Response to referees' comments on manuscript entitled 'Changes in mean evapotranspiration dominate groundwater recharge in semi-arid regions'

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Dear Editor,

For clarity, we use regular black font for the quoted reviewer comments and *blue* italicized font for our responses. The line numbers specified in our responses refer to the track changes pdf attached.

Editor

Comment 1: Dear authors, thanks for the resubmission. As you can see, both referees agree the revisions have improved the paper. I agree. One referee is satisfied, the author not that enthusiastic. From my own reading I think a bit more discussion on the limitations of the selected model and how this could be 'meaningfully' used in climate sensitivity analysis is required. Also, quite some studies show that diffusive flow in the unsat zone in semi-arid regions (especially when it is dry) is not the most important process (but pref flow is). Therefore, the applicability of Richards' en MvG equations is a point of concern that would be nice to see in the discussion.

Reply to comment 1: *We have expanded the discussion section in the manuscript and elaborated on the limitations of using Richards' equation for estimating the groundwater recharge in locations where considerable runoff is expected (e.g., areas with significant topography and rocky terrains) and where focused recharge is dominant due preferential flow paths (lines 207-216).*

Comment 2: The second referee also challenges you to think of the wording as you look at R/P ratios instead of R-values. The referee has a point and I leave it up to you to see how that could be implemented.

Reply to comment 2: *We checked again the text in the MS to make sure that there are no misleading wordings. We found that the abstract, indeed, was not clear enough regarding the fact that we focused on the ratio R/P. Therefore, we revised the*

abstract to reflect that (lines 6-8; 10-11). However, it is important to note that there is only one type of change in the climate conditions, considered in our work, under which the mean precipitation changes. In all other changes, the mean P does not change and changes in R/P are only due to changes in R.

Reviewer 1

Comment: I appreciated so much the efforts for improving the overall quality of the paper that is now more acceptable for publication, in my opinion. I think that the limits of the study are now better defined, as well as the focus on evapotranspiration change impacts on groundwater recharge. I'm still not completely convinced about the last analytical section (Section 4), even I acknowledge that it is now better explained with all the hypothesis discussed for the subsequent presentation of formulas. I think that neglecting the runoff could be not applicable in so many contexts (even if semi-arid regions) and that's my only one concern.

Reply to comment: *We thank the reviewer for the supportive feedback. Regarding the runoff, we limit our analyses to regions where independent estimations of R agreed with our simulated R, suggesting that our method is adequate for these locations. According to these simulations, the runoff was negligible in most locations. We now further clarify this point in the discussion (lines 213-216).*

Reviewer 2

Comment 1: I appreciate the authors addressed some of the reviewer comments. However, I understand that studying recharge/-precipitation can be (for particular purposes) more relevant than studying absolute recharger rates. However, then it is key that the paper also changes the associated language throughout the entire manuscript. For example, the title right now is already misleading.

Reply to comment 1: *We checked again the text of the MS to make sure that there are no misleading wordings. We found that the abstract, indeed, was not clear enough regarding the fact that we focused on the ratio R/P. Therefore, we revised the abstract to reflect that (lines 6-8; 10-11). However, it is important to note that there is only one type of change in the climate conditions considered in our work, under which the mean precipitation changes. In all other changes, the mean P does not change, and changes in R/P are only due to changes in R.*

Comment 2: The mathematical derivation provides no theory that can meaningfully be used to describe recharge sensitivity to climate. So I struggle what the value of this is.

Reply to comment 2:

In this research, we found that the R/P ratio exhibits higher sensitivity to changes in the mean potential evapotranspiration (E_p) than to changes in the mean annual precipitation (P). The mathematical expressions are necessary to explain why this is not trivial and why naively one would expect only sensitivity to the ratio E_p/P.