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Forecasting the weather
- ensemble techniques
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Measurement of Thermodynamic Processes in the Atmospheric Boundary Layer using Small Unmanned Aerial Vehicles

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To improve the understanding of processes in the lower atmosphere - the atmospheric boundary layer (ABL) - new measurement strategies are needed that will help to fill the gaps which are left open by commonly used measurement systems using remote sensing, towers or radiosoundings.
For this purpose a UAV platform named MASC (Multi-purpose Automatic Sensor Carrier) has been developed at the University of Tübingen that is able to carry meteorological payloads. MASC is equipped with an autopilot to be able to fly pre-defined routes autonomously. Its flexibility and low cost are the main advantages of the system compared to manned aircraft systems.

As the basic meteorological payload a measuring unit was designed and developed which is capable of measuring temperature, humidity, pressure and aircraft attitude with high resolution and precision. The unit is designed to fit on MASC, but is easily exchangeable and does not interact with the navigation and power units of the aircraft. In this set-up, the measuring system can be used to measure vertical profiles of the ABL, as well as turbulent flux in heat, humidity and momentum.
In detail, the system consists of meteorological sensors including a five-hole probe connected to high precision pressure transducers, a fast response thermocouple and a fast response humidity sensor. Additionally, to calculate position and attitude of the aircraft, an inertial measurement unit (IMU) and a GPS receiver are installed in the unit.
The thermocouple is designed to be able to measure temperatures in a range of -20°C to 200°C. First tests are demonstrated that proof high sensitivity and fast response times that allow to resolve turbulent fluctuations as fast as 20Hz and more. To measure humidity, two of the fastest solid-state sensors on the market with specified static response times of about 2s were compared and shown to be able to resolve turbulent fluctuations up to at least 2Hz. Both of the sensors are based on capacitive measuring principles.
All sensors are directly connected to a central board computer developed in cooperation with the University of Applied Sciences Ostwestfalen-Lippe (AMOC - Aerial Meteorological On-Board Computer). This embedded computer is equipped with two microcontrollers, a 24-bit analog-digital-converter, an SD-card and common interfaces (Analog, SPI, CAN, Uart) for all the sensors mentioned above, as well as additional optional periphery.
A wireless module is connected to the board computer and makes it possible to send live data to a ground station computer. On the ground station all sensor data can be visualized and observed during the flight, making it possible to see if sensors are functional and adapting the flight plan according to the current meteorological situation.
All data is logged onto the sd-card at a rate of 100Hz. In post-processing, the raw sensor data is used to calculate turbulent flux, wind vector and precise attitude of the UAV.

First tests and results will be presented, including vertical profiles of the ABL and power spectra of humidity and temperature. The presented data will include measurements from the field campaign BLLAST (Boundary Layer Late Afternoon and Sunset Turbulence), which will give the possibility to compare the system to tower data, remote sensing instruments, radiosoundings, tethered balloons and other UAV systems.