New baseflow separation and recession analysis approaches for streamflow
M. K. Stewart, Hydrol. Earth Syst. Sci. Discuss., 11, 7089–7131, 2014

- Review -

General comments

The author presented a new approach to separate baseflow from streamflow based on different flow components of total streamflow. It is stated that recession analysis can give very misleading results when only total streamflow is considered. The paper is surely in the scope of HESS and very interesting for the readership as a step forward to a more objective and process-based baseflow separation and recession analysis is made. However, I think the manuscript could be improved in several ways. Suggested improvements are: a) the link between the presented analysis and the published literature could be easily improved. At some points necessary references are missing (e.g. (5) in Section 8.3) or the cited papers are not the best choice. b) As a new method is proposed more guidance is needed how to apply the procedure (catchment types, streamflow data, time step). It should be clearly stated whether this method is focused on an event-based or not c) It is a long manuscript. I am not sure if all parts are essentially needed or at least a more comprehensive structure of the different section will improve the readability of the paper.

Specific comments

1. It might be helpful to spend some more time to clearly describe the technical assumptions to apply this method. For example, it could be more precisely explained whether this is a recession event-specific analysis method (like master recession) or a continuous separation method for an entire streamflow series (like minima-method). Interestingly, the Author mentioned shortly in the discussion 8.2 that an analysis of total streamflow (without considering different components) is feasible during low flow, when quickflow in streamflow is very small. But the proposed method characterized early and late recession behavior. Later will typically occur during low flow; more clarity is needed here. Section 8.1 nicely summarizes the features of the proposed method, but some guidance is needed to evaluate the relationship between response times of catchments and the required time step in data (hourly vs. daily data). In other words, is this approach applicable with daily streamflow data in larger catchments when the response characteristics of quickflow/baseflow are more or less unknown?

2. As many papers using the –dQ/dt-Q-method, the Author cited the paper that has introduced this method(Brutsaert and Nieber, 1977). However, recession analysis is an on-going discussion in hydrology and from my point of view the discussion in section 3 has a lack of appropriate references (P7099L4-P7100L8). Several papers (Rupp and Selker, 2006; Biswal and Marani, 2010; McMillan *et al.*, 2011; Shaw and Riha, 2012) have discussed the shortcomings of the –dQ/dt-Q-method, which should be mentioned here as these analysis giving misleading results (P7100,L8).
3. This is extensive and comprehensive manuscript, therefore a clear structure with distinctive sections is helpful to guide the reader through a) the recession analysis theory, b) the new baseflow separation method, c) the application in the study catchment and d) the justification of the proposed approach. The high number of different sections (1-9 each with different subsections) makes it somehow difficult to follow the argumentation of the Author. Perhaps its worthwhile to consider a separate justification of the approach in one section and remove all isotope and transit time theory (e.g. 5, 7.4, 7.5, 8.4) from the first part of the paper? Another example is the mixed methods and results in section 7.1 (P7012/7013). One could argue that the calibration procedure (P7103,L1-P7104,L18) could for logical reasons be placed into the methods section above.
4. P7102, L2-15: Firstly, why is the catchment area not mentioned? This information might be interesting as the author referring to method by Hewlett and Hibbert (1967) who focused on recession behavior and recession analysis in “small watersheds”. Is the proposed approach restricted to a certain catchment size? Secondly, the study also focuses on baseflow separation and recession analysis, therefore some information about the geology (perhaps in Fig. 3) might be interesting as recent studies argue that besides physiographic characteristics also geology is a valuable descriptor for baseflow generation processes (Bloomfield *et al.*, 2009; Stoelzle *et al.*, 2014). Thirdly, some information about the streamflow regime is needed to evaluate the differences between summer and winter events and their characteristic recession behavior (e.g. is there significant influence of snow/snowmelt?).
5. P7102, L14-15: What is suggested by the information of runoff accuracy? Is this 30- year-old estimation still valid? Information about the accuracy during low flow might be even more valuable to evaluate the magnitude of the separated baseflow component.
6. P7014,L20-29: The discussion of the flow duration curves in Fig. 4e and 5e is very interesting. What are plausible processes for different FDC-patterns in

winter and summer? Already published references might be helpful for the reader to link recession behavior with FDC analysis.

7. At the end I wonder how reliable the results and implications of this paper are as only data from one catchment is used during the analysis. The author could at least inform the reader when specific recession behavior of the study catchment and/or specific results not apparently valid in other catchments.

Minor/technical comments:

1. P7091,L8: The author could add a reference to “Hortonian view of catchments” or explain shortly why this association is relevant for baseflow separation methods.
2. P7091,L10-12: The author should give references for the mentioned “recent modelling studies”. What does “[…] ,although it may be embedded in later modelling calculations” exactly mean?
3. P7092,L8-9: “[…] and based generally on the results of tracer hydrograph separations” This statement puzzles me as the author later stated that the BRM method can be applied using streamflow time series alone. I guess that tracer data justified the proposed method, however, this needs to be clarified.
4. P7092, L11-12: FDCs are for the first time mentioned here. The author could shortly comment on the purpose of applying the method to FDC. Perhaps a link to section 4 might be helpful here.
5. P7093, L13: “…has proven to be effective in many catchments,…” Reference(s) would be helpful to point out the effectiveness of such separations in application.
6. P7094, L1: Sloto and Crouse (1996) seems to be very arbitrary reference here. This report presented a tool to apply a baseflow separation based on a minima-method, but other papers before have discussed the minima-method more detailed. The author should at least insert a “e.g.” here.
7. P7094,L16: “Other authors…” – references?
8. P7096,L11: Please link the “evidence” to the according section in this paper (section 7.4?)
9. P7103,L22-23: Are the slope values really comparable?
10. P79104,L6-7: “the line shown on the lower part of the streamflow points has a slope of 4” – Clarify which line is meant here.
11. P7106, L2: How many recessions with which length?
12. P7107,L9: What does “mm (over the catchment area)” mean?

13. P7110, L16-19 Please give references for misinterpretation in previous studies (or some examples what kind of misinterpretation was done in the past).
14. P7110,L20: Kirchner (2009).
15. P7111,L2: Please characterize “misleading information”
16. P7111, L22: Should be Stoelzle et al. (2013)
17. P7113, L12: Is only a graphically separation of early and late recession behavior possible?
18. P7113, L14-22: SW-GW-interaction is a long time neglected field in hydrology, perhaps it is worthwhile to add some more information how the proposed method can help to improve the understanding of SW-GW-interaction (e.g. Barthel, 2014)
19. P7114, L22-23: What is the (relevant) information in this sentence?

Figures

Figure 1:
The schematic relationship between streamflow and baseflow is very interesting. Is the quickflow here the streamflow minus baseflow or total streamflow? It might be helpful to show all three components (streamflow, quickflow, baseflow) and/or multiple examples (three different recessions over time, each with separated quickflow and baseflow). Furthermore it seems valuable to show the reader schematically the Hewlett and Hibbert (1967) approach in this figure, which is introduced before P7094L6-16).

Figure 4-6:
My expectation was a separate analysis of baseflow and quickflow. It is somehow confusing that sometimes streamflow with quickflow is compared, sometimes (also in the manuscript) baseflow with quickflow. For me it is not always clear whether streamflow is total streamflow or quickflow component. What is the dashed, vertical line in Figure 4c, 5c, 7c? In Figure 4 the bold font-style (f) should be removed.

Figure 7:
(a) What are the numbers (4) and (2) here? The number of analyzed recessions?

References

Barthel R. 2014. HESS Opinions 'Integration of groundwater and surface water research: an interdisciplinary problem?'. *Hydrology and Earth System Sciences* **18**: 2615–2628. DOI: 10.5194/hess-18-2615-2014.

Biswal B, Marani M. 2010. Geomorphological origin of recession curves. *Geophysical Research Letters* **37**: L24403. DOI: 10.1029/2010GL045415.

Bloomfield JP, Allen DJ, Griffiths KJ. 2009. Examining geological controls on baseflow index (BFI) using regression analysis: An illustration from the Thames Basin, UK. *Journal of Hydrology* **373**: 164–176. DOI: 10.1016/j.jhydrol.2009.04.025.

Brutsaert W, Nieber JL. 1977. Regionalized drought flow hydrographs from a mature glaciated plateau. *Water Resources Research* **13**: 637–643.

McMillan HK, Clark MP, Bowden WB, Duncan M, Woods RA. 2011. Hydrological field data from a modeller's perspective: Part 1. Diagnostic tests for model structure. *Hydrological Processes* **25**: 511–522. DOI: 10.1002/hyp.7841.

Rupp DE, Selker JS. 2006. Information, artifacts, and noise in dQ/dt−Q recession analysis. *Advances in Water Resources* **29**: 154–160. DOI: 10.1016/j.advwatres.2005.03.019.

Shaw SB, Riha SJ. 2012. Examining individual recession events instead of a data cloud: Using a modified interpretation of dQ/dt-Q streamflow recession in glaciated watersheds to better inform models of low flow. *Journal of Hydrology* **434-435**: 46–54. DOI: 10.1016/j.jhydrol.2012.02.034.

Stoelzle M, Weiler M, Stahl K, Morhard A, Schuetz T. 2014. Is there a superior conceptual groundwater model structure for baseflow simulation? *Hydrological Processes* 1–22. DOI: 10.1002/hyp.10251.