Referee #1

General Comment: The authors have addressed all comments and remarks. With the revision, the explanations became clearer and smoother. After consideration of a few further minor comments below, the manuscript should be published.

→ We thank the Reviewer for valuable comments to improve the quality of the manuscript.

Detailed comments

L192: Explanation of the abbreviation RRT (only emerges in 4.1)

→ The abbreviation RRT is defined in Section 3.4 at its first appearance.

Before: Therefore, a radiation test is performed on all thermistors in a vacuum chamber at room temperature

After (Line 192-193): Therefore, a rotational radiation test (RRT) is performed on all thermistors in a vacuum chamber at room temperature

Before: the rotational radiation test (RRT) in Fig. 5(c).

After (Line 220): the RRT in Fig. 5(c).

L205: '30 data' ◊ '30 data points' (?)

→ 30 data points are used.

Before: 30 data

After (Line 207): 30 data points

L247: For easier understanding, a sentence should be added here (or at another suitable place) saying that the applied concept of transferring the individual radiation sensitivities from the RRT tests based on the five chosen units to Eq. 2 does not necessarily rely on 'realistic' irradiation and ventilation conditions in the RRT setup, but – due to the proportionality with the UAS results - rather on the consistence of the existing conditions in the RRT over the radiation tests of all other sondes as part of the representativeness of the results from the five thermistor pairs.

→ We agree that the comment is necessary for better understanding of the RRT. The suggested sentence is added in the revised manuscript.

Added statement (Line 247-251): The applied concept of transferring the individual radiation sensitivities from the RRT based on the five chosen units to Eq. (2) does not necessarily rely on 'realistic' irradiation and ventilation conditions in the RRT setup, but rather on the consistence of the existing conditions in the RRT over the radiation tests of all other sondes. The representativeness of the RRT results of the five thermistor pairs as part of all thermistors is based on the proportionality with the UAS results.

Section 4.2: The procedure in described section 4.2 is to a wide extent identical to that in section 4.1.With regard to the writing style, I suggest to avoid too much copy-pasting of whole sentences where possible.

→ Section 4.2 is partly rewritten to avoid repeated expressions.

L281 (maybe already in L234): The heat transfer coefficient is not only dependent on the thermal conductivity of air, but also on the viscosity (approximately proportional to T) and density (inversely proportional). Wouldn't it be better to say more generally that the heat transfer therefore correlates positively with temperature overall, i.e. as a net effect?

→ As suggested, the heat transfer is explained more generally.

Before: because the convective heat transfer between the sensor and air is reduced as the thermal conductivity of the air is decreased at cold temperatures (Lee et al., 2021).

After (Line 232-233): because the convective heat transfer between the sensor and air is reduced at cold temperatures with positive correlations between the thermal conductivity and the viscosity of air and the air temperature (Lee et al., 2021).

Before: This is attributed to the decrease of the thermal conductivity of air at cold temperatures, which reduces the heat transfer from the sensor to air despite the constant irradiation.

After (Line 284-287): The thermal conductivity and the viscosity of air decrease as the air temperature decreases while the density of air is inversely correlated with the temperature. The net effect of these air properties is that the heat transfer from the sensor to air is positively correlated with the air temperature (Lee et al., 2022). The effect of long-wave radiation from the sensor is minor compared with that of convective heat transfer.

Fig. 6 and Fig. 7: The units given in the x-axis titles should be hPa (instead of kPa) to be consistent with the axis labels

→ The unit is changed to hPa.

Modified Figure (Figures 6 & 7): The unit of x-axis title is changed to hPa.

Referee #2

General Comment:

In this second round of the review, the authors have improved the text of the manuscript providing several clarifications and explanations which were missing or not sufficient in the previously submitted version. Nevertheless, also on the basis of the new text added, I think there are still major revisions to apply to the paper and a few major concerns in the presented analysis.

→ We thank the Reviewer for valuable comments to improve the quality of the manuscript.

I report below my major comments.

The authors state that various factors of irregularity in the production process of the thermistors and the environments of the RRT chamber can be responsible for a portion of the total uncertainty. Several possible technical reasons are reported. Despite the large number of tested thermistor It is not clear how this can affect the DTR performances and uncertainties over long term, putting the DTR sonde still at an experimental level. Irregularities in the production process may mean that: 1. the results presented in this paper cannot be used as a general assessment of the dual-thermistor sondes performance. Instead, the presented analysis should be reported as an additional step in the optimization of DTRs and an investigation of what must be improved in the future productions process; 2. this radiosonde type cannot be easily employed on routine basis in a reference network and it's not yet ready to improve the accuracy of temperature measurement in the upper air within the framework of the traceability to the SI. These aspects must be reflected in the paper.

→ As the Reviewer mentioned, this paper is an additional step before an optimization of the DTR. Nevertheless, the paper is meaningful because it shows whole characterization processes of the DTR including the fabrication and the evaluation. This was the first time for us to finish the whole process step by step. We admit that there is much room for the improvement in the fabrication of the DTR, the evaluation using laboratory setups, and comparison soundings. Each process is being polished for an optimization. Very recently, the irregularity of the sensor fabrication is improved and the calibration uncertainty is reduced with minimizing the spatial temperature deviations in the climate chamber. Moreover, we plan to conduct more comparison soundings this year. If there is a major improvement on the DTR or a new finding worth reporting, we will continue to report. This point is added in the revised manuscript.

Added statement (Line 425-427): Future works include an optimization of each process shown in this study such as the fabrication of the DTR and the evaluation using laboratory setups to improve the uncertainties due to irregularities in the production and testing of sensors.

Before: Future works may include more parallel sounding tests in various conditions including cloudy and windy weather to better characterise the performance of the DTR.

After (Line 427-429): In addition, more parallel sounding tests in various conditions including daytime and nighttime and/or cloudy and windy weather will be conducted to better characterise the performance of the DTR.

Another question is: can the residuals in the plot of Figure 5 be related to this "production" uncertainty? The authors did not fully answer to my request for clarification about residuals after the first review stage.

→ Figure 5 shows individual radiation sensitivities (not residuals) of pairs of thermistors at a specific condition using the rotational radiation test (RRT) setup. The RRT result is transferred to the radiation correction formula obtained using the upper air simulator (UAS). Since the UAS experiment on a pair of thermistors takes a very long time, only five representative pairs are selected for the UAS testing as shown by arrows in Fig. 5(c) and (d). Then, the individual sensitivity of the RRT is incorporated in the radiation correction formula obtained by the UAS and thus the production (radiation sensitivity) irregularity in Fig. 5 is neutralized as shown in Fig. 7(f). The representativeness of the five thermistor pairs from the RRT results is based on the proportionality with the UAS results.

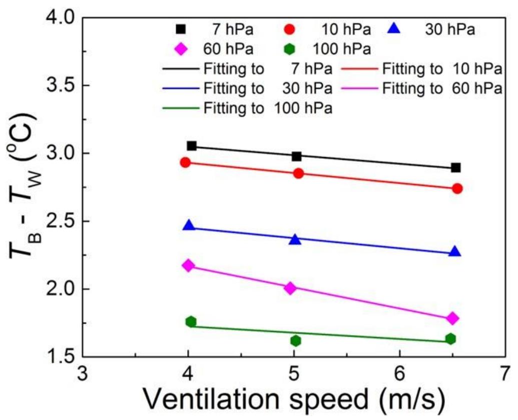
Added statement (Line 247-251): The applied concept of transferring the individual radiation sensitivities from the RRT based on the five chosen units to Eq. (2) does not necessarily rely on 'realistic' irradiation and ventilation conditions in the RRT setup, but rather on the consistence of the existing conditions in the RRT over the radiation tests of all other sondes. The representativeness of the RRT results of the five thermistor pairs as part of all thermistors is based on the proportionality with the UAS results.

The number of parallel soundings, particularly at night, is too small to provide solid conclusions. I ask the authors to remove section 6.3 from the manuscript or at maximum report this in the appendix, although the clear need for a nighttime radiation correction, also stated by the authors themselves, suggest completely removing this part from the manuscript.

→ All contents on the nighttime soundings are removed from the paper while the daytime contents remain.

The authors state that "The ventilation speed for five units in Figure 6 is fixed at 5 m·s-1 and thus the effect of air ventilation cannot be identified. The effect of air ventilation is studied with a separate pair of thermistors". Given the irregularities in the production process can the values of the standard deviation of the residual for the pair of thermistors (reduced from 4.1% to 3.4% when the air ventilation is actually changed 4–6.5 m·s−1) be considered typical? Otherwise I'd sugesst the authors to extend the assessment of the effect of air ventilation to a larger number of thermistors.

→ The effect of ventilation is not significant in the range of 4–6.5 m·s^{-1} as shown in the Figure below and thus the decrease of the residuals is small when Eq. (10) is used to reflect the ventilation effect. Eq. (9) is deduced when the ventilation speed is 5 m·s^{-1} while Eq. (10) is from 4–6.5 m·s^{-1} using an average of the sensitivity coefficient (–0.08 °C/(m·s^{-1})) over the range. The ventilation effect will become significant below 4 m·s^{-1} because the convective cooling will be weakened as studied by the GRUAN. This remains to be our future study because we have learned that there are some researchers who wants to collect more data with a slow ascent of radiosondes.



Added statement (Line 432-433): Since the radiation correction formula presented in this study is valid for the ventilation speed of 4–6.5 m·s^{-1}, the range should be widened to extend the applicability of the DTR.

Specific comments: Below also a few specific comments are also reported.

Introduction: the authors state that: "Radiosonde observations are often co-located with global navigation satellite system radio occultation and used as a reference for validating their one-dimensional interpolation which follows the flight trajectories of balloon soundings". I think the sentence must be more general, applications using GNSS data do not always consider interpolation along the balloon flight trajectories.

→ The sentence is modified to deliver that both techniques are mutually helpful.

Before: Radiosonde observations are often co-located with global navigation satellite system radio occultation and used as reference for validating their one-dimensional interpolation which follows the flight trajectories of balloon soundings.

After (Line 34-36): Radiosonde observations can be co-located with global navigation satellite system radio occultation and these measurements are compared with each other to enhance the applicability and reliability of both techniques.

Line 35: provide a more general sentence considering that ground-based remote sensing measurements are not always less accurate than radiosoundings in all the atmospheric regions and conditions.

→ We have changed the sentence in the prior comment.

Line 44: It is not only needed to have "sufficiently small uncertainties" but also to well quantify them and in a traceable way. This is the motivation behind GRUAN, which must be reflected in the text. Please rephrase.

→ The sentence is modified to include the traceability as well as uncertainty.

Before: To investigate the climate change, a certain level of measurement uncertainty in radiosoundings should be secured.

After (Line 43-44): To investigate the climate change, a certain level of measurement uncertainty in radiosoundings should be secured in a SI-traceable way.

Line 121-122: likely a repetition from the previous text, reword.

→ The sentence is modified to avoid a repetition.

Before: First, the thermistors on the sensor boom are individually calibrated using a climate chamber from −70 to 30 ℃ to evaluate the uncertainty of raw temperature measurement before radiation correction (Fig. 2(a)).

After (Line 121-122): First, the calibration of thermistors attached to the sensor boom is conducted from −70 to 30 ℃ in a climate chamber (Fig. 2(a)) and the uncertainty of raw temperature measurement is evaluated.

Line 131-132: It would be interesting to show the differences between the second-order and third-order polynomial. I recommended adding these results to the manuscripts. Although from a separate paper under printing, a short sentence/summary of these results would be helpful for the reader.

→ A short summary of using the second-order and third-order polynomial is added.

Added sentence (Line 145-147): In the work of Yang *et al.*, the maximum value of the residuals was 117 mK and 13 mK for the second-order polynomial and the third-order polynomial, respectively.

Line 159-160: the authors state: "One of the practical ways to reduce the calibration uncertainty is to conduct another round of calibration with the thermistor set (35 pairs) rotated 180° in the chamber and average out the effect of temperature deviations.". It is not clear to me if the authors performed the suggested additional round of calibration or not in the DTR assessment. Clarify and in the negative case, please, justify the related additional uncertainty contribution.

→ The idea is that the temperature deviations between the front and the rear can be averaged out if the thermistor set is rotated 180° in the second round of the calibration. The temperature of thermistors at the rear side is colder than the front side because wind blows from the rear side fan. However, the idea is not tried because we have found another effective way to reduce the spatial temperature deviation by moving the thermistor set (35 pairs) lower than the rear side fan to avoid the direct wind. The wind blows above the thermistor set and then the spatial temperature deviation within the thermistors set is reduced by about one fourth.

Before: One of the practical ways to reduce the calibration uncertainty is to conduct another round of calibration with the thermistor set (35 pairs) rotated 180° in the chamber and average out the effect of temperature deviations. Another way is to find other locations with smaller temperature deviations.

After (Line 160-162): One of the practical ways to improve the calibration uncertainty is to find a location with reduced spatial temperature deviations in the climate chamber. More recently, the deviations are reduced by about one fourth of Fig. 3(b) at −70 °C by moving the thermistor set (35 pairs) lower than the rear side fan to avoid the direct wind.

Line 181: replace "next" with "following"

→ The word is replaced as suggested.

Before: next

After (Line 183): following

Line183-188: see the general comments on irregularities in the production process.

→ This is answered in the General comment.

Line 194: The decrease with the temperature of (TB_on − TW_on) deserves more attention and specific measurements or more detailes discussion may be optionally added to the manuscript.

→ It is hard to figure out what this comment is about because there is no such mention in Line 194 of the previously revised manuscript. If this comment is about the temperature effect on radiation correction, there are several factors affecting the convective heat transfer from the sensor to the air (i.e. cooling of sensor). The thermal conductivity and the viscosity of air decrease as the air temperature decreases while the density of air is inversely correlated with the temperature. The net effect of these air properties is that the convective heat transfer from the sensor to air is positively correlated with the air temperature. The detailed calculation is introduced in our previous paper (Lee *et al*. Atm. Meas. Tech. 5, 1107-1121, 2022). The effect of long-wave radiation from the sensor is minor compared with the effect of convective heat transfer. We have explained this point in the revised manuscript.

Before: because the convective heat transfer between the sensor and air is reduced as the thermal conductivity of the air is decreased at cold temperatures (Lee et al., 2021).

After (Line 232-233): because the convective heat transfer between the sensor and air is reduced at cold temperatures with positive correlations between the thermal conductivity and the viscosity of air and the air temperature (Lee et al., 2022).

Before: This is attributed to the decrease of the thermal conductivity of air at cold temperatures, which reduces the heat transfer from the sensor to air despite the constant irradiation.

After (Line 284-287): The thermal conductivity and the viscosity of air decrease as the air temperature decreases while the density of air is inversely correlated with the temperature. The net effect of these air properties is that the heat transfer from the sensor to air is positively correlated with the air temperature (Lee et al., 2022). The effect of long-wave radiation from the sensor is minor compared with that of convective heat transfer.

Lines 212-213: repetition, please remove.

→ The sentence is removed.

Removed sentence: Slight variations of air flow and/or pressure in the RRT chamber (not monitored) may partly be responsible for the observed distributions of radiative heating of the sensors in Figs. 5(c) and (d).

Line 263: The decrease in the uncertainty due to the change in ventilation speed appears to be small; can the authors provided a more detailed explanation? For example the range “4.5-6 m/s-1” means that results are an average over this range of values? If the measurements were at different values in this range, could you show a plot for this?

→ This is answered in the General comment.

Line 307: "…. in Eq. (18) and thus the effect of air ventilation cannot be identified in Fig. 7(f)", this is redundant, remove, please.

→ The phrase is removed.

Removed phrase: in Eq. (18) and thus the effect of air ventilation is not yet included in Fig. 7(f)

Line 319-322: beyond limitation in the number of compariaon profile, the fact that the sky was normally cloudy further decreases the value of the comparison with RS41, because of the larger uncertainties in cloud conditions tipically affecting the radiosonde measurements (e.g. radiation correction).

→ We agree that the number of comparison profile is not enough and thus we are preparing more comparison soundings this year. The Reviewer has a point on the cloud condition and the uncertainty. We plan to study how the cloud condition (reflection/screen of solar radiation) would affect the effective irradiance measurement and radiation correction of the DTR this year.

Line 355-356: this means that a proper correction would require a much larger number of parallel soundings than 3 only.

→ All contents on the nighttime soundings are removed from the paper.

Line 375: which previous work are you referring to here?

→ This part is removed.

Line 376: see general comments on the need for radiation correction also for nighttime DTR sonde profiles

→ This is answered in the General comment.

Section 6.3: In the previous review stage, I asked to improve the description of the results; the authors, instead, added a long description based on GRUAN related experiments. However, see my general comment on section 6.3.

→ All contents on the nighttime soundings are removed from the paper while the daytime contents remain. We think that there is nothing much to be added in Section 6.3 except comparing with the previous relevant works by the GRUAN.