Seasonal rainfall predictability over the Lake Kariba catchment area

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ABSTRACT

The Lake Kariba catchment area in southern Africa has one of the most variable climates of any major river basin, with an extreme range of conditions across the catchment and through time. Marked seasonal and interannual fluctuations in rainfall are a significant aspect of the catchment. To determine the predictability of seasonal rainfall totals over the Lake Kariba catchment area, this study used the low-level atmospheric circulation (850 hPa geopotential height fields) of a coupled ocean-atmosphere general circulation model (CGCM) over southern Africa, statistically downscaled to gridded seasonal rainfall totals over the catchment. This downscaling configuration was used to retroactively forecast the 3-month rainfall seasons of September-October-November through February-March-April, over a 14-year independent test period extending from 1994. Retroactive forecasts are produced for lead times of up to 5 months and probabilistic forecast performances evaluated for extreme rainfall thresholds of the 25th and 75th percentile values of the climatological record. The verification of the retroactive forecasts shows that rainfall over the catchment is predictable at extended lead-times, but that predictability is primarily found for austral mid-summer rainfall. This season is also associated with the highest potential economic value that can be derived from seasonal forecasts. A forecast case study of a recent extreme rainfall season (2010/11) that lies outside of the verification period is presented as evidence of the statistical downscaling system's operational capability.

Keywords: Lake Kariba catchment, coupled ocean-atmosphere model, statistical downscaling, seasonal forecasting, economic value

INTRODUCTION

Southern Africa is a region of significant rainfall variability at a range of temporal and spatial scales and is prone to serious drought and flood events (e.g. Tyson, 1986); Nicholson et al., 1987; Lindesay, 1998; Reason et al., 2000). The region is also sensitive to precipitation shifts and variability (IPCC, 2007; Reason et al., 2006). Despite the diverse climatic zones, rainfall in southern Africa is mainly observed during the austral summer between October and May. The future spatial and temporal rainfall distribution and variability is uncertain (Gordon et al., 2000; Hachingonta et al., 2007). The region's summer climate is mainly driven by oscillations of the inter-tropical convergence zone (ITCZ) (Beilfuss, 2012). The temporal and spatial distribution of convection is associated with evaporative losses that strain food and water resources (Jury et al., 1999; Lyon B, 2009). The South Atlantic and Indian Oceans, being the major sources of moisture for southern Africa, play a major role in determining the spatio-temporal variations of rainfall in the region (Matarira and Jury, 1992; Levey and Jury, 1996; Jury et al., 1999). The aforementioned studies have provided ample evidence for regional forcing features of composite wet and dry spells caused by the atmospheric circulation. Harrison (1986), Harangozo, (1989) and Barclay et al. (1993) have found that the seasonal cycle of convective spells over southern Africa and the surrounding oceanic basins during the austral summer are characterised by equatorial extratropical temperature gradients. This is caused by differential solar heating between the equator and the mid-latitudes. A more recent study has determined how the external forcing of major wet spells over southern Africa varies through the summer (Fauchereau et al., 2009). The wet spells occur at intervals of approximately 20 to 35 d (Levey and Jury, 1996), and half of all of the wet spells appear quasi-stationery from November to March. Southern Africa is a predominantly semi-arid region with a high degree of interannual rainfall variability. Although much of the recent climate research has focused on the causes of drought events, the region has also experienced extremes of above-average rainfall (Washington and Preston, 2006), the most recent examples being the major flooding episodes that devastated Mozambique during 2010 and 2011 when many people were killed and nearly 200 000 people made homeless.

There is increasing change in high rainfall events in some parts of the southern Africa region (Reason et al., 2014). The variability of such rainfall can have detrimental consequences for water resources, population and property. This variability can affect the sustainability of major dams and reservoirs due to flood risks to the population and properties on the floodplain. The region's water resources, agriculture and rural communities are impacted considerably due to high rainfall variability (Cook et al., 2004). The remote influence of El-Niño–Southern Oscillation (ENSO) events has been seen to be contributing to major floods and drought events in southern Africa (Mason and Jury, 1997; Cook, 2000 Reason and Rouault, 2002). Southern African precipitation shows high variability at all timescales (Mason and Jury, 1997). The proximity of the Agulhas, Benguela, and Antarctic circumpolar currents leads

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