PROGRAMME OF THE EUROPEAN UNION

co-funded with esa

Geophysical validation of Total Ozone retrievals from TROPOMI/S5P against ground-based observations and consistency to other satellite sensors

Katerina Garane, M. E. Koukouli, D. Balis @ AUTH, Greece

C. Lerot, T. Verhoelst, J.-C. Lambert, M. Van Roozendael @ BIRA-IASB, Belgium

K.-P. Heue, P. Valks, F. Romahn, W. Zimmer, D. Loyola @ DLR, Germany

A. Pazmino @ LATMOS, France

Outline

- Available TOC datasets (satellite & ground-based)
- Validation of the NRTI and the OFFL TOC products against ground-based measurements
- Indirect comparison of the TROPOMI TOC products to other satellite missions

Update from

Garane, K., Koukouli, M.-E., Verhoelst, T., Lerot, C., Heue, K.-P., Fioletov, V., Balis, D., Bais, A., Bazureau, A., Dehn, et al.,: **TROPOMI/S5P total ozone column data: global ground-based validation and consistency with other satellite missions**, Atmos. Meas. Tech., 12, 5263–5287, https://doi.org/10.5194/amt-12-5263-2019, 2019.

Level 2 TOC Data used for the validation

S5p/TROPOMI Total Ozone Column

S5P Product Requirements for TOC:
Mean Bias: 5 %
Random Unc. : 2.5 %

TOC UPAS processor versions:

Proc. Version	Time range
01.00.00 – 01.01.08	Until July 2020
02.01.03 & 04	7/2020 – 7/2021
02.02.01 & 02.03.00	7/2021 – 7/2022
02.04.01	7/2022 - …

→ Significant changes for the NRTI TOC (New surface albedo retrieval algorithm - TROPOMI GE_LER)

→ OFFL TOC: Significant changes (Updated CLOUD input)

→ Level 1b version 2.0.0 (NRTI & OFFL)

→ Level 1b version 2.1.0 (NRTI & OFFL)

Filters applied until 7/2020 (v.1):

NRTI TOC	OFFL TOC
0 < TOC < 1008.52 DU	0 < TOC < 1008.52 DU
180 K < Eff. Temper. < 260 K	180 K < Eff. Temper. < 260 K
Fitted RMS < 0.01	0 < Ring Scale Factor < 0.15
	-0.5 < Eff. Albedo <1.5

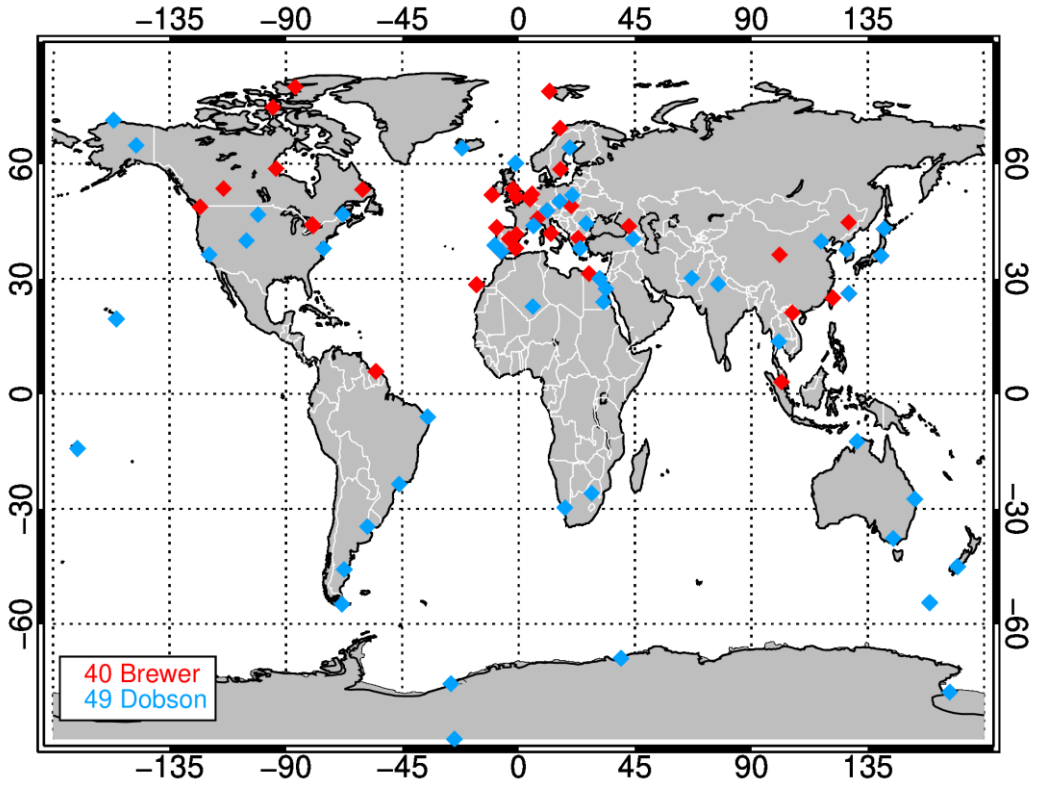
Filter applied since 7/2020 (v.2)
→ qa >0.5

Level 2 TOC Data used for the validation

Satellite data from other missions:

- GOME2-MetOpB GDP4.8
- GOME2-MetOpC GDP4.9

- OMI/Aura GODFITv4
- OMPS/Suomi-NPP GODFITv4



Ground Based TOC measurements:

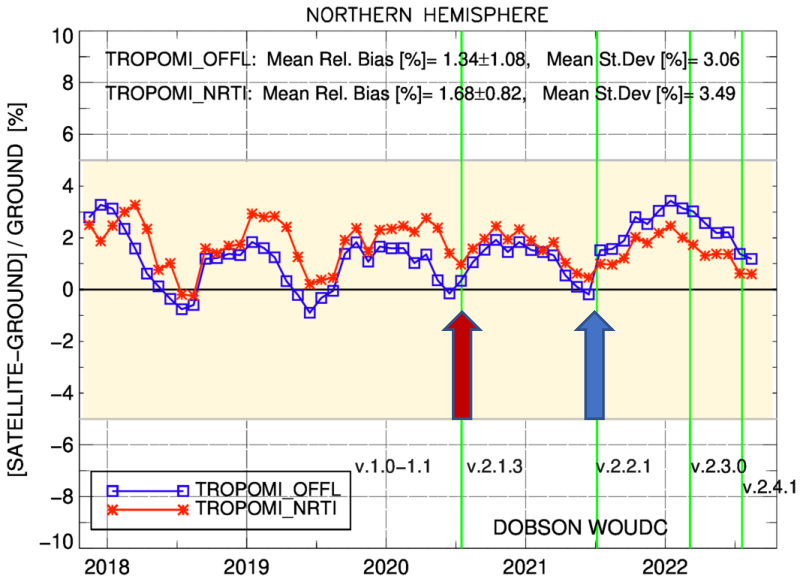
- Daily TOC DS measurements from WOUDC
  Dobson 49 instr. ; Brewer 40 instr.

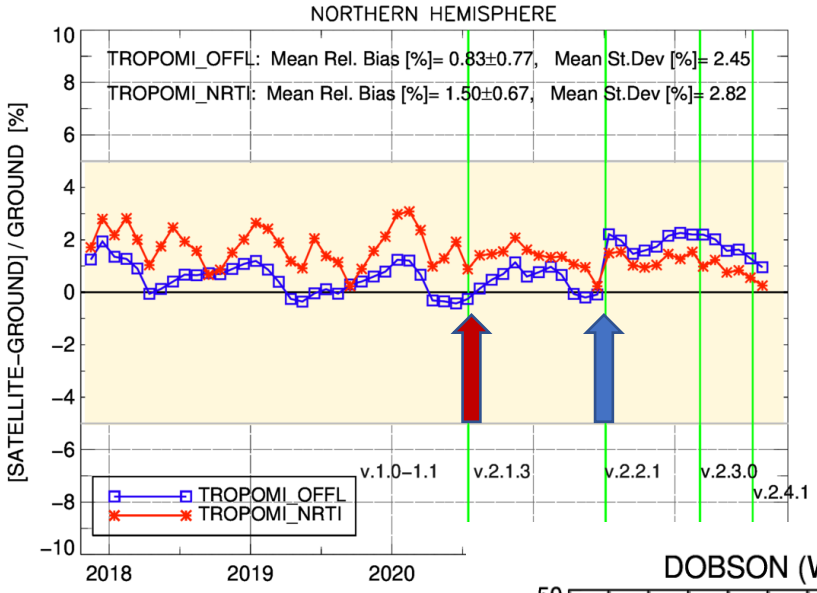
Co-location criteria

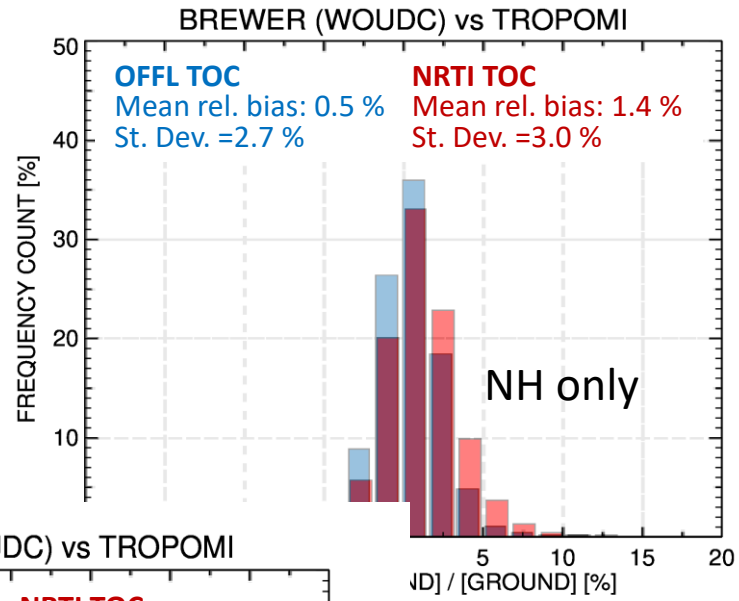
- Spatial search radius: up to 10 km (0-5 km for the majority of co-locations)
- WOUDC (daily TOCs): same day

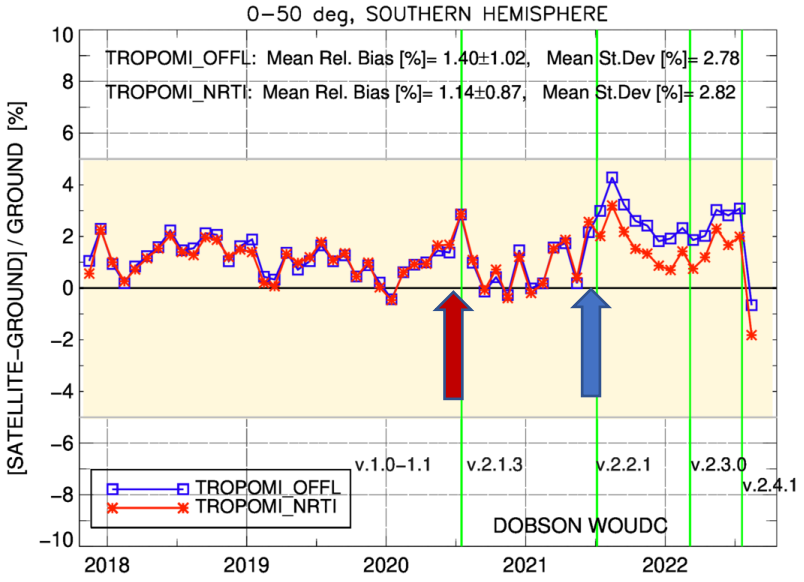
Validation results w.r.t. GB meas.

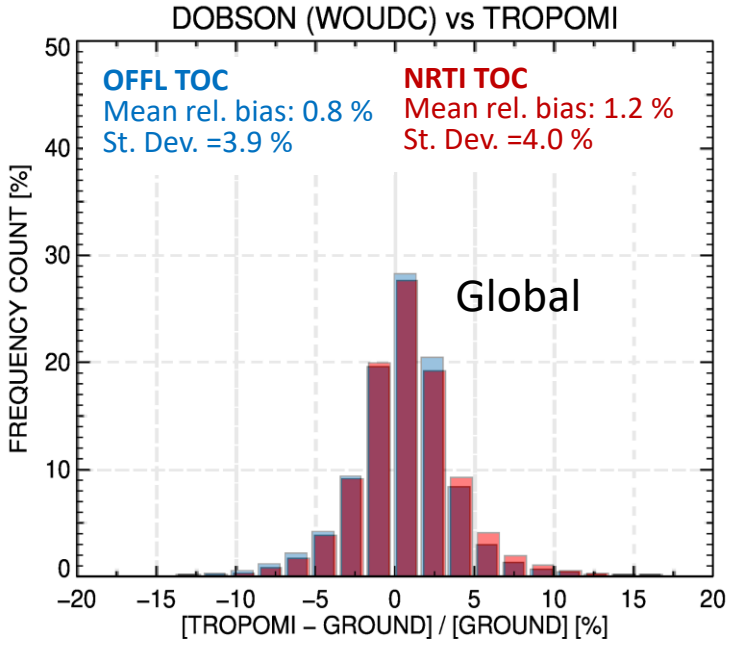
PROGRAMME OF THE EUROPEAN UNION
co-funded with esa











☐ OFFL
✱ NRTI

Validation results w.r.t. GB meas.

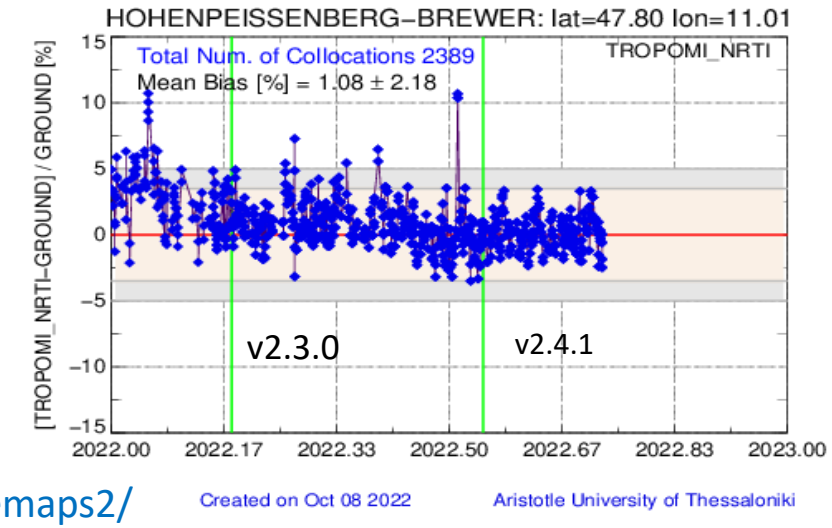
PROGRAMME OF THE EUROPEAN UNION

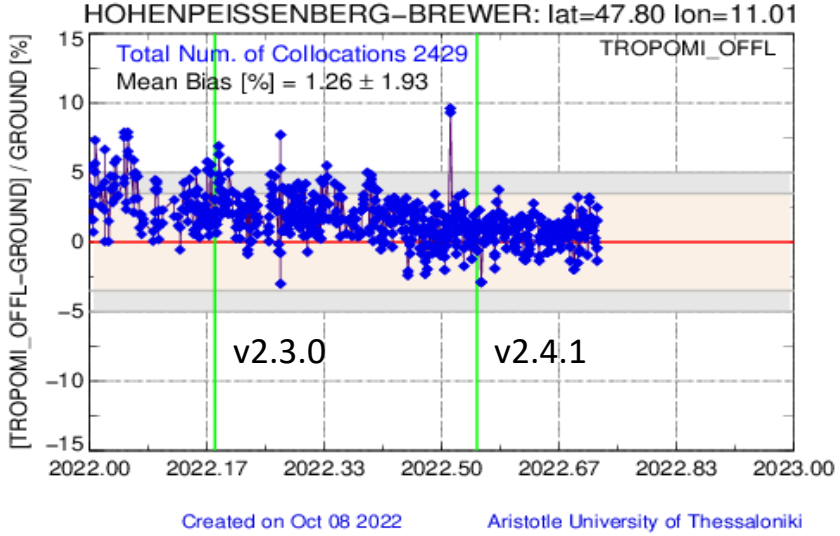
co-funded with

		OFFL		NRTI	
Proc. Version	Time range	Mean Bias (%)	Dispersion (%)	Mean Bias (%)	Dispersion (%)
1.0.0 – 1.1.8	Until July 2020	+0.5±0.6	2.6	+1.7±0.7	3.1
2.1.3 & 2.1.4	7/2020 – 7/2021	+0.5±0.6	2.5	+1.3±0.4 (-0.4 %)	2.8 (-0.3 %)
2.2.1 &2.3.0	7/2021 – 7/2022	+1.8±0.3 (+1.3 %)	2.0 (-0.5 %)	+1.1±0.3 (-0.2 %)	2.3 (-0.5 %)
2.4.1	7/2022 – 8/2022	No changes seem to be introduced by the L1b v2.1 data			

Ozone mapping center

http://lap.physics.auth.gr/ozonemaps2/

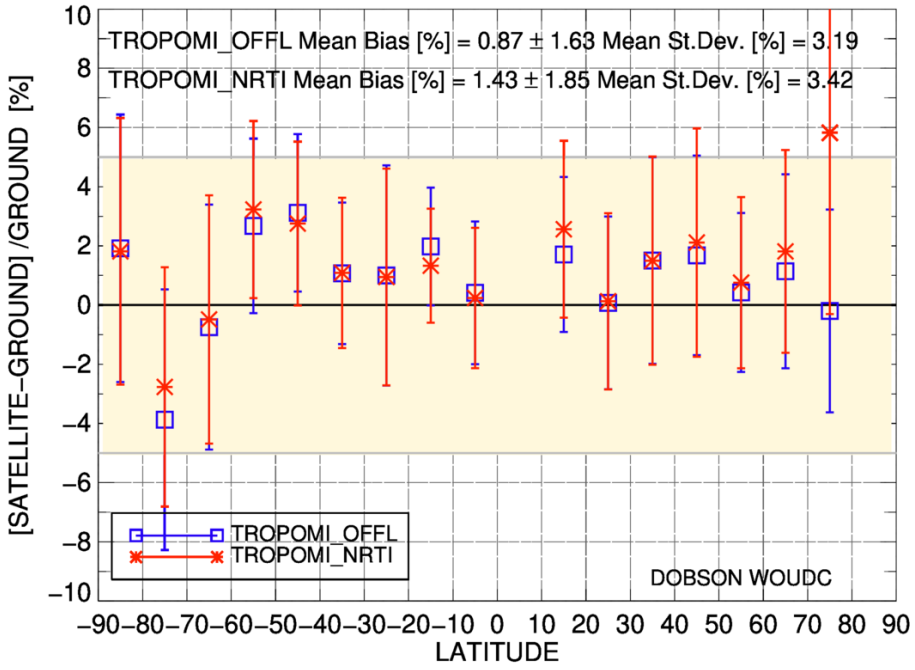


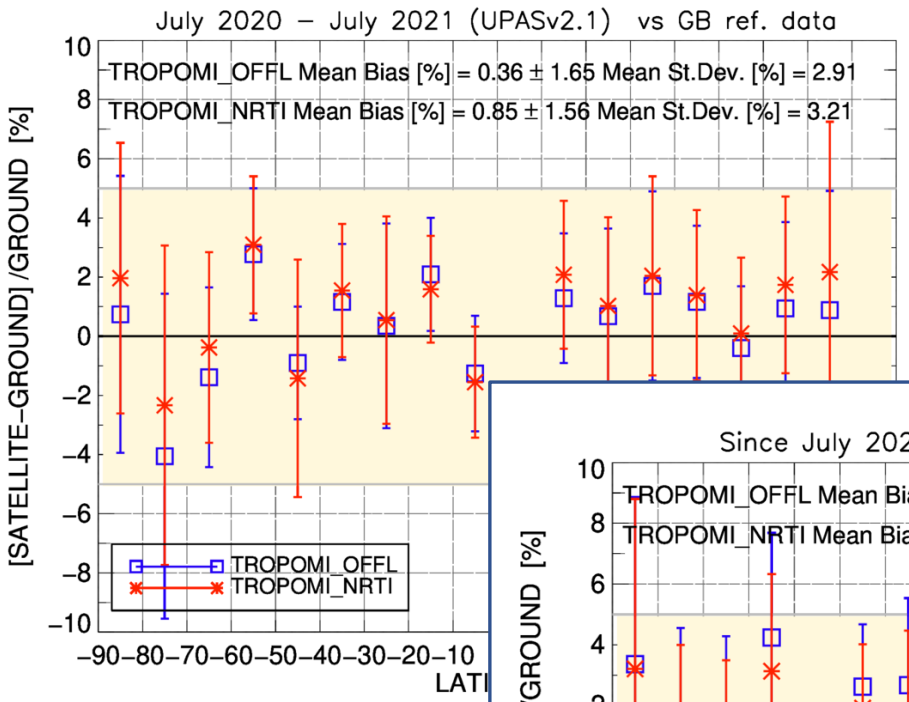


Validation results w.r.t. GB meas.

PROGRAMME OF THE EUROPEAN UNION
co-funded with esa

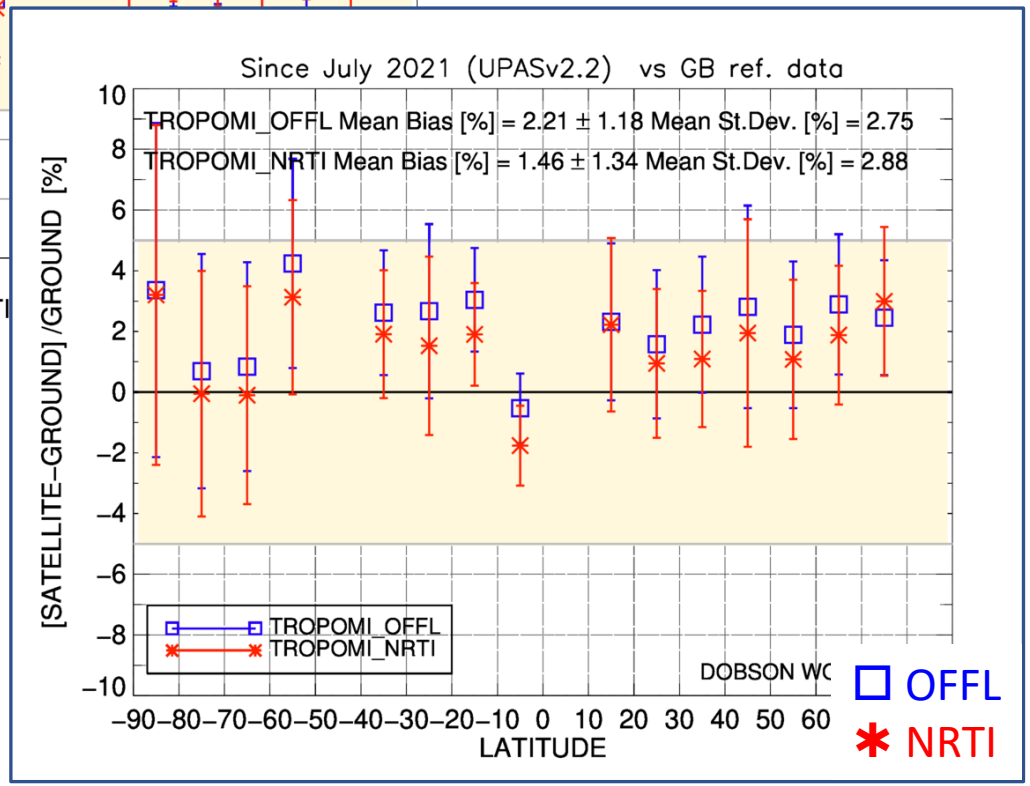
Full dataset





UPAS v2.2:

- Surf. albedo climatology (3 years of TROPOMI)
- New L1b V2.0 input
- Updated CLOUD input: OFFL



UPAS v1: different albedo parameters

NRTI: surface climatology (OMI)

OFFL: fitted effective albedo

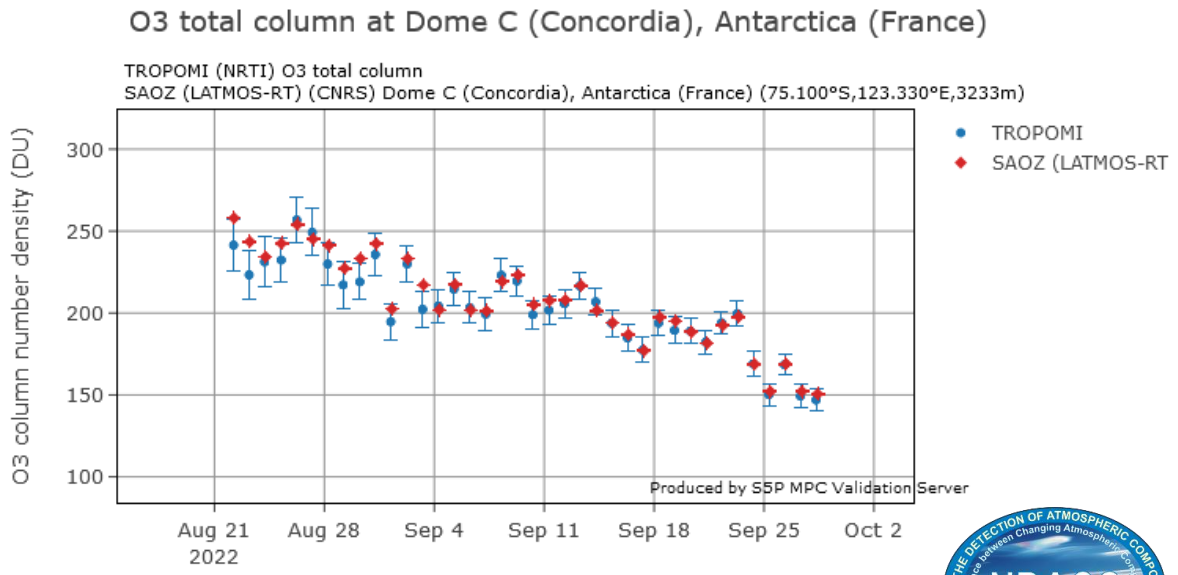
UPAS v2.1:

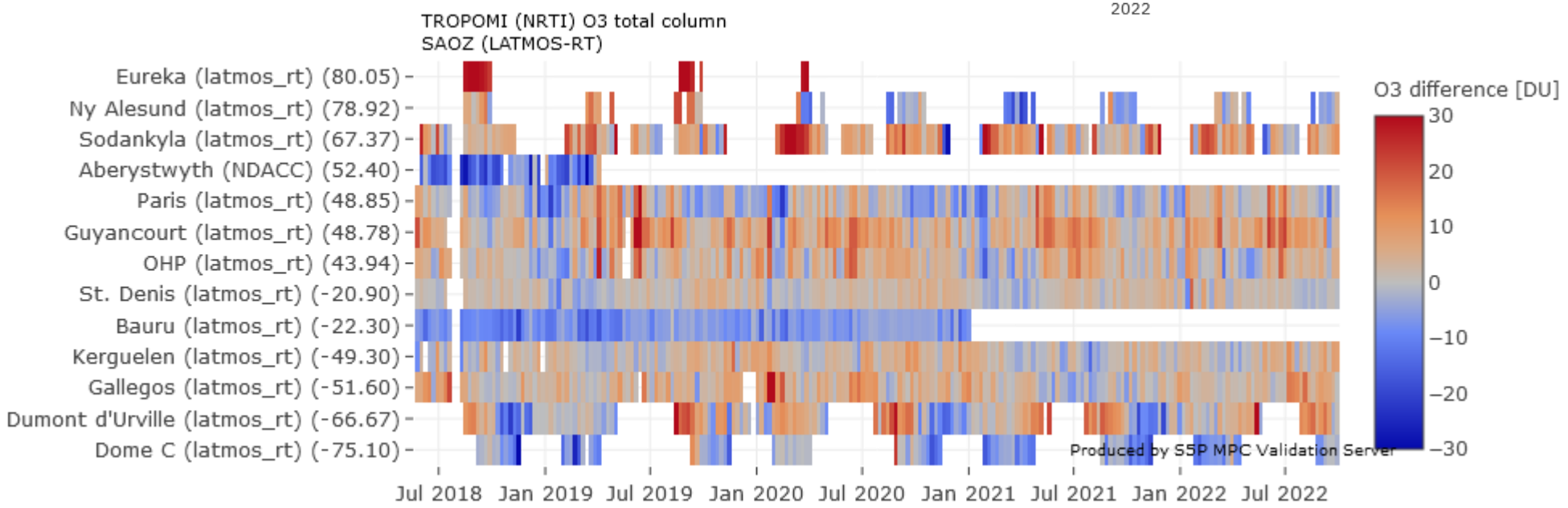
- New surface albedo retrieval algorithm (TROPOMI GE_LER): NRTI
- Updated CLOUD input product: OFFL & NRTI

Validation using NDACC ZSL-DOAS data

Validation using the LATMOS_RT SAOZ (automated Zenith Scattered Light DOAS) correlative data:

- Near-real time feedback on S5P total O_3 data quality (time lag: 2-3 days)
- Complementary to direct sun as they cover difficult regimes: high SZA, and/or cloudy scenes
- Confirm excellent S5P O_3 data quality, e.g., during ozone hole formation in the current Antarctic spring

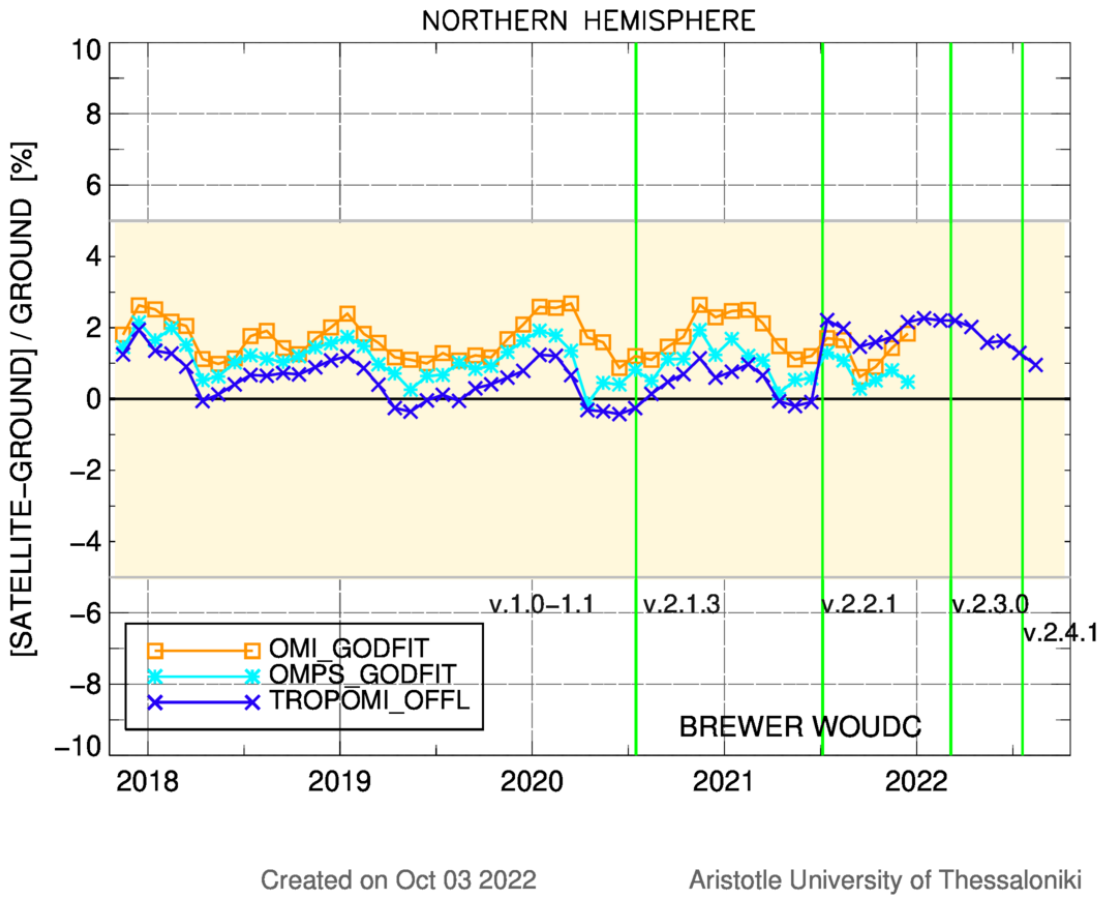




Courtesy of T. Verhoelst

Consistency checks with other missions

Total O_3 OFFL & GODFIT v4



GODFIT v4 data provided by Christophe Lerot & Jonas Vlietinck

☐ OMI GODFIT v4
✱ OMPS GODFIT v4
✖ TROPOMI OFFL

- **UPASv1 & v2.1**: TROPOMI TOCs lower bias than OMI (1-2 %) & OMPS (0.5 %) depending on season
- **UPASv2.2** : TROPOMI TOCs higher ~1-1.5%

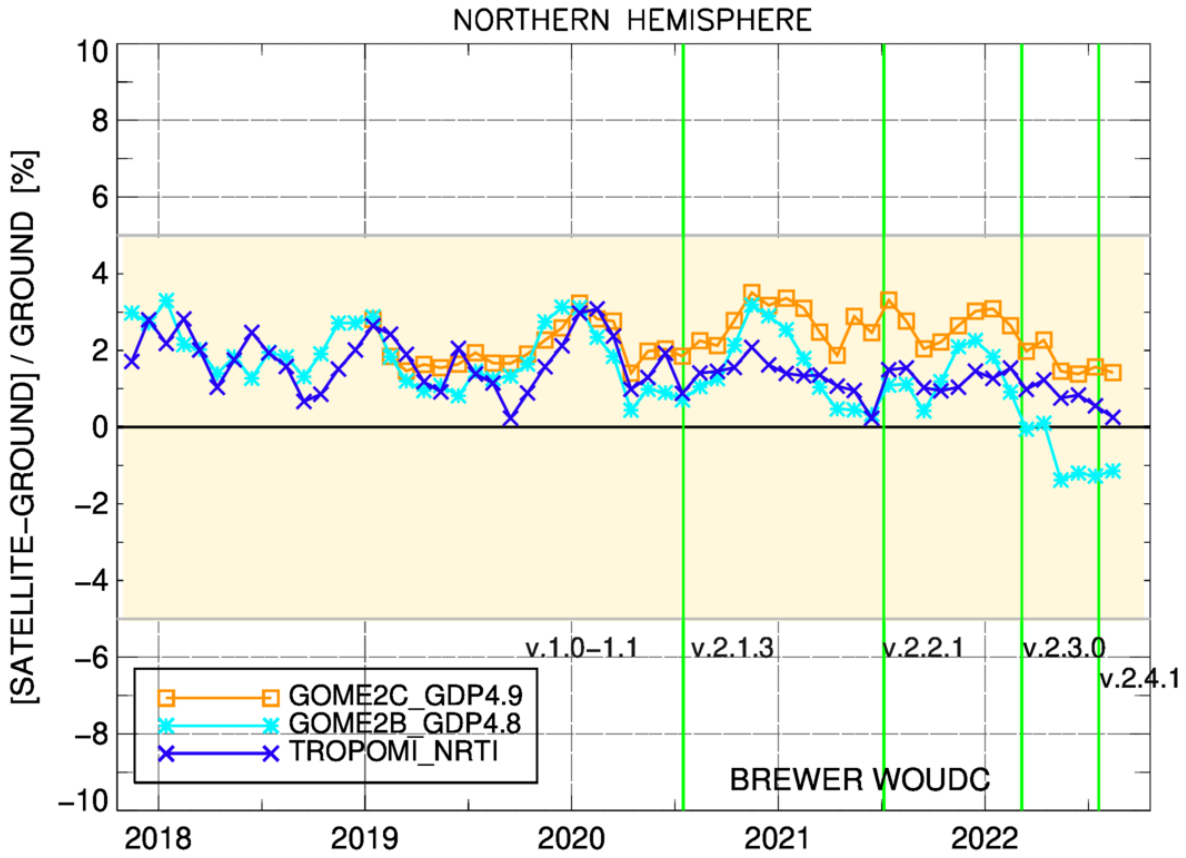
Consistency checks with other missions

Total O_3 NRTI & GDP4.8(9)

GDP data provided by Pieter Valks

DLR

☐ GOME2C GDP4.9
✱ GOME2B GDP4.8
✖ TROPOMI NRTI



- **UPAS v1:** agreement within ±0.5%
- **Since UPAS v2.1:** TROPOMI has a much lower seasonality, reporting lower TOCs by ~ 1-2% during winter months (w.r.t. GOME2B). GOME2C → +2% w.r.t. TROPOMI

Conclusions

AFTER FIVE YEARS OF OPERATION, TROPOMI/S5P total ozone…

- Global relative bias w.r.t. the ground-based TOC measurements:

  0.5- 0.8 % (OFFL) and

  1.2-1.4% (NRTI)

  → **within the mission requirements (5%).**
- The biases at individual stations and latitudes also satisfy this requirement.
- **The scatter of the differences also complies with mission requirements of ±2.5%.**
- The overall consistency of TROPOMI/S5P total ozone to the products of other satellite missions is good, reporting differences within ±2% (OFFL vs GODFIT v4 & NRTI vs GDP)

Thank you for your attention!

ARISTOTLE UNIVERSITY OF THESSALONIKI

agarane@auth.gr