Hydrological simulation as a tool for agricultural drought assessment

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Abstract

Following a discussion on the concepts of drought and of hydrological modelling, the ACRU Model is described and then applied at three locations in Natal in order to compare the severity of the 1979-1983 drought with previous droughts in the past 50 years. This is done by using the Model as a simulator of runoff, of supplementary irrigation requirements and of crop yields. Hydrological modelling is shown to be a potentially powerful tool in rational drought assessment. The simulations indicate that the current drought may be classed as the worst experienced in the past 50 years. However, the results also indicate that drought in terms of water resources and water requirements and crop yields do no necessarily coincide.

Introduction

That the intensity of the drought of the early 1980's has reached crisis proportions over many parts of Southern Africa is felt by rural and urban dweller alike. Irrigating time allotments have been curbed, farm dams have dried up, a succession of crop failures has placed severe demands on assistance to farmers by the State and urban water usage has been restricted by up to 50%. It has been maintained by many that this is the worst drought in "living memory" and stated by public officials that we are in the grips of the "200 year" and even the "500 year drought".

As scientists it is important that perceptions of a natural hazard such as drought do not cloud our objectivity and it is up to us to make rational assessments of the situation we are in. Within the scope of hydrology and engineering in an agricultural context our concerns He with the effects of drought

- on water resources supply and demand, i.e. on runoff generated and crop irrigation requirements, and
- on crop yield losses through moisture stress.

A rational method of assessing the above is the application of hydrological modelling to drought situations. In this paper an agrohydrological model developed in the Department of Agricultural Engineering at the University of Natal in Pietcrmaritzburg, namely the ACRU Model, is used to illustrate the severity of the drought in terms of runoff, supplementary irrigation requirements and crop yield estimates at three selected locations in Natal. As a preamble to the hydrological model application, the concept of drought is first discussed. Some basic aims and methods of hydrological modelling are then examined, before the ACRU Model is described. Finally simulations arc presented from which the severity of the present drought is viewed in a historic perspective.

Droughts: Concepts

A "normal" climate, as described by mean values, very seldom exists and information concerning the "extremes" of climate is often more important than average conditions. One such "extreme" of climate *is* the phenomenon of drought. A study of drought requires an objective definition but to date no universally acceptable definition has been developed, partly because drought is a ''non-event" as opposed to a distinct event such as a flood (Hershfield, Brakensiek and Comer, 1973).

Drought is a geophysical phenomenon referring to subnormal conditions of water occurrence in some physical environment like the atmosphere, the soil, a region or a river. Confusion arises when an attempt is made to apply a single definition to a drought, According to Thomas (1965), meteorological drought differs from agricultural drought and hydrological drought in turn differs from both of these. A meteorological drought can be defined as a prolonged and abnormal moisture deficiency. Agricultural drought is said to exist when soil moisture is depleted so that the yields of plants are reduced considerably. Both meteorological and agriculrural droughts can be terminated by rainfall. Hydrological drought, on the other hand, can be thought of as a period during which the actual water supply is less than the minimum water supply necessary for normal operations in a particular region (Thomas, 1965). Drought is therefore a relative rather than an absolute condition.

From the above descriptions drought may be understood as being a supply and demand phenomenon. Hence Gibbs' (1975) qualitative definition of it as a "lack of sufficient water to meet requirements" is probably as satisfactory a general definition as any other. It is essential to distinguish at the outset between drought and aridity, where both arc characterized by a lack of water, but, while aridity carries the connotation of a more or less permanent climatic condition, drought is a temporary condition.

Whatever criterion for drought is used, general analysis should always be concerned with the following aspects (Yevjevich, 1967):

- the duration of periods meeting non-cxccedence criteria (for example, x consecutive days with less than y mm per day);
- the probability of occurrence (for example, of a drought of selected duration or intensity);
- its severity;
- its time of occurrence within the annual cycle; and
- its areal extent.

While this assessment does not deal with Yevjevich's five criteria *per se,* it does cover all the criteria indirectly from the specific point of view of drought assessment by hydrological modelling.