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TROPOMI/S5P Total Column Water Vapor Product: validation against AERONET ground-based measurements

Katerina Garane (agarane@auth.gr),
Ka Lok Chan, Maria Elissavet Koukouli, Diego Loyola, Dimitris Balis

Satellite Data

The **TROPOMI/S5P Total Column Water Vapor (TCWV)** is a new product retrieved from the visible blue band (435–455nm), using an algorithm that was originally developed for GOME-2 (Chan et al., 2020, AMT). The algorithm is based on the DOAS technique and is presented by Chan et. al, 2022 (STE).

Uncertainty: ~ 10-19 % (tropics)

TROPOMI/S5P TCWV data availability:
May 2018 to December 2020, almost 2.5 years.

Filtering criteria (according to Chan et al., 2022):
(a) solar zenith angle <85°,
(b) effective cloud fraction <0.5,
(c) Root Mean Square fit residual <0.002 and
(d) Air Mass Factor >0.1

Ground-based Data

For the validation purposes of this work, the co-located precipitable water Level 2.0 (quality-assured) measurements from **the NASA AERONET** (AErosol RObotic NETwork, https://aeronet.gsfc.nasa.gov/) were used. The network uses CIMEL Sun photometers located at about 1300 stations globally to monitor precipitable water, among other products.

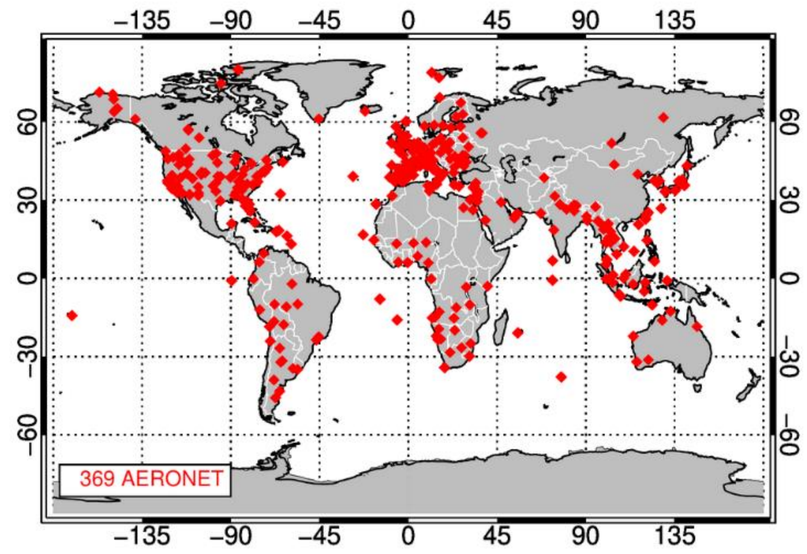
Validation by Perez-Ramirez et al., 2014: dry bias of approximately 5–6 %

AERONET processing algorithm: version 3 (Giles et al., 2019), cloud-free dataset.

Uncertainty: ~10 %

Co-location methodology:

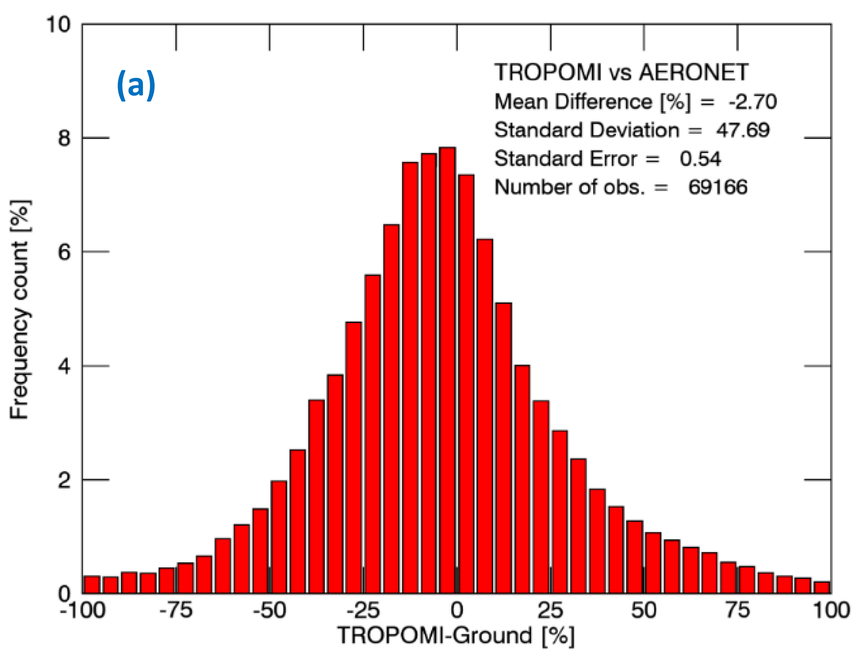
The two datasets, satellite and ground-based, were co-located in space (max distance = 10km) and in time (pixel with the min time difference within 30') and the percentage differences of the comparisons were calculated and statistically analyzed.



Spatial distribution of the 369 AERONET ground-based stations used for the comparisons to TROPOMI/S5P TCWV product.

Validation Results

Garane et al., AMTD, https://doi.org/10.5194/amt-2022-94



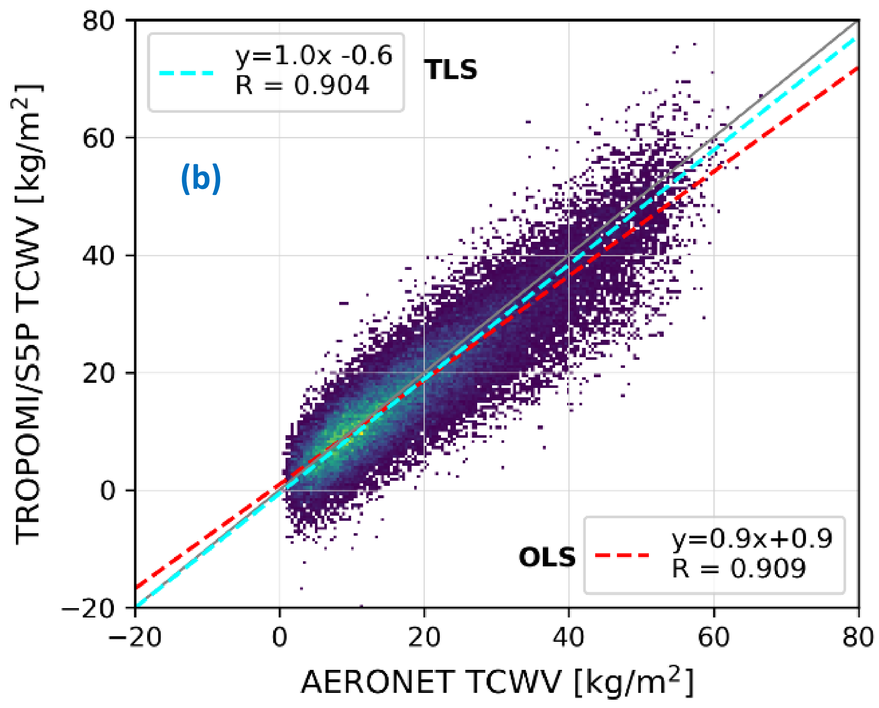
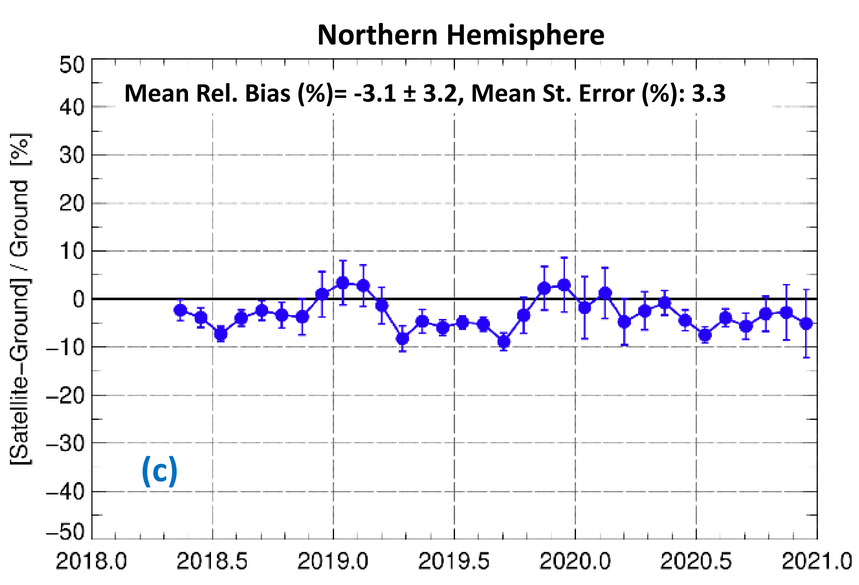


Figure a: The distribution of the satellite and ground-based co-location relative differences.

Figure b: Density scatter plot that shows the correlation between TROPOMI/S5P TCWV and the AERONET observations. The statistical analysis was performed using the ordinary least squares (OLS - red dotted line) and the total least squares (TLS - cyan dotted line) methods.

	NH	SH	Globally
Mean Bias ± 1σ	-3.1 ± 3.2 %	+0.9 ± 8.6 %	-2.7 ± 4.9 %
Standard Error (99.7 % CI)	3.3 %	8.2 %	0.5 %
Co-locations	58 200	11 000	69 200



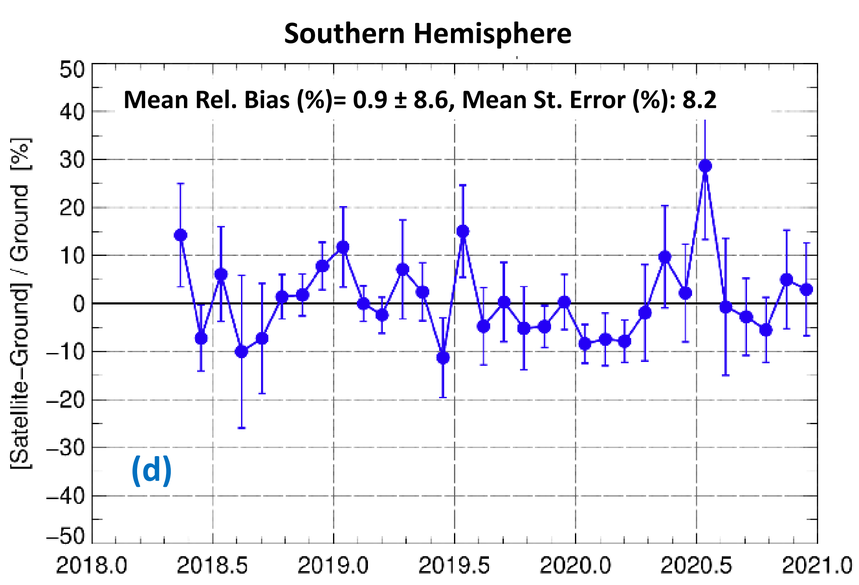
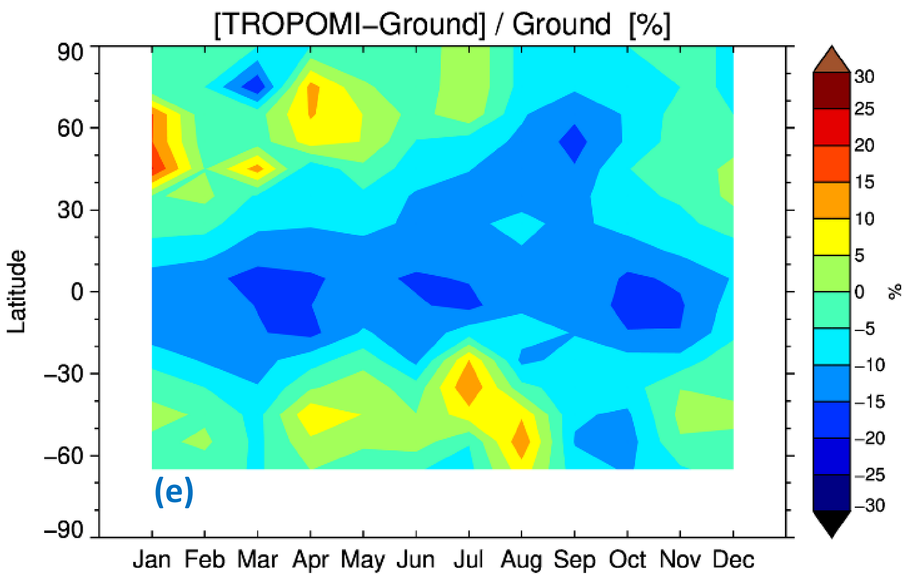


Figure c: The time series of the monthly mean relative differences between TROPOMI/S5P TCWV and ground-based AERONET measurements, shown for the Northern Hemisphere. The error bars stand for the standard error of the mean with a confidence interval (CI) of 99.7%.

Figure d: The same as in Figure c, but for the Southern Hemisphere relative differences.



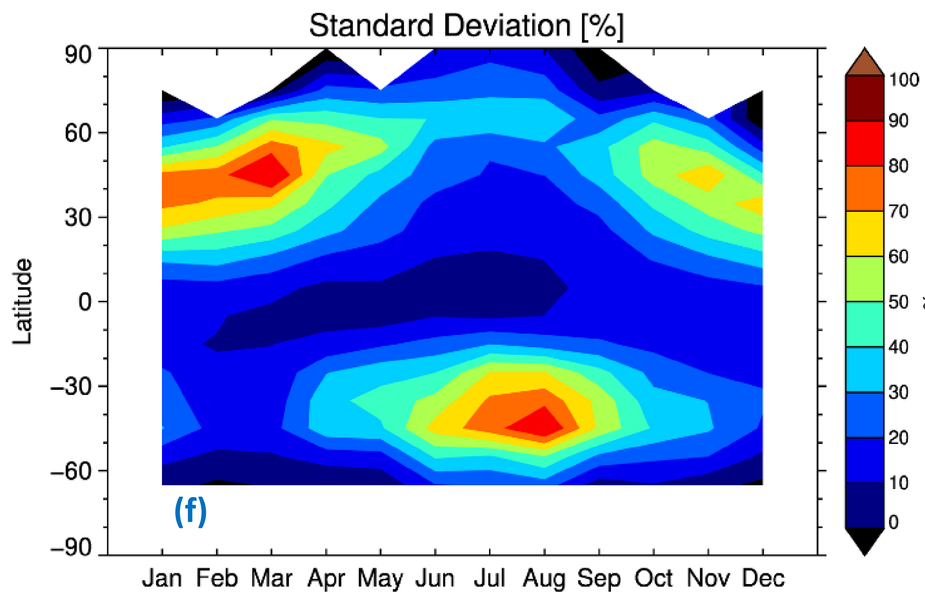


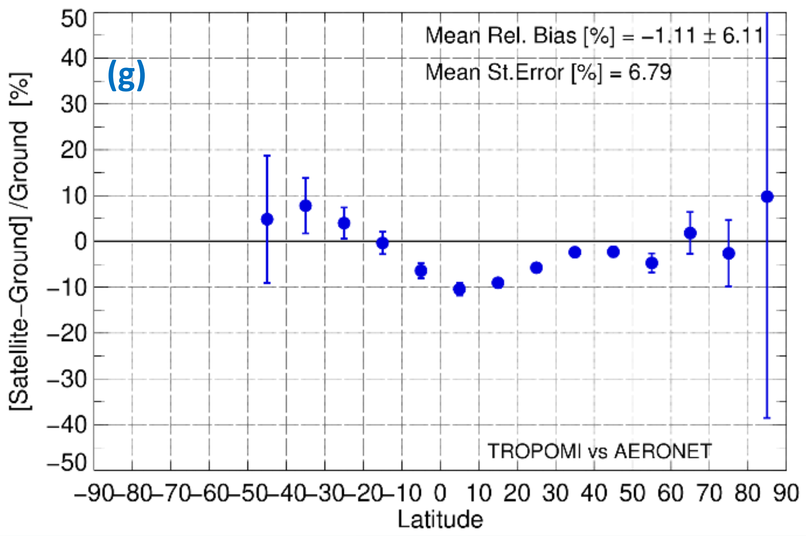
Figure e: The seasonal and latitudinal variability of the mean relative differences between satellite and ground-based TCWV observations.

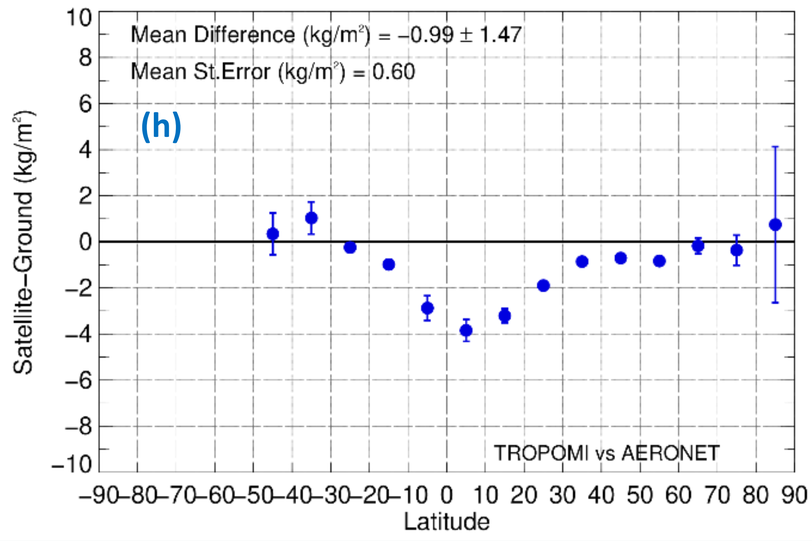
Figure f: The same as in Figure e, but for the respective standard deviations (in %).

Figure g: The relative percentage differences between co-located TROPOMI/S5P TCWV measurements and ground-based observations from AERONET instruments plotted versus latitude.

Figure h: The same as in Figure g, but for the differences between satellite and ground-based observations in kg/m^2.

In both panels the error bars show the standard error of the mean with a confidence interval (CI) of 99.7%.





Conclusions

The overall mean relative difference between TROPOMI/S5P and AERONET TCWV observations is -2.7 %, within their uncertainties. Pearson correlation coefficient is 0.91.

Considering the dry bias of the AERONET observations, which is about -5 to -10 % and varies with season and latitude, it can be concluded that **the satellite TCWV observations have a dry bias with respect to the "absolute" truth of about -8 to -13 %, respectively.**

Acknowledgments:
We thank the AERONET PI investigators and their staff for establishing and maintaining the 369 sites used in this work.