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Interactive comment on "Global dust cycle and uncertainty in CMIP5 models" *by* Chenglai Wu et al.

Anonymous Referee #1

This paper examines the dust cycle simulated by 15 models from the Coupled Model Intercomparison Project (CMIP5). Annual mean dust emission, burden, lifetime, deposition, and surface concentration are examined. Large discrepancies are found in global dust emission and burden, while simulated dust deposition and concentration are within a factor of 10 at most stations. Wet deposition is found to contribute about 12-39% of total dust deposition. Overall, the paper is well organized and results are clearly presented. Further improvements are suggested as follows.

Major comments:

1. It is not clear why the MERRA2 is included in CMIP5 model comparisons. It's not a fair comparison since meteorological fields and total AOD in the reanalysis are assimilated with observations, but not in CMIP5 models. Although results from the MERRA2

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[Discussion paper]

can provide some insights on how well the dust cycle is captured when meteorological fields are constrained with observations, this aspect is not fully discussed in the paper, e.g., how model biases in meteorological fields, such as surface 10 m wind, precipitation, and atmospheric circulation, in CMIP5 models are transformed to biases in dust simulation. I'd suggest either better justifying why the reanalysis is used and the benefits of such a comparison or removing the comparison with MERRA2 results.

2. In section 4, some model discrepancies are attributed to potential causes, such as model biases in vegetation cover (lines 312-314), wind speed and precipitation (lines 343-345). I wonder if it's possible to add analysis to verify these hypotheses by examining a few relevant variables from CMIP5 model output, if available. This will help us better understand the underlying causes of model biases.

3. Previous studies of dust simulation in CMIP5 models are thoroughly reviewed in the introduction but not in the result section. Please consider adding discussion and comparisons with current findings in the analysis.

Minor comments:

1. Section 2, CMIP5 models have different horizontal resolutions. Did you interpolate model results to the same grid for comparison?

2. Line 118, I don't think GFDL-CM3 model uses dynamic vegetation to update dust source map. Please double check.

3. Line 130, please add "in diameter" after "have the larger size range of 0.0632-63.2 μm"

4. Lines 166-167, it seems that dust burden and deposition are not affected by the assimilation of total AOD, right? Please clarify.

5. Lines 191-196, can you provide how many years of data are available for dust deposition and surface concentration and add the info to Table 2? Deposition data cover "several to hundreds of years", while CMIP5 data are averaged over 1960-2005. Can

you add a short discussion on how the inconsistency of data may affect the comparison?

6. Line 220, can you please clarify how dust lifetime is calculated?

7. Lines 226-228, only one model year (2000) is used in AeroCom model intercomparisons, while 46-year averages (1960-2005) are used here. This may contribute to the discrepancy as well.

8. Lines 280-281, "... (Somalia, Ethiopia, and Kenya), East India, and northern part of Indo China Peninsula, which are rarely regarded as potential dust sources". Nogal Valley of Somalia and the Chalbi desert in Kenya are dust sources (Ginoux et al. 2012).

9. Lines 291-292, previous studies in addition to "Wu et al. 2018" also identified dust sources in North America, such as Prospero et al. (2002) and Ginoux et al. (2012). Please add more references here.

10. Lines 301-302, "The models consistently simulate the largest dust emission in North Africa...", is this consistent with AeroCom results?

11. Line 340, 0.1 of erodibility?

12. Line 408, does AOD assimilation affect dust deposition in MERRA2?

13. Line 418, "classified into two groups", based on what criteria?

14. Line 457, please add "surface" before "dust concentration"

15. Lines 476-477, the vertical distribution of dust could be another reason. The model may simulate higher dust concentration above the surface.

16. Line 496, please add a statistical significance level to correlation coefficients.