Review for HESS
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Predicting groundwater recharge for varying landcover and 2 climate conditions: – a global meta-study.

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Summary

This work aims to improve our understanding of the key factors which are important in estimating diffuse groundwater recharge at a global scale. An empirical model was developed using predictive variables, which characterized the meteorological, topographical, lithological and vegetation domains, all of which were determined from globally available datasets. Results are validated against findings from 715 studies worldwide which were found in the literature, as well as statistics provided by the Food and Agriculture Organisation (FAO). In order to minimise the effects of model structure uncertainty on results, the performance of multiple models was assessed. This work is of interest to the journal as it contributes to the understanding of large scale hydrological processes, whilst also trying to use methods that gain knowledge from globally available datasets. I believe this paper should be accepted with minor revisions. Prior to acceptance I would particularly expect the main suggestions to be addressed.

Main Suggestions

1. Model validation

    a) I believe this work validates modelling results against the estimations found in the literature and those of the FAO simultaneously. It could be a good exercise to validate the model using each dataset independently, to see how the use of the newly compiled information improves (hopefully) model estimations.
    b) Line 425: Figure 11 compares modelled recharge estimates to those of the FAO, why is this done, if in line 412 it states the comparison is unreliable? Would it not be better to compare modelled results to those of the 715 recharge sites? I think this is particularly important, as the compilation of this information to validate model results is one of the key things which separates this work out from others. Hence, I would like to see how they compare to each other.

2. Selection of model predictors

    a) Lines 123-130: Would benefit from explaining the rationale used in selecting the potential predictors further (especially as it is deemed a “key step”), i.e. why is the number of rainy days important? Why were mean precipitation and potential evapotranspiration selected as well as aridity index?

Minor Suggestions

1. Lines 76-79: Questions the reliability of the FAO estimates. Please make it clear why these estimates are unreliable. How are they derived?

2. Line 79: States no study has previously validated modelled estimates against small scale recharge estimates. However, Doll and Fiedler (2008) used local recharge estimates to test the performance and modify the algorithm used to determine recharge for arid and semi-arid cells.

3. Line 109: Would be interesting to know how the use of different recharge estimation methods found in the literature varied spatially and why. Could be shown graphically.

4. Line 118: Were certain climates or land uses over or under represented by the 715 recharge estimation sites? Is there an inherent bias in the dataset collected? A histogram could be useful.

5. Line 114: Recharge estimates in the literature may be representative of different time periods, especially if they were determined via water balance are water table fluctuation methods. However, the model predictors and the modelled recharge estimates are given as a mean for the period of 1981 and 2014. How was the inconsistency in the timeframe of the data managed? How did it effect model validation using the new dataset?

6. Lines 127-128: Were there any predictors which you would have liked to use, but were not available from the global datasets?

7. Line 201: I'm uncertain whether there were predictors which were rejected prior to the main bulk of the work. i.e. were there initially more predictors than shown in Table 1, with those in Table 1 just being those accepted for use?

8. Line 284: States that maps illustrating the percentage of rainfall becoming recharge were generated. However, these are not shown in this work.

9. Line 287: Refers to the koopan classification which I believe is meant to be K$\ddot{o}ppen - Geiger$.

10. Line 415: Section 2.3 states that Figure 8 (global recharge estimation map) was derived from the best model found. It would be good to repeat this in the Figure heading "Best model estimation".

11. Line 415: Interesting to see some of the regions where greater recharge estimates are determined (South America, Indonesia) also coincide with areas which are less represented by the 715 studies. How uncertain are results in these areas? Could the uncertainty of these estimates be assessed?

12. Line 417: Figure 9 clearly indicates the importance of mean annual precipitation for mean annual diffuse recharge at the global scale. It would be interesting to contrast this to the relationship between mean annual precipitation and the annual recharge rates reported in the studies, in order to illustrate whether the influence of meteorology on groundwater recharge is site specific.

13. Line 486: Is this work able to say whether there are regions in the world which have declining or augmenting rates of recharge in the 1981-2014 time period?

14. Figures and Tables

    a) Generally, the figure style should be more consistent. Some figures don't have extents marked out (1, 2, 6, 7, 8, 10) whereas others do (3, 4, 5, 9, 11).
    b) Figure sizes should be more consistent; Figure 3 appears smaller than Figure 4, Figure 6 appears smaller than Figure 7 and Figure 8 appears smaller than Figure 9.
    c) Figures sitting one above the other should sit more squarely to one another (6 and 7, 8 and 9).
    d) Figure 5 is made up of multiple figures and therefore would benefit from a, b, c notation.
    e) Axis labels, legends and titles above map figures are often too small to read.

15. References

    a) Please include website addresses in reference of websites (Line 574: AQUASTAT)

16. Readability

    a) Generally, this paper is well written, making it easy to read and understand key concepts.

References

Doll,P. and Fiedler,K. (2008). Global-scale modeling of groundwater recharge. Hydrol. Earth Syst. Sci., 12, 863–885