Atmos. Chem. Phys. Discuss., 15, C1848–C1854, 2015
www.atmos-chem-phys-discuss.net/15/C1848/2015/
© Author(s) 2015. This work is distributed under
the Creative Commons Attribute 3.0 License.

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Radiative forcing and climate response to projected 21st century aerosol decreases" *by* D. M. Westervelt et al.

Anonymous Referee #2

Received and published: 23 April 2015

In this study, the authors simulate the 21st century climate based on RCP emission scenarios and using the GFDL climate model. By fixing aerosol emissions to 2005 levels, the authors isolate the aerosol contribution to total climate response. They find that the four RCPs yield similar responses, because aerosol emissions decrease similarly in all scenarios. Aerosol decreases exert a positive radiative forcing, contribute to surface temperature rise, and increase in precipitation rates and cloud droplet radius.

The paper is well written and the analysis is reasonably wide-ranging, although shallow in places. Figures are well chosen and illustrate the discussion well. However, the paper suffers from two serious flaws. First, the authors take the results of their model uncritically, without giving sufficient reasons for the reader to believe the quantitative aspects of the paper. Second, the methods and results presented in the paper are not

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

novel and the authors do not take opportunities to analyse results in a deeper, more original way. Because novelty is a criterion for publication in *Atmos. Chem. Phys.*, I can only recommend rejection of the paper.

1 Main comments

- The authors clearly have confidence in their model and its representation of aerosol impacts on climate, even though the mechanisms of some of those impacts have not been confirmed by observations. For example, on page 9297, line 1, the authors write that "aerosols have strong impact on precipitation", but the observational evidence is mixed and the choice to represent that impact via the autoconversion rate for all cloud regimes is debated (e.g. section 7.6.4 of the IPCC report). The strong precipitation anomaly shown by the model in the mid-20th century (page 9310, line 4) is not seen in historical reconstructions and many CMIP5 models (Ren *et al.*, doi:10.1002/jgrd.50212, 2013). Also, the model has a strong present-day ERF of -1.8 W m^{-2} (page 9307, line 9) (and incidentally must therefore have a large climate sensitivity to be able to match observed warming). That strong ERF is probably due to a large sulphate AOD: the decrease in sulphate AOD given in Table 1 is larger than the median anthropogenic sulphate AOD simulated by AeroCom models (Table 4 of Myhre et al., doi:10.5194/acp-13-1853-2013, 2013) Taken together, those facts mean that the results presented here are for a strong aerosol contribution. (I do not understand why the author think their forcing is only "slightly" overestimated [page 9308, line 25].) The authors need to clearly place their findings in the context of their model's characteristics: with a weaker aerosol ERF, many of their conclusions, such as the one on Page 9317, lines 26–28, would be quite different. Finally, the authors acknowledge that the lack of nitrate aerosol representation is a limitation of their study (Page 9301, lines 10–16 and Page 9327, lines 4–7). Indeed, other studies

ACPD
15, C1848–C1854, 2015

included nitrate aerosols and showed that it influences aerosol radiative forcing in the 21st century, because SO2 emissions decrease and NH3 emissions increase. So what is the added value of using a model that does not include nitrate aerosols?

- The main objective of the study is to expand on the findings of Levy et al. (2013) by using four, rather than only one, RCPs (page 9298, line 23). But the authors acknowledge, in a long paragraph (pages 9302-9303) and even a dedicated section (section 5.3, page 9324) that RCPs are very similar in terms of aerosol emissions, representing a "narrow range for emissions of air pollutants and their precursors" (page 9303, line 17). From this statement, it is clear that no novel insight will result from replicating Levy et al. (2013) four times. Indeed, the conclusions of the study can already be read in FAQ 7.2 of the IPCC report. One way to make an original contribution would be to analyse almost forensically the differences that arise from the slightly different trajectories taken by the RCPs. So the authors should take opportunities to analyse results more deeply. For example, it would be interesting to study why AOD trends do *not* correlate with emission trends in some regions (page 9306, line 17). Or study in details the feedback of climate change on aerosols which is apparent from Figure S3 and only briefly mentionned on page 9306, line 22. Another line of enquiry is to understand why RCP6.0 and RCP8.5, which have the same aerosol ERF by the end of the 21st century, end up with a 0.4 K difference in their aerosol-driven temperature anomaly (Figure 4). Another interesting question to answer is why LWP is little affected by aerosol changes in North America, but shows a strong trend in East Asia (Page 9321, line 1).

ACPD
15, C1848–C1854, 2015

CC BY

2 Other comments

- Page 9295, line 3: Please cite IPCC chapters, rather than the whole report. Myhre *et al.* (2013), already cited elsewhere, is a good choice in this context.
- Page 9295, line 15: “generally”: more specifically, on a global average.
- Page 9295, line 17: Negative aerosol radiative forcing leads to a cooling only if it is the only radiative forcing exerted.
- Page 9296, line 9: Emission datasets are notoriously uncertain, especially for China, but more recent assessments seem to confirm that Chinese emissions indeed peaked around 2005, see Klimont et al., doi:10.1088/1748-9326/8/1/014003, 2013.
- Page 9297, line 12: “warming the surface”: as a feedback? Because absorption of radiation will cool the surface first.
- Page 9297, line 16: This statement is only valid for liquid clouds. Homogeneous nucleation of ice crystals occurs in the atmosphere.
- Page 9298, line 14: Although I agree that the choice of emission dataset influences results quantitatively, studies that do not use RCP scenarios likely find the same qualitative results. So I am not sure that the authors have a good basis to exclude them from Table 1.
- Page 9301, line 2: It would be a good place to describe the representation of second indirect effects.
- Page 9301, line 4: That statement is unclear. If BC remains externally mixed, does it still become hydrophilic and act as a CCN?

ACPD
15, C1848–C1854, 2015

- Page 9301, line 12: But nitrate is a large contributor to aerosol mass in many regions (e.g. Jimenez et al., 2009). And because aerosol indirect effects are non-linear, having the right background aerosol number matters (e.g. Carslaw et al., 2013). So nitrate is important also in present-day, in spite of perhaps exerting a weak radiative forcing.
- Page 9301, line 21: Rigorously speaking, RCPs were used in CMIP5 simulations, which form the basis of parts of the IPCC assessment.
- Page 9305, line 6: Are those "minor updates" relevant to the results of this study? If so, we would need to know what they were.
- Page 9307, line 3: "(mostly decreases)": In the future, possibly, but historical aerosol emission changes have been increases.
- Page 9307, line 5: More specifically, effective radiative forcing here.
- Page 9308, lines 21–24: That comparison is awkward. Why not compare to CO2 radiative forcing in 2100?
- Page 9309, lines 19–20: You seem to have decided that aerosol effects on climate are large before even doing the analysis. I recommend saying something like "are expected to have significant effects".
- Page 9311, line 19: On a global, annual average, the evaporation flux must be balanced by the precipitation flux, so aerosol impacts on cloud microphysics can only change the timing of precipitation, not global amounts. Only aerosol impacts on evaporation have that ability.
- Page 9312, lines 1–2: The authors have not shown that precipitation responds more strongly to aerosol than to CO2 forcing, so is Shindell *et al.* (2012) really relevant here?

ACPD
15, C1848–C1854, 2015

CC BY

- Page 9313, lines 7–10: If the authors were looking at climate feedbacks on aerosols, choosing the RCP scenario that best tracks recent greenhouse emissions would be justifiable. But here, the authors would need to show that recent aerosol emissions are best represented by RCP8.5. In any case, since the authors show the other RCPs in the supplementary material, they do not really need to justify which RCP is highlighted in the main text.
- Page 9314, line 2: BC is also removed by wet deposition, yet does not seem to show the same increases over tropical oceans than OC and SO_2. Why not?
- Page 9314, line 11: The link with Fang *et al.* (2011) needs to be made more clearly here. Do you mean that aerosols not being deposited over land are transported in greater numbers to the oceans? Other changes could explain the observed increase: a decrease in low maritime cloud cover, or aerosols getting higher up in the atmosphere in a warmer climate, perhaps?
- Page 9315, line 8: CO2 is a good example of radiative forcing and temperature response not being collocated: its radiative forcing peaks in the Tropics, but the temperature response is maximal at the Poles.
- Page 9315, line 19: To be clear, having a model that simulates two ITCZs is not a good thing. Correct?
- Page 9315, line 21: In fact, the ITCZ response shown by the authors is a northward shift, which is expected when removing a negative forcing located in the north hemisphere (e.g. Allen and Sherwood, doi:10.1007/s00382-010-0898-8, 2010). However, the effect does not seem statistically significant in the GFDL model.
- Page 9316, line 20: For cloud effective radius, it is difficult to imagine a teleconnection mechanism. There are not many areas where radius changes are

ACPD
15, C1848–C1854, 2015

statistically significant, though. Is that due to a large unforced variability of effective radius in the model?

- Page 9317, line 17: What emissions?
- Page 9318, lines 9–10: Can the ratio be larger than 100%?
- Page 9322, section 5.2: This kind of correlation analysis is rather futile because, as stated by the authors, one does not expect aerosols and their climate response to be collocated. So what could we expect to learn from correlations?

3 Technical comments

- Page 9306, line 1: Delete "?".
- Page 9315, line 16: Should be "insignificant"?
- Figure 1 and Page 9318, line 21: Figure 1 is used very late in the paper. Why is it not placed after the current Figure 8?

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 9293, 2015.

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper