Algorithm Description

SCIAMACHY BrO Vertical Columns

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Data provider: Institute for Environmental Physics
University of Bremen
Otto-Hahn-Allee 1
D-28359 Bremen
Responsible Scientist: Andreas Richter
richter@iup.physik.uni-bremen.de
Internet: http://www.iup.physik.uni-bremen.de/doas

Forward Model:

The BrO Vertical Column product uses airmass factors derived with the radiative transfer model SCIATRAN (Rozanov et al., 1997), This model includes the effects of multiple scattering and atmospheric refraction and sphericity, but not polarisation.
The data analysis which is based on the DOAS technique (see next section) uses Lambert Beer's law of absorption and thus implies the "forward model" of an optically thin atmosphere.

Inversion Procedure:

The inversion procedure is based on the well known Differential Optical Absorption Spectroscopy (DOAS) method (e.g. Platt, 1994).

The basic concept of the DOAS retrieval on satellite measurements is application of Lambert Beer's law to the earthshine measurements using an absorption free direct solar irradiance measurement as background spectrum. To separate the effects of broad band extinction by Rayleigh and Mie scattering from the structured absorption by the trace species of interest, a polynomial of low order is fitted to the optical density simultaneously with the absorption cross-sections of all relevant absorbers. The resulting fit coefficient is the slant column density, i.e. the integrated amount of molecules per unit area averaged over all contributing light paths through the atmosphere.

Details on the implementation of the DOAS algorithm can be found in Richter, 1997; a description of the application to GOME data is given in Richter et al., 1998. Compared to GOME, the configuration of the retrieval had to be changed for analysis of SCIAMACHY measurements as described in Afe, 2005 and Afe et al., 2004.

The following settings have been used in the DOAS analysis:

Parameter	Value
wavelength window	336 - 347 nm
absorption cross-sections	BrO (Wahner et al., + 0.17 nm) O3 (Bogumil et al., 2003, 223 K & 243 K) O_4 (Greenblatt et al.(modified), 1990) NO2 (Bogumil et al., 2003, 243K)

	Ring (Vountas et al., 1998) Undersampling
empirical functions used	none
degree of polynomial	cubic
offset and slope correction	offset and slope
background spectrum	daily ASM solar measurement
normalisation	none
data source	uncalibrated lv0 and lv1 data

Table 1: DOAS settings used for the BrO retrieval from SCIAMACHY measurements

For the vertical columns, a very simple airmass factor has been used which is based on a purely stratospheric profile. This has implications on the data accuracy as discussed below.

Auxiliary Data:

No auxiliary data is used with the exception of the absorption cross-sections listed above and the vertical BrO profile used for the airmass factor calculation.

Sensitivity and Error Analysis and Algorithm Validation:

No dedicated algorithm validation has been performed. However, the same algorithm has been used for GOME BrO column analysis (Richter et al., 1998, Richter et al., 2002). Comparison of the GOME and SCIAMACHY data products shows good agreement. Some differences remain which are related to the improved spatial resolution of SCIAMACHY, the difference in time of measurements and effects of the difference in fitting window used.

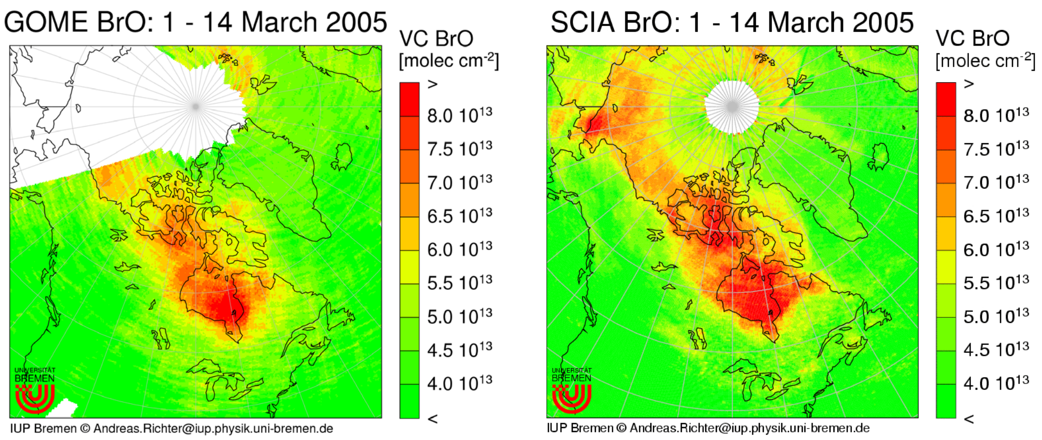

Fig. 1: Comparison of GOME (left) and SCIAMACHY BrO vertical columns for the first two weeks of March 2005. As result of the permanent failure of the tape recorder on ERS-2, only partial coverage is available from GOME. Similarly, SCIAMACHY measurements have less coverage owing to the alternating limb nadir measurements. Note that the solar zenith angle at overpass is different for the two instruments.

Compared to GOME measurements, the SCIAMACHY BrO columns have slightly larger scatter, mainly as result of the reduced ground pixel size. There also is a tendency for larger values.

As result of an interference with an instrument polarisation sensitivity in the standard BrO fitting window, the analysis had to be shifted towards UV wavelengths. Unfortunately, this leads to a cross-sensitivity with HCHO which so far could not be removed.

The use of a simplified airmass factor has a large impact on the data product:

- over dark surfaces, the tropospheric contribution is underestimated, in particular if BrO is present close to the surface
- over bright surfaces, the free tropospheric background BrO is overestimated which leads to enhanced columns over snow and ice and also over low clouds.
- depending on solar zenith angle, boundary layer BrO over bright surfaces is either underestimated (SZA > 75°) or overestimated (STA < 65°).

No cloud clearing has been applied to the BrO product. Thus, in some measurements BrO might be hidden below a cloud while in others BrO in the free troposphere might be overestimated. The reason for not applying cloud clearance and correction is that up to now, no reliable cloud product exists for ice covered regions which are one main area of interest for BrO measurements.

Recommendations for Product Validation:

Validation of BrO vertical columns should concentrate on situations with high signal such as boundary laser BrO events in polar spring. For these situations, the large footprint of SCIAMACHY measurements has to be taken into account. As the airmass factor used is not strictly applicable under bromine explosion conditions, dedicated products have to be created in iteration with validation groups. Please contact Andreas.Richter@iup.physik.uni-bremen.de and enquire about the availability of such products.
For situations where mainly stratospheric and free tropospheric BrO contribute to the measurements, the time of measurement is very important as the stratospheric BrO has a marked diurnal cycle. Comparison with twilight measurements from the ground is not straight forward but requires correction for photochemical changes.

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