Atmos. Chem. Phys. Discuss., 7, S938–S943, 2007
www.atmos-chem-phys-discuss.net/7/S938/2007/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The direct effect of aerosols on solar radiation based on satellite observations, reanalysis datasets, and spectral aerosol optical propertiesfrom Global Aerosol Data Set (GADS)" *by* N. Hatzianastassiou et al.

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Received and published: 3 April 2007

I. General Comments

1) The aerosol optical properties (extinction optical thickness, AOT, single scattering albedo, and asymmetry parameter), which are used in the model as input data, were taken from the Global Aerosol Data Set (GADS). The computation of these optical properties is done by GADS based on aerosol microphysical data (e.g. concentration, size distribution, composition, spectral refractive index) and other relevant information, such as height profiles, from aerosol measurements and model results, as explained by Koepke et al. (1997). Subsequently, the radiative computations, (the aerosol direct

radiative effects, DREs) are performed with the spectral radiative transfer model. The term "match" referred to the use of a detailed spectral radiative transfer model, rather than a broadband one, in combination with the detailed spectral aerosol properties from GADS. To avoid confusion, this term has been removed and the sentence re-written more clearly (page 3, lines 23-26).

As explained in the previous paragraph, the GADS aerosol optical properties are used as input data to the model. How GADS determines these properties is beyond the scope of this study, and only a very short description is given in sub-section 2.2. A complete description can be found in GADS references (see e.g. Koepke et al., 1997; Hess et al., 1998). As stated by the Referee, the treatment of processes affecting the computed optical properties, such as mixture, is a crucial matter for determining the aerosol radiative effects (e.g. Jacobson, 2001). These processes are carefully taken into account by GADS. The aerosol particles are described by 10 main aerosol components that are representative for the atmosphere and characterized by their size distribution and refractive index, depending on the wavelength. These aerosol properties are based on components resulting from aerosol emission, formation and removal processes within the atmosphere. The aerosol properties stand as mixtures of different substances, both external and internal. Typical components include water-soluble, water-insoluble, soot, sea-salt and mineral. A complete description of the aerosol components and their mixtures can be found in the works by Koepke et al. (1997) and Hess et al. (1998). These are now mentioned in the sub-section 2.2.

Uncertainties of aerosol optical properties are not provided by GADS. These uncertainties refer to various aspects, such as the quality and incompleteness of measurements, quality of data (refractive index and size distribution) for describing the aerosol components, aerosol height distribution, description of aerosol particles with limited number of components or validity of amount and mixture of components for describing aerosol as an average for a specific location. All these, result of course in limitations of the GADS aerosol optical properties. The specification of uncertainties requires comparison against measurements, satellite- or surface-based, of corresponding aerosol optical properties, i.e. aerosol optical thickness, single scattering albedo and asymmetry parameter. Nevertheless, 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 on a global basis, 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 overlapping with the time period covered by our study (i.e. 1984-1995). For example, such surface data (e.g. AERONET) are mainly available from 2000 onwards. However, we have attempted a comparison between our GADS-derived aerosol optical depth data and 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 exhibits a rather satisfactory comparison, with a correlation coefficient 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. Moreover, we have attempted a comparison of our GADS-derived (re-computed for actual relative humidity values, as explained in section 2.2.) aerosol optical depth data with available TOMS measurements at the visible wavelength of 0.5 microns. The comparison was performed on a pixel-level (1deg x 1deg latitude-longitude) and monthly mean basis, for the years 1984-1995. The results of our comparison show that apart from rare cases, the absolute differences between GADS and TOMS aerosol optical thickness (AOT) are mostly within +/-0.25, whereas the relative percentage differences are mostly smaller than 50% and even 25% over extended areas. It was found that GADS generally underestimates AOT, but there are also some areas (e.g. parts of Sahara desert and India in January, European continent and Australian desert in July) where GADS overestimates AOT. Overall, the scatterplot

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comparison between TOMS and GADS, with a total of 81609 matched pairs, indicates a bias equal to 0.04 (GADS underestimation), and a standard deviation of differences equal to 0.06. These results are not too bad if one takes into account the very different philosophy and nature of the two datasets, and also the errors associated with the TOMS data and the discrepancies between satellite and climate model products themselves (see e.g. Zhao et al., 2005; Schulz et al., 2006). In conclusion, we believe that GADS is not really adequate for a month to month and year by year assessment of aerosol radiative effects, but is useful for climatological assessments. Reference to the GADS-related uncertainties was made at the end of the conclusions section (4). The uncertainties in other model input data are given in sub-section 2.3.

2) The value of DFTOA = -1.23 W/m2 that was given in Table 3 (Table 2 in the previous version of manuscript) for Jacobson (2001) was not correct. It is now corrected to -1.8 W/m2 according to Fig. 4a of the paper by Jacobson (2001). Moreover, the corresponding value at surface, DFsurfnet = -4.6 W/m2 has been added in the last column of Table 3. It is true that a better agreement between the present and other studies is obtained at TOA than at surface. The differences are discussed in the second paragraph of sub-section 3.5 (page 15, line 15 through to page 16, line 19) and possible reasons are given.

3) As explained in comment (1), the aerosol information is not retrieved by satellites, but is taken from the GADS dataset. The satellite and reanalysis data used are for the rest of the surface and atmospheric parameters, as explained in sections 2.2 and 2.3. Probably, some confusion was created by the first sentence of the Abstract, which is now corrected appropriately. Note that in GADS, the aerosol particles at any place in the atmosphere are modeled as components, each of them meant to be representative for a certain origin that is an internal mixture of all chemical substances having a similar origin. These components are also externally mixed to form aerosol types. The microphysical properties of aerosol components (size distributions, spectral refractive indices, modal radii, densities and mass concentrations), which are also used

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for the computation of the aerosol optical properties, are specified in GADS so that the relevant information is provided to the user.

4) As explained in comments (1, 3), only retrieved cloud optical properties (ISCCP) are used in the model, whereas the aerosol properties are taken from GADS. The retrieval procedure of ISCCP cloud optical properties can be found in relevant papers, e.g. Rossow et al. (1996), Rossow and Schiffer (1999). No emphasis was given to the treatment of cloud optical properties in this study, since it is beyond its scope. A thorough explanation can be found in a series of papers, e.g. Hatzianastassiou and Vardavas (1999; 2001), Hatzianastassiou et al. (2004c, 2005) to which reference was made in sub-section 2.1, page 5, lines 1-2. Briefly, a total of 16 cloud types are considered in the model, including specific individual cloud types for low, middle and high clouds, as well as liquid and ice cloud components. The optical thickness values are taken from ISCCP and they are subsequently grouped as low, middle and high clouds, whereas the single scattering albedo and asymmetry parameter are computed based on the ISCCP-assumed microphysical properties (see e.g. Hatzianastassiou et al., 1999; 2001; 2004c; 2005). As already explained, the aerosol properties are not retrieved by satellites, but they are taken from GADS. However, the comment of the Referee is correct in that in this study the aerosol direct radiative effect is not accounted for absorbing aerosols within and above clouds, leading thus to an underestimation. This has been clearly stated in sub-section 2.1 (page 5, lines 3-11). Moreover, it has been noted in sub-section 3.5 (page 16, lines 2-12) that this is a possible reason for the smaller aerosol DRE in the present study compared with that by Jacobson (2001).

5) In the Introduction, page 3, lines 10-13, the advantage of a detailed spectral resolution in aerosol optical and radiative properties, and the radiative transfer model for computing aerosol DREs, is now discussed with respect to the study by Jacobson (2001).

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