

## ***Interactive comment on “Robust observational constraint of uncertain aerosol processes and emissions in a climate model and the effect on aerosol radiative forcing” by Jill S. Johnson et al.***

### **Anonymous Referee #1**

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This manuscript investigates the constraint on aerosol forcing uncertainties by observations of aerosol mass, number, and optical depth. The manuscript builds upon earlier work from the authors using statistical fits of climate model simulations in order to fully sample the uncertainty space of many (27) uncertain aerosol parameters in the model. The authors use the observations to determine which portions of the parameter space provide poor agreement with the observations and can be ruled out. They then determine how much this narrows the direct and cloud-albedo indirect forcing uncertainty ranges.

I feel this paper is ready for publication in ACP once several minor comments have

C1

been addressed.

P6 L5: Have the authors thought about how much additional information would be added if they had the simulations/emulators built over all of the years with observations such that observations could be compared with the same month-year? What if the exact days/times could be compared? Certainly each of these steps requires a jump in computational investment, so it doesn't make sense to add here. But if the authors have ideas about how much it could help, it would be an interesting thing to discuss (perhaps in the conclusions?).

P6: At least some of the PM<sub>2.5</sub> networks where sulfate concentrations were taken also have OC or OA. Why was OA from those sites not used (e.g. IMPROVE)?

P12 L11-12: The incorrect model year relative the measurement year could also cause this mismatch, right? I could imagine this being a big issue for regions with significant biomass burning emissions, which have significant interannual variability.

Figure 6: I appreciate the challenge in creating this figure. Is there any way that it can be made more crisp. The combination of very small fonts and rough resolution makes it very hard to read (at least when printed).

P18 L31: Need to say “northern-hemisphere winter” here (it's said in the next sentence), but it should be clear when “winter” is first used.

P19 L13: Is nitrate not included at all in the simulations? It seems like that could throw things off a lot (which is I guess what you're saying). It would be good to make it clear that nitrate was not included (if it's not) or if it's just incorrect.

Have the authors looked at how much the observations impact the direct aerosol \*effect\* (the radiative effect of natural and anthro aerosols relative to no aerosols) rather than the radiative forcing? I wonder how different the level of constraint would be. This isn't necessary for the paper unless the authors can do this quickly and agree that it's interesting.

C2

