

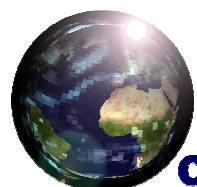
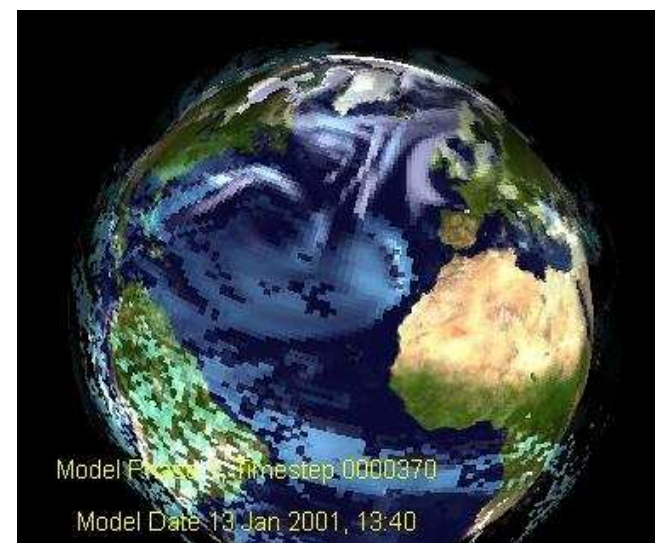
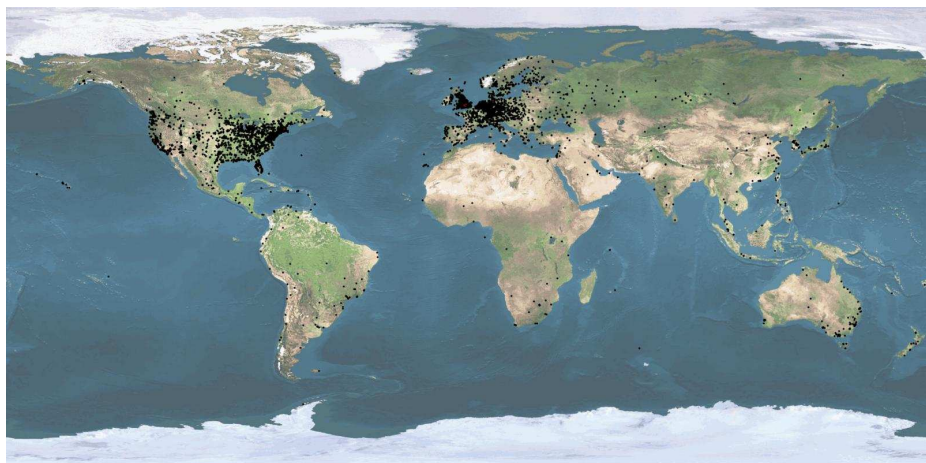
Categories of Uncertainty and Their Implications for Adaptation Planning

Dave Stainforth

SoGAER, Exeter University;



**Climate Change Impacts and
Adaptation:
Dangerous Rates of Change
September 2008**



climateprediction.net

Communication

- Assessment of uncertainty.
- The relationship between our models and reality.

Reducing or Quantifying Uncertainty?

In 2001 the IPCC Third Assessment Report identified nine high priority areas for action, one of which was:

“Improve methods to quantify uncertainties of climate projections and scenarios, including long-term ensemble simulations using complex models.”

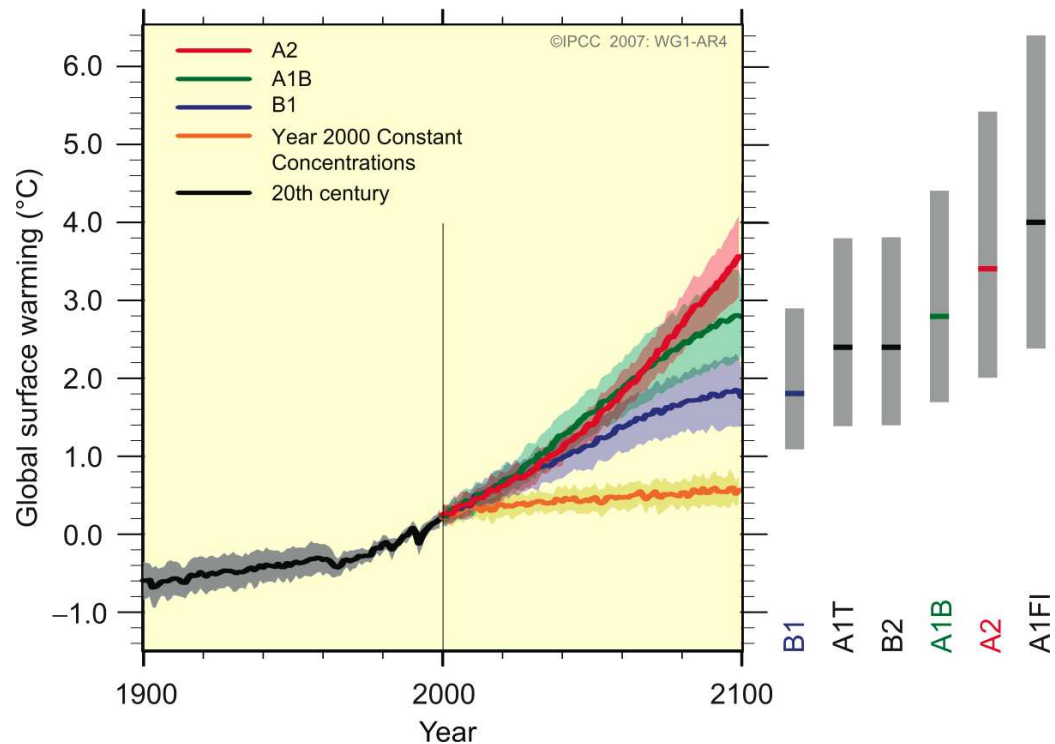
IPCC TAR SPM, 2001.

Sources of Uncertainty In Climate Forecasts

- Forcing Uncertainty.
- Initial Condition Uncertainty
 - Microscopic Initial Condition Uncertainty.
 - Macroscopic Initial Condition Uncertainty.
- Model imperfections
 - Model Inadequacy.
 - Model Uncertainty.

Sources of Uncertainty

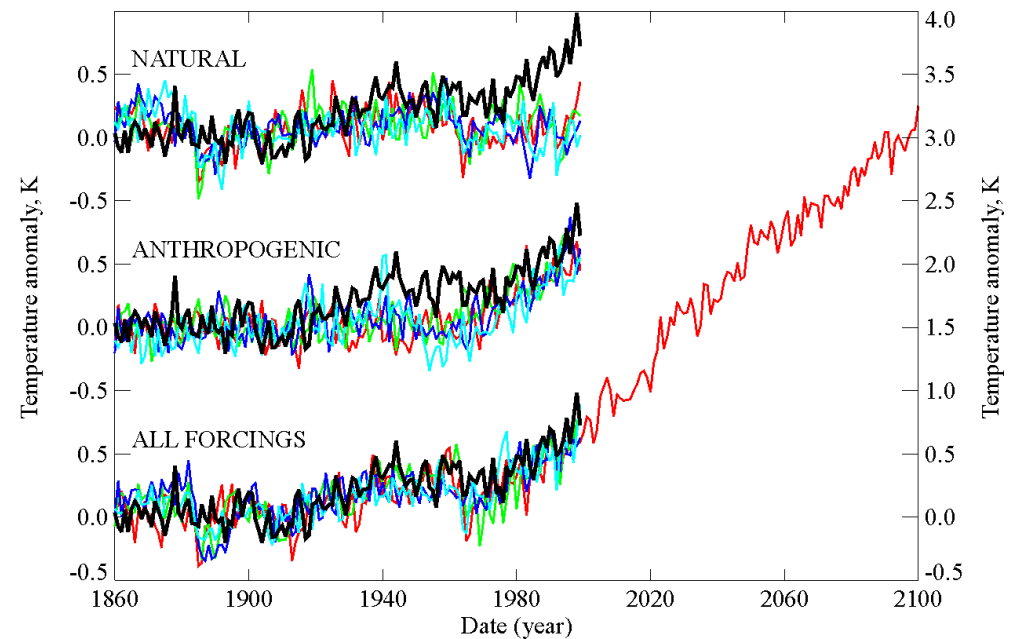
- **Forcing uncertainty:**
Changes due to factors external to the climate system e.g. greenhouse gas emissions (natural and anthropogenic), solar radiation etc.
How much will mankind emit?
Response: **Scenarios for possible futures.**



Source: IPCC, Fourth Assessment Report, Summary for Policy Makers

Sources of Uncertainty

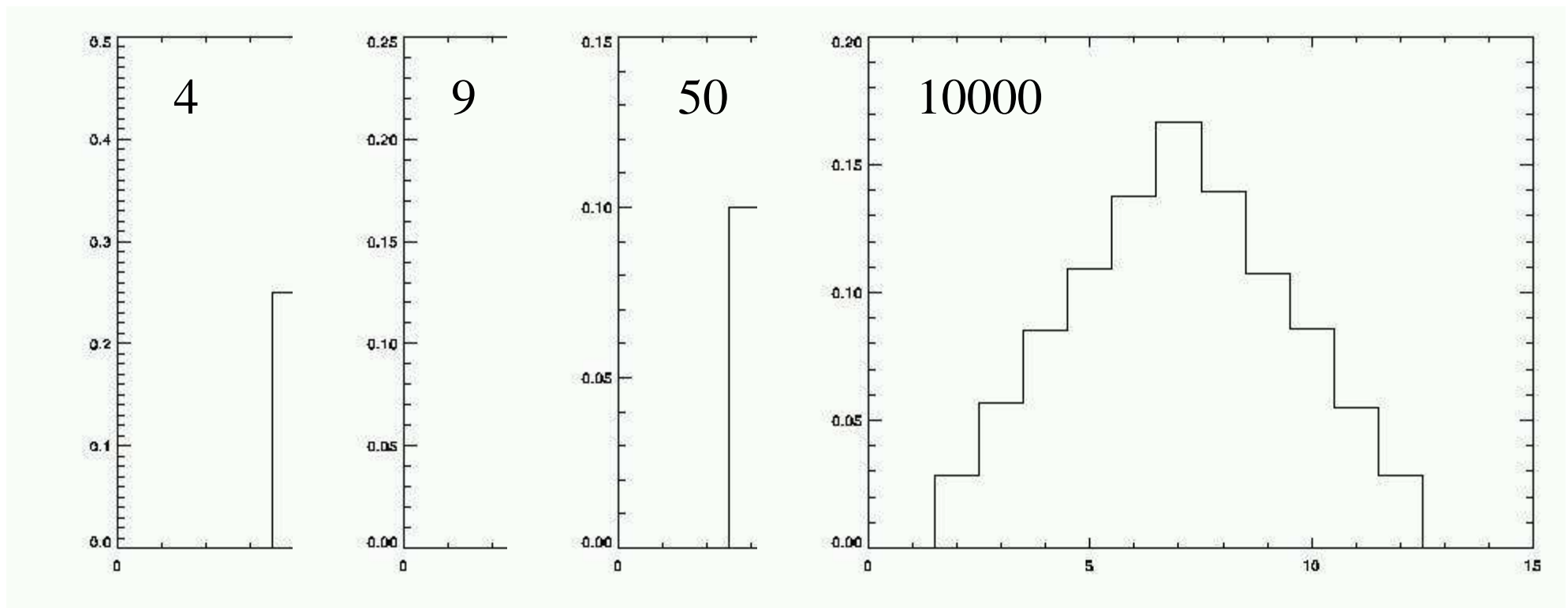
- **Initial Condition Uncertainty**
How is the prediction affected by our imprecise knowledge of the current state of the system at even the smallest scales?
Response: **Initial Condition Ensembles**



Source: IPCC, Third Assessment

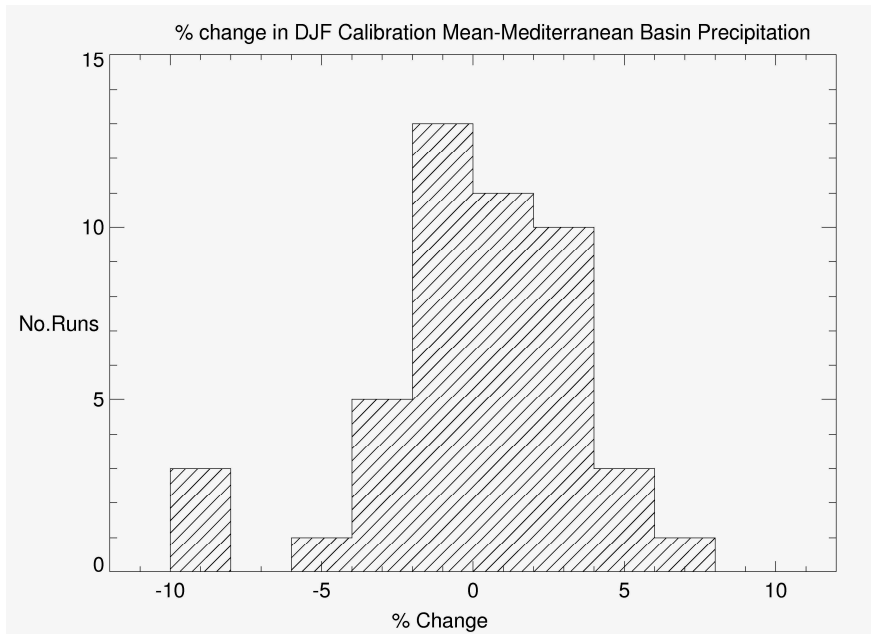
Sources of Uncertainty

- Initial Condition Uncertainty
Consider throwing 2 dice.

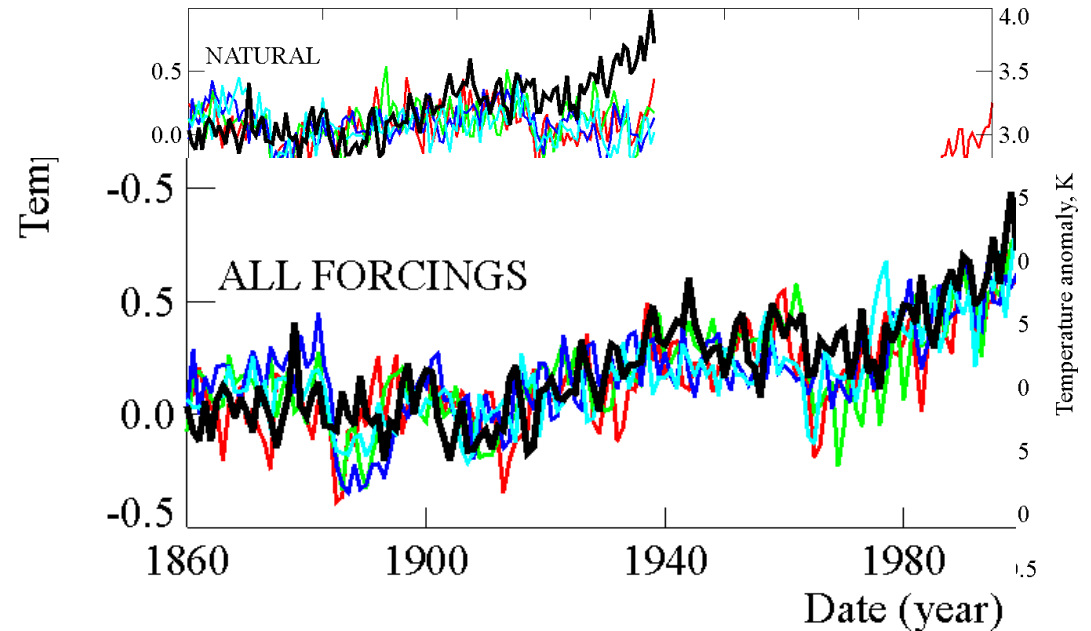


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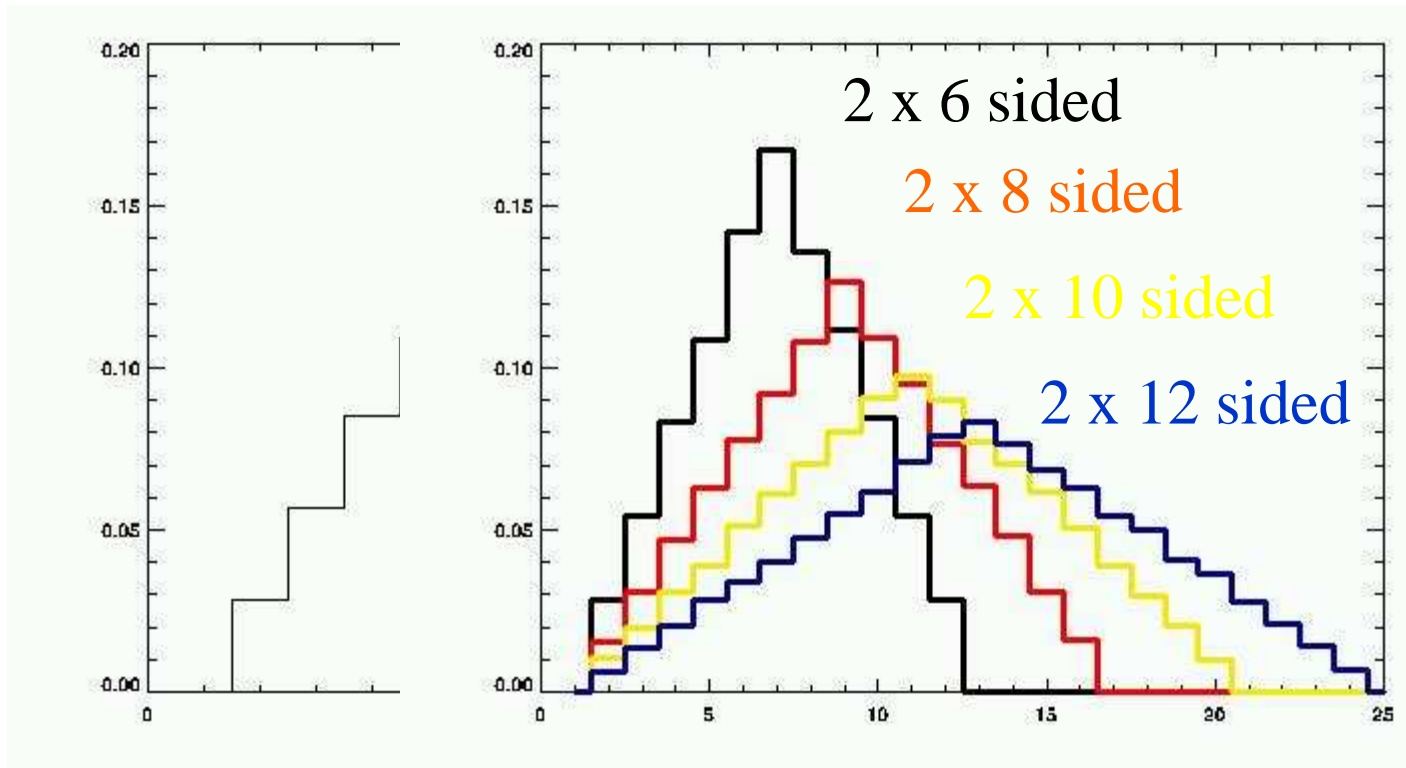
Source: Large (50 member) IC ensemble from climateprediction.net.



Source: IPCC, Third Assessment

Sources of Uncertainty

- Model imperfections:
Models are different from reality.



Sources of Uncertainty

and How to Include Them In a Climate Forecast

- **Model Inadequacy**
All models are unrealistic representations of many relevant aspects of the real world system.
- Response: **A context for all climate forecasts.**
 - Processes known to be important are absent.
e.g. ice sheet dynamics, atmospheric and oceanic chemistry, stratosphere circulation.
 - Parameterized processes are unlikely to capture small scale feedbacks.
 - Inadequate simulation of some processes which should result from the fundamental processes included.
e.g. hurricanes, diurnal cycle of tropical precipitation.

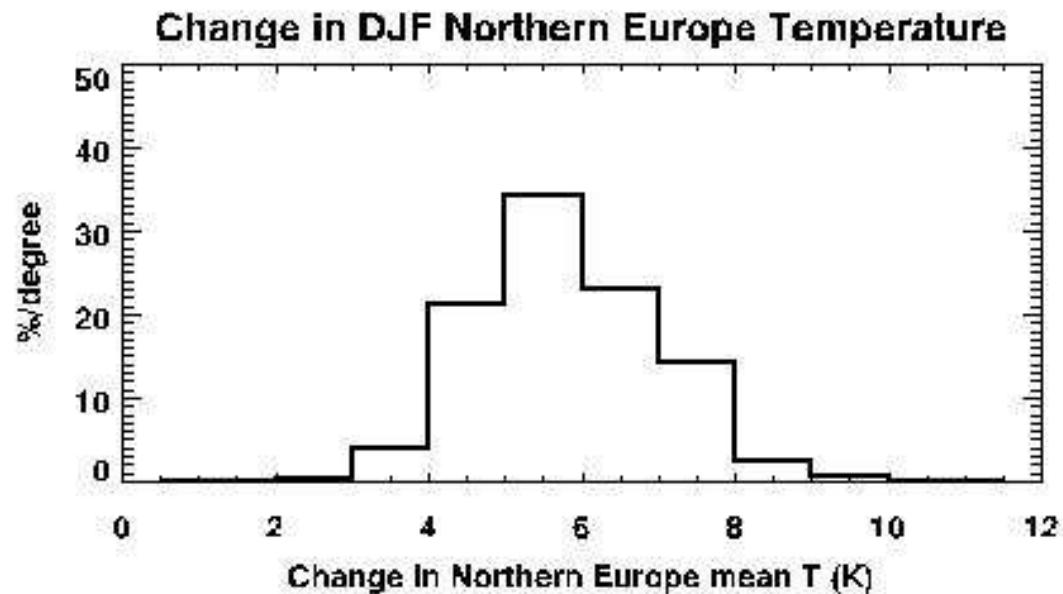
Sources of Uncertainty

and How to Include Them In a Climate Forecast

- **Model uncertainty:**

Climatic processes can be represented in models in different ways e.g. different parameter values, different parameterization schemes, different resolutions. What are the most useful parameter values and model versions to study within the available model class? What is the range of possibilities?

Response: **Perturbed-Physics Ensembles**



Stainforth et al.2006

The Challenges

- How to design experiments to explore these uncertainties within the models?
- How to relate models and reality?

“Subjective Probabilities”

- “A probabilistic climate projection is ... a subjective probability, providing an estimate based on the available information and strength of evidence (similar to horse-racing odds)”
www.ukcip.org.uk – ukcip08 – what will be provided.
- “PDF plots will show the probability of a particular projected change for a user-defined location, climate variable, averaging period, time-slice and emissions scenario.”
www.ukcip.org.uk – description of ukcip08 outputs.

Pragmatists and Nihilists

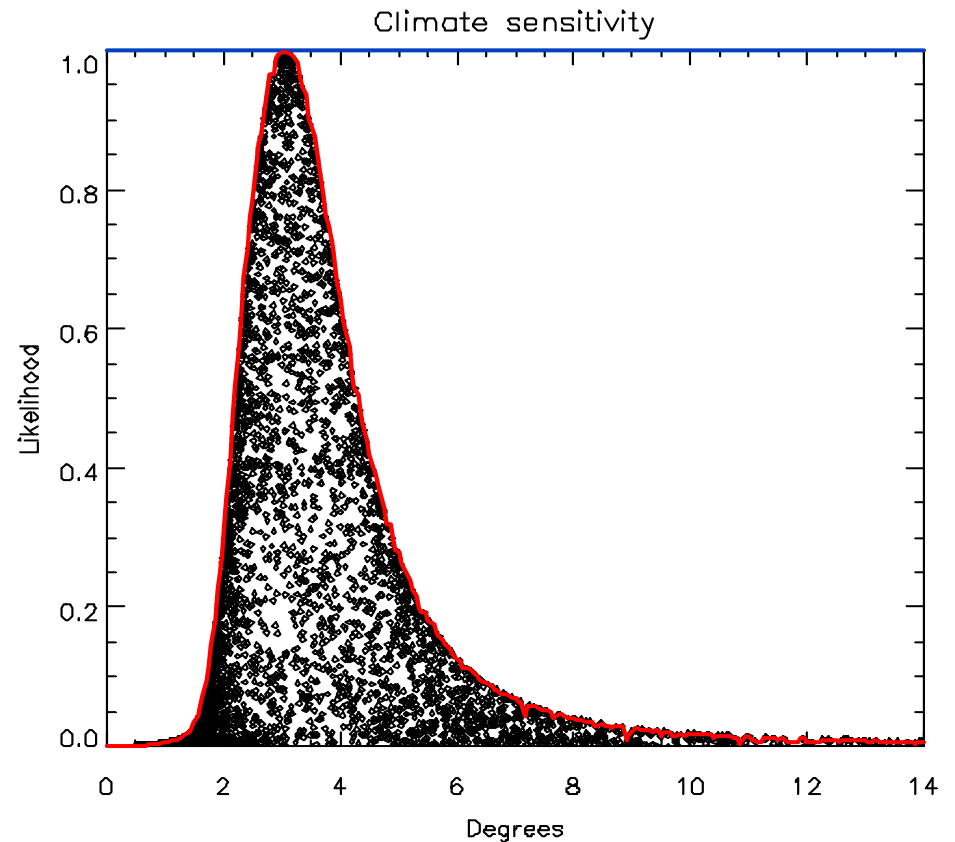
The world of Myles Allen:

1. “Subjectivist” (e.g. Rougier, 2006; Murphy et al, 2004): using expert priors on model parameters weighted by goodness-of-fit to observations.
2. “Pragmatist” (Allen et al, 2000; Forest et al, 2002): focus on relative goodness-of-fit to observations, minimizing influence of prior assumptions.
3. “Nihilist” (IPCC, 2001/7; Smith, 2002; Stainforth et al, 2005, 2007): focus on spread of model results, irrespective of goodness-of-fit to observations.

Likelihood profiling

Further words from Myles:

- “Find the relative likelihood of the most likely (most realistic, **or least unlikely**) model as a function of the forecast variable of interest.
- Evaluate likelihood only over observable quantities that are
 - **Relevant to the forecast.**
 - **Adequately simulated by the model (including variability).**”

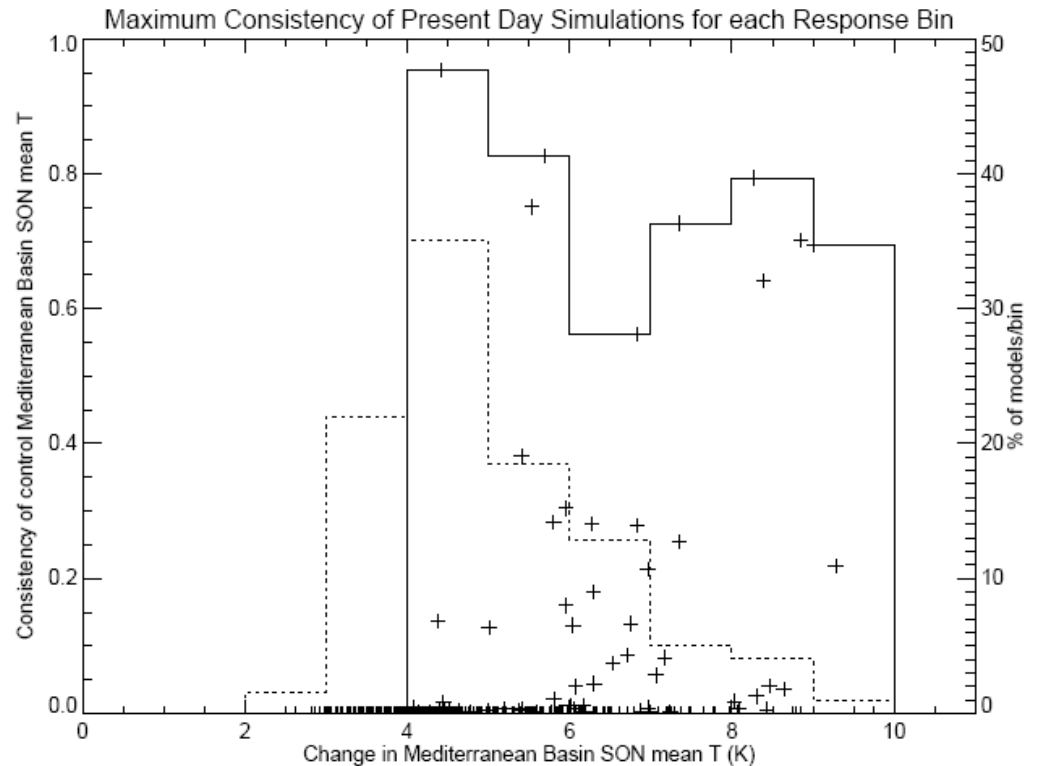


Allen et al. 2008

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Stainforth et al. 2007

Where now?

- We've made substantial progress since the TAR.
- Should be cautious about promising reductions in uncertainty when we've only begun to explore and understand the sources of uncertainty.
- We should push our models as far as we can in our impacts / adaptation relevant variables.
- Develop a range of futures consistent with what we know so far. We need to focus and expand efforts on how to develop and communicate these techniques. Something that the weADAPT group is doing.
- Don't ignore the non-linearities in the system; be careful about whether subjective probabilities have any meaning in the climate change context.
- Develop more robust ways of evaluating models' abilities:
 - Agreement in distribution,
 - Can models shadow reality?
 - Exploration of decision sensitivities in the light of scientific information.