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Integrated Catchment Modelling in a Semi-arid Area

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INTRODUCTION

Water management in South Africa is increasingly being shifted towards the public domain as was intended by the National Water Act (1998). This means that water managers, managing Catchment Management Agencies (CMAs) or similar bodies, will increasingly need water quality and quantity management tools to be able to make informed decisions. Integrated catchment modelling (ICM) is regarded as being a valuable tool for integrated water resource management. It enables officials and scientists to make scientifically based decisions on issues such as assessing anthropogenic impacts on water resources, evaluating the assurance of water supply, assessing the impacts associated with land use change, forecasting floods, etc. In this study, the application of a hydrological model for ICM is demonstrated.

MODELLING SYSTEM

The modelling process involves intensive monitoring, description of natural processes, development of model algorithms, model calibration and validation. The spatially distributed parameter, modular J2000 catchment hydrology model was used (Friedrich Schiller University of Jena, Germany). J2000 operates within the JAMS (Jena Adaptive Modular System) framework, including a system library for inputs, outputs and runtime, the process modules describing natural processes and the graphical user interface for visualization of set-up and results.

INPUT DATA

Required input data are digital elevation model (DEM), weather (precipitation, temperature, wind speed, relative humidity, radiation or sunshine hours), vegetation, soil, geology, land use, hydrology (water flow and quality) and hydrogeology.

SETTING UP OF SPATIAL MODEL

DEM, vegetation, land use, geology and soil raster files are generally used to delineate Hydrological Response Units (HRUs, areas that are homogeneous in terms of hydrological response). HRU delineation is performed in ArcInfo to spatially distribute physical parameters (i.e. land use, soil, vegetation and geological properties) across the catchment (**Figure 3**). Functionalities for parameter optimization, statistical and sensitivity analyses are also included in the model.

EXAMPLE OF APPLICATION

The J2000 process model was applied to the Sandspruit seasonal tributary of the Berg River, in the semi-arid climate (300-400 mm a^{-1} precipitation) of the Western Cape (**Figure 1**). The performance of the model was tested by comparing simulated and measured flow at the catchment outlet (**Figure 2**). Statistical analyses indicated a good fit between simulated and observed runoff (**Figure 4**). The model quantifies and outputs a variety of variables in numerical and graphical format, for example potential and actual evapotranspiration (**Figure 5**), the components of runoff (**Figure 6**), infiltration, groundwater recharge etc.

Figure 1: Location of the study area with climate stations

Figure 2: The flow monitoring station at the outlet of the Sandspruit catchment

Figure 3: Example of spatial HRU delineation in the Sandspruit pilot catchment (150 km²)

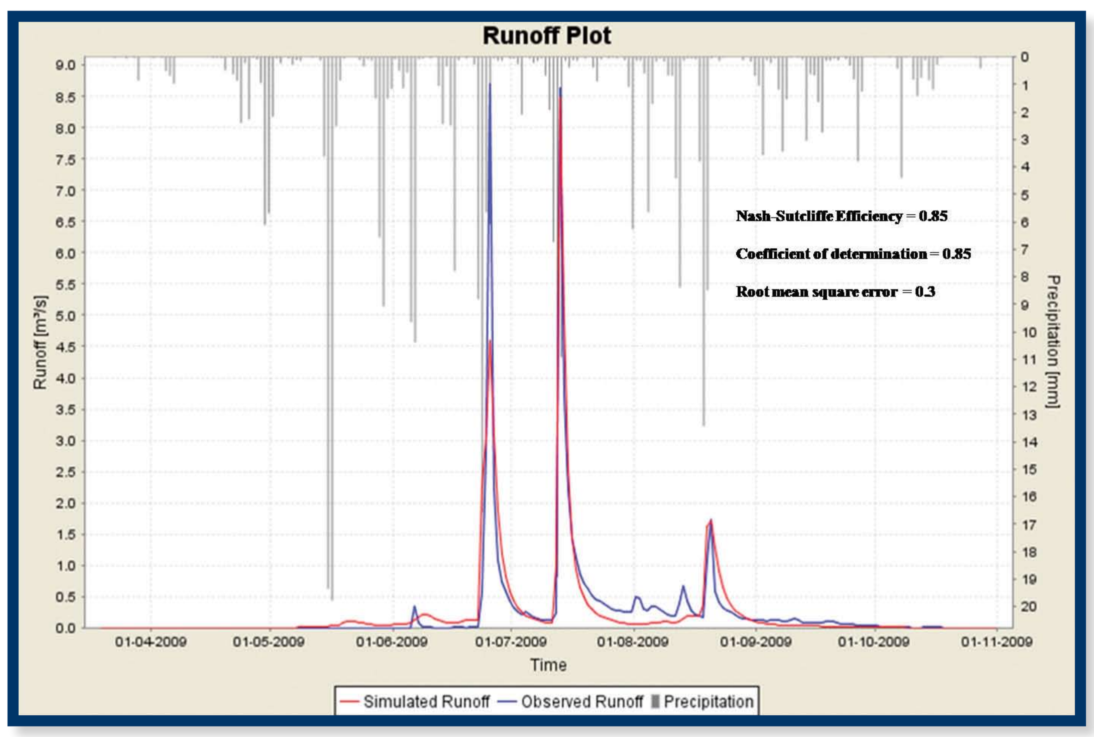

Figure 4: Output graph of simulated and observed runoff obtained with the J2000 hydrological model

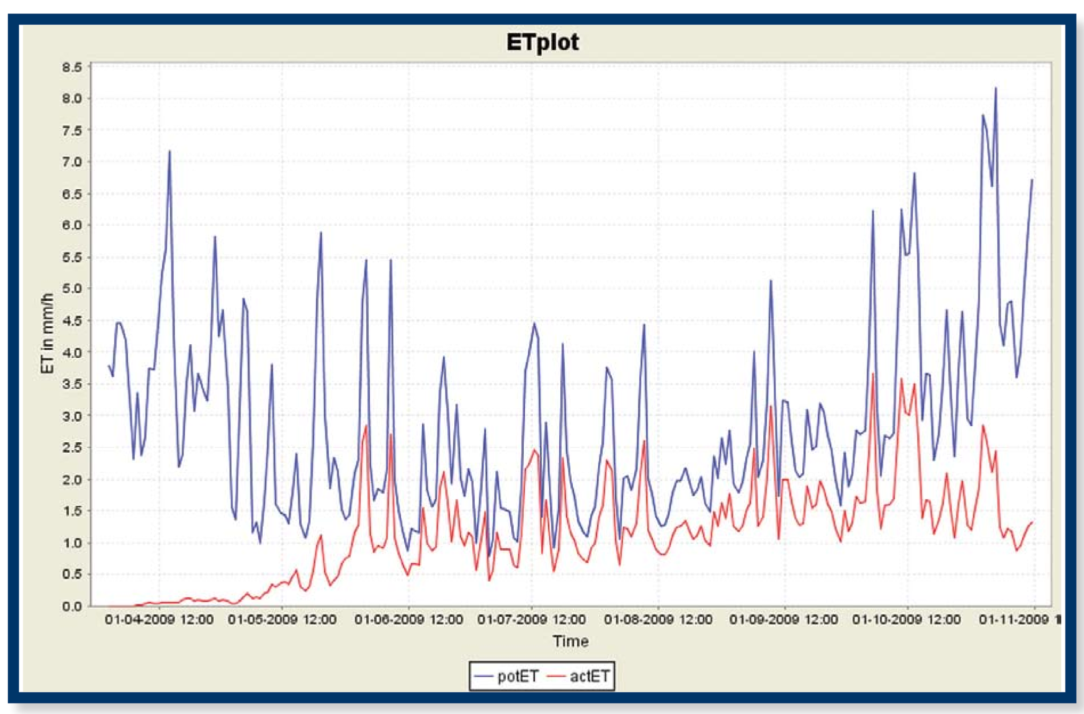

Figure 5: Output graph of actual and potential evapotranspiration

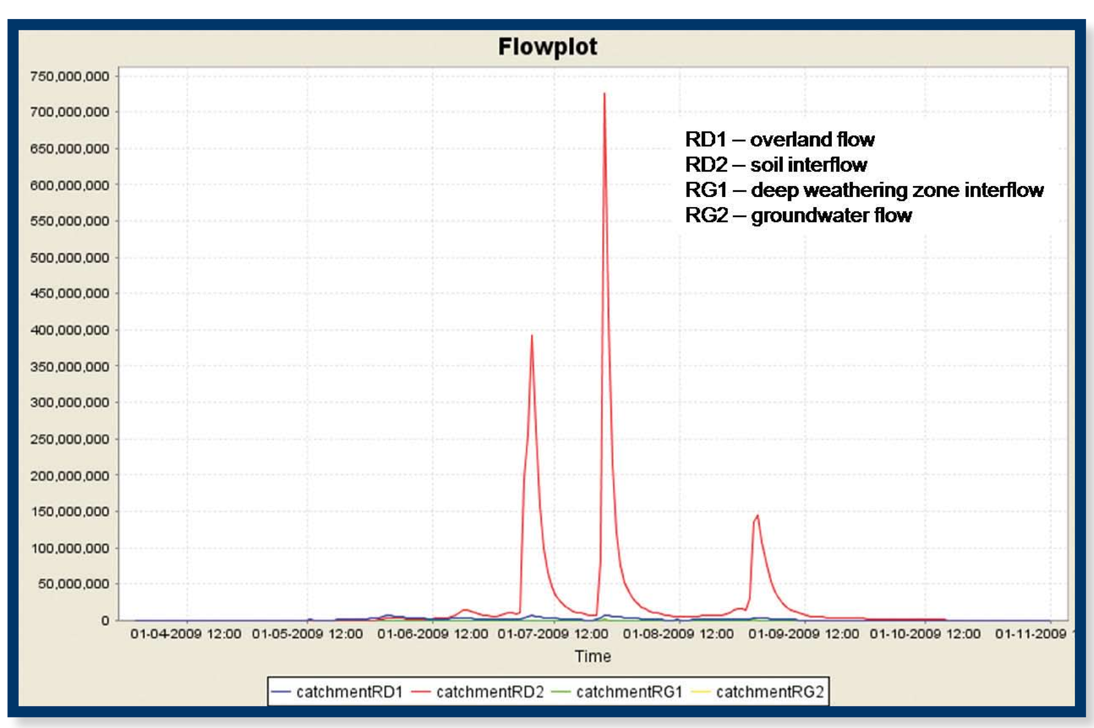

Figure 6: Output graph of streamflow components

DISCUSSION

Model output was found to be very sensitive to the number and spatial distribution of weather stations (**Figure 1**), land use and, to a lesser extent, the number of HRUs. The importance of adequate monitoring (spatial and temporal) of climatic and environmental variables should also be highlighted. Accurate ICM relies on accurate input data and suitable representation of catchment physical properties. The results from this investigation are encouraging for the use of ICM as a water resource management tool. The results obtained require further validation as additional data is collected, before the implementation phase takes place.

ACKNOWLEDGEMENTS

The authors wish to thank CSIR, WRC, NRF and FSU (Jena, Germany)

Integrated catchment modeling is a valuable tool for scientifically-based decision making in water resource management at a catchment scale.

Water Research Commission

NRF National Research Foundation

K-8106 (www.kashan.co.za)