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Vertical profiles of tropospheric ozone from MAX-DOAS measurements during the CINDI-2 campaign - Part 1: developing a retrieval algorithm

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Measurements of tropospheric ozone (O_3) are very valuable for studies of atmospheric chemistry, air pollution, and climate change, as well as for satellite validation. The MAX-DOAS technique has been widely used to derive vertical profiles of trace gases (e.g. NO_2, SO_2, and HCHO) and aerosols in the troposphere. However tropospheric O_3 has not yet been routinely derived from MAX-DOAS measurements due to the prominent influence of stratospheric O_3 absorption on the retrieval of tropospheric O_3. In this study, we present two new retrieval approaches for tropospheric O_3 from MAX-DOAS measurements. Both methods use different ways to overcome the effects of stratospheric O_3. In Method 1 stratospheric O_3 profiles derived from external data sources are considered in the retrieval. In Method 2 stratospheric and tropospheric O_3 are separated based on the temperature dependence of the O_3 absorption structures in the UV spectral range. The feasibility of both methods is first verified by applying them to synthetic spectra. Then they are applied to real MAX-DOAS measurements during the CINDI-2 campaign held in Cabauw, The Netherlands in September 2016. The obtained results are compared with other independent O_3 measurements (in-situ, long path DOAS, ozone sonde) and CAMS model simulations. Good agreement of the near-surface O_3 concentrations with the independent data sets is found for both methods. However reasonable O_3 profiles are only derived using Method 1. Sensitivity studies indicate that the approximation of Ring spectra used in the DOAS fit can partly explain the discrepancy of Method 2. In general Method 1 can well retrieve tropospheric O_3 profiles and can be applied to other MAX-DOAS measurements. However, for Method 2 some problems, especially the correction of the Ring effect, still need further work. In a separated future study, we will compare the O_3 results from different instruments and participants during the CINDI-2 campaign in order to investigate the uncertainties in relation to instruments and software used for the profile retrieval and the DOAS fit.