Probability and climate change

UK/Russia Climate Workshop, October, 2003

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South Oxford on January 5th, 2003

Photo courtesy of Dave Mitchell

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Was this flood just another weather event, or was it something to do with climate change?

- **The difference between weather and climate and its importance for attribution**
- **What we can say about weather: attributing cause and effect in a chaotic system.**
- **Who/what was to blame for the 2000 UK floods?**
- **Implications for climate modelling.**

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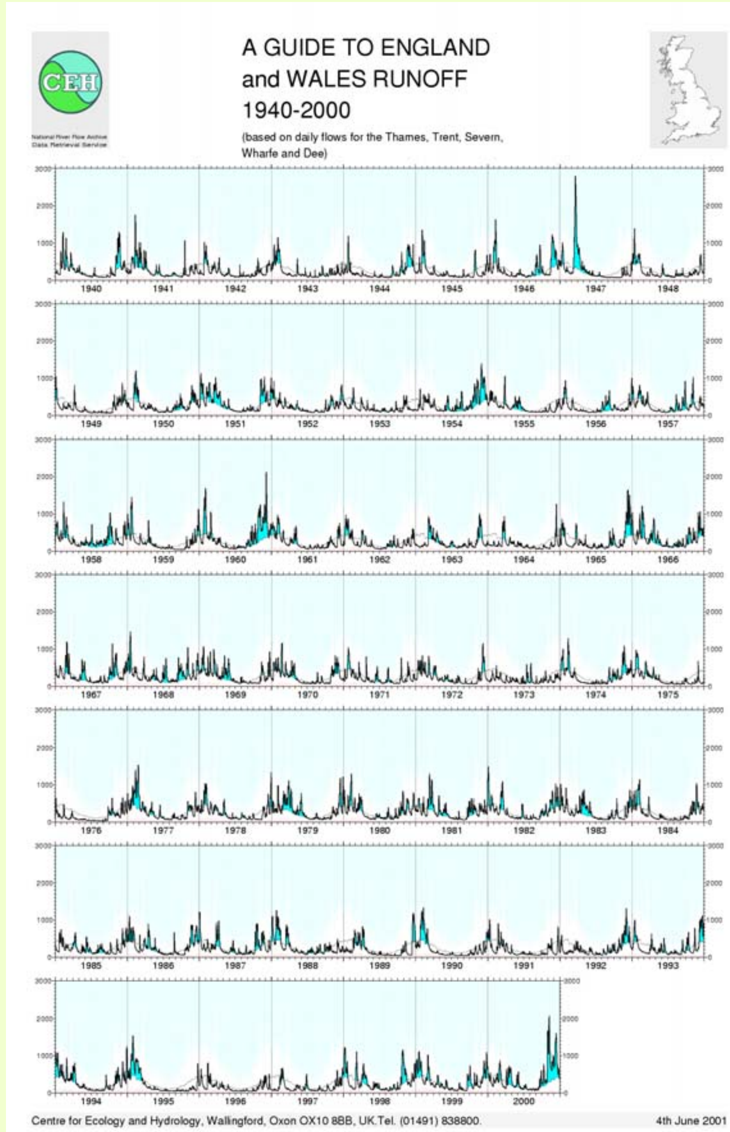
Autumn 2000 events “were extreme, but cannot *in themselves* be attributed to climate change.”



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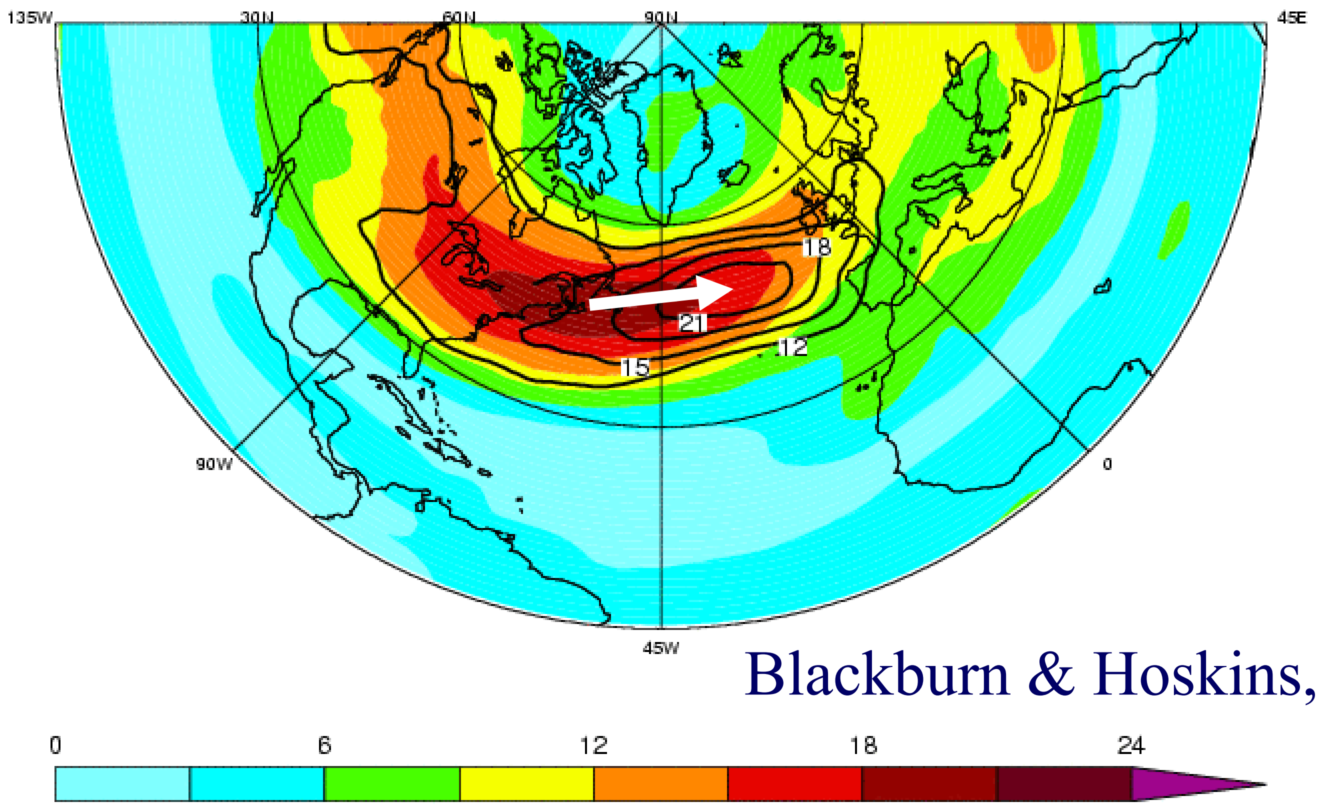
The problem in Autumn 2000: a *consistently* displaced Atlantic jet-stream

The Atlantic Jet Stream (500hPa wind speed)
Autumn climatology (colours) & Autumn 2000 (contours)



Blackburn & Hoskins, 2003

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But the jet-stream varies with the weather: how can we pin down the role of climate change?

- Lorenz' definition of weather and climate: "climate is what you expect, weather is what you get."
- And in the 21st century: "climate is what you affect, weather is what gets you."
- We can demonstrate links between greenhouse gases and climate (the shape of the weather attractor) but most impacts arise from the changing probabilities of natural weather events.
- Climate may be perfectly predictable, even though weather is not.
- Focus on changes in risk.

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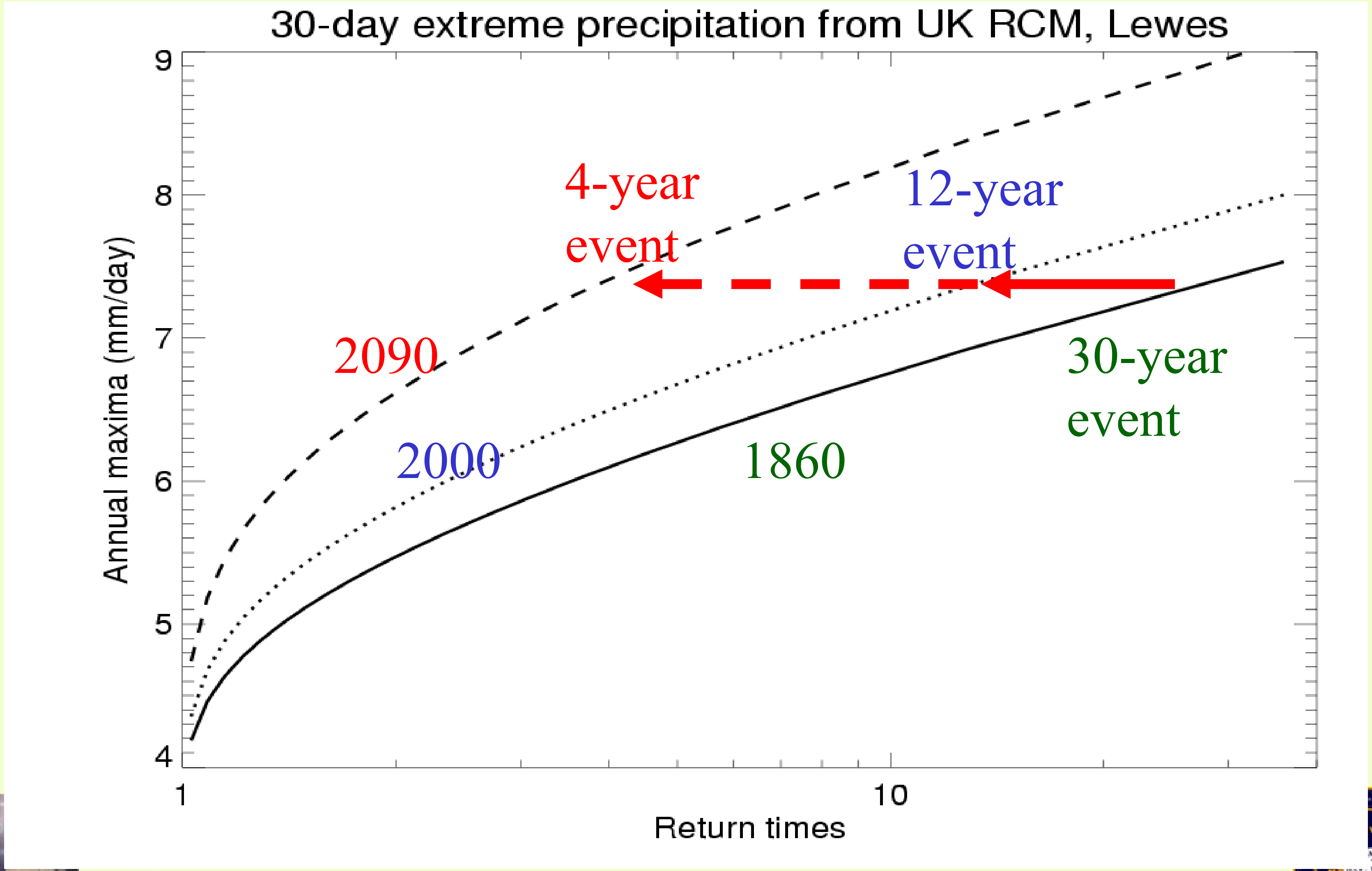
Model-simulated changes in extreme rainfall in southern England



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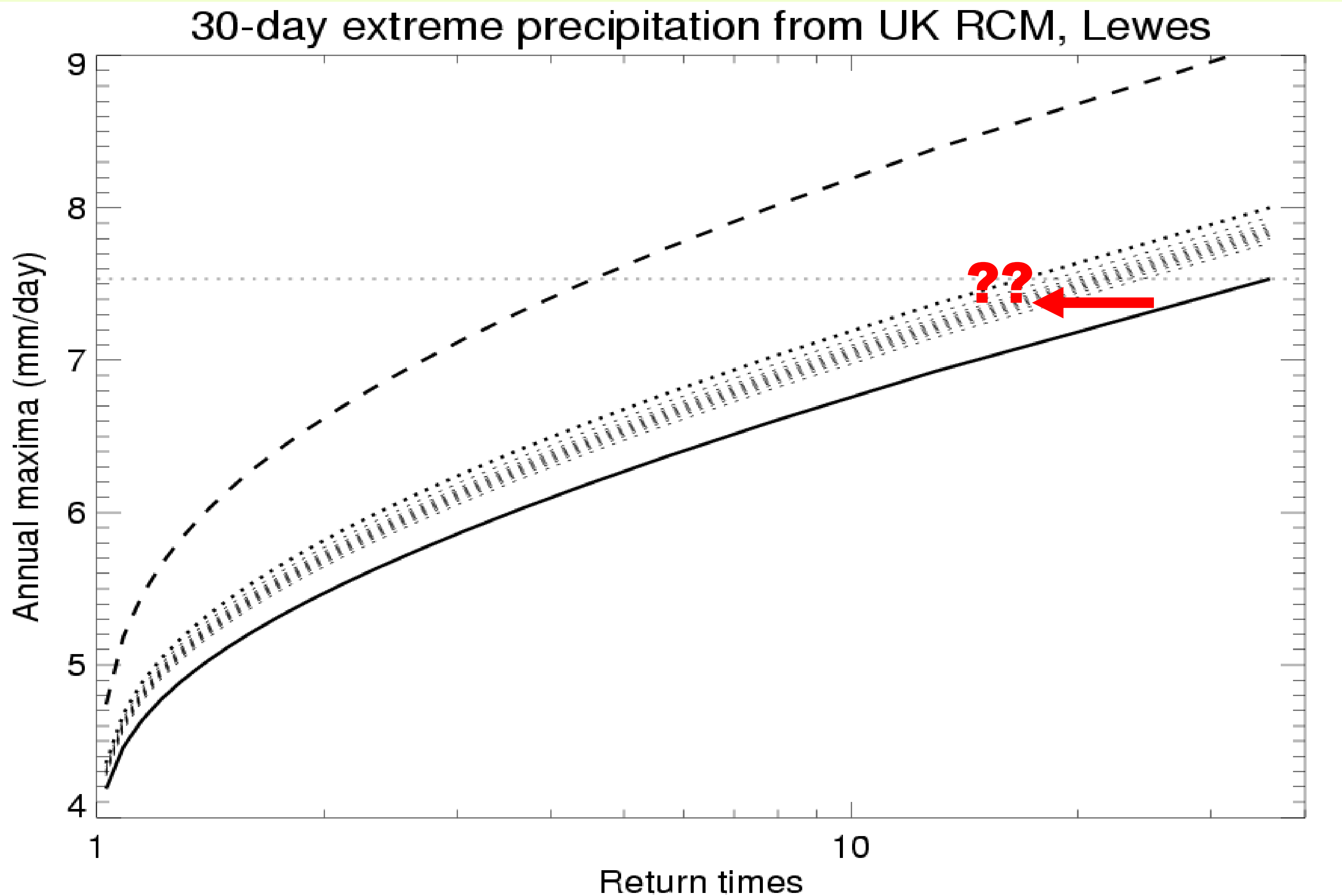
Accounting for uncertainty in global mean response 1860-2000



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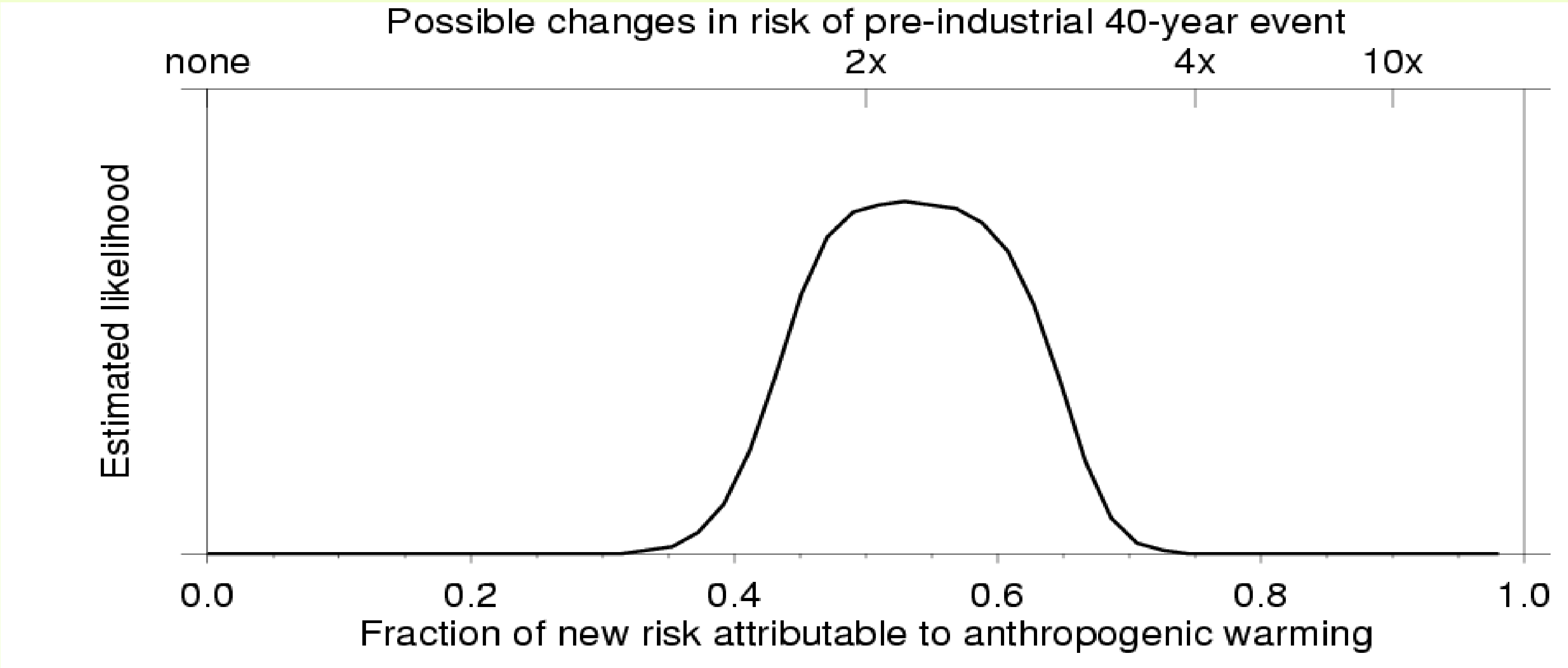
How anthropogenic climate change may have contributed to the risk of the October 2000 floods (but only global response uncertainty)



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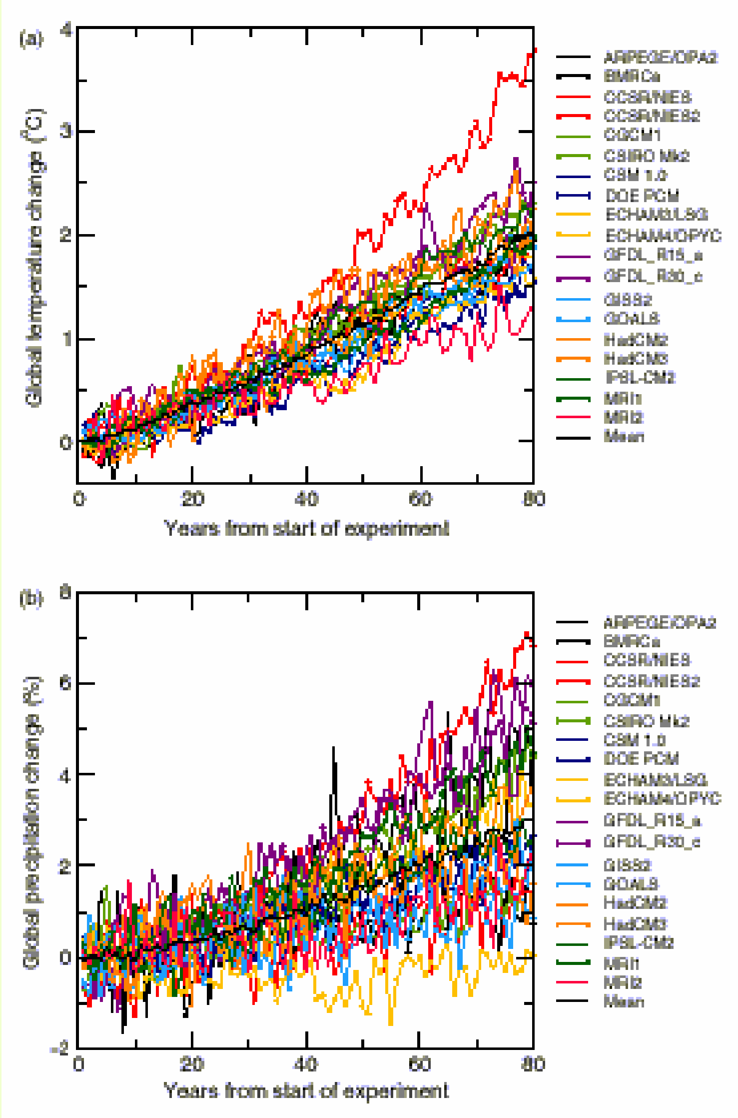
Allowing for more than global-mean response uncertainty using a multi-model ensemble

Global temperature change under 1% per year increasing CO_2

(CMIP-2 model inter-comparison)

Global precipitation change under 1% per year increasing CO_2



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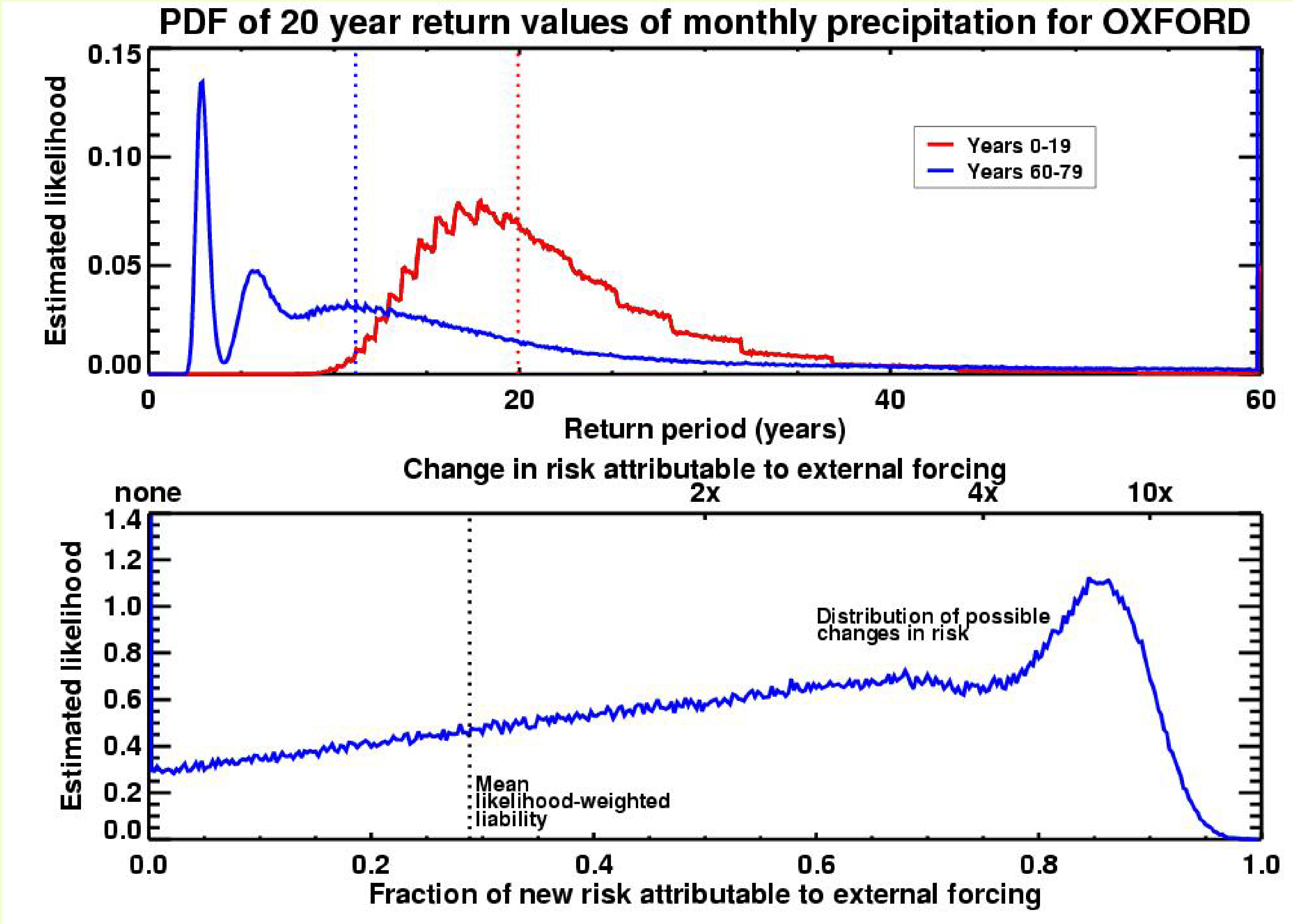
Change in risk of 20-year-return monthly rainfall anomalies across the CMIP-2 ensemble



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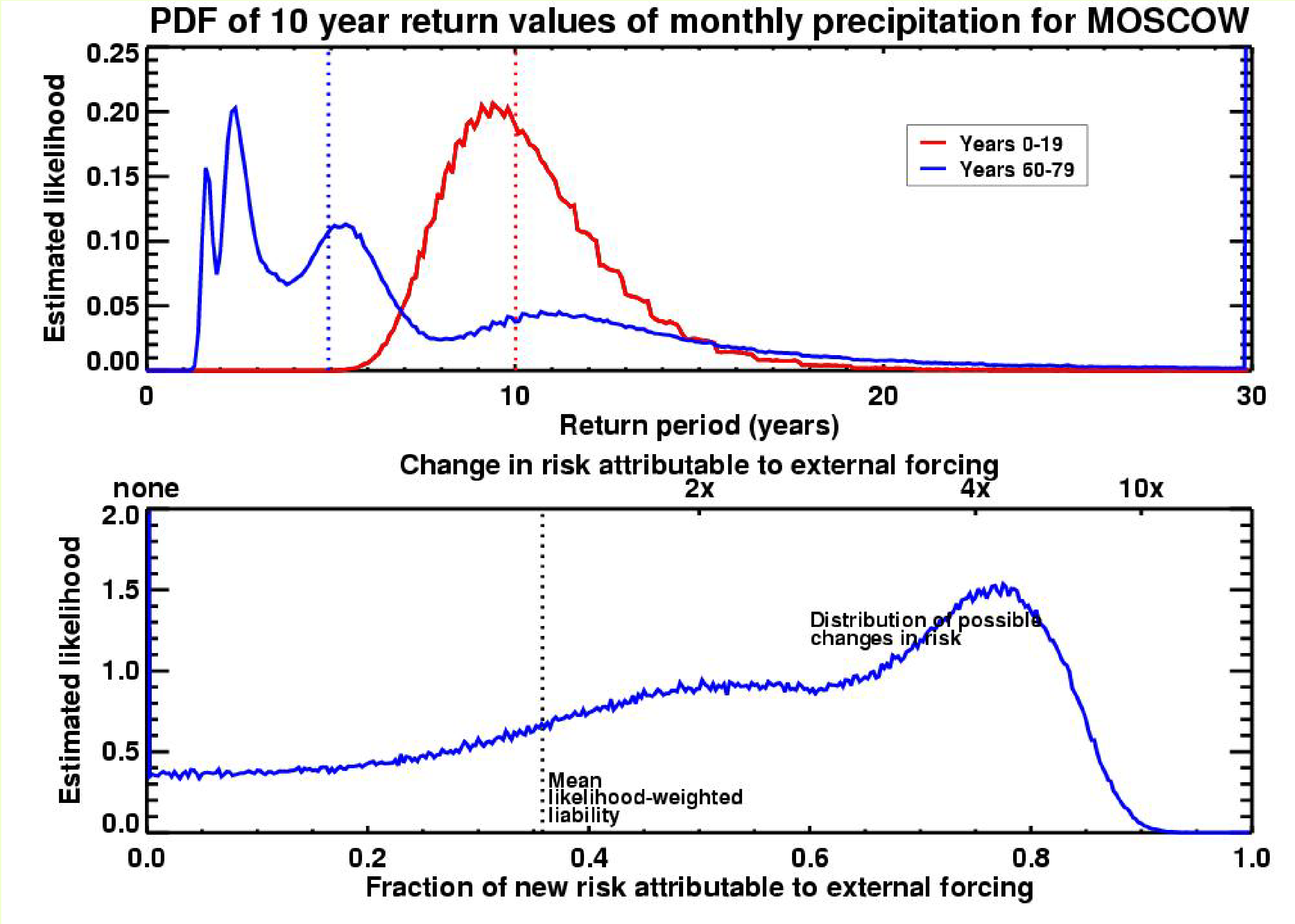
Change in risk of 10-year-return monthly rainfall anomalies across the CMIP-2 ensemble



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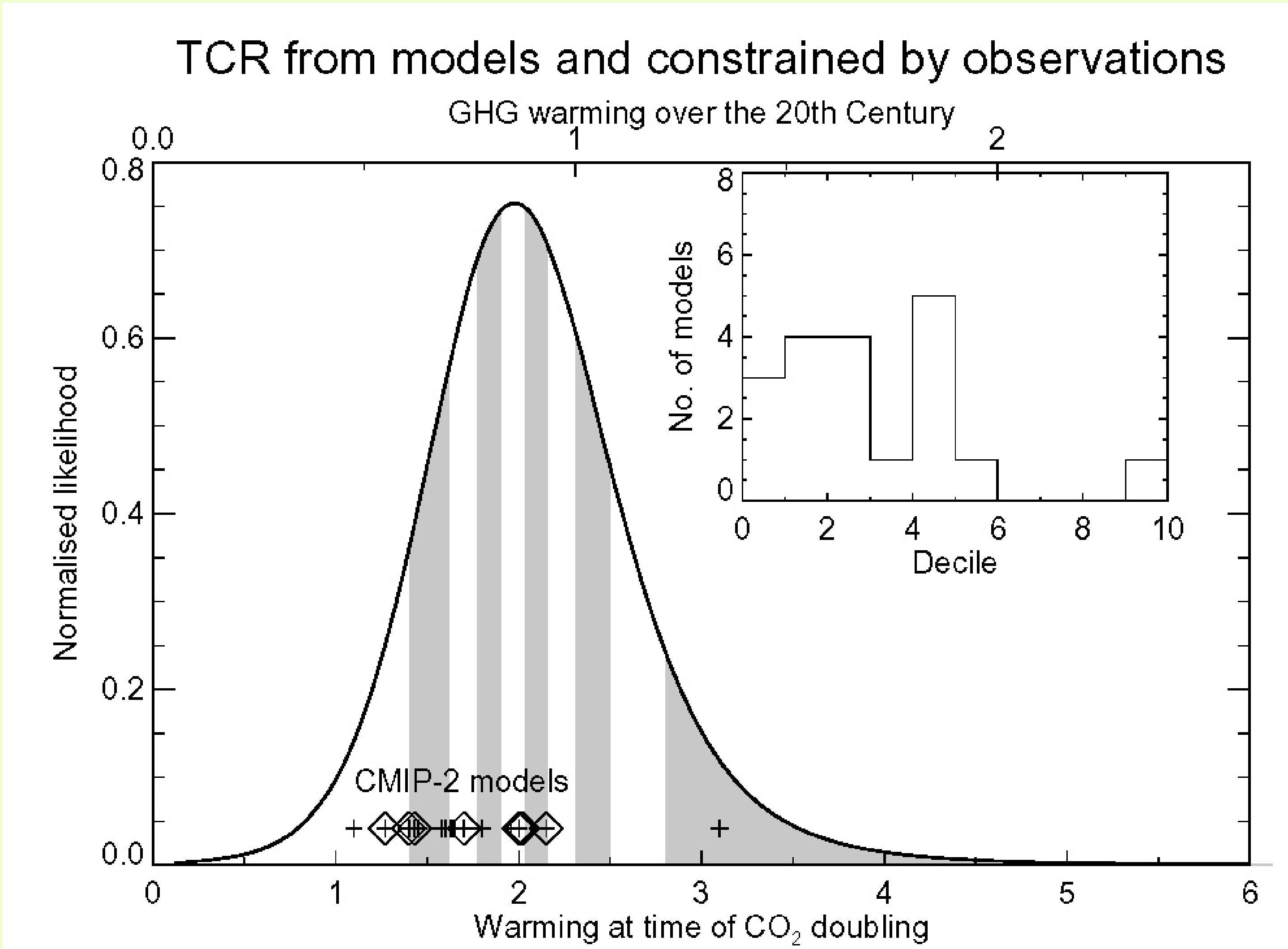
But available models don’t cover all possibilities



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Allowing for model error in climate forecasting

- **Long-term forecasts need to account for uncertainty in climate system (atmosphere, ocean, biosphere and cryosphere) response to external drivers.**
- **Initial-condition ensembles required to account for chaotic variability.**
- **Impossible to predict response to varying model, so large-scale Monte Carlo simulation the only option.**
- **Need to allow for uncertain forcing, increasing ensemble size to hundreds of thousands.**
- **Ideal for distributed computing: Windows implementation of HadCM3 (Stainforth et al, 2002).**

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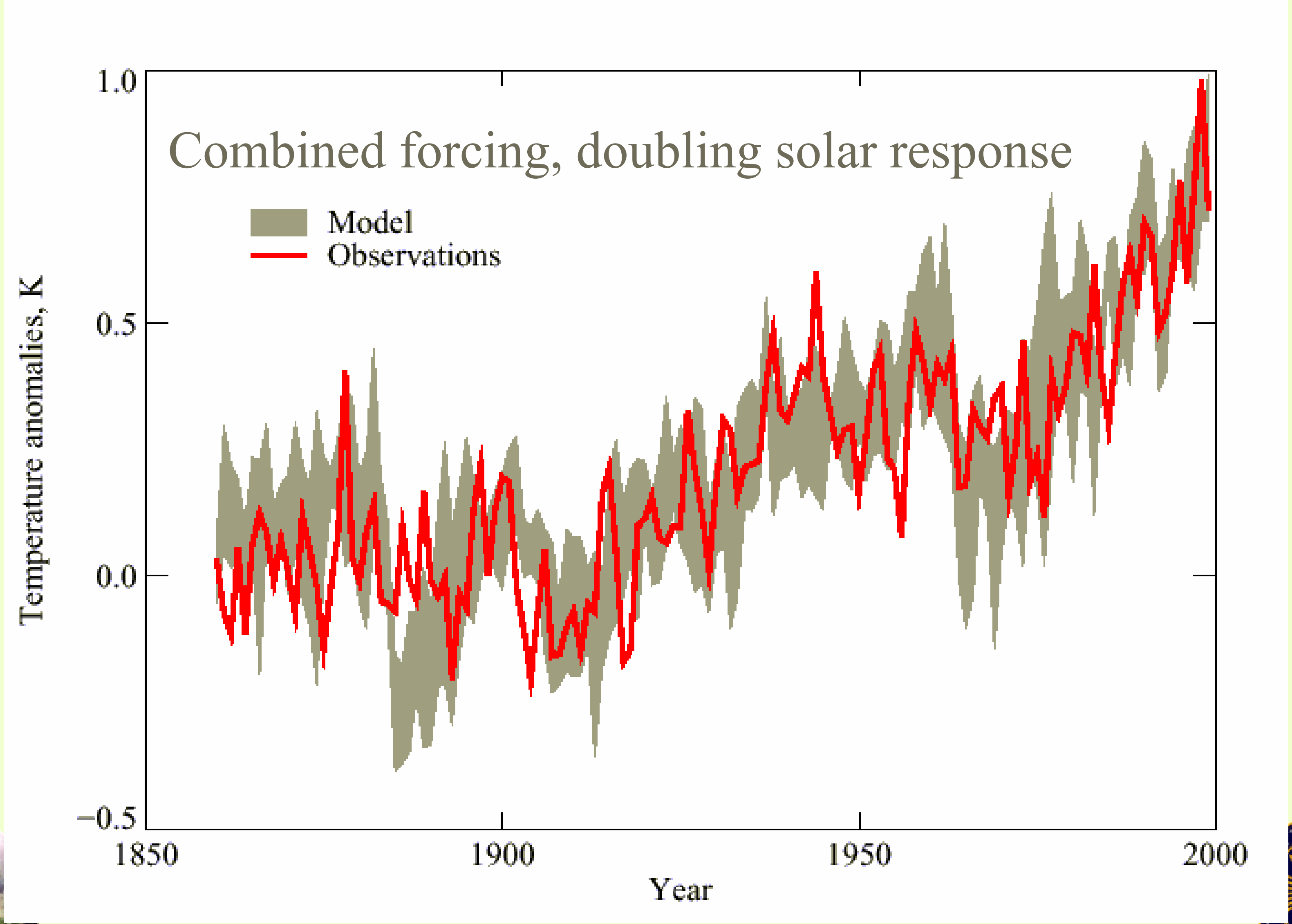
Must allow for forcing uncertainty: e.g. solar forcing of 20th century climate change



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- Using idealised experiments to identify parameter perturbations that change response to CO_2 without changing control climate (like “singular vectors”).
- Launch ensemble of coupled simulations of 1950-2000 and compare with observations.
- Run on to 2050 under a range of natural and anthropogenic forcing scenarios.
- Establish which forecast variables are consistently related to well-sampled observables.
- Weight ensemble for a specific forecast variable to ensure consistency with relevant observables.

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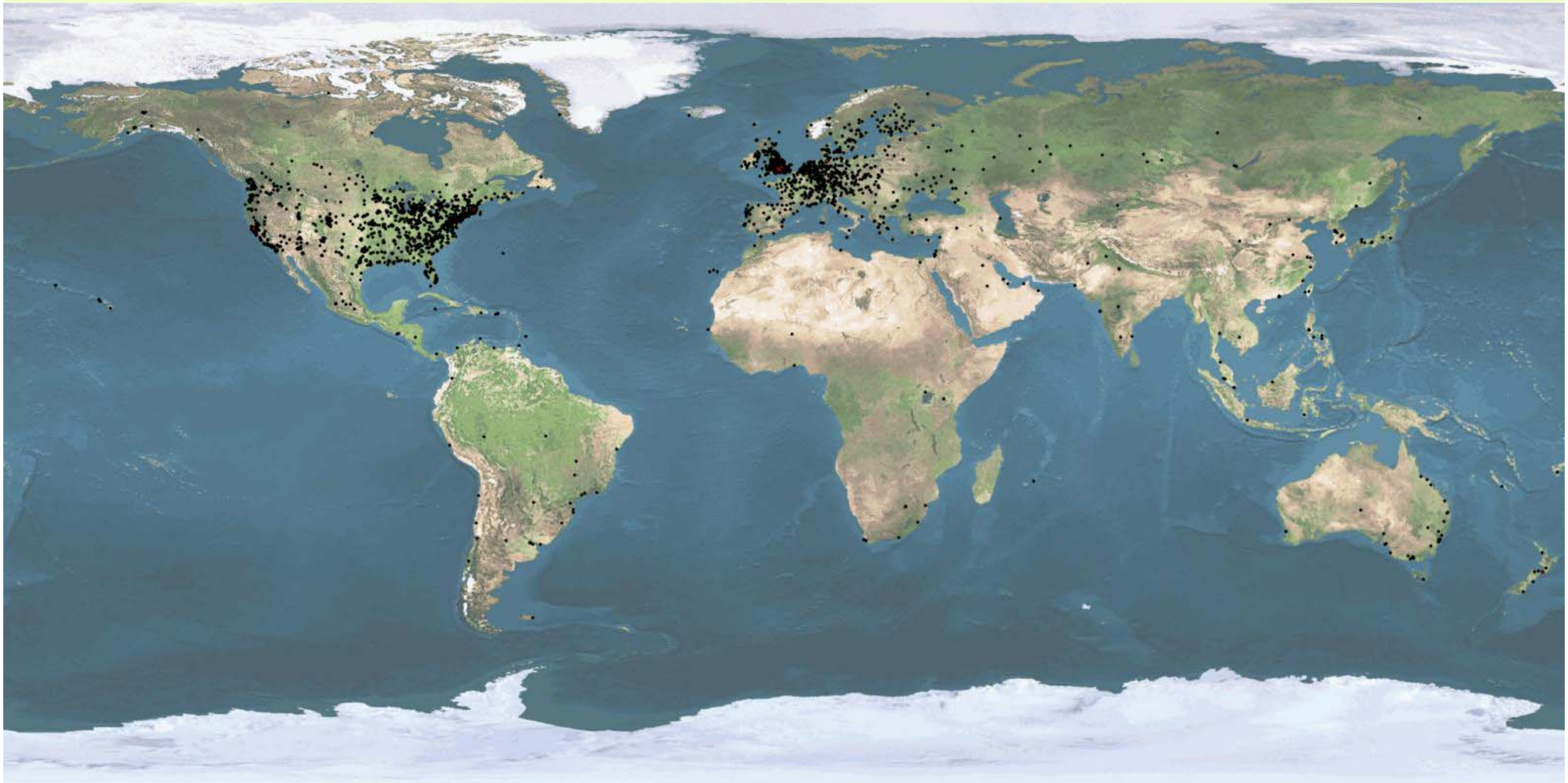
The world's most powerful climate modelling facility



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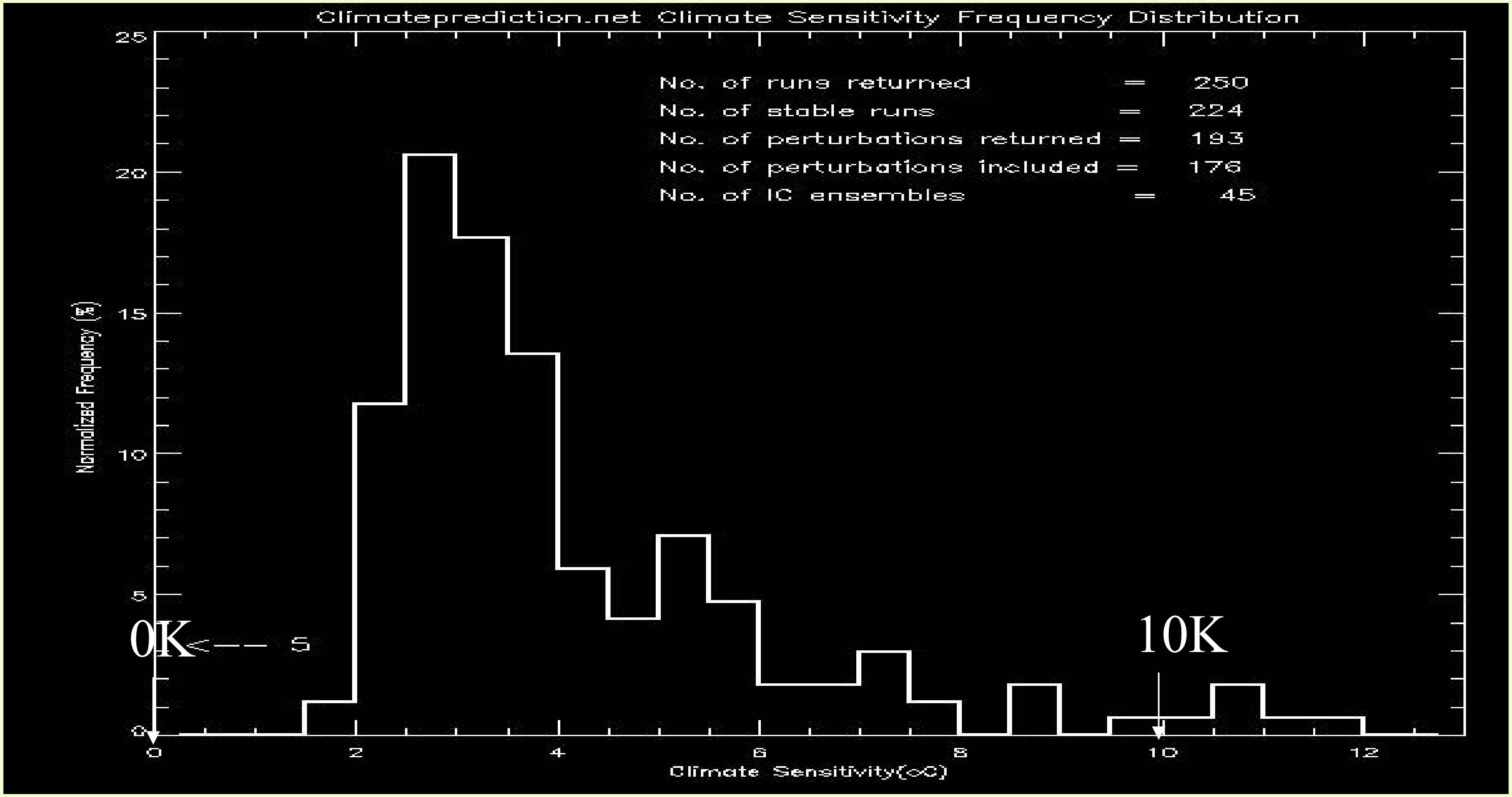
Initial results: a broad range of sensitivities



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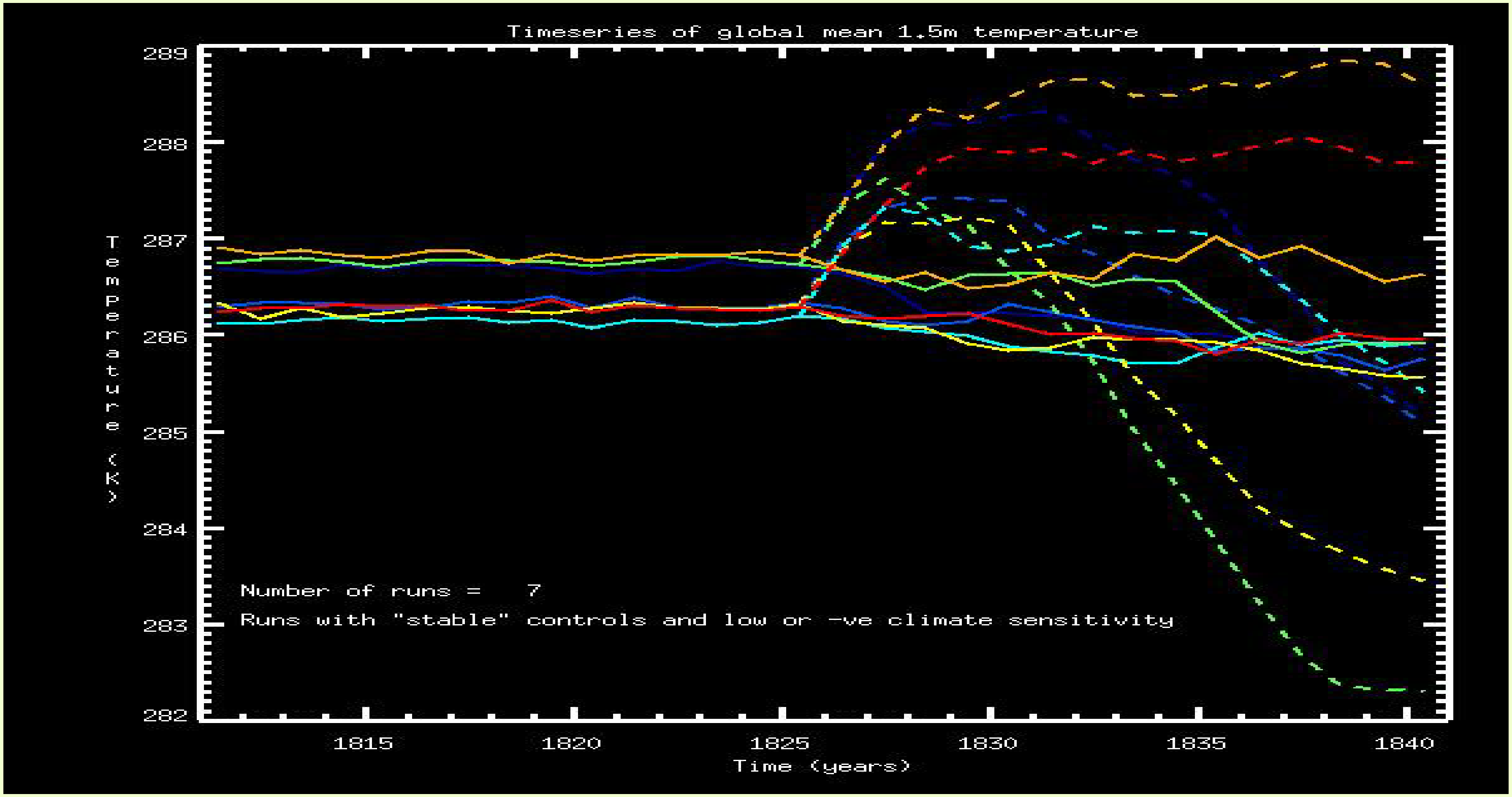
Including some negative…



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Climate*prediction*.net progress to date

- **Launched 12th September, 2003.**
- **35,000 active participants (221 in the Russian Federation); 408,000 model years completed (~2 Earth Simulators); 2,950 experiments already returned.**
- **Already demonstrating much richer behaviour than could be explored with in-house ensembles.**
- **Results available to the community via volunteer "results nodes."**
- **Calling for diagnostic subprojects from interested scientists: DTI funds for visits to Oxford?.**

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Summary

- **Most climate impacts are related to changing risks, not just predictable trends.**
- **Quantifying changes in risk requires an understanding of the non-linear nature of the climate system and large Monte Carlo climate forecasts with full-scale non-linear models.**
- **The most efficient way of achieving this is via distributed computing, and also a perfect tool for fostering trans-national collaboration.**

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