



WP3 NIDFORVal project: TROPOMI validation (before public release)

Corinne Vigouroux, Gaia Pinardi, Bavo Langerock (BIRA-IASB)

Does the TROPOMI HCHO products reach the requirements ?

- systematic uncertainty < 40-80 %
- precision of 1.2x10¹⁶ molec/cm² for a single pixel
 From De Smedt, EGU 2018: 0.7x10¹⁵ molec/cm²





A) HCHO validation using the FTIR network RPRO-OFFL (v01.01.02) NRT (v01.01.02)

FTIR data providers: C. A. Bauer Aquino, C. Becker, T. Blumenstock, M. De Mazière, O. García, M. Grutter, C. Guarin, J. Hannigan, F. Hase, C. Hermans, N. Jones, R. Kivi, D. Koshelev, E. Lutsch, M. Makarova, J.-M. Metzger, J. Notholt, I. Ortega, M. Palm, C. Paton-Walsh, A. Poberovskii, M. Rettinger, J. Robinson, D. Smale, W. Stremme, K. Strong, R. Sussmann, Y. Té

WP1: FTIR HCHO harmonization & data collection

• Vigouroux et al., AMT, 2018: 21 stations provide HCHO time series using harmonized retrieval parameters.



- For this 28th September validation:
 - 16 stations provided data on very short notice: many thanks to all of the FTIR partners !

TROPOMI validation: which data sets?

- FTIR data: 18 stations with coincidences (16 new data; + Altzomoni & Mexico: "old" data: few coincidences in May)
 - FTIR systematic uncertainty is 11-26%.
 - FTIR median random uncertainty (on single measurement): 0.3 x10¹⁵ molec/cm²

- TROPOMI data:
 - "OFFL": We merge the version v01.01.02 of OFFL (from August 2018) and RPRO data (from May to August 2018):
 Total period covered: 11th May 2018 (removed first days of reprocessing) 31st August 2018 (less than 4 months)

• "NRT": v01.01.02 starts only the 8th August 2018

TROPOMI validation: Regridding / smoothing

• Collocation: 30km, 12 hours

- Use **the mean of TROPOMI good pixels (QA flag>0.5) within 30km** of the station; Only when **at least 10 pixels** remain from filtering, the collocation is used.
- In practice: 45 (±25) pixels.
- Use the **daily means of FTIR** measurements.

Before the daily averaging of TROPOMI and FTIR:

- Each FTIR profile is re-gridded on TROPOMI pressure grid.
 Regridding may require extrapolation (mountain stations) -> used TROPOMI a priori (when available: NRT)
- Rodgers 2003: the TROPOMI a priori profile is substituted to the FTIR one (when available: NRT).
- Rodgers 2003: the FTIR re-gridded/extrapolated profile is smoothed using the TROPOMI column Averaging Kernel.
- Both TROPOMI and smoothed FTIR column are then scaled to the height of the station.

From June ESRIN meeting (old Operational Processor vs Scientific BIRA data) to new operational data OFFL+RPRO

		ALL sites		
	Bias	Stand. Dev. (% and molec/cm ²)	Correlation	
Old OP	-43%	172% ; 9x10 ¹⁵	0.34	
Internal data: BIRA settings	-6%	55%; 3x10 ¹⁵	0.91	

« BIRA settings »: big improvement compared to previous operational processor.

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As expected: similar validation results

OFFL+RPRO v01.01.02 vs NRT v01.01.02

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Internal data: BIRA settings	-6%	55% ; 2.9x10 ¹⁵	0.91
OFFL + RPRO v.01.01.02 (which include BIRA settings)	-10%	57% ; 2.6x10 ¹⁵	0.82
NRT v.01.01.02	-26%	57% ; 2.6x10 ¹⁵	0.83

« BIRA settings »: big improvement compared to previous operational processor.

As expected: similar validation results

Very similar std & correlation; Mean bias is worse... Check why.

OFFL+RPRO v01.01.02 vs NRT v01.01.02



- NRT shows usually biases similar to OFFL+RPRO. (often negative)
- The difference in the mean of all data is mainly coming from higher positive biases at Kiruna and Wollongong.

Mean Bias: OFFL+RPRO and NRT v01.01.02



- TROPOMI systematic uncertainty requirement: 40-80%
- All stations are within 80%, except Kiruna.
- 15 (of 18) stations are within 40%.

Focus on OFFL+RPRO v.01.01.02 (more statistics)



- Mean nb of pixels in this validation: 45+/-25.
- Requirement for averaged pixels: 1.2x10¹⁶/sqrt(45)= 1.8x10¹⁵ molec/cm²
- For 14 (on 18) sites: the std > reported TROPOMI errors: missing random error source ?

Focus on OFFL+RPRO v.01.01.02 (more statistics)



launch requirements). Collocation should play a role

Clean polar stations





 Eureka, Thule, Ny-Alesund: ok in bias and std



- Kiruna: too high bias (>100%), but good std.
- Sodankyla: mean bias ok, but too large std.
- This 2 results are consistent: at both 67°sites, high bias May-July 2018

Polluted sites

- All polluted sites show std > the pre-launch requirements (1.2x10¹⁶ molec/cm²).
- It is not the case for clean sites, so we know that this is due to collocation criteria / spatial / temporal variability: more validation work is needed.



 Variability is well captured.

Focus on OFFL+RPRO v.01.01.02 (more statistics)

• Correlation is good = 0.82, and slope is 0.64.







B) HCHO validation using the UV-Vis networkRPRO-OFFL (v01.01.02)

RPRO+OFL data, processor v01.01.**02** from ESA HUB: "RPRO" 11/5 to 1/8, "OFL" 2/8 to 5/9/2018

UV-Vis data providers: AUTH (A. Bais), LufBlick (A. Cede), Chiba University (H. Irie), MPI-Mainz (T. Wagner), KNMI (A. Piters), UNAM (M. Grutter De La Mora), BIRA (F. Hendrick)

INOE (A. Nemuc), IAP/RAS (O. Postylyakov), NIWA (R. Querel), IUP-Bremen (A. Richter), NILU (K. Stebel), USTC Hefei (C. Liu), University of Alaska (W. Simpson), UToronto (K. Strong), UColorado (R. Volkamer), UWollongong (S. Wilson), IUP-Heidelberg (U. Friess), INTA (M. Yela, O. Puentedura), DLR (K.L. Chan), NASA (J. Herman), DWD (R. Holla), FMI (J. Hovila), JAMSTEC (Y. Kanaya), IERSD-NOA (S. Kazadzis), ULeicester (R. Leigh), GIST (J. Chong)

UV-vis Ground-based data

- Latest update 20 Sept.: partners uploaded their data on the NIDFORVAL ftp.
- <u>MAXDOAS</u>: harmonized recommendations; most sites follow outcome of CINDI campaigns and QA4ECV project
- <u>Pandora</u>: new HCHO directSun product (M. Tiefengraber) received from 3 pandonia stations (data from Nov to May → not used here)
- Uncertainty estimates: MAXDOAS: random ~30%, systematic ~20%



Comparisons examples

MAXDOAS vs S5P HCHO pixels within 20km of stations



Results overview: UV-VIS

MAXDOAS vs S5P HCHO pixels within 20km of stations Daily comparisons



Good comparisons except for the Mexican sites → Is this related to the comparison choices? Selection of S5P pixels within radius of 5km instead of 20km



Results overview: UV-VIS

MAXDOAS vs S5P HCHO pixels within 20km of stations Daily comparison differences



All the stations are within the bias requirements of 80%, most of them within 40%

- The std is usually > expected precision !
- → Structural comparison errors?!
- → Some random error in syst_SAT_error?

Conclusions based on FTIR and UV-Vis

- The NRT v01.01.02 data show similar bias and std than OFFL+RPRO v01.01.02 data.
- The OFFL+RPRO and NRT v01.01.02 biases (mostly negative) are within the 80% requirement at all sites (except Kiruna), and within 40% for 21 (out of 28) sites.
- For all clean FTIR sites (except Sodankyla & Paramaribo): the standard deviation are within the pre-launch random uncertainty requirements (and often much better, as expected).
- For all polluted sites: the std is > pre-launch random uncertainty requirements.
 Collocation should/could play a role.

Conclusions based on FTIR and UV-Vis

- For almost all FTIR and UV-Vis sites: the std > reported TROPOMI errors:
 - Missing random error source ? Random errors to be improved in the TROMOPI files ?
 - Might be improved when improved validation ? Missing a priori profiles for OFFL-RPRO PDGS/HARP overpasses files, smoothing not included yet for MAXDOAS comparisons,...
- **Future** within NIDFORVal:
 - harmonization in FTIR/UV-Vis comparison (collocation criteria, smoothing,...)
 - detailed inter-comparisons will be performed for sites where both FTIR and UV-Vis are present

• Extra-slides

Focus on OFFL+RPRO v.01.01.02 (more statistics)



• Very good correlation for monthly means (0.92), and the slope is 0.68.

Mountain clean stations



- The biases are within the 40% requirements for all clean moutain stations.
- The std are within the prelaunch requirements (1.2×10^{16}) molec/cm²) and within the achieved one (0.7×10^{15}) $molec/cm^2$, except Mauna Loa: few negative outliers remain.

Other clean stations





- The bias at Lauder is within the 80% requirements, but is > 40%.
- The std is within the pre-launch requirements (1.2x10¹⁶ molec/cm²) and) but NOT within the achieved one (0.7x10¹⁵ molec/cm²).

- The bias at Paramaribo is within the 40% requirement.
- The std is NOT within the pre-launch requirements (1.2x10¹⁶ molec/cm²).
- Outlier remains.

Polluted sites

- All polluted sites show bias within the 40% requirements (except Wollongong)
- But all show std > the pre-launch requirements (1.2x10¹⁶ molec/cm²).
- It is not the case for clean sites, so we know that this is due to collocation criteria / spatial / temporal variability: more validation work is needed.



Positive bias only at Wollongong + highest latitude sites (Eureka & Ny-Alesund): to be explored?

Comparison RPRO/OFFL data and NRT (all v01.01.02)



• Similiar standard deviation (as shown in the Table)

Comparison RPRO/OFFL data: from 11 May July & from 8 August



Comparison RPRO/OFFL data: from 11 May July & from 8 August



Comparison NRT data: from 18 July & from 8 August



Comparison NRT data: from 18 July & from 8 August



Very similar bias and Std, when enough comparisons.