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Hydrology and Earth System Sciences Discussions

Interactive comment on "Multi-criteria assessment of the Representative Elementary Watershed approach on the Donga catchment (Benin) using a downward approach of model complexity" *by* N. Varado et al.

Anonymous Referee #1

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1. Contributions

The main contribution of this paper is, firstly, that this paper presents the application of the Representative Elementary Watershed (REW) approach to the Donga catchment in Benin, which has different environmental setting with the other catchments where the previous applications of the REW approach were made. Therefore, this paper can add more confidence regarding the applicability of the REW approach to the catchment system in different environmental conditions around the world.

Secondly, this paper illustrates the way to validate the performance of the resulting numerical model based on the REW approach with measured internal state variable data such as measured groundwater level, soil moisture content, and streamflow time series from several points along the channel network of the Donga catchment.

Finally, to appropriately describe hydrological processes of the Donga catchment, this paper pointed out what is a possible weak point of the current REW model, which led poor model performance, and what could be the alternative to improve the current model performance for the Donga catchment where the perched water table seems to play an important role to the rainfall-runoff processes.

2. Technical soundness

The paper is technically sound in general and the detailed questions regarding technical soundness are given below.

2.1. Is the description of numerical experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?

Yes, numerical experiments conducted in this paper are generally well described. However, more descriptions regarding parameter estimation are required. Full description on the parameter estimation part will be very valuable for the future REW model users, as published papers that describe the REW model applications to natural catchments are not so many. More detailed comments on parameter estimation are given in 7. Specific comments.

2.2. Are mathematical formulae, symbols, abbreviations, and units correct?

Yes, on the whole, mathematical formulae, symbols, abbreviations, and units are correct, while several symbols are necessary to be corrected, or included. Details are given in 7. Specific comments.

2.3. Does the paper present novel concepts, ideas, or data?

Yes, the paper utilizes novel hydrologic modeling approach, that is, the REW approach for physically based and distributed hydrologic modeling at the catchment scale. The paper shows an idea to assess the performance of the REW model by using several types of data, for example, groundwater level, soil moisture content, and streamflow time series measured at several points along the channel network. Moreover, the paper utilized two different spatial discretisations to assess the effect of different spatial discretisations in terms of the model prediction. The data set presented in the paper is very valuable for the study of hydrological processes at the Donga catchment which will help the local community around the Donga catchment to manage their water resources.

3. Prior publication

3.1. Has this work been published elsewhere?

No, the REW model application work to the Donga catchment has not been published in elsewhere. Therefore, the work presented in the paper is original.

4. Organization and style

The paper is generally well written and organized. The title clearly reflects the contents of the paper, the abstract provides a concise and complete summary, and the text was written and structured in a well organized way for the presentation of the work.

4.1 Should any parts of the paper (text, formulae, figures, tables) be reduced, combined, or eliminated?

No, all text, formulae, figures and tables are necessary for the presentation of the work. Some minor changes in tables and figures will be asked for more clear presentation of them, which is summarized in 7. Specific comments.

4.2 Is the language fluent and precise?

The manuscript has to be revised and improved in terms of English usage for more smooth and proper transfer of the messages of the paper to the average reader.

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5. Evaluation

On the whole, the paper approaches hydrological process studies in the Donga catchment in a well systematized way and presents results from well designed numerical simulations in an easy way to follow. All materials and discussions presented in the paper are important in the context of understanding and modeling rainfall-runoff processes of the Donga catchment. Overall quality of the paper is already good enough to be published in HESS. However, minor changes and additional discussions regarding the reviewer comments should be made in the manuscript before publication.

The paper presents a number of simulation results from the REW model. However, it is difficult to clearly know exactly what parameter values or ranges are estimated for each simulation. The reviewer thinks that in the REW model there are more parameters than those shown in Table 4 and more input information regarding soil depth, surface slope etc are necessary to run the REW model. Necessary information with respect to estimated parameter values and input data should be provided in the manuscript.

The reviewer thinks that based on Fig. 6, 8, 11, and 12, the delay between the beginning of the rainfall and the discharge are not captured at all by any of REW model simulations. This seems to be caused from insufficient model complexity of the REW model structure in describing the role of perched water table to the rainfall-runoff processes in the Donga catchment. However, the reviewer thinks that the delay in streamflow could be captured by considering the routing process as well as parameter variabilities across REWs. This has to be addressed in the text by putting more discussions or materials.

The paper presents comparison between measured soil moisture content, and groundwater levels at the point or grid scale and simulated ones at the REW scale at Fig. 9 and 10. In this case, consideration of spatial scale will be important factor in comparison, and relevant information and discussions should be given in the text. For example, in the case of soil moisture comparison shown in Fig. 9, the information regarding follow-

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ing questions should be given explicitly: how many measurement points vertically and horizontally were taken?, what is mean depth of Zone U over the time?, is mean depth of Zone U comparable with the depth scale used for the soil moisture measurement? etc. For the comparison of groundwater level shown in Fig. 10, following information should be given in the manuscript: total soil depth, channel elevation, and ground surface elevation. Moreover, REW-scale average groundwater level should be carefully compared with point scale measured groundwater level.

6. Recommendation

Publish with changes by the author(s).

7. Specific comments

7.1. At line 11 at page 2354:

There is a typo. “is we only look at” should be replaced by “if we only look at”.

7.2. At line 6 at page 2355:

The author(s) wrote “The Upper Oueme watershed in Benin (Fig. 1)”. However, the location of the Upper Oueme watershed is not denoted in Fig. 1.

7.3. At line 28 at page 2357:

“the concentrated flow zone” should be replaced by “the concentrated overland flow zone”.

7.4. At line 14 at page 2358:

“G an intern production” should be replaced by “G an internal production”.

7.5. At line 4 at page 2359:

“2nd and 3rd orders lead” should be replaced by “2nd and 3rd Strahler order lead”.

7.6. At line 2 at page 2360:

“yearly time scales” should be replaced by “monthly time scales”.

7.7. At equation (2) at page 2360:

“Yimod” in denominator should be replaced by “Yiobs”.

7.8. At line 14 at page 2360:

“the mean of the measured values”: denote the way to get the mean explicitly. For example, “the arithmetic mean of the measured values” or “the geometric mean of the measured values”.

7.9. At Table 4.

“nc” should be replaced by “no”.

7.10. At Table 4.

The reviewer thinks that yc and yo should also be shown in IC category. Instead of yr, mr should be in IC category.

7.11. At Table 4.

The reviewer thinks that Table 4 doesn’t contain all parameters which can be found in the REW model used for the Donga catchment study. For example, additional parameters are shown at the Table 5 of the recent Reggiani and Rientjes’ paper (2005, water resources research, 41, W04013, doi:10.1029/2004WR003693).

7.12. Table 7 and 8.

Efficiency value for the simulation with daily scale distributed rainfall data and 2nd order discretisation is 0.50 at Table 7, while 0.51 in Table 8. These two values should be identical one another.

7.13. At Fig. 4.

“Zone C: concentrated flow” and “Zone O: overflow” should be replaced by “Zone C:

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concentrated overland flow” and “Zone O: saturated overland flow” respectively.

7.14. At Fig. 9.

Month notation in x-axis of the graphs should be rewritten.

7.15. From Fig. 6. to Fig. 12.

For the clear presentation of the results, the following information should be given at the every caption of Fig. 6. to Fig. 12: a) simulation time scale (daily, decadal, or monthly), b) simulation period, c) discretization (2nd or 3rd), and d) rainfall variability (distributed, or homogeneous).

7.16. Adding new table regarding parameter estimation.

The reviewer suggests that additional table should be prepared to present all parameter values estimated for the Donga catchment, which will be a good reference for the future REW model users. This is especially important, because the REW approach is still in the early stage in terms of the test of the approach as a new novel hydrologic modeling framework in the physically based and distributed way. Therefore, parameter estimation part should be well described in the text, and all parameter values, their ranges, and methodologies to estimate parameter values should be well summarized in a tabulated form.

7.17. Description regarding modeling the routing part of the rainfall-runoff processes in the Donga catchment.

The reviewer thinks that the Donga catchment (580 km2) is not small enough to ignore the routing part of the rainfall-runoff processes. However, the reviewer couldn’t find any descriptions regarding the way to model the routing part of the rainfall-runoff processes in the Donga catchment. More materials and/or descriptions regarding modeling the routing part of the rainfall-runoff processes in the Donga catchment should be prepared by the author(s).

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7.18. Detailed description and/or discussions on the simulation results with regard to state variables and exchange mass fluxes.

The author(s) made a nice description on the simulation results step by step, and made a conclusion. However, the reviewer is not sure if the necessary information on model simulation results is all given in the text so that anyone can reach the same or very similar conclusion that the author(s) made.

For example, at Fig. 6, 8, 11, and 12, the delay between the beginning of the rainfall and the discharge are not captured in all cases. With more information on model simulation results with regard to state variables and exchange mass fluxes, more discussions should be made to explain this. In the reviewer's analysis of the results presented in the paper, the delay might be caused from inappropriate choice of parameter values. Therefore, it seems to the reviewer that the additional work on parameter estimation would improve the model performance to capture the delay with given model structure. In Fig. 4, there is no exchange mass flux allowed between Zone C and Zone O, that is to say, infiltration excess overland flow is not allowed in the REW model that the author(s) used. So, the main runoff generation mechanism will be dominated by saturation excess overland flow. In Fig. 6, 8, 11, and 12, model response (streamflow) to the rainfall seems to be very immediate. The immediate model response to the rainfall events indicates that well developed saturated surface area is always found in the catchment. Because the saturated surface area is a function of ys (mean depth of Zone S), the reviewer thinks that the exchange mass flux from Zone S to Zone O is underestimated so that the saturated surface area could be developed well over the catchment during the whole year which prevents the model from capturing the delay between the beginning of the rainfall and the discharge. The magnitude of exchange mass flux is determined by parameter values so that the appropriate selection of parameter values could lead to the proper description of the inner REW-model state, for example, no saturated surface area during the dry season that help capture the delay between the beginning of the rainfall and the discharge. However, the reviewer cannot make any conclusion due to the lack of information regarding model simulation results, e.g., saturated surface area over the time, exchange mass flux from Zone S to Zone O over the time, etc. In sum, the reviewer suggests that the author(s) should provide more information in the text that will help make conclusions, and put more discussions regarding what causes the problems arisen in the simulation results. This will definitely be the valuable information as well as good guidance for the future REW model users.

For Fig. 10, the reviewer thinks that the author(s) need to put more information and discussions for the clear interpretation of the results shown in Fig. 10. For example, total soil depth of REW no.1, channel elevation of REW no.1, the bottom elevation of Zone S of REW no.1, and the range of saturated surface area fraction of REW no.1 during the simulation period will definitely help better understand the results shown in Fig. 10. The reviewer would like the author(s) to provide information mentioned above in the text.

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 2349, 2005.