Improving MAX-DOAS tropospheric NO_2 profile retrievals using ground-based in-situ and direct-sun observations

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Nitrogen dioxide (NO_2) is one of the air pollutants and a precursor of nitric acid and tropospheric ozone. Additionally, NO_2 emissions are potentially a tracer of CO_2 emissions[1,2]. Satellite observations of NO_2 have provided important information on the sources of NOx and their time evolutions. Spatial-resolution of recent NO_2 satellite observations has been significantly improved, such as TROPOMI developed by ESA and the Korean geostationary environmental satellite (GEMS). A Japanese satellite (TANSO-3 onboard GOSAT-GW) will also be launched in 2024. The satellite-observed NO_2 vertical column density and assumed concentration profile are compared and validated with ground-based observations. In particular, ground-based observation by Multi-AXis Differential Optical Absorption Spectroscopy (MAX-DOAS), which uses scattered sunlight, can obtain the vertical column density and the vertical profile of tropospheric NO_2. Therefore, the satellite-observed NO_2 vertical column densities and the assumed vertical profiles are generally compared with those with MAX-DOAS observations. However, it is known that the satellite-observed NO_2 vertical column densities are systematically smaller than those with the ground-based MAX-DOAS observations[3]. The bias is more distinct in polluted urban areas, up to ~50%, than in remote areas[3]. Several candidates for the cause have been pointed out but are still debated.
Here, we revisit the retrieval of NO_2 vertical profiles with the ground-based MAX-DOAS observations. Observations of MAX-DOAS installed at JAMSTEC Yokosuka Headquarters in an urban area (Yokosuka, Kanagawa) indicate that the retrieved NO_2 vertical column density depends significantly (up to ~18%) on the ‘a priori’ vertical profile required for the MAX-DOAS retrieval. When a priori vertical profiles assuming higher fractions of NO_2 present in the lower atmosphere (0–1 km altitude range) are used, the NO_2 column densities tend to be small, implying that the aforementioned bias between satellite and ground-based observations may be partly remedied. The shifts in the NO_2 vertical column densities and the NO_2 surface concentrations retrieved with such an improved MAX-DOAS algorithm were supported by the independent direct-sun Pandora spectrometer observations, and in-situ measurements of cavity attenuated phase shift spectroscopy (CAPS), respectively. These comparisons result in more plausible a priori vertical profiles and, finally, the NO_2 vertical profile retrievals with MAX-DOAS measurements are to be improved.

References
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