

Interactive comment on “A novel method for cold region streamflow hydrograph separation using GRACE satellite observations” by Shusen Wang et al.

Anonymous Referee #1

Received and published: 18 December 2020

This paper proposes a new method to separate the baseflow from the total runoff using GRACE observations. An analytical relation was derived for the baseflow with three unknown parameters. This relation was derived with the assumption that the surface runoff is zero in the winter such that the total discharge is equal to the baseflow for these months. This new method was tested in a snow-dominated region and compared to several existing methods focusing on the baseflow hydrograph and baseflow index for the winter, snowmelt and summer seasons.

This paper is well written and structured. Also, it is an interesting topic which could contribute to improved baseflow separation in large river basins. I have a couple of

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major and minor comments that would improve the paper.

Generic comments:

1. When deriving the analytical solution (Eq.4), it seems the following assumption was made: $S_s = 0$ with S_s the surface water storage. However, in the winter when the surface runoff is equal to zero, the surface storage is not necessarily zero. Please clarify this as this could influence the validity of Eq.4. Also, for months with very low TWS values (e.g. $Stot \approx -100$ mm in September according to Figure 6), the baseflow Q_b seems to be negative according to Eq.4 which does not make sense and is not visible in Figure 8. So what did you do for these months when $Stot < a$?

2. The resulting baseflow according to the proposed method depends on the parameter values mentioned in Table 1. However, it remains unclear how these parameters were estimated. In line 126, it is mentioned the model was calibrated with an iteration scheme, but additional details are missing. For example, which scheme was applied, how many different parameter combinations were tested and what parameter ranges were used? It would be interesting and valuable to look into different parameter combinations with similar performances and how this could influence the results. How much do you think your results would change if you would use a different model performance metric or calibration scheme?

3. According to Figure 8, the baseflow is relatively high compared to the total discharge. Do you have any observations that could verify this? Is it possible all methods significantly overestimate the baseflow especially during months when the fast runoff is not zero? Would you get similar results with the manual approach?

4. Please include in the Discussion a section on GRACE uncertainties and how this could affect your results. Based on Figure 1, there are several open water bodies in and near the basin which could affect the GRACE observations. Also, please discuss whether this methodology is applicable in other regions that are not snow-dominated. For example, areas with zero rainfall during dry seasons in arid regions? Are there

specific criteria (climate, minimum/maximum basin size etc.) for which this methodology is applicable? Do you have any recommendations to further improve this approach and maybe expand it to other regions with different climatic conditions?

Specific comments:

1. Line 11: Please specify the region for which your approach is valid.
2. Line 11: Please specify what you mean with “the model [. . .] does not require a priori parameterisation” as there are three unknown parameters which were calibrated (line 121).
3. Line 21: What about groundwater flow from deep aquifers that contribute to the baseflow?
4. Line 22: What about rapid subsurface flow that contribute to fast runoff but where the water is located below the surface?
5. Line 23-26: Please explain more detailed how baseflow separation helps with respect to hydrogeology characterisation, rainfall-runoff relationships, flow regulations, water quality etc.
6. Line 20 – 26: Please add references to support this section.
7. Line 29: Are there no recent reviews on this topic?
8. Line 30: Please explain the manual approach more detailed. Based on which criteria are baseflow and fast runoff typically distinguished?
9. Line 42: What causes large uncertainties in snow-dominated regions?
10. Line 45: Why is there a limit on the watershed size?
11. Line 72: Please be more specific: which weaknesses do you intend to address with your new method?
12. Line 93: Do you mean $dS/dt = Q$ on monthly time scale? Are you referring to the

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total storage (Stot) and total discharge (Qobs)?

13. Line 96: Do you mean $dSs/dt = Qr$?

14. Line 97: Are you assuming all water stored on the surface infiltrates into the soil and hence contributes to the baseflow? Is this always the case?

15. Line 111: Are you sure k is the hydraulic conductivity and not the reservoir coefficient which indicates the mean residence time in the basin and depends on the hydraulic conductivity as well as other properties?

16. Line 126: Based on Table 1, you also used the Pearson correlation coefficient, significance level and mean absolute error to evaluate your results. Please mention that here.

17. Line 135: Please explain how you compared the different methods. For example, you used the baseflow index (BFI) and specifically looked at three seasons (winter, snowmelt and summer season).

18. Section 3: Please clarify clearly which months belong to which season (summer, winter, autumn, snowmelt etc.). Based on which criteria did you identify the winter period (fixed months, based on the temperature or something else)?

19. Line 174: How much is the annual evaporation?

20. Line 193 “less than half of the spring snowmelt peak”: It doesn’t look like less than half in Figure 5.

21. Line 207: maximum variation of what exactly?

22. Line 211: How high does the evaporation get in this region where the average temperature is 1°C ? In other words, how significant is the contribution of the evaporation?

23. Line 226: How did you estimate the drainable water storage? Please explain this in Section 2.

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24. Line 258: Please be more specific: how and based on which criteria did you examine the data?

25. Line 261 “little impact”: Please show some numbers to support this statement.

26. Line 310 – 315: Are you referring to Figure 11 here? If yes, your observations are very difficult to see in that figure.

27. Data availability: There is no data available for the snow water equivalent with the given link and the link for the discharge data is not valid anymore.

28. Supplements: Please specify the version of the temperature and snow data used in this study.

Technical comments:

1. Line 13 and 14: “estimates” instead of “estimate”

2. Figures 2, 4 and 5: Please add the vertical blue lines shown in Figure 3 to allow easier comparisons.

3. Figure 5: Please show the start of the winter in this figure.

4. Line 225: Please refer to Figure 7 here.

5. Figure 7: Please add the variable name in the label of y-axis.

6. Figures 8-10: Please mark the following seasons in this figure: winter season, snowmelt season and summer season. You compare the different techniques for these seasons, hence marking them would allow for a better graphical comparison for specific seasons. Also, please use the same colours in Figure 8 as in Figures 9 and 10.

7. Line 265: Please refer to Figure 10 here.

8. Line 269: Please illustrate this in a figure.

9. Line 272: Please refer to Figure 9 here.

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10. Figure 11: Is your model on the x- or y-axis? Please use the same colours as in Figure 10. It would also be helpful if you would add a 1:1 line.

11. Lines 327, 328, 332: Please remove “may”

12. Line 338: Please replace “recommend” in this sentence.

13. Line 352: Please remove “accurately”

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2020-524>, 2020.

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