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Atmospheric Measurement Techniques Discussions

Interactive comment on "An update on the uncertainties of water vapor measurements using Cryogenic Frostpoint Hygrometers" *by* H. Vömel et al.

Anonymous Referee #2

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This manuscript describes recent improvements in the understanding and treatment of errors and uncertainty in balloon sonde water vapor measurements made using the CFH chilled mirror hygrometer. The CFH is used by a number of groups worldwide for measurement of water vapor, particularly in the UTLS where water vapor concentrations are typically below those measurable with standard radiosondes. The CFH has been used as an in situ comparison for validation of satellite and lidar measurements of UTLS water vapor.

The subject matter is highly appropriate for Atmospheric Measurement Techniques and overall the manuscript is well organized and clearly written. The manuscript will be of interest and useful to the atmospheric science community engaged in studying UTLS

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Discussion paper

water vapor and its role in climate since the CFH is an instrument that has the potential to contribute significantly to a long-term record of UTLS water vapor changes to study interannual variation and identify trends.

General comments: The authors state at the beginning of the introduction that “Cryogenic frostpoint hygrometers are widely considered as reference instruments” and then more generally in section 2.2 that “Frostpoint and dewpoint hygrometers. . .are not calibrated against water vapor standards and are considered water vapor standards”. The authors, however, also state in the introduction “not all frostpoint or dewpoint hygrometers are equivalent, and some understanding of the technical realization is needed to properly interpret the reported frostpoint temperature and to be able to estimate the measurement uncertainty.” Many laboratory frostpoint instruments are certified by comparison with metrological water vapor standards, which verifies that the reported mirror temperature does accurately represent the equilibrium saturation temperature–more than just a traceable calibration of the thermistor itself. This seems to be part of the motivation for the “manufacturer-independent ground check” that has been instituted. The authors invoke the framework of Immler et al. (2010) in the discussion of “reference”, but perhaps for the reader a more complete definition of how the term is used here would be helpful, especially given the extensive discussion of data filtering.

The brief description of the principle and operation of the CFH (with reference to the more complete description in Vömel et al. (2007)) should be expanded somewhat and care taken to be precise, such as the mirror is actively illuminated and the control signal is a decrease in the light reflected by the mirror due to diffuse scattering by the mirror condensate. This could be accomplished with only slight modifications and additions to the text.

The focus of the manuscript is on the uncertainty related to the PID control loop, but for context and to present a complete picture, a brief discussion of the parameterization used to relate the saturation temperature to partial pressure, and the reliance on co-measured temperature and pressure to determine mixing ratio and relative humidity and the contribution from these to the overall measurement uncertainty would be helpful.

Another comment is related to the ordering of Figures 9 and 10–it seems they should be reversed to match the order in which they are discussed in the text.

Specific comments and suggestions on manuscript text:

Minor grammatical: In many instances, commas are missing following introductory clauses.

Page 1, line 20: “considered as” could be changed to “considered to be”–but see comment on “reference” above.

Page 1, line 27: “grows nor shrinks”-more specifically, its scattering is maintained at a constant value.

Page 2, line 32: “regulate the bulk reflectivity”–it isn’t the condensate that is providing the reflectivity, but decreasing it due to diffuse scattering.

Page 3, line 19: “in a poorly behaving”

Page 6, line 29: recalibrated over what time period?

Page 6, line 30: “is less than 0.02 K”–with a couple of exceptions.

Page 8, line 15: Highest RH in 1 s, or within some averaging/smoothing period? Figure 1R would return a higher RH than Figure 1L, even if the central values were identical.

Page 9, line 29: “does not significantly change throughout the time of a typical sounding”–was this tested under large dynamical changes in H2O such as might be encountered in the atmosphere? It seems likely to hold as long as the mirror condensate does not experience significant changes in scattering, i.e. error signal remains small at all times.

Page 10, line 16: “measurable” contamination is almost never observed in the troposphere.

Page12, line 13: “the CFH agrees with this reference to better than 0.1 K”–CFHs are one- or few-use devices not a singular instrument, and based on figure 9 I would say “individual CFHs (typically) agree with this reference to within 0.2 K” or similar. The “typically” would cover the two instances where the difference was observed to exceed 0.2 K.

Page 12, line 20: “section 0” should be “section 2.4”

Page12, line 26: While truly random errors will not produce incorrect long-term trends, they do affect the ability to detect trends and are therefore quite important in terms of understanding the long-term behaviour of the variable in question.

Page 17, Figure 1: “responses”

Page 18, Figure 2: “Water vapor profile from a CFH sonde launched at Lindenberg”. Cause of the high/low deviations in the descent profile following time-lag correction?

Page 21, Figure 5: As noted above, time span over which the calibration runs were conducted?

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