Determination of atmospheric NO_2 column densities using a Pandora instrument measuring direct-sun spectra at Yokosuka, Japan: Improved validation of TROPOMI satellite observations

*Yugo Kanaya[1], Hisahiro Takashima[2,1], Masato I. Nodzu[3], Takashi Sekiya[7], Kazuyuki Miyazaki[1], Henk Eskes[4], Gaia Pinardi[5], Daniel Santana Diaz[6], Moritz Müller[6], Alexander Cede[6]

1. Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2. Fukuoka University, 3. Tokyo Metropolitan University, 4. KNMI, 5. BIRA-IASB, 6. LuftBlick, 7. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Satellite observations of NO_2, a key atmospheric pollutant, have provided critical information on global distribution of NO_x sources and their temporal changes since 1995, and advanced understanding of atmospheric chemistry. A recent remarkable improvement is with their spatial resolution, reaching 7×3.5 km for TROPOMI (Sentinel-5P), launched in 2017. However, there is still a fundamental issue of low bias in the determined tropospheric NO_2 column densities (e.g., 25-50% for TROPOMI), when evaluated against ground-based spectroscopic observations. Potential causes would be (1) a-priori vertical profile shapes, (2) co-present aerosols and/or surface albedo, and (3) spatial inhomogeneity of NO_2, while (4) uncertainty in the ground-based observations could also be important. At Yokosuka (32.32˚N, 139.65˚E), located on the south edge of Tokyo-Yokohama metropolitan area, we newly started direct-sun Pandora spectrometer observations in November 2018 and strengthened validation capability, where the scattered-sun MAX-DOAS observations (from a JAMSTEC original instrument) had been solely referenced before. Results during winter 2018/2019 showed TROPOMI (within 0.1˚ from Yokosuka) had ~40% low bias against MAX-DOAS. The magnitude of difference was similar to the results from longer comparison during Feb-Sep 2018 for TROPOMI and earlier comparisons for OMI (QA4ECV). Pandora (in direct-sun mode) gave values ~24 % less than MAX-DOAS; the cause of difference was likely spatial inhomogeneity, as pollution levels were higher in the northeast for the sight of MAX-DOAS than in south for Pandora. This was consistent with the fact that TROPOMI gave ~18% higher values, when the averaging area was shifted to northeast by 10 km. As such, the importance of factors (3) and (4) was newly evaluated. By considering MAX-DOAS profile shapes in the recalculation of satellite products, we will discuss on factor (1), and the possibility to derive near-surface NO_2 concentrations from satellite observations.

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