Water SA 46(2) 182–196 / Apr 2020
https://doi.org/10.17159/wsa/2020.v46.i2.8233

Research paper

Verification of runoff volume, peak discharge and sediment yield simulated using the ACRU model for bare fallow and sugarcane fields

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The Agricultural Catchments Research Unit (ACRU) model is a daily time step physical-conceptual agrohydrological model with various applications, design hydrology being one of them. Model verification is a measure of model performance and streamflow, soil water content and sediment yield simulated by the ACRU model have been extensively verified against observed data in southern Africa and internationally. The primary objective of this study was to verify simulated runoff volume, peak discharge and sediment yield against observed data from small catchments, under both bare fallow conditions and sugarcane production, which were located at La Mercy in South Africa. The study area comprised 4 research catchments, 101, 102, 103 and 104, monitored both under bare fallow conditions and sugarcane production, with different management practices per catchment. Observed data comprised: daily rainfall, maximum and minimum temperature, A-pan evaporation and runoff for the period 1978–1995, and peak discharge and sediment yield for the period 1984–1995. The data were checked for errors and and inconsistent records excluded from analysis. Runoff volume, peak discharge and sediment yield were simulated with the ACRU model and verified against the respective observed data. In general, the correlations between observed and simulated daily runoff volumes and peak discharge were acceptable (i.e. slopes of regression lines close to unity, $R^2 \geq 0.6$ and the Nash–Sutcliffe coefficient of efficiency close to unity). Similarly, the correlation between observed and simulated sediment yield was also good. From the results obtained, it is concluded that the ACRU model is suitable for the simulation of runoff volume, peak discharge and sediment yield from catchments under both bare fallow and sugarcane land cover in South Africa.

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DATES
Received: 1 April 2019
Accepted: 3 April 2020

KEYWORDS
ACRU
bare fallow
peak discharge
sediment yield
streamflow
sugarcane

INTRODUCTION

The Agricultural Catchments Research Unit (ACRU) model is a daily time step, physical-conceptual agrohydrological model (Schulze, 1975; Schulze et al., 1995; Smithers and Schulze, 1995; Smithers et al., 1996). In addition, the ACRU model is not an optimising model and parameters are estimated from physical characteristics of catchments. It is a multi-purpose model with application in design hydrology, crop yield modelling, reservoir yield simulation, irrigation water demand and supply, and assessment of climate change, land use and management impacts (Schulze et al., 1995; Jewitt and Schulze, 1999). The ACRU model, together with simulated outputs such as streamflow, soil water content and sediment yield, has been extensively verified against observed data in southern Africa and internationally (Schulze, 2011). To verify is to determine the correctness of simulated output through comparison with observed data, hence model verification is a measure of the model's performance (Schulze, 2011). Model verification can be in terms of either absolute output values or in terms of the relative sequences and orders of magnitude of output responses (Lumsden et al., 2003). For simulations using a daily time-step model to be acceptable, the absolute difference between the sum of simulated streamflow and the sum of observed streamflow should be less than 10%, the slope of the regression line of simulated vs observed values should be close to unity and the minimum acceptable coefficient of determination (R^2) should be 0.60 (Schulze and Smithers, 1995). However, model goodness-of-fit is better evaluated by the Nash–Sutcliffe coefficient of efficiency (NSE) (Nash and Sutcliffe, 1970) than the R^2 because R^2 is insensitive to additive and proportional differences between model simulations and observations (Harmel et al., 2014). The NSE is a normalised statistic from which the relative magnitude of the residual variance compared to the measured data variance is determined (Nash and Sutcliffe, 1970). The NSE shows how well the plot of observed against simulated data fits the 1:1 line, with NSE values close to unity corresponding to a perfect match of the model to the observed data (AgriMetSoft, 2019). In addition, model performance is examined based on its ability to generate reasonable key statistics like percentiles and extreme values (Rashid et al., 2015), and maintain similarities in shapes and distributions of peaks between observed and simulated values (Kim et al., 2014). Continuous assessment of the accuracy and sensitivity of models is vital in the prioritisation of model structure modifications and the identification of more efficient parameterisations (Merritt et al., 2003).

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