

kCARTA : A fast pseudo line-by-line radiative transfer algorithm with analytic Jacobians, fluxes, Non-Local Thermodynamic Equilibrium and scattering for the infrared

by DeSouza-Machado et. al.

We thank the anonymous referees for their detailed read of the paper and providing introspective comments, many of which have resulted in changes to the revised version of the manuscript. In particular we have improved the accuracy of the computed kCARTA radiances by changing our default options (now linear-in-tau, higher resolution spectral database in the 15 um region). This update has already been pushed to github. We have also shortened the paper by removing the sections describing comparisons between the HITRAN/GEISA/CO₂ line-mixing databases, and the impact of spectroscopic uncertainties on TOA radiances. This has been replaced by a section where we compare kCARTA versus LBLRTM TOA radiances.

Below we detail our responses to their individual concerns. For ease of review, we type-faced the reviewers questions in blue. When we refer to pages and line numbers in our answers, the context should make it clear whether we are talking about the original manuscript or our current revised manuscript.

Reviewer 2

Specific comments

1). What studies have the authors done to ensure that the 11 temperature grid points are adequate to represent the temperature dependency of optical depths of gases for each atmospheric layer. Please quantify the errors of interpolation due to 11 point grid and the choice of interpolation method (spline vs linear).

We have addressed the first part of this question above. The spline versus linear interpolation errors work out to be 0.0004 ± 0.0040 K when averaged over all monochromatic spectral points, for 49 regression profiles, with a maximum absolute difference of 0.342 K (in the 15 um region). This information has been inserted into Appendix B of the revised manuscript.

2). The kCARTA package is optimized for the thermal infrared spectral region. Though the authors claim it is trivial to extend the database out to span the far infrared to ultra-violet range, the package does not include Rayleigh scattering and an accurate multiple scattering radiative solver, which are important for the shortwave top of atmosphere radiation calculations.

Correct, we have fixed Section 9 and Appendix to state that PCLSAM is optimized for the thermal infrared away from solar scattering effects, so we have codes to read in ODs uncompressed by kCARTA for arbitrary atmospheres, which can then be passed to for example LBLDIS.

3). On page 2 line 40, it will be useful to describe the relative errors between kCarta and the MNLBL.

The UMlbl code computes only optical depths, and does not have any radiative transfer computations. As mentioned above and in the next question, we have added a section that describes detailed top-of-atmosphere radiance intercomparisons against LBLRTM.

4). Section 2.1 on page 4. Although the authors described the UMBC-LBL model line shape calculations and mentioned that extensive comparisons with LBLRTM and GENLIN2 have been performed, no quantitative results have been shown to illustrate differences among different LBL models. For some molecules, a sub-Lorentz line shape is used by LBLRTM, what about the UMBC-LBL?

As asked by two reviewers, we have added a section that describes detailed inter-comparisons against LBLRTM. We are also happy to provide interested users with a database generated entirely using the optical depths in LBLRTM.

5). The method used by kCARTA for calculating the downwelling background radiative is very efficient and much more accurate relative to a constant diffusive angle. However, for a non-Lambertian surface (e.g a specular reflection surface), this may not be a good approximation.

Correct, an example BRDF for sunglint is modeled in Appendix A of the Nalli et. al 2016 paper we have referenced.

There are some minor errors in the manuscript:

1. In the figure caption for Figure 6, 0.005 cm⁻¹ should be 0.0005 cm⁻¹.

Fixed

2. Not all the symbols used in this paper are defined. For example, Omega in equation (3), g under equation (C1). . .

Fixed

3. Some of the links given in Appendix A are not available.

Fixed the line-by-line code link to point to https://github.com/sergio66/UMBC_LBL. The others were valid/accessible.

4. Line 149, the symbols in the equation are not explained by the text or the appendix B.

Fixed

5. Line 230, please correct typo “limemixing”

Fixed