Review of “Unfiltering of the EarthCARE Broadband Radiometer (BBR) observations: the BM-RAD product” by Velázquez Blázquez et al.

27 September 2023

General comments

The manuscript prepared by Velázquez Blázquez et al. presents an approach to derive unfiltered shortwave (SW) and longwave (LW) radiances from the EarthCARE Broadband Radiometer (BBR). This is an essential processing step to remove unwanted features in the directly measured radiances that are associated with the instrument spectral response. The approach follows that of existing CERES and GERB broadband radiometer measurements that rely on spectral radiance databases simulated by a radiative transfer model. The errors associated with the unfiltering process are reported to be below 0.5% and 0.1% in the SW and LW, respectively.

The paper will serve as a useful reference within the scientific literature for any future users of the EarthCARE BBR data. Overall the paper is clear and logical, well written, and supported with appropriate figures. I noticed some inconsistencies with the EarthCARE overview paper that is also part of this special issue. There are several other aspects that I think would benefit from further clarifications and explanations, especially regarding the radiative transfer simulations. There is also a new paper for CERES unfiltering that should be considered. After addressing these concerns, as outlined in my comments below, I recommend publication in AMT.

Specific comments

L20: In Wehr et al. 2023, the spectral limits of the BBR SW and TW channels are stated as < 0.25 to 4.0 µm for SW and 0.25 to > 50 µm for TW. Here, the spectral limits are stated as 0.25 to 5 µm for SW and 0.25 to 500 µm for TW. Since both studies are new, I expect the limits have not changed, rather there is an error somewhere. In most other studies, this might seem like a picky comment because there is probably very little energy difference between the two sets of spectral limits. However, since the purpose of this study is spectral unfiltering, the instrument spectral limits seem like a basic characteristic to ensure is correct and consistent.

L21: Similar to the comment above, the stated spatial resolution of the detector array (700m along track and 600 m across track) is inconsistent with that stated in Wehr et al. 2023 (648 m along track, 800 m across track). Please check that stated numbers are correct and consistent. Do these numbers represent resolution, or sampling distance? It also should be noted that these numbers are relevant to nadir only.

L31: I calculate that, at an EarthCARE altitude of 393 km with an orbital period of 92.5 min, the duration between fore and aft 55° views of the surface is 2.79 minutes. If the authors agree, it would be better to update “about 2 minutes” to “about 3 minutes”.

L32: Similar to the first two comments above, the stated swath of the detector array (∼ 17 km for the nadir view and ∼28 km for the two oblique views) is inconsistent with that stated in Wehr et al. 2023 (±10.2 for nadir and ±16 for off-nadir views). Please ensure values are correct and consistent. This is information that data users are likely to pick up on and, once published, incorrect numbers can be easily propagated into other works.

L28: There is a reference to another paper that describes the BMA-FLX processor (Velázquez-Blázquez et al., 2023), but as far as I can tell this paper is not available anywhere online. It would have been good for the reviewers to at least see a draft copy of this paper if it is to be cited here.

L59-60: For the CERES instrument flying on the NOAA-20 satellite, there is a dedicated LW channel. So, the statement that LW is calculated by subtraction is not *always* true.

Equation 6: What is the value of “A” for the EarthCARE BBR spectral responses shown in Figure 1?

L97, L100, and elsewhere: The paper mentions both “unfiltering factors” and “unfiltering coefficients”. I think they are referring to the same quantity. Please choose one term and stick to it to avoid confusion.

L101: Does 5,544 correspond to the number of unique scenes, or does this number include multiple simulations of the same scene at different solar zenith angles? Please clarify in the paper.

L101: Why are there many more simulations for thermal? Since the solar simulations require further stratification (by SZA and RAA) I would expect that having relatively more solar simulations would be beneficial.

L103-108: The reader needs some evidence that the simulations cover the full range of conditions that could be encountered in reality. For example, are the authors confident that the simulations span all combinations of clouds (optical depth, phase, altitude, effective radius, organization, etc), aerosols (optical depth, composition, size distribution, hygroscopicity, etc.), trace gases (tropical, mid-latitude, and polar atmospheres, etc), and surfaces (spectral variability, BRDF, etc)? Very limited information is given. It is not even mentioned where the atmospheric profiles are coming from for the radiative transfer. Full details are needed.

Figure 2: I usually like flow charts to vizualise the products but in this case I am left slightly confused. I see that the B-NOM and B-SNG are provided on different grids/domains, but it is not clear to me why two different product flows are needed. If the B-SNG provides measurements at the detector level, then why not just aggregate the B-SNG radiances over the small/standard/full domains? Also, I do not understand why L_{LW} is used in the B-NOM flow chart, but L_{TW} is used in the B-SNG flow chart. Since L_{LW} is not directly measured, a synthetic L_{LW} is presumably also used with the B-NOM processing. In that case, the two flows are identical other than the final step that deals with the spatial domains, so I must be missing something. To rectify these misunderstandings, I suggest the descriptions of the B-NOM and B-SNG products are further expanded and contrasted in Section 4.1.

Figure 3: A couple of suggestions for improvement:

- It would be clearer if each subplot was labelled individually and referred to in the caption.
- The colours of the data points in the bottom two plots are all red. It would be better to keep the same colour coding as the plots above so that it is easy for the reader to see that the points with the large residuals are the ocean sun glint points.
- The title of the upper right plot says “VZA=50”. In the text, it says VZA was 55°, which I expect is correct given the BBR VZA. Please fix this error.

L165-167: As well as the spread from water vapour, it seems that the cloudy points in Figure 4 are generally more to the left of the fit line, whereas the clear-sky points are generally more to the right. If Equation 6 was calculated separately for cloudy and clear (and also possibly separately for tropical, mid-latitude, and polar regions), would that help to reduce the RMS error?

Section 4.5: Since there are no results presented in this section, it doesn’t seem to fit. I suggest removing Section 4.5 and mentioning the MSI unfiltering in Section 6 when results are shown, or even just in the conclusions.

Figure 6: It looks like the polynomial fit is not doing very well at capturing the upper end of the thermal radiance values (clear sky). The unfiltering factor shows little dependence on the radiance magnitude beyond 90 W/m2/sr, but the fit shows a sharp increase. Does this create larger errors for the clear scenes? Would it make sense to have a separate LW unfiltering factor fit for cloudy and clear-sky?

L208-210: The relative error values stated in the text do not seem to match those in the table. For SW, the text says ≈0.5% for clear sky but all of the SW clear-sky values in the table are less than this (0.35,0.36,0.42,0.46). For SW cloudy, the text says ≈0.4% but all values in the table are identically 0.34%. For LW the text says “well below 0.1% for all of the scene types”, but 4 out of the 10 scenes are at or above 0.1% in the table, and the values below this are only just below. Assuming the values in the table are correct, I suggest updating the text to something like: “For the solar radiation, the relative error on the unfiltered radiances is 0.34% for cloudy conditions and increases to 0.35-0.46% for clear sky conditions. For the thermal radiation, the relative error is 0.10 ± 0.02 % for all scene conditions.”

L219-220: The claim that the MSI-based unfiltering does not perform better does not seem to be well supported by the statistics shown in Table 2. The majority of the statistics in Table 2 *are* improved with the MSI-based approach. This also contradicts a statement in the conclusions where it is claimed that MSI radiances are useful to further reduce the unfiltering error.

Table 2: I find it difficult to compare the different example scenes, and also compare to the results in Table 1, because the radiances of the scenes themselves are different. Please include the relative error in % in this table, as was done in Table 1. This will help the comparisons greatly, and is particularly important given that the errors stated in the conclusions and abstract are in %.

Data availability: The doi given to the EarthCARE demonstration products does not seem to include the radiative transfer database used for unfiltering. Per AMT policy, I think the libRadtran simulation database (radiative transfer input profiles and output spectra) should be made available since this is essential underlying data required for this study.

A paper describing the updated unfiltering algorithm for the CERES instruments is now in the public domain: https://doi.org/10.5194/egusphere-2023-1670. The authors did not refer to this paper, which is understandable since it has only been available for about 2 months. However, given the relevance to the EarthCARE unfiltering algorithms, I think the authors need to consider this paper in their revision. It includes several important updates compared to the earlier CERES unfiltering algorithm (already cited). For example, they implemented the Cox-Munk BRDF model over ocean, MODIS retrieved BRDFs over land, considered seasonal variations, increased angular resolution, and used MODTRAN version 5 that has several advantages (see paper for details) to build their simulation database. I recommend adding a paragraph or two comparing and contrasting the EarthCARE BBR approach with this new CERES method. Future users of the EarthCARE BBR data will likely find such a comparison very useful.

Technical corrections

L42: “data bases” -> “databases”

L45: remove “the”