

# ***Interactive comment on “A Radiative Transfer Module for Calculating Photolysis Rates and Solar Heating in Climate Models: Solar-J 7.5” by Juno Hsu et al.***

## **Anonymous Referee #2**

Received and published: 11 April 2017

This paper is generally very well written providing substantial details on methods and scientific explanation of comparative results, and limitations. It addresses needs for a more complete fast radiative transfer model for climate (and forecast) models by extending the Fast-J/Cloud-J code mainly by extending infrared spectral bin coverage to 12 microns following the RRTMG-SW model. The resulting model, called Solar-J, appears to combine the best features of both packages.

I recommend the publication of the manuscript following minor revisions.

P.S. Access to Solar-J worked fine.

Scientific presentation:

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1. While this referee has some gaps regarding the scientific background of all aspects involved in this work, the scientific content, descriptions, and justifications appear well done and very detailed and extensive. This is very commendable. No needed revisions have been identified on that front.

2. Minor revisions are needed regarding the presentation of Solar-J in the context of its inheritance from Fast-J, Fast-J2 and Cloud-J. In the conclusion section, it is indicated that 8-stream scattering, semi-spherical geometry, UV transmission, and cloud quadrature were taken from Cloud-J. This referee did not find any clear prior mention that the 8-stream and semi-spherical geometry were already present in the original code from which Solar-J began. Actually, the 8-stream code would have been from Fast-J2 while the spherical earth consideration for solar radiation would have been in Fast-J. There is much discussion in the introduction and elsewhere on the merit of the 8-stream approach, giving the initial impression that this is a new added feature, i.e. while it was present in Fast-J2.

There are back and forth references to Fast-J and Cloud-J which tends to confuse if one was not already familiar with both. It would be best to present the contributions and relations of each to Solar-J in the introduction (e.g. in the second paragraph of the introduction) and, from that point, maybe just refer to Cloud-J afterwards which would have been the starting point of Solar-J.

For clarity, it would be needed to indicate, from the beginning, likely in the introduction since the 8-stream approach is highlighted here, all components and features stemming from Fast-J and its successors Fast-J2 and Cloud-J, prior to the additions made to generate Solar-J. It is acknowledged that this is done regarding the spectral configuration and also, but only later, the Cloud-J cloud quadrature.

The mention of both 2-stream and 8-stream is provided in the introduction to highlight (it needs to be made explicit in the introduction) the advantage of “continuing with the 8-stream approach from Cloud-J” vs. the 2-stream approach of RRTMG-SW.

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Considering the above comments, there might be some benefit in correspondingly revising the introduction (and related text locations here and there such as the abstract – see (3) below).

3. The quality of the abstract and conclusions section is not as high generally as that of the remainder of the paper. Comments on the composition of the conclusions section is provided later. A few comments mostly on the scientific presentation of the abstract follows bellow.

- As alluded to in (2) above, there is mention of Solar-J including the 8-stream scattering a few other features without indicating that these were inherited from Fast-J/Cloud-J. The sentence ‘ Solar-J is a ...’ in lines 15-16 could moved to line 11 with mention of Cloud-J. The following sentence needs to then attribute these mentioned features as inherited from Cloud-J.

- A new paragraph could then begin from line 17 indicating the extension based on RRTMG-SW.

- Lines 18-19. The statement “successfully matches RRTMG’s atmospheric heating profile” does not seem consistent with Fig 2b unless this is meant to refer to the general features of Fig 2a in addition to F2c,d. One might consider adding another comment pointing to the level of difference (e.g. “with maximum differences of 3 K in the upper stratosphere stemming from the absence of radiation below 200 microns and the coarse UV-bin resolution of RRMTG-SW”)

- Lines 23-24. “less systematic” is unclear – to remove if not clarified. Meaning of “larger” is also unclear.

- Line 24-25. There a missing link between the previous sentence referring to discrepancies/differences for the cirrus cloud example (not indicating if Solar-J is better) and the following sentence referring to Solar-J combining the best of both models. Maybe this has to do with the phrasing of the previous sentence (referring to lines 23-24).

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- Line 28 and also line 367 (conclusion). “about 5x” is for clear-sky only. Another 2.8x should be indicated the cloud quadrature (see page 14).

3. Line 352. For completeness, may be best to indicate “biases relative to Solar-J results” or something like “differences relative to Solar-J results identified here are errors caused by the 2-stream approximation used with RRTMG.”)

4. There is referencing to applicability of Solar-J with climate and chemistry-climate models. This should/could be extended at least to weather prediction models (if not also air quality models as well - CTMs and Coupled chemistry-weather).

Composition corrections and suggestions:

- Both RRTMG vs RRTMG-SW are used in the abstract and various places in this work. If the short version RRTMG is preferred, would be best to indicate, in the introduction, that it will be used from that point onwards. In the abstract, likely best to just use RRTMG-SW.

- Line 39. Suggest replacing “The major” by “Major” since other major challenges are also present as indicated later in the introduction.

- Line 45. Replacing “, however” by “. However”

- Line 46. “Thus” unnecessary. Can start with “In terms of . . .”

- Line 269. Replace “into stratosphere” by “into the stratosphere”

- Line 280. Suggested rephrasing. “The benefit of moving the Solar-J (and Cloud-J) band edge to 442 nm should be investigated.”

- Line 329. Should “Figure 3(a)” be indicated as “Figure 3a” for consistency with this paper or is it the labelling used in Painemal et al. (2016).

- Line 358. Suggest “One other source”

- Line 369. The mention of EC92, Fu96 and Key02 should be accompanied here be

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the references (which are present in the reference list).

- Line 417. Might be good to replace in this proportionality” by “similarly proportional”.
- Line 444. Might be best to replace “Fast-J 8-stream” to “Solar-J 8 stream”
- Line 446. “Feautrier solves” to “Feautrier approach solves”.
- Line 454. “Cloud-J (and hence Fast-J) has”
- Line 471. “increases”
- Lines 484-485. Suggestion of adding commas: “approach, when suitably averaged over time, “
- Line 489. “of atmospheres”
- Line 493. Rephrasing needed for “where the number of ICAs per grid cell ranging from 1 to 3,500 and averaged 170.”
- Line 504. Suggest removing the sentence beginning with “Obviously”.
- Line 517. “of a scattering matrix generator and a block-“ (added “a”s)
- Line 524. “in a  $\sim 4x$ ”
- Line 537. Rephrase “on long experience”
- Line 549. “that that are” to “that are”
- Line 553. “less that” to “less than”
- Conclusions section. Composition to use past tense (presented vs present, taken vs was taken, “can focus vs focused, . . .). A revisit of the conclusion composition and content might be beneficial.
- Line 557. “accurate, consistent with . . . in the atmosphere” seem too much and not precise. Suggest instead finding a sentence or two referring to Solar-J incorporating

strengths of both Cloud-J and RRTMG-SW.

- Line 562. Would be better to replace “The components of” by referring to Solar-J combining the best of Cloud-J and RRTMG-SW.

- Line 574-575. Rephrasing needed with “Ideally, there is a tradeoff . . . in all three parameterizations.” - Line 575. “ and, however, these ..” to “. These . . .”

- Line 576. “ are clearly mapped” to “would be mapped” or “would have some impact on climate. ..” or “are expected to impact. . .” or “could have an impact ...”

- Lines 577-578. “For Solar-J, the next steps consist of (i) moving the . . . and (ii) developing ..” or something similar.

- Line 579. Wonder if “A third opportunity” could be rephrased.

Tables: Moving the table captions outside the table frames will likely be necessary.

Figures:

- Figure 4. (1) Extra space in Fig 4a x-axis title units ( $\text{g/m}^2$ ) to remove. (2) Missing space in Fig 2b legend at the top “Solar-J(solid. . .”. (3) In caption, replace “at fours SZAs” by “at four SZAs”

- Figure 5. (1) In legend of Fig 5c,d replace “Ebert&Kerry” by “Ebert&Curry”. (2) Missing space in Fig 5d title “(d)Cloud. . .”

- Figure 6. Numbers below above colour bars in panels seem rather small. However, not much space to increase their size. So maybe ok.

References: I did not check that all references are accounted for.

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