Turkana Jet research unlocks new understanding of East African droughts

Story of change: Key findings & emerging impacts

Summary

- The Turkana Jet is a high-speed wind feature which carries water vapour from the Indian Ocean across East Africa to Central Africa.
- Existing weather and climate models underestimate the strength of the Turkana Jet, hampering their ability to predict drought.
- New observations of the Turkana Jet collected by researchers from the Kenya Met Department, the University of Nairobi and the University of Oxford have been used as a benchmark for UK Met Office forecasting models for East Africa.
- 20 million people in the Horn of Africa have been affected by the recent and severe cycle of droughts.
- Improved confidence in regional models and forecasts will allow better policy and planning to mitigate the impact of extreme climate events on their lives.

Turkana County, Kenya

University of Oxford
REACH Improving water security for the poor
UK International Development Partnership | Progress | Prosperity
Met Office
Republic of Kenya
Ministry of Environment and Forestry
Kenya Meteorological Department

Introduction

East Africa is prone to droughts which can have serious effects for millions of lives and livelihoods. An estimated 20m people currently live in acute deprivation due to multiple failed rains in recent years. Understanding the climate processes leading to drought is a crucial task for climate scientists looking to improve predictions of East African rainfall on timescales from days to decades.

One feature of the East African climate known to be important for drought is the Turkana Jet. The Turkana Jet is a very fast wind, which carries water vapour away from East Africa, into Central Africa, where it falls as rain. Unfortunately, up until recently, our understanding of the Turkana Jet, and associated processes, has been limited to fewer than five academic papers.

Through the REACH programme, we have undertaken a programme of observational and modelling work to address key shortfalls in our understanding of the Turkana Jet and its role in East African drought. This work is providing much-needed evidence to improve current modelling and predictions, which will support policy and practice for governments and donors in the region.

Figure 1: RIFTJet team members Dennis Ong'ech, Rose Nkatha, and Bonface Wanguba prepare to launch weather balloons.

Key findings

REACH work on the Turkana Jet is split into three complementary components:

How does the Turkana Jet influence the average climate and rainfall in East Africa?

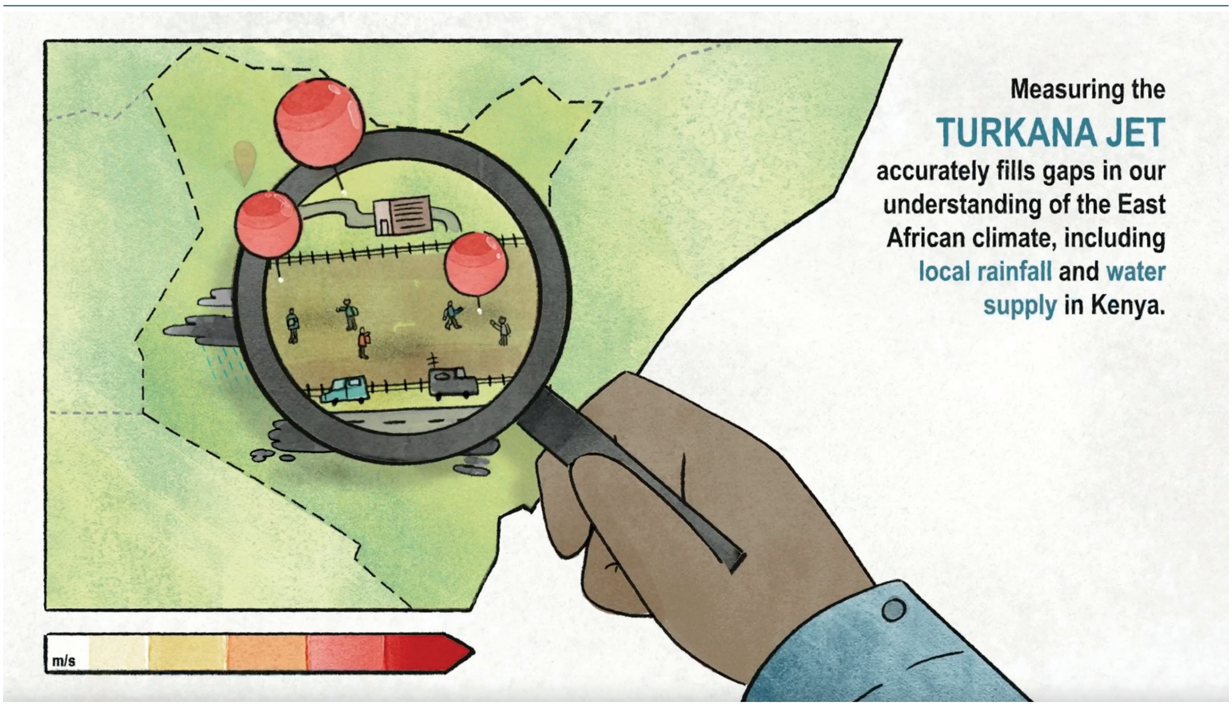
For this work, REACH collaborated with the Met Office in the UK to run a series of state-of-the-art experiments to uncover how the Turkana Jet and East African mountains and valleys affect East African climate. We found that the presence of the Turkana Jet dries out East Africa, substantially reducing the average rainfall in East Africa. The low average rainfall leaves the region exposed to recurrent droughts.

What is the role of the Turkana Jet in droughts?

We addressed droughts on two timescales, interannual (year-to-year) and intra-seasonal (within one season). We found that, in general, dry years of below average rainfall occur when the Turkana Jet is strongest, and therefore carries more water vapour away from East Africa.

The same process happens on shorter timescales, within the rainy seasons: dry spells of 10 days or more within the major rainy seasons are associated with a stronger Turkana Jet. Together, these results clarify a key process/climate feature leading to drought in East Africa.

Figure 2: A new REACH animation developed by Dr Ellen Dyer highlights the importance of improved climate modelling for policy and practice in Kenya and more widely in Africa.



How well do models used for weather and climate forecasting capture the Turkana Jet, and associated links with rainfall?

In March-April 2021, the REACH programme undertook a unique observational programme in northwest Kenya to measure the Turkana Jet for the first time in 40 years with modern technologies.

The field programme, named RIFTJet, documented the real-world wind speeds and water vapour transport associated with the jet. Comparison was made between these observations and results from models. A key finding is that many of the models we use to forecast weather and climate underestimate the strength of the Turkana Jet, with implications for their ability to simulate drought.

Scientific impacts

In relation to the aims above, we have made key breakthroughs in our understanding of East African climate. Specifically, we are now confident that the Turkana Jet is a crucial factor leading to dry conditions in East Africa, on timescales from days to millions of years. Moreover, we now know about some of the key deficiencies in weather and forecast models, which limit their ability to predict drought reliably. Going forward, this knowledge will enable us to improve those forecast models so as to improve drought predictions.

There are seven publications arising from this programme of work, which are either published or under review. These are in high impact journals, including Nature and Geophysical Research Letters. Additionally, a key output is a unique observational dataset of the Turkana Jet, which we hope can be used by a variety of scientists studying African and dryland climate systems.

A new REACH animation highlights the importance of improved climate modelling for policy and practice in Kenya and more widely in Africa.

Policy and practice impact

There are two major areas where the work has influenced policy and practice:

1. Guidance on improvements to UK Met Office forecast model in Africa

The observations of the Turkana Jet, collected via the RIFTJet field programme, were used to evaluate the Met Office regional forecast model. Under its normal settings, our analysis found that the model, which uses a spatial resolution of 10 kilometres globally, severely underestimates the speed of the Turkana Jet (by 20%). Further research, conducted at the Met Office, found that by adjusting the setup of the model (up to 2.2 kilometres), a much better match with observations could be achieved.

Our RIFTJet observations, therefore, justify using the improved, high-resolution versions of the Met Office model to forecast rainfall and drought in East Africa. With major model developments underway – including via the Met Office's flagship K-Scale (kilometer-scale) modelling programme – we expect that the RIFTJet observations will continue to provide a crucial benchmark for climate models in an African context.

By increasing confidence in regional models and their forecasts, the RIFTJet observations will support weather- and climate-related planning decisions in the Horn of Africa, covering a population of over 100 million people.

2. Justification for expansion of climate observations in Kenya

The RIFTJet field programme was a collaboration with REACH and the Kenya Met Department. Part of the aims of the project was to justify a business case for expanding the network of climate observations in Kenya, so as to improve weather and seasonal forecasts. Discussions with the Kenya Met Department are ongoing in this regard, with two milestones in 2023-2024:

1. Meeting with Kenya Met Department and REACH in July 2023, to discuss findings from RIFTJet and to establish framework for continued collaboration

- Field observations programme with Kenya Met Department planned for March-April 2024, with the aim of providing vital climate measurement of rainfall onset, during a season where rains have recently failed.

3. Capacity building

The RIFTJet field project included a team of 12 from Kenya Met Department, Oxford University and University of Nairobi. This encompassed two MSc students (one male, one female) and three staff members from Uni of Nairobi, Kenya Met Department Officers and scientists from Oxford.

All team members were trained in elements of climate observations including, setting up of automatic weather stations, releasing weather balloons, and using a theodolite for balloon tracking. The project lead, an early career scientist, learnt a great deal about organising climate field programmes.

During the project, the REACH team undertook several workshops with all team members aimed at learning how to analyse the observational data, using coding software, such as Python. The REACH team also organised seminars to discuss the regional meteorology together with the Kenya Met Department.

Following the field project, the two MSc students and one University of Nairobi staff member joined and completed an online coding course run from University of Oxford in the summer of 2021. The MSc students are working with REACH to write a publication using the field data.

Outputs

Published

Munday, C., Washington, R. and Hart, N. 2021. African low-level jets and their importance for water vapor transport and rainfall. *Geophysical Research Letters*, 48 (1): e2020GL090999. doi: 10.1029/2020GL090999

Munday, C., Engelstaedter, S., Ouma, G., Ogutu, G., Olago, D., Ong'ech, D., Lees, T., Wanguba, B., Nkatha, R., Ogalo, C., Gàlgalo, R.A., Dokata, A.J., Kirui, E., Hope, R. and Washington, R. 2022. Observations of the Turkana Jet and the East African dry tropics: The RIFTJet field campaign. *Bulletin of the American Meteorological Society*, 103 (8): E1828–E1842, doi: 10.1175/BAMS-D-21-0214.1

Munday, C., Savage, N., Jones, R.G. and Washington, R. 2023. Valley formation aridifies East Africa and elevates Congo Basin rainfall. *Nature*, 615: 276–279. doi: 10.1038/s41586-022-05662-5

Spavins-Hicks, Z.D., Washington, R., and Munday, C. 2021: The Limpopo Low-Level Jet: Mean climatology and role in water vapour transport. *Journal of Geophysical Research: Atmospheres,* 126 (16): e2020JD034364. doi: 10.1029/2020jd034364

Other outputs:

'Rivers in the sky' shape African climate – research, University of Oxford news, February 2023.

The invisible rivers implicated in African drought, REACH Blog, February 2021.

Contact:

Dr Callum Munday
University of Oxford

callum.munday@seh.ox.ac.uk

Dr Gilbert Ouma
University of Nairobi

gouma@uonbi.ac.ke

Professor Richard Washington
University of Oxford

richard.washington@ouce.ox.ac.uk

Dr Ellen Dyer
University of Oxford

ellen.dyer@ouce.ox.ac.uk

Professor Dan Olago
University of Nairobi

dolago@uonbi.ac.uk

Story of change themes

- Groundwater
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- Health
- Climate
- Cities
- Basins

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