

Review of “A set of methods to quantitatively evaluate the below-cloud evaporation effect on precipitation isotopic composition: a case study in a city located in the semi-arid regions of Chinese Loess Plateau”

by Meng Xing et al.

This paper presents a two-year time series of event-based precipitation and daily water vapour isotope data from the Chinese Loess Plateau with the aim to quantify the below-cloud evaporation effect on precipitation. The study compares two existing frameworks with which the below cloud evaporation effect is qualitatively and quantitatively assessed: the first method is based on the water vapour isotope measurements and the second is based on a mass conservation model. Overall, I found this paper inspiring to read, it presents high quality measurement data, shows carefully compiled figures and several interesting analyses. I have five major comments on the science and one formal request that should be addressed in a revised version of the manuscript. The formal request is to carry out a thorough English grammar check as the manuscript contains numerous parts that are unclear language-wise. In this review step, I decided to focus on the content, and listed only the most important language issues in the minor comments.

My major comments are:

- 1) I like the comparison of two different methods to assess the below cloud evaporation effect on precipitation isotopes. However, I have difficulties to understand the mass conservation model in particular the definition of the remaining fraction of raindrop mass F_{raindrop} . From what I read in Section 2.3.3 and from the Appendix, I get that the mass of the rain drop without evaporation is compared to the sum of the mass of the rain drop without evaporation (m_{noevap}) and the mass of the evaporated rain drop. Doesn't that account double for the non-evaporated rain drop mass? I would have defined $F_{\text{raindrop}} = (m_{\text{noevap}} - m_{\text{ev}}) / (m_{\text{noevap}})$ with m_{ev} the total evaporated water from the falling raindrop. It would be useful to have a mass balance equation clearly defining the problem. As it is presented now, I don't understand this method.
- 2) The structure of the results Section 3.1 seems confusing to. The Section's concluding sentence is “This reminds us that ... the below-cloud evaporation effect on altering the precipitation isotopic composition should be carefully noticed in the arid and semi-arid area”. In my opinion in a paper on below cloud evaporation effects on precipitation isotopes this should come upfront as a hypothesis and all the results should be presented in the framework of this hypothesis.
- 3) I do not agree with the conclusion that vapour isotope time series can be extracted from precipitation. This of course depends very much on the application of such an approach. But, in particular in dry regions of the world, precipitation events are rare so deriving vapour isotopes from precipitation can be very misleading. No data is available for the sometimes long dry spells without precipitation. These periods are likely to exhibit very special vapour isotope signals about which no information can be gained from precipitation data. This fact should be noted in the manuscript. For tree ring isotope time series but also for low accumulation ice core sites, this is an important point.
- 4) To me it is unclear which temperature was used to compute the equilibrium vapour from precipitation (ground temperature, cloud base temperature, temperature at

1500 m) and what in general is the influence of temperature on the position of the measurement data points in the Δd - $\Delta \delta$ space. The equilibrium vapour d from rain water can vary substantially for a given pair of δ -values with temperature. Could the author comment on this?

- 5) In general, the importance of different timescales is not discussed enough. The presented data is daily for vapour and event-based for precipitation samples. In Graf et al. 2019 short term variations in below cloud effects were studied. Also, when the authors discuss the different LMWL for precipitation and water vapour they should note that the two datasets do not have the same temporal resolution. It would also be nice to discuss the expected location of different types of precipitation events (deep convective events vs. frontal systems) in the Δd - $\Delta \delta$ space, e.g. when discussing Fig. 5.

A few selected minor comments:

- 1) P. 1, L. 1:
 - Is it important to mention that the isotope data come from a city? It would shorten the title if this information was left out.
 - Is it really a case study that is presented? I would not say so. A case study for me refers to one event. Here two years of data are presented
 - There are two methods that are mentioned and compared in the paper. I would find it nice to mention this in the title.

Therefore, how about changing the title to:
 "A comparison of two methods to quantitatively evaluate the effect of below-cloud evaporation on the precipitation isotopic composition in the semi-arid region of the Chinese Loess Plateau"
- 2) P. 2, L. 33: "initial precipitation" can be confusing. Do you mean that the isotope composition of the rain water is changed as it travels from the saturated environment in the cloud towards the surface? Or do you mean the isotope composition of the precipitation at the beginning of a precipitation event?
- 3) P.2, L. 41: this method only allows to obtain vapour data during precipitation events
- 4) P. 2, L. 53: the fact that the evaporation intensity is related to the local relative humidity is already said further up at L. 47. The abstract could contain more information if it was streamlined a bit more. In particular, I would find it nice to include a few numbers, e.g. variability range of measured isotope values, strength of below cloud evaporation.
- 5) Introduction: a definition of the deuterium excess (and the delta scale, which is currently in the methods section) with a reference to Dansgaard 1964 would be useful.
- 6) P. 4, L. 106: "Accordingly, the deuterium excess in the surrounding water vapor will increase." This is not necessarily true. Also the above explanation why the deuterium excess in rain decreased due to evaporation is not entirely correct. The described process is an equilibrium fractionation process. The reason for the decrease in rainfall deuterium excess due to evaporation is a non-equilibrium process (due to the different diffusivities of the isotopologues).
- 7) P4. L. 115: Two important studies that investigated the impact of different processes within clouds are Spiegel et al. 2012a,b. They found that the origin of the water

vapour forming near surface clouds (fog) is key in determining the temporal evolution of cloud water isotopes.

- 8) P. 4, L. 134: an overview of the increasing number of available water vapour isotope observations can be found in Wei et al. 2019.
- 9) P. 7, L. 226: over which time window were the precipitation samples accumulated?
- 10) P. 8, L. 246: How many injections were done for liquid sample measurements?
- 11) P. 9, L. 251: Additional uncertainty can come from the uncertainty of the collection system. Fischer et al. 2019 compared simple collocated sampling systems that collected rainfall during 10 precipitation events over Europe and found a resulting uncertainty of 2‰ in $\delta^2\text{H}$ and 0.3‰ in $\delta^{18}\text{O}$ and 5‰ in deuterium excess due to the combined effect of the small-scale variability in the rainfall isotope composition and the sampling system.
- 12) P. 9, L. 261: it would be important to include information on the inlet properties (length, heating system for sampling line and inlet, protective system to avoid liquid or solid precipitation to enter the inlet system, filter).
- 13) P. 9, L. 277: add “e.g.,” since there were many studies showing this effect
- 14) P. 9, Section 2.3: add an estimate of total uncertainty of the water vapour isotope measurements (see Aemisegger et al. 2012) including precision at the given averaging time window, water vapour mixing ratio correction and liquid reference standard uncertainty.
- 15) P. 12, L. 397: “is roughly more negative”: the vapour data are expected to be more depleted due to isotopic fractionation. Can the authors clarify what they mean by “basically followed the same trend”?
- 16) P. 12, L. 403: “Hence the perfect distribution characteristics of water vapor and precipitation on the $\delta^{18}\text{O}$ - $\delta^2\text{H}$ plot would make us suppose that the precipitation isotopic composition is mainly determined by its local water vapor isotopic composition in this study site.” I don’t really agree with this. Could the authors detail their reasoning? I know that a lot of people are convinced by the argumentation that if the vapour and precipitation data follow the same LMWL they must be related to each other. I am very sceptical about this. A temporal correlation coefficient or an analysis as follows later in Fig. 3. seems more convincing to me.
- 17) P. 13, L. 411: which temperature did the authors use to deduce the water vapor isotopic composition at the cloud base from equilibrium fractionation?
- 18) P. 13, L. 421-430: here a few numbers would be useful. In Aemisegger et al. 2015 a difference of up to -1.4‰ for $\delta^{18}\text{O}$, 1.4‰ for $\delta^2\text{H}$ and +12.8‰ in deuterium excess was found between vapour and precipitation at the ground.
- 19) P. 14, L. 438: “than its actual value” -> than the cloud water
- 20) P. 14, L. 448: The 10‰ deviation from 0‰ in ocean water is due to continental recycling, see Aemisegger et al. 2014 for a detailed discussion on this.
- 21) P. 14, L. 452: “considering the kinetic fractionation processes of moisture transportation” this is a confusing statement. Reformulate. Kinetic (non-equilibrium fractionation) is due to the differences in diffusivities of the individual water molecules.
- 22) P. 14, L. 456: I don’t understand this sentence: “Moreover, it is unable to discern other below-cloud processes only based on d-excessp.”
- 23) P. 14, L. 460: what are “non-exchange” processes?
- 24) P. 15, L. 481: Replace “except” by “in addition”

- 25) P. 15, Fig. 4: Add a measure of uncertainty to the Figure (e.g. 1 average error bar in both directions within the Figure where the legend is shown for all data points if the figure gets too busy when adding error bars to all the data points). Here the uncertainties of precipitation and vapour data should be combined to obtain total uncertainty. Especially the four data points in the lower right corner of the Figure are probably affected by large uncertainties (given the low precipitation amounts sampled).
- 26) P. 15, Fig. 4: This Figure and the derived slopes and information is not directly comparable to Graf et al. 2019, since here $\delta^{18}\text{O}$ is used and in Graf et al. 2019 $\delta^2\text{H}$ is used on the y-axis.
- 27) P. 16, L. 520: “amount **are** associated with high RH...”
- 28) P. 18, L. 537: This remains to be shown. It could potentially be so. Make clear that this has not been shown yet.
- 29) P. 21, L. 629: “Moreover, in the near-saturated air column, the raindrop is hardly evaporated”. But it equilibrates with environmental vapour.
- 30) P. 22, L. 661: Why does the mass conservation method overestimate the raindrop evaporation ratios relative to the isotopic method?
- 31) The conclusions are very short and difficult to read language-wise. Please revise.

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