Intensity and spatial extension of drought in South Africa at different time scales

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Abstract

The standardised precipitation index (SPI) is an index that allows monitoring the intensity and spatial extension of droughts at different time scales (3, 6, 12 and 24 months). The SPI is linked to the probability occurrence of dry or wet events. The SPI allows monitoring operationally any location with a 30-year time series. It is also used here to do a retrospective analysis of the spatial extension and intensity of droughts in South Africa since 1921. According to this index, the 8 most severe droughts at the 6-month time scale for the summer rainfall region of South Africa happened in 1926, 1933, 1945, 1949, 1952, 1970, 1983 and 1992. There is considerable decadal variability and an 18 to 20 year cycle is only found in the number of dry districts. The total number of wet and dry districts per decade seems to have increased since the 1960s. Drought lasting 3 years is not uncommon for each of the 8 South African rainfall regions defined by the South African Weather Service. Combining the retrospective analysis with real time monitoring could be extremely beneficial in the development of response, mitigation strategies and awareness plans.

Keywords: South African drought, drought monitoring, El Nino, climate change

Introduction

Drought is a regular and recurrent feature of South African climate. A drought is a shortage of precipitation over an extended period. Its impact on society depends on its intensity but also on its duration. Over Southern Africa, the recent period (since 1970) is characterised by strong interannual rainfall variability. In particular, countries experienced more intense and more widespread droughts (Richard et al., 2001). A common time-scale for agricultural droughts is the season (3 to 6-month time scales) when deficiency in precipitation results in damage to crop (Harsch, 1992). Studies of the normalised vegetation index dataset (Los et al., 1994) show that the impact of droughts on vegetation (Farrar et al., 1994) is particularly strong where annual rainfall amount varies from 300 to 500 mm (Richard and Poccard, 1998). This is the case for most of South Africa. Hydrological drought is associated with precipitation shortage on a longer time scale (12 months to 2 years or more) and its effect on surface or subsurface water supply (Meigh et al., 1999). Although all droughts originate from a lack of precipitation, hydrologists want to know how the precipitation shortage influences the hydrological system. As a result hydrological or agricultural drought can be out of phase and their impacts on various economic sectors can be appreciably different. It takes longer for precipitation shortage to become evident in soil moisture, streamflow, groundwater and dam levels. It is therefore useful to define a drought index that will represent different time scales from 3 months to 2 years.

Hayes et al. (1999) used the standardised precipitation index (SPI) to monitor the 1996 drought in the United States of America. They show how the SPI can be used operationally to detect the start of a drought, its spatial extension and temporal progression Hayes et al. (1999) shows that the onset of the drought in the USA in 1996 could have been detected one month in advance of the Palmer Drought Severity Index (PSDI). The PDSI (Palmer, 1965) is the most used index in the USA but has some limitation (Guttman, 1998; McKee et al, 1995). Although it is quite a recent index, the SPI was used in Turkey (Komuscu, 1999), Argentina (Seiler et al*;*, 2002), Canada (Anctil et al.; 2002), Spain (Lana et al.; 2003), Korea (Min et al.; 2003), Hungary (Domonkos, 2003), China (Wu et al*.;* 2001) and Europe (Lloyd-Hughes and Saunders; 2002) for real time monitoring or retrospective analysis of droughts. The SPI is consistent with regard to the spatial distribution of rainfall that occurs with great variability in South Africa due to geographical location, orography and the influence of the oceans. Using that index to develop a climatology of the spatial extension and intensity of droughts gives also an additional understanding of its characteristics and an indication of the probability of recurrence of drought at various levels of severity.

The main goal of this paper is to present the SPI and its potential use for real time monitoring of spatial extension and intensity of droughts in South Africa. Because we can learn from past events or compare real time with similar past conditions, the SPI of the 93 SAWS (South Africa Weather Service) rainfall districts at different time scales was calculated at the end of every month since 1922 and displayed on a chart of South Africa. This atlas is available on a web site (http://www.egs.uct.ac.za/~rouault/spi1.html). An extract from the atlas displays the intensity and spatial extension of the 20 worst droughts since 1922 at the 6-month scale at the end of April. Another one show the conditions at different time scale at the end of December 1982, beginning of the most severe drought since 1921 according to the SPI. The last part of the paper show that the SPI is also valuable when studying the interannual and interdecadal variability of rainfall in South Africa and provide new insights on the topic.

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Received 15 May 2002; accepted in revised form 30 July 2003.