Title:	Intercomparison of NO2, O4, O3 and HCHO slant column measurements by MAX-DOAS and zenith-sky UV–visible spectrometers during CINDI-2
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Abstract:	In September 2016, 36 spectrometers from 24 institutes measured a number of key atmospheric pollutants for a period of 17 d during the Second Cabauw Intercomparison campaign for Nitrogen Dioxide measuring Instruments (CINDI-2) that took place at Cabauw, the Netherlands (51.97-N, 4.93-E). We report on the outcome of the formal semi-blind intercomparison exercise, which was held under the umbrella of the Network for the Detection of Atmospheric Composition Change (NDACC) and the European Space Agency (ESA). The three major goals of CINDI-2 were (1) to characterise and better understand the differences between a large number of multi-axis differential optical absorption spectroscopy (MAX-DOAS) and zenith-sky DOAS instruments and analysis methods, (2) to define a robust methodology for performance assessment of all participating instruments, and (3) to contribute to a harmonisation of the measurement settings and retrieval methods. This, in turn, creates the capability to produce consistent high-quality ground-based data sets, which are an essential requirement to generate reliable long-term measurement time series suitable for trend analysis and satellite data validation. The data products investigated during the semi-blind intercomparison are slant columns of nitrogen dioxide (NO2), the oxygen collision complex (O4) and ozone (O3) measured in the UV and visible wavelength region, formaldehyde (HCHO) in the UV spectral region, and NO2 in an additional (smaller) wavelength range in the visible region. The campaign design and implementation processes are discussed in detail including the measurement protocol, calibration procedures and slant column retrieval settings. Strong emphasis was put on the careful alignment and synchronisation of the measurement systems, resulting in a unique set of measurements made under highly comparable air mass conditions. The CINDI-2 data sets were investigated using a regression analysis of the slant columns measured by each instrument and for each of the target data products. The slope and intercept of the regression analysis respectively quantify the mean systematic bias and offset of the individual data sets against the selected reference (which is obtained from the median of either all data sets or a subset), and the rms error provides an estimate of the measurement noise or dispersion. These three criteria are examined and for each of the parameters and each of the data products, performance thresholds are set and applied to all the measurements. The approach presented here has been developed based on heritage from previous intercomparison exercises. It introduces a quantitative assessment of the consistency between all the participating instruments for the MAX-DOAS and zenith-sky DOAS techniques.
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