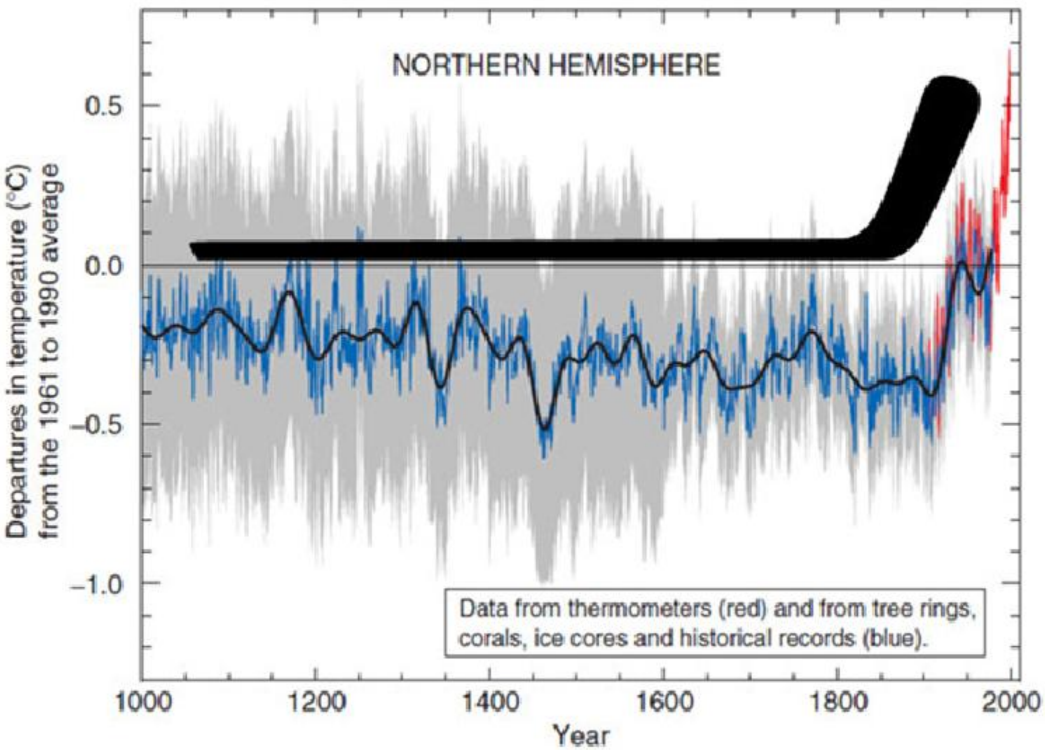
Getting real on climate sensitivity

Nicholas Lewis

September 2019, Dublin

How I became a climate scientist

- Hooked on Climate Audit blog – Steve McIntyre



Why I focus on climate sensitivity

PHILOSOPHICAL TRANSACTIONS A

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Research

CrossMark

The $10 trillion value of better information about the transient climate response

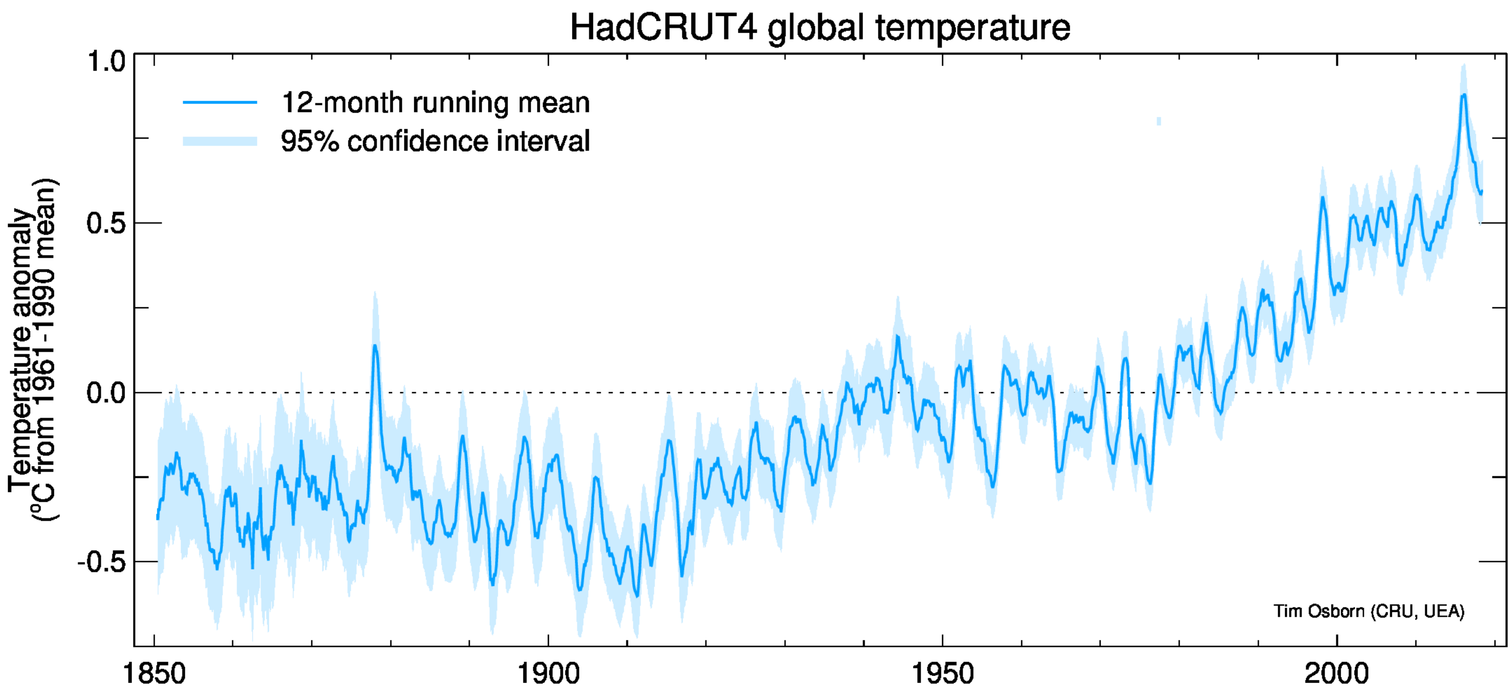
Chris Hope

Judge Business School, University of Cambridge,

- Very valuable to know climate sensitivity accurately
- I saw serious statistical errors in published studies

My current views on climate science

- Much of the basic science is OK
- IPCC: ‘It is extremely likely that human activities caused more than half of the observed increase in GMST from 1951 to 2010.’ [Best estimate ~100%]



- I remain sceptical of climate model simulations

My publication record

- 8 peer reviewed climate sensitivity papers

JOURNAL OF CLIMATE

1 AUGUST 2018 LEWIS AND CURRY 6051

The Impact of Recent Forcing and Ocean Heat Uptake Data on Estimates of Climate Sensitivity

NICHOLAS LEWIS

Bath, United Kingdom

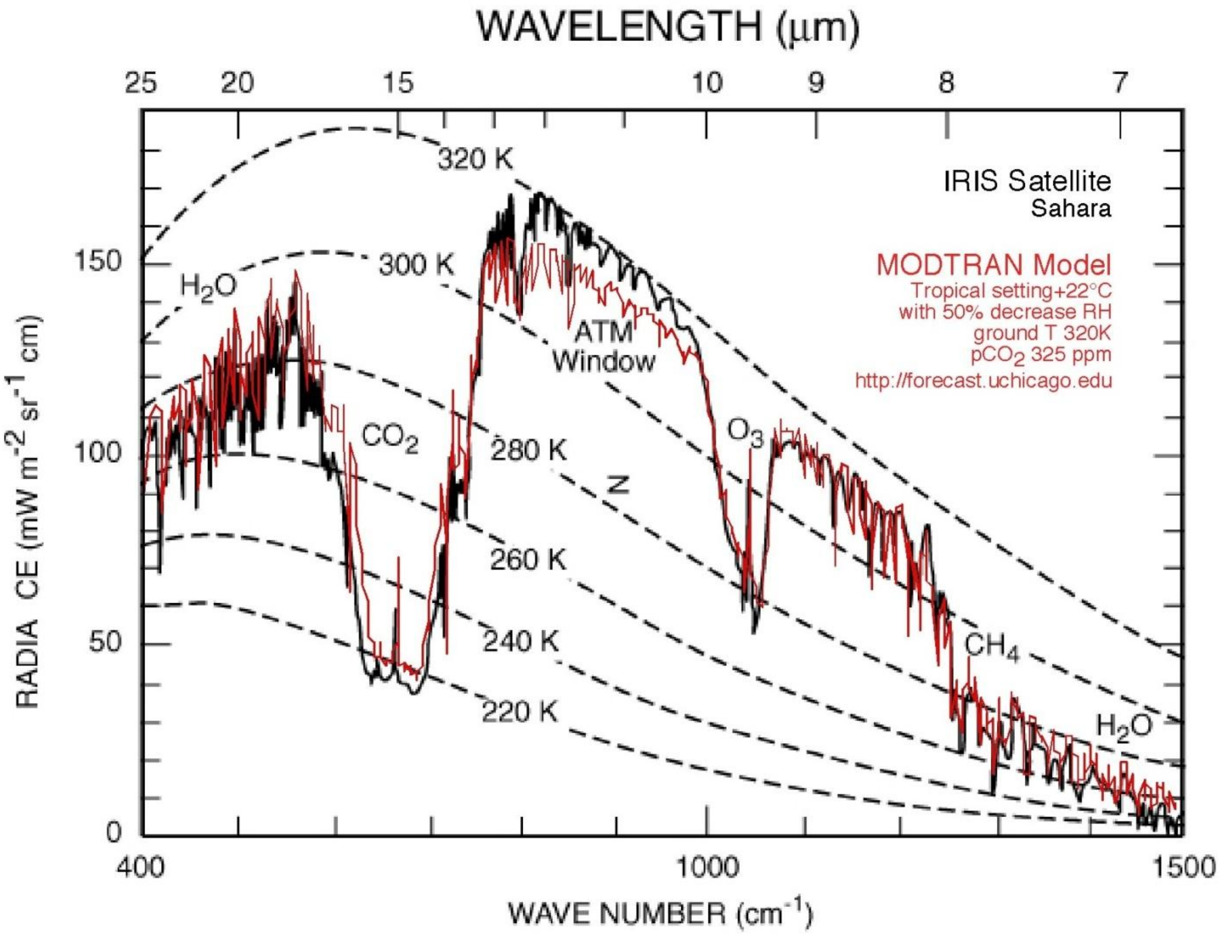
JUDITH CURRY

Climate Forecast Applications Network, Reno, Nevada

Engagement with other scientists

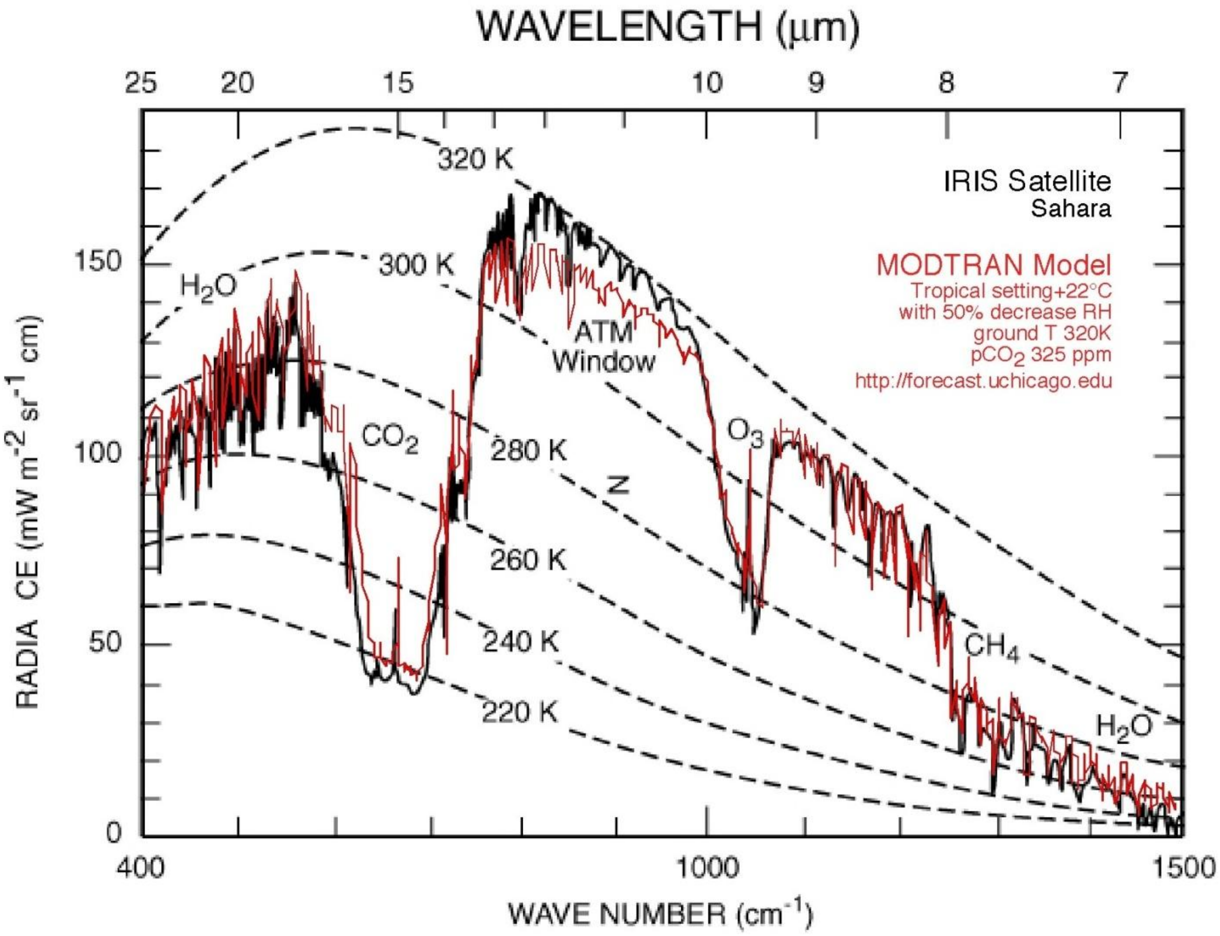
Greenhouse effect

- GHGs impede radiation emitted by the Earth
- Basic radiative physics – not disputable



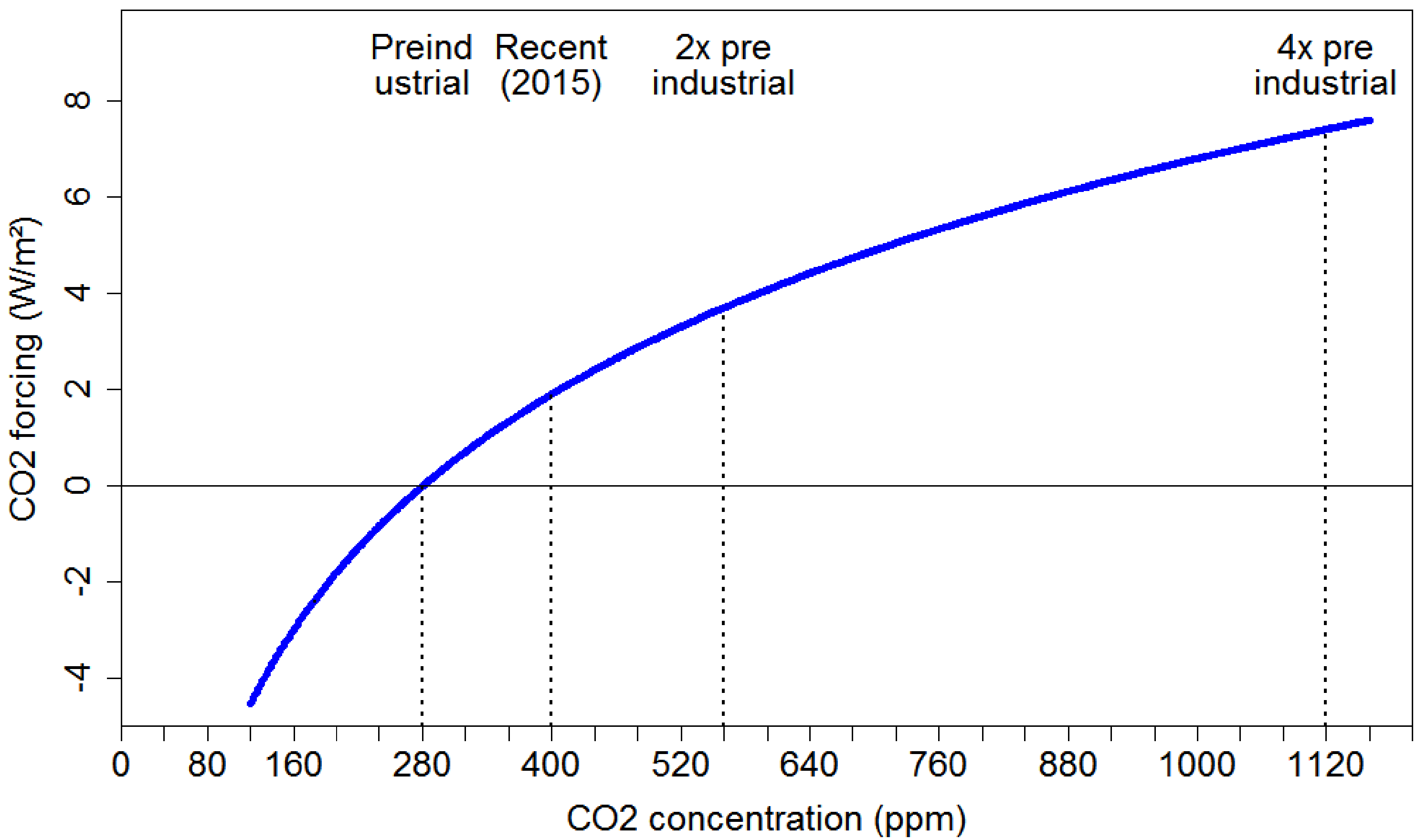
Greenhouse effect

- Big CO_2 trough in radiation to space: grows as level ↑
- Water vapour – key gas but temperature-governed



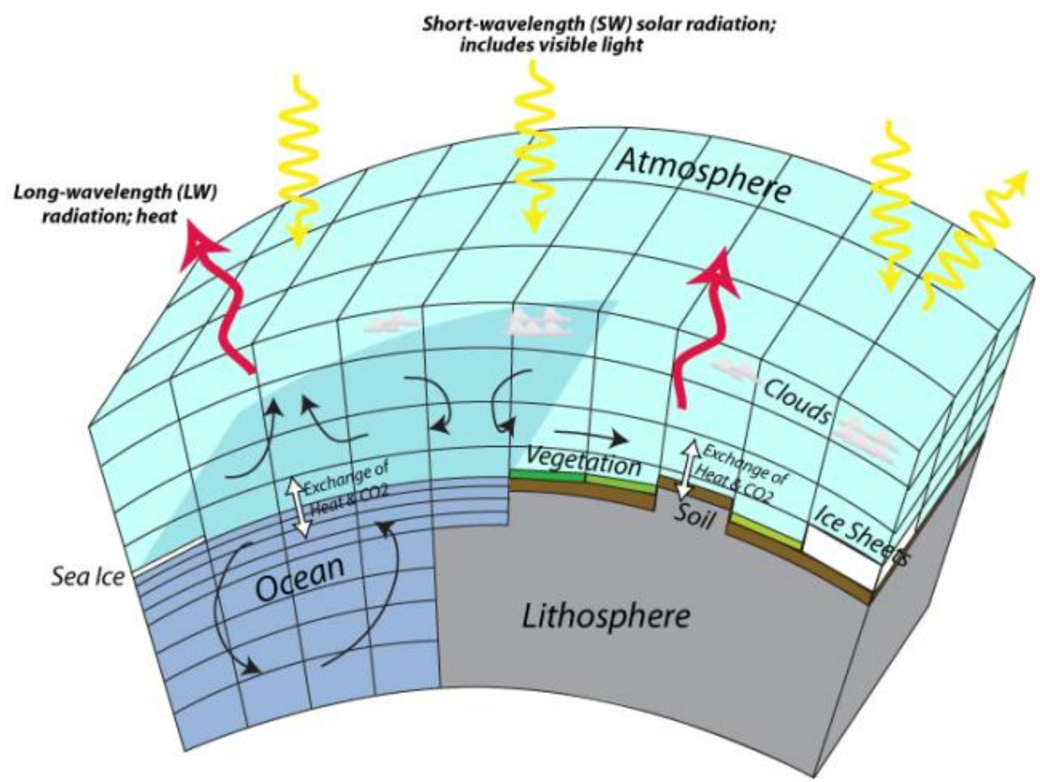
Is CO_2 absorption saturated?

- Effect of CO_2 is logarithmic – same for each 2x



Global climate models

- 3D simulation models (GCMs) – key in science & policy
- GCMs physically-based but use huge approximations



Climate sensitivity

- Basic surface warming ~1.2°C per CO_2 doubling
- +/– ‘feedbacks’ increase/reduce basic warming
- Main feedbacks: water vapour, clouds, snow/ice
- Equilibrium climate sensitivity: metric used to quantify resulting long term warming

  ECS = resulting long-term warming if 2x CO_2
- Transient climate response: shorter term metric

  TCR = warming at yr 70 if gradually double CO_2

Long term climate sensitivity - ECS

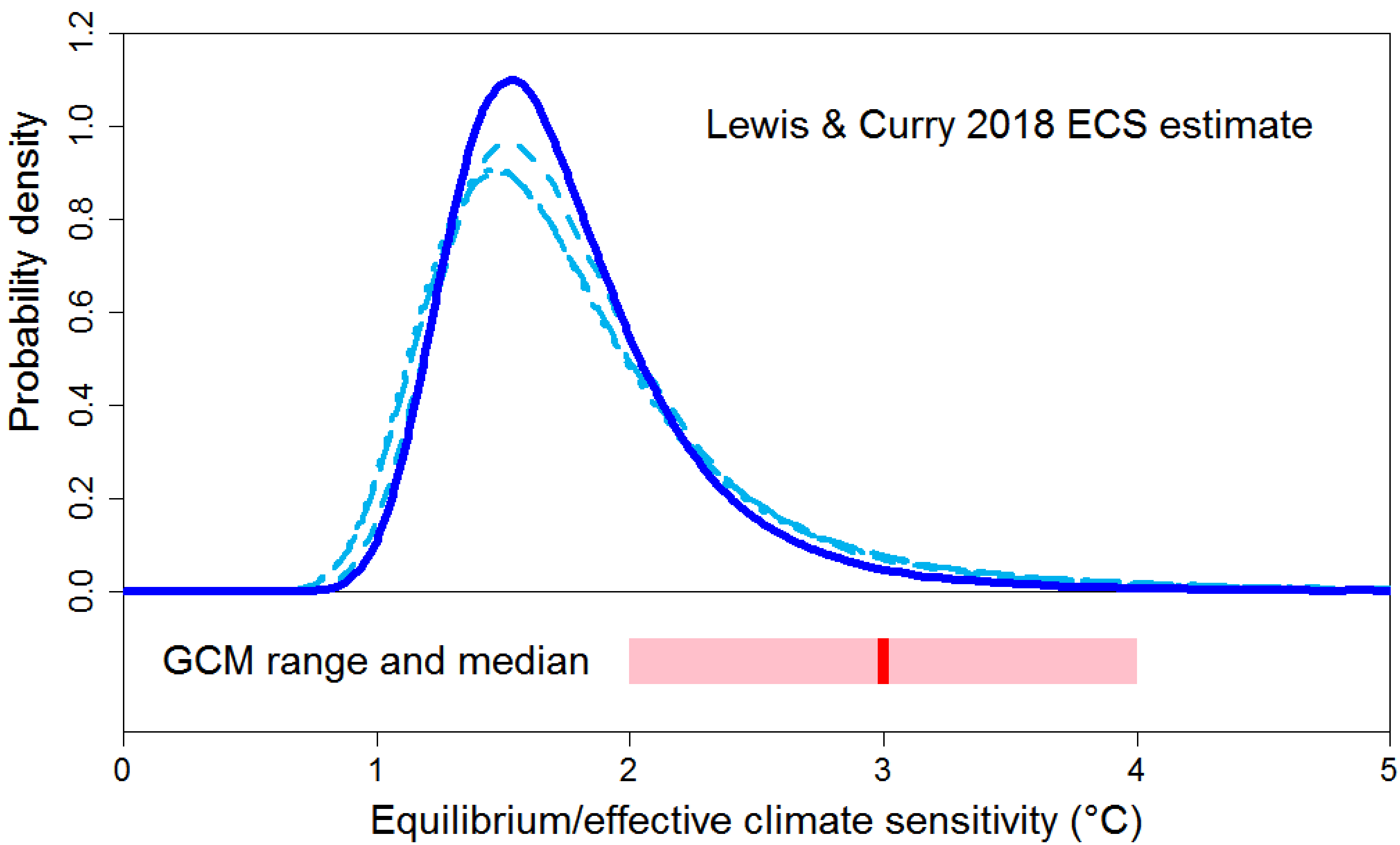
- ECS range unchanged since 1979; mainly GCM-based
- IPCC (AR5) ECS 66% range 1.5–4.5°C: very uncertain
- Typical GCM ECS ~3.3°C : 1.2°C basic, 2.1°C feedbacks

	ECS Range (°C)	**ECS Best estimate** (°C)	**TCR Range** (°C)
Charney Report 1979	1.5–4.5	3.0	
NAS Report 1983	1.5–4.5	3.0	
Villach Conference 1985	1.5–4.5	3.0	
IPCC First Assessment 1990	1.5–4.5	2.5	
IPCC Second Assessment 1995	1.5–4.5	2.5	
IPCC Third Assessment 2001	1.5–4.5	None given	1.1–3.1 [a]
IPCC Fourth Assessment 2007	2.0–4.5	3.0	1.0–3.0
IPCC Fifth Assessment 2013	1.5–4.5	None given	1.0–2.5

[a] Range based on models only.

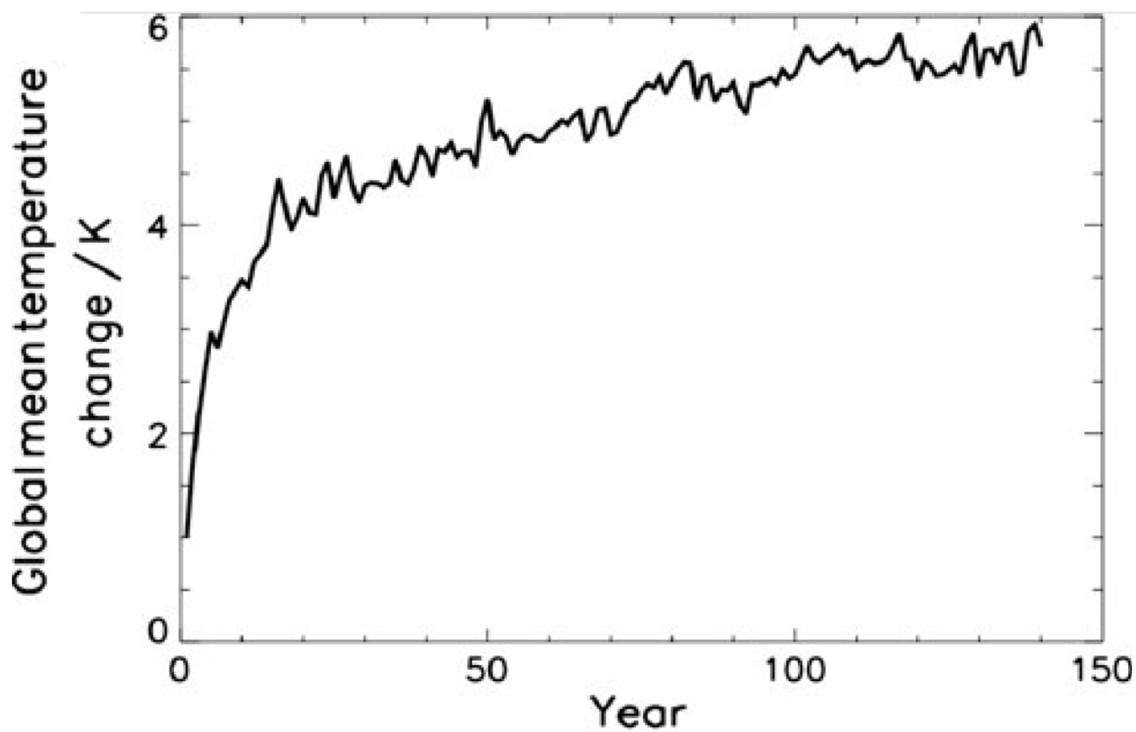
Long term sensitivity – Observations

Last 150 years observations => ECS 1.7°C (1–3°C)



Multidecadal climate sensitivity – TCR

- Large ocean heat capacity slows rise towards ECS
- Fast warming for 20 years, then slow for 1000+ years
- So ECS not a good metric for multidecadal warming



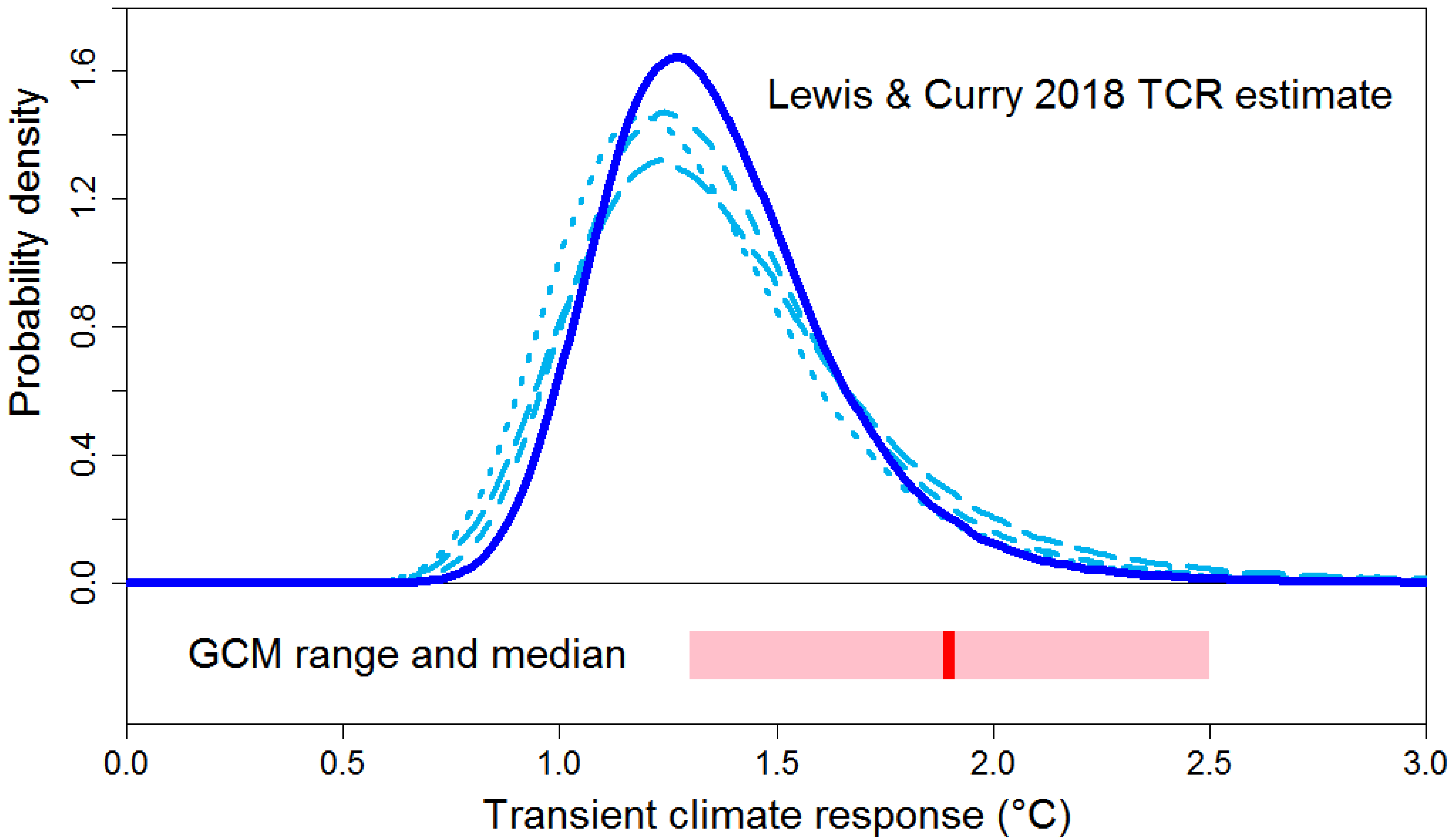
Warming in a typical GCM after CO_2 is abruptly quadrupled

Multidecadal climate sensitivity – TCR

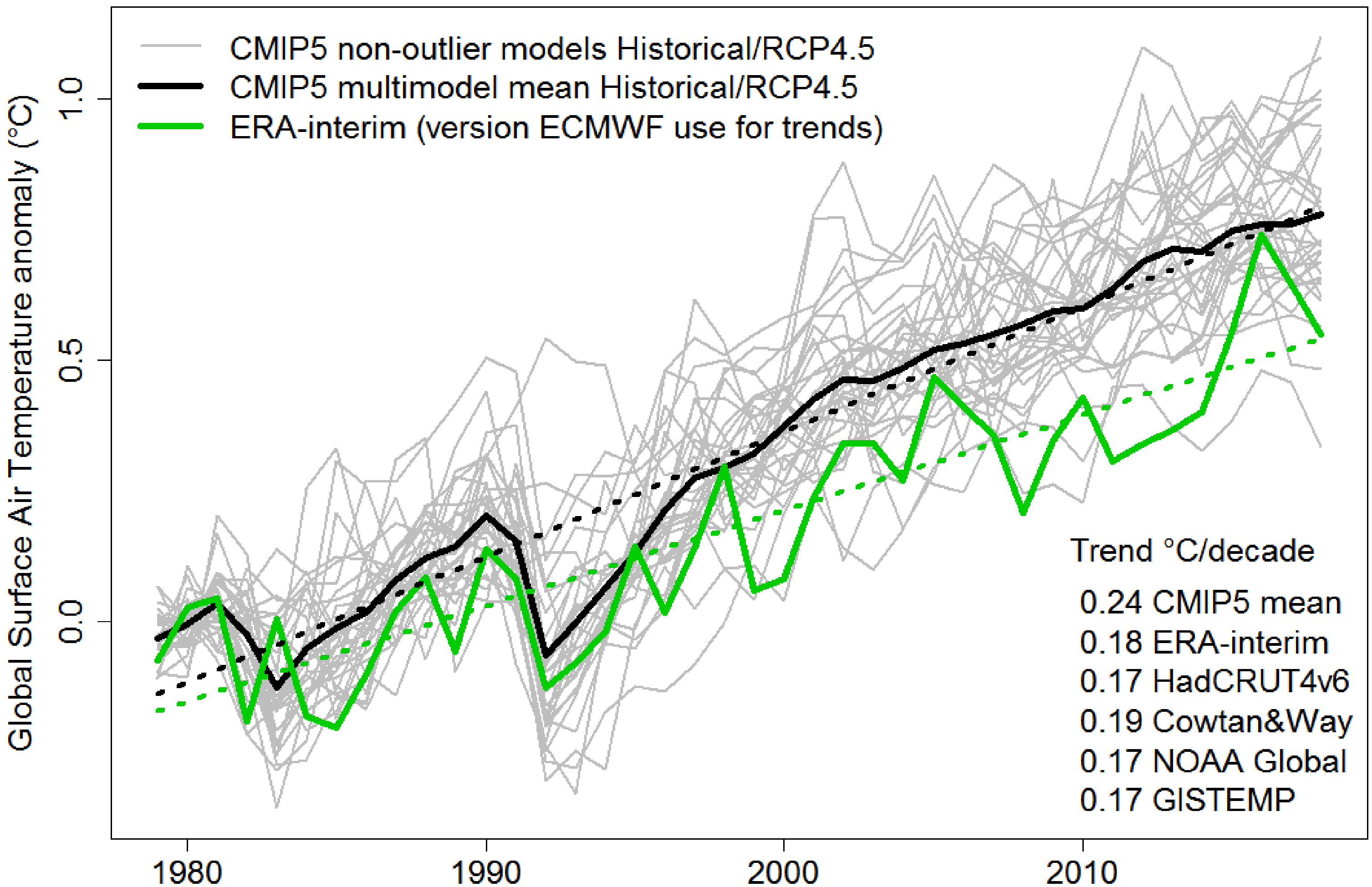
- Metric used is the Transient climate response
- TCR: warming at year 70 if smooth CO_2 rise to 2x
- TCR is lower and less uncertain than ECS
- < 2100 warming depends more on TCR than ECS
- IPCC AR5 TCR range: 1.0–2.5°C
- GCM TCR range 1.3–2.5°C; average 1.8–1.9 °C

Multidecadal sensitivity - Observations

Last 150 years observations => TCR 1.35°C (1–2°C)



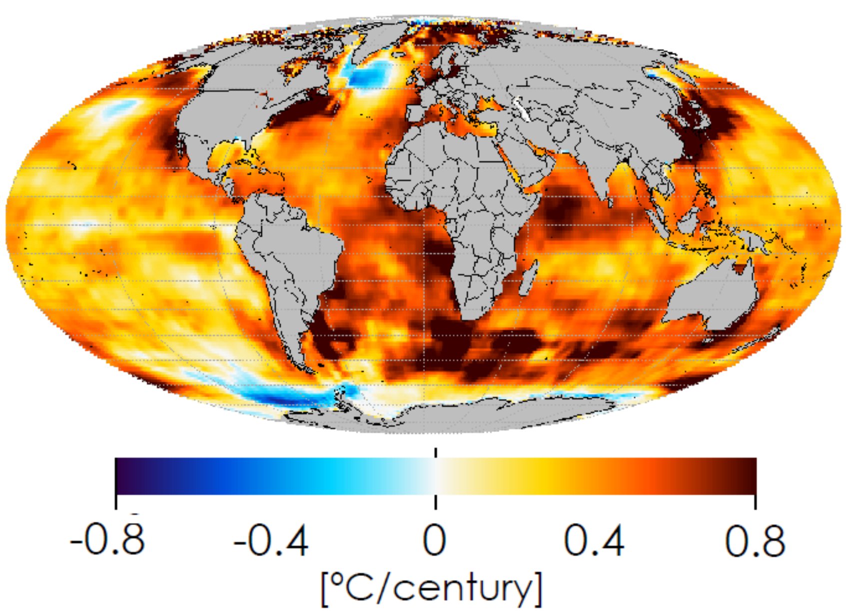
Models over-warmed 1979–2018



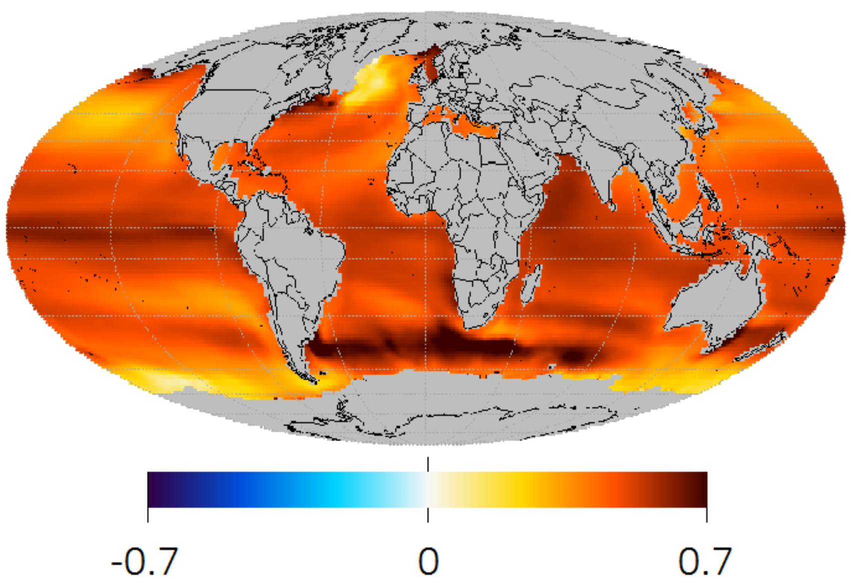
Why do observations & GCMs differ?

- GCM-simulated historical warming patterns ≠ actual
- GCM ECS low if follow observed warming pattern!
- Did natural variability depress historical sensitivity?
- Such claims are due to use of a flawed SST dataset

Observed SST trend 1870-2017



CMIP5 Historical SST trend 1870-2016



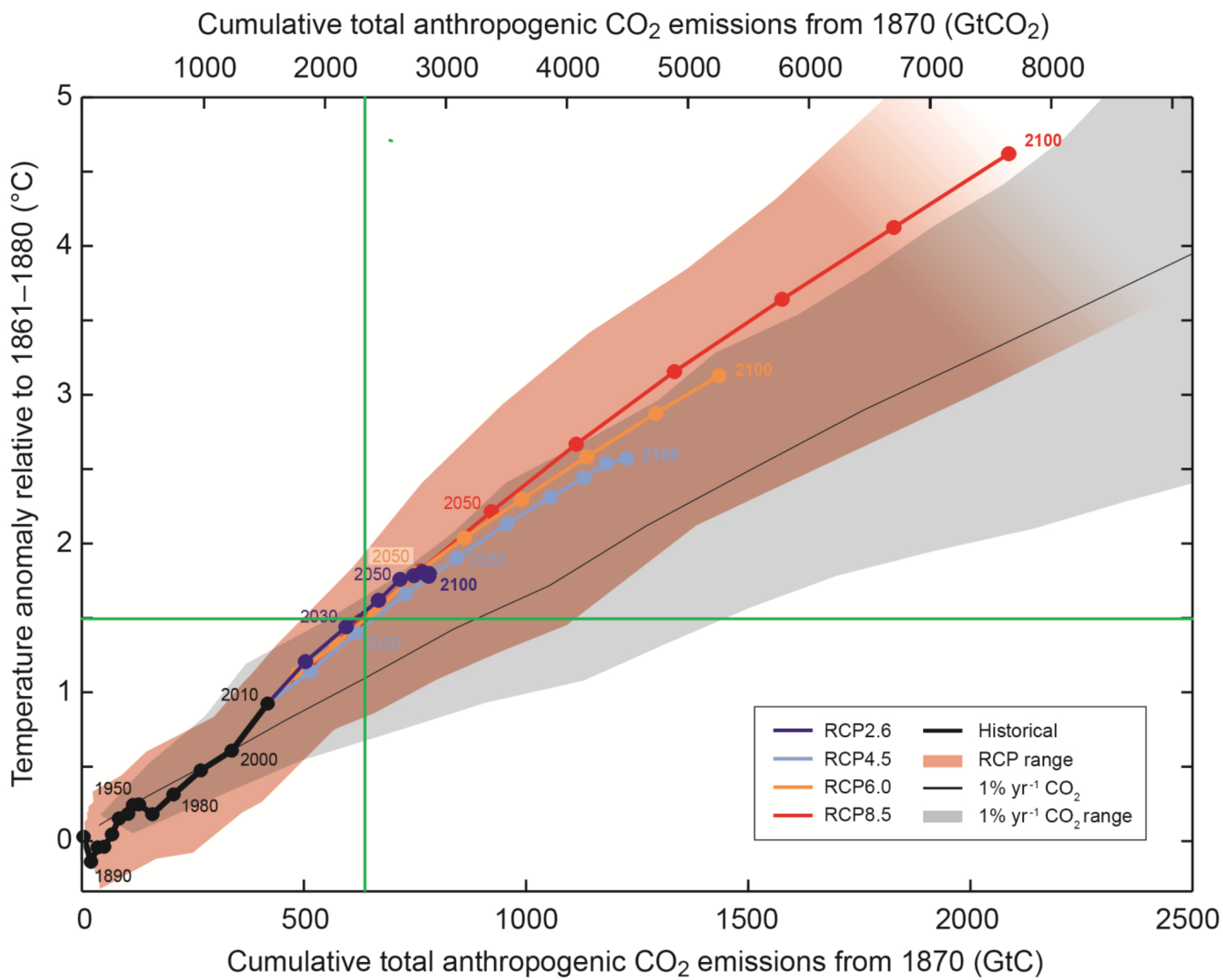
Relating warming to CO_2 emissions

- 40% of human CO_2 emissions remain in atmosphere
- Airborne CO_2 fraction will fall *very* slowly, to 15-20%
- ESMs project no cooling after emissions cease

  ESM = GCM with carbon etc. cycle model added
- In ESMs, warming $\propto$ cumulative CO_2 emissions
- This is why people talk about 'carbon budgets'
- Carbon budget: cumulative emissions for $\leqslant$ 2°C (say)
- ESM-derived carbon budgets are driving policy

Warming relative to emissions in AR5

On RCP6.0 scenario, 3.2°C rise in 2090s; green lines show 1.5°C rise for 625 GtC emissions



Transient climate response to emissions

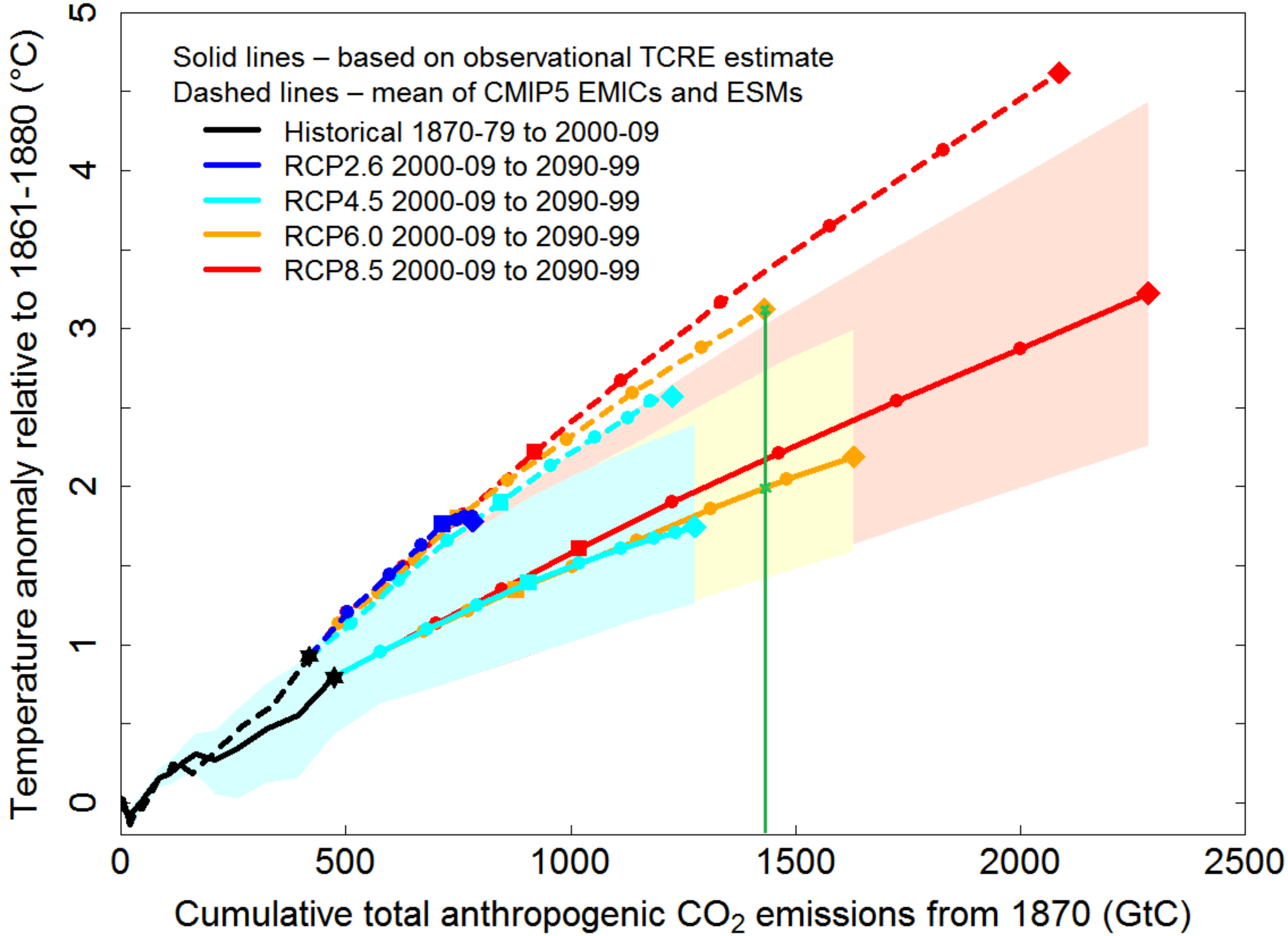
- AR5 ESM-derived carbon budgets ridiculously low
- There is a simpler way to project future warming
- Use the Transient Climate Response to Emissions
- TCRE = warming per 1000 GtC cumulative emissions
- TCRE estimated over ~70 yrs; ESMs or observations

Projecting future warming using TCRE

- TCRE = warming per 1000 GtC cumulative emissions
- In ESMs TCRE averages ~1.65°C, but ranges widely
- AR5 assessed a 0.8–2.5°C TCRE range; mainly ESMs
- Project future warming as: Future emissions x TCRE + warming from human non-CO_2 emissions etc.
- This is what IPCC SR1.5 did – link to ESMs is indirect
- But ESMs carbon uptake increase with CO_2 too weak & ESMs carbon uptake decrease as warms too strong
- Observational TCRE estimate 1.05°C, range 0.7–1.6°C

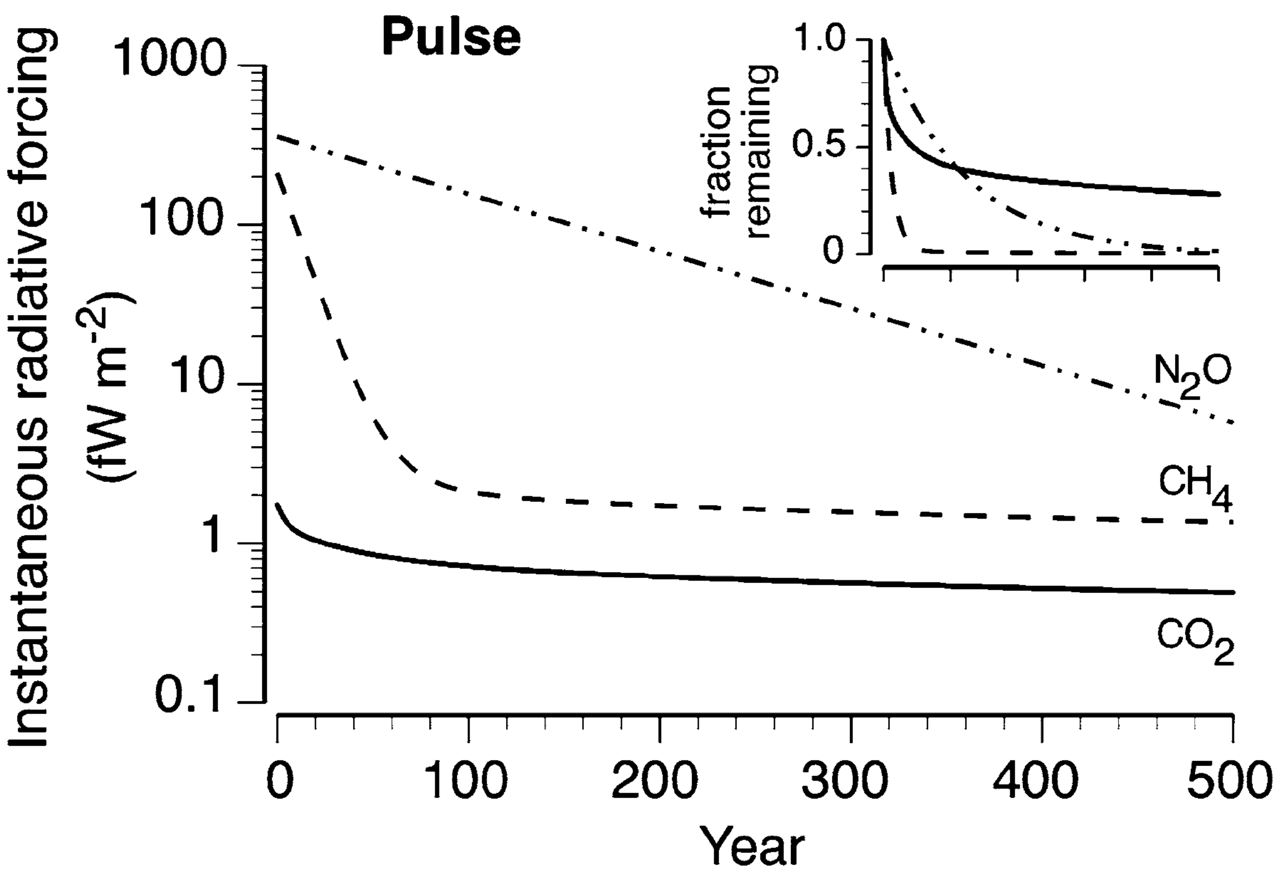
Warming from observed TCRE, TCR, ECS

Warming on RCP6.0 (yellow lines) at AR5 2090s emissions (green line) is 2.0°C vs 3.2°C per IPCC AR5



Methane & Nitrous Oxide

- Unlike CO_2, atmospheric CH_4 & N_2O are broken down
- Exponential decay; Lifetimes (yrs): CH_4 12½; N_2O 120



Policy implications

- IPCC AR5 ESM projections linking warming to cumulative emissions are driving climate policies
- IPCC projections => rapid reductions in CO_2 emissions needed to meet $\leqslant$ 2°C (or 1.5°C) target
- Observation-based projections => slower CO_2 emission reductions will meet $\leqslant$ 2°C target
- Low net emissions needed post-2100 if want $\leqslant$ 2°C
- CH_4 & N_2O emissions matter, but CH_4 decays quite fast

Policy issues

- Many climate change policies are wasteful/harmful
- Unclear that serious problems if warming 2–3°C
- AGW a long term problem; adjust policy adaptively
- Maybe not the most serious environmental problem

Conclusions

- Best observational estimates of climate sensitivity are (for doubled CO_2 concentration):
  – long term: 1.7°C, 45% below typical GCMs
  – multidecadal: 1.35°C, 25%+ below typical GCMs
- Likely warming to 2100: 60-65% of AR5 projection
- Near zero emissions in 2050 not vital: if still high but soon drop, likely warming in 2100 is only ~2°C
- Warming of 2–3°C most unlikely to be disastrous

Thank you for listening

Nic Lewis

Presentation slides and notes will be available, together with papers and articles by me, at

www.nicholaslewis.org