GOME measurements of stratospheric and tropospheric BrO

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Introduction

The Global Ozone Monitoring Experiment (GOME) is a UV/visible spectrometer on board of the European satellite ERS-2. GOME is a 4 channel double monochromator covering the wavelength range of 230 - 800 nm with a spectral resolution of 0.2 - 0.4 nm. ERS-2 was launched into a polar sun-synchronuous orbit in April 1995. With a ground pixel size of 40 x 320 km^2 (40 x 960 km^2) GOME reaches global coverage at the equator within 3 days.
The main objective of GOME is the global measurement of ozone columns, but other trace gases such as NO_2, SO_2, HCHO, BrO and OClO can be retrieved from the spectra as well. In this study, BrO columns have been derived from GOME spectra and are discussed in view of the contributions from the boundary layer, the free troposphere and the stratosphere.

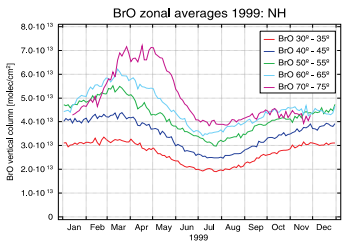
Analysis method

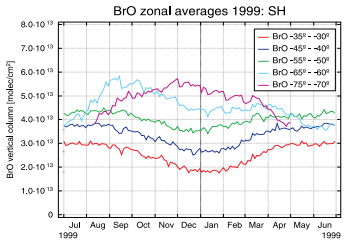
GOME lv1-spectra have been analysed using the IUP Bremen Differential Optical Absorption (DOAS) algorithm to derive slant columns of BrO in the 345 - 359 nm wavelength region. The settings for the fit are similar to those used for ground-based zenith-sky BrO measurements. Vertical columns have been computed with the radiative transfer model GOMETRAN using a simple stratospheric profile, resulting in a significant underestimation of tropospheric contributions.

Global behaviour of BrO

Zonal averages of BrO for both hemispheres have been computed for all GOME measurements from 1999 as shown in the plots. The main results are

- Winter maximum, summer minimum
- Increase of columns with latitude
- Similar behaviour in both hemispheres with 6 month shift
- Qualitative agreement with model predictions for stratospheric BrO, but much larger vertical columns
- Strong signature of boundary layer BrO in polar spring in both hemispheres
- Evidence for a tropospheric background at all seasons and latitudes
- Higher summer values at high latitudes in the southern hemisphere
- Little variation from year to year (see December 1999 to January 1999 transition in the southern hemisphere)

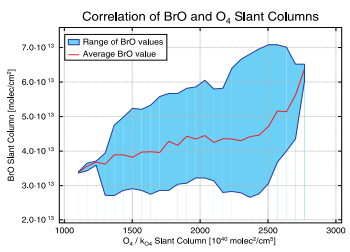




BrO in the free troposphere

Comparison of GOME BrO vertical columns with models, balloon borne observations and ground-based measurements in previous studies has lead to the conclusion, that a significant tropospheric background of several ppt BrO must be present in the atmosphere at all latitudes.
To test this assumption, GOME BrO columns taken in February 1999 over the remote equatorial Pacific (170°E, 10°S - 260°E, 10°N) have been correlated to the simultaneously measured O_4 columns. O_4, the dimer of atmospheric oxygen can be used as a qualitative indicator of the tropospheric light path. No simple relation exists between O_4, cloud cover and cloud top height but in first approximation low O_4 columns correspond to situations with high clouds and high O_4 columns to cloud free scenes. The correlation between BrO and O_4 shows, that

- Small O_4 columns are associate with small BrO columns
- Both small and large BrO columns are measured with large O_4 columns
- The scatter of the data is large
- The tropospheric BrO contribution for this situation can be estimated to be up to 4 10^{13} molec/cm^2 for the slant column corresponding to 0.5 - 2 ppt uniformly mixed BrO in the troposphere



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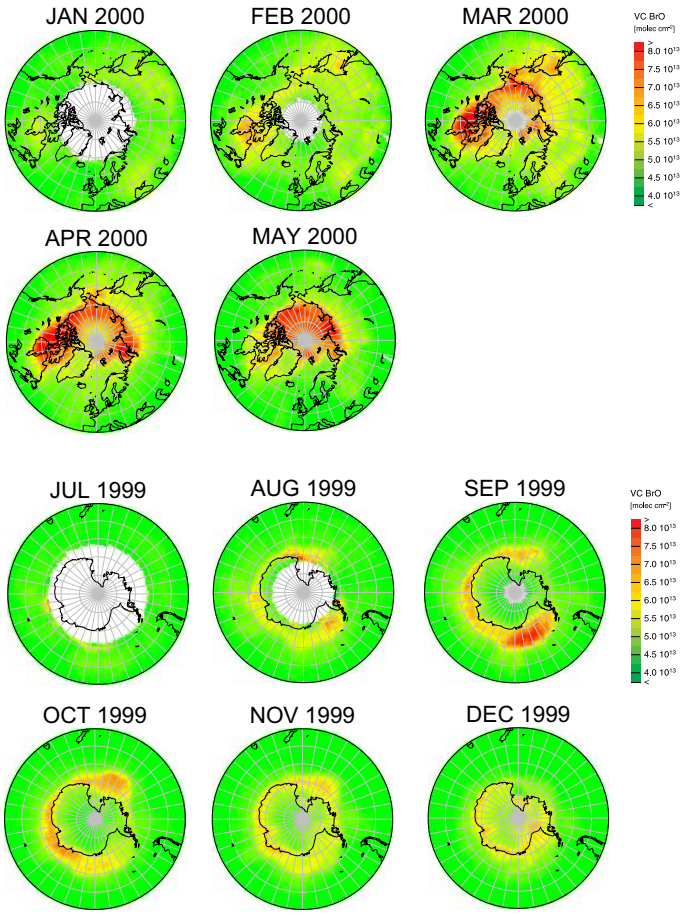
BrO in the Boundary Layer

Very large BrO columns are observed in polar spring in both hemispheres and attributed to boundary layer BrO. This interpretation is supported by coincident measurements from the ground and the correlation with low ozone events and changes in the ratio of gaseous to particulate mercury compounds. The main observations are

- High BrO over sea ice and along coast lines
- Little BrO over continents (Greenland, Antarctica)
- With sunrise movement towards the poles



Summary

GOME measurements have been analysed for BrO using the DOAS method. The seasonal variation in both hemispheres is similar with a maximum in winter and an increase with latitude. This is in qualitative agreement with model predictions for the stratospheric BrO. However, the vertical BrO columns measured by GOME are much larger than what can be explained by the stratospheric Br_y, indicating significant contributions of tropospheric BrO.
In polar regions, large areas of enhanced boundary layer BrO associated to low ozone events are observed in both hemispheres in spring. BL BrO is mostly located over sea ice and along the coast lines and shows somewhat higher values in the northern hemisphere.
Comparison of BrO and O_4 columns over the equatorial Pacific shows a clear signal of 0.5 - 2 ppt of BrO in the free troposphere, in agreement with results from other studies.

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