Verification and validation of tropospheric formaldehyde retrievals from GOME-2 on MetOp-A&B.

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Since the launch of MetOp-A in October 2006, BIRA-IASB has been involved in the validation and quality assessment of the minor trace gases measured by the GOME-2 instrument (http://cdop.aeronomy.be). A continuous monitoring of the precision, accuracy and stability of the products has been developed for GOME-2/MetOp-A, and has been extended to MetOp-B operational products delivered since July 2013. In this work, we present the results of tropospheric formaldehyde retrievals obtained with more than one year of data from Metop-B and around 7 years of data from Metop-A.
Our retrieval settings (version 14) are essentially based on the algorithm described in De Smedt et al. (2012). These scientific retrievals (http://h2co.aeronomy.be) are used to assess and improve the quality of the current version of the operational formaldehyde product (http://o3msaf.fmi.fi/products/oto_hcho.html). Both retrieval algorithms share the same basis, but differ on several aspects (see table below) related to the algorithm main purpose, scientific or operational.

Method

Validation protocol established within the O3M-SAF for trace gas data products: step-by-step approach where each sub-product is verified, i.e. for H_2CO:

- Slant columns and fit it residuals (SCD and RMS).
- Normalized slant columns (ΔSCD) (reference sector correction).
- Air mass factors without cloud correction (AMF clear).
- Air mass factors with independent pixel cloud correction (AMF).
- Tropospheric vertical columns (VCD).

Common retrieval settings	Differences	Scientific algorithm	Operational Algorithm
H_2CO SCD retrieved in 328.5-346 nm	Slit function	Fitted during wavelength calibration	Pre-flight model (Siddans et al., 2006)
Absorption cross-sections: H_2CO (298K), O_3 (228K, 243K, I_0), BrO (223K), NO_2 (220K, I_0), 2 Ring vectors generated using SCIATRAN (Rozanov et al., 2001; Vountas et al., 1998), polarisation vectors from the calibration key data (EUMETSAT, 2009) .	O_2-O_2 treatment	Pre-fit in 339-364 nm	Not included
	BrO treatment	Pre-fit in 328.5-359 nm	Included in 328.5-346 nm
Background correction in the remote Pacific	DOAS reference	Daily radiance in the equ. pacific	Daily solar irradiance
H_2CO profile shapes from IMAGES CTM	IMAGES version	Daily profiles, 2x2.5°	Monthly climato, 5x5
Scattering weights simulated with LIDORT at 340 nm	Surface albedo	OMI climato. (Kleipool et al., 2008)	TOMS/GOME climato. (Koelemeijer et al., 2003)
Cloud correction (IPA), cloud screening, no explicit aerosol correction.	Cloud product	O2 Frescov6 (Wang et al., 2008)	OCRA/ROCINN v2.0 (Loyola, 2004, 2007).

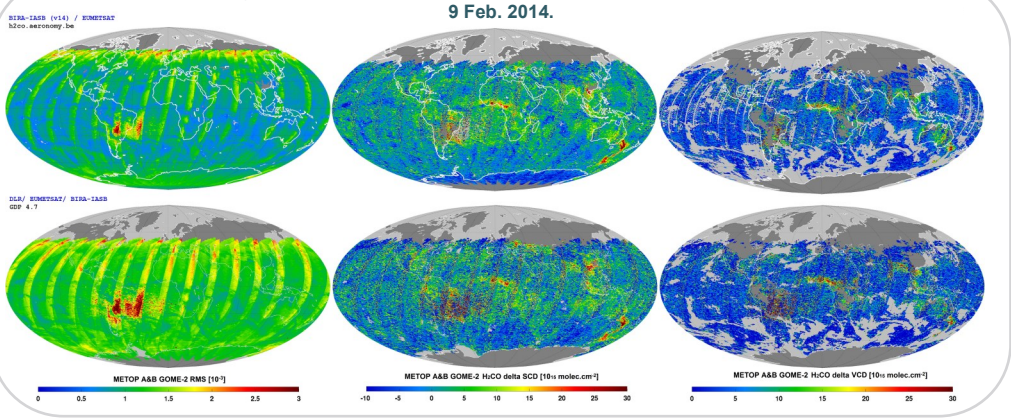
Verification towards the scientific algorithm

- Good quality of the GOME-2B results, with values comparable to those of GOME-2A at the beginning of the mission in 2007. Similar conclusions using both GDP4.7 and scientific retrievals.
- Good level of consistency between GOME-2A and GOME-2B in 2014, but GOME-2A noise level larger by approximately a factor 2, due to degradation effects.
- Degradation effect mitigated in the scientific algorithm by means of optimised DOAS settings (pre-fit of BrO) and a dynamically adjusted slit function, nevertheless the impact of the degradation is clearly apparent in both products.
- Differences in AMFs resulting from the different input data bases used for surface albedo and cloud parameters. The relative impact of cloud and albedo on the AMF is modulated depending on the particular situation of the different emission regions.
- Differences in the effective cloud fraction and cloud top height values rather important. Not only impact the calculation of the AMF, but also the statistics of valid H_2CO measurements (cloud fraction larger than 0.4 are excluded) .

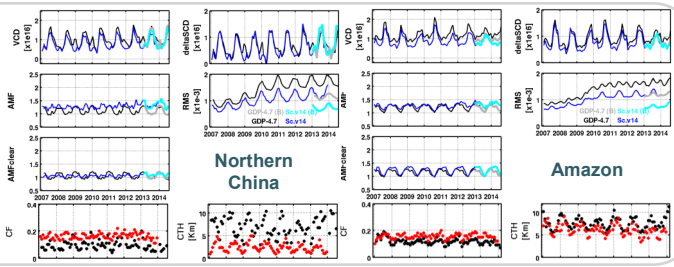
Validation using MAX-DOAS measurements

- 5 years in Beijing and Xianghe/China.
- 6 months in Bujumbura/ Burundi.
- MaxDOAS H_2CO columns based on OE profiling algorithm. Provides also information on the vertical H_2CO profiles and aerosols.
- Seasonal variations are well captured by GOME-2 A&B, but satellite columns underestimate MaxDOAS by 40-50%.
- The impact of the a priori profile shape and of the satellite averaging kernels explain a large part of the differences between the ground-based and the satellite observations.

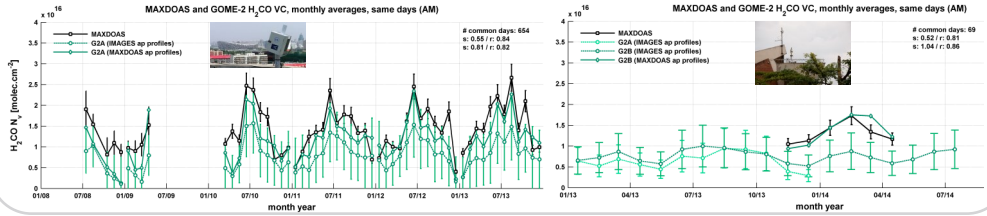
GOME-2 A&B 1-day composite maps of RMS, H_2CO ΔSCD and H_2CO VCD (Sc.v14 and GDP-4.7) 9 Feb. 2014.



Sc.v14 and GDP-4.7 comparison from 2007 to June 2014, for both GOME-2 on METOP-A (blue and black) and METOP-B (cyan and grey) in the Northern China and Amazon regions.
Fresco v6 and OCRA/ROCINN cloud properties are shown in red and black, respectively.



MAXDOAS validation in Beijing/Xianghe (2008-2013) and in Bujumbura (Nov.2013-Apr.2014)



Summary

- GOME-2B H_2CO slant columns, fit residuals, and scatter are comparable to those obtained from GOME-2A spectra in 2007, both for the operational and scientific products.
- GOME-2 A&B GDP 4.7 H_2CO retrievals are in very good agreement with scientific retrievals of the BIRA-IASB algorithm when using exactly the same settings (not shown).
- The reduced H_2CO slant column noise level in the in the scientific algorithm (v14) is primarily obtained by the pre-fit of BrO in 328.5-359nm.
- Remaining differences between the operational and scientific H_2CO vertical columns are mainly related to the different input parameters used for the air mass factor calculation, namely the cloud product and the surface albedo.
- Further improvement of the H_2CO operational product will be obtained, both for GOME-2 A&B, by implementing developments from the scientific algorithm (v14) into the UPAS processor (next version GDP 4.8).

- O3-SAF validation Report, Offline Total Formaldehyde, GOME-2/ Metop-A (O3M-10 OTO HCHO), 2010.
- O3-SAF ORR validation Report, Offline Total Formaldehyde, GOME-2/Metop-B (O3M-58 OTO HCHO), 2013.
- De Smedt et al., Improved retrieval of global tropospheric formaldehyde columns from GOME-2/MetOp-A addressing noise reduction and instrumental degradation issues. Atmospheric Measurement Techniques, 2012.

The H_2CO data products from GOME-2 were generated at BIRA using level-1 data developed by EUMETSAT. Level-2 and level-3 H_2CO scientific products from GOME-2 have been jointly supported by Belgian PRODEX (A3C and TRACE-S5P), ESA (PROMOTE) and EU (AMFIC). BIRA is involved in the O3MSAF (CDOP-2 project) where it supports the development and validation of the GOME-2 H_2CO operational product generated at DLR. Multi-sensor H_2CO developments at BIRA are currently supported by EU FP7 (QA4ECV project).

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