Improved algorithm baseline for the generation of total ozone climate data records

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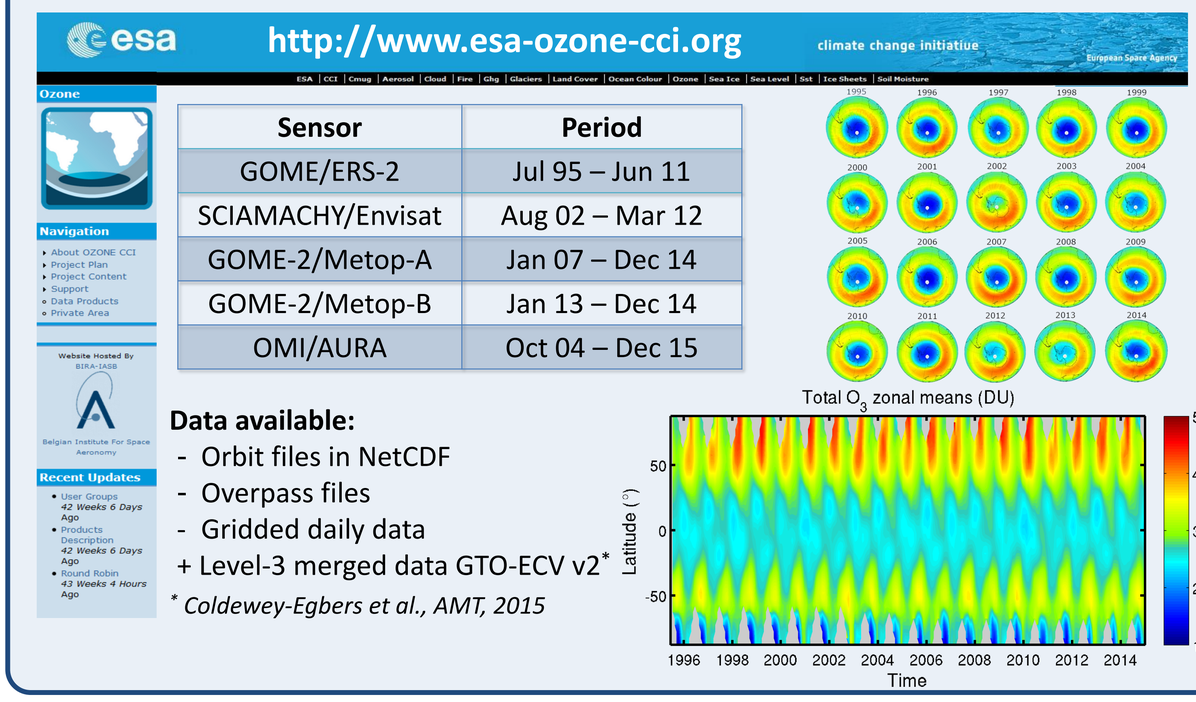
Abstract

The direct-fitting total ozone retrieval algorithm GODFIT v3 developed at BIRA-IASB has been applied in the past years on nadir observations from the instruments GOME, SCIAMACHY, GOME-2A/B and OMI to generate climate data records characterized by a high level of accuracy, temporal stability and inter-sensor consistency. The latter has been achieved among others thanks to the application of an original soft-calibration procedure making use of reference Brewer spectrophotometer data. (Lerot et al., JGR, 2014)

As part of the on-going activities within the Ozone_cci project, new algorithmic developments have been carried out. A new a priori total column-classified ozone profile climatology released by Labow et al. (2015) is now used. Covariance matrices associated with this climatology have been constructed and are used to estimate smoothing errors on a pixel-basis. Also, a better treatment of the instrumental slit functions and their time variation has been implemented. We use now the ozone cross-sections measured by Serdyuchenko et al. (2014) of which the temperature dependence is better characterized. This improved algorithm GODFIT v4 has been used to reprocess the full GOME mission and we present here the impact of those changes on the product as well as first validation results. GOME and OMI show remarkable temporal stability without the need for any soft-calibration based on external data. A combination of those two sensors will therefore be used as long-term reference instead of Brewer data to soft-calibrate the other sensors, allowing to maintain the independence of the satellite data sets against ground-based.

ESA CCI-1 total ozone data sets based on GODFITv3



Sensor	Period
GOME/ERS-2	Jul 95 – Jun 11
SCIAMACHY/Envisat	Aug 02 – Mar 12
GOME-2/Metop-A	Jan 07 – Dec 14
GOME-2/Metop-B	Jan 13 – Dec 14
OMI/AURA	Oct 04 – Dec 15

Data available:

- Orbit files in NetCDF
- Overpass files
- Gridded daily data

+ Level-3 merged data GTO-ECV v2*

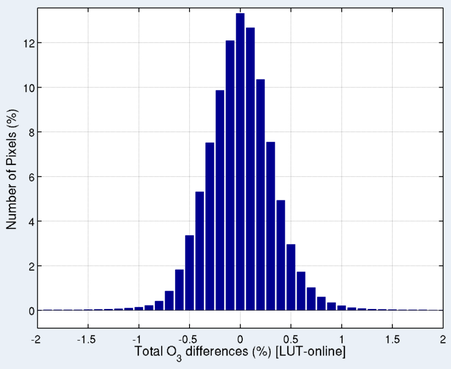
* *Coldewey-Egbers et al., AMT, 2015*

The GODFITv4 algorithm

Main features

- Direct fitting of measured radiances in the Huggins bands (325-335 nm).
- State vector includes a.o. total ozone, effective temperature and albedo.
- Simulated spectra are computed on-the-fly with LIDORT or extracted from pre-calculated tables. The latter option, used for treating OMI data, is faster by a factor of 10, while maintaining a very high level of accuracy.
- Correction factors to account for polarization.
- Semi-empirical formulation for the Ring correction.
- Characterization of the slit function and online convolution of cross-sections.
- Optional soft-calibration of level-1 reflectances to reduce the impact of calibration limitations.

LUT – online differences (%)

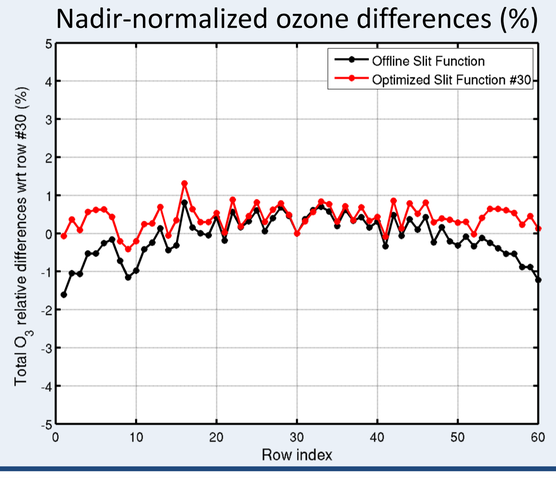


Instrumental slit function optimization

GODFIT has the capability to characterize instrumental slit functions by adjusting pre-determined functions (e.g. Gaussian) or by optimizing the pre-measured slit functions. For OMI, this helps to reduce row-dependent systematic errors, while the temporal stability of the GOME-2A product is improved when accounting for the temporal evolution of the slit function.

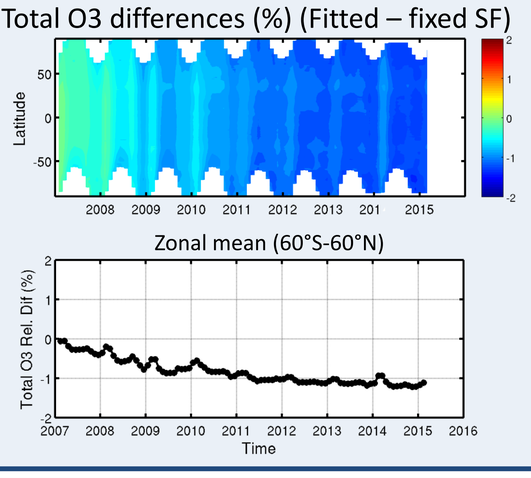
1. Row dependence of the OMI data set

Nadir-normalized ozone differences (%)



2. Time evolution of the GOME-2A slit function

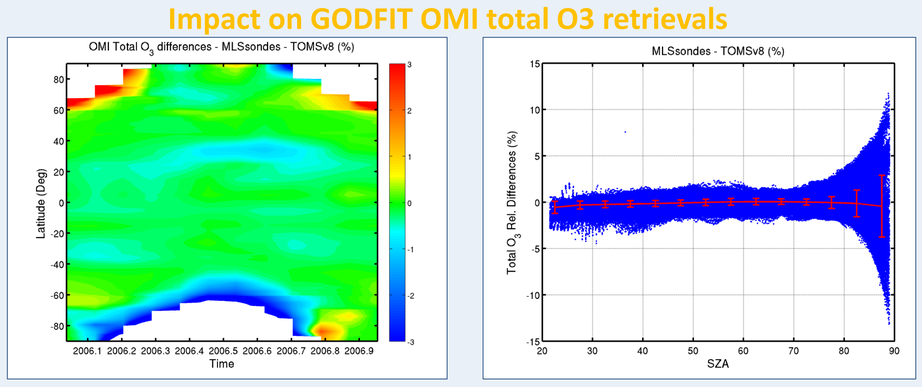
Total O3 differences (%) (Fitted – fixed SF)



A priori O_3 profiles

- GODFIT v3: Total column-classified climatology TOMSv8 (Mc Peters et al., JGR, 2007) combined with the tropospheric column climatology from OMI/MLS (Ziemke et al., ACP, 2011).
- GODFIT v4: The total column-classified climatology recently released by Labow et al. (JGR, 2015), also in combination with the OMI/MLS tropospheric climatology.

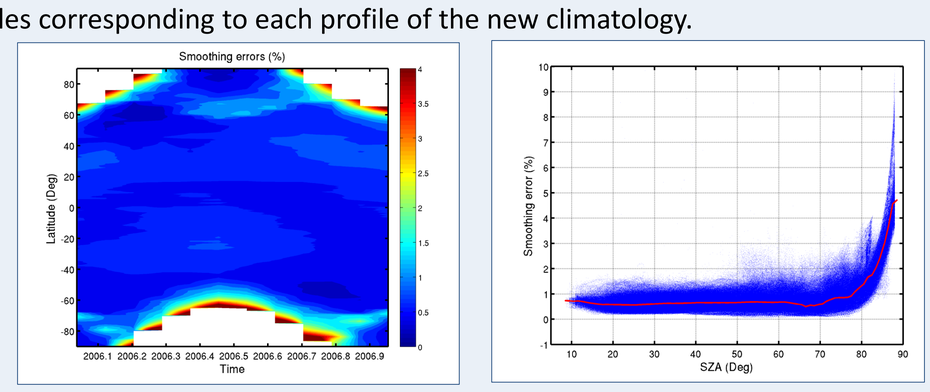
Impact on GODFIT OMI total O3 retrievals



- Overall small impact, except at large SZAs as expected.

Smoothing error estimates

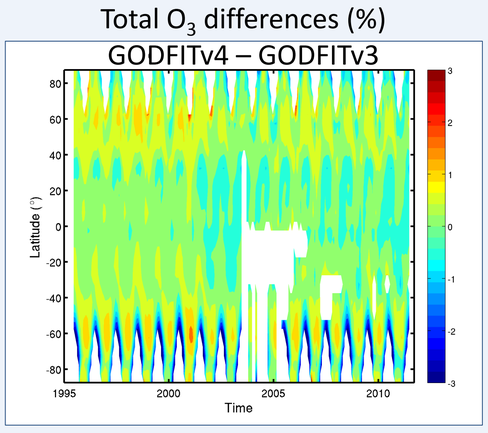
- Error due to the a priori profile on the retrieved column. Dominant at large SZAs.
- It can be computed as $\varepsilon=\sqrt{ASA^T}$, where *A* is the total column averaging kernel and S is the covariance matrix of the profile climatology.
- *S* has been constructed for the MLS/sondes climatology using the ensemble of the TOMSv8 profiles corresponding to each profile of the new climatology.



GODFITv4 applied to GOME/ERS2

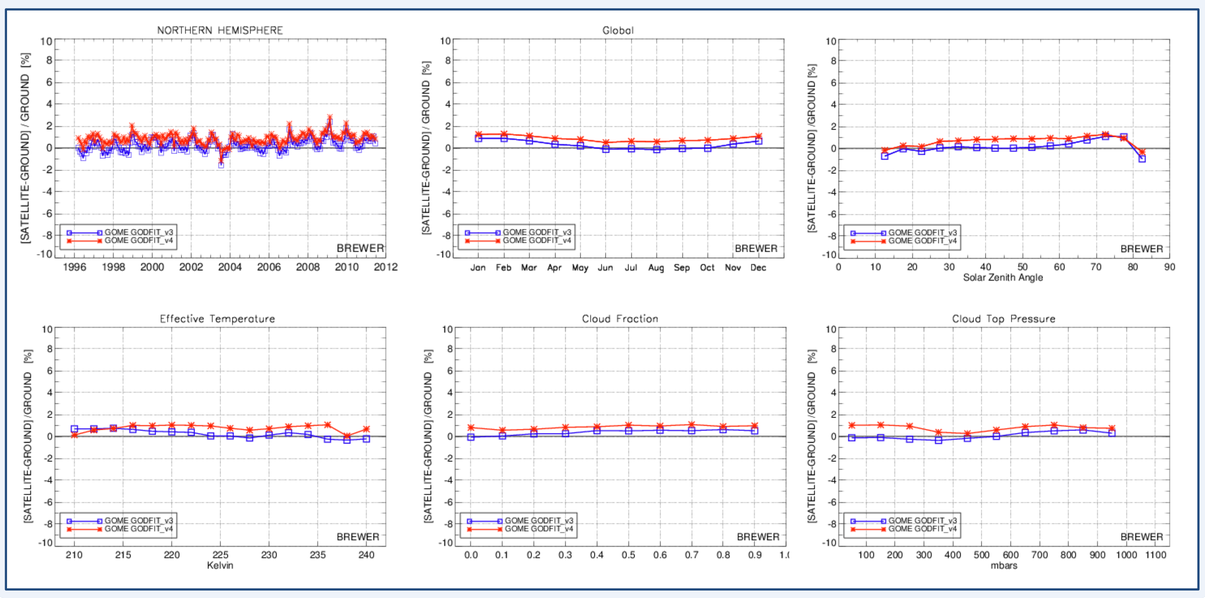
Total O_3 differences (%)

GODFITv4 – GODFITv3



- The GODFITv3 GOME data set was already of very high quality.
- The new GODFITv4 baseline maintains this high quality, while eliminating the link to the Brewer measurements. The largest impact is visible at large SZAs in the Southern Hemisphere.
- First validation results suggest a further reduction of the SZA/seasonal dependence.
- The high temporal stability of the product allows to use it as a long-term reference.

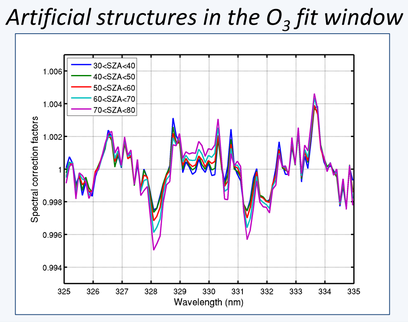
First validation results



OMI-based soft-calibration of SCIAMACHY

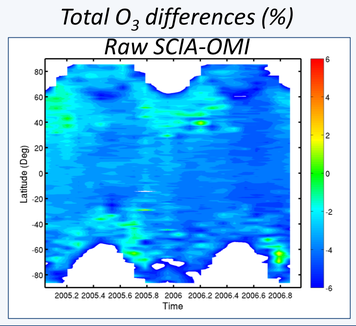
- Statistical comparison of L1 and simulated spectra to identify artificial structures.
- Simulations done using the GODFIT forward model and OMI ozone columns as reference.
- A large bias in SCIAMACHY columns is explained by systematic structures in the L1 spectra. Once these are removed, the consistency with OMI is much better.

Artificial structures in the O_3 fit window



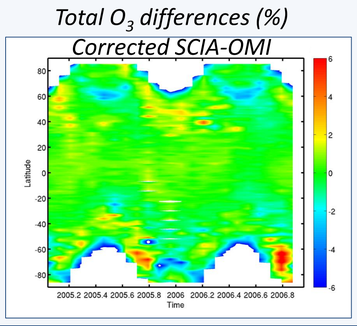
Total O_3 differences (%)

Raw SCIA-OMI



Total O_3 differences (%)

Corrected SCIA-OMI



Conclusions

- New developments have been carried out in the algorithm GODFIT used to generate the total ozone ECV within the Ozone_CCI project. In particular, a new total O_3 column-classified profile climatology based on MLS and sonde measurements has been tested. Instrumental slit functions, as well as their possible time evolution, are better characterized. The O_3 cross-sections measured by Serdyuchenko et al. (2014) are now used in the forward model with an improved treatment of the solar I_0-effect.
- Once applied to GOME/ERS2, this new baseline leads to an excellent total O_3 data product, without any link to ground-based observations. First validation results indicate a further reduction of the SZA-dependence of the satellite/Brewer differences.
- The OMI mission is being reprocessed with this new baseline and it is anticipated that GOME and OMI can be combined as a long-term reference to soft-calibrate other sensors (SCIAMACHY, GOME-2A/B) which are planned to be reprocessed by the end of 2016 as part of the CCI activities.