Validation and correction of TROPOMI tropospheric NO_2 column density data using 4AZ-MAXDOAS at Chiba, Japan

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To quantify and solve the reported negative bias in tropospheric nitrogen dioxide ($tropNO_2$) column data from the latest sensor TROPOspheric Monitoring Instrument (TROPOMI) aboard the Sentinel-5 Precursor satellite, we conducted ground-based four-different-azimuth-viewing multi-axis differential optical absorption spectroscopy (4AZ-MAXDOAS) observations at Chiba, Japan (35.63ºN, 140.10ºE, 21 m a.s.l.) in 2019. A comparison with simultaneous $tropNO_2$ observations by 4AZ-MAXDOAS enabled an evaluation of the spatial inhomogeneity of $tropNO_2$, which was considered responsible for a bias in results. Supported by inter-directional differences of up to 40% among 4AZ-MAXDOAS data, we found a significant horizontal spatial inhomogeneity in $tropNO_2$ around the observation site. We then compared 4AZ-MAXDOAS data with coincident TROPOMI data. TROPOMI data had a 53% smaller $tropNO_2$ column density as an annual average compared to 4AZ-MAXDOAS data, confirming the negative bias in TROPOMI data. However, the correlation between the magnitude of the bias and the coefficient of variance in four-azimuth directional data from 4AZ-MAXDOAS observations was not evident. This suggested that NO_2 horizontal inhomogeneity couldn't fully explain the observed bias. We also applied a correction using the $tropNO_2$ vertical profiles from 4AZ-MAXDOAS and the averaging kernels from TROPOMI. The correction reduced the bias to ~30% for annual average data, depending on the $tropNO_2$ profiles used, indicating that there was a significant contribution of $tropNO_2$ vertical profiles to the bias. These results not only quantified the reported negative bias but also emphasized the effectiveness of validation and correction using multi-directional ground-based data.

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