



Projected Impacts of Climate Change in Southern California and the Western U.S.

Sam Iacobellis and Dan Cayan

Scripps Institution of Oceanography
University of California, San Diego

Sponsors: NOAA RISA Program, California-Nevada Applications Project (CNAP)
California Energy Commission

A satellite-style image of Southern California, showing the coastline on the left and inland terrain on the right. The terrain is a mix of brown, tan, and green, with white clouds scattered across the landscape. The ocean is dark blue with white surf along the coast.

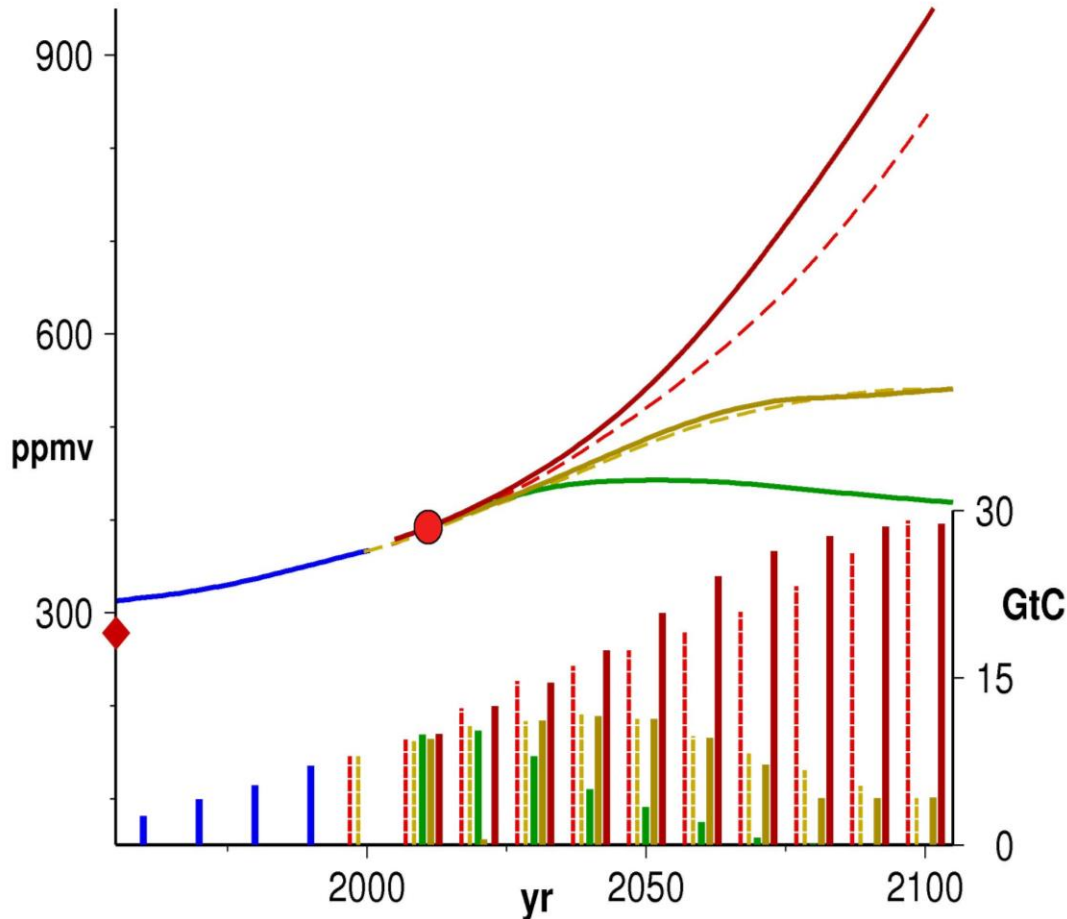
Projected Regional Impacts

- Temperature
- Precipitation
- Sea Level Extremes

GOAL: Inform you about some of our research examining how climate change may impact Southern California

Global Atmospheric CO₂ Concentration (ppmv) and Carbon Emissions (GtC)

IPCC 4th and 5th Assessment Scenarios



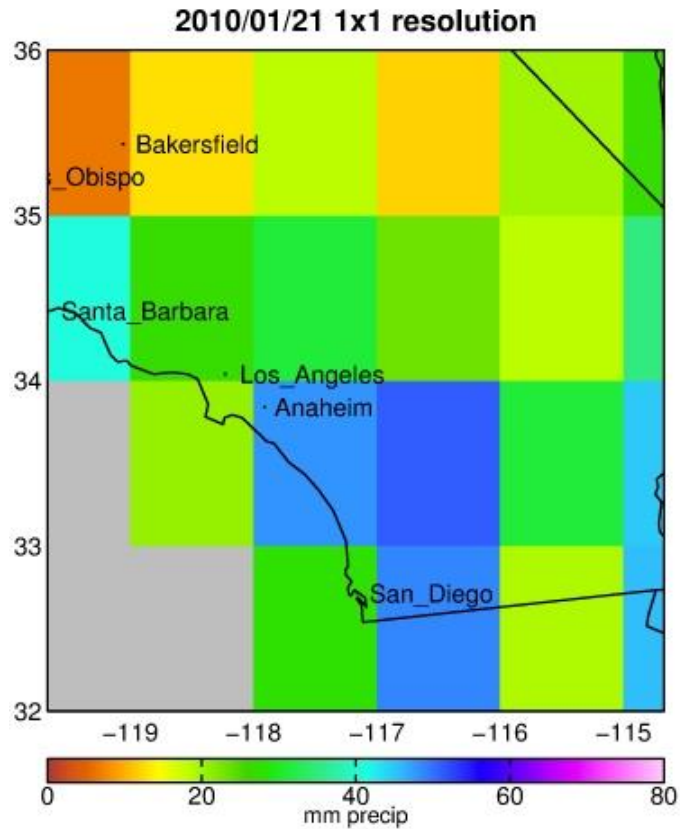
- RCP 8.5
- RCP 4.5
- RCP 2.6
- - SRES A2
- - SRES B1
- historical
- 2011 (392ppmv; 2011 Mauna Loa)
- ◆ pre-industrial (280ppmv)

Projections based on climate models forced with various scenarios of CO₂ concentration

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

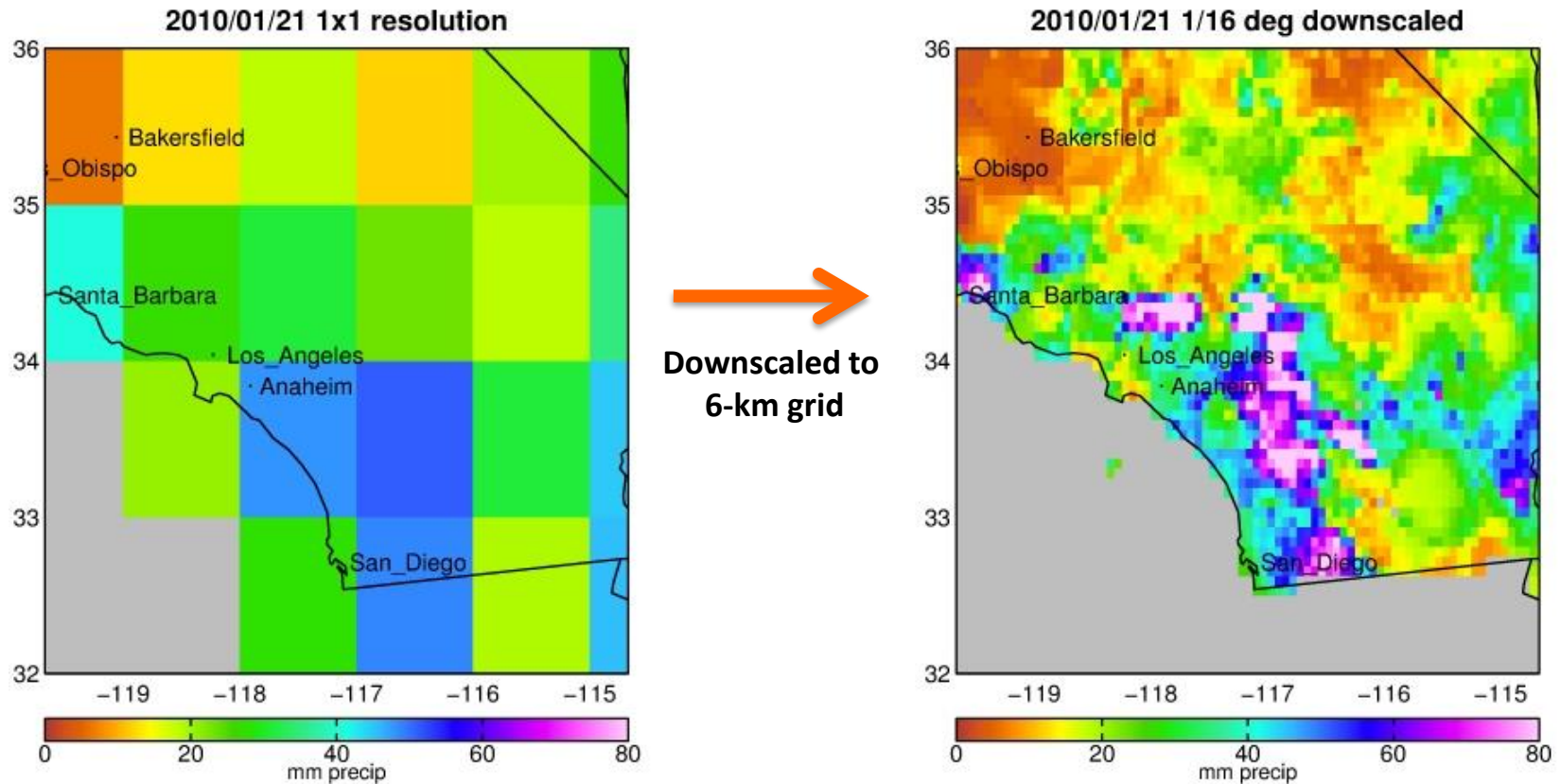
Downscaling

Precipitation from January 21, 2010 storm:



Downscaling

Precipitation from January 21, 2010 storm:



Downscaling resolves regional precipitation features

LOCA: Localized Constructed Analog statistical downscaling (Pierce et al 2014)

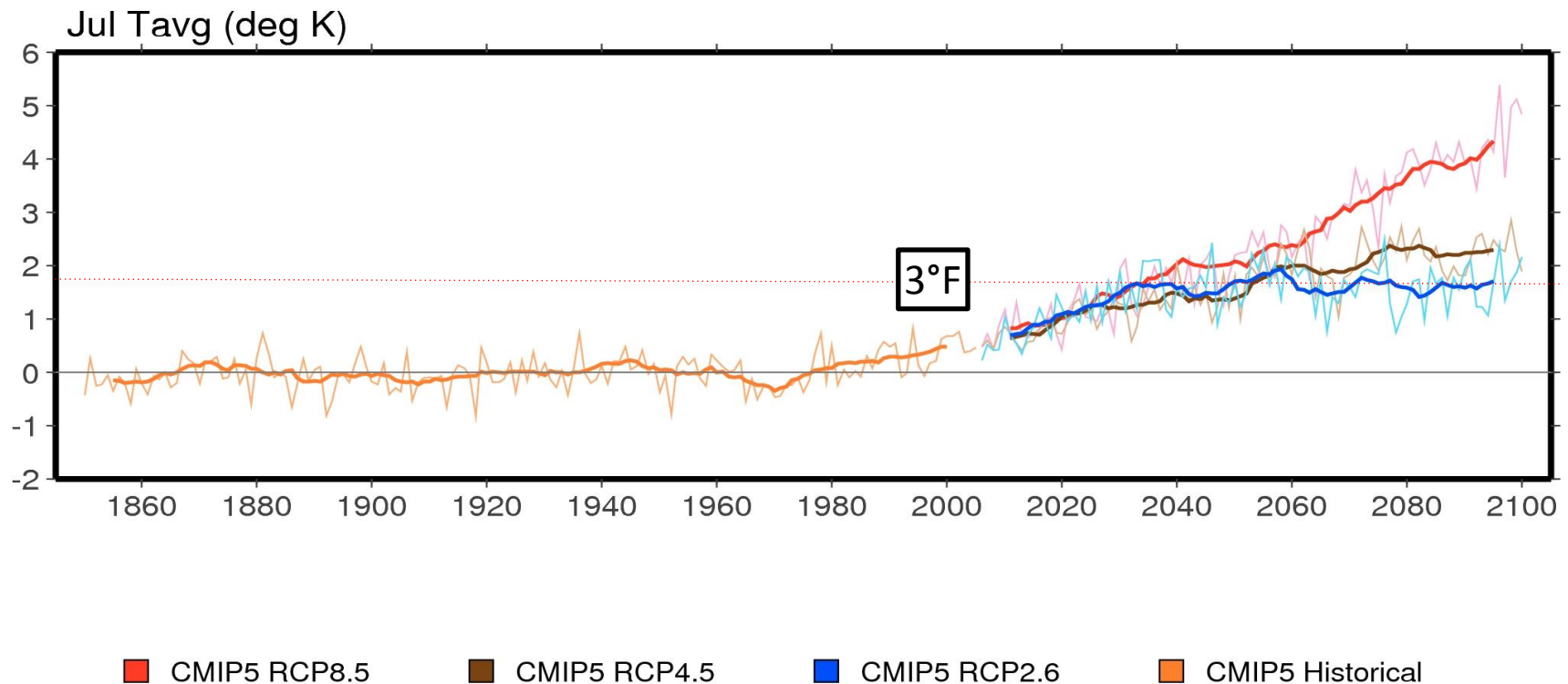
Temperature



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*

CMIP5 (14 models), simulation medians, San Diego, CA
(1961-1990 Historical Mean Removed)



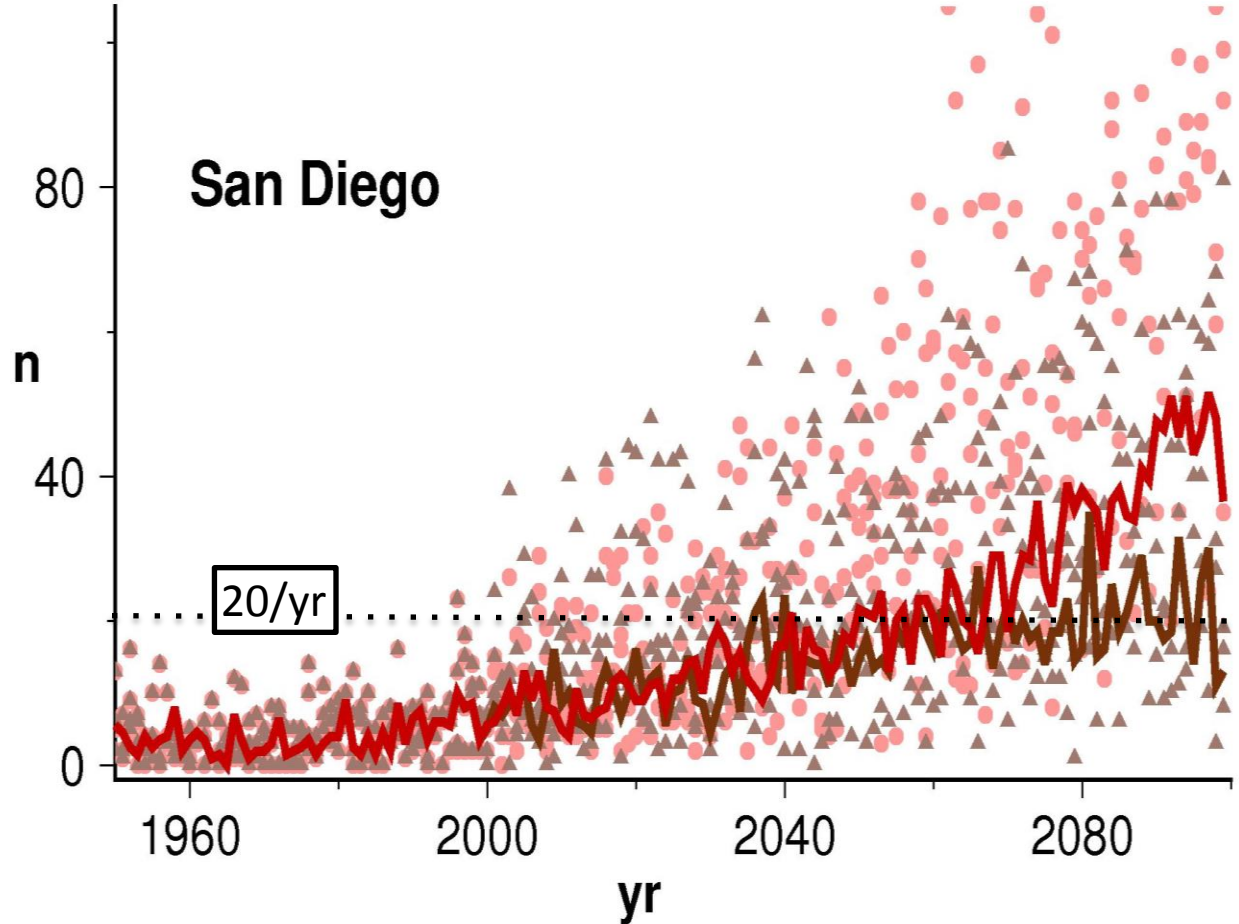
CMIP5 = Coupled Model Intercomparison Project Phase 5

Impacts of Increasing Temperatures: Heat Waves

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.

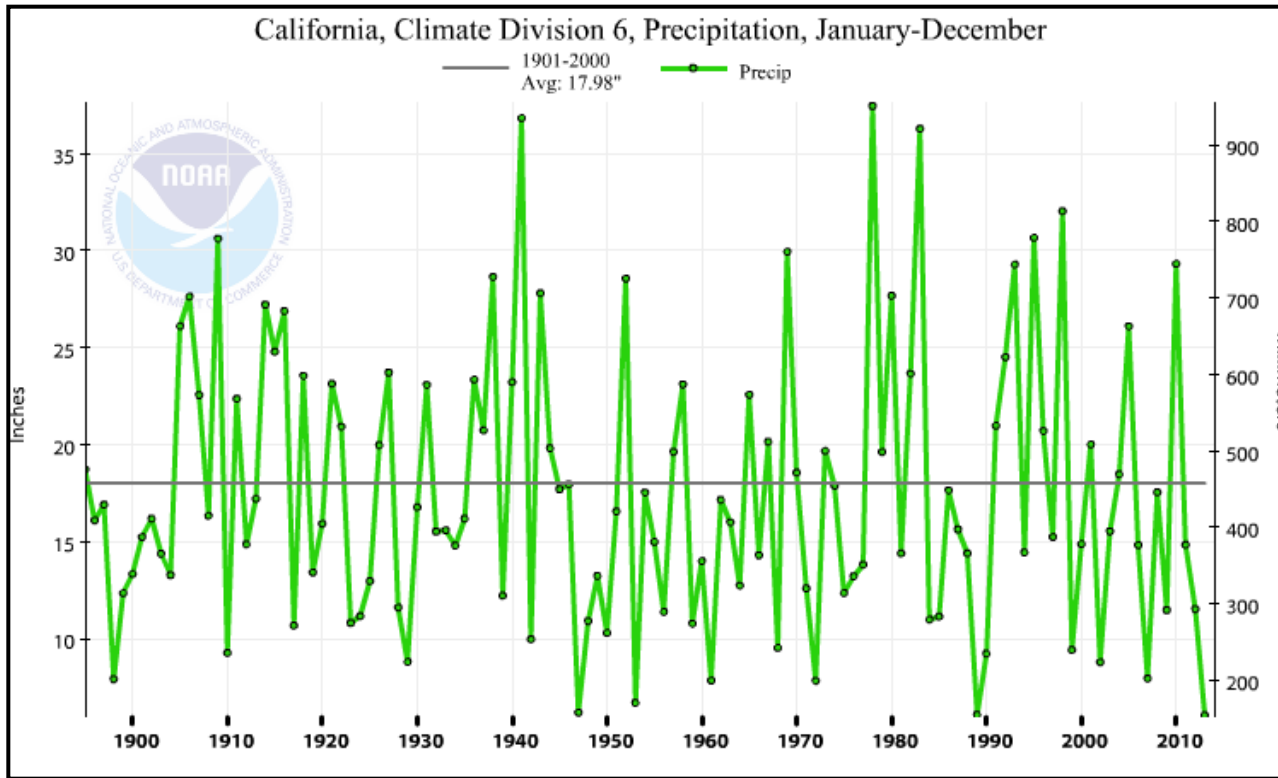


Additionally, most models project more warming at night
=> less nighttime relief during heat wave episodes

Precipitation



Annual Precipitation Time Series: South Coast Drainage



Great year-to-year variability in San Diego precipitation

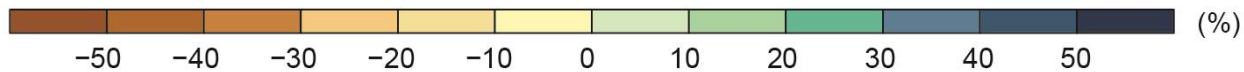
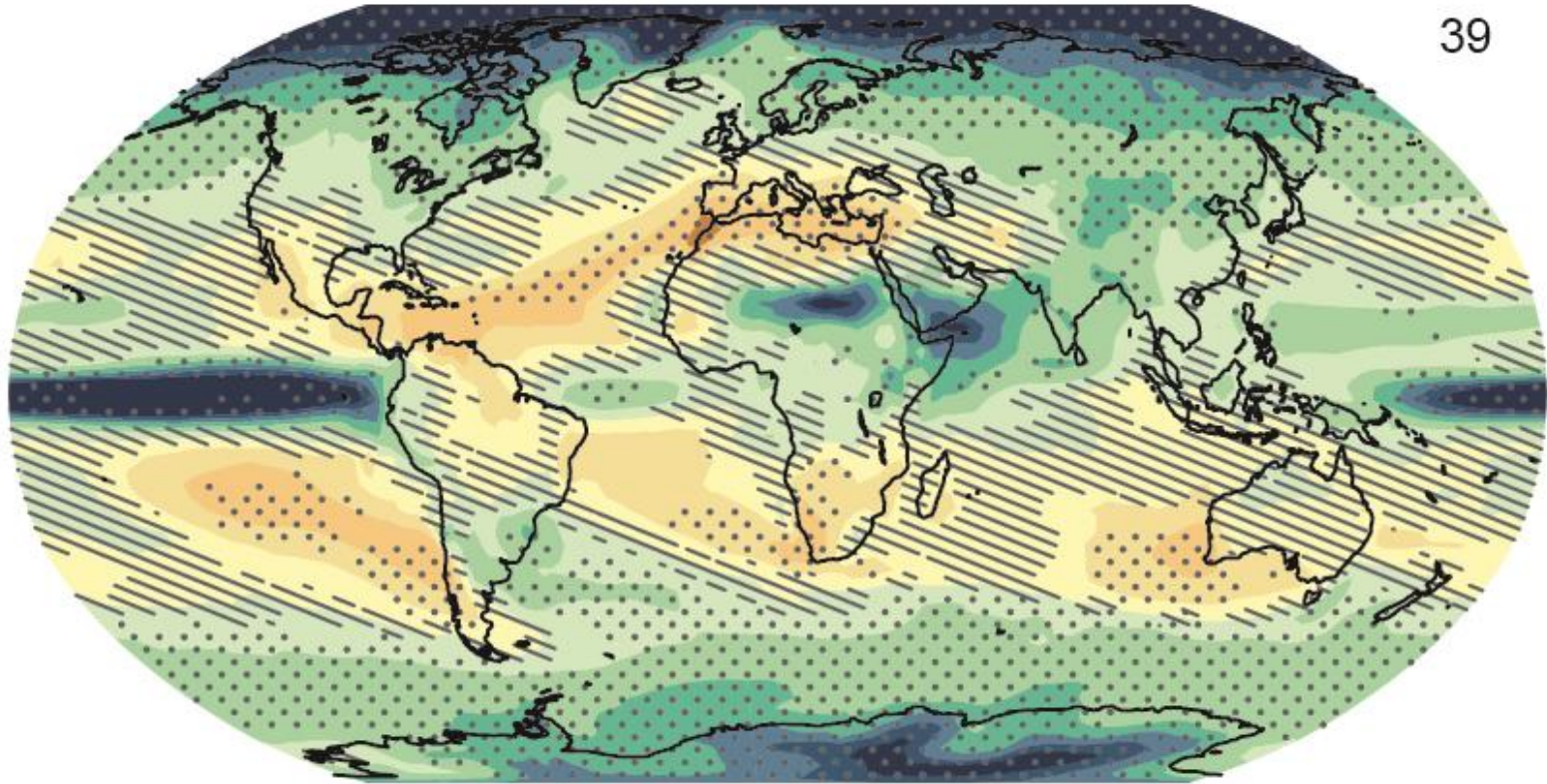
Ranges from ~33% to 200% of average

and, when Southern California is dry--
Northern California is often dry
and the Colorado River drainage is sometimes dry

Projected Change (%) in Average Precipitation (1986-2005 to 2081-2100)

RCP85 – Mean of 39 models

39



Globally, dry regions become drier including the Southwest United States!

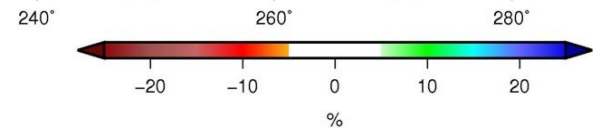
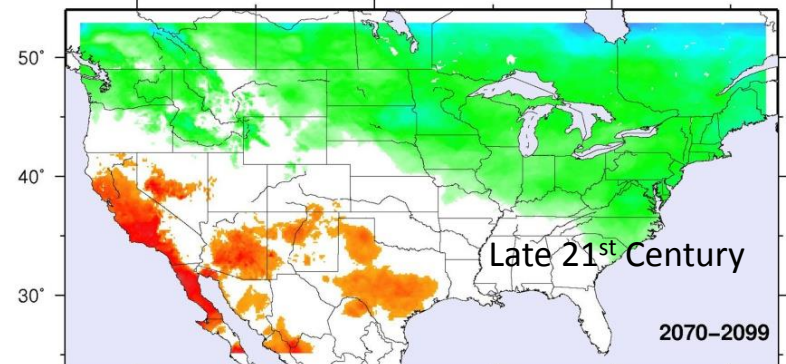
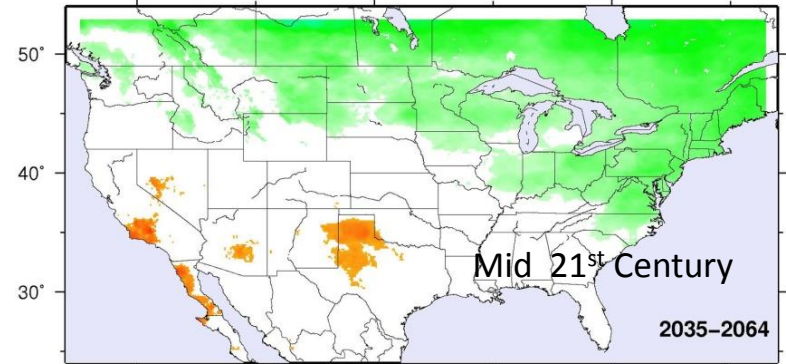
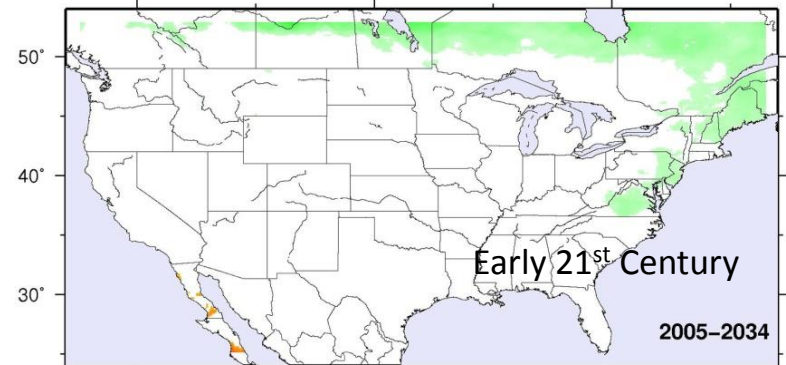
Downscaled Projected Precipitation Change

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

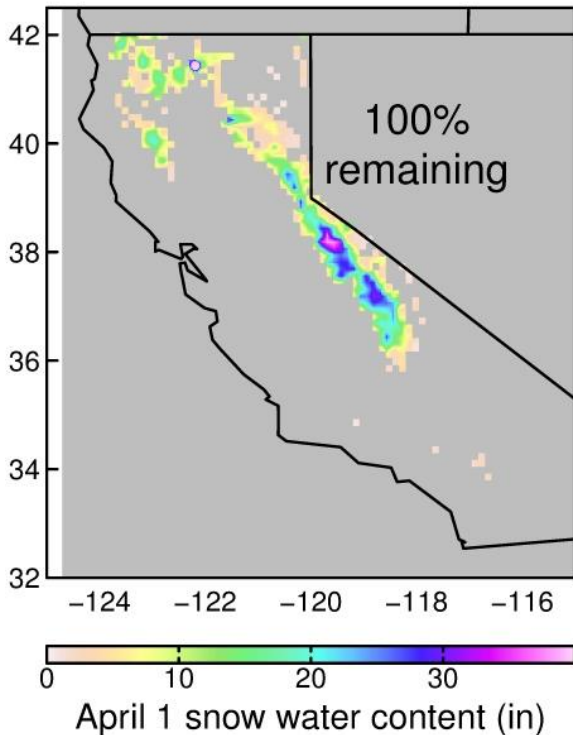
median precip percent of historical (water yr precip) 1961–1990
BCSD 16 SRESA2 + 16 SRESB1 + 16 SRESA1B



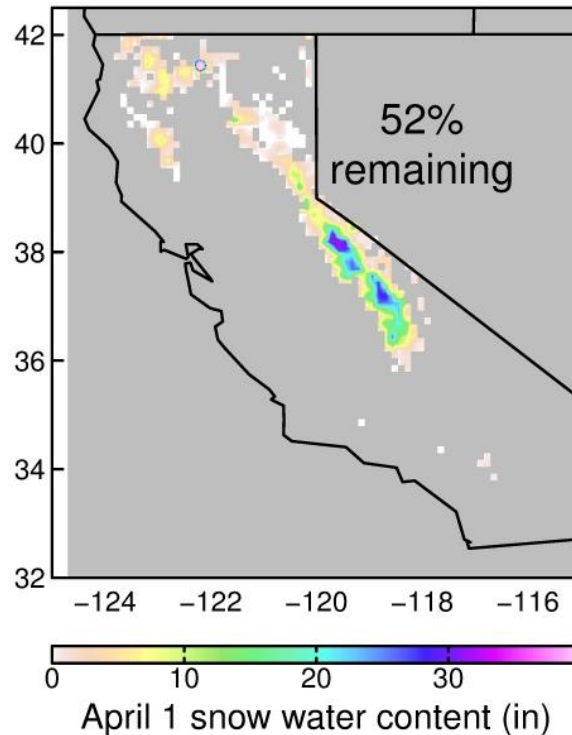
Substantial Decline of California Spring SnowPack from Projected Climate Warming

high or even higher losses by end of 21st Century depending on how much warming

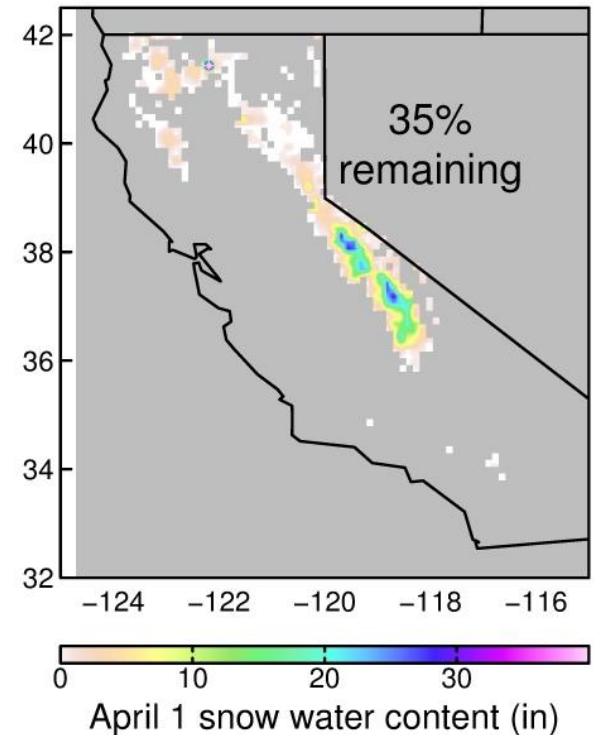
Historical (1961–1990)



Lower warming range (2070–2099)



Higher warming range (2070–2099)



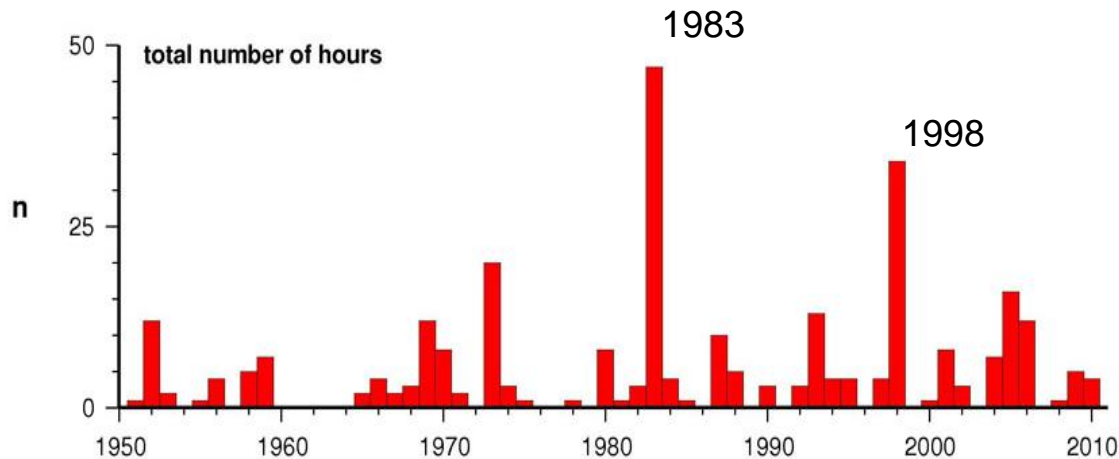
/net/puddle/data/cmip5_BCCA_and_VICed/west_us_BCCA_2012-06-10/plot_future_change_SWE_Apr1_v2.R Fri Dec 14 14:46:43 2012

Sea Level



Extreme sea level occurrences

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



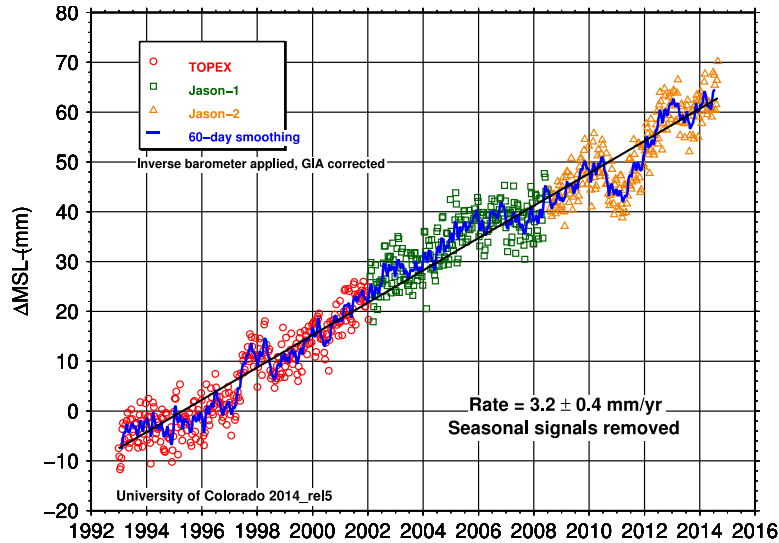
Highest California sea levels have mainly occurred in a few stormy years, especially during large El Ninos (1983 and 1998)

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

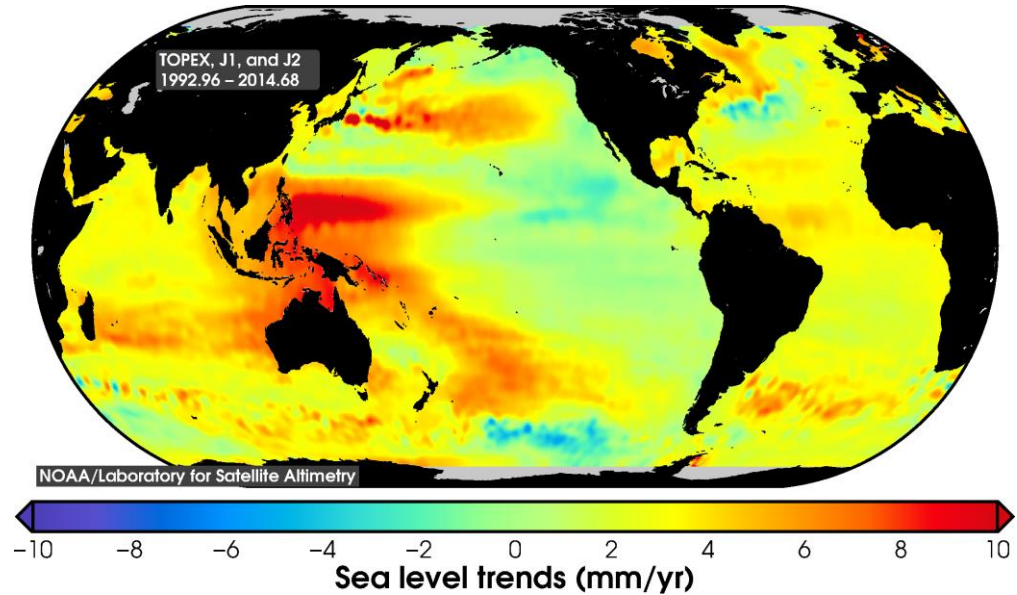
As global sea levels increase, expect number of extreme events to also increase.

Sea Level Rise during Historical Period

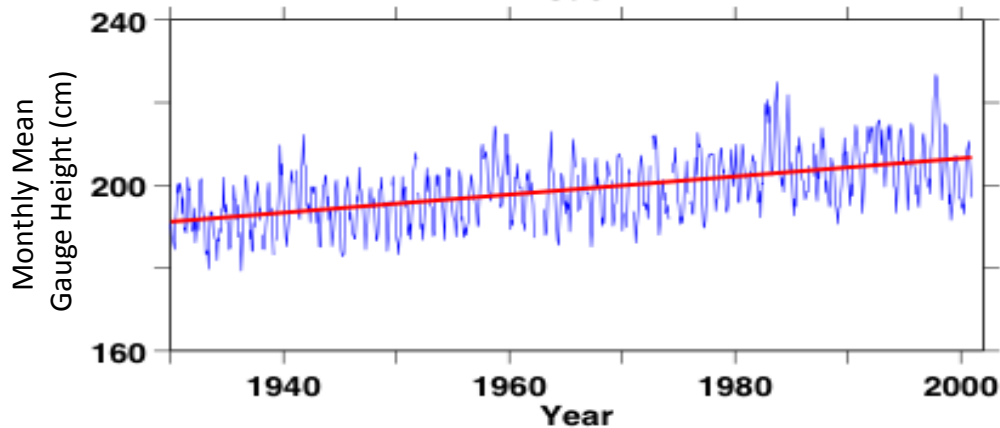
Global Mean from Satellite (1992-present)



Global MSL not evenly distributed



San Diego

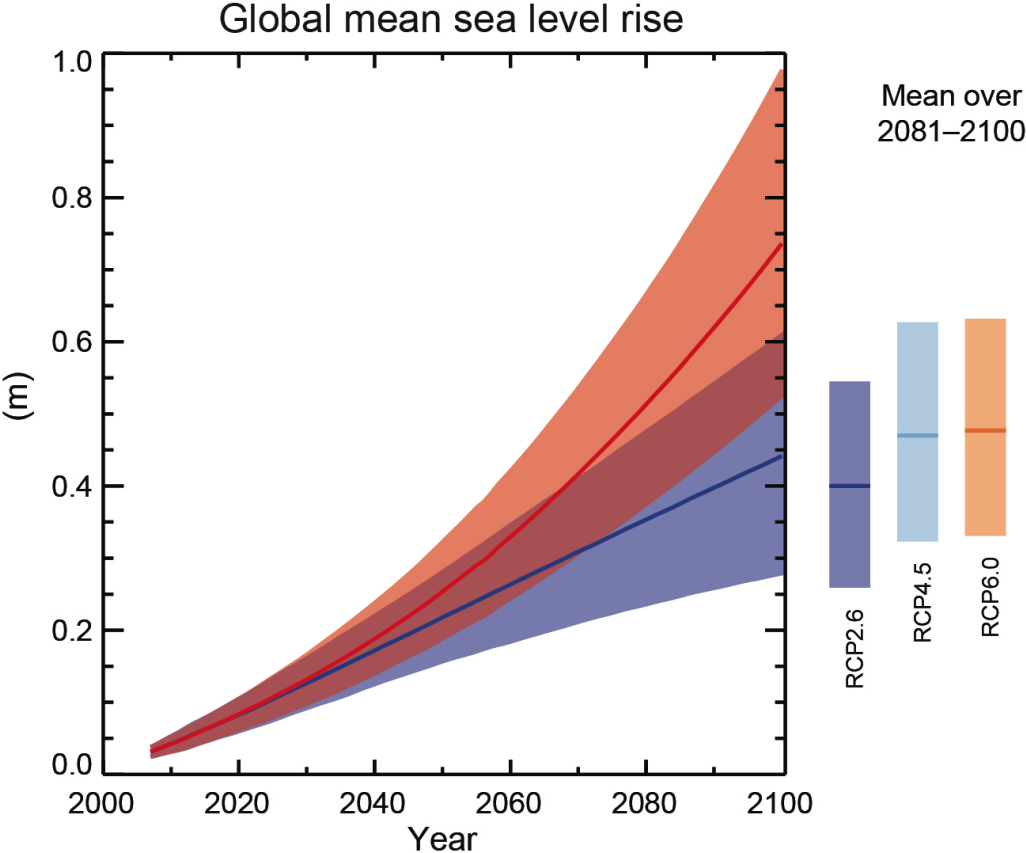


Over most of 20th Century, increasing trend of about 2.2 cm per decade in San Diego

Global Sea Level Projections into 21st Century

IPCC 2013:

Total GLOBAL MEAN rise projected between 0.3 – 1.0 m by 2090-2099

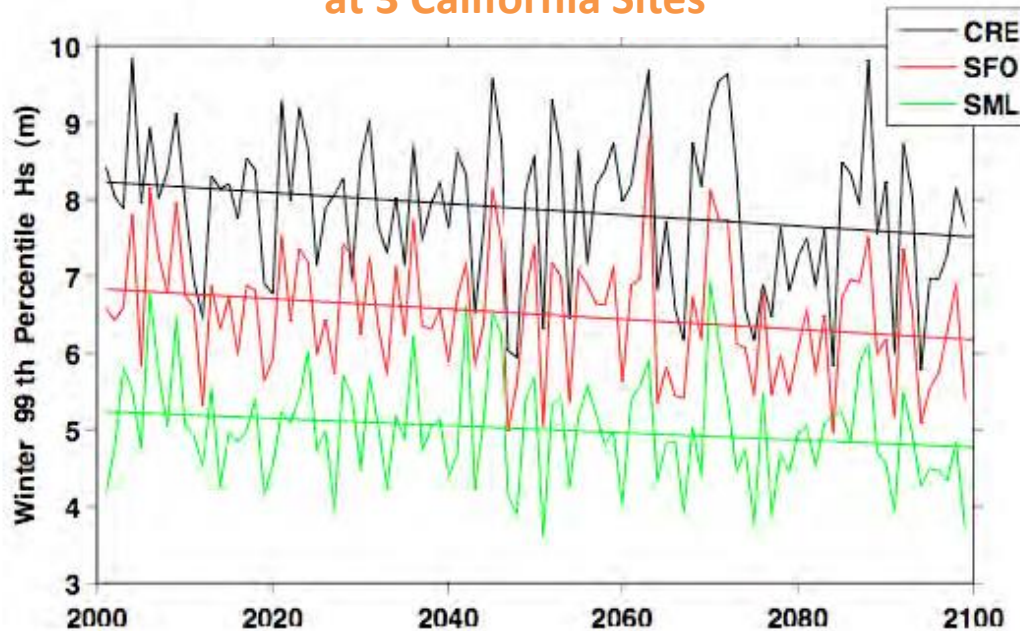


Projections of N Pacific Wave Climate in 21st Century

Method: Force wave model with projections of surface wind from coupled climate models. Examine wind and wave height statistics.

Study: Cayan et al, 2009 focused on California

99th Percentile of Significant Wave Height at 3 California Sites



Notable decreasing trend in extreme waves along California coast
=> due to poleward shift of storm track
and/or decreased wind speeds

Also, significant decadal variability

Wavewatch III forced with NCAR CCSM3 model winds

Extreme Sea Level Events

Despite projected decrease in extreme storm frequency, extreme sea level events are projected to increase due to rising global sea levels.

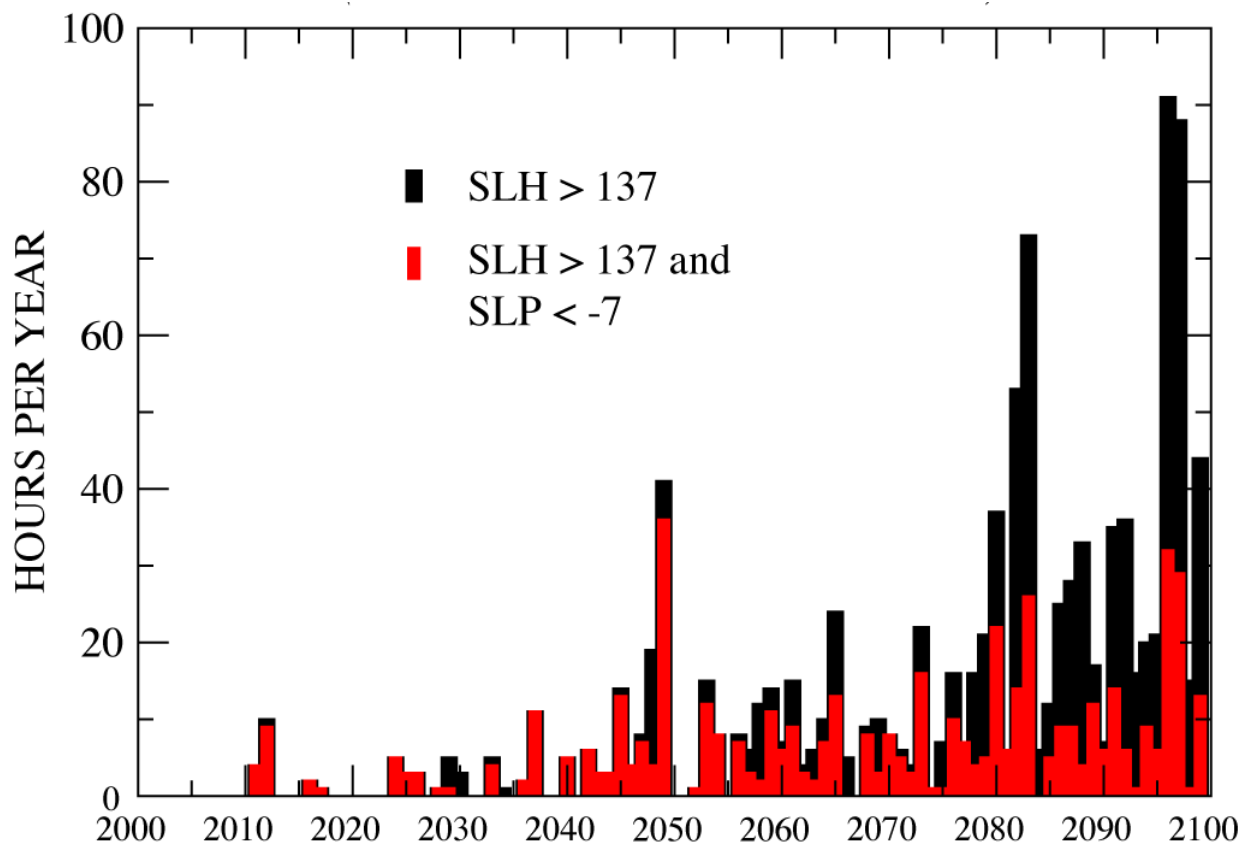


Figure 5. Projected total exceedances of San Francisco hourly sea level height (SLH) above historical 99.99 percentile (black), and number that are coincident with sea level pressure anomalies less than -7mb. Projected sea level from GFDL model weather and Nino3.4 SST with a linear trend of 30cm over 2000-2100. (Cayan et al. In Review)

Summary



- California has a dry, volatile climate. Southern California's water supply is vulnerable to weather extremes
- Warming is already underway and more is expected to come. Projected local impacts include increased heat waves and wildfires
- While not unanimous, most model projections point toward reduced precipitation in Southern California
- Reduced snowpack in Sierras would further exasperate California's water supply problems
- Sea level rise is likely to continue resulting in increasing frequency and duration of extreme water level events