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Reply on RC2

Marco Rosoldi et al.

Author comment on "Intercomparison of Vaisala RS92 and RS41 radiosonde temperature sensors under controlled laboratory conditions" by Marco Rosoldi et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-337-AC2, 2022

Reviewer 2 comment:

In the manuscript, Intercomparison of Vaisala RS92 and RS41 radiosonde temperature sensors under controlled laboratory conditions, the authors describe a laboratory setup to characterise the temperature sensors of the Vaisala RS92 and RS41 radiosondes. The concept to characterize radiosonde's sensors in a dedicated setup under well-controlled laboratory conditions is employed to achieve measurement traceability for reference observations. This could answer the long-standing need in the research-community for independent and traceable assessment of measurement- and calibration errors of radiosondes.

However the experiment and the methodology described in this manuscript have several severe shortcomings that make it hard to draw reliable conclusions from the measurement data. In its current shape manuscript does not meet the quality standards for publication in AMT, and I don't think this can be remedied by a major revision, since the shortcomings in the experimental setup are of a more fundamental nature, which would require a modification of the setup and a complete repeat of the experimental work. On this basis, I would recommend to reject the manuscript for publication in AMT.

Authors' reply:

The authors thank the reviewer 2 for his time and comments. The authors believe that the experimental setup and methodology described in the manuscript are suitable to reliably characterize the temperature sensors of the radiosondes tested, compatibly with the current state of the art for such a characterization based on laboratory tests with climatic chambers. Please see below the authors' replies for each specific comment

Reviewer 2 comment:

The main issue concerns the lack of ventilation in the experiment:

The authors do not provide an exact number for the ventilation speed in the chamber at the location of the radiosondes' temperature sensors, it is stated in line 499 that "the ventilation is weak". This is an important difference with the way radiosondes are normally

operated, namely with a ventilation of 3-7 m/s (WMO-CIMO recommendation) provided by the lift of the balloon. This ascent-driven ventilation makes sure that the sensors, that are located near the tip of the sensor boom, do not sample air that is contaminated by the casing of the radiosonde. This lack of ventilation is the likely cause for the periodic peaks in for the RS92 in Figure 3 (that are not addressed by the authors). The RS92 is equipped with two humidity sensors that are alternately heated to remove contamination. It appears that during the experiment, this heating of the RH sensors leaks through to the temperature sensor by conduction. In case of proper ventilation, these periodic peaks in the temperature signal would have been suppressed.
For future reference: this heating can be switched off by subjecting the RS92 to T < -60C or to pressures lower than 100 hPa. The heating function is reactivated by initialisation in the GC25 unit.

Authors' reply:

To address the reviewers' comments, the ventilation speed in the chamber at the location of radiosondes' temperature sensors has been estimated with a portable digital anemometer (wind speed range and uncertainty 0.3-30m/s and 5%, respectively) and resulted in 2m/s. This ventilation speed is not so far from the assumed ventilation of 3-7m/s on the sensors during radiosoundings, and it does not seem to be weaker than that produced during the ground check with the GC25, whose results have so far been used to characterize the calibration accuracy of the RS92 temperature sensor. Indeed, it is very hard to reproduce under controlled laboratory conditions the real ventilation on the sensors in radiosoundings, which results from the complex combination of the balloon lifting vertical speed, the horizontal wind, as well as rotations and pendulum motions of the radiosonde. The text of the manuscript will be amended, including the above estimate of the ventilation speed on the sensors inside the climatic chamber.
As for the periodic peaks of the RS92 temperature signal in Fig. 5 (I suppose the reviewer 2 refers to Fig.5 instead of Fig.3), these peaks immediately appeared to the authors, somehow related to the periodic switching on and off of the two humidity sensors and their heaters. However, although the temperature signal is certainty affected by the swapping cycle of humidity sensors and their heaters, this effect is challenging to be properly quantified, also considering the irregular duration and intensity of the peaks. Therefore, the RS92 temperature signal has been considered characteristic of the simultaneous operation of the radiosonde's temperature and humidity sensors and appropriate to characterize the calibration accuracy. Certainly, it is very reasonable to assume that simulating conditions more similar to those of a radiosounding, with a stronger ventilation in the chamber, can reduce the effects of the heating of the humidity sensors on the temperature signal. Therefore, taking into account the reviewer's comment, the text of the manuscript will be amended as follows:

1) *Mentioning the disturbance to the RS92 temperature signal due to the RS92 sensors' architecture and periodic switching on and off of the two humidity sensors and their heaters, in particular those closer to the temperature sensor.*

2) Mentioning in the results and conclusions that:

- *The potential effects of a stronger ventilation on RS92 sensor have been estimated, by removing the peaks in RS92 temperature signals and recalculating the statistical quantities used to characterize the noise and calibration accuracy (the authors performed this estimate assuming that, in case of proper ventilation, the periodic peaks in RS92 temperature signals would have been suppressed, as suggested by the reviewer)*
- *The results of the above estimate indicate noise and calibration uncertainty values for the RS92 up to 0.03 °C lower than those obtained in our experiment, which are*

presumably overestimated up to 0.03 °C compared to those with a stronger ventilation, under conditions more similar to those of a radiosounding.

On the other hand, it's useful to point out that, to authors' knowledge, it does not exist a publicly available documentation, from the manufacturer or independent, showing how and to what extent the signal and the calibration accuracy of the RS92 temperature sensor change with respect to those reported in this work under ventilation conditions more similar to those of radiosoundings. Moreover, in the documentation provided by the manufacturer, the ventilation and pressure conditions to which the calibration of RS92 temperature sensor refers are not reported. However, the results on the calibration accuracy obtained from the laboratory tests performed in this work are in very good agreement with those provided by the manufacturer.
Therefore, arguing that the experimental setup and methodology described in this work do not allow to obtain reliable results seems not supported by the necessary documentation and laboratory tests. Instead, further laboratory experiments should be recommended by using a measurement configuration suitable for simulating conditions more similar to those of a radiosounding, with decreasing pressure levels and stronger ventilations on the sensors, in order to assess if and to what extent the results of this work may change under those conditions. The recommendation to carry out the above experiments will be added in the manuscript conclusions.

Reviewer 2 comment:

The lack of ventilation also affects the results of the temperature-change experiment, an example of which is presented in Figure 6. Due to the thermal mass of the table on which the radiosondes is mounted, it takes several minutes for the setup to stabilize. During this stabilisation phase, the temperature recordings appear noisy. However, this is not to be interpreted as as noise from the sensor (an instrument property) but rather the result from thermal gradients and other inhomogeneities in the setup which cause for example small-scale turbulences. Proper ventilation in the setup would reduce this transient noise.

Authors' reply:

If the authors understood correctly, in the previous comment the reviewer argues that the noise increase in radiosondes' temperature readings, observed after each temperature change and reported in Table 3, is not be interpreted as noise from radiosondes' sensors (sensors' property), but rather the result from the thermal instability of the experimental setup, which takes several minutes to stabilize. Such an argument does not seem plausible because, as reported in the description of the methodology (lines 319-321), the acquisition period considered after each temperature change was started as soon as the thermal stability was achieved in the chamber, typically about 15 min after the change. For the example shown in Fig.6, the acquisition period considered after the temperature change started 17 min after the change. This time interval between each temperature change and the start of the acquisition period was sufficient to achieve the thermal stability of the setup, which is demonstrated by the readings of reference thermometers used to identify the stability conditions and whose standard deviation measures the setup stability. Indeed, the values of the setup stability before and after each change reported in Table 3 indicate that the stability after each change is similar to that before that change, and even higher for the change #3, corresponding to the measurements shown in Fig. 6. Now, if the noise increase in radiosondes' temperature readings resulted from the setup instability, the values of this instability after each change should have been much higher than those observed before the change, also considering the higher response time of the reference thermometers compared to radiosondes' temperature sensors. On the contrary, the values of the setup stability during the acquisition periods before and after each *change are very similar. Therefore, the higher noise values measured after the changes in radiosondes' temperature readings are due to radiosondes' sensors (sensors' property) and not to the instability of the measurement setup. As for the thermal mass of the frame on which the radiosondes are mounted, this should affect the time interval required to achieve the stability, but not the noise level once the stability was achieved.*

Reviewer 2 comment:

Furthermore, I don't think there is much added value in investigating the behavior of the radiosonde when subjected to a temperature change associated with e.g. leaving a building. This pre-flight situation (with very limited ventilation) does not represent the actual operational mode of the radiosonde during an ascent for which it is devised.

Authors' reply:

The tests of the experiment performed with two climatic chambers aim to investigate potential effects on the radiosondes' temperature sensors of fast and steep thermal changes (in the order of about 20 °C) that radiosondes may meet when passing from indoor to outdoor environment before launch (no matter the ventilation conditions during the pre-launch phase). These thermal changes are simulated by quickly moving the measurement frame equipped with the two radiosondes between the two climatic chambers. The test results reveal that such thermal changes may increase the noise and the calibration uncertainty of temperature sensors, at least during the first part of a radiosoundings. In our opinion, this result can be of great interest for metrology, meteorology and climate communities, as it indicates a possible underestimation of the above uncertainty contributions in the algorithms currently used to process the raw measurements of both radiosonde models.
Similarly to the tests performed at the first stage of the experiment, the tests with two climatic chambers were performed under the ventilation conditions described above and generated by the chambers to homogenize the temperature field inside. The supposed invalidity or irrelevance for radiosoundings of the outcome of these tests due to the limited ventilation in the chambers (if the reviewer's comment refers to this) needs to be demonstrated by means of similar tests performed under conditions more similar to those of a real radiosounding, with decreasing pressure levels and stronger ventilations on the sensors. To our knowledge, similar tests have never been carried out by the manufacturer or independently.
Furthermore, the potential effects of a stronger ventilation, estimated as mentioned in the authors' second reply, should only affect the results obtained for the RS92, and not significantly enough to compromise their plausibility.
Surely, the outcome of our tests needs to be confirmed by further tests with multiple pairs and production batches of radiosondes and under conditions more similar to those of radiosoundings.