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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Understanding Processes that Control Dust Spatial Distributions with Global Climate Models and Satellite Observations" *by* Mingxuan Wu et al.

Anonymous Referee #2

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General Comments:

Dust particles play important roles in the climate system and local environment, so it's critical to advance the current understanding of how the spatial distribution of dust and relevant processes are represented in the climate models. Here dust mass budget, extinction profile, and surface concentrations from three GCMs (CESM1, CESM2, and E3SMv1) and one reanalysis product (MERRA2) are compared with multiple satellite products, e.g., MODIS, MISR, CALIOP, and station observations. All the models underestimate dust transport over the oceans, although E3SMv1 performs slightly better due to its higher mass faction of fine mode dust. MERRA2 also shows better agreement

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Discussion paper

with CALIOP DOD. The discrepancies among the satellite products are also discussed.

The paper is overall well written. The authors did a credible job in analyzing how different model settings, such as dust source function, geometric standard deviations, mass fraction, and model layers, affect the simulation of dust in the three GCMs that used the same dust emission scheme. The findings help better understand the performance of the widely used GCMs. I have some comments regarding the methodology, and some clarification probably would further improve the paper.

1. Here model performances are evaluated by comparing model results with satellite retrievals. As noted by the authors, due to the differences in the instruments and retrieval algorithms, certain discrepancies are found among satellite products, adding difficulties to the evaluation. I wonder if the authors can include some discussion on the uncertainties of the satellite products themselves, e.g., their estimated errors in AOD in comparison with ground observations, which probably could be found in previous publications.

2. Some details about model settings are not clear, which may affect the interpretation of model results. For instance, are surface winds nudged in all the GCMs or only in the E3SMv1? If it's only nudged in E3SMv1, how would this affect the intercomparison? All the three models used the DEAD dust emission scheme, is the same tuning factor applied? If not, it is expected to have quite different emissions regardless of other settings.

3. While many factors, such as dust source map and mass faction, can affect dust transport, meteorological conditions may also play a role. I think adding a brief discussion about how meteorological factors could affect dust transport in the models in section 4 would complement current analysis.

Specific Comments:

1. L85, what does "L1B" standard for?

2. L100, It's actually "three models", since MERRA2 is a reanalysis.

3. L129, do you have any idea why the source function in CESM2.1 is so dramatically different from CESM1.2?

4. L143 "fine dust" instead of "find dust"?

5. L164, "see Figure 3 in Kok 2011", wrong citation? I did not find information about MERRA2 in Kok (2011).

6. L168, model levels are inconsistent with the values in Table 1.

7. L183-188, is Ångström exponent <0.3 applied by Pu and Ginoux (2016) or only in the DOD you retrieved?

8. L459-460, can smaller fractions of fine dust in the models also contribute to the biases?

9. L494, what criteria did you use to select the 12 sites? Availability of records? Geographic location?

10. L514, "E3SMv1 produces small amount of dust emission in the Antarctic (Fig. 2c)". It is interesting that CESM1 did not show any dust emission in the Antarctic despite that it used the same source function as E3SMv1. Is this due to different snow coverage?

11. Fig. 1b, station names are labeled for some sites but not others. Why?

12. Fig. 5, is the collocation method similar to that described for dust extinction in L232-241?

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