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The Cryosphere Discussions
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Interactive comment on "Intrusion, retention, and snowpack chemical effects from exhaust emissions at Concordia Station, Antarctica" *by* Detlev Helmig et al.

Anonymous Referee #1

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GENERAL COMMENTS

This study reports observations of air and snow chemistry from a 14 month measurement campaign at Dome C, East Antarctica with a focus on pollution episodes caused by the year-round operated Concordia station. Gasphase concentrations of nitrogen oxides (NOx) inreased by several orders of magnitude during a total of 15 events of pollution transport from the station during the study period, with concurrent decreases in ozone indicating titration by nitric oxide. While near-surface air concentrations of NOx settled to background levels within hours, firn air concentrations remained elevated for days to up to a week. The snow chemical composition may be affected as indicated by

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nitrate concentrations in snow below the top layer being higher near the station than further away. The authors conclude that these observations provide insight to the discussion on how representative snow photo-chemistry studies near research stations are for the wider Antarctic ice sheet.

The detection of elevated NOx and associated O3 decrease when sampling station power generator exhaust, and of course also any kind of motorised traffic (air plane, ski doo, tractors etc) is not new, but a well-known limitation of studies of background atmospheric chemistry at most polar research stations. This is typically mitigated by careful filtering of atmospheric measurements.

A new insight from this study is the observation that pollution plumes diffuse into the upper snowpack and remain there for several days, with the potential to alter chemical composition of the upper snowpack near the station and therefore compromise local snow photochemistry being representative for the wider ice sheet. Understanding changes in air and snowpack chemistry near Concordia station would be potentially very useful for the design of future experiments at Dome C and elsewhere. Rather than just casting doubt on previous measurement campaigns I suggest the authors improve the manuscript by broadening the range of considered chemical species and by providing more quantitative detail in their discussion of pollution impacts on snow chemistry as promised by the title:

- the abstract states that other reactive chemical species were also measured, notably formaldehyde and gaseous elemental mercury (GEM). Even though not as sensitive to pollution as NOx I urge the authors to present and discuss those data during pollution events to achieve a more general picture of pollution impacts near the station. For example formaldehyde has been discussed as a snowpack HOx radical precursor at Dome C (Preunkert et al., 2015), and it would be important to understand if and how station pollution changes also nearby CH2O profiles in snow.

- snow nitrate profiles observed in the clean-air sector near the station show a less

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steep decline with depth and slightly higher concentrations than at sites further away (>5km). Please discuss the role of spatial variability in snow accumulation and stratigraphy. The presence of sastrugi as well as substantial snow drift around buildings/obstacles as seen on Fig.1 certainly have an impact on snow chemistry profiles. Accumulation rate determines exposure time of a given snow layer to actinic flux as well as stratigraphy/ snow optical properties.

- can the authors provide an estimate of at least the order of magnitude of how much snow nitrate could be produced from pollution episodes throughout a year, knowing O3 and NOx in firn air & assuming HOx levels in summer?

- I'd suggest to double-check with co-author Savarino, who has measured the stable nitrogen isotope 15N in atmospheric and snow nitrate over several years now at Dome C. Assuming d15N in NOx from the station plume is different from other sources, did they ever detect any evidence from existing measurements of d15N in nitrate in snow (or in atmospheric particulate no3) that would indicate a contribution from local pollution?

SPECIFIC COMMENTS

Abstract & l162: in the text and Fig.4 a total of 50 pollution events are reported, whereas the abstract states 15 occasions of plume transport, how do the different numbers arise? Please explain.

l96-115 Please clarify the schedule of the firn air sampling. Apparently inlets were switched between the 2 snow towers every 24 hr (caption of Fig.6)?

l235-239 This section requires further clarification: e-folding depth depends in a non-linear fashion on both, absorbing impurities (BC, HULIS etc) as well as on snow density & grain size/shape (scattering). Thus, the variability observed (Warren et al., 2006; France et al., 2011) is not only due to BC deposition but in part also due to the snow stratigraphy present at DC.

FIGURES

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Fig.1: To better illustrate the location of the Atmospheric Observatory add a wind rose and boundaries of the clean air sector. Fig.2: Text only is hard to follow so please add a schematic indicating location and height/depth of all inlets and sensors, as well as of the snow pit profile. Fig.6: caption "... measurements FROM the snow tower ..." Supplement-Fig S-1 and S-2: in the online version no supplement was available. I suggest to show the O3 mixing ratios and the surface snow no3 also in the main manuscript.

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