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3 dimensional distributions of NO_2, CHOCHO, and HCHO measured by the University of Colorado 2D-MAX-DOAS during MAD-CAT

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We present results of 2 dimensional Multi Axis-DOAS (2D-MAX-DOAS) measurements to infer 3-dimensional measurements of trace gases by characterizing boundary layer vertical profiles and near surface azimuth horizontal distribution of NO_2 (14 angles covering 360°). We combine the established optimal estimation inversion with a new parameterization approach; the first method to derive NO_2 tropospheric vertical profiles and boundary layer height and the second one to retrieve the azimuth horizontal distribution of near surface NO_2 mixing ratios, both at multiple wavelengths (350 nm, 450 nm, and 560 nm). This was conducted for three cloud-free days in the framework of the intensive Multi Axis DOAS Comparison campaign for Aerosols and Trace gases (MAD-CAT) in Mainz, Germany 2013. By retrieving NO_2 at multiple wavelengths range-resolved distributions of NO_2 are derived using an 'Onion-peeling' approach, i.e. exploiting the fact that the optical path lengths at different wavelengths probe different horizontal air masses. We also measure glyoxal (CHOCHO) and formaldehyde (HCHO) distributions, and present to our knowledge the first 3-dimesional trace-gas distribution measurements of CHOCHO by a ground-based instrument. We expand the 2D-MAX-DOAS capabilities to calculate azimuth ratios of HCHO-to-NO_2 (RFN) and CHOCHO-to-NO_2 (RGN) to pinpoint volatile organic compound (VOC) oxidation chemistry and CHOCHO-to-HCHO (RGF) ratios as an indicator of biogenic and/or anthropogenic VOC emissions. The results of RFN correlate well with RGN and we identify azimuth variations that indicate gradients in the VOC/NO_x chemistry that leads to O_3 and secondary aerosol production. While there is a clear diurnal pattern in the RFN and RGN, no such variations are observed in the RGF, which shows rather constant values below 0.04 throughout the day, consistent with previous measurements, and indicative of urban air masses.