Stay Cool San Diego 5/14/2014

Planning for 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

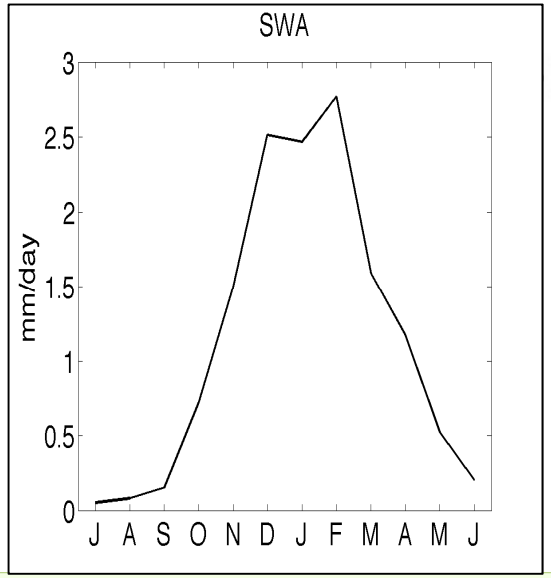
Sponsors:

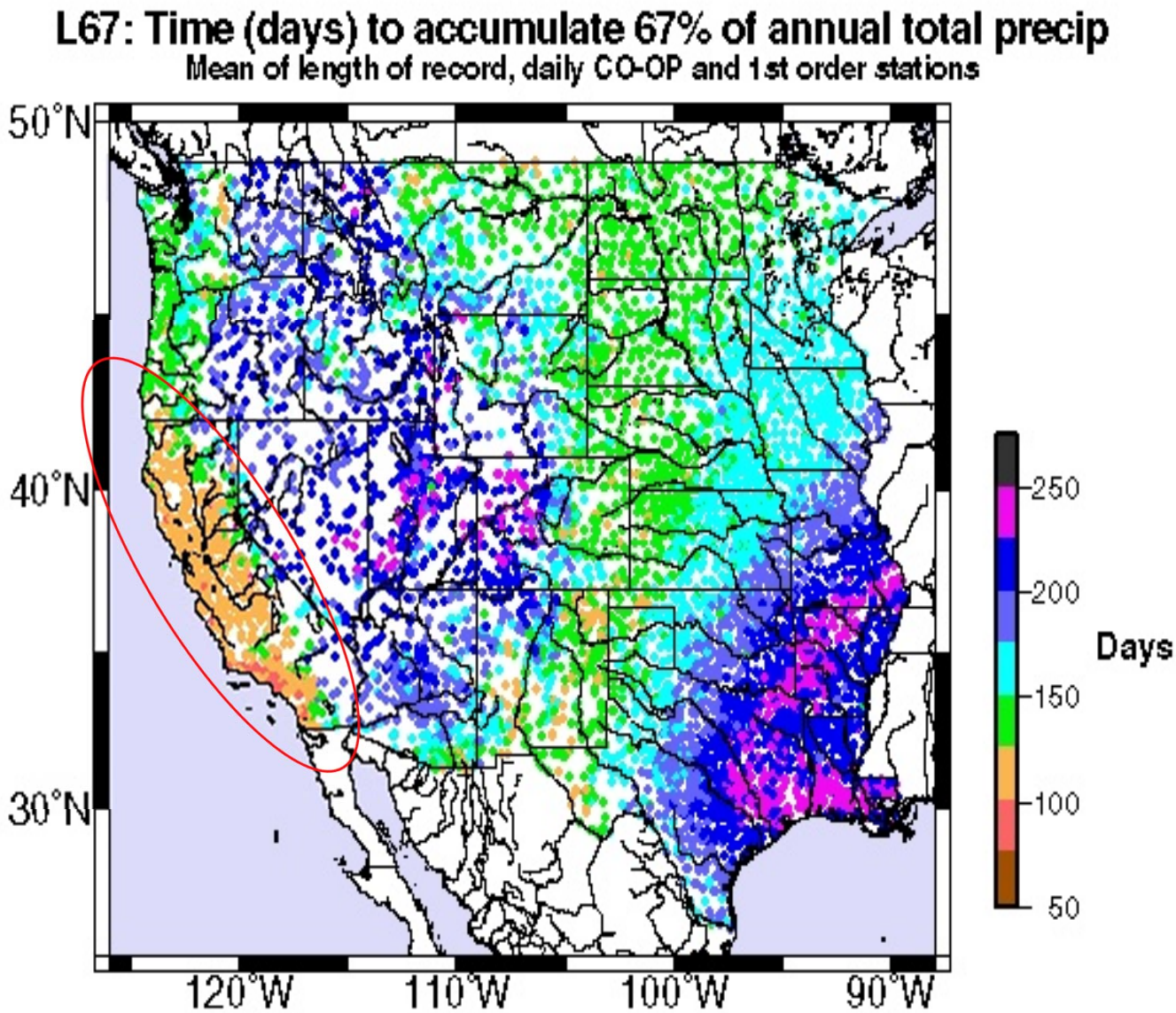
California Energy Commission

NOAA RISA program

California DWR, DOE, NSF

California's vulnerabilities to Climate Change are conditioned by our background climate setting

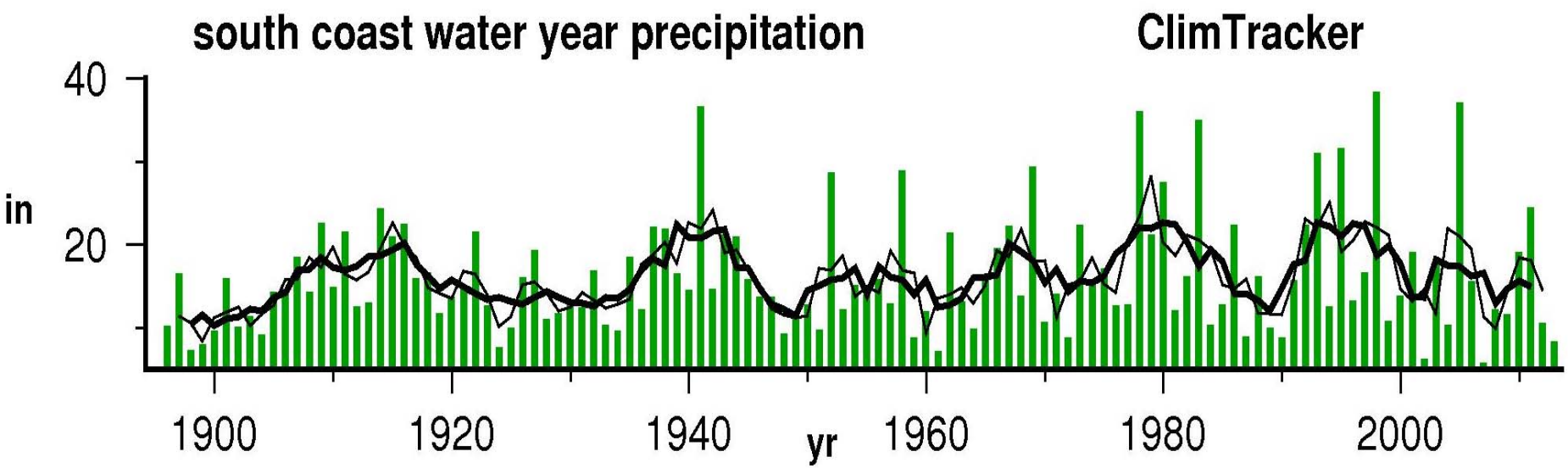




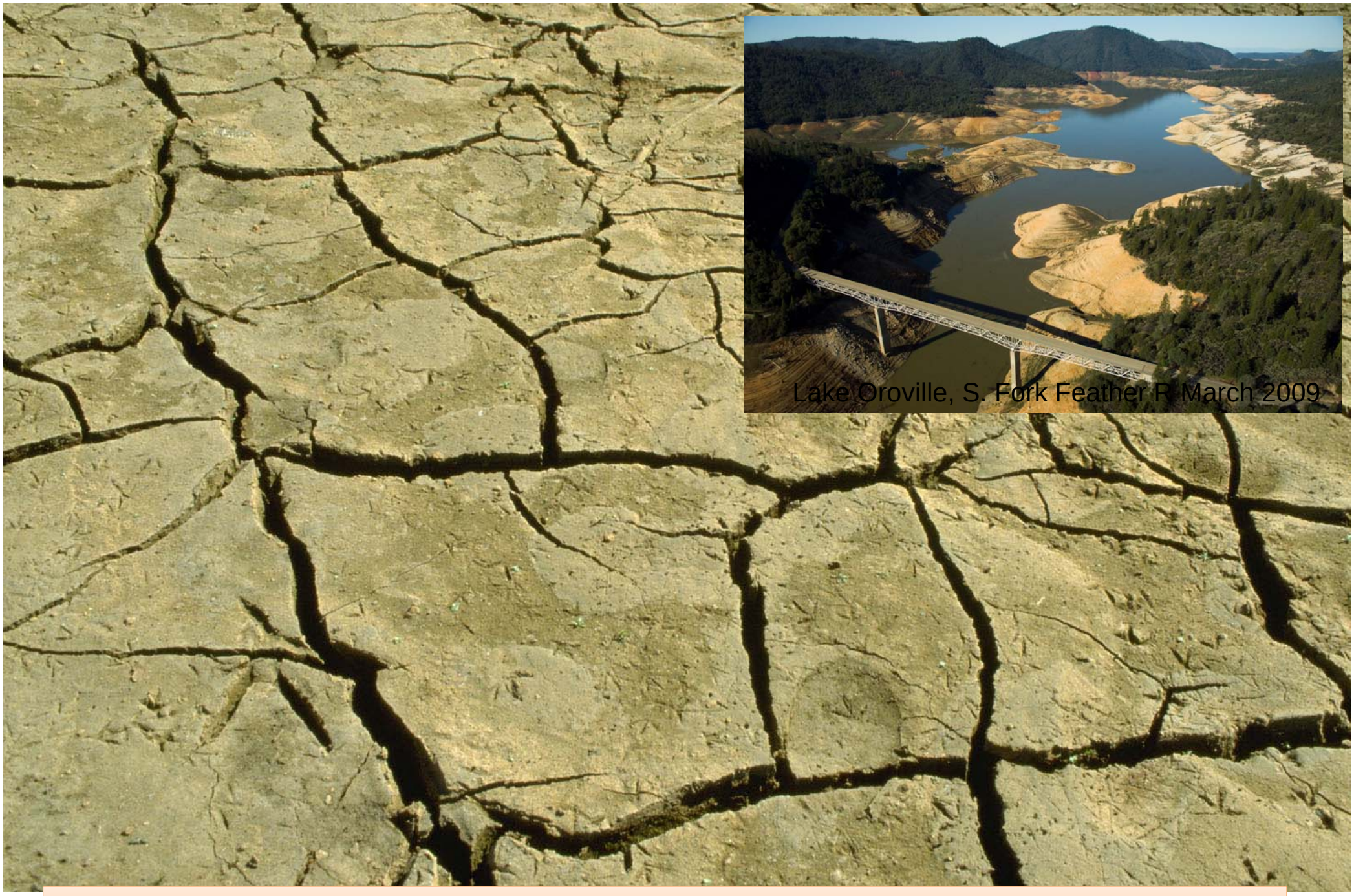
California is remarkable in having only about 120 days to accumulate two thirds of its annual precipitation. When Pacific winter storms are directed away from California during this seasonal window, unusually dry conditions result as in our current 2013-14 Winter. Of the entire U.S., the year-to-year delivery of precipitation is the most volatile!

Great year-to-year variability in California precipitation

Southern California Coast area average shown here from Western Regional Climate Center
)



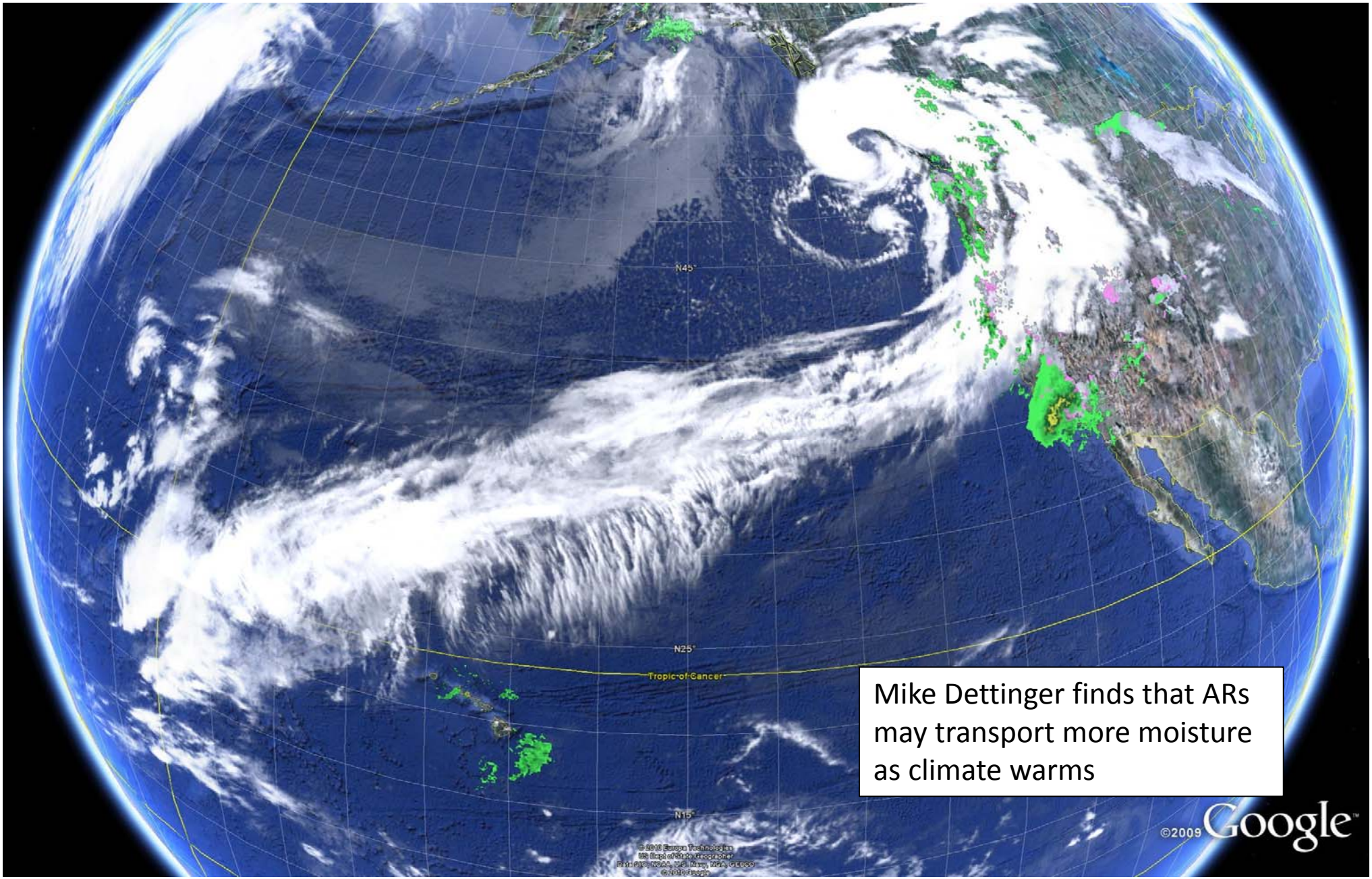
- Annual precipitation ranges from ~33% to 280% of average
- Intermittant very wet and very dry years
- Multi-year wet and dry spellls



California's history is marked by wet and *dry* spells

California Department of Water Resources photos

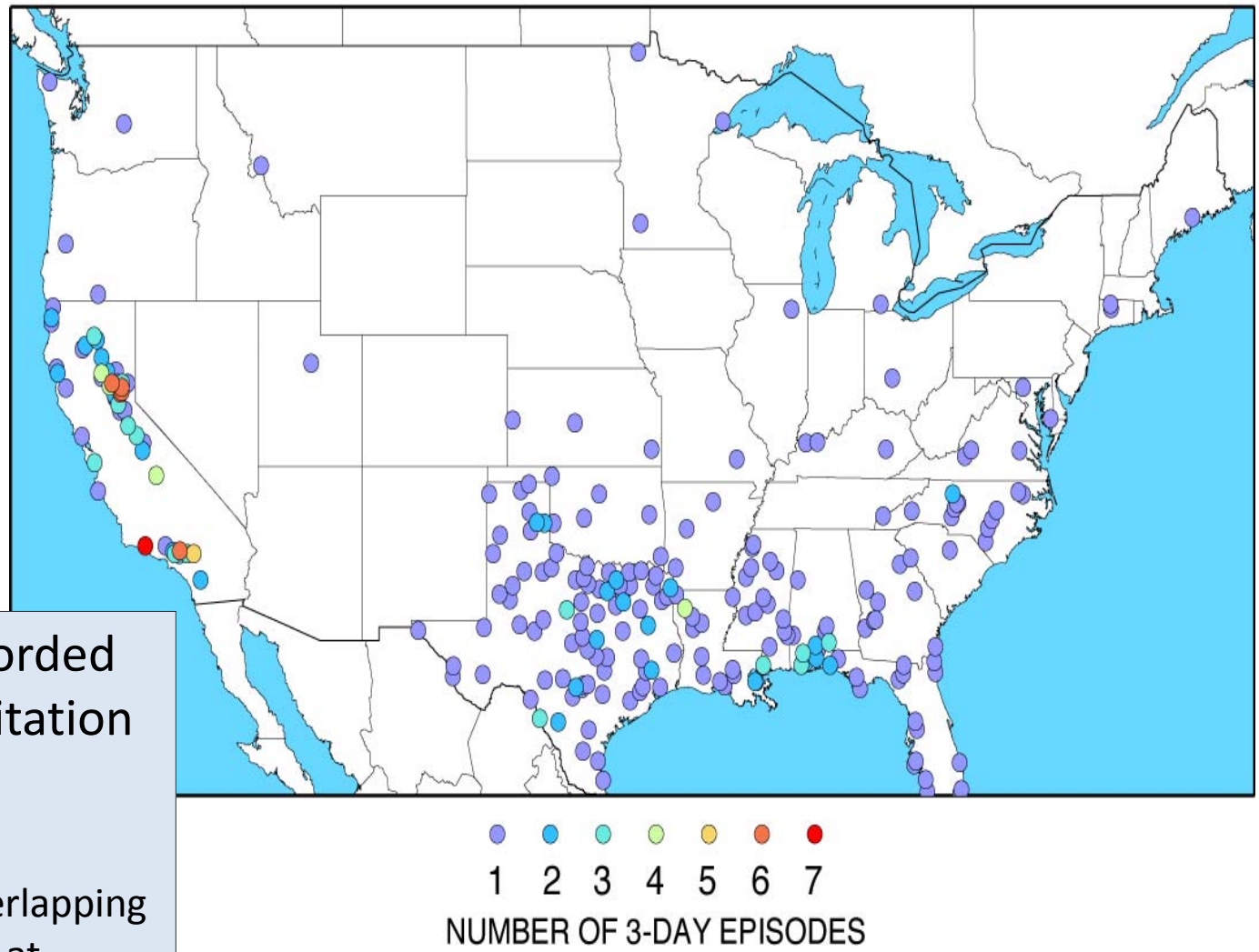
Atmospheric Rivers
flood producers and water suppliers for the western states



Mike Dettinger finds that ARs may transport more moisture as climate warms

High variability of weather and short term climate will continue

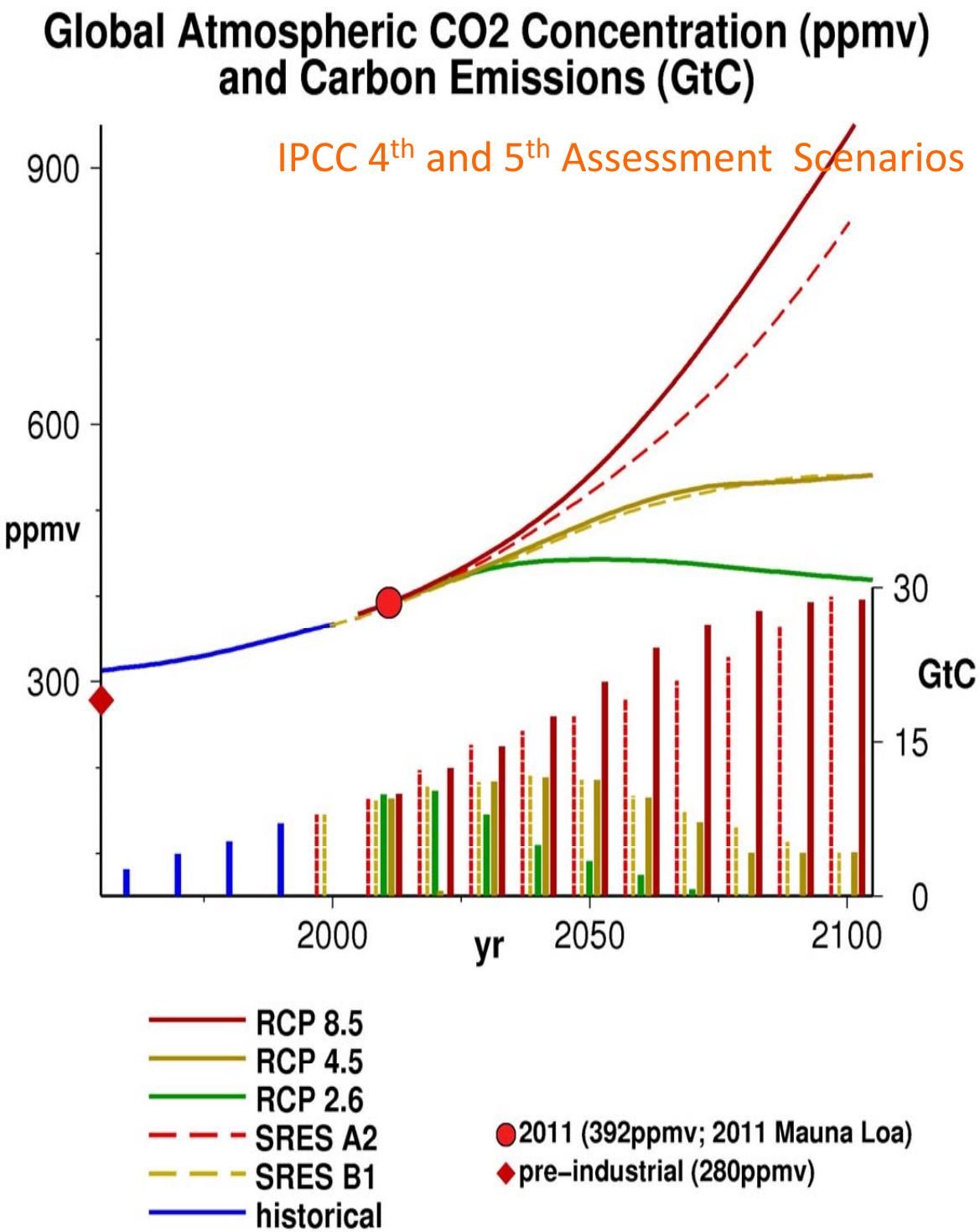
California records some of Nation's heaviest 3-day rainfall



Locations 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/SIO

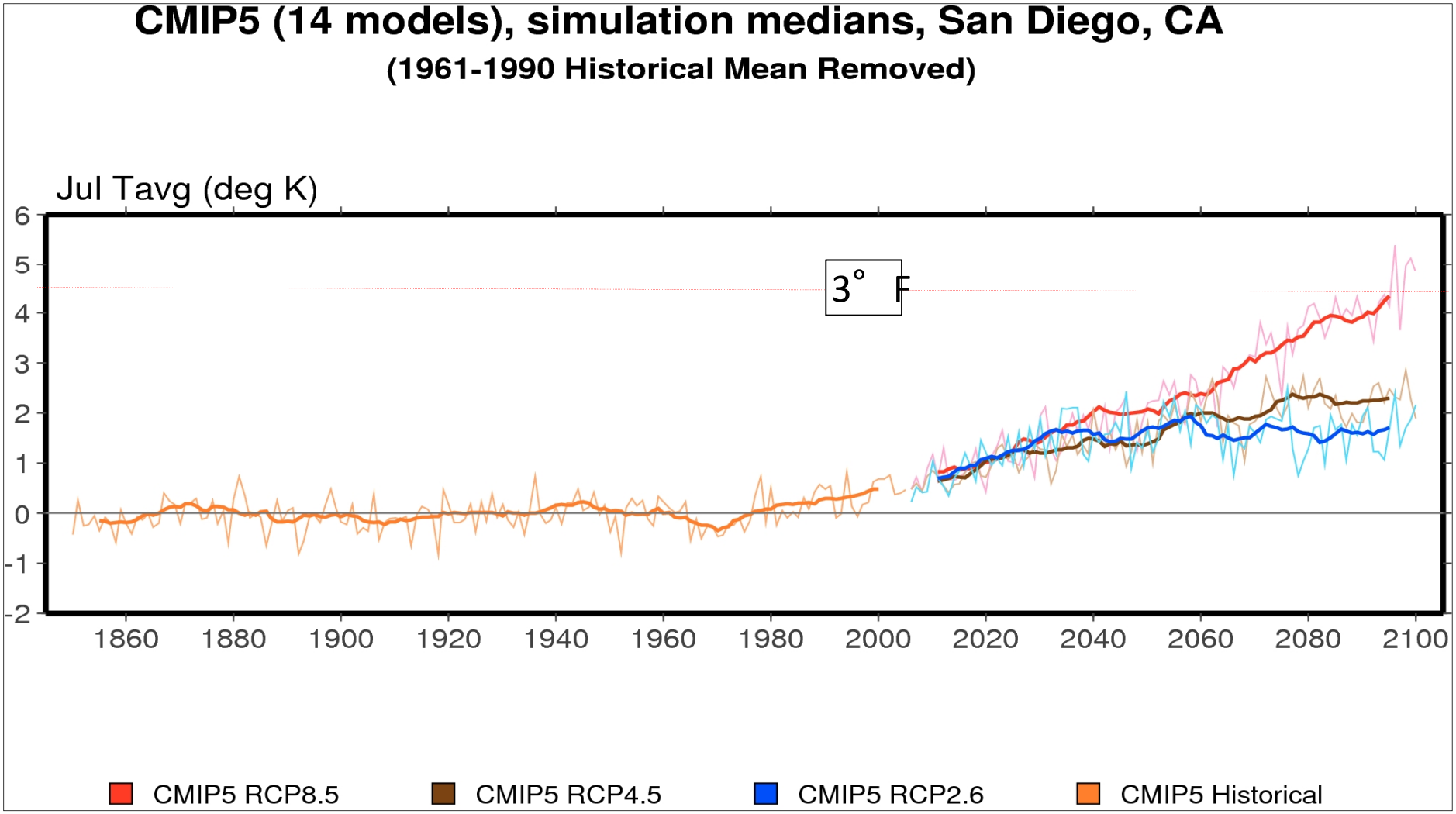


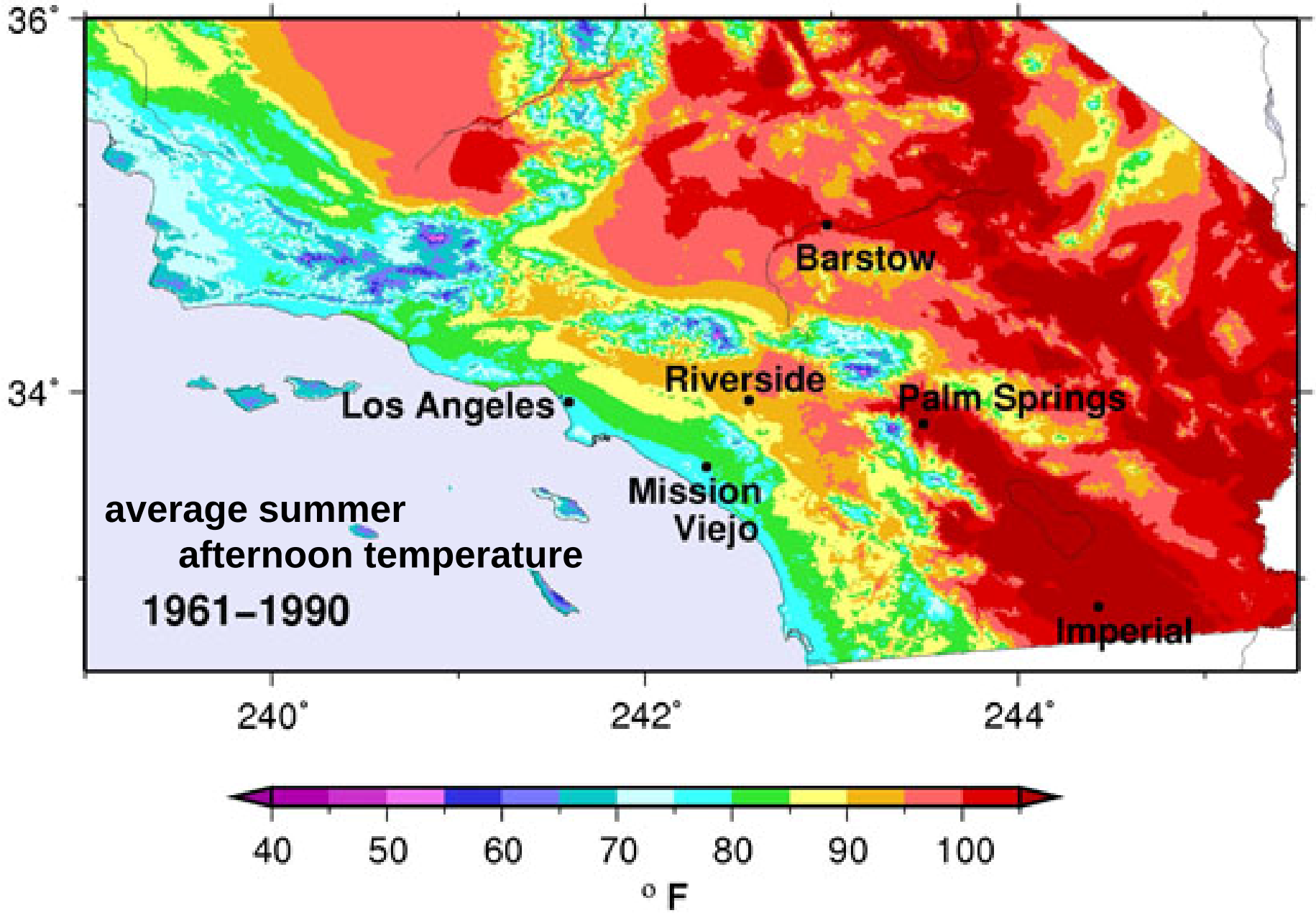
Greenhouse gas (GHG) concentrations will rise, but how much?

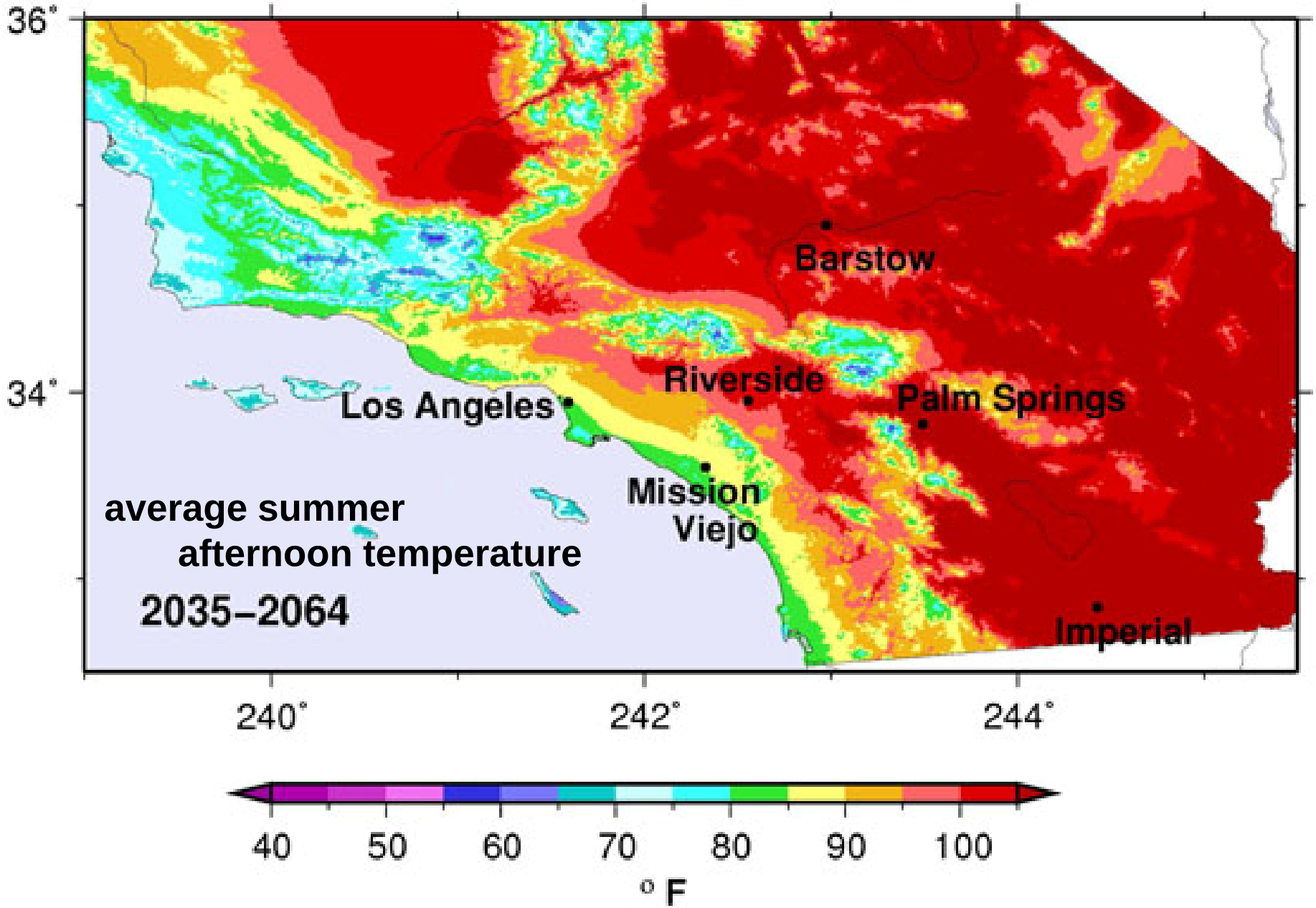
GHG emissions trajectories have considerable implications for global and regional climate in future decades

Projected Climate Warming through the 21st Century

- *because of greenhouse gas build-up we are committed and are already warming*
- *amount of warming in future decades depends on greenhouse gas emissions*




36°
34°
240°
242°
244°
Barstow
Riverside
Palm Springs
Los Angeles
Mission Viejo
Imperial
average summer afternoon temperature
1961–1990
40
50
60
70
80
90
100
° F



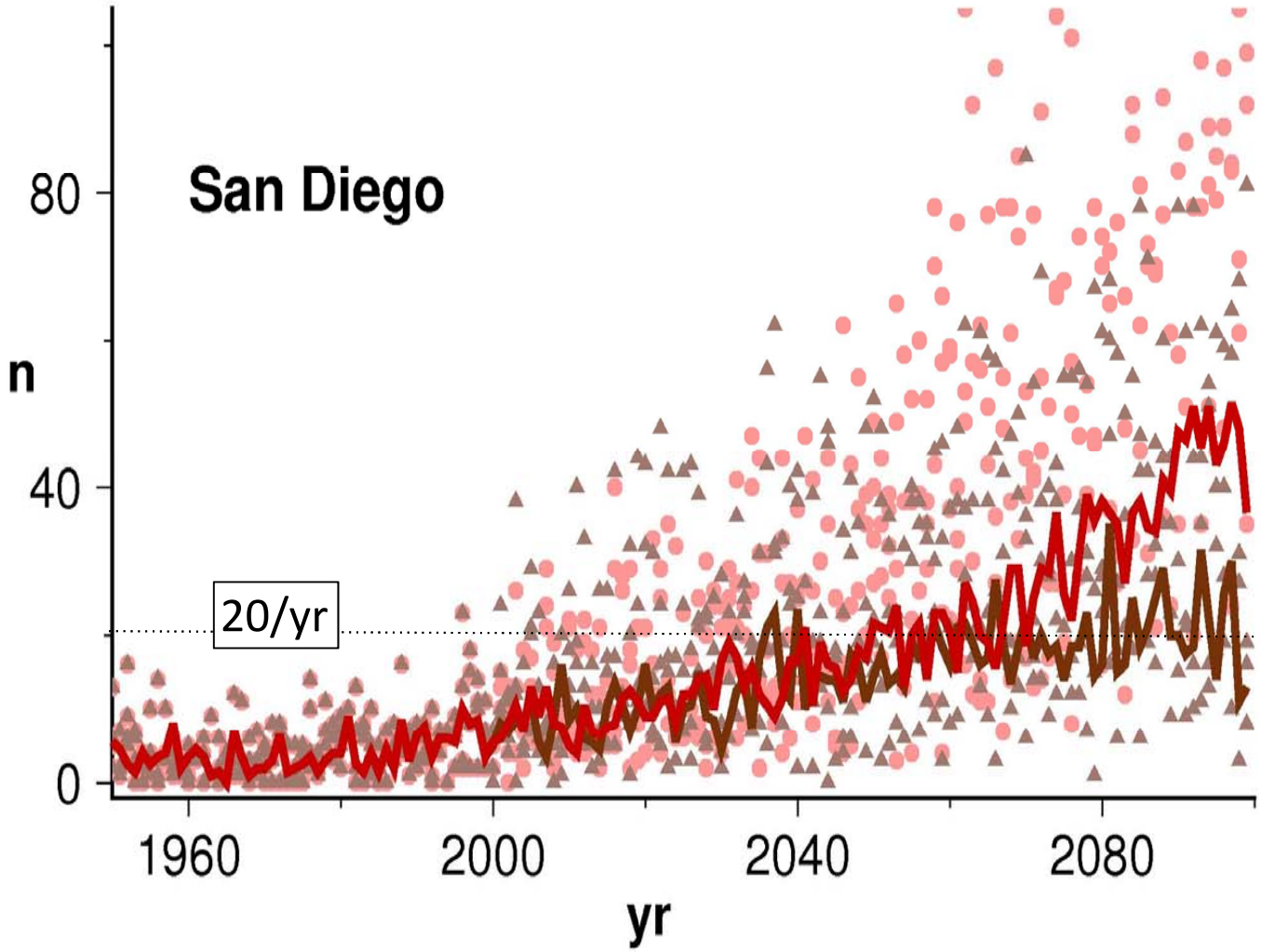
GFDL A2 1km downscaled to 1km
Hugo Hidalgo Tapash Das Mike Dettinger

Heat Waves

Projected in San Diego

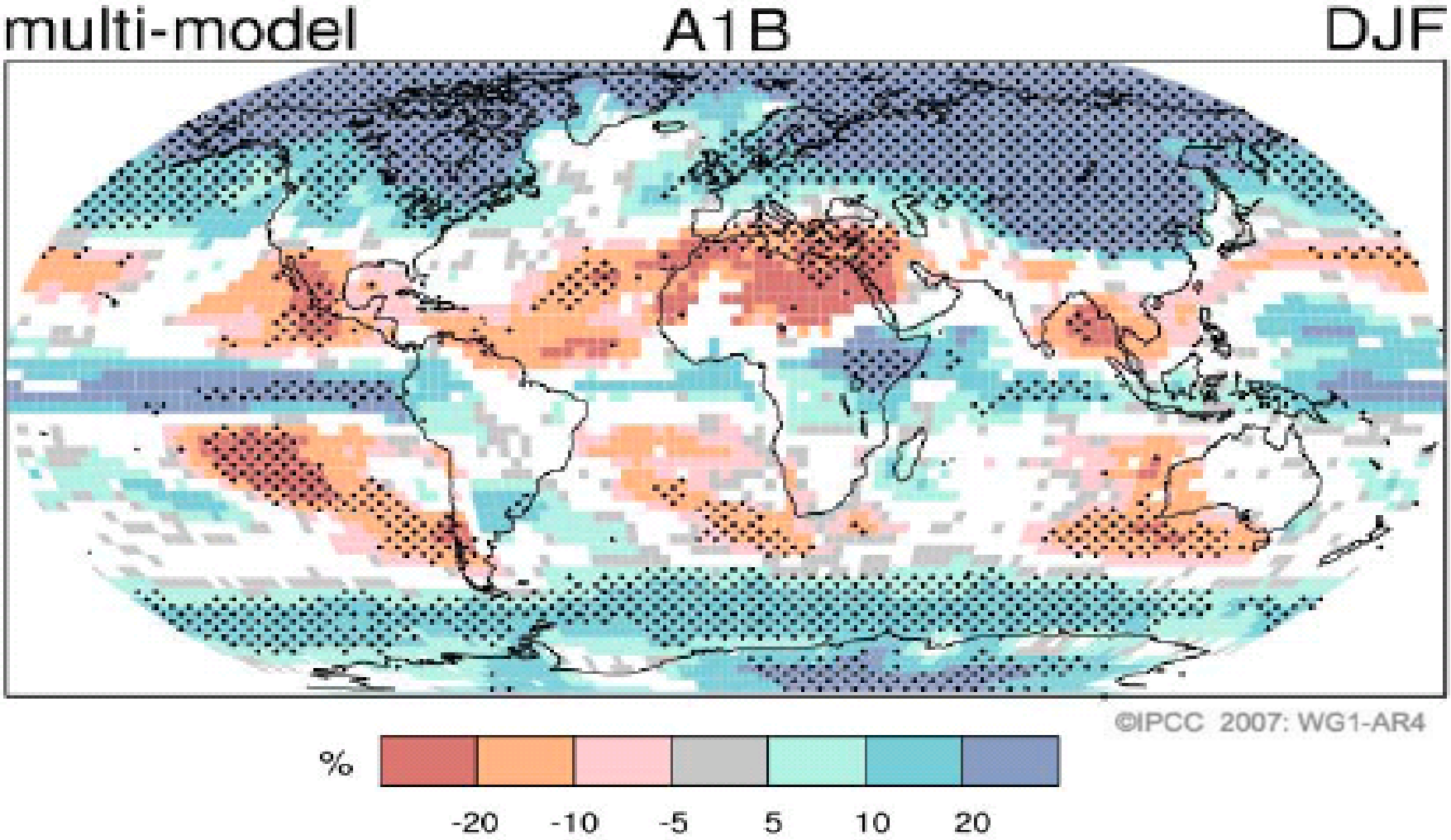
SRES A2 and SRES B1 GHG Emissions Scenarios

Number of Days (n), April–October, When Maximum Temperature (Tmax) Exceeds the 98th Percentile Historical (1961–1990) Level of 82° F at San Diego from Four BCCA Downscaled GCMs. Brown carrots and red dots shown for B1 and A2 emission scenarios, respectively. Thick brown (B1) and red (A2) lines show median value from the four simulations.



April through October number of days above the historical (1961-1990) 98th percentile maximum temperature for 4 global climate models (cnrmcm3, ncarccsm3, gfdlcm2.1, ncarpcm1) from BCCA downscaling for sresa2 (red) and sresb1 (brown). Heavy lines indicate median number of days (per year). 98th percentile values range from 81.7 °F to 82.9 °F.

Projected patterns of precipitation changes 2090-2099 versus 1980-1999



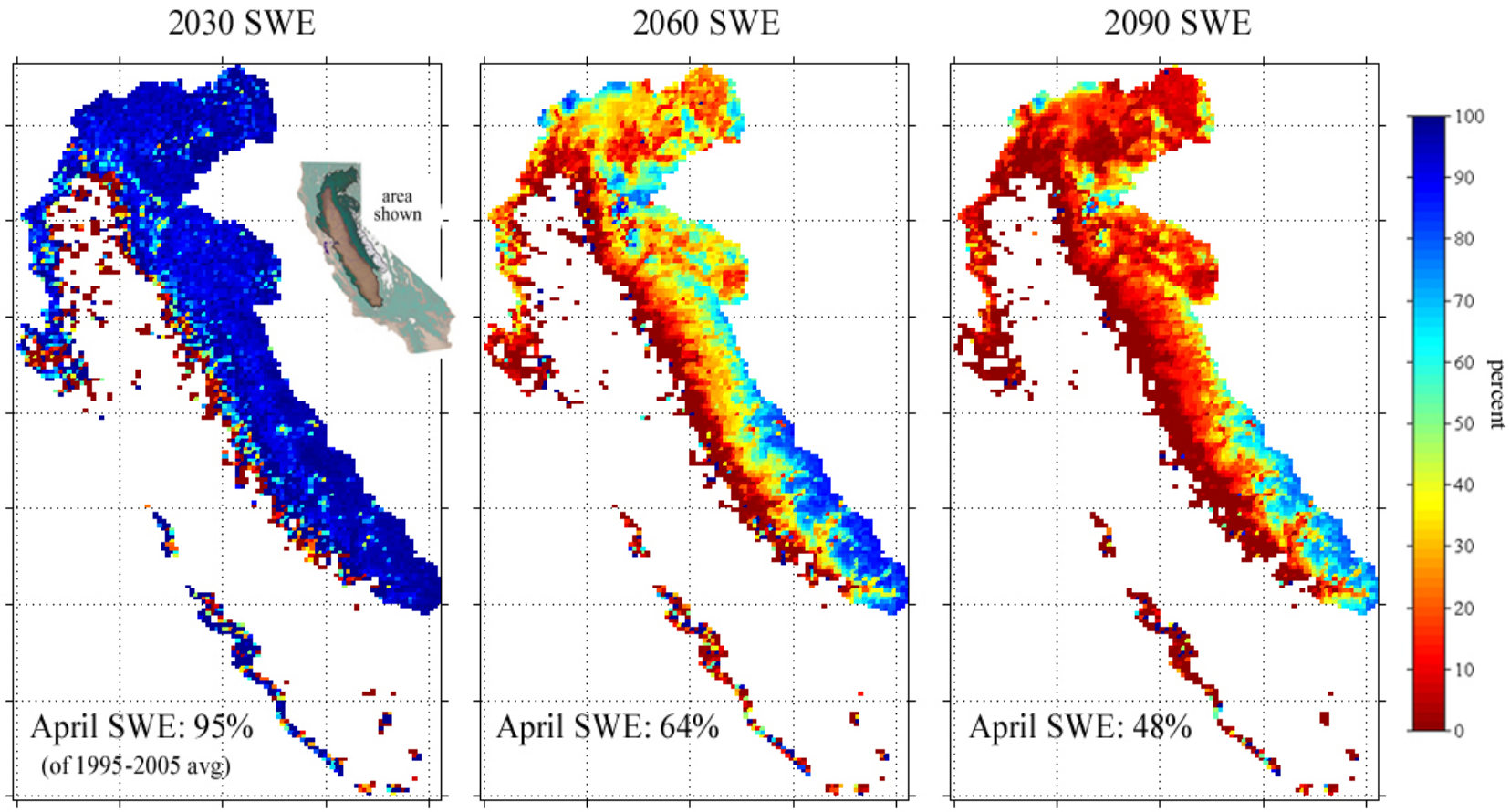
Globally, dry regions become drier possibly including the Southwest U. S:

California's Sierra Nevada snowpack
How long will it remain?

Sponsors:
California Energy Commission, California
NASA program
US Geological Survey
US Department of Energy

Douglas Alden
Scripps Institution of Oceanography
Installing met station, Lee Vining, CA

Warming drives loss of spring snowpack



•Under this scenario, California loses half of its spring (April 1) snow pack due to climate warming. Less snow, more rain, particularly at lower elevations. The result is earlier run-off, more floods, Less stored water. This simulation by Noah Knowles is guided by temperature changes from PCM's Business-as-usual coupled climate simulation. (this is a low-middle of the road emissions and warming scenario)

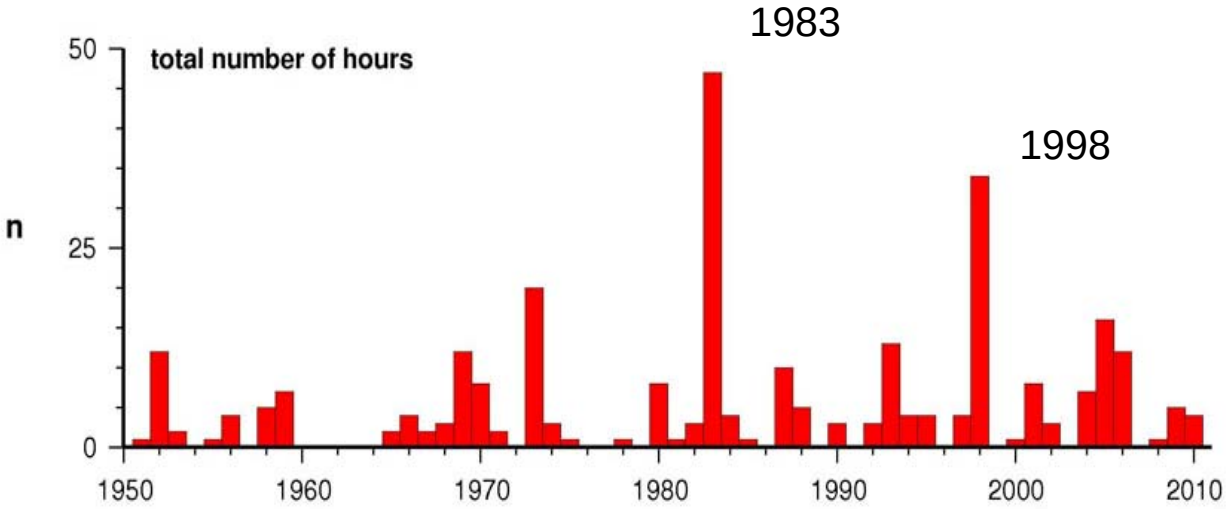
Knowles, N., and D.R. Cayan, 2002: Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary. *Geophysical Research Letters*, **29**(18), 1891.

Sea Level Rise Issues West Coast

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

Extreme sea level occurrences San Francisco

observed at or above 99.99% historical hourly threshold 1.41m above mean



Highest California sea levels have mainly occurred in a few stormy years, especially during large El Ninos (1983 and 1998)

from hourly sea level record at Ft Point, mouth of San Francisco Bay

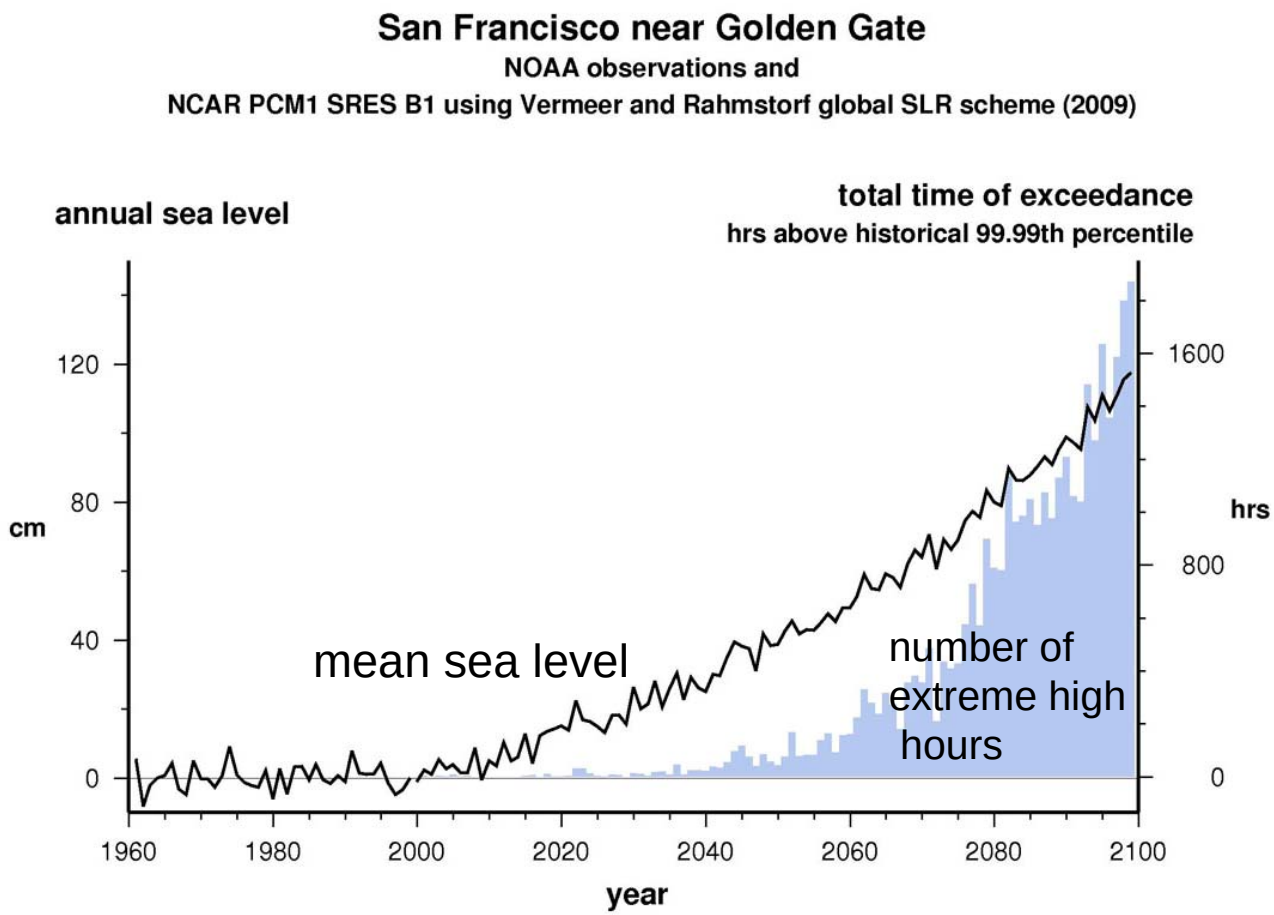
Cayan slide

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.



historical 1970–2000 avg annual sea level (cm): –0.54
historical 1970–2000 avg hrs above 99.99th percentile: 0.71

historical 1961–1990 99.99th percentile: 1.394m
NCAR PCM1 1961–1990 99.99th percentile: 1.413m

Summary --Preparing for Climate Change in California

•California's mediterranan and coast-mountain setting is primed for high vulnerability to climate change impacts.

•California Climate is highly variable. Climate Change will exacerbate existing climate stresses and cause new ones.

•California and the western U.S. have warmed over the last several decades, leading to changes in hydrologic and associated measures

•Although there are large uncertainties, we can expect substantial changes in many systems. If Climate Change follows high end trajectory, changes will be enormous. California needs to plan and adapt.

•*Monitoring of physical, biological and human systems is needed to understand processes, inform models and detect changes.*

•*Continued investigation of regional change sfrom historical observations and from evolving flobal and regional models is needed*

•*Impacts cover range of sectors and systems—interdisciplinary approach is needed.*

•*Rapid changes and science findings requires ongoing communication with decision makers.*