

Review of the manuscript entitled “Nitrate deposition and preservation in the snowpack along a traverse from coast to the ice sheet summit (Dome A) in East Antarctica ” by *Shi and co-workers*.

This manuscript reports on nitrate in samples collected in the frame of an intensive program of snow sampling made along a traverse from the coast to Dome A (East Antarctica). The samplings include 120 surface snow samples (upper 3 cm), 20 snowpits (down to 1.5-3.0 m depth), and a few crystal ice samples. From the coast to the inner plateau, an increasing trend of nitrate present in surface snow is observed whereas the content of deeper snow pit layers are lower at inland sites than at the coast. Extremely high concentrations are found in crystal ice (reaching almost 1 ppmw). Data are discussed with respect to occurrence of post-depositional remobilization of nitrate, wet and dry deposition, and possible role of other ions (sodium and sulfate).

Overall evaluation:

First, the authors have to be congratulated for having successfully conducted such a very large snow-sampling program, likely sometimes done under harsh weather conditions. The data certainly contain valuable information in view to better understand incorporation, remobilisation and partial preservation of nitrate atmospheric signal in cold archives. This topic is clearly relevant for the Cryosphere journal.

As it stands the manuscript however requires major revisions and a re-evaluation prior to publication. Indeed, at several places in the manuscript data discussions are incorrect, and generally do not enough consider atmospheric information available for the Antarctic atmosphere. Given the scarcity of data presented in this work, I strongly encourage the authors to reformulate the manuscript and in the following I try to identify what would be addressed in an in depth reformulated version of this manuscript.

**Introduction.** This paragraph has to be reworded on several aspects:

Lines 54-86: You missed here several important papers that have discussed in details the origins of nitrate in Antarctica. For instance, Legrand and Kirchner (1990) extensively discussed (1) the absence of link between solar activity and nitrate in snow, (2) what are the main possible sources of nitrate for Antarctica (stratospheric reservoir and long-range transport in the upper troposphere of lightning production, etc). Also model simulations from Legrand et al. (1989) discussed the source of nitrate for Antarctic regions.

Legrand, M., and Kirchner, S.: Origins and variations of nitrate in South Polar precipitation, J. Geophys. Res., 95, 3493-3507 1990.

Legrand, M. R., F. Stordal, I. S. A. Isaksen, and B. Rognerud (1989), A model study of the stratospheric budget of odd nitrogen, including effects of solar cycle variations, *Tellus B*, 41(B4), 413–426, doi:10.1111/j.1600-0889.1989.tb00318.x.

Lines 80-83: You missed here to report two recent papers from Wolf et al. that strongly question the assumption that solar flares and SPE are recorded in ice. Also model simulations do not support at all such an assumption (Legrand et al., 1989; Duderstadt et al., 2014).

Wolff, E. W., M. Bigler, M. A. J. Curran, J. E. Dibb, M. M. Frey, M. Legrand, and J. R. McConnell (2012), The Carrington Event not observed in most ice core nitrate records, *Geophys. Res. Lett.*, 39, L08503, doi:10.1029/2012GL051603.

Wolff, E. W., M. Bigler, M. A. J. Curran, J. E. Dibb, M. M. Frey, M. Legrand, and J. R. McConnell (2016), Comment on “Low time resolution analysis of polar ice cores cannot detect impulsive nitrate events” by D.F. Smart et al., *J. Geophys. Res. Space Physics*, 121, doi:10.1002/2015JA021570.

Legrand, M. R., F. Stordal, I. S. A. Isaksen, and B. Rognerud (1989), A model study of the stratospheric budget of odd nitrogen, including effects of solar cycle variations, *Tellus B*, 41(B4), 413–426, doi:10.1111/j.1600-0889.1989.tb00318.x.

Duderstadt, K. A., J. E. Dibb, C. H. Jackman, C. E. Randall, S. C. Solomon, M. J. Mills, N. A. Schwadron, and H. E. Spence (2014), Nitrate deposition to surface snow at Summit, Greenland, following the 9 November 2000 solar proton event, *J. Geophys. Res. Atmos.*, 119, 6938–6957, doi:10.1002/2013JD021389.

A few sentences on the physical form of nitrate (partitioning between the gas phase, and particulate phase) would be welcome (see my next comment) to better introduce the data discussion with respect to deposition, remobilization, etc.

**Data discussion (Section 3):** Please reconsider your data in the light of recent papers dealing with nitric acid gas phase and nitrate in the aerosol phase and their changes over the year in Antarctica.

For instance, check the following recent paper and references therein:

Legrand, M., Preunkert, S., Wolff, E., Weller, R., Jourdain, B., and Wagenbach, D.: Year-round records of bulk and size-segregated aerosol composition in central Antarctica (Concordia site) - Part 1 : Fractionation of sea-salt particles,

Atmos. Chem. Phys., 17, 14039-14054, <https://doi.org/10.5194/acp-17-14039-2017>, 2017.

**Two overall comments:**

The idea that nitrate is trapped on coarse sea-salt particles is incorrect (or not enough precise): Atmospheric data show that nitrate stays on the intermediate size particles (1-2 micron range) and not on the coarse ones like sea-salt (even at the coast): Jourdain and Legrand (2002); Teilina et al. (2000), Rankin et al. (2003), and Legrand et al. (2017).

Teinila, K., Kerminen, V.-M., and Hillamo, R. (2000), A study of size-segregated aerosol chemistry in the Antarctic atmosphere, J. G. R. 105, 3893-3904.

Rankin, A. M. and Wolff, E. W.: A year-long record of size-segregated aerosol composition at Halley, Antarctica, J. Geophys. Res., 108, 4775, <https://doi.org/10.1029/2003JD003993>, 2003.

Jourdain, B. and Legrand, M.: Year-round records of bulk and size-segregated aerosol composition and HCl and HNO<sub>3</sub> levels in the Dumont d'Urville (coastal Antarctica) atmosphere: Implications for sea-salt aerosol fractionation in the winter and summer, J. Geophys. Res., 107, 4645, <https://doi.org/10.1029/2002JD002471>, 2002.

The relationship between NssSO<sub>4</sub> and nitrate: The interpretation of the correlation between nitrate and sulphuric acid referring to Brown et al. (2006) is misleading. Indeed this study discussed of the reaction of N<sub>2</sub>O<sub>5</sub> on acidic sulphate promoting the formation of HNO<sub>3</sub> in a polluted atmosphere at night. Whatever the Antarctic site, the acidic sulphate is maximum in summer whereas, if present, N<sub>2</sub>O<sub>5</sub> can only exist in the Antarctic atmosphere in winter (due to photolysis of the NO<sub>3</sub> radical in summer, N<sub>2</sub>O<sub>5</sub> does not exist in summer). So the correlation seen in snow cannot be explained like that.

**Other comments:** Information on the chemistry of ice crystal are rather rare, so may important to develop this aspect in the revised manuscript (showing the full chemical composition and its comparison with snow).

Did you have measured MSA ?

I think you can say that nssCl is HCl and it can be interesting to compare with gas phase HNO<sub>3</sub>.

End of the review.