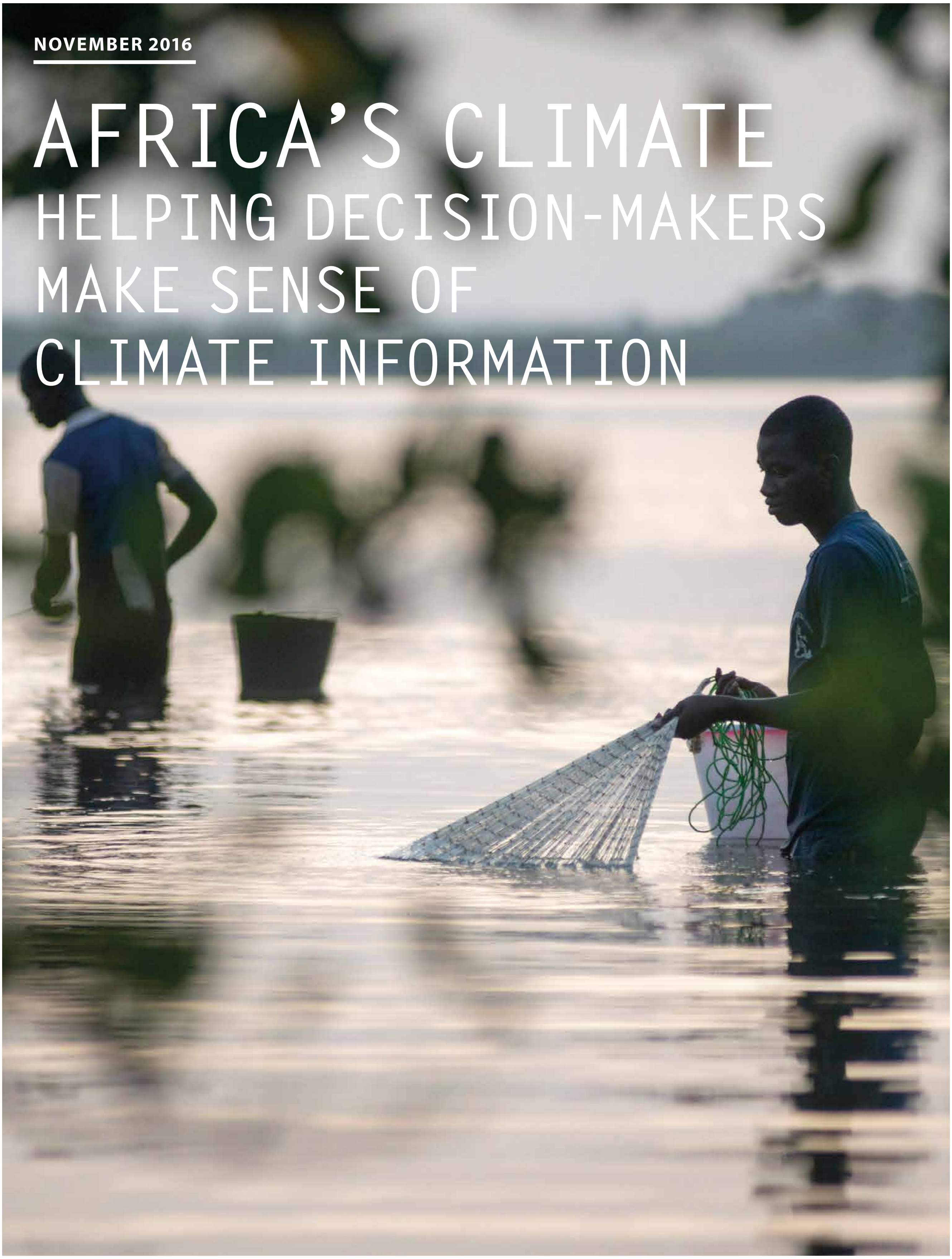
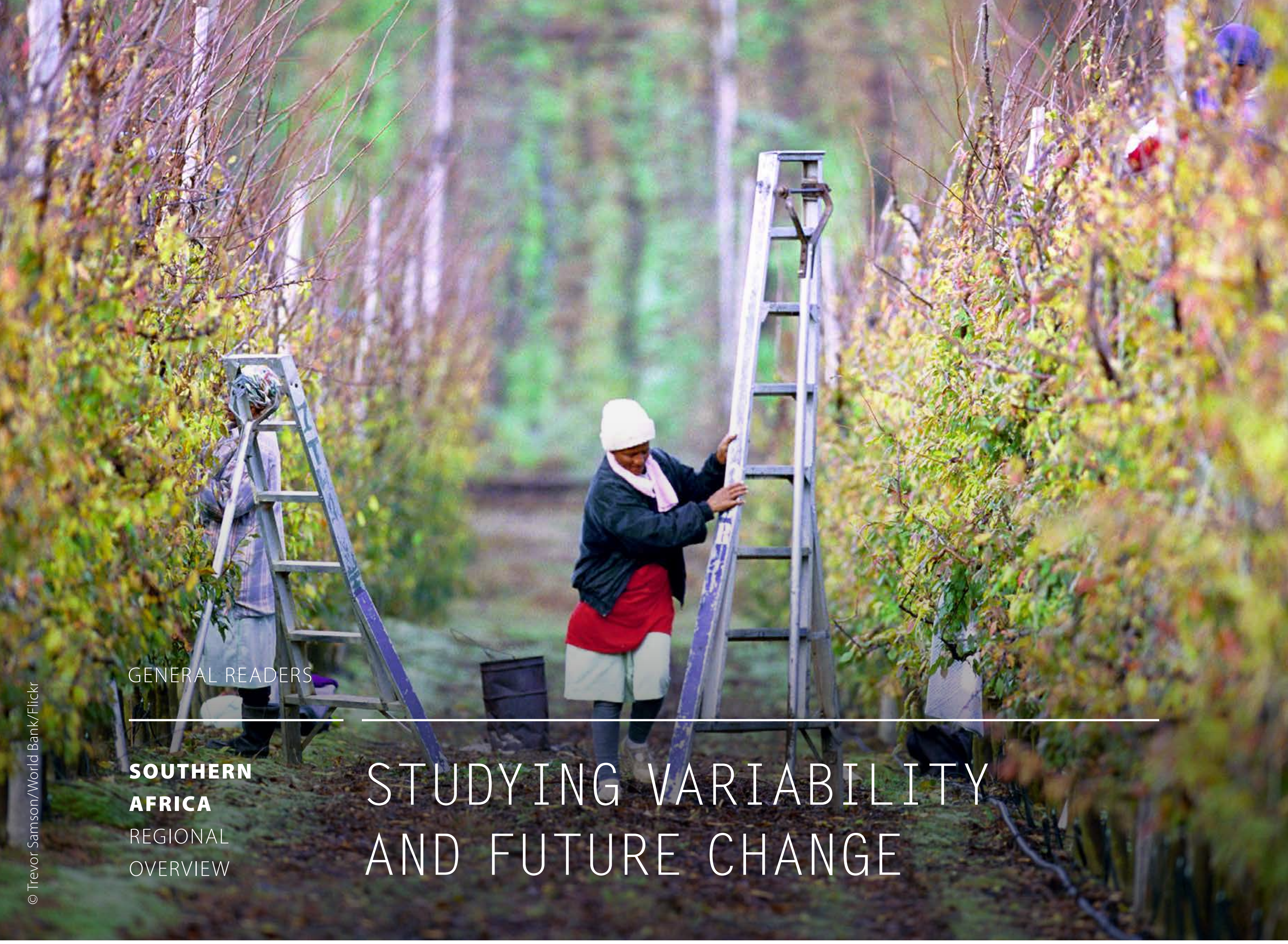
NOVEMBER 2016

AFRICA'S CLIMATE

HELPING DECISION-MAKERS MAKE SENSE OF CLIMATE INFORMATION



FUTURE CLIMATE FOR AFRICA



GENERAL READERS

SOUTHERN AFRICA
REGIONAL OVERVIEW

STUDYING VARIABILITY AND FUTURE CHANGE

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UMFULA CLIMATE RESEARCH TEAM

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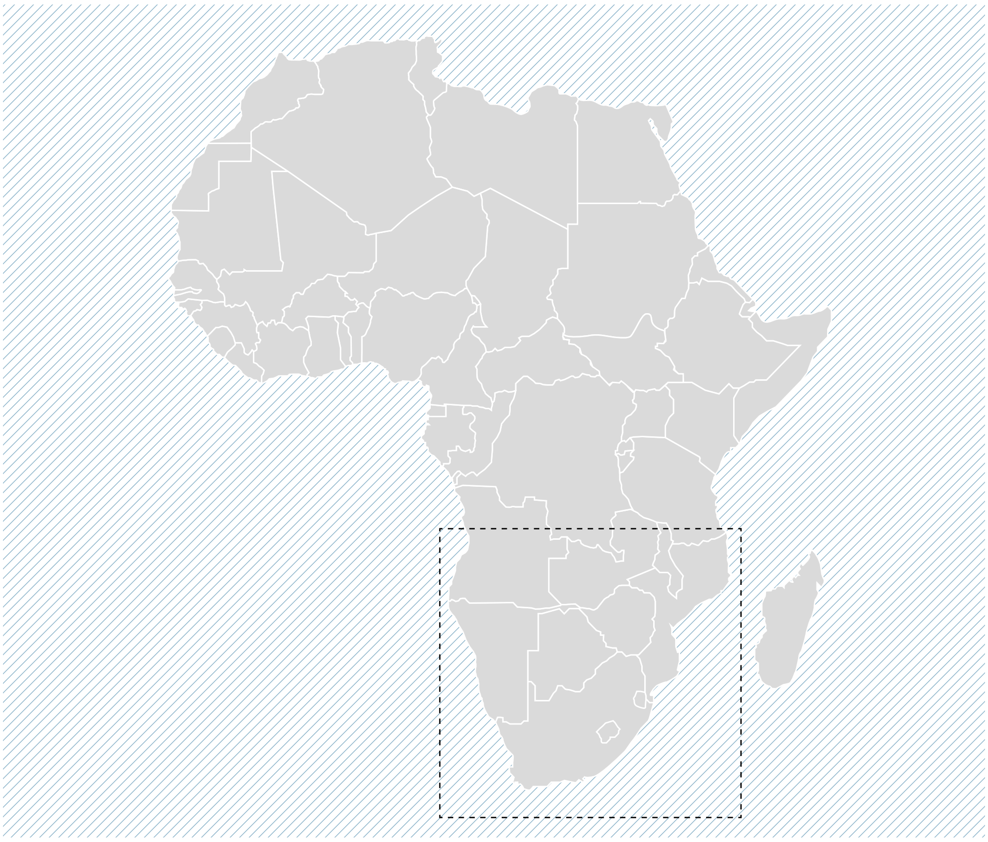


NEED TO KNOW

Southern African countries need reliable, robust climate information to be able to buffer their economies and communities against the impacts of climate change. Scientists working on climate modelling for the region are concerned with:

- understanding the complex physical forces that drive the 'natural' variability of the climate across the region
- refining and improving the climate models, in order to give more reliable forecasts for how the climate might shift in the future
- calibrating how reliable the current climate simulations are.

UNDERSTANDING SOUTHERN AFRICA'S CLIMATE SYSTEM

Southern African communities need to adapt urgently to the region's changing climate, and informed decision-making is key to acting pre-emptively.

Southern African economies are exposed to weather and climate vulnerabilities, particularly through sectors such as agriculture, energy, and water management. It follows that the supply of essential resources are all extremely at risk as the climate becomes more changeable and extreme. Communities and countries need to begin planning, adapting and investing now so they can be more resilient.

Having reliable and useful climate information at their fingertips is therefore critical. 'Climate information services' are developing and spreading this information more effectively through the region. But there is still a great deal of uncertainty about what climate change will mean for the region, and decision-makers struggle to know which sources of information to trust and use.

Through improving our understanding of how the climate system works in southern Africa, and improving the mathematical models that simulate the future climate, climate scientists working in the region hope to provide reliable climate information to those who need it.

GETTING THE SCIENCE RIGHT

There are two main challenges to producing suitable, reliable climate information.

1) How the atmosphere and oceans create 'uncertainty' in projections

The interplay between the atmosphere and oceans, which drive our climate, is extremely complex. These interactions can produce large variations in weather or climate, spanning seasons, years, and even decades. El Niño events, for instance, can bring severe droughts in sub-tropical Africa and floods to east Africa, relative to 'normal' years.

Projecting how the climate will change in future, as greenhouse gases increase in the atmosphere, needs mathematical modelling tools that can capture and simulate these complicated and region-specific ocean-atmosphere interactions.

2) Large timeframes, great distances: why climate modelling is difficult
Modelling weather and climate is difficult, not least because of the variations through time and across distance. Models divide distance into a grid with one grid typically covering tens of kilometres. As a result, information at the local scale, for example a typical farm or village, is difficult to produce in a reliable way. A key challenge is to develop models and understanding that allow us to provide climate information at the appropriate space and time scale for specific planning decisions. This could be irrigation management in a large river catchment, or deciding which crops to grow in a particular agricultural region in the future.

Much of the climate science being undertaken in the southern African region aims to improve our understanding of the physical forces that shape southern African's climate. There is strong emphasis on seeing what climate models can tell us about the near-term climate changes, and the risks for specific regions within countries here. Researchers have access to an archive containing over 40 climate models that have simulated the next five to 50 years of climate change under increasing greenhouse gas concentrations. Many models have even run up to 100 years into the future.

However, these produce a wide range of results. In order to understand which models are credible, we need to better understand the fundamentals of how the seasons change over the region, and how the oceans influence or modify these seasonal changes in rainfall, wind, and temperature.

WHAT WE KNOW (AND DON'T KNOW) ABOUT THIS CLIMATE SYSTEM

During winter, the skies above southern Africa are generally clear, and there is little rainfall. As the summer approaches, the sun moves south across the subcontinent, heating the land surface rapidly and drawing in moisture from surrounding oceans. Southern Africa has a complex array of mountain ranges (see grey shading in Figure 1) with a high plateau covering much of the subcontinent, and several mountain ranges that are higher than 2,500m. The sun's heating effect is amplified over the higher terrain, and the sharp gradients in the terrain interrupt and redirect the low-level, moisture bearing winds across the region, leading to a complex flow of air (Figure 1). The mountainous terrain is also efficient at triggering the development of thunderstorms. However, we do not fully understand the workings of these systems, such as clusters of thunderstorms called mesoscale convective complexes, and the regional air movement that helped create them.

Further south, in the sub-tropics, waves of high-altitude westerly air, about 10km above the ground, also shape the climate. These waves either encourage or suppress how warm air rises here, and can bring widespread rainfall over southern Africa. Further bands of clouds – known as tropical temporal troughs – bring rainfall and thunderstorms across the region. An important gap in our knowledge is how these waves and cloud bands impact thunderstorms further north over the continent.

The oceans on either side of the subcontinent play a significant role in the region's climate. For example, warm ocean temperatures in the tropical oceans and the Agulhas current create warm, humid air, and changes in the strength of the high air pressure systems over oceans, all influencing the flow of moisture over the subcontinent, and therefore the amount of rainfall across the region.

Ocean temperatures also play a key role in the likelihood of extreme weather events such as cut-off lows, tropical cyclones and tropical temporal troughs' cloud bands, which bring strong winds and flooding across the region (Figure 1).

Nevertheless, more research is needed to better understand the links among ocean temperatures, the high pressure systems, and extreme events over southern Africa.

The El Niño weather phenomenon can also disrupt air flow and impact on extreme events. Some of the worst droughts in sub-tropical Africa, and the worst floods for east Africa, have occurred during El Niño events. And yet, scientists still don't have a clear understanding of how El Niño influences the wet season over sub-tropical southern Africa.

HOW CREDIBLE ARE OUR CLIMATE SIMULATIONS?

Climate models are mathematical tools that try to simulate how the climate will behave in the future, based on the physical forces that are known to shape the climate system. To test the accuracy of these models, they are first used to replicate the past climate, and this is compared to historical records. Then, they are run forward to project the future climate as greenhouse gas levels increase and cause regional temperatures to rise.

The difficulty is that the various models can give different results. In order to test which simulations are the most credible, and therefore which will generate the most useful climate information, we need to understand three things:

- How do these forces balance and produce the weather and climate over seasons and years that we have already observed over southern Africa?
- What are the differences between models that are responsible for the different climate simulations over southern Africa, and how does this inform our trust in the models?
- What do the future simulations say about likely changes in the behaviour of regional air circulation patterns?

The climate scientists tackling these questions are trying to understand the link between the various physical forces that shape air movement and cloud, thunderstorm, and rainfall formation. Current climate models tend to overestimate southern African wet season rainfall, so there is a need to analyse the processes that are causing this.

Much of the climate risk for southern Africa is associated with year-to-year variability in the regional weather. For climate models to offer useful information, they will need to be able to simulate this variability realistically, and a great deal of work is being done to assess whether the models are capable of doing so.

For southern Africa, it is particularly important to simulate changes in the local (e.g. south-west Indian Ocean) and remote (tropical Pacific) ocean temperatures. These models also need to reproduce the shifts in the high pressure systems over the oceans which, together with ocean temperatures, are important for how much moisture moves inland into southern Africa.

For southern Africa, tropical cyclones and cut-off lows can produce severe flooding and damaging winds. Severe droughts are typically associated with substantial changes of the average seasonal cycle, such as the 2015/16 El Niño event. Scientists are currently working to assess whether climate models simulate these seasons and then see how they may change in the future.

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.

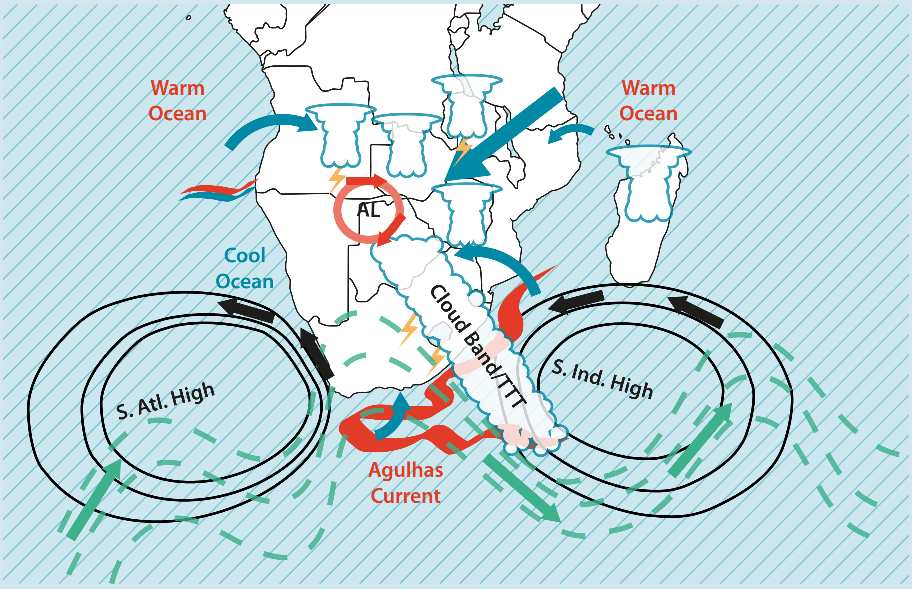
The team is generating new insights and more reliable information about climate processes and extreme weather events and their impacts on water, energy and agriculture. These insights will support the more effective use of climate information in national and local decision-making. See www.futureclimateafrica.org/project/umfula/

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[1]
Schematic detailing key features of the southern African climate system



AL Angola Low
Thunderstorms
Low-level Moisture Transport
Upper-level Flow
TTT tropical temporal troughs

1 Map: produced by the authors.

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