AFRICA'S CLIMATE
HELPING DECISION-MAKERS
MAKE SENSE OF
CLIMATE INFORMATION
Central Africa’s Climate System

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Central Africa Regional Overview

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Central Africa is one of the most important climatic regions in the world: the Congo Basin is the biggest water catchment in Africa; and the Congo rainforest is the second largest tropical forest on Earth (see Figure 1). It is one of three major global hotspots of thunderstorm activity. Thunderstorms, also known as convective systems, are a key part of the large-scale air circulation that transfers warm air from the tropics towards the poles. This influences the climate and weather across Africa and the globe.

During the rainy seasons, the Congo is the wettest place on Earth, and adds 3.5mm to global sea level each year. Central Africa also has the world’s most intense thunderstorms and the highest frequency of lightning flashes.

The Congo rainforest is a vital store for carbon: the trees draw atmospheric carbon dioxide from the air and store it in their leaves, wood, and roots, and also transfer it into the soil. The amount of carbon stored just in the above-ground vegetation means that the Democratic Republic of Congo’s national carbon stock is the second largest in the world. These forests are critical for offsetting climate change. The rainforest is also particularly vulnerable to changes in rainfall, or length of dry seasons. Small changes in rainfall patterns could cause large changes in land cover.

Given the above, and the fact that so much of the population in central Africa relies on rain-fed agriculture, understanding the implications of climate change for this region is vital.

2 Cecil, D. J. 2006. LIS/OTD 0.5 Degree High Resolution Monthly Climatology (HRMC). Dataset available online from the NASA Global Hydrology Resource Center DAAC, Huntsville, Alabama, U.S.A.
THE REGIONAL CLIMATE

The movement of the Inter Tropical Convergence Zone (ITCZ) dominates central Africa’s climate. The ITCZ is a region in the atmosphere where the low-level trade winds from the north-east and south-east meet. It moves to its most northerly position in the northern hemisphere summer, before migrating south to its most southerly position during the northern hemisphere winter. The ITCZ crosses the equator twice a year, resulting in two rainy seasons (March to May, and September to November) and two dry seasons (June to August, and December to February) in the central part of the region. This, and the complex topography of the region, shapes the regional climate.

Central Africa is bordered to the north and south by subtropical dry areas. The contrast in air temperature and pressure encourages the formation of strong winds around 5km above ground over northern and southern central Africa – the African Easterly Jets – and their strength and interaction with the regional climate changes with the seasons. The jets are both active from September to November, bringing heavier rains than in March to May, when only the northern jet is noticeable. The March to May rainfall season is usually longer, whilst the September to November period is relatively short, with heavier rains.

The Atlantic and Indian oceans play an important role in shaping the regional climate. During the southern hemisphere summer, differences in surface air pressure between the two oceans drive an east-west air circulation cell which makes the rainfall more variable over southern central Africa. The transport of low-level water vapour from the Atlantic Ocean brings clouds and rain to central Africa throughout the year.

Other oceanic factors also influence the regional climate, such as pressure and sea surface temperature variations in the South Atlantic High, Atlantic, and Indian oceans, and as far away as the North Atlantic. These factors make rainfall in central Africa more variable from year to year, which could have implications for future changes in the system. How these interactions among air circulation, land surface, and sea surface temperatures are manifested

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Shortage of climate information

The central African climate system is one of the most understudied in Africa and the world. This is mainly due to a shortage of weather records. There are far fewer meteorological stations spread out across the region than the World Meteorological Organization recommends. In the past few decades, changes in the management of meteorological services, alongside economic crises and political instability, have led to the breakdown of much of the network of weather stations. There has been a dramatic decrease in the number of rain gauges in the region over the past two decades. The result is a large gap in weather and climate information, particularly for the Congo.

The Congo is therefore disproportionately underrepresented in global climate databases, such as the Climate Research Unit database (CRU). Figure 2 shows the number of CRU weather stations in central Africa, compared with the UK, an area less than one tenth in size. For the remaining weather stations in central Africa, instruments are not well maintained or calibrated, so the quality of the information they gather is not reliable. This, alongside the difficulty of accessing the existing records from these stations, has hindered the ability to study current climate variability, and how this might change in the future.

Because of the overwhelming importance of the region for the planet’s climate, this leaves a significant gap in climate science globally.
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in central Africa needs a lot more research. The influence of El Niño on the region, for instance, is more uncertain than for east, west, and southern Africa. Recent work suggests a complex set of global interactions have varying effects across the basin.6

BUILDING BETTER CLIMATE MODELS

Climate models represent complex physical atmospheric processes using mathematical equations. These tools are important for understanding present climate systems, and projecting future changes. The credibility of climate model simulations depends on their ability to show the regional climate system, as well as processes of change. We can test the credibility of models by comparing their simulations of historical climate to observed historic data.

For central Africa, models tend to disagree with one another in their representation of historical climate, leading to large amounts of uncertainty about the current and future climate system.7 If there are large variations between model simulations of historical climate, the same uncertainty will carry forward when the models are run to simulate the future climate. For instance, in some seasons, rainfall differs by a factor of five between different climate models,8 meaning the level of uncertainty about future rainfall trends is relatively high.

Models also vary vastly in where they position rainfall over the region, with strong discrepancies in where the maximum rainfall occurs. These differences are partly because of the limited understanding of the region’s climate system, along with the shortage of weather station information. This makes it difficult to test which models are the most credible. If we cannot establish how credible models are for simulating the historical climate, it is difficult to decide which projections of future climate are trustworthy. Assessing the climate model simulations for the region is a central part of current research in this field.

CURRENT RESEARCH AND FUTURE PLANS

Owing to the shortage of weather station information, there would be benefits from studying large scale circulation systems more closely in order to improve our understanding of regional climate dynamics. Recent work has studied the drivers of atmospheric circulation for the lower atmosphere, which in turn influence how much moisture is provided by the Atlantic Ocean to central Africa.9, 10 Further research is also exploring how the atmospheric jets (fast-moving air currents) in the middle and the upper atmosphere over central Africa contribute to the uplift of air in different seasons, and how this relates to rainfall variability over the region. Researchers are now prioritising efforts to overcome these large differences in the model results, to reduce the high levels of uncertainty.

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Researchers from a range of organisations (see UMFULA, below) are looking at a number of appropriate climate models and the available weather records for the region. The team has studied the circulation factors influencing modelled rainfall, and assessed the range of possible future climate change and its implications for the region’s rainforests. This has allowed us to fully appreciate the importance of moisture circulation patterns in models, which is closely related to how they simulate rainfall patterns. If we can measure moisture fluctuations into the Congo Basin, this will allow climate models to simulate rainfall more accurately. New research will also assess regional climate models, particularly those that are good at simulating local thunderstorm activity. We are also studying the relationship between sea surface temperature and rainfall more closely.

FCFA’S UMFULA PROJECT

Project objectives
UMFULA (“river” in Zulu) is a four year research project that aims to improve climate information for decision-making in central and southern Africa, with a particular focus on Tanzania and Malawi. UMFULA is a global consortium of 15 institutions specialising in cutting edge climate science, impact modelling and socio-economic research.

UMFULA aims to support long-term – five to 40 year – planning decisions in central and southern Africa around resource use, infrastructure investment and cross-sectoral growth priorities, by identifying adaptation pathways that are robust and resilient in the face of climate change and other non-climate stressors.

The team is generating new insights and more reliable information about climate processes and extreme weather events and their impacts on water, energy and agriculture. These insights will support the more effective use of climate information in national and local decision-making. See www.futureclimateafrica.org/project/umfula

The institutions involved in UMFULA are:
• Grantham Research Institute on Climate Change and the Environment (London School of Economics and Political Science)
• Kulima Integrated Development Solutions
• University of Oxford
• University of Cape Town
• Sokoine University of Agriculture
• Lilongwe University of Agriculture and Natural Resources
• University of Leeds
• Council for Scientific and Industrial Research
• University of Manchester
• University of KwaZulu-Natal
• University of Sussex
• University of Dar Es Salaam
• University of Yaoundé
• Tanzanian Meteorological Agency
• Mozambique National Institute of Meteorology

FIGURES

Figure 1
The Congo Basin (dark blue) and the Congo rainforest play an important role in global climate regulation.14

14 Map: produced by the authors.

Figure 2
This figure shows the sparse distribution of weather stations contributing to global datasets in central Africa (left), compared with the UK (right), an area less than one tenth in size.15

Figure 3
Land surface height for the African continent. The eastern boundary of the Congo Basin gives way to high mountainous regions, which influences the flow of air and moisture into the region. The north-west of the basin also features high topography, for example, Mount Cameroon.16

Figure 4
Schematic of the central African climate system. The movement of the Inter Tropical Convergence Zone (ITCZ) throughout the year dominates the climate system in central Africa and surrounding regions. The location of large thunderstorms moves north and south throughout the year. The large scale circulation brings moisture to the region via the trade winds. Moisture is also recycled heavily in the basin.

16 https://lta.cr.usgs.gov/GTOPO30
17 Map: produced by the authors.