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3D Remote Sensing of Trace Gas Distributions with HAIDI (Heidelberg Airborne Imaging DOAS Instrument) - Power Plant and Ship Emissions observed during the EMeRGe Campaigns

Katja Bigge, Udo Frieß, Denis Pöhler, and Ulrich Platt
Institute of Environmental Physics, Department of Physics and Astronomy, Heidelberg University, Heidelberg, Germany

Compared to ground-based or satellite measurements, atmospheric observations based on aircraft missions have many advantages, such as the potential to observe a large atmospheric volume using remote sensing measurements, among which Differential Optical Absorption Spectroscopy (DOAS) is a well established method for the observation of integrated trace gas concentrations along the light path. However, the interpretation of remote spectroscopic measurements using scattered sunlight is complicated due to the lack of prior knowledge on the light paths between sun and detector, and thus on the observed air volume. Using radiative transfer calculations, quantities commonly derived from DOAS measurements are integrated vertical columns of various trace gases, providing no information about their vertical distribution.

On the ground, tomographic approaches have been used to reconstruct the spatial distribution of trace gases by using multiple viewing directions and detectors. HAIDI, the Heidelberg Airborne Imaging DOAS Instrument, was designed to transfer this concept to the air. In addition to its excellent temporal and spatial resolution (40 m x 40 m at 1.5 km flight altitude, 266 m x 266 m at 10 km flight altitude, at 10 ms temporal resolution), HAIDI uses three separate scanning telescopes aimed at +/-45° forward- and backward looking angles and the nadir direction. In combination with a 3D radiative transfer model, this allows a reconstruction of the 3D distribution of the detected trace gases in the vicinity of the flight track.

HAIDI joined the EMerGe (Effect of Megacities on the Transport and transformation of Pollutants on the Regional to Global Scales) missions on HALO, the High Altitude and LOng range research aircraft based at DLR (German Aerospace Center) in Oberpfaffenhofen, Germany. The EMerGe missions targeted the emission outflows of megacities to investigate their compositions and the atmospheric impact of urban pollution in Europe (July 2017) and Asia (March 2018). HAIDI observed a number of trace gases such as NO_2, SO_2 and HCHO. For NO_2 and SO_2 in particular, strong plumes originating from power plants and ships were found, which were then used for inversion of the 3D distribution of the plume and emission estimation. Here we present the method and results of the HAIDI measurements during the EMeRGe missions.