A high-frequency chilled-mirror hygrometer for turbulent stationary and airborne dew point measurements

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A chilled-mirror hygrometer (CMH) prototype for in-situ UAS (unmanned aircraft system) measurements has been developed and compared against industrial state-of-the-art alternative lightweight humidity sensors. It is shown that the newly developed sensor resolves dew-point measurements up to 10 Hz at a sampling frequency of 50 Hz, and can therefore resolve turbulent dew-point fluctuations, measured by UAS. The CMH sensor is relatively low cost, and easy to maintain. The latest version of the sensor combines an in-house made housing and circuit board and is tuned to fit in the MASC-3 (multi-purpose airborne sensor carrier) research UAS of the University of Tübingen. However, the sensor can be modified to compliment EC (eddy-covariance) stations that monitor turbulent surface fluxes (e.g. turbulent vertical humidity or momentum fluxes) where the CMH sensor would substitute expensive equipment.

The proposal substantiates further how the sensor can be used for several meteorological applications, e.g. an installation of a low-cost EC-stations network, studying the CBL (convective boundary layer) or buoyancy-driven flows in general, since the sensor is able to resolve turbulent density fluctuations once combined with pressure and temperature readings. It is shown that the CMH sensor supports a comprehensive evaluation of turbulence in the atmosphere, including the hard to measure structure parameter for humidity $C^2_q$ that quantifies turbulent eddies and structures in the lower atmosphere.

Field campaigns and validation measurements against i.a. scintillometers and meteorological mast measurements have been conducted and new ones are planned for the future, together with the German Meteorological Service (DWD). Constant development of the CMH continuously improves the sensor and motivates a secondary goal; the possibility to offer a commercially available product to the meteorological community and the humidity sensor industry in the future. The market situation and a realistic reception of such a sensor have previously been assessed and has evolved in two business plans.