Solar Climate Intervention Research at CSU using ARISE

Research to detect, attribute and quantify SCI effects and risks

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CESM Workshop
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Project Team

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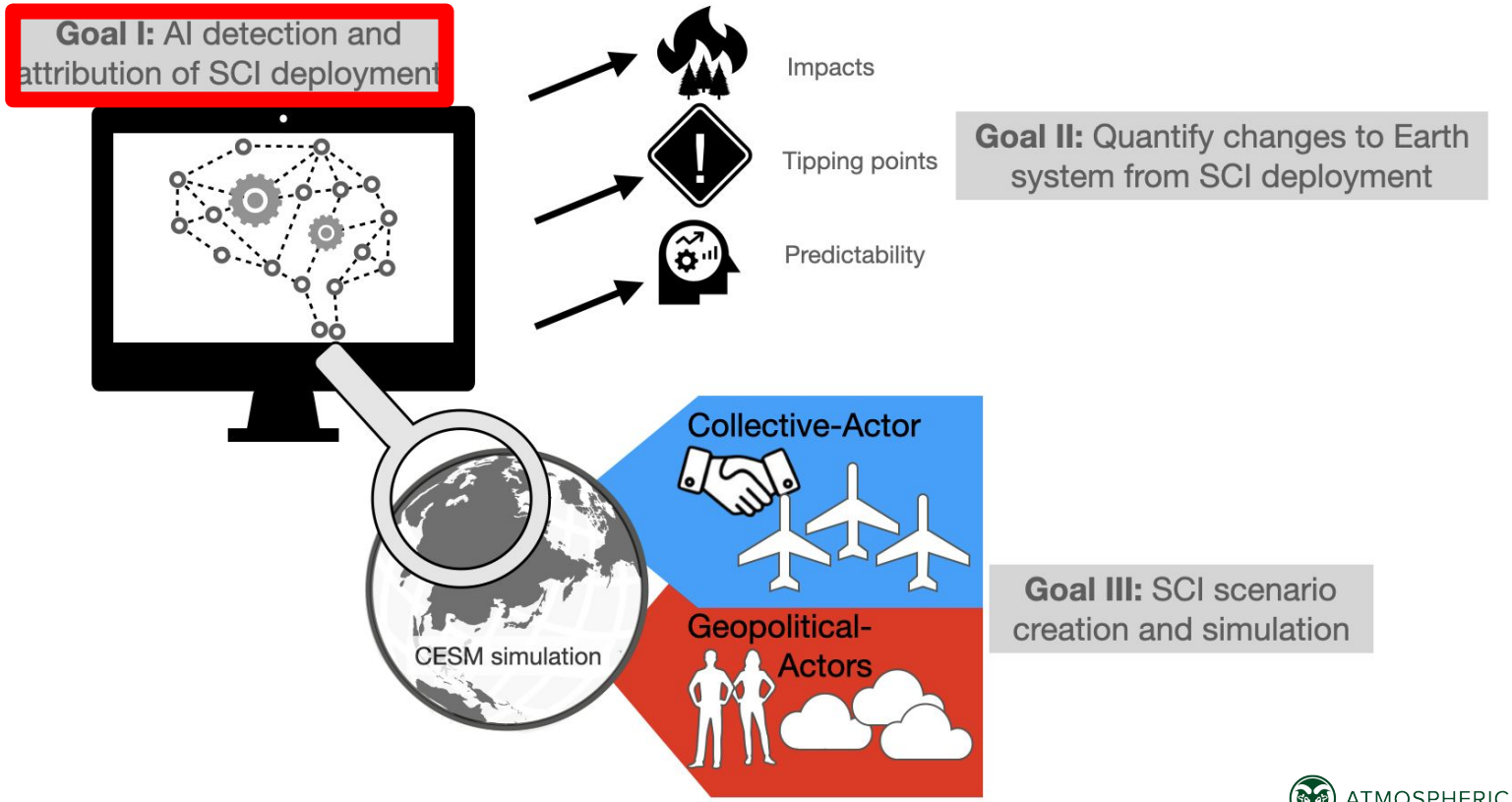
Ivy Glade

Danielle Touma
(CSU and NCAR ASP)

AI to detect, attribute and quantify Solar Climate Intervention (SCI) effects and risks under a range of geopolitical scenarios



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Can We Detect An SAI World?

20 members of SAI scenario

Near-surface temperature trends: First decade after deployment

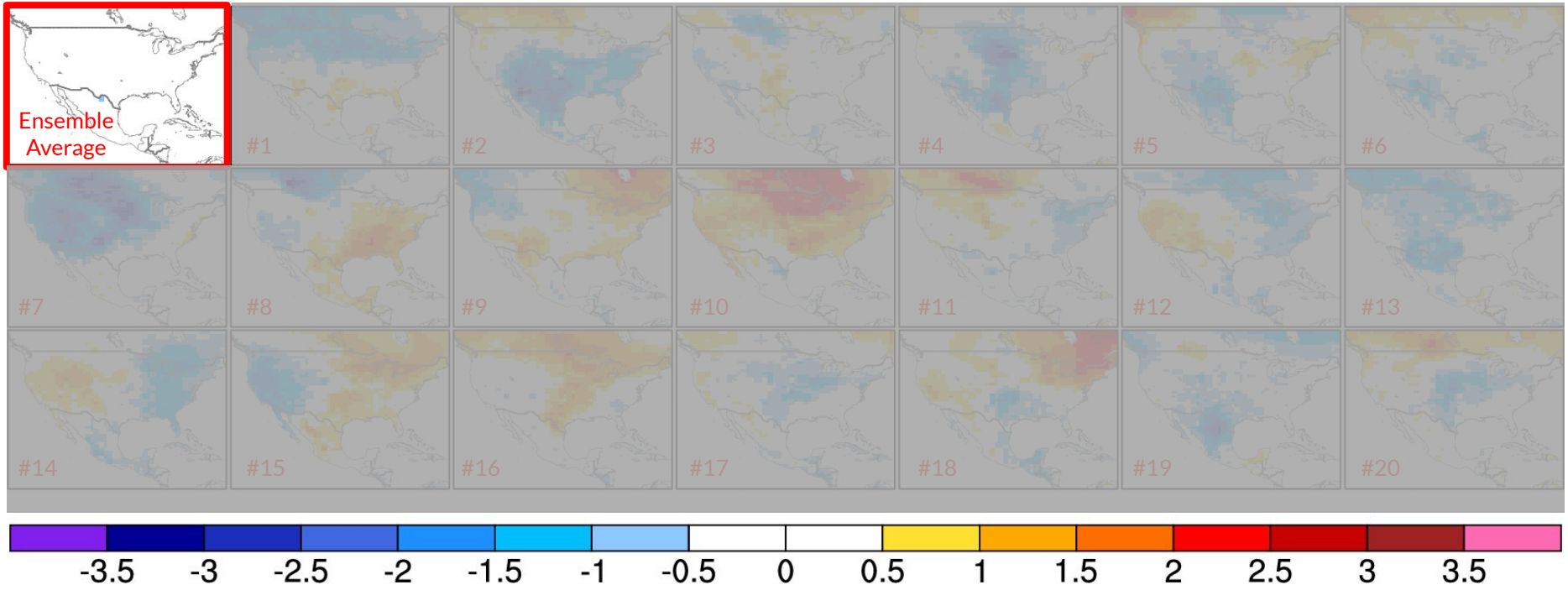

Figure by Dr. Lantao Sun

Can We Detect An SAI World?

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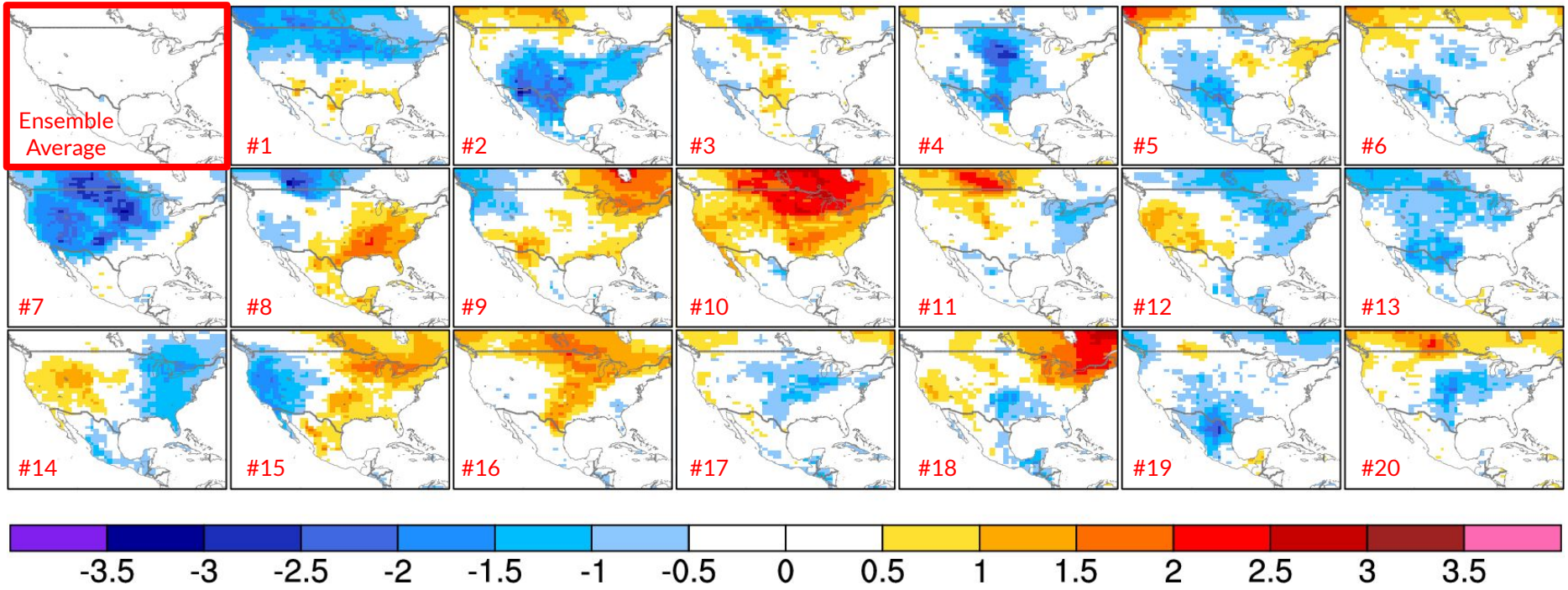

Figure by Dr. Lantao Sun

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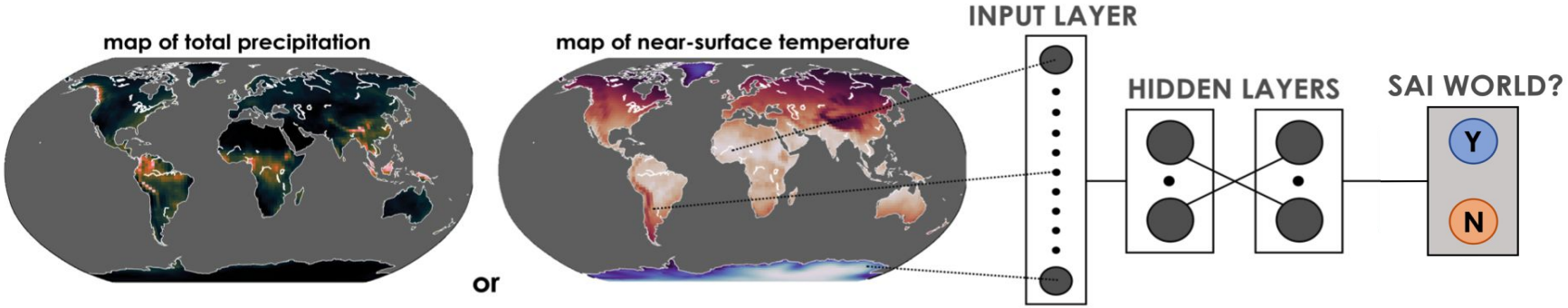
Detection of Regional Impacts using XAI

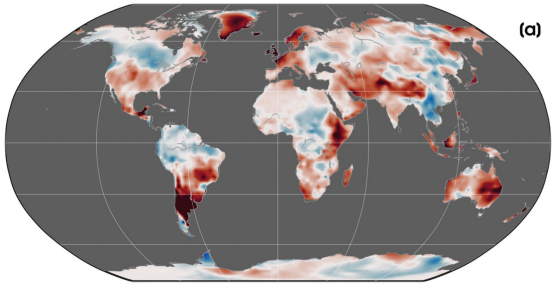


- When might we detect the regional impacts of SRM on earth system variables?
- How different would an SRM world be from one without SRM?
- How will this vary regionally?

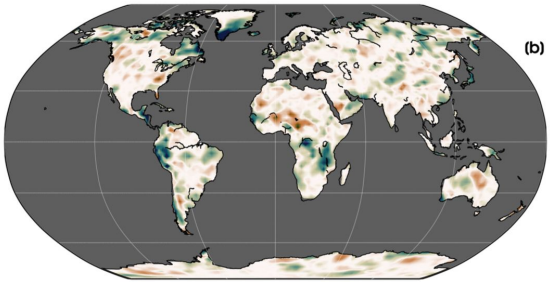
Labe, Barnes and Hurrell (2023)

Regional Patterns used for AI Detection

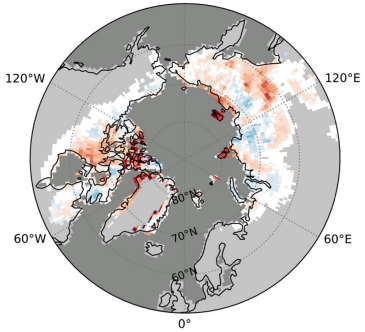
Temperature Extremes



Precipitation Extremes



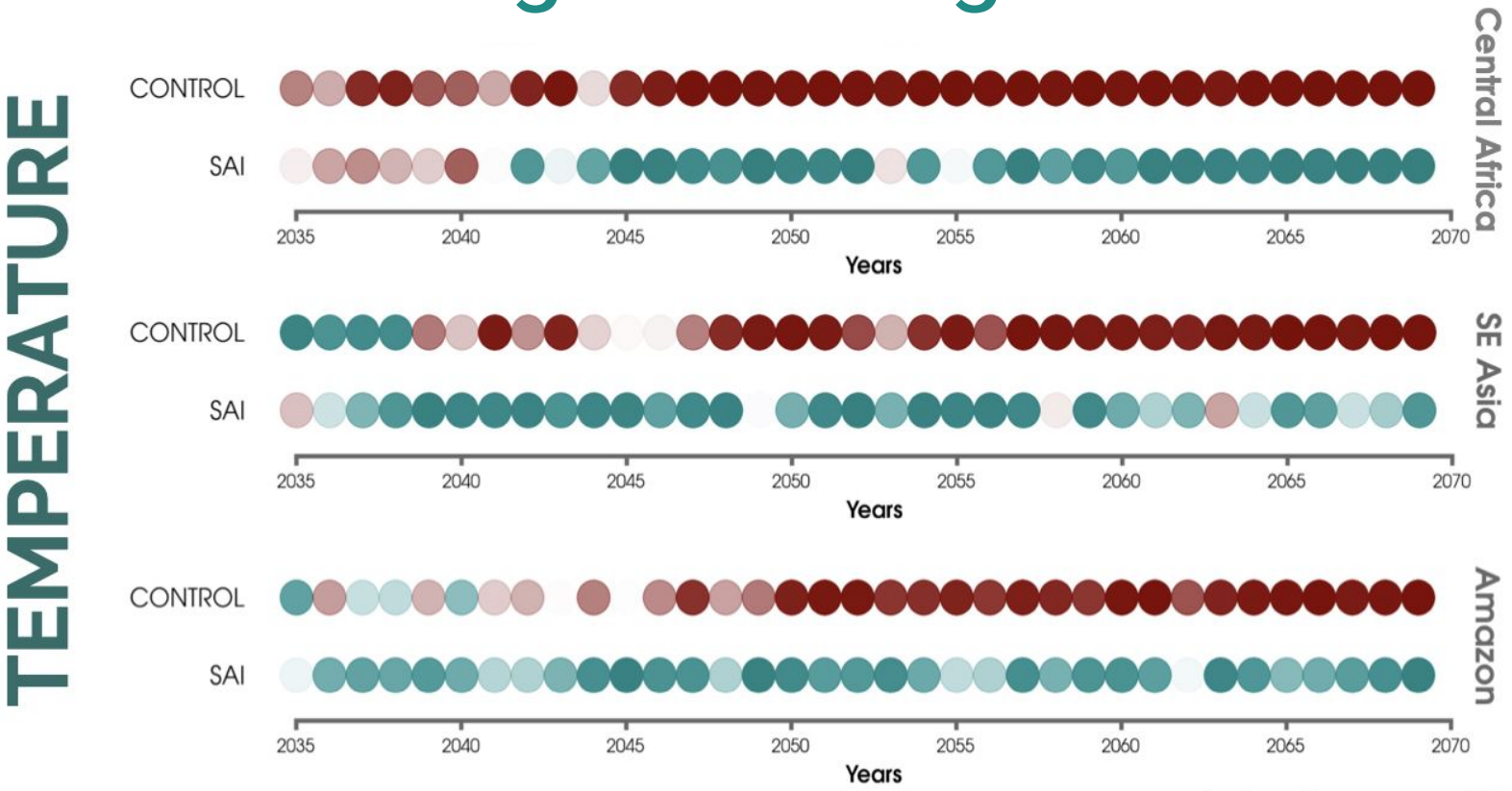
Permafrost



- Detection of regional impacts 1-15 years after deployment (in CESM2-ARISE), much earlier than some reports suggest.
- Detectable patterns offer insights into where observations may be most useful for the specific scenario.

Labe, Barnes and Hurrell (2023)
Morrison, Barnes and Hurrell (2023b)

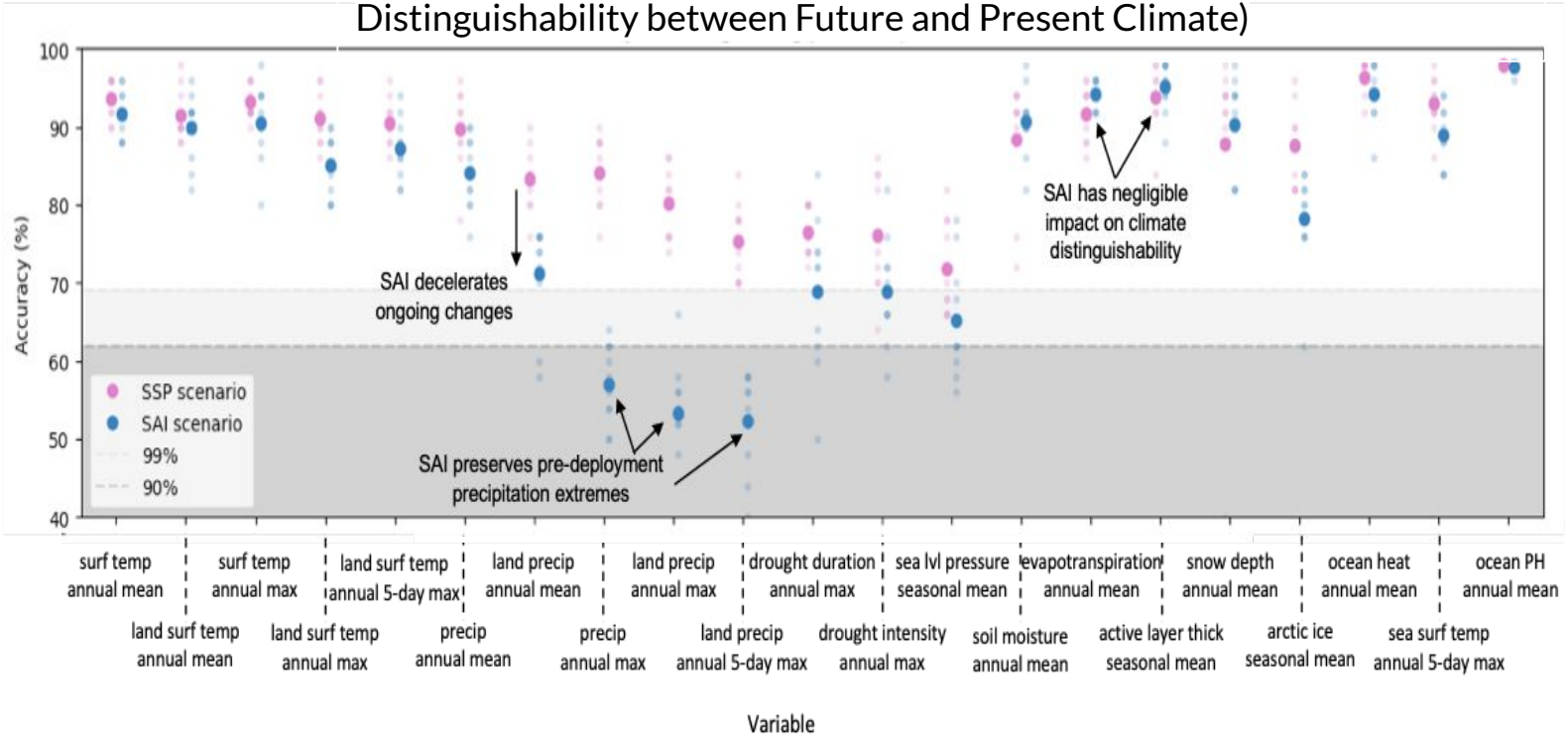
Regional Emergence



Labe, Barnes and Hurrell (2023)

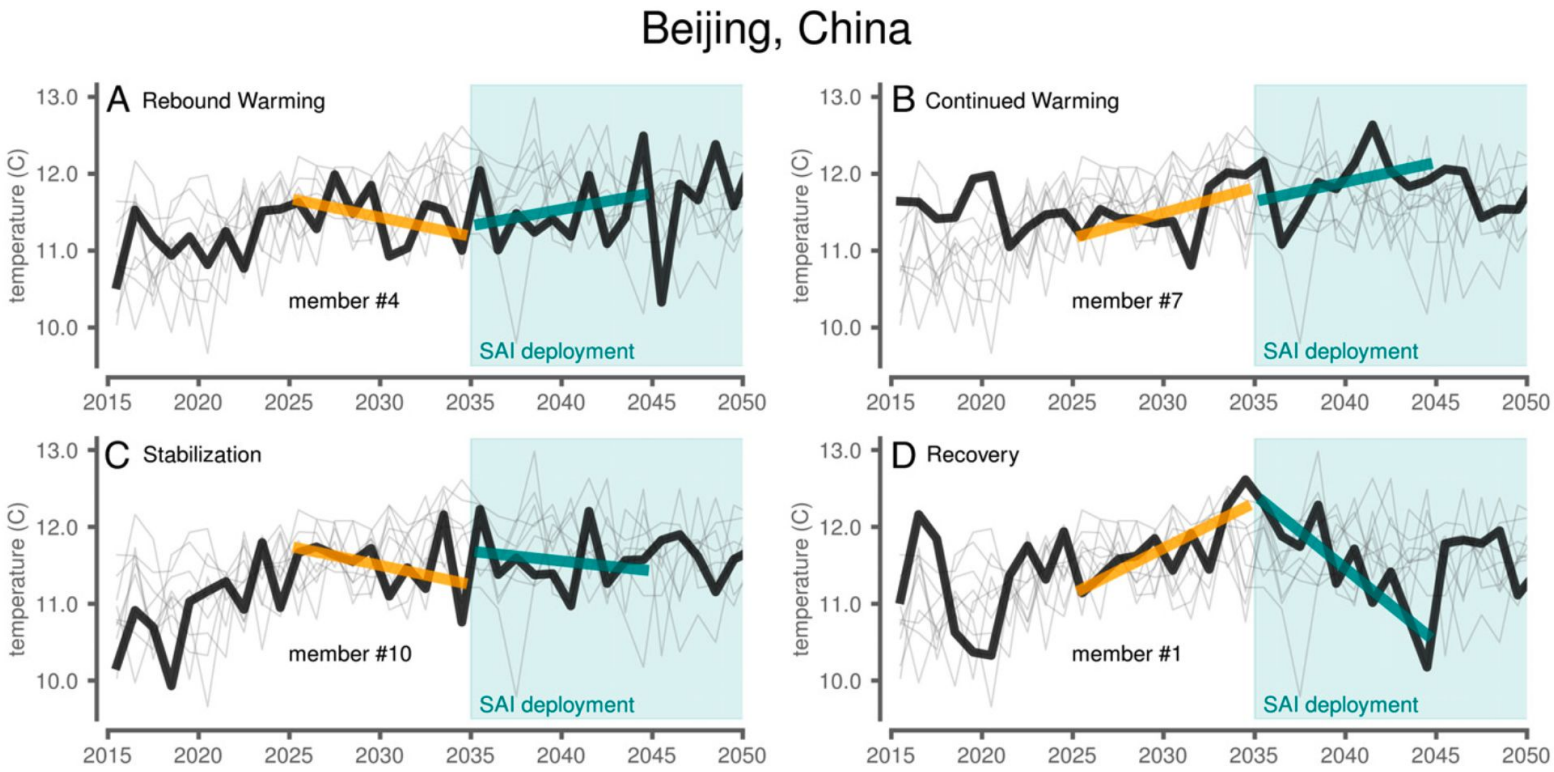
Quantifying Climate Distinguishability

Distinguishability between Future and Present Climate)



Mamalakis, Barnes and Hurrell (2023)

Potential for Perceived Failure



Keys, Barnes, Diffenbaugh, and Hurrell (2022)

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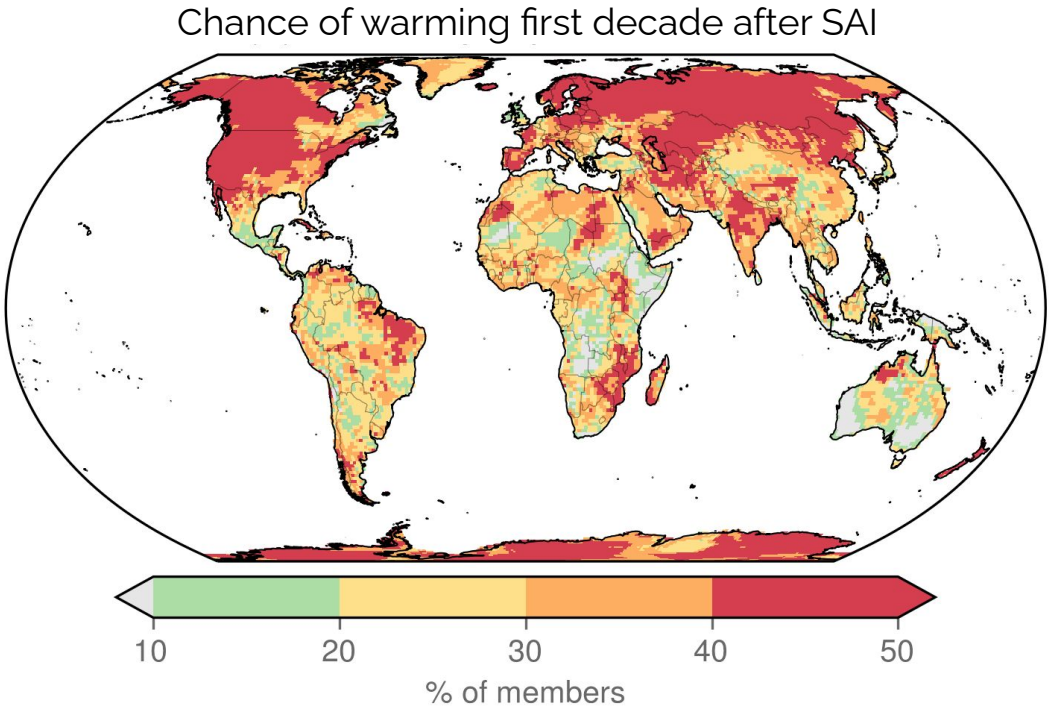
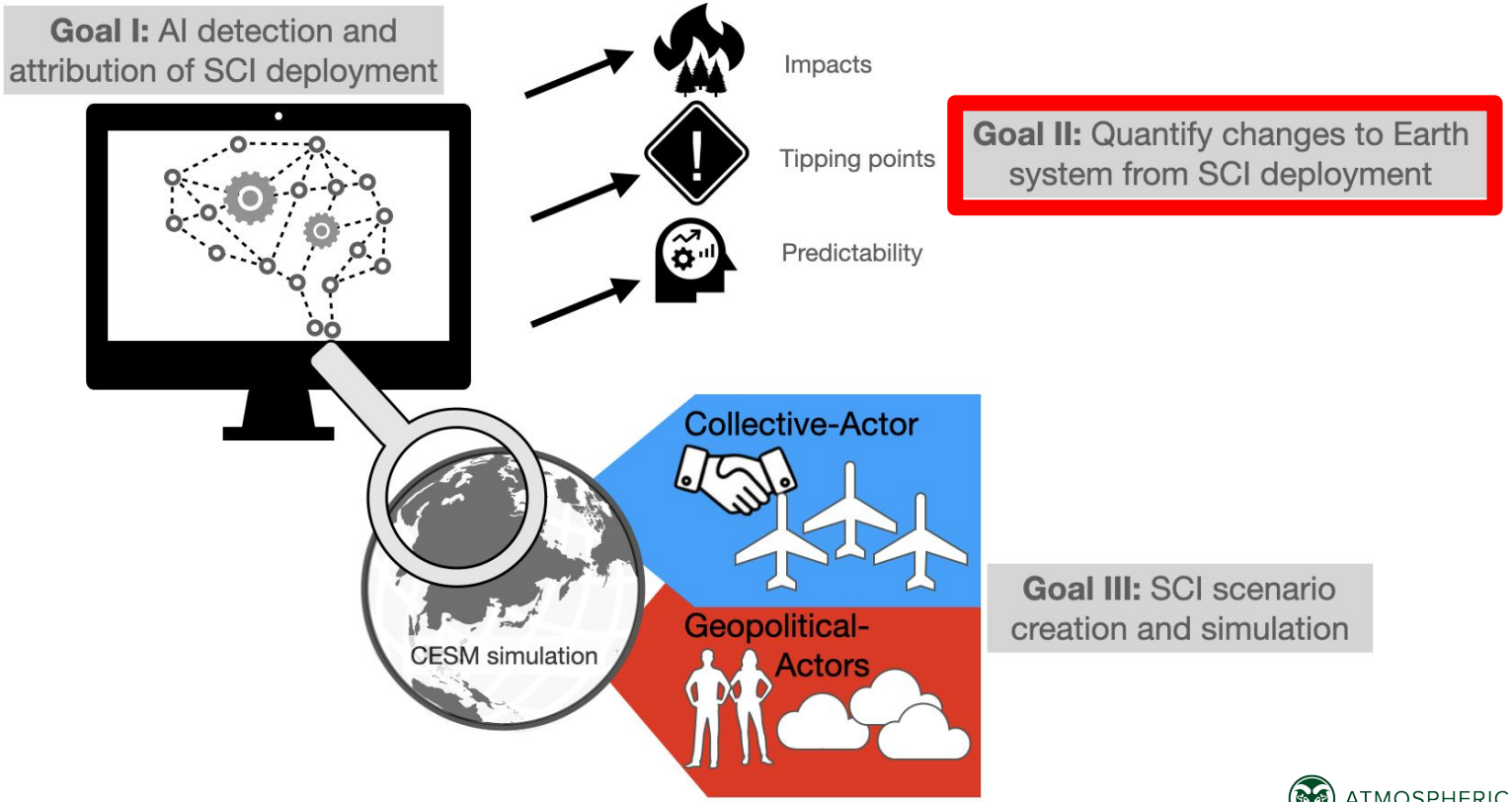


Implications:

- The masking effects of internal climate variability will need to be well modeled and studied for planning of any climate mitigation scenario
- The most populous and powerful countries globally experience the greatest probability of potential perceived failure.
- Climate models are essential for exploring methods to detect and attribute SAI impacts and risks

Keys, Barnes, Diffenbaugh, and Hurrell (2022)

AI to detect, attribute and quantify Solar Climate Intervention (SCI) effects and risks under a range of geopolitical scenarios



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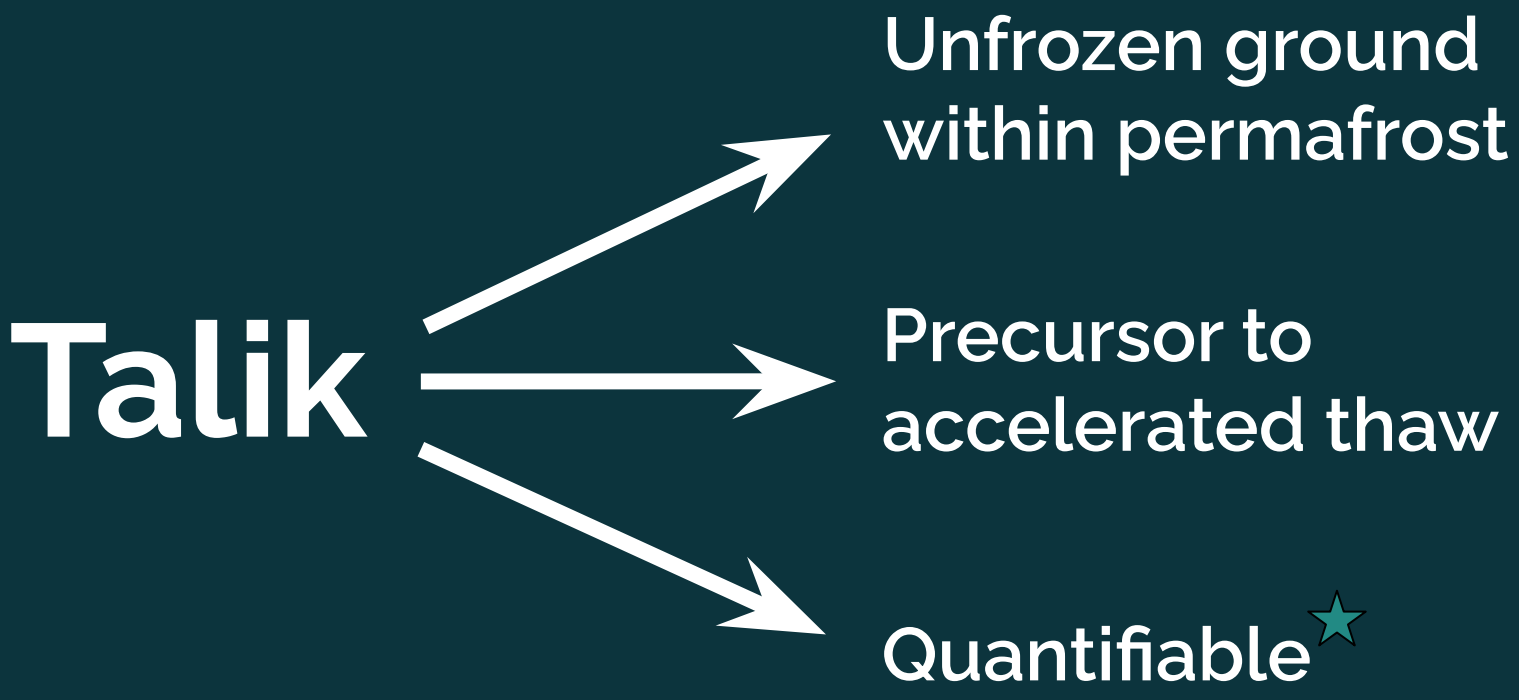
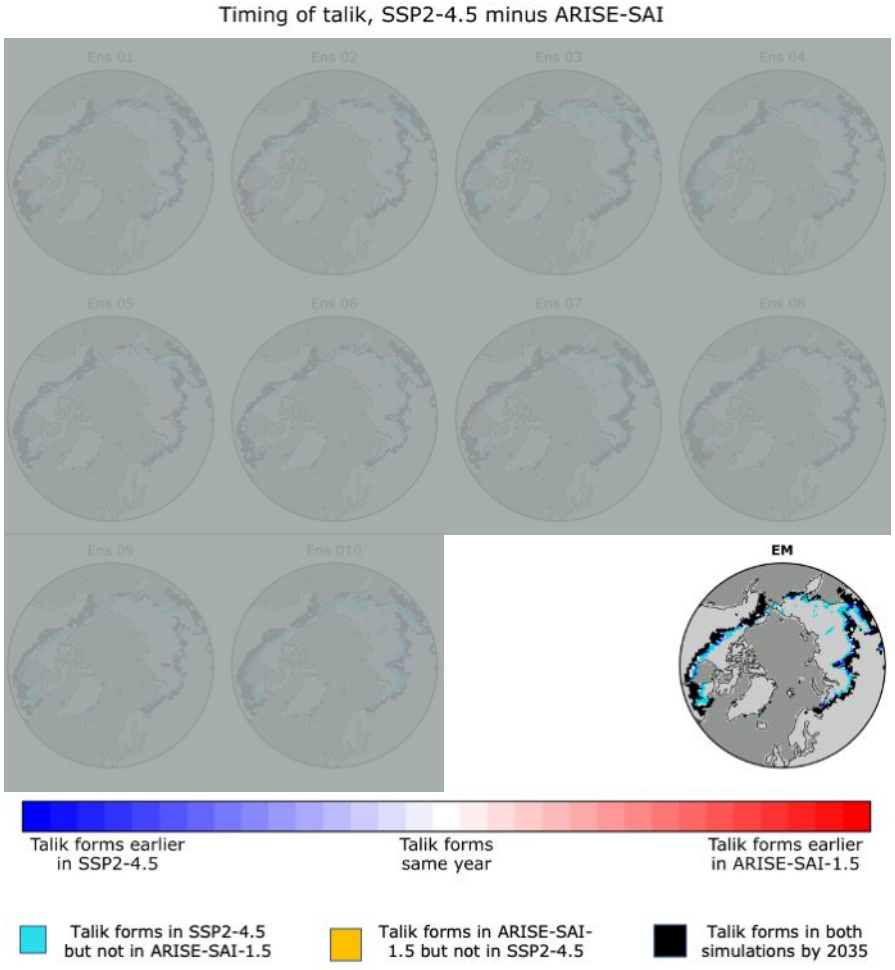
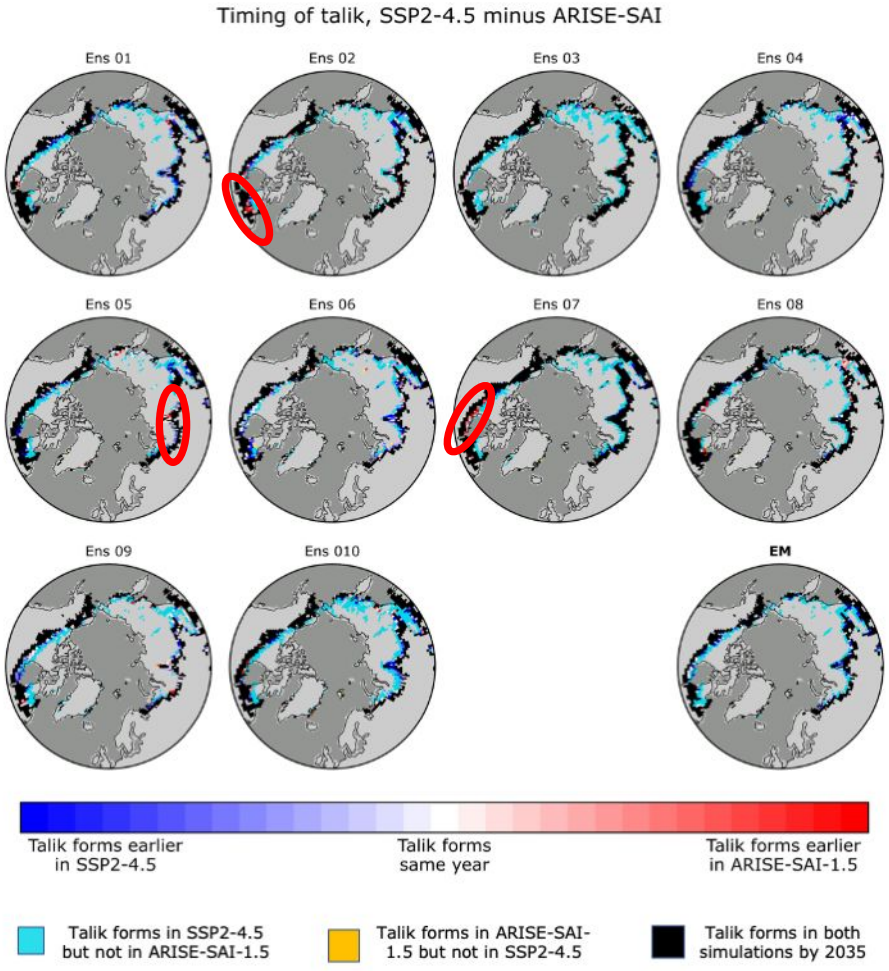
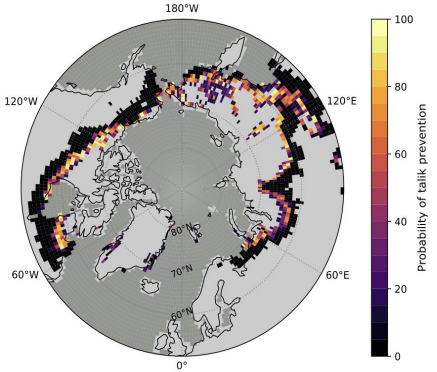

Talik
Unfrozen ground within permafrost
Precursor to accelerated thaw
Quantifiable



Morrison, Barnes, Hurrell (2023b)



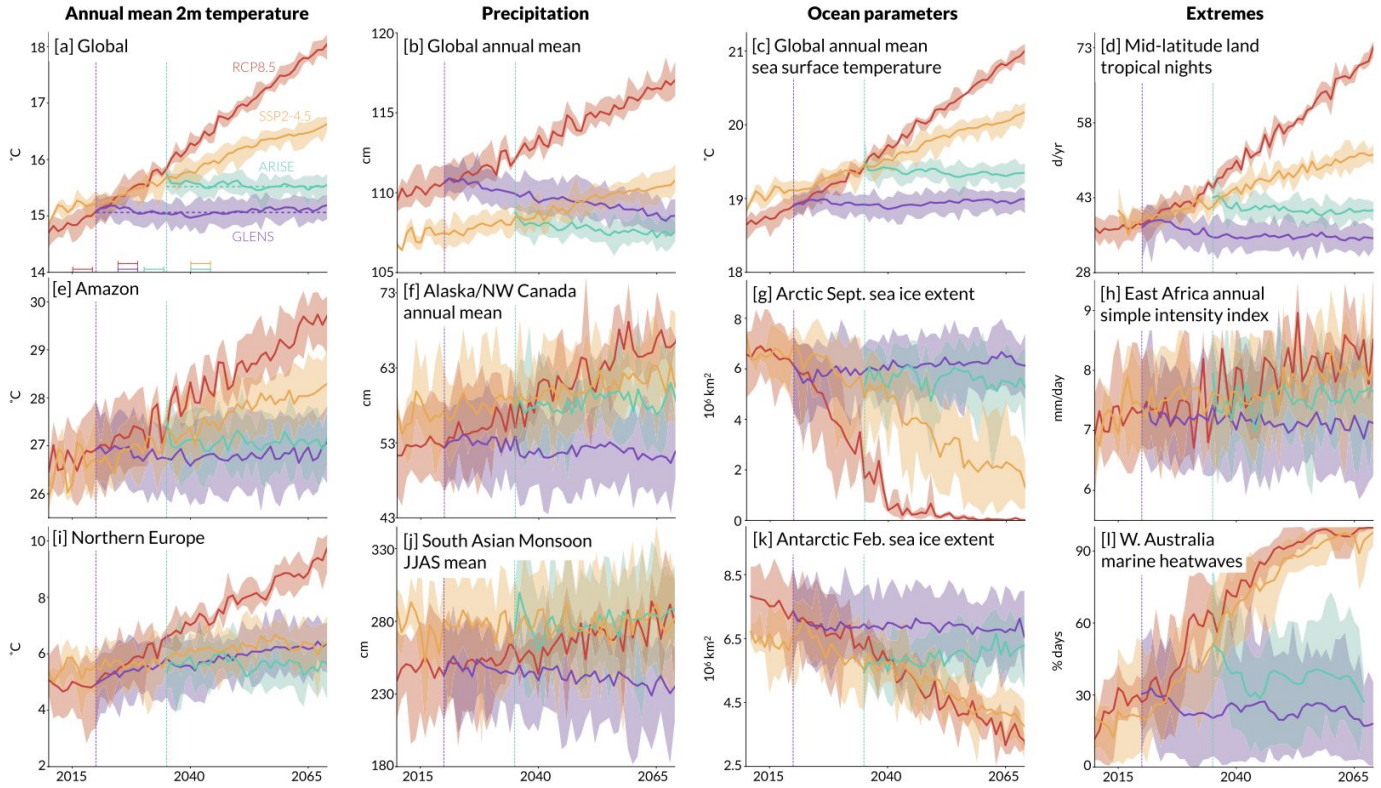
Natural variability affects likelihood of avoiding a permafrost tipping point under SAI



Morrison, Barnes, Hurrell (2023b)

Assessing Outcomes in Stratospheric Aerosol Injection Scenarios Shortly After Deployment

Hueholt, D. M., E. A. Barnes, J. W. Hurrell, J. H. Richter, and L. Sun, 2023, *Earth's Future*



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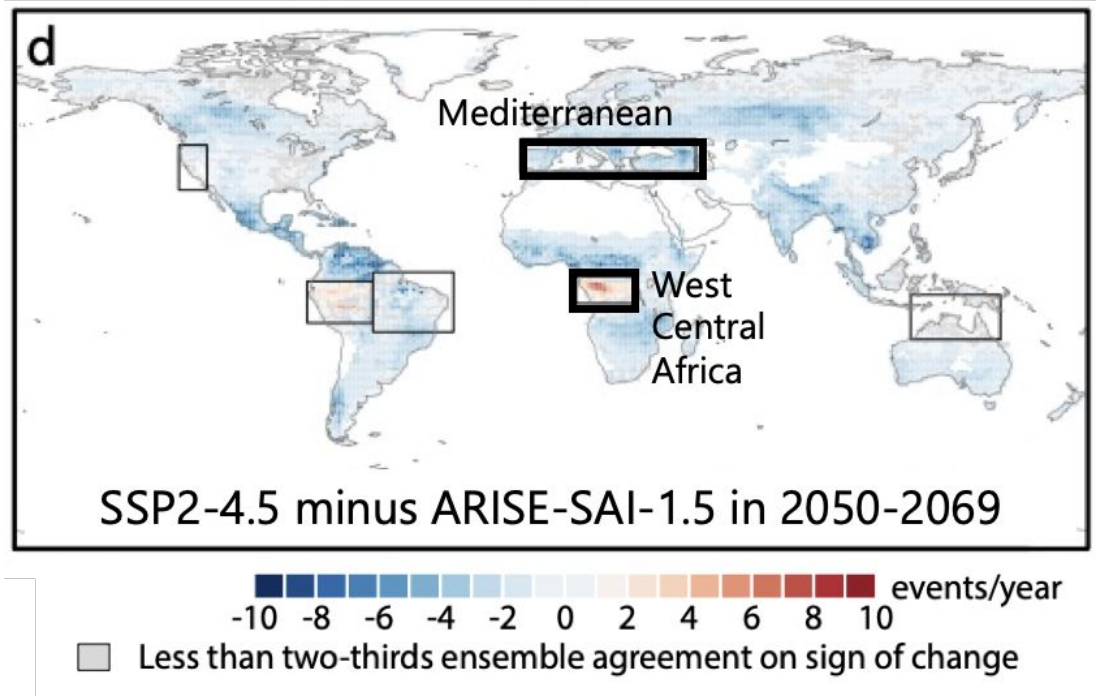
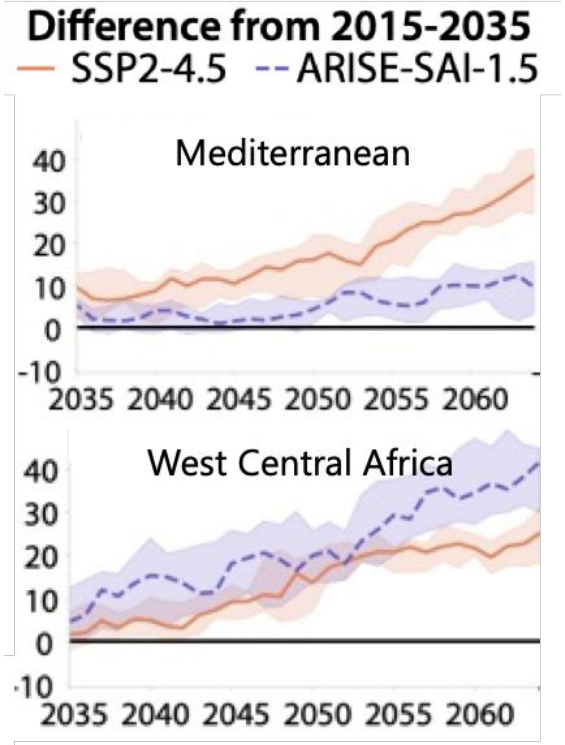
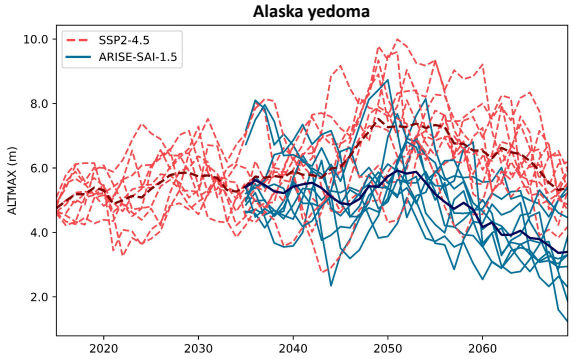
Impact of SAI on Extreme Fire Weather Event Frequency

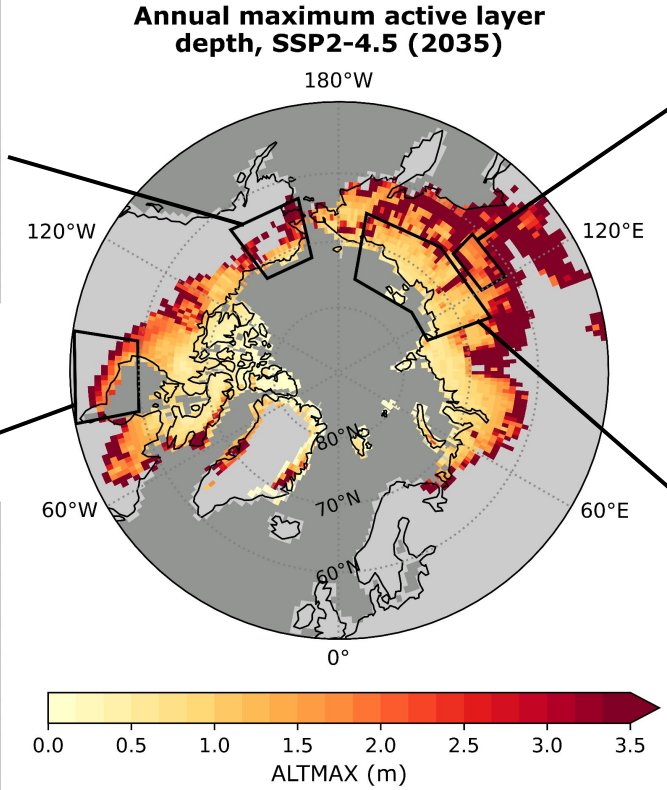


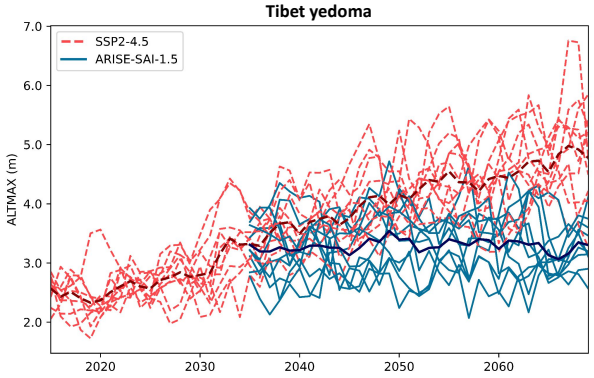


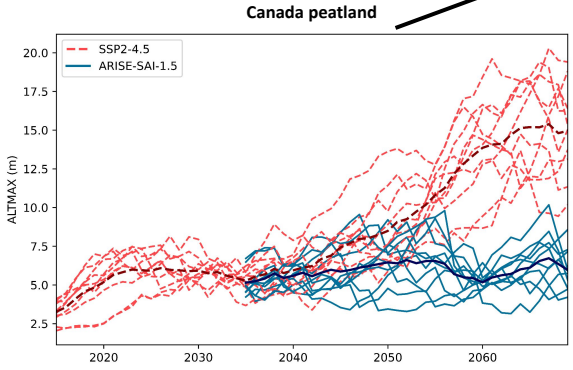
Touma, Hurrell, Tye, Dagan (2023)

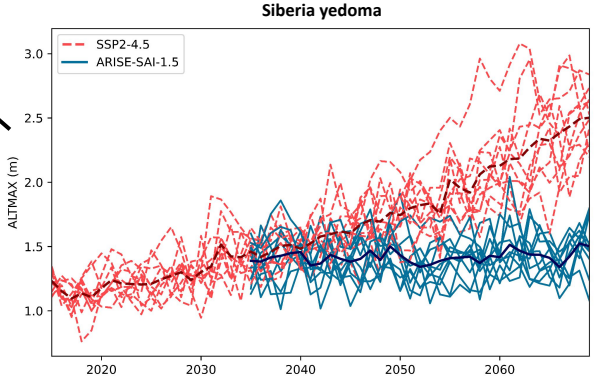
SAI to stabilize terrestrial permafrost under ARISE-SAI-1.5







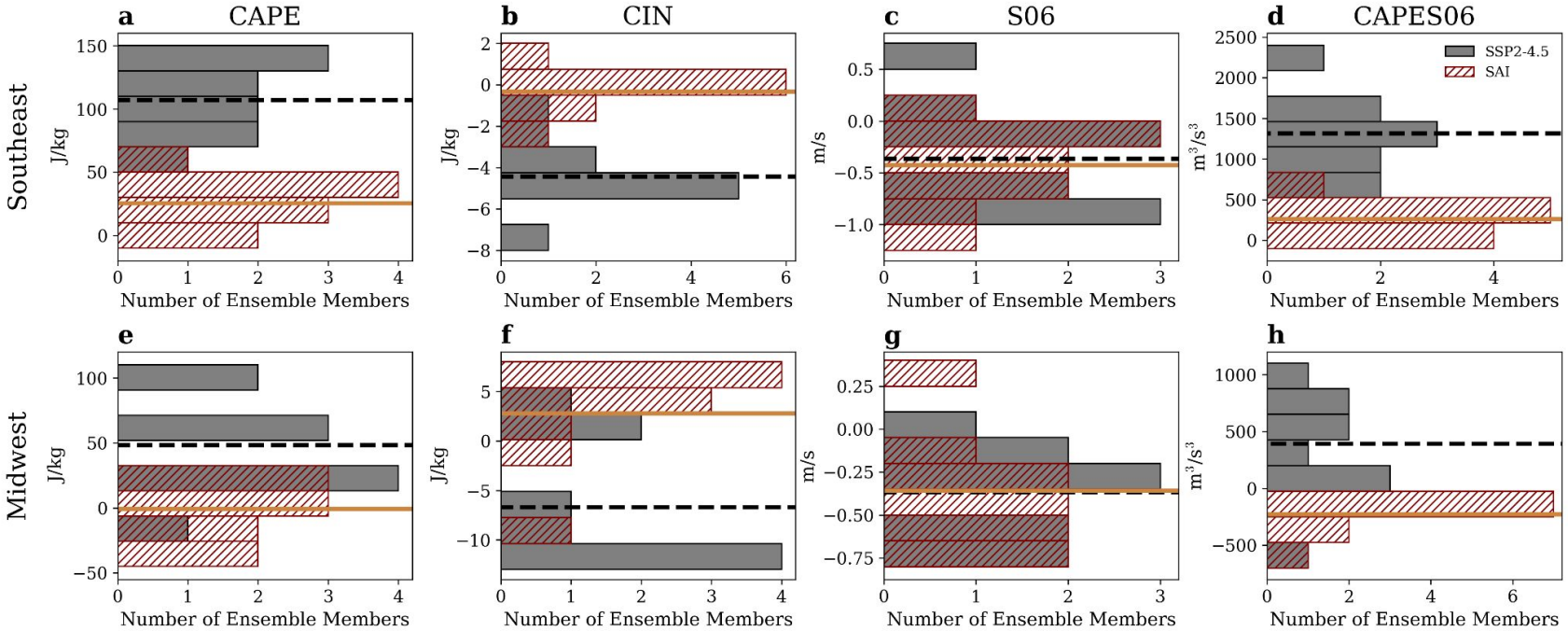




Morrison, Barnes, Hurrell (2023a)

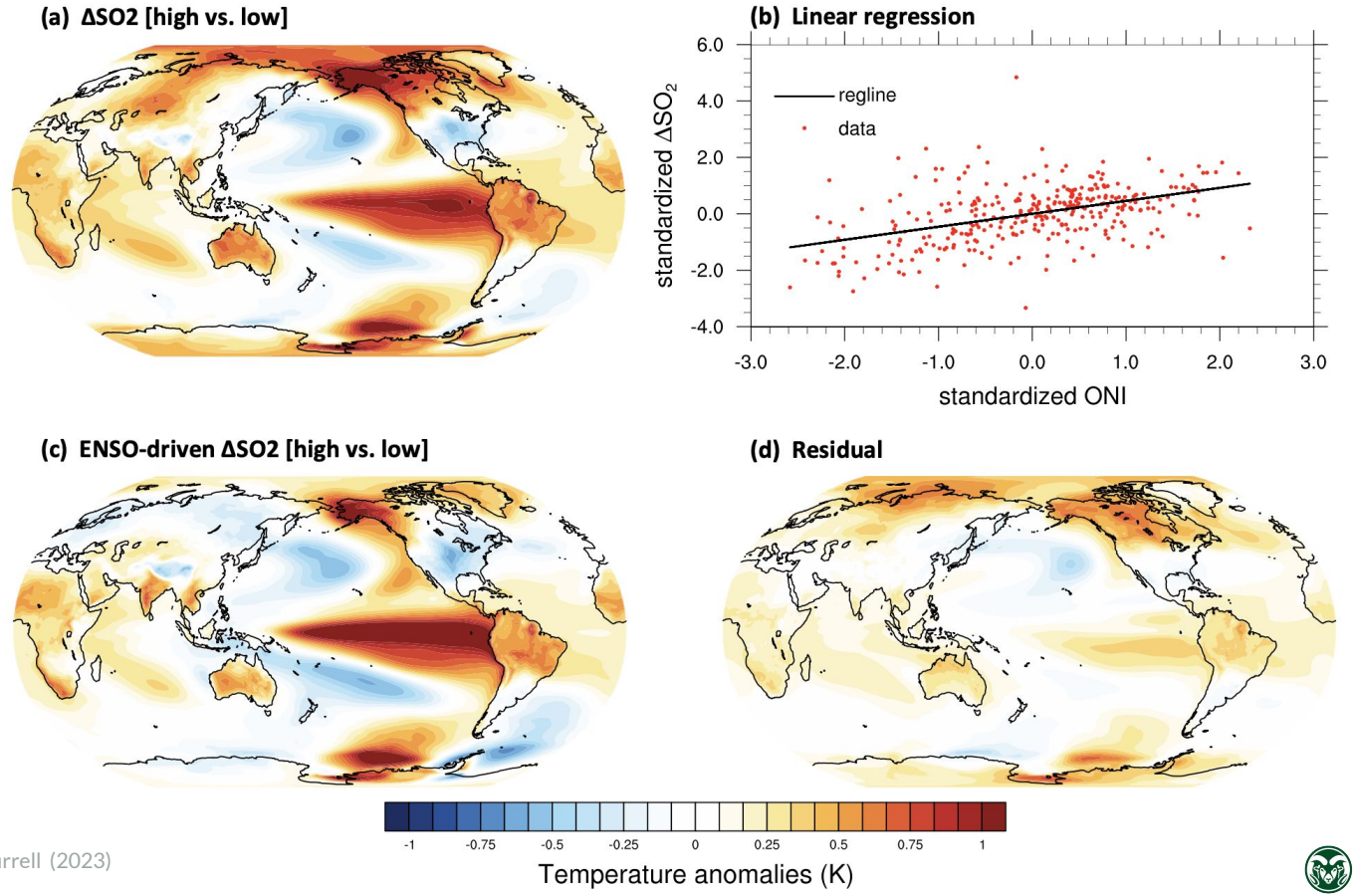
Changes in Large-Scale Convective Parameters

Histograms (2060-2069) – (2015-2034)



Glade, Hurrell, Sun, Rasmussen (2023)

Impact of ENSO on Injection Controller



Diao, Barnes, Hurrell (2023)

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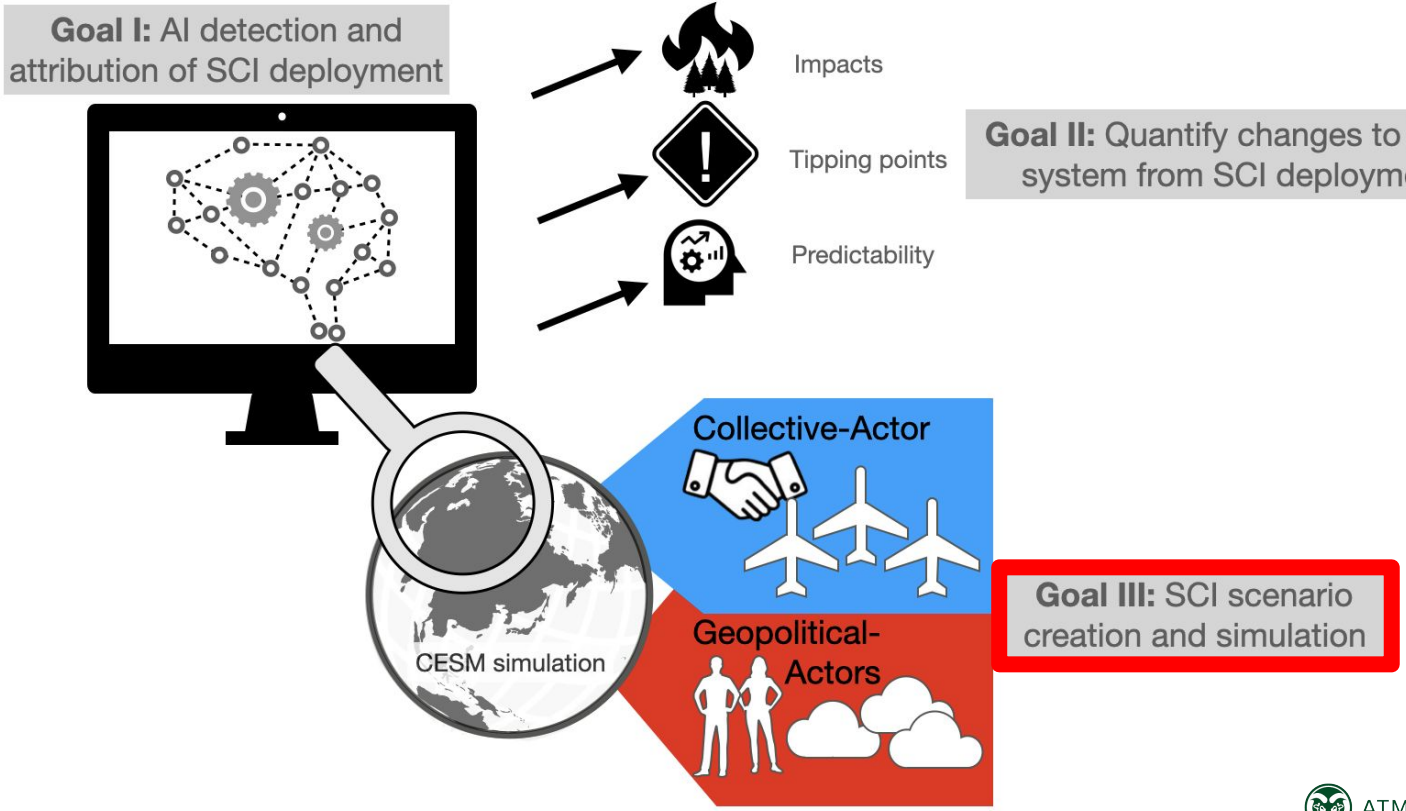

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Single Actor Scenarios

- Climate models allow us to explore a range of single actor scenarios (e.g. individual nations, consortium of concerned nations, non-state actors).
- This includes the possible reactions to single actor deployment.
- But, there are still too many possibilities to simulate them all.
- How can we leverage AI methods to learn the sensitivity of the earth system to a wide variety of possible scenarios?

Bell and Keys (2023)
Connolly, Mamalakis, Barnes and Hurrell (in prep)

Publications

Published

Barnes, E. A., J. W. Hurrell, and L. Sun, 2022: Detecting changes in global extremes under the GLENS-SAI climate intervention strategy, Geophysical Research Letters, http://dx.doi.org/10.1029/2022GL100198.

Keys, P., E. A. Barnes, N, S. Diffenbaugh, J. W. Hurrell, and C. M. Bell, 2022: Potential for Perceived Failure of Stratospheric Aerosol Injection Deployment, Proceedings of the National Academy of Sciences, 119 (40) e2210036119, https://doi.org/10.1073/pnas.2210036119

Labe, Z. M., E. A. Barnes, and J. W. Hurrell, 2023: Identifying the regional emergence of climate patterns in the ARISE-SAI-1.5 simulations, Environmental Research Letters, https://doi.org/10.1088/1748-9326/acc81a

Hueholt, D., E. A. Barnes, J. W. Hurrell, L. Sun, and J. H. Richter, 2023: Assessing outcomes in stratospheric aerosol injection scenarios shortly after deployment, Earth's Future, https://doi.org/10.1029/2023EF003488

Touma, D., J. W. Hurrell, M. R. Tye, and K. Dagon, 2023: The impact of stratospheric aerosol injection on extreme fire weather risk, Geophysical Research Letters, https://doi.org/10.1029/2023EF003626

Publications

Submitted

Mamalakis, A., E. A. Barnes, and J. W. Hurrell, 2023: Quantifying “climate distinguishability” after stratospheric aerosol injection using explainable artificial intelligence, Geophysical Research Letters, submitted.

Morrison, A. L., E. A. Barnes, and J. W. Hurrell, 2023: Stratospheric aerosol injection to stabilize Northern Hemisphere terrestrial permafrost under the ARISE-SAI-1.5 scenario, Geophysical Research Letters, submitted.

Diao, C., E. A. Barnes, and J. W. Hurrell, 2023: Influence of ENSO on stratospheric sulfur dioxide injection in the CESM2 ARISE-SAI-1.5 simulations, Geophysical Research Letters, submitted.

Bell, C. M., and P. W. Keys, 2023: Strategic Logic of Unilateral Climate Intervention, Environmental Research Letters, submitted.