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Assessment of GloSea4 seasonal forecasts for SADC and the global oceans

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INTRODUCTION

The main objective of this research is to demonstrate the skill of the UK Met Office Hadley Centre's coupled global seasonal forecasting system, GloSea4 (Arribas et al., 2011), as a seasonal forecasting tool for the Southern African Development Community (SADC) and the global oceans, with special emphasis on the equatorial Pacific Ocean. In addition, the value of including GloSea4 forecasts in multi-model systems is tested. These investigations are conducted by testing the model's ability to predict seasonal rainfall totals during the austral spring (SON), mid-summer (DJF) and autumn (MAM) seasons in the region, and by testing for monthly sea-surface temperature anomalies during mid-summer. The model's ability to simulate the region's intra-seasonal rainfall and low level circulation characteristics is investigated through self-organising maps (SOM).

DATA AND METHOD

The deterministic skill of GloSea4 in the SADC region is tested by downscaling 14 years' (1996 to 2009) ensemble mean (nine members) hindcasts of the 850 hPa geopotential height fields and the model's precipitation, to the University of East Anglia's (UEA) Climate Research Unit (CRU), version TS3.1 seasonal precipitation data, at a 0.5°x0.5° resolution using model output statistics (MOS). In addition to the MOS hindcasts, GloSea4's precipitation fields are directly extrapolated onto the CRU grid, thereby enabling the testing of the model's raw precipitation hindcasts. These projections are done using the CCA option of the CPT. The model domain covers the area from 10°S to 40°S and from 5°E to 45°E. The same downscaling procedure described in Landman et al. (2012) is used. For SON, the hindcasts are available for the initialisation months of August (one-month lead time) and May (four-month lead time). For DJF, the hindcasts are available for November and August initialisation, and for MAM, February and November. In order to generate probabilistic rainfall output, GloSea4 ensemble means are retro-actively downscaled to create a seven-year hindcast period from 2003 to 2009 (the CCA calibration is made on the seven-year period 1996–2002). SST hindcasts over the equatorial Pacific Ocean (Niño3.4) are similarly recalibrated to the 1°x1° resolution data of NOAA's OI.v2. The intra-seasonal characteristics of the model are assessed through self-organising maps.

A 4x3 SOM is calculated and captures the various stages of the main rain producing weather systems of the DJF season (e.g. ridging high pressure systems and tropical-temperate troughs). The SOM is trained on the daily mean NCEP re-analysis sea-level pressure (SLP) data for all the 1996 to 2009 DJF days. These daily SLP fields are normalised relative to the SLP domain averaged over the entire period, prior to the training of the SOM. The GloSea4 daily SLP hindcasts for the nine ensemble members for DJF (initialised in August) are similarly normalised before being mapped to the SOM. The differences in the node frequencies of the ensemble members with respect to the NCEP frequencies are calculated in order to investigate the bias of the intra-seasonal characteristics of the SLP circulation.

RESULTS

The deterministic skill in predicting seasonal rainfall over the SADC region is first assessed by calculating the Kendall's tau-ranked correlations between observed (CRU) and three-year-out cross-validated hindcasts over 14 years. **Figure 1** shows the Kendall's tau differences between raw model rainfall and downscaled rainfall hindcasts. Negative differences are found where the downscaling outscores the raw model precipitation output, therefore justifying statistically post-processing the model data. The best result is found when using 850 hPa heights as the predictor in the MOS model. **Figure 2** shows the relative operating characteristics (ROC) scores for the SON, DJF and MAM seasons at one- and four-month lead times. GloSea4 is best able to discriminate wet DJF seasons from dry seasons, and by using the low level circulation of the model in a MOS system, improves the raw precipitation hindcasts of the model. A weighted combination of GloSea4 hindcasts with ECHAM4.5-GML-CFSSST hindcasts of the IRI (see Landman et al., 2012) in a multi-model system improves on the skill of each of the models (not shown owing to space limitations), subsequently justifying the use of a multi-model system with GloSea4 as one of the component models.

Figure 3 shows the MSE skill score (climatology is the reference hindcast) of the existing multi-model SST forecast system administered by the CSIR, and of an extended system defined by the existing multi-model plus GloSea4 output to predict Niño3.4 SST anomalies. A general improvement in the skill is found with the multi-model which includes GloSea4 hindcasts – with the most improvement in the longer lead hindcasts. The skill assessment of the global oceans shows that the highest skill is found over the tropical oceans.

Figures 4a and b show that the main synoptic features are captured by the coupled model for DJF hindcasts initialised in August. However, the frequency of some of these features differ from that observed. The frequency of nodes representative of tropical-temperate linkages are mostly underestimated in the GloSea4 four-month lead time forecast (e.g. node 1 and 9 in **Figure 4b**), while the frequency of ridging high pressure systems are overestimated (e.g. node 4 and 8). Although variations in the magnitude of the node frequency errors for the various ensemble members occur, the direction of the errors are mostly consistent.

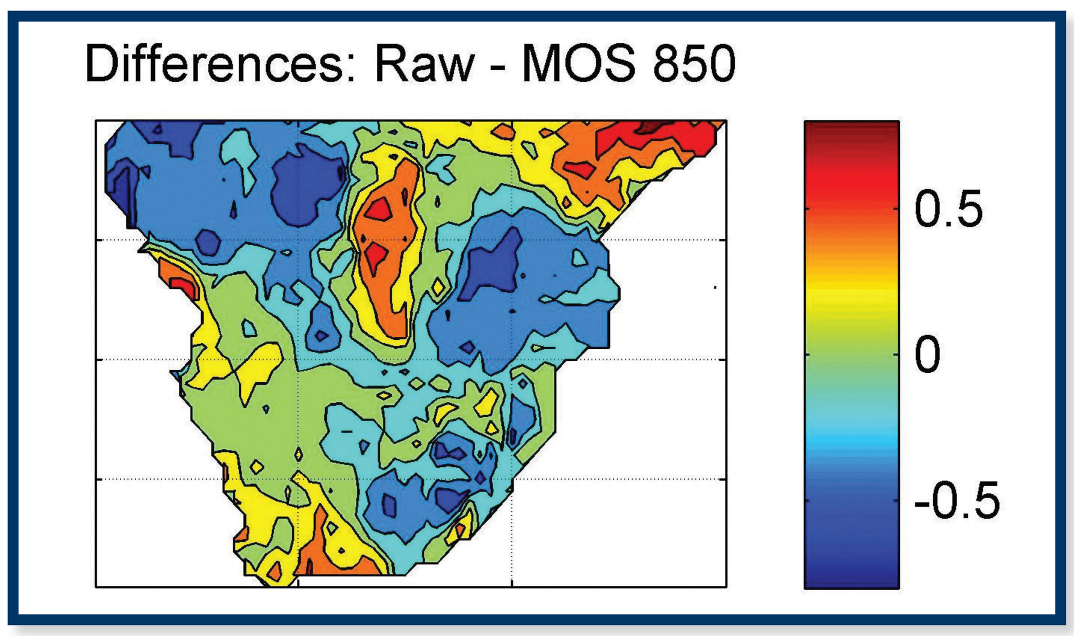

Figure 1: Skill (Kendall's tau-ranked correlation) differences between raw GloSea4 DJF rainfall and downscaled rainfall. Downscaling is performed using the model's 850 hPa geopotential heights of the DJF hindcasts initialised in August

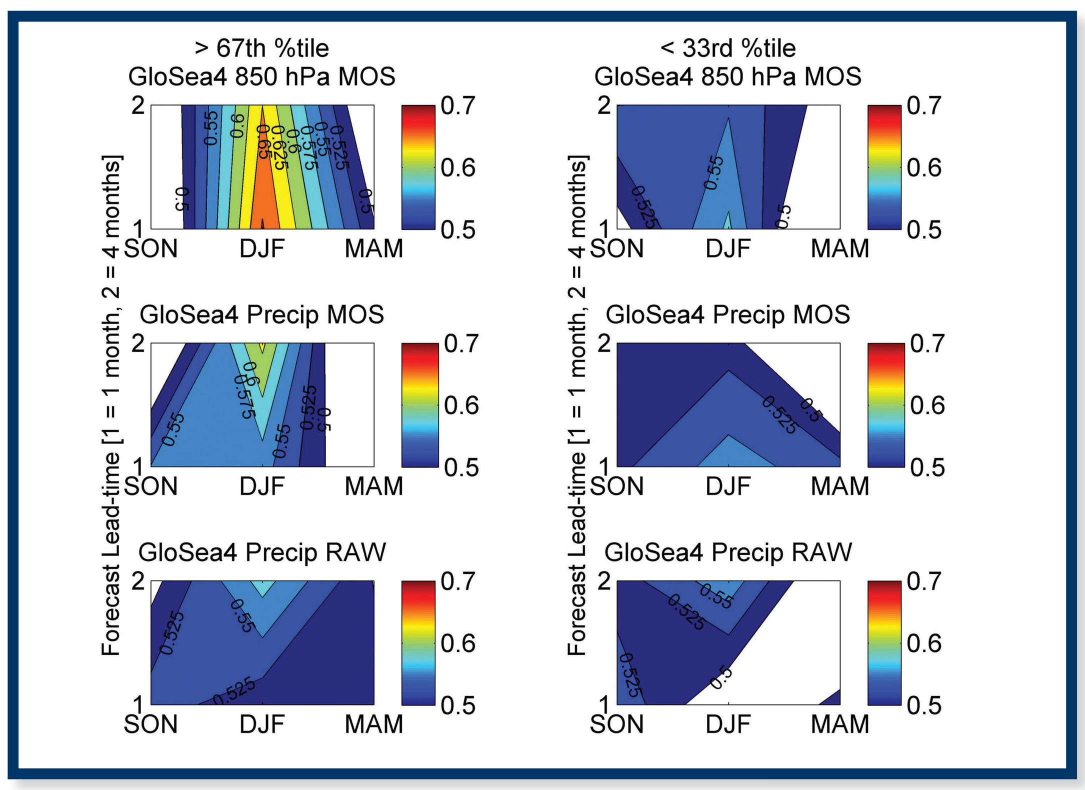

Figure 2: ROC scores for SADC for the seven-year retro-active test period

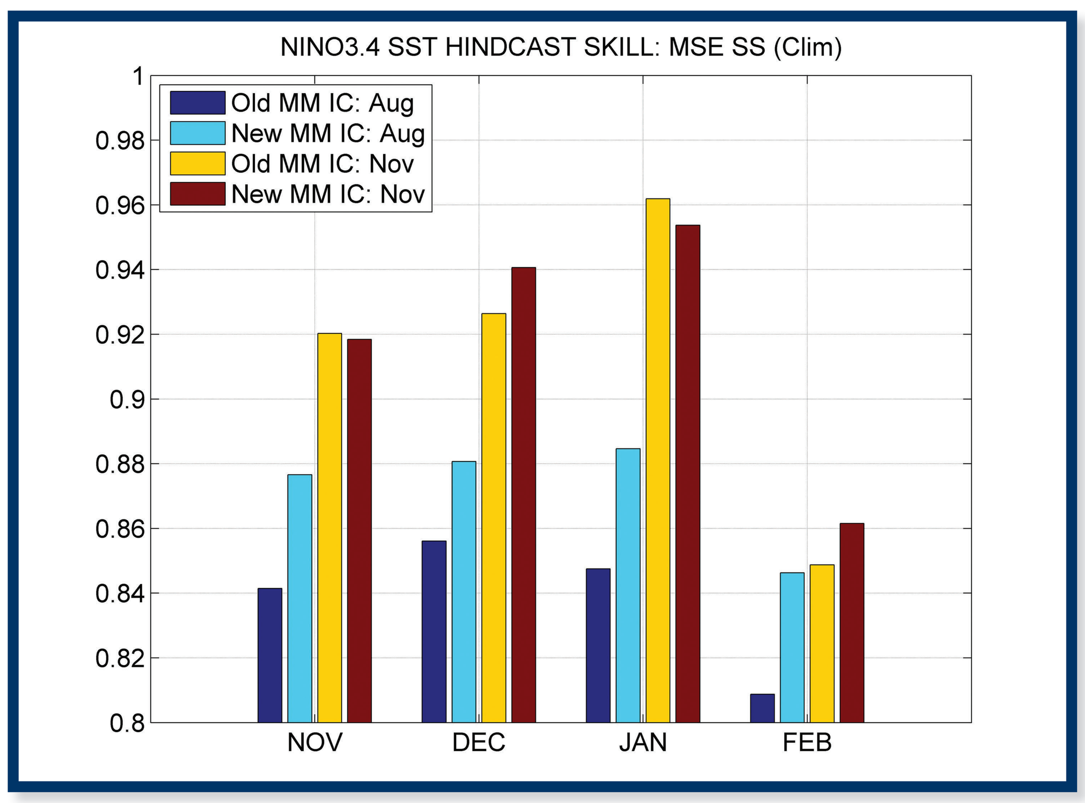

Figure 3: MSE skill scores predicting Niño3.4 SST with recalibrated hindcasts from the current multi-model system ('old') and from a multi-model system that includes GloSea4 hindcasts ('new')

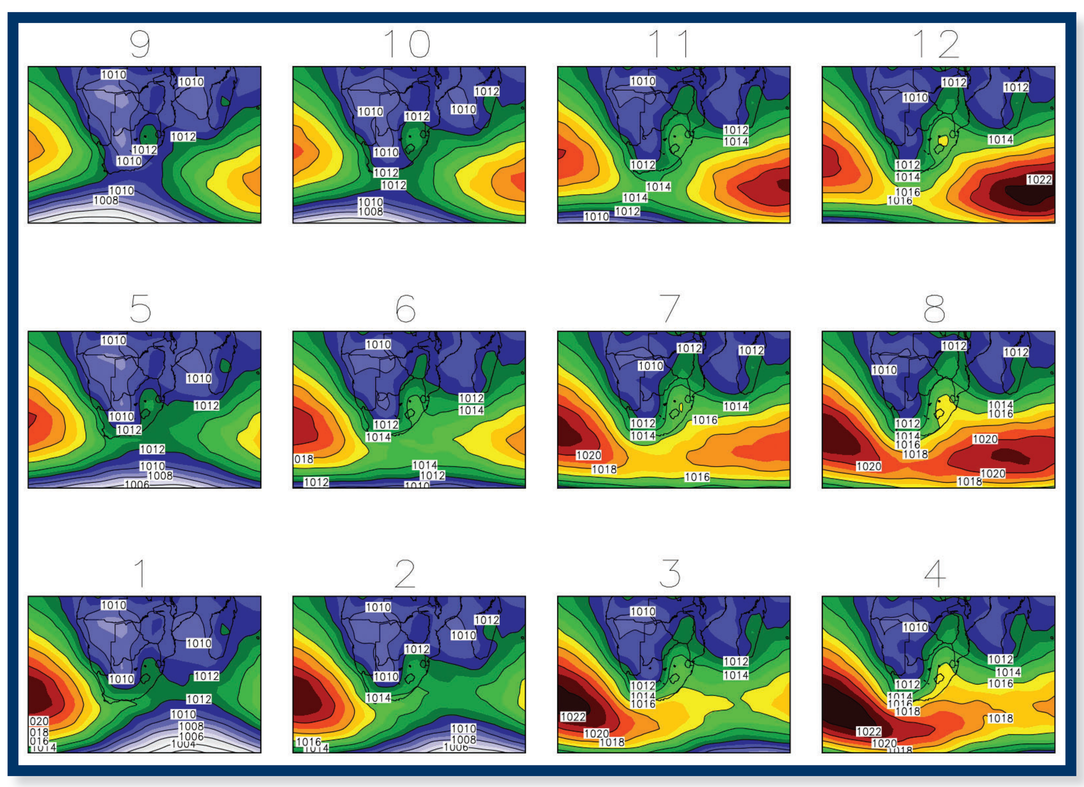

Figure 4a: SOM of sea-level pressure based on daily mean NCEP reanalysis data for DJF from 1996 to 2009

Including the GloSea4 system into South African forecast systems improves our ability to predict seasonal-to-interannual variability over the larger part of southern Africa and the tropical oceans.

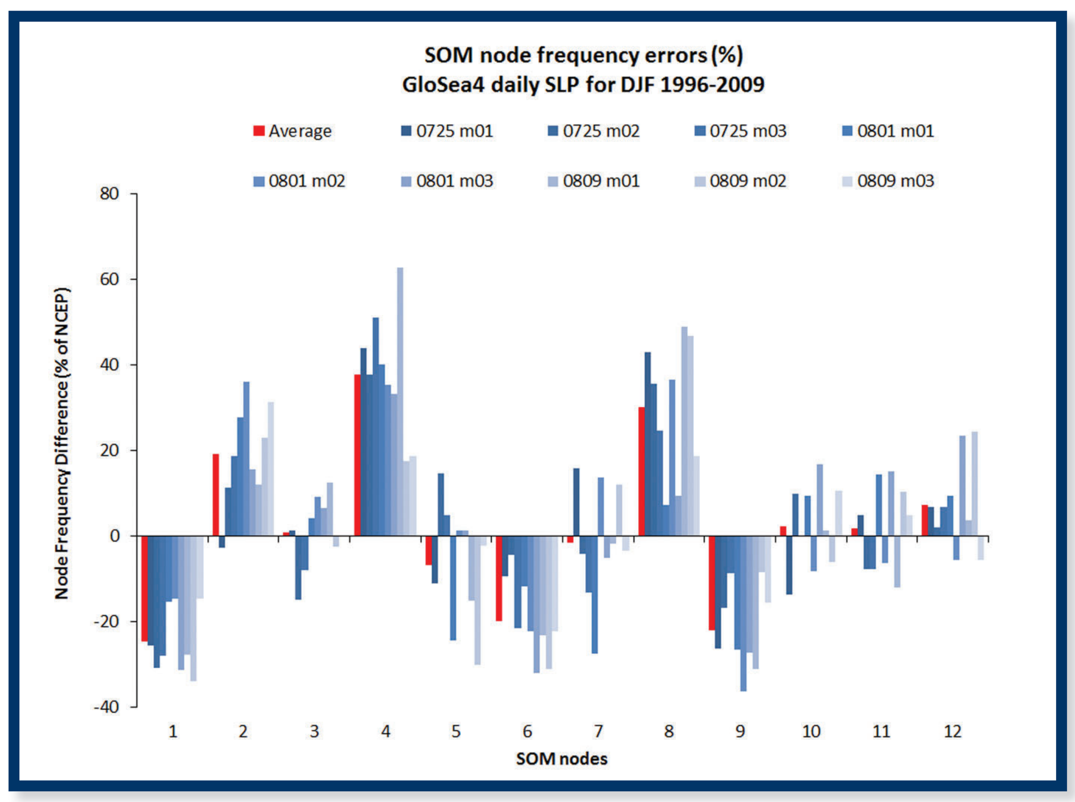

Figure 4b: SOM node frequency biases of the daily sea-level pressure ensemble members

CONCLUDING REMARKS

Seasonal hindcasts from the GloSea4 system have been tested in this study. It was found that this coupled model has the ability to predict seasonal to inter-annual variability at elevated levels of skill over the larger part of southern Africa and the tropical oceans. Both of these outcomes are of importance for southern African forecast users, as well as modellers responsible for developing forecast systems, including multi-model systems. The model's ability to simulate intra-seasonal characteristics was also assessed, and it was found that the model is able to capture some of the well-known synoptic structures of the region.

ACKNOWLEDGMENTS

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REFERENCES

Arribas, A., et al. 2011. The GloSea4 ensemble prediction system for seasonal forecasting. *Mon. Wea. Rev.*, 139, 1891–1910.
Landman, W.A., et al. 2012. Seasonal rainfall prediction skill over South Africa: One- versus two-tiered forecasting systems. *Wea. Forecasting*, 27, 489–501.