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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Simulation of solar radiation during a total solar eclipse: a challenge for radiative transfer" *by* C. Emde and B. Mayer

C. Emde and B. Mayer

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We thank the referee for the detailed review which considerably improved the quality of the manuscript. Most of the comments will be included in the revised version. Detailed answers to the specific comments and questions are given below; the original reviewer comments are included in italics.

Reply to "Specific comments":

I am a little skeptical about the use of word "horizontal" to describe the 3-dimensional transport of photons.

This sentence will be modified in the sense that net-horizontal photon transport

requires a 3-dimensional radiative transfer model.

In a few cases I have been confused by the use of the term "backward calculations" of the Mode Carlo. From the text in several places I understood that the photons start at the surface propagating in the atmosphere and they undergo scattering and absorption, as it would be the case if they were starting from the TOA and they were propagating towards the surface. If this is the case, does "backward" refers to the processes or to the direction of the photon paths? Please clarify this issue and consider explaining this better in the manuscript.

Only the photon paths are reversed in the backward calculation whereas the scattering and absorption processes are treated in the same way as in the forward calculation. The mathematical proof for this is based on the reciprocity principle and can be found in detail in the book "3D radiative transfer in cloudy atmospheres" by Marshak and Davis (2004). This will be clarified in the revised version of the paper.

Figure 5: These figures do not show the entire domain 1000x1000 km2, but only a part of it. Please indicate this in the caption. The same occurs for Figure 8. Although it is not important, it would be better if the distance scales in the two figures are the same.

We did not show the full region, because the main features of the photon distribution (i.e. the "line" for radiance and the "corona" for irradiance) would not be cleary visible. The same distance scale for Figure 8 would not include the whole shadow, so we needed different scales. We will include this in the caption.

500, 9: The use of "first accurate" implies that all other simulations reported so far are inaccurate, which is a very strong statement.

We will replace "first accurate" by "first three-dimensional".

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500, 15: "in most parts of the spectrum." Please be more specific.

The wavelength range will be specified explicitly (320 to 500 nm).

500, 16: Is it true that there are no spectrally resolved measurements under the umbra so far? Probably astronomers have already conducted such measurements.

Of course we cannot be totally sure, but to our knowledge there are no such measurements. Anyway, this statement is not very important for the paper, so we will remove it.

501, 12: The distribution of solar irradiance at the TOA has nothing to do with clouds. Moreover its distribution is very well known but stating that is known with "very high accuracy" it is probably too strong.

It is true, that it does not have to do with clouds. We correct this sentence and write "high accuracy" instead of "very high accurracy".

502, 23: From a first reading it is not obvious why the ET irradiance is distributed differently at different locations. Please consider adding "is derived, under the eclipse conditions."

Will be included.

506, 2: In Figure 3 ZL (capital L) seem to denote the sum (zl + re), which is used in eq 2 and in the relevant discussion, but it not referenced at all. Please make the text and figure consistent.

The figure will be corrected to make it consistent with the text.

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506, 6: The paper has quite a lot of figures, most of which are absolutely necessary to illustrate the methods and results. One figure that could be omitted is Figure 4, and especially the top panel, because it does not add too much information. The results are very well described in the text, so the figure could be safely removed.

The figure could be removed. But we think that a figure showing model validation is more convincing than just the text.

508, 16: From Figure 7 it seems that the maximum of the wavelength dependence occurs at around X=0.5. May the authors could reconsider the limits in the x-axis of the small figure.

We checked extending the x-limit of the small figure up to X=0.5 but it turned out that the spectral differences are not as well pronounced as in the original plot. So we keep the original figure.

509, 17: In both Figure 5 and 8 the distance of 400 km is outside the limits.

400 km will be replaced by 300 km.

511, 5: Is the interpolation responsible for the straight segments in the curves of Figure 11, especially in the UV part?

Yes, this is due to linear interpolation. We did the solar eclipse simulations on a coarse wavelength grid. We will include markers in figures 11, 12 and 15 to show the simulated values.

511, 18-21: This description of the photon pathways is a little unclear. The sentence "followed by the higher atmosphere" refers to another pathway of photons, less typical? Please rework

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this section.

Ok. This section is really not very clear. We will replace it by:

"Using the Monte Carlo code we may look at individual photon paths. We found that photons reaching the centre of the umbra mostly get there after two scattering processes: After entering the atmosphere outside the umbra, they are first scattered at a high altitude. Then they travel a long distance horizontally through the optically thin higher atmosphere into the umbra. In the centre of the umbra they undergo the second scattering process, downward towards the sensor. The results show that these second-order scattering processes are less wavelength-dependent than the single-scattering processes which dominate the radiance under non-eclipse conditions."

512, 12: "factor of three" looks rather as a factor of 2 in Figure 12.

We show here the relative difference between a calculation with and without aerosol. If $L_a = 3L$ then $(L_a - L)/L = 2$. So a relative difference of 2 means that the radiance is increased by a factor of 3.

513, 13: The curves in Figure 13 seems to be non-symmetric around t=0 s. Could you comment on this?
514, 8: The same stands for Figure 14. Please explain.

This asymmetry is described (p.415, 20ff):

" This is explained by the photon distribution shown in Fig. 5 . The moon shadow travels roughly from from South-West to North-East; this implies that the line between $P1$ and $P2$ (from where most of the photons receiving the detector under non-eclipse conditions originated, see Fig. 6 is covered by the elliptical moon shadow after the eclipse but not before the eclipse."

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This explanation will be moved to section 3.2.2, where the asymmetry appears first.

Reply to “Technical corrections”

All technical correction will be considered apart from

501, 16: Replace “measuring the output” with “validation of the model output with measurements”

Here we really mean that it is difficult to measure radiation during the total solar eclipse at the ground, not that it is difficult to compare with measurements. Once we have measurement data it would be rather simple to validate the model output.

510, 16: Replace "must not" with "cannot"

Here we implement the suggestion by reviewer 2:
“ because for such large domains the curvature of the Earth has to be taken into account.”

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 499, 2007.