

Responses to reviewer 2 comments

General Assessment

In this study, the authors analyzed hydroclimate responses of Central–South Asia and the Tibetan Plateau to stratospheric aerosol injection (SAI), a proposed geoengineering method to reduce anthropogenic warming. The authors used a set of different SAI experiment results from CESM model simulations. These SAI simulations differ in the targeting temperature level, injection location, and background scenarios. In specific, 1) G6-1.5K-SAI injects SO₂ at two subtropical latitudes with the aim of stabilizing global warming at 1.5K under the background scenario of SSP2-4.5; 2) G6solar directly reduces solar irradiance to bring global mean warming under the background scenario of SSP5-8.5 to the level of SSP2-4.5; 3) G6-sulfur injects SO₂ into the tropical lower stratosphere with the aim of bringing down global mean warming under the background scenario of SSP5-8.5 to the level of SSP2-4.5; 4) Geo-SAI injects SO₂ at four points (30NS and 15NS) with the aim of stabilizing global warming at 1.5K under the background scenario of SSP2-8.5.

The authors focus on analyzing the mean and peak response of the regional hydroclimate in response to multiple scenarios and strategies of SAI. This study, if well done and well written, could be a useful contribution to the geoengineering and climate change community. It would help to understand regional climate response to different SAI strategies. However, the current presentation of this study is poor. Most part of this manuscript is lengthy (and repetitive) descriptions of facts. After reading through the manuscript, I see a lot of lengthy discussions on the response of different climate variables in different regions to GHG forcing and SAI forcing, but I find little new scientific insights. I think the problem is that too much similar information is listed with little focus. I think this study needs to be re-written and condensed by making main messages more salient.

Specific comments:

Comment 1: Line 25 (abstract): Temperature change is usually not expressed by percent.

Response: We thank the reviewer for this comment. We agree that temperature change is more appropriately expressed as an absolute change rather than as a percentage. Accordingly, we have revised the Abstract and the corresponding tables to report temperature changes in °C, while retaining percentage changes (%) for the other hydroclimatic variables. The relevant text, table headings, and captions have been updated consistently throughout the manuscript.

Comment 2: Lines 29-31 (abstract): By stating transient forcing scenario achieve only partial mitigation, it feels like temperature stabilized simulations would achieve fully mitigation. That is obviously not true. The difference in ‘stabilized’ and ‘transient’ simulations are different cooling target for SAI. Thus, the naming of ‘stabilized’ and ‘transient’ simulations would just cause confusion.

Response: We thank the reviewer for this important clarification and agree that our previous terminology could imply a distinction that is not physically appropriate. All of the SSP and SAI simulations considered here evolve transiently in time, and the main difference among the SAI experiments is their experimental design and targeted temperature or forcing objective rather than a

fundamentally different dynamical regime. We have therefore removed the terms “temperature-stabilized” and “transient forcing” from the manuscript and now refer to the simulations by their specific experiment names, including G6-1.5K-SAI, Geo-SAI, G6solar, and G6sulfur. We also revised the Abstract to remove wording suggesting that one group achieves “full” mitigation while another provides only “partial” mitigation. The revised text now describes the responses directly for each experiment without implying a hierarchy of mitigation effectiveness.

Comment 3: Line 65 : ‘SRM’ has not been defined. Also, there is no introduction of SRM here, which breaks the logic of this paragraph.

Response: We agree that SRM was introduced too abruptly in the original manuscript. We have therefore revised the first paragraph of the Introduction to define solar radiation modification (SRM) at its first occurrence and briefly introduce the Geoengineering Model Intercomparison Project (GeoMIP) as the coordinated framework for evaluating SRM experiments. This revision provides a clearer transition from the regional hydroclimatic vulnerability discussed in the paragraph to the motivation for investigating SRM impacts. The revised text now reads:

Solar radiation modification (SRM) is a form of climate intervention that aims to limit surface warming by reducing the amount of incoming solar radiation reaching the Earth’s surface. To systematically evaluate the climate responses to such interventions, the Geoengineering Model Intercomparison Project (GeoMIP) was established in 2011 to coordinate and standardize climate-model experiments of SRM (Vioni et al., 2024).

Comment 4: Line 85: A robust increase of what?

Response: We appreciate the reviewer’s comment. We agree that the original sentence did not clearly identify the variable showing a robust increase. We have revised the sentence to explicitly refer to annual mean precipitation. The revised text now reads:

Annual mean precipitation is projected to increase robustly across most of Central Asia, with particularly strong responses over the Tianshan Mountains and northern regions under different emission scenarios (Jiang et al., 2020).

Comment 5: Line 95: If only two citations are given for the broad concept of SRM, these two papers cannot represent the broad SRM research.

Response: We appreciate the reviewer’s comment. We agree that the two citations originally provided were insufficient to represent the broader body of SRM research. We have therefore expanded the literature cited in this paragraph. The revised text now reads:

SRM has received growing scientific attention as a potential supplementary approach for limiting some impacts of anthropogenic greenhouse gas (GHG)-driven warming (Robock et al., 2008; Kravitz et al., 2011; Crutzen, 2006; Tilmes et al., 2018; Richter et al., 2022; Vioni et al., 2024).

Comment 6: Lines 136-138: I don't think the naming of 'transient' (G6solar and G6sulfur) and 'temperature-stabilized' (G6-1.5K-SAI and Geo-SAI) experiments make much sense. All SSP and SAI simulations are transient forcing experiments. These naming are just confusion. The difference between 'transient' (G6solar and G6sulfur) and 'temperature-stabilized' are just the targeted temperature level for these different SAI simulations. There is no underlying dynamic difference between 'transient' and 'stabilized' runs here.

Response: We agree with the reviewer that the terms "transient" and "temperature-stabilized" are potentially confusing in this context because all simulations are transient, while the SAI experiments mainly differ in their targeted temperature or forcing objectives and experimental configurations. To avoid this ambiguity, we have removed this classification throughout the manuscript and now refer to each simulation by its specific scenario name, namely G6-1.5K-SAI, Geo-SAI, G6solar, and G6sulfur, together with their corresponding SSP baselines where appropriate. This revision provides a clearer and more accurate description of the experiments.

Comment 7: Line 138: There is no need to use AW for available water.

Response: We appreciate the reviewer's suggestion. We have removed the abbreviation AW from the manuscript. Because P-ET represents a climatic water-balance diagnostic rather than direct water availability, we now refer to this variable consistently as "climatic water balance (P-ET)" throughout the manuscript, figures, and supplementary material. The revised text now reads:

Climatic water balance (P-ET) was calculated as precipitation minus actual evapotranspiration. This diagnostic represents the balance between atmospheric water input and evapotranspiration loss and is used here as an indicator of hydroclimatic moisture balance. It should not be interpreted as direct water-resource availability because it does not explicitly account for groundwater, surface-water and cryospheric storage, glacier melt, or anthropogenic water use and management.

Comment 8: Lines 150-194: There is no need to give this much space for the introduction of the regions studied.

Response: We appreciate the reviewer's suggestion. We agree that the original Study Area subsection contained excessive geographic and climatological detail. We have substantially condensed Section 2.1 by removing detailed country and geographic-feature descriptions, precipitation statistics, and extended discussion of regional circulation mechanisms. The revised text now reads:

The study region extends approximately from 8°–45° N and 40°–100° E and is divided into four hydroclimatically distinct subregions: WCA, ECA, TIB, and SAS (Figure 1). WCA and ECA are relatively dry, whereas TIB is characterized by a cold, high-elevation climate and SAS by a warm, monsoon-dominated climate (Iturbide et al., 2020). These contrasting climatic regimes provide a useful framework for assessing spatially heterogeneous hydroclimatic responses to greenhouse-gas forcing and SRM.

Regional precipitation is governed primarily by the interaction of the mid-latitude westerlies (Wei et al., 2023), Asian monsoon systems, and complex topography. WCA and ECA are strongly influenced by the westerlies, with much of their precipitation occurring during winter and spring (Zhang et al., 2019; Yang et al., 2020). The TIB lies within the transition between westerly and monsoonal circulation, with summer precipitation dominated by the Asian monsoon and winter precipitation associated with westerly disturbances (Hussain et al., 2021; Wang et al., 2025; Botsyun et al., 2022). In contrast, SAS receives abundant summer precipitation associated with the South Asian monsoon (Luo et al., 2024). These pronounced hydroclimatic contrasts make the four subregions suitable for evaluating region-dependent responses to future warming and SRM.

Comment 9: Line 225: Readers want to know what is the starting date of SAI in these simulations. Why not just state it clearly?

Response: We appreciate the reviewer’s comment. We agree that the SAI starting date should be stated explicitly. The revised text now reads:

This experiment uses an intermediate emissions baseline (SSP2-4.5), with SAI deployment beginning in 2035, reflecting both the anticipated exceedance of 1.5 °C warming and a plausible implementation timeline, and adopts an injection strategy that avoids the tropical pipe by injecting SO₂ at 30°N and 30°S rather than near-equatorial locations (Visioni et al., 2024).

Comment 10: Lines 283-286: normalization of hydroclimatic responses by the amount of sulfur injection imply that hydroclimate variables considered here would change linearly with the amount of SAI, but it won’t be true. Please comment.

Response: We appreciate the reviewer’s important comment. We agree that hydroclimatic responses to stratospheric aerosol injection are not expected to scale linearly with the amount of SO₂ injected because aerosol microphysics, injection latitude and altitude, background climate state, circulation responses, and experimental control strategies can introduce substantial nonlinearities. Our sulfur normalization is therefore not intended to assume or demonstrate a linear relationship between SO₂ injection and the hydroclimatic response. Rather, it is used as a descriptive scaling diagnostic, in which the simulated hydroclimatic trend is divided by the corresponding mean SO₂ injection rate to facilitate comparison of response magnitudes across experiments with different sulfur burdens. We do not extrapolate these normalized values to other injection amounts or interpret them as causal sensitivities. We have revised the manuscript to clarify this point and have replaced the term “efficiency” with “sulfur-normalized response” where appropriate. The revised Methods now explicitly define the normalization and clarify that the resulting ratio is a descriptive scaling metric and should not be interpreted as the sensitivity $\partial R / \partial I_{\text{SO}_2}$.

Comment 11: Line 288: For leaf area index (LAI), do some of these models include dynamic vegetation? This should be clarified. Static vegetation vs. dynamic vegetation would have different effects on LAI.

Response: We appreciate the reviewer's comment. We have clarified the treatment of vegetation and LAI in the CESM2-WACCM6 simulations used in this study. The revised text now reads:

We used monthly data for temperature, precipitation, ET, snowfall flux, snowmelt flux, runoff, SM, and LAI from all available ensemble members of each scenario (Table S1). CWB was computed from precipitation and actual evapotranspiration (P-ET). It is used here as a diagnostic of hydroclimatic moisture balance rather than as a direct measure of specific water-resource variables such as groundwater, surface water or cryosphere storage. In CESM2-WACCM6, LAI is prognostically simulated by CLM5 and therefore responds to changing environmental and biogeochemical conditions, although natural vegetation biogeography is prescribed rather than dynamically simulated (Lawrence et al., 2019). For the analysis, 2015–2034 was defined as the present-day reference period and 2055–2084 as the future analysis period. Future changes were evaluated relative to the corresponding GHG background and present-day reference appropriate to each experiment.

Comment 12: Lines 365-366: decrease and reduce relative to what?

Response: We appreciate the reviewer's comment. We have revised the text to clearly specify the reference scenarios and baselines for all statements describing decreases or reductions, avoiding ambiguity in the interpretation of scenario comparisons.

Comment 13: Lines 358-387: This description is a bit hard for me to digest. I suggest re-organize it to focus on the main point.

Response: We appreciate the reviewer's comment. We have reorganized and condensed this part of the Results section by removing excessive descriptions and emphasizing the key findings, including the dominant regional patterns and scenario-dependent hydroclimatic responses.

Comment 14: Lines 430-433: "These results demonstrate that regional hydroclimatic impacts of SAI cannot be inferred from global averages XX'. This conclusion is self-evident and one does not need to infer it from the results shown here.

Response: We appreciate the reviewer's comment. We agree that this statement was overly general and have revised the text to focus on the specific regional differences revealed by our simulations rather than presenting it as a general conclusion.

Comment 15: Overall, I feel the section of 3.1 and 3.2 is boring. It lists a lot of facts without providing much scientific insights. I suggest condense these sections to focus on the new findings.

Response: We appreciate the reviewer's comment. We have substantially revised Sections 3.1 and 3.2 by condensing repetitive descriptions and focusing on the major scientific findings, including regional contrasts, scenario-dependent responses, and the implications of SRM-induced hydroclimatic changes.

Comment 16: Lines 437-440: I have difficulty in understanding what is stated here.

Response: We have revised this section to improve clarity by simplifying the explanation and explicitly describing the comparison framework and interpretation of the reported responses.

Comment 17: Again, I find section 3.1, 3.2, 3.3, and 3.4 is really boring to read. It's really hard for me to digest the main message conveyed. It's just a lengthy description of facts. I suggest condense/combine these sections to make the main point more salient. By reading these four sub-sections, I just got lost.

Response: We appreciate the reviewer's valuable comment. We have revised Sections 3.1–3.4 by reducing lengthy descriptions, removing repetitive interpretations, and restructuring the Results section to highlight the main scientific messages. The revised version emphasizes the key regional patterns, physical responses, and differences among scenarios while maintaining the essential quantitative results.

Comment 18: Section 3.5: Are these seasonal cycles detrended from their respective annual mean?

Response: We appreciate the reviewer's comment and have clarified this point in the revised Section 2.4. The seasonal-cycle curves shown in the main figures are calculated from the raw monthly values and are therefore neither linearly detrended nor demeaned, because they are intended to retain both changes in the mean climatic state and changes in the intra-annual seasonal structure. As a sensitivity analysis, we additionally constructed annual-mean-removed seasonal cycles by subtracting each individual year's mean from its 12 monthly values. Importantly, this transformation does not alter the annual peak month or seasonal amplitude, because subtracting a constant annual mean leave both the location of the monthly maximum and the peak-to-trough difference unchanged. Consequently, the primary peak-timing and amplitude diagnostics are invariant to annual-mean removal. No additional linear temporal detrending was applied because these seasonal metrics are calculated independently within each year, thereby limiting the influence of long-term changes in the mean climate state on the estimated seasonal amplitude and peak timing.

Comment 19: Lines 576-580: As commented above, the difference between 'transient' (G6solar and G6sulfur) and 'temperature-stabilized' are just the targeted temperature level for these different SAI simulations. There are no underlying dynamic differences between 'transient' and 'stabilized' simulations here. But these statements read like there are some dynamic reasons that cause the different roles of precipitation in AW between 'stabilized' and 'transient' simulations.

Response: We thank the reviewer for pointing this out. We agree that our previous comparison between "temperature-stabilized" and "transient" simulations could incorrectly suggest that the differences in the regression results arose from distinct underlying dynamical regimes. We have therefore removed this terminology and revised the relevant Results and Discussion text to interpret the regression outcomes at the level of the individual experiments. Statements implying that the relative importance of precipitation or other predictors was caused by a "stabilized" versus "transient" dynamical distinction have been rephrased. The revised discussion now attributes differences in the

regression patterns to the specific forcing pathways, SAI designs, and experiment configurations, while emphasizing that the MLR results represent statistical associations rather than causal physical attribution.

Comment 20: Section 4.1 and 4.2 It does not make much sense to have such lengthy sections in the Discussion part. Why not condense them and merge most parts into Result section? Currently, they are just lengthy descriptions without focus. Discussion section should not be written like that.

Response: We appreciate the reviewer's valuable comment. We agree that the previous version of Sections 4.1 and 4.2 contained excessive descriptive details that overlapped with the Results section and reduced the focus of the Discussion. In the revised manuscript, we have substantially condensed these sections and reorganized the Discussion to emphasize the broader implications, physical mechanisms, and regional differences rather than repeating individual variable responses. Detailed descriptions of precipitation, climatic water balance, runoff, and other hydroclimatic variables have been retained in the Results section, while the revised Discussion now focuses on synthesizing the major findings, explaining the underlying processes, and highlighting their implications for hydroclimatic responses under different SRM scenarios. These changes improve the distinction between Results and Discussion and provide a more focused interpretation of the study outcomes.

Comment 21: Figure 2 (and other relevant figures): The current layout of different lines should be reconsidered. For example, I don't see the logic here by showing the lines of G6solar and 'G6sulfur-SSP4.5' and 'G6sulfur-SSP8.5' together. If the authors want to compare G6solar and G6sulfur, the authors should plot G6solar and G6sulfur together.

Response: We thank the reviewer for this helpful comment. We agree that the previous layout of Figure 2 made the comparison among transient-forcing experiments unnecessarily complicated because two differently referenced G6sulfur curves were shown together with G6solar. To improve clarity while preserving the manuscript-wide classification of temperature-stabilized versus transient-forcing experiments, we revised Figure 2 so that the transient-forcing column now contains only SSP5-8.5, G6solar, and G6sulfur. The temperature-stabilized column remains unchanged, showing SSP2-4.5, G6-1.5K-SAI, and Geo-SAI. This revised layout enables a more direct comparison between G6solar and G6sulfur and removes the ambiguity introduced by displaying both G6sulfur-SSP2-4.5 and G6sulfur-SSP5-8.5 contrasts in the same panel. The updated figure can now be read:

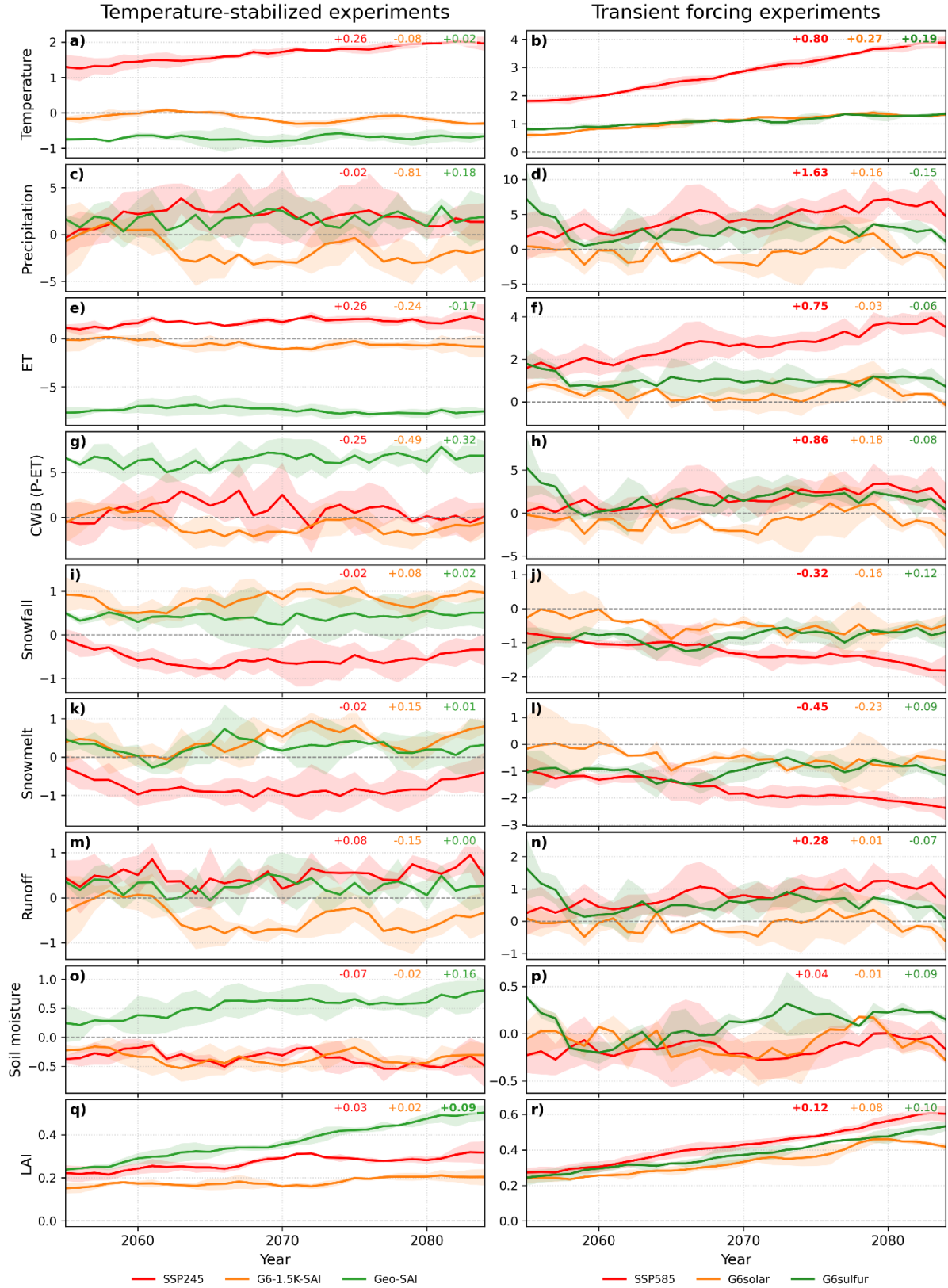
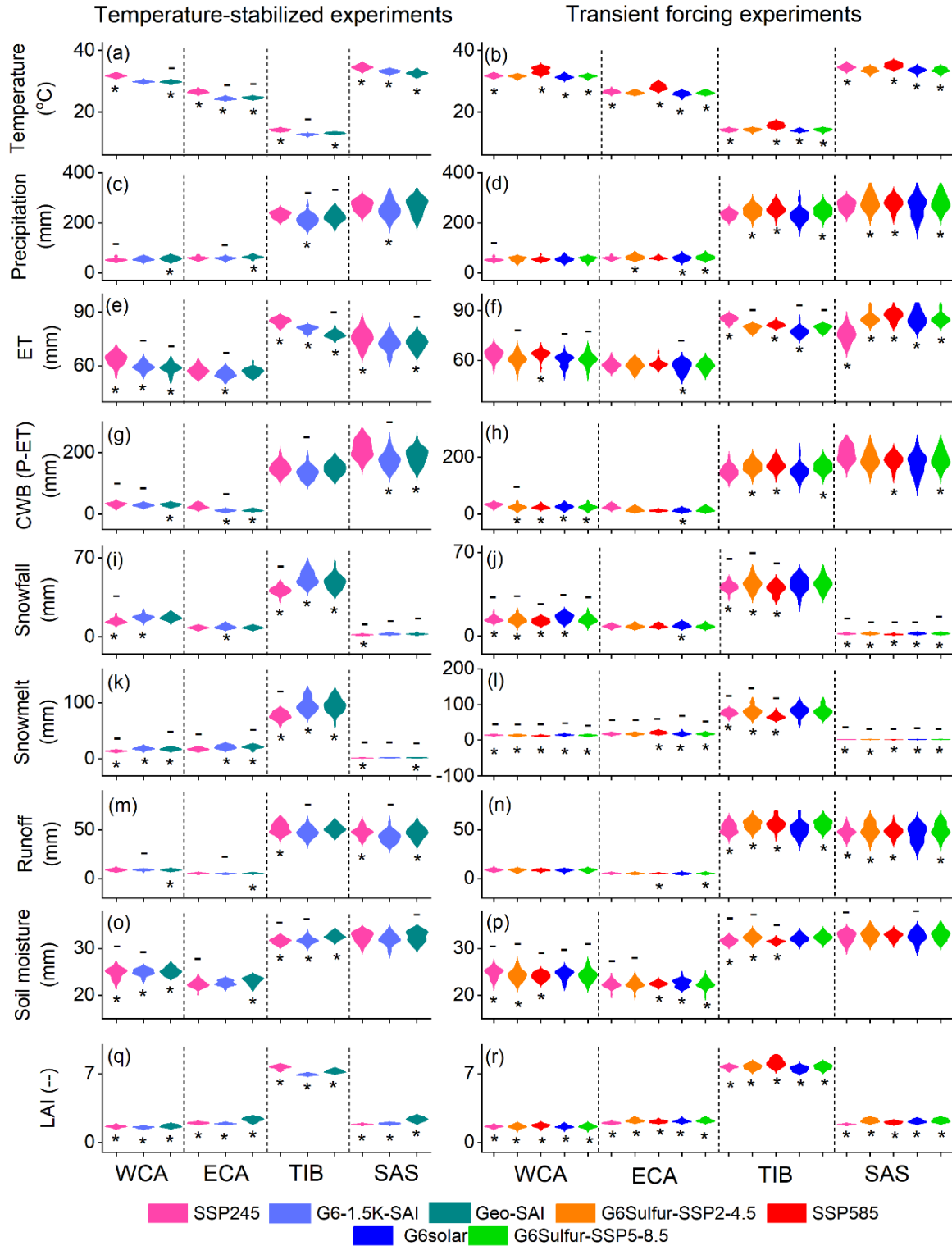


Figure 2. Annual mean anomalies of temperature, precipitation, ET, CWB, snowfall, snowmelt, runoff, soil moisture, and LAI during 2055–2084 relative to the corresponding 2015–2034 baseline under temperature-stabilized experiments (left column) and transient forcing experiments (right column). Solid lines denote ensemble-mean annual anomalies, and shaded envelopes indicate the spread across ensemble members after

applying a 5-year running mean. Colored numbers indicate the mean linear trend over 2055–2084, and bold values denote trends that are statistically significant at the 95% confidence level based on ensemble-member trend distributions.

Comment 22: Figure 4: What is the unit of each variable for each panel?

Response: We appreciate the reviewer's comment. We have revised Figure 4 to explicitly indicate the unit of each variable in the corresponding y-axis labels. Temperature is reported in °C; precipitation, ET, available water, snowfall, snowmelt, runoff, and soil moisture are reported in mm; and LAI is dimensionless.



Comment 23: Figure 5: This figure just shows changes in terms of percent for the same variables of Figure 4. If so, I suggest put this one in supporting material. Also, usually, temperature change is not represented in percent.

Response: We appreciate the reviewer's comment. We would like to clarify that Figures 4 and 5 represent two distinct hydroclimatic characteristics. Figure 4 shows changes in the annual peak

magnitude of each variable, whereas **Figure 5** shows changes in the seasonal amplitude, which quantifies the strength of intra-annual variability. Therefore, Figure 5 is not a percentage representation of the same quantity shown in **Figure 4**, and the two figures provide complementary information on changes in hydroclimatic seasonality. Because changes in seasonal amplitude constitute an important component of our analysis of seasonal dynamics, we have retained Figure 5 in the main manuscript. We agree, however, that temperature changes should not be expressed as percentages. We have therefore revised **Table 1** and **Table S7** so that changes in temperature are reported in °C, while percentage changes are retained for the other variables.

Table 1. Regional mean annual changes in temperature (TMP; °C) and percentage changes (%) in precipitation (PCP), evapotranspiration (ET), CWB, snowfall, snowmelt, runoff, SM, and LAI during 2055–2084 relative to 2015–2034 across WCA, ECA, TIB, and SAS under SSP2-4.5, SSP5-8.5, G6-1.5K-SAI, G6solar, G6sulfur, and Geo-SAI. Positive (negative) values indicate increases (decreases) relative to the corresponding present-day climatology. SSP2-4.5, G6-1.5K-SAI, and G6sulfur-SSP2-4.5 are referenced to the SSP2-4.5 baseline, whereas SSP5-8.5, G6solar, G6sulfur-SSP5-8.5, and Geo-SAI are referenced to the SSP5-8.5 baseline. Bold values denote statistically significant changes at the 95% level.

Region	Scenario	TMP	PCP	ET	CWB	Snowfall	Snowmelt	Runoff	Soil moisture	LAI
WCA	SSP245	1.64	-0.16	4.4	< -100	-12.9	-14.5	1.06	-2.7	24.9
	SSP585	2.7	6.1	6.4	-8.9	-26.1	-28.1	4.0	-2.2	46.1
	G6-1.5K-SAI	-0.26	0.21	-1.57	< -100	18.1	8.6	-2.2	-1.4	18.2
	Geo-SAI	-0.59	4.09	-10.4	< -100	12.8	7.0	2.8	2.0	43.8
	G6solar	0.89	-0.52	0.49	-9.2	-9.2	-8.4	-0.98	-1.7	35.7
	G6sulfur-SSP245	1.44	-4.0	10.1	< -100	-17.3	-18.5	-8.6	-4.3	28.2
	G6sulfur-SSP585	0.99	-0.67	1.15	-16.6	-19.0	-18.1	-2.6	-1.5	37.0
ECA	SSP245	1.70	6.9	4.1	27.0	1.66	-0.88	2.67	-0.87	15.0
	SSP585	2.9	12.3	8.3	45.1	-7.4	-12.4	11.4	1.95	33.8
	G6-1.5K-SAI	-0.57	-1.6	-5.7	27.6	21.4	8.3	-6.7	-0.92	6.2
	Geo-SAI	-0.47	4.4	-1.59	53.0	11.8	8.4	4.7	5.5	34.1
	G6solar	0.99	4.2	0.50	34.8	0.26	-0.66	4.1	2.5	27.9
	G6sulfur-SSP245	1.17	4.7	-0.71	46.4	-4.82	-7.07	-2.40	-0.42	25.5
	G6sulfur-SSP585	0.97	4.2	0.96	31.0	-5.6	-6.7	3.01	2.2	29.3
TIB	SSP245	1.8	5.2	7.4	6.8	-8.1	-10.2	3.2	-2.6	22.2
	SSP585	3.0	11.4	6.5	15.1	-19.5	-20.6	7.8	-0.63	32.5
	G6-1.5K-SAI	-0.13	-2.9	-2.2	-1.99	18.4	2.5	-6.1	-3.0	7.7
	Geo-SAI	-0.03	-0.98	-5.7	2.9	10.0	-0.40	-1.3	1.9	13.6
	G6solar	1.1	-0.86	-2.5	0.41	-8.08	-6.4	-2.1	0.52	18.7
	G6sulfur-SSP245	1.6	8.1	0.33	16.0	-10.8	-11.0	3.9	-0.39	21.8
	G6sulfur-SSP585	1.2	6.0	-0.06	10.8	-12.4	-10.9	4.6	1.03	22.2
SAS	SSP245	1.6	2.7	5.0	3.9	-28.4	-29.8	8.4	-0.17	18.5

SSP585	2.7	5.3	5.2	5.4	-48.7	-51.3	8.7	-0.67	28.6
G6-1.5K-SAI	0.28	-3.5	1.1	-10.7	7.9	2.1	-2.4	-0.9	21.5
Geo-SAI	0.05	3.6	-22.2	64.8	1.5	-5.1	5.1	1.1	38.0
G6solar	1.2	-1.4	2.0	-12.5	-24.6	-23.6	0.03	-1.0	30.5
G6sulfur-SSP245	1.4	7.1	38.3	-28.4	-28.0	-28.6	13.6	2.0	33.3
G6sulfur-SSP585	1.1	6.1	3.7	13.3	-25.8	-25.1	9.7	0.98	35.3

Table S7. Changes in annual peak temperature (TMP; °C) and percentage changes (%) in peak precipitation (PCP), ET, CWB, snowfall, snowmelt, runoff, SM, and LAI during 2055–2084 relative to 2015–2034 across WCA, ECA, TIB, and SAS. Positive (negative) values indicate increases (decreases) relative to the corresponding present-day climatology. Bold values denote statistically significant future-versus-present differences at the 95% level ($p < 0.05$) based on Welch’s tests applied to ensemble-member period-mean annual peaks. G6-1.5K-SAI is evaluated relative to SSP2-4.5, whereas G6solar and Geo-SAI are evaluated relative to SSP5-8.5; G6sulfur is evaluated relative to both SSP2-4.5 and SSP5-8.5, as indicated by the scenario labels. Corresponding member-bootstrap 95% confidence intervals are provided in Table S8.

region	scenario	TMP	PCP	ET	CWB	Snowfall	Snowmelt	Runoff	SM	LAI
WCA	SSP2-4.5	2.0	-1.43	4.29	-0.21	-9.29	-19.29	0.74	-2.79	28.70
	SSP5-8.5	3.4	4.49	4.33	7.04	-24.94	-28.59	2.68	-2.10	42.53
	G6-1.5K-SAI	0.0	3.26	-2.49	-9.03	11.63	7.10	-0.53	-1.96	21.59
	Geo-SAI	-1.6	10.51	-3.81	35.42	3.68	3.89	5.42	2.09	38.30
	G6solar	1.3	6.21	-1.83	13.73	-6.50	-13.86	0.02	-0.58	33.81
	G6sulfur-SSP2-4.5	5.9	2.80	-0.83	-24.14	-11.60	-24.09	-2.36	-4.70	30.11
	G6sulfur-SSP5-8.5	-2.0	6.17	-0.68	7.59	-17.96	-22.81	3.09	-1.35	35.95
ECA	SSP2-4.5	1.9	1.57	0.95	7.54	7.01	-2.89	3.43	-0.77	10.47
	SSP5-8.5	3.3	3.23	2.17	22.80	4.51	-11.81	6.54	2.52	21.49
	G6-1.5K-SAI	-0.4	-0.58	-2.11	-49.19	17.84	19.48	-2.84	0.51	7.15
	Geo-SAI	-1.3	8.91	0.39	30.45	1.65	19.99	9.61	5.43	33.66
	G6solar	1.0	1.67	-0.84	37.28	10.64	1.52	4.88	3.02	24.39
	G6sulfur-SSP2-4.5	6.2	8.21	0.10	-31.47	6.19	-4.68	2.69	-0.40	24.33
	G6sulfur-SSP5-8.5	0.4	8.37	0.34	65.39	0.67	-3.44	8.38	2.21	27.63
TIB	SSP2-4.5	1.7	3.29	5.88	6.69	-6.03	-14.63	6.15	-3.67	19.06
	SSP5-8.5	3.1	13.02	2.55	18.76	-9.83	-26.27	12.38	-1.82	26.31
	G6-1.5K-SAI	0.1	-5.43	0.51	-4.17	18.71	5.91	-2.44	-3.36	7.44
	Geo-SAI	-0.9	-0.69	-2.74	2.38	9.60	3.96	1.23	1.68	12.70
	G6solar	1.4	1.04	-2.68	3.74	-2.18	-9.93	0.99	0.17	16.46
	G6sulfur-SSP2-4.5	13	10.51	-0.94	19.06	-0.08	-9.48	14.59	-1.25	19.99
	G6sulfur-SSP5-8.5	-1.5	9.75	-0.10	15.26	-0.47	-10.68	11.22	1.09	20.03
SAS	SSP2-4.5	1.9	2.07	6.52	5.96	-29.71	-25.03	9.86	0.39	16.29
	SSP5-8.5	3.2	7.53	4.74	9.44	-49.01	-44.31	12.08	0.12	32.53
	G6-1.5K-SAI	0.6	-3.80	2.35	-12.20	-4.74	-2.03	-1.52	-1.09	21.09
	Geo-SAI	-1.1	4.00	-12.41	8.91	-5.98	-7.99	8.44	-0.47	53.73
	G6solar	1.6	2.17	2.61	2.85	-24.14	-21.68	5.35	-0.40	40.09
	G6sulfur-SSP2-4.5	3.1	6.76	20.29	-3.25	-24.12	-21.25	15.22	1.82	41.45
	G6sulfur-SSP5-8.5	-1.6	9.24	2.65	12.81	-24.99	-19.82	15.55	0.77	45.06

Comment 24: Figure 7: I think here relative importance only represents the magnitude, but not the sign of contribution of each factor?

Response: We appreciate the reviewer's comment and agree that the LMG relative-importance metric represents the magnitude of each predictor's contribution to the explained variance (R^2) and does not retain the sign of the association. Accordingly, the positive LMG contributions in Figure 7 indicate each predictor's relative share of explained variance rather than whether its relationship with CWB is positive or negative. The direction of each association is determined from the corresponding MLR regression coefficient. We have clarified this distinction in Section 2.6 and revised the Figure 7 caption accordingly. We also emphasize that LMG contributions are interpreted as statistical relative importance rather than causal physical effects.

***Method section 2.4:** Predictor importance was quantified using the LMG metric (Lindeman et al., 1980) and expressed as the percentage contribution to explained variance. Raw and deseasonalized LMG results are shown in Figure 7 and Figure S2, respectively. LMG values indicate relative explanatory contribution rather than effect direction or causality; the sign of each association was determined from the corresponding regression coefficient. Accordingly, all MLR results are interpreted as statistical associations rather than physical attribution.*

***Updated figure caption:** Figure 7. Relative importance of hydroclimatic predictors for CWB based on the LMG decomposition of the raw monthly MLR models across (a) WCA, (b) ECA, (c) TIB, and (d) SAS under SSP2-4.5, G6-1.5K-SAI, SSP5-8.5, G6solar, G6sulfur, and Geo-SAI. Stacked bars show the percentage contribution of temperature (TMP), snowfall, snowmelt, runoff, soil moisture (SM), and leaf area index (LAI) to the total model R^2 , with contributions within each scenario summing to 100%. Numerical labels are shown for contributions of at least 8%. Because LMG decomposes explained variance, the values are non-negative and represent the magnitude of each predictor's relative contribution rather than the sign of its association with CWB; the direction of the association is determined from the corresponding MLR coefficient. LMG values are therefore interpreted as relative statistical importance rather than causal effects.*

Comment 25: Now, solar radiation modification is usually used to refer to SRM, but in the manuscript, solar radiation modification and solar radiation management are both used.

Response: We appreciate the reviewer's comment. We agree that the terminology should be consistent throughout the manuscript. We have therefore replaced the term "solar radiation management" with "solar radiation modification" throughout the revised manuscript and now use solar radiation modification (SRM) consistently in accordance with current usage in the literature.

Comment 26: Table S2: I suggest add a column listing starting year of SAI.

Response: We thank the reviewer for this helpful suggestion. We have revised **Table S2** to include a new column reporting the SAI start year for each experiment.

Table S2. Summary of stratospheric sulfur injection characteristics and experimental configurations for the CESM2 experiments used in this study. Injection rates represent approximate mean values over 2055–2084.

Differences in injection amount, location, and strategy reflect the distinct GHG backgrounds, control objectives, and experimental configurations of G6-1.5K-SAI, G6sulfur, and Geo-SAI. Sulfur-normalized responses are used only as a descriptive scaling diagnostic and should not be interpreted as measures of comparative efficiency or effectiveness. (Lee et al., 2025; Tilmes et al., 2020; Vioni et al., 2021; Vioni et al., 2024).

Experiment	Baseline Scenario	Start year	Injection Strategy	Injection Locations	Injection Altitude (km)	Mean Injection Rate (Tg SO ₂ yr ⁻¹)	Notes
G6-1.5K-SAI	SSP2-4.5	2035	Feedback-controlled SAI	30°N, 30°S	~21–25	~11.7	Designed to limit global-mean warming to approximately 1.5°C relative to preindustrial conditions
G6sulfur	SSP5-8.5 vs SSP2-4.5	2020	Feedback-controlled SAI	10°N–10°S	~25	~21	Injection increases over time under SSP5-8.5 forcing to offset part of the GHG-induced warming response
Geo-SAI (Geo SSP5-8.5 1.5)	SSP5-8.5	2020	Feedback-controlled SAI	15°N, 15°S, 30°N, 30°S	~20–25	~25–35	Feedback-controlled injection responds to the SSP5-8.5 forcing trajectory and maintains the prescribed climate-control objectives