The NMME and Southern Africa's Seasonal Forecasts

Willem A. Landman[1] and Christien Engelbrecht[2]

[1]University of Pretoria and the [2]South African Weather Service

Willem.Landman@up.ac.za

UNIVERSITEIT VAN PRETORIA UNIVERSITY OF PRETORIA YUNIBESITHI YA PRETORIA

South African Weather Service

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Introduction

Two of the main centers in South Africa that produce seasonal forecasts for the region are the South African Weather Service (SAWS) and the University of Pretoria (UP). SAWS runs their own fully coupled ocean-atmosphere model and the seasonal forecasts produced by their model are combined with forecasts from NMME models to produce 3-month multi-model seasonal forecasts for South Africa. At UP, NMME models are used for rainfall and maximum temperature forecasts for SADC, and tailored forecasts for malaria occurrence over the Limpopo Province of South Africa, inflow forecasts into Lake Kariba, dry-land crop yield forecasts for selected farms in South Africa, and rainfall forecasts for farms in South Africa and Namibia based on their own archived rainfall data.

Rainfall Predictability Research

Predictability research on southern African seasonal rainfall variability is mostly focussed on the austral summer rainfall regions. The GFDL-CM2p5-FLORB01 (referred to here as "GFDL") was recently used to demonstrate that there also exits seasonal rainfall predictability over the austral winter rainfall region of the Southwestern Cape (Figure 1; **Archer, E., Landman W.A., Malherbe, J., Tadross, M. and Pretorius, S. (2019). South Africa's winter rainfall region drought: a region in transition? Climate Risk Management. Volume 25, 2019, 100188. doi: 10.1016/j.crm.2019.100188**).

Southern Africa's rainfall predictability was compared with the predictability of regions globally which are also affected by ENSO. The work showed that southern Africa's summer predictability ranks in more or less the bottom third of the regions considered (Figure 2; **Landman, W.A., Barnston, A.G., Vogel, C. and Savy, J. (2019). Use of ENSO-related seasonal precipitation predictability in developing regions for potential societal benefit. International Journal of Climatology, 39, 5327–5337. doi: 10.1002/JOC.6157**).

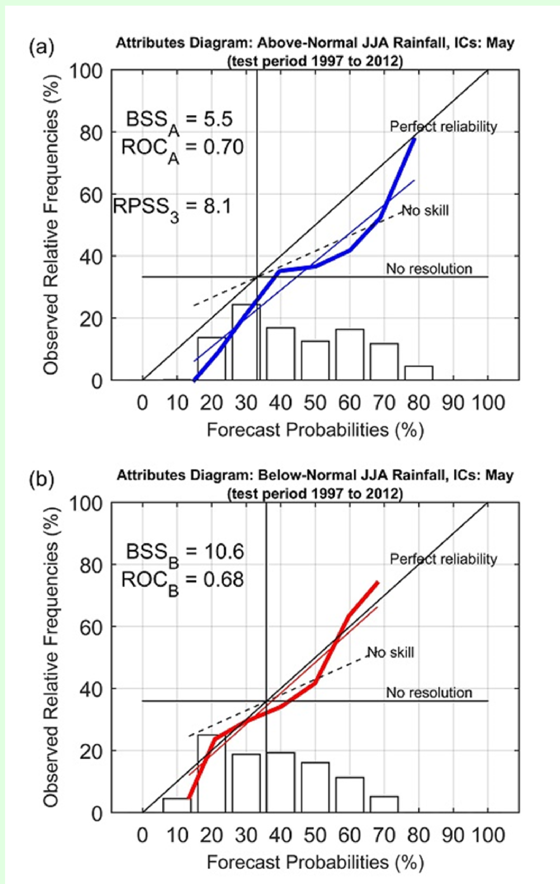


Figure 1: Reliability diagram and associated frequency histogram for above-normal (a) and below-normal (b) JJA rainfall totals over the Southwestern Cape. The Brier skill score (BSS) and relative operating characteristic (ROC) score for two categories are presented, as well as the ranked probability skill score (RPSS) over the three categories.

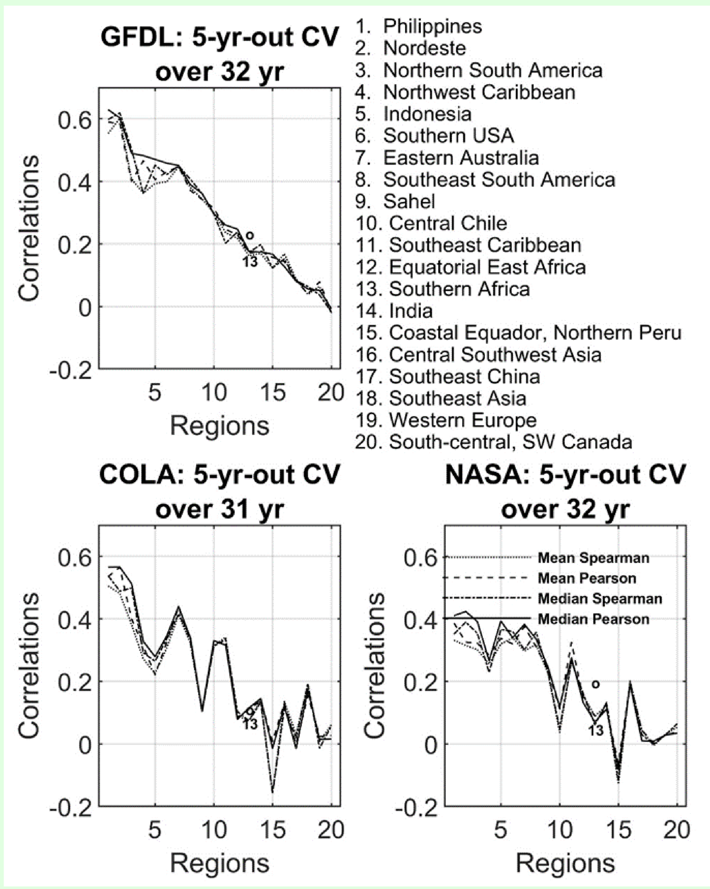


Figure 2: Median and mean correlations (Pearson and Spearman) for each of the 20 regions and for three NMME models. Southern Africa's results are marked with "13" and for the Limpopo River catchment area values (median Pearson) an "o" is used. The list shows the 20 regions ranked in terms of highest to lowest median Pearson values according to the GFDL model.

SST Predictions and Operations

UP makes use of NMME forecasts (GFDL) and a statistical SST model that uses antecedent SST fields as predictor in a CCA model. Probabilistic (Figure 3) and deterministic forecasts (Figure 4) from the NMME and statistical models are constructed with the use of the Climate Predictability Tool (CPT) and then averaged. Niño3.4 forecasts are subsequently included in the IRI/CPC forecast plume, and predicted global SST anomalies are provided to the Council for Scientific and Industrial Research (CSIR) in South Africa to serve as boundary forcing for their AGCM.

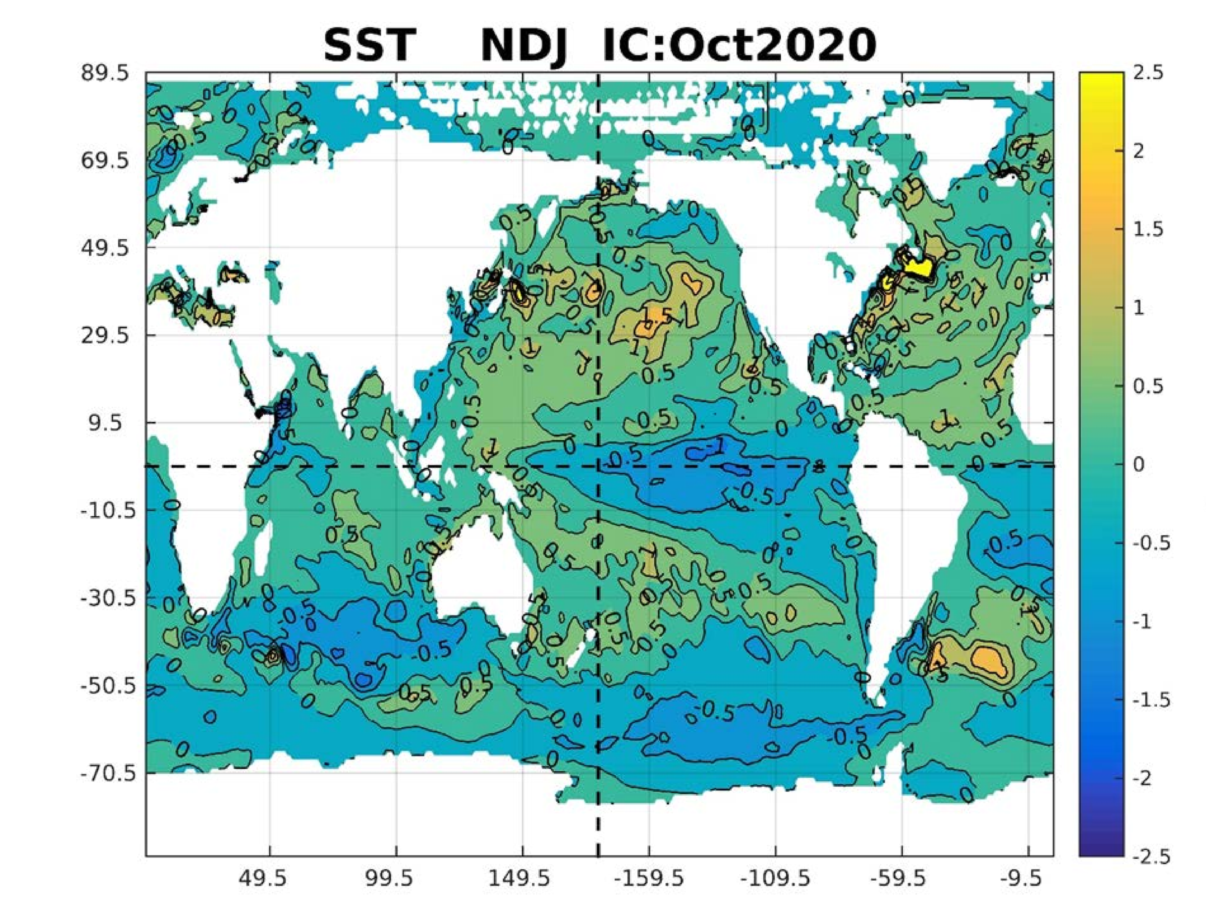


Figure 3: SST anomaly forecast for Nov-Dec-Jan 2020/21, produced in October 2020.

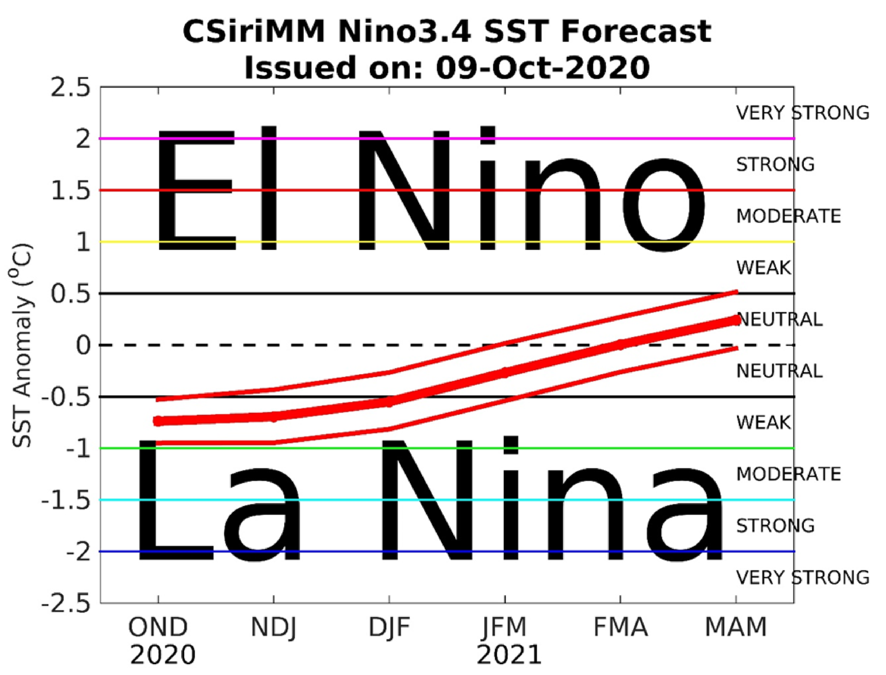


Figure 4: Niño3.4 SST forecasts produced in October 2020.

Operational Forecasts for Southern Africa

Rainfall and Maximum Temperature

GFDL forecasts are improved by correcting the mean and variance biases using the CPT. Forests are probabilistic and made for three categories with the outer two categories, respectively, defined by the 25th and 75th percentile values of the climatological record. Along with the forecasts, skill maps representing ROC scores are presented. Forecasts are produced for a 6 month period represented as 3-month run-on seasons.

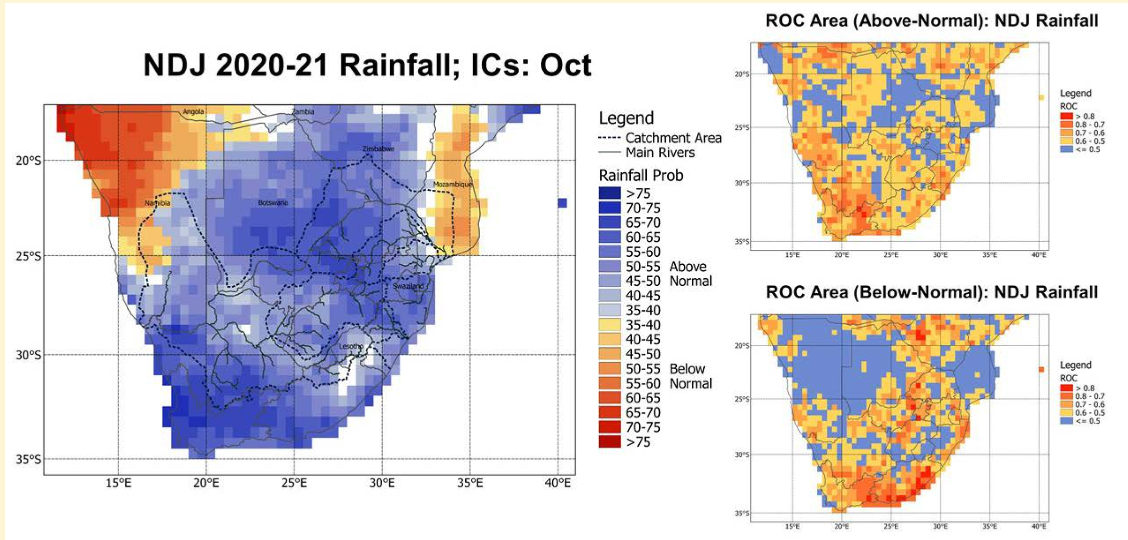


Figure 5: Nov-Dec-Jan 2020/21 probabilistic rainfall forecasts and associated skill (ROC) maps. GFDL forecast initialized in October 2020.

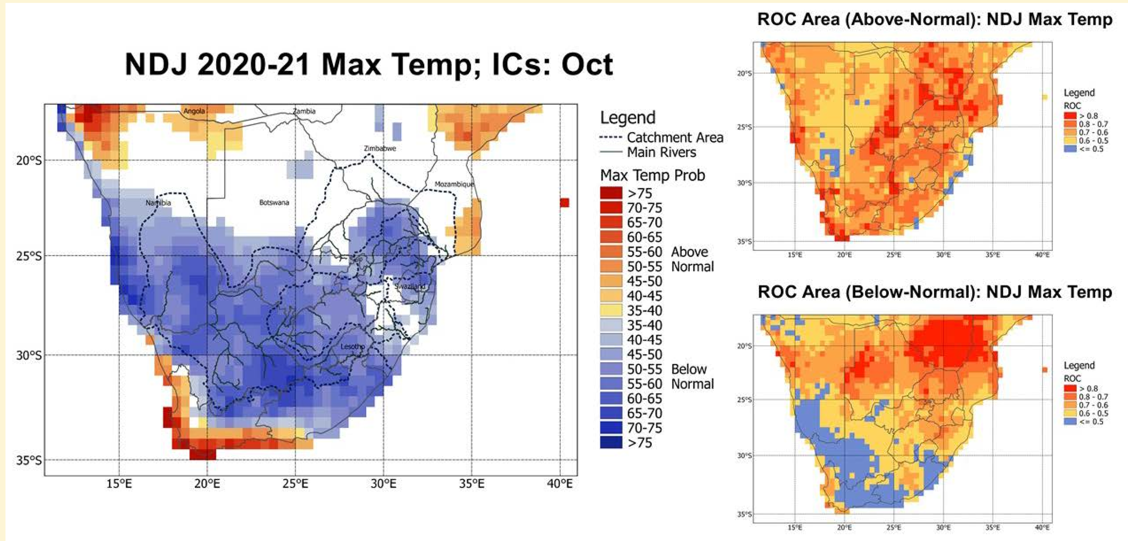


Figure 6: Nov-Dec-Jan 2020/21 probabilistic maximum temperature forecasts and associated skill (ROC) maps. GFDL forecast initialized in October 2020.

Tailored Forecasts

Seasonal Malaria in Limpopo Province

The GFDL model was used to test the predictability of the incidence of seasonal malaria in the Limpopo province of South Africa (Figures 7 & 8; **Landman, W.A., Sweijd, N., Masedi, N. Minakawa, N. (2020). The development and prudent application of climate-based forecasts of seasonal malaria in the Limpopo province in South Africa. Environmental Development, 35, 100522, doi: 10.1016/j.envdev.2020.100522**) as well as for operational malaria forecasting (Figure 9).

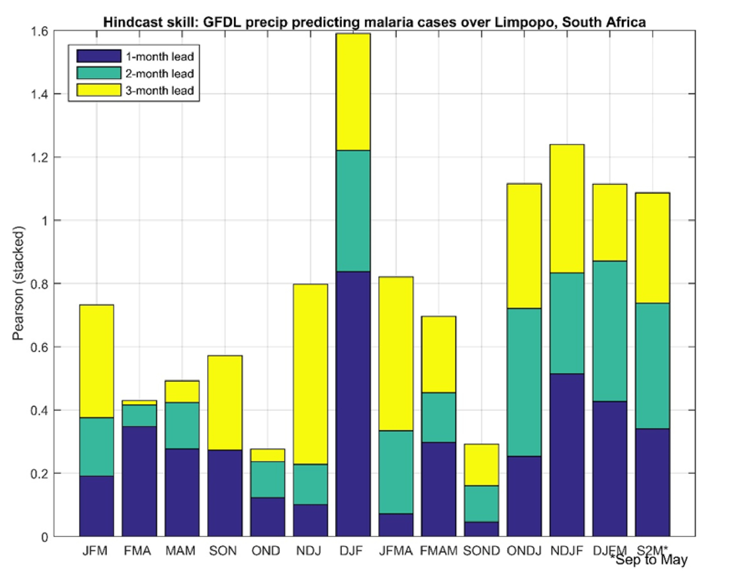


Figure 7: Correlations between cross-validated hindcasts and observed malaria incidence for the seasons indicated. Forecast lead-times up to three months are presented.

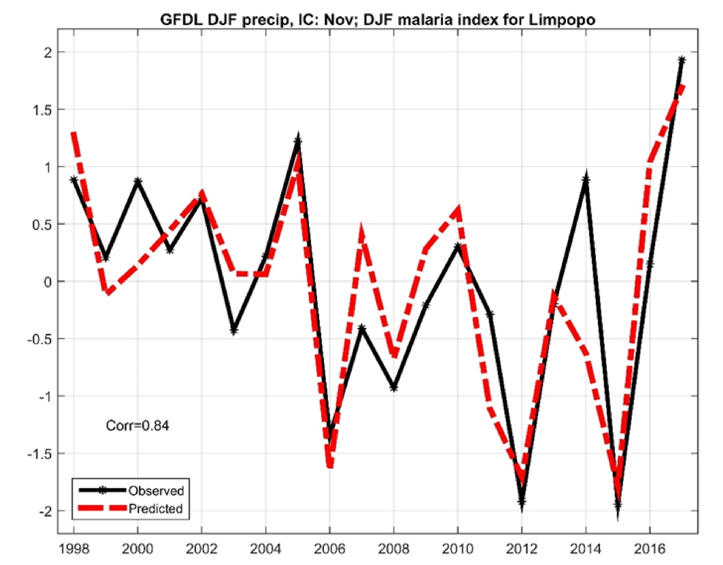


Figure 8: Cross-validated malaria incidence hindcasts (1-month lead) for the Dec-Jan-Feb seasons using GFDL-based rainfall data as predictor. Time series have been normalized.

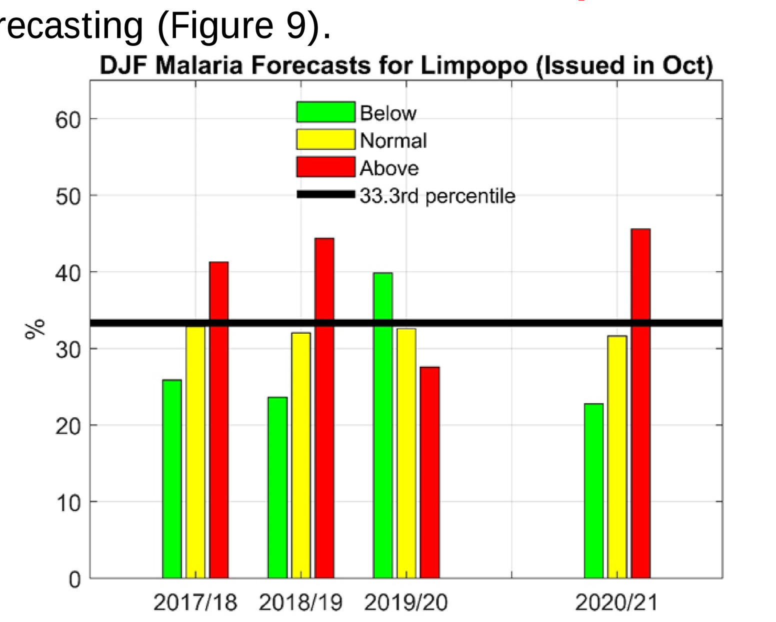


Figure 9: Retro-active forecasts for the three most recent seasons and for the coming season. GFDL rainfall fields are the predictors in a statistical model.

Inflow Forecasts for Lake Kariba

The GFDL model output is used to continue with work on inflow predictability of a few years ago (**Muchuru, S., Landman, W.A. and DeWitt, D. (2016). Prediction of inflows into Lake Kariba using a combination of physical and empirical models. International Journal of Climatology, 36, 2570–2581, doi: 10.1002/joc.4513**).

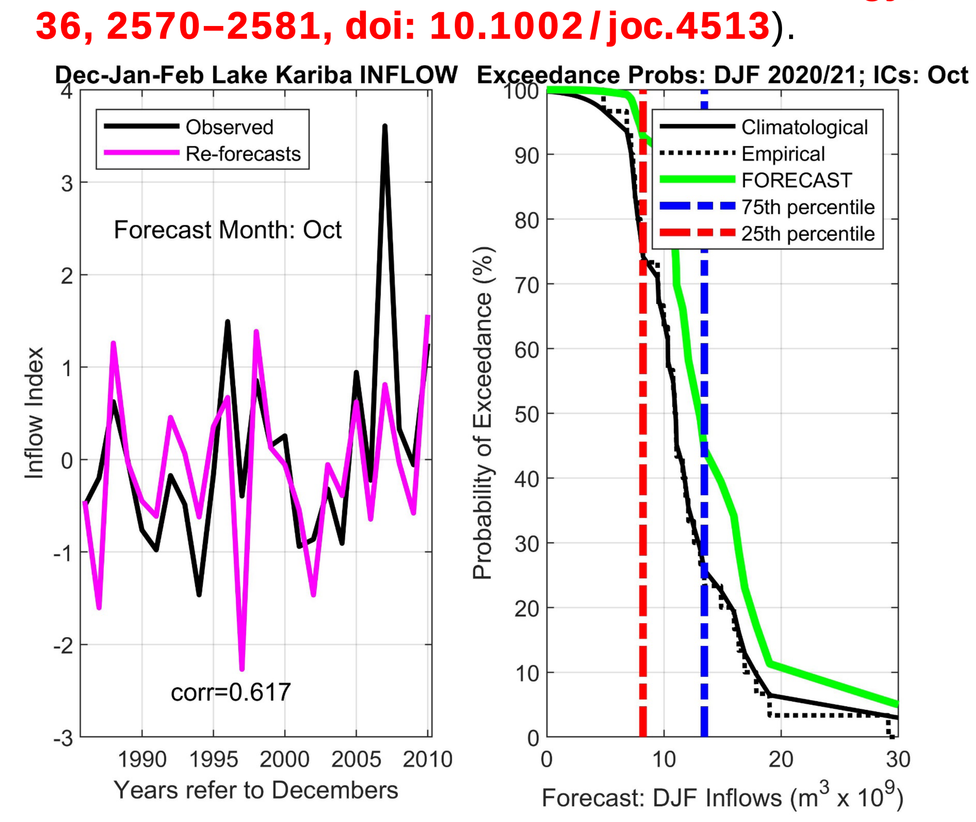
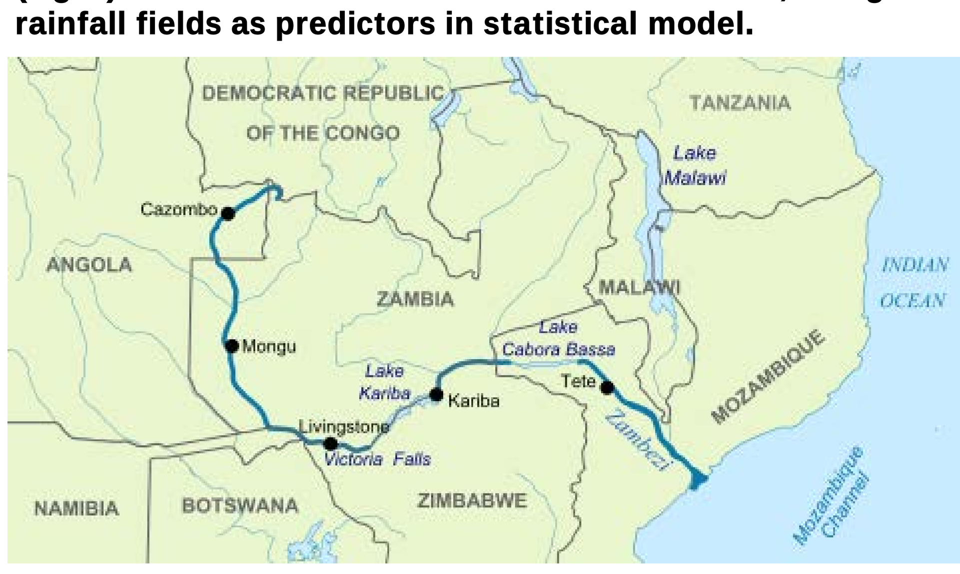


Figure 10: Cross-validated (left) and real-time forecasts (right) for Dec-Jan-Feb inflows into Lake Kariba, using GFDL rainfall fields as predictors in statistical model.



End-of-season Crop Yield Forecasts for a Farm

Crop yield data provided by the farmer are used as the predictand in a statistical model that uses GFDL rainfall fields as predictor.

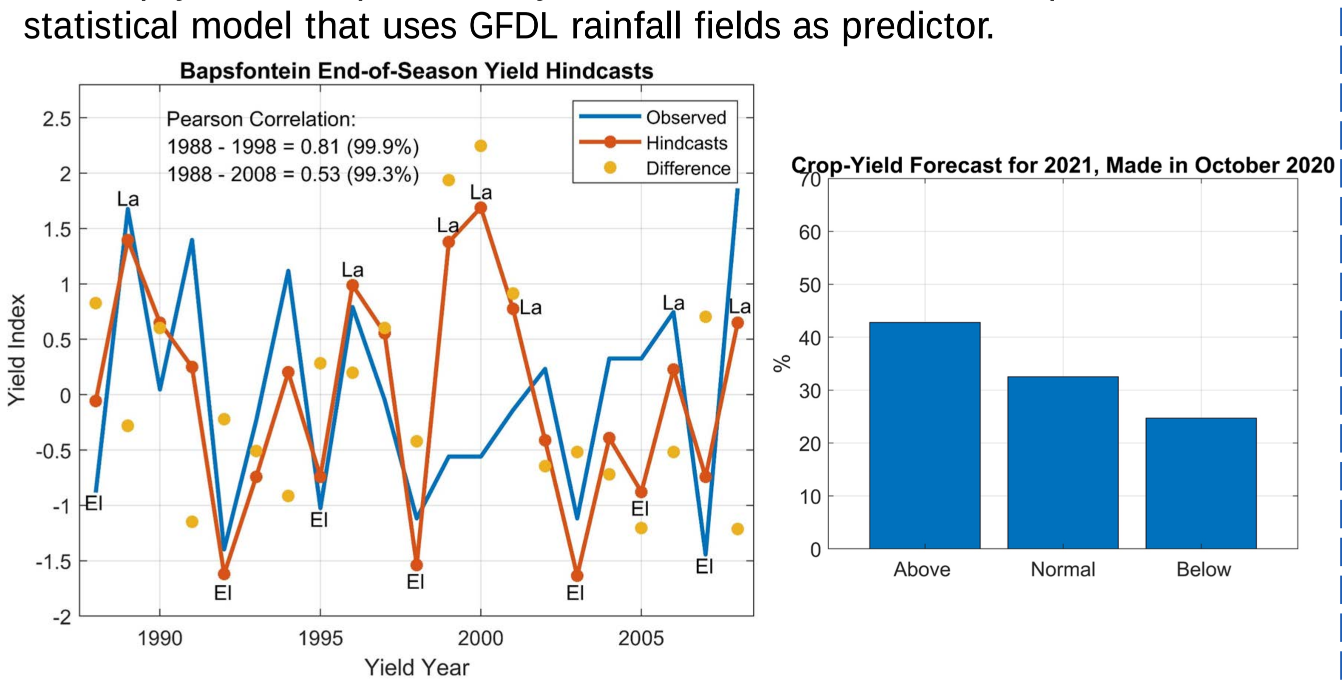


Figure 11: Cross-validated (left) and real-time forecast (right) for end-of-season crop yields at a farm in South Africa.

Rainfall Forecasts for Farmers

A number of farmers have made the rainfall records of their farms available. GFDL rainfall fields are used in a statistical model to predict seasonal rainfall at the farm based on the farmer's own data (**Landman, W.A., Archer, E.R.M and Tadross, M.A (2020). Citizen science for the prediction of climate extremes in South Africa and Namibia. Frontiers in Climate, 2:5, doi: 10.3389/fclim.2020.00005**). Figure 12 is for the case of a farm in northern Namibia and for a farm in central South Africa.

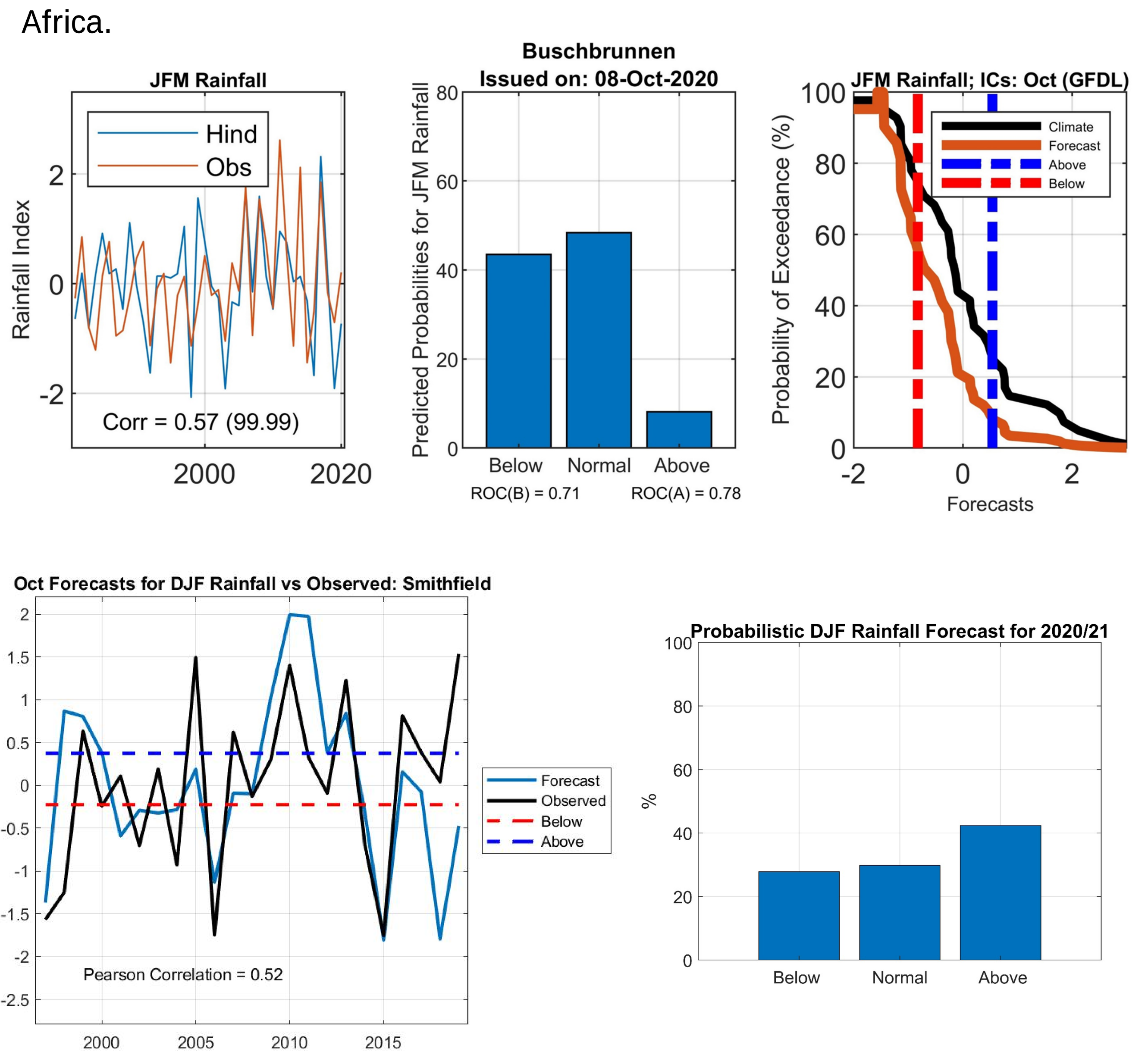


Figure 12: Cross-validated (left) and real-time forecasts (middle and right) for farms near Grootfontein, Namibia (top) and in central South Africa.