From the sun to the earth: climate 1879-2129

Myles Allen

Departments of Physics, University of Oxford

myles.allen@physics.ox.ac.uk

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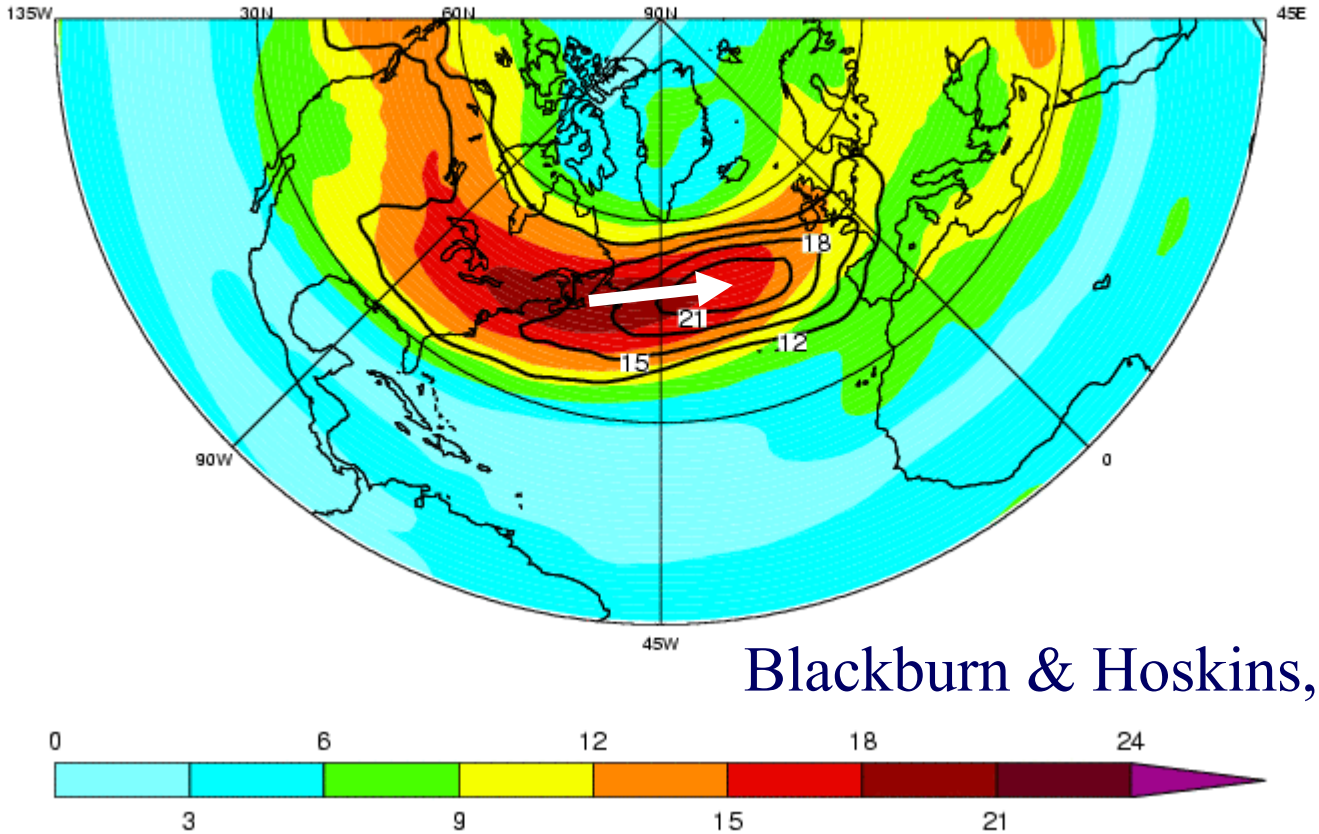
South Oxford on January 5th, 2003

Photo courtesy of Dave Mitchell

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

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

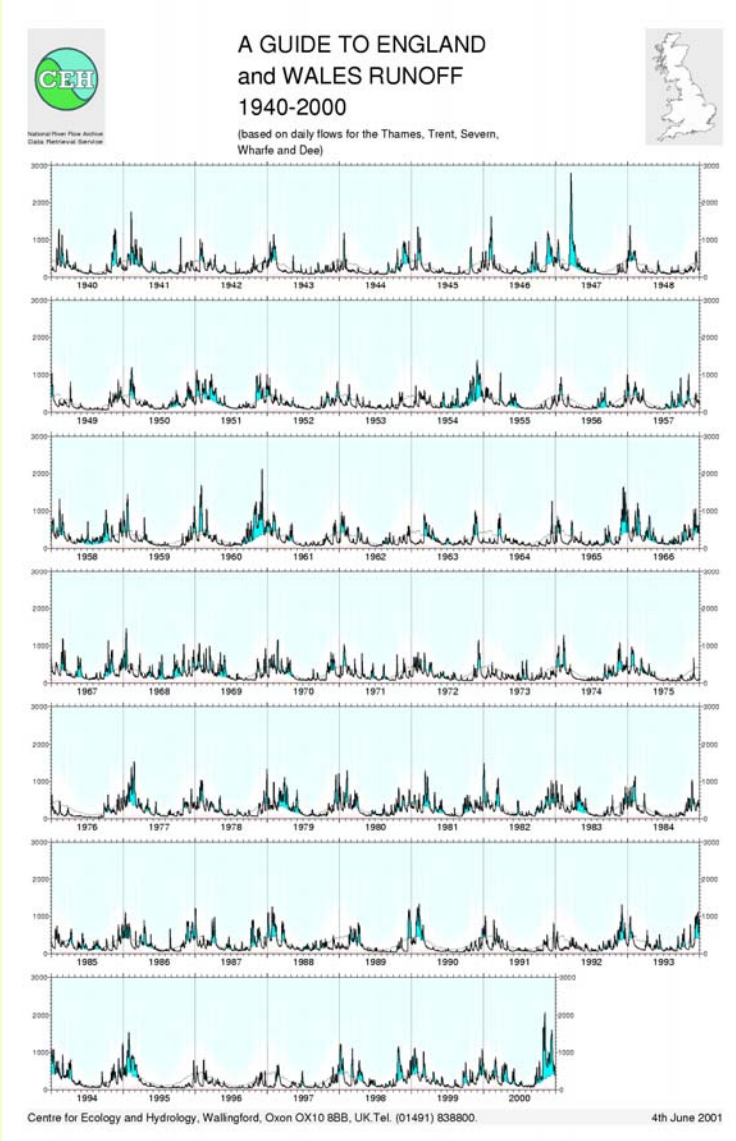


Blackburn & Hoskins, 2003

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

- "Climate is what you expect, weather is what you get" (Lorenz, 1982)
- and in the 21st century:
- "Climate is what you affect, weather is what gets you"

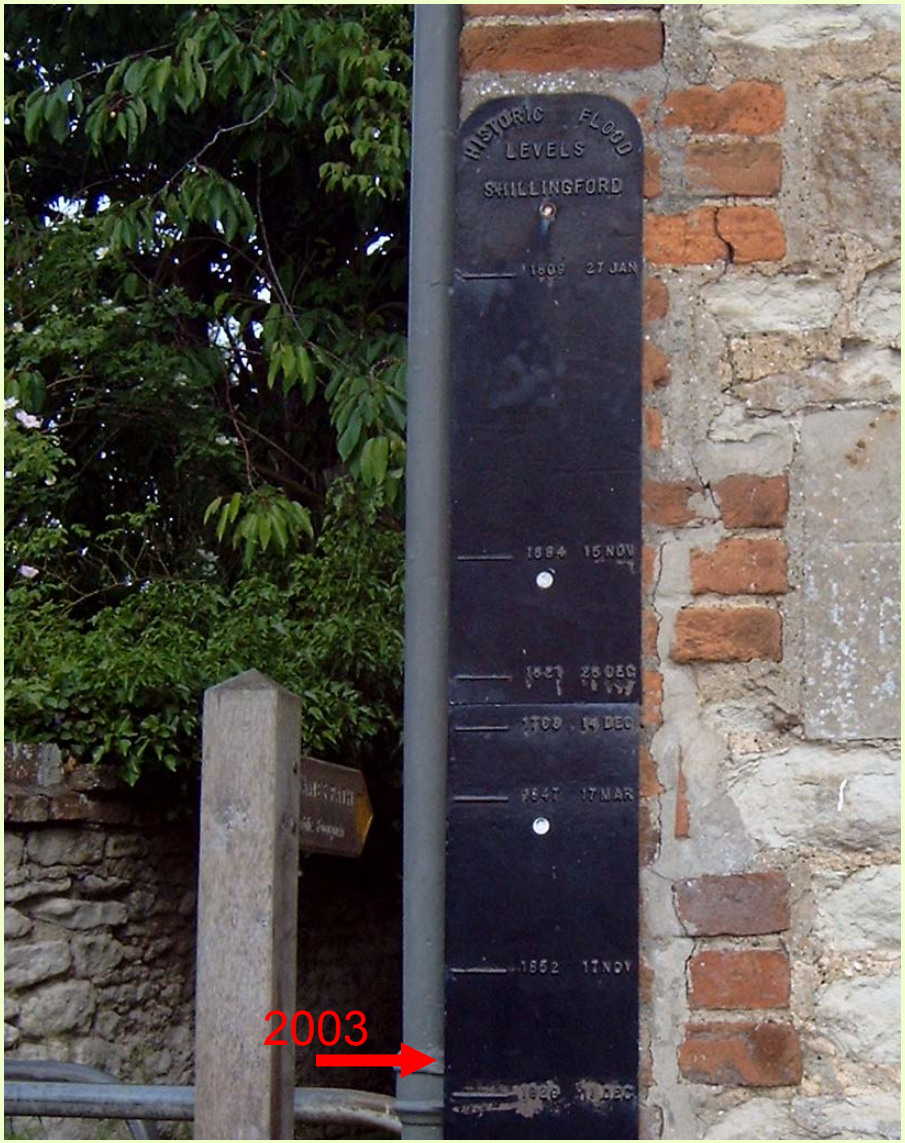
Autumn 2000 events "were extreme, but cannot *in themselves* be attributed to climate change."



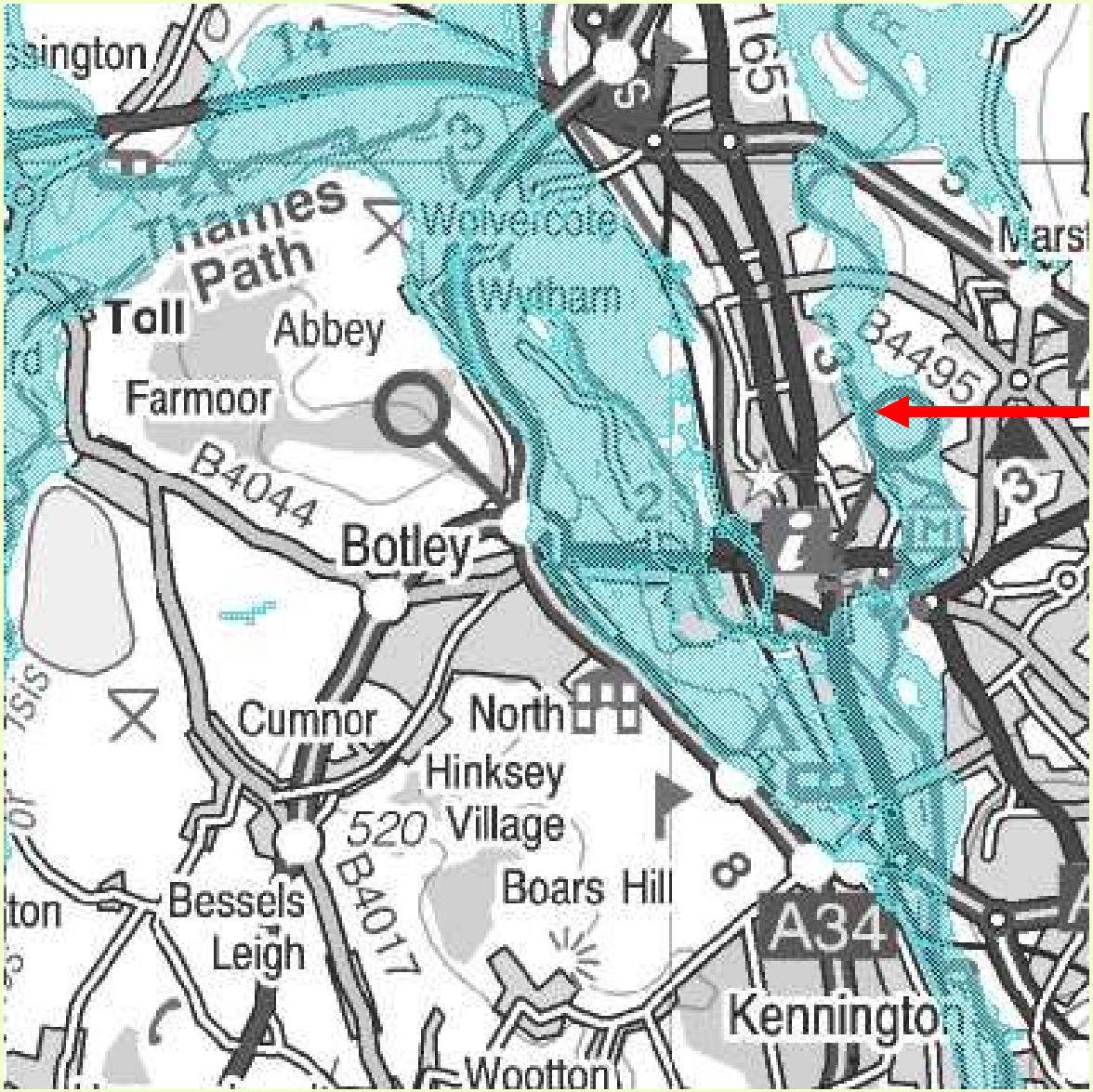
It has happened before

Osney lock flood marks, 1894 and 1947

Shillingford historic flood levels



Areas of risk in Oxford



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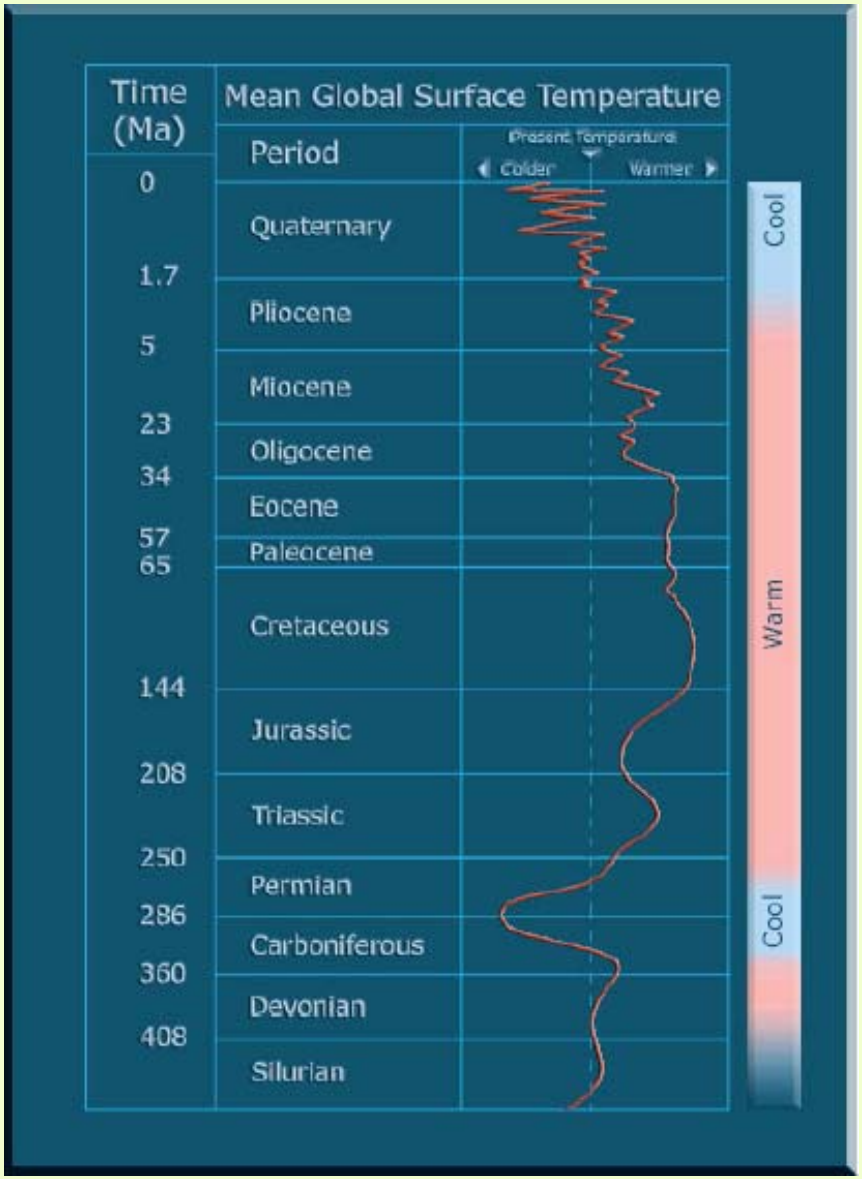
Climate has changed in the past



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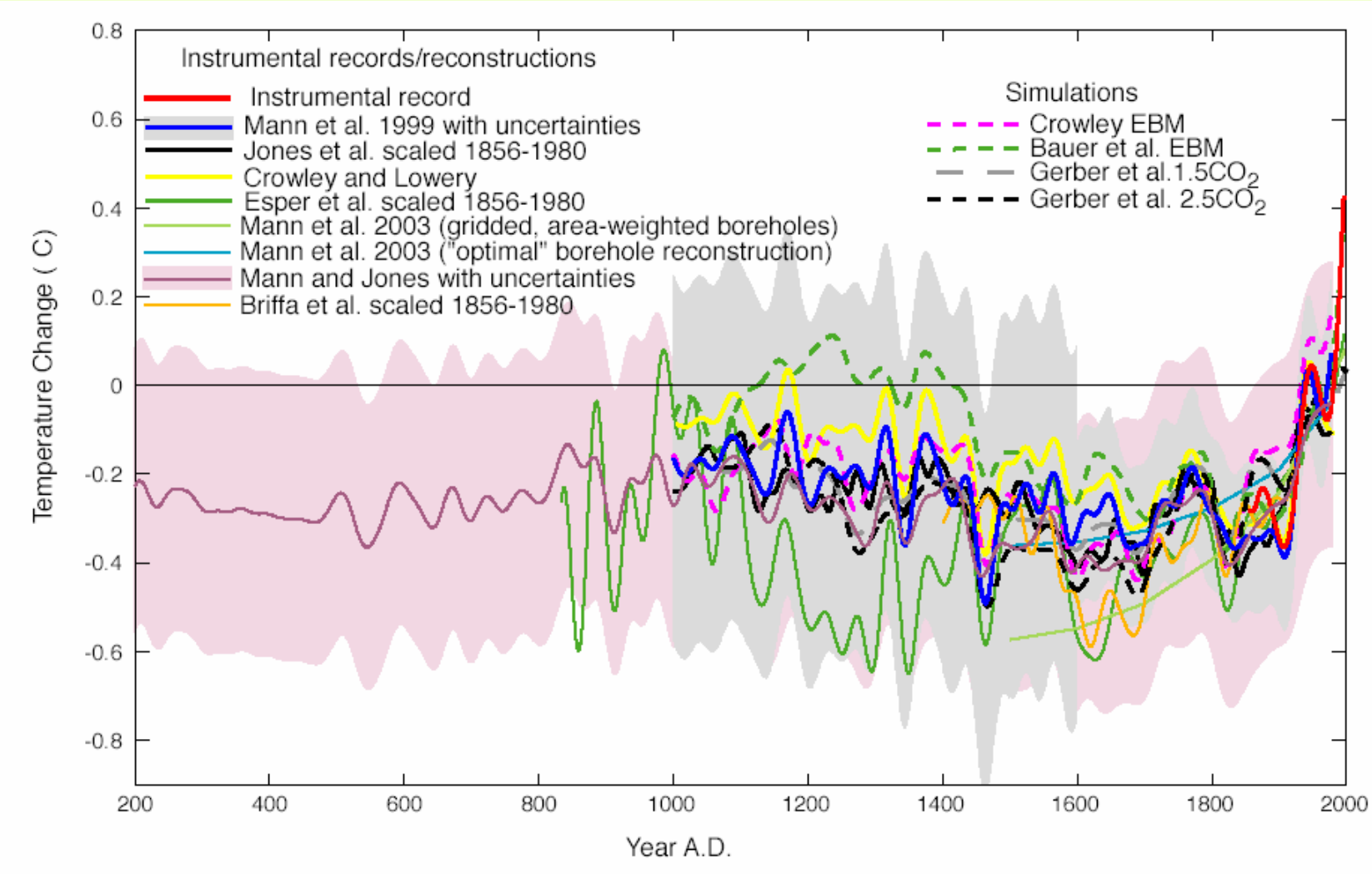
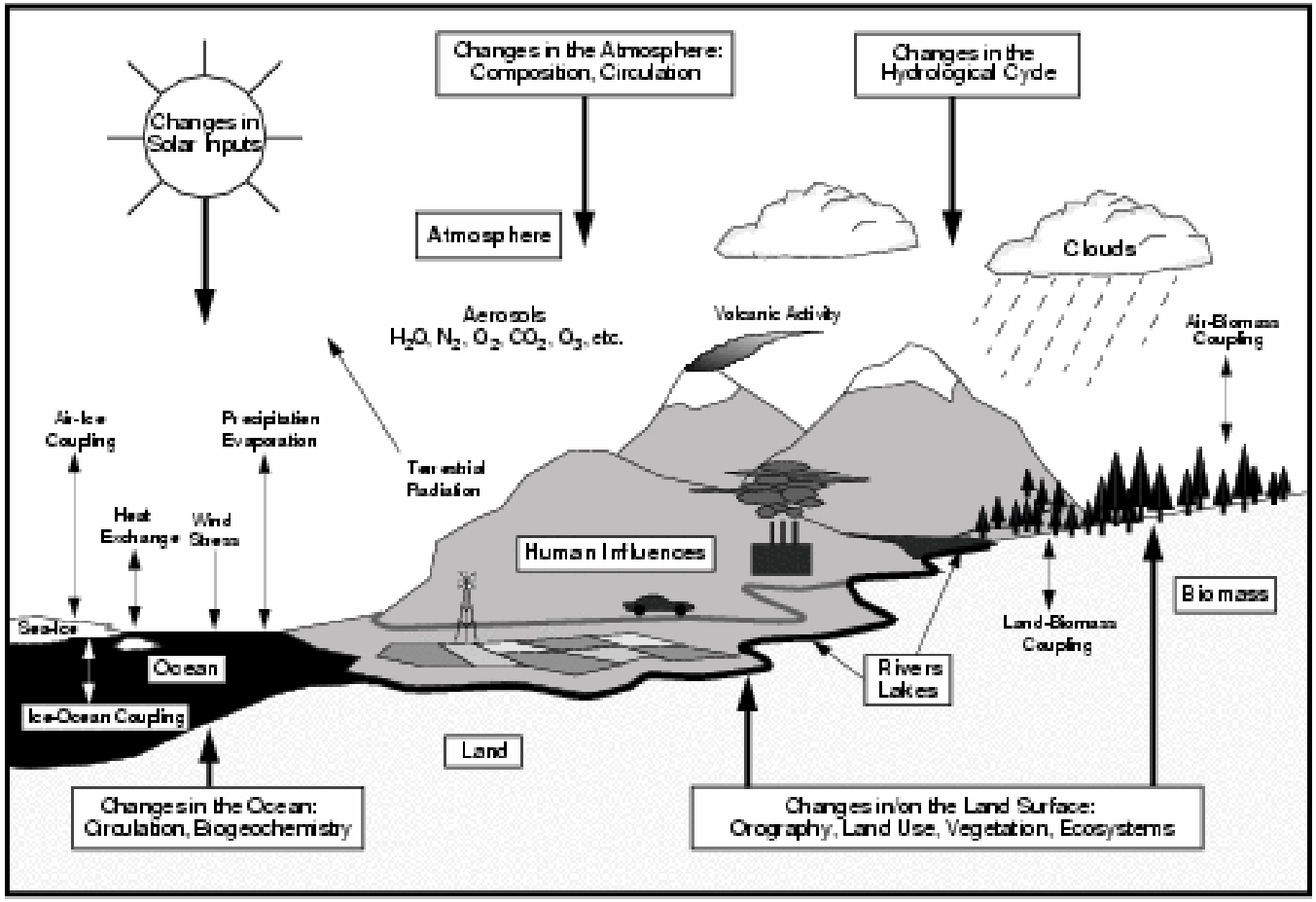
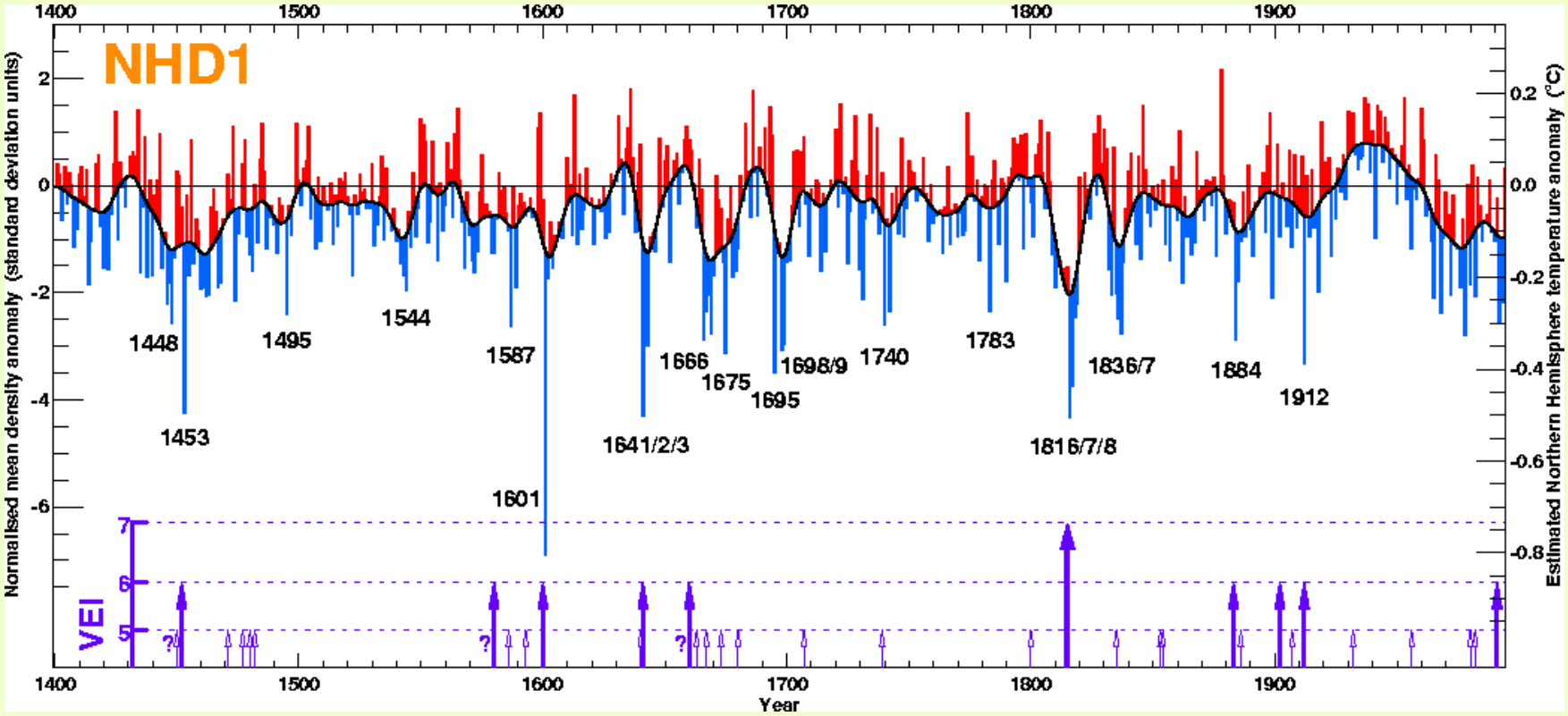
Northern Hemisphere temperatures over the past millenium



Factors affecting climate



Volcanic eruptions: the main external driver of short-term fluctuations



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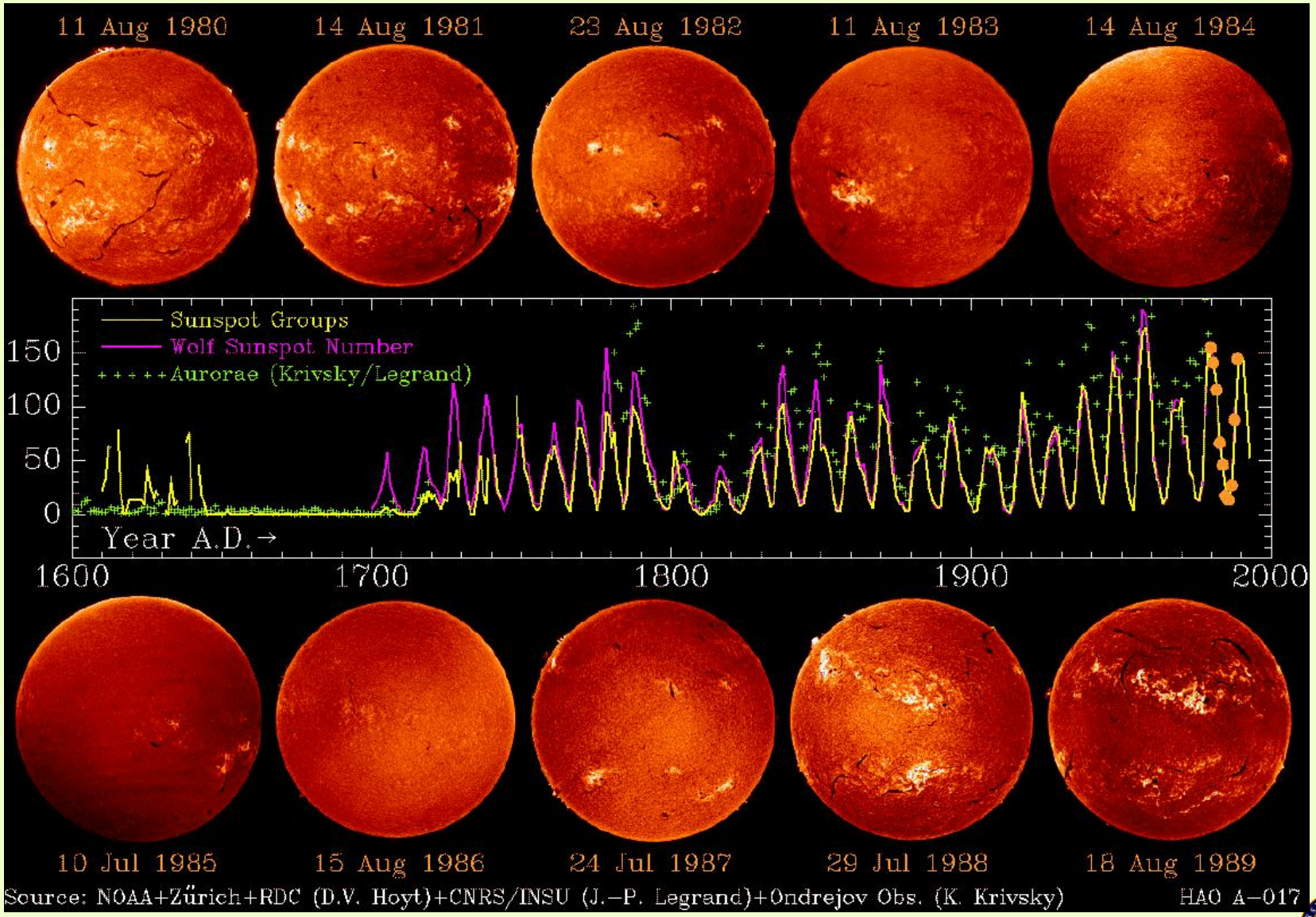
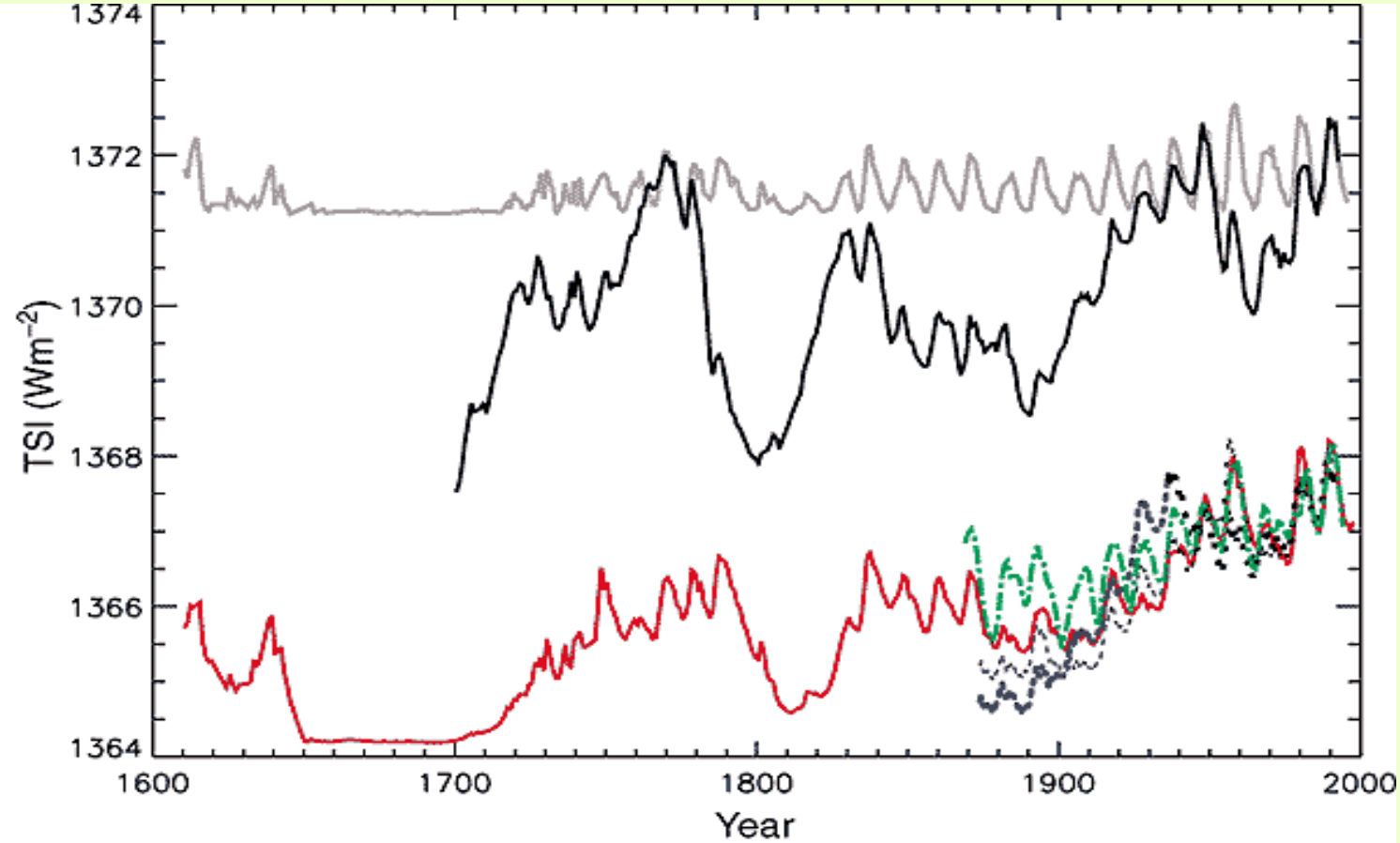
Solar variability: the main external driver of long-term fluctuations -- until recently



Reconstructions of solar output, 1600-present



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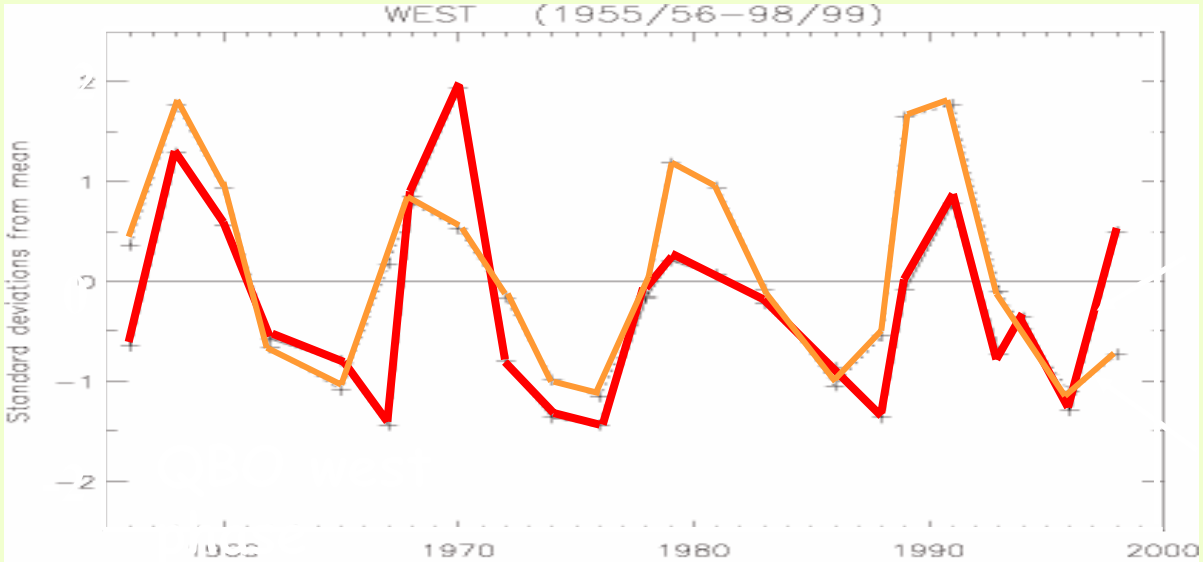
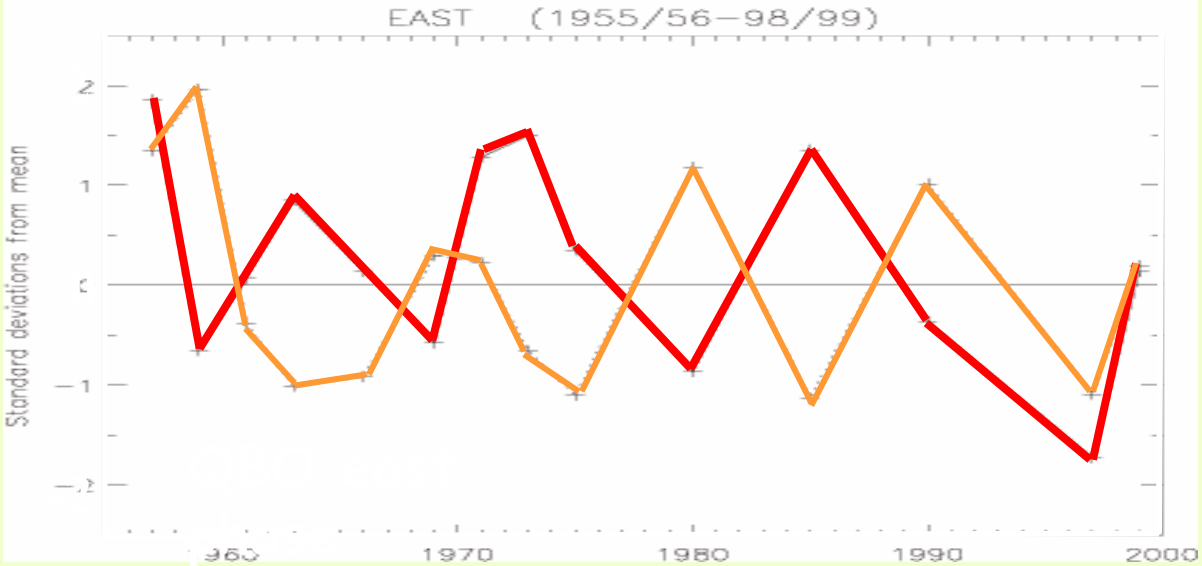
Evidence for solar influence on climate





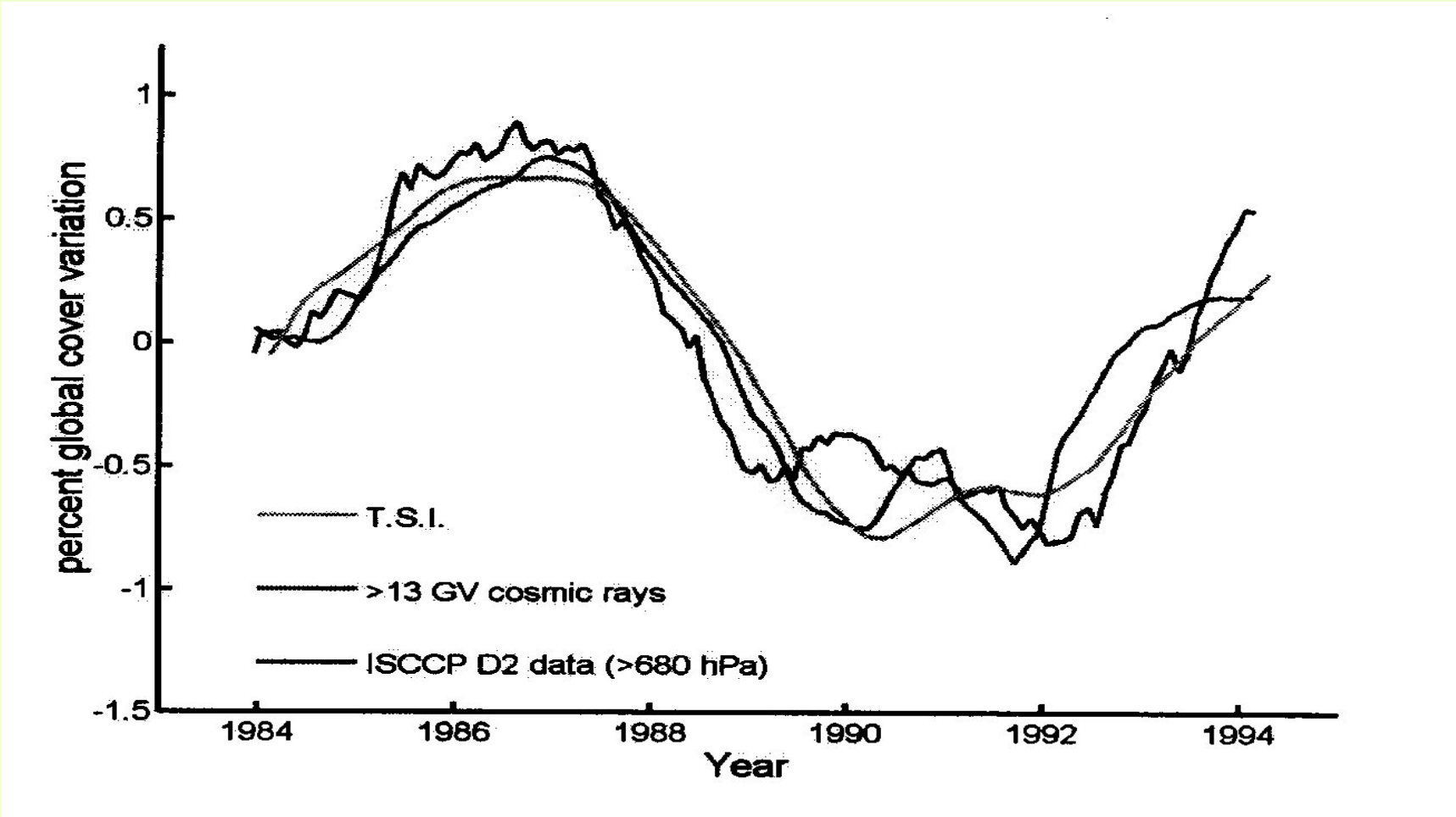
North polar temperatures

Solar output

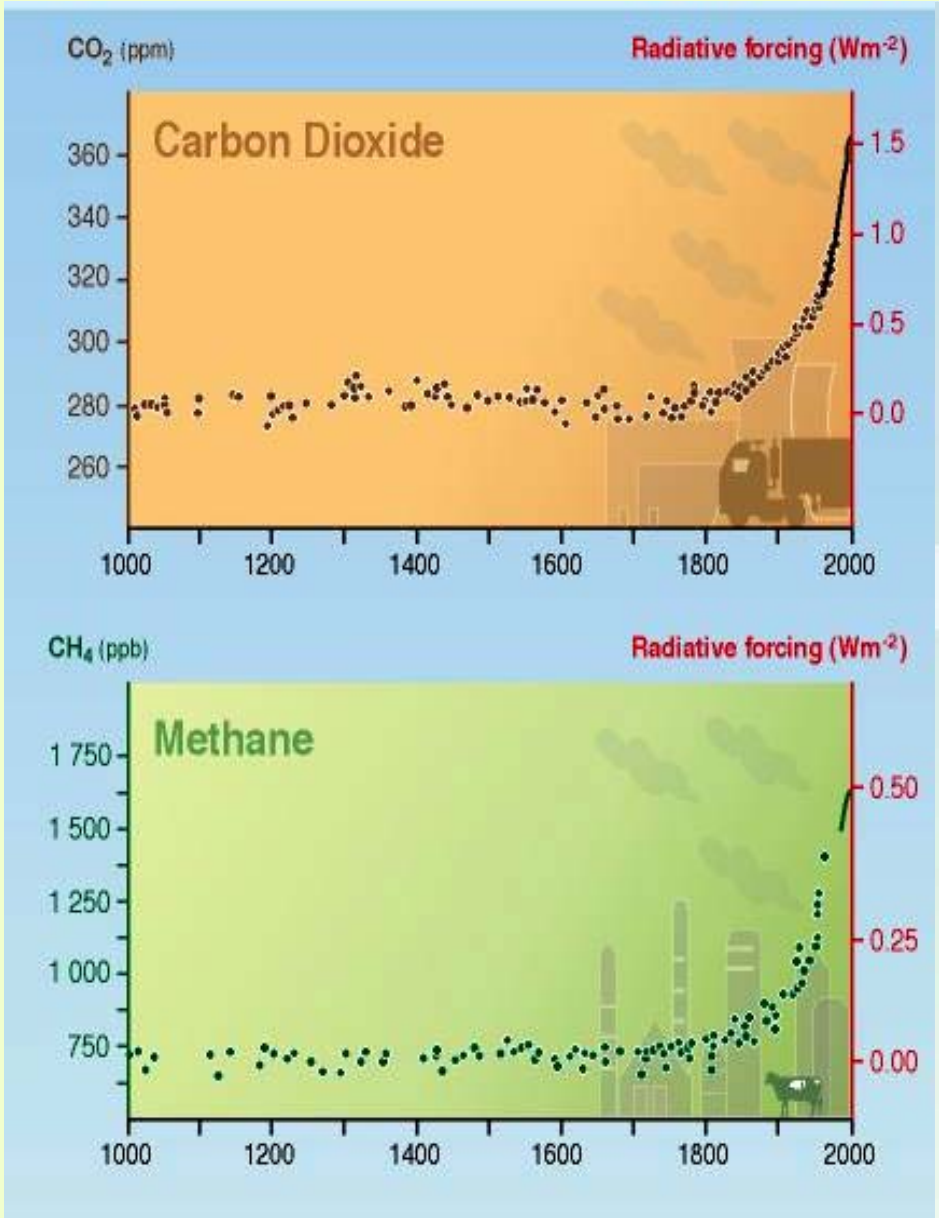
West-phase QBO

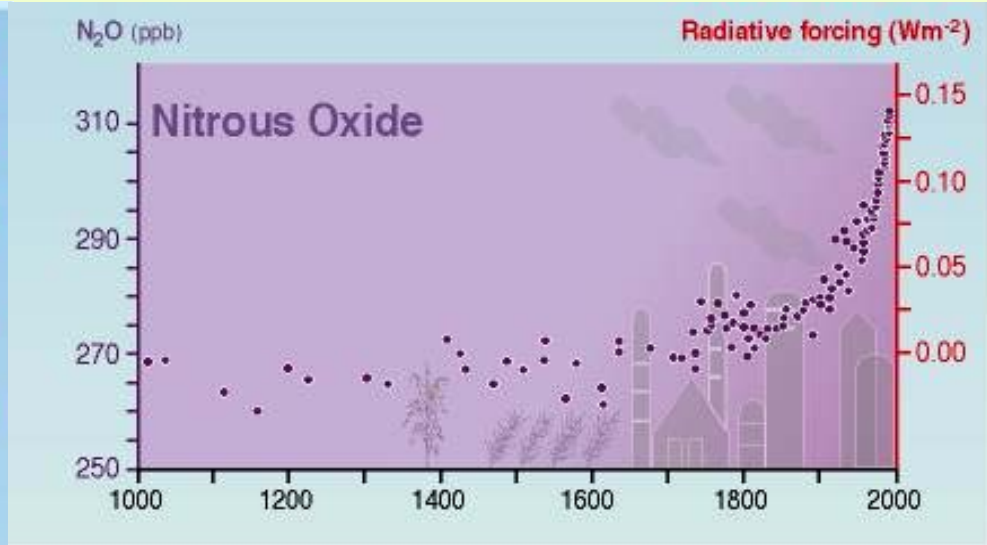
East-phase QBO

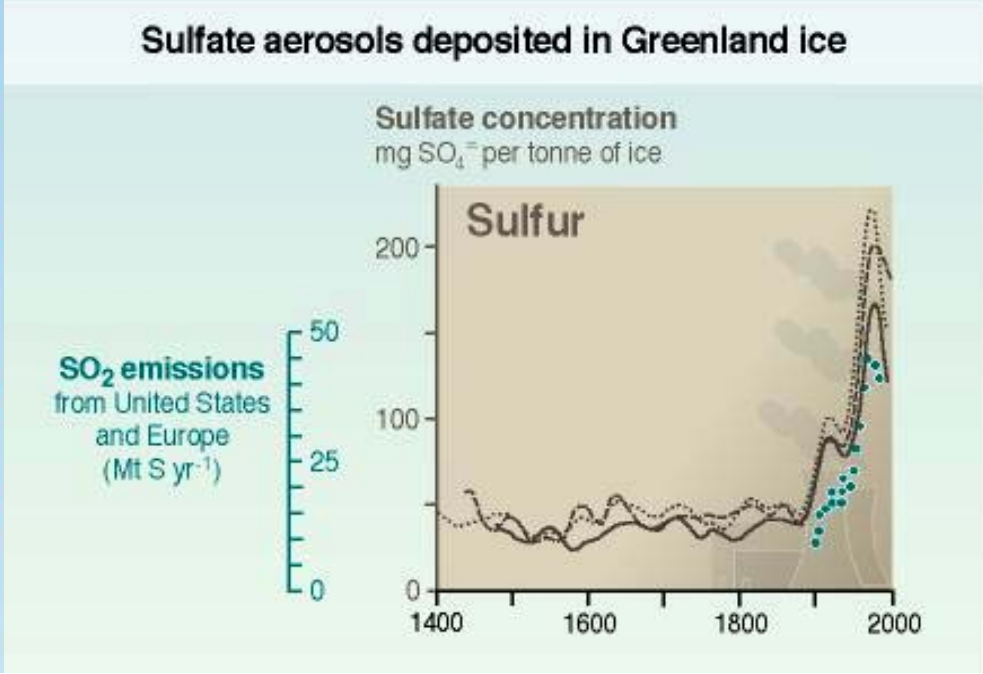
And some more contentious evidence

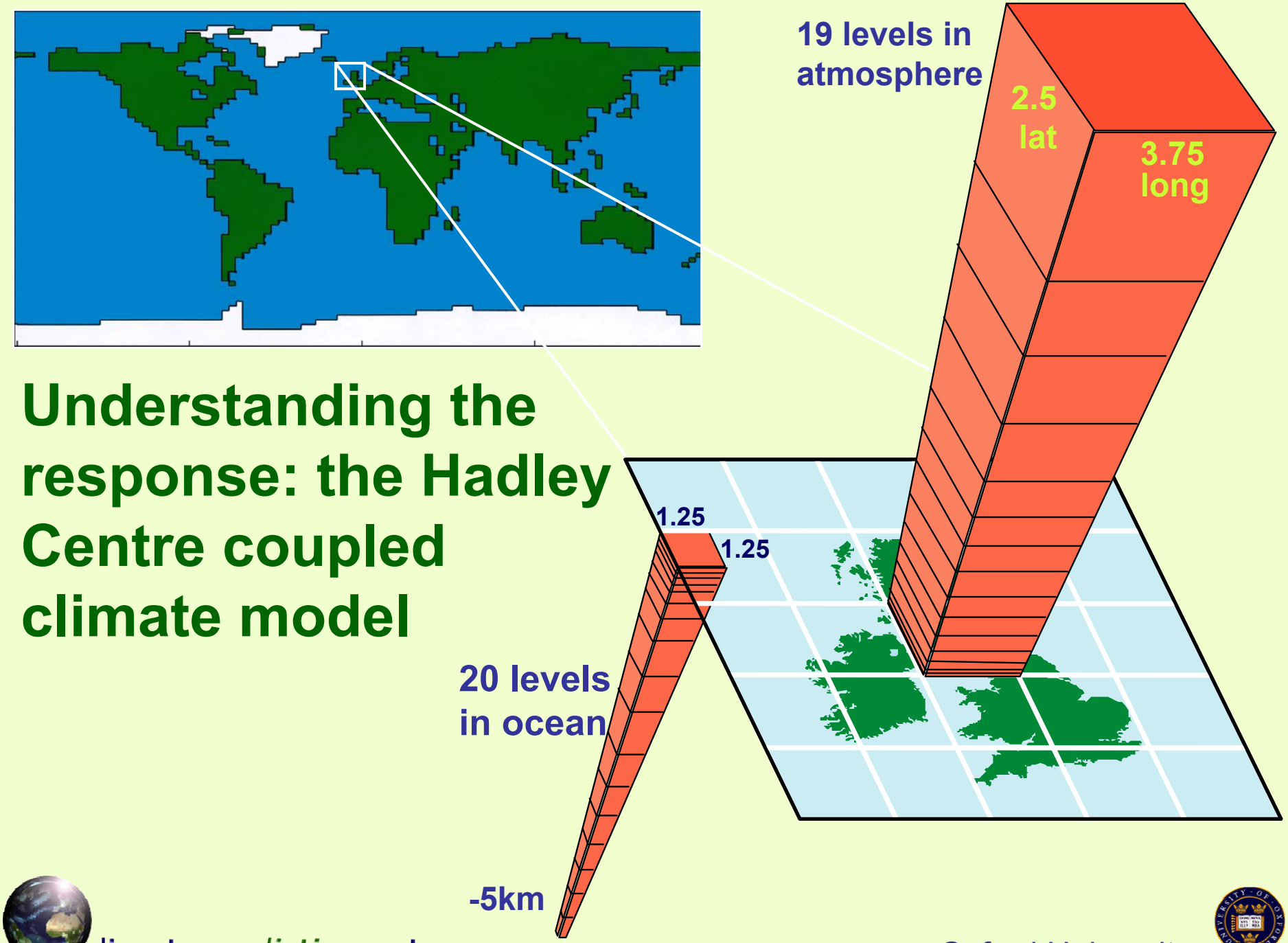


Anthropogenic drivers of climate change









Understanding the response: the Hadley Centre coupled climate model

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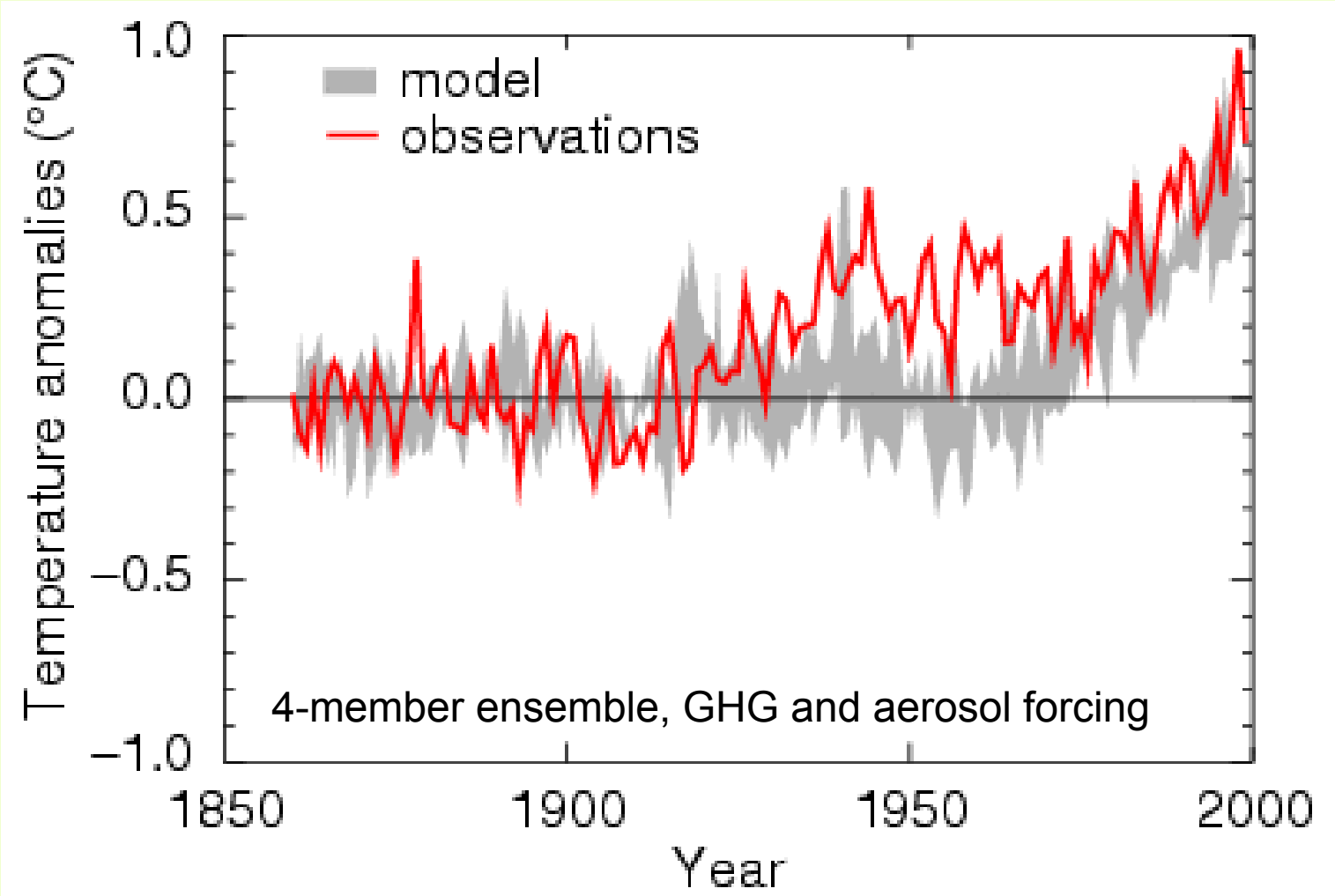
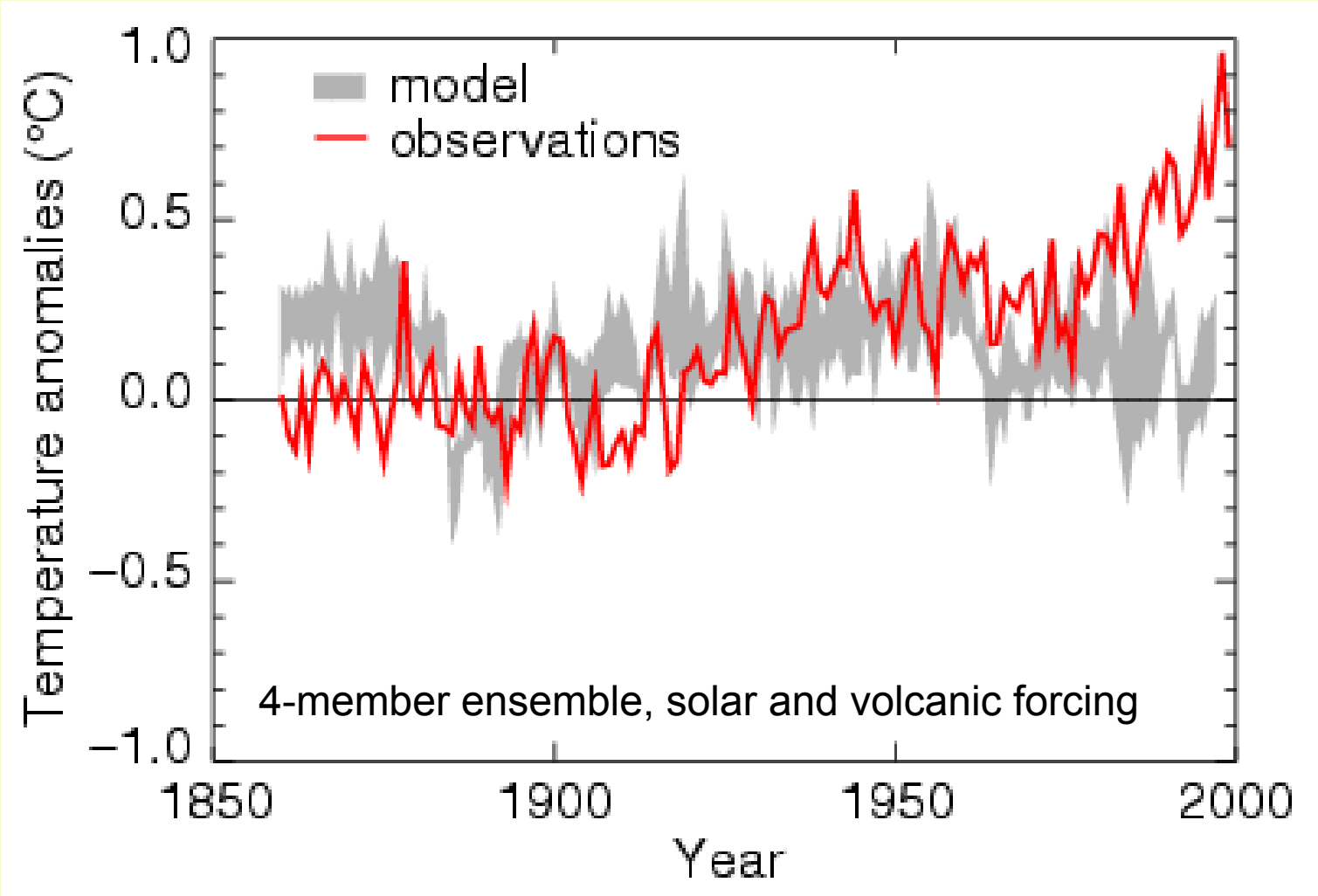
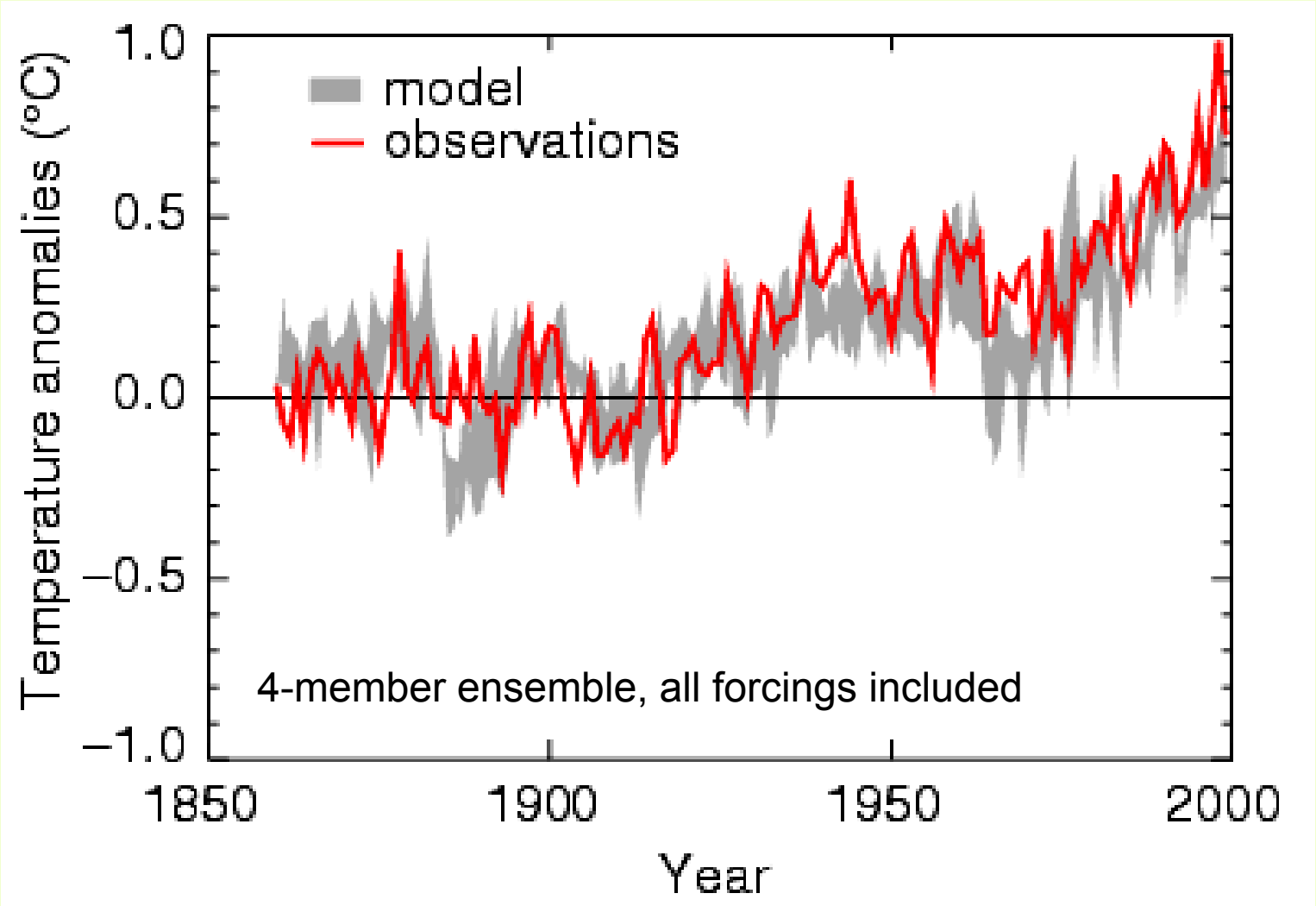
How the drivers add up: anthropogenic sources



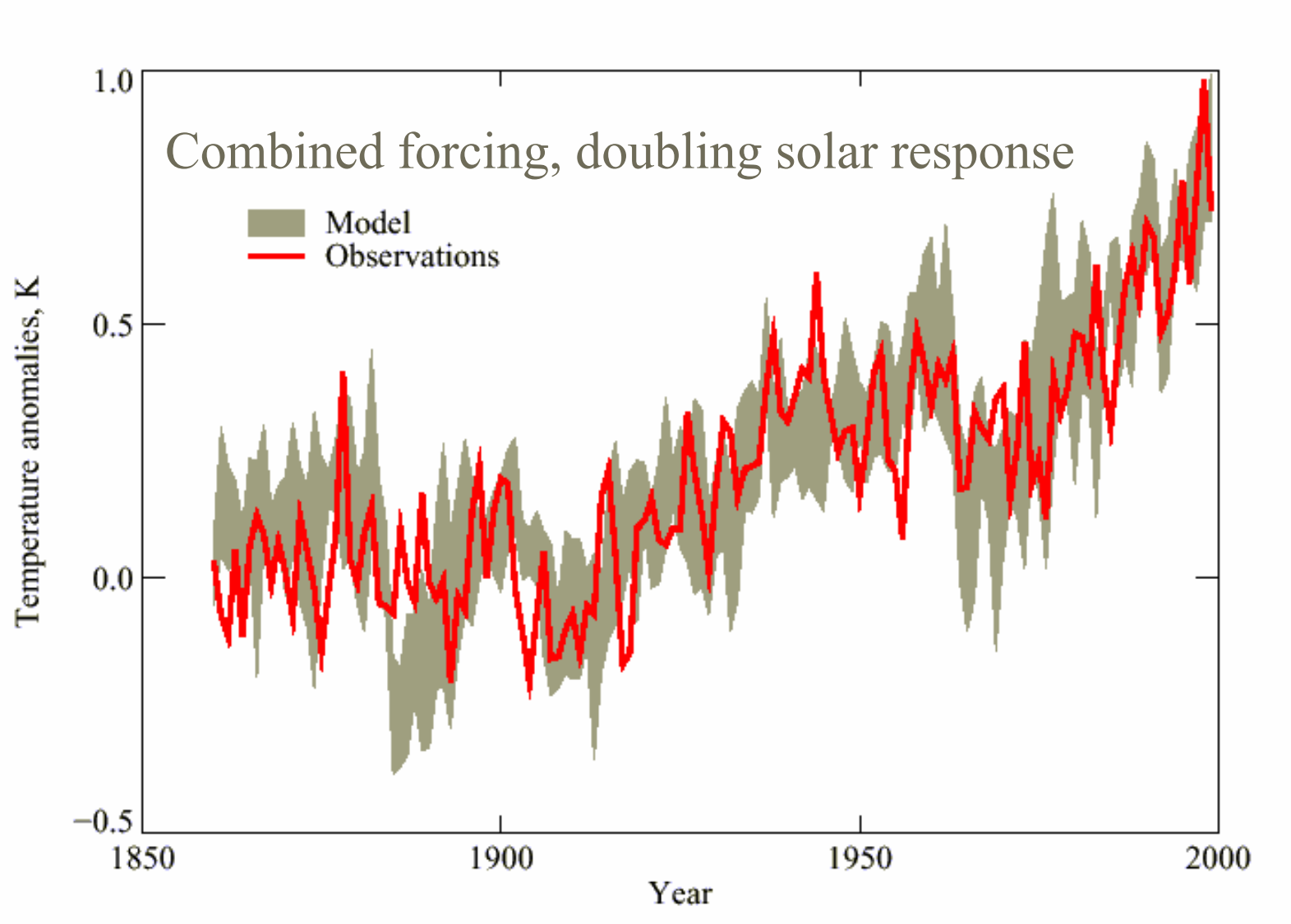
How the drivers add up: natural sources



How the drivers add up: all known sources



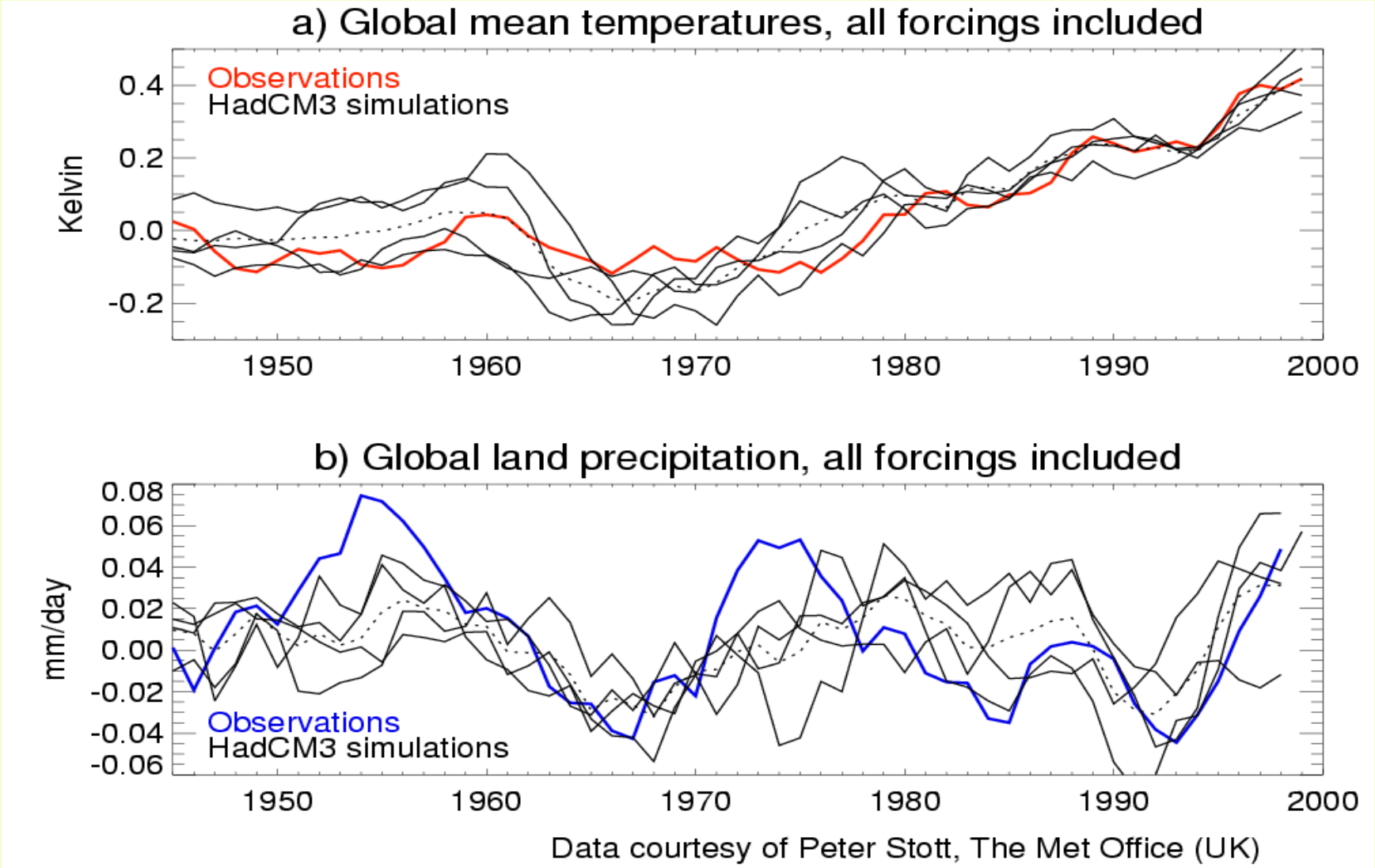
Some evidence that models are underestimating the response to solar variability



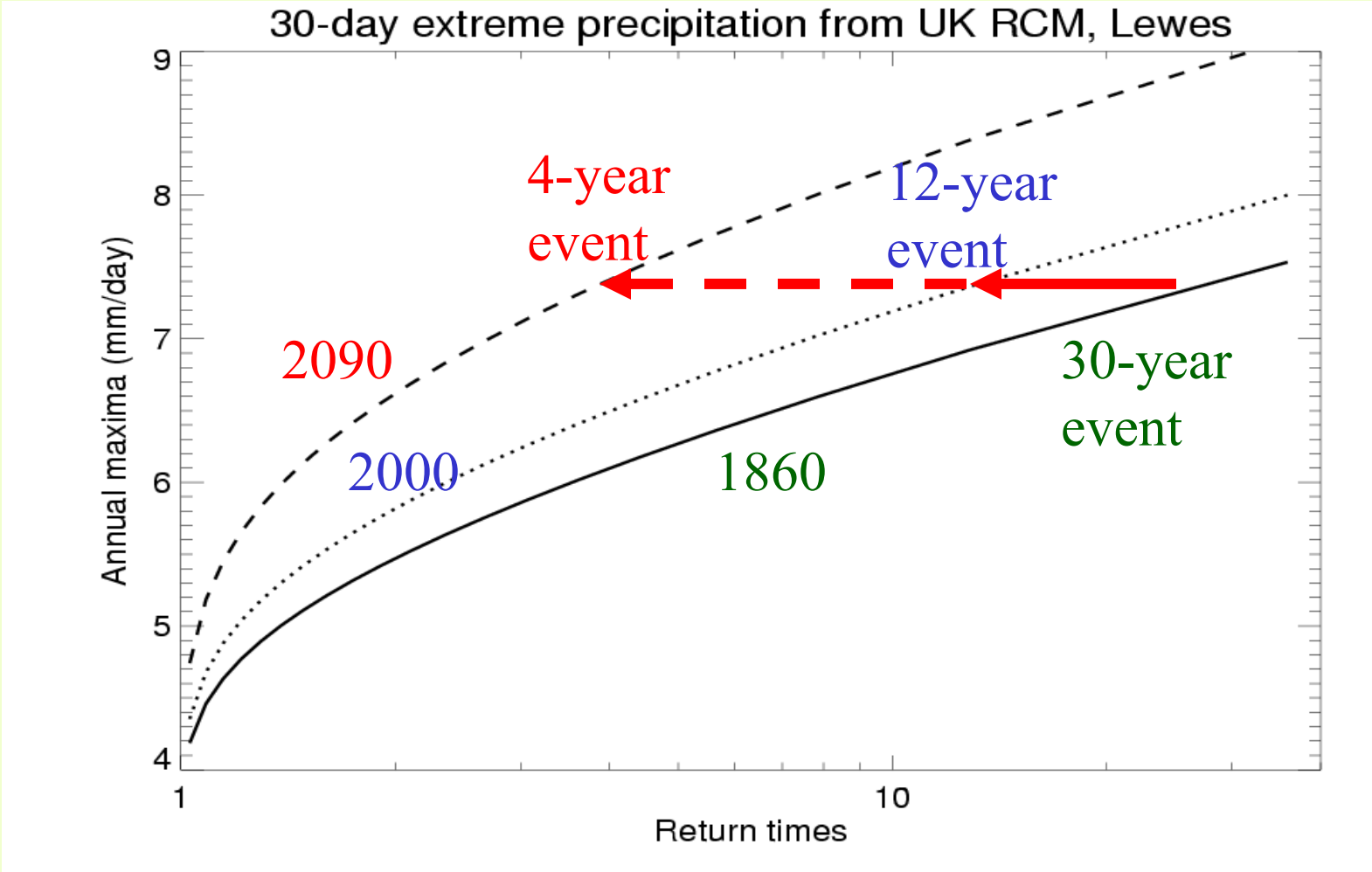
The 2001 conclusions of the Intergovernmental Panel on Climate Change

- **"Most of the warming over the past 50 years is is likely (meaning a better than 2 in 3 chance) to have been due to the increase in greenhouse gas concentrations."**
- **But what does this tell us about flooding in Oxford?**

Some evidence of external influence on mean precipitation



Model-simulated changes in extreme rainfall in southern England



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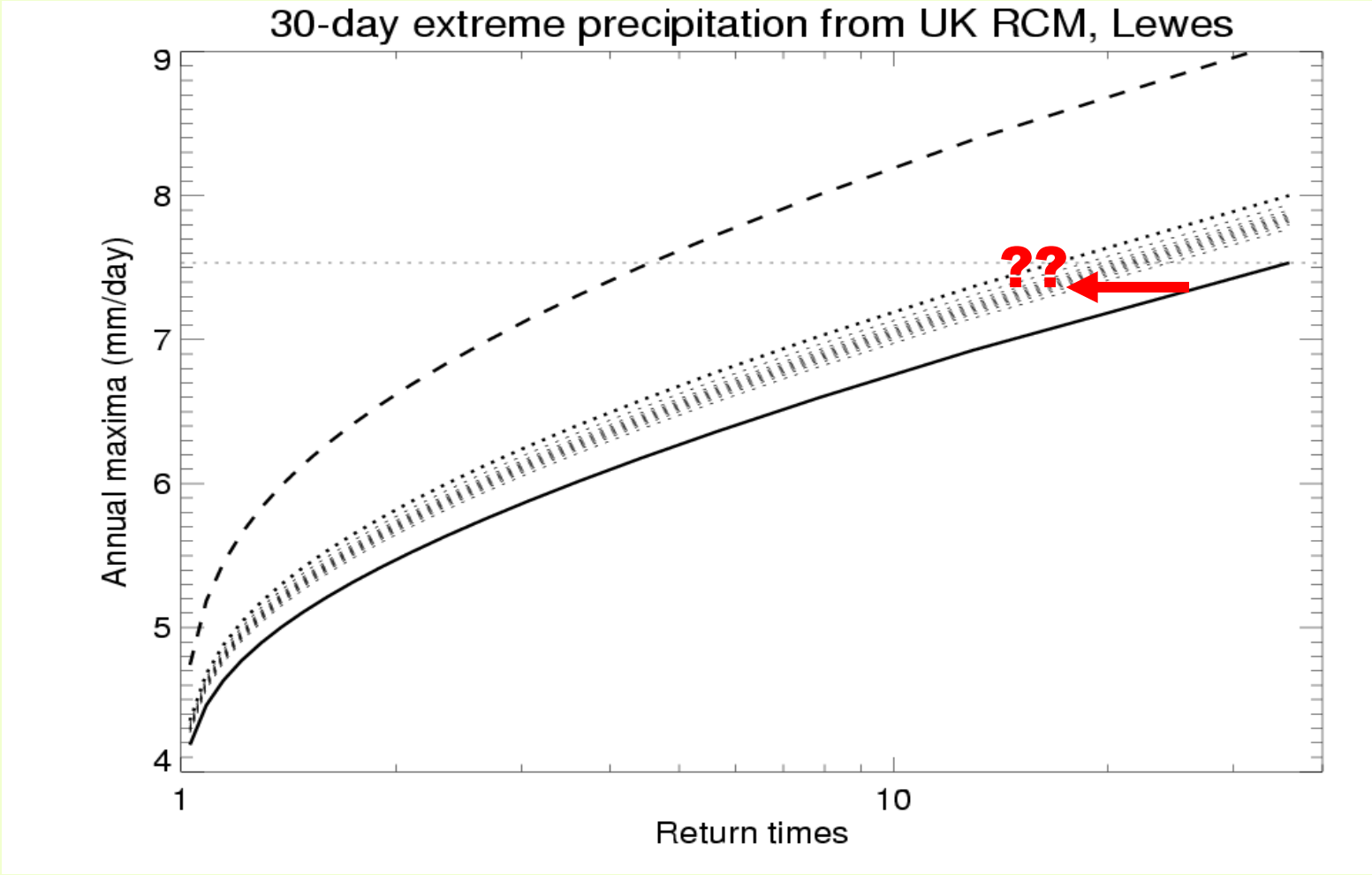
Accounting for uncertainty in global mean response 1860-2000



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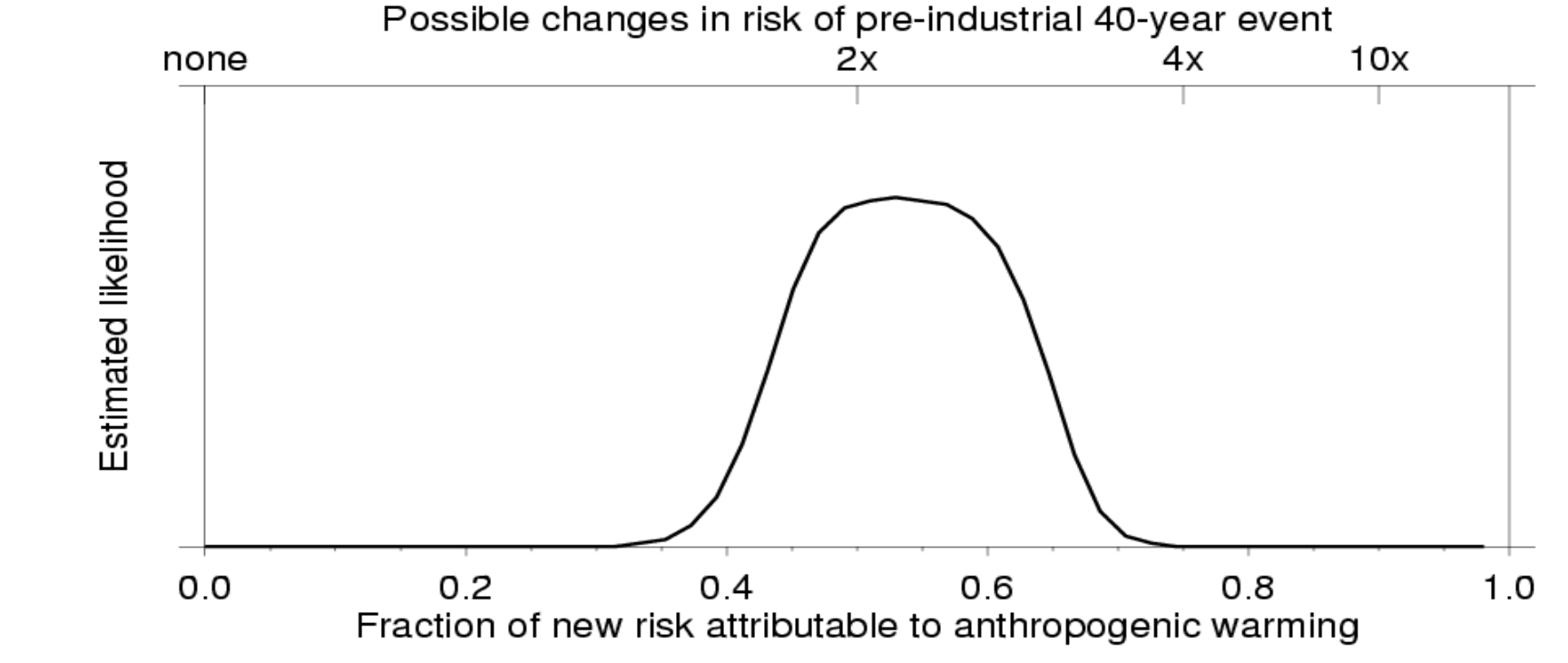
How anthropogenic climate change may have contributed to the risk of the October 2000 floods (but only global response uncertainty)



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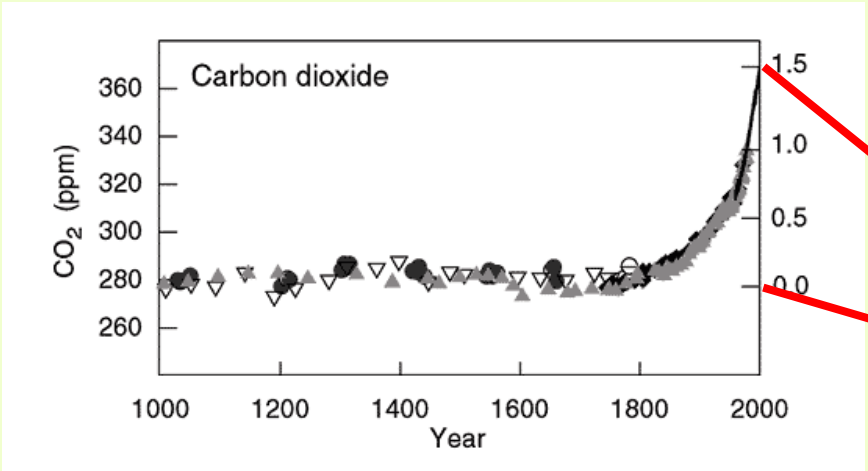
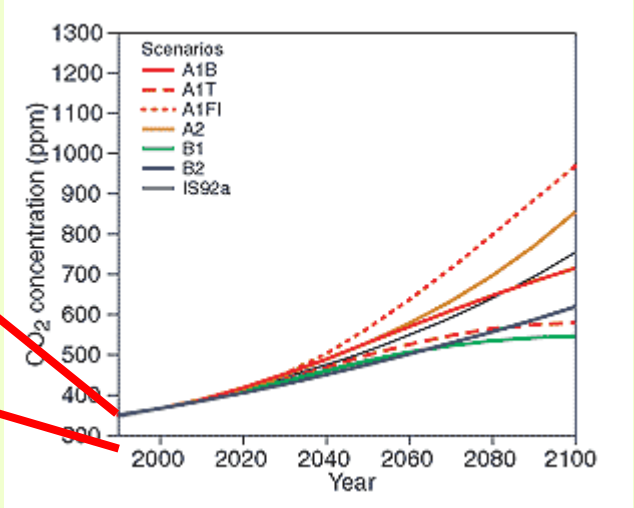
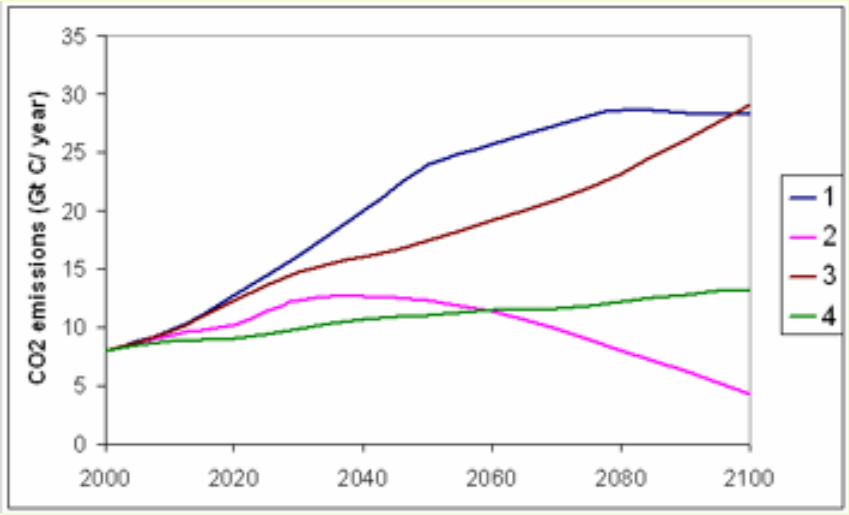
And now for the next 125 years: prospects for the main driver of current climate change

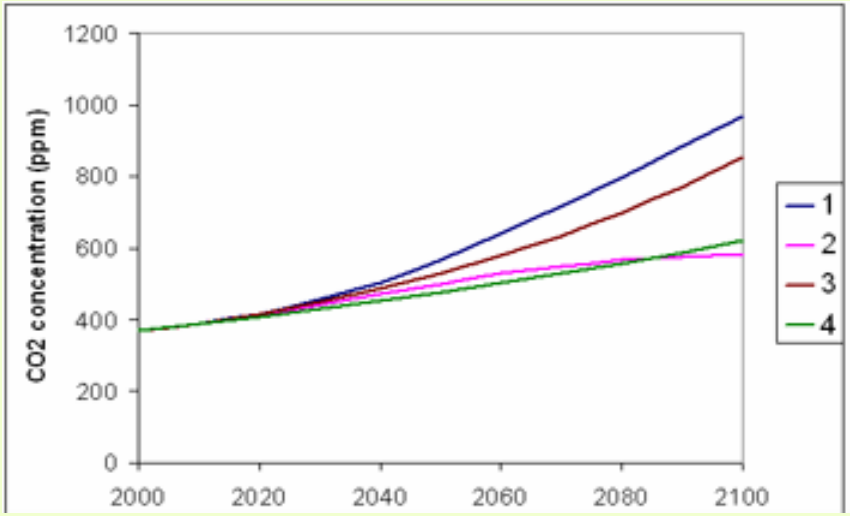




Note different scale! Source: IPCC Third Assessment Report

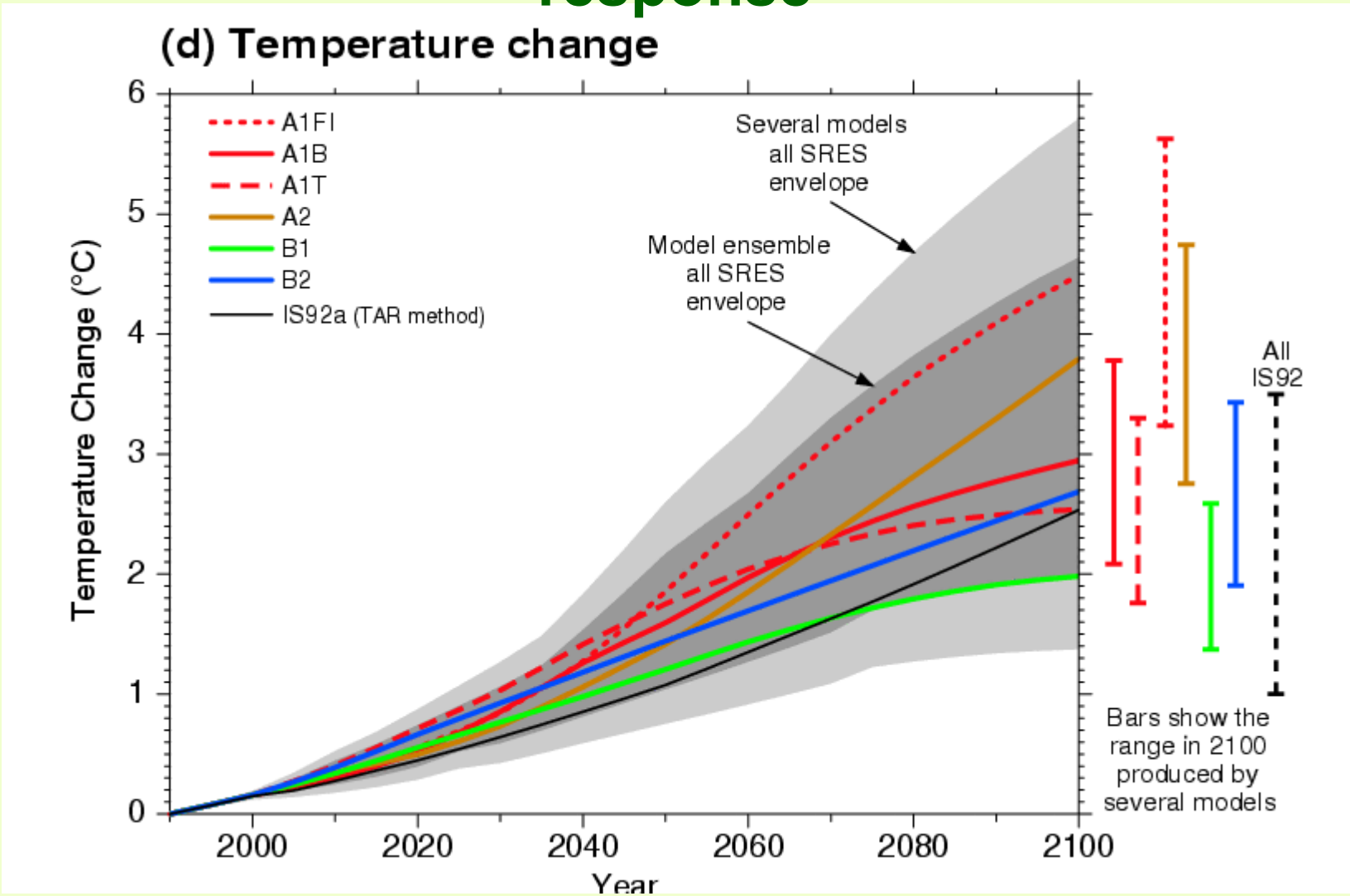
Uncertainty in future greenhouse gas loading





Four scenarios of future greenhouse gas emissions, and Resulting CO_2 concentrations in the atmosphere

And uncertainty in the global temperature response



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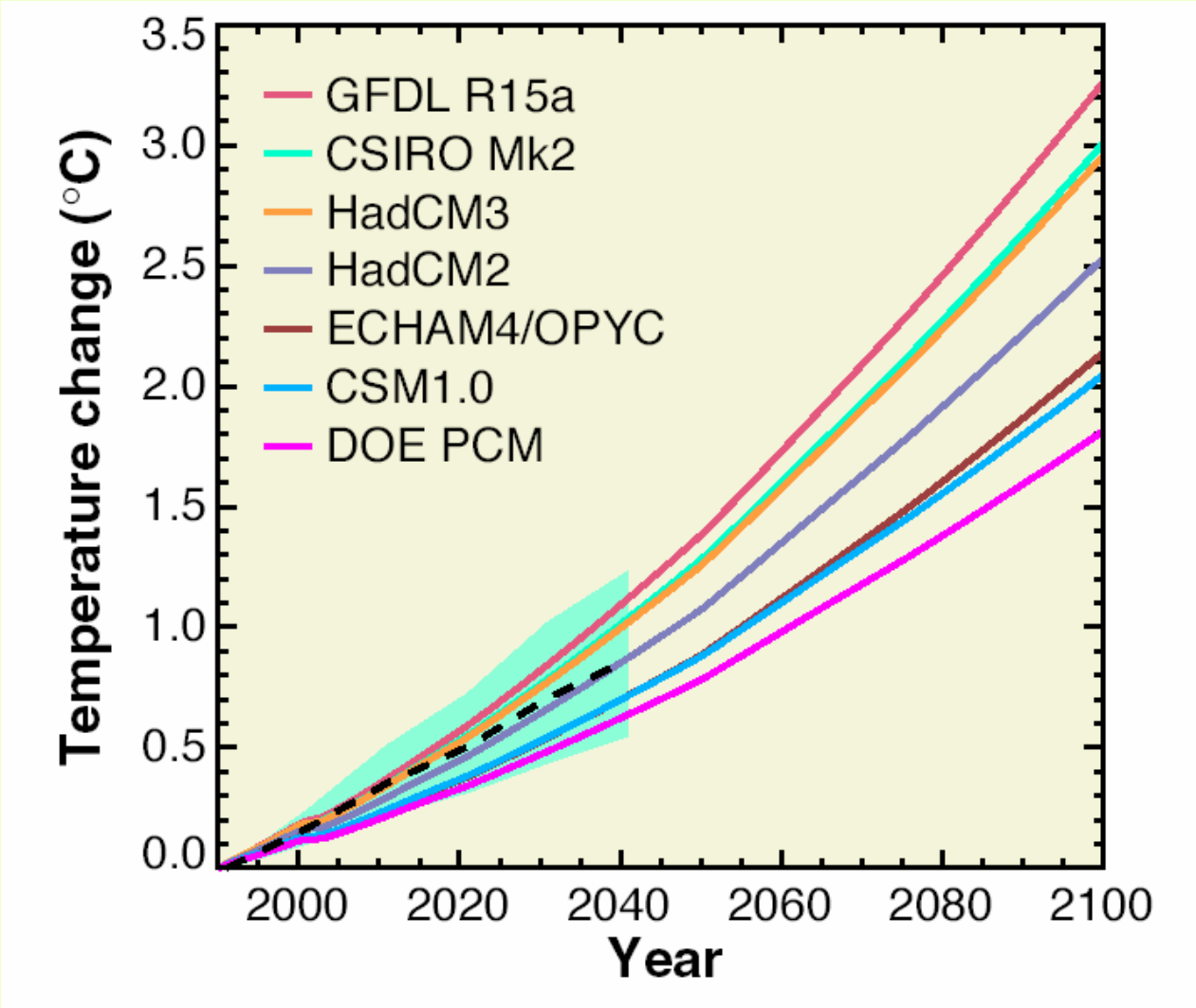
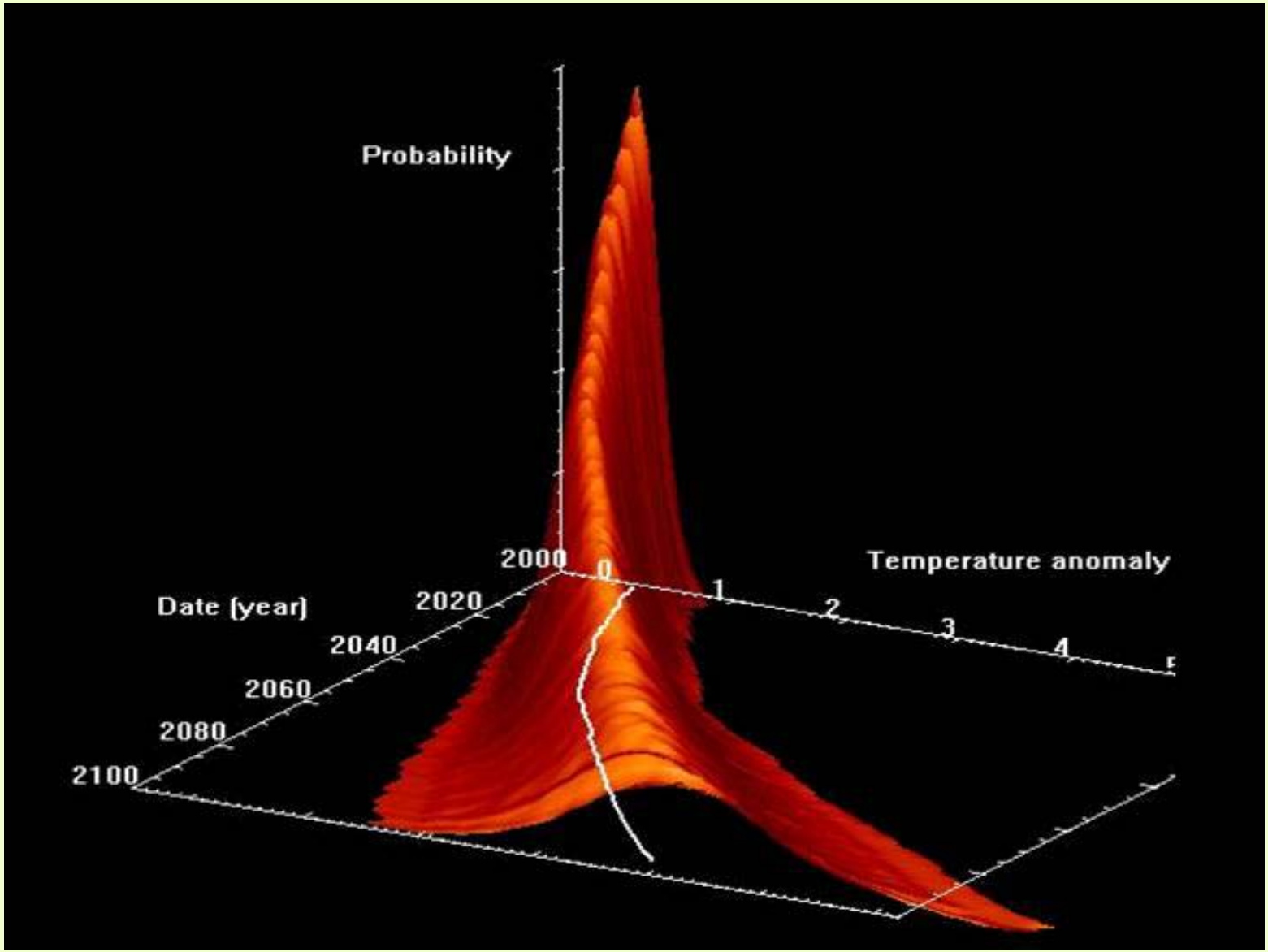
Warming rates under one emissions scenario compared to the responses of several models



Plume shows range consistent with recent observations: Models span c. 10-90% range.

How the probability envelope evolves into the future under one emissions scenario



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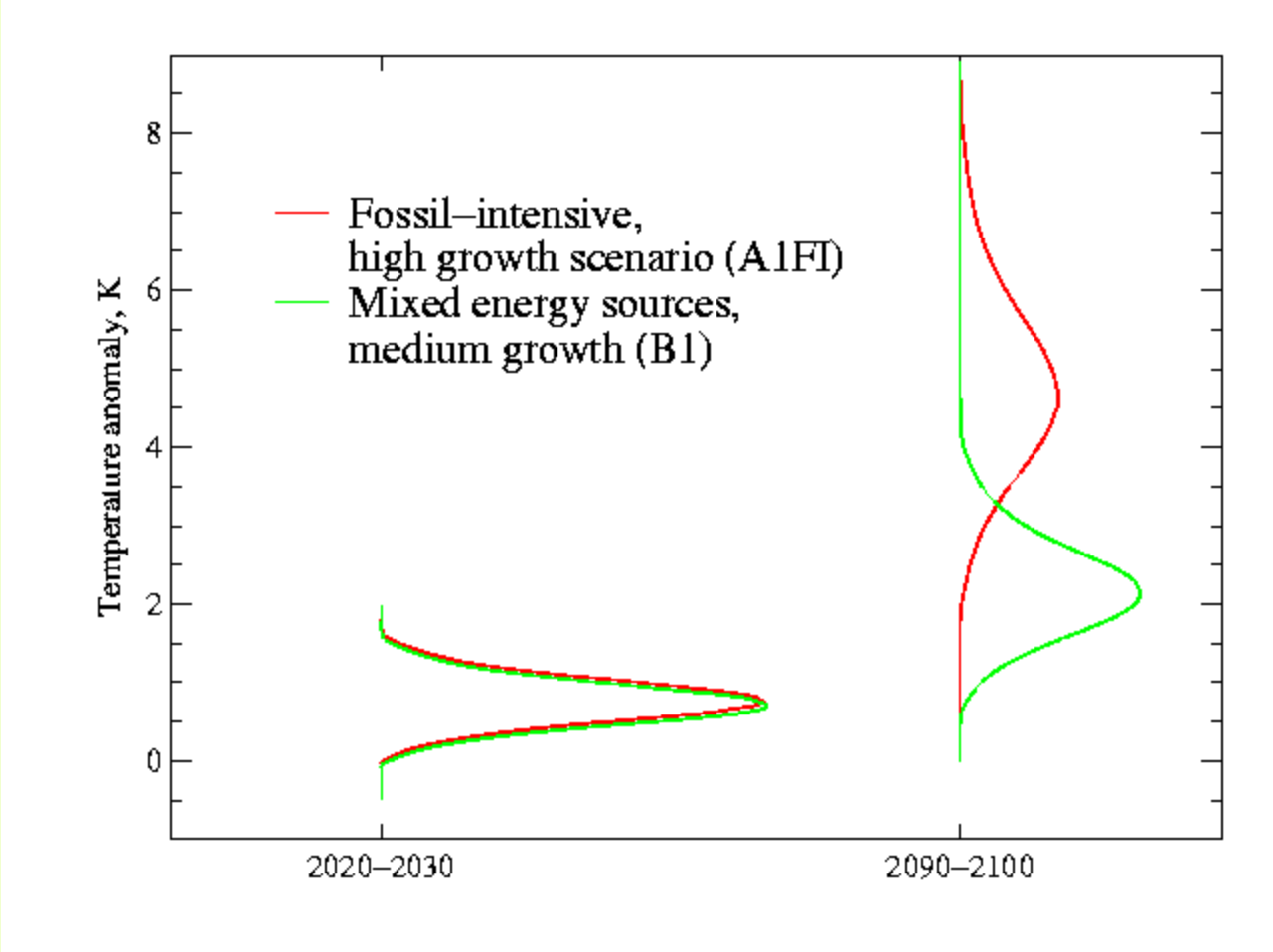
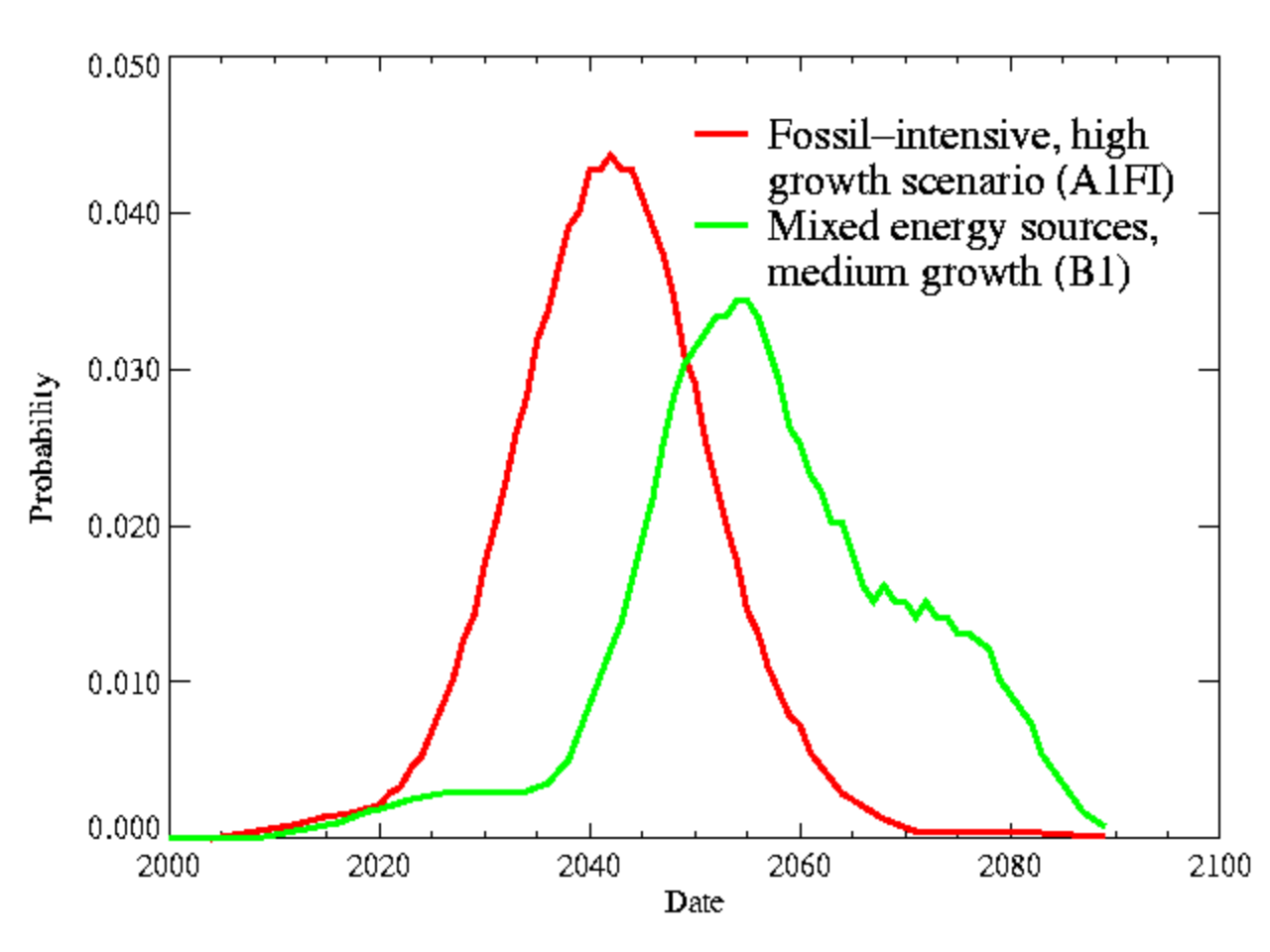
Uncertainty in global warming under two scenarios of future emissions



Changing emission path buys time but does not eliminate risk

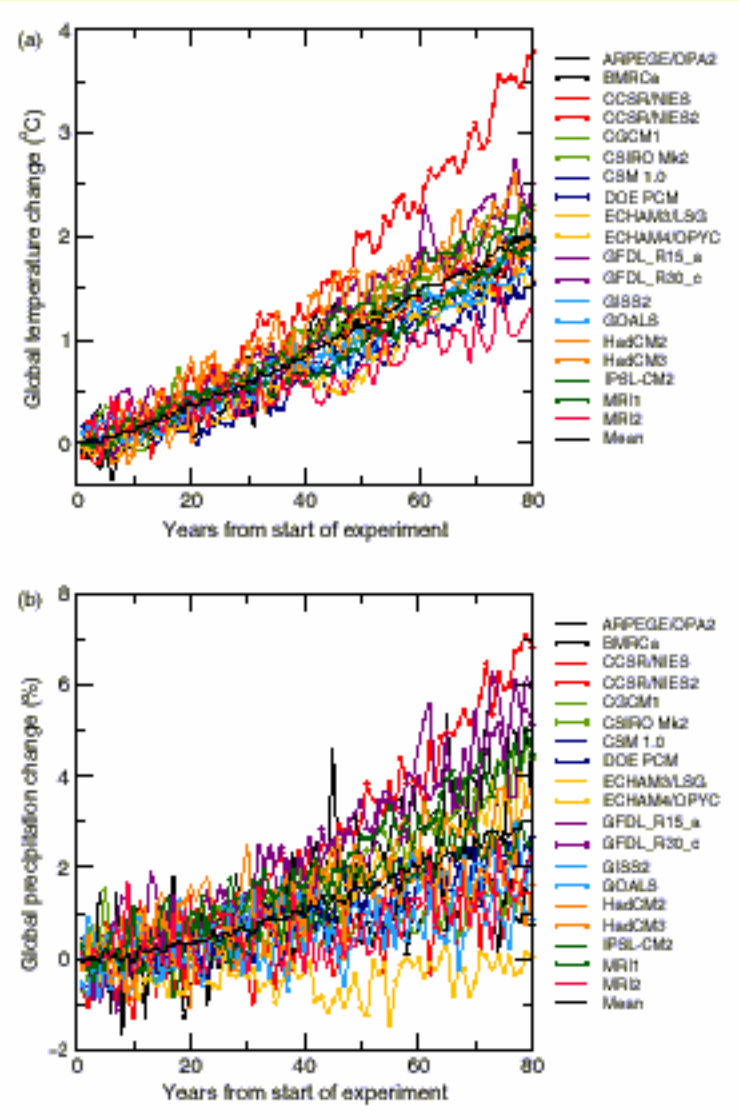


Ranges of uncertainty in more than global temperature require multi-model ensembles

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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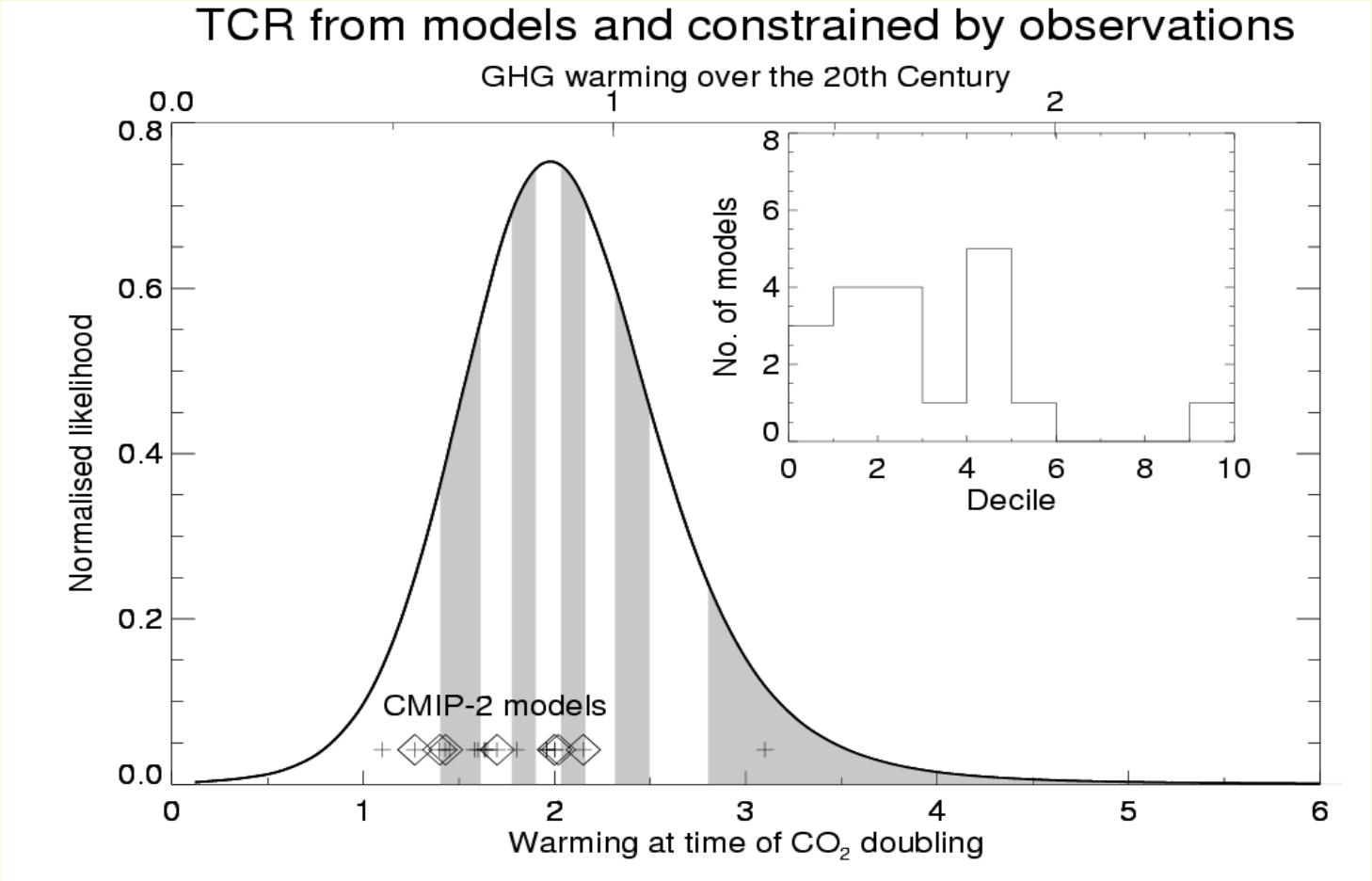
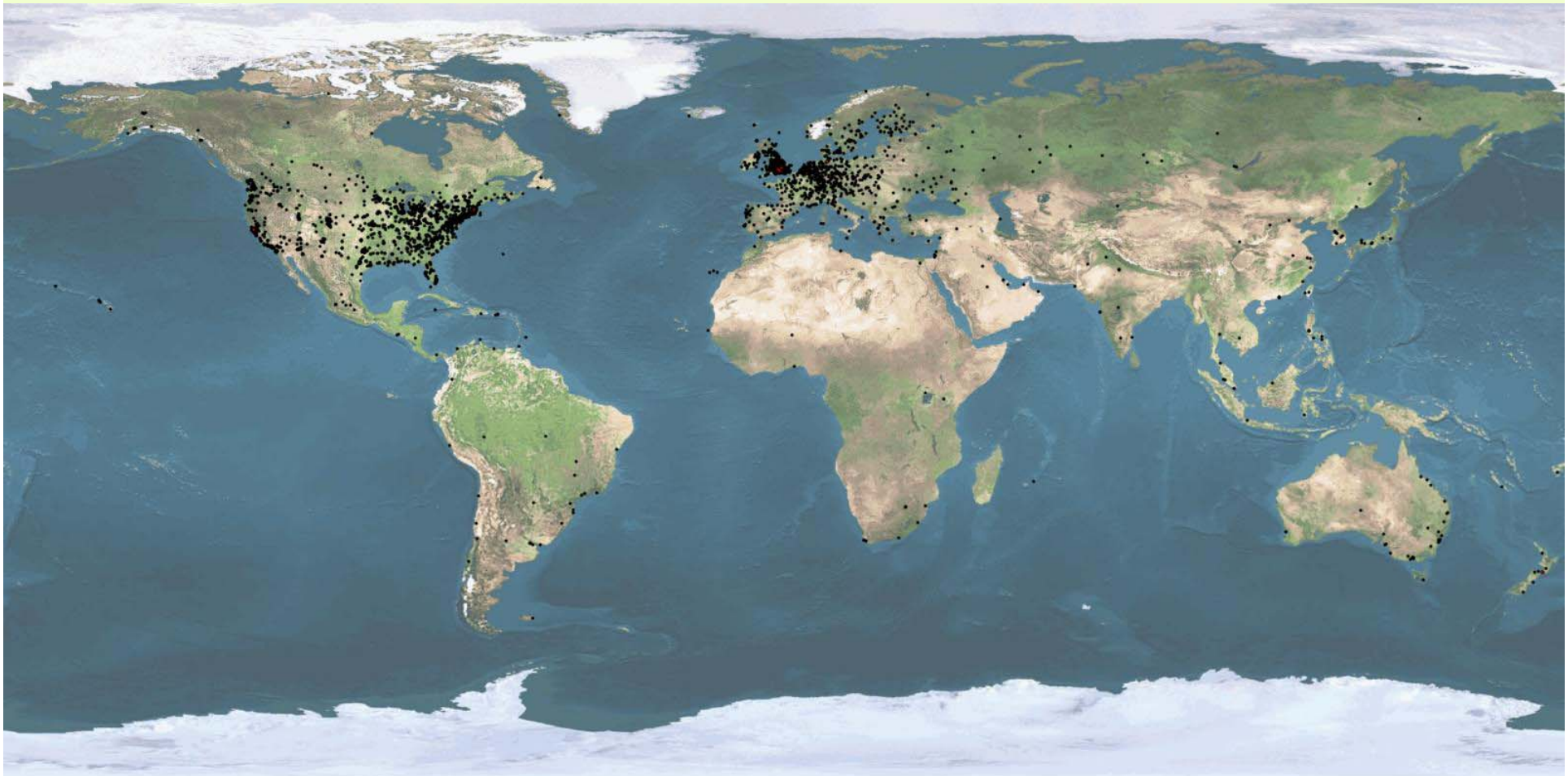
But do available models provide a representative sample of changes consistent with data?



Dealing with uncertainty in modelling climate change

- Climate is predictable, but not directly observable. Weather is observable, but unpredictable.
- Any cause-and-effect statement about climate change involves probabilities: looking at the *spread* of results from lots of climate simulations.
- On long time-scales, simulations must allow for uncertainty in modelling, not just chaotic variability in the atmosphere-ocean system.
- But full-scale climate models are expensive to run: the largest ensembles to date are only 20-50 members…

The world's largest climate modelling experiment: www.climate*prediction*.net



~50,000 volunteers, 130 countries, ~2M GCM-years

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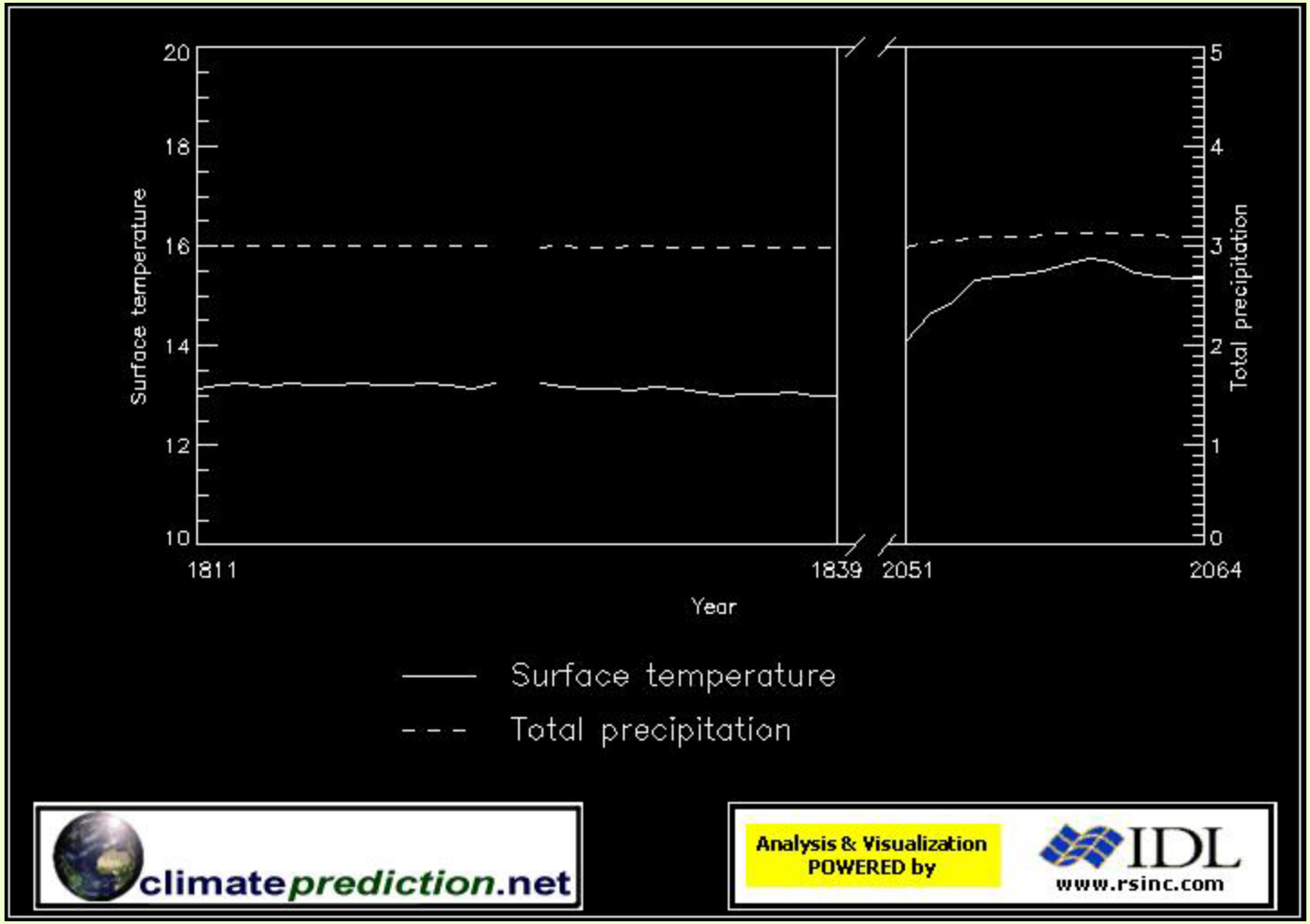
- Launched 12th September, 2003.
- 50,000 participants (c.f. 500,000 on SETI@home); >2M model years simulated (~1.5 Earth Simulators); 25,000 experiments already returned.
- Already demonstrating much richer behaviour than could be explored with in-house ensembles.
- The next step: choose a representative set of models to perform an explicit forecast to 2050.


20
18
16
14
12
10
Surface temperature
5
4
3
2
1
0
Total precipitation
1811
1839
2051
2064
Year
Surface temperature
Total precipitation
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IDL
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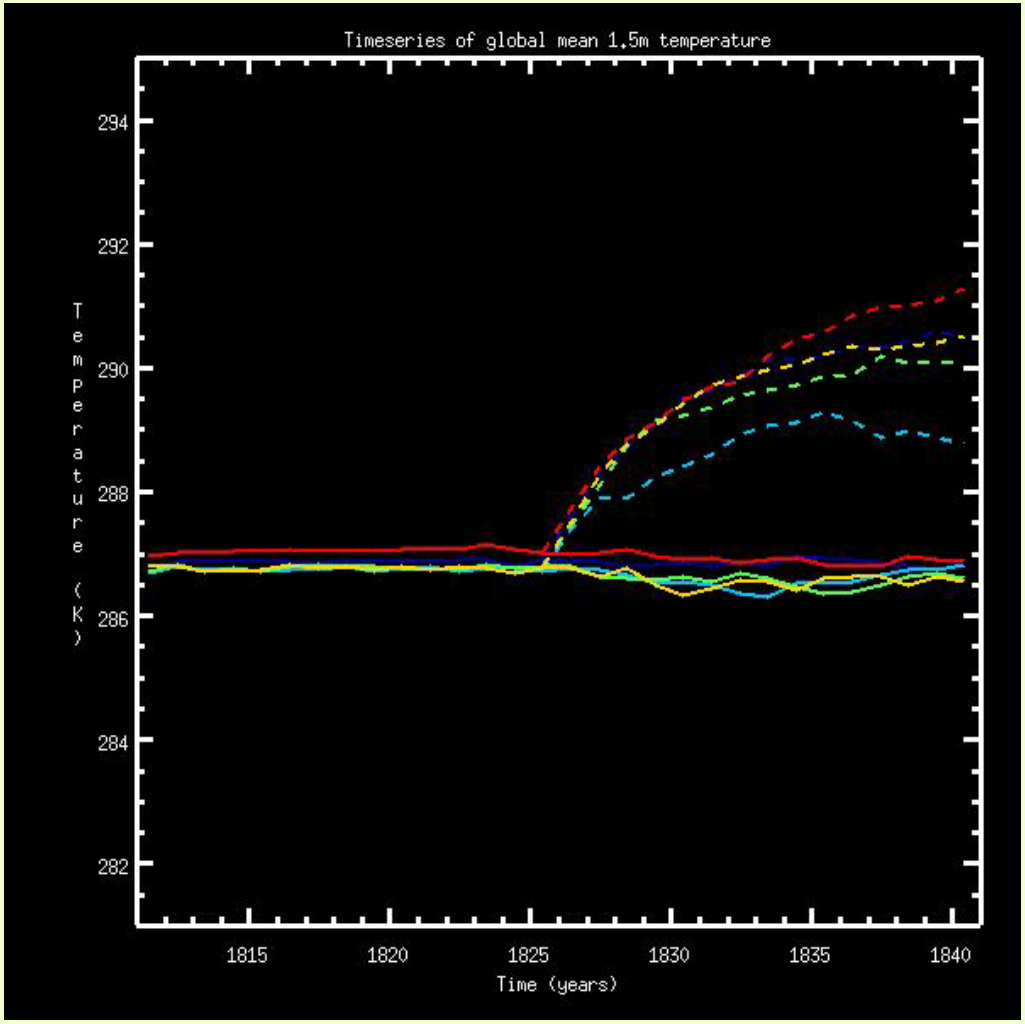

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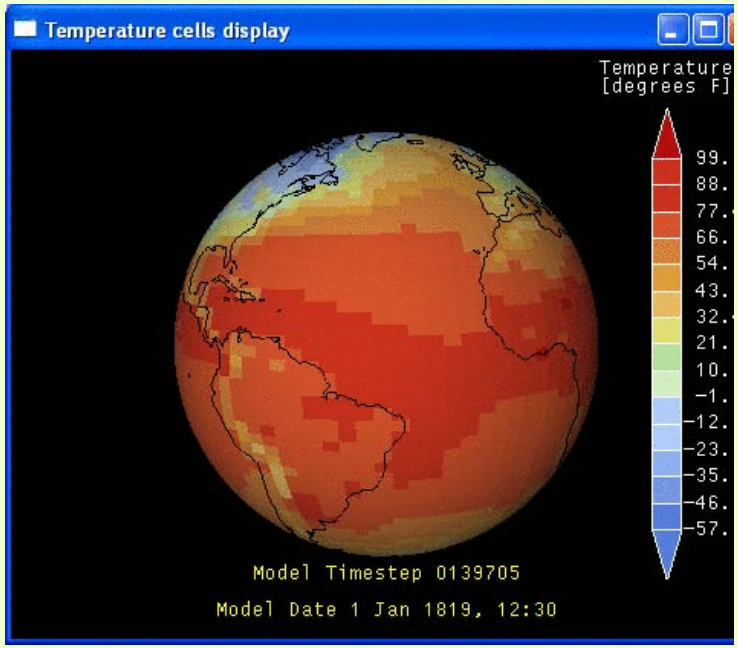
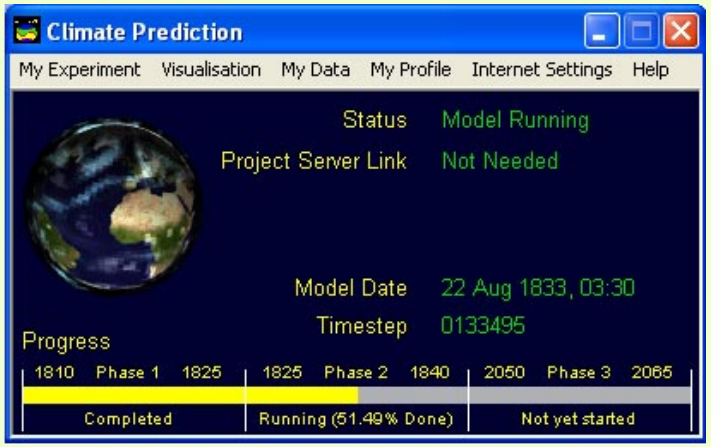
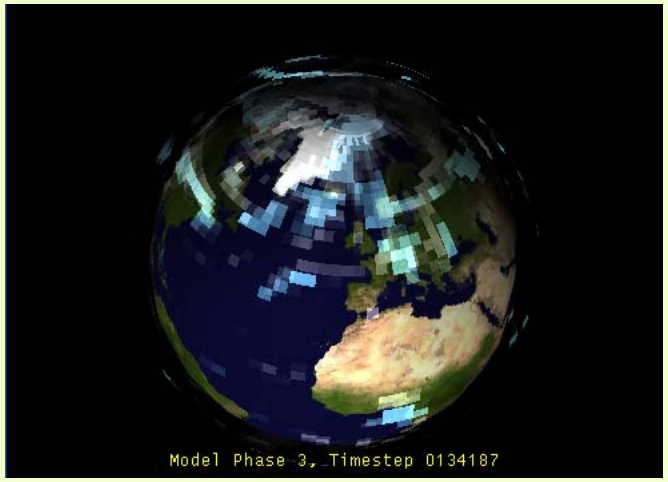
Standard Visualisation Package







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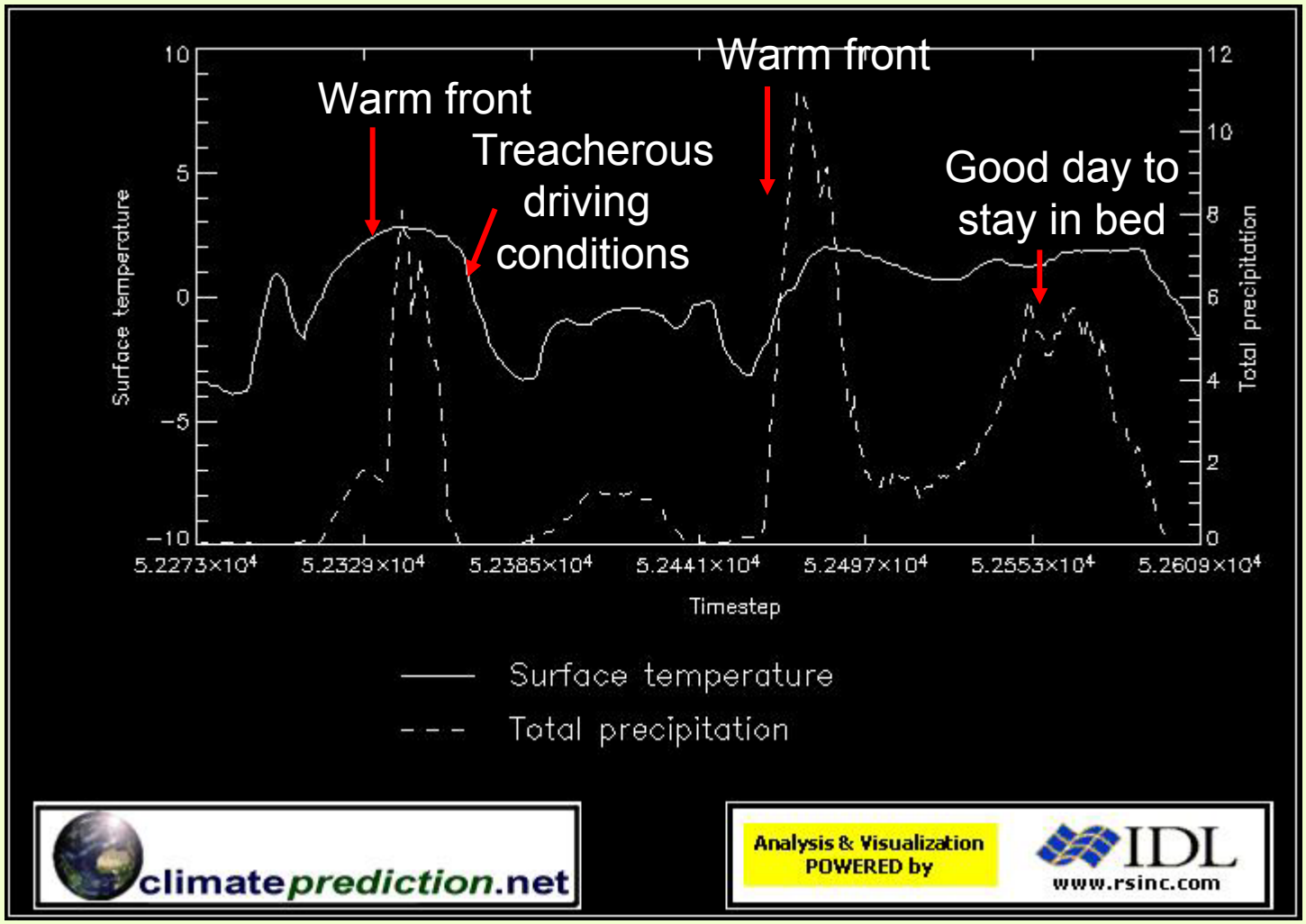
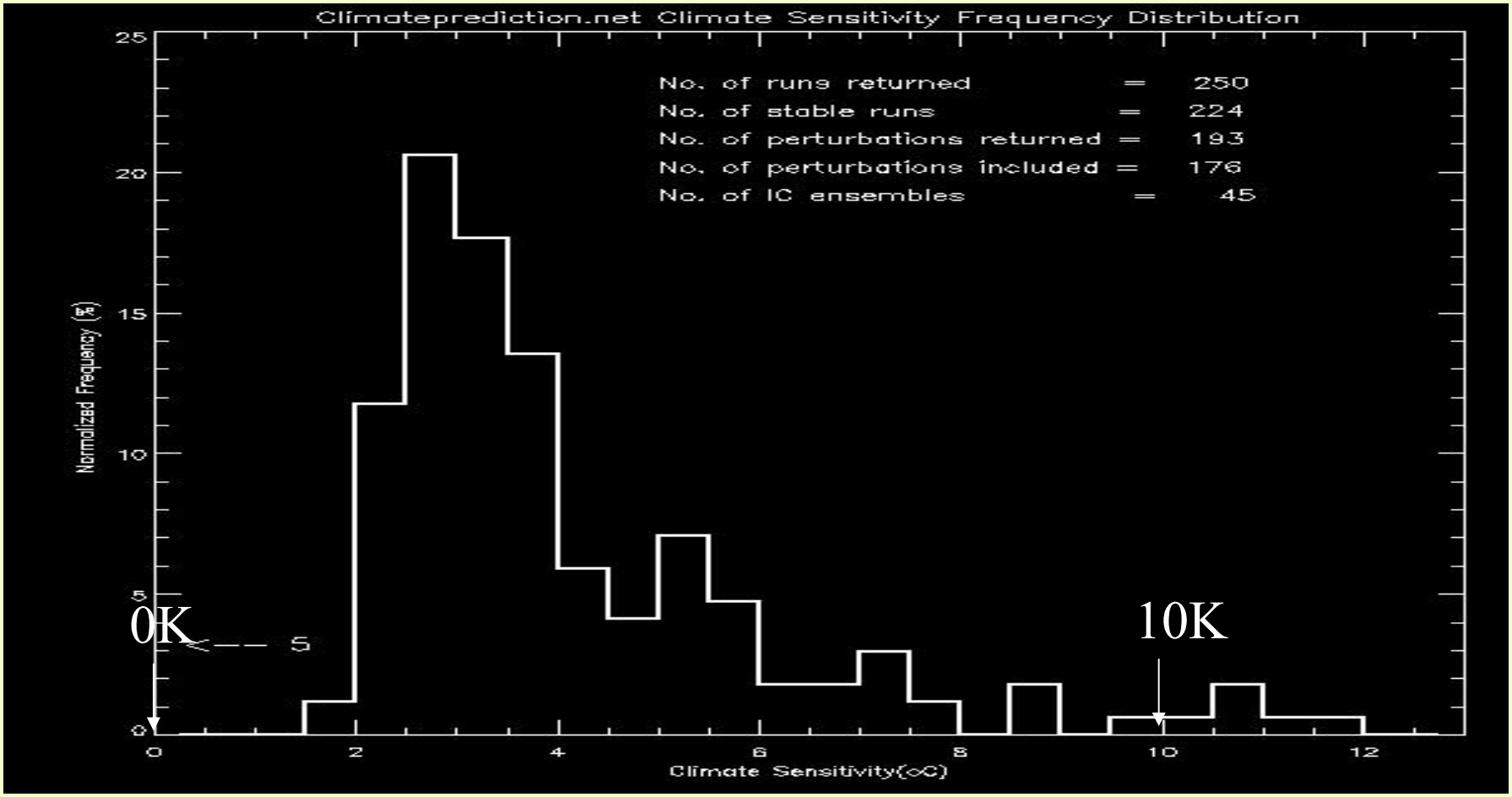


11th-18th December 1828, London

Initial results: a broad range of sensitivities



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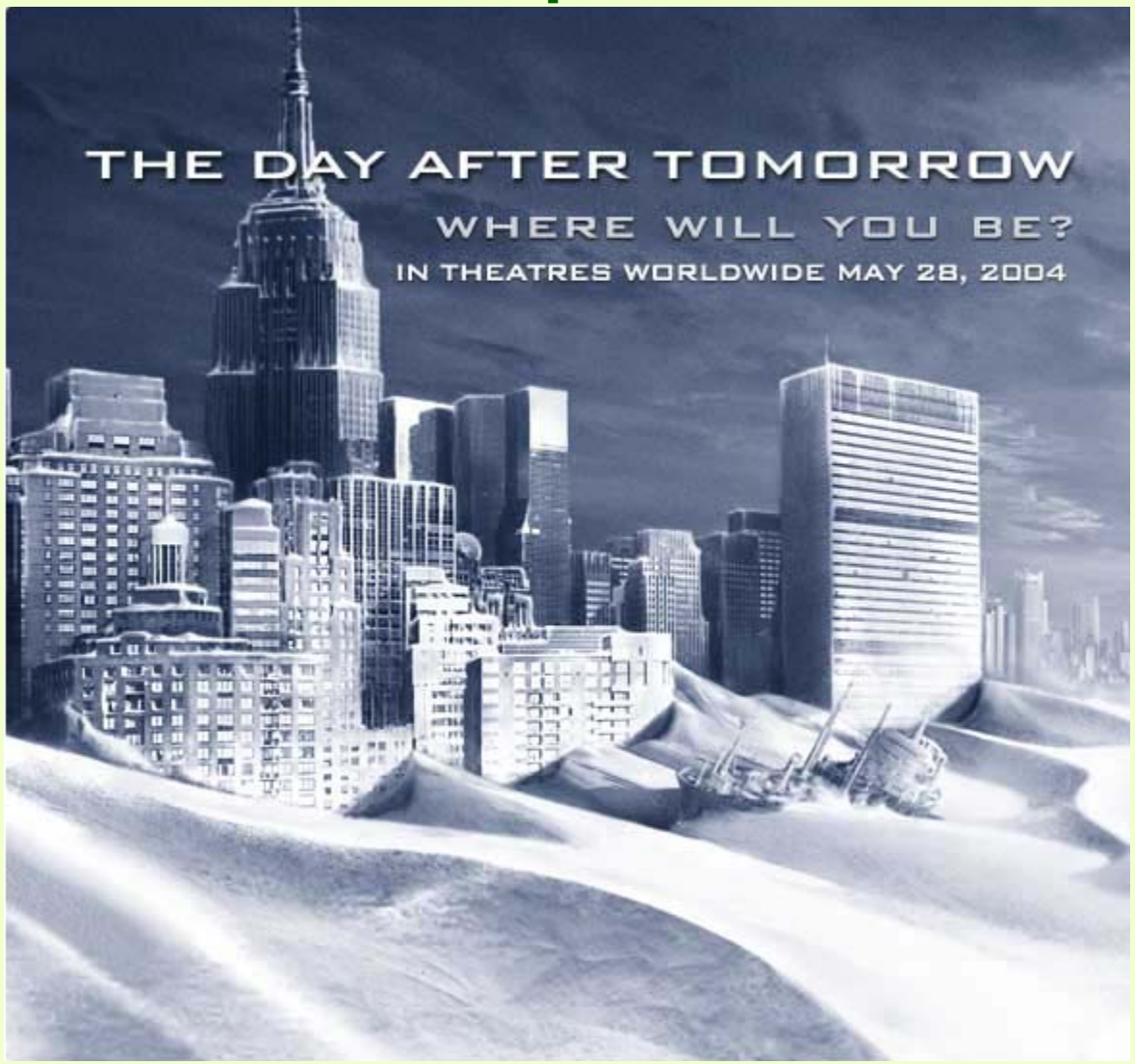
www.climate*prediction*.net next steps

- Choose a representative set of models to perform an explicit forecast to 2050.
- Must explore range of responses to CO_2, but also range of atmosphere responses to ocean changes.
- Launched last week: new experiment exploring the atmospheric response to a slowdown in the North Atlantic overturning circulation.

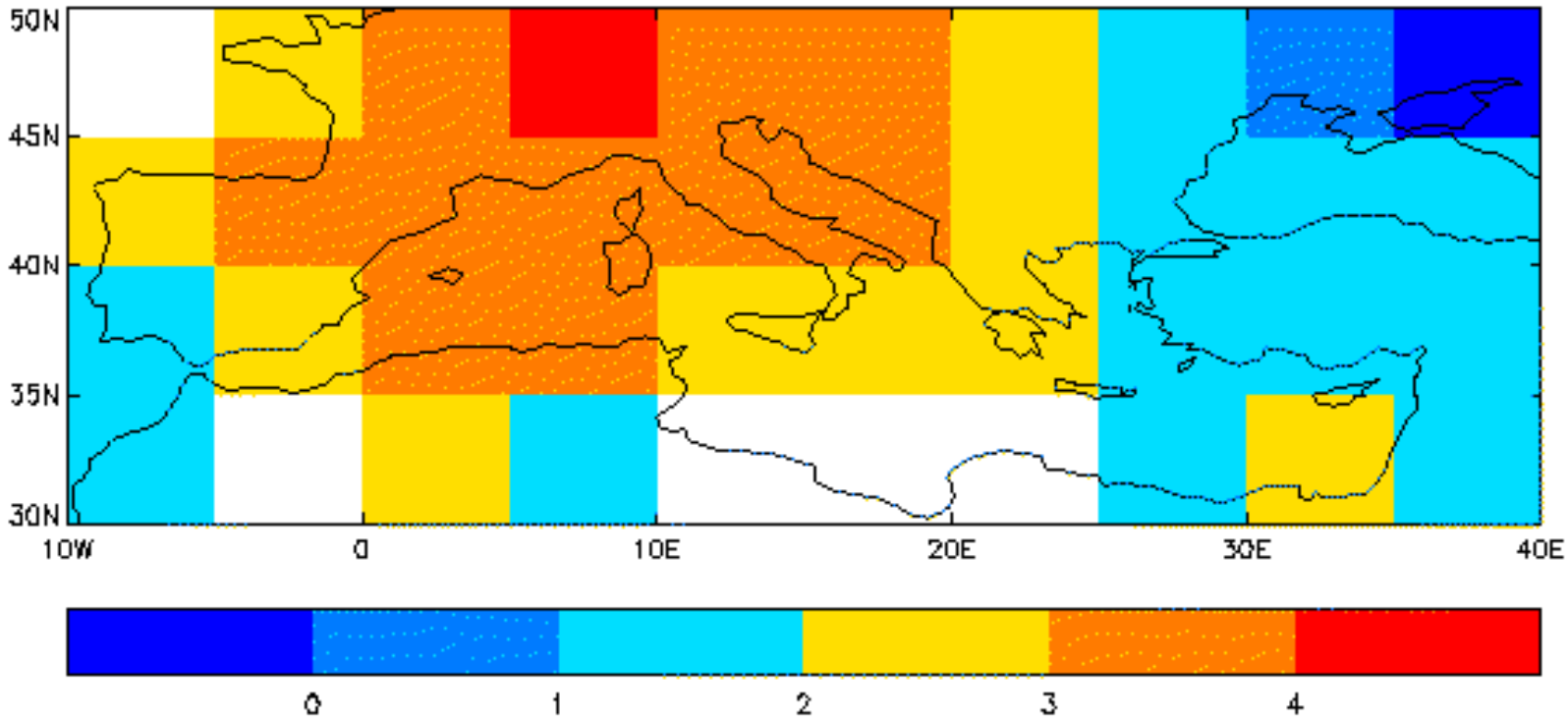
Not many of the models do this, but that's kind of the point…



So what are the most important uncertainties in climate prediction?

- For global temperatures, response uncertainty dominates next few decades, with emissions scenario playing a larger role only the the second half of the 21st century.
- For regional changes and specific risks, local chaotic variability will play a larger role, but ranges still not quantified.
- So what do I think is going to happen to emissions?

June-August temperatures in 2003, relative to 1961-90 mean, in Mediterranean region



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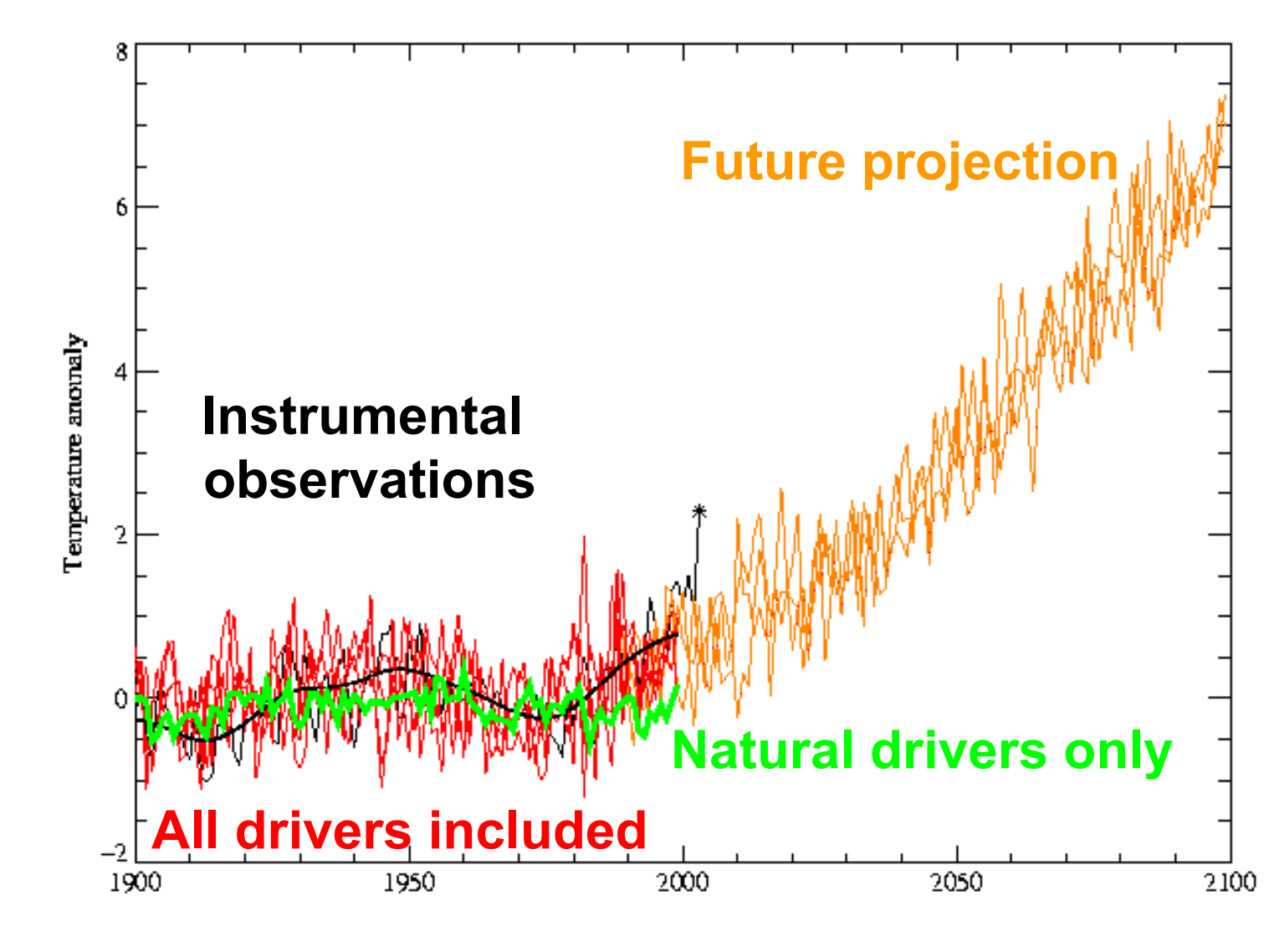
Modelling Southern European summer temperatures



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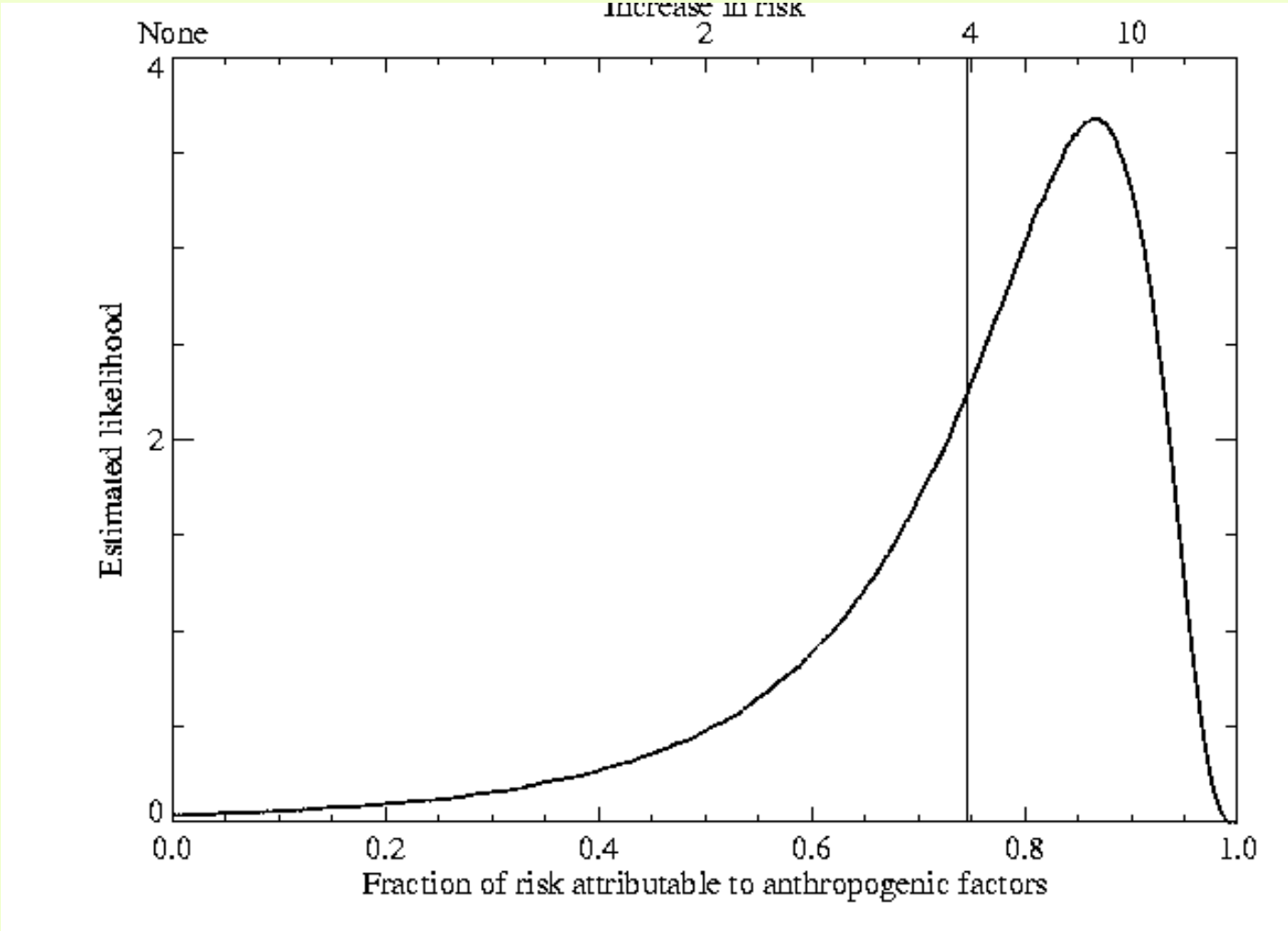
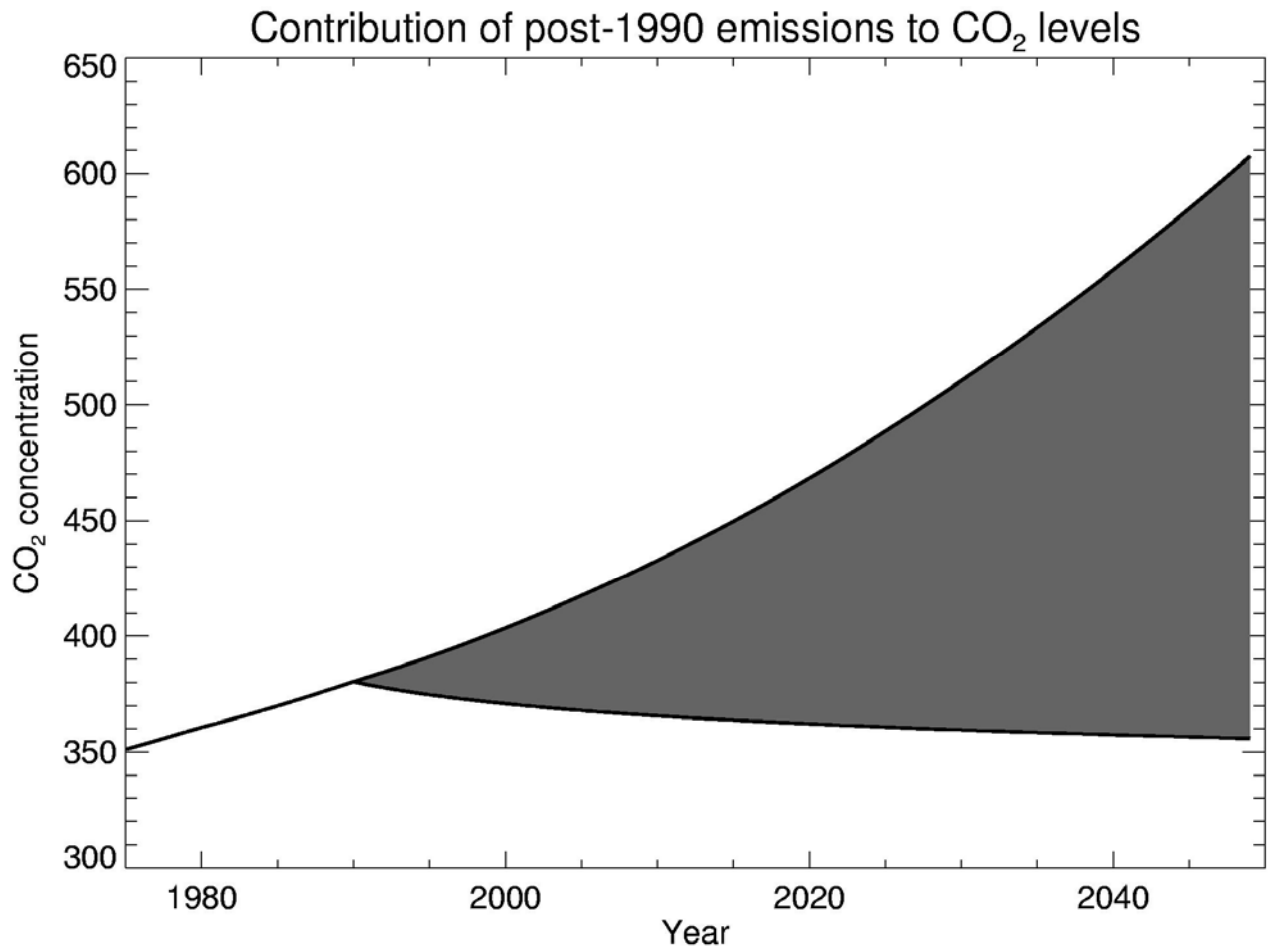
Human contribution to the risk of the 2003 heatwave



Why this matters

- We (Stott, Stone & Allen) estimate that there is a better than 9 in 10 chance that past human influence has more than doubled the risk of a heatwave equal or greater than the summer of 2003.
- "Plaintiffs ... must show that, more probably than not, their individual injuries were caused by the risk factor in question, as opposed to any other cause. This has sometimes been translated to a requirement of a relative risk of at least two." (Grossman, 2003)

By the 2030s, >50% of anthopogenic GHG loading will be due to post-1990 emissions



Why I think greenhouse gas emissions may come down faster than Kyoto progress indicates

- Contribution of past GHG emissions to some current climate risks may already exceed 50%, the threshold for civil tort actions.
- Over the coming decade, both the cost and inevitability of climate change will become much clearer, fuelling demands for compensation.
- Both plaintiffs (insurance companies & property owners) and defendants (energy companies) have very deep pockets.
- The risk, even quite remote, of a successful class-action suit would have far more impact than any conceivable intergovernmental negotiation.