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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Shortwave radiative forcing and efficiency of key aerosol types using AERONET data" *by* O. E. García et al.

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Dear Referee#1,

We would like to thank your comments in order to improve the manuscript, which are fully addressed below. Please note that your comments are numbered.

1. One relevant point concerning the methodology is the way the authors define the radiative forcing concept. Thus in section 2 the authors state: "Direct radiative forcing from atmospheric aerosols, denoted as deltaF , is defined as the difference in the energy levels between a situation where aerosols are present, FA, and a situation where these atmospheric particles are absent, FC". This statement does not reflect the correct idea after the shortwave aerosol radiative forcing that represents the change in

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the net solar radiation associated to the inclusion/exclusion of atmospheric aerosols. The application of this definition to the radiative forcing computed at TOA is compatible with equation (2) in the manuscript, but the computation of the shortwave radiative forcing at BOA does not lead to equation (1) in the manuscript. In fact the radiative forcing at BOA will be equal to equation (1) multiplied by the factor (1-alpha) with alpha the surface albedo. This fact needs to be clarified and carefully took into account in any comparison with results derived in other studies. In fact, the use of equation (1) implies an overestimation in the absolute values of radiative forcing strongly dependent on the surface albedo. In order to improve the manuscript the authors must discuss and clarify appropriately this point using a different denomination for the variable defined in equation (1) that as stated above does not correspond to the broadly used concept of aerosol radiative forcing at BOA.

Following the referee's recommendation, the aerosol radiative forcing, DF, at the bottom of the Atmosphere (BOA) and at the TOA has been re-evaluated to account for the change in the net solar radiation associated to atmospheric aerosols. Thus, these new values of DF at the BOA have been added to the manuscript, including a comparison between the two definitions of DF at the BOA. The new definition takes into account the upward fluxes with and without aerosols at the BOA (see eq. 1 of figure 1).

This definition can be re-written at the BOA as the eq. 2 of figure 1.

where SA is the surface albedo. Note that the radiative forcing at the TOA applying the eq. (1) coincides with our original definition, so no need to make changes (see eq. 3 of figure1).

In order to evaluate the radiative forcing at the BOA, using eq. (2), the surface albedo has to be considered. For that, we have used the average of the spectral surface albedo provided by the V2 AERONET inversion algorithm at 0.44, 0.67, 0.87 and 1.02 μm for each almucantar retrieval (SA_AERONET hereafter). These SA spectral values are given at any location in the AERONET webpage as an operational product of

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AERONET network (http://aeronet.gsfc.nasa.gov).

In order to estimate the possible uncertainties introduced by the SA assumed we have analyzed the differences in the radiative forcing at the BOA calculated: (1) using the SA_AERONET values (i.e, only four wavelengths,DF_BOA_SA_AERONET, eq. 2), and (2) considering the spectral solar upward fluxes and the spectral surface albedo in the whole solar spectral range (0.2-4.0 μm) in the same manner as it is used in the AERONET retrieval algorithm (DF_BOA_SA_WHOLERANGE, eq. 1). For that, we have considered the AERONET stations used in the study of García et al. [2008], which have different range of surface albedo (vegetation, desert, snow, ocean): Brazilian sites, GSFC, Solar Village, Sede Boker, Bratts Lake, Toravere, Mauna Loa, Nauru and Bermuda. Our tests document a mean difference less than 10%, as shown the table 1 (figure 2) and figure 3. The differences in the radiative forcing at the BOA are defined by eq.4 of figure 1:

Therefore, considering the surface albedo averaged at the four AERONET wavelengths (0.44, 0.67, 0.87 and 1.02 μm) may be a good approximation for evaluating the aerosol radiative forcing at surface.

2. The rest of minor comments have been modified following the referee's recommendations.

References

García, O.E., Díaz, A.M., Expósito, F.J., Díaz, J.P., Dubovik, O., Dubuisson, P., Roger, J.-C., Eck, T.F., Sinyuk, A., Derimian, Y., Dutton, E.G., Schafer, J.S., Holben, B.N. and García, C.A.: Validation of AERONET estimates of atmospheric solar fluxes and aerosol radiative forcing by ground-based broadband measurements, J. Geophys. Res., 113, D21207, doi:10.1029/2008JD010211, 2008.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 32647, 2011.

$$\Delta F = \left(F_A^{\downarrow} - F_A^{\uparrow}\right) - \left(F_C^{\downarrow} - F_C^{\uparrow}\right) \qquad \text{(eq.1)}$$

$$\Delta F_{BOA} = \left(F_{A,BOA}^{\downarrow} - F_{C,BOA}^{\downarrow}\right)(1 - SA) \qquad \text{(eq.2)}$$

$$\Delta F_{TOA} = \left(F_{C,TOA}^{\uparrow} - F_{A,TOA}^{\uparrow}\right) \qquad \text{(eq.3)}$$

$$\text{Difference}(\%) = \frac{\Delta F_{BOA\_SA\_AERONET} - \Delta F_{BOA\_SA\_WHOLERANGE}}{\Delta F_{BOA\_SA\_WHOLERANGE}} \qquad \text{(eq.4)}$$

Fig. 1. Equations.

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Station	Mean (%)	Standard Error of the Mean (%)	Standard Deviation (%)
Bermuda	-3,1	0,5	8, 8
Bratts_Lake	-7,8	0,2	4,0
Brazilian	-9,9	0,1	2,1
GSFC	-7,8	0,4	7,4
MLO	-0,1	0,01	0,1
Nauru	-3,8	1,4	8,5
Sede_Boker	-8,8	0,2	2,9
Solar_Village	-3,8	0,2	9,7
Toravere	-8,4	0,4	6,7

Fig. 2. Table 1. Statistics of the differences (%) given as equation (4).

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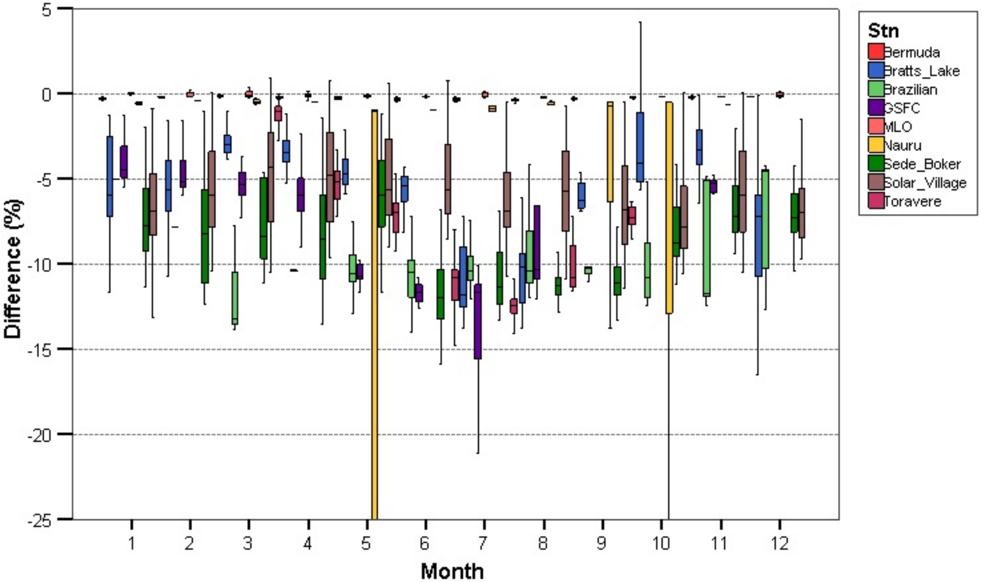

Fig. 3. Box plot of the monthly differences (%, eq. 4) for each AERONET station.

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