

„Variation of deuterium excess in surface waters across a 5000-m elevation gradient in the east-central Himalaya “

Voss et al.

Comments to the authors

General remarks

The manuscript describes the results of a sampling campaign in the Himalayan in 2016 with the aim to determine the isotope altitude gradient for the study region. The major findings are nonlinear trends of the isotope ratio with respect to altitude, which are explained by changes in moisture sources including snowmelt (e.g. P10L41). A second emphasis is put on the deuterium excess value to delineate moisture sources.

The manuscript is adequately organized and contains no grammatical or orthography errors. Text is concise and to the point. The English is fine and does not need any revision; but note that I am not a native speaker.

However, the manuscript suffers from many technical and scientific drawbacks. For the technical details on terminology please see my comments below, but I got the impression that the field of isotope hydrology is rather new for the first author with respect to conventions and expressions. Using percentage differences in isotope values as for d in Figure 3 is useless.

From the scientific point of view, I see a major flaw in using a mixture of various water samples from snow and ice, glaciers, surface water, river water, springs and groundwater, and lakes to determine the isotope altitude gradient. Note that this gradient relates to precipitation and not to the water types sampled in this study. River water can be used as a substitute under specific circumstances but the authors fail to explain how and why their samples can be used to determine the isotope altitude effect for the region. So, how can you use a suite of various sample types to conclude on a specific parameter (altitude effect) that, in fact, relates to a complete different type of samples (rain water)?

Overall, the study also lacks clear scientific objectives in the introduction. Some ideas are mentioned but it remains unclear (also in the conclusions) if the results could be used to e.g. better manage high mountain water resources on a local (see e.g. Königer et al. 2017, doi:10.1002/hyp.11291) or regional scale.

The authors need to clearly explain what were the aims of the study (Introduction), how does the sampling strategy was designed to fulfill these scientific goals (Methods) and how does the data (Results) helped to solve these scientific question (Discussion and Conclusions; the latter with an outlook to future work and recommendations)

Unfortunately, I have to reject the study for publication in HESS at current stage but encourage the authors to re-submit a strongly revised version of this interesting data set.

Specific comments

P2L14 The definition of deuterium excess is a bit awkward. I notice what you mean, but in fact deuterium excess itself is not a “deviation from the GMWL” but its definition, of course, used the dual-isotope equation of the GMWL. By definition, d is calculated with the slope of 8 from the GMWL and can be visualized as the intercept of a line with slope 8 which crosses the given isotope pair in a dual isotope plot of $\delta^{18}\text{O}$ vs $\delta^2\text{H}$. Thus, the GMWL connects points of $d = 10 \text{ ‰}$. Either rephrase here or simply delete “which....(GMWL),” to avoid confusion.

Also note that sea surface temperature (SST) also modifies the deuterium excess. Please this information to the sentence.

P1L39 The term stable isotope “lapse rates“ is unfamiliar to me. In hydrology, to my knowledge, this is typically referred to as ‘(isotope) altitude effect’ or ‘altitudinal (isotope) gradient’ (cf. Mook 2000)

Mook, W.G. (ed.) (2000): *Environmental Isotopes in the Hydrological Cycle - Principles and Applications*. - International Hydrological Programme (IHP-V), Technical Documents in Hydrology, **39**, IAEA/UNESCO.

P2L16 In addition, the information that d relates to the moisture source (and more specifically to the rH and T at this point of origin during evaporation) is missing from the text. This makes this sentence hard to understand for the readers as you here directly move on to the identification of sources of precipitation by deuterium excess values. Please provide here a few more details.

P2L38 “Arun River catchment” (catchment/watershed/basin missing from text)

P3L1 change to ‘8480 m in altitude’ to make clear that you are talking about height (and not distances) here.

P4L10-25 and Figure 1: It is unclear to me how groundwater (Figure 1) relates to the type of samples described in the text. I assume that the term “springs and surface-water tributaries [...] (N = 50)” relates to these points? Please bring text and figure labels/caption in line so that the reader can follow what samples are taken at which location.

Also note that lakes might undergo strong evaporation processes, also in high and cold environments and that these samples might be not indicative of the original precipitation.

Overall, samples from river water are rather problematic with respect to the altitude effect as river water is affected by the ‘catchment effect’ (see Dutton et al. 2005). High altitude springs, gaining groundwater conditions along the river course and surface runoff change the isotope values with respect to the on-site precipitation. This can be of minor influence, but for rivers in high altitude regions this should definitely be considered and discussed.

Dutton, A., Wilkinson, B.H., Welker, J.M., Bowen, G.J. and Lohmann, K.C. (2005): Spatial distribution and seasonal variation in $^{18}\text{O}/^{16}\text{O}$ of modern precipitation and river water across the conterminous USA. - *Hydrological Processes*, **19**, 4121-4146.

P4L35 Either ‘L-2140i cavity ringdown’ or ‘laser spectrometer’

P4L38 round hydrogen isotope precision to 0.3‰

P4L38 This sentence makes no sense. Stable isotope analytical uncertainty can never be reported in percent, as it is not a concentration but a relative deviation. Therefore, standard deviations must always be given in the same unit as the value (in this case in permil that serves as a unit).

Change to ‘Analytical uncertainties for the stable isotope are reported as standard deviation in the data repository.’

Note also that the term „water stable isotope“ does not exist. Water has no stable isotopes but oxygen and hydrogen of the water molecule does.

P4L40/41 See my comment above about deuterium excess. Simply indicate that you have calculated the d -value after that equation. I also suggest to give the equation clearly in a single line with number and change the asterisk to ‘×’.

- P5L2 see my comment above. Change to “4.1 Stable isotope values...”; next line: “oxygen and hydrogen isotope values...”
- P5L29 “ r^2 of 0.01” makes no sense to me. Looking on Figure 2b I cannot see how the r^2 value of the linear regression of the Sabha Khola Pre-Monsoon can be 0.01? By simply looking on the data this must be higher (or better) from my impression. Or not all data points are shown. Please check and correct.
- P6 Figure 2 This Figure shows the results of the study. However, it is unclear to me what is exactly shown.
 First, have all water types been mixed (river, snow, groundwater, spring, lakes)? As each of these hydrological compartments have their own behavior with respect to isotopic fractionation, it makes not really sense to mix them up (or at least not to use different symbols to separate them).
 Second, what is shown on the x-axis? Is this the sampling site altitude or (as stated in the caption) the “mean catchment elevation of the drainage areas of the samples“. If the latter – how was that elevations derived? From a GIS model of the sub-catchments? Please clarify here, not only in the Figure caption bus also in the text.
 Third, the rather stable isotope values in the lower regions of the watershed (<3000masl) could be the result of a sampling artifact as most samples of the lower region seems to be influences by groundwater (Figure 1b, Sabha Khola), which tend to have rather stable isotope values with low seasonality while the steeper gradients relies on samples that were sampled close or along the river course (Figure 1a)
- P7L5 See my comment on precision of stable isotope values. Simply state that error is smaller than symbol size and skip percent values here.
- P7L22 What is the ‘anomaly’? Do you refer the sample in Figure 3 that plots closer to the glacier-melt dominated regions (x-axis)? Please clarify.
- Figure 3 As already mentioned above, I don’t think that percentage can be used here to express differences on d -values on the y-axis. Use Δd values here (the difference in deuterium excess between pre and post monsoon) and not percent values, which makes no sense here.
- P10L19/20 You have to consider that the sampling of river water always gives you an integrated signal from the regions above your sampling point as tributaries are continuously entering your stream (in contrast to precipitation samples). As a consequence you will never measure the real (or true) “precipitation isotope signal” in a river, especially not in high relief terrains as in your study. Thus, you cannot use a river water sample to calculate the (precipitation) elevation isotope gradient. Your river water signal will be always more negative than any on-site precipitation as the river water represents a mixture of high altitude water and water derived from sources near your the sampling site. This may led to a significant underestimation of the real isotope altitudinal gradient with increasing uncertainty further downstream.
 Please include a brief discussion about the limitations of river water samples with respect to rainfall-derived lapse rates. I agree that river water data can be used to estimate on altitudinal isotope gradients but be careful to clearly state that your values relate to river water (and not to rainfall).

P16L16 I doubt that you can cite a manuscript “under review” (van der Veen). Check with the Editor but either it is published at time of final acceptance of this manuscript or delete.

Technical comments

P1L16 and throughout the manuscript: please change δD to δ^2H (note: delta-symbol *italic*) to follow the actual conventions for the notation of stable isotopes (Coplen 2011; Brand et. al. 2014)

Brand, W., A., Coplen, T., B., Vogl, J., Rosner, M. and Prohaska, T. (2014): Assessment of international reference materials for isotope-ratio analysis (IUPAC Technical Report). - *Pure and Applied Chemistry*, **86**, 263-467, [doi:10.1515/pac-2013-1023].

Coplen, T.B. (2011): Guidelines and recommended terms for expression of stable-isotope-ratio and gas-ratio measurement results. - *Rapid Communications in Mass Spectrometry*, **25**, 2538-2560, [doi:10.1002/rcm.5129].

P2L14 and throughout the manuscript: Change the ‘d’ to italic: “Deuterium excess (*d*-excess)”; or to ‘*d*’ only (not ‘-excess’ after *d*) but I notice that both abbreviations are used in the literature.

P2L44 introduce abbreviation ‘masl’

P4L19 space characters missing (N=6 -> N = 6); check also line 24.

Tables

Table 1

In headline change to permil-symbol (‰); not 0/00. To what does the “std. dev. for each sample” refer to? To the number of injections in the laser instrument? Then specify the number of injections in Table caption and methods. Also check superscript of ¹⁸O (also in in Tables 2 and 3).

Further: The samples have no date/time? Please add this information as it essential to the reader; in particular for the river water samples taken from the streams. Please also provide a table with the exact GPS locations for each sample in the supplementary material (or include here). The sampling locations cannot be identified from Figure 1 and need further details provided either in the tables or in the supplementary material.

Table 3

What was the weighing parameter for the regression equation? And why was it not used or discussed in the text? Please specify.

Figures

Figure 2 Lines in figure appear grey in my copy. I suggest using clear black and white colors for axis, lines and also symbols (no grey filling, make them black and put the white symbols on top layer)
In (c) change y-axis label to ‘*d*-excess’ (not D-Excess). Also for Figure 5.

Figure 3 y-axis makes no sense. See my comments above.

Figure 4 Change rainfall data to bar graphs with suitable resolution. The ‘spikes’ does not give a correct impression about the rainfall data collection interval (daily?). Same for the weekly *T* data.