

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

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Referee: *Bonne et al. present new measurements of more than one year of vapour isotopes from southern Greenland. The authors provide a detailed description of the methods used to obtain the data, as well as time series analysis, theoretical considerations of processes, and interpretation of the data using models. They conclude that the local vapour could be in isotopic equilibrium with precipitation, shifting moisture source regions with seasons and individual events, and that the isotope enabled GCM they compare with generally performs well but has significant problems in capturing the levels and variability in deuterium excess. Overall the manuscript is well organised, with the necessary tables and good figures. I find the language to have a somewhat uneven*

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quality, especially in the first part of the manuscript. Suggestions for specific corrections are made in the detailed comments below, but the manuscript would benefit from being read through carefully for language problems.

Authors: The introduction has been adapted to improve its readability.

Referee: *The novel character of the data seat warrants publication, and I think the authors have made a good effort of providing a rich interpretation of the data, although there are still several open questions. As also listed in the detailed comments, I'm not convinced by the authors assessment of equilibrium between vapour and precipitation. At least from the data presented here. Taking this, and the other comments below, into account I think the manuscript would be suitable for publication.*

General comments

Referee: *As already mentioned I found the manuscript to have some problems with language. Particularly I find that the abstract reads a bit like a list and could be rewritten more fluently.*

Authors: A large part of the abstract was reformulated to improve its readability.

Referee: *Of more technical character, the authors should be careful with the terminology around isotope ratios, both with respect to consistency (see comment for P30523 L2) and physical meaning (see comment for P30522 L10-11 and P30533 L8).*

Authors: The terminology has been corrected.

Technical corrections

Referee:

P30522 L5-7: The sentence “This record depicts small summer diurnal variations .” seems a bit on its own, and is the equilibrium of surface vapour and precipitation also for summer? Please rewrite for clarity.

P30522 L10-11: “delta18O enrichment ” the enrichment (of vapour?) is of 18O not delta18O. Similar with deuterium excess. If you want to refer to the delta18O and

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deuterium excess values, simply write higher or lower values, whatever the case may be.

P30522 L12: replace "is" with "has".

P30522 L13: "The strong correlation ..." it is the first time the correlation is mentioned. Give correlation first, then the Rayleigh distillation interpretation.

P30522 L19: replace "is" with "has".

Authors: The abstract has been changed and these comments have all been taken into account.

Referee: P30523 L2: "Water stable isotopologues" on this page you use three different terminologies for stable water isotopes. Examples: "Water stable isotopologues" (L2), "water stable isotopes" (L3-4) and "water isotopes" (L8). The correct terminology is "stable isotopologues of water". Traditionally, the convention of using the term "stable water isotopes", although incorrect, has been made for convenience. In more recent years some have begun using "water stable isotopes". Whatever term you chose, please be consistent throughout the manuscript.

Authors: We chose the common determination "stable water isotopes" and applied it throughout the paper. The mention of "water stable isotopologues" is used at the first occurrence of this expression, to explain exactly what this terminology designates.

Referee: P30523 L5: replace "this" with "it". "this" refers to something in the previous sentence. Perhaps reformulate by starting the sentence with "We briefly summarize the key findings ...".

Authors: The sentence has been inverted.

Referee: P30523 L9: replace "variation" by "deviation".

Authors: This has been replaced.

Referee: P30524 L2-3: "with a mean slope of 8 resulting from equilibrium fractionation" equilibrium fractionation will not give a slope of 8. See Figure 4 in Jouzel and Merlivat

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(1984).

Authors: You are right that this slope does not only comes from equilibrium fractionation, but is the common average slope observed for meteoric waters. This sentence has been corrected.

Referee: P30524 L5: "140 000 yr" the oldest part of the NEEM core with any kind of age control (fitting to Antarctic time scales) is 128.5 kyr.

Authors: We will use this value.

Referee: P30524 L11: the papers (Dansgaard, 1964; Sjolte et al., 2011) produce a spatial isotope-temperature slope. Is it not relevant also to cite a paper (e.g. Johnsen et al. 1992) that uses a spatial relation for temperature reconstruction?

Authors: This citation has been added.

Referee: P30524 L17: "... and in moisture origin." As cited later, Sime et al. 2013 investigates influences of moisture sources on the Greenland isotope-temperature slope for warm climates.

Authors: This citation has been added to this assertion.

Referee: P30525 L15-16: "The data have shown that the surface water vapour is in isotopic equilibrium with the snowfall and the surface snow." based on what is actually concluded in the previous publications I think the authors should soften up this statement.

Authors: There is evidence of possible isotopic equilibrium between water vapour and surface snow in NEEM. In Steen-Larsen et al. 2011: "The surface atmospheric water vapor appears in isotopic equilibrium with the snow surface indicating a large water exchange between the atmosphere and snowpack". In Steen-Larsen et al. 2014: "Our observations are consistent with calculations assuming isotopic equilibrium between surface snow and water vapor." We have therefore reformulated our sentence.

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Referee:

P30526 L24: replace “confronts ” with “compares”?

P30526 L26: replace “the acquisition of ” with “obtaining”?

P30527 L5-6: “In Sect. 2.5 are summarized the instrument set-up difficulties and improvements, and the data quality. ” please rewrite.

Authors: All these corrections have been done.

Referee: P30529 L13-14: “For all precipitation sample isotopic ratio R_p , we obtain vapour isotopic ratio $R_v = R_p / \alpha$. ” rewrite for readability. Perhaps something like “For all precipitation samples, with isotopic ratios denoted R_p , we obtain a theoretical isotopic ratio of vapour, $R_v = R_p / \alpha$. ”

Authors: This sentence has been adapted.

Referee: P30529 L17-20: Did you test how much the uncertainty in the temperature during the precipitation will affect the estimated vapour composition? You could add this as a range bar in Fig. 9.

Authors: See comment P30540 L20-25.

Referee: P30531 L17: replace “Unstabilities” with “Instabilities”.

Authors: Done

Referee: P30533 L8: “... depleted d measurements ...” again, measurements cannot be depleted in d, only in either 18O or D. Do you mean that the low d values are artefacts?

Authors: Thanks. We have reformulated the sentence and clarified that these very low d values might be linked to an artifact of the corrections applied.

Referee: P30533 L9: replace “the repeatability ” with “repetition”? If this does not work, rewrite sentence more clearly.

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Authors: This sentence has been adapted.

Referee: P30536 L6-7: “the seasonal cycle ” should it be “the mean seasonal cycle”?

Authors: Yes. It has been changed for more clarity.

Referee: P30538 L6: “positive snow albedo and liquid cloud feedbacks ” to avoid misunderstandings maybe reformulate to “positive feedbacks from changes in snow albedo and liquid cloud content”.

Authors: This new formulation has been adopted.

Referee: P30540 L20-25: “We conclude from this comparison that surface water vapour may be at equilibrium .” This conclusion might have some truth to and it is of course not strongly formulated. However, as suggested above, I think that you could estimate the range of uncertainty in the calculated condensate by looking at the temperature range during the time where you think the precipitation fell. There is quite some scatter in the values and I am not convinced by the plot in Fig. 9.

Authors: Standard deviations have been included for the isotopic composition of vapour calculated from theoretical equilibrium with precipitation. The uncertainty calculation takes into account the precision on isotope measurements, and the variability of surface air temperature during the sampling period. An explanation on the calculation of errors has been included in Part 2.3.

Referee: P30542 L25: replace “confronted” with “compared”.

Authors: Done

Referee: P30543 L6-7: What is the approximate elevation of the first model level? Do you compare to any near-surface variables in the model like 2m temperature, or is it only data from the first model level? What are the possible implications of any discrepancies in definition between the measured and modelled parameter (e.g. measured surface air temperature against first model level temperature)?.

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Authors: What is compared here are surface observations with first model level outputs. No surface output of LMDZ are available in our data set. The first level altitude of LMDZ is coded in pressure levels. Over Greenland, the top of this first layer is at about 15hPa above the ground level.

Referee: *P30543 L15-16: So it is the model orography causing the cold and dry bias, because of too high surface elevation in the model?*

Authors: What is important here is the altitude of the grid, but also the land/sea mask. From one grid cell to another, the station might be considered to be on the ice sheet or over the ocean. These suppositions have been included in the text.

Referee: *P30546 L26: missing parenthesis around the citations?*

Authors: Yes. This has been changed.

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