Chapter 2
What's on the 5th IPCC Report for West Africa?

Jens O. Riede, Rafael Posada, Andreas H. Fink and Frank Kaspar

Abstract The status of knowledge on observed and projected climate change is regularly summarized in the assessment reports of the Intergovernmental Panel on Climate Change. The latest IPCC report (2013) concludes that Africa as a whole is one of the most vulnerable continents due to its high exposure and low adaptive capacity. Here, the major conclusions of the report for Western Africa are summarized. Although there are still large gaps in the available data, evidence of warming over land regions across Africa, consistent with anthropogenic climate change, has increased. Temperature projections over West Africa for the end of the 21st century from global climate simulation range between 3 and 6 °C above the late 20th century baseline depending on the emission scenario. A similar range is produced with regional climate models that are used to downscale global climate simulations. For some regions, unprecedented climates are projected to occur at around 2040. Important progress has been made in the understanding of West African weather systems during the African Monsoon Multidisciplinary Analysis (AMMA; phase 1: 2002–2010, phase 2: 2010–2020) project. For many processes in ecology, agriculture or hydrology, precipitation is one of the most important parameters. In addition to the total precipitation, the onset of the rainy season is of special interest for agriculture. In the past a shift of the rainy season was discussed, but currently a shift cannot be observed for West Africa. However, the length of the Sahelian rainy season reveals an increasing trend of 2–3 days per decade, with a drier phase within. Since the 1950s annual precipitation has tended to decrease in western and eastern parts of the Sahel region, with a very dry period in the 70s and 80s and a slight increase of precipitation afterwards, until today. However, climate projections show a slight increase of total precipitation and a longer rainy season with a drier phase within.

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2.1 Introduction

Climate variability and climate change have impacts on many sectors, such as agriculture, water availability and health. Depending on the adaptive capacity of a society, these impacts might result in strong vulnerability. One of the main features responsible for climatic conditions over West Africa is the West African monsoon system (WAM). The underlying atmospheric processes and interactions with the land surface and ocean are complex and not yet fully understood. Several recent research activities have addressed the knowledge gap the and did advance our understanding of the WAM system. Among these are the African Multidisciplinary Monsoon Analysis (AMMA, phase 1: 2002–2010, phase 2: 2010–2020) or the GLOWA-Impetus and GLOWA-Volta project. Results of these activities have been published in several special issues (Lafore et al. 2010; Plocher et al. 2011; Speth et al. 2010).

The status of knowledge on global and regional climate change and related impacts has been summarized in the 5th Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). Widespread impacts of climate change have been identified on all continents and detailed regional summaries are available.

The following sections provide a summary of these findings. Section 2.2 gives a short introduction to the climate of West Africa. Sections 2.3 and 2.4 provide a summary of the major IPCC conclusions about observed and projected climate change in West Africa. Readers not familiar with the work of IPCC can find some background information in Box 1.

Box 1. The Intergovernmental Panel on Climate Change
The IPCC is a scientific body under the auspices of the United Nations (UN) which reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. This international body publishes Assessment Reports (AR) periodically to provide a clear and up to date view of the current state of scientific knowledge about climate change. The IPCC is currently organized in 3 Working Groups and a Task Force. Working Group I deals with “The Physical Science Basis of Climate Change”, Working Group II with “Climate Change Impacts, Adaptation and Vulnerability” and Working Group III with “Mitigation of Climate Change”. The Task Force on National Greenhouse Gas Inventories is to develop and refine a methodology for the calculation and reporting of national greenhouse gas emissions and removals. The preparation of the last report (Fifth Assessment Report, AR5) involved more than 830 authors and review editors from over 80 countries. They in turn drew on the work of over 1000 contributing authors and about 2000 expert reviewers who provided over 140,000 review comments.

The assessments have become much more complete over time, evolving from making very simple, general statements about sectorial impacts, through greater concern with regions regarding observed and projected impacts and associated vulnerabilities, to an enhanced emphasis on sustainability and equity, with a deeper examination of adaptation options (Hewitson et al. 2014). The AR5 provides an assessment of regional aspects of climate change in different parts of the world. The evidence linking observed impacts on biological, physical, and (increasingly) human systems to recent and ongoing regional climate changes has become more compelling since the AR4. One reason for this is the improved reporting of published studies from hitherto under-represented regions of the world, especially in the tropics (Rosenzweig and Neofotis 2013).

That said, there is still a large disparity between the copious evidence being presented from Europe and North America, as well as good quality data emerging from Australasia, polar regions, many ocean areas, and some parts of Asia and South America, on the one hand, and the much sparser coverage of studies from Africa, large parts of Asia, Central and South America, and many small islands, on the other. However, as the time series of well-calibrated satellite observations become longer in duration, and hence statistically more robust, these are increasingly providing a near global coverage of changes in surface characteristics such as vegetation, hydrology, and snow and ice conditions that can usefully complement or substitute for surface observations (Stocker et al. 2013).

The IPCC AR5 includes an extensive chapter dedicated to Africa in which the observed climate trends and projections are described (Niang et al. 2014). In this section we summarize observed and projected climate trends described in the IPCC Report, with a special focus on the Western part of the continent.

2.2 Climate Zones in West Africa

The climate in Africa has huge variation between the most northern parts in Tunisia and the most southern parts in South Africa. Therefore a variety of climate zones exist in Africa: from tropical rainforest climates in East, Central and West Africa to alpine climate on the East African Mountains. The term "West Africa" is commonly used to refer to the western part of Africa, although the geographical boundaries of this area are not clear and differ from one source to another. For instance, Lélé and Lamb (2010) considers "West Africa" as being bounded by the Atlantic Ocean to the west and south, by the north of the Sahel-zone at around 20° N latitude to the north, and by 10° E to the east. Another definition of Western Africa is the economic area "Economic Community of West African States" (ECOWAS) including 15 countries in Western Africa (Benin, Burkina Faso, Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo). This is the definition that has also been used in the latest IPCC report. On average the region is around 300 m above sea level, with only a few mountainous regions.

Wet and dry tropical climate zones occur in the region. Figure 2.1 shows the distribution of annual precipitation in the region. Precipitation has a strong south-north-gradient: the annual amount decreases significantly from the Atlantic coast in the south towards the Sahara in the north. The aridity increases accordingly with the distance from the ocean. Based on these great differences in precipitation, three climatic zones exist in Western Africa (e.g., according to Njeri et al. 2006, Fink et al. 2016): (a) The Sahelian zone, with irregular annual rainfall that does not exceed 500 mm, and a maximum rainfall occurring in August. This zone is located roughly at 12.5° N latitude and its climate is semi-arid. (b) The Sudanian zone with a precipitation amount between less than 200 mm in the north of Nigeria and 1000 mm in the north of Mali. The climate is sub-humid and located approximately between 9° N and 12.5° N. (c) The tropical humid Guinea Cost zone located along the Gulf of Guinea, characterized by annual mean rainfall higher than 1500 mm.

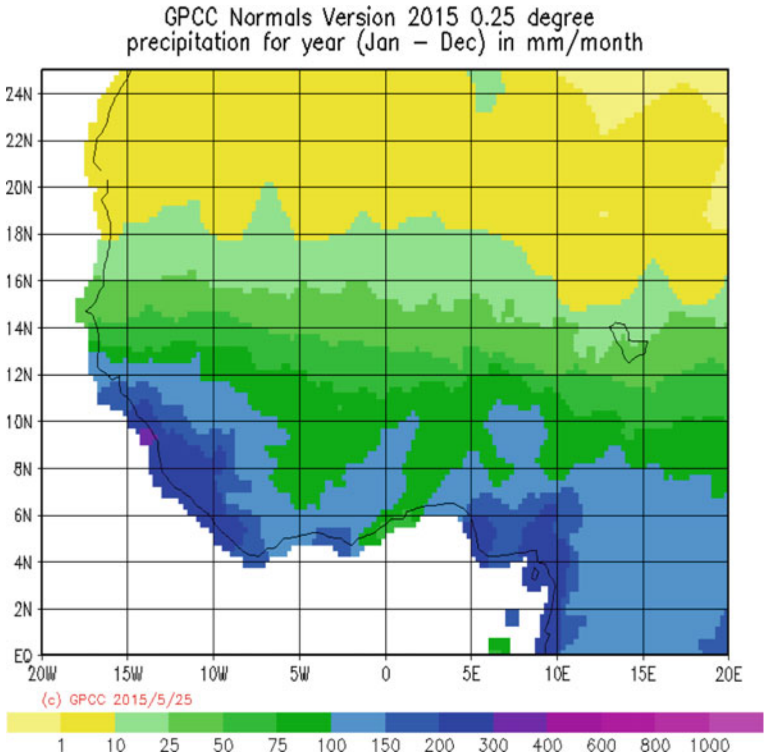


Fig. 2.1 Annual precipitation based on the gridded dataset of the global precipitation climatology center—version 2015 (Becker et al. 2013; Meyer-Christoffer et al. 2015)

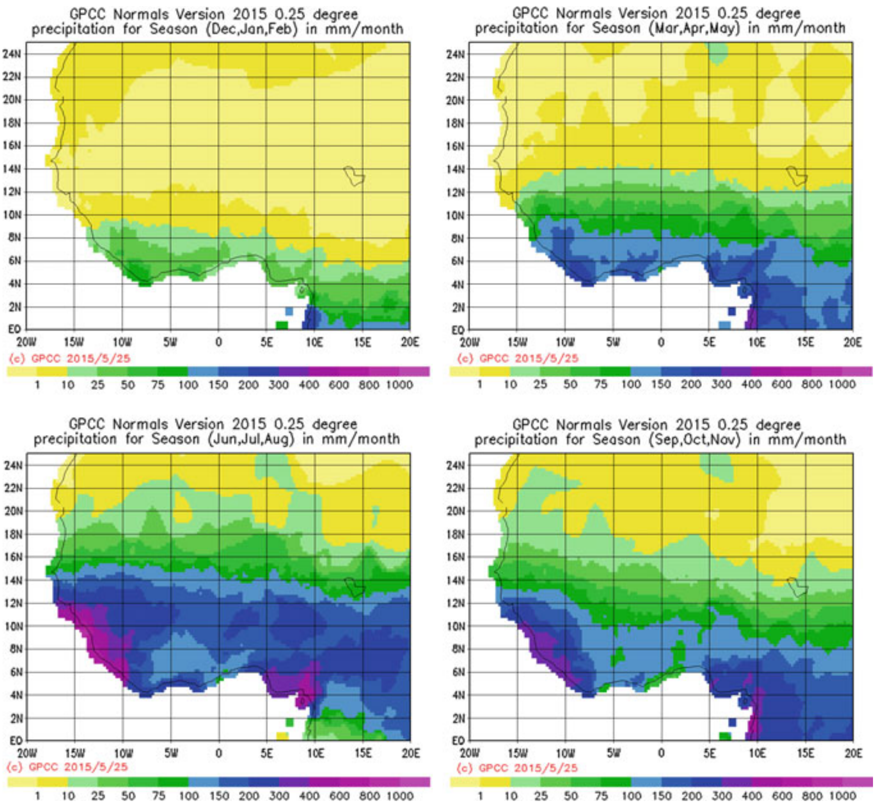


Fig. 2.2 Average annual precipitation over West Africa based on the gridded dataset of the global precipitation climatology center (version 2015; Meyer-Christoffer et al. 2015). There is a strong pattern in seasonality (*upper left*) dry season, DJF, end of dry season, beginning of rainy season from the south to the north MAM (*upper right panel*), rainy season JJA (*lower left panel*), end of rainy season SON (*lower right panel*)

Rainfall in this zone varies according to the orientation of the coastline and inland mountains with coastlines perpendicular to the SW monsoon. These coast show very high precipitation amounts, contrary to, for example the Ghana-Togo dry zone (Fink et al. 2016). The Guinea Cost and the Sudanian zone both have a bi-modal rainfall distribution (Fig. 2.2) (UNEP 2006).

Rainfall in the tropics is mostly convective and therefore rather unevenly distributed over time and space. Convective events can occur at any time in the year, but are more likely in the rainy season. A characteristic feature in Western Africa is that the isolated convective showers organize into large thunderstorm complexes. For details on West African rainfall types see Fink et al. (2010b). The seasonal patterns of rainfall and temperature in Western Africa are influenced by two air masses: the dry and usually hot Harmattan north-easterly winds originating from the Sahara, and the low-level monsoonal south westerly winds originating from the

Atlantic Ocean. The movement of the air masses is associated with northwards and southwards pulsations of a narrow confluence zone of discontinuity ("Intertropical Discontinuity" (Fink et al. 2016)) between the dry Harmattan and the tropical maritime monsoon to the south.

Annual temperatures in these zones are in the range of 26–30 °C, but distinct differences exist in the overnight temperatures and near-surface humidity in winter: night-time temperatures regularly fall below 10 °C in the Sahel. On the Guinea coast, minimum temperatures typically do not fall below 18 °C. Relative humidity stays below 50 % throughout the day in the Sahel, whereas values are high throughout the year on the Guinea coast (Fink et al. 2016).

Box 2. Climate Scenarios (Representative Concentration Pathway Scenarios (RCP))

Climate projections for the period until 2100 are performed with global climate models. Applying the models for that time frame requires assumptions about the atmospheric composition, i.e., the concentration of atmospheric greenhouse gases. The development of future atmospheric composition depends on the emissions of these gases from anthropogenic and natural sources. Anthropogenic emissions are driven by economic and technological development as well as political decisions, especially related to usage of fossil fuels and land use. In order to make climate model runs of different groups comparable, they have to be based on the same assumptions on future emissions or concentration. Assumptions about future development are typically aggregated in 'scenarios'. The assumptions can vary greatly, but should be internally consistent within one scenario. For the climate model runs in the 5th Assessment Report, the scenarios are called 'Representative Concentration Pathways' (RCPs). These scenarios prescribe the temporal development of emissions and concentrations of the full suite of greenhouse gases, aerosols and chemically active gases, as well as land use/land cover. Four main scenarios have been defined with different targets of radiative forcing in the year 2100: RCP 8.5, RCP 6.0, RCP 4.5, RCP 2.6. The numbers refer to the radiative forcing in W/m^2 in 2100. Differences in the radiative forcing between these scenarios are relatively small up to 2030, but become very large by the end of the 21st century and dominated by CO_2 forcing. RCP 8.5 is a high pathway which reaches >8.5 W/m^2 by 2100 and continues to rise for some time after 2100; RCP 6.0 and RCP 4.5 are so-called "stabilization pathways" in which the forcing is stabilized at approximately 6 and 4.5 W/m^2 shortly after 2100. In RCP 2.6 the radiative forcing peaks at approximately 3 W/m^2 before 2100 and then declines to approx. 2.6 W/m^2 in 2100. In order to reach such a forcing, greenhouse gas emissions have to be reduced substantially over time.

The scenarios are used to run global climate models for the 21st century. Such models are developed and operated by several modeling centers. Taken together, the ensemble of results for each RCP scenario allows for assessing

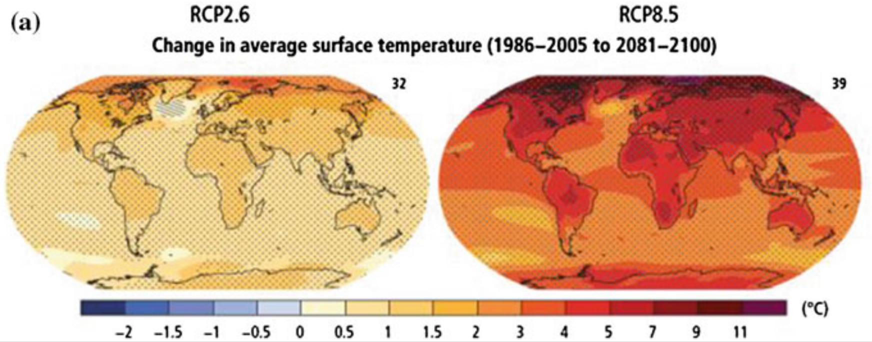


Fig. 2.3 Change in average surface temperature based on a multi-model mean projections for 2081–2100 relative to 1986–2005 under the RCP2.6 (*left*) and RCP8.5 (*right*) scenarios. *Thin lines* denote one ensemble member per model, *thick lines* the CMIP5 multi-model mean. On the *right-hand side* the 5th, 25th, 50th (median), 75th and 95th percentiles of the distribution of 20-year mean changes are given for 2081–2100 in the four RCP scenarios

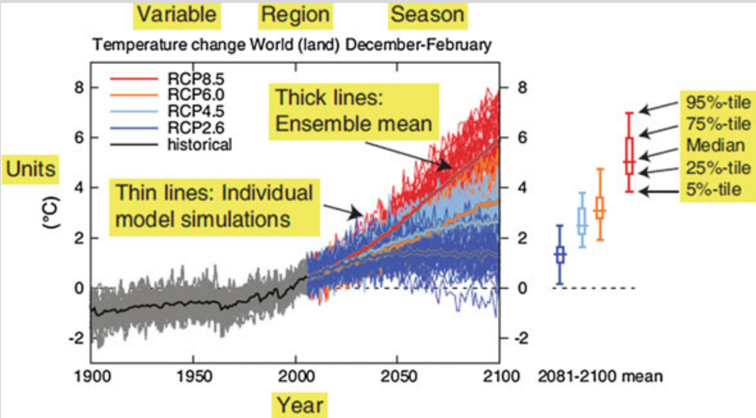


Fig. 2.4 Explanation of the features of a typical time series figure presented in the IPCC AR5. (IPCC AR5 Figure AL.1)

the uncertainty that arises from the use of different models. To provide a framework for systematic comparison the centers agree on so-called "Model Intercomparison Projects (MIPs)". Many results of the AR5 are based on the 5th Coupled Model Intercomparison Project (CMIP5[1]). The typical resolution of the atmospheric component of global climate models in the AR5 is in the order of 1°–2°. Regional Climate Models (RCMs) are used to simulate regional climate at higher spatial resolution. Lateral boundary conditions are taken from global climate simulations. Again, several centers contribute with

[1]The **Coupled Model Intercomparison Project (CMIP)** provides infrastructure in support of climate model diagnostics validation, intercomparison documentation and data access.

their models within the "COordinated Regional climate Downscaling Experiment (CORDEX)".

Global climate projections based on the scenarios result in strongly different changes in global surface temperature.

Geopolitical agreements to control emissions may affect further anthropogenic emissions of greenhouse gases (GHG), aerosol particles and other factors like land use change. To assume the climate of the future, different scenarios have been developed, and based on these scenarios potential climate changes are simulated to provide these results for decision makers. Integrated Assessment Models (IAMs) have been used for the RCPs including economic, demographic, energy, and simple climate components; therefore simple models have been used to produce time series of GHGs concentrations that are used as forcing in Atmosphere-Ocean General Circulation Models.

2.3 Observed Climate Trends

The IPCC AR5 pointed out that on a global scale temperatures have increased since 1950 and the global temperature will continue to rise until the end of the century. During the last 50–100 years the temperature has increased by 0.5 °C or more over most parts of Africa. In particular, the minimum temperature increases faster than the maximum temperature (Stern et al. 2011; Funk et al. 2012; Nicholson 2013) and focusing on climate scenarios, it is very likely that land temperatures over Africa will rise faster than the global average, especially over the arid regions like the Sahel (Fig. 2.5) (Stocker et al. 2013). One problem with the verification of these trends is a lack of observational data over several regions in Africa.

> *"…there is low to medium confidence in historical trends in daily temperature extremes in Africa and South America as there is either insufficient data or trends vary across these regions."*
>
> (IPCC AR5I, Stocker et al. 2013)

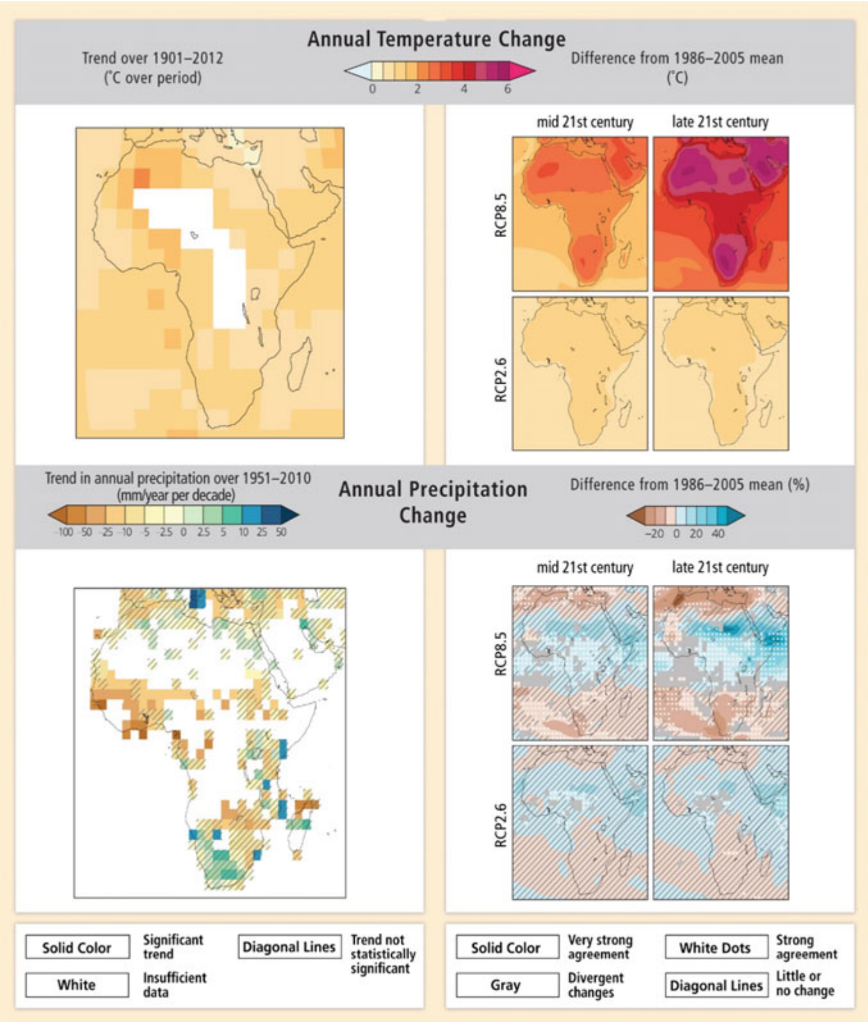
The interpretation of precipitation observations is more complex than those for temperature. In general, trends in precipitation come with higher uncertainties than those in temperature (Rowell 2012) and exhibit higher spatial and seasonal dependence (Orlowsky and Seneviratne 2012). Therefore, observed trends in precipitation vary more than those for temperature. Over Africa it is very likely that precipitation has increased over the eastern and southern parts. However, it is very likely that there is a decrease in precipitation over the western and eastern Sahel region in northern Africa between 1951 and 2010 (Fig. 2.5). Note that the IPCC report pointed out that the lack of sufficient observational data does not allow for conclusions to be drawn about trends in annual precipitation over the past century, and that there are discrepancies between existing observed precipitation datasets (Sylla 2013; Nikulin et al. 2012; Kim 2013). Areas with insufficient observation data are shown in Fig. 2.5 as white shapes.

2.4 Climate Trends in West Africa

For the IPCC assessment report all available data have been used to get a picture of global and regional historical and ongoing development of climate. On the regional scale for West Africa and the Sahel, observations show an increase in annual mean temperature over the last 50 years. As mentioned by the AR5 of the IPCC, "Collins (2011) shows statistically significant warming of between 0.5 and 0.8 °C between 1970 and 2010 over the region using remotely sensed data with a greater magnitude of change in the latter 20 years of the period compared to the former" (Collins 2011). Moreover, there is strong evidence of an anthropogenic signal in continent-wide temperature increases in the 20th century (Min and Hense 2007; Stott et al. 2010; IPCC 2014). Also, climate extremes have increased, as there is a decrease in number of cold days and nights and an increase in number of warm days and warm nights between 1961 and 2000 (New et al. 2006; Niang et al. 2014).

Over the Sahel the precipitation has decreased over the course of the 20th century, whereas over the last 20 years a recovery of the precipitation has been observed (WGI AR5 Section 14.3.7.1; (Nicholson et al. 2000; Lebel and Ali 2009; Ben Mohamed 2011; Ackerley et al. 2011; Biasutti 2013)). The lack of long time series and the gaps in the understanding of the weather system lead to a differential view and interpretation of this signal. Several studies focused on the precipitation recovery in West Africa lead to different causes: (1) natural variability (Mohino et al. 2011) or (2) a forced response to increased greenhouse gases (Haarsma et al. 2005; Biasutti 2013; Dong and Sutton 2015) or (3) reduced aerosols (Ackerley et al. 2011). A recently published study reported that the annual rainfall trend is statistically positive for the Sahel between the West Coast and 15°E (Sanogo et al. 2015) between 1980 and 2010. At the same time, the onset of the rainy season has not significantly shifted, although the length of the Sahelian rainy season reveals an increasing trend of 2–3 days per decade (Sanogo et al. 2015). During the 1970s and 1980s western Africa and especially the Sahel was challenged by several droughts.

> *"Confidence is low for a global-scale observed trend in drought or dryness (lack of rainfall) since the middle of the 20th century, owing to lack of direct observations, methodological uncertainties and geographical inconsistencies in the trends."*
>
> (AR5 WGI chapter 2 (Hewitson et al. 2014))


Annual Temperature Change
Trend over 1901–2012
(°C over period)
0 2 4 6
Difference from 1986–2005 mean
(°C)
mid 21st century
late 21st century
RCP8.5
RCP2.6
Trend in annual precipitation over 1951–2010
(mm/year per decade)
-100 -50 -25 -10 -5 -2.5 0 2.5 5 10 25 50
Annual Precipitation
Change
Difference from 1986–2005 mean (%)
-20 0 20 40
mid 21st century
late 21st century
RCP8.5
RCP2.6
Solid Color
Significant trend
White
Insufficient data
Diagonal Lines
Trend not statistically significant
Solid Color
Very strong agreement
Gray
Divergent changes
White Dots
Strong agreement
Diagonal Lines
Little or no change

◀ **Fig. 2.5** Modified graphic from the IPCC chapter AR5 WG2 Chapter 22, show observed and projected changes in annual average temperature and precipitation. (Top panel, left) Map of observed annual average temperature change from 1901–2012, derived from a linear trend. [WGI AR5 Figures SPM.1 and 2.21] (Bottom panel, *left*) Map of observed annual precipitation change from 1951–2010, derived from a linear trend. [WGI AR5 Figures SPM.2 and 2.29] For observed temperature and precipitation, trends have been calculated where sufficient data permit a robust estimate (i.e., only for grid boxes with greater than 70 % complete records and more than 20 % data availability in the first and last 10% of the time period). Other areas are white. Solid colors indicate areas where trends are significant at the 10 % level. Diagonal lines indicate areas where trends are not significant. (Top and bottom panel, right) CMIP5 multi-model mean projections of annual average temperature changes and average percent changes in annual mean precipitation for 2046–2065 and 2081– 2100 under RCP2.6 and 8.5, relative to 1986–2005. Solid colors indicate areas with very strong agreement, where the multi-model mean change is greater than twice the baseline variability (natural internal variability in 20 yr means) and ≥90 % of models agree on sign of change. Colors with white dots indicate areas with strong agreement, where ≥66 % of models show change greater than the baseline variability and ≥66 % of models agree on sign of change. Gray indicates areas with divergent changes, where ≥66 % of models show change greater than the baseline variability, but <66 % agree on sign of change. Colors with diagonal lines indicate areas with little or no change, where <66 % of models show change greater than the baseline variability, although there may be significant change at shorter timescales such as seasons, months, or days. Analysis uses model data and methods building from WGI AR5 Figure SPM.8. See also Annex I of WGI AR5. [Boxes 21-2 and CC-RC]. (*Source* Fig. 22-1 IPCC WG2 Chapter22, Niang et al. 2014)

2.4.1 Droughts in West Africa

In the 4th Assessment Report (AR4) it has been concluded that droughts had become more common, especially in the tropics and the sub-tropics since the 1970s (IPCC 2007). The IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX") described in the Assessment Report 4 (IPCC 2007) states that there are not sufficient direct observations of dryness to suggest high confidence in observed trends on a global scale. However, there was enough information on dryness to show a significant increase in more intense and longer droughts worldwide with a medium confidence. Due to the fact that there are only a few direct measurements of drought related variables such as soil moisture (Robock et al. 2000), often drought proxies like the Palmer Drought Index (PDSI), Standardized Precipitations Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI) or hydrological drought proxies (Vidal et al. 2010; Dai 2011) are used to assess drought. The use of different drought proxies for the ranking of drought events is problematic because the chosen proxies (e.g., precipitation, evapotranspiration), together with the time scale, strongly affect the ranking (Vidal et al. 2010; Sheffield et al. 2012).

Another problem comes with the complexity of drought as calculated parameter. Drought can be at best incompletely represented by commonly used drought indices. Therefore the interpretation of the results can produce discrepancies between different studies depending on the proxy. For example, Sheffield et al. (2009) found decreasing trends in the duration, intensity and severity of drought globally, while Dai (2011) found a general global increase in drought, with several regional variations. In the latest IPCC (IPCC chapter 2) (Hartmann et al. 2013) it is stated that there is still a problem with drawing conclusions about drought because of global differences in data availability, quality and length of records. However, there is an indication with a high confidence that dryness increases in the Mediterranean and West Africa.

2.5 Future Climate of West Africa

Exposition and the huge land mass may increase the possibility of a faster temperature increase in Africa than in other regions. Therefore, temperatures in Africa are projected to rise faster than the global average increase during the 21st Century (Christensen et al. 2007; Sanderson et al. 2010; Joshi et al. 2011; James and Washington 2013). Global mean temperature is expected to rise by more than 2 °C on average in the ensemble-mean of global projections above the late-20th-century baseline over most land areas of the continent in the mid-21st-century for RCP8.5, and to exceed 4 °C over most land areas in the late-21st-century for RCP8.5.

Following the RCP8.5 mean annual temperature, changes in mean annual temperature will affect Africa with an uneven magnitude. Larger changes are expected over northern and southern Africa and smaller changes over central Africa. The ensemble-mean changes are less than 2 °C above the late-20th-century baseline in both the mid- and late-21st-century for RCP2.6. Under different scenarios the global average near-surface air temperature moves beyond 20th Century simulated variability by 2069 (±18 years) under RCP4.5 and by 2047 (±14 years) under RCP8.5 (Mora et al. 2013). Comparing this global pattern with the African pattern, these unprecedented climates are projected to occur one to two decades earlier than the global average because the relatively small natural climate variability in this region generates narrow climate bounds that can be easily surpassed by relatively small climate changes. Figure 2.5 shows projected temperature increases based on the CMIP5 ensemble, based on Fig. 2.4 (Niang et al. 2014).

West Africa is expected to be strongly impacted by temperature increase. The latest IPCC report shows a warming range of 3 and 6 °C above the late 20th Century baseline (Meehl et al. 2007; Fontaine et al. 2011; Diallo et al. 2012; Monerie et al. 2012; Niang et al. 2014) (Fig. 2.3). Diffenbaugh and Giorgi (2012) identify the Sahel and tropical West Africa as a hotspot of climate change for both RCP4.5 and RCP8.5 pathways and unprecedented climates are projected to occur earliest (late 2030s to early 2040s) in these regions (Diffenbaugh and Giorgi 2012). Observed and simulated variations in past and projected future annual average temperature over the Economic Community of West African States (ECOWAS) are captured in Figs. 2.5 and 2.6; the graphics indicate that the projected temperature rise is very likely to exceed the 1986–2005 baseline by between 3 and 6 °C across the region by the end of the 21st century under RCP8.5.

As mentioned before, precipitation is more uncertain than temperature, which results in higher uncertainties for the climate projections (Rowell 2012; Orlowsky

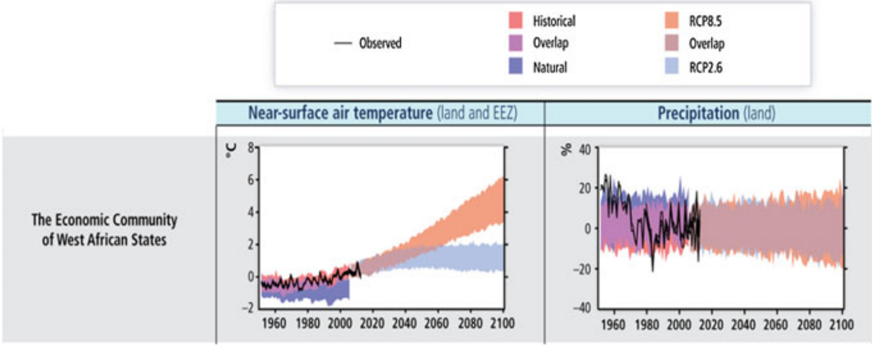


Fig. 2.6 Observed and simulated variations in past and projected future annual average temperature over ECOWAS. Black lines show various estimates from observational measurements. Shading denotes the 5–95 percentile range of climate model simulations driven with "historical" changes in anthropogenic and natural drivers (63 simulations), historical changes in "natural" drivers only (34), the "RCP2.6" emissions scenario (63), and the "RCP8.5" (63). Data are anomalies from the 1986–2005 average of the individual observational data (for the observational time series) or of the corresponding historical all-forcing simulations. Note this figure is a slightly modified picture taken form IPCC WGII Fig. 22-2 (Niang et al. 2014)

and Seneviratne 2012). The fluctuation in annual precipitation is illustrated in Fig. 2.6. In general, the difference between the model bias of the scenarios RCP8.5, in orange, and RCP2.6, in light blue, is obvious for temperature but not for precipitation. Using the mean of historical observed precipitation, it is seen that there was a huge variation in annual precipitation in the past. The model does not predict a drastic change in the amount of precipitation until 2100.

Recent studies have shown an inter-model variation precipitation projection especially in the amplitude and direction of change that is partially attributed to the inability of GCMs to resolve convective rainfall (Christensen et al. 2007; Fontaine et al. 2011, Roehrig et al. 2013; Klutse et al. 2015). Furthermore, the rainfall season is predicted to be wetter and delayed by the end of the 21st Century (Christensen et al. 2007). However, using RCMs, the CORDEX initiative analyzed recently the result of ten RCMs along with the ensemble of their statistics in simulating daily precipitation characteristics during the WAM period (Klutse et al. 2015). In the regional projections, huge discrepancies occur between the RCMs and the observations, and among the RCMs themselves. Main differences between the models are the impact of convective events during the WAM period. Convective effects determine mean precipitation and daily statistics such as intensity of rainy days, frequency, extremes and duration of rainfall events. A more detailed analysis of regional climate model can be found in the chapter "Climate Change over West Africa: Recent Trends and Future Projections" (Sylla et al. 2016 (this book)).

Overall, there is a low confidence of the delay in the onset of the West African rainy season with intensification of late-season rains in the latest projections of the CMIP5.

2.6 Summary

Based on the latest IPCC Assessment Report 5, this chapter discussed the current climate conditions in Africa with a special focus on West Africa based on observations and gives an outlook into the future based on climate scenarios and projections. Since 1950 temperature over West Africa has increased and it will increase further in the future. As observed, the number of cold days and nights has decreased whereas the number of warm days and nights has increased. Precipitation is relevant for many processes in ecology, agriculture or hydrology. Since the 1970s West Africa has been affected by several droughts; during this time precipitation was below the average. Following the IPCC report, the amount in precipitation has increased since 1986. Projections indicate an increase in precipitation until 2100 depending on the scenario. Also, the onset of the rainy season has not significantly shifted since 1980. However, the length of the Sahelian rainy season reveals an increasing trend of 2–3 days per decade, with a drier phase within.

Overall, the possibility of detailed scientific analysis of long-term changes is still restricted due to the limited availability of sufficient observational data. Therefore, an improvement of the observations network, data rescue activities of historic climate data and an improvement of the climate data management in the region is urgently needed.

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