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Discussions

Interactive comment on "Combining analytical solutions of Boussinesq equation with the modified Kozeny–Carman equation for estimation of catchment-scale hydrogeological parameters" *by* Man Gao et al.

Anonymous Referee #2

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Title: Combining analytical solution of Boussinesq equation with the modified Kozeny-Carman equation for estimation of catchment-scale hydrogeological parameters Ref. MS #HESS-2019-453

Overview:

The authors claim to develop a novel methodology to estimate the catchment-scale hydrogeological parameters of saturated hydraulic conductivity, K; drainable porosity, f; and the soil depth, D by combining the existing analytical solution of the Boussinesq

equation and the Kozeny-Carman equation. Subsequently, the developed approach is tested in four real-world study sites to conclude that the obtained soil parameters are well within the acceptable range. Although solutions to both the Boussinesq and the Kozeny-Carman equations exist in the literature, the authors' idea to combine both the solutions for estimating of aquifer property seems novel and interesting. It is worth mentioning that in earlier attempts to model the low flows from the delayed hillslope discharge, the soil depth, D is considered as a calibration parameter apart from K and f (e.g., Matonse and Kroll, 2009). The theoretical advancement, when established, could be helpful for modelling of the hydro-geologically ungauged basins wherein only streamflow data is available. However, there are several issues for which I am negative in recommending the paper for acceptance. Looking at the merits of the theoretical approach, the authors may be asked for a fully revised manuscript for resubmission.

Specific comments:

1. Getting first-hand information on spatial distribution of soil depth, D is easy in comparison to K and f. Unless the catchment under study is strictly ungauged and inaccessible, it can be obtained from the available well-logs directly and by vertical electrical sounding experiment indirectly that is neither costly nor time consuming. How would the authors justify the necessity of estimating the soil depth by analytical or empirical methods? This needs to be clearly justified in Introduction.

2. The title and the spatial scale of catchment chosen seem to be contradictory. Although, the authors claim for catchment-scale estimation, the study areas chosen do not reflect the same as all the four areas have the extent of 0.102 – 1.35 km2, which are only at the hillslope-scale. It is also reflected in the results obtained (Line #265-270), where the author state that the late-time recession is relatively fast except for SchÓğneben rock glacier (SPG) catchment. It could be due to the fact that a small hillslope would recede fast. The authors need to rethink and either change the title or test the approach at a suitable scale.

3. The delayed recession from the SPG could have resulted due to delayed release from snow and glacier melt. If this is the case, choosing this area poses a serious question as the Boussinesq equation and its solution deals with the draining hillslope aquifers, and not the glaciers. The authors can refer Winkler et al. (2016) for more details on the SPG.

4. It is good to see that the authors have considered both the early-time and late-time recessions; however, plotting at least one season of discharge data for each catchment would be more informative.

5. Form Fig. 3, it seems that the early-time and late-time recessions cannot be inferred from the analyzed recession data. Hence, a longer time series need to be analyzed with clear recession events (e.g., Rupp et al., 2009). As mentioned in Lines #257-258 and Fig. 3, it is not clear what is the physical basis of choosing the lower envelop lines with b=1 and b=3 to derive the recession intercepts. The range of this value looks too high.

6. The sensitivity analysis is not sufficient with only 10% change of independent variable (Fig. 5). Moreover, analysis for at least one more site would be informative.

7. Following Rupp and Selker (2006), consideration of variable time interval for recession analysis is interesting. The authors should mention the range of time interval considered for arriving at Fig. 3. Further, is this range same for all the four catchment or different?

8. Estimation of the hydraulic parameters considering both early- and late- time recession does not represent the same zone of aquifer that contribute to recession flow. Hence, it would not be better to say effective K, effective f rather than K and f.

9. Page 14: The field application results show that there is a huge gap between the estimated and observed soil hydraulic parameters, which may result in significant uncertainty in estimating the subsurface flux. Therefore, it is always advisable to calibrate

the parameters for their field use. An uncertainty analysis could strengthen the outcome of these results.

10. Eqs. (23)-(26) and Fig. 6: These are the ideal aquifer cases where K and f decrease with increase in the aquifer thickness, D. Therefore, these Eqs. could be far from the real hillslope cases.

11. The ability of the present approach in estimating the hydrogeological parameters can be tested fully by modelling the streamflow with the Boussinesq equation-based models with the estimated parameters instead of calibrating the model. I hope this would be the authors' next plan. However, rather than comparing the estimated parameters with the pedo-transfer function-based estimated results, testing the parameters in real modelling case would strengthen the claim in discussion.

Editorial:

1. Some long sentences need to be fragmented for clearer meaning: Lines #236-238, #242-243, #306-308

2. Line #115: Should be '. . . one-dimensional subsurface flow from the sloping aquifer' not 'on the'.

3. Reference for Eq. 1?

4. Line #119: From Fig. 1, the distance from river to ridge is B.

5. References for Eqs. 3 and 4?

6. Line #157: The verb form of the term should be 'recede', not 'recess'. Change accordingly at all subsequent appearances.

7. Lines: #157-160: It will be better to mention that the time duration between rainfall excess and beginning of recession depends upon catchment characteristic, extent, topography and depression storage.

8. Line #163: Replace '. . .in terms of. . .' by '. . .as per. . .'.

9. Line #200: Typo in Eq. 19. Replace 'r' by gamma.

10. Line #214: Change to '. . .fall under. . .'.

11. Line #221: Change to '. . .For SPG, the data published. . .'

12. Lines #234-235: Change to '. . .saturated hydraulic conductivity, K and soil/saprolite thickness, D. . . '. Change likewise at all other places.

13. Line #396: Change to 'Thus, detailed. . ., '.

14. Line #410: Change to '. . .equivalent values at. . .'.

References

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