



Turbulent Interaction of Wind Turbines with the Atmospheric Boundary Layer above Land Surface Observed by Small Unmanned Research Aircraft

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In wind energy meteorology, UAV have the clear advantage compared to manned aircraft that they allow to fly very close to the ground and even in between individual wind turbines in a wind farm. Compared to meteorological towers and lidar systems, the advantage is the flexibility of the system, which makes it possible to measure at almost any site with a minimum of preparation. Compared to a measurement tower, or lidar systems, adapting the measurement location to the current wind direction is easy.

At the Center of Applied Geoscience at the University of Tübingen, the research UAV MASC (Multi-purpose Airborne Sensor Carrier) was developed. UAV of type MASC have a wingspan of about 3~m and a maximum take-off weight of 7.5~kg, including payload. The standard meteorological payload includes instruments for temperature, humidity, barometric pressure and wind measurement. It is possible to resolve turbulence fluctuations of wind and temperature up to 20~Hz.

The autopilot ROCS (Research Onboard Computer System), which is developed at the Institute of Flight Mechanics and Control, University of Stuttgart, makes it possible to automatically follow predefined waypoints at constant altitude and airspeed. At a cruising speed of 24~m/s and a battery life of approx. one hour, a range of 80~km is feasible.

The project 'Lidar Complex', funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, was initiated by the research network 'WindForS', based in Southern Germany. The goal of the project is to establish lidar technology for wind energy plant site evaluation in complex terrain. Additional goals are the comparison of different measurement techniques and the validation of wind-field models in not IEC 61400 conform terrain. It is planned to design a turbulent wind-field generator, fed by real measurement data, which can be used to analyse WEC behaviour. Two test sites were defined for the 'Lidar Complex' project, one in IEC-conform terrain about 15~km from the Baltic Sea, the other in the Swabian Alb, only 2~km downstream of a 100~m steep escarpment. At both sites, flight measurements were performed in 2013 with the UAV MASC. The data that was collected allows to investigate the influence of thermal stability of the atmosphere at the test site and turbulence intensity around individual wind energy converters (WECs). Several measurement flights were done to investigate the wake structure downstream a running WEC. Preliminary results will be presented as well as an outlook for future research with the instrument.