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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Stratocumulus cloud thickening beneath layers of absorbing smoke aerosol" *by* E. M. Wilcox

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I thank the reviewer for a thoughtful review of the discussion paper.

Comment: There is something about this sentence that makes it hard to understand, perhaps it could be split differently to aid the reader (18641, lines 8-14).

Reply: The description of the OMI data in the second-to-last paragraph of section 2 has been substantially revised. This section should read more clearly now.

Comment: The author quotes the single scattering albedo of the aerosol at 0.55 micron (18643, line 10). What, if any, wavelength dependence of aerosol properties have been used in the calculations?

Reply: The wavelength dependence of the single scattering albedo is taken from the column-integrated measurements reported in Eck et al. (2003) obtained with surface sun photometers in southern Africa during the SAFARI 2000 field campaign. Figure 14 of that paper indicates a wavelength dependence of approximately -0.01 per 100 nm. That is the value used to extrapolate the 550 nm value reported by Haywood et al. (2003) to other wavelengths in the broadband radiative transfer model of Chou (1992). A sentence describing this procedure and a reference to the Eck et al. (2003) paper have been added to section 3 of the revised paper.

Comment: The study uses AOD of 0, 0.4 and 1.0 as illustrations (18643, line 12 onwards). It would be useful if the author could give an example of the range of AODs anticipated in the region of study.

Reply: The values of AOD in figures 2b and 3 are chosen to illustrate the radiative fluxes for a range of AOD values and to provide an estimate of the forcing efficiency (flux divergence per unit optical depth). Estimating the optical depth of aerosols above clouds is a technical challenge and was deemed not necessary to illustrate the dynamical response of clouds to smoke radiative forcing in this paper. Such estimates have been presented by Chand et al. (2009) using Calipso lidar data. Mean values for all-sky conditions can be found in fig. 2a of Chand et al. (2009) and additional estimates of the radiative forcing efficiency that indicate the range of observed AOD values can be found in supplementary figure 2 of the same paper. That supplementary figure shows that AOD values in 5° x 5° lat.-lon. boxes range from 0 to 1 with the bulk of AOD samples less than 0.6. These numbers and a reference to the AOD distributions published by Chand et al. has been added to section 3 of the revised paper.

Comment:: It is not clear from the text (18644, line 5) how to compare the forcing efficiency of Magi et al (2008) with the flux convergence calculated here. I think the discussion of the differences is valid, but not very transparent to the reader.

Reply: Indeed, the radiative forcing efficiency values reported by Magi et al. (2008)

are not directly comparable for the reasons indicated in the paper, mainly that the Magi et al. values are for clear-sky conditions over the continent, while the focus of this paper is radiative convergence above oceanic clouds. Furthermore, Magi et al. report that the single-scatter albedo is negatively correlated with AOD. This means that the empirical relationship between flux divergence and AOD will yield a stronger dependence of radiative forcing on AOD than the values calculated here, which apply a uniform single-scatter albedo.

The discussion paper neglected to cite the forcing efficiency values reported in the Chand et al. (2009) paper. By virtue of their Calipso retrieval of optical depth in clear or cloud skies they estimate a forcing efficiency 59 W mˆ-2 τ550nmˆ-1 for clear-sky conditions and 91 W mˆ-2 τ550nmˆ-1 for overcast conditions. Their values are larger than estimated in the present paper because they adopt a lower single scattering albedo (0.85). In the revised manuscript the last paragraph of section 3 has been revised to make the comparison with the Magi et al. results clearer and to cite the Chand et al. forcing efficiency values.

Comment: Do we expect there to be no difference at 600hPa, and in particular do we expect the cooler temperature SST cases to be warmer under a clean sky? A little more discussion would be useful here (18645, line 11-14).

Reply: Because the smoke radiative forcing is weak at 600 hPa, there is little or no difference in temperature expected between the high smoke loading and low smoke loading samples at this level. Likewise, the free troposphere is decoupled from the boundary layer at this location; therefore the underlying SST is not expected to contribute to any difference in temperature between the two populations at 600 hPa. The cooler temperature among the low smoke aerosol loading cases at lower SSTs cannot be explained with the data or analysis presented in this study. Revisions to the last paragraph in section 4 reflect these comments.

Comment: various typos.

Reply: Fixed.

References:

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