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The origin of sea salt in snow on Arctic sea ice and in coastal regions

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Abstract. Snow, through its trace constituents, can have a major impact on lower tropospheric chemistry, as evidenced by ozone depletion events (ODEs) in oceanic polar areas. These ODEs are caused by the chemistry of bromine compounds that originate from sea salt bromide. Bromide may be supplied to the snow surface by upward migration from sea ice, by frost flowers being wind-blown to the snow surface, or by wind-transported aerosol generated by sea spray. We investigate here the relative importance of these processes by analyzing ions in snow near Alert and Ny-Ålesund (Canadian and European high Arctic) in winter and spring. Vertical ionic profiles in the snowpack on sea ice are measured to test upward migration of sea salt ions and to seek evidence for ion fractionation processes. Time series of the ionic composition of surface snow layers are investigated to quantify wind-transported ions. Upward migration of unfractionated sea salt to heights of at least 17cm was observed in winter snow, leading to Cl^- concentration of several hundred µM. Upward migration thus has the potential to supply ions to surface snow layers. Time series show that wind can deposit aerosols to the top few cm of the snow, leading also to Cl^- concentrations of several hundred µM, so that both diffusion from sea ice and wind transport can significantly contribute ions to snow. At Ny-Ålesund, sea salt transported by wind was unfractionated, implying that it comes from sea spray rather than frost flowers. Estimations based on our results suggest that the marine snowpack contains about 10 times more Na^+ than the frost flowers, so that both the marine snowpack and frost flowers need to be considered as sea salt sources. Our data suggest that ozone depletion chemistry can significantly enhance the Br^- content of snow. We speculate that this can also take place in coastal regions and contribute to propagate ODEs inland. Finally, we stress the need to measure snow physical parameters such as permeability and specific surface area to understand quantitatively changes in snow chemistry.

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