

Hydrol. Earth Syst. Sci. Discuss., referee comment RC2  
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## **Comment on hess-2021-287**

Anonymous Referee #2

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Referee comment on "Evidence for high-elevation solar recharge and interbasin groundwater flow in the Western Cordillera of the Peruvian Andes" by Odiney Alvarez-Campos et al., Hydrol. Earth Syst. Sci. Discuss.,  
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The paper "Evidence for high-elevation solar recharge and interbasin groundwater flow in the Western Cordillera of the Peruvian Andes" by Alvarez-Campos presents a multi tracer (isotopic and geochemical) assessment on the influence of groundwater flowpaths from a close basin solar in spring water upwelling at lower elevations that supply water to the city of Arequipa, Peru. Overall, I find the paper well-structured and clearly written and the findings generally well supported by the presented data and analysis. My major concern relates to the insufficient description of sampling collection and laboratory analyses. Given the relevance of the paper for the management of water resources in the region of study, I consider it is suitable for publication in HESS after some points described below are implemented in the manuscript.

Major comments:

L111-113: tritium and residence time come as a surprise for the reader. I suggest adding a few statements or a short paragraph to the introduction mentioning the value of tritium in the context of the study, highlighting particularly research on the study region for similar purposes.

Section 3.1. It would be helpful to include the elevation of the sites for reference in this section so the reader does not need to check Table 1 many times. Also, it is confusing that the authors sometimes mentioned only the names of the sites, other times only the sites IDs (presented in Table 1), and others, both names and IDs. I strongly suggest to homogenize this in the whole manuscript, figures and tables for consistency and clarity

(i.e., this issue is common in this and the rest of the paper sections).

L260: describe how snow was sampled.

L261: report the period and frequency of rainwater sampling. If not collected throughout the whole study period, indicate why. I strongly suggest to give a name to the precipitation water sampling in Table 1 and use it in the whole manuscript. Also, show it and add it to the legend in all relevant maps.

L267-272: the description of water sampling collection is quite incomplete and requires substantial improvement. Some of the main issues are: how was water from river and springs samples? How were samples collected for stable isotope analysis stored to avoid fractionation by evaporation? How was rainwater sampled to assure evaporative fractionation did not affect the water samples? What sites were samples for tritium, specify? Report the make, model, and accuracy of devices used to measure physico-chemical parameters in situ and how often and how they were calibrated. Please update the paragraph with this and other relevant information that might be missing.

L286: I am puzzled about the construction of the LMWL using data for 3 months only. In section 2.3, it is mentioned that the very dry winter occurs between June and August, however, it is not clear if precipitation during those months is at all nonexistent, or just very little compared to the wet summer monsoon one (November to April). Even for the latter, using an isotopic dataset from January through March 2019 might not be entirely representative of the local conditions. I strongly suggest the authors to include a time series of precipitation during the study period in the paper for reference, and discuss if and how the limitation of the available isotopic dataset could influence their findings. Showing the precipitation amount data could also help to link their findings about the influence of modern day recharge on their findings and the developed conceptual model.

Section 3.3: there is very little information about the chemical analysis. Please report standards, calibration curves, detection limits, etc. used for the analysis of anions and cations. Also report QA/QC procedures to secure high quality of the produced data.

L.346-350: I strongly suggest to show the data supporting these statements (i.e., similarity between spring and surface waters). One option is to have a subplot in Figure 6 showing the springs' isotopic compositions. It would also be good to include the isotopic composition of precipitation in such a plot (e.g., adding a third panel, or plotting together with the springs and surface water isotopic fingerprints?)

L.447 and L.502: how do the authors infer that residence time should be several hundred years old? If anything, based on the Tritium dead results, one could say that groundwater is older than ca. 60 years based on the 1960s bombings. However, without further

evidence, saying that water is of certain age seems arbitrary and could be misleading. The authors might be right, but further discussion is needed to justify their statement. Otherwise, please recognize the limitations of the presented dataset and do not speculate about water aging. Based on this comment, I strongly suggest the title of section 5.3 is updated to "Insights into groundwater age" or something similar since results presented are not conclusive.

Light/heavy versus enriched/depleted: throughout the manuscript, the authors use these terms interchangeably. I strongly suggest the authors to avoid using the terms light/er when referring to depleted isotopic compositions to avoid confusion with the commonly used isotopic terminology of light (more abundant) versus heavy (less abundant) isotope ratios. Please revise the whole manuscript to make changes accordingly.

Minor comments:

L50-55: Please support these statements with appropriate references.

L65: add references to support the final statement of the paragraph.

L67: this is not true for the whole western South America because i) the northern (tropical) Andes in the north are generally humid and salars are mostly common in areas of the central Andes. Please specify the particular region of the Andes for which this statement applies in the whole manuscript.

L96: report elevations of the Laguna and salar

L145-147: add references for the statements in these lines

L159: similar to L67, specify the specific region across the Andes for which this statement applies.

L170: specify which rivers

L173: from 2018 to ??? please specify

L196: report values of the predicted precipitation decrease

L227-232: Misti and Pichu Picu volcanic complexes are quite relevant for context. It would be super helpful to show them in Figure 3.

L261: report names (or IDs) of the sampled springs

L.282: add references for memory effect on isotopic analysis

L.290-292: six sampling sites are listed here, whereas only four sites were mentioned in section 3.1. Please clarify. Also, please report the instrument and standards used for tritium analysis.

Sections 4.1 and 4.2: I suggest merging both sections into a single one as they present very similar and related information. Suggestion for title of new sections: Isotopic composition of precipitation, surface, springs and salar water (i.e., dismiss the times series portion of the titles)

L304: cross-referenced subplot 4c) is missing. See comments in Figure 4 below and update accordingly.

L308: cross-referenced subplot 5c) is missing. See comments in Figure 5 below and update accordingly.

L.373: briefly justify why the use of the Gibbs diagram could be considered robust for the study area groundwater.

L.379: Precipitation dominance for any of the samples as suggested here and in the last line of Figure 8 caption. Please revise and update accordingly.

Section 4.3 I find it odd that geochemical information on surface waters is not described in the results section, particularly regarding figures 9 and 10. Please revise the whole section

and describe important results regarding surface waters.

L.418: how was it identified that surface waters were not evaporated? Please mention this in results sections and cross-reference a figure or table to support this observation.

L.430: enhance local evaporation

L.442: both isotopes actually

L.445: Please show the isotopic composition of Laguna Salinas surface water during the dry and rainy season in the figures.

L.449: add elevation of Tacune mountains

L.478: cross-reference Fig. 6

L.482: relative to surface-

L.508: please cross-reference Fig. 7

L.548: it is

Table 1: assign a code to precipitation sampling site and add it to the table. Also, specify the period of rainwater sampling, it seems it was January-March 2019 according to the text.

Table 2: as in Table 1, please show clearly which sample sites correspond to the Characato and Chiguate districts.

Figure 2: Suggest to use a topographical map instead so that the elevation differences are more easily visualized. Also, it would be very useful for the reader if the area shown in figure 3 would be marked in this map for reference. It would also be very helpful to show

the different water types samples in different colors for reference in the legend of the figure. Also include this in the caption: "Names of the sampling sites are shown in Table 1 for reference".

Figure 4: subplot c) is missing. Either add the subplot or update the caption of the figure accordingly. Also, please mark the dry season Laguna Salinas surface water samples in a) for reference.

Figure 5: the figure has very low quality, please update it to meet publication standards. Subplot c) is missing. Either add the subplot or update the caption of the figure accordingly. Also, please mark the dry season Laguna Salinas surface water samples in a) for reference.

Figure 6: add the IDs of the sampling sites as those are also used in the manuscript.

Figure 10: quality of the Figure seems to be low. Please improve it.

Technical issues:

L67: have formed

L74-77: Very long sentence, difficult to understand. Please rewrite.

L75: suggest using the term tracer instead of component here and in the whole manuscript.

L116: study area

L130: the population of the capital city

L144: 6.7 Ma ago?

L217-219: sentence is difficult to read, please rewrite.

L245: odd sentence in caption of Figure 3. Revise.

L256: six smaller high-elevation

L265: ...in Characato was used to collect rainwater. Also, use the same number of decimals as in Table 1.

L286: were obtained

L.345: spring waters instead of springs

Figure 11: I think it is better to keep using the a) and b) type of cross-reference for the subplots for consistency throughout the manuscript, instead of the current top/bottom.