HCHO and NO_2 MAXDOAS retrieval harmonization as part of the QA4ECV project

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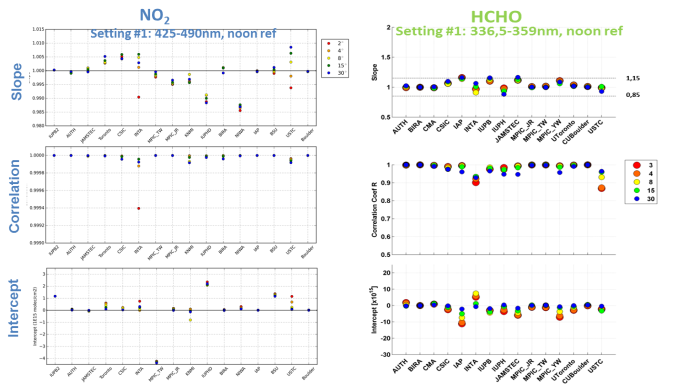
Introduction

Over the last years, ground-based MAXDOAS measurements have played an increasing role for the ground truthing of space-nadir observations of air quality relevant trace gases such as NO_2 and HCHO. Current MAXDOAS network data however lack harmonization in terms of data acquisition, data processing and data reporting. This issue is addressed as part of the ongoing **EC FP7 QA4ECV project** (Quality Assurance for Essential Climate Variables; http://www.qa4ecv.eu/) which aims at developing standardized quality control procedures for Climate Data Records generation. In particular, tools and best-practices for MAXDOAS measurements are developed and tested on a selected number of sites to be used as Fiducial Reference Measurement (FRM) as part of the project.

We present a **status of the QA4ECV MAXDOAS harmonization activities** addressing **spectral fitting and air mass factor calculations**. Results from a large scale intercomparison exercise involving 15 groups are presented for both NO_2 and HCHO. We also introduce an approach allowing for harmonized conversion of slant columns into vertical columns through application of generic look-up tables of air mass factors parameterized as a function of solar and viewing angles, wavelength, boundary layer height, aerosol optical depth (AOD) and surface albedo. The advantages and drawbacks of the LUT approach are investigated and the **application of the resulting data set for comparison with GOME-2 satellite measurements** is discussed.

1. NO_2 and HCHO slant column intercomparison

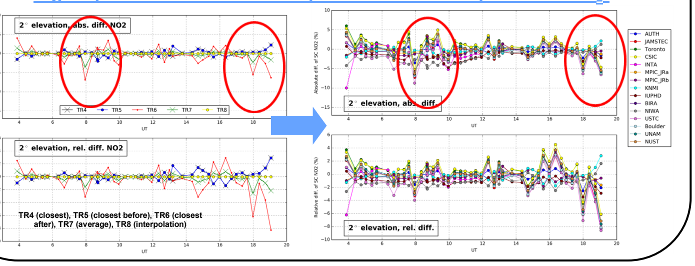
- Efforts in the past (Roscoe et al., 2010; Pinardi et al., 2013) to evaluate the agreement between groups (different instruments and different retrieval codes). Here: estimation of agreement of different DOAS retrieval codes on common data and settings, and identification of systematic differences. Exercise opened to the DOAS community (more than 20 groups involved).
- Compare DSCD of each group for different angles; scatter plots wrt to a ref:



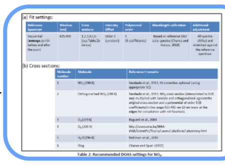
As expected, NO_2 analysis are more stable and coherent than HCHO: differences of retrieved slant columns between ± 1% for NO_2, and ± 15% for HCHO (with noon reference spectra) and up to $1x10^{16}$ molec/cm^2 or 8% and $2x10^{16}$ or 50% (with sequential reference). Differences between groups are mostly related to slit function choice (measured or optimized/analytical), details of the calibration procedure and sequential reference selection.

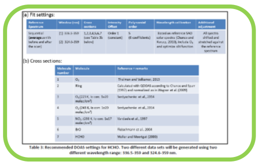
Sensitivity tests performed with one code (**IUPB** and **BIRA QDOAS**) to identify sources of differences between groups and optimize the analysis precision. Dominant effects: the choice of the reference spectrum, the slit function treatment and the wavelength calibration. [Peters et al.; Pinardi et al in prep]

E.g. impact of choice of the sequential reference spectra on NO_2:



Recommendations on DOAS settings to use within QA4ECV:



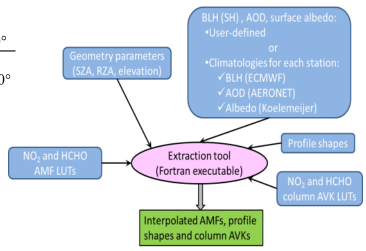


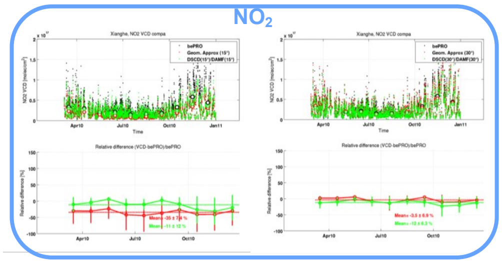
2. NO_2 and HCHO harmonized LUTs of AMFs and profile shapes

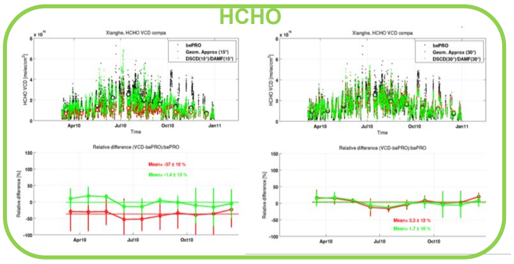
- Harmonization of the conversion of NO_2 and HCHO SCDs to VCDs within the QA_4ECV groups through the use of AMF LUT applied to high elevation angles (α >10°)

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

- Example of application in Xianghe and comparison to GA and OEM (bePRO):



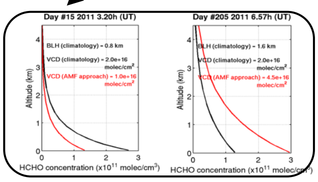




Good agreement with OEM when using the LUT AMF approach (better than using the Geometrical Approach (GA) -lower bias and less marked seasonality of the differences with OEM).

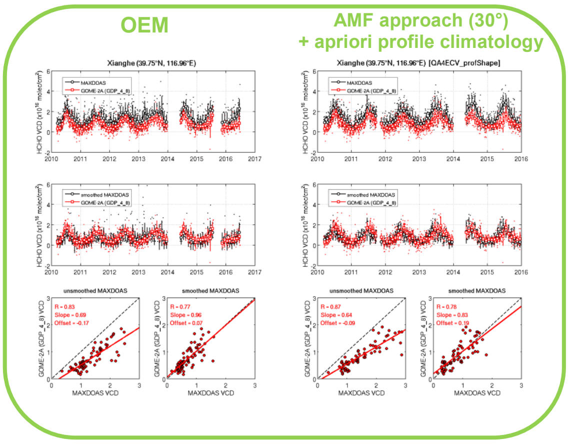
- Use of the a-priori profile climatology for the comparison with satellite:

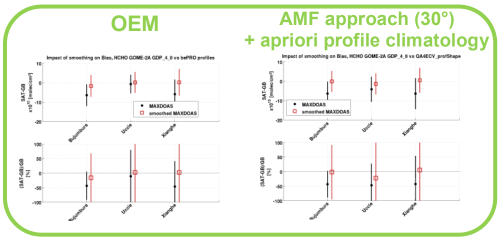
A) extraction of the profile based on the BLH climatology + scaling to the retrieved VCD

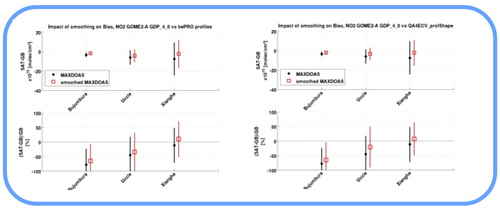


B) convolute the scaled profile to the satellite column AVK

$VCD_{MAXDOAS,smoothed}$ = AVK_{SAT} . **ParCol_profile**$_{MAXDOAS}$







Very promising HCHO and NO_2 validation results with LUT approach; very similar results than with OEM profiles at BIRA stations.

Conclusions and outlook

- Harmonization of MAXDOAS retrieval steps is in a very good shape, with revisited slant columns and homogeneous conversion into VCD (+ profile shapes and AVKs) at the 12 QA_4ECV MAXDOAS stations.
- First validation results on GOME-2 GDP data with the QA_4ECV LUT approach for NO_2 and HCHO at BIRA stations are very promising; good consistency with the results obtained when using the profiles coming from the bePRO OEM. Tests on other stations are ongoing.

Selected References

Roscoe et al.: AMT, 3, 1629-1646, 2010;
Pinardi et al.: AMT, 6, 167-185, 2013;
Peters et al.: in preparation for AMT;
Pinardi et al.: in preparation for AMT