



Overview: California's Fourth Climate Change Assessment



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Outline

- Background on California's Climate Change Assessments
- The Fourth Assessment: Climate Projections
- Key Findings for Adaptation

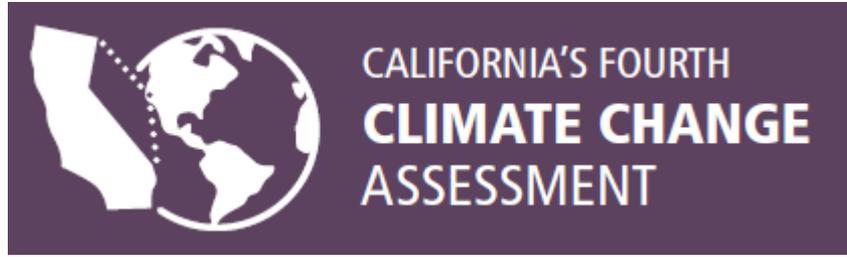
DWR's Roles & Responsibilities

Mission statement:

“To manage the water resources of California in cooperation with other agencies, to benefit the State’s people, and to protect, restore, and enhance the natural and human environments.”

- Plan, design, construct, operate, and maintain California’s State Water Project, the nation’s largest state-built water and power development and conveyance system
- Improve and maintain Central Valley flood management systems and provide statewide flood management financial assistance
- Protect and restore the Sacramento-San Joaquin Delta
- Educate the public about the importance of water and its proper use
- Regulate the safety of 1200 dams
- Regional water management, focusing on technical & financial assistance to local agencies to advance Integrated Regional Water Management
- Statewide planning, focusing on data and updating the California Water Plan (Bulletin 160 Series)

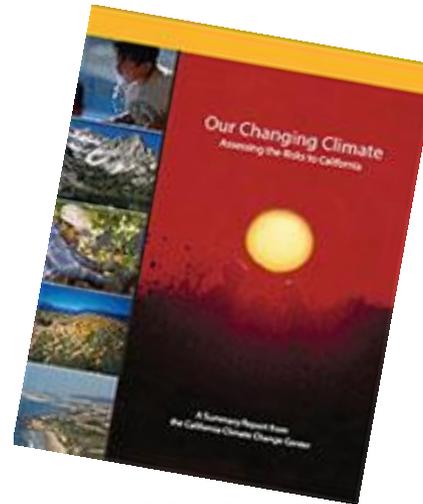




Background on California's Assessments

+ “Modern” Assessments

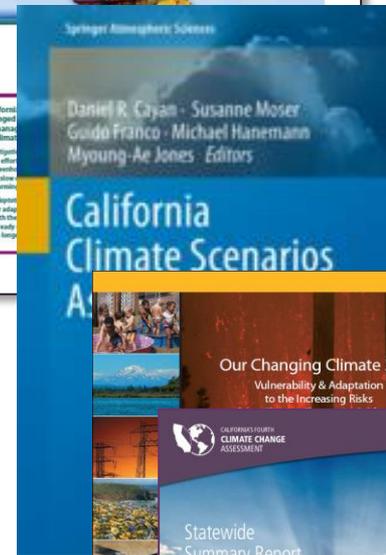
- Executive Order S-3-05, signed by Governor Schwarzenegger called for the **preparation of regular assessments of the science**
- **The scientific community in California has produced four Assessments addressing policy-relevant questions**



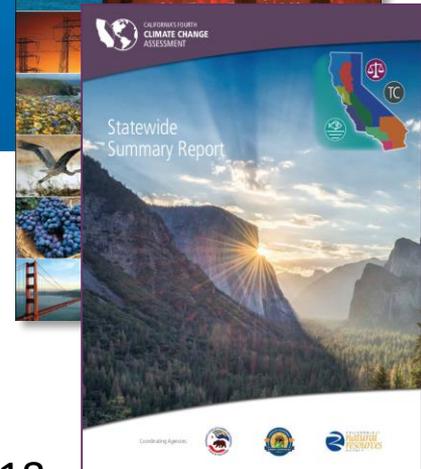
2006



2008
2009



2012



2018

+ The Fourth Assessment

- Features more than 50 reports
 - 44 core technical reports/studies on specific topics
 - 9 regional reports
 - 3 statewide topical reports: ocean and coast, tribal and indigenous communities, and climate justice
 - One **statewide summary/integration report**
 - Overview Brochure

- With the exception of the brochure, all of these products were peer reviewed by experts from within and beyond California

- Over 100 authors were involved from: UC Davis, UC Merced, UC Santa Cruz, UC San Diego, UC Berkeley, UCLA, UC Riverside, UC Irvine, USC, USGS, RAND, LBNL, ICF, Arizona State University, TNC, Climate Readiness Institute, Susanne Moser Research & Consulting, Four Twenty Seven, DWR, OEHHA, CDPH, and CEC

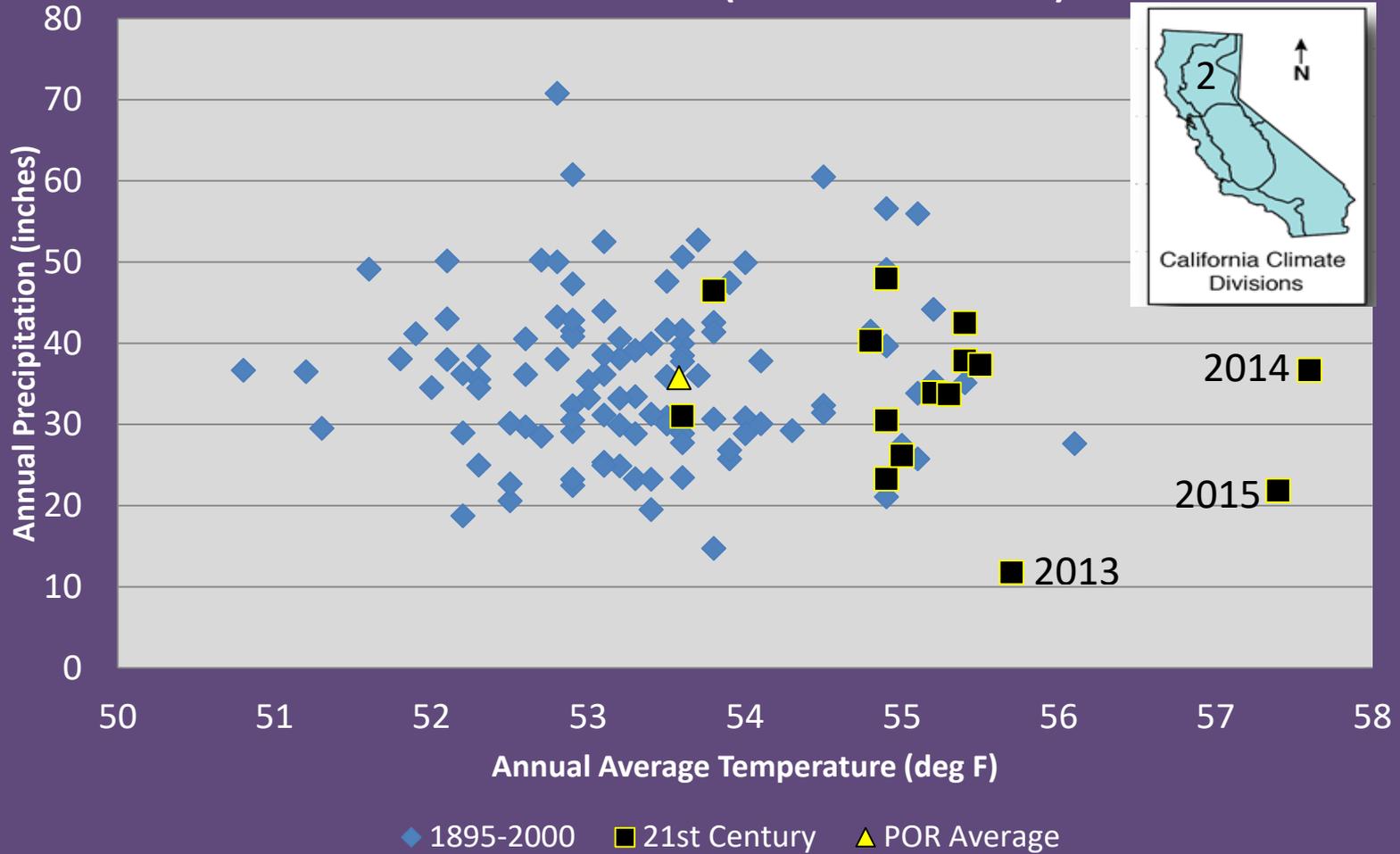


In the Past 100 years...

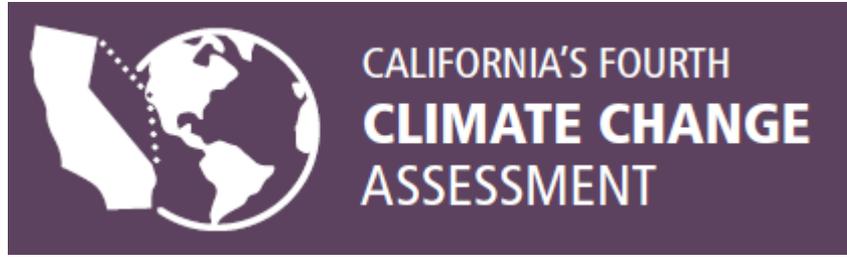
- ❖ 1°F rise in average temperatures
- ❖ 10% overall loss of snowpack in the Sierra Nevada
- ❖ Changes in runoff timing
- ❖ An average sea level rise of 7" along the California coast

The Drought, This Time: Hot and Dry

Climate Division 2 (Sacramento Basin)



Source: NOAA Climate Division 2 Calendar Year Data



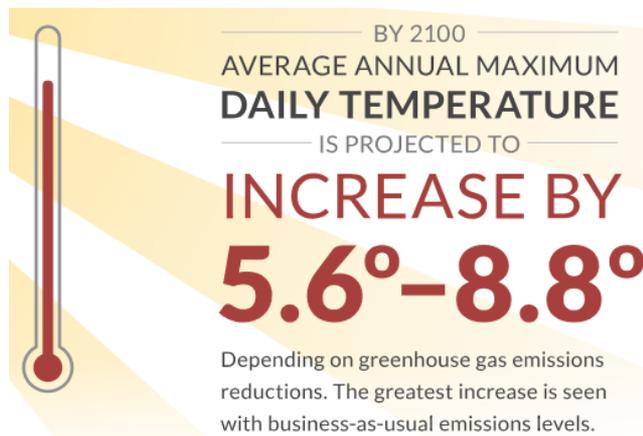
Climate Projections

**It's tough to make predictions, especially
about the future.**

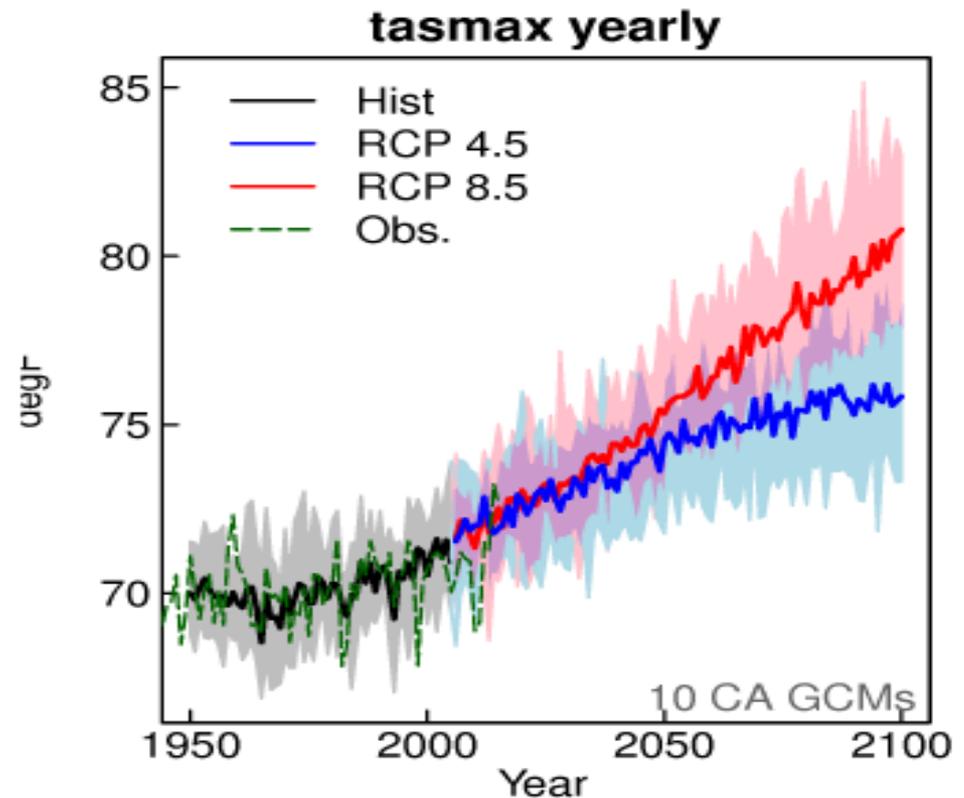
--Yogi Berra

+ Temperature Projected to Rise Substantially

- Under plausible future greenhouse gas emissions



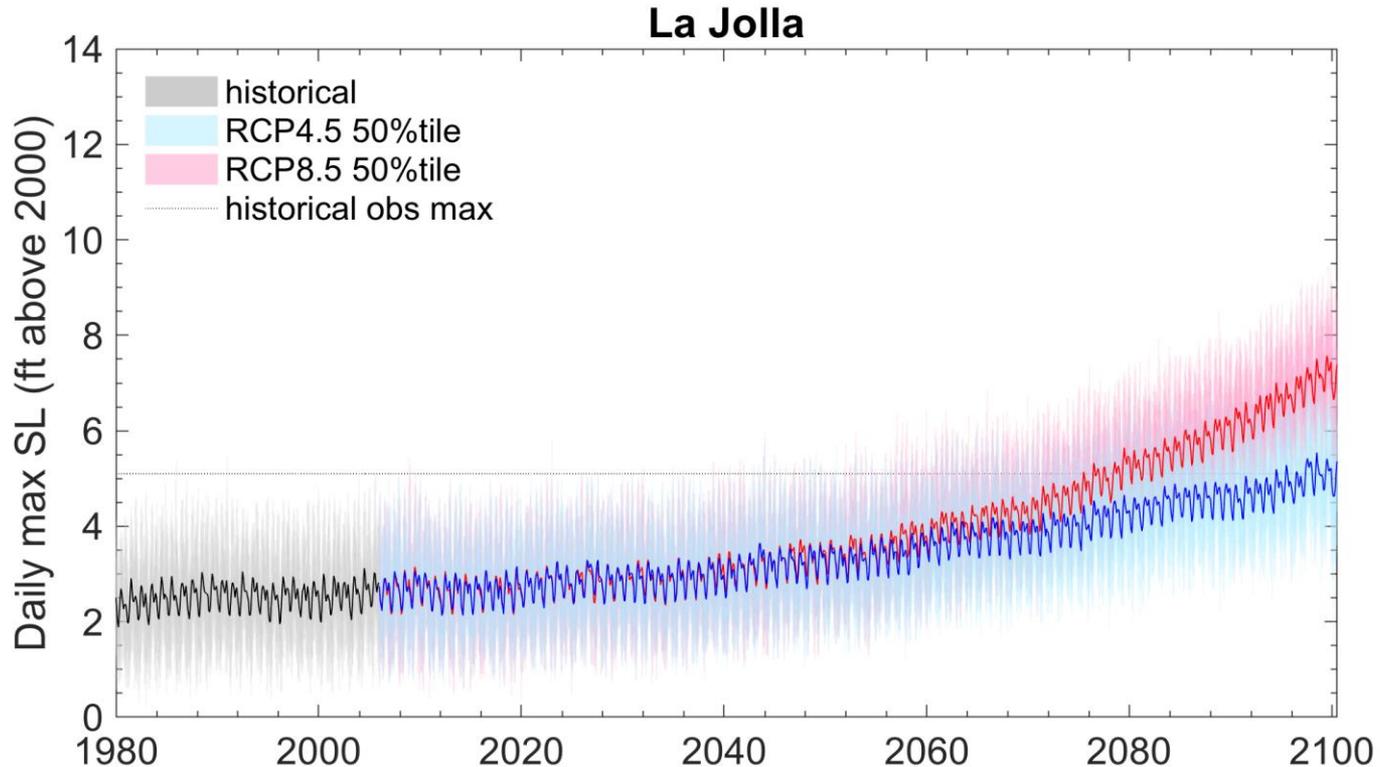
Pierce, Cayan, Kalansyi, 2018





Sea Levels Projected to Rise Substantially

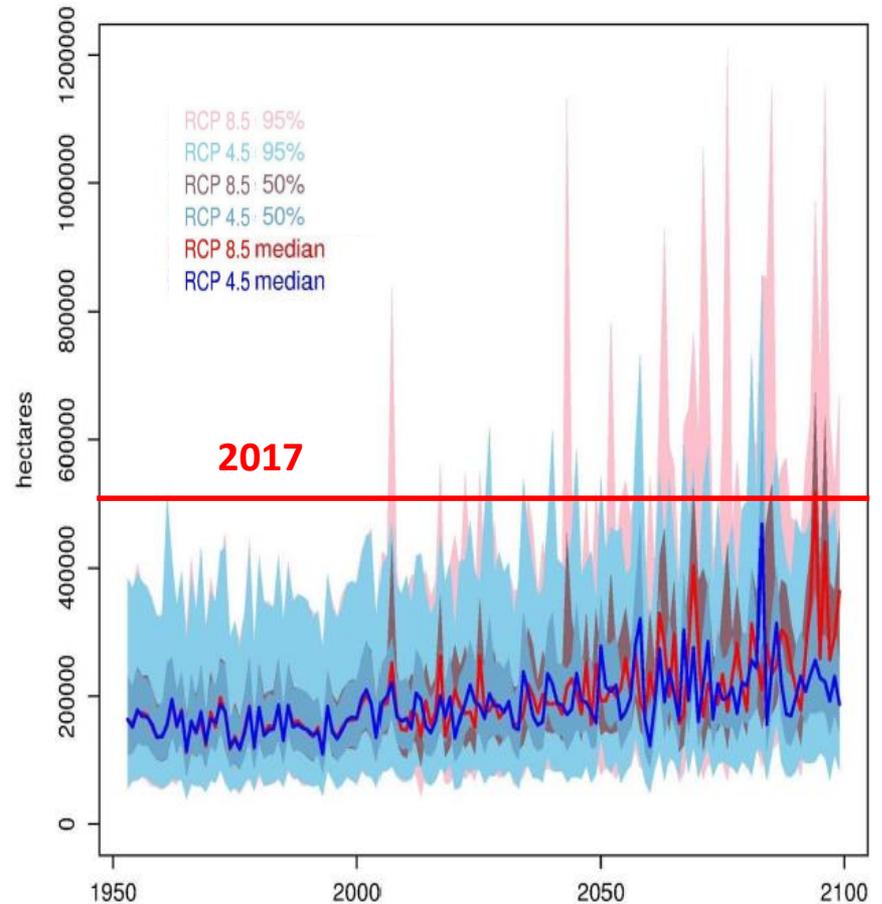
- Increased rates even under moderate greenhouse gas emissions



+ Wildfire Projections

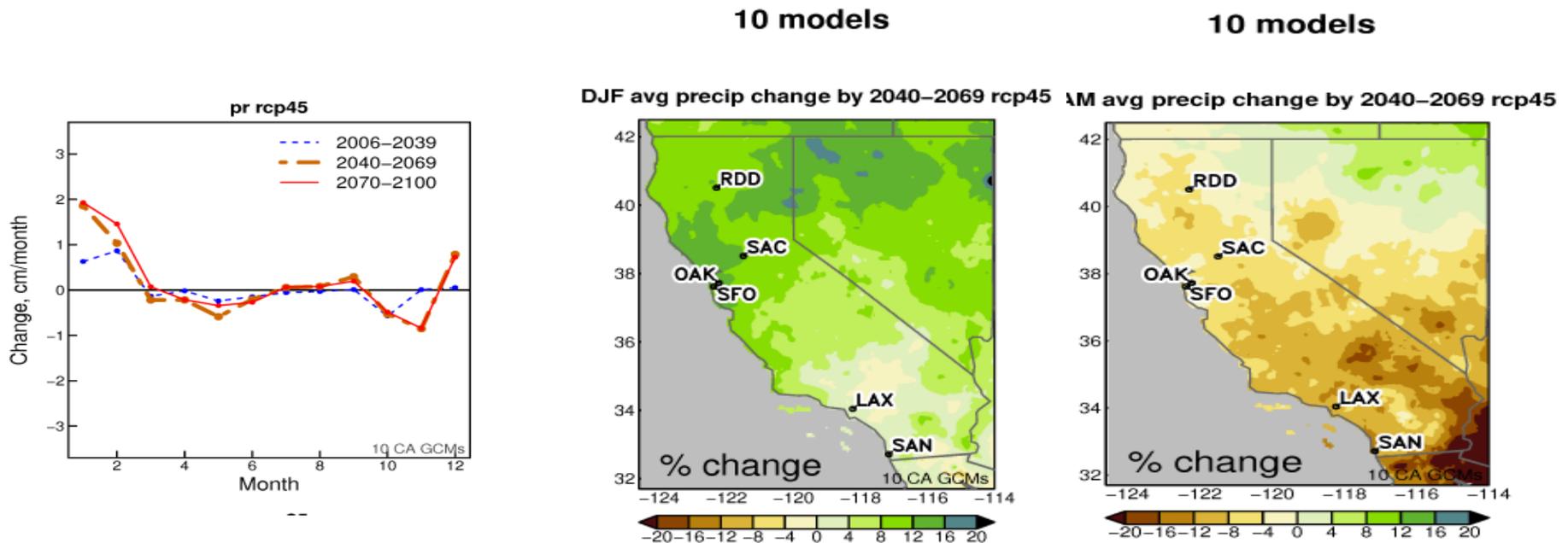
- The Assessment used the results of a new statistical model trained with historical data up to 2013.
- Remarkably, the model simulated extreme events after 2013 and during the subsequent decades of similar or greater magnitude than what was experienced in 2017

Westerling, 2018

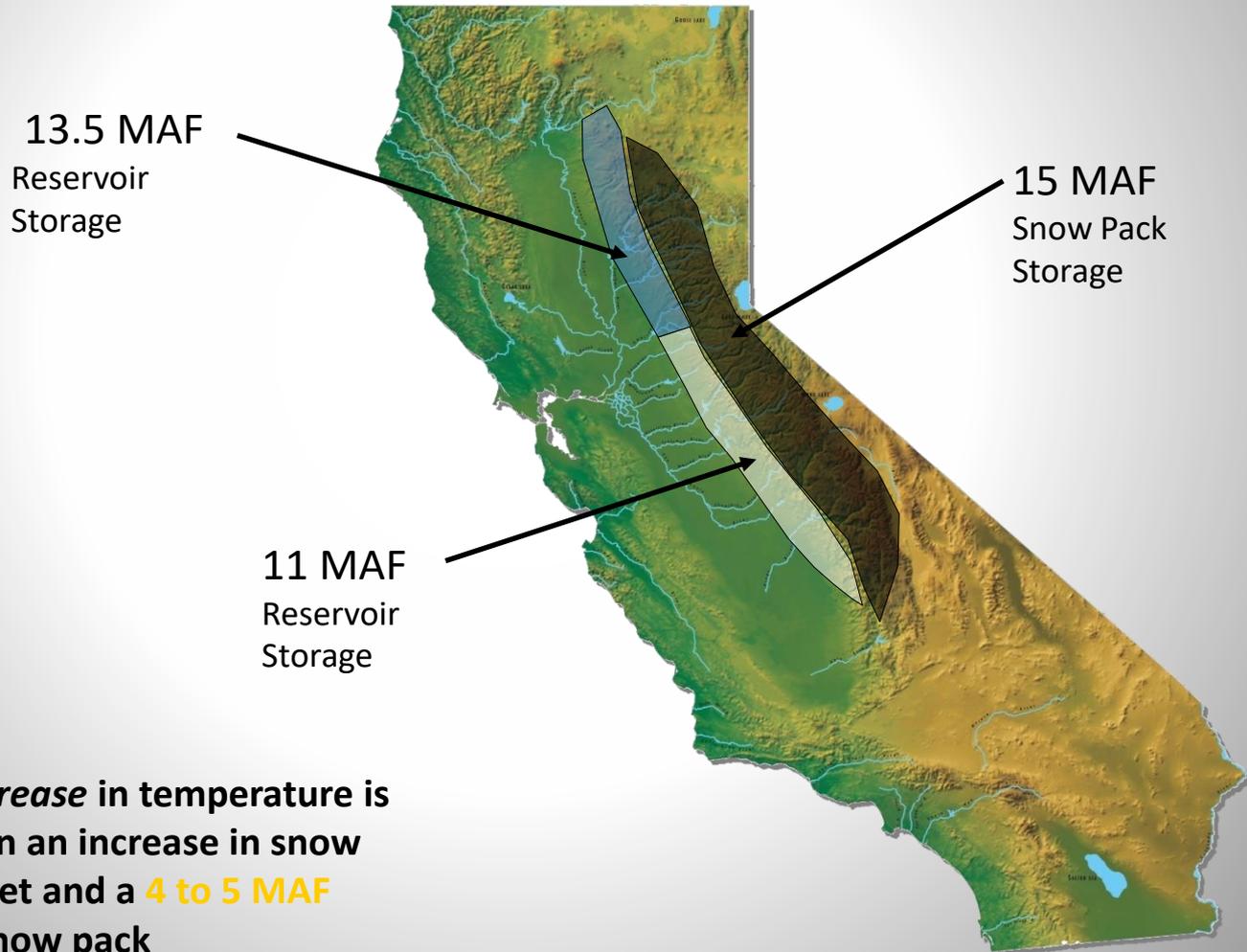


+ Wetter Winter but Drier Springs – A Shorter Wet Season

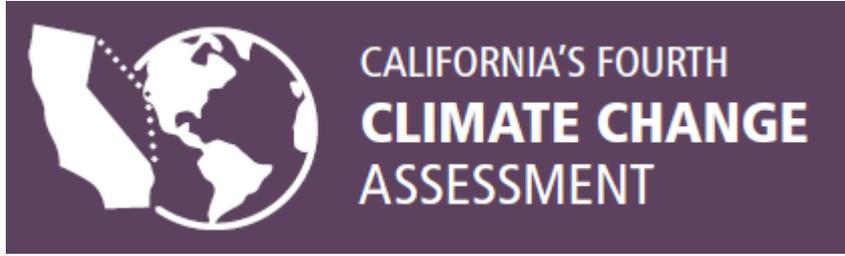
- Projected Precipitation Increase in Dec-Feb (DJF)
- Projected precipitation decrease in Mar-Apr (MAM)
- 10 LOCA downscaled RCP4.5 GCMs mid-21st century



Potential Snowpack Impacts from Climate Change



A moderate 3°C increase in temperature is projected to result in an increase in snow elevation of 1500 feet and a **4 to 5 MAF decrease** in Sierra snow pack



Key Findings for Adaptation

+ Actions: Wildfires

- A scientific review concluded that **reducing tree density and restoring beneficial fire can improve long-term resilience of California's forests** (*Moghaddas et al., 2018*).
- Fuel treatments could reduce increases in burned area in the Sierra Nevada and increase forest health.
 - A management scenario that treated ~30% of vegetated area **reduced the increase in area burned** by 16-31% (*Westerling, 2018*).
- Increasing understanding of potential megafires fueled by dead trees remains a critical research need.



+ Actions: Management of Water Supply

- Promising adaptation options identified in the Fourth Assessment could improve reservoir operations and flood safety (*Aghahouchak et al., 2018; Avanzi et al., 2018; He et al., 2018*). These include:
 - Probabilistic hydrological forecasts
 - Better measurements of the snowpack
- Institutional, regulatory, and legal approaches will need to be developed and adapted to quickly implement science-based solutions (*Green Nysten et al., 2018*).

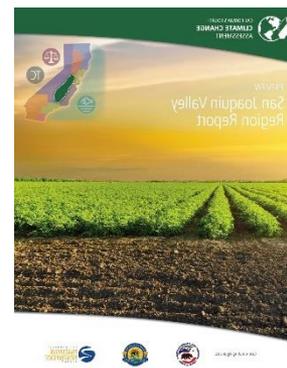
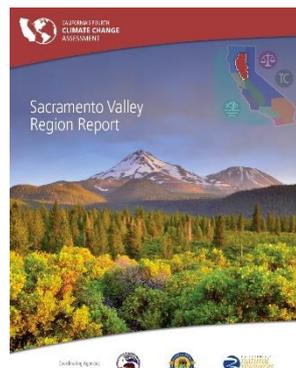
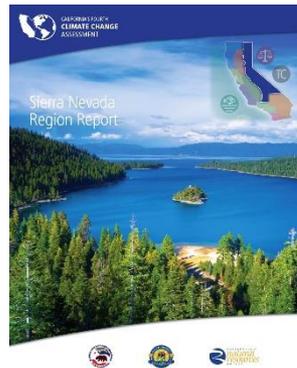
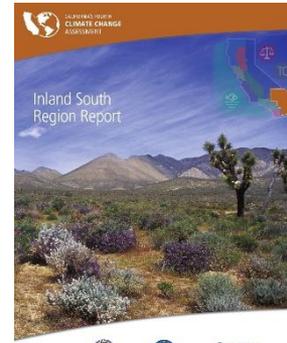
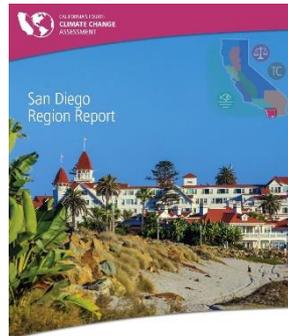
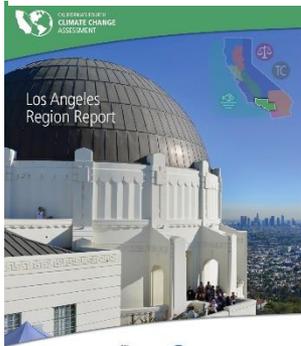
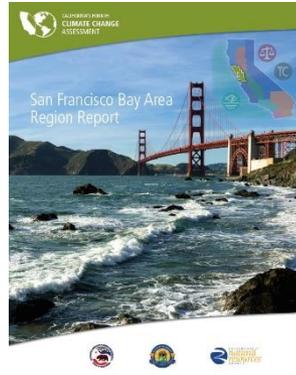
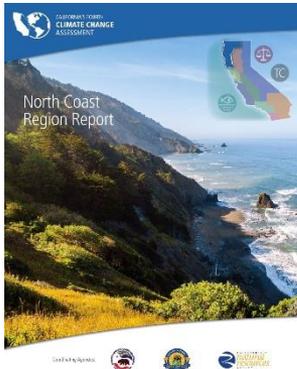
+ Governance-related findings

Organizational barriers and governance challenges can delay and even prevent local governments from taking action.

- Top barriers to climate adaptation in CA local governments:
 - Lack of funding
 - Insufficient staff resources and capacity
- Action: Developed the Adaptation Capability Advancement Toolkit (Adapt-CA, <http://arccacalifornia.org/adapt-ca/>)
- Additional insights in this area from the regional and topical reports.



+ 9 Regional Reports





<http://www.climateassessment.ca.gov>

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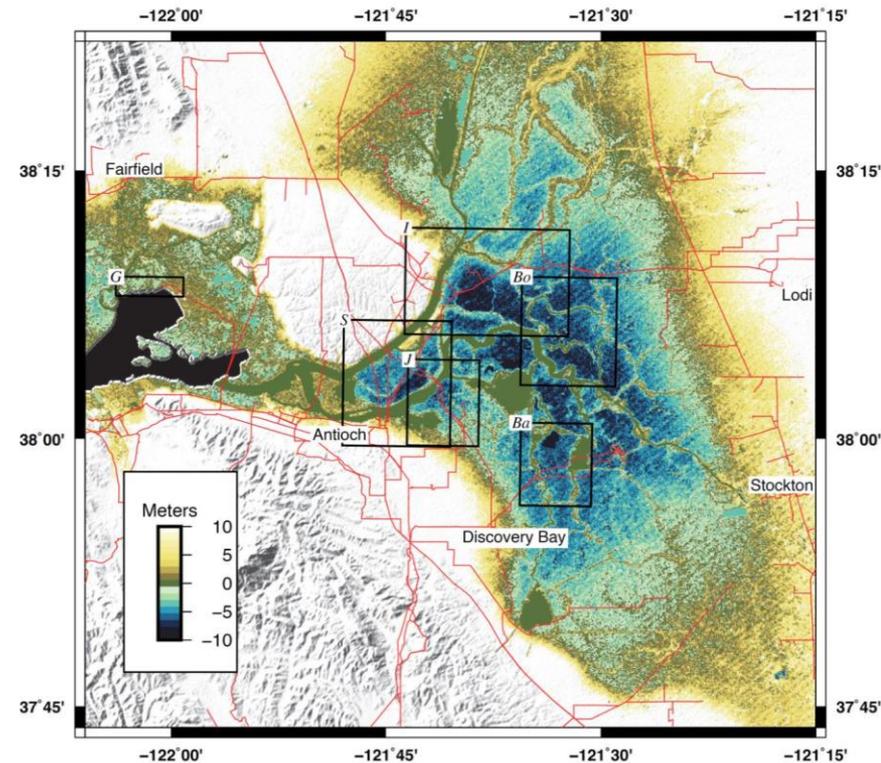
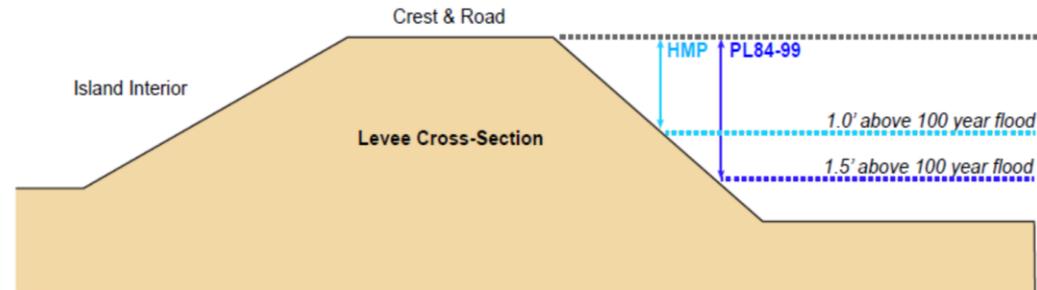
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178

+ Subsidence of Levees

Sacramento-San Joaquin Delta

- **High subsidence rates** for some of the levees in the Delta: **~0.4 to 0.8 inches per year.**
- Subsidence + SLR + storms could cause overtopping or failure of the levees.
 - Could expose natural gas pipelines and other infrastructure to damage or structural failure.
- At this rate of subsidence, levees may fail to meet the federal levee height standard between 2050-2080.



+ Implications of Paris Agreement for Climate in California - Preliminary Estimations

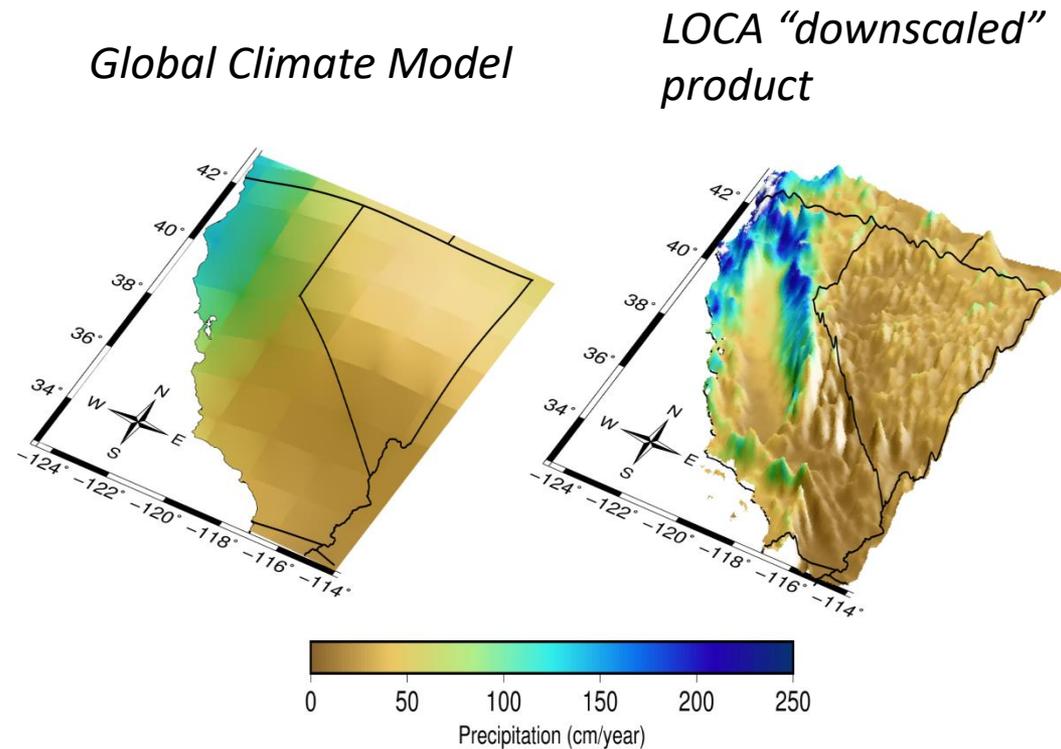
- The 2015 Paris Agreement established the ambitious goal of *“holding the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C”*

- There are several estimates of the amount of additional CO₂ emissions that can be emitted to comply with the goals of the Paris Agreement. We used 652 GtC to 790 GtC

Case	Baseline: 1976 - 2005	RCP 8.5 End of Century	Stabilization 1.5 °C	Stabilization 2 °C
Annual Average Temperature	14 °C	19 °C	15.2 °C	15.6 °C
Number of extreme hot days: Sacramento	1.6	14.3	2.37	2.9
April 1 st Snow Water Equivalent (mm)	477	- 74 %	- 22 %	- 22.8 %
Soil Moisture (mm)	298 mm	- 10 %	- 1.3 %	- 2.5 %
Wildfires: area burned (Hectares)	169,084	+ 63 %	+ 20 %	+ 20 %
Sea Level Rise (cm) increase in 2100 from year 2000: mean values	NA	137	28	41

+ Climate Scenarios

- Scripps developed a new method known as Localized Constructed Analogs (LOCA).
 - The federal government later on also adopted LOCA for the 2018 National Assessment
- Climate scenarios with daily resolution from 1950 to 2100 with grids about 3.7 x 3.7 miles
- Variables include temperature, precipitation, humidity, solar radiation, soil moisture, and other parameters.
- Results available for 32 global climate models (GCMs) with special emphasis for 10 GCMs.
- Other downscaling using a dynamical modeling approach (Hall, Berg, et al. UCLA) offers even higher resolution and important additional physical insights



Pierce, Cayan, Kalansky, 2018

+ Assessments Before the “Modern” Era

- **1988:** AB 4420 (Sher) mandated the Energy Commission to produce a report about the **potential impacts of climate change to California.**
- **2003:** CEC produced a report under its Public Interest Energy Research Program on **economic impacts to energy** and other sectors.

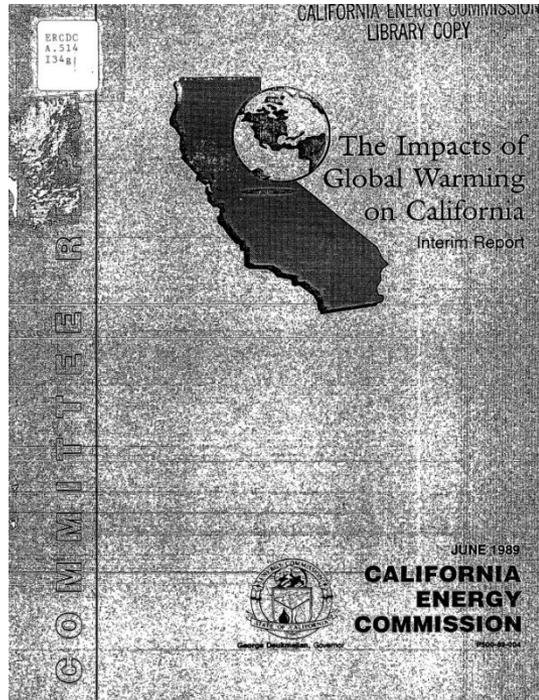
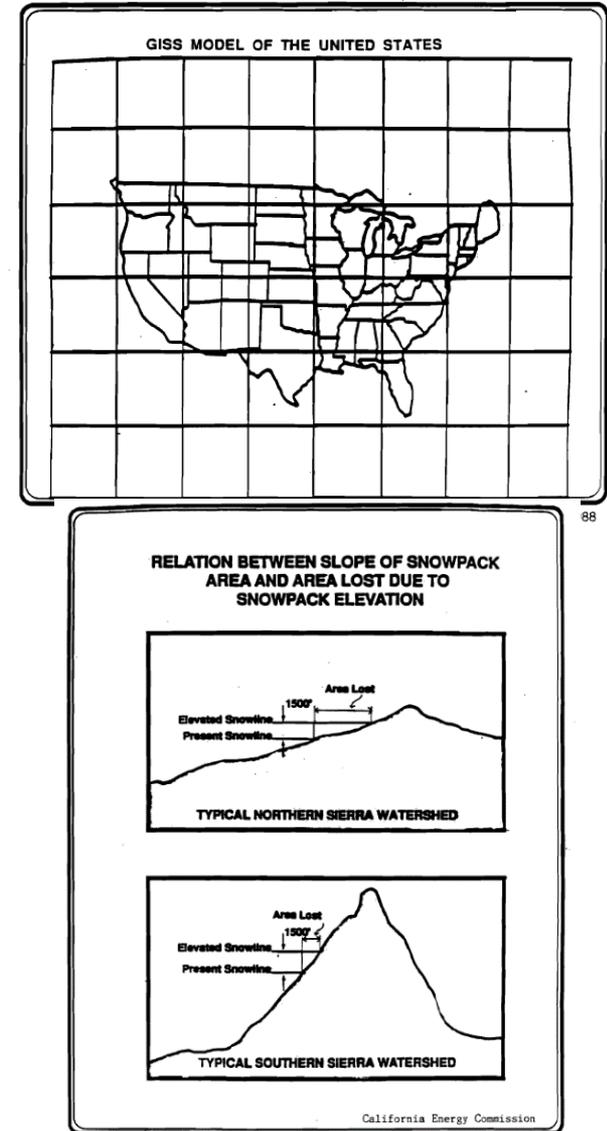


Figure 5

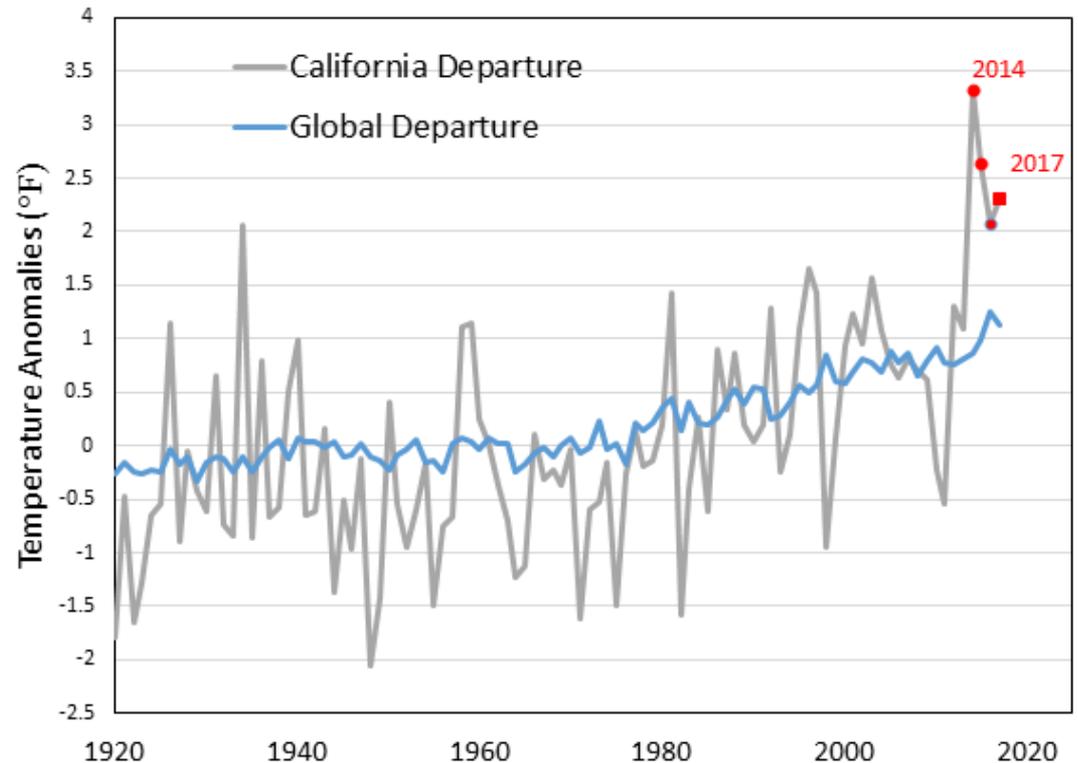


+ Link between the Assessments and Policy in California

	FIRST CALIFORNIA CLIMATE ASSESSMENT	SECOND CALIFORNIA CLIMATE ASSESSMENT	THIRD CALIFORNIA CLIMATE ASSESSMENT	FOURTH CALIFORNIA CLIMATE ASSESSMENT
YEAR	2006	2009	2012	2018
DESCRIPTION	Understanding climate impacts in California. Developed to provide support for undertaking greenhouse gas emission reductions.	Understanding how climate change will affect specific sectors. Made the case that adaptation could reduce costs.	Increased understanding of vulnerability in natural and human systems, and generated two pilot regional assessments.	Technical and regional reports designed to support adaptation actions at the state, regional, and local level.
DRIVER	Executive Order S-3-05	Policymakers' desire to know if adaptation was needed.	2009 Climate Adaptation Strategy	2015 Climate Change Research Plan
OUTCOME	Assembly Bill (AB) 32	2009 Climate Adaptation Strategy	Supported passage of new climate adaptation laws.	Informing the implementation of AB 2800, which requires a report on how engineering standards should be changed to consider climate change. Other outcomes to be determined.

+ California is warming along with the global climate

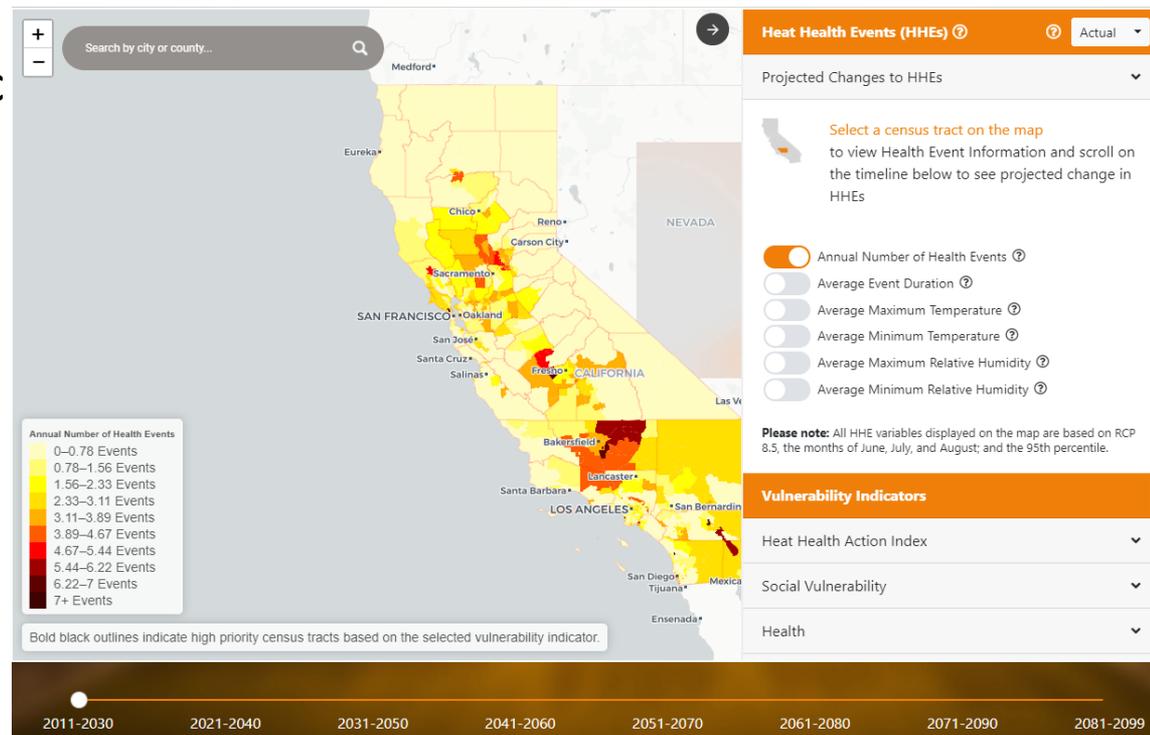
- Warming of approximately 1 °F has occurred since 1950
- 2014-2017 was unusually warm, along with associated impacts



Data source: California Climate Tracker, Western Regional Climate Center

+ Action: Public Health

- Development of a prototype warning system: **California Heat Assessment Tool (CHAT)**, to improve health alert systems in California, taking into account results from epidemiological studies.
- CHAT could support public health departments taking action to reduce heat-related morbidity and mortality outcomes.

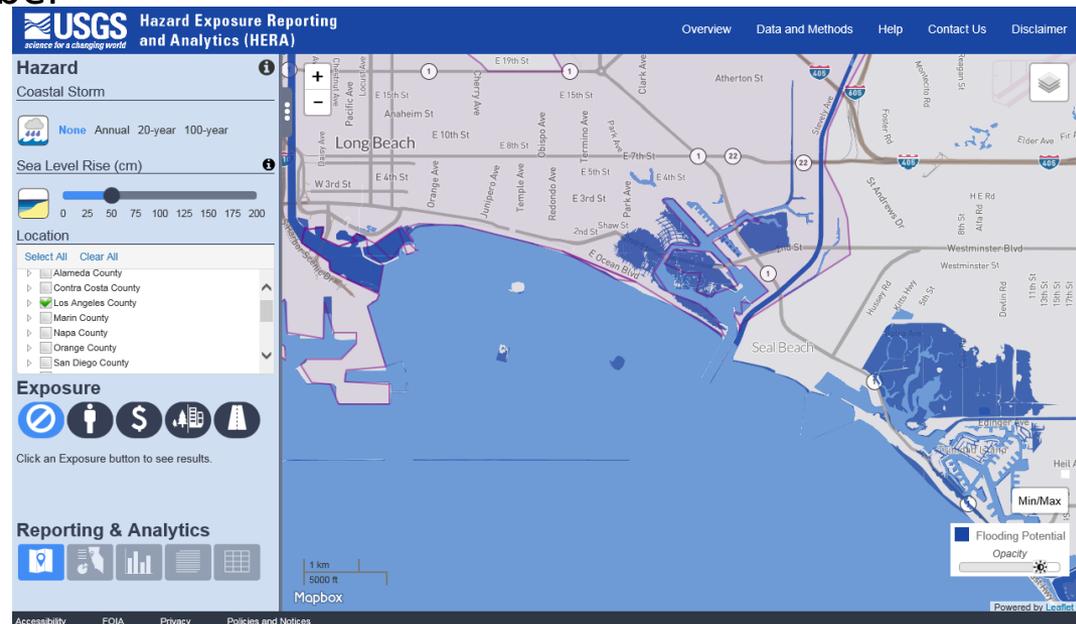


<https://www.cal-heat.org/>

Steinberg et al., 2018

+ Actions: Coastal Impacts

- **Technical guidance on design and implementation of natural infrastructure** (*Newkirk et al., 2018*).
- **CoSMoS** model: recently enhanced for the Fourth Assessment and used to project impacts along the CA Coast (*Erikson et al., 2018*)
- **HERA** (Hazardous Exposure Reporting and Analytics), makes CoSMoS more useful for planners. Includes number of residents affected, value of properties flooded, and more.



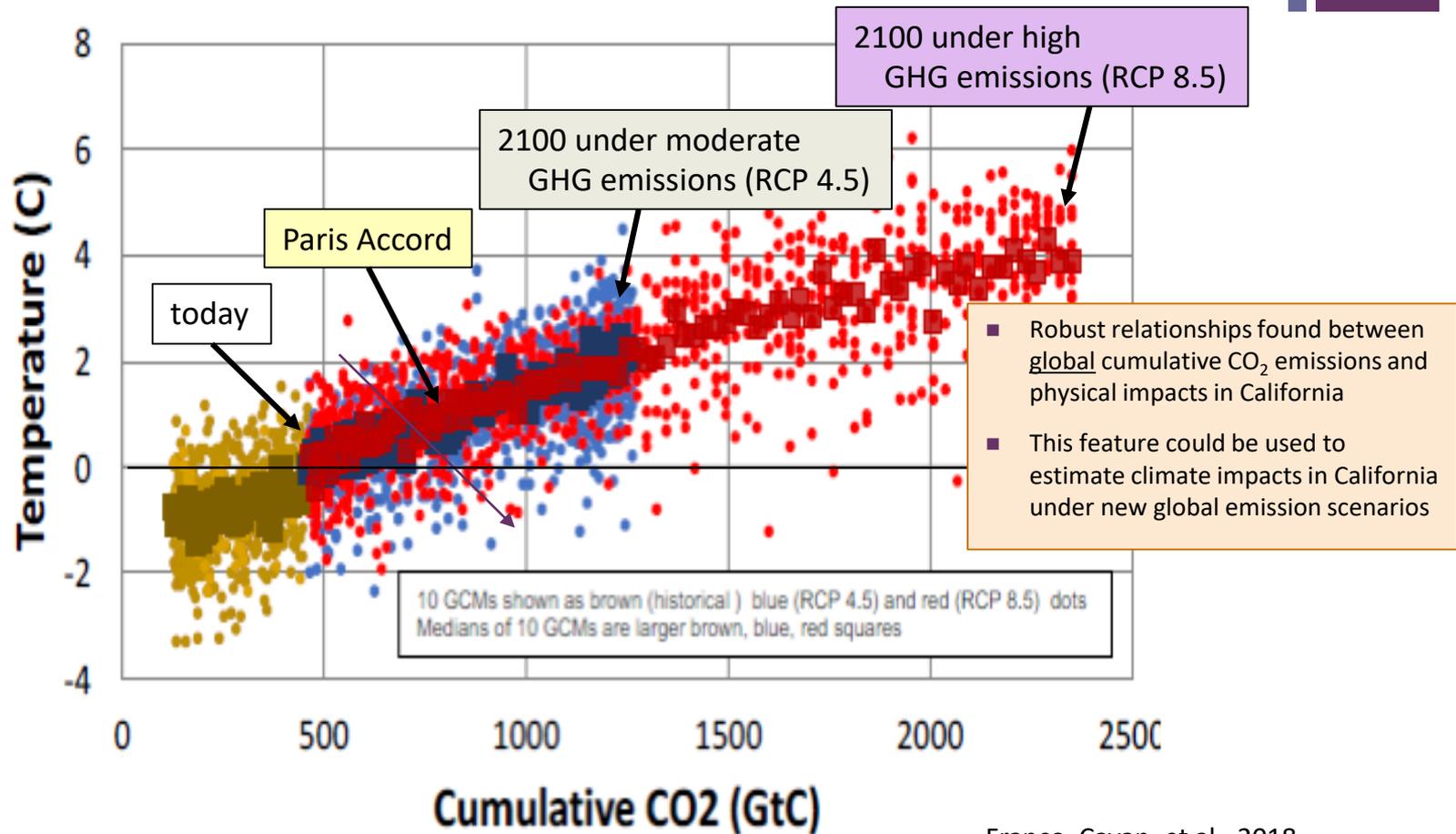
https://walrus.wr.usgs.gov/coastal_processes/cosmos/

<https://www.usgs.gov/apps/hera/>

<https://data.pointblue.org/apps/ocof/cms/index.php?page=flood-map>

[ge=flood-map](#)

+ Adaptation Needs Will be Less if Global GHG Emissions are Greatly Reduced



+ Deep GHG Reduction & Public Health

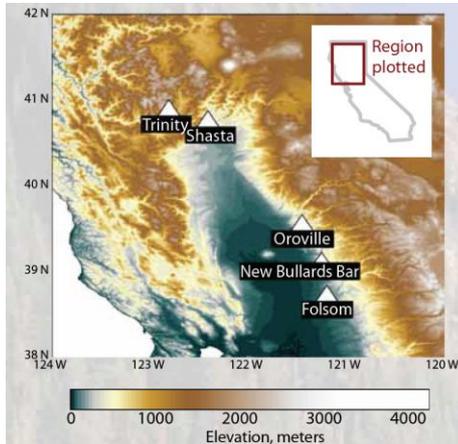
- **Deep greenhouse gas emission (GHG) emission reductions (80% below 1990 levels) in California** are associated with drastic reductions of conventional air pollutants, **which could significantly improve health outcomes.**
- **The public health benefits are comparable with costs to reduce GHG emissions.**
- **Changes to heat advisory thresholds from the National Weather Service are needed to better protect vulnerable populations.**

Zapata et al., 2018
Roland-Holst et al., 2018

Guirguis et al., 2014

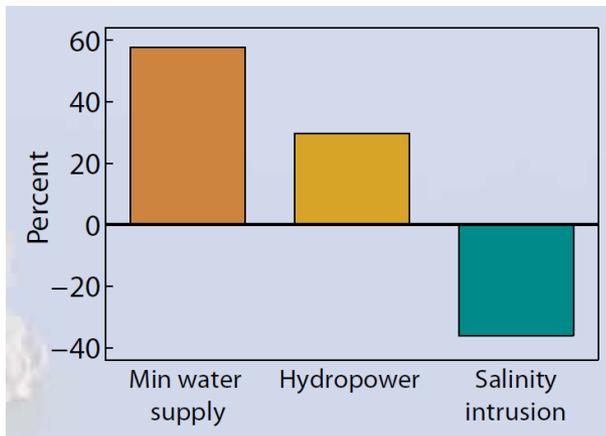


Use of Probabilistic Forecast and Modern Decision Science



- DWR is now implementing this approach (INFORM) based upon more than a decade of development and demonstration that has shown to be a win-win situation under current conditions and in a changing climate
- NOAA, CEC, and DWR supported the development and demonstration of INFORM

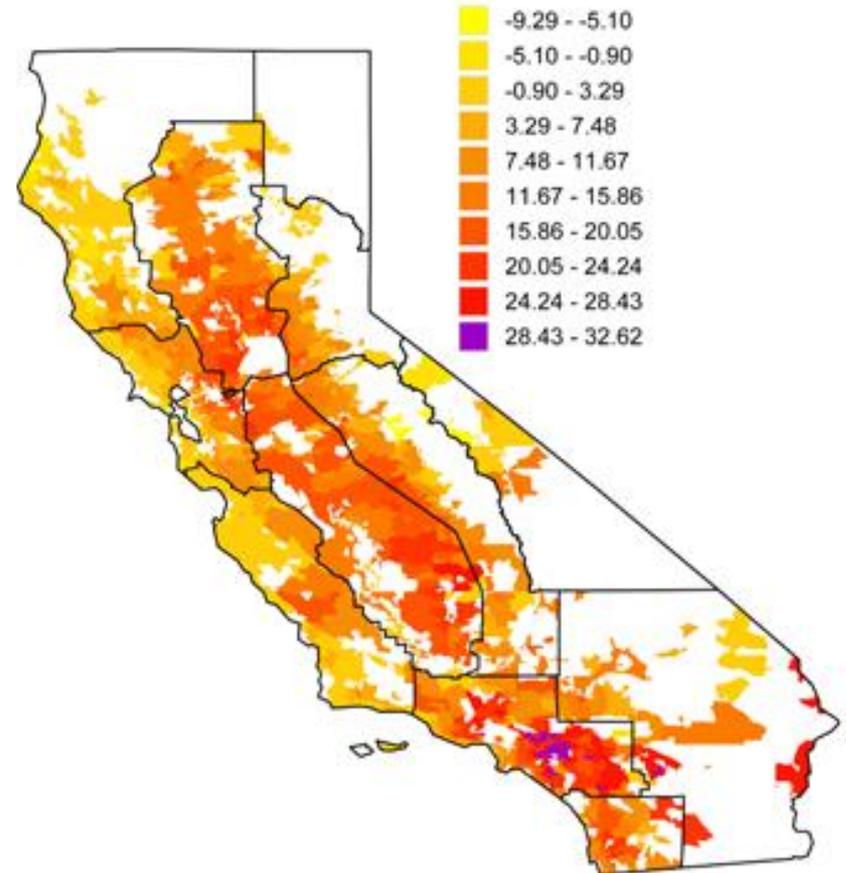
Comparison of INFORM with conventional management practices under different climate scenarios



Georgakakos et al., 2012

+ Actions: Energy Impacts

- **Increases in peak hourly demand in our homes during the hot months of the year could be more pronounced than changes in annual demand.**
- Findings from the Fourth Assessment are informing state agencies' approach to adaptation—including a new quasi-legislative process to consider climate adaptation for investor-owned utilities.



Projected percent changes in average annual household electricity consumption in 2080-2099 for RCP 8.5 relative to a 2000-2015 baseline. Data source: Auffhammer, 2018.



Topical Reports

Climate Justice

Sona Mohnot, Greenlining Institute

Coast & Ocean

Gary Griggs, UC Santa Cruz

Tribal & Indigenous Communities

Stephanie Lucero, Center for Collaborative Policy



In the Next 35 years...

- ❖ **1 – 3.6°F temperature rise**
- ❖ **25 - 40 % reduction in snowpack**
- ❖ **Sea level rise: 5"-24"**
- ❖ **Less summer/fall runoff**
- ❖ **More intense wet and dry periods**