On the use of harmonized HCHO and NO$_2$ MAXDOAS measurements for the validation of GOME-2 and OMI satellite sensors

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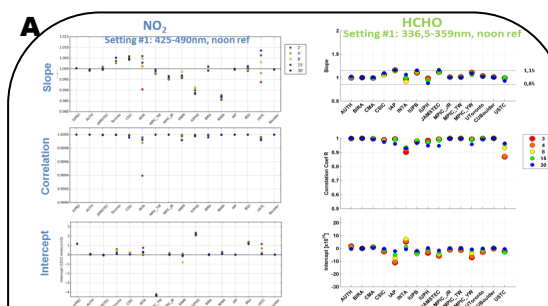
Abstract

During the last decade, the MAXDOAS technique has been increasingly recognized as a source of **Fiducial Reference Measurements (FRM)** suitable for the validation of satellite nadir observations of species relevant for climate and air quality like NO$_2$ and HCHO. As part of the **EU FP7 QA4ECV (Quality Assurance for Essential Climate Variables**; see http://www.qa4ecv.eu/) project, efforts have been recently made to **harmonize a network of a dozen of MAXDOAS** spectrometers in view of their use to assess the quality of satellite climate data records generated within the same project.
Harmonization tasks have addressed both retrieval steps involved in MAXDOAS retrievals, i.e. the **DOAS spectral fit** providing the differential slant column densities (DSCDs) and the **conversion of the retrieved DSCDs into vertical profiles and/or vertical column densities (VCDs)**. In this work, we illustrate the successive harmonization steps and present the resulting QA4ECV MAXDOAS database v2. The approach adopted for the conversion of slant to vertical columns is based on a simplified look-up-table approach. The strength and limitation of this approach are discussed using reference data retrieved using an optimal estimation scheme.
The **QA4ECV MAXDOAS database** is then used to **validate satellite data sets of NO$_2$ and HCHO columns** derived from the OMI/AURA and GOME-2/MetOp sensors.

1. MAXDOAS harmonization

NORS and QA4ECV projects heritage/aim:

■ **Slant columns**: test of different settings on common data (MAD-CAT campaign, IUP-Bremen spectra) to revisit baseline settings and verify consistency of retrieval codes ➔ large-scale intercomparison exercise (Sect. A)
■ **Vertical columns/profiles**: harmonized AMF-based LUT approach for the VCD calculation (+profiles) at all QA4ECV sites to ensure an homogeneous network (Sect. B)
■ **Reporting in standardized format**: QA4ECV **GBv1** dataset (each group with their own preferred algorithm and methods) submitted in the UVVIS.DOAS.GEOM HDF file format (http://avdc.gsfc.nasa.gov), **GBv2** (outcome of A and B) is being tested ➔ full traceability of data, including ancillary data (cloud conditions, location of effective air-masses, AOD, winds, …)

■ use of AMF LUT applied to 30° elevation angles:

$$VCD_\alpha = \frac{DSCD_\alpha}{DAMF_\alpha} = \frac{SCD_\alpha - SCD_{90°}}{AMF_\alpha - AMF_{90°}}$$

■ extraction of the profile based on the BLH climatology + scaling to the retrieved VCD

This profile can then be smoothed with the satellite column AVK within the validation step.

$$VCD_{MAX,smoothed} = VK_{SAT} * ParCol\_prof_{MAX}$$

Most differences between groups are related to the slit function choice (measured or optimized/analytical), the details of the calibration procedure and the sequential reference selection.

QA4ECV Recommendations and outcome on DOAS settings :

E.g., see **Peters et al. AMT 2017** for NO$_2$

Overview of the QA4ECV GB dataset:

2. Validation results

A validation webserver in development (**https://qa4ecv-dev.stcorp.nl/**) will gather all the validation results of the QA4ECV satellite products. Validation results performed offline to investigate the best options to be integrated in the server: 2.A) coherence of QA4ECV GBv2 and OEM; 2.B) tests on cloud filtering from MAXDOAS data. So far, only OMI NO$_2$ and HCHO data are available.

OMI pixels selection:
validity flag +CRF<0.5, within 50km; validity flag (including cloud & SZA filtering), within 100km
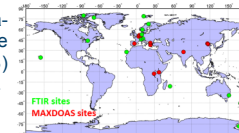
2.B Testing the effect of removing thick clouds from MAXDOAS dataset

2.A GBv2 vs OEM
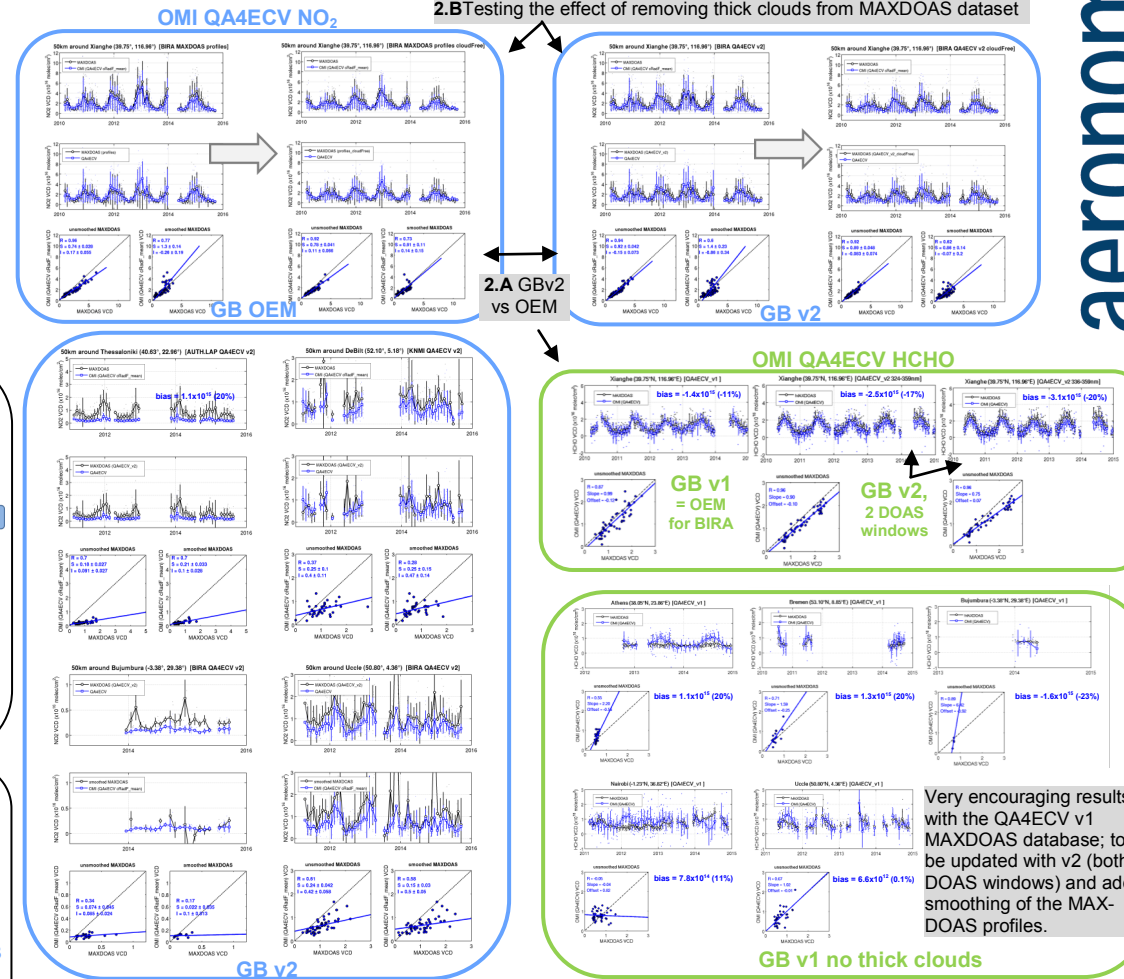
Ongoing analysis with the first GB v2 NO$_2$ data. Investigations of cloud filtering and smoothing of the MAXDOAS data.

Very encouraging results with the QA4ECV v1 MAXDOAS database; to be updated with v2 (both DOAS windows) and add smoothing of the MAX-DOAS profiles.
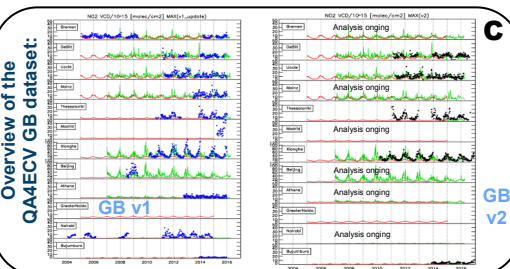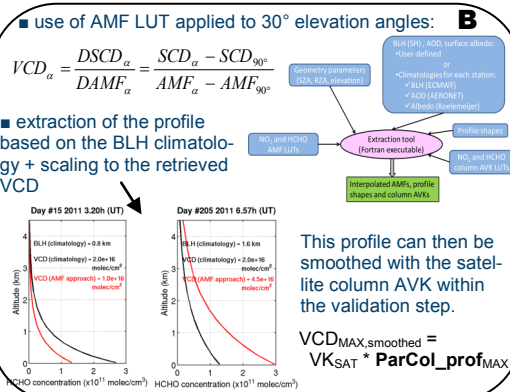
Conclusions

- Harmonization of MAXDOAS retrieval steps is in a good shape, with revisited slant columns and homogeneous conversion into VCD (+ profile shapes and AVKs) at the 12 QA4ECV MAXDOAS stations.
- First validation results of the QA4ECV OMI product with the LUT approach for NO$_2$ and HCHO are promising; good consistency with the results obtained when using bePRO OEM profiles. Testing of additional MAXDOAS cloud filtering within the validation is ongoing. Extension to the GOME-2 QA4ECV dataset planned in the summer, when GOME-2 data will be available (see De Smedt, poster n° X5.422).
- Very important harmonization work of the MAXDOAS datasets and validation strategies set up, that will be used for the TROPOMI NO$_2$ and HCHO validation (NIDFORVAL project).

Selected References

Peters et al.: AMT, 10, 2017
De Smedt et al.: EGU 2017 poster X5.422
Boersma et al.: EGU 2017 oral 8311
http://www.qa4ecv.eu/ and documents therein.