



EGUsphere, referee comment RC1  
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## **Comment on egusphere-2022-1327**

Anonymous Referee #1

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Referee comment on "The Far-Infrared Radiation Mobile Observation System (FIRMOS) for spectral characterization of the atmospheric emission" by Claudio Belotti et al., EGU sphere, <https://doi.org/10.5194/egusphere-2022-1327-RC1>, 2023

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This paper describes a new portable infrared spectrometer that is able to provide spectral radiance observations from 100 to 1000  $\text{cm}^{-1}$ . This spectrometer (FIRMOS) is the successor of the REFIR-PAD system, and is serving as a technology demonstrator for the future FORUM instrument. It was deployed to a dry, high-altitude site at Mount Zugspitze in Germany, where there are other instruments which were used to help evaluate this instrument.

In general, the paper was well written, especially the first half of the paper that discusses the technical details of the FIRMOS instrument. The latter part of the paper compares temperature and humidity retrievals from the FIRMOS against radiosondes, Raman lidar, E-AERI, and ERA5 reanalysis. Due to the relatively few observations that were available, this latter section is somewhat weak. However, there are always data limitations, so this isn't necessarily crippling to this paper.

This paper would greatly benefit from having a comparison with both the E-AERI in radiance space. Due to the differences in the spectral resolutions, I would recommend the authors use the "double difference technique" outlined in Tobin et al. JGR. 2006. As the two instruments are essentially collocated (although vertically offset by 4 m), the spectral differences between 405 and 600  $\text{cm}^{-1}$  should be within the instrument noise (if both systems are well calibrated).

Line 253: did you assume any cross-level covariance in your a-priori? Were there any cross-correlations between temperature and humidity? There should certainly be cross-level correlations in temperature due to the atmospheric lapse rate, and a long analysis of radiosonde data from the region (or ERA5 data) should indicate if there should be other correlations in the a-priori. If you assume the a-priori is a diagonal matrix, that will essentially increase the information content (DFS) of the retrievals.

Line 260: It is important to note that the gradient in a cloud-free measurement is zero only because it is so dry at the Zugspitze location. If you were in a tropical location, there would be a negative slope. This needs to be stated.

Line 279: In the selection of the 625 cases, did the Raman lidar (or the backscatter lidar, which was briefly mentioned later in the paper) confirm that these were cloud-free?

Line 288: it was not clear if the uncertainty used in the retrievals was the NESR or the sum of the NESR and the CalErr. Please clarify this in the text. If the latter, then the chi-squared term being less than 1 could be due to the very conservative estimate of the thermistor error in the blackbodies (stated on line 230).

Line 293: the mean residual also will contain any bias error in the forward model (not only instrument calibration error).

For the two comparisons in Fig 15: it would be nice to include the integrated water vapor (IWV) amount for the two cases. Also, for line 309, the authors suggest that the DOF depends on the surface water vapor content, but it is really dependent on IWV? Turner and Löhnert (JAMC, 2014) showed that the DOF in the water vapor retrieval using AERI observations in the 538-588 cm<sup>-1</sup> region depends on IWV.

Figure 20: please replot using a skew-T approach, so that differences of a few degrees can be more easily identified and quantified.

Fig 23 and resulting analysis: this is pretty unsatisfying. I realize the purpose is to show that the FIRMOS is capturing the evolution of the event well, but the very coarse resolution of the ERA5 data in a mountainous region is totally inadequate to the task. I highly recommend that the comparison be made against higher-resolution NWP output, such as the (order)2-km resolution ICON data from the DWD. And that the figure include a subpanel showing the bias and RMS difference between the NWP model and the FIRMOS.

Question: Why did the authors not perform KLIMA retrievals using the E-AERI spectra, and then compare the retrievals from the E-AERI with the FIRMOS? This seems like it would be a relatively simple comparison and include a lot more data (e.g., there seems to be hundreds of points in Fig 22), and open up an interesting discussion because their spectral differences between the two instruments.