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

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I would like to thank referee 2 for the thorough review and address some of the major points brought up by the referee, before the current review period closes (May 30). A more specific, thorough point-by-point response will be provided when the discussion period has concluded. The referee cites two main flaws: 1) thinking uncritically about the model results and 2) lack of novelty.

1)

We acknowledge that a more critical view of the model results would add value, and we will add text that frames our results better in light of certain caveats. However, this was done to a certain extent already in the ACPD manuscript. In particular, the referee

cites our strong present-day aerosol effective radiative forcing (ERF) as one example. This was addressed in the main text and mentioned as a caveat to our forcing results. We provided a reasonable explanation for our large negative forcing (too strong cloud lifetime effect). We note that the IPCC AR5 range for present-day aerosol ERF is -0.1 to -1.9 W m^{-2}, so our estimate is indeed within that range albeit on the higher end. This is also not unique to our model (CM3), as Takemura (2012) with the SPRINTARS model estimates a -1.87 W m^{-2} present-day ERF for the indirect effect alone. Also, despite a stronger present-day aerosol ERF, our 2100 – 2000 positive forcing due to aerosol decreases is in agreement with most models, as shown in Table 1 of the ACPD manuscript. (Our value is 1.05 – 1.37 W m^{-2}, compared to 1.46 in Rotstayn et al. (2013), 1.26 in Levy et al. (2013), 1.72 – 1.96 in Takemura (2012), 0.68 – 1.42 in Shindell et al. (2013), etc.)

The referee also criticizes an overconfidence in our model, citing a lack of observational confirmation of certain aerosol-cloud-climate mechanisms. In fairness, many mechanisms by which aerosols impact clouds and climate have not been robustly confirmed by observations, and many other CMIP5 models also include such mechanisms. In addition to being a CMIP5 and IPCC model, CM3 has been rigorously evaluated against observations, including in two papers that are cited in the original manuscript (Donner et al., 2011; Naik et al., 2013). Additionally, Golaz et al. (2011) evaluated cloud forcing, precipitation, cloud cover, and liquid water path in CM3 against various satellite observations and found reasonable agreement. The model mechanisms and their validation have been described thoroughly in these papers, and such a discussion would not be germane to nor bears repeating in the manuscript.

A lack of nitrate aerosol forcing is also seen as a major flaw. Indeed, Bellouin et al. (2011) have used a CMIP5 model with RCP simulations to 2100 and included effects of ammonium nitrate. An older study by Bauer et al. (2007) included projections to 2030 with nitrate. Both of these papers are cited in our manuscript, and as the referee notes, the lack of nitrate aerosol forcing in GFDL CM3 is mentioned. Again, however, CM3 is not alone in the lack of nitrate aerosol forcing. In fact, according to Shindell et al. (2013) and Schmidt et al. (2014), only two models included nitrate forcing for their CMIP5 simulations. Nitrate aerosol forcing is under development in CM3, but expecting it for this work is an unrealistic standard to hold against CM3 considering the current state of the climate modeling community. Additionally, in order for inclusion of nitrate aerosol forcing to be useful, model representation of inorganic aerosol thermodynamics and chemistry must be robust and accurate. Most models, including Bellouin et al. (2011), use a simple equilibrium approach for the reaction between nitric acid and ammonia. As reported in Bellouin et al. (2011), the subsequent model-measurement agreement for nitrate aerosol mass concentration is somewhat mixed (within a factor of 2, significant scatter, bias both high and low, see Fig. 2 of Bellouin et al. (2011)).

2)

Regarding novelty, the referee makes several helpful suggestions that we are open to including in the final version of the paper. For example, a detailed analysis of LWP and other parameters would be useful, as would an understanding of the temperature anomaly differences between RCP6.0 and RCP8.5. However, we feel that the referee has severely understated our work in several cases. There is more to the study than simply adding more RCPs, including a thorough regional analysis (not seen in previous papers), different (new) climate response parameters, comparison of aerosol-driven forcing with total forcing (new), etc. While the RCPs aerosol and precursor emissions are quite similar at least on the global scale, we were careful to point out differences and how those differences affect AOD, forcing, and climate response. For example, the relative effects of the aerosol-driven climate response are quite different between the RCPs and this is shown in Sect. 4.1.3. Regional differences are discussed in Sect. 4. We also note in the conclusions as well as in the main text the "mid-century variation in the climate response and radiative forcing trajectories" and discuss reasons why (i.e. elimination of coal energy use in RCP2.6, mid-century increase in coal energy in RCP6.0, etc.). Regarding the IPCC FAQ 7.2, the referee may be referring to this

sentence ("It is projected, however, that emissions of anthropogenic aerosols will ultimately decrease in response to air quality policies, which would suppress their cooling influence on the Earth's surface, thus leading to increased warming."). To consider this statement as "the conclusions of our study" as the referee does unfairly understates our contributions. We would like to emphasize some of our more novel conclusions and point out that these are mentioned in the abstract, intro, and/or conclusions:

- 30-40 percent of warming in 2100 in East Asia under RCP8.5 could be from aerosol decreases
- Region-by-region analysis of climate response, including 2-3 K for East Asia, 10 K for the Arctic
- Climate response and radiative forcing trajectories closely follows the aerosol and precursor emissions trajectories (and thus the energy use trajectories), even for climate parameters such as liquid water path and cloud droplet effective radius.
- Spatial-temporal correlations (or anti-correlations) between changes in aerosols and changes in climate response.
- Good agreement with previous studies on the effects of decreasing aerosols on climate

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