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Hydrology and Earth System Sciences Discussions

Interactive comment on "A daily water balance model for representing streamflow generation process following land use change" *by* M. A. Bari and K. R. J. Smettem

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Anonymous Referee #4

AC: We would like to thank the referee for open and constructive criticism to our paper. We have responded to it and modified the paper as detail as we possible could. Please see the response below:

General comments:

RC: The processes occurring in the research area are quite distinctive to other areas in the world. This means that the possibilities to compare this study with other studies are little. However, this should not mean that the results are as easily accepted as it is written in the paper. The lack of an appropriate calibration and validation overview, including objective function performances and parameter sensitivity analysis makes

the paper a kind of black box, with a statement that the model is successful, but no explanation except a comparison with previously used models and some single point measurements (shallow boreholes).

AC: Description of the calibration process is elaborated (Section 5). Section 6.3.1 (daily streamflow) elaborated and Table 1 with statistical criteria of model performance has been added. The observed groundwater level was taken as a guide for changes in storage content and parameter calibration. All the parameters were calibrated against observed streamflow data, with some statistical criteria as now added into the text (sections 5, 6.3.1, 6.3.2). The best parameter set gave best performance for predicting both the groundwater level and streamflow.

AC: Presentation of model results was elaborated. Two figures (groundwater level trend and flow duration curves) are now presented and results discussed in detail. Uncertainty of model parameters is now discussed in Section 6.4. The rainfall analysis is again reviewed. There was no instrumental error. Accordingly the text is modified to give a better picture of the model performance (section 6.4).

RC: The 'downward approach' is used to define the model structure, with added complexity when needed. This is a proper way to improve model performance, but, as mentioned in the paper (pg.824), a balance should be found between model complexity and model performance. Maybe, with adding more complexity the performance would even increase. However, no such analysis is undertaken, neither on the performance nor on the complexity.

AC: The 'downward approach' was used to develop the present model and we stopped adding complexity once our objectives were met. Instead of adding more complexity and testing the performance we concentrated on incorporating the salt balance component into the model. For details see - Bari, M.A. and Smettem, K.R.J., 2005b. A daily salt balance model for representing streamflow generation process following land use change, Hydrology and Earth Systems Science Discussions, 2:1147-1183.

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RC: The used model is very flexible, due to the presence of two calibrated probability distribution functions in line, one for the Dry Store depth and one for the Wet Store depth, with a third one with (I assume) fixed values for the Subsurface Store. Adding even more non-linearity by the (ia) parameter makes the model capable of predicting many different runoff reactions. It is therefore not surprisingly that the model is successful.

AC: The model is innovative, simple and flexible. Our ultimate objective is to develop a basin-scale salt and water balance model in which the present model would be used as 'building block'. At the basin-scale the spatial variation of streamflow and salinity is so large (as the present experiment shows) that without a simple flexible 'building block' model, development of a basin-scale model would be extremely difficult if not impossible.

RC: But what physical meaning do the internal storage volumes have? Can this be more accurately verified, by comparison with more field data? So the main question is: How is the spatial distribution of these storage volumes translated to the field.

AC: The upper limit of the store volumes was determined from observed data and is described in the monthly model. How the conceptual soil moisture content of each of the store changes with time was given into the monthly paper (Bari and Smetttem, 2004). Changes in content of all five stores are now discussed in detail in Section 6.3.4 and presented in Table 2. In the Lemon catchment spatial variations were taken into account by dividing it into two subcatchments (cleared, uncleared). Described in Section5.

RC: As a final remark, the paper is innovative is such a way that the topic is rare, especially with such a big influence of the land use change. However, the study is limited to the optimization of a highly flexible model to the measured groundwater and runoff data, without a clear description of the advantages in, e.g. the use of this methodology or the regional applicability of the model or any research objective whatsoever, except

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for applying the model on measured basins with (similar) land use change prospective. Therefore, the objective to understand changes on flow and salinity generation processes following clearing (pg.825) is not reached, while model structure and process verification has not been performed.

AC: We restate that the model is innovative, simple and flexible. Our ultimate objective is to develop a basin-scale salt and water balance model in which the present model would be used as 'building block'. At the basin-scale the spatial variation of streamflow and salinity is so large (as the present experiment shows) that without a simple flexible 'building block' model, development of a basin-scale model would be impossible.

AC: The regional applicability and objective of the model is elaborated in the last para of Section1 and a new para in Section6.4.

AC: At this stage we were not sure how many parameters of the model would be able to be estimated a priori. But we firmly believe that a 'formal optimization procedure'will not be necessary. Therefore the model was applied to 4 additional experimental catchments and then the parameters were classified into three groups: 'known', 'fixed'; and 'variable'. The 'known' and 'fixed' sets are estimated a priori and only 'variable' set with 7 parameters are calibrated for all other subsequent applications. For details see - Bari, M.A. and Smettem, K.R.J., 2005a. Parameter sensitivity to climate and landscape variability of a simple, lumped salt and water balance model, Hydrology and Earth Systems Science Discussions, 2:1405-1447.

Specific comments:

RC: I guess a certain over-parameterization is present in the model structure, looking at the list of variables in which a total number of 10 free parameters are given, not to mention the additional variables that need to be measured or calibrated (soil conductivity values, interception related constants, transpiration related constants, stream and soil morphological aspects). With which and how many measurements were these variables determined? The way in which the calibration is performed should be stated

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and is missing in this paper.

AC: We attempt to keep the number of parameters to the absolute minimum, required to represent the process - streamflow generation on a daily time step following clearing of native forest. This was the model development strategy - 'downward approach' - annual, monthly then daily. Therefore the number of parameters in the daily model could be considered high, but necessary.

AC: Observed data were used as much as possible eg. Porosity, soil moisture content, hydraulic conductivity, top soil thickness, groundwater level, regolith thickness, surface slope, stream depth etc. A table for key parameters is given in the paper, which describes the monthly model. Soil properties and moisture content profiles were taken from five locations within each of the catchments. Hydraulic conductivity measurements were completed at each of the bore locations (72 for Lemon and 20 Ernies).

AC: Description of the calibration process is elaborated (Section 5). Section 6.3.1 (daily streamflow) elaborated and Table 1 with statistical criteria of model performance has been added. The observed groundwater level was taken as a guide for changes in storage content and parameter calibration. All the parameters were calibrated against observed streamflow data, with some statistical criteria as now added into the text (sections 5, 6.3.1, 6.3.2).

RC: Also the way the results are presented is weak, with only a few vague pictures of single year results. The use of more common comparative performance measures, like the coefficient of efficiency (Nash-Sutclife) of RMSE values are more indicative, as long as the data series are explained well. The statement that the model performs successful is not acceptable as such. Then on page 842 it is mentioned that some parameters are important, but some of them are a priori determined. How certain are these values, knowing the importance of their influence?

AC: Presentation of model results has been elaborated. Two figures (groundwater level trend and flow duration curves) are now presented and results discussed in detail.

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Uncertainty of model parameters is discussed in Section 6.4.

AC: Description of the calibration process is elaborated (Section 5). Section 6.3.1 (daily streamflow) elaborated and Table 1 with statistical criteria of model performance has been added. The observed groundwater level was taken as guide for changes in storage content and parameter calibration. All the parameters were calibrated against observed streamflow data, with some statistical criteria as now added into the text (sections 5, 6.3.1, 6.3.2).

RC: A final statement is the question about the rainfall records, while its uncertainty is mentioned to be high (pg.843), but is it still low enough to be this convinced about level of model complexity and the successfulness of its results?

AC: The rainfall analysis is again reviewed. There was no instrumental error. Accordingly the text is modified to give better picture of the model performance (section 6.4).

Technical corrections:

RC: For the equations, separate the 'if' statements more from the equation itself. -Don't use a reference twice for the same statement (about downward approach, Klemes, pg.826).

AC: Done as suggested.

RC: -Don't show the two soil evaporation and transpiration equations, without explaining where they come from and why these are used (pg.828).

AC: Variable defined and elaborated.

RC: -Paragraph 6.1 is not part of the results or discussion, while it is a part of the previous known behaviour of the groundwater system -Use a better example of why the model represents the shallow groundwater system 'very well' (pg.838). A range between 2-10-Explain more why the daily model performs better than the monthly model (pg.840). -In figure11, the line should be y=x, to be able to judge the R-squared.

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AC: Modified as suggested. How the daily model is better than the monthly model is discussed in Sections6.3.3 and 6.3.4.

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 821, 2005.