

ARISE-SAI: Climate Intervention simulations for actionable science & stakeholder engagement

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Mari Tye, Daniel Visoni, Brian Dobbins & Many Others*

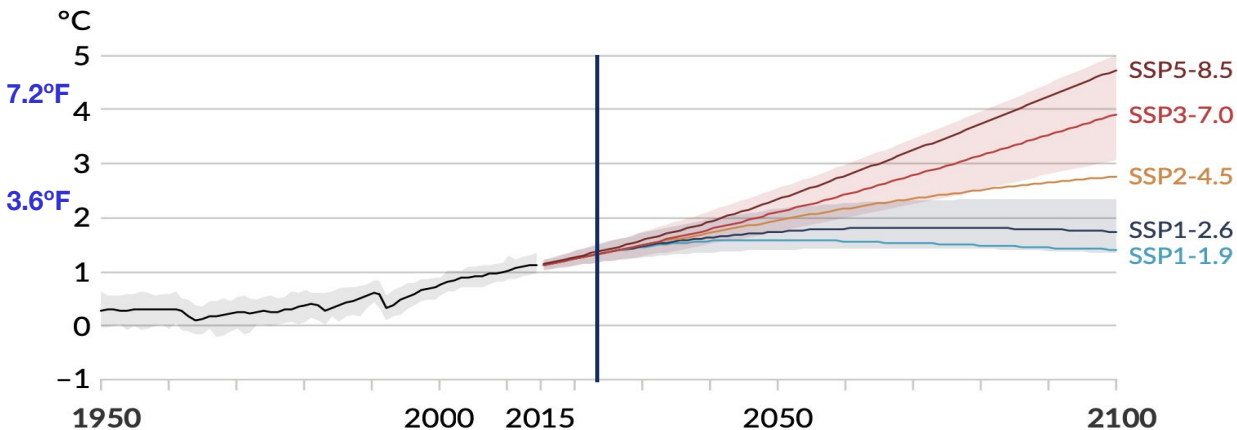


June 12, 2023



Why Climate Intervention?

(a) Global surface temperature change relative to 1850–1900

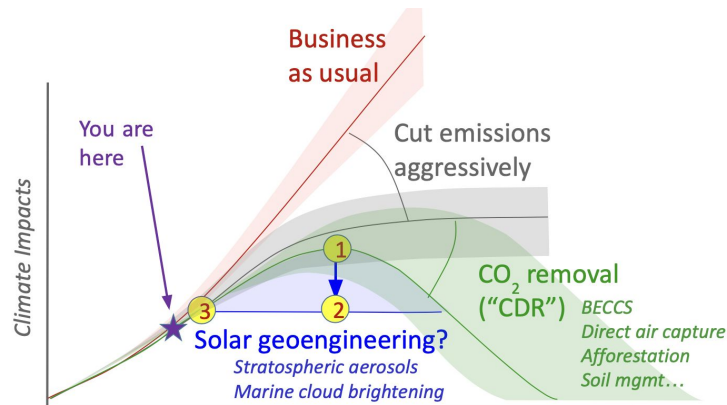


Global mean surface T will most likely reach:

1.5°C over PI in 2025 - 2035

2°C over PI in 2035 - 2060

Solar geoengineering using stratospheric aerosol injection (SAI) or Marine Cloud Brightening (MCB) can potentially reduce some of the worst consequences of climate change





Safe Climate Research Initiative


ARISE: Assessing Responses and Impacts of Solar climate intervention on the Earth system


Main Dataset for Analysis



Partnership between:
**SilverLining NGO, NCAR, AWS,
and University Community**


- Shared goal
- Co-designed experiments
- Simulations on Cheyenne HPC & AWS Cloud Computing
- Community Analysis



UKESM Intercomparison  **Met Office** 

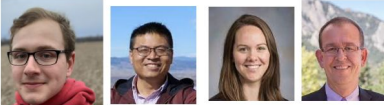

Scenarios & Strategies, Optimization: 

Marine Cloud Brightening 

aws  **SILVER LINING**  **Funding & Partnership Building**




DECIMALS FUND  *Developing Country Impacts Modelling Analysis for SRM*

Impacts on crops  **RUTGERS** 

Impacts, processes, variability, Machine Learning  **Colorado State University** 

GLENS ARISE NCAR
Simulations & Impacts
Reducing/understanding uncertainty

\$ 750,000 in Cloud Computing

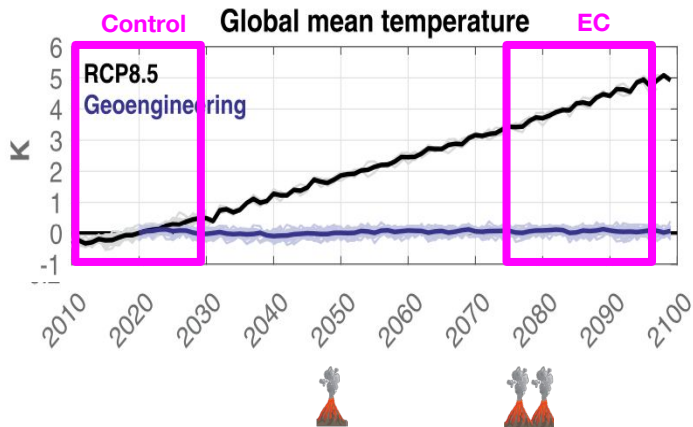
  

Tuesday 5:30 - 7:30 pm (including Reception)

ARISE-SAI Design

Aimed for more realistic experimental setup than GLENS; Co-create with the community

GLENS:



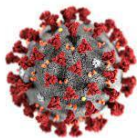
Unrealistic start date; High emissions scenario
EC analysis to focus on high signal-to-noise



1 Mt. Pinatubo, ~ 20 Tg SO₂

ARISE-SAI-1.5

SILVER LINING



Experimental Design:

- Background scenario?
- Start of intervention?
- How much to cool?
- Injection strategy

Limited time: teams waiting for data! Limited computing

PNAS

RESEARCH ARTICLE

EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES
SUSTAINABILITY SCIENCE

OPEN ACCESS

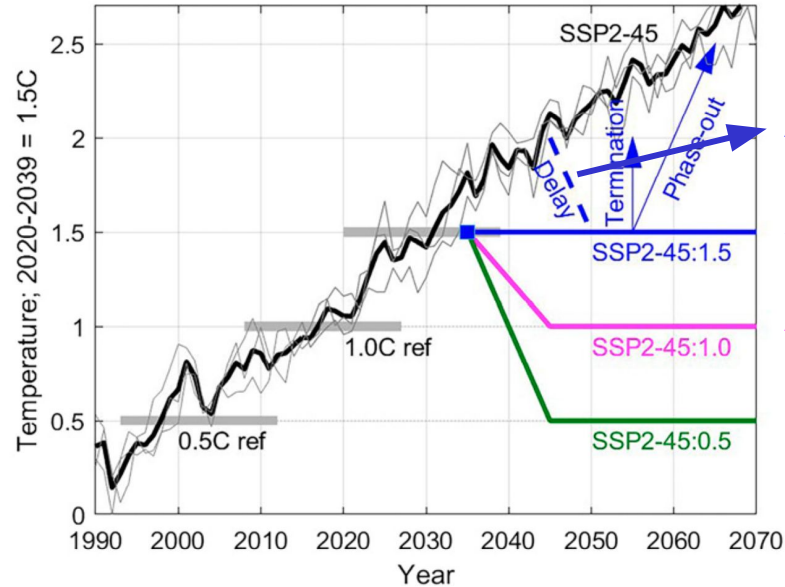
Scenarios for modeling solar radiation modification

D. G. MacMartin^{a,1}, D. Visioni^b, B. Kravitz^b, J.H. Richter^c, T. Felgenhauer^d, W. R. Lee^a, D. R. Morrow^e, E. A. Parson^f, and M. Sugiyama^g

Edited by William Clark, Harvard University, Cambridge, MA; received February 7, 2022; accepted June 22, 2022

ARISE-SAI

Multiple scenarios make most sense



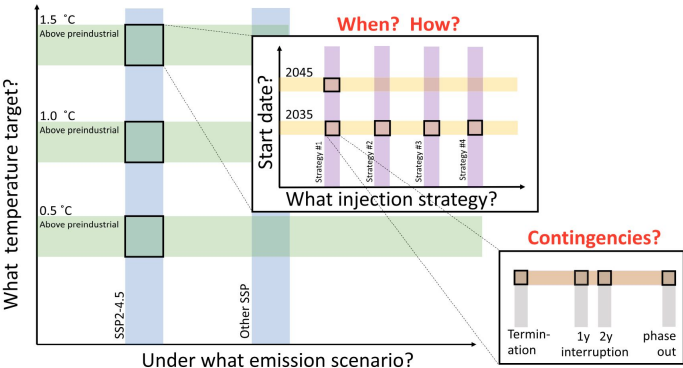
ARISE-SAI-2045 AWS

ARISE-SAI: Cheyenne

ARISE-SAI-1.0: AWS

Using full TSMLT version of CESM2(WACCM)

Fig. 2. Graphical illustration of scenarios described in Section 3. Simulation results for historical (through 2014) and SSP2-45 (2015 on) are from the CESM2(WACCM6) model, as described in Section 4 (three ensemble members; mean shown in thicker lines); simulation data for the SRM scenarios here are shown in Figs. 3 and 4.



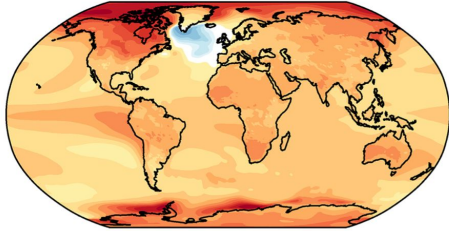
MacMartin et al. 2022

- Lots of choices to be made already in this space but computing limited**
- Background scenario: SSP-2.45
 - Start of intervention: 2035
 - Cool: to 1.5°C, 1°C
 - End simulations in 2070
 - Injection altitude lowered to 21.5 km

Community Analysis: University Partners

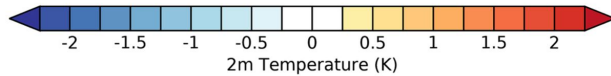
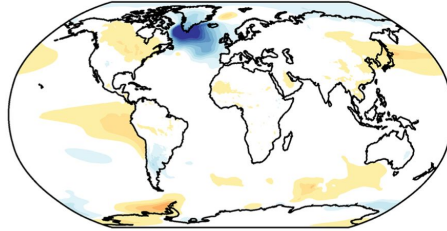
No Intervention

(c) SSP2-4.5(2050-2069) - SSP2-4.5(2020-2039)



SAI

(d) ARISE-SAI-1.5(2050-2069) - SSP2-4.5(2020-2039)



Richter et al. (2022)

Examples of other Analysis:

- Rutgers: Land changes/crops
- Cornell/NOAA: Stratospheric response
- CSU: fire risk, permafrost, extreme weather
- UK Met Office: Comparison with UKESM

<https://www.cesm.ucar.edu/community-projects/aise-sai>

Engagement from very beginning: focus on science/processes

Information usable by Stakeholders

Utilize expertise across NCAR to create information directly usable by stakeholders

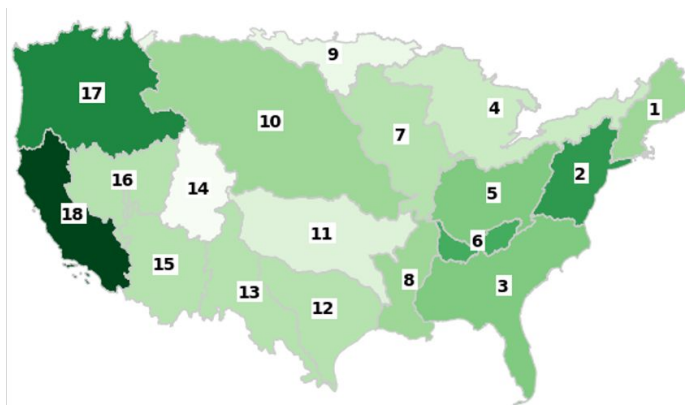
Focus to date has been on global analysis, understanding processes

Need to foster closer connections to stakeholders and what information is needed for decision-makers

Example: Water availability metrics
(Mari Tye in collaboration with RAL)

Relative skill was determined from the ability for CESM2 to reproduce ~20 rainfall and runoff indices similar to observations

Hydrological Unit Code (HUC) 2 Regions



- 1 New England (NE)
- 2 Mid-Atlantic (MA)
- 3 South Atlantic-Gulf (SA)
- 4 Great Lakes (GL)
- 5 Ohio (OH) 6 Tennessee (TN)
- 7 Upper Mississippi (UM) 8 Lower Mississippi (LM)
- 9 Souris-Red-Rainy (RR)
- 10 Missouri; (MR)
- 11 Arkansas-White-Red (ARK)
- 12 Texas-Gulf (TX)
- 13 Rio Grande (RG)
- 14 Upper Colorado (UC)
- 15 Lower Colorado (LCO)
- 16 Great Basin (GB)
- 17 Pacific Northwest (PN)
- 18 California (CA)



Opportunity to connect with NSF Convergence Proposal

Future: Information usable by Stakeholders

Comparison of Extreme Precipitation in Projected Climates (2040 - 2070)

Boxes: proportion of total rainfall that comes from events heavier than 95th percentile

SAI will likely reduce the intensity of events > 95% (smaller contribution to annual total)

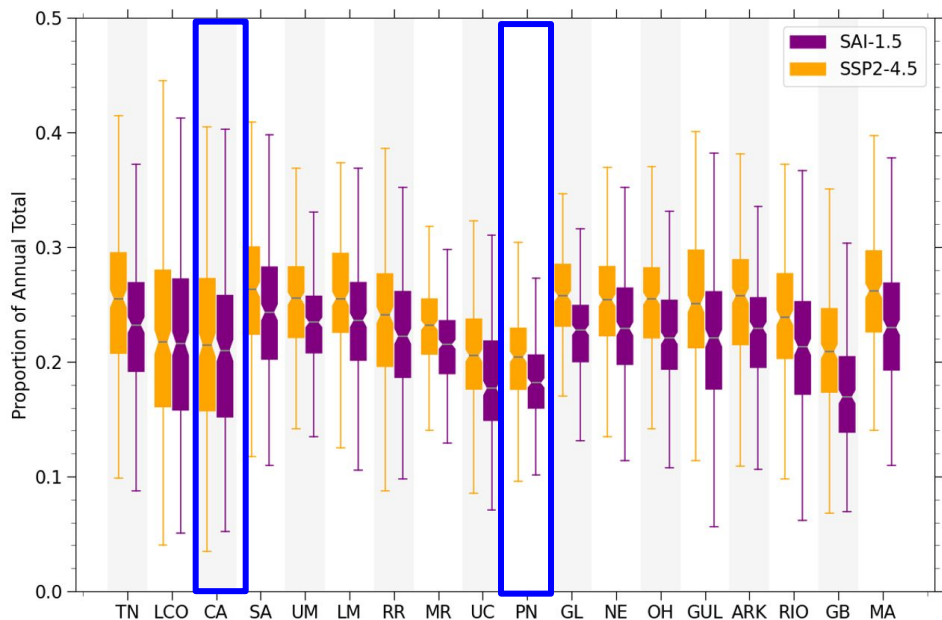


Figure by Mari Tye

Looking forward: wishlist

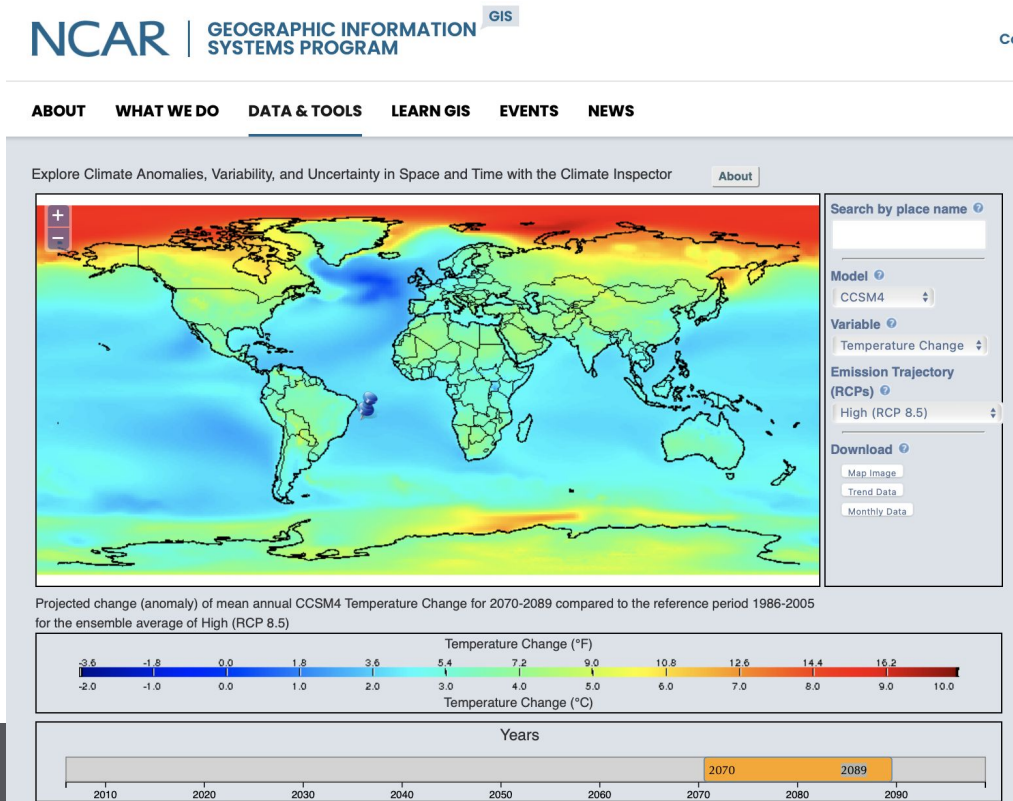
Utilize expertise across NCAR to create information directly usable by stakeholders

Utilize downscaling methods to provide local-scale information

Utilize the NCAR GIS Program's **Climate Inspector**

Visualization tool that already takes in CMIP-type simulations

Temperature, Precipitation: anomaly, variability, trends; Single-location figures



Accessibility: Data on AWS

Idea: To make the data accessible to anyone from anywhere - democratize data & analysis

Registry of Open Data on AWS



Community Earth System Model v2 ARISE (CESM2 ARISE)

atmosphere climate climate model geospatial ice land model oceans sustainability

Description

Data from ARISE-SAI Experiments with CESM2

Update Frequency

Rare once complete (August 2022)

License

<https://www.ucar.edu/terms-of-use/data>

Documentation

(<https://github.com/NCAR/CESM2-ARISE>)

Managed By



Resources on AWS

Description

Project data files

Resource type

S3 Bucket

Amazon Resource Name (ARN)

`arn:aws:s3:::ncar-cesm2-arise`

AWS Region

`us-east-2`

AWS CLI Access (No AWS account required)

`aws s3 ls --no-sign-request s3://ncar-cesm2-arise/`

PROS:

- Accessible & can be downloaded by anyone without an account
- Analysis on the cloud possible

CONS:

- On the cloud analysis not in all's skillset
- No available notebooks/support
- Computationally intensive requires 'credits'
- User support: currently unavailable

ARISE-SAI-1.5 uploaded to AWS; ARISE-SAI-1.0 & ARISE-SAI-2045 soon available

Summary

We have co-created a community dataset for analysis of climate intervention with and for the community: <https://www.cesm.ucar.edu/community-projects/arise-sai>

- There are many dimensions of the climate intervention space; Multiple scenarios are needed, yet computational and human resources are limited
- Community Input/Support: takes a lot of time
- Dedicated resources are needed to maintain support and relationships
- Data 'up on the cloud' or on NCAR's CDG: big step forward, yet more needs to be done
- Scientific papers: need to continue; outputs & outreach to stakeholders is also needed



**Daniel
Visioni**
Cornell U.



Brian Dobbins
NCAR

Thank you!

ARISE Talks & Reception: Tuesday 5:30 - 7:30 pm (including Reception)