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Interactive comment on "Hydrograph separation: an impartial parametrization for an imperfect method" *by* Antoine Pelletier and Vazken Andréassian

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Review of "Hydrograph separation: an impartial parametrization for an imperfect method"

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General Comments

This paper is the latest in a long series of efforts to make robust and automated or reproducible separations of baseflow. In doing so the authors may have improved the methodology and using catchment characteristics is desirable. The application

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to a variety of catchments in France illustrates its capacity to provide regionalisation of baseflow estimates over a wide range of catchment types (rainfall, topography, geology etc).

The paper is generally understandable but in places the writing is idiomatic and not very precise. I do not think that papers need to be overly formal in their writing style but the final version should probably be a little less conversational in style.

My main concern with this paper is not the new methodology or its application but more fundamentally, what is it that we are calculating when we perform two-component hydrograph separations. As outlined in several publications (including Gonzales et al., 2009 [cited] and Cartwright et al. 2014: Hydrology and Earth System Sciences, 18, 15-30), baseflow estimates based on hydrographs (eg filters or graphical separations) are commonly higher than those based on chemical mass balance. Some studies have sought to "tune" filters using geochemistry (this is discussed in Section 2.4 and was employed by Gonzales); however, this may miss the point that the system involves more than two components.

River flow comprises surface runoff, groundwater inflows, and a range of intermediate stores of water (bank return flows, interflow, water stored in pools on the floodplain). These various stores probably contribute differently to river flow at different stages of the hydrological cycle. If we define baseflow (or slow flow) as all the delayed stores of water, then it may consist of any and all of these stores and not just be groundwater (i.e. the deeper waters contained in the aquifers). These intermediate stores of water are likely to have a geochemistry more similar to that of the surface runoff (especially if residence times are insufficient for significant geochemical reactions in the catchment to progress), which may explain the discordance between estimates of baseflow from chemical mass balance and hydrograph techniques. The paper needs to be more explicit on these points.

For example:

Section 2.5. “Streamflow in a river is seen as having two origins, groundwater – the sum of contributions of various aquifers – and surface water, made of surface runoff and subsurface interflow, i.e., water that does not stay too long underground. Surface water response to climatic events is much quicker than that of groundwater and this speed difference is time-coherent all along the hydrograph.”

Section 3.1 “which underpins the concept of baseflow – can be represented by a conceptual reservoir, whose outflow will represent the groundwater contribution to streamflow”.

Section 3.1.1. “What recharges the aquifer with water that will be baseflow afterwards?". The part of rainfall that does not contribute to surface runoff or to evaporation is generally named recharge, as it is thought to feed groundwater storage.”

These examples implicitly assume that all delayed inputs are from groundwater. This is an oversimplification of the system and something that needs to be acknowledged and addressed. Presumably the time responses of these other reservoirs are shorter than for groundwater (which may be problematic). This is an important point as it does not matter how good the concepts and their applications are if the conceptualisation is not correct or well explained

Overall, I think the paper is an advance to this field but it might be more imperfect than they conceive. It certainly removes some of the arbitrary and more difficult parameterisation of other techniques. Attention to the points above and the possible other limitations (see below) would improve its impact.

Specific comments

Abstract

This section is too brief (it reads like a highlights section). Put some more detail in to emphasise what new understanding of hydrology you made and/or the limitations of the technique (see later)

Introduction (Section 1) and Hydrograph separation: a short review (Section 2)

These sections should be combined. The order is fine but Section 2 really just provides more background material, so is really part of the introduction

The literature is also rather dated; it is good to see the older classic discussions included but there have been more recent papers. Please add some more recent studies.

Section 3

The number of variables make reading this section difficult and there may be some duplication of parameters (I think that Tau is used for two different variables – I may be wrong here but check). I would suggest adding a Table of variables, which would help the readability.

Some of the explanations here are also not very clear to understand and should be read carefully for clarity

The text “For the sake of simplicity, a straightforward hypothesis is added: baseflow must be equal to total flow at least once in a hydrological year, when measured streamflow reaches its yearly minimum” glosses over a major issue. This may be a desirable simplification but is it correct? This is a common assumption for perennial streams in semi-arid areas with long dry periods but is it justifiable in the higher rainfall areas of France? Like several other assumptions in the paper, this rather bald assumption detracts from the study and needs more justification.

In a similar way “In this paper, we make the hypothesis that the best candidate for a proxy of recharge is a linear fraction of total flow itself. It is quite well-correlated with the behaviour of recharge given above. In addition, it is available without a further model or hypothesis.” glosses over a major issue. Intuitively, I would have thought that recharge is not a linear function of flow as at high flows the ration of streamflow to baseflow is higher. More justification is also needed here.

With all these justifications, the text may become long. If so, the details of the mathematics could go in an appendix / supplement and the important conceptualisations / justifications in the main paper.

The response time (Tau) is a critical parameter in the context of this paper. You should define exactly what it is.

Section 4

Do the authors have sufficient temporal geochemistry data from any of the catchments to look at whether the baseflow separations can predict the geochemistry of the rivers. This might be something as simple as EC data. While the chemical mass balance approach to hydrograph separations is not foolproof, it does allow some checking to be made (the Gonzales et al., and Cartwright et al., papers amongst many other studies looked at this). It might go someway to answering the question as to how many stores of water there may be.

Looking at the geochemistry may also help in justifying the assumption that at low flows, the river is fed entirely by groundwater as at those times one would expect that the river geochemistry is very similar to that of groundwater in near-river shallow aquifers. This would be difficult for the larger rivers that could be fed by multiple aquifers but it may be possible for the smaller rivers.

Section 5

This section is a rather short summary of the findings. One aspect that needs addressing is what the limitations of this technique are. Most baseflow estimates based on hydrographs have some limitations around

1) Regulated rivers (i.e. those with dams or barrages on them)

2) Areas where groundwater abstraction results in disconnection

3) Rivers that receive inputs from canals or the like

4) Rivers where major pumping of water occurs

Is this the case here and can you outline practical limits where you think that this technique applies less well? Can you discuss the implications for applying this in practice?

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