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# Field tests of a new, extractive, airborne 1.4 $\mu$m -TDLAS hygrometer (SEALDH-I) on a Learjet 35A

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A highly accurate and precise quantification of atmospheric humidity is a prerequisite for cloud studies as well as for environmental models in order to get a deeper understanding of physical processes and effects. On the one hand numerous trace gases measurements in airborne "laboratories" have to be corrected for water vapor influence; on the other hand satellite measurements have to be validated by in-situ $H_2O$ measurements on aircrafts.

The vast majority of the airborne hygrometers require a precise and frequent sensor calibration in order to ensure a sufficient performance. UT/LS sensors in particular are often calibrated before and after each individual flight. But even this might not be sufficient which explains why recently in-flight calibrations are becoming more common. Nevertheless all calibrated sensors completely depend on the performance of the water standard used for calibration. Therefore it remains an open question if in-flight calibrations are the way to go: They also might suffer from inflight disturbances and they would need validation during flight conditions. Water calibrations at low humidity are even more complicated due to the strong water adsorption and the resulting sampling problems. An abstention from calibration would avoid many of these problems. In addition, calibration free sensors are much easier to debug as they can hardly have errors which can be hidden by calibration parameters (such as leaks, etc.). Robust cal-free sensors should therefore perform more stable in flight when the sensors boundary conditions might change. The situation can be improved further with extractive cal-free sensors as the boundary condition in measurement volume (pressure, temperature, path length, flow pattern, etc.), i.e. in an extractive cell, are much better controlled than for an open path sensor. Further cal-free extractive sensors can be designed maintain its integrity when attaching and detaching it from the carrier (airplane). This makes it much easier to validate the sensor function e.g. by a direct comparison with a primary water standard and to ensure traceability of the results to metrological standards. On the other hand it remains important to investigate sampling effects and artifacts in order to provide true measurements of the outside air.

The SEALDH-I (Selective Extractive Airborne Laser Diode Hygrometer) is a new, absolute 1.37 $\mu$m Tunable Diode Laser Absorption Spectroscopy (TDLAS) hygrometer, which uses an advanced spectroscopic multiline fit and instrument stabilization process to enable a calibrations-free [1] evaluation of TDLAS signals [2]. SEALDHI is a compact (19" 4 HU), light weight (23 kg), fully extractive TDL hygrometer especially designed for space- and weight-limited airborne applications. It is based on an internal optical cell with 1.5 m optical path length. SEALDH-I's time resolution is limited by the flow through the cell: With an unpressurized inlet and gas handling system, we achieve with typical flows of 40 liter/min which leads to exchange times in the order of 0.5 sec. The laser scanning frequency of typically 140 Hz sets a maximum time resolution of 7 msec. Averaging data for about 2.1 sec ensures an excellent precision of 0.033 ppmv, which results in a band width and path length normalized precision of 72 ppbv·m·$(Hz)^{-1/2}$. A dynamic range from 30 to 30000 ppmv has been proved and already validated in a blind intercomparison campaign [3]. The fast measurements, its excellent precision, validated accuracy, and absolute, calibration-free evaluation in combination with the compact, robust setup, allows airborne measurements from ground level up to the lower stratosphere. Furthermore SEALDH-I permits via its fast response time in combination with the large concentration range the resolution of fine atmospheric spatial structures and temporal fluctuations, particularly in clouds [4], where concentration gradients of 1000 ppmv per second can be present.

We will present the result of the first successful flights of SEALDH-I on board of a Learjet 35A. Further detailed evaluations of the inflight data and discussion on the performance and future application possibilities will be presented at the meeting.

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