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Interactive comment on “Beyond direct radiative forcing: the case for characterizing the direct radiative effect of aerosols” by C. L. Heald et al.

Anonymous Referee #2

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This paper calculates the direct radiative effect (DRE) and the direct radiative forcing (DRF) using the GEOS-Chem chemical transport model with online radiative transfer calculations. The authors highlight the differences between DRE and DRF predictions in their model. The authors use a case with no anthropogenic emissions as the baseline for DRF (rather than a 1750 pre-industrial case), although they still refer to their simulation as pre-industrial, which is confusing, and it's not obvious how much this will affect comparison to other models that use a 1750-based pre-industrial cases (which the authors do in Table 3).

I feel that the paper is useful, though it needs some work before it may be published. There are issues addressed by reviewer 1, and I will focus generally on other issues that I found. I consider my revisions to be minor.

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Primary issue:

Throughout: The use of the term “pre-industrial”. In the IPCC and elsewhere (e.g. AEROCOM) pre-industrial typically refers to the year 1750, though other years are occasionally used (e.g. 1800 or 1850). In 1750 (and certainly the later dates), anthropogenic emissions are far from zero (e.g. biofuel). I’m not aware of any study where “pre-industrial” is defined as shutting all anthropogenic emissions off. Thus, the “pre-industrial” simulation performed here is not “pre-industrial” in the traditional sense. Furthermore, the AEROCOM studies use 1750 as a basis, and you compare to the AEROCOM DRFs in Table 3, but this makes for an apples/oranges comparison (not quite as bad as swapping DRE for DRF, but still 2 very different DRFs!).

Calling the simulation “no-anthro” would avoid confusion for the reader, which is important here since the purpose of paper is to reduce confusion between different, but related definitions of radiative differences between simulations. However, it is not obvious how best to compare directly to the AEROCOM simulations without performing simulations with 1750 emissions. Maybe the authors could determine if the differences between 1750 emissions and no-anthro are minor?

Minor issues.

P32927 L3-5. Please go into details as to the history of the usage of DRE. There are no citations here, which makes it unclear if the authors are saying this is a new term. Review 1 goes into the previous DRE vs. DRF studies in detail, so I won’t say more here.

P32927 L10. In the IPCC, “pre-industrial” is defined as 1750. Good to state this explicitly, and good to make it clear that this is not what you calculate in the paper (once you introduce the simulation). The start date is certainly important for forcing (e.g. Carslaw, Nature, 2013).

P32928 L25, end of intro. I was missing clear statements of what the goals of this

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paper are. Is it to demonstrate that DRE and DRF are different? Is it to show the DRE and DRF results in the default GEOS-Chem-RT simulations.

P32929 L12 and throughout. When I see "GCRT" I think "GOCART", which is also a global CTM with online radiative transfer. To avoid confusion, I suggest using GEOS-Chem-RT.

P32933 L5: Since your results may depend greatly on what you assume about the BC optics (e.g. coating effects), please briefly describe here. At the end of the paper you mention ignoring coating effects, but it should be stated up front. Also, I agree with reviewer #1 that the Cappa study is currently a lone horse showing that the coating effect is negligible, and alone it probably doesn't justify ignoring coating effects.

P32933 L7: Is water uptake to only sulfate considered? I'm guessing you consider water uptake to other species too, but this isn't mentioned.

P32934 L23-27: Can you elaborate on why aerosols produce a warming over the sahara and the middle east? Surely the single-scattering albedo of the particles is higher than 0.3-0.4 (the visible surface albedo). Is the warming because of the LW absorption effects of the aerosols?

P32935 First paragraph: This seems like it belongs in the methods section.

P32935 L13: Is it reasonable to assume that as much as 20% of the dust in the middle of major deserts (e.g. the sahara) is anthropogenic? It might be worth mentioning that there should be regional variability in the number that you're currently ignoring.

P32937 L3-9: Can you give more detail on how you calculated the cloud-sky TOA DRF? If it just $-0.36 = 0.6*(-0.57) + 0.4*x$ and solve for x? I had to think for a minute to come to this.

P32938 L10: Why is boreal springtime the peak DRF?

P32941 L16: Could cite Carslaw, Nature, 2013 along w/ Menon.

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