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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol indirect effects – general circulation model intercomparison and evaluation with satellite data" *by* J. Quaas et al.

Anonymous Referee #2

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1. This is an ambitious and important paper. It aims to assess the parameterizations of processes used to represent aerosol indirect effects on stratiform liquid water clouds, in a collection of 10 leading chemical transport models. Aerosol optical depth (AOD) relationships to six cloud-related factors are considered: (1) cloud droplet number concentration; (2) liquid water path (LWP); (3) cloud fraction; (4) cloud top temperature; (5) cloud albedo; and (6) OLR.

2. This is primarily a correlation study, identifying the diversity in the way the aggregate of mechanisms operating in each model produces a net effect on clouds, given specific changes in AOD. Comparisons are made with satellite observations of AOD vs. each of the six cloud parameters.

3. Introduction, P12735, Lines 21-22. You might also want to include Twohy, Coakley,

& Tahnk, JGR 114, 2009, regarding the interpretation of satellite retrievals of AOD in the presence of clouds.

4. Methods. P12736, Lines 8-10. Are the models sampled at 2.5 degrees daily average or instantaneously, coincident with the satellite overpasses? – This is ambiguous here, though I think it is clarified on P12738, lines 2-3.

5. Methods. P12736, Lines 15-16. There are several subtleties associated with the CCN-AOD relationship given in Andi's paper. For example, humidification can introduce large variations in the CCN-AOD relationship (e.g., Kapustin et al., JGR 2006), and there can be enormous variations in RH in the vicinity of clouds. I don't have any great suggestions about how to get around these issues, but the statement in the paper seems overly optimistic. Line 18. The Minnis et al. reference is for CERES, not MODIS. Line 22. The 10:30 and 1:30 local times apply near the Equator. Also, did you use MODIS Collection 4 or Collection 5 aerosol products?

6. Methods. P12736, Line 26. You use the diversity among MODIS Terra, MODIS Aqua, and AATSR as an indicator of uncertainty in the satellite-derived quantities. For the data shown in the Supplemental Material, they are all quite similar. But some mention of the actual uncertainties in the satellite-derived parameters, to the extent this is available, would be helpful here, especially as the three sources entail similar limitations in many respects, and you are depending upon slopes derived from the retrieved quantities, which are yet more sensitive to measurement errors than the individual retrieved values.

7. Methods. P12737, Line 9. Does the difference between 10:30 AM and 1:30 PM equator-crossing time provide convincing information about diurnal variability, given other uncertainties in the measurements, combined with the lack of late afternoon sampling?

8. Methods. P12738, Lines 11-13. Is Feingold's log-log relationship valid over the entire range of interest? It might be; the process does plateau out for high enough aerosol

concentrations, but such high concentrations might never occur at the averaging spatial scales considered here.

9. Section 3.1, P12739, Line 16. Africa as a whole is dominated by dust during many but not all seasons; same with Oceana. In November-December, for example, smoke often dominates Africa. Your seasonal stratification might reflect this difference.

10. Section 3.1, P12739, Lines 20-22. How confident are you that the satellite land-ocean AOD differences are accurate? MODIS uses different algorithms over land and water. In Collection 4 and earlier, MODIS over-land AOD was much higher than AERONET [e.g., Kinne et al., 2006]. For Collection 5, the over-land algorithm allows negative AOD, which improves MODIS-AERONET agreement in an average sense, but not event-by-event, and there is still a high bias to the MODIS over-land values.

11. Section 3.1, P12740, Line 13. Minor copy-edits I happened to catch. ". . . for the slope of Nd vs. total aerosol light scattering. . ." Line 14. ")" missing.

12. Figure 2. I think the full-page figure you have in the Supplemental Material is so much more revealing than the abbreviated version given in Figure 2, that I'm tempted to suggest you include the full figure in the article itself.

13. Section 3.2, P12742, Line 1-2. A bit more perspective would be helpful on how meaningful you think the specific, detailed agreements (and disagreements) between the models and measurements.

14. Section 3.3, P12742, Lines 20-24. Right. The implication of these apparent correlations is controversial. You might find the following paper interesting in this respect, as it gives an example of how different remote sensing techniques can come to *opposite* conclusions about the aerosol/cloud fraction relationship: Tian et al., JGR 2008, doi:10.1029/2007JD009372.

15. Section 3.3, P12743, Lines 27-29. You might add something about specific, coincident measurements of multiple parameters needed to strengthen the observational

base for model validation of these effects. It would be worth making a point here, and possibly also in the Conclusions section, about the needs implied by the current work.

16. Section 3.4, P12744. As you know, T_top derived from TOA radiances actually samples a profile within the cloud, and to some extent, the atmosphere above it, depending on conditions and wavelengths used. Some mention of the impact this might have on the interpretation of these comparisons might be included in this section.

17. Section 3.6, P12745. Having a qualitative list of likely mechanisms involved in the OLR/AOD relationship is important, but in addition, providing at least a broad perspective on how well constrained the net relationship is from actual observations, would be helpful.

18. Section 3.7, P12748, Line 9. Why not work with a summary of different satellite-inferred anthropogenic AOD estimates, such as Yu et al. that you reference in the Introduction?

19. Section 4. P12750, Line 6. You make the point here about measurement uncertainties. The distinction between diversity and uncertainty is blurred for measurements (and models) in this paper, as it is in nearly all global-scale studies of aerosol effects, due to limitations in the data and complexity of the models. Addressing this directly is beyond the scope of the work presented here (and nearly everywhere else). But I think it would enhance the value of this effort if you could say a little more about key measurements and accuracies required, at the appropriate spatial and temporal scales, to take a significant next step in model validation of indirect effects on global scales, with the understanding that suborbital as well as satellite measurements might be needed. You have already done all the hard work required to extract these insights.

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