

## Referee #2

**General Comment:** The manuscript by Lee et al. provides the description and the metrological characterisation of a dual thermistor radiosonde (DTR) comprising two sensors with different emissivities. The work described in the manuscript is done in continuity with previous efforts of scientific community and of the authors themselves. The use of DTR has the main objective to improve the adjustment of the daytime solar radiation effect on the temperature sensors which is a critical issue for all radiosonde types.

The manuscript is well structured and, beyond the introduction, sufficiently well written. The metrological characterisation of the DTR is detailed and comprises of the major steps needed to fully characterise investigated sensor. Nevertheless I have major concerns about the scientific quality of the manuscript which are detailed below.

There is a strong imbalance between the metrological characterisation of the DTR and the scientific discussion related to the assessment of the DTR performance in the atmosphere.

→ We thank the Reviewer for valuable comments. We have added more discussions on the performance of the DTR to address the Reviewer's comments. The specific changes are made as below.

1. The metrological characterisation of the solar radiation correction and the quantification of the uncertainty budget for the DTR are not supported by sufficient validation of results: the comparison with the RS41, which can be assumed in the context of the manuscript as a "community standard" (although the only reference is known to be the cryogenic frostpoint hygrometer), is quickly presented and lacks of discussion for the differences shown in Fig. 9. This is a very important aspect to show the performances of the DTR measurements. A broader discussion on the consistency with the RS41 should be included.

→ More discussion is added as responses to this comment and the later comment in Section 6.3. Please see the response to the comment of Line 349-353 in original manuscript or Line 416-432 in revised manuscript.

2. The experimental set up discussed in the manuscript looks sufficiently robust, although this could be compared with previous experiments available in literature in order to show what are the pros and cons of the metrological characterization carried out by the authors. A few assumptions in the manuscript must be well justified by means of references or quantitative results. For example, when the term  $(T_{B\_raw} - T_{W\_raw})$  is used instead of  $(T_{B\_on} - T_{W\_on})_{UAS}$  to obtain the irradiance using Eq. (10) in the adjustment of the DTR measured profile, this is done without justifying their effect on the measurements compared to the results obtained in the laboratory experiments. Also the uncertainty due to the solar radiation correction is smaller

than for other radiosondes (according to the literature) and a comparative discussion could be provided in the benefit of the reader.

→ Although both  $(T_{B\_raw} - T_{W\_raw})$  and  $(T_{B\_on} - T_{W\_on})_{UAS}$  are linearly proportional to the total radiation flux, the portion of the long-wave and the short-wave radiation may affect them because the emissivity and absorptivity of thermistors are dependent on the radiation wavelength. For aluminium coating, the reflectance is 0.8–0.9 below 1000 nm in wavelength and 0.9 above 1000 nm. This implies that the influence of the portion of 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.

**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.

→ The uncertainty due to the solar radiation correction is smaller than other radiosondes because the DTR measures the effective irradiance while others use the simulated irradiance constructed from the average of clear and cloudy sky cases. This results in the increase of the radiation correction uncertainty in troposphere.

**Line 72-74: (Before)** the SI traceability of the simulated irradiance is incomplete and may increase the radiation correction uncertainty → **(After)** the SI traceability of the simulated irradiance is incomplete if the sky is clear or cloudy because the simulated irradiance is constructed from the average of clear and cloudy sky cases (Von Rohden et al., 2022). This results in the increase of the radiation correction uncertainty in troposphere.

3. The manuscript introduction is not well written and lacks of fairness and accuracy. I strongly recommend the authors to pay great care in writing inaccurate or wrong statements. Specific comments on the introduction are provided in a revised pdf version of the manuscript along with several specific comments, attached to this review.

→ The specific comments in the pdf version are addressed as below.

**Line 10:** probes?

**Line 10:** sensors → probes

**Line 12:** radiosounding

**Line 12:** sounding → radiosounding

**Line 26:** If you refer to Bojiinski please use the term "Essential Climate Variables".

**Line 30:** environmental parameters → essential climate variables

**Line 29:** repetition

**Line 33:** environmental parameters → meteorological parameters

**Line 29:** collected measurements

**Line 33:** measurement → collected measurement

**Line 30-31:** This sentence is quite generic, should refer to many other aspect like time integration, representativeness, different atmospheric regions. I recommend to remove.

**Removed sentence:** Radiosonde measurements are known to be more accurate than measurement methods based on remote sensing techniques, such as LIDAR and satellite.

**Line 32:** "for calibrating" or validating. This paragraph is a bit uncorrect. Must be rephrased.

**Line 34-36: (Before)** Thus, radiosonde measurements are often used as reference to correct other measurement data. → **(After)** 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.

**Line 32:** This is independent on the needs of calibrating /validating other techniques.

**Removed word:** Hence,

**Line 37-38:** if GCOS is referring to the "meteorological community" this is evidently wrong because this is a climate initiative by WMO

**Removed phrase:** , such as the Global Climate Observing System (GCOS)

**Line 39:** Replace with "in the upper troposphere/lower stratosphere".

**Line 42-43: (Before)** when the project deliverables were limited to the field of upper air measurement by radiosondes → **(After)** in the environments imitating the upper troposphere/lower stratosphere

**Line 40:** investigate or detect.

**Line 43:** resolve → investigate

**Line 40:** remove

**Removed phrase:** long term

**Line 40-41:** unclear, rephrase

**Line 43-44: (Before)** a certain amount of measurement uncertainty of radiosonde sensors is required for actual soundings in addition to the ground-based facilities → **(After)** a certain level of measurement uncertainty in radiosoundings should be secured.

**Line 42-43:** replace with "a dataset of traceable measurements with quantified uncertainties"

**Line 45-46: (Before)** the highest level of quality control in the upper air measurement in terms of uncertainty → **(After)** a dataset of traceable measurements with quantified uncertainties

**Line 43-44:** Please refer in the numbers and citation to Dirksen et al 2014

**Line 55-57 (Added statement):** The uncertainty of the GDP of RS92 during daytime was gradually increased from 0.2 °C at the surface to 0.6 °C at 30 km with the coverage factor  $k = 2$  (Dirksen et al., 2014).

**Line 59-61 (Added statement):** Using the setup, the uncertainty of the GDP of RS41 is evaluated to be about 0.3 °C ( $k = 2$ ) at 35 km. It is also found that the daytime GRUAN profile is 0.35 °C warmer than the manufacturer's at 35 km (Von Rohden et al., 2022).

**Line 45:** replace with "adjustment" or "correction".

**Line 48:** compensation → correction

**Line 50-51:** this sentence must be rephrased to say way otherwise remove, the following sentence is sufficient.

**Removed sentence:** Thus, the uncertainty evaluation on the radiation correction by manufacturers cannot be fully accepted.

**Line 54:** remove

**Removed word:** algorithm

**Line 61:** remove this is already clear from the context

**Removed phrase:** long term

**Line 64:** replace with "measuring on the same payload of radiosondes"

**Line 69-70:** during soundings → measuring on the same payload of radiosondes

**Line 67-68:** one or more references here may help

**Line 72-74: (Before)** the SI traceability of the simulated irradiance is incomplete and may increase the radiation correction uncertainty → **(After)** the SI traceability of the simulated irradiance is incomplete if the sky is clear or cloudy because the simulated irradiance is constructed from the average of clear and cloudy sky cases (Von Rohden et al., 2022). This results in the increase of the radiation correction uncertainty in troposphere.

**Line 71:** put a comma

**Line 77-78:** air ventilation and temperature → air ventilation, and temperature

**Line 73:** replace with "showed to be"

**Line 79:** was → showed to be

**Line 79:** remove

**Removed word:** formulas

**Line 83:** be consistent in using the tense of verbs

→ Present tense is used in general unless conducted earlier than this work.

**Line 85-86: (Before)** The obtained formulas were used in 80 an intercomparison sounding test that was performed in July, 2021. → **(After)** The obtained formulas are used in an intercomparison sounding test performed in July, 2021.

**Line 85:** add "from parallel soundings"

**Line 91 (Added phrase):** from parallel soundings

**Line 85:** repeated verb

**Line 90-92: (Before)** Finally, the difference between the corrected temperatures of DTR and the RS41 radiosonde is presented with the DTR uncertainty → **(After)** Finally, the corrected temperatures of the DTR and the RS41 from parallel soundings are compared and the difference between them is discussed in terms of the uncertainty.

**Line 106-107:** May be this sentence could be removed, need too many details which are discussed later in the text.

**Removed sentence:** Then, the effective irradiance and other environmental factors are parameterised into a single equation to calculate the radiation correction of the white sensor ( $T_{W\_raw} - T_{W\_cor}$ ).

**Line 131-132:** It would be interesting to show the difference between the second-order and third order polynomial. I recommend to add these results to the manuscript.

→ A separate paper from our group which clearly shows the difference is added as a reference.

**Line 145:** (not shown here) → (Yang et al., 2021)

**Line 141:** use a different way to indicate the thermistors to avoid confusion with the other sensors in the chamber.

**Line 153 & 155:** sensors → sensors (thermistors)

**Line 156:** why  $k=1$  and not  $k=2$ ? Please clarify

→ The probability distribution is assumed to be a normal distribution function and the standard deviation is used for standard uncertainty ( $k = 1$ ).

**Line 175-178: (Before)** Since the temperature error is roughly distributed within  $\pm 0.05$  °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)** 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.

**Line 158:** not 100% clear, please expand the sentence. The following sentence clarifies but the reading of this unit is not fully clear.

**Line 180-183: (Before)** A difficulty faced during the radiation correction of these thermistors is the unit difference in terms of the correction value. → **(After)** 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.

**Line 176:** The count distributions shown in Figure 5 are not discussed here at all: no statistical indicators are reported, commented, for example nothing is said why the distribution in Figure 5d is skewed while not that in Figure 5c. Are there potential hysteresis or stabilization effects? Then you must describe in the text your setup in comparison to other available in literature and describe pros and cons. As it stands the description is very minimal.

→ Various factors of irregularity in the production process of the thermistors and the environments of the RRT chamber can be responsible for the count distributions in Fig. 5. 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. The ventilation and air pressure depends on the performance of the vacuum pump and the sealing of the RRT 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.

**Line 96-97: (Before)** ellipsoidal shape with 0.55 mm diameter and 1.1 mm length → **(After)** ellipsoidal shape with  $0.55 \pm 0.1$  mm diameter and  $1.1 \pm 0.3$  mm length

**Line 186-188: (Before)** The irregular connection between the sensor and boom may affect the thermal conduction between them. → **(After)** 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).

**Line 210-213 (Added statement):** 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).

**Line 197-201:** I suggest to use a generic notation for all the five equations

→ We would like to use the current form of equations because they are straightforward with coefficients in Table 1.

**Line 211:** soundings

**Line 250:** sounding → soundings

**Line 214:** better to use a different way to indicate equation, this one may generate confusion

→ Eq. (9) and Eq. (10) are simplified 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  $960 \text{ W} \cdot \text{m}^{-2}$ , 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  $960 \text{ W} \cdot \text{m}^{-2}$  (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.

**Line 250-252: (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)** 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  $S$ .

**Eq. (9): (Before)**  $S = S_0 \times (T_{B\_on} - T_{W\_on})_{UAS} / [T_0(T_{W\_on}) + A_0(T_{W\_on}) \cdot \exp(-P/P_0(T_{W\_on})) + A_1(T_{W\_on}) \cdot \exp(-P/P_1(T_{W\_on}))]$ ,  $S_0 = 960 \text{ W} \cdot \text{m}^{-2}$

→ **(After)**  $S = S_0 \times (T_{B\_raw} - T_{W\_raw}) \cdot (T_{B\_on} - T_{W\_on})_{UAS}^{-1}$ ,

**Eq. (10): (Before)**  $S = S_0 \times (T_{B\_on} - T_{W\_on})_{UAS} / [T_0(T_{W\_on}) + A_0(T_{W\_on}) \cdot \exp(-P/P_0(T_{W\_on})) + A_1(T_{W\_on}) \cdot \exp(-P/P_1(T_{W\_on})) - 0.08 \cdot (v - v_0)]$ ,  $S_0 = 960 \text{ W} \cdot \text{m}^{-2}$  and  $v_0 = 5 \text{ m} \cdot \text{s}^{-1}$

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

**Line 216-217:** redundant, remove

**Removed phrase:** by Eq. (9) to estimate the irradiance ( $960 \text{ W} \cdot \text{m}^{-2}$ ) by using  $(T_{B\_on} - T_{W\_on})_{UAS}$ ,  $(T_{B\_on} - T_{W\_on})_{RRT}$  and other environmental parameters

**Line 222-223:** Do the residuals reduce after including the effect of air ventilation? Please provide details and maybe amend the plot in Figure 6.

→ The ventilation speed for five units in Figure 6 is fixed at  $5 \text{ m} \cdot \text{s}^{-1}$  and thus the effect of air ventilation cannot be identified. The effect of air ventilation is studied with a separate pair of thermistors. The standard deviation of the residual for the pair of thermistors is 4.1% with Eq. (9) while it is reduced to 3.4% with Eq. (10) when the air ventilation is actually changed ( $4\text{--}6.5 \text{ m} \cdot \text{s}^{-1}$ ).

**Line 258-259 (Added statement):** and thus the effect of air ventilation cannot be identified in Fig. 6(f).

**Line 259 (Added statement):** by a separate pair of thermistors

**Line 263-264 (Added statement):** The standard deviation of the residual for a pair of thermistors is 4.1% with Eq. (9) while it is reduced to 3.4% with Eq. (10) when the air ventilation is actually changed ( $4\text{--}6.5 \text{ m} \cdot \text{s}^{-1}$ ).

**Line 245:** same comment as above

→ We would like to use the current form of equations because they are straightforward with coefficients in Table 2.

**Line 265:** Same comment as at line 222 and not clear why residuals are not evaluated after the inclusion of wind speed. Please motivate.

→ As mentioned, the effect of air ventilation is studied with a separate pair of thermistors. The ventilation speed for five units in Figure 7 is fixed at  $5 \text{ m}\cdot\text{s}^{-1}$  and thus the effect of air ventilation cannot be identified. The standard deviation of the residual for a pair of thermistors is  $0.10 \text{ }^\circ\text{C}$  with Eq. (18) while it is reduced to  $0.04 \text{ }^\circ\text{C}$  with Eq. (19) when the air ventilation is actually changed ( $4\text{--}6.5 \text{ m}\cdot\text{s}^{-1}$ ).

**Line 306-307 (Added statement):** and thus the effect of air ventilation cannot be identified in Fig. 7(f).

**Line 307 (Added statement):** by a separate pair of thermistors

**Line 311-314 (Added statement):** When the air ventilation is actually changed ( $4\text{--}6.5 \text{ m}\cdot\text{s}^{-1}$ ), the standard deviation of the residual for a pair of thermistors is  $0.10 \text{ }^\circ\text{C}$  with Eq. (18) while it is reduced to  $0.04 \text{ }^\circ\text{C}$  with Eq. (19).

**Line 272:** Please say how many soundings were performed during the intercomparison.

→ More information on soundings is added.

**Line 319-322 (Added statement):** One, two, or three DTRs were tested in parallel with a RS41 in a single flight. The number of comparison ( $N$ ) was  $N = 12$  at daytime and  $N = 6$  at nighttime from 7 and 3 soundings, respectively. 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.

**Line 274-275:** What's the effect of this assumption compared to the lab experiments? Do you have results to show? Otherwise, please comment.

→ → Although both  $(T_{B\_raw} - T_{W\_raw})$  and  $(T_{B\_on} - T_{W\_on})_{UAS}$  are linearly proportional to the total radiation flux, the portion of the long-wave and the short-wave radiation may affect them because the emissivity and absorptivity of thermistors are dependent on the radiation wavelength. For aluminum coating, the reflectance is  $0.8\text{--}0.9$  below  $1000 \text{ nm}$  in wavelength and  $0.9$  above  $1000 \text{ nm}$ . This implies that the influence of the portion of the long- and short-wave radiation would be a few percent of the radiative heating of the DTR even when the portion below  $1000 \text{ nm}$  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  $0.8\text{--}0.9$  below  $1000 \text{ nm}$  and  $0.9$  above  $1000 \text{ nm}$  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.

**Line 275:** Please report the time of the launch and more details on the payload configuration. These are important elements to evaluate the quality of the collected profiles.

→ More information on soundings is added in the earlier comment.

**Line 289-290:** Should this correction, event to a certain extent, be needed also during daytime? Please comment in clear way.

→ 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<sub>n</sub>), 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<sub>n</sub> cools the temperature sensor, higher up LRB<sub>n</sub> 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<sub>d</sub> at daytime shown in Fig. 4c of Philipona *et al.* is similar to that of the LRB<sub>n</sub> 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.

**Line 306:** The nighttime residual adjustment in the upper atmosphere due to long wave emission of the black thermistor at night is estimated on 6 soundings only. This increases the DTR uncertainty. And moreover, please, provide results above significance of the DTR at night time.

→ We agree that the data is not enough in this work and thus we are preparing for more intercomparison soundings this year to provide more decisive and diverse results of the DTR. As mentioned in the earlier comment, the long-wave radiation imbalance (cooling) of sensors at stratosphere should not be the issue of the DTR only because the same phenomenon was observed in the previous work based on the measurement of long-wave radiations. These findings suggest that an application of radiation correction is needed even at nighttime (RS41 applies no radiation correction at nighttime).

**Added statement (Line 374-376):** The long-wave radiation imbalance (cooling) of sensors at stratosphere should not be the issue of the DTR only because the same phenomenon was observed in the previous work based on the measurement of long-wave radiations. These findings suggest that an application of radiation correction is needed even at nighttime.

**Line 319:** In the formula a variance is reported, make the text and the formulas coherent.

**Line 398-400: (Before)** DTR uncertainty gradually increases up to about 0.35 °C in the troposphere and is maintained in the stratosphere. However, at nighttime, the uncertainty slightly is decreased to about 0.3 °C as the uncertainty of effective irradiance is decreased. → **(After)** DTR uncertainty gradually increases up to about 0.35 °C at the tropopause and is maintained in the stratosphere (0.33 °C at 30 km). However, at nighttime, the uncertainty slightly is decreased to 0.3 °C at the tropopause and 0.25 °C at 30 km as the uncertainty of effective irradiance is decreased.

**Line 338:** Again, sometimes the authors uses  $k=1$ , some other  $k=2$ , please ensure consistency.

→ The expanded uncertainty ( $k = 2$ ) is used throughout manuscript.

**Line 346:** Again, how many soundings? This is a crucial elementn for the radiosonde intercomparison.

→ More information on soundings is added in the earlier comment.

**Line 349-353:** Comments in this section are quite faint and not extensive as they should be. This section should indeed contain a lot of elements to demonstrate the performance of you dual thermistor sonde in comparison with the most popular sensor on the market. A deeper analysis

and comments should be done with a spirit similar to the discussion provided by Dirksent et al., 2014 when comparison RS92 GDP with CFH, assuming obviously the latter as the reference.

Moreover, although requiring additional work, the authors have the unique opportunity to compare two radiosondes types with the related uncertainties, so they should do their best to include RS41 uncertainty.

→ The manufacturer specifies that the uncertainty of RS41 is 0–0.3 °C in 0–16 km and 0.4 °C at 16 km and higher up (Vaisala, white paper). However, the detailed process to obtain the uncertainty such as laboratory experiments is not disclosed. Recently, we have obtained a radiation correction formula of RS41 under a well-defined irradiance in the UAS (Lee *et al.* Atmos. Meas. Tech., *in print*). However, the correction formula cannot be applied to RS41 because the manufacturer does not provide raw temperature in soundings. Even though raw temperature would be provided, the correction formula cannot be applied because the irradiance used by RS41 is unknown. In this regard, the GRUAN uses their own simulated irradiance constructed from the average of clear and cloudy sky cases in their recent publication on RS41 (von Rohden *et al.*, Atmos. Meas. Tech., 2022). The maximum uncertainty by the GRUAN is about 0.3 °C at  $k = 2$  which is larger than our previous work (0.17 °C at  $k = 2$ ) because the irradiance in our work is assumed to be  $1360 \text{ W}\cdot\text{m}^{-2}$  at stratosphere with a small (lab scale) uncertainty. Therefore, one of the prerequisites for the evaluation of uncertainty on the radiation correction is to “know” the irradiance in soundings. Simulation of irradiation is not fully SI-traceable and costs a large uncertainty. This work aims at improving this issue by measuring the irradiance using dual thermistors. Because of the unknown irradiance and its uncertainty, the uncertainty of RS41 specified by the manufacturer should be used for the comparison with the DTR. Then, the combined uncertainty of the RS41 (0.4 °C) and the DTR (0.33–35 °C) is 0.52–0.53 °C at 16 km and higher up and thus the observed differences between the RS41 and the DTR are within their combined uncertainty at daytime. These are explained in the revised manuscript.

**Line 418-434: (Before)** However, the difference at daytime gradually increases with height above 15 km and becomes greater than the DTR uncertainty at 30 km. This implies that the radiation-corrected temperature of DTR is slightly higher than that of RS41 on average at daytime; however, the uncertainty of the RS41 radiosonde is not considered here. A similar trend was observed during the radiation correction of the RS41 radiosonde by GRUAN using the SISTER setup (Von Rohden *et al.*, 2021). The radiation-correction temperature of the RS41 radiosonde obtained by GRUAN is higher than that provided by Vaisala at daytime.

→ **(after)** The manufacturer specifies that the uncertainty of RS41 is 0.3 °C in 0–16 km in altitude and 0.4 °C above 16 km (Vaisala). Then, the combined uncertainty of the RS41 (0.4 °C) and the DTR (0.33–35 °C) is 0.52–0.53 °C ( $k = 2$ ) at 16 km and higher up. Thus, the observed differences between the RS41 and the DTR are within their combined uncertainty at daytime. Nevertheless, the radiation-corrected temperature of DTR is about 0.4 °C higher than that of RS41 around 30 km at daytime. A similar trend is observed in the radiation correction of the RS41 radiosonde by the GRUAN using the SISTER setup (Von Rohden *et al.*, 2022). The

radiation-corrected temperature of the RS41 obtained by the GRUAN is 0.35 °C warmer than that provided by Vaisala at 35 km although the difference of temperature between the GRUAN and Vaisala is within their combined uncertainty.

Recently, we have obtained a radiation correction formula of RS41 under a well-defined irradiance in the UAS (Lee et al., 2021). However, the correction formula cannot be applied to RS41 because the irradiance and its uncertainty in soundings are unknown. In this regard, the GRUAN uses a simulated irradiance calculated by the average of clear and cloudy sky cases for their radiation correction of RS41 (Von Rohden et al., 2022). The maximum uncertainty of RS41 by the GRUAN is about 0.3 °C at  $k = 2$  which is larger than our previous work on RS41 (0.17 °C at  $k = 2$ ). This is because the irradiance in our work is assumed to be  $1360 \text{ W} \cdot \text{m}^{-2}$  at stratosphere with a small uncertainty obtained by the laboratory experiments corresponding to the irradiance. Therefore, one of the prerequisites to the uncertainty evaluation on the radiation correction is to know the irradiance and its uncertainty in soundings. This work may contribute to improving the measurement of the irradiance and the estimation of its uncertainty using dual thermistor radiosondes.

**Line 366:** replace with "discussed"

**Line 447:** demonstrated → discussed

**Line 369-370:** Without considering, the RS41 uncertainty this statement is not valid.

**Line 450-452: (Before)** The corrected temperature of DTR was mostly consistent with that of RS41 within the expanded DTR uncertainty. → **(After)** The corrected temperature of the DTR was about 0.4 °C higher than that of RS41 around 30 km at daytime although the difference is within the combined uncertainty ( $\sim 0.5 \text{ °C}$  at  $k = 2$ ) of the RS41 and the DTR.

**Line 371:** also more parallel soundings. This is a very important aspect to mention here.

We are preparing for more parallel soundings this year to provide more decisive and diverse results of the DTR. Besides the nighttime correction, one of our interests is how DTR would respond while/after passing through clouds.

**Line 453-455 (Before)** Future works may include more sounding tests in various conditions including cloudy and windy weather to better characterise the DTR performance of in-situ radiation measurements and corrections. → **(After)** Future works may include more parallel sounding tests in various conditions including cloudy and windy weather to better characterise the performance of the DTR. Especially, the radiation correction of the DTR is expected to be different from others while/after passing through clouds because the DTR responds to an *in-situ* radiation flux.

**Line 475:** Caption must report also details to understand the content of the right plot.

**Line 572-574 (Added statement):** Line The temperature difference between the dual thermistors ( $T_{B\_raw} - T_{W\_raw}$ ) is linearly proportional to the irradiance, and the radiation-induced heating of the white sensor ( $T_{W\_raw} - T_{W\_cor}$ ) is corrected based on the irradiance measured by ( $T_{B\_raw} - T_{W\_raw}$ ).