

The number of Lines in the comments corresponds to the original manuscript. The number of Lines in the responses (in red) corresponds to the revised manuscript with changes noted.

Radiative closure tests of collocated hyperspectral microwave and infrared radiometers, by Lei Liu et al.

This is an interesting work which describes a radiative closure experiment in clear sky conditions performed by using collocated measurements collected with the HiSRAMS radiometers and the AERI Fourier transform spectroradiometer. Measurements were performed during three field campaigns: in 2021 and 2022 from ground, while in 2023 both from airborne and from ground. HiSRAMS is composed of two FTS radiometers operating in the oxygen band between 49 – 58 GHz and the water vapor band between 176 – 183 GHz; AERI is a well known Fourier spectroradiometer operating in the far and mid infrared portion of the Earth’s emission spectrum, between 500 and 1800 cm^{-1} . The observations took place in zenith-pointing view with AERI from ground, and both in zenith- and nadir-pointing view with HiSRAMS. Simultaneous collocated radiosoundings were launched during the three campaigns to measure the vertical profiles of temperature and water vapor. Simulations were performed by the authors to mimic the measurements of HiSMRAMS radiometers by using a validate code (Bliankinshtein et al. 2019) that uses the Rosenkranz gas absorption parameterization, and the well known code LBLRTM (Clough et al. 2005) to mimic the AERI measurements. To estimate possible biases, the differences between the measurements and simulations were calculated with the associate standard deviations by propagating, respectively, the spectral measurements uncertainties and the errors on the radiosondes, accounting also for the spatial inhomogeneity. The closure is well reached in the spectral bands below 800 cm^{-1} and above 1200 cm^{-1} simulating the AERI observations and in the weak absorption bands of Oxygen (50-54 GHz) and Water Vapor (176-181 GHz), even though for water vapor the differences remains inside the 3- σ error. The bias with AERI comparison is attributed to the presence of very optically thin cirrus clouds or aerosols, the latter is attributed to the calibration procedure in zenith-pointing observations.

The paper is well structured and written, even though I suggest few corrections to enhance the clarity:

Thank you for the accurate summary of our work and your valuable comments, which have greatly contributed to improving our paper!

1) Lines 92-94. I would change the sentences in : “The small fluctuations in the temperature and water vapor profiles have a negligible effect in AERI and HiSRAMS detected radiances”.

Done.

2) Lines 95-99. I would improve the discussion about the temperature inversions shown in the inset of Fig. 2a, if the authors want to mentioned it, it is fine but I think the description should be more accurate. For instance, from FC2021 (blue profiles) to me seems there are more than two temperature inversion, at least one at around 2.5 km (T starts to increase again) stronger than the one at 1.2 km. Also, for FC2022 I can see at least two inversions, one at 0.5 km as pointed out,

but also one at 2.5 km, similar to 2021, etc.. Maybe, if you could increase the grid vertical resolution on the y axes in both figures 2a and 2b would be helpful.

Thank you for your comment regarding the temperature inversion features observed in radiosonde measurements. This stands as a key feature distinguishing the clear-sky temperature retrieval performance between AERI and HiSRAMS, which will be described and discussed in our upcoming retrieval paper. Thus, we would like to retain this description within this manuscript. We have revised the discussion on temperature inversions, specifically in Lines 101 to 103. Additionally, we have updated Figures 2a and 2b with a higher vertical grid resolution.

3) Line 119, “against” → “pointing”

We revised the sentence in Lines 128-131.

4) I think it would be clearer indicating the actual radiance unit in all figures for AERI, I assume they are $\text{mW}/(\text{m}^2 \text{ sr cm}^{-1})$, but it would be clearer if it would be specified, in particular for me it is more helpful when I have to quantify the biases.

Thank you for pointing this out. One radiance unit (RU) equals to $1 \text{ mW}/(\text{m}^2 \text{ sr cm}^{-1})$. We have specified the unit of AERI observed radiance in Line 128. For all the figures involved AERI observed radiance and/or radiance bias, we have included the unit in the captions.

5) Section 2.2.1. Just a curiosity, I was wondering why you did not use the latest version 12.15 of LBLRTM, with the updated continuum 4.1 version?

We began simulating the AERI-observed DLR in 2018. To maintain consistency with our prior work, we chose to employ version 12.9. Following your recommendations, we compared versions 12.9 and 12.16. The primary difference lies in the far-infrared spectrum. In the spectral range where significant radiance disparities exist between the two LBLRTM versions, the observed differences between simulations and actual observations are already large due to relatively inadequate calibration at the spectral detector’s edge. Hence, we have retained the use of version 12.9 in this study. For ease of reference, Figure R1 has been included in the Supplement document (Section 1). We added this comparison in the manuscript in Lines 210-213.

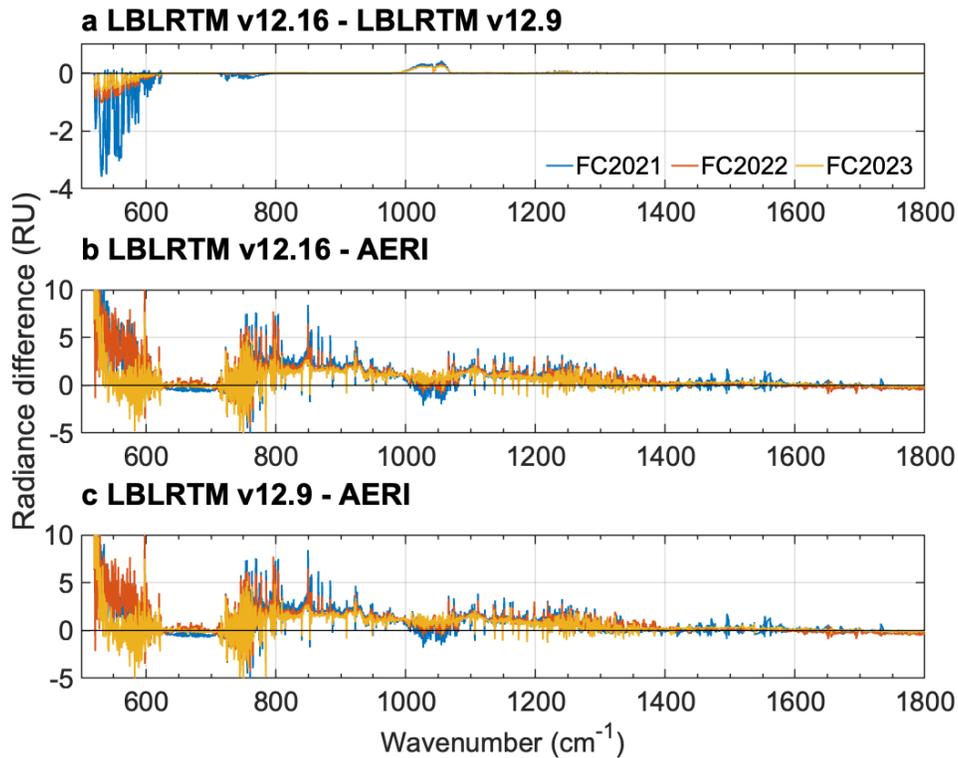


Figure R1. (a) DLR difference between LBLRTM simulations using version 12.16 and version 12.9. (b) DLR difference between LBLRTM v12.16 simulations and AERI observations. (c) DLR difference between LBLRTM v12.9 simulations and AERI observations.

6) Line 103, please write the coordinates in the standard form such as: [45.32° N, 75.66° W]

We changed the description of the coordinates to Lines 70-71 in the standard form you suggested.

7) Line 112, “..200 level are inputs..” → “..200 levels are provided in inputs..”

Done.

8) Line 220, “errors” → “those”, “..inputs..”, → “.. input profiles..”

Done.

9) Equations (1) and (2), I think it would be clearer if you could replace the x parameter with R_V to indicate the vector of the radiances or brightness temperatures. Also, please shift the $x \rightarrow R_V =$ Radiance of BT to the right side. Since the uncertainty of the measurements play a key role in the study and discussion of a radiative closure experiment, I suggest to explain in detail the components of the errors, for instance, from lines 220-222 I assume that the standard deviation on the model is obtained by summing in quadrature the $1-\sigma$ error on the radiosondes profiles due to the instrumental error and that one due to spatial variability, is it so? In this is the case it would be really helpful to follow if the authors could write the formulas for the errors propagation used.

Thank you for the suggestions! We have revised Eq. 1 and Eq. 2 and now they are located in Lines 229 and 231, respectively. Yes, we combine the uncertainties in quadrature, which is similar to Eq. 2. To avoid the repetition, we included an additional sentence in Lines 241-242 to explain the method for combining these uncertainties.

10) I suggest to indicate the average biases arising for both instruments.

We have included the mean and standard deviation of BT biases for both instruments in Figure 13. The mean and standard deviation of HiSRAMS' BT biases cover the entire spectral range of each radiometer, whereas for AERI, they correspond to the channel associated with CO₂ and water vapor, respectively.

11) Figure 9, I suggest to exchange figure 9c with 9b and viceversa to be coherent with the next figure 8. Also it would be really helpful to indicate O₂ and WV band at the top of the two columns and zenith and nadir views horizontally.

Thank you for the suggestions! We have updated Figure 9 to ensure consistency with Figures 5 and 10. Additionally, subtitles have been included in Figures 5 and 10.

12) Line 301, do not indicate Fig. 10a because I think is misleading here.

We updated the sentence in Line 330-332.

13) Line 313, “, the measurements uncertainty ..” → “, both the contribution of the simulation and measurement uncertainty is not negligible..”

We updated the sentence in Lines 343-345.

14) In Figure 12, please add the correlation coefficients.

We have updated Figure 12.

References:

Bliankinshtein, N., Gabriel, P., Huang, Y., Wolde, M., Olvhammar, S., Emrich, A., Kores, M., and Midthassel, R.: Airborne Measurements of Polarized Hyperspectral Microwave Radiances to Increase the Accuracy of Temperature and Water Vapor Retrievals: an Information Content Analysis, AGU Fall Meeting Abstracts, A13K-2959, 2019
Clough, S. A., Shephard, M. W., Mlawer, E. J., Delamere, J. S., Iacono, M. J., Cady-Pereira, K., Boukabara, S., and Brown, P. D.: Atmospheric radiative transfer modeling: a summary of the AER codes, Journal of Quantitative Spectroscopy and Radiative Transfer, 91, 233-244, 10.1016/j.jqsrt.2004.05.058, 2005.