EL NIÑO SOUTHERN OSCILLATION BASED RAINFALL FORECASTS IN SOUTHERN AFRICA. I. SEASONAL FORECASTS CAN HELP COMMUNAL FARMERS MANAGE DROUGHT

D.H. Cobon[1], L.S. Unganai[2] and J.F. Clewett[1]

[1] QDPI, Queensland Centre for Climate Applications, PO Box 102, Toowoomba, Qld 4350, Australia.
E-mail: david.cobon@dpi.qld.gov.au and jeff.clewett@dpi.qld.gov.au
[2] Department of Meteorological Services, Belvedere, Harare, Zimbabwe. E-mail: advisor@weather.utande.co.zw

ABSTRACT

Drought is the single most important natural disaster affecting some parts of southern Africa virtually every year. Because of the region's heavy dependence on rain-fed agriculture, drought is usually associated with widespread crop failure, livestock deaths, environmental degradation, famine and socio-economic stress. Reliable seasonal rainfall forecasts could lead to proactive drought mitigation strategies. In this study, the utility of probabilistic seasonal forecasts was examined in terms of forecast skill and timeliness for decision making. The Southern Oscillation Index (SOI) in spring was a useful indicator of summer rainfall (Nov-Mar) for c. 50% of stations in southern Africa and of drier than normal conditions for c. 20% of stations. The SOI average would have been useful to forecast severe droughts in parts of southern Africa between 1930 and 1992. The El Niño Southern Oscillation (ENSO) signal was greatest in central South Africa, Zimbabwe, Tanzania and Kenya. Forecast lead-times were 0-2 months, which was considered adequate for decision making by communal farmers - provided the forecasts were relevant and tailored for the local area. The climate analysis package Rainman International with international data is a useful forecasting tool on sub-continental and local scales. Training of agricultural extension officers in the use of climate analysis software like Rainman International is necessary to ensure effective dissemination to, and application of forecasts by, communal farmers.

Keywords: El Niño Southern Oscillation, daily rainfall forecasts, Zimbabwe

1. INTRODUCTION

Much of southern Africa is predominantly semi-arid and experiences high interannual rainfall variability. Most the population rely on rain-fed agriculture and cycles of drought and flood impact negatively on food production and socio-economic well-being. A principal cause of interannual rainfall variability is the El Niño Southern Oscillation (ENSO) (Lindesay 1998, Mason & Jury 1997). Rainfall anomalies in tropical eastern Africa tend to be out of phase with those in subtropical southern Africa (Nicholson 1986); in general, the tropics are drier when subtropical southern Africa is wetter (e.g. 1974, 1976), and vice versa (e.g. 1982). Forecasting ENSO events can help people prepare for climate extremes, provided there is sufficient advance warning and the forecasts are tailored and disseminated to rural areas (Phillips, Makaudze & Unganai 2001). To be useful, forecasts must demonstrate skill and a significant shift in probabilities from climatology. Extension officers in local areas play an important role in agricultural decision making, and training them in the use of climate tools may be one way of improving decision making in relation to climate.

In this paper, Rainman International is used to assess the impacts of ENSO on summer rainfall in southern Africa at subcontinent and local scales, to determine the skill of forecasts and to identify their usefulness to subsistence agriculture in terms of forecast lead-times and shifts in probability distributions from climatology.

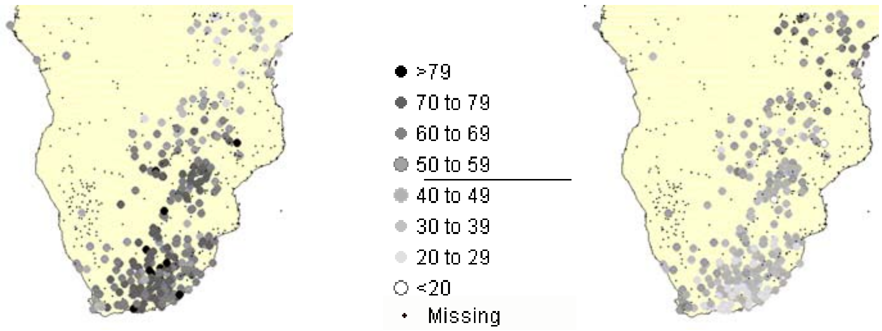
2. MATERIALS AND METHODS

Southern Africa was defined as that part south of the equator. Monthly summer (Nov-Mar) rainfall data was obtained from the National Climate Data Centre, USA for 675 stations. Stations were selected for 90% completeness of record between 1930 and 1990. A total of 281 stations (42%) were analysed using Rainman International (Clewett *et al*. 1999, Clewett *et al.* 2003). The impact of ENSO on summer rainfall was measured as the percent chance of rainfall (median rainfall at sub-continental scale) in categories of the 3 month average SOI (Clewett *et al.* 1991) compared to climatology at monthly lead-times of 0 to 3 months. The Kruskal-Wallis (KW) and Kolmogorov-Smirnov (KS) (Conover 1971) tests assessed the significance of SOI relationships with rainfall. Statistical significance was indicated if

KW and KS tests were at least 0.9, with the KW test indicating difference of the SOI categories from climatology and KS indicating SOI category specificity.

3. RESULTS

During the months Aug-Oct an average SOI > 5 was associated with above median rainfall in central South Africa and Zimbabwe and below median rainfall in southern Kenya and Tanzania (Figure 1). The opposite occurred for SOI <-5.



SOI > 5 SOI < -5

Figure 1. Percent chance of exceeding median summer rainfall (Nov-Mar) when the SOI average (Aug-Oct) is either >5 or <-5. (Source Rainman International).

The ENSO signal decreases with greater forecast lead-times, with the forecasts from 55%, 54%, 20% and 16% of locations differing significantly (KW ≥ 0.90) from climatology at lead-times of 0-3 months respectively. Local-scale analysis confirmed summer rainfall anomalies in locations representing northern and southern parts of the subcontinent to be out of phase (Figure 2).

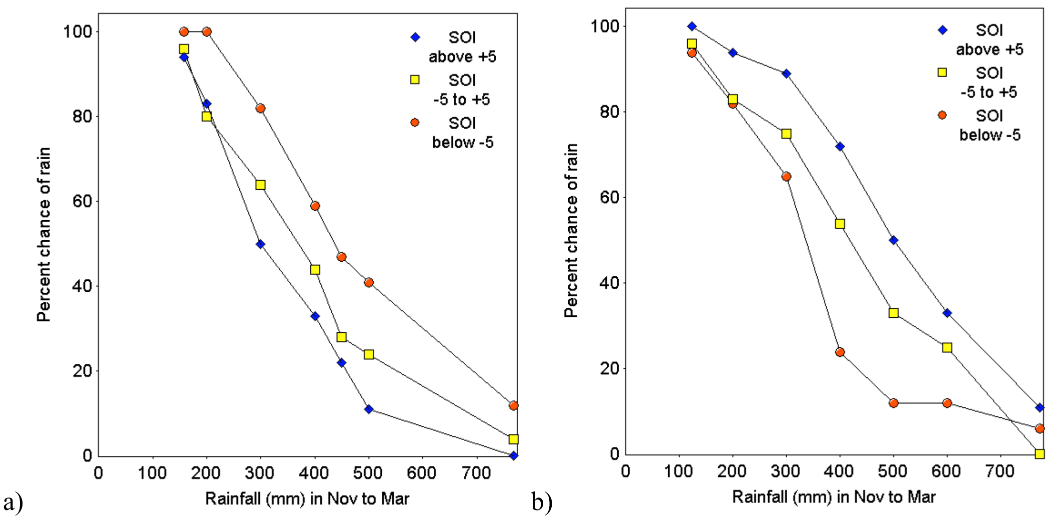
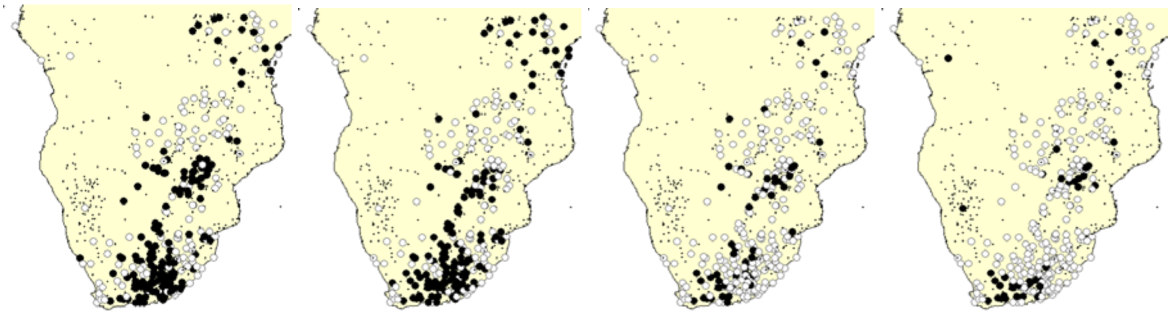


Figure 2. Percent chance of summer (Nov-Mar) rainfall using SOI average (Aug-Oct) at a) Narok, Kenya (Lat. $1^0$06'S Long. $35^0$47'E) (KW=0.96, $KS^{\#}$=0.90) and b) West Nicholson, Zimbabwe (Lat. $20^0$59'S Long. $29^0$22'E) (KW=0.97, $KS^{\#}$=0.99).$^{\#}$ SOI<-5. (Source Rainman International).

The percent chance of receiving mean summer rainfall (425 mm) at West Nicholson in Zimbabwe was 20% and 65% for years when the SOI was <-5 and >5 respectively. For most locations the skill in the forecasts occurred for La Niña rather than El Niño conditions (Figure 3). The average SOI over Aug-Oct (zero lead-time) was <-5 in 17 years and >5 in 18 years of the 60 year record used here, and was -10.9, -12.2, -11.6, -21.7 and –12.3 before the major drought summers of 1946-47, 1965-66, 1972-73, 1982-83 and 1991-92 respectively.

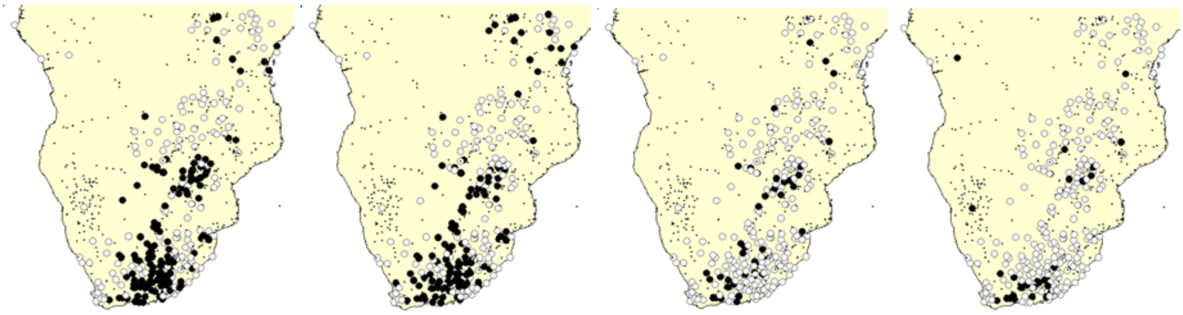


Zero lead-time
55% stations

1 month lead-time
54% stations

2 month lead-time
20% stations

3 month lead-time
16% stations



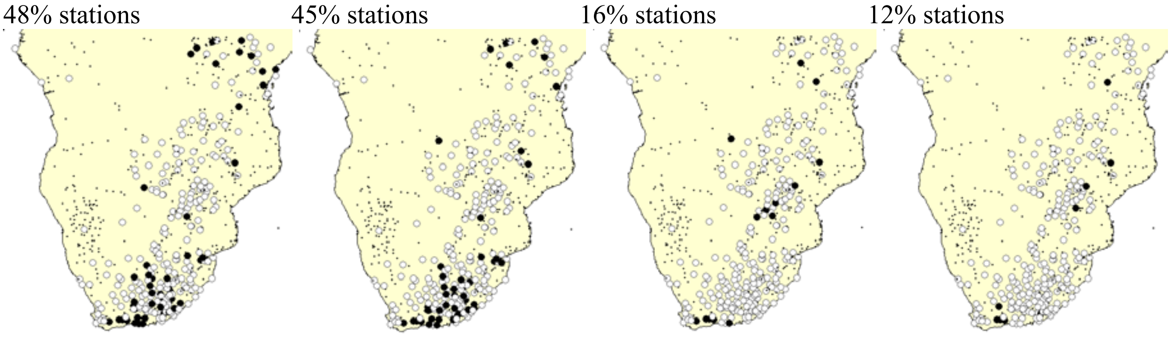
SOI > 5

Zero lead-time
48% stations

1 month lead-time
45% stations

2 month lead-time
16% stations

3 month lead-time
12% stations



SOI < -5

Zero lead-time
17% stations

1 month lead-time
16% stations

2 month lead-time
5% stations

3 month lead-time
4% stations

Figure 3. Locations with significant KW ($P \geq 0.90$) (top panel) indicating useful skill of a summer (Nov-Mar) rainfall forecast at lead-times of 0-3 months, and significant KW and KS ($P \geq 0.90$) when the 3 month average SOI was either >5 (middle panel) or <-5 (bottom panel). ○ KW or KS < 0.90, ● KW or KS ≥ 0.90. (Source Rainman International).

4. DISCUSSION

The use of ENSO based probability forecasts for summer rainfall can help reduce the impacts of drought in southern Africa. They showed useful skill at most of the locations, they provided useful shifts in the probability distributions in over 50% of years and they accurately predicted the onset of severe drought. Lead-times of 0-2 months may provide adequate time to disseminate forecasts to communal farmers. Rainman International can tailor forecasts for a local area as well as providing overviews at the subcontinent scale. Providing forecasts are relevant and tailored, farmers can adjust decisions such as area planted, choice of crop and variety, fertilizer application or animal numbers. However, farmers must also understand probabilistic forecasts and have the confidence to use them in decision making. Experience in Australia indicates that this is most likely to occur in regions where climate extension officers work with farmers. Regional climate champions running 'train-the-trainer' workshops for extension officers can be used to foster the application of seasonal forecasts in communal areas. Rainman International is an easy-to-use tool for extension officers, which provides both a continental and local assessment of rainfall forecasts.

5. ACKNOWLEDGEMENT

This work was funded by the Australian Centre for International Agricultural Research.

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