Referee #1

General Comment: I want to thank the authors for addressing the points raised after the first review. This has greatly improved the quality of the manuscript.

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

Major comments

Section 3.2 shows in a convincing way the mechanism behind the influence of the ambient temperature on the radiation error. However, when making the comparison between the measurements and the theoretical calculation as in the plot in Fig 3b, the uncertainties in the data should be shown in the plot and taken into account when making statements about the agreement between measurements and calculations.

→ The experimental data in Fig. 3(b) is displayed by the mean and the standard deviation (of three repeated experiments). Since the expanded uncertainty of ΔT_{rad} is 0.1 °C at k = 2 (as shown in Table 9), the theoretical value is roughly consistent with the experimental value within the uncertainty.

Before: The radiation correction ($T_s - T_a$) at T_a = 20 °C and −70 °C is calculated by Eq. (5) and displayed together with the experimental values as shown in Fig. 3(b).

After (Page 7, Line 192-193): The radiation correction ($T_s - T_a$) at T_a = 20 °C and −70 °C is calculated by Eq. (5) and displayed together with the experimental values (mean and standard deviation of three repeated experiments) as shown in Fig. 3(b).

Added statement (Page 7, Line 197-199): The theoretical value is roughly consistent with the experimental value within the uncertainty of ΔT_{rad} (0.1 °C) as obtained in Section 4.9.

l277-282: The temperature oscillations due to the radiosonde rotation reported by von Rohden 2021 (AMT-187) can't be attributed to changes in distance to the lightsource. In the inset of Fig 2 of von Rohden 2021, it can be seen that the radiosonde is mounted such that the temperature sensor aligns with the axis of rotation, so that the distance variations are of the order of 1-2cm. This leads to ~3% variations of the flux on the temperature sensor, which is not sufficient to cause temperature variations of 0.3K. Therefore, the reason for the difference between the rotational temperature error dependence observed by von Rohden 2021 and reported in this paper still is not clear. Although it is mentioned that so-called raw data is used in the analysis: the data in the plot of Fig 6a appear to be 2 digits only.

→ In the work of von Rohden *et al.*, although the sensor is aligned with the rotation axis, the distance variation of the sensor boom is bigger than this work. If the distance variation of the sensor is not the reason, the effect of the sensor boom (distance variation) would be responsible for the observed difference between two works. This may explain the appearance of the maximum peak once (von Rohden *et al*) or twice (this work) in a full cycle. The previous manuscript was written in this context and we would like to keep this discussion.

l405-415: The plot in Fig 9 shows the comparison of the Vaisala correction and the correction based on the UAS experiments. In addition to the discussion of the quantitative differences at low pressures, the authors should comment on the qualitative difference between the shape of both curves.

→ We have added qualitative statements on the curves of radiation correction.

Added statement (Page 17, Line 419-423): Since solar direct irradiance (1360 W·m^{-2}) and additional diffuse irradiance (400 W·m^{-2}) are applied for all pressures, the radiation correction of this work can be exaggerated at high pressures. The radiation correction of the UAS is smaller than that of the manufacturer at low pressures, which is consistent with the recent finding using an independent laboratory setup. In the work of von Rohden *et al.*, the radiation correction was smaller than the manufacturer's by 0.35 K at 35 km (von Rohden et al., in review, 2021).

Minor (mostly language-related) comments

l69: 'the temperature effect" is unspecific. Suggested rephrasing: the influence of the ambient temperature on the radiation error was not investigated.

→ It is rephrased as suggested.

Before: the temperature effect on the sensors was not considered

After (Page 3, Line 69-70): the influence of the ambient temperature on the radiation error was not investigated.

l143: It is important to distinguish between the radiation error and the correction for this error. The radiation error is the difference between the measured temperature and the real air temperature (which is approximated by Ton - Tair). In the correction, an estimate of the radiation error is subtracted from the measured temperature.

→ Radiation error and the correction of the error are distinguished.

Before: The true radiation correction is the temperature difference between the sensor with irradiation and air ($T_{\mathrm{on}} - T_{\mathrm{air}}$).

After (Page 5, Line 143): Radiation error is the temperature difference between the sensor with irradiation and air ($T_{\mathrm{on}} - T_{\mathrm{air}}$).

l145: the heating of air by the absorption of visible radiation is negligible in this case. Do you perhaps mean the heating of the walls of the experiment chamber by the radiation? Do you have an estimate of the magnitude of this effect?

→ Although we have measured the temperature (a few centimeters) below the window using an independent thermometer, no significant response to the radiation state is observed. In general, the temperature is continuously increased by a few tens of mK while repeating the experiments three times for 10 min.

Before: The test section is also slightly heated by the irradiation and thus may affect the sensor installed for the air temperature measurement. The temperature rise due to irradiation (ΔT_{rad}) is defined as the difference in the temperatures with irradiation (T_{on}) and without irradiation (T_{off}) as previously reported.

After (Page 6, Line 145-149): It is difficult to measure true air temperature at a shaded area in the test chamber using an independent thermometer because the test section is also slightly heated by the irradiation. The temperature measured below the window is continuously increased by a few tens of mK while repeating the experiments for 10 min. Thus, the radiation correction value (ΔT_{rad}) is obtained by the difference in the temperatures with irradiation (T_{on}) and without irradiation (T_{off}) as previously reported.

l153: rapid -> enhanced. Regardless of temperature -> for all measured temperatures.

→ Changed as suggested.

Before: rapid

After (Page 6, Line 155): enhanced

Before: regardless of temperature

After (Page 6, Line 155-156): for all measured temperatures

l158: with -> in terms of

→ The word is replaced.

Before: with

After (Page 6, Line 160): in terms of

l166: insert comma after reduces.

→ A comma is inserted.

Before: reduces especially

After (Page 6, Line 168): reduces, especially

l180: similarly with - > similar to

→ The phrase is changed.

Before: similarly with

After (Page 7, Line 182 & 197): similar to

Referee #2

Summary:

The authors have revised their manuscript substantially and addressed most of my major concerns. However, a few points remain, on which the authors should elaborate.

→ We thank the Reviewer for the opportunity to further improve our manuscript. To comply with the Reviewer comments, the manuscript is revised as below.

Comments:

A) Application to real atmospheric observations and comparison to the Vaisala radiation correction table

The authors have included a discussion about steps required to transfer their laboratory measurements to atmospheric observations and have discussed their comparison with the radiation correction applied by Vaisala. The authors can show a qualitative agreement with the correction by Vaisala and are able to discuss the assumptions they had to make in this comparison.

→ As mentioned by the Reviewer, we have included the steps (assumptions) required to transfer our laboratory measurements to atmospheric observations in the previous revision. The mean over rotations of a radiosonde was used to calculate the effective irradiance to the sensor boom. The effect of surface albedo was also incorporated in addition to the solar direct irradiation. Using these approaches, a quantitative comparison with the manufacturer's correction table was made in **Figure 9** and **Table 11**.

B) Uncertainties and their interpretation

Although the authors have expanded their discussion about the flow speed in the test chamber, they have not addressed my question about the flow regime or the possibility of gradients in the test chamber. They explain that they measured 49 points with a spacing of 5 mm, but only provide an average of these measurements. It should be easy to make a statement whether significant gradients were observed and what the flow regime most likely is. My guess is that the flow regime should be turbulent, but the authors should make this statement and justify it.

→ As the Reviewer mentioned, the flow regime is turbulent because Reynolds number is high (~10^5) at the experimental condition of $P = 550$ hPa and room temperature. In the test chamber, 49 points on the same plane were measured one by one using the LDV and the standard deviation was 0.47 $\mathrm{ms^{-1}}$. Although the flow rate of the outermost points tends to be smaller than others, no significant spatial gradient is observed. This may be because the outermost point is spaced 10 mm apart from the walls of the test chamber.

Before: The measurement dimension using the LDV was 35 mm x 35 mm around the sensor (central) location with 5 mm interval (49 points) in the test chamber (50 mm x 50 mm).

After (Page 13, Line 331-333): The measurement dimension using the LDV was 30 mm x 30 mm around the sensor (central) location with 5 mm interval (49 points). Thus, the outermost measurement points were spaced 10 mm apart from the walls of the test chamber (50 mm x 50 mm).

Added statement (Page 13, Line 334): The flow regime is turbulent because Reynolds number is high (~10^5) at this experimental condition.

Before: The average by the LDV over the entire measurement area was 4.63 $m \cdot s^{-1}$.

After (Page 13, Line 334-335): The average and the standard deviation by the LDV over the entire measurement area were 4.63 $m \cdot s^{-1}$ and 0.47 $m \cdot s^{-1}$, respectively.

Added statement (Page 13, Line 335-337): Although the flow rate of the outermost points tends to be smaller than others, no significant spatial gradient is observed. This may be because the spacing (10 mm) between the outermost measurement points and the walls of the test chamber.

The argument for the uncertainty estimate in section 4.6 is in contradiction with the same argument in section 4.7 and 4.8. The reason for the sqrt(3) is the assumption that the uncertainty is equally distributed in the a particular range. That would argue for using the maximum value, not the half-maximum and scaling it by sqrt(3) to make it Gaussian equivalent. This argument should be applied consistently throughout. Section 3.6: The uncertainty of the rotation is still close to the actually measured signal, which appears unlikely.

→ The reason of the half-maximum used in section 4.6 is that ($T_{\mathrm{on\_max}} - T_{\mathrm{on\_min}}$) is about double of ($T_{\mathrm{on\_max}} - T_{\mathrm{on}}$) or ($T_{\mathrm{on}} - T_{\mathrm{on\_min}}$) which is equivalent to the maximum in section 4.7 and 4.8.

Added statement (Page 15, Line 359-360): The reason of using the half-maximum is that ($T_{\mathrm{on\_max}} - T_{\mathrm{on\_min}}$) is about double of ($T_{\mathrm{on\_max}} - T_{\mathrm{on}}$) or ($T_{\mathrm{on}} - T_{\mathrm{on\_min}}$).

Lines 273ff: Whether the effect of rotation is temperature dependent is speculation and not supported by the measurements provided. However, the effect of rotation is small, so this discussion becomes largely irrelevant.

→ As the Reviewer mentioned, the temperature dependence of rotation effect will be largely irrelevant because the effect of rotation is small.

Lines 277ff: The main reason, why the measurements of Rohden differ is that in their setup the axis of rotation is not parallel to the sensor. Therefore, the exposed cross section changes in their setup. The authors may highlight their statement that thermal conduction from the sensor boom is likely very small. I believe this is the essential result of this section.

→ The statement on the thermal conduction is highlighted.

Before: The relatively small ($T_{\mathrm{on\_max}} - T_{\mathrm{on\_min}}$) with respect to ΔT_{rad} observed in this work suggests that the contribution of the thermal conduction to ΔT_{rad} is small compared to that by the direct irradiation of the sensor.

After (Page 11, Line 283-285): It should be highlighted that the relatively small ($T_{\mathrm{on\_max}} - T_{\mathrm{on\_min}}$) with respect to ΔT_{rad} observed in this work suggests that the contribution of the thermal conduction to ΔT_{rad} is small compared to that by the direct irradiation of the sensor.

C) Rotation and tilt discussion

The authors have substantially expanded the discussion about rotation and tilt of the sonde in flight. This makes is simpler to translate their results to atmospheric observations.

→ We thank the Reviewer for his/her valuable comments to expand our discussion on the rotation and tilting of the radiosonde.

D) Underlying physical model

Using the polynomial fit simplifies the presentation of the data and their discussion. It avoids a speculation about an underlying physical model.

→ We thank the Reviewer for suggesting a polynomial fitting in the previous revision. After using the fitting, the presentation is clearer than the former version.