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Comment on hess-2021-527

Anonymous Referee #2

Referee comment on "Spatial and temporal simulation of groundwater recharge and cross-validation with point measurements in volcanic aquifers with variable topography" by Alemu Yenehun et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-527-RC2, 2022

General

In this study Alemu Yenehun et al. estimate groundwater recharge and study the spatial and temporal recharge patterns for the Lake Tana region in Ethiopia. Three (well-) established recharge estimation methods are applied, a model approach using the physically based WetSpass model, the groundwater table fluctuation method, and the chloride mass balance method. I applaud the Authors for conducting such an extensive study in a research area where data acquisition I assume can often be challenging. I think the main contributions from this paper are 1) an improved understanding of the groundwater recharge fluxes in the case study area, and 2) the comparison of different recharge estimation methods. These contributions are valuable, as groundwater is an important source of drinking water in the region and a better understanding of the resource in this region would serve many. I found the manuscript generally well written (minor textual improvements are required), but some restructuring and changes to the figures might be required to improve the readability of the manuscript. The main concern I have for this manuscript are related to the methodology and the description thereof, discussed in detail below and in separate line comments. Additionally, while I think the study is worth publishing, I am unsure whether the contribution fits the scope of HESS ("substantial new concepts, ideas, methods, or data") in its current form. In my opinion, it would fit much better in other journals where it can be submitted as a case study (e.g., Hydrogeology journal), and reviewed as such. If the Authors wish to publish in HESS, I think a more elaborate analysis and discussion of the uncertainties in recharge estimation could be done to better fit within the scope of the journal.

Methods description

From the description of the methodology and data following in this manuscript, it is hard

to reproduce the results and gain a full understanding of the modeling procedure. This could partly be solved by sharing the scripts, input, and output data used in this study. However, often a more detailed description of the modeling procedure is also required. The WetSpass model requires substantial data input, which is not always clearly described in the manuscript. From the description of the data, it seems that different time periods were used to generate the input data for WetSpass. Perhaps this could be clarified using a table that summarizes the different data sources and time series characteristics (e.g., measurement interval, period, operator). Given the high temporal variability of the different hydrometeorological variables, I assume the same time periods for all variables are used, but I could not verify this from the current manuscript. A few times it is mentioned "expert judgement" is used, but it remains unclear what values were applied and why. The calibration process is only briefly described, and the calibrated parameters are not reported. I general, I think it would be good to rewrite the methods section with reproducibility in mind.

Uncertainties in recharge estimates

The Authors mention in the introduction that it is important to take uncertainty in recharge estimation into account (line 47), and thus I was expecting a more elaborate analysis or discussion of the uncertainty in recharge estimation methods applied in this manuscript. As the WetSpass model is manually calibrated, no parameter uncertainties are available. It therefore remains unknown how uncertain these recharge estimates are. This could be addressed by a sensitivity analysis or a more elaborate uncertainty analysis. A discussion of the limitations of the different methods and the uncertainties of the recharge estimates at the end of section 4 would be a welcome addition to the current manuscript.

Title

The title suggests a more general study on volcanic aquifers, while a case study is presented. I think it would be better if the title reflects the fact that it is a case study. Additionally, the title suggests that there are "point measurements" of groundwater recharge. In my view it be better to refer to these as 'point estimates', as they are empirical estimates from a recharge estimation method and not real measurements.

Line comments

L31: add a comma after floodplain

L72: regionalize

L77: were all these studies in a specific study area? If so, good to mention that.

L123: Perhaps refer to the GitHub repo: https://github.com/WetSpass

L123: No reference to Wang et al (1996) required?

L132/135/139: Sentences introducing these equations would be nice.

L133: Should there not be a change in storage term?

L142: Which evaporation equation was used?

L144: I think it would be good to state which physically based equations (e.g., Darcy) were used and elaborate a bit on the model (e.g., finite differences).

L147-156: This description is rather vague, what was done exactly? How were the values changed?

L157-162: This could be elaborated and made more specific. How many parameters were calibrated, how many data points were used for calibration, was there a formal objective function used or only visual goodness of fit?

L164-164: "to validate the recharge estimates from WetSpass."

L165: I was a bit confused here, perhaps change to "During model calibration".

L174: remove "our" or mention the operating organization

L177: remove "relatively"

L178-179: Add a reference for this statement

L183: Can mostly be specified?

L187-188: I think at least a reference would be appropriate here.

L191: The naming "so-called first-class stations" seems inappropriate here, I suggest rephrasing, also in the Figures.

L198-201: How many monitoring wells were used? What period were the groundwater tables observed? Does the period overlap with the discharge data and the meteorological data? Is this the same data as that mentioned in L306?

L205-206: One value per year, does that mean the model is calibrated to just a very few data points? How many rivers were in the dataset?

L231-232: Unclear what "appropriate" is here.

L279: How many pumping and slug tests were done? What values for Sy were found, are these reported or available somewhere?

L282: Perhaps a separate subheading for the CMB.

L306: So the recharge estimates from the WTF method are only representative for that period. Is this considered when comparing to the other methods?

L325: Perhaps this could be combined with Fig. 2. with the hydrogeological setting?

L336: Where is 4.1? Also, I suggest starting with 4.3 (verification), before discussing the water balance components.

L342: At this point I do not know for what period WetSpass computes the recharge.

Perhaops write: “The annual recharge over the period 20XX-20XX..”

L348: minor typo.

L351: Change “Next to” to “Apart from”.

L360: minor typo

L366: values

L379: Exclude the lake in figure 7B. Perhaps add subplot with the precipitation. The legend in Fig7a has a mistake in the values. Why was a continuous coloring scheme not used (e.g., from yellow to blue), this would make the figures much easier to interpret. In the figure caption, specify “long term” by mentioning the exact years.

L407-447: I do not think this is a proper “Model verification”, as the same data is used for calibration! We cannot verify a model using the same data that was used for calibration. Perhaps this section can be renamed to “Calibration results”.

L427-429: A high R2 was obtained after the calibration, which may be interpreted as that the model can explain a large part of the observed discharge variation. However, Fig. 8 also clear shows a large systematic error between modelled and observed discharge, which I think could be more clearly stated. Contrary to what is stated in the text, the simulated discharge is always higher compared to the observations. This would be a good point to get back to in the discussion.

L448: Here the section “Model verification” starts in my opinion.

L448-463: Is there a reason the estimates from the CMB method were not used here?

L465: Figure 9 could be condensed/smaller.

L500-549: This section could be placed earlier, as the results described in this section were previously used to compare to WetSpass. Add “method” after WTF throughout the

section.

L506: “has been taken”

L526: Change “to catch up” to “to capture”.

L557: Perhaps the higher range of values could be reported here.

L560-591: Just a suggestion. Perhaps the Authors can come with a nice plot that visualizes the different recharge estimates from all the other studies, and those from this study.

L595: minor typo.

L612: Perhaps I misinterpret, but I added the percentages of runoff (29%), recharge (22%), and evapotranspiration (53), and these do not add up to 100% (=104%). Why is this, are there model errors or changes in storage?

L640: Some recommendation/implications for future studies and work could be added at the end.