September 5, 2019

Dear Editor and Reviewers,

Thank you again for the additional suggestions for improving our manuscript. Please see below our response, and explanation of changes made to the manuscript (inserted in red font).

We hope you will find these corrections satisfactory to allow publication of the manuscript.

Cordially,

Detlev Helmig

Suggestions for revision or reasons for rejection (will be published if the paper is accepted for final publication)

The author have addressed in my view to satisfaction the reviewer comments and submitted a revised manuscript, which should be published in "The Cryosphere". Below I list a few minor comments, which should be addressed to clarify the argument presented.

Since this work addresses primarily air chemistry i.e. the chemical composition of air above the snow and in the interstitial air of the surface snow pack I strongly suggest replacing "snowpack chemical effects" throughout the text (possibly also in the title) with more precise terminology such as chemical composition of the interstitial air of the surface snow pack or air of the open pore space in the snowpack. The impacts of station exhaust on snow chemical composition and reactivity are discussed only qualitatively in light of snow nitrate profiles with no quantitative conclusions.

The title was changed to:
"Impact of exhaust emissions on chemical snowpack composition at Concordia Station, Antarctica"

We searched the entire document for "chemical effects" and did not find any other occurrences of that terminology.

L14 / L228-234 GEM and CH2O are mentioned now also in the abstract, but throughout the manuscript not a single quantitative measurement is mentioned for these two species. Even though GEM and CH2O results related to pollution were not conclusive, at least order of magnitude and standard deviation of these observations during pollution events should be included. Otherwise it is hard to judge for the reader what was going on.

We added as sentence in the abstract summarizing the findings of the GEM and CH_2O measurements.

L138 - Please add here also very brief methodology detail / references for GEM and CH2O measurements, most importantly time resolution, limit of detection, and the mentioned instrument problems.

Two brief sections referring to published literature with the method characterization were added to the experimental section.

L240-243 This is an interesting question, but as the the authors noted in their rebuttal to a related reviewer comment, direct snow nitrate alteration is likely to be minor because the nitrate reservoir in the snowpack is so much larger than in the atmosphere. So either do a quantitative budget analysis or weaken the statement.

We added the sentence: "However, the overall quantitative effect is likely relatively minor given the large overall NO_3^- reservoir in the solid phase of the snowpack." and deleted the last sentence of the paragraph "Further, the transformations of NO_X into these higher oxidized species may potentially leave a long-term chemical signature in the snowpack (such as of $NO3^-$)."

L303-306 the more likely scenario leading to increased snow NO3 near the station is the reduced nitrate loss due to decreased light penetration into the snow and therefore decreased photolysis rates from BC and possibly HULIS (Humic LIke Substances) contamination, as described in the previous section, and not direct deposition of NO3 from NOx rich air. Please clarify also in light of the large imbalance in NO3 mass distribution between snow and atmosphere.

We removed the words 'NOx-enriched', so that now the sentence reads: "A tendency of potentially enhanced snowpack NO_3^- levels in two snow pits collected at the camp, compared to data from three sites at further distance, supports the suspicion that the snowpack chemical oxidized nitrogen composition at the station may be compromised (i.e. contaminated) from the re-occurring ventilation of the snowpack with polluted air."

L306-09 Mention here also the findings from the d15N studies at Dome C: no pollution signal in the snow; how about atmospheric nitrate? Did any of the nitrate filter samples collected over the years show pollution signal in d15N?

The NOx pollution in the exhaust plume does not have the time to be oxidized to nitrate before reaching the HiVol sampler. Even if that was the case, with weekly-integrated sample collection, episodic pollution plumes will constitute a relatively small portion of the nitrate collected on the filter. Aerosol collection has been ongoing at dome C since 2009. In 2014, Joel Savarino installed a meterorological sensors adjacent to the HiVol sampler. The aerosol collection has since been differentiated by the wind direction and speed such that collection is stopped when the wind is blowing from the station and when air flow is stagnant. Thus far, no significant change has been seen in the data between the two configurations.

An estimation of the relative contribution of the occurrence of pollution conditions can be deduced from the sample collection time. The average collection time per sample without the wind condition differentiation was 10,188 min per sample in 2013-2014, compared to 10,005 min per sample in 2014-2015. Consequently, potential pollution transport events accounted to approximately 1.8 % of the time on average.