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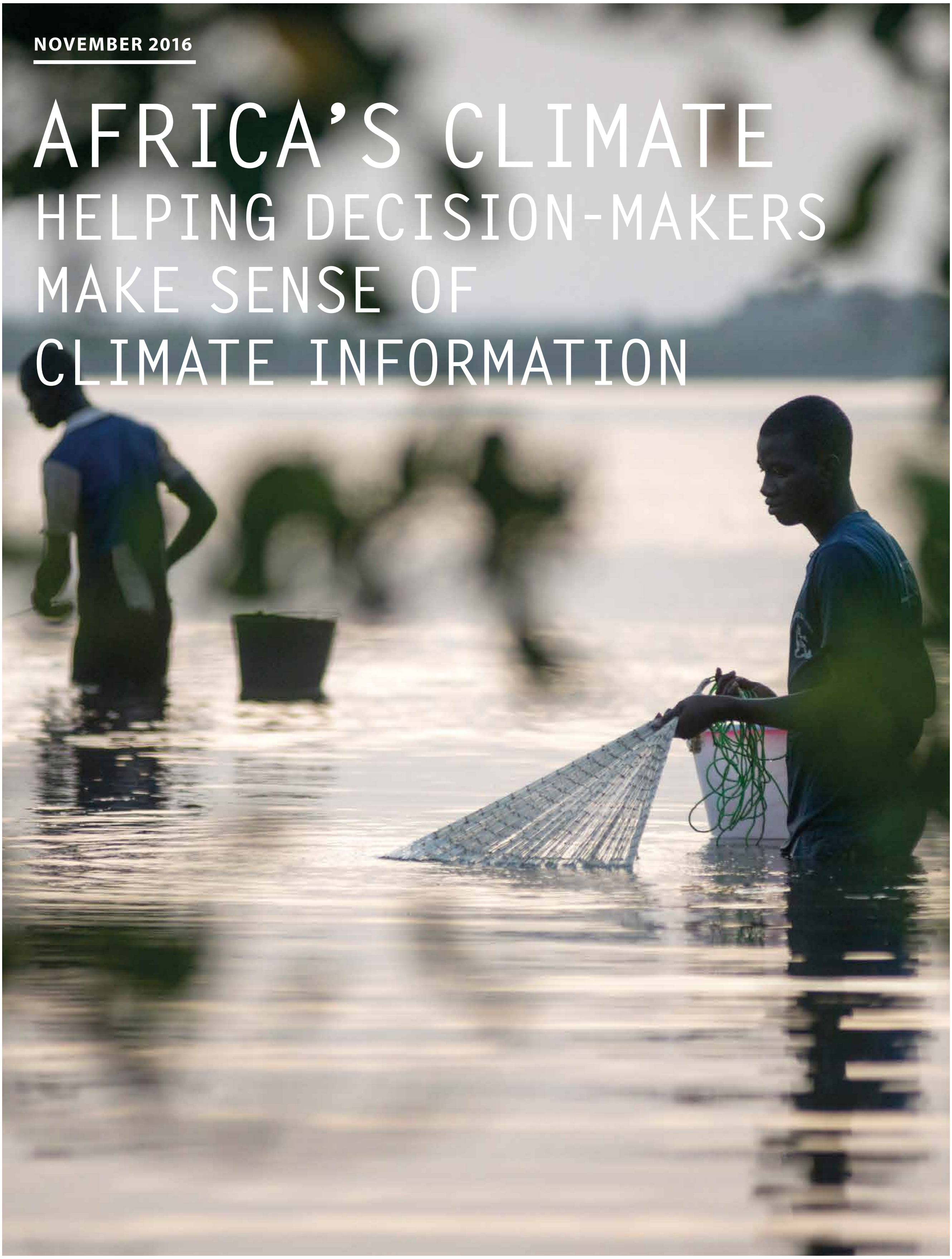
AFRICA'S CLIMATE

HELPING DECISION-MAKERS MAKE SENSE OF CLIMATE INFORMATION



FUTURE CLIMATE FOR AFRICA

SCIENTISTS

CENTRAL AND SOUTHERN AFRICA
BURNING QUESTIONS

BURNING QUESTIONS FOR CLIMATE SCIENCE

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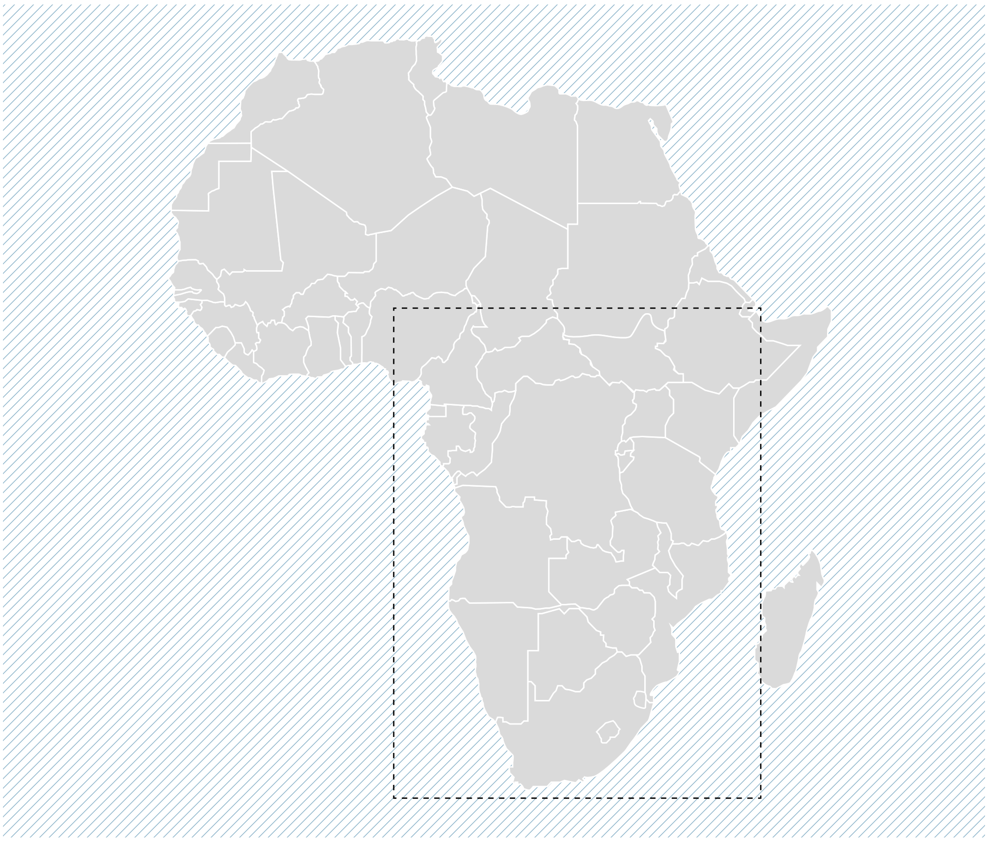


NEED TO KNOW

Societies and economies in central and southern Africa are extremely vulnerable to climate change and extreme weather events. Policy-makers need credible climate information if they are to plan for and address regional development challenges. New research into the climate of this area will investigate:

- Why the region is so vulnerable to climate change.
- The gaps in our understanding of the current climate system and how it might change in response to human-induced warming.
- How climate researchers are addressing some of these gaps, with the aim of improving climate change modelling.

THE STATE OF CLIMATE SCIENCE IN CENTRAL AND SOUTHERN AFRICA

The gaps in our knowledge of the central and southern African climate system have contributed to dramatic differences in future climate projections produced by climate models, both in the size of the change, and the direction

Our understanding of the climate system in central and southern Africa is at a relatively early stage compared to many other world regions. Several factors are responsible for this situation, including: a poor weather station network; relatively low investment in climate services (such as national meteorological services); and a lack of dedicated international science campaigns. As a consequence, there are fundamental gaps in our scientific understanding of the central-southern African climate system.

This is a problem because effective adaptation to climate change relies on credible information about how climate and extreme events might change in the next five to 40 years. Climate models can provide this information for adaptation planners. But without tackling gaps in the basic climate science, it is difficult to judge the quality of models' projections of future climate change. Scientists working in this area of research, as part of the Future Climate for Africa initiative, hope to be able to improve our understanding of the regional climate system, and how well it is captured by climate models.

WHY WE NEED TO UNDERSTAND THE CENTRAL-SOUTHERN AFRICAN CLIMATE SYSTEM

Economies are sensitive to the impacts of climate change and extreme events

Agriculture contributes a large proportion to the regional economy: 20% in Zambia, 30% in Tanzania, Madagascar and Mozambique, and over 40% in the Democratic Republic of Congo (DRC) and Malawi. Yet it is highly dependent on rainfall, with only 5% of cropland equipped for irrigation. The proportion of electricity produced by rainfall-sensitive hydroelectric sources is high: over 30% in Tanzania, Madagascar, Swaziland and Zimbabwe, and almost 100% in DRC, Lesotho, Malawi and Zambia.[1] To address regional development needs, especially in the agricultural and energy sectors, we need to understand the nature of regional climate change.

1 World Bank, 2014. World Development Indicators 2014. World Development Indicators. Washington, DC. https://openknowledge.worldbank.org/handle/10986/18237 (Accessed July 2016).

The gaps in our knowledge of the central and southern African climate system have contributed to dramatic differences in future climate projections produced by climate models, both in the size of the change, and the direction. For instance, while many models agree that temperature will increase in southern Africa (Figure 1), they do not agree on the amount of warming.

In the two models in Figure 1, the difference is as much as 2°C in some places. A 2°C difference in the average climate could change the frequencies of extreme events, such as drought, as well as affecting day to day weather patterns. The patterns of rainfall change are also vastly different: over the Congo Basin, for example, one model shows the area will get wetter by the end of the century, while another model shows that it will get drier.

Divergence between future climate projections is a well-known issue with climate models, and adaptation planners are often faced with a choice of more than 30 modelled future climates, each with different outcomes. It is very difficult to establish which, if any, of these is more credible, particularly as the models also simulate large differences in the present day climate.

In the present day extreme weather and climate events, in particular floods and droughts, have a lasting impact on the regional economy and society

In the present day, extreme weather and climate events, in particular floods and droughts, have a lasting impact on the regional economy and society. Flooding in January 2013, caused by a cloud band extending south from the tropics to the mid-latitudes, resulted in over 100 deaths and 200,000 people being displaced in southern Africa (Figure 2). More recently, a drought from November 2015 to January 2016 left nearly 17 million people in conditions of acute food insecurity.[2]

Future changes in the average climate will be accompanied by changes in the frequency and size of extreme events. The severe impacts detailed in the examples above illustrate why it is so important to understand the climate drivers behind such extreme events, and how they might change in the future.

GAPS IN UNDERSTANDING OF THE CENTRAL-SOUTHERN AFRICAN CLIMATE SYSTEM

The impact of global and regional ocean conditions

Global and regional ocean dynamics affect southern African rainfall. El Niño events, which originate in the Pacific Ocean, are often associated with drought over southern Africa. The regional climate system is also influenced by changes in the pattern of surface temperatures in the Indian Ocean and in the Benguela region in the south-east Atlantic. Despite much work into understanding these interactions, the ways in which the oceans affect the central and southern African climate system are still unclear.

Climate models have difficulties representing the links between ocean dynamics and the regional climate system. For example, most climate models overestimate average sea surface temperature (SST) by up to 2°C in the south-east Atlantic Ocean,[3] and are generally poor at simulating the known links between El Niño events and African rainfall.[4] These model errors probably affect the model simulation of the present day climate, but this influence is unclear. It is important to understand these problems in the present climate if we are to assess model reliability in projecting the future climate.

2 www.fews.net/southern-africa

3 Wang, C., L. Zhang, S. Lee, L. Wu, and C. R. Mechoso, 2014. "A global perspective on CMIP5 climate model biases", *Nature Climate Change*, vol. 4, no. 3, 201–205.

4 Dieppois, B., M. Rouault, and M. New, 2015. "The impact of ENSO on southern African rainfall in CMIP5 ocean atmosphere coupled climate models", *Climate Dynamics*, vol. 45, no. 9–10, 2425–2442.

Connectivity between the central and southern African climates remains an area of much uncertainty. Tropical rainfall and thunderstorms are key drivers of the tropical circulation. They influence local and regional climate dynamics through changing the location and amount of heating in the atmosphere. In the southern African summer the main band of tropical rainfall, the Inter Tropical Convergence Zone (ITCZ), shifts south from the equator to Angola, southern DRC and Zambia. The direct effect of tropical rainfall on regional circulation in southern Africa has received almost no attention.

Despite the importance of the interaction between weather systems inside and outside the tropics, we have not paid enough attention to their dynamics

Thunderstorms also interact with weather systems outside the tropics that pass south of South Africa in the path of the mid-latitude westerly winds. This interaction produces large, north-west to south-east oriented cloud bands. These cloud bands contribute a large proportion of annual regional rainfall,[5] and can be the source of extreme flood events.[6] Despite the importance of the interaction between weather systems inside and outside the tropics, we have not paid enough attention to their dynamics. In part, this is due to climate scientists studying the two regions separately.

ADDRESSING THE KEY KNOWLEDGE GAPS

A focus on the whole region

By focusing on the central-southern Africa climate system as a whole, we hope to give new insights into how the regional climate system works. This can be achieved by investigating phenomena, such as tropical-extratropical cloud bands, which rely on the interaction between the two regions. In addition, we will use high resolution models, which can better represent tropical rainfall processes, such as thunderstorms. We hope that these models will provide an insight into how rainfall in central Africa affects region-wide air circulation and rainfall patterns.

Researchers working in this area (see UMFULA below) will also have a particular *focus on understudied regional circulation features*, such as the Botswana High and the Angola Low. These circulation features, which are important for regional rainfall, interact with remote climate influences, such as El Niño events. However, the origin of these features and their precise role in maintaining the average state of the climate and influencing year to year changes is unclear. Understanding these features is very important, particularly as recent work has suggested that the simulation of these features in climate models affects their simulation of rainfall across the region.[7]

Finally, climate scientists will try to understand why models differ in their simulation of present day climate and future change. To do this, the scientists will look closely at how well models simulate interactions between different parts of the climate system: the oceans, regional circulation features, and rainfall. This will help us understand not only how, but why models are different from each other and from weather station records. This will help to guide improvements in the modelling of the regional climate system. We will also identify models that simulate present climate and year to year variability in a plausible way, based on the analysis related to the points above, and then use these models to assess future change.

5 Todd, M., and R. Washington, 1998. Extreme daily rainfall in southern African and Southwest Indian Ocean tropical-temperate links, *S. Afr. J. Sci.,* 94(2), 64–70.

6 Hart, N. C. G., C. J. C. Reason, and N. Fauchereau, 2012. "Building a tropical-extratropical cloud band metbot", *Monthly Weather Review,* vol. 140, no. 12, pp. 4005–4016; Manhique, A. J., Reason, C. J. C., Silinto, B., Zucula, J., Raiva, I., Congolo, F. & Mavume, A. F. (2015) "Extreme rainfall and floods in southern Africa in January 2013 and associated circulation patterns", *Natural Hazards,* vol. 77, no. 2, pp. 679–691.

7 Munday and Washington (submitted) Circulation controls on southern African precipitation in coupled models: the role of the Angola Low.

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/

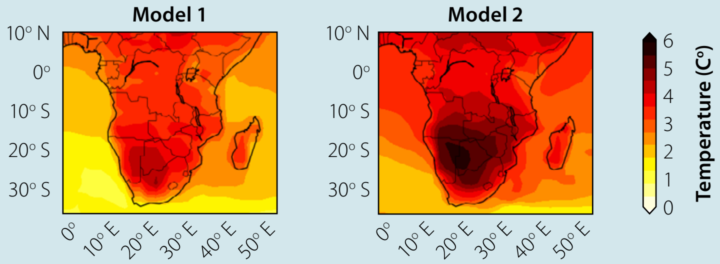
The institutions involved in UMFULA are:

- 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

(a) Future annual temperature change. The whole of central and southern Africa is projected to warm by the end of the century compared to the recent past (1979–2005). Darker shades indicate stronger projected increases in temperature.[8]



(b) Future annual rainfall change: blue colours are where the amount of rainfall is projected to be greater at the end of the century compared to 1979–2005, orange colours indicate projected decreases in rainfall.

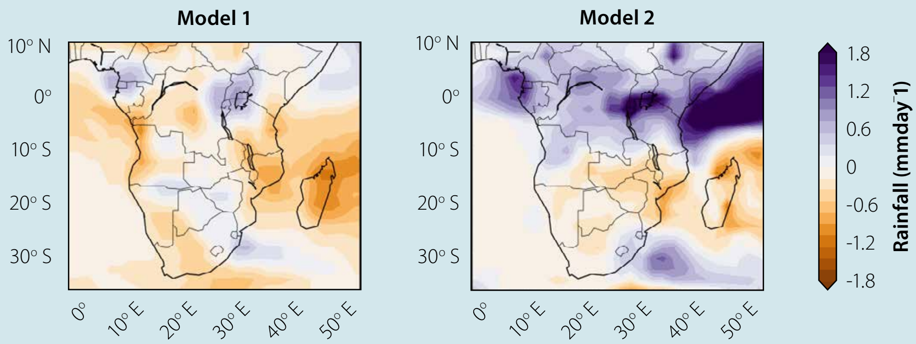
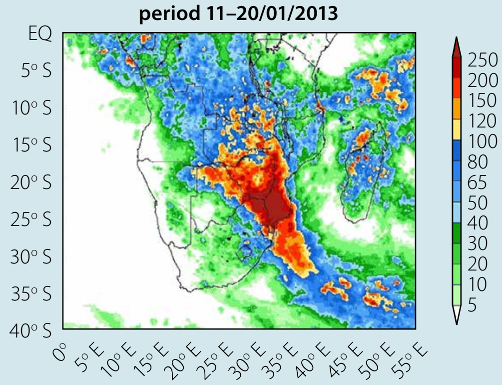


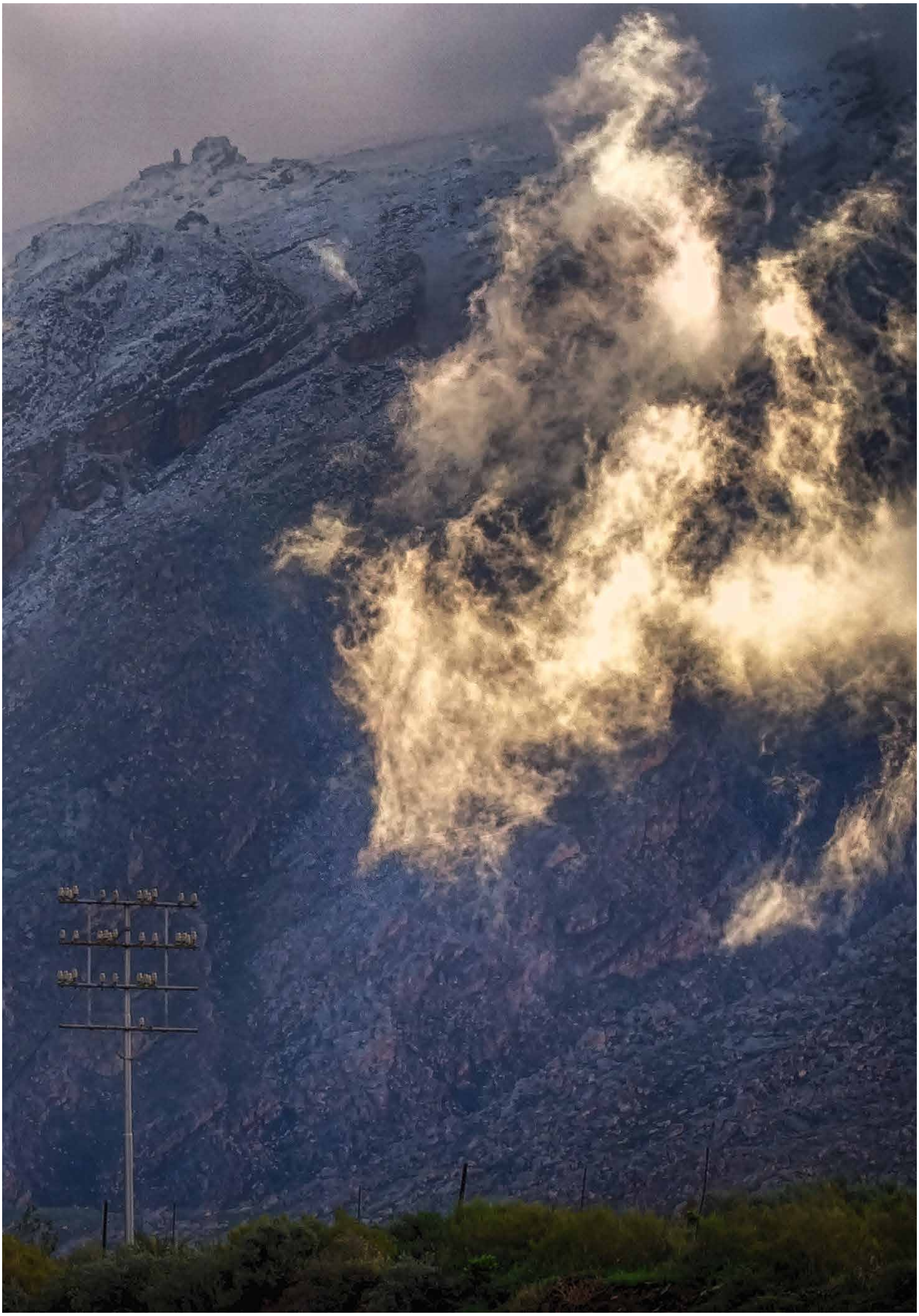
Figure 2

Flooding in January 2013 caused by interactions between thunderstorms and weather systems to the south of the continent. These floods resulted in over 100 deaths, and 200,000 people displaced from their home.[9]



8 Maps: produced by the authors.

9 Adapted from Manhique, A. J., C. J. C. Reason, B. Silinto, et al. Nat Hazards, 2015. 77: 679. doi:10.1007/s11069-015-1616-y.



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