Stratospheric Aerosol Injection Effects on Global Climate Classification

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Introduction

Our research focuses on solar radiation modification and the Köppen-Geiger climate classification.

- **Solar radiation modification (SRM):** theoretical process of manipulating the atmosphere to prevent consequences of global warming. It is modeled after volcanic eruptions that have produced cooling effects in the past by ejecting aerosols into the atmosphere that block sunlight from reaching the Earth's surface.
- SAI would certainly produce global cooling akin to a major volcanic eruption, but current science lacks confidence regarding how this cooling would be distributed on a regional scale.
- **Köppen-Geiger climate classification:** system that organizes the world into climate categories based off large, global sets of precipitation (pr) and near-surface air temperature (tas) data.

With the influence of climate change, many regions are shifting climate zones, taking on characteristics of a climate classification that differs from the original under a stable global climate. Here, we have analyzed these shifts, allowing us to produce the beginning of an assessment of SAI that could be used to determine whether it is worth utilizing in the future. Additionally, comparing SAI to different emission scenarios illustrates the possible futures of global warming, which is essential in combating the issue of climate change.

Methods

Coupled Model Intercomparison Project; Phase 6 (CMIP6): a project providing past, present, and future projections of climate change through climate models.

Geoengineering Model Intercomparison Project (GeoMIP): CMIP6 project. Comparison of climate models based on the effects of geoengineering processes (SRM).

- **SSP2-4.5:** demonstrates climate changes under a lower greenhouse gas emission scenario.
- **SSP5-8.5:** demonstrates climate changes under a higher greenhouse gas emission scenario.
- **G6sulfur:** model containing stratospheric sulfur dioxide that maintains global mean temperature at SSP2-4.5 levels despite actual emissions at SSP5-8.5 levels.

These models were analyzed in Python, where Köppen-Geiger classifications were used to map regions according to climate class (Tropical A and Polar E). Shifts in climate zones over time were calculated using the criteria located in table 2.

**visuals only represent G6sulfur scenarios*

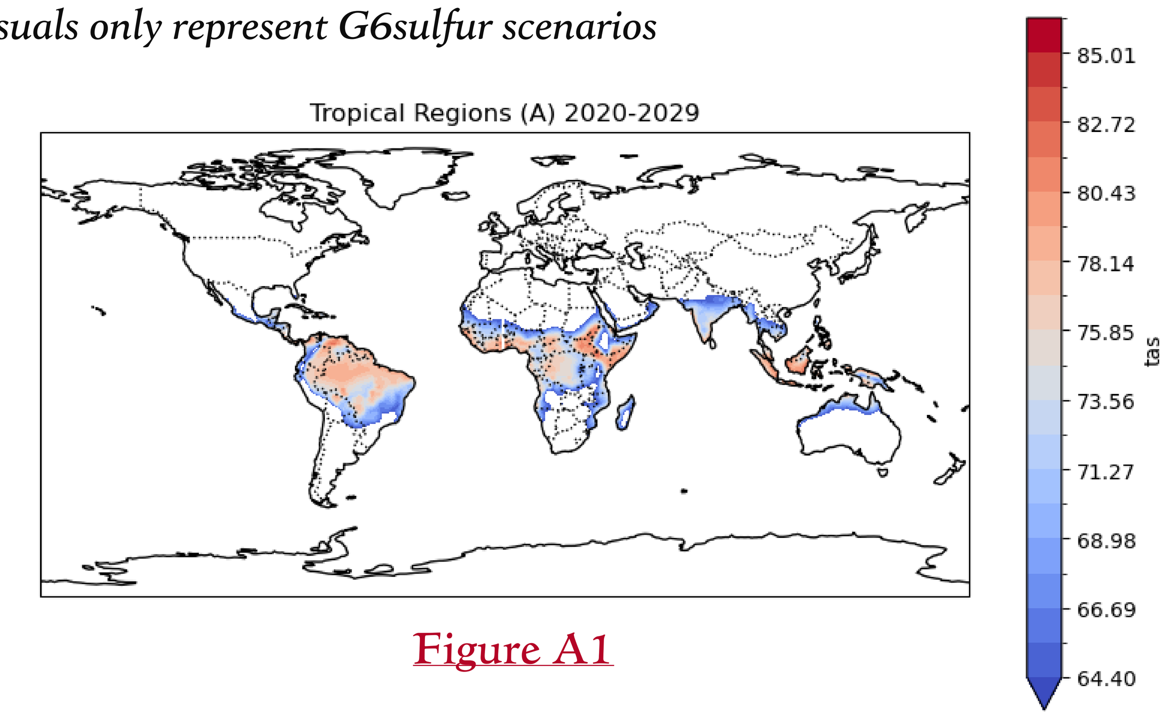

Figure A1

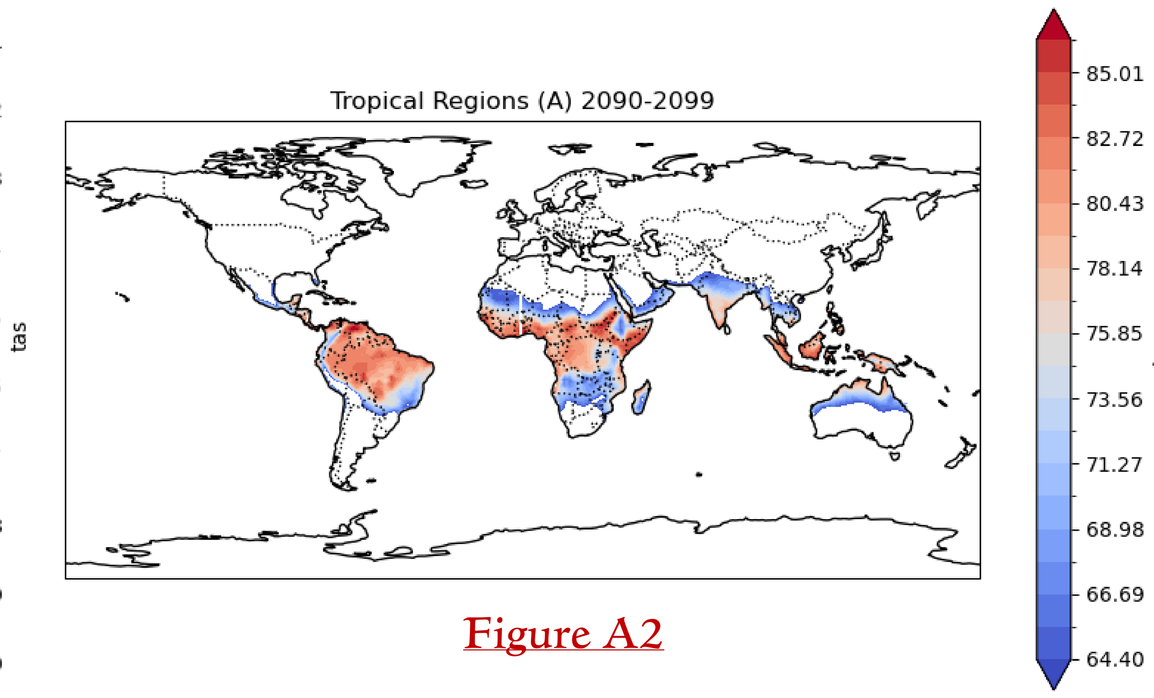

Figure A2

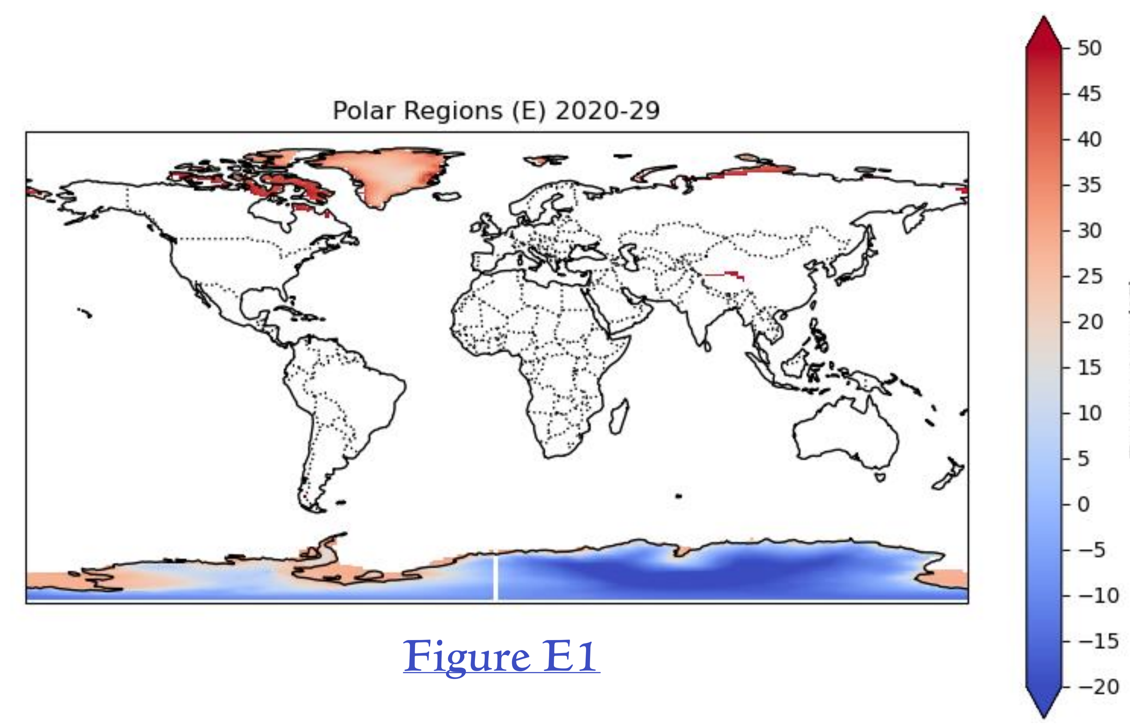

Figure E1

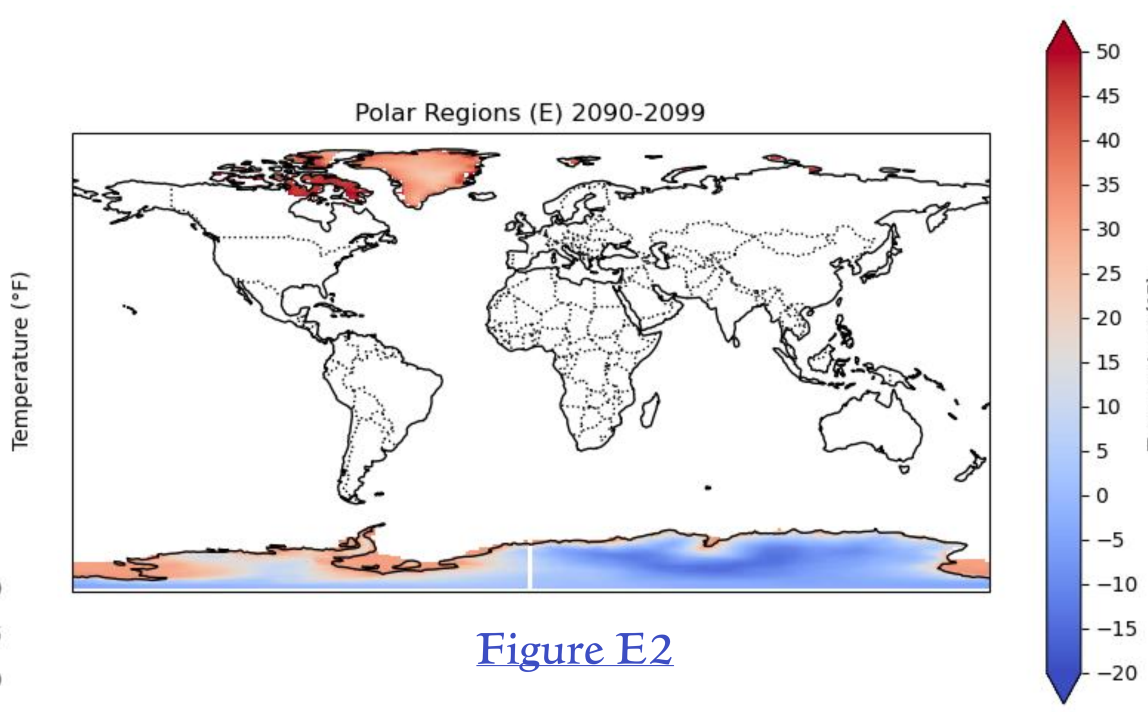

Figure E2

Table 1: Change in Land Area, 2020s-2090s

Scenario	Tropical Land	Polar Land
G6sulfur	6.44%	-0.99%
SSP2-4.5	5.71%	-0.62%
SSP5-8.5	9.73%	-2.16%

Table 2: Köppen-Geiger Climate Classification Criteria

Tropical (A)	Polar (E)
Tcold ≥ 18°C	Thot < 10°C

Key: *Tcold (mean temperature of the coldest month), Thot (mean temperature of the hottest month)*

Discussion

In an ideal world, the SAI and SSP2-4.5 percentages of change in land area would be completely equal if SAI were to work extremely effectively. Since SSP2-4.5 is a lower greenhouse gas emission scenario, SAI producing similar results while actual emissions are at the level of SSP5-8.5 indicates that it could be useful in the future to prevent regional changes in climate. In comparison to the changes under SSP5-8.5, SAI appears to reduce impacts.

The SAI scenario through the G6sulfur models produced percentages that roughly fall in the middle of both scenarios. While these percentages not being closer to those of SSP5-8.5 indicate that SAI possesses the ability to inhibit warming, whether SAI is a reliable method of climate intervention is still very debatable.

These results display that SAI is working at a noticeable level, but they only contain data on two of the five climate classifications. Analyzing the entirety of the Köppen-Geiger climate classification is fundamental in developing confidence in SAI's use and how it could theoretically work, so it is crucial that additional extensive research is done on this topic.

Results (A)

- We see a 6.44% increase in land area that meets the criteria of the tropical climate classification in the future SAI scenario (Fig. A2) but did not meet the criteria under the present SAI scenario (Fig. A1).
- The SSP2-4.5 scenario contained a 5.71% increase in tropical land area, which is considerably less than the 9.73% increase under SSP5-9.5.
- Regions that were originally classified as tropical zones in A1 generally saw increases in monthly mean temperature in A2. This increase is seen in all scenarios.
- The change in land area under SAI being less than that of SSP5-8.5 but still greater than that of SSP2-4.5 suggests that SAI should not be our only form of climate mitigation.

Results (E)

- We observe a 0.99% decrease in land area that meets the criteria of the polar climate classification in the present SAI scenario (Fig. E1) but did not meet the criteria in the future SAI scenario (Fig. E2).
- The SSP2-4.5 scenario contained a 0.62% decrease in polar land, while the SSP5-8.5 displayed a 2.16% decrease.
- Regions that are classified as polar zones in both E1 and E2 generally saw increases in monthly mean temperature in E2. This increase is seen in all scenarios, demonstrating the vulnerability of the Arctic.

References