



Sea ice dynamics as a control for halogen deposition in polar regions

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Bromine and iodine chemistry is extremely active at the sea ice margins of both polar regions, with enhanced concentrations of BrO and IO in the air column compared to the open ocean surface or snow-covered land. So-called "Bromine explosions" occur principally over first-year sea ice close to the sea ice edge, and are the major source of reactive bromine in the polar atmosphere. This results in an increase of bromide (Br⁻) deposited to the snowpack, compared with the Br/Na sea water mass ratio.

The main source of iodine is phytoplankton, which colonize the underside of sea ice, producing iodocarbons and probably I₂. Though it has been discovered that atmospheric iodine around Antarctica is produced from algae growing on the underside of the relatively thin seasonal sea ice, satellite measurements do not show exceptional iodine activity above Arctic sea ice. However, in opposition to Antarctica, boundary layer observations show relatively small atmospheric IO concentrations downwind of ice-free open ocean, including leads and polynias.

Analysis of bromine and iodine has been carried out in the Talos Dome ice core (Antarctica) which covers the last 215 ky, and in a shallow/firn core drilled at the summit of the Holtedahlfonna glacier (Northern Spitsbergen, Svalbard), covering the last 10 years.

Talos Dome Br⁻ is positively correlated with temperature and negatively correlated with sodium (Na). Based on the Br/Na seawater ratio, bromide is depleted in the ice during glacial periods and enriched during interglacial periods. Total iodine, consisting of iodide (I⁻) and iodate (IO₃⁻), peaks during glacials with lower values during interglacial periods. Although iodate is believed to be the most stable iodine species in atmospheric aerosols, it was present only in the ice core only during glacial maxima.

Glacial-interglacial changes in the multi-year sea ice extent will almost certainly alter the distance between the sea ice edge and Antarctic plateau, which will influence the total bromide flux (arising both from sea salt and Br⁻ from bromine explosions) and its ratio with sodium. A simple 1-D transport model of this scenario is able to reproduce the measured fluxes of bromine and sodium. The seasonal sea ice extent will also alter the surface area available to algal colonization, and hence iodine emission.

In support of the Antarctic results, analysis of iodine and bromine in the Svalbard shallow/firn core appears to confirm the linkage between sea ice and these halogens. In particular, changes in I concentration are associated with the extent of sea ice at spring time, while Br⁻, evaluated as enrichment relative to the Br/Na sea water mass ratio, is influenced by changes in the seasonal sea ice area.

The Arctic and Antarctic ice core results suggest that sea ice dynamics are arguably the primary driver of halogen fluxes in polar regions and that both halogens could be used to understand the past variability of sea ice.