Evaluation of satellite-based tropospheric NO_2 vertical column density using MAX-DOAS observations and their integrated analysis

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Tropospheric NO_2, a major component of nitrogen oxides (NOx) emitted from anthropogenic sources (cars and power plants) and also from forest fires and lightning, is now regarded as a pollution marker detectable from space with a highest sensitivity. Temporal and spatial variations in the NO_2 density have been depicted by satellite observations and even their long-term trend is discussed. However, the tropospheric NO_2 vertical column density (TropoNO2VCD) reported from satellite observations may be biases low; they can be only half of the true value near the urban region (Kanaya et al, 2014). As such, accurate understanding of the TropoNO2VCD values derived from satellites is still poor. In this study, we re-examined the TropoNO2VCD product from OMI/Aura satellite derived with DOMINOv2 algorithm in terms of the influence from assumptions in the vertical profile and co-existing aerosol effect. Here, ground-based MAX-DOAS observations of TropoNO2VCD made at Yokosuka (35.32˚N, 139.65˚E) during 2007-2014 were regarded as true values and were compared with satellite values. Applying averaging kernels from satellite observations to the MAX-DOAS profiles removed most of the low bias, suggesting that the assumption in the vertical profile shape was critical. In the DOMINOv2 algorithm, NO_2 vertical profile shapes were borrowed from TM4 model simulations with a coarse spatial resolution; it tended to underestimate weight of NO_2 present near the surface in urban regions and this fact was overlooked when the tropospheric air mass factor (AMF) was determined, resulting in the low bias. When AMF was re-determined by borrowing MAX-DOAS based vertical profile shape, instead of that of TM4, the OMI-based TropoNO2VCD increased by as much as a factor of 2.2 in average and showed better agreement with MAX-DOAS observations. Similarly, the corresponding near-surface concentrations increased and showed better consistency with the values from ground-based monitoring. In summary, utilizing correct vertical profile shapes enabled reasonable estimation of TropoNO2VCD and surface-level concentrations from satellite. On the other hand, shielding effect from co-existing aerosols was found important when cloud fraction was 0.03 or lower. The tendency was consistent with the analysis results of OMI using POMINO algorithm, taking aerosol effect into account explicitly.

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