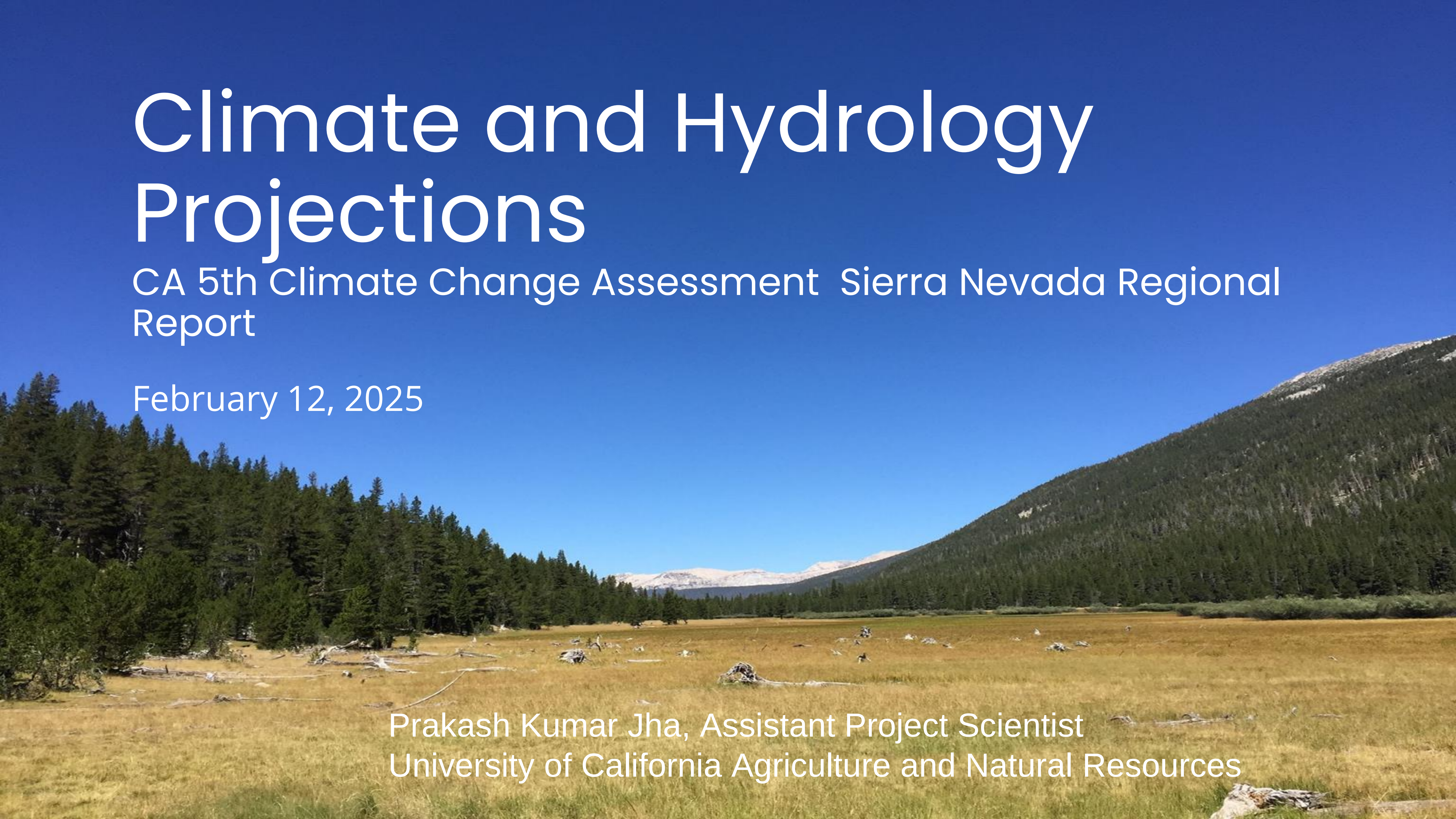

Climate and Hydrology Projections

CA 5th Climate Change Assessment Sierra Nevada Regional Report

February 12, 2025

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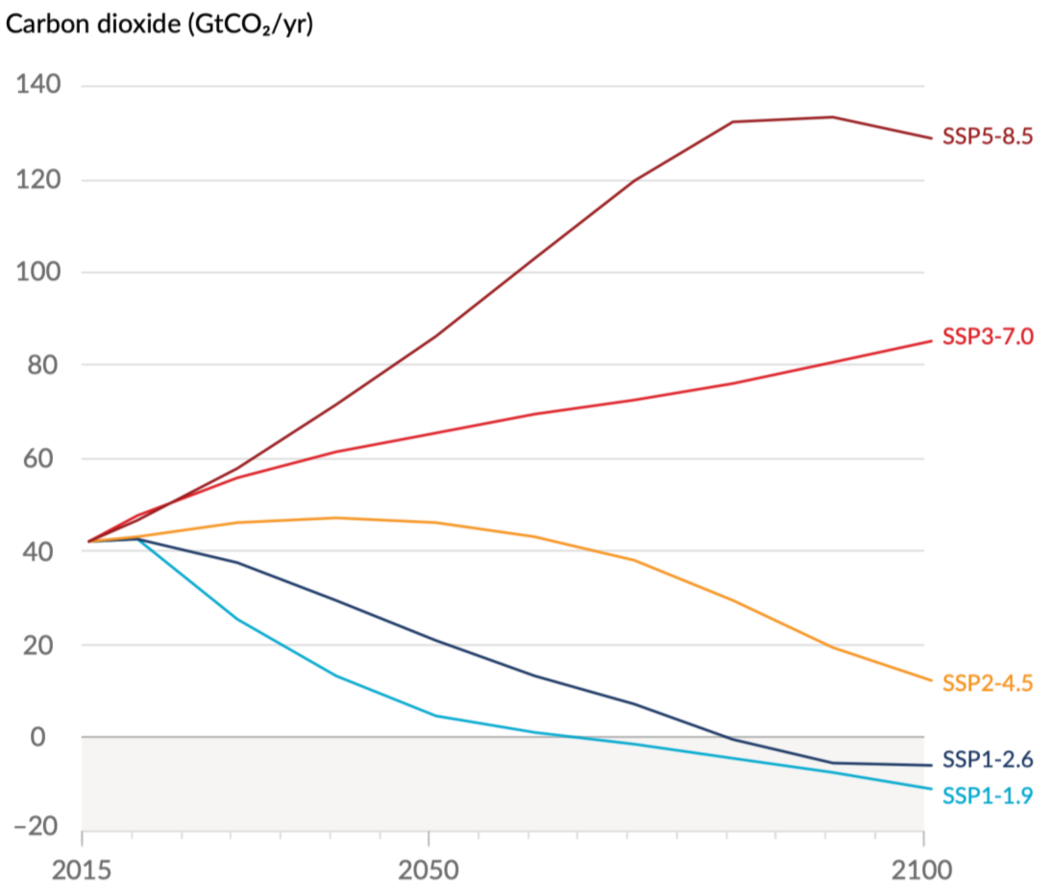
Warming in the future depends on emissions of greenhouse gases & aerosols

We used
SSP5-8.5 and SSP2-4.5



RCP 8.5

RCP 4.5

RCP 2.6

Source: IPCC AR6

Which models to use for climate projections in California?

Top performing CMIP6 GCMs for California

- EC-Earth3
- EC-Earth3-Veg
- ACCESS-CM2
- UKESM1-LL
- HadGEM3-GC31-LL

Based on representation of

Climate system

- atmospheric circulation, blocking, extreme precipitation, Santa Ana winds, ENSO

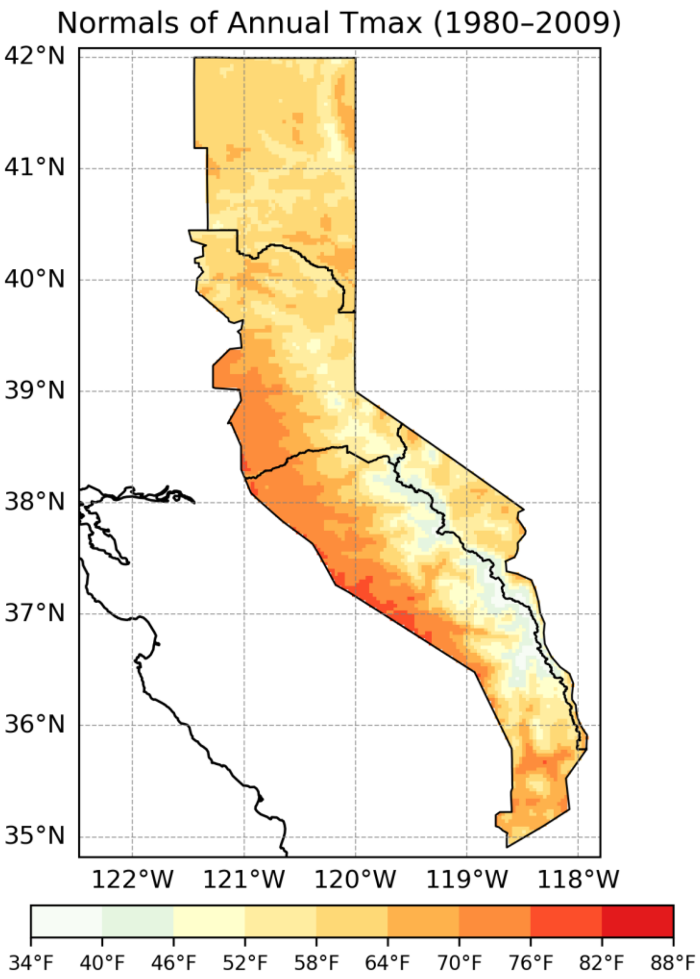
Statistical skill: errors, skill scores

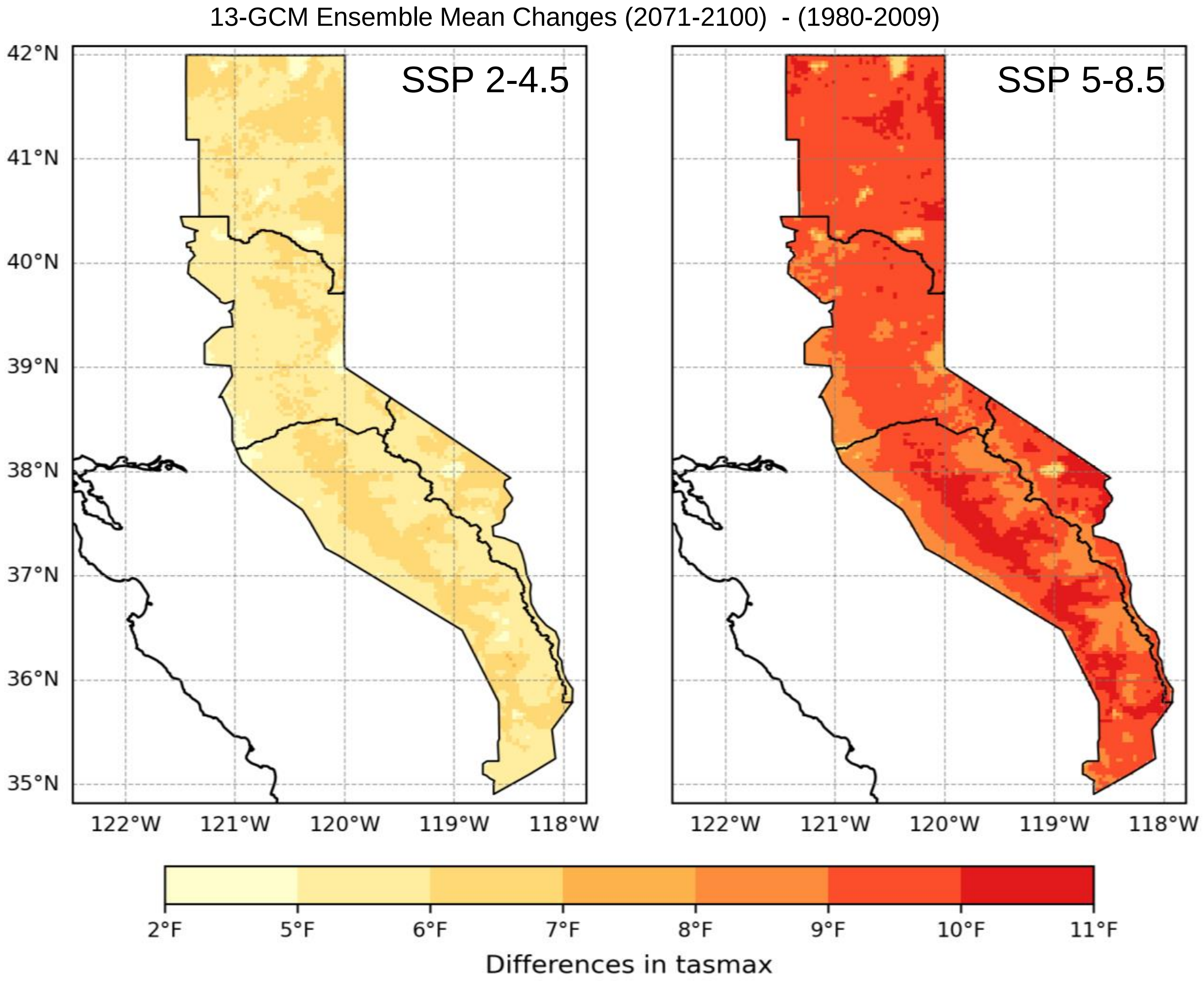
Source: Krantz et al., 2021

We utilized these GCMs, except UKESM, along with additional models that were statistically downscaled to a 3 km resolution using LOCA2, developed by the Scripps Institution of Oceanography and made available through CalAdapt.

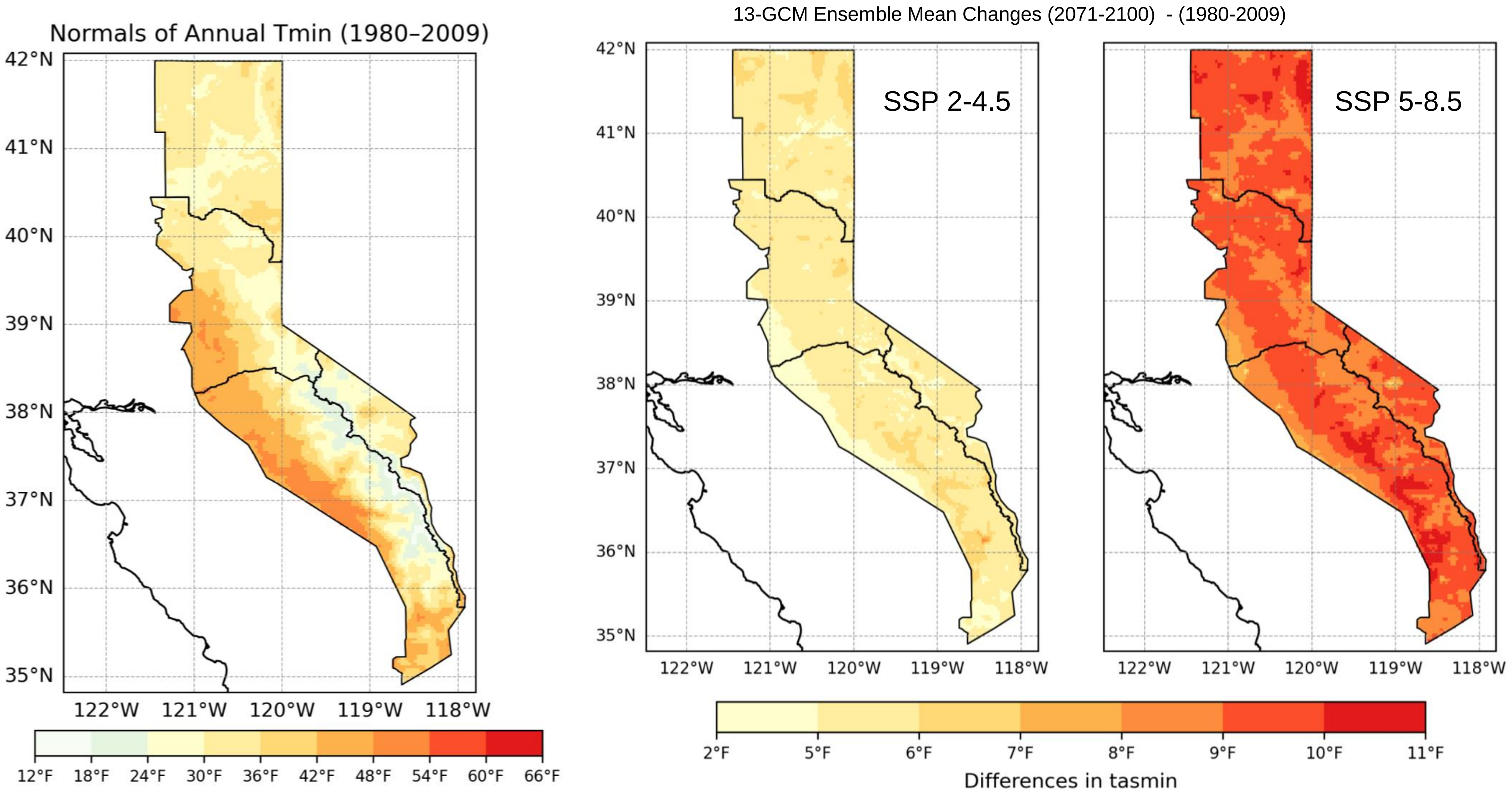
Maximum temperature (Average annual)

~ 9ºF increase in the average annual T_{max} & T_{min} by 2070–2099 under SSP 585
~4ºF lower under SSP 245



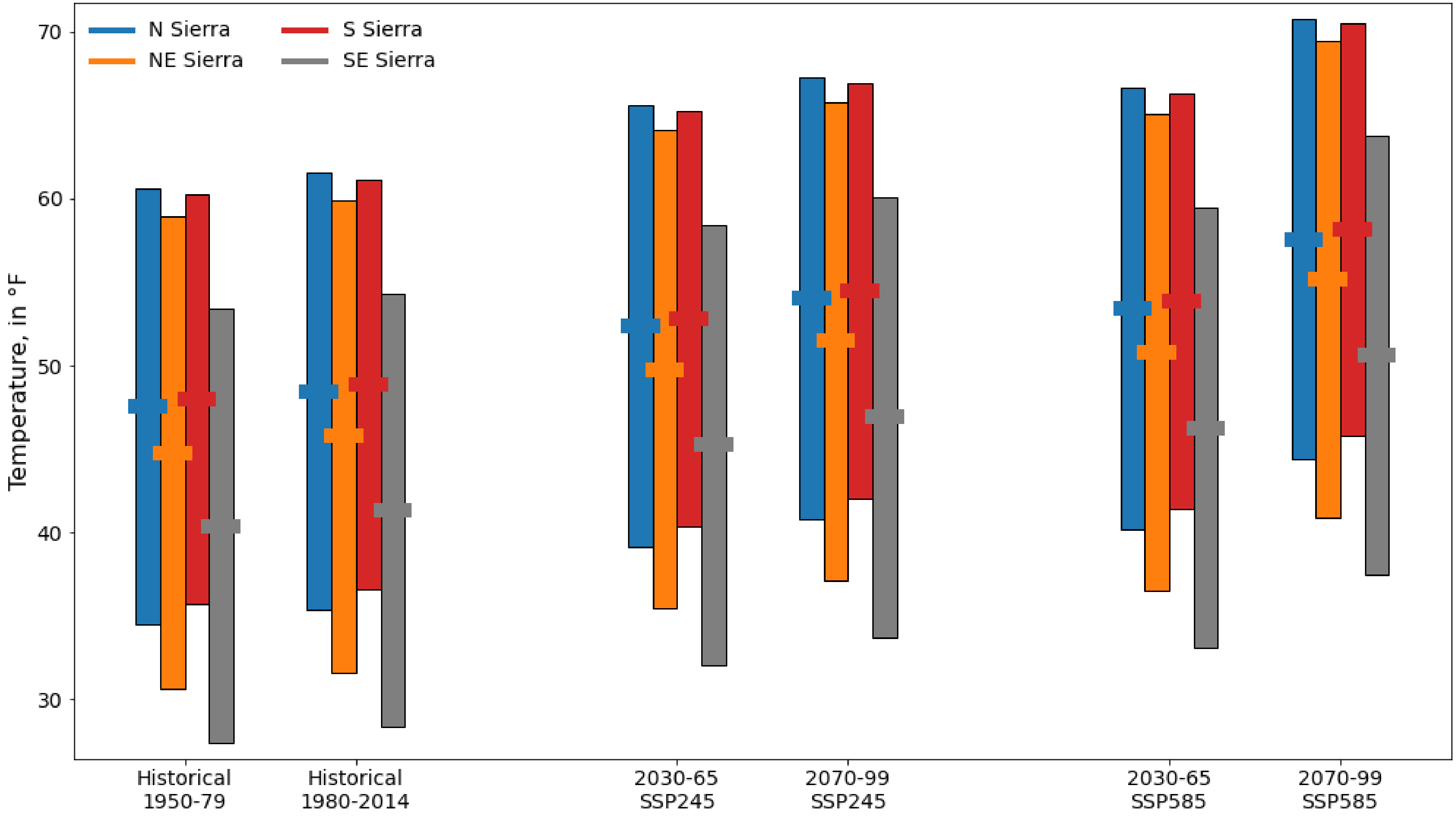


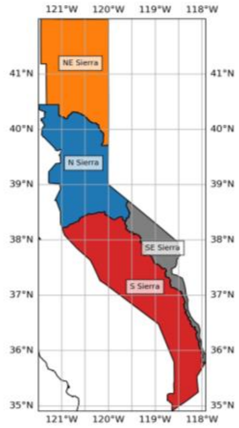
Average annual minimum temperature



30-year averages (Temperature)

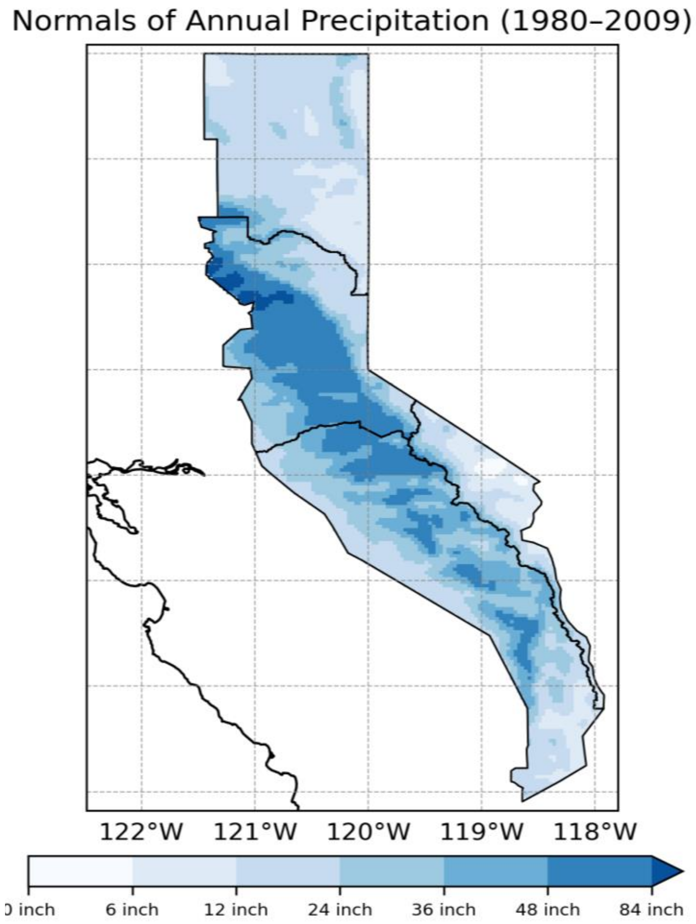
Av. warming will vary from 9.1 ºF to 9.4 ºF in SSP585 and ~4 ºF lower in SSP245

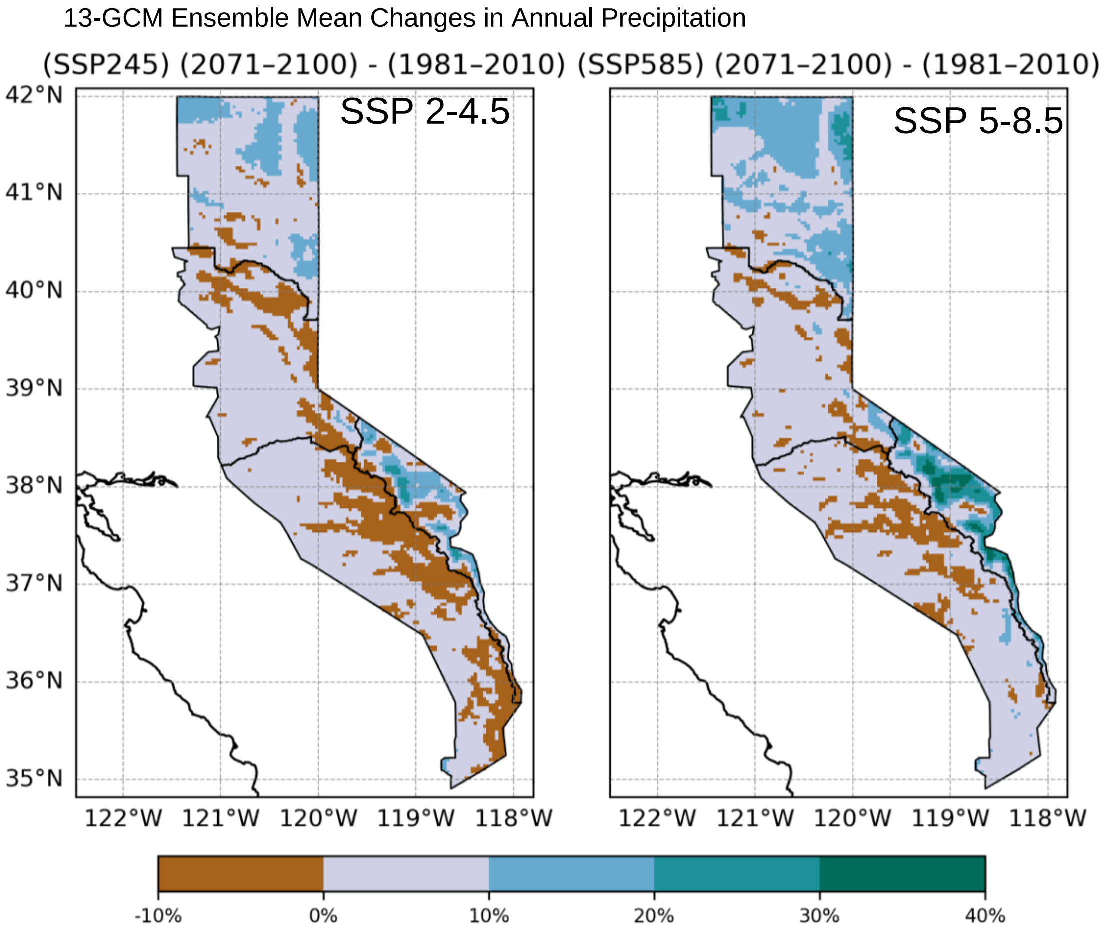




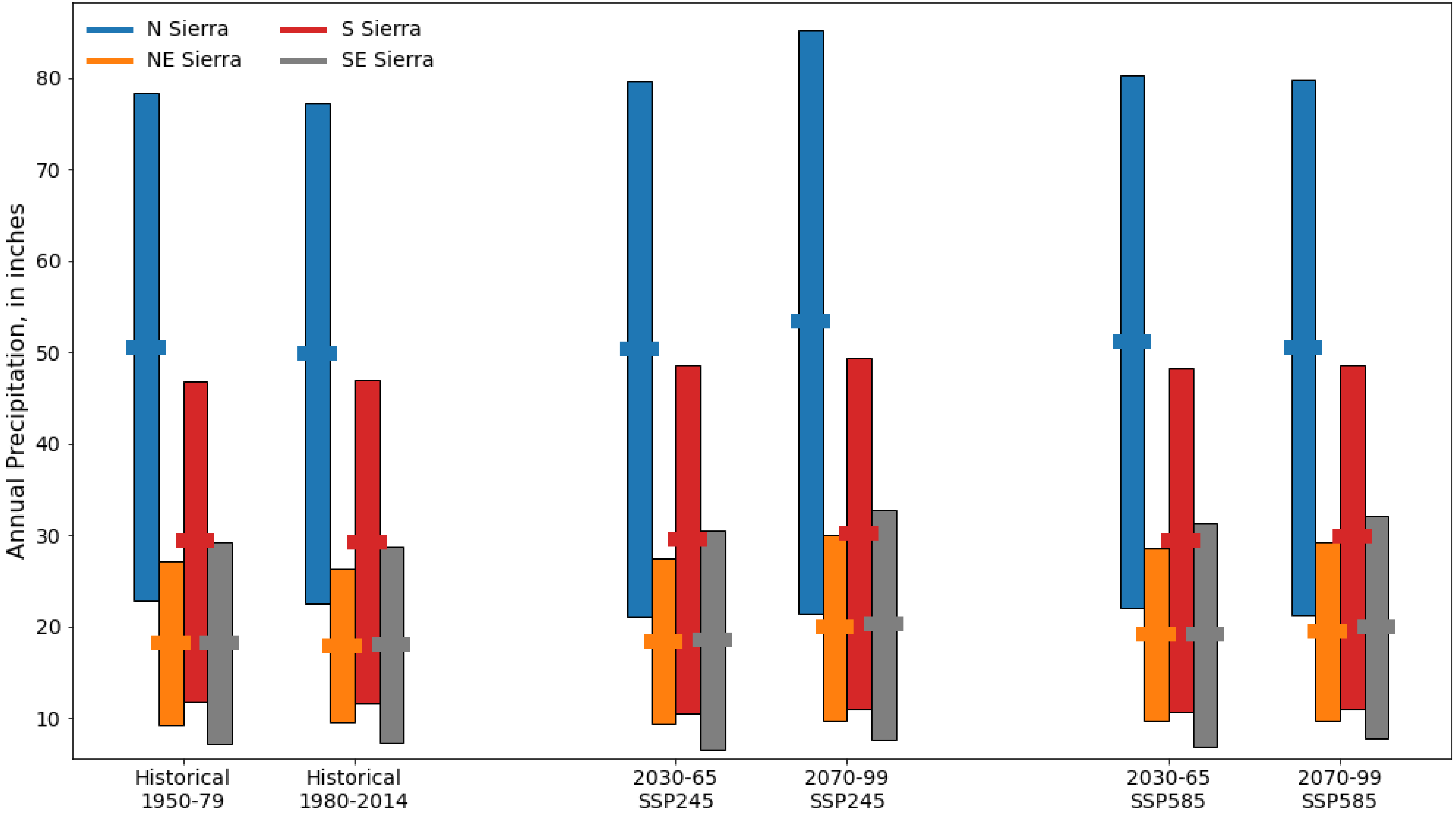
Annual Precipitation

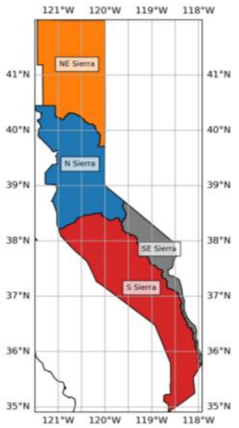
- Future changes in precipitation are less certain
- Region-specific variations
- A slight (11%) increase is projected by 2070–2099
- More precipitation extremes, with prolonged dry periods, followed by intense storms (Huang et al., 2020; Swain et al., 2018; Williams et al., 2015).





30-year averages Precipitation (region-specific)





Snow Water Equivalent (April)

By midcentury, only small areas will retain historical snowpack levels, except northern Sierra

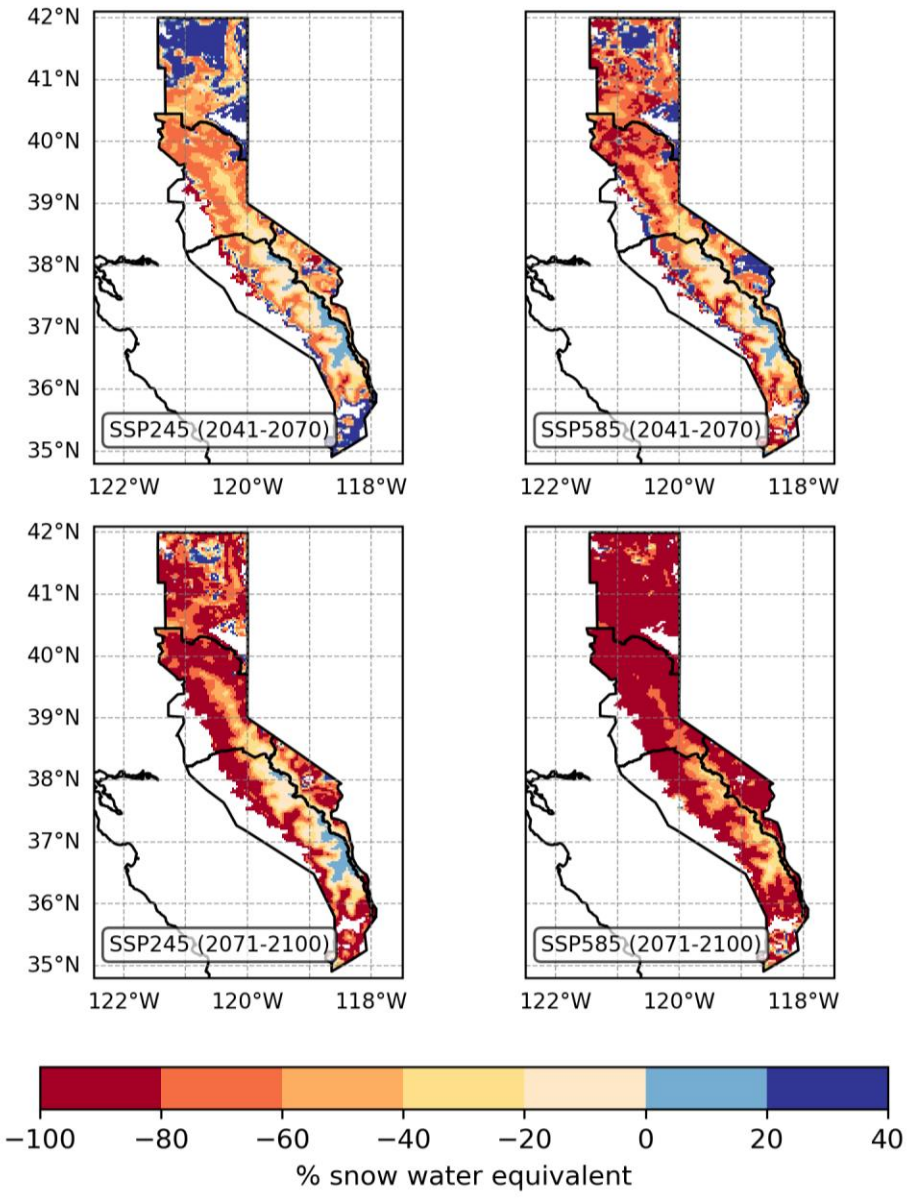
By the end of the century, snowpacks are projected to decline by 90% across most of the Sierra Nevada under SSP 585

Why?
Increase in rain-to-snow ratio, snow melting

Hydrological projections were simulated using the VIC hydrological model, forced by 3 GCMs (CNRM-ESM2-1, EC-Earth3-Veg, MPI-ESM1-2-HR).

Source: https://wrf-cmip6-noversioning.s3.amazonaws.com/index.html#lusu/CEC/VIC_SIMULATIONS/GCMs/

% change in SWE (future –historical)
(average of 3 GCMs)



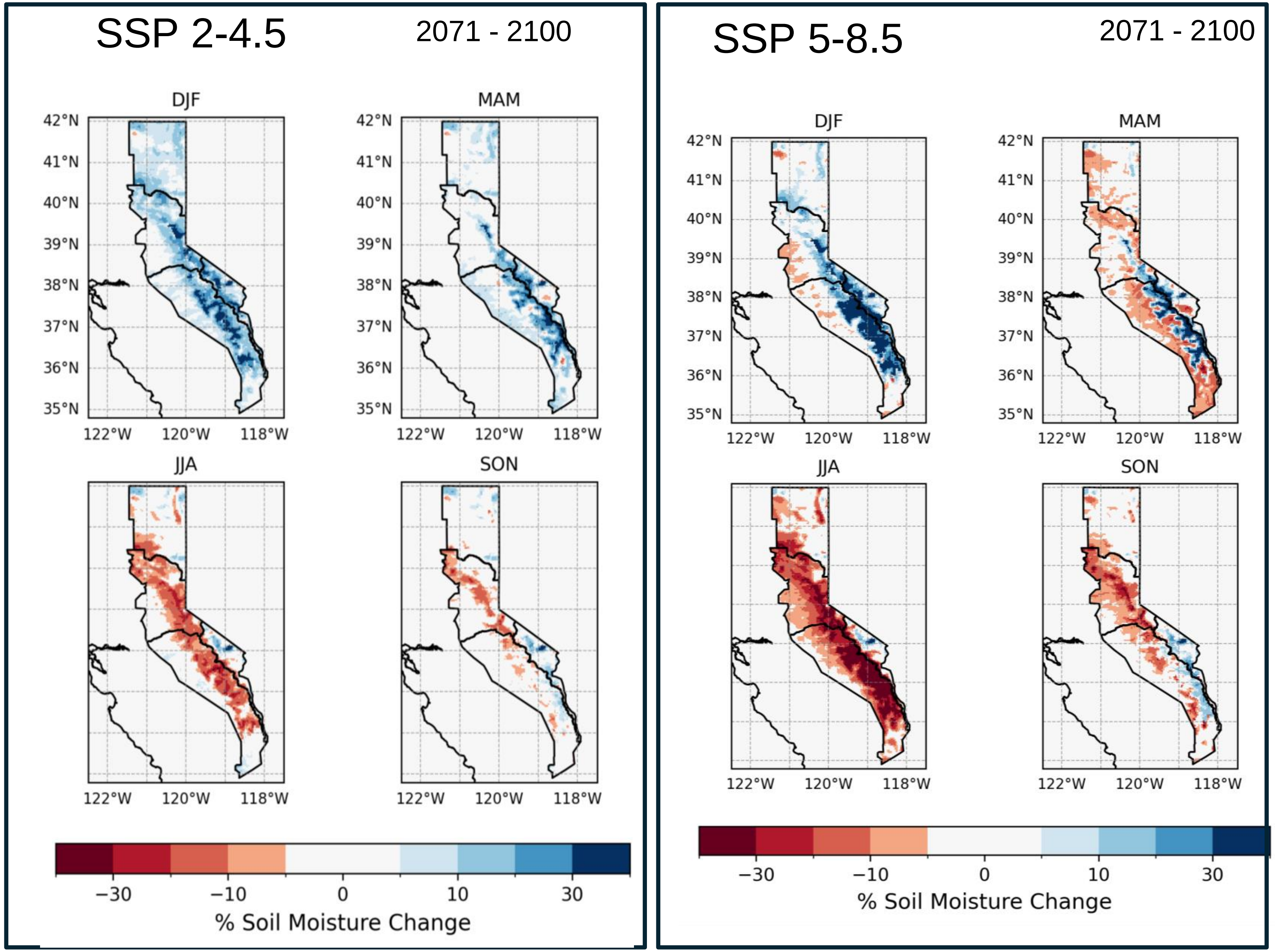
Soil Moisture

Soil moisture is projected to **decline during the summer**.
During winter and spring, the changes vary.

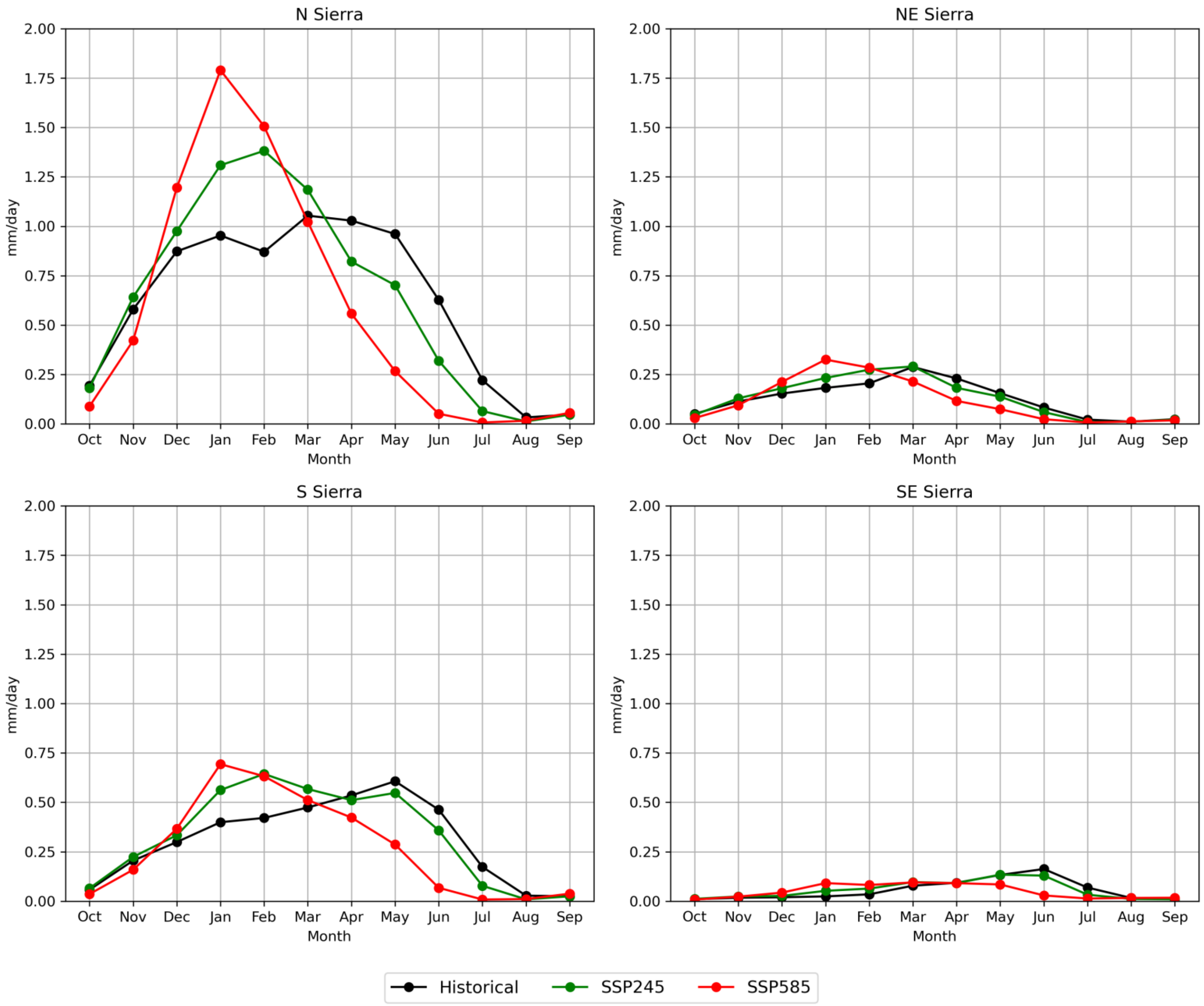
Lower soil moisture reduces ET, increases dry fuel loads and hence increases chance of wildfire

The Fire Weather Index (FWI) is directly related to soil moisture.
FWI = f (T, RH, θ),
Where θ is soil moisture

5th Assessment



Runoff (2071–2100)



In future, winter and spring runoff will increase but summer runoff will decrease in all projections

Why?

1. Earlier snowmelt
2. Increase in rain-to-snow ratio
3. Slight increase in precipitation

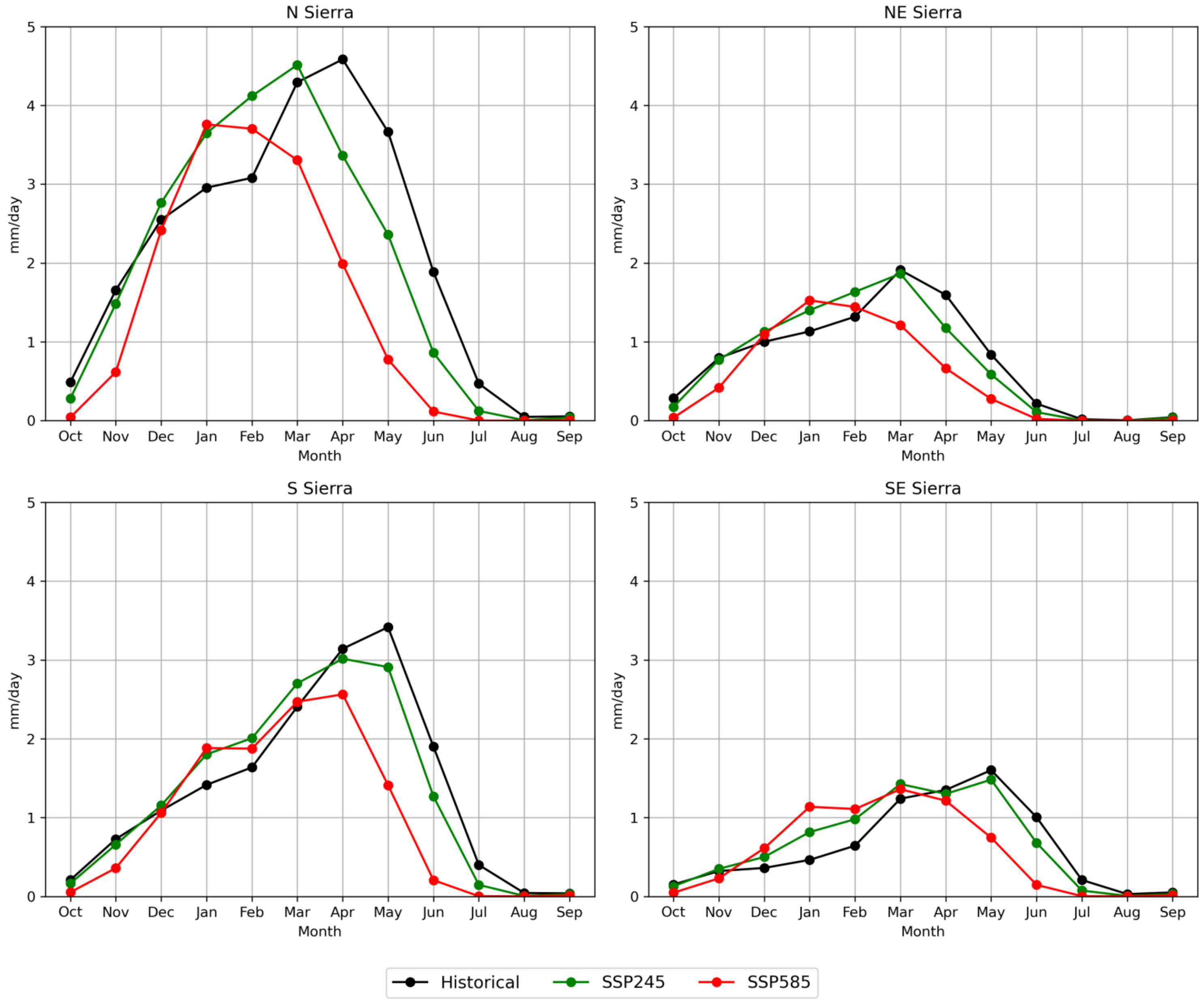
Implications?

Projected runoff
(as % of 1961-1990 averages)

SSP	NE Sierra	N Sierra	S Sierra	SE Sierra
Annual total				
SSP2-4.5	111	107	112	121
SSP5-8.5	96	91	88	110
January–March				
SSP2-4.5	125	140	139	154
SSP5-8.5	116	134	125	156
July–September				
SSP2-4.5	93	49	56	115
SSP5-8.5	78	43	41	137

The annual total runoff will increase
from 88 to 121%

Snowmelt (2071–2100)

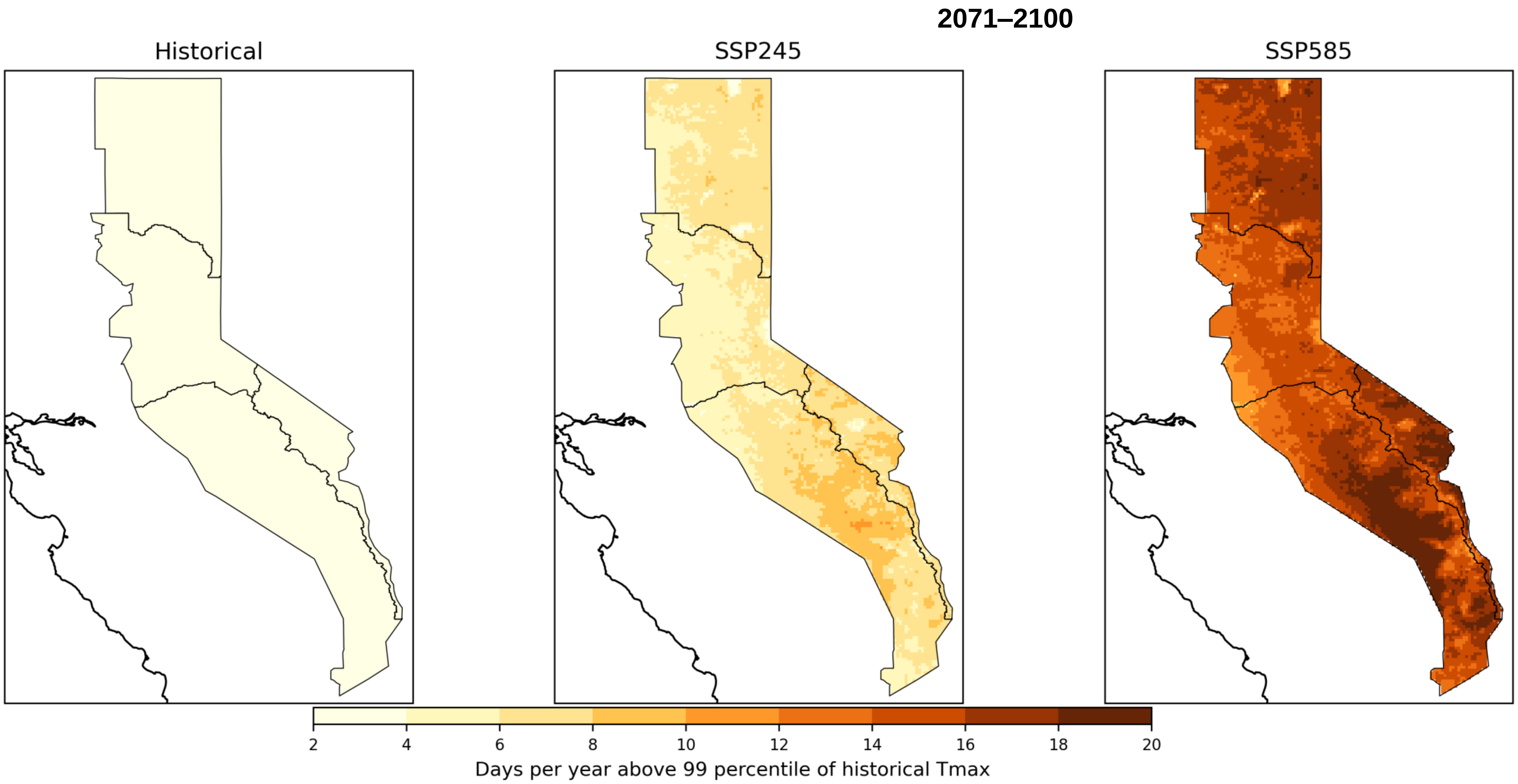


Earlier snow melting

By June, snowpacks mostly melted

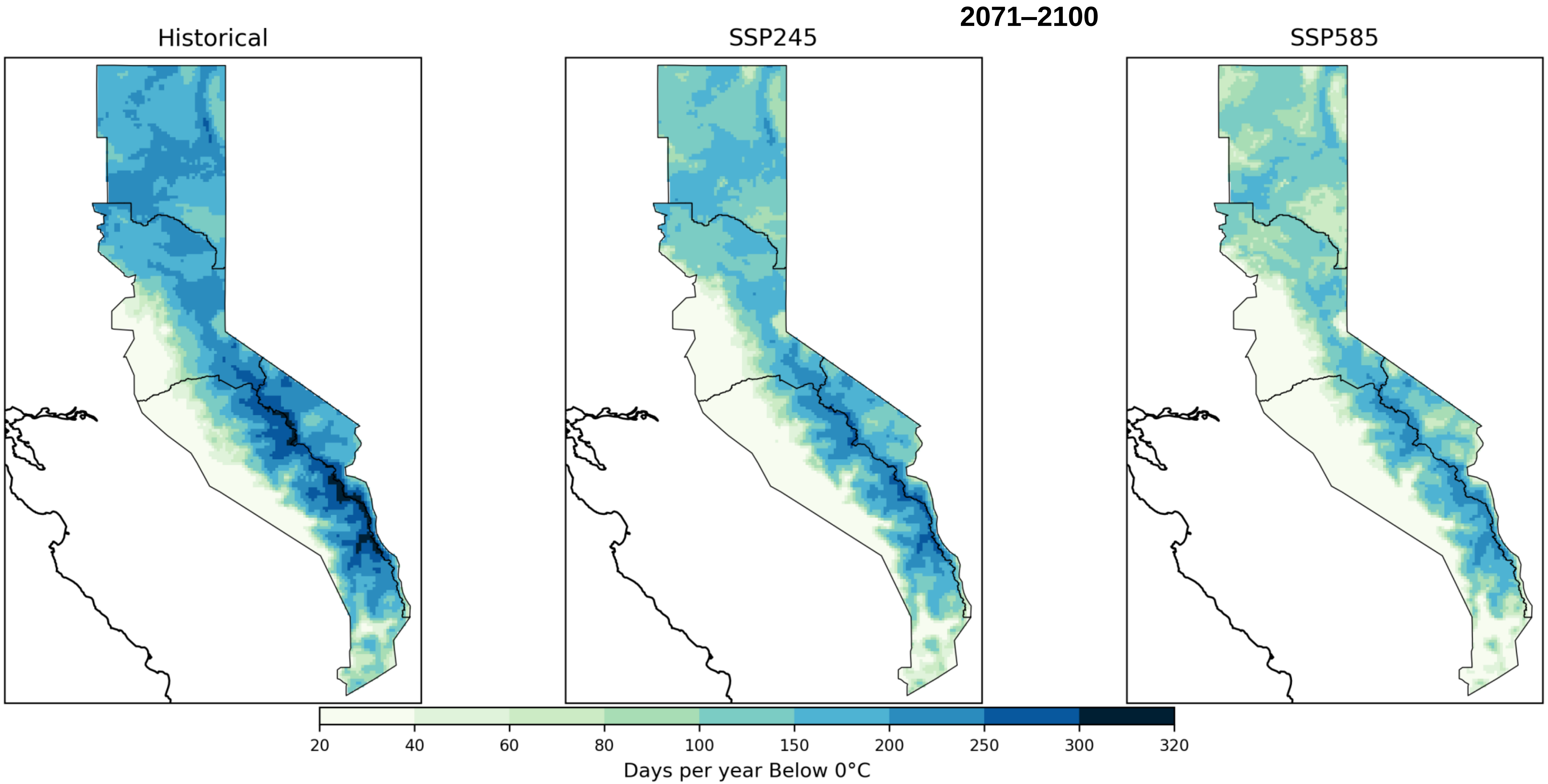
Heatwaves

Every year 10 to 20 days will exceed 99th percentile of historical T_{max}



Freeze

Days below 0°C will significantly decrease in future



Thank You

References

Huang, X., Swain, D.L. and Hall, A.D., 2020. Future precipitation increase from very high resolution ensemble downscaling of extreme atmospheric river storms in California. Science advances, 6(29): eaba1323.

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Williams, A.P., Seager, R., Abatzoglou, J.T., Cook, B.I., Smerdon, J.E. and Cook, E.R., 2015. Contribution of anthropogenic warming to California drought during 2012–2014. Geophysical Research Letters, 42(16): 6819-6828.