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# Distributed wind measurements with multiple quadrotor UAVs in the atmospheric boundary layer

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A swarm of quadrotor UAVs is presented as a system to measure the spatial distribution of atmospheric boundary layer flow. The big advantage of this approach is, that multiple and flexible measurement points in space can be sampled synchronously. The algorithm to obtain horizontal wind speed and direction is designed for hovering flight phases and is based on the principle of aerodynamic drag and the related quadrotor dynamics using only on-board sensors.

During the FESST@MOL campaign at the Boundary Layer Field Site (Grenzschichtmessfeld, GM) Falkenberg of the Lindenberg Meteorological Observatory - Richard-Aßmann-Observatory (MOL-RAO), 76 calibration and validation flights were performed. The 99 m tower equipped with cup and sonic anemometers at the site is used as the reference for the calibration of the wind measurements. The validation with an independent dataset against the tower anemometers reveals that an average accuracy of $\sigma_{rms} < 0.3$ m s$^{-1}$ for the wind speed and $\sigma_{rms,\Psi} < 8°$ for the wind direction was achieved.

Furthermore, we compare the spatial distribution of wind measurements with the swarm to the tower vertical profiles and Doppler wind lidar scans. We show that the observed shear in the vertical profiles matches well with the tower and the fluctuations on short time scales agree between the systems. Flow structures that appear in the time series of a line-of-sight measurement and a two-dimensional vertical scan of the lidar can be observed with the swarm and are even sampled with a higher resolution than the deployed lidar can provide.

In addition to the intercomparison of the mean wind velocity measurements, turbulence data of the UAV-swarm measurements are analyzed and a comparison to sonic anemometer measurements is provided.