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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Divergence of sun-rays by atmospheric refraction at large solar zenith angles" *by* R. Uhl and T. Reddmann

Anonymous Referee #1

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The manuscript presents interesting new findings about the refraction of radiation in the Earth's atmosphere and the consequences for atmospheric photochemistry. The relevance of beam divergence is described which has been neglected in previous papers. The methodology seems to be correct, but the description is too short in my view, causing unneccessary effort for the reader to understand the concept and to believe the results. Even though having worked on a similar topic (refraction of radiation in the atmosphere) several years ago, I find the manuscript hard to understand. Without more detailed explanation, the paper addresses only a rather small audience, although the topic should be interesting for a broader readership. I therefore recommend to add more explanation of the basic concepts, to describe the figures in more detail, and to better illustrate the relevance for atmospheric chemistry. I think this should not be hard to accomplish for the authors, as they have done these calculations anyway and should

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be able - without too much effort - to present this interesting topic in a more comprehensible way. Finally, the paper discusses beam divergence and path modification but neglects the angular extension of the solar disk. I would strongly suggest to include the latter, as it seems to be a straightforward task for the model developed by the authors, and it would guarantee that all relevant effects are included, see below. Provided the suggested changes, I think the paper will be an interesting contribution for ACP.

Specific points:

1. An introduction is missing, describing the photolysis of which species and hence which wavelengths are target of this study. The calculation is done at only one wavelength, 550nm, and it should be motivated why exactly this wavelength was chosen and why it is relevant for stratospheric photochemistry

2. To understand the description of the methodology in sections 2.2 and 2.3 requires enourmous effort by the reader. The results are probably correct but it is left to the reader to decide why. In particular, statements like "of course, this equation also holds for the spherically symmetric atmosphere" (after equation 1) or "Obviously, a is the distance of earth's centre ..." are not really obvious. I suggest to provide some additional explanations and to introduce some intermediate results of the computation, rather than only the starting point and the end result. If the text becomes too technical or formula-oriented this way, the calculations could be moved to an appendix and only the parts relevant for the methodology could be presented in the main text.

3. Figures 3, 4, 6 deserve more explanation of what is shown and what the individual curves are.

4. Section 3.1: The text explains how beam divergence is calculated, but an extra figure (basically a magnification of the relevant part of figure 1) would facilitate understanding. Also, it should be mentioned that the relevant quantity in this context is the direct normal irradiance (in contrast to the direct horizontal).

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5. Section 4: Calculations at other wavelengths than 550nm are mentioned. However, in section 3.2 only model input data for 550nm are described. Please briefly describe the spectral cross sections etc used for these calculations.

6. At the end of section 4 it is pointed out that the angular extension of the solar disk of 0.5 degree was not considered in the study. Why? Having the ray tracing tool available, it should be straightforward to do the integration over the solar disk. I strongly encourage the authors to do this calculation in order to present a result including all relevant effects. I don't have a feeling for the absolute values, but couldn't the angular divergence of the solar beam and its modification through refraction be of comparable importance to the beam divergence? Refraction causes a focussing of the 0.5 degree opening angle which would at least offset, if not over-compensate the beam divergence effect.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 2037, 2004.