Referee #1

General Comment: The manuscript presents a method to estimate and correct the solar radiation error of radiosonde temperature measurements, using a dual thermistor radiosonde. Accurate in situ measurements of temperature profiles by radiosondes constitute a highly relevant topic, for example for climate monitoring, and reference-quality temperature measurements by radiosondes are of high demand.

The method presented in this paper relies on the temperature difference between a black-coated and an aluminum-coated thermistor to derive the effective radiation field which is used in the temperature correction of the Al-coated temperature sensor. The advantage of this method is that it does not rely on modeled assumptions on the radiation field or sensor properties, but aims to measure it directly. With this approach, the authors continue earlier pioneering work by e.g. Schmidlin 1986.

The novel aspect is that the approach relies on purely experimental sensor characterisation in terms of sensitivity to radiation. This is different from previous studies using dual or multiple sensor techniques which are based on solving multiple heat balance equations and therefore require a number of assumptions or estimates with regard to sensor dimensions, material properties and other parameters. Although there are not many easily accessible publications on multi-sensor radiosondes (Schmidlin, Luers, and references herein), the authors should refer to these in their study.

The manuscript is clearly structured. However, it reads as a straightforward and rather technical description with a strong emphasis on the metrological aspects, in particular uncertainties. Although this should of course make up a significant part, more motivation, explanation or interpretation would be appropriate or even required in several places with regard to the methods and results (see detailed comments) in the light of the physical processes taking place. This would not only ‘loosen up’ the text but may help understanding the effects and improve the potential impact in the radiosonde data user community.

→ We thank the Reviewer for valuable comments to improve the quality of the manuscript. As the Reviewer mentioned, the manuscript was oriented to metrological aspects rather than meteorological and physical understanding. We have reinforced the latter part by addressing detailed comments as below.

Detailed comments

Abstract:

L9: The white sensor is in fact coated with Aluminum, and should be referred to as such here. The classification "white" can be used later in the manuscript.

→ The word “white sensor” is replaced by “aluminium-coated sensor” in the Abstract because it is not classified as “white sensor” yet.

Before: white

After (Line 9, 17, 21, & 22): aluminium-coated

The abstract should mention the ratio of the heating rates of the white and the black sensors (which is 1:3), see e.g. Schmidlin (1986)

→ The ratio of the degree of heating between white and black sensors is presented (1:2.4).

Added statement (Line 16-17): to investigate the degree of heating of aluminium-coated and black sensors (the average ratio = 1:2.4)

L12-15: Think of a different phrasing: more motivating instead of just list a number of facts.

→ Motivations of each characterization procedure are added.

Before: individually calibrate the temperature of the thermistors in a climate chamber; test the effect of temperature on the resistance reading using radiosonde boards in the climate chamber; individually perform radiation tests on thermistors; and perform parameterisation of the radiation measurement and correction formulas using an upper air simulator with varying temperature, pressure and ventilation speed.

After (Line 13-20): individually calibrate the temperature of the thermistors in a climate chamber from −70 to 30 ℃ to evaluate the uncertainty of raw temperature measurement before radiation correction; test the effect of temperature on the resistance reading using radiosonde boards in the climate chamber from −70 to 20 ℃ to identify a potential source of errors owing to the boards, especially at cold temperatures; individually perform radiation tests on thermistors at room temperature to investigate the degree of heating of aluminium-coated and black sensors (the average ratio = 1:2.4) and use the result for obtaining unit-specific radiation correction formulas; and perform parameterisation of the radiation measurement and correction formulas with five representative pairs of sensors in terms of temperature, pressure, ventilation speed, and irradiance using an upper air simulator.

Introduction:

L32: It may be referred to the co-location issue and flight trajectories of balloon soundings.

→ The co-location issue is mentioned.

Before: Thus, radiosonde measurements are often used as reference to correct other measurement data.

After (Line 34-36): 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.

Before: Thus, radiosonde measurements are often used as reference to correct other measurement data

L57: Remove "…as previously reported (Lee et al.)"

→ The phrase is removed

Removed phrase: as previously reported (Lee et al., 2018a).

L72: "freezing" -> "climate"

→ The word "freezing" is replaced by "climate"

Before: freezing

After (Line 78): climate

Section 2.2:

The authors should reference to the work of Francis Schmidlin (NASA Tech. Paper 2637, 1986) on the multiple thermistor radiosonde.

→ The work of Schmidlin *et al*. is referred as a pioneering research of radiation correction.

Added statement (Line 103-105): Previously, a pioneer work using multiple thermistors with different spectral responses (emissivity and absorptivity) was conducted for the radiation correction. In the work, however, complete knowledge on material properties of air and sensors and sensor geometry is required to solve multiple heat balance equations (Schmidlin et al., 1986).

Before: DTR utilises the temperature difference

After (Line 105-106): DTR utilises the purely experimental temperature difference

Section 3.1:

L114-115: The exact procedure for the calibration and characterisation measurements is unclear at this point. Add a sentence that these will be discussed in detail in the following sections.

→ Brief explanations are added for each procedure as in the case of Abstract. A sentence that these will be discussed in detail in the following sections is added as suggested.

Before: First, the thermistors on the sensor boom are individually calibrated using a climate chamber (Fig. 2(a)). Then, the temperature effect on the resistance reading by radiosonde boards is tested in the climate chamber (Fig. 2(b)). The temperature increase of all thermistors due to irradiation is individually recorded at room temperature (Fig. 2(c)) to compensate for the difference among units for radiation correction. The radiation measurement and correction formulas of DTR are obtained using the UAS with varying temperature, pressure, ventilation speed and irradiance (Fig. 2(d)). The laboratory experimental results are combined and applied to the DTR sounding system. Then, the sounding results of DTR are compared with those of a commercial radiosonde through dual soundings (Fig. 2(e)).

After (Line 121-130): First, the thermistors on the sensor boom are individually calibrated using a climate chamber from −70 to 30 °C to evaluate the uncertainty of raw temperature measurement before radiation correction (Fig. 2(a)). Then, the temperature effect on the resistance reading by radiosonde boards is tested in the climate chamber from −70 to 20 °C to identify a potential source of errors owing to the boards, especially at cold temperatures (Fig. 2(b)). The temperature increase of all thermistors due to irradiation is individually recorded at room temperature (Fig. 2(c)) to include the differences in the sensitivities of the individual thermistors in the radiation correction. The radiation measurement and correction formulas of DTR are obtained in terms of temperature, pressure, ventilation speed and irradiance using the UAS (Fig. 2(d)). The laboratory experimental results are combined and applied to the DTR sounding system. Then, the sounding results of DTR are compared with those of a commercial radiosonde through dual soundings (Fig. 2(e)). Each characterization procedure will be discussed in detail in the following sections.

L115: “via” -> “due to”

→ It is changed.

Before: via

After (Line 125): due to

L116: “…to include the differences in the sensitivities of the individual thermistors in the radiation correction.”

→ The suggested statement is used.

Before: to compensate for the difference among units for radiation correction.

After (Line 125-126): to include the differences in the sensitivities of the individual thermistors in the radiation correction.

Fig. 2 (c): Which parts of the sensor boom beyond the thermistors are irradiated?

→ The diameter (*D*) of the beam spot on the sensor is 45 mm and the distance between the sensor bead and the beam boundary is 25 mm. These are marked in Figure 2(c).

Modified Figure (Figure 2(c)): The diameter of the beam spot and the distance between the sensor bead and the beam boundary are marked.

Added statement (Line 197-199): The diameter (*D*) of the beam spot on the sensor is 45 mm and the distance between the sensor bead and the beam boundary is 25 mm.

Section 3.2:

Obviously, spatial temperature inhomogeneities within the calibration "box" dominate the calibration uncertainty (Fig. 3 (b)), which to a wide extent dominates the overall uncertainty of the corrected temperature (Fig. 9 (c) and (d)). Could this be reduced, e.g. through suitable ventilation?

→ The deviations are due to the temperature difference between the front door side and the rear fan side of the chamber. If the effect of ventilation is increased, the uncertainty due to the stability of sensor temperature is increased. 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 to average out the effect of temperature deviations. Another way is to find a different location with smaller temperature deviations inside the chamber. Recently, we have found that the maximum temperature deviations are reduced to 0.1 °C when the thermistor set is moved below the horizontal level of the fan.

Added statement (Line 157-162): The uncertainty due to spatial temperature deviations $U(T_{\mathrm{Ref\_devi}})$ in the chamber dominates the calibration uncertainty. The deviations are due to the temperature difference between the front door side and the rear fan side of the chamber. 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. The temperature deviations can be affected by the thermal insulation of the door and the aisles for data cables as well as the ventilation by the fan in the chamber.

L127: "…by the five…"

→ "The" is added.

Before: by five reference PRTs

After (Line 138): by the five reference PRTs

L129: "gradient" -> "differences" or "deviations"

→ The word "gradient" is changed to "deviations".

Before: gradient

After (throughout manuscript): deviations

Before: $T_{\mathrm{Ref\_grad}}$

After (throughout manuscript): $T_{\mathrm{Ref\_devi}}$

Modified Figure (Figure 3 and Caption): $T_{\mathrm{Ref\_grad}}$ is changed to $T_{\mathrm{Ref\_devi}}$

L131: Between "polynomial equation" and "yields" you may insert ", i.e. the inclusion of a quadratic term, which is not present in the Steinhart-Hart equation, "

→ The statement is added as suggested.

Added statement (Line 144-145): i.e. the inclusion of a quadratic term, which is not present in the Steinhart-Hart equation

L132: "…, the Steinhart-Hart equation is modified…"

→ The sentence is changed as suggested.

Before: Therefore, the former equation is adopted

After (Line 145-146): Therefore, the Steinhart-Hart equation is modified

Section 3.3:

L144-146: Make more clear that the effect of the temperature of the radiosonde electronics board on the thermistor resistance (or temperature) measurement is investigated here.

→ The purpose of the experiment in Section 3.3 is explained more clearly.

Before: To measure the temperature using the thermistors via Eq. (1), the measurement of the sensor resistance by the radiosonde boards should be evaluated in the temperature range of the sensor calibration.

After (Line 164-166): To properly measure the temperature using the thermistors via Eq. (1), the effect of the temperature of the radiosonde electronics board on the thermistor resistance measurement should be investigated in the same temperature range of the thermistor calibration.

Fig. 4(b): Use symbol for unit; don't use "k" and "M" for x-axis labels of resistance; Caption: "… (c) Residual after conversion of resistance to temperature as function of temperature.

→ The resistance unit, Ω is used in Fig. 4(b); The x-axis labels are changed to 10^3, 10^4, and 10^5; Caption of Fig. 4(c) is changed as suggested.

Modified Figure (Figure 4 and Caption): The unit of resistance, x-axis labels, and the caption of (c) is changed.

L155: What is meant by "roughly distributed"?

→ The statement is deleted.

Before: Since the temperature error is roughly distributed within ±0.05 °C, the standard deviation of all data points is obtained (0.04 °C) and is used for uncertainty (k = 1) due to the influence of temperature on the resistance reading by radiosonde boards.

After (Line 175-178): Assuming that the probability distribution is a normal distribution function, the standard deviation (SD) of all data points (0.04 °C) is used for standard uncertainty due to the influence of the temperature of radiosonde electronics boards on the resistance (or temperature) measurement.

Section 3.4:

The first paragraph should be worded more clearly and more precisely. E.g., L158: "… the unit difference in terms of the correction value.": Does that mean something like "sensitivity to irradiation and therefore the amount of radiation correction may vary for individual radiosondes, presumably related to the production process of the thermistors..."?;

→ The first paragraph is worded more clearly.

Before: A difficulty faced during the radiation correction of these thermistors is the unit difference in terms of the correction value.

After (Line 180-183): The purpose of the calibration of thermistors and the investigation of the temperature effect on radiosonde electronics boards is to assess the accuracy (or uncertainty) of raw temperature measurement before radiation correction. The next step is to investigate the sensitivity of individual thermistors to irradiation because the amount of radiation correction varies for individual radiosondes, presumably related to the production process of the thermistors.

L161: "Irregularities in the construction of the leads connecting sensor and boom…" It is interesting that these variations in the properties of the sensors, such as e.g. its diameter, have such a big influence. The authors should discuss this in more detail. A helpful reference may be de Podesta et al. (2018) (DOI: 10.1088/1681-7575/aaaa52).

→ The size of glass beads is irregular according to the manufacturer specification. The distribution of the size is specified in the revised manuscript. We also suspect the connection part between the sensor leads and the boom for one of the reasons of the observed difference of individual radiation test in Fig. 5(d) because the soldering and the coating of epoxy resin were conducted manually. Radiative heating of the glass beads, leads, and connection parts should be affected by their size as in the case of de Podesta *et al*.

Before: ellipsoidal shape with 0.55 mm diameter and 1.1 mm length.

After (Line 96-97): ellipsoidal shape with 0.55 ± 0.1 mm diameter and 1.1 ± 0.3 mm length

Before: The irregular connection between the sensor and boom may affect the thermal conduction between them.

After (Line 186-188): The connection between the sensor leads and the boom may be irregular because the soldering and the coating of epoxy resin were conducted manually. Radiative heating of glass beads, leads, and connection parts between the sensor leads and the boom should be affected by their size as previously reported (De Podesta et al., 2018).

Second paragraph:

What irradiance is applied? What are the conditions with regard to air pressure and ventilation in the RRT? Is the pump used to vary the pressure, or to create an airflow, or both? If there is no significant ventilation I would expect a certain variation of the results from that, because the cooling efficiency should strongly vary with air flow at low or vanishing flow rates. That might at least partially explain the distributions in Figs. 5 (c) and (d). If the ventilation is controlled, is it adjusted similar to what is used in the UAS (~5 m·s−1)?

→ The RRT irradiance at the sensor position is 800 $W \cdot m^{-2}$ with 0.8% standard deviation for each irradiation. The ventilation and air pressure depends on the performance of the vacuum pump and the sealing of the chamber lid using an O-ring. Unfortunately, these factors were not monitored. Thus, there can be variations in the air flow and the pressure that may vary the cooling efficiency. We agree that the RRT system needs an improvement such as the measurement of air pressure at least. This point is explained in the revised manuscript.

Added statement (Line 192-195): The RRT irradiance at the sensor position is 800 $W \cdot m^{-2}$ with 0.8% standard deviation for each irradiation. The ventilation and the pressure in the chamber are not measured. Since they depend on the performance of the vacuum pump and the sealing of the chamber lid using an O-ring, there can be slight variations in the ventilation and the pressure.

Added statement (Line 210-213): Although the irradiance is constant for each sensor, the cooling efficiency of the sensors may vary depending on the bead size of thermistors, air flow, and the pressure. 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).

Fig. 5 (b): Rad. warming of Al-coated is more than one third of that for the black thermistor in Fig. 5 (b), and the absolute value of ~1.2 K in the example seems unexpectedly large at a first glance (is that a typical example?). Does that mean that the reflectivity of the Al-coating is not that close to one, but say ~0.7 or so?

→ The average ratio of the radiative heating of aluminium-coated and black sensors is 1:2.4 in the RRT experiment. We think that the reflectivity of Al-coating cannot be simply estimated using these measurements because the radiative heating of sensors is affected by various parameters. Previously, when we measured the reflectance of Al coating of the DTR from a different batch (not this work), the reflectance was 0.8-0.9 below 1000 nm in wavelength and higher than 0.9 above 1000 nm in wavelength.

Added statement (Line 206-207): The average ratio of the radiative heating of aluminium-coated and black sensors is 1:2.4 in the RRT experiment.

Quantitative information on irradiance (is it the 960 $W \cdot m^{-2}$?), pressure and ventilation for the RRT tests would be helpful to better assess or classify the results.

→ The RRT irradiance at the sensor position is 800 $W \cdot m^{-2}$ with 0.8% standard deviation for each irradiation. The ventilation and the pressure are not measured but they rely on the performance of the vacuum pump with the sealing of the lid using O-ring. This point is mentioned in the earlier comment.

Is there a test to see if the two thermistors influence each other (e.g. via heat conduction)? This could be assessed by selective irradiation.

→ We have not thought about the idea nor conducted such experiment.

How are the T-differences extracted/evaluated from the data in Fig. 5 (b)?

→ The temperature rise by the irradiation in Fig. 5(b) is determined by the difference of the average temperature for the last 30 seconds (30 data) before the shutter is opened and closed. The mean temperature rise of the three repeated measurements is assigned as the RRT value for each pair of thermistors in Fig. 5(c) and (d).

Before: Then, the shutter is opened and a pair of thermistors are illuminated for 180 s. Temperatures of the white (T_W) and black (T_B) sensors are recorded (Fig. 5(b)), and 107 pairs of dual thermistors are tested in total.

After (Line 202-206): Then, the shutter is opened and closed for 180 s each and this process is repeated three times for the illumination on each pair of thermistors. The temperatures of the white (T_W) and black (T_B) sensors are recorded (Fig. 5(b)), and 107 pairs of dual thermistors are tested in total. The temperature rise by the irradiation is determined by the difference of the average temperature for the last 30 seconds (30 data) before the shutter is opened and closed. The mean temperature rise of the three repeated measurements is assigned as the RRT value for each pair of thermistors.

Section 4.1:

First paragraph: (How) Is the angle of the sensor boom, i.e. the irradiation angle and boom orientation, and the angle relative to the air flow taken into account in the UAS measurements?

→ The sensor boom is installed upside down in parallel with the air flow and perpendicular to the irradiation direction.

Added statement (Line 218-219): The DTR is installed upside down in the test chamber of the UAS with the thermistors and the sensor boom in parallel with the air flow but perpendicular to the irradiation.

L190: Better: "… with the fitting coefficients being functions of T_W_on…"

→ The phrase is changed as suggested.

Before: are the fitting coefficients with a T_{W_on} function

After (Line 228): are the fitting coefficients being functions of T_{W_on}

L193/194: Isn't the point here that the effective long-wave cooling is different for the two thermistors, according to the different emissivities, whereas the SW-absorption does not depend on T?

→ The effect of temperature on the degree of the temperature difference between two thermistors is observed. This is because the convective heat transfer between the sensor and air is reduced as the thermal conductivity of the air is decreased at cold temperatures as studied in Lee *et al.* Atmos. Meas. Tech. Discuss. *in press*.

Before: Interestingly, (T_{B_on} − T_{W_on}) gradually increases with decreasing sensor temperature in the UAS. A similar phenomenon was previously observed in a chamber with no apparent air ventilation (Lee et al., 2018a). A possible reason might be that the long-wave radiation from thermistors decreases with the environmental temperature even though the irradiance is maintained at cold temperatures.

After (Line 230-233): Interestingly, the level of (T_{B_on} − T_{W_on}) gradually increases as the temperature decreases especially for low pressures. A similar phenomenon was previously observed in a chamber with no apparent air ventilation (Lee et al., 2018a). The observed effect of temperature on (T_{B_on} − T_{W_on}) is 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).

Eq. (2): What motivated the exponential functions as fitting model?

→ The exponential functions are purely empirical because they agree well with the experimental data.

L216: The radiation flux of 960 W·m−2 is known. Is the (re)fitting done for the purpose of estimating uncertainties in terms of the residuals?

→ Eq. (9) and Eq. (10) are corrected to deliver the meaning clearly. The backbone of Eq. (9) and (10) is Eq. (2). Since Eq. (2) is obtained when the radiation flux is 960 $W \cdot m^{-2}$, an unknown radiation flux can be measured by the temperature difference of two thermistors using the linear relationship with the $(T_{B\_on} - T_{W\_on})_{UAS}$ at 960 $W \cdot m^{-2}$ (the denominator in Eq. (9)). Therefore, the $(T_{B\_on} - T_{W\_on})_{UAS}$ in Eq. (9) and (10) should be replaced by (T_{B_raw} − T_{W_raw}) where T_{B_raw} and T_{W_raw} are raw temperatures of the black and white sensors, respectively.

Before: Hence, Eq. (2) is employed to measure the *in-situ* irradiance based on the fact that $(T_{B\_on} - T_{W\_on})_{UAS}$ is linearly proportional to *S*.

After (Line 250-252): Hence, Eq. (2) is employed to measure the *in-situ* irradiance using (T_{B_raw} − T_{W_raw}), where T_{B_raw} and T_{W_raw} are raw temperatures of the black and white sensors, respectively, based on the fact that the temperature difference between two sensors is linearly proportional to S.

Before: $S = S_0 \times (T_{B\_on} - T_{W\_on})_{UAS} / [T_0(T_{W\_on}) + A_0(T_{W\_on})\cdot\exp(-P/P_0(T_{W\_on})) + A_1(T_{W\_on})\cdot\exp(-P/P_1(T_{W\_on}))]$, $S_0 = 960\ \mathrm{W\cdot m^{-2}}$

After (Eq. (9)): $S = S_0 \times (T_{B\_raw} - T_{W\_raw}) \cdot (T_{B\_on} - T_{W\_on})_{UAS}{}^{-1}$,

Before: $S = S_0 \times (T_{B\_on} - T_{W\_on})_{UAS} / [T_0(T_{W\_on}) + A_0(T_{W\_on})\cdot\exp(-P/P_0(T_{W\_on})) + A_1(T_{W\_on})\cdot\exp(-P/P_1(T_{W\_on})) - 0.08\cdot(v - v_0)]$, $S_0 = 960\ \mathrm{W\cdot m^{-2}}$ and $v_0 = 5\ \mathrm{m\cdot s^{-1}}$

After (Eq. (10)): $S = S_0 \times (T_{B\_raw} - T_{W\_raw}) \cdot [(T_{B\_on} - T_{W\_on})_{UAS} - 0.08\cdot(v - v_0)]^{-1}$,

Eq. (10): Is the equation valid only for 7-100 hPa and 4-6.5 $\mathrm{m\cdot s^{-1}}$?

→ The effect of ventilation speed is investigated in the range of v = 4-6.5 $\mathrm{m\cdot s^{-1}}$ and P = 7-100 hPa. The sensitivity coefficient against the ventilation is -0.08 °C / ($\mathrm{m\cdot s^{-1}}$) averaged over the pressure range. The coefficient will be significantly bigger when v is lower than 4 $\mathrm{m\cdot s^{-1}}$ while it will be a bit smaller when P is higher than 100 hPa.

Added statement (Line 264-265): The absolute value of the sensitivity coefficient (-0.08 °C / ($\mathrm{m\cdot s^{-1}}$)) against the ventilation speed will be significantly bigger when v is lower than 4 $\mathrm{m\cdot s^{-1}}$ while it will be a bit smaller when P is higher than 100 hPa.

Fig. 6 (also Fig. 7): The trend of the data points is difficult to see at low p; consider using a logarithmic scale.

→ Logarithmic scale is used for Figs. 6 and 7.

Modified Figures (Figures 6 & 7): Logarithmic scale is used for x-axis of Figures 6 and 7.

Section 4.2:

Eq. (19): Validity range with regard to p and v?

→ The effect of ventilation speed is investigated in the range of v = 4-6.5 $\mathrm{m\cdot s^{-1}}$ and P = 7-100 hPa. The sensitivity coefficient against the ventilation is -0.1 °C / ($\mathrm{m\cdot s^{-1}}$) averaged over the pressure range. The coefficient will be significantly bigger when v is lower than 4 $\mathrm{m\cdot s^{-1}}$ while it will be a bit smaller when P is higher than 100 hPa.

Added statement (Line 312-314): The absolute value of the sensitivity coefficient (-0.1 °C / ($\mathrm{m\cdot s^{-1}}$)) against the ventilation speed will be significantly bigger when v is lower than 4 $\mathrm{m\cdot s^{-1}}$ while it will be a bit smaller when P is higher than 100 hPa.

L234f: Please discuss the influence of the temperature dependence of the efficiency of convective cooling, i.e. at low temperatures the thermal conductivity of air decreases leading to an increase of the radiative heating of the temperature sensor.

→ This manuscript was written before the revision of the previous UAS paper (amt-2021-246). The influence of the temperature is discussed in line with the previous paper.

Before: $(T_{W\_on} - T_{W\_off})_{UAS}$ gradually increases with decreasing sensor temperature (T_{W_on}) in UAS. This is attributed to the decrease of the long-wave radiation from thermistors at cold temperatures, despite the constant irradiation.

After (Line 278-281): $(T_{W\_on} - T_{W\_off})_{UAS}$ shows a temperature dependency. $(T_{W\_on} - T_{W\_off})_{UAS}$ at –68 °C is 118.9 ± 3.5% (mean ± SD of five units) of that at 20 °C, when P = 5 hPa. In the previous study, the ratio for RS41 investigated by the same manner is 119% (Lee et al., 2021). 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.

Section 5:

At what time was the daytime sounding performed? What was the cloud situation?

→ The daytime sounding was performed from 11:00 am to 5 pm local time while the nighttime sounding was from 12:00 am to 4 am. is cloudy

Added statement (Line 321-322): The daytime sounding was performed from 11:00 am to 5 pm local time while the nighttime sounding was from 12:00 am to 4 am. The sky was normally cloudy.

Add more discussion on what is observed in the plots in Fig. 8. The reconstructed solar (ir)radiance decreases with altitude in the stratosphere. This is opposite to what is expected. Please compare the reconstructed radiation profile to RTM calculations, and discuss the differences. See for example Philipona et al 2020 (doi: 10.1127/metz/2020/1044) for in situ measurements of the radiation profile.

→ The negative irradiance in the stratosphere at nighttime is very clear because the temperature of the black sensor is distinctively lower than the white sensor above 20 km at nighttime (Fig. 8d). Previously, the same phenomenon was observed in the Figure 4b of Rolf Philipona *et al.* (2013) in Journal of Atmospheric and Oceanic Technology (DOI: 10.1175/JTECH-D-13-00047.1). The authors explained that "The sum of the absorbed and emitted fluxes result in the longwave radiation balance of the sensor during the night (LRB_n), which is negative in the lower troposphere, and then becomes positive and again negative further up in the stratosphere.

Hence, in the lower troposphere, LRB_n cools the temperature sensor, higher up LRB_n warms the temperature sensor, and above 25 km it again cools the temperature sensor." The effect of long-wave radiation was also applied to the daytime as they mentioned that "The longwave radiative impact on the sensor from above and from below is very similar during the day and during the night (Fig. 4c)." Indeed, the pattern of LRB_d at daytime shown in Fig. 4c of Philipona *et al.* is similar to that of the LRB_n at nighttime in Fig. 4b. Therefore, the decrease of the effective irradiance in the stratosphere at daytime is highly likely due to the negative longwave radiation balance of the sensors.

Added statement (Line 346-356): The negative net irradiance at nighttime was also observed in the previous work for the radiation correction of radiosondes based on the measurement of radiative flux profiles using two pyranometers for measuring downward and upward solar short-wave radiation, and two pyrgeometers for measuring upward and downward thermal long-wave radiation (Philipona et al., 2013). The long-wave radiation balance (LRB) of the sensor defined by the sum of the absorbed and emitted fluxes corresponds to the effective irradiance at nighttime in this work. Both the LRB in the work of Philipona *et al.* and the effective irradiance at nighttime in this work are negative in the lower troposphere, and then become positive and again negative further up in the stratosphere. This means that temperature sensors of radiosondes are cooled in lower troposphere, warmed in higher up, and again cooled further up in the stratosphere and thus should be corrected accordingly. The profile of the LRB at nighttime was similar to that of daytime (Philipona et al., 2013). In this regard, the decrease of the effective irradiance in the stratosphere observed at daytime is highly likely due to the negative LRB of the sensors as observed in the nighttime soundings.

In particular, it could be discussed more how the different long-wave backgrounds in the experiments and in the situations during the real soundings may influence the results, or what potential systematic errors of the radiation correction may be in connection to this. Can it be assumed without reservation that the sensitivity of the thermistors is the same with regard to long-wave and short-wave radiation (wavelength-independent emissivity/absorptivity)?

→ The radiation correction formula of the DTR is obtained based on the portion of the long-wave and the short-wave radiation from a solar simulator used as a radiation source in the UAS experiments. As the reviewer pointed out, the emissivity/absorptivity is dependent on the radiation wavelength. In this regard, the temperature rise of the DTR upon irradiation can be affected by the actual ratio of the long-wave and the short-wave radiation in soundings. For aluminum coating, the reflectance is 0.8–0.9 below 1000 nm in wavelength and 0.9 above 1000 nm. This means that the influence of the ratio between the long-wave and the short-wave radiation will be within a few percent of the radiative heating of the DTR even when the portion below 1000 nm is drastically different between the laboratory experiments and soundings.

Added statement (Line 328-335): The radiation correction formula of the DTR is obtained based on the portion of the long-wave and the short-wave radiation from the solar simulator used as a radiation source in the UAS experiments. The emissivity and absorptivity are dependent on the wavelength. In this regard, the radiative heating of the DTR in soundings can be affected by the actual ratio of the long-wave and the short-wave radiation. For aluminium coating, the reflectance was 0.8–0.9 below 1000 nm and 0.9 above 1000 nm in wavelength. This means that the influence of the ratio between the long- and short-wave radiation would be a few percent of the radiative heating of the DTR even when the portion below 1000 nm is drastically different between the laboratory experiments and soundings.

Mention in the caption of Fig. 8 that the effective irradiance is calculated using Eq. (9) (or 10).

→ The caption of Fig. 8 is modified.

Before: (b) calculated effective irradiance based on (T_{B_raw} – T_{W_raw}) and (c) radiation correction value of the white sensor at daytime.

After (Figure 8 Caption): (b) effective irradiance based on (T_{B_raw} – T_{W_raw}) calculated by Eq. (10) and (c) radiation correction value of the white sensor at daytime calculated by Eq. (19).

Section 6.2

L340/341: "enhance" -> "improve" or "reduce"; It should be discussed here (or in 3.2) whether and how the calibration uncertainty, which is obviously due to air temperature inhomogeneities within the calibration volume, can be reduced.

→ The word is changed as suggested. Reduction of calibration uncertainty is discussed in earlier comments.

Before: enhance

After (Line 410): improve

Section 6.3

Fig. 9 (f): The >0.2 K offset at ~16 km is striking, please comment on this.

→ We think that the number of nighttime soundings is not enough to smooth out the averaged profiles.