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Long-term record of atmospheric and snow surface nitrate from Dome C (Central Antarctica)

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Nitrate is the end product of the oxidation of atmospheric nitrogen oxides and one of the most abundant ions present in polar ice and snow, mainly as nitric acid in present-climate conditions. Nitrate stratigraphies from snow and ice layers have the potential to provide records of past changes in atmospheric composition, including atmospheric NO_x cycling and oxidative capacity, as well as past solar activity or major variations in Earth's magnetic field.
Nevertheless, in order to exploit such a potential, chemical concentrations in the air, snow, firn and ice core need to be correlated. Hence, the knowledge of the link between atmosphere and snow composition at the time of deposition is basic to reconstruct past climate and past atmospheric chemical composition. The extent of such knowledge depends on whether the species of interest are gaseous or in the condensed phase, and if they are reversible and/or irreversibly deposited to snow.
In order to provide a contribution to their air-to-snow exchange in the Antarctic plateau, as well as to the understanding of dominant sources and sinks of nitrate, we present here nitrate records in atmospheric aerosol and surface snow sampled at high resolution, all year-round, at Dome C along 9 years (November 2004 - November 2013).
This represents the longest and most highly resolved record from continental Antarctica, where continuous and long-term atmosphere and snow samplings are particularly difficult due to the extreme meteorological conditions and, at the same time, need of extra-care in avoiding contamination due to the low level of ion concentrations.
Results confirm, on a larger statistical data set with respect to previous observations, nitrate seasonal pattern with summer maxima both for aerosol and surface snow, in-phase with UV solar irradiance. Such a temporal pattern is likely a combination of nitrate sources and post-depositional processes that enhance during summer. Moreover, a case study of synoptic analysis for a major nitrate event showed the occurrence of a stratosphere-troposphere exchange in the sampled days.
The sampling of both matrices carried out at high resolution at the same time allowed detecting a recurring lag, about one-month long, of summer maxima in snow with respect to aerosol. Such a temporal shift can be explained only by taking into account deposition and post-deposition processes taking place at the atmosphere-snow interface, including likely both a net uptake of gaseous nitric acid and a replenishment of the uppermost surface layers driven by a larger temperature gradient in summer. Such a possibility was tested in a preliminary way by a comparison with measurements of surface layers temperature carried out in 2012-13 time period.
A comparison with nitrate concentration in the gas phase and total nitrate obtained from Dome C (2012-13) showed the major role of gaseous HNO_3 to total nitrate budget hinting to the need of further investigation of the gas-to-particle conversion processes.