EMS Annual Meeting Abstracts,
Vol. 6, EMS2009-130, 2009
9th EMS / 9th ECAM

Turbulent Fluxes of Sensible Heat Measured by Research UAV 'M^2AV Carolo'

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Research aircraft equipped for turbulence measurements in the atmospheric boundary layer (ABL) are suitable platforms to measure area-representative mean values and statistical moments of second order – like variance, spectral distribution and turbulent fluxes – in situ i.e. without the use of any theoretical assumptions. Since manned research aircraft are expensive the use of small unmanned aerial vehicle (UAV) or mini aerial vehicles (MAV) is attractive. Such research UAV are able to measure vertical profiles of the lower troposphere, for instance. The next, more challenging league is the measurement of the turbulent fluctuations of the wind vector and simultaneously at least one scalar quantity in order to calculate turbulent fluxes using eddy covariance. To do this, fast and accurate sensors are required, with small weight, small dimensions and small power consumption, in order to be operated on a small research UAV. Beside absolute and relative measurement accuracy, the response time of the sensors has to be short (in the order of several 10 Hz) to resolve turbulent eddies also in stable stratification (i.e. sub-metre range). Since light, small and fast sensors for air humidity and trace gases are not available currently, the first step is to measure the vertical flux of sensible heat H.

Beside a slow (about 1 Hz) water vapour sensor, the automatically operating meteorological mini aerial vehicles (M^2AV) are equipped with two temperature sensors and a wind measurement unit. One of the temperature sensors is slow but offers a high absolute accuracy, while the fast sensor (up to 100 Hz) has a high relative accuracy but is unstable in time. The two signals are blended using a complementary filter. The wind vector can be calculated using the inertial velocity (aircraft speed relative to the earth) and the true airspeed (aircraft speed relative to the airflow). The true airspeed of M^2AV is computed from five-hole-probe pressure measurements whereas the aircraft inertial velocity, position, and attitude is calculated by combining data from a global positioning system (GPS) and an inertial navigation system (INS). Both the temperature and the wind units were calibrated in several wind tunnels and in-flight, using specially designed flight patterns, also in comparison with a 99-m tower of the German Meteorological Service (DWD).

Measured time series are analysed in several ways. Fourier-based power spectra allow the identification of any harmonic distortion of the signal. Any deviation from Kolmogorov's law – to identify how far the inertia subrange of turbulence was resolved – is better identified using structure functions. The presentation will also show first results, in terms of turbulent heat fluxes, from LITFASS-2009 campaign.