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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Annual variation in precipitation δ^2H reflects vapor source region at Barrow, AK" *by* Annie L. Putman et al.

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General comments

This paper presents a new dataset of isotopic composition of precipitation sampled in the Barrow, AK, Arctic station, together with an innovative method to analyze and interpret its seasonal and event time scales variations. The authors propose interesting tools to use the Lagrangian atmospheric backtrajectory model for a quantitative and statistical evaluation of the observed isotopic variations. They conclude that the seasonal variations of water isotopic values are partly due to migration of the moisture origins. They focus on the influence of three parameters which are shown to explain a large part of the observed variations of the isotopic composition: the cooling along atmospheric transport, the dew point at the moisture source and the presence of moun-

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Discussion paper

tains along the transport.

The authors made a good effort to provide a rich interpretation of their observations. The manuscript is well organized and provides necessary tables and figures. There are, however, several issues regarding discussion of the results. I recommend accepting the article after the authors address the points listed below.

Specific comments

Modeling:

The moisture source modeling used in this paper relies on strong assumptions. However, potential errors caused by these assumptions are poorly pointed out. A companion paper describing the method is currently under review and might contain these information. As this paper is not yet readable, one would need a summary of these information and eventually more details in the method description or in supplementary material, in particular concerning the points addressed below.

Contrary to Sodemann et al. 2008b method, the moisture source modeling used here does not take into account variations of the specific humidity in the air parcels along the trajectory. Processes such as the lost moisture through precipitation or reevaporation of already condensed droplets along transport are not taken into account, but could have a strong impact on the isotopic composition. Can you give more details on the potential errors inherent to this moisture sources modeling?

Also concerning the moisture sources modeling, moisture uptakes are assimilated to air masses sinking into the planetary boundary layer (PBL) above the ocean surface. Nothing is written about the potential presence of sea ice above the ocean in the region where the PBL is reached, which could however have a strong influence on the evaporation. Do you also take into account the sea ice cover in the region were the air parcels sink into the planetary boundary layer? For example: the moisture sources for the winter events are originating from a very wide range of latitudes. If most sources

are originating from the south, some sources are coming from high latitudes, up to 85°N (see winter sources latitudes on Figure 2). Can we really expect strong evaporation in those regions, over a potentially closed ocean? Have you checked the presence of sea ice in the moisture sources regions for this type of events?

Interpretation of results:

Concerning the interpretation of results at the seasonal scale, the seasonal variations described in the article are mostly the result of the relative preponderance of different types of synoptic scale events across the seasons. The intra-seasonal variability of the different events is often on the same order of magnitude than the variations of seasonal averages, which is too rarely pointed by the author. The clarity of the explanations might benefit from a more stronger distinction of the synoptic scale and seasonal scale variations.

Technical corrections

Abstract:

The abstract is quite long and could be more concise.

P.1, L.1 to 5: The first three sentences of the abstract could rather be at the beginning of the introduction, as they don't describe the work presented in this article but general situation of research in the domain.

P.1, L.8: "occurred" > "occuring"

Methods:

P.3, L.13-14: There might be an effect of sublimation of snow which could influence the isotopic composition of water, particularly for sunny periods, even within 24 hours. Did you make some experiments to test the evolution of fresh snow on your sampling site?

P.3, L.14: At which temperature were the samples stored, and how long?

P.4, L.1-4: Considering that a moisture source is corresponding to an air parcel sinking into the PBL is a strong assumption. More justifications of this method would be expected. If this method is described in Putman et al. (2015), add a reference here.

P.4, L11-12: By “the most temporally homogeneous thee-hour time window”, do you mean homogeneity in the precipitation amount or in the meteorological records? Do you have particular criteria to define the preference for the middle of the event? Were the event times defined automatically or manually?

P5., L.5: “The same was done for an array...”: explicit that this is to calculate $Q_{sat,z}$ and define $Q_{sat,z}$.

P.5, L.5-6: Explicit h_z, T_z, P_z: fractional relative humidity, temperature and pressure at elevation z.

P.5, L.25: Are mtn values assigned manually or automatically? If automatic, then explicit the criteria.

Results and discussion

P. 6, L.6-15: This is a very qualitative description of Figure 1. The mean latitude of moisture sources could be introduced before and used to give quantitative aspects to this description. This description focuses on the seasonal averages of the moisture sources, but Figure 2 shows a very strong variability at the event time scale, which can be of a larger order of magnitude than the variations of the seasonal average for the mean latitude of the moisture source. For example, some events in winter have moisture sources located as north as in summer, or even further north. The normalisation of the maps from Figure 1 can also give an impression of wider or more local moisture sources depending on the total number of events and the difference between each event. Is this description of moisture sources regions still valid for absolute values without normalization to the number of events, or for individual events instead of the average of all events?

P. 6, L. 30-32: Not clear if the last sentence refers to Feng et al. (2007).

P. 7, L. 6-7: This sentence is really affirmative, whereas Figure 4 shows a very strong dispersion, particularly for the averaged VLAT. This affirmation should be tempered and a statistical evaluation of the spline fits and there correlations should be given, as well as the standard deviations of the data series. The seasonal scale might not be the better scale to look at.

P. 8, L.3: How did you choose the temperatures from 10C to -15C in you theoretical cooling experiments? What would be the effect on the slopes of a variation of these temperatures on the order of magnitude of the observed variations?

P. 8, L. 18: Rather write “more than 20C” instead of “> 20C”.

P. 9, L. 1: “amount” instead of “amounts”?

P.9, L.5: How was the 7C criteria chosen? Is it close to the median of the distribution of ΔT_{cool}?

P. 9, L.12: Insert a reference to figure 6 to show the repartition of small and large ΔT_{cool} across seasons.

P. 10, L.6: This is not directly about precipitation d-excess but can be of interest: some studies of water vapour d-excess in Arctic regions have depicted a partial conservation of the source d-excess signal under certain atmospheric transport conditions, with relations between observed d-excess and moisture source relative humidity.
Bonne, J.-L., Masson-Delmotte, V., Cattani, O., Delmotte, M., Risi, C., Sodemann, H., and Steen-Larsen, H. C.: The isotopic composition of water vapour and precipitation in Ivittuut, southern Greenland, Atmos. Chem. Phys., 14, 4419-4439, doi:10.5194/acp-14-4419-2014, 2014.
Bonne, J.-L., et al. (2015), The summer 2012 Greenland heat wave: In situ and remote sensing observations of water vapor isotopic composition during an atmospheric river event, J. Geophys. Res. Atmos., 120, 2970–2989, doi:10.1002/2014JD022602.

Steen-Larsen, H. C., A. E. Sveinbjörnsdottir, Th. Jonsson, F. Ritter, J.-L. Bonne, V. Masson-Delmotte, H. Sodemann, T. Blunier, D. Dahl-Jensen, and B. M. Vinther (2015), Moisture sources and synoptic to seasonal variability of North Atlantic water vapor isotopic composition, J. Geophys. Res. Atmos., 120, 5757–5774, doi:10.1002/2015JD023234.

Conclusions

P. 10, L. 29-31: This conclusion on the origins of moisture is valid for the average of the seasonal moisture sources, but should be tempered by pointing out the event to event variation of the moisture sources.

References

P.13, L. 32-36: Logically, the two papers numbering should be inverted (2008a and 2008b).

Tables and figures

Table 1 and 2: The legends do not clearly describe the contents of the tables. Why are different intercepts given for each variable in Table 2 and only one value in Table 1, if the only difference between the two tables are the division of all samples in two groups?

Figure 7: Parenthesis not closed in right y-axis label.

Figure 3 and 7: It would be more readable with x-axis ticks corresponding to the beginning of the years instead of the beginning of each December.

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