Validation of tropospheric NO2 columns measurements from GOME-2, OMI and TROPOMI using MAX-DOAS and direct-sun network observations with focus on dilution effects

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Ground-based remote sensing MAX-DOAS and Pandora direct-sun instruments measuring in the UV-Vis spectral region are nowadays widely used to monitor atmospheric NO2 columns. Owing to the multiple geometries used, these techniques can differentiate total, tropospheric and stratospheric NO2 content and therefore provide an appropriate source of correlative data for the validation of satellite instruments such as GOME-2, OMI and TROPOMI.

In this study we combine ground-based remote sensing correlative measurements available from over 40 sites distributed worldwide to address the validation of GOME-2, OMI and TROPOMI data products. For GOME-2, we concentrate on the GDP operational product generated within the EUMETSAT AC SAF project and on the climate data record generated within the EU QA4ECV project, while for OMI we address both the TEMIS and QA4ECV data products. Regarding TROPOMI, the operational OFFL product is considered. To derive tropospheric NO2 columns from direct-sun total NO2 data, we use estimates of the stratospheric contribution available from each satellite data product.

A negative bias is generally found between the different satellite data products and the ground-based tropospheric NO2 measurements, which is mostly prominent in urban sites characterized by strong localized emission sources (up to about -32% to -45%, e.g. for OMI TEMIS and GOME-2 GDP vs MAX-DOAS ensemble). In an attempt to quantify and correct for the horizontal dilution happening around urban stations (due to diffusion and transport and to the spatial averaging of high resolution structures), we use high-resolution gridded NO2 maps obtained from one year of QA4ECV data. Results from applying this dilution correction show a clear improvement of the agreement between GOME-2 and OMI data at polluted urban locations. Further, the impact of the satellite ground pixel size (GOME-2 40x80km², OMI 13x24km²) and site location is investigated.
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