Atmos. Chem. Phys. Discuss., 7, S7093–S7099, 2007
www.atmos-chem-phys-discuss.net/7/S7093/2007/


Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Attenuation of global ultraviolet and visible irradiance over Greece during the total solar eclipse of 29 March 2006" *by* A. Kazantzidis et al.

**A. Kazantzidis et al.**

Received and published: 22 November 2007

Response to referee 3

We thank the referee for his/her helpful suggestions and constructive remarks. We have accordingly modified the attached version. The introduced changes are explained below.

Comment of the referee: [The results are interesting, but the motivation of using model comparisons is not clear. The authors refer well to earlier studies, but the novelty and the main point of the paper is not clearly pointed out. What is the key question where they answer?]

The text in the abstract and conclusion paragraph of the revised manuscript has been modified according to the referee suggestions. The abstract and conclusion paragraphs (and also the relevant sections) of the revised manuscript have been modified to point out:

a. The availability of several instruments in the vicinity of the eclipse path

b. The challenging task to compare measurements with model calculations under good weather conditions

c. The performance of comparison with 3-D model results for the first time

d. The presentation of global irradiance and ozone measurements from multi channel radiometers during an eclipse for the first time

Specific comments

1. Measurement results about the amount of attenuation of solar irradiance during the eclipse have been added in the abstract of the revised manuscript.

2. The authors believe that the availability of several instruments in close proximity to the path of the umbral shadow could provide a challenging test for the models. Specifically, the formulas adapted by Koepke et. al., (2001) for the 1-D model have been compared with measurements during the eclipse of August 11, 1999, under cloudy conditions. In addition, in our study it is the first time that 3-D model results during a solar eclipse are compared with measurements. The text in the abstract and conclusion paragraphs has been modified in the revised manuscript, in order to explain our intention.

3. As far as concerned the irradiance measurements, the availability of several instruments in close proximity of the umbral shadow, compared to earlier studies, is a novelty. In addition, irradiance measurements from multichannel radiometers have never been used before for studying an eclipse. As referenced in the previous comment, the use of these measurements under good weather conditions provide a unique opportunity



ACPD

7, S7093–S7099, 2007

to test the 1-D and 3-D model results. Finally, the overturned ratio of the 305/380 nm irradiance is reported, although it remains a challenge for a future research. The text in the last paragraph of Introduction has been modified in order to present all these points.

4. The following text has been added I the revised manuscript (paragraph 3.1): The maximum change in the solar zenith angle for the same time between these consecutive days is less than 1.2 degrees and the corresponding model calculated cloud-free difference in channel irradiance is 2.1% at 305nm, 1.4% at 312nm and less than 1% at all other NILU-UV channels.

5. The text has been modified according to the suggestion of the reviewer.

6. Yes, the model calculations represent clear sky conditions. It is stated in the revised manuscript.

7. The NILU-UV6 radiometers have 5 channels in the UV region and 1 for the visible. The wavelengths of the maximum spectral response in the UV region are the 305, 312, 320, 340 and 380nm. The spectral response of all instruments have been measured in our laboratory and processed according to the methodology described in Bernhard et al (Optical Engineering 44(04), 041011, 2005). For all instruments, the wavelength of the spectral response maximum differs by less than 0.2nm relative to the value of the instrument that was established at Kastelorizo, while the full width at half maximum in identical. So, the spectral response of this instrument was used as a generic spectra response. As far as concerned the possible forthcoming uncertainties of this hypothesis, in figure 4 from Bernhard et al. (Optical Engineering 44(04), 041011, 2005), you can examine the effect on solar irradiance for a much larger difference in the spectral response maximum wavelength (0.5 nm): even at 305 nm, the difference is less than 5% for the same interval of solar zenith angles (31-44 degrees). Of course the irradiance conditions during the eclipse are not the same. But also in this case, we found out 1% difference when applying the maximum expected shift (0.2nm) in 1-D model calcu-



ACPD
7, S7093–S7099, 2007





EGU

lations of 305nm channel irradiance. Such a difference can be considered negligible compared to the reduction of irradiance due to the eclipse.

8. The discussion about the attenuation amount of UVA and PAR has been extended according to the suggestion of the reviewer. More comments have been added about the measured decrease of irradiance and the differences between model estimates and measurements.

9. Instead of adding an extra figure, a more detailed presentation of the agreements between modeled and measured values is given in paragraphs 4.1 and 4.2. The following document has been added in paragraph 4.1: The agreement between measurements and modeled values at all sites is within 2% for visible parts of the sun of more than 70% and becomes worse as the eclipse progresses. The differences at Heraklion range from 10% to 60% for sun visible parts of 60% and 10% respectively. The differences at Nicosia, for the same visible sun percentages, range from 2% to 30%. At Kastelorizo, the site with the highest eclipse percentage, the agreement between measurements and model estimates is within 8% for visible fraction of sun’s disk equal to 10%. However, close to the totality the agreement becomes worse (within 60%) as both measurement and model uncertainties become more significant.

The following document has been added in paragraph 4.2: The differences between modeled and measured irradiance at these wavelength regions are examined. For visible parts of the sun of more than 60% and apart from exceptional cases where the impact of cloudiness on measurements is obvious, the differences of irradiance at 380nm is less than 3% at all sites. At Heraklion, the differences between measured and modeled values range from 5% to 80% for visible fractions of the sun equal to 60% and 10% respectively. In contrast, the half difference is observed at Nicosia is at the eclipse maximum. The agreement between model estimates and measurements at Kastelorizo is within 3% for visible parts of the sun down to 10% and increases to 20% close to totality. Differences of the same magnitude observed also for PAR.



ACPD

7, S7093–S7099, 2007

10. The comparison of PAR with irradiance at 380nm is discussed (due to lack of measurements at specific visible wavelengths) in order to indicate the effect of the eclipse on visible irradiance with respect to a typical UVA wavelength. During the eclipse, diffuse radiation originates from photons that have entered the top of the atmosphere far away from the measurement site becomes important. Since photons at shorter wavelengths are more effectively scattered than photons at longer wavelengths, they have a smaller chance of reaching the instrument. This result is confirmed not only for UV wavelengths, but also when comparing PAR with irradiance at 380nm.

11. Our report of model underestimation of the eclipse spectral effect remains as a challenging task for a future research. Please note, that it is the first time that the formulas of Koepke compared with measurements under good weather conditions. Probably, some updated formulas based on new findings and more detailed measurements during another solar eclipse could provide better results. Please also note that the model underestimation of spectral effect has been confirmed also from direct sun spectral measurements (Kazadzis et al., ACPD special issue on eclipse of 29 March 2006).

12. As discussed in paragraph 7, the use of a standard tropical profile in model calculations instead of a midlatitude profile (both scaled to 300DU) enhanced irradiance at 312nm by 60%. It is difficult to estimate the effect of ozone profile on irradiance during the eclipse, because we do not know the eclipse effect on the profile. Unfortunately, no ozone profile data were available, but experimental evidence that there was an oscillation in the total ozone column is provided by Zerefos et al. (Atmos. Chem. Phys., special issue on eclipse of 29 March 2006).

13. The text at Figure caption 4 has been modified according to the suggestion of the reviewer.

14. The text has been modified to clarify our point: The calculation of total ozone using the irradiance ratio of 312/320 nm has not been used here, since the influence of possible ozone variability in irradiance at 312 nm is less compared with the irradiance



ACPD
7, S7093–S7099, 2007

at 305nm.

15. Also in ratio of irradiances at 305 nm and 320 nm the overturned behavior is appeared. Unfortunately, according to ACP facilities for author comments, the figure cannot be included in our response

16. We do not know what is the reason of ozone increase at Nicosia and Kastelorizo before totality. Unfortunately, due to lack of detailed ozone measurements, only assumptions (see also our response to comment 12) can be made.

17. As far as concerned the discussed ozone changes please refer to our previous comment. The effect on changing radiative conditions, due to multiple scattering, on the angular response of the instrument is a matter of discussion. Under non- eclipse conditions conditions, the angular response error of the instruments could be considered within 3% for all NILU-UV channels and the agreement in irradiance and ozone is within 5% and 0.3% respectively at the same solar zenith interval (all referred in the revised manuscript). According to Emde (2007), the difference between 1-D and 3-D approximations for solar irradiance at 311nm is 1.5%, 1000s before the centers of apparent moon and sun disks coincide. But even very close to totality, the chance to receive photos coming from directions close to the horizon is very small. So, we assume that the measurement error due to the imperfect angular response of the instrument remains small. Unfortunately, due to lack of any radiance measurements during the eclipse, an extensive analysis cannot be performed.

18. The differences between the MYSTIC estimates and the measurements are discussed thoroughly in the revised manuscript. Instead of adding a figure, the following text was added: For the 380nm channel, the agreement between the model calculations and the measurements just before the beginning of totality is within 10%. The measured irradiance decreases more rapidly during totality but the percentage difference of the two radiative quantities close to the time of the eclipse maximum is less than 5%. After the end of totality the model overestimates the irradiance by ˜20%.



ACPD

7, S7093–S7099, 2007

Similar results were obtained also for the 340 nm channel (not shown here). However, for the 312 nm channel the model estimates during totality are three times lower, most likely because of the increasing noise in the measurements during the totality (the measured raw counts were only 30% higher than the dark current), but also because of the possible uncertainties in determining the spectral response of this channel. Close to and after the end of totality the agreement between the modeled and the measured values is within 40%.

19. The difference between the midlatitude and the tropical profiles, when scaled to the same total ozone value, is mainly at the height of the ozone maximum. The first one was considered more appropriate for Kastelorizo (36.15o N). The use of a standard ozone tropical profile (usually applied for sites below 30o N) just helps to provide a short sensitivity analysis about the possible impact of profiles in model calculations. Unfortunately, no ozonesondes were performed at the eclipse day in Greece or generally in the vicinity of the moon shadow.

20. The text has been modified according to the suggestion of the reviewer.

Technical corrections

1. The text has been modified according to the suggestion of the reviewer.

2. The cloud observations at the ground based stations derived from METAR reports. In these reports (provided usually every 30 minutes) the cloud amounts are described with the words few (1-2 octas), scattered (3-4 octas), broken (5-7 octas) and overcast (8 octas). Unfortunately, no detailed cloud information was available in such a short time intervals.

---

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 13475, 2007.