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Ground-based lidar observations of vertical aersosol and water vapor profiles within the boundary layer over heterogeneous terrain

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Connecting the earth's surface with the free troposphere, the planetary boundary layer (PBL) comprises complex dynamics of turbulent behavior. This especially applies for areas with heterogeneous terrain. Relevant near-ground processes such as released energy fluxes and the emission of aerosols and trace gases directly interact with the atmosphere. Therefore, the PBL's physical state is determined both by the near-ground processes as well as entrainment of air parcels from higher layers. The mainly turbulence-driven transport of particles and properties throughout the PBL constrain a comprehensive understanding of the PBL's behavior. Hence, the energy balance closure problem as well as errors in precipitation forecast in long-term numerical weather predictions, amongst others, remain unresolved challenges. Here, ground-based lidar profiling is a well suitable method for observing the PBL, as data sampling allows for high temporal and vertical resolutions (Here: Sampling rate of 100\,Hz and 7.5\,m). During the CHEESEHEAD campaign, carried out in summer 2019, our newly developed ATMONSYS lidar performed measurements over complex terrain in northern Wisconsin. There, our lidar system was embedded in a dense network of multiple in-situ and remote sensing instruments. The central aim of this campaign was to further contribute to solve the energy balance closure problem. With the ATMONSYS lidar, vertical columns of aerosol backscatter coefficients, water vapor and temperature have been recorded. The presented work shows what the data is suitable for in terms of resolution and temporal extent in the first place. As a second point, focus is given on structure and variability of aerosol backscatter coefficient distributions and water vapor concentrations as well as their implications on the prevailing state of the PBL. Based on the presented findings, we discuss the potential and suitability of this experimental data for deriving transport processes within the PBL.