

Can stratospheric aerosol intervention save coffee and chocolate from climate change?

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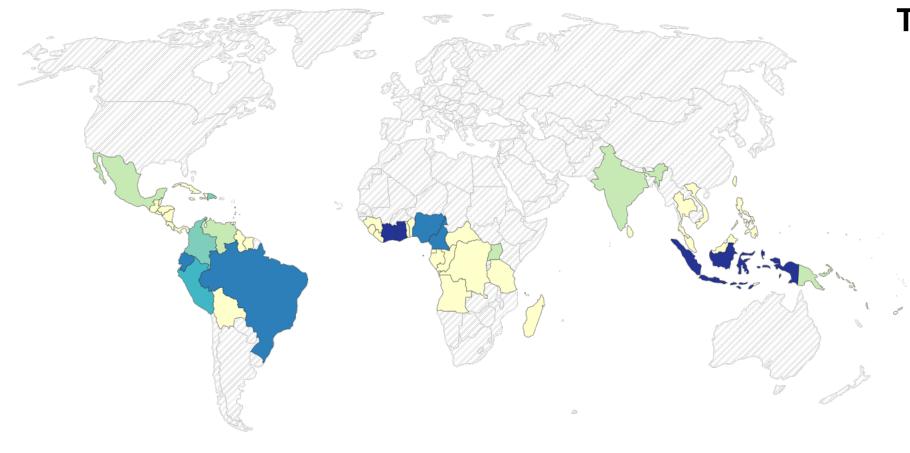


Why study coffee and cocoa?

Cocoa bean production, 2022

Our World in Data

Cocoa bean production is measured in tonnes.



Top 5 Producers

- 1. Cote d'Ivoire
- 2. Ghana
- 3. Indonesia
- 4. Ecuador
- 5. Cameroon



Tree Crops

Take 3-5 years to start producing

 Live for decades (30-40 years but up to 80-200!)

 Age and accumulate stress over the years

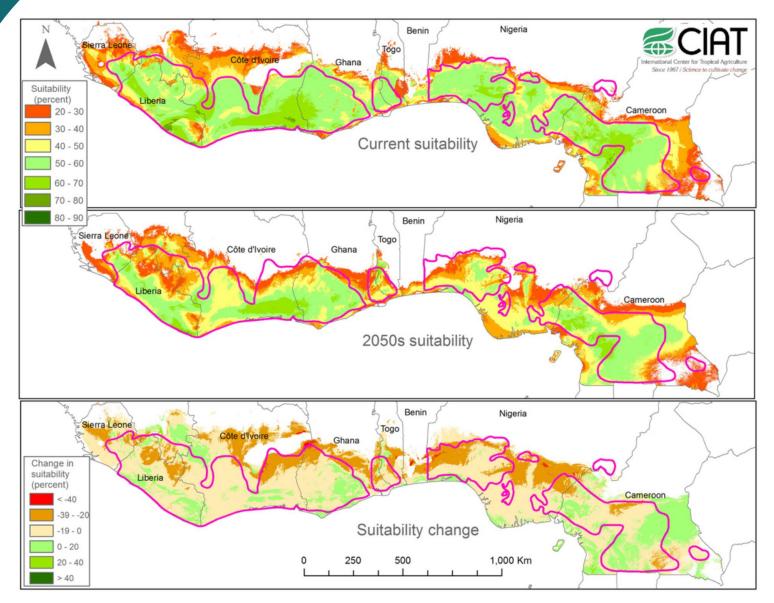
 Bean quality dependent on specific climate conditions



Schroth et al. (2016)

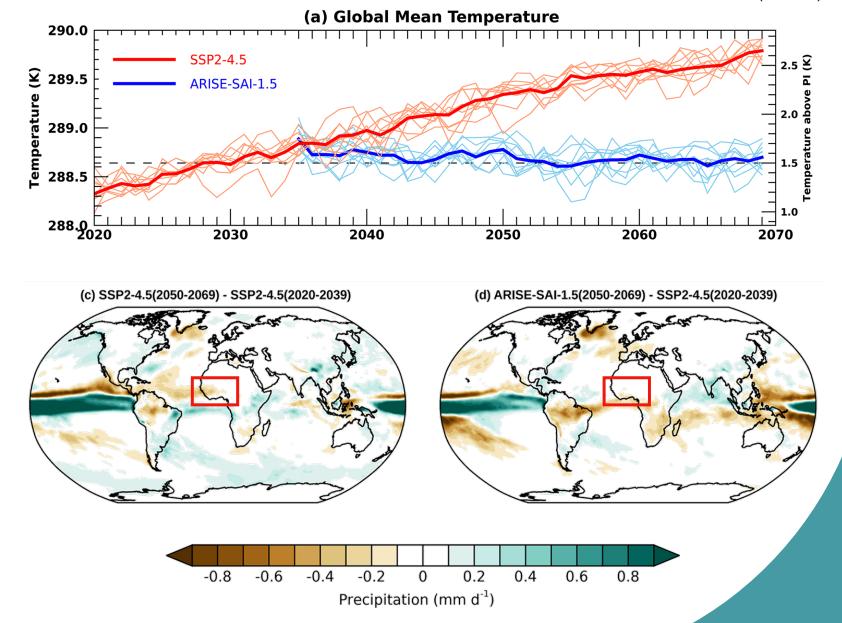
What will global warming do?

rising temperatures and a longer dry season will diminish the suitable area for cocoa and therefore yields



What might SAI do?

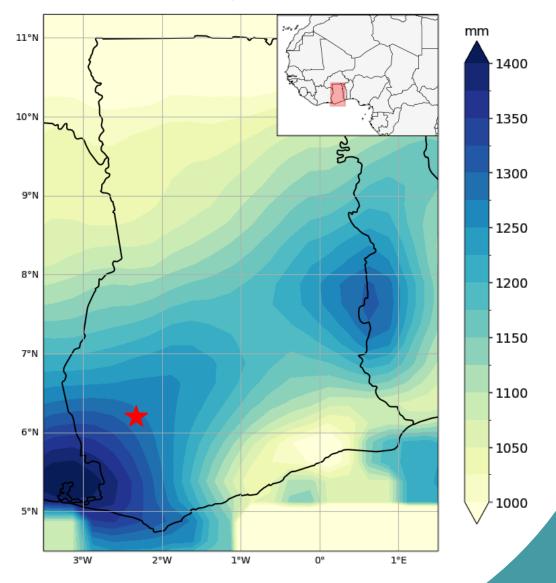
- ARISE-SAI-1.5
 - CESM2-WACCM
 - 2035-2069
 - Background scenario: SSP2-4.5
 - Target: maintain global temps at 1.5K
- Past studies found drying due to SAI, but ARISE-SAI maintains rainfall in West Africa
- High CO2 + equal temp + equal rain = ??



Method

- Ghana: 6.2N, 2.33W
- ISIMIP Bias Adjustment and Downscaling
 - SSP2-4.5 (2050-2069)
 - 6 models | 1 ensemble member each
 - GFDL-ESM4
 - IPSL-CM6A-LR
 - MPI-ESM1-2-HR
 - MRI-ESM2-0
 - UKESM1-0-LL
 - CESM2-WACCM
 - ARISE-SAI-1.5 (2050-2069)
 - 1 model | 1 ensemble member
 - CESM2-WACCM

Mean Annual Precipitation (1980-2010)



Crop Model: ALMANAC

Kiniry et al. (1992)



Developed to model competition among crops and grasses



Daily timestep, process-based, site-based model



Growing degree day (GDD) system for phenological development



Captures these processes:

- Light interception, dry matter production, and biomass partitioned into plant parts
- Stress due to drought, flooding, temperature, nitrogen, and phosphorus

Agricultural Land Management Alternative with Numerical Assessment Criteria (ALMANAC)

Daily Variables:

Kiniry et al. (1992)

Maximum Temperature

Minimum Temperature

Precipitation

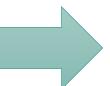
Relative Humidity

10-m Wind

Solar Radiation



Permanently 10year-old trees to isolate climate impact



Yields

Stress days

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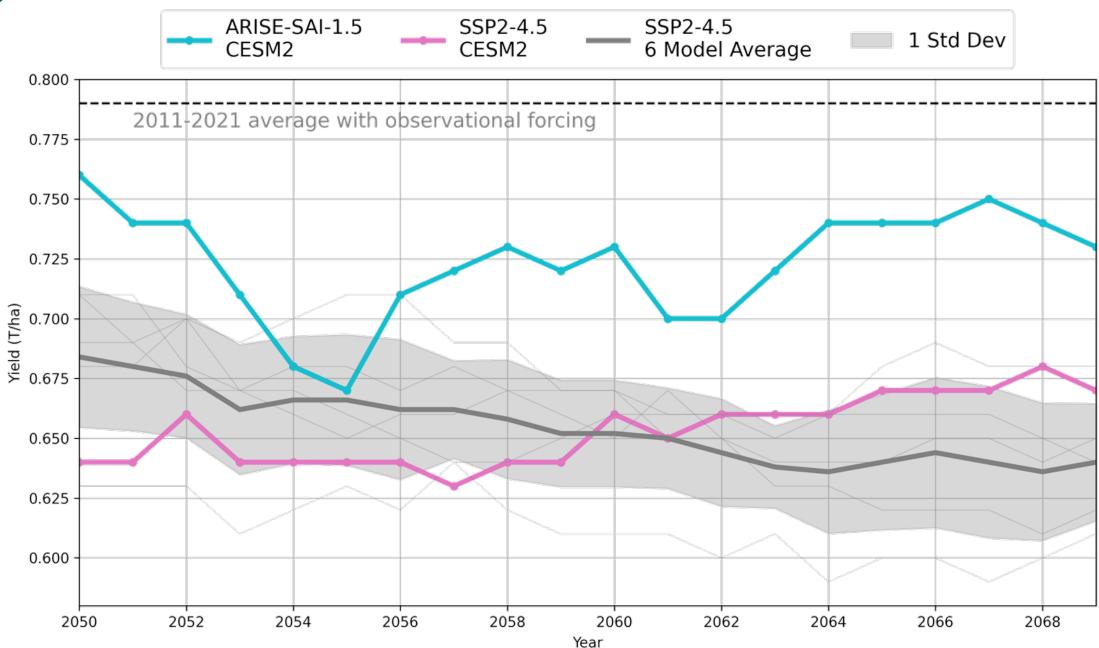
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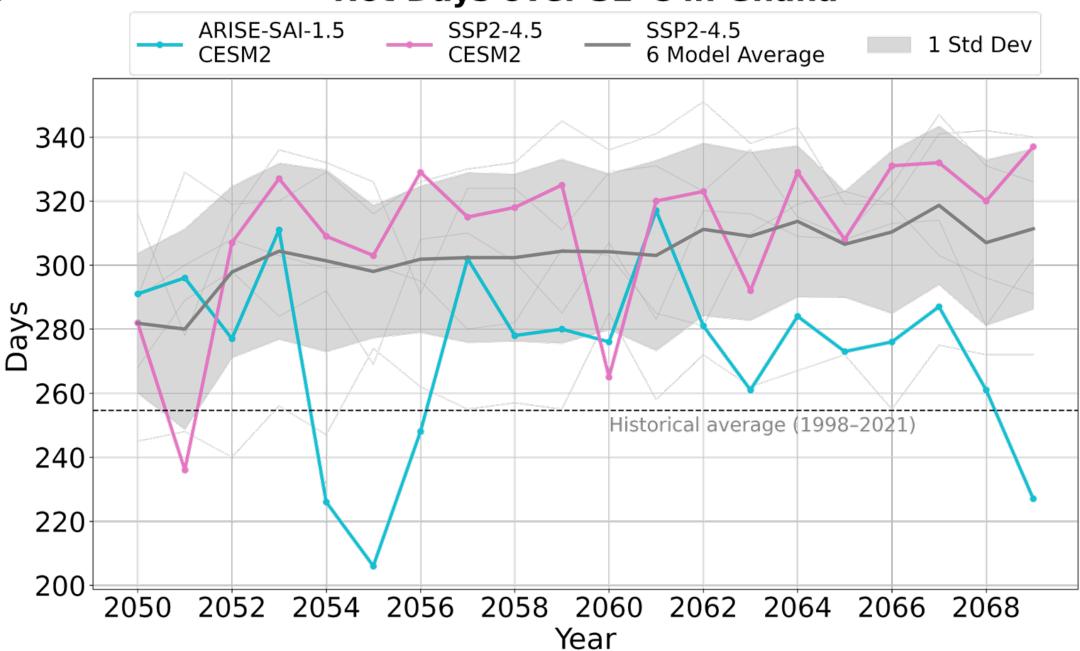
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Cocoa yields in Southwestern Ghana in ARISE-SAI-1.5 and SSP2-4.5

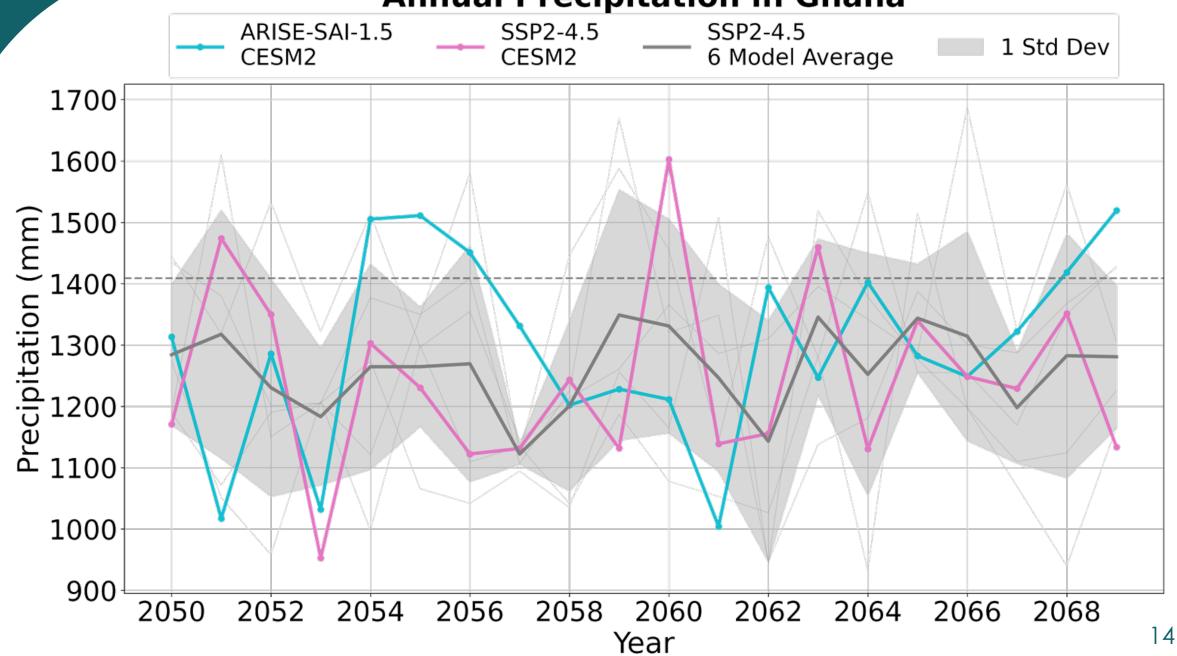


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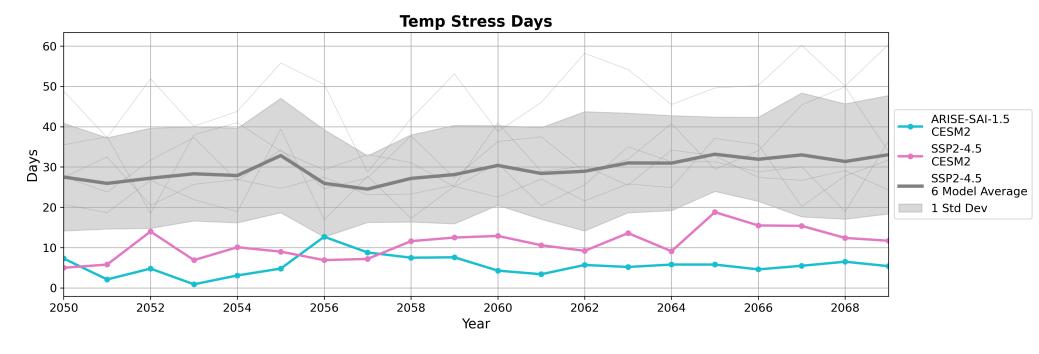
Hot Days over 32°C in Ghana

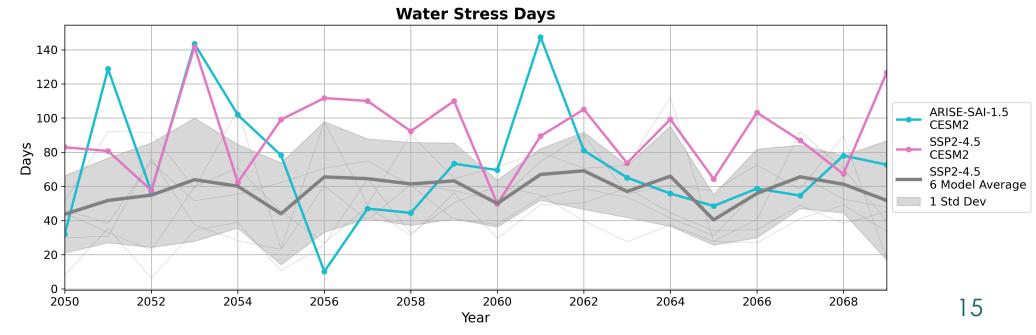


Annual Precipitation in Ghana

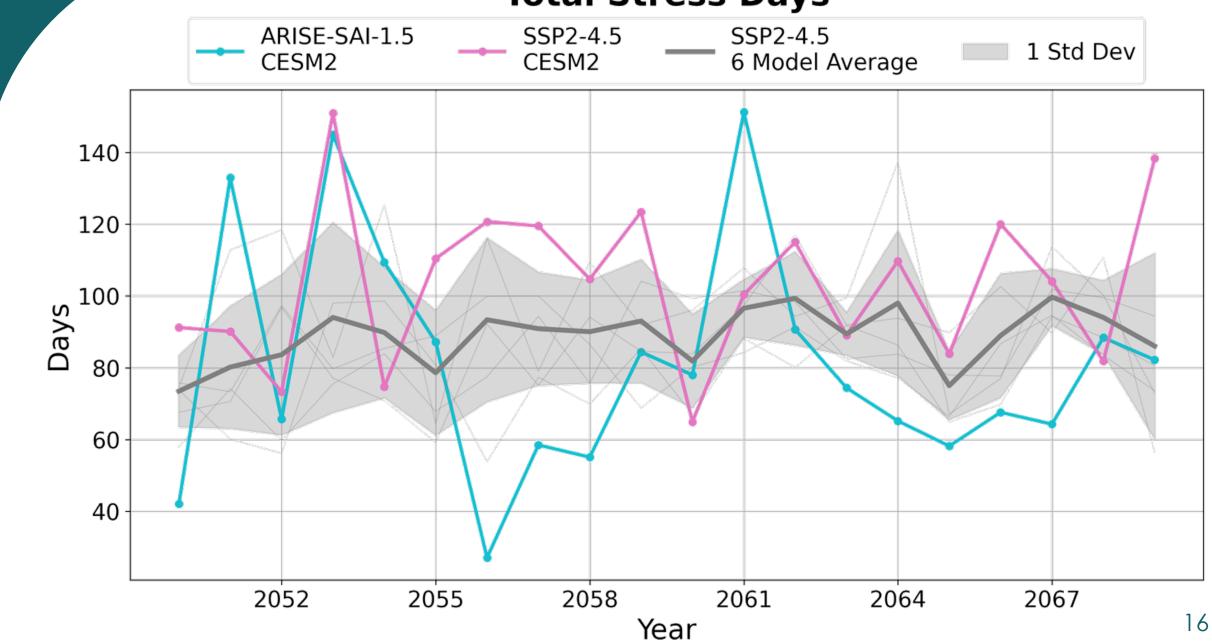


Stress days =
days when the
dominant (or
limiting) stress
was temperature
or water





Total Stress Days



Takeaways



Doesn't say: SAI inherently/definitely can save cocoa yields. Just one site in Ghana might **not be representative of the country or West Africa**.

- Assumes management doesn't change and trees don't age
- Need more ensemble members



Does say: At this one specific location, as simulated by our crop model and CESM, **SAI improves yields** compared to climate change without it.

Same temp + same rainfall + high CO2

