

Interactive comment on “Measurement report: Spatial variations in snowpack ionic chemistry and water stable isotopes across Svalbard” by Elena Barbaro et al.

Anonymous Referee #2

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Review on "Measurement report: Spatial variation in snowpack ionic chemistry and water stable isotopes across Svalbard"

The paper presents the results of a snow chemistry survey carried out on several glaciers across Svalbard in the spring season. The authors analysed snow pit samples for their major ion loads and stable water isotope composition in order to understand the spatial distribution pattern of different chemical species in the snowpack across the archipelago. The comprehensiveness of the presented data set makes it valuable for improving our understanding of which role transport processes, deposition patterns and sea ice formation processes play for the chemical composition of the seasonal

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snowpack on Svalbard. Therefore, I suggest the manuscript to be published in ACP as a measurement report.

However, according to the title of the paper setting focus on both ionic chemistry and stable water isotopes of the snowpack I am missing a more detailed description of the stable water isotope survey, in the methods, results and discussion section. From the introduction it does not really become clear to me for which reason stable water isotopes are analysed in this study. What is the major aim of the stable water isotope analyses and what is the connection to the ionic composition? What do you want to explain with the help of the stable water isotopes? I also propose to give a short overview of the current knowledge about stable water isotopes in snow on Svalbard in the introduction as it has been shortly done for the chemical impurities. Furthermore, in order to understand the distribution pattern of major ions and stable water isotopes on Svalbard I think it is highly necessary to give more details on the different glacier sites, i.e. about their similarities and differences regarding size, shape, exposition to wind, distance to the sea ice edge.

At the moment the authors provide values for ionic loads and stable water isotopes only as values summed up or averaged over the entire depth of the snowpack that has been sampled. Hence, I think that it is of high value for the manuscript if also the vertical distribution pattern of the ionic composition and of stable water isotopes is included as this can deliver additional information about seasonal differences in transport processes, moisture sources and accumulation. Therefore, I strongly recommend to add a chapter about the stratigraphic differences and similarities regarding the ionic load and the stable water isotope composition to the Results chapter of the manuscript.

When explaining the observed spatial differences in the ionic and isotopic composition of the snowpack at the different sites, I also strongly suggest to discuss the role of post-depositional processes, in particular the reallocation of snow, and thus reallocation of ions and isotopes due to wind drift in more detail. Katabatic winds blowing down glacier valleys might cause significant removal, redistribution and redeposition of snow and

thus might bias the ionic and isotopic composition of the snowpack. It is necessary to consider the aspect of wind drift in particular when trying to explain unexpected distribution patterns of ions and stable water isotopes (e.g. lack of altitudinal gradient in the stable water isotope composition).

Specific comments:

Title: The title should also indicate the seasonal aspect of the study.

Abstract: L46 Please write δD instead of $\delta 2H$ throughout the manuscript as this is the most common notation.

1. Introduction:

L81-82 It is unclear where the last part of the sentence (“... and has also experienced...”) refers to – the west or the east of the archipelago. Please rephrase.

L 84-98 Please add some information about the state-of-the art of the spatial distribution of stable water isotopes in the snowpack on Svalbard.

L 100-110 Please state clearly what stable water isotopes are used for in this study, i.e. what is the objective connected with the analysis of stable water isotopes.

2. Methods:

L 118 Please give more details on the different glacier sites. How different are they regarding their size and shape? How are they oriented, i.e. what is their flow direction (N-S, W-E)? Are there differences in their exposition to wind (e.g. U-shaped valleys vs. plateaus)?

L122 Where does “these zones” refer to? Accumulation and ablation zones or the ELA? Please be precise here.

L128-129 Why do you use different sampling resolutions at the different sites? Treating all sites in the same way would increase the comparability of the data that you derive.

Please explain why you use this sampling strategy.

L 152 Delete “as recommended for this device and column” as this information is unnecessary.

L198-202 The description of the stable water analysis is very short. Please give more details here: How many injections did you use per sample? How was the raw data corrected (e.g. for memory effects, drift)? Which standards did you use?

3. Results:

It is worth to include a chapter about the vertical distribution of major ions and stable water isotopes in the snowpack, i.e. to add a chapter about the stratigraphy and the spatial differences (or similarities) between the different glacier sites.

L241 How did you calculate the SWE-weighted mean? Please add this information.

L249-251 Do you have any explanation for this unusual pattern? Due to the altitudinal effect one would expect the stable water isotope composition to become lighter with increasing height as you did observe on KGV, ALB, HDF and LF. What about reallocation of snow by wind drift? Are there differences in the exposition of the different glacier sites to wind drift? Is there any influence of the glacier size and shape on the snow accumulation pattern and thus potentially also on the distribution of the stable water isotope composition in the snow? What about post-depositional effects that might alter the isotopic composition of the snowpack, such as diffusion and sublimation? Please add some possible explanations to the discussion chapter 4.4.

4. Discussion:

L 259 What do you mean by “unpublished data”? Please specify.

L260 Finish the sentence after “firn cores” and start a new sentence “Our study . . .”.

L 286 The sentence is incomplete. Please check.

L 315-319 I could not catch what you want to say here. Please rephrase and make two sentences.

L 336-338 What do you think might be the reason for this pattern? What about long-distance transport of pollutants to the site? Please discuss.

L395 The d excess is also influenced by the relative humidity in the moisture source region.

L 399-401 Please explain what the Kruskal-Wallis test is and what it is used for in general (statistically). Just from the values in Table 2, I cannot see a significant difference between the d excess values at AF and the other sites, e.g. a d excess of almost 17% also occurs at HDF3, values > 14% also occur at ALB1 and ALB2.

L 414 Actually, the d excess is the parameter that provides information about moisture source variations. $\delta^{18}\text{O}$ is rather related to the condensation temperature at the precipitation site. I suggest to also calculate the relation between log-transformed Na^+ and the d excess and to compare the results with the relation between log-transformed Na^+ and $\delta^{18}\text{O}$.

L 430-433 What about reallocation of snow by wind drift? Depending on the exposition of the site it can significantly alter the ionic and isotopic composition of the snow after deposition.

Figure 1: Please add all glacier site abbreviations to the figure captions.

Technical corrections:

I suggest to use present tense throughout the manuscript whenever you are talking about results, in particular in the following paragraphs: L48-55, L216-253, L 281-288, L 290-302.

I also strongly recommend to make shorter sentences in order to increase the readability of the text, in particular in the following paragraphs: L58-59, L74-78, L105-108.

- L106 Add comma after the bracket.
- L124 Delete one dot behind “i.e.” in the bracket.
- L154 Delete the commas enclosing “as well as DPA”.
- L155 Add “the” before “solid phase”.
- L174 Delete the bracket before “Barbaro et al.” and enclose 2017 by brackets.
- L177 Use plural for “calibration”.
- L 178 Consider to use “delivered” instead of “gave”.
- L183 and L184 Add “all” before “cases”.
- L186 Add “the” before “bulk ionic load”.
- L214 Delete the comma after ELA.
- L216 Replace “snow pits samples” by “snow-pit samples”.
- L 258-259 Delete the bracket before “Virkkunen et al.” and enclose 2007 by brackets. The same for “Vega et al.” (delete the bracket before and enclose the year in brackets).
- L 263 Delete the bracket before “Spolaor et al.” and enclose 2013 by brackets.
- L 278 Add “the” before “snowpack”.
- L 284 Too many brackets re-write: (0.32; Millero et al., 2008; Figure 3).
- L292 Write Cl-/SO42- instead of Cl-:SO42-. Add “on” before “those”.
- L 300-301 Delete “which is a derived variable” as this has been explained before.
- L 312 Add “an” before “underrepresentation”.
- L 359 Add a dot after the bracket and delete “and”.
- L 368 Delete the comma after “always”.

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L 369 Delete the bracket before “Jacobi et al.” and enclose the year by brackets.

L 379 Delete the space after “this”.

L 400 “was” needs to be shifted behind “d”.

L 411 Delete the comma after “higher”.

L 417 Replace “glaciers sites” by “glacier sites”.

L 428 Replace “suggests” by “suggest”.

Figure 2: Replace “glaciers zone” by “glacier zones”.

Figure 3: L 705 Delete “the” before “spring”.

Figure 5: L 726 Add “the” before “oxygen”.

Table 1: Replace “Universit! de Franche-Comté” by “Université de Franche-Comté”.

Table 2: Replace “compare to sea water” by “compared to sea water”. Please also add the unit for $\delta^{18}\text{O}$, δD and d excess in the table captions.

Table 4: Add a comma after Millero et al.

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