Climate Realism

Understanding Agreement & Disagreement in Climate Science

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What is Climate Realism?
Acknowledging *Knowledge* and *Ignorance*

- There are many scientific agreements and disagreements in climate science.
- This talk is not about who is right and who is wrong.
- The key questions of my talk:
- **Which knowledge claims are reliable and trustworthy and which are less so?**
- **What do we really know about terrestrial climate change?**
- **Why do we accept certain scientific claims about climate change but are doubtful about others?**

What is Climate Realism?

What do we reliably *know* about terrestrial climate change?

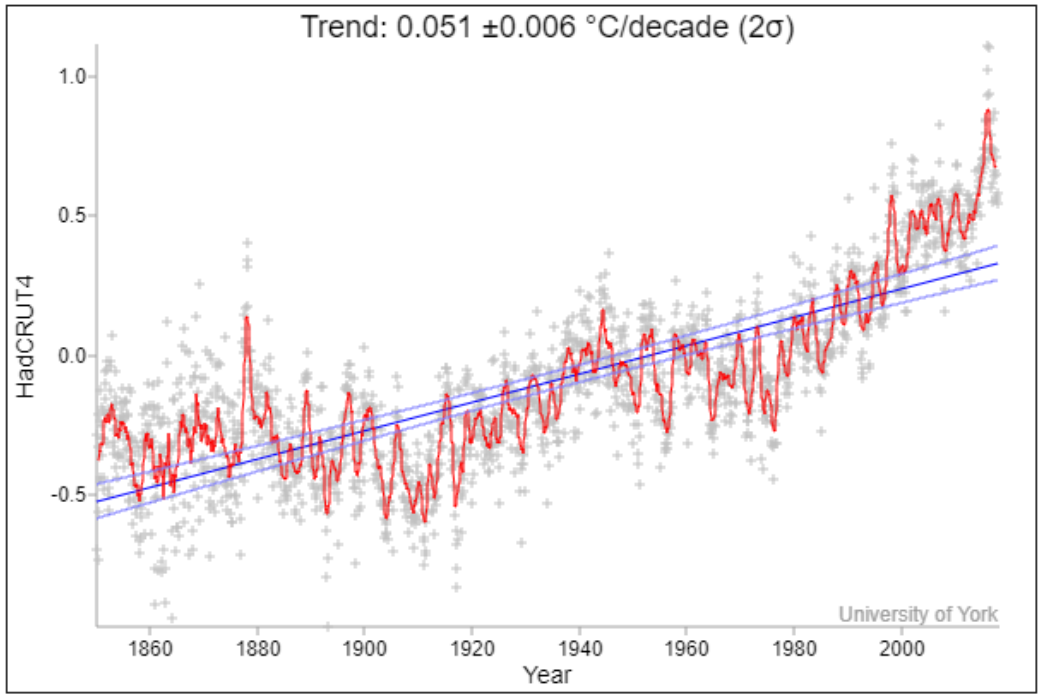
- **RECENT & PRESENT:** more robust knowledge based on empirical observations and verifiable temperature measurements
- **PAST:** ambiguous knowledge based on circumstantial evidence and estimates of paleoclimate proxy data
- **FUTURE:** Climate is a highly complex, chaotic and non-linear system; affected by numerous known & unknown factors, dynamics and feedback loops, i.e. long-term future climate cannot be predicted reliably.

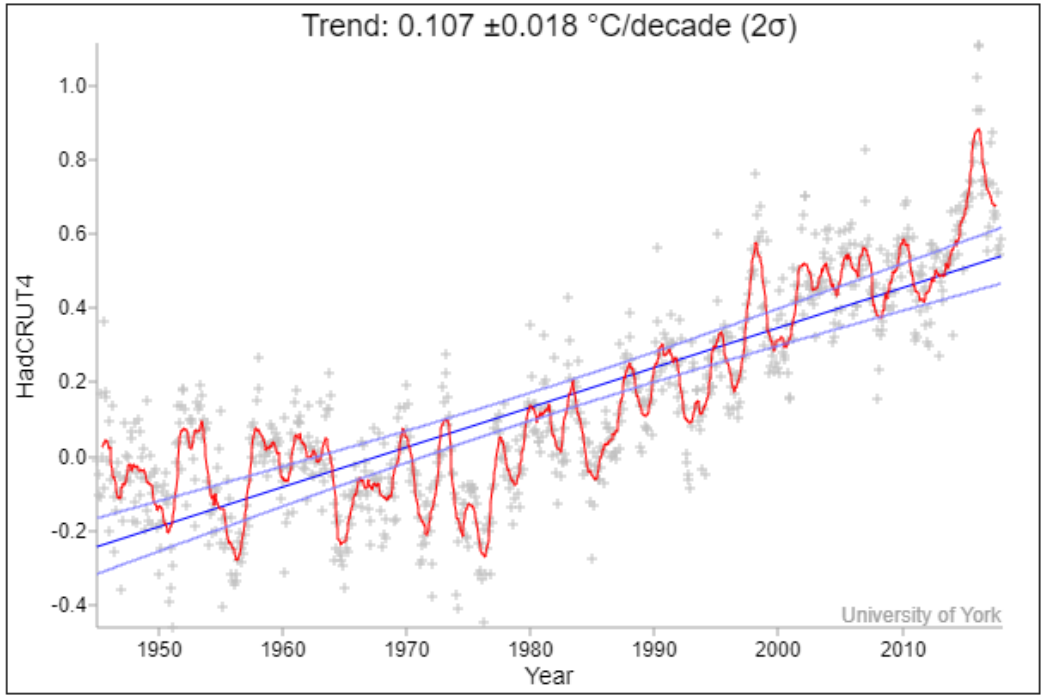
Empirical vs *Theoretical* Knowledge

- **Empirical evidence - verifiable** data and **replicable** methods.
- Reliable data and reliable estimates & predictions **diminish** the further one moves back or forward in time.
- Modern warming trend (since ~1850) generally agreed because **observational data is fairly robust** and **based on verifiable measurements**.
- Controversy increases as climate research moves further back in time and further into the future.
- Climate realism acknowledges significant difference between **verifiable knowledge** and **hypothetical knowledge based on indirect evidence.**

General Agreement
The Modern Warm Period

- **Met Office's HadCRUT4** dataset starts in 1850 -- not enough temperature data before then to reliably construct global temperature.



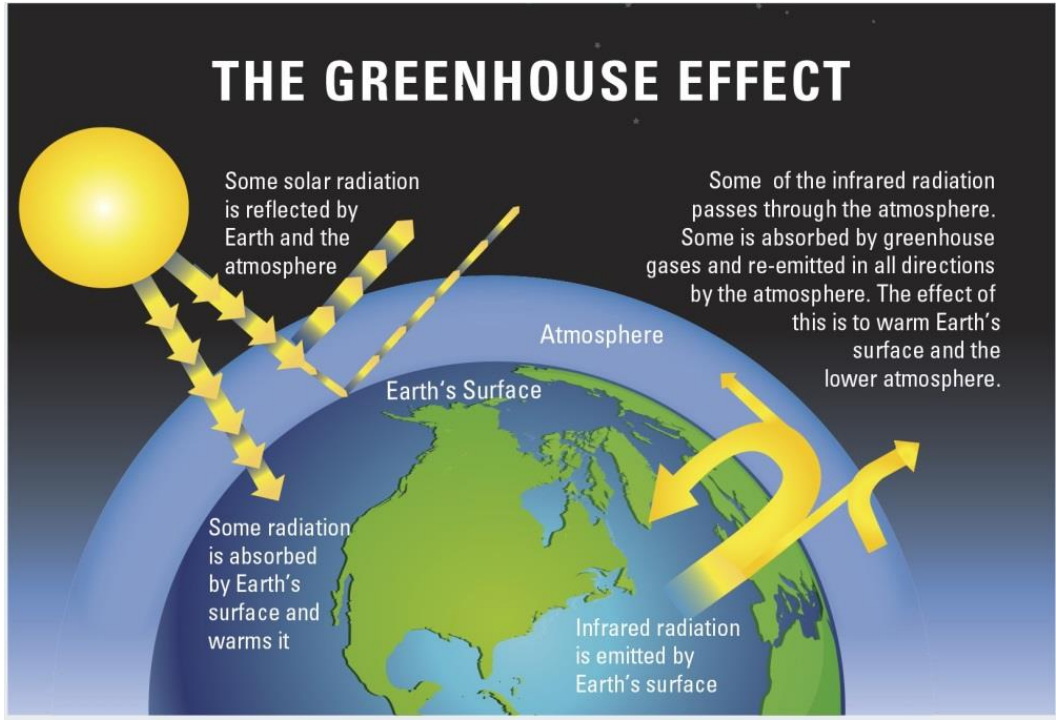


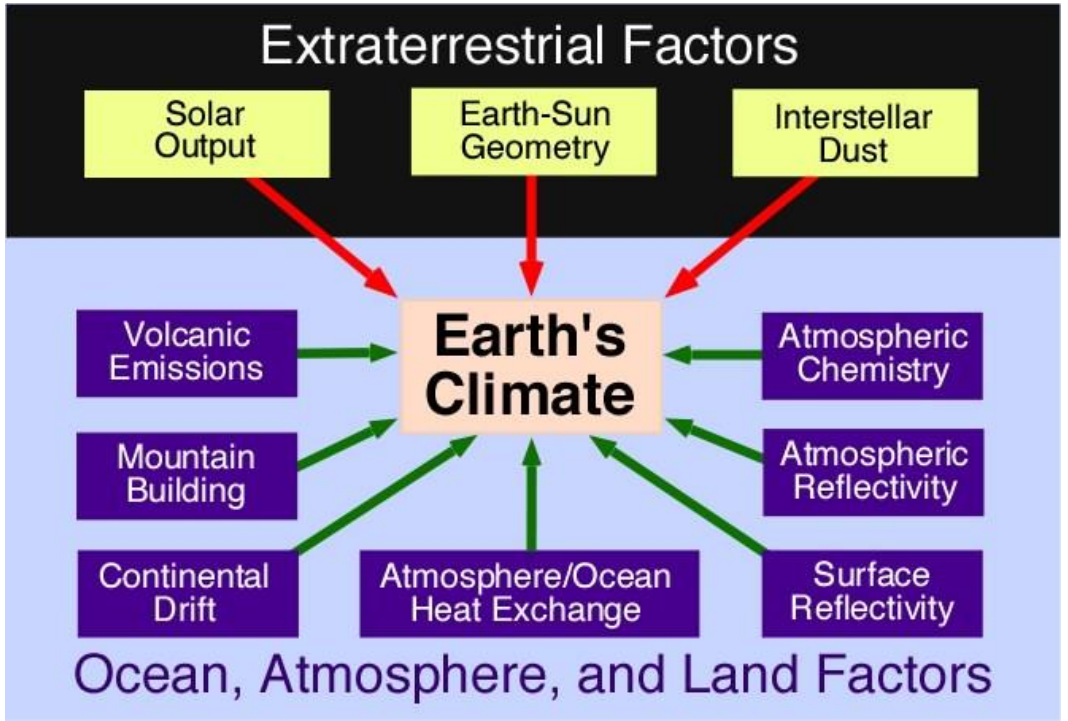
http://www.ysbl.york.ac.uk/~cowtan/applets/trend/trend.html

General Agreement

- Global mean temperature has risen by ~1°C since 1850
- CO2 has increased in the atmosphere from approximately 0.030% to 0.040% (or 400 parts per million, ppm) over the past 50 years.
- CO2 is a greenhouse gas and the greenhouse effect is real.
- Anthropogenic CO2 emissions have been rising steadily and have been contributing to global warming.
- Since 1990 global temperatures have risen between 0.13 °C and 0.19 °C per decade, depending on which of the official data sets is used.
- This warming trend is a third to two-thirds of the rate predicted by the IPCC in 1990 (0.3°C per decade) and slower than most climate models forecast.

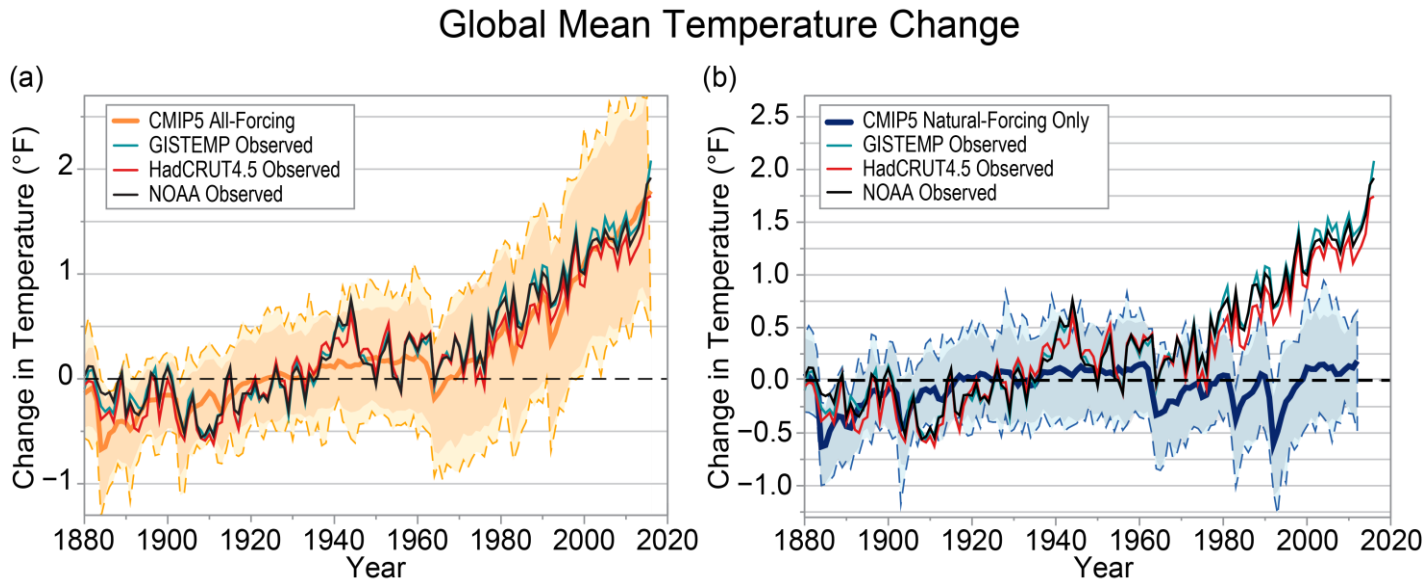
Human & Natural Causes of Climate Change





The IPCC Climate Change Consensus

- "It is extremely likely that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together." – IPCC 5th Assessment Report 2013



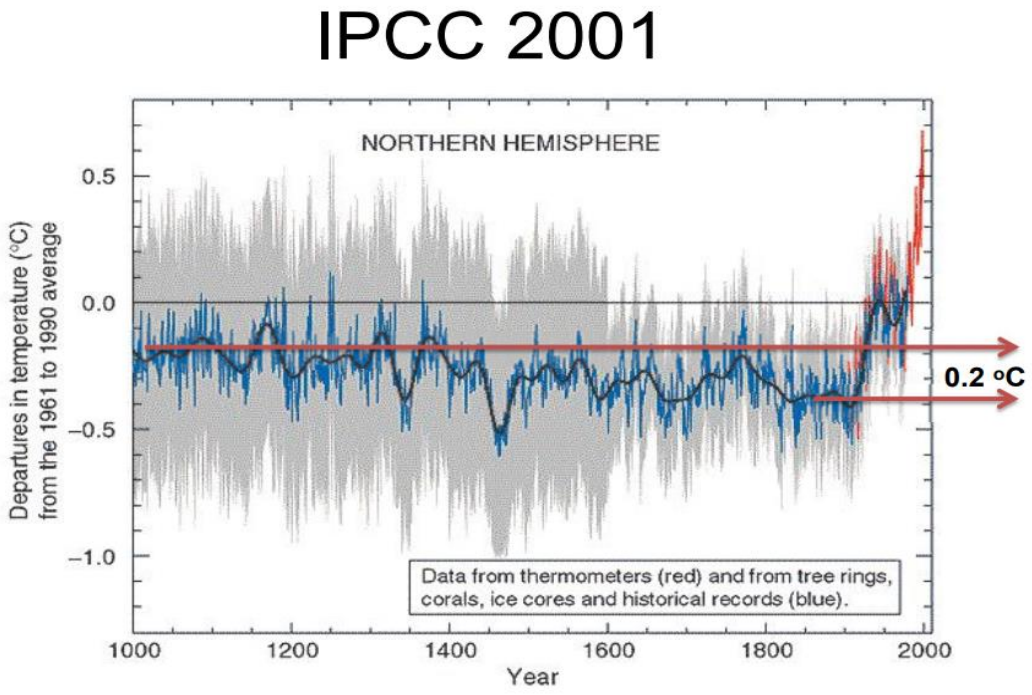
USGCRP, 2017: *Climate Science Special Report: Fourth National Climate Assessment, Fig 3.1*

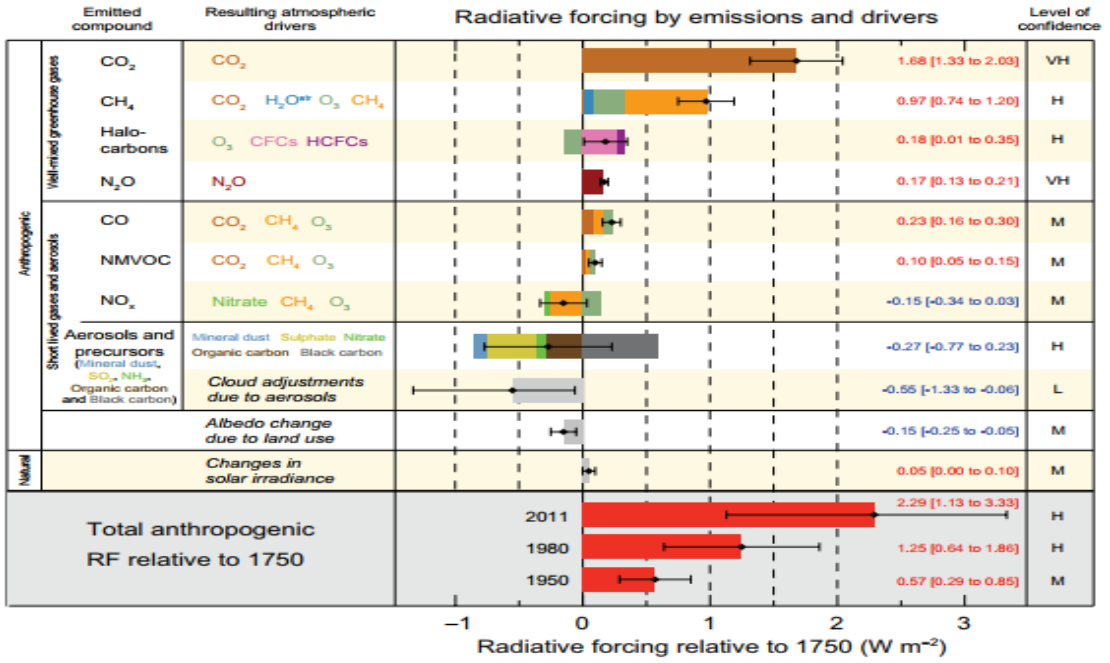
1. Disagreement
Quantifying Anthropogenic and Natural Climate Change

- **How do scientists estimate how much of the modern warming is due to anthropogenic CO2 emissions and how much due to natural variability?**
- Very difficult task due to lack of sufficiently reliable knowledge of natural variability over long periods of time (decades, centuries, millennia).
- If natural variability of past climate change is low, human factor in modern warming is more significant.
- If natural variability is more significant, anthropogenic contribution to climate change is smaller.

Estimating Natural Variability

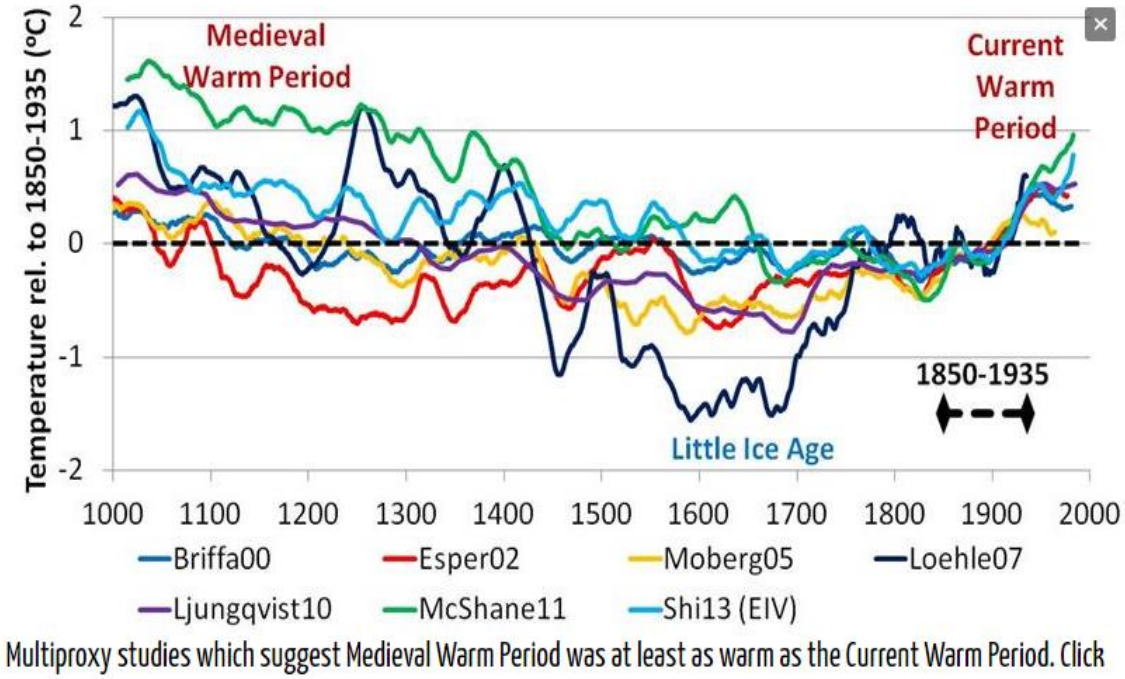
- How do scientists estimate how much of the modern warming is due to **natural variability** and how much due to **anthropogenic CO2 emissions?**



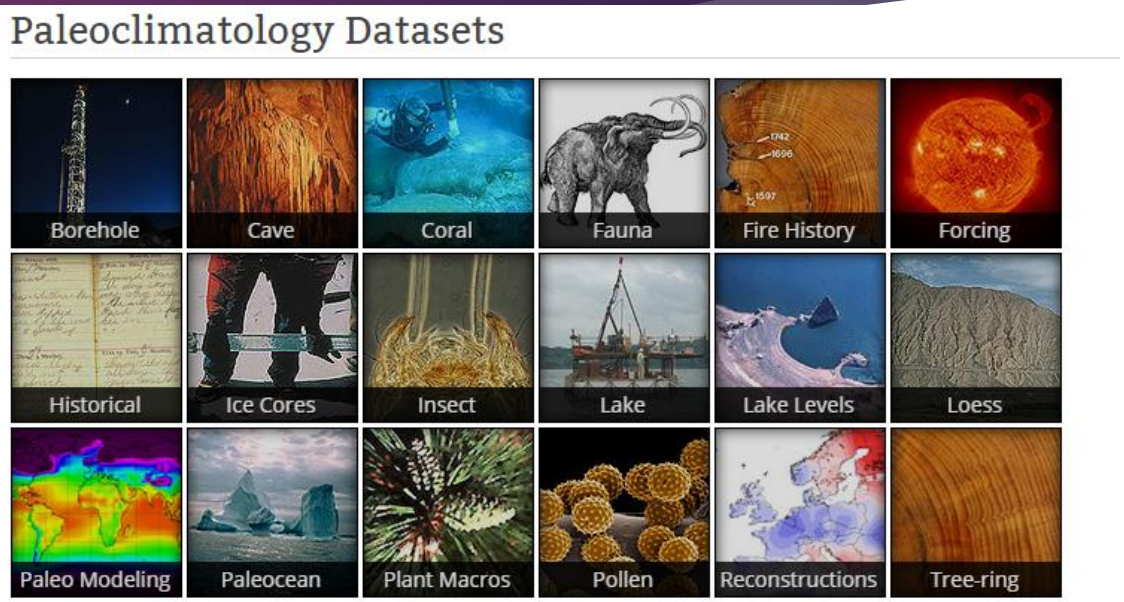


IPCC, 2013, Fig SPM.5

What if natural variability of historical climate change is much more pronounced?



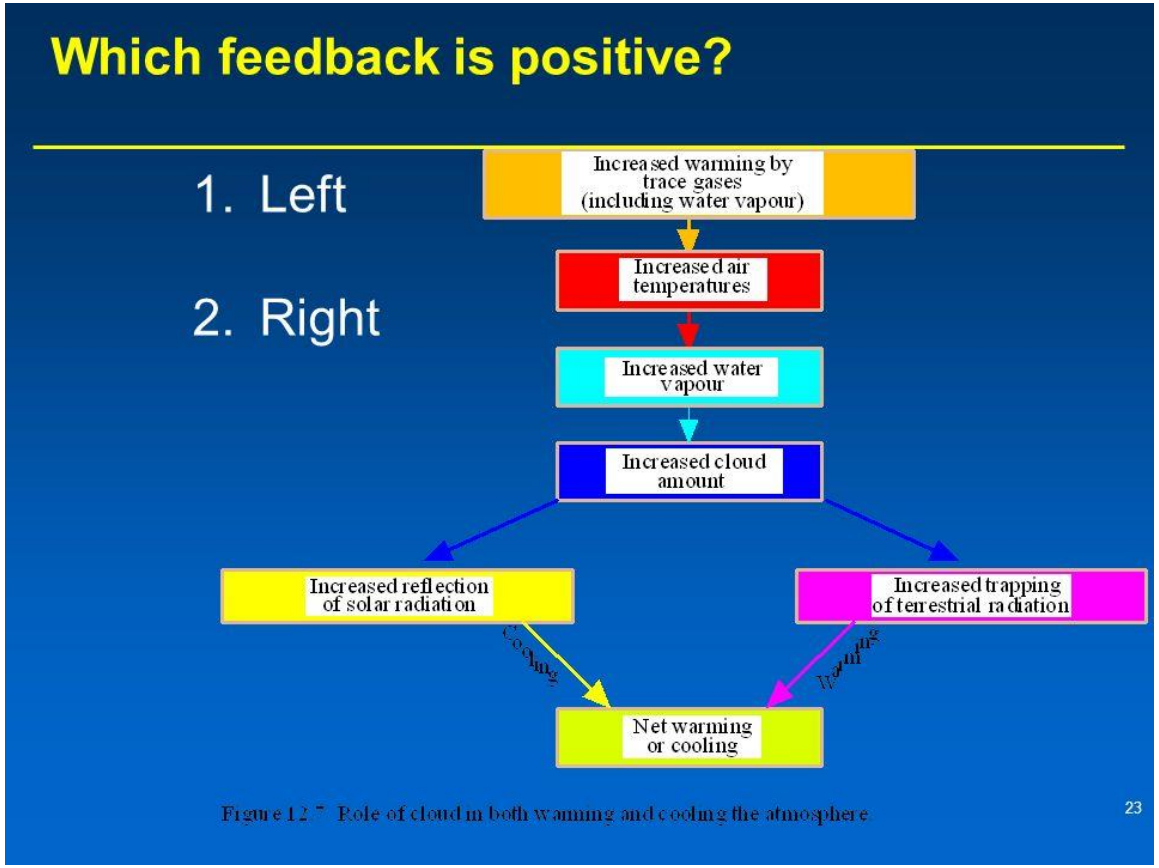
R. Connolly, and M. Connolly (2014)



The problem is that all paleo-climatological reconstructions of historical climate change rely on proxy-data that are inherently vague, uncertain and often contradictory = **GIGO problem**

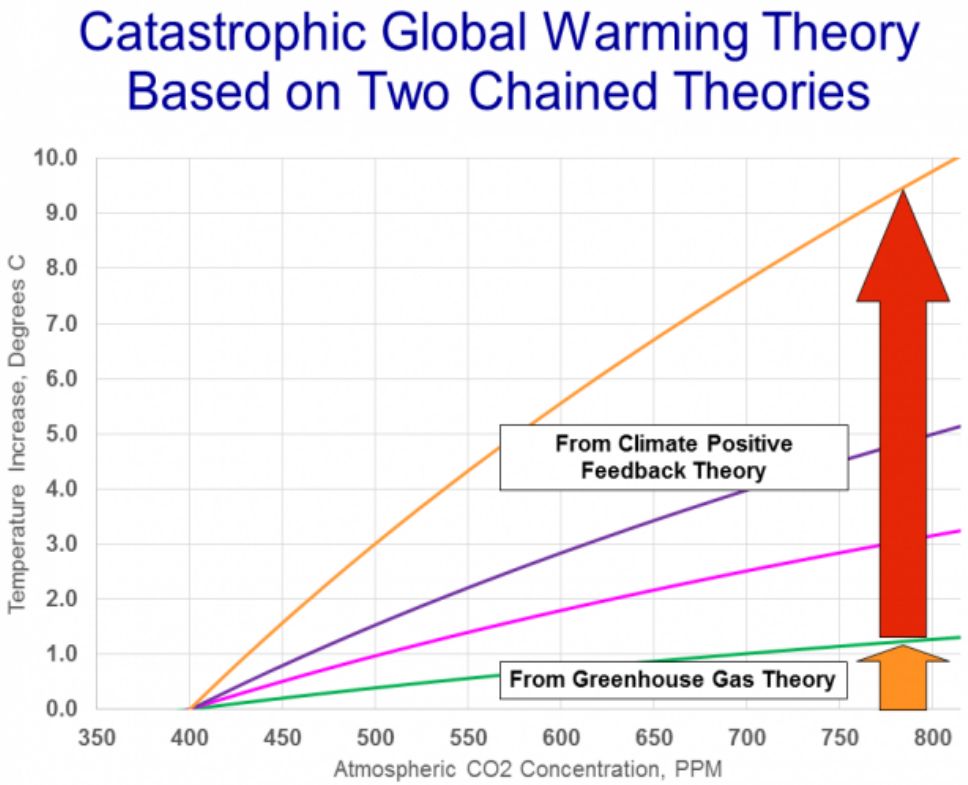
2. Disagreement
Positive vs Negative Feedbacks

- **Most climate models assume that positive feedbacks in the climate system far outweigh negative feedbacks.**
- How do clouds react to changes in temperature?
- Do they counter warming or amplify it?
- How clouds affect global temperature is one of the most contentious problems in climate science.



Positive Feedbacks cause strong global warming

- Without any feedbacks, a doubling of CO2 would result only in 1°C global warming (IPCC 2007).
- If water vapor and clouds respond to this small rise in temperature by amplifying the warming it would constitute a ***positive feedback***.
- If they counter-balance the warming, it would be a ***negative feedback***.



3. Disagreement
Climate Sensitivity

- The equilibrium climate sensitivity refers to the change in global temperature that would result from **a doubling of atmospheric CO2 concentration**
- Most climate models suggest that the equilibrium climate sensitivity is likely to be in the range 1.5°C to 4.5°C, with a best estimate value of about 3°C.

Table 1: Evolution of equilibrium climate sensitivity estimates in the last 35 years and the range for transient climate response since 2001

	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.

From: Lewis and Crok (2014)

Climate Sensitivity
Models Vs Observations

- Climate sensitivity estimates based on **computer model simulations** suggest ~3°C per doubling of CO2.
- Empirical estimates of climate sensitivity from **observational data such as temperature and ocean heat records** suggest much less (~2°C or less).
- Climate realists trust observational studies more, claim that climate models display too much sensitivity to CO2 & exaggerate future global warming.

Table 2: Recent empirical estimates for ECS that incorporate observationally-based aerosol forcing estimates, compared with those from models and in IPCC reports

Study	Best estimate (°C)	Likely range (°C)
Ring et al. 2012 (using 4 surface temperature datasets)	1.80	1.4–2.0
Aldrin et al. 2012 (main results)	1.76	1.3–2.5
Lewis 2013 (preferred main results[20])	1.64	1.3–2.2
Otto et al. 2013 (2000s data)	2.00	1.5–2.8
Otto et al. 2013 (1970–2009 data)	1.91	1.3–3.0
Average of the above[a]	1.79	1.3–2.4
CMIP3 models (per AR4 Table 8.2)	3.20	2.1–4.4
CMIP5 models (per AR5 Table 9.5)	2.89	1.9–4.5
IPCC AR4 2007	3	2.0–4.5
IPCC AR5	None given	1.5–4.5

[a]Giving a 50% weight to each of the two Otto 2013 estimates.

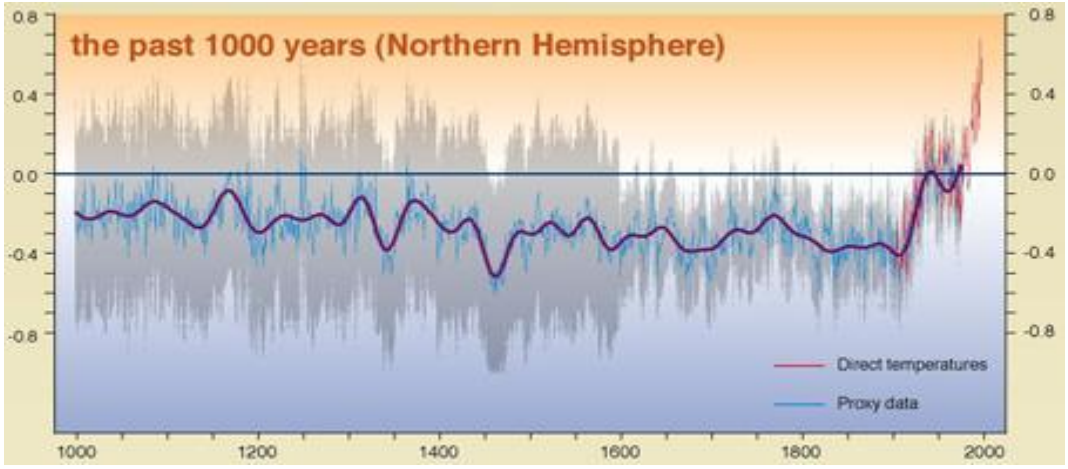
source: Lewis and Crok (2014)

4. Disagreement
How warm was the Medieval Warm Period?

- The Medieval Warm Period lasted from about 950 to 1250.
- Because paleo-climate proxy records as well as their selection and interpretation are highly contentious, there has been controversy about the magnitude and extent of the MWP.
- The IPCC concludes MWP was not as warm as today, many sceptics claim MWP was warmer or as warm than today.
- **Reality: We do not know with any degree of confidence whether MWP was global or how warm it was.**
- **We do not know what caused the MWP** -- possible causes include increased solar activity, decreased volcanic activity, and changes to ocean circulation.

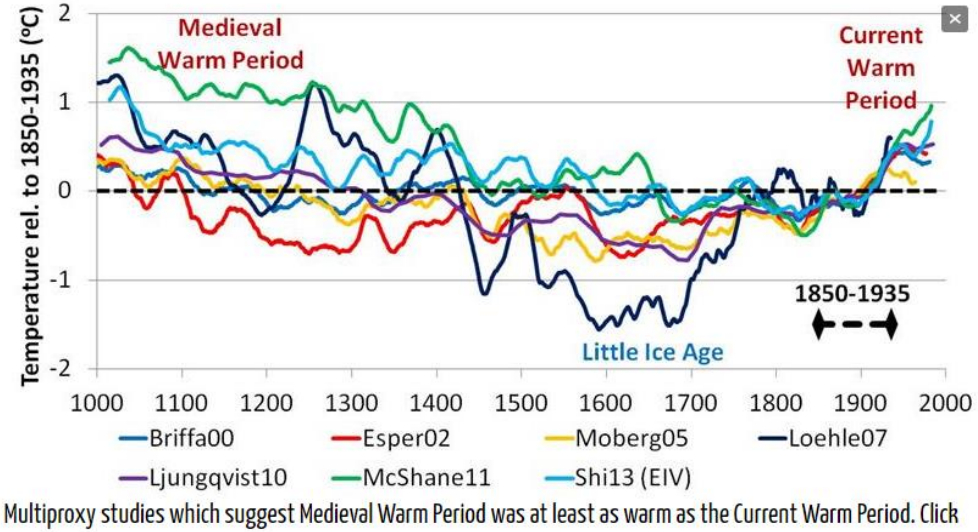
The Medieval Warm Period

How the IPCC sees the MWP



Hockey stick chart from the 2001 IPCC Third Assessment Report, showing Northern Hemisphere surface temperatures (departures from the 1961-1990 average, in degrees Celsius) of the past 1,000 years.

How climate sceptics see the MWP

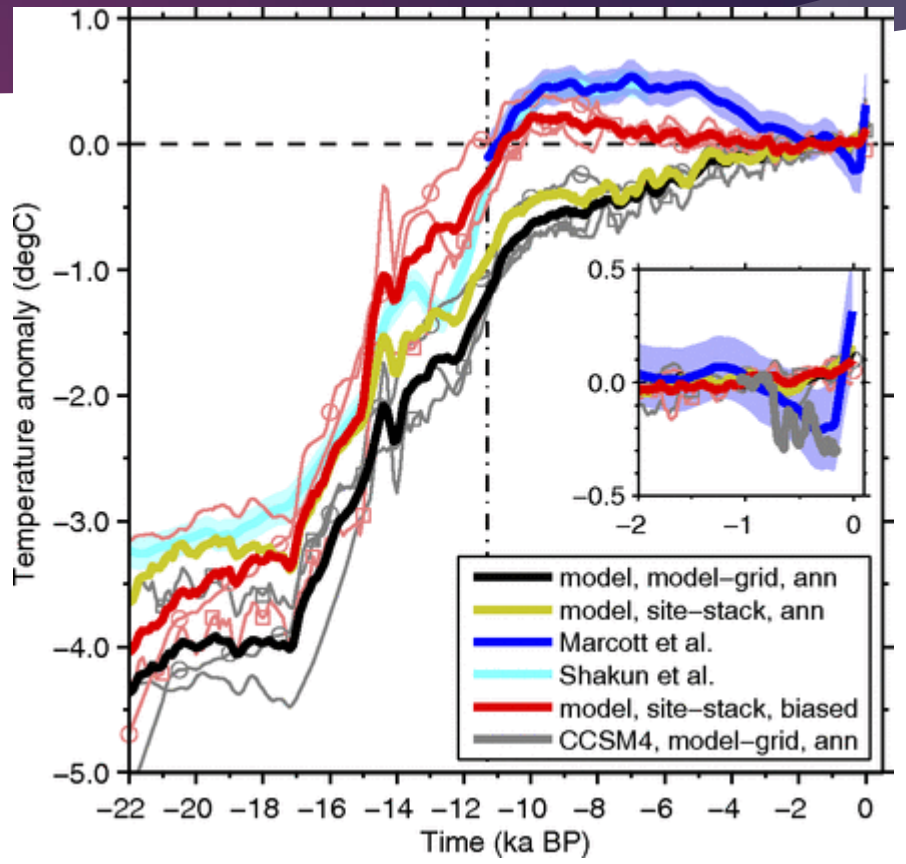


R. Connolly, and M. Connolly (2014)

The Holocene Temperature Conundrum

Paleo-climate proxy records suggest global cooling during the Late Holocene, following the peak warming of the Holocene Thermal Maximum (~10 to 6 ka) until the rapid warming of the modern warm period (Marcott et al., 2013)

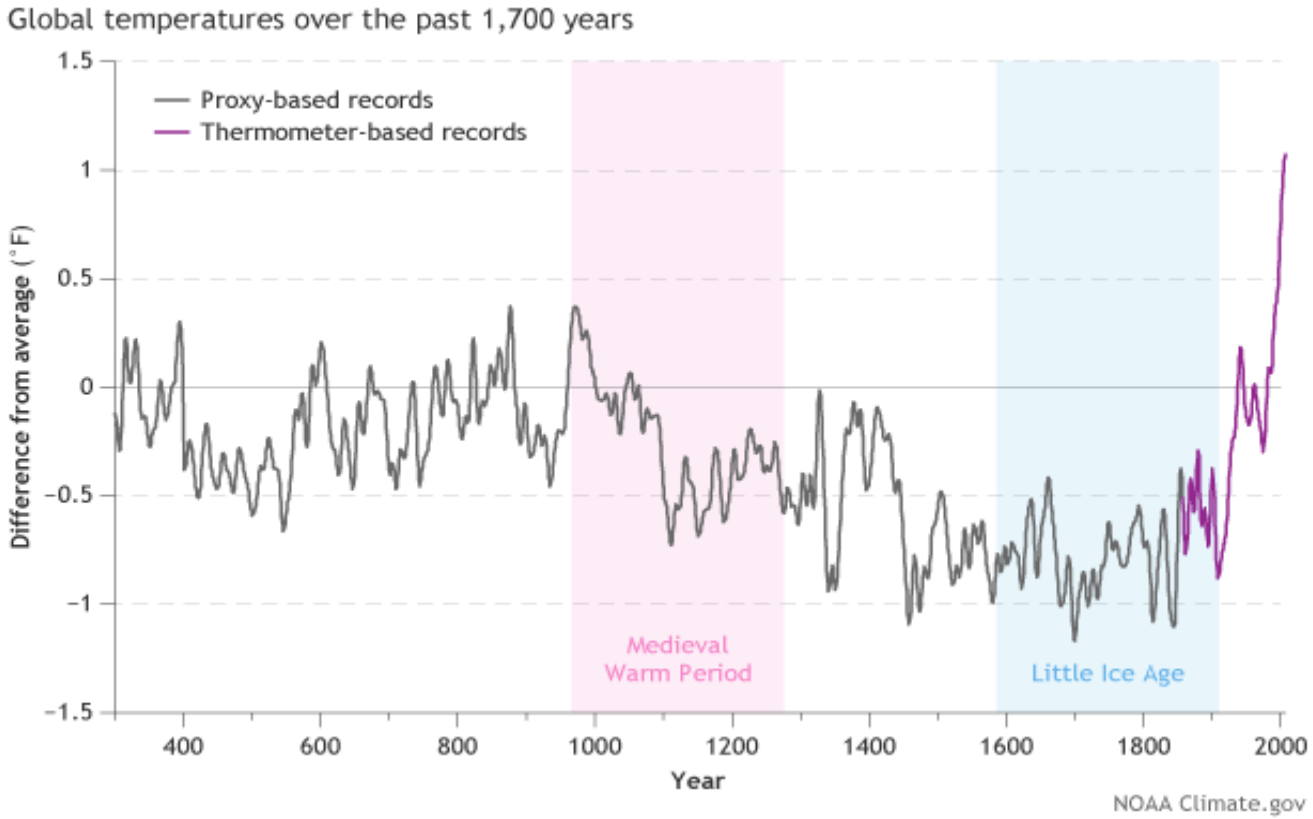
"This global cooling is puzzling because it is opposite from the expected and simulated global warming trend due to the retreating ice sheets and rising atmospheric greenhouse gases. " – Liu et al. 2014



Liu et al. 2014

5. Disagreement
How Exceptional is the Modern Warm Period?

- **NOAA (2015) conclusion:** "Over the past two millennia, climate warmed and cooled, **but no previous warming episodes appear to have been as large and abrupt as recent global warming."**



The Jury Is Out
Previous warm periods in China

- "The reconstruction was developed using proxy temperature data from five locations across China, and an observed temperature dataset provided by Chinese Meteorological Administration covering the decades from the 1870s to the 1990s."
- "Relative to the 1870s–1990s climatology, our two reconstructions both show three warm intervals during the 270s–390s, 1080s–1210s, and after the 1920s; **temperatures in the 260s–400s, 560s–730s and 970s–1250s were comparable with those of the Present Warm Period." --**Ge et al. 2013

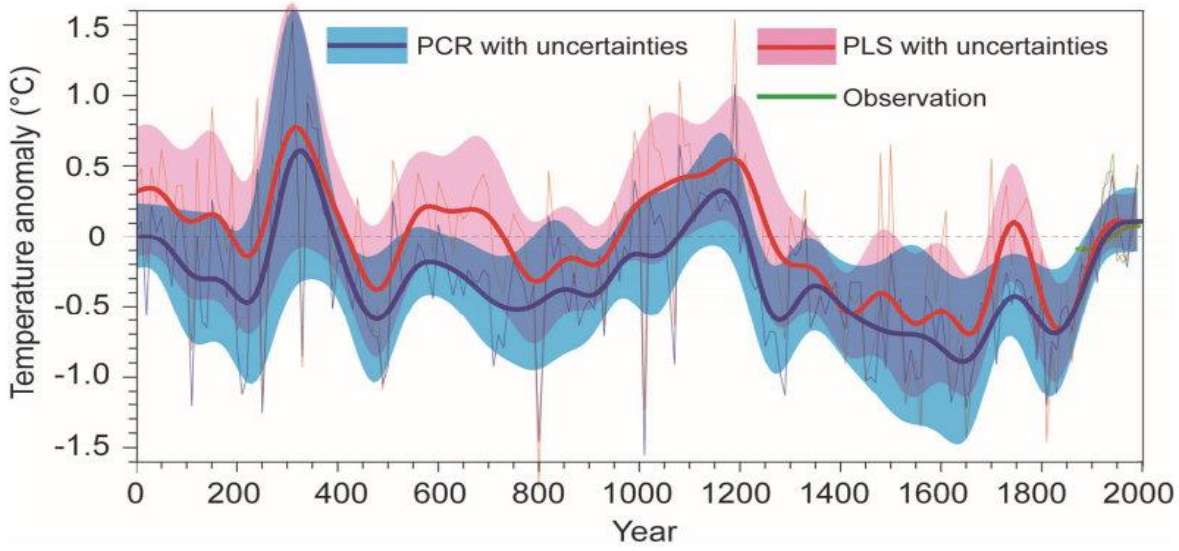


Fig. 2. Ensemble temperature reconstructions based on PLS (red line) and PCR (blue line) methods at decadal (slim lines) and centennial time scales (solid lines, smoothed by a 5-point FFT filter) along with uncertainties at the 95 % confidence level (shaded areas). The referenced value is the mean temperatures from the 1870s to the 1990s. The green line indicates the observed average air temperature.

Ge et al. 2013

Conclusion
The Science Isn't Settled

- **Human and natural factors are contributing to global warming**
- It is currently impossible to reliably quantify their specific contributions.
- Feedbacks in a highly complex system such as the climate of planet Earth are extremely difficult to quantify.
- The biggest uncertainty about future climate change is due to a manifest lack of understanding of historical natural variability and the climate's feedback mechanisms.
- *"The climate system is particularly challenging since it is known that components in the system are inherently chaotic; there are feedbacks that could potentially switch sign, and there are central processes that affect the system in a complicated, non-linear manner. These complex, chaotic, non-linear dynamics are an inherent aspect of the climate system."* – IPCC 1990
- ***"The climate system is a coupled non-linear chaotic system, and therefore the long-term prediction of future climate states is not possible."*** – IPCC 1990