

## Review AMT-2021-9:

### Improving thermodynamic profile retrievals from microwave radiometers by including Radio Acoustic Sounding System (RASS) Observations

#### ANSWERS to REFEREE 1

We wish to thank very much both Referees for carefully re-reading our manuscript for the third time and for offering additional comments towards its improvement. We believe all of your notes and recommendations are very useful. We hope that our latest changes will make our manuscript clearer and more transparent. Please, find below our point-to-point answers in red.

#### Minor corrections:

**Line 337:** we have demonstrated the augmentation → we have demonstrated the extension.  
Done.

**Line 447:** It is mentioned that the BC is computed with the TROPoE retrievals. I doubt this would be a good idea as the TROPoE retrieval is obtained to minimize the distance with the observation. So, if the observations is biased, we of course end with an atmospheric profile compensating the bias in the observation. Thus, I assume that the difference between the observation and the simulation from the TROPoE retrievals should tend to zero as the PR want to minimize this distance. I think the authors wanted to mention TOPROE background profiles from the climatology as it is confirmed in line 498 and explained in their reviewer's answers. Please correct the text accordingly.

We have found that there are often spectral features in the observed minus computed brightness temperature residuals that could not be explained by any physically realistic atmospheric profiles, and can only result because of a calibration error in the observations. This TROPoE bias-correction method is aimed purely to remove this unphysical spectral signature. We realize that this bias-correction approach could introduce a bias in the retrieved temperature and humidity profiles. The more appropriate method to determine this spectral bias correction is with using independent radiosondes; however, these are not always available which is why we wanted to present both bias correction methods in this paper.

The text in the paper is changed (additional text is highlighted):

“While this radiosonde BC method can be employed for the XPIA dataset, for other campaigns this approach would not be possible if co-located radiosonde observations were not available. For this situation, an alternative method for correcting the MWR Tb biases is presented. **There are often spectral features in the observed minus computed brightness temperature residuals that could not be explained by any physically realistic atmospheric profiles, and can only result because of a calibration**

**error in the observations. This alternative bias-correction method is aimed purely to remove this unphysical spectral signature.”**

“The Tb bias is then computed for each of the 22 channels as the averaged difference between the observed Tb from the MWR zenith observations and the forward model calculated Tbs at zenith using the TROPoe-retrieved profiles (Y1) of those selected clear-sky days. This method identified spectral calibration errors in the MWR observations that could not be explained by physically realistic atmospheric profiles. This bias-correction technique, **which accounts for those unphysical spectral calibration features**, will be referred to as ‘TROPoe BC’.”

**Line 635:** as a function of the height → as a function of height

We found two places in the paper with this phrase (but not on line 635) and changed them accordingly.

**Figure 8:** bottom right: change 0-5 km averaged into 0 – 3 km averaged.

Sorry, we cannot find this text in the “Retrievals\_paper\_review2\_final.pdf (or docx)”, it was in the previous version.

## **Review AMT-2021-9:**

### **Improving thermodynamic profile retrievals from microwave radiometers by including Radio Acoustic Sounding System (RASS) Observations**

## **ANSWERS to REFEREE 2**

We wish to thank very much both Referees for carefully re-reading our manuscript for the third time and for offering additional comments towards its improvement. We believe all of your notes and recommendations are very useful. We hope that our latest changes will make our manuscript clearer and more transparent. Please, find below our point-to-point answers in red.

- Line 105: "atmospheric temperature and humidity content" -> "atmospheric temperature, humidity, and liquid water content"

MWRs are sensitive to the LWP, not the LWC, therefore we use "atmospheric temperature, humidity, and liquid water path (LWP)".

- Lines 137-140: I suggest replacing the following sentence:

"is still limited, being a function of both radar frequency and atmospheric conditions (May and Wilczak, 1993). It is determined both by the attenuation of the sound, which is a function of atmospheric temperature, humidity, and frequency of the sound source,

and the advection of the propagating sound wave out of the radar's field-of-view" with:

"is limited by sound attenuation, which is a function of both radar frequency and atmospheric conditions (May and Wilczak, 1993) such as temperature, humidity, and the advection of the propagating sound wave out of the radar's field-of-view"

Done.

- Lines 146: "has been" -> "has been and still is"

Done.

- Line 244: "inline" - not sure this is the proper word.

The word "inline" is deleted.

- Lines 303-307: I'm missing the introduction of the forward model for  $T_v$  and its Jacobian (at lines 361-365).

MonoRTM is used as the forward model only for  $T_b$ ,  $T_v$  in TROPoe is directly computed from the ambient temperature and water vapor mixing ratio (using basic thermodynamic equations). Similarly, the Jacobian is computed analytically from this equation.

- Lines 320-323: I'm missing how  $\sigma_{T_b}$  and  $\sigma_{T_v}$  are estimated to be included in  $S_e$ .

$\sigma_{T_b}$  (lines 355-359) is set to the standard deviation from a detrended time-series analysis for each channel during clear-sky time frame, smaller for K-band channels and larger for V-band channels.  $\sigma_{T_v}$  (lines 362-364) is calculated based on SNR, smaller for high SNR and larger for low SNR.

- Lines 328-333: I'm missing how LWP is estimated to be included in  $S_a$ .

We make an assumption for LWP, but the uncertainty in the assumed LWP value in the prior is very large as to have no impact (constraint) on the retrieval. On page 16, lines 330-331, we added the sentence:

"LWP is arbitrarily assigned in  $X_a$ , with large values chosen for its uncertainty in  $S_a$ , so that it does not impact (constrain) the retrieval"

- Line 382: I suggest replacing "to reduce the degrees of freedom associated with clouds" with "to eliminate uncertainties associated to clouds"

Done.

- Line 404: Maybe the authors mean the TOPROe background profiles from climatology? This is also noted by the reviewer. Please modify the text accordingly.

We already explained to referee 1 why we included the TROPoe bias-correction technique in this paper. We understand that using independent radiosondes is more appropriate for spectral bias correction. However, radiosonde data are not always available. Additionally, there are often spectral features in the observed minus computed brightness temperature residuals that could not be explained by any physically realistic atmospheric profiles. TROPoe bias-correction method is aimed purely to remove this unphysical spectral signature.

The text in the paper is changed (additional text is highlighted):

“While this radiosonde BC method can be employed for the XPIA dataset, for other campaigns this approach would not be possible if co-located radiosonde observations were not available. For this situation, an alternative method for correcting the MWR Tb biases is presented. **There are often spectral features in the observed minus computed brightness temperature residuals that could not be explained by any physically realistic atmospheric profiles, and can only result because of a calibration error in the observations. This alternative bias-correction method is aimed purely to remove this unphysical spectral signature.**”

“The Tb bias is then computed for each of the 22 channels as the averaged difference between the observed Tb from the MWR zenith observations and the forward model calculated Tbs at zenith using the TROPoe-retrieved profiles (Y1) of those selected clear-sky days. This method identified spectral calibration errors in the MWR observations that could not be explained by physically realistic atmospheric profiles. This bias-correction technique, **which accounts for those unphysical spectral calibration features**, will be referred to as ‘TROPoe BC’.”

- Lines 714-720 (and in general): References to figure formatting (panel position, line color, marker type, etc) could be removed from main text and left in the figure caption only.

This text is changed.

- Line 736: Any comment on the why RASS 449 Tv bias seems to depart above 1.3 km?

Data availability is getting smaller with height, but the Tv bias is around 0.2 C at that height and should be considered small.

- Lines 741-742: I suggest adding the sentence:

"the RASS biases, because of the combined information from RASS and MWR."

Done.

- Line 836: "and above around 1.5 km AGL" -> "and only between 1.5 and 3 km AGL"

Done.