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Comment on gmd-2021-203

Anonymous Referee #1

Referee comment on "Fast infrared radiative transfer calculations using graphics processing units: JURASSIC-GPU v2.0" by Paul F. Baumeister and Lars Hoffmann, Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-203-RC1>, 2021

Fast IR Transfer Calculations using GPUs: JURASSIC-GPU v2.0

P.F. Baumeister & L. Hoffmann

Referee comments

Summary

The paper describes the JURASSIC radiative transfer model, which can be used to simulate the measurements of hyperspectral infrared instruments in both limb and nadir-viewing geometries. This is a fast, band-averaged RTM using the Emissivity Growth Approximation to approximate transmittances of complex paths along the line of sight.

Noting the expected large increase in the data volume from hyperspectral satellite instruments in the next few years, the second part of the paper describes some experiments implementing the code on a GPU system. However, this is outside my area of expertise so I limit my comments on this part to a few trivial, grammatical suggestions.

Main Comments

1) There should be a bit more acknowledgement and review of the approaches used in some of the other fast RTMs already used operationally. For example RTTOV which, like JURASSIC, is a band-averaged model, widely used in NWP applications, which has a different technique ('predictors') for evaluating transmittance of complex paths. Also the OSS model from AER, a high-speed monochromatic model which is a candidate for operational processing for future instruments.

2) Clearly the number of path segments has a significant impact on computation. However it seems that the JURASSIC ray-tracing doesn't distinguish between the step size required for accurate ray-tracing (including, particularly, the integration of absorber amount within each segment), and the segmentation used for the subsequent EGA calculation and radiative transfer. In particular if a coarser spacing can be applied to the latter, there would be a significant saving in CPU time. Even so, I am surprised that the ray-tracing takes up so large a fraction of the computation time.

3) Regarding the 'continuum approximation' (L220 onwards). I believe a similar assumption is possible if the spectral features from the different absorbers are uncorrelated across the band. However, with hyperspectral instruments you are dealing with bands of less than 1 wavenumber, where there may be just a couple of individual lines, perhaps one from the target molecule and one from an interfering molecule. So both the uncorrelated and continuum assumptions would seem to break down. Is this a fundamental limitation on the accuracy of JURASSIC compared, say, to other band models such as RTTOV, or do you have some proposed mechanism for dealing with such cases?

4) Figure 1 and the associated text (L238) are very misleading. This suggests the Beer-Lambert Law is being used, ie complex path transmittance is simply the product of component homogeneous path segment transmittances. This is, of course, only true for monochromatic transmittances, not band-averaged transmittances as shown here. However, the error seems confined to just this part of the manuscript and is not, in fact, how JURASSIC actually evaluates path transmittances (as detailed in 2.6).

5) There are various references to using the 'bisection' method for interpolating the look-up tables (L256, L385). If I understand correctly this is basically an iterative approach, progressively dividing the tabulation axes by factors of two, and a significant CPU overhead. However, since your tabulation axes seem to be at regular intervals, surely you can evaluate your required interpolation nodes directly?

Minor comments

L18: Suggestion: replace 'of about 4 and 15 μm of wavelength' with

'from 4-15 um'

L19: Suggestion: start sentence 'Here, in the longwave part ...' to clarify that you regard the mid-IR as part of the longwave region

L30: 'next to' ? Do you mean 'as well as' ? There should probably be a reference or two to go with this statement.

L34: Perhaps also mention IASI-NG which will have a higher data rate than IASI, and the Chinese FengYun-4 GIIRS instrument already in orbit.

L46: 'Massive amounts'. Perhaps 'a large number' sounds less excitable.

L47: Suggestion '... provide a speedup factor of more ...'

L60: 'Russell' (two 'L's) (also missing in several other places)

L69: 'Michelson' (one 's')

L71: Presumably 'for the Atmosphere' still contributes a part of the CRISTA-NF acronym

L101: It seems strange that JURASSIC should used a fixed value of Re. Can this really not be varied to match a particular viewing geometry (preferably without having to recompile the entire code)?

L115: Suggest '4--15' (in LaTeX, or en-dash) to indicate continues range, rather than '4...15' which implies a sequence.

L158: Delete 'being' - superfluous.

L175: The O2 and N2 continua arise from 'Collision Induced Absorption' which, in

my mind, is a very different process from the CO₂ and H₂O continua which are largely the accumulation of line wings. Nowadays, HITRAN has a completely new file category for CIA (including these O₂ and N₂ continua), in parallel with the line database and molecular cross-sections.

L183: emissivity, in this equation, should be defined either before or immediately afterwards. L187 is a bit too remote.

L219: '...small, if...' the comma is superfluous (in English grammar if not German!)

L226: How do you establish the pressure and temperature associated with the homogeneous conditions?

L245: It might be useful to mention what units 'u' is measured in. And there should be an integral before the 'ds', along the length of the 'cell'.

L275: Reference to Eq(19) suggests that a 'Delta e' term might be included after all. I assumed (from L.221) that it was not.

L289: epsilon_2 - you seem to have switched notation. Here I understand this to represent the emissivity of both path segments combined but in L282 it would be the emissivity of just segment#2

L292-294: Is the appearance of the wavenumber nu significant or an oversight? In any case, I couldn't understand the point being made here - please try rewording it.

L303: Suggestion: 'computer' or 'computationally intensive' (unless 'compute intensive' is generally accepted usage - it's not really my field!).

L377: 'monotonically' rather than 'monotonously' (which has now acquired a quite different meaning in English, as in 'tediously' or 'boringly').

L396 (and following). According to Wikipedia, kB and MB seem to be the recommended abbreviations.

L448: 'Wizard' (one 'z')

L447: (pedantically) 'fewer' rather than 'less' for discrete, countable items.
Also L513, L519.

L473: Suggest 'from 2120 to 2605' rather than 'at 2120 to 2605', and again later
in the same line.

L489 (and subsequently) I'm not keen on the introduction of a new unit, the
'kray'. I'd prefer 6.2×10^3 rays/s

L493: 'After loading ... this context'. Wording could be improved ('yet' can
mean both 'not yet' and 'although', which makes the overall meaning
ambiguous).

L503: 'deduct' - do you mean 'deduce', or did you really mean 'deduct' as in
'subtract' ?

L514: '2k' expand to 2000 (as with 1000 in previous line).

L528: 'performance ... 11% higher' Does this mean that the required time is 11%
longer or shorter? 'higher' could be interpreted either way.

L573: '... restructuring ... has ...' (singular)

L575: ' ... both a GPU ...' (remove superfluous comma after 'both')
