Reply to reviewer 3's comments:

We appreciate reviewer 3's helpful comments. In response to reviewer 3's suggestions, we have modified the manuscript listed below.

Anonymous Referee #3

Received and published: 31 January 2011

I have reviewed "Saharan and Asian Dust: Similarities and differences determined by CALIPSO, AERONET, and a coupled climate-aerosol microphysical model" by Su and Toon. The paper builds on an earlier dust modeling study and expands the analysis to discriminate differences in the source and transport meteorology and dust particle microphysical characteristics between Saharan and Asian dust.

The budget analysis presented is novel and I think very useful to other modelers. This should be commended. But I am puzzled by some aspects of it. The authors quote an overall Saharan dust source strength of 1539 Tg per year. Of this amount, 94% is transported across the plane at 10 E longitude, and the remaining 6% is attributed to northward transport. There are I think two problems with this analysis. The first is there is no explicit accounting for dust losses near the source region. Isn't some of this 1539 Tg simply lost by settling before it is transported anyway? Or is that somehow removed from these totals presented here? The second question this raises is about the overall source distribution. Again, your number is 1539 Tg emissions for the Sahara, and the discussion is the fraction transported across the line at 10 E longitude. But I think you are using the Ginoux et al. (2001) based source function to describe source locations. This is explicit in the previous paper, Su and Toon (2009), in which Figure 4 shows significant dust sources *west* of 10 E longitude. So I'm confused by the budget and the subsequent discussion (and Figure 2 - 5). Are you only talking about Saharan dust generated *east* of 10 E longitude? Or is that 10 E longitude plane an error in the paper (i.e., I wouldn't be asking this question if you were talking about dust transported across a line at 20 W longitude, that would enfold all the Saharan dust)? Or is there something else going on?

To address reviewer 3's suggestions, we have modified the manuscript to make it clearer:

1. The Saharan Desert refers to all the sources located in the North Africa including the part west of 10E plane. The 10E plane was used to indicate a reference location for comparisons in this paper. To address reviewer 3's suggestions and concerns, the definitions of Saharan Desert and Asian Desert have been added into the manuscript (see page3, lines 1-3). Also, in response to reviewer 3's comments, we have added another plane near the west coast of Africa (10W plane) based on Prospero et al. (2002) and Su and Toon (2009). Other planes in Africa have been extended westwards accordingly (10W, 55W, 100W, and 145W) (see pages 7-10, figures 2, 3, 4, and 5).
2. The "94%" sentence has been modified as The flux across the 10W plane is about 70% of the total amount of Saharan dust (1547 Tg) lifted in the model for the year. About 6% of the dust (93 Tg) goes north toward Europe in the model. Another 3% of the dust is lifted to the west of the 10W plane. The remainder of the dust (about 21% of that lifted) is removed locally over the Sahara before it

can reach the 10W plane (see page 8, lines 10-14).

The discussion in Section 3.3 is interesting and tries to offer an explanation for differences in observed dust particle size distribution at Dakar (Saharan dust) and Xianghe (Asian dust). The model does a reasonable job capturing the observed size distributions.
The apparent bimodal distribution simulated and observed at Xianghe suggests some sort of lofting mechanism is needed to keep larger particles from falling out of the model. But the appeal to dynamics appears to be simply wrong. I agree that Figure 13 shows descent for air parcels traveling from the Sahara to Dakar. But the authors' claim that the Xianghe trajectory shows ascent of air parcels from source regions to Xianghe is just not right; the parcels appear to actually be descending, and quite rapidly. So, although there may be a dynamical explanation for the differences in the particle size distribution, it isn't evident at all in what is presented. Additionally, the importance and connection of Figures 12 and 14 to Figures 13 and 15, respectively, needs to be made more explicit. I Figures 12 and 14 are there for context, but really all the information you need that you're looking at dust in these cases could come from the AERONET measurements.

We significantly modified this discussion. It is very difficult to do the proper trajectories since the dust is mainly in mixed layers. The mixing in the Saharan air layer, likely absent for much of the Asian dust, likely keeps the Saharan dust relatively uniform. However, there is ascent in the Asian dust layers since they are lifted in cyclones. The lofting of the dust is likely suspending some particles, that would otherwise fall out.

Page 4, Line 4: more recent reference to CALIPSO data you might consider: Winker et al. THE CALIPSO MISSION A Global 3D View of Aerosols and Clouds. Bull. Amer. Meteor. Soc. (2010) vol. 91 (9) pp. 1211-1229

This reference to CALIPSO has been added into the manuscript (see page 4, line 11).

Page 5, Line 14: Rasch et al. 1997 is not the correct reference for NCEP reanalyses. Try one of these: Kalnay et al. The NCEP/NCAR 40-year reanalysis project. B Am Meteorol Soc (1996) vol. 77 (3) pp. 437-471 Kistler et al. The NCEP-NCAR 50-year reanalysis: Monthly means CD-ROM and documentation. B Am Meteorol Soc (2001) vol. 82 (2) pp. 247-267

Rasch et al. 1997 has been replaced by Kistler et al. 2001 for the NCEP re-analyses reference (see page 5, line 22).

Page 7, Line 11 - 14: Something about these numbers doesn't make much sense to me. Your total dust emission is 1539 Tg/yr, which seems in line with most models. But 94% of this mass is transported across the 10 degree east plane. You attribute the other 6% to northward transport. But isn't there loss in the source region? And a lot of it? My look at budgets in other models suggests that although the emissions may be quite high, a lot of that dust is essentially immediately removed by gravitational

sedimentation at the source. So where does that fit into the budget? Also, I take issue with saying that the annual flux is "about" 1446.61 Tg. Six significant figures seems awfully precise.

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1. The Saharan Desert refers to all the sources located in the North Africa including the part west of 10E plane. The 10E plane was used to indicate a reference location for comparisons in this paper. To address reviewer 3's suggestions and concerns, the definitions of Saharan Desert and Asian Desert have been added into the manuscript (see page3, lines 1-3). Also, in response to reviewer 3's comments, we have added another plane near the west coast of Africa (10W plane) based on Prospero et al. (2002) and Su and Toon (2009). Other planes in Africa have been extended westwards accordingly (10W, 55W, 100W, and 145W) (see pages 7-10, figures 2, 3, 4, and 5).
2. We added: The flux across the 10W plane is about 70% of the total amount of Saharan dust (1547 Tg) lifted in the model for the year. About 6% of the dust (93 Tg) goes north toward Europe in the model. Another 3% of the dust is lifted to the west of the 10W plane. The remainder of the dust (about 21% of that lifted) is removed locally over the Sahara before it can reach the 10W plane (see page 8, lines 10-14).

Page 7, Line 17: properly speaking, the SAL is the hot, dry air mass advected west of Africa. I've not seen it defined as the broad dust pall that exists over the source region. The SAL does not necessarily contain dust.

The SAL definition has been added into the manuscript (see page 8, lines 20-21).

Page 8, Line 10: "the" Caribbean.

Modified (see page 9, line 13).

Page 10, Line 14: "snowfall"

Modified (see page 11, line 15).

Page 11, Line 21: What is the "soil erodibility factor?" Please explain in the text.

Defined (see page 12, lines 22-23).

Page 12, Lines 6-7: What are "power averaged winds?" Please explain in the text.

Defined (see page 13, lines 7-8).

Page 13, Lines1-2: Are the wind speeds similar at the transport altitudes for the Saharan and Asian dust?

The wind speed is higher at the transport altitudes for Asian dust than for Saharan dust

(see page 14, lines 4-7).

Page 13, Line 18: Use the capital Greek “delta” symbol rather than “nabla” in the equation and through the descriptive text. “nabla” is incorrect, implying divergence.

Modified (see page 14, line 22 and line 26).

Page 15, Line 2: Rather than “decline in altitude” simply say “descend.”

Modified (see page 16, line 7).

Page 15, Line 10: I think you mean 6.3 mm/s.

Yes, it should be 6.3 mm/s. Modified (see page 16, line 15).

Page 19, Lines 1-2: Why are you not using as well the real part of the refractive index from the AERONET observations? And I guess the question I have is if there is anything profound in the result? By using appropriate refractive indices for dust for each region you can get approximately the observed single scatter albedos. They are different for Asian and Saharan dust. Does that mean you need a separate set of dust tracers in your model to properly account for their different radiative effects? That would be a useful point to make. Also, you could easily consolidate Figure 18 into a single figure, which would make the point even more clearly.

Yes, I am using two sets of dust tracers (with a different refractive index for Asian and Saharan dust) to properly account for their different radiative effects, which I am working on another paper. Probably there are other ways to treat the problem, such as using different refractive indecies in the optical calculations, since Saharan and Asian dust are separated spatially. Also, I separate Figure 18 because the error bars will make the figures difficult to read if I put them together. I mention in the Abstract and conclusion that one needs to assume the composition of Asian and Saharan dust is different.

A final point about the figures: Figures 1, 2, 4, 5, 6, 8, and 9 all have dates on the x-axis. Please invest the small amount of time to label the dates better than “days in May 2007”. Something like “May 2007” would be fine with days ranging 1 through 31. It’s just a suggestion, but would lend the figures a more polished look.

The days (Fig.1) and months (Fig.2, 4, 5, 6, 8, and 9) have been labeled.