The development and prudent application of climate-based forecasts of seasonal malaria in the Limpopo province in South Africa

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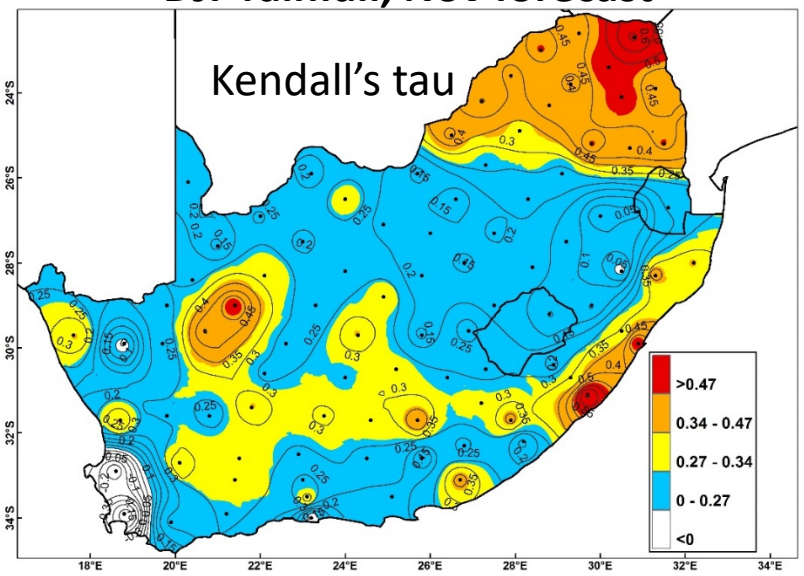
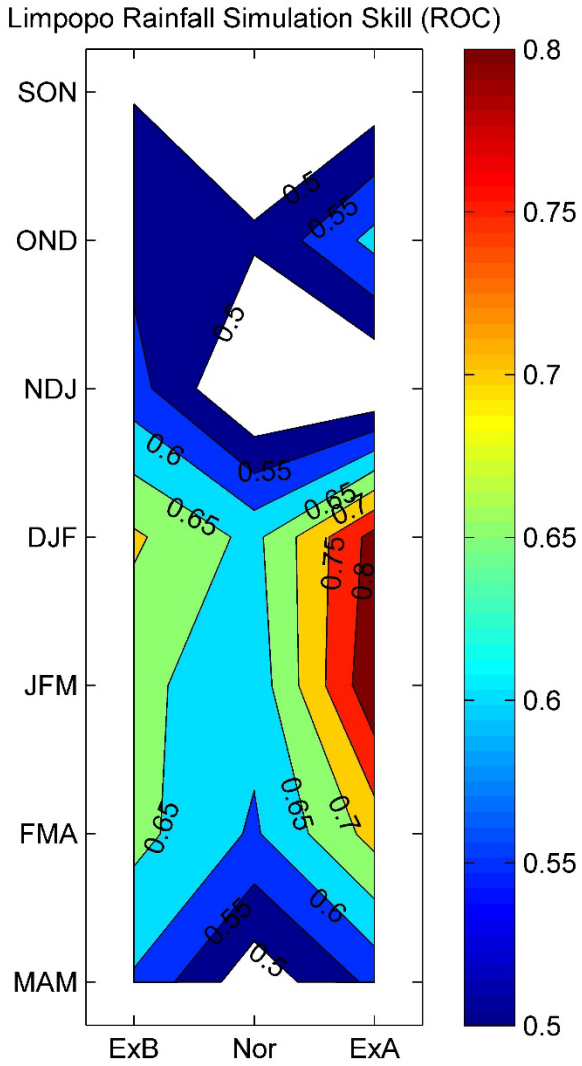
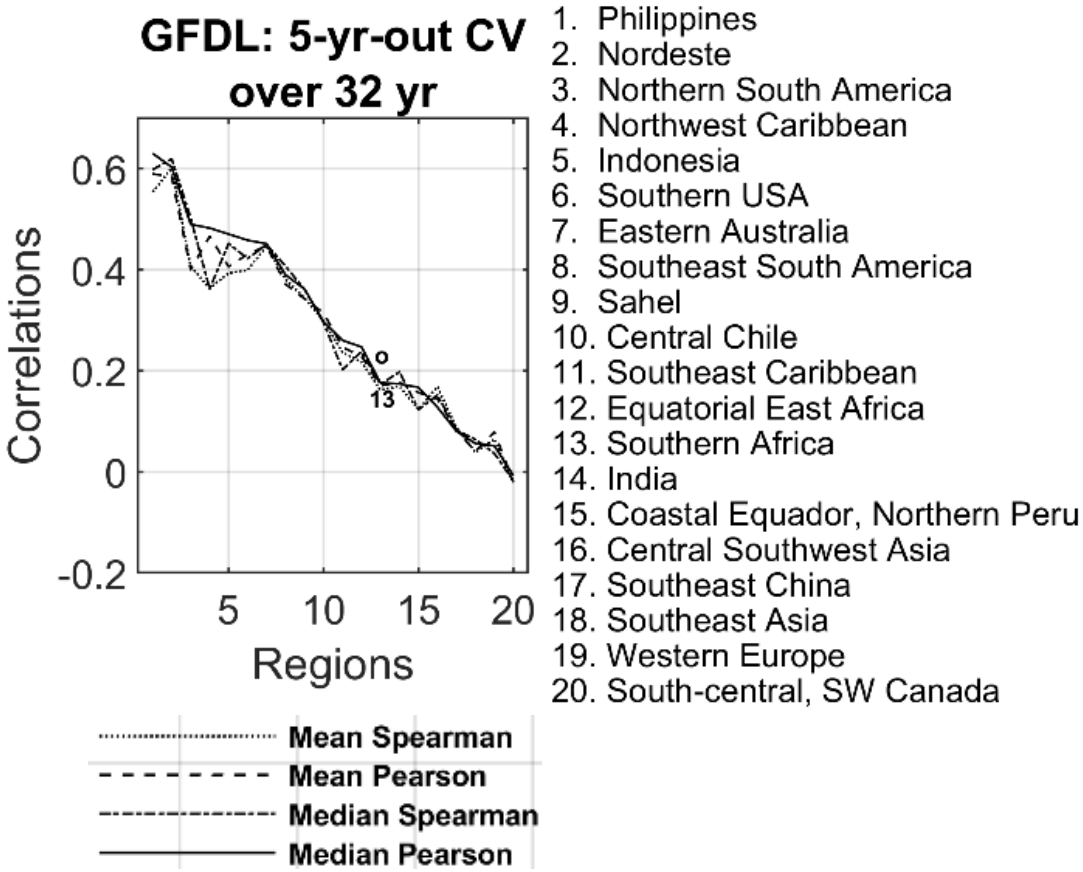
South African Society for Atmospheric Sciences 2020 Online Seminar, 20 November

DJF rainfall, Nov forecast

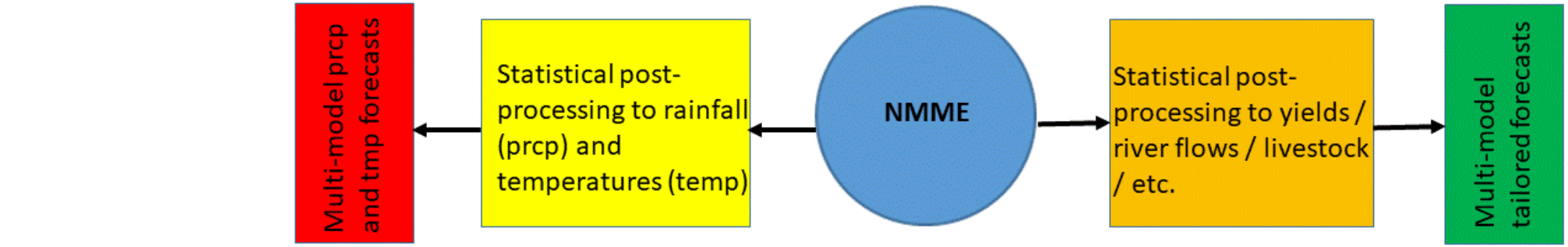


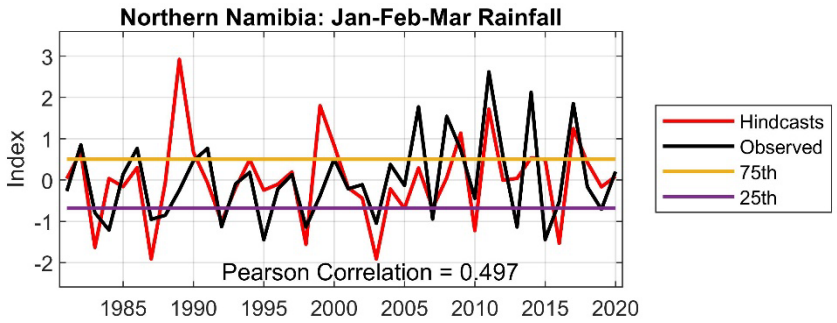


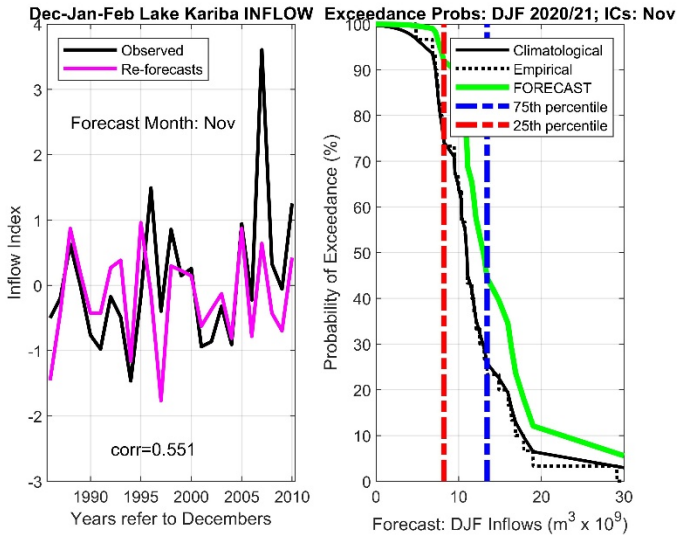


Limpopo seasonal rainfall predictable

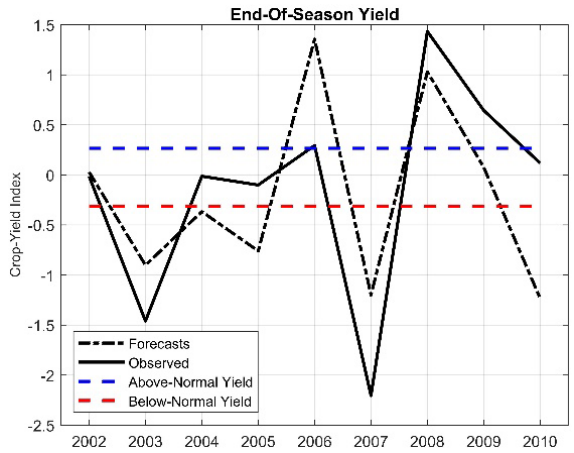
Skill for southern Africa modest, Limpopo skill elevated

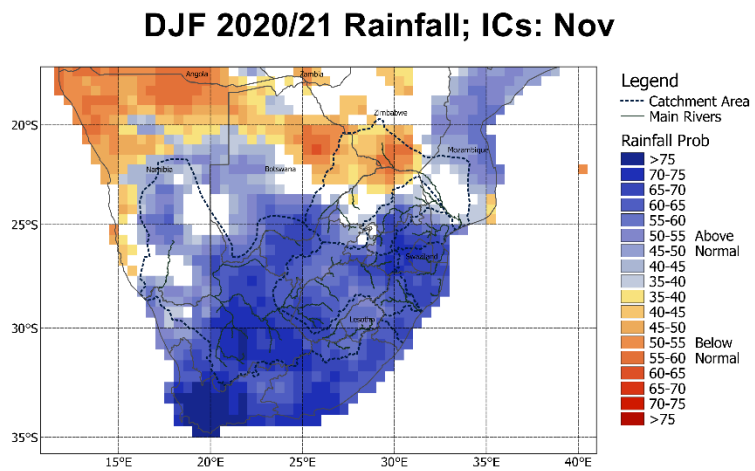

Multi-model prcp and tmp forecasts
Statistical post-processing to rainfall (prcp) and temperatures (temp)
NMME
Statistical post-processing to yields / river flows / livestock / etc.
Multi-model tailored forecasts

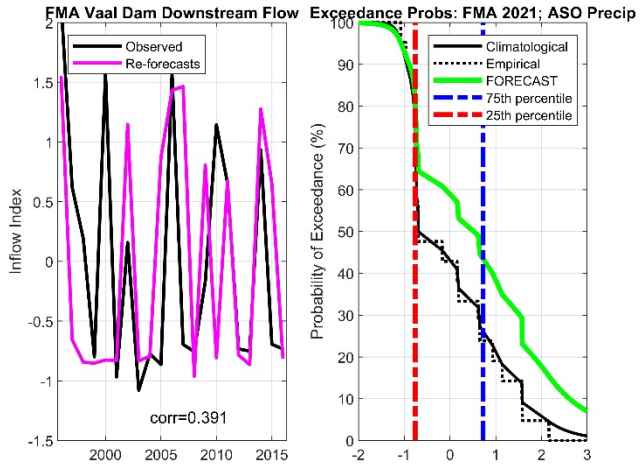

Northern Namibia: Jan-Feb-Mar Rainfall
Index
Pearson Correlation = 0.497
Hindcasts
Observed
75th
25th


Dec-Jan-Feb Lake Kariba INFLOW
Observed
Re-forecasts
Forecast Month: Nov
Inflow Index
corr=0.551
Years refer to Decembers

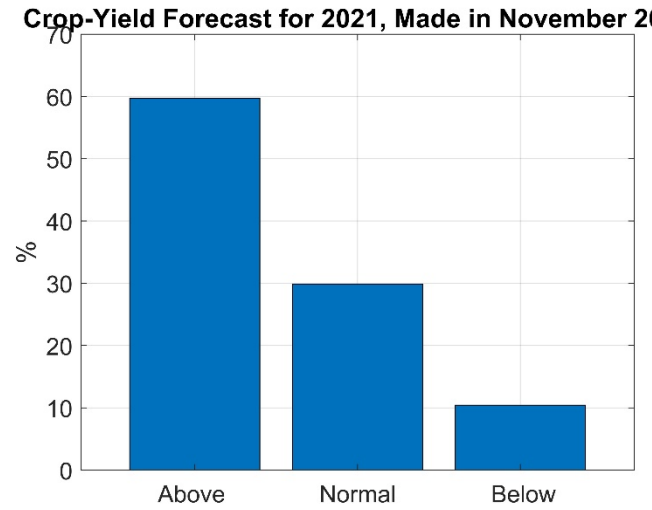
Exceedance Probs: DJF 2020/21; ICs: Nov
Climatological
Empirical
FORECAST
75th percentile
25th percentile
Probability of Exceedance (%)
Forecast: DJF Inflows (m3 x 10^9)

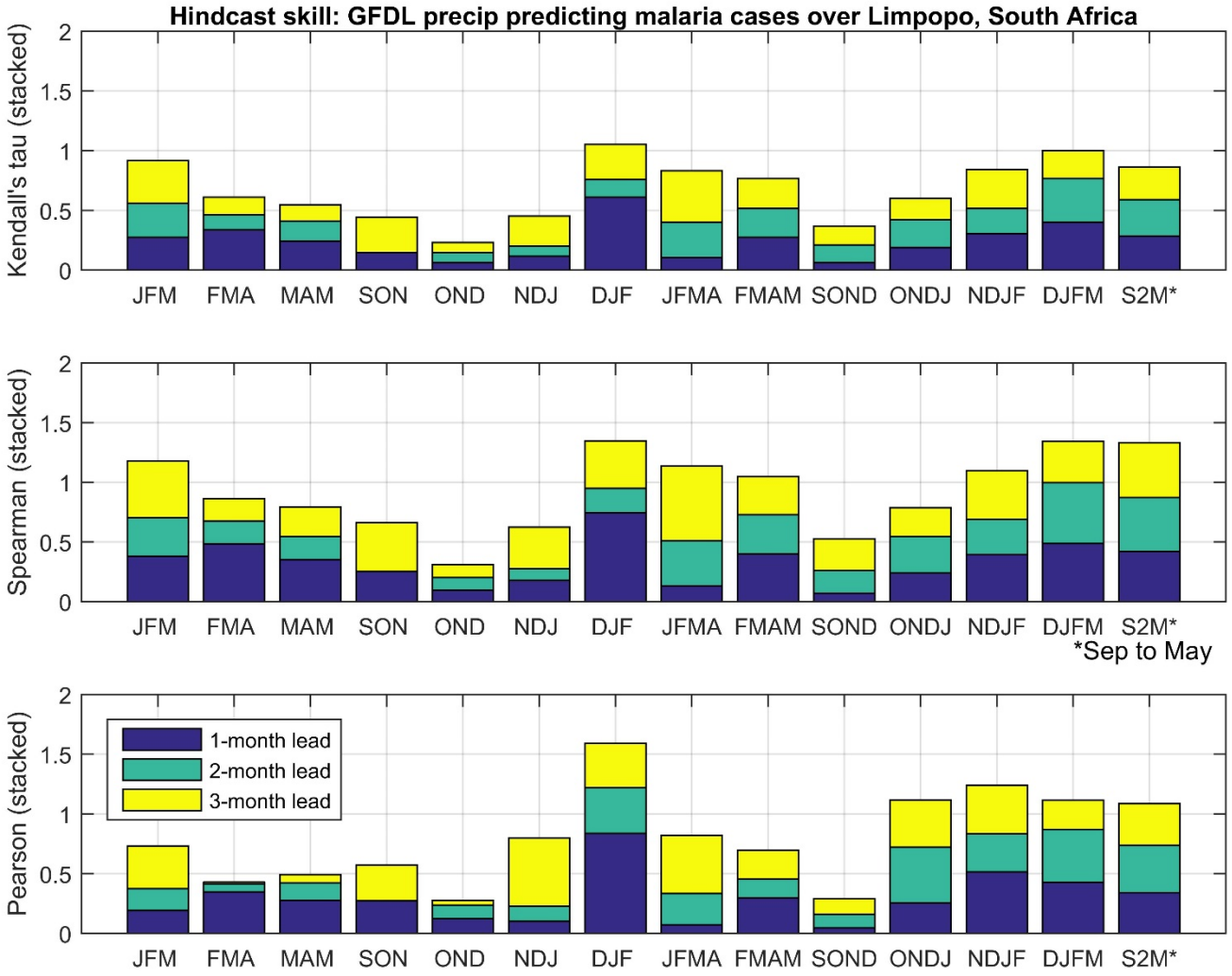

End-Of-Season Yield
Crop-Yield Index
Forecasts
Observed
Above-Normal Yield
Below-Normal Yield


DJF 2020/21 Rainfall; ICs: Nov
Legend
Catchment Area
Main Rivers
Rainfall Prob
>75
70-75
65-70
60-65
55-60
50-55 Above
45-50 Normal
40-45
35-40
35-40
40-45
45-50
50-55 Below
55-60 Normal
60-65
65-70
70-75
>75

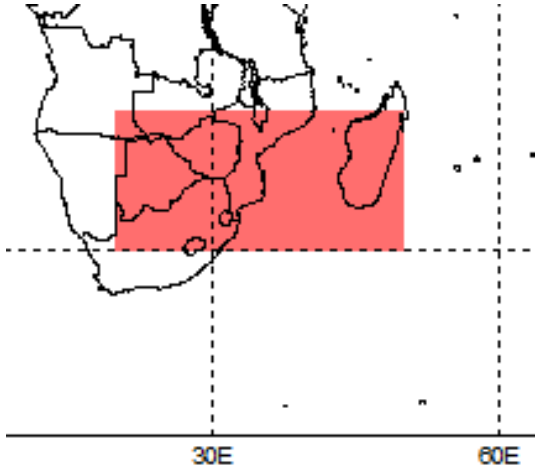

FMA Vaal Dam Downstream Flow
Observed
Re-forecasts
Inflow Index
corr=0.391

Exceedance Probs: FMA 2021; ASO Precip
Climatological
Empirical
FORECAST
75th percentile
25th percentile
Probability of Exceedance (%)

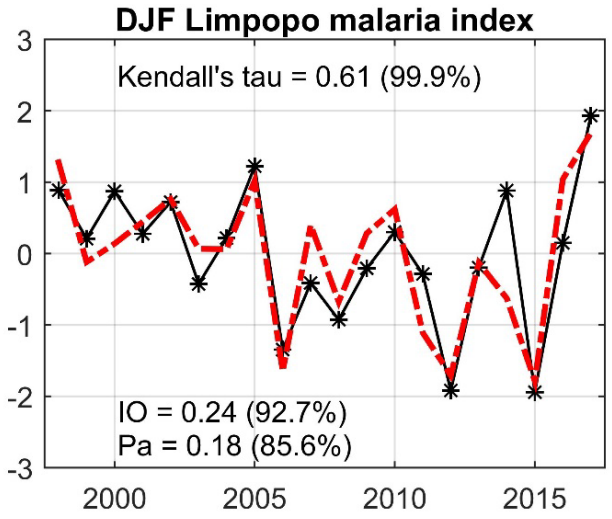

Crop-Yield Forecast for 2021, Made in November 2020
%
Above
Normal
Below

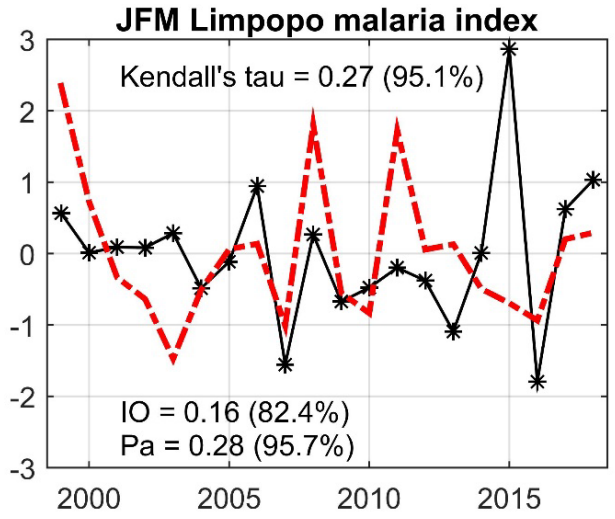


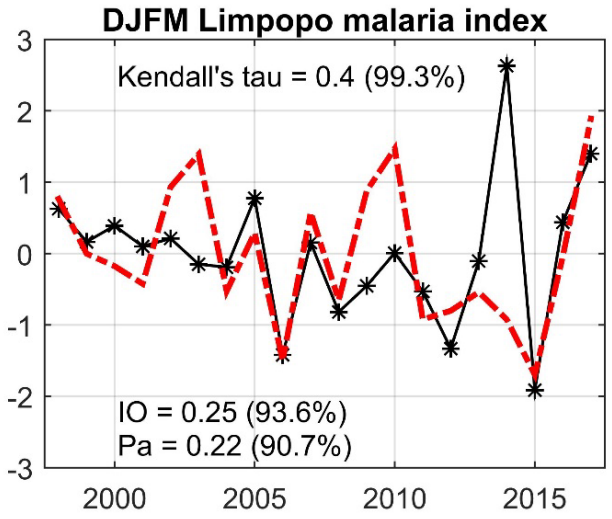
Correlations between hindcasts (re-forecast) and observed for the seasons indicated. Lead-times up to 3 months are presented.

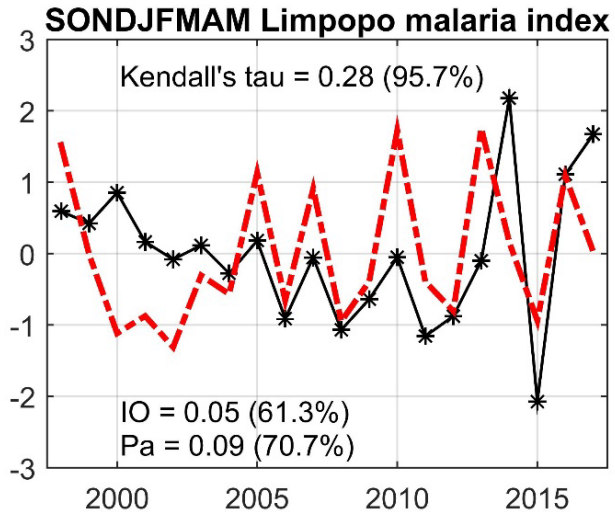


1. Natural logs (ln) of the malaria seasonal data resulted in data to become normally distributed (Lilliefors test)
2. **GFDL-CM2p5-FLOR-B01** seasonal rainfall forecasts are statistically downscaled to seasonal malaria values (canonical modes of forecasts used in a multiple linear regression model as predictors)

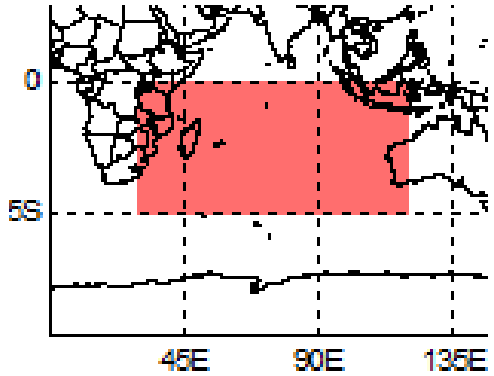


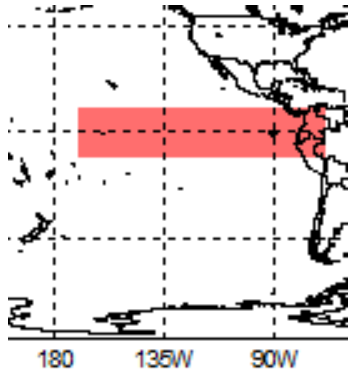


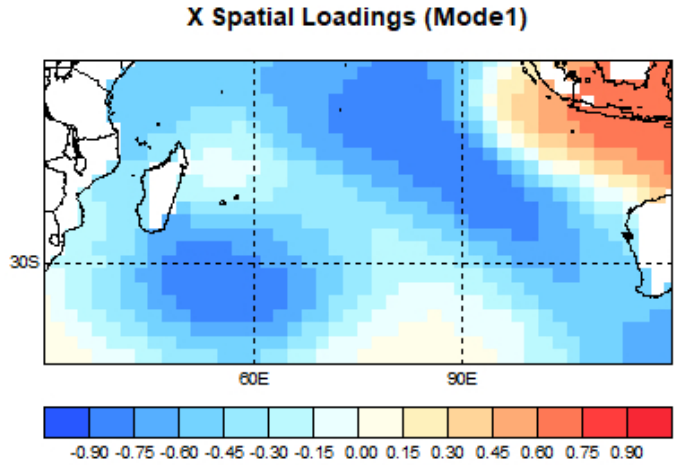




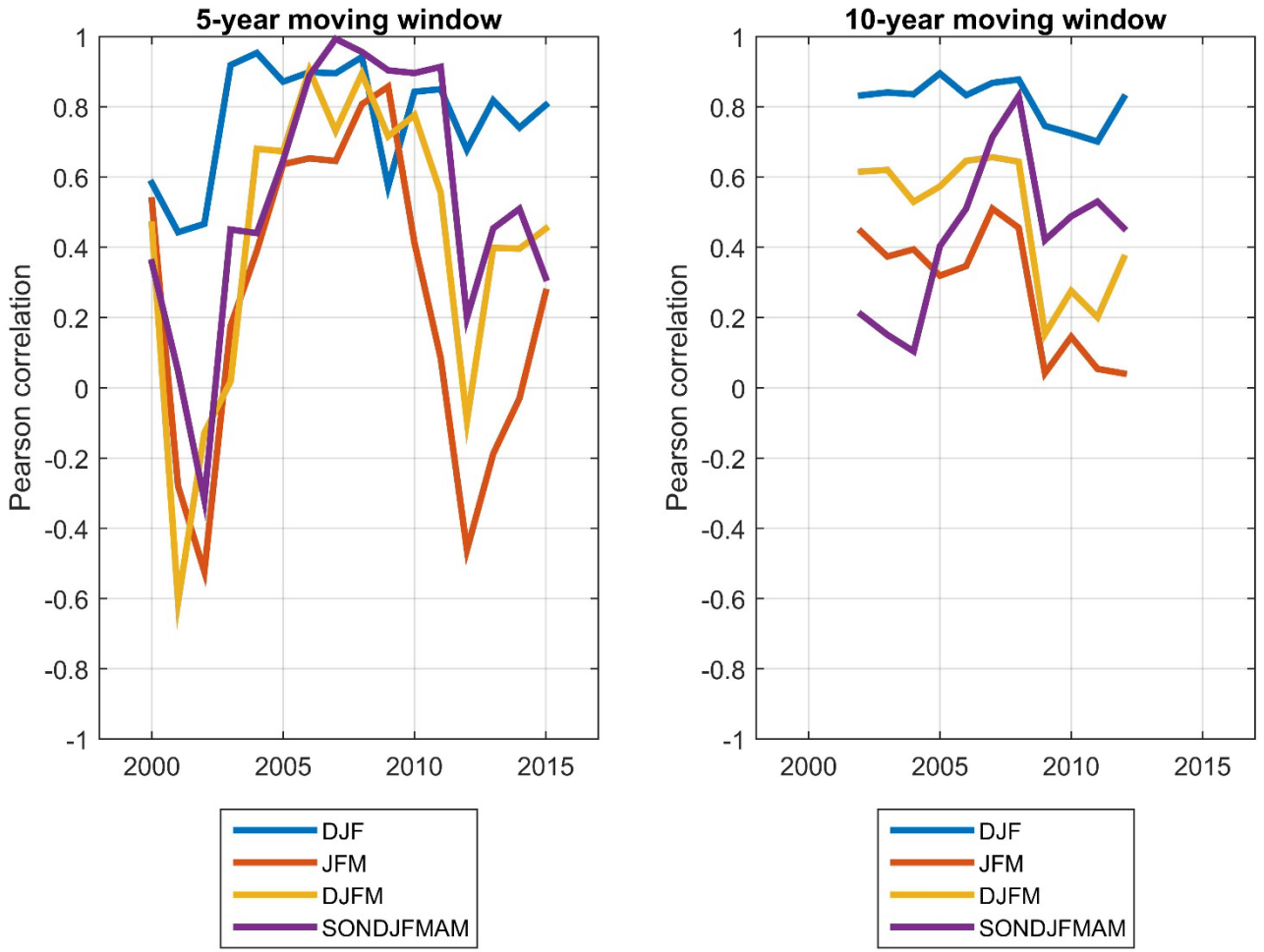
SST as predictors are used as baseline: Multiple linear regression models





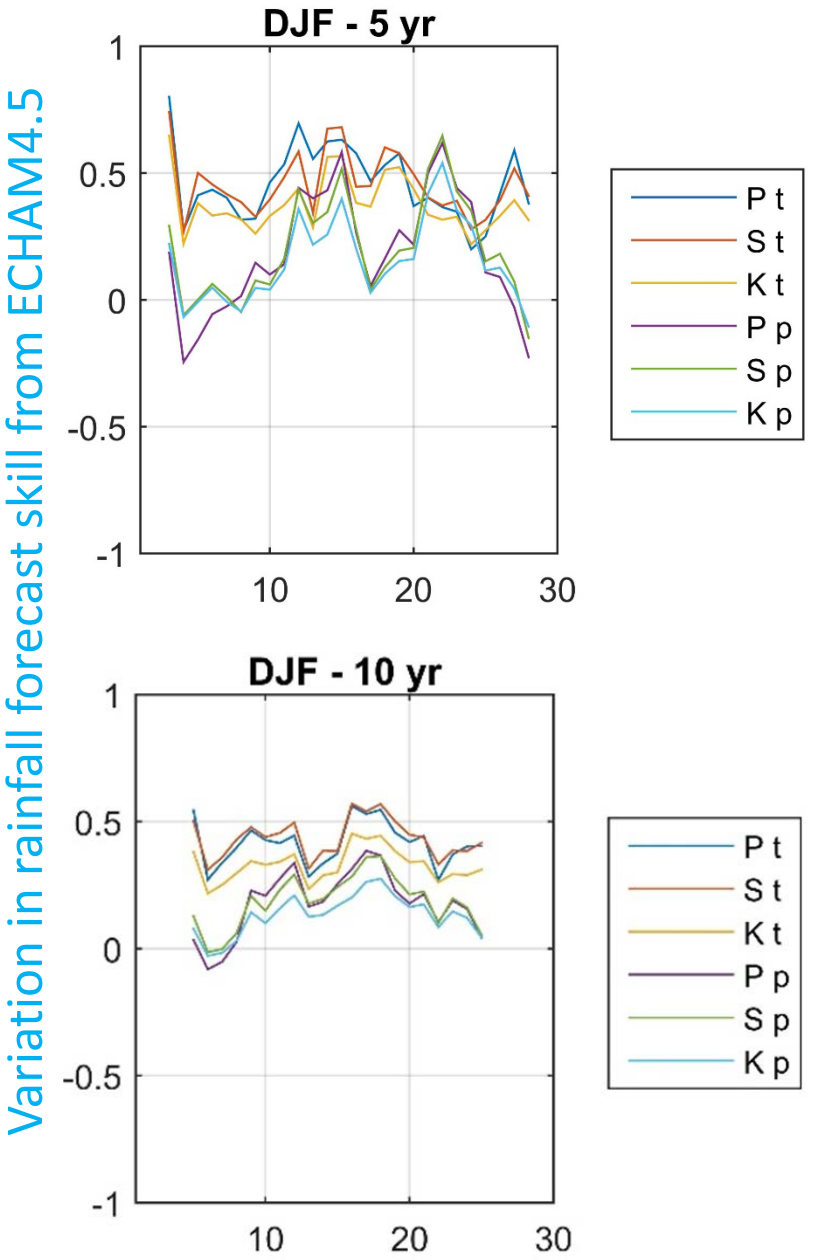


Cross-validated malaria cases hindcasts (1-month lead) for the four seasons indicated. Time series have been normalised. The top value on each panel is the Kendall's tau (Kt) correlation between hindcast (red dashed) and observed (black asterisked). IO: Kt when using Indian Ocean SST as predictor; Pa: Kt when using equatorial Pacific Ocean SST as predictor.

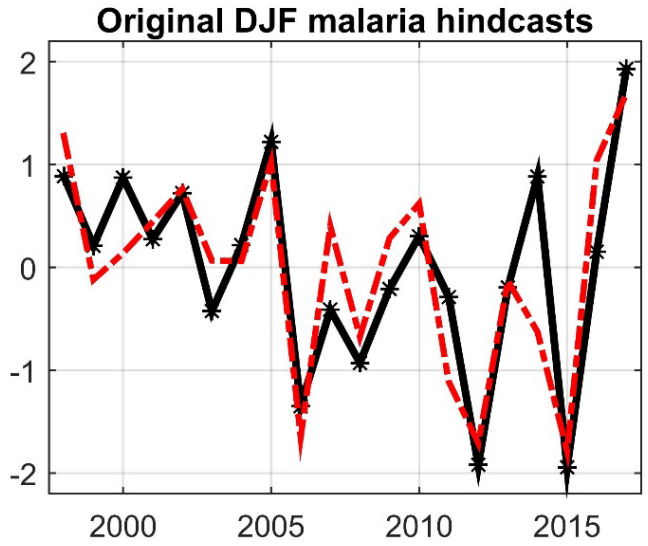


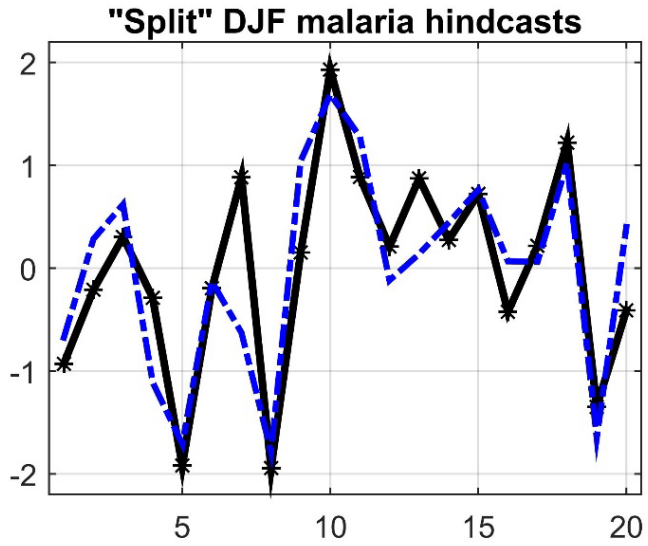
Respectively 5- and 10-year moving windows are used to calculate correlations between observed and hindcasts for the four seasons indicated. The DJF season is not only found to be associated with highest skill (correlations), but is also the season during which forecast skill remains the most consistent.

Variation in rainfall forecast skill from ECHAM4.5

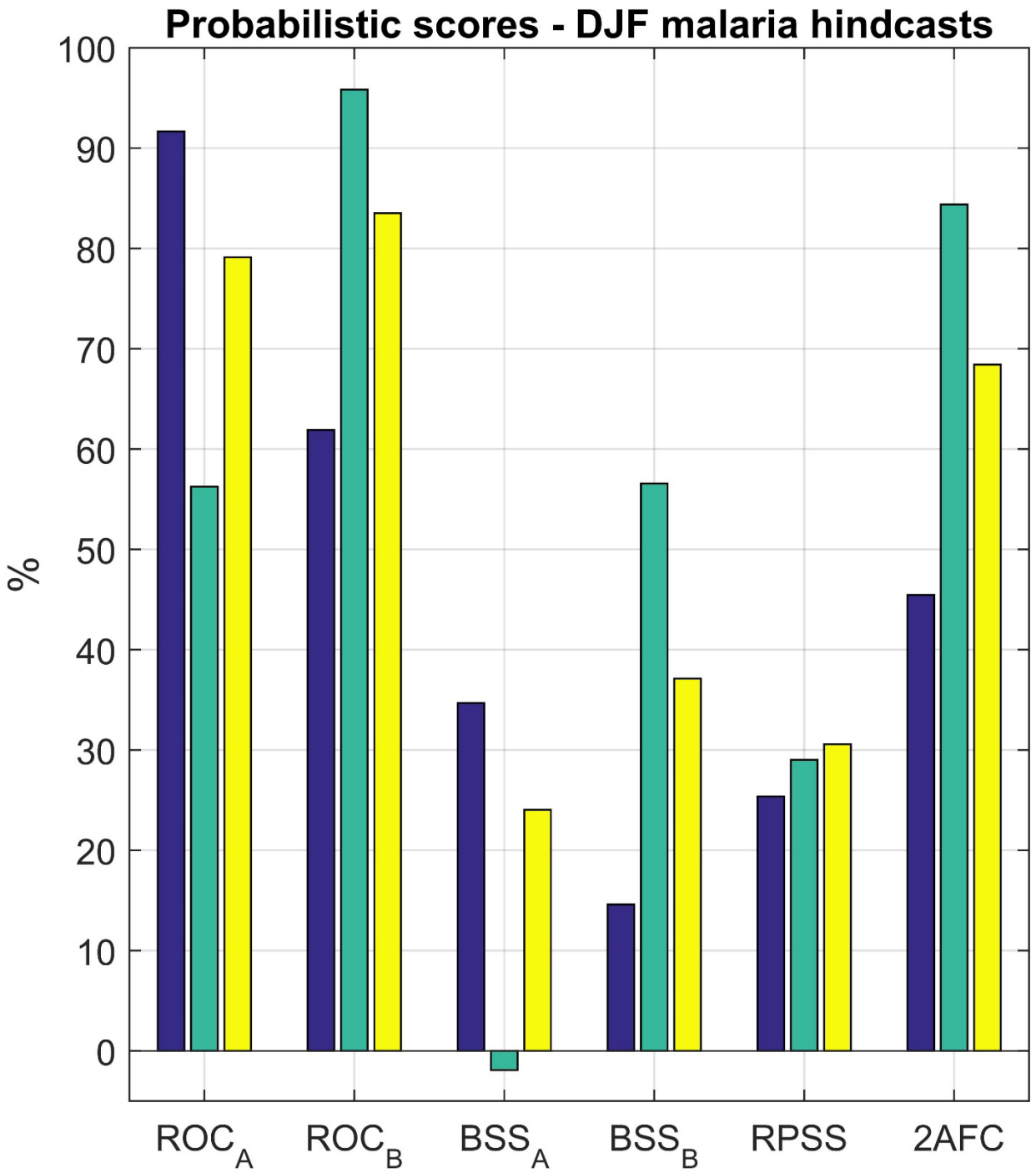


1. Seasonal forecasts should be expressed probabilistically – and also need to be **verified** as such
2. **Probabilistic forecasts** are produced through the calculation of error variances of downscaled ensemble mean values
3. Typically, the **first 10 years** of the 20-year period are used to train the statistical model to produce probabilistic forecast for the **second 10-year** period
4. To obtain 20 years of probabilistic forecasts, we **swapped the two 10-year periods** around, with the result that the second 10-year period can be used to also produce probabilistic forecasts for the first 10-year period. This process results in the production of **20 years of probabilistic forecasts**

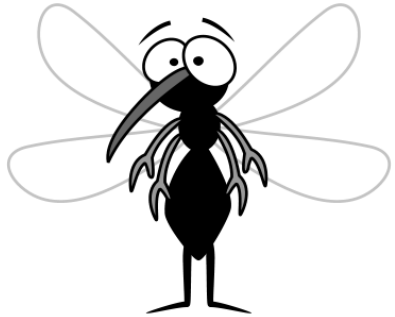




Top panel shows the DJF hindcasts from before. Bottom panel shows the cross-validated hindcasts by placing the second 10 years of the 20-year period In front of the first 10 years.



1998/99 to 2007/08
2008/09 to 2017/18
1998/99 to 2017/18

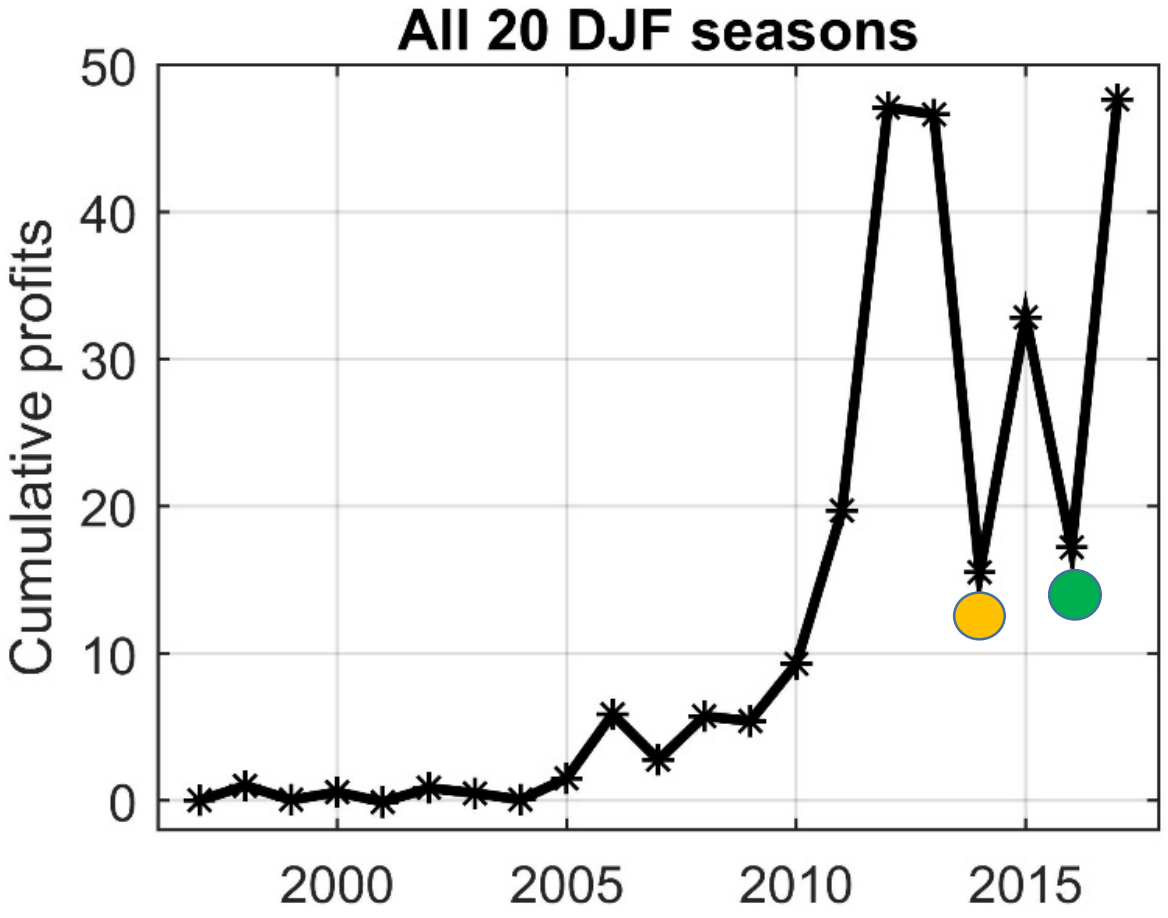


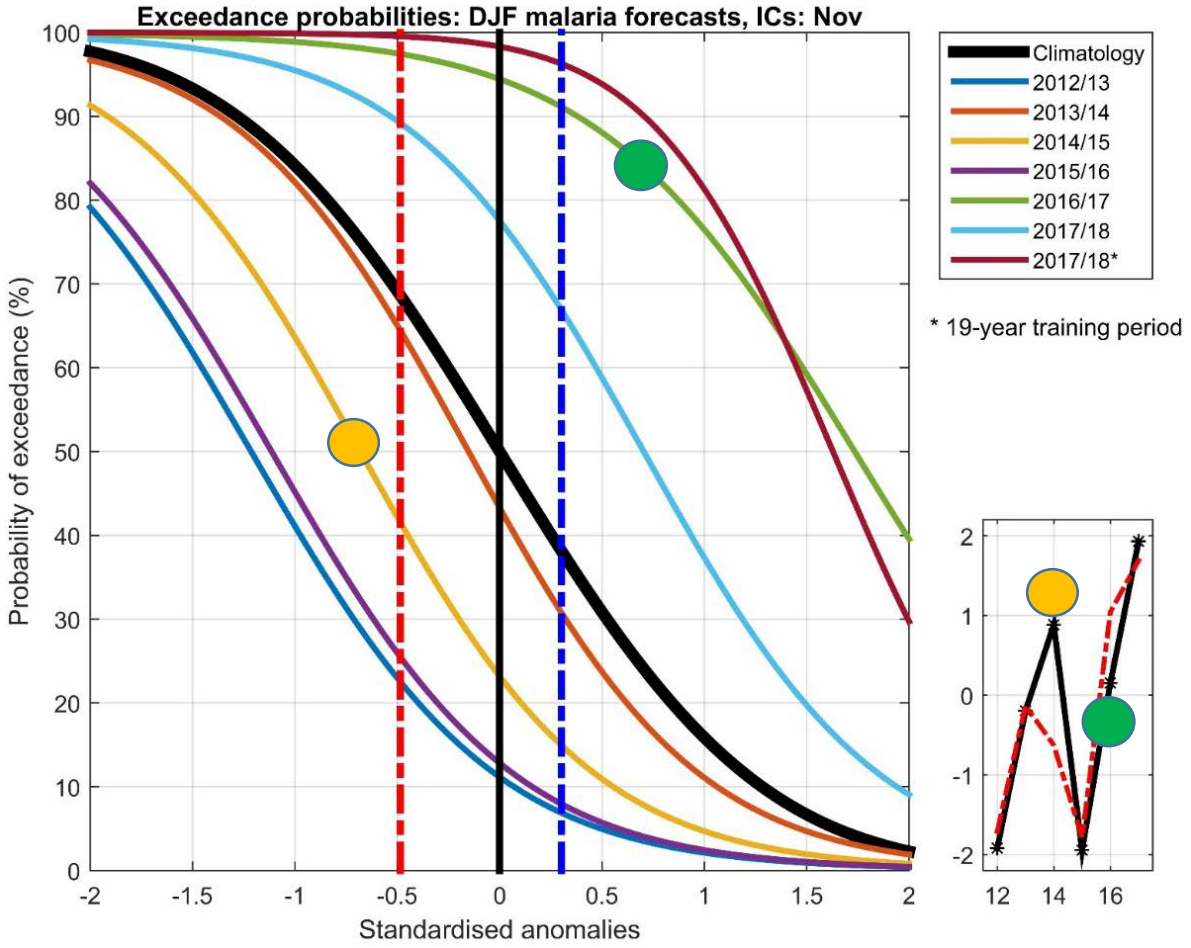
Resolution slopes:

	Above	Below
98/99-07/08	1.60	0.80
07/08-17/18	0.42	1.52
98/99-17/18	0.98	1.12

Note on resolution slopes: The full period shows slopes that are close to perfect reliability

1. **First 10** years more **above**-normal DJF cases – high ROC-**A** and BSS-**A**
2. **Second 10** years more **below**-normal DJF cases – high ROC-**B** and BSS-**B**
3. THUS **skill** level is a **function of verification period**
4. **2AFC** (probability of a correct decision made by, for example, a **health practitioner**), shows values great than 50% for the whole and for second 10-year period





2014/15: "Wrong"

2016/17: Over-confident

Summary:

- **Limpopo** is area of relatively **high seasonal predictability**
- Existing **experience** in statistical downscaling for **applications** modelling applied here for **malaria predictions**
- **Justification** presented to use physical **global coupled models'** output as input in malaria models (statistical, in this case)
- Issues to be cognizant of:
  - Verification **period** may strongly influence perceived forecast **skill**
  - Some predicted years may simply be **"wrong"**
  - Such years may have **serious implications** on future health operations

The final paragraph of the paper:

- We have developed and presented a robust and skillful seasonal forecast system for mid-summer malaria incidence…
- …we have demonstrated how occasional false-positive and false-negative forecasts can result in material financial losses.
- Therefore we urge caution in relying on these forecast models exclusively for disease management….
- …we therefore suggest… to make sure that good climate monitoring systems are in place to supplement forecasts from models…
- …we propose that disease surveillance and control activities should not be replaced by forecasts…
- …forecasts should only be used to supplement health practices that are currently going on in the region.