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Measuring Vertical Profiles of Wind, Temperature and Humidity within the Atmospheric Boundary Layer using the Research UAVs 'M^{2}AV Carolo'

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The measurement of vertical profiles is important to characterise the vertical structure of the atmospheric boundary layer (ABL). For instance, the dependence of the potential temperature on altitude defines the thermal stratification. The mechanical shear (i.e. the variation of wind speed and direction) produces turbulence and turbulent fluxes. The top of the ABL is required for scaling approaches (e.g. Deardorff scaling in the convective boundary layer, local scaling in the stable boundary layer).
The Meteorological Mini Aerial Vehicles (M^{2}AV) are self-constructed, automatically operating research aircraft of 6 kg in weight (including 1.5 kg scientific payload) and 2 m wingspan. These systems are capable of performing turbulence measurements (wind vector, temperature and humidity) and are used as a new instrument for measuring vertical profiles of the lower troposphere.
Compared to a radiosonde, the spatial resolution of the M^{2}AV is significantly higher. Especially the wind measurement is significantly more accurate compared to radiosonde data when using an aircraft that is equipped with a proper flow sensor (mainly a five-hole probe). It is important to maintain flow angles (sideslip and angle of attack) within the calibration range (typically 10 to 20 degree). This limits the vertical speed (the rate of climb and descent) of the research aircraft.
In general there are two approaches to measure vertical profiles with research aircraft. Instantaneous profiles (slant flight pattern) are suitable if only little time is available, if the ABL is very in-stationary (or the aircraft is slow), if the dependence of the profile on time is requested (repeated slant flight patterns over one location) or if the dependence of the profile on the location is requested (saw-tooth pattern). For mean profiles (horizontal straight and level flights 'legs' at several altitudes within the ABL) it is necessary to use fast sensors. If the response time is too large, the vertical profiles have large systematic errors when the aircraft is climbing or descending rapidly.
The talk will be focused on data, which was obtained from several field campaigns in the Antarctic and Europe. Vertical profiles were performed both manually and guided by the autopilot of the automatically operating M^{2}AV. These profiles were compared (among others) to the 99 m tower at Falkenberg and groundbased remote sensing systems.