General review of the manuscript AMT-2020-519

Title: "Characterizing and correcting the warm bias observed in AMDAR temperature observations"
Authors: Siebren de Haan, Paul M. A. de Jong, and Jitze van der Meulen.

Manuscript Number: AMD-2020-519

Reviewer #2: Mikhail A. Strunin

Recommendation: Manuscript can be published in AMT after appropriate revision

General comments

The presented manuscript is related to an important and relevant topic of obtaining correct data on vertical distributions of air temperature using the AMDAR systems installed on commercial airplanes. As the authors note numerous investigations have shown that there are systematic discrepancies between the air temperature measured by the AMDAR system during airplane descending and climbing with the data of radio-sounding data and weather prediction models. The authors explain these discrepancies through the time lag between the temperature readings of the AMDAR system during aircraft climbing or descending and the radio-sounding observations in the temperature-stratified atmosphere. To eliminate this systematic error, the authors applied the original method for correcting AMDAR temperature measurements, based on a statistical analysis of the differences between the AMDAR system readings and radio-sounding data.

Undoubtedly, the statistical approach has the right to use, however, a number of uncertainties in the manuscript require several remarks regarding the physical base for the reasons of the delay in the AMDAR system. This is important, since the authors do not consider the nature of the arising temperature lags, limiting their research by a purely statistical approach.

It seems that the reason for the time lags is the inertia of the temperature and pressure sensors used in the AMDAR system. Typically commercial aircraft are equipped with Rosemount 102 temperature sensors of various modifications, whose thermal inertia is about 1 to 2 seconds, depending on the flight conditions. Measurements of pressure, both total and static, also have some inertial properties. In this case, the main reason for the delay in the pressure readings relative to the true altitude is the time lag in the air pipes connecting the pressure receivers (Pitot tube) with the pressure transducer installed inside the aircraft fuselage. Obviously, the value of time lag will also depend on the type of aircraft, because the configuration of the location of the sensors could be different on different types of aircraft.

The authors also do not consider possible distortions of the air flow nearby the aircraft fuselage skin during aircraft maneuvers, when the pressure and temperature receivers, which are mounted on the skin, could fall into the zone of the so-called "aerodynamic shadow". This could significantly distort the readings of the sensors. The authors are limited themselves to introducing corrections to pressure readings using some universal function. However, such a method can give a completely satisfactory result, but a fine analysis of errors, perhaps, is not beyond the scope of this manuscript.

Generally, the manuscript is of undoubted interest, since the suggested methods could improve the quality of assimilated AMDAR data for meteorological models and prognostic programs. Below the number of remarks are presented, some of which are of principled importance for the subject of the manuscript.

Specific comments

Major specific remarks

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).

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.

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.

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.

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.

<u>There are also a few minor specific remarks:</u>

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.

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.

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?

line 200 and bellow. Путаница на рисунках 2 и 3, поправка на запаздывание по температуре и вертикальная нулевая ось на рисунках обозначены практически одинаковыми линиями.

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.

Technical corrections

There are many technical confusing of the terms, concerning conventional aerodynamic and aerospace techniques, pictures and tables do not have all necessary titles.

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

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

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.

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

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

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

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

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.

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.

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.

Authors should improve English language of the manuscript. I would advise authors to refer to native speakers English speakers to correct the text.

Conclusion:

Manuscript “Characterizing and correcting the warm bias observed in AMDAR temperature observations” presented by Siebren de Haan, Paul M. A. de Jong, and Jitze van der Meulen can be published in AMT after appropriate revision.