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Satellite observations of enhanced tropospheric BrO plumes around polar coastal polynyas

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Bromine radicals play an important role in tropospheric chemistry by destroying ozone catalytically. Especially, strong ozone depletion events are observed in the Arctic and Antarctic boundary layer during polar spring due to rapid releases of bromine from the liquid to the gas phase and an autocatalytic sequence of reactions that is termed Bromine explosion. The spatial extent of these BrO explosion events is varied and the sources and release mechanism of reactive halogen remain still open questions. Satellite observations which have large spatial coverage are useful to answer these open questions by detecting different BrO explosion cases over the Polar Regions.

In this study, we analyzed BrO plumes of long and narrow shape found along coastlines using OMI and GOME-2 measurements. Tropospheric BrO column densities were derived by applying the Differential Optical Absorption Spectroscopy (DOAS) and a residual method, in which an estimate of the stratospheric BrO column using an empirical multiple linear regression model is subtracted from the total BrO column. From OMI and GOME-2 satellite observations, enhanced tropospheric BrO columns located around coastal polynyas extending almost $\sim$25 km along coastlines were found in both the Arctic and Antarctic regions. These intense BrO explosion events were investigated together with meteorological model data, SMOS thin sea ice thickness data and MODIS true color images. It was found that BrO plumes developing around the coastal polynyas are linked to thin sea ice, high surface wind speeds, temperatures below freezing point and upward air movement. The cyclonic circulation induced by a low pressure system located near the coastline forces offshore winds over the ice shelf, which can lead to an opening of the coastal polynya where fresh sea ice production is exceptionally strong. As new sea ice forms within the polynya, sea salt aerosols or frost flowers which can act as bromine source can enter the polar boundary layer. Our results demonstrate that specific BrO explosion events forming along the coastline for short periods of time can occur during new sea ice formation in coastal polynyas. A better understanding of the release mechanisms and spatial variation of BrO around leads and polynyas is expected when high spatial resolution TROPOMI data (3.5x7 km^2) will become available.