Comments on "How does sea ice influence $\delta^{18}O$ of Arctic precipitation? " by Faber et al

March 22, 2016

This paper investigates the joint influence of sea ice cover and sea surface temperature on precipitation $\delta^{18}O$ in the Arctic, based on 5 simulations with an isotopic general circulation model. The idea is very interesting but I find the analysis is shallow and disappointing. I recommend publication after major revisions. Below are some suggestions to improve the paper.

1 Major comments

1.1 The abstract is misleading

- The abstract emphazing the influence of sea ice on $\delta^{18}O$ of Arctic precipitation except on central Greenland is misleading. Actually, there is almost no change in $\delta^{18}O$ over most of Greenland, even coastal Greenland. The main conclusion of this paper, which deserves to be emphasized in the abstract, is that moderate changes in Arctic sea ice conditions will have no effect on $\delta^{18}O$ over most of Greenland, especially where ice cores are available.
- Same in the conclusion. e.g. l 317-320: "significant changes", but it should be emphasized that they are mainly local, not where most of the ice cores are.
- l 313: "relatively" -> "completely"?

1.2 Need for model evaluation in the Arctic

- Before using a model, some evaluation of this model is necessary. Can you add a figure showing the distribution of precipitation $\delta^{18}O$ in the Arctic compared to precipitation data wherever they are available? (GNIP, snow samples, ice cores...)
- If the model features some biases, what are the consequences on the conclusions? For example, is the absence of large-scale isotopic response specific to this model, and can it be linked to the representation of the large-scale circulation or of boundary layer processes?

1.3 Sea surface conditions rather than sea ice cover

- The authors discuss the sensitivity to sea ice conditions, but actually they cannot separate the effects of sea ice cover and sea surface temperature. I suggest they reword all sentences by replacing sea ice by sea surface conditions. e.g. l 134 and elsewhere.

1.4 Question on precipitation weighting

- l 156: The precipitation weighting is not clear. Isn't $\delta^{18}O_p$ weighted by precipitation already on Figures 4 and 5? If not, what does it represent? Precipitation $\delta^{18}O_p$ should always be precipitation weighted. Otherwise, biases are introduced that depend on the arbitrary choice of the temporal sampling. If you didn't weight by precipitation, this is a mistake. Then once $\delta^{18}O_p$ is precipitation weighted, you don't need to further apply any precipitation weighting, so fig 6 is useless.

1.5 $\delta^{18}O_p$-temperature relationships

- l 161: the scatter diagrams in fig 5 are interesting but underexploited. The authors calculate the slope for all simulations together but don't do anything with it. What is interesting in this diagram is that in spite of the similar slope, the different simulations appear to be shifted. For a given surface air temperature, the $\delta^{18}O_p$ is all the larger as the sea ice is overall reduced. This explains why the slope for all simulations together is larger than that for individual simulations. There is an offset that depends on sea surface conditions and that adds up to the temperature effect. This is interesting.

- As a consequence, I disagree with the implications for the interpretation of $\delta^{18}O_p$ signals written by the authors l 169-174.

  - "In this study the $\delta^{18}O_p$-temperature relationship is found insensitive to changes in the pertubations of sea ice": the slope is the same but there is an offset, which is very important for the interpretation of $\delta^{18}O_p$ temporal signals!
  - "Interpreting $\delta^{18}O_p$ changes to temperature changes using an Arctic spatial slope will therefore not be dependent on the sea ice distribution in the climate where the spatial slope is estimated". Do you mean interpreting temporal changes at a given location? If so, this assertion is wrong. Because of the offset, the temporal changes in $\delta^{18}O_p$ at one location will show a larger slope with temperature than expected from the Arctic spatial slope, whatever the climate used for the slope estimation. In other words, the effect of sea ice is to disturb the $\delta^{18}O_p$-temperature relationship so that the temporal relationships will look stronger than the spatial relationships.

- l 314: revise this conclusion.

1.6 The link with vapor origin is not clear

- l 200-204: to test the hypothesis of an advective effect, you can analyze wether the $\delta^{18}O_v$ signals are downstream or upstream compared to the wind directions.

- The discussion on air mass origin is not clear. l 224-225: "changes in the contribution of vapor origin": if it was the case, shouldn't we expect an isotopic response at a more regional scale? l 224: "shows": how can you eliminate the hypothesis that all the $\delta^{18}O_p$ response is due to temperature?

-> The message about the influence or about the absence of influence of a change in air mass origin should be clarified and better supported by model analysis.

- Symptomatic of this unclear message: l 233: the authors mention "large scale circulation". Then they refer to Fig 9, where there large-scale circulation is not discussed.

- l 235-241: what is the link between these references and this study? How do these references support your point or advance the discussion?

- l 253: "all these mechanisms have the potential to alter the isotopic composition." But do they play a role in this study?

- l 255-268: This is not clear. What is the link between storm systems and moisture sources? Can you support it by model analysis?

-> It would be useful to make a clear distinction between what your model analysis actually shows, with rigorous analysis, and what you can speculate based on the litterature.

- l 310-311: it looks like moisture sources don't explain much of the isotopic signal based on the model analysis. Comparing Fig 3 and Fig 4, it looks like $\delta^{18}O_p$ simply follows air temperature. So why do you need to involve the effect of moisture source?

1.7 Some suggested additional analysis to clarify the link with large-scale circulation

- One hypothesis to explain the absence of isotopic response in Greenland is that air trajectories that end up in Greenland travel in the free troposphere above the boundary layer, so are not sensitive to sea surface conditions and are not recharged by Arctic evaporation. Can you test this hypothesis in the model? For example, you can look at isotopes and large-scale circulation for vertical cross-sections from the ocean to central Greenland?

- l 282-290: this is interesting. What is the vertical distribution of $\delta^{18}O_v$ response in your model? This is easy to look at in your simulations. Looking at this will help you to understand why the isotopic response is so local.

2 Miscelaneaous

- l 18: add more references, including the key historical ones

- l 32: "demonstrate" -> "suggest": Observations don't demonstrate anything in absence of some form of modelling

- l 64: The citations for the isotopic versions of CAM3 are wrong: [1] was for MUGCM; Noone 2003 was a workshop with no written record; [2] only cites Noone 2003. Same problem l70.

- l 67: what is a 3rd generation isotope scheme? This is not a commonly accepted classification. Be more specific or don't mention it.

- l 130-132: "match the spatial distribution": to be more quantitative, calculate the spatial correlation between SST and $\delta^{18}O$ changes. l 133-l152 don't add much to the discussion once we have read the first paragraph and looked at the figures. The correlation would add a quantification.

- l 156: "precipitation weighted $\delta^{18}O_{p.wgt}$" -> "precipitation weighted $\delta^{18}O_p$, named $\delta^{18}O_{p.wgt}$,"

- Figure 3 caption: are these annual mean?

- Figure 4 caption: are these annual mean?

- l 205: Latent heat flux is not a proxy for evaporation, they are actually the same, ignoring a multiplication factor.

- Figure 8: how many grid points are considered for each year? Can you add this information? Can you add error bars? (standard deviation)

- l 246: "weakening": for which years? Aren't there any years with strengthening of the wind speed? If so, there could be an effect of looking at individual years versus using climatological SSTs.

References

[1] D. Noone and I. Simmonds. Associations between delta18O of Water and Climate Parameters in a Simulation of Atmospheric Circulation for 1979-95. *J. Climate*, 15:3150–3169, November 2002.

[2] David Noone and Christophe Sturm. *Comprehensive Dynamical Models of Global and Regional Water Isotope Distributions, in Isoscapes: Understanding movement, pattern, and process on Earth through isotope mapping.* Springer Netherlands, 2010.