# Subseasonal forecasts for humanitarian decision-making in Kenya: understanding forecast skill and the latest results from the S2S ForPAc real-time pilot study

Dave MacLeod **(on behalf of the ForPAc team)**

Display uploaded for EGU2020 session AS1.9

Department for International Development

NERC SCIENCE OF THE ENVIRONMENT

SHEAR Science for Humanitarian Emergencies & Resilience

UNIVERSITY OF OXFORD

**ForPAc**

Towards Forecast-based Preparedness Action

# Towards Forecast-based Preparedness Action (*For*PAc):

## Probabilistic forecast information for defensible preparedness decision-making and action

RED CROSS RED CRESCENT CLIMATE CENTRE

Met Office

Kenya Meteorological Department

UNIVERSITY OF OXFORD

KING'S College LONDON

HelpAge International age helps

christian aid

IGAD CLIMATE PREDICTION AND APPLICATIONS CENTRE ICPAC

National Drought Management Authority NDMA Committed to ending drought emergencies

University of Sussex

Kenya Red Cross

# Contents / summary

**The problem:**

- significant impacts of flood and drought over Kenya, e.g. 2018 event
- Information ‘gap’ between seasonal forecasts (1 month ahead of rainy season) and heavy rainfall advisories (few days ahead of heavy rain events)

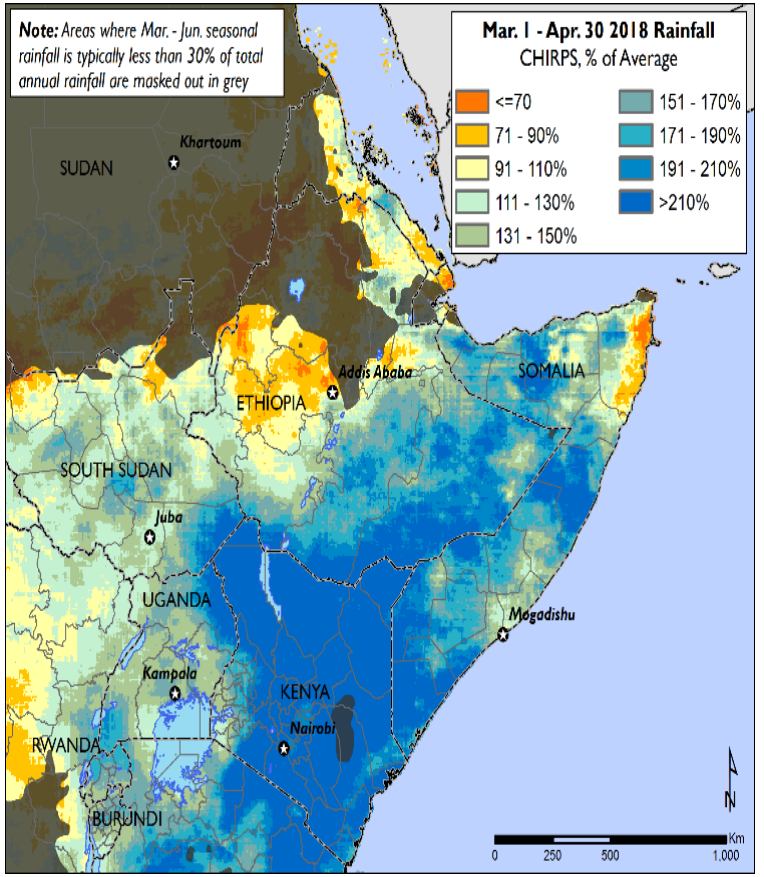
**Evaluating the solution:**

- Verification of subseasonal forecasts
- Representation of MJO teleconnection
- Forecasts for extreme events in 2018

**Next steps:**

- the S2S-ForPAc pilot of real-time subseasonal forecasts
- co-design of forecast products
- activities so far

# March-April-May 2018 (long rains) was the wettest on record

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## Kenya's Patel dam bursts, sweeping away homes in Solai

10 May 2018 Share

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## Red Cross warns of crisis as floods hit Tana River

SUNDAY APRIL 22 2018

Tana River residents take refuge on a tree to escape from raging floods as they await evacuation. At least 1,800 people have been marooned by floods in Tana River County. PHOTO | STEPHEN ODUOR | NATION MEDIA GROUP

## Lethal flash floods hit east African countries already in dire need

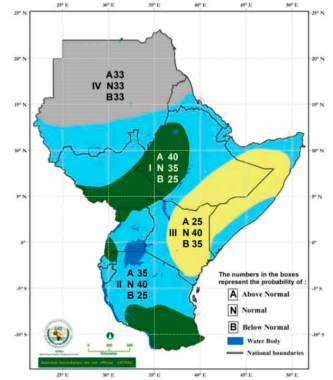
**In Kenya, Rwanda and Somalia death toll reaches 300, with hundreds of thousands more people displaced, adding to crisis in region stricken by drought**

## Outbreak of Rift Valley Fever feared as flooding persists

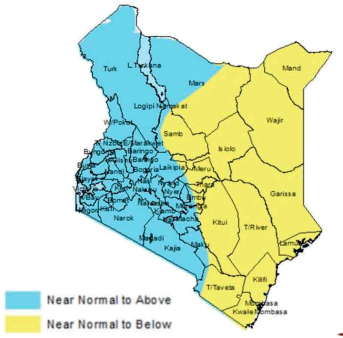
May. 21, 2018, 12:45 am | By AGATHA NGOTHO @agathangotho

# Strong predictability for short rains (OND) but not long rains (MAM)

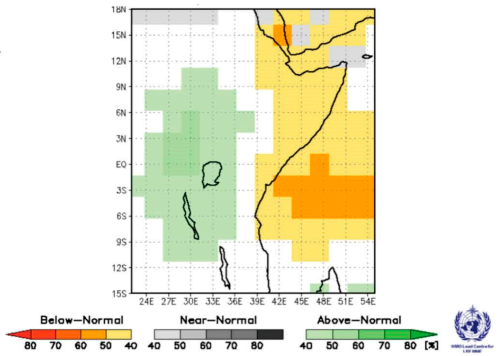
(a) GHACOF consensus forecast




(b) KMD seasonal forecast




(c) Multi-model GPC forecast




**1 No strong warnings of flooding from seasonal forecasts**

**Figure from [Kilavi et al 2018 ](#) Atmosphere,** Extreme Rainfall and Flooding over Central Kenya Including Nairobi City during the Long-Rains Season 2018: Causes, Predictability, and Potential for Early Warning and Actions

Kenya Meteorological Department
Ministry of Environment & Forestry
State Department of Environment

P.O.Box 30259-00100, Ngong Road, Dagoretti-Corner, Nairobi.
Tel: +2542038567880-5, +254724255153-4Email:director@meteo.go.ke

## Heavy Rain Advisory: Update

| | |
|---|---|
| **Message Type:** | Heavy Rain |
| **Message Update No.:** | One |
| **Advisory No.** | 03/2018 |
| **Date of Origin:** | 15th March 2018, 0600UTC |
| **Validity:** | 16th March to 19th March, 2018 |
| **Severity:** | Moderate to high |
| **Certainty:** | Probability of occurrence (High) |

**2 Kenya Met Department heavy rain advisories anticipated extreme rainfall events during MAM 2018, with lead time less than one week**

See [MacLeod et al 2020 NHESSD](#) Are Kenya Meteorological Department heavy rainfall advisories useful for forecast-based early action and early preparedness?

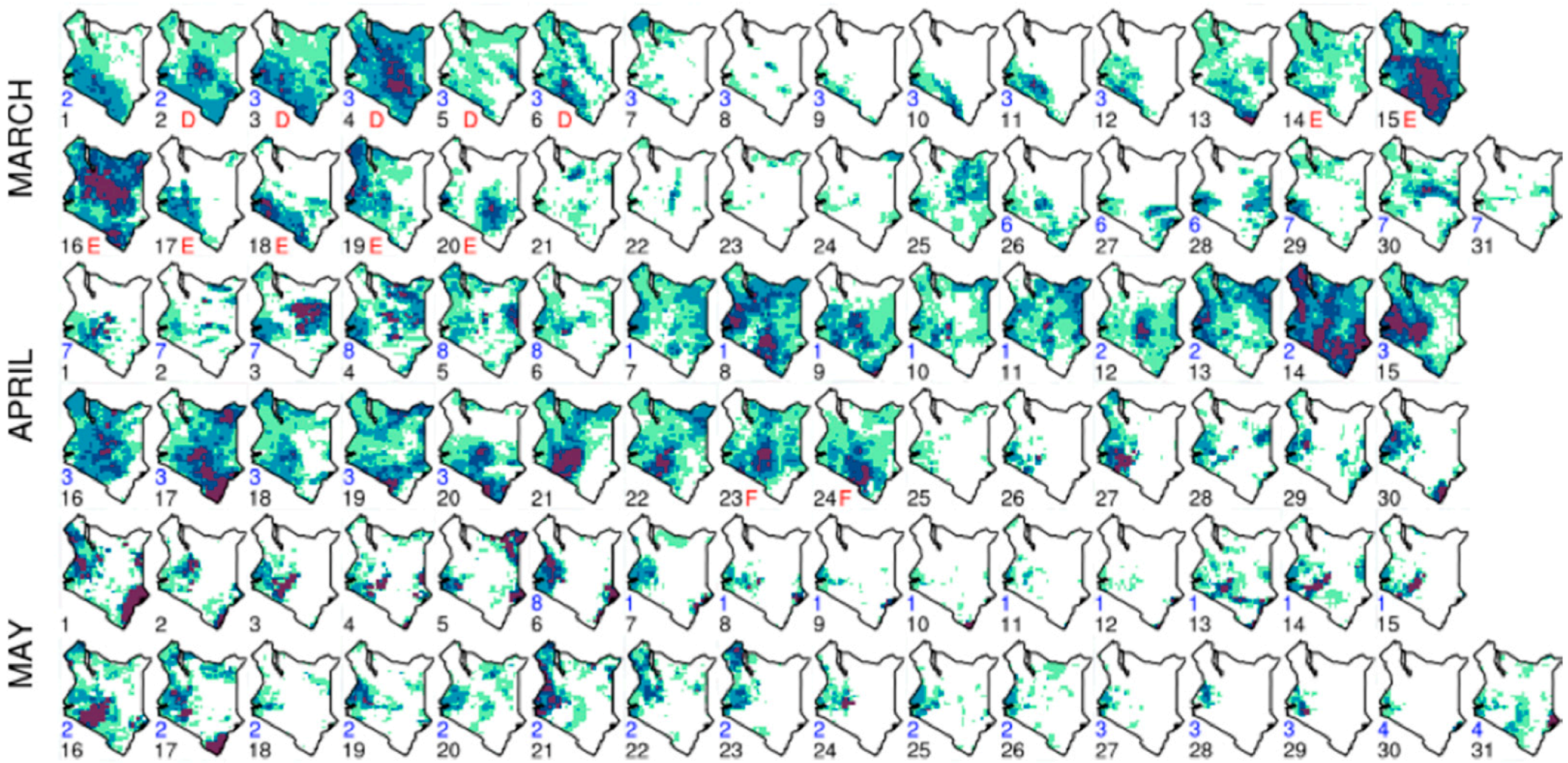
**3 No available forecasts bridge the gap between seasonal forecasts and existing rainfall advisories**

# Findings from workshops with stakeholders in Nairobi flood management

- Preparedness actions limited by lead time
- No forecast uncertainty given
- Provider trust issues
- With extended lead time preparedness actions could include:
  - Large scale drainage clearance
  - Rehabilitation of buildings, infrastructure in informal settlements

Can early warning lead time be extended with subseaonal forecasts?

# Variability within MAM 2018 linked to MJO zone 2-3 (+ other factors incl tropical cyclones)



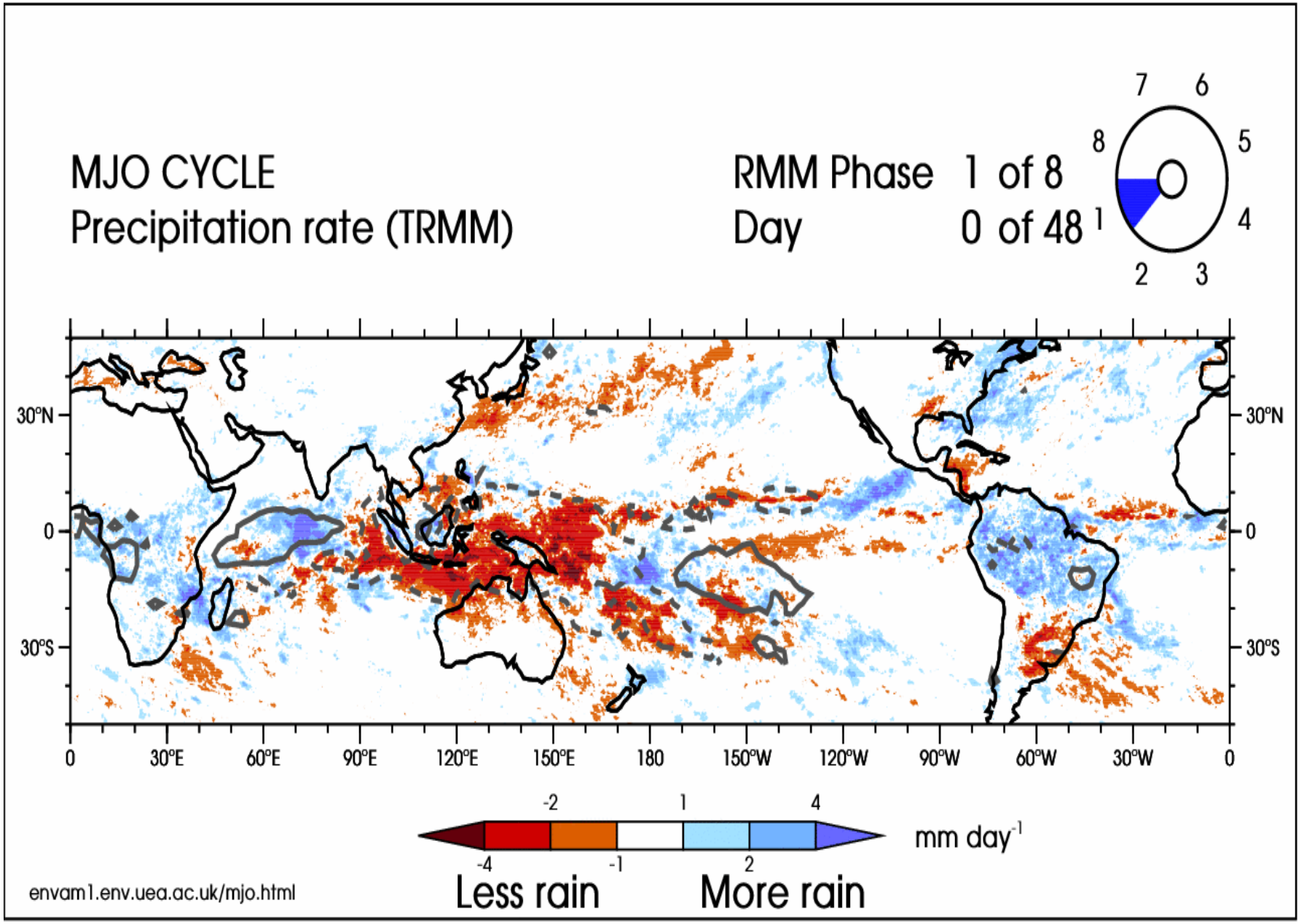

**Blue numbers indicate a MJO activity in specified phase 1-8 on that date**

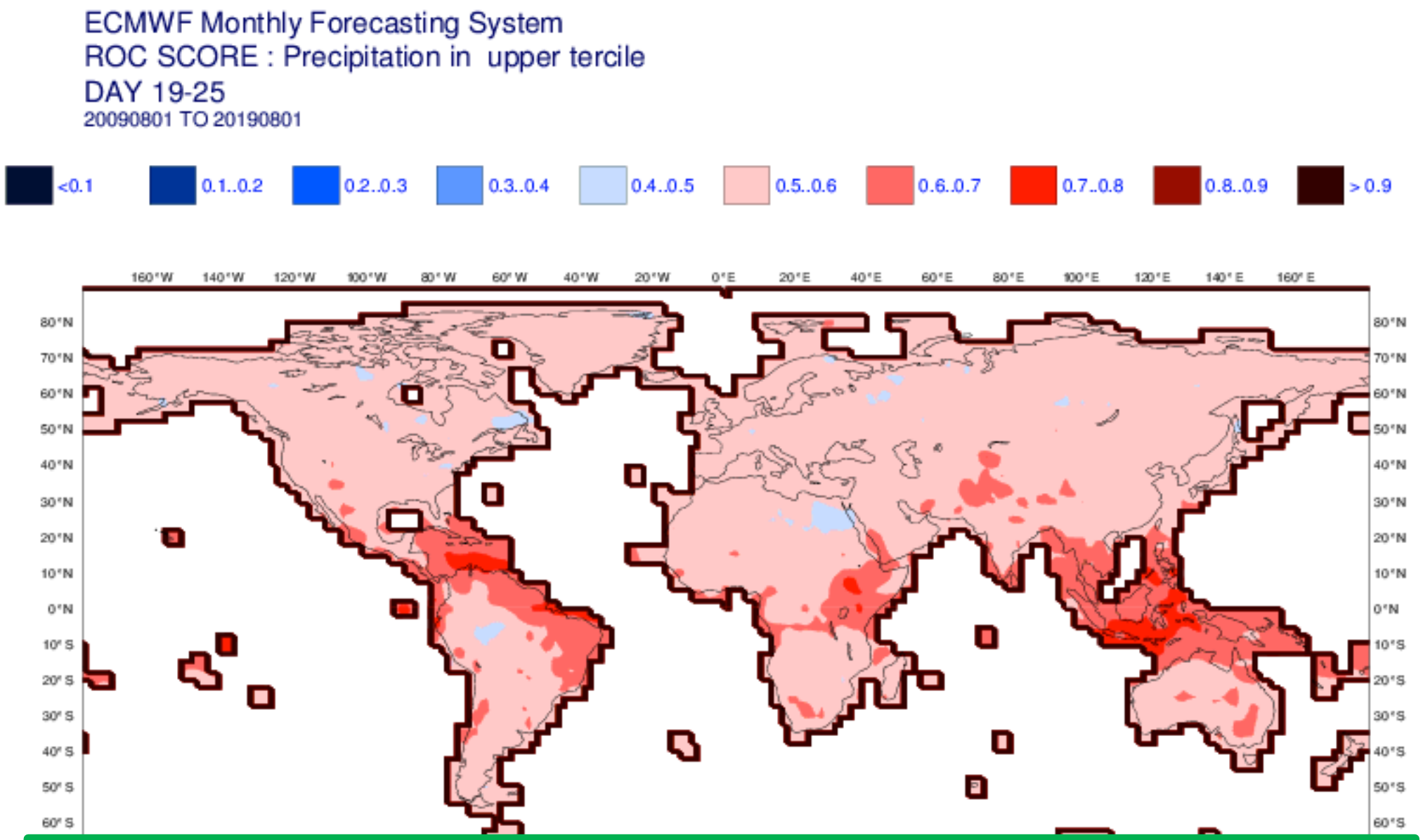
[Kilavi et al 2018]

**Madden-Julian Oscillation (MJO) is a key source of predictability on subseasonal timescale**

**MJO is predictable 2-3 weeks ahead (Vitart et al 2019)**

**Active MJO linked to remote rainfall impacts in Greater Horn of Africa (Berhane & Zatichik 2014, Zatichik 2017)**



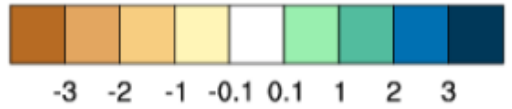



**Greater Horn of Africa is a 'hotspot' of subseasonal predictability**

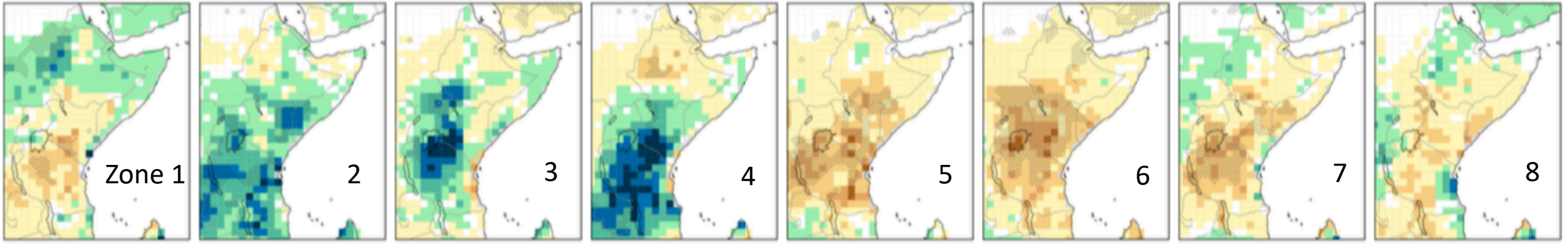
Figure from www.ecmwf.int

# How well do models represent the MJO teleconnection?

Rainfall anomaly (mm/day) when MJO magnitude in zone is > 1




Average rainfall when MJO is in zone 1-8. In reality…




…and in ECMWF subseasonal forecast model

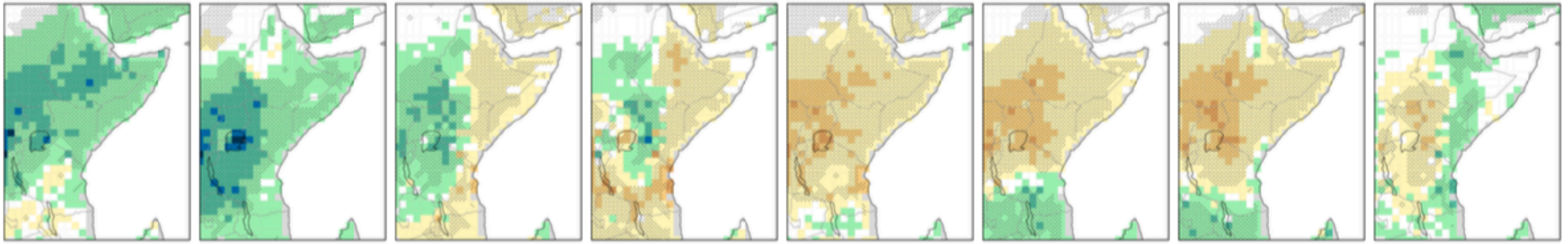
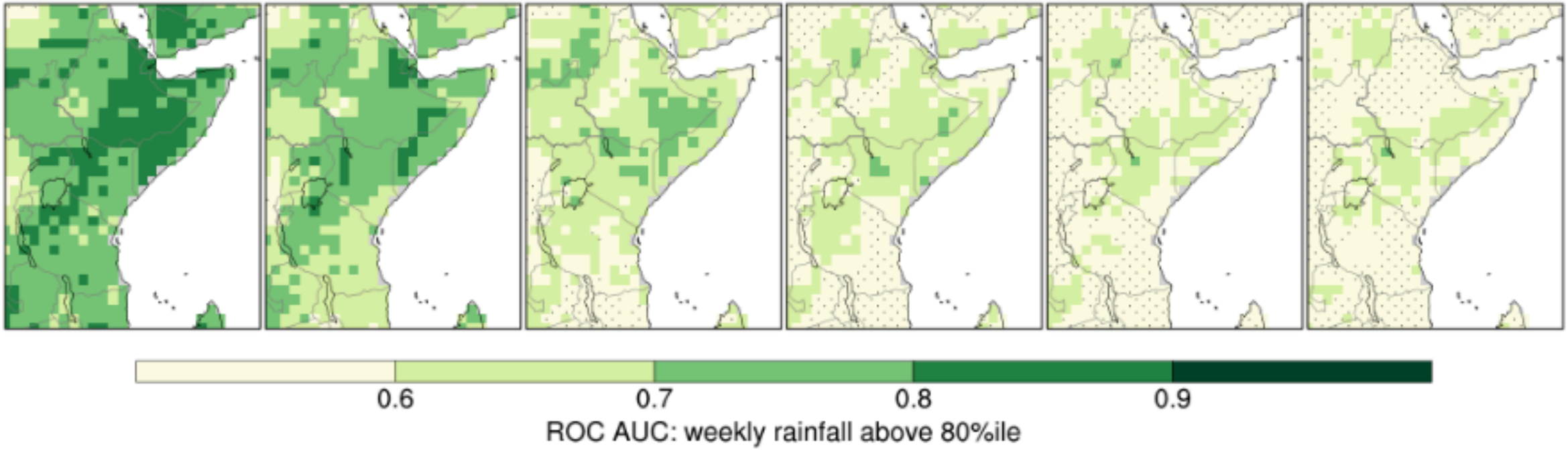


Figure from MacLeod et al *Drivers and subseasonal predictability of extreme rainfall and flooding in equatorial East Africa*, in preparation

[weeks in MAM, CHIRPS rainfall obs]

# Forecast verification – ECMWF reforecast 1997-2016, only weeks falling in MAM

Probabilistic skill of predicting 80%ile rainfall totals – i.e. wettest week out of five (on average 2-3 per rainy season)




Skillful discrimination at two week lead and beyond

Figure from MacLeod et al *Drivers and subseasonal predictability of extreme rainfall and flooding in equatorial East Africa*, in preparation.
Stippling indicates areas not significant at 95% level.
See also Andrade et al, *"Sub-seasonal precipitation prediction for Africa: Forecast evaluation and sources of predictability"*, submitted to MWR

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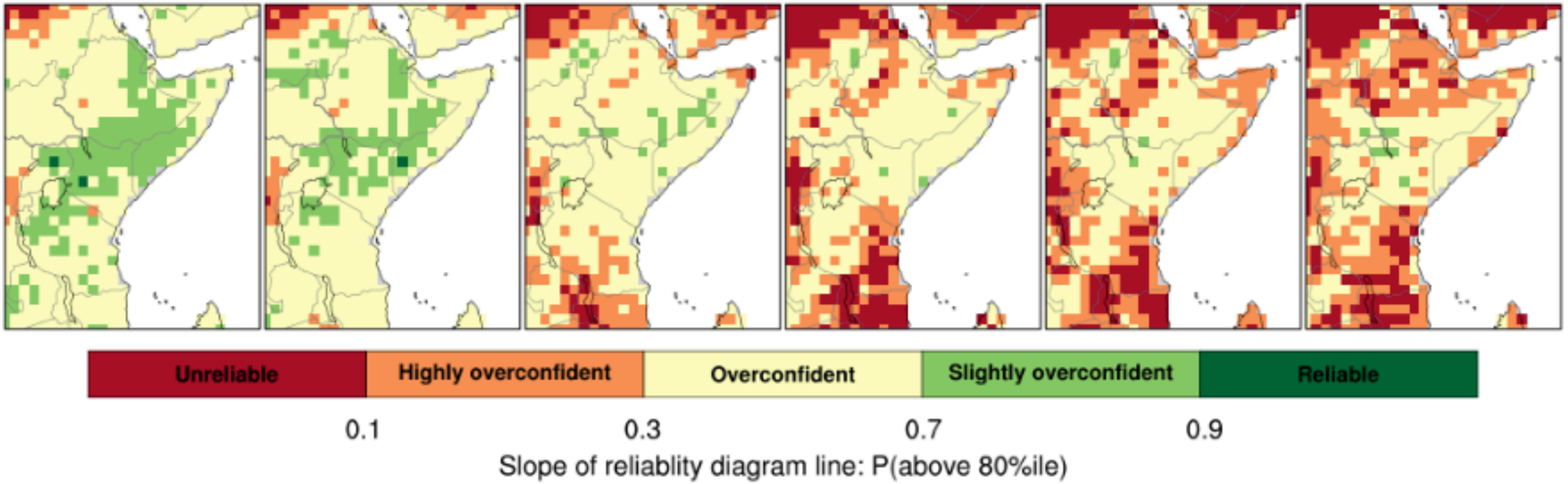


Probabilities are only slightly overconfident over Kenya at week 2

Figure from MacLeod et al *Drivers and subseasonal predictability of extreme rainfall and flooding in equatorial East Africa*, in preparation.
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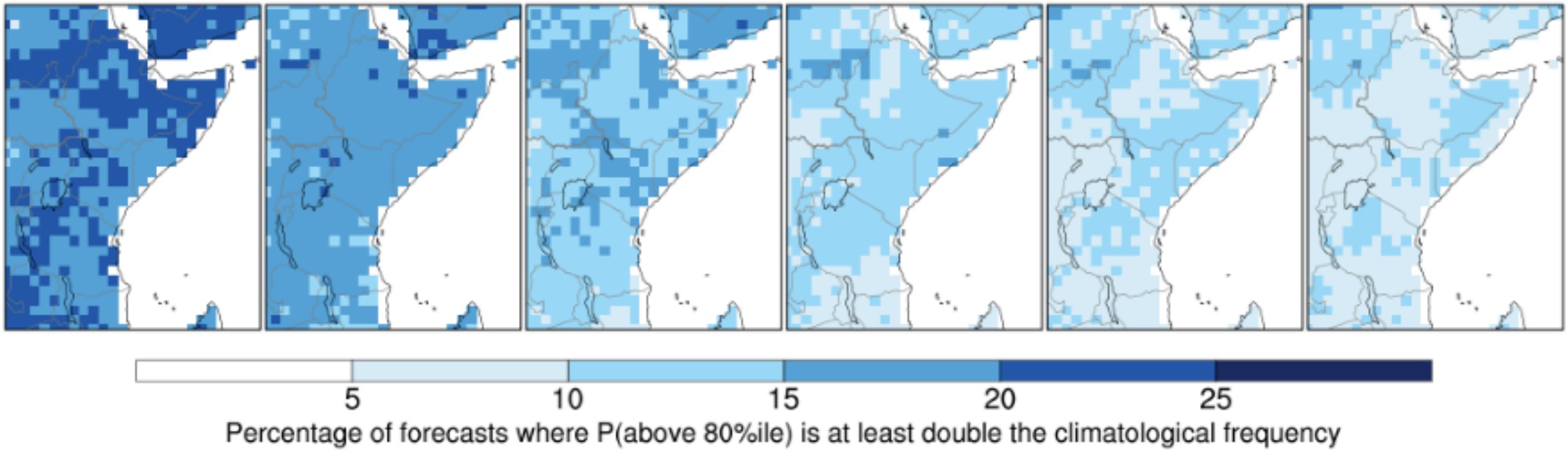
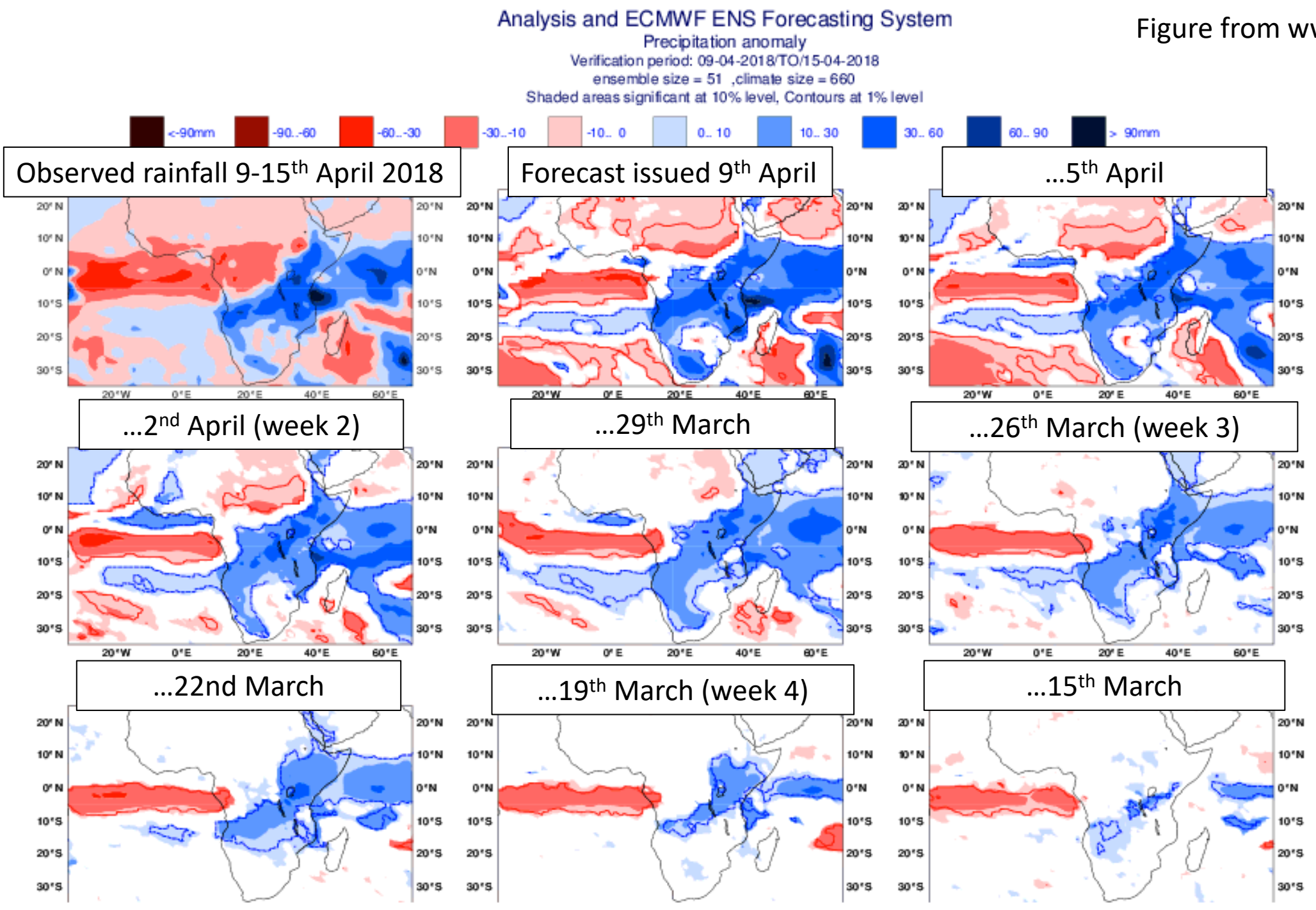



Forecasts have some sharpness (forecasts = more actionable [assuming reliability])

Figure from MacLeod et al *Drivers and subseasonal predictability of extreme rainfall and flooding in equatorial East Africa*, in preparation.
Stippling indicates areas not significant at 95% level.
See also Andrade et al, *"Sub-seasonal precipitation prediction for Africa: Forecast evaluation and sources of predictability"*, submitted to MWR

Evaluation of forecasts for individual events suggests ‘windows of predictability’ where strong wet signals are seen four weeks ahead (see next slide)

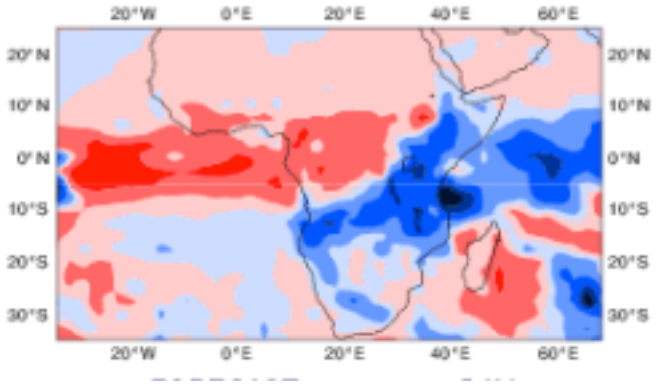
Figure from www.ecmwf.int



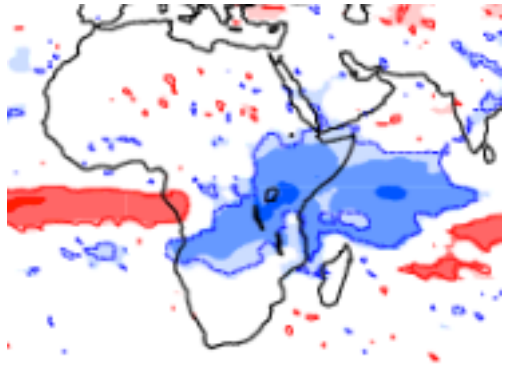
# Other models are available…

Figure from www.ecmwf.int

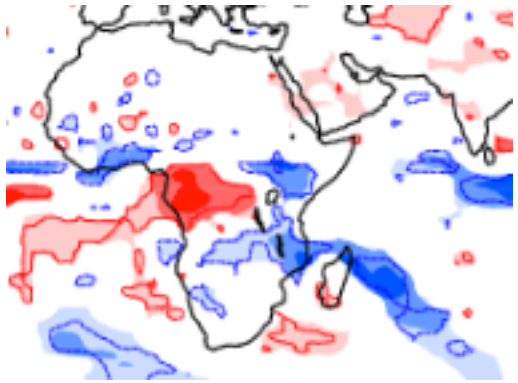
**Analysis**



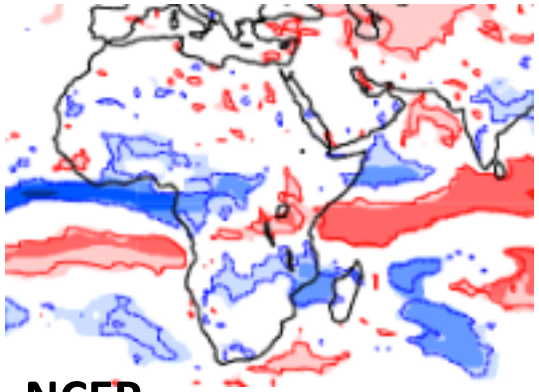

**ECMWF**



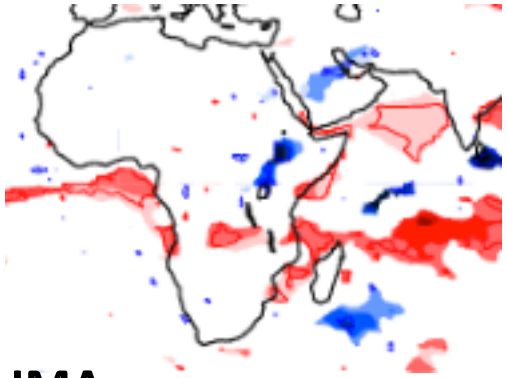
**BOM**



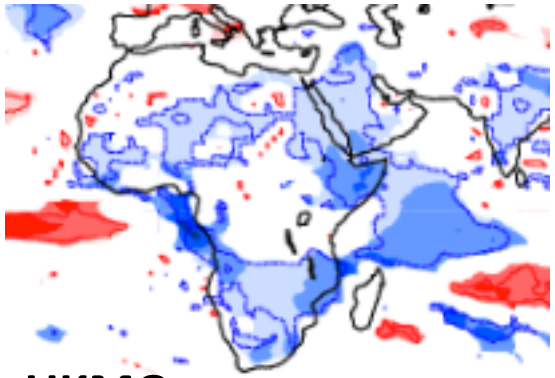
**Meteo France**



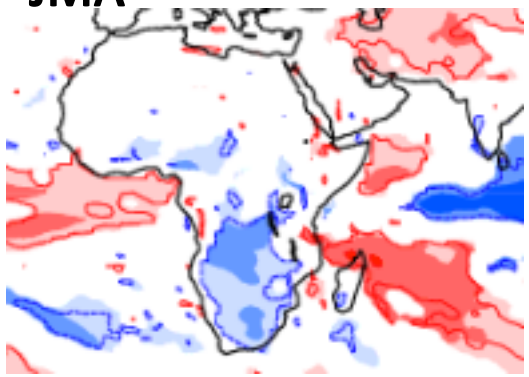
**CMA**



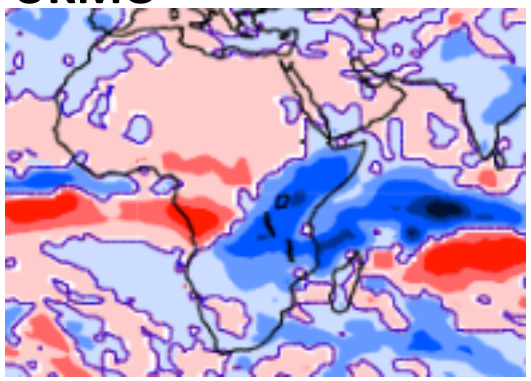
**NCEP**



**JMA**



**UKMO**



Ensemble mean forecast for 9-15th April 2018

S2S models initialized 22th March (day 19-25)

**The problem:**

- Information ‘gap’ between seasonal forecasts (1 month ahead of rainy season) and heavy rainfall advisories (few days ahead of heavy rain events)
- Stakeholders indicate potential usefulness of subseasonal forecasts for flood management in Kenya

**The solution:**

- Subseasonal forecasts can anticipate the wettest weeks (1 in 5, occurring on average 2-3 times per season), with reliable and bold probabilities for week two lead
- Case studies suggest ‘windows of predictability’ where lead time of events of up to four weeks ahead

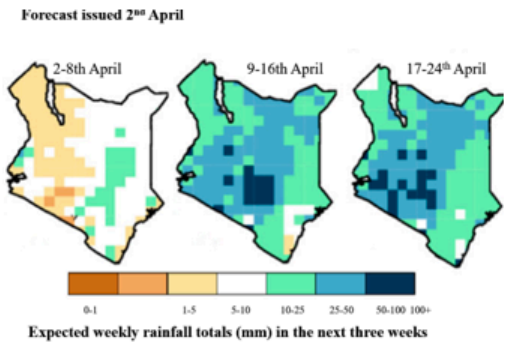
**Testing the solution:**

- Through ForPAc, Met Office (GloSea) subseasonal forecasts have been communicated to KMD on an experimental basis since 2018
- In November 2019, ForPAc granted real-time access to S2S data for 2 year trial period as part of S2S phase 2
- ForPAc is teaming up with another S2S pilot project, Africa-SWIFT, to pilot the use of subseasonal forecasts in Kenya
- Forecasts will be communicated through project partners & stakeholders
  - ForPAc has held probabilistic information training with stakeholders in recent years, where possibilities of subsesaonal forecasts have been highlighted
  - Co-design & co-development of forecasts with stakeholders is central
  - **Aiming at first test forecasts provided to stakeholders for MAM 2020**

**So far:**

- 2019 SWIFT partners at University of Reading UK set up quasi-operational forecast pre-processing (data download, pre-processing)
- Nov 2019 – SWIFT/ForPAc workshop with partners in Nairobi to kick-off pilot and begin working on forecast data
- February 2020 – ForPAc stakeholder workshop in Nairobi to co-design form of forecast information **[ see next slide ]**
- February 2020 –KMD and ICPAC partners came to UK for a week to co-develop forecast products (python, forecast data on JASMIN)
- March 2020 forecast provision begins

# February 2020 – ForPAc stakeholder workshop in Nairobi: discussing needs with stakheolders and deciding on optimal form of forecasts

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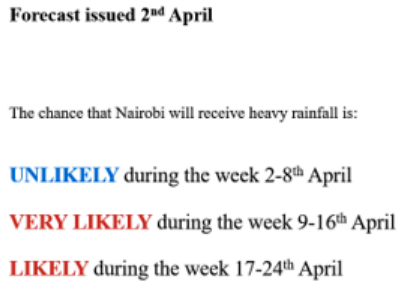


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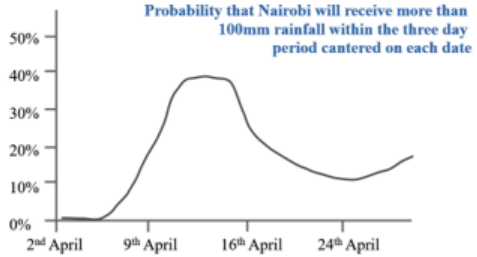


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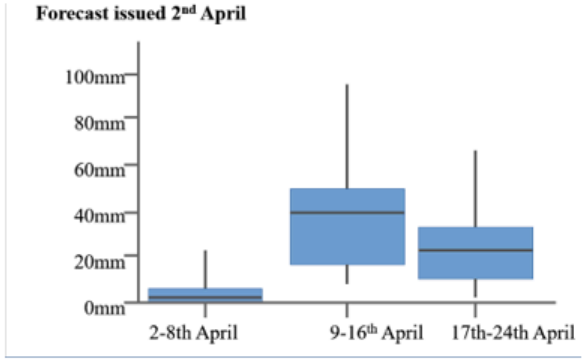


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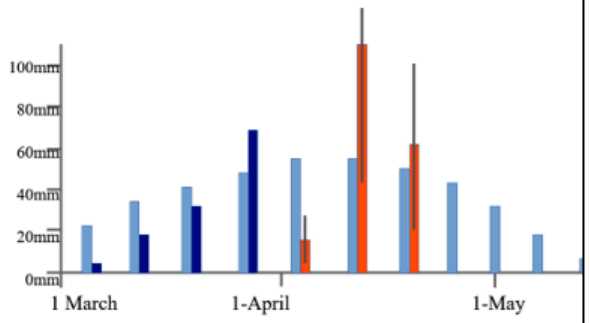
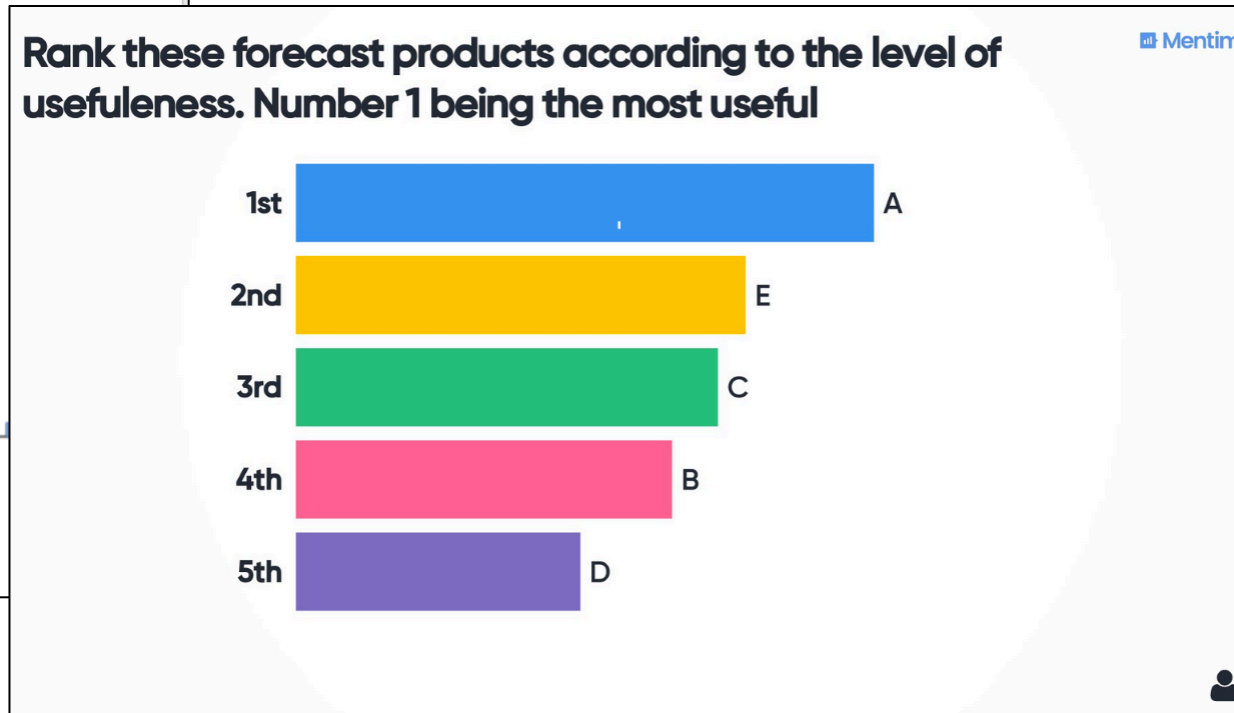



E

Mock forecast visualizations (left) provided to stakeholders, who were asked order them in terms of 'usefulness' (below)

This ranking helps to determine the development of forecast products which will then be communicated back to stakeholders



# Summary

Clear benefit to extending the window for humanitarian early actions

ECMWF & UKMO subseasonal forecasts anticipated wettest episodes during extreme MAM 2018 season – at least two weeks ahead. Probabilities for wet week occurance are reliable and have sharpness, for at least week two ahead. Potential windows of opportunity at longer lead.

Ongoing pilot to co-design, develop and communicate subseasonal forecasts to stakeholders in Nairobi city flood management – beginning MAM 2020

COVID-19 has limited the pilot to date:

- Kenya Red Cross and other stakeholders prioritizing COVID-19 related assistance and support
- In person dissemination (at community meetings, in informal settlements) limited due to transmission risk

# More ForPAc research on S2S predictability over Greater Horn of Africa

See www.forpac.org, or contact me at David.Macleod@physics.ox.ac.uk

Kilavi, M., et al., 2018. **Extreme rainfall and flooding over central Kenya including Nairobi city during the long-rains season 2018: causes, predictability, and potential for early warning and actions**. *Atmosphere*

MacLeod, D., 2018. **Seasonal predictability of onset and cessation of the east African rains**. *Weather and climate extremes*, *21*, pp.27-35.

Kolusu, S.R.,et al. 2019. **The El Nino event of 2015-2016: climate anomalies and their impact on groundwater resources in East and Southern Africa**. *Hydrology and Earth System Sciences*

MacLeod, D., 2019. **Seasonal forecasts of the East African long rains: insight from atmospheric relaxation experiments.** *Climate Dynamics*

MacLeod D. & Caminade C. 2019 **The moderate impact of the 2015 El Nino over East Africa and its representation in seasonal reforecasts.** Journal of Climate

MacLeod et al Are Kenya Meteorological Department heavy rainfall advisories useful for forecast-based early action and early preparedness? Open discussion paper under review at Natural Hazards and Earth System Science

MacLeod et al. Causal links between ENSO and the Greater Horn of Africa short rains. Submitted to Geophysical Research Letters

MacLeod et al Drivers and subseasonal predictability of extreme rainfall and flooding in equatorial East Africa, *in preparation*