Development of an OCIO Slant Column Product for GOME-2

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1 Introduction

- stratospheric ozone loss is relatively well understood and expected to decrease in the coming years due to strong reductions in emissions of ozone depleting substances
- in cold stratospheric winters, large ozone depletion is expected also in the coming decade
- interaction between climate change, changes in circulation patterns, stratospheric temperatures, and chlorine activation has the potential to extend ozone depletion further into the future than expected
- measurements of OClO by UV/visible nadir satellite spectrometers provide long-term data sets of chlorine activation at least as qualitative indicators
- the GOME2 instruments will provide at least 15 years of data
- so far, OClO retrievals from GOME2 observations were noisy and had clear artefacts

3 Validation

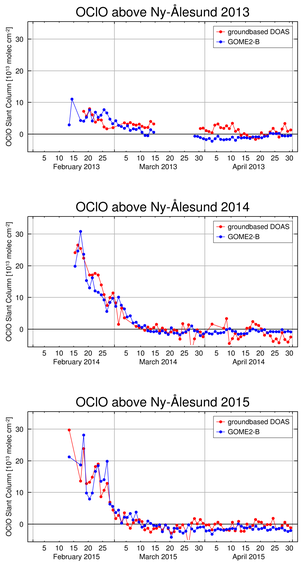


Figure 7: Comparison of OClO slant columns from GOME2-B and the zenith-sky DOAS instrument in Ny-Alesund for the years 2013, 2014, and 2015

Validation data

- zenith-sky DOAS observations in Ny-Alesund (79°N, 12°E) background spectrum from March 18 of each year
- data interpolated to mean time of satellite overpass
- SZA increases over time period leading to smaller slant columns (photolysis)

Satellite data

- all GOME2-B measurements within 200 km of station
- assumption: AMF is similar for satellite and ground-based measurement at these geometries

Results

- very good match of seasonal and inter-anual variability
- some differences expected from differences in volumes probed

Acknowledgements

- Funding by the University of Bremen and the O3M SAF visiting scientist project O3_AS14_02 are acknowledged
- GOME2 lv1 data were provided by EUMETSAT

2 The new OClO product

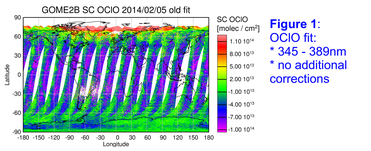


Figure 1: OClO fit:
* 345 - 389nm
* no additional corrections

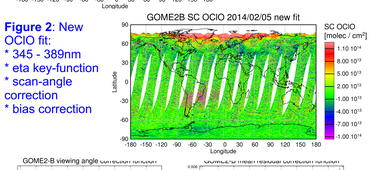


Figure 2: New OClO fit:
* 345 - 389nm
* eta key-function
* scan-angle correction
* bias correction

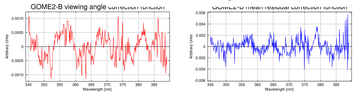


Figure 3: Empirical functions derived from residual analysis to correct for GOME2-B scan angle dependence (left) and other biases (right). The corresponding functions for GOME2-A are not identical but have a similar spectral structure.

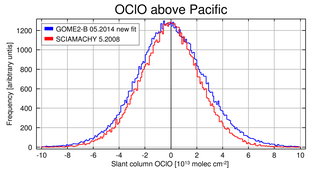


Figure 4: Distribution of OClO slant columns over the equatorial Pacific where no OClO is expected. The distribution represents the random noise in the retrieved slant columns which is similar between SCIAMACHY and GOME2-B.

Problem

- OClO slant columns from GOME2 data showed much more scatter than SCIAMACHY data when using the standard fitting window 365 - 389 nm
- when using a larger fitting window, large cross track and regional biases are observed (Fig. 1)
- large OClO columns were retrieved in activated situations but OClO enhancement was also observed at large SZA without chlorine activation

Approach for improvement

- use of a larger fitting window 345 - 389 nm
- inclusion of two empirical correction x-sections for a) scan angle dependence and b) spurious large OClO values by residual analysis of measurements where OClO is expected to be negligible and not included in the fit
- inclusion of eta key-function

Results

- scan angle dependence is much reduced
- scatter of values is reduced approximately to SCIAMACHY levels
- biases are much reduced
- temporal drifts are still present in the data so normalisation over the Pacific is needed for consistent time series

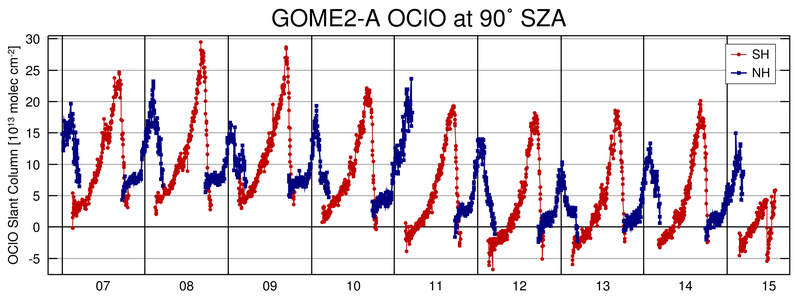


Figure 5 (top): GOME2-A OClO at 90° SZA for both hemispheres. As the latitude at which SZA 90° is reached changes with season, the values are not over a constant latitude. No normalisation has been applied and a clear long-term drift is apparent.

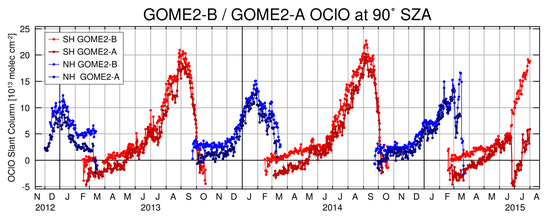
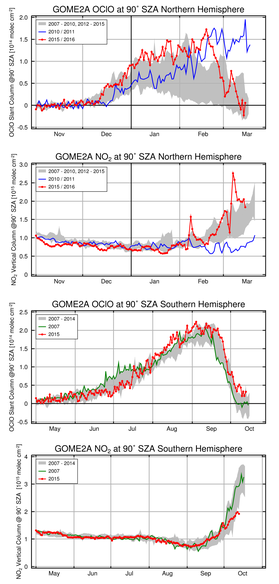


Figure 6 (right): Comparison of GOME2-A and GOME2-B OClO columns at 90° SZA

4 Application to recent years



Northern hemisphere

winter 2010 / 2011
- relatively late onset of chlorine activation
- largest OClO columns from mid February onwards until end of observations
- very low NO_2 columns indicating denitrification

winter 2015 / 2016
- early activation from mid December
- rapid deactivation after major warming in February
- NO_2 columns low early in season but then rapid increase and large spikes during the two warmings

Southern hemisphere

- much less variability in observations
- 2015 was year with largest OClO columns
- NO_2 was unusually low at end of season

Figure 8: Comparison of interannual variability of 90° SZA OClO slant columns and NO_2 vertical columns in both hemispheres. The gray shaded area shows the range of values over all years excluding the ones highlighted in colour. Individual years are normalised to have zero OClO in October and April for the northern and southern hemisphere, respectively.

5 Conclusions

- a new OClO slant column product has been developed for the two GOME2 instruments
- empirical calibration functions need to be included in the DOAS fit to remove systematic biases
- the larger fitting window used results in much reduced noise compared to earlier products
- even with empirical calibration functions, normalisation is needed to remove long-term drifts in the OClO values
- validation with ground-based measurements in Ny-Alesund shows good agreement
- the recent winter 2015 / 2016 was characterised by early and strong activation in the northern hemisphere but activation was less persistent than in 2010 / 2011

Selected references

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