Water supply prediction science: Can better modeling help us anticipate and respond to the challenge of climate change?

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You may be asking yourself:

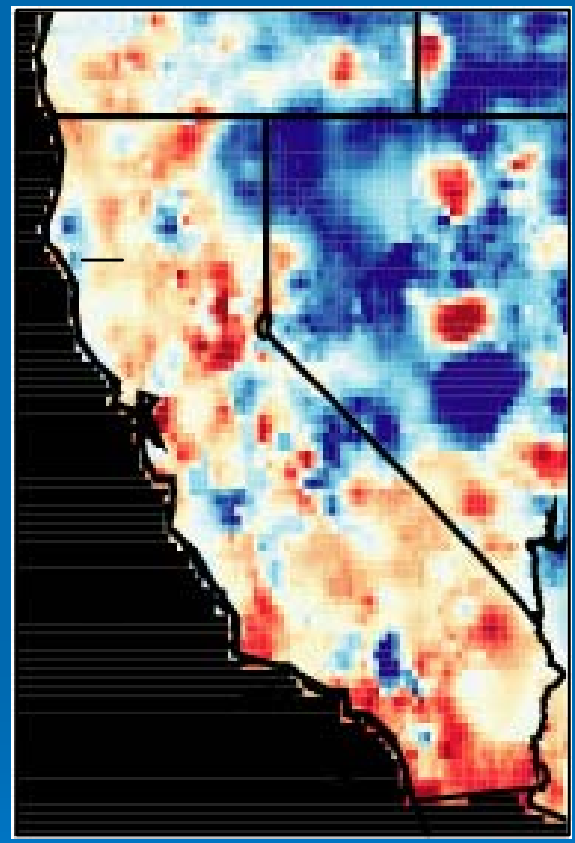
- Is climate change “real?”
- Can academic-style research benefit real-world water managers? (Or is it too idealized?)
- Are uncertainties too great to allow for action?

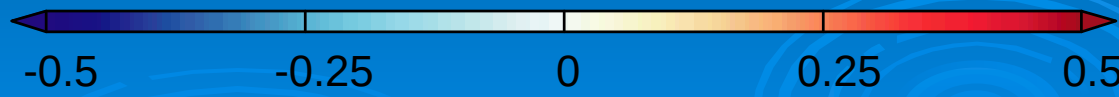
California is experiencing climate change

Much of California has warmed

Warming

Cooling



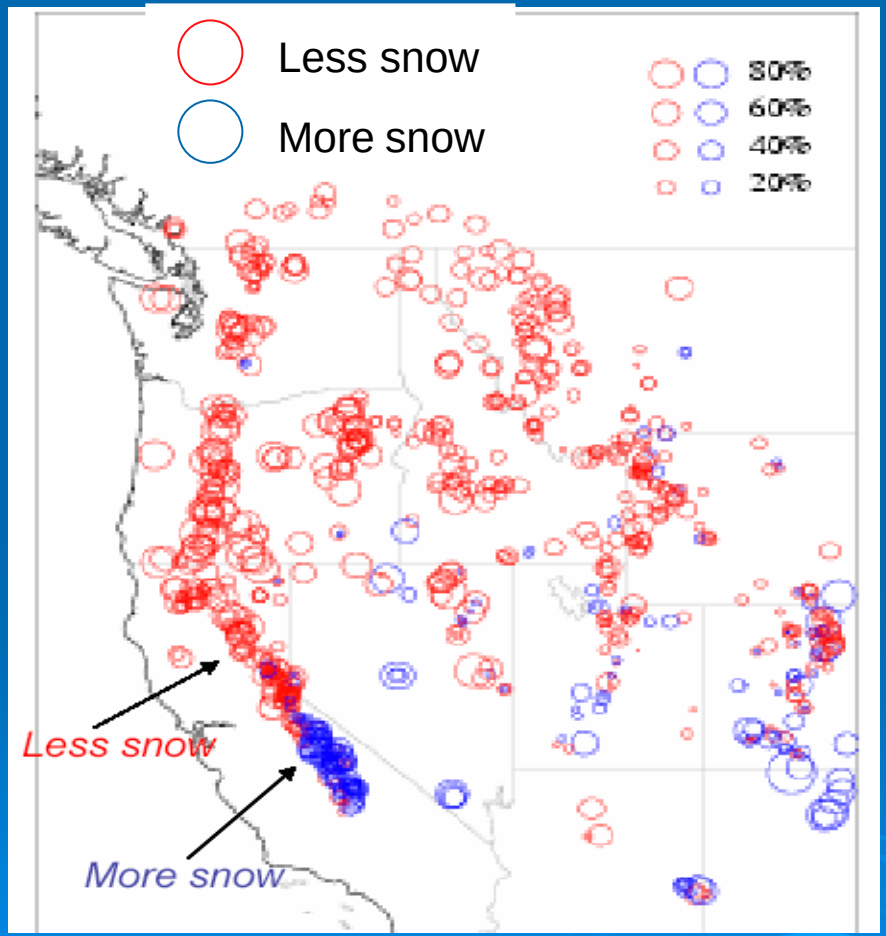


Trends in wintertime temperatures, 1949-1998, deg. C/10 yr

Source: Celine Bonfils, UC Merced

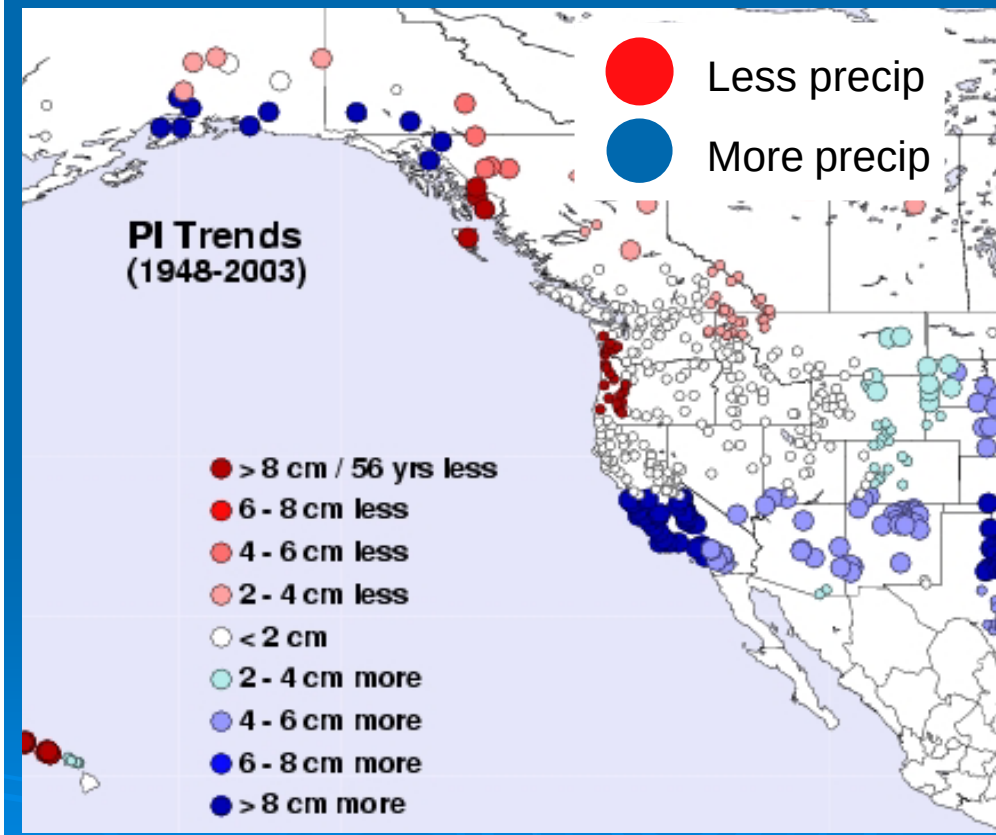
There is less snow in most of the west

50-yr trends in snow water content



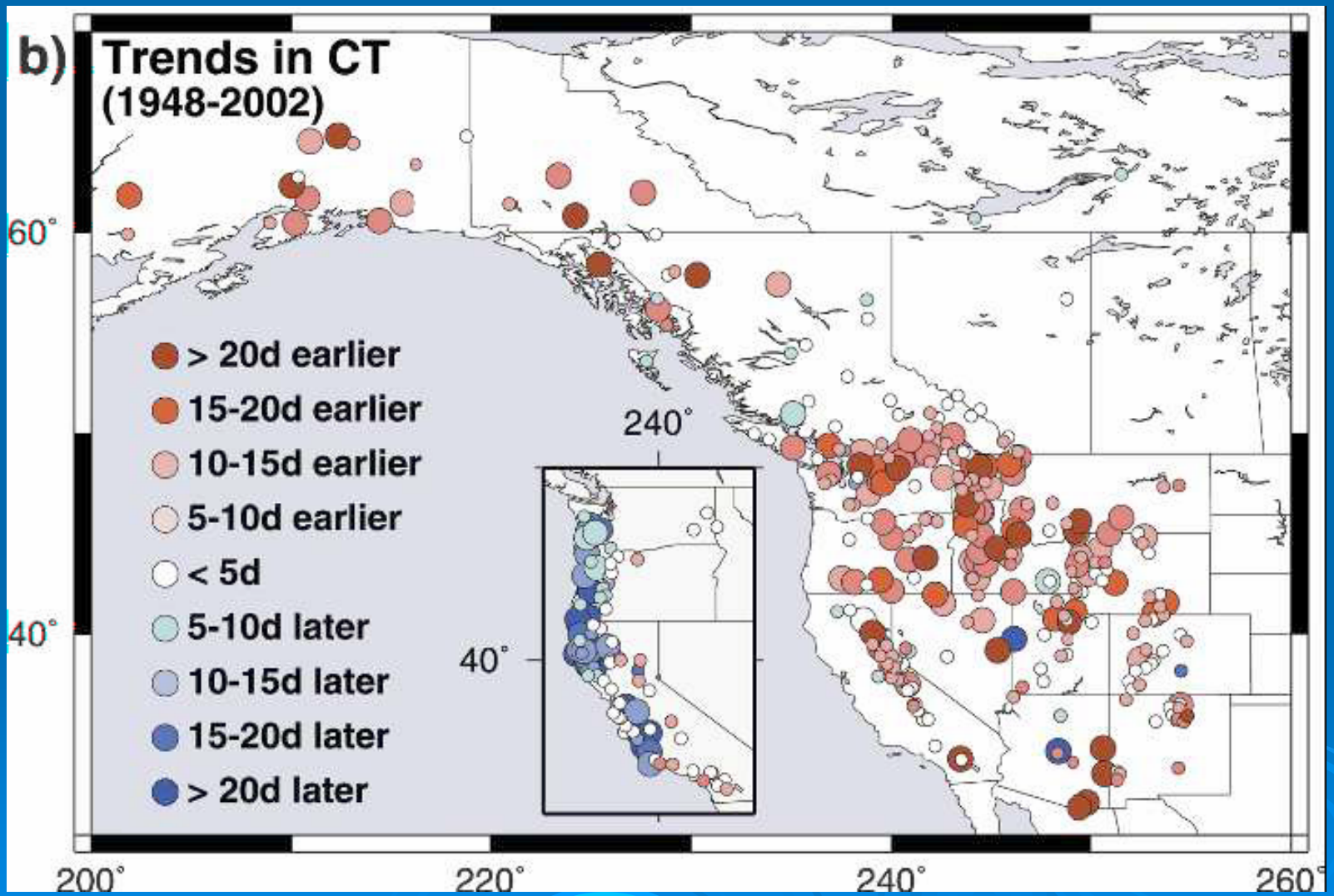
Source: P. Mote, *Geophys Res. Lett.*, 2003

50-yr trends in precipitation



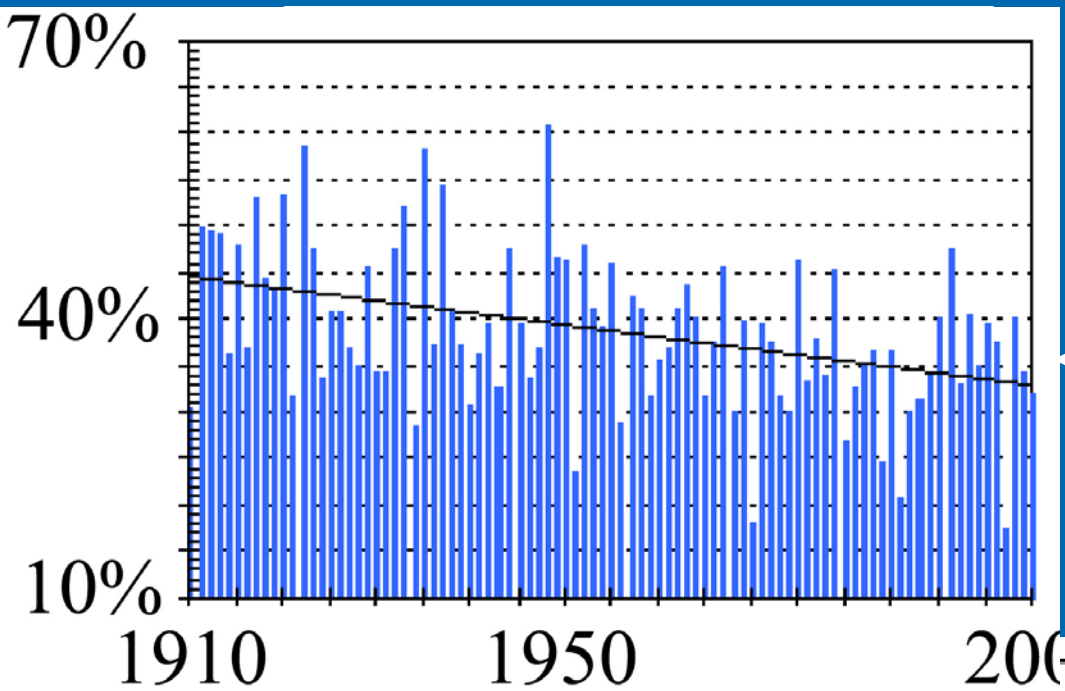
Source: Iris Stewart, UCSD

River flows are coming earlier in the year



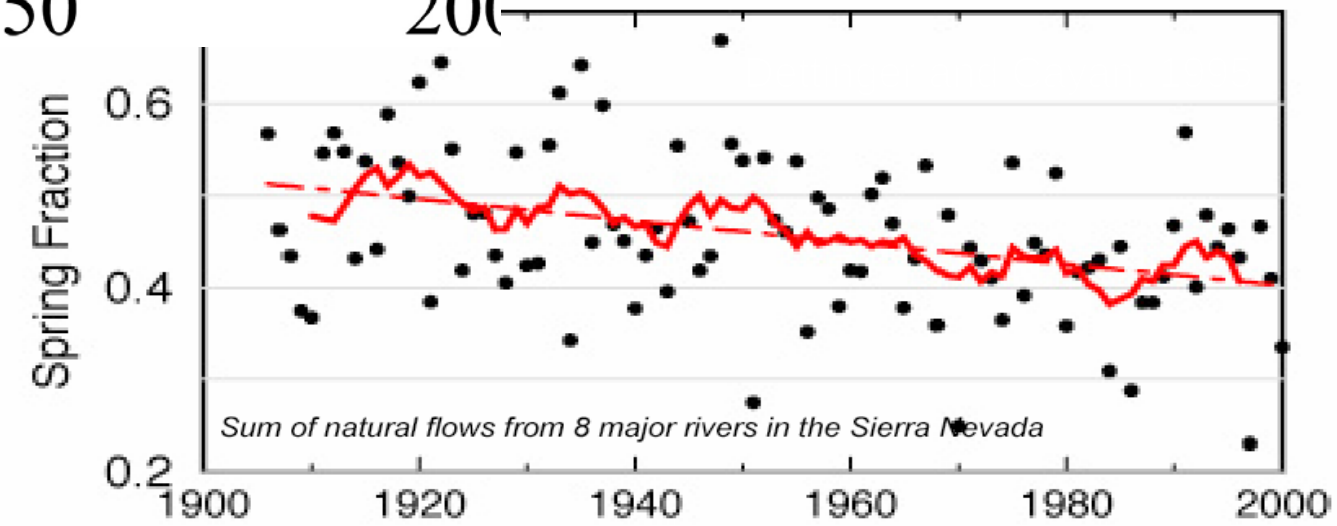
Source: Iris Stewart, UCSD

Late-season runoff is decreasing, due to warming



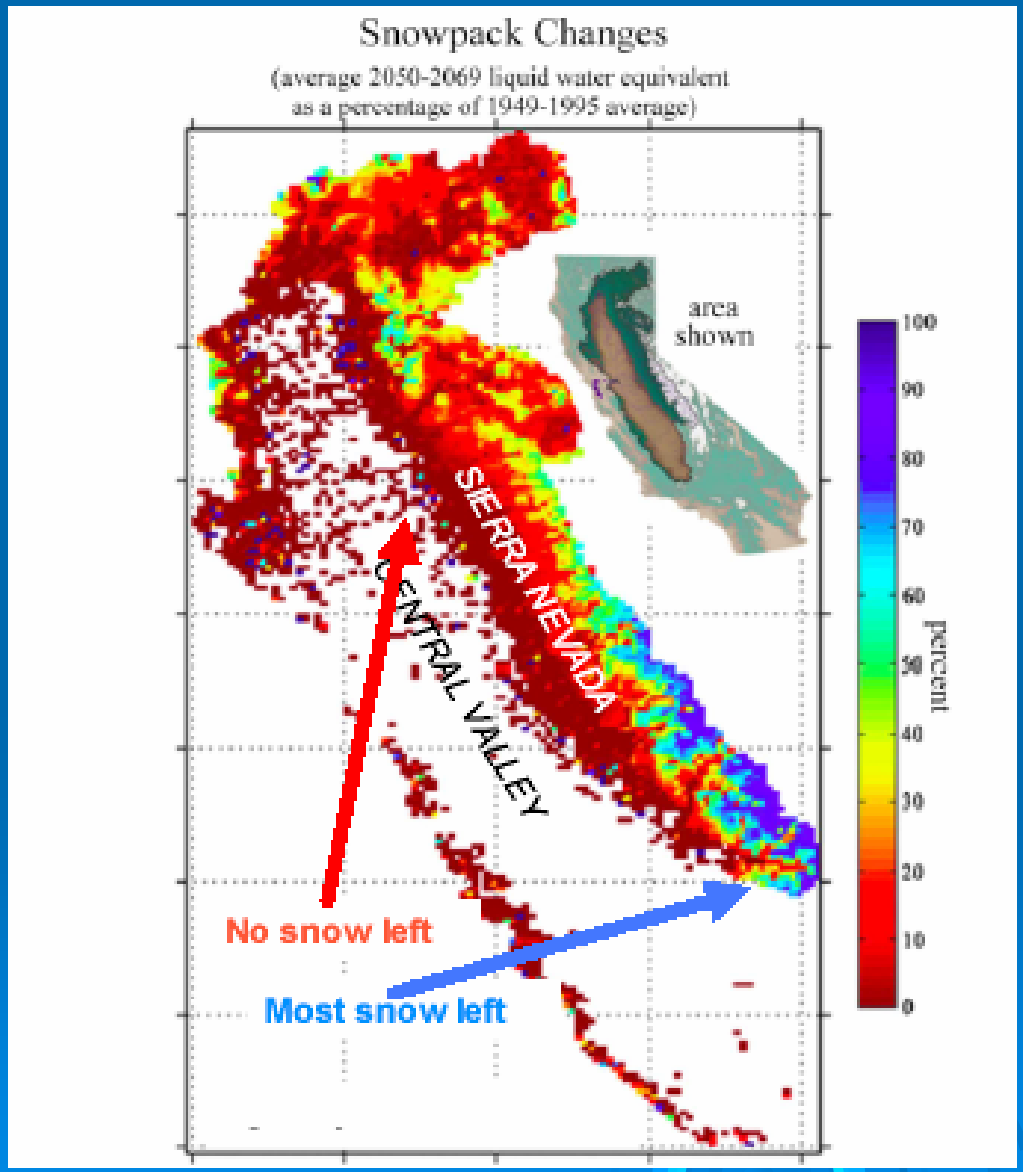
Sacramento river system

8 major rivers



It’s going to get worse…

Much of our snow will disappear



Model: PCM (low sensitivity)

Projected snow water content in 2050-2069, as a fraction of 1949-1995 average

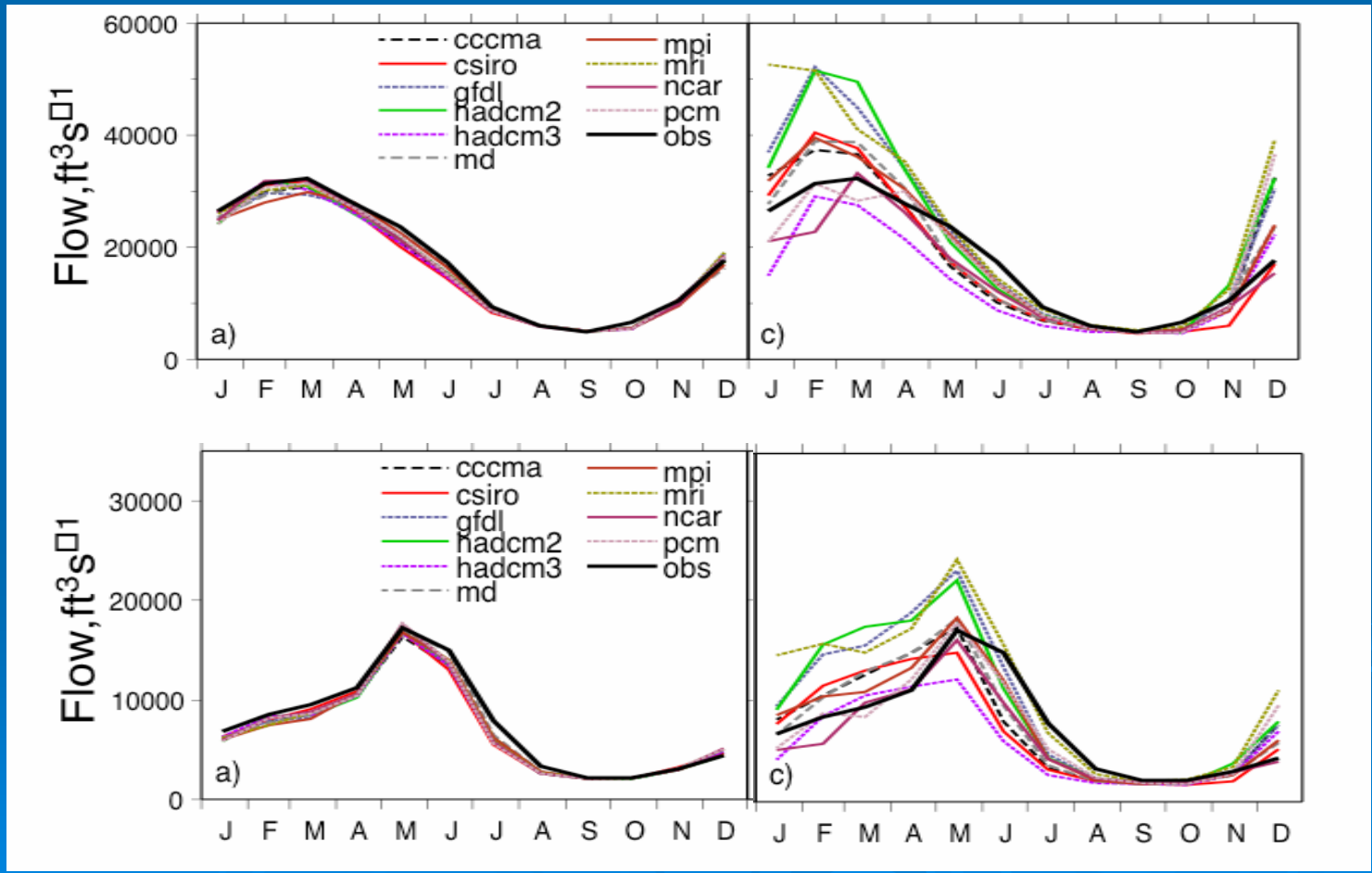
Source: Knowles *et al*, 2003

River flows will happen earlier in the year

Today late 2000s

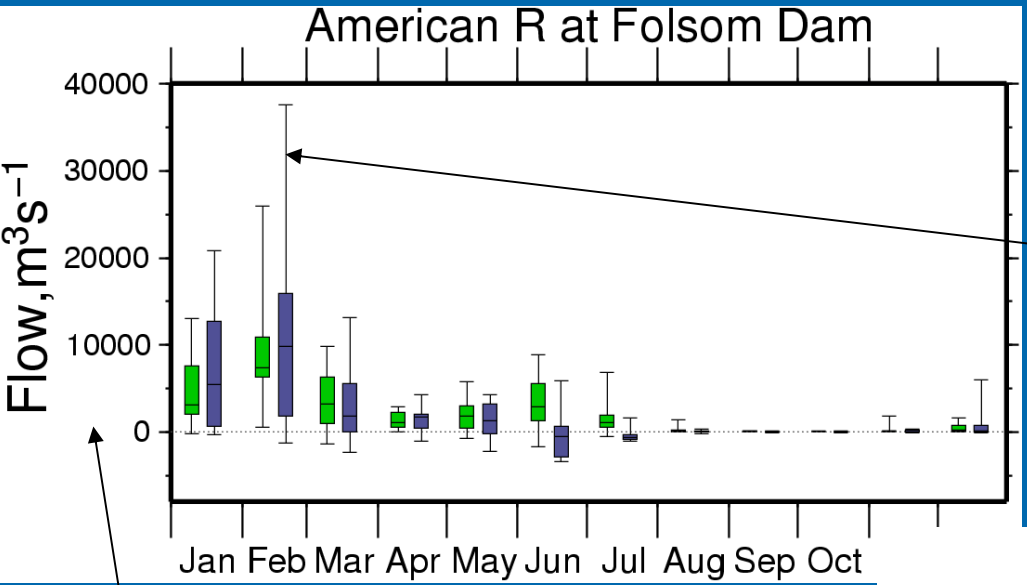
Northern Sierra

Southern Sierra



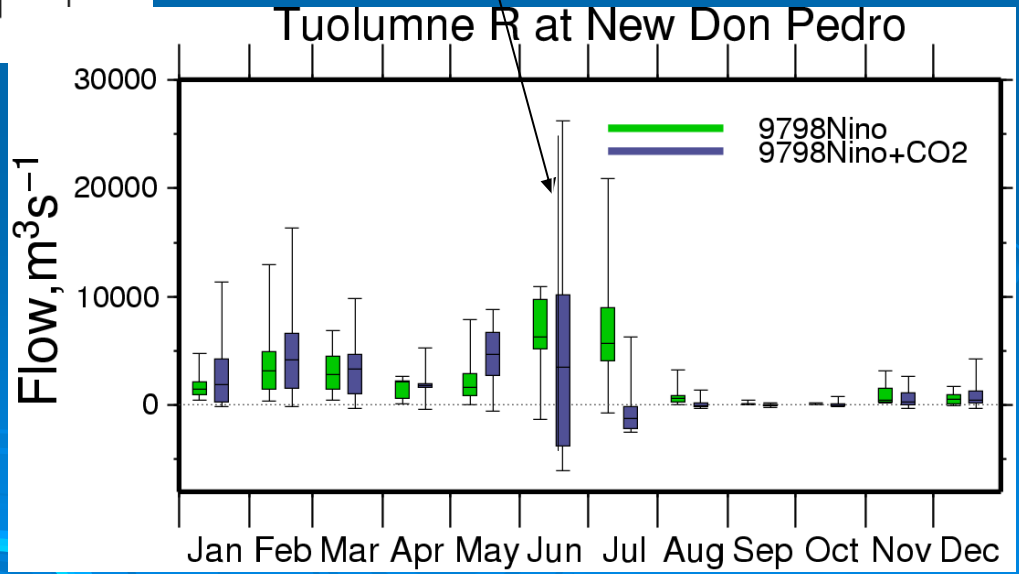
E. Maurer and P. Duffy, **Uncertainty in Projections of Hydrologic Impacts of Climate Change in California,** *Geophys. Res. Lett.*, 2005

El Niño in a warmer climate: higher mean flows, and more variability



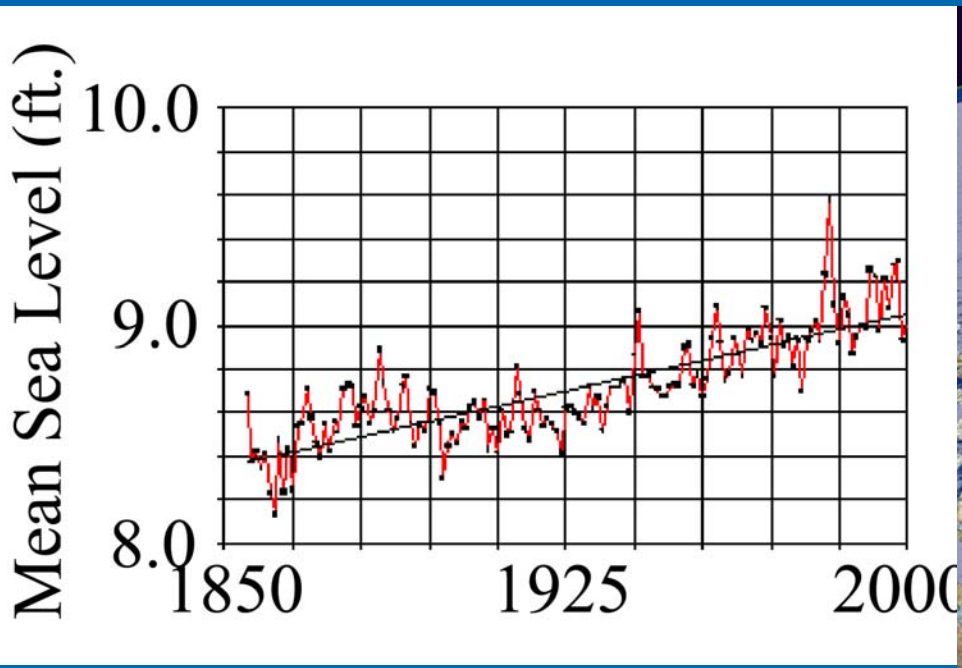
Lengths of bars indicate year-to-year variability

Monthly flows relative to present-day multi-year mean

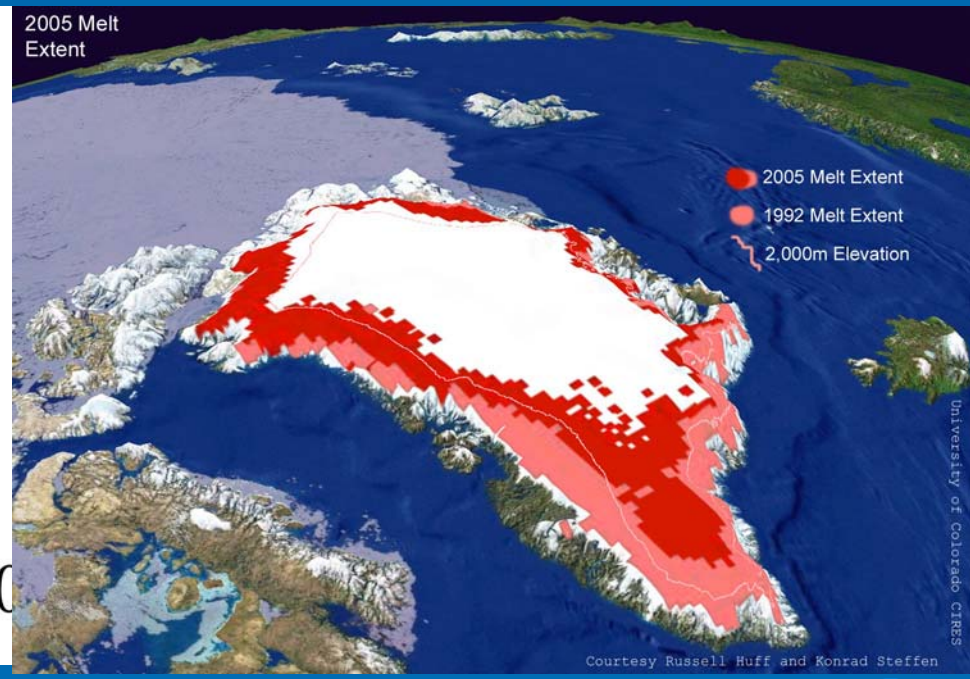


E. Maurer, S. Gibbard, and P. Duffy, *Geophys. Res. Lett.* 2006

Sea level rise will accelerate



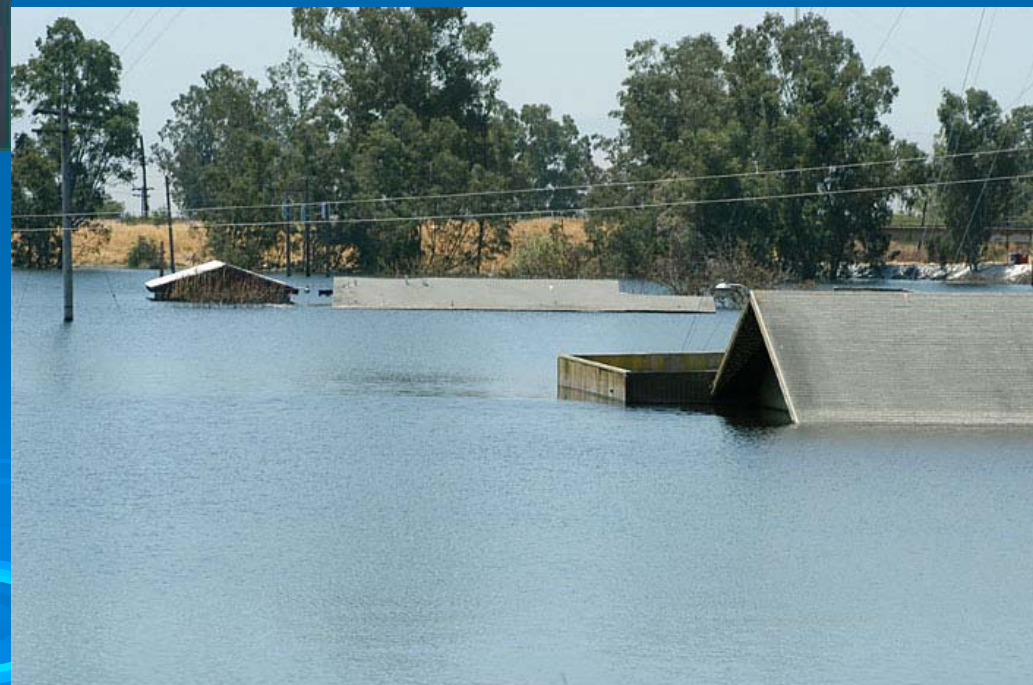
Observed sea level rise at San Francisco



Projected sea level rise up to 4 meters by 2100(Overpeck *et al. Science*, 2006)

Levees are vulnerable

“DRMS” project wil assess risks, and strategies for mitigation



Threats:

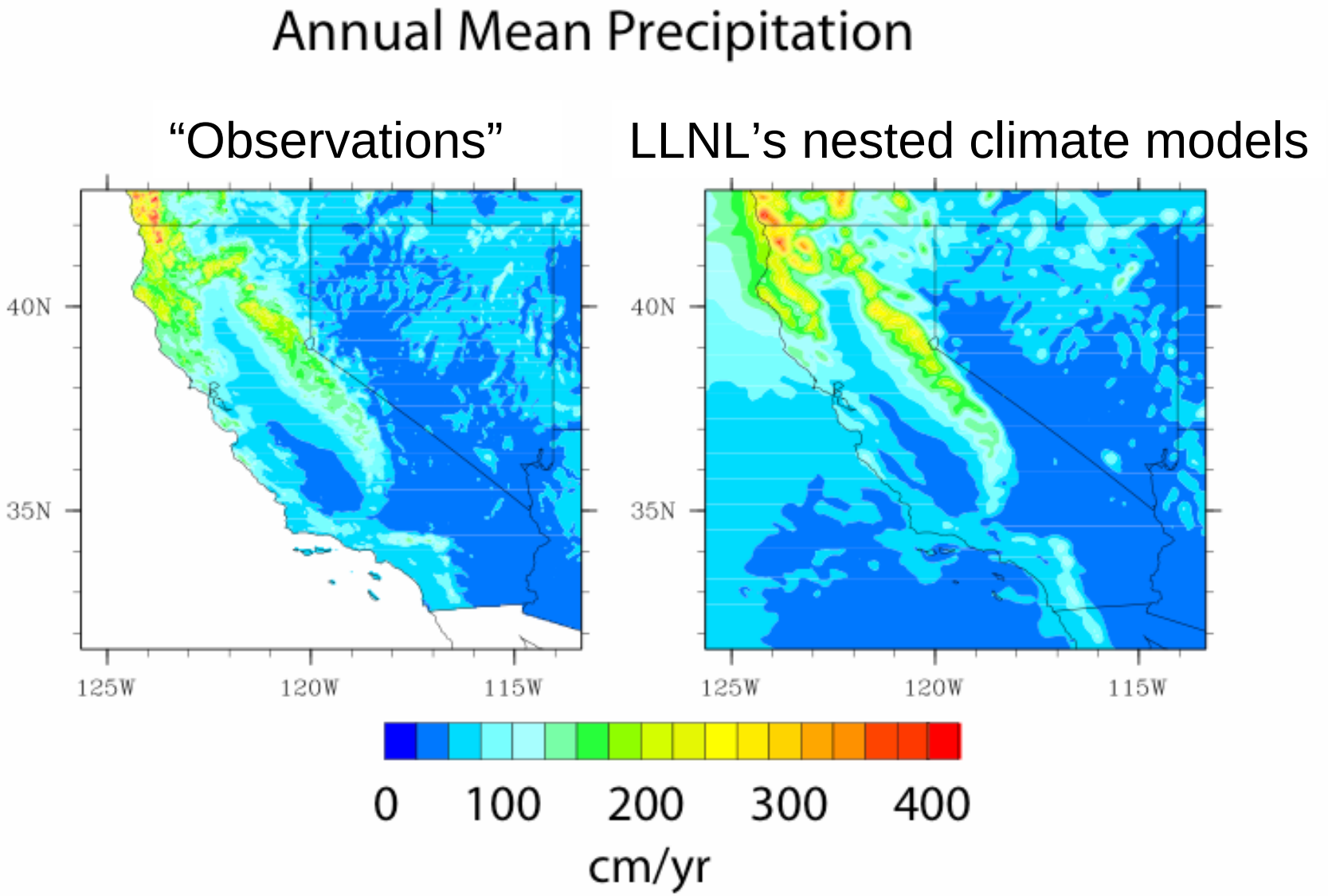
Earthquake, river flood, sea level rise, subsidence, “normal failures.”

Problem summary:

1. Warming is shifting seasonal timing of river flows, and threatens the water supply.
2. Increased year-to-year variability would complicate planning.
3. Flood risk seems likely to increase.
4. Sea level will rise, perhaps substantialy.
5. Levees are vulnerable to a range of threats.
6. Water quality may be affected.

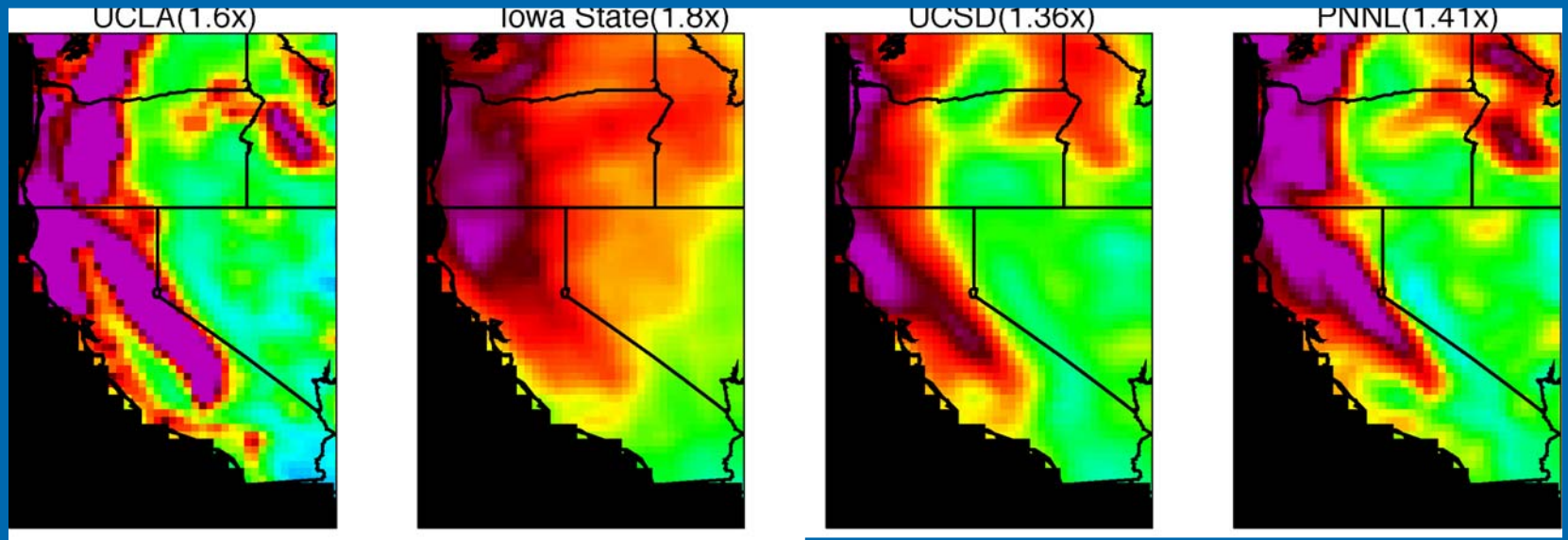
Today's science can usefully address these problems

Climate models have improved

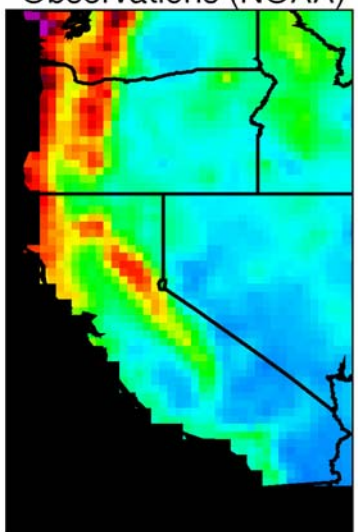


In case you are not impressed…

Model 1 Model 2 Model 3 Model 4



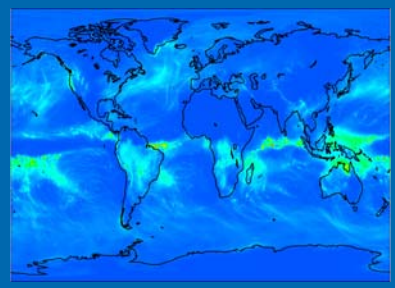
Observations (NOAA)



Winter precipitation simulated by typical limited-domain climate models

We use a linked sequence of models…

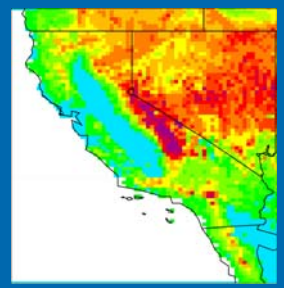
Global Climate Models



~75 km grid size

Predict climate, including precipitation, boundary conditions for downscaling

Regional Climate Models



~10 km grid size

Surface Hydrology Models

~5 km grid size

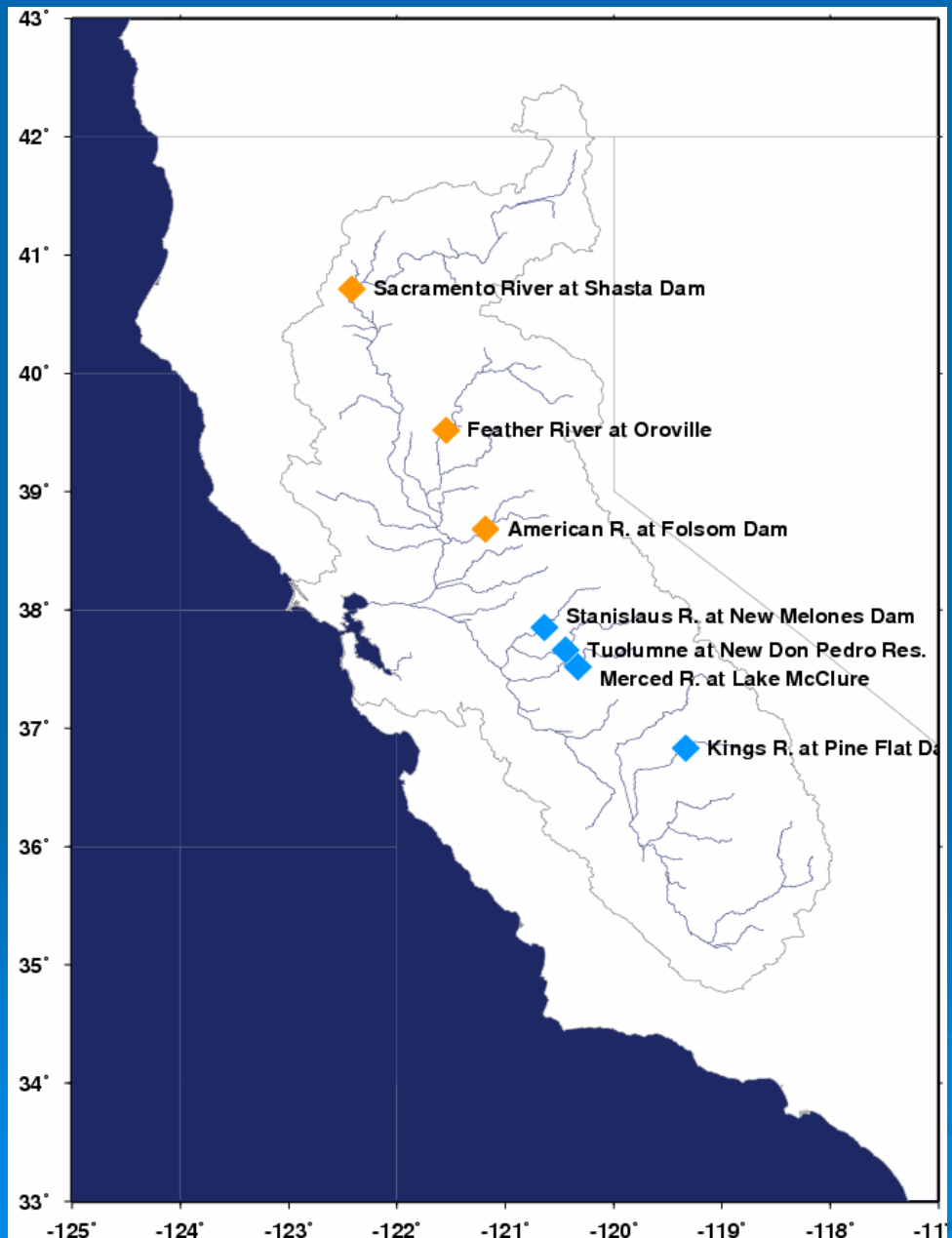
Predicts runoff, given precipitation, etc. from climate model

Water Infrastructure Models (CALSIM)

(Water agencies)

High resolution climate simulations use 200x more computer time than coarse-resolution simulations (which are already very demanding)

Stream gauge locations



Water supply feeds agriculture in Central Valley, and major urban areas.

Gauges are at the inflows to 7 major reservoirs, accounting for most of the inflow from the Sierra Nevada.

3 North gauges represent the total discharge from the Northern part

4 South gauges represent the total discharge from Southern part

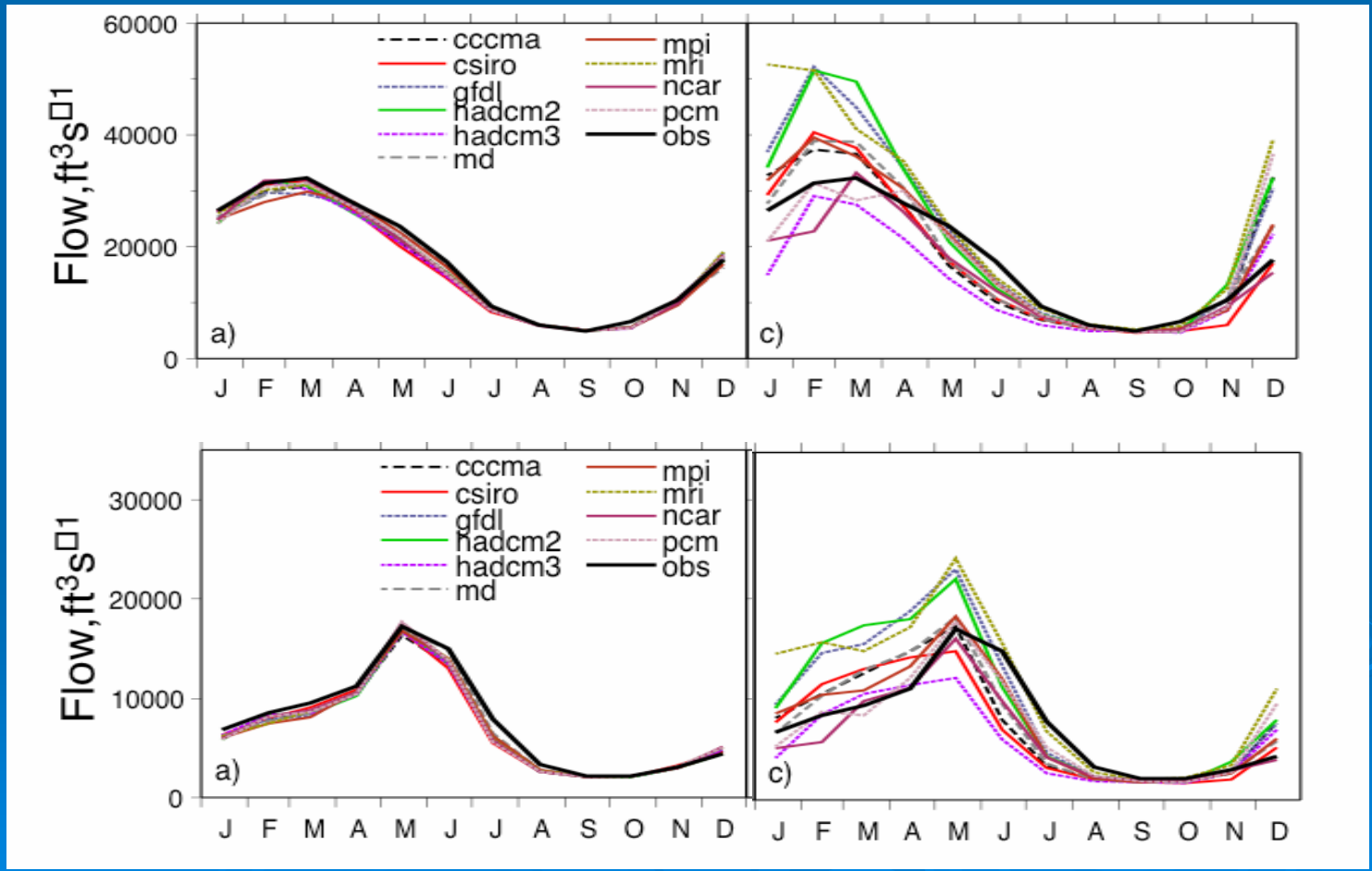
Work done by Ed Maurer while visiting LLNL

Despite uncertainties, some conclusions are robust

Today late 2000s

Northern Sierra

Southern Sierra



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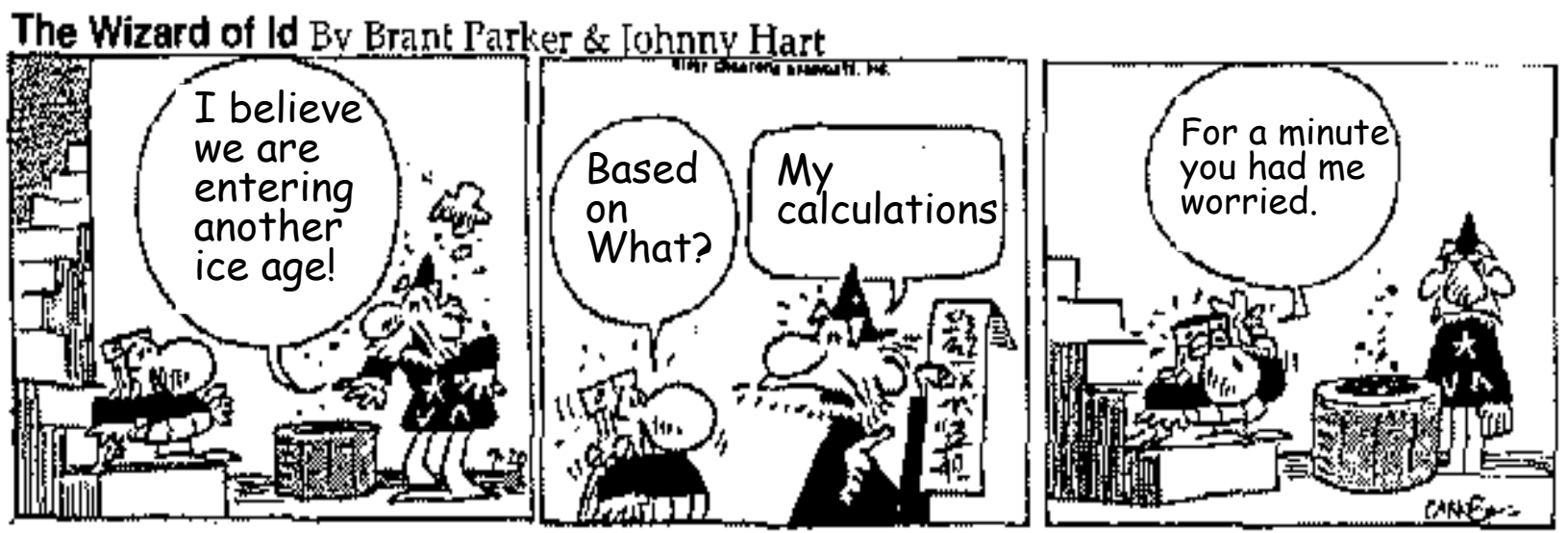
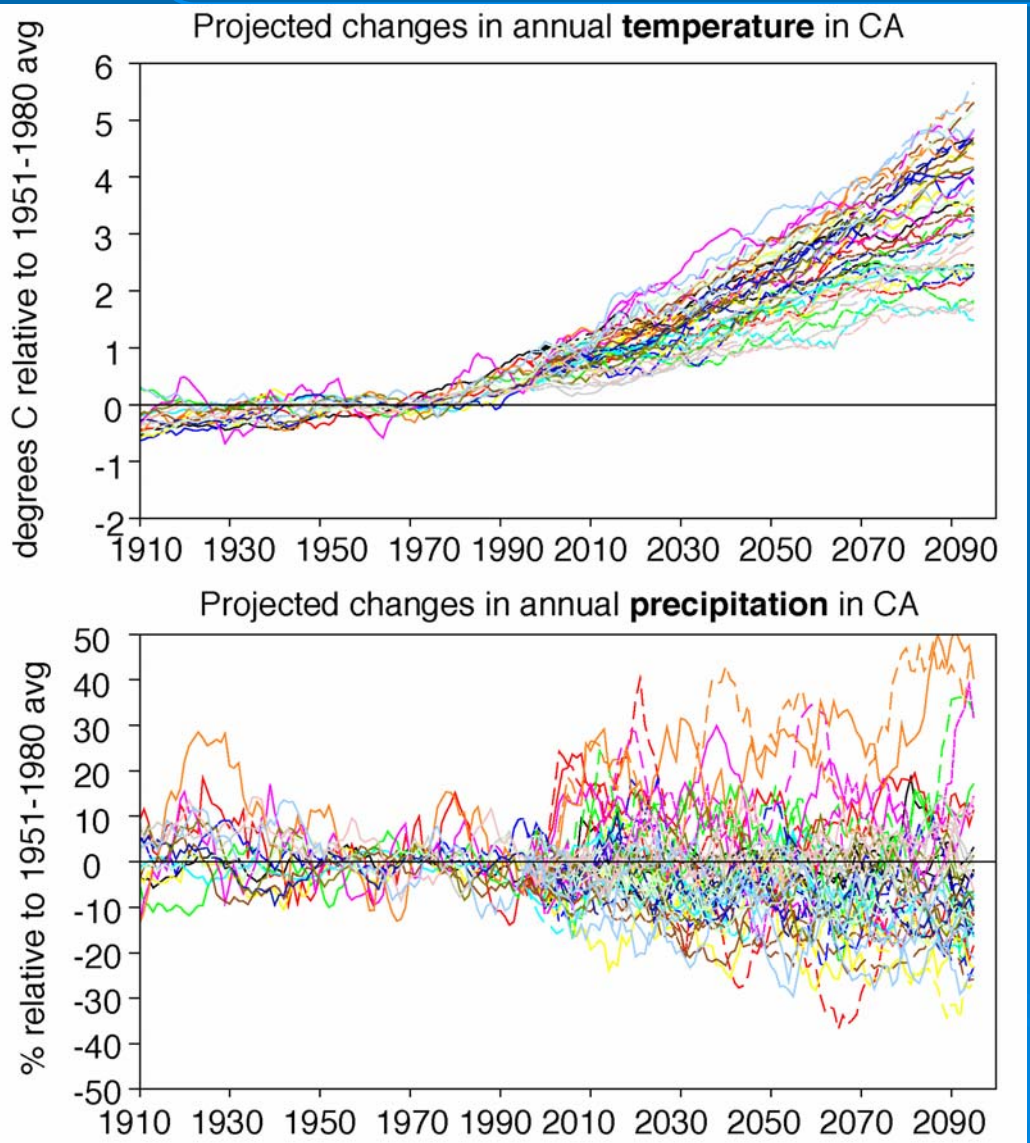
It is important to quantify uncertainties!



Our projections account for uncertainties



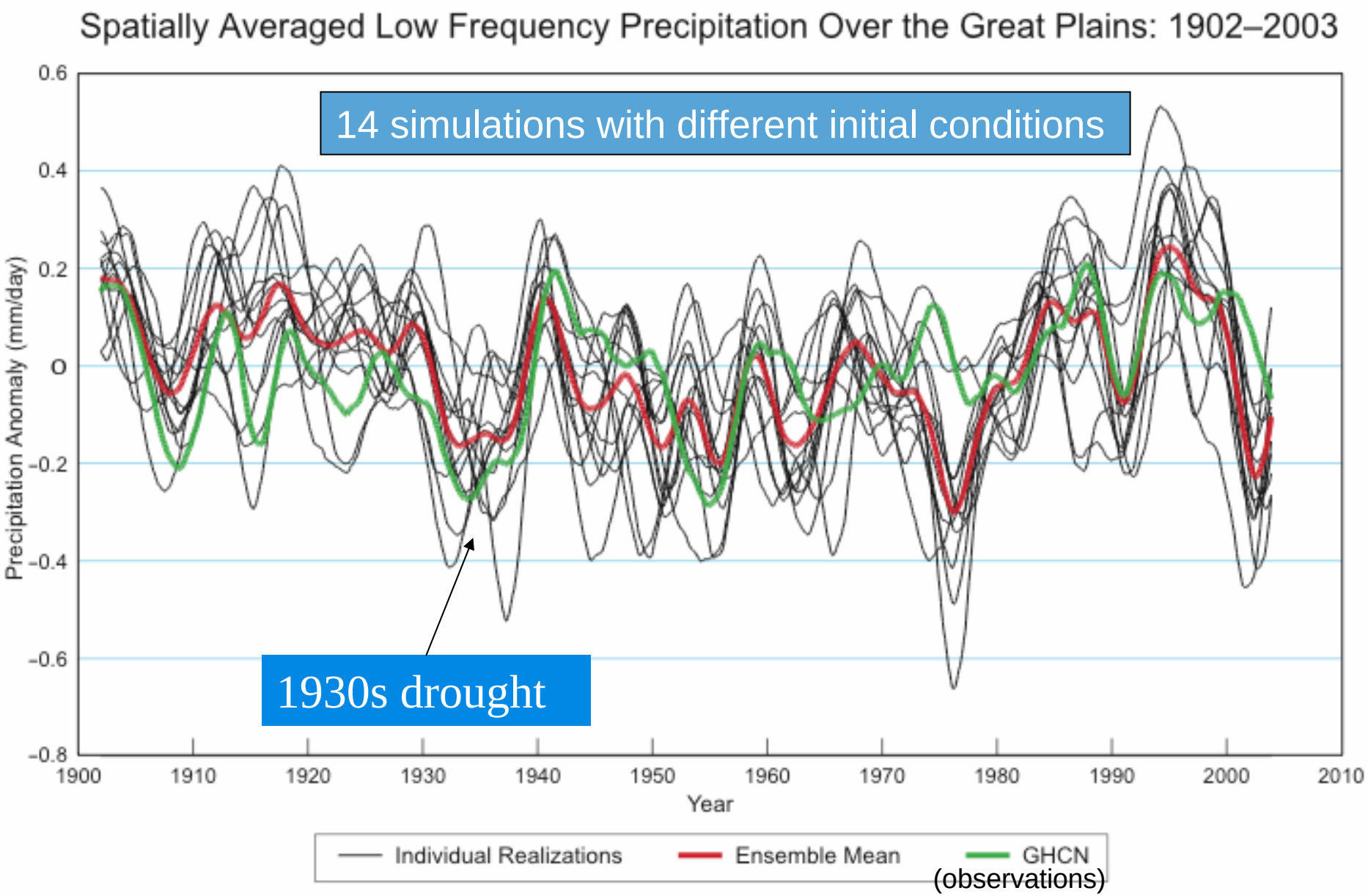
These results express uncertainties in

1. future emissions of greenhouse gases

2. how the climate system responds.

Courtesy Celine Bonfils, UC Merced

Great Plains droughts are predictable, in principle



We want to work with decision-makers

“I’m from the government and I’m here to help.”

The Institute for Research on Climate Change and its Societal Impacts (IRCCSI)

A University of California Intercampus Research Program

What is IRCCSI? | Some background | Affiliated people | Projects | Workshop announcement | Center for Water Supply Prediction Science | Interesting links

http://irccsi.llnl.go

Societal impacts:
How might climate change affect California?

Air quality

Extreme events

Agriculture

Recreation

Human health

Water availability

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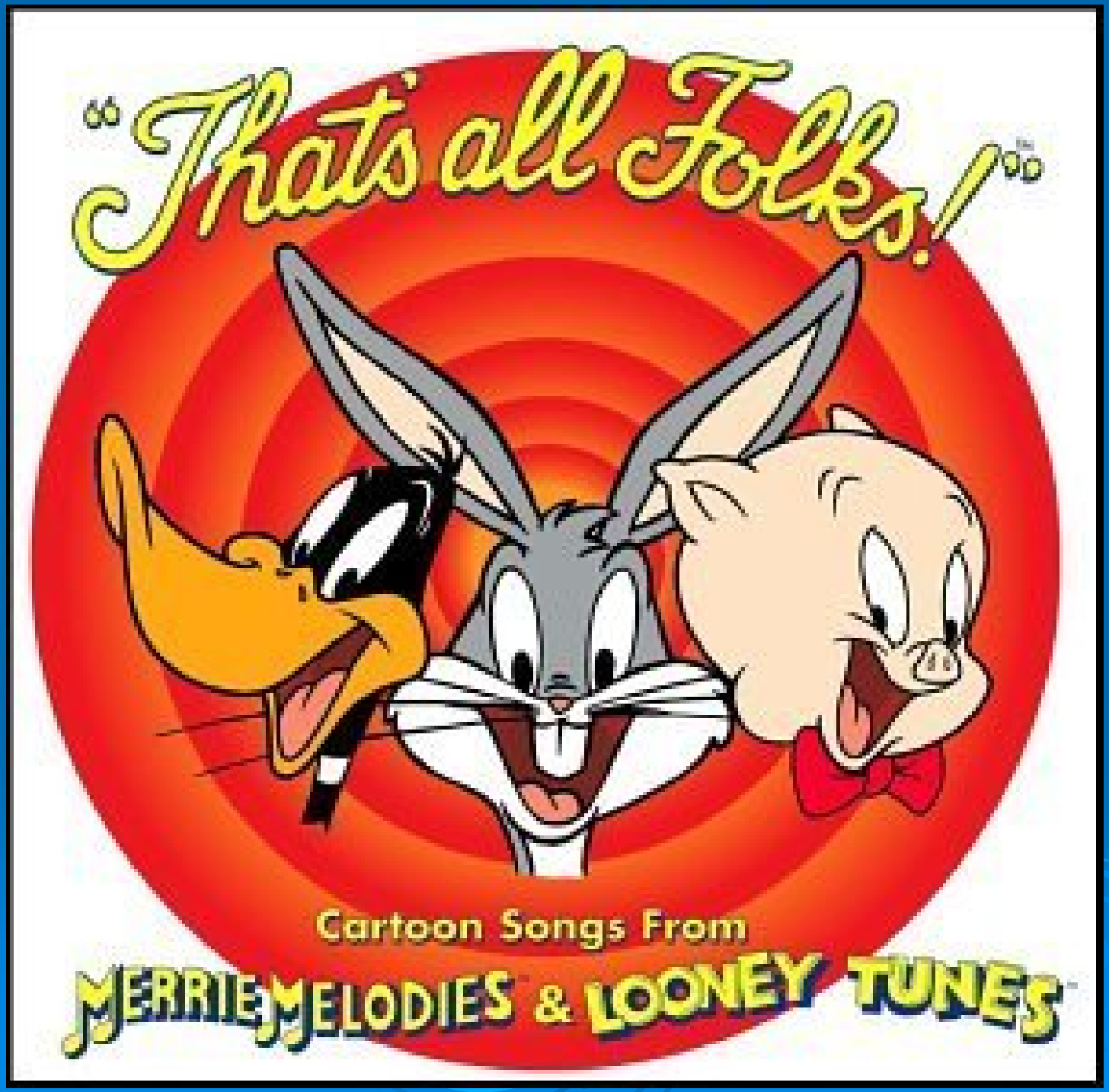
Center for Water Supply Prediction Science

- Goals:
- "Bridge the gap" between researchers and water managers;
- Apply cutting-edge science to real-world problems.
- Questions:
- Is new infrastructure needed?
- Should infrastructure be operated differently?

Final Thoughts

- Climate change will affect water supply, flood risk, and probably water quality in California.
- Today's science can help decision makers, and is rapidly improving.
- We need to quantify uncertainties better; this requires closer coordination among research institutions.
- We need to develop policies that make sense despite uncertainties;
- This requires closer ties to decision-makers and a willingness to do "real-world science".


"That's all Folks!"
Cartoon Songs From
MERRIE MELODIES & LOONEY TUNES