

## **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**

**Meng Xing, Weiguo Liu, Jing Hu, and Zheng Wang**

The manuscript “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“ presents a two-year dataset of the stable water isotope composition of water vapour and precipitation collected in Xi’an in northwestern China. The authors apply two methods to calculate the remaining precipitation fraction after below-cloud evaporation. The results from these two methods are compared and differences are discussed using sensitivity studies. This study presents a valuable dataset of paired precipitation and water vapour measurements that are well described and characterised. But it is difficult to follow the analysis of the below-cloud effects. Further, the purpose of this study is not fully clear after reading the manuscript.

### **General comments:**

- The two methods used to calculate the below-cloud effect have to be better introduced: What assumptions are needed? How did you choose the unknown values? What are the differences between the methods? Why are you using the isotopic method as a benchmark and not the mass conservation method?
- Due to the large number of assumptions needed in the below-cloud evaporation models, the sensitivity analysis has to be more prominent. Further, the different model simulations have to be introduced better. Currently, it is difficult to understand the difference between the models and the different simulations.
- The manuscript is often repetitive. References to the methods are repeated in many places and the introduction to the sections and paragraphs are too general without leading towards the main topics of the paragraphs.

### **Specific comments:**

- Introduction: this section is very long, consider shortening it.
- line 269: model -> do you mean mode? (same on line 281)
- line 269-271: For how long did you measure each liquid injection? Did you apply a drift correction?
- Line 287: “measured by a CTC Analytics autosampler...”, do mean that the samples were injected using the autosampler? I expect the measurements to be done by the laser spectrometer.
- Lines 311-331: This paragraph seems out of place as it discusses a method that hasn’t been introduced yet.
- Lines 334-335: The first part of this sentence is difficult to understand, consider reformulating.
- Lines 344-347: For how long did you measure each liquid injection? Did you apply a drift correction?
- Lines 349-350: The humidity-isotope dependency as shown in S1a and S1b shows a dependency on the isotopic composition of the standards as reported by Weng et al. (2020). For example in S1b, LS-1 shows a decrease in  $\Delta\delta^2\text{H}$  with decreasing humidity while LS-3 shows an increase with decreasing humidity. The linear calibration function of  $\delta^2\text{H}$  does not take this into account. Therefore, the humidity-isotope calibration functions (eq 1 and 2) should be reconsidered to include this isotope-dependency.
- Line 355: “ $\delta_{\text{humidity calibration}}$  is the calibrated data for water vapor stable isotope” do you mean “... is the *humidity-dependency corrected* data..”?
- Line 266: representative -> do you mean “representativeness”?
- Line 373-374: “of which 100 precipitation samples have corresponding daily average water vapor isotopic results” Does this mean you compared the precipitation isotopes with daily average water vapour data? If yes, this would mean that you don’t always compare the same time periods with each other. To compare precipitation and water vapour, the water vapour isotopic composition should be averaged over the time period of the precipitation event.
- 388: “various” -> do you mean “different”?
- Lines 389-397:  $\delta_{\text{pv-eq}}$  and  $d\text{-excess}_{\text{pv-eq}}$  are defined twice in different ways. On lines 390-391, it says that these variables represent the equilibrium vapour from the precipitation samples, on lines 396-397, it says that they represent the water vapour composition at cloud base.
- Line 396:  $d\text{-excess}_{\text{pv-eq}}$  and  $d\text{-excess}_{\text{pv-eq}}$  ->  $d\text{-excess}_{\text{pv-eq}}$  and  $d\text{-excess}_{\text{gr-v}}$

- Sections 2.5.2 and 2.5.3: These two sections introduce the two methods used to calculate the below-cloud effect. After reading these two sections, I still didn't fully understand which assumptions were made. I think that part of the Appendix A has to be mentioned in 3.5.2 (e.g. how the isotopic composition of precipitation at the cloud base is estimated). A conceptual schematic of the properties (and assumptions) between cloud base and ground and how they differ between the two methods might help to understand the two models better.
- Section 2.5.3 The first and last paragraph repeat a lot of information already mentioned earlier in the manuscript.
- Line 508-509: "the corresponding day's water vapour isotopic composition" why do you not compare the per-event mean water vapour isotopic composition? The water vapour isotopic composition changes strongly pre-, intra- and post-event (e.g. Aemisegger et al. 2015). If you average over the full day instead of the precipitation period, the average water vapour isotopic composition can differ strongly.
- Line 513: Is there any seasonal cycle in the mean cloud base at your measurement location?
- Line 525-526: "equilibrium prediction" -> do you mean "equilibrium water vapour from precipitation"?
- Line 534: How is  $\delta^{18}\text{O}_{v\text{-eq}(1500\text{m})}$  calculated?
- Lines 535-542: The sentence "our results indicate that it is possible to derive the isotope composition of atmospheric water vapor based on that of the precipitation in the semi-arid area." seems to contradict "It is worth noting that we do not propose to extract the water vapor isotope time series from precipitation data." What is your message here?
- Line 555: d-excess is 0‰ during equilibrium fractionation only at temperatures around 20°C.
- Lines 560-561: Kinetic/non-equilibrium fractionation should be introduced earlier, and used consistently.
- Line 562-563: "Therefore, during the moisture transportation, the water vapor d-excess may be modified." What do you mean with *moisture transportation*? Diffusion or large-scale advection? It is important to specify the scale of the process.
- Line 584-585: "...from through..." -> this is a repetition.
- Lines 591-593: Can you be more specific about what is the *new* learning from your results? It has been known before, that snow does not interact strongly with surrounding water vapour below the cloud base during its fall (e.g. Gedzelman and Arnold, 1994).
- Line 603:  $\Delta^2\text{H}_v$  -> do you mean  $\Delta\delta^2\text{H}_v$ ? This notation isn't used consistently in the manuscript.
- Line 603-621 and Fig.5: The discussed connection between meteorological conditions and the isotopic values is difficult to see in these figures. Boxplots instead of scatterplots might work better.
- Line 615-617: I don't understand this sentence. Are you referring to the temperature dependency of equilibrium fractionation?
- Line 670: "below-unsaturation" -> what does that mean?

### Figures:

- Fig. 1: The labels of the subfigures are very small
- Fig.4: The linear fit does not fit well to the data. Why do you try to find a linear fit for snow and rain together? As these hydrometeors are influenced by different processes while falling, it is unlikely, that they lie on the same line in this diagram.
- Fig.5: label text is very small. The dark red of very high values (e.g. temperature) is difficult to see.

### References:

Aemisegger, F., Spiegel, J. K., Pfahl, S., Sodemann, H., Eugster, W., and Wernli, H., 2015: Isotope meteorology of cold front passages: A case study combining observations and modeling, *Geophys. Res. Lett.*, 42, 5652– 5660, doi:10.1002/2015GL063988.

Gedzelman, S. D. and R. Arnold, 1994: Modeling the isotopic composition of precipitation. *J. Geophys. Res. Atmos.*, 99, 10455–10471, doi:10.1029/93JD03518.

Weng, Y., Touzeau, A., and Sodemann, H., 2020: Correcting the impact of the isotope composition on the mixing ratio dependency of water vapour isotope measurements with cavity ring-down spectrometers, *Atmos. Meas. Tech.*, 13, 3167–3190, doi: 10.5194/amt-13-3167-2020.