Referee comments for ”Total power calibration in FTIR emission spectroscopy for finite interferograms” by Heizmann et al., (2025)

1 General Comments

This paper presents improvements to FTIR emission spectroradiometery by modifying the standard total power calibration procedure by Revercomb et al., (1988), to improve the robustness and capability of such instruments when measuring unequal-sided interferograms by correcting the phase error through deriving a correction factor from the reference blackbodies. This work is within scope for AMT, has sound methodology, and I believe it may be published after the following revisions have been addressed.

In my opinion, the most significant improvement which may be made is that this work does not adequately present the scope of this work, the wider implications of this calibration technique, and how this new technique compares to the usual method. The introduction, in its current state, is brief and does not adequately introduce the utility of the work presented. The number of references to primary sources is also lacking, and some suggestions are provided in the following comments. Two instruments are introduced, the AERI and NYAEM-FTS, but measurements from either of these instruments are not strongly featured in the discussion. Given that the authors have specified improvements to trace gas retrievals as one of the motivating factors for higher resolution emission FTIR spectra, there should be some introduction on exactly why current instrument resolution (e.g., AERI) is insufficient, and why higher resolution spectra would improve retrievals.

It would also make sense for Section 2 to be moved to the introduction, as that is background material, and for the main results (that is, Figures 2 and 3 and associated text) should be expanded, possibly showcasing wider applicably of this calibration method. Specific comments and technical suggestions are given below.

2 Specific Comments

Lines 17-18: Emission FTIR instruments have been used to retrieve cloud microphysical properties (e.g., Turner et al., 2005; Rowe et al., 2019; Richter et al., 2022), any of which would be a better reference for cloud radiative properties.

Turner and Blumberg (2019) also use AERI spectra for thermodynamic profiling of the atmosphere. Along that line, an updated (and much longer time series of) AERI trace gas retrievals is available at Hung et al., (2025). You could point to the limited AERI spectral resolution being one of the limiting factors for vertical sensitivity to trace gases in that work to motivate the need for improvements to emission FTIR spectral resolution for trace gas measurements. The Mariani et al., (2013) reference retrieves column amounts of gases, and so the retrieval may be (presumably) less sensitive to spectral resolution.

Line 21: "In order to achieve higher resolution, which is especially important for trace gas retrievals" should include a reference. There are many suitable references among the solar FTIR community, such as through NDACC-IRWG or TCCON, which discuss fitting various line broadening effects. I would also suggest adding some additional text to motivate why one would want to use (specifically) FTIR emission spectroscopy to measure atmosphere composition (e.g., do not need sunlight, better equipped to monitor diurnal cycles, workable during polar night, etc).

Line 25: "trace gas retrievals are currently being developed". Is it possible to include an example of this in your results? I appreciate that this may be a significant amount of effort, so I do not believe that this is mandatory for this work, but I believe it would strengthen this paper to include an example/case study of such a retrieval (possibly on simulated spectra) when this new calibration technique is applied, especially for gases which have retrieval windows coinciding with some water lines.

Line 27: "most information" is ambiguous. Does "information" here refer to the spectra or retrievals of interesting quantities from the spectra such as the previously mentioned trace gases or aerosols.

Figure 1: Please define the y-axis unit "a. u.".

Lines 105-106: This sentence is confusing. If I am reading it correctly, it may be rephrased as "...i.e., there is a phase shift ϕ_i (ν) relative to the source signal (external) ϕ_s (ν) and therefore the amplitude of the spectra. This means the spectra cannot be used because of artifacts due to the complex contribution". Please clarify accordingly.

Lines 162-163: Provide some more detail on "We use Arctic atmospheric composition and thermodynamic profiles". For example, specifying the precipitable water vapour is important for putting your simulated spectra in context. Depending on your location, the Arctic humidity can vary one or two orders of magnitude between summer and winter, so one spectra would likely not be representative of the range of conditions found in the region. It may also be useful to look at two spectra to capture this range, one for low humidity (e.g., 0.1 cm precipitable water) and one for high humidity (e.g., 2 cm).

Figures 2 and 3: Given that one of your main motivations is to improve spectral line fitting for trace gas retrievals, including similar plots for the windows used to perform those retrievals is important (e.g., the windows used for AERI retrievals in the Mariani et al. (2013) and Hung et al. (2025) references), especially when those windows contain some water lines.

Lines 186-194: My understanding is that the particular window in Fig. 2 was chosen due to the strong water line, where the modified calibration should provide the best performance gain. The authors say the relative differences are much less when the water vapor absorption is weak - it would be good to quantify this by including the exact numbers for spectral regions of interest. Again, windows used for trace gas retrievals are suggested, especially for evaluating suitability of higher resolution spectra for such retrievals.

Lines 202-205: Add the exact quantification for specific claims in the conclusion. E.g., for the statements "We have quantified the deviations from the best estimate..." and "...provides a lower limit of the error introduced by water vapor lines...".

3 Technical Corrections

Instances of "i. e." and "e. g." in the text should be changed to "i.e., and e.g.," throughout the text.

Line 55 and Equation 1: Define ν, or specify that this (and following) equations are for monochromatic light.

Line 47: Change to "Most applications, e.g., trace gas retrievals, ...".

Line 92: Remove "basically".

Line 97: Insert a comma after ”In Fourier transform spectroscopy”.

Line 103: Change to “This phenomenon is referred to as a phase error..”.

Line 110: The reference “Revercomb et al.” is missing the year.

Line 118: Same as above.

Line 121: Remove “here”.

Line 127: Insert comma after “In the real world all interferograms are finite”

Line 143: Change to “spectrum without high-frequency components being concentrated around the ZPD”.

Line 172: replace “mitigate” with “ignore”.

Line 176: Do you mean “Mertz’s”.

Line 194: remove “, anyway”.

Figure 3 caption: capitalize ”Figure 2”.

Line 207: Add commas to the following text “most of the time we can**,** and usually should**,**”.

4 References

Hung, J., Liu, L., Palm, M., Mariani, Z., Manney, G. L., Millán, L. F., Strong, K. (2025). Autonomous Year-Round Measurements of O_3, CO, CH_4, and N_2O in the High Arctic With the Atmospheric Emitted Radiance Interferometer. Journal of Geophysical Research: Atmospheres, 130(11). https://doi.org/10.1029/2024JD042847

Richter, P., Palm, M., Weinzierl, C., Griesche, H., Rowe, P. M., Notholt, J. (2022). A dataset of microphysical cloud parameters, retrieved from Fourier-transform infrared (FTIR) emission spectra measured in Arctic summer 2017. Earth System Science Data, 14(6), 2767–2784. https://doi.org/10.5194/essd-14-2767-2022

Rowe, P. M., Cox, C. J., Neshyba, S., Walden, V. P. (2019). Toward autonomous surface-based infrared remote sensing of polar clouds: Retrievals of cloud optical and microphysical properties. Atmospheric Measurement Techniques, 12(9), 5071–5086. https://doi.org/10.5194/amt-12-5071-2019

Turner, D. D. (2005). Arctic Mixed-Phase Cloud Properties from AERI Lidar Observations: Algorithm and Results from SHEBA. Journal of Applied Meteorology and Climatology, 44(4), 427–444. https://doi.org/10.1175/JAM2208.1

Turner, D. D., Blumberg, W. G. (2019). Improvements to the AERIoe Thermodynamic Profile Retrieval Algorithm. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 12(5), 1339–1354. https://doi.org/10.1109/JSTAR