

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

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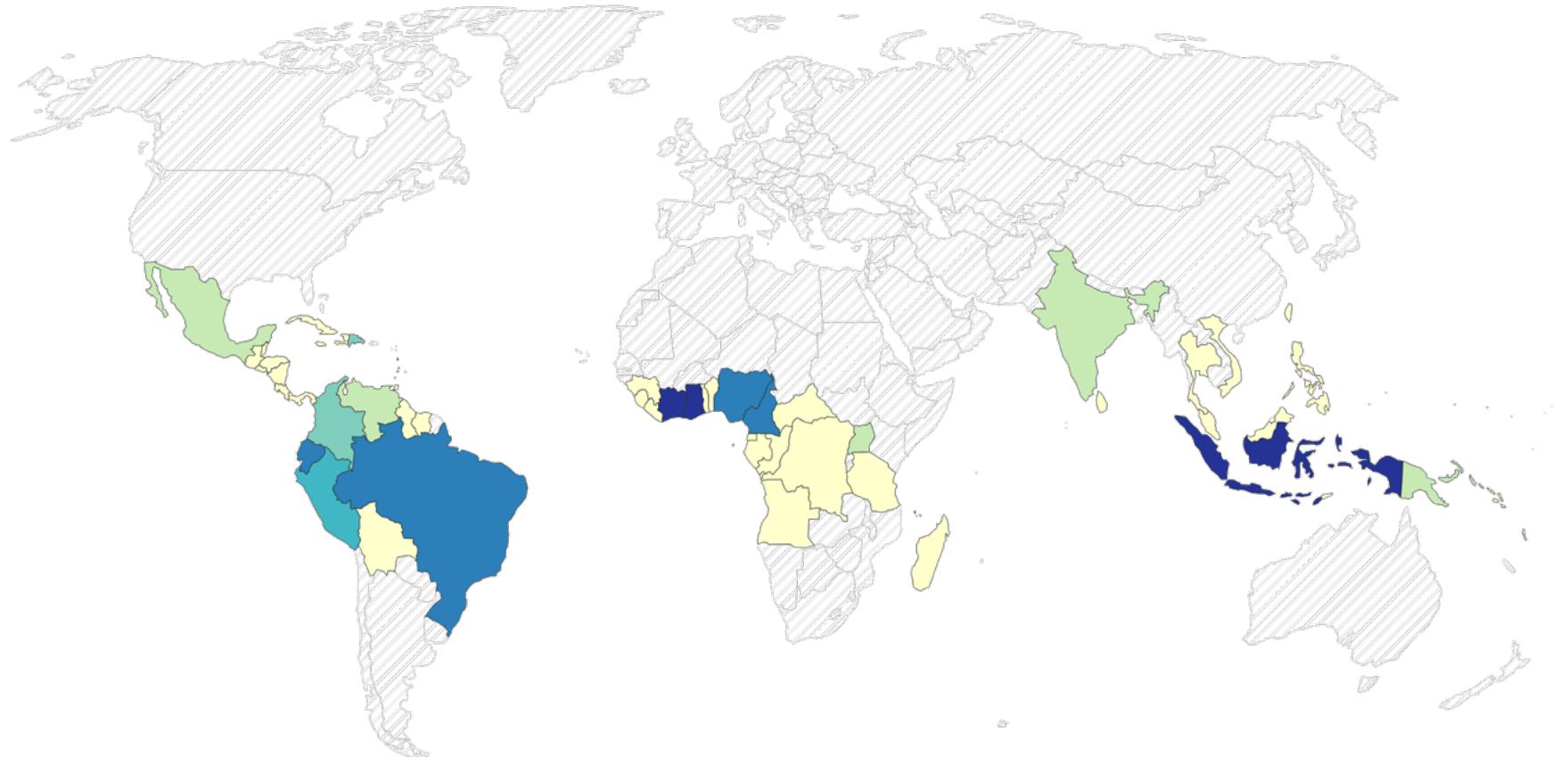
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A photograph showing two cups of coffee with heart-shaped marshmallows floating on top. The cups are white with dark brown rims. The background is a light-colored wooden surface.

Why study
coffee and
cocoa?

Cocoa bean production, 2022

Cocoa bean production is measured in tonnes.



Top 5 Producers

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

A photograph of a woman in a bright orange t-shirt and blue jeans bending over to pick yellow cocoa pods from the ground. She is in a lush green forest setting with many cocoa trees. The foreground is covered with fallen leaves and some ripe cocoa pods. A large, semi-transparent teal circle is positioned behind her, containing the text.

~70% of global
cocoa comes from
West Africa

Tree Crops

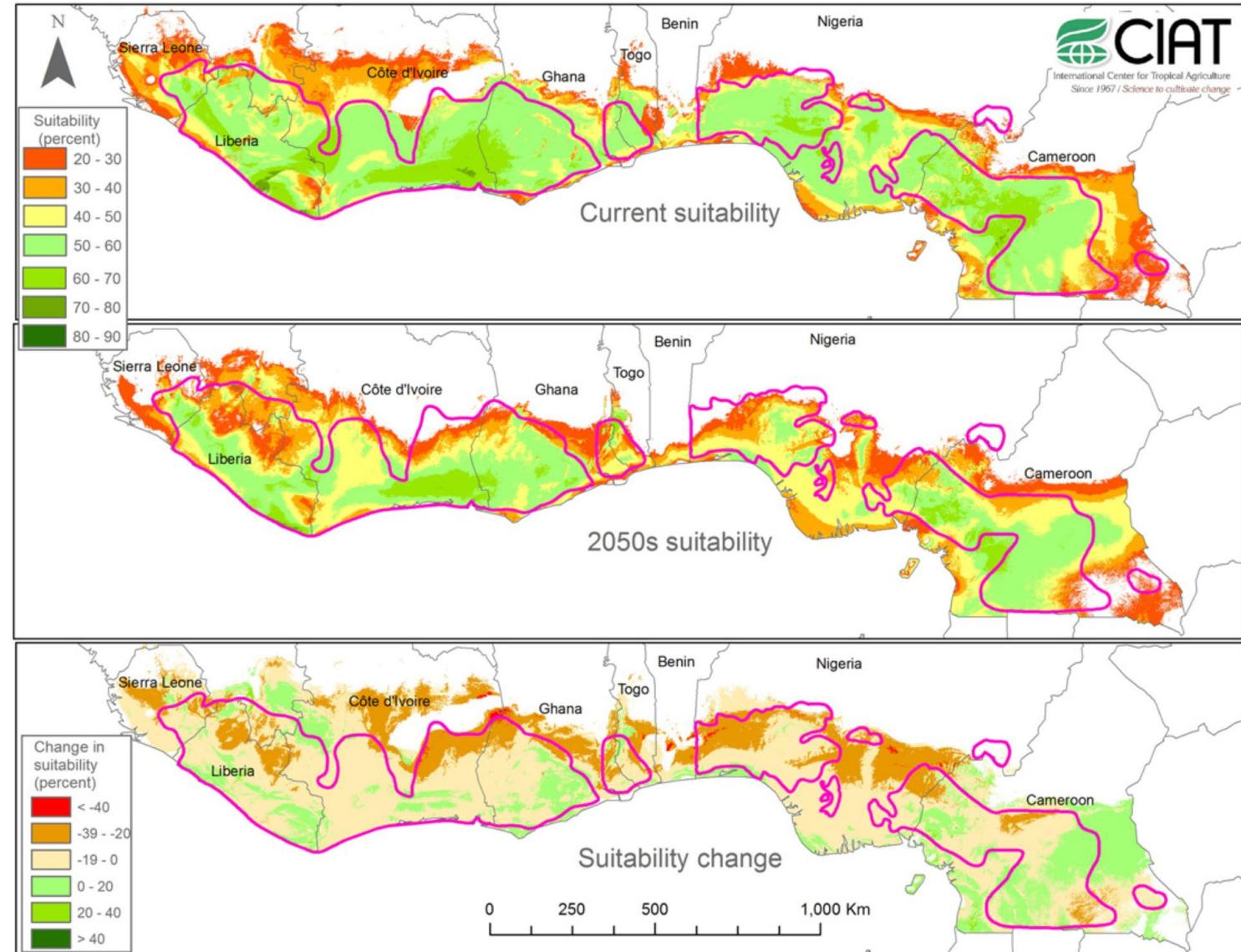
- Take 3-5 years to start producing
- Live for decades (30-40 years but up to 80-200!)
- **Age and accumulate stress over the years**
- Bean quality dependent on specific climate conditions



What will global warming do?

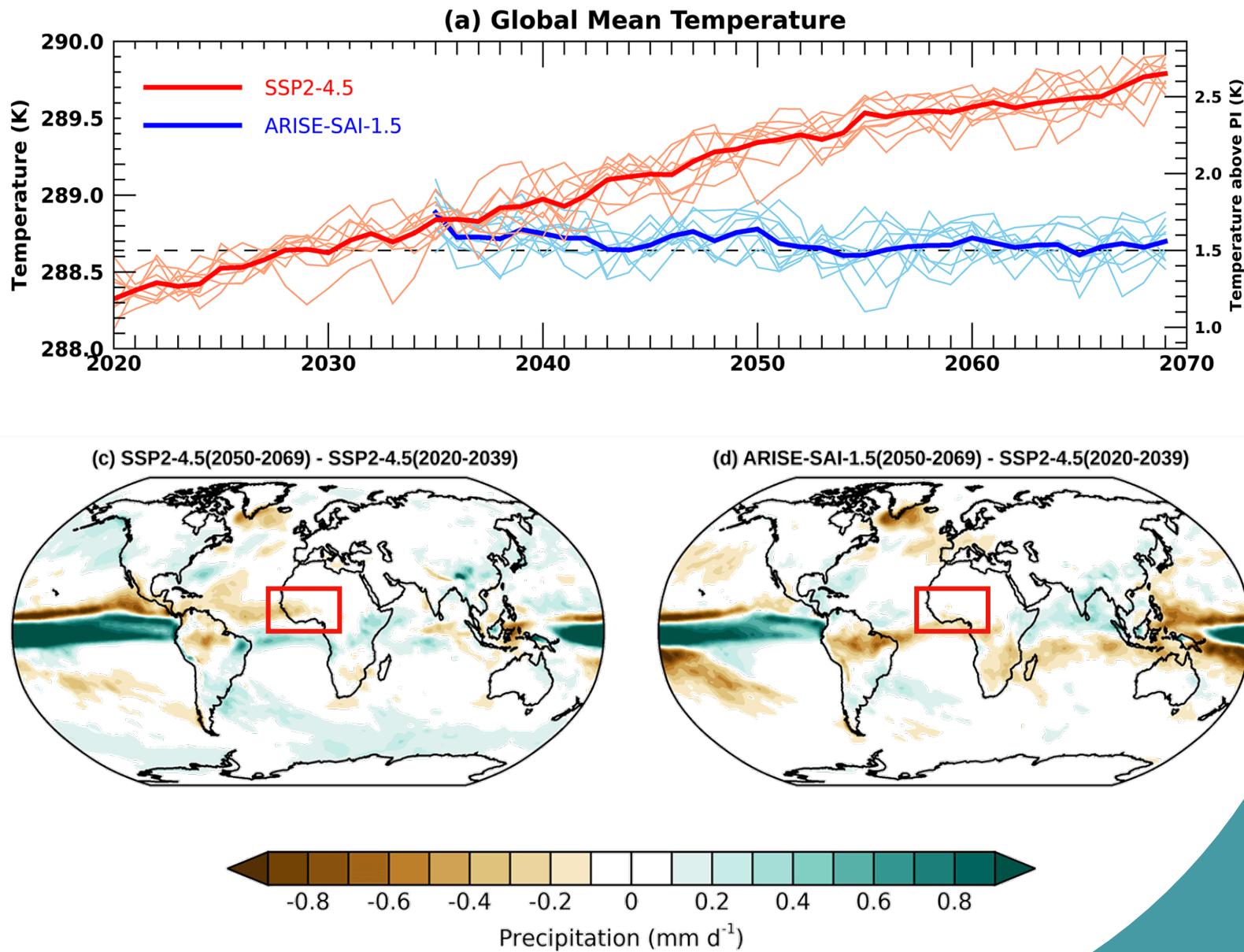
Current studies predict **rising temperatures** and a **longer dry season** will **diminish the suitable area** for cocoa and therefore yields

Schroth et al. (2016)



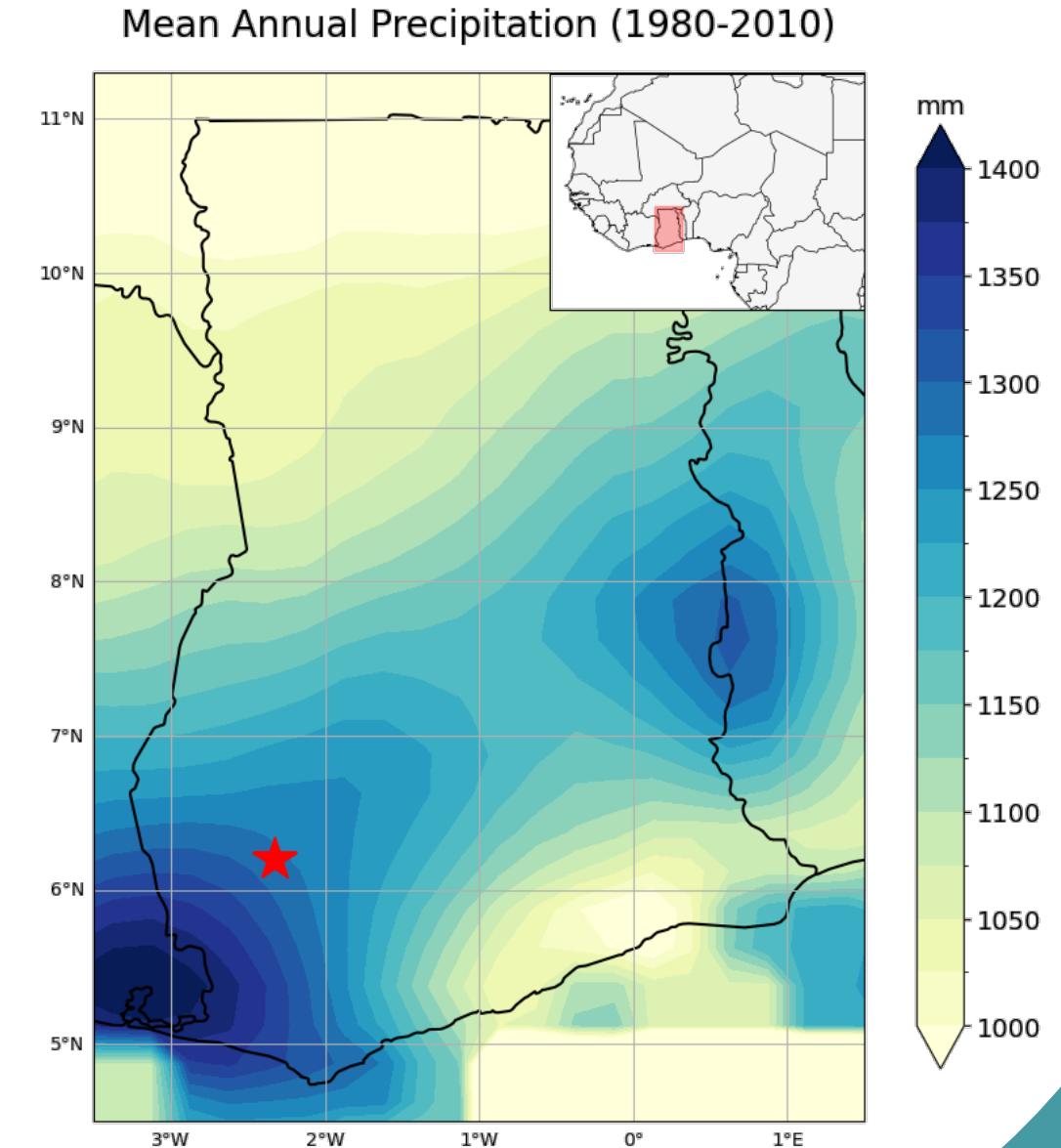
What might SAI do?

- 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



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

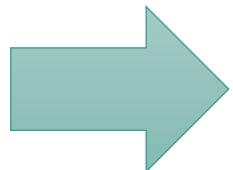
Minimum Temperature

Precipitation

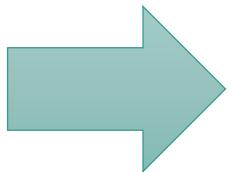
Relative Humidity

10-m Wind

Solar Radiation



ALMANAC
Permanently 10-year-old trees to isolate climate impact

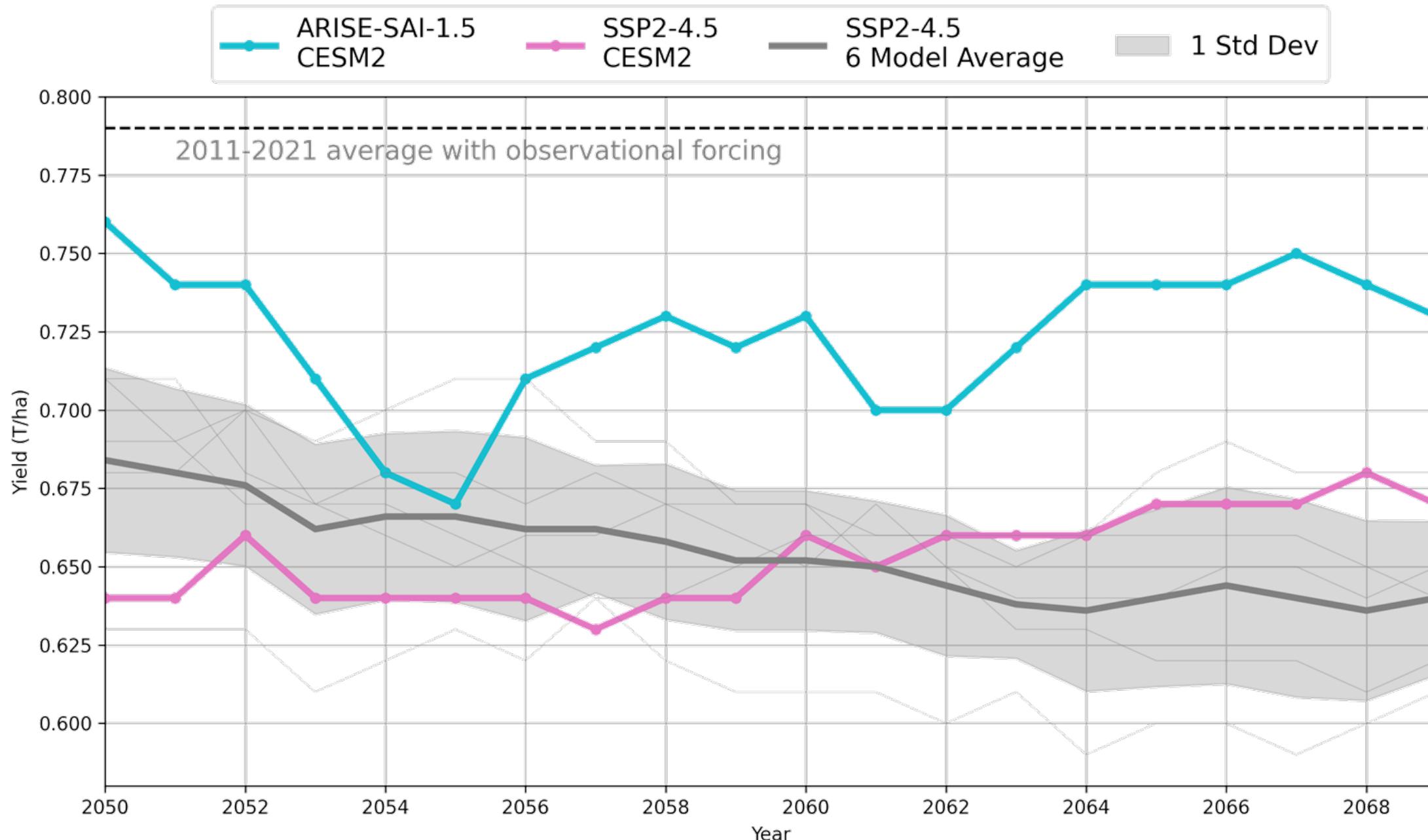


Yields

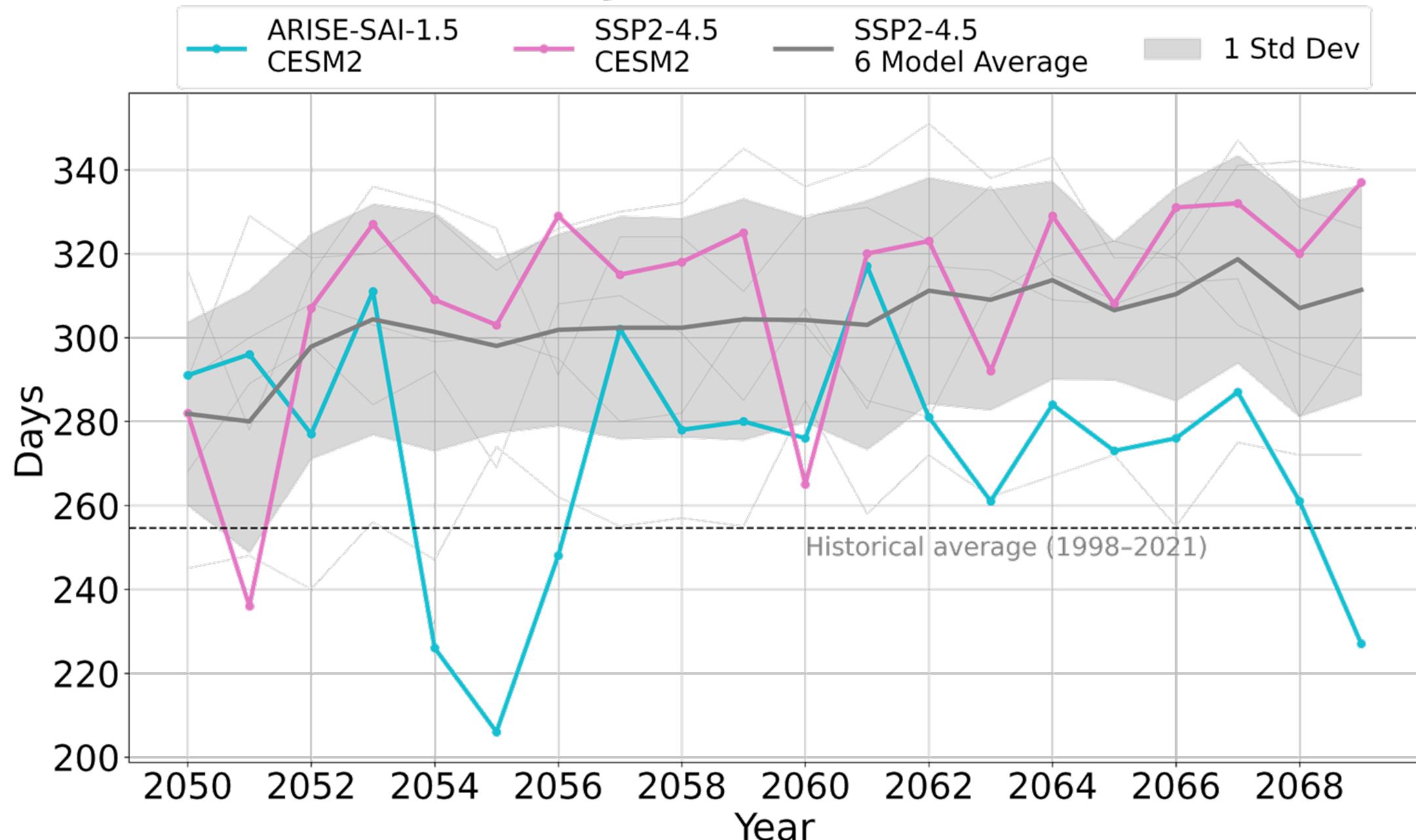
Stress days

PRELIMINARY Results

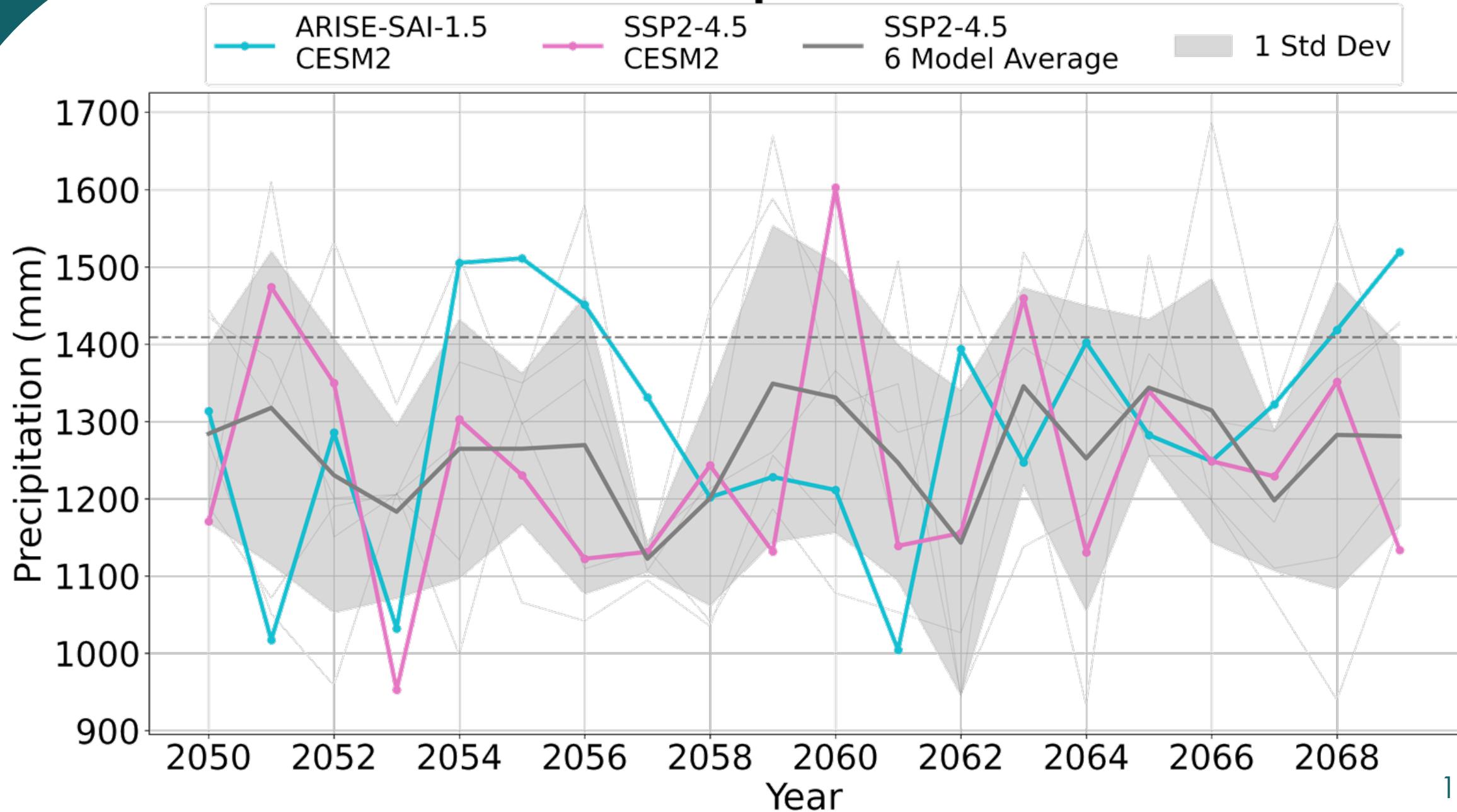
Cocoa yields in Southwestern Ghana in ARISE-SAI-1.5 and SSP2-4.5



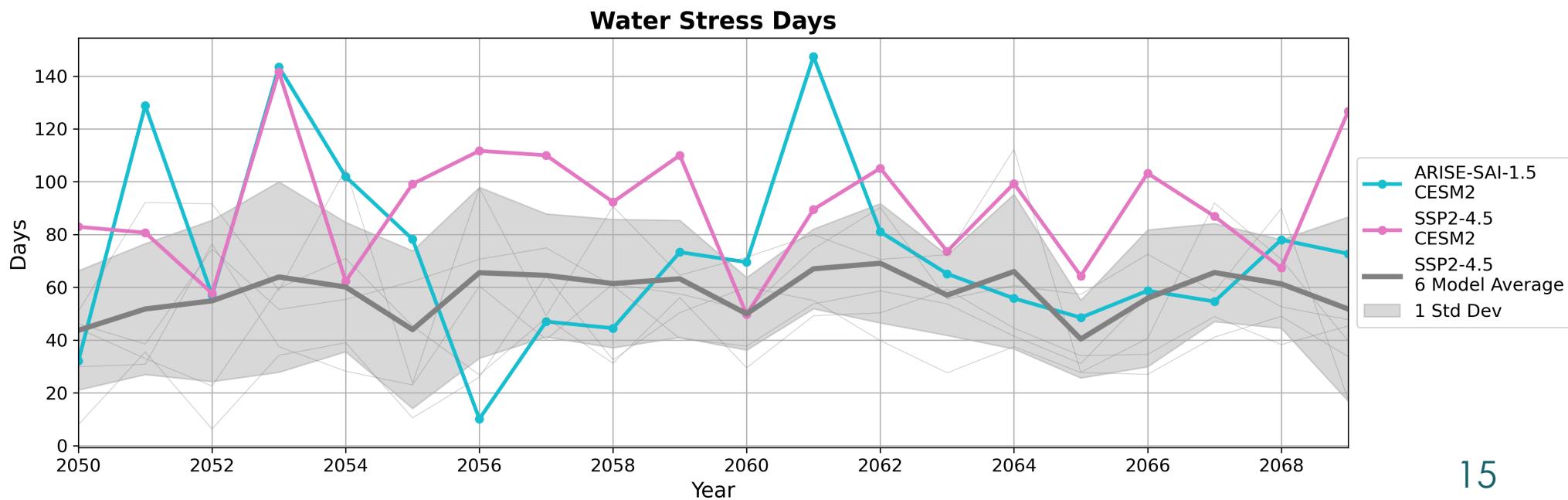
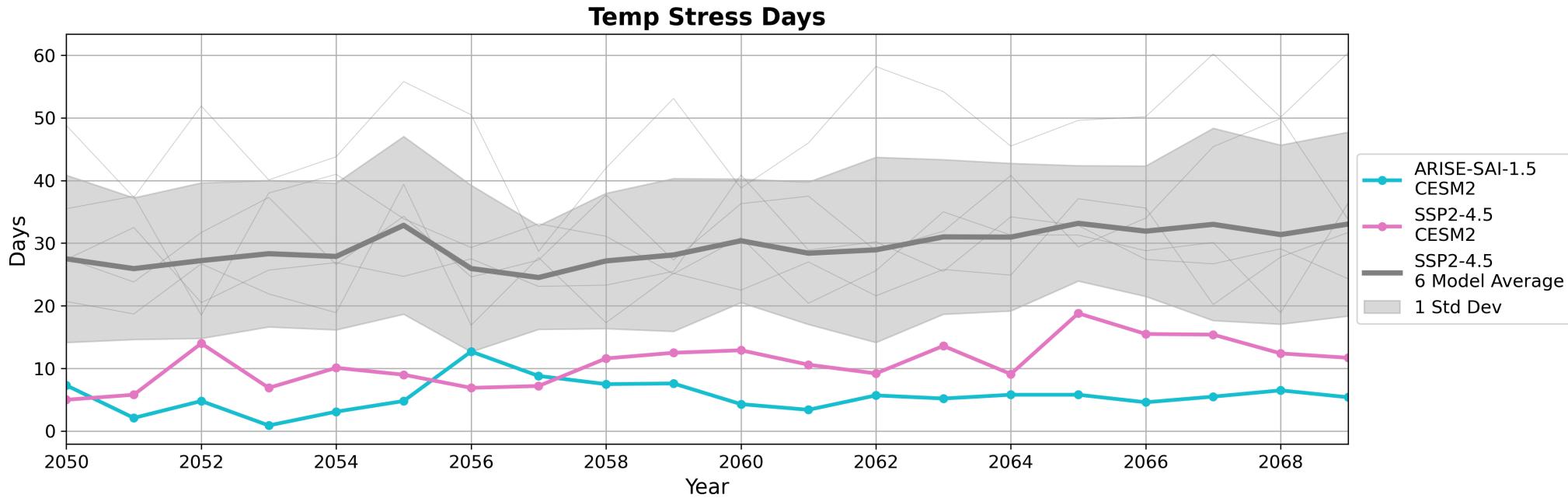
Hot Days over 32°C in Ghana



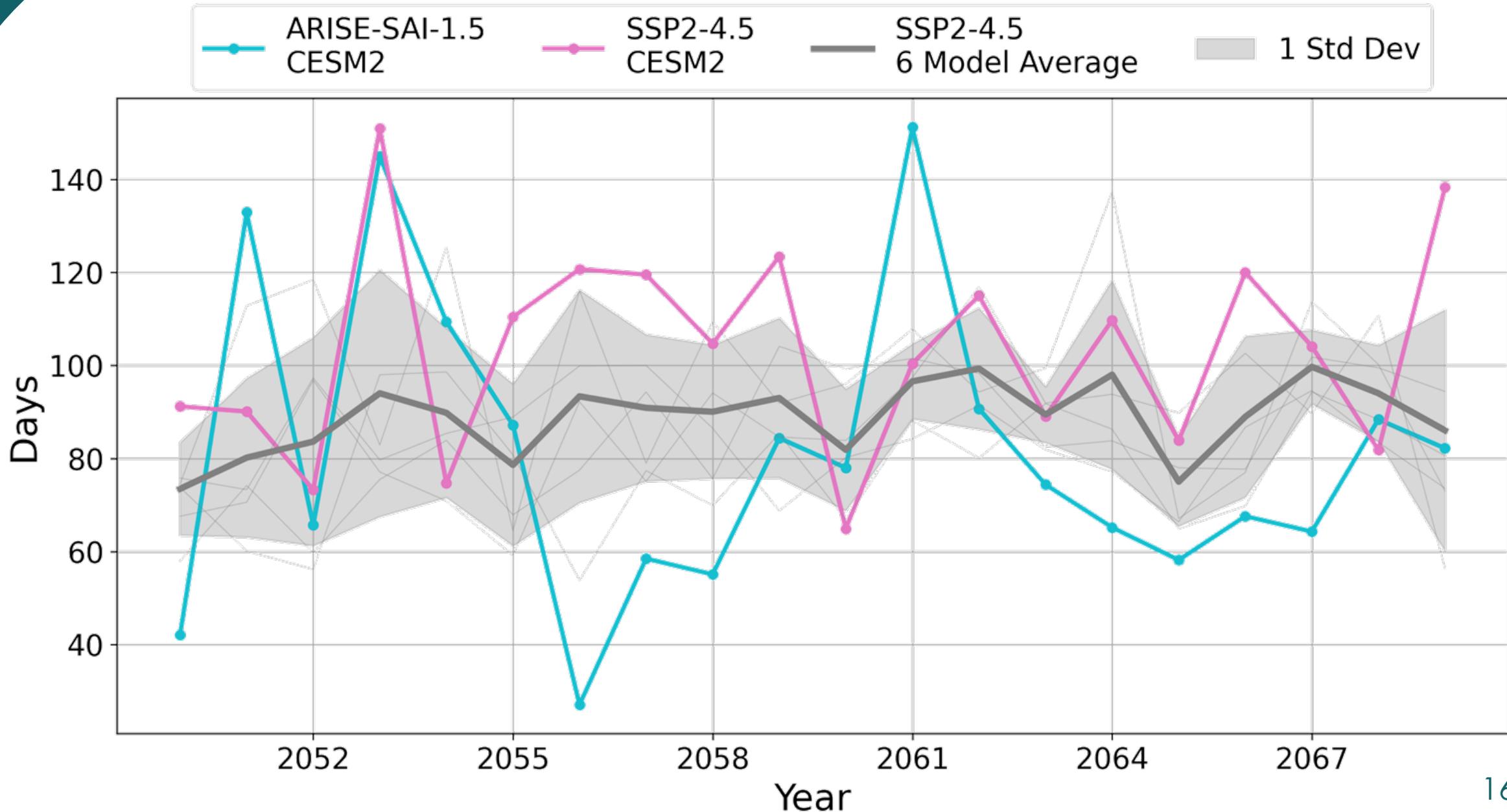
Annual Precipitation in Ghana



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

Thank you



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