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Unmanned meteorological measurements with the 'M^{2}AV' aircraft - Comparison with remote sensing and the Helipod

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At the Institute of Aerospace Systems (ILR), Technische Universität Braunschweig, Germany, the 'Carolo' family of miniature unmanned aerial vehicles was developed. Since the ILR has several years of experience in the field of airborne turbulence measurements with the helicopter-borne turbulence probe Helipod, the knowledge in the field of real-time meteorological measurements was used to develop an autonomous meteorological micro aerial vehicle, shortly called M^{2}AV which is based on the 'Carolo' family. The M^{2}AV is a self constructed model aircraft with two engines and a wingspan of two meters - hence the name 'Carolo T200'. The maximum take-off weight is 4.5 kg, including 1500 g of payload. It is hand-launched which makes operating the aircraft easy. With an endurance of approximately 50 minutes, the range accounts for 60 km at a cruising speed of 20 m/s.
For the mounting of meteorological sensors a noseboom was constructed to minimise the aircraft's influence on the measurements and to get the sensors positioned close to each other. For temperature measurement, a split sensor concept as applied in the Helipod is used: One sensor is a sealed element made by Vaisala with high accuracy but slow response time in the magnitude of 5 s. The other sensor is a thin foil element specially made by Dantec for the M^{2}AV with a more fragile mechanical design and rather poor long-term stability but very fast response time in the range of 50 ms. By complementary filtering, the characteristics of both sensors can be combined: Long-term stability with high accuracy and fast resolution of several millikelvin for a measurement range from -40 to +60 ^{o}C. For measuring humidity, a Vaisala Humicap sensor is used which fulfils the requirements regarding size and weight. This led to a rather slow sensor with a response time in the magnitude of 5 s but good accuracy about 2 %

relative humidity over a wide temperature range.
Since one focus of meteorological research at the ILR is the investigation of turbulent fluxes in the atmospheric boundary layer, the M^2AV was equipped with a miniature 5-hole probe. The 5-hole probe has a mass of 22 g and a diameter of 6 mm. It is intended for the measurement of angles of attack and sideslip in the range of -20^o to +20^o each. For the calculation of the meteorological windvector the attitude of the aircraft is also needed in high precision. A three dimensional GPS attitude alignment system was integrated as a supplement to the inertial measurement unit (IMU) with accelerometers and gyros. This gives the opportunity to combine the GPS and IMU data via a post processing.
The M^2AV's implemented autopilot hardware offered some free capacities for data acquisition. Depending of the analog to digital converters topology, resolutions of 12 bit up to 24 bit were achieved with data rates in excess of 100 Hz. The data are stored on a standard flash card (like multimedia card) of any size which can be read out easily with any PC containing a card reader.
The presentation will show results of analysed meteorological data sets measured by the M^2AV. In October 2005 the M^2AV participated the meteorological field experiment 'LAUNCH 2005' in Lindenberg near Berlin. The M^2AV data were compared with lidar and sodar measurements. Furthermore, an in-situ comparison of temperature, humidity and wind vector data with the helicopter-borne turbulence probe Helipod will give information about the M^2AV data quality.