





S5P TROPOMI L2_O₃ (RPRO + OFFL)

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(1) Royal Belgian Institute for Space Aeronomy (BIRA-IASB)
 (2) Aristotle University of Thessaloniki (AUTH)
 (3) Deutsches Zentrum fur Luft- und Raumfahrt (DLR)
 (4) LATMOS- CNRS













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- S5P and reference data
- Co-location approach
- Comparison using the MPC Automated Validation Server (VDAF-AVS), the Multi-TASTE versatile validation system, and the HARP Toolset
 - Bias and spread
 - Influence quantities: SZA, Clouds, Teff, QA Value
 - Evaluation of ex-ante uncertainties
 - RPRO and OFFL vs. NRTI
- Comparison using the AUTH validation system (summary only, cf. next talk)
- Conclusion and Recommendation



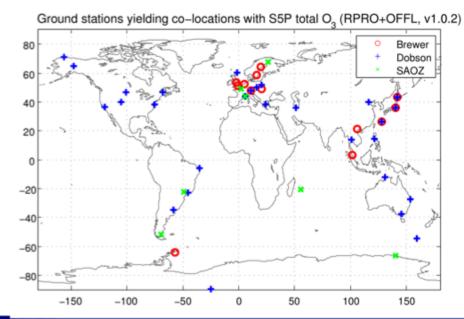


S5P TROPOMI data available for this validation

- RPRO (reprocessed), OFFL (GODFIT) processor v1.0.2: November 7th, 2017 August 1th, 2018
- OFFL, processor v1.0.2: July 13th September 14th, 2018

Reference data available for this validation

- GO3OS Brewer & Dobson direct-sun measurements (from WOUDC, also via EVDC): approx. 40 stations with up to 200 <u>unique</u> co-locations each.
- NDACC ZSL-DOAS/SAOZ measurements
 - LATMOS RT (real time) processing facility
 - 8 stations, ±240 co-locations each
- QC'ed by CORR_2 @ BIRA-IASB



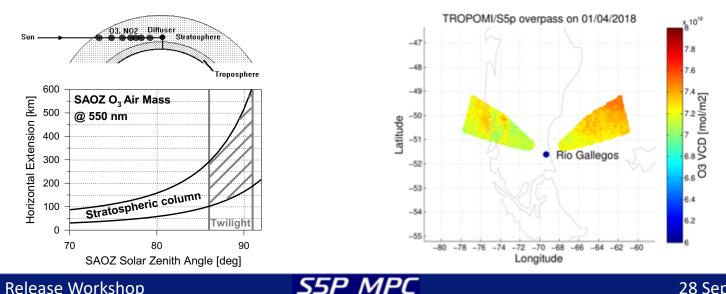
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Co-location approach

- Direct Sun:
 - VDAF-AVS and Multi-Taste : station within pixel and <3h time difference (if not daily means)
 - AUTH : all pixels within 50km, daily means only hitherto
- Twilight Zenith-Sky: TROPOMI pixels averaged over ZSL-DOAS observation operator; max 11h time difference



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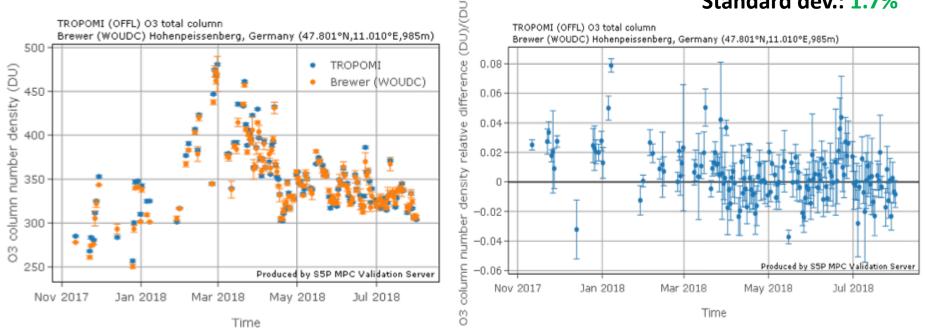




Comparison using the MPC Automated Validation Server (VDAF-AVS)

S5P vs. Brewer @ Hohenpeißenberg

Median diff.: 0.4% Standard dev.: 1.7%



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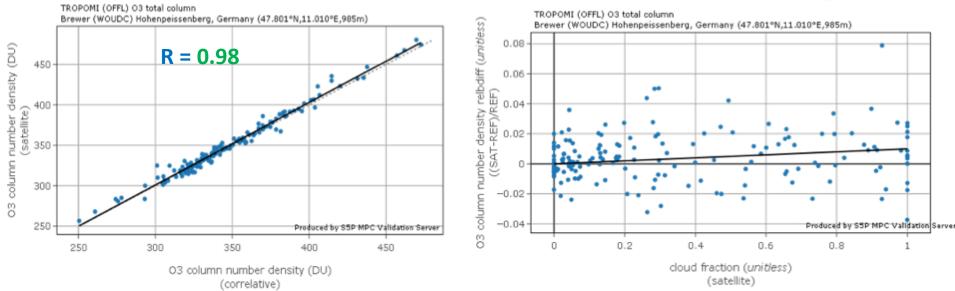


28 September 2018

Comparison using the MPC Automated Validation Server (VDAF-AVS)

S5P vs. Brewer @ Hohenpeißenberg

O3 total column correlation at Hohenpeissenberg, Germany



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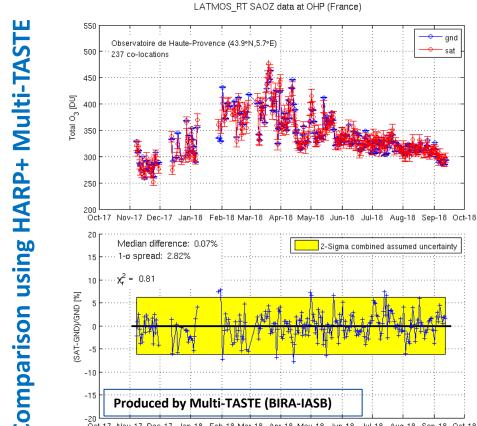
Correlations at Hohenpeissenberg, Germany

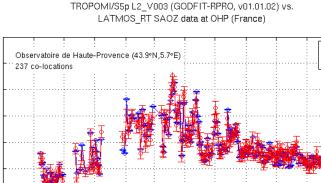
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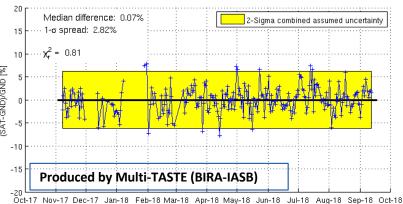


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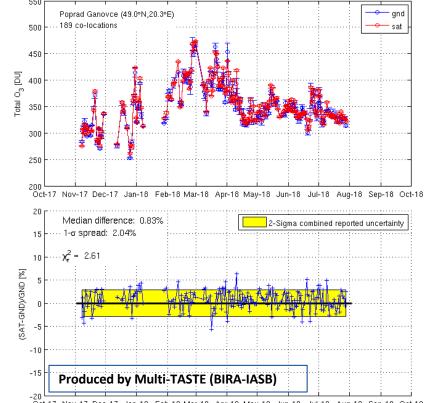








TROPOMI/S5p L2_V003 (GODFIT-RPRO, v01.01.02) vs. WOUDC Brewer data at Poprad Ganovce (Slovakia)



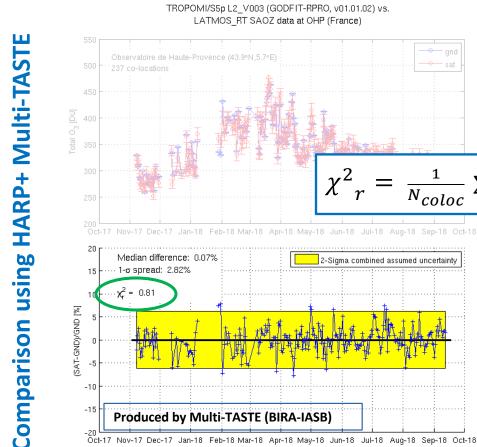
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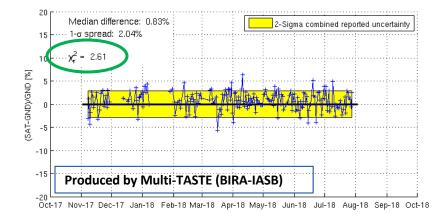






TROPOMI/S5p L2_V003 (GODFIT-RPRO, v01.01.02) vs.

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TROPOMI/S5p L2_V003 (GODFIT-RPRO, v01.01.02) vs. WOUDC Brewer data

50

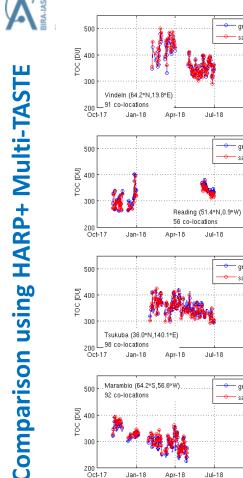


and

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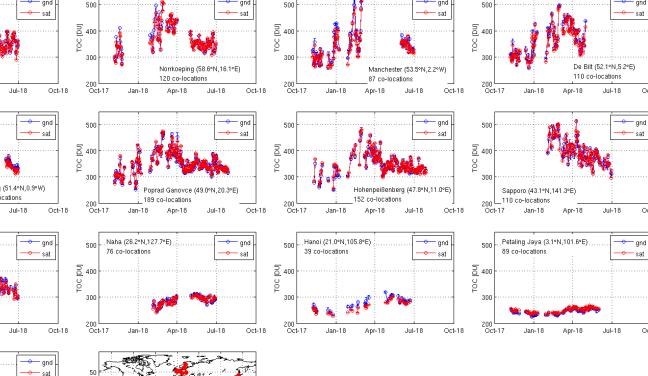


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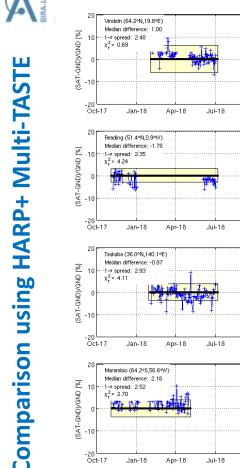


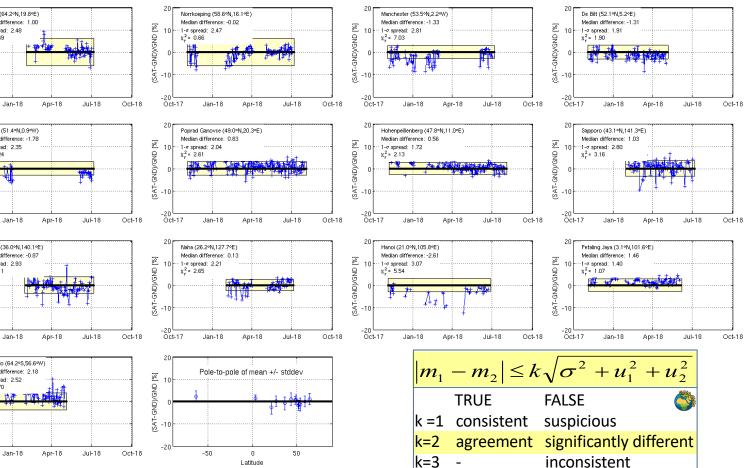
50 100 150



TROPOMI/S5p L2_V003 (GODFIT-RPRO, v01.01.02) vs. WOUDC Brewer data

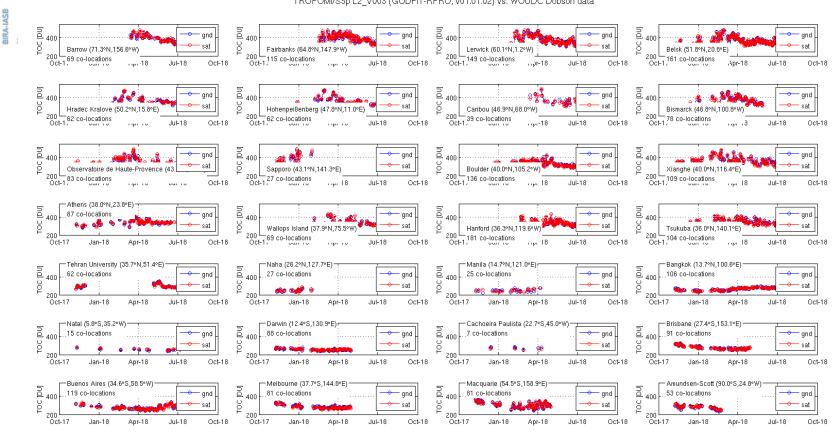




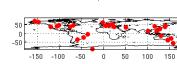


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Multi-TAST

HARP+

using

Comparison

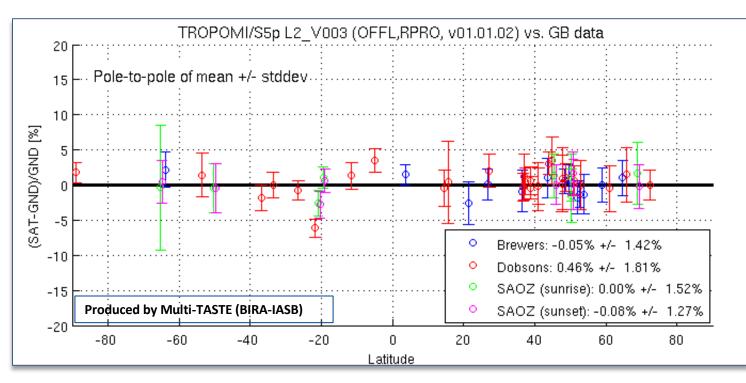


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TROPOMI/S5p L2 V003 (GODFIT-RPRO, v01.01.02) vs. WOUDC Dobson data





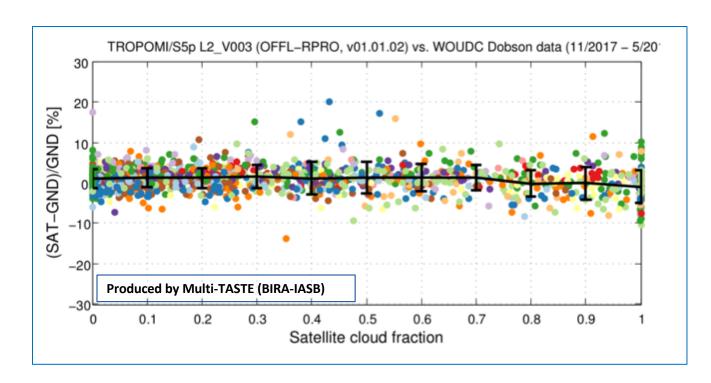


qa_value>0.5

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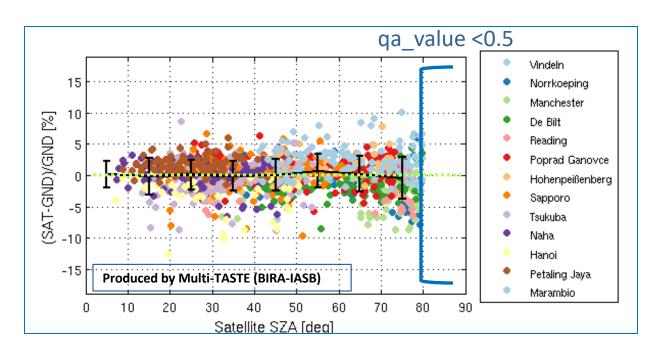


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Multi-TASTE HARP+ using Comparison

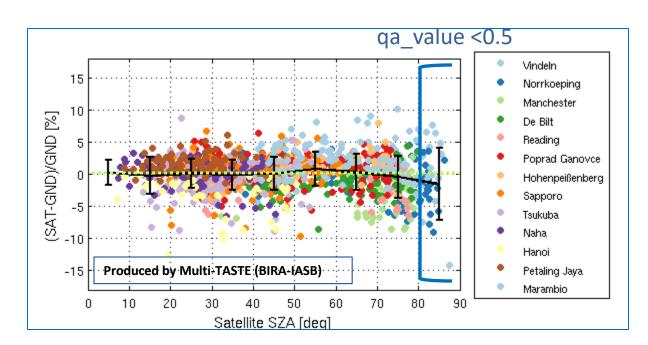


Filtered: qa_value>0.5









Unfiltered







Vindeln 15 Norrkoeping Manchester (SAT-GND)/GND [%] 10 De Bilt Reading 5 Poprad Ganovce Hohenpeißenberg I/S5p L2_V003 (GODFIT-RPRO, v01.01.02) vs. WOUDC Dobson data Sapporo -5 Tsukuba Naha. -10 Hanoi -15 Produced by Multi-TASTE (BIRA-IASB) Petaling Jaya Marambio 200 210 220 230 240 250 O₂ effective temperature [K] (SAT-GNE N -5 Comparison -10 Produced by Multi-TASTE (BIRA-IASB) -15 205 235 240 245 200 210 215 220 225 230 250 O₂ effective temperature [K]

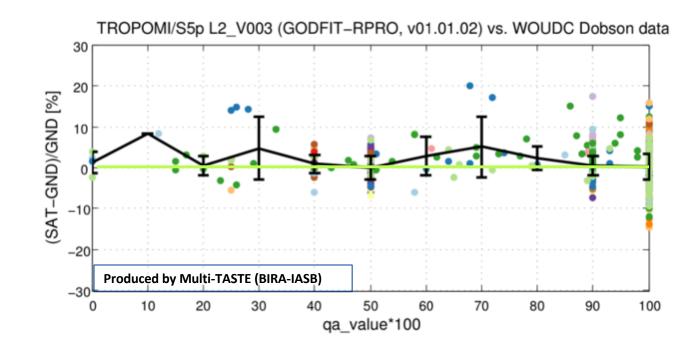
TROPOMI/S5p L2_V003 (GODFIT-RPRO, v01.01.02) vs. WOUDC Brewer data

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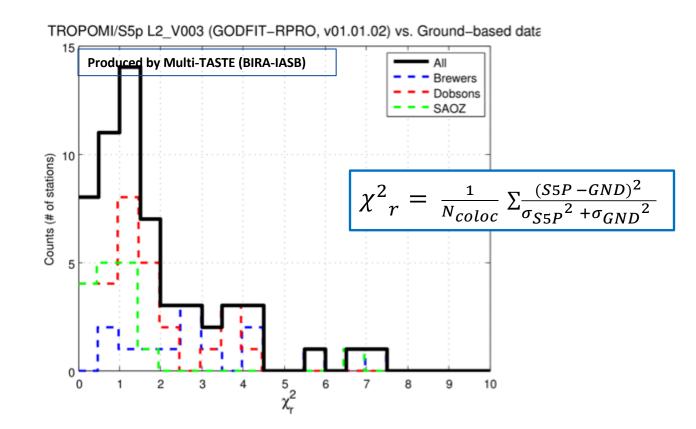
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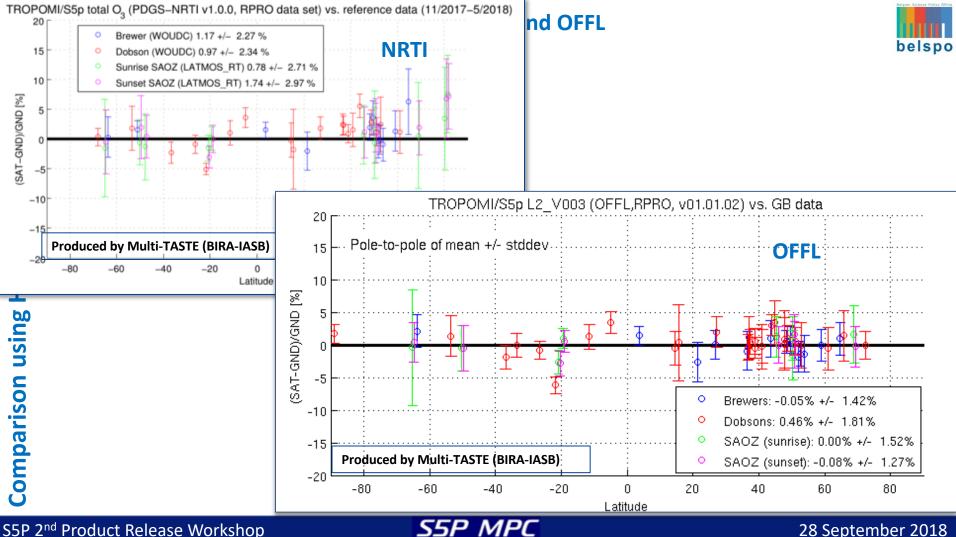






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Comparison using the AUTH validation system: brief summary (see next talk)

- No significant dependences on geometrical, input or product parameters are detectable.
- The TROPOMI mean bias and mean standard deviation (vs. Brewers and Dobsons) is within requirements:

	Dobson	Brewer	User requirements
Mean bias (%)	0.8 - 0.9	0.3 - 0.4	3.5 – 5 %
Mean St. dev.	2.3 - 3.1	1.9 – 2.3	1.6 - 2.5 %

- Compared to Aura OMI-DOAS and OMI-TOMS, TROPOMI reports higher values by 1 1.5 %.
- Compared to OMI-GODFIT and OMPS-GODFIT, TROPOMI reports lower values by 1%



issue 1.0.0, 2018-09- - Released

- Conclusion for RPRO & OFFL v1.0.2
- S5p captures accurately short-term variations in total ozone observed above approx. 50 ground stations (**Pearson correlation score >0.9**).
- The bias rarely exceeds 3%, with a network median bias of <1%. This is well within the mission requirements (bias at most 3-5%)
- The standard deviation of the difference wrt direct-sun data rarely exceeds 2%. This is <u>within the mission requirements (</u><2.5%).
- The ex-ante uncertainties provided in the S5P data files look realistic.
- The bias varies by a maximum of 2% over the sampled range of influence quantities (SZA, clouds), except perhaps at extreme Teff (TBC). The spread increases at low Sun elevation (SZA > 80°).
- **QA_value filtering** recommendations might need further polishing.

Coherent with analysis by AUTH and DLR (see next presentations)

MPC Product Readme file

SP MPC

<u>Blas</u>: the systematic difference between SSP and reference ground-based data at individual stations rarely exceeds 2%, as depicted in Figure 1. The median blass calculated over the entire ground-based networks is of the order of 0-0.5%. Between 50'S and 50'N, the mean agreement with other satellite data usually is within 1% as well. This median blas value falls well within the mission requirements (max, blas of 3.5-5%).

- <u>Random difference</u>: the ±1c spread of the differences (between S5P and reference data) around the median value rarely exceeds 2-3% for the comparisons with direct-sun instruments. Combining random errors in satellite and reference measurements with irreducible co-location mismatch effects, it is likely that the random uncertainty on the S5P measurements falls within mission the requirements of max. ±2.5%.
- Dependence on influence quantities: The analysis of potential dependence of the SSP bias and comparison spread on the Solar Zonith Angle (SZA), Air Mass Factor (AMF) and cloud fraction (CF) of the SSP measurement does not reveal yet any variation of the bias larger than 2% over the range of those influence quantities. Biases of -3% and +3% could exist at very small (<210K)) and large (>240K) effective temperatures respectively, but this needs confirmation with more co-locations in these regimes. No bias larger than 1% is observed at more moderate effective temperatures.
- <u>Geographical patterns:</u> Maps of the bias between S5P and other satellike data sets reveal
 patterns correlating with weather patterns and atmospheric circulation features. These
 patterns are likely to be associated with differences in the processing of the cloud properties,
 and also to differences in overpass times (3.5 hours difference between S5P and GOME-2),
 although there is a systematically positive difference between S5P and GOME-2 total zone
 values in these structures. Due to an issue in the used albedo climatology, the ozone total
 column is likely to be underestimated beyond 55°.
- <u>Short-term variability:</u> Qualitatively, at all of the 50 reference stations, short scale temporal variations in the ozone column as captured by ground-based instruments are reproduced very similarly by S5P. The overall good agreement is corroborated by Pearson correlation coefficients always above 0.95.

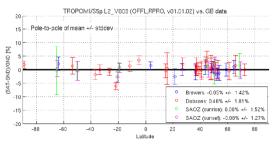


Figure 1 - Meridian dependence of the median and spread (±1 sigma) of the bias between SSP TROPOMI L2_03 (PDGS OFFL processor v1.0.2, RPRO+OFFL data set) and ground-based reference ozone column data, represented at individual stations from the Antarcia to the Arctic and per reference measurement type (Brewer, Dobson and SAOZ). The values in the legend correspond to the median and spread of all median (per station) differences. For clarity, sunrise and sunset SAOZ results have been offset by -0.5' and +0.5' in latitude.



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SSP MPU

issue 1	I.0.0, 2018-09 Released	Page 9 of 15
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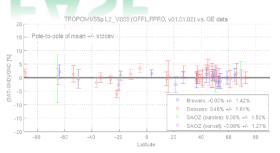


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