



Southern California's Vulnerability to Climate Change

October 20, 2011

Tony Haymet

Director

Thanks to Dr. Dan Cayan, Scripps Oceanography
Sponsors: California Energy Commission, NOAA RISA program,
USGS, DoE, California Department of Water Resources

There is a high likelihood of substantial climate change in CA “Mediterranean” regions

This pending change, coupled with
population increase, land use, and other forces,
places an imperative to
measure, understand, plan for, and adapt to
climate change impacts across the California
landscape

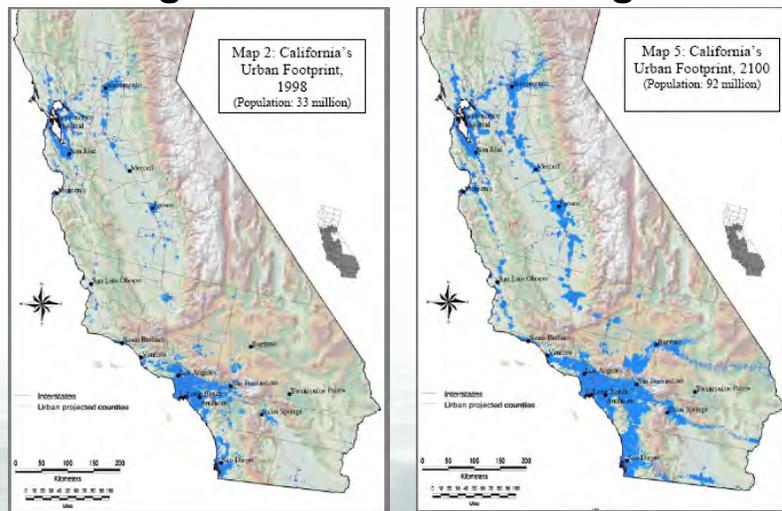


Outline

- Temperature
- Rainfall
- Snow versus rain
- Wildfires
- Sea level rise
- Southern California Beach industry
- (SF Bay and Delta system)
- Water supply



California's Human Footprint Will Also Change as its Climate Changes

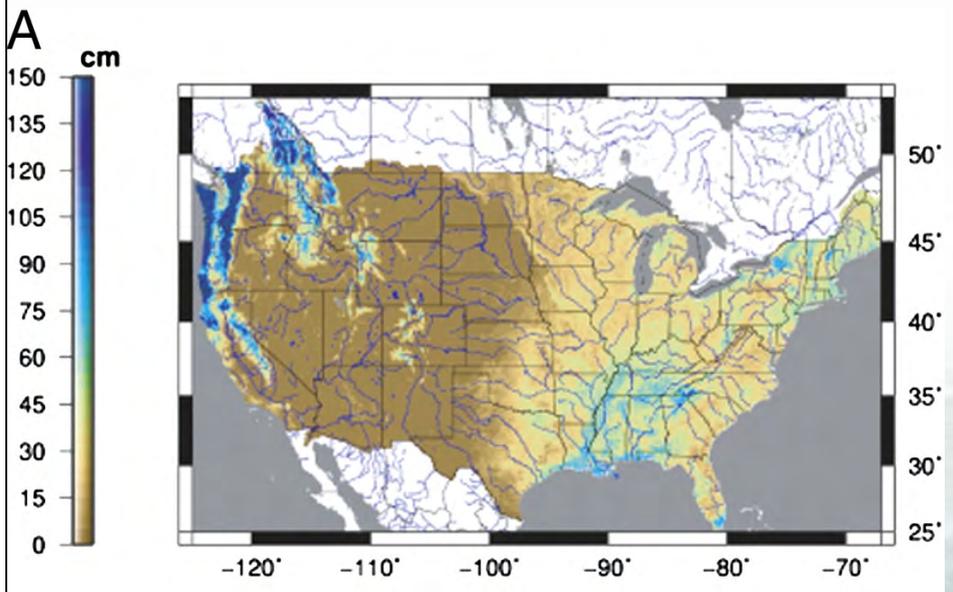


Source: John D. Landis and Michael Reilly "How We Will Grow: Baseline Projections of the Growth of California's Urban Footprint through the Year 2100" Institute of Urban and Regional Development University of California, Berkeley

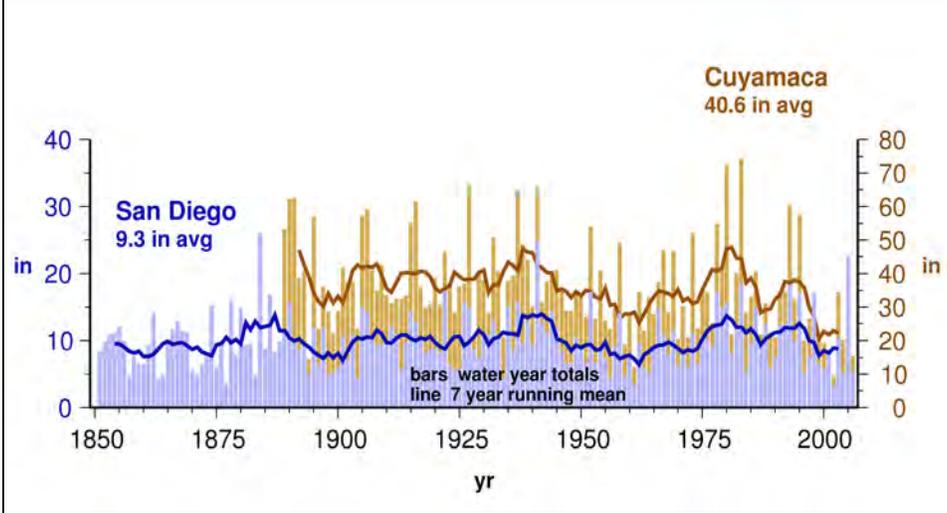
California floristic province is identified as one of the world's key high biodiversity strongholds



Annual Runoff across the United States Strong Aridity in the West



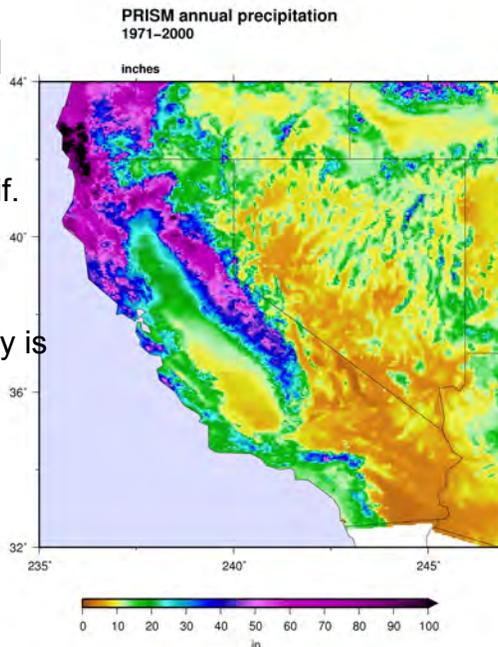
Highly Variable: Yearly Precipitation in San Diego Region Ranges from ~33% to 280% of Average (water year is Oct. through Sept.)



Precipitation is Heavily Influenced by location in CA

- Range of precipitation in Calif. is 1 to 100 inches per year

- Volume of precipitation delivered to San Diego County is only enough to supply 5 to 10 percent of water consumed



Best Projections of Climate change impacts on California

**warmer ?— yes, almost certainly
drier ?— maybe**

(not “predictions”; these are our best engineering estimates so we can invest our infrastructure funds as wisely as possible)

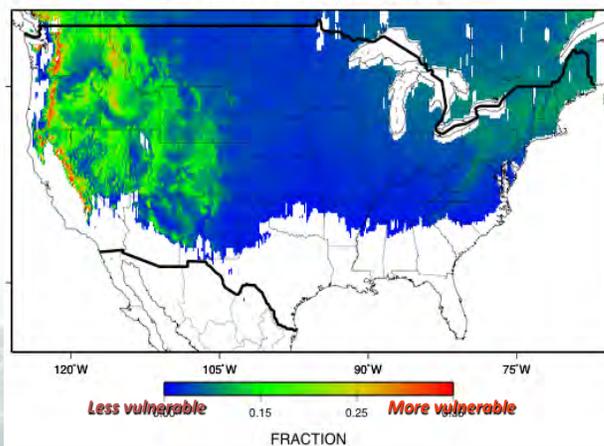


Now, six quick graphs on precipitation

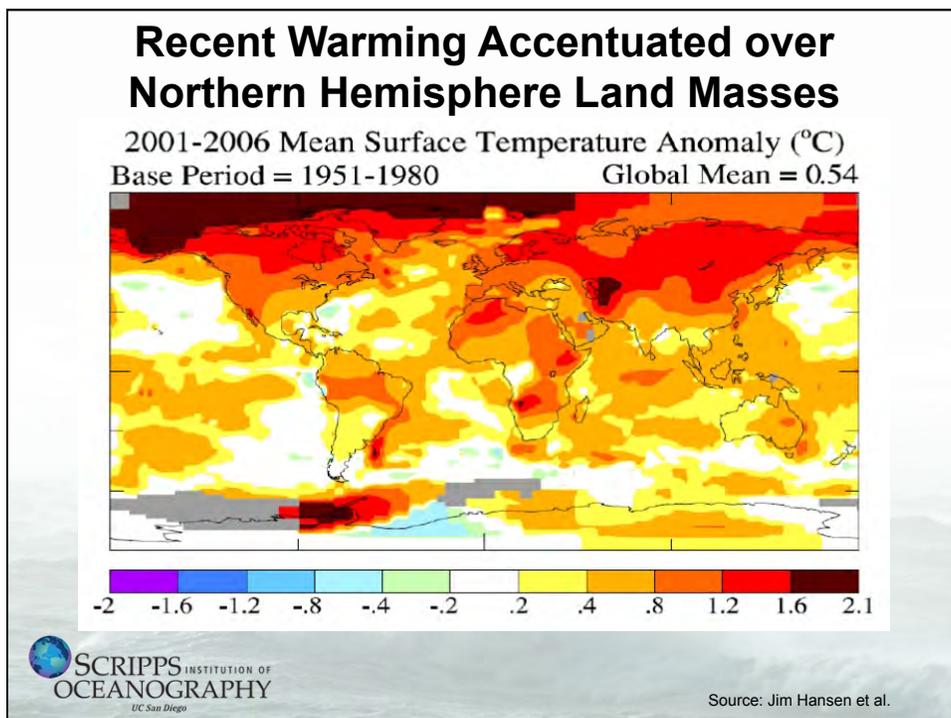
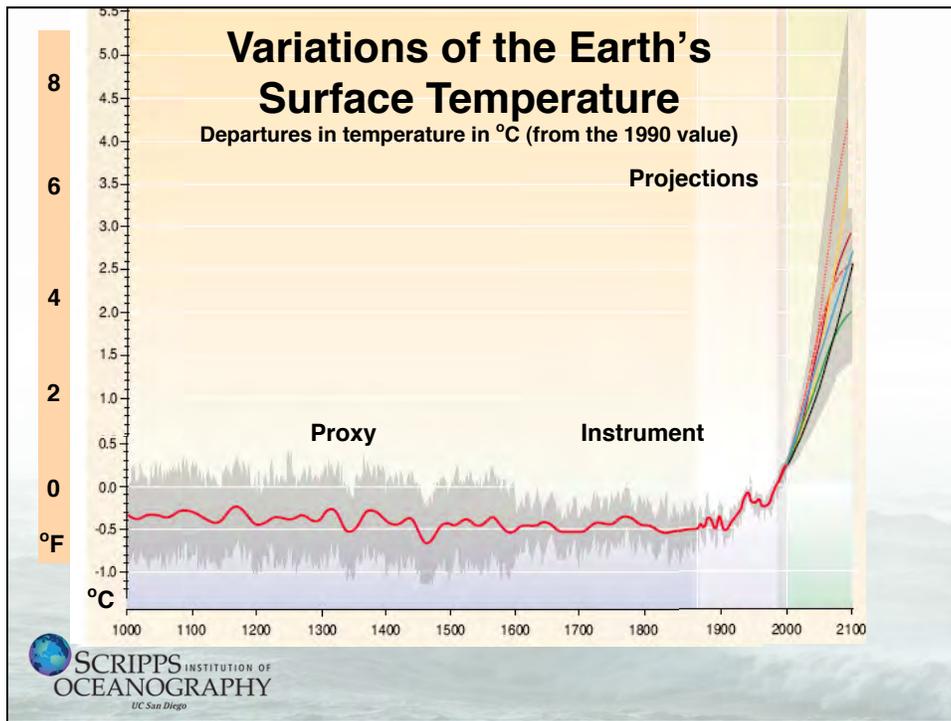
Rain versus Snow: what happens if we get warming of 3 Degrees C ?

Landscapes of the western United States, such as the west slope of the Sierra Nevada, have a significant fraction of their water budget falling in a temperature zone that is vulnerable to climate warming.

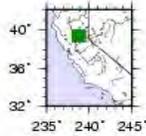
FRACTION OF ANNUAL PRECIPITATION FALLING IN THE DAILY TEMPERATURE RANGE: $-3C < T_{avg} < 0C$
[from 1950-1999 VIC 1/8-degree INPUT DATA]



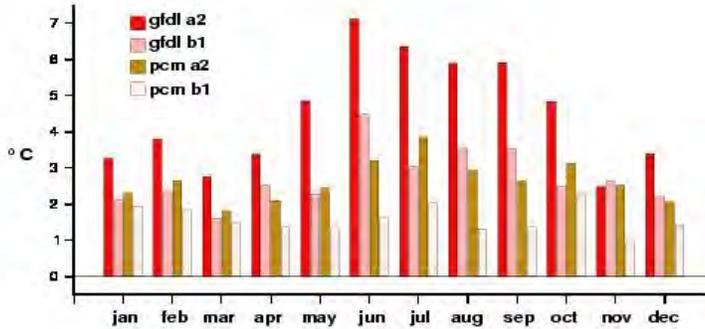
Computed by Mike Dettinger from gridded historical US weather data (from Bates et al, 2006 WRR)



Seasonally intensified warming?



Nocal temperature anomaly
2070–2099 minus 1970–1999

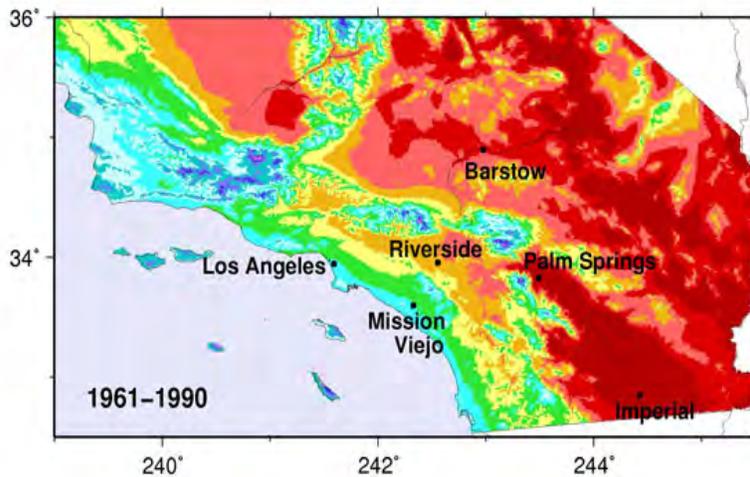


Recent models suggest amplified summer warming, which could produce serious impacts on California & Nevada ecosystems, energy, water and health



Estimated Present-day Historical July Average Daily Temperature Maximum

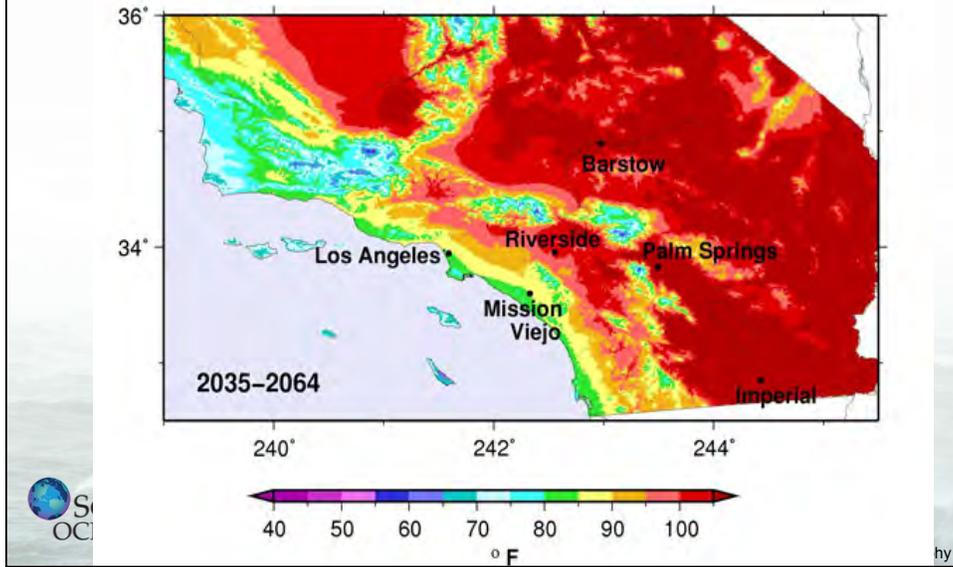
1km downscaled to 1km



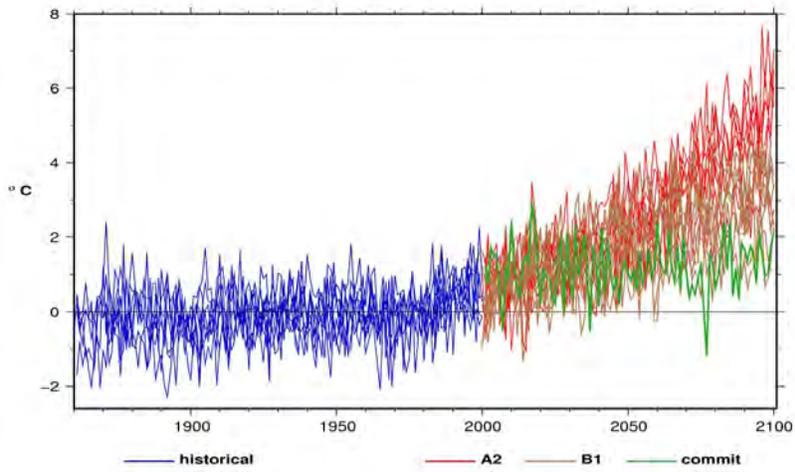
Source: Hugo Hidalgo, Tapash Das, Mike Dettinger/Scripps Oceanography

One Climate Model Scenario of July Average Daily Maximum Temp mid 21st century

GFDL A2 1km downscaled to 1km



Annual Temperature Projections, Sacramento area from 8 IPCC AR4 global climate models, SRES A2, B1 and commit

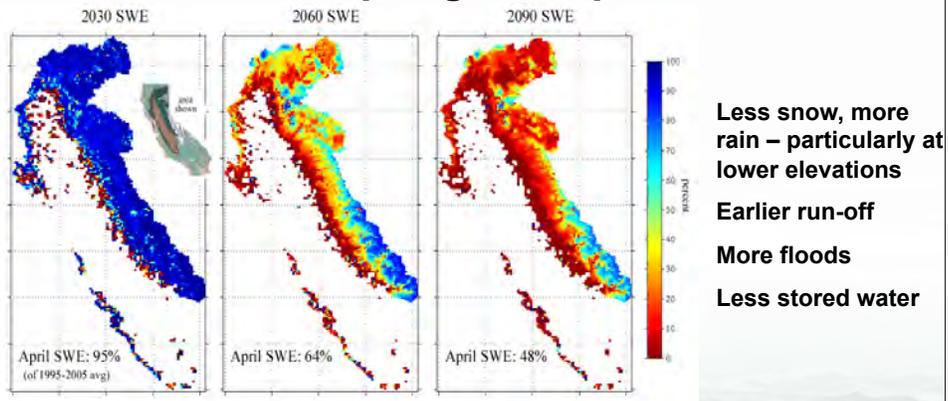


GFDL CM2.1 -- NCAR PCM1 -- MIROC3.2 -- CSIRO Mk3.0
IPSL CM4.0 -- MPI ECHAM5 -- CNRM CM3.0 -- UKMO HadCM3

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego

Sacramento Temperatures

We Face Significant Losses of Spring Snowpack



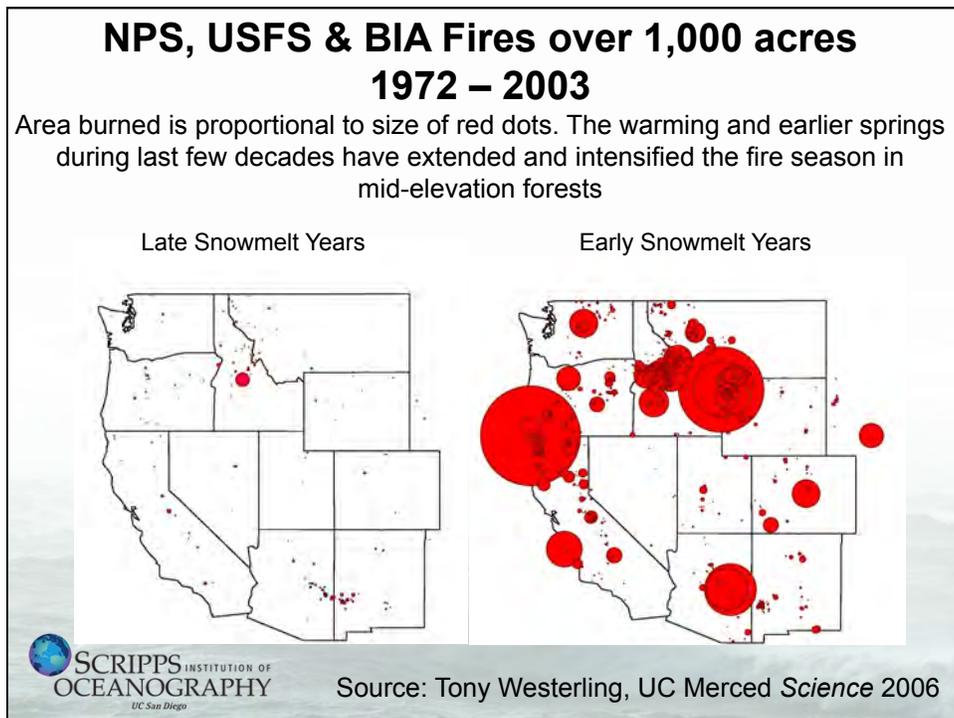
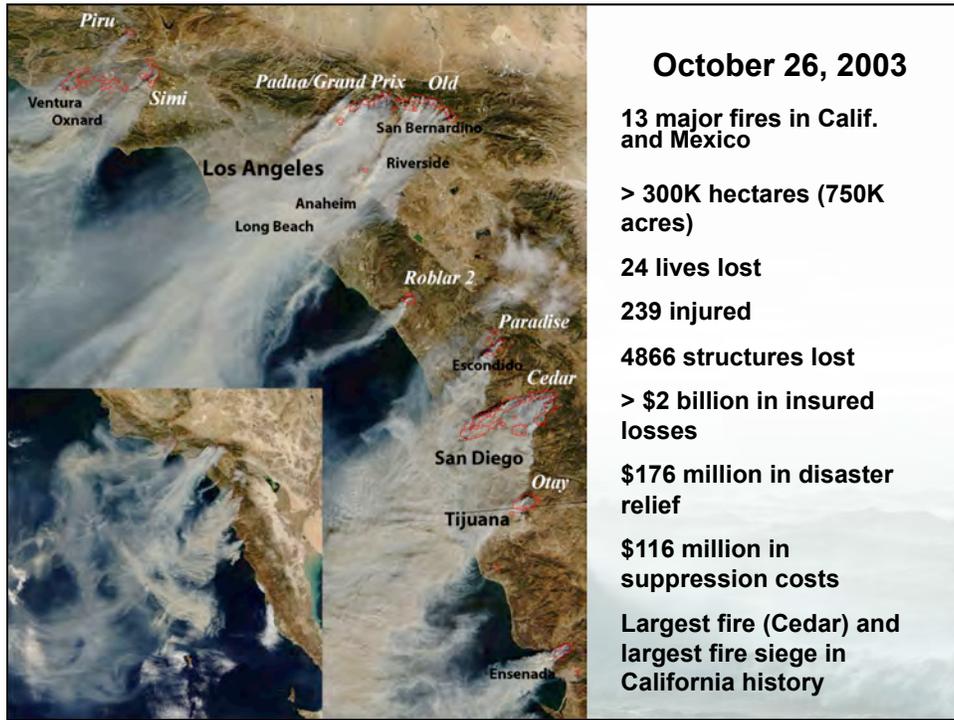
By the end of the century California could lose half its late spring snowpack due to climate warming. This simulation is guided by temperature changes from PCM's business-as-usual climate simulation (A middle-of-the-road emissions scenario)



Source: Knowles and Cayan 2001

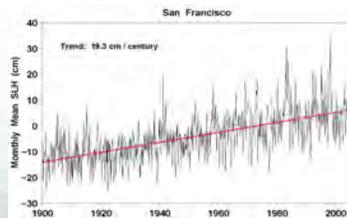
Since 1985, the Number of Large Wildfires in Western U.S. Increased by 4X
MOSTLY MOUNTAIN FOREST FIRES, NOT SHRUBLAND FIRES



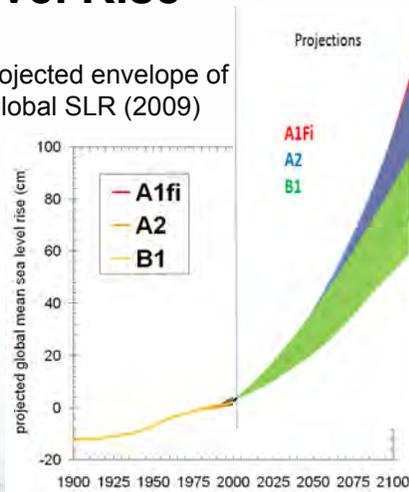


Sea-Level Rise

Observed SFO (left) and modeled Global (right). Sea level rise estimates based upon an envelope of output from several GHG emission scenarios



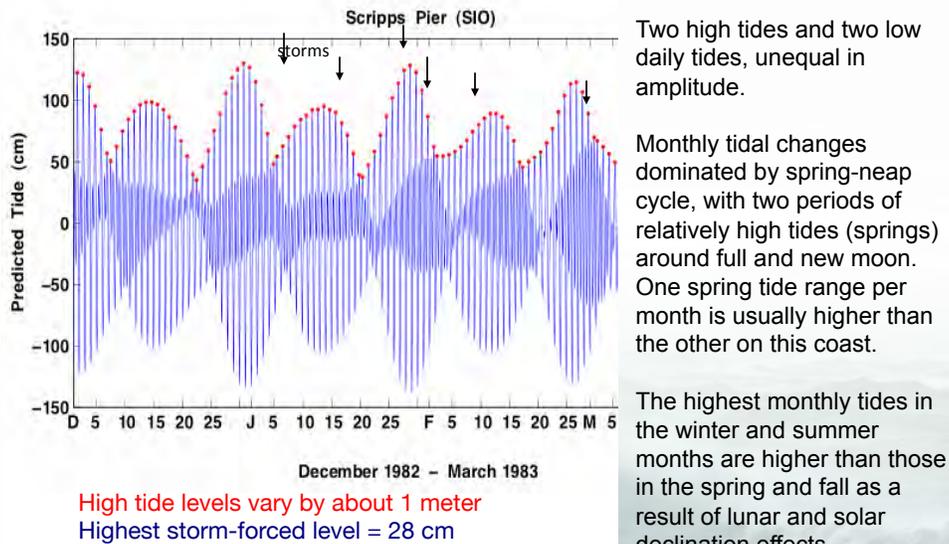
Projected envelope of global SLR (2009)



Climate models only provide loose guidance on the amount of sea-level rise; full physics models are still under development. But it is quite likely that rates will increase greatly in future decades.



Coincidence of Storms and High Tides in Winter 1983: Heavy Coastal Damage



Beach industry in California

- A huge industry that brings in a lot of money
- In 1998, CA beaches brought \$14B in direct revenue California beaches alone have more tourist visits than combined visits to all 346 National Park Service properties including national seashores and monuments such as the Lincoln Memorial and Washington Monument.
- (King, P., 1999. The Fiscal Impact of Beaches in California, Public Research Institute, San Francisco State University, Report, 29 pp.)

California beaches: adapting to sea level rise

Difficult choices...

Armor the beaches?



Malibu, Broad Beach



Ken Hively / Los Angeles Times / June 25, 2008
http://www.latimes.com/news/local/la-me-beach31-2008dec31.0.7928541_story

Sand replenishment?



Goleta Beach, Santa Barbara

<http://coastalcare.org/2010/07/goleta-beach-California>

The Impacts of Sea-Level Rise on the California Coast

“In an analysis prepared for three California state agencies, the Pacific Institute estimates that 480,000 people; a wide range of critical infrastructure; vast areas of wetlands and other natural ecosystems; and nearly \$100 billion in property along the California coast are at increased risk from flooding from a 1.4-meter sea-level rise – if no adaptation actions are taken.”

“Approximately 1,100 miles of new or modified coastal protection structures – such as dikes and dunes, seawalls, and bulkheads – are needed on the Pacific Coast and San Francisco Bay to protect against coastal flooding from a 1.4 m sea-level rise. The cost of building new or upgrading existing structures is estimated to be at least \$14 billion (in year 2000 dollars), with an additional \$1.4 billion per year in maintenance costs. “

“An overwhelming two-thirds of that property is concentrated on San Francisco Bay.”

Populations and critical infrastructure at risk are shown in detailed maps prepared by the Pacific Institute (and available at http://www.pacinst.org/reports/sea_level_rise/maps/). “

Pacific Institute Report commissioned by the Ocean Protection Council, the Public Interest Research Program of the California Energy Commission, and the California Department of Transportation



http://www.pacinst.org/press_center/press_releases/sea_level_rise_3_11_09.html

Summary

Vulnerabilities in Southern California to climate changes include:

- warmer temperature
- reductions to precipitation and extended drought
- change in mix of snow and rain
- sea level rise

Reasons for concern are adverse effects upon:

- water supply and demand
- ecosystems
- wildfire
- energy demand (air conditioning) and energy supply
- human health
- agriculture
- beaches, coastal property, infrastructure, recreation



Conclusions

Weather, natural climate variability, and human-caused climate change are all drive climate impacts in California.

Need no-regrets strategy to shield our region from impacts:

- periodically assess vulnerabilities at regional and local levels
- understand key processes
- monitor the environment and the systems that may be affected
- develop a knowledgeable and networked community of scientists, policy experts and decision makers.

Understanding the climate and its impacts is not enough---
an equal challenge is solving the many societal and institutional barriers to adaptation to climate change



Adaptation – the question is not whether, but how soon, & how costly?