A satellite based study of tropospheric bromine explosion events and their linkages to polar cyclone development

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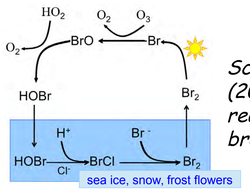
1 Introduction

Intense, cyclone-like shaped plumes of tropospheric BrO are regularly observed by the UV-vis satellite instrument GOME-2/MetOp-A over Arctic and Antarctic sea ice in polar spring. The plumes are associated with an autocatalytic chemical chain reaction involving tropospheric ozone depletion and initiated by the release of bromine from cold brine-covered ice or snow to the atmosphere. This impacts on the oxidizing capacity and chemistry of the polar troposphere and may change its temperature and local weather, as ozone is a major greenhouse gas.

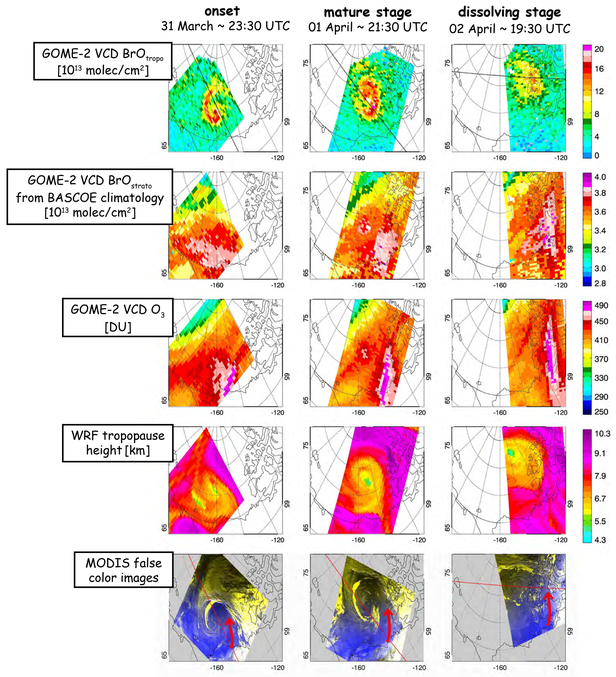
- High tropospheric BrO concentrations occur in two weather situations:
  - -stable boundary layer, low wind speeds (closed reaction chamber, plumes away from genesis region explained by transport)
  - -unstable boundary layer, high wind speeds (brine coated snow, frost flowers, sea salt blown into troposphere)
- Cold temperatures favor bromine explosion



Scheme by Jones et al. (2009) showing chemical reactions involved in the bromine explosion

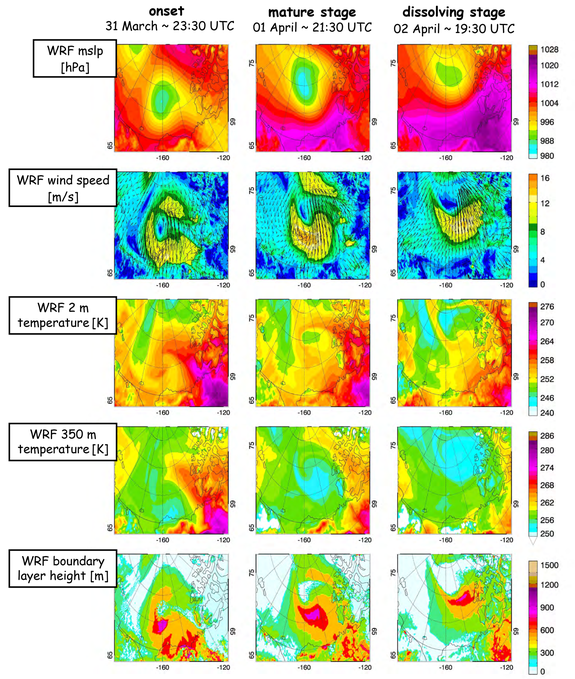
Here, we make combined use of satellite retrievals and numerical model simulations to study the impact of polar weather systems on the bromine explosion. General characteristics of bromine explosion events linked to transport by polar weather systems are derived based on a new detection method.

2 BrO Cyclone Transport Event – Beaufort Sea, April 2011



Satellite observations, together with parameters used for GOME-2 tropospheric BrO retrieval

- BrO plume spatially separated from dry conveyor belt (a dry, O_3-rich lower stratospheric air stream)

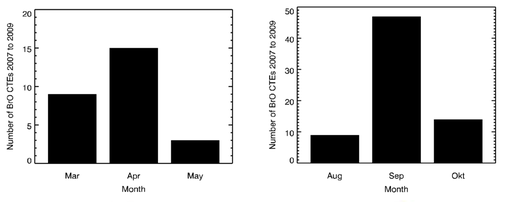


Weather Research and Forecasting regional model simulations (20x20 km horizontal grid spacing) of the BCTE

- BrO plume coincides with regions of frontal lifting, high wind speeds and colder temperatures
- Weather conditions favored blowing snow and recycling of BrO on aerosol surfaces

3 Climatology of satellite based BCTE detections

Arctic north of 70°N **Antarctic south of 60°S**



(Top) Frequency distributions and (bottom) tracks of BCTEs between 2007 and 2009 based on combining GOME-2 tropospheric BrO satellite retrievals with cyclone tracks (K. I. Hodges, University of Reading) from NCEP-CFSR mean sea level pressure model data

- About twice as many cases in Antarctic (70) compared to Arctic (27)
- All events occurred over sea ice during polar spring

4 Conclusions

- Fronts play an important role in generating tropospheric BrO in the lower troposphere
- High wind speeds, vertical lifting and lower temperatures favor bromine activation cycle, blowing snow production and recycling of BrO on aerosol surfaces
- Strength and frequency of BCTEs determined by bromine sources (e.g. young sea ice), cyclone strength and frequency, which are all expected to change under global warming
- Further studies needed to quantify the relative importance of surface production of BrO and brine coated snow and ice lifted by frontal systems, future changes of BCTEs as well as their impact on tropospheric chemistry

5 References

Blechschmidt et al. (2016): An exemplary case of a bromine explosion event linked to cyclone development in the Arctic, Atmos. Chem. Phys., 16, 1773-1788, doi:10.5194/acp-16-1773-2016.

Zhao et al (2015): A case study of a transported bromine explosion event in the Canadian high arctic, J. Geophys. Res. Atmos., 120, doi:10.1002/2015JD023711.

Jones et al. (2009): BrO, blizzards, and drivers of polar tropospheric ozone depletion events, Atmos. Chem. Phys., 9, 4639-4652, doi:10.5194/acp-9-4639-2009.

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MODIS data and WRF model source code provided by: MODIS (http://modis.gsfc.nasa.gov/), WRF (http://www2.mmm.ucar.edu/wrf/users/)