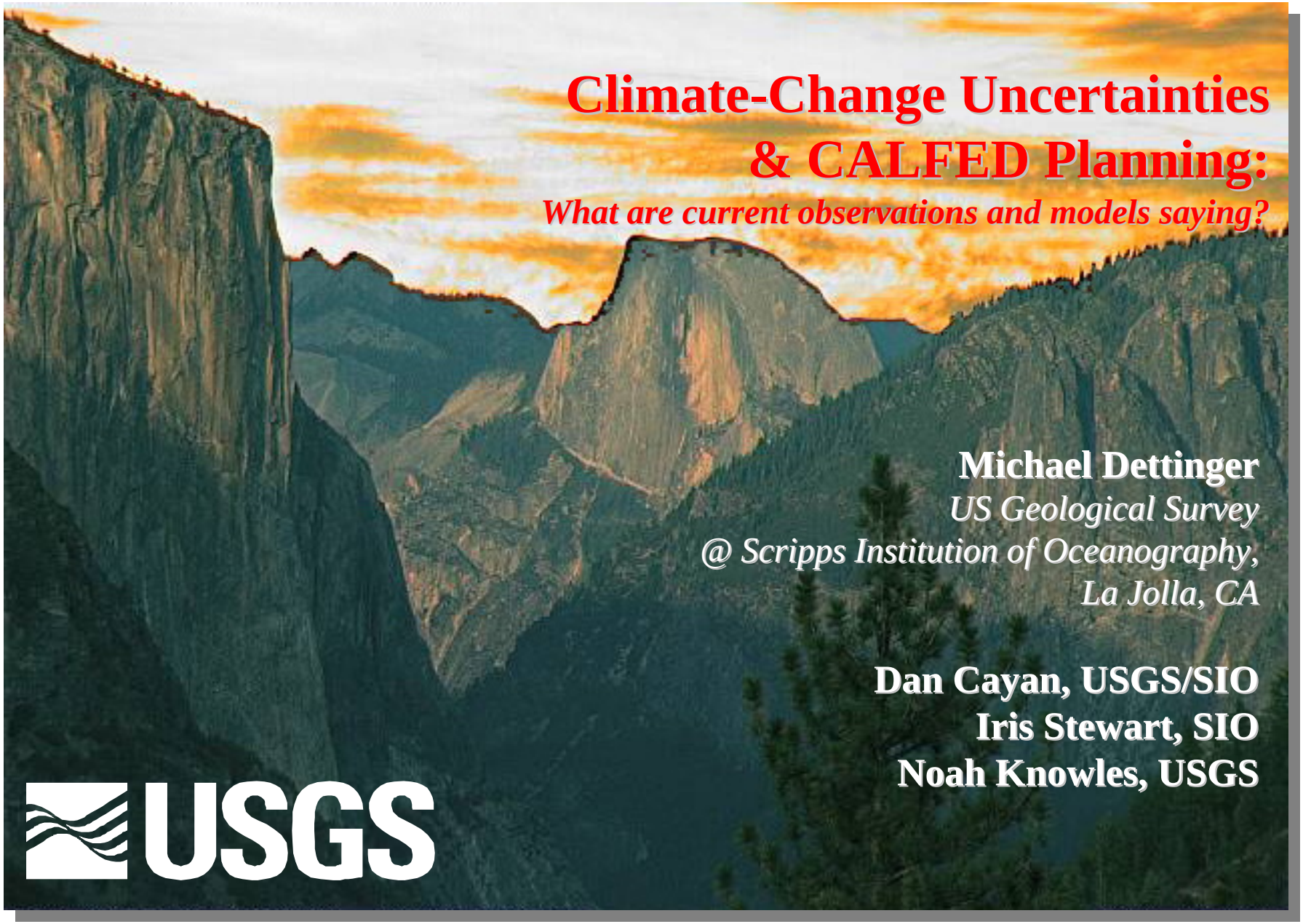
Agenda Item 8-10

Presentation on Climate-Change Uncertainties and CALFED Planning

(Informational Item)



Climate-Change Uncertainties & CALFED Planning:

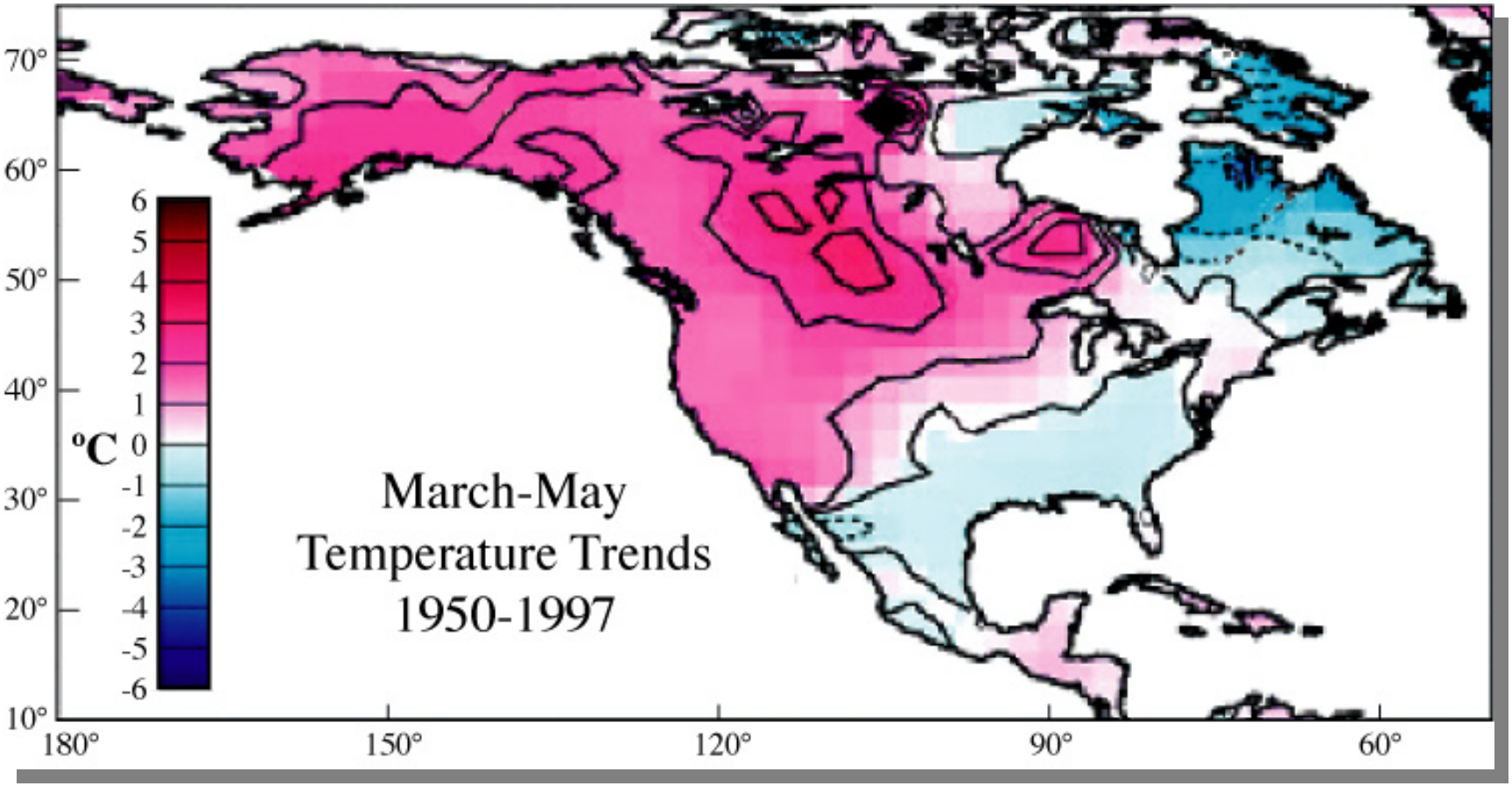
What are current observations and models saying?

Michael Dettinger
US Geological Survey
@ Scripps Institution of Oceanography,
La Jolla, CA

Dan Cayan, USGS/SIO
Iris Stewart, SIO
Noah Knowles, USGS

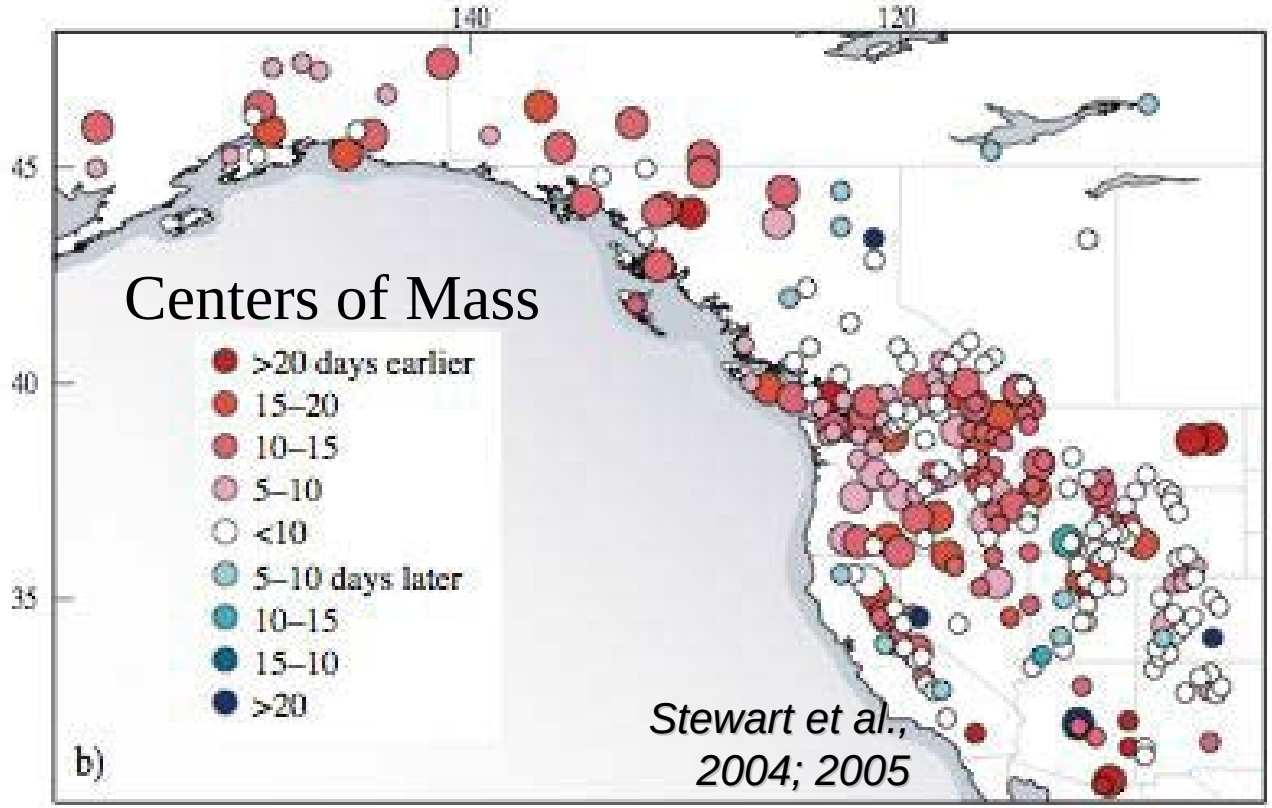
USGS

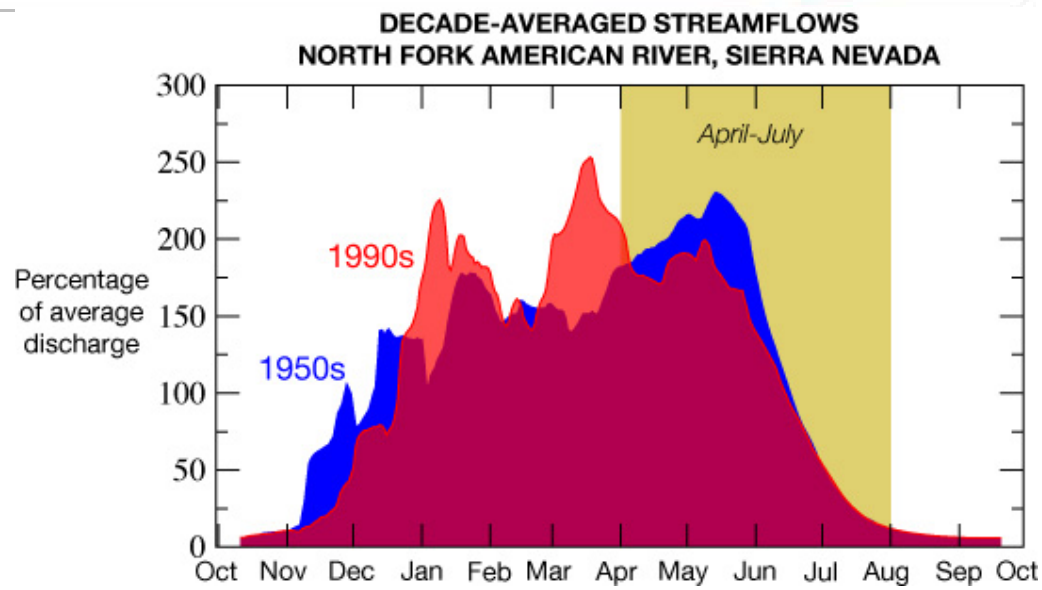
During the past 50 years, long-term winter-spring warming trends have changed the West.



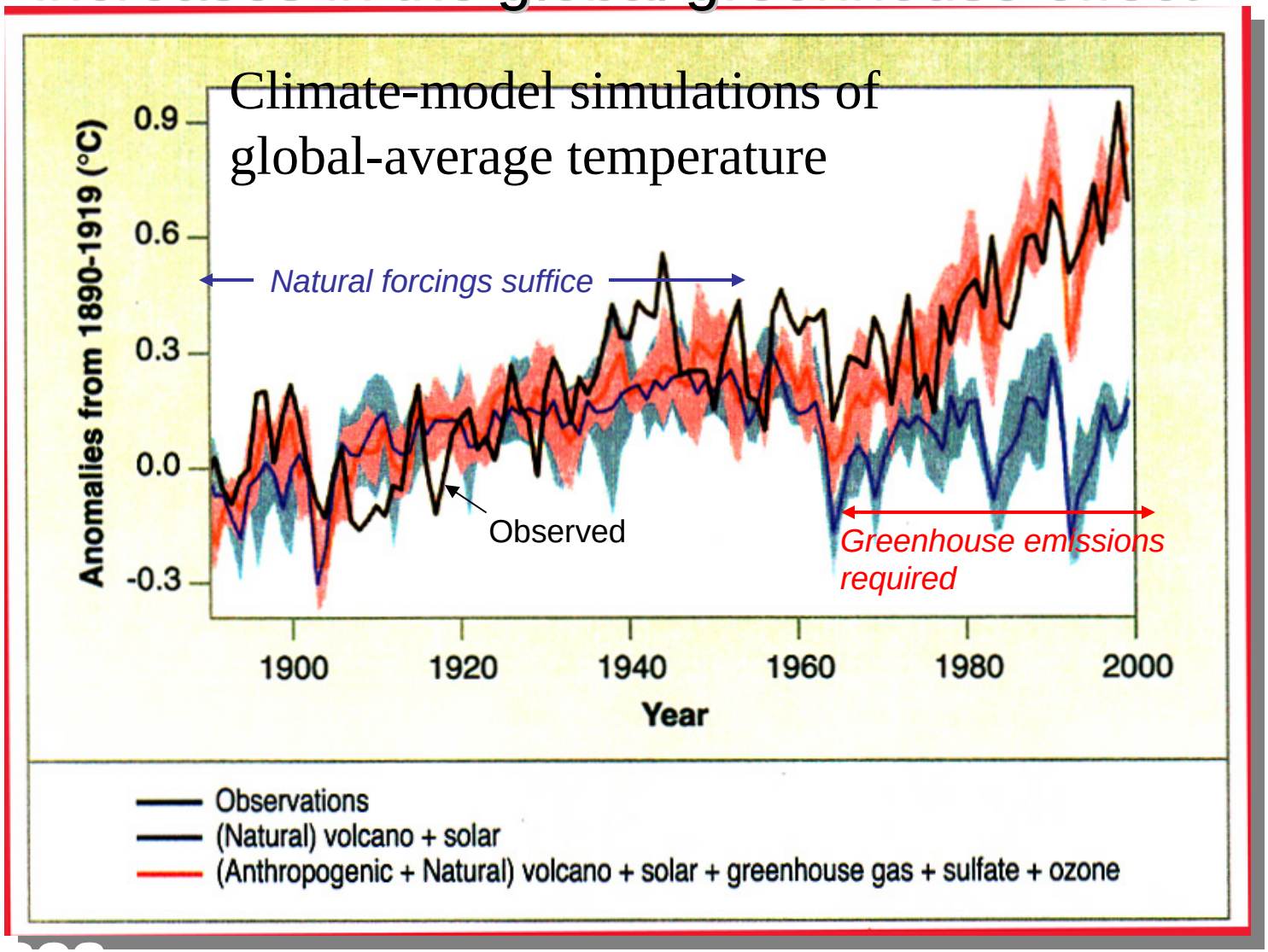
Cayan et al., 2001

By several measures, Western *(and Northeastern)* streamflows have been also been observed to arrive earlier in the year during recent decades.



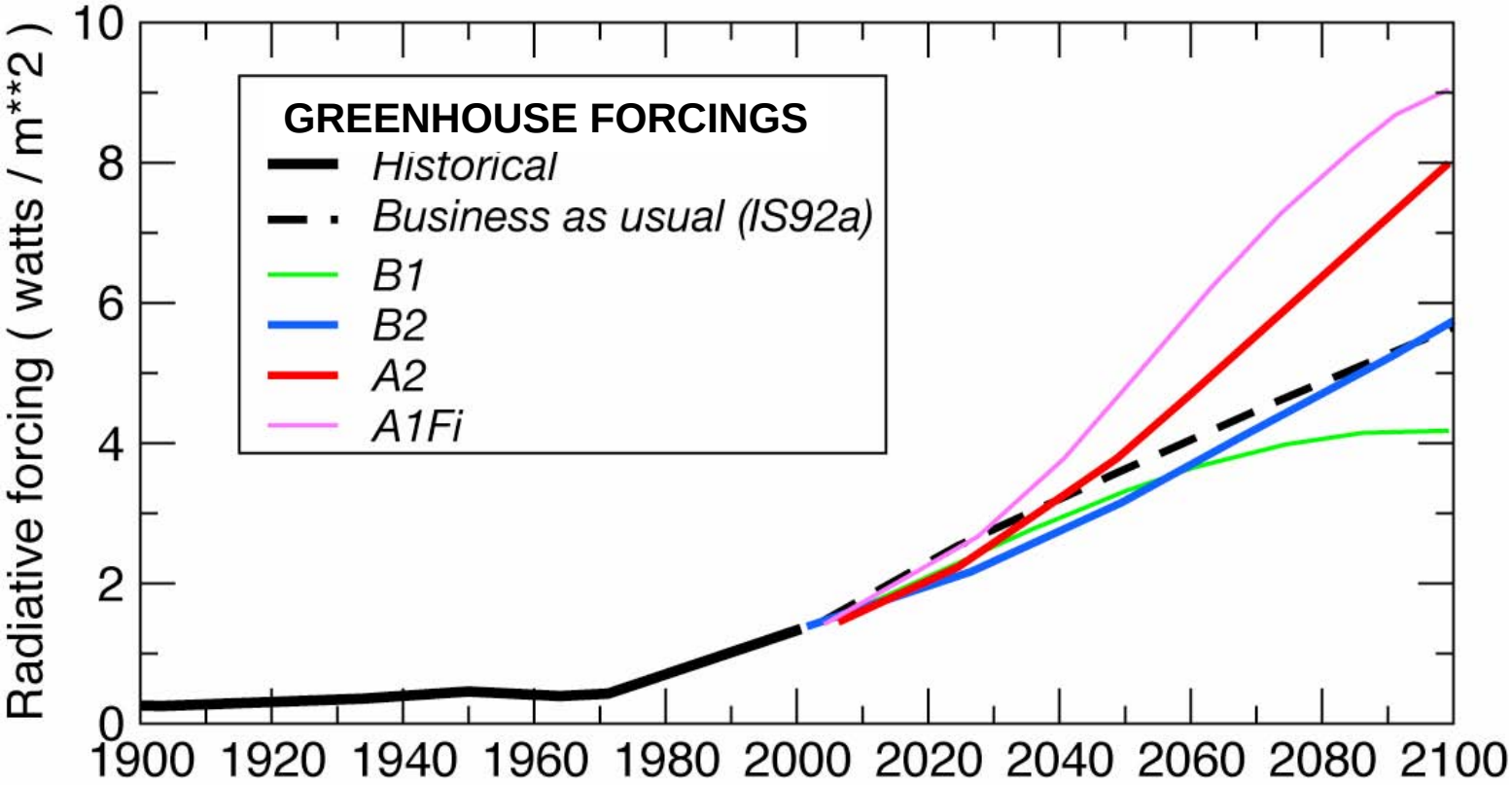


These recent western changes appear to be *in large part* due to global warming trends from increases in the global greenhouse effect.

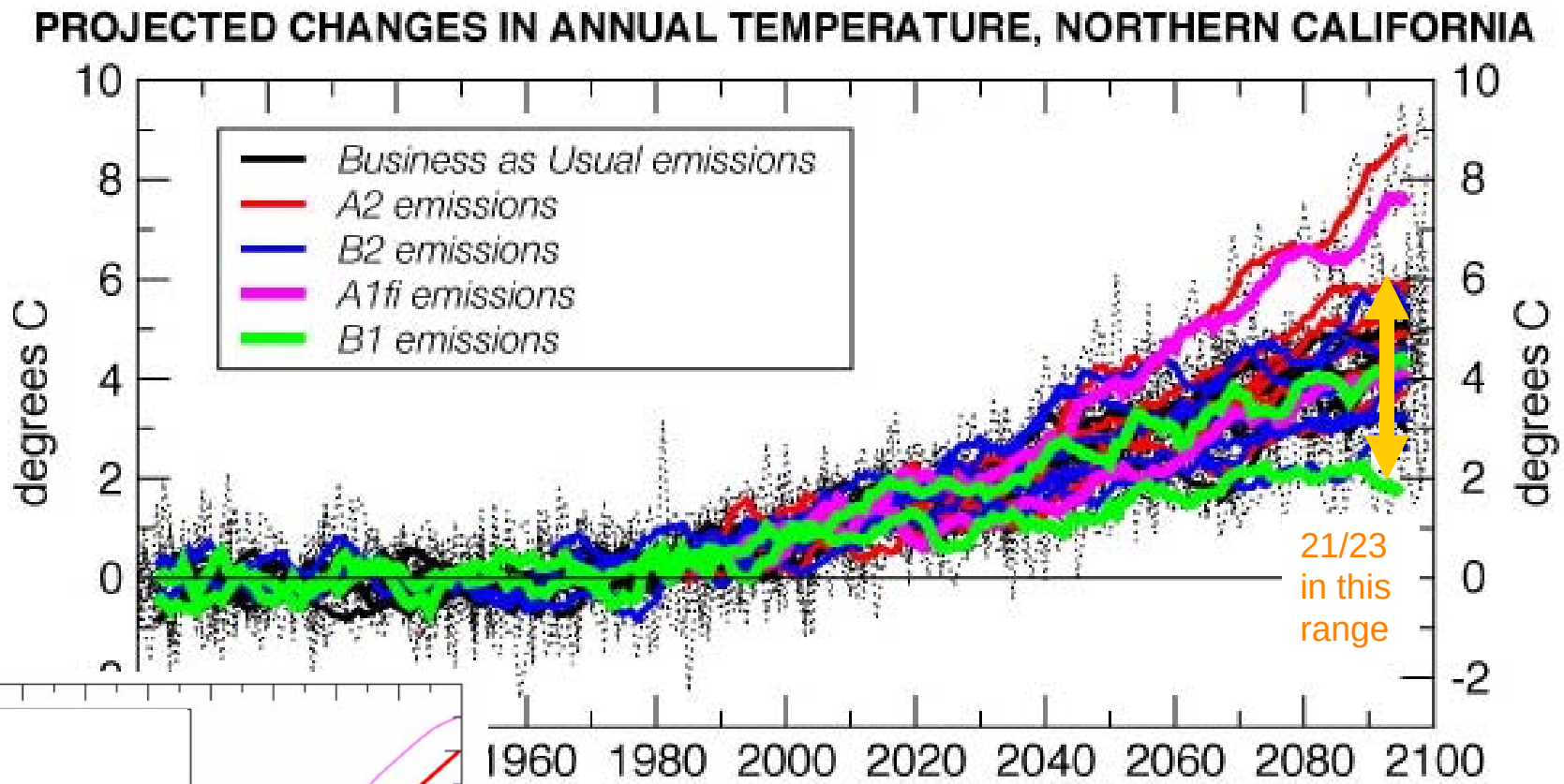


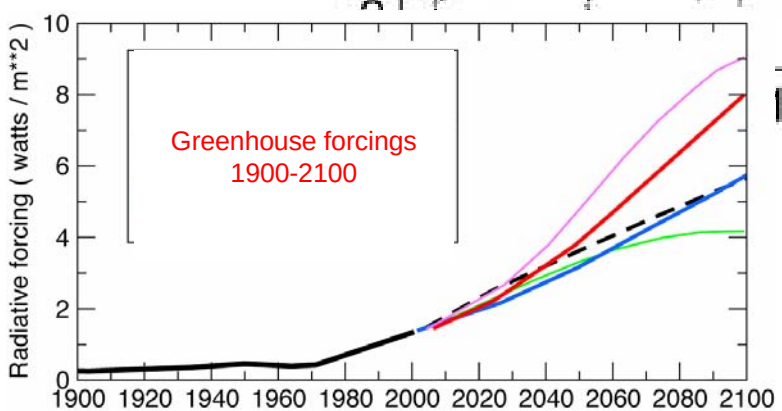
Meehl et al., in press

We don’t know how these forcings will evolve in the future, other than to know that the greenhouse effect will continue to increase in the foreseeable future.



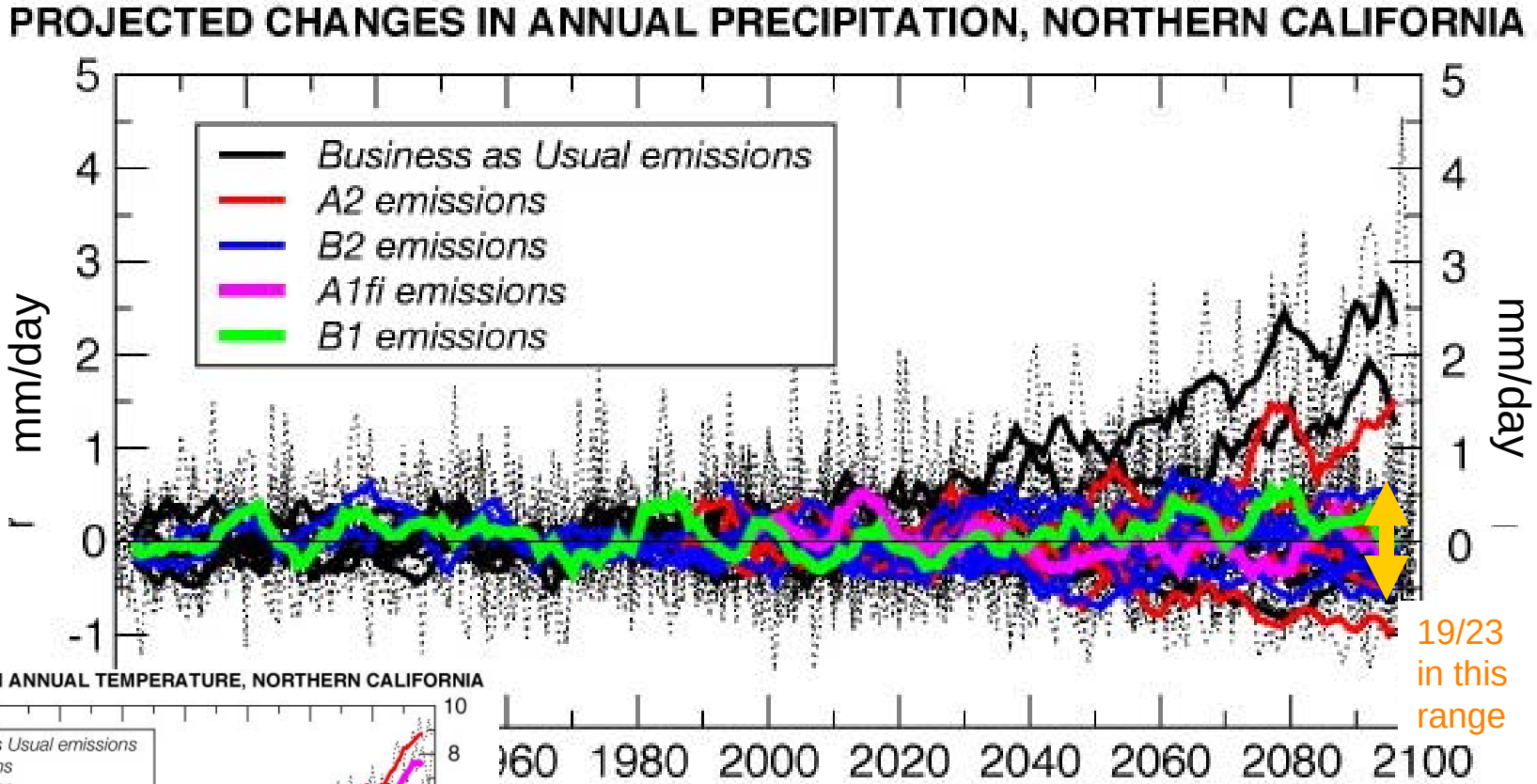
In response, current climate models yield consistent warming scenarios for California.

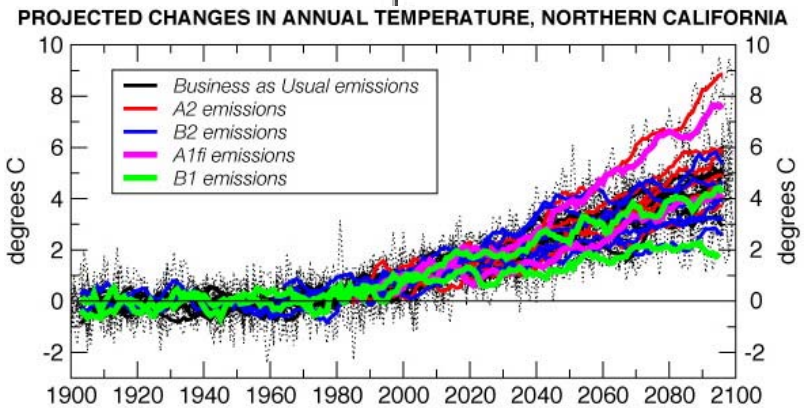




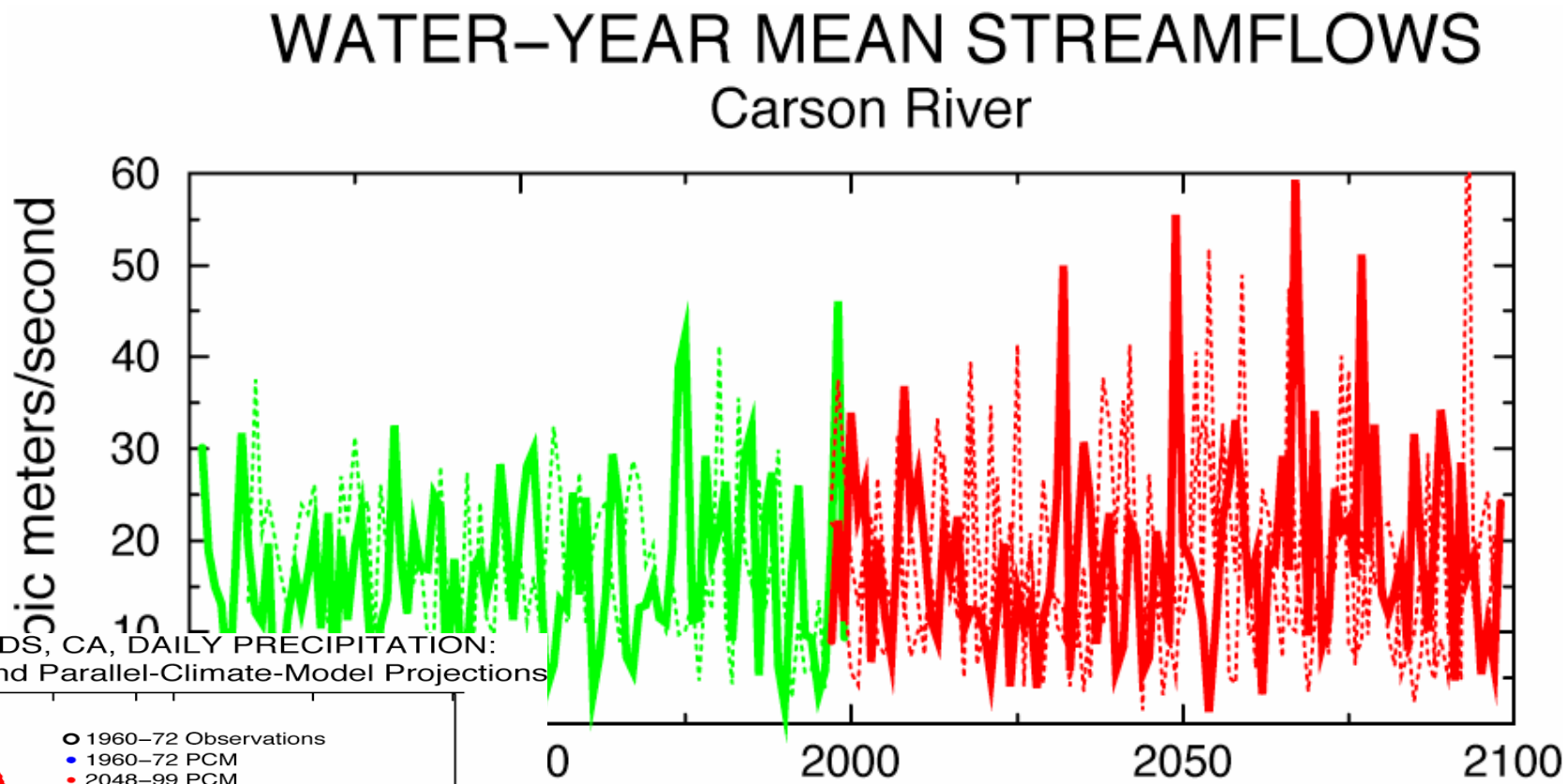
not more than about 20 year away

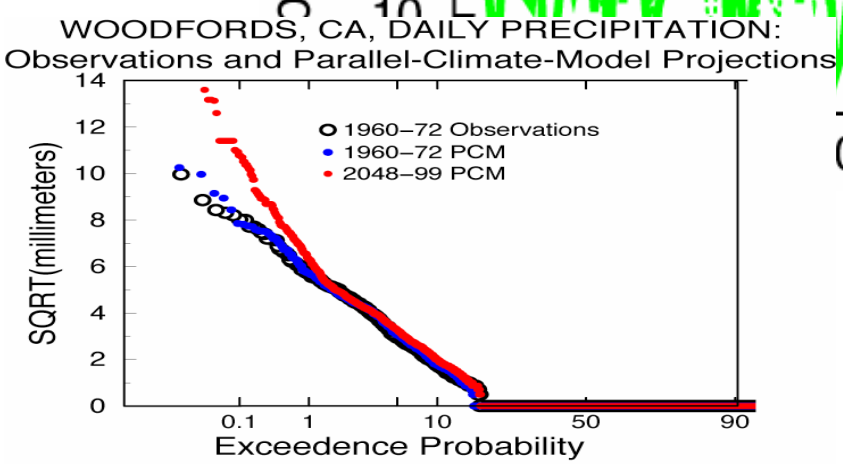
The same climate models provide no such consensus re: future precipitation.

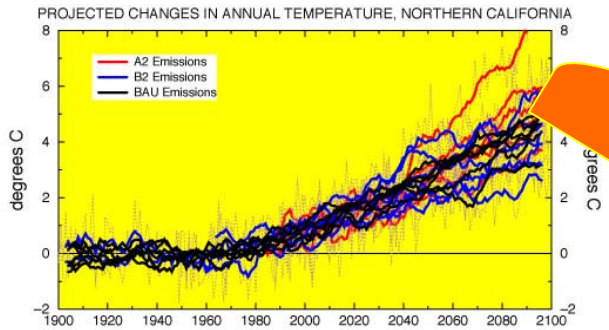


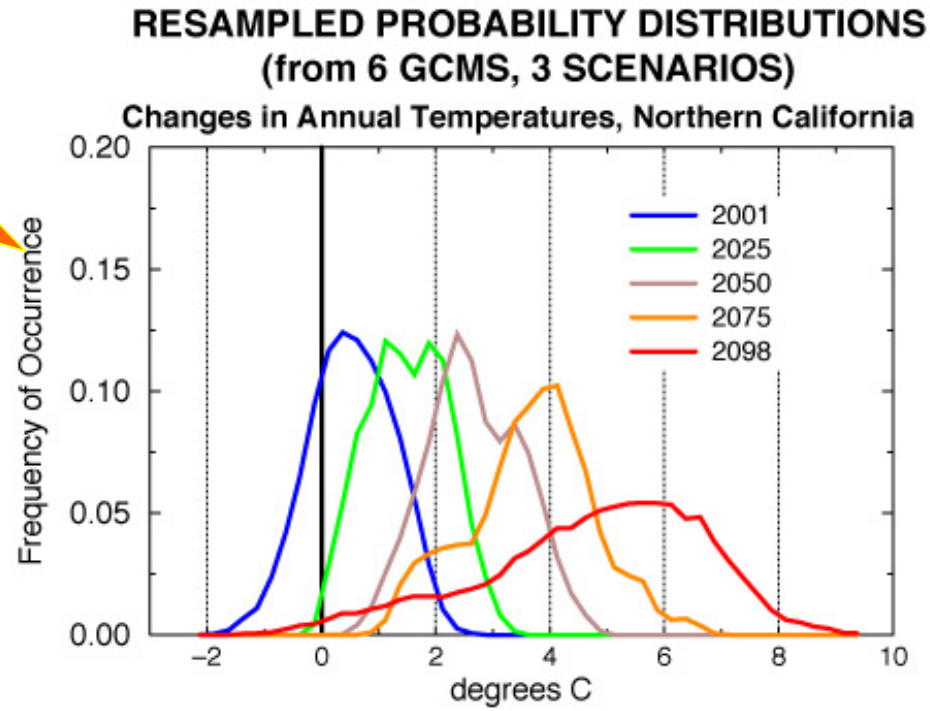


However, the variability of precipitation & streamflow IS projected to increase.



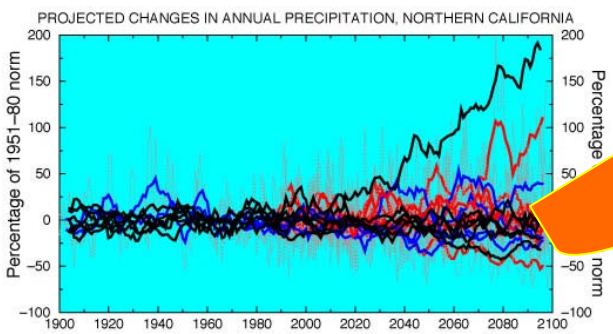


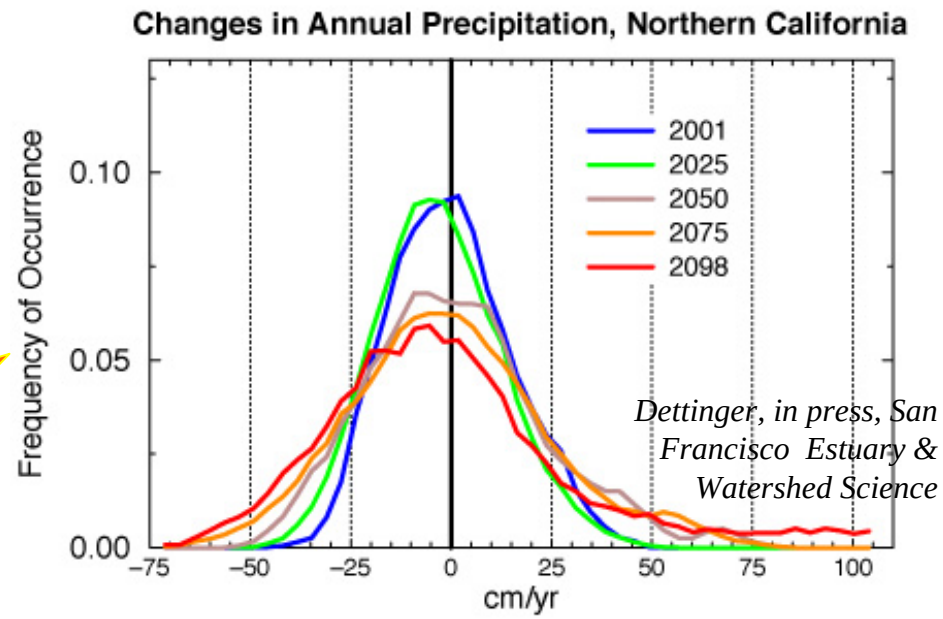




To review a bit, with a little smoothing, we can describe the odds of obtaining various levels of climate change in current projections…

1. *Warmer*
2. *Wetter or drier?*
3. *More precipitation variability*

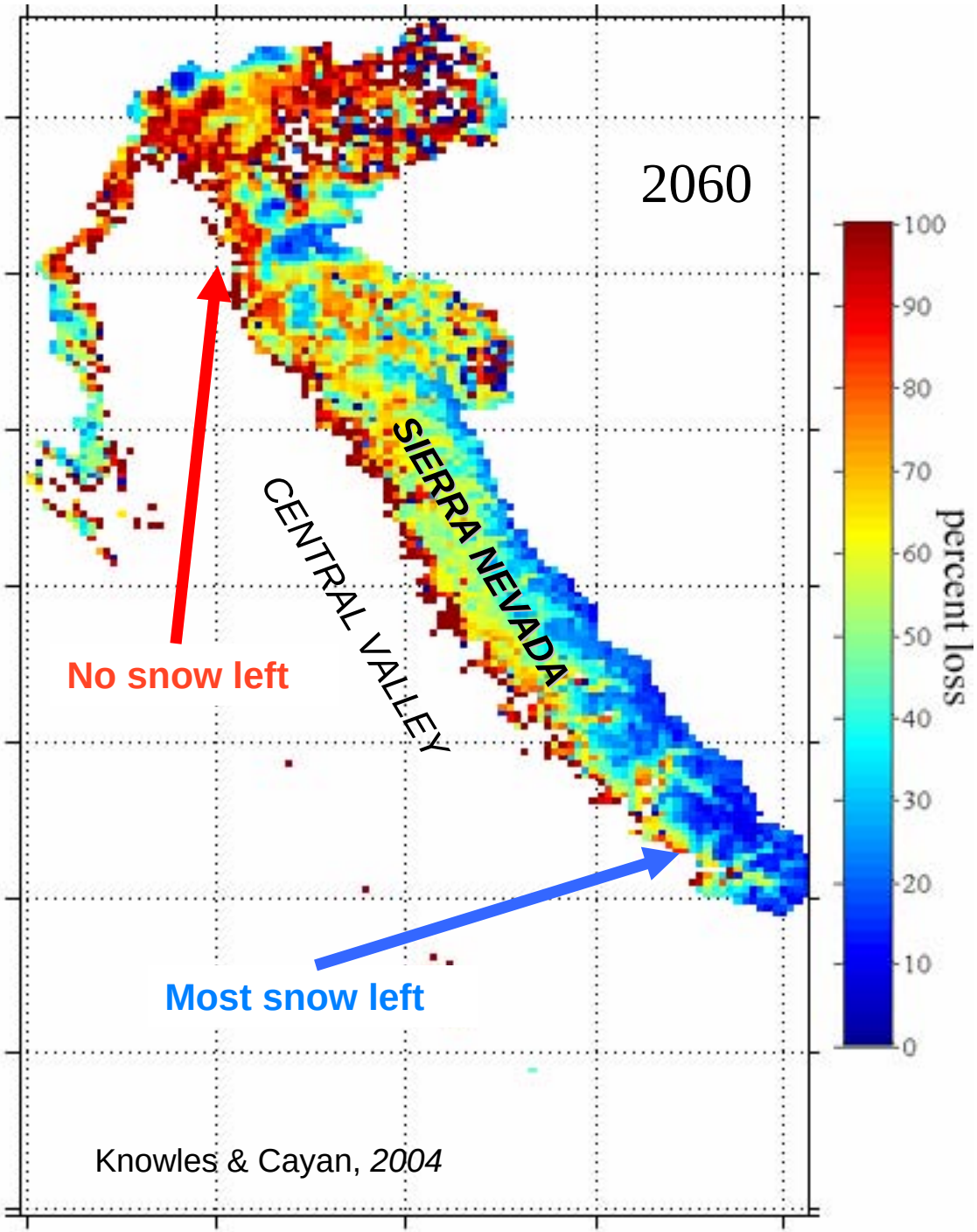




Dettinger, in press, San Francisco Estuary & Watershed Science

By the middle of the 21st Century, *even in the coolest scenarios*, earlier snowmelts & major reductions in snowpacks of the Sierra Nevada are projected...

--> About 30% less April snowpack overall



Knowles & Cayan, *2004*

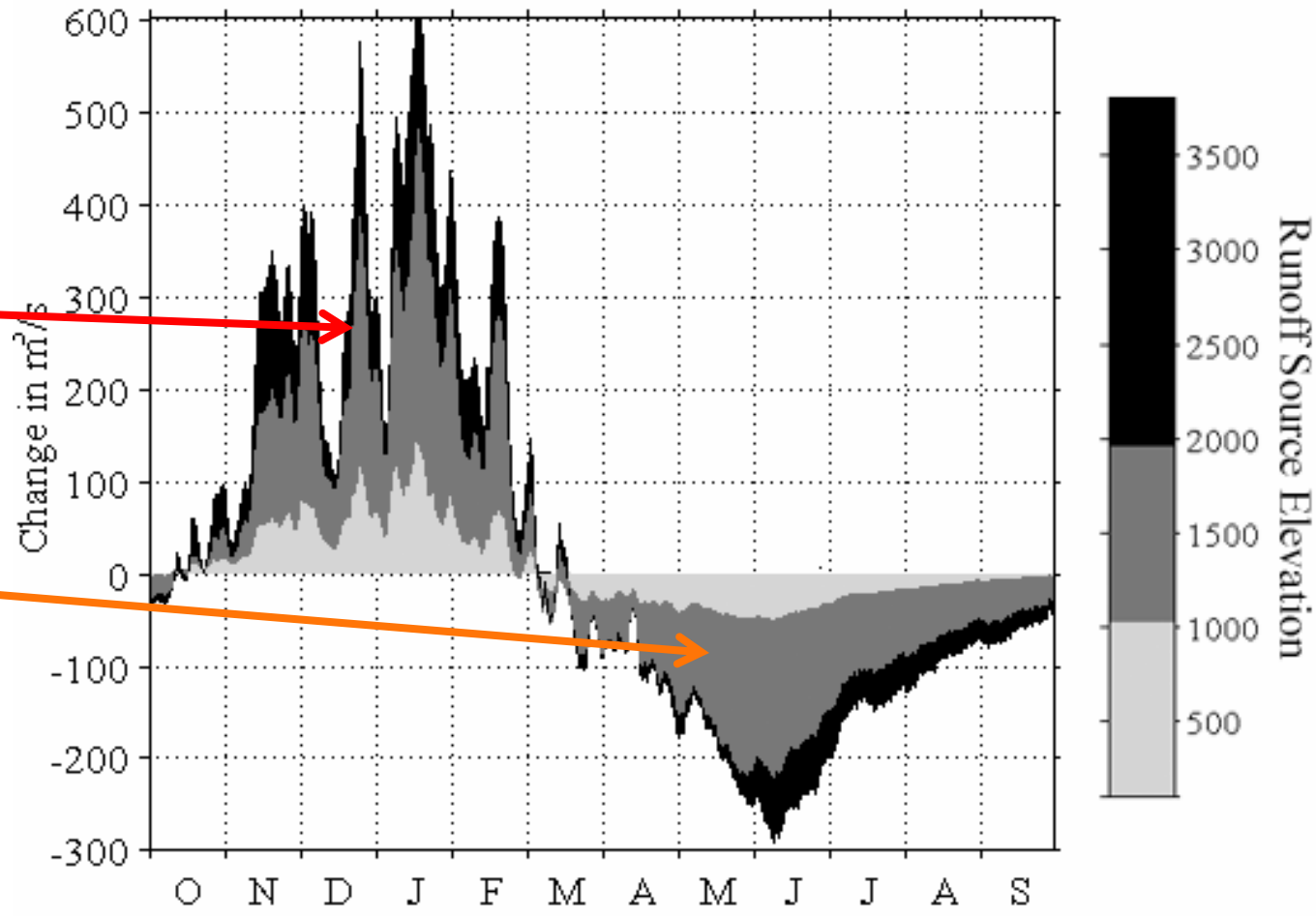
Changes in Sierra Nevada Outflow, 2060 – 2000

Even the coolest projections would cause

more severe winter floods

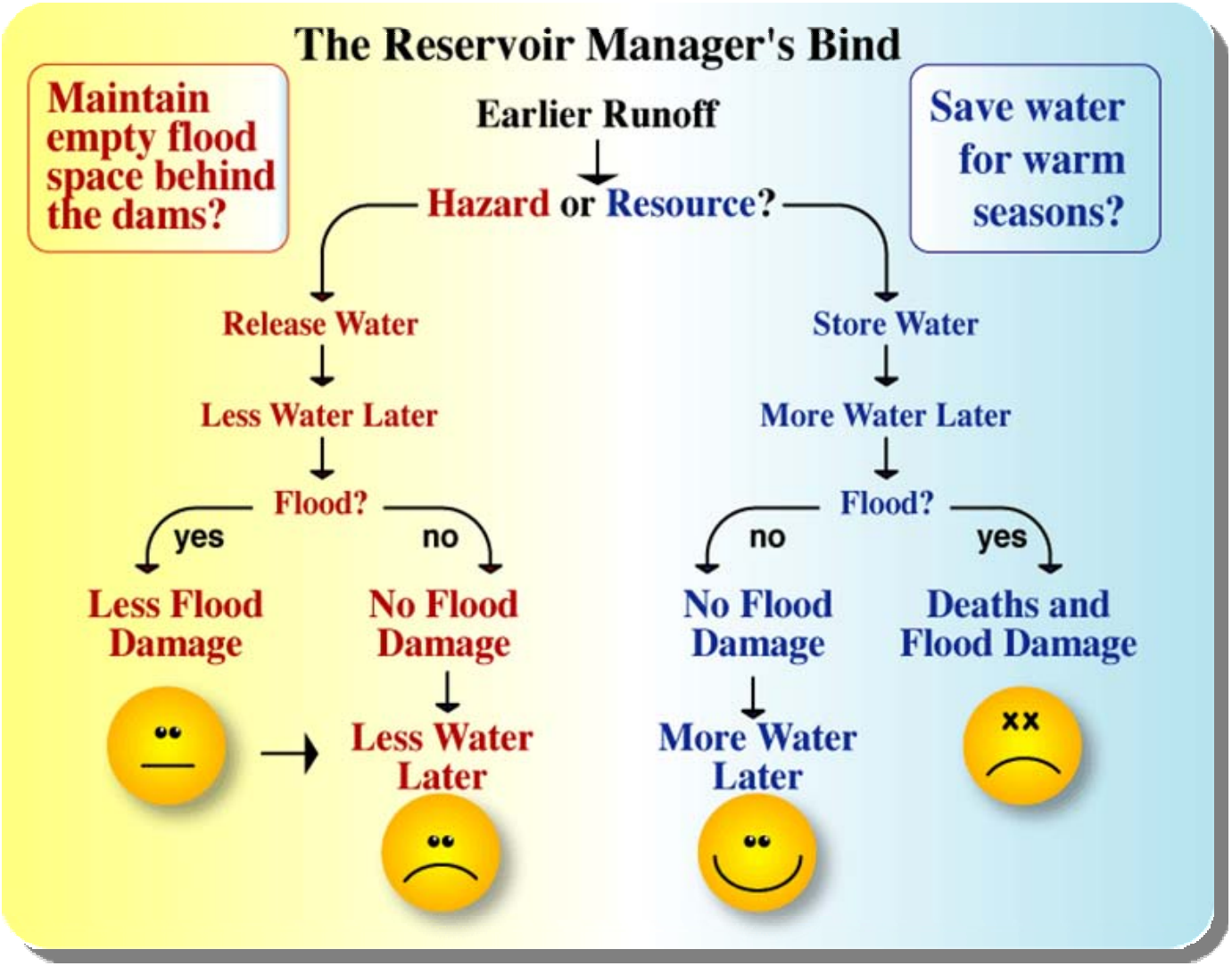
and

lower summertime flows *(threatening a saltier estuary as a result).*



Drought & flood are two sides of the same climate-change response (each year)

…which may put water management in a real bind!



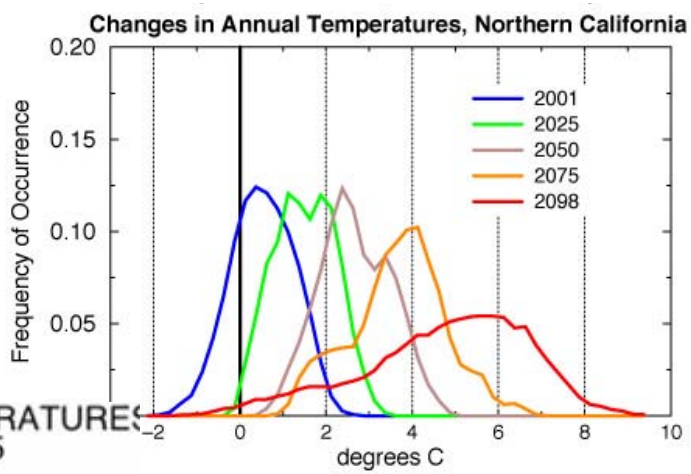
To put the projected streamflow-timing changes into perspective…

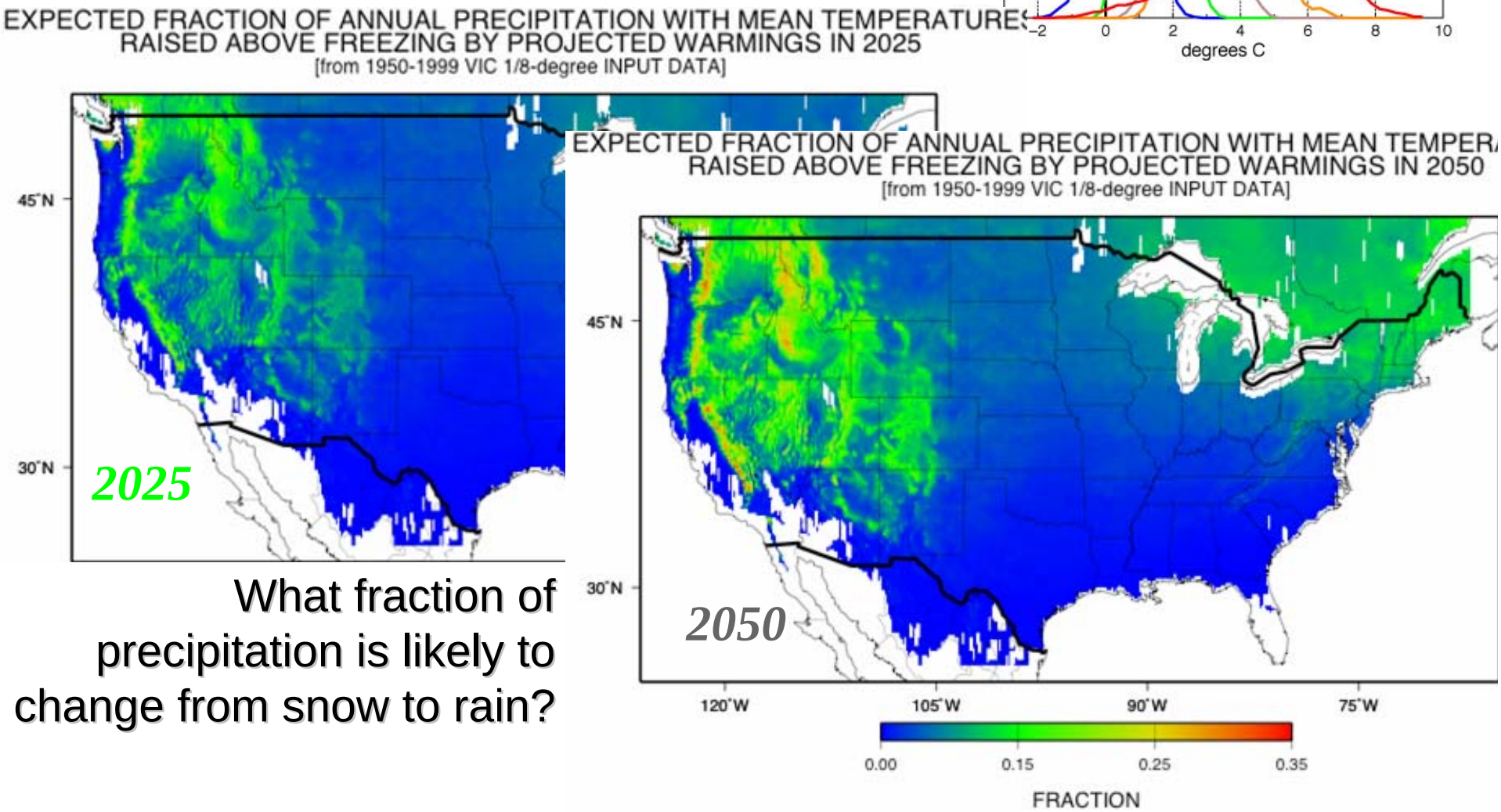
In the Sierra Nevada:

- The average April 1 snowpack now contains about 15 million acre-feet of water.
- The major foothill reservoirs can hold a total of 21 million acre-feet.
- Reservoir storage set aside for flood control reaches a total of about 5.2 million acre-feet in an average year.
- Conservatively projected changes in spring snowpack total about 5.4 million acre-feet by 2060.

Finally:

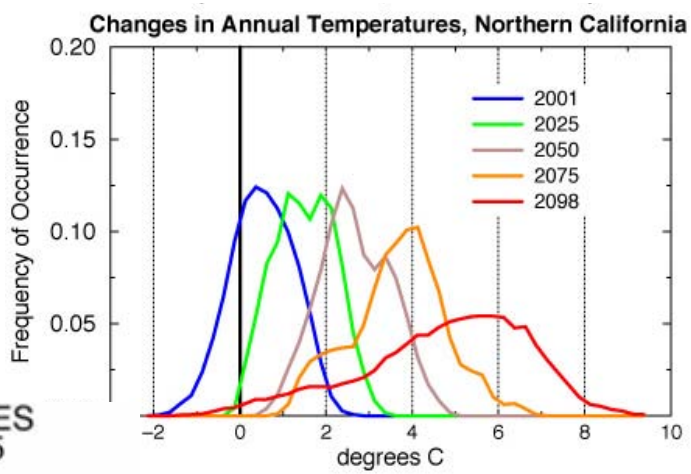
Is California any more or less vulnerable to these changes than is the rest of the Nation?

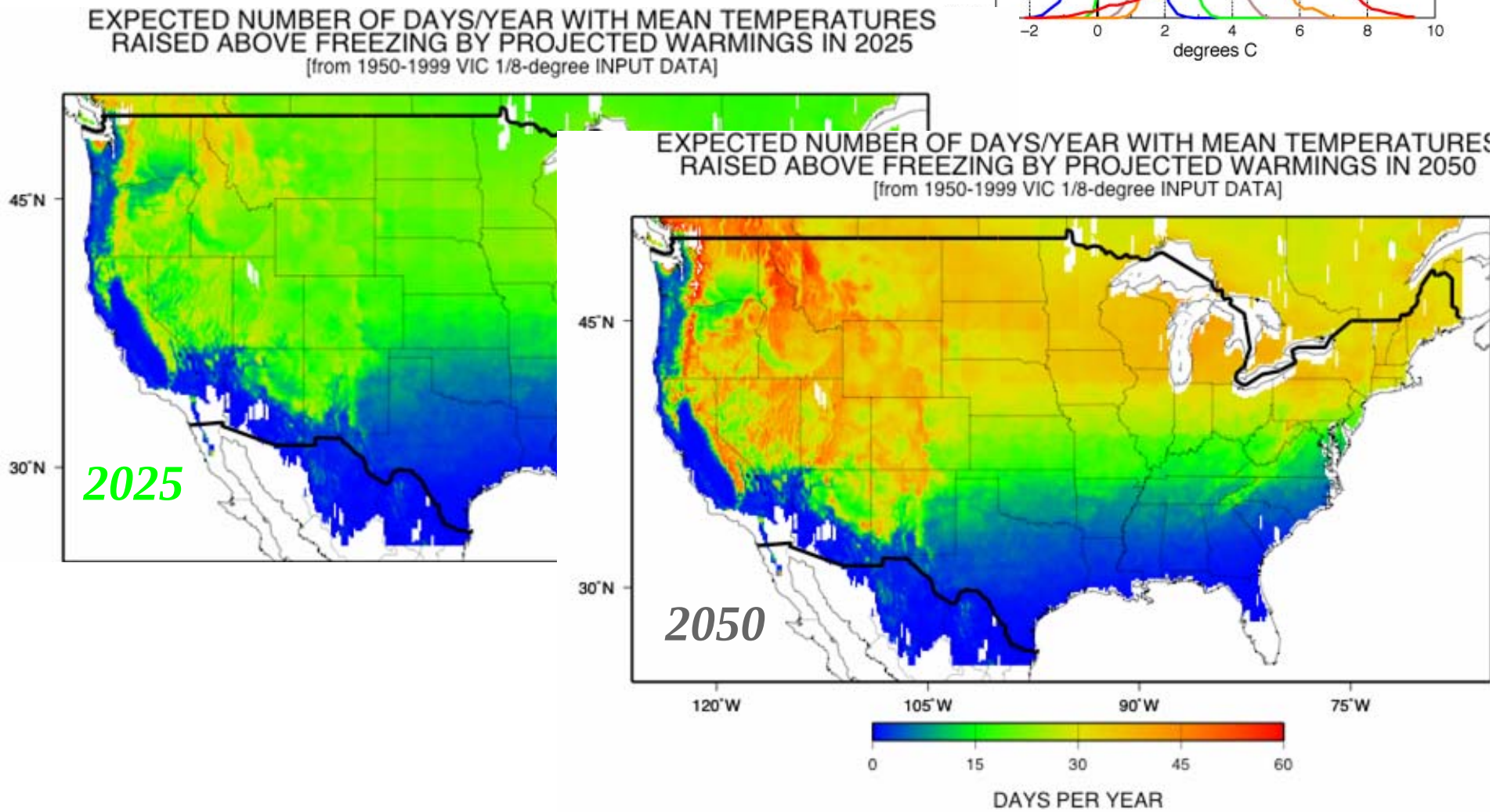




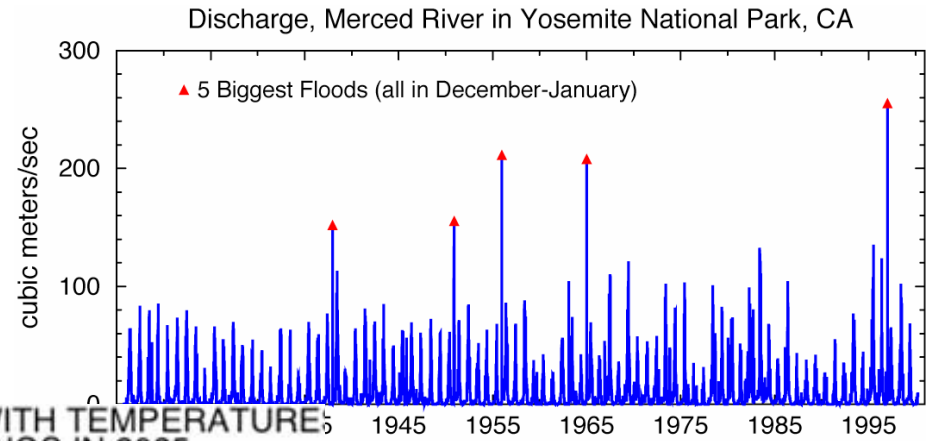
What fraction of precipitation is likely to change from snow to rain?

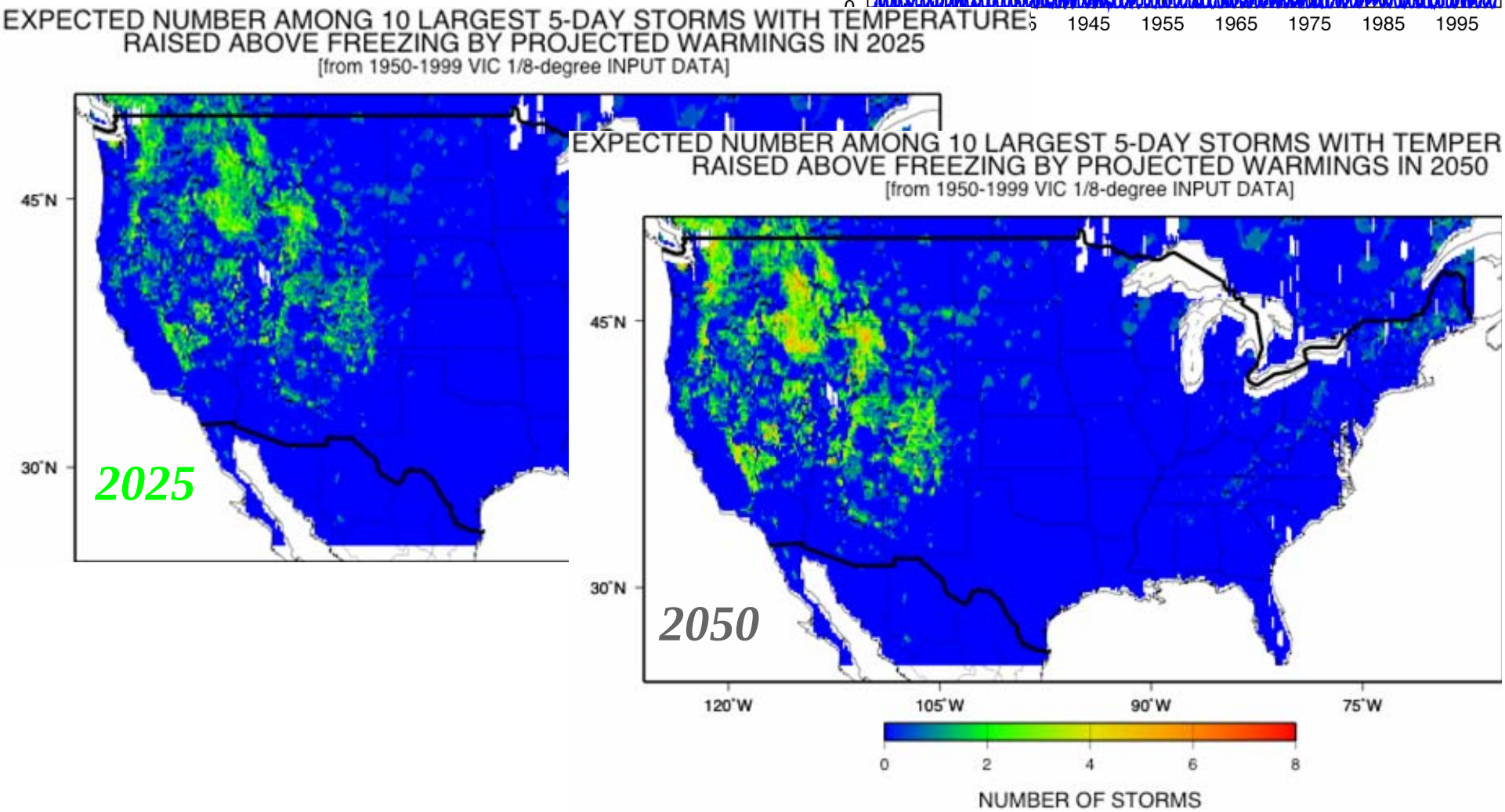
How many days will change from frozen to above-freezing?





How many of the largest storms will change from snowy to rainy?





WHAT ARE CURRENT PROJECTIONS TELLING US?

Northern California temperature projections are broadly in consensus (+3 to +6 or more ºC) --> causing earlier flows, more floods & drier summers

•

Warming already underway and coming fast

•

Northern California precipitation projections are a bit more scattered, with MOST showing small (drier?) changes but with a couple of outliers much wetter

•

California water supplies/ecosystems are likely to experience these changes earliest and and most intensely.

RELEVANT REFERENCES

- Cayan, D.R., Kammerdiener, S., Dettinger, M.D., Caprio, J.M., and Peterson, D.H., 2001, Changes in the onset of spring in the western United States: Bulletin, American Meteorological Society, 82, 399-415.

- Dettinger, M.D., in press, From climate-change spaghetti to climate-change distributions for 21st Century California: San Francisco Estuary and Watershed Science, 35 p.

- Dettinger, M.D., and Cayan, D.R., 1995, Large-scale atmospheric forcing of recent trends toward early snowmelt in California: Journal of Climate 8(3), 606-623.

- Dettinger, M.D., Cayan, D.R., Meyer, M.K., and Jeton, A.E., 2004, Simulated hydrologic responses to climate variations and change in the Merced, Carson, and American River basins, Sierra Nevada, California, 1900-2099: Climatic Change, 62, 283-317.

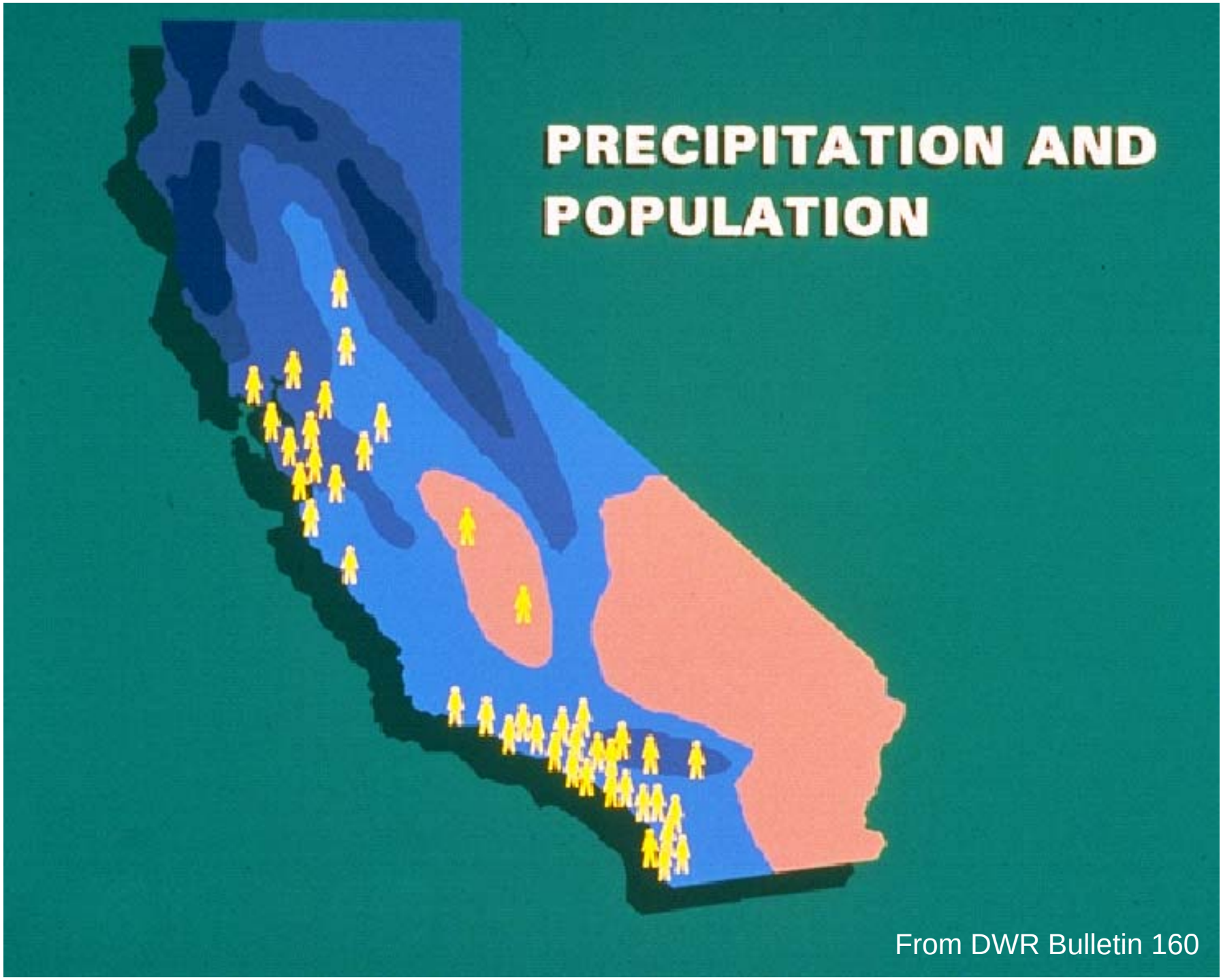
- Knowles, N., and D. Cayan, 2004, Elevational dependence of projected hydrologic changes in the San Francisco estuary and watershed. Climatic Change, 62, 319-336.

- Stewart, I., Cayan, D.R., and Dettinger, M.D., 2004, Changes in snowmelt runoff timing in western North America under a ‘Business as Usual’ climate change scenario: Climatic Change, 62, 217-232.

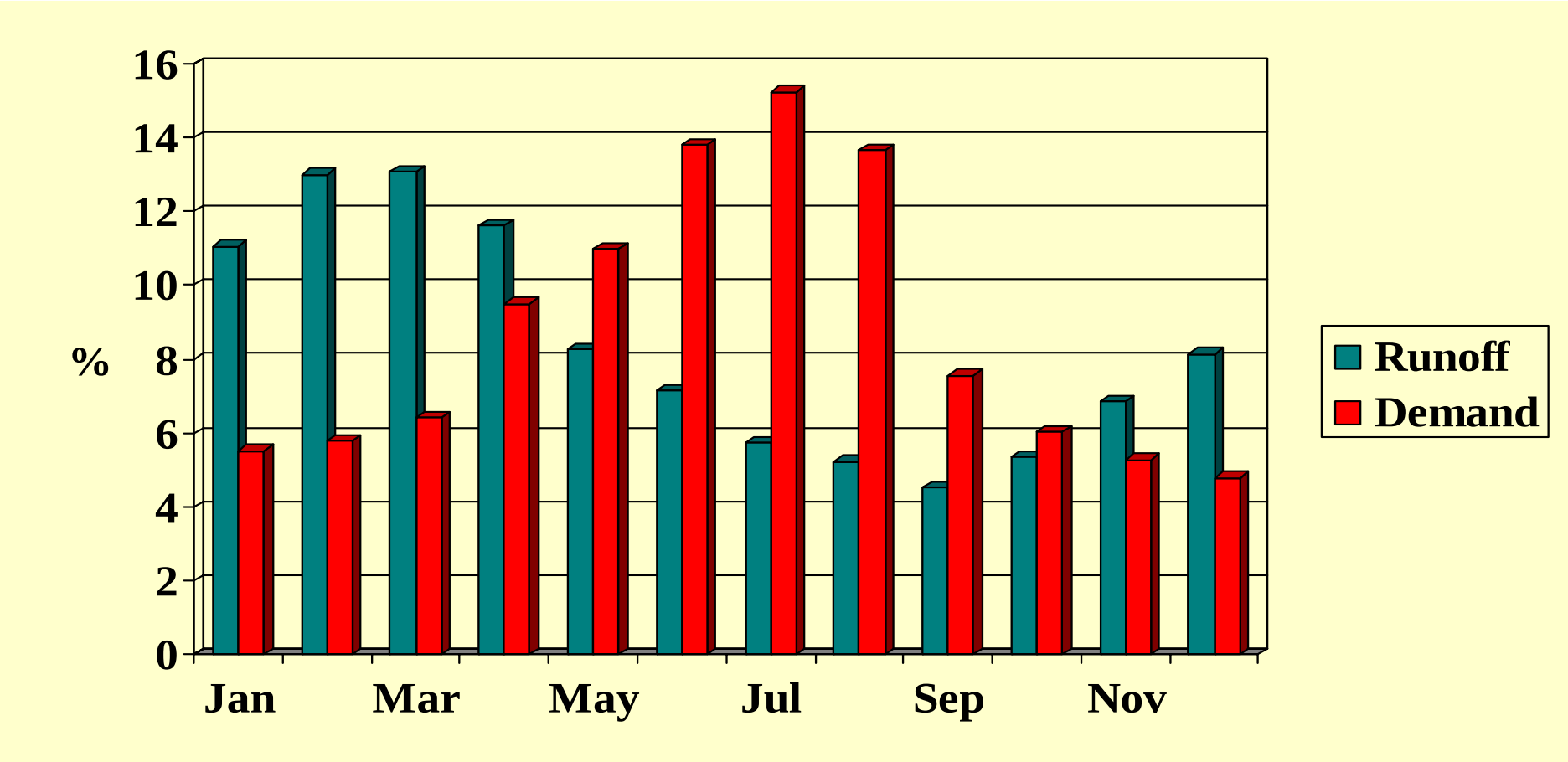
Climate Change and Water Resources Challenges in California

Modeling Support Branch
Department of Water Resources

California's Water Resources


PRECIPITATION AND
POPULATION
From DWR Bulletin 160

Seasonal Mismatch of Supply and Demand



Water Resources Management Tools

Water Resources Models

CALSIM II

reservoir operations, Delta exports, carryover storage, etc

DSM2

flow, water levels, salinity, etc

IGSM2

groundwater flow, surface water flow, and surface-groundwater interaction

CALSIM II Grid

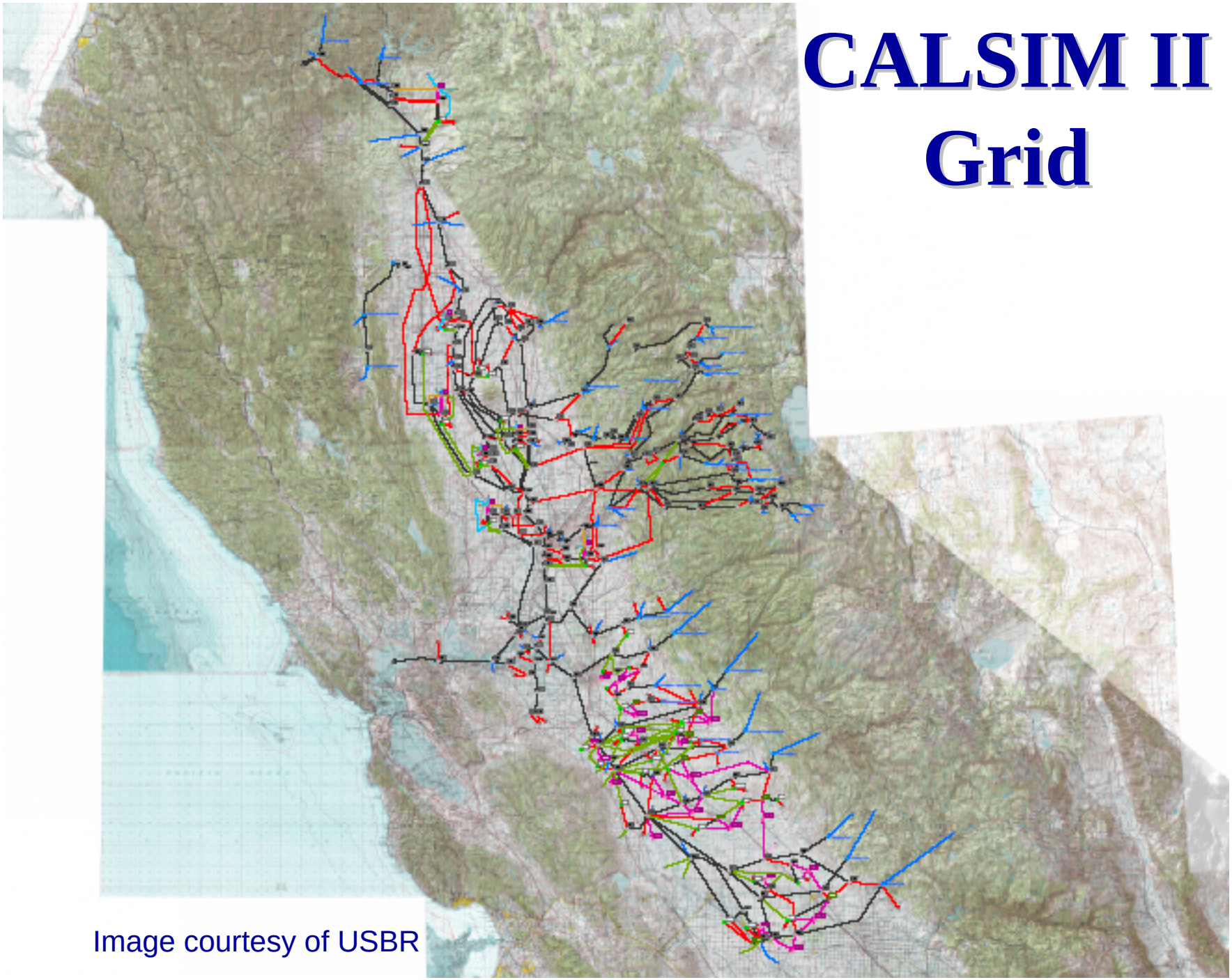
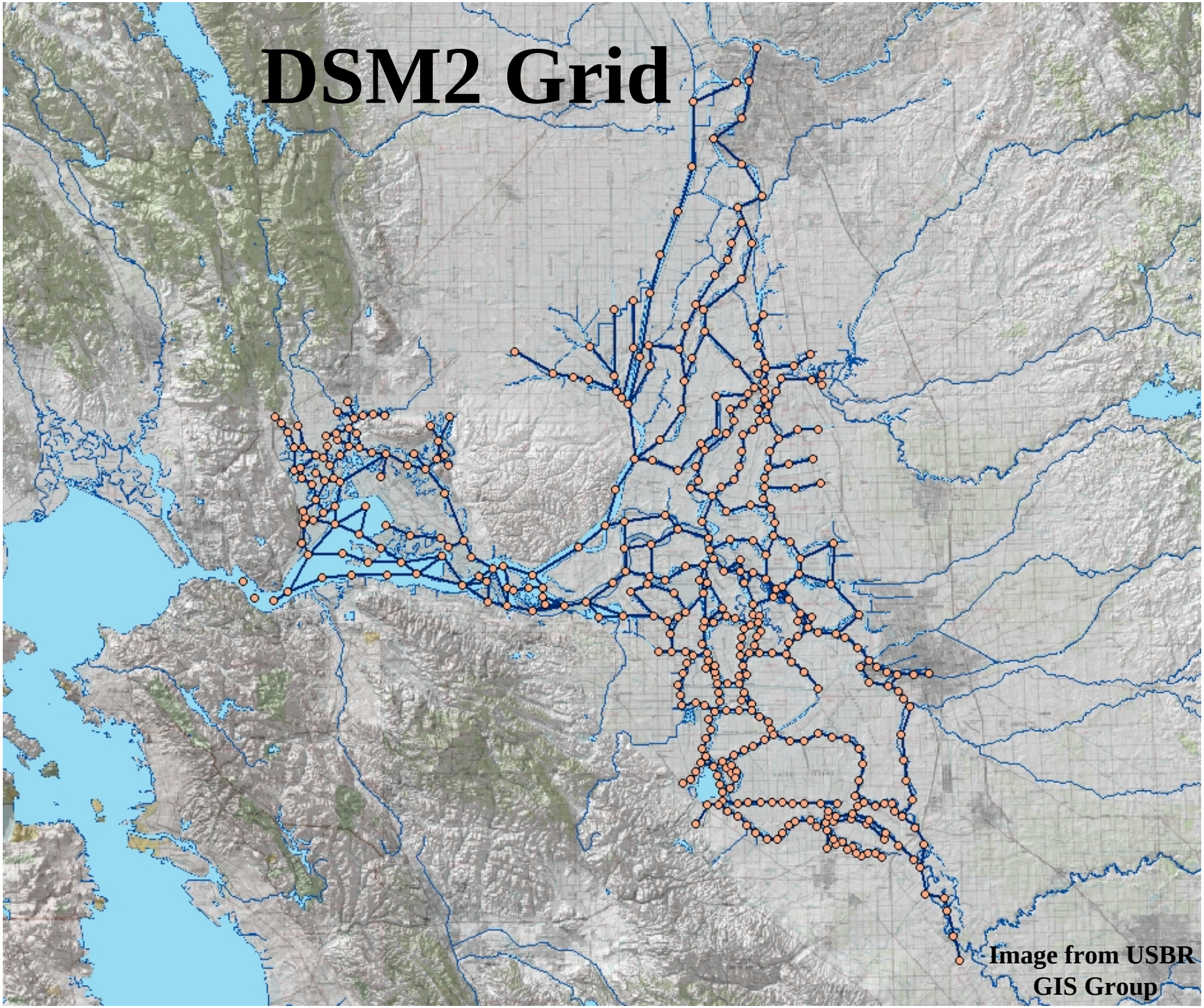
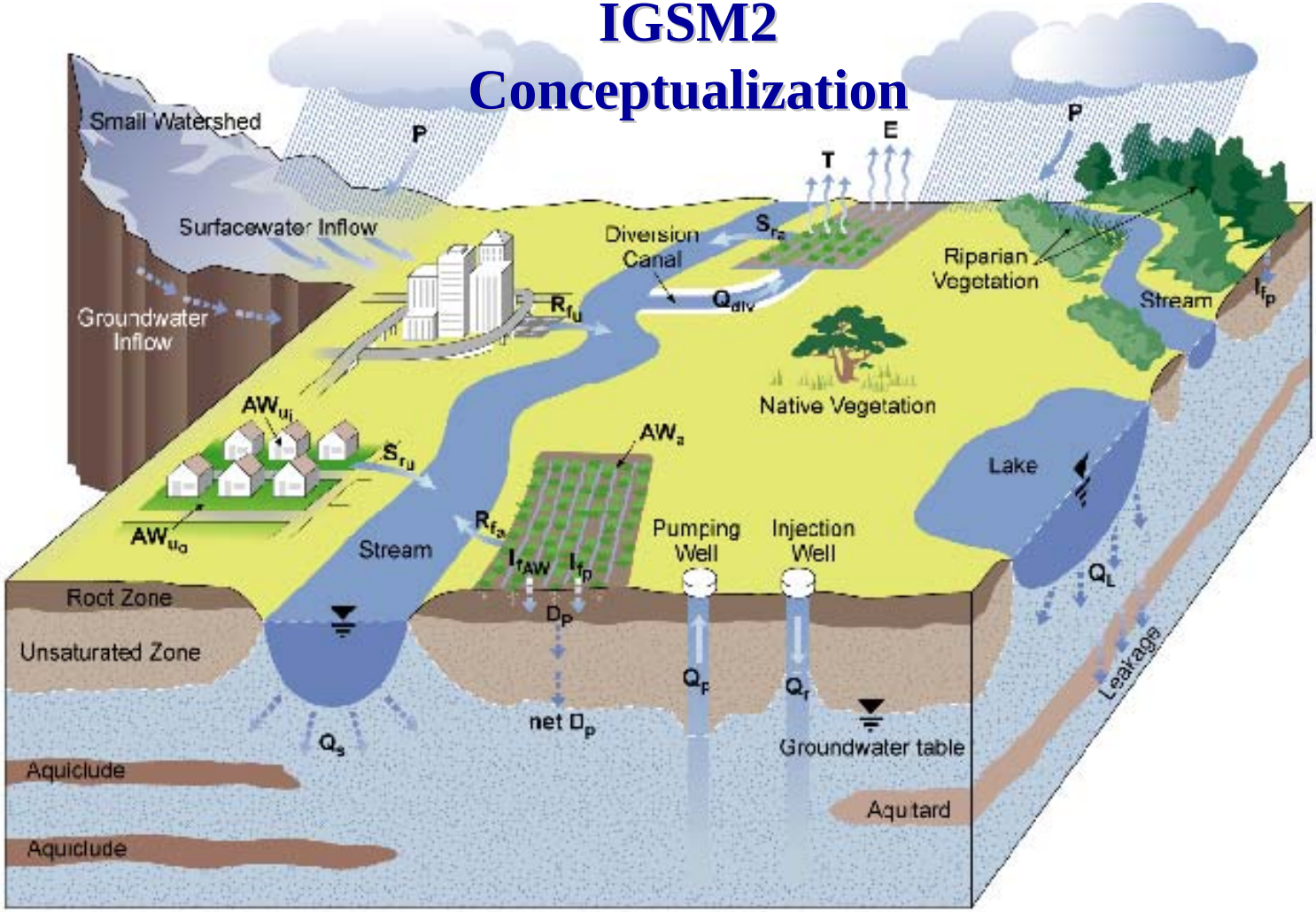


Image courtesy of USBR

DSM2 Grid



IGSM2 Conceptualization



LEGEND

P. ..... *Precipitation*

AW_a .... *Water applied to agricultural lands*

AW_{u_i}.... *Water applied to indoor urban lands*

AW_{u_o}... *Water applied to outdoor urban lands*

E. ..... *Evaporation*

T..... *Transpiration*

I_{f_p}..... *Infiltration of precipitation*

$I_{f_{AW}}$..... *Infiltration of applied water*

Q_{div}..... *Surface water diversion*

S_{r_a}..... *Agricultural runoff*

S_{r_u}.. ..... *Urban runoff*

R_{f_a}..... *Agricultural return flow*

R_{f_u}..... *Urban return flow*

D_P..... *Deep percolation of water to the unsaturated zone*

net D_p.. *Recharge to the groundwater aquifer*

Q_p..... *Pumping from groundwater aquifer*

Q_r..... *Recharge to groundwater aquifer*

Q_s..... *Stream-groundwater interaction*

Q_L..... *Lake-groundwater interaction*

Climate Change Impacts on Water Resources

Water Resources Impacts

- Frequency
- Magnitude and Duration

- Supply Reliability
- Demand Shifts

- Municipal, Ag, and Industrial
- Environmental

DWR/Reclamation Management Issues

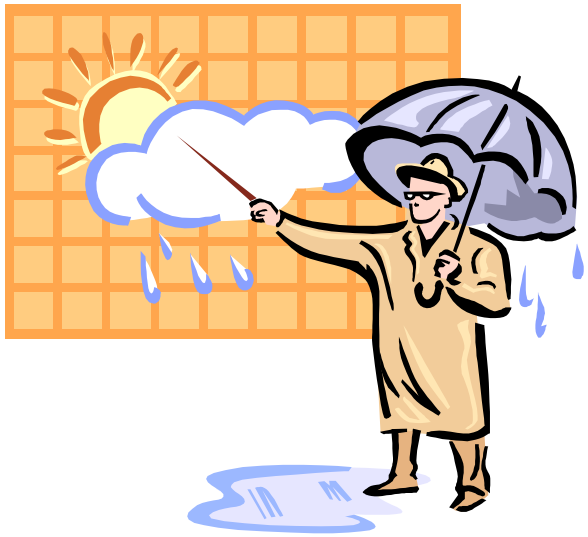
- CVP/SWP Allocations
- Cold Water Resources

- Delta Salinity

- Flood Control
- Drought Mitigation

Joint DWR-USBR Climate Change Team

Climate modelers forecast possible future climate conditions



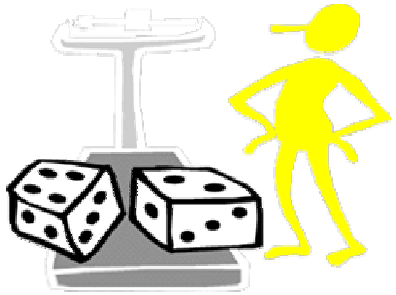
impacts and risks

Uncertainty

Given the variability and uncertainty in climate projections over California,

how do we apply climate change impacts and risk assessment to planning and management of California's water resources?

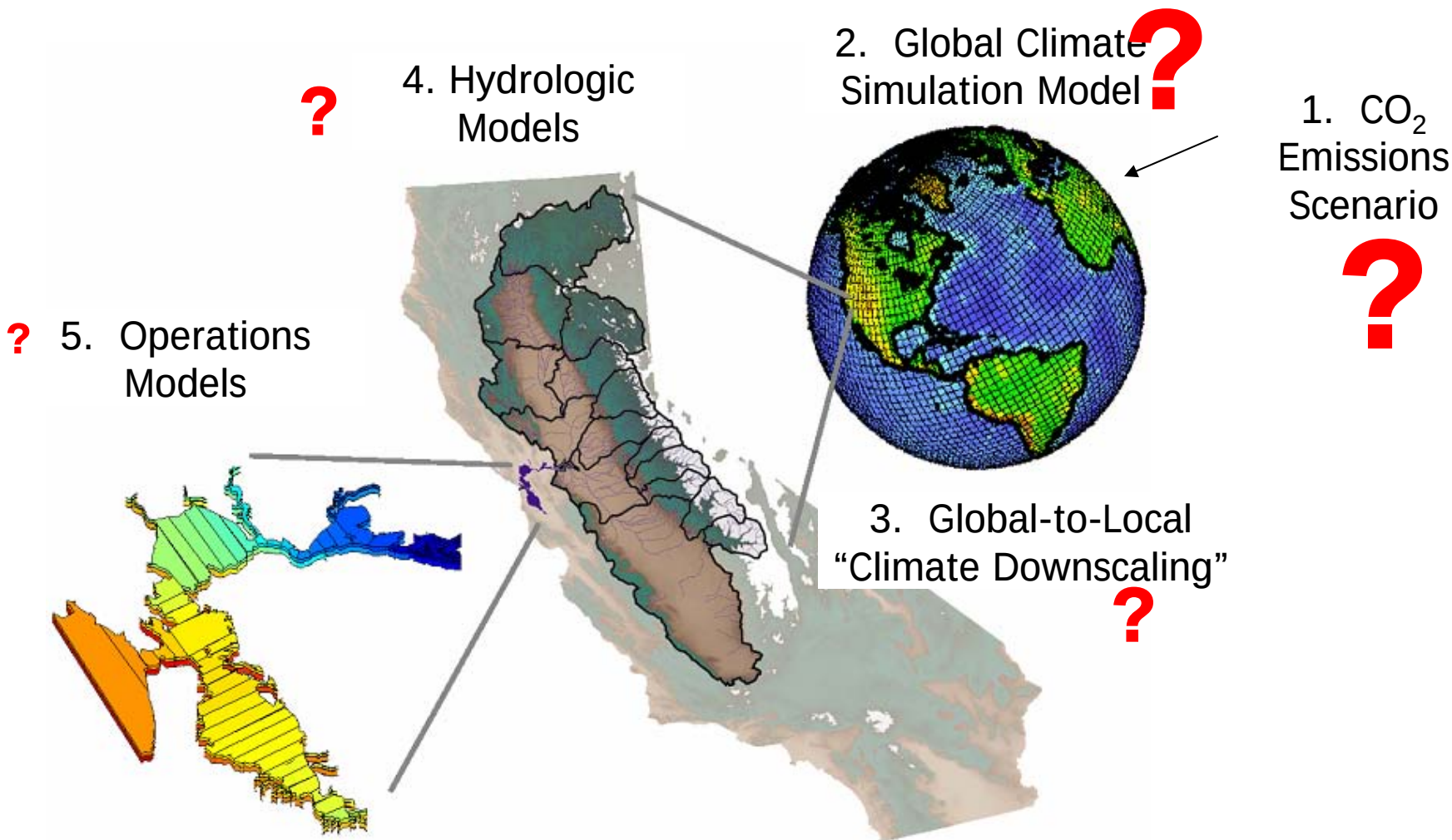
Risk Assessment



Risk =

Impact * Probability

Impacts Probability: Sources of Uncertainty

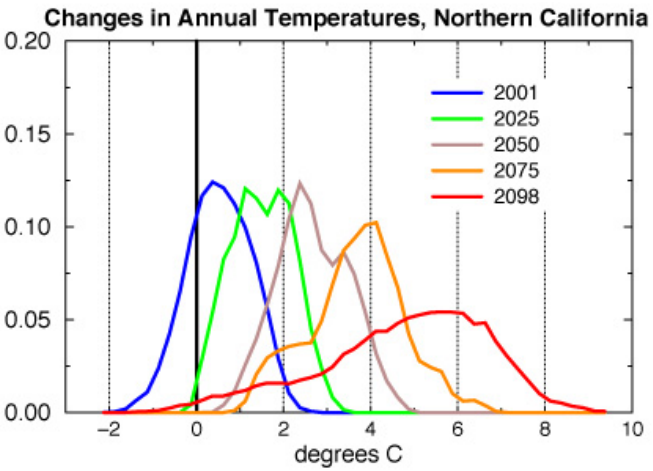


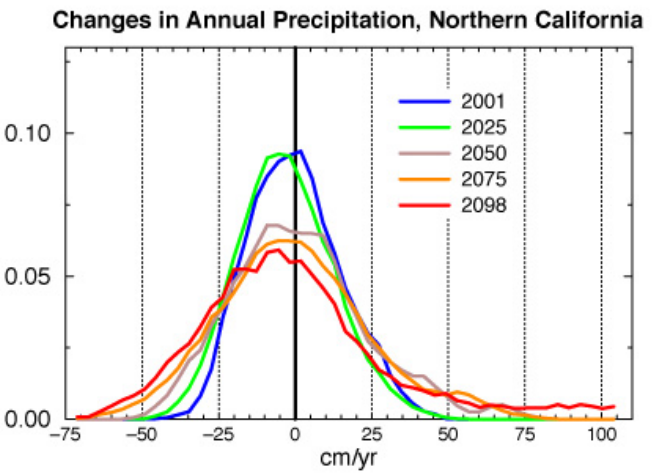
Adapted from Cayan and Knowles, SCRIPPS/USGS, 2003

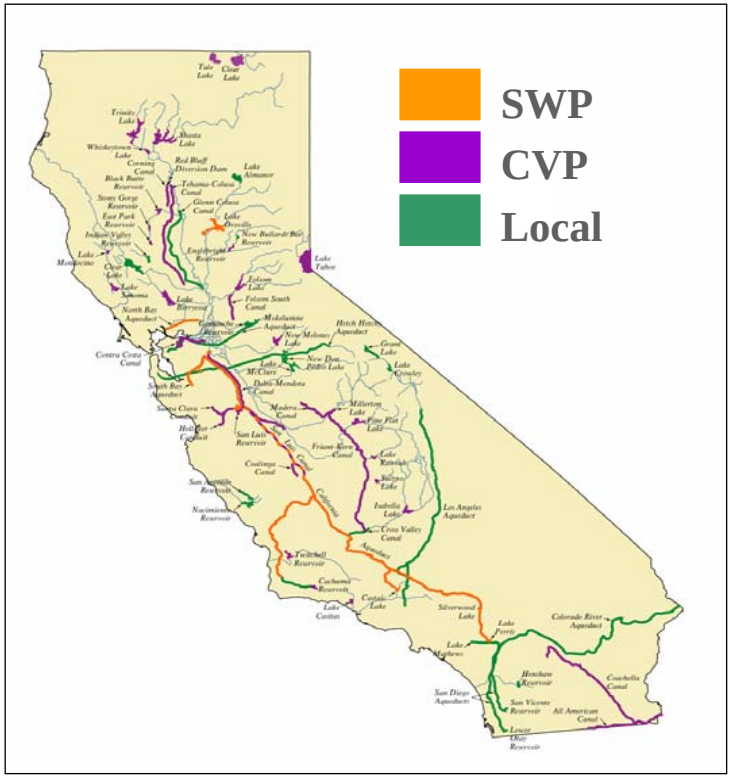
Working towards “Risk”

- Apply proven methods with agency tools
  - Reservoir operations analyses with CALSIM II
  - Delta water quality analyses with DSM2
- Coalition Building

Working towards “Risk” cont.







Adapted from Dettinger, USGS/SCRIPPS, 2004

Contact Information