

Response to RC2

Thank you very much for the insightful comments provided on this paper. We have responded to the comments turn-by-turn below. In the responses, we abbreviate the submitted version as 'SV' and the revised version we are now finalising as 'RV'.

“Thus, I only really have two concerns. The first is that the entire analysis is only a single case...”

This is an important point to highlight and so we have added more discussion about this in RV. We also acknowledge that there is clearly a greater range of PREFIRE observation conditions to test: observations from different sensors in the cross-track array, observations from Satellite 2, and different in-orbit environments to which there may be some sensitivity (daytime/nighttime causing thermal effects in the satellite bus).

We believe that focusing on a single case has allowed us to scrutinise many details of the atmospheric profile and uncertainties at all points in the closure tests. We hope that the rigorous methodology of this study can be employed to strengthen future longer-term monitoring and validation experiments.

“Second: there were other ground-based spectrally resolved instruments at the site also. Why were these not included in the analysis?...”

This is a salient point and so we have investigated the potential for including AERI in the analysis. Direct comparison of AERI and FINESSE observations at anything close to native resolution is highly non-trivial due to differences in the instruments' spectral sampling and line shape.

A potentially simpler approach is using our atmospheric profile to simulate AERI radiances. We show the agreement obtained using the ERA5-DW profile in Figure RC2-1 (middle panel) with the equivalent residuals for FINESSE shown in the bottom panel. It is immediately evident that the AERI residuals show improved agreement with the simulations in the centre of the 15 μ m CO₂ band. However, at the same time, the residuals in the band wings are markedly higher (exceeding the expected uncertainty levels) and there is a noticeable negative bias across the main atmospheric window which is not seen in the FINESSE observations. Work is ongoing to explore why these enhanced residuals in the AERI comparison are present (using observations from across the campaign) and this will form the basis of a separate study led by the McGill team. We note that the AERI and FINESSE instruments were displaced by c.50m at the site which may lead to some differences in near-surface atmospheric conditions sensed by the two. Sensitivity tests show that PREFIRE would be insensitive to these changes, but they may add confusion in interpreting ground-based results. For these reasons we have not included the comparison in the RV.

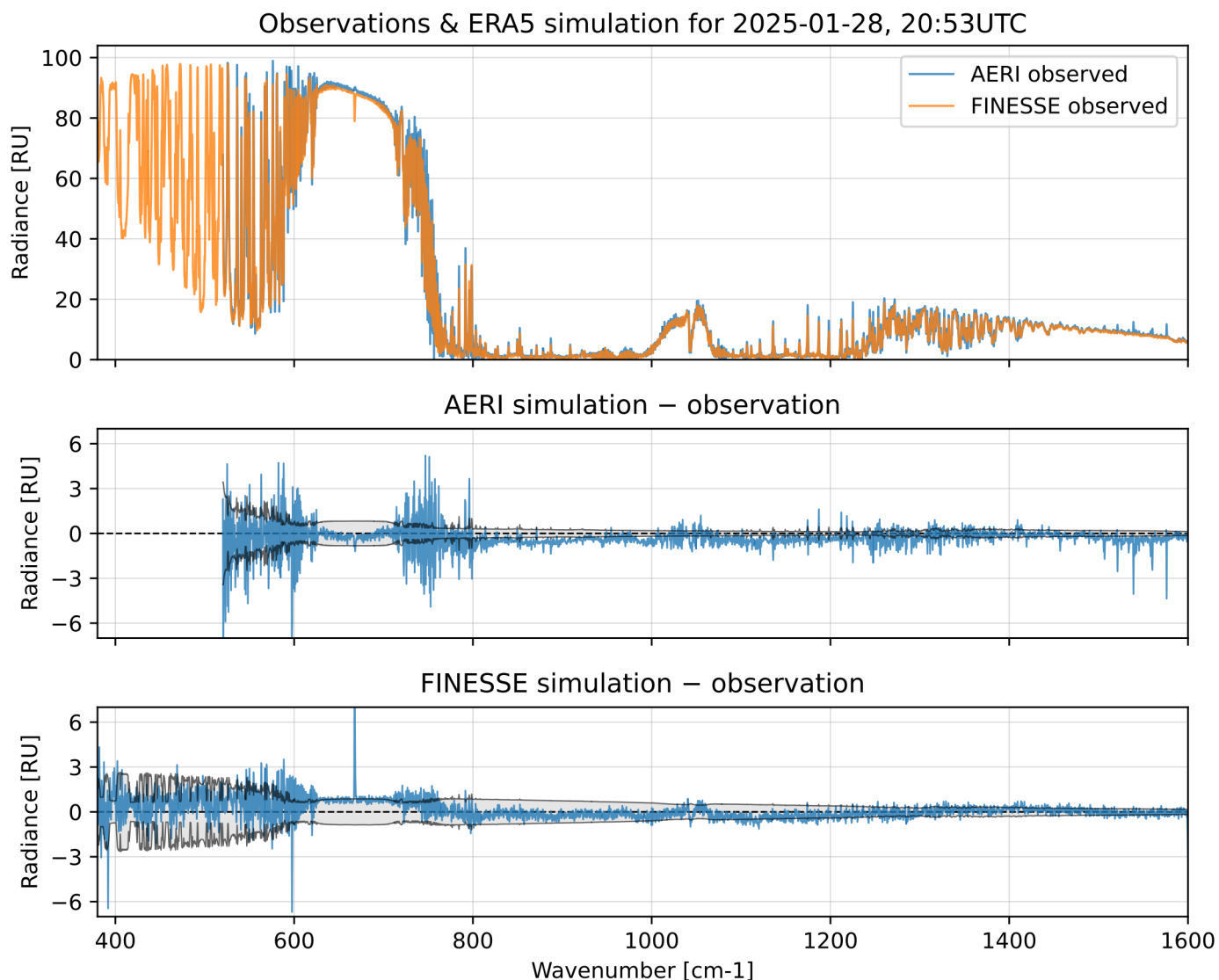


Figure RC2-1: Comparison of AERI (middle panel) and FINESSE (bottom) residuals for the ERA5-DW profile used in SV. The shading and black lines in the bottom two panels indicate the uncertainty ranges due to NESR, instrument calibration, and uncertainty in input the profile quantities (that is, all sources considered in the SV except spectroscopic uncertainty).

“Third, and this is a recommendation not a requirement: The authors show that there is a near-surface temperature error...”

We believe that performing a full retrieval of thermodynamic profiles from FINESSE is unlikely to alter the results significantly from what we present in the RV. As can be seen from Fig. 5 (in RV), the residuals predominantly lie within the combined observational/simulation uncertainty estimates. By using independently gathered thermodynamic profiles we can exploit the high spectral resolution and accuracy of the FINESSE instrument to assess, insofar as is possible given other uncertainties, the agreement of current spectroscopy with the observations. As hinted at by the reviewer, most retrievals assume the spectroscopy as a given. We argue that this is not true for the far-infrared in particular, given the relative lack of field or laboratory spectroscopic measurements across this range.

Considering the comments from both reviewers, we have slightly reframed the paper to focus more on validation of the PREFIRE L1 observations (please see AC1 for details). As such, we have used FINESSE to constrain these temperature and humidity errors seen in the SV, in effect a ‘manual’ retrieval of these quantities. PREFIRE has very limited sensitivity to the H₂O spectroscopy (see Fig. 5g,h in SV) and so we do not lose an opportunity to assess this accuracy by following this approach.