

# ***Interactive comment on “Comparing Bayesian and traditional end-member mixing approaches for hydrograph separation in a glacierized basin” by Zhihua He et al.***

## **Anonymous Referee #1**

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**Summary:** This paper provides an interesting comparison of traditional end-member mixing analysis approaches versus Bayesian statistical approaches for estimating contributions of different runoff components in a glacierized basin in Central Asia. The paper provides an interesting in-depth analysis of the effect of different sources of uncertainty on the Bayesian modeling results. The results clearly highlight that the Bayesian approaches predict more or less the same runoff contributions as the EMMA model when both models have a large sample size, but the Bayesian approach reaches a much smaller uncertainty that is about 50-60% of the EMMA approach. The results

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further show that the Bayesian approach is superior to the EMMA approach in situations where sample numbers are low and end members look very similar (e.g. snow and glacier melt signature is similar). The results further show that explicitly considering the correlation between 2H and 18O in the mixing model, further reduces the uncertainty in the results. The paper is well motivated, and the introduction provides a comprehensive overview of the current research on isotope hydrograph separation of runoff components in glacierized basins. The authors explain well the limitations of existing “traditional” approaches such as end-member-mixing-analysis and describe clearly the advantages that Bayesian approaches provide to this problem. My only recommendation would be to add a figure showing the time series of the isotope and EC data and to clarify the “fractionation effect” in the methods and results section. It is currently not clear what this Bayesian modeling scenario encompasses and because of that the section that describes the results of this scenario analysis is confusing. Other than that, the paper, overall, is well written and easy to comprehend. The authors made all relevant code available.

## Specific Comments:

Line 146: Please specify what “pure plastic bottles” are? Typically, we state the type (e.g. HDPE or glass) and size of the bottle used to sample water.

Line 108: Please be more specific. What do you mean by “water sampling uncertainty” here? Do you mean the uncertainty associated with having just a few samples?

Line 159: What is the size of the Golubin glacier in the watershed? You mention that glaciers cover about 17% of the watershed. What is the fraction that the Golubin glacier represents in the 17%? What is the streamflow (volume) contribution of the glacier to the entire basin? Is the Golubin glacier representative of the elevation range and snow accumulation of the other glacierized areas in the basin? Did you take grab samples from the other glaciers for comparison? I am a bit concerned that the glacier melt contribution of the Golubin glacier is too small to really make a difference isotopically.

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Line 177: Please specify the model and manufacturer of the pH, EC and TDS meter used in this study. Please indicate the precision that this instrument can achieve.

Line 178: How did you determine what constitutes an “abnormal isotopic compositions”? Please describe the method/approach you used.

Line 185: It would be helpful if the authors could add text on how much rainfall and streamflow the Ala-Archa basin typically gets and what the mean annual temperature is. In addition, I would like to suggest providing a graph of the temperature, precipitation and streamflow observed in the Ala-Archa basin between 2012 and 2017 so that the reader can evaluate the interannual variability in the hydro-climate. Since the authors decided to average isotope and EC values across 5 years of observations, this information might help explaining some of the uncertainty in the data.

Line 185: Please add a time series graphs of your isotope and EC, pH and TDS measurements. This graph does not have to be in the main text but could be provided as supplemental material so that the reader can see how the collected data looks like.

Line 250: Please show the histograms of the isotope and EC data. The Bayesian approach assumes that the data is normally distributed, however, based on the data range shown in Figure 3, it looks like that some data might not have been normally distributed? You could report results from a normality test to be sure.

Line 300: It is not quite clear what you mean by “the fractionation effect”. Could you be more specific and clarify to the reader when, were this fractionation effect might occur and how it could impact the observed values?

Line 435: The results section on the fractionation effect is confusing. This is mainly because it is not clear what the fractionation effect is and how it is estimated in the sample groups. I would recommend clarifying this in the methods.

Line 463: I would suggest rephrasing to: “The TEMMA estimated similar CRCs for most mixing models but at a larger uncertainty than the Bayesian approaches.”

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Figure 3: During the glacier melt season the snowmelt end member has a much lower EC value than what was estimated for the cold and snowmelt seasons. Can you explain why the EC is all the sudden so much lower? Since it is most likely not fresh snow that is melting during the glacier melt season, this trend is somewhat surprising.

Minor comments: Line 43: Should be “led” instead of “leaded”. Line 114: Use “of” instead of “for the”. Line 124: Should be “glaciers cover” instead of “glacier covers” unless you only have one glacier. . . Line 127: Should be “shows”. Line 129: Word missing. Please insert “runoff” after “generates”. Line 138: Should be “since the 1960s”. Line 158: Should be “was” instead of “were”. Line 162: Suggest using “from early March”. Line 163: Suggest using “due to” instead of “caused by”. Line 168: Please add “meltwater samples”. Line 172: “at Helmholtz” Line 183: “split” would be a better word than “distributed”. Line 292: please delete “keeping”. Line 309: Language! Please rephrase the second part of this sentence. Line 469: Replace “occasionally” with “sporadically”. Line 499: Replace “though” with “despite”. Line 520: replace “spring points” with “springs”. Figure 1: Please remove the underscore for the Rain collector label in the legend.

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