Answers to review https://doi.org/10.5194/amt-2023-170-RC2

General points

The manuscript describes the algorithm to obtain spectrally unfiltered shortwave (SW) and longwave (LW) radiances at top-of-atmosphere from the observations by the BBR instrument on board of EarthCARE. The spectral unfiltering is needed to correct for the spectral sensitivities of the instrument and for the contamination of SW radiation in the LW channel and vice versa. This paper is part of the special issue describing the algorithms for EarthCARE.

The structure and overall story of the manuscript is quite clear. However, when it comes to the details of the algorithm, the equations, and the steps that are taken, the paper is not clear and sometimes ambiguous, especially in Section 2. Since the BM-RAD algorithm should be perfectly clear to avoid errors later on, corrections in the manuscript are needed. These changes are not very difficult but necessary, and therefore these are major revisions. Furthermore, several technical corrections should be applied throughout the paper.

Specific points

- In the Introduction (Section 1) more high-level information on the aim of the BBR instrument in combination with other EarthCARE instruments is needed.

Thanks for your comment. Indeed, a brief introduction about the BBR role in the EarthCARE mission would help the reader understanding better the importance of the paper. Below the new paragraph included:

The EarthCARE (Earth Clouds, Aerosols and Radiation Explorer) mission (Illingworth et al., 2015; Wehr et al., 2023) is a collaborative mission between the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA). EarthCARE's primary objective is to enhance our understanding of the processes affecting clouds, aerosols, and radiation in Earth's atmosphere. The mission aims to provide valuable information for improving climate model parametrizations and the understanding of how these components influence the global climate. EarthCARE integrates a suite of instruments including a lidar, radar, and radiometric instruments. Among these instruments, the Broadband Radiometer (BBR) plays the role of providing crucial information for the radiative closure of the mission. This process involves verifying that the radiative transfer simulations, which are fed with atmospheric products from the mission's active sensors, report radiative fluxes within 10 W m2 of the fluxes derived from the BBR-

- The paragraph starting on L. 29 seems too detailed for the Introduction.

Thank for your suggestion. However, we consider relevant to include this information in the paper as it briefly describes the instrument and the EarthCARE product where the radiances are stored.

- L. 25: what is the function phi? Please mention that it is the spectral response function, and is needed to separate between reflected solar and emitted thermal fluxes.

Already clarified in the text.

- L. 29: all three references should be between brackets.

Thank you, corrected.

- Section 2: This section contains bugs, is unclear and should be improved and clarified. The symbols are unclear, the different unfiltering steps are not clearly separated.

We have modified the section following the comments from the reviewer, clarifying symbols and correcting bugs.

- Equation 1: please give the integration limits; this holds for all integrations.

Fixed.

- L. 58: SW channel: do you mean SW radiation ?

It is not the SW radiance, but the SW channel. It is difficult to manufacture a LW filter as opposed to the quartz filter used for the SW channel.

- L. 58: efficient > an efficient

Corrected.

- L. 62, Eq. 5: subscript SW - in other places you use sw. Please be consistent in the subscripts throughout the paper. SW and LW are clearer subscripts than sw and lw.

Thanks for spotting the typos. Typo in subscript corrected in equation 5. Following the recommendation of the reviewer the subscript sw has been replaced by SW, lw by LW and tot by TW.

- L. 64: observed. > observed:

Corrected.

- Eqs. 7 and 8: I find it confusing that the spectrally integrated radiance has the same symbol L as is used for the spectrally dependent L(\lambda). Please use a clear distinction in symbols.

We appreciate this comment from the reviewer, but please note that the notation is used through several official documents and, therefore, we would prefer not to introduce a new symbol to make the difference between the spectral and integrated radiances. Every time any spectral quantity is mentioned it is followed by (lambda).

- L. 76-79: "This conversion .... solar radiation": Please clearly separate these 3 factors.

Rephrased to consider the referee comment.

- Eqs. 8-9: The terminology in these equations, e.g. the subscripts "sw,sol" and "lw,th", is not clear.

We understand it refers to Eqs 9-10. Clarification is included in the text for the subscripts.

- L. 85: L_sol,L_th: where is now the subscript unfil, which was used in Equations 7-10 ?

Subscript unfil has been removed for clarity in equations 7-10

- L. 93-94: please clearly separate these different steps.

Rewritten.

- Eqs. 13-14: what happened to the fil and unfil subscripts introduced in earlier equations?

Removed also from previous equations.

- L. 97: alpha_sw, alpha_lw: these are new variables! Where are alpha_sol and alpha_th introduced in Eqs. 9-10?

Typo in Eq 9 and 10 corrected. Now notation is consistent everywhere using alpha_SW and alpha_LW

- L. 97: the name "unfiltering process" is quite confusing: there is an unfiltering step and a decontamination step. Please clarify the entire Section 2.

We agree that the terminology can be misleading but it is commonly used in the field. The unfiltering process includes the contamination removal and the unfiltering itself.

- L. 102: double bracket)

Corrected.

- L. 103: physical > geophysical

Corrected.

- L. 104: remove , in such as,

In our opinion, this is not needed, as it clarifies that the ancillary models and data are for instance the surface reflectances from the Aster Spectral Library data (Baldridge et al., 2009) and the Optical Properties of Aerosols and Clouds (OPAC) software

- L. 106: aerosols: how about clouds? what are the ranges in optical thickness and height of aerosols and clouds?

Some more details have been added to the manuscript, but full description of the radiative transfer simulation database is available at
https://gerb.oma.be/public/almudena/SITS_DB_compressed/GeoType_data_base_desc.pdf

- L. 114: droplets

Typo corrected.

- L. 119: are the three spectral response functions of the instrument independent of the (3) viewing directions?

Yes, each view has its own spectral response

- L. 136: MSI-based algorithm

Updated

- Figure 2: please use the same font style for the symbols and equations in this figure.

Fixed

- L. 140: The Fig. > Figure; same comment on L. 156.

Corrected

- L. 148: It is quite remarkable that alpha does not depend on cloudiness. What is the explanation that the solar contamination in the longwave channel does not depend on cloudiness, since thick clouds in the daytime reflect a lot of radiation.

Indeed, the solar contamination depends on the cloudiness, but the alpha coefficient appears to be independent of the cloudiness type.

- L. 150: m/s; note that all units should be written in upright font.

Corrected

- Fig. 3: the red colored dots in the two lower plots are unrelated, I assume, to the legend of the upper plots. Then please make these dots black, and define the residual in the main text.

Lower plots updated to match the legend of the upper ones

- Eq. 16: symbol a is already used in Eq. 15, and has a different meaning there. Please use unique symbols for each quantity. The same remark holds for the next equations. Please be consistent in symbols and terminology.

Fixed.

- Fig. 4: On the basis which points did you determine the precise relationship shown in the 4 plots? The a and b coefficients are exactly the same, but the data points are different. That seems strange.

Caption adapted to make clear that the same fit is used for the 4 surface types.

- Caption Fig. 4: please explain the two types of points in each subplot.

Done in the caption.

- Sect. 4.4, first sentence: Please explain where we are in the procedure of the flow diagram. Do you mean spectral unfiltering to obtain the correct SW radiances? Is this the step after the decontamination?

Clarified in the document.

- Eq. 17: apart from the reuse of earlier symbols, this is an unclear formula. Please make a multiplication with the inverse or add brackets.

Formula rewritten.

- Fig. 5: the plots and their legends are poorly readable. Please use a larger font.

Fixed

- L. 190: stand-alone algorithm

Added.

- L. 196: “much smaller than for the CERES and GERB instruments”: what is the reason?

Reason added: The primary reason for this is that the BBR optics has only one mirror while CERES has two and GERB has five.

- Fig. 6: what are the fit coefficients? This fit function does not hold for larger radiances.

Indeed, the second order polynomial fit doesn't fit very well the scenes with very high radiances, in which an error of ~0.3% could be introduced in the worst case. That was considered acceptable given the low occurrence of such a high thermal radiance.

- Caption Fig. 6: use correct ordering: (a) ..., (b) .....

Corrected

- Caption Fig. 6: please explain: are these the alpha factors of Eq. 10 or of Eq. 14?

Equation referenced in the caption.

- Table 1 header: what is the reason that you switch between LW and th, and between SW and sol?

Changed SW to solar and LW to thermal

- Section 5: Section 5 is very short. How did you do the analysis? Please explain how you arrive at Table 1.

Yes, indeed the section is relatively short, but it must be understood as a high level verification that the algorithm performs as expected. The full verification of the algorithm is done using test scenes in section 6.

- Title Section 5: do you mean algorithm verification instead of performance verification? The next section is about performance verification.

Yes, indeed, thanks for your comment. Title updated to BM-RAD algorithm verification.

- L. 217: Table 2

corrected

- L. 225: Please summarize the results of Fig. 7: which conclusions do you draw from it?

Some more information has been added in the document. A summary of the conclusions can be found in section 7.

- Fig. 7: The plots in the right column are somewhat smaller than in the other columns. Please make all subplots the same size. How will you orient this figure to make it readable? Preferably landscape.

Figure now in landscape mode.

- Caption Fig. 7: "RT sim (truth)"

Corrected.

- References: Please correct all references, because the initials should be put after the surname.

Corrected.

Technical corrections throughout the manuscript

- level 1 > level-1, level 2 > level-2

All corrected.

- Subscripts which are words, abbreviations or acronyms should be in upright font. For example, fil in L_fil on l. 50 should be upright. This occurs many times in the manuscript.

Fixed

- Symbols should be in italic font.

Corrected

- L. 67: Fig. 5 > Figure 5. If it is the starting word of a sentence, Fig. should be written in full.

Corrected

- Always use a space between number and unit: e.g. L. 91: 5 µm

Corrected where needed.

- Units should be written in upright font (e.g. l. 152, and many other places)

Fixed

- Fig., Eq., Sect. should be written with capital.

Verified and corrected where needed.

- Tables: please put the table caption above the table.

Done

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