California 4th Climate Change Assessment Climate Projections

David Pierce, Julie Kalansky, Dan Cayan

Scripps Institution of Oceanography, UC San Diego

January 16th, 2019
CEC Webinar

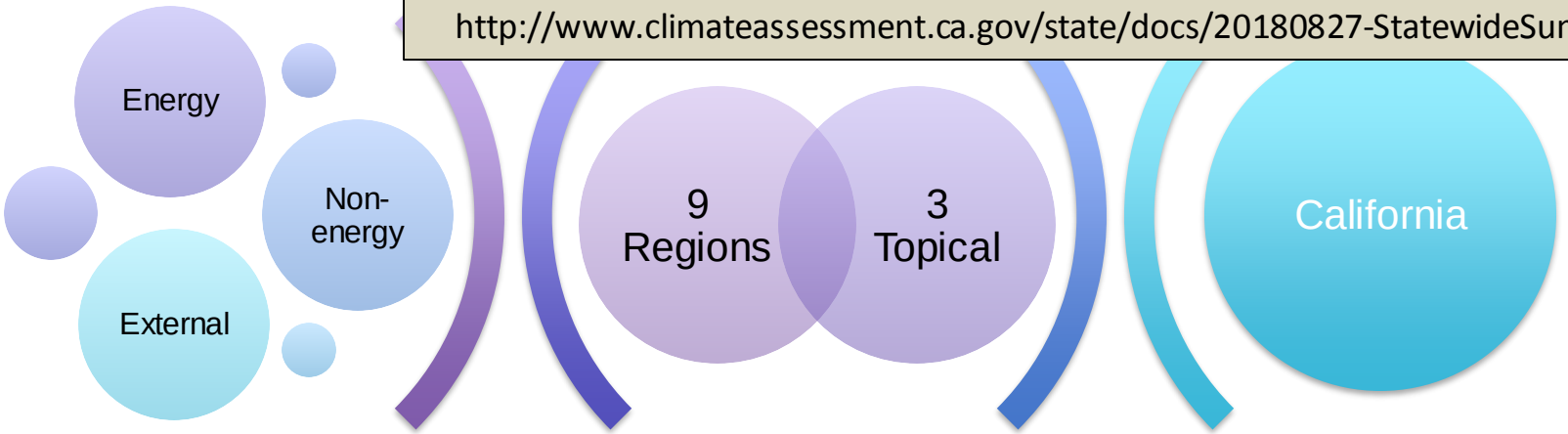
Sponsors:

California Energy Commission (CEC)
NOAA via CNAP RISA
USGS/DOI via SW Climate Science Center
U.S. Department of Energy
US Army Corps of Engineers/ US Bureau of Reclamation

CA 4th Climate Change Assessment

www.climateassessment.ca.gov/

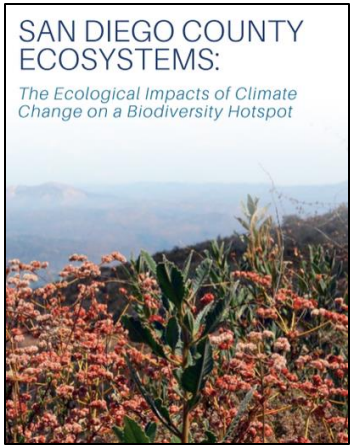
overview:
http://www.climateassessment.ca.gov/state/docs/20180827-StatewideSummary.pdf

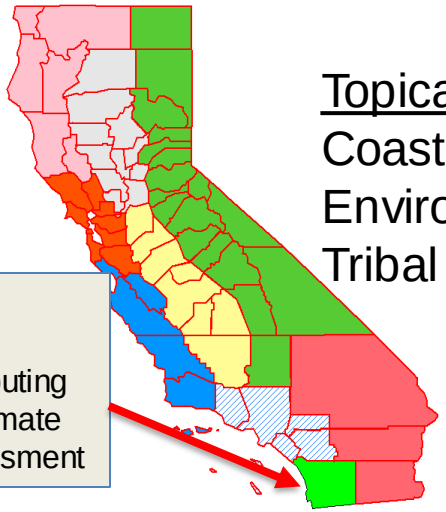


Technical Reports

Regional and Topical Synthesis Reports

Statewide Summary Report





San Diego is one of nine regions contributing a Regional Climate Change Assessment

Topical
Coastal
Environmental Justice
Tribal

The Climate Scenarios Report

David Pierce, Julie Kalansky and Dan Cayan
Fourth California Fourth Climate Change Assessment, 2018

CLIMATE, DROUGHT, AND SEA LEVEL RISE SCENARIOS FOR CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT

A Report for:

California's Fourth Climate Change Assessment

Prepared By:
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Daniel R. Cayan[1]

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Scripps Institution of Oceanography, La Jolla, California

Daily temperature and precipitation over California at a resolution of 1/16° (about 6 km, or 3.7 miles) were generated to support climate change impact studies for the energy system and other sectors featured in the California's Fourth Climate Change Assessment. The data, derived from 32 coarse-resolution (~ 100 km) global climate models (GCMs), were bias corrected and downscaled Localized Constructed Analogues (LOCA) statistical method. The data cover 1950-2005 torical period and 2006-2100 for two future climate projections using medium and high se gas and aerosol emissions scenarios. Statewide, temperature is projected to increase 2- ium emissions scenario) to 4-7 °C (high emissions scenario) by the end of this century. on shows fewer wet days, wetter winters, drier springs and autumns, and an increase rs as well as maximum precipitation in a single day.

s that closely simulate California's climate are identified for studies where all 32 GCMs used. Additional variables were downscaled for these 10, including wind speed, d relative humidity, and surface solar radiation. Four models that span the temperature pitation changes from the 10 are identified for studies that cannot accommodate the 10. ed shows small decreases, while relative humidity changes are more complicated, with reases but decreases inland. Surface solar radiation shows small Southern California n spring.

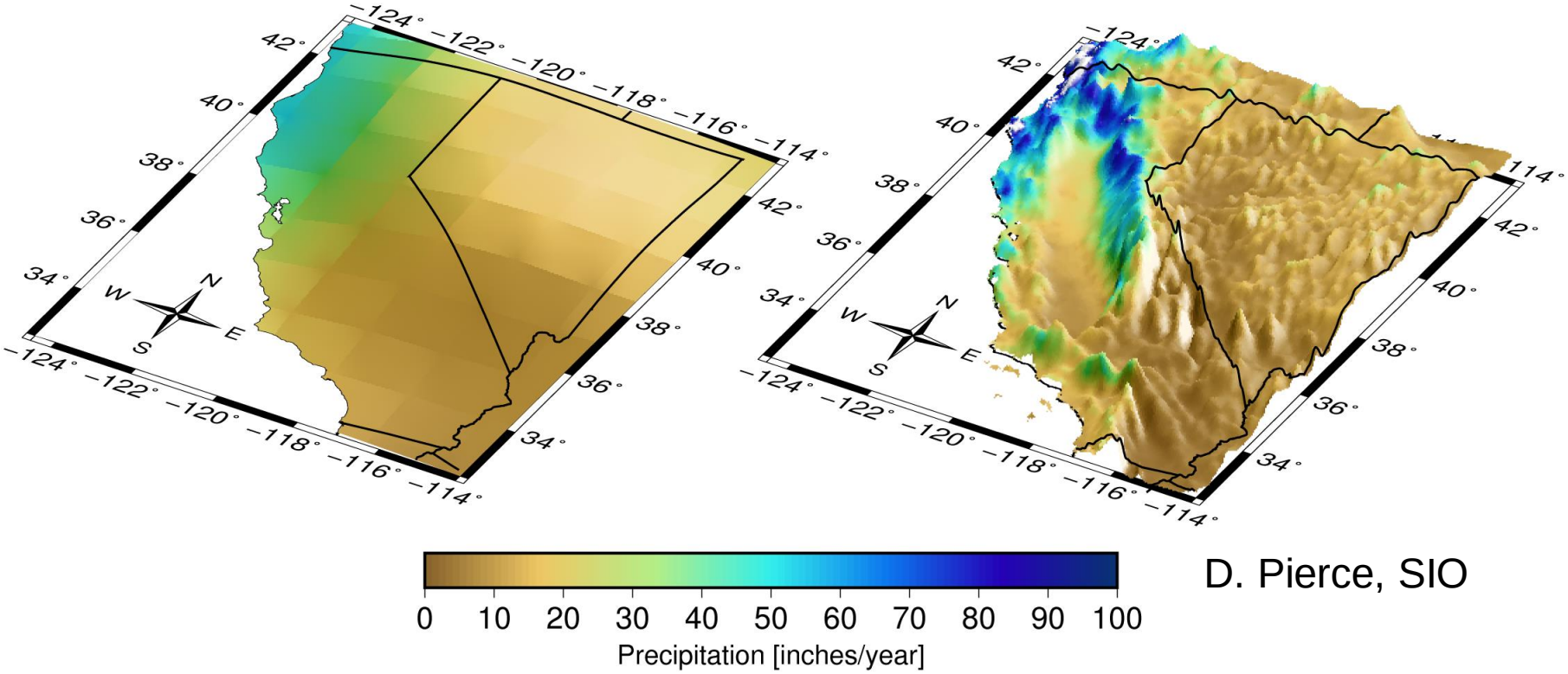
scaled fields were applied to the Variable Infiltration Capacity (VIC) land surface model snow cover, soil moisture, runoff, water loss from plants, surface heat fluxes, and other s. Moisture deficit is projected to increase over much of the state, particularly Northern and the Sierra Nevada, while top level soil moisture is projected to decrease, ly in Southern California. Most streamflows shift to earlier in the year, with the bigger erienced in basins which currently have substantial contributions from snowmelt.

Two versions of a 20-year dry spell were identified from one of the GCM simulations to investigate future drought: the original episode from 2051-2070, and one shifted earlier in the century with temperatures consistent with 2023-2042. For both, we provide downscaled temperatures and precipitation along with VIC hydrological output.

Sea level rise (SLR) projections for California were generated using a probabilistic approach employing estimates of the components that contribute to global and regional SLR, including new science on the possibility of increased contribution from Antarctica. Hourly projections of sea level at selected coastal locations were generated out to 2100 that include tides, regional and local weather influences, and short period Pacific climate fluctuations along with the aforementioned sea level rise scenarios.

The climate scenario and SLR data are available online from cal-adapt.org.

Downscaling

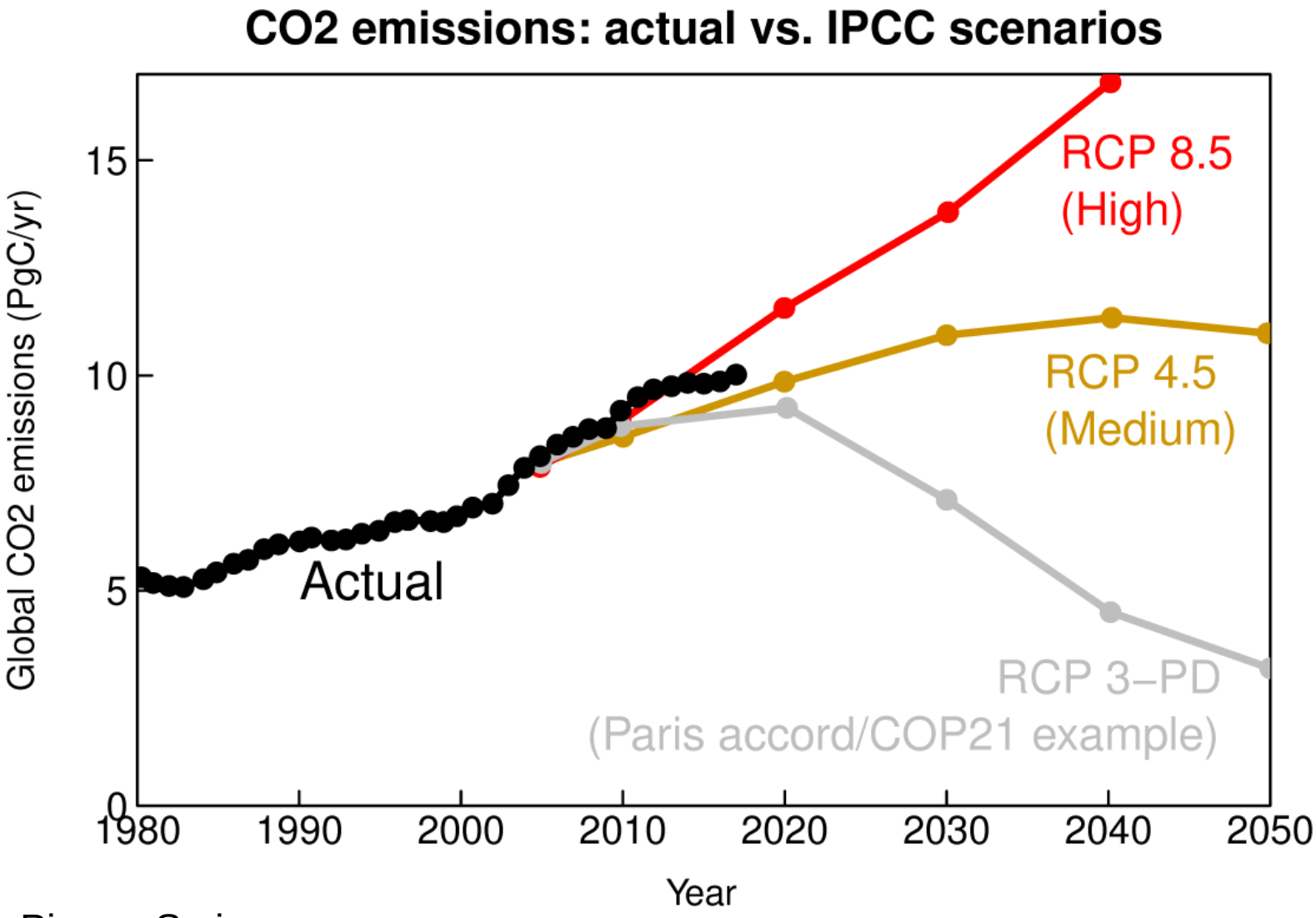


D. Pierce, SIO

Tmax
Tmin
Precipitation
Winds
Humidity
Solar Radiation

Soil Moisture
Run-Off/Recharge
Snow Water Equivalent
Landscape drying

Greenhouse Gas Scenarios



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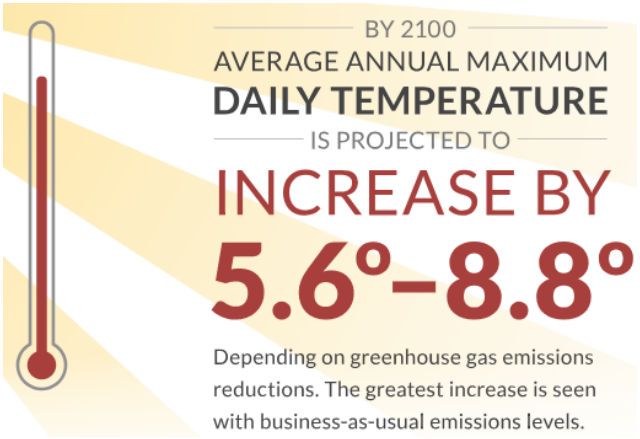
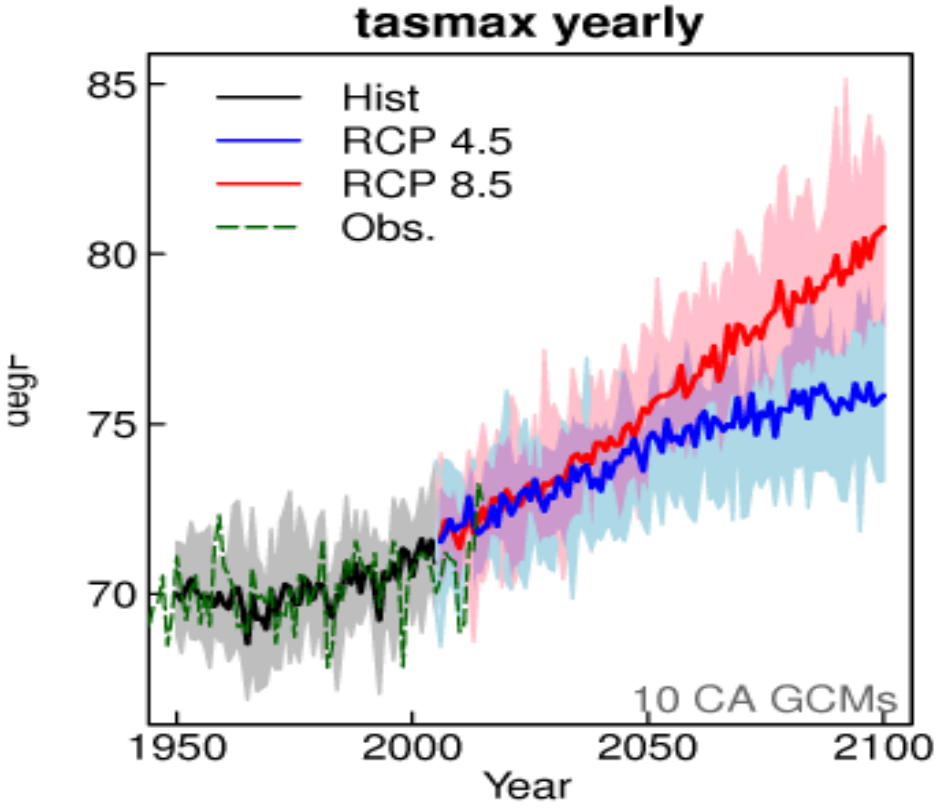
Redrawn from Peters et al., Nature Climate Change, 2013

Temperature is Projected to Rise Substantially

but wide range in possible outcomes

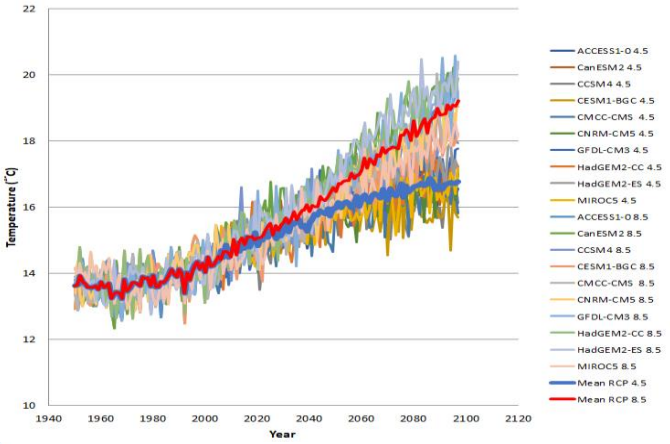
The Fourth Assessment Scenarios were based primarily upon 2 RCPs and 10 GCMs which were found (DWR CTAG) to provide a reasonable representation of California's climate, particularly for water resource related phenomena

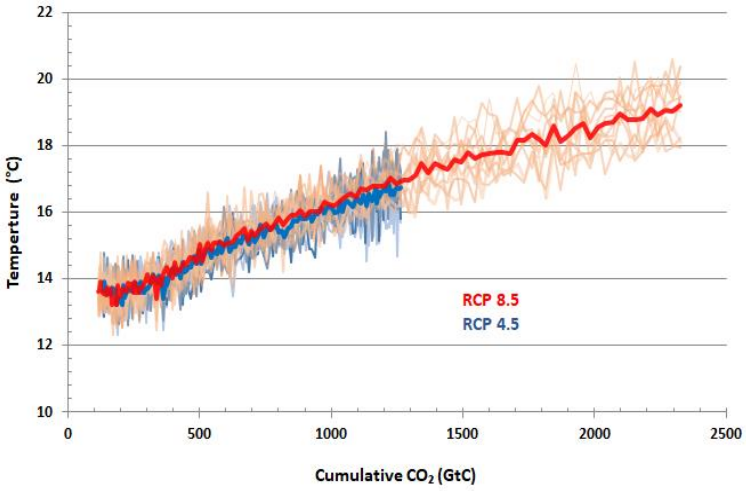




Cumulative Global Carbon Dioxide Emissions and Impacts in California

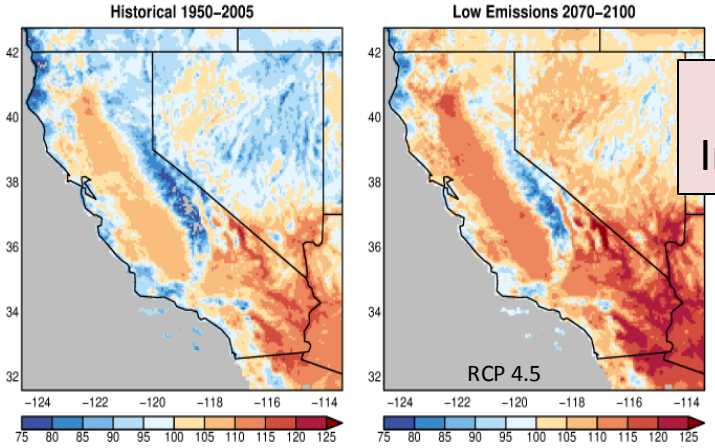
- Robust relationships found between <u>global</u> cumulative CO_2 emissions and physical impacts in California.
- This feature could be used to estimate climate impacts in California under new global emission scenarios.





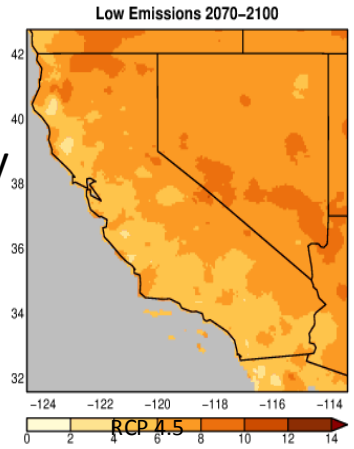
Franco et al. 2018 , California Fourth Assessment Report
"Cumulative CO2" contribution to technical reports

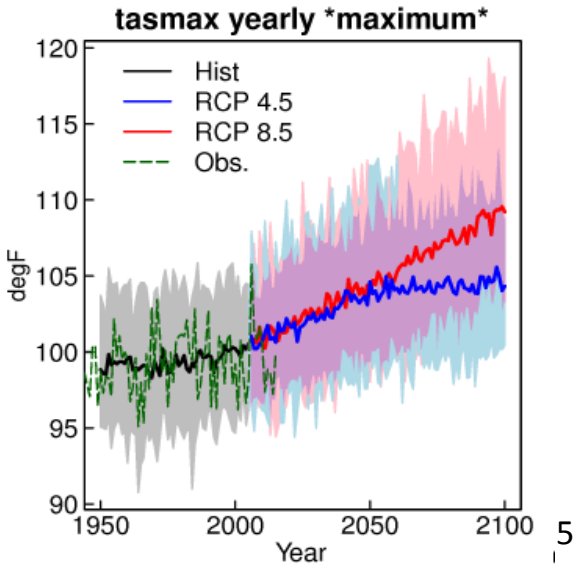
Hottest day of the year, historical vs. end of century (deg F):



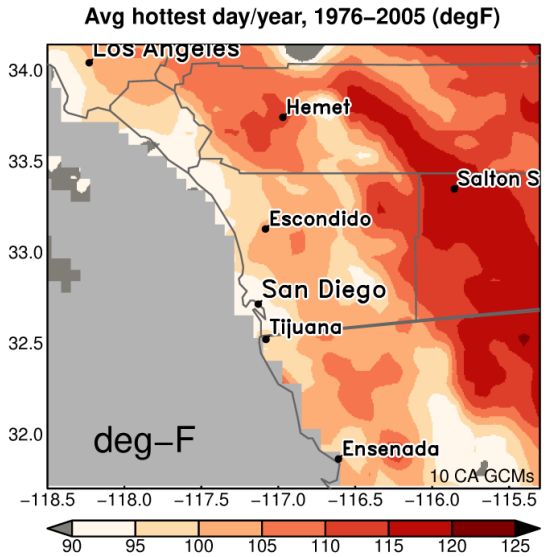
and, intensity of heat waves
Increases (RCP 4.5, 10 model average)

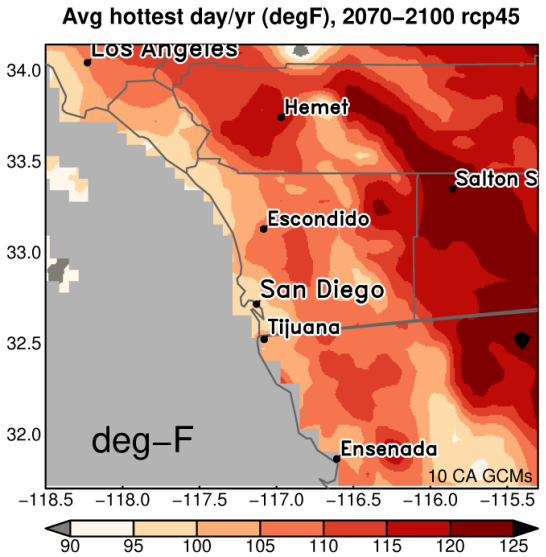
Change in hottest day of the year (deg F):

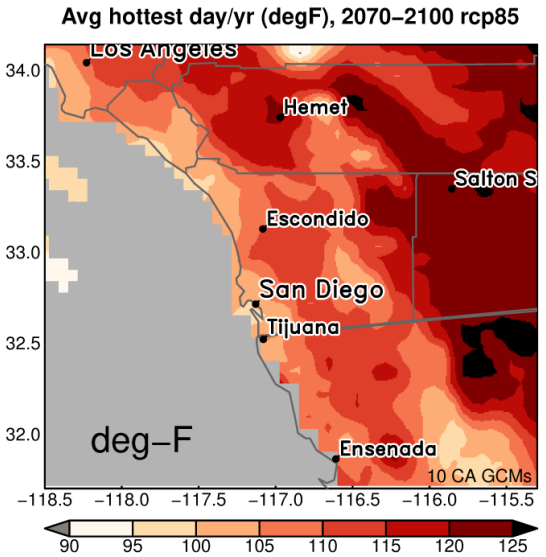




Heat Waves Intensity Will Increase







Heat wave *FREQUENCY* will also increase

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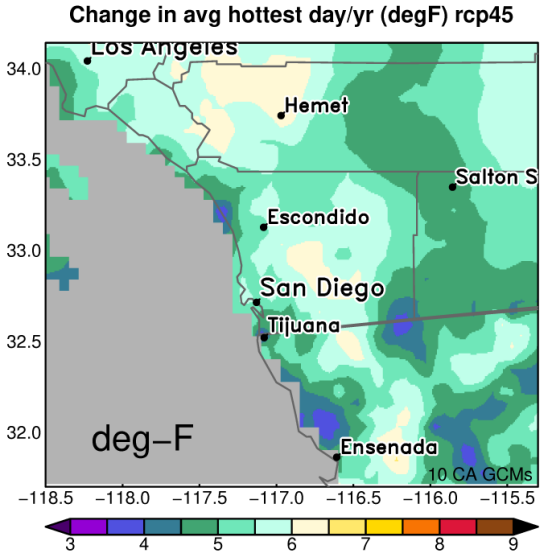
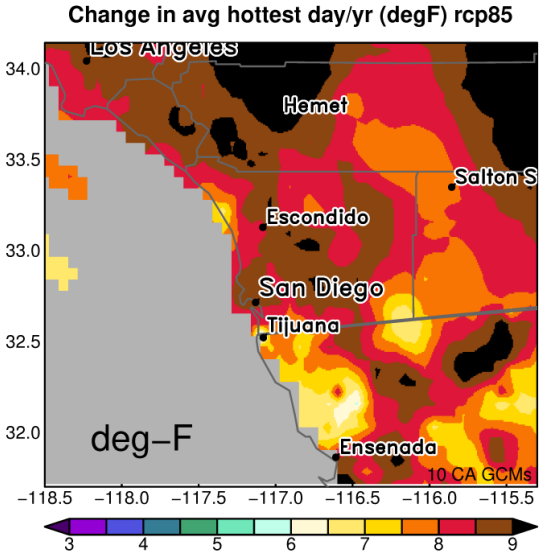
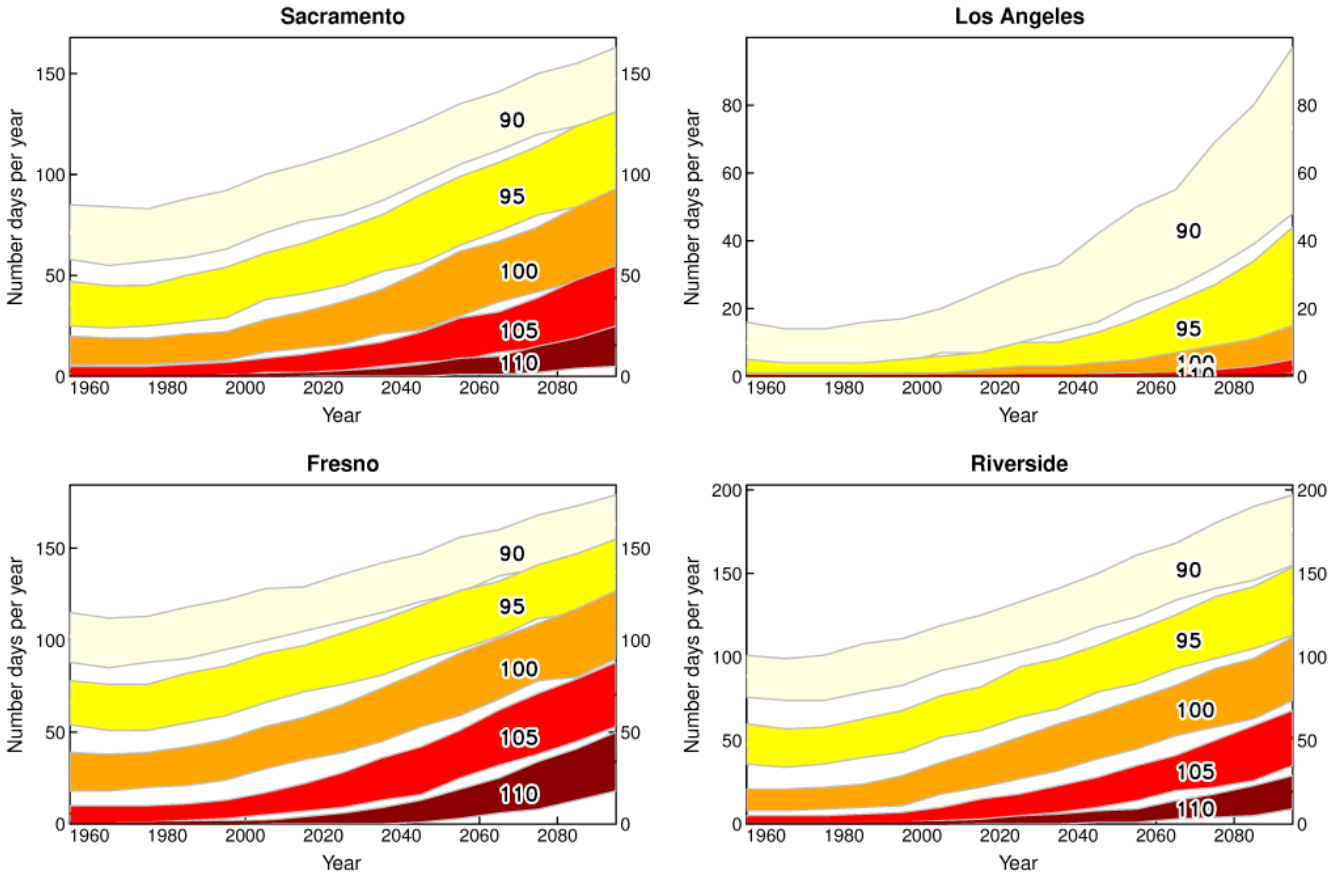




/net/loca/CA_NV_2016–04–02/california_atlas/Region_San_Diego_Ensenada/avg_highest_day_year_tasmax_v2.R Tue Jun 26 12:37:25 2018

Range of Number of Days/year >= threshold (deg F): RCP 8.5

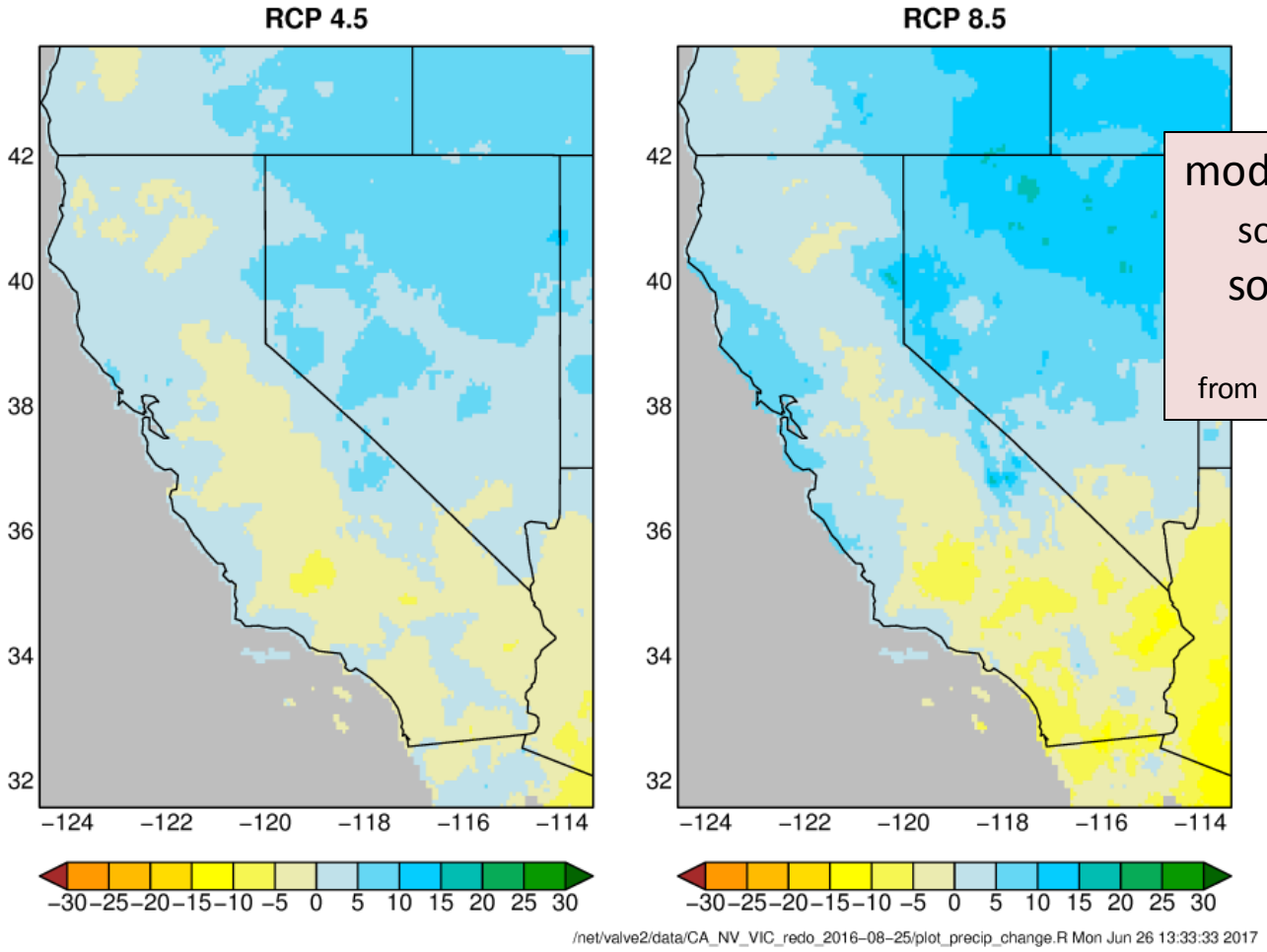
(range encompasses 2/3rds of years)



David W. Pierce, Scripps Institution of Oceanography

Figure 6

Change in annual precip [%], 2070–2100 w.r.t. 1950–2005



models suggest:

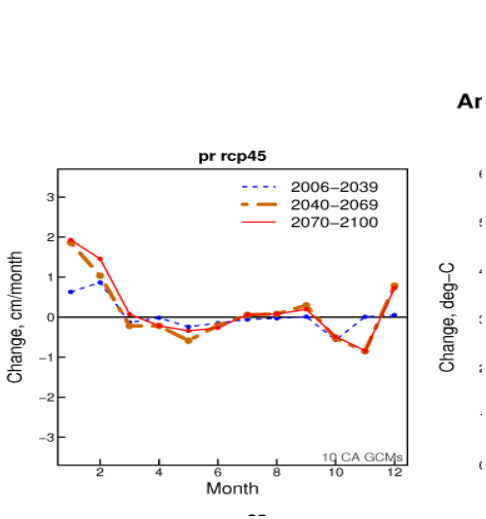
somewhat wetter NoCal

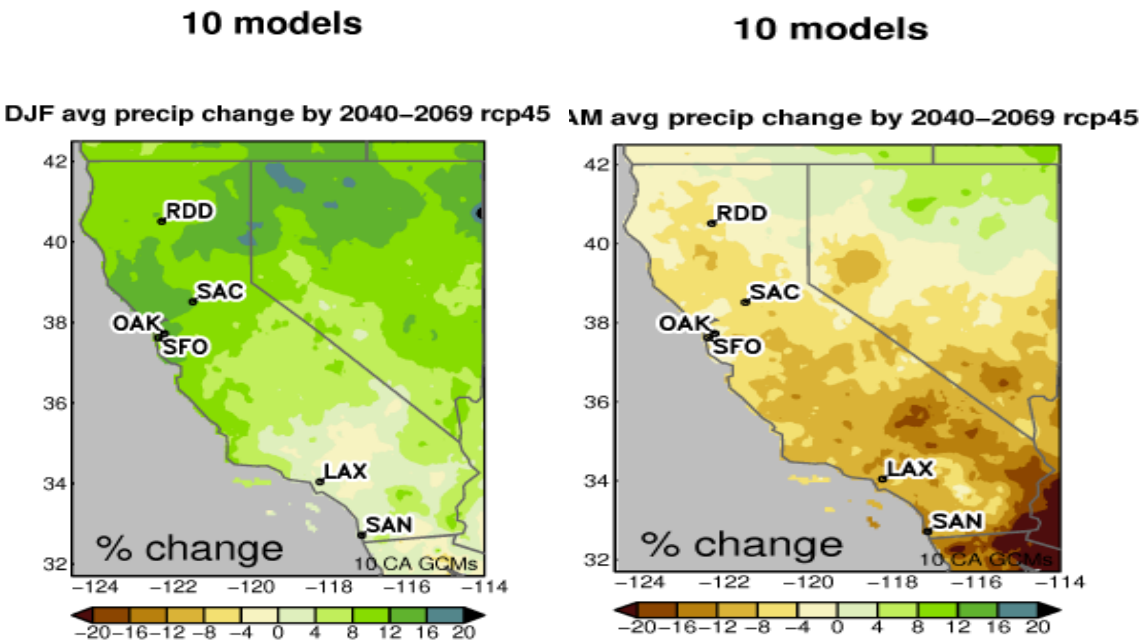
somewhat *drier* SoCal

from 32 CMIP5 GCMs downscaled w LOCA

Wetter Winter but Drier Springs – A Shorter Wet Season

- Projected Precipitation Increase in Dec-Feb, Decrease in Mar-Apr (MAM) 10 LOCA downscaled RCP4.5 GCMs mid-21st century

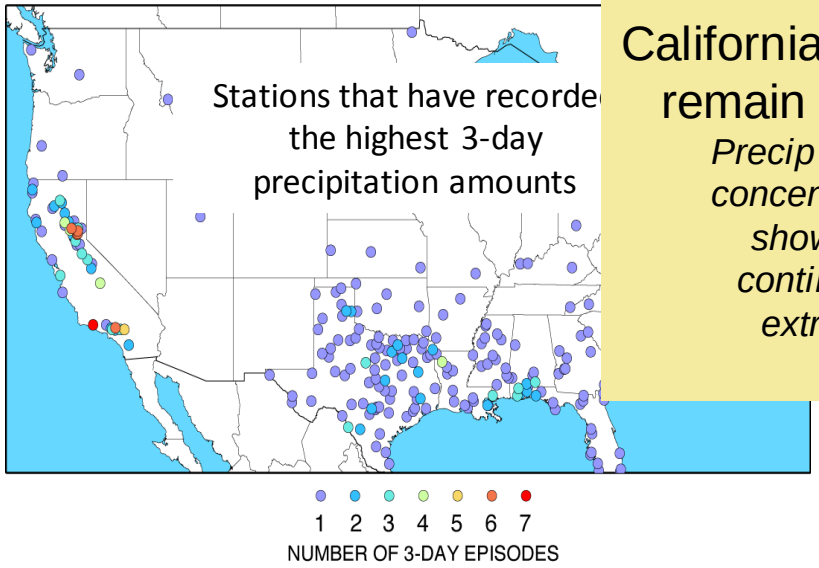




PLAN FOR HIGH VARIABILITY

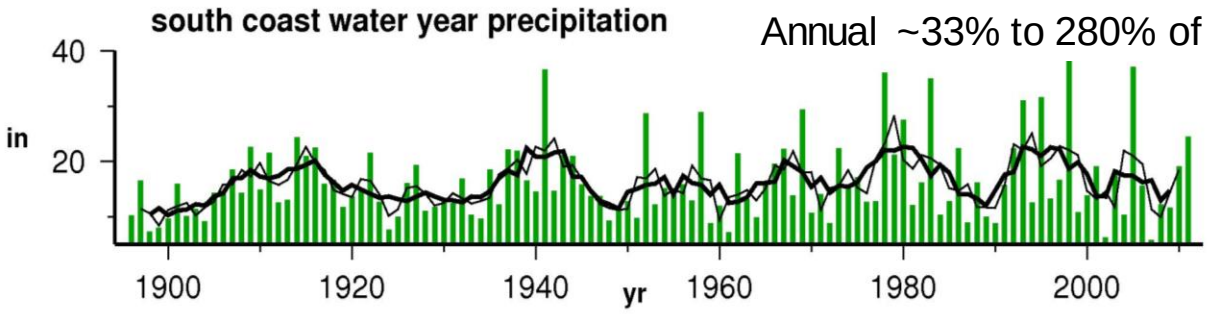
California Precipitation probably will remain extremely variable

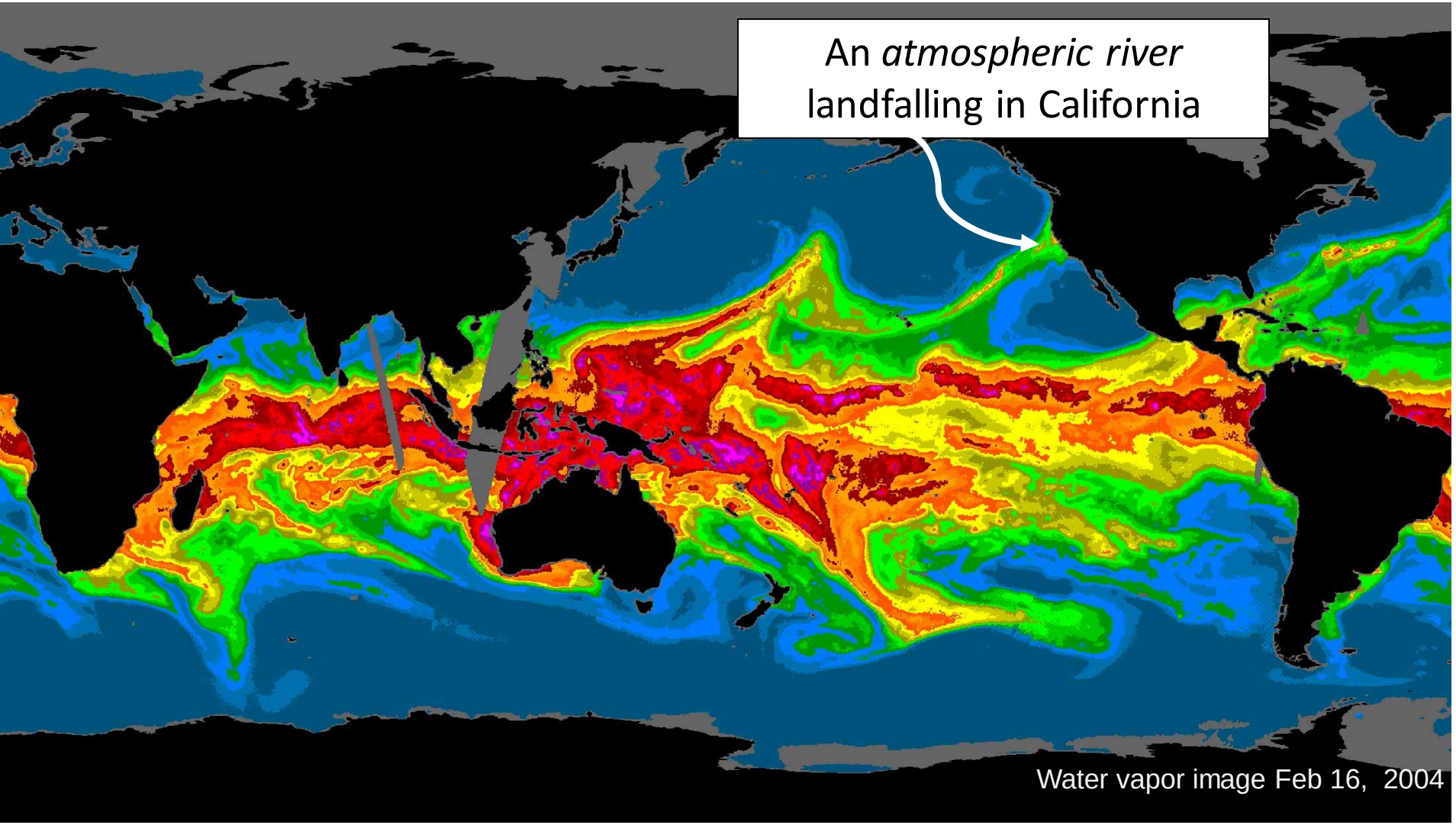
Precip change uncertain
concensus of CMIP5 models
shows little change in NoCal
continued potential for
extremely heavy events



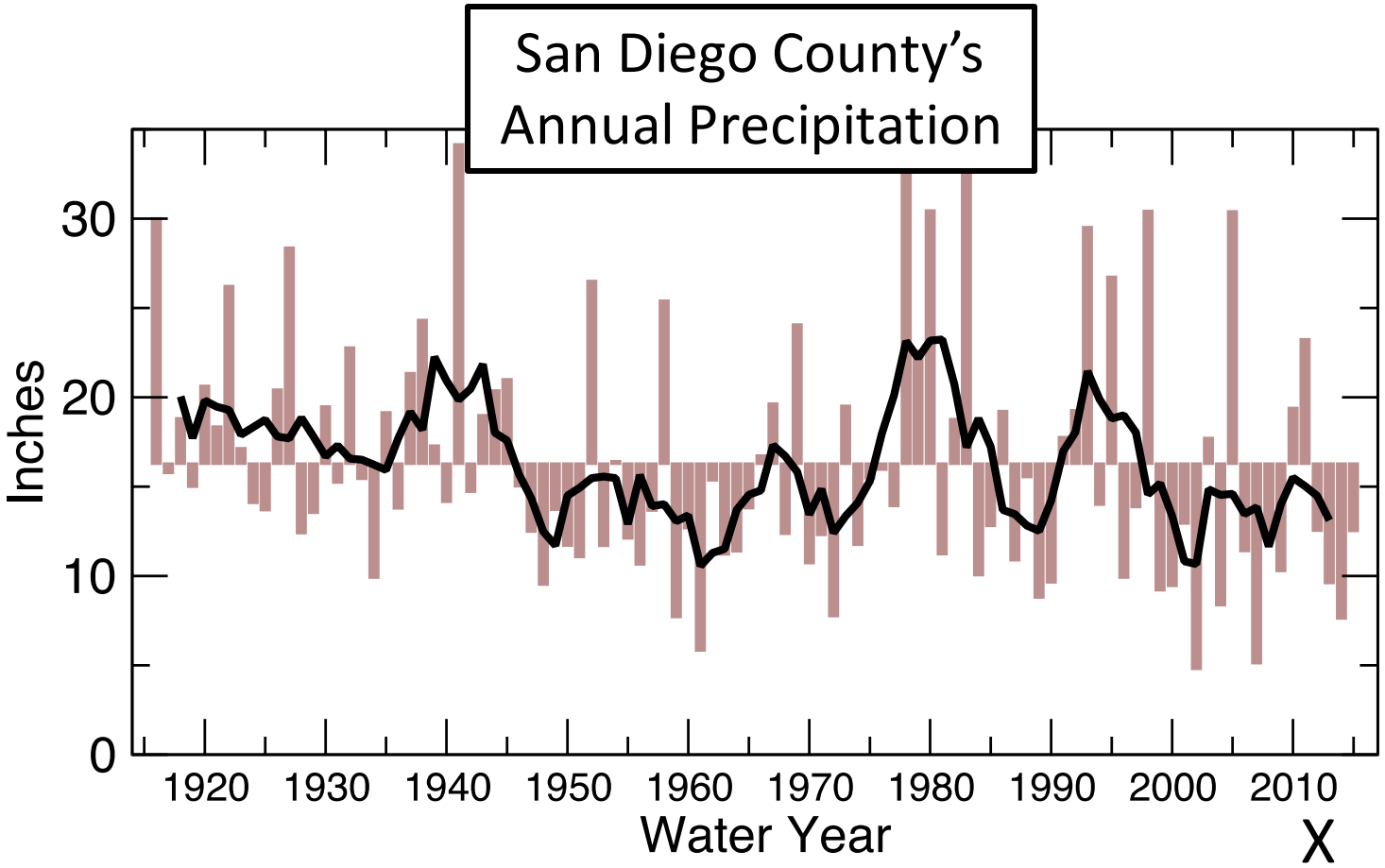
Great year-to-year variability

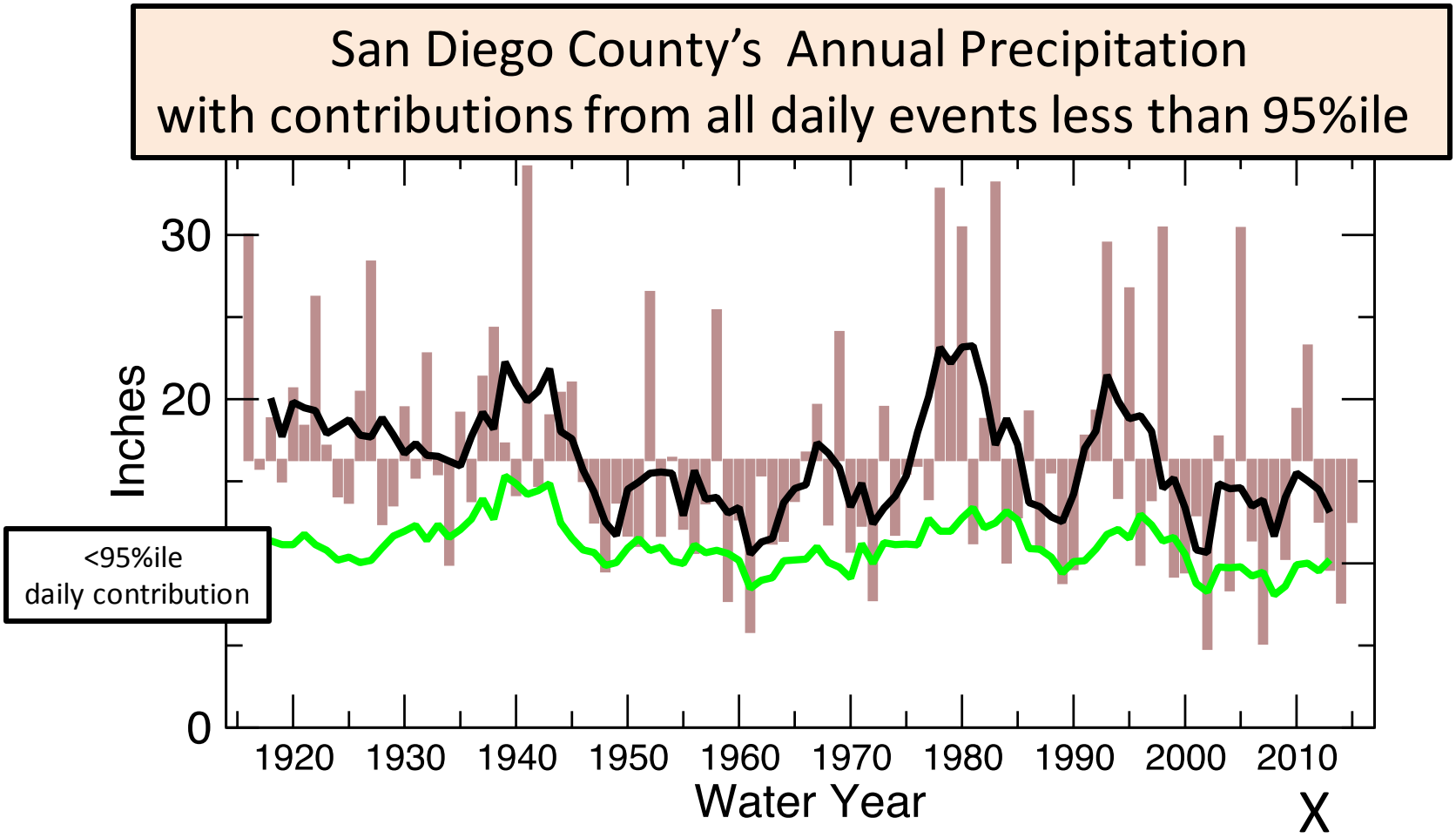
Annual ~33% to 280% of average

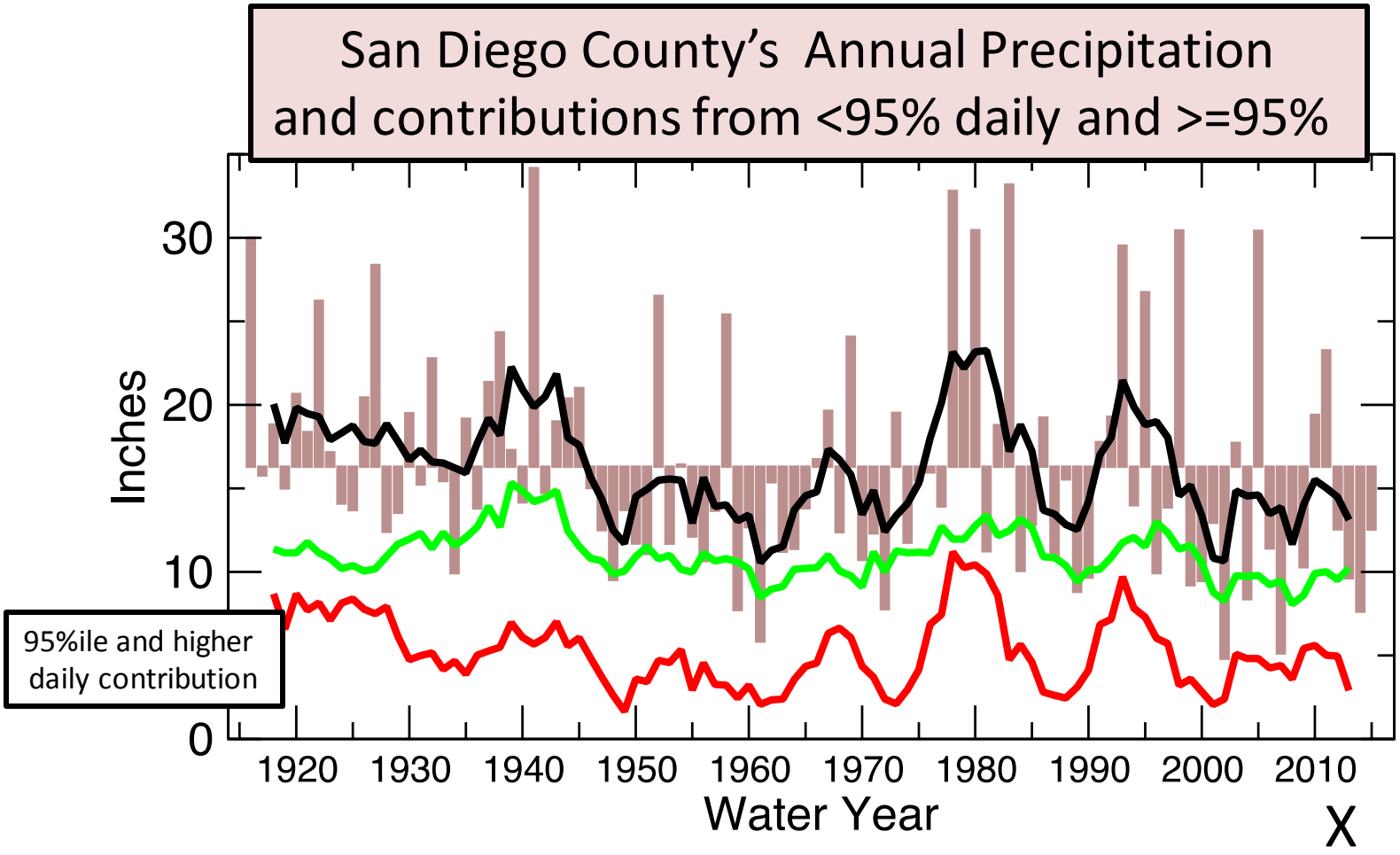



An *atmospheric river*
landfalling in California
Water vapor image Feb 16, 2004


Feb 28, 2017
Mission Valley
ROAD
MAY
FLOOD
Photo Credit: Richard Klein; KPBS


San Diego County's
Annual Precipitation
Inches
0
10
20
30
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Water Year
X

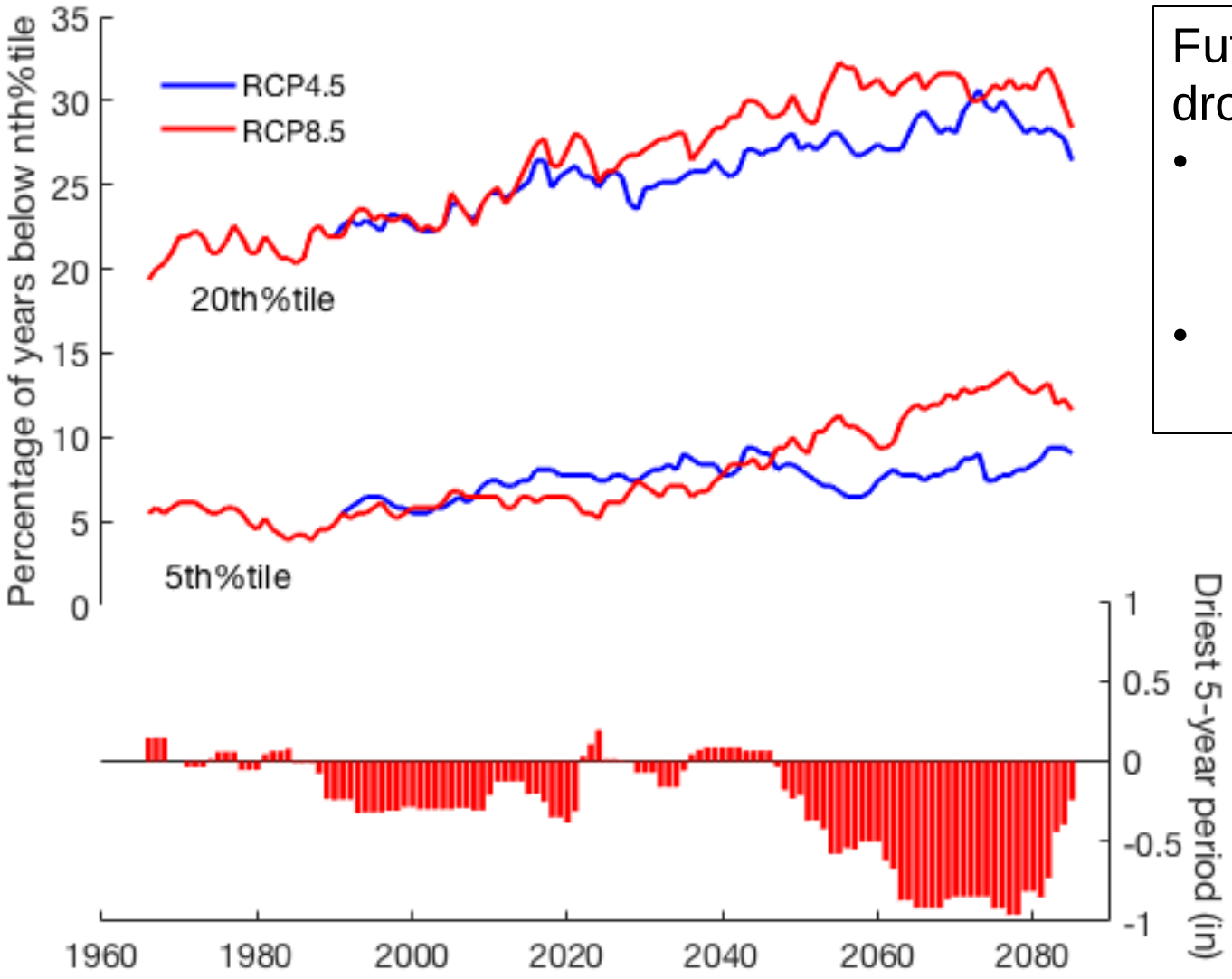

San Diego County's Annual Precipitation
with contributions from all daily events less than 95%ile
30
20
0
Inches
<95%ile
daily contribution
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Water Year
X


San Diego County's Annual Precipitation
and contributions from <95% daily and >=95%
Inches
30
20
10
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Water Year
X
95%ile and higher
daily contribution
<95%ile daily contribution

drought outline on Lake Mead, still dropping,
73 % of normal inflow now expected

photo and comment by Kelly Redmond 2/21/2015

More Droughts Too

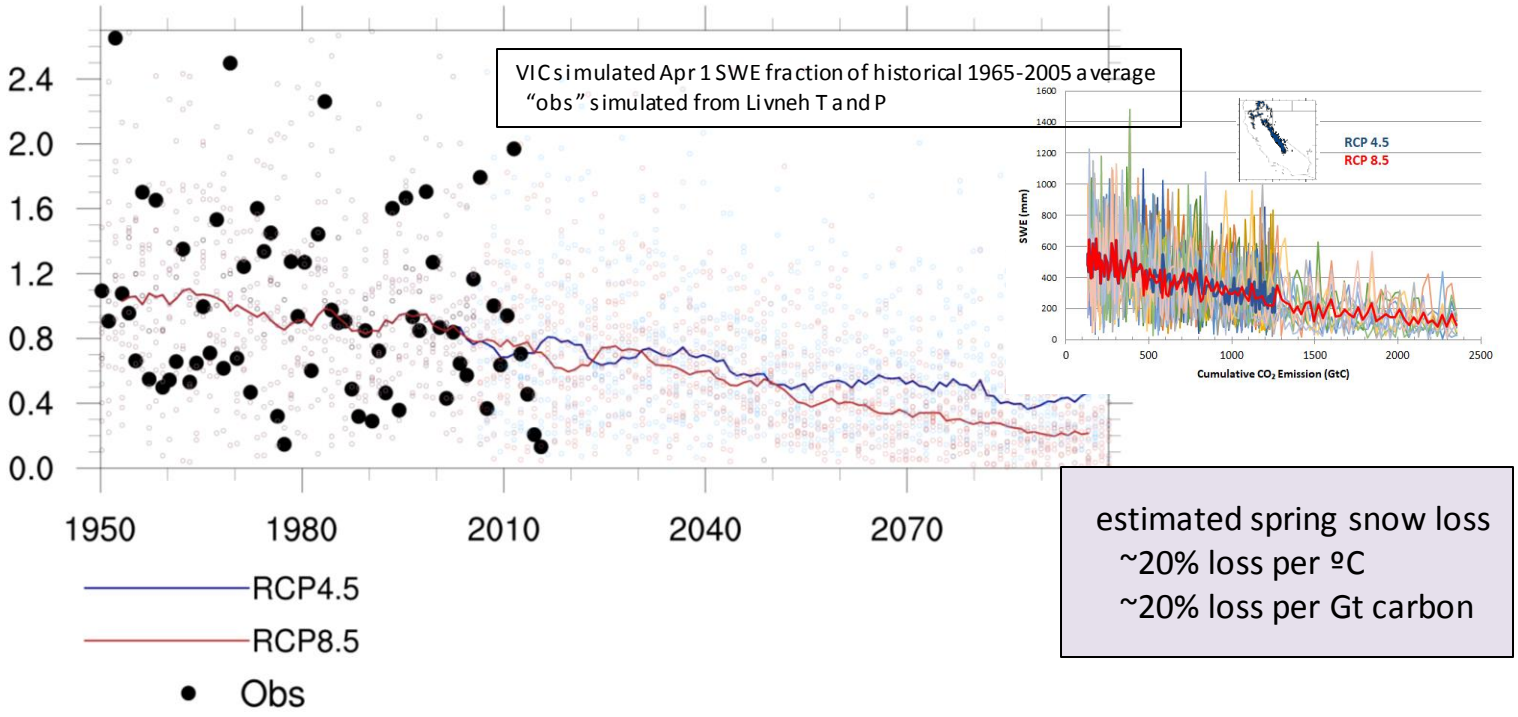


Future 20-year drought scenario

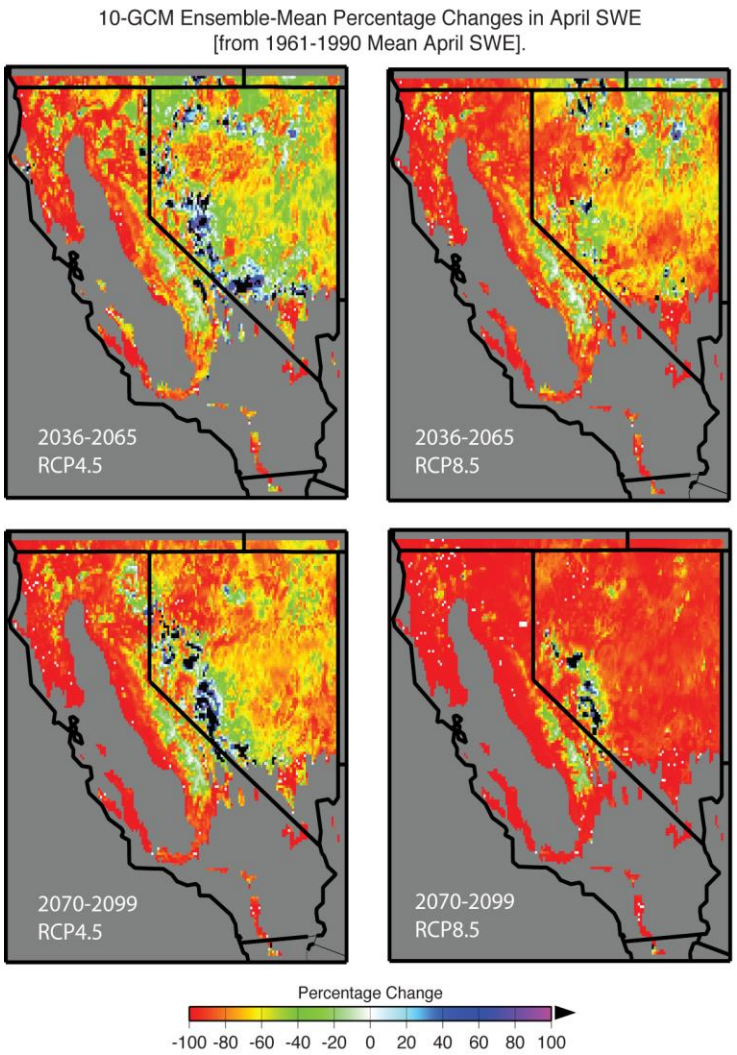
- 79% of historical median precipitation
- 57% of historical run-off median

Jennings et al., 2018

Spring Snow Storage Decline under projected warming



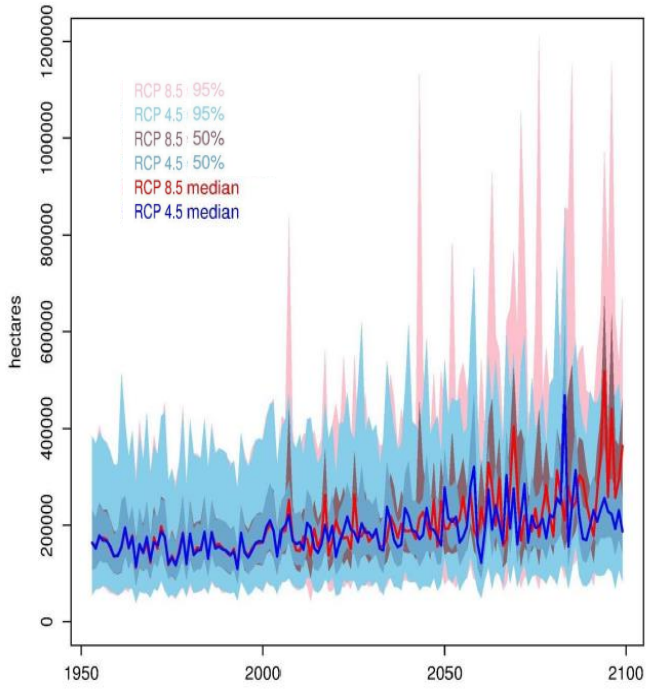
estimated spring snow loss
~20% loss per ºC
~20% loss per Gt carbon



Changes in April 1 snow-water content projected for 2036-2065 (top panels) and 2070-2099 (bottom panels), under two greenhouse-gas concentration pathways into the future. Based upon 1961-1990 normal. *(Dettinger et al. Sierra Nevada Assessment)*

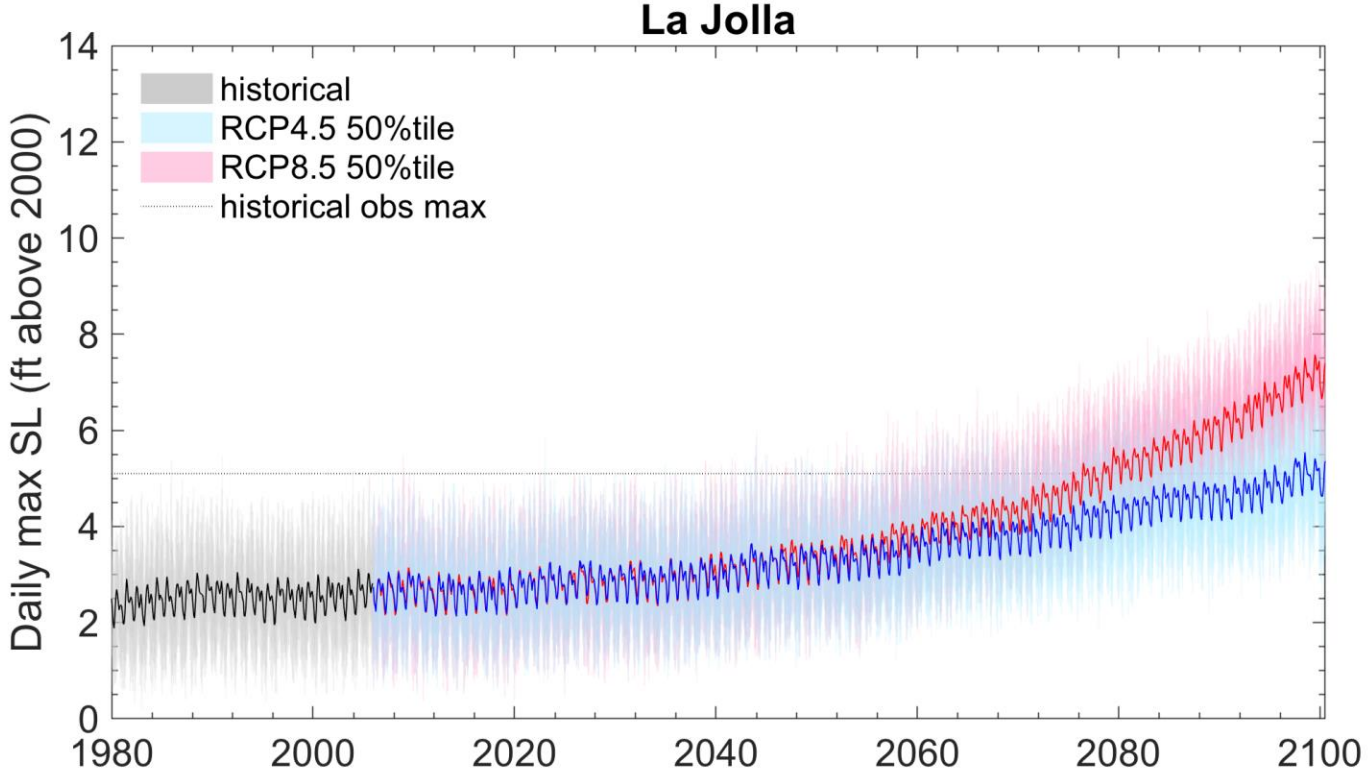
Wildfire Projections

- The Assessment used the results of a new statistical model trained with historical data up to 2013.
- Remarkably, the model simulated extreme events after 2013 and during the subsequent decades of similar or greater magnitude than what was experienced in 2017

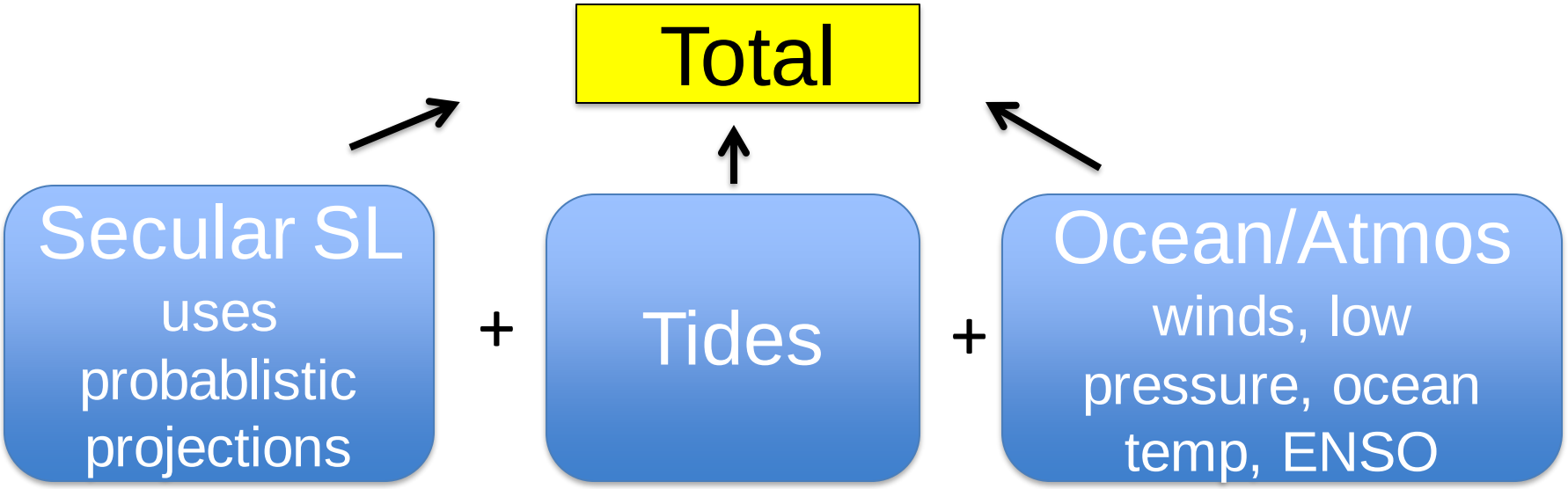


Sea Levels Projected to Rise Substantially

- Even under moderate greenhouse gas emissions

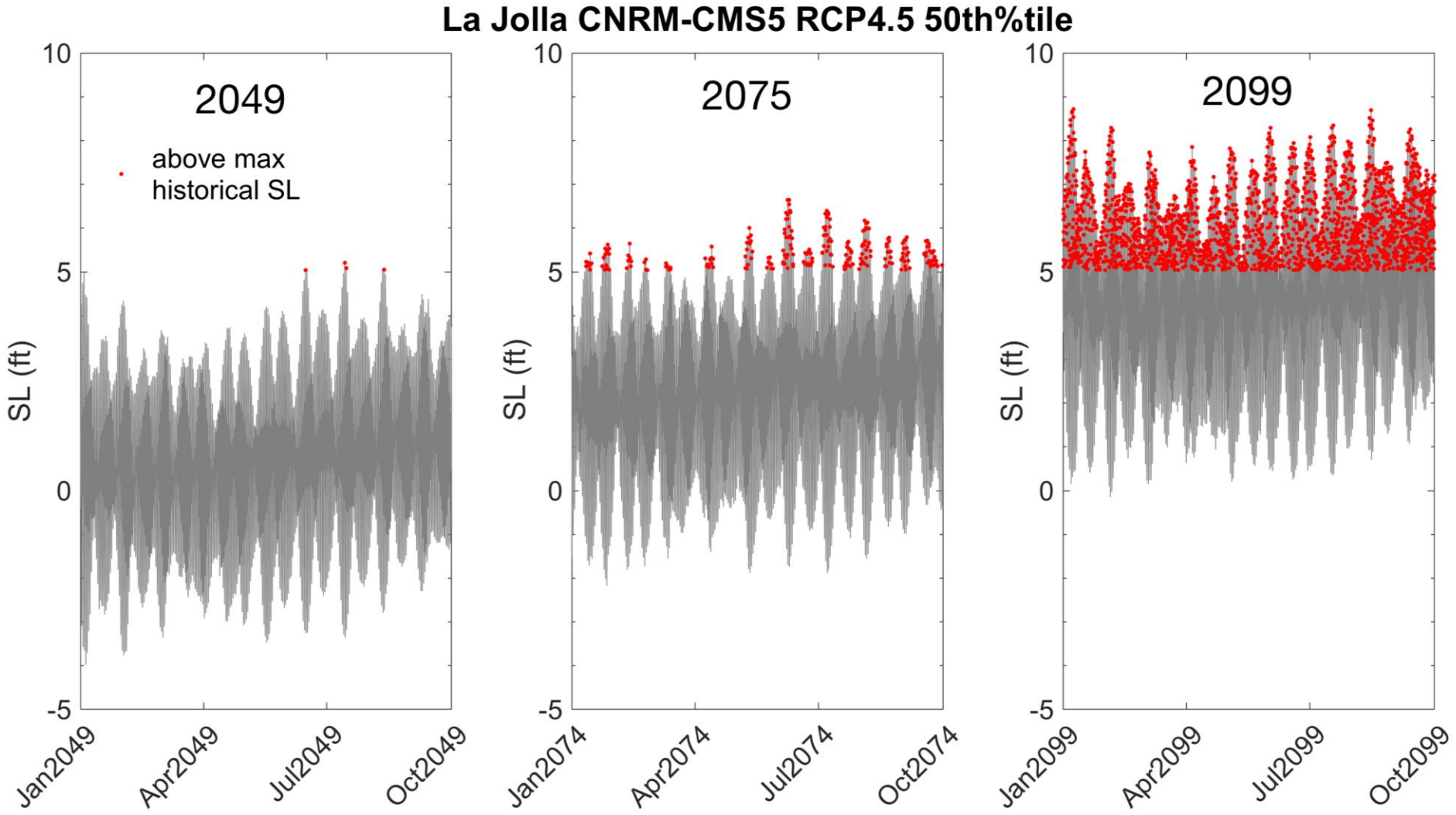


What goes into the Hourly Projections



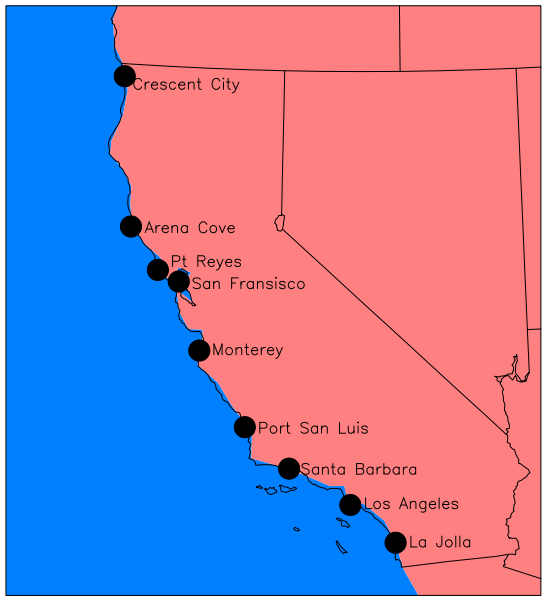
- Does include how different dynamical features, tides, weather impact sea level a bit farther off shore at the location of the gauges
- Does NOT include wave height or wave run-up

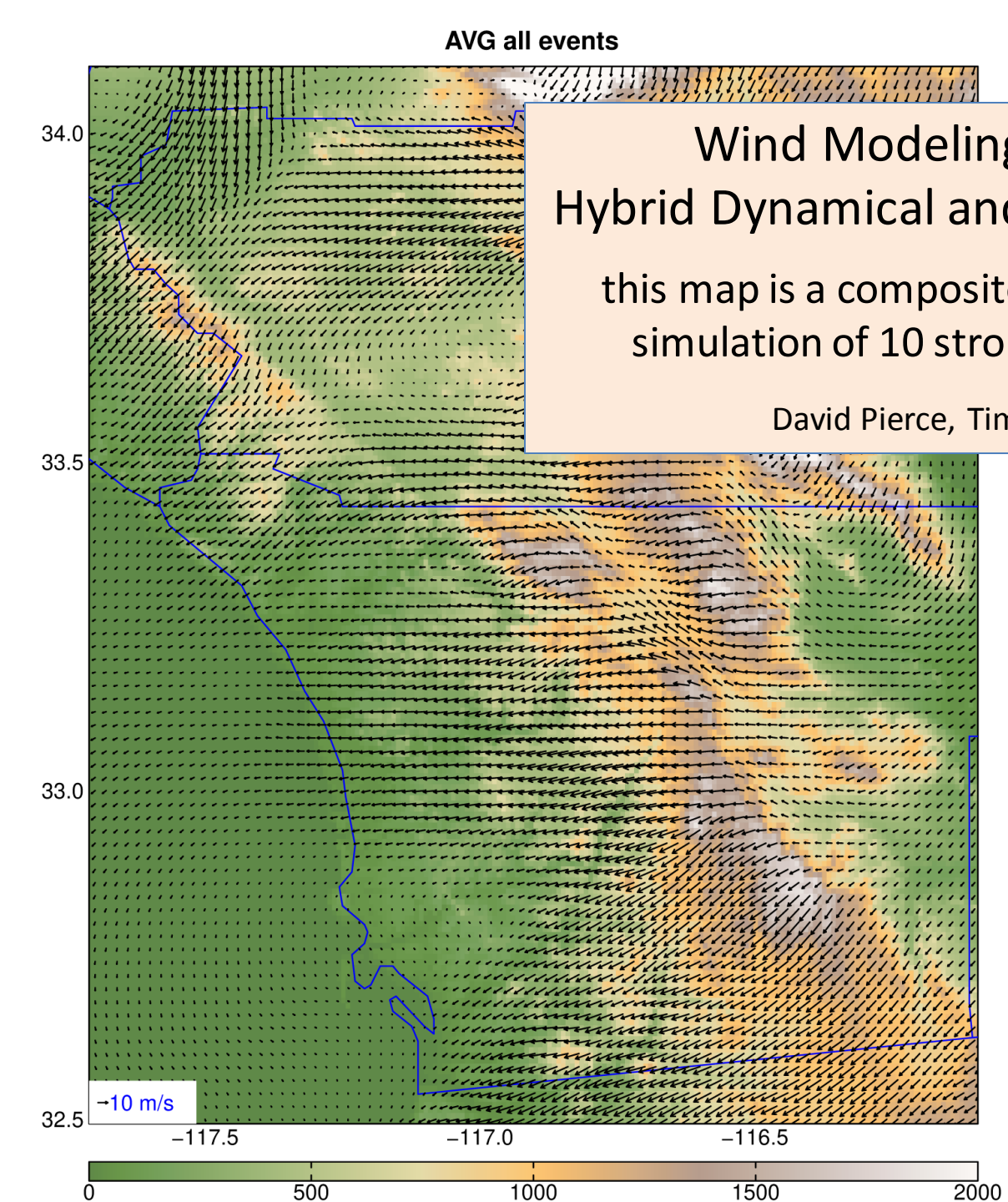
Hourly Sea Level projected for La Jolla from single model:
High sea levels increase rapidly end of century



Stations for Hourly Data

Abbrviation	Station Name	Number
cc	Crescent City	9419750
pa	Arena Cove (Point Arena)	9416841
pr	Point Reyes	9415020
sf	San Francisco	9414290
mt	Monterey	9413450
sl	Port San Luis	9412110
sb	Santa Barbara	9411340
la	Los Angeles	9410660
lj	La Jolla	9410230





Wind Modeling (in progress): Hybrid Dynamical and Statistical Downscaling

this map is a composite of 4km hourly WRF model simulation of 10 strong Santa Ana Wind Events

David Pierce, Tim Brown, Dan Cayan

Summary: Projected Future of California Hydroclimate

Results from ensembles of statistically downscaled GCMs under different future scenarios

Warmer climate produces greater moisture deficits and diminished spring snow pack

Climate models project higher variability of precipitation in California, within seasons and across years

Increased wetness, when it occurs, owes to more frequent, more intense precipitation events.

Heavier precipitation events and higher mountain snow altitudes produce larger floods

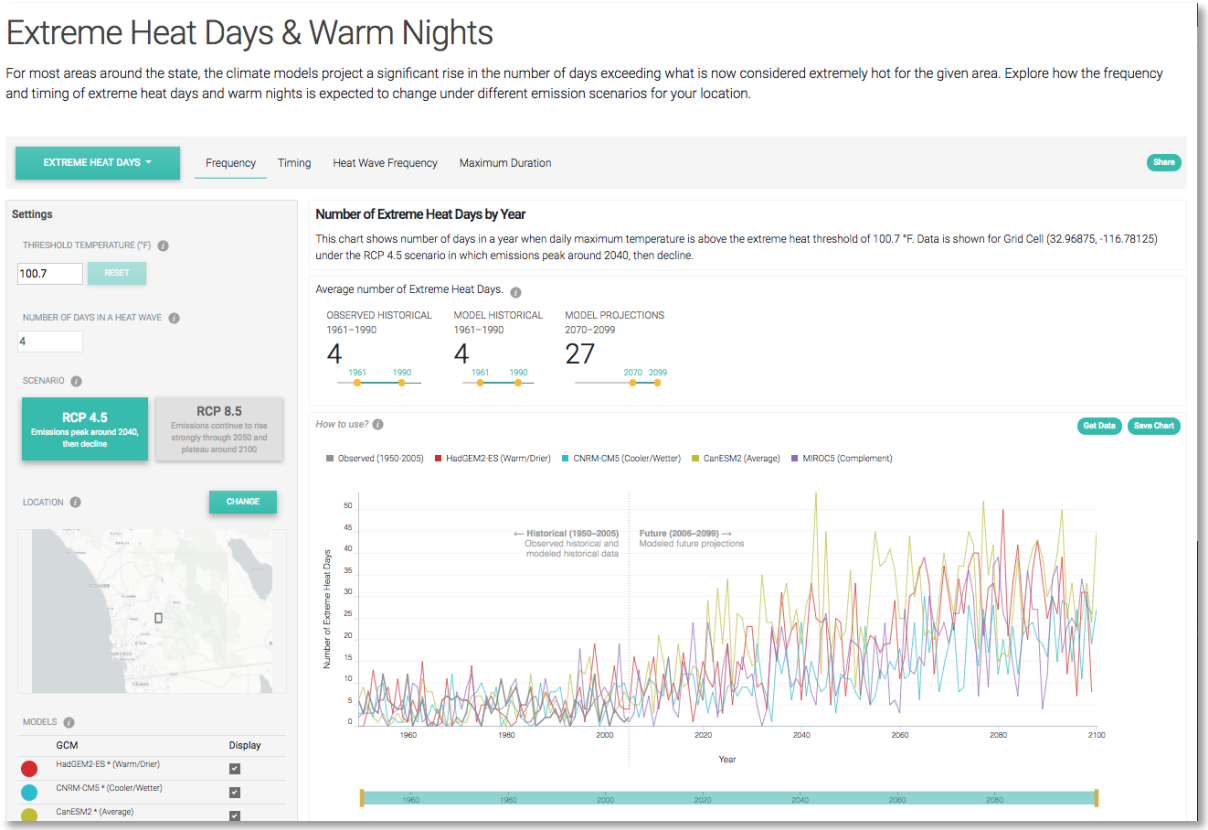
Increased dry days in spring and fall leads to shorter wet season.

Increased dry days leads to more dry years; More dry years leads to more dry decades.

More dry years in presence of warming leads to severely diminished snow pack

to view and obtain climate projections:

CAL-Adapt: cal-adapt.org



Cal-Adapt

- Historic data and future projections
- Many Variables
- Can select regions
- Generates figures
- Download Data

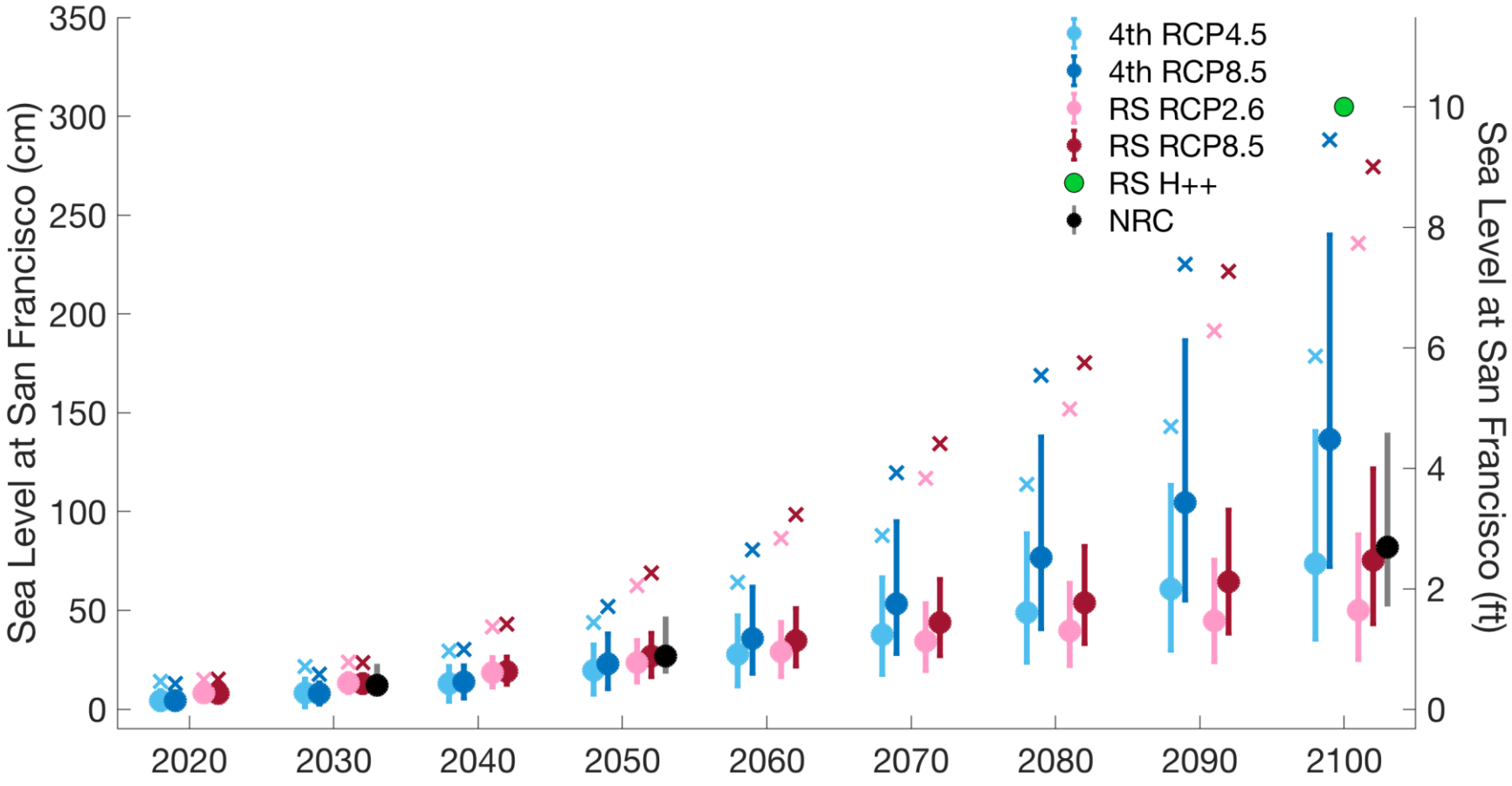
Variables

Annual Averages ◆ Extreme Heat Days & Warm Nights ◆ Cooling Degree Days and Heating Degree Days ◆ Snowpack Sea Level Rise ◆ Wildfire ◆ Streamflow ◆ Extended Drought

Extra Slides

Sea Level Rise

Lots of uncertainty end of century GHG emissions and Ice Sheets (Antarctica)



Models for Hourly Data

- ACCESS1-0
- CMCC-CMS
- **CNRM-CM5**
- **CanESM2**
- GFDL-CM3
- HadGEM2-CC
- **HadGEM2-ES**
- **MIROC5**

Green, **bold** models indicate recommended models to use