Review of recent developments in seasonal forecasting of rainfall

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Abstract

General circulation models generally provide underestimates of the seasonal forecastability of the atmosphere as a result of their inability to simulate adequately the atmospheric response to sea-surface temperature anomalies and because of their exaggeration of the effects of the chaotic behaviour of the atmosphere. As a result, statistical forecast models will continue to provide a useful supplement to the dynamic models, although there is a need for the statistical models to capture explicitly the non-linear behaviour of the ocean-atmosphere system. Of concern, however, is the observation that forecast skill in many areas of the world appears to have decreased since the late 1980s. Careful validation of this possibility is required for South Africa.

Introduction

Because of the high degree of inter-annual rainfall variability in the Southern African region, skilful seasonal forecasts could greatly assist in planning policies for the amelioration of drought and flood conditions (Vogel, 1994). Partly in response to the devastating effects of the 1991/92 drought in Southern Africa, the South African Weather Bureau (SAWB) and a number of research groups in the South African universities have begun to release seasonal rainfall forecasts in the last few years (Mason et al., 1996). In October 1994, at the initiative of the SAWB, the South African Long-lead Forecast Forum (SALFF) was founded with the purpose of developing and co-ordinating the seasonal forecasting capabilities of the country. Mason et al. (1996) presented a review of the prospects for the further development of the capabilities for Southern Africa, concluding that there are good prospects for improving seasonal forecast skill and lead-times over most of the region. Much of the predictability of rainfall over Southern Africa is attributable to variability in the tropical atmospheric circulation, which responds directly to boundary forcing such as sea-surface temperature anomalies, including El Nino events. As a result, highest forecast skills are obtainable for the peak rainfall months December to February over the summer rainfall region. In this review, an update of international developments in seasonal forecasting since the Mason et al. (1996) review is presented and implications for forecasting capabilities in Southern Africa are discussed.

Developments in seasonal forecasting using statistical methods

Estimating the potential predictability of the atmosphere

The potential for predicting atmospheric variability beyond the two-week limit of numerical weather forecasting arises for two reasons. Firstly, certain features of the large-scale components of the atmosphere may have greater predictability than the synoptic conditions, which tend to display a higher degree of chaotic behaviour. The large-scale atmospheric components, such as westerly waves, may have some influence on the probability of individual synoptic weather patterns, thus making probabilistic forecasts of general conditions beyond two weeks possible. A second source of potential predictability of the atmosphere comes from the influence of more slowly evolving boundary conditions such as sea-surface temperatures, snow cover and soil moisture. These boundary conditions can have an important influence on the overlying atmospheric circulation.

Estimates of the potential predictability of the atmosphere have been made using general circulation model (GCM) output. The atmospheric modelling intercomparison project (AMIP) has provided an opportunity for estimating potential predictability from boundary-layer forcing, specifically from sea-surface temperatures. The project involved the GCM-simulation of atmospheric variability for the 10-year period 1979 to 1988 using observed sea-surface temperatures for the same period. The simulated ensemble variability for the AMIP period could then be compared with the ensemble variability of control runs, using unvarying climatological sea-surface temperatures (Dix and Hunt, 1995). If sea-surface temperatures do provide a source of atmospheric predictability then the correlations between individual GCM AMIP experiments, differing only in their initial conditions, should be significant. In Fig. 1 the average correlations between three ensembles are represented for the CSIRO nine-level GCM (Dix and Hunt, 1995). The results confirm that most predictability lies within 20° of the equator, and particularly in areas where rainfall is predominantly from a single well-organised quasi-permanent circulation system, such as the Inter-Tropical Convergence Zone (Hastenrath, 1995). Tropical sea-surface temperatures are the main source of predictability, even within the mid-latitudes (Lau and Nath, 1994). Unfortunately, even within the tropics, estimated potential predictability is disproportionately small over the land area (Dix and Hunt, 1995) (Fig. 1), including over Southern Africa (Harrison, 1996).

Sea-surface temperatures are generally prescribed in general circulation models to provide forecasts of the state of the atmosphere with lead-times of about one to five or six months. For lead-times of about two weeks to one month, extended-range numerical weather forecasts are provided (Palmer and Anderson, 1994), which are based on attempts to model the evolution of the

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