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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Accurate 3D radiative transfer simulation of spectral solar irradiance during the total solar eclipse of August 21, 2017" *by* Paul Ockenfuß et al.

Anonymous Referee #2

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General comments

This paper presents 3D radiative transfer simulations of surface spectral irradiance near and in the umbra shadow during 21 August 2017 eclipse. The study provided detailed sensitivity analysis based on a well-recognized 3D radiative transfer model (MYSTIC). They showed that the irradiance is sensitive to spectral albedo, ozone vertical distribution, and surrounding mountains. They found that simulations agree reasonably well with observations. The results are very useful for the community for understanding the radiative transfer processes during a solar eclipse. The paper is well-organized and addresses relevant scientific questions within the scope of ACP. I recommend it for

Printer-friendly version

Discussion paper

publication in ACP after a minor revision.

My main concern is that the simulations are under clear atmospheric conditions without discussion about possible cloud effects. Bernhard and Petkov (2019) mentioned that "The sky was free of clouds in the direction of the Sun, with small clouds lingering only near th horizon." This is consistent with GOES-16 images (see http://www2.mmm.ucar.edu/imagearchive/ and http://rammb-slider.cira.colostate.edu/?sat=goes-16&z=4&im=12&ts=1&st=20170821174538&et=20170821200037&speed=130&motio 1&hide_controls=0&mouse_draw=0&follow_feature=0&follow_hide=0&s=rammb-slider&sec=full_disk&p%5B0%5D=geocolor&x=9288&y=3872). Even though thin cirrus clouds were not in the direction of the observer and the Sun, they could be potentially important generating significant amount of diffuse radiation reaching the surface near and in the totality region. Could the presence of thin cirrus clouds explain the larger observed spectral irradiance compared to the model simulations? Maybe, a simple simulation for a fraction of thin cirrus cloud not shading the Sun could help to answer this question. The results could be included in discussion section.

Some specifics:

1. Spell out MYSTIC in line 7 in abstract and line 54 in introduction section.

2. "contribution function" is introduced in line 70 of section 2. This is an important concept in this paper. However it is not very clear to me. A better explanation will be helpful.

3. Remove Mayer (2009); Emde and Mayer (2007) in line 50 in section 2.2 since they were already referenced before.

4. Is w(d0,lambda,t) e-tau in line 16 of section 2.3 the direct component for partial eclipse conditions? If so, make it clear.

5. "Because its time dependence is in the order of weeks, it is kept constant during the eclipse." in line 25 of section 2.3. Consider to remove this sentence since it was

referenced.

6. “The spectral irradiance of the 315 nm wavelength is remarkably lower than the visible irradiances, which is mainly due to ozone absorption.” Is that really true? Perhaps one needs to compare irradiance during the totality with that in partial eclipse. If we look at 17:15:00, the relative difference between irradiance at 315 nm and 555 nm is about that same. I understand that ozone absorption reduces the irradiance at 315 nm reaching the troposphere, where most of the scattering takes place. Of course, the Rayleigh scattering is strongest among all wavelength considered. A better discussion will help readers to understand this point.

7. Figure 7 is very confusing. “Most of the diffuse photons originate from the vicinity of a line (black in Figure 7) at TOA between the point directly above the observer (black dot in Figure 7) and the intersection point of the observer-sun line with the TOA (yellow dot).” in line 65 of section 3.1. Not sure about a line at TOA because the scattering occurs in the atmosphere. “Black dot” should be green dot? “the vicinity of a line” is confusing. It seems that most of the diffuse photons originate from an area about 20 km in radius around the yellow dot. Is figure 7 (upper panel) for the partial eclipse at the observer’s site since it says for 17:20 and the observer is out of the ellipse? If possible, it would be nice to have the artifact white circle removed.

8. In Figure 9 caption, suggest to indicate 17:20 (totality) and 17:12 (partial eclipse).

9. A discussion of the physical mechanism of different surface albedo on surface irradiance for partial and total eclipse will be useful (first paragraph on pager 6).

10. Figure 10 is hard to understand. Why “From this, it can be seen that areas in a distance between 20 km and 400 km are the reason for most of the observed changes.” (line 43 on page 6)? The purpose of this is to assess the validity of assumption of spatially uniform albedo, which may not valid for the Pacific Ocean. Perhaps ignore this figure and just make a statement to about the result: surface albedo is not important beyond 400 km, and the results of simulations will not change even if the albedo is

different from the ocean albedo for the Pacific.

11. line 80 on page 6, “+-20% at 304 nm”. 20% is out of scale in Figure 11. At least mention it in the figure caption.

12. Paragraph line 81 on page 6, “Here the contribution of the direct irradiance is larger than in the ultraviolet, and direct radiation is not affected by the vertical distribution of the absorber but only by the column.” Perhaps mention ozone absorption optical depth at the peak of the Chappuis bands is about 0.04 compared to the absorption optical depth of 1.8 at 304 nm, or a sentence about ozone absorption cross section in Fig. 11 since it is already there.

13. Would be nice to have the same legends for both upper and lower panels in Figure 11.

14. line 4 on page 7, “+-30% at 304 nm”. But 30% is out of scale in Figure 11.

15. line 3 on page 8, “The last series will be denoted as P2017. The overall effect shares many characteristics with the curves in Figure 9, where the surface albedo was changed. Eight minutes before the totality, changes of up to 2% can be observed for the shorter wavelengths. The increase in direct irradiance is the reason for the vanishing differences at longer wavelengths. Observations during totality show reductions in irradiance of up to 60%. This shows that a disproportionally high amount of radiation is coming from the horizon (For isotropically incoming radiance, we would expect only 3% reduction in irradiance.). . .” I don’t get it. Figure 9 shows the theoretical calculations. I don’t see why changes of irradiance (relative to what?) can be observed.

16. Description of Figure 12 should be included in the text. Maybe in the last paragraph of section 4.2.

17. Line 45 on page 10, “To correct the simulation for these errors, which have nothing to do with the eclipse, the simulation values were multiplied by the average deviation between 19:00 and 20:00 for each wavelength.” Do not understand this? Also, do you

assume that the atmospheric state didn't change?

18. Suggest to combine figures 15, 16, 17 to Figure 15a, 15b, 15c to reduce the number of figures. Suggest to remove "ratio" since the "ratio" is already in the title of Y-axis.

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