Response to Reviewer #2

We thank the reviewer for taking the time to review our manuscript, and for their supportive comments.

Note that in between the time of submission and now, two more ensemble members of the 60N constant injection simulation became available, so we redid the analysis with these instead of the Arctic High simulation. This did not change any of the conclusions, but we now have 3 ensemble members of each of the seven strategies used in this study. Figures and results have been updated accordingly.

Brody and coauthors provide a novel and useful analysis of design space of stratospheric aerosol injections in CESM2-WACCM. Specifically, it is interesting to see the trade-offs between optimizing temperature and precipitation responses extends to the pattern of response when designing SAI interventions, in addition to the well known trade offs in the global mean responses. The manuscript is well written and is largely ready for publication. However, I believe the analysis would be benefit substantially from a more rigorous assessment of the uncertainty due to natural variability. I am concerned that internal variability presents a significant constraint on the ability to optimize climate responses that must be quantified. Particularly when computing the sum of anomalies, the noise in the pattern can increase substantially as the number of signals being combined is increased (i.e., the sum of variances than the mean of variances). One approach may be to compute the Pareto front with all 18 possible combinations of individual ensemble members from each of the existing strategies. This could be used to generate a "cloud" of such Pareto fronts and uncertainty ranges for the dots in Fig. 6 and 8.

Good idea! Showing the pareto fronts generated by individual ensemble members is the sensible complement to showing the individual ensemble members of the simulated strategies. Note that the background emissions in the three individual ensemble members of SSP2-4.5 simulations are not exactly the same, so SAI simulations corresponding to different SSP2-4.5 ensemble members do not share the same background emissions and are not directly comparable. However, we have compared the pareto fronts generated by the individual ensemble members in the same ensemble (i.e., one for the 1st ensemble, one for the 2nd ensemble, and one for the 3rd ensemble), and concluded that there always exist better strategies than the existing ones.

The right plot in Figure 1 is what it looks like with the pareto front generated with each of the ensemble individually, shown as black triangles. As you can see, the spread is rather large compared to the distance between the pareto front and existing strategies, suggesting that the results of optimization may not be significant.

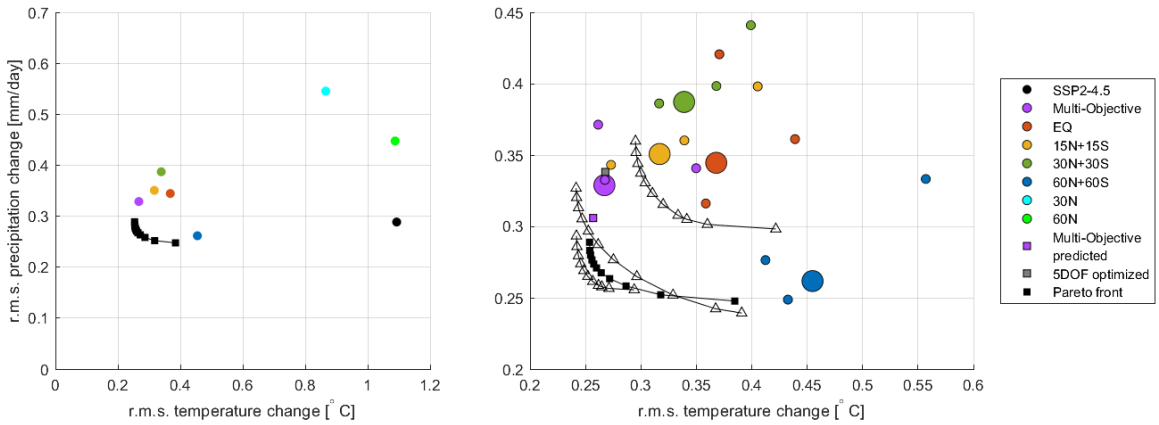

Figure 1. Pareto Front of ensemble means (left) and Pareto Front of individual ensembles (shown as black triangles) (right).

Figure 2 is what it looks like with each ensemble member of the existing strategies and pareto front shown on its own panel. The locations of simulated strategies and the pareto front are different in each panel, but the pareto front is closer to the origin than the existing strategies in each panel. This suggests that although there is a large spread in the resulting climate with each strategy, there are always better strategies than the existing ones.

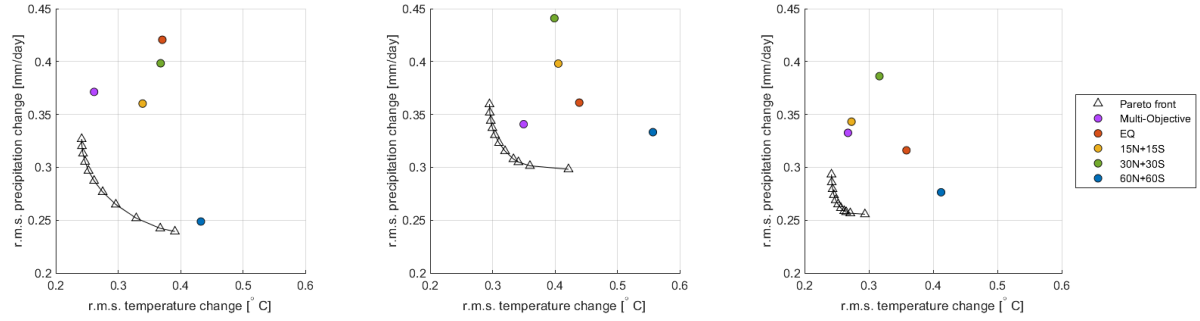

Figure 2. Pareto Front of the optimized strategies using individual ensembles in the (a) first ensemble, (b) second ensemble, and (c) third ensemble, compared to the simulations of the existing strategies in the same ensemble.

Additional minor comments follow.

- Line 4: "latitudes of injection" -> "latitudes and altitudes of injection"

We specifically don't look look at varying altitudes, as it doesn't significantly change the resulting climate pattern, only the amount of injection needed to achieve that pattern (Zhang et al. 2022)

- Line 5: ", managing up to" -> ". For example, managing up to"

We will make this change.

- Line 113:" the Atlantic Meridional Overturning Circulation" -> "rate dependent responses, such as the Atlantic Meridional Overturning Circulation (Hankel 2024)". Hankel, C. 2024 https://www.pnas.org/doi/abs/10.1073/pnas.2411357121

We will make this change.

- Line 205-206: How is the standard error computed? Is is computed using variance across an initial condition ensemble?

Standard error is computed using annual-mean values from each of the 20 years from 2008-2027 in each of the 3 ensemble members of the SSP2-4.5 (without SAI) simulation. Autocorrelation correction is applied to account for the fact that consecutive years are not fully independent.

- Line 370: "at low cooling" -> "at lower cooling"

We will make this change.

- Line 403: "greater accuracy" -> "greater precision"

We will make this change.

- Fig 6,8,9: I assume since the 1C cooling is the reference point, the overall emission magnitude can change? It would be useful to see total emissions would help see if there are overall SAI efficiency differences between the optimizations

This is a good idea. I'll add a "total" line to these plots.