SST prediction methodologies and verification considerations for dynamical mid-summer rainfall forecasts for South Africa

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ABSTRACT

Seasonal-to-interannual hindcasts (re-forecasts) for December-January-February (DJF) produced at a 1-month lead-time by the ECHAM4.5 atmospheric general circulation model (AGCM) are verified after calibrating model output to DJF rainfall at 94 districts across South Africa. The AGCM is forced with SST forecasts produced by (i) statistically predicted SSTs, and (ii) predicted SSTs from a dynamically coupled ocean-atmosphere model. The latter SST forecasts in turn consist of an ensemble mean of SST forecasts, and also by considering the individual ensemble members of the SST forecasts. Probabilistic hindcasts produced for two separate category thresholds are verified over a 24-year test period from 1978/79 to 2001/02 by investigating the various AGCM configurations' attributes of discrimination (whether the forecasts are discernibly different given different outcomes) and reliability (whether the confidence communicated in the forecasts is appropriate). Deterministic hindcast skill is additionally calculated through a range of correlation estimates between hindcast and observed DJF rainfall. For both probabilistic and deterministic verification the hindcasts produced by forcing the AGCM with dynamically predicted SSTs attain higher skill levels than the AGCM forced with statistical SSTs. Moreover, ensemble mean SST forecasts lead to improved skill over forecasts that considered an ensemble distribution of SST forecasts.

Keywords: AGCM, SST predictions, seasonal forecasting, South Africa

INTRODUCTION

South Africa's seasonal rainfall variability is associated with different levels of predictability and is dependent on the time of the year: Spring (September-October-November) season rainfall totals are for the most part not predicted with high confidence owing to the fact that this season is mostly influenced by transient weather systems, while the best forecast skill has been demonstrated during mid-summer (Landman et al., 2005; Landman et al., 2012) when the tropical atmosphere starts to dominate the atmospheric circulation over South Africa (e.g. Mason et al., 1996; Landman and Mason, 1999). Some useful prediction skill is also found during austral autumn (Landman et al., 2005). However, the modelling work presented here only focuses on mid-summer (December to February – DJF), owing to the relatively high skill found for this season (Landman et al., 2005; Landman et al., 2009; Landman et al., 2012), and because the larger part of South Africa's austral summer rainfall areas receive most of their rainfall during this season.

The use of dynamically based atmospheric models as **real-time operational** seasonal forecasting tools has been practised in South Africa since the turn of the century (e.g. Landman et al., 2001). Major advances in the use of atmospheric general circulation models (AGCMs) for operational seasonal forecasting in South Africa also continued to occur at the Universities of Cape Town and of Pretoria, and at the Council for Scientific and Industrial Research. A notable recent advancement is the development of a fully coupled ocean-atmosphere model at the South African Weather Service (SAWS; Beraki et al., 2014). In addition, a notable acquisition by SAWS is the World Meteorological Organisation's Global Producing Centre for Long-Range Forecasts (GPCLRF) status. As part fulfilment of this obligation, SAWS runs the ECHAM4.5 AGCM (Roeckner et al., 1996) operationally, and so this model is the focus of this paper. However, the ECHAM4.5 forecast ensembles used in this study are obtained from the Data Library of the International Research Institute for Climate and Society (IRI) and not from the archives of SAWS, since the IRI archived data set of this AGCM is more comprehensive. For example, the IRI has available a variety of ECHAM4.5 hindcast sets and for various forecast lead-times. These archived sets can be used to help determine some of the modelling strategies that SAWS, and possibly other institutions in South Africa involved with AGCM operations, can follow in order to optimise their own operational seasonal forecasting systems.

Employing predicted or persisted SST anomalies in AGCMs provides a means of generating forecasts of seasonal-average weather (Graham et al. 2000; Goddard and Mason, 2002), since the evolution of global sea-surface temperature (SST) anomalies over several months ahead is predictable, especially over the tropics, even with statistical models (Landman and Mason, 2001). Coupled ocean-atmosphere general circulation models (CGCMs) have also been increasingly used worldwide for operational seasonal forecast production (e.g. DeWitt, 2005; Graham et al., 2011). Furthermore, it has been shown through the DEMETER (Development of a European Multimodel Ensemble system for seasonal to inTERannual prediction) project that fully coupled systems can predict both the evolution of SSTs and atmospheric conditions at elevated levels of

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