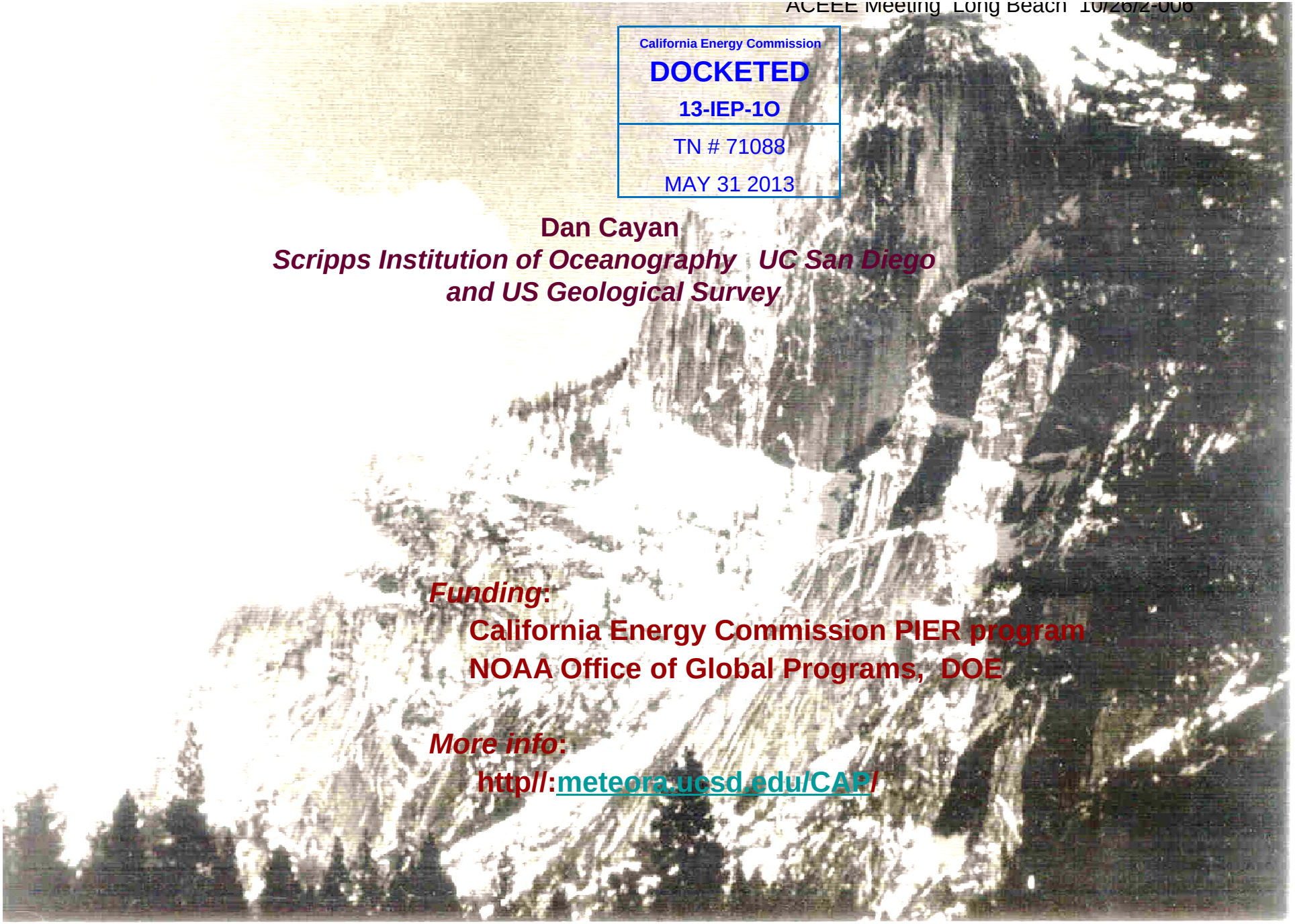


Dan Cayan
Scripps Institution of Oceanography UC San Diego
and US Geological Survey

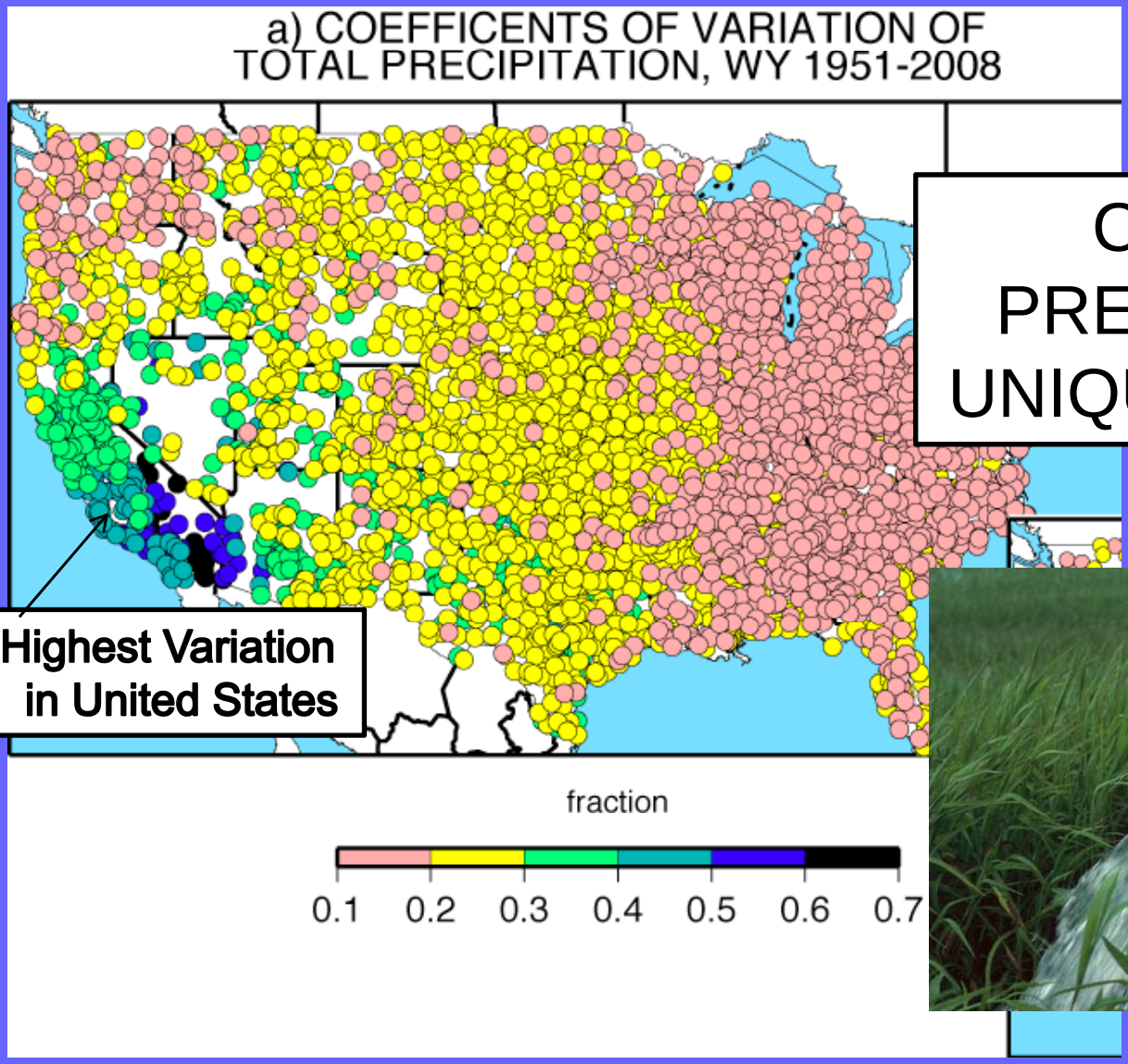
***Funding*:**
California Energy Commission PIER program
NOAA Office of Global Programs, DOE

***More info*:**
http//:meteora.ucsd.edu/CAP/

California is known as a climate
where not much happens

but observations say otherwise

and climate change projections
indicate some extremes will grow

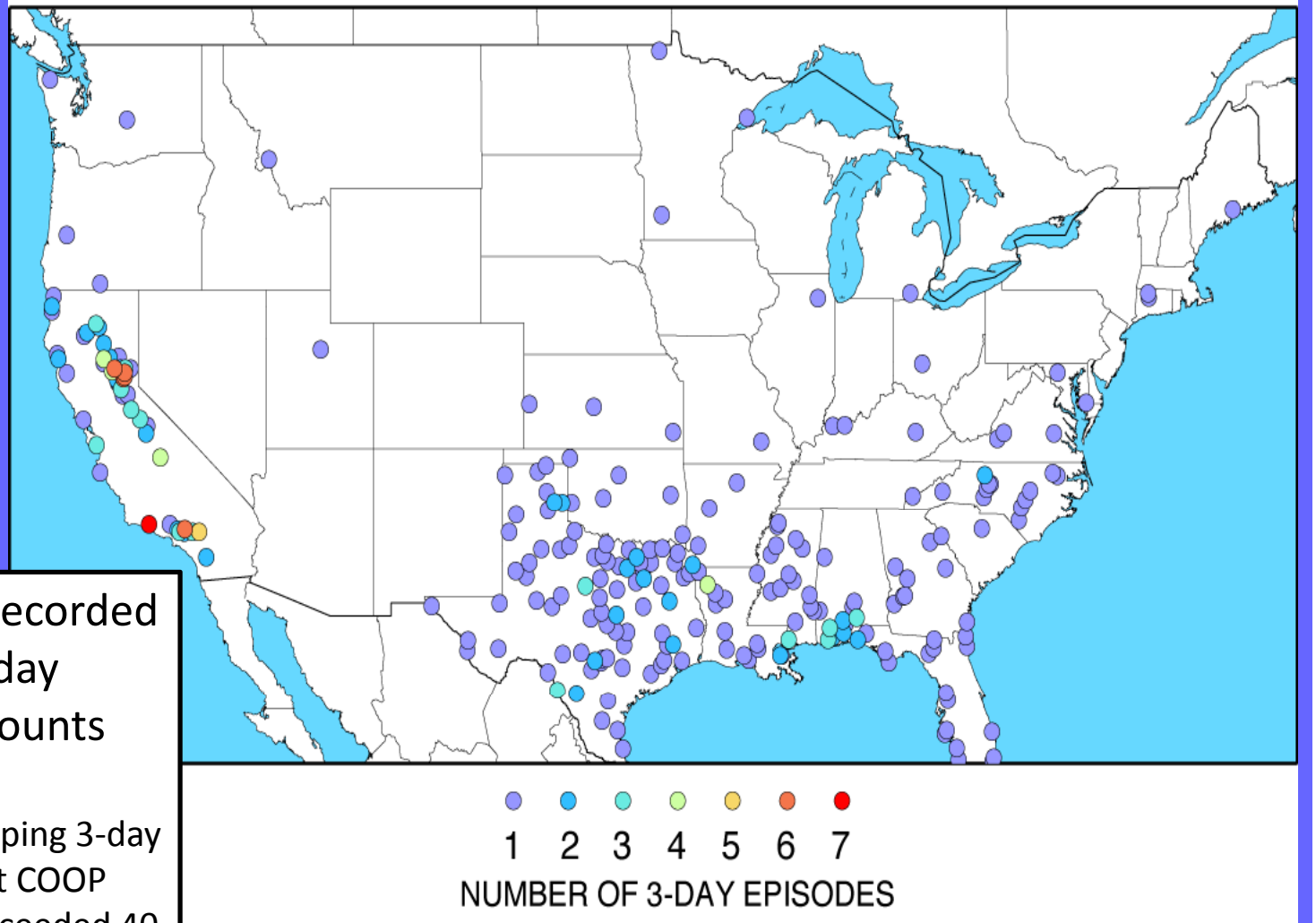


Highest Variation in United States

CALIFORNIA PRECIPITATION IS UNIQUELY VARIABLE

Mike Dettinger USGS

High variability of weather and short term climate will continue



Stations that have recorded the highest 3-day precipitation amounts

Numbers of non-overlapping 3-day precipitation totals at COOP weather stations that exceeded 40 cm (15.75”) from 1950-2008.

Mike Dettinger USGS

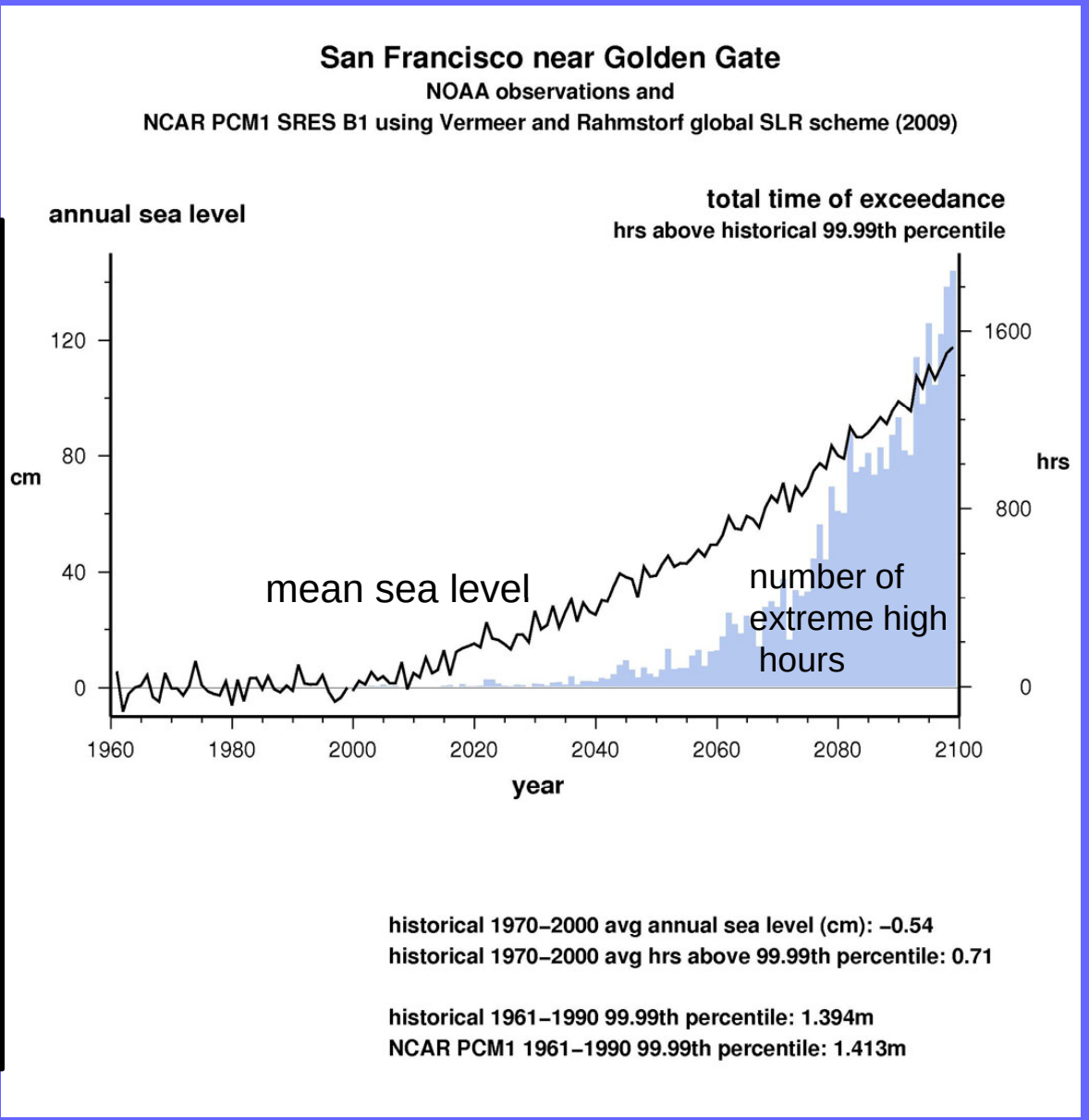

during high sea levels, the sea is often not quiescent
January 1983 Monterey Bay, California

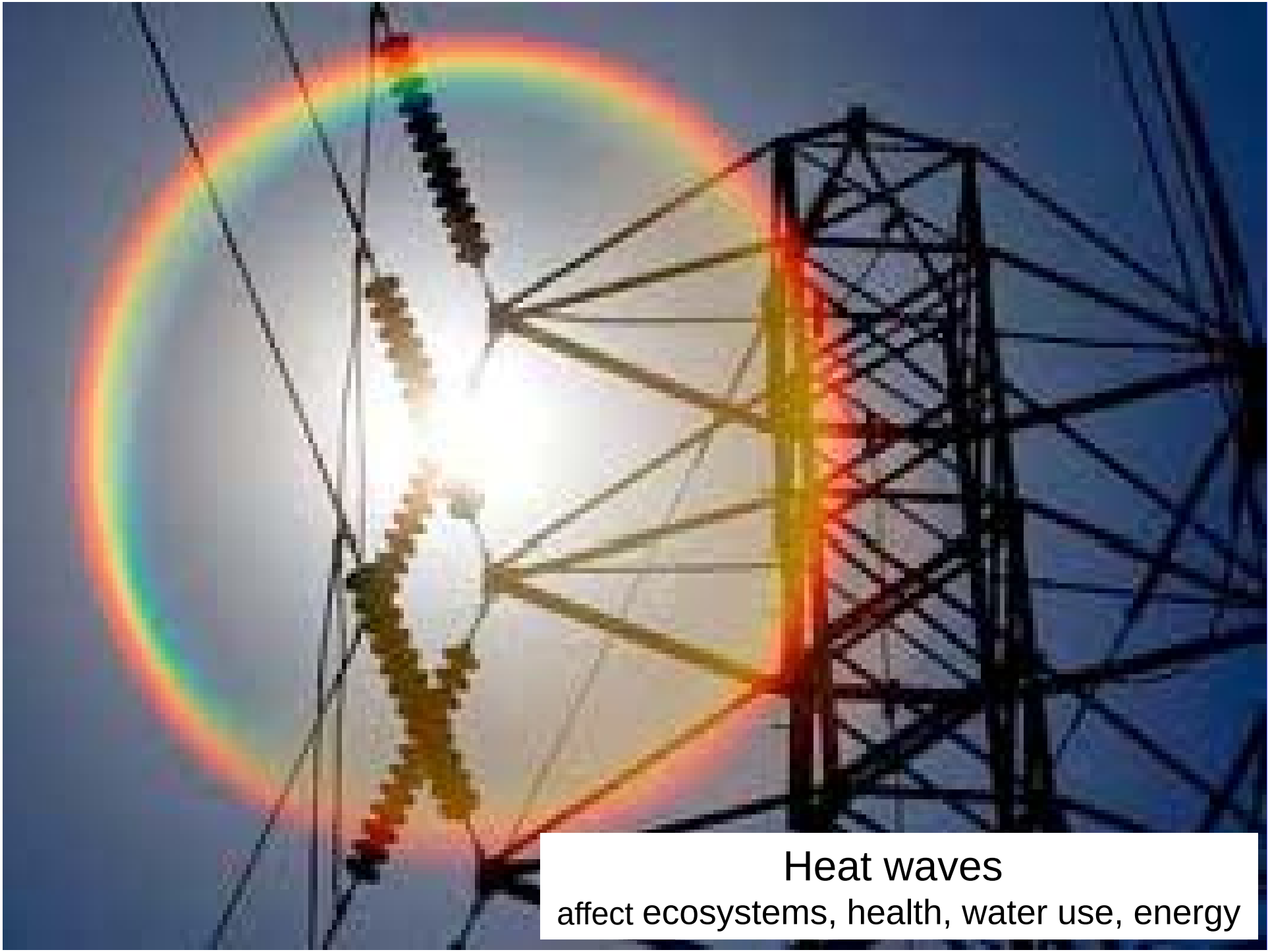
The *pace* of climate change is projected to be rapid

INCREASING SEA LEVEL EXTREMES

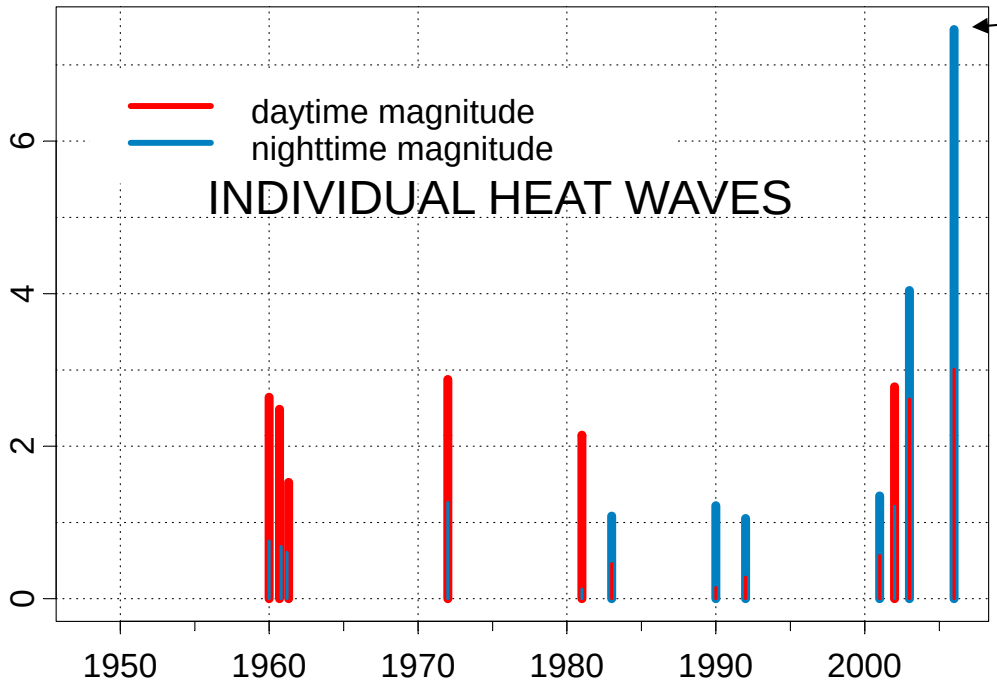
As mean sea level rises the frequency and magnitude of extremes would increase markedly. Under plausible rates of sea level rise, an event which in present day occurs less than once per year occurs scores of times per year by mid 21st Century and becomes commonplace by end of 21st Century.

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



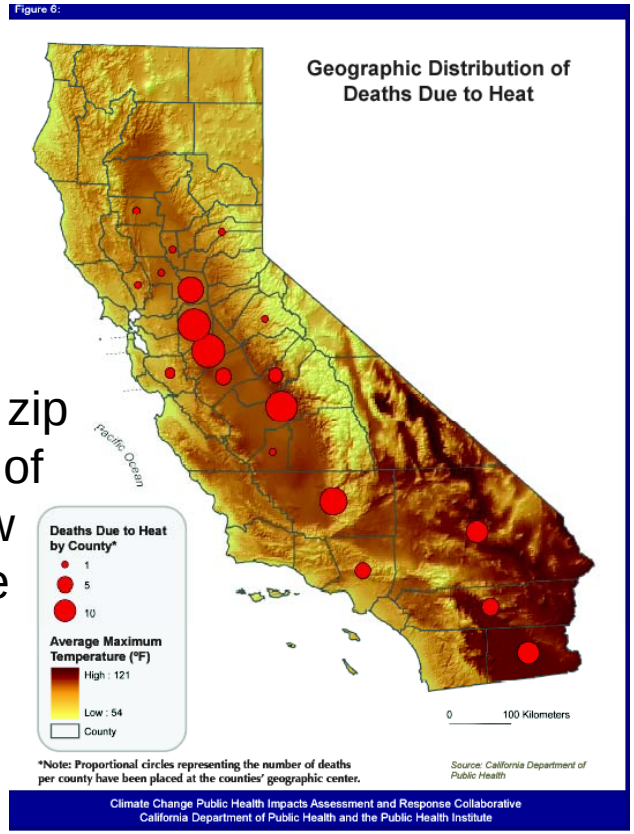

Heat waves
affect ecosystems, health, water use, energy

California Heat Waves might be Changing!



End of July 2006

The heat wave of July 2006 was an unprecedented deadly event.



California heat wave activity increased during last decade

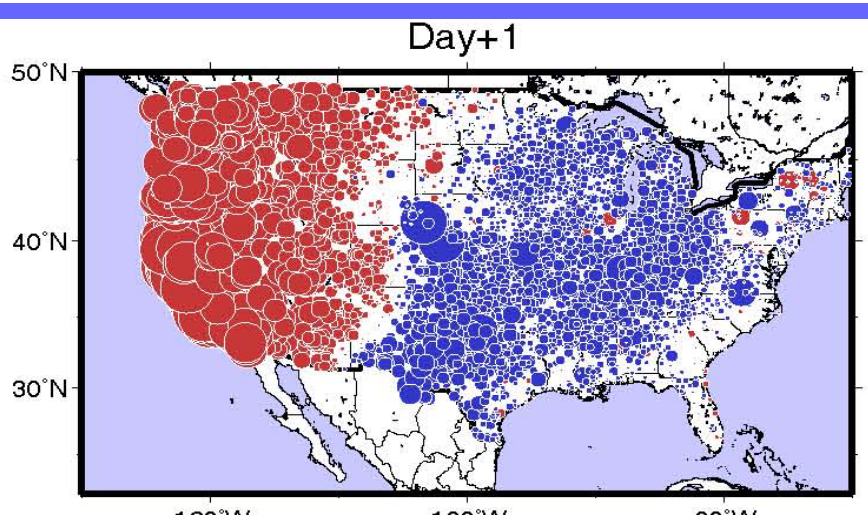
Specifically, nighttime-accentuated heat waves are on the rise…

99% of cases lived in zip codes where > 50% of residents live below Poverty Guide Line

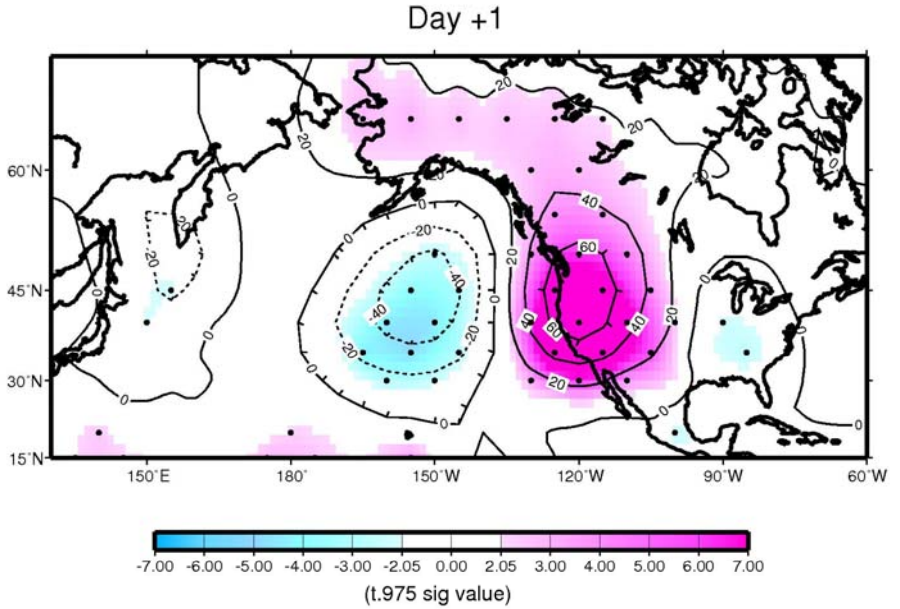
~600 total excess deaths

Alexander Gershunov Scripps Institution of Oceanography

Persistent heat waves have *broad* footprints



Composite 700ht Anoms, 31 Hi Tmax dates lasting >= 3days
(days when >= 9 Sasha stns have hot days by 99%ile criteria)

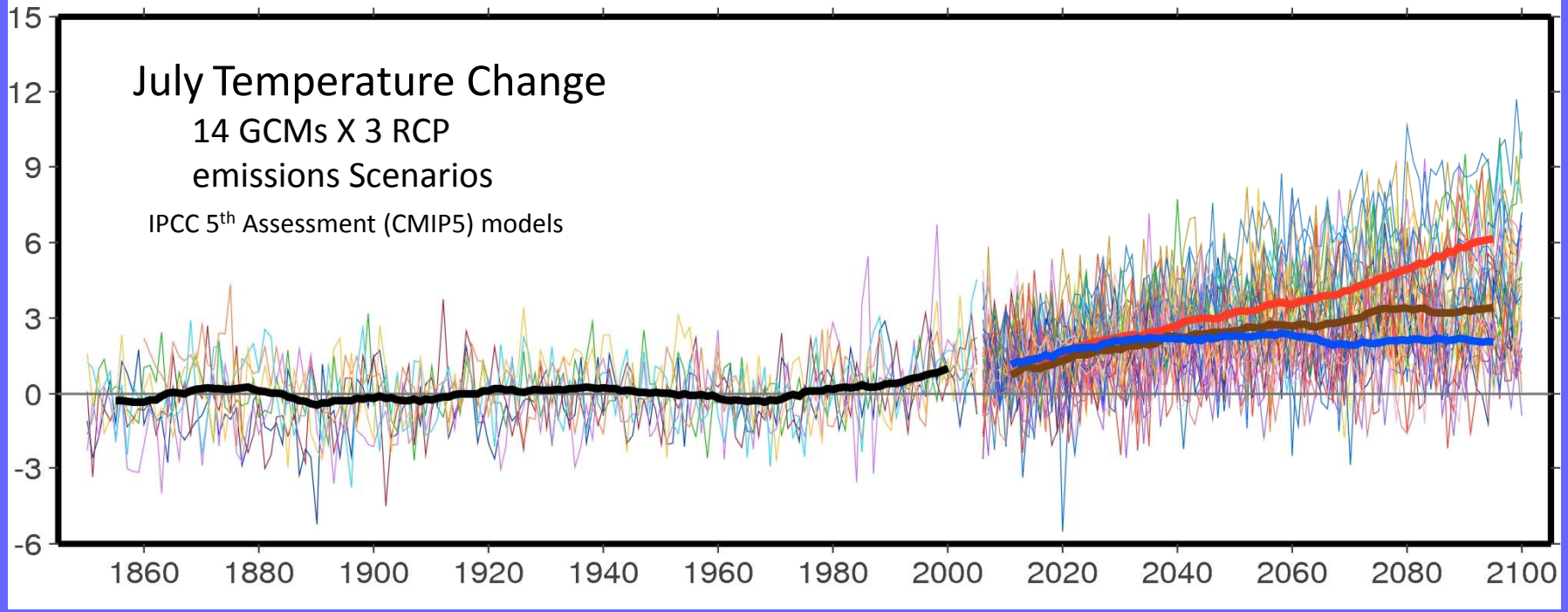


daily afternoon temperature (Tmax) anomalies and 700mb height anomalies

from 31 historical 3 day and longer heat waves (1948-2005)

Projected Climate Warming is substantial

especially during summer in interior locations



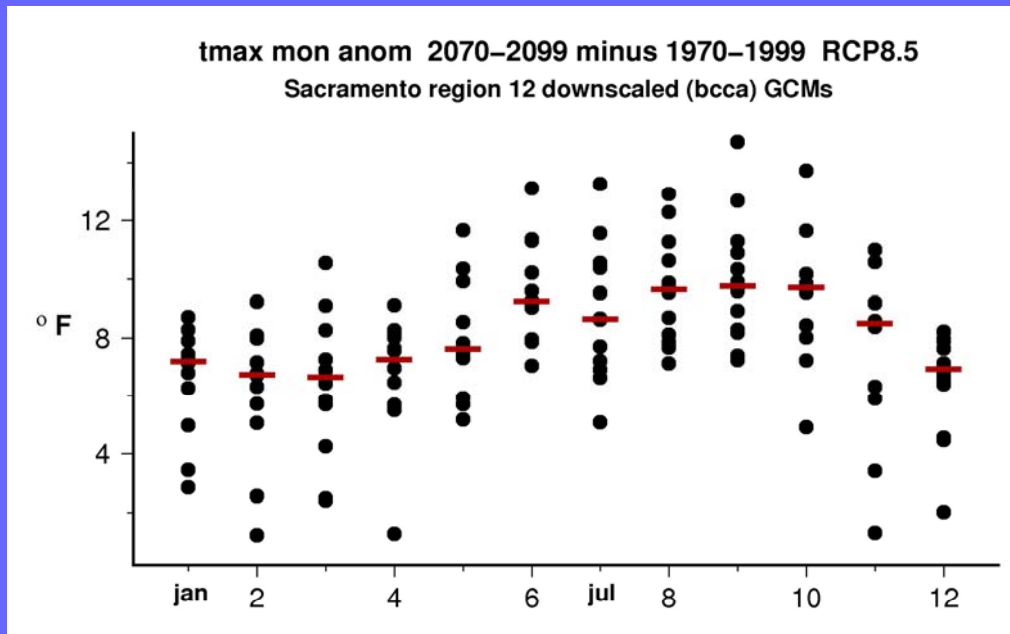
Climate Warming:

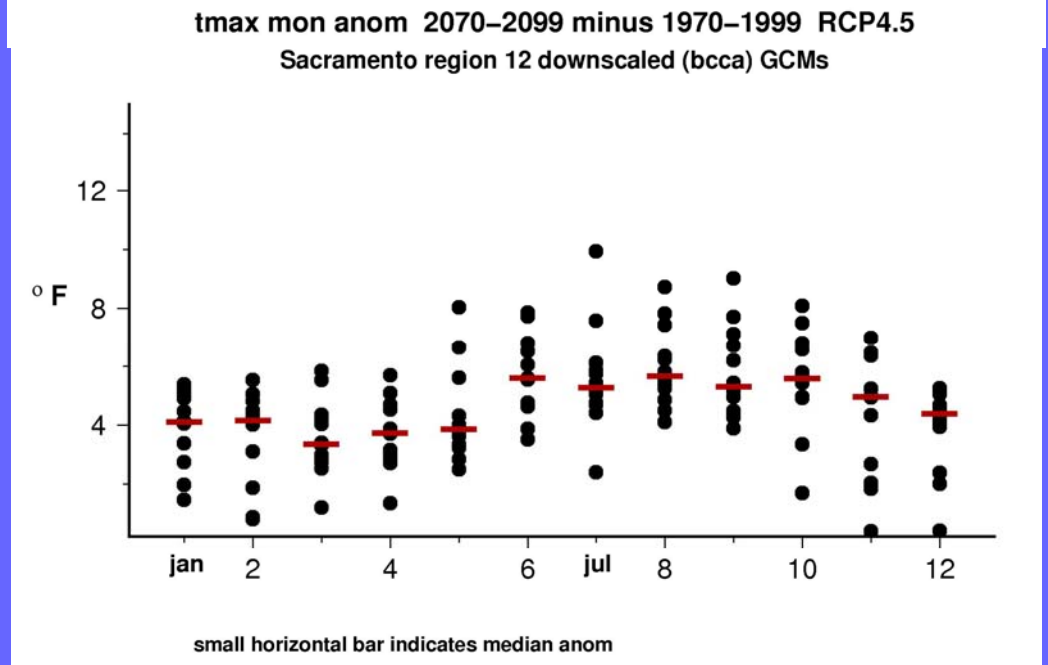
summer warming higher than winter

interior warming greater than coastal/marine

nighttime warming has exceeded daytime warming in last few decades

heat wave incidence projected to become more frequent, intense, durable





Projected Warming is intensified in summer

12 downscaled AR5 GCMs

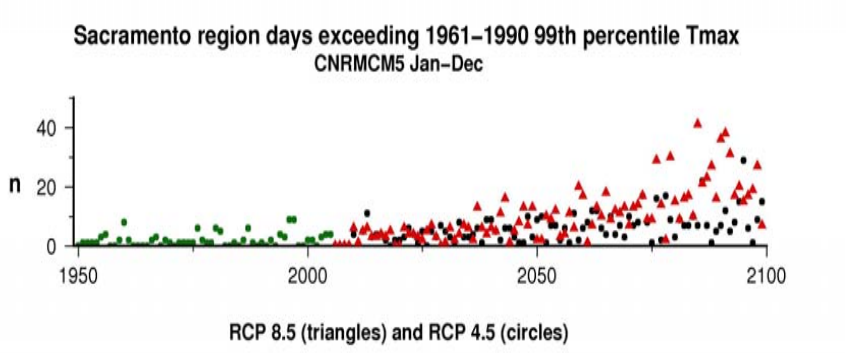
RCP 4.5 and RCP 8.5 emissions scenarios

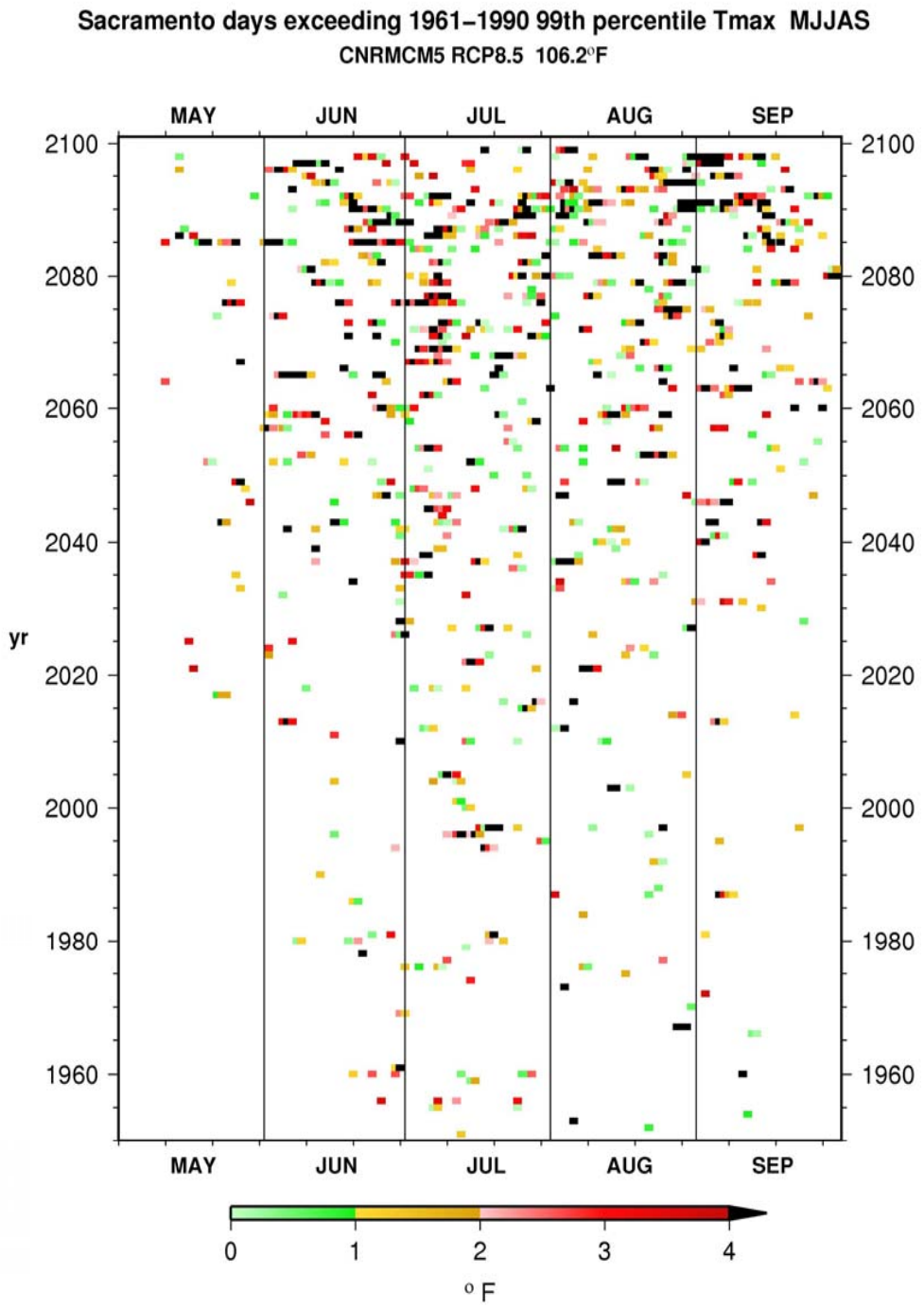
Projected Growth of Heat Wave Occurrence

Over 21st Century, trends toward:
Increased frequency,
higher intensity,
longer duration

And, trend toward
earlier start and later end
to heat wave season.

from BCCA downscaled CNRM RCP8.5 simulation



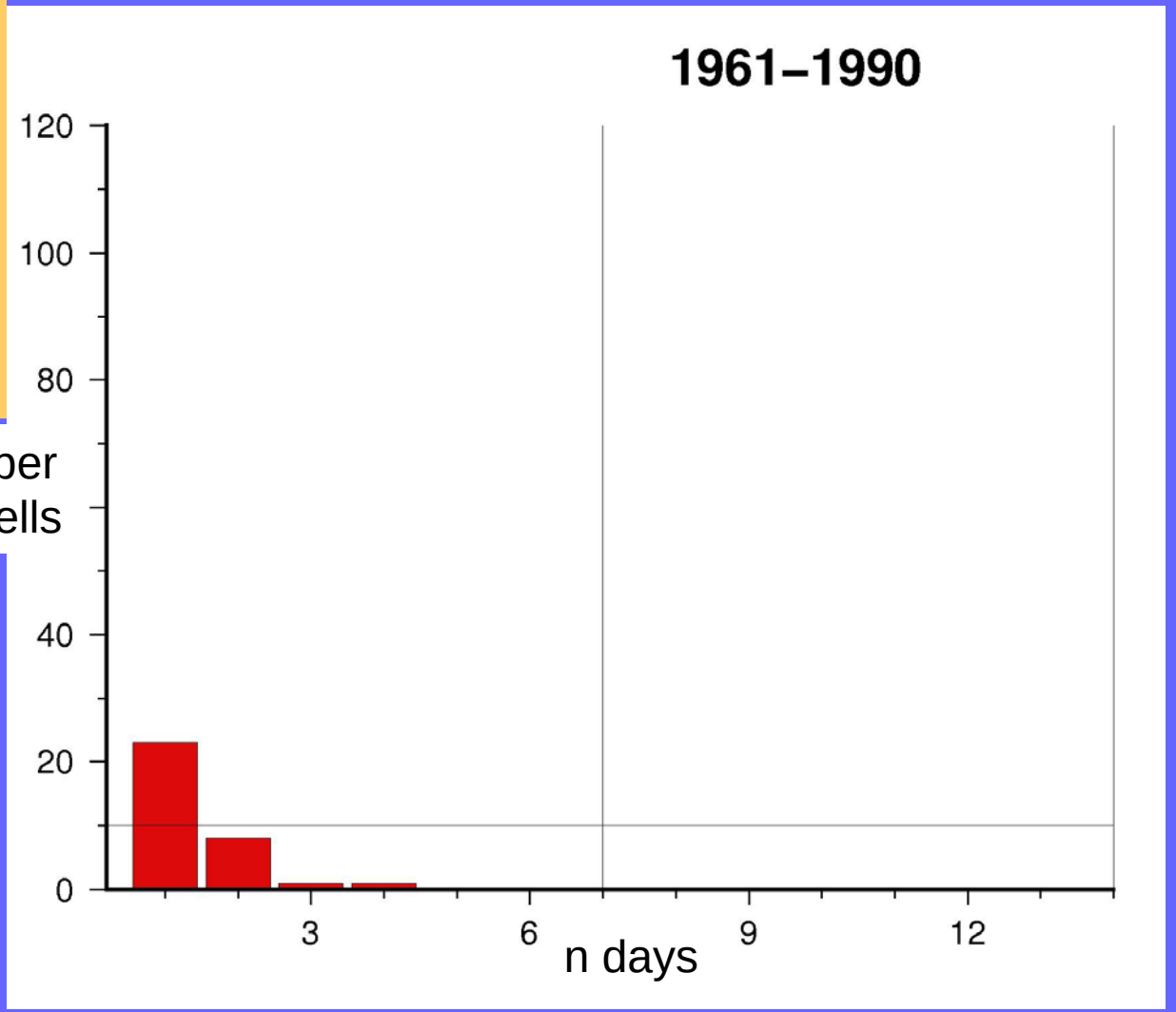


Projected Heat spell census, Sacramento high sensitivity model, higher GHG emissions scenario

Heat spell length
Sacramento

Number of heat spells (y) of Length in days (x) when Maximum daily temperature Exceeds the 99.9th percentile Tmax 1961-1990 (102 °F)

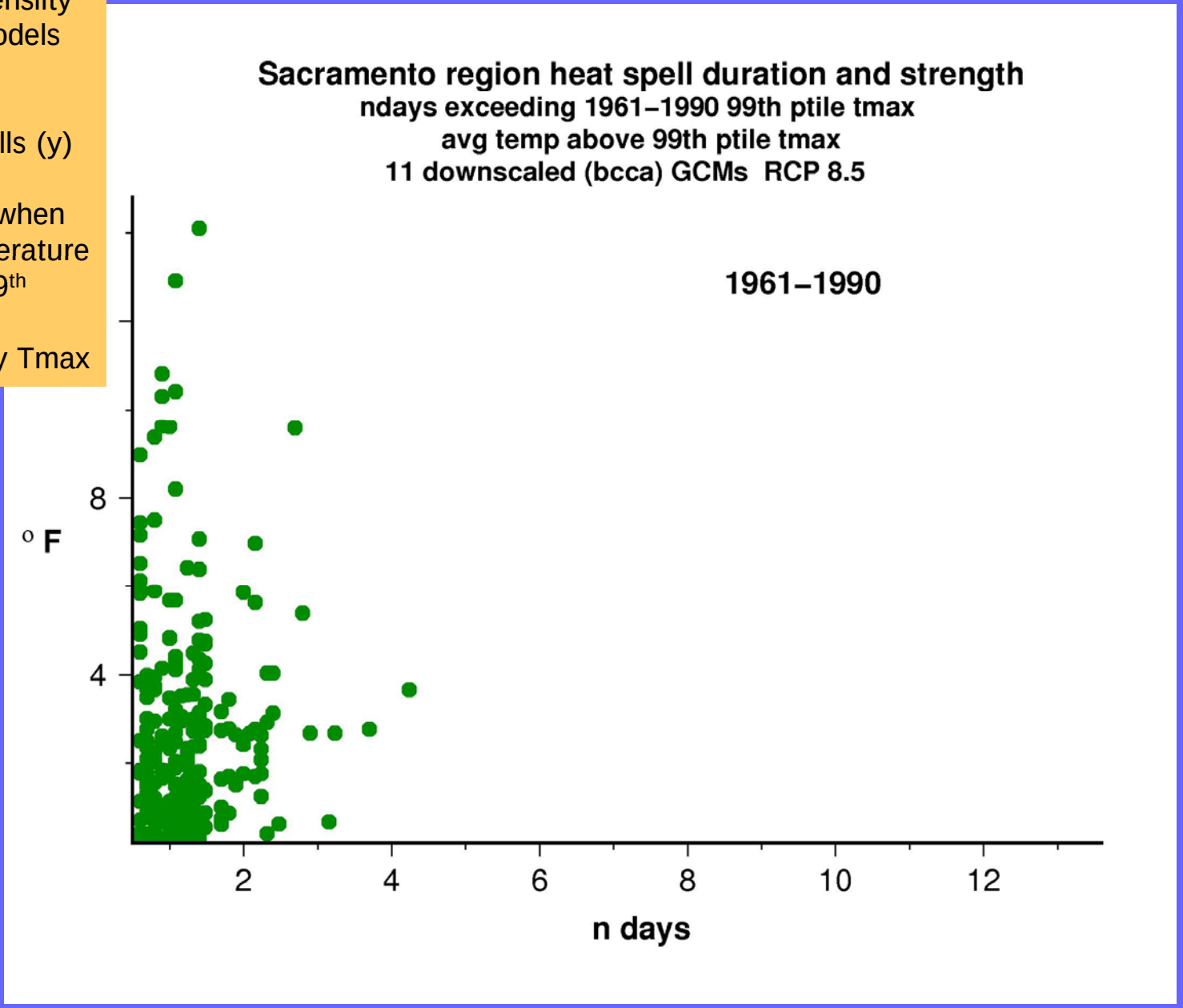
From BCCA CMRM5 RCP8.5



Length of heat spell

Heat spells in Sacramento by duration and intensiity from 11 climate models Sacramento

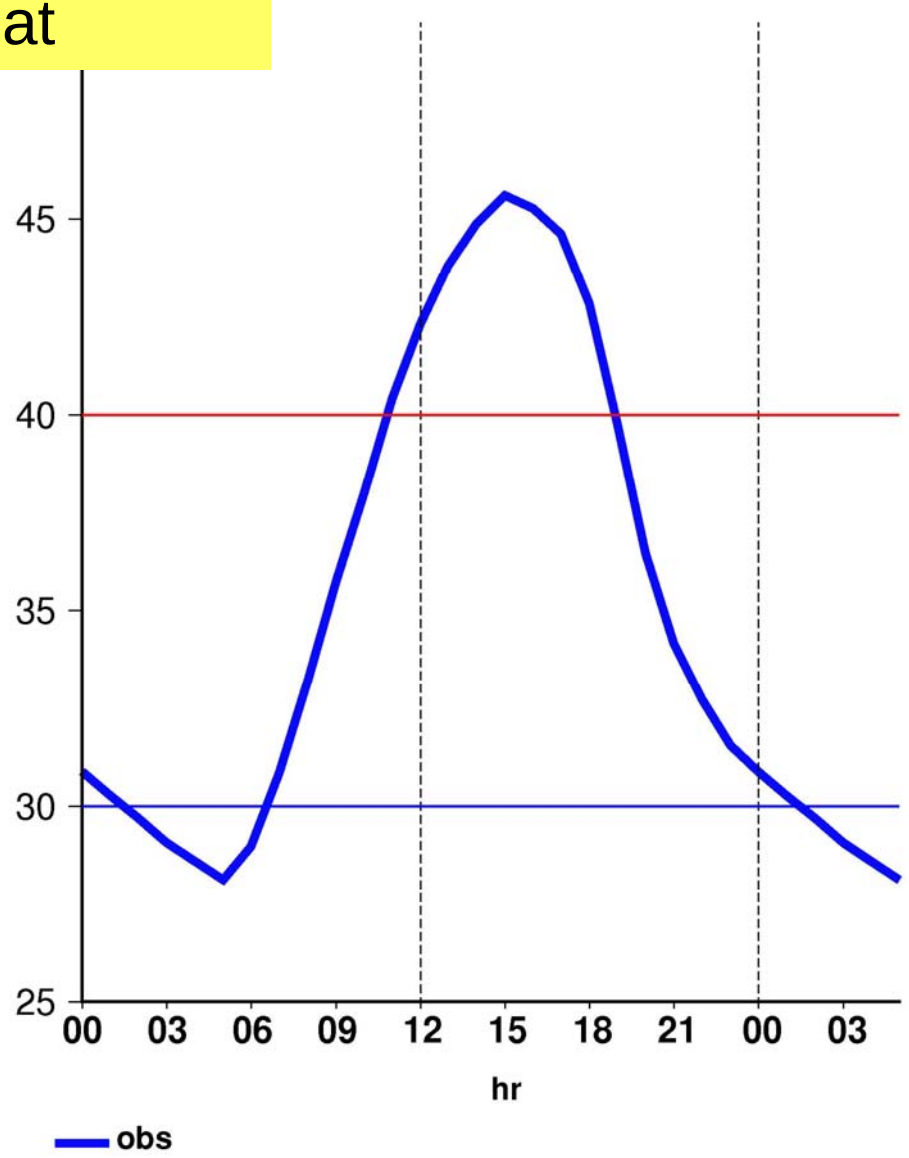
Number of heat spells (y) of
Length in days (x) when Maximum daily temperature Exceeds the 99.9th percentile
Of 1961-1990 for July Tmax (40 °C)



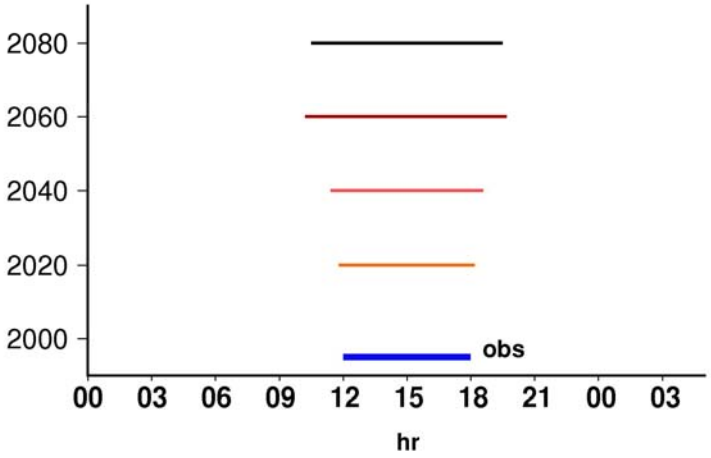
Projected Decadal Extreme Hot Days
more hours of extreme heat

model and observed hourly temp shown is an extreme Tmax during a given decade with climatological diurnal cycle attached.

Sacramento daily maximum temperature
Model is CNRM5 BCCA downscaled
heavy blue line is observed Tmax (45.6 ^{o}C = 114 ^{o}F)



Hours of Day above 40°C (104°F)



in conclusion:

The Environment we plan for will likely not be accurately informed by 50-100 years of experience

Anthropogenic, global climate change is already occurring

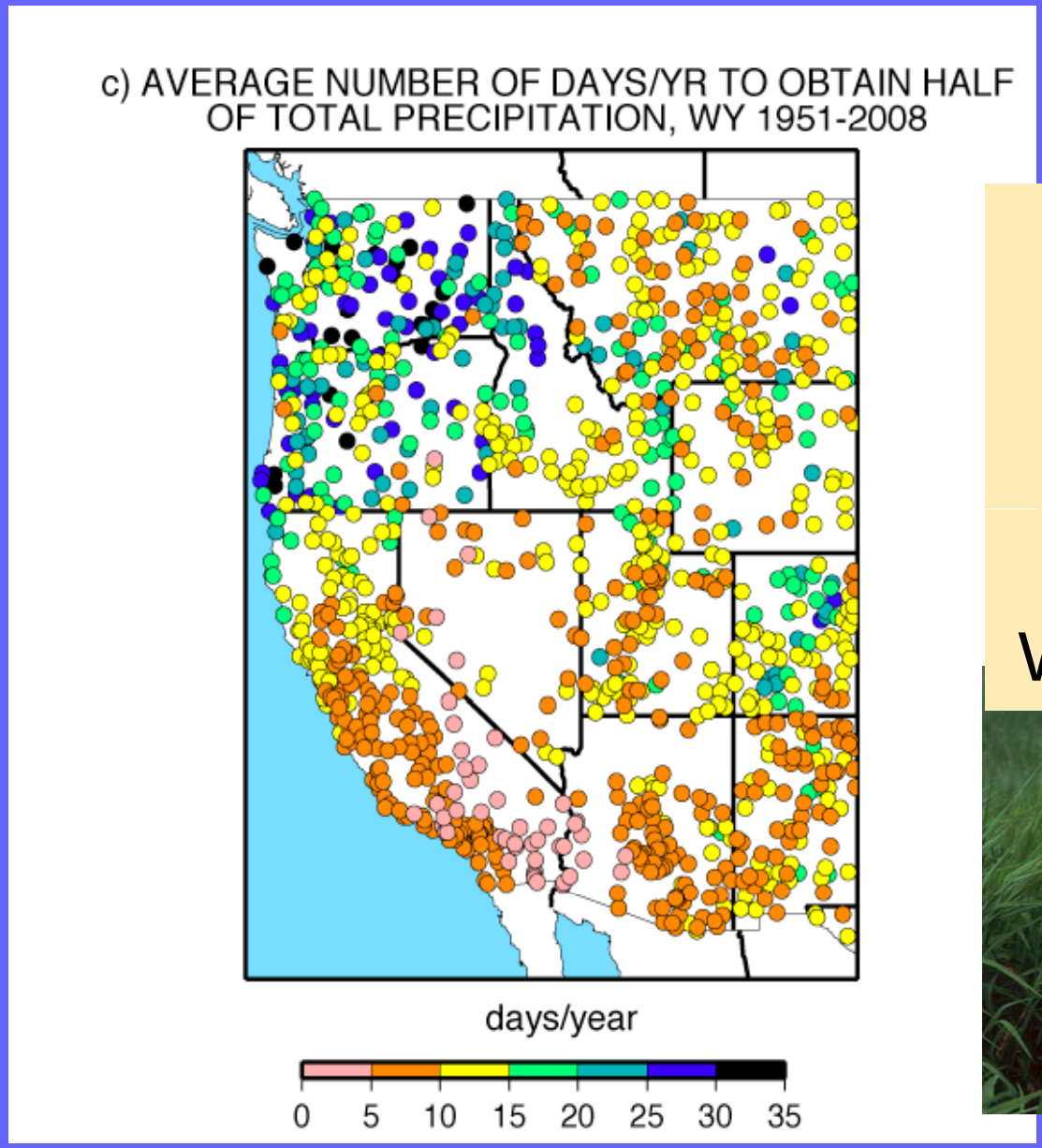
Projected future warming could be moderate (less than 3C) or very large (3-6C) depending on greenhouse gas emissions

Summer warming may be greater than in winter. .

Earlier, longer, more intense summers expected.

Climate warming will likely be most remarkable when coupled with natural fluctuations, such as heat waves.

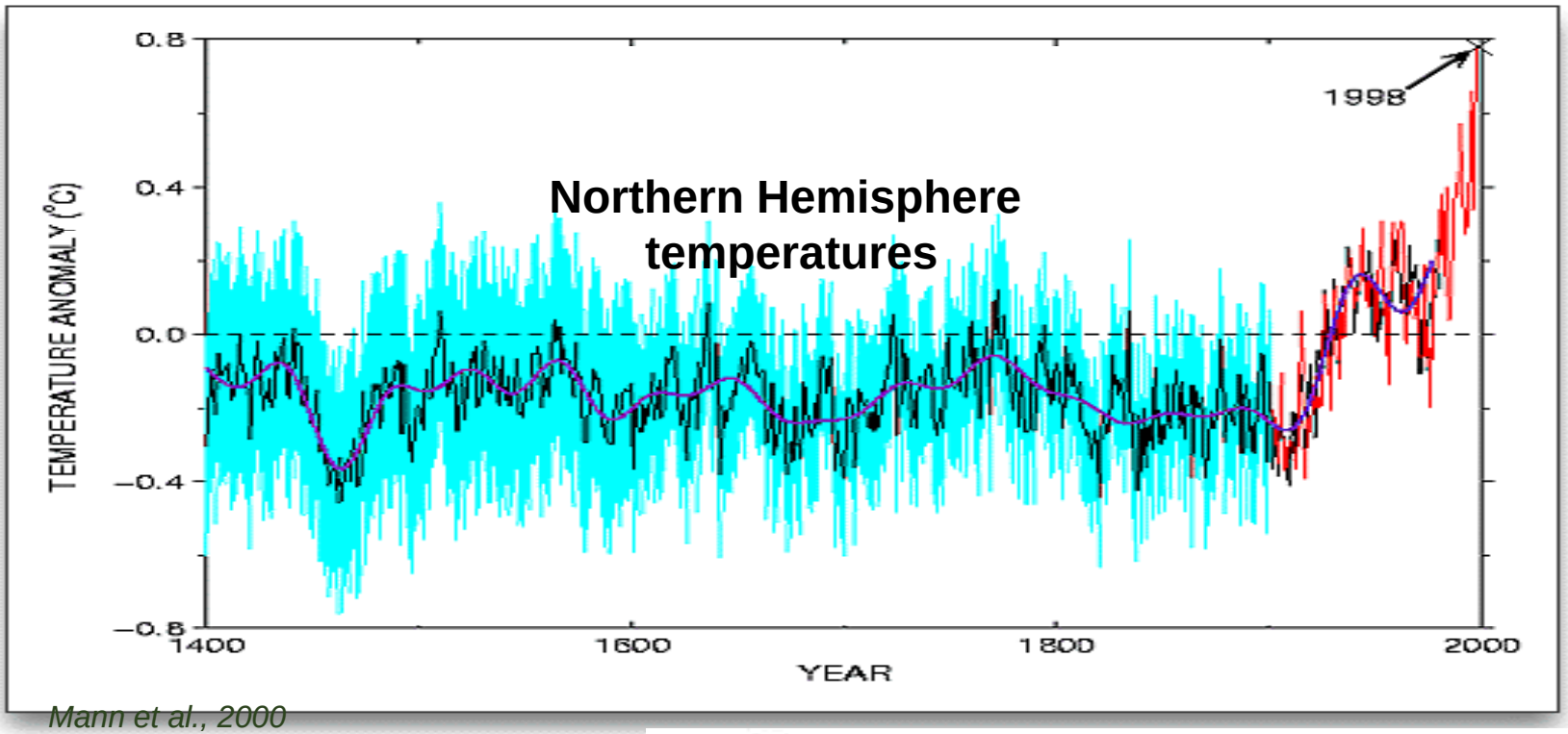
Heat Wave frequency, intensity, duration increases and season lengthens.



JUST A FEW STORMS EACH YEAR ARE THE CORE OF CALIFORNIA'S WATER SUPPLIES

Mike Dettinger USGS

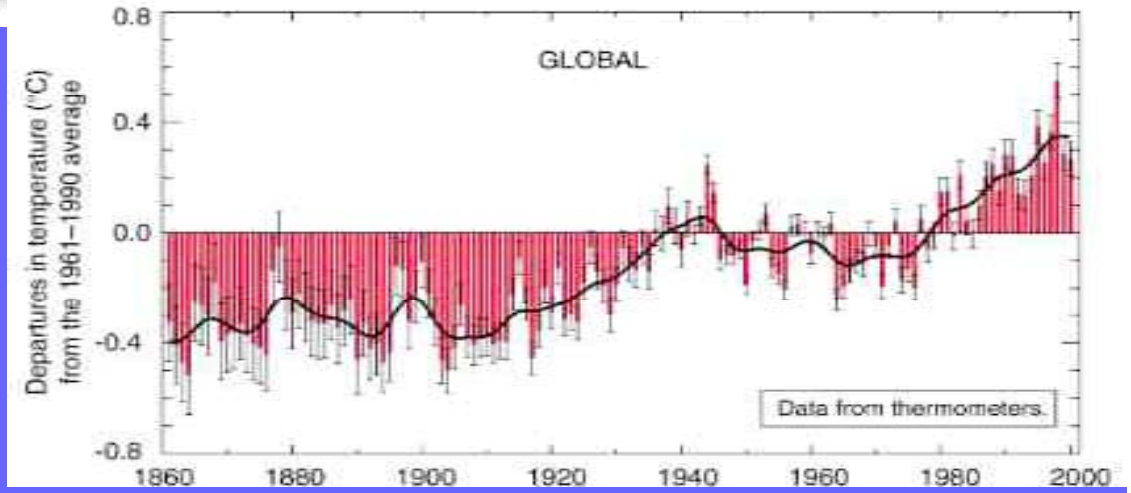
Observations suggest that global temperatures have *already* risen at a extremely rapid pace.



Mann et al., 2000

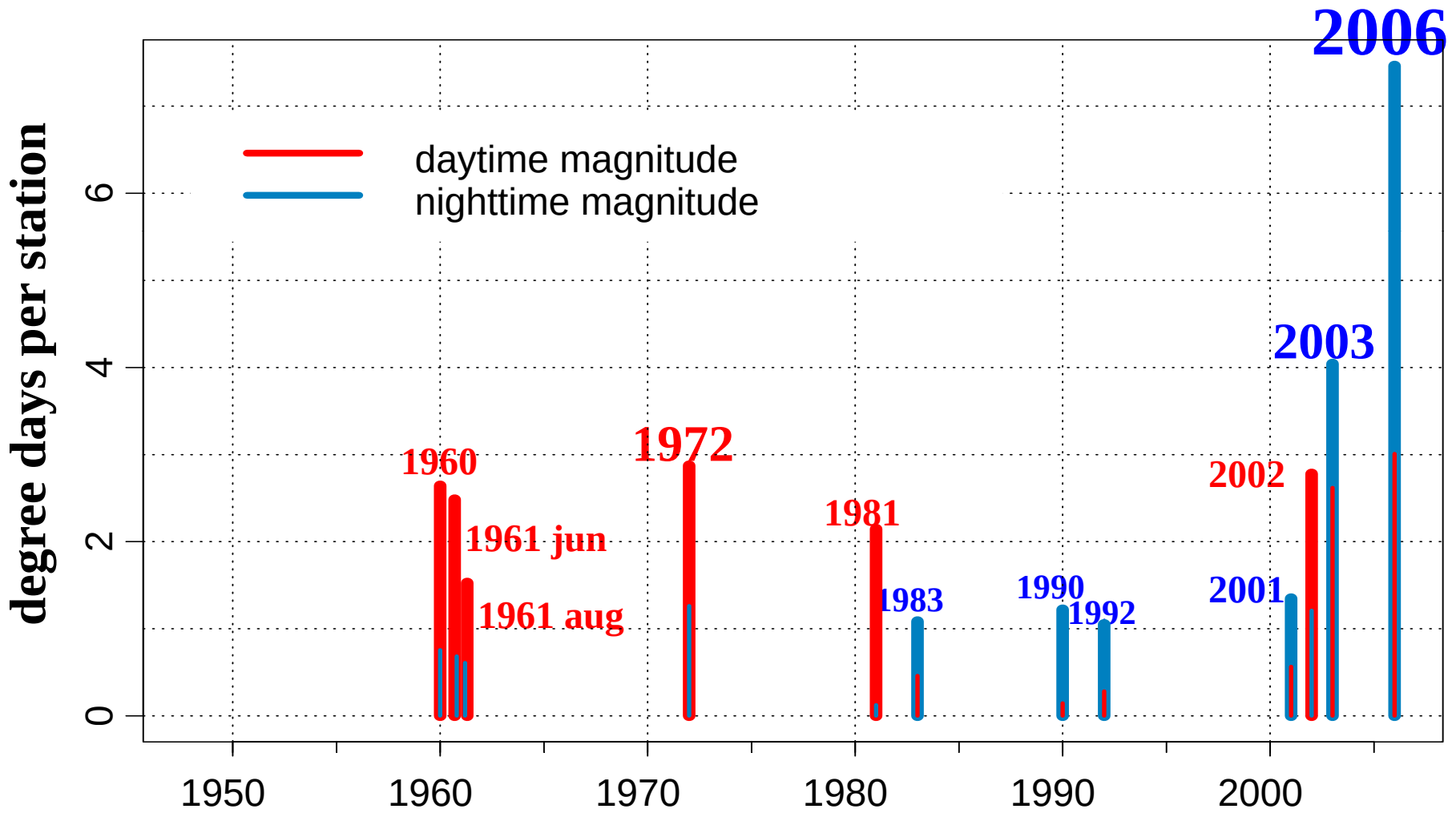
1990's warmest decade in instrumental record (NASA/NOAA)

1. 1998 warmest year
2. 2002
3. 2003
4. 2004
****2005 2nd (or 1st) warmest**



LARGE CALIFORNIA HEAT WAVES—
regional magnitudes reflecting local intensity, duration, spatial extent

in degree days summed over the region
for the six greatest daytime and six greatest nighttime events



Gershunov, Cayan and Iacobellis, *Journal of Climate*, 2009