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dynH2O: A Metrological Approach to Manage the Effects of Dynamic H2O Concentration Changes on Hygrometers in the Field

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Measuring atmospheric water vapor is an essential but challenging task. The naturally occurring concentrations varies over four orders of magnitude and adsorption and desorption processes on sensors and in sampling systems can distort and attenuate the signal. During airborne measurements H2O concentration gradients that exceed 1400 ppm/s are common and pose an additional challenge [1]. Despite the highly dynamic conditions, especially on research aircrafts like HALO, instrument calibration under static conditions is the norm. This leads to unknown sensor behavior in dynamic conditions and makes it difficult to reliably correct or even identify the influences of dynamic concentration changes on the data. With dynH2O we present an approach to characterize the dynamic response behavior of hygrometers in a metrological and traceable way [2]. dynH2O consists of A) a preparative unit to generate fast and repeatable steps in the water vapor concentration. To generate the concentration steps fast pneumatic valves are used to switch between the flow of two humidity generators which is than mixed into a base flow of dry air. This approach allows the lower and upper bound of the concentration step to be selected independently over a flow range from 13 to 120 standard liters per minute (= sl/min). The generated gas mixture is than passed into B) a flow channel optimized to create a flat concentration front which is monitored by C) an open-path, calibration-free direct Tunable Diode Laser Absorption Spectroscopy (dTDLAS) hygrometer. The dTDLAS reference instrument is operated as a traceable optical gas standard with a temporal resolution of up to 1000 Hz and no sampling delays due to the use of a rotational symmetric multipath cell which is embedded into the walls of the flow channel of the setup. A device under test (DUT) is placed directly behind the optical measurement plane. To characterize the DUT the ideal sensor response is simulated based on the data from the optical reference instrument. The simulated ideal DUT response is used to separate the dynamic response from the setup from the response of the DUT, making the results independent from the setup and easier to transfer to the field. A first order lowpass is used to model the corrected response behavior of the DUT. The characterization of a polymer-based hygrometer will be presented and possibilities to apply the characterization to correct or mitigate the nonlinear distortions of the time axis caused by dynamic H2O concentration changes, by means of different deconvolution methods, will be discussed.

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[2] Witt, F.; Bubser, F.; Ebert, V.; Bergmann, D. C9.1 Temporal Hygrometer Characterization: Design and First Test of a New, Metrological Dynamic Testing Infrastructure. In System of Units and Metreological Infrastructure. SMSI 2021, digital, 5/3/2021 - 5/6/2021; AMA Service GmbH: Wunstorf, Germany, 2021 - 2021; pp 308–309.