Report

Climate Summary for Kakamega and Siaya Counties, Kenya

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1. Introduction

This report summarises both the recent past and future projections of the climate of Kakamega and Siaya counties in Kenya to contribute to the objectives of the WISER project “Strengthening the use of Climate Information Services in Western Kenya”.

In Phase 1 of the project, a curriculum was developed in collaboration with UNDP and the Kenyan School of Government to support county planners in the mainstreaming of climate information within their planning processes. During this phase, a numbers of needs were identified which this WISER project was well placed to meet. These included overviews of the climate in the recent past and future projections for the pilot counties, which could support briefings and training tailored to support county decision-making processes across different sectors and timeframes. The information presented here aims to address this need, initially for two of the pilot counties, Kakamega and Siaya. In addition, guidance on the interpretation of the data is provided to aid its use in understanding the impacts of a changing climate across multiple sectors.

The report first details the data used and its limitations. It then provides a short summary of the current scientific knowledge of the climate of Kenya. The recent past temperature and rainfall conditions of Kakamega and Siaya are described in more detail and a discussion of the future climate of Kenya is then included.

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2. Application of the information and its limitations

2.1 Application

This report contains a basic analysis of the climates of two counties in Kenya to support County Directors of Meteorology (CDMs) and strategic planners to write County Integrated Development Plans (CIDPs) that are informed by current and potential future climate in their county. An additional use for the information provided here is for material to use in the training of government officials. These county climate summaries do not provide all the information necessary to carry out risk assessments or to fully assess adaptation options. In these cases, specific studies using a wide range of data sources, including local expertise on social and physical vulnerabilities, and further analyses of relevant climate metrics and impact assessments will be needed. Users should remain aware of the limitations of the information and avoid over-interpretation of the results shown. Guidance on what individual graphs and maps show and what level of detail can be assumed from these are provided alongside the figures.

2.2 Limitations of observation datasets

The datasets used here to describe the recent past climate of Kenya, are based on measurements made from ground recording stations and/or remotely by satellite systems. Uncertainties in the observations records can arise through errors in the instrumentation used, issues to do with how the instruments are sited (i.e. placed in an area that is too exposed or sheltered), and changes in the instruments (such as being moved or upgraded). For many parts of the world, such as in East Africa, there is limited coverage by ground measurement stations so detailed spatial changes are not captured in the datasets. Observation datasets are normally presented on a regular grid across the globe. This allows them to be more easily compared with data from climate models. For grid-boxes where no stations are present, the data from nearby stations is mathematically interpolated to fill-in the gaps using a number of different calculation methods. Care should be taken to appreciate that a grid box value taken from a gridded dataset is not directly comparable with an individual point measurement made at a station, as it may be an average of several point measurements or calculated through interpolation.

Observations of the Earth’s surface can also be made remotely with the use of instruments onboard satellites, and this approach is particularly useful for areas where ground based stations are sparse. However these instruments must be calibrated using ground based measurement which can introduce errors.

Additionally, only relatively short records, stretching back to around the 1970s, are available from satellites so long-term trends cannot yet be estimated using these datasets.

The information on temperature provided in this report, the University of East Anglia's CRU TS4.01 dataset was used (Harris et al. 2014). The data can be downloaded from the following website: https://crudata.uea.ac.uk/cru/data/hrg/cru_ts_4.01/. It consists of records from approximately 6100 stations across the globe, which are re-gridded on to a 0.5° latitude by 0.5º longitude regular grid (this is equivalent to approximately 55km at the equator). Precipitation information was taken from the CHIRPS (Climate Hazards Group InfraRed Precipitation with Station data) dataset (Funk et al., 2015) which is available to download from: http://chg.geog.ucsb.edu/data/chirps/. The data spans 50°S to 50°N in a band around the equator and is available at 0.05° resolution. CHIPS interpolates data from the Tropical Rainfall Measuring Mission Multi-satellite (TRMM) with estimates from several ground rain gauge datasets such as from the Global Precipitation Climatology Centre (GPCC) (Becker et al. 2013). The GPCC dataset was also used to provide some additional analysis of trends in rainfall amounts as the CHIRPS data is only available from 1981. GPCC data can be downloaded from: https://climatedataguide.ucar.edu/climate-data/gpcc-global-precipitation-climatology-centre.

2.3 Limitations of global climate model datasets

The future climate of Kenya has been described using data from Global Climate Models (GCMs). These are advanced computer simulations of physical processes within the atmosphere, oceans and the land surface and their interactions which make up the climate system. These calculations require massive amounts of supercomputing resource, but even the most powerful supercomputers available cannot model the climate system perfectly and compromises are needed:

- The calculations within a GCM are solved on a grid which is typically around 1 to 2.5° in the horizontal and with tens of layers extending vertically through the atmosphere and oceans. A higher resolution model, with smaller grid boxes, will typically be able to simulate meteorological processes more accurately; however this requires large amounts of computing power. Some phenomena, such as the formation of storm clouds, occur at spatial scales smaller than the even the most powerful GCMs can resolve. These smaller processes must be mathematically approximated, using a technique known as parameterisation, instead.
- The climate system is very complex and contains multiple processes that act at different spatial and time scales. The relative importance of these

processes changes depending on the scales of interest. As current computational power cannot include all of the processes, some which are determined to be less important are excluded or simplified.

- A GCM simulation only represents one possible pathway of how the climate may develop into the future. To try to understand how uncertain the future simulation is, multiple versions from the same model can be run with small adjustments made to how the model represents the climate processes. Or alternatively GCMs from different institutes which use different methods to simulate the processes can be compared. These are called climate model ensembles. Both require large amount of computing costs so the number of different models or versions that can be run is finite. Users should note that while the spread or the degree of agreement across an ensemble range is indicative of the level of uncertainty it is only a ‘snapshot’ of current scientific understanding and modelling capability. Areas where there is good model agreement is likely to suggest confidence in that projection, however models which lie outside of it should not be neglected without good reason.

The data used to provide information on the projected future climate of Kenya is taken from the same GCMs that form the basis of the Intergovernmental Panel on Climate Change (IPCC) reports. These models are known as the CMIP5 models (Coupled Model Intercomparison Project Phase 5). These have been shown to have good representation of many aspects of the global climate, such as general patterns of warming. However, there are some key areas where scientific understanding is more limited and this leads to deficiencies in the models. Some which are relevant to East Africa are discussed in section 2.2 below and for a full review of the performance of the GCMs, see Chapter 9 of the Working Group 1 report of the 5th Assessment of the IPCC (Flato & Marotzke et al. 2013).

3. Overview of the climate of Kenya

3.1 Current climate

Kenya is situated on the equator in the east of Africa (figure 1). It has a diverse geography, with a coastal region in the east and several mountain chains inland, with the Rift Valley cutting across from north to south, and Lake Victoria situated in the west.

The amount of rainfall received by Kenya varies across the country, the north and east are typically drier (less than 100mm per month on average) and the west and central mountainous regions are wetter (up to 250mm per month depending on the season) (figure 2). Most of the country experiences the majority of its rainfall in two main seasons with the long rains from March-May and the short rains in October-

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November (figure 3). Temperatures do not vary greatly throughout the year in Kenya, but a warmer period is found from October to May and a cooler period occurs in June to September (figure 4). The east and north-west are warmer with mean temperatures of around 24-32ºC depending on the season. The remaining parts have mean monthly temperatures that are typically 20-26ºC. The climate of the mountainous areas can be very different to the surrounding region due to their high elevation and average temperatures are 10-14ºC per month.

3.2 Climate variability and causes

The varied geographical setting of Kenya, in combination with complex mechanisms in the atmosphere in this region of the world, leads to variable rainfall in terms of both the timing of seasonal rainfall (onset and cessation) and variation in amounts from year to year. Within the atmosphere a number of large-scale features that are remote to Kenya interact with more local processes in a number of different ways to contribute to the complexity of the climate.

Two of the most important processes related to rainfall variability are briefly described below to provide an insight on the complexities of the climate. They also highlight that there is currently limited scientific understanding of some processes which leads to uncertainty when using climate models to determine the future climate of East Africa. A detailed review of the current scientific understanding for rainfall variability over East Africa can be found in Nicholson (2017).

El Nino and La Nina

El Nino and La Nina are the names given to a large natural fluctuation in the Earth's climate system which has consequences across the globe. El Nino sees sustained warming in the eastern equatorial Pacific Ocean which occurs on an irregular basis every few years. La Nina is the term for a cool period of sea surface temperatures in the same region. They strongly influence the atmosphere above and the relationship between the ocean and atmosphere circulations is known as the El Nino Southern Oscillation (ENSO). During an El Nino heat is released into the above atmosphere, changing the wind patterns and affecting rainfall patterns around the world.

It has been shown that there is link between ENSO and year-to-year rainfall variability in East Africa, with El Nino leading to wetter than normal conditions and La Nina leading to drier than normal condition during the short rains. However, this relationship is not true for every El Nino or La Nina episode. More recent research has also shown that the sea surface temperature of the Indian Ocean is also an important factor in East African rainfall variability. The degree of dominance of each ocean in determining rainfall variability and understanding why their relationships vary on a decadal timescale is an area of ongoing research.

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Madden-Julian Oscillation (MJO)

The MJO is a disturbance of clouds, rainfall, winds and pressure that moves in an eastward direction around the Earth in the tropics, taking around 30-60 days to complete a circuit. The MJO consists of two parts, known as phases, which act in opposite ways across the two halves of the globe. One phase enhances clouds and rainfall and the other suppresses their formation, resulting in areas at the surface receiving more rainfall than average followed by less rainfall than average. The strength, or how much of an effect the MJO has on rainfall, varies from cycle to cycle. On average there are around three cycles per year with periods of little or no activity in between, although this is also variable. Within East Africa, variability within both the long and short rain seasons is strongly related to the passage of the MJO. Where it is positioned across the region affects the direction and strength of winds. For example when the MJO is centred over the western Indian Ocean, anomalously warm winds come from the east and bring significant moisture to East Africa. Then as the MJO moves away to the eastern Pacific Ocean, these winds become stronger, drier and colder. The interaction of these regional scale winds with the complex terrain of East Africa is a current area of ongoing research.

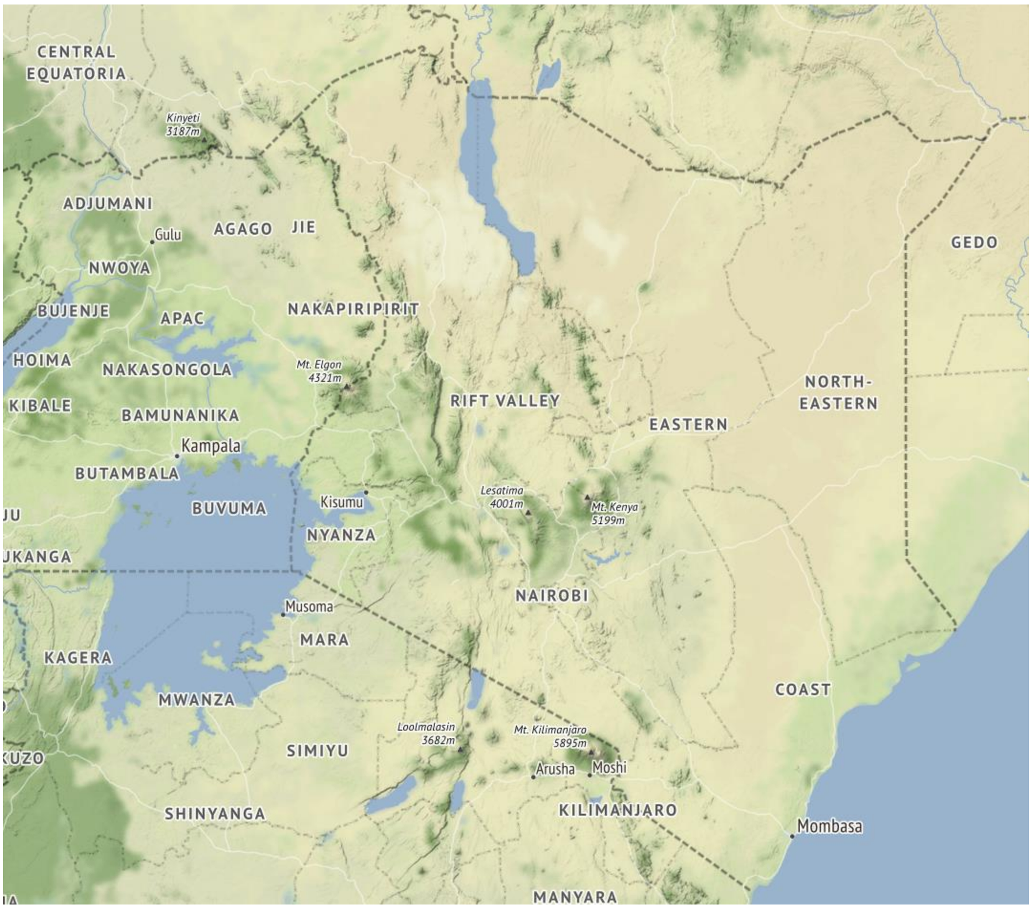


Figure 1: Map of Kenya and Lake Victoria

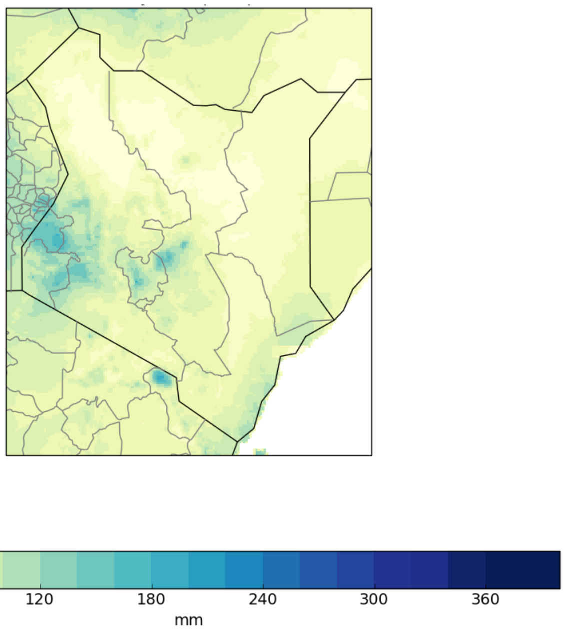


Figure 2: Map of Kenya showing average monthly rainfall totals calculated across all months in the period January 1983 to December 2013. The dataset used is CHIRPS.

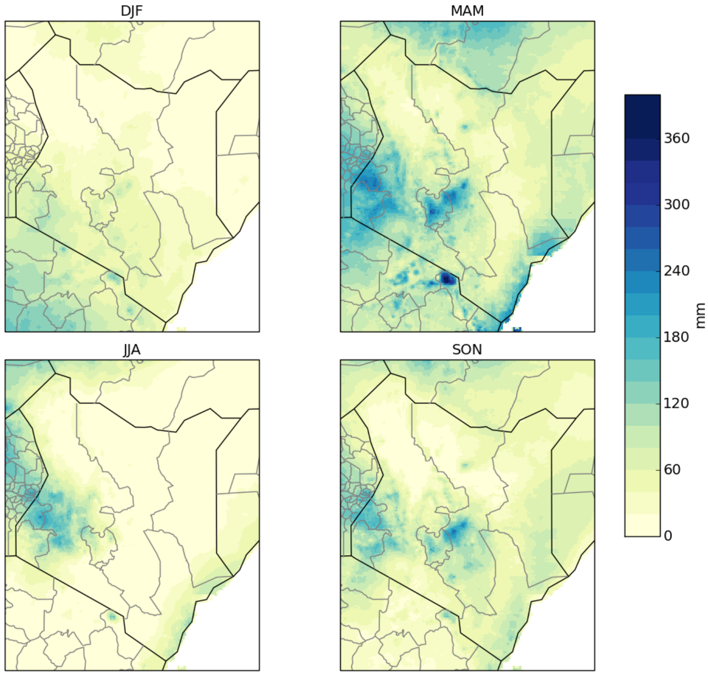


Figure 3: Map of Kenya showing average monthly rainfall totals over four 3-monthly periods during January 1983 to December 2013. (DJF = December, January and February; MAM = March, April and May, JJA = June, July, August, SON = September, October and November). The dataset used is CHIRPS.

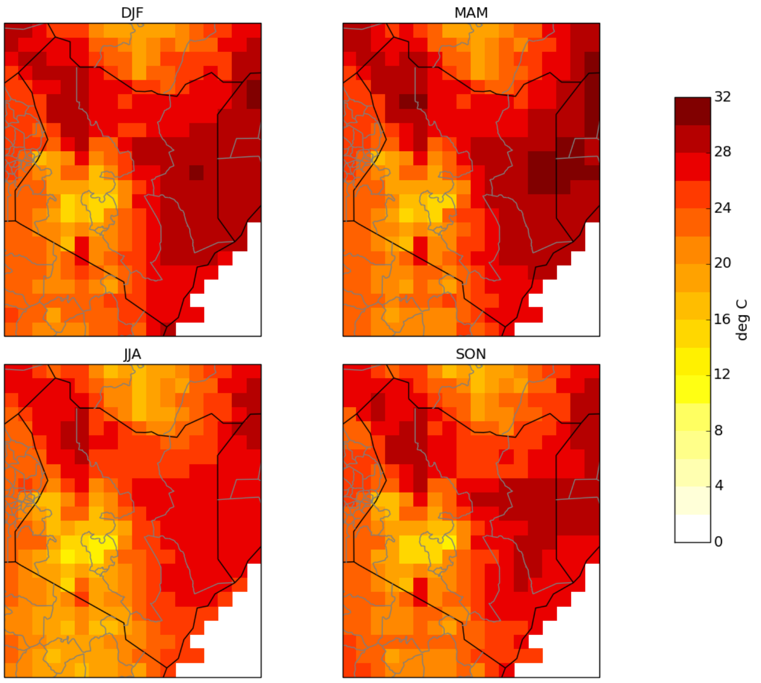


Figure 4: Map of Kenya showing average temperature over four 3-monthly periods during January 1983 to December 2013. (DJF = December, January and February; MAM = March, April and May, JJA = June, July, August, SON = September, October and November). The dataset used is CRU TS4.01.

4. Summary of recent past climate in Kakamega County

4.1 Rainfall

Kakamega county has two peaks in rainfall which occur in April and August on average (figure 5). The April peak is larger, with around 240mm received at that time, and in August the county receives about 180mm on average. The driest period is from December to February where around 60-80mm of rainfall occurs.

Figure 5 shows an average of all the rainfall occurring across the county and is an average across a thirty year period, from 1983-2013. It should be used in conjunction with figures 6 and 7 to assess variability across the county and from year to year. The figure is also based on monthly averages so it is not detailed enough to assess onset or cessation of rainfall at a daily scale. The dataset, CHIRPS, is a blend of satellite and rain gauge data, so although it provides our best estimate for monitoring rainfall across the region, locally measured point rainfall figures may differ to these.

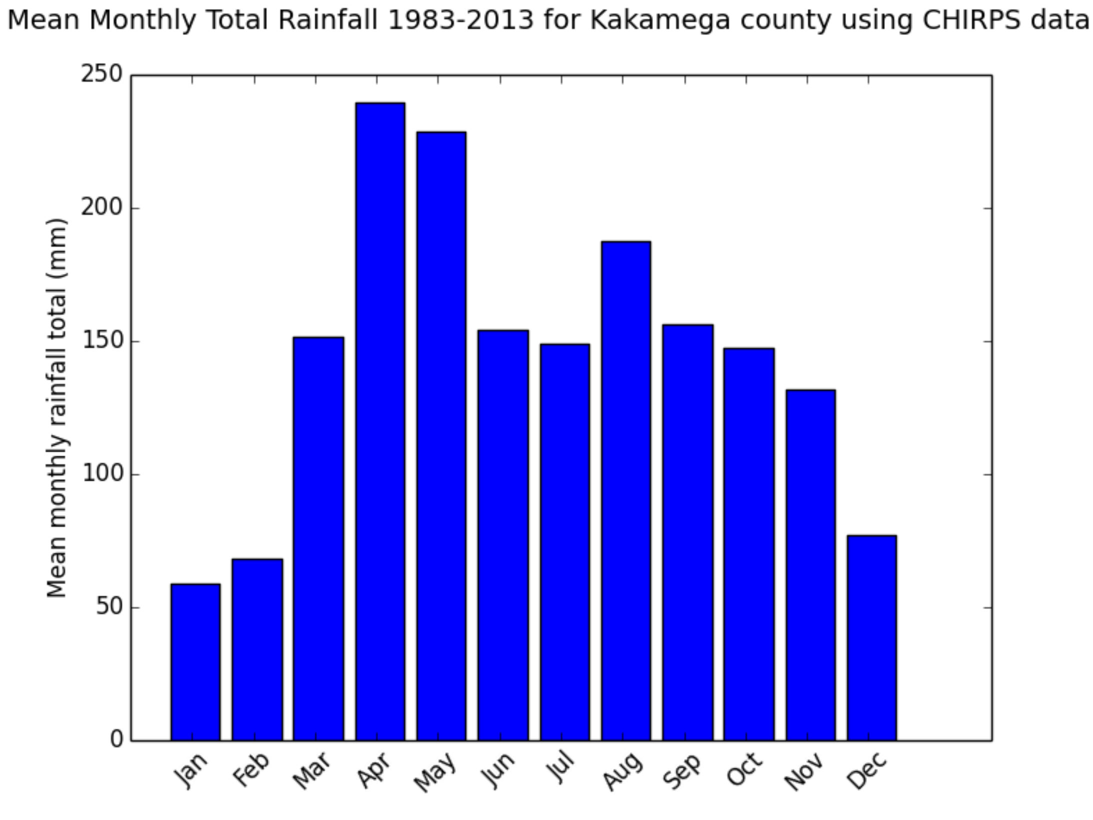


Figure 5: Bar graph showing the average total rainfall in Kakamega county for each month calculated over the period from January 1983 to December 2013. The dataset used is CHIRPS.

Figure 6 shows a map of rainfall distribution across Kakamega county, averaged across four three-month periods. The drier season of December to February (DJF) and the wetter period during the long rains in March to May (MAM) can be clearly seen. For much of the rest of the year, rainfall is seen to be fairy evenly distributed across the county and across the months, with slightly more rainfall in June-August (JJA).

Some differences are noted across the county in the CHIRPS dataset. Some grid boxes show higher levels of rainfall where the influence of mountains is felt, and the north-east of the county is generally drier. These patterns in the CHIRPS dataset are likely to be realistic, but the boundaries between different grid boxes should not be taken too precisely. These occur due to the way the data are interpolated onto a grid and then displayed using a colour scale with distinct bands. The data are an average across 30 years, so for an understanding of the variability between years figure 7 must be used.

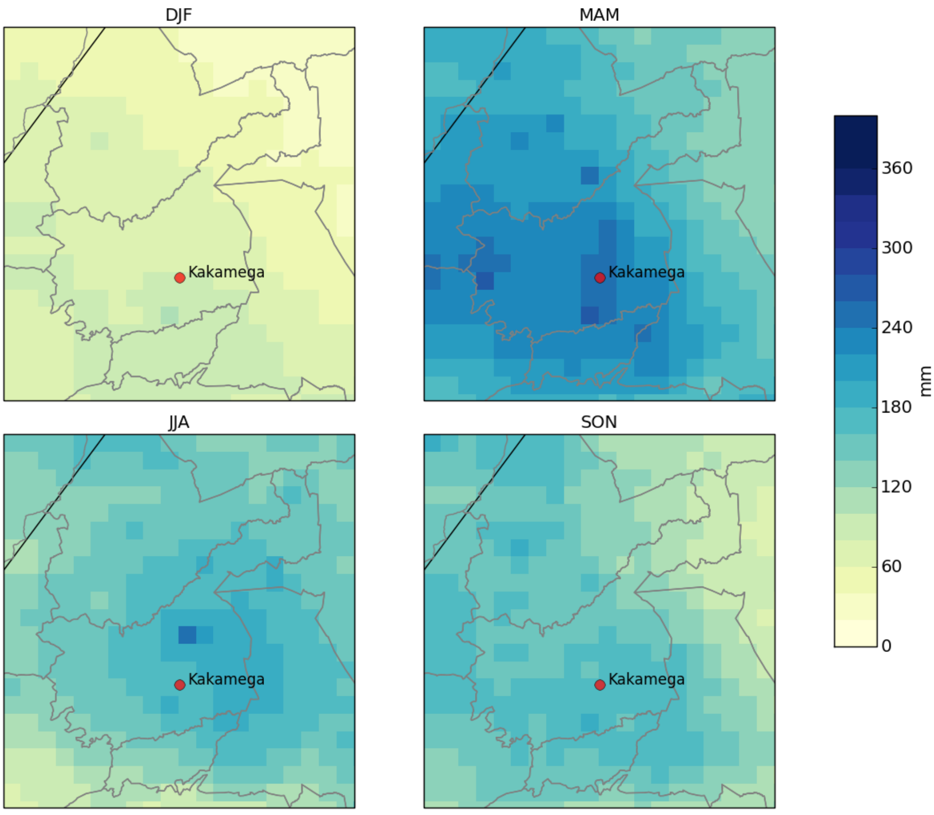


Figure 6: Map of Kakamega county showing average monthly rainfall totals over four 3-monthly periods during January 1983 to December 2013. (DJF = December, January and February; MAM = March, April and May, JJA = June, July, August, SON = September, October and November). The dataset used is CHIRPS.

Figure 7 displays the monthly totals of rainfall received as an average across the whole of Kakamega county from 1983-2013. It can be seen that this amount is very variable from month to month and year to year. The data spans a range of approximately 5mm per month to nearly 350mm per month. Some of this variability occurs due to the seasonal nature of rainfall in the region; however these extreme values do not happen every year. The graph shows that the mean value across all the months is approximately 150mm per month. The standard deviation, which describes the amount of variation in the data, is also shown as a dashed line, and highlights the variable nature of rainfall in Kakamega.

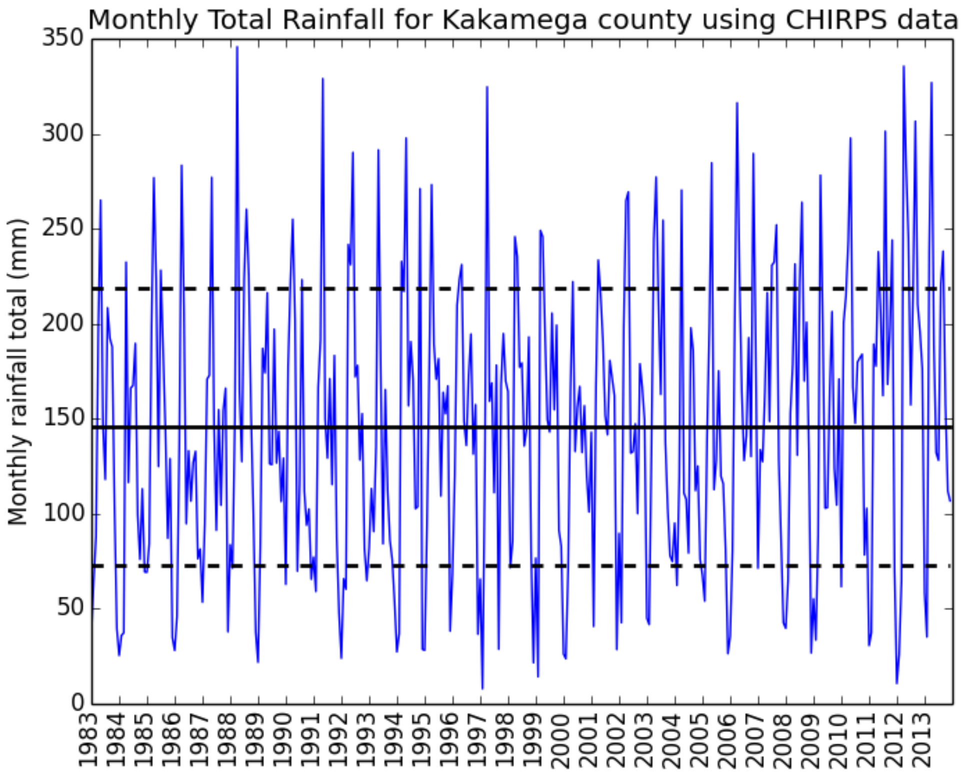


Figure 7: Line graph showing the variation in monthly totals of rainfall over Kakamega county from 1983 to 2013 (blue line). The average monthly total rainfall (solid black line) and the standard deviation (dashed line) are displayed. The dataset used is CHIRPS.

Trends in rainfall amount across the four three-month periods for Kakamega from 1901 to 2013 are shown in figure 8. The trend is calculated using a statistical method called the LOWESS fit (locally weighted scatterplot smoothing). No clear trends are particularly evident for Kakamega for most of the year. However, from September to November a significant increasing trend is present from the 1980s onwards (Pearson test shows a p-value=0.005). The very variable nature of the rainfall for this region is also clear from these graphs, with every season showing some years with extreme lows and extreme high values of rainfall.

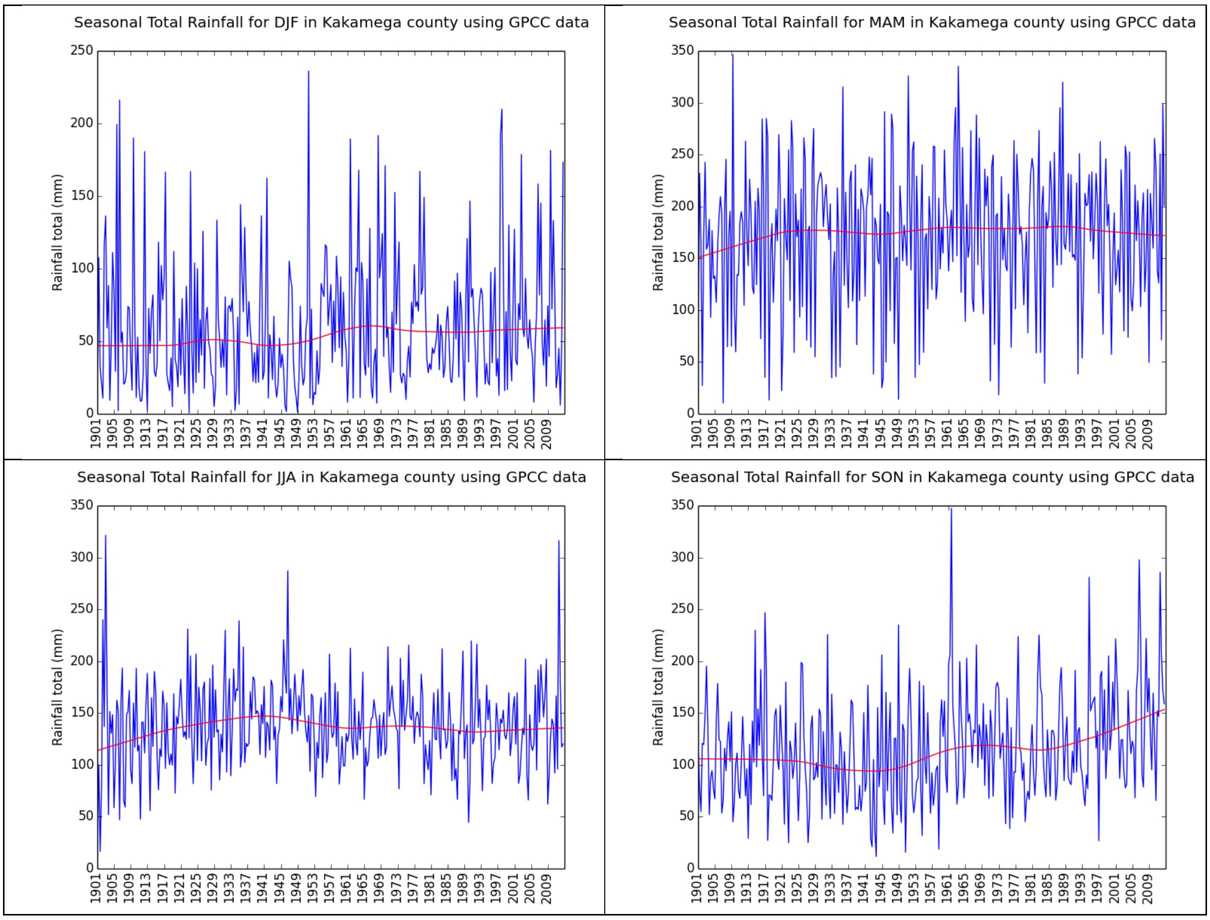


Figure 8: Line graph showing the variation in monthly totals of rainfall over Kakamega county from 1901 to 2013 (blue line). A trend line (lowess fit) is shown in red. The dataset used is GPCC.

4.2 Temperature

The mean monthly temperature across Kakamega county is found to be fairly consistent throughout the year (figure 9). A slightly warmer period occurs in February and March with temperatures of approximately 26-27°C on average and a slightly cooler period occurs in June, July and August of approximately 23-24°C on average. This figure should be used in conjunction with figures 8 and 9 to assess variability across the county and between years.

The change in temperature across Kakamega county for four three-month periods is displayed in figure 10. This map again displays that temperatures are fairly similar across the year. The southern and western areas of the county are found to be slightly warmer than the northern and eastern areas.

The dataset used is CRU TS4.01 which is at quite a low horizontal resolution of 0.5º. This means the grid boxes displayed in the map are quite big and the county only spans into four boxes. Although the maps are not very detailed, the temperatures in this region are not highly variable so the dataset will provide a good estimate for the general patterns across the county. Mountainous areas will be cooler than the surrounding areas typically represented here.

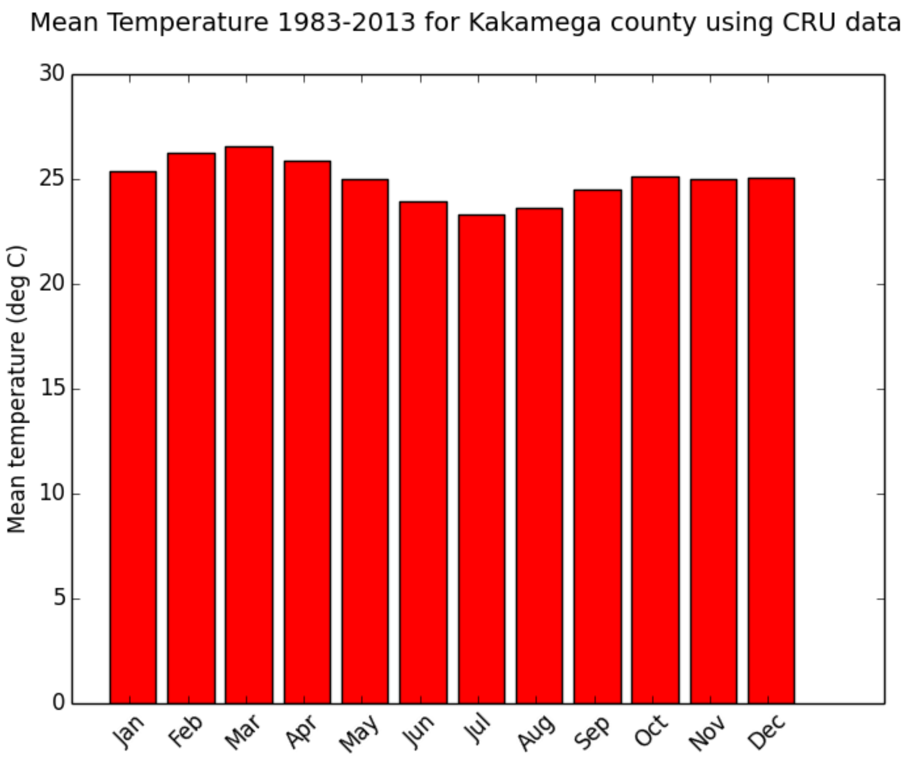


Figure 9: Bar graph showing the average temperature in Kakamega county for each month calculated over the period from January 1983 to December 2013. The dataset is CRU TS4.01.

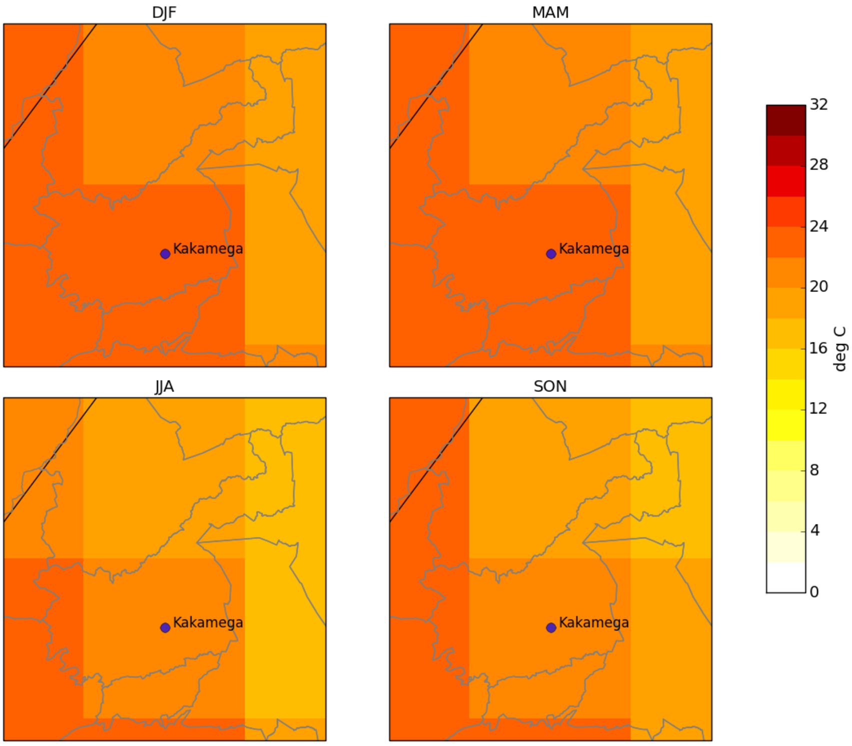


Figure 10: Map of Kakamega county showing average temperature over four 3-monthly periods during January 1983 to December 2013. (DJF = December, January and February; MAM = March, April and May, JJA = June, July, August, SON = September, October and November). The dataset used is CRU TS4.01.

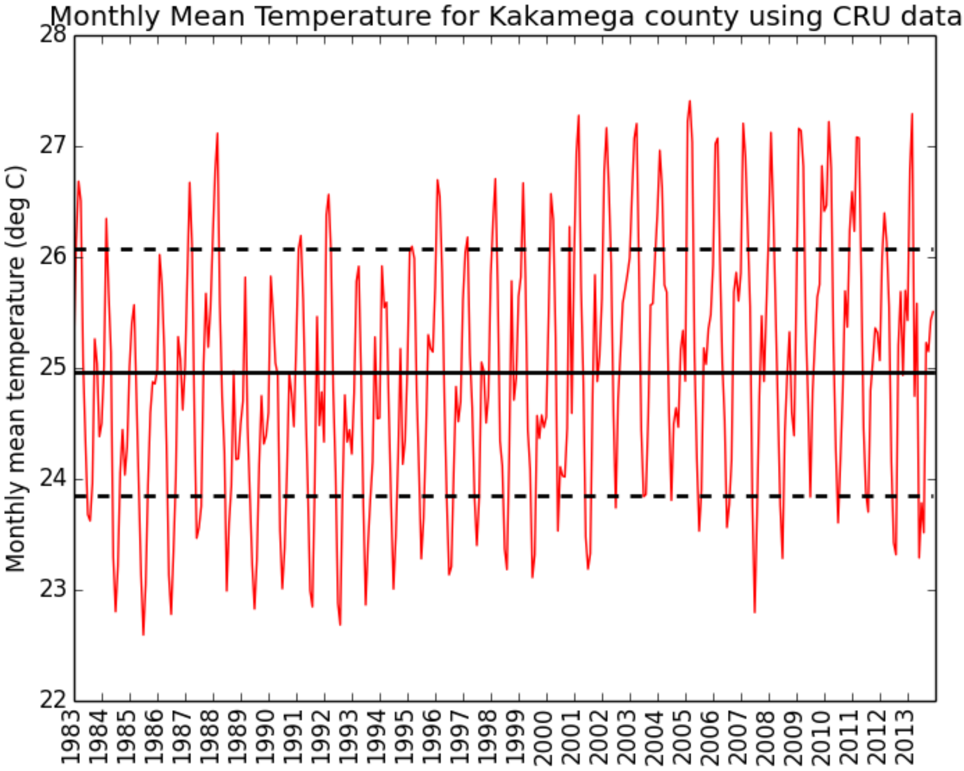
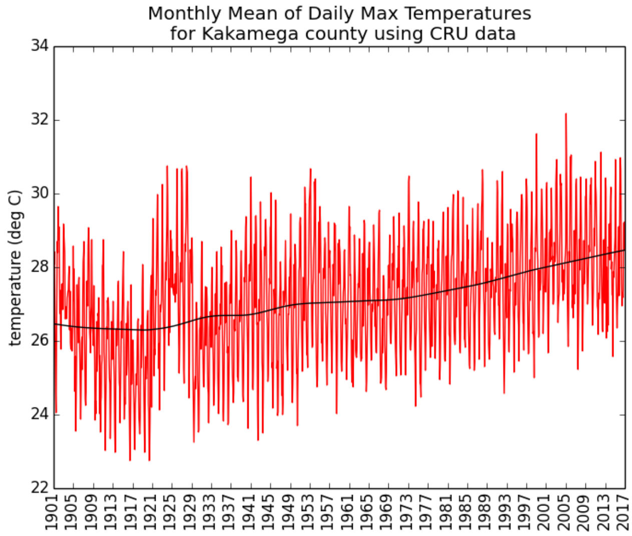


Figure 11: Line graph showing the variation in monthly mean temperature in Kakamega county from 1983 to 2013 (red line). The average monthly temperature for the whole period (solid black line) and the standard deviation (dashed line) are displayed. The standard deviation shows the amount of variation in the data.

The mean temperature over the recent past (1983-2013) across Kakamega county is shown in figure 11. This period is not long enough to assess long-term trends but the variability across the year and between years can be determined. Overall, a cycle across each year is noted, but there is little variation from year to year. The mean across the 30 years is close to 25°C with a small standard deviation, a measure of the variation, of 1°C on either side of the mean.

The trends in mean, maximum and minimum temperatures for Kakamega are shown in figure 12. The trend has been calculated using a statistical method called the LOWESS fit (locally weighted scatterplot smoothing). For all three of these measures, it is clear that temperatures have been increasing in the county over the last century by around 1-2°C, with the biggest changes noted for minimum temperatures. Seasonal cycles and large variations from year-to-year are also noted. Some years of sustained above-normal temperatures are also evident, such as in the 1920s, which may be related to large scale phenomena such as ENSO.


Monthly Mean of Daily Max Temperatures
for Kakamega county using CRU data
temperature (deg C)
34
32
30
28
26
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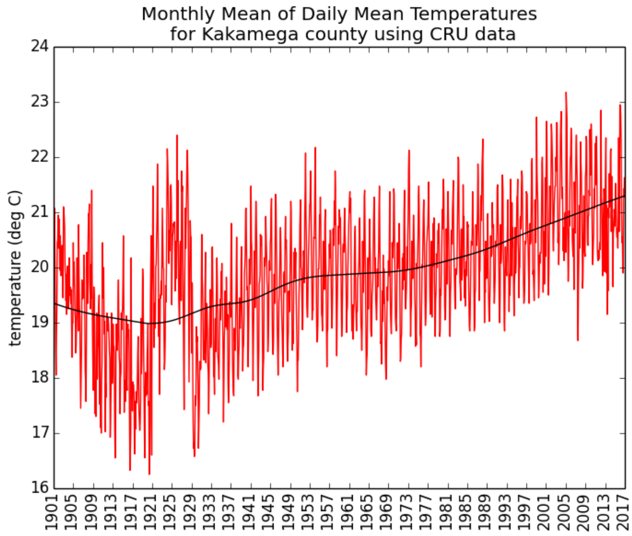
22
1901 1905 1909 1913 1917 1921 1925 1929 1933 1937 1941 1945 1949 1953 1957 1961 1965 1969 1973 1977 1981 1985 1989 1993 1997 2001 2005 2009 2013 2017


Monthly Mean of Daily Mean Temperatures
for Kakamega county using CRU data
temperature (deg C)
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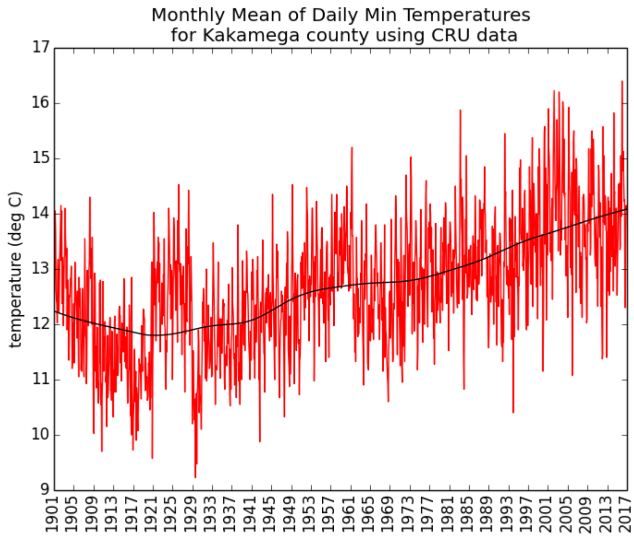

Monthly Mean of Daily Min Temperatures
for Kakamega county using CRU data
temperature (deg C)
17
16
15
14
13
12
11
10
9
1901 1905 1909 1913 1917 1921 1925 1929 1933 1937 1941 1945 1949 1953 1957 1961 1965 1969 1973 1977 1981 1985 1989 1993 1997 2001 2005 2009 2013 2017

Figure 12: Trends in monthly mean of daily max (top), daily mean (middle) and daily min (bottom) temperatures across Kakamega county from 1901 to 2017. The black line shows a trend line (lowess fit). The data used is CRU TS4.01.

5. Siaya County climate summary

5.1 Rainfall

Siaya county has two peaks in rainfall which occur in April and November on average (figure 13). The April peak is larger, with around 220mm received at that time, and in November the county receives about 140mm on average. A drier period occurs in January and February with around 60mm per month on average. A second drier period also occurs in July where approximately 70mm of rainfall occurs on average.

Figure 13 shows an average of all the rainfall occurring across the county and is an average across a thirty year period, from 1983-2013. It should be used in conjunction with figures 18 and 19 to assess variability across the county and from year to year. The figure is also based on monthly averages so it is not detailed enough to assess onset or cessation of rainfall at a daily scale. The dataset, CHIRPS, is a blend of satellite and rain gauge data so although it provides our best estimate for monitoring rainfall across the region, locally measured point rainfall figures may differ to these.

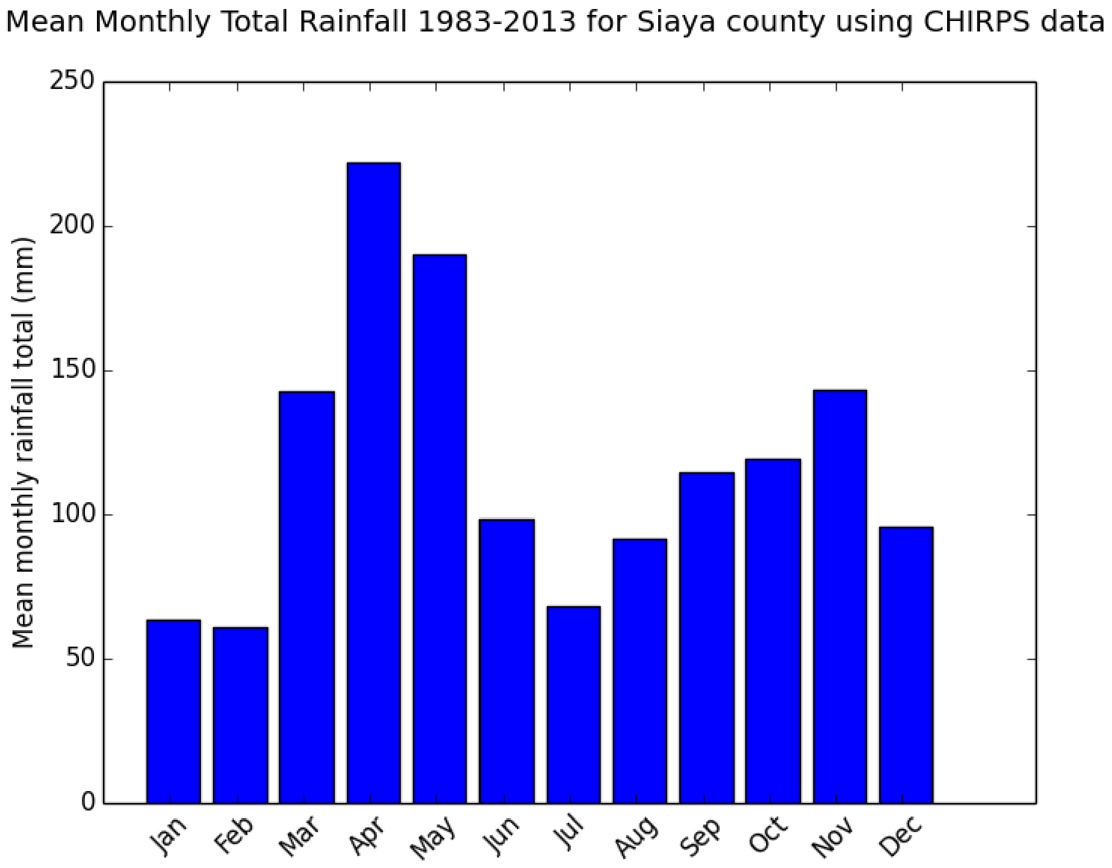


Figure 13: Bar graph showing the average total rainfall in Siaya county for each month calculated over the period from January 1983 to December 2013. The dataset used is CHIRPS.

Figure 14 shows a map of rainfall distribution across Siaya county, averaged cross four three-month periods. The dry period in January and February (present in the DJF map) can be clearly seen. The June, July and August map (JJA) which contains another drier period is also evident. The wetter period around April (present in the MAM map) is also displayed. A trend across the county appears to exist with drier conditions typically present in the south and west through the year, with wetter conditions in the north and east.

The general patterns across the county displayed in the CHIRPS dataset are likely to be realistic, but the boundaries between different grid boxes should not be taken too precisely. These occur due to the way the data are interpolated onto a grid and then displayed using a colour scale with distinct bands. The data are an average across 30 years, so for an understanding of the variability between years figure 15 must be used.

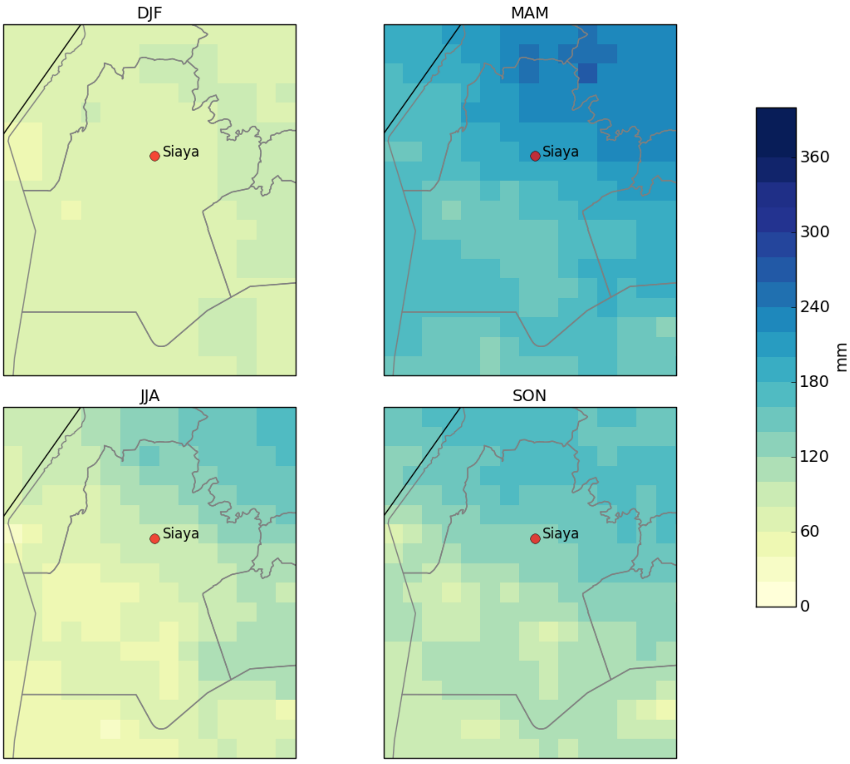


Figure 14: Map of Siaya county showing average monthly rainfall totals over four 3-monthly periods during January 1983 to December 2013. (DJF = December, January and February; MAM = March, April and May, JJA = June, July, August, SON = September, October and November). The dataset used is CHIRPS.

Figure 15 displays the monthly totals of rainfall received as an average across the whole of Siaya county from 1983-2013. It can be seen that this amount is very variable from month to month and year to year. The data spans a range of approximately 5mm per month to nearly 300mm per month, with one particularly large peak of about 380mm in 2007. Some of this variability occurs due to the seasonal nature of rainfall in the region; however extreme values do not happen every year. The graph shows that the mean value across all the months is approximately 120mm per month. The standard deviation, which describes the amount of variation in the data, is also shown as a dashed line, and highlights the variable nature of rainfall in Siaya.

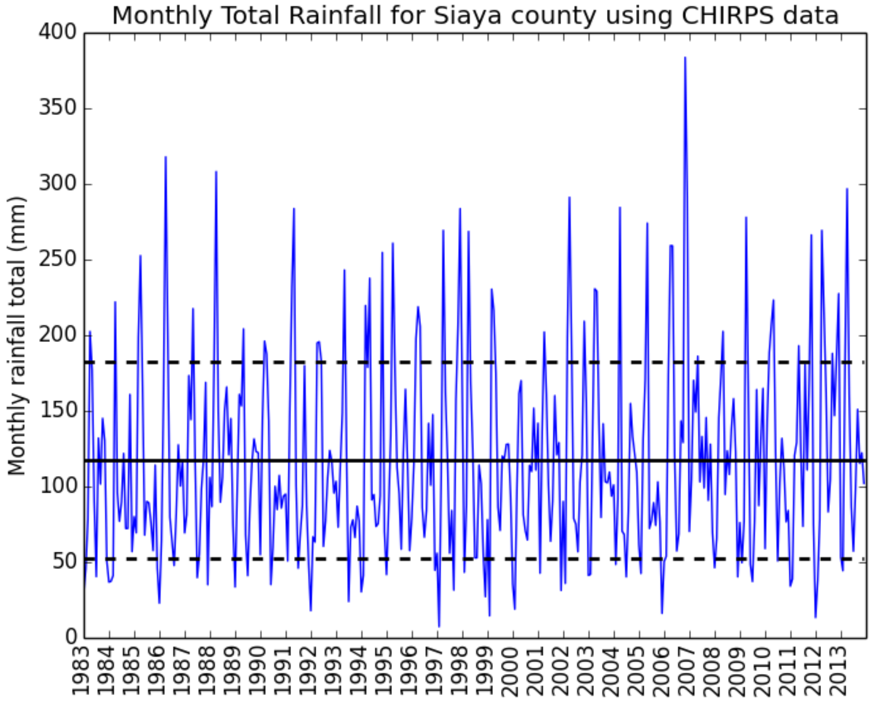


Figure 15: Line graph showing the variation in monthly totals of rainfall over Siaya county from 1983 to 2013 (blue line). The average monthly total rainfall for the whole period (solid black line) and the standard deviation (dashed line) are displayed. The standard deviation shows the amount of variation in the data.

Trends in rainfall amount across the four three-month periods for Siaya from 1901 to 2013 are shown in figure 16. The trend is calculated using a statistical method called the LOWESS fit (locally weighted scatterplot smoothing). No clear trends are particularly evident for Siaya, apart from in September to November which shows a statistically significant increase from the 1970s onwards (Pearson test shows a p-value=0.03). The very variable nature of the rainfall for this region is also clear from these graphs, with every season showing some years with extreme lows and extreme high values of rainfall.

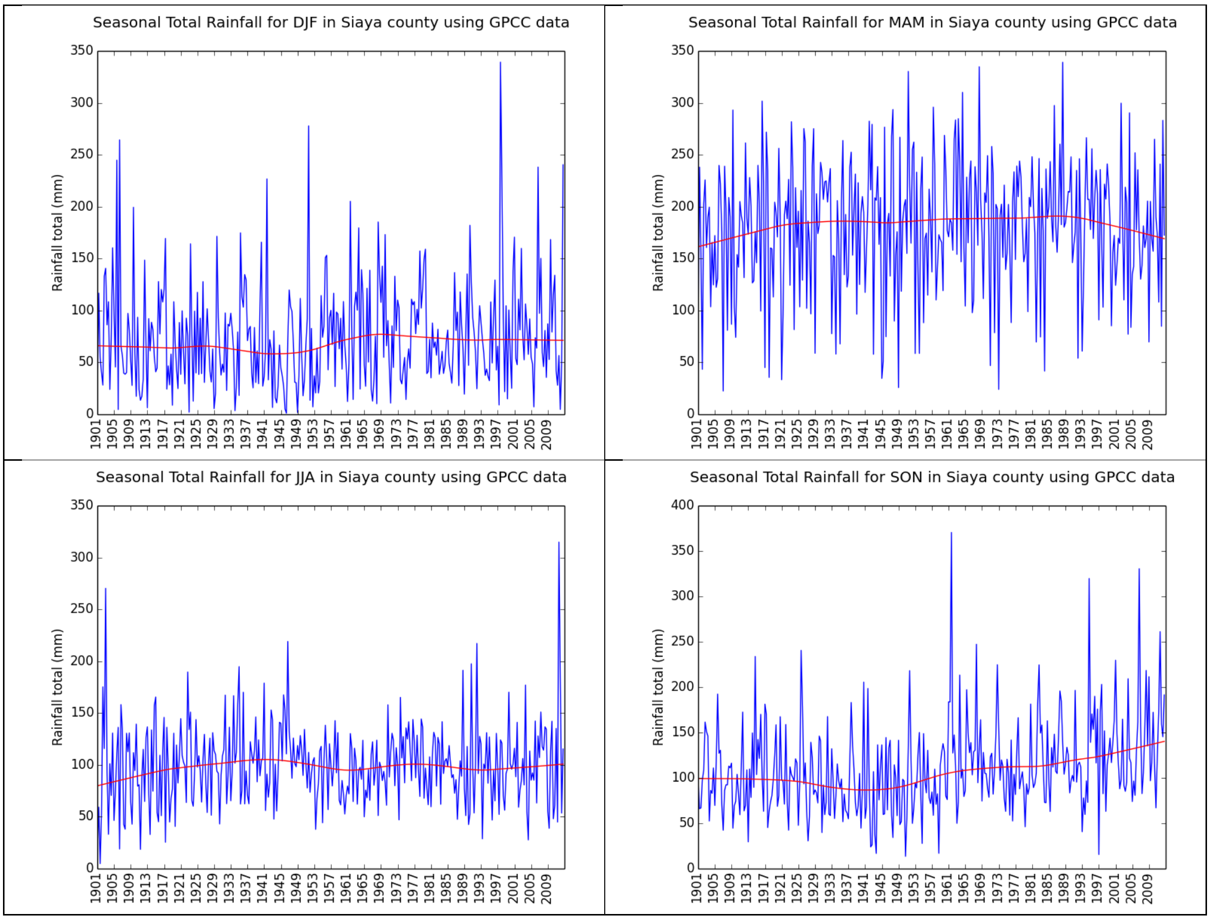


Figure 16: Line graph showing the variation in monthly totals of rainfall over Siaya county from 1901 to 2013 (blue line). A trend line (lowess fit) is shown in red. The dataset used is GPCC.

5.2 Temperature

The mean monthly temperature across Siaya county is found to be fairly consistent throughout the year (figure 17). A slightly warmer period occurs in February and March with temperatures of approximately 26-27°C on average and a slightly cooler period occurs in June, July and August of approximately 23-24°C on average. This figure should be used in conjunction with figures 18 and 19 to assess variability across the county and between years.

The change in temperature across Siaya county for four three-month periods is displayed in figure 18. This map again displays that temperatures are similar across the year and across the county. The dataset used is CRU TS4.01 which is at quite a low resolution of 0.5º. This means the grid boxes displayed in the map are quite big and the county only spans into a few boxes. Although the maps are not very detailed, the temperatures in this region are not very variable so the dataset will provide a good estimate for the general trends across the county. Hilly areas will be cooler than the surrounding lower-lying areas typically represented here.

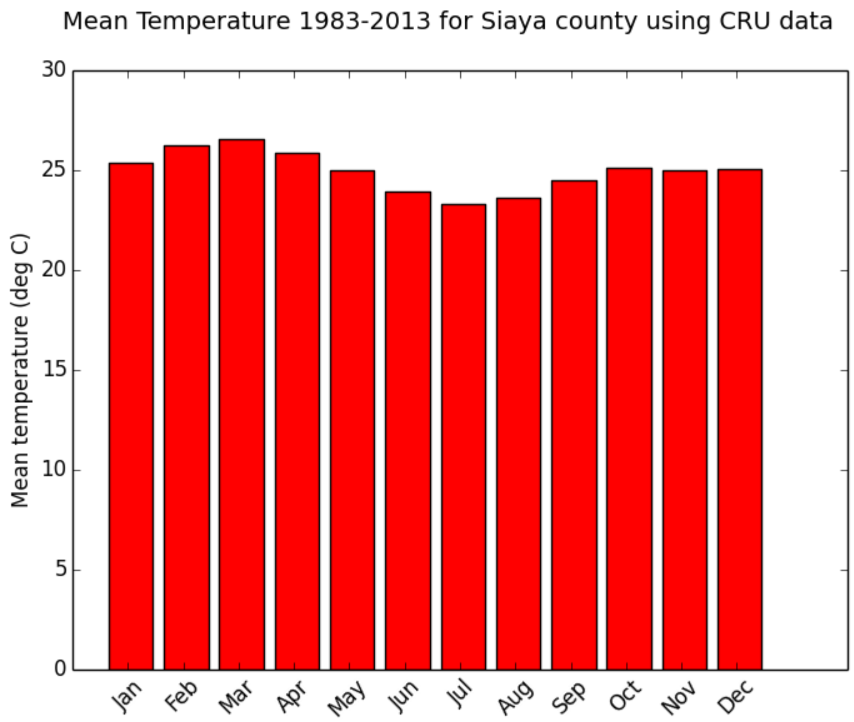


Figure 17: Bar graph showing the average temperature in Siaya county for each month calculated over the period from January 1983 to December 2013.

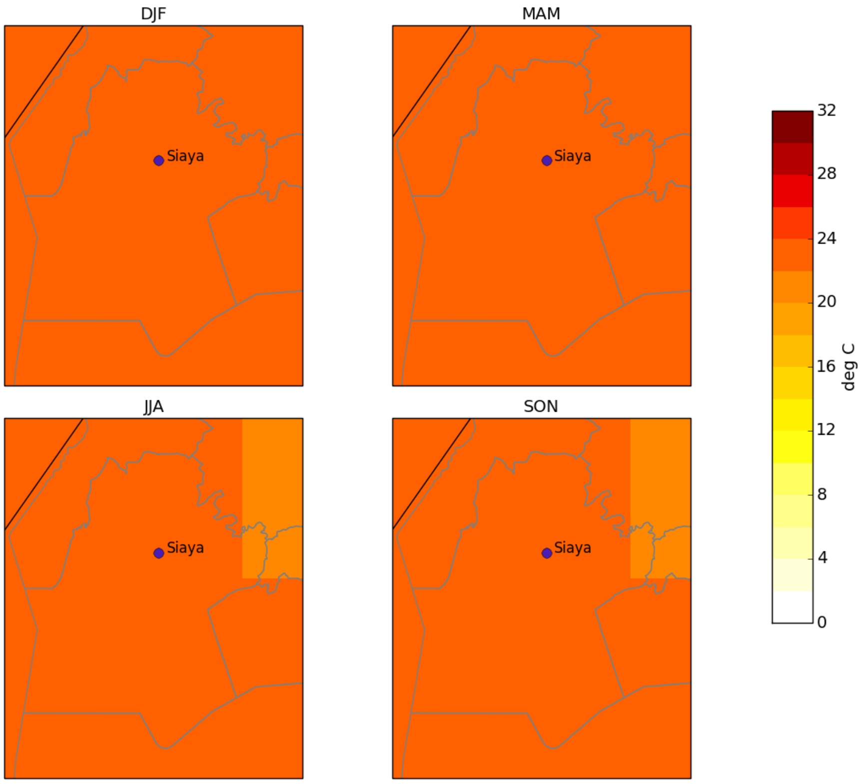


Figure 18: Map of Siaya county showing average temperature over four 3-monthly periods during January 1983 to December 2013. (DJF = December, January and February; MAM = March, April and May, JJA = June, July, August, SON = September, October and November). The dataset used is CRU TS4.01.

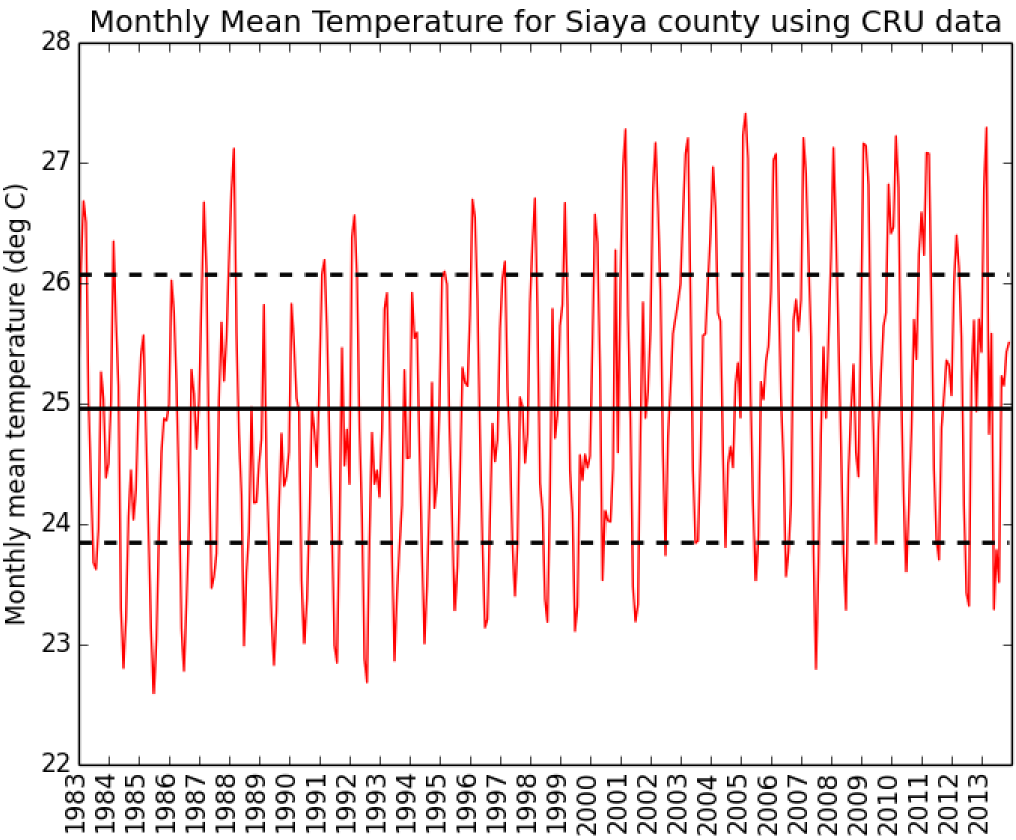
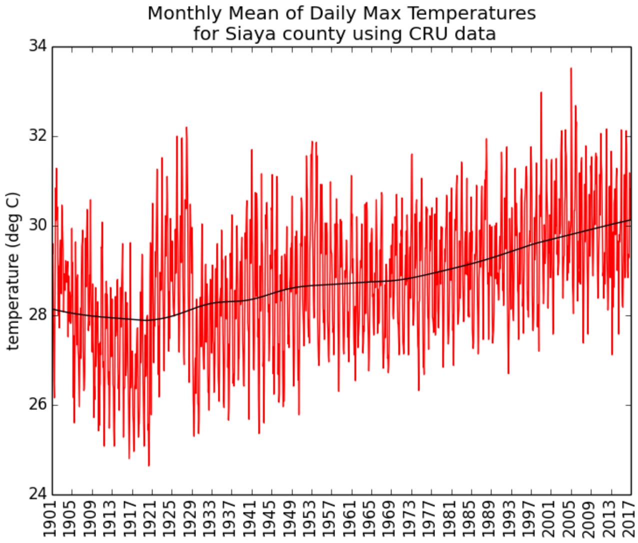
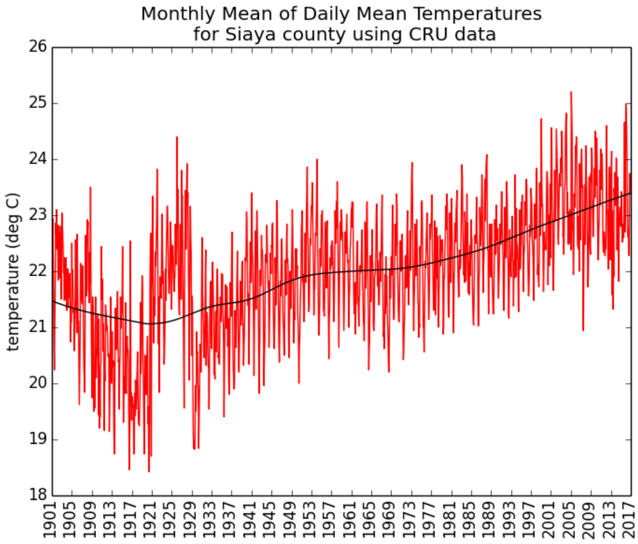


Figure 19: Line graph showing the variation in monthly average temperature in Siaya county from 1983 to 2013 (red line). The average temperature over the whole period (solid black line) and the standard deviation (dashed line) are displayed. The standard deviation shows the amount of variation in the data.

The mean temperature over the recent past (1983-2013) across Siaya county is shown in figure 19. This period is not long enough to assess trends but the variability across the year and between years can be determined. Overall, a cycle across each year is noted, but there is little variation from year to year. The mean across the 30 years is close to 25°C with a small standard deviation, a measure of the variation, of 1°C on either side of the mean.

The trends in mean, maximum and minimum temperatures for Siaya are shown in figure 20. The trend has been calculated using a statistical method called the LOWESS fit (locally weighted scatterplot smoothing). For all three of these measures, it is clear that temperatures have been increasing in the county over the last century by around 2°C. Seasonal cycles and large variations from year-to-year are also noted. Some years of sustained above normal temperatures are also evident, such as in the 1920s, which may be related to large scale phenomena such as ENSO.





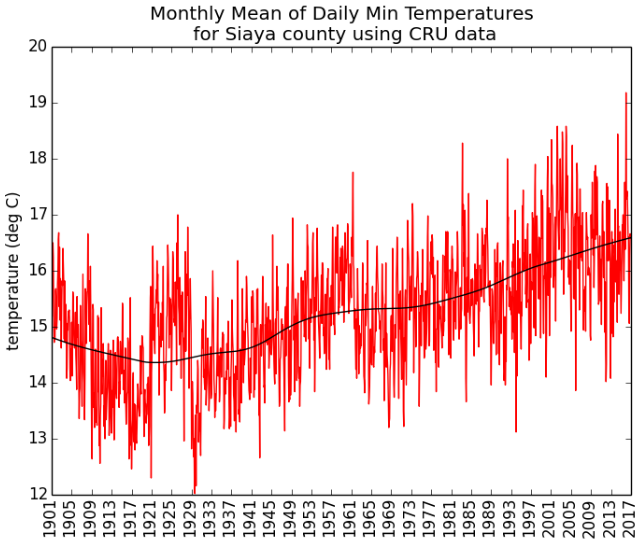


Figure 20: Trends in monthly mean of daily max (top), daily mean (middle) and daily min (bottom) temperatures across Kakamega county from 1901 to 2017. The black line shows a trend line (lowess fit). The data used is CRU TS4.01.

6. Future projections of the climate in Kenya

6.1 Rainfall

The climate mechanisms that are important for rainfall in East Africa are not thoroughly understood and it is also not known how well climate models represent these processes. Therefore detailed rainfall projections at the county level are not provided as these may indicate a level of detail that is misleading. The results are therefore provided at the country level where signals from the models can be interpreted more broadly and provide messages which are more robust.

For each of the four three-month periods, the models included within CMIP5 were assessed to determine which showed the driest, the mean and the wettest projection for Kenya as a whole. These results are shown at figure 21. It should be noted that the models run at different horizontal resolutions and define their model grids differently over the globe, this results in different patterns of grid boxes in these results. Broadly across all four periods, the models show a range of results from drier to little change to wetter projections. For the Lake Victoria Basin within Kenya the most uncertain period is the short rains within the September to November (SON) period. The spread in these results is approximately a decrease of 80mm per month to an increase of 60mm per month. The long rains during the March-May period (MAM) show a slight decrease of around 20mm per month to an increase of 30 mm per month.

The change in future rainfall over time during the rest of the century is shown in figure 22 for the four three-month periods as projected by the CMIP5 climate models. These graphs show that no clear wetter or drier signal is present overall in any of the periods. It is also evident that the rainfall is projected by some of the models to be much more extreme in future, with some years showing much wetter conditions compared to the recent past and some which will be much drier. Results from individual models cannot be determined using these graphs, and as it is not known at present which models are more reliable than others, it is not advisable to single out individual projections. On the whole, the limits that the majority of projections lie within can be assessed for each three-month period to provide some guidance on likely change. However the outlying model projections cannot be neglected at present and should be factored in to decision making if they are required to be fully risk averse.

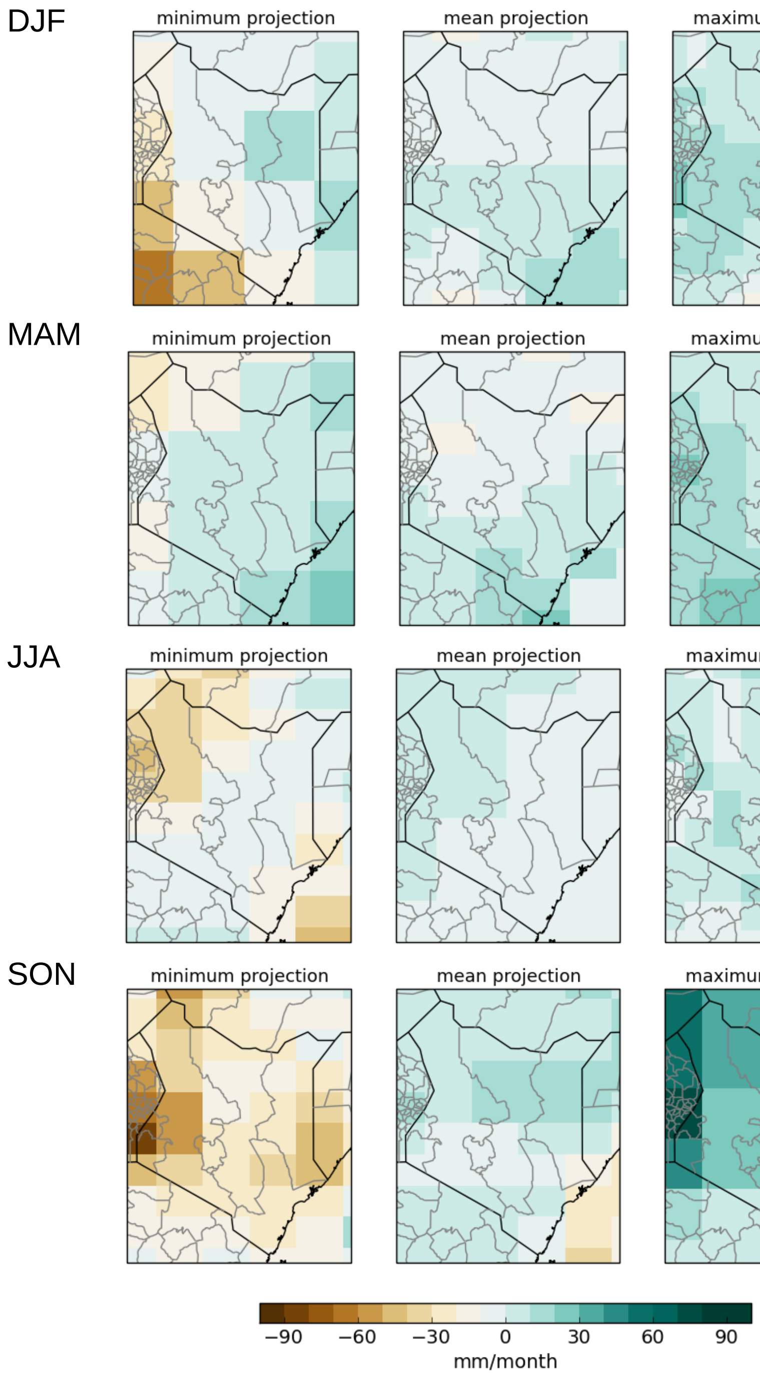


Figure 21: Maps showing future rainfall change for Kenya from the CMIP5 models for the four three-month periods. These show the change between 1983-2013 and 2020-2050. For each season the model showing the minimum amount, the mean amount and the maximum amount of rainfall for Kenya on average are displayed.

The models have been run assuming high emissions of greenhouse gases (RCP8.5).

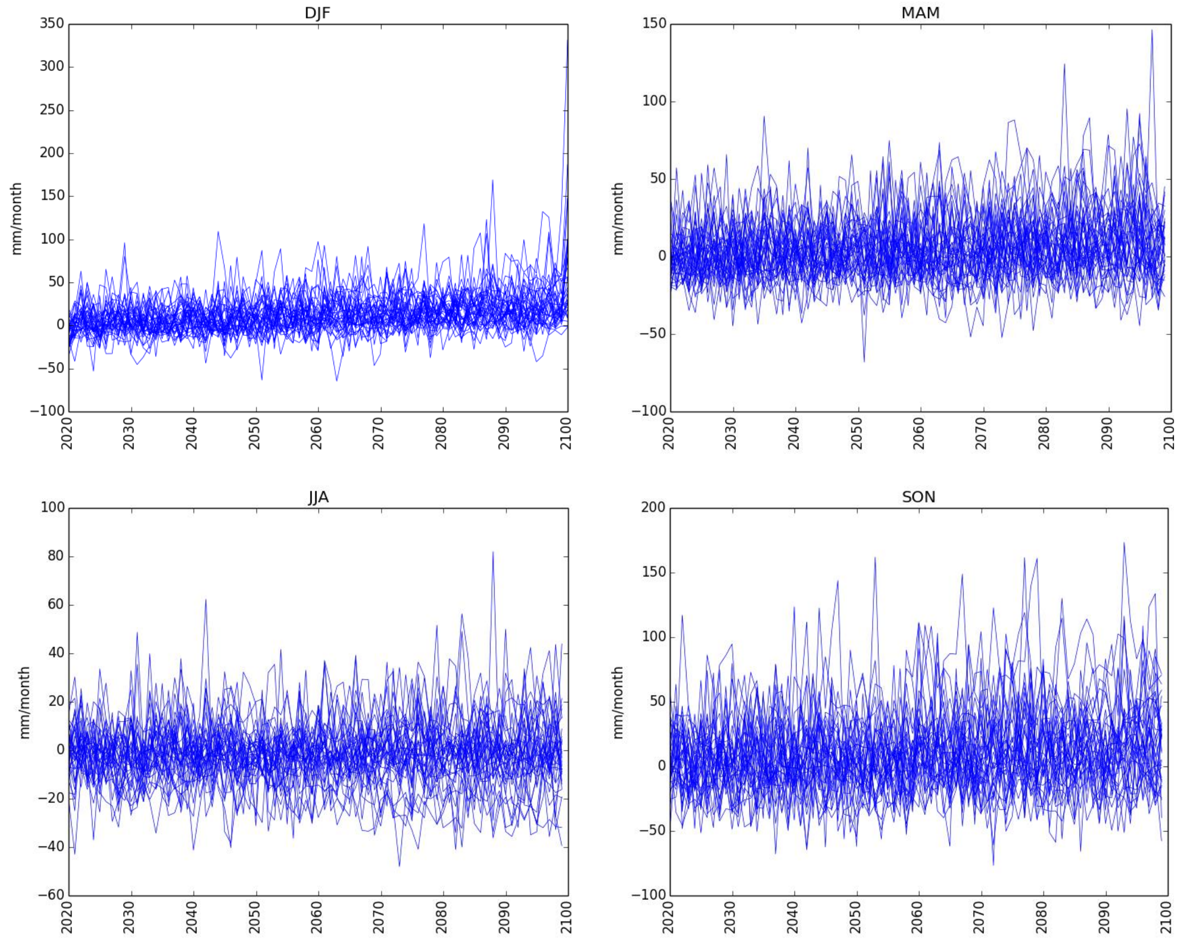


Figure 22: Line graphs showing the rainfall change expected in the future compared to the recent past period of 1975-2005 for four three-month periods from the CMIP5 models, averaged across Kenya as a whole. The models have been run assuming high emissions of greenhouse gases (RCP8.5).

6.1 Temperature

In a similar manner to the rainfall projections, temperature projections from the CMIP5 models are shown here at the country scale rather than the county scale to prevent over-interpretation of the results. However, GCMs show less uncertainty for temperature projections than for rainfall projections as the mechanisms leading to warming are better understood, so overall we have more confidence in these results.

Figure 23 shows the minimum, mean and maximum projections of temperature change from the ensemble of CMIP5 models for Kenya as a whole. These projections show the difference between temperatures averaged across 2020-2050 and those averaged across the recent past from 1983-2020. They use the RCP8.5 scenario which assumes concentrations of greenhouse gases are high in future decades. They show that for the Lake Victoria Basin the warming could extend from a small amount of around 0.15 to a larger amount of 0.6ºC.

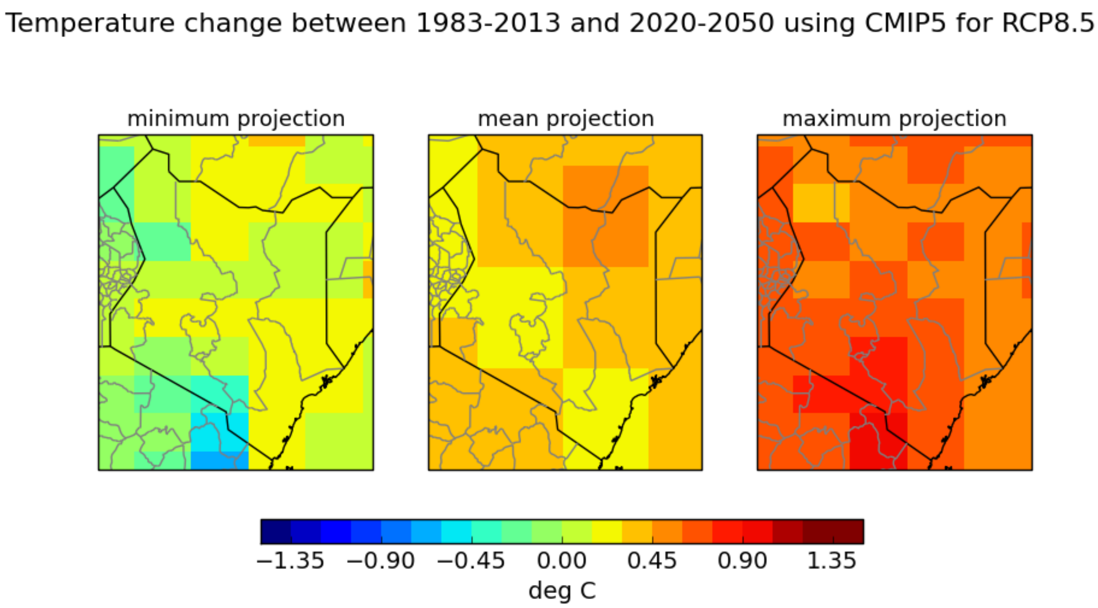


Figure 23: Maps showing future temperature change for Kenya from the CMIP5 models for the four three-month periods. These show the change between 1983-2013 and 2020-2050. For each season the model showing the minimum, the mean and the maximum temperature change for Kenya on average are displayed. The models have been run assuming high emissions of greenhouse gases (RCP8.5).

The change in future temperature over time in the rest of the century is shown in figure 24 for the four three-month periods as projected by the CMIP5 climate models using a very high emission scenario (RCP8.5). For all four of the three-month periods a rising trend is noted. There are only a few models which show any sign of a decrease in temperature. Indications of slightly cooler years occur occasionally in DJF up until 2070 and very occasionally in MAM up until the 2040s. Overall, warming in Kenya appears to be a robust message. By the end of the century the models suggest that at least 2°C of warming will have occurred and there may be as much as 7°C. The results presented here use the RCP8.5 scenario which represents the high end of expected global greenhouse gas concentrations. For scenarios where emissions are mitigated or reduced, the expected temperature rise will be less than this. As it is not currently possible to say which models are most reliable and future emissions are unknown, these high end projections of temperature cannot be ruled out from decision making processes at present.

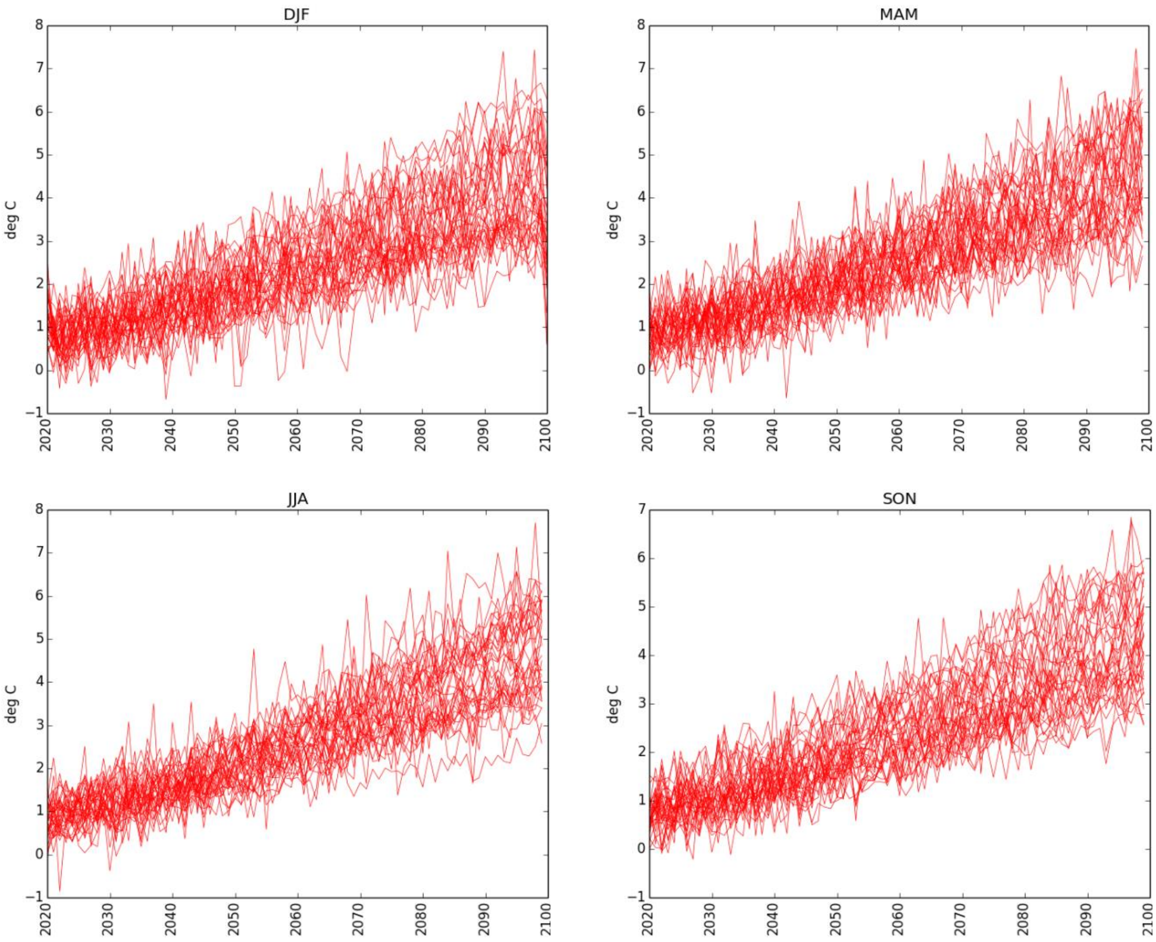


Figure 24: Line graphs showing the temperature change expected in the future compared to the recent past period of 1975-2005 for four three-month periods from the CMIP5 models, averaged across Kenya as a whole. The models have been run assuming high emissions of greenhouse gases (RCP8.5).

Summary

This report describes the recent past and future projections of the climate of Kakamega and Siaya counties in Kenya. This information has been provided to support county decision-making processes, and in particular to aid strategic planners to write CIDPs that are informed about the climate of their county. The climate summaries provided here do not negate the need for local expertise on social and physical vulnerabilities and for further analyses of relevant climate metrics to inform detailed risk or adaptation assessments.

Users should be aware that the datasets used to summarise both the climate of the recent past and to provide messages about the future climate contain uncertainties. These uncertainties arise through sparse coverage of observations and the methods used to combine measurements and interpolate them onto global grid. Future projections of the climate are limited by a lack of understanding about some atmospheric processes and the inability to simulate these fully due to current computational power availability. Further guidance on the limitations of the individual maps and graphs within the report has been provided along with some explanations to aid their interpretation.

The counties of Kakamega and Siaya are situated with the Lake Victoria Basin in the west of Kenya. They experience rainfall throughout the year but experience peaks within the long rains, typically in April, and later in the year during August for Kakamega and November for Siaya. Kakamega is typically slightly wetter in the centre of the county and drier to the north-east. Siaya is typically drier in the south-west and wetter in the north-east. The rainfall for both counties is variable both within a year and from year-to-year. Examination of past rainfall indicates no clear trends, except a rise in rainfall during September to November in recent decades for both counties. No clear signal in future rainfall is indicated by the CMIP5 global climate models for Kenya. They show a range of results from drier to little change to wetter. Some models also indicate more extremes in rainfall with some years expected to be much wetter and some much drier than in the past.

Mean temperatures across Kakamega and Siaya counties are found to be fairly consistent throughout the year. They are typically slightly warmer in February and March with a slightly cooler period in June, July and August. Temperatures are also fairly consistent across each county. The dataset used to examine temperature is at a low resolution but as temperatures in this region are not highly variable it is assumed to provide good estimates. Warming trends are present for both counties for the past few decades. Future projections of temperature assessed using the CMIP5 global climate models suggest this warming trend will continue into the future.

The high end scenario assessed here (RCP8.5) suggests that for the Lake Victoria Basin, this warming could be around 0.15 - 0.6ºC on average by 2020-2050. Warming across the whole of Kenya is indicated to be at least 2ºC by the end of the century by all of the models at all periods of the year using the high end concentrations scenario.

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