

**Will we ever be able to attribute
individual weather events to
anthropogenic climate change?**

March, 2003

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South Oxford on January 5th, 2003



Photo courtesy of Dave Mitchell

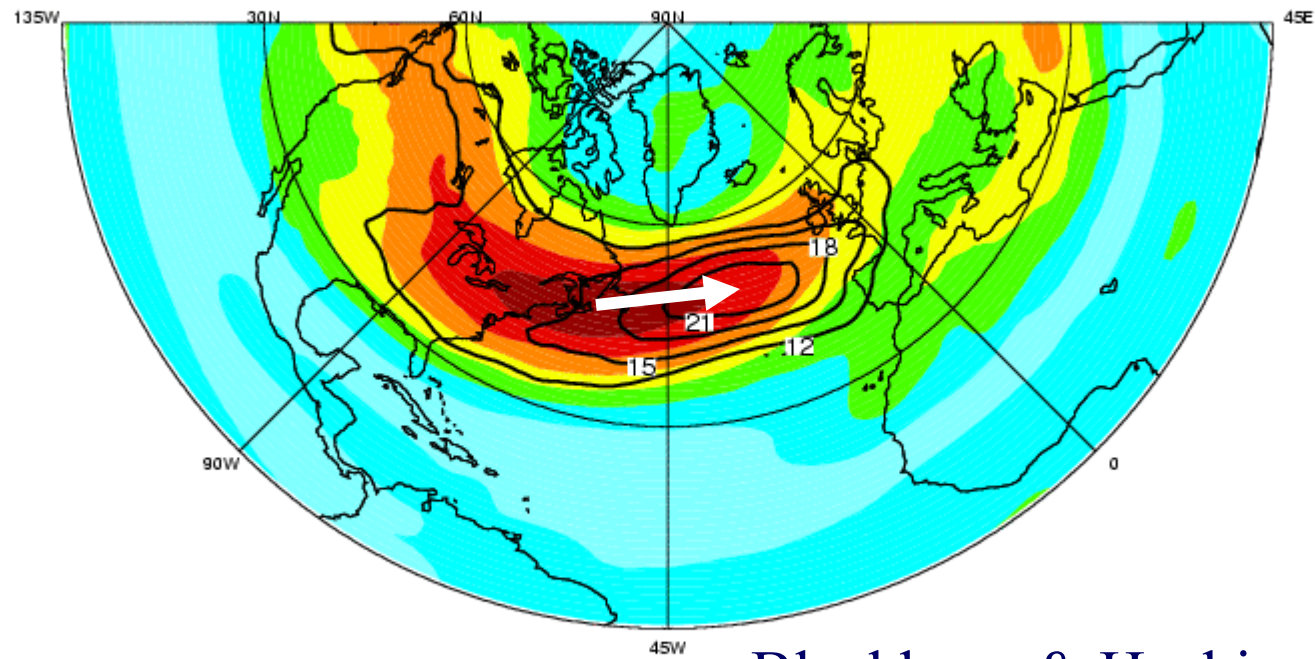
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Was this just another weather event, or was it something to do with climate change?

- The difference between weather and climate
- Some chaos theory: understanding climate as the “shape of the weather attractor”
- Attribution of recent observed large-scale temperature trends: the IPCC’s conclusions
- What we can say about weather: attributing cause and effect in a chaotic system
- Who was to blame for the 2000 UK floods?
- Could the “polluter pay”?

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

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



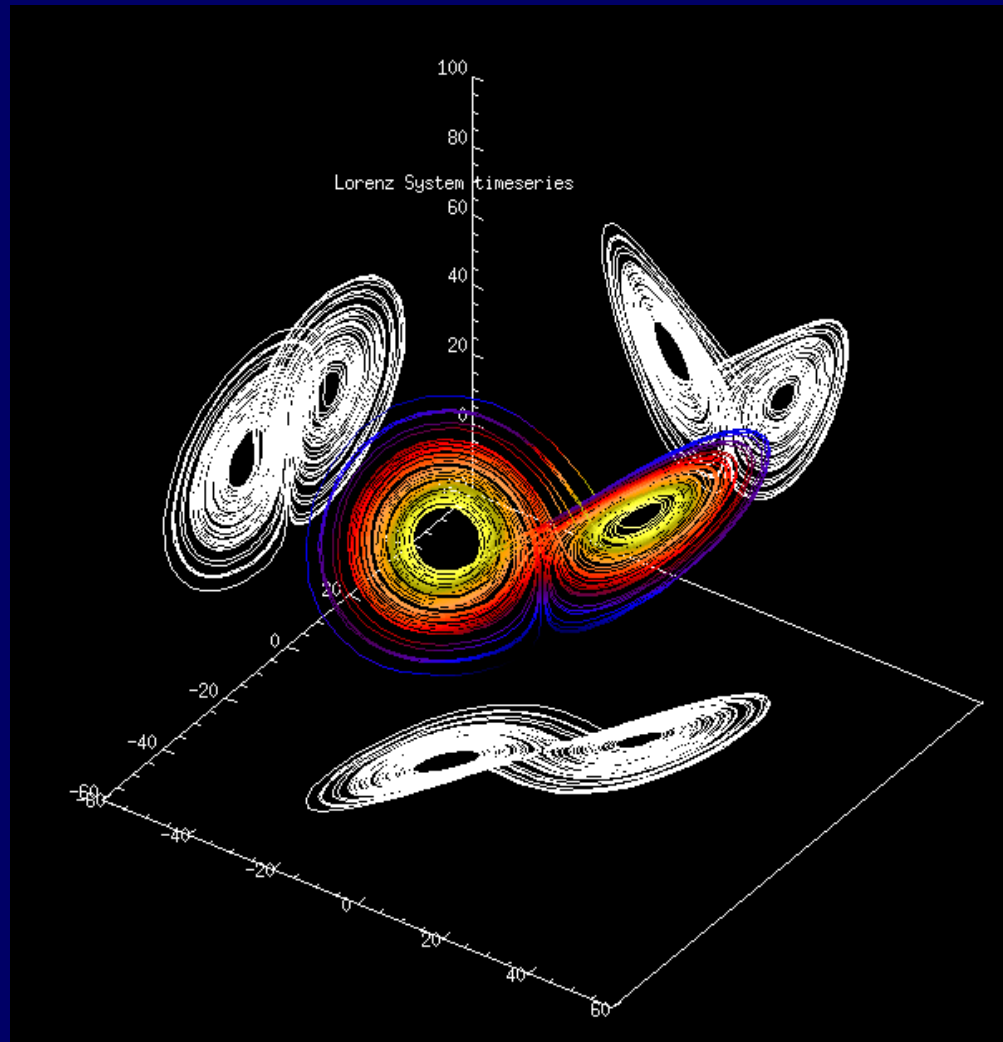
Blackburn & Hoskins, 2003



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”
- Climate means the weather we should *expect*, on average, at a given time of year
- Climate may be perfectly predictable, even though weather is not

The Lorenz (1963) model of deterministic chaos: unpredictable weather, predictable climate

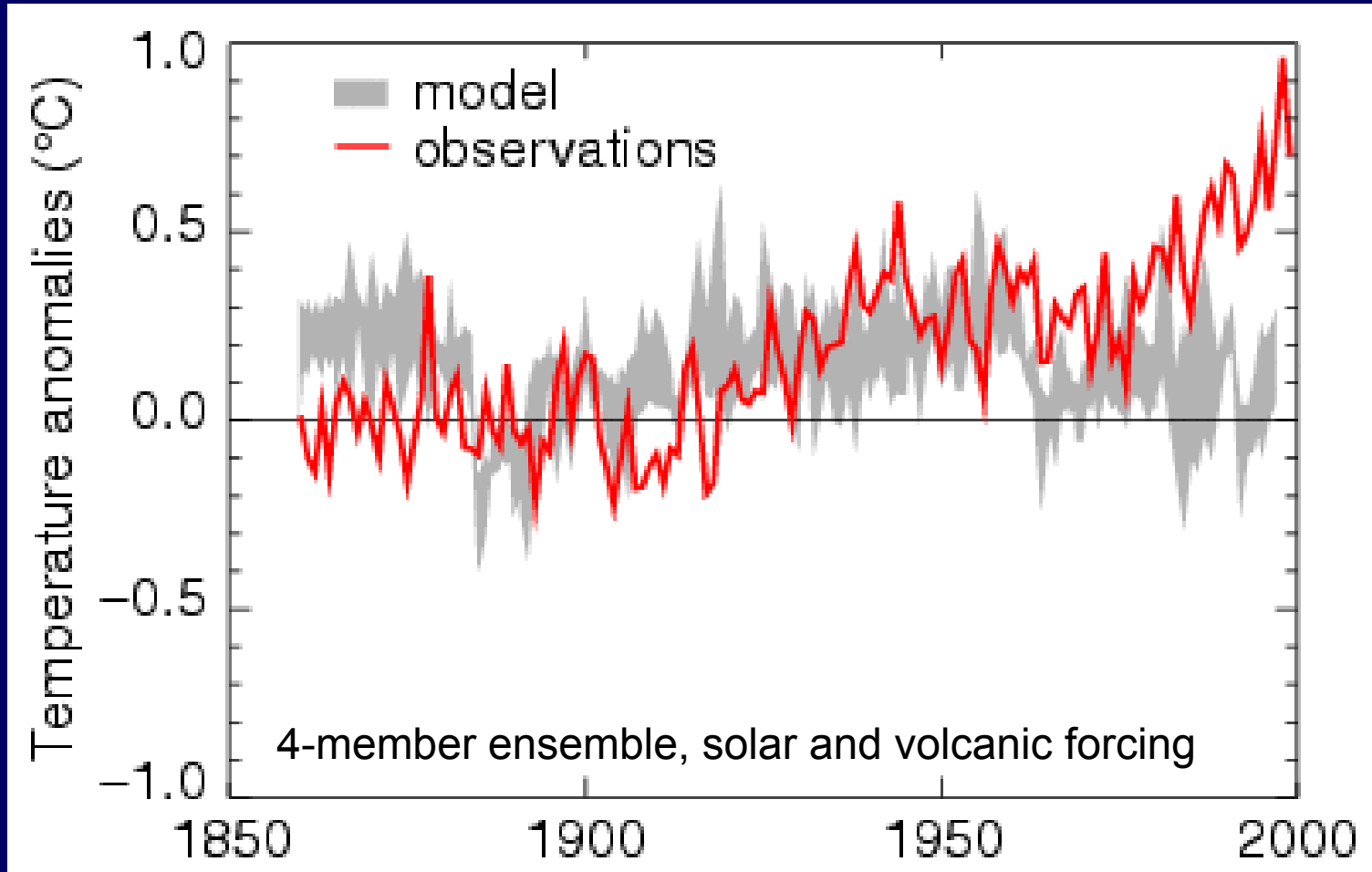


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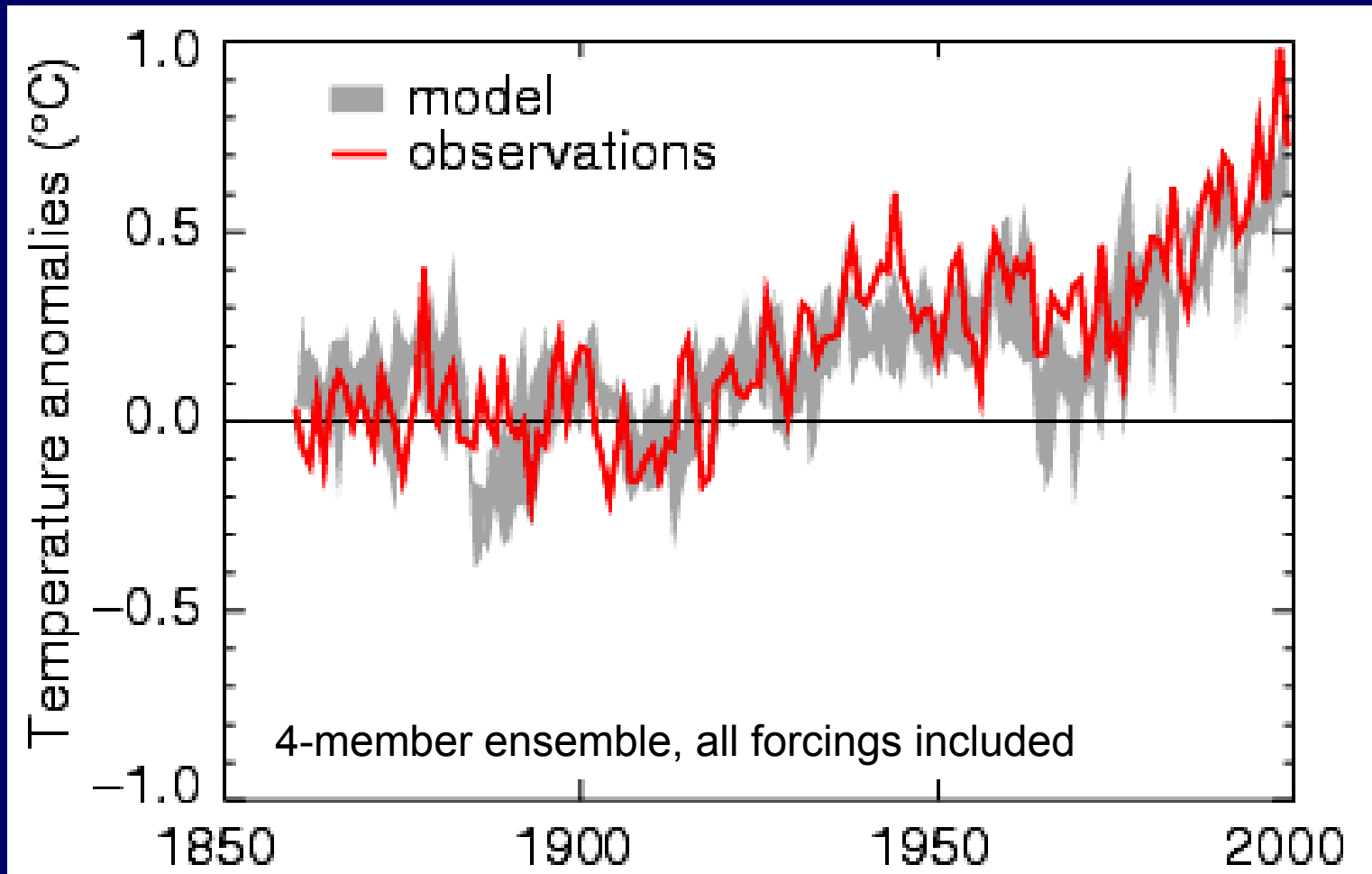
The IPCC's definition of detection and attribution

- “Detection”: demonstrating (at a specified confidence level) that an observed change in *inconsistent* with pure internally-generated variability
- “Attribution”: demonstrating that the observed change is *consistent* with the response to one external forcing scenario and *inconsistent* with all “reasonable” alternatives

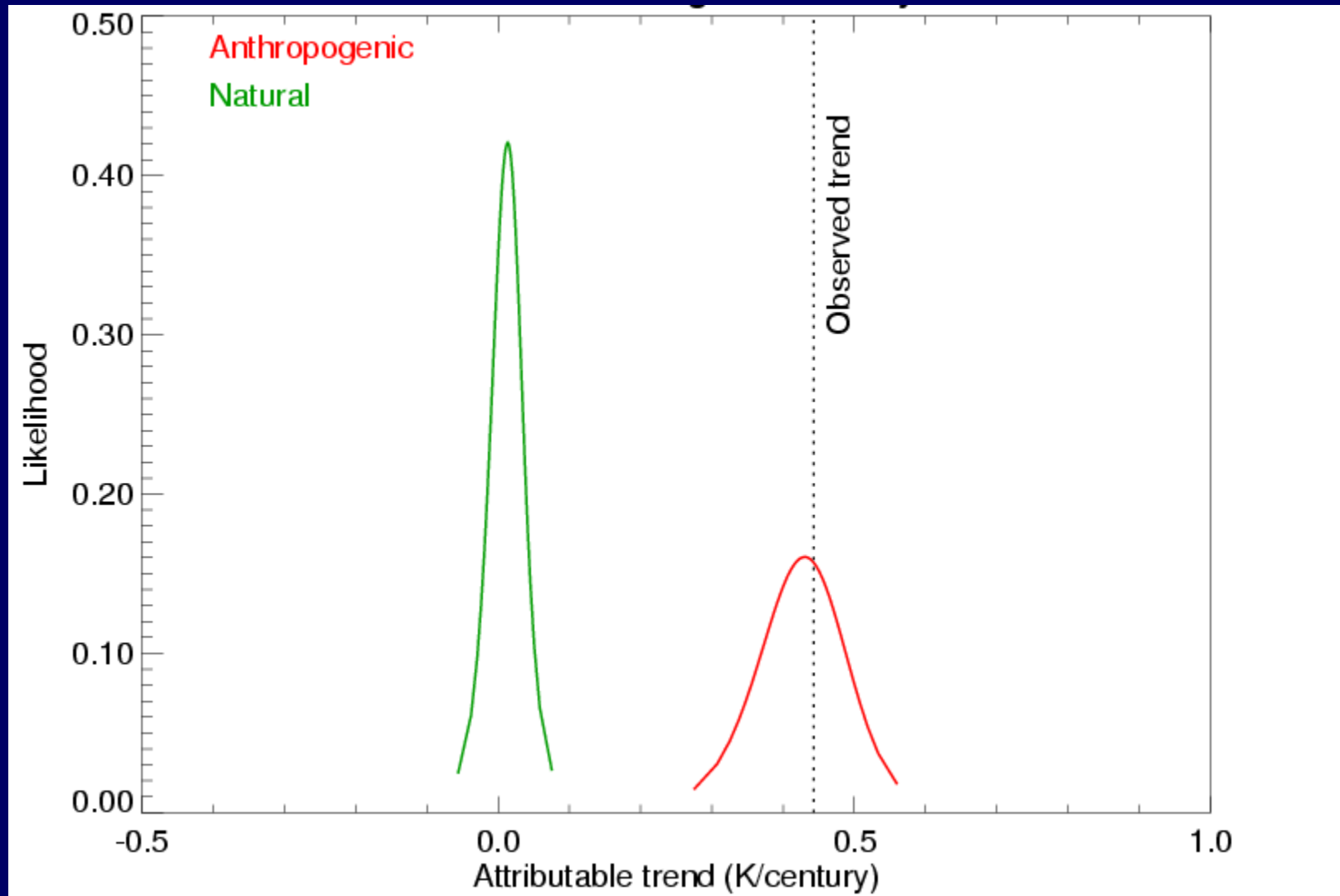
Attribution 1: “the warming over the past 50 years is ... unlikely⁷ to be entirely natural”



Attribution 2: observations are consistent with combined natural and anthropogenic response



The conclusion: “most of the warming over the past 50 years is likely to have been due to the increase in greenhouse gas concentrations”



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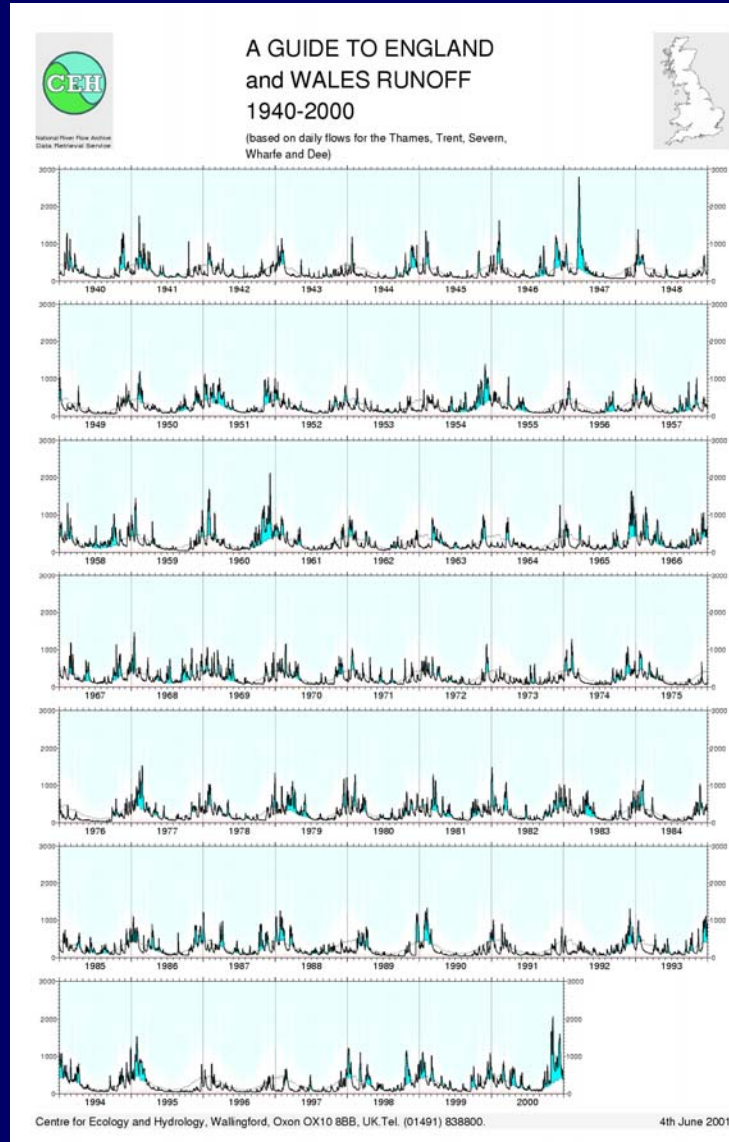
The IPCC attribution process applies to changes in *climate* (expected weather)

- IPCC assumes that we can add up the responses to different external drivers
- Probability arises from uncertainty in
 - how the climate is changing
 - how different factors contribute to that change
- Climate change itself is *deterministic*, controlled by external factors.

But who cares about global temperature and precipitation?

- **A single flood is not controlled by past greenhouse gas emissions as global temperatures appear to be.**
- **Hence we can never attribute “this flood” to past emissions as we can attribute the observed global warming.**
- **So the question “Is this flood due to climate change?” has no answer.**
- **But this does not mean that nothing can be said at all.**

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

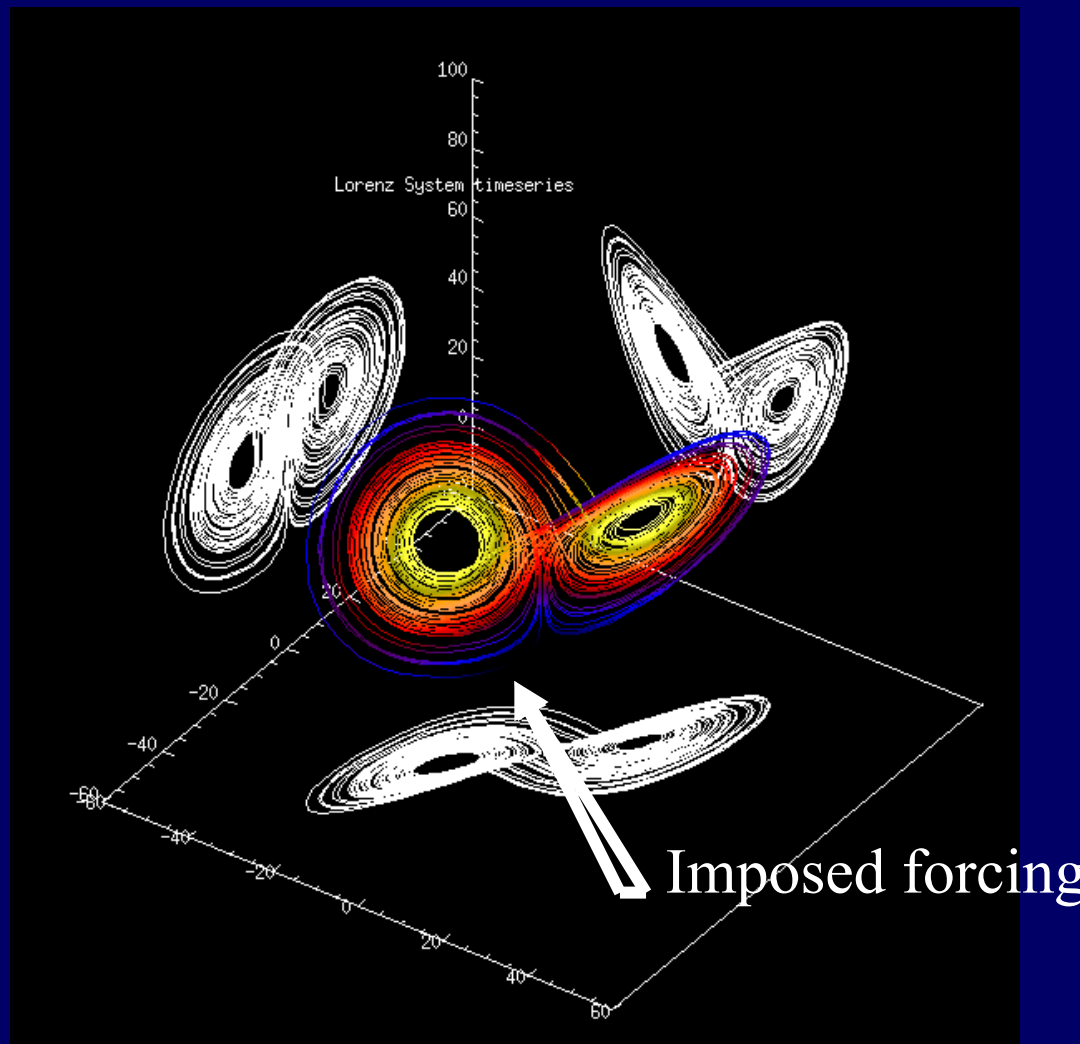


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Can we be more quantitative? The challenge of probabilistic attribution.

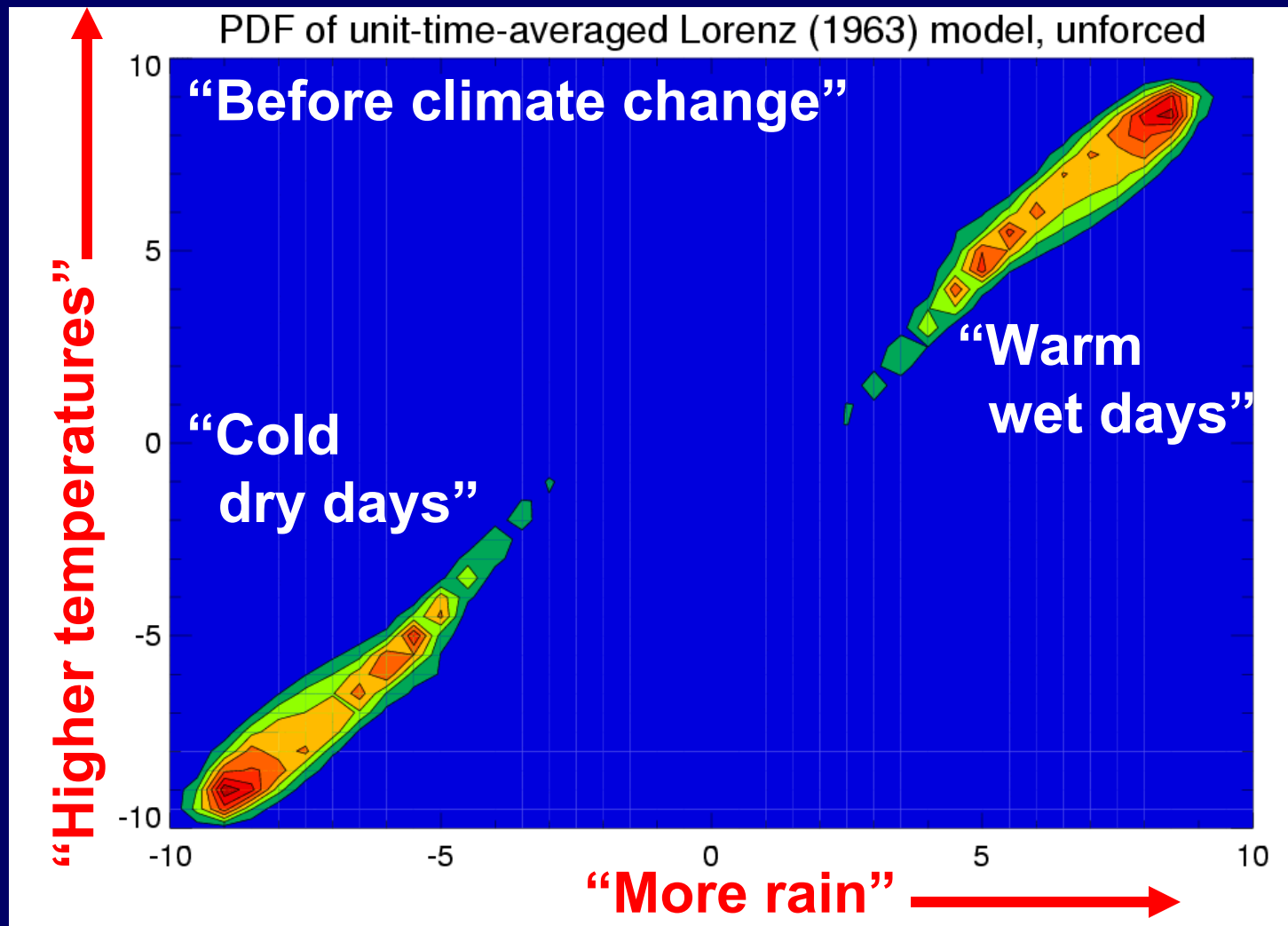
- Lay-person's definition of attribution: how would the climate be different if we had not raised greenhouse gas concentrations?
- For a specific flood, this means: how has the *risk* of this flood changed because of past emissions?
- For this we need:
 - P1: probability of flood occurring now
 - P0: probability of flood without GHG increase
 - $1 - P0/P1$: fraction of risk attributable to GHGs
 - Both P0 and P1 are uncertain

Back to our simple chaotic system, now with an “external driver of climate change”

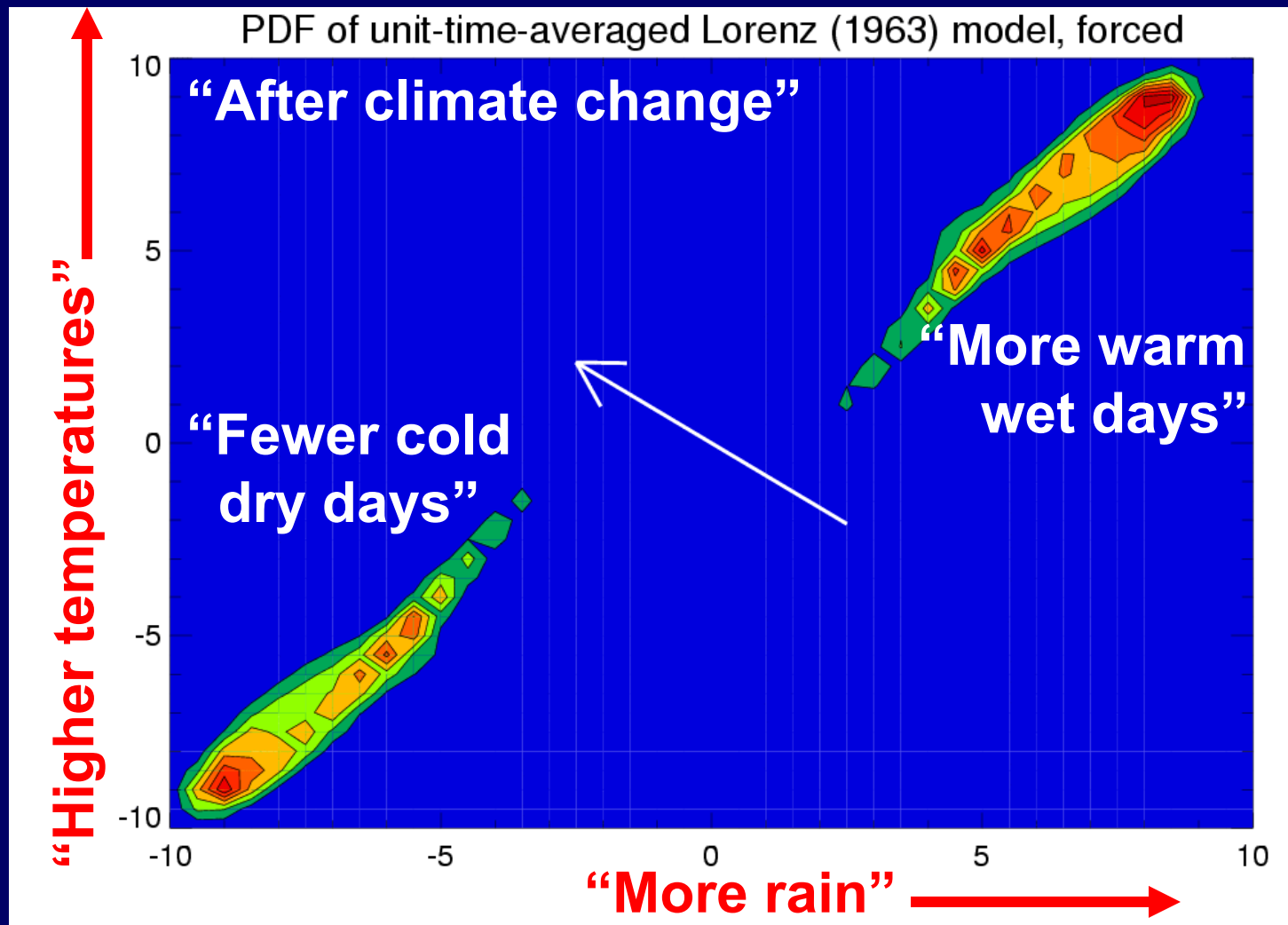


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Showing the impact of external driving on our simple chaotic system



Showing the impact of external driving on our simple chaotic system



How the distribution of “rainfall” changes as the external driving increases

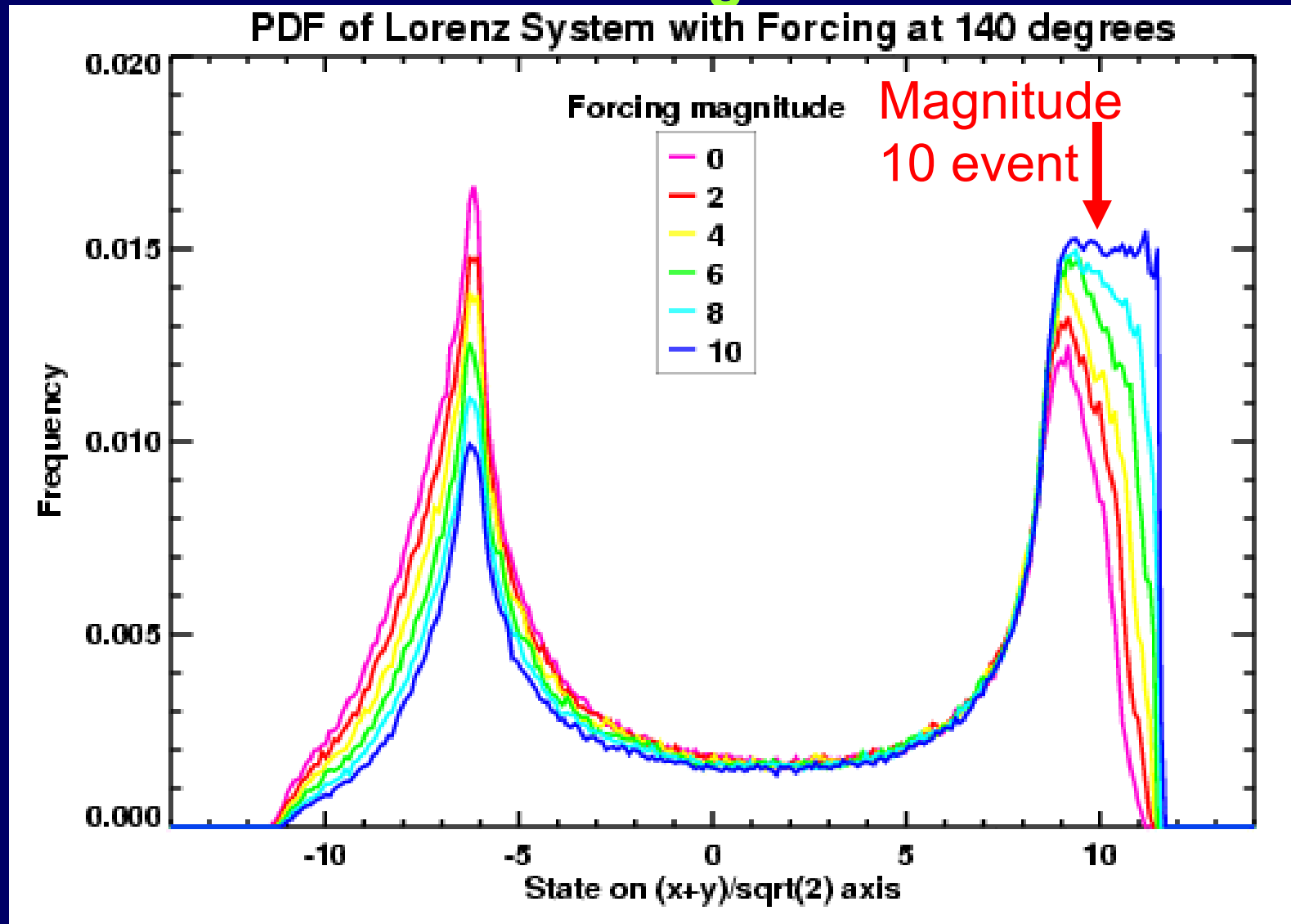
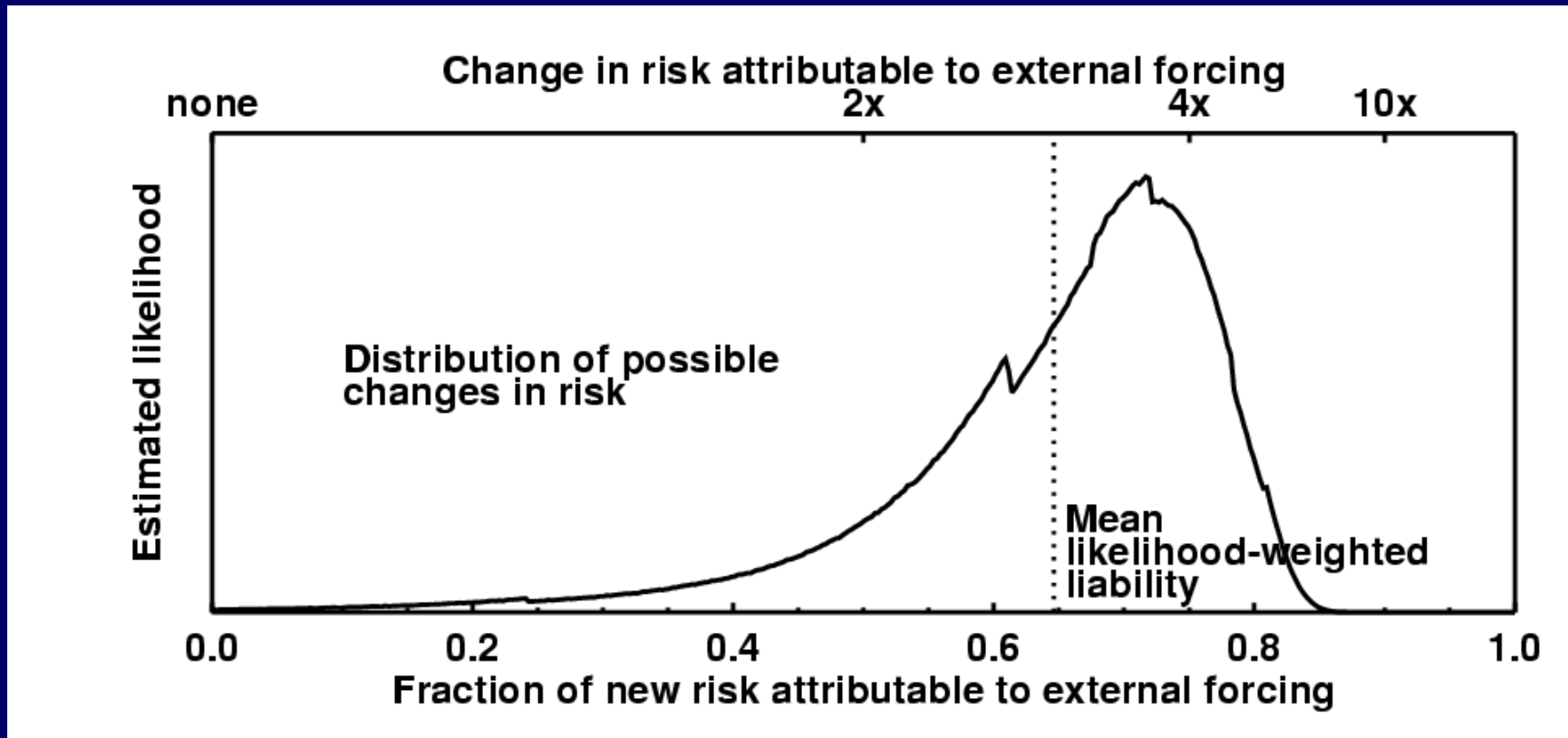
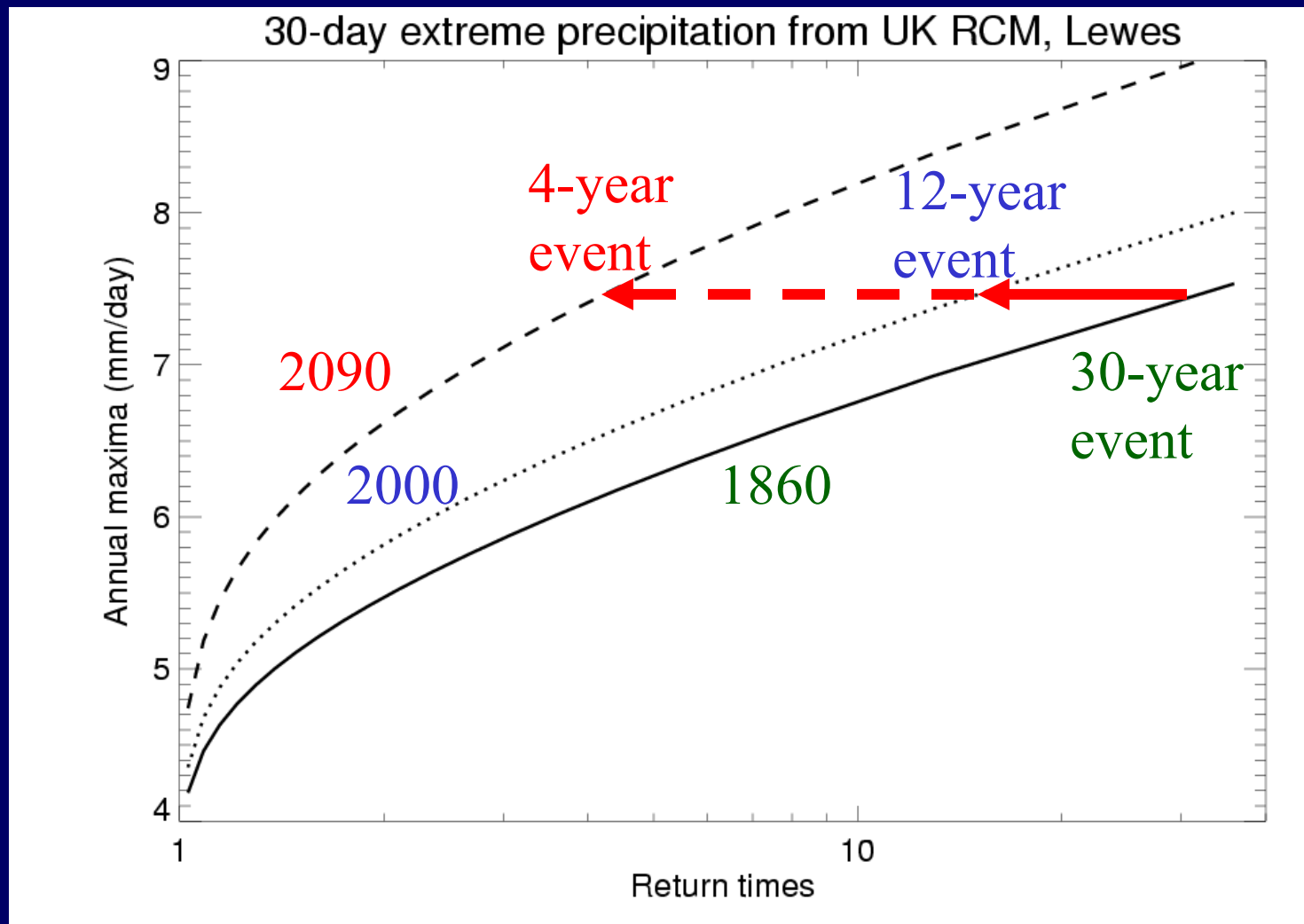


Figure courtesy of Daithi Stone

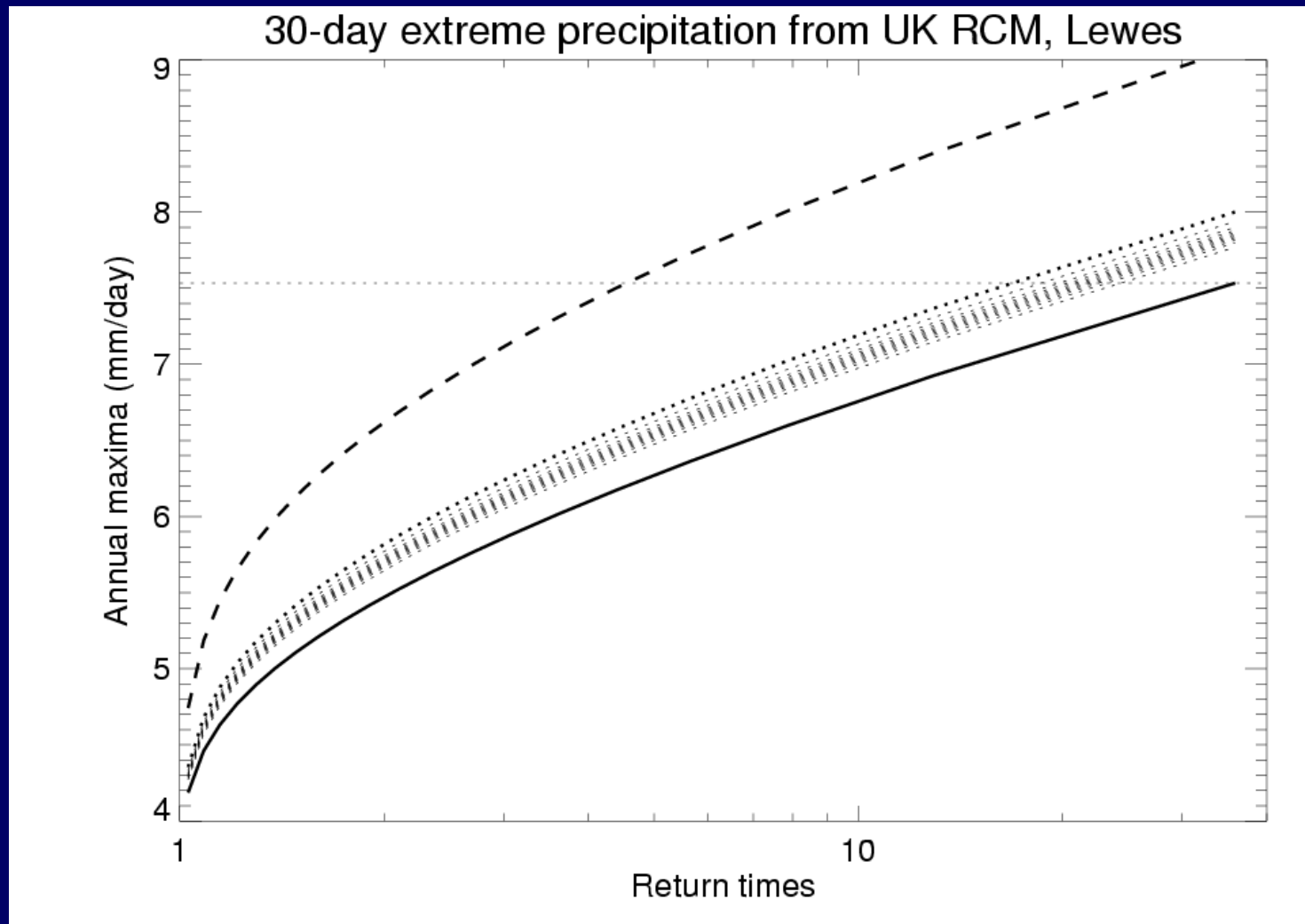
Distribution of possible changes in risk of a magnitude-10 event



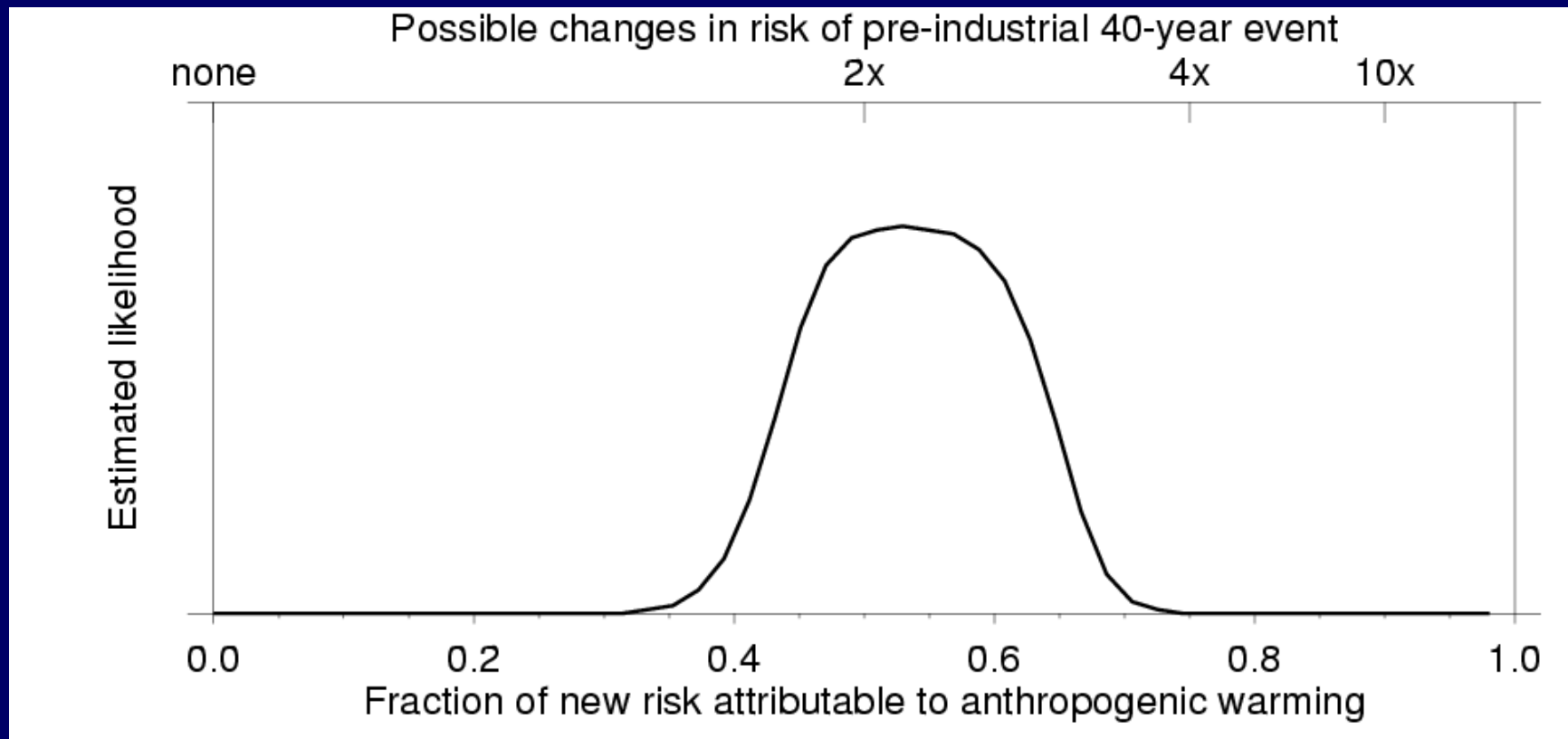
Model-simulated changes in extreme rainfall



Accounting for uncertainty in global mean response 1860-2000



How anthropogenic climate change may have contributed to the risk of the October 2000 floods

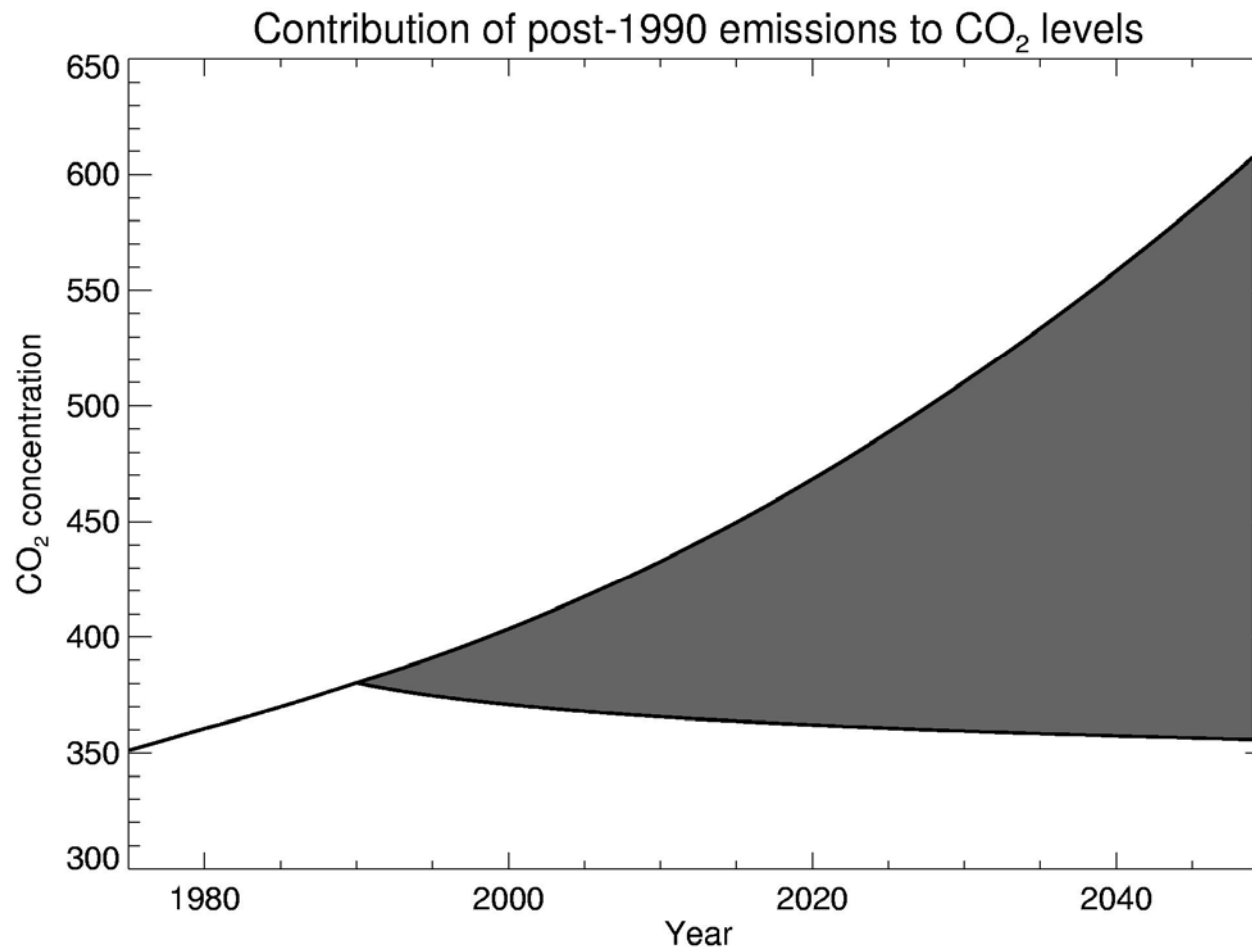


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Why does this matter?

- You do not have to prove that *your* lung-cancer was caused by smoking to have a case against the tobacco company
- The minimum attributable increase in risk required for courts to begin to assign liability is around a factor of two
- The contribution of past greenhouse gas emissions from fossil fuels alone to some current climate risks may already exceed this threshold, although more research is needed
- But who would pay?

Contribution of post-1990 emissions to future CO₂ levels



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What this means for you

- If you drove a car here today (or worse, like me, took an aeroplane), or own shares in an old-fashioned oil company, you are risking Our Common Future for the sake of your present convenience
- So what? You live on a hill, and can turn up the air-conditioning.
- But...
- You may also be risking your retirement pension...