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Simultaneous gas-phase and total water detection for airborne applications with a multi-channel TDL spectrometer at 1.4 μm and 2.6 μm

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Water vapor measurements especially within clouds are difficult, in particular due to numerous instrument-specific limitations in precision, time resolution and accuracy. Notably the quantification of the ice and gas-phase water content in cirrus clouds, which play an important role in the global climate system, require new high-speed hygrometers concepts which are capable of resolving large water vapor gradients. Previously we demonstrated a stationary concept of a Tunable Diode Laser Absorption Spectroscopy (TDLAS)-based quantification of the ice/liquid water by independent, but simultaneous measurements of A) the gas-phase water in an open-path configuration (optical-path 125 m) and B) the total water in an extractive version with a closed cell (30 m path) after evaporating the condensed water [1]. In this case we used laboratory TDLAS instrumentation in combination with a long absorption paths and applied those to the AIDA cloud camber [2].

Recently we developed an advanced, miniature version of the concept, suitable for mobile field applications and in particular for use on aircrafts. First tests of our new, fiber-coupled open-path TDLAS cell [3] for airborne applications were combined with the experiences of our extractive SEALDH instruments [4] and led to a new, multi-channel, "multi-phase TDL-hygrometer" called "HAI" ("Hygrometer for Atmospheric Investigations"). HAI, which is explicitly designed for the new German HALO (High Altitude and Long Range Research Aircraft) airplane, provides a similar, but improved functionality like the stationary, multi-phase TDLAS developed for AIDA. However HAI comes in a much more compact, six height units, 30 kg, electronics rack for the main unit and with a new, completely fiber-coupled, compact, 21 kg, dual-wavelength open-path TDL-cell which is placed in the aircraft's skin. HAI is much more complex and versatile than the AIDA precursor and can be seen as comprised of four TDL-spectrometers, as it simultaneously measures with two independent wavelengths (1.4 μm for troposphere and 2.6 μm for UT/LS to permit full coverage of water vapor concentrations from ground level to the stratosphere) both of which are applied to two measurement scenarios: A) in two independent extractive, closed cells (1.5 m path, 300 ccm cell volume) for redundant total water measurements at 1.4 and 2.6 μm and B) in a dual-wavelength open path cell (4.3 m path length) for a selective gas phase water detection. All HAI channels, but the 2.6 μm closed cell, are fibred-coupled. Depending on the sampling inlet (forward direction, ram pressure borrowed) we achieve in the closed cells a flow of 7 slm at 120 hPa which leads with a bulk flow assumption to a gas exchange time of 0.3 sec. Both lasers are synchronized and wavelength tuned at repetition frequencies of up to 1 kHz depending on the spatial resolution needed. HAI runs autonomous [5] allowing almost maintenance-free operation even in harsh environments. HAI is further combined with our long-term experience in TDLAS data evaluation [6] especially in rapidly changing and disturbed processes [7], [8] which leads to a highly precise, long term stable, fast, accurate, calibration-free, interference resistant hygrometer which can help to clarify several important issues - both from a technical perspective (e.g. influence of sampling system) as well as from a scientific view (e.g. determination ice-content of cirrus clouds).

In the presentation we will discuss HAI's novel setup, its performance during the first tests, and show results from the first successful flights on HALO during the TACTS and EMSVAL campaigns in 2012.

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