Geophysical Research Abstracts
Vol. 15, EGU2013-10968, 2013
EGU General Assembly 2013

Satellite Observation of the Seasonal Distribution of Tropospheric Bromine Monoxide in the Arctic and its Relation to Sea-Ice, Temperature, and Meteorology

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Each year during spring, periods when near-surface ozone mixing-ratios in the polar troposphere are severely reduced are observed. Reactive halogen species are known to play an important role in the destruction of tropospheric ozone, and past satellite observations showed that areas of up to several thousand square kilometres are affected by activated bromine. The processes leading to atmospheric bromine activation are not well understood yet, but probably require saline surfaces such as first-year sea-ice, frost flowers, or brine. Hence, the distribution and type of sea-ice directly affects the chemical composition of the springtime lower troposphere.

In the presented study, four years of satellite measurements of bromine monoxide (BrO) by the second global ozone monitoring experiment (GOME-2) instrument are used to assess the distribution of areas affected by bromine activation. While it is usually difficult to resolve the vertical distribution of trace-gases in the troposphere, the applied retrieval algorithm is capable of separating the tropospheric column from the total column and furthermore to quantify the sensitivity to near-surface BrO. The algorithm therefore allows to select only those measurements with sufficient information for subsequent statistical evaluation. The selected GOME-2 measurements are then correlated to the sea-ice distribution and complementary meteorological data.

As a result, a bimodal correlation between surface air temperature over sea-ice and the distribution of BrO is found. The retrieval algorithm allows to verify the influence of both the release process of reactive bromine and its advection by surface meteorology using a single data-set. During the beginning of spring, the release of reactive bromine is negatively correlated to temperature. Later in the season, however, the BrO distribution is controlled by the availability of ozone, which, in turn is controlled by mixing processes. It is furthermore shown that, depending on time, the strong influence of the meteorology makes it difficult to study the underlying physico-chemistry of the bromine activation from saline surfaces. Nevertheless, this study clearly reveals that a change of meteorology and sea ice distribution in a changing climate – especially in the Arctic – will severely affect the chemistry of the future polar troposphere.