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Tropospheric NO_2 column densities deduced from zenith-sky DOAS measurements in Shanghai, China, and their application to satellite validation

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Abstract. Zenith-sky scattered sunlight observations using differential optical absorption spectroscopy (DOAS) technique were carried out in Shanghai, China (31.3 ° N, 121.5 ° E) since December 2006. At this polluted urban site, the measurements provided NO_2 total columns in the daytime. Here, we present a new method to extract time series of tropospheric vertical column densities (VCDs) of NO_2 from these observations. The derived tropospheric NO_2 VCDs are important quantities for the estimation of emissions and for the validation of satellite observations. Our method makes use of assumptions on the relative NO_2 height profiles and the diurnal variation of stratospheric NO_2 VCDs. The main error sources arise from the uncertainties in the estimated stratospheric slant column densities (SCDs) and the determination of tropospheric NO_2 air mass factor (AMF). For a polluted site like Shanghai, the accuracy of our method is conservatively estimated to be <25% for solar zenith angle (SZA) lower than 70 °. From simultaneously performed long-path DOAS measurements, the NO_2 surface concentrations at the same site were observed and the corresponding tropospheric NO_2 VCDs were estimated using the assumed seasonal NO_2 profiles in the planetary boundary layer (PBL). By making a comparison between the tropospheric NO_2 VCDs from zenith-sky and long-path DOAS measurements, it is found that the former provides more realistic information about total tropospheric pollution than the latter, so it's more suitable for satellite data validation. A comparison between the tropospheric NO_2 VCDs from ground-based zenith-sky measurements and SCIAMACHY was also made. Satellite validation for a strongly polluted area is highly needed, but exhibits also a great challenge. Our comparison shows good agreement, considering in particular the different spatial resolutions between the two measurements. Remaining systematic deviations are most probably related to the uncertainties of satellite data caused by the assumptions on aerosol properties as well as the layer heights of aerosols and NO_2.

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