

Regional Climate Impacts— Climate Variability and Change Confronts California

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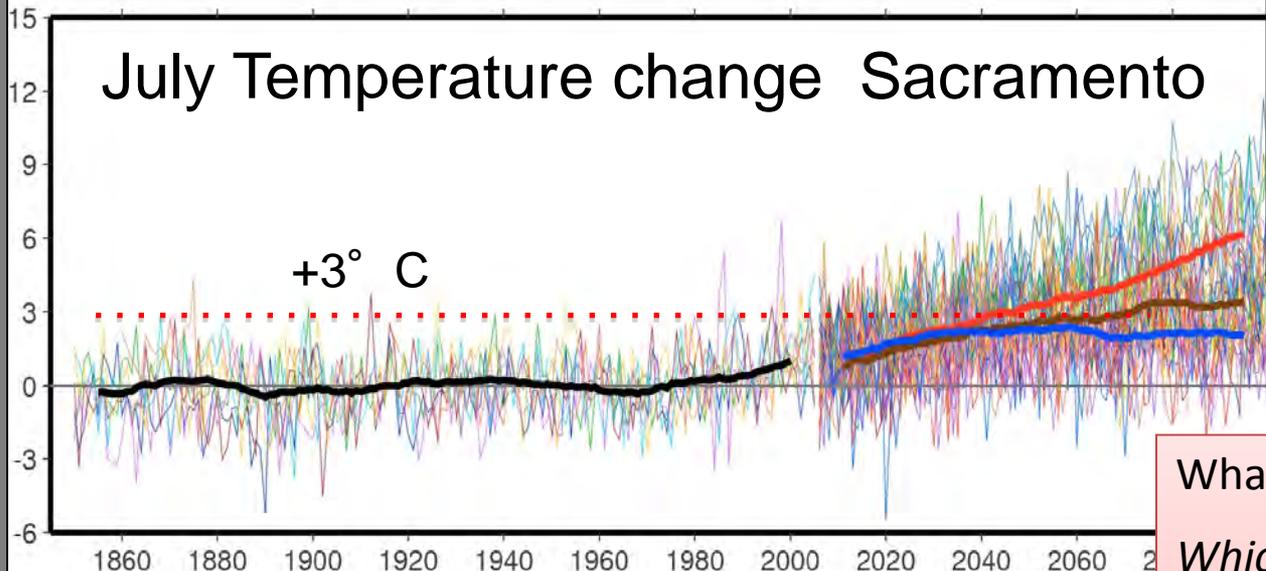
much support from Mary Tyree, Mike Dettlinger and other
colleagues

Sponsors:

California Energy Commission
NOAA RISA program
California DWR, DOE, NSF

virtually all climate simulations project warming,
but with a wide envelope of temperature change

CMIP5 simulations, Jul tempDM (deg K), Sacramento, CA
(1961-1990 Historical Mean Removed)



CMIP5 GCMs project +3° C
summer warming by 2060,
under mid and high RCPs

14 GCMs X 3 RCP Emissions
Scenarios IPCC 5th Assessment
(CMIP5) models

What we'd like to know

*Which emissions pathway will we
take?*

*How much summer amplification
of warming?*

*How will temperature change in
Near term?*

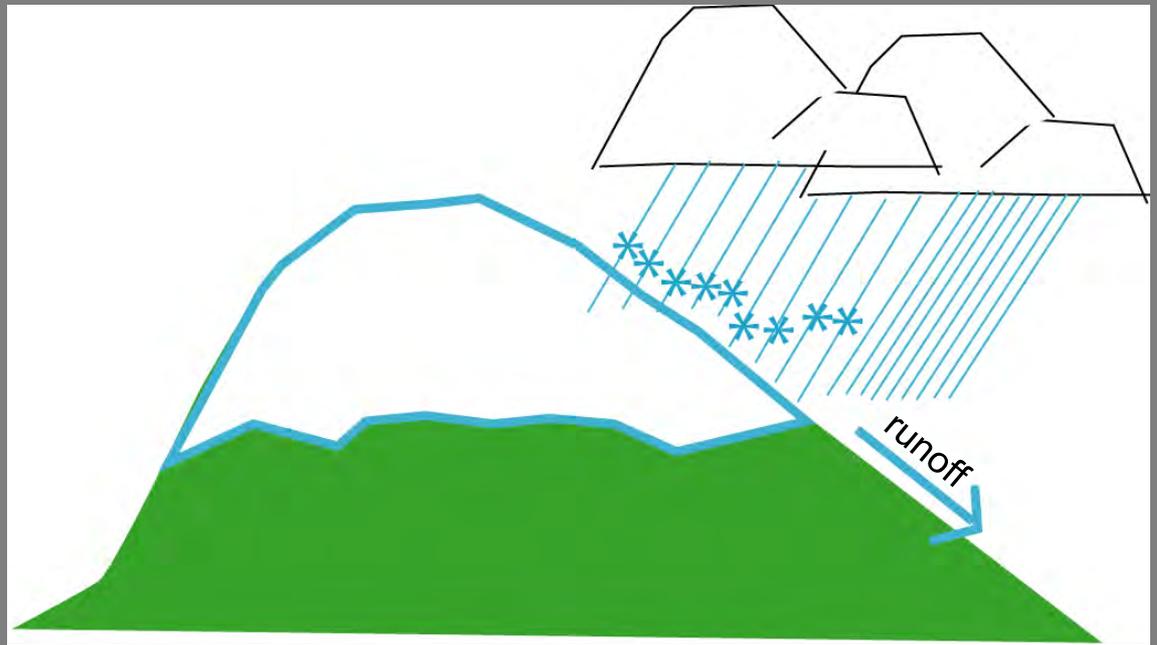
(solid line = 11-yr smoothed median of simulation)

regional snow and hydrology—
a sensitive index of climate variation and change

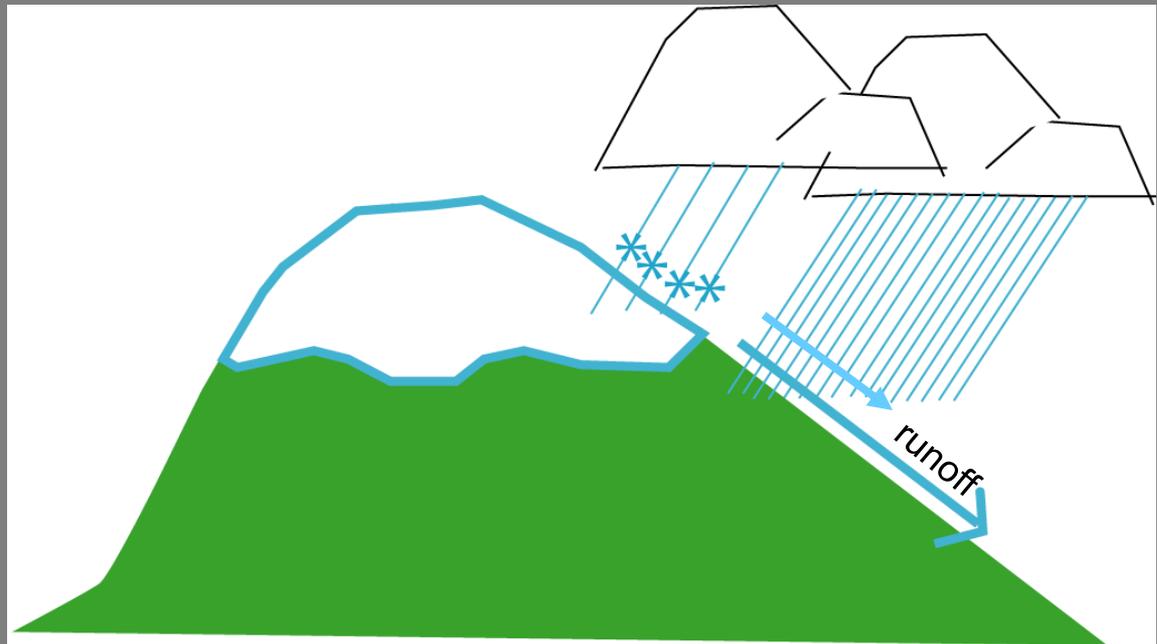


*Douglas Alden
Scripps Institution
of Oceanography
Installing met station
Lee Vining, CA*

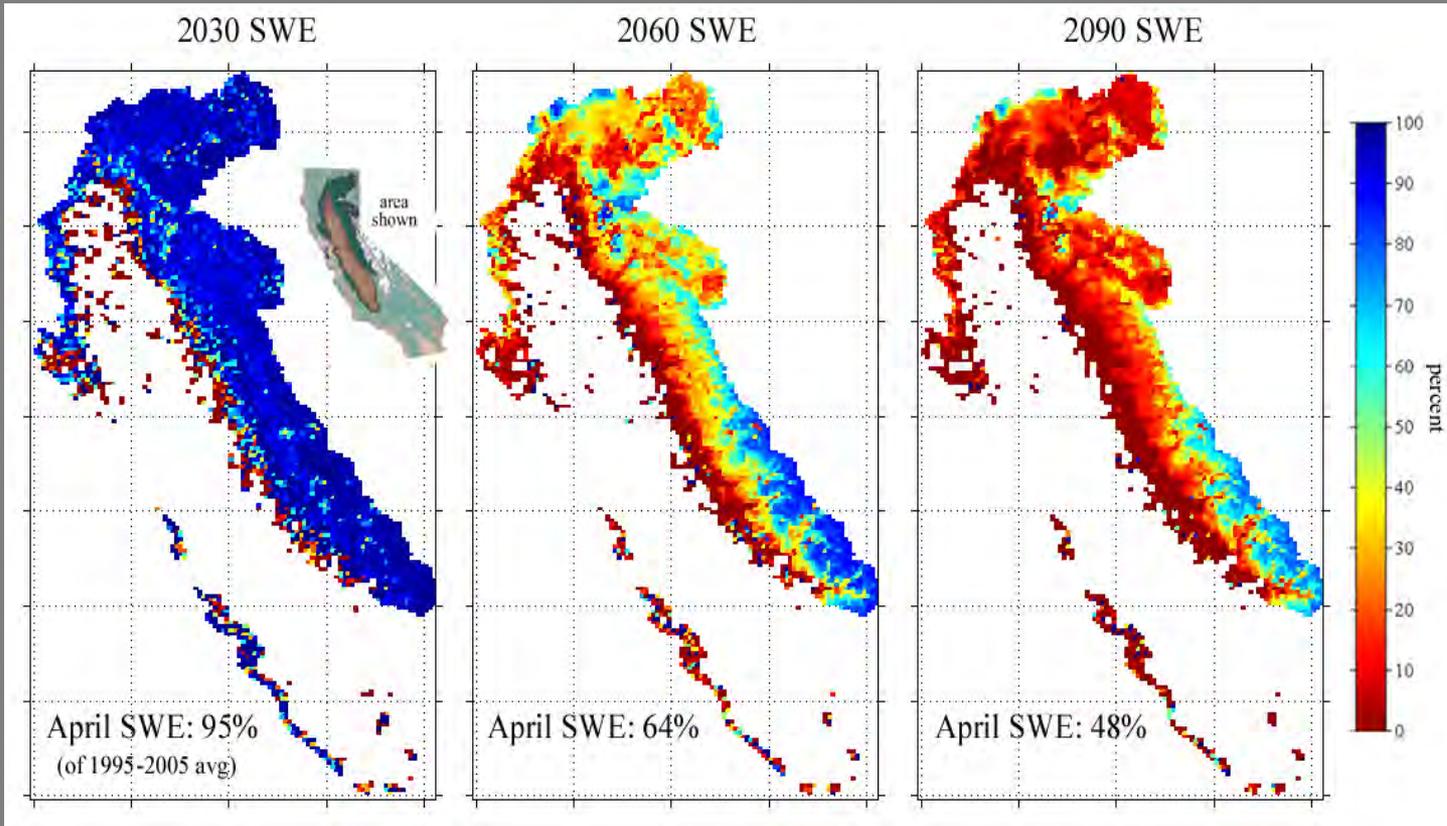
historically:
“Cool” storms
contribute immediate
runoff from smaller
areas of the river
basin (the rest goes
into snowpack for
later)



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



We face significant losses of spring snowpack



- Less snow, more rain
- Particularly at lower elevations
- Earlier run-off
- More floods
- Less stored water

By the end of the century California could lose half of its late spring snow pack due to climate warming. This simulation by Noah Knowles is guided by temperature changes from PCM's Business-as-usual coupled climate simulation. (a middle of the road emissions scenario)

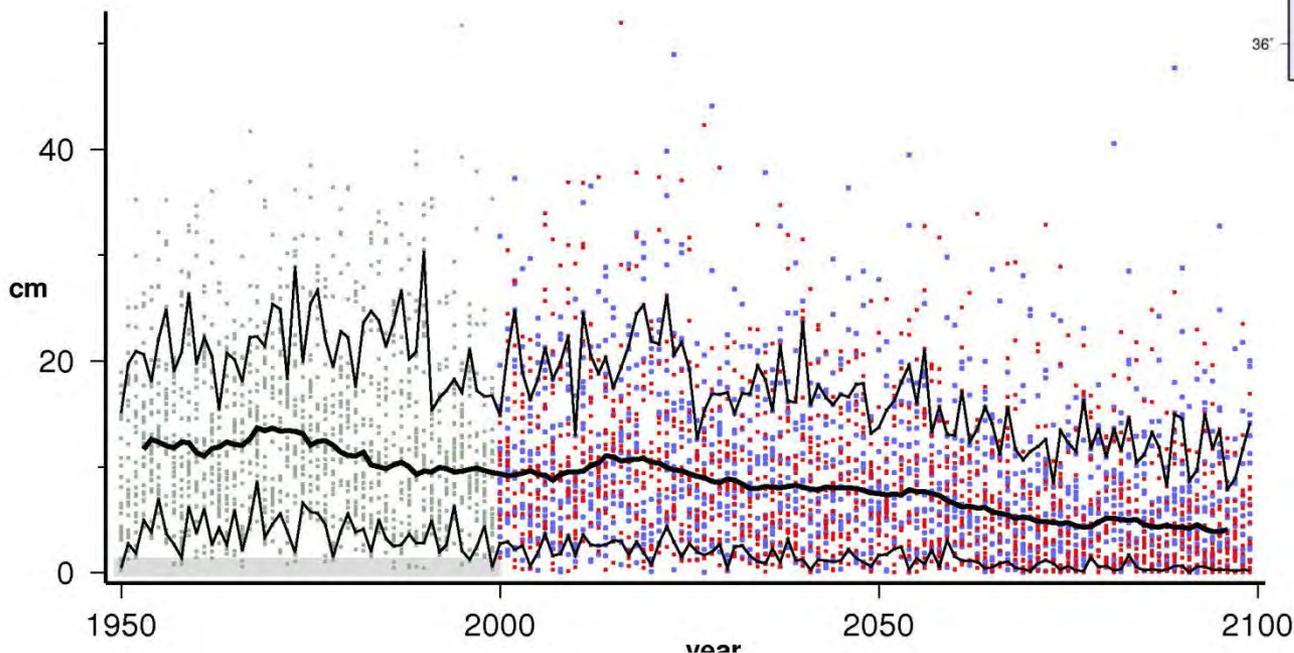
projected reduction in Sierra Nevada+ spring snow pack
VIC model estimates indicate ~25% loss per C°

Sierra Nevada Spring Snow Water Equivalent

32 BCSD (16 SRESA2 and 16 SRESB1)

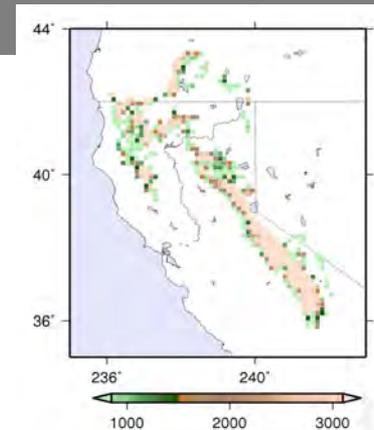
7-year smoothed median: heavy black line

90th and 10th percentiles: light black lines



declining Apr 1 SWE:
2050 median SWE ~ 2/3 historical median
2100 median SWE ~ 1/3 historical median

■ SRESA2
■ SRESB1
■ historical



Need to know:

How much winter and spring warming?

Changes in cool season precipitation?

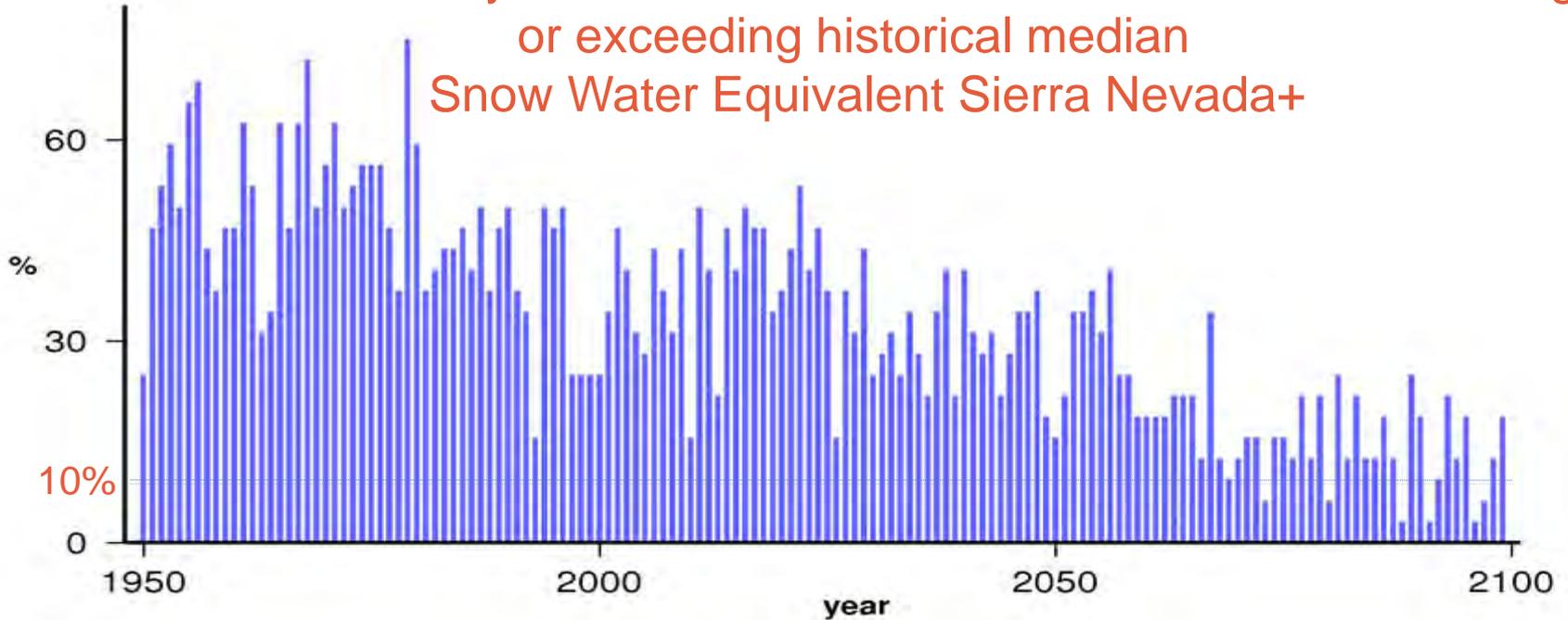
California April 1 SWE from climate simulations

Odds a year is above the average historical median (11.86cm; 1961–1990)

32 BCSD (16 SRESA2 and 16 SRESB1)

Median Apr 1 SWE 11.9cm

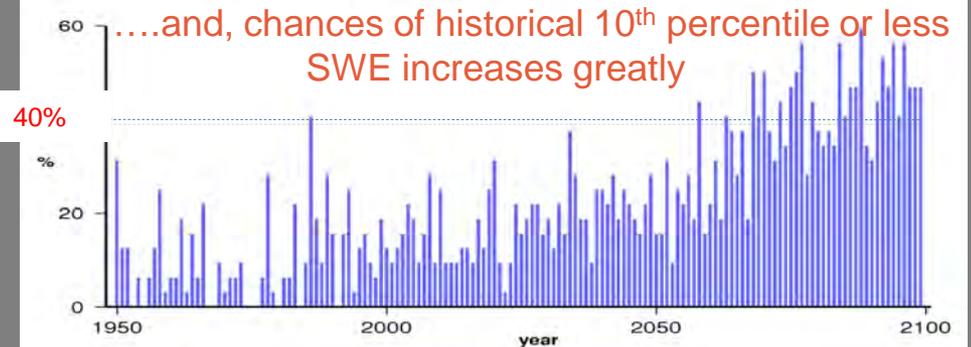
over 21st Century occurs a marked decline of chances of reaching or exceeding historical median
Snow Water Equivalent Sierra Nevada+



California April 1 SWE from climate simulations

Odds a year is below the historical 10th percentile (3.60cm; 1961–1990)

32 BCSD (16 SRESA2 and 16 SRESB1) 10th % Apr 1 SWE 3.6cm

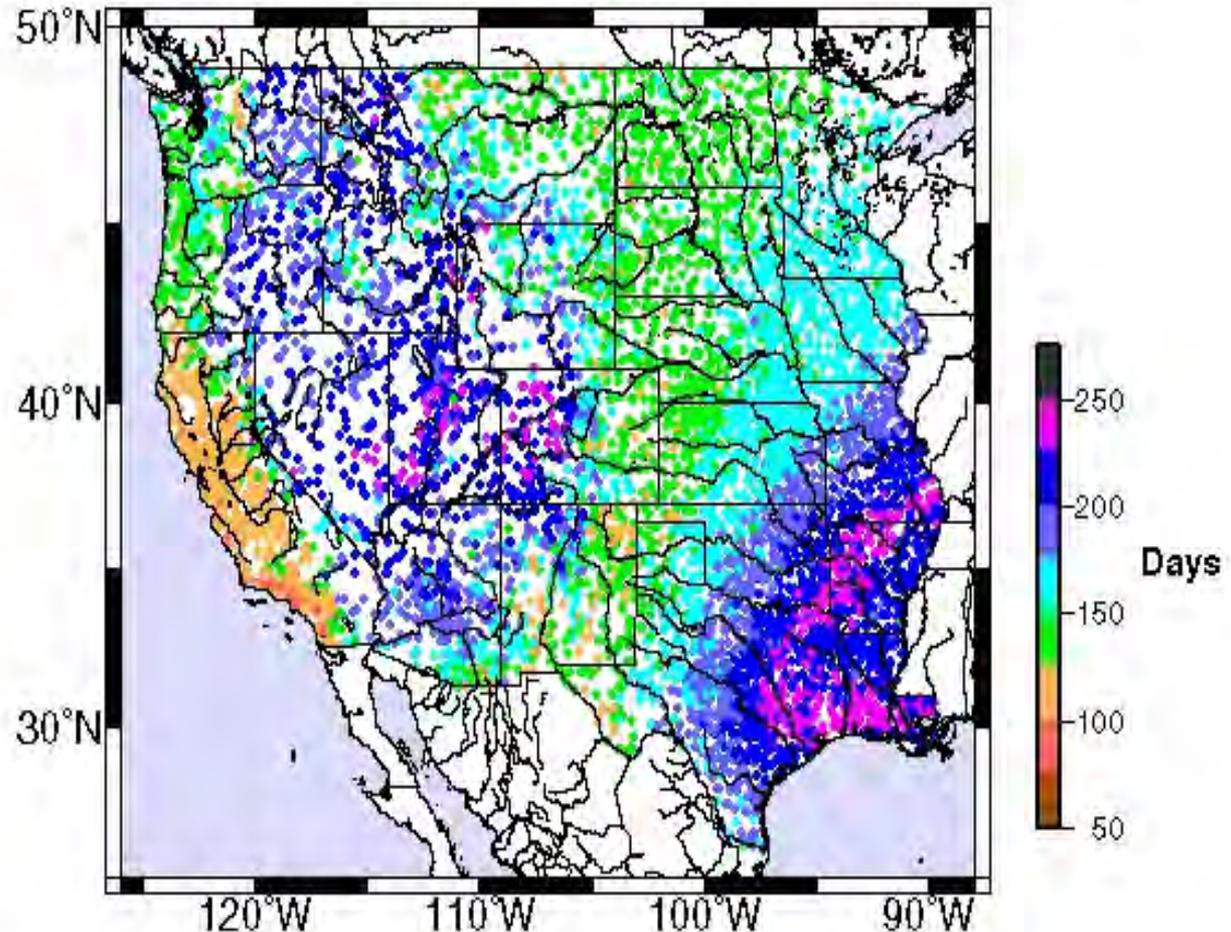


understanding how vulnerabilities to Climate Change are conditioned by regional climate settings

California is remarkable by having only about 120 days to accumulate two thirds of its annual precipitation. When Pacific winter storminess is away from California (as it was this winter) during this seasonal window, unusually dry conditions result. Of the entire U.S., California year-to-year variation in precipitation is has the most volatile!

How will climate change alter Pacific storminess and thus California's seasonal Precipitation change?

a. **L67: Time (days) to accumulate 67% of annual total precip**
Mean of length of record, daily CO-OP and 1st order stations

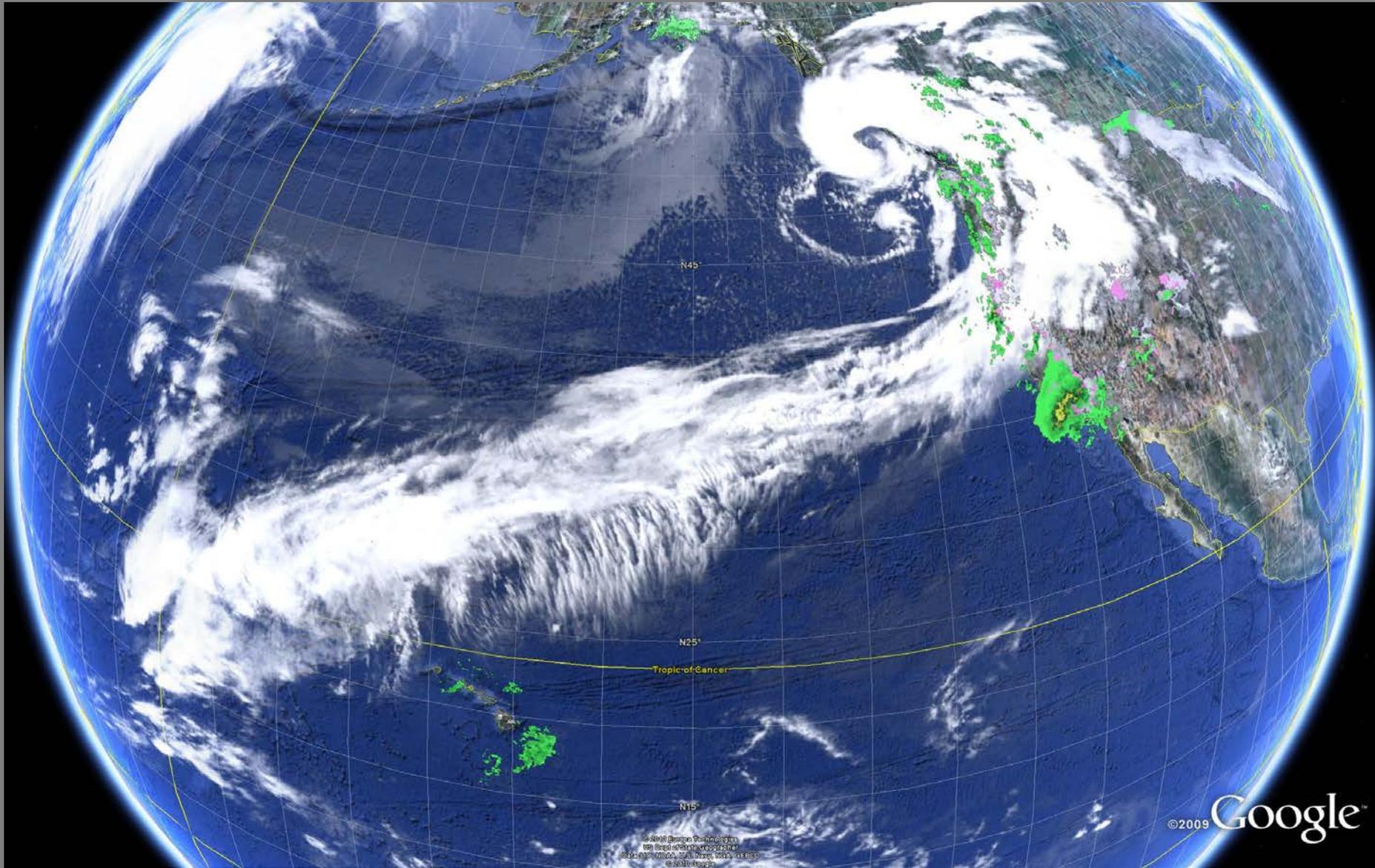




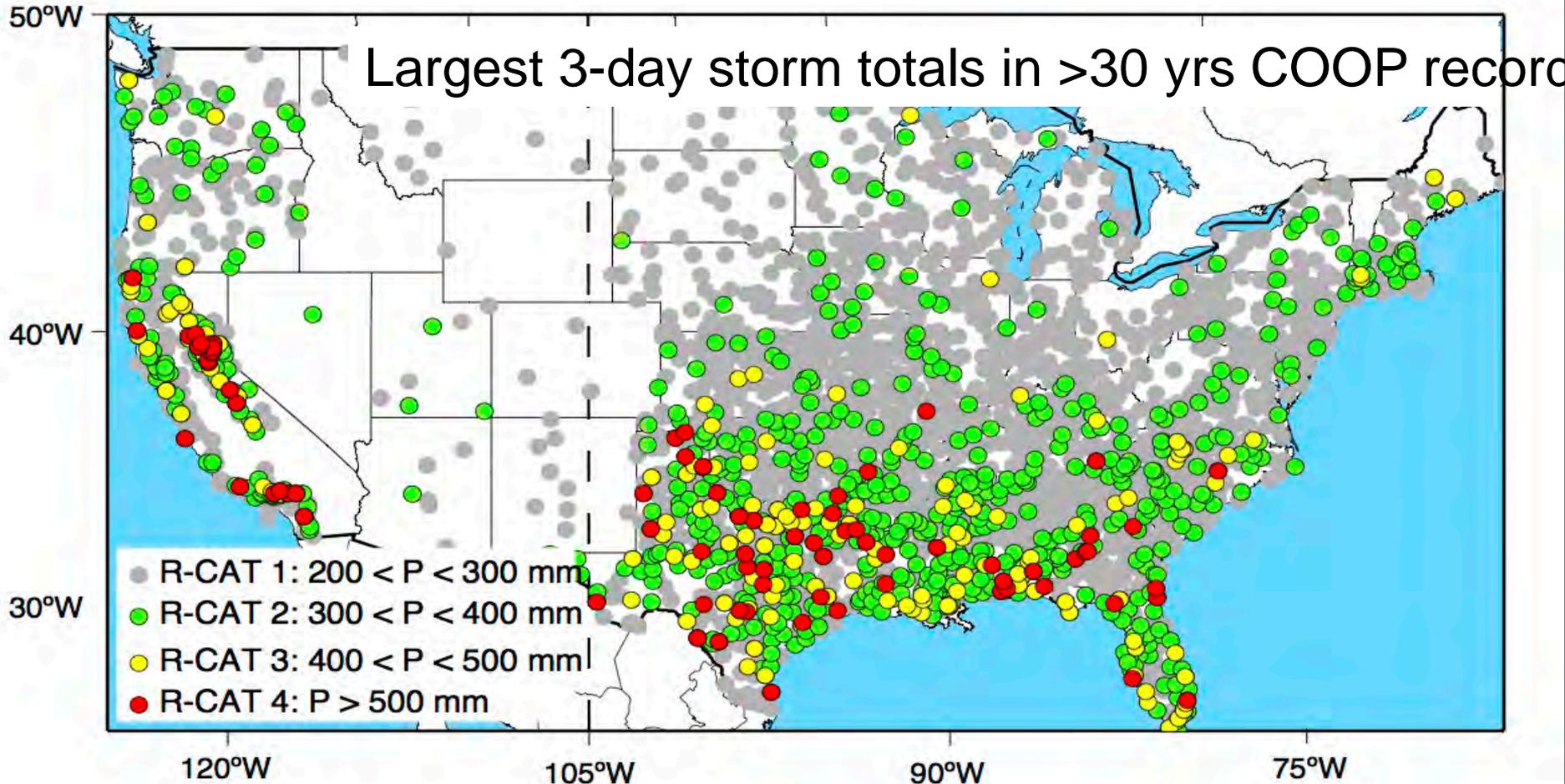
California's history is marked by extended dry spells

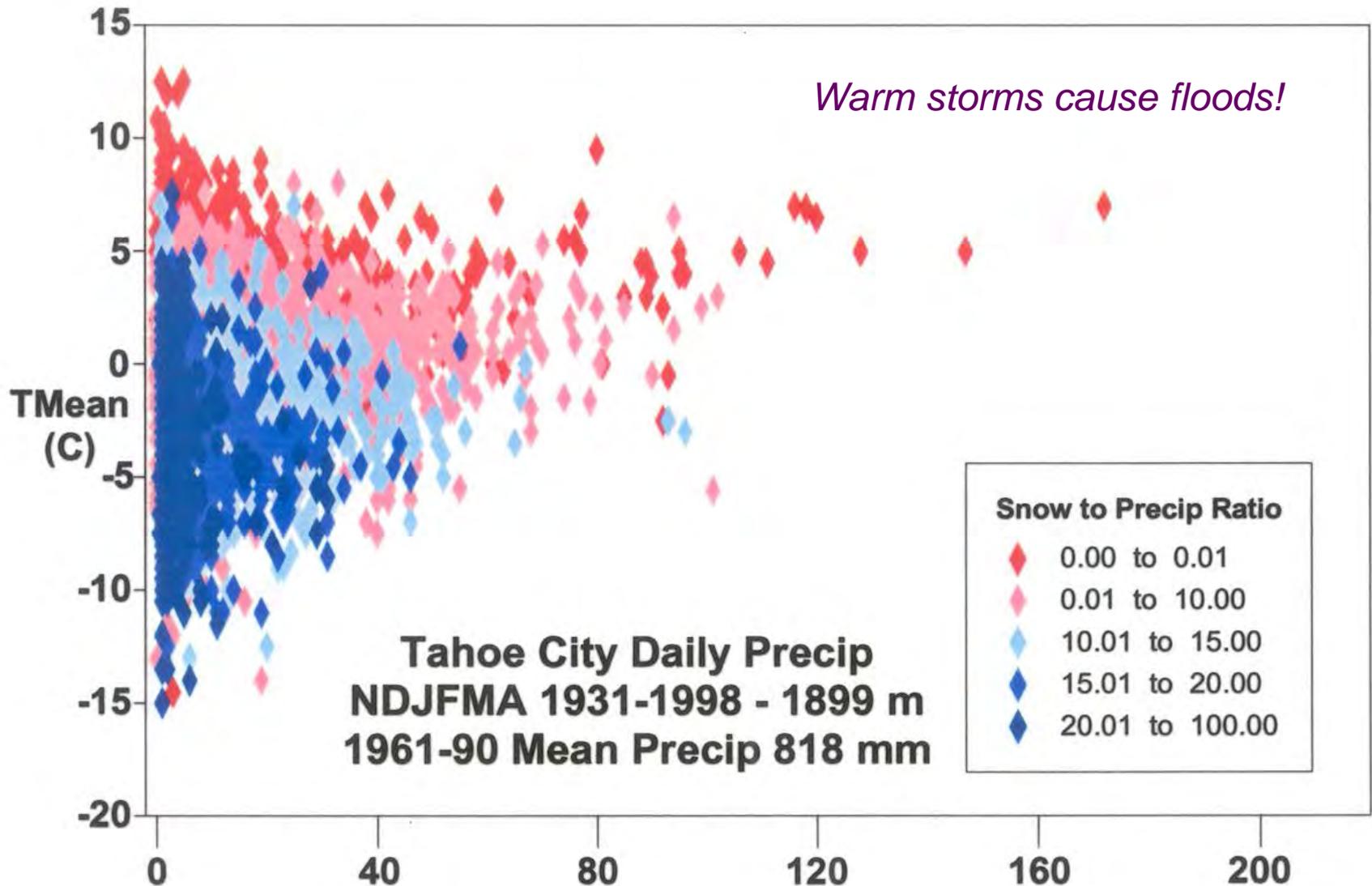
Atmospheric Rivers

flood producers and water suppliers for the western states



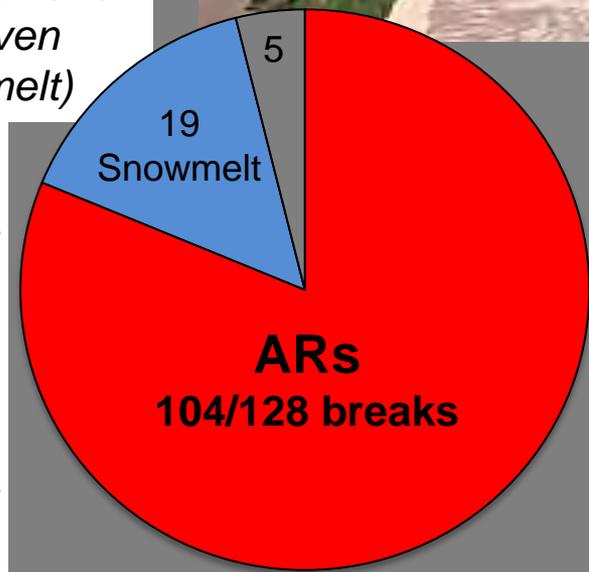
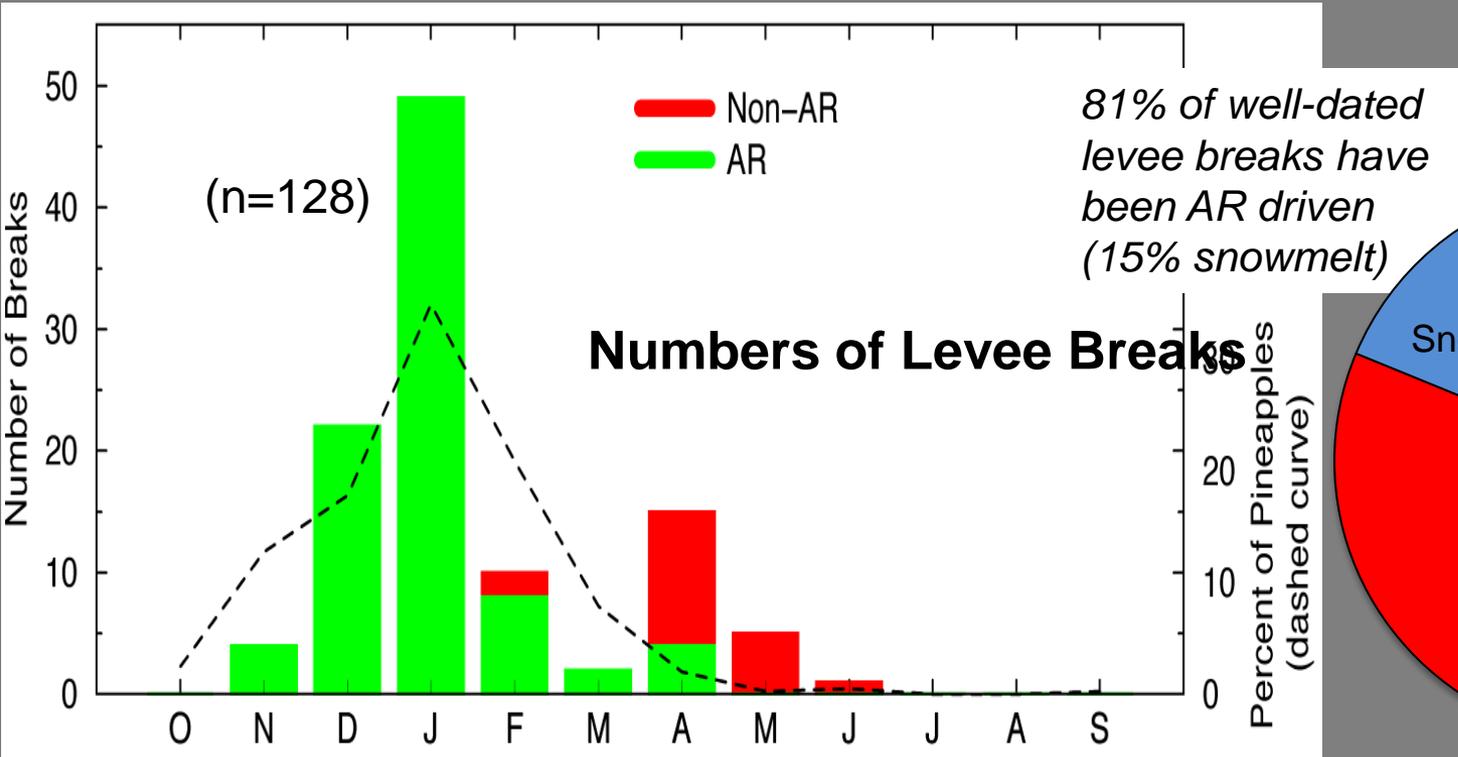
just how BIG are these storms?





wettest days occur during WARM storms
this makes snow lines higher and runoff even higher

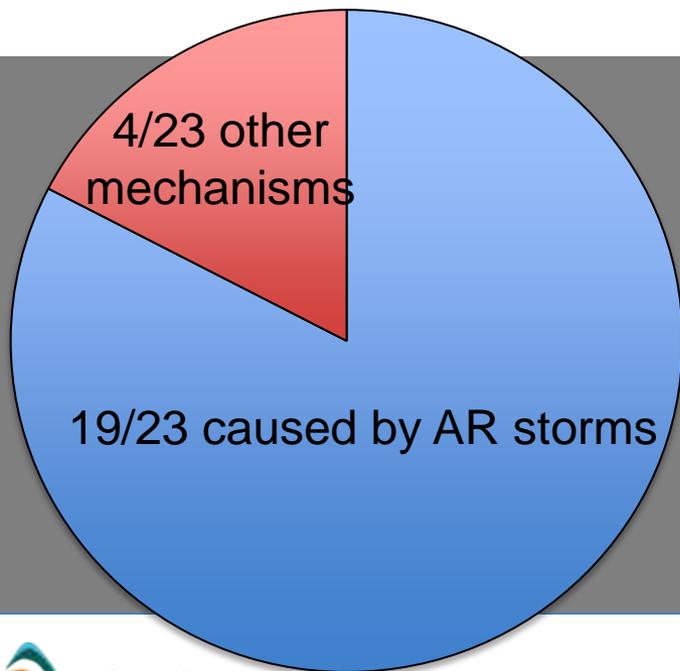
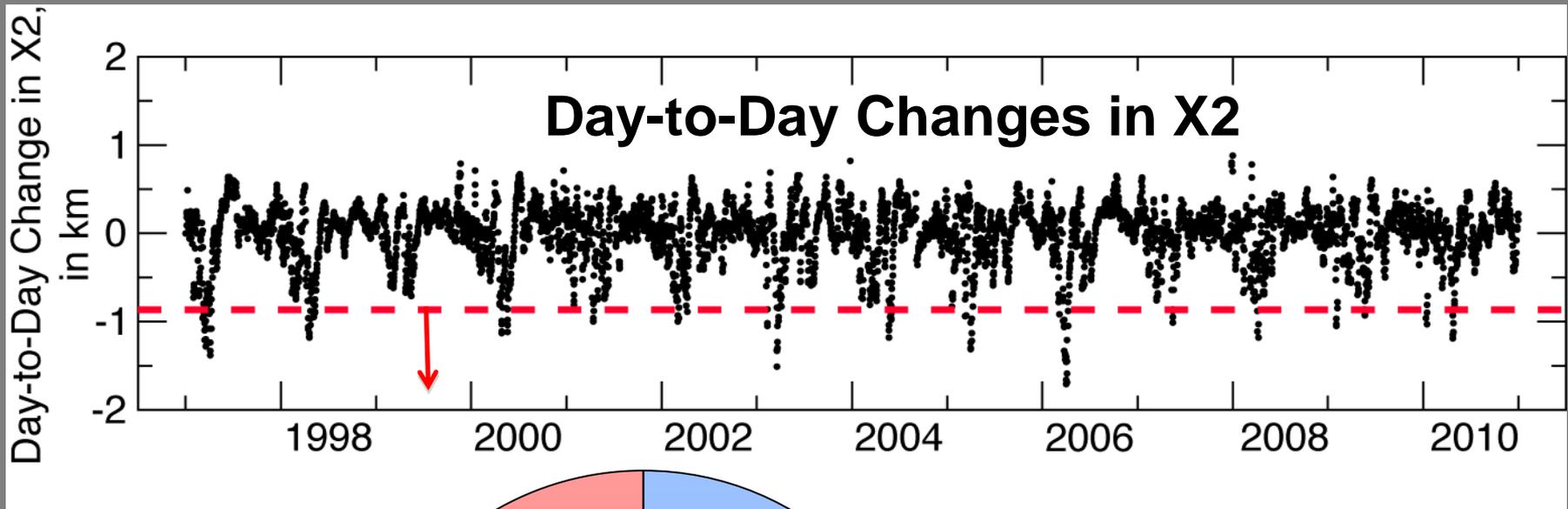
Central Valley levee breaks, 1951-2006



During the times of year when ARs make California landfalls, they are THE mechanism behind historical levee breaks.

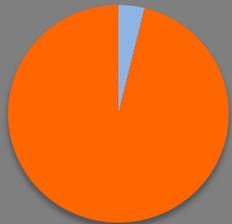


Florsheim & Dettinger, book chapter, in press; Florsheim & Dettinger, GRL, 2007



83% of largest (daily-scale) X2 retreats, WY1997-2010, have been due to

All Calendar Days

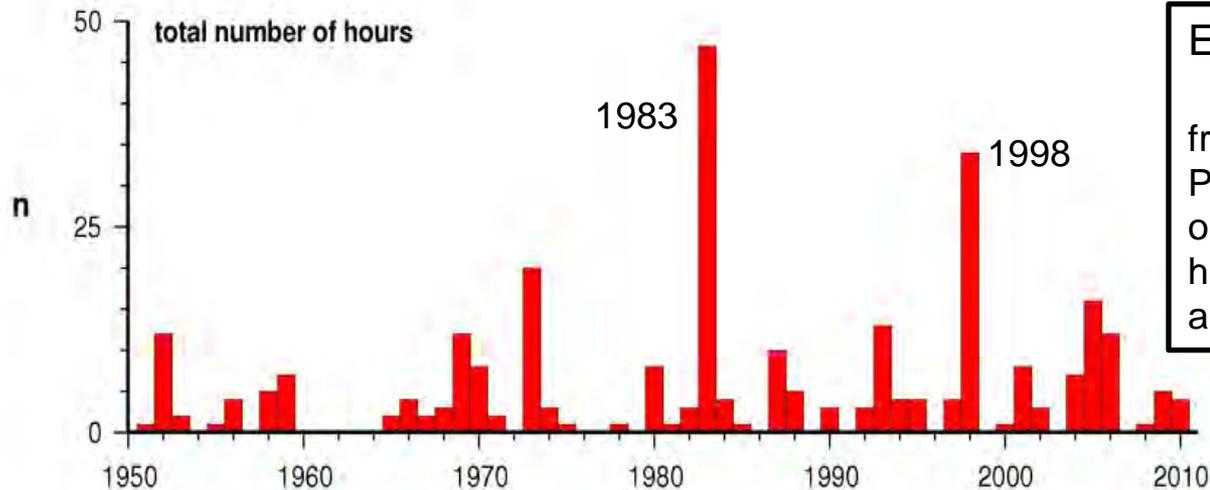


understanding climate patterns that allow rare events is critical



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

highest California sea levels have occurred in just a few years,
especially large El Ninos (1983 and 1998)



Extreme sea level occurrences
San Francisco
from hourly sea level record at Ft
Point, mouth of San Francisco Bay
observed at or above 99.99%
historical hourly threshold 1.41m
above mean

Need to know:

Will El Nino effects change in future climate?

MODELED INCREASING SEA LEVEL EXCEEDENCES

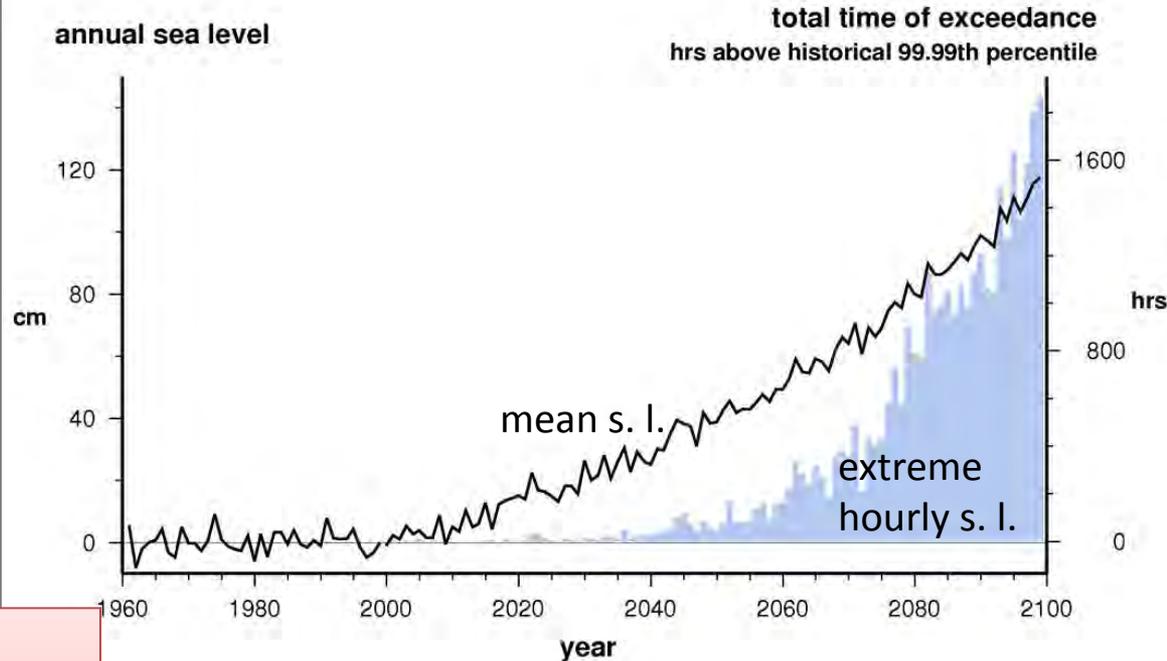
As mean sea level rises the frequency and magnitude of extremes increase markedly. Under plausible rates of sea level rise, an event which in present day occurs less than once per year occurs scores of times per year by mid 21st Century and becomes commonplace by end of 21st Century.

Need to know:

Rate of regional sea level rise

Nature of changes in North Pacific storms

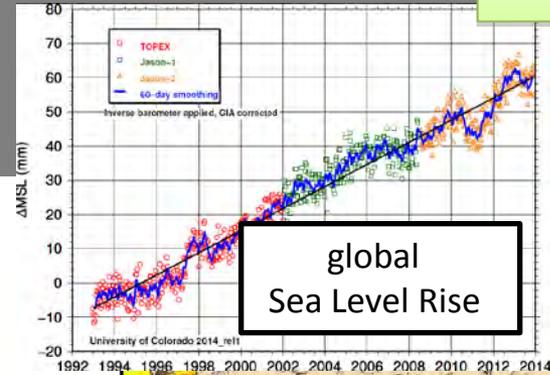
San Francisco near Golden Gate
NOAA observations and
NCAR PCM1 SRES B1 using Vermeer and Rahmstorf global SLR scheme (2009)



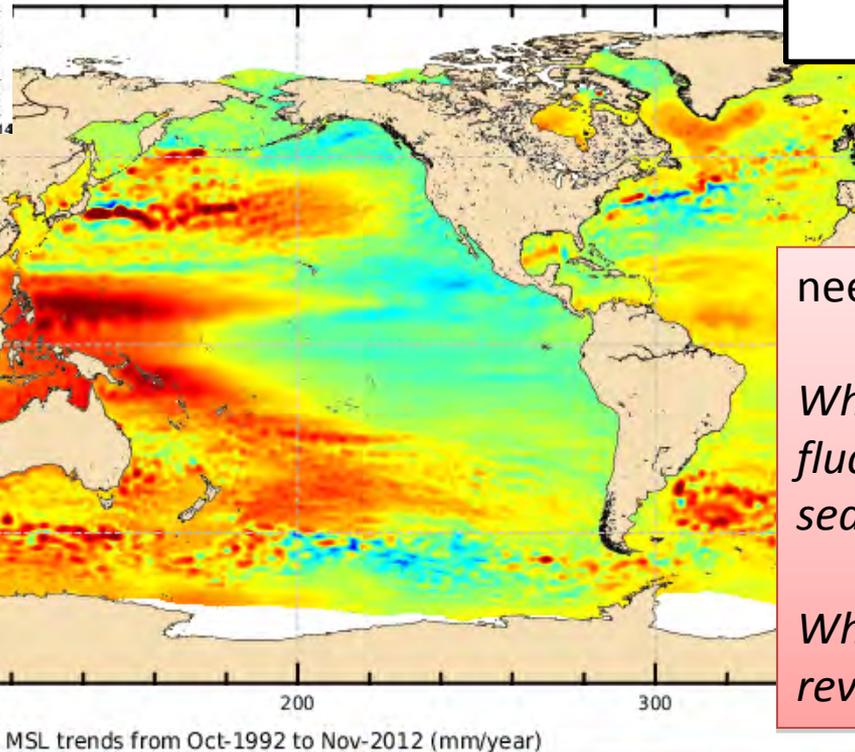
ncar pcm1 sresb1 GCM
using Vermeer and Rahmstorf SLR
historical 1970–2000 avg annual sea level (cm): -0.54
historical 1970–2000 avg hrs above 99.99th percentile: 0.71

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

California's climate impacts can be dictated by climate well beyond our region



observed uneven sea level change over the Pacific basin

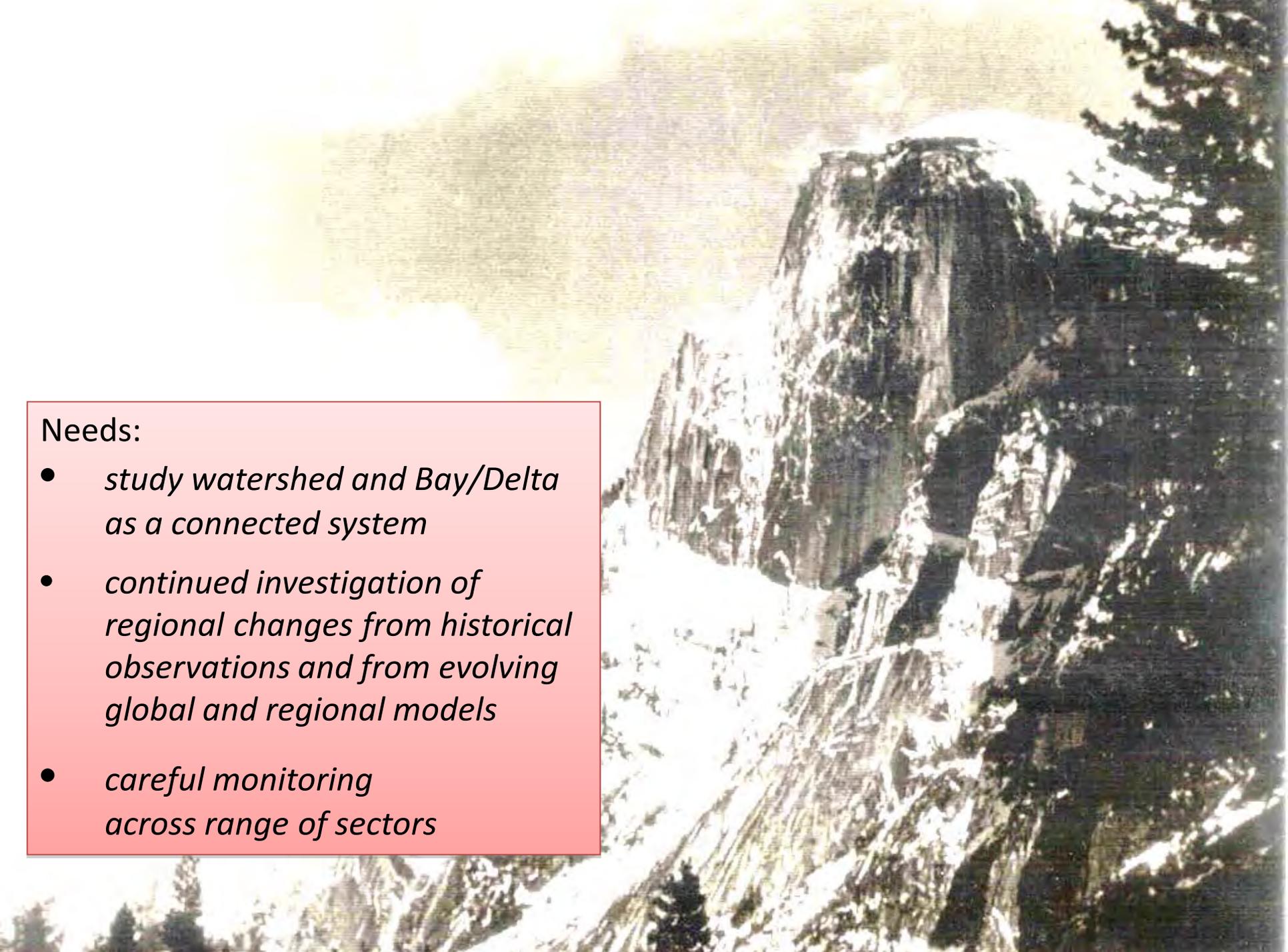


need to know:

What drives decadal fluctuations in Pacific sea level structure?

When will present pattern reverse?

sea level change 1993-2010 (mm/yr) as measured by satellite altimetry.



Needs:

- *study watershed and Bay/Delta as a connected system*
- *continued investigation of regional changes from historical observations and from evolving global and regional models*
- *careful monitoring across range of sectors*

