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Vertical distribution of tropospheric BrO in the marginal sea ice zone of the Northern Weddell Sea

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The free radical bromine monoxide (BrO) strongly influences the chemistry of the troposphere in Polar regions. During springtime with the return of sunlight after Polar night BrO is released in an autocatalytic reaction mechanism from saline surfaces (bromine explosion). Then BrO affects the oxidative properties of the lower atmosphere and can induce complete depletion of ozone within a matter of days or even hours. In addition, elemental mercury can be oxidized by BrO which makes this toxic compound soluble leading to a deposition into the biosphere.
Despite numerous observations of elevated BrO levels in the Polar troposphere, bromine radical sources, as well as the details of the mechanisms leading to bromine explosions and the interactions between atmospheric dynamics and chemistry are not yet completely understood. To improve the understanding of these processes, an accurate determination of the spatio-temporal distribution of BrO is crucial.

Here we present measurements of BrO performed during two cruises of the German research ice breaker Polarstern in the marginal sea ice zone of the Antarctic Weddell Sea between June and October 2013 when four major periods with elevated BrO concentrations and simultaneous ozone depletion occurred. The events were observed by (1) a ship-based Multi AXis Differential Absorption Spectroscopy (MAX-DOAS) instrument on Polarstern and (2) a compact MAX-DOAS instrument operated on a helicopter. Several flights were performed in the boundary layer as well as in the free troposphere up to altitudes of 2300 m on days with elevated BrO levels.

Vertical profiles of aerosol extinction and BrO concentrations were retrieved for both instruments using our HEIPRO (HEIdelberg Profile) retrieval algorithm based on optimal estimation. Elevated BrO levels in the time series from ship-borne measurements show a strong correlation to southerly wind directions indicating transport from sea ice areas. Maximum retrieved BrO mixing ratios at ground level (0-100m) were 46 ppt.
BrO profiles retrieved from helicopter measurements quantitatively agree with the results from the ship-based instrument and indicate a mixing of BrO within the entire boundary layer. Typical boundary layer altitudes were around 500 m and no BrO was observed in the free troposphere.
In addition to retrieved BrO and aerosol extinction profiles from both instruments, we present ozone mixing ratios as well as relevant meteorological data. We discuss the origin of the probed air masses, possible correlations of elevated BrO with aerosols, and implications for BrO source and sink mechanisms.