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Discussions

# *Interactive comment on* "Assessment of surface water resources availability using catchment modeling and the results of tracer studies in the meso-scale Migina Catchment, Rwanda" *by* O. Munyaneza et al.

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Author's Response for Referee #1

Ref. No.: hessd-15375-2013 Title: Assessment of surface water resources availability using catchment modeling and the results of tracer studies in the meso-scale Migina Catchment, Rwanda

Dear Referee #1:



We appreciated very much your thorough review of the manuscript and the provision of constructive comments which are very helpful for the improvement of the manuscript. In the following, we would like to explain our responses in detail for each comment. We particularly refer to revisions that we would like to include (largely have included already) in the revised manuscript, if invited by the Editor to resubmit a revised manuscript to HESS.

General comments

Major issue 1: Referee #1: "This paper tried to address the assessment of water resources availability of the Migina catchment at Rwanda from a hydrological modeling prospective. I think that there is a real need for such work; however this paper should be rewritten with a better focus on the central theme of assessment of water resources availability (e.g., using different scenarios and assess the impacts). I have not seen a contribution that can serve as an advancement of science within the work presented to assess the water resources availability at the study area".

Authors: While assessing the water resources availability, the paper determined the different water budget components: ET, percolation, direct runoff, and baseflow using a rainfall-runoff modeling tool. For rainfall-runoff models, only the total flow generated could be verified using the measured flow records. There are no or limited ways to verify simulated values of the different components than there are for the total flow. This piece of work went beyond the standard calibration of the total flow to verify estimated values of one component, i.e. baseflow. Baseflow contribution estimates cannot be validated using the standard method, but this paper introduced a new approach with which the baseflow results by the rainfall-runoff model were verified using the results of tracer investigations. This is not a strict model validation (like a split sample test as recommended by Klemes, 1986), but, it provides insights into the model behavior and the model performance.

Major issue 2:

Referee #1: In addition, I suggest that the manuscript should have better information on how the model was parameterized and how results were interpreted.

Authors: Yes, we agree with the reviewer and we have elaborated more on this and added Table 2 which actually summarizes all information on the model parameters.. We have rephrased paragraph 3.4.1 on Page 15385, Line 13, as follows: "In the present study, the basin model was created using the HEC-GeoHMS and then imported into the HEC-HMS with all its hydrologic elements: 5 sub-catchments, 10 junctions, 11 reaches, and outlet of a basin (Fig. 4). Where applicable, the junction elements were assigned to observed flow data, for use in comparison with simulated flows during the calibration process. In the model parameterization process, each hydrologic element was supplied with initial conditions and parameter values based on the requirements of the different computation methods as discussed in the Section 3.3 above. Initial parameter values were selected based on previous (published) works where available, otherwise default values from the manual were applied. Table 2 shows the five model routines: canopy, surface, loss, transform; and baseflow, the type of parameters used for each method, and values attributed to each parameter in the modeling process (calibrated)."

About the interpretation of the results: Three types of results were interpreted / discussed: ïČij Calibration results (i.e. parameter values) ïČij Flow simulation results ïČij Water budget component computations

The following paragraph was included at the beginning of the discussion section on Page 15388, Line 5: "The results analysis was undertaken by carrying out statistical analysis of flow results and basin parameters, comparing parameter values of calibrated adjacent sub-catchments, and comparing the simulated values of water budget components with the tracer method results".

The following paragraph was also added on the same Page 15388, Line 9, in the calibration results of the revised manuscript. "The model is calibrated using two years



of rainfall and runoff data collected as part of this study (August 2009 to June 2011). However, owing to the lack of reliable long-term flow observations, a classical model validation (e.g. split sample test) could not be done in this study and all available data were used for the model calibration. The finally calibrated parameters for each sub-catchment are presented in Table 2. The data challenge often applies to Rwanda, where many catchments are ungauged and even the gauged catchments have unreliable data sets. Additionally, the suitability of the model was checked using the results of tracer investigations. This is not a strict model validation (like a split sample test as recommended by Klemes, 1986), however, it provided further insights into the model behavior and the model performance". See also the response to the major issue #1.

The following sentence was added on Page 15392, Line 13, in the water budget component results of the revised manuscript. "This high contribution of baseflow to total flow also confirm the perennial river system observed in the Migina catchment during the study period, which is also supported by Munyaneza et al. (2012a)".

Major issue 3:

Referee #1: Another major note that the authors need to consider is to address the limitations associated with the approach that the authors undertook to answer the paper main question.

Authors: We have addressed this comment in the revised version by adding new text in the method section about the limitations which are associated with the applied catchment model and tracer methods in assessing water resources availability in the meso-scale catchment. This was also added in the flow results part on Page 15390, Line 14, as follows: "The main reason that our model simulates high and low recession of baseflow at Cyihene-Kansi and Migina outlets after a storm event, may be linked to the inflexibility of the model structure. The results could have been improved by using flexible model structure, e.g. FLEX-Topo (Savenije, 2010; Fenicia et al., 2008a,b and 2010; Gao et al., 2013). Savenije (2010) demonstrated that FLEX-Topo model allows the groundwater time scales to be lumped and determined by manual calibration on the recession curve. A more flexible model structure would allow to design in particular the runoff generation module (different runoff response functions) based on the obtained process understanding and physiographic characteristics and dominant landscape elements such as riparian zones, hillslopes and hilltops.".

Specific comments

Comment 1:

Referee #1: HEC-HMS is a deterministic model. How do you see the application of its result in the face of climate change. Authors: We agree that HEC-HMS is a deterministic model. It can also be used for climate change impact assessment like similar other hydrological models, such as Soil Water Assessment Tool (SWAT). However, with the current version of our HEC-HMS model of the Migina catchment, the main problem is that it is calibrated with only two years of data. This restricts us to test the performance of the model for a long-term simulation, say 20-30 year, which is necessary for application in climate change impact assessment.

Comment 2:

Referee #1: After you stated your problem and why it is important can you give a glimpse of your paper results and what have you found at the introduction paragraph? I suggest rewriting the Introduction paragraph to present the whole story of your paper (why, how and what you have found!). Authors: The whole introduction has been rewritten in the revised manuscript.

Comment 3:

Referee #1: Page 15381, Line 16. What about soil properties. In your input data there is no say about soil texture/properties. How do you address the lack of soil data in setting up your model? Authors: For the clarification, the following sentence was added in the revised version on Page 15382, Line 17. "Though the model used (HEC-HMS)



does not allow entering soil texture/properties during the model set-up, the expected difference in response of different soils is addressed partially during calibration through adjustment of infiltration rates in different sub-catchments". Comment 4:

Referee #1: Page 15382, Line 8. How did you address the spatial variability in radiation and air temperature values across the various sub-watersheds modeled to estimate reference crop evaporation values? Authors: As mentioned in the manuscript on Page 15382, Line 17, only one station (CGIS) was used for radiation and air temperature values across the entire basin being the only one in the basin. "Considering the small size of the Migina catchment (about 260 km2), we did not expect the average radiation and temperature to vary in a way that could considerably affect evaporation values". This sentence was added in the revised manuscript. This assumption came back in the discussion part to demonstrate that authors are aware of this assumption.

Comment 5:

Referee #1: Page 15388, Line 10. How the watershed soil percent is treated as a variable? In table 2 you showed that the soil percent has been calibrated in your modeling work while in table 1 you showed that you have information about land use and imperviousness which to me means you have information about watershed soils. Authors: We agree with the reviewer, the use of “soil (%)” is confusing. The value expresses in percentage terms the soil storage initially filled with water. The percentage value would be high during the wet conditions and low in dry conditions. In the revised manuscript, Table 2, we replaced “soil (%)”with “initial wet soil storage”, and “Soil initial Storage (%)”with “Soil Storage (mm).”.

Technical Corrections:

Referee #1: I have realized that the manuscript has many typo errors so I recommend re-editing it. Authors: We have made a double check of our paper and all possible edits were addressed in the revised manuscript, much editing have been done based on specific comments raised by Referee #2.

Referee #1: Swap Figures 1 and 2. Figure 1 should give the location of your catchment. Authors: We have made this correction in the revised manuscript.

Referee #1: From where did you get the information listed in Table 1? Authors: The results presented in Table 1 come from analysis using Thiessen polygon method (May 2009 to June 2011) for rainfall as shown on Page 15382, Line 9-11; use of ArcGIS software for land use as shown on Page 15383, Line 16; from HEC-GeoHMS analysis for the basin characteristics (area, reach length, river slopes, imperviousness, etc) as shown on P15383, L18-20 and supported by previous studies (see P15380, L15-17). The sentence on P15382, L9-11 was reformulated in the revised manuscript as follow. "Rainfall data at 12 stations scattered in the study area were analysed using Thiessen polygon method (May 2009 to June 2011) for the interpolation of the daily rainfall average and using the Mass Curve Method for quality control".

Referee #1: Page 15380, Line 10. Rewrite the sentence "supported the idea of building: : :" with breaks. It is too long. Authors: We have rewritten and split the sentence into two in the revised manuscript as follow: "The University of Rwanda (UR), Huye Campus, which lies in the Migina catchment, supported the idea to build a pilot demonstration site on which models can be built/tested. This result is an integration of water resources development to the university curriculum development and planning processes".

Referee #1: Page 15381, Line 1-5. This introductory should be moved up the study area section. Authors: We have made this correction in the revised version. The following sentence was added in the study area for clarity of Migina rivers flow direction and the arrow showing flow direction was added on the swapped revised Fig. 1. "The main flow direction in the catchment is from north to south. The main stream is located in the eastern part of the catchment. Therefore, most of the valleys drain from north-west to south-east towards the main stream".

On behalf of the authors, Omar Munyaneza, Kigali, Rwanda June 2014

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