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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Quantifying the range of the dust direct radiative effect due to source mineralogy uncertainty" *by* Longlei Li et al.

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COMMENT

The manuscript discusses the direct radiative effect of dust aerosol (as defined as soil particles suspended in the atmosphere) due to source mineralogy uncertainty, focusing on the relation to the dust aerosol composition. It is well-organized. I read over the manuscript and the comments from referees #1 and #2 as well as the reply of the author. Basically, I agree with those comments and the reply from the author.

RESPONSE

Thanks much for Reviewer 3's careful reading of our manuscript and for the comments.

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COMMENT

However, I do have a seeming important question. This manuscript tried to estimate the direct radiative effect of dust aerosol and only considered the mineral aerosol as it is defined. The direct radiative effect of dust aerosol happened during the long-range transport of dust aerosol. While the dust aerosol travels to thousands of kilometers away from its source area, the mineral aerosol will certainly mixes and interacts with the pollution aerosol and its chemical composition of the aerosol would be changed and its optical properties would in turn be changed, so as its direct radiative effect. Therefore, this manuscript estimate the direct radiative effect of only mineral aerosol without considering its mixing and the interactive reaction with pollution aerosol, such an approach could be the biggest fact causing the uncertainty to the estimation of the direct radiative effect???

In 2010, Huang et al. studied the "Relation between optical and chemical properties of dust aerosol" (Huang et al, JGR-atmos. , 115, D00K16, doi:10.1029/2009JD013212). The strong heterogeneous chemical reaction on dust, and the mixing of dust with various pollutants during the long range/regional transport of dust plumes was observed. they found the linear relationship between optical properties and aerosol chemical composition. Soluble ions, i.e., SO42−, NO3−, NH4+, and K+, were the major contributors to the light extinction in fine particles, while mineral aerosol contributed more to that in coarse particles. Black carbon, as a strong light absorbing species, was found to contribute to the light extinction in both fine and coarse particles. Strong absorbing of aerosol at 439 nm was observed due to the significant proportion of iron oxides in the dust aerosol other than black carbon. The transport pathways of dust, concentrations of pollutant precursors and meteorological conditions were the main factors affecting the mixing extent of pollutants with dust.

In the references of the manuscript "Quantifying the range of the dust direct radiative effect due to source mineralogy uncertainty" by Longlei Li et al." , the paper mention above of Huang et al. (JGR-Atmos, 2010) was not cited and this manuscript totally

ignored the direct radiation effect caused by the mixing and interactive reaction of dust aerosol with pollution aerosol, so as the correctness of such an estimation would be questionable! I suggest that this manuscript should have a major revision considering the mixing and interactive reaction of dust aerosol with pollution aerosol during its long-range transport in the atmosphere.

RESPONSE

Thanks very much for the comments and for the careful reading of the Reviewer #3. We are taking all the above as one general comment.

It is a very good point. We actually had already briefly discussed this point in the appendix of the preprint. Those discussions in the appendix are suitable to most if not all of existing papers addressing dust direct radiative effect (DRE) using models like CAM (we have the discussion in the appendix but not in the main text, because the main text has already been very long).

As stated in the manuscript, our goal is to quantify dust DRE uncertainty due to uncertainty in the soil abundance of the minerals. So, our focus is on the sensitivity of optical properties of dust to its mineralogical composition. We compared the resultant DRE range only with that induced by some of the others, which are known important for dust DRE, and whose uncertainties are well known. The complex chemical reaction is not well included in our model. Implementation of the chemical reaction to our model is outside our scope and the scope of ACP.

Nevertheless, we hypothesize that the overall effect of the heterogeneous chemistry on dust DRE in our model should be small compared to the sensitivity to iron oxides on the following basis.

1) In CAM5/6, coarse-mode dust very well dominates over fine-mode dust in the estimated dust DRE and the perturbation to the base dust DRE. Here we take the shortwave dust DRE as an example, as the dust DRE uncertainty range we estimated at the

shortwave bands is much greater than at the longwave bands (Fig. 14 of the preprint): in the baseline, coarse-mode dust DRE is ∼-0.11 W/m2 (cited value for shortwave dust DRE at the top of the atmosphere under all-sky conditions here and elsewhere below this in the reply) versus that accumulation-mode dust DRE is ∼-0.07 W/m2 and Aitken-mode dust DRE is ∼0.00 W/m2; the perturbation to the base DRE by dust in the coarse mode is between ∼[-0.21593, 0.25807] W/m2 in CAM5 versus that in the accumulation mode is between ∼[-0.01140, 0.01985] W/m2 and in the Aitken mode is between ∼[-0.00107, 0.00047] W/m2; Considering air-pollution elements are mainly found in the fine-mode dust (Huang et al., 2010; Kandler et al., 2009) due to the large surface-to-volume ratio and long residence time of the small-sized particles in the atmosphere, the chemical reaction seems unlikely to be as influential as iron oxides in our model to dust DRE

2) The soluble coating could enhance the scattering of incoming radiation and "dust" aerosol optical depth (DOD). However, the resultant large size (primarily due to water uptake) also leads to a higher dust removal rate compared to non-aging dust, decreasing DOD. Also, we had tuned our model toward a constant DOD but not a total aerosol optical depth (AOD). So, the contribution of non-dust species to the total AOD is somewhat not much relevant

3) While East Asian dust undergoes mixing that could affect its optical properties, this is much less true for dust from most other source regions. Notably, African dust is transported toward the Caribbean (across the Atlantic Ocean) or to the Mediterranean without any substantial change in its optical properties (e.g., Denjean et al., 2015, 2016). For possible mixing in the remote regions, its impact on dust DRE would be tiny according to the points in 1) and 2).

As a response, we added two sentences in the methodology section as below (will insert Huang et al., 2010 and some others as well in the revised manuscript):

"To compare the uncertainty in the DRE from mineralogy to the other effects whose un-

certainties have been well quantified, we perturb the DOD and the imaginary complex refractive index of the minerals. We do not compare the resultant DRE uncertainty due to other error sources (see the appendix), such as chemical reactions that could occur on airborne dust particles with aerosols like sulfuric acid (H2SO4), nitric acid (HNO3), HCL, etc. (e.g., Li and Shao, 2009; Huang et al., 2010; Tobo et al., 2010)."

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