Response to Reviewer 2

We thank the reviewer for the constructive comments. Line numbers refer to the submitted manuscript, while section and figure numbers refer to the revised manuscript.

General comments

General comment 1:

Reviewer comment: *The distinction between the SSP5-8.5 and SSP5-3.4-OS baselines and the different SAI scenarios is central to the manuscript. However, the comparison between the two pathways could be developed more systematically throughout the Results, Discussion and Conclusion sections. In particular, the manuscript should more explicitly highlight how and why the response to SAI differs between a sustained high-emission pathway and an overshoot pathway associated with strong mitigation and CDR.*

Response: We revised the Abstract, Results, Discussion and Conclusion to distinguish changes relative to the 2015-2034 reference from SAI effects relative to the corresponding simulation without SAI during 2060-2079. The two 1.5°C SAI experiments are now compared consistently to show how the response differs between the sustained high-forcing and overshoot backgrounds. We also identify regional exceptions and do not attribute the differences solely to the injection amount.

General comment 2

Reviewer comment: *The manuscript relies on a single Earth system model (CESM2-WACCM6). Although this limitation is acknowledged in the Discussion, I suggest that its implications be emphasized more clearly when interpreting the regional precipitation and moisture-budget responses. Such responses can be strongly model-dependent, and the conclusions should therefore be framed accordingly.*

Response: We have revised the abstract, discussion and conclusion to state that the results are specific to CESM2-WACCM6. We also clarify that three ensemble members represent only part of the internal variability and do not capture uncertainty across models, while the approximately 1° resolution limits the representation of terrain, convection and local hydrology.

General comment 3:

Reviewer comment: *The statistical analysis deserves further clarification. The authors use a Welch's t-test with only three ensemble members for each scenario and consider $p < 0.05$ as statistically significant. Given the very small number of ensemble members, the authors should provide additional justification for the robustness and appropriateness of this statistical approach and discuss its implications for the reported significance levels.*

Response: We clarified that the Welch tests compare three member-specific 20-year means in each experiment, not annual values. Welch's test avoids assuming equal variances, but it does not overcome the limitations of the small ensemble. We therefore report unadjusted $p < 0.05$ and BH-adjusted $q = 0.05$ fractions separately, together with effect sizes and ensemble spread, and acknowledge the limited statistical power and shared simulation histories.

General comment 4

Reviewer comment: *The manuscript would benefit from a clearer distinction between statistical significance and magnitude of change. In several places, the reduction in the percentage of statistically significant grid cells under SAI is interpreted as evidence that SAI "effectively returns temperature conditions closer to the baseline state." Statistical significance alone does not necessarily quantify the magnitude or practical importance of the change. Consider reporting and discussing the actual magnitude of changes alongside their statistical significance.*

Response: We removed this inference. Relative to 2015-2034, continental mean temperature changes by +2.99°C and +1.67°C in the two experiments without SAI, compared with +0.15°C and −0.10°C in the two 1.5°C SAI experiments. The corresponding WSDI changes are +192.4 and +96.2 days per year without SAI and +5.4 and −1.3 days per year with SAI. We use these magnitudes, rather than reduced statistical significance, to describe proximity to the reference period.

General comment 5

Reviewer comment: *The title emphasizes that SAI minimizes drying only when combined with strong decarbonization. This is an interesting and potentially important conclusion, but the manuscript should make this central message more explicit and quantitatively demonstrate it throughout the Results and Discussion sections.*

Response: The original claim is not supported across all regions. We therefore changed the title to "African climate extremes and the surface moisture budget under stratospheric aerosol injection and temperature overshoot". The revised Discussion and conclusion report pathway-specific and regional differences without presenting strong decarbonisation as a universal condition for reducing drying.

General comment 6

Reviewer comment: *The authors should say a few more words about the uncertainties and limitations associated with the SAI experimental design itself, including the use of idealized feedback-controlled injection scenarios and prescribed global temperature targets. These simulations should not necessarily be interpreted as representing a realistic future deployment strategy.*

Response: The Methods now describe the global temperature and temperature-gradient control objectives. The Discussion clarifies that the feedback-controlled injections are idealised and that achieving a global temperature target does not guarantee recovery of regional precipitation or the surface moisture budget.

Specific comments

Line 1 Title

Reviewer comment: *In the title, please consider whether "minimises drying" is fully supported by the results across the whole African continent. The results show important regional contrasts, including reduced moisture availability under some SAI scenarios in East and Southern Africa. The title may therefore need to better reflect the regional and scenario-dependent nature of the response.*

Response: We have revised the title as "Temperature stabilization using Stratospheric Aerosol Injections minimises drying over some African region only when combined with a strong decarbonization effort" to reflect the regional variation and scenario dependent nature of the response

Lines 24 to 32 Abstract

Reviewer comment: *The abstract is generally informative, but the main quantitative findings could be presented more consistently. For example, the abstract reports that precipitation indices exhibit significant changes over 40-80% of the area, whereas the Results section gives substantially lower percentages for several precipitation indices. Please check that all percentages reported in the abstract are consistent with the results presented in the main text and figures.*

Response: We removed the 40-80% statement. The Results now report unadjusted and BH-adjusted detection fractions separately. For example, the unadjusted PRCPTOT fractions are 30.9% and 30.3% in the two experiments without SAI, whereas the BH-adjusted fractions are 3.9% and 0%.

Line 41 Acronyms

Reviewer comment: *All acronyms must be clearly defined from the first occurrence they are used. Therefore, please apply this instruction to "CMIP6" and all other acronyms used throughout the text.*

Response: We have defined CMIP6, CESM2-WACCM6, ETCCDI, SAI, SRM and CDR at first occurrence and use the abbreviations thereafter.

Lines 65 to 66 Terminology

Reviewer comment: *Please clarify the terminology used throughout the manuscript between "stratospheric aerosol injection (SAI)", "stratospheric aerosol geoengineering (SAG)", and "solar radiation modification (SRM)". The manuscript uses these expressions somewhat interchangeably. A consistent terminology would improve readability.*

Response: We use SAI for the experiments analysed and SRM for the broader class of interventions. SAG is no longer used as an interchangeable term.

Lines 111 to 114 Regions

Reviewer comment: *There appears to be an inconsistency between the description of the regionalization in the text and the caption of Figure 1. The text mentions five sub-regions (North, West, Central, East and Southern Africa), whereas the Figure 1 caption additionally mentions Northeast Africa (NEAF). Please clarify the regional classification and apply the same terminology consistently throughout the manuscript.*

Response: This has been resolved in the text and Figure 1. To enable robust sub-continental interpretation and to avoid continent-wide averaging that can mask localized signals, the African domain was stratified into five sub-regions as depicted in Figure 1: North Africa (NAF), West Africa (WAF), Central Africa (CAF), East Africa (EAF) and Southern Africa (SAF). See Page 3, lines 112- 115, and Figure 1

Line 138 Scenario notation

Reviewer comment: *Please ensure consistency in the notation of the overshoot scenario. The manuscript uses SSP5-3.4-OS and SSP5-34-OS in different places. The scenario name should be standardized throughout the text, tables and figures.*

Response: We now use SSP5-3.4-OS consistently. Table 1 defines the abbreviated SAI labels, parent pathways and temperature targets.

Lines 138 to 157 Experimental design

Reviewer comment: *The experimental design should be described more clearly.*

Response: Table 1 now lists all five experiments, their description, and temperature targets. The Methods explain the branch histories and distinguish the experiments from the two fixed 20-year reference periods, 2015-2034 and 2025-2044.

Line 165 ETCCDI reference

Reviewer comment: *Please clarify the citation and terminology associated with the ETCCDI framework. The text currently states "the Expert Team on Climate Change Detection and Indices (ETCCDI) Peterson (2002)". Please check the corresponding reference and citation year, and revise the sentence.*

Response: We cite Zhang et al. (2011), define ETCCDI once and distinguish the standard ETCCDI indices from the additional temperature indices in Table 2. The Peterson citation is removed from this statement.

Lines 199 to 208 Statistical samples

Reviewer comment: *The statistical methodology needs further explanation. It would be useful to specify exactly what constitutes the samples in the Welch's t-test: are the tests performed using annual values, ensemble-member means, or period means? Given that only three ensemble members are available, this point is particularly important for assessing the robustness of the significance analysis.*

Response: Each group contains three member-specific period means. Annual values within each 20-year period are first averaged for each member, giving n = 3 versus n = 3. Detection fractions are calculated over testable African land, and testable coverage is reported separately.

Line 214 Grammar

Reviewer comment: *Please revise the sentence "these indices plateau begin to decline" for grammatical clarity.*

Response: The revised sentence states that, under SSP5-3.4-OS, the temperature indices level off and subsequently decline.

Lines 284 to 287 Mechanisms

Reviewer comment: *The physical mechanisms invoked to explain the precipitation response to SAI are interesting. However, the discussion could be strengthened by distinguishing more clearly between the mechanisms supported directly by the simulations and mechanisms inferred from previous studies.*

Response: The revised Discussion reports the precipitation and evapotranspiration changes directly. Energy-balance and circulation mechanisms reported by Niemeier et al. (2013) and Simpson et al. (2019) are presented only as possible explanations because their regional contributions were not isolated in this analysis. We also removed the general attribution of increased West African surface moisture budget to reduced evapotranspiration because evapotranspiration increases in both overshoot SAI comparisons.

Lines 295 to 305 Water availability

Reviewer comment: *The interpretation of the surface moisture budget deserves some caution. In particular, the statement that SAI "could help preserve surface water availability" in West Africa should be framed carefully because the analysis is based on P - ET, which represents a simplified surface moisture balance and does not directly quantify water availability in rivers, soils, reservoirs or groundwater.*

Response: We removed the claim that SAI preserves surface water availability. The revised text explains that the surface moisture budget compares precipitation with actual evapotranspiration, while water availability also depends on storage, runoff, drainage and human use.

Lines 314 to 329 Repetition

Reviewer comment: *This paragraph appears to substantially repeat the preceding description of Figure 5. Please consider removing the duplicated material and using this space to provide additional interpretation of the seasonal differences.*

Response: We replaced the repeated description with seasonal SAI-minus-parent contrasts. In West Africa, the largest positive change occurs in MAM under SSP585_1.5 SAI and in JJA under the two overshoot SAI experiments. In East Africa, the largest decrease occurs in DJF under SSP585_1.5 SAI and in MAM under both overshoot SAI experiments. Southern Africa shows a decrease in DJF in all three experiments.

Lines 331 to 332 Contradictory East African claim

Reviewer comment: *Please clarify the apparent contrast between the statement that East Africa is the greatest beneficiary, with an increase of approximately 0.5 mm/day, and the preceding results indicating that SAI produces lower moisture levels than the high-warming baseline in East Africa. The reference scenario used for each comparison should be explicitly stated.*

Response: We removed the term "beneficiary". Relative to the corresponding simulation without SAI, the East African surface moisture budget decreases by 0.173, 0.029 and 0.047 mm day^{-1} in the three SAI experiments. The revised text keeps this comparison separate from changes relative to the earlier reference period.

Lines 396 to 398 Lower forcing and drying

Reviewer comment: *The conclusion that excessive drying associated with SAI can be mitigated under a lower-emission scenario is one of the most important findings of the study. I suggest developing this point further and providing a more quantitative comparison of the hydrological response between the two emission pathways.*

Response: At the common 1.5°C target, the East African surface moisture budget decreases by 0.173 mm day^{-1} under SSP585_1.5 SAI and by 0.029 mm day^{-1} under SSP534OS_1.5 SAI. The corresponding Central African changes are −0.104 and −0.047 mm day^{-1}, while continental PRCPTOT changes by −38.6 and +0.1 mm per year. We therefore narrowed the conclusion to these quantities and regions rather than retaining the original continent-wide claim.

Lines 401 to 409 Limitations

Reviewer comment: *The limitations section is useful, but it could be expanded to include the idealized nature of the SAI experiments, the relatively coarse spatial resolution of the model for regional hydrological analysis, and the uncertainty associated with using a single model.*

Response: The revised limitations cover the single model, approximately 1° resolution, three-member ensembles, statistical assumptions, shared simulation histories, idealised feedback control, broad geographical boxes and unmodelled impact processes.

Tables and figures

Reviewer comment: Table 1; *The notation used for the SAI experiments should be standardized. In particular, please make clear whether "Geo SSP5-34-OS 1.5" and "Geo SSP5-34-OS 2.0" refer to temperature targets or experiments. It would also be useful to explicitly indicate which simulations are used as baselines and which are used as SAI experiments.*

Response: The revised table lists the two experiments without SAI and the three SAI experiments, including the parent pathway, global temperature target and ensemble size for each. The reference periods are defined separately.

Reviewer comment: Table 2; *Please carefully check the definitions and units of all indices. In particular, the units associated with R1MM, R20MM and PRCPTOT appear potentially inconsistent with their definitions. Please verify the table against the standard ETCCDI definitions.*

Response: Table 2 now lists only the eleven indices calculated in the final analysis. R1mm is reported in days, Rx5day and PRCPTOT in mm, CWD and CDD in days, SDII in mm day^{-1}, annual GDD in °C days and GDD intensity in °C. R20mm and GSL were removed. The 10-35°C day count is described as a broad temperature indicator rather than a crop-specific optimum.

Reviewer comment: Figure 2; *Please clarify why only selected indices are presented in Figure 2 and explain whether the omitted indices exhibit similar temporal behaviour. This would help readers understand whether the selected indices are representative of the overall response.*

Response: Figure 2 shows mean temperature, GDD intensity, PRCPTOT and CWD. The time series for all eleven calculated indices are provided in Figures 1 and A4, so the omitted indices are not assumed to behave like those shown in Figure 2.

Figure 3

Reviewer comment: *The figure caption should clearly identify all scenarios represented in the figure. This is particularly important because the manuscript considers both 1.5°C and 2.0°C SAI targets, whereas the caption appears to focus only on the 1.5°C experiments. Please verify that the figure, caption and corresponding discussion are fully consistent.*

Response: The revised caption identifies the reference and all five experiments, including SSP534OS_2.0 SAI. It also defines the 2060-2079 future period, the 2015-2034 reference period and the BH-adjusted significance markings.

Figure 4

Reviewer comment: *The caption states that four scenarios are represented, but the manuscript considers several SAI experiments, including a 2.0°C target. Please clarify which scenarios are included in this figure and why some experiments may have been excluded.*

Response: Figure 4 now includes all five experiments, and the caption identifies them. It also states that the heatmap shows unadjusted $p < 0.05$ detection fractions.

References

Reviewer comment: Reference formatting; *Please carefully check the References section for consistency, completeness and formatting. Several references appear to contain incomplete bibliographic information or inconsistencies in formatting.*

Response: The references have been checked for consistency and completeness

Reviewer comment: Kravitz et al. 2017; *The reference to Kravitz et al. (2017) appears incomplete and should be checked carefully.*

Response: We completed the Kravitz et al. (2017) reference by adding the missing publication details and DOI.

Reviewer comment: Mupangwa et al. 2016; *The reference to Mupangwa et al. (2016) should be checked against the statement for which it is cited in the Introduction section, particularly the claim concerning the contribution of agriculture to the Gross Domestic Product.*

Response: We removed the unsupported GDP statement and the Mupangwa et al. (2016) citation from that passage. The revised Introduction uses Sultan and Gaetani (2016) to support the broader discussion of climate sensitivity in African agriculture.

Reviewer comment: Ofori and Asongu 2021; *The reference to Ofori & Asongu (2021) appears to concern foreign direct investment, governance and inclusive growth rather than the specific agricultural statement for which it is cited. Please verify whether this is the appropriate reference.*

Response: We removed the citation and the unsupported GDP statement.

Reviewer comment: Emmons et al.; *Please check the consistency between the citation of Emmons et al. in the text and the year given in the reference list.*

Response: We use Emmons et al. (2020) consistently, which is the correct publication year.

Reviewer comment: Danabasoglu et al.; *Similarly, please verify the citation year and bibliographic details of Danabasoglu et al. in the text and reference list.*

Response: We use Danabasoglu et al. (2020) consistently and corrected the bibliography entry.