Editor Prof. Joel Savarino

We thank Prof. Savarino very much for his careful and thoughtful review of our work. Please see below for point-by-point responses in blue following Prof. Savarino's comments, in the order of (1) comments from Referees, (2) author's response.
Prof. Joel Savarino's comments are in black, and the responses are in blue.

(1) comments from Referees

The reviewers still think that the propagation of errors is not correctly done and are not mentioned when certain estimates are made (eg lines 439, 473, 505) , that the scientific content is relatively poor although interesting questions are asked without the data being able to answer them and that the article is too long for its scientific content.
For example, the dechlorination of marine aerosols is a well-known process, so there is no need to write a 20+ lines paragraph to indicate that the results are consistent with previous studies;

(1) author's response

Thanks for the comments. In the revised manuscript, all of the errors were included when calculating the non-sea-salt fractions of ions in snow.
Following the comments from both editor and reviewer, the article was significantly shortened, and now it is a short communication instead of a research artic (see responses below).

Indeed, dechlorination of sea salt aerosols is a well-known process, and a detailed discussion on the process was omitted in the revised manuscript. In the updated version, only the possible source of $nssCl^-$ in snow was simply mentioned. Please see the first paragraph in Section 4.1,

"$nssCl^-$ accounted for (39±24) % of Cl^- on the traverse, with higher values in the interior areas. The elevated fractions of $nssCl^-$ are likely associated with the 'secondary' HCl which is produced by the reactions between sea salts and acids (e.g., HNO_3 and H_2SO_4) (Finlayson-Pitts, 2003)."

(2) comments from Referees

Similarly, the discussion on potassium is rather poor and does not allow to conclude, the ternary diagram is useless, a discussion on nss sulfate is sufficient, the principal components analysis does not bring any new element justifying such a development. Several essential references on e.g. the stability of nitrate in snow are missing (Freyer 1996, Neubauer 1988, Legrand 1990).

(2) author's response

Agreed and thanks for the comments.

For the discussion on main origins of nssK^+, the data of refractory black carbon (rBC), a tracer of biomass burning emissions in the Southern Hemisphere (Sigl et al., 2016), was included. In Antarctic snow, the nssK^+ has three main sources, biological activity on the coast (Rankin and Wolff, 2000), terrestrial particle mass transport, and combustion emissions in the Southern Hemisphere (Virkkula et al., 2006; Hara et al., 2013). Considering that all sampling sites are at least several tens of kilometers away from the coast, the contribution of biological activity to snow K^+ would be rather minor (Rankin and Wolff, 2000). A lack of correlation between K^+ (or nssK^+) and refractory black carbon (rBC; Figure below), which mainly represent the biomass burning emissions in the Southern Hemisphere (Sigl et al., 2016), suggests that K^+ is unlikely dominated by biomass burning emissions in surface snow.

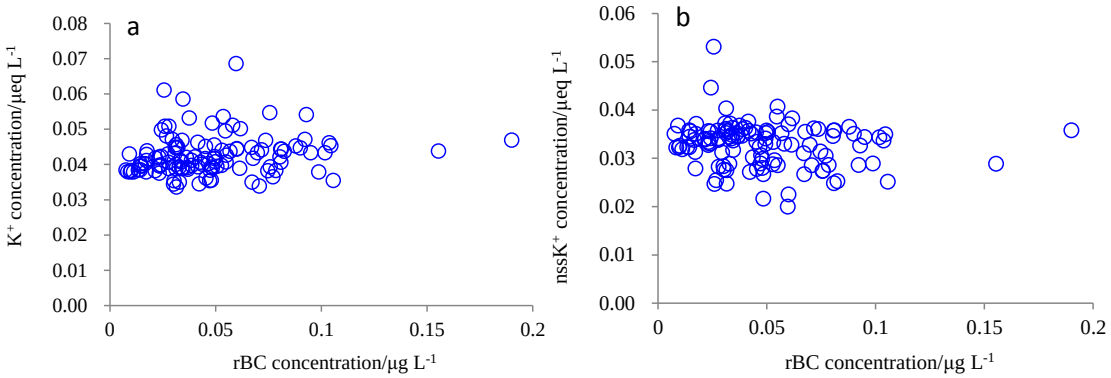

Figure. Correlations between refractory black carbon (rBC) and K^+ (nssK^+) in Antarctic surface snow collected in 2012-2013 campaign. The rBC analysis system consists of an ultrasonic nebulizer and desolvation system (CETAC UT5000) coupled with a Single Particle Soot Photometer (SP2, Droplet Measurement Technologies, Boulder, Colorado).

Following the reviewer's suggestion, all ternary diagrams and related context were excluded in the revised manuscript. In the revised manuscript, only the non-sea-salt fractions of ions were discussed, and the discussion on the modification to sea salts with the aid of the relationships among Cl^-, Na^+ and SO_4^{2-} was excluded.

Indeed, parts of the principal components analysis (PCA) results are similar to the outcomes of correlation analysis between ions and Na^+ in the original version. In this case, the parts associated with PCA method and discussions were excluded in the revised manuscript.

In the previous version, indeed, several import works on nitrate in snow were missing (Freyer 1996, Neubauer 1988, Legrand 1990). In the revised manuscript, the discussion on snow nitrate was excluded, considering the word limits of a brief communication and that nitrate in the snow across the Antarctic ice sheet (and on this traverse) has been extensively investigated (e.g., Frey et al., 2009; Erbland et al., 2013; Shi et al., 2015; Shi et al., 2018). Consequently, only the work of Neubauer and Heumann (1988) was included in the introduction in the revised manuscript.

Neubauer, J., and Heumann, K.G.: Nitrate trace determinations in snow and firn core samples of ice shelves at the Weddell Sea, Antarctica, Atmospheric Environment (1967), 22, 537-545, 1988.

(3) comments from Referees

The correlations of nitrate and sulfate with accumulation have already been shown and either their interpretation has already been made (sulfate) or do not allow to deduce a result without knowing a priori this result by other means (nitrate).

(3) author's response

Agreed. Following the comments, the correlations of chloride, nitrate, and sulfate with snow accumulation rate were excluded in the revised manuscript. In the manuscript, we only focus on the occurrence, sources and variability of non-sea-salt fractions of ions in snow. Please see the revised manuscript.

(4) comments from Referees

In spite of this and like the reviewers, I think that the data from the traverse deserves to be published, especially because this type of measurement is rare in Antarctica. I therefore suggest to the authors to drastically shorten the size of the manuscript by focusing on the new results of their study compared to previous ones and passing quickly over the similarities. To this end I recommend the submission of a short paper in the form of a brief communication rather than a research article.

(4) author's response

Thanks to Prof Joel Savarino, and following your suggestion, the scientific content in the manuscript was significantly shortened. Now, the revised version is in the form of a brief communication rather than a research article, and we only focus on the non-sea-salt fractions of ions in the revised manuscript. Several important revisions were made to meet the requirements of a brief communication:

1) The manuscript title now is, Brief communication: Spatial and temporal variations in surface snow chemistry along a traverse from coastal East Antarctica to the ice sheet summit (Dome A)

2) The abstract was significantly shortened and improved. Now, the total word number is ~100, meeting the requirements of a brief communication.

3) Three figures (required by a brief communication) were kept in the revised version. The ternary diagram, correlations of chloride, nitrate, and sulfate with snow accumulation rate, the PCA results are omitted. The other figures were moved to the supplementary materials.

4) The Introduction was significantly shortened, and spatial and temporal variations in chemical ions in Antarctic snow and ice were generally reviewed. Then, raised why we carried out the present investigation.

5) In the section Results, the ion variations in snow pits and ion concentrations in surface snow were concisely summarized.

6) In the section Discussions, we focus on: 1) the non-sea-salt fractions of ions in surface snow, including the spatial patterns and main sources of the non-sea-salt fractions of ions, and 2) non-sea-salt fractions and fluxes of ions in snow pits, including the seasonal variations of the non-sea-salt fractions of ions and the related controlling factors, and the ion fluxes were also calculated.

7) The section Conclusions was revised accordingly.

Through the abovementioned revisions, the updated version tends to meet a brief accumulation.

References

Erbland, J., Vicars, W., Savarino, J., Morin, S., Frey, M., Frosini, D., Vince, E., and Martins, J.: Air-snow transfer of nitrate on the East Antarctic Plateau - Part 1: Isotopic evidence for a photolytically driven dynamic equilibrium in summer, Atmos. Chem. Phys., 13, 6403-6419, doi:10.5194/acp-13-6403-2013, 2013.

Finlayson-Pitts, B.J.: The tropospheric chemistry of sea salt: a molecular-level view of the chemistry of NaCl and NaBr, Chem. Rev., 103, 4801-4822, 2003.

Frey, M.M., Savarino, J., Morin, S., Erbland, J., and Martins, J.: Photolysis imprint in the nitrate stable isotope signal in snow and atmosphere of East Antarctica and implications for reactive nitrogen cycling, Atmos. Chem. Phys., 9, 8681-8696, 2009.

Hara, K., Osada, K., and Yamanouchi, T.: Tethered balloon-borne aerosol measurements: seasonal and vertical variations of aerosol constituents over Syowa Station, Antarctica, Atmos. Chem. Phys., 13, 9119-9139, 2013.

Rankin, A.M., and Wolff, E.W.: Ammonium and potassium in snow around an emperor penguin colony, Antarct. Sci., 12, 154-159, doi:10.1017/S0954102000000201, 2000.

Shi, G., Buffen, A.M., Hastings, M.G., Li, C., Ma, H., Li, Y., Sun, B., An, C., and Jiang, S.: Investigation of post-depositional processing of nitrate in East Antarctic snow: isotopic constraints on photolytic loss, re-oxidation, and source inputs, Atmos. Chem. Phys., 15, 9435–9453, doi:10.5194/acp-15-9435-2015, 2015.

Shi, G., Hastings, M.G., Yu, J., Ma, T., Hu, Z., An, C., Li, C., Ma, H., Jiang, S., and Li, Y.: Nitrate deposition and preservation in the snowpack along a traverse from coast to the ice sheet summit (Dome A) in East Antarctica, The Cryosphere, 12, 1177–1194, doi:10.5194/tc-12-1177-2018, 2018.

Sigl, M., Fudge, T.J., Winstrup, M., Cole-Dai, J., Ferris, D., Mcconnell, J.R., Taylor, K.C., Welten, K.C., Woodruff, T.E., Adolphi, F., Bisiaux, M., Brook, E.J., Buizert, C., Caffee, M.W., Dunbar, N.W., Edwards, R., Geng, L., Iverson, N., Koffman, B., Layman, L., Maselli, O.J., McGwire, K., Muscheler, R., Nishiizumi, K., Pasteris, D.R., Rhodes, R.H., and Sowers, T.A.: The WAIS Divide deep ice core WD2014 chronology - Part 2: Annual-layer counting (0-31 ka BP), Clim. Past, 12, 769-786, doi:10.5194/cp-12-769-2016, 2016.

Virkkula, A., Teinilä, K., Hillamo, R., Kerminen, V.M., Saarikoski, S., Aurela, M., Koponen, I.K., and Kulmala, M.: Chemical size distributions of boundary layer aerosol over the Atlantic Ocean and at an Antarctic site, Atmos. Chem. Phys., 6, 303-310, 2006.

End of responses to Prof. Savarino.