Atmos. Chem. Phys. Discuss., 13, C12703–C12709, 2014
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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "The isotopic composition of water vapour and precipitation in Ivittuut, Southern Greenland" *by* J.-L. Bonne et al.

**J.-L. Bonne et al.**

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## Specific comments

***Referee:*** *1. In general the main scientific contribution of this manuscript is the new observation data of vapor isotope ratio. In fact, the authors described technical aspects in detail. Thus, the manuscript should have emphasized the importance of the original contribution of the new data. In this point, several important studies, including a recent publication written by the same co-authors, have been published (see reference suggested below). In introduction, you should review these studies and examine technical aspects of the similar observation studies. Then, the results first compared with the*

*observation.*

**Authors:** We have modified the introduction and the discussion of our results especially the relationship between deuterium excess and moisture source relative humidity, including more references and a comparison of the relationships observed at other latitudes.

***Referee:*** *For example, Midhun et al. (2013) showed the RH vs d-excess correlation is less prominent over the Bay of Bengal. This suggests that the RH vs d-excess correlation at marine vapor (Uemura et al., 2008) would be modified through precipitation along the moisture transport. This is not the case in your data (fig 13). Does it mean that the precipitation amount from moisture source to the Greenland is small?*

**Authors:** We have compared the RH vs d-excess relationship arising from Ivittuut data with the relationships obtained from other areas (Southern Ocean, tropical Atlantic, Mediterranea area, and Bay of Bengal). We suggest that the source signal is preserved along transport to south Greenland, as shown for the Southern Ocean, and unlike what is observed in the Bay of Bengal, where the source signal may be lost due to the intense convective activity, for which other processes are at play (Risi et al, 2008). Our finding is consistent with simulations (Jouzel et al 2013) suggesting that atmospheric distillation processes can preserve a source signal at high latitudes.

The following references have been added to the introduction and discussion sections.

Jouzel, J., G. Delaygue, A. Landais, V. Masson-Delmotte, C. Risi, and F. Vimeux (2013), Water isotopes as tools to document oceanic sources of precipitation, Water Resour. Res., 49, 7469–7486, doi:10.1002/2013WR013508.

C. Risi, S. Bony and F. Vimeux, 2008 . Influence of convective processes on the isotopic composition (18O and D) of precipitation and water vapor in the tropics : 2. Physical interpretation of the amount effect, Journal of Geophysical Research, vol 35, doi :10.1029/2008GL035920



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***Referee:*** *Basically, the result of data vs model comparison (e.g., fig 13 of this manuscript) is very similar to that of Pfahl and Wernli (2008). But this paper was not cited. If the Lagrangian models are essentially the same, the new contribution of your data is that the RH vs d-excess relation were confirmed in a new location.*

**Authors:** The comparison with the results from Pfahl and Wernli (2008) have been included in part 4.4.

***Referee:*** *Suggested References*
*Benneti, M., Reverdin, G., Pierre, C., Merlivat, L., Risi, C., Steen-Larsen, H. C., and Vimeux, F., Deuterium excess in marine water vapor: dependency on relative humidity and surface wind speed during evaporation, Journal of Geophysical Research: Atmospheres, DOI: 10.1002/2013JD020535, 2014*

*Pfahl, S. and H. Wernli, Air parcel trajectory analysis of stable isotopes in water vapor in the eastern Mediterranean, Journal of Geophysical Research, VOL. 113, D20104, doi:10.1029/2008JD009839, 2008.*

*Uemura, R., Yohei Matsui, Kei Yoshimura, Hideaki Motoyama, and Naohiro Yoshida Evidence of deuterium excess in water vapor as an indicator of ocean surface conditions, Journal of Geophysical Research, VOL. 113, D19114, doi:10.1029/2008JD010209, 2008*

*Midhun, M., P. R. Lekshmy, and R. Ramesh, Hydrogen and oxygen isotopic compositions of water vapor over the Bay of Bengal during monsoon, Geophysical Research Letters, Volume 40, Issue 23, pages 6324–6328, DOI: 10.1002/2013GL058181, 2013*

**Authors:** These references have been added .

***Referee:*** *2. Analysis of the synoptic timescale variability (Section 3.2) is interesting. But the events were selected from 4 seasons, and then the averaged data was used for discussion. This is somewhat inconsistent with the following analysis of seasonal variability (Section 3.4) because seasonal moisture-source shift also influences vapor*



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*isotope signal. Could you check the logical consistency and clarify your point?*

**Authors:** In fact, there was a mistake in the description of the figure, as the Flexpart backtrajectory simulation only covered the period September 2011 to December 2012, there was not 14 but 8 synoptic events represented here from the 14 synoptic events selected among the data set, and not 14. During this period, 6 events are between September and December, and only 1 event is in spring and 1 event in summer.

Concerning the seasonal dependency, we have tested to compute this average backtrajectory while removing spring and/or summer events. The corresponded figures have been attached to this response. The spring event appeared very similar to the others. The summer moisture source maps show the same type of behavior, but corresponds to the most south moisture uptake at D+0 en D+1.

***Referee:*** *3. P30540, L5-7, " ... snow precipitation samples show generally higher dp than liquid precipitation, reflecting the different equilibrium fractionation coefficients for solid or for liquid phases ... " This statement is not true because liquid precipitation at the ground is often solid precipitation in the clouds (e.g., Bergeron process). Snowflakes melt until they reach ground. In this case, the solid-vapor equilibrium coefficient should be used.*

**Authors:** Using remote sensing data from CloudSat and CALIPSO, Liu et al. (2012) have shown a predominance from low level clouds in the Arctic and over Northern Atlantic region. This is not a proof of the physical phase of the water in the clouds concerned by our measurements, and we made explicit the hypothesis that the liquid precipitation samples correspond to liquid condensates in the clouds (for the calculation of fractionation coefficients, and the interpretation of the differences between liquid and snow precipitation in winter). This is now clarified in our revised manuscript (part 2.3).

***Referee:*** *4. P30540, L8-25, " ... 18OV and 18Ov time series ... and the Northern Atlantic region ... " I don't agree with this analyses. First, the observation and equilibrium vapor values are NOT "very consistent". The vapor observation data contains*



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*many data gaps due to technical difficulties of automated operation. The system failed to obtain about 50% of the data. This makes it difficult to compare observation and equilibrium calculated values. Second, the data appear to be scattered. Correlation coefficient with significant test and its slope (should be near 1) should be shown.*

**Authors:** A systematic comparison is limited by the timing of the precipitation and vapour measurements, which do not cover the same periods, and limit objective statistical analyses (e.g. correlation). We have added the error bar on the calculation of vapour at equilibrium with precipitation. We have re-formulated the description of the results to clarify the main findings of the comparison.

**Technical corrections**

***Referee:*** *Abstract, "... the first continuous record ... " The data set contains many data gaps due to technical difficulties of automated operation. Thus, this is not the continuous record.*

**Authors:** There was a lack of precision in this sentence. What we meant was that our observations are based on continuous measurement technique, contrary to cold trap sampling approach or precipitation sampling for example.

***Referee:*** *P30527, L16-18, "Thanks to partnerships established with local authorities ... both sides." Move this sentence to Acknowledgement.*

**Authors:**This sentence has been moved to Acknowledgement.

***Referee:*** *P30529, L7, "After discarding samples affected by storage effects". What is the storage effect? Do you mean the evaporation in the collector? If so, how did you set a criteria of 'bad' sample?*

**Authors:** The precipitation in the collector is not sampled immediately after each precipitation event. For this reason, it is possible that the water store in the collector in between precipitation event and sampling time undergoes evaporation. In this case, fractionation might have occured in the collector. In the case of evaporation, this is



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expected to alter the meteoric relationship between dD and d18O. For this reason, we have chosen to retrieve the precipitation samples presenting deltaD/delta18O ratios far from Global Meteoric Water Line. In our case, data with ratios over 9.5 were retrieved.

***Referee:*** *P30535, L25-27, "Hourly averaged measurement ... compared to the 6.5 value reported by Steen-Larsen et al. (2013)". So, what do you want to say by this comparison? Is the difference statistically significant? If so, what does it mean?*

**Authors:** We have modified the text to just report the consistency with results obtained for precipitation sampled in summer, at the event scale, above the Greenland ice sheet (NEEM).

***Referee:*** *P30538, L4-14, "... These events will be investigate more in detail in a forthcoming paper..." This section (3.2.) should be deleted because it is an incomplete paragraph without supporting data. This topic should be discussed in a forthcoming paper as the author described.*

**Authors:** A paper is in preparation concerning this 2012 summer heat wave event. This paper is aiming a comparison of Ivittuut observations with NEEM water vapour isotopic observations and a study of the origin of humidity during this event using different modelling tools including water tagging. The Ivittuut isotopic observations by themselves will not be described in this paper. In our mind, the description of this specific event is important here, as it illustrates how changes in transport can affect the water vapour isotopic composition. We have added a reference to Neff et al. (2013) who investigated the air backtrajectory showing long distance transport for the 2012 heat wave. The reference to our work under progress has been removed from this subsection.

***Referee:*** *P30539, L17-18, "For precipitation ... by a slope of 7.5 ...". What do you want to say by the slope of 7.5? What does it mean?*

**Authors:** This slope has been obtained through the analysis of the linear relationship



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d18O and dD in all our precipitation samples. The sentence has been modified for more clarity. The value is representative of results from high latitude precipitation, where the meteoric slope deviates from 8 due to the impact of low temperatures on the fractionation coefficients. For example, Steen-Larsen et al. (2011) obtained summer slopes of 7.6-7.8 (for subsets of samples with high and low d-excess) at NEEM, which is very close to our observations.

***Referee:*** *P30541, L28, "... detrending to remove seasonal effect ". Why did you remove seasonality? Why did you use 15day running mean to remove it?*

**Authors:**To be able to study the variations occurring on a synoptic (day to day) time scale, we wanted to remove the influence of seasonal variations on our signal. For this purpose, we have used a 15-day- running-average. Indeed, our observation period is not long enough to extract an appropriate seasonal cycle. The text has been adapted to explain why we have decided to use anomalies against 15-day-running-average values.

***Referee:*** *Fig 7 Fig 8; It is nearly impossible to see gray and white lines of map.*

**Authors:** Those two figures have been changed for a better readability. The color scales were changed, as well as the color of continents, parallels and meridians.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/13/C12703/2014/acpd-13-C12703-2014-supplement.zip

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Interactive comment on Atmos. Chem. Phys. Discuss., 13, 30521, 2013.