Comments on manuscript HESS-2021-390

Modelling groundwater recharge, actual evaporation and transpiration in semi-arid sites of the Lake Chad Basin: The role of soil and vegetation on groundwater recharge

By Neukum et al.

This paper presents an interesting approach for evaluating groundwater recharge in a remote semi-arid area. The study is based on soil water content and chloride content data, measured in selected study sites. Quantifying groundwater recharge is particularly crucial in the Sahelian part of West Africa, and considering the few number of studies in these areas, the data scarcity, and the difficult access to field work, the present study would deserve to be published. Nevertheless, I have different comments that should be addressed before publication.

General comments

In the introduction, a large part is given to the question of evapotranspiration partitioning, but this is not really discussed in the paper, and no mention of that is present in the conclusion. Authors should therefore either better discussed their results, or change the focus of the introduction (and title).

The paper from Tewolde et al 2019 presented an approach which is (at least partly) similar, involving most of the authors of the present manuscript, and some of the soil data seem to derive from the same database. Therefore, the differences between the two papers, their complementarity, and the added values of the present study, involving a modeling approach, should be described in the introduction.

The authors should also define what is considered under the term « recharge », since the soil water infiltration may not reach the water table. In addition, the depth of transpiration uptake can overcome the maximum depth of the soil profiles and affect the effective groundwater recharge.

The evaluation of recharge rates obtained from this study should be discussed and compared with previous evaluations in these areas, or under similar environment (e.g. Tewolde 2019, but nor only). A discussion of the spatial significance of the results is lacking. In such arid environments, recharge is mainly focused, and strongly controlled by surface hydrology (e.g. flooding episodes). Results regarding the variations of recharge rates in relation to surface hydrological conditions, would greatly help to go further in up-scaling of recharge rates.

Regarding the time variations of recharge fluxes (interannual *versus* seasonal), a strong impact of the extension of flooded areas is expected. The study sites are located in flooding plains, which involve a “binary” behavior of water infiltration, between periods of saturated soil surface, and non-saturated periods. During submersion phases, a constant maximum flux of water infiltration could be estimated? This does not appear in Figure 5.

Description of data and method

This section doesn't allow to fully understand the data and method and needs to be rewritten.

Details are needed on the choice of study sites, their situation regarding surface hydrology and flooding occurrences.

A dedicated "geochemical data" section is needed. Regarding the chloride concentrations of rainfall water, the authors should describe the rainfall collectors (always open or only during rainfall events? It is important for dry deposition), and the water analysis and precision, a crucial information for these very low concentrations. I would suggest including a table with the concentration data and corresponding rainfall amounts. It is suggested that the rainfall collection was not exhaustive (42 samples between 2014 and 2020). Therefore, an evaluation of the "missing" chloride input should be discussed. What was the proportion of non-sampled rainfall?

Two sampling locations of rainfall water are mentioned, how did they compare? The atmospheric chloride inputs could also be compared with previous regional evaluation in tropical Africa (e.g. Laouali et al 2012).

Regarding the chloride concentrations of soil water, detailed information is lacking on the different soil profiles collected: sampling dates and locations, the depth of the saturated zone, the distance between soil profiles of a same site, etc... Are the chloride data different from those published by Tewolde et al 2019? Which data were previously published, and which data are new? Why was the profile ST4 from Tewolde et al 2019 discarded? It should be explained in the data section. Here also a table would be useful.

The description of the methods needs to be clarified.
Regarding the chloride mass balance, describe the assumptions, the equations, etc… Storage of chloride in the vadose zone is important and should be discussed regarding steady-state *vs* transient state assumptions.

Regarding the FAO-dual Kc concept, it is not clear how it was integrated in the 1D modelling approach.

Explain the "scenarios". I have the feeling that it is a kind of sensitivity analysis, please explain.

Detailed comments

l. 20: What is a "potential recharge rate" ?

l.129-130 : what explains the higher value of potential evapotranspiration in the Salamat site, located at the same latitude as the Logone site? Local environment? Is the difference greater than uncertainty?

l. 171: I didn't find table S1: From my uploaded file, the supplementary document only included a truncated Table, without titles.

l.203 : explain which data were used to define the upper boundary conditions. Did they include the full saturation of the top soil?

l.227-228: unclear. What is a "Cauchy" boundary condition?

l. 229-230: a first reference is made here to the sampling of ponding water. It should be described in the data section

l.231: I didn't understand the definition of "ET scenarios". Explain which are the corresponding assumptions and objectives.

Figure 5 : The caption is not complete (Obs ? profile dates ?)

Figure 6: indicate the sampling periods. Also, it would be interesting to add rainfall data together with recharge rates, if possible.

Figure 7: the contrast between the top and bottom solute fluxes is huge. It implies a strongly intransient behavior, and accumulation of chloride. Please comment on that, regarding the long-term behavior and the resulting soil salinization. Also, what could be expected from soil leaching during flood events?

Figure 8: not sure if this figure is useful

References cited

Laouali, D., Galy-Lacaux, C., Diop, B., Delon, C., Orange, D., Lacaux, J.P., Akpo, A., Lavenu, F., Gardrat, E., Castera, P., 2012. Long term monitoring of the chemical composition of precipitation and wet deposition fluxes over three Sahelian savannas. Atmos. Environ. 50, 314–327. https://doi.org/10.1016/j.atmosenv.2011.12.004

Tewolde, D.O., Koeniger, P., Beyer, M., Neukum, C., Groeschke, M., Ronelngar, M., Rieckh, H., Vassolo, S., 2019. Soil water balance in the Lake Chad Basin using stable water isotopes and chloride of soil profiles. Isot. Environ. Health Stud. 55, 459–477. https://doi.org/10.1080/10256016.2019.1647194