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Hydrology and Earth System Sciences Discussions

Interactive comment on "Water balance modelling in a semi-arid environment with limited in-situ data: remote sensing coupled with satellite gravimetry, Lake Manyara, East African Rift, Tanzania" *by* D. Deus et al.

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Reply to Reviewer 3-C5029-2011

We want to thank Referee 3 for his thoughtful contribution and comments on our manuscript. We would like to take this opportunity to explain our point of view concerning the general comments, criticism and questions.

Reviewer general comment:

The authors suggest that they combine remote sensing data and in situ observations with model simulations; however, although several such data sets are described (in great detail at points), the paper does not clearly state which and how remote sensing data is incorporated into the model. Furthermore, the paper shows a somewhat circular logic in that the authors state both that they are using the model results to "test the utility of GRACE satellite gravimetry total water storage (TWS) data on a smaller un-gauged lake catchment basins and minor lakes that are not included in the global satellite altimetry mission network" and that "the results were validated by comparing. . .the lake water balance with. . .satellite gravimetry GRACE equivalent water thickness data. . ."

Answer:

We have now pointed out clearly which datasets have been used to force the model in the modified manuscript. We have also simplified and modified the manuscript in order to explain the model more clearly. We incorporated remote sensing data in the model by extracting input data and parameters from remote sensing datasets in text format. The hydrological model requires input data and parameters in text format. We do not think that we based the paper on a circular logic. However, to avoid confusion, we have have edited the manuscript to make the scientific argumentation clearer. We used GRACE derived TWS data to validate our water balance result and in the course to test the utility of the dataset in smaller lakes and catchments. We do not use them during the modelling.

Which remote sensing data sets were used as input to the model and which were compared to the model are of key importance in this study; however, the authors refer to 2 different remotely sensed precipitation data sets and 1 in situ data set without stating which was used to force the model. Similarly in situ and remotely sensed temperature data sets were described without saying which went into the model. Also, virtually no details are given on the source and quality of the ground-based meteorological observations. As commented by referee #2, the type of ET measurement can be quite

important.

Answer:

We agree that the input data are not clearly detailed. We provide now a table of input data. Specifically, we used TRMM precipitation, in-situ air temperature and MODIS LST datasets to force two separate models. The results produced using the model forced with air temperature and MODIS LST respectively are similar. The quality of in-situ rainfall data was good and that is why the data indicated a good correlation with TRMM precipitation dataset; besides in-situ rainfall dataset was used for validation purpose only.

A lot of space is spent describing the parts of the J2000g model that are pretty basic, such as the water balance equation, and ET calculations that could have simply been cited. For this paper, the connections between the lake and terrestrial area should have been more clearly described. For example, is the land surface allowed to runoff into the lake? Does base flow transfer between the terrestrial area and the lake in one or both directions? How is flow routed over the land surface? How are base flow and runoff calculated? Without this information, it would not be possible for fellow scientists to reproduce the results.

Answer:

1- We have simplified and largely modified the model description. 2- We have adressed the specific requests form the reviewer. Water from the land surface can enter the lake; actually the simple model setup assumes that all water that is not evaporated or stored in the soil enters the lake. Base flow transfer does only take place in on direction (land to lake). Flow is not routed at all in this model. It is simply summed up from runoff generation. Base flow and runoff calculation are presented e.g. Krause and Hanisch 2009. Total runoff is calculated from the water balance Q = P – ET +/ DS on a monthly basis. Potential ET is estimated by the Penman-Monteith approach and actual ET is calculated from potential ET and soil water budget. The total runoff is then

split into direct runoff and groundwater recharge based on slope and hydrogeology of the respective grid cell or HRU. Of course much more sophisticated model layouts are imaginable but with the limited data and knowledge a simple but robust model seems to be more feasible. The model and its sources can be requested from the authors to enable fellow scientists to reproduce the results.

The authors also suggest that future efforts should address groundwater interactions; however, without a description how the subsurface processes are currently represented (and given that groundwater accounted for only 0.27% of the total catchment inflow in Table 2), this is a difficult assertion to assess. In addition, “groundwater” is listed as an inflow in Table 2, but from the description of the modelling approach, I wonder where this groundwater inflow is coming from, the lake?

Answer:

The 0.27% are in relation to total rainfall. Considering that a large amount of that rainfall (about 90 %) is evaporated the groundwater contribution is relevant.

The paper may have been more novel had the authors compared the model performance given in situ meteorological forcing to that given remotely sensed meteorological forcing.

Answer:

We agree with the reviewer that more validations, more data are always better. Nonetheless, we wanted to provide a robust approach for these regions of the world where only scarce in-situ data are available. For that we assume that the model is robust and that the input data adequate. We showed that the RS data have a good spatial coverage with a sufficient accuracy. The model has been adapted from a model that has been used worldwide. We are providing a solution in arid/semi-arid areas in-situ meteorological forcing parameters are quasi-absent. That is why we opted to use both remote sensing and in-situ data to force the model.

The authors mention in the introduction: “In the East African Rift the topography of the rift escarpments and volcanic highlands plays an important role in controlling local climate and thus the lake basins.” The authors never address what role the topography played in the simulated water budget.

Answer:

It is a good point and we have now amended the manuscript. Topography is an important factor for the distribution of meteorological input, and in the model the slope/aspect combination of specific HRU or grid cells plays a role in ET calculation and separation of total runoff generation into direct runoff and groundwater recharge.

Additional comments: 1. Does the title clearly reflect the contents of the paper? The title does not make sense. Satellite gravimetry is a form of remote sensing. The title says “remote sensing coupled with satellite gravimetry”, which might imply that the satellite gravimetry was somehow integrated into a modelling framework with other remote sensing data; however, GRACE data was simply evaluated against a model that was forced with other remote sensing data.

Answer:

We agree that satellite gravimetry is a form of remote sensing; we have modified the title to: “Water balance modelling in a semi-arid environment with limited in-situ data using remote sensing, Lake Manyara, East African Rift, Tanzania”.

2. Is the overall presentation well structured and clear? The paper did not flow very well. The methods, results, and discussion were mixed in many places.

Answer:

We have modified the overall presentation as recommended by reviewer 1.

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

Answer:

We have modified the paper to accommodate all issues that have been raised up by reviewers. So some parts have been clarified, reduced, combined or eliminated.

*The colours and labels on the axes do not match the colours and labels in the legend for many cases in Figs. 10, 11; 16, 17.

Answer:

We have modified the mentioned figures to match the colours and labels in the legend. The figures have been renamed to 9, 10, 13 and 14.

*Overall, I found the level of detail given to the input data sets to be excessive. Since the authors did not derive or modify the data sets, it would be more appropriate to simply cite the source, time step, spatial resolution.

Answer:

We agree that we did not derive or modify the dataset; so it would be better to point out the source, time step and spatial resolution. We modified this to remove un-necessary explanations.

*In the section on topography, the authors say: “Surface runoff causes soil erosion”, and though true, this is irrelevant to their study.

Answer: We have removed the statement “Surface runoff causes soil erosion”.

*In section 3.1.1, the authors should clarify which precipitation data set they used or how they merged data sets.

Answer:

We used TRMM precipitation data to force the model. In-situ and GPCP precipitation were used for validation purpose only. This has been clarified.

*The discussion of soil type (3.1.2) is inappropriately detailed given that a soil map is

not provided and the effects of soil type are never discussed.

Answer:

In the model we used different soil parameters for soil types derived from maps available for the study area. We thought it was appropriate to describe different soil types available in the area of interest. We have modified and remove all un-necessary explanation.

Reference

Krause,ÂăP. and Hanisch,ÂăS.: Simulation and analysis of the impact of projected climate change on the spatially distributed water balance in Thuringia, Germany, Adv. Geosci., 21, 33-48, doi:10.5194/adgeo-21-33-2009

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