

Interactive comment on “Dust aerosol impact on North Africa climate: a GCM investigation of aerosol-cloud-radiation interactions using A-Train satellite data” by Y. Gu et al.

Anonymous Referee #2

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This manuscript attempts to quantify the climatic effect of the aerosol indirect effect using a GCM with the empirical relationship between ice cloud properties and AOD obtained from the A-train satellite data. It is a very interesting paper and I recommend a publication after a revision.

My major concerns are:

(1) About the 5 years of integration of climate model: This seems too short for me. The feedback of water vapor and clouds is the major factor that leads to uncertainties in climate models. A quick check can be done if you run climate simulations longer, for example, for 20 years, and then compare model results from the final 10 years. You

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may see that the pattern and magnitude of the simulated climatic effect of aerosols can be different. Also, because of uncertainties with model results, a commonly used approach is to perform significance test on model results to distinguish model noise and climatic effect of aerosols.

(2) About the De-AOD-IWC relationship from A-train data, is this the same throughout the year? Or this has seasonal variations? In Africa the observed AOD includes the contributions of BC and OC aerosols from biomass burning, which needs to be clarified in the manuscript.

More specific comments:

(1) The abstract can be shortened.

(2) Introduction: Most of the previous studies mentioned were published before 2007; more updated studies on climatic effects of dust should be cited, especially the GCM modeling studies that examined direct and indirect of dust.

(3) Line 3 on Page 4 and Figure 1: Longwave radiative forcing of dust is missing, although you mention about it later. Actually I think Figure 1 can be removed because it is a general definition of aerosol forcing and not something special in this paper.

(4) Line 3 on Page 8: Usually we would choose to use higher resolution model to have better characterization of clouds. Why chose 4x5 resolution for this study?

(5) Page 8: About the UCLA GCM, do you have any references that evaluated the simulated water and ice clouds in the model?

(6) Figure 2 and related discussions: What are the relative humidity and size distributions assumed in calculation of optical properties of different aerosol species? The single scattering albedo of dust is about 0.8, which is in the low end of estimates in previous modeling and observation studies. May need to discuss how this would influence your results?

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- (7) Bottom of Page 11: It is stated that “When there is no aerosol, $\Delta\tau$ must be prescribed or calculated from other cloud microphysical parameterizations.” Describe exactly whether it is prescribed or calculated in this study. If prescribed, give the values.
- (8) Line 11 on Page 13: Simulated IWCs are used. How accurate are they? Any evaluation with measurements?
- (9) Section 3 is a little confusing to me. Is it a one-column study using the radiative transfer model? Or a calculation within the GCM for the desert area?
- (10) Bottom of Page 12: Why is surface albedo assumed to be 0.1? I would expect it is higher for deserts?
- (11) I would suggest comparing forcing values obtained here with those in previous studies.
- (12) Line 7 on page 14: “while semi-direct effect can be inferred from the results for cloudy conditions”. Explain in more details how you estimate semi-direct effect here.
- (13) Page 15: How do you treat the oceans in climate simulations? Prescribed SSTs or using a mixed-layer or dynamic ocean? Yue et al. ACP 2011 found that simulated climatic effect of dust can be quite different with different assumptions about SSTs.
- (14) Page 15: The manuscript is focused on ice clouds, but how about your assumptions of water clouds under clean and dusty conditions?
- (15) Line 20 on Page 16: Why present model results for JJA only? Results for other seasons might be different and interesting.
- (16) Figures 5-7: it might be helpful to have significance test on model results, so that you just need to discuss results that are statistically significant.
- (17) About cloud cover in Figures 5 and 7, can you show water cloud and ice cloud separately? Feedback in water clouds can contribute to the changes in parameters shown in Figures 5-7, which should be discussed in the text.

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- (18) Conclusion: I would suggest having a final paragraph to discuss sources of uncertainties with model results from this study. For example, $\Delta\tau$ -AOD-IWC relationship from A-train data may include the impacts of BC/OC from biomass burning; assumptions about SST can influence simulated climatic effect; second aerosol indirect effect should be considered in future studies; etc.

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