



## LINKING SEASONAL FORECASTS TO USER NEEDS IN THE LIMPOPO BASIN IN SOUTHERN AFRICA

Micha Werner<sup>1,2\*</sup> Patricia Trambauer<sup>2</sup> Hessel Winsemius<sup>1</sup>  
Shreedhar Maskey<sup>2</sup> Florian Pappenberger<sup>3</sup> Emanuel Dutra<sup>3</sup>  
Plus several others from the DEWFORA team

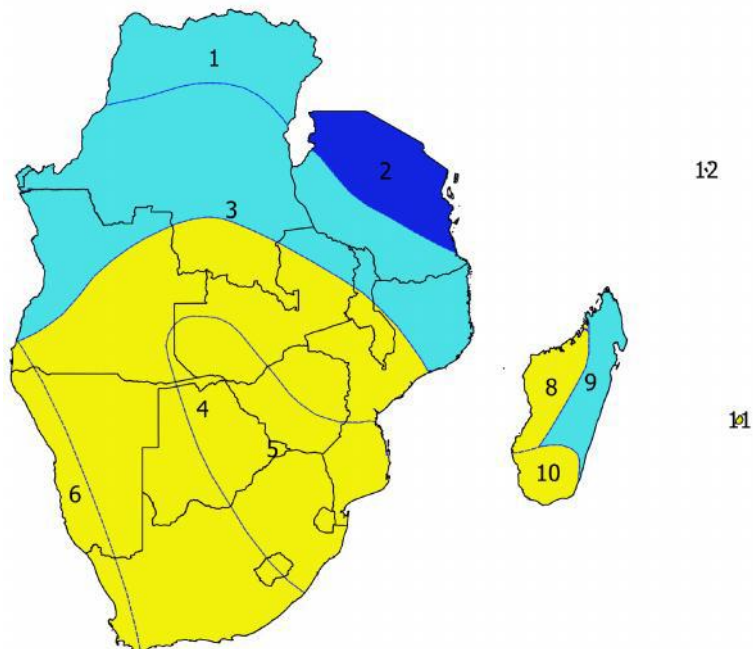
<sup>1</sup> Deltares, P.O. Box 177, 2600MH Delft, the Netherlands

<sup>2</sup> UNESCO- P.O. Box 3015, 2601 DA Delft, the Netherlands

<sup>3</sup> ECMWF, Shinfield Park, RG2 9AX Reading, United Kingdom

# 19<sup>th</sup> SARCOF Statement – Issued 26-28 August 2015

OCTOBER-NOVEMBER-DECEMBER 2015

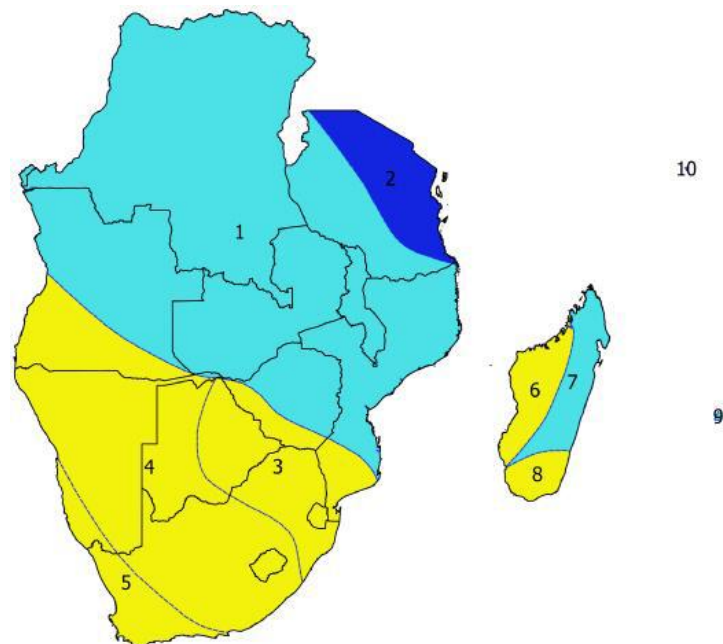


**Zone 4:** Central Mozambique, southern Malawi, northern half of Zimbabwe, most of Zambia, southernmost DRC, south-eastern half of Angola, bulk of Namibia, western half of Botswana, most of central and western parts of South Africa, western parts of Lesotho.

**Increased chances of normal to below-normal rainfall**




DECEMBER 2015-JANUARY-FEBRUARY 2016



**Zone 4:** Southern third of Zimbabwe, eastern half of Botswana, north and central South Africa, eastern Lesotho, Swaziland and southern Mozambique.

**Increased chances of normal to below-normal rainfall**



“If there is a drought, the small farms will collapse, they won’t function, they will get no profit from their animals...

... if I can get advance about drought, then I will be able to organise some feeds for the cattle, I will be able to see to it that my dam is up to date, you know, water is enough in the dams”

Stephen Lebotsa, Chairman  
Mobidibeng dairy Cooperative  
Limpopo Province, South Africa

FUTURE IS



<http://www.euronews.com/2013/06/17/africa-is-always-at-risk-of-drought/>

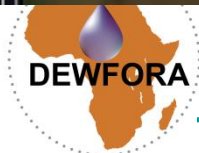
“The situation is that there is not enough water in Southern Africa, the rainy season is short....

... so we need research to better manage the water resources”

Jakkie Venter, Area Manager,  
Department of Water Affairs,  
Tzaneen area office,  
Limpopo Province, South Africa



FUTURE IS



# The DEWFORA Approach

**An evidence-based protocol for designing and implementing drought early warning systems**

What is the science available?

What are the societal capacities?

How can science be translated into policy?

How can society benefit from the forecast?



# SEASONAL HYDROLOGICAL FORECASTING OF USER RELEVANT VARIABLES: LIMPOPO BASIN

## ➤ *Droughts in the Limpopo:*

1982/83, 1987/88, 1991/92, 1994/95, 2002/03, 2004/05, 2006/07



## *Questions:*

*Do we have the science to provide skilful (hydrological) drought forecasts?*

*and*

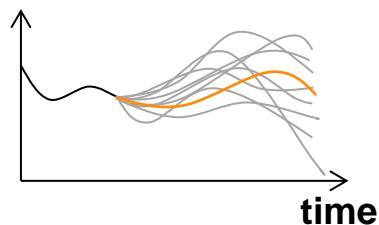
*Do these provide variables that are useful to water users?*



# METHODOLOGY

## Meteorologic alforcing

- Precipitation
- Temperature (mean, max, min, - ensembles)



ECMWF S4

Ensemble Streamflow Prediction

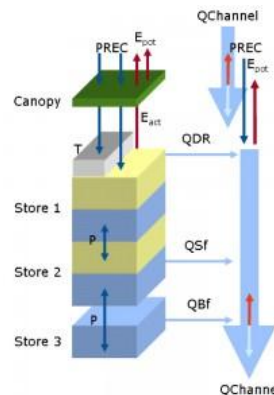
ESP Conditioned on ENSO

## "Pre-processing"

- Bias-correction of precipitation
- Estimation of potential evaporation (PE)

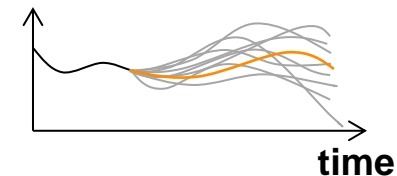
## Hydrological forecasting

- PCR-GLOBWB hydrological model
- DELFT-FEWS forecasting shell



## Results

- Predicted (ensembles) streamflow, soil moisture, and other hydrological fluxes



Possible states of the forecast → Probability of (not) exceeding thresholds



# ASSESSING SKILL...

Forecast is justified if it supports better decision making → *then it has value*

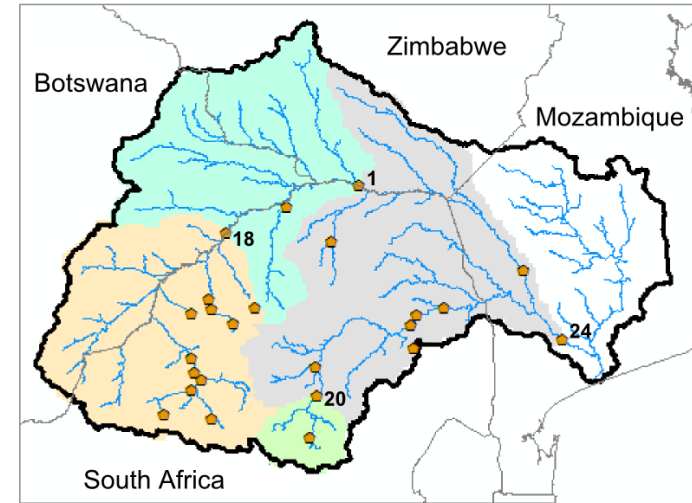
➤ Major use in the basin: irrigation.

Meaningful indicators for a better decision making:

- **Standardised Runoff Index (SRI)**
- **Agricultural drought (soil moisture)**
- **Reservoir levels: curtailments in irrigation**

➤ Verification skill scores (assess quality):

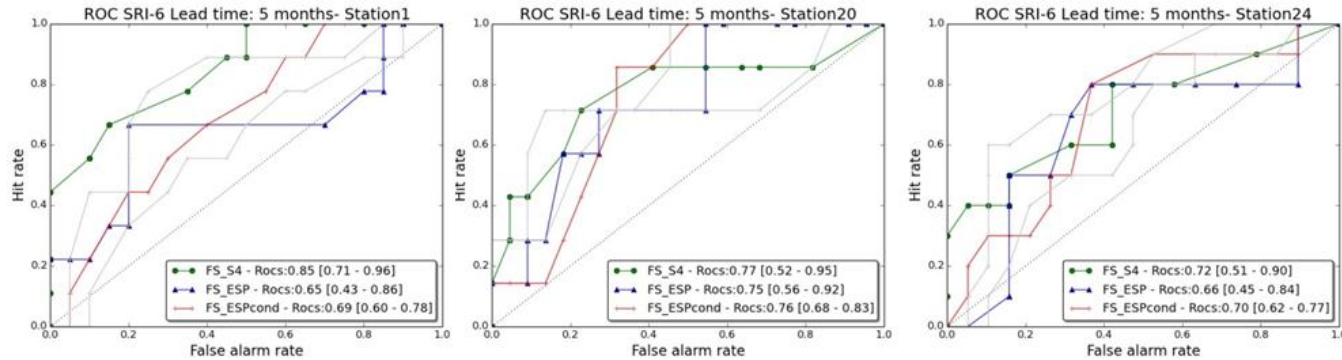
- ROC → *Ability of the forecast to discriminate between events and non-events*
- BSS → *Relative skill of the probabilistic forecast over that of climatology*
- Rank histogram → *How well does the ensemble spread of the forecast represent the true variability (uncertainty) of the observations*





# SKILL ASSESSMENT: *ROC DIAGRAMS*

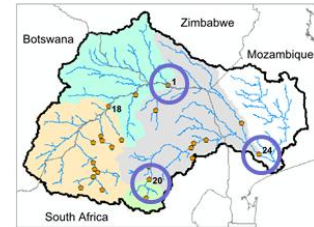
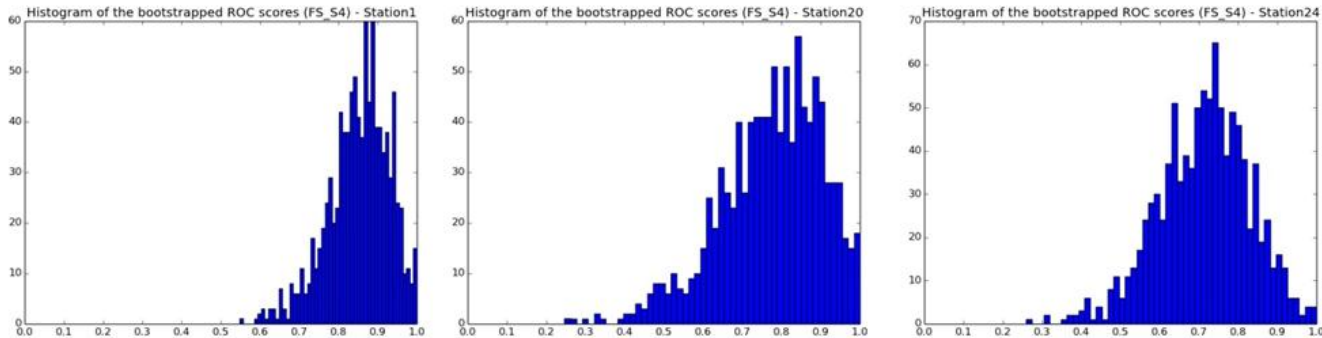
## SRI6 ≤ -0.5 : Skill in predicting moderate drought at 5 months lead time



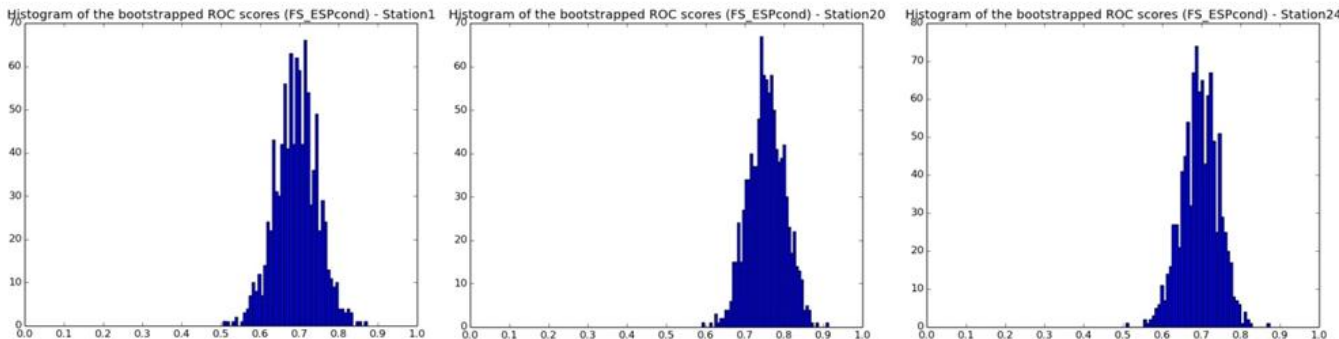
ROC Score:  
area under the  
curve.

1 : Perfect  
< 0.5 : No skill

FS\_S4



FS\_ESPcond



0

1

0

1

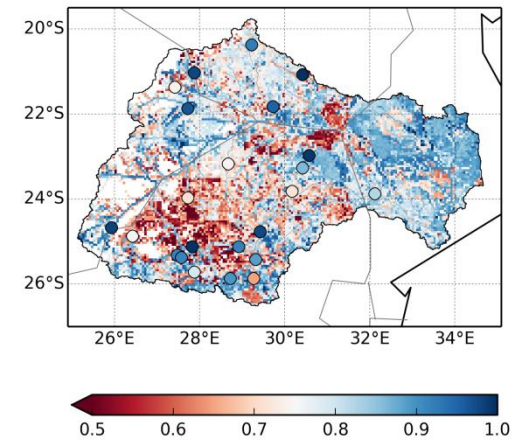
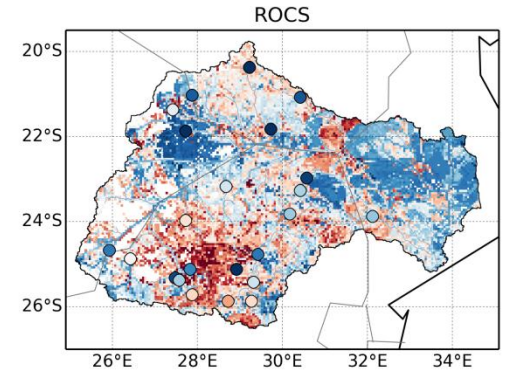
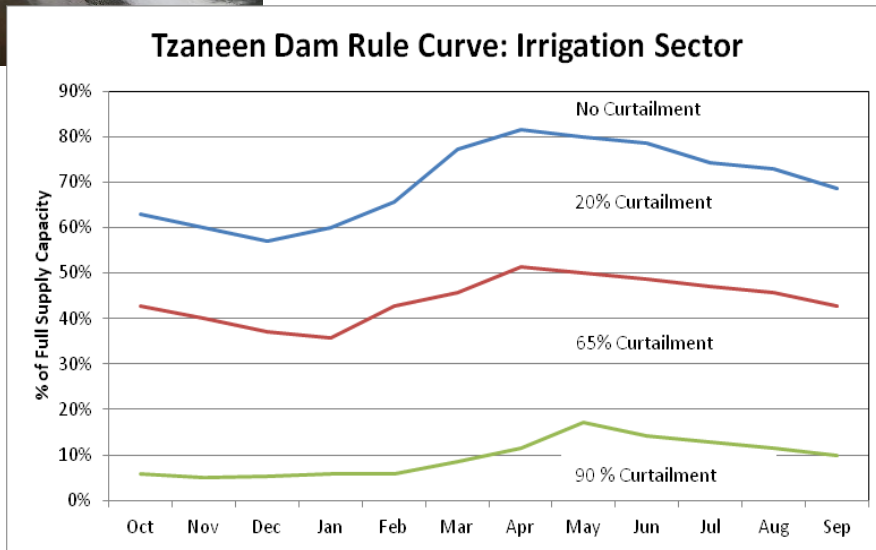
0

1

# ROCS SOIL MOISTURE & WATER LEVEL IN RESERVOIRS



**Tzaneen Dam**  
 Curtailments (hedging) to irrigation & water supply if reservoir levels lower than normal



**ROCS for: Water Level (WL) < 50th percentile (upper plot), and WL < 37.5th percentile (lower plot) for the FS\_S4 forecasts**



P. Trambauer, M. Werner, H.C. Winsemius, S. Maskey, E. Dutra, S. Uhlenbrook (2014). Hydrological drought forecasting and skill assessment for the Limpopo river basin, Southern Africa. *Hydrol. Earth Syst. Sci. Discuss.*, 11, 9961-10000

- Does **seasonal forecasting** gain importance in the **future** due to **climatic change**?
  - Do **critical weather conditions** (that may benefit from forecasting) **occur more frequently**?
  - Can these then be **forecast with skill**?
- **Critical conditions for subsistence farming**
  - Rainfed agriculture (Maize):

**Dry Spells**
  - Dairy farming (cows):

**Extreme Heat Index**
  - Concentrate on forecasts for **DJF** wet season



Source: <http://www.unesco-ihe.org/Project-Activities/Project-Portfolio/Small-holder-System-Innovations-in-Integrated-Watershed-Management>

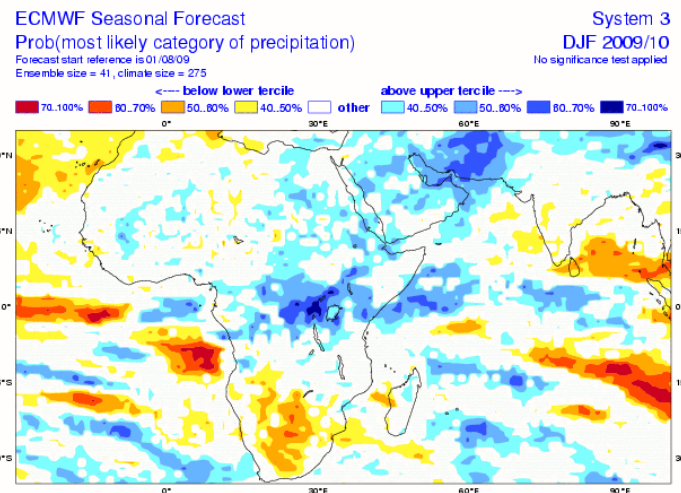
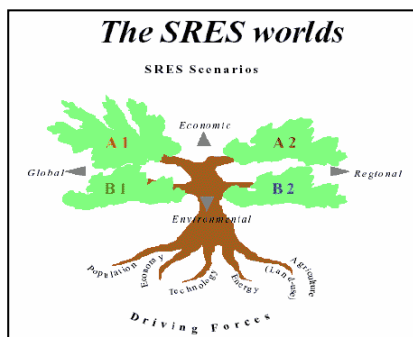
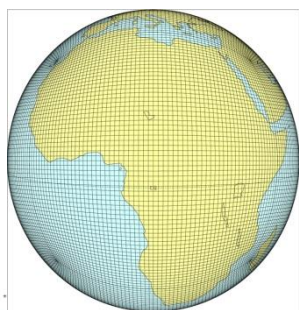


## Possible evolution of the climate

- Multiple **climate models**
- Conditioned on **A2 emission scenario**
- Downscaled using Regional climate model over Southern Africa (CCAM)

## 7-month ahead **probabilistic seasonal forecast** – updated monthly

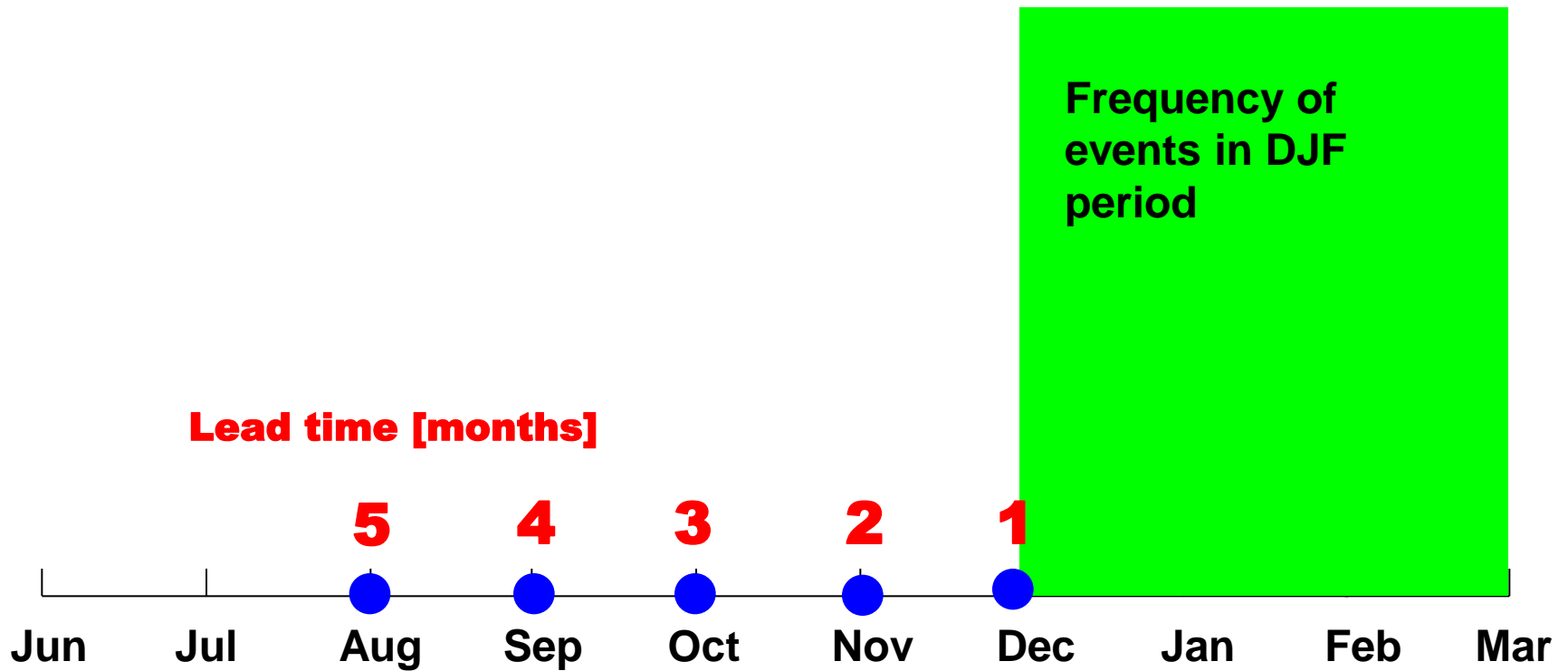
- 15 ensemble members
- 0.5 degrees scale
- Climatology: ERA-Interim (1978 – 2014)



Forecast issue date: 15/08/2009

# FORECASTING SKILL FOR DJF SEASON

science



# FREQUENCY OF EVENTS IN DJF SEASON

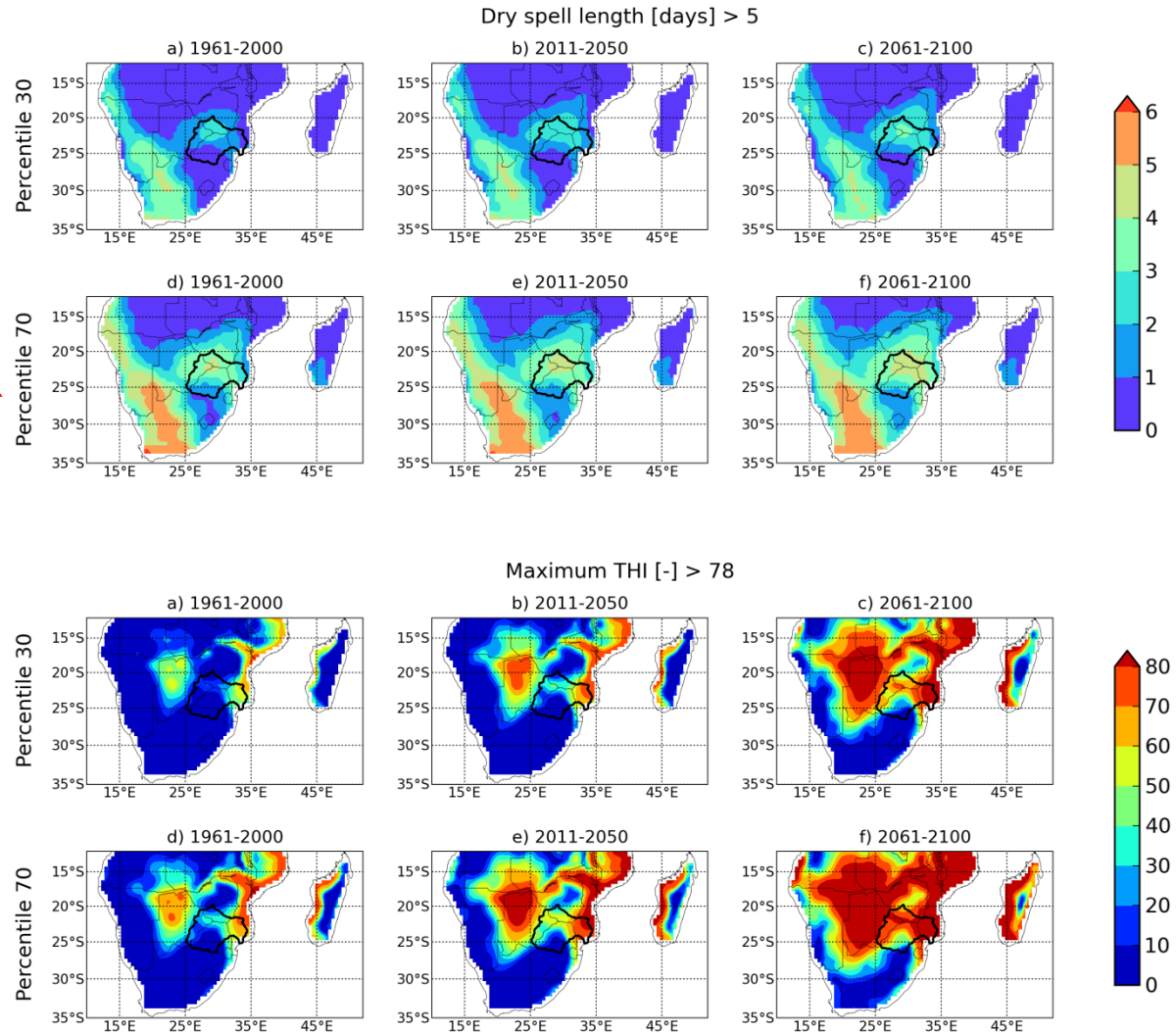


Expected number of **dry spells longer than 5 days**

Probability of non-exceedance



Expected number of **days with Temperature Heat Index > 78**

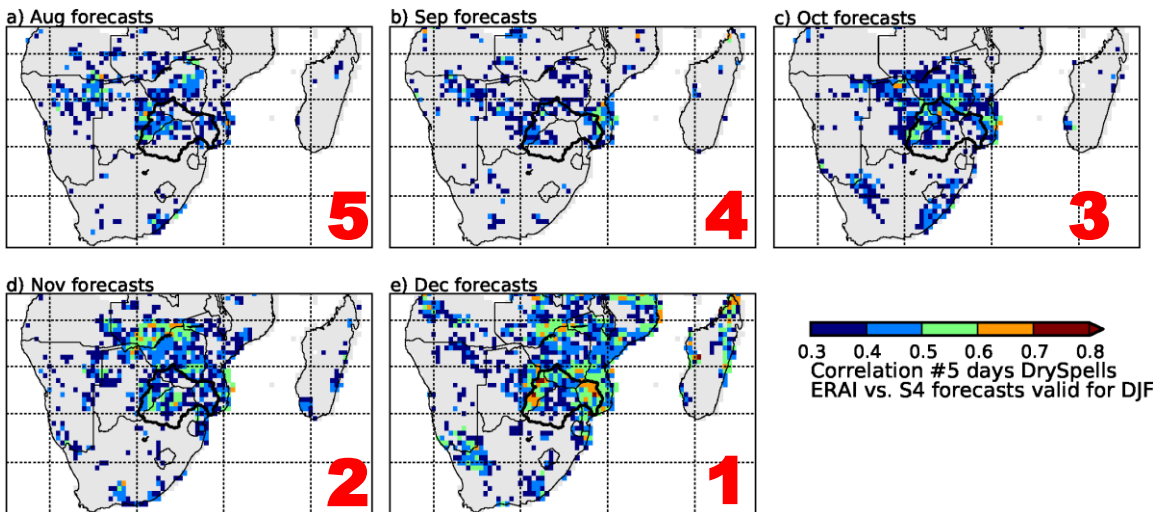


Changing climate

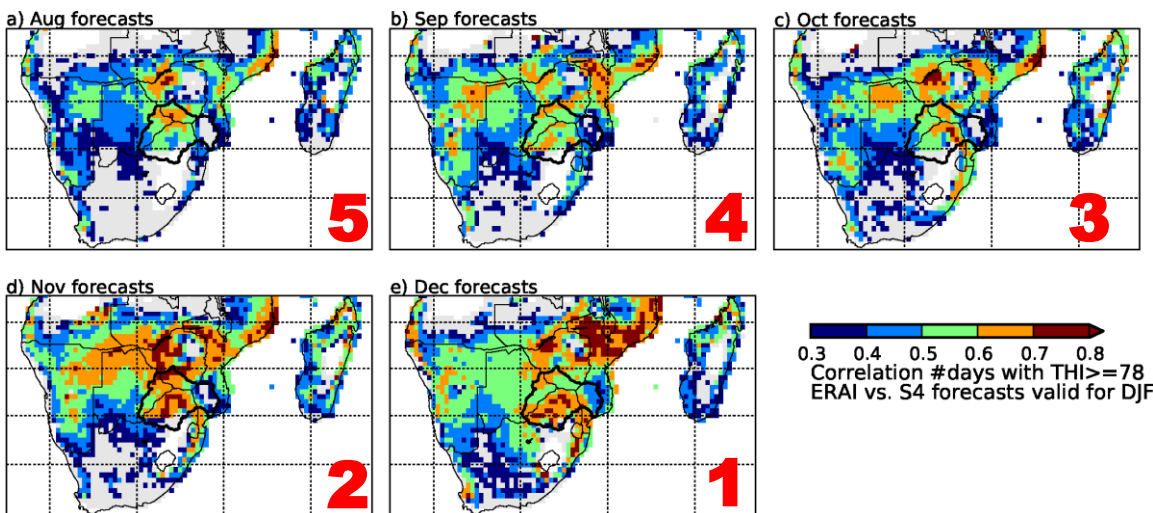
# HOW WELL CAN WE FORECAST EVENTS?



Skill of forecasts of **dry spells longer than 5 days**

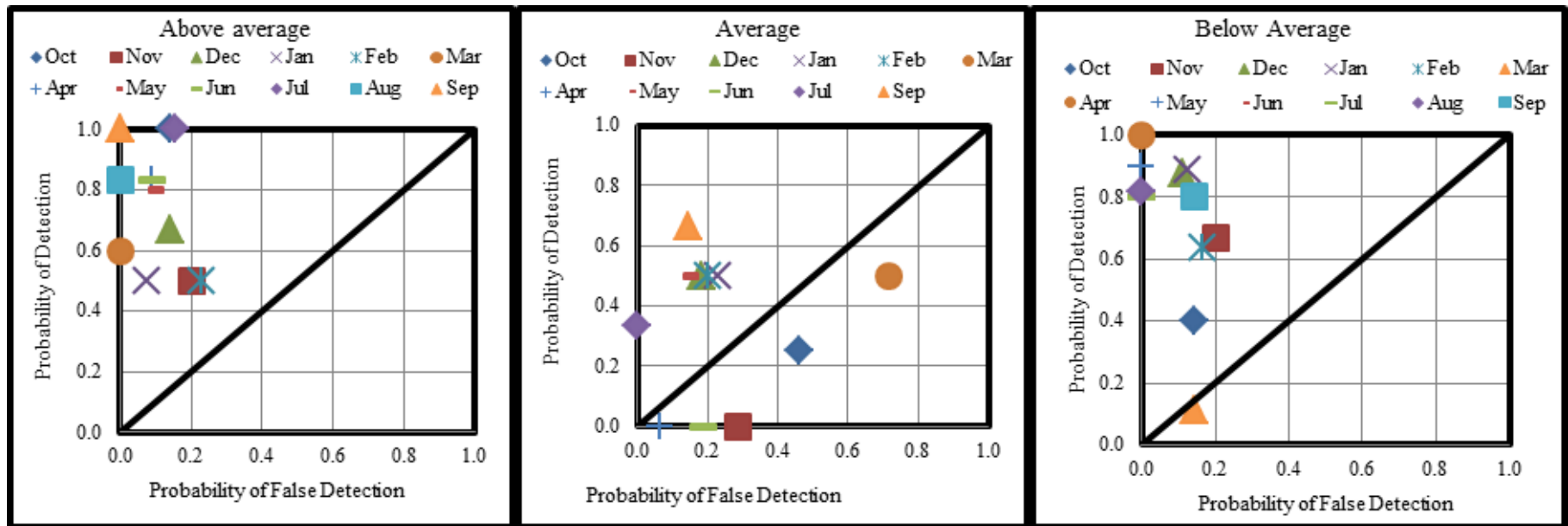


Skill of forecasting **days with Temperature Heat Index > 78**



Skill reduces with lead time [months]

# STREAMFLOW FORECASTING IN THE INCOMATI BASIN (ONE BASIN SOUTH OF THE LIMPOPO) USING STOCHASTIC FORECASTS



**The ROC curve of streamflow forecast by seasonal SST, ENSO, rainfall and flow at Dolton**



Sunday RKM. Masih I. Werner M. van der Zaag P. Streamflow forecasting for operational water management in the Incomati River Basin, Southern Africa. Physics and Chemistry of the Earth, Parts A/B/C. Vol. 72-75: 1-12.

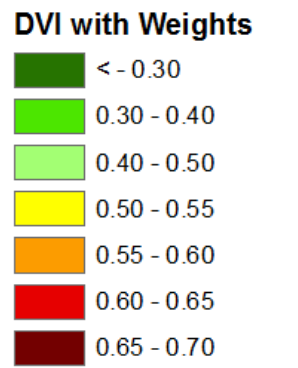


# Social Performance of (drought) warnings

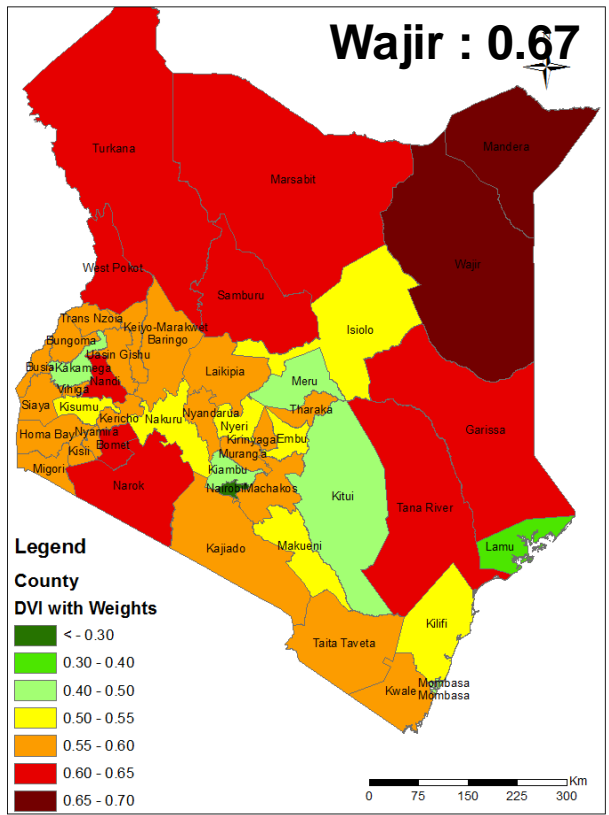


Cumiskey L. Werner M. Meijer K. Fakhruddin SHM. Hassan A. 2015. Improving the social performance of flash flood early warnings using mobile services. International Journal of Disaster Resilience in the Built Environment. 6: 57-72.

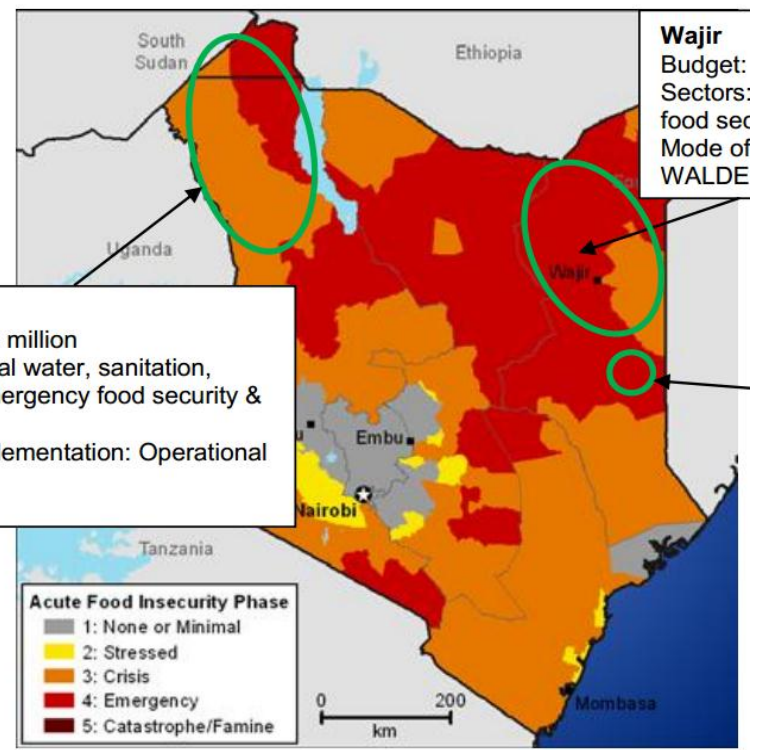
## INDEX



**Nairobi :  
0.27**



**Country Average: 0.56**



Source: Fewsnets September 2011

**Drought 2010 - 2011  
4,3M people affected in Kenya**



Naumann G., Barbosa, P., Garrote, L., Iglesias, A., Vogt, J. 2014. Exploring drought vulnerability in Africa: an indicator based analysis to be used in early warning systems. Hydrol. Earth Syst. Sc. 18(5): 1591-1604

# CONCLUSIONS

- There is skill in seasonal forecasting in Southern Africa with lead times of up to some 5 months, though that depends on the variable being forecasted.
- Forecasts should focus on variables that relate to decisions users make (e.g. farmers, irrigators, reservoir operators).
- Communicating warnings, and responses to cope with droughts needs to be developed to achieve the desired social performance

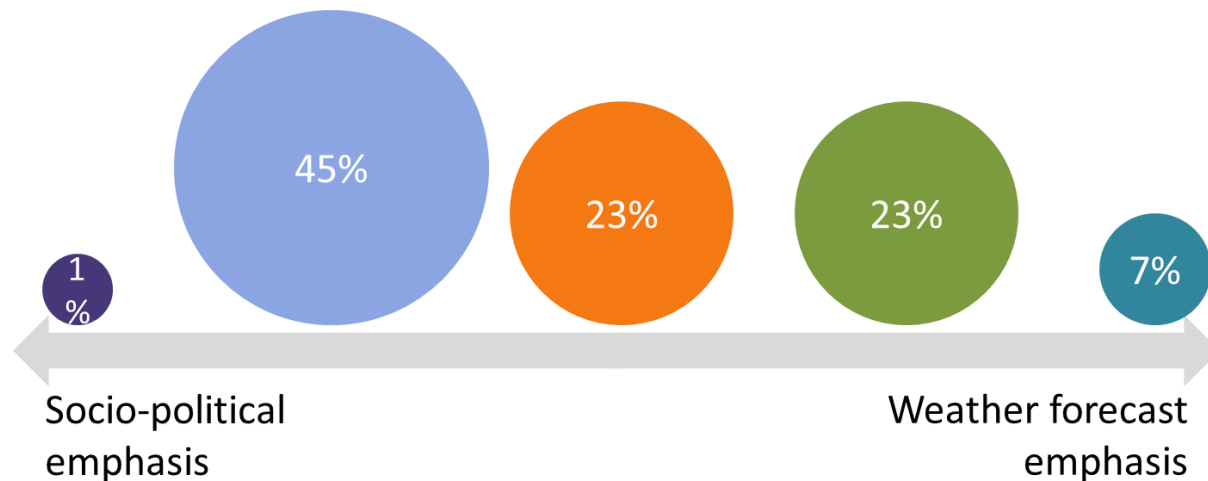
What is the science available?

What are the societal capacities?

How can science be translated into policy?

How can society benefit from the forecast?

**Four main challenges remain!**



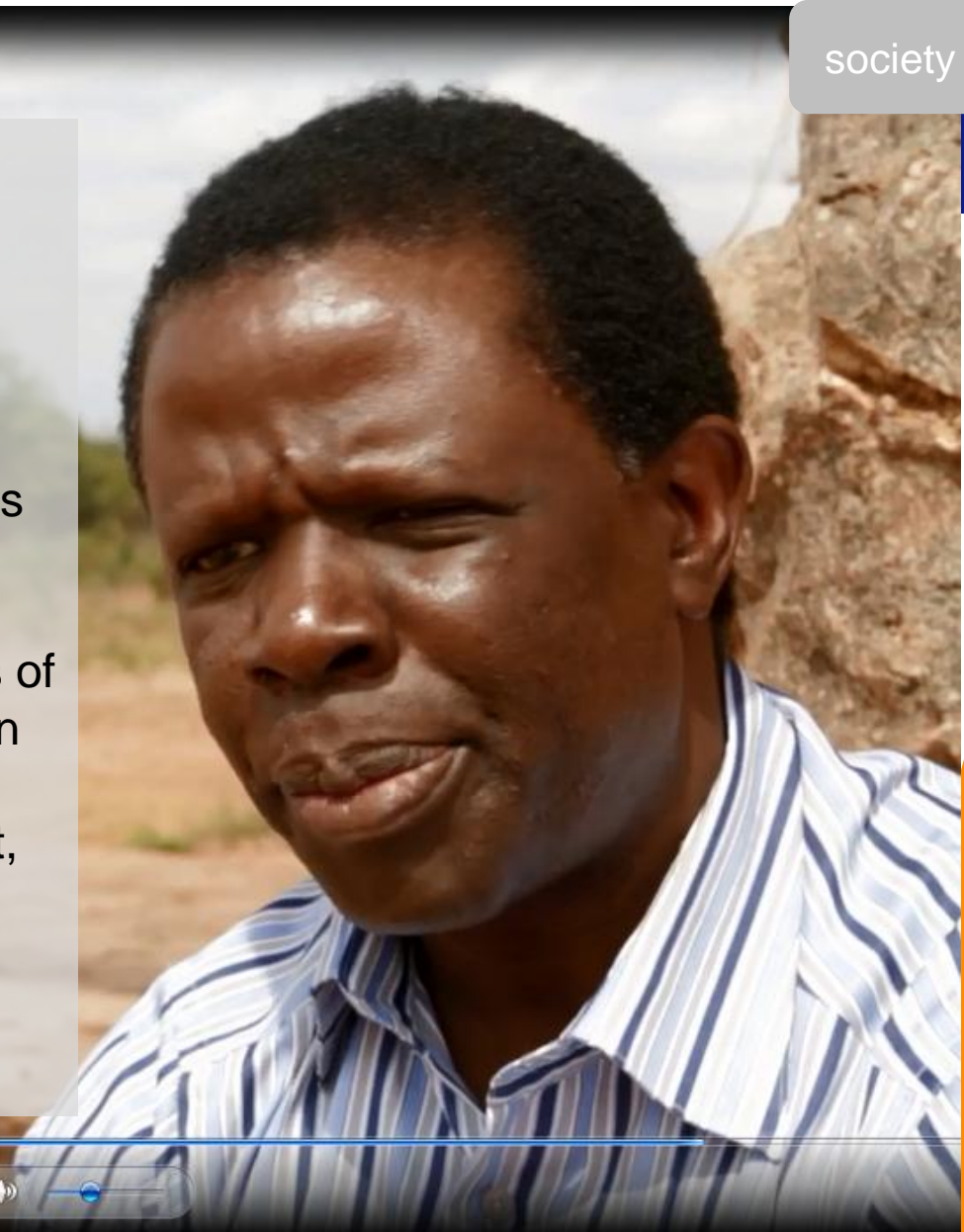
Experts from agencies & institutions across Africa interviewed on critical issues that need to be addressed in drought forecasting & warning (40 people, 18 countries)

“The **challenges** that are ahead for drought forecasting and monitoring are basically data, **we don't have enough data...**

The **methods** for forecasting drought have **not** been properly done, so there is also a challenge there...

And lastly the **socio-economic** aspects of droughts; we have **poverty** issues within the African **communities**, that would really interfere with **coping** with drought, **whether we forecast it or not**”

Gilbert Ouma, 2013  
ICPAC & University of Nairobi



14:54



<http://africanclimate.net/en/water-africa-changing-climate>