Dear Dr. Browne,

In addition to the reviewer comments, we have also made the following changes based upon conversations with various collaborators while this paper was in the discussion stage.

Table with values of parameters used in model

We have now included an additional table in the manuscript (Table 2) that presents the values of parameters used in the model to help readers easily see which observations we have used for model input.

Removal of NRF_{τ_z} from manuscript

Joël Savarino and Joseph Erbland (LGGE, France) have recently used a snow chemistry column model to investigate nitrogen recycling between the air and snow at Dome C, Antarctica (manuscript was in review in ACPD at the time of writing). Conversations with them, initiated by a reviewer of their manuscript, convinced all of us that NRF_{yr} (not NRF_{τ_z}) represents the total number of nitrogen recyclings between the air and snow archived in ice cores. We have decided to remove NRF_{τ_z} from our manuscript and have changed NRF_{yr} to simply *NRF*. In sum, it is not necessary to multiply *NRF* by τ_z to calculate the degree of recycling archived in ice-core records because the majority of recycling happens in the first year after deposition to the ice sheet. Most of the recycling occurs between the air and the snow surface layer (~ top 2 cm) because snow-sourced HNO_3 is re-deposited only to the surface layer. In contrast, loss of nitrate occurs throughout the snow photic zone. Model-estimates of nitrogen recycling at Dome C in Erbland et al. [2015] (4 recycling events) and in this study (9 recycling events) are now more similar in magnitude. The difference (4 versus 9 may be due to the assumption in Erbland et al. that 20% of snow-sourced nitrate is transported away via katabatic winds (f_{exp} = 0.2). We are able to calculate f_{exp} in our modeling framework, and we calculate that 25% of snow-sourced nitrate is transported away at Dome C (f_{exp} = 0.25), which is slightly larger than the assumption in Erbland et al. Larger values of f_{exp} will lead to larger loss of snow nitrate, which may also lead to a larger number of recycling events via transport and redeposition of snow-sourced NO_x throughout East Antarctica. Additionally, the *NRF* values calculated for East Antarctica (*NRF*=5-10) are within the uncertainty of *NRF* values estimated by Davis et al. [2008]. These comparisons are described in section 3.3.

Since NRF_{τ_z} is now removed from the manuscript, we have moved the discussion of τ_z to later in the manuscript because τ_z is needed to calculate *f*. Additionally, in section 3.6., *f* is now compared to *NRF* across Antarctica instead of NRF_{τ_z}, which leads to a different relationship between spatial patterns of nitrogen recycling and photolysis-driven loss of snow nitrate. This relationship is discussed in the text, but the change does not significantly alter our conclusions.

Figure 7 now shows only *NRF* and Figure 9 now shows τ_z in addition to *f* and $\delta^{15}N(NO_3^-)$. We have moved τ_z into Figure 9 because τ_z is still used to calculate *f* and is no longer used to estimate the degree of nitrogen recycling (NRF_{τ_z}). Figure 10 now shows *NRF* vs. *f* instead of NRF_{τ_z} vs. *f.* Instead of separating the data into East and West Antarctica, we have separated the data by the number of years that nitrate remains in the snow photic zone.

Thank you for considering this manuscript for publication.

Sincerely,

Maria Zatko, Lei Geng, Becky Alexander, Eric Sofen, Katharina Klein

References:

Davis, D. D., Seelig, J., Huey, G., Crawford, J., Chen, G., Wang, Y., Buhr, M., Helmig, D., Neff, W., Blake, D., Arimoto, R., Eisele, F.: A reassessment of Antarctic plateau reactive nitrogen based on ANTCI 2003 airborne and ground based measurements. *Atmos. Environ*., 42, 2831-2848, doi:10.1016/j.atmosenv.2007.07.039, 2008.

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