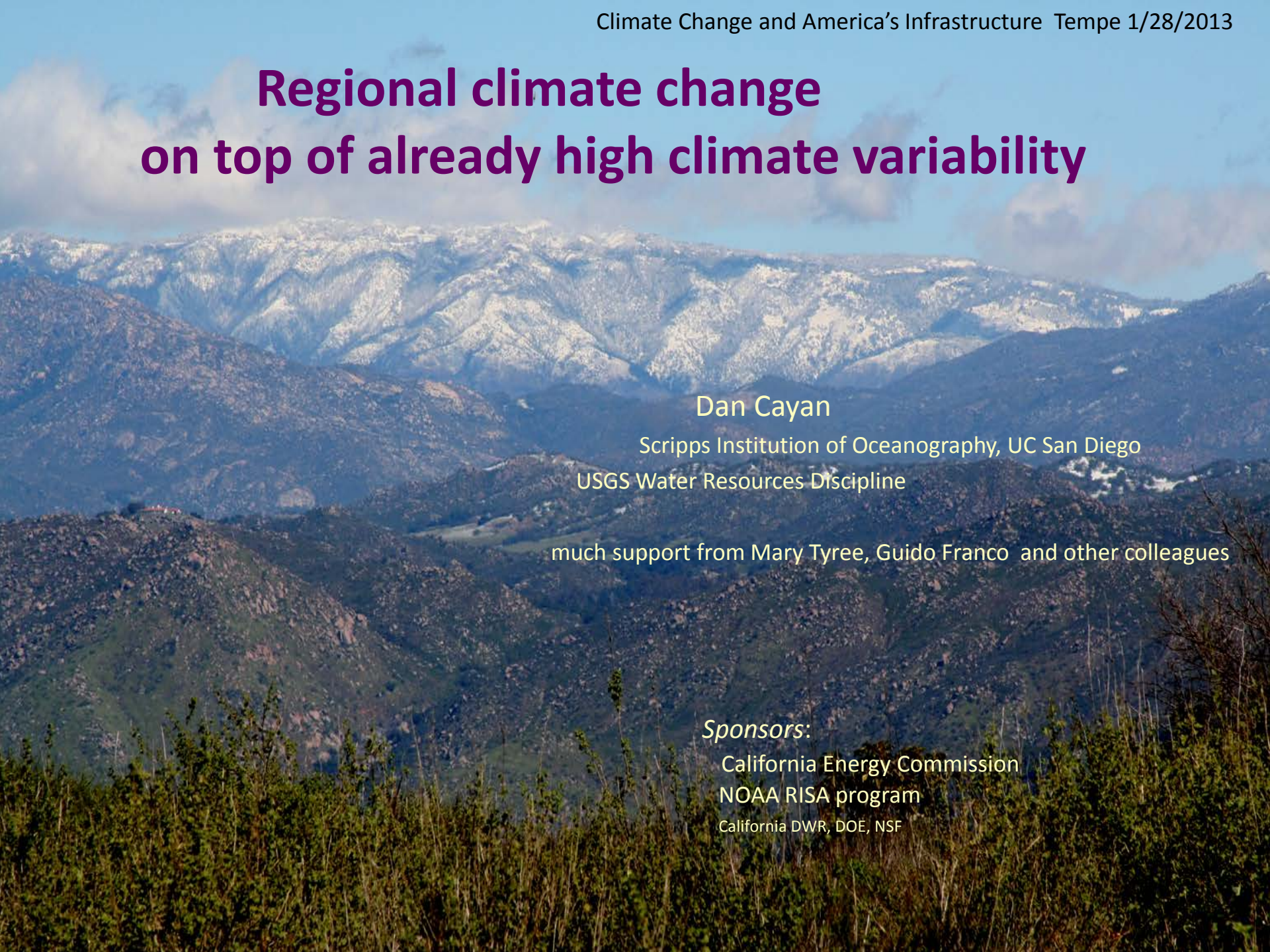
Regional climate change on top of already high climate variability



Dan Cayan

Scripps Institution of Oceanography, UC San Diego

USGS Water Resources Discipline

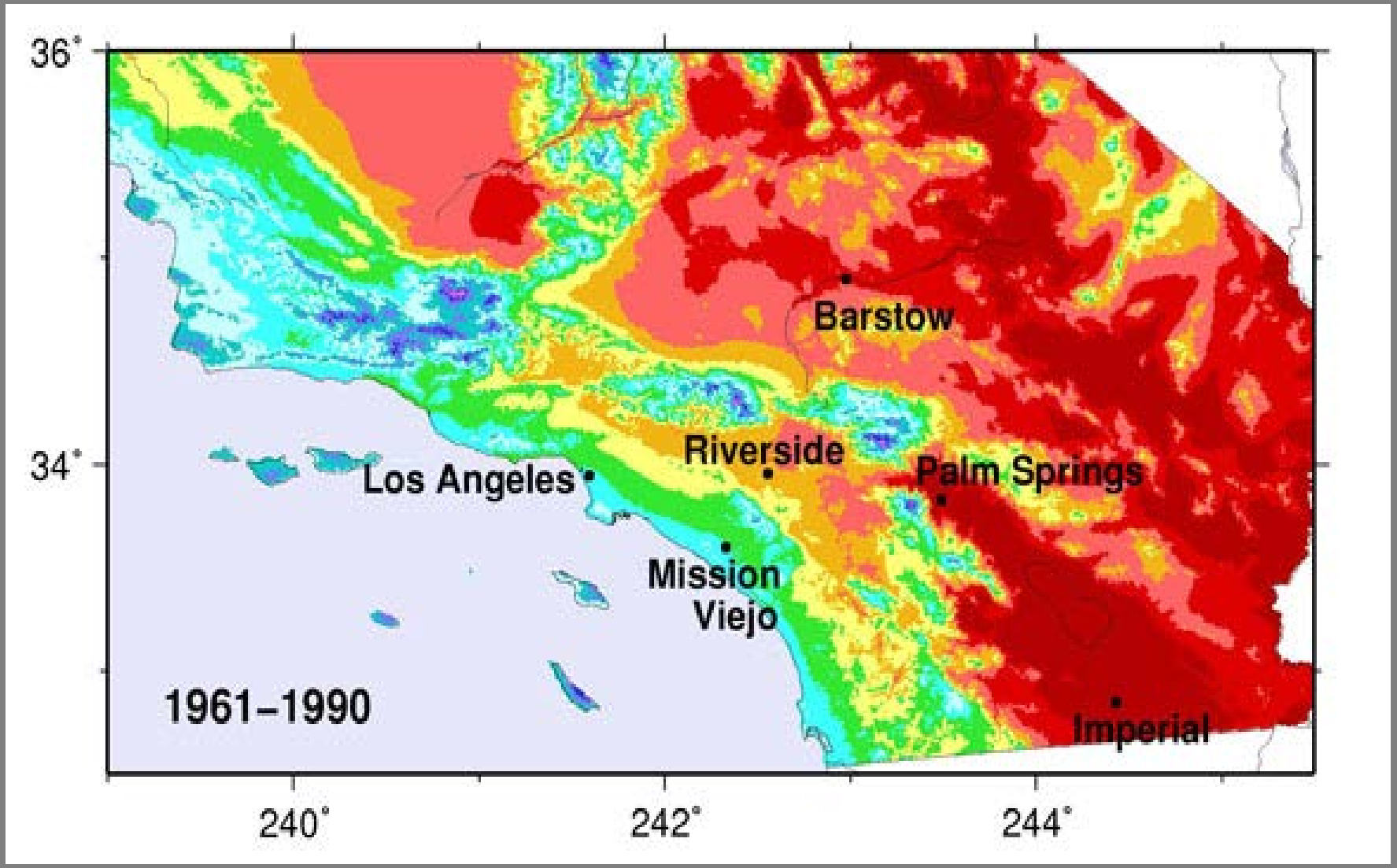
much support from Mary Tyree, Guido Franco and other colleagues

Sponsors:

California Energy Commission

NOAA RISA program

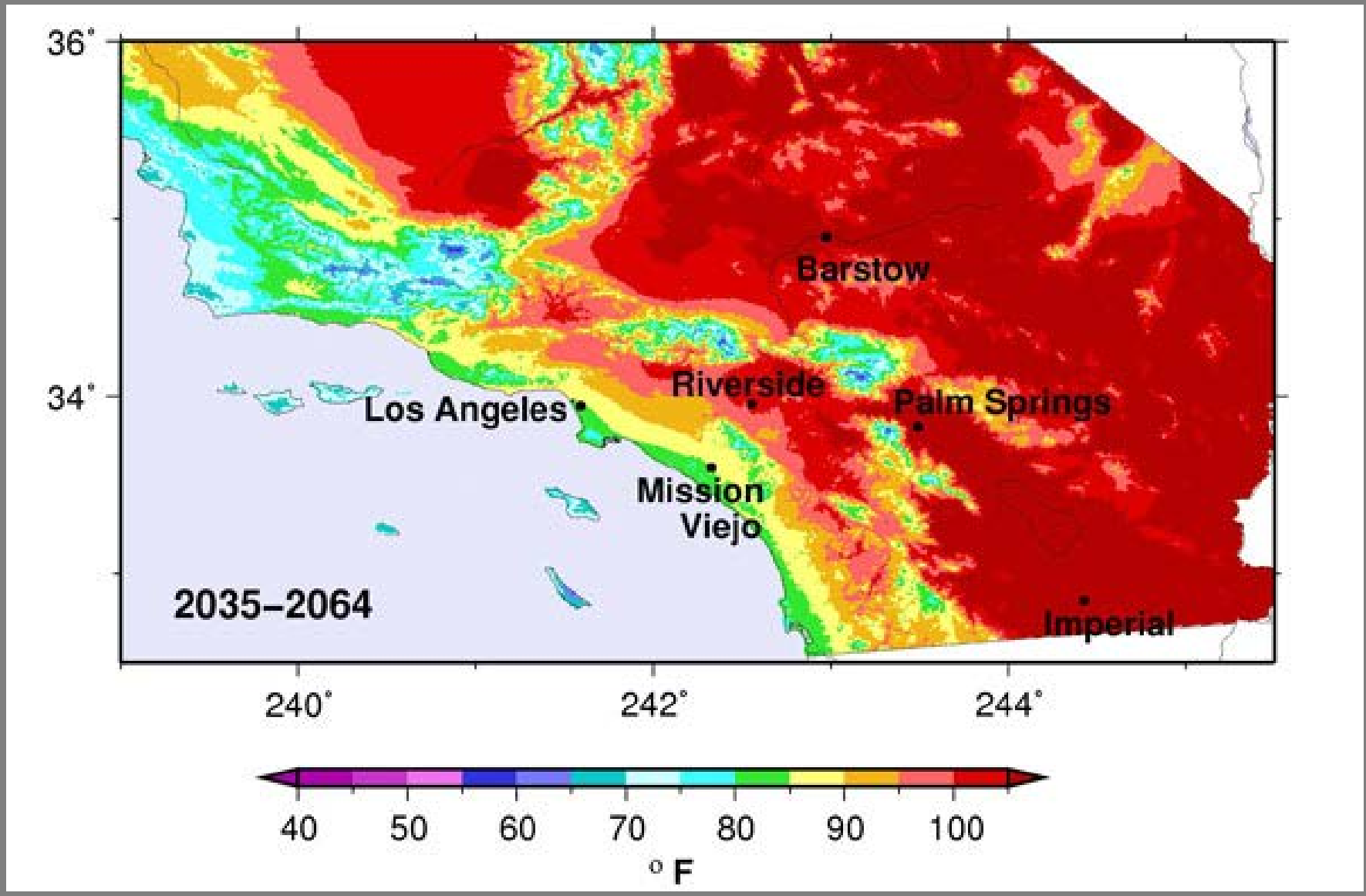
California DWR, DOE, NSF



estimated present-day historical July average daily Tmax

1km downscaled to 1km

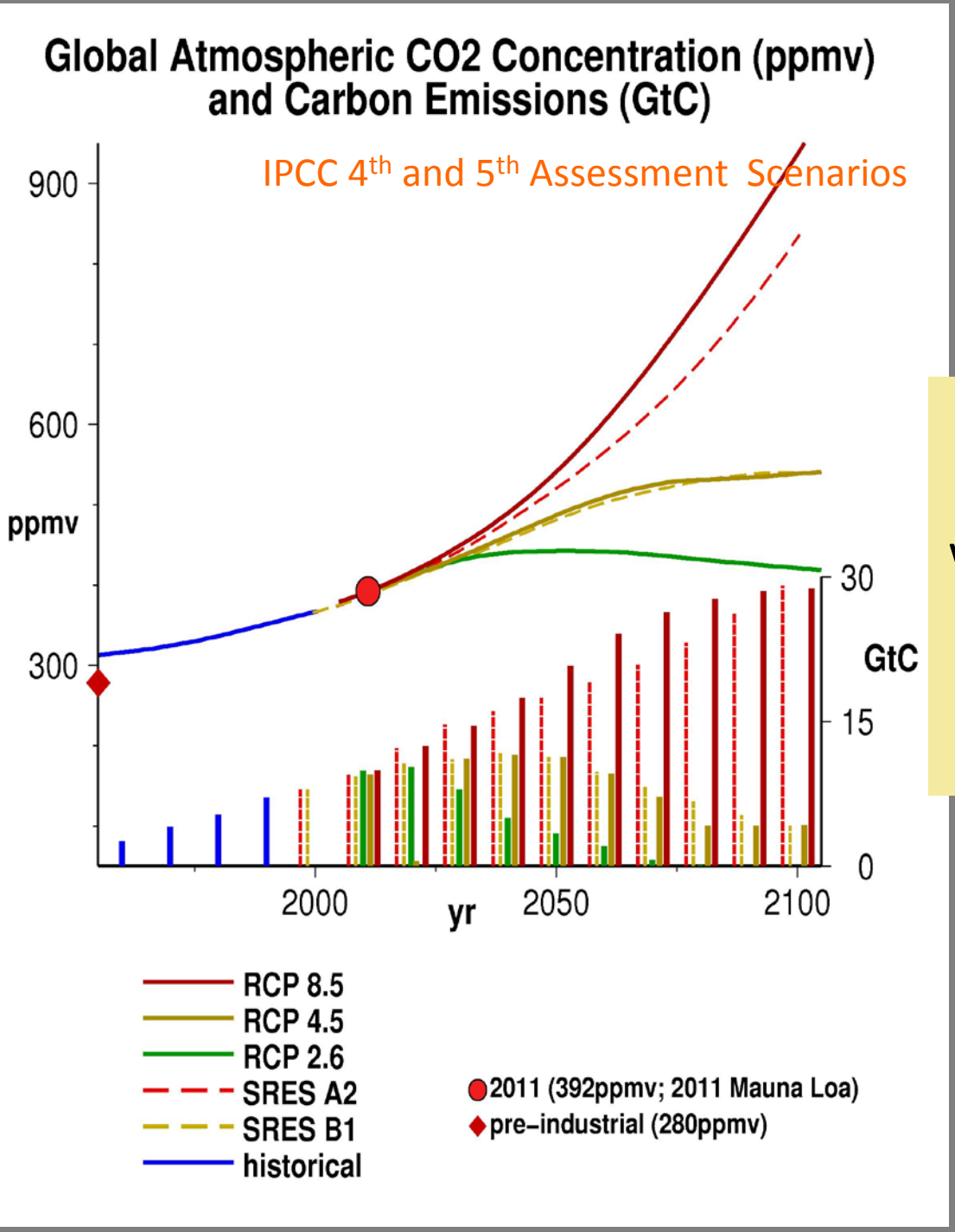
Hugo Hidalgo, Tapash Das, Mike Dettinger



One climate model scenario of July average daily Tmax mid 21st Century

GFDL A2 1km downscaled to 1km

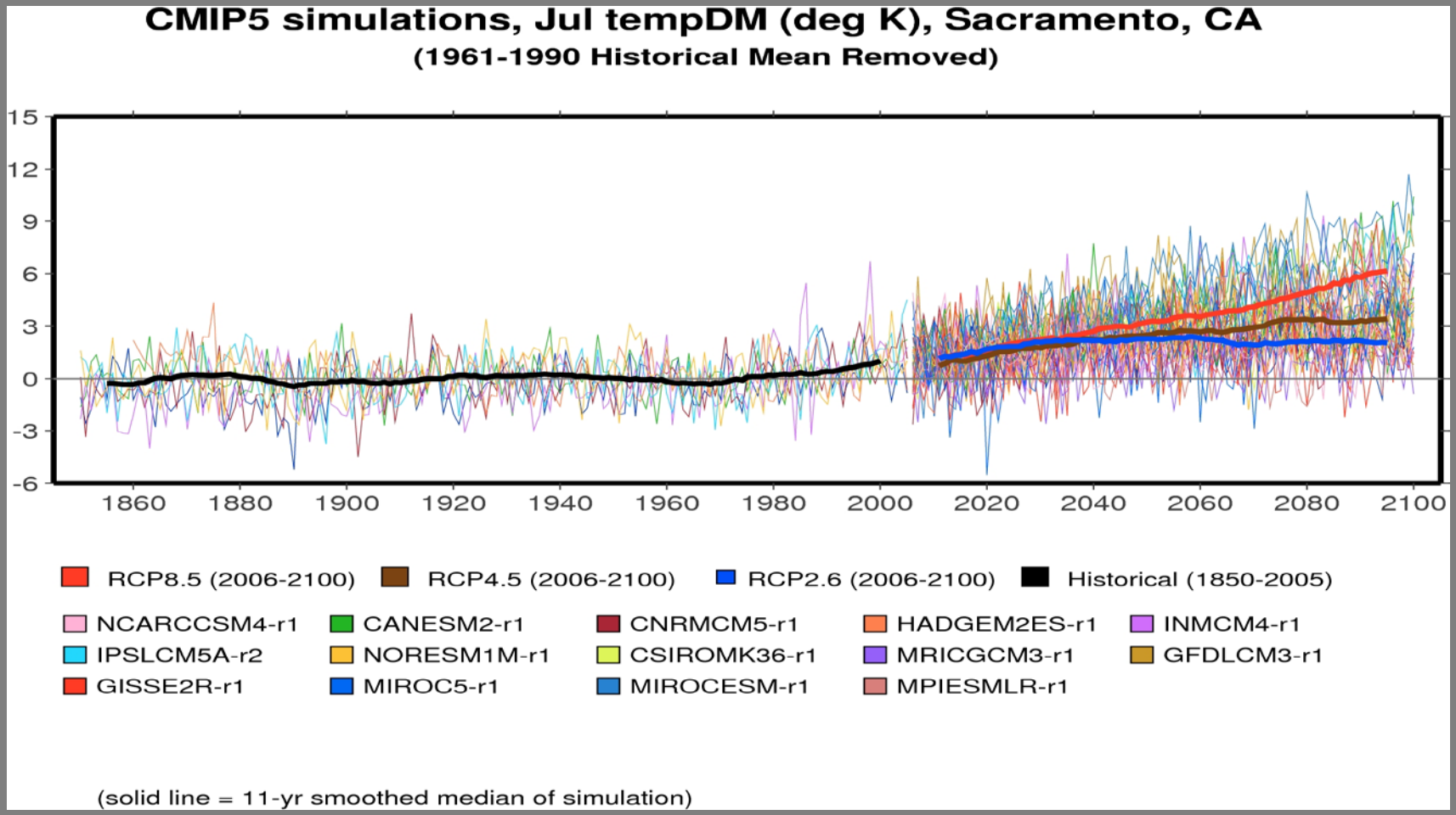
Hugo Hidalgo Tapash Das Mike Dettinger



different greenhouse gas emissions trajectories would have enormous impacts on climate in future decades

Temperature Change 14 GCMs X 3 RCP Emissions Scenarios

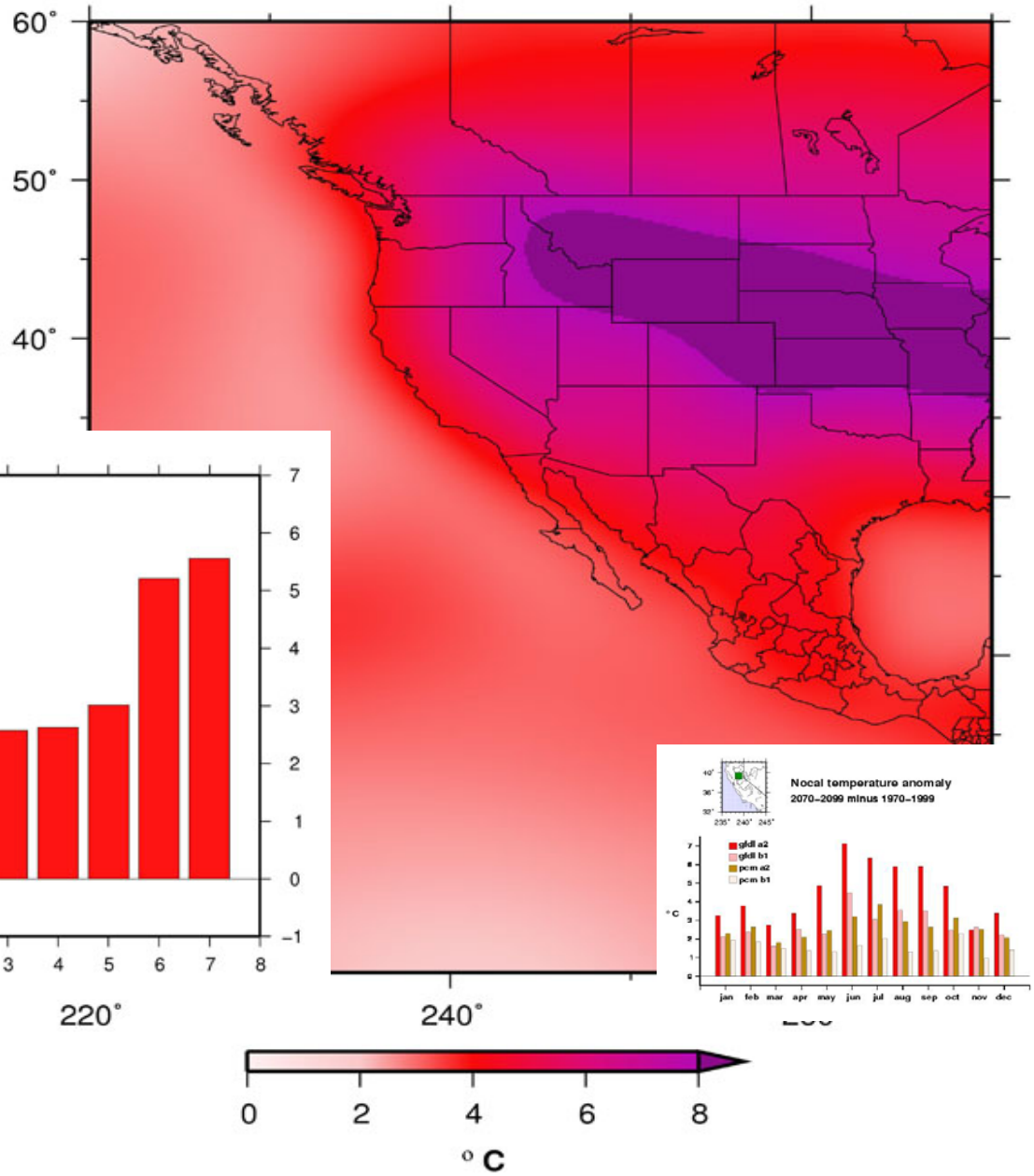
IPCC 5th Assessment (CMIP5) models

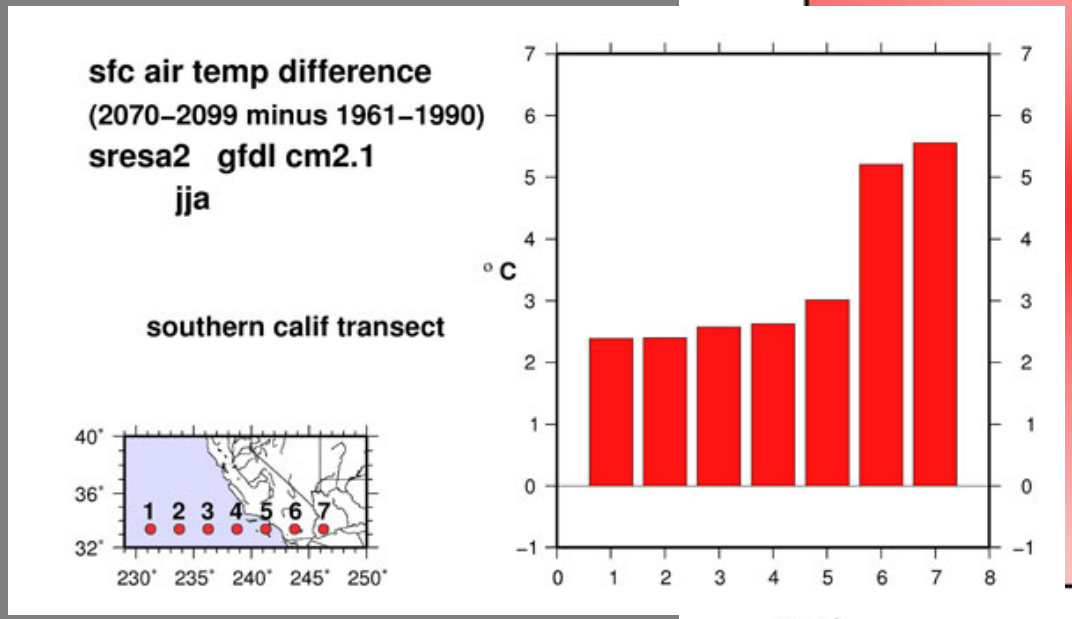


Climate models project ocean warming by end of century of 1.5-2.C
greater warming on land than oceans would amplify thermal gradient across California coast-interior

Summer land warming is accentuated

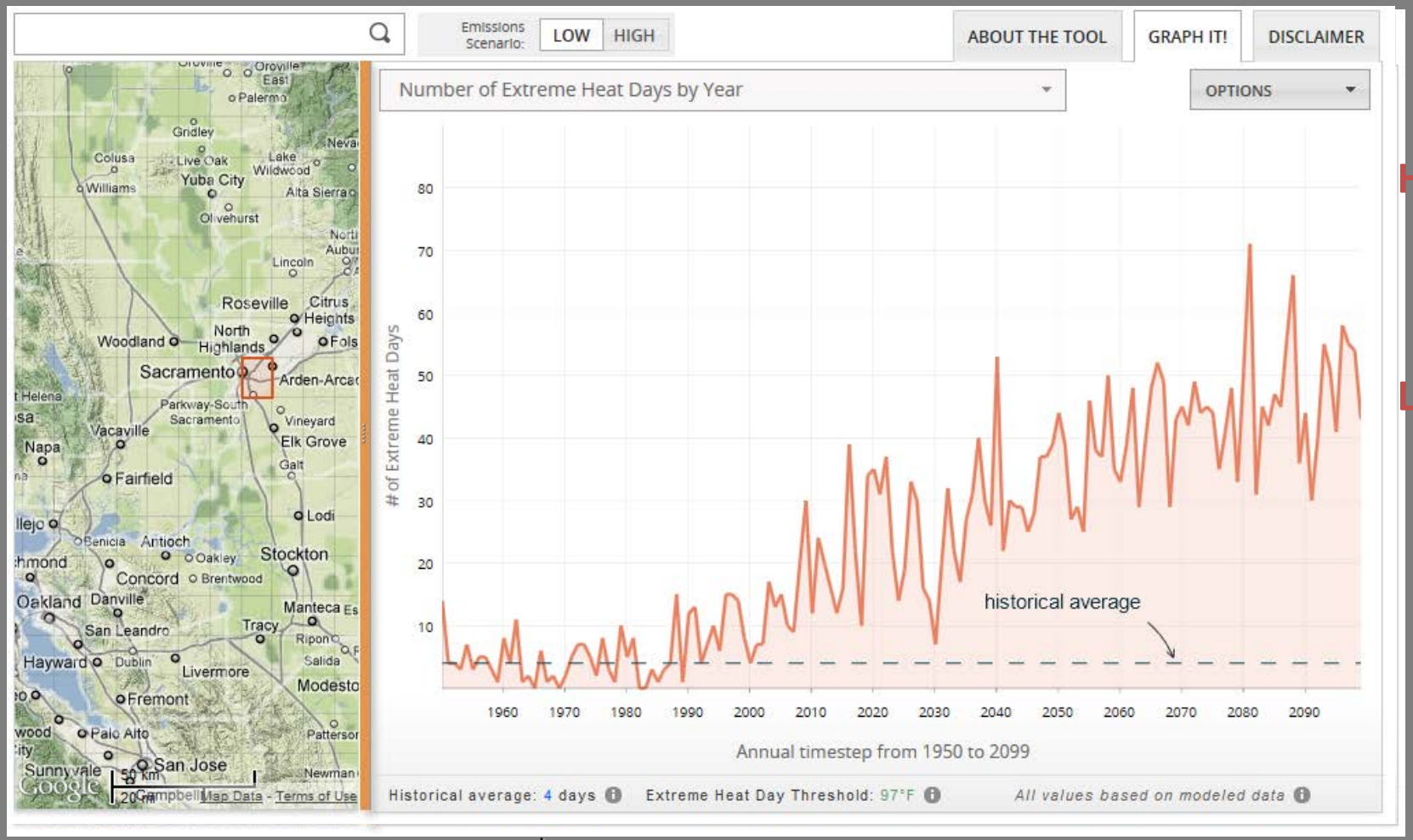
GFDL CM2.1 Jun-Aug air temp change
2070-2099 minus 1961-1990





Increase in Extreme Heat Days*

Projections Depend Strongly on Emissions Scenarios



Cal-adapt

Source: http://cal-adapt.org

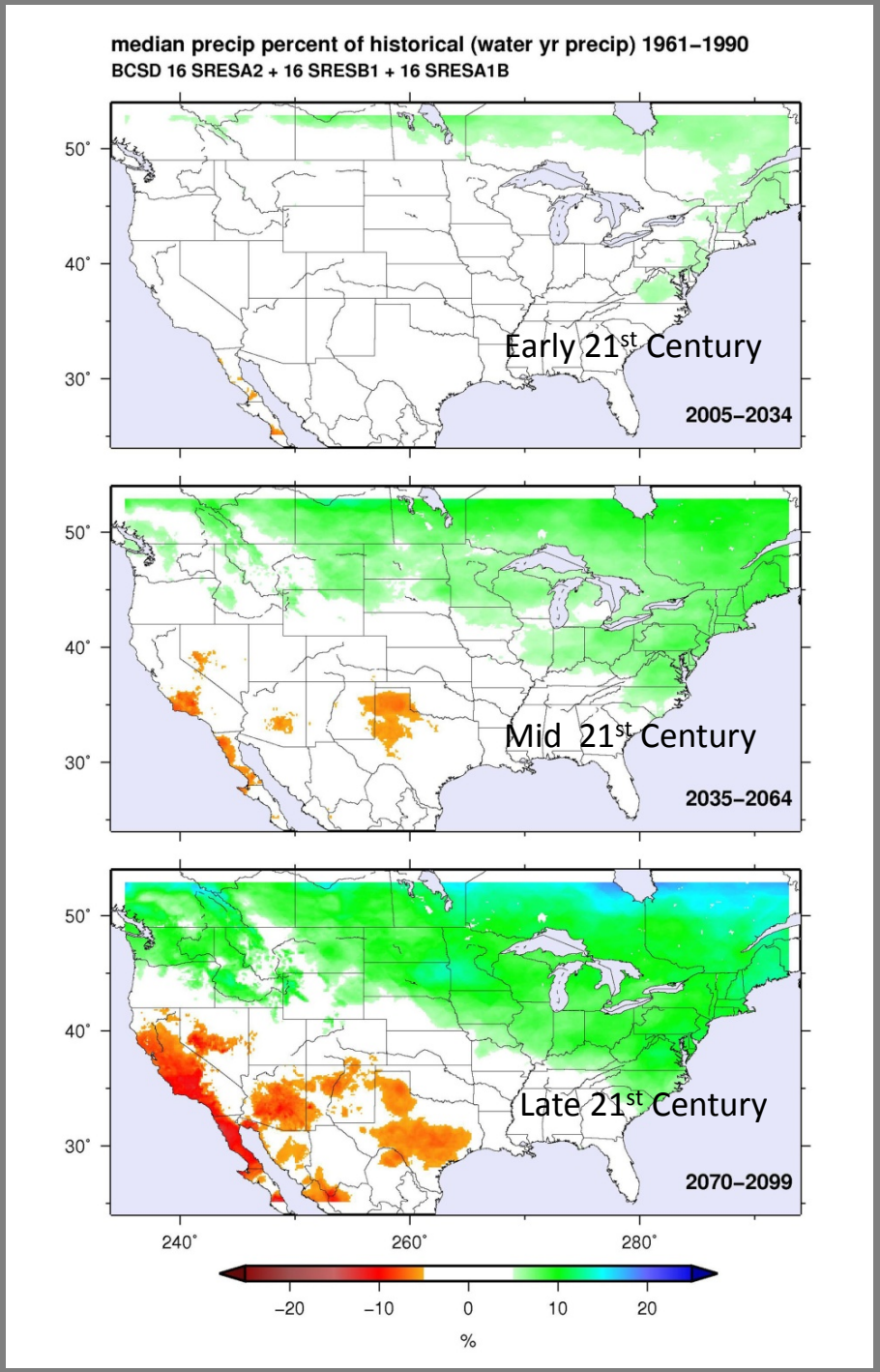
* 98th Percentile of historic daily maximum temperature between 1960-1991 for the given location (Sacramento)

Projected Precipitation Change

Incrementally drier Southwest, especially Southern California develops over the 21st Century.

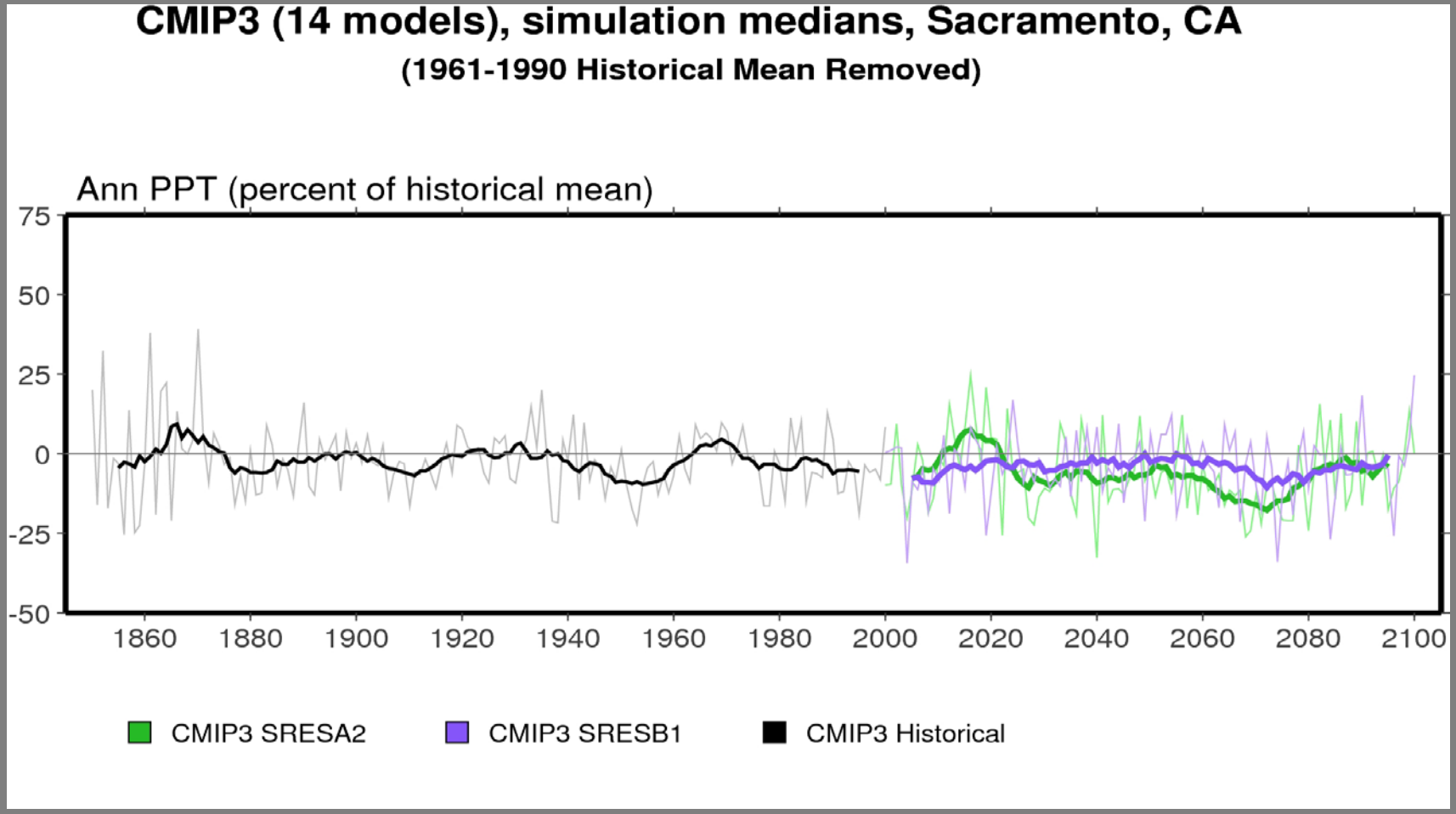
Drying becomes greater as climate becomes warmer

from 48 climate model simulations downscaled to 12km using BCSD

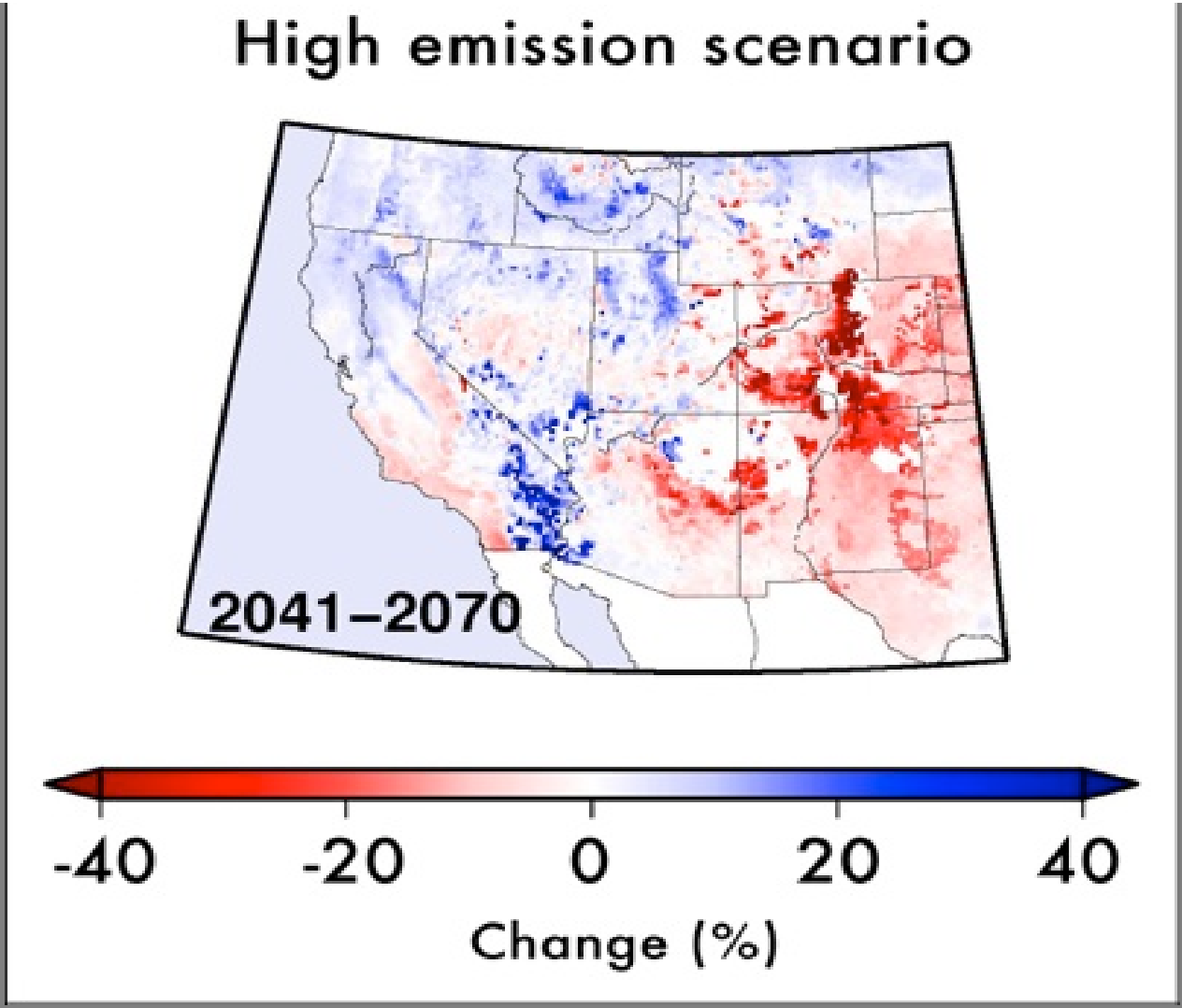


Precipitation Change 14 GCMs X 2 Emissions Scenarios

IPCC 4th Assessment models



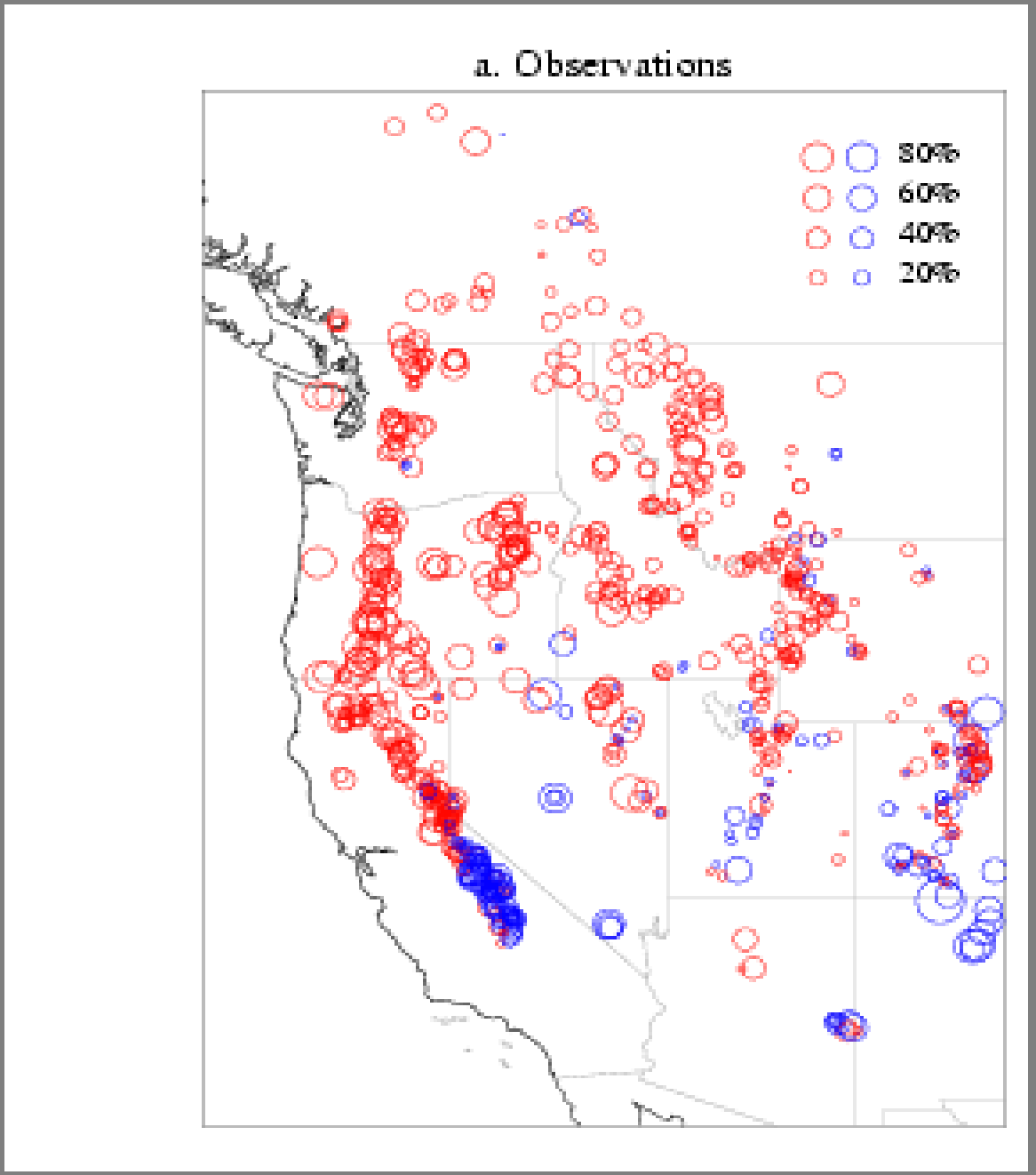
Projected Runoff Change 2041-2070



A2 mid-century (2041-2070) percent change from the historical period (1971-2000) for annual runoff, as obtained from median of 16 VIC simulations.

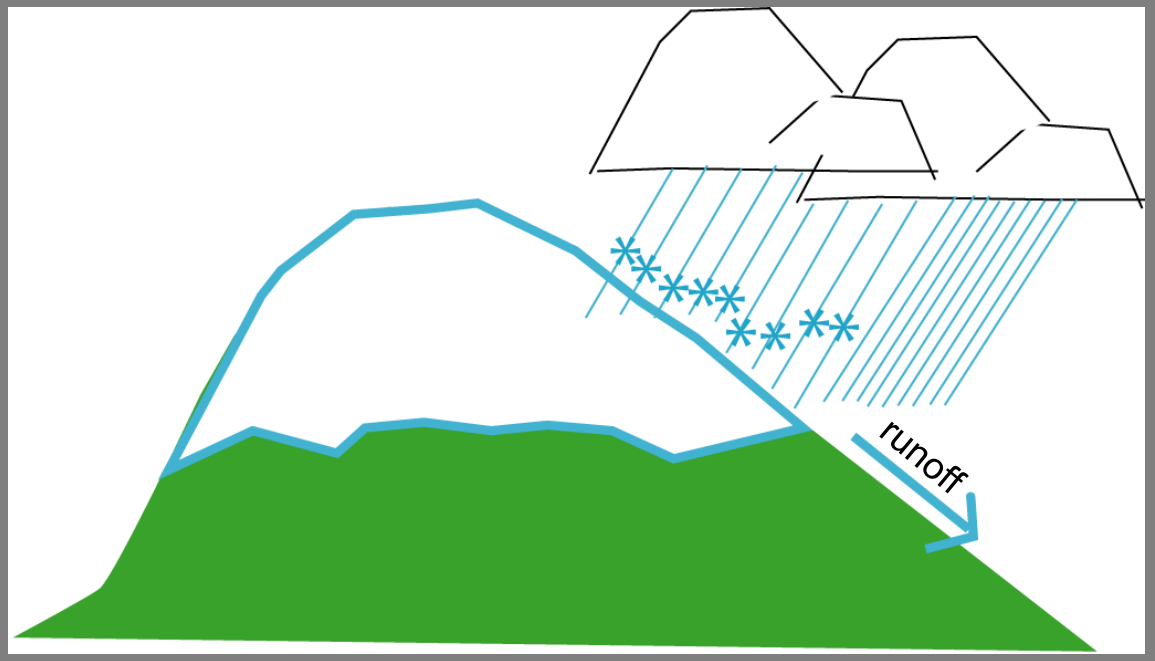
Trends
April 1 Snow Water Equivalent
1950-1997

Spring Snowpack has declined since 1950, mostly because of warmer winters and springs

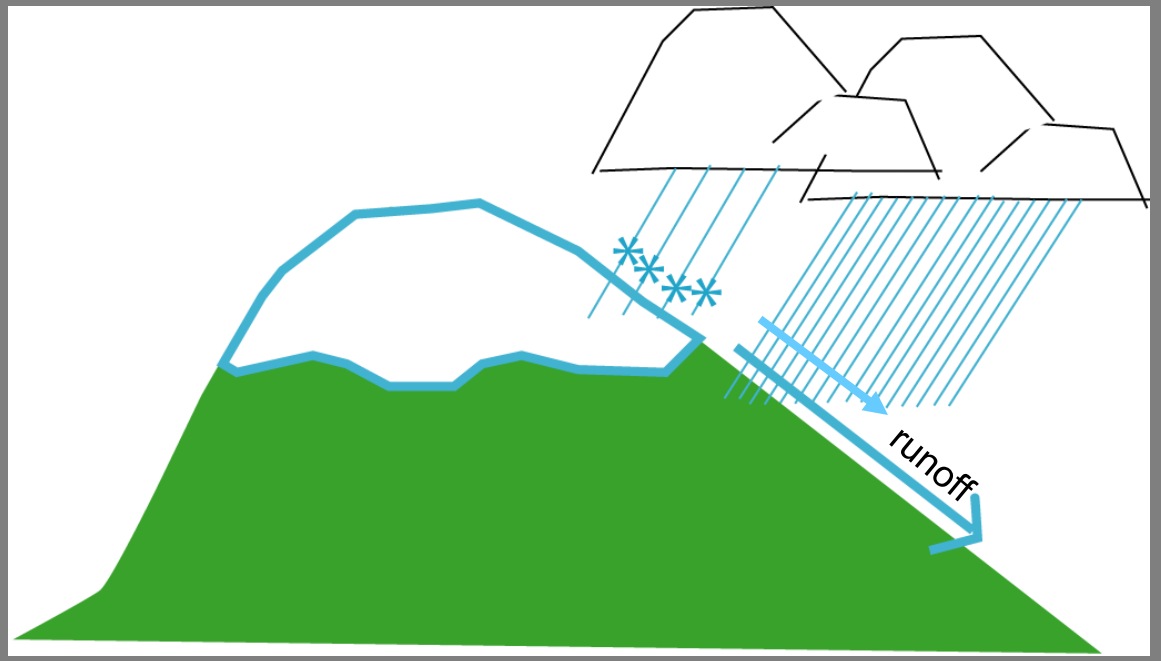


Source: Phil Mote et al. (2004) (university of Washington

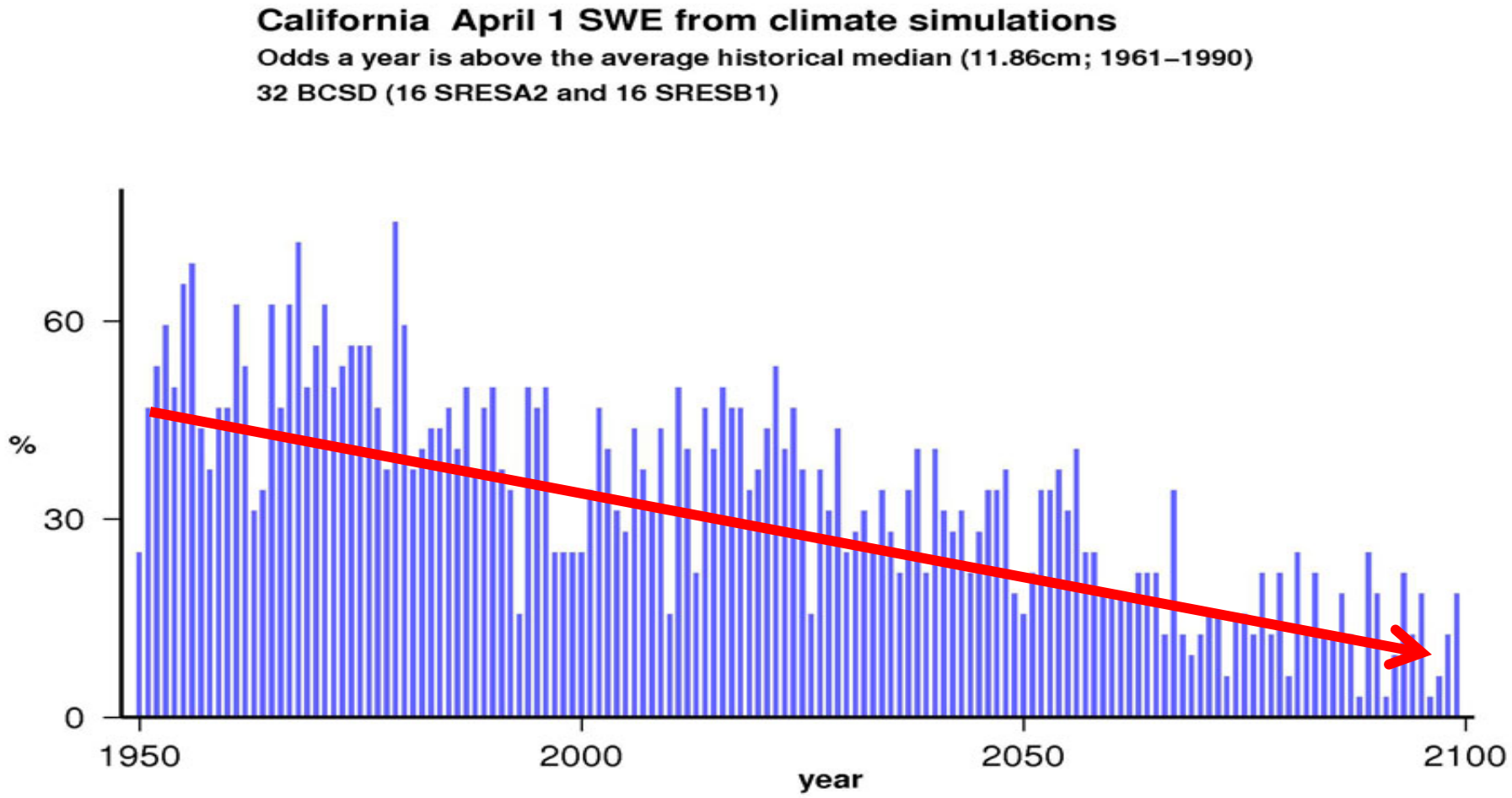
historically:
"Cool" storms contribute immediate runoff from smaller areas of the river basin (the rest goes into snowpack for later)



In a warmer climate:
Warm storms contribute immediate runoff from larger areas of the river basin



Declining odds of median or higher snowpack

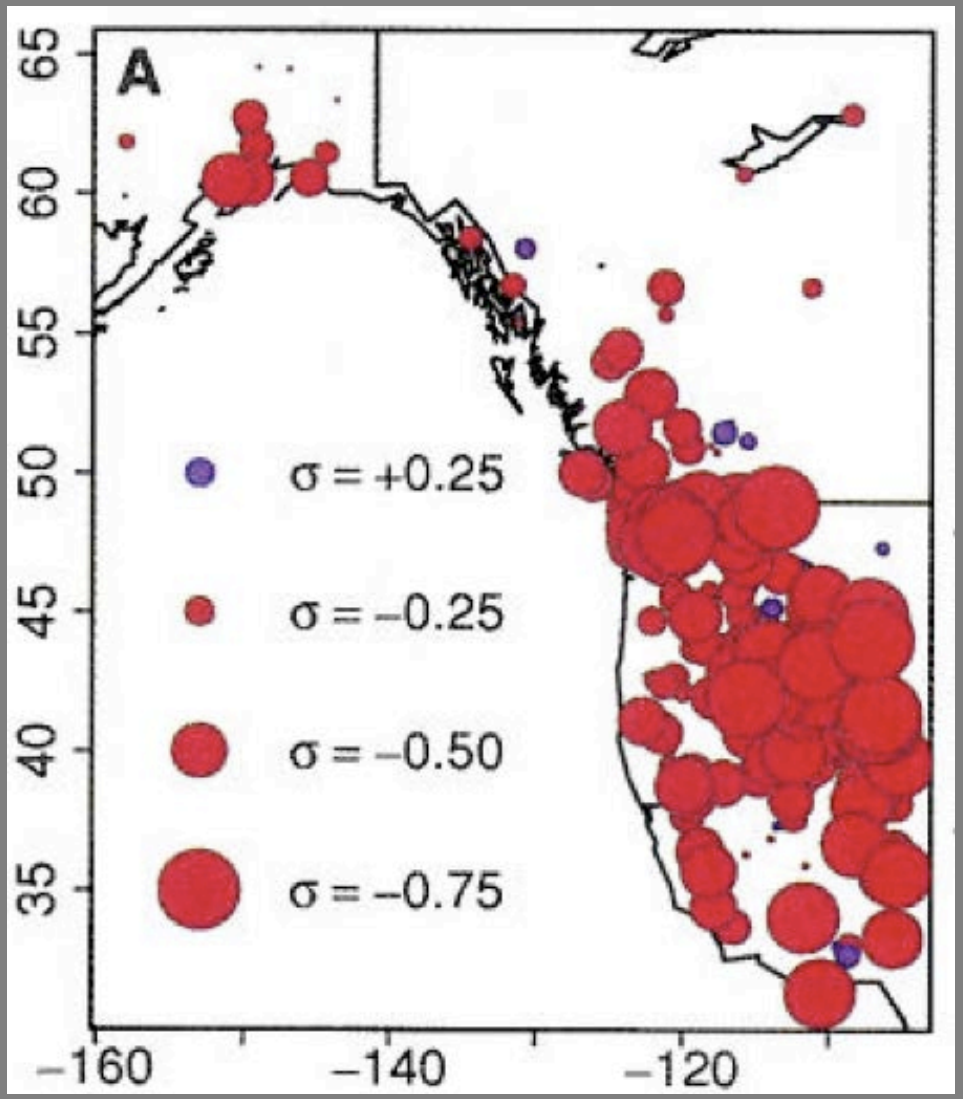


Source: Cayan et al. (2011)

Other recent trends:

Warming/drying has increased forest wildfire risks.

→ Linked wildfire increases & warming



Westerling et al., Science, 2006

since 1985 the number of large wildfires in western U.S. increased by 4X

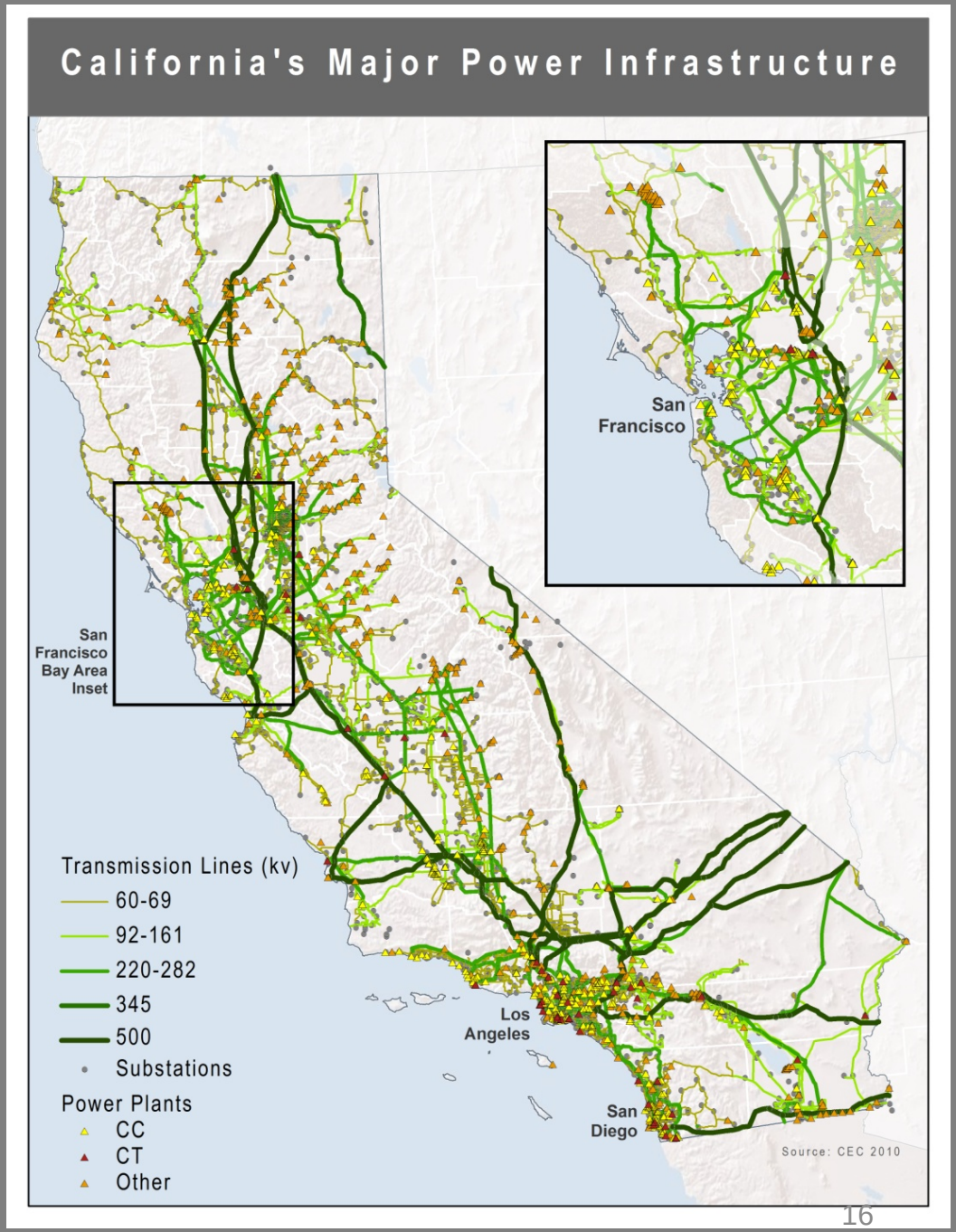
Anthony Westerling et al. Science August 2006

- **Need for More Generation on Hottest Days**
  - •Decreased Gas Plant Generation Efficiency
    - • Current Nameplate 44.1 GW
    - • Need 3.5 additional GW (8%)
  - •Peak Period Demand (90%tile)
    - •21% higher cooling demand
    - •Need 12.1 additional GW (27%)
  - •Substation Loss
    - •2.7% higher losses
    - •Need 1.6 GW (3.6%)
  - •Total Required Generation Capacity:
    - •Current capacity 44.1 GW
    - •Need 17.2 additional GW (39%)

- **•Need for More Transmission Capacity**
  - •Transmission lines
    - • 7% - 8% loss of peak period capacity
    - •21% higher peak load
    - •Need up to 31% additional transmission capacity

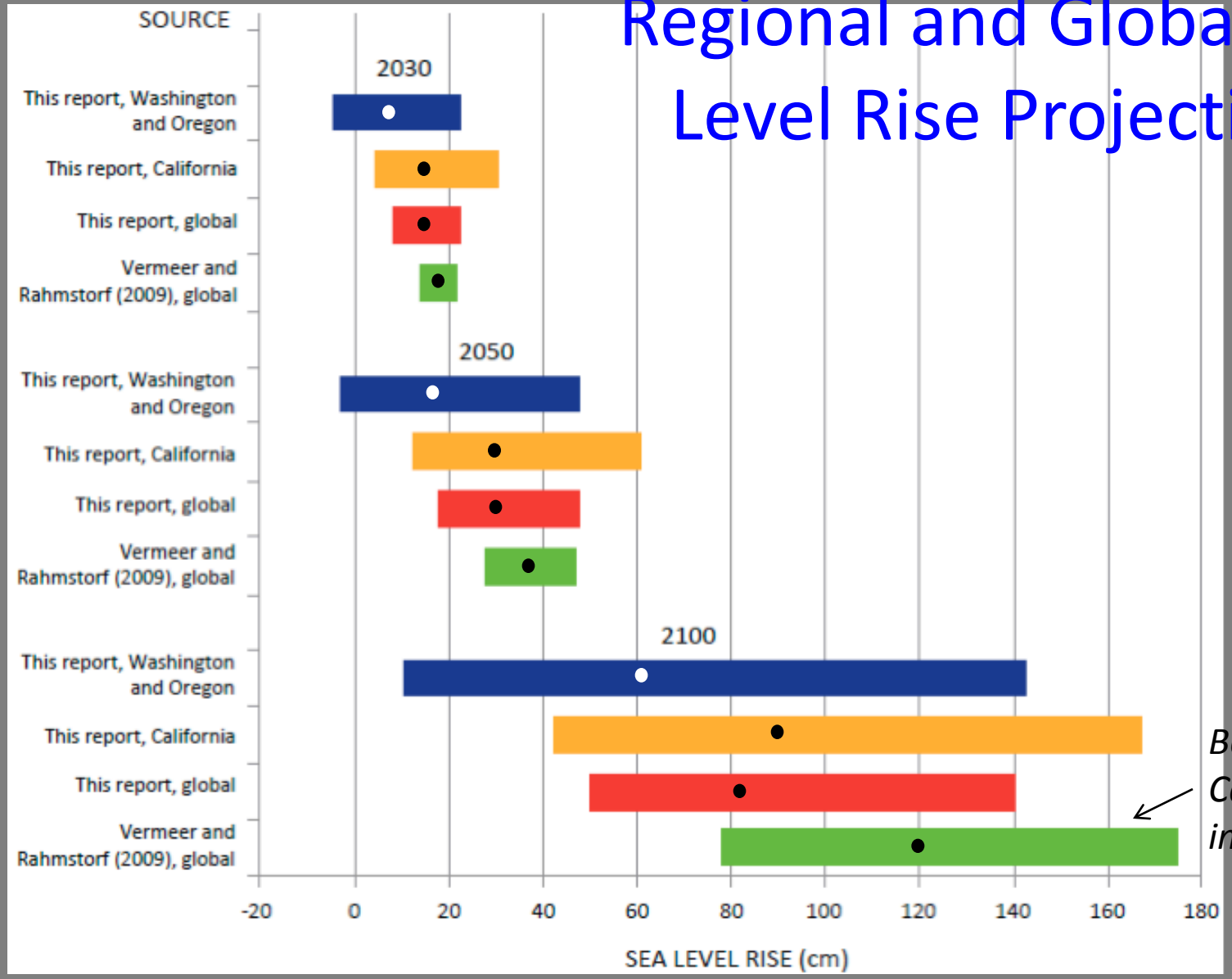
- •End of Century and Mid Century Impacts
  - •Focused on End of Century
  - •Mid Century under 2100 impact
  - •Growing Population

Sathaye et al., 2012



during high sea levels, the sea is often *not* quiescent

Regional and Global Sea-Level Rise Projections



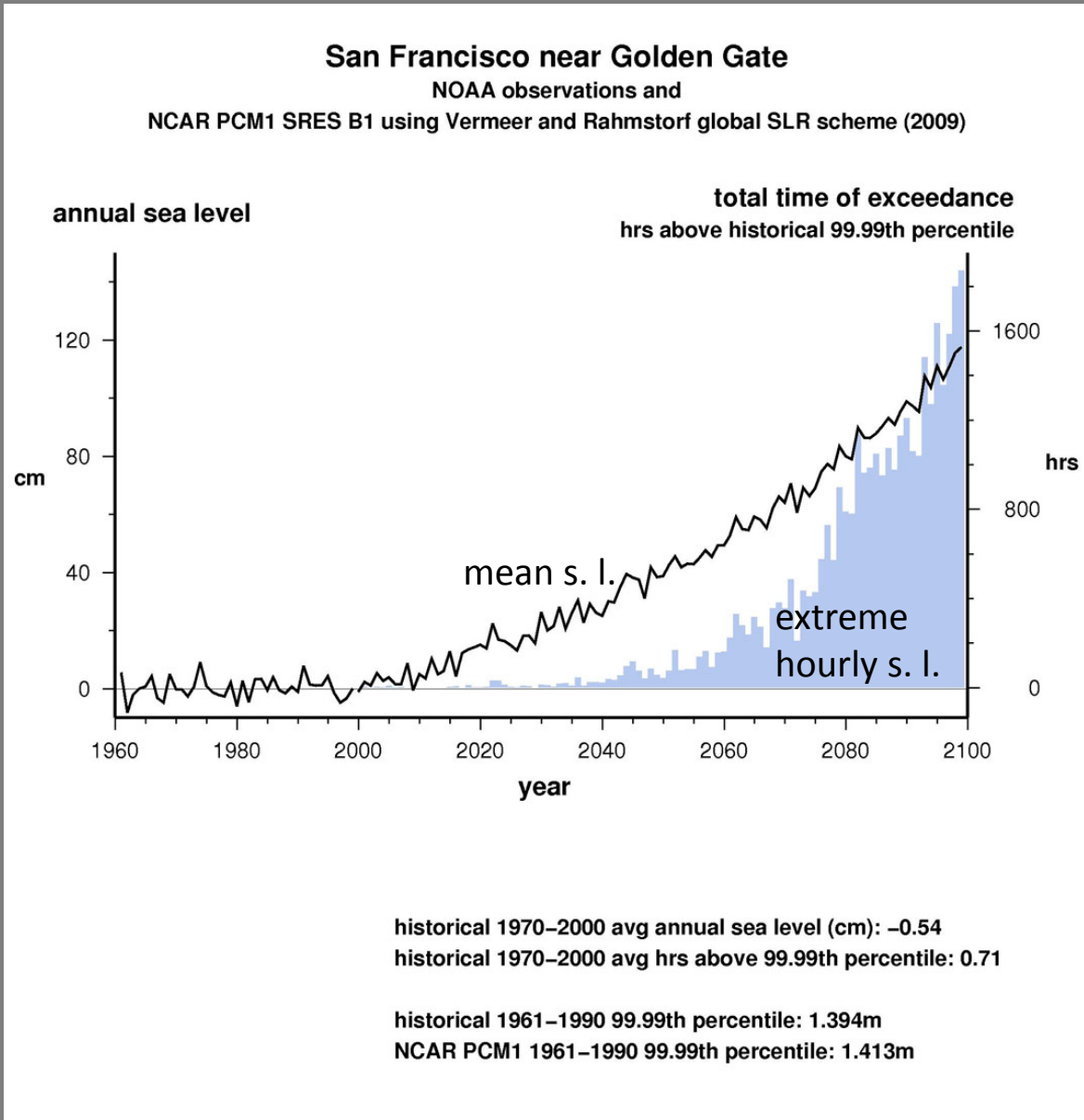
Being used by California for interim planning

NRC West Coast SLR study 2012

INCREASING SEA LEVEL EXCEEDENCES

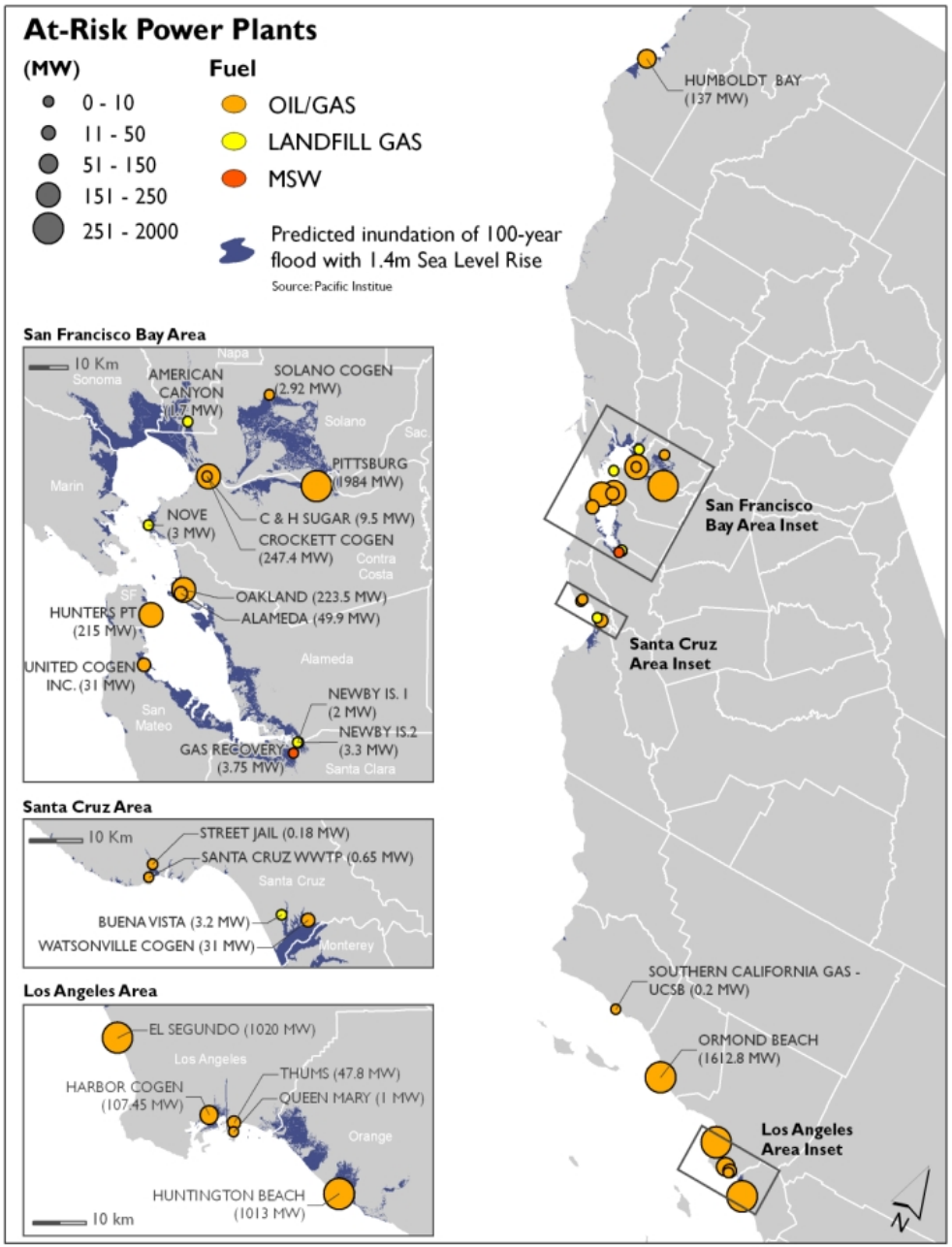
As mean sea level rises the frequency and magnitude of extremes would increase markedly. Under plausible rates of sea level rise, an event which in present day occurs less than once per year occurs scores of times per year by mid 21st Century and becomes commonplace by end of 21st Century.

Importantly the duration of extremes becomes longer, so exposure to waves is considerably greater.



ncar pcm1 sresb1 GCM
using Vermeer and Rahmstorf SLR

Cloern et al. 2011 PLOS ONE
NRC West Coast Sea Level Study 2012

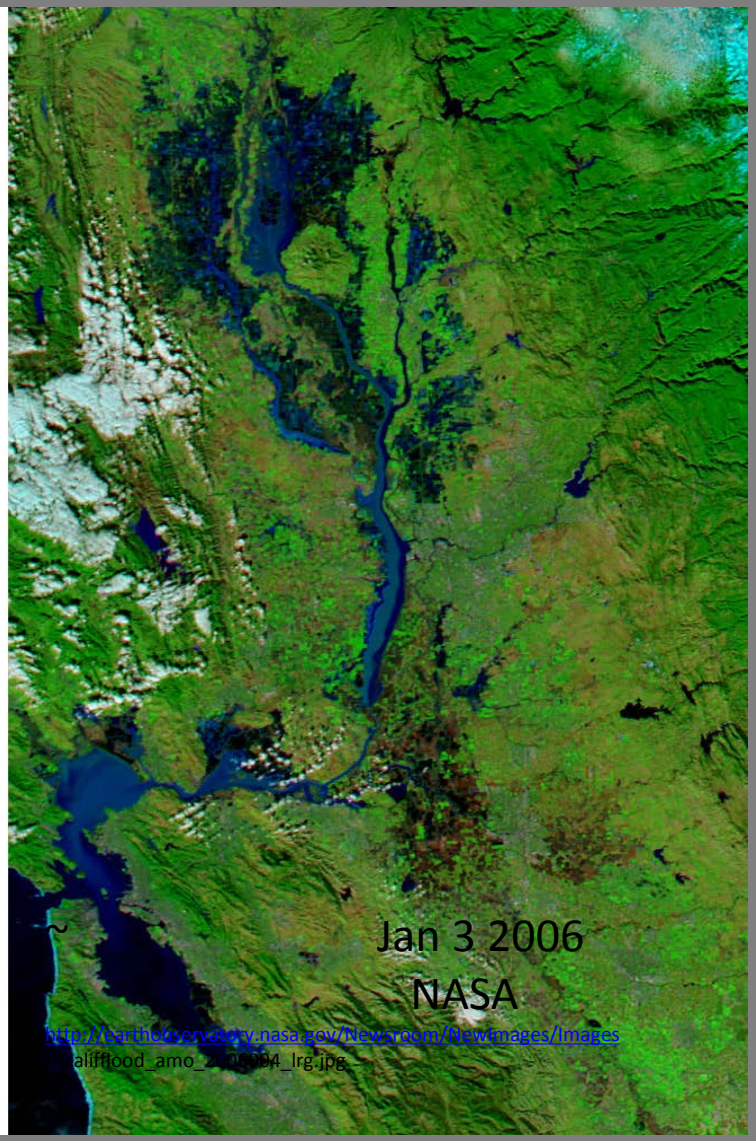


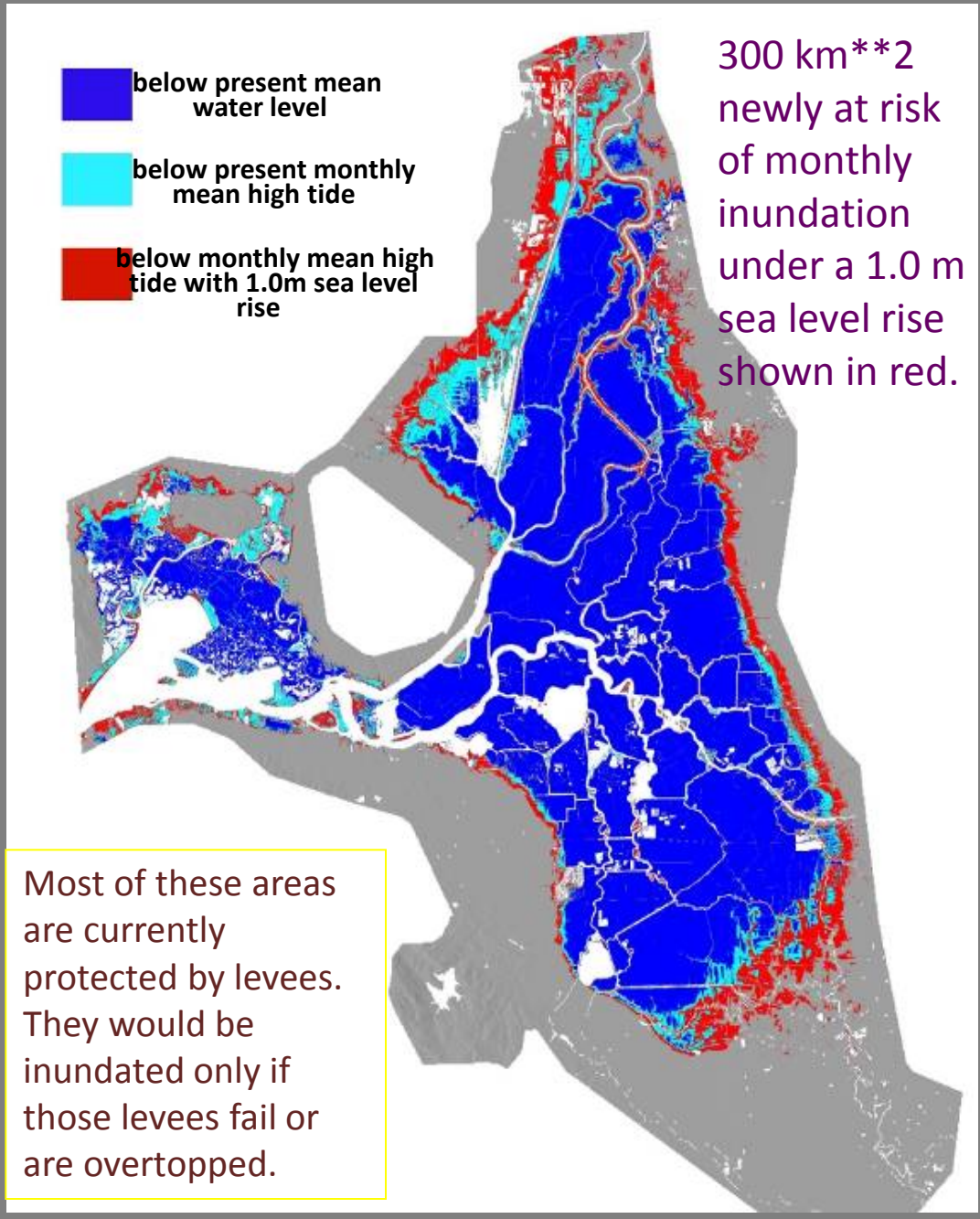
Power plants
and other infrastructre
along the California coast
at risk from sea level rise

Sacramento-San Joaquin Delta

California's water supply hub

vulnerable to floods & sea level rise





300 km**2 newly at risk of monthly inundation under a 1.0 m sea level rise shown in red.

Most of these areas are currently protected by levees. They would be inundated only if those levees fail or are overtopped.

Noah Knowles

Summary/Conclusions

Warming is already underway and considerably more is projected.

Along with warmer mean temperatures, extremes will intensify. Heat waves become hotter, longer, and occupy a broader season.

Recent IPCC model projections for precipitation are scattered, but *several* simulations show moderate drying in the Southwest and increases in precipitation across the northern tier of the U.S.

Wildfire could become a larger threat.

Climate warming projections, combined with recent global sea level rise estimates suggest increases along the West Coast coast sea levels of 0.5m to more than 1.5m by 2100. Tides, weather, short period climate will exacerbate SLR impacts.

To plan and prepare for impacts, knowledge of regional and local details of climate, natural and human systems matter greatly. Vulnerability assessments and downscaling Is crucial.

Frank Gehrke,
California Cooperative Snow Surveys, DWR