PREDICTING ENSO SST EXTREMES

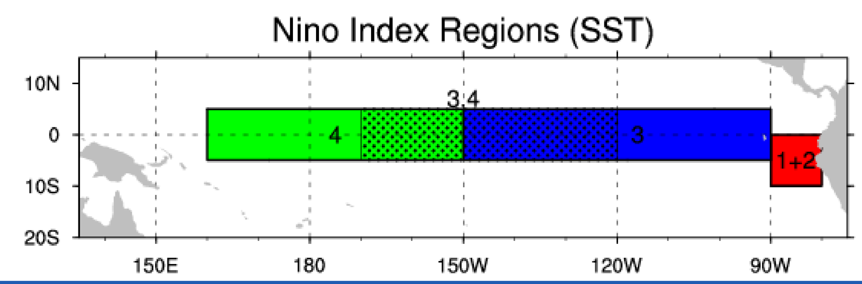
Willem A. Landman
University of Pretoria, South Africa

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

access
Alliance for Collaboration on Climate & Earth Systems Science

INTRODUCTION

An operational seasonal forecasting initiative at the University of Pretoria was established 2016, called Seasonal Forecast Worx (SFW). Forecasts distributed by SFW every month include rainfall and temperatures for the region, malaria forecasts for the Limpopo Province, dry-land crop-yield and rainfall forecasts for a number of farms in South Africa and Namibia, etc. Monthly forecasts of El Niño and La Niña events are also provided and are included in the ensemble of El Niño-Southern Oscillation (ENSO) forecasts administered by the International Research Institute for Climate and Society (IRI), USA. The poster shows some of SFW's archived ENSO forecasts, and in particular archived forecasts for the Nino3.4 area (5°N-5°S, 170°W-120°W) during the austral mid-summer season of December-January-February (DJF).



METHODOLOGY

THE SST FORECAST SYSTEM

The SST forecast system is based on a multi-model approach by including forecasts from a statistical model (canonical correlation analysis – CCA) that uses the most recent 3-month mean antecedent global ERSST.v5 field as predictor and the OI.v2 global SST as predictand, and from CGCM data of the North American Multi-Model Ensemble (NMME; GFDL-SPEAR). The GFDL-SPEAR SST forecasts are improved by correcting the mean and variance bias of the forecasts. The multi-model forecast is the average of 1 X statistical forecast + 2 x corrected GFDL forecast. Forecasts are produced on the OI SST 1°x1° resolution grid. Take note of the category thresholds as shown in Figure 2 (i.e., 25-50-25).

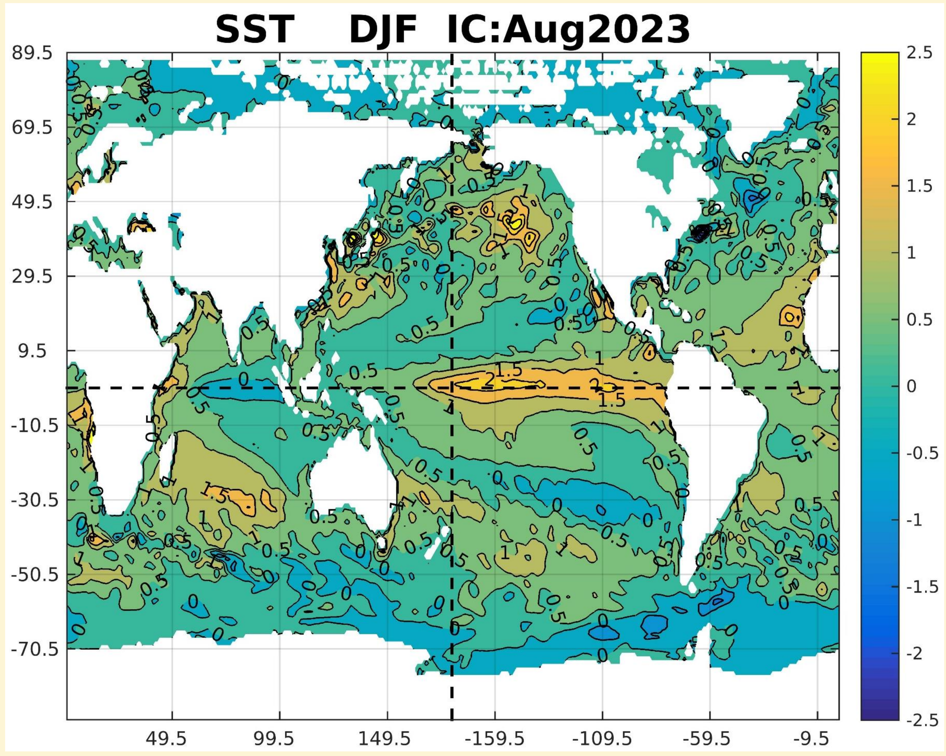


Figure 1: Real-time global SST anomaly forecast for DJF 2023/24 (El Niño), issued in August 2023.

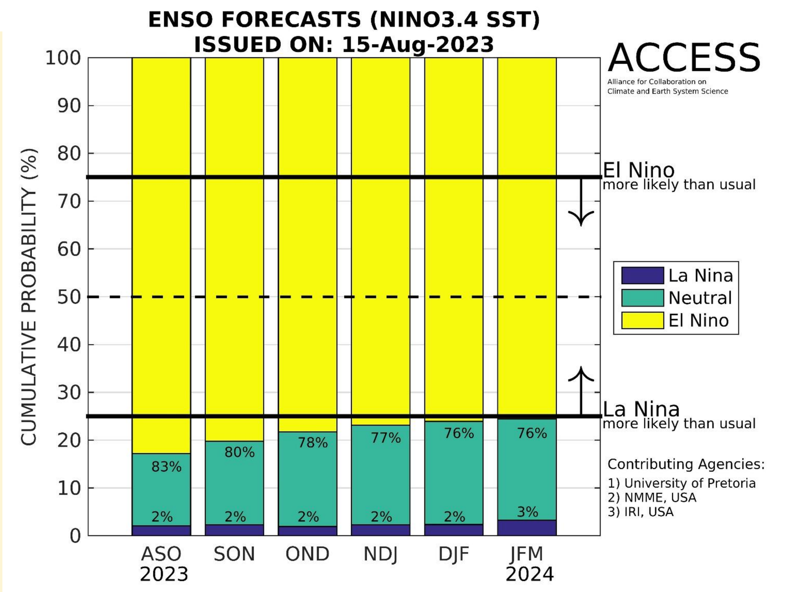


Figure 2: Real-time Niño3.4 SST probability forecast, issued in August 2023.

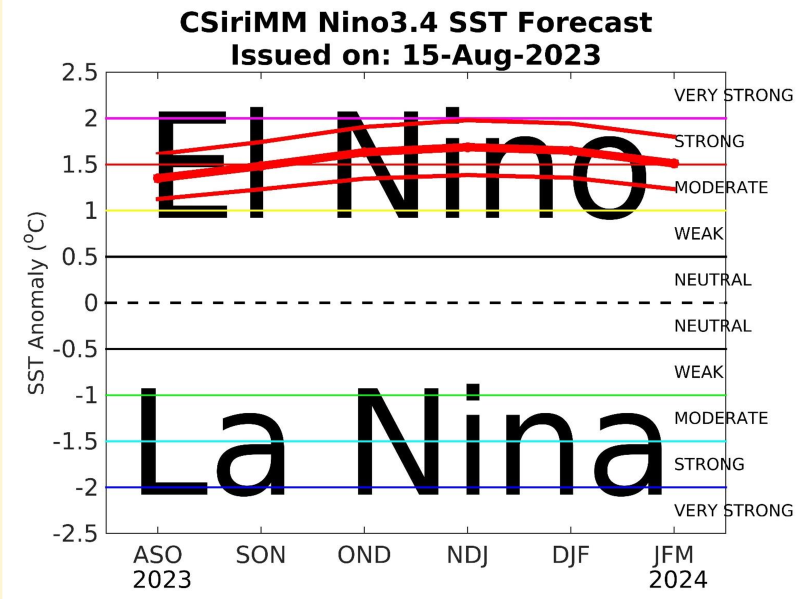


Figure 3: Real-time Niño3.4 SST anomaly forecast with 25% confidence limits, issued in August 2023.

VERIFICATION OF NIñO3.4 SST HINDCASTS (RE-FORECASTS)

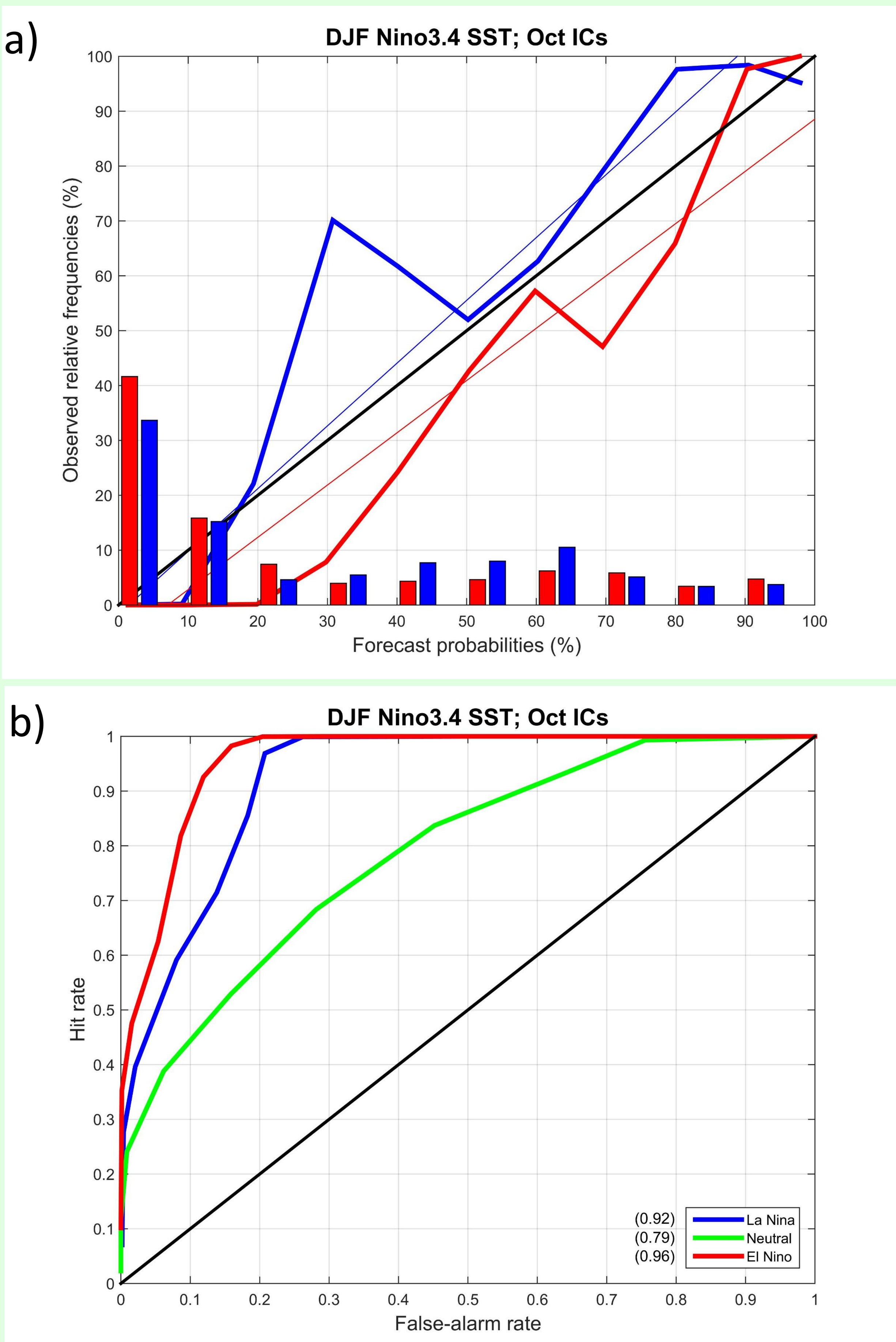


Figure 4: a) Reliability diagram (reliability plots [thick blue and red], weighted least-squares regression lines [thin blue and red], and frequency histograms), and b) relative operating characteristic (ROC) diagram for probabilistic DJF Niño3.4 SST hindcasts. Category thresholds are represented by 25-50-25.

TAYLOR DIAGRAMS FOR SINGLE-MONTH NIñO3.4 SST HINDCASTS

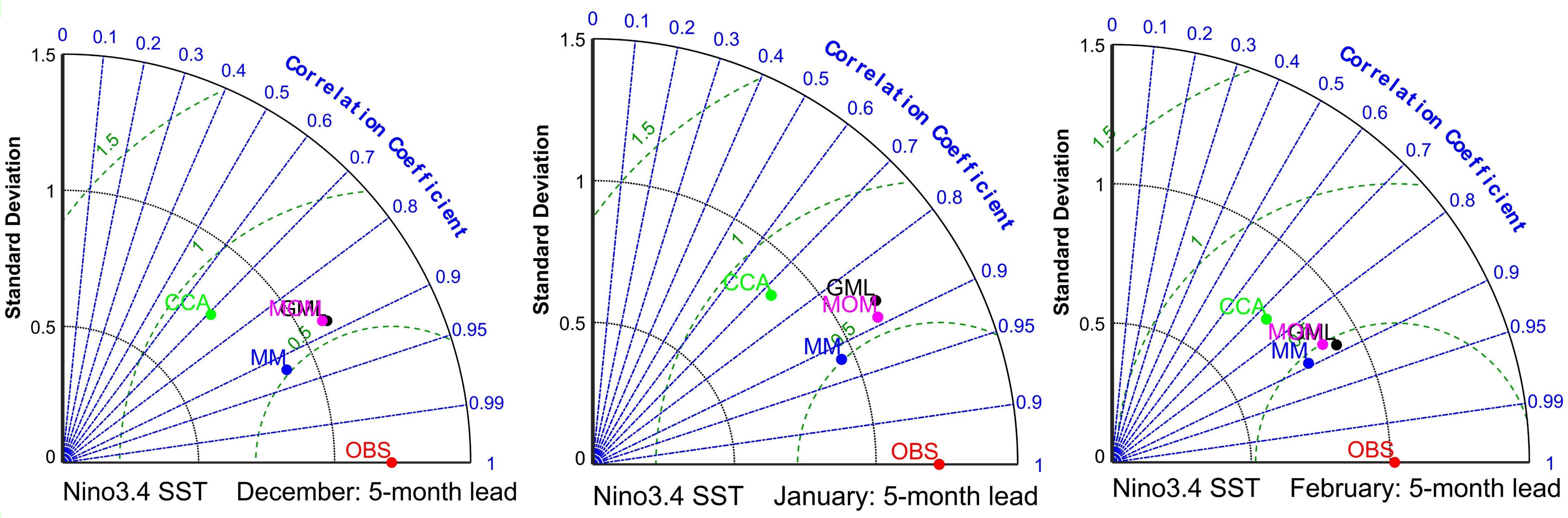


Figure 5: Taylor diagrams of Niño3.4 SST hindcasts over 28 years for the months of December, January and February at a 5-month lead-time. The hindcasts were produced by four forecasting systems (CCA: statistical model; MOM: coupled GCM1; GML: coupled GCM2; MM: multi-model [(CCA+MOM+GML)/3]; OBS represents observed values). Standard deviations are represented by solid black curves, the root-mean squared errors of the hindcasts by dashed green curves, and the correlations between the observed and hindcast values by the angled blue straight lines.

Verification of operational forecasting systems is of the utmost importance. Figure 4 shows verification results for probabilistic ENSO forecasts. In summary the forecasts of ENSO events are both reliable, highly confident, and can discriminate among El Niño, La Niña and ENSO-neutral events.

Figure 5 shows Taylor diagrams of deterministic December, January and February Niño3.4 SST hindcasts. In summary, 1) the physical coupled models outscore the statistical model; 2) the multi-model (MM) has the best skill (highest correlation and lowest RMSE) among the four systems considered; and 3) although the MM has the highest skill, its standard deviation values are consistently lower than those of the coupled models (i.e., the MM is less able to capture really extreme ENSO events).

ARCHIVED NIñO3.4 REAL-TIME SST FORECASTS

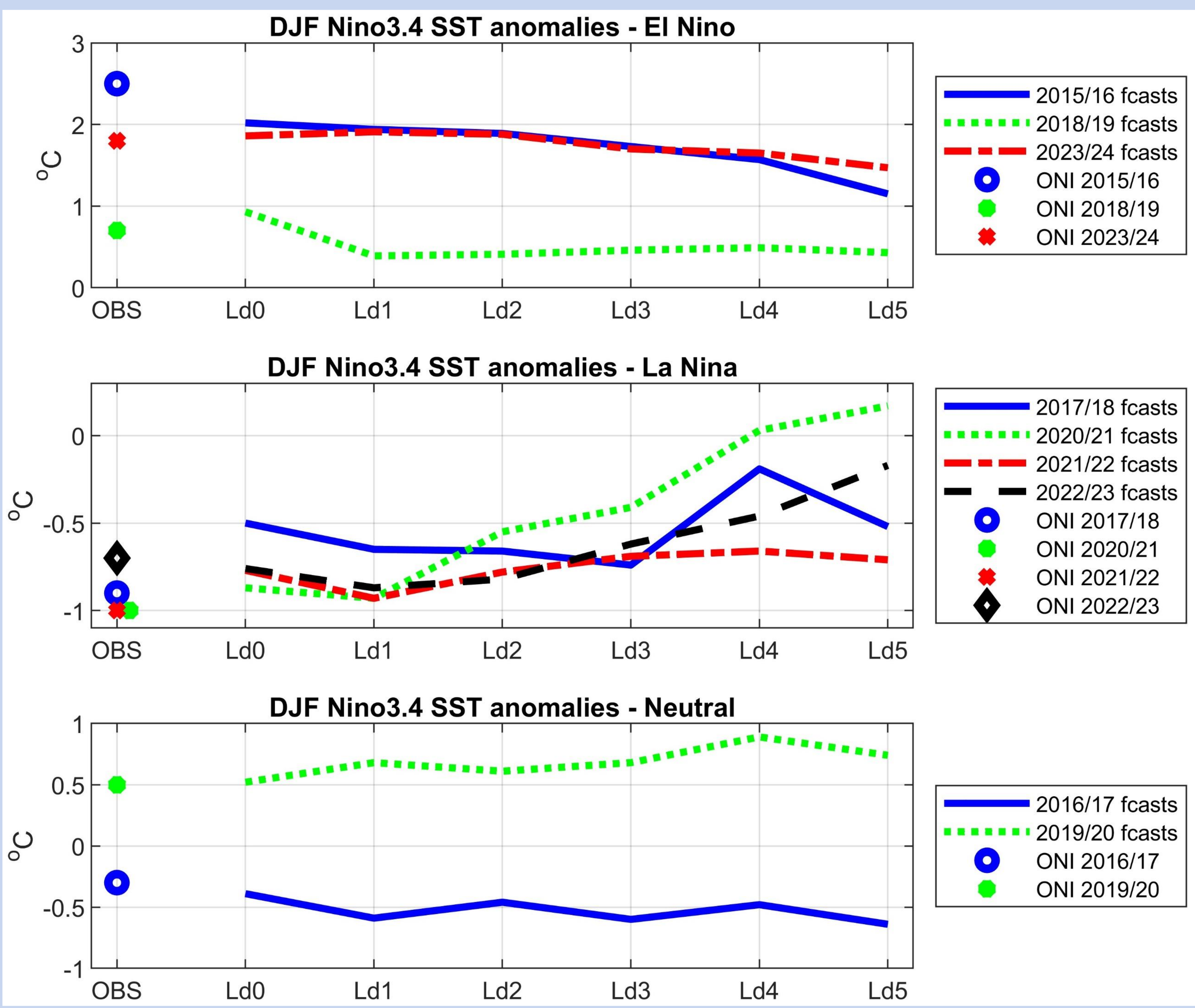


Figure 6: Archived DJF Niño3.4 SST forecasts. Ld0: 0-month lead forecast (i.e., DJF forecast made early December; Ld1: 1-month lead forecast (i.e., DJF forecast made early November; ...; Ld5: 5-month lead forecast (i.e., DJF forecast made early July); OBS: observed ONI (Oceanic Niño Index) SST anomalies.

Figure 6 shows the Niño3.4 SST anomaly forecasts produced in real-time by SFW. During the 9-year period of operational output, there were two ENSO-neutral events, three El Niño events, and four La Niña events.

A general conclusion is that the SFW forecasts tend to underestimate the strength of El Niño and La Niña events, which is in agreement to the hindcast verification result. Notwithstanding, the intensities of the strong El Niño events of 2015/16 and 2023/24 are captured with reasonable skill.

CONCLUDING REMARKS

With the assistance from international institutions, projects, programmes and general collaboration, South Africa has established operational SST, and by extension ENSO, forecasting capabilities that in turn contribute to an international forecasting effort (i.e., the IRI ENSO forecast plume). Moreover, the SST forecasts are also contributing to the operational seasonal forecasting effort at South Africa's Council for Scientific and Industrial Research by providing real-time global SST forecasts to them every month.

Verification should be seen as part and parcel of the seasonal forecasting process. Here we showed that ENSO events can be predicted with skill months in advance using our developed techniques. It was also showed that SFW's operational ENSO forecasts, albeit lacking in its ability to capture really extreme events, have skill in the sense that below-average Niño3.4 SSTs were predicted during La Niña events and above-average SSTs during El Niño events.

International Conference on: Integrated Responses to the Intensification of Extreme Climate and Weather Events in Developing Economies, 22-24 May 2024, STIAS, Stellenbosch