Response to I. Cartwright (Referee)

Reply explanation: The reviewers' comments are shown in black, while the author's replies and revises are shown in blue.

Comments: The authors present an interesting analysis of sensitivity of the two-component chemical mass balance method based on specific conductivity (SC). The paper is generally clear, although the final version should be read carefully for grammar and understanding.

Reply and Revise: We appreciate the positive comment for this study. And we have asked an English native language agency to check and correct the grammar and structure of the manuscript.

Comments: My main concern is how the errors in the baseflow SC are dealt with. As noted by the authors, this has a major impact on the results of the chemical mass balance. Aside from the question as to whether to use the 99th percentile or the maximum SC, there are several common ways of estimating the SC of baseflow in chemical mass balance studies, these include:

1) Measurement in near-river groundwater bores

2) Using a single value based on the highest SC of the river throughout the study period

3) For multi-year studies, assigning a constant value for each water year (generally based on the highest SC in low summer flows)

4) Assuming that the baseflow SC varies linearly between the SC of successive low flow periods (the paper of Miller et al., 2014 uses that strategy).

These strategies can produce very different estimates of baseflow from the same river SC data. This is especially true for catchments where the contrast between the SC of surface runoff and baseflow are large and where the maximum SC in the river varies between successive low flows.

In practice, it is very difficult to estimate the SC of baseflow due to

* Groundwater having spatially variable SC and the fluxes of groundwater from different areas of the catchment varying over time as water tables rise and fall

* Baseflow being comprised of different components (groundwater, interflow, bank return waters), all of which have different SC, that contribute to river flow in different proportions at different times.

An uncertainty of 5% (section 4.2) is probably over optimistic. In section 4.1, it would be better to calculate an uncertainty based on the last three strategies noted above (perhaps with or without the 99th percentile constraint as well). While there is no foolproof methodology for estimating the SC of baseflow, this would yield a better estimate of what the realistic uncertainties are.

Reply and Revise: We are very grateful for your explanation of the common strategies of estimating the conductivity of baseflow and the complexity of the conductivity of baseflow. We fully agree with your description.

We have recalculated the sensitivity indices and the uncertainty based on the fourth strategy (the baseflow conductivity varies linearly between the conductivity of successive low flow periods) you mentioned with the 99^{th} percentile constraint (Sect. 4.1; Sect. 4.2; Table 1; Figures 1&2).

Based on the results of the recalculation, we found that the mean uncertainty of BF_C is about 10%, and the original use of 5% is indeed too optimistic. We have changed the uncertainty (Page 7, lines 32--33).

Other minor comments:

Comments: Equation (1). Suggest changing the nomenclature – Q is commonly used for streamflow in papers.

Reply and Revise: Well taken, we have changed the nomenclature and used SC as the variable name of specific conductance throughout the paper.

Comments: Somewhere in the introduction, you should outline the necessary conditions for chemical mass balance

a) Contributions from end-members other than baseflow and surface runoff are negligible

b) The SC of runoff and baseflow are constant (or vary in a known way) over the period of record

c) Instream processes (such as evaporation) do not change SC makedly

d) Baseflow and surface runoff have significantly different SC

Reply and Revise: Well taken, we have added the assumptions of conductivity two-component hydrograph separation method (chemical mass balance method) as suggested (Page 2, lines 3--7).

Comments: Check consistency with spelling of Eckhardt throughout

Reply and Revise: Well taken, we have checked the spelling and revised the mistake (Page 2, line 26).

Comments: Page 2 lines 12-15 is not very clearly written – try to rephrase it

Reply and Revise: Well taken, we have rephrased the sentences (Page 2, lines 26--28).

Comments: Section 2.2. The errors in streamflow y are only briefly discussed. The value of 3% may be fine but this value looks to come from a thesis and it is not certain whether the gauges studied are relevant to this study. Presumably someone has addressed this for the USGS gauges? More justification of this value is needed.

Reply and Revise: Well taken, the value of 3% came from the uncertainty analysis in streamflow of Yellow River, China. This value may be unfair for the USGS gauges, so we have read some articles to find a more reasonable value.

Olson et al. (2007) and Sauer et al. (2010) indicated that the continuous records of water level in USGS gauges are translated to streamflow by applying the rating curve. And the water level measurements are accurate to the nearest 0.01 foot or 0.2 percent of water level. However, we did not find a description of the uncertainty in streamflow on the website of USGS. Hamilton et al. (2012) indicated that streamflow data from USGS are often assumed by analysts to be accurate and precise to within ±5% at the 95% confidence interval.

Based on the above, we have revised the value of 3% to 5%, and have revised the references and related content (Page 4, lines 32--33).

Comments: Page 4, Lines 10-30. Do you need this amount of detail for these minor errors? Perhaps keep the text as is, but I do not think that the figures are strictly necessary.

Reply and Revise: Well taken, we have reduced the description of this section and have added Fig. 1 and Fig. 2 and related descriptions to the Supplement S1 (Page 5, lines 3--31).

Comments: Page 5, line 6. State the assumptions that the uncertainties are uncorrelated and have a Gaussian distribution.

Reply and Revise: Well taken, we have added the assumptions as suggested (Page 5, line 35).

Comments: Section 4. This application is appropriate but as noted above, the uncertainties in the SC of the baseflow (and possibly yk) are understated.

Reply and Revise: Well taken, we have recalculated the sensitivity indices and the uncertainty based on the fourth strategy (the baseflow conductivity varies linearly between the conductivity of successive low flow periods) you mentioned above with the 99^{th} percentile constraint (Sect. 4.1; Sect. 4.2; Table 1; Figures 1&2).

Based on the results of the recalculation, we found that the mean uncertainty of BF_C is about 10%, and the original use of 5% is indeed too optimistic. We have changed the uncertainty (Page 7, lines 32-33).

Comments: Conclusions. You should add a sentence or two stating what the main sources of error are and how practitioners can go about reducing those. For example, better rating curves are probably more important than better loggers and more work on understanding the SC of baseflow (although it is not clear how you might do that) is more important than understanding the SC of surface runoff.

Reply and Revise: Well taken, we have added the relevant content as suggested (Page 9, lines 6--9).

References:

Olson, S.A., and Norris, J.M., 2007, U.S. Geological Survey streamgaging…from the National Streamflow Information Program: U.S. Geological Survey Fact Sheet 2005–3131, 4 p. (Also available at http://pubs.usgs.gov/fs/2005/3131/.)

Sauer, V.B., and Turnipseed, D.P., 2010, Stage measurement at gaging stations: U.S. Geological Survey Techniques and Methods, book 3, chap. A7, 45 p. (Also available at http://pubs.usgs.gov/tm/tm3-a7/.)

Hamilton, A.S., and Moore R.D., 2012, Quantifying Uncertainty in Streamflow Records , Canadian Water Resources Journal / Revue canadienne des ressources hydriques, 37:1, 3-21, DOI: 10.4296/cwrj3701865