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SLIDES: Future Water Availability in the West: Will There Be Enough?

Michael Dettinger

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Future Water Availability in the West: *Will there be enough?*



**Michael
Dettinger,**
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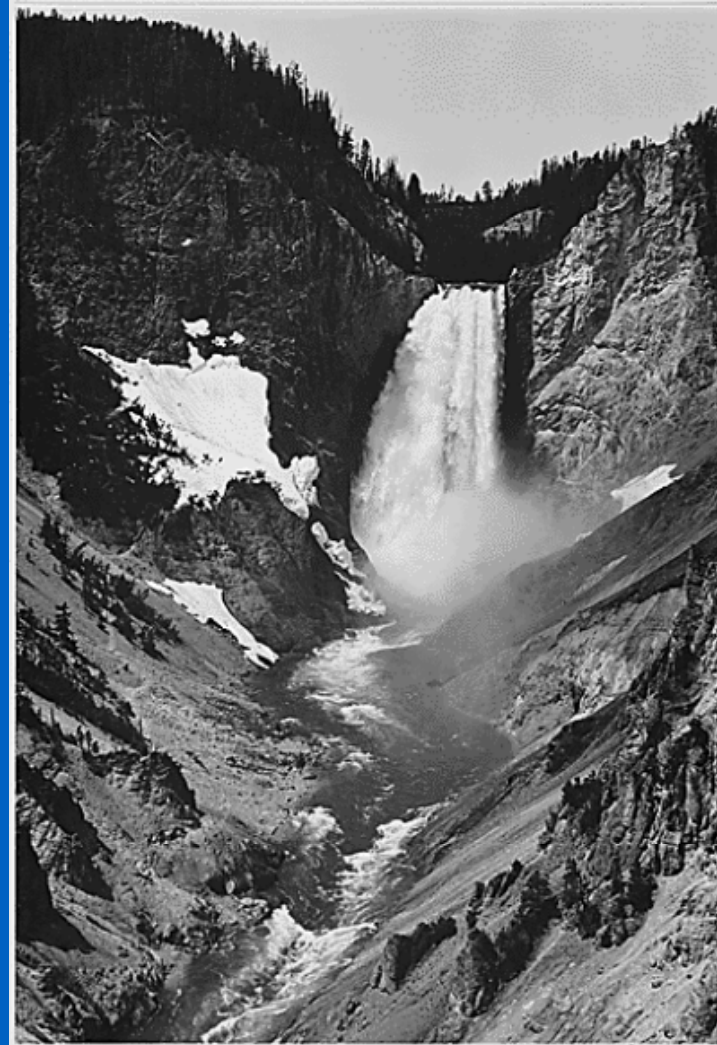
*with
contributions
from*
**Julio
Betancourt,
Dan Cayan, &
others**

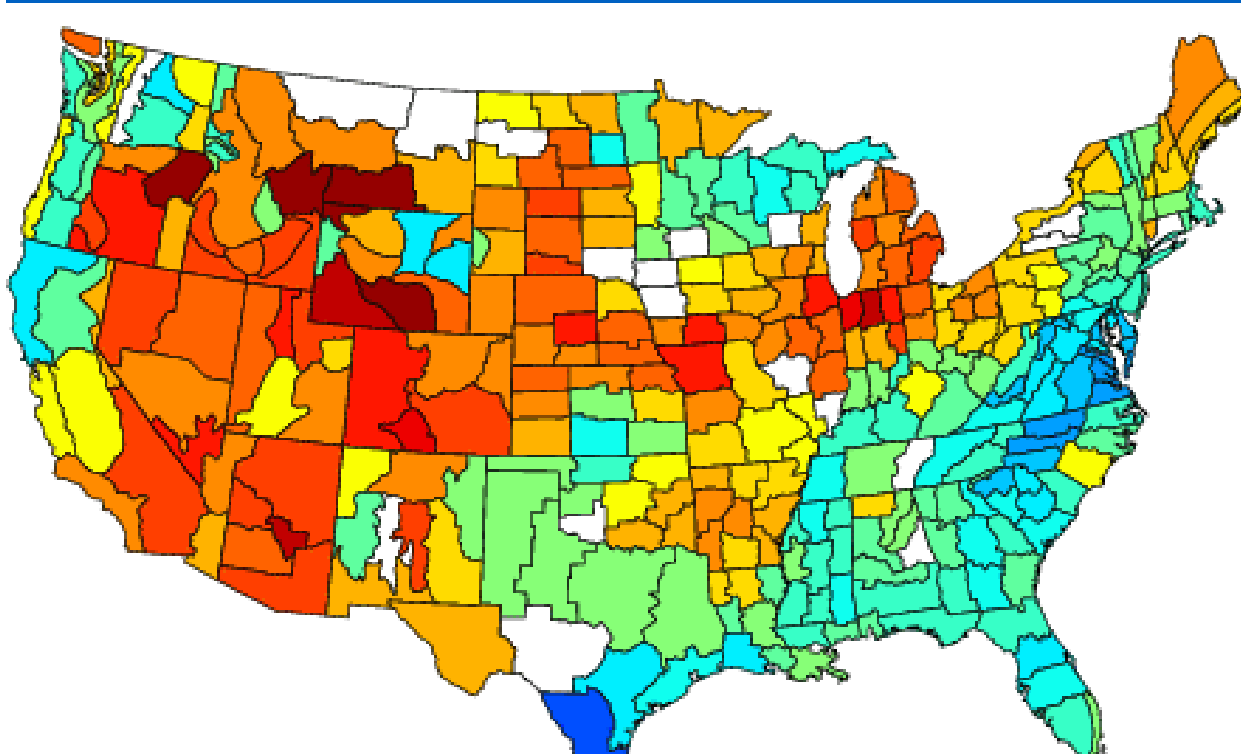
OUTLINE

**Natural variations of
water availability**

**Projected greenhouse
effects on
water availability**

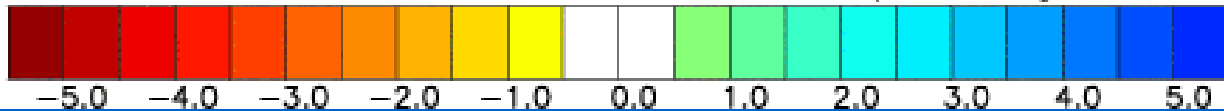
**Uncertainties &
strategies**





Drought Index, April 2003

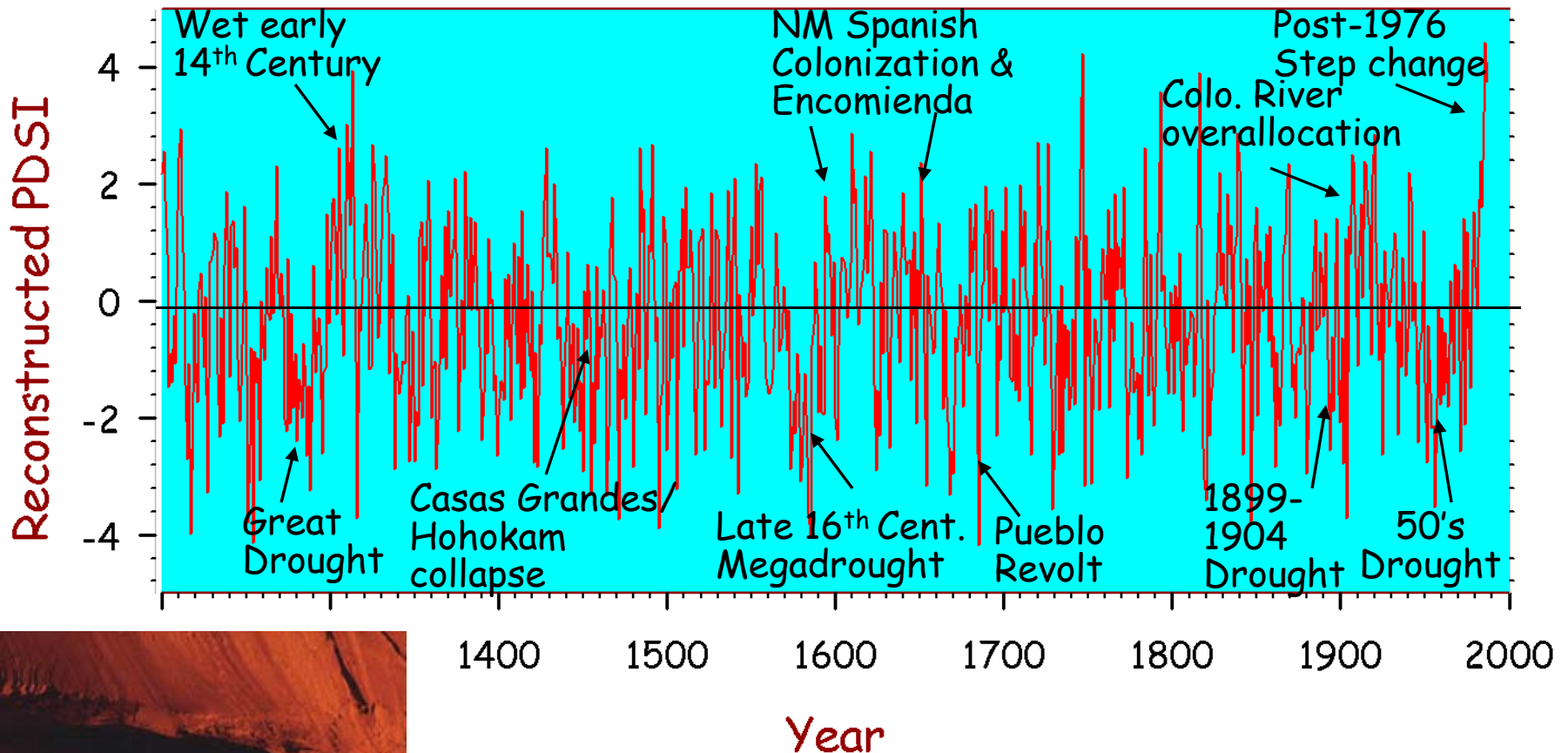
NOAA-CIRES/Climate Diagnostics Center



We are currently in the grip of a devastating drought in much of the West...

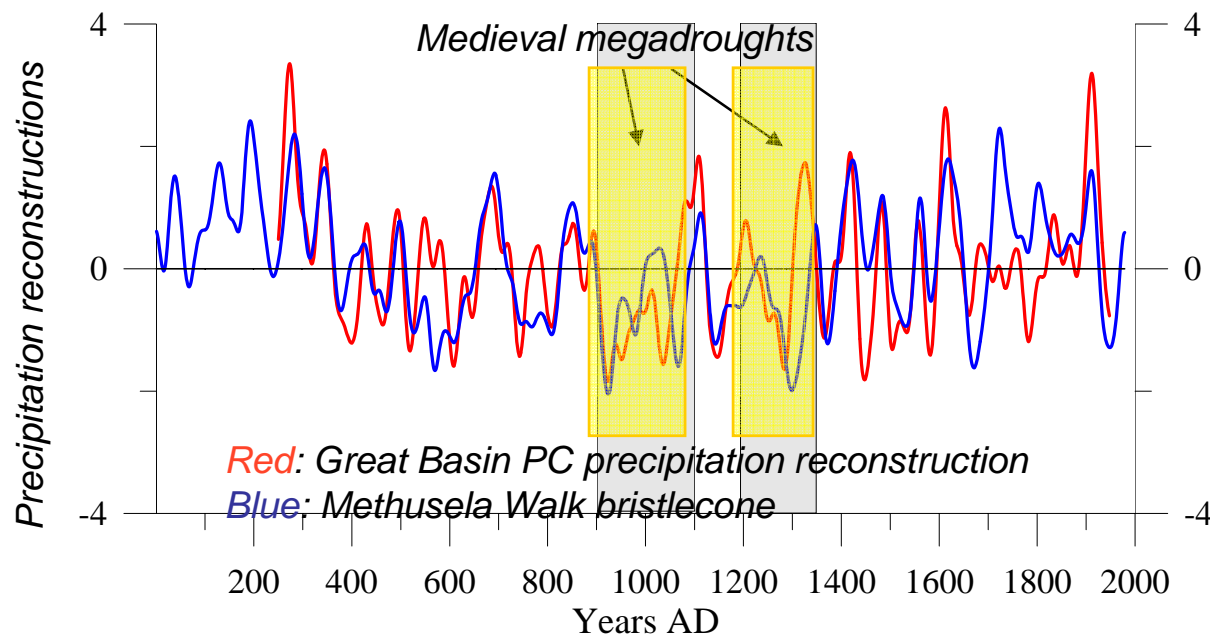
But, such droughts are just part of the naturally recurring range of events in the West...

Cook's Southwest Drought Index



courtesy of Julio Betancourt, USGS, Tucson

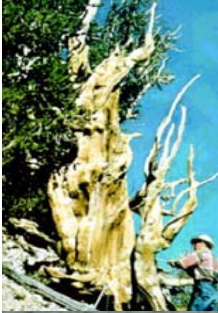
...and droughts in the West are not necessarily limited to the sort that we have known and accommodated during the past 100 years or so.



courtesy, Malcolm Hughes

Mega-droughts have reduced runoff from the eastern Sierra Nevada for about 100 years each, at least twice in the past 1000 years... with sustained streamflow reductions of -30%!

In addition to highlighting the occasional megadrought in the West, such studies show the highly unusual character of the 20th Century, ...



Temperature reconstructions from upper treeline: bristlecone pine

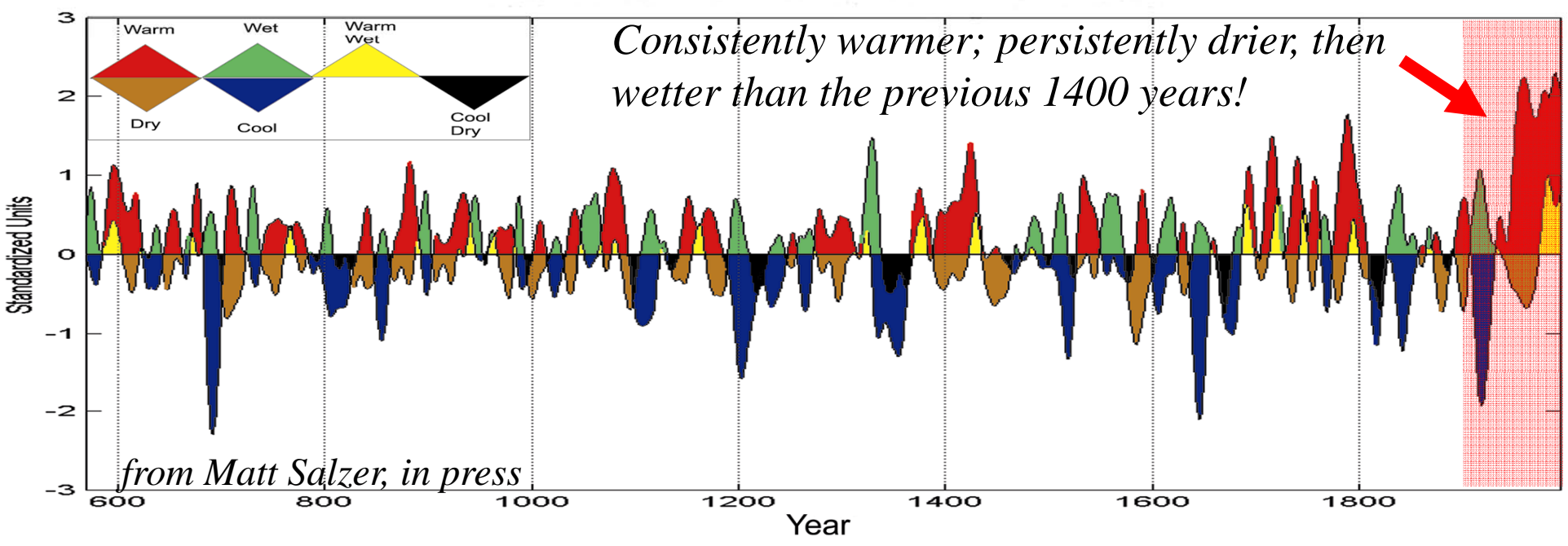


San Francisco Peaks, AZ

Precipitation reconstructions from lower treeline: Douglas fir, ponderosa, pinyon pine



the highly unusual character of the 20th Century, ...



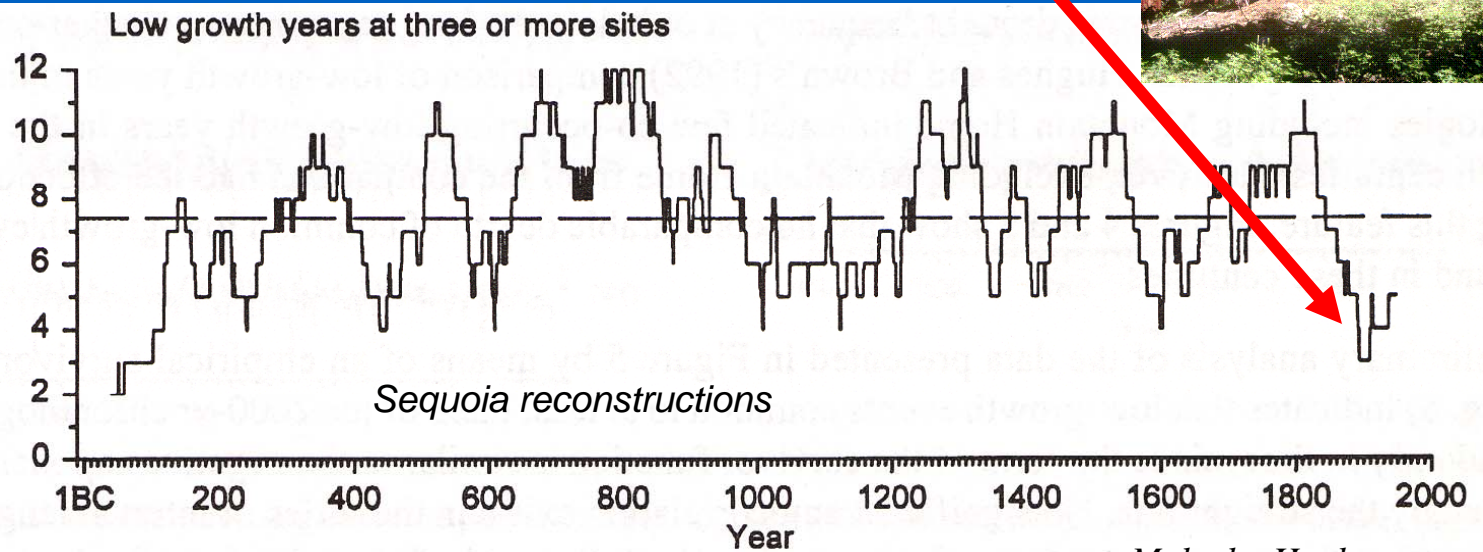
...and, e.g., the 20th Century yielded fewer-than-"normal" sharp (deep, brief) droughts in California.



Numbers of
Short sharp droughts

frequent

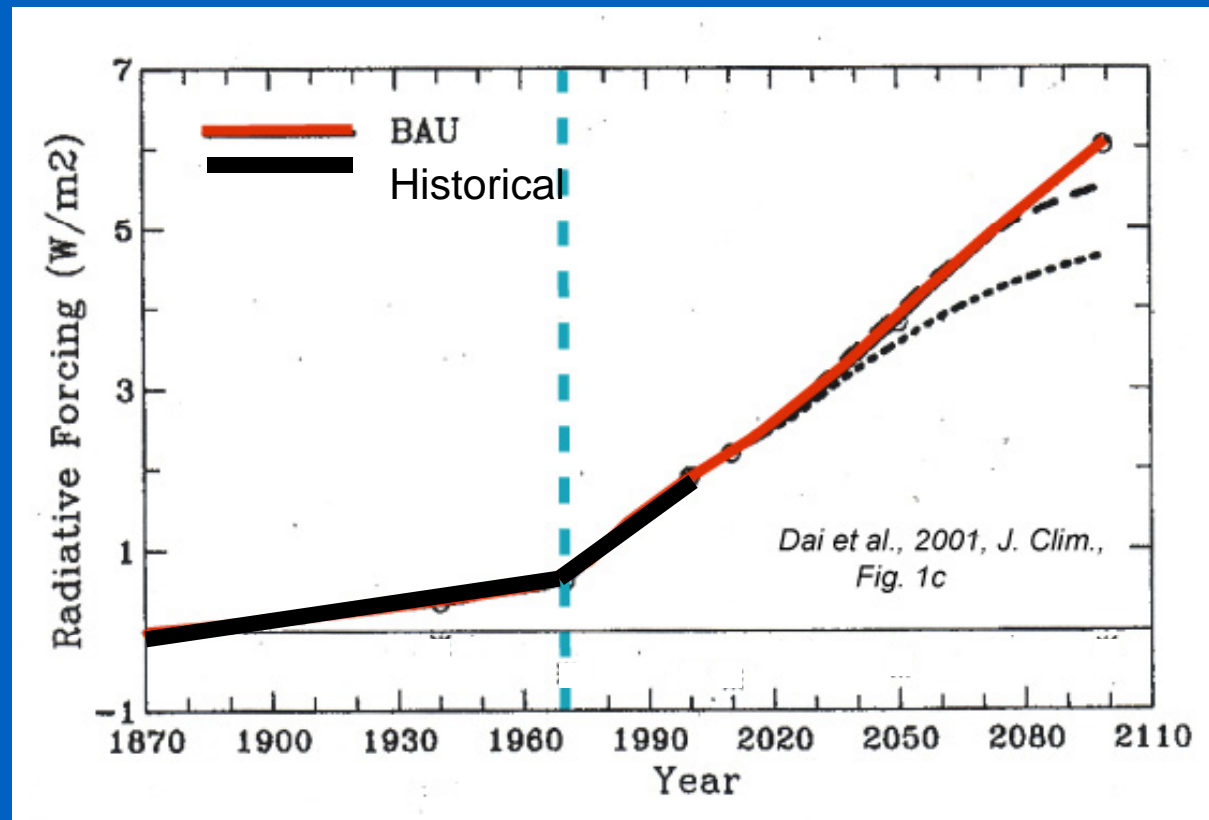
rare



courtesy, Malcolm Hughes

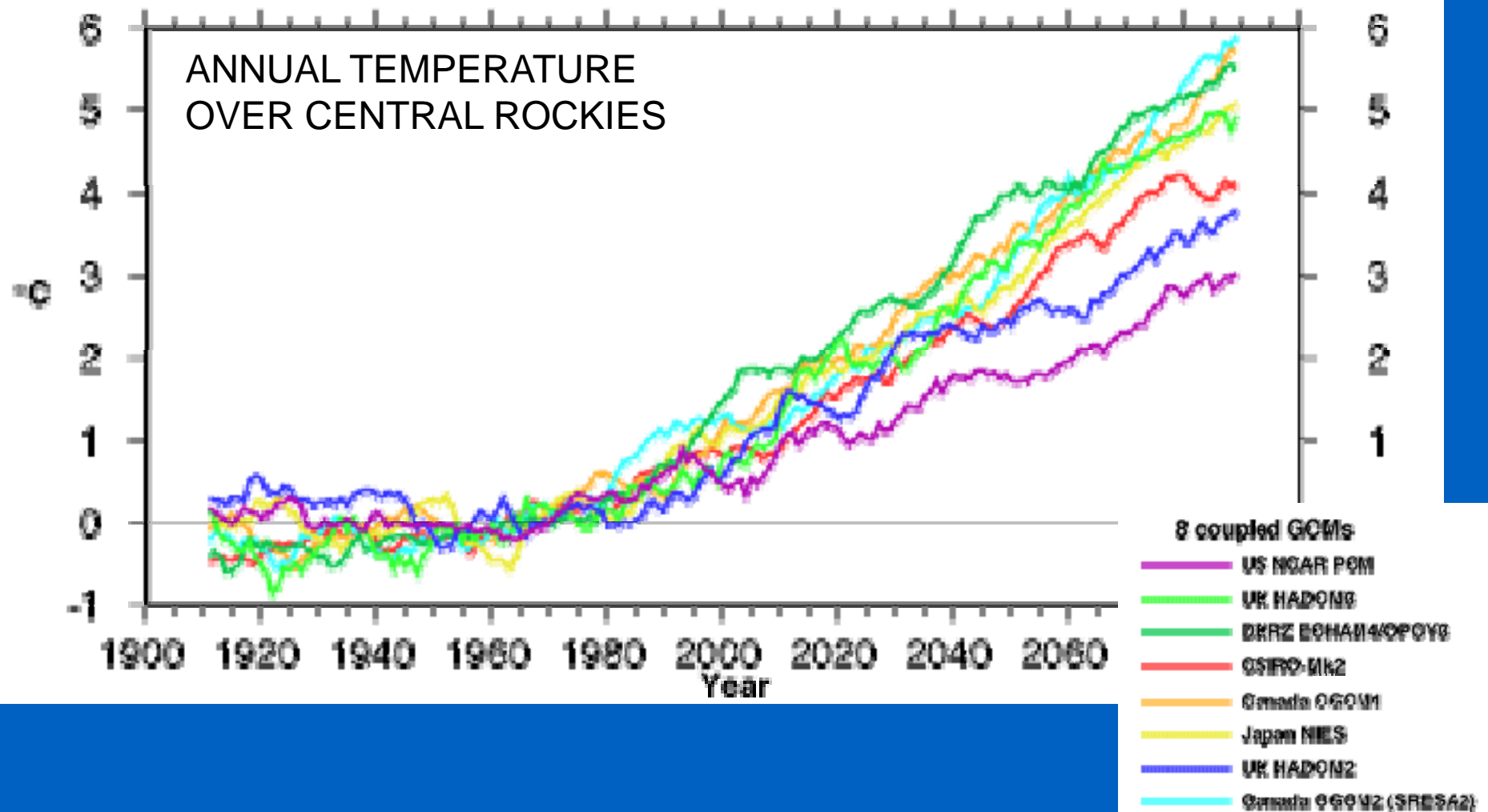
---> *Can the water systems of the late 20th Century accommodate a less benign climate?*
(Either with OR without global warming...)

In the near future, global-warming trends are likely to be superimposed upon these 'normal' climate variations that our infrastructures & institutions accommodate...

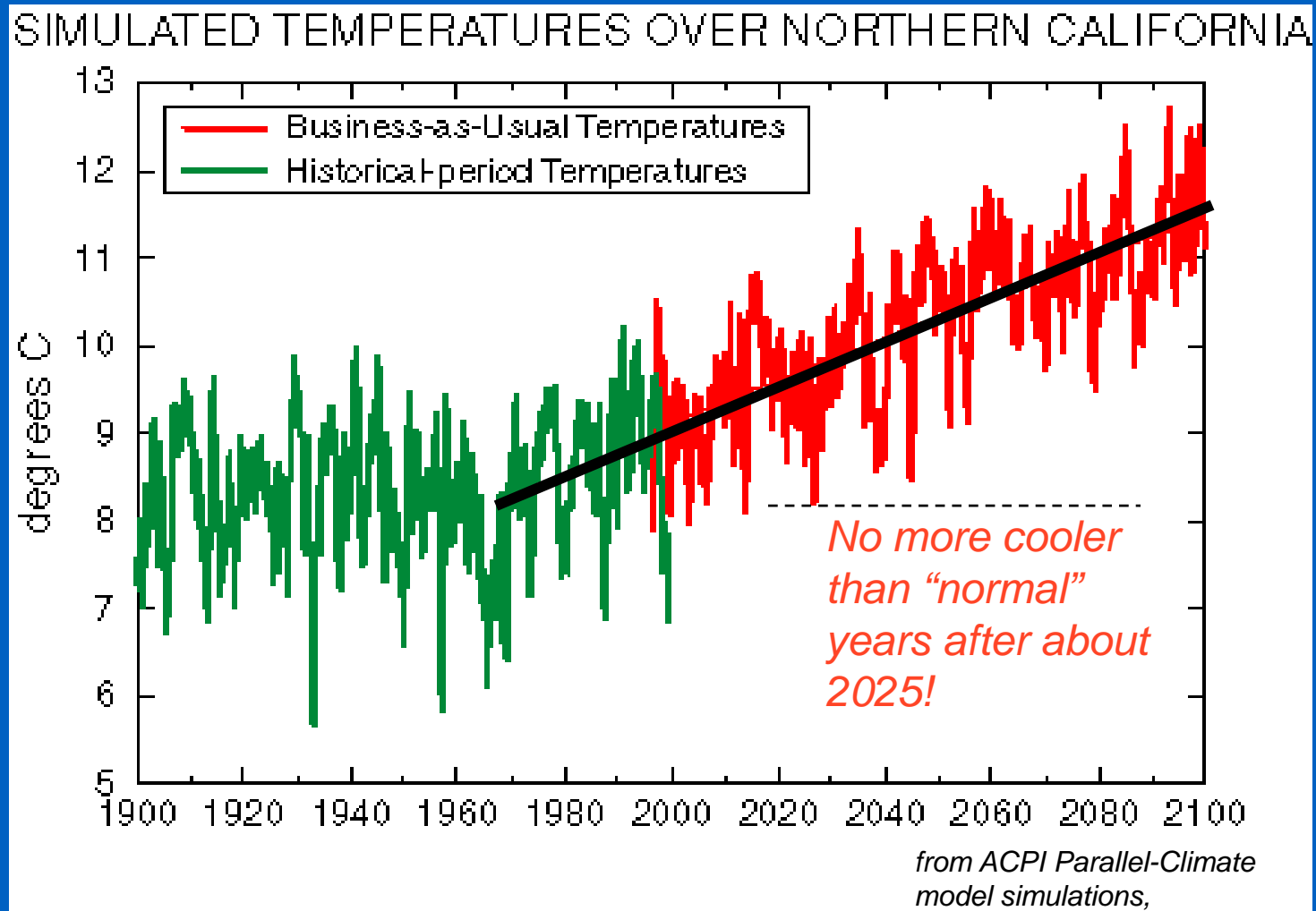


...in response to accelerations of the greenhouse effect that began 30+ years ago!

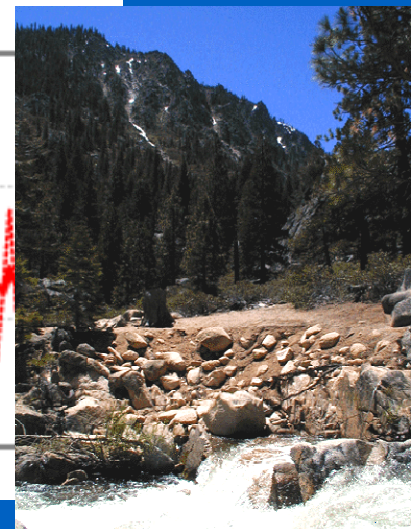
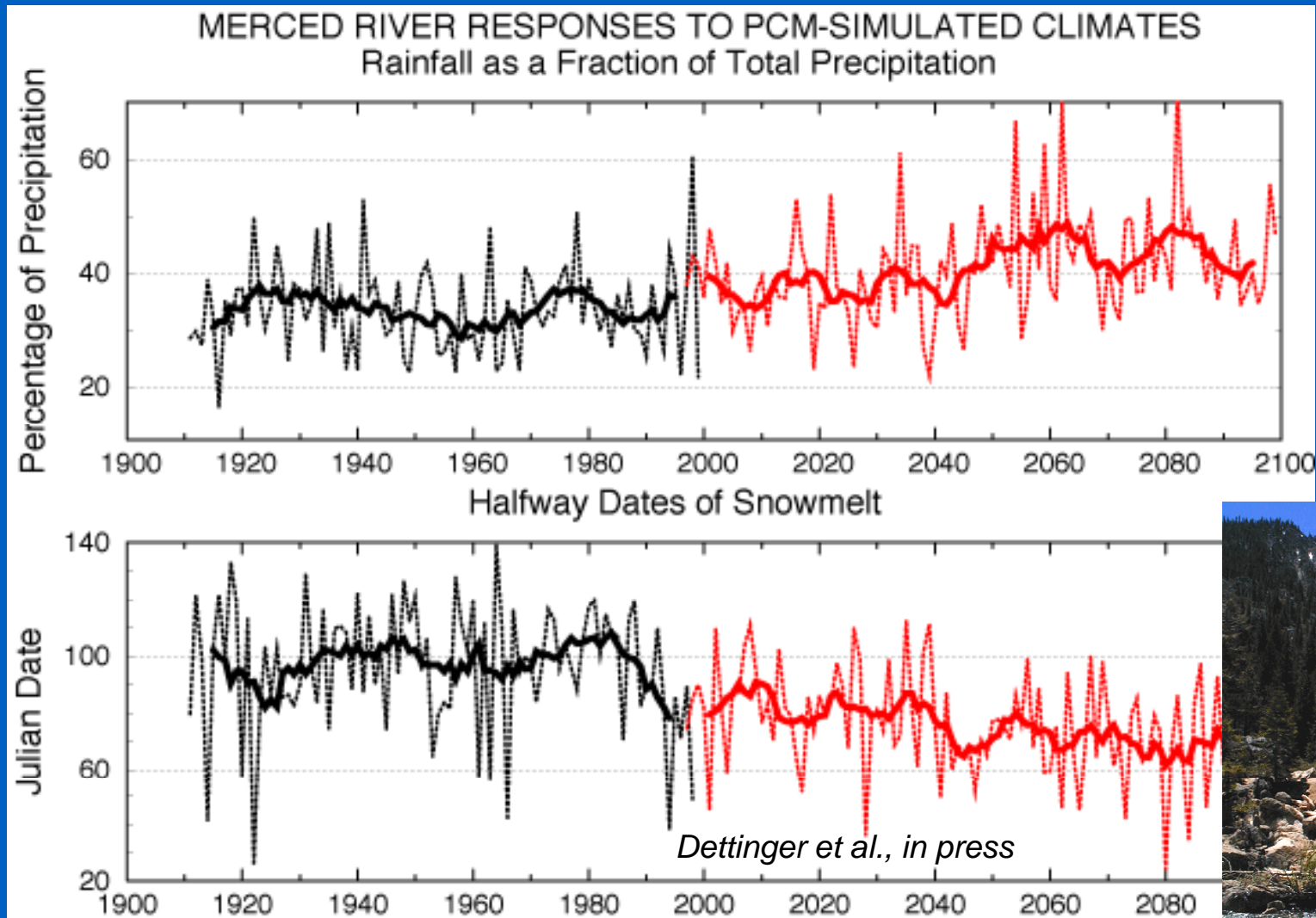
Under this (restricted) forcing, climate models yield a relatively narrow range of warming scenarios for the West.



Even in the coolest of these models, temperatures begin rising in the 1970s, and unequivocal change might be expected by the 2020s.



With only this warming (i.e. no precipitation changes included, yet)
would come **less snowfall, more rainfall,**
& **earlier snowmelt...**

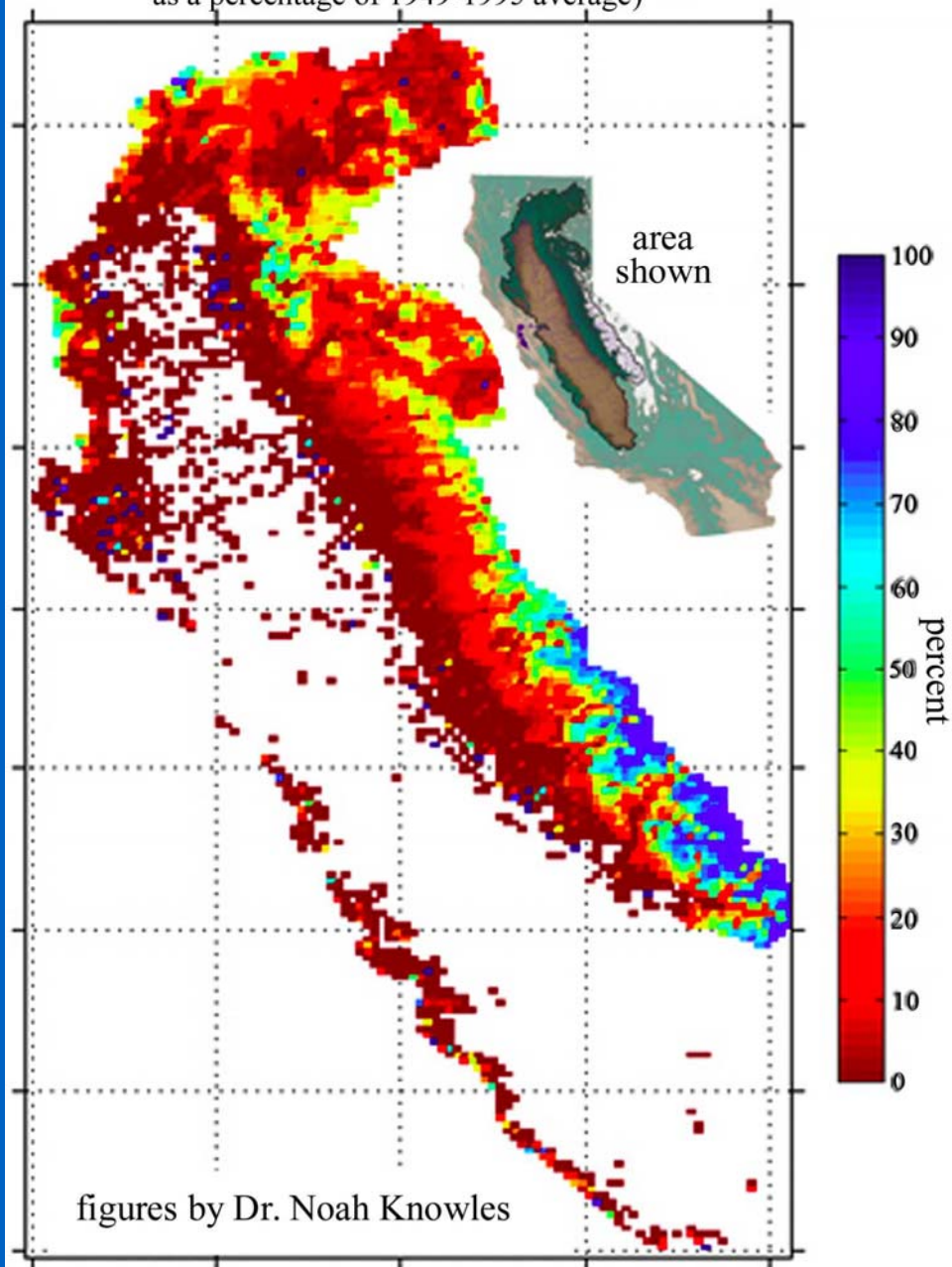


So that by the middle of the 21st Century, even in the coolest of the models, **major reductions in snowpacks of the Sierra and Rockies are projected...**

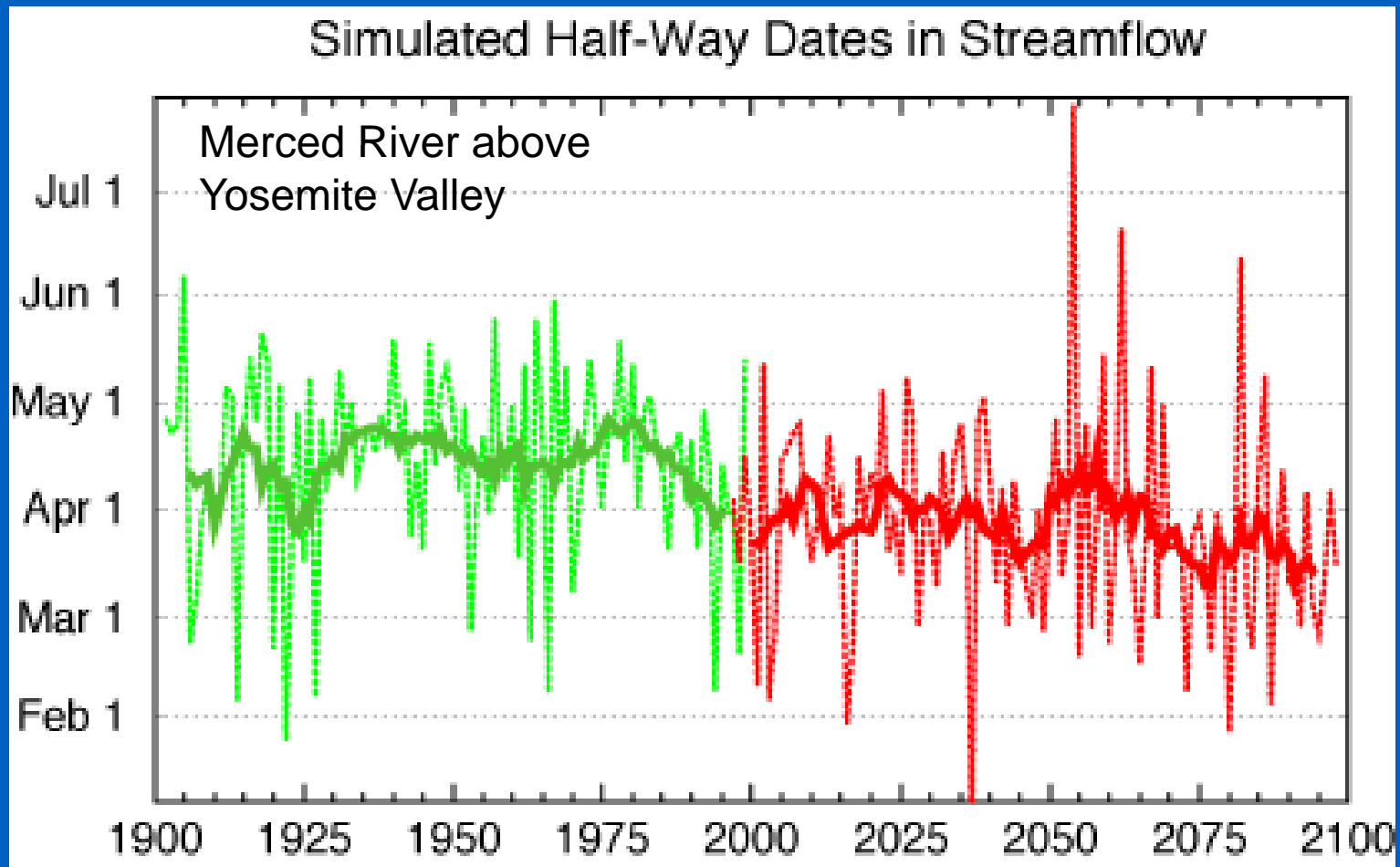
Knowles & Cayan, GRL, 2002



Snowpack Changes
(average 2050-2069 liquid water equivalent
as a percentage of 1949-1995 average)

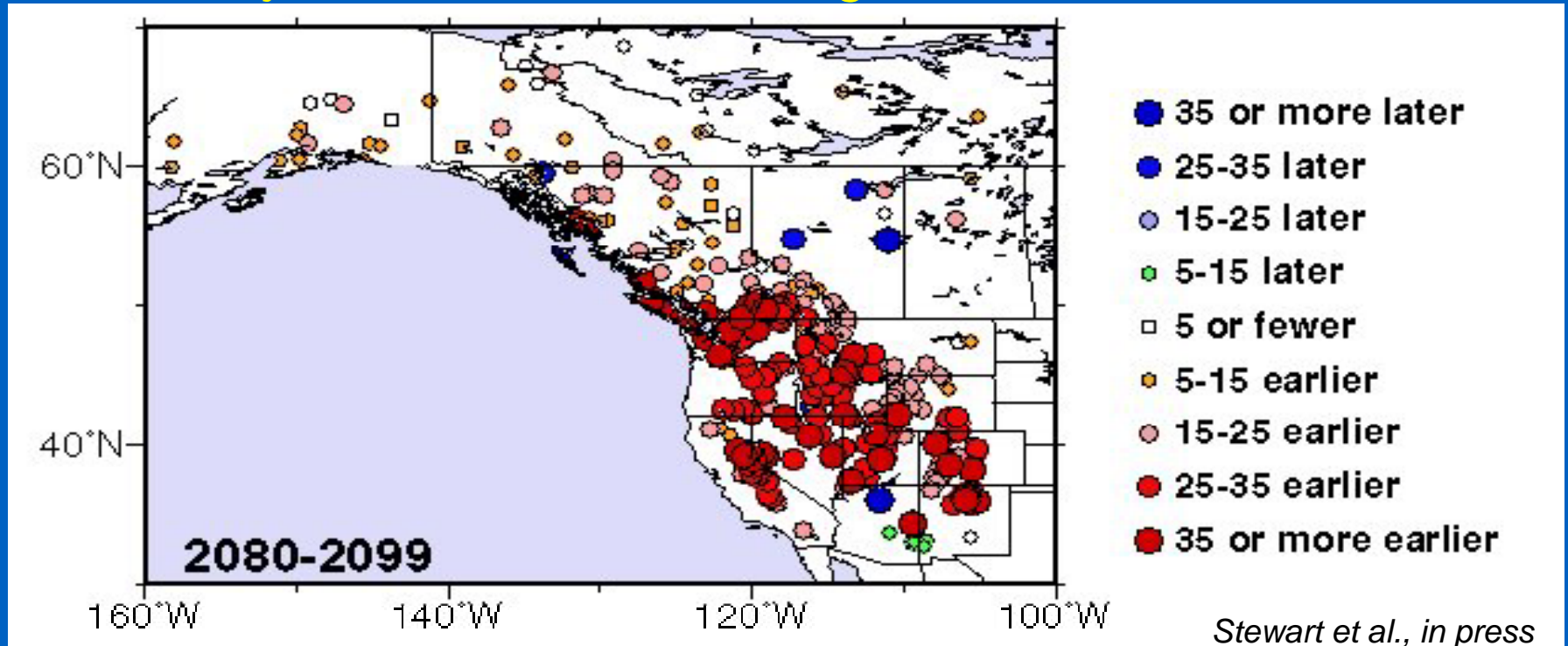


All this results in **earlier runoff**.



...throughout the West.

Projected streamflow timings, 2080-99 vs 1951-80

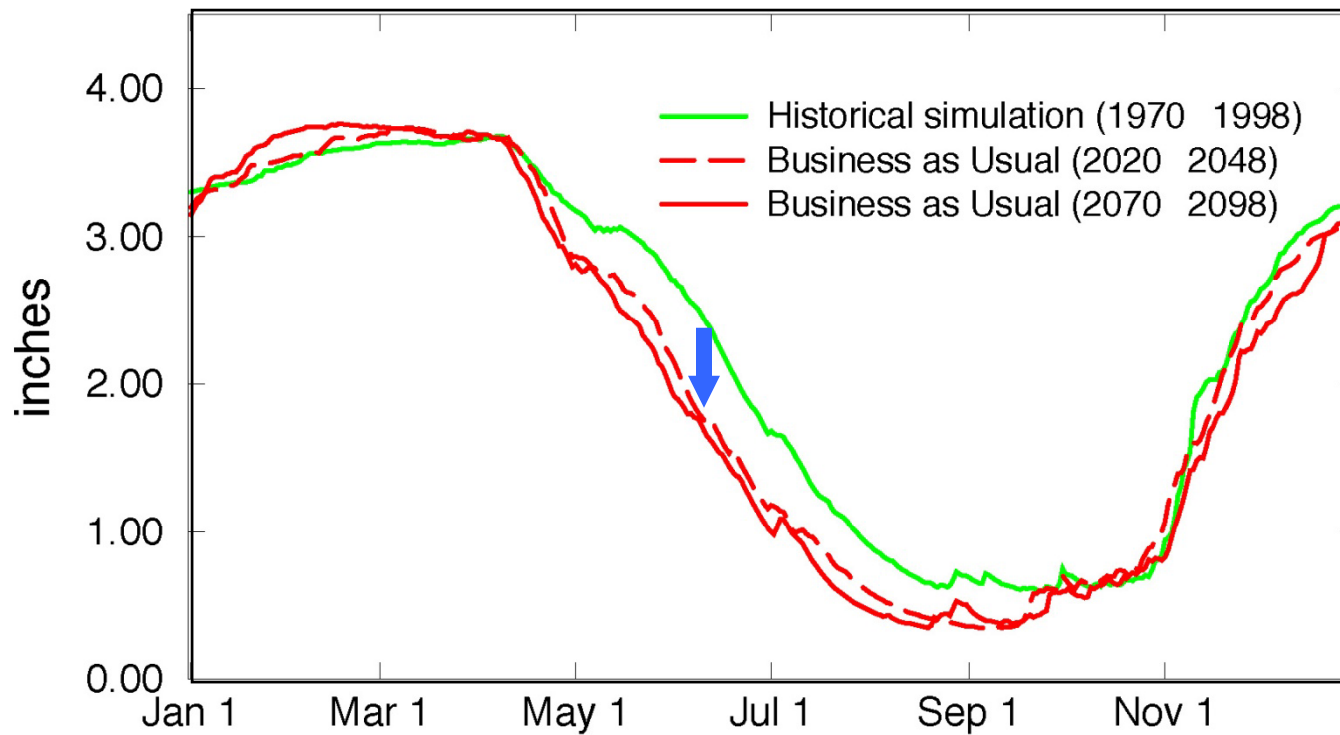


... and we **already observe 30+ years of such trends** in streamflow records all over the West.



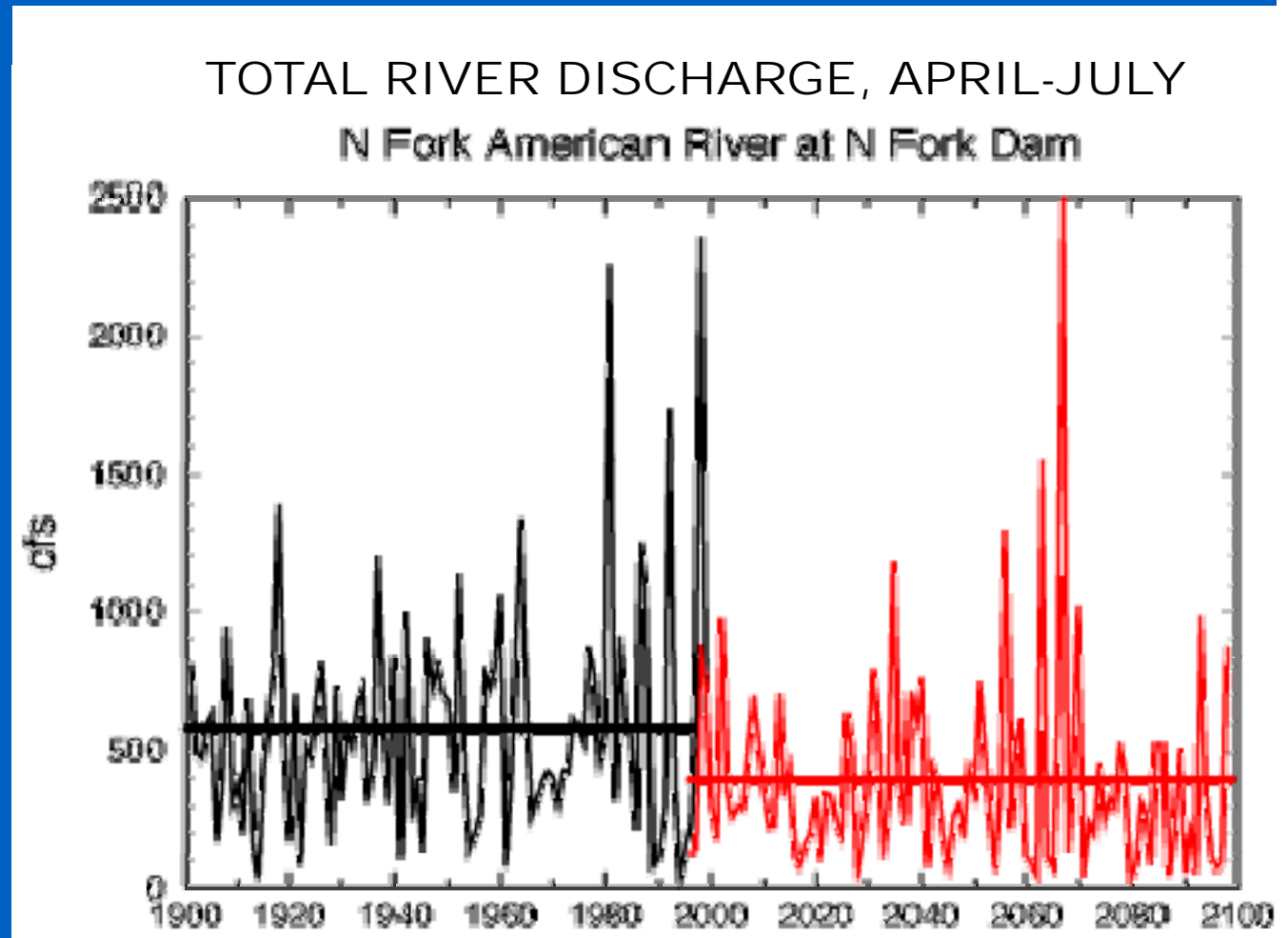
With all this runoff leaving the watersheds earlier, summer conditions will be much drier and **summer streamflow will decline.**

Changes in Soil Moisture Seasonality
Merced River basin abv Yosemite Valley



NOTE:
Unless summer precipitation increases markedly, the summertime flow reduction is NOT caused by increased evaporation.

In many settings, this change in streamflow timing will mean **less runoff captured in Sierran and Rockies reservoirs, ...**

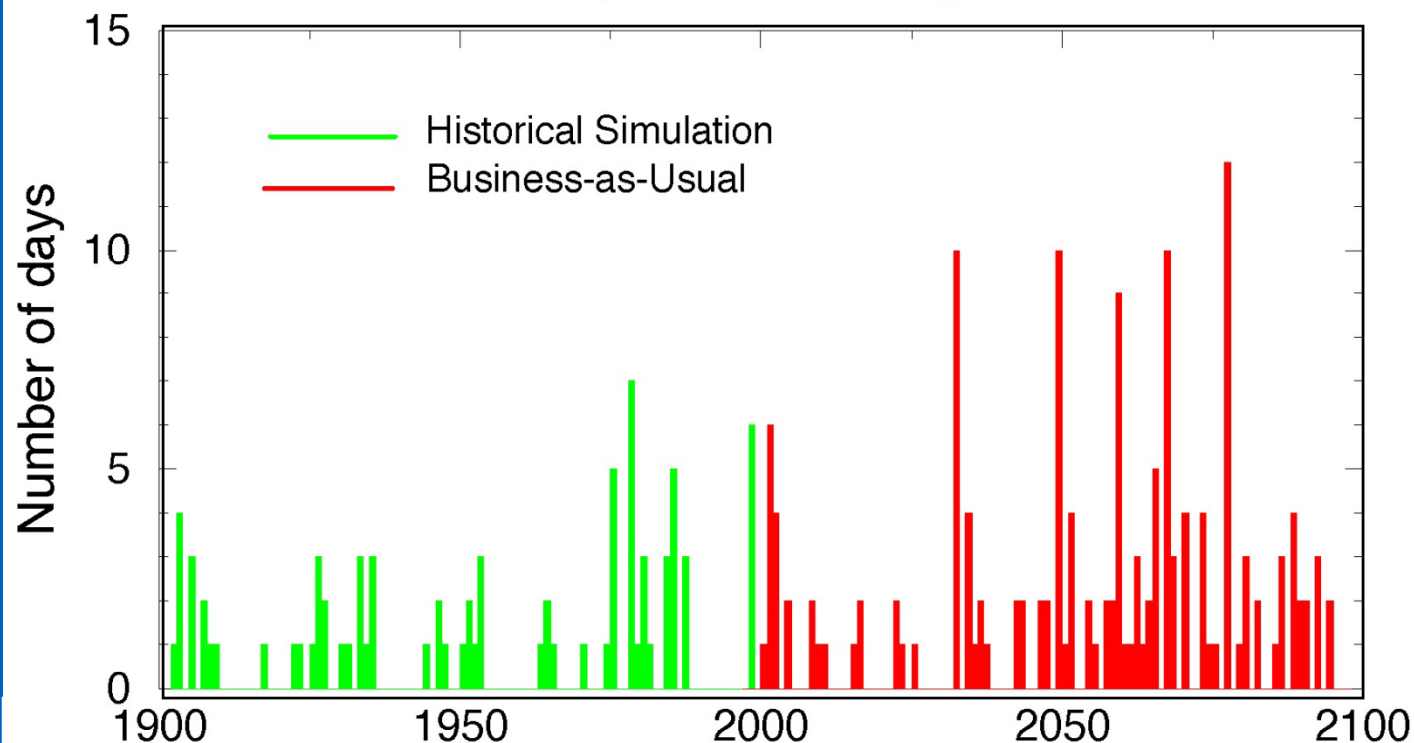


from ACPI Parallel-Climate
model simulations,

Dettinger et al, in press

...because
the change
would also
entail
more
severe
winter
floods.

MERCED RIVER AT HAPPY ISLES
Number of Days with Discharge > 140 cms

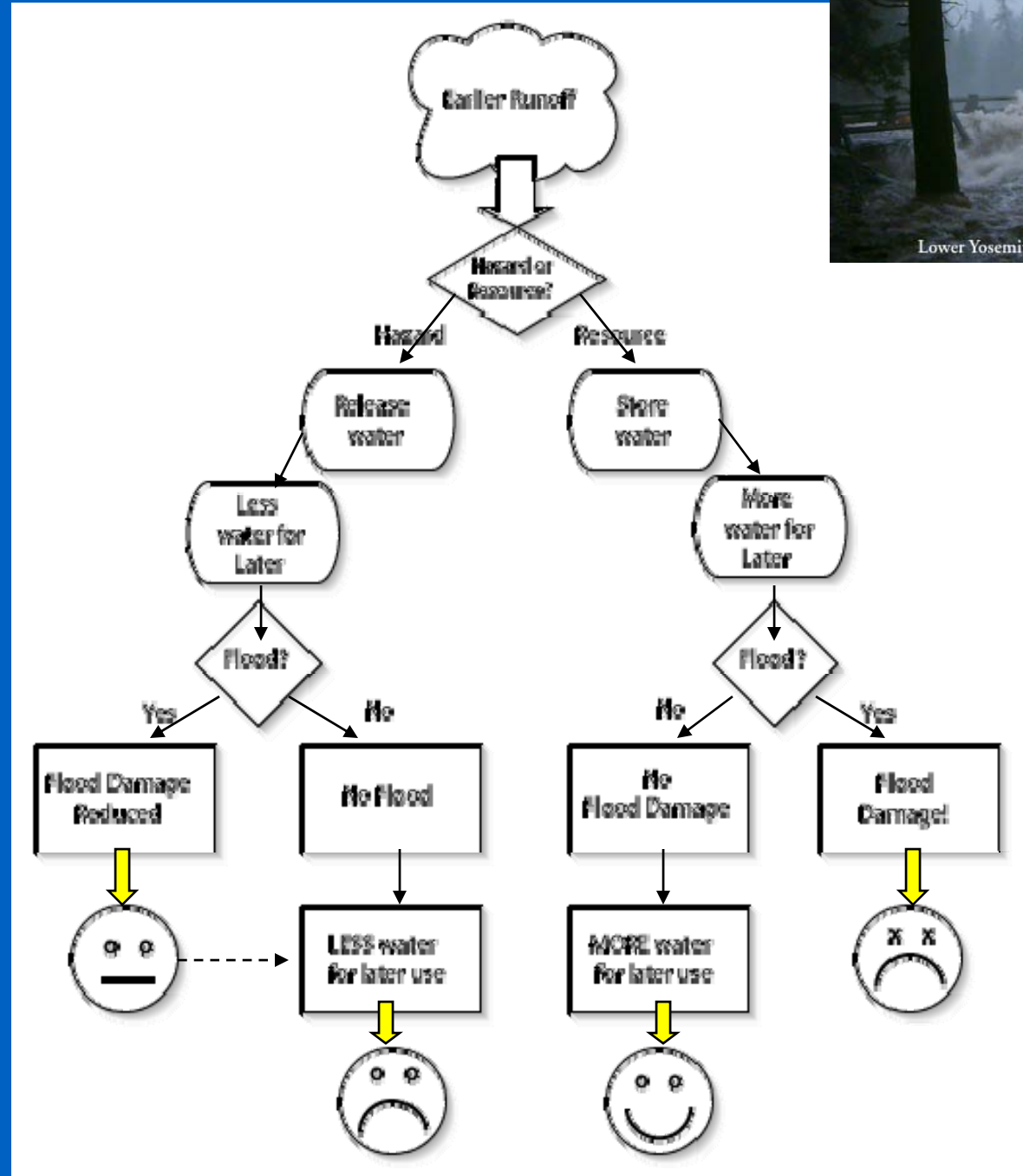


Dettinger et al., in press;
<http://www.cgd.ucar.edu/cas/ACACIA/workshops/precip/dettinger.pdf>

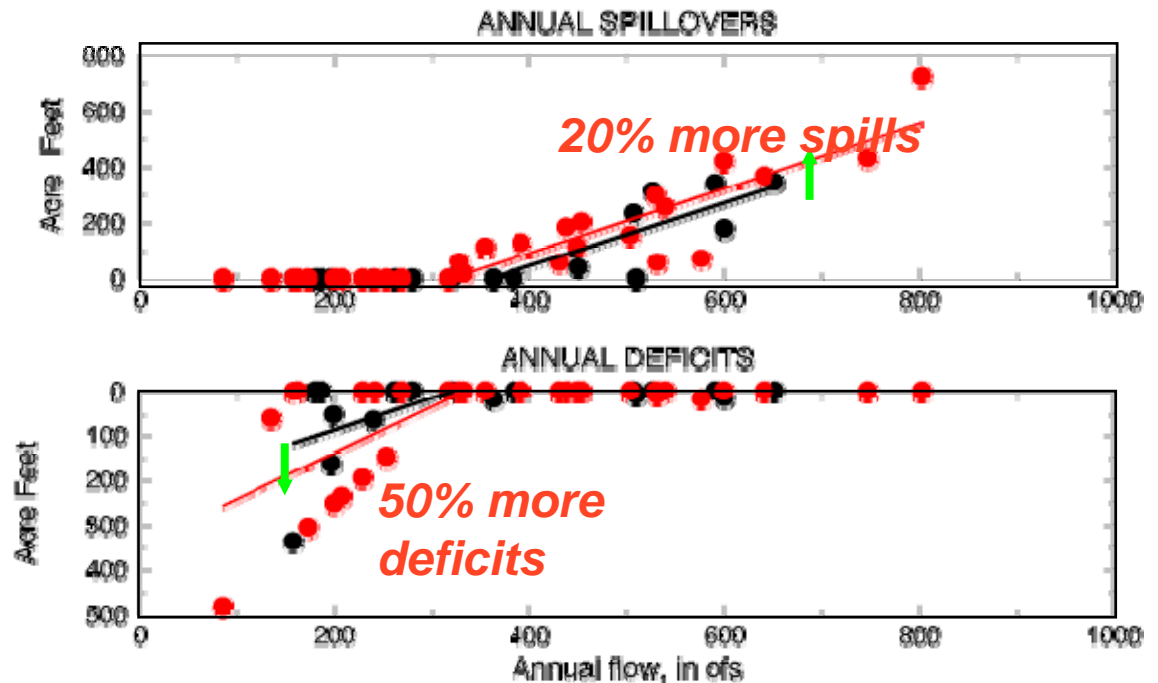
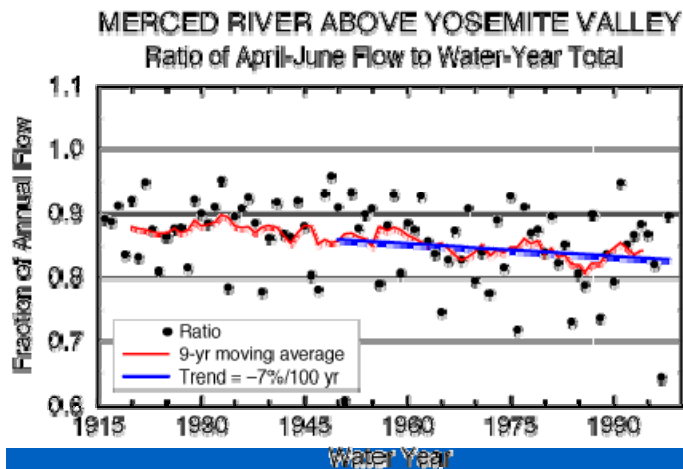
The reservoir manager's bind:

Save the water for warm-season uses?

Or maintain lots of empty flood-control space behind the dams?

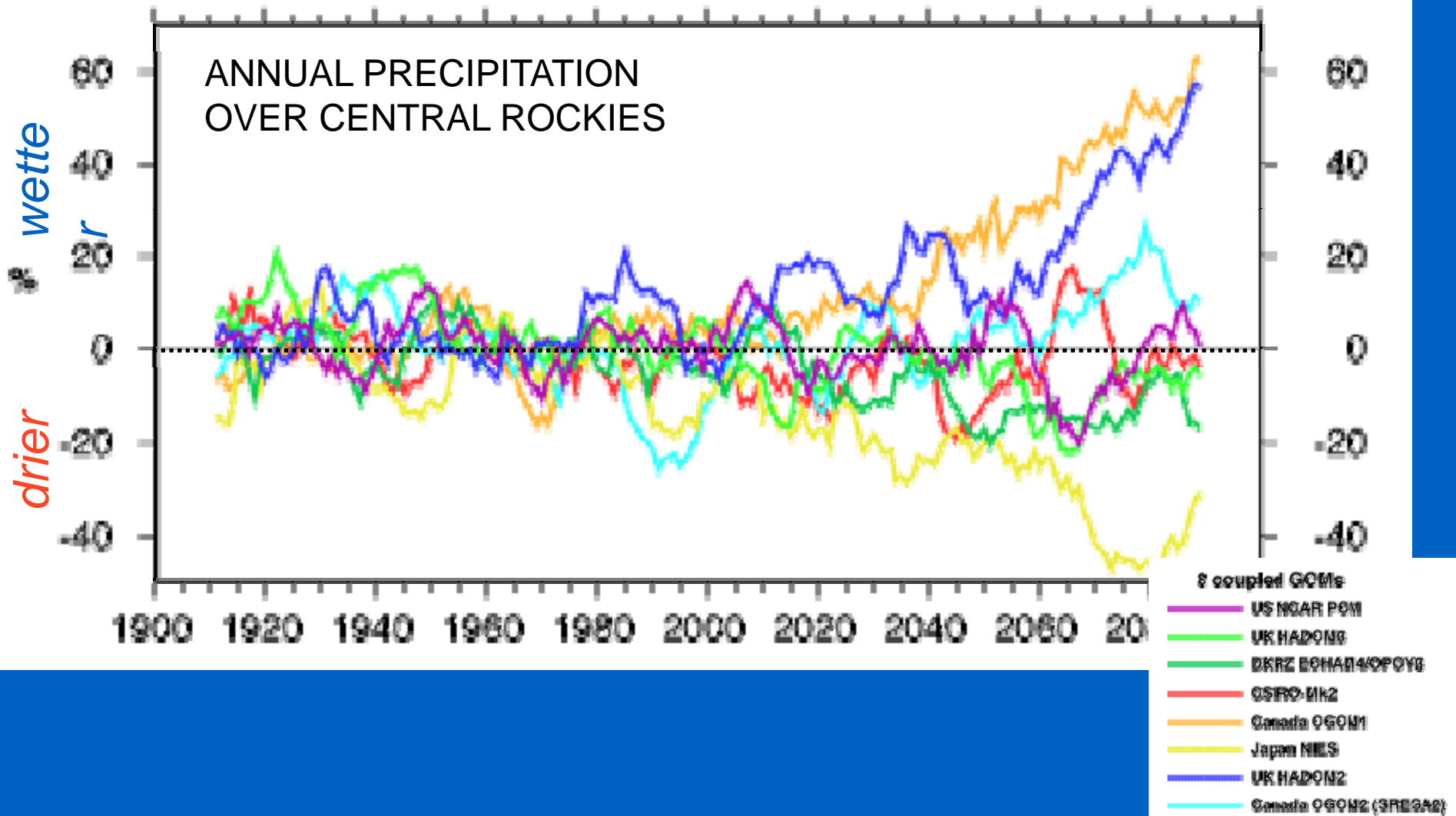


Notably, even the *small* historical timing shifts on the upper Merced would yield **more spillovers & more deficits** (in an imaginary reservoir under simple *FIXED* rules).



→ So, how well will such projected shifts (within the year) of the availability & risks of supply be handled by current water systems?

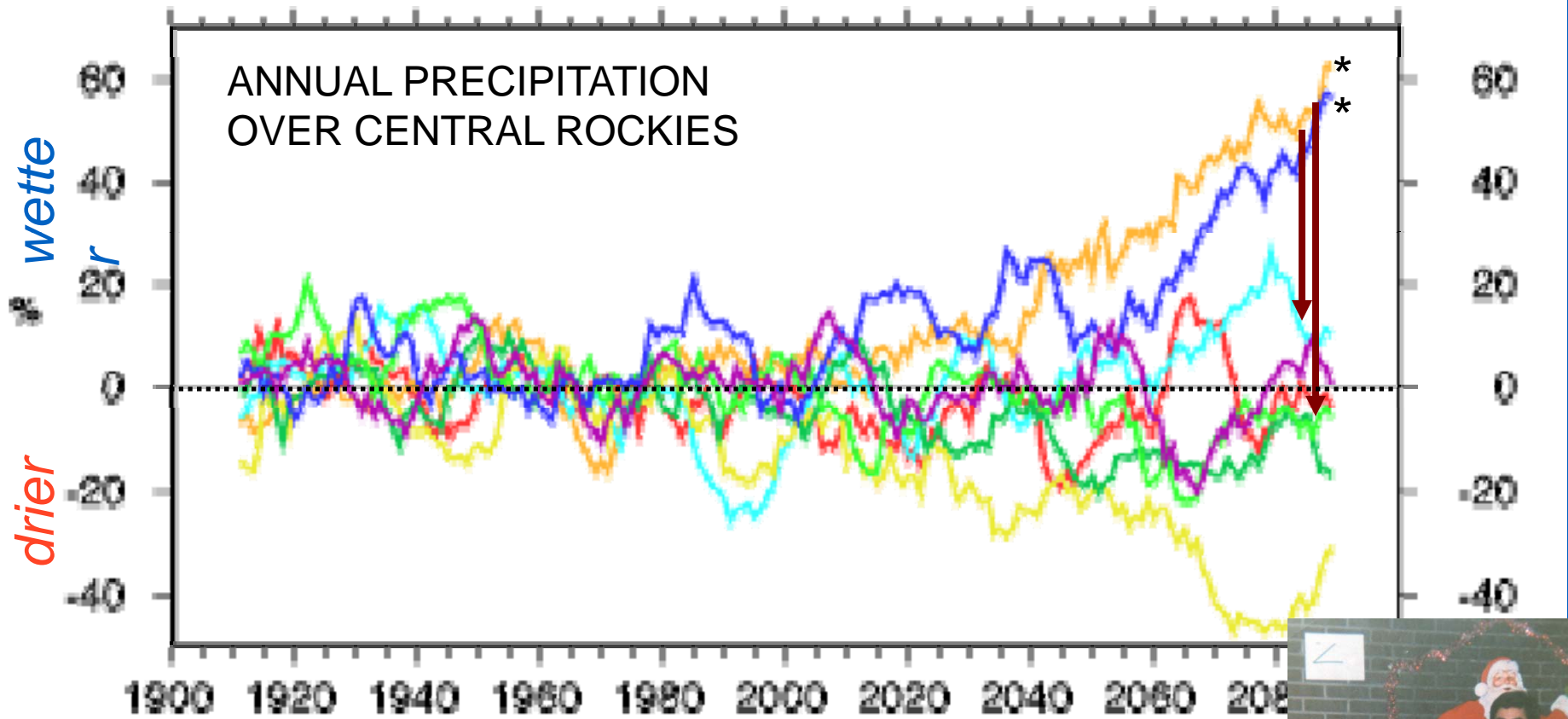
Under the same greenhouse forcing, climate models provide less consensus regarding precipitation in the West.



Will the West be wetter or drier? We don't know.

Some older models () yielded wetter;*

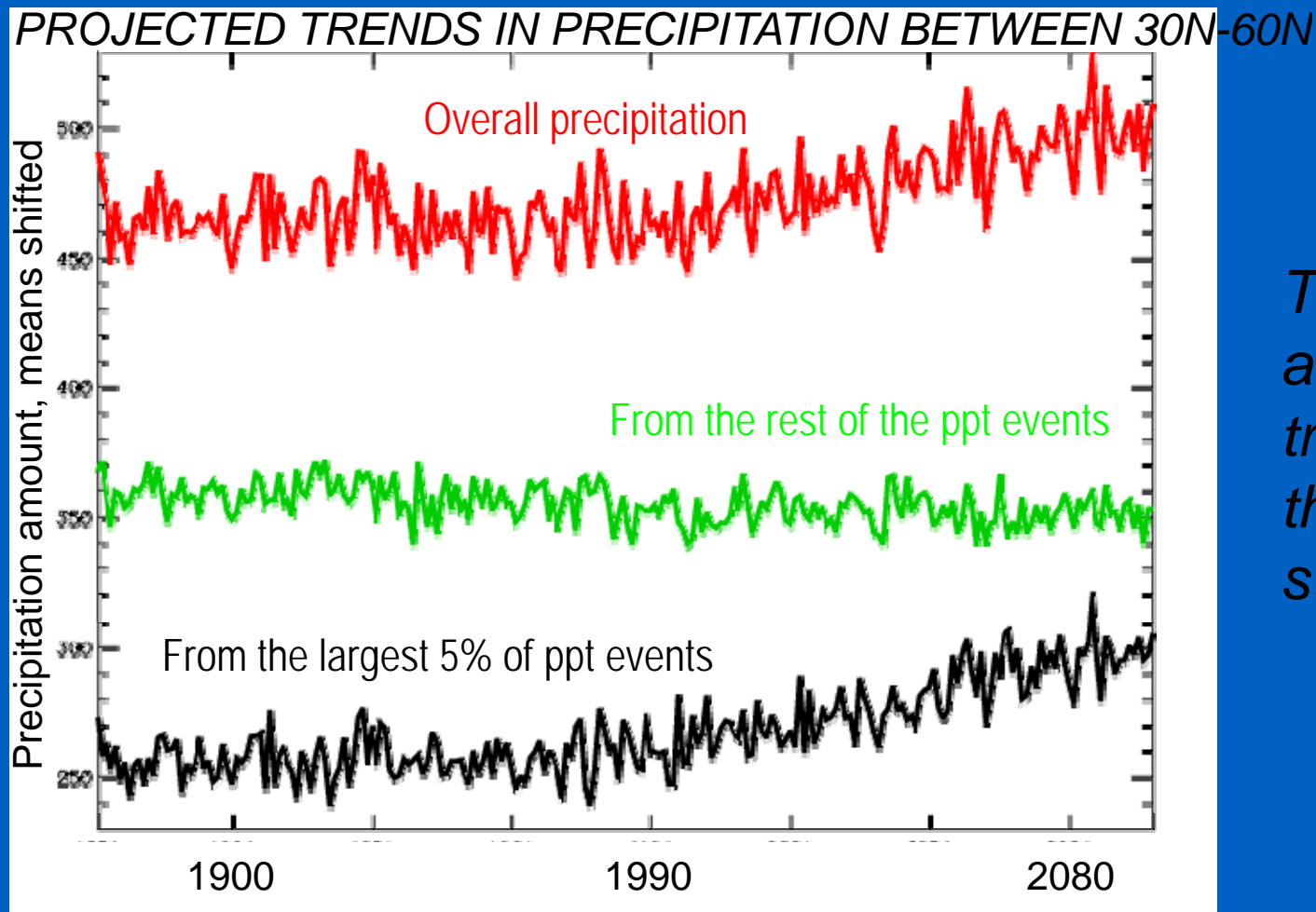
newer ones generally are yielding small changes.



... and, in the panel, Marty Hoerling may speak about a scenario under which we would see considerable Western dry-ness.



But even in the models that project little change in average precipitation, **extreme precipitation events increase markedly.**

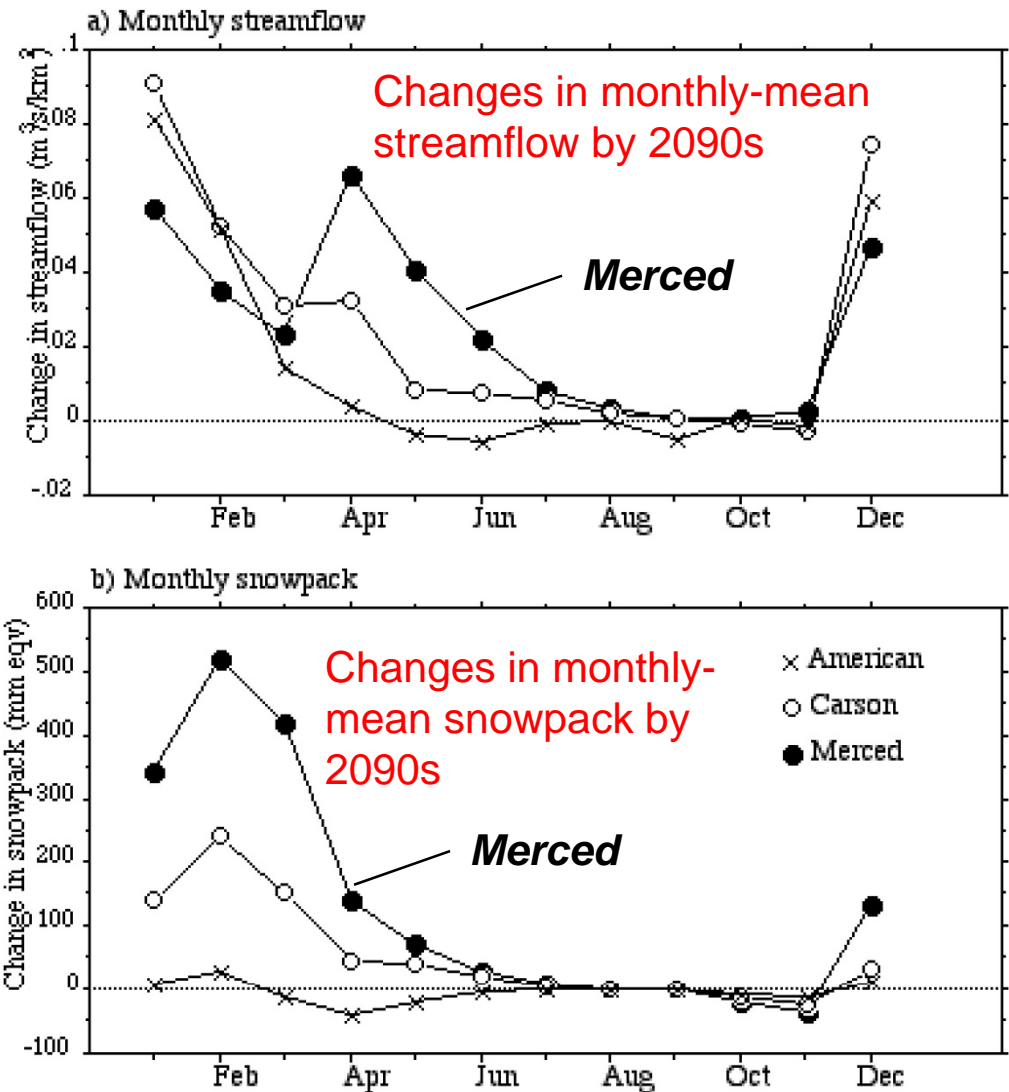


*That is,
all the
trend is in
the big
storms!*

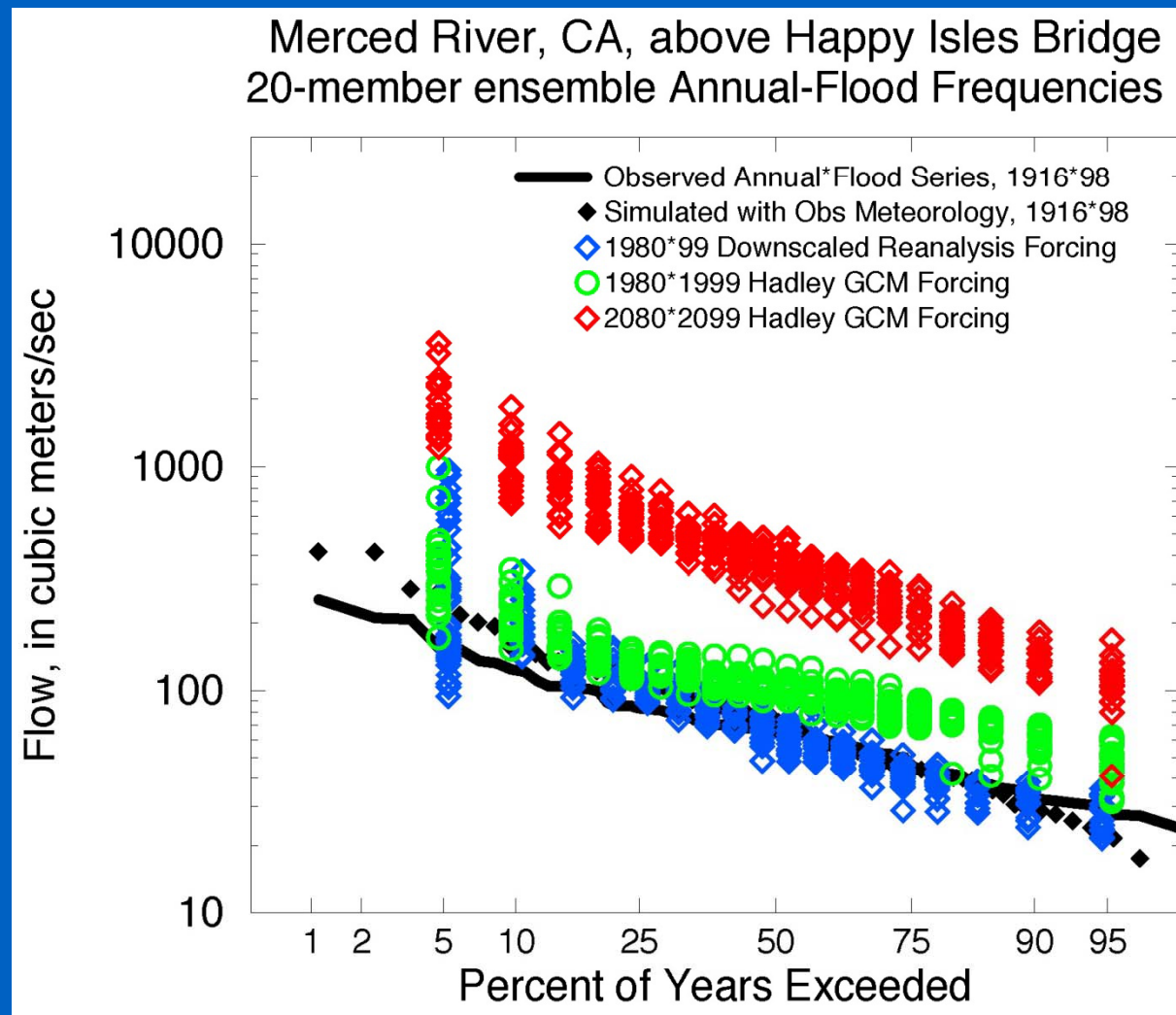
from ACPI Parallel-
Climate model

With enough additional precipitation (nearly 2x in this example), the winter snowpack & spring snowmelt seasons can survive a moderate warming (+3.5°C), ...

HadCM2 2090-99PROJECTED River and Snowpack Responses



...but with
much **larger**
winter floods!
(10x today, in this
case)



Wilby & Dettinger, 2000

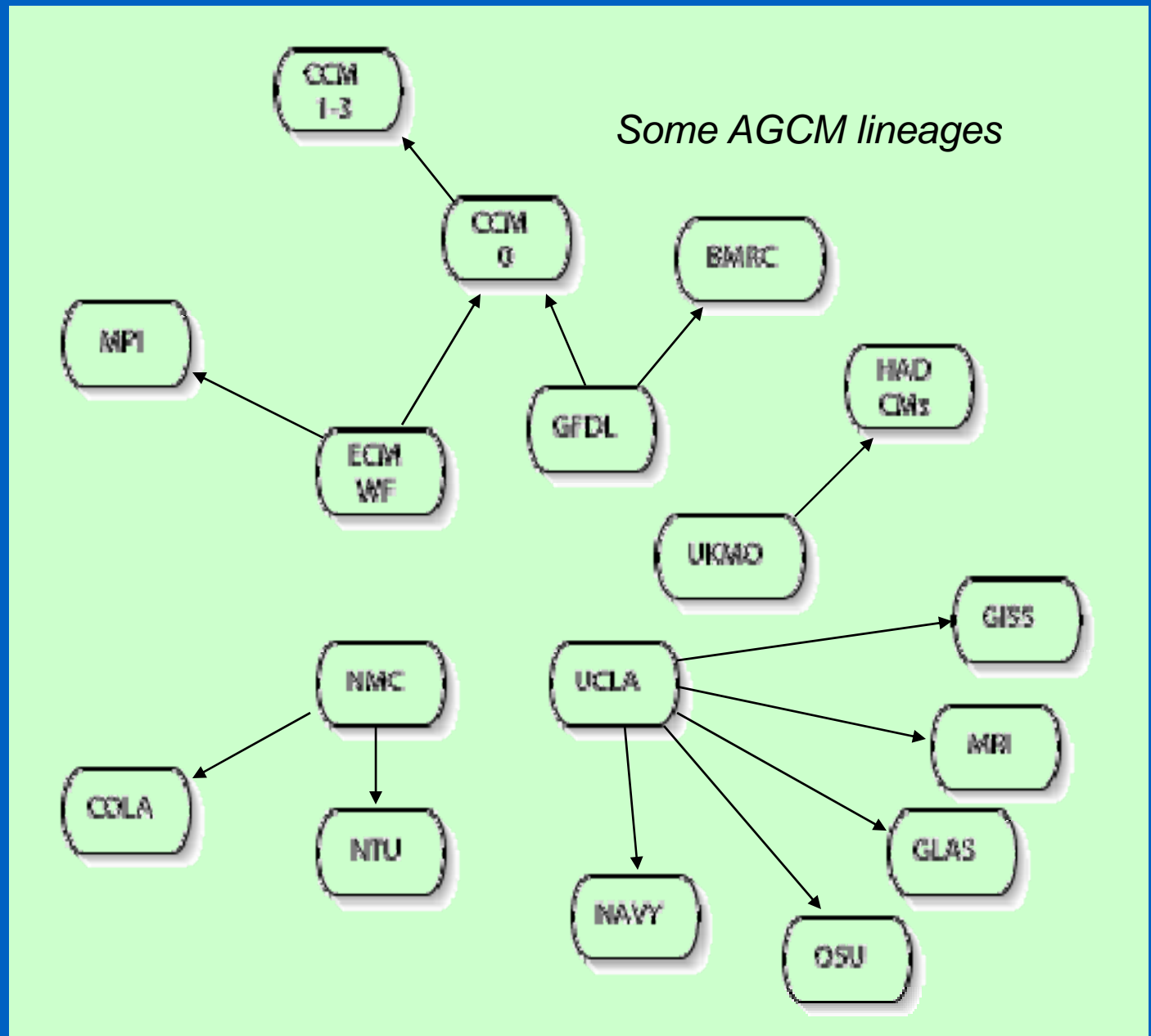
--> *Can we make all the tradeoffs
necessary to accommodate even a wetter
(warmer) climate?*



How certain
are we of
such
projections?

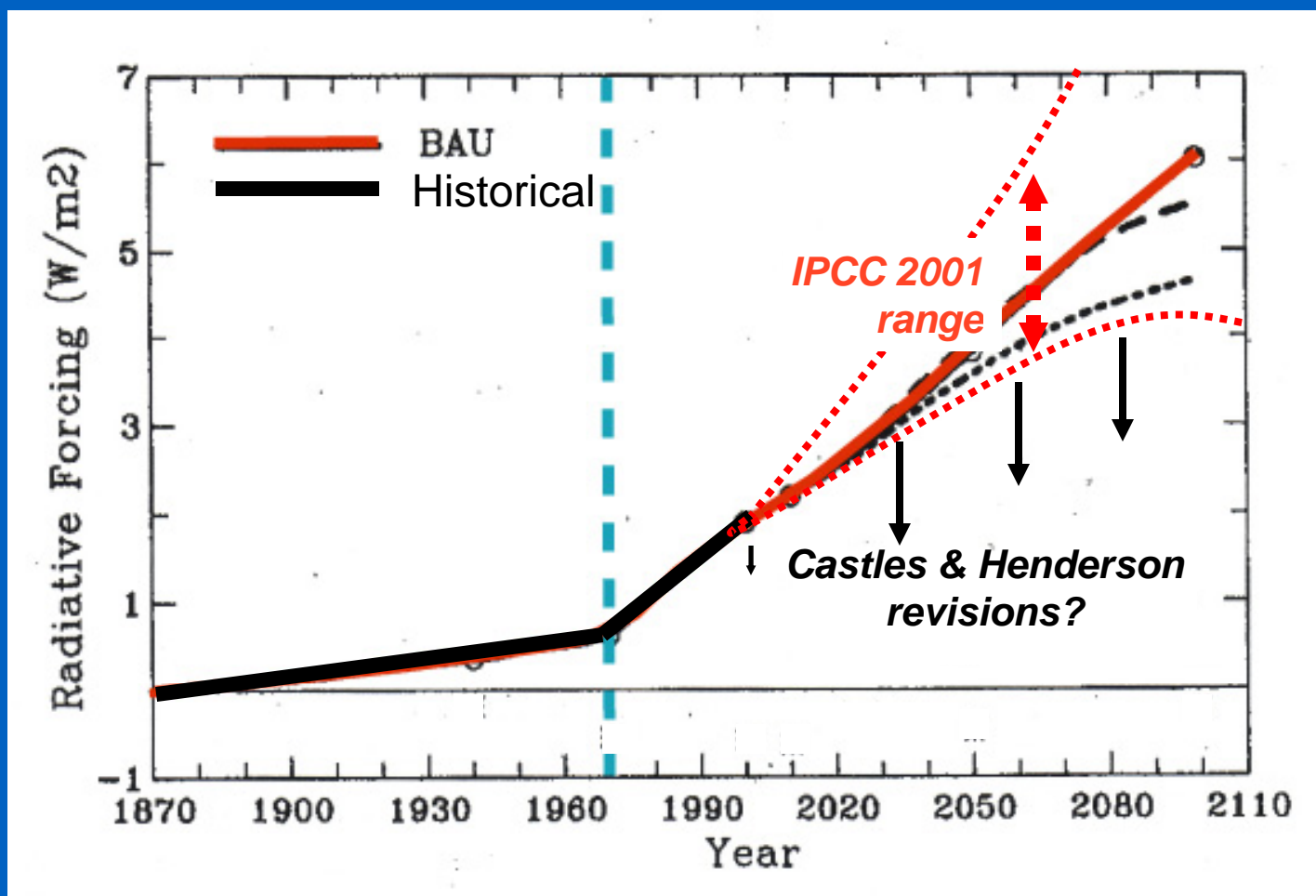
Really
uncertain, on
the whole,
because...

Climate
models are
not really
independent
“samples” of
the future,...

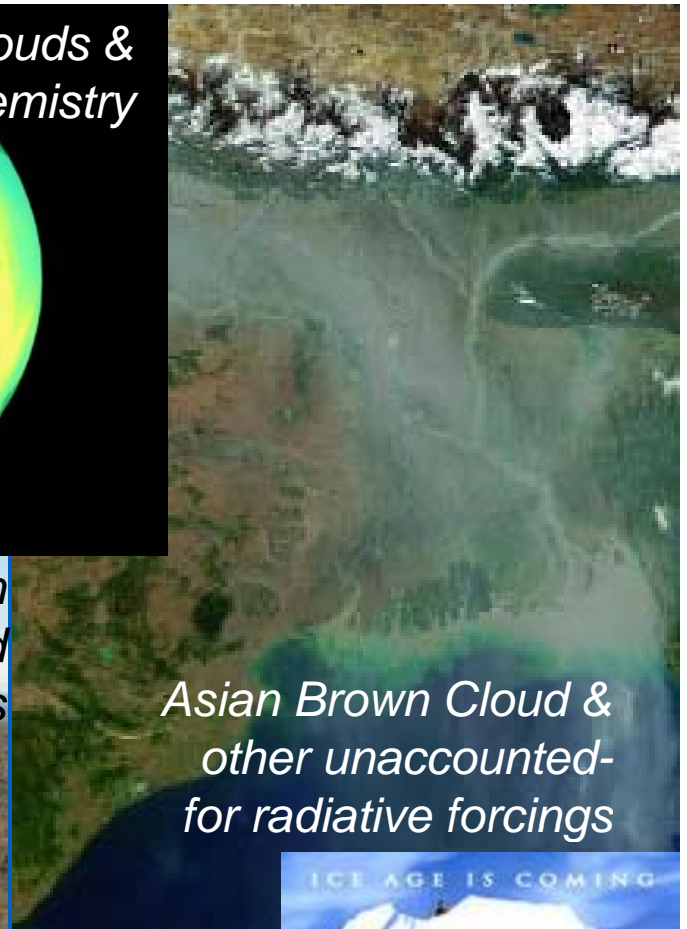
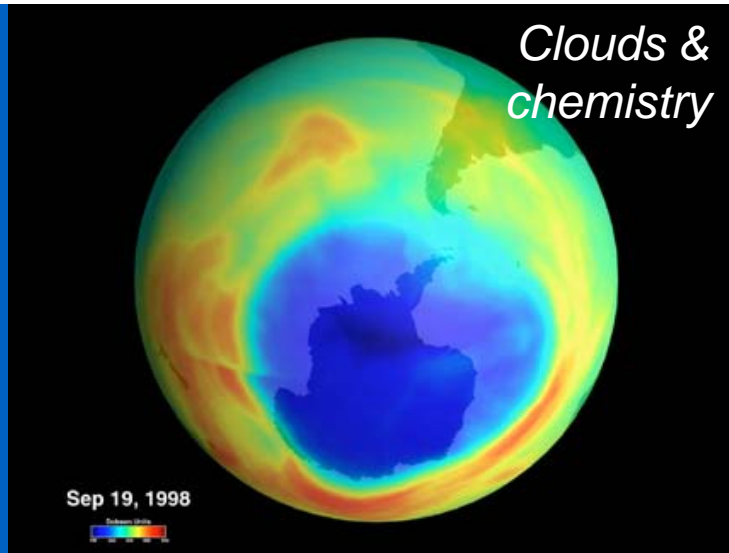


modified from Edwards, 2000

...emissions scenarios may not be as accurate as the selections now used imply, ...



... and current climate models don't include all the important natural processes and human impacts that will be at work. For example...



Thus...

- Large uncertainties exist in climate-change projections (as well as in the “natural” future) of water supply, but...
 - The potential for impacts on water availability are large enough to ...
- * Suggest that climate change poses threats that are worth addressing even now.

Metropolitan Water District's response to uncertain future demands may provide an informative analog...

- Large uncertainties (+ or - 50%) exist in demand projections by 2050, so MWD...
 - Develops specific strategies to cover middle-of-the-road projection over the next 50 yrs.
- > If demand growth is slower than expected, buildout can be adjusted to take longer than 50 yrs.
- > If demand is faster, buildout can be completed sooner and additional plans will be developed again prior to 50 yrs.

So, will there be enough water?

Enough-to-get-thru-another-20th-Century
will not be enough for the 21st Century.

But, rather than just obtaining more supplies,
climate-change uncertainties mean that
Flexibility/robustness need to be focus for now.

Good news: Water managers in many settings are already revising plans & operations to accommodate:

- changing conditions on the Colorado
- endangered fisheries and ecosystems
- fast approaching limits of supply (vs demand).

**We need to provide the tools
to include climate resilience in the current revisions.**