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Halogen activity in the coastal boundary layer at Neumayer III/Antarctica – results from two and a half years of observations

Jan-Marcus Nasse (1), Udo Frieß (1), Denis Pöhler (1), Stefan Schmitt (1), Holger Sihler (1,2), Rolf Weller (3), Thomas Schaefer (3,4), Zsófia Jurányi (3), Helene Hoffmann (3), and Ulrich Platt (1)

(1) Institute of Environmental Physics, Heidelberg University, Heidelberg, Germany (jan.nasse@iup.uni-heidelberg.de), (2) Max-Planck Institute for Chemistry, Mainz, Germany, (3) Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, (4) now: Leibniz Institute for Tropospheric Research, Leipzig, Germany

The role of Reactive Halogen Species (RHS - IO, BrO, ClO, etc.) in the lower polar troposphere has been subject of intense research for over three decades. Elevated BrO mixing ratios have been identified as the cause of Ozone Depletion Events (ODEs) and the coincidental oxidation of gaseous elemental mercury frequently occurring in polar springtime in Arctic and Antarctic. An autocatalytic release mechanism from saline surfaces (sea ice or aerosols), the so-called bromine explosion, has been identified as the likely cause of the rapid increase of inorganic bromine mixing ratios over large areas. Laboratory studies and recent field observations suggest however, that other release pathways might exist. The role of halogens like iodine and chlorine species remain unclear – for a large part due to a lack of observations.

From January 2016 until August 2018, we operated an automated Long-Path Differential Optical Absorption Spectroscopy (LP-DOAS) instrument at the German research station Neumayer III (NMIII) in coastal Antarctica. Over the 31 months observation period a temporal coverage of about 60% was reached with interruptions mainly due to blowing snow during strong storms. The instrument's coverage of the UV and visible spectral range allows the detection of a wide range of trace gases including ClO, BrO, OClO, IO, O_3 and NO_2 at temporal resolutions of 5-30 minutes. Co-located instruments (e.g. MAX-DOAS, ozone monitor, CPC, SMPS, nephelometer) and extensive meteorological observations at NMIII station allow detailed interpretations of the data set.

In addition to the well-known springtime events, our analysis unexpectedly reveals halogen activity throughout large parts of the year, which seems to be modulated by the semi-annual oscillation over the Southern Ocean and the associated occurrence and strength of cyclones that transport salty aerosols to snow surfaces on the ice shelf at NMIII. Most of the non-springtime events occur during surface temperature inversions in shallow layers close to the ground and seem to be the result of local chemistry rather than transport. BrO mixing ratios frequently exceed 20 ppt and peak up to unprecedented 110 ppt. Furthermore, ClO mixing ratios up to 90 ppt could be detected and the influence of inter-halogen reactions on ozone mixing ratios was observed. The source mechanism for reactive chlorine, however, remains unclear. IO most of the time was below the detection limit of 1-2 ppt and sporadically reached 3-4 ppt.