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Atmospheric Measurement Techniques Discussions

Interactive comment on "Fast-response high-resolution temperature sonde aimed at contamination-free profile observations" *by* K. Shimizu and F. Hasebe

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Major issues

Comment: Section 2 provides a theoretical discussion of the measurement method and derives the relevant time constant of the sensor. But it is not quite clear to me how this happens. At the end it seems that the time constant was measured in the lab and the presented formalism is not really used at all. The same holds for the radiation effect that was measured in the lab and not derived using equation (1). None of the relevant constants here have been discussed.

The entire section therefore is more confusing then enlightening. It would be more appropriate to explain why this specific designed was chosen, what advantages to existing methods it promised and how the performance was tested in the lab and in the field. The formulas presented in this section might be useful to quantitatively explain the observed behavior, namely the independence of the time constant from pressure, and the radiative impact on measurement bias. In the current form, I don't quite see this connections.

The content of table 1 should be explained in more detail in this section.

Reply: The first three paragraphs of Section 2 have been rearranged for better clarity by summarizing the theoretical framework in the first paragraph and describing experimental procedures to determine the parameters in the second and the third paragraphs. Since the whole citation is too lengthy to describe here, please refer to the revised manuscript to see the complete change.

Question: Is the GPS generally accurate enough to resolve the small scale motion of the radiosonde?

Answer: The uncertainty in the GPS horizontal position is approximately several to 10 meters (e.g., Misra and Enge, 2001) depending on several conditions such as the number and position of available positioning satellites, ionospheric condition, and receiver noise. Within the time interval of a minute or so, however, these factors remain essentially the same, so that the relative change in the horizontal position could be traced by successive GPS signal in an accuracy much better than the uncertainties mentioned above. Otherwise, we cannot measure horizontal wind vectors from GPS signal. This is the basis of our estimation of the sequential positions of the sonde swinging like a pendulum. The movement of sondes shown in Figs. 4 and 6 are thus reliable. The sentence that starts from "As the GPS" in p.3300, l.3 has been replaced by the following: Note that the short term change in the horizontal position could be accurately traced by successive GPS signal, although the overall uncertainty is approximately several to

10 meters depending on several conditions such as the number of available positioning satellites (e.g., Misra and Enge, 2001). On the other hand, as the GPS altitudes are not accurate enough to measure differential height, the vertical position of the balloon is assumed to be 25 m above the sonde referring to the length of the suspension line.

Question: Are there possible delays between the GPS time and the time stamps from other sensors, in particular the temperature measurement?

Answer: The clock on board radiosonde is synchronized with that of GPS. The delay of the time stamp is less than the sampling interval of 1/6 second.

Question: The observed pendulum motion seems to have a rather large amplitude. Is that realistic? Are there possible biases that might affect the scale?

Answer: The amplitude of the pendulum motion is confirmed by the sonde movement speed obtained by GPS raw data. In view of the general consensus that GPS could provide the movement speed in every second with the accuracy of 0.2 m/s (Section 5.2.1 of Misra and Enge, 2001), there will be no reason to doubt this value. The GPS-based wind measurement system on radiosondes relies on the speed and direction of the instrument resulting from both the atmospheric and the pendulum motions of sondes. We can estimate the magnitude and phase of the pendulum motion quite accurately by using the deviation of the raw GPS speed data from the slowly-varying averaged wind. The description of GPS accuracy has been inserted to line 3 of page 3300.

Question: Does the pendulum frequency match the expected value (to the first order: $f = \sqrt{\frac{g}{stringlength}}$)?

Answer: The pendulum frequency will be $f = \frac{1}{2\pi}\sqrt{\frac{g}{stringlength}}$. The observed pen-

dulum frequency roughly corresponds to this value.

Comment: It impresses that measurements of the air temperature inside and outside the balloon have been made. This demonstrates that the authors tried everything to improve the understanding of the result of their measurement. It would be great if more details about these measurements were provided. Where exactly were the sensors located? How was the skin temperature determined? Please also discuss the results of these measurements in more detail.

Reply: A new illustration has been drawn and inserted in the text as new Fig. 9. The explanation of these measurements are described in the caption of this figure.

Minor issues

page 3295 line 24: I don't think there will be sensors free of a radiation effect, at least none of this kind. So the better way to put it would be something like: " ... a sensor with a radiation bias that is small (or negligible) with respect to the desired overall measurement uncertainty ..."

Reply: Suggested sentence is not impressive for us as it may hold in every sensor by choosing some moderate value for the uncertainty. Our use of the terminology "free from radiation correction" expresses our wish to ultimately develop an idealized system. Although it will not be realized easily, it is true that such a sensor is certainly anticipated. We would like to retain this sentence by slightly modifying to "almost free from radiation correction."

page 3301, line 18: Please provide time zone (GMT + x)

Reply: Revised as suggested.

page 3302 line 12: Of what magnitude are these angles in the considered cases?

Reply: In the case of the suspension line of 30 m, such negative pulses showed up when the solar zenith angle was about 25 degrees while the swing angle was 40 degrees. In the case of 120 m suspension line, on the other hand, they did not appear when the solar zenith angle was about 42 degrees while the swing angle was about 10 degrees. These values have been inserted to the caption of Figs. 8 and 11 in the revised version.

page 3308 caption of table 1 second line: The term "error" seems inappropriate here, what is meant is most likely the bias (or "systematic error") caused by the radiation.

Reply: Revised as suggested.