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Atmospheric Chemistry and Physics Discussions

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

Anonymous Referee #1

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Review on "Measurement report: Spatial variations in snowpack ionic chemistry and water stable isotopes across Svalbard" by Barbaro et al.

In this paper, the authors conducted snow observations on several glaciers in Svalbard in spring time, and showed spatial variations of the loads of chemical substances in snowpack and water stable isotopes. The spatial variations influenced by an unique location of Svalbard , which is in the boundary area of sea ice cover, are valuable data to evaluate transportation processes of chemical substances and water vapor surrounding Svalbard. Especially, a spatial variation of Br, which is reported by less common of previous research is very important, and suggests release processes of Br

from sea ice during sea ice formation. Moreover, the unification of observation methods of snowpack and chemical analyses conducted by several laboratories enhances the reliability of the data. For these reasons, I suggest that this manuscript is worthy of being a publication of ACP as a measurement report.

However, I believe that the data currently described in this manuscript are not enough. The authors also observed snow stratigraphy of snowpack and collected snow samples for chemical analyses from each snow layer according to the snow stratigraphy. Nevertheless, only total loads of chemical species in snowpack are reported in the current manuscript. I am strongly proposing that spatial variations of SWE-weighted mean concentrations as well as total load are at least reported in the main content of the manuscript and vertical profiles of stratigraphy of snow pack and concentration of chemical substances and water stable isotopes are reported in the main content of the manuscript or the supplementary materials. As the authors mentioned in the manuscript, the periods of snow accumulation are different from observation site to site. Therefore, load of chemical substances might be biased by the differences of the period of snow accumulation. Therefore, I believe that this measurement report should report both of spatial variations of loads and concentrations of chemical substances. Moreover, I can imagine that the spatial variations might be different from in autumn, winter, and early spring. Therefore, the vertical profiles of chemical substances indicating seasonal variations are also valuable.

I also have several concerns about the evaluations of the spatial variation in the results and the discussions.

Specific comments

Title: In this article, only seasonal snow (autumn, winter, and spring) is treated. The authors should titled in such a way that the seasonal snow is made explicit.

L90: Valence of Na ion is 1. Na+

L92: Main subject of Goto-Azuma et al. is influence of melt water on chemical profiles in snowpack. Winther et al. does not show chemical data. I believe that there are more appropriate references. For example, Issakson et al., 2001 showed the chemical data of ice core from Lomonosov fonna, and Matoba et al., 2002 showed chemical data of snowpack and ice core from Vestfonna.

L124. This protocol was used for the project of C2S3, and was not authorized by international organizations. Therefore, please change the description to avoid misunderstandings, and describe more details of the method.

Major ion analyses 2.2 Major ion analyses Please unify the items described in each analytical condition in each laboratory. Please added followings: Flow rate of IC at Hornsund and Venice. Information of the guard column in Uppsala Filtering method in Venice Authors used the terms “eluent” in Hornsund, and “mobile phase” in Uppsala and Venice. Please unify the term.

L158 Cation was determined in Uppsala. L174 In Barbaro et al., 2017, analytical methods of amino acid were described, but not of anion and cation. Please cite appropriate references.

2.2.4 Instrumental performance of each laboratory. I suggest that this part is described in the first chapter of 2.2.

3. Result As the authors mentioned, the periods of snow accumulation are different from observation site to site. Therefore, load of chemical substances might be biased by the differences of the period of snow accumulation. To evaluate the impacts of chemical substances on the environment of snowpack in Svalbard, the total loads of chemical substances are appropriate. On the other hand, to evaluate the transport process of chemical substances from the other regions to Svalbard, the concentrations of chemical substances are also appropriate.

L216 Please add the names of observation sites as “Hornsund area (HB and WB,

southern Spitsbergen)”

L219 same zone -> accumulation zone.

L223 Figure S1 is important data and should be in the main text, and not in the supplemental materials.

L216 “Hornsund area” L230 “Hornsund region”, L234 “Hornsund glaciers” Please unify them.

L241 Figure S2 is important data and should be in the main text, and not in the supplemental materials. The spatial variation of water stable isotopes is very important.

L246 Please add the names of observation sites in “NW Spitsbergen (XXX, XXX).

L250-253 I could not catch what the authors would state.

4. Discussion Temporal variations of chemical substances are not subjects of this article. Therefore, the part L257-265 is not necessary for this article.

4.1 Why not specify the percentage of sea-salt derived components in all chemical species, and show the prominence of sea salt as an origin?

L281-288 For this discussion, nss-Mg2+ should be used rather than total Mg2+.

L297 Generally, SOx does not originate from biomass burning. Does the authors mean the transportation of the secondary aerosols of ammonium sulfate formed by SOx from coal combustion and ammonium from biomass burning?

L298-302 I could not catch what the authors would state.

L304-312I could not catch what the authors would state. At the ocean around Svalbard, algae bloom can occur in autumn. I am not sure that the autumn bloom can affect the snow chemistry in Svalbard. I just cite a reference (Andyna et al., 2014)

4.2 Chlorine depletion L349: Under the reaction of chlorine depletion, sea salt NaCl reacts with acid. Therefore, the acid should be described as HNO3 and H2SO4 instead

of NO3- and SO42-.

L351 The weight ratio of Cl/Na is 1.8. 1.174 is the mole ratio of that. In this paper, weight units are used for loads of chemical substances. In Figure 3, Cl/Na ratio is 1.80. Please change the number of Cl/Na and confirm the calculation of Cl depletion rate.

Whitlow et al., (1992) indicated that Cl/Na in snowpack at the Summit of Greenland was higher than the ratio of seawater. According to this paper, Cl depletion occurs on aerosol particles and the Cl-depleted aerosol particles are scavenged during the transportation of air mass. Thus, Cl/Na of residue of air mass becomes higher values. On the other hand, Cl/Na in Svalbard is lower than seawater in this article. If the authors indicate the characteristics of snow in Svalbard based on the difference from Greenland, the worth of this articles should be higher.

4.3 Br enrichment Hara et al., 2017 showed that Br was concentrated on frost flowers formed on new sea ice before the end of polar night, and consistent with this article.

4.4 L394 "*" is used for PC calculation. "d=δ2ÎŮ - 8 δ18Î§" L395 d-excess is influenced by not only SST but also relative humidity and wind speed (Gat, 1996; Uemura et al., 2008)

4.5 L426-429 If the water vapor is long-range transported from lower latitude, isotopically heavier molecules should be removed from air mass during the transportation and delta value of 18O should be decreased. Moreover, it is not understandable that Na from sea splay is accumulated in air mass during the transportation of air mass from far south. Because, the amount of Na scavenged from the air mass is much larger than that input from sea spray on the ocean surface. I believe simply the reason for the correlation between d18O and Na concentration in the high latitude area is as below: At high latitude areas, air mass is transported from simply from low elevation site to high elevation site without any strong disturbance of atmospheric condition. In this case, isotopically heavier molecules and chemical substances from sea spley are scavenged from air mass gradually. Thus, d18O and Na concentration shows positive correlation.

References L532 Goto-Azuma et al., The name of the journal is "Publication of the International Association of Hydrological Sciences".

Figure 2 Caption. Please describe the name of observation site in the figure caption. as "HDF; Holtedahlfonna". KV should be KVG.

Table 1 What does the "air temperature" in Table 1 indicate? Please describe time and date.

References for this review. Andyna, M. et al., 2014, Geophys. Res. Lett., 41, doi 10.1002/2014GL061047. Hara et al., 2017, ACP, 17, 8577-8598. doi:10.5194/acp-17+8577-2017. Issakson et al., 2001, J. Glociol., 47, 335-345. doi: 10.3189/172756501781832313 Matoba et al., 2002, J. Geophys. Res., 107, D23, 4721.doi:10.1029/2002JD002205

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