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Atmospheric Measurement Techniques Discussions

Interactive comment on "A guide for upper-air reference measurements" *by* F. Immler et al.

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This paper addresses the important topic of obtaining upper-air environmental measurements that are suitably accurate for climate studies, and more importantly, are KNOWN to be suitably accurate because a rigorous uncertainty analysis emphasizing traceability has been performed and documented. While this may seem obvious on one level, not many suitably accurate upper-air measurements exist today, nor will they in the future unless a systematic and rigorous approach to obtaining and characterizing upper-air data is undertaken.

This is a well-written paper that describes a framework for making reference-quality upper-air measurements with uncertainty estimates that are sufficiently well-considered and comprehensive to make them useful for climate research, specifically as part of the GRUAN network. The approaches to uncertainty assessment that are

described are sound and thorough (with one exception), and the study formalizes and generalizes the uncertainty-related considerations that are important for both in-situ and remote-sensor measurements.

My only comment on the content of this paper is to suggest adding a section or paragraph that at least acknowledges an important source of uncertainty that is not discussed, namely sensor time-lag error. While most sources of measurement uncertainty do fit nicely into the categories of a systematic or a random error, time-lag error does not. It is a dynamic error that is distinctly different from a calibration or other bias error that generally reflects static measurement conditions. Its magnitude depends on the gradient of the measurand and the sensor response time, and while it is akin to a bias error in that it can be corrected (with knowledge of the sensor response characteristics, such as the sensor time constant as a function of its dependences), it is in general not straightforward to correct. Nonetheless, it is a real error that merits discussion in the paper, even if it is difficult to do anything about it. Time-lag error in RS90 temperature measurements (small in magnitude) is discussed by Luers (1997, JTech), and time-lag error in RS92 humidity measurements (larger in magnitude) is discussed by Miloshevich et al. (2004, JTech).

Given that time-lag error for RH measurements may be either positive or negative and is proportional to the local humidity gradient, consider the assumption that overall there are equal distributions of positive and negative humidity gradients at any given altitude level in the atmosphere. A given feature in the humidity profile of a given sounding may be substantially affected by time-lag error, but statistically time-lag error would add no mean bias to an ensemble-averaged dataset of sufficient size, although it would add to the variability (random error). However, time-lag error can (and does) lead to an overall bias in the tropopause region because the humidity gradient is generally negative just above the tropopause, leading to a moist bias just above the tropopause that can be envisioned as "smoothing" the troposphere-stratosphere transition. The impact of time-lag error on the mean bias and variability for a small dataset is illustrated in Figs. 14

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and 15 of Miloshevich et al. (2009, JGR).

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