Responses to Reviewer 1 for *Assessing the potential efficacy of marine cloud brightening for cooling Earth using a simple heuristic model* by Robert Wood.

Reviewer comments in black; responses in red

The manuscript investigates the potential of marine cloud brightening (MCB), a geoengineering approach to mitigate global warming by the artificial seeding of clouds with sea salt aerosols to increase their albedo. By developing and applying a heuristic MCB model, the author is able to constrain the effect of various important MCB parameters (the total mass of injected aerosol, the size of the injected aerosol particles, and their number). After that, the author uses these results to discuss implications for other fields currently involved in assessing and developing potential MCB projects (engineering, climate modeling, and large-eddy simulations).

Considering the increasing interest in MCB, not only in science but also in governmental and nongovernmental organizations, this manuscript is highly relevant. Moreover, it is very interesting, well written, and I have only very minor comments, which the author may want to consider. Accordingly, I do not need to see the manuscript again and fully support its publication in Atmospheric Chemistry and Physics.

I thank the reviewer for their time spent reading and reviewing. I provide detailed responses below.

Minor Comments

Ll. 47 – 49: A recent paper by Glassmeier et al. (2021) vividly illustrates that the sign of LWP adjustments depends not only on the meteorological conditions but also on the number of aerosol particles, causing positive adjustments when the aerosol number is small and negative adjustments when the aerosol number is large. While I agree that the magnitude of these negative adjustments is probably meteorology dependent, the general trend caused by the number of aerosol particles is probably very relevant to the efficiency of MCB. Therefore, I suggest a short discussion of this effect.

Additional sentences are added to the introduction to discuss this result.

Ll. 49 – 51: Shortly before Ackerman et al. (2004), Wang et al. (2003) also discussed negative LWP adjustments.

Excellent point. A citation to Wang et al. (2003) has been added in this location.

Ll. 63 – 65, 620 – 630: In all discussed MCB spraying apparatus, seawater droplets and not aerosol particles are injected into the atmosphere. Since the seawater droplets are slightly larger than aerosol particles, Brownian coagulation might be slower than estimated here.

Adjusted text slightly. The Brownian coagulation kernel is not strongly dependent upon particle size over the range 75-150 nm (it drops by 30% over this range), but the point is well-taken, and a sentence has been added to the manuscript. The particle equilibration time in the sprayer is uncertain.

Ll. 177 – 187: While I believe that I understand what the author is doing here, the last sentence confuses me. I assume that Eq. (4) results from an optimization problem based on MODIS data but not fitting satellite observations. Please clarify.

The idea is to adjust the cloud cover used in the heuristic model to account for the fact that if only a small region is sprayed, one would choose this to be in a region with the highest climatological cloud cover (i.e. subtropical Sc decks). If a greater region is sprayed, the choicest regions have already been taken, so less optimal regions with lower amounts of cloud have to be sprayed. By stacking up the 10x10 degree boxes according to their monthly mean cloud amounts, we can determine the mean low cloud cover as a function of the fraction of ocean sprayed.

Mathematically, if the pdf of low cloud cover is p(f), and the sprayed area fraction (f_{spray}) includes only boxes with cloud cover in excess of some value f_*, then one can write:

$$f_{\mathrm{spray}} = \int_{f_*}^{1} p(f)\, df$$

The mean low cloud in these regions is f_{low} given by:

$$f_{\mathrm{low}} = \int_{f_*}^{1} f p(f)\, df$$

Thus, f_{low} can be related to f_{spray} via the parameter f_*. Eqn. 4 is determined as a fit to the MODIS data presented in this parametric fashion.

Ll. 279 – 301: Choosing a Poisson distribution to parameterize track overlap is probably the right choice. However, as long as the spraying vessels do not move, I would assume that tracks are parallel since they are all inside the same boundary layer. Of course, these tracks might overlap if a spraying vessel is directly leeward of a second.

The Poisson distribution seems to work similarly even if the tracks are all aligned and overlaps come from sprayers that are too close laterally or are leeward of each other. I was somewhat surprised by this result. I have not yet found a way to use a Poisson type approach if the tracks themselves are not uniform (which we know they are clearly not given that they spread from a point source).

L. 293: Maybe one should note that n is integer.

Done

Ll. 473 – 474: I assume the generally larger size of natural sea spray particles is responsible for their shorter lifetime compared to injected sea salt particles. One should state this clearly.

This is now stated.

Technical Comments

L. 166: I assume that this should be ϕ!"# and not f!"#.

Correct. Thanks. This has been changed in the revised manuscript.

References

Ackerman, A. S., Kirkpatrick, M. P., Stevens, D. E., & Toon, O. B. (2004). The impact of humidity above stratiform clouds on indirect aerosol climate forcing. Nature, 432(7020), 1014-1017.

Glassmeier, F., Hoffmann, F., Johnson, J. S., Yamaguchi, T., Carslaw, K. S., & Feingold, G. (2021). Aerosol-cloud-climate cooling overestimated by ship-track data. Science, 371(6528), 485-489.

Wang, S., Wang, Q., & Feingold, G. (2003). Turbulence, condensation, and liquid water transport in numerically simulated nonprecipitating stratocumulus clouds. Journal of Atmospheric Sciences, 60(2), 262-278.