

Dear Editor,

We sincerely thank the three reviewers for their constructive comments and helpful suggestions on our manuscript entitled “*Assessing the Impact of Solar Climate Intervention on Future U.S. Weather Using a Convection-Permitting WRF Model*” (Paper No. egusphere-2025-3490), submitted to *Geoscientific Model Development*. Their comments have helped improve our paper. We have submitted a revised version of the manuscript in both **track-changes** and **clean (non-track-changes)** formats. Our responses to each reviewer comment are provided in **blue** beneath the corresponding feedback, with line numbers referring to the revised clean (**non-track-changes**) version.

In addition to addressing the reviewers’ comments, we have made several substantive changes to improve the clarity and presentation of the manuscript:

1. **Figures:** Following the suggestions of Reviewers #1 and #3, we have moved Figure 1 to the Supplement and added the term *anomaly* to Figures 4–7 for clarity. We also updated Figure 9 with thicker coastlines and state boundaries and corrected a minor issue in Figure 10 that affects only values near $x = 0$ and does not change our conclusions.
2. **Supplementary Figures:** In addition to the new Figure S1 (formerly Figure 1), we have added two supplementary figures (Figures S4 and S5) in response to suggestions from Reviewers #2 and #3.
3. **Clarifications and Discussion:** Based on feedback from all three reviewers, we have added substantial clarifications and expanded discussions of the methodology and interpretation of the results.

We appreciate the reviewers’ thoughtful feedback and thank the editor for considering our revised manuscript for publication.

Sincerely,

Lantao Sun, James W. Hurrell, Kristen L. Rasmussen, Bali Summers, Erin A. Sherman, Ben Kravitz

Reviewer #1:

Reviewer #1 Evaluations:

This study examined potential effect of SAI on future convective storms over the conterminous United States. The authors utilized global climate model (CESM) simulation results of stratospheric aerosol injection (SAI) to drive the mesoscale regional weather model, WRF. Two sets of ensemble SAI simulation results are used: GLENS and ARISE. The CESM simulated climate change are added to ERA5 data to drive WRF with a horizontal resolution of 4km. The novelty of this study lies in the fact that only a few studies examined the effect of SAI on the thermodynamic environments relevant to weather pattern, and no studies have examined how SAI would affect mesoscale weather using a convective permitting weather model. This study found that SAI could mitigate warming, extreme precipitation, and intense convective activities. I recommend publication after the following comments are addressed:

Response: We thank the reviewer for the careful summary of our study and the positive assessment of its novelty and significance. We appreciate the constructive comments and suggestions. Below, we provide detailed responses to the comments raised, which have helped improve the clarity of the revised manuscript.

Lines 35-38: It might not be appropriate to emphasize a single country's policy in a scientific paper that is not devoted to policy discussion.

Response: We agree with the reviewer that emphasizing a single country's policy is not appropriate in this context. We have therefore rephrased the sentence to remove the specific U.S. framing and to focus on the broader scientific discussion of solar climate intervention.

Revised sentence (Lines 35-37):

“Solar Climate Intervention (SCI), also referred to as solar geoengineering or solar radiation management, has been the subject of growing scientific investigation in the context of climate change (e.g., NASEM 2021; Patrick et al. 2022; The Royal Society 2025).”

Reference:

National Academies of Sciences, Engineering, and Medicine: Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance, Washington, DC, The National Academies Press, 2021. <https://doi.org/10.17226/25762>.

Patrick, S. M.: Reflecting Sunlight to Reduce Climate Risk: Priorities for Research and International Cooperation, Council Special Report No. 93, Council on Foreign Relations, New York, USA. 2022. Available at: <https://www.cfr.org/report/reflecting-sunlight-reduce-climate-risk>.

The Royal Society: Solar Radiation Modification: Policy Briefing. The Royal Society, London, UK. 2025. Available at: <https://royalsociety.org/news-resources/projects/solar-radiation-modification/>.

Lines 51-52: It would be helpful to briefly describe the experiment design and strategy for GeoMIP and GLENS simulations. This is important because all climate response to SAI would be dependent on the SAI strategy.

Response: We have added additional descriptions for GeoMIP and two Geoengineering large ensembles (Lines 53-57).

Lines 70-77: It's a bit unconventional to have a 'result' figure (Figure. 1) in the Introduction part.

Response: We originally included this figure to help motivate the use of high-resolution WRF simulations by illustrating changes in the convective environment. However, we appreciate the reviewer's comment and have now moved the figure to the Supplementary Material.

Line 103: What is 'delta signal' ? This should be elaborated more.

Response: "Delta signal" refers to the climate change signal derived from global climate model projections. It is calculated as the climatological difference between a future period and a baseline period. We have revised the text to explicitly define this term and clarify how it is applied in the regional model configuration (Lines 97-100).

Lines 104-105: "This results in future thermodynamic environments for the same weather events simulated in the control run." I don't quite understand this sentence. Please rephrase.

Response: Thanks for pointing this out. In the PGW framework, the imposed climate change signal modifies the mean thermodynamic structure while preserving synoptic-scale conditions that are very similar to those in the control simulation. This allows PGW simulations to isolate how the same weather events may evolve under a warmer climate. An example of this behavior is shown in Fig. 8 of Dougherty and Rasmussen (2020). We have rephrased the sentence in the revised manuscript to clarify this point at Lines 100-102.

Reference:

Dougherty, E., and Rasmussen, K. L.: Changes in flash flood-producing storms in the U.S., *Journal of Hydrometeorology*, 21, 2221–2236, <https://doi.org/10.1175/JHM-D-20-0014.1>, 2020.

Line 191: What is the horizontal resolution for ERA5 reanalysis and ARISE and GLENS output? I believe some data interpolation have been done before adding simulated climate change signal to ERA5. This information would be useful.

Response: That is correct. ERA5 reanalysis has a horizontal resolution of approximately 25 km, while the ARISE and GLENS outputs have horizontal resolutions of approximately 100 km. During WRF preprocessing, both datasets are interpolated to the 4 km WRF grid. We have clarified this in the revised manuscript at Lines 191-193.

Line 206: How to modify relative humidity? Please explain

Response: Relative humidity is perturbed using the same delta approach applied to the other variables. Specifically, we calculate the climatological difference between the future and baseline periods (2015–2024 and 2060–2069) and add this delta change to the ERA5 reanalysis for the initial and boundary conditions. Following Brogli et al. (2023), we perturb relative humidity rather than specific humidity. We have clarified this procedure in the revised manuscript (Line 208).

Line 276: Stratospheric aerosol absorb infrared and longwave radiation.

Response: Completely agreed! We have revised the sentence to clarify that stratospheric aerosols absorb both shortwave and longwave radiation (Line 275).

Line 366: What is ‘RR’ in equations (1) and (2)?

Response: “RR” refers to the radar reflectivity range used in each WRF simulation. We have clarified this in the revised manuscript (Line 376).

Reviewer #2:

Reviewer #2 Evaluations:

The manuscript titled “Assessing the Impact of Solar Climate Intervention on Future U.S. Weather Using a Convection-Permitting WRF Model” aims to examine the impact of SCI on severe storms over the contiguous United States, by developing a pseudo dynamical downscaling technique and applying it in parallel to the global warming and climate intervention simulations. The methodology is novel in its application and the results are sound. I therefore recommend acceptance of this study after addressing the following issues:

Response: We thank the reviewer for the careful summary of our study and the positive assessment of the methodology and results. We appreciate the constructive comments provided below and address them in detail. We believe that the revisions have improved the clarity and quality of the manuscript.

1. Please provide the necessary details about the WRF simulation, for example, how many ensembles are run for each scenarios? Are they all using the same initial boundary conditions? What are the starting and ending date of each ensemble, March to August?

Response: Thank you for these suggestions. We have added additional details on the WRF simulations in the revised manuscript. Both the PGW and PSAI simulations are conducted as single-member runs. Each simulation is initialized on 1 March 2011 and integrated through 31 August 2011, using perturbed initial and boundary conditions derived from the global climate model projections.

Single-member simulations are standard practice for PGW studies (for example, Rasmussen et al. 2017; Rasmussen et al. 2023; Dominguez et al. 2024), and this protocol is followed here. We also recognize the usefulness of ensemble simulations for quantifying internal climate variability. To address this, we have conducted ten-member PGW and PSAI ensembles by using individual ARISE members as boundary forcings. Due to computational limitations, these ensembles were performed only for the April 2011 tornado super outbreak. These ensemble simulations help characterize the internal variability in convective environments across global climate models and how this variability influences the population, intensity, and frequency of convective storms. We have rewritten the last paragraph in Section 5.2 to discuss this effort.

Changes added to the manuscript:

Line 189: “single-member”

Line 190: “single-member”

Revised Section 5.2 last paragraph:

“More in-depth scientific results will follow. For example, we find that the changes in the occurrence of each reflectivity range exhibit clear seasonal variability (Figure S5). It will therefore be interesting to further investigate the seasonality of the results as well as the underlying mechanisms. In addition, we are conducting a parallel study focused on the influence of SAI on the super tornado outbreak of 25-28 April 2011 (Summers et al. 2026), including additional

ensembles forced by individual global climate model members of future projections to explore the role of internal climate variability. Further PGW and PSAI simulations are underway to extend the analysis over a longer period of record.”

Reference:

Summers, B., Rasmussen, K., Hurrell, J. W., Sun, L., and Yu, H.: Future projections of the 2011 super tornado outbreak under global warming and stratospheric aerosol injection, submitted to *Earth's Future*, 2026.

2. Please describe in more detail the pronounced difference between the observations, the CESM, and WRF outputs, i.e., the warming/cooling and drying model biases in your study region (Figure 8 in linking to Figure 4), and discuss how would the difference affect your results.

Response: The WRF control simulation exhibits a warm and dry bias over the central United States, consistent with previous WRF-based studies (for example, Liu et al. 2017; Rasmussen et al. 2023). Because this bias is present in both the control and the corresponding PGW and PSAI simulations, the imposed climate change signal itself is likely less affected. However, earlier research has shown that the spread in global climate model future projections can be influenced by differences in the basic state, motivating efforts to use emergent constraints to quantify these relationships (Hall et al. 2019). Therefore, the biases identified here may contribute to uncertainty in the projected future changes with and without SAI.

It is very challenging to use original Figure 4 directly to explain the differences shown in Figure 8, because both WRF and CESM exhibit biases relative to observations. In addition, CESM and WRF have different physical configurations, so even with identical forcing their responses may not be identical. Nevertheless, the similarity in the large-scale temperature patterns shown in Figure 8 suggests that WRF is able to reproduce the broad environmental changes simulated by CESM when driven with consistent boundary conditions. We have incorporated these points into the final paragraph of Section 4.1 (Lines 298-301).

Reference:

Hall, A., Cox, P., Huntingford, C. *et al.* Progressing emergent constraints on future climate change. *Nat. Clim. Chang.* **9**, 269–278 (2019). <https://doi.org/10.1038/s41558-019-0436-6>

3. Figure 9, please consider use the log-scale for Y-axis, so that the results are more distinguishable.

Response: Thanks for the suggestion. The Y-axis in original Figure 9 is already displayed in log-scale.

4. The region in Figure 10, i.e., the central America is where WRF show strong discrepancy (biases) from either the observation and the CESM results. Please discuss and justify how reliable these results are.

Response: We have added discussion in Section 5.2 noting that WRF biases in this region may contribute to uncertainty in the simulated storm activity and its projected changes. While these biases likely affect the quantitative magnitude of the response, a detailed investigation of the underlying mechanisms is beyond the scope of this methodology-focused study. We acknowledge this limitation in the revised manuscript (Lines 451-452).

5. Please provide some seasonal breakup results, for example MAM and JJA, especially for the storm activities. Discuss the similarity or difference of SAI mitigation effect, and the potential mechanisms.

Response: Thank you for the great suggestions. Figure R1 shows the June-July-August changes in the occurrence of each reflectivity range over the full domain (left) and the Eastern U.S. (right). In contrast to the March-April-May results (formerly Figure 12), the convective activities in June-July-August are more complex and exhibit seasonal differences. Further analysis is needed to understand such seasonal difference and the underlying mechanisms.

Since the focus of this paper is to introduce a methodology, not on detailed analysis on convective storm activities and their underlying mechanism, we added this figure to supplementary material with corresponding discussions in the last paragraph of section 5.2 (Lines 460-462) to motivate further research.

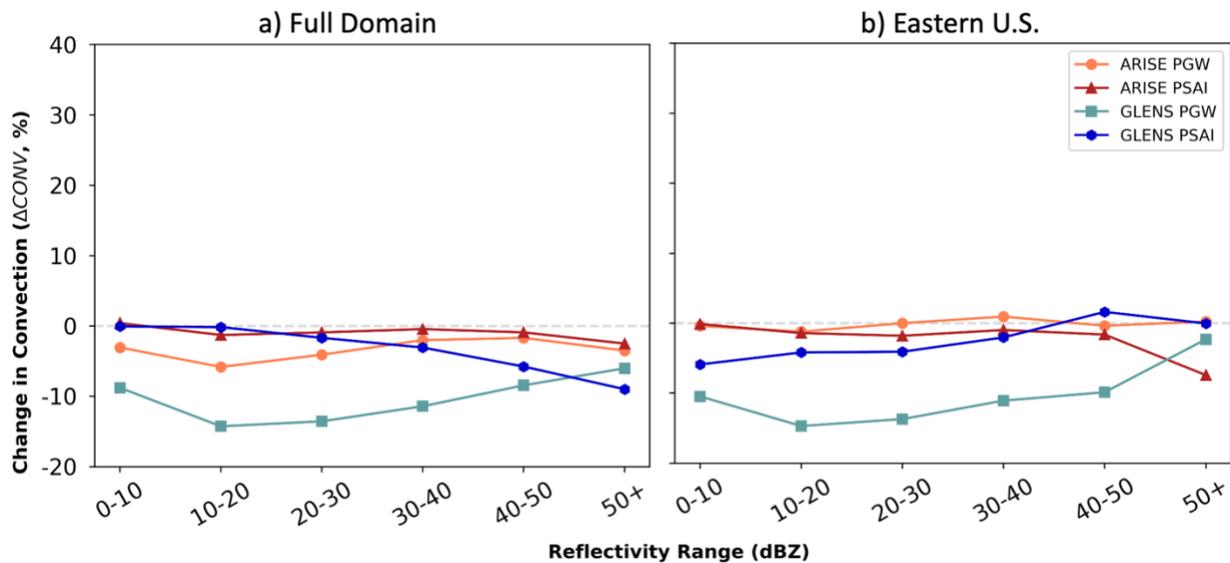


Figure R1: June-July-August changes in the occurrence of each reflectivity range over the full domain (left) and the Eastern U.S. (right). The total number of occurrences within each reflectivity bin is summed over each domain, and ΔCONV is computed following Eqs. (1) and (2). This metric represents the percentage change in convective population in the PGW and PSAI simulations relative to the control simulation, shown as a function of radar reflectivity range (dBZ).

6. The use of “March-August 2011” in Table 2 and the caption of Figure 11 may cause unnecessary confusion. Please setup a specific subsection describing this “case study”, by providing comprehensive information about all the storms occurred during this 6-month period, where individual event like the tornado super outbreak occurred, the intensity of these storms, etc. Then

come up with a better naming of this “psedo event” under global warming and SAI-mitigated scenarios.

Response: We appreciate this suggestion and agree that a detailed case study analysis can provide valuable insight. We are conducting a parallel study focused on the influence of SAI on the U.S. super tornado outbreak of 25–28 April 2011, and a manuscript titled “Future Projections of the 2011 Super Tornado Outbreak Under Global Warming and Stratospheric Aerosol Injection” has been submitted to *Earth’s Future*. In the present manuscript, however, our primary objective is to introduce and demonstrate the methodology for evaluating convective storms under the PGW and PSAI frameworks rather than to analyze individual storm events. For this reason, we use the March–August 2011 period to provide a statistical representation of environmental and storm-related changes without cataloging each severe convective event. We have clarified this motivation in Section 5.1 (Lines 412-415).

Reviewer #3:

Reviewer #3 Evaluations:

The authors have used existing ensemble simulations covering 2010-2099 of scenarios of future global warming and future global warming plus SAI to provide different lateral boundary conditions for the WRF regional model over the CONUS region. They do so to use a convection permitting model to examine the impacts on storms of a future world under global warming and SAI by simulating a single March-August period under 2011 conditions, global warming, and global warming plus SAI conditions. This pseudo global warming technique is not new, but the authors have extended it to SAI simulations and present some initial results.

The paper is well written and of interest to the scientific community. However, I have the following comments:

Response: We thank the reviewer for the clear summary of our study and the positive assessment of its relevance and contribution. We appreciate the constructive comments provided below and address each of them in detail. We believe that the revisions made in response to these comments have improved the clarity and quality of the manuscript.

General – There are several figures in the manuscript that are of little value (see detailed comments below), whereas the comparison of results from the global models and the WRF convection permitting model were not made clear for precipitation changes. I understand that some features of precipitation are known to be poorly modelled by global climate models and therefore some of the metrics may not work so well for those models. However, it would have been interesting to see the comparison, at least of the mean or perhaps a 90th percentile precipitation. Some discussion of how CESM implements SAI compared to how it is done in WRF (taking the extra AOD signal from CESM simulations) is required.

Response: Thank you for these thoughtful comments. We have taken several actions to address them:

- We have moved the original Figure 1 to the supplementary material as suggested.
- We have added a comparison Figure R2 of precipitation changes between WRF and CESM and included it in the supplementary material. Because hourly precipitation output is limited in the CESM simulations, we were unable to calculate the 90th-percentile precipitation.
- We have added further description of how SAI is implemented in CESM and how the corresponding aerosol perturbation is incorporated into WRF in a simplified manner.

Detailed comments:

Line 57-63: Can you briefly state the impacts on the hydrological cycle seen with previous studies.

Response: Yes. We have rephrased these sentences to briefly summarize the impacts of SAI on the hydrological cycle reported in previous studies (Lines 57-59).

Fig 1: This is showing NDSEV data that you have calculated from the ARISE and GLENS data and does not really give more insight than what you have described and what is shown in the Glade 2023 paper with MUCAPE, MUCIN, SO6, and CAPESO6 metrics. I feel this is not the place for this figure given that this is the introduction. Given that this paper is concerned with the CONUS region, it would be better to show this data averaged over the CONUS region for the WRF simulations as well as the original GLENS and ARISE simulations in the results section on precipitation. Alternatively, this figure as is could be moved to supplementary material.

Response: We agree with the reviewer that this figure is not essential in the Introduction. We have therefore moved it to the supplementary material.

Fig 2: This is simply showing the global mean temperature curves for the different ARISE and GLENS simulations which is published already and referred to in the text. Therefore, I don't believe this adds value to this paper. The amount of global warming by 2100 could be mentioned in the text.

Response: We appreciate the reviewer's comment. Although Fig. 2 presents previously published global mean temperature time series from Tilmes et al. (2018) and Richter et al. (2022), our intention was to provide visual context for readers who may be less familiar with the ARISE and GLENS simulations and to illustrate the baseline climate trajectories on which the PSAI framework is built. Because our methodology directly relies on these simulations, we believe that retaining this figure offers helpful background.

Fig 3: What is the red box?

Response: The red box denotes the eastern U.S. domain that is analyzed in subsequent figures. We have added a description to the caption to clarify this.

Fig 5: What is the vertical dashed line?

Response: The vertical dashed line indicates the zero extinction coefficient. We have added this description to the caption to clarify its meaning.

Line 238: This sentence is repeated in line 242.

Response: Thank you for pointing this out. We have removed the repeated sentence in the revised manuscript.

Line 260: I am not sure what is the novel simulation technique that you developed to allow comparison of current and future storms? The PGW technique has been used before.

Response: We agree with the reviewer that PGW is a well-established approach and the novel part of this paper is the introduction of the PSAI approach. The sentence has been rephrased (Lines 258-259).

Line 265-267: It would be better to have this just before section 4.1 as it applies to temperature and precipitation.

Response: Done.

All figures showing anomalies: can the captions and titles in the panels make it clear that these are anomalies. The caption describes how the GLENS and ARISE anomalies are calculated but not the WRF anomalies. Please add.

Response: Thanks for the suggestions. We have modified the Figures 4-7 (formerly Figures 5-8) to reflect anomalies.

Line 295: Could the extra surface cooling in GLENS-PSAI compared to GLENS-SAI be related to how SAI has been implemented in WRF compared to how it is done in CESM? I have not found a description of how it is done in CESM. Also, in CESM simulations there may have been changes in aerosol in the troposphere caused by the SAI which were not included in WRF. Please comment on this.

Response: We have added descriptions regarding how the SAI is employed in CESM, with more details referred to Tilmes et al. (2018) and Richter et al. (2022).

Regarding the extra surface cooling in GLENS-PSAI relative to GLENS-SAI, several factors may contribute. One possibility is that GLENS-PSAI produces more precipitation in the cooling region, whereas this signal is weaker in GLENS-SAI (Figure R2). These differences may arise from the distinct physical parameterizations in WRF and CESM. Differences in the implementation of SAI may also play a role, although the magnitude of this effect is unclear.

In CESM-SAI, the aerosol injection, microphysics, and stratospheric aerosol–chemistry–climate interactions are fully simulated. The aerosol extinction coefficient signal extends down to approximately 400 hPa (Fig. 4a), likely due to stratosphere–troposphere transport. In WRF-PSAI, we prescribe the CESM-derived aerosol optical depth anomaly down to 400 hPa to represent this influence. By contrast, we intentionally exclude the near-surface aerosol anomalies seen in CESM-SAI because they may not be directly linked to stratospheric aerosols. Including these additional near-surface anomalies in WRF would likely introduce further cooling.

In the revised manuscript, we have incorporated this information at Lines 127-128, 298-300, 312-314.

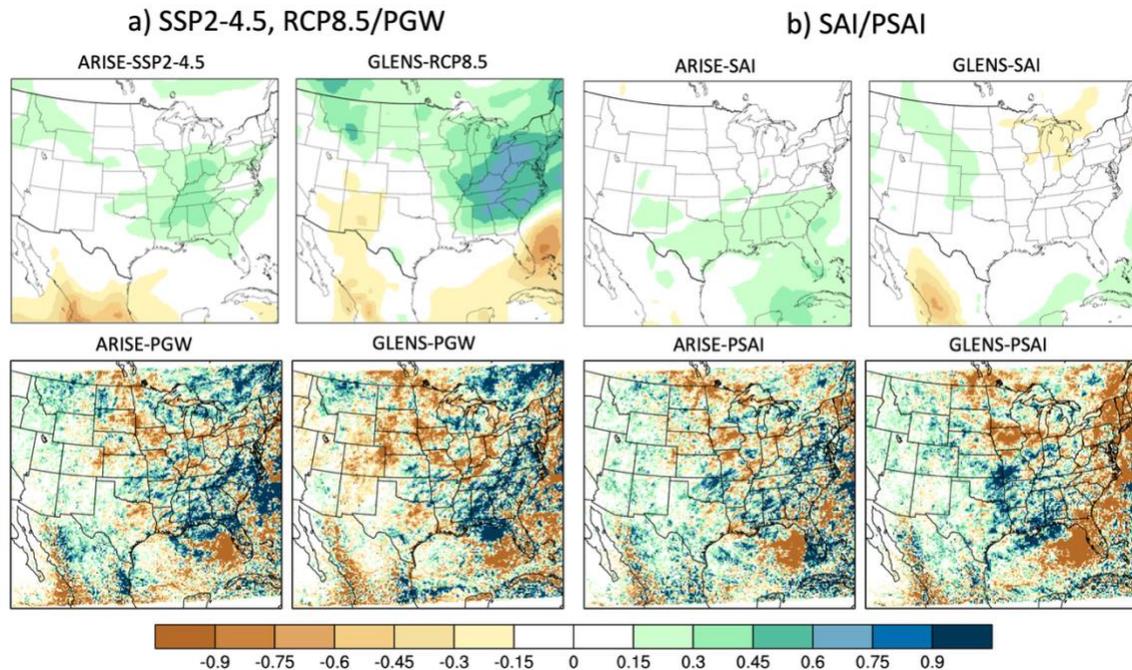


Figure R2: a) precipitation anomalies (mm/day) for 2060–2069 relative to the 2015–2024 baseline climatology from (top) CESM2-WACCM SSP2-4.5 and CESM1-WACCM RCP8.5 simulations, and (bottom) the corresponding ARISE-PGW and GLENS-PGW WRF simulations. b) Surface air temperature anomalies for 2060–2069 relative to the 2015–2024 baseline from (top) ARISE-SAI and GLENS-SAI simulations, and (bottom) the corresponding ARISE-PSAI and GLENS-PSAI WRF simulations.

Section 4.2: Can you see similar matching patterns for mean precipitation in the same type of plot as Fig 8? Or if you are interested in extreme rainfall, you could look at rainfall over the 90th percentile of the historical/control simulation seen in each simulation type.

Response: Thank you for the helpful suggestion. We do find similar spatial patterns in mean precipitation anomalies. As shown in Figure R2, without SAI, an increase in precipitation is evident over the eastern United States, particularly under the more extreme GLENS-RCP8.5 scenario. With SAI, this increase is reduced (for example, ARISE-SAI) or nearly eliminated (GLENS-SAI). The WRF simulations generally reproduce this behavior, although with finer-scale but noisier patterns and larger magnitudes.

We have included Figure R2 in the supplementary material, and added discussions to Section 4.2 (Lines 309-312):

“Figure S4 shows the spatial variability of mean precipitation anomalies in the CESM and WRF simulations. Without SAI, an increase in precipitation is evident over the eastern United States, particularly under the more extreme GLENS-RCP8.5 scenario. With SAI, this increase is reduced (for example, ARISE-SAI) or nearly eliminated (GLENS-SAI). The WRF simulations generally reproduce this behavior, although with finer-scale but noisier patterns and larger magnitudes.”

Fig 9: Can you see the same in GLENS and ARISE averaged over the same domain? I imagine GLENS and ARISE will not have the very high rainfall rates but you might see a similar pattern.

Response: Thank you for the suggestion. The available CESM precipitation output is limited, particularly for the GLENS simulations, but we were able to construct the precipitation PDF for the ARISE simulations over the same eastern U.S. domain. The resulting distribution shows a similar qualitative pattern to Fig. 8 (formerly Figure 9), although with lower overall precipitation magnitudes, as expected from the coarse-resolution CESM output. This comparison is already discussed in the second paragraph of Section 4.2.

Fig 10: why are the maps zoomed in compared to all the others? There are no coastlines or latitude/longitudes so difficult to see where this is. GLENS-PGW has a similar signal to ARISE-PGW.

Response: The percentage frequency plot is noisy so we focus on the eastern U.S. where severe convective storms occur more frequently. We have thickened the coastal and state line in the revised manuscript to improve the visualization. We agree with the reviewer on the similarity between GLENS-PGW and ARISE-PGW and have added one sentence to highlight this (Lines 344-345).

Fig11 and 12: Could an equivalent measure for GLENS and ARISE GW and SAI be shown even if the highest echo tops and reflectivities are lower for the global models?

Response: Thanks for the suggestions. These two figures are based on hourly data. Unfortunately, hourly outputs are very limited in CESM and, moreover, these variables are not output.

Lines 429-430: Multiple years with a convection permitting model has been done using the UKMO model -

<https://journals.ametsoc.org/view/journals/bams/102/6/BAMS-D-20-0020.1.xml>

Response: Thank you for pointing this out and for providing the reference. We have added this work to the manuscript to acknowledge recent progress in multi-year convection-permitting simulations using global models, such as those conducted with the UKMO system (Lines 88-89). Extending the present approach to global convection-permitting climate simulations represents an important direction for future research.

Line 437-438: stratospheric aerosols do fall out over a few years.

Response: Thank you for the comment. While stratospheric aerosols do eventually descend into the troposphere, it is unclear whether the near-surface aerosol anomalies seen in CESM-SAI arise from stratospheric transport or from other model-specific processes. For this reason, we intentionally excluded these near-surface anomalies from the WRF-PSAI forcing. We have clarified this in the revised manuscript (Lines 448-449).

Line 441-446: I think extending the PGW to SAI only really involved adding the AOD forcing. So initial results comparing the WRF convection permitting simulations with the global CESM simulations are of interest.

Response: We agree. Extending the PGW framework to the SAI scenario primarily involves incorporating the CESM-derived aerosol optical depth forcing into the WRF simulations. The initial comparisons between the convection-permitting WRF results and the corresponding CESM simulations are therefore of particular interest. We have incorporated this clarification into the last paragraph of revised manuscript (Lines 454-455).

Line 446-449: I believe only 1 season was simulated with WRF. Do you intend in future to simulate ensembles or multiple years either by taking each year 2060-2069 compared to baseline and using those anomalies to apply to ERA5 2011 or by using your existing mean anomalies and applying to different ERA5 years?

Response: Yes, actually we recently completed two types of simulations:

- Using existing ensemble-mean anomalies from CESM2-SSP245 and ARISE-SAI, respectively, and applying to the 2023-2024.
- Using individual members from CESM2-SSP245 and ARISE-SAI, respectively, and applying to 2011 super tornado outbreak (March 25-28). This leads to 10-member ensemble WRF PGW-ARISE and PSAI-ARISE simulations.

We believe these new simulations can further demonstrate how severe convective storms may be affected by global warming and SAI, and how internal climate variability may play in their influence on 2011 super tornado outbreak. We have modified the last paragraph to reflect these points.