Validation of GOME O_3, NO_2, BrO, and OClO Measurements in Southern High Latitudes

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Abstract
GOME columns of O_3, NO_2, OClO, and BrO have been validated by comparison with ground-based zenith-sky measurements at Arrival Heights (78°S, 170°E). Good agreement was found for most situations, but some discrepancies remain for BrO and ozone in summer.

1. Introduction

The Global Ozone Monitoring Experiment (GOME)[1] 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-synchronous orbit in April 1995. With a ground pixel size of 40×320 km^2 (40×960 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, the operational O_3 product and NO_2, BrO and OClO columns derived at the IUP Bremen are validated with the ground-based zenith-sky measurements performed in Arrival Heights (78°S, 170°E) by NIWA.

2. Analysis And Validation Method

Uncalibrated GOME lv1-spectra have been analysed using the IUP Bremen Differential Optical Absorption (DOAS) algorithm [5, 8] to derive slant columns of NO_2, BrO and OClO. Slant columns have been converted to vertical columns using airmass factors (AMF) computed with the radiative transfer model GOMETRAN [7]. Simple standard profiles have been assumed for NO_2 and BrO. Chemical enhancement of AMFs has been neglected as well as the seasonal variation of atmospheric constitution.
The ground-based measurements have been analysed with the NIWA DOAS algorithm [3,4], using airmass factors derived from GOMETRAN and Monte Carlo [2] simulations. A single background spectrum has been used for each measurement period and the absorber amount in this background spectrum determined using the Langley plot method.
For the validation, all GOME measurements of a day within 200 km of Arrival Heights have been averaged. The ground based measurements have been analysed for the time of the GOME overpass. It is important to note, that in particular during summer this is not the optimum measurement time for zenith-sky observations that have lowest errors during twilight. However, at least for absorbers with a pronounced diurnal variation such as NO_2, BrO and OClO, measurements during twilight can not be readily compared with GOME measurements performed at approximately local noon.

3. Results

(i) O_3 Vertical Columns

Operational GOME Ozone columns (GDP lv2-products) for Arrival Heights have been

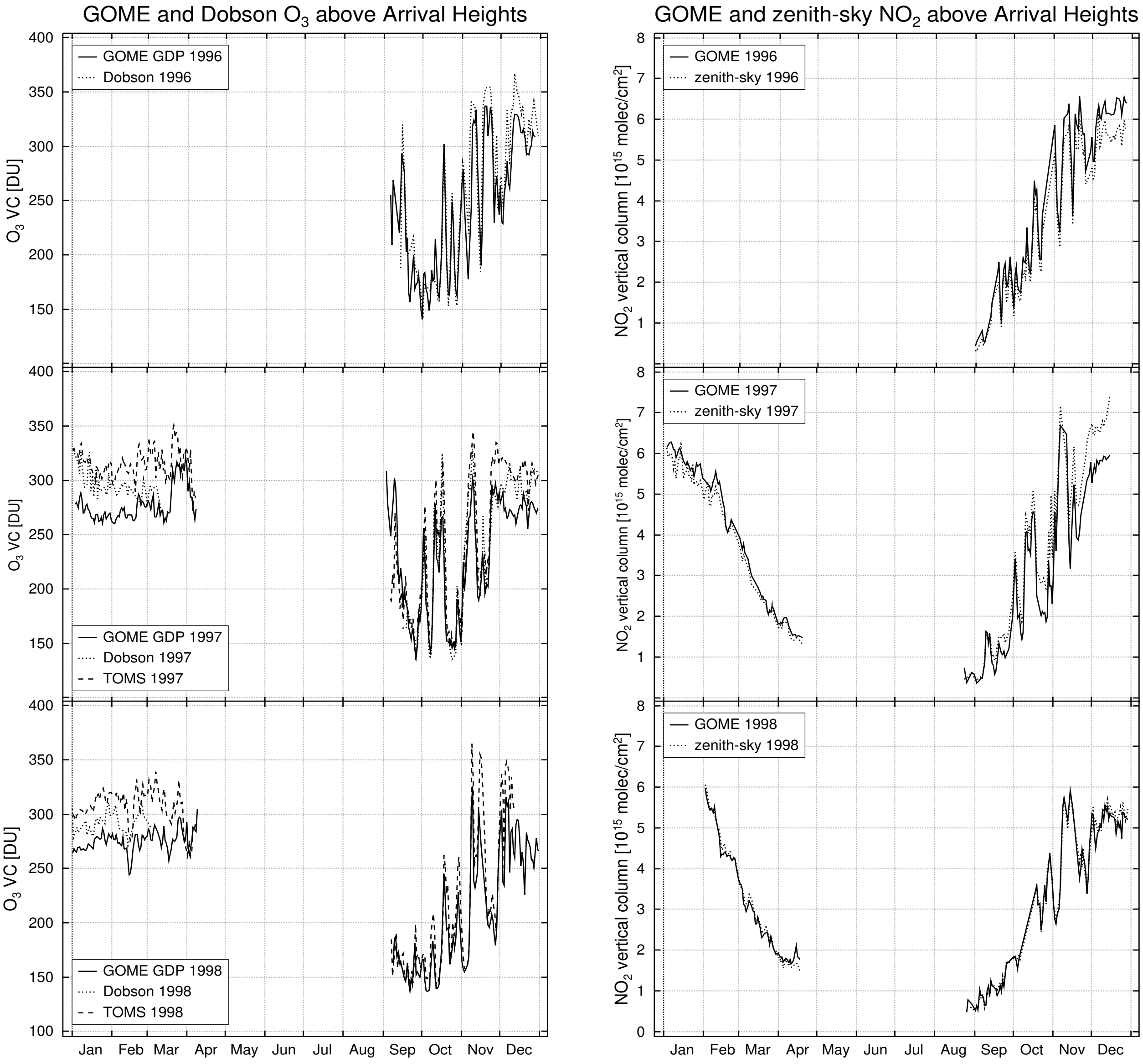

Figure 1. GOME and zenith-sky vertical columns of O_3 and NO_2 above Arrival Heights

compared with ground-based Dobson and TOMS satellite measurements. Excellent agreement was found between all instruments after polar sunrise, but in summer, GOME O_3 columns are lower than Dobson columns. At the same time, TOMS O_3 columns are even larger than those measured by the Dobson instrument. Just before winter, the results step back into agreement.

Both GOME slant columns and AMF from the operational GDP agree well with the IUP analysis. Changes in surface albedo, not fully corrected for, could explain at least part of the difference between GOME and Dobson results, but an inconsistency between the three instruments remains and has been observed in other studies as well (*J.-C. Lambert, private communication*).

(ii) NO_2 Vertical Columns

GOME-IUP NO_2 columns (425 - 450 nm) have been compared to ground-based NO_2 columns derived in the 404.1 - 424.3 nm window. Both the seasonal and the short term fluctuations are captured well by the GOME measurements. In each autumn and also

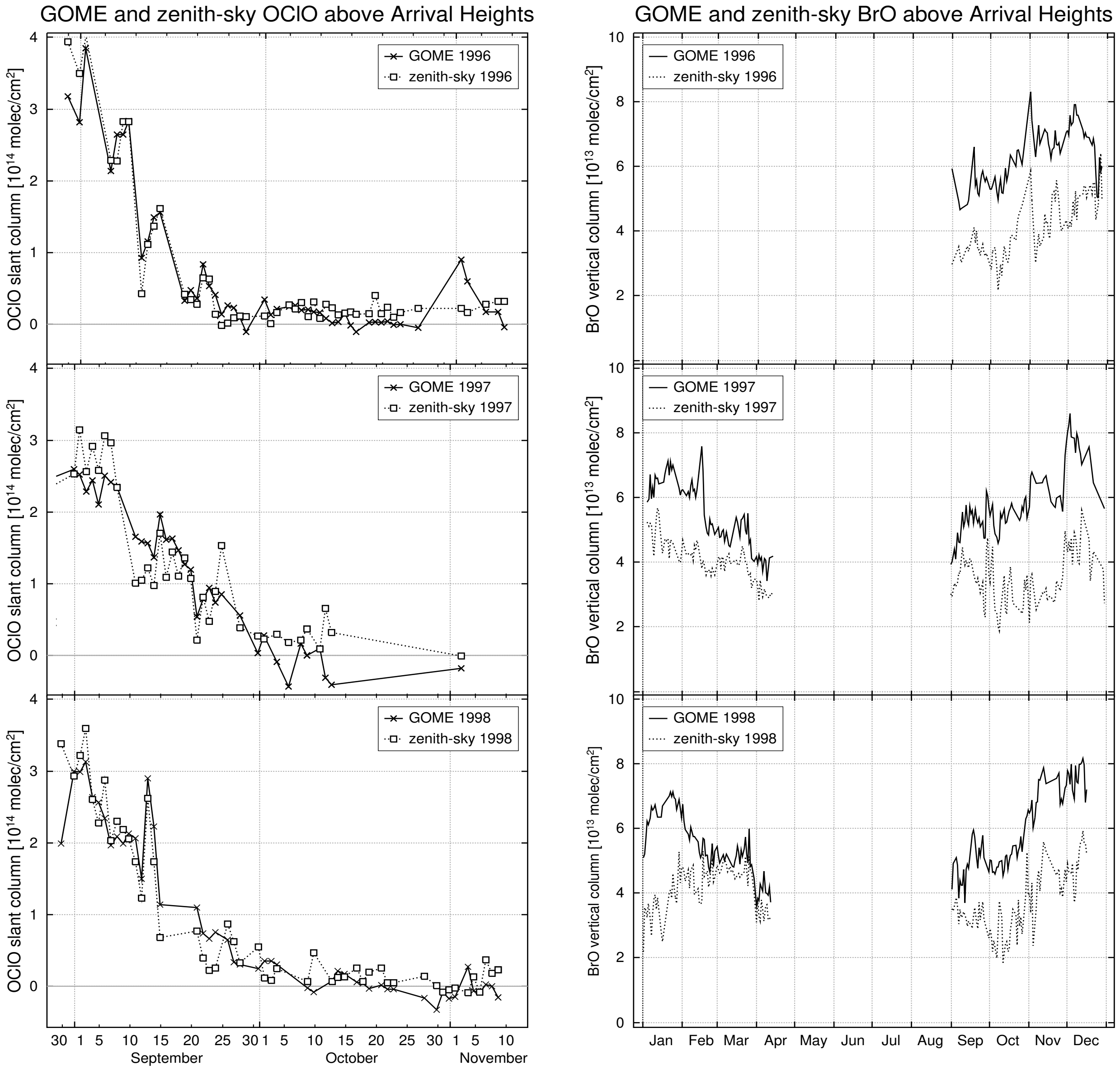

Figure2. GOME and zenith-sky columns of OClO and BrO above Arrival Heights

in spring 1998 the agreement is excellent, however, discrepancies of up to 0.5×10^{15} molec/cm^2 exist in the summers of 1996 and 1997. The reasons for the remaining discrepancies are not clear but changes in aerosol loading affecting the two viewing geometries differently, inaccuracies in the airmass factors, or instrumental drifts, could be responsible.

(iii) OClO Slant Columns

GOME-IUP OClO slant columns have been compared with zenith-sky slant columns from the NIWA instrument. For OClO, photochemical changes along the light path can not be neglected and therefore the measurements have not been converted to vertical columns. For large zenith angles, the stratospheric airmass factors of zenith-sky and nadir measurements are very similar, making direct comparison possible. As shown in the figure, good agreement between GOME and ground-based measurements was found for all years, both in seasonal and year-to-year variations.

Assuming that this result is representative, chlorine activation can (at least qualitatively) been monitored with GOME at southern high latitudes.

(iv) BrO Vertical Columns
GOME-IUP BrO columns have been compared to BrO measured by NIWA. For the AMFs, a simple stratospheric profile has been assumed, neglecting photochemical changes along the light path. In general, GOME BrO columns are larger than those seen by the ground-based instrument. There is good agreement in short term variations, but poor agreement in the seasonal variation during summer 1997/98. These discrepancies are similar to those observed at some other stations and are discussed in more detail in [6]. Briefly, possible explanations are significant BrO concentrations in the boundary layer and/or free troposphere, or ground based instrumental drifts at small SZA. While the reasons for the large differences are not yet fully understood, it seems likely that they are more a problem of interpretation than of data quality and analysis procedures.

4. Summary

GOME measurements above Arrival Heights from 1996 to 1998 have been analysed for O_3, NO_2, OClO and BrO using the DOAS method. Validation with ground-based zenith-sky and Dobson measurements shows excellent quantitative agreement for most measurements of O_3, OClO, and NO_2, but some discrepancies for BrO. Both short term and year to year variations are captured by the satellite measurements, demonstrating the ability of GOME to monitor ozone depletion, halogen activation and NO_2 abundance at the same time on a global scale.

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