DETAILED COMMENTS for GMD Manuscript gmd-2021-325 "Computation of longwave radiative flux and vertical heating rate with 4A-Flux v1.0 as integral part of the radiative transfer code 4A/OP v1.5" by Yoann Tellier et al.

The paper describes the implementation and testing of a dedicated clear sky Outgoing Longwave radiation spectral module for the 4A/OP code. The paper outlines some of the math involved in changing the quadrature into exponential integrals. Comparison of the output against other models is performed. The spectral (quasi monochromatic) nature of the output allows the authors to present results that demonstrate how changes to trace gases change the OLR in expected spectral regions.

The nature of the paper (algorithm) means there is not much new scientific that can be presented in this paper. I find the paper well written, though I have some questions/comments (see below).

Based on what they have presented, I suggest to complement Section 4.2 on OLR sensitivity to perturbations of the profiles, can the authors also present a study of how OLR changes if they perturb the spectroscopy in their atlas? In other words, they have stated the flux computed by LBLRTM 12.8 (I believe using HITRAN 2012) is very close to what is computed by their model (using GEISA 2015). Can they also approach that from another avenue, namely can they add in the uncertainties of the (GEISA) database parameters such as line strengths, line shifts, air and self broadening etc, to their atlas, generate optical depths and then re-compute OLR to show how the spectral differences and total OLR change? The parameter changes could be done independently, and also randomly put together. These should be relatively straightforward to do, though it may be time consuming to generate new database(s).

Equation 6 (where the authors define $E_n(x)$) could be augmented by some of the recurrence relations used to derive the final equations eg I assume $\int^{x0} E_2(x)dx = E_3(x0)$?

Could the authors estimate or comment about expected differences in computed flux and heating rates using (a) constant, linear-in-tau or exponential-in-tau temperature variations and (b) how flux and heating rate calculations be impacted as you change the spectral resolution?

Below are some additional minor comments/suggestions

1. Traditionally the angular quadrature for eg upward flux is done by taking a stream of radiation leaving the surface at a particular angle, then doing the radiative transfer to the Top of Atmosphere at that angle; repeat for different angles and sum. The method outlined in this paper is a neat way of doing that, but they state it is for a plane parallel atmosphere. Can the authors comment how the output of their code would change if it were modified to account for spherical geometry (ie the atmosphere can be thought of as concentric shells around the earth)?

2. I believe Grant Petty's "Introduction to Atmospheric Radiation" also derives flux integrals in terms of exponential integrals of order n (but with the events of last couple years I seem to have misplaced my copy and can't verify this, sorry)

3. Abstract, line 13 : just use " and a standard deviation of"

4. Line 20-27 : The authors should be careful and differentiate between line-by-line models such as LBLRTM and 4A/OP, versus the rapid but less accurate flux calculators such as RRTM and ecRad, used in GCMs

5. Line 28 : please elaborate how “layers” in your model are defined for the atmosphere. For example Table 1 talks about 43 versus 61 vertical levels – what is pressure at Top of Atmosphere for either scenario, and how would number of levels affect the accuracy. Maybe you could phrase it “satellite observations are modeled by dividing the atmosphere onto layers that are thin enough that the properties of any layer do not vary significantly eg Ttop-Tbottom is less than 5 K, water vapor mixing ratio changes by less than 1 percent across the layer, etc.
6. Line 30 : I assume by “radiation parametrization” the authors mean the optical depths used in the fast models?
7. Line 37 : “with these six benchmark models among which 4A/OP LBL code” is an incomplete sentence.
8. Line 44 : “the radiance at the correct layer temperature, pressure levels ...”
9. Line 53 : does “contraction” mean “integration over angles”
10. Line 68 : Is the internal resolution of 4A/OP always 5e-4 cm-1 (ie from FIR to NIR)? Actually please first mention the OLR spectral range used by 4A/OP here (10-3250 cm-1)
11. Line 78 “The sublayer temperature in 4A-Flux varies linearly” ...
12. Line 104, beginning of Sec 2.2.1 “We focus on the downwelling flux in this section.”
13. Line 106 “As we focus on the longwave only, the radiative contribution of deep space (less than 3 K) to the downwelling flux ...”
14. Line 109 replace “injecting” with “inserting”
15. Line 126,127 : perhaps “assumption” rather than “hypothesis” would be a more appropriate word, in the last two lines of Page 5? and elsewhere in Page 6
16. Equation 16, perhaps more fully say $H = \frac{g}{c_p}\frac{\partial F}{\partial p} = \frac{\partial T}{\partial t}$
17. Table 1 : I’m quite surprised calculations at all levels takes so much longer than OLR at TOA, which requires the calculation at all intermediate levels!
18. Page 11, caption for Fig 2 : rephrase “for every pair of model and physics variant”?
19. Line 263 : I’m pretty sure LBLRTM12.8 uses HITRAN 2012, MT-CKD3.2 and CO2 linemixing by Lamoroux; can you explicitly state this and give similar spectroscopy references for 4A/OP (eg GEISA 2015 etc)
20. Figure 3 : variability of WV and O3 sub-panels could be better plotted using logs for the x-axis
21. line 339-344 : Please also see and refer to the new J. CLim paper “An Analytical Model for Spatially Varying Clear-Sky CO2 Forcing” Nadir Jeevanjee, Jacob T. Seeley, David Paynter, and Stephan Fueglistaler e: 09 Nov 2021 Print Publication: 01 Dec 2021 DOI: https://doi.org/10.1175/JCLI-D-19-0756.1 Page(s): 9463–9480
22. lines 380-400 : is there any particular physical significance to these “kinks” ... if so could you explain in a summary?
23. line 478 : This brings me back to the point I mentioned above ... the HITRAN and GEISA databases should be pretty similar, so perhaps you should consider the assessing the impact of uncertainties in the spectroscopic databases on OLR fluxes.