AMT-2019-455

Measurement Characteristics of an airborne Microwave Temperature Profiler (MTP)

by Mareike Kenntner et al.

Reply to the referee #2 comments

We like to thank the reviewer for providing helpful advice to improve the quality of our study. In the following we give our reply regarding the points raised by the reviewer #2. The statements and comments given by the referee are printed in black italics and our comments are presented in blue.

Answers to referee #2

General Comments

The paper sometimes reads more like a technical report than a journal article. I would suggest the authors begin with a broader view of such instruments, including their basic operating principles and their scientific applications. Reference to similar instruments should be included here as well. Then state the motivation for this work and how it supports research with MTP data.

The intent of our study is to provide the specific characteristics of this particular design of MTP instrument, purchased from JPL. We would like to remind the reviewer that this instrument was not designed by the authors of this study, and this publication is not intended to be a general introduction to the instrument. Such an introduction was already given in the studies mentioned in our publication (e.g. Mahoney and Denning, 2009; Lim et al., 2013), and as a result, we do not see the necessity to include the suggested overview of microwave instruments in use.

The authors note that the MTP was developed by a team at JPL. While the developers have not published comprehensive instrument characteristics, one wonders whether they may have performed some of the work described in this paper. Have the authors reached out to the developers to understand whether this information exists within the JPL group, and if their results are consistent with the DLR team's findings?

Indeed, we did have contact to the group at JPL. The instrument design and the components used in this design, differ from those used in earlier designs of the instrument. Earlier versions of the instrument are mounted inside the aircraft cabin, and hence, the investigation of changing surrounding temperatures has not been performed by JPL. Some results and observed instrument behaviour and characteristics were partly discussed with JPL staff, and regarded as expectable. They also compare well to figures and characteristics shown in older documentation, (e.g. the patent for the horn antenna and rotating mirror design from 1976; Fletcher et al.; United States Patent for a Highly Efficient Antenna System Using a Corrugated Horn and Scanning Hyperbolic Reflector; US Patent No. 3,949,404).and the considerations about the instrument design; given in the internal documents/ private communication with JPL provided with the transfer of the instrument to DLR.

While interesting, the work presented in Section 5 on sensitivity of LO frequencies and elevation angles seems to be outside the central theme of the paper. After presenting results on performance of various components, calibration methods, and associated uncertainties, it would seem more natural to discuss how performance and uncertainty impact the final measurement and applications. There is some reference to use of the data for gravity waves

and the requisite accuracy for that application, but a more general discussion would make the paper more broadly relevant to readers.

We agree with both reviewers, that Section 5 of the paper fits better as an appendix, as it only presents a very brief investigation of fast-to-apply improvements to the measurement strategy. However, as noted by reviewer 1, there is a lot of room for interesting investigations into implications for radiative transfer calculations and retrieval error estimation, which, if attempted, should be presented in a study of its own. We decided to move this section to an appendix. The in-depth assessment of measurement strategy impacts on the retrieved temperature profiles, including the general discussion about consequences for data analysis, should be considered in a study of its own.

Substantial improvement to the readability of the paper is needed. As noted in Comment 1 above, much of the information is presented as if this were a technical report. Following the Introduction, each section needs to begin with an overview of its contents, motivation for including that content, and how the content fits into the overall purpose of the paper. The material within a section is often not well-organized, paragraphs seem short and choppy, and transitions between topics are lacking.

We have revised the manuscript according to the reviewer's recommendation.

Specific Comments and Questions

P4 eq. 2.1 - Is T the physical temperature? BT is defined here as brightness temperature, but elsewhere in the paper, TB is used (e.g., eq 3.3 on p9).

Yes, this is the Planck equation, based on absolute temperature T.

Following a comment from reviewer #1, we have changed all instances of "BT" in the text to "TB" to be more consistent in the use of the abbreviation of brightness temperature.

p4 line 28 - You state that the target is heated to a constant temperature of approximately 40C. In Table 1 the value is given as 41C. Why not just use 41C in both places?

Looking back at our data, we have corrected both values to 45C, which better represents the temperature of the thermostats used to heat the target (recorded in the MTP's housekeeping data, and shown as orange line in Fig. 8 of the revised manuscript).

p5 lines 1 - The explanation of brightness temperature is awkward and confusing. How about "...which is the temperature of an ideal blackbody emitting the equivalent radiance..."

We have changed the wording according to the reviewer's recommendation Thank you for this helpful suggestion.

p6 line 12 - Reference is made to the antenna diagram. It would be good to direct readers to the corresponding figure (Fig 2, I believe).

We have added the reference to figure 2, both for the antenna diagram, as well as for the earlier mentioned instrument transmission function.

p6 line 13 - "half-sphere" should read "hemisphere"

We have corrected the wording of the revised text.

p8 line 5-10 - It would be informative to share the range of ambient temperatures experienced outside the pod in flight.

We agree. The information (190 – 260K, or warmer, if lower flight levels are flown – up to 300K at the surface) is added in the revised text.

p9 line 6 - "a" should read "at"

The typo is corrected in the revised version of the manuscript.

p10 line 16 - Section 4 includes uncertainty from pointing errors in addition to calibration methods. The title should reflect this, or the point error material should be placed elsewhere.

As suggested earlier, a broader discussion of implications for brightness temperature error is desirable, and some other characteristics influencing the measurement accuracy could also be discussed, as pointed out by Reviewer one. Hence, we have added a new Section (Section 5 in the revised manuscript) to discuss further sources of measurement uncertainty, in which the pointing error is included, as well as some discussion of other error sources, such as synthesizer errors.

p14 line 23 - The sentence that begins with "Note that this definition of usable legs..." is confusing. I'm not sure what you mean.

The chosen flight segments are cut so that no flight manoeuvres lead to large changes in the measured signals. The cutting criteria are based on aircraft parameters only – not on any readings of MTP housekeeping data (as in the laboratory measurements). Hence, times, in which the instrument is still adjusting to new surrounding conditions, are still part of the data used in the investigation. We have changed the wording to make this clearer.

p17 line 9 - This sentence lacks a verb.

The sentence has been corrected.

p22 line 17 - If the authors choose to keep Section 5 as a discussion of new measurement strategy, it would be interesting to demonstrate the impact of LO shifts and/or elevation angle changes on simulated data.

Since the authors decided to skip this section, and to only note the already shown considerations in an appendix, such work should be part of a stand-alone study to assess the impacts of measurement errors and possible changes in the measurement strategy on the retrieval output.

p22 line 31 - "full-with-half-maximum" should read "full-width-half-maximum"

The typo is corrected in the revised version of the document.

p34 Figure 5 - A legend is needed here

A legend with 6 different lines and their explanations would fill quite a large portion of the (already quite busy) plot. Hence, the meaning of the colours and line styles are explained in the figure caption.

p40 Figure 11 and 12 - These figures are too small to differentiate the individual lines/methods.

The two figures are now combined. In the upper panel (Figure 11 in the original manuscript) lines are clearly separated, displaying the offsets between individual methods. In the lower portion of the new figure (formerly Figure 12), the offset-correction is applied, and the plot demonstrates that this is a powerful correction, leading to very similar brightness temperatures being derived from all methods, so that the lines partly overlap.

p44 Figure 15 (left panel) - It's impossible to distinguish the 58.363 GHz line from the 56.363 GHz line

The 58.363 GHz lines are plotted in the background, and similar to lines of the other frequencies – hence, they are not well visible. We have added a sentence in the figure caption to point this out to the reader.

p45 Figure 16 - The legend indicates lines for 6 altitudes are shown, but I can only see 4 on the left plot.

At horizontal viewing angle, there is such a small difference between the lines representing altitudes at or below 8 km overlap in the left panel. We have added a sentence in the figure caption to point this out to the reader.