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Interactive Comment

Interactive comment on "Modelling the direct effect of aerosols in the solar near-infrared on a planetary scale" *by* N. Hatzianastassiou et al.

N. Hatzianastassiou et al.

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I. General Comments

As stated by the Referee, and described in the text (Section 1, page 2, lines 19-22), the novelty of this study is that it computes the direct aerosol radiative effect at TOA, in the atmosphere and at the Earth's surface at fine wavelength intervals, while previous studies treated the near-infrared (IR) spectral range, or even the whole solar spectrum as one interval.

As indicated in the text (Section 1, page 2, lines 22-24) this is critical, since the optical properties of aerosols vary within this spectral range, making their interaction with solar radiation very sensitive to wavelength. Reference was made to Hatzianastassiou et al. (2004b, Tellus-B) to demonstrate the importance of performing detailed computations of aerosol forcing, using spectrally resolved aerosol properties.

To respond to the Referee's comment, we have performed detailed sensitivity tests with our model, in which the sensitivity of aerosol DREs to the wavelength dependence of aerosol optical properties was investigated by using in the model the averaged near-IR GADS aerosol optical properties instead of the spectrally resolved. The results of the sensitivity tests reveal very large differences, exceeding 30 percent over most areas for the aerosol DRE at TOA, 75 percent for the aerosol DRE in the atmosphere, and 20 percent for the aerosol DRE at surface, whereas locally the differences are even much larger. These are now indicated in Section 2 (Model and methodology), page 7, lines 12-20, but also in Section 7 (Conclusions), page 18, lines 10-13.

As for the other point of the Referee, i.e. missing validation of GADS aerosol properties with surface measurements, we do not present such a validation in this study because it is beyond its scope. The GADS dataset of aerosol optical properties is very well known, and has been used as a reference in a series of published studies (e.g. King et al., 1999; Chin et al. 2002; Morcrette 2002; Kinne et al. 2003; Textor et al. 2006). Moreover, such a comparison is not an easy task because of the different nature of the data. The GADS dataset was created to represent a comprehensive aerosol climatology by compiling aerosol data globally that existed from different measurements and models. In addition, such a comparison is difficult because there are not many available globally distributed surface-based aerosol optical properties, especially at near-IR wavelengths, that overlap with the time period covered by our study (i.e. 1984-1995). Such data (e.g. AERONET) are available from 2000 onwards.

However, to reply to the Referee's comment, we have attempted a comparison between our GADS-derived aerosol optical depth data with available AERONET measurements at the visible wavelength of 0.5 microns. Although at present the number of AERONET stations exceeds 300, only 17 stations with data in the period 1993-1995 were found, which resulted in a limited number of matched data pairs for comparison. The scatterplot of these data reveals a satisfactory comparison with a correlation coefficient

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equal to 0.5, a standard deviation of differences between AERONET and GADS equal to 0.04 and a bias of 0.12 (underestimation by GADS). These results indicate some agreement, given all the difficulties already mentioned and the uncertainties and errors involved in surface measurements themselves.

II. Specific Comments

1. It is true that comparing aerosol DRE as defined in our study (with a minus without aerosols) with the forcing of greenhouse gases (present minus pre-industrial concentration of gases) is not a like-to-like comparison. Moreover, the present study focuses on the direct radiative effect (DRE) of aerosols, which is the overall effect of natural plus anthropogenic aerosols on the radiative energy budget. It is different to the direct climate forcing (DCF), which represents the corresponding effect of anthropogenic aerosols only (see Section 1, page 3 lines 2-4). It is DCF that can be compared to the effect of anthropogenic greenhouse gases. Therefore, the relevant sentence in the Abstract has been removed while a similar sentence in conclusions (Section 4.4, page 9166, lines 20-21 in ACPD paper) was removed too.

2. Page 1, line 8 (Page 9152, line 21 in ACPD paper): "... affect ..." was re-written to "... may affect ...", as indicated by the Referee.

3. Section 1, Page 1, line 21 (Page 9153, line 5 in ACPD paper): "...in total ..." was added after "an opposite way", as indicated by the Referee, since the sentence refers to the overall effect of aerosols. Of course, there are absorbing aerosols, but their effect on a global mean basis (not regional) is estimated to be smaller than that of scattering aerosols.

4. Section 1, Page 2, line 21 (Page 9154, line 9 in ACPD paper): "... an important improvement ..." was replaced by "... one of the important improvements ...".

5. The paragraph starting with "The methodology followed ..." in Section 1 (Introduction), page 9155, lines 11-23 in the ACPD paper has moved to Section 2, which was

renamed as "Model and methodology", in page 6 lines 31-32 through page 7, lines 1-11, according to the suggestion of the Referee.

6. Section 2, page 4, lines 25-30 (page 9157, line 8 in ACPD paper): the relevant sentence was re-phrased avoiding the use of "error". Also, reference to existing works (e.g. Haywood and Shine, 1997; Haywood and Ramaswamy, 1998) is now made while explaining what occurs in the case of absorbing aerosols above clouds.

7. Section 3.1, page 9, lines 7-8 (page 9160, line 14 in ACPD paper): it is now explained that blanks in Figs 1 to 3 correspond to areas with missing data. This is also valid for Figs 4-8 (as explained in Section 4.1, page 11, lines 30-31).

8. We do not agree with the Referee. When looked carefully, Figs 1 to 3 reveal quite significant differences between the three wavelengths 0.9, 1.75 and 3.5 microns, even with the changing colorbar scale in each of them. Moreover, it is one of the main objectives of this study to show that significant differences exist both in terms of aerosol optical properties and radiative effects not only between UV-visible and near-infrared spectral intervals, but also within the range of near-infrared itself. Therefore, we prefer to keep Figs 1-3 in the same format.

9. In Section 3.1, page 9, lines 19-28, it has been explained how the water soluble and insoluble components are defined in GADS.

10. In Section 3.2, page 11, lines 3-4 (page 9162, line 5 in ACPD paper): it is now explained which cloud parameters of NASA-Langley dataset are used in our study.

11. Section 4.1, page 12, lines 6-14 (page 9163, line 11 in ACPD paper): the radiative forcing of dust aerosols has been discussed based on the references suggested by the Referee. In addition, more details on the treatment of mineral and dust aerosol by GADS have been also provided.

12. Page 9166, line 18 in ACPD paper: the aerosol DRE appears noisy, especially in July (Fig. 4b) because of the behaviour of surface albedo (Rg). It is well known

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from the literature that there is a "critical" value of surface albedo above which the aerosol cooling effect at TOA (positive values in Fig. 4) changes to a warming effect (negative values). The warming effect is due to particle absorption which is increased through multiple reflections between the surface and the aerosols above. This is the case in Fig. 4b, because of quite large surface albedo values in July. In contrast, this occurs much less in January (Fig. 4a) because of smaller surface albedo values, below the "critical" point. To ensure this we have performed sensitivity tests with our model both with constant surface albedo values and with increasing/decreasing albedos. The results of these sensitivity studies validate our statement, demonstrating that the sign of aerosol DRE at TOA is strongly dependent on surface albedo; the sign of DRE changes whenever the surface albedo values become larger or smaller than the critical value of Rg. These have been clarified in the text (Section 4.1, page 12, lines 30-34 through page 13, lines 1-4).

13. Section 4.4 (page 9166, line 18 in ACPD paper): the relevant sentence was removed from the text (see specific comment 1).

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 9151, 2006.