Development of a multi-year climate prediction model

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Abstract

The available water resources in Southern Africa are rapidly approaching the limits of economic exploitation. The situation is compounded by claims that global warming will have a serious adverse effect on future water supplies. There was therefore an urgent need to characterise the numerical properties of the hydrometeorological processes in such a way that the effects of global warming, if any, could be evaluated and accommodated. Other than increases in both areal rainfall and open water surface evaporation, no other changes were detected, that could be attributed to climate change arising from human activities. Nor is there evidence to support the view that such changes are likely to occur within the normal planning horizon of the next 30 years. A climate prediction model was developed based on the statistically significant 21-year periodicity in the hydrometeorological processes, and its direct association with corresponding periodicity in solar activity.

Keywords: climate change, climate model, water resources

Introduction

The Commission of Enquiry into Water Matters was appointed by the State President of South Africa on 1 July 1966. The Commission's report RP 34/1970 was published in 1970. The report led to the establishment of the Water Research Commission (WRC). One of the recommendations made in the report was:

> Long range weather forecasts, if reliable, can provide valuable information for the operation of storage works and for planning of irrigation programmes and can aid in improving the efficiency of water utilisation. The Commission recommends, therefore, that thorough investigations and research be promoted by the Weather Bureau and other interested organisations into the possibilities of making reliable long-range weather forecasts up to a year or more ahead.

Thirty years have passed and still no such methods have been developed, while the need for them has become critical. It was with this urgent need in mind that studies were commenced some three years ago. Right from the beginning, it was obvious that the task would be difficult, otherwise a forecasting method would have been developed long ago. It was equally obvious that the perfect method would not be achievable. The objective was to develop a general model that would be of immediate use as well as provide the basis for future applications, particularly the incorporation of the effects of climate change, should such effects be demonstrated numerically with an acceptable degree of confidence.

Claims have been made that human activity has accelerated global warming, and this in turn will result in increased variability in the hydrometeorological processes, specifically rainfall and river flow, which together pose a threat to water supplies (Intergovernmental Panel on Climate Change, 2001). While there have been a number of publications addressing the hydrological aspects of climate change (Paoli, 1994; Abu-Zeid et al., 1992; Fantechi et al., 1991 and Duplessy et al., 1990 for example), most of them start with the assumption that climate change will have an adverse effect on the hydrological processes, without assessing the validity of the claims or quantifying the hydrological responses to the degree required by water resource planners. These claims will remain suspect until quantifiable linkages can be found between atmospheric processes and hydrometeorological responses. An ultra-cautious approach was adopted in the analyses in view of the high level of international controversy that exists.

Data

The largest and most comprehensive hydrometeorological database yet assembled in South Africa was studied. It consisted of 11 804 years of data from 183 sites and 7 different hydrometeorological processes. Details are given in Table 1.

TABLE 1
Database used in the analyses

Set	Process	Stations	Years
1	Water surface evaporation	20	1 180
2	Concurrent rainfall	20	1 180
3	District rainfall	93	7 141
4	River flow	28	1 877
5	Flood peak maxima	17	1 235
6	Groundwater	4	312
7	Southern oscillation index	1	114
	TOTAL	183	11 804

The sites were selected on the basis of their geographical representativeness and long, reliable records. All except two of the records (Southern Oscillation Index and Zambezi River flow) were extracted from official databases operated by the South African Weather Service (SAWS) and the Department of Water Affairs and Forestry (DWAF). Other than minor patching of missing data, the data were not smoothed, filtered or in any way manipulated before or during the analyses.

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