Optical degradation in GOME-2 level 2 data products – Updated results for BrO, NO_2, HCHO

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GOME-2 Global Ozone Monitoring Experiment

Introduction

The overall aim of this study was to provide input on the following questions:

1. What is the effect of GOME-2 degradation on the accuracy (absolute values) of level 2 products?
2. What is the effect of GOME-2 degradation on the precision (scatter) of level 2 products?
3. Is the degradation dominated by throughput loss or are there also systematic spectral structures linked to instrument changes or degradation related calibration deficiencies?
4. Are there possibilities to correct for degradation effects on GOME-2 level 2 products?
5. What happened with GOME-2 level 2 products during the 2nd throughput test, and what can we learn from these results?

To tackle these questions, different approaches have been selected and have been tested on selected data sets. In addition, SCIAMACHY level 2 data has been used to compare to the results of the GOME-2 data analysis. Only parts of this comprehensive study are presented here. For more information and the complete study report, please contact us.

Operational IUP level 2 products (BrO, NO_2, HCHO, O_3, and H_2O) were checked for degradation signals in the time series. In the following, an emphasis is put on BrO and HCHO since they are important GOME-2 products and shows clear degradation effects. The quantity of interest is the vertical column (VC) which is deduced from the retrieved slant column (SC) through division by appropriate air mass factors (AMF). The VC has also been cosine corrected for line of sight effects. The other main values going along with the VC are the root mean square (RMS) giving basically the spread of the VCs within a given box of geo-coordinates, the earthshine fit window intensity (INT), and the spread of the retrieval residuals, Chi-square (c^2or ChiSq). In addition, we present results for NO_2, which also shows signs of degradation, but not as severe as BrO and HCHO.

VC	Vertical column of trace gas species, Units: molec./cm^2 (HCHO, BrO, SO_2, NO_2), Dobson Units (O_3) and g/cm^2 (H_2O)
RMS	Standard deviation of all selected VCs for a given box, measure of precision Units: same as for VCs
χ^2	Mean standard deviation of the fit residuals, measure of fit quality Units: arbitrary
INT	Earthshine radiance intensity integrated over the fit window

GOME-2 on MetOP-A

Spectral range	312-800
Orbit	Sun-synchronous, 820 km
Viewing geometry	nadir
Pixel size	80 x 40 km^2
Data available	January 2007 to today

Data product	Spectral region used
SO_2	312.5 – 317.0 nm
O_3	326.0 – 335.0 nm
BrO	336.0 – 347.0 nm
HCHO	337.0 – 353.0 nm
OClO	365.0 – 389.0 nm
CHOCHO	424.0 – 457.0 nm
NO_2	425.0 – 450.0 nm 425.0 – 497.0 nm
H_2O	688.0 – 700.0 nm

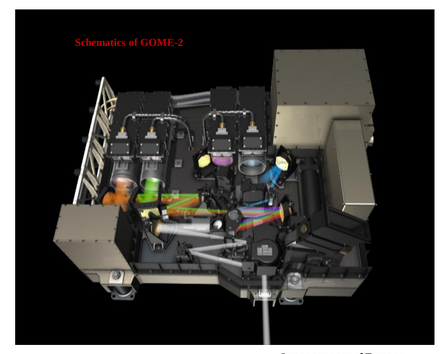
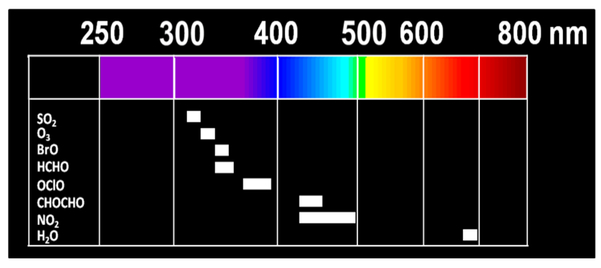


Image courtesy of Eumetsat



Noël, 2009

GOME-2 and SCIAMACHY time series from January 2007 to March 2012 have been plotted for geo-locations where natural or anthropogenic variations are minimum. In the following, two regions were selected, one over the Southern Pacific Ocean (25°S-15°S and 150°W-110°W) and one over the Sahara Desert (20°N-30°N and 0°E-30°E). The locations of all the boxes are shown in Fig. 1.

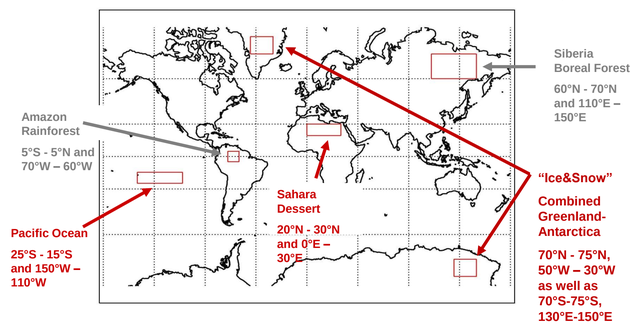
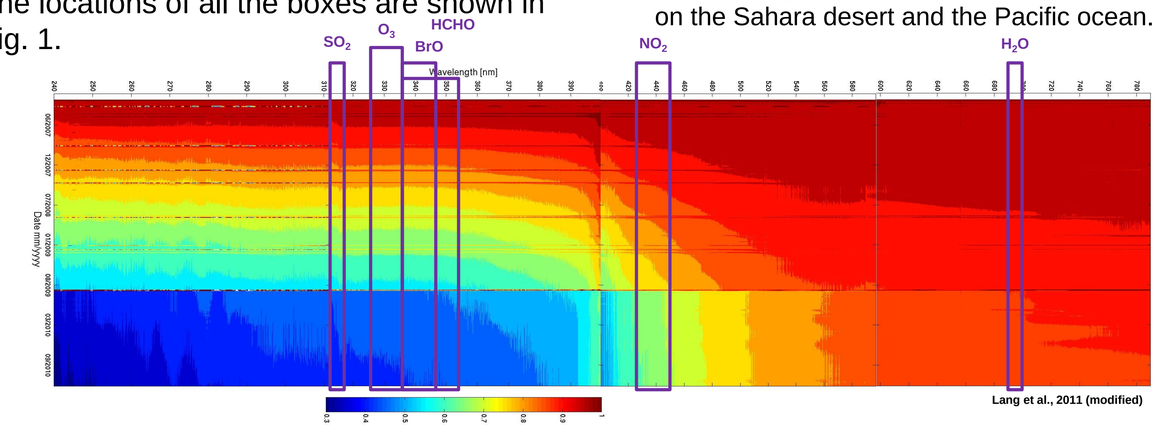


Fig. 1: Set of geo-locations. We concentrate here on the Sahara desert and the Pacific ocean.



Lang et al., 2011 (modified)

Fig. 2: GOME-2 throughput loss. Vertical axis denotes time, horzontal the wavelength. Marked in purple are the trace gas fitting windows.

Time series

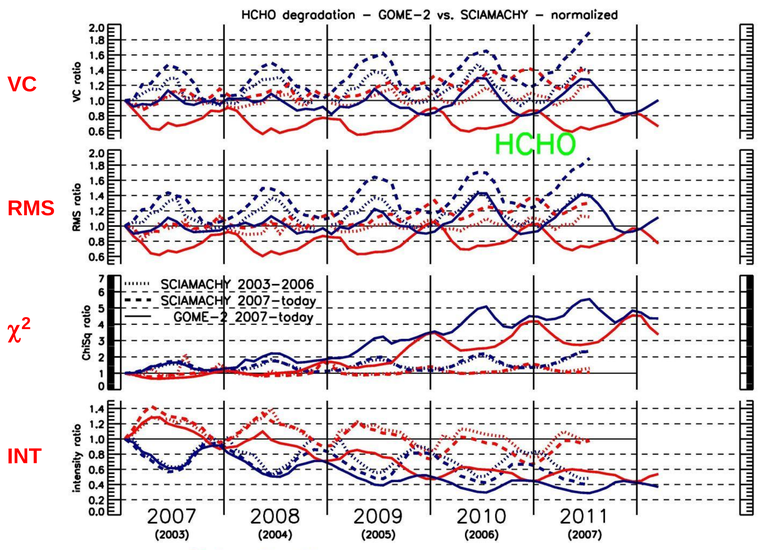


Fig. 3: GOME-2 and SCIAMACHY HCHO time series for VC, RMS, χ^2, and INT normalized to January 2007. The behavior of χ^2 and INT are similar to BrO. VCs and RMS slightly increase for SCIAMACHY, not so much for GOME-2

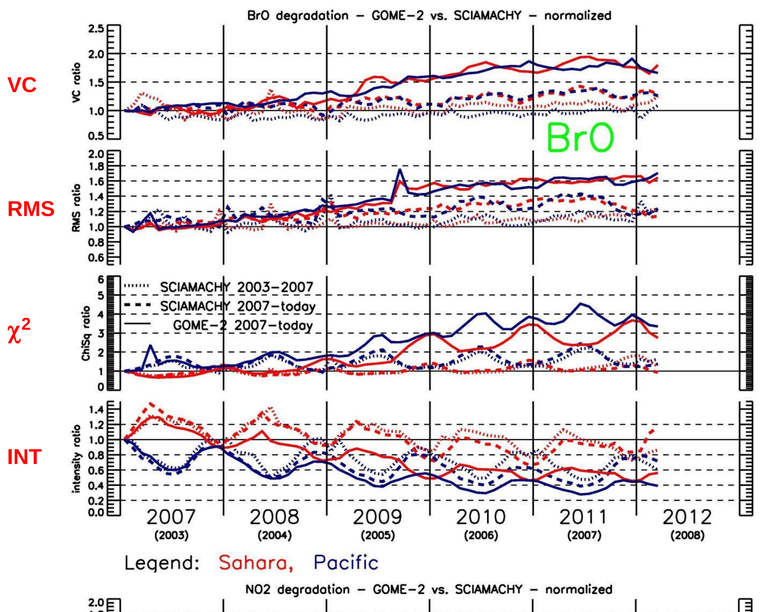


Fig. 4: GOME-2 and SCIAMACHY BrO time series for VC, RMS, χ^2, and INT normalized to January 2007. For GOME-2 the VCs steadily increase, there is a slight increase for SCIAMACHY VCs after 2008. RMS increases more for GOME-2 than it does for SCIAMACHY. The fit quality (χ^2) increases significantly for GOME-2, not so much for SCIAMACHY. The fit window intensity also decreases significantly for GOME-2.

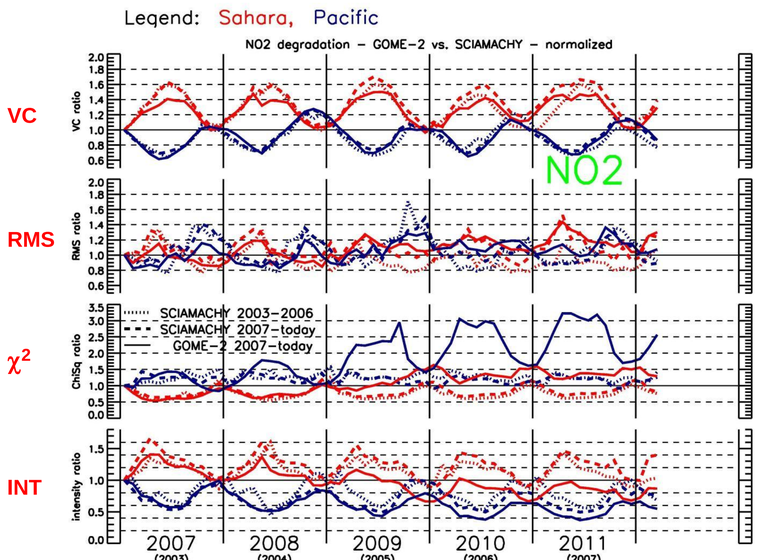


Fig. 5: GOME-2 and SCIAMACHY NO_2 time series for VC, RMS, χ^2, and INT normalized to January 2007. VCs are more or less congruent, the RMS slightly increases for GOME-2 and the fit quality (χ^2) has large seasonal variation over the Pacific. The increase in χ^2 is moderate. GOME-2 intensity loss is larger when compared to SCIAMACHY.

Intensity vs. χ^2 distributions

The assumption is that the intensity dependent fit quality (χ^2) follows the distribution $\frac{1}{\sqrt{INT}}$, taking all data (pixel) from one year (e.g. 2011) and binning them intensity-wise confirms this assumption (cf. Fig. 6). Adding 2007 through 2010 to the results allows conclusions about degradation effects. For NO_2 the abovementioned assumption is true, but BrO and HCHO show an interesting anomaly. From year-to-year fit residuals increase at the same intensity. This behavior is not the case for SCIAMACHY BrO and HCHO. The investigation of BrO data being retrieved with earthshine reference spectra (cf. Fig. 8) leads to the conclusion, that the source of this additional degradation may come from the calibration unit of GOME-2 (cf. Fig. 7).

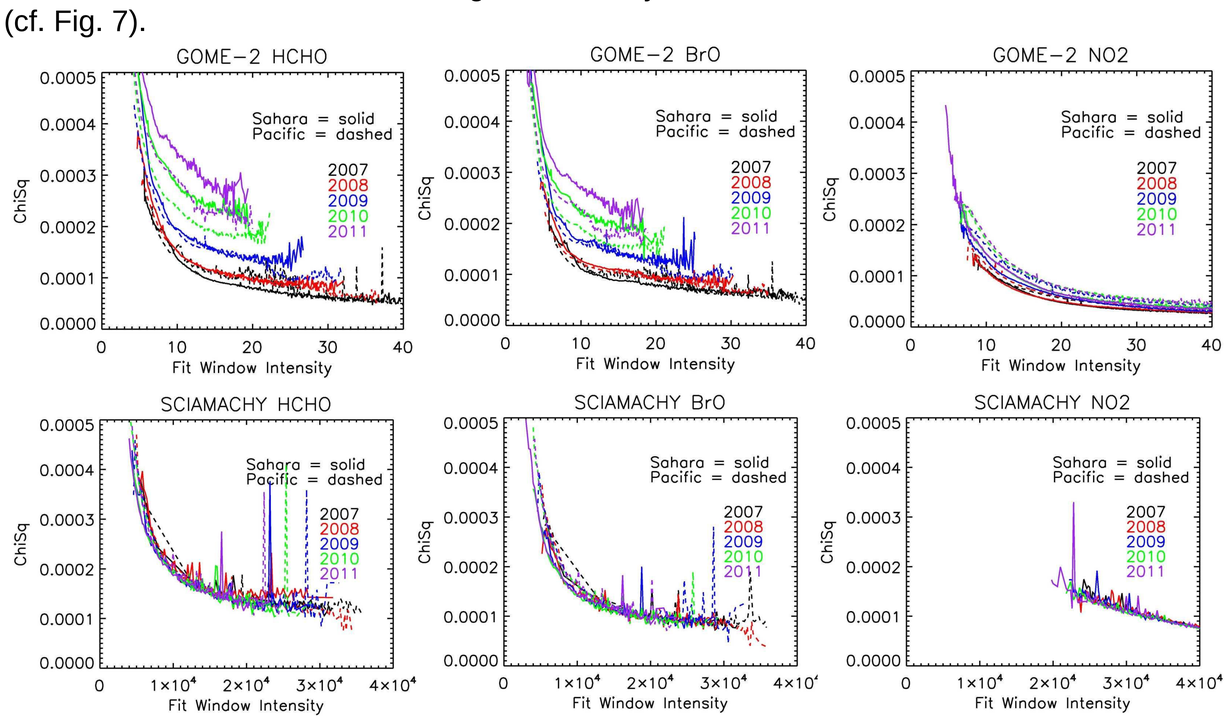


Fig. 6: GOME-2 and SCIAMACHY BrO, HCHO, and NO_2 χ^2 intensity dependencies.

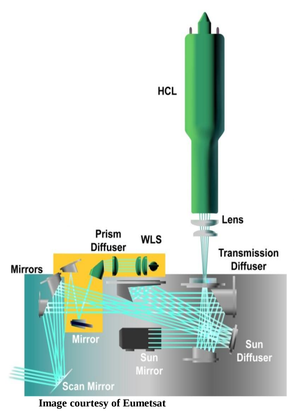


Image courtesy of Eumetsat

Fig. 7: Scematic of GOME-2 calibration unit.

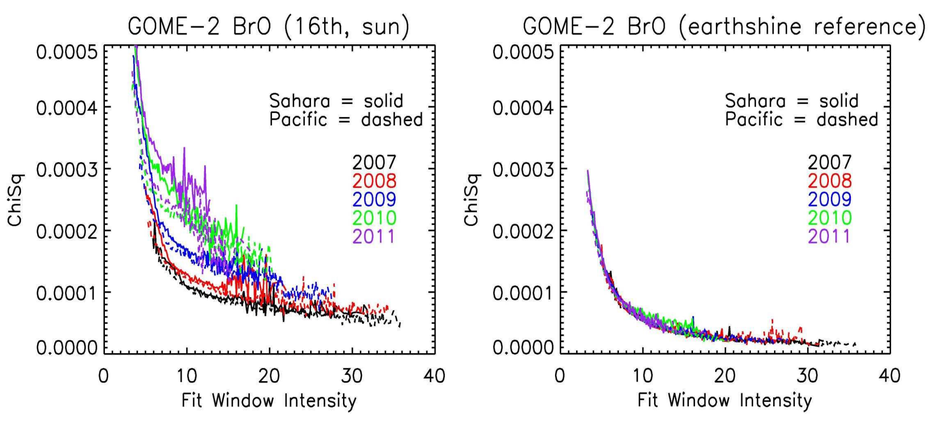


Fig. 8: GOME-2 BrO χ^2 intensity dependency for sun (left) and earthshine (right) reference spectra. Only data from the 16th of each month has been used.

Conclusions

1. What is the effect of GOME-2 degradation on the accuracy (absolute values) of level 2 products?

→ Degradation significantly deceases fit quality (χ^2 rises), especially for retrieval of weak absorbers in channel 2.

2. What is the effect of GOME-2 degradation on the precision (scatter) of level 2 products?

→ Degradation has a smaller effect on precision (RMS) than on fit quality.

3. Is the degradation dominated by throughput loss or are there also systematic spectral structures linked to instrument changes or degradation related calibration deficiencies?
4. Are there possibilities to correct for degradation effects on GOME-2 level 2 products?

→ Yes, degradation is dominated by throughput loss.

→ A systematical component has been additionally identified with its possible source in the solar measurements.

5. What happened with GOME-2 level 2 products during the 2nd throughput test, and what can we learn from these results?

→ First moderate warming increased fit quality of level 2 data. Further heating decreased fit quality and stayed at low level after TT2. Rate of fit quality loss slowed down after TT2.

Selected References

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Acknowledgements

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