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Discussions

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

D. Penna et al.

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Response to Reviewer #2

Tracer-based analysis of spatial and temporal variation of water sources in a glacierized catchment by Daniele Penna, Michael Engel, Luca Mao, Andrea Dell'Agnese, Giacomo Bertoldi, Francesco Comiti

We thank the reviewer for his/her detailed comments (both from a conceptual and from a formal and language point of view) that have helped us to improve the paper. The reviewer's comments are quoted in their entirety and the authors' responses are given directly afterwards.

Comment 1: “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 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.”

Response 1: We changed the revised version of the manuscript according to these suggestions, introducing new details on the sampling and measurement method, adding error estimates, and shortening some sections and some figure and table captions. We believe that the revised manuscript is now more concise and clearer.

Comment 2: “Although the discussion of the isotopic variation of the various water source endmembers 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

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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 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."

Response 2: We agree with the reviewer and understand his/her concern about the lack of a separation analysis aimed at distinguishing the contribution of snowmelt and ice melt to streamflow. However, we have just submitted a new manuscript specifically focusing on three-component hydrograph separation to quantify the role of snowmelt, glacier melt and groundwater on runoff in the Saldur catchment in different times of the three observation years. Therefore, in this revised paper, we think it is important to confine ourselves to describe the dataset, to present first results of the isotopic characterization of the study area, to report a clear identification of the end-members and their role on groundwater recharge without going into detailed analysis of three component hydrograph separation for streamflow data, that will constitute the core of the new ongoing work. However, we welcome the suggestion of the reviewer to expand

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the analysis on the snowmelt contribution to groundwater recharge. We computed the contribution of snowmelt to groundwater for each sampling date for two of the three observations years (2012 and 2013, too few snowmelt data in 2011), we included a new graph (Fig. 10) showing the monthly evolution of snowmelt faction in groundwater for the fours springs, and added a new discussion part in the revised version of the manuscript (and some sentences in the Material and Methods section as well). In addition, receiving the reviewer's suggestion, we changed the third objective in the Introduction as follows: 3) understand the seasonal variability of tracer concentration in stream water and in groundwater." As for the title, also due to the added analysis, we prefer to keep the original title of the manuscript, that stresses the use of tracers, not trivial in this environment.

Comment 3: "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."

Response 3: Please, see the response to comment 2.

Comment 4: ""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."

Response 4: We preferred to keep Section 4.1 distinct from the other sections because it includes a general presentation of the tracer dataset. We agree that the paper was a bit lengthy, so we deleted and reformulated some parts to make it more concise and streamlined.

Comment 5: "Move section 4.6 Temporal hydrological dynamics up in the Results section. It creates a disconnect in the presentation of the tracer data analysis."

Response 5: We understand the reviewer's concern and carefully considered changing

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the paper structure, moving Section 4.6 up and so modifying the order of the results. However, we realized that moving Section 4.6 up would create a disconnection in the logical thread we tried to create in organizing the paper structure. Indeed, as mentioned in response to comment 23 by reviewer 1, Section 4.6 describes part of Fig. 6 (a dense and informative Figure), that is further commented in Section 4.7.1. Thus, we believe that the current position of Section 4.6 provides a conceptual link with the following Section that deals with the analysis of the spatial variability of tracer concentration and that, in turn, is connected to the following Section that deals with the analysis of the temporal variability of tracer concentration. Therefore, moving Section 4.6 up would mean introducing the results about the description of the tracer dataset later and the identification of end-members later in the manuscript. But we need this information to explain well the variations in stream stage and tracer concentration included in Fig. 6. Therefore, also in agreement with the specific objectives (Section 1) we preferred to keep the original organization of the results that can be summarized as follows: "4.1 Tracer concentration in different waters": a sort of presentation of the tracer dataset. "4.2 Isotopic composition of rainfall": analysis of the isotopic variability of rainfall data and analysis of the air mass origin. "4.3 Isotopic composition of snow, snowmelt and ice melt" "4.4 Isotopic composition of stream water and groundwater": this and the previous short sections conclude the presentation of the results inferred from the tracer composition of all water sources collected in the study. "4.5 Identification of end-members": in this position, this section comes after the description of the tracer composition of all water sources. "4.6 Temporal hydrological dynamics": this short section introduces all the analysis about the temporal and spatial variability of the tracer composition of water sources that in turns precedes the analysis of snowmelt contribution to groundwater recharge over the season (new part included in the revised manuscript). "4.7 Spatio-temporal dynamics of tracer concentration in stream water and groundwater" "4.7.1 Temporal variability of stream water and groundwater EC and δ2H" "4.7.2 Spatial variability of stream water and groundwater EC and δ2H" "4.7.3 Seasonal change in snowmelt and ice melt contribution to runoff" "4.8 Role of

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snowmelt on groundwater recharge". This section was improved with the inclusion of new analysis about the seasonal variation of estimates of snowmelt contribution to groundwater.

Comment 6: "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 vapour masses that form precipitation over the study area. Similar statements are needed that address objectives 2-4"

Response 6: We have re-structured Section 3 as follows: 3.1 Field measurements and sampling 3.2 Laboratory analysis 3.3 Data analysis We also stated more clearly the method used to accomplish each objective listed in the Introduction.

Comment 7: "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 ‰)"

Response 7: Done.

Comment 8: "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.".

Response 8: We merged this sentence to the following one: "In order to better predict the future hydrological behaviour in such rapidly changing environments there is an urgent need to obtain a more detailed understanding of runoff origin and the dynamic interactions between meltwater and streamflow in glacierized catchments."

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Comment 9: “Page 4882, line 1: The transition to the previous sentence is awkward. Consider rephrasing.””

Response 9: See comment above.

Comment 10: “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.”

Response 10: Done as follows: “One clear example is given by the Vinschgau/Venosta valley, in South Tyrol (Eastern Italian Alps), where most of the economy is based on the cultivation of apples.”

Comment 11: “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?”

Response 11: Done. Unfortunately, we do not have information on how gneiss and schist influenced the EC of surface and subsurface water in the catchment. The EC values we found in groundwater are typically between 100 and 300 ïĄ■S/cm, and slightly lower for stream water: although a masking effect due to the low EC of meltwater occured, these not-so-high values (compared to other sites in the Southern Alps) suggest a moderate solution of the bedrock.

Comment 12: “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).”

Response 12: The uncertainty in precipitation estimation in similar environmental conditions could be up to 30% (Carturan et al., 2012). However, our data have been validated during the summer season and integrated during the winter season using a

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nearby station located in a wind sheltered position at the same elevation of the used station (about 10 km far away) where snow height data and other micrometeorological data were available for an accurate estimation of precipitation. We performed several winter surveys to compare snowfall accumulation in the two locations and we found little difference. For methodological details on the approach see Mair et al. (2013). In any case this study refers only to the summer season, where snowfall is limited, and precipitation data are used only for a qualitative comparison with tracers and discharge observations. For this purpose, our data are accurate enough.

Carturan, L., Dalla Fontana, G., & Borga, M., 2012. Estimation of winter precipitation in a high-altitude catchment of the eastern Italian Alps: validation by means of glacier mass balance observations. Geogr. Fis. Dinam. Quat., 35, 37–48. doi:10.4461/GFDQ.2012.35.4

Mair, E., Bertoldi, G., Leitinger, G., Della Chiesa, S., Niedrist, G., and Tappeiner, U., 2013. ESOLIP – estimate of solid and liquid precipitation at sub-daily time resolution by combining snow height and rain gauge measurements. Hydrol. Earth Syst. Sci. Discuss., 10, 8683-8714, doi:10.5194/hessd-10-8683-2013, 2013.

Comment 13: “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?”

Response 13: The sections were natural and well confined laterally by stable large boulders. We monitored their geometry through time and applied different rating curves when relevant changes were evident. We specified this in the new manuscript.

Comment 14: “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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Response 14: Overall, at LSG, the discharge range for which salt dilution discharge measurements were taken corresponds to 94.6% of the total number of observations. Therefore, we believe it is representative of the typical discharge values. However, we recognize that a certain degree of uncertainty exists, especially for discharge values higher than 4.5 m3/s, typically occurred during relatively intense rainfall events. We specified this in Section 2, also taking into account one of the comments by the first reviewer (comment 12).

Comment 15: "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"."

Response 15: Done.

Comment 16: "Page 4886, lines 14 ff.: How was water sampled; with an automatic sampler (e.g. ISCO) or manually as grab samples?"

Response 16: By grab sampling. We specified this in the revised manuscript.

Comment 17: "Page 4886, lines 24-25: Please rephrase this sentence."

Response 17: We changed as follows: "Similarly, SPR4 emerged from sand sediment and flowed down to the stream."

Comment 18: "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?"

Response 18: For each layer in the snow pit, two samples were taken directly by the sampling bottles (around 60 cc for each bottle). The samples were stored in portable coolers in the field, and let melted in the lab at 20°C. Two samples from the same layers were mixed and analysed. Sometimes, especially for surface snow, a higher volume of

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snow (approximately 1 L) was sampled by means of plastic bags, stored in a cooler, let melted at 20°C and analysed. We added this information in Section 3.1.

Comment 19: "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."

Response 19: Please see our response to comment 2.

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

Response 20: We changed it as follows: "Given the covariance between δ2H and δ18O values of all samples, we reported in the paper only δ2H values in cases where information deriving from both isotopes were redundant."

Comment 21: "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."."

Response 21: Done.

Comment 22: "Page 4890, lines 23-26: Adding a figure showing the mixing diagram of all endmembers based on the EC and isotopic values would be helpful to support the description of observed end-member signatures."

Response 22: We have already added a new Figure (Fig. 10, snowmelt contribution to spring water over time) and an additional one would make the paper even longer. Moreover, we believe that the suggested figure would be very similar and partly redundant with Fig. 5. Therefore, we prefer to avoid including this.

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Comment 23: “Page 4893, line 5: Please add examples for the “additional unknown factors”.

Response 23: We removed the sentence since it didn’t add any relevant information to the paragraph.

Comment 24: “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 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.”

Response 24: We agree with this comment and changed the text accordingly.

Comment 25: “Page 4896, line 1: Please specify whether you mean the horizontal or vertical error bars by “long error bars”.”

Response 25: Both. We specified this.

Comment 26: “Page 4896, line 13: Delete “distinctly glacier-fed”, this information was already provided in the first part of the sentence.”

Response 26: Done.

Comment 27: “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).”

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Response 27: We added the snowpack signature in Fig. 5, but excluded it from the mixing space because snowpack is not a direct hydrological input.

Comment 28: “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.”

Response 28: We realized that this was not strictly true because also in 2012 and 2013 few samples have been taken not always in the afternoon but sometime in the morning. We removed the sentence.

Comment 29: “Page 4898, lines 11-14: This sentence is hard to follow. Consider splitting it up into two. “

Response 29: Done.

Comment 30: “Page 4898, line 15 ff.: Consider rephrasing the sentence into “There was an overall pattern of more negative. . .” and delete “was evident”.”

Response 30: Done.

Comment 31: “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”.”

Response 31: Done.

Comment 32: “Discussion: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.”

Response 32: We added the average and standard deviation of the isotopic and EC

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composition of glacier melt, since this is relevant in the paragraph. Yes, we agree about the possible contribution of early light snowmelt that caused depleted isotopic values and low EC values in stream water, but in this paragraph we are mainly referring to the period in August, when most of the snowpack is likely already melted.

Comment 33: “Minor comments: Page 4881, line 10: Delete “and”.”

Response 33: We believe that “and” should be kept, but we added a comma.

Comment 34: “Page 4881, line 19: Delete “Thus,””

Response 34: Done.

Comment 35: “Page 4881, line 24: Replace “on” with “to”.”

Response 35: Done.

Comment 36: “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.””

Response 36: We merged this sentence to the following one: “In order to better predict the future hydrological behaviour in such rapidly changing environments there is an urgent need to obtain a more detailed understanding of runoff origin and the dynamic interactions between meltwater and streamflow in glacierized catchments.”

Comment 37: “Page 4882, line 24: Change “contribute” to “contributes”.”

Response 37: Done.

Comment 38: “Page 4883, line 2: Replace “along with” with “based on”.”

Response 38: Done.

Comment 39: “Page 4883, line 4: Replace “of” with “over”.”

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Response 39: Done.

Comment 40: “Page 4883, line 12: Replace “lying” with “located”.”

Response 40: Done.

Comment 41: “Page 4883, line 17: Delete “snout”.”

Response 41: We believe that “snout” here should not be removed.

Comment 42: “Page 4883, line 19: Replace “originated” with “originating”.”

Response 42: Done.

Comment 43: “Page 4883, line 22: Delete “of” in front of “the winter snowpack”.”

Response 43: Done.

Comment 44: “Page 4884, line 8: Change “occur also” to “also occur”.”

Response 44: Done.

Comment 45: “Page 4885, line 22: Replace “by” with “with”.”

Response 45: Done.

Comment 46: “Page 4886, line 21: Replace “and the” with “when the”.”

Response 46: Done.

Comment 47: “Page 4886, line 26: Replace “approximately monthly” with “on a monthly basis”.”

Response 47: Done.

Comment 48: “Page 4887, line 4: Delete “of the”.”

Response 48: Done.

Comment 49: “Page 4888, line 9: Insert “is” before “defined”.”

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Response 49: We think “is” should not be inserted here.

Comment 50: “Page 4888, Equation 6: Remove the left square bracket in front of C2.”

Response 50: Done.

Comment 51: “Page 4890, line 2: Replace “was intermediate” with “had values”.”

Response 51: Done.

Comment 52: “Page 4890, line 15: Did you mean “samples” instead of “samplers”?”

Response 52: No, we meant snow samplers, i.e., snow lysimeters. We changed the term to “snow lysimeters”.

Comment 53: “Page 4890, line 16: Replace “and very low, of 12 and 2 μScm$-$1,” with “with 2 – 12 μScm$-$1,”.”

Response 53: We changed the sentence here in order to include the standard deviation, as required in a comment above.

Comment 54: “Page 4890, line 1: Remove period after -65 or add a zero after the period.”

Response 54: Done.

Comment 55: “Page 4890, line 20: Replace “that” with “which”.”

Response 55: Done.

Comment 56: “Page 4890, line 21: Add “to streamflow” after “ice melt”.”

Response 56: Done.

Comment 57: “Page 4892, line 6: Please insert “was” after “what”.”

Response 57: Done.

Comment 58: “Page 4892, line 26: Replace “of 0.2” with “by 0.2”.”

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Response 58: Done.

Comment 59: “Page 4893, line 15: Delete “too”.”

Response 59: Done.

Comment 60: “Page 4893, line 16: Replace “where” with “at which”.”

Response 60: Done.

Comment 61: “Page 4893, line 19: Replace “laid on” with “fell on”.”

Response 61: Done.

Comment 62: “Page 4893, line 23: Replace “it” with “the line”.”

Response 62: Done.

Comment 63: “Page 4893, line 24: Insert “a” before “slightly”.”

Response 63: Done.

Comment 64: “Page 4893, line 27: Replace “less negative” with “enriched”.”

Response 64: Done.

Comment 65: “Page 4894, line 1: Replace “localized” with “located”.”

Response 65: Done.

Comment 66: “Page 4895, line 6: Insert “thereby” before “increasing”.”

Response 66: Done.

Comment 67: “Page 4896, line 10: Delete “that the”.”

Response 67: Done.

Comment 68: “Page 4897, Line 11: Insert “of” before “less than”.”

Response 68: Done.

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Comment 69: “Page 4897, line 13: Replace “associated to” with “associated with”.”

Response 69: Done.

Comment 70:” Page 4897, line 15: Insert “a” before “water stage”.”

Response 70: Done.

Comment 71: “Page 4897, line 21: Suggest replacing “of the isotopes in rainfall” with “ of the rainfall isotopic composition”.”

Response 71: Done.

Comment 72: “ Page 4897, line 26: Delete “up” and replace “background” with “isotopic composition”.”

Response 72: Done.

Comment 73: “ Page 4898, line 21: Replace “relatively fast” with “flashy”.”

Response 73: We prefer to keep “relatively fast” since “flashy” seems to suggest a too rapid process.

Comment 74: “ Page 4898, line 24: Insert “period” after “sampling”.”

Response 74: We inserted “time” that we believe is more appropriate than period here.

Comment 75: “ 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.”

Response 75: We rephrased as follows: “Isotopes in the Saldur River in August 2013 (Fig. 7, panel a) were noticeably less negative compared to the previous sampling time and disagreed with patterns showed by the isotopic composition of the springs (Fig. 7, panel c).”

Comment 76: “ Page 4899, line 1: Replace “over space, among” with “across”.”

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Response 76: Done.

Comment 77: " Page 4902, line 5: Replace "among" with "over"."

Response 77: Done.

Comment 78: " Figures and Tables:I would suggest combining tables 3 and 4 into one table."

Response 78: Done.

Comment 79: " 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"."

Response 79: Done.

Comment 80: " 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:" with "Inset:". Rephrase " average (n=8) precipitation δ2H vs. elevation of bulk rainfall collectors"."

Response 80: Done. We simply removed "during the monitoring period"

Comment 81: " Figure 4: Add equation of linear fit (local meteoric water line) to the plot."

Response 81: Done.

Comment 82: " 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.""

Response 82: Done.

Comment 83: "Figure 6: At S3-LSG, on five occasions in 2011, multiple samples during

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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."

Response 83: Thank you for the suggestion, we changed the sentence.

Comment 84: " Figure 7: Delete "the" in front of four. Delete "numerous" and insert commas in the listing of locations."

Response 84: Done.

Comment 85: "Figure 8: Please explain the number plotted above each box plot in the figure caption."

Response 85: As suggested by the first reviewer (comment 35), we added "n=" before each number above the boxes in the plot.

Comment 86: "Figure 9: Replace "of selected locations" with "measured at selected"."

Response 86: Done.

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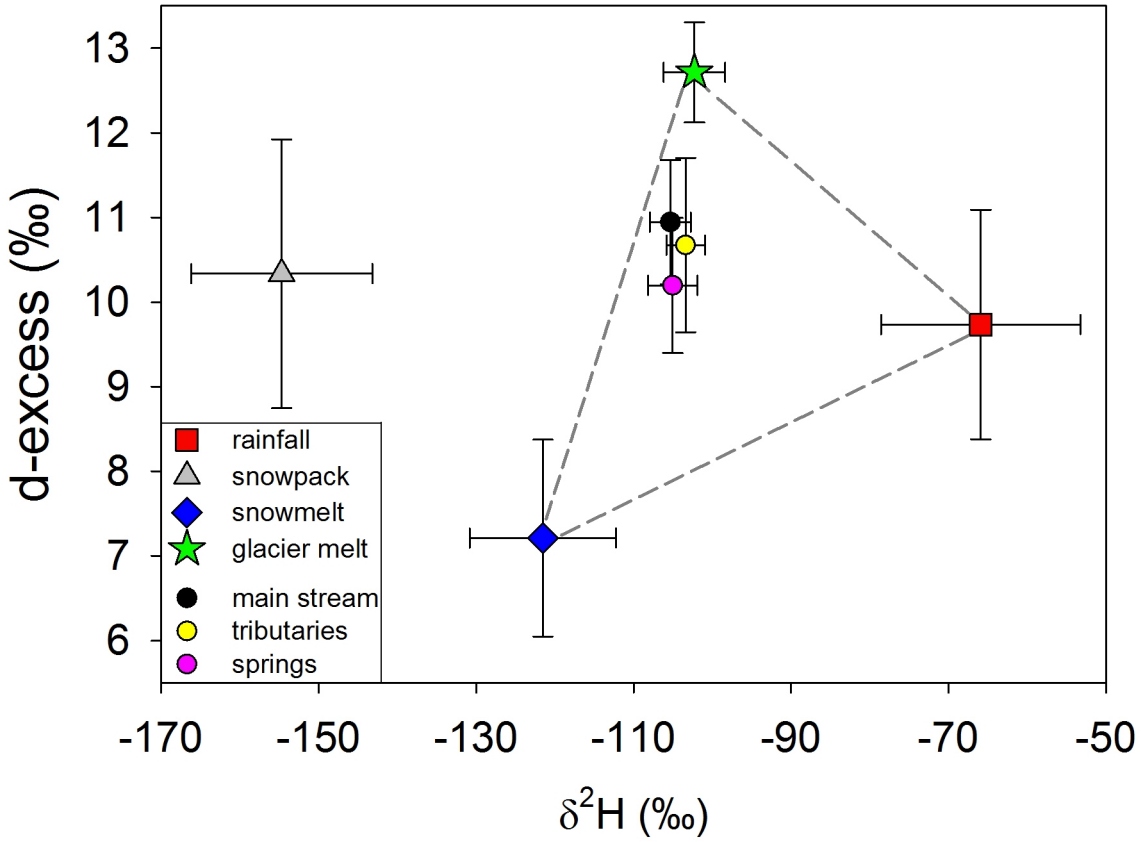

Fig. 1. Fig. 5. Mixing diagram between d2H and d-excess of all average values of samples collected in the Saldur catchment. The error bars represent half of the standard deviation. The d2H an. . .

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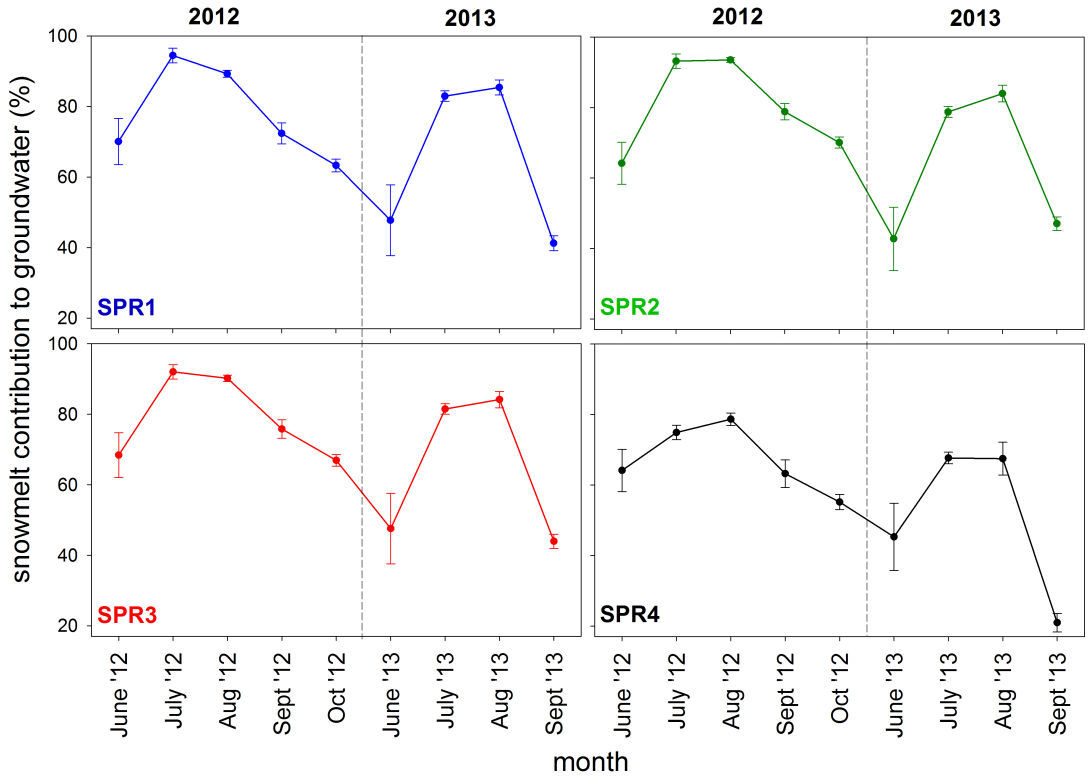

Fig. 2. Fig. 10. Snowmelt contribution to groundwater recharge based on d2H data for different sampling times in 2012 and 2013. The error bars indicate the ± uncertainty at 70%.

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