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Quality assessment of three years of Sentinel-5p TROPOMI NO_2 data

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For more than three years now, the first atmospheric satellite of the Copernicus EO programme, Sentinel-5p (S5P) TROPOMI, has acquired spectral measurements of the Earth radiance in the visible range, from which near-real-time (NRTI) and offline (OFFL) processors retrieve the total, tropospheric and stratospheric column abundance of NO_2. The S5P Mission Performance Centre performs continuous QA/QC of these data products enabling users to verify the fitness-for-purpose of the S5P data. Quality Indicators are derived from comparisons to ground-based reference data, both station-by-station in the S5P Automated Validation Server (AVS), and globally in more in-depth analyses. Complementary quality information is obtained from product intercomparisons (NRTI vs. OFFL) and from satellite-to-satellite comparisons. After three years of successful operation we present here a consolidated overview of the quality of the S5P TROPOMI NO_2 data products, with particular attention paid to the impact of the various processor improvements, especially in the latest version (v1.4), activated on 2 December 2020, which introduces an updated cloud retrieval resulting in higher NO_2 columns in polluted regions. Also the upcoming v2, due in April 2021 but already used to produce a Diagnostic Data Set, is discussed.

S5P NO_2 data are compared to ground-based measurements collected through either the ESA Validation Data Centre (EVDC) or network data archives (NDACC, PGN). Measurements from the Pandonia Global Network (PGN) serve as a reference for total NO_2 validation, Multi-Axis DOAS data for tropospheric NO_2 validation, and NDACC zenith-scattered-light DOAS data for stratospheric NO_2 validation. Comparison methods are optimized to limit spatial and temporal mismatch errors (co-location strategy, photochemical adjustment to account for local time 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 mismatch errors, and (3) the dependence of these on key influence quantities (surface albedo, cloud cover…)

Overall, the MPC quality assessment of S5P NO_2 data concludes to an excellent performance for the stratospheric data (bias<5%, dispersion<10%). The tropospheric data show a negative bias of -30% and a dispersion of 3Pmolec/cm^2 vs. ground-based data. This dispersion is larger than the mission requirement on data precision, but it can partly be attributed to comparison errors such as those due to differences in 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 over specific scenes. Besides the impact of the processor upgrade to v1.4 on the bias in polluted scenes, we discuss the implications of the reported negative biases in S5P tropospheric (and total) columns on NO_2 reduction estimates, e.g. in the context of SARS-CoV-2 lockdown measures. Feedback from this work on the ground-based reference data is also briefly reported.