We kindly thank the reviewer for his comments and questions.
Below you will find our response to these comments and questions together with questions and comments themselves.
Kind regards,
Siebren de Haan , et al.

Response to reviewer 1

Line 120 and bellow. The authors describe the method for determining the time delay of the air temperature recording in the AMDAR system. The very value of the correction to the temperature cannot be large. With a typical time constant for Rosemount 102 sensors of 1 s and an airplane ascent or descent rate of 10 ms-1 (this value even exceeds the standard rate of climb of civil aircraft of 5 ms-1), as well as with standard temperature stratification in the atmosphere in 0.0065 K/m, the correction will be no more than 0.065 K. It is the values of the correction that were obtained by the authors (see Figures 2 and 3).

» This is indeed the magnitude of the first correction.

However, the question arises, what will be the magnitude of the correction and its sign for unstable temperature stratification in the atmosphere? Super-adiabatic temperature gradients are often observed in the lower part atmosphere, in the surface and boundary layers.

» We do not correct the temperature measurement, but the reference height, assuming the delay is independent of the weather

From the description provided by the authors, it is also unclear what altitude is used to correct the air temperature, barometric or geometric, based on the global positioning system. This is important in this case, since the registration of the barometric altitude also occurs with a time delay relative to the true altitude due to the pressure inertia of the aircraft air pipe.

» We added the following :Finally, we correct the reference height of the temperature measurement using the vertical velocity of the aircraft."

Line 150 and bellow. The procedure presented by the authors for the AMDAR pressure processing has the goal for correcting its value, taking into account the distortion of the air flow depending on the speed and altitude of flight, which is quite fair. However, the proposed method does not allow estimating the value of the pressure readings lag in the AMDAR system, which was declared by the authors. Authors need to clarify these aspects of the study.

» The pressure lag, when present, is included in the correction.

Line 200 and bellow. Figures 2 and 3 show the vertical profiles of the discrepancy between the AMDAR air temperature readings and the radio-sounding data. Obviously, the authors succeeded in significantly diminishing of the discrepancies between different observation methods. At the same time, the manuscript implicitly declares that the proposed correction methods make it possible to exclude systematic errors of determining the air temperature in the AMDAR system. However, as it follows from the figures that the observed peaks on the profiles represent a systematic error. If the residual error were random, then the profiles of the discrepancies would have chaotic peaks. The systematic character of the discrepancies is also confirmed by the profile of standard deviations in Figure 2. The maxima on these profiles correspond to the heights where peaks are observed on the profiles of discrepancies. It would be desirable to clarify the nature of the residual systematic discrepancies.

» the increase of standard deviation near the surface is related to natural variability of temperature and the fact that both measurements are not completely Colocated. The larger standard deviation near the top could be related to general measurement inaccuracies of the aircraft temperature measurement

line 165 and bellow. Figure 1 provides a diagram for evaluating corrections to pressure measured by the AMDAR system. The aircraft number is given, but its type is not indicated. The question arises as to how applicable this diagram is to other types of aircraft.

» This diagram is just an example; diagrams of other aircraft showed a similar picture.

line 165 and bellow. Approximation formula (19) is presented without justification; it is necessary to clarify at what values of the parameters it is valid and what is the possible error.

» the justification is stated in the lines preceeding this equation.

line 185 and bellow. The authors do not indicate the region (or rgions) where the comparisons of the aircraft and radio-sounding data were fulfilled, as well as the weather conditions during comparisons. Has the temperature stratification always been close up to the standard?

» we added information on the geographical coverage to the text

line 200 and bellow. There is confusion in Figures 2 and 3 and the profiles of temperature lag correction and the vertical zero axes in the figures are indicated by almost the same lines.

» changed the linestyle of the axes

line 55 (and hereinafter): it is need to use the conventional aerodynamic term "dynamic pressure" instead of "impact pressure".

» wording is changed

line 65: There is no need for formula (2) to determine the speed of sound, the Mach number is well-known parameter.

» We added some words on the measurement of temperature using Bernoulli's equation. In this derivation the speed of sound is needed

line 65: Formula (3) for the indicated air speed does not make sense for this manuscript, since it is necessary to use the true aircraft airspeed taking into account the current air temperature.

» adjusted accordingly

line 70 (and hereinafter): it is need to use the conventional aerodynamic term "total air temperature" instead of "stagnation temperature".

» adjusted accordingly

line 80, Table 1: not "Parameter resolution of time and position", but "Time and position resolution". What is time resolution "1 s - 1 ms"?

» adjusted accordingly

line 115: (and hereinafter): it is need to use the conventional meteorological term "vertical temperature gradient" or "temperature stratification" instead of "lapse rate".

» adjusted accordingly

line 155, table 2: It is need to indicate dimensions of mean and standard deviation values in the title of the table.

» adjusted accordingly

line 155, figure 1: What is the type of aircraft EU0884? This is important because the correction diagram depends on type of aircraft. Titles of axes in figure should be larger.

» adjusted accordingly

line 200, figure 2: Labels of the axis of height is not indicated. Title of temperature axis is not shown. What is the "number in bin"? Titles of axes in figure should be larger. It also seems that lines of "tay" and vertical zero axis are confused.

» adjusted accordingly

line 210, figure 3: Labels of the axis of height is not indicated. Title of temperature axis is not shown. What is the "number in bin"? It is needed to indicate "synoptic hours" in top of the axis. Titles of axes in figure should be larger. It also seems that lines of "tay" and vertical zero axis are confused.

» adjusted accordingly

Response to reviewer 2

1. – a+b) we defined the variables, and changed Ta to Ts as proposed
   – c) it is defined after the equation
   – def) acronyms are defined
2. we changed the line style
3. we added the following text: "The temperature measurement can be influenced by several phenomena such as, air flow disturbances, incorrect calibration or sensor drift, in accuracies of recovery factor. Some of them phenomena are not easily quantified."
4. we tried to find a relation between bias and the recovery factor , but were not successful

Response to reviewer 3

line 17 'Upper air observations from aircraft are an important source of information for numerical weather prediction (NWP).' Possibly reference Ingleby et al (2021).

» Done: added reference

line 21,22 'ECMWF has introduced an aircraft and flight phase dependent temperature correction (Cardinali et al., 2004).' The ECMWF bias correction of aircraft temperatures was announced in a short newsletter item by Isaksen et al (2012, see below), an update is given in Ingleby et al (2019). Cardinali et al (2004) did -not- discuss aircraft temperature biases. I think the work at NCEP by Zhu et al (2015) should also be mentioned.

» Done: added references

line 29 'The formal difference is slightly smaller than 0.4K (Painting, 2003).' I'm not sure what this means - clarify or delete. It might be worth mentioning the EUFAR workshop on aircraft temperature measurements (Nov 2020): https://www.eufar.net/shared-subjects/s/3fa8510de42844d6b30 (I particularly remember the presentation by Bob Sable on TAT sensors - it seems the industry preoccupation is with avoiding icing of the sensors in extreme conditions and accuracy was a secondary consideration.)

» Deleted

line 40 'Aircraft sensors' I recommend that the book by Wendisch and Brenguier (2012) is referenced in this section.

» we added text to clarify

line 70ff 'Aircraft temperature measurement' This is key and should probably be expanded slightly - to mention the convertion of kinetic energy to temperature (mainly by adiabatic compression within the TAT probe). Perhaps mention typical differences between Ta and Ti. Section 2.5 of Wendisch and Brenguier is useful - it derives equations like (4). WMO seems to be encouraging use of WMO No. 8 'Guide to Meteorological Instruments and Methods of Observation' rather than Painting (2003).

» Done: used the proposed reference

line 91 '2.5 Numerical weather prediction model data' Either here or earlier the geographical domain being used should be mentioned.

» Done: added a description of the region

line 115,116 'Since generally an atmospheric profile has a temperature lapse rate of -6.5 K/km' 'Since average tropospheric profiles have ...' would be more accurate.

» Done

line 123,124 'the temperature is really biased assuming that the bias not related to the time difference, is independent of the flight phase' perhaps 'there is an additional bias term, which may be independent of the flight phase'

» Done

line 145 What is the typical time difference tau? How much does it vary? Is it linked to aircraft type and/or airline?

»

line 147 'possible' - 'possibly'

» Done

line 161 'Thus, when we have an (estimate) of the mapping f-1 we can correct the temperature measurement.' Either remove the brackets or extend them: '(an estimate of)'. More fundamentally I haven't fully understood this mapping, any extra explantion would be welcome. From Figure 1 I think that larger corrections are needed at lower airspeeds - is this correct (and true of other aircraft)?

» Done: we added some text

line 190,191 'Radiosondes are generally launched at the main hours (00, 06, 12, 18 UTC), as required by WMO, with the majority of launches around 00 and 12 UTC (these timestamps represent the observation at a level of 500 hPa at the whole hour)' 'before the main hours' (often about 45 minutes before, but different NMSs vary). I have heard it said that they should reach 100 hPa at about the main hour. BUFR radiosonde reports have the time of each individual level.

» Done: we added some words

line 214 'The most left panel' - 'The left-most panel'

» Done

line 215,217 'The reason for the difference in bias with the time of day is not understood. Assuming that the AMDAR bias is constant we observe that the radiosonde bias, changes over the day from overestimation at 06 UTC to neutral at 12 UTC and underestimation at 18 UTC to slightly underestimation at 00 UTC.' Radiosondes are mainly available at 00 and 12 UTC as already stated. Apart from low levels the sample at 00 UTC is quite small - because there are fewer flights at night. The proportion of cargo flights at night may well be higher? Given

the sampling issues for both aircraft and radiosondes I would advise against suggesting a diurnal cycle in radiosonde biases. Radiosondes have larger uncertainty in the -stratosphere- in sunlight (Dirksen et al, 2014).

» Done: we added some words

line 218 'Figure 4' - interesting variation with aircraft type Looking at the ECMWF bias corrections by aircraft type I see even larger biases for some B787 aircraft (US-AMDAR) and small negative (cool) biases for some Airbus aircraft. Please increase the size of the text labels in figure 4 to improve clarity.

» Done

line 225 'the second is an accuracy related correction.' perhaps 'the second comes from the interconnected nature of aircraft measurements: there is a Mach number correction to the temperature and a temperature correction to the Mach number and it appears that avionics systems do not iterate to convergence.'

» Done

line 236,237 'The Mode-S EHS information can be applied to correct the AMDAR temperature bias, for those air spaces where Mode-S EHS information is available.' This is not a long-term solution. The meteorological community needs to persuade the aviation industry to improve their avionics/measurements.

» Done

line 258 'Painting, J. D.: WMO AMDAR Reference Manual, WMO-no.958, WMO, Geneva, http://www.wmo.int, 2003.' http://www.wmo.int no longer exists and WMO regard this document as superseded, see https://community.wmo.int/activity-areas/aircraft-based-observations/resources/manua and-guides