The "Pause" in Global Warming: Climate Policy Implications

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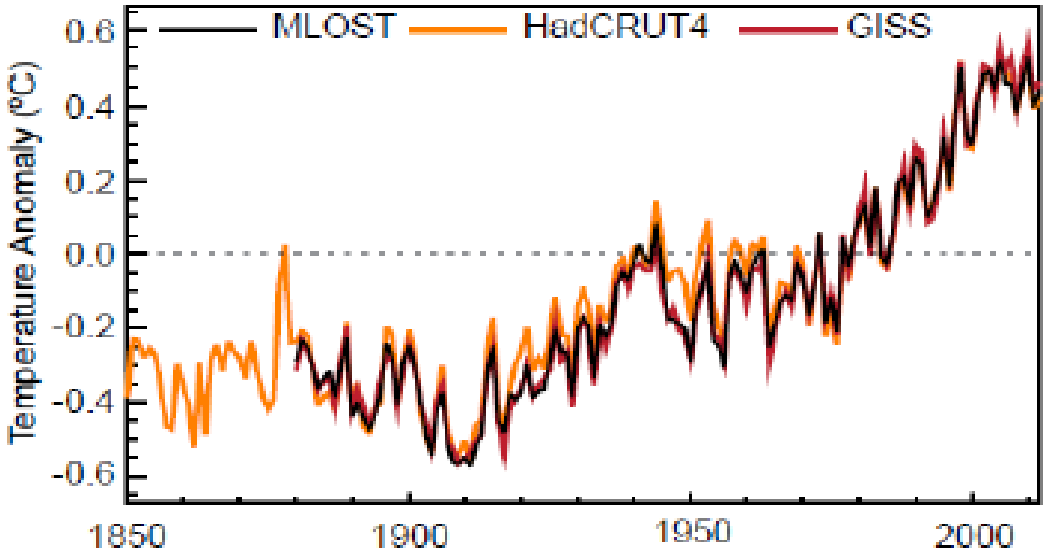
Outline

- The duration
- What matters: not the *Pause* but the *Flaws*
- Indications of problems with GCMs
- Implications for economic models (IAMs)
- Implications for policy

The Duration

IPCC Fig 2.20

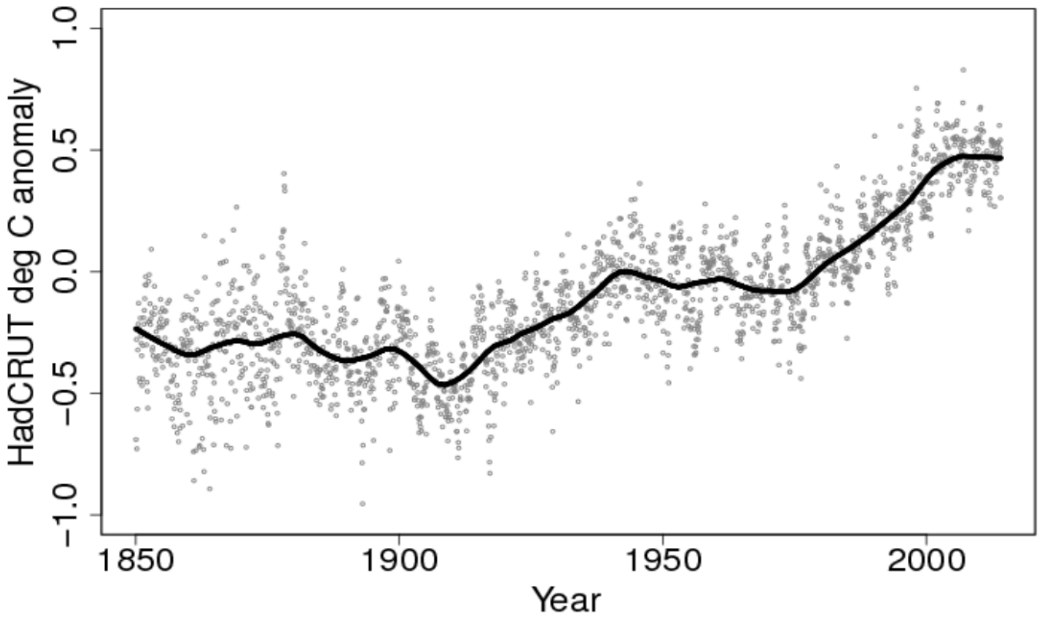
- 1850-2012
- Lots of "pauses"
- Dips, spikes, etc



The Duration

HadCRUT4

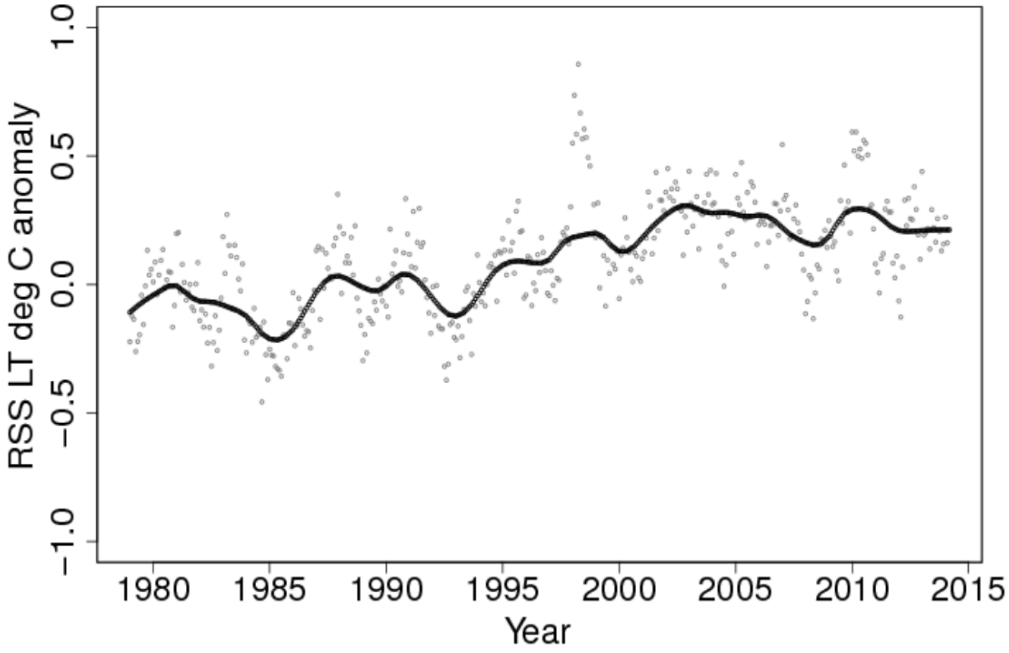
- 1850-2013
- Lots of "pauses"
- Dips, spikes, etc



The Duration

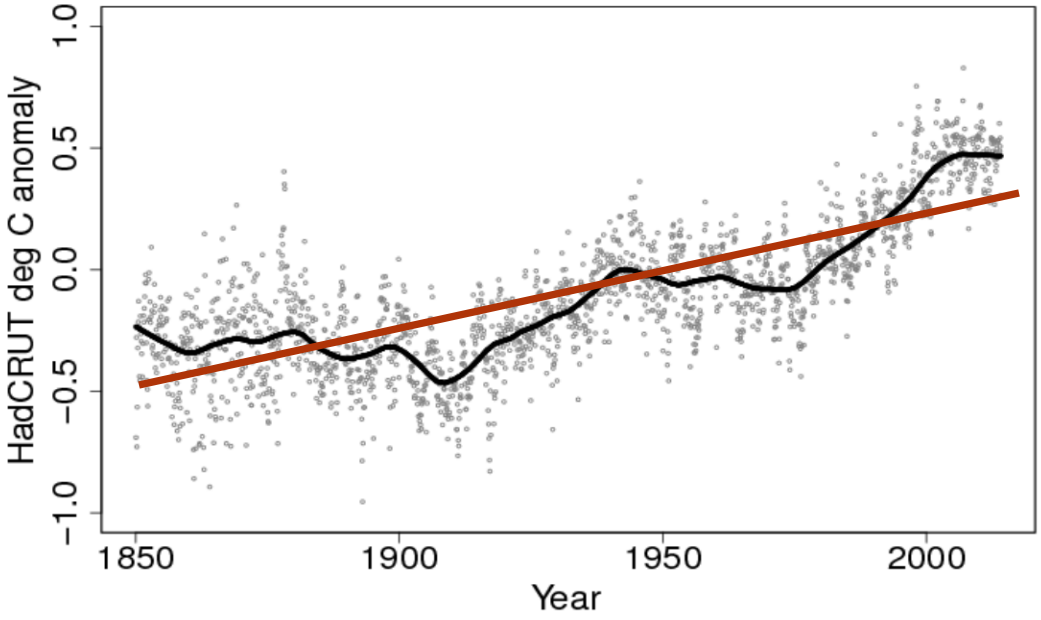
RSS

- 1979-2012
- Lots of "pauses"
- Levels off after '98



Trend magnitudes

- Warming trend (°C per decade) allowing the sample start date to move forward in time



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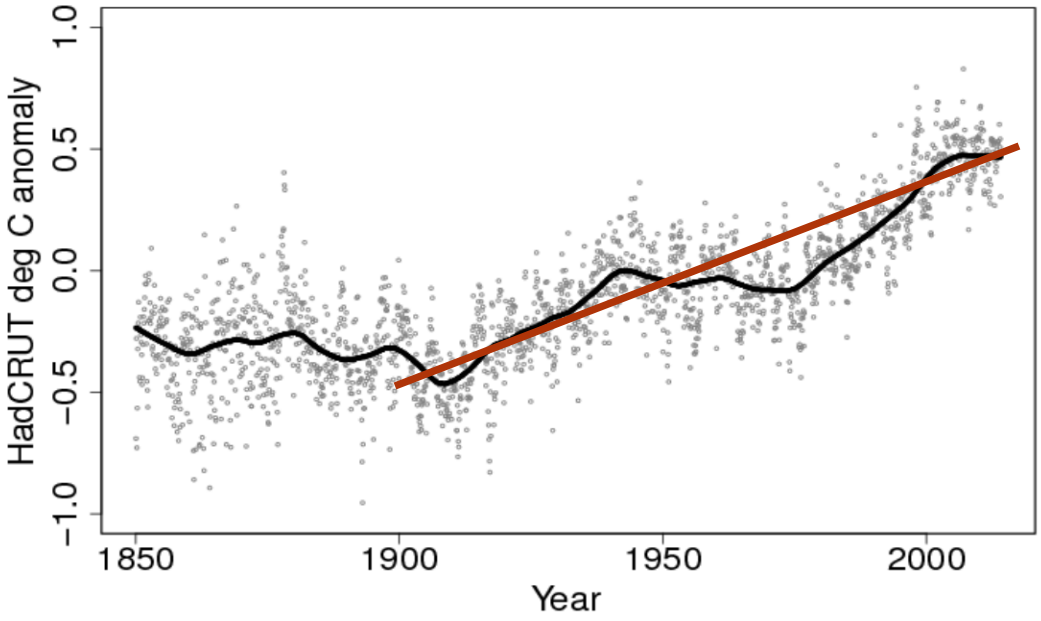

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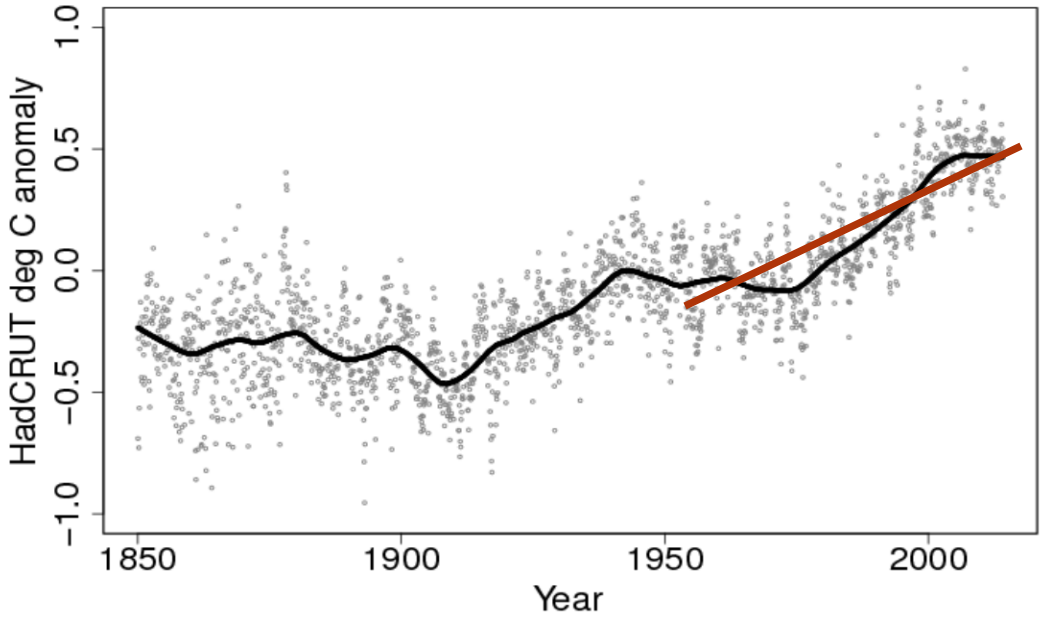

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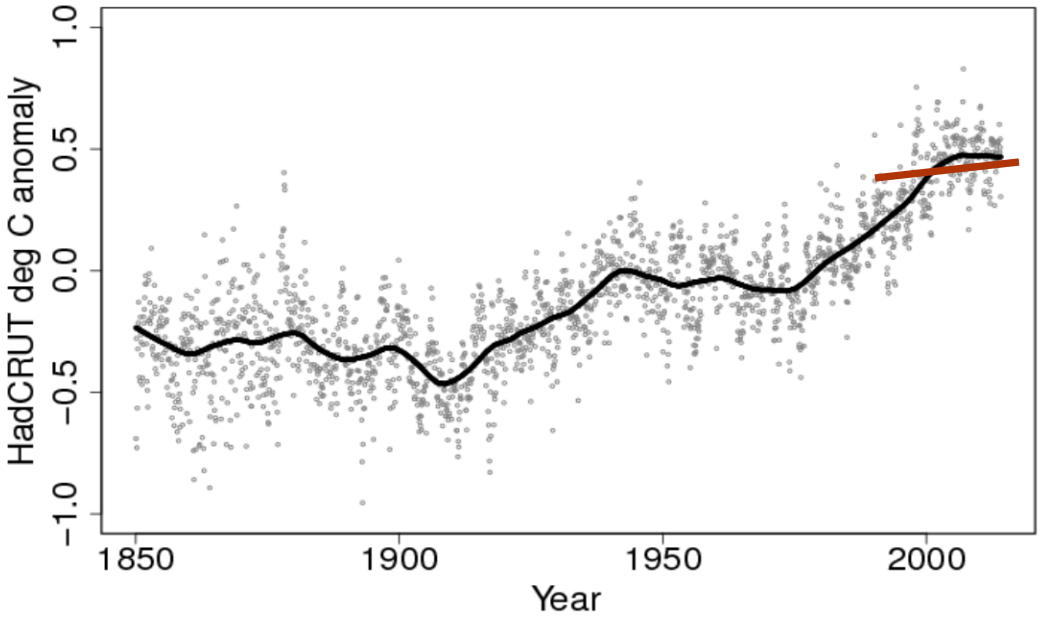

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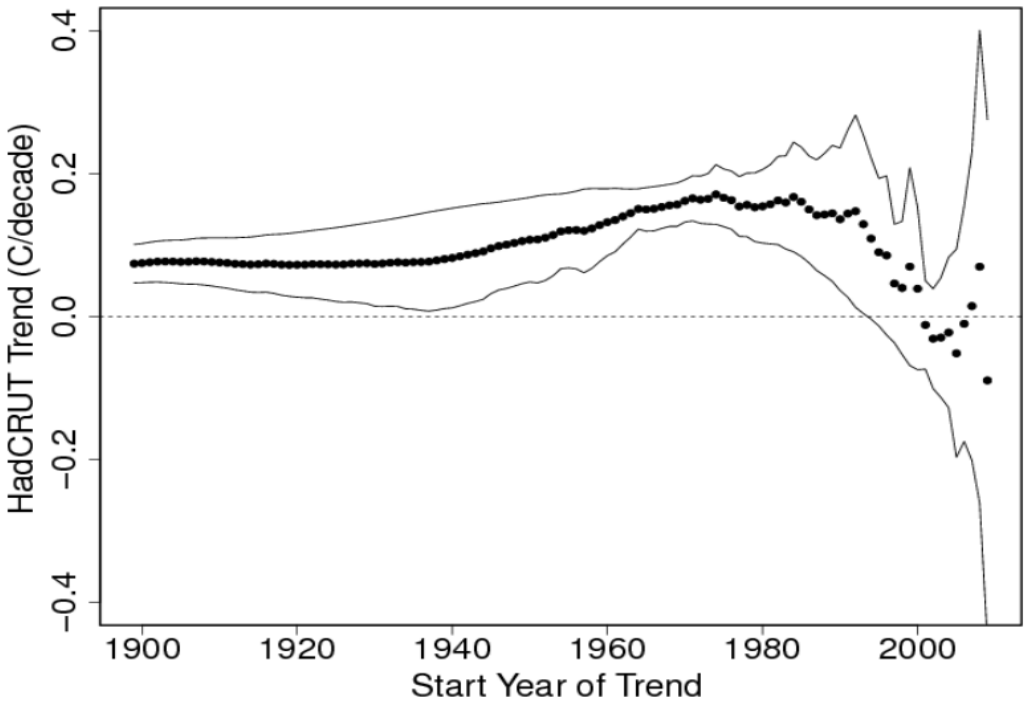

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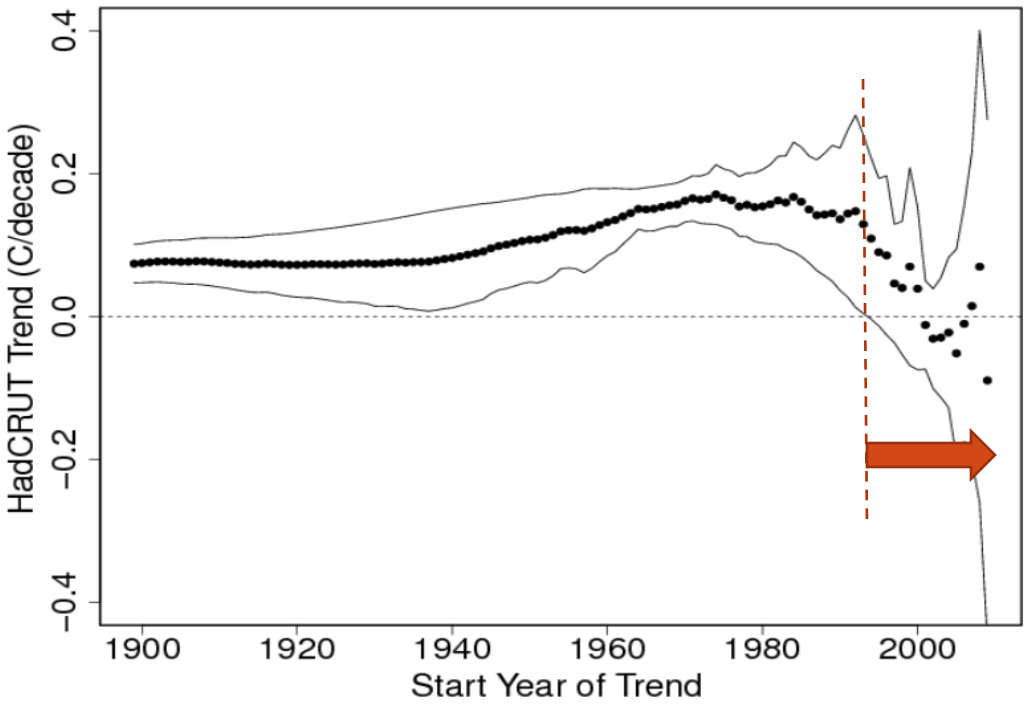


Sample beginning in 1994 or thereafter has an insignificant trend

Trend goes negative in 2001

The Duration

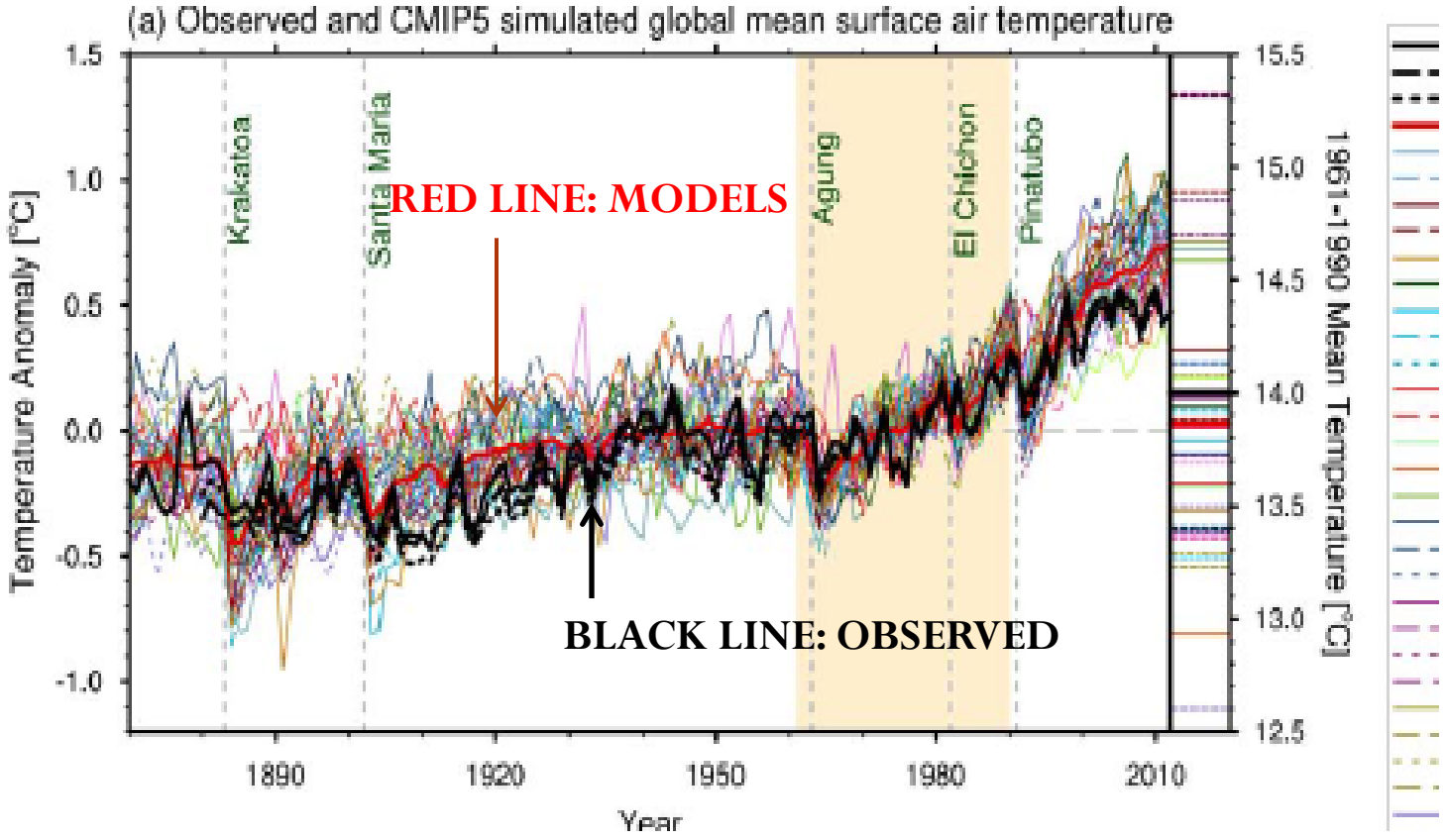
- A trend line through the HadCRUT4 surface record for the past **20 years** (or any shorter duration) yields no significant warming trend

- A trend line through the RSS troposphere record for the past **26 years** (or any shorter duration) yields no significant warming trend

- On its own this means nothing

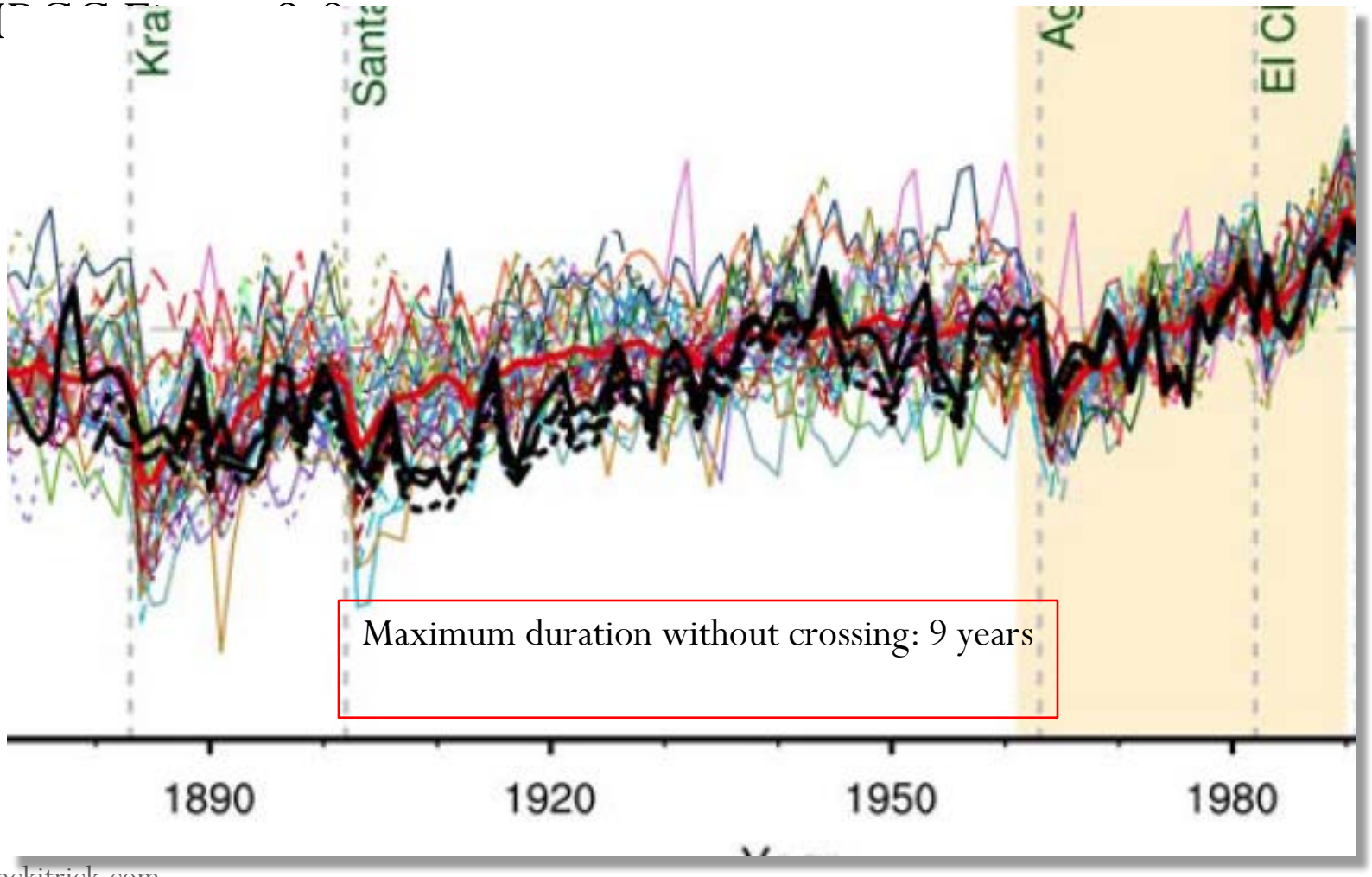
Comparison to GCMs

- IPCC Figure 9.8



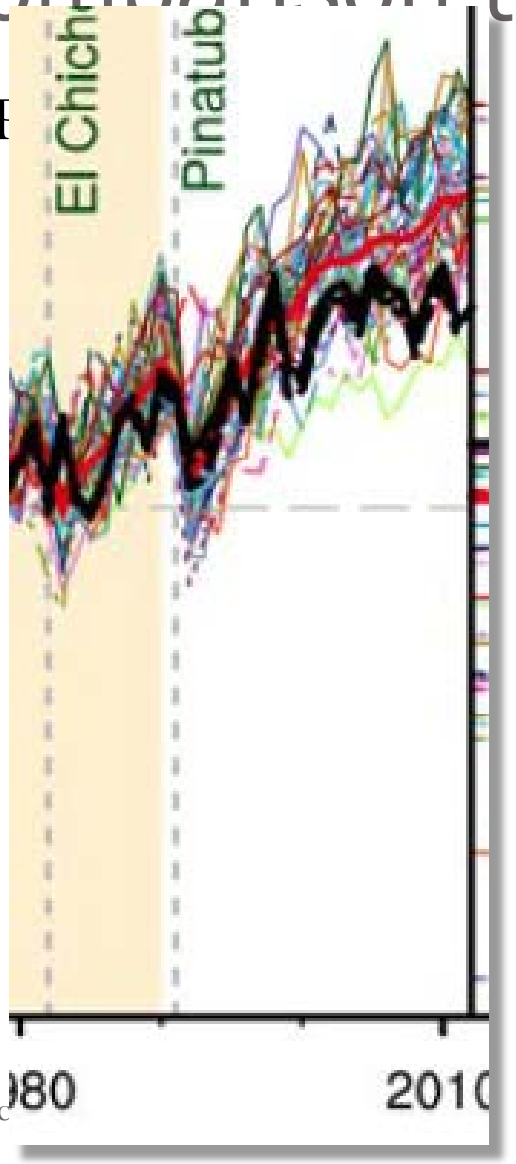
Comparison to GCMs

- IPCC [illegible]



Comparison to GCMs

- IF



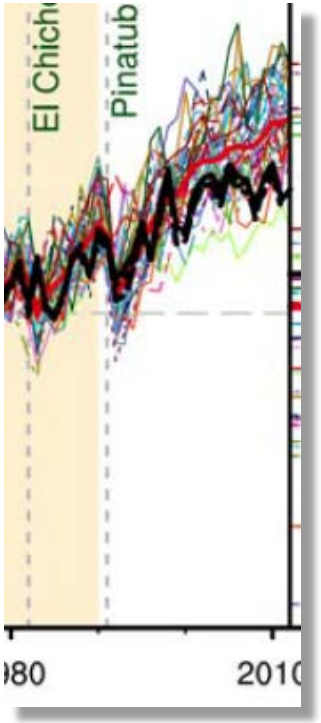
Duration without crossing:

14 years and climbing

This is the real issue:

- At the point when the modelers could no longer peek at the answer, they started getting it wrong

The discrepancy



- 1990 to 2014: CO_2 levels +13%
- 2005-2011: Radiative Forcing +43% (IPCC SPM-9)
- Models all agree on what should have happened

The discrepancy

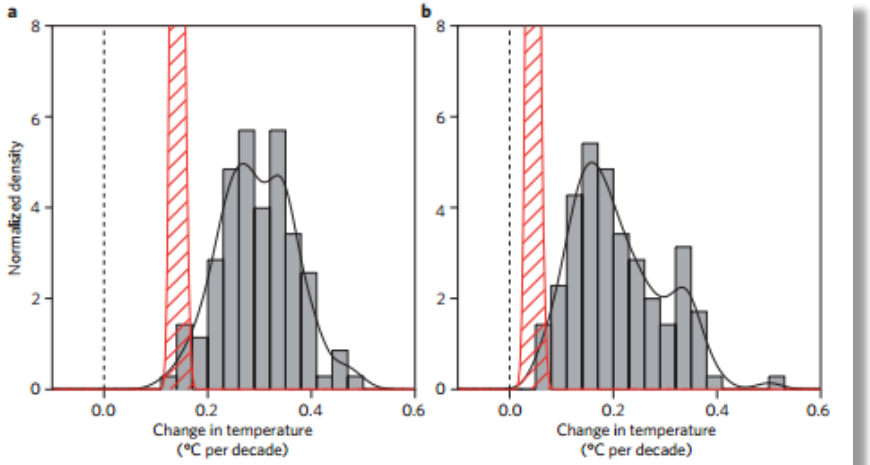
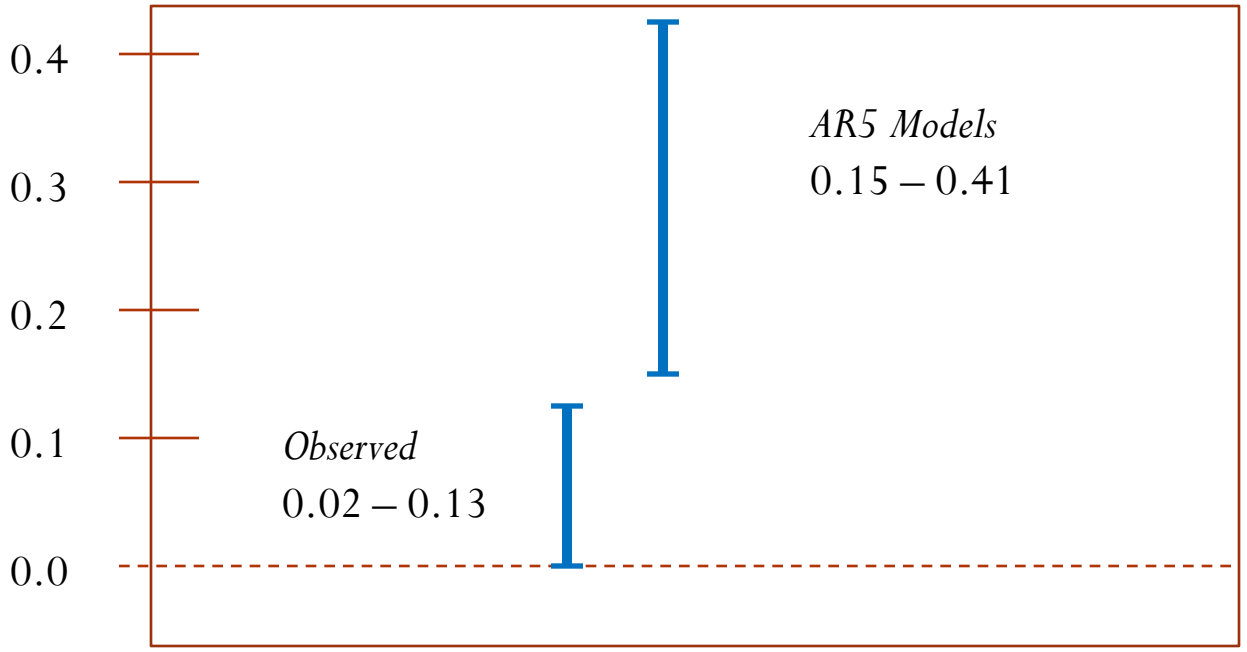


Figure 1 | Trends in global mean surface temperature. **a**, 1993–2012. **b**, 1998–2012. Histograms of observed trends (red hatching) are from 100 reconstructions of the HadCRUT4 dataset[1]. Histograms of model trends (grey bars) are based on 117 simulations of the models, and black curves are smoothed versions of the model trends. The ranges of observed trends reflect observational uncertainty, whereas the ranges of model trends reflect forcing uncertainty, as well as differences in individual model responses to external forcings and uncertainty arising from internal climate variability.

- IPCC: 111 out of 114 models predicted too much warming
- Fyfe et al. (2013) GCM trends averaged 0.21 °C/decade, more than 4x observed level

Further indicators

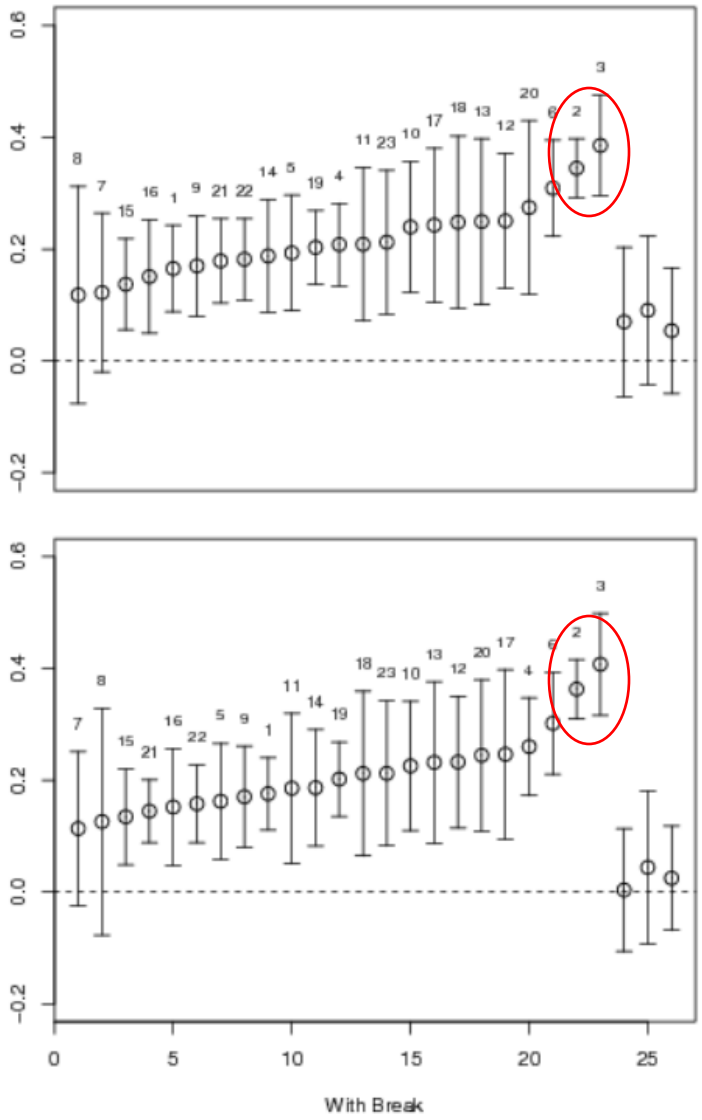
- Tropical troposphere, 1979-2012:



Further indicators

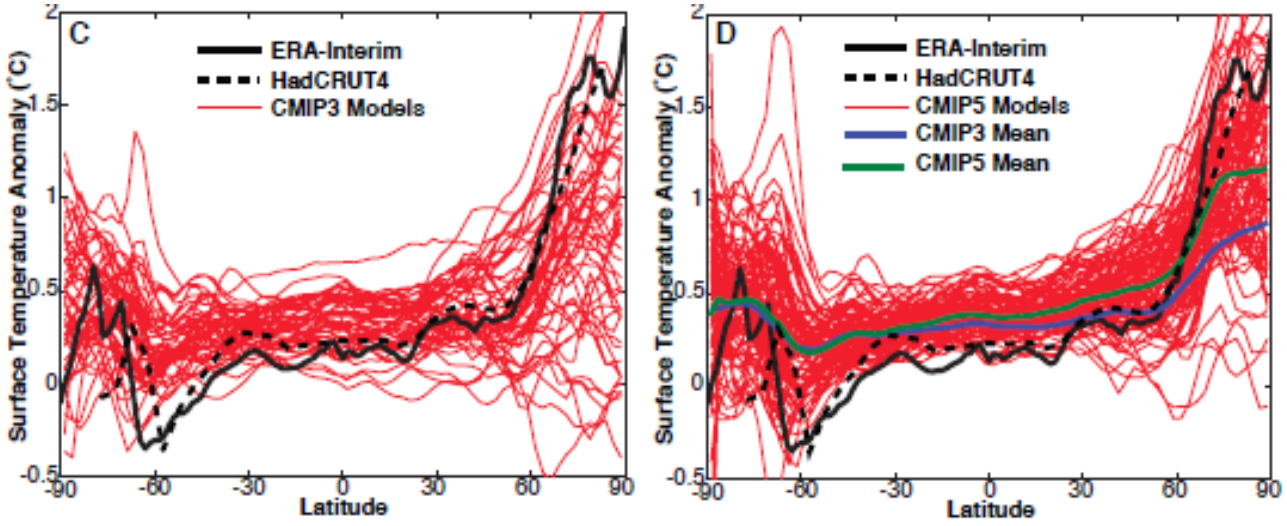
- Tropical Troposphere

  1958 – 2012



Swanson (*GRL* 2013)

- Models are becoming more like each other and less like the real world



Swanson (*GRL* 2013)

- "Curiously, the CMIP5 simulations appear to be approaching a consensus… **However, this consensus appears to explicitly exclude the observed warming."**

- Same for simulation of temperature extremes: models more alike but don't overlap observations

The Challenge

- If things continue as they have been, in five years, at the latest, we will need to acknowledge that something is fundamentally wrong with our climate models. A 20-year pause in global warming does not occur in a single modeled scenario.

Han von Storch
Institute of Coastal Sciences, Germany

The Challenge

- Depending on when you start counting, this hiatus has lasted 16 years. Climate model simulations find that the probability of a hiatus as long as 20 years is vanishingly small. **If the 20 year threshold is reached for the pause, this will lead inescapably to the conclusion that the climate model sensitivity to CO2 is too large.**

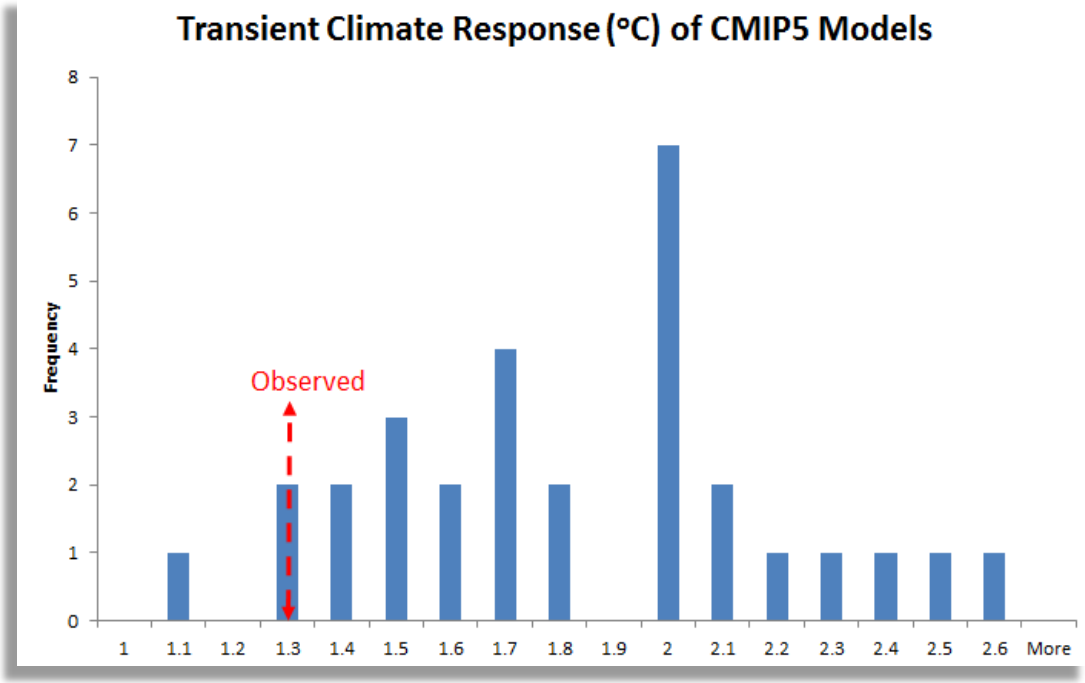
Judith Curry
Climatologist and Chair of Earth and Atmospheric Sciences, Georgia Tech

The other side

- The discrepancy can be explained away by
  - The ocean is absorbing more heat then expected
  - Changes in Pacific wind patterns
  - Poor coverage of the Arctic surface
  - Declining stratospheric water vapour
  - …
- If so, climate may still be highly sensitive to CO2
- These are all new hypotheses, yet the science was "settled" over a decade ago

As things stand…

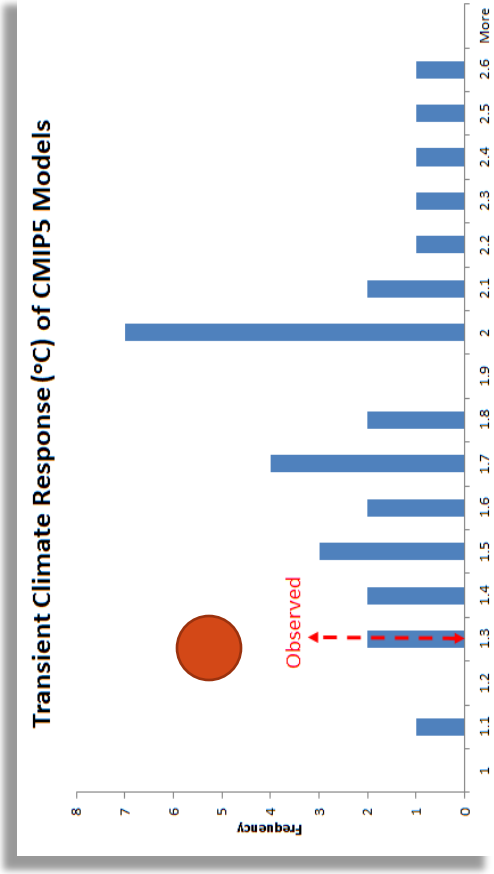
- Empirical evidence points to sensitivity at low end of model scale



Implications for policy

- Social Cost of Carbon estimated using Integrated Assessment Models (IAMs)

- These are calibrated to match GCMS, not reality



IAMs

- 3 main ones
  - DICE – Nordhaus et al.
  - PAGE – Hope et al.
  - FUND – Tol et al.

- All use very simple econ model and exceedingly simple climate model

IAMs

- 3 Main Sources of Uncertainty:
  - Discount rate by which future damages are weighed less against current income
  - Sensitivity function that translates changes in CO2 to changes in Temp
  - Damages function that translates changes in Temp into changes in utility via effects on consumption and productivity.

Guesswork

- Within standard uncertainties, IAM estimates of the Social Cost of Carbon falls somewhere between $0 and $206 / tonne

- The range primarily reflects the range of sensitivity & feedbacks

Damage functions

-
- Damage as a % of Income:

$$\frac{D_t}{Y_t} = [1 - 1/(1 - m(\Delta T_t)]$$

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DICE: $m(\Delta T_t) = 0.0023888\Delta T_t^2$

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$$\frac{D_t}{Y_t} = [1 - 1/(1 - m(\Delta T_t)]$$

DICE: $m(\Delta T_t) = 0.0023888\Delta T_t^2$

Weitzman:

$$m(\Delta T_t) = 0.0023888\Delta T_t^2 + 0.0000051\Delta T_t^{6.754}$$

Pindyck 2013

- "[The] models are so deeply flawed as to be close to useless as tools for policy analysis. Worse yet, their use suggests a level of knowledge and precision that is simply illusory, and can be highly misleading."

Sensitivity

-
- ΔT_{2x} → Warming from doubling CO2

$$\Delta T_{2x} = \frac{\lambda}{1-f}\Delta F_{2x}$$

- ΔF_{2x} : doubling of radiative forcing
- λ = basic sensitivity
- f : feedback parameter

Sensitivity

- $$\Delta T_{2x} = \frac{\lambda}{1-f}\Delta F_{2x}$$

- $f = 0$: $\Delta T_{2x} = \lambda \Delta F_{2x}$ (a small number)

- $f = 1$: $\Delta T_{2x} = +\infty$

Sensitivity

-
- Standard assumption:

f is 0.61

Sensitivity

-
- Standard assumption:

$$f \text{ is } \quad 0.61 \quad \pm .44$$

Sensitivity

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- Standard assumption:

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- ~ 1% chance a tonne of CO2 would raise Earth temperature to that of the interior of the sun

Sensitivity

- The long term trend in the HadCRUT4 series is about 0.8 °C per *century*,

- Should atmospheric CO2 double by 2100, IAMs deem it equally likely that the world's temperature will increase by 1.6 degrees or 23.7 degrees.

Sensitivity

- The long upper tail drags up the median and average
- Empirical evidence would confine discussion to lowest end of the distribution

Policy implications

- New information has emerged in recent years that indicates climate models predict too much warming in response to CO2 emissions.
- Unless explained away, will be decisively confirmed in the next two to four years.
- If so, it will lead to a major re-think of the structure of climate models and a downward revision to standard sensitivity estimates.

Policy implications

- IAMs yield such a wide range of results as to be useless (and misleading) for policymaking.
- Worse, they are calibrated, not to empirical data, but to GCMs, and are therefore biased towards oversensitivity.
- Indeed they are even worse than GCMs.
- Their outputs and estimates should be shelved until the sensitivity issue in GCMs is closer to being resolved.

Conclusions

- There is a prima facie case that the social cost of carbon has been overstated
- The uncertainties will largely be resolved in the next 2-4 years
- There is no downside to waiting for this, and considerable upside