Response to Referee #3

We thank the referee for their review. Below are the original comments in *italics* with our responses in normal text.

This manuscript describes the theoretical foundations of EarthCARE's radiative flux and heating rates product, ACM-RT, that derives from applying a radiative transfer model to aerosol and cloud profiles retrieved from the cloud profiling radar, lidar, and multi-spectral imager. The primary focus is to document the details of the radiative transfer calculations with an emphasis on establishing the value of the unique use of 3D radiative transfer modeling. The subject is appropriate for Atmospheric Measurement Techniques, the methods are thoroughly described, and the results are compelling. My only concerns are that (a) in places the paper reads too much like a technical report or theoretical basis document and (b) the paper assumes too much 'insider knowledge' of the EarthCARE products and nomenclature to be fully understood by the general reader. I recommend the paper be published in AMT after the following minor revisions to address these concerns.

1. The paper reads too much like a report or technical document in some places. The abstract refers to the study as a "report" on at least 3 occasions and the compositing process in Section 3 reads very much like a technical document as opposed to a paper. As opposed to strictly describing a recipe, are there any elements of the thought process or motivating physics that could be described? Similarly, the lists of wavenumber ranges for RRTMG's LW and SW bands in Section 4.1.1 seem out of place in a paper, perhaps they could be converted to a table at least to avoid devoting two paragraphs to lists of numbers. Another example concerns the detailed description of the Lorenz-Mie calculations starting on Line 221 that includes the increments used to step through particle radii. I suggest adopting a more narrative approach throughout the paper to improve readability.

For the specific example related to the RRTMG wavenumber intervals, we have put them in a new table. These intervals are not easily found in the literature; listing them here will be useful to readers for they help define computation of all optics described in the paper. We have not changed text related to Lorenz-Mie calculations. As noted in the manuscript, tabulated values of liquid cloud optics are used in ACM-RT. In our opinion, description of the tables is an important detail for some readers.

It is important to note that the manuscripts in this "special edition" essentially double as regular publications and, overly technical, Algorithm Theoretical Basis Documents (ATBDs). Currently, the manuscript is an attempt to straddle these two types of documents. Rewriting to have "a more narrative" style would detract from the balance we believe we have struck.

2. While the paper is part of a special issue that likely fills in several additional mission details, I believe this paper should largely stand alone. At a minimum all acronyms should be spelled-out but it would be useful to add a few additional details regarding the ACM-CAP, A-ICE, C-CLD, etc. products. I also didn't see clear definitions of "Hawaii frame" and "Halifax frame".

Explicit definitions of the "Halifax" and "Hawaii" frames have been added at the beginning of Section 5. We have expanded all acronyms and abbreviations when they first appear. We have selectively modified the text to identify what is being used from EarthCARE products that are not the focus of the manuscript.

3. Line 158: it seems one or more words is missing after "ACM-COM's …"

The sentence was adjusted to make it clear that we are discussing "ACM-COM profiles".

4. While the accuracy of the radiative transfer model and, in particular, the 3D Monte Carlo calculations are discussed at length, a broader discussion of the anticipated sources of error in the ACM-RT product itself owing to retrieval uncertainties and errors in the supplemental meteorological variables and surface albedo is lacking. To what extent do these uncertainties offset the value of modeling 3D effects? I realize the point of the closure studies after launch is to answer this very question, but have any sensitivity studies been conducted to assess the relative magnitudes of geophysical parameter errors vs. radiative transfer errors?

We agree with the reviewer that propagation of input uncertainties through radiative transfer models is important. We are in the process of preparing a manuscript for the ACMB-DF (radiative closure) processor that will show errors in radiative quantities relative to reference values computed from the test scenes. This will, however, lack assessment of errors in the retrievals, meteorology, and surface properties. The next step will be incorporation of input errors (uncertainties) and their impacts on computed radiative fluxes and radiances. We are simply not prepared right now to present results pertaining to these issues.

Provision of quantitative estimates of radiative uncertainties requires both characterization of inputs errors and a methodology to utilize them. For example, it is not enough to know just the magnitudes of input uncertainties, which are challenging in their own right, but one also needs to consider correlations in uncertainties in both space and time. We expect that the study of propagation of input uncertainties through the radiative transfer models will be sufficiently complex to warrant a dedicated manuscript. That said, as presented in this manuscript, using 3D instead of 1D radiative transfer removes that source of uncertainty from computed radiative fluxes and radiances.

5. What does the black rectangle in Figure 7 represent? It is not described in the caption or in the narrative.

The rectangles indicate the size of assessment domains over which radiative transfer results are averaged for the radiative closure. This has been made clear in the figure caption.