Review Zhang et al.

I only have some clarification issues with this paper. It is a straightforward discussion of aerosol impacts in the E3SMv1 model, with only slight insights (i.e. few explanations of why they find the things they find). It would be a better paper if at least some possibilities for why they obtain the results they do, together with graphs/results added to show why they believe these are the causes of their results. I list below areas where clarification is needed.

Line 12-14: Strange that you say there are linear relations from 1870-2014, while the linear relations diverge after 1970. Do you mean the slope of the linear relationship changes after 1970?

Line 16-17: you need to explain that the increase in radius is stronger than would be predicted by the increase in LWP, here.

Line 19-20: How much does sulfate affect ice clouds through homogeneous nucleation? This is normally a very small change. Where is this discussed/shown in the manuscript?

Line 121-123: The observed standard deviation of updraft velocity within warm stratiform clouds is 0.5 m/s (Paluch and Lenschow, 1992), so employing a lower bound of 0.2 m/s is too high. What study has been done to justify this as compensation for the potentially underestimated turbulence strength?

Line 140-144: what is the justification for the threshold is used for sulfate aerosols? Is this a tuning decision? If so, this should be stated and explained. In typical parcel model simulations, particles smaller than 50 um can nucleate ice, depending on the updraft velocity.

Line 172: delete “the” in “the emission”

Line 176: Dust and sea salt are also not evaluated in the simulations. What is the reasoning for this choice?

Line 213: change “While” to “, while”

Line 208: here it states that BC is scaled by a factor of 10, but the figure states that it is a factor of 5. Which is correct?

Line 222-223: you state that anthropogenic sulfate affects the dust life cycle, which seems correct, since it can coat dust, causing more removal by precipitation. However, it seems here that dust decreases when sulfate decreases, which is opposite to my intuition. You casually explain that this is through sulfate causing changes in surface winds and moisture, with no explanation of how or why this occurs. Please add this explanation, and why these indirect effects would be larger than the one I mention above.

Figure 3 caption, line 1: marine organic aerosols are also excluded.

Line 229-231: How do changes in dust cause changes in carbonaceous aerosols? Please restate

Figure 5 cation states " Simplified names (E removed) are used. But E is not removed in any of the figure headings.

Figure 6 and discussion: please explain whether a minimum Nd is applied (and why).

Line 322-323: the inference from figure 7 (comparing 7b and 7c) and from Figure 8b is that Nd decreases in response to increasing CCN after 1970. Does the previous sentence explain this somehow?

Line 354: are the reported ΔlnLWP, ΔlnIWP, and cloud optical depth grid-average values or in-cloud values?

Line 384-386: please explain how sulfate aerosols are calculated. Since the aerosol model only treats sulfate mixed with other species, how is sulfate aerosol calculated such that homogeneous nucleation can occur? Or, is there no homogeneous nucleation of cirrus clouds? Or is the effect of sulfate here mainly the result of sulfate deposition on and mixture with, for example, dust aerosol?

Line 396-399: You might explain that F and F_{clean} both include thee indirect effect, so this difference assumes that the indirect effect is the same in F and F_{clean}.

Line 466-471: what is the physical reasoning behind the choice of the threshold size of sulfate aerosols (and how are sulfate aerosol sizes determined?) or is this choice just tuning? What in particular is tuned? Was the SW or LW forcing too high compared to other models otherwise?

Line 541-542: How do BC aerosols weaken vertical motions? How do they reduce high-cloud amounts? Why is this sentence here in the conclusions, even though it is not discussed in the paper?

Line 558-560: There is no improvement of natural aerosol emissions that is likely to improve the calculation of ERF_{aer} as much as improving physical processes (i.e. enhanced mixing at cloud top) especially since the model is unlikely to be able to reproduce the darkening expected when aerosols increase as seen in observations (see Zhang, Zhou, Goren, Feingold, ACP, 2022). It is better to understand why one approach vs the other would be a better next step.