This is a very interesting study, in a sense that it lets the reader take away with motivating-unresolved questions rather than answers. To briefly summarize the study, the authors apply an innovative diagnostic technique, that was recently developed to use on satellite observations, to a climate model (E3SMv2) in which they can turn off/down/up parameterized processes related to aerosol-cloud interactions (ACI). They conclude that spatial correlations between Ac and Nd from either clean or polluted climate states fail to predict a change in Ac from direct perturbed-control climate simulations (i.e., present-day versus pre-industrial).

After reading the manuscript, I take away three key points from this work:

- Present day Ac-Nd small-scale spatial correlation (regression slope) is completely opposite between E3SMv2 and satellite observations, which remains an open-question to be resolved.
- The process sensitivity experiments confirm that spatial regression method ("the innovative diagnostic technique" that has been used in satellite studies to infer cloud albedo susceptibility) is indeed providing process level understanding, as turning off/down/up sensitivity parameters in E3SMv2 does change spatial-regression derived susceptibilities in the direction that one would expect from physical understanding of ACI.
- Even in a "world" with no precipitation-suppression mechanism and quadrupled sedimentation-entrainment feedback, a polluted climate simulation still possesses brighter clouds than a cleaner climate simulation, a response that is in the opposite direction of our physical expectation. This remains an open-question as well.

The manuscript is very well written in a super concise and direct way. As a reviewer and someone who works in the direct field, I appreciate the clear and concise writing which made the reviewing process very efficient! That being said, from a general ACP reader perspective, I think some necessary contexts, descriptions, and discussion remain to be added.

I think this research is highly worthy of publication, but I do have some concerns and questions that I think the authors should address first.

**Major comments:**

- Regarding the sensitivity experiments on sedimentation (or scaling fall velocity), I am quite confused. First, are you turning off/up/down (or scaling) the sensitivity of droplet fall speed to drop size or the actual fall velocity for all drops? If latter, I don't think it makes sense as it affects all drops with different sizes in the same manner and your size-dependence is not affected, plus how would quadrupled fall speed for all drops and thereby sedimentation flux lead to enhanced size-dependence of sedimentation (the essence of sedimentation-entrainment feedback). If former, 4 times the sensitivity of sedimentation to drop size leads to enhanced entrainment driven darkening potential makes perfect sense to me. However, I suspect that's not the case as I was totally lost in the statements between lines 147-153.
- In general, although I appreciate the stimulating questions raised by this work, I feel that the authors should provide some of their interpretations and/or speculations at the very least in a *Discussion* section.

- Regarding the present-day Ac-Nd spatial correlation comparison between E3SMv2 and satellite, an "apple-to-apple" comparison in my view, I wonder if it is related to the representation of the stratocumulus deck in E3SMv2? Are these clouds precipitating under conditions we expect them to precipitate? Could you show the simulated maps of cloud field and probability of precipitation? What can possibly lead to the completely opposite susceptibility pattern in the LWP-Nd space (no matter causal or dur to confounding), this troubles me quite a lot, some speculations would help, I think.
- Regarding the result that Ac-Nd spatial correlation do not predict the PD-PI experiment, an "apple-to-orange" comparison in my view, first, when you say "…everything else being held constant" (lines 161-162), does it imply no circulation changes can be attributed to the brightening signal (by keeping the exact same meteorology all the time)? does it mean there is absolutely no other feedbacks (large-scale) contributing to this brightening? If so, is it possible that the cloud regime totally changes between PD and PI and you are comparing stratocumulus (in PD) to cumulus (in PI) (for example, perhaps?) I think showing the actual cloud field in PI and PD simulations would help a lot.
- The main conclusion relies on the assumption that the simulate PD-PI results represent the true aerosol effect, but without these above mentioned feedbacks, to what extent do you think this assumption is robust?
- I think in the *Discussion* section, the fundamental difference between climate simulations and satellite observations should be discussed, in a sense that what should we expect when we see a difference in Ac-Nd spatial correlations between observations and simulations. Also, to some extent, we expect the PD-PI simulation from GCMs to overestimate cloud brightening, compared to observations.
- Does this configuration of your model produce an inverted-V LWP-Nd mean-state relationship for the NE Pacific?

**Minor comments:**

- I do not quite get the (main conclusion) statement of "present-day correlations constrain cloud albedo change by anthropogenic aerosols." Essentially, you have <u>one</u> simulated albedo change that the present-day correlation failed to predict. So, I would recommend rephrase this statement.
- Line 56, what's vertical grid spacing in this configuration? Do you need to refine it to capture the observed stratocumulus field in this region?
- Lines 73-74, does this mean you have to force the winds and large-scale circulation to PD conditions and if so, does this creates an energy imbalance in the simulation?
- Line 81, even limited to only daytime, you would get some variations in susceptibility (as has been shown between Terra and Aqua observations), I don't think it will change the conclusion, but just curious about whether you see variations in susceptibility between morning and afternoon?
- Line 88, what is the purpose of this minimum insolation of 575 $Wm^{-2}$ threshold? Related to solar zenith angle?
- Figure 2, before I was about to post this report, I saw the reply made by the authors to the 1st reviewer, and I realized this figure has been updated.

- Lines 185-187, I think some contexts are needed for “cloud seeding proposals” “marine cloud brightening” for a general reader.
- All figures, perhaps roughly indicating an effective radius isoline similarly to Zhang et al. (2022) and Zhang & Feingold (2023) helps to discern the LWP-Nd region with high likelihood of precipitation?