Anonymous Referee #2 **(Review comments in bold;** response in regular type.)

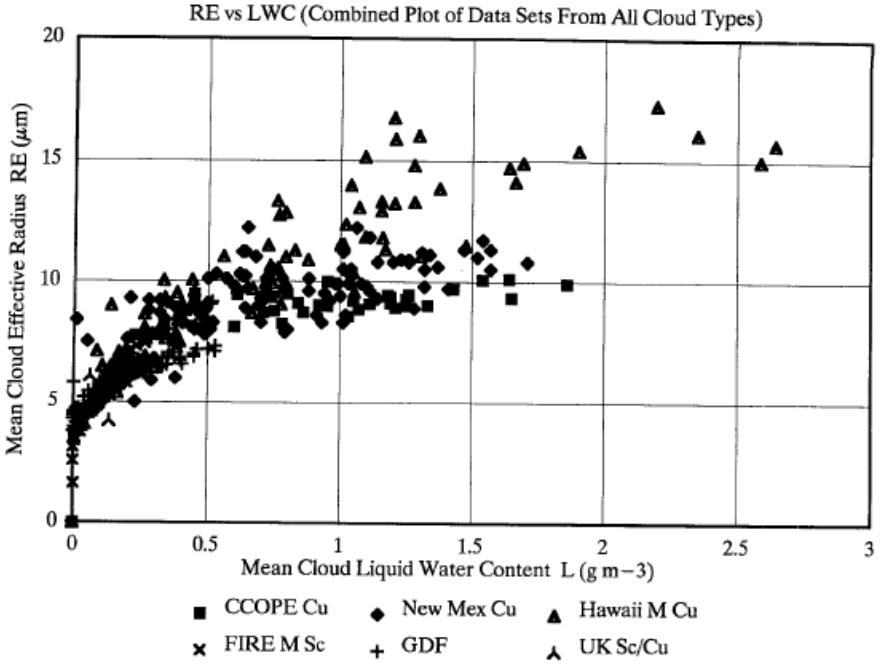
The authors study the impact of the meteorological fields driving an offline aerosol model on the aerosol distributions simulated by that model, and on the aerosol forcing exerted. The paper is detailed and complete, and aerosol differences are well attributed to differences in the meteorological fields. The discussion tends to overemphasize some differences, and authors should not hesitate to discuss agreement where appropriate, as mentioned below. I would recommend publication after minor revisions to address the following comments.

1. **Main comments**
   - **The authors discuss differences throughout the paper, but seem to be unaware that the more striking results are actually about the lack of differences. For example, multiplying the condensed water content by three leads to virtually no differences in global-averaged direct and indirect forcing for a given set of meteorology. This is very likely due to compensating impacts on different aspects of the aerosol distributions, but suggests an impressive robustness in forcing estimates with respect to wet removal – interannual variability would in fact influence aerosol forcing more than that.**

     Since the main purpose of this paper is to identify which meteorological variables are responsible for the differences in the aerosol simulations, we have been focusing on finding the differences associated with the differences in meteorological fields. Multiplying the condensed water content only changes the magnitude of the wet deposition by large-scale precipitation which accounts for about half or less of the total deposition of aerosols. The ADE changes from -0.48 W m^{-2} to -0.64 W m^{-2} in IMPACT-CAM5 and from -0.25 W m^{-2} to -0.30 W m^{-2} in IMPACT-AM3. The change is roughly proportional to the change of aerosol burdens. The first AIE changes from -1.74 W m^{-2} to -1.77 W m^{-2} in IMPACT-CAM5 and from -1.26 W m^{-2} to -1.44 W m^{-2} in IMPACT-AM3. These changes are much smaller than changes of aerosol burdens and ADE. One important reason is the nonlinear nature of the AIE which is not proportional to the changes in the aerosol loadings. It also depends on reference aerosol loading (the pre-industrial case). The following is added to the discussion *"Also the indirect forcing for a given set of meteorology is relatively more stable than aerosol burdens and ADE to the wet deposition treatments. One important reason could be the nonlinear nature of AIE (AIE is not proportional to the changes in the aerosol loadings and also depends on the PI aerosol loading), although other compensating impacts on different aspects of the aerosol distributions cannot be excluded."*

- **The impact of the very large changes in vertical transport and relative humidity is larger, with global-averaged forcing from IMPACT-AM3 and IMPACT-CAM5 differing by 30%. However, uncertainties in aerosol emissions (present-day and pre-industrial), absorption, and indirect effects are likely to dwarf that number.**
  The 30% difference is based on the assumption that all variables (e.g. the emissions, absorption, etc) other than the meteoroglical fields have no uncertainties. We agree that uncertainties in aerosol emissions, absorption and indirect effects are likely to dwarf our numbers. The following has been added to the discussion
  "The 1st aerosol indirect effect from the IMPACT-CAM5 model (-1.74 W m-2 to -1.77 W m-2) is also larger than that from the IMPACT-AM3 model (-1.26 W m-2 to -1.44 W m-2) by ~30%. This is mainly due to the higher low and middle level cloud fraction in tropical and subtropical regions from CAM5 as well as the relatively larger increase of cloud optical depth from PI to PD. While uncertainties in aerosol emissions (present-day and pre-industrial), absorption, interannual variability and other indirect effects are likely to dwarf this difference, it is still important to quantify the role that meteorological differences by themselves play in different model results."

- **In their sensitivity study, the authors choose to multiply the condensed water content (L+W) by three from 0.5 to 1.5 cm^{-3} m^{-3}. Why chose those numbers? Are they the limits of some range constrained by observations?**
  The condensed water content has a very large range from observations. Below is a figure from Bauer et al. (1994) showing that the observed in-cloud liquid water content (x-axis) can vary from 0 to 3 g m^{-3} (or cm^{-3} m^{-3}). Both 0.5 g m^{-3} and 1.5 g m^{-3} have been used in the literature and this choice was generally based on the comparison between model results and observations. We chose to use both values to give a range of simulated results.



(Figure 6(a) from Bauer et al. 1994)

Bower, K. N., T. W. Choularton, J. Latham, J. Nelson, M. B. Baker, J. Jensen, 1994: A Parameterization of Warm Clouds for Use in Atmospheric General Circulation Models. J. Atmos. Sci., 51, 2722–2732.

2. Minor comments

Page 10682, line 10: Is that the dry or wet particle radius?

Dry. "dry" is added to clarify.

Page 10686, line 8: "significantly larger". Is that statistical significance?

The following table gives the annual global mean large-scale precipitation from five consecutive year data from CAM5 and AM3. These two 5-year serials are significantly different from each other with the confident level of 99% according to the Student's t-test.

mm/day	year 1	year 2	year 3	year 4	year 5	**5-year mean**	**stddev**
CAM5	0.859	0.867	0.872	0.861	0.866	**0.865**	**0.005**
AM3	1.108	1.110	1.103	1.101	1.097	**1.104**	**0.005**

Page 10687, line 20: In the baseline models CAM5 and AM3, do aerosols interact with radiation and cloud microphysics, and affect meteorology? Section 2.2 is silent on that subject. If aerosols interact with meteorology in those models, then there is an internal consistency between aerosol and meteorology, and the impact of meteorology on aerosol forcing is conceptually different than for offline aerosol models.

Aerosols interact with radiation/cloud microphysics and affect meteorology in the baseline model CAM5 and AM3. We state this explicitly in section 2.2 in the revision: "Both the CAM5 and AM3 models have their own active aerosol modules in which aerosols can interact with radiation, cloud microphysics and affect the meteorology." It is true that in our off-line fields from CAM5 and AM3, then, there is an inconsistency between our off-line aerosol predictions and the predicted meteorology, and the internal model-generated aerosol forcing is conceptually different from that from the offline aerosol models. Here due to the fact that the comparison of aerosol burdens/lifetimes between the base CAM5 and AM3 models is very similar to the comparison between C1/C2 and A1/A2, we are suggesting that this inconsistency is not great and the difference in meteorological fields might play the dominant role in the comparison.

Section 4.1: Is it really necessary to give percentages with two decimal digit precision?

We have changed to one decimal digit precision where it is appropriate.

Page 10694, line 15: Where does the "50% of OM is HULIS" come from? It sounds large.

The fraction of fossil fuel organic matter from fossil fuel combustion that is absorbing is not known with any precision. We picked 50% as being between 0 and 1. This is somewhat of a kludge, however, since HULIS is thought to be mainly oxidized and/or polymerized organic matter (Sun et al., 2007; Cappa et al., 2011), while primary organic matter from fossil fuel combustion may not be highly oxidized. However, the aerosol model used in this paper does not account for the formation of SOA which should be more absorbing. Hence, our simple choice is 50%. We will add this explanation to the paper.

Cappa, C. D., D. L. Che, S. H. Kessler, J. H. Kroll, and K. R. Wilson, 2011: Variations in organic aerosol optical and hygroscopic properties upon heterogeneous OH oxidation, J. Geophys. Res., 116, D15204, doi:10.1029/2011JD015918.

Sun,H., L. Biedermann, and T. C. Bond, 2007: Color of brown carbon: A model for ultraviolet and visible light absorption by organic carbon aerosol, Geophys. Res. Lett., 34, L17813, doi:10.1029/2007GL029797.

Page 10695, line 2: Please detail how the cloud-free relative humidity is computed.

The definition is added in the revision. The cloud-free relative humidity is defined as H_clr=(H-f_cld)/(1-f_cld) where H is the grid-box averaged relative humidity and f_cld is the cloud fraction. This assumes the relative humidity inside cloud is always 100%.

Page 10696, lines 16–17, and page 10697, lines 10–11: You are discussing small differences there – it would be more relevant to discuss why there is agreement.

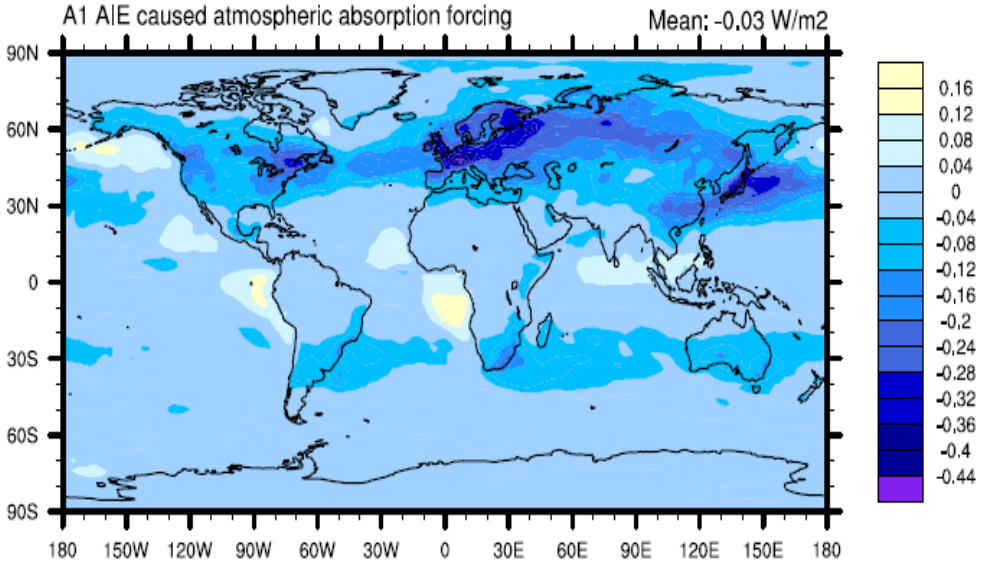
This line and the following line have been rewritten to discuss the agreement.

"*The absorption of radiation in C1 is smaller than in A1 (all-sky: 0.65 W m-2 vs. 0.72 W m-2, clear-sky: 0.64 W m-2 vs. 0.78 W m-2). However, this difference is smaller than the difference in the burdens of BBC/FFC in these two cases. This is due to the increased water uptake in C1 which increases the absorption of short wave radiation by the internally mixed BBC/FFC.*"

Page 10697, lines 25–26, and Table 9: How can the first indirect forcing be weaker at the surface than at the TOA?

First of all, when calculating the 1st aerosol forcing, the direct forcing is not included (no scattering or absorption by aerosols). (AIE_{TOA}-$AIE_{surface}$) is the atmospheric absorption forcing (including absorption by water vapor, O_3, O_2, CO_2) due to the aerosol 1st indirect effect. The

increased reflectivity of clouds by the 1st AIE can increase the atmospheric absorption above clouds but decrease it below clouds. The net effect depends on the height of clouds. Below is a figure showing global distribution of this atmospheric absorption forcing for case A1. The 1st AIE at TOA is -1.26 W m^{-2} and -1.23 W m^{-2} at the surface. So the atmosphere absorption forcing is -0.03 W m^{-2} or we can say the 1st aerosol indirect effect causes atmospheric absorption to decrease by 0.03 W m^{-2} globally. In areas to the west coast of Africa and America where large fractions of low marine stratocumulus clouds form, the increased atmosphere absorption (mainly by water vapor) above the clouds outweighs the decrease below the clouds. However, in areas that are not dominated by these low marine stratocumulus, the decreased atmospheric absorption overweighs the increased absorption above the clouds.



3. Technical comments

Page 10683, line 9: Typo "humudity".

Done

Page 10683, line 14: Typo "precipiation".

Done

Page 10684, line 21, and page 10685, first paragraph of section 3, and elsewhere in the paper: Please spell out "yr".

Done

Page 10695, line 10: "factor" should read "fact".

Done

Page 10701, line 12: "emphasize" should read "emphasis".

Done

Table 4: Typo "Aitkin"

Done