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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Discussion on key challenges facing the application of the conductivity mass-balance (CMB) method: a case study of the Mississippi River Basin" *by* Hang Lyu et al.

Anonymous Referee #2

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This manuscript discussed the key challenges for applying the conductivity mass balance (CMB) method for baseflow separation and recommend guidelines for the method, which significantly augment the user confidence in applying the CMB for baseflow separation. This work is timely, given that the preliminary literature is lacking the sufficient knowledge in this research theme. Authors adopted large dataset and tests in the Mississippi River Basin to conclude. However, some uncertainties need to be addressed before publication. I, therefore, recommend moderate revision for the current version of the manuscript.

1. In this study, more than 200 sites were included in the data analysis. However, some conclusions were drawn from the simple examination, which lacks the robust evidence of whether these conclusions will hold. For instance, A) the impacts of topography and altitude (Line 276) is concluded by a simple spatial plot (figure 7). In my view, such suggestion is acceptable, but not robust. I suggest the authors can make a scatter plot the correlation against the median elevation of sub-watersheds or other indices that can represent the watershed topography. B) Impact of anthropogenic factors. In this section, the authors only discussed the reservoir as an indicator of human interruption. Disapprovingly, authors only mention the evaporation. The reservoir/dam can provide substantial sources of water in the low flow periods. This may decrease the conductivity in streams and hence undermines the groundwater contribution to streams and leads to an underestimate of baseflow conductivity. Besides, there are other anthropogenic factors such as groundwater pumping and agriculture activities that affect the conductivity in streams and should be discussed in the manuscript.

2. The authors stressed that there is a large amount of watershed where CMB can not be applied. The following question is why this happens in this watershed? I assume that further tests are needed to answer this question. Based on my experience, I suggest the authors can test, but not limited to, the following variables: A) watersheds area, B) Watershed locations, C) snow- and rain-dominated hydrological regimes, D) Land cover and land use. E) Climate regions.

2.1 In Figure 8, authors only examined the relationship between correlation and watershed area in two sub-watersheds. Why don't you examine such relationship for all study watersheds? In smaller watersheds, low flows are mainly fed by groundwater. In contrast, there is always a large amount of surface runoff in the low flows period due to the spatial heterogeneity of climate. In my opinion, you could test all sub-watersheds as well as the entire Mississippi River Basin, and it can drive a threshold of watershed area, above which the CMB methods cannot be applied.

2.2 In this study, the authors concluded that headwater watersheds have a better rela-

tionship between discharge and conductivity. I assume this is likely due to differences in hydrological regimes, i.e., snow-dominated and rain-dominated. In upper streams, high flows are mainly stimulated by the snow-melt process (e.g., Dyer, 2008). They can be classified as snow-dominated watersheds, while lower watersheds are more likely to be rain-dominated systems. Two systems have a distinct hydrological process, and there is potential uncertainty whether there is a significant difference between the two systems.

Dyer, J., 2008. Snow depth and streamflow relationships in large North American watersheds. Journal of Geophysical Research: Atmospheres, 113(D18).

2.3 Land cover and land use can be a factor. Forest cover and agriculture land use can have different conductivity concentrations. In the forest watersheds, Li et al. (2018) (in supplementary) showed that conductivity of baseflow and surface runoff did not change over time. In contrast, agriculture practices such as fertilizer application can influence the concentrations of conductivity and hence affect the CMB method accuracy.

2.4 Mississippi River basin is the large watershed. The basin has sizeable spatial heterogeneity of climate. The role of climate on hydrology, particularly for low flows are more pronounced in the larger watersheds. It is worth conducting an analysis of this topic. For simplicity, Climate North America (http://climatena.ca/) can provide climate data for the basin.

In sum, further analysis is, for sure, needed to address the knowledge gaps as mentioned above.

Li, Q., Wei, X., Zhang, M., Liu, W., Giles-Hansen, K. and Wang, Y., 2018. The cumulative effects of forest disturbance and climate variability on streamflow components in a large forest-dominated watershed. Journal of Hydrology, 557, pp.448-459.

3. One recommendation of this manuscript is that the parameters SCro and SCbf can be determined by the 99th percentile and dynamic 99th percentile methods. I

agree with the authors to select the 99th percentile of conductivity. However, there is also a concern related to this recommendation. For the CMB method, the SCbf is often corresponding to the lowest flows with potential time lags (Li et al. 2014; in your manuscript). With the recommendation of using the 99th percentile, it might be a chance that the 99th percentile does not correspond to the lowest flows. Therefore, this should be mentioned in the discussion.

4. The title can be rephrased as “Key challenges facing the application of the conductivity mass balance method: a case study of the Mississippi River Basin”

5. Table 1 should be reorganized. It is meaningless to use the site number. I suggest the site characteristic such as watershed area, relief, slope, and climate, can also be listed in table 1. As such, the sensitivity can be compared with watershed characteristics.

6. The objective should be concise. In Line 85, “to resolve some of the questions”. Please be more specific, which questions you are going to resolve in this manuscript.

7. Section 2.5, the meaning of the sensitivity and uncertainty should be elaborated more. For instance, larger values of sensitivity indicate higher sensitivity. A similar explanation is needed for uncertainty.

8. The language should be polished by the professionals before publication. Here I list some of the suggestions while I read the manuscript.

i. First two sentences in the abstract. Suggestion: The conductivity mass balance (CMB) method has a long history of application to baseflow separation studies, which uses site-specific and widely available discharge and specific conductance data.

ii. Line 17, insert “in” ; the parameter in the method

iii. Lines 45-47, rewrite

iv. Line 125, the key parameters need to be calculated

v. Line 140, for at least 5 years

vi. Line 147, delete unbroken

vii. Figure 8 is not clear. Please redraw.

All in all, the above mentioned are the suggestions for this manuscript. I am looking forward to your revision.

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