

Interactive comment on “Spatial variations in snowpack chemistry and isotopic composition of NO_3^- along a nitrogen deposition gradient in West Greenland” by Chris J. Curtis et al.

Anonymous Referee #1

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Curtis et al report measurements of ion concentrations and nitrate isotopes in 3 locations representing different snow accumulation regimes in western Greenland. All observations show gradients from the coast to the inland site on the ice sheet, with sea salt and sulfate concentrations highest at the coast while nitrate concentrations are highest inland. Most of their discussion focuses on nitrate and its nitrogen isotopic composition, where they conclude that postdepositional processing likely determines the observed spatial gradient. Given that the latter has been somewhat contested in the literature, such a study is important. They also provide estimates of the deposition flux of nitrate, ammonia, and sulfate at each location. The authors otherwise do not do as much analysis of the other data sets, such as the ions other than nitrate and oxygen

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isotopic composition of nitrate.

Although the manuscript is well written as far as English language and grammar, it's missing some important background information making it somewhat hard to follow the analysis of the data. Some specific comments on this are below. The technical details seem scientifically sound. Abstract: The authors should start the abstract with a motivation for this study. Why should one be interested in the observed spatial gradients?

Introduction: The introduction needs more background information. It is very short relative to the length of the entire paper. The introduction should present the potential sources of the observed ions in Greenland and discuss what controls the isotopic composition of nitrate. It should include a discussion of postdepositional processing, which is never really defined. It should explicitly discuss why one should care about the observed spatial gradients, which seems to be the main motivation of the study.

Methods: Please state over what snow depth the snow samples were collected. Over the first 10 cm? Deeper? Shallower?

Figure 1: What do the colors mean?

Section 4.3.1: Provide a reference for the statement that “gas-phase aerosol NO_3^- may be enriched in ^{15}N compared to wet deposited NO_3^- ”. Also, “gas-phase aerosol NO_3^- ” does not make sense. Nitrate is either the gas-phase or the aerosol phase (i.e., equilibrium partitioning between the two phases).

Section 4.3.2: This section was particularly hard to read because postdepositional processing is never defined. Many studies on ice sheets have shown that photolysis dominates postdepositional processing, but this is not even mentioned until the very end of this section. Perhaps if the authors properly introduce this process in the introduction, it will make it easier to clarify this section as well. It would be useful to give the fractionation factors for the processes involved.

Conclusion: Like the abstract, the conclusion focuses on the observed gradients with-

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out explicitly stating why this matters. Again, a more thorough introduction may help with this.

Some relevant references that could be included in the introduction and/or discussion and data comparison:

Kunasek, S.A., Alexander, B., E.J. Steig, M.G. Hastings, D.J. Gleason and J.C. Jarvis, Measurements and modeling of $\Delta^{17}\text{O}$ of nitrate in snowpits from Summit, Greenland, *J. Geophys. Res.*, 113, D24302 (2008).

Geng, L., M.C. Zatzko, B. Alexander, T.J. Fudge, A.J. Schauer, L.T. Murray and L.J. Mickley, Effects of post-depositional processing on nitrogen isotopes of nitrate in the Greenland Ice Sheet Project 2 (GISP 2) ice core, *Geophys. Res. Lett.*, 42, 5346-5354, DOI: 10.1002/2015GL064218 (2015).

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