



From climate-change spaghetti to climate-change distributions

*What are the models
trying to tell us?*

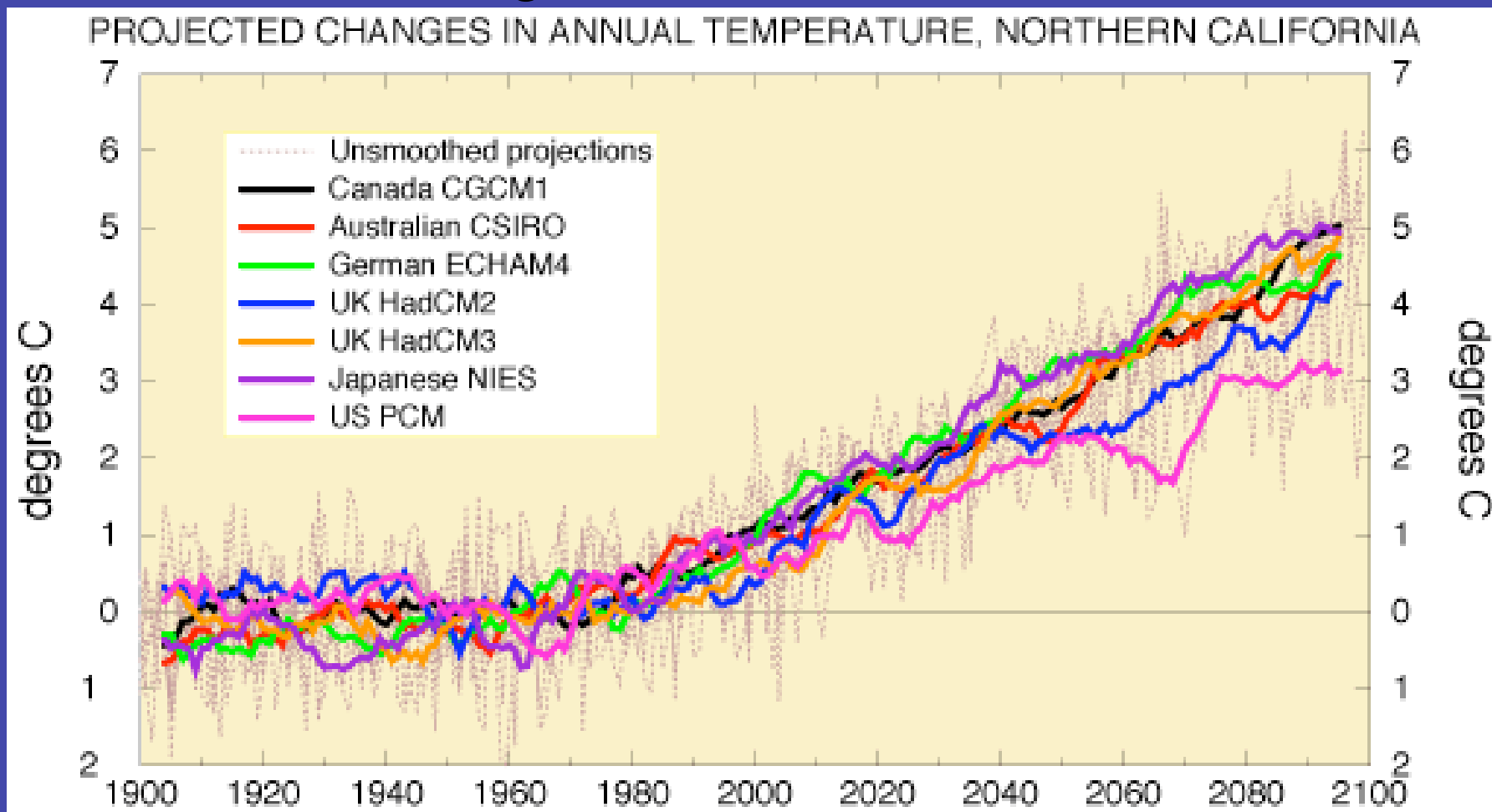
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*Sponsored by
USGS & the
PIER-funded
Climate-Change
Research Center
at Scripps
Institution of
Oceanography*



Satoshi Sekiguchi / AP

Under a business-as-usual emission scenario, climate models yield a fairly narrow range of warming scenarios for California...



Still, the lessons we take from projections and reconstructions continue to be **very uncertain...**

21st Century Western US Climate - Conclusions

Greenhouse Effect

Rising Temperatures

Rising Sea Level

Less Snow & Snowpack
Early Runoff

More Flooding

Drier Summers

More or Less Precip?

Paleoclimates

Continued Drought and Flood

20th Century Warming
Unprecedented

Natural MegaFloods

MegaDroughts Possible

20th Century Unusually
Benign (wet)

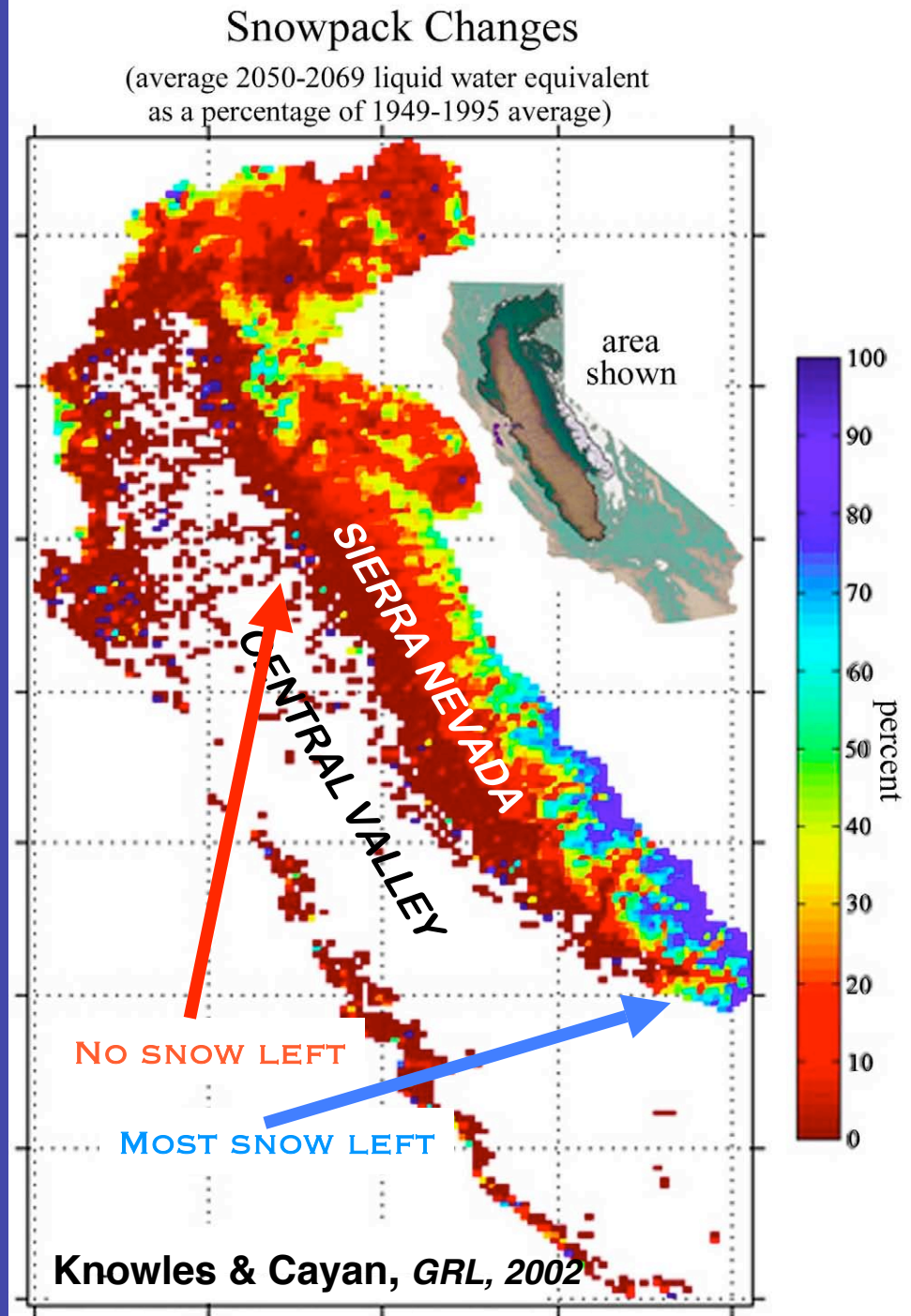
Gradual /Abrupt Change?

More
Certainty



Uncertainty
and Beyond

However, by the middle of the 21st Century, *even in the coolest of the models, earlier snowmelts & major reductions in snowpacks and water resources* of the Sierra Nevada are projected...



So we are being whipsawed by projections of
disruptive near-future climates
that are **highly uncertain**.

At the same time, California is currently in
engaged in making some major and long-term
decisions balancing resource management &
ecosystems restoration (e.g., CALFED & SWP Updates).

Climate-change issues are part of the
discussion...

**But what climate changes should we be
preparing for?**

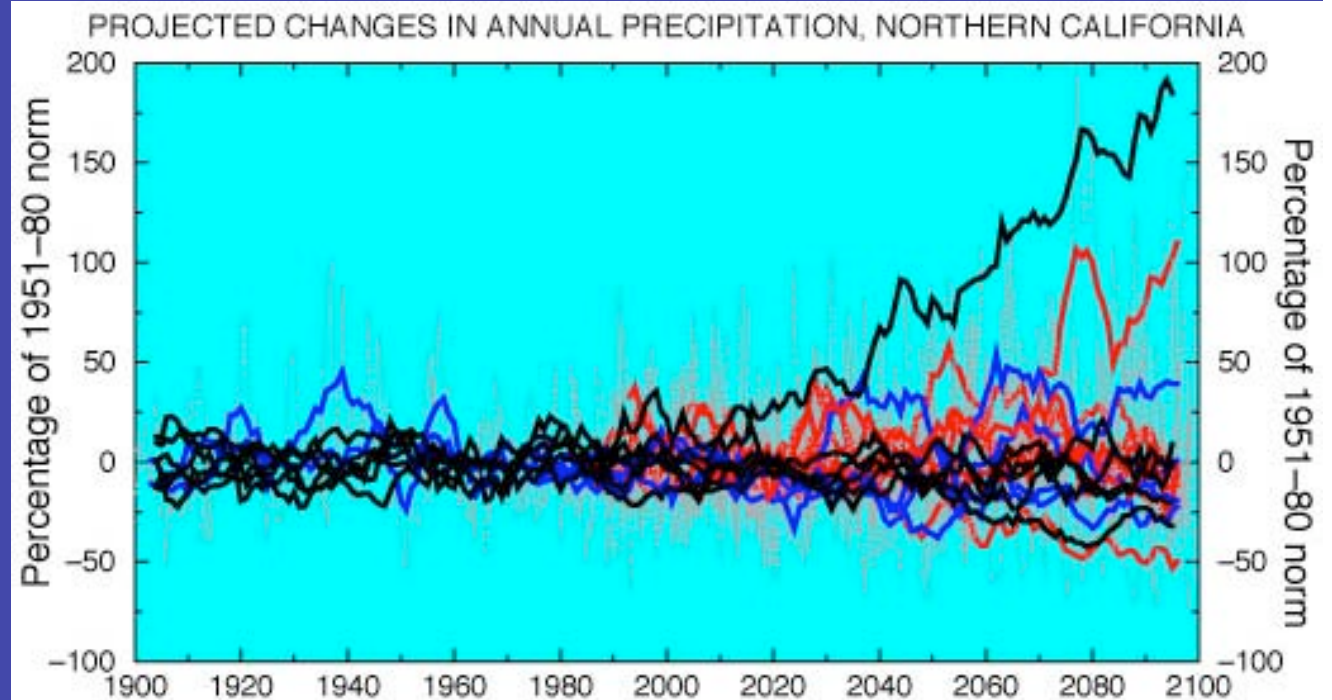
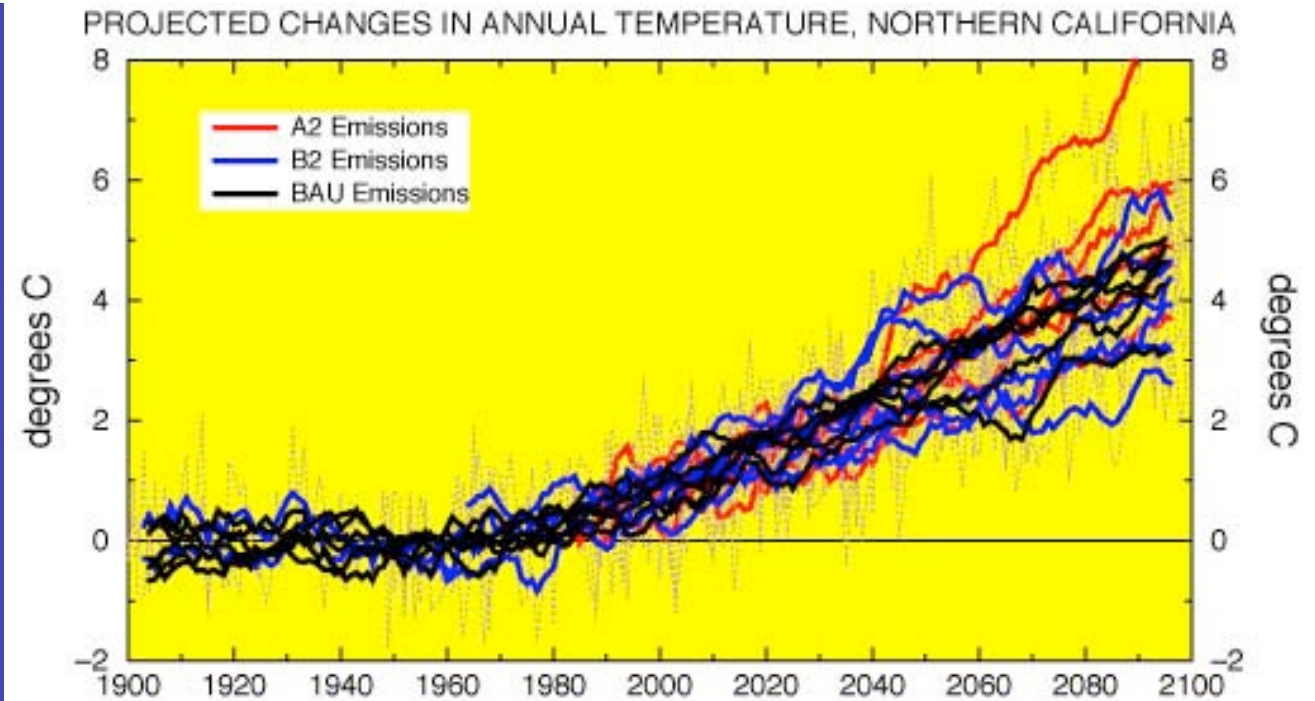
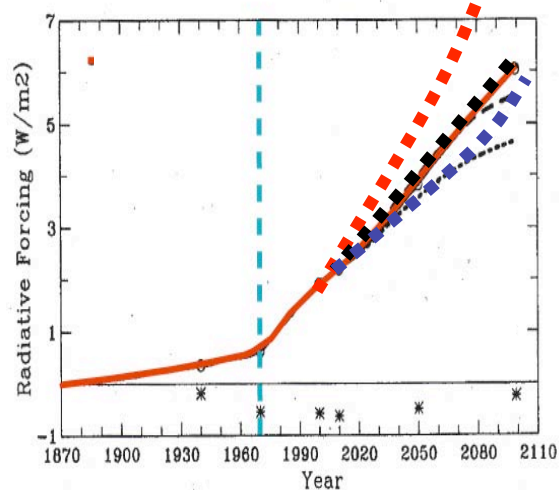
What climate changes should we prepare for?

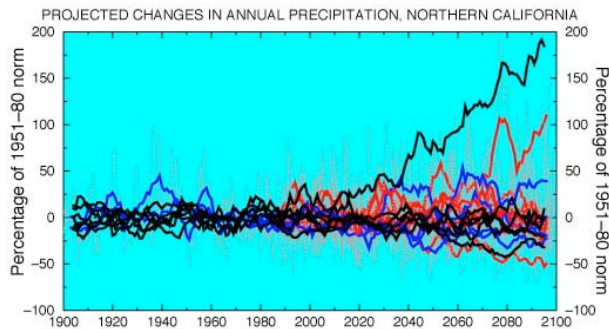
- ✓Recent PIER-funded (& other) studies bookend possibilities by choosing HadCM (or CCC) warmest/wettest projections and PCM (or other) cooler/"drier" projections
- ✓Recent DOE-funded studies "chose" a model with least climate changes

These approaches have led to public misconceptions re: what c-c projections (in general) are suggesting:
a relatively modest warming & wetter future for California?

A BROADER PERSPECTIVE GIVES A DIFFERENT VIEW:

For California, the influence of uncertainties about emission scenarios and scatter among models aren't so different (among currently available projections).

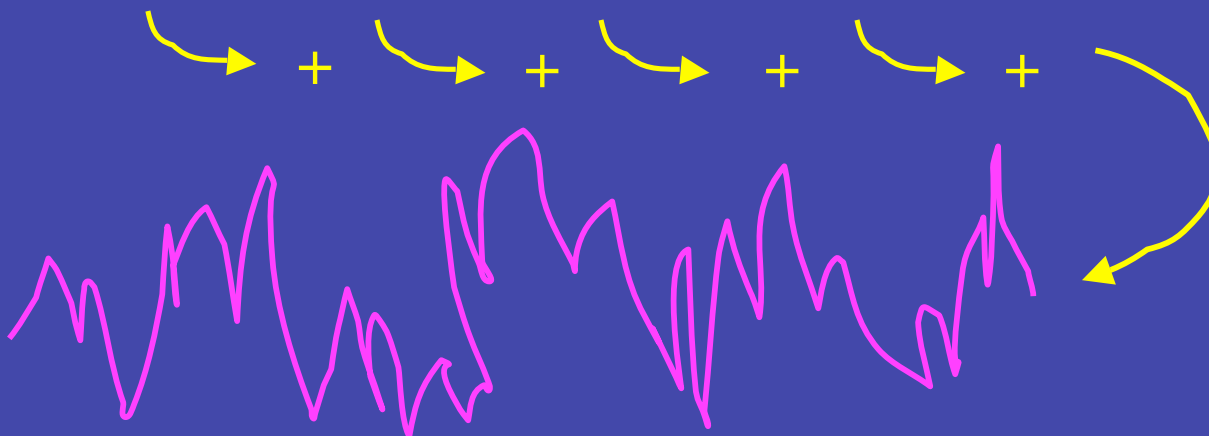
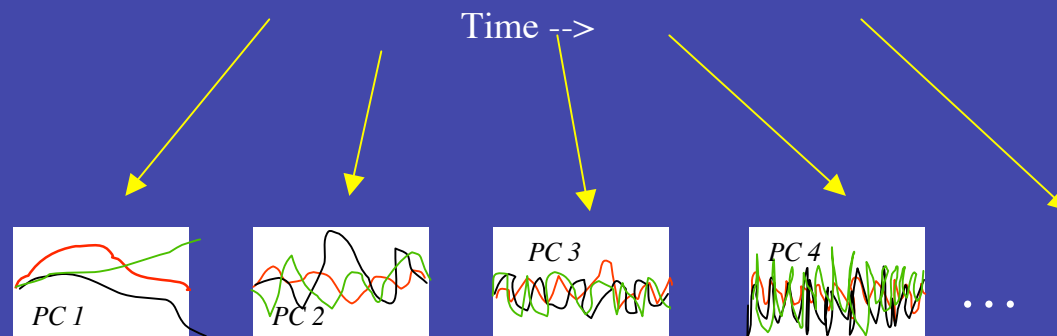
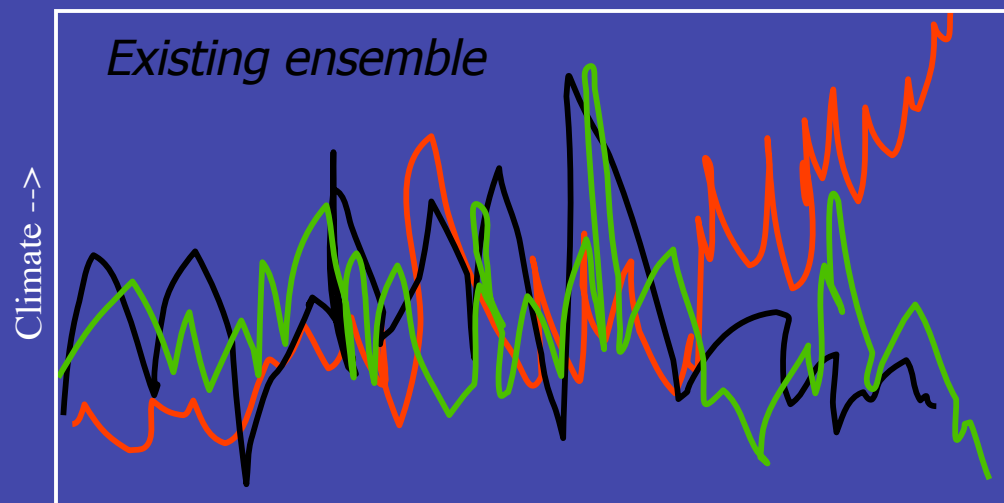




Lets look at this ensemble of projections in more detail:

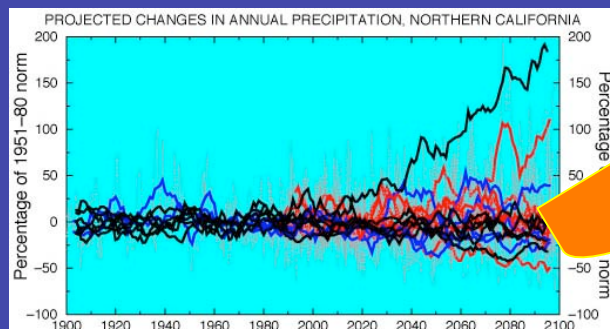
Let me separate the ensemble projections into independent components (by PCA) and then randomly shuffle those components to effectively increases the number of realizations.

This allows us to form a simple estimate of the projection distribution function (pdf).

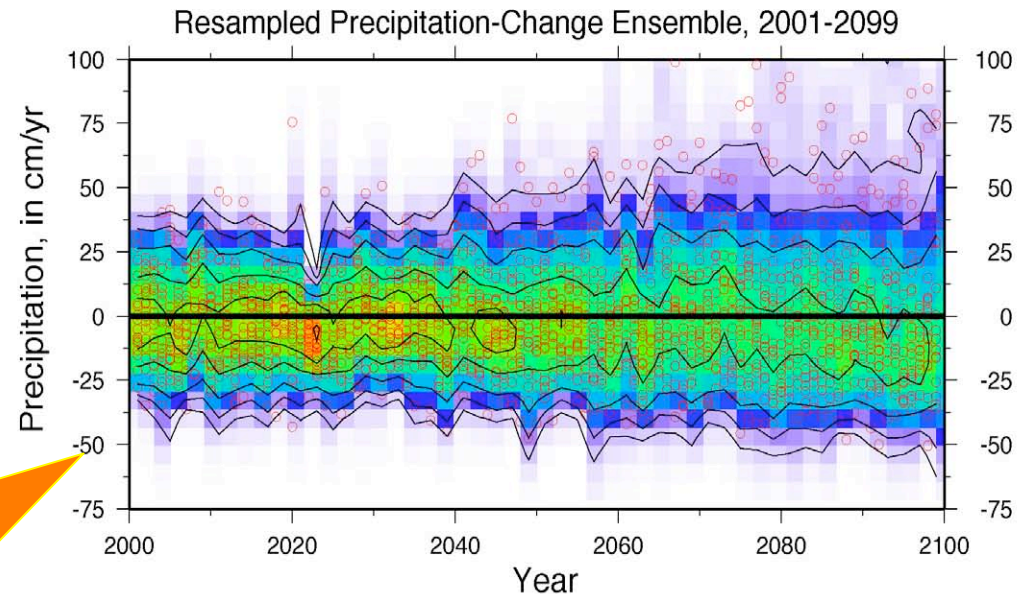
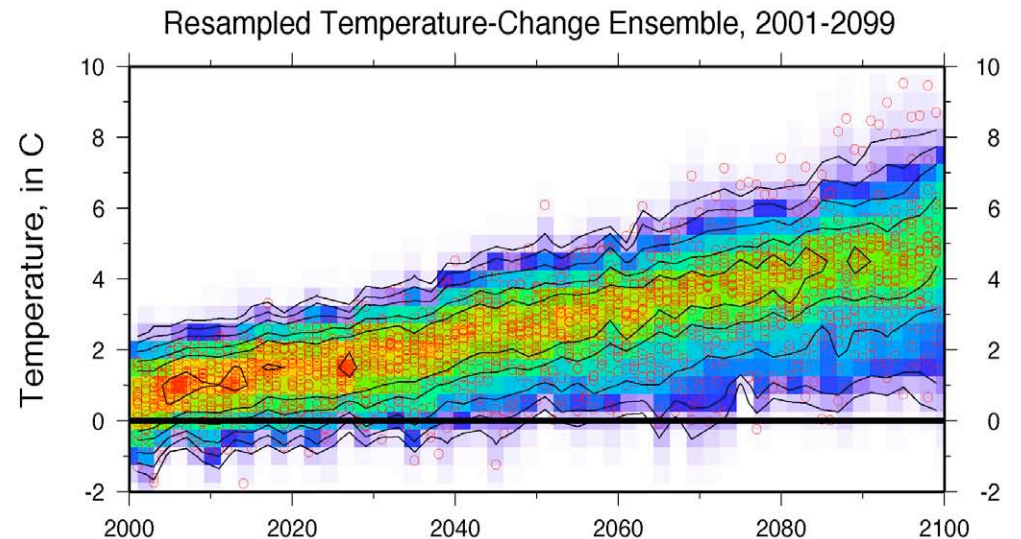


HOW DOES THE ENSEMBLE EVOLVE?

The PCA-resampling procedure yields an estimate of time-varying joint projection distributions (pdfs) of temperature and precipitation change during the 21st Century, allowing us to better visualize what the projections are doing.



IPCC/SRES Projections: JOINT Probabilities PRECIPITATION & TEMPERATURE CHANGES, NORTHERN CALIFORNIA



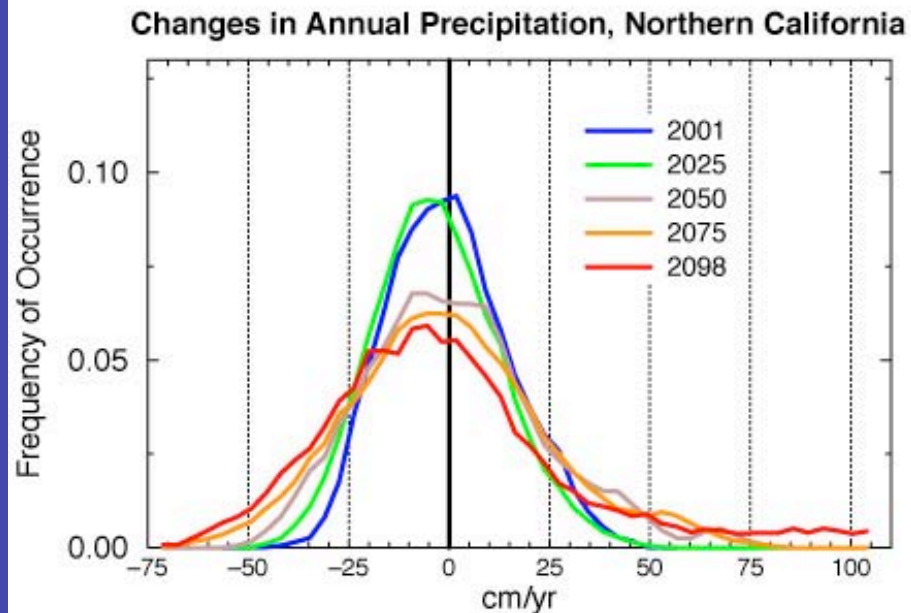
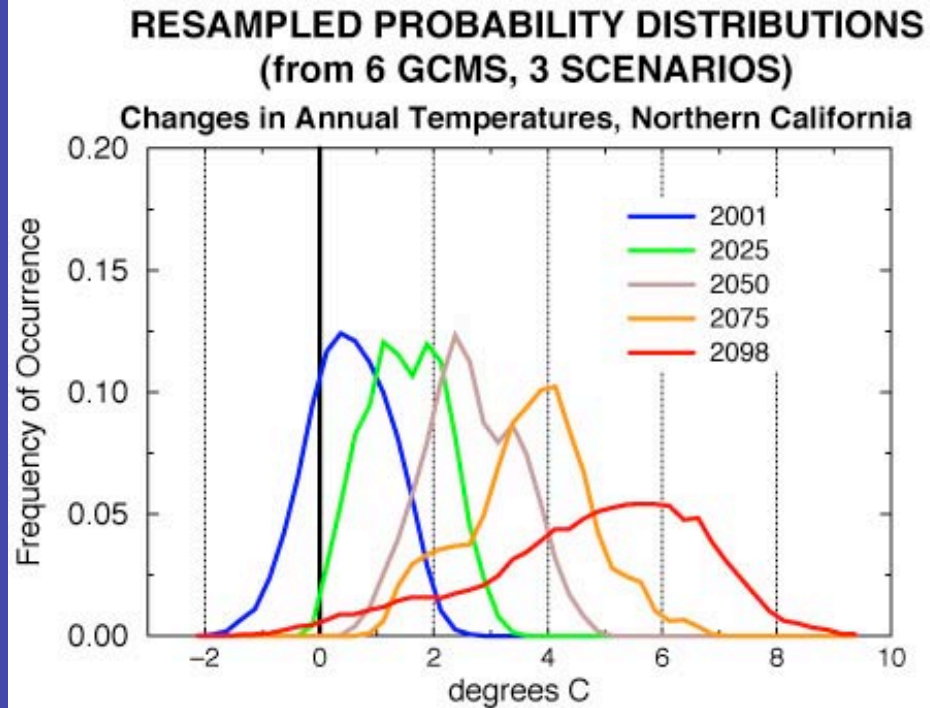
[Red dots, 18-member IPCC-ensemble projections;
contours and shading, 20,000-member resampled probabilities;
contours at 0.006, 0.0125, 0.025, 0.05, 0.075, 0.125, 0.175]

Time slices through
these component-
resampled pdfs
emphasize:

❖ Important temperature (& snowmelt) changes within about 20 years

❖ Strong tendency toward little precipitation change, with a hint of slightly drier

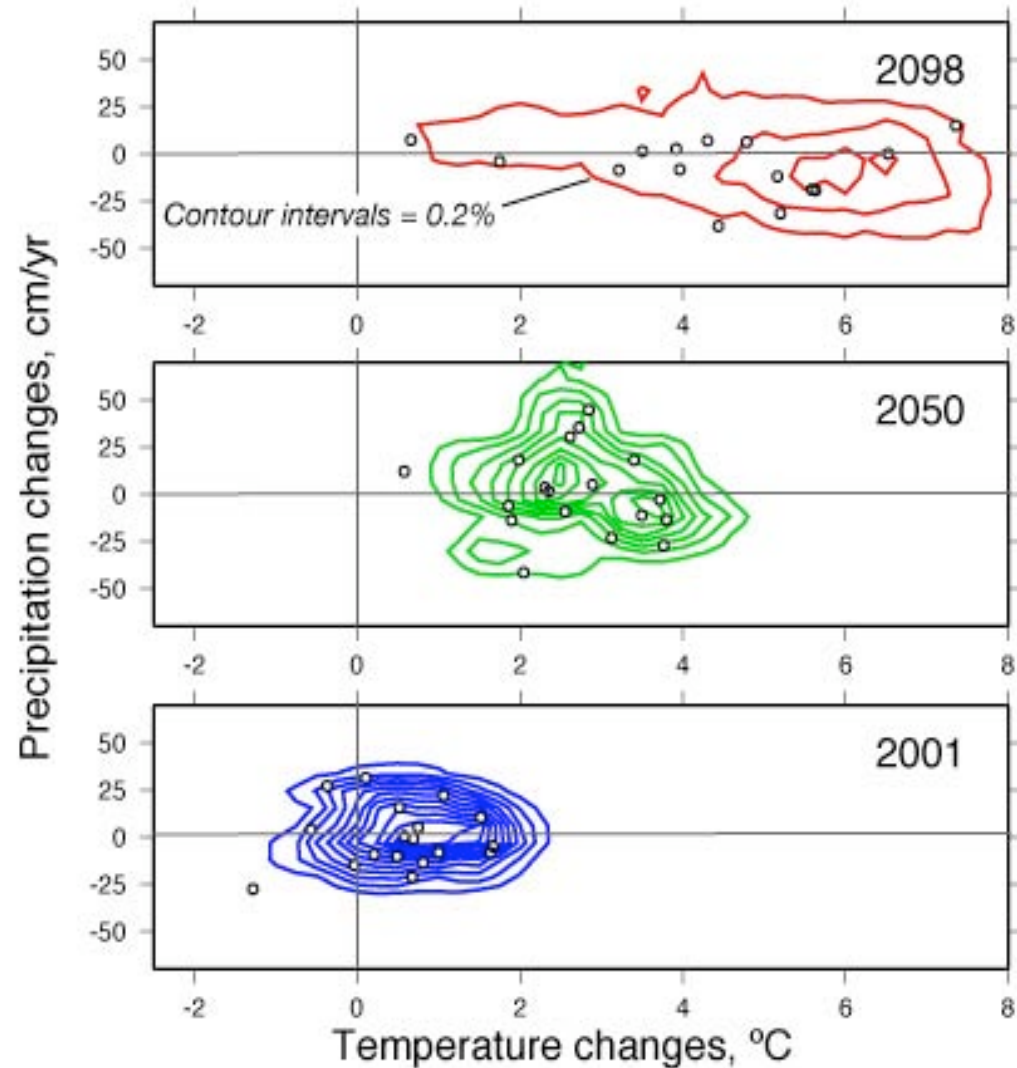
❖ General spreading of possibilities (espec. temperatures) due to model and emissions uncertainties



WHAT JOINT BEHAVIORS OF TEMPERATURE & PRECIPITATION ARE INDICATED?

There is an interesting tendency for the warmer projections to be drier and for the cooler projections to be wetter...but we can't explain it, so we can't rely on it to be a general rule.

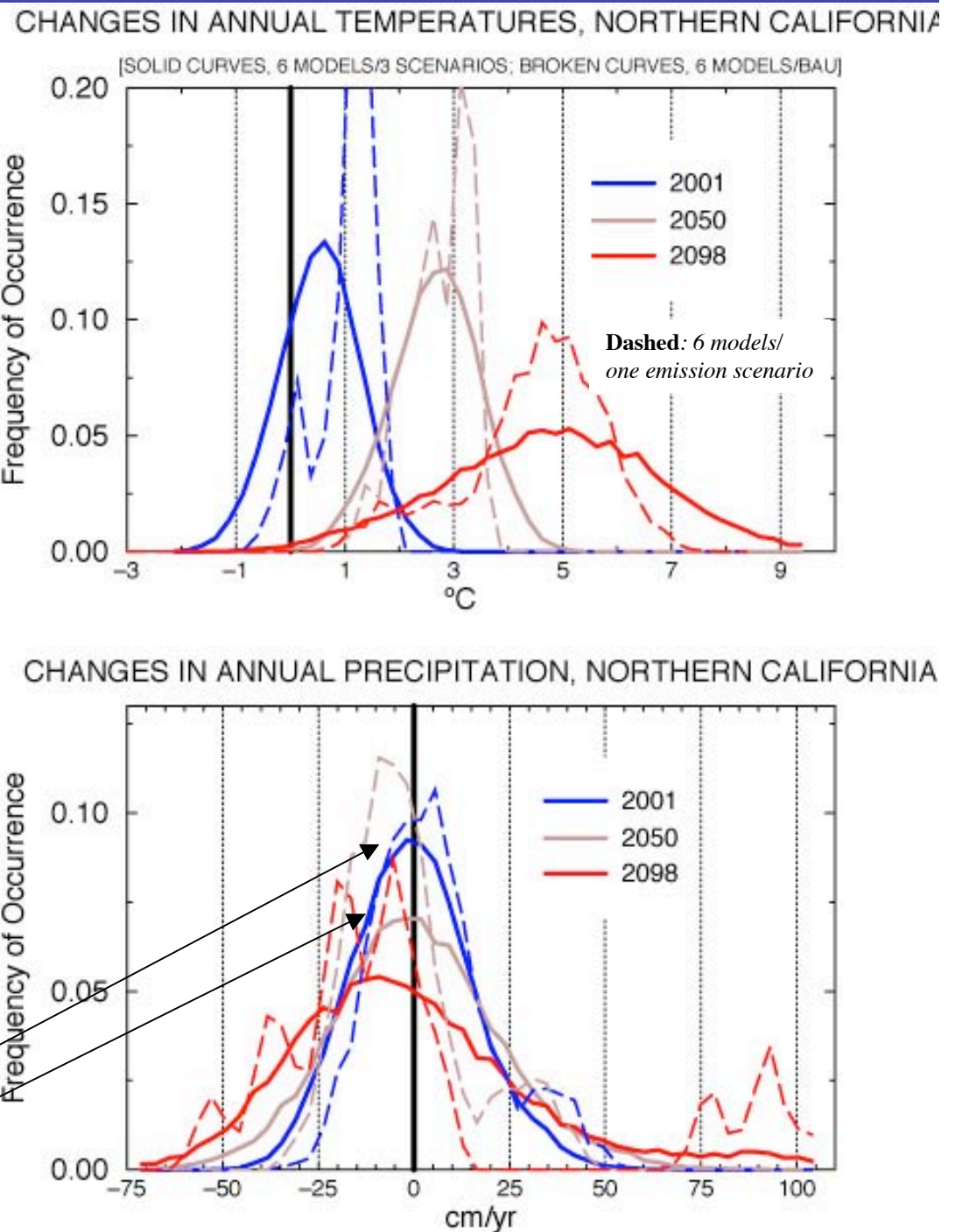
JOINT PDFS OF NORTHERN CALIFORNIA CLIMATE CHANGE



WHERE DO THESE UNCERTAINTIES COME FROM?

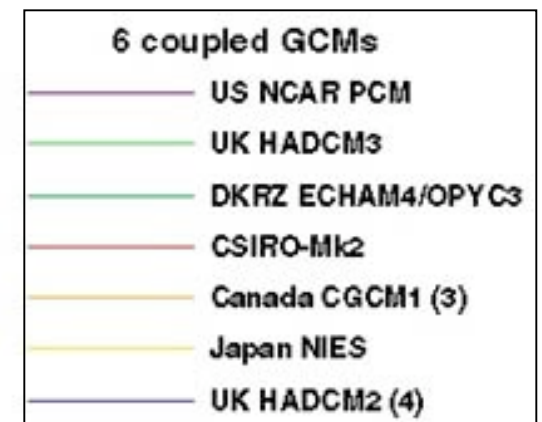
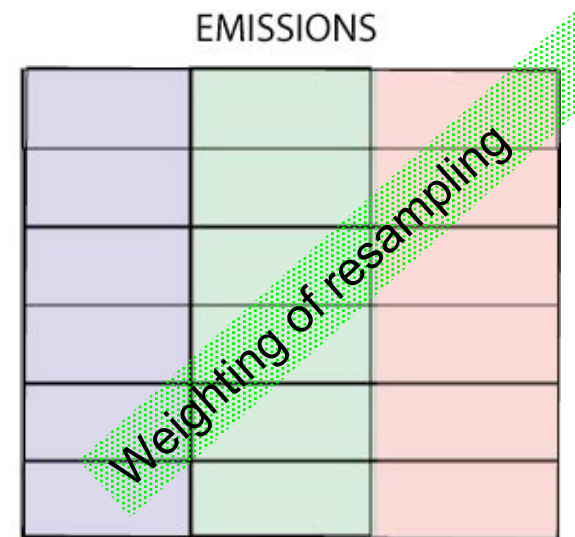
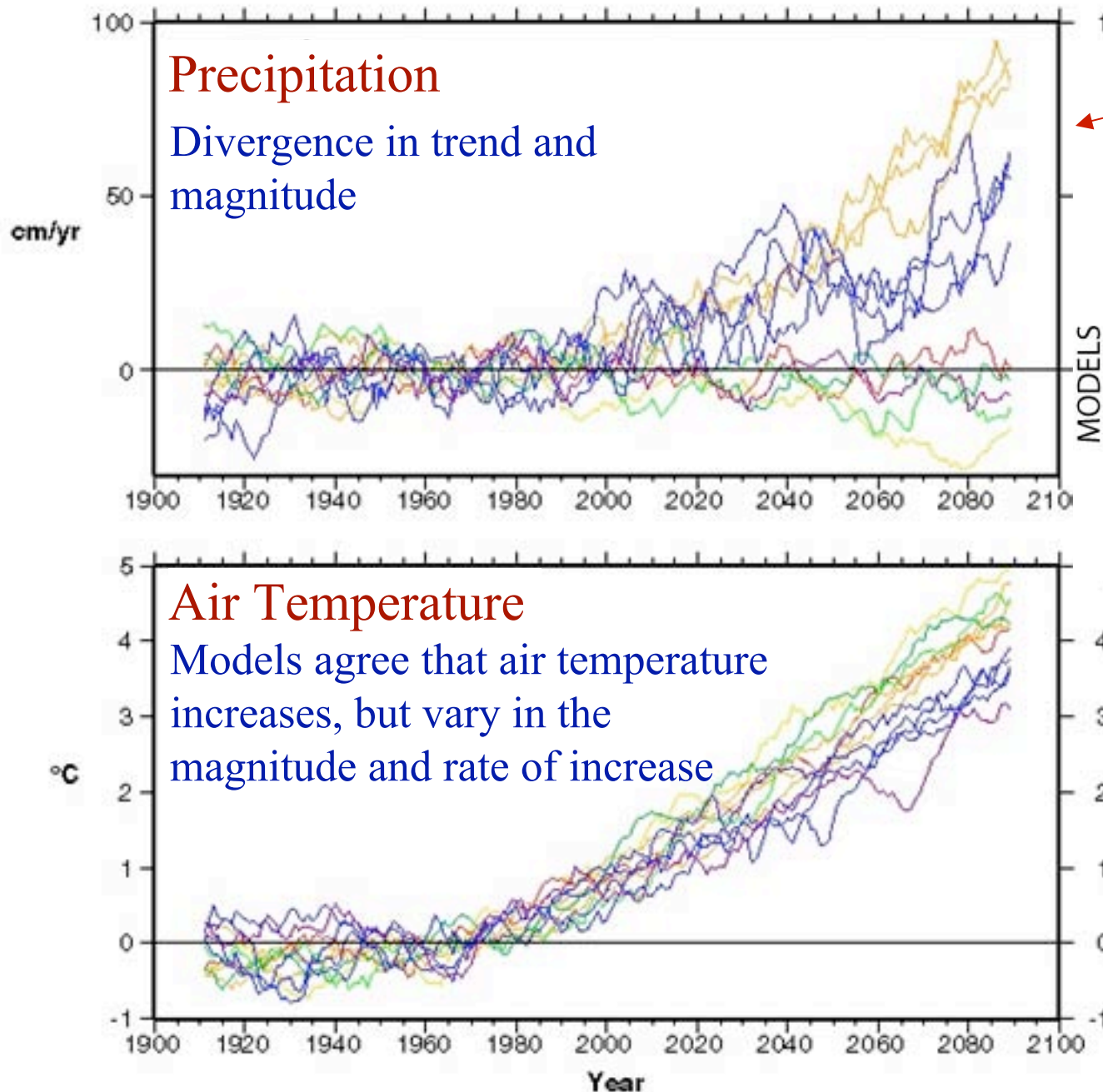
Forming a smaller ensemble from 6 models forced by just one set of emissions shows **model differences contribute about 1/2 of the overall scatter**. The other half mostly comes from differences between the emission scenarios.

Dashed: Responses to one emission
Solid: Full ensemble



Climate Change Predictions for Northern California Differ

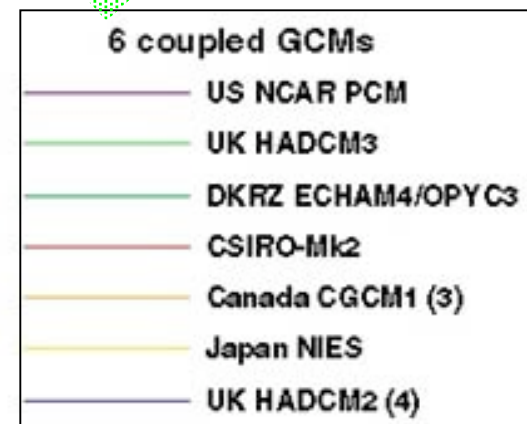
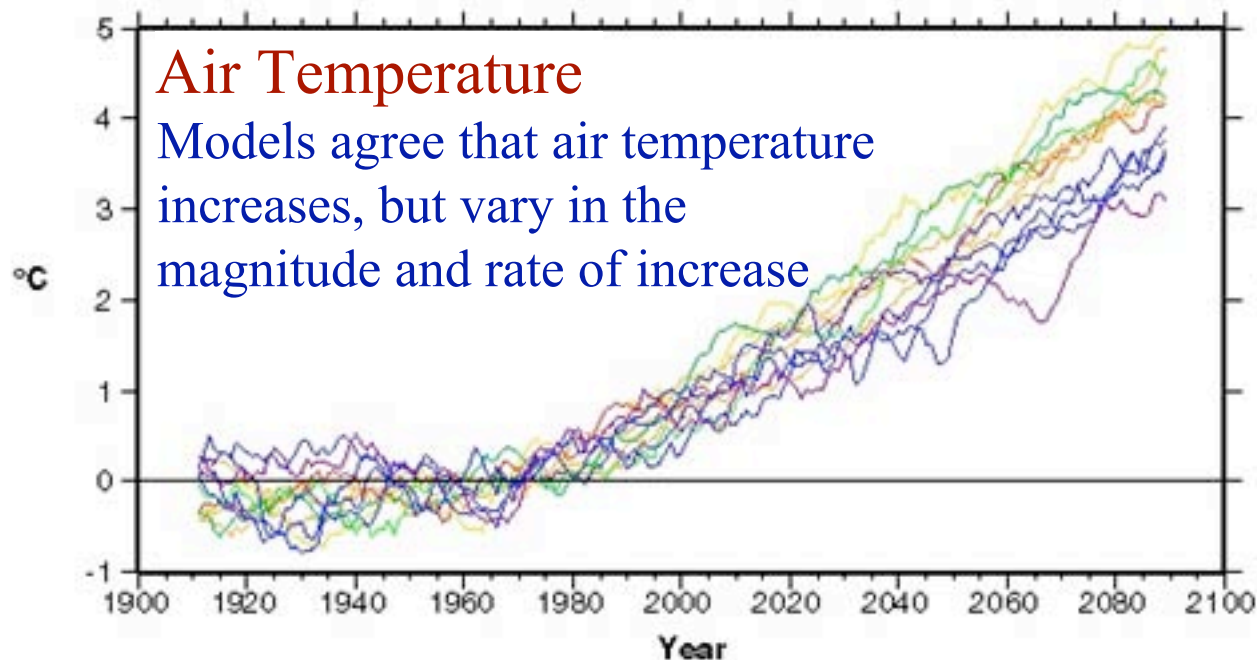
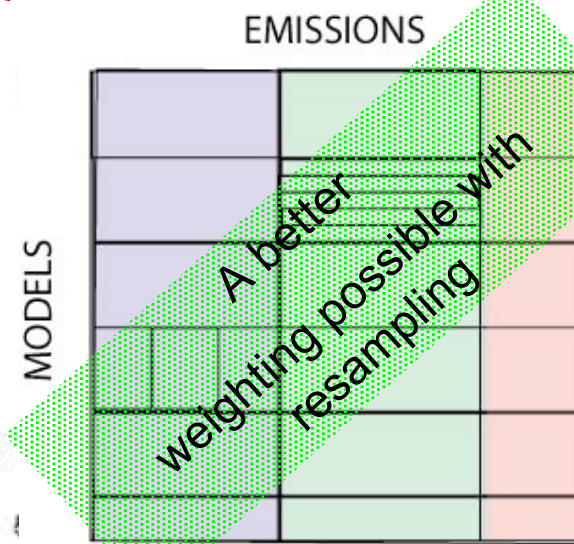
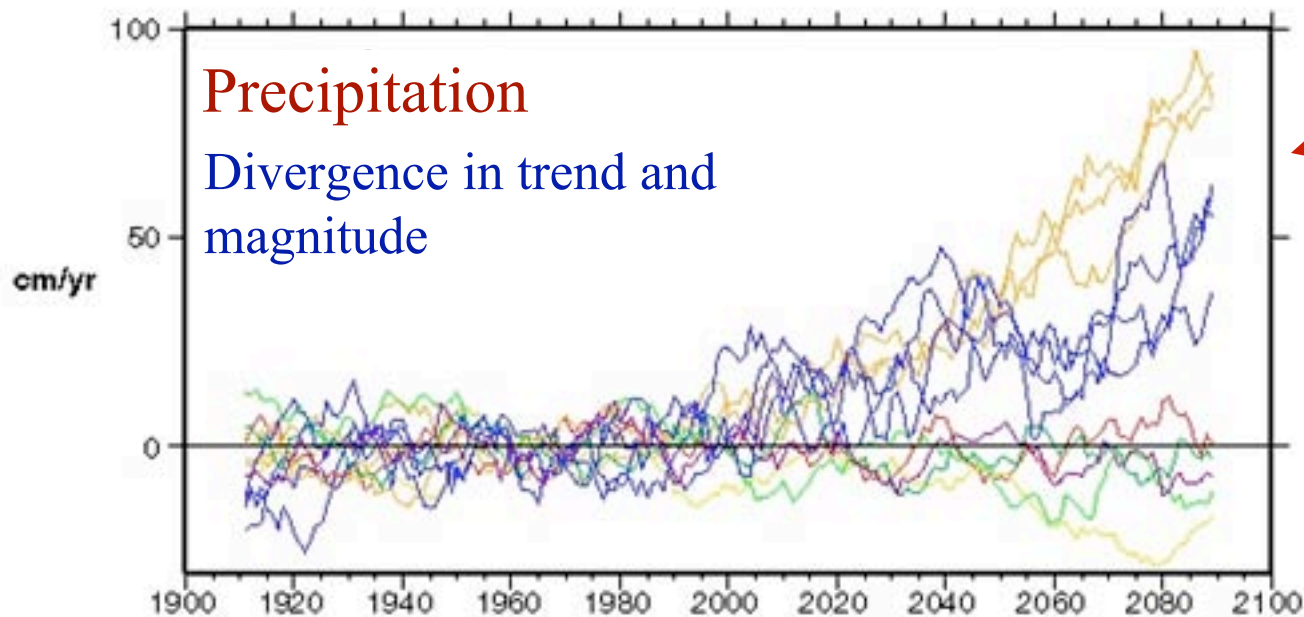
*Stolen from
F. Chung's
talk*



(Source: D. Cayan, April 2003, ISAO Workshop)

Climate Change Predictions for Northern California Differ

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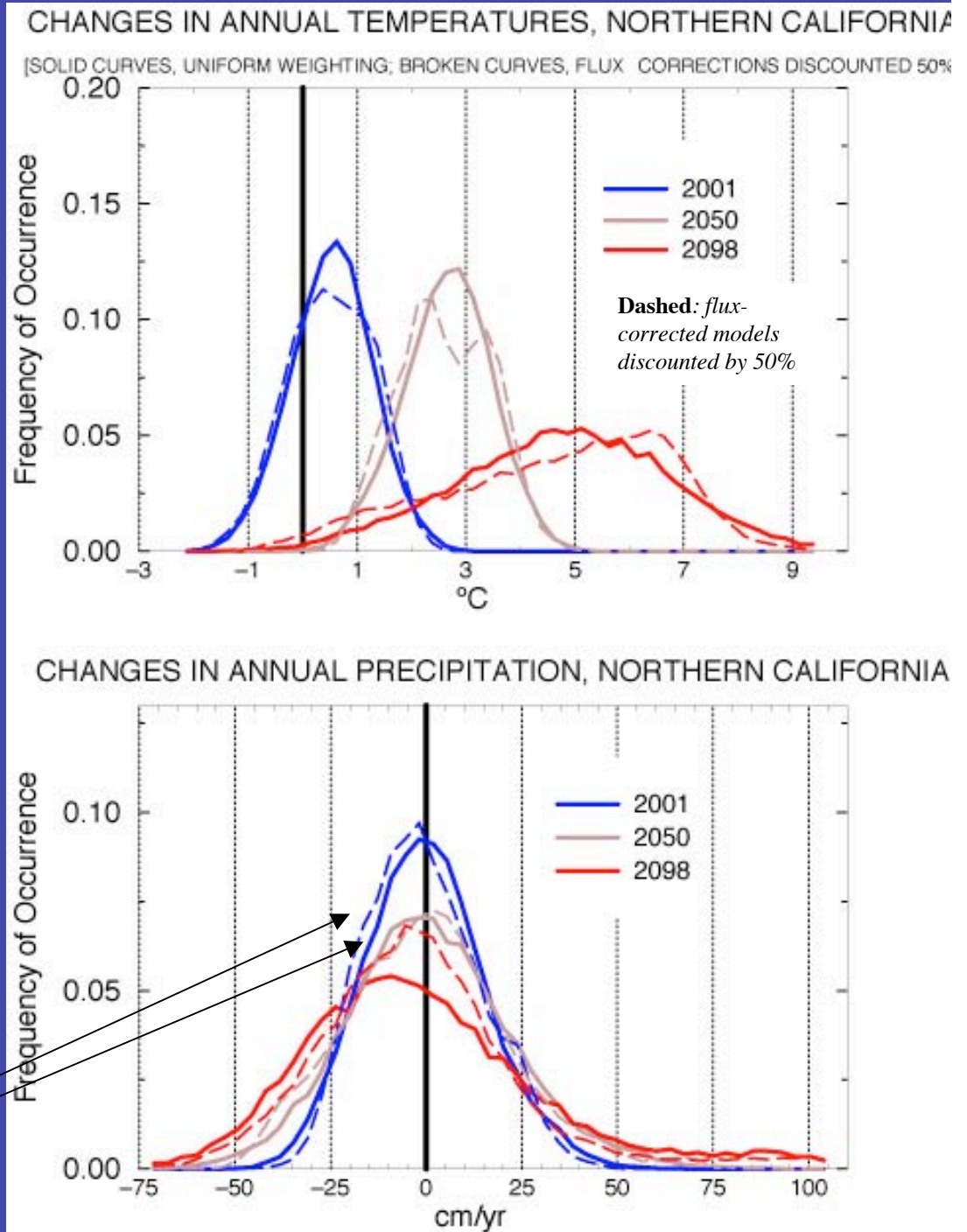


(Source: D. Cayan, April 2003, ISAO Workshop)

WHAT IF SOME MODELS ARE BETTER THAN OTHERS?

Weighting the resampling by model climatological drift shows that **choice of models** may not be so crucial as long as a fairly complete ensemble is available.

Dashed: Model-types weighted differently
Solid: All models weighted equally

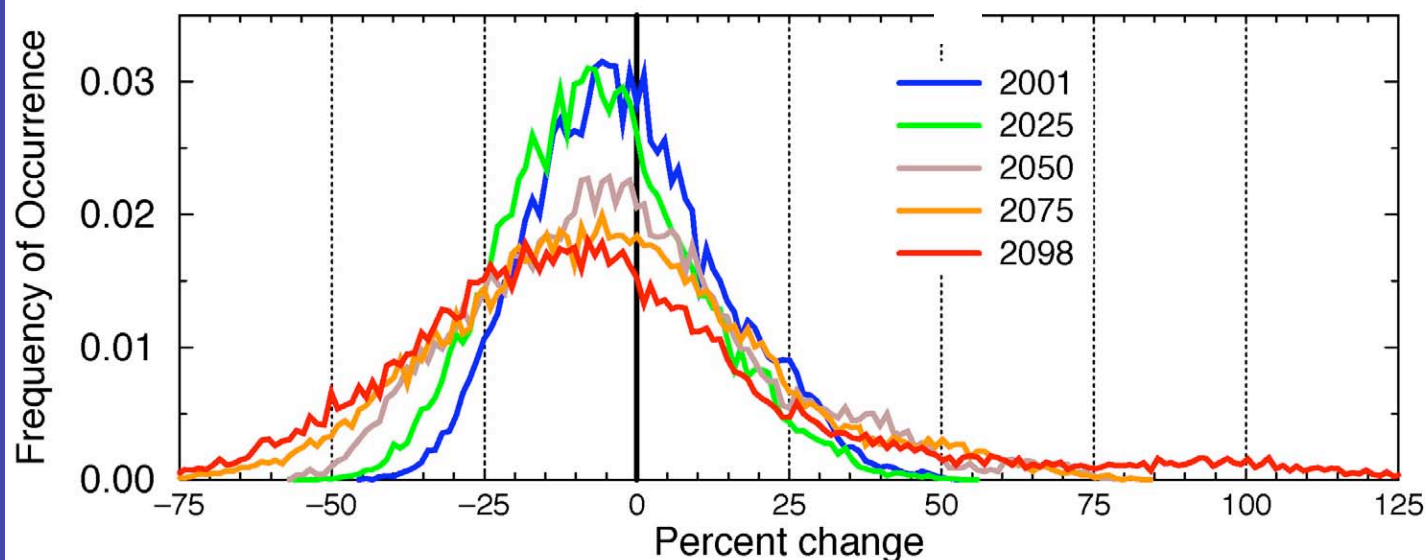


Ultimately,
such climate
changes and
uncertainties
imply
corresponding
changes in
California
streamflows...

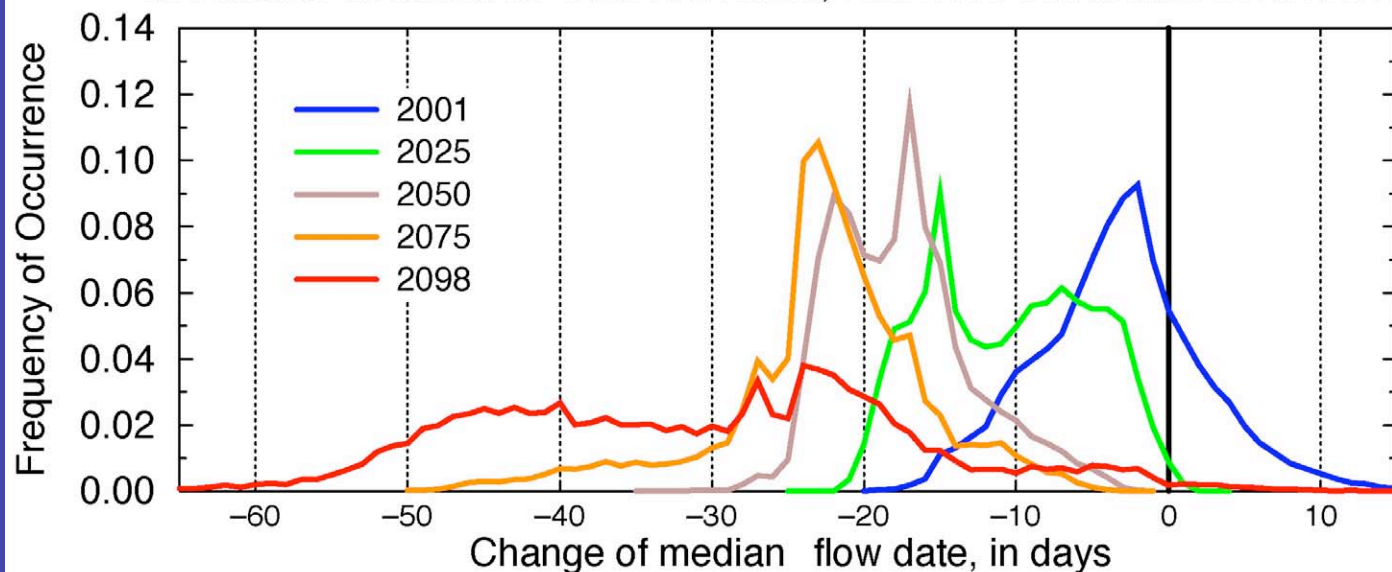
Should we be
starting to
address the
modes of these
distributions?



CHANGES IN ANNUAL STREAMFLOW, NORTH FORK AMERICAN RIVER



CHANGES IN MEDIAN FLOW DATES, NORTH FORK AMERICAN RIVER



WHAT IS THE ENSEMBLE TRYING TO SAY?

Northern California temperature projections are broadly in consensus (+3 to +6 or more °C), enough for 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



These results hold even if we weight some models less than the others (without eliminating any completely).

To paraphrase Myles Allen (Nature 2003):

“It is time for climate modelers to start identifying changes that can be ruled out as unlikely rather than simply ruled in as possible.”

Or even more boldly...

Is it time for California analysts to address what is more likely rather than what is just possible?

The End



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