S5P MPC VDAF Validation Web Article: Total Carbon Monoxide

Contributing authors

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Product definition

The following table contains a description of the S5P TROPOMI processor versions used in this report.

Processor Version	In operation from	In operation until
01.00.01	RPRO orbit 449, 2017-11-14	RPRO orbit 2873, 2018-05-03

The data used in this report has the following DOI: https://doi.org/10.5270/S5P-1hkp7rp.

Product requirements are described in the Sentinel-5 Precursor Calibration and Validation Plan for the Operational Phase source: ESA; ref: ESA-EOPG-CSCOP-PL-0073; issue: 1.0 date 2017-06-11, Sentinel-5P-Calibration-and-Validation-Plan.pdf

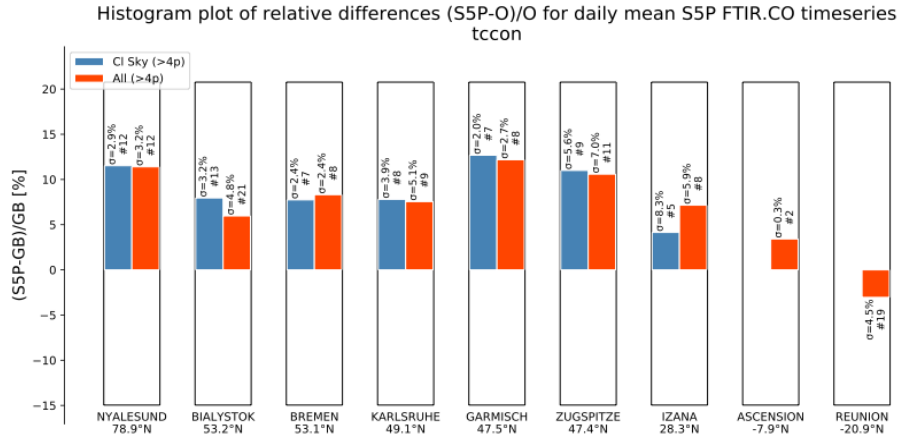
Validation results

Sentinel-5 Precursor TROPOMI L2_CO carbon monoxide column data retrieved with the OFFL processor (v1.0.1) have been compared to correlative reference measurements acquired by FTIR instruments contributing to both the NDACC and TCCON networks. Over the period tested (November 2017 up to 1 May 2018) and with respect to the reference data available at the time of this analysis, of the order of 14 NDACC stations and 9 TCCON stations contributed, sampling many latitudes from the Arctic to the Antarctic. NDACC provides CO concentration profiles with sensitivity between the surface and ±20km. TCCON measures dry air column averaged CO concentrations: an S5P xCO value is computed using the S5P surface pressure and water column (N. Deutscher (2010)).

S5P CO data have been filtered on the solar zenith angle (< 80 deg), the sensor zenith angle (< 65 deg), sensor azimuth angle (> 0 deg), and on the cloud properties: cloud height < 5000 m, and clear-sky conditions with cloud optical depth < 0.5. S5P ground pixels within a 50km radius from the reference measurement have been taken into account and averaged to form a representative S5P measurement. Altitude differences between the satellite pixel and the groundbased instrument altitude (e.g. for mountain sites, where the mean altitude of the S5P pixels is typically below the FTIR station) are compensated by scaling the S5P CO column proportionally to the altitude of the instrument. The S5P CO a priori profile is used to estimate the fraction of the satellite column between the satellite pixel surface altitude and the instruments altitude. Due to the limited number of co-locations available at present time, the reported statistical indicators are sensitive to the pixel selection. If clear sky conditions do not occur for a least 5 pixels in the S5P average, the data are not taken into account in the present analysis, as it happens currently for Izaña, Ascension and Reunion. The results illustrated in Figures 1 and 2 and summarized below are therefore preliminary.

Ground-based data comparisons with the S5P MPC Validation Data Analysis Facility (VDAF) lead to the following preliminary conclusions:

- Short-term variability: for all the reference stations, short scale temporal variations in the CO column as captured by ground-based instruments are reproduced very similarly by S5P OFFL. This overall good agreement is corroborated by Pearson correlation coefficients well above 0.7.
- Bias: the relative difference between S5P and reference data averaged over the entire ground-based networks is of the order of 10%. The mean relative difference may exceed 10% at individual stations with few co-locations. This bias falls well within the mission requirements (bias at most 15%).



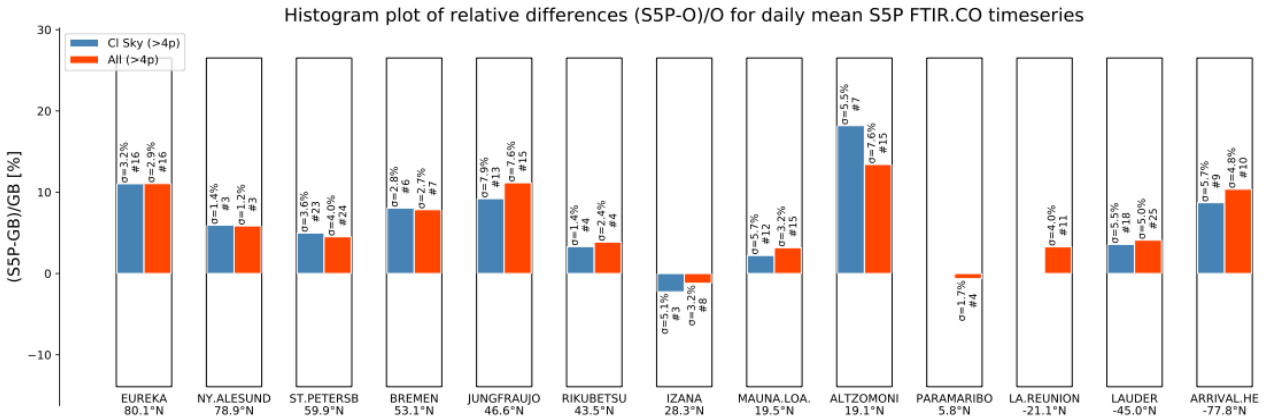


Figure 1 - Mean and spread (1 sigma) of the percent relative difference between S5P L2_CO and ground-based FTIR column data from TCCON (top) and NDACC (bottom) on a daily basis. The values in the legend correspond to the median and spread of all median differences. The mean bias is typically below 10%. Higher values are reached at stations with limited co-locations.

- Random uncertainty: The 1σ spread of the relative difference (between S5P and reference data) around its median value rarely exceeds 7%. Combining random errors in satellite and reference measurements with irreducible co-location mismatch effects, this value can be taken as a conservative upper limit of the random uncertainty on the S5P measurements, which satisfies the mission requirements (random uncertainty < 10%).

Overall, product quality of this initial L2_CO dataset appears to comply with the S5P mission requirements. Current conclusions are nevertheless based on a limited initial dataset of measurements between November 2017 and 1 May 2018. The current validation analysis need to be extended over a full year of measurements, hence, a full cycle of key influence quantities, in order to enable detection of potential patterns, dependences, seasonal cycles and longer term features like drifts.

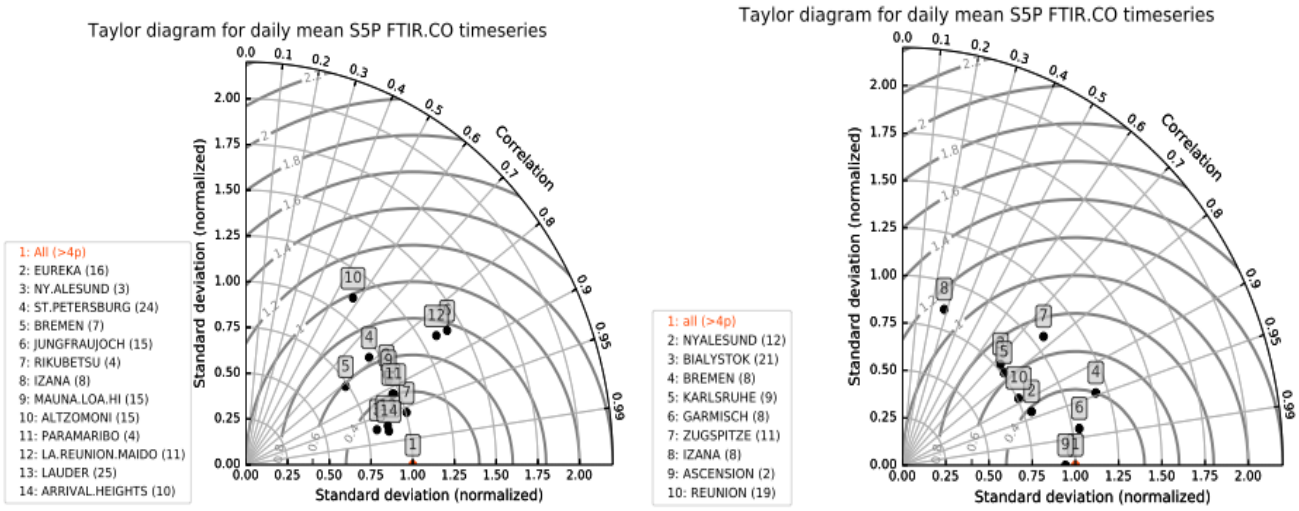


Figure 2 - Taylor diagrams for the S5P L2_CO (OFFL processor v01.00.01 & RPRO data set, normalized to 1) and ground-based FTIR column data from NDACC (left) and TCCON (right) on a daily basis. Most stations have a correlation above 0.7 and the distance to S5P reference on x-axis is below 0.5, or equivalently the standard deviation of the difference between the S5P and FTIR time series (distance to S5P reference on x-axis) is below 0.5 of the STD of the corresponding S5P time series. Outliers are Altzomoni (close to the highly polluted Mexico City, where an improved co-location method is appropriate) and Izana (very few co-locations available).

Striping

Figure 3 shows an NDACC FTIR measurement at St. Petersburg and the S5P CO pixels surrounding the measurement. The plot illustrates the stripes in the CO L2 data product and that these are important also in the microscale, eg in the validation studies were pixels are selected around groundbased instruments.

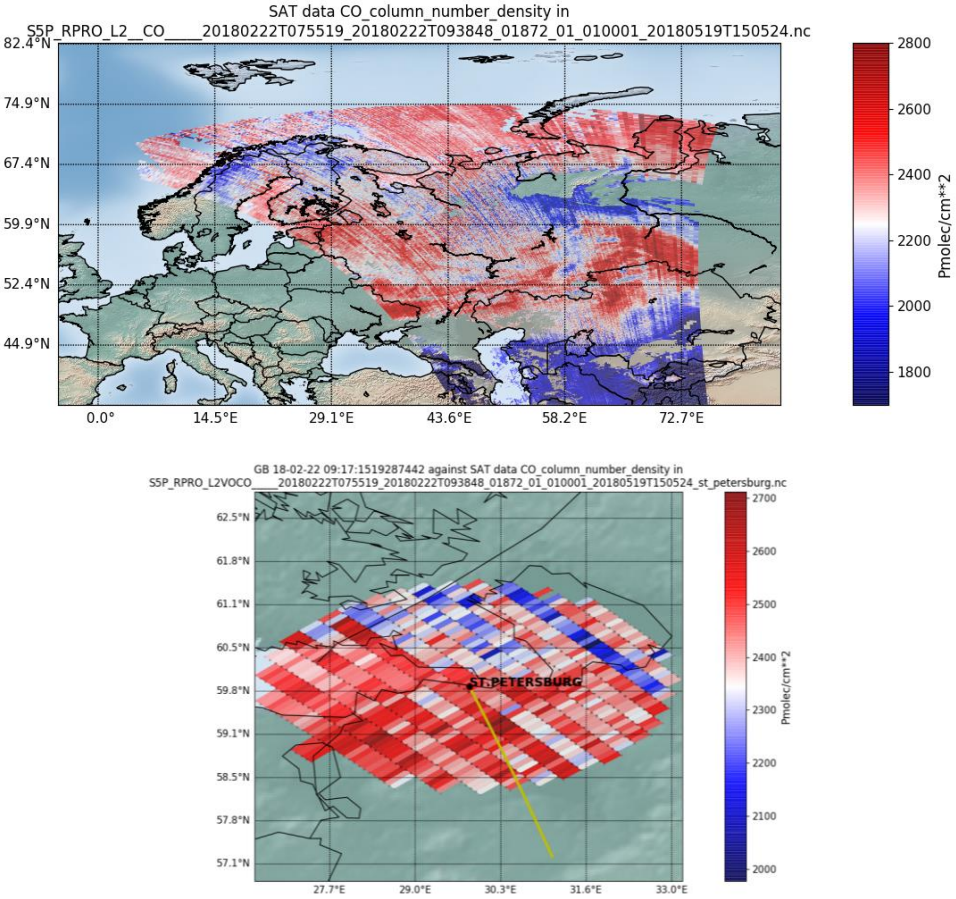


Figure 3 – Example of stripes in the L2 CO data (top) and an overpass at St.-Petersburg (bottom) showing the S5P CO pixels in a radius of 140km around a ground-based FTIR NDACC measurement (the line of sight is indicated by the yellow line).

Acknowledgments

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