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A chemical fingerprint of surface UV in the 20th century firn record of nitrate stable isotopes at Dome C, East Antarctica

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Recent studies on atmospheric particulate nitrate (NO_3^-) demonstrated that the nitrogen and triple oxygen stable isotopic composition of NO_3^- allows constraining atmospheric sources and sinks, namely oxidation pathways of reactive nitrogen. However, the application of this tool to past atmospheres using ice cores is complicated. Especially in the low accumulation regions of East Antarctica significant post-depositional processing via UV-photolysis and evaporation in the upper snow pack alters not only NO_3^- concentrations but also its isotopic signature. Conversely, it is hypothesized here that the degree of post-depositional fractionation allows to infer past atmospheric conditions at the surface.

Nitrate $^{15}N/^{14}N$ and $^{18}O/^{16}O$ isotopic ratios were measured at Dome Concordia, Antarctica 75.1∘S, 123.3∘E) in a 6m-snow pit extending 60 years back in time. A significant anti-correlation observed between $\delta^{15}N(NO_3^-)$ and $\delta^{18}O(NO_3^-)$ ($r=-0.75$, $p<0.01$) suggests that photolysis dominates post-depositional processing. Annual UV radiation doses at Dome C were calculated for 1956-2004 using a radiation transfer model and ozone column data from Halley (75.6∘S, 26.6∘W) and are found to be significantly correlated with $\delta^{15}N(NO_3^-)$ ($r = 0.7$, $p<0.001$). We conclude that due to the non-linear nature of isotopic fractionation $\delta^{15}N(NO_3^-)$ is a sensitive parameter recording recent decadal trends in surface UV radiation. In the light of on-going surface studies at Dome C we discuss the potential of nitrate stable isotopes to reconstruct paleo-UV conditions from deep cores and limitations due to accumulation rate variability.