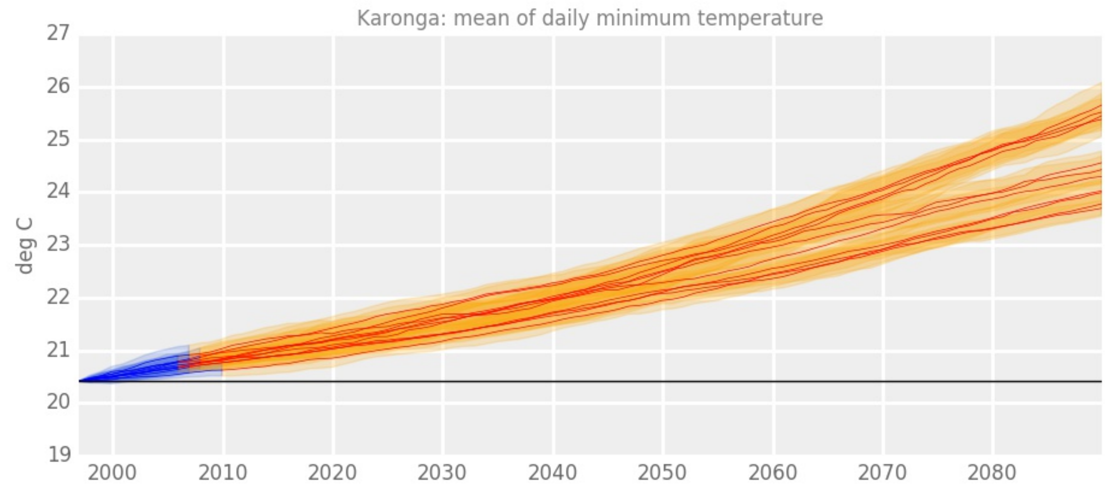

Figure 19: Statistically downscaled projected changes in seasonal mean daily minimum temperature under the RCP 8.5 concentration pathway for Karonga

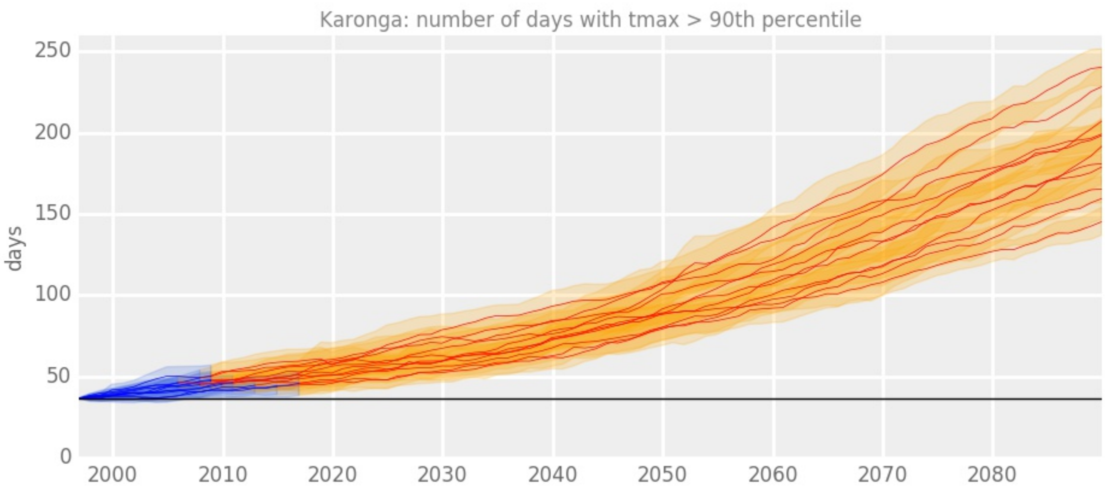

Figure 20: Statistically downscaled projected changes in the frequency of days with Tmax > 90th percentile of the historical period (1986-2005) under the RCP 8.5 concentration pathway for Karonga

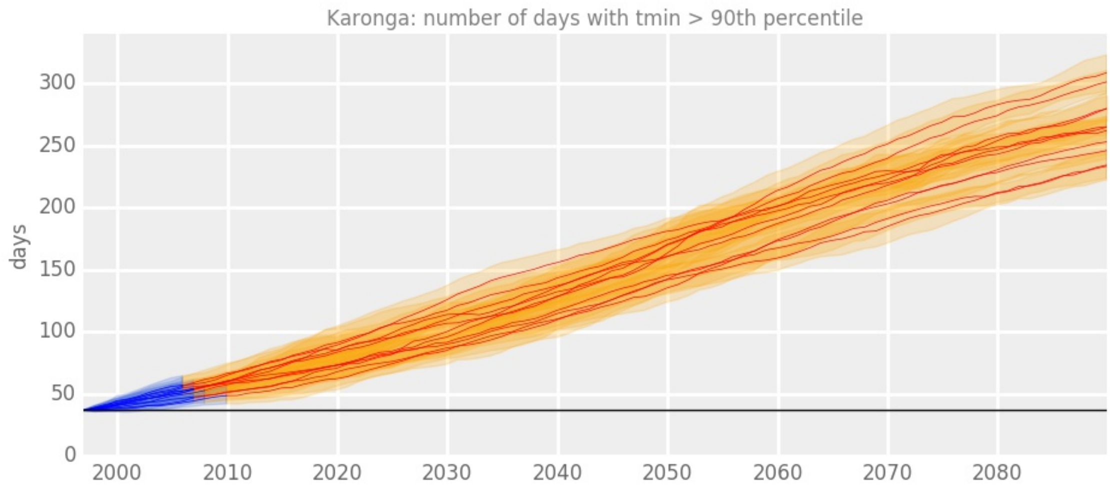

Figure 21: Statistically downscaled projected changes in the frequency of days with Tmin > 90th percentile of the historical period (1986-2005) under the RCP 8.5 concentration pathway for Karonga

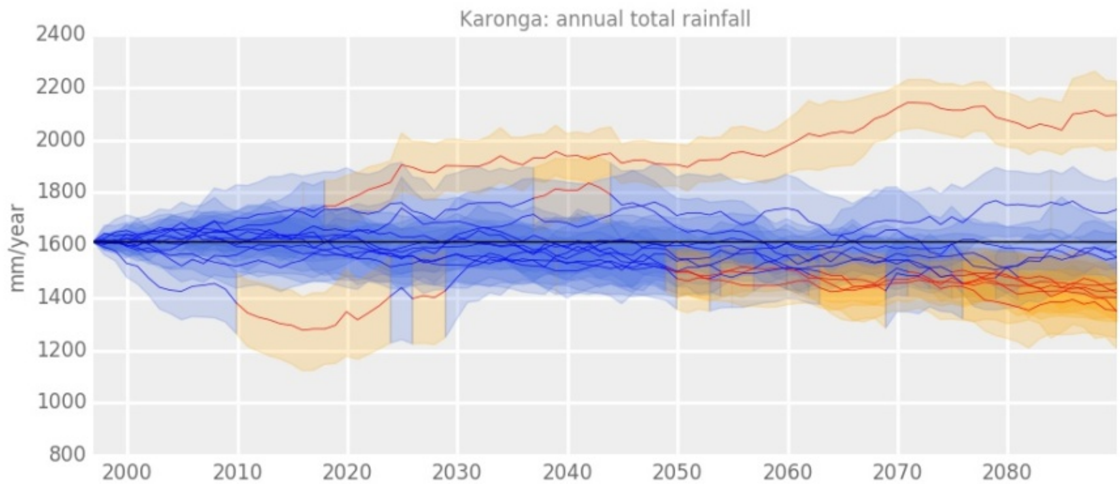

Figure 22: Statistically downscaled projected changes in annual total rainfall under the RCP 8.5 concentration pathway for Karonga

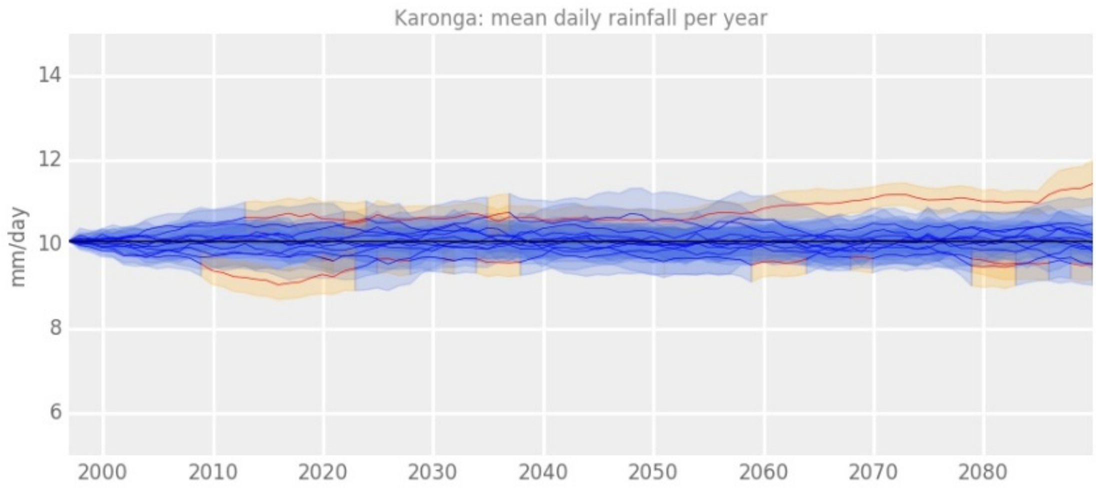

Figure 23: Statistically downscaled projected changes in the daily intensity of rainfall under the RCP 8.5 concentration pathway for Karonga

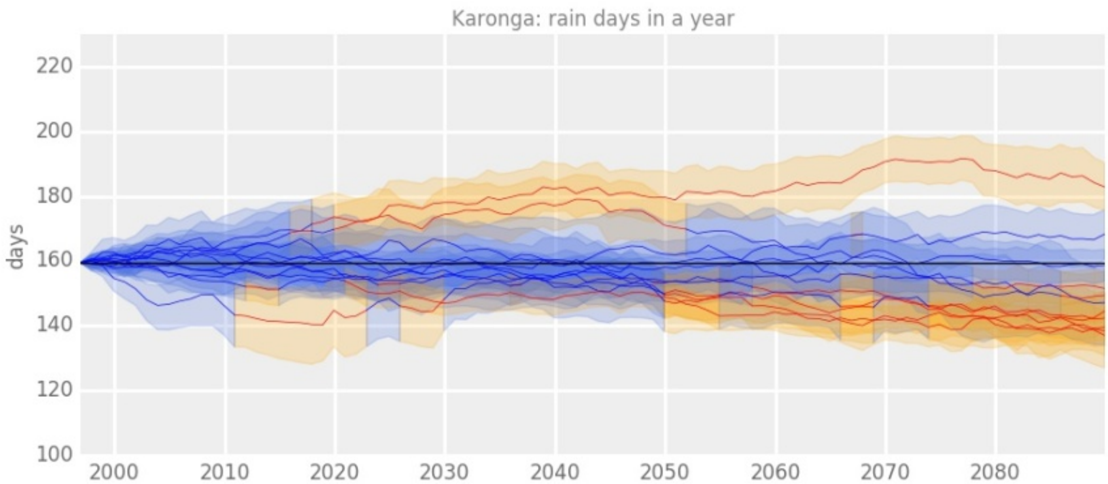

Figure 24: Statistically downscaled projected changes in the frequency of rain days under the RCP 8.5 concentration pathway for Karonga

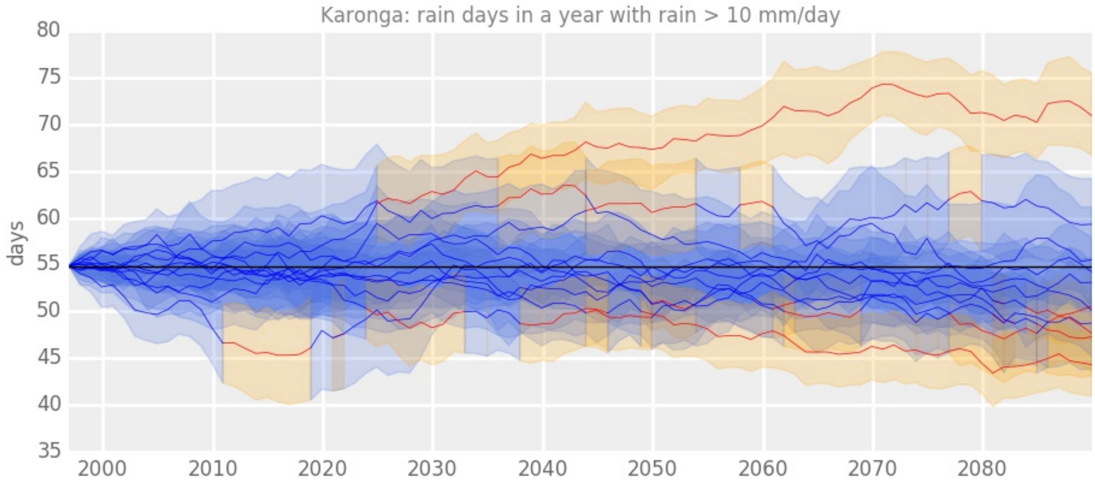

Figure 25: Statistically downscaled projected changes in the frequency of heavy rain days under the RCP 8.5 concentration pathway for Karonga

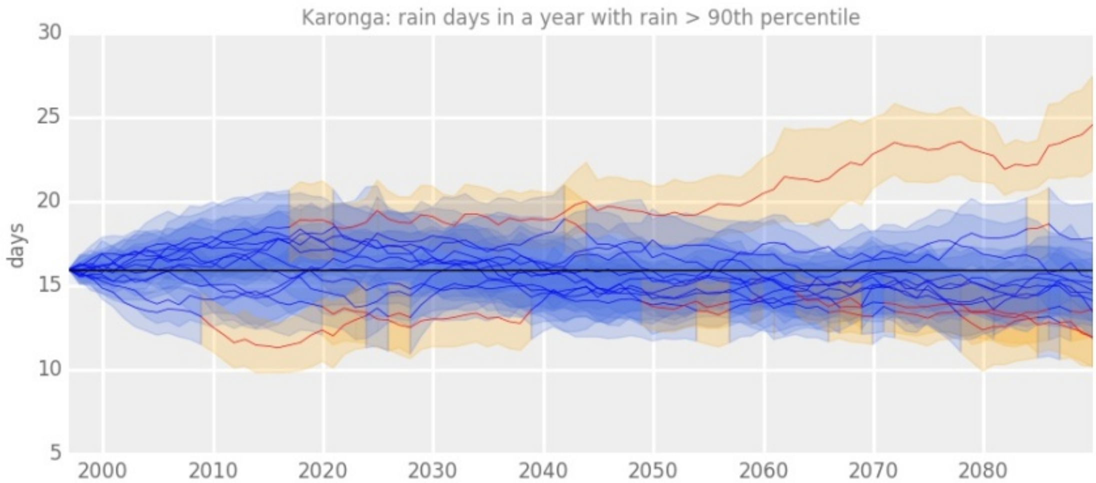

Figure 26: Statistically downscaled projected changes in the frequency of days with rainfall > 90th percentile of the historical period (1986-2005) under the RCP 8.5 concentration pathway for Karonga.

The contents of this Working Paper reflect the views of the author only and not those of the UK Department for International Development or the Economic and Social Research Council.