Sentinel-5 Precursor NO_2 and HCHO validation using NDACC and complementary UV-Vis DOAS systems

G. Pinardi*[1], C. Vigouroux[1], B. Langerock[1], M. De Mazière[1], J. Granville[1], J.C. Lambert[1], F. Hendrick[1], M. Van Roozendael[1]
and the NIDFORVAL data providers
(1) BIRA-IASB *gaia.pinardi@aeronomie.be

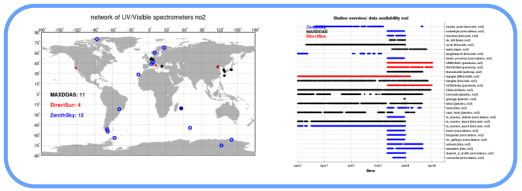
n° X5.133

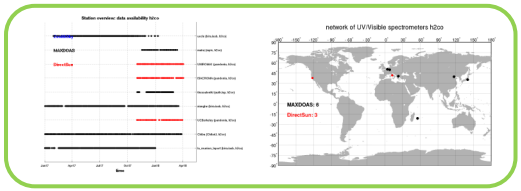
Abstract

The NIDFORVal project (S5P NItrogen Dioxide and FORmaldehyde Validation using NDACC and complementary FTIR and UV-Vis DOAS ground-based remote sensing data) is part of the S5PVT and aims at providing an assessment of the quality of two operational S5P products: nitrogen dioxide (NO_2) and formaldehyde (HCHO). Two different and independent ground-based remote sensing techniques are involved: Fourier Transform Infrared (FTIR) and UV-Visible Differential Optical Absorption Spectroscopy (UV-Vis DOAS). These techniques can provide accurate NO_2 total (DirectSun DOAS), stratospheric (ZenithSky DOAS) and tropospheric (Multi Axis (MAX) DOAS) columns, as well as HCHO total columns (FTIR and MAXDOAS).
Within the project, high quality measurements from over 60 ground-based stations and 80 instruments will be gathered from NDACC and complementary networks or recent infrastructures, extending the overall data set to a large range of observation conditions sampling high, mid- and low latitudes, as well as unpolluted, sub-urban and urban polluted sites.
A first phase of the project has been focusing on defining homogenized and characterized FTIR and UV-Vis DOAS recommendations for the analysis of ground-based NO_2 and HCHO data time-series over the whole S5P mission timeline (10/2017-2023). Since the TROPOMI launch in October 2017, ground-based data is being collected for the validation of the S5P products during the commissioning phase E1. Only a subset of ground-based stations is ready for operational data submission in rapid delivery mode, which are used to compare with the available L2 operational dataset, making use of common tools derived from the experience developed in precursor projects (e.g., Multi-TASTE, AC-SAF, GECA, NORS) and new S5P-related developments (e.g., HARP tools).
First comparisons of UV-Vis DOAS stations are reported in this poster, and the plans for the routine operations phase (E2) are the progressive accumulation of large data sets that will allow for improved statistics, a refined categorization of validation sites and search for patterns or specific behaviors in validation results, analysis of seasonal cycle effects and verification of long-term consistency throughout the mission. FTIR results are reported in the companion work of Vigouroux et al. in the same session (X5.134).

1. UV-vis DOAS data

Collection of Uv-vis NO_2 and HCHO VCDs has started, covering October 2017 to February 2018
ZenithSky: stratospheric NO_2 VCD from 14 stations.
MAXDOAS: tropospheric NO_2 VCD from 10 stations and tropospheric HCHO VCD from 6.
DirectSun: total NO_2 VCD from 4 stations and total HCHO from 3 stations (3 pandonia instruments).





2. TROPOMI data

Comparisons have been performed with **available TROPOMI data**:
- NO_2 data: February 2018 data from KNMI (Eskes pers. comm.)
- HCHO data: November 2017 to February 2018 data from DLR UPAS-2 v12 and BIRA PROTO v1.2 (De Smedt et al. AMT, 2018+ talk De Smedt, EGU2018)

Data Filtering:
NO_2: cloud_fraction_intensity_weighted<0.5
HCHO: cloud_fraction_intensity_weighted<0.6 and solar_zenith_angle<70 and tropospheric_air_mass_factor >0.1 and hcho_vcd> (mean(hcho_vcd)-3*std(hcho_vcd))

Colocations: Use for each day the average of TROPOMI good pixels within 20km of the station; use the value only if at least 5 good pixels are provided. Use the interpolated value of gb measurements around TROPOMI overpass.

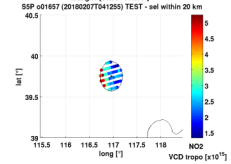
•**Disclaimer**: The presented work has been performed in the frame of the Sentinel-5 Precursor Validation Team (S5PVT) or Level 1/Level 2 Product Working Group activities. Results are based on preliminary (not fully calibrated/validated) Sentinel-5 Precursor data that will still change.
•**Acknowledgements**: S5P is a European Space Agency (ESA) mission on behalf of the European Commission (EC). The TROPOMI payload is a joint development by ESA and the Netherlands Space Office (NSO). The Sentinel-5 Precursor ground-segment development has been funded by ESA and with national contributions from The Netherlands, Germany, and Belgium. We would like to thank Anna Iannarelli (SERCO), Monica Campanelli (ISACROMA - CNR) and Paul Wooldridge (UCBerkeley) for operating the UNIROMA1, ISACROMA and UCBerkeley Pandora instruments and all the **Data providers** groups: BIRA, UToronto, CNRS-LATMOS, KNMI, MPIC, AUTH, ChibaU, JAMSTEC, INTA and the pandonia network.
• **Funding**: Belgian national agency (Belspo) through the TROVA project, and the UVvisDOAS data have been funded by the individual national agencies of each partner.

3. Validation results

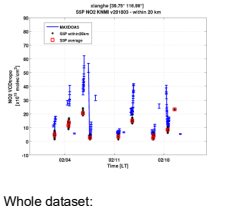
Comparisons have been performed on a daily and monthly basis

tropo and total NO_2

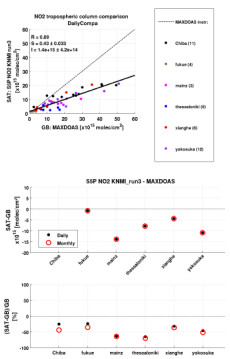
One day example Xianghe:



Full time-series:



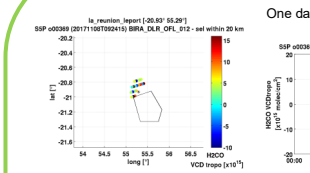
Whole dataset:



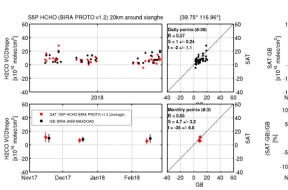
Very good coherence between daily and monthly comparisons.
TROPOMI NO_2 VCDs always smaller then ground-based.

HCHO

One day example:



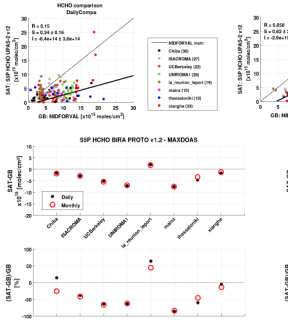
Full time-series:



Whole dataset:

Daily comparisons:

Monthly comparisons:



For HCHO, the monthly comparisons are greatly reducing the scatter

For some stations larger differences between daily and monthly comparisons. **The BIRA PROTO v1.2 is a clear improvement compared to UPAS-2 v12 for most stations.**

	Daily ovp ALL sites				Monthly means ALL sites			
	Bias	Stand. Dev. (% and molec/cm^2)	Slope	Corr	Bias	Stand. Dev. (% and molec/cm^2)	Slope	Corr
HCHO UPAS-2 v12	-81%	47%; $3.4x10^{15}$	0.34	0.15	-70%	36%; $3.3x10^{15}$	0.62	0.06
HCHO BIRA PROTO v1.2	-30%	50%; $3.2x10^{15}$	0.74	0.24	-37%	40%; $3.1x10^{15}$	-1.1	-0.04
NO2 KNMI (tropo)	-42%	18%; $4.8x10^{15}$	0.43	0.89	-50%	14%; $4.8x10^{15}$	0.51	0.91
NO2 KNMI (total)	-32%	21%; $3.5x10^{15}$	0.25	0.81	-37%	21%; $3.5x10^{15}$	0.15	0.55

Conclusions

- Ground-based data collection is in a good shape.
- Validation procedures are in place for MAXDOAS and DirectSun (NO_2 and HCHO). Stratospheric NO_2 comparisons will follow soon. Filtering and colocation will be further explored and adapted.
- First validation results of the preliminary TROPOMI NO_2 and HCHO products are very promising. General tendency to an underestimation wrt the ground-based columns. Smoothing need to be applied to remove the a-priori profile uncertainty. Tests on prototype HCHO product show a clear improvement of using a larger DOAS fitting window and improved background correction (De Smedt et al., AMT 2018).
- Separation of the results per station type (urban, suburban, remote) is ongoing.

aeronomie.be