Structure and precursors of the 1992/93 drought in KwaZulu-Natal, South Africa from NCEP reanalysis data

Lawrence T Dube* and Mark R Jury
Department of Geography & Environmental Studies, University of Zululand, KwaDlangezwa 3886, South Africa

Abstract

The historical context and potential causes and structure of the 1992/93 drought in KwaZulu-Natal are analysed using NCEP reanalysis data. The analysis indicates that increased westerly winds with surface marine lows and continental highs prevailed over Southern Africa. Anomalous divergence and subsidence occur over the eastern subcontinent, coupled with reduced tropical moist inflows. Mid-latitude confluence, anticyclonic vorticity and upper level convergence suppressed convection over KwaZulu/Natal. The precipitable water field reflects a SE-NW orientated stationary wave-train pattern over Southern Africa with KwaZulu-Natal anti-phase with the Zambezi valley. A meridional overturning cell is seen as a driving mechanism behind the 1992/93 drought over South Africa. The velocity potential shows a dipole between the Zambezi and the SW Indian Ocean, and it appears that the kinematic structure was more important than the thermodynamic. Impacts include a reduction in crop yield and streamflows, and a slowing of economic activity.

Keywords:

Introduction

The majority of the population in Southern Africa rely on agriculture at a subsistence level for food and are particularly susceptible to changes in rainfall and climate. This problem is exacerbated by the high degree of inter-annual and intra-seasonal rainfall variability over the Southern African subcontinent (Preston-Whyte and Tyson, 1988; Crimp, 1997). Another factor compounding the drought problem is the growing population of Southern Africa which is placing increasing pressure on already limited water resources. Improving the understanding and prediction of the weather systems affecting Southern Africa will be of assistance to engineers, hydrologists and agriculturalists in effective water management and in ensuring food security for the population.

Widespread and sustained droughts that have periodically afflicted Southern Africa over the past three decades are those in 1964, 1968, 1970, 1982, 1983 and 1984, often in association with the El Niño (Preston-Whyte and Tyson, 1988). From 1987 to 1996 KwaZulu-Natal experienced a gradual decline and rise of rainfall (Fig. 1a), with the minimum reached in 1992/93. Various drought simulation studies with predicted sea surface temperatures (SSTs) as inputs, have been undertaken in South Africa and elsewhere (Walker, 1989; Hunt, 1991; Mason., 1992; Montecinos et al., 1997; Mullan et al, 1997; Rautenbach, 1997; Ronchail, 1997; Pathack et al., 1993; Landman et al, 1997; Rocha and Simmonds, 1997 a, b; Thiao and Barnston, 1997). Statistical techniques have also been employed (Landman, 1994; Hastenrath, 1995; Mason et al., 1996; Landman et al., 1997; Jury, 1998) to demonstrate structure and causality. QBO signals and ENSO teleconnections to climate anomalies over Southern Africa have been studied (Lindesay, 1988; Jury, 1992; Jury and Levey, 1993; Jury et al., 1993; Jury et al., 1994; Pathack et al., 1993; Jury, 1997). All these efforts highlight a wide scope to be covered in search of improved drought forecasting skill and a better understanding of drought-inducing meteorological processes. Acquiring accurate drought forecast skills has been such a priority that National Meteorological Services and tertiary institutions across Africa are undertaking research on this application whose value is increasingly appreciated by agriculturalists, hydrologists and politicians for decision-making (South African Weather Bureau, 1992; Jury, 1996). It is against this background that a study on precursors of the 1992/93 drought over KwaZulu-Natal was accomplished.

Background and methods

KwaZulu-Natal is located along the east coast of South Africa. Climatologically it is classified as a summer rainfall region. The altitude ranges from sea level to over 3 000 m, resulting in a considerable range in temperature. Topography varies from the flat coastal plains of Maputaland to the rugged, broken terrain of the Valley of a Thousand Hills and the Drakensberg Mountains. The rainfall also varies considerably, from 500 mm to over 2 000 mm/a. River systems of the province run west to east, cutting through geological layers and resulting in deeply incised valleys (Camp et al., 1995; Camp, 1997). Extremes of maximum temperatures and evaporative losses are low due to the moderating effect of the Agulhas Current.

With this variation in topography, geology and climate, KwaZulu-Natal possesses enormous diversity of natural resources. In recent years, however, increased water demand from the urban, industrial, and agricultural centres has placed an untenable burden on the environment. Following the 1992/93 drought, urban water restrictions were in force, many farmers went bankrupt, and there were major economic repercussions (Financial Mail, 1993a, b, c; The South African Sugar Association, 1993a, b, c; Landbouweekblad, 1993; Farmer's Weekly, 1993).

* To whom all correspondence should be addressed.
☎+27 35 902 6324; fax: +27 35902 6338 e-mail: ltdube@pan.uzulu.ac.za
Received 23 March 2001; accepted in revised form 11 December 2002.