Reviewer 1:

1. 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 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 ^{2}H and ^{18}O 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.

Reply: Thanks for your positive comments on this paper. We have addressed all your concerns in the revised manuscript. A figure has been added to the supplement to show the time series of water isotope and EC data along with temperature, precipitation and streamflow data. The fractionation effect has been explained in more details, and the related expressions have been refined to reduce confusion.

2. 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.

Reply: We specified the bottles as 50 ml high-density polyethylene (HDPE) bottles in the revised manuscript.

3. 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?

Reply: Specified this as "water sampling uncertainty associated with the representativeness of the water samples caused by the limited sample site and sample size". See lines 120-121.

4. 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.

Reply: The Golubin glacier has an area of ~5.7 km^2 and extends over an elevation range from 3232 to 4458 m a.s.l.. The elevation range of the entire glacierized area extends from 3218 to 4857 m a.s.l., with about 76% located between 3700 and 4100m a.s.l.. Both the elevation range and the mean elevation (3869 m a.s.l.) of the Golubin glacier are close to those of the entire glacierized area (mean elevation is 3945m a.s.l.). The Golubin glacier represents about 14.4% of the entire glacierized area, while its elevation range covers around 95.6% of the entire glacier range. We only collected meltwater samples from the Golubin glacier, due to the logistic limitations in the remaining glacierized area. Considering the isotopic compositions of snow and glacier meltwater are particularly dependent on the elevation of glacierized area, the sampled meltwater from the Golubin glacier could represent meltwater originated from the primary melting locations in the entire glacierized area. We added these explains in the revised manuscript. See lines 146-150 and 625-626.

5. 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.

Reply: Specified as "We used the Hanan Instruments HI-9813 PH EC/TDS portable meter to measure the EC values of water samples, with a measurement precision of 0.1 µs/cm". TDS and pH values of water sample were not recorded. See lines 209-210.

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

Reply: We used threshold values to identify abnormal values of $\delta^{18}O$ and EC located far away from the sample clusters. For $\delta^{18}O$, sample values higher than 5‰ were excluded. For EC, sample values higher than 210 µs/cm were excluded. We specified that in the revised manuscript. See lines 214-217.

7. 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.

Reply: A figure for the daily precipitation, temperature and streamflow measured at the basin outlet during 2012-2017 has been added in the supplement (also see the following Figs. S1c-e). Related sentences have been added to describe the hydro-climate data: "The annual mean precipitation and temperature measured at the Baitik meteorological station during 2012-2017 are 538 mm yr^{-1} and 7.2 ℃, respectively. The mean daily streamflow during 2012-2017 is about 6.3 m^3/s." The CRC estimated by the mixing approaches refer to the mean contributions in each of the three seasons during the period of 2012-2017. See lines 150-152 and 222.

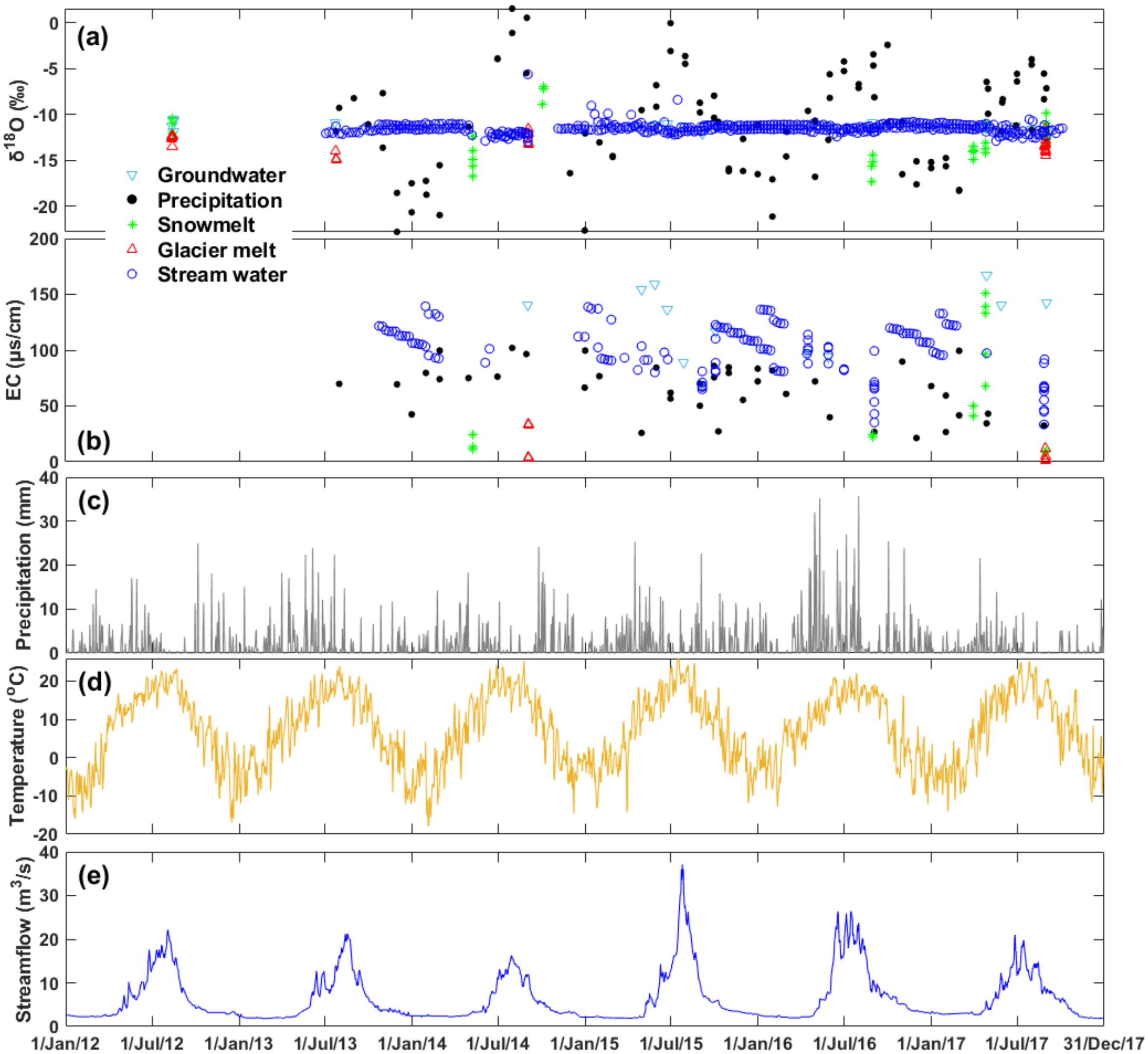

Figure S1. (a)-(b) Tracer signatures of water samples during the sample period of 2012-2017;(c)-(d) Daily precipitation and temperature measured at the Baitik meteorological station in 2012-12017; (e) Daily streamflow measured at the Ala-Archa hydrologic station during 2012-2017.

8. 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.

Reply: Please, see the above figure. The pH and TDS data were not recorded.

9. 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.

Reply: Figure 3 only shows the maximum and minimum tracer signatures of each water source. It is not related to the distributions of measured water tracers. The histograms of isotope and EC data in the glacier melt season have been presented in Fig. 5 in the manuscript. A Kolmogorov-Smirnov test has been carried out for both isotope and EC tracers of all water sources. The tracer data of runoff components (i.e., rainfall, snowmelt, groundwater and glacier melt) generally pass the normal distribution test at significance levels of p-values > 0.3, while the tracer data of stream water pass the normal distributions test at significance levels of p-values > 0.1. The EC data of glacier melt pass the normal distribution at a significance level of p-values > 0.06, which can be caused by the low sample size. We thus assume the prior distributions of tracers of runoff components are normal in Eqs. 6-8. The prior distributions of tracers of stream water are first assumed as normal in Eqs. 6a and 8a, and the mean tracer signatures are then calculated by the mixing of tracers of runoff components in Eq. 9. We reported the test results in the revised manuscript. See lines 282-288.

10. 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, where this fractionation effect might occur and how it could impact the observed values?

Reply: The water sources for runoff, such as rainfall and meltwater, are subject to evaporation before reaching the basin outlet, especially in summer. However, the isotopic composition of stream water was measured at the basin outlet, and the contributions of runoff components are quantified for the total runoff at the basin outlet. After the long routing path from the sampled sites to the basin outlet, the isotopic compositions of rainfall and meltwater mixing at the basin outlet could be different from those measured at the sampled sites, caused by the evaporation fractionation effect. The isotopic composition of water sources at the sample sites are assumed to be normally distributed in Eqs. 6-7, and the changes in the isotopic compositions of water sources caused by the evaporation fractionation effect are represented by the modification variables $\xi^{18}O$ and $\xi^{2}H$ *in Eq. 10. The evaporation fractionation has no effects on the observed isotopic compositions, but does have one on the quantification of runoff components, which is considered* *as a source of model uncertainty in the study. We added a more detailed explanation for that in the revised manuscript. See lines 377-393.*

11. 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.

Reply: Please, see the previous response. We added a more detailed explanation in the method section. See lines 383-393. The quantification of runoff components in two Bayesian scenarios are compared. In the first scenario (using Bayesian_3_Cor and Bayesain_4_Cor), the fractionation effect on isotopic compositions of water sources are ignored, i.e., the isotopic compositions of water sources at the basin outlet are assumed as same as those measured from the sample sites. In the second scenario (using Bayesian_3_Cor_F and Bayesian_4_Cor_F), the evaporation fractionation effect on the isotopic compositions of water sources have been considered. The mixing of water tracers of stream water are represented by Eq. 10. Figure 9 illustrates the effects of fractionation on the quantification of runoff components in all three seasons. The estimated changes in $\delta^{18}O$ *of each water source are presented in Figs. 9a-c, and the contributions of runoff components quantified by the two scenarios are compared in Figs. 9d-f.*

12. 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."

Reply: Done. Thanks.

13. 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.

Reply: In the cold and snowmelt seasons, some snowmelt samples also have EC values as low as those in the glacier melt season (see Fig. 3). The snow samples in the glacier melt season were only collected from the accumulation zone of the glacier, thus resulting in small variability in the EC values. The snowpack in the accumulation zone is accumulated by fresh snow in the snow period (summer type accumulation glacier).This leads to low EC values in the snowmelt samples. We added this discussion in the revised manuscript. See lines 435-440.

14. 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.

Reply: All done. Thanks.