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Hydrology and Earth System Sciences Discussions

Interactive comment on "Confirmation of *ACRU* model results for applications in land use and climate change studies" *by* M. L. Warburton et al.

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The authors wish to thank Mr Schmidt for his review of the paper.

On the international use of ACRU

Outside of South Africa, Lesotho and Swaziland, the ACRU model has been applied in Zimbabwe (Butterworth et al., 1999; Makoni, 2001), Eritrea (Ghile, 2004) and further afield in the USA (Martinez et al., 2008) where the model was expanded to accommodate the flatwoods of the southeastern United States, in Germany (Herpertz, 1994; Herpertz, 2001) under snow-melt conditions and more recently in New Zealand (Kienzle and Schmidt, 2008; Schmidt et al., 2009) and Canada (Forbes et al., 2010). The authors acknowledge the difficulty in applying the ACRU model in developing countries where climatic, soils and land use data are not always readily available.

A sentence reflecting the international application of the model has been added to the attached revised manuscript – Section 2.

On the streamflow response variables

Addressed in attached revised manuscript – Section 4.4.

On the goodness of fit statistics used

The goodness of fit statistics used in the paper were the - Average error in flow - Difference between the means - Difference between the standard deviations - Correlation Coefficient - Regression Coefficient (slope) - Regression Intercept - Coefficient of Determination: R2 - NashâĂŤSutcliffe Efficiency Index (Ef) As these statistics are those suggested in Schulze (1995), and Smithers and Schulze (2004), the documentation which supports the ACRU model, it is believed that the ability of the model to represent the surface runoff processes is adequately measured by these statistics.

On Calibration

The ACRU model has been conceptualized and structured as an operational model to be run on catchments where streamflow data are not available, and using national databases of climate, soils, and land use as sources of information, in order to give acceptable results across a range of hydroclimatic regimes. Calibration is a refinement which can be undertaken on catchments with high quality streamflow data, however, few such catchments exist in the developing world or where decisions need to be taken.

For these very reasons no calibration was undertaken as this would distort the applicability of the model. The purpose of this study was to demonstrate the ability of the ACRU model to simulate under a wide range of climatic regimes and land uses using a robust method of configuration where national level datasets (and not detailed field based values) as well as experience-based (but well referenced) default parameters were used, with the objective to demonstrate that the model would be suitable to use in extrapolation situations such as climate and land use change impact studies where data beyond the readily obtainable would not be available. Furthermore, to adjust certain model parameters which have been substantiated through experience, available data and previous applications (and, again, well documented) appears flawed to the authors when it is considered that the quality of the observed streamflow data from operational catchments against which calibration is performed is imperfect and the length of the observed streamflow data is relatively short (Addressed in attached revised manuscript – Section 1).

On splitting the analysis period into dry and wet sequences

Although the model was run for a long historical climate period, the period of available observed streamflow data of acceptable quality that was used in the confirmation study was only 10 years. In addition, within this 10 year period there are a number of missing values. Thus, to split the available observed streamflow data into wet and dry cycles would not give statistically sound results given that the periods of observed data would be short.

On the tradeoff between catchment size and hydrological complexity

The authors agree with the reviewer that when using a model such as ACRU it is important to balance the level of spatial disaggregation with the improvements in model accuracy. A sensitivity study to determine the appropriate levels of spatial disaggregation of a catchment and the level of soil and land cover information required to give the most favorable model results has been undertaken by Smithers et al. (2007). The findings indicated that catchments should not be modelled as lumped entities, but rather disaggregated into relatively homogenous hydrological response units (HRUs). The results obtained by Smithers et al. (2007) agreed with those obtained by Chetty et al. (2003) and Herpertz (1994). The results from these studies were the justification the authors used to decide to disaggregate the Mgeni, Luvuvhu and Upper Breede

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catchments into relatively homogenous HRUs for the purposes of this study.

On the dynamic changes of the variables representing the land use

Each land use unit in the model configuration for this study is assigned a specific land use. However, both between and within years the land use of each unit will have a degree of spatial variation in it as the individual compartments of, say forestry or sugarcane, within a subcatchment were aggregated into the land use unit. Therefore, in the commercial forestry land use unit, for example, individual compartments are lumped together where they may be at different growth stages and with some areas even clear felled. Thus, the variables representing the land use components are age representative of the diversity of growth cycles/stages within the land use unit. The grouping of land uses in this way has been done to balance the level of spatial disaggregation with the improvements in model accuracy. Representing each 'field' which makes up a given land use unit does not improve model accuracy, but simply increases the spatial disaggregation and effort in configuring an operational catchment.

Furthermore, the variables representing the land use components vary month-by-month, thus the growth cycle through the year is represented. The impacts of the year-to-year differences in climate on the land use are incorporated in that during a period of sustained soil water stress the water use coefficients in ACRU are reduced such that the plant suffers a reduction in its physiological functions and loses its ability to transpire at maximum rates. Once the stress is relieved through rainfall (or irrigation) the water use coefficients are adjusted to the initial values over a recovery period which, in ACRU, is temperature dependent.

On documentation of adjunct and disjunct impervious areas

The documentation of the representation of adjunct and disjunct impervious within the ACRU model has been improved (see attached revised manuscript).

On ACRU parameter sensitivity

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An investigation and discussion of the sensitive ACRU parameters is beyond the scope of this study, as a comprehensive analysis of the sensitivity of ACRU variables has been documented by Schulze (1995). Those findings concluded that the output simulated by the ACRU model is most sensitive to rainfall and the soil depth from which runoff generation occurs, and somewhat less sensitive to the coefficient of initial abstraction, the baseflow coefficient, the A and B horizon saturated drainage response and the quickflow response factor.

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Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/7/C3031/2010/hessd-7-C3031-2010-supplement.pdf

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