

Boundary layer dynamics, aerosol composition, and air quality in the urban background of Stuttgart in winter

**Hengheng Zhang⁽¹⁾, Wei Huang^(1,2), Xiaoli Shen^(1,3),
Ramakrishna Ramisetty^(1,4), Thomas Leisner⁽¹⁾, Harald
Saathoff⁽¹⁾**

⁽¹⁾ *Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Karlsruhe, Germany, E-mail: Hengheng.zhang@kit.edu*

⁽²⁾ *Now at: Institute for Atmospheric and Earth System Research/Physics, Faculty of Science, University of Helsinki, Helsinki, Finland*

⁽³⁾ *Now at: Purdue University, West Lafayette, IN, USA*

⁽⁴⁾ *Now at: TSI Instruments India Private Limited, Bangalore, 560102, India*

The spatial distribution and temporal variation of aerosol particles within the planetary boundary layer is of great relevance for air quality and human health. This is of special interest for the city of Stuttgart, which is located in a basin. To characterize the evolution of the boundary layer structure and its relationship with surface level aerosol concentrations, we conducted comprehensive measurements in the urban background of downtown Stuttgart from February 5th to March 5th, 2018. We combined scanning aerosol lidar with radiosonde measurements to determine the boundary layer structure and spatial aerosol particle distributions. Furthermore, we measured aerosol particle number concentration, size distribution, chemical composition, as well as various trace gases (O₃, CO₂, NO₂, SO₂) 3.7 m above ground level, employing a mobile container equipped with various aerosol instruments (such as condensation particle counter (CPC), scanning mobility particle sizer (SMPS), optical particle counter (OPC), aerosol mass spectrometer (AMS)) and gas monitors. One main novelty of our study is that our scanning lidar conducted zenith scans from 90° to 5°. This allows us to investigate the evolution of the boundary layer structure and to retrieve the optical parameters of the aerosol near ground level that can be compared with in situ measurements. Comparing lidar and in situ measurements indicates that the lidar retrieved extinction coefficients are affected by potentially high aerosol water content caused by high relative humidity. After accounting for the impact of humidity on aerosol particle backscatter, a good agreement between lidar results and in situ optical particle counter (OPC) measurement was achieved. In addition, the lidar retrieved boundary layer height shows a good agreement with radiosonde data and ECMWF Reanalysis v5 (ERA5) data for different meteorological conditions. As expected, the ground level aerosol concentration showed a negative correlation with boundary layer height. In addition, meteorological conditions like wind speed, temperature, solar radiation, and relative humidity affect not only the structure of the boundary layer but also the relationship between boundary layer height and surface aerosol concentration.