Comment on amt-2021-187
Anonymous Referee #1

Referee comment on "Laboratory characterisation of the radiation temperature error of radiosondes and its application to the GRUAN data processing for the Vaisala RS41" by Christoph von Rohden et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-187-RC1, 2021

Review of “Laboratory characterisation of the radiation temperature error of radiosondes and its application to the GRUAN data processing for the Vaisala RS41” by Rohden, et al.

Summary:

The manuscript by Rohden et al. describes the new laboratory simulator (SISTER) for solar radiation errors in radiosonde temperature measurements at the Meteorological Observatory Lindenberg. The paper describes the setup of this simulator flow and radiation chamber and some measurements of the radiation error of the Vaisala RS41 radiosonde inside this simulator. These laboratory measurements are then combined with modeled radiative flux calculations and applied to actual radiosonde ascent data. The authors then compare their radiation error estimate with that operationally provided by Vaisala.

The radiation error is the dominant error source for radiosonde measurements in the stratosphere and of great importance for long term climate records. The paper is very detailed and an important step in providing a generalized method of evaluating the radiosonde radiation error.

The paper does not address the connection to the already established procedures for the Vaisala RS92 radiosonde, which should be an important aspect to describe the transition from observations using the Vaisala RS92 to RS41 radiosonde models.

I would recommend publication of this manuscript after some revisions, which I outline below.

Major comments:

The GRUAN product for the Vaisala RS92 temperature measurements was established using a predecessor of this new and improved radiation simulator. The GRUAN product for the Vaisala RS41 is based on the measurements using the current simulator. The authors did not mention this transition and how the radiation error correction based on these new
measurements might compare to the radiation error correction measurements of the RS92 using the older simulator. Ideally, the Vaisala RS92 would have been evaluated using SISTER as well, but given the complexity of these measurements, this may not have happened. Nevertheless, some estimation of the difference between the RS92 corrections using the older and the RS41 corrections using the newer simulator is needed to gauge what systematic error this new simulator might introduce in the measurements.

I disagree with the evaluation that the radiation correction based on SISTER is statistically consistent with that provided by Vaisala. While this is true for each individual profile, for the mean correction in a dataset of 154 sonde, the factor $1/\sqrt{154}$ in Equation 20 should substantially reduce the uncertainty estimate for the entire data set and make it statistically different than that of Vaisala. While this is negligible for forecasting, this would be important for long term climate series. Of course, this does not answer which algorithm is correct; but, as the authors point out, the GRUAN approach is, at least, well documented and traceable, whereas that of Vaisala is not.

Section 5 is probably very similar to what was done by Dirksen et al. (2014); however, there is no reference to that paper in this section. Dirksen et al. (2014) is mentioned in the introduction, but here it would be good to highlight, what the differences are to that paper, e.g. the treatment of the zenith angle near the horizon and maybe some other aspects.

Minor comments:

Section 2.2: Can you make a statement how far the setup is from turbulent flow, i.e. is there anywhere in the parameter space a risk that the laminar flow will change to turbulent flow?

Line 285: The pressure sensors in the RS41 radiosondes usually have an offset, that is compensated for during the ground check. Was a similar pressure correction done here? The offset correction may easily be in the range 0.5 to 1.5 hPa for an individual sonde and would affect the low pressure analysis.

Section 2.3.6: I understand the argument how to simulate the diffuse radiation with direct radiation. However, there should be a geometric scaling factor, which expresses the difference between the two. I assume this is hidden in the flux of 527 Wm$^{-2}$ that was used in this measurement. This scaling needs to be explained a little better.

Lines 376-384: It is not clear what is explained here. Is this another explanation for section 2.3.6? Is the difference of the diffuse curves not an indication that the value of 527 Wm$^{-2}$ is too large and that the geometric scaling factor should be something different? Please clarify.

Line 350 and Equation 5: Is there any physical justification for the simple model? Why did the authors choose $1/\sqrt{v}$ and $1/\sqrt{p}$ in the polynomial? Isn't the deviation from that model at low pressures an indication that it may not be the most suitable fit?

Figures 4 and 13 are pretty to look at, but not very helpful in evaluating quantitative differences. I can't tell exactly, where different data points belong. The left panel of Figure 13 has the corresponding line plot in Figure 14, but Figure 4 and the right panel of Figure 13 do not. I would suggest replacing both with a suitable line plot.

I could not follow the discussion of the uncertainty interpolation in lines 402-412. Please rewrite. The right panel of Figure 13 as line plot may be a big help in explaining what is happening here.
Lines 604ff: Vaisala uses a time lag correction for the temperature, GRUAN does not. At Lindenberg this seems to be justified. However, at tropical stations, which have a strong temperature gradient also in the stratosphere, this may have a stronger effect. Have you looked at that? Does the Lindenberg result still hold in the tropics?

Technical comments:

Line 18: Comparisons

Line 27: Delete “for example”

Line 54: Change “reduces” to “decreases”

Line 55: delete “the decreasing”

Line 75: “… by direct …”

Line 77: change “caused by” to “due to”

Line 83: “Following the GRUAN …”

Line 87: “… radiative flux …”

Line 88: Change “By lack …” to “Due to the lack …”

Line 90: Change “… solar position …” to “… position of the sun …”

Line 94: “… applied to the …”

Line 103: “the Lindenberg Observatory …”

Line 104: change “… of the SISTER …” to “… of SISTER …”

Line 105: “… an unfolded …”

Line 106/107: change “together with” to “and”

Line 108: “… and includes …”

Line 121: LDA has not yet been spelled out

Line 140: change “one of the middle legs” to “one leg”

Line 140: Does 180 mm refer to the diameter of a round tube or the width of a rectangular tube. Figure 1 and the description are a little fuzzy on this point.

Line 141: Change to “… is mounted. To generate a radially uniform flow a rectifier …”

Line 150: change “radiosonde’s casing” to “housing of the radiosonde electronics”

Line 153: I can’t really see the threads in the Figures. Maybe just remove the reference to Figure 1 and 2.

Line 166: “… an RS41 …”
Line 168: delete “which is”

Line 172: delete “generally speaking”

Line 174: “flow velocity profiles”

Line 180: delete “which is”

Line 180: How did you extrapolate to pressures below 20 hPa?

Line 206: The lamp flux decreases with distance, not the lamp output.

Line 210: Units should probably be Wm\(^{-2}\)

Line 238: “… sensor boom …”

Line 258: “… typically for …”

Line 260: Delete “again”

Line 266: Delete “that are”

Line 268: change “for various” to “at different”

Line 272: Just a comment: It might have been good to replace the incidence angle of 20 deg with 75 deg.

Line 294: delete “rapid”

Line 296: delete “Temporal”

Line 300: delete “temporally-consistent”

Line 325: spaces before and after “and”

Line 326: “temperature, “

Line 346: delete “also in a complex way”; change “turbulence conditions” to “turbulent flow”; change “are” to “is”

Line 350: Delete “It is found that”

Line 358: change “monotonous” to “monotonic”

Line 365 ff: better “The fits were created for all of the six incident angles, i.e. for 0 deg, 20 deg, 40 deg, 59 deg, zenith and diffuse. The two zenith and the two diffuse radiation configurations were averaged as explained in Sect. 2.3.5 and 2.3.6”

Line 367f: Delete sentence “The parameterization ...”. The reference is from that section to Eq 5.

Line 369: Hasn’t the normalization to a constant irradiation not already been done? Why mention this here?

Line 386: change “leaps” to “steps”
Line 397: Delete, this seems to be a repeat of the previous explanation.

Line 400: What is “plus another component”? Do you refer to the factor 1/(2 * SQRT(3))? If so, you could reference GUM and point out that the value lies with equal probability somewhere in that range.

Line 415: A set of lines plot would be better to show this difference.

Lines 433 and 446: Change “on” to “onto”

Line 454: change “augmented” to “influenced”

Equation 7: change “=” to “≈”

Line 541: “The apparent discontinuities ...”

Lines 545ff: Gravity waves can happen anywhere above the tropopause, i.e. also below 25 km. The question is, shouldn’t you use a form of theoretical rise rate instead of the measured to avoid biasing the temperature profile? You discuss this in the Summary and Conclusions, without actually reaching a conclusion. Maybe delete this short discussion here and add a sentence or two in the Summary.

Line 554: Why did you only use 154 profiles and not years’ worth of profiles (several thousand?)

Figure 20: The right panels seems to have squeezed vertical axis labels.

Line 623: “... and the ventilation speed ...”

Line 635: Delete: “Fig 13. shows that”

Lines 654ff: Wouldn’t a cloud model based on radiosonde RH still beat the dumb statistical assumption in most cases?

Line 674: Delete “Fig. 11 shows that”