# Comparison of GOME BrO Measurements with SLIMCAT Model Results

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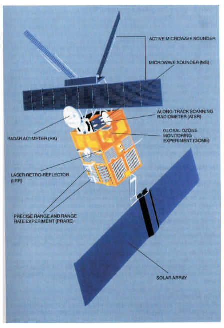
## Introduction

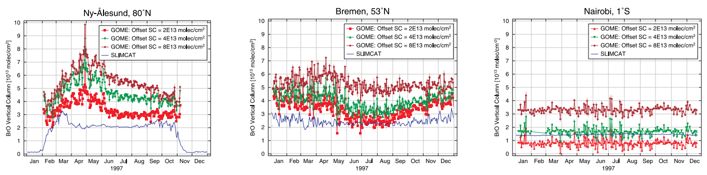
Bromine Monoxide (BrO) is an important trace gas in the stratosphere as it is involved in catalytic ozone destruction, both in high and mid-latitudes. BrO also seems to be the key species in the tropospheric boundary layer ozone depletion events observed in spring in the Arctic and Antarctic. More recently, indication was founds for a substantial amount of BrO throughout the free troposphere, with important implications for atmospheric chemistry in this region.
Most measurements of BrO are performed using UV/visible absorption techniques, either using lamps on the ground (long path DOAS), or by observing scattered sun light from the ground, from balloons or from satellites. With the exception of the balloon measurements, none of the methods provides vertical profiles of BrO, and much work has been done on trying to deduce the vertical distribution from the measurements.
In this study, total BrO columns measured from the satellite instrument GOME are compared to stratospheric BrO columns computed by the 3d CTM SLIMCAT in an attempt to derive information on tropospheric BrO.

## GOME Instrument




The *Global Ozone Monitoring Experiment* (GOME) is a grating spectrometer observing light scattered back by the atmosphere and reflected from the ground in a near nadir viewing geometry. GOME covers the spectral range of 240 to 790 nm with 0.2 - 0.4 nm resolution. The spatial resolution is 320 x 40 km2, resulting in a global coverage every three days. The instrument has been launched on ERS-2 in a polar sun-synchronous orbit in April 1995, and is operational since fall of that year.
Using the *Differential Optical Absorption Spectroscopy* (DOAS) technique, a number of atmospheric trace gases can be retrieved from the spectra, including $O_3$, $NO_2$, BrO, OClO, $SO_2$, HCHO, and $H_2O$. In the absence of clouds, a large part of the photons observed by GOME have penetrated down to the troposphere, and global maps of tropospheric concentration fields can be derived from the measurements.
Due to the large pixel size, the spatial resolution of the data sets is limited, and also only (local) mid-morning measurements are available as a result of the ERS-2 orbit. To overcome these limitations, a geostationary observing platform is required as recently proposed in the GEOSCIA-project.

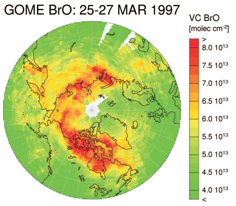
## Comparison of GOME and SLIMCAT



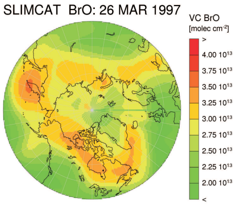

For the comparison of GOME and SLIMCAT BrO data, the SLIMACT model was sampled at the time of GOME overpass (roughly 10:30 LT), and the vertical profile integrated.
In the plots above, all data for 1997 is compared for three representative stations at different latitudes.
Unfortunately, as a result of an interference effect on the GOME diffuser plate, the GOME BrO columns are subject to an unknown offset in the slant columns. In this example, three different offsets have been assumed and are shown in the plots.
As can be seen, GOME BrO always is higher than model BrO, and does show a different seasonality. From the selected offsets, 4E13 molec/cm2 gives the most consistent picture at the equator, assuming that no tropospheric BrO is present there. Therefore, this scenario is giving a lower limit of the atmospheric BrO column.

## Stratospheric BrO variability

GOME BrO: 25-27 MAR 1997




SLIMCAT BrO: 26 MAR 1997




The number density maximum of stratospheric BrO is located close to the tropopause. Therefore, similar to the situation for ozone, any change in tropopause height will result in a change of stratospheric BrO column.

An many cases, the separation between tropospheric and stratospheric BrO from GOME measurements is based on the total amount only, assuming that stratospheric variability is small. As shown in the figures left, this assumption is not always fulfilled, leading to overestimations of tropospheric BrO columns under certain conditions.

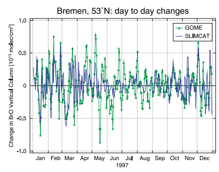
Using SLIMCAT data, a more accurate estimate of the stratospheric column is available, a step towards more quantitative tropospheric BrO columns from GOME.

However, from the absolute values shown in the figures, it is already clear, that no dramatic change of the values is to be expected.

## Discussion

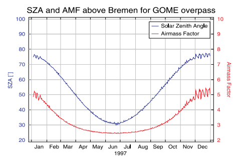
When comparing GOME and SLIMCAT results, three main features can be seen:

- GOME measurements are consistently larger, in particular at high latitudes
- day to day variations are very similar, at least in fall, winter and spring (see figure to the right)
- GOME measurements see a clear seasonal variation while SLIMCAT predicts more or less constant values




As SLIMCAT has been successfully validated against ground-based and balloon measurements of BrO the reason for the differences has to be either a GOME problem or a substantial amount of BrO in the troposphere. Several problems could be present in the GOME data:

- a cross-section problem. However, this would only lead to a scaling of all values.
- an offset problem. However, as shown to the left, this can not explain the observations.
- an airmass factor problem. However, as shown to the right, the seasonality of the solar zenith angle (and therefore any airmass factor changes) does not coincide with the observed differences to the model.




Therefore, we conclude, that there must be a global BrO background with a maximum in spring at high latitudes but significant values throughout the atmospheres at all times.

## Conclusions

A comparison of GOME total BrO columns with SLIMCAT stratospheric BrO columns shows, that

- GOME measurements systematically are larger than SLIMCAT predictions
- the day to day variability is reproduced well by SLIMCAT
- the difference between measurements and model vary with latitude and season, having largest values in spring at high latitudes
- known problems in the GOME data analysis can not explain the observed differences

From these observations, it is concluded, that

- a global tropospheric background of BrO exists
- it seems to be independent of the observed BL events at polar sunrise
- correction of stratospheric variability is necessary for quantitative analysis of polar BL events from space

For a quantitative description of the tropospheric background BrO, more work is needed in the satellite data analysis, in particular with respect to the airmass factors.

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## Selected References

J. P. Burrows et al., The Global Ozone Monitoring Experiment (GOME): Mission Concept and First Scientific Results, *J. Atmos. Sci*., vol. 56(2), pp. 151-175, 1999.
R. Fitzenberger et al., First Profile Measurements of Tropospheric BrO, *GRL*, 27 (18): 2921-2925, 2000.
A. Richter, F. Wittrock, A. Ladstätter-Weißenmayer, and J. P. Burrows, GOME Measurements of Stratospheric and Tropospheric BrO, *Adv. Space Res., in press*
Van Roozendael, M., et al., Intercomparison of BrO measurements from ERS-2 GOME, ground-based and balloon platforms, Adv. Space Res., in press
Wagner, T., Satellite Observations of Atmospheric Halogen Oxides, *Ph.D. thesis*, University of Heidelberg, 1999.

see also: www.iup.physik.uni-bremen.de

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