

**Seminar on Physics and Chemistry
of the Atmosphere
04.12.2020, WiSe 2020/2021, IUP Bremen**

**Satellite Based Remote Sensing of Halogens in the Arctic
Atmosphere**

I. Bougoudis¹, A.-M. Blechschmidt¹, A. Richter¹, S. Seo¹, J.P. Burrows¹

¹Institute of Environmental Physics, University of Bremen
e-mail: ibougoudis@iup.physik.uni-bremen.de

Over the last decades, air temperature in the Arctic has increased more rapidly than in other parts of the globe. The name of this phenomenon is Arctic Amplification and it has drastic impacts on all the sub-systems of the Arctic ecosystem.

Bromine oxides play a key role in the atmospheric composition of the Arctic. During polar springs, bromine molecules are released from young sea ice covered regions. A rapid chemical chain reaction starts, the so-called “bromine explosion”, which depletes ozone, alters the production of OH, and thereby eventually changing the oxidizing capacity of the troposphere. Furthermore, halogens oxidize elemental to gaseous mercury, which may then be deposited and harm the ecosystem. Based on current literature, there is considerable uncertainty on the impact of Arctic Amplification on halogen evolution; on one hand, the rapid long-term melting of sea ice results in formation of more young sea ice, which favors bromine release. On the other hand, bromine explosion events are triggered by low temperatures, an effect which can be assumed to be dampened due to Arctic Amplification. Moreover, changes of further meteorological drivers, such as cyclone frequency and wind speeds may impact on BrO amounts in the Arctic troposphere.

The aim of this study is threefold; firstly, the development of a long-term time-series of BrO which constitutes a basis to investigate the impact of Arctic Amplification on BrO amounts in the Arctic troposphere is presented¹. For this purpose, we have used data from 4 UV-VIS instruments (GOME, SCIAMACHY, GOME-2A and GOME-2B) onboard different satellites, so that a 22 year long-term dataset is created. Despite of differences between the sensors (time of overpass, spatial resolution, etc), our long-term dataset shows remarkable agreement and consistency. This is to our knowledge the first of its kind. The tropospheric BrO dataset is presented for both the Arctic region (i.e. from 70.0^o to 85.0^o latitude bins) and the Hudson Bay, while the trends appearing over the 22 years are discussed.

Secondly, the investigation of the impact of Arctic Amplification on the atmospheric halogen composition and the relation to changes in driving mechanisms and sources is presented. For this purpose, we have acquired external datasets of sea ice age (NSIDC) and meteorological parameters (ERA-5 and WRF ASR-2) and compared them with the tropospheric BrO dataset we developed. We infer that the long-term increase of tropospheric BrO columns is in general agreement with the increase of first year ice extent, while air temperature seems to be the most important meteorological parameter to the appearance of enhanced BrO plumes on a daily basis.

Thirdly, we present the first to our knowledge effort on modeling bromine explosions by implementing an artificial neural network². Our approach uses sea ice age (NSIDC) and

meteorological key parameters (ERA-5) (2 meter air temperature, mean sea level pressure, 10 meter wind speed and direction, boundary layer height) as inputs, and models Arctic tropospheric BrO. By training the neural network with one year of data, we were able to reproduce bromine explosion events of other years that were driven by the input parameters. Also, the neural network is able to satisfactorily reproduce spatial patterns of polar spring averages (March, April, May) of different years, when compared to the actual satellite measurements.

¹ These results have been published in: *Bougoudis, I., Blechschmidt, A.-M., Richter, A., Seo, S., Burrows, J. P., Theys, N., and Rinke, A.: Long-term time series of Arctic tropospheric BrO derived from UV-VIS satellite remote sensing and its relation to first-year sea ice, Atmos. Chem. Phys., 20, 11869–11892, <https://doi.org/10.5194/acp-20-11869-2020>, 2020.*

² These results will be included in: *Bougoudis, I., Blechschmidt, A.-M., Richter, A., Seo, S. and Burrows, J. P.: Modeling Tropospheric BrO in the Arctic Using an Artificial Neural Network Approach, in preparation.*

We gratefully acknowledge the funding by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Projektnummer 268020496 – TRR 172, within the Transregional Collaborative Research Center “Arctic Amplification: Climate Relevant Atmospheric and Surface Processes, and Feedback Mechanisms (AC)³”.