Quality assessment of two years of Sentinel-5p TROPOMI NO2 data

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For more than two years now the first atmospheric satellite of the Copernicus EO programme, Sentinel-5p (SSP) TROPOMI, has acquired spectral measurements of the Earth radiance in the visible range, from which near-real-time (NRTI) and offline (OFFL) processors retrieve operationally the total, tropospheric and stratospheric column abundance of atmospheric NO2. In support of these routine operations, the SSP Mission Performance Centre (MPC) performs continuous QA/QC of these data products and produces key Quality Indicators enabling users to verify the fitness-for-purpose of the SSP data. Quality Indicators are derived from comparisons to ground-based reference data, both station-by-station in monitoring mode in the SSP Automated Validation Server (AVS) and globally in more complex in-depth analyses. Complementary quality information is obtained from product intercomparisons (NRTI vs. OFFL) and from satellite-to-satellite comparisons. After two years of successful operation we present here a consolidated overview of the quality of the SSP TROPOMI NO2 data products delivered publicly.

SSP NO2 data are compared routinely to ground-based network measurements collected through either the ESA Validation Data Centre (EVDC) or network data archives (NDACC, PGN). Direct-sun measurements from the Pandonia Global Network (PGN) serve as a reference for total NO2 validation, Multi-Axis DOAS network data for tropospheric NO2 validation, and NDACC zenith-scattered-light DOAS network data for stratospheric NO2 validation. Comparison methods are optimized to limit spatial and temporal mismatch to a minimum (information-based spatial co-location strategy, photochemical adjustment to account for local time measurement difference). Comparison results are analyzed to derive Quality Indicators and to conclude on the compliance w.r.t. the mission requirements. This include estimates of: (1) the bias, as proxy for systematic errors, (2) the dispersion of the differences, which combines random errors with seasonal and irreducible mismatch errors, and (3) the dependence of bias and dispersion on key influence
quantities (surface albedo, cloud cover...)

Intercomparison of SSP products (NRTI vs. OFFL) and comparison to other satellite data, including a similar processing of OMI measurements, complement the ground-based validation with relative biases and spatio-temporal patterns/artefacts related to instrumental issues (e.g. striping) and to the sensitivity to geophysical features (e.g. clouds and sea/ice albedo contrast).

Overall, the MPC quality assessment of SSP NO$_2$ data concludes to an excellent performance for the stratospheric column data (bias2 vs. ground-based data. This dispersion larger than the mission requirement on data precision can partly be attributed to comparisons errors such as those due to differences in horizontal resolution. Total column data are found to be biased low by 20%, with a 30% station-to-station scatter. After gridding to monthly means on a 0.8°x0.4° grid, comparisons to OMI data yield a much smaller dispersion (within the requirement of 0.7Pmolec/cm$^2$), and a minor relative bias. NRTI and OFFL perform similarly, even if they occasionally differ in specific cases of direct comparisons.