Review of Radiation correction and uncertainty evaluation of RS41 temperature sensors by using an upper-air simulator
Lee et al.
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The paper describes the application of the in house developed upper air simulator (UAS) to investigate the radiation temperature error of the Vaisala RS41 radiosonde.
The UAS is used to simulate the conditions, both radiation and ambient temperature, that are encountered in the upper atmosphere during a radiosounding.
The main finding of the paper is that lowering the air temperature in the UAS from +20 to -67C leads to an increase of approximately 20% of the radiation temperature error, which the authors postulate is due to changes in the efficiency of the -radiative and conductive- energy transfer mechanisms.
This work is very relevant, because it reports on a manufacturer-independent and traceable method to characterize and quantify error sources in radiosonde temperature measurements. This is an essential prerequisite for providing reference quality data that is suitable for e.g. climate monitoring, especially since the corrections applied by Vaisala in the processing of their radiosonde data are not disclosed to the user.
However, several improvements to the manuscript are necessary to make it suitable for publication.

Major comments

My overall impression is that the manuscript is lacking in interpretation of the findings. The method and the results are presented all right, but there is no real attempt made to come to a deeper understanding of the results.
The main message of the paper is the essential role of the ambient temperature during the measurements, and that lowering the air temperature from +20 to -67C leads to an increase of approximately 20% of the observed radiation temperature error. This is a considerable effect, with potentially far-reaching consequences for the uncertainty estimates of radiosonde data products. Therefore this observed temperature effect requires more elaborate discussion than that is currently included in the manuscript, and the authors should make an attempt to provide a quantifiable physical justification and/or explanation for this observed temperature-dependent difference.

There should be a clear separation between the description of the measurements and the presentation of the results. Currently these are entangled in section 3. I recommend presenting the description and the results in different sections.
Furthermore, provided a more extensive discussion of the assumptions that are made in the data analysis, together with their effect on the quality or uncertainty of the correction.

With regard to the representativeness of the conditions in the UAS compared to the real atmosphere: there are significant differences between the long wave radiation environment in the laboratory setup and in the free atmosphere. In the laboratory setup there is a uniform background emitted by the walls of the measurement chamber, with only a small temperature difference (approximately 1-2K) with respect to the temperature sensor. In the free atmosphere the long-wave radiation background is composed of, amongst others, contributions from the air masses and surface below and from the cold cosmic background

above. Therefore, the question is how well the environment inside the UAS is representative for the conditions encountered in the stratosphere, and it cannot be excluded that the observed low-temperature effect is to some extent specific for the conditions inside the measurement chamber.
I realize that it is a challenge to recreate the exact atmospheric and radiative conditions of the upper atmosphere in a laboratory set up, but the authors should discuss this.
In connection to this it would be very useful to use the dual thermistor that is discussed in another paper by the same authors (Lee et al. Meteorol. Appl. 25: 283–291 (2018), doi: 10.1002/met.1690) to make a connection between tests in the UAS and in situ measurements at high altitude. This should provide an answer to the question whether measurements in the UAS can replicate the temperature difference between both sensors of the dual thermistor radiosonde at high altitude for an ambient temperature of -67C?

The introduction should include more discussion of, and references to, other relevant work.

The influence of the thermal coupling between sensor boom and temperature sensor for the radiation error should be discussed in more detail.

The differences with the Vaisala radiation correction are listed in Table 11, but without much further discussion or interpretation of these differences. The UAS-based findings should be presented in a plot, together with Vaisala correction, so that it is easier for the reader to see the differences between both correction methods. At this place a discussion of the observed altitude-dependence of these differences would be appropriate.

In the description of the experiments the following information appears to be missing:
the length of the exposure times, and the number of repetitions.

Show uncertainties in the plots of figures 2-6

Please provide a more detailed description of how Delta_T is determined. Is this the difference between the radiosonde temperature and the air temperature in the UAS?

Specific comments

l23-24: it should be mentioned that radiosondes perform in situ measurements
l26: add pressure to the list of ECVs
l26: (concerning the high accuracy), provide an estimate how high this accuracy is.
l28: This sentence needs to be rephrased. I assume you want to say something like...
l29-30: rephrase: may lead to inhomogeneities in data records due to the use of different radiosonde models.
l33: of the ECVs -> of selected ECVs
l37: rephrase: are exposed to solar radiation, which leads to radiative heating of the temperature sensor.
l37: As background info to the reader, provide a typical estimate of the radiation temperature error for current (and previous) radiosondes.
l40: A proper reference for the need to reduce sensor size would be de Podesta et al 2020.

l41: This sentence is unclear, please rephrase. What do you mean by the combined effect of solar radiation?
l48: Add a one-line description of how Schmidlin1986 corrected the radiation error.
l50-52: include the quantitative result of Philipona2013, i.e. the magnitude of the correction they derived
l57: add proper reference (von Rohden et al. AMT 2021, doi:10.5194/amt-2021-187)
l59-64: The chamber system used by Lee2018, Lee2020, and in this manuscript is one and the same. This should be clear from the text.
l65-66: Add a sentence explaining how the radiation correction is evaluated. This is discussed in detail in the later sections, but a brief mentioning of the principle should be given in the introduction.
l66: Provide additional details on the UAS. The possibility to tilt and rotate the radiosonde are important innovations that should be mentioned here.
l81-82: do you mean the temperature of the test chamber, or the temperature of the air inside the test chamber?
l92: What are the results of the laser Doppler velocimetry characterisation of the airflow inside the test chamber?
l96: It is not clear whether 980 W/m2 is the flux at the position of the radiosonde's sensor, so inside the test chamber, or if it denotes the flux at the window of the test chamber.
l102-103: Should the study still be seen as proof of concept?
l100: mention the accuracy at which the pyranometer is calibrated at KRISS.
l107: Remove 'it seems that'. The following sentence makes clear that you know the manufacturer's radiation correction is not applied.
l116: considered -> employed
l119: Change section number to 3
l128: I don't understand this sentence. Do you mean that the relative uncertainty of Delta T is larger at high pressure because of its smaller value?
l129: Motivation for using exponential functions for fitting?
l144-146: See remark in the major comments above about physical justification for the different radiation error at low temperature. Changing the temperature from +20C to -67C has a 20% effect on the observed radiation error. This is a significant difference which merits a thorough discussion of the effects involved. Preferably with appropriate references. For example, what could be the effect of temperature to the convective heat exchange?
l170-171: This is a bold conclusion that should be reached only after thorough verification and discussion.
l177: Despite the limited investigated range of ventilation, is it reasonable to assume a simple linear relationship between radiation effect and ventilation speed?
l205-206: please rephrase. Say something along the lines that the exposed surface of the sensor boom depends on the incidence angle, and passes through a maximum twice during a full rotation.

Table 10: Vaisala provides more detailed information on calibration uncertainty of the temperature sensor in the White Paper ‘Vaisala Radiosonde RS41 Measurement Performance’, B211356EN-B-LOW-v3

Figure 5: the plots show the effect of the rotation on the sensorboom on the radiative heating of the temperature sensor. Figure 11 of von Rohden 2021 presents the same effect, however

with a considerably larger magnitude (up to 0.3K for p=7hPa and 16s rotation period). This difference in findings should be addressed by the authors.
The amplitude and shape of the oscillations also depend considerably on the incidence angle (equivalent to solar elevation), which is not investigated in the study. This may lead to considerably larger T_(on_max) - T_(on_min) in Fig. 5b, and therefore to higher uncertainty estimates due to sonde rotation.
Fig 5 a) shows the results for 100 hPa, where the effect is rather small. It would be more meaningful showing the results for p=5 hPa.
The bump around 100 hPa in the pressure dependence of the amplitude for the black and red curve is striking. Does this reflect the uncertainty of the measurement?
Finally, mention in the caption the values of v, and T for the data in the plot.