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Bacterial nitrate production within dry Arctic snow and its impact on the overlying atmosphere

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Nitrate (NO_3^-) in the snow is an essential component of the pool of nutrients in the Arctic environment. Believed to stem mostly from atmospheric deposition, nitrate in the snow undergoes strong post-depositional processing including physical release (sublimation, evaporation) and photochemical transformation into atmospheric reactive nitrogen (NO_x and HONO). The latter exerts a strong influence on the regional oxidative capacity of the atmosphere, through its interaction with ozone, peroxy radicals (RO_x) and reactive halogen species.

Here we document a case where nitrate production within the Arctic snowpack has been identified, based on the comprehensive isotopic composition of nitrate samples collected in the snow and the atmosphere in the European High Arctic in Ny Ålesund, Svalbard (79°N) from February to April 2006. The dual isotope plot of snow nitrate (Δ^{17}O vs. δ^{15}N) reveals that the isotopic composition of nitrate in the snow is well described by the mixing of two widely different sources, possessing end-members compositions on the order of (-13 ‰;36 ‰) and (5 ‰;0 ‰) in the δ^{15}N × Δ^{17}O space. While the first bound corresponds to the atmospheric component, the isotopic data clearly indicate the existence of another, non-atmospheric, source of nitrate in the snowpack, possessing a zero Δ^{17}O and a positive δ^{15}N (5 ‰), which in some cases seems to represent almost 100% of the nitrate burden of certain snow layers. In light of the present knowledge, our data indicate that in-situ production of nitrate occurs within the snowpack under dry conditions (no melting), most probably due to nitrification of ammonium or mineralization of organic nitrogen species, both mediated by metabolically active bacteria.

The presence of metabolically active nitrifying bacteria has great relevance for the cycling of nutrients in the Arctic environment; in addition, the potential concurrent activity of denitrifying bacteria could explain the occurrence of reactive nitrogen (NO_x and HONO) snow surface emissions that were measured during dark periods, thus not attributable to photochemical processes in the snow.