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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Tracer-based analysis of spatial and temporal variation of water sources in a glacierized catchment" *by* D. Penna et al.

Anonymous Referee #2

Received and published: 4 August 2014

Manuscript: hess-2014-153 Tracer-based analysis of spatial and temporal variation of water sources in a glacierized catchment D. Penna, M. Engel, L. Mao, A. Dell'Agnese, G. Bertoldi, and F. Comiti

Review comments:

I think this is an interesting study presenting a large data set consisting of isotopic signals and EC measurements of various water sources in the Saldur River watershed in the Italian Alps. The study improves our understanding of source water contributions and their interannual and intraannual dynamics in snow-dominated and glacierized systems. My main concern with this paper is the lack of analysis performed on the data (see main comments below) and the lack of details provided on the measurements

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and methods used in the data collection. There are numerous instances throughout the paper where details are missing. For example, little to no information is given on equipment used (models, resolution) in the field or lab. This does not allow us to evaluate precision. More detail could be given on lab procedures (i.e., Were samples filtered? How was snow melted and stored?). There are cases where averages or medians are given with no error estimates (or statistics) and this makes it hard to evaluate the results. Some of the figures have confusing figure captions. In contrast to the lack of detail provided in the methods section the description of the data set in sections 4.1 – 4.5 is lengthy and could be substantially shortened and streamlined. I think that major revisions are needed to streamline the content and to add more analysis results before this paper will be suitable for publication.

Main comments:

Although the discussion of the isotopic variation of the various water source end-members is interesting it does not contribute much to the process understanding of runoff generation in glacierized or snow-dominated systems unless the collected data is analyzed in more depth. I would like to see a more rigorous three-component analysis conducted on this rich data set. The manuscript in its current form is more or less a presentation of a data set with very little analysis results. Thus the title of the manuscript is misleading by promising a "tracer-based analysis of spatial and temporal variation of water sources" which was only conducted in a descriptive way (with exception of the annual average estimates of snowmelt contributions to groundwater). If this study intends to just present a data set with minor analysis I would suggest renaming the title into just "Spatial and temporal variation of water sources in a glacierized catchment". I would also suggest to reformulate the study objectives which promised "(3) understand the seasonal variability of snowmelt and ice melt contribution to runoff, and (4) quantify the role of snowmelt on groundwater recharge.". Both objectives implicate quantitative as in fractional contribution estimates of snow melt and ice melt to streamflow and groundwater. Instead the study present only average estimates of

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snowmelt contributions to groundwater and no estimates for snowmelt or ice melt contributions to streamflow. However, I think despite the differences in sampling time the time series of the various streamwater isotopic data could be used to estimate both snowmelt and glacier melt contributions to streamflow. Uncertainty arising from the differences in sampling time within one day (e.g. morning vs. time of daily peak flow vs. evening) could be compensated in the analysis by estimating the diurnal variation in the streamwater isotopic composition from multiple sub-daily samplings. Similarly, the calculated averages (over three years) of snowmelt contributions to groundwater could be expanded into monthly or seasonal estimates.

General comments:

Since detailed data of the isotopic signature and EC values of different end-members is available it would be interesting to quantify how much snowmelt and ice melt was contributing to the various tributaries and the main stem over the course of the three years.

“Section 4.1 Tracer concentrations in different waters” could be combined with or incorporated into sections 4.2 - 4.4. Overall I think sections 4.1 to 4.4 could be shortened and streamlined to reduce the length of the paper.

Move section 4.6 Temporal hydrological dynamics up in the Results section. It creates a disconnect in the presentation of the tracer data analysis.

Divide the Methods and Material section into Field sampling and laboratory analysis and Data Analysis Methods or something similar to provide more structure. In addition, please state clearly the methods used to accomplish the objectives listed in the introduction. Right now there is general mentioning of Deuterium excess and a two-component isotopic hydrograph separation that determines snowmelt contributions to groundwater. A more clear association of all methods with the objectives is needed, e.g. the deuterium-excess was computed to identify the origin of vapor masses that form precipitation over the study area. Similar statements are needed that address

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objectives 2-4.

Please consistently add the standard deviation when stating average or median values for the isotopic composition or EC (e.g. median value of -65 $\pm$ 10 ‰.

Specific comments: Introduction:

Page 4881, lines 23-25: Consider changing sentence to “In order to better predict the future hydrological behaviour in such rapidly changing there is an urgent need to obtain a more detailed understanding of hydrological processes and of runoff origin in glacierized catchments.”. Page 4882, line 1: The transition to the previous sentence is awkward. Consider rephrasing.

Page 4882, lines 18-19: “The primary voice in the economy of population living there is the cultivation of apples.” This sentence is awkward. Please rephrase.

Study Area: Page 4884, line 23 ff.: Please add the geologic age or tectonic period of the Matsch Unit. Also how does the composition of gneiss and schist influence electric conductivity values of groundwater and streamwater?

Materials and Methods: Page 4885, line 15: What is the uncertainty in measured precipitation associated with using a non-heated unshielded rain gauge. I am assuming that gusty winds are frequently occurring during the winter period likely causing a substantial undercatch of precipitation. How were precipitation records corrected for undercatch (e.g. Tretyakov or Nipher correction for precipitation undercatch).

Page 4885, lines 22-24: Was water stage measured in natural cross-sectional areas or defined/constructed cross-sectional areas? If the former, how much did the cross-section area change over the study period?

Page 4886, line 1: The authors mention that salt dilution discharge measurements were conducted for a discharge range of 0.58 – 4.5 m3/s. What percentage of the observed daily or hourly discharge range did these measurements cover? How well were high flow events captured with these reference measurements?

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Page 4886, lines 3-4: The authors mention that a rating curve could not be established for the tributary on the left side of the valley. To point out more clearly that stage data were used instead of discharge data I would recommend adding a sentence stating for example: “thus, for tributary T2-SG) stage was used throughout the study”.

Page 4886, lines 14 ff.: How was water sampled; with an automatic sampler (e.g. ISCO) or manually as grab samples?

Page 4886, lines 24-25: Please rephrase this sentence.

Page 4886, line 27: How much snow was collected and melted for each sample? At what interval was snow sampled? How were snow samples stored and melted for isotopic analysis?

Page 4889: Why did you decide to quantify the contribution of snowmelt to groundwater and not as typically done in other studies the contribution of snowmelt and glacier melt to streamflow? Your objectives state that your third goal is to “ . . .understand the seasonal variability of snowmelt and ice melt contribution to runoff”, however, the methods section does not state the methodological approach used to gain this understanding.

Page 4889, lines 18-20: Awkward wording. Please rephrase this sentence.

Page 4890, lines 17-18: Awkward phrasing. Suggest rephrasing to “Thus, the isotopic composition of rainfall, ice melt and snowmelt allowed a more clear separation of these end members than EC.”.

Page 4890, lines 23-26: Adding a figure showing the mixing diagram of all end-members based on the EC and isotopic values would be helpful to support the description of observed end-member signatures.

Page 4893, line 5: Please add examples for the “additional unknown factors”.

Page 4895, Lines 11-17: The similarity of the oxygen-Deuterium relationship of stream water (streamwater meteoric water line – MWL) compared to snowmelt and ice melt

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only indicated that these water sources undergo similar fractionation processes. However, since the authors neglected to estimate the fractional contribution of snowmelt or glacier meltwater to streamflow it is difficult to interpret whether the similarity of the streamwater and snowmelt MWL is due to a large contribution of snowmelt to streamflow (without the snowmelt undergoing substantial fractionation on the way to the stream) or a generally low fractionation (e.g., low enrichment) of the snowmelt water during its transport to the stream due to the short transit times of the snowmelt water to the stream.

Page 4896, line 1: Please specify whether you mean the horizontal or vertical error bars by “long error bars”.

Page 4896, line 13: Delete “distinctly glacier-fed”, this information was already provided in the first part of the sentence.

Page 4896, line 15: I would like to see the snowpack signature added to the mixing diagram in Fig. 5. Even though it is not a direct end member it would be interesting to see how the isotopic signature evolved into the snowmelt isotopic signature shown as end-member (in terms of d-excess and deuterium space).

Page 4898, lines 3-6: Please add the approximate sampling hours in parentheses so for the different sampling years to underline the differences in flow and isotopic composition observed.

Page 4898, lines 11-14: This sentence is hard to follow. Consider splitting it up into two. Page 4898, line 15 ff.: Consider rephrasing the sentence into “There was an overall pattern of more negative. . .” and delete “was evident”.

Page 4899, lines 16-18: Consider rephrasing to “ Figure 8 is showing box-whisker plot of the stream water isotopic composition of four selected sampling locations along the Saldur River for the months June to October”.

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Page 4900, last paragraph: In this discussion of temporal dynamics it would be helpful to mention the end-member isotopic composition of groundwater, snowmelt and ice melt again or to at least point out which one was more depleted than the other. Regarding the discussion of the signatures the more negative streamwater isotopic values could also indicate early snowmelt contributions, which are typically isotopically lighter due to melt out of the lighter oxygen/deuterium isotopes.

Minor comments: Page 4881, line 10: Delete “and”.

Page 4881, line 19: Delete “Thus,”.

Page 4881, line 10: Delete "and".

Page 4881, line 24: Replace “on” with “to”.

Page 4881, lines 23-25: Consider changing sentence to “In order to better predict the future hydrological behaviour in such rapidly changing there is an urgent need to obtain a more detailed understanding of hydrological processes and of runoff origin in glacierized catchments.”.

Page 4882, line 24: Change “contribute” to “contributes”.

Page 4883, line 2: Replace “along with” with “based on”.

Page 4883, line 4: Replace “of” with “over”.

Page 4883, line 12: Replace “lying” with “located”.

Page 4883, line 17: Delete “snout”.

Page 4883, line 19: Replace “originated” with “originating”.

Page 4883, line 22: Delete “of” in front of “the winter snowpack”.

Page 4884, line 8: Change “occur also” to “also occur”.

Page 4885, line 22: Replace “by” with “with”.

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Page 4886, line 21: Replace “and the” with “when the”.

Page 4886, line 26: Replace “approximately monthly” with “on a monthly basis”.

Page 4887, line 4: Delete “of the”.

Page 4888, line 9: Insert “is” before “defined”.

Page 4888, Equation 6: Remove the left square bracket in front of C2.

Page 4890, line 2: Replace “was intermediate” with “had values”.

Page 4890, line 15: Did you mean “samples” instead of “samplers”?

Page 4890, line 16: Replace “and very low, of 12 and 2 μScm$-$1,” with “with 2 – 12 μScm$-$1,”.

Page 4890, line 1: Remove period after -65 or add a zero after the period.

Page 4890, line 20: Replace “that” with “which”.

Page 4890, line 21: Add “to streamflow” after “ice melt”.

Page 4892, line 6: Please insert “was” after “what”.

Page 4892, line 26: Replace “of 0.2” with “by 0.2”.

Page 4893, line 15: Delete “too”.

Page 4893, line 16: Replace “where” with “at which”.

Page 4893, line 19: Replace “laid on” with “fell on”.

Page 4893, line 23: Replace “it” with “the line”.

Page 4893, line 24: Insert “a” before “slightly”.

Page 4893, line 27: Replace “less negative” with “enriched”.

Page 4894, line 1: Replace “localized” with “located”.

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Page 4895, line 6: Insert “thereby” before “increasing”.

Page 4896, line 10: Delete “that the”.

Page 4897, Line 11: Insert “of” before “less than”.

Page 4897, line 13: Replace “associated to” with “associated with”.

Page 4897, line 15: Insert “a” before “water stage”.

Page 4897, line 21: Suggest replacing “of the isotopes in rainfall” with “ of the rainfall isotopic composition”.

Page 4897, line 26: Delete “up” and replace “background” with “isotopic composition”.
Page 4898, line 21: Replace “relatively fast” with “flashy”.

Page 4898, line 24: Insert “period” after “sampling”.

Page 4898, lines 25-26: “. . .that continued the negative trend before increasing on the last sampling date.” this part is confusing and disconnected from the first part of the sentence. Consider rephrasing.

Page 4899, line 1: Replace “over space, among” with “across”.

Page 4902, line 5: Replace “among” with “over”.

Figures and Tables:

I would suggest combining tables 3 and 4 into one table.

Figure 2: The EC plot (Fig. 2b) is missing the SNPK values? I am assuming the statement “EC data of the snowpack were not available.” is addressing this issue. To make point it out more clearly I would suggest adding “EC data of the snowpack (SNPK) were not available”.

Figure 3: Instead of saying “during the monitoring period” please state the actual period, e.g. “collected between April 2011 and October 2013. Replace “In the inset:”

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with “Inset:”. Rephrase “ average (n=8) precipitation δ2H vs. elevation of bulk rainfall collectors”.

Figure 4: Add equation of linear fit (local meteoric water line) to the plot.

Figure 5: Consider rephrasing “whereas this was not possible for snowmelt and glacier melt samples.” to “whereas the snowmelt and glacier melt composition was not.”.

Figure 6: At S3-LSG, on five occasions in 2011, multiple samples during the day were taken but, for the sake of clarity, only three samples collected at early morning (if available), approximately at peak flow and before sunset are shown. This sentence is awkward. Consider rephrasing for more clarity. E.g. On five occasions in 2011 multiple samples were taken within one day at S3-LSG; only samples taken in the morning, at peak flow and before sunset are shown in graphs j-l.”

Figure 7: Delete “the” in front of four. Delete “numerous” and insert commas in the listing of locations.

Figure 8: Please explain the number plotted above each box plot in the figure caption.

Figure 9: Replace “of selected locations” with “measured at selected”.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 4879, 2014.