



Is global warming just a giant natural fluctuation?

Será o aquecimento global apenas uma flutuação natural gigantesca?

Coimbra, 30 Jan. 2015

S. Lovejoy, McGill, Montreal

November
2014

“Friends of Science” Versus Science

Montreal



Friends of Science

Montreal



Association des Communicateurs Scientifiques

Toronto



Ottawa



What is the climate?

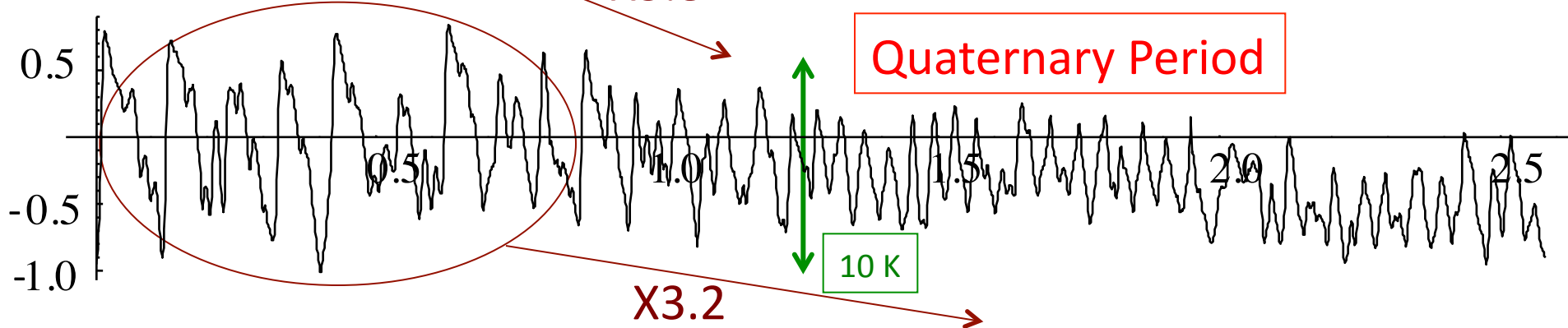
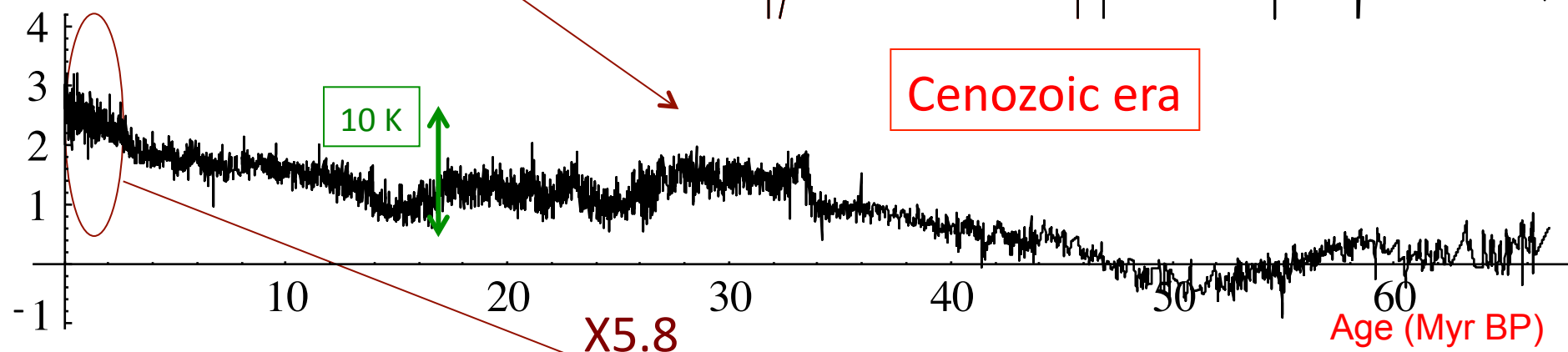
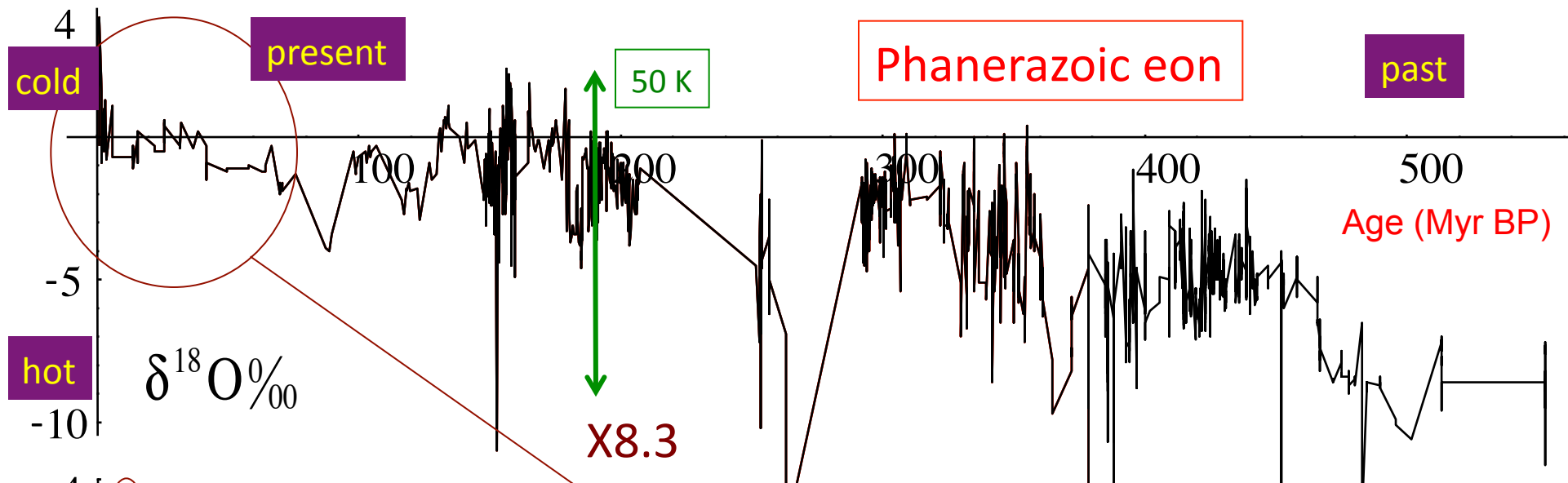
A voyage through scales

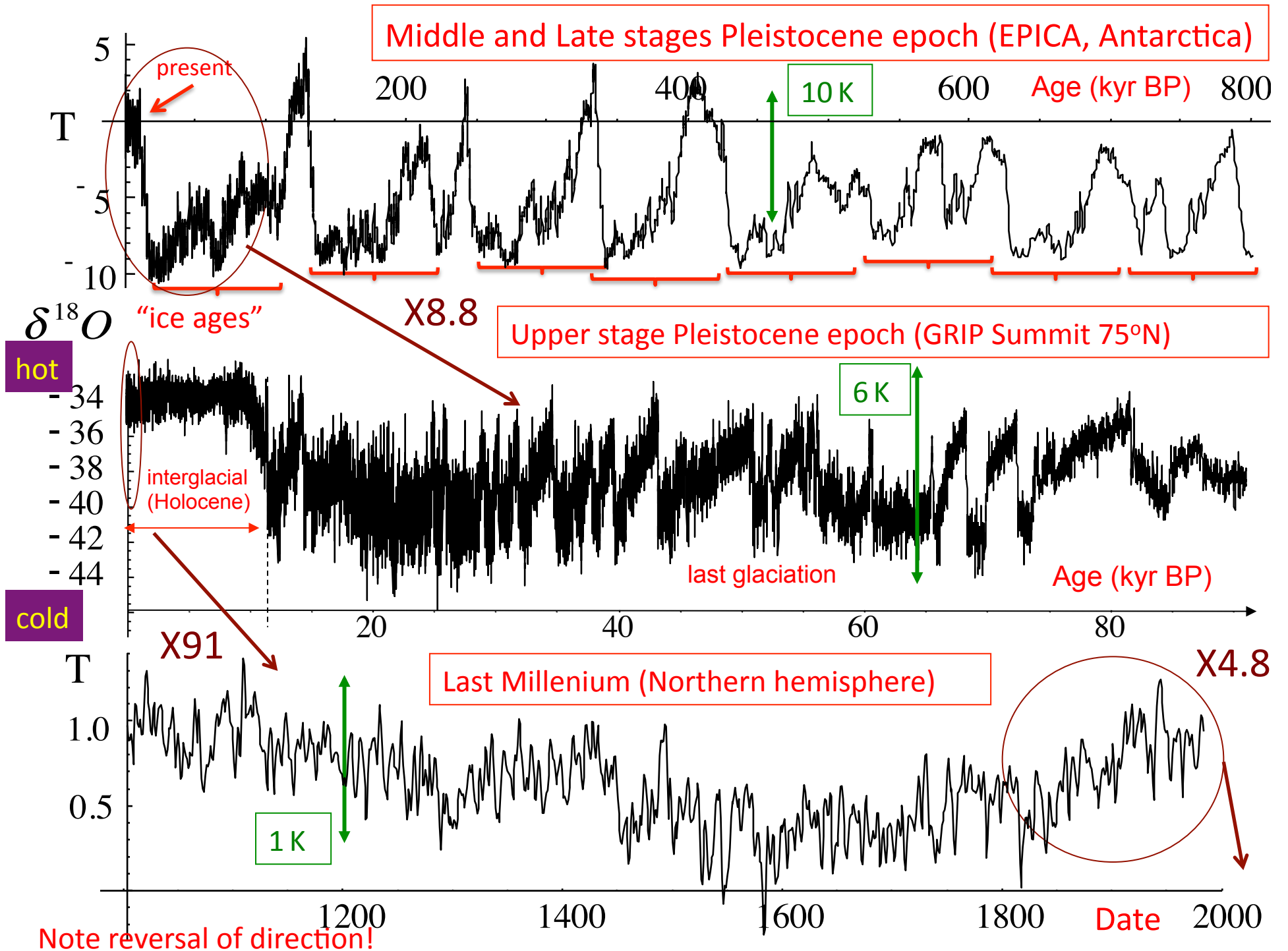
From the age of the earth to
0.001 seconds:

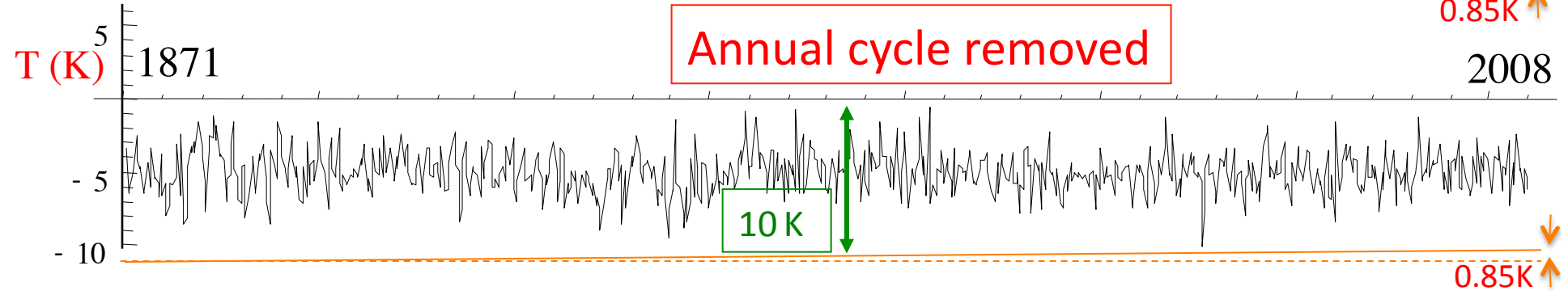
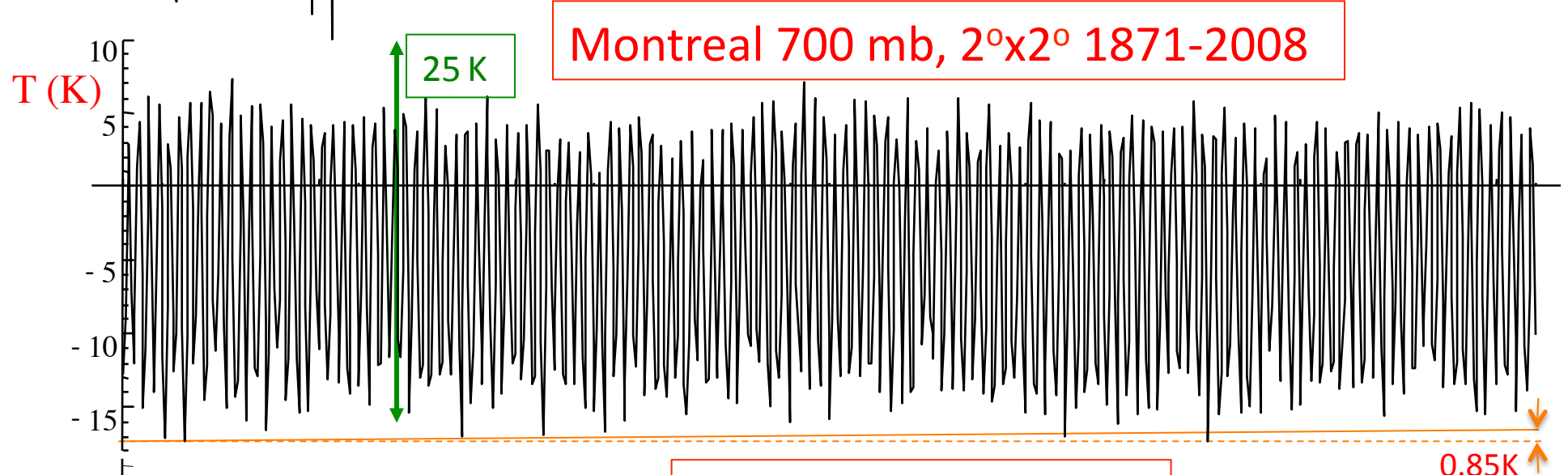
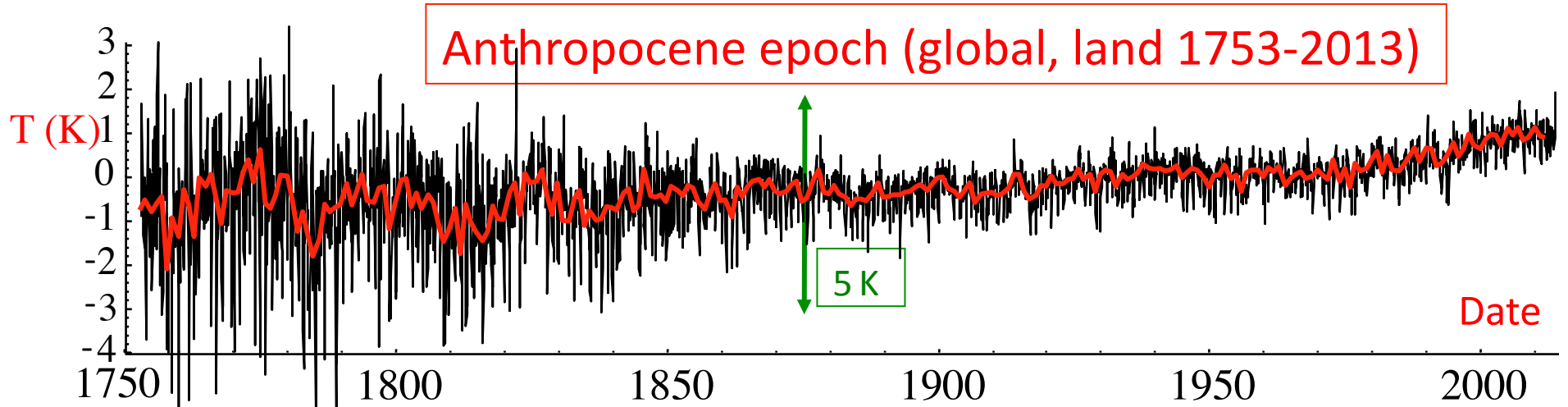
20 orders of magnitude in time

In space: the size of the planet to
millimetres:

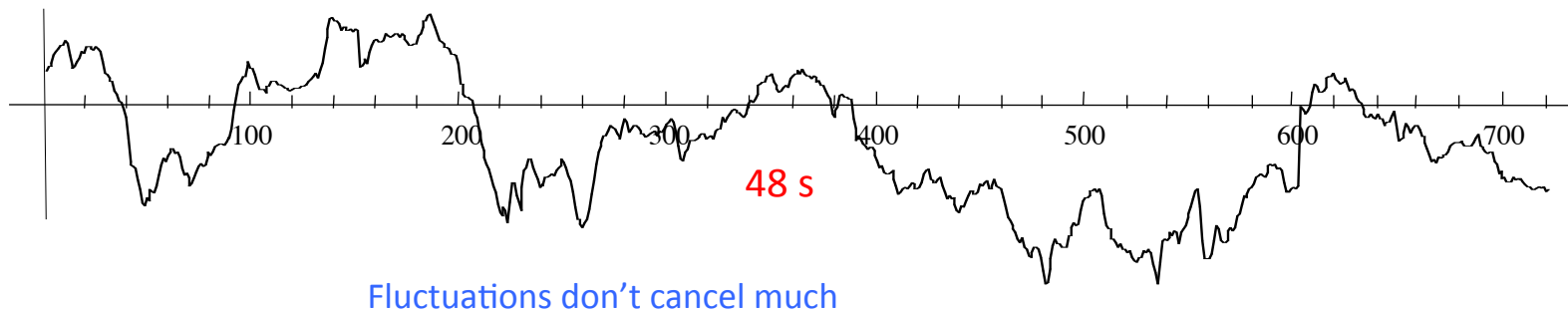
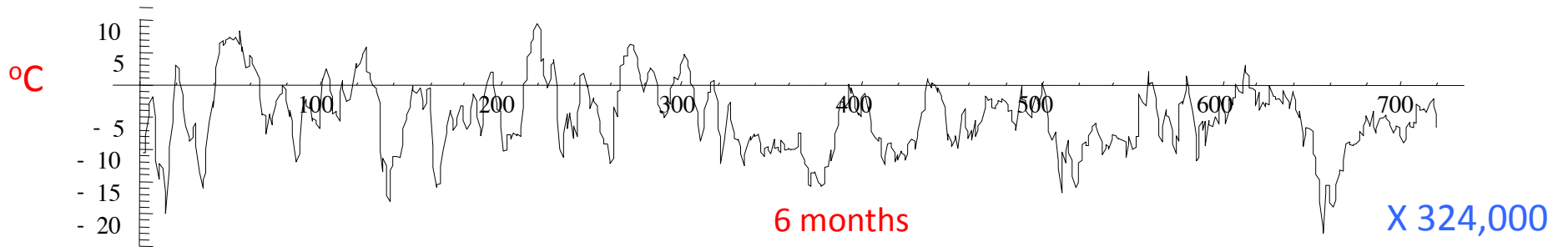
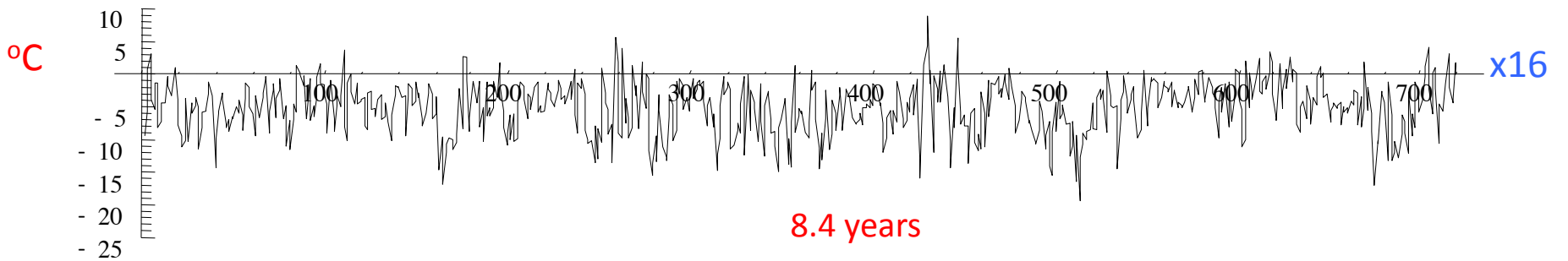
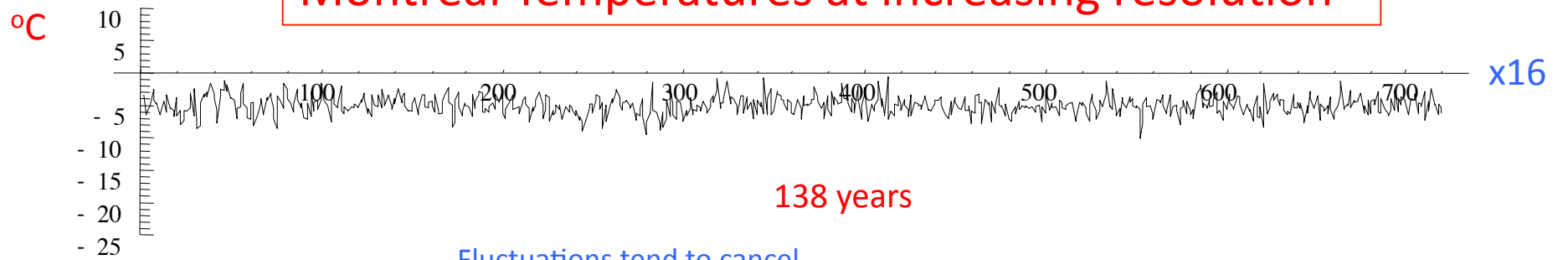
10 orders of magnitude







Montreal Temperatures at increasing resolution



The climate is not what you expect...

Clima

Tempo

"Climate is what you expect, weather is what you get."

-Lazarus Long, character in R. Heinlein 1973

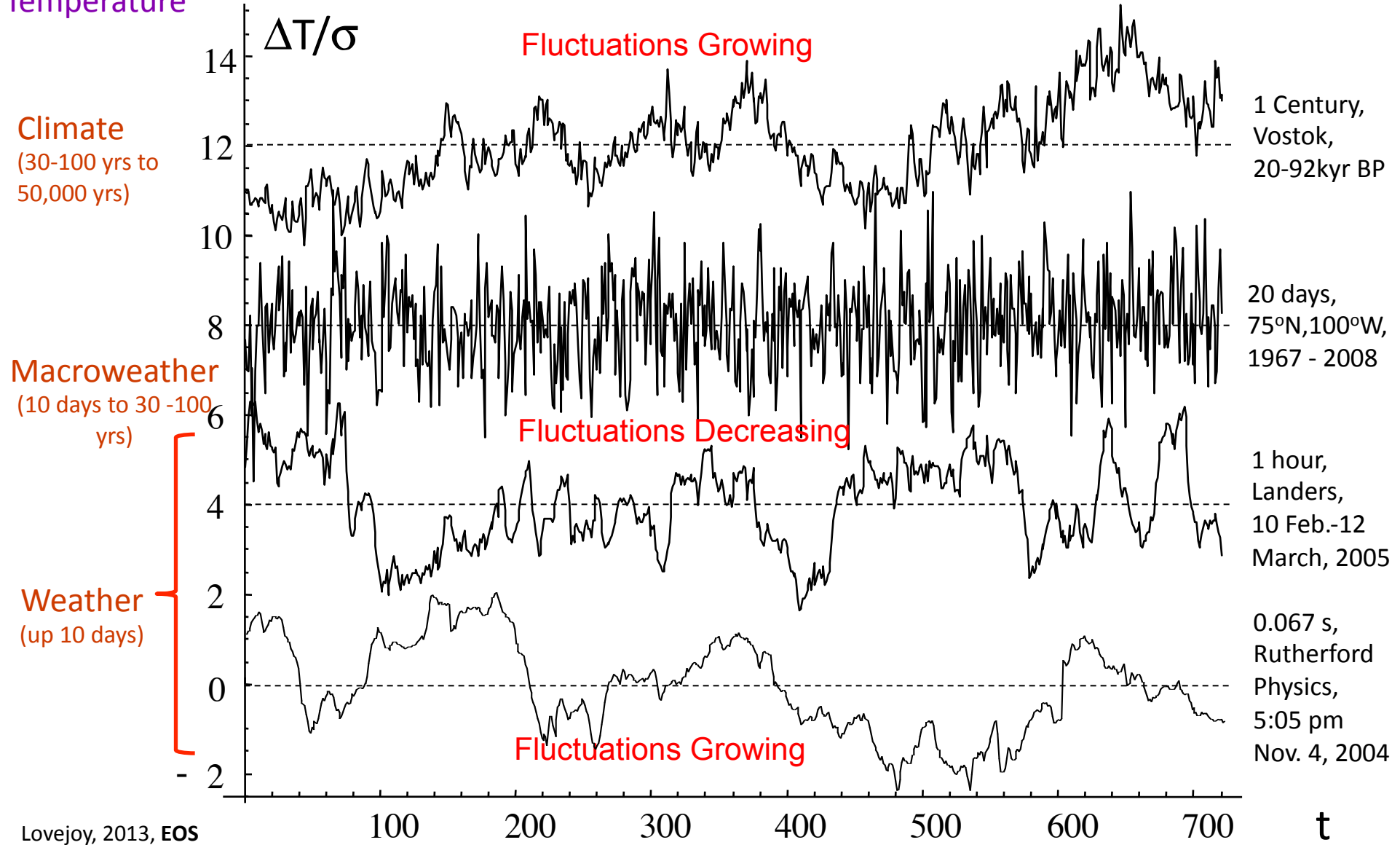
"Climate in a narrow sense is usually defined as the "average weather" ... The classical period is 30 years, as defined by the World Meteorological Organization (WMO)... Climate in a wider sense is the state, including a statistical description, of the climate system."

-Intergovernmental Panel on Climate Change, 2007

Painel Intergovernamental sobre Mudanças Climáticas- 2007

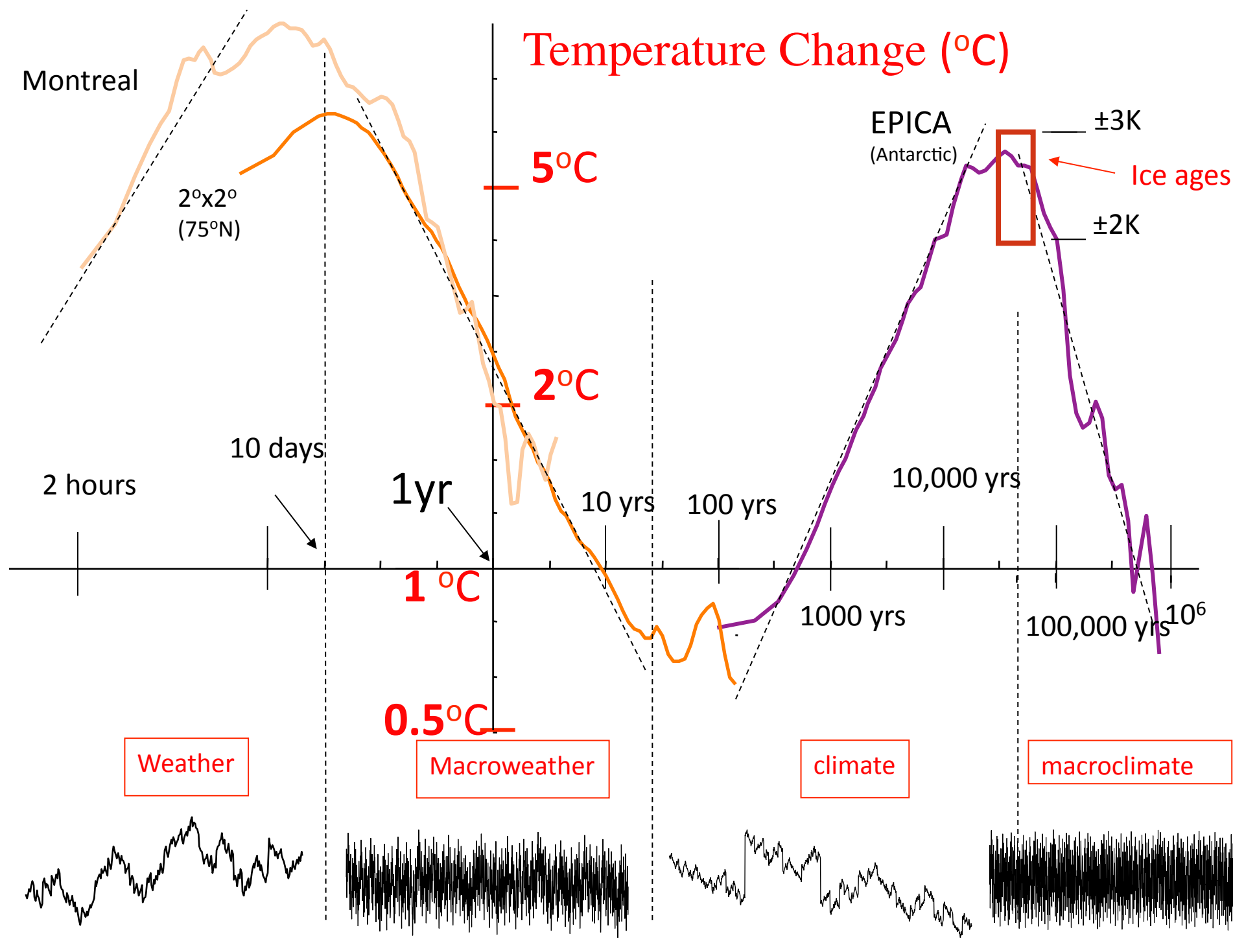
Trichotomy: Weather – macroweather - climate

Temperature



Lovejoy, 2013, EOS

Temperature Change (°C)



Montreal

2°x2°
(75°N)

5°C

2°C

1°C

0.5°C

EPICA
(Antarctic)

±3K

Ice ages

±2K

2 hours

10 days

1 yr

10 yrs

100 yrs

1000 yrs

10,000 yrs

100,000 yrs

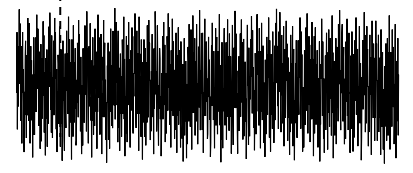
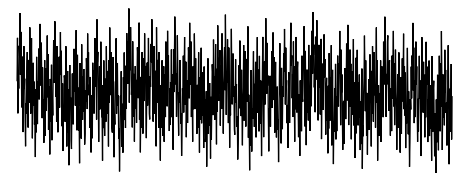
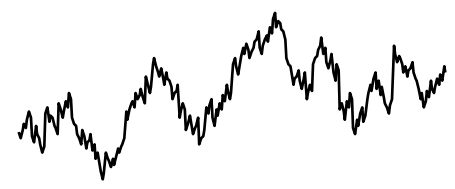
10⁶

Weather

Macroweather

climate

macroclimate



Conclusion:

“Macroweather is what you
expect

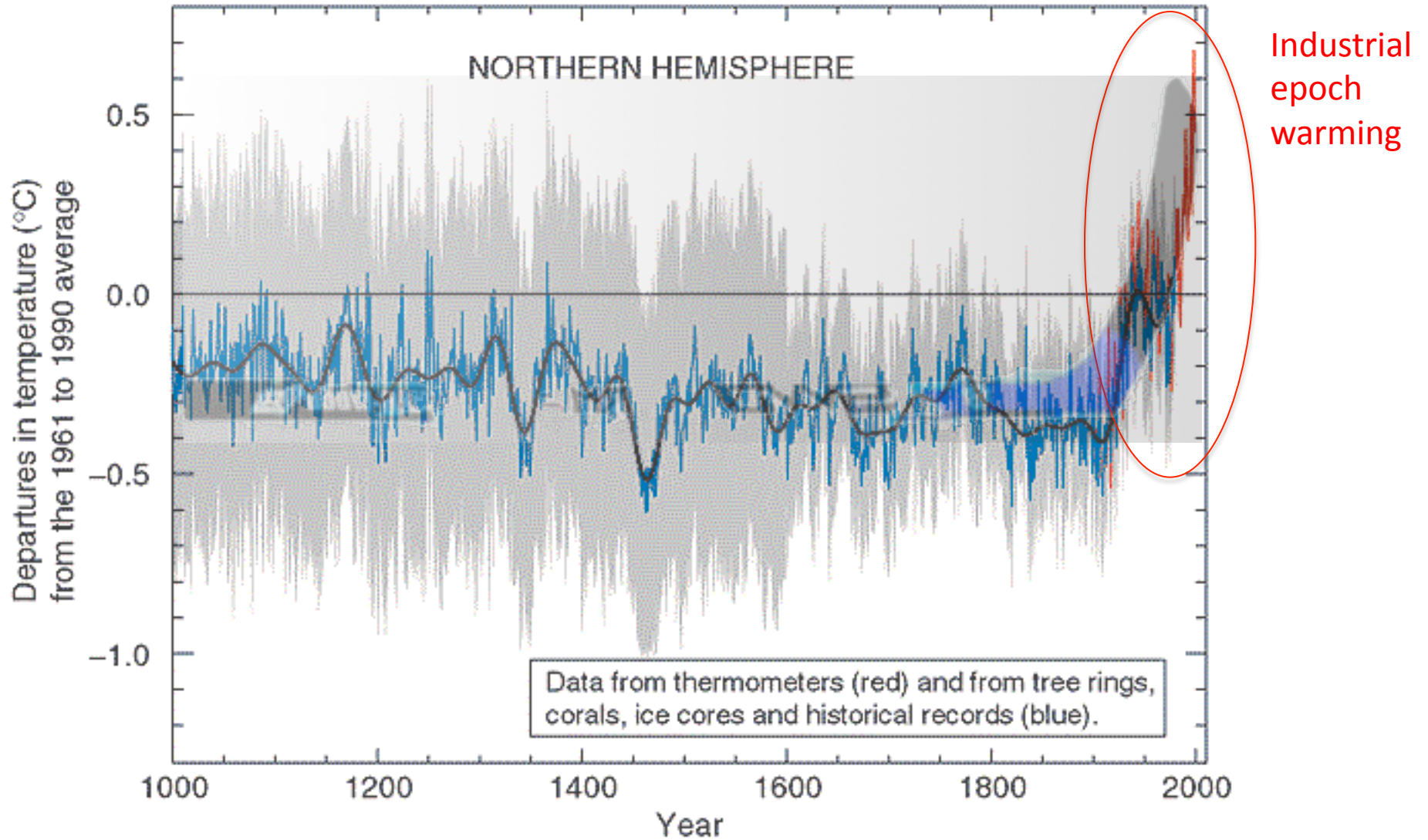
The climate is what you get!”

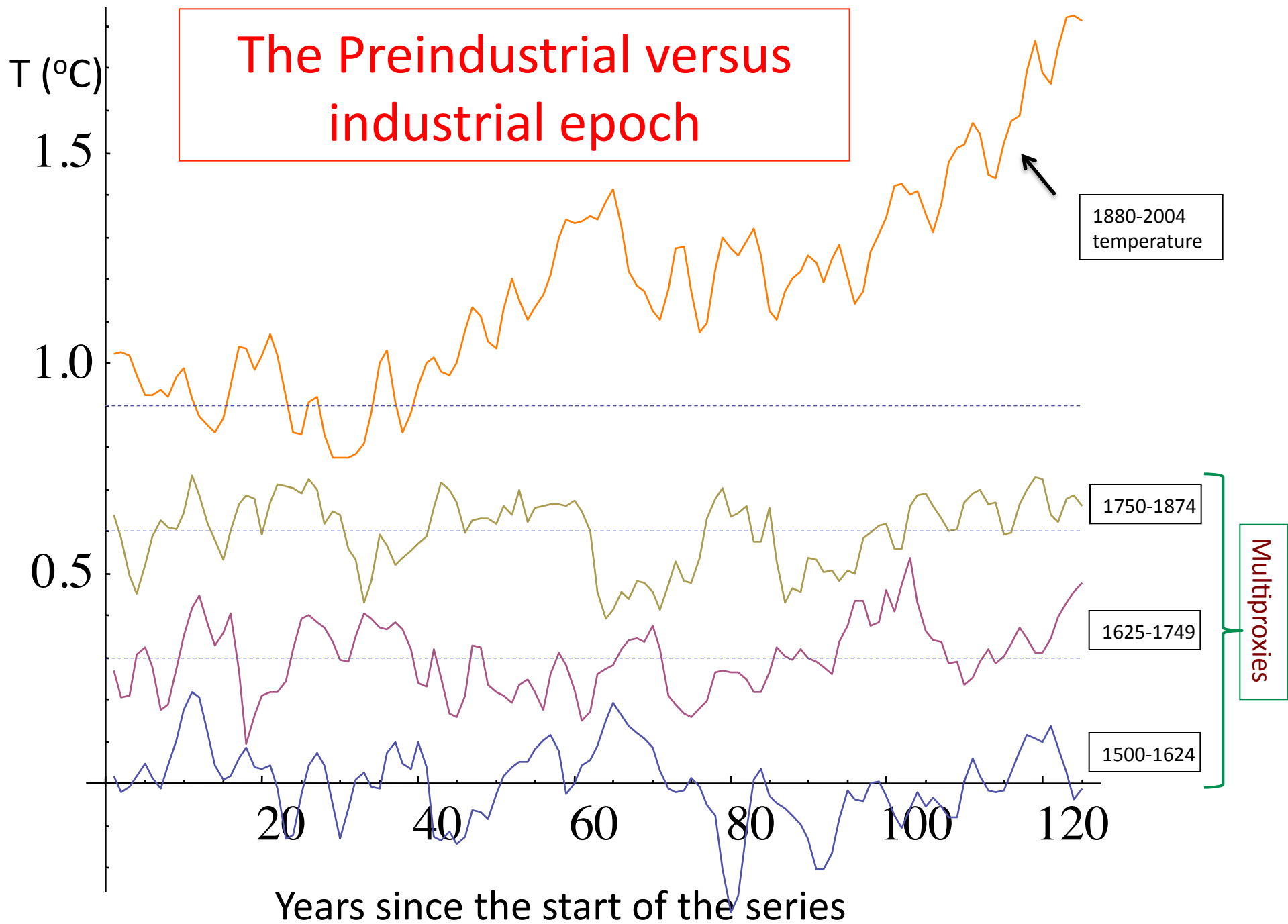
Weather, macroweather and the climate are distinguished by the way they change under a zoom!

Evidence for warming

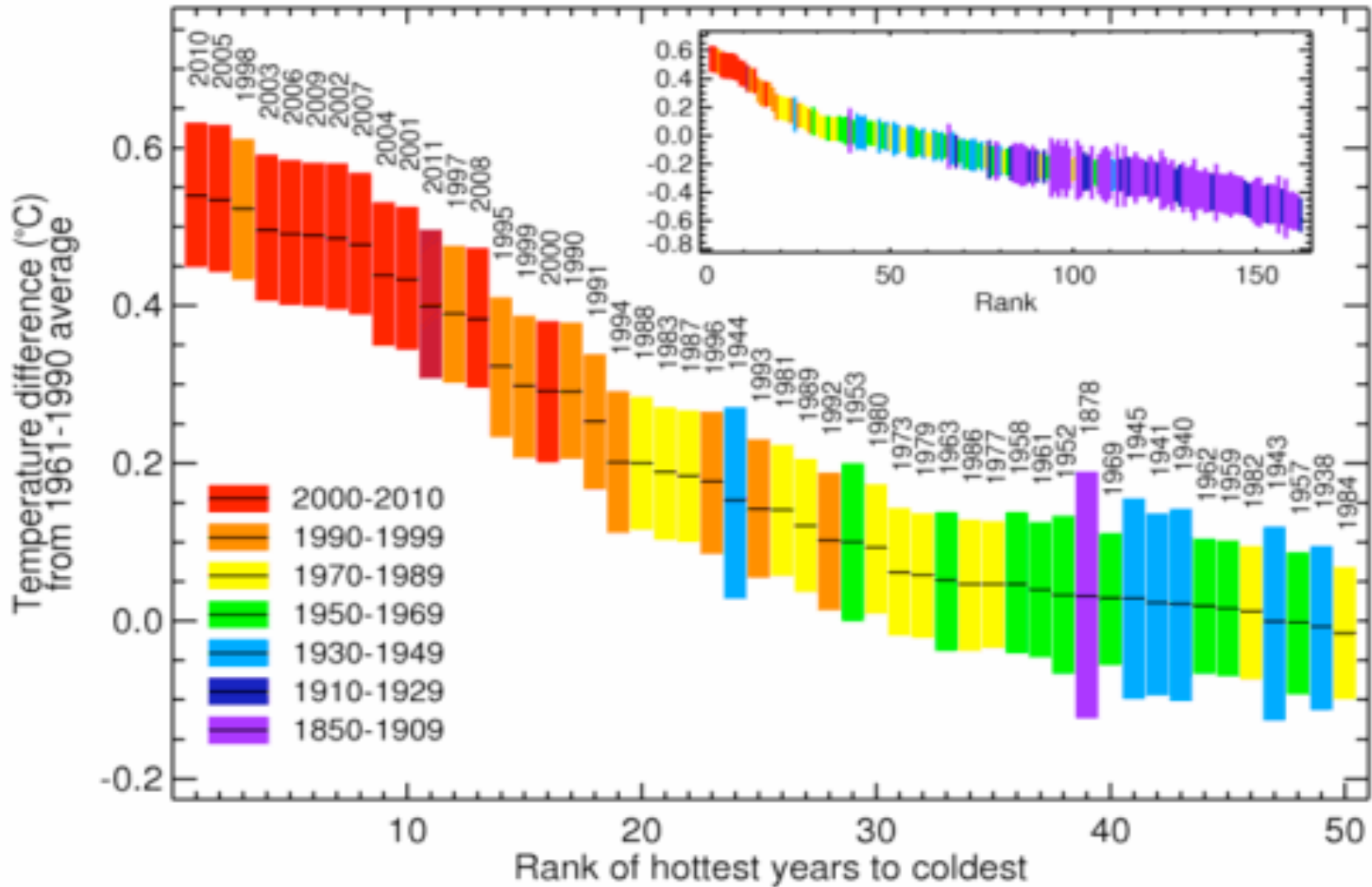
The “hockey stick”

Mann, Bradley, Hughes 1998





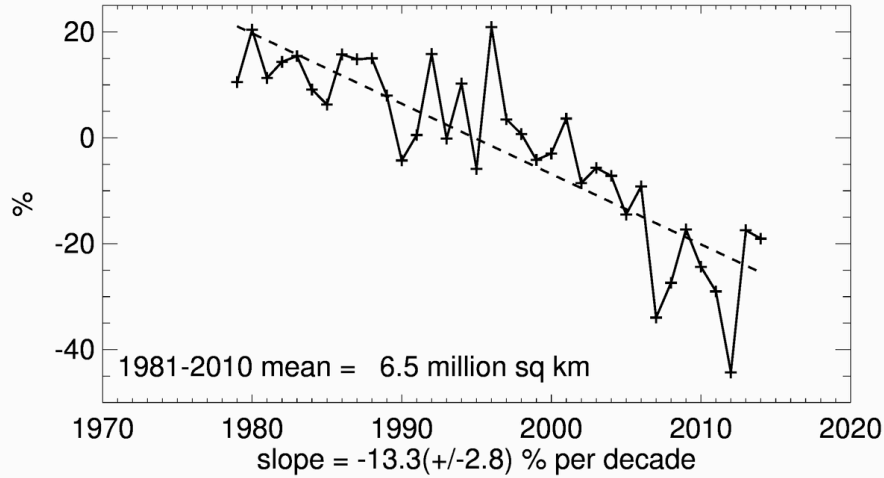
Ranking of temperatures from hottest to coldest



The Arctic

(melting of sea ice)

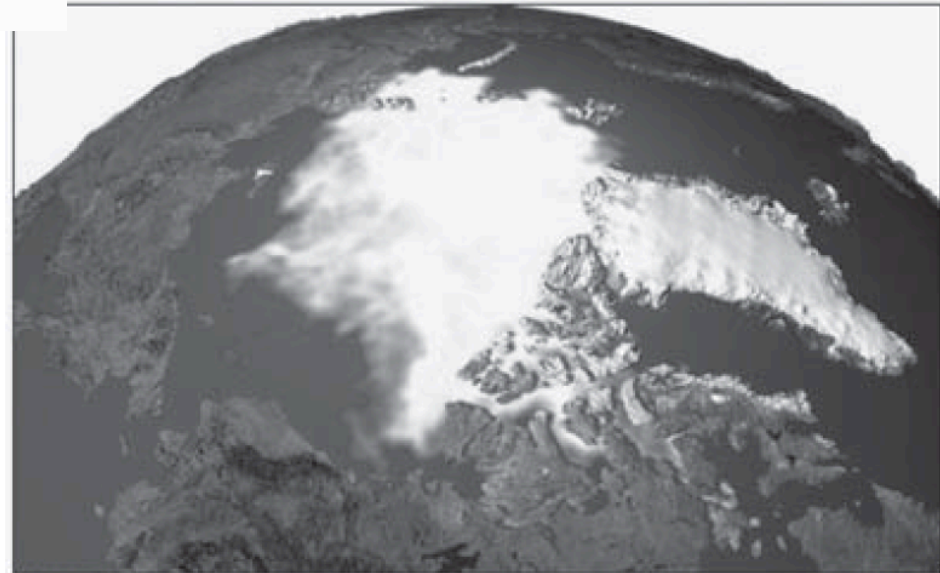
Northern Hemisphere Extent Anomalies Sep 2014



1979

SSMI Composite Data

Over 2 million square km of sea ice
lost over 35 years



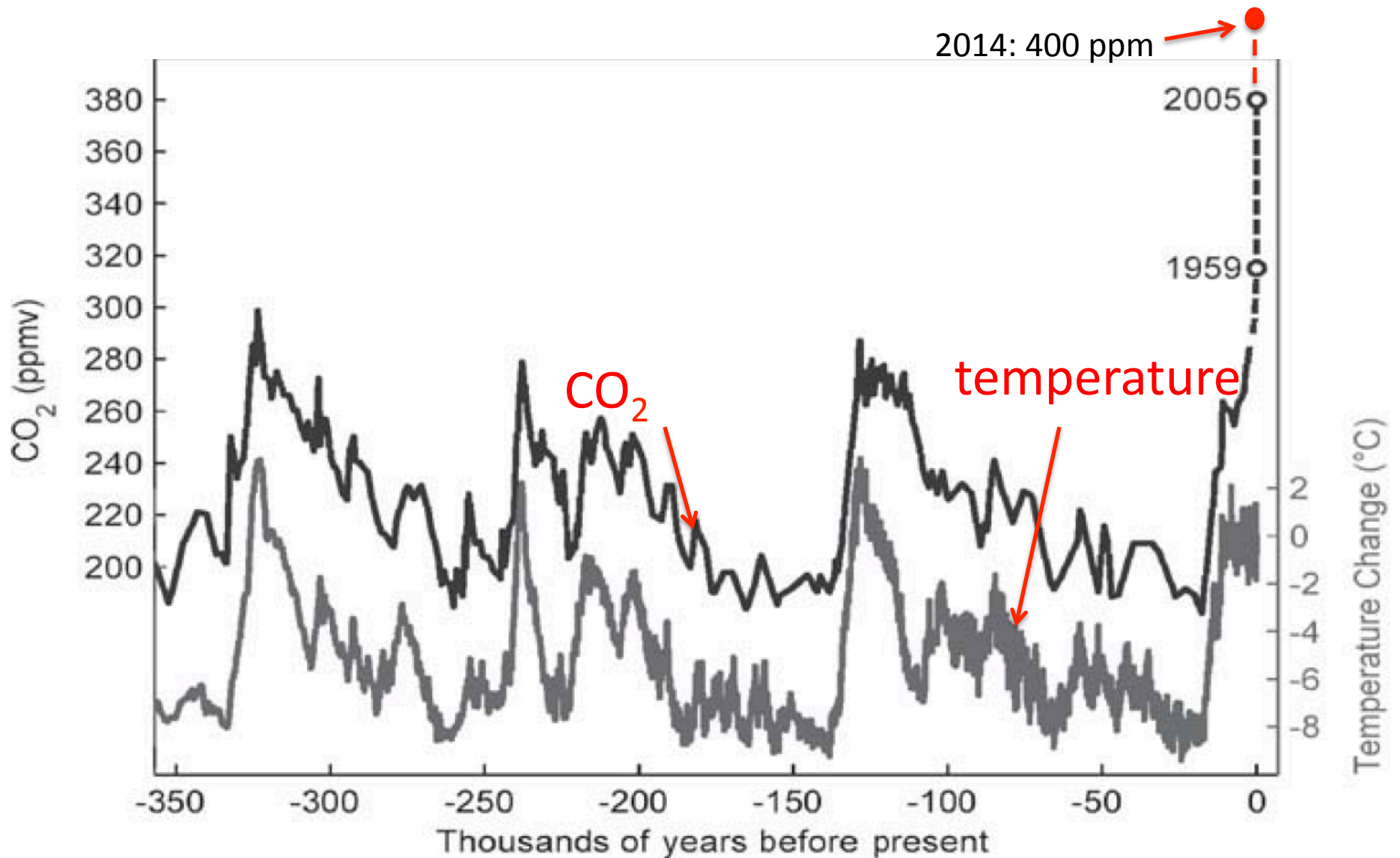
2005

2003 SSMI Composite Data



Anthropogenic Theory

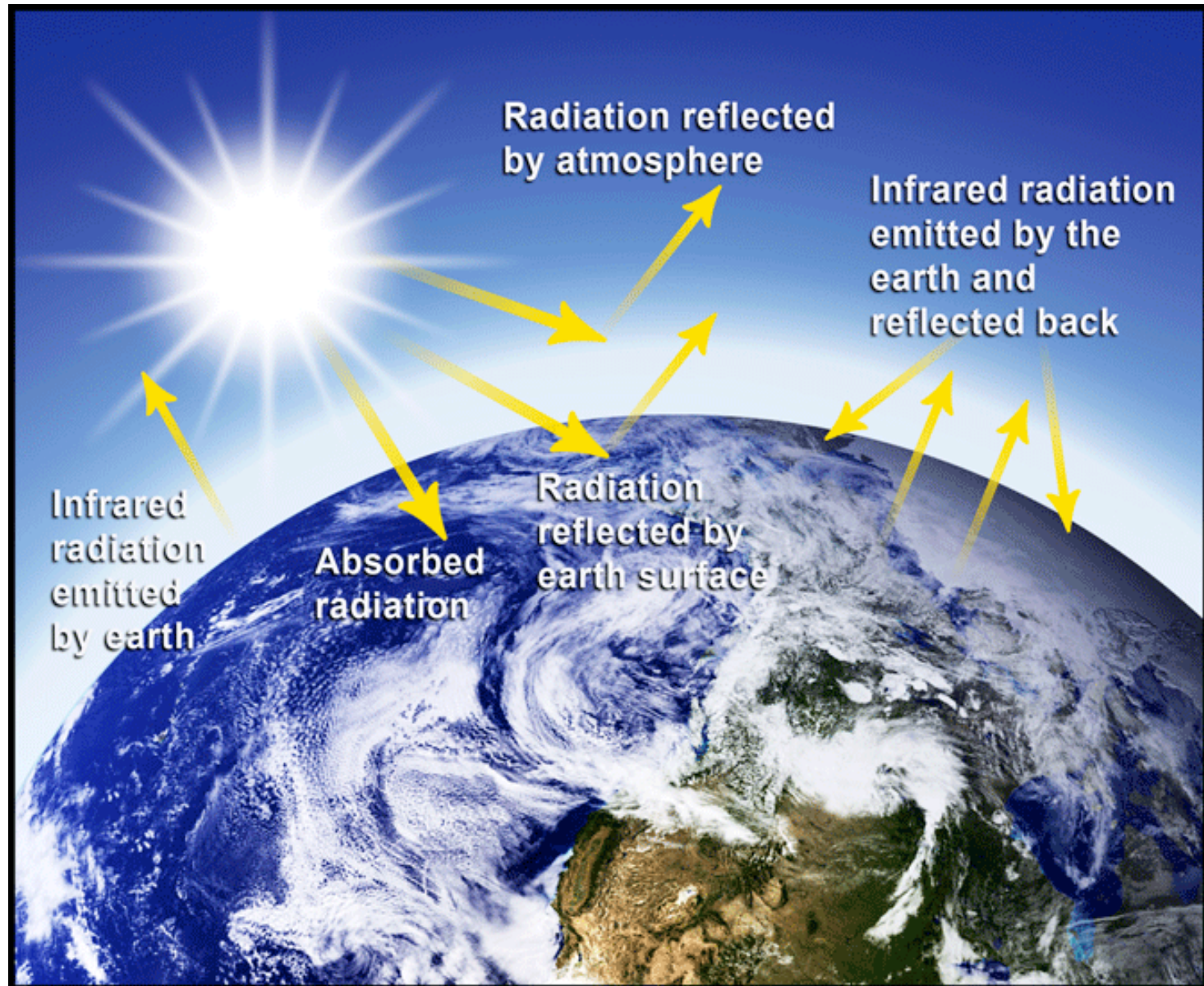
CO₂: The last 350,000 yrs



Source: J. R. Petit and others, "Climate and Atmospheric History of the Past 420,000 Years from the Vostok Ice Core, Antarctica," *Nature* 399 (June 1999): 429–36.

The theory of anthropogenic warming: the “Greenhouse effect”

Efeito de estufa



Anthropogenic warming: Pre-GCM era

1896

Nobel prize winner Svante Arrhenius: CO₂ doubling: 5 – 6°C of warming, “climate sensitivity”



Svante Arrhenius
(1859 –1927)

1938

Callender estimated the warming as 2° C



Guy Stewart Callendar
1898 - 1964

1957

Keeling started his celebrated CO₂ measurements at Mauna Loa and at the south Pole



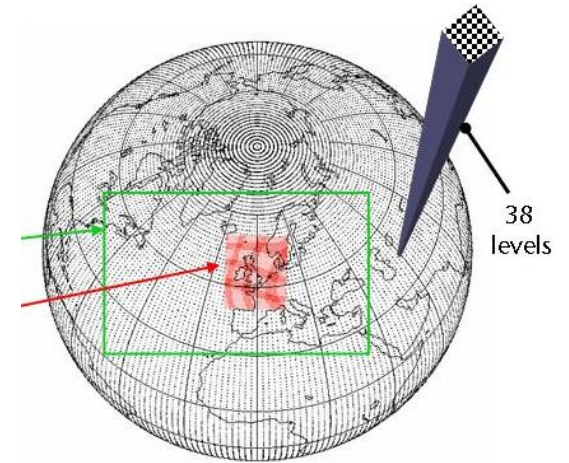
Charles David Keeling
1928 –2005

GCM = Global Circulation Model
Modelo de Circulação Global

GCM era (post 1975)

GCM's: for CO₂
doubling:

US National Academy of Science	(1979):	1.5- 4.5°C
IPCC3	(2002):	1.5- 4.5°C
IPCC4	(2007):	2- 4.5°C
IPCC5	(2013):	1.5- 4.5°C



MilkyWay-2: World's fastest supercomputer



3,120,000 cores: 3×10^{16} Flops (Nov. 2014)

1998 climate models somewhat over-forecast the warming in the 2000's

IPCC 5 (2013) extremely

IPCC 4 (2007) “it is likely that human influence has been the dominant cause of the observed warming since the mid-20th century”

Natural variability Theory: A Giant Natural Fluctuation

Doubting the warming (pre 2006)

- 1. The models are unreliable they have not been tested, they aren't valid.
 - predictions of warming doesn't depend on the models
- 2. **Pre 2004:** "Heat Island effect": warm biases due to urbanization?
 - The effect is very small
- 3. **1995- 2005:** Satellite temperatures versus surface measurements ...
 - 4 errors discovered (now there is agreement).

2006: "Because of the complexity of the problem, environmental skepticism was once tenable. No longer. It is time to flip from skepticism to activism."

-Michael Shermer, editor of the *Skeptical Inquirer*

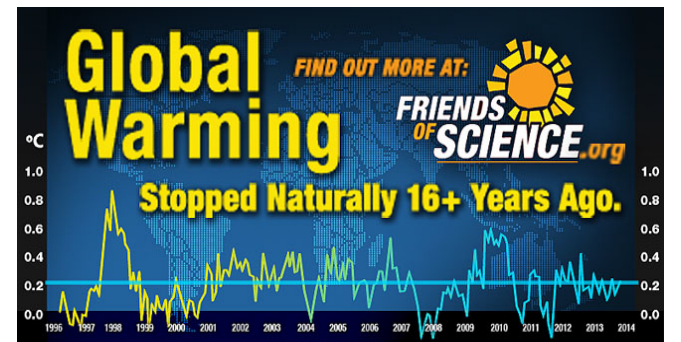
Skeptics and Deniers (post 2006)

Accepting the warming:
Alternative theory - Natural
variability (including solar)

1. The warming is due to natural variability.

2. The “pause”: the earth has stopped warming
since 1998.

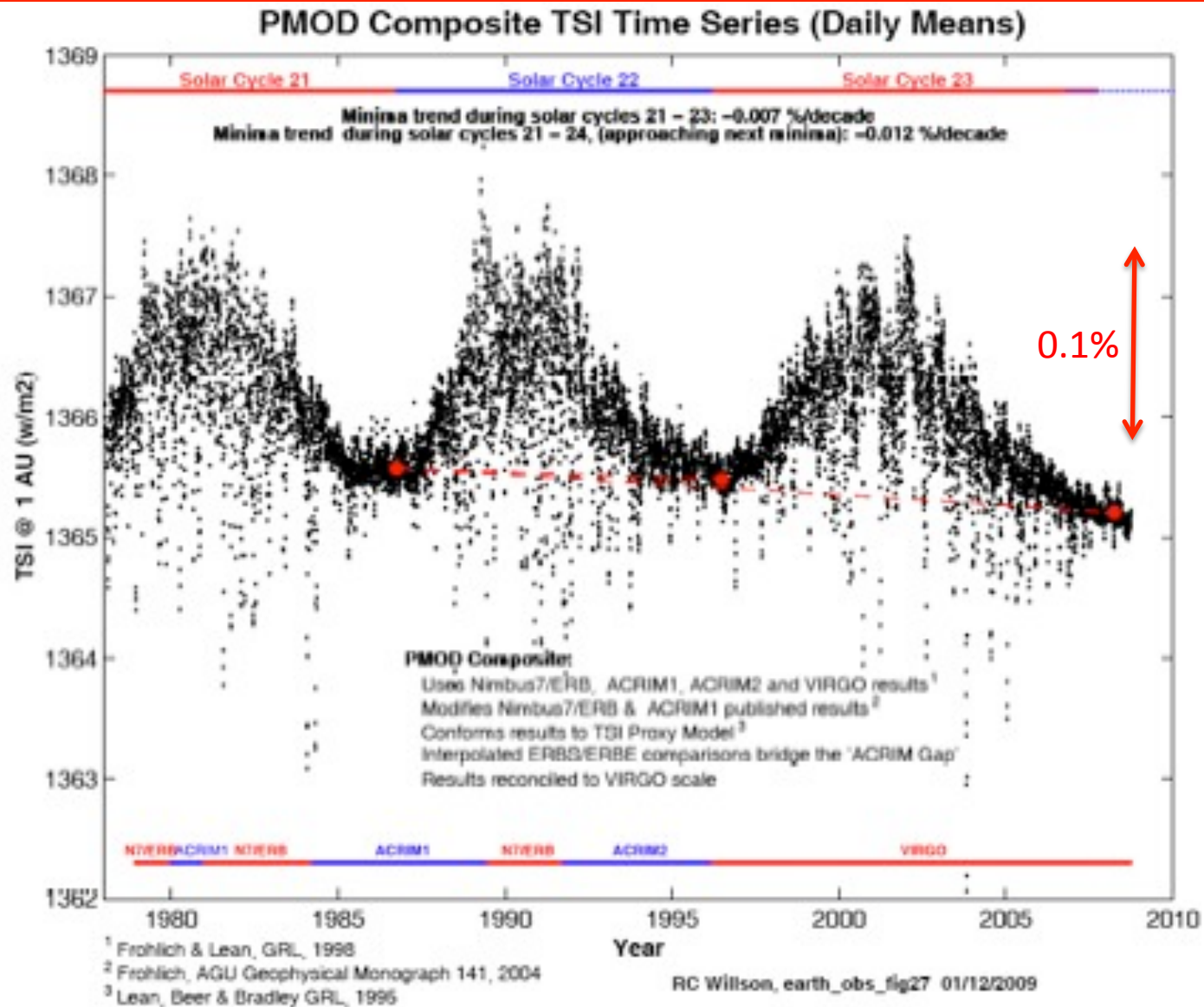
Implausible but not disproved until 2014...



The sun ? (1):

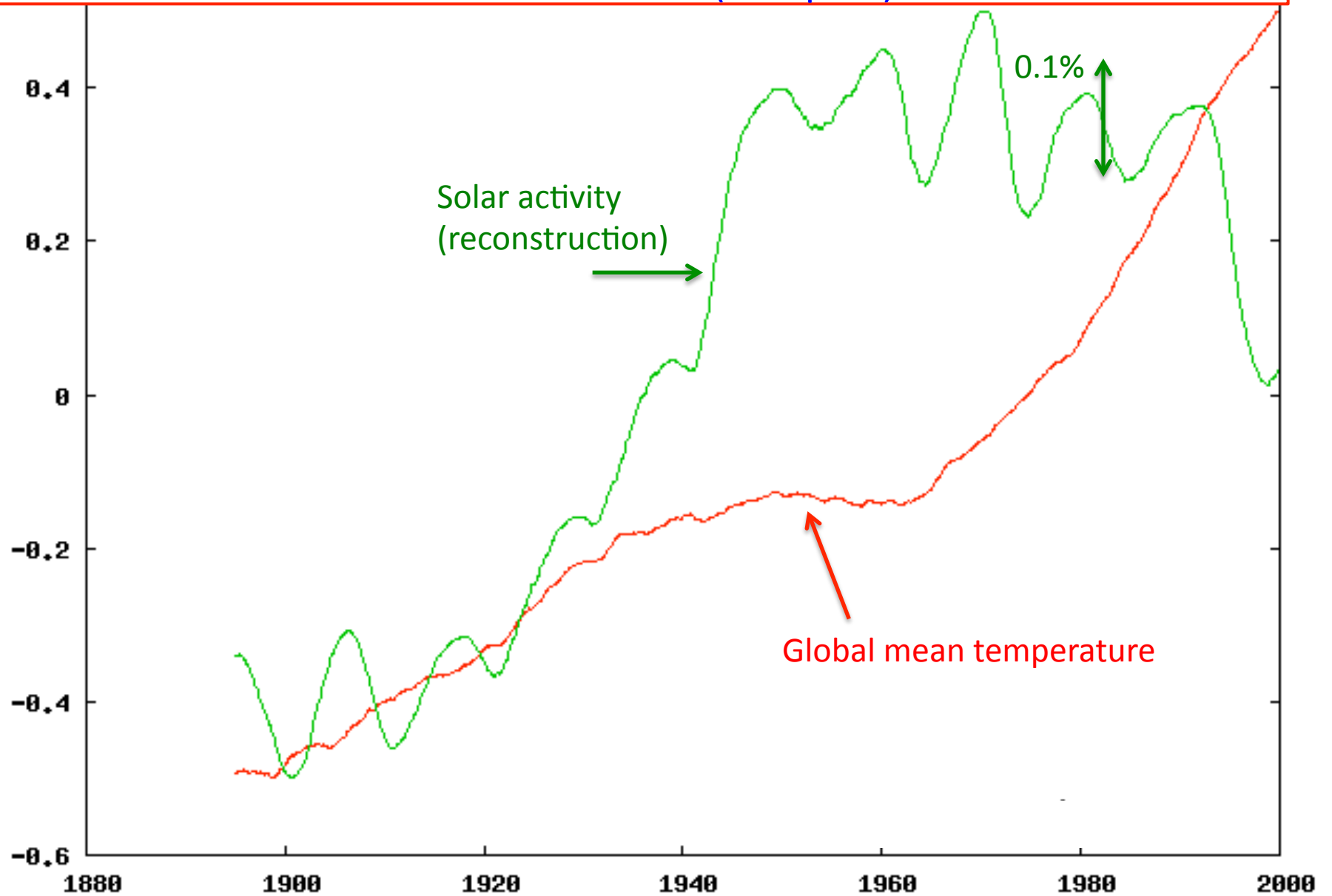
Total Solar Insolation

(satellite)



The sun ? (2):

Solar reconstruction (sunspots)



Disproving Natural warming

Clim Dyn (2014) 42:2339–2351
DOI 10.1007/s00382-014-2128-2

Scaling fluctuation analysis and statistical hypothesis testing of anthropogenic warming

S. Lovejoy

Received: 9 January 2014 / Accepted: 26 March 2014 / Published online: 6 April 2014
© Springer-Verlag Berlin Heidelberg 2014

Abstract Although current global warming may have a large anthropogenic component, its quantification relies primarily on complex General Circulation Models (GCM's) assumptions and codes; it is desirable to complement this with empirically based methodologies. Previous attempts to use the recent climate record have concentrated on “fingerprinting” or otherwise comparing

1 Introduction

Well before the advent of General Circulation Models (GCM's), (Arrhenius 1896), proposed that greenhouse gases could cause global warming and he even made a surprisingly modern quantitative prediction. Today, GCM's are so much the dominant tool for investigating the

Dec. 12, 2014

The screenshot shows the Altmetric interface for the article. At the top, a circular score of 181 is displayed. Below it, a box highlights the text: "Is one of the highest ever scores in this journal (ranked #1 of 759)". To the right, a list of news outlets is shown, including Haaretz and TG Daily, with their respective article titles and dates. The Haaretz article is dated 2014-04-13T13:20:00+ and the TG Daily article is dated 2014-04-14T07:00:00+.

181

Score in context

Is one of the highest ever scores in this journal (ranked #1 of 759)

show more...

Mentioned by

- 18 news outlets
- 5 blogs
- 31 tweeters
- 4 Facebook users

Readers on

- 29 Mendeley
- 0 CiteULike

Track this article

- Get email updates when this article is shared

Scaling fluctuation analysis and statistical hypothesis testing of anthropogenic warming

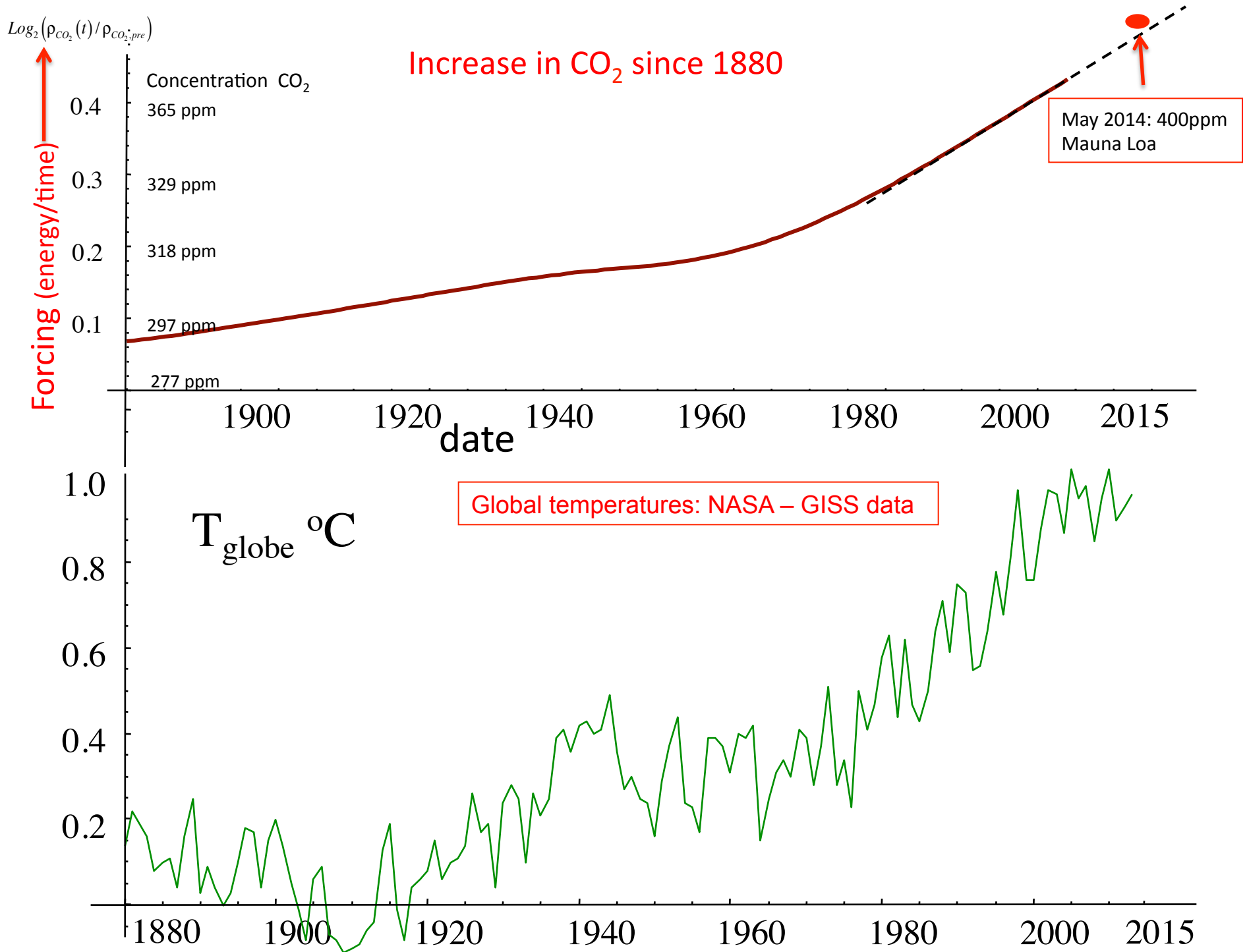
News Blogs Twitter Facebook Score Demographics Help

So far Altmetric has seen 18 stories from 18 outlets.

HAARETZ Global warming is man-made with 99.9% certainty, study says
Hareetz
McGill physicist Shaun Lovejoy can't show it's man's hand behind the mayhem, but if it isn't Mother Nature, who's left? ..
2014-04-13T13:20:00+

TG DAILY Odds that global warming is due to natural factors: Slim to none
TG Daily
An analysis of temperature data since 1500 all but rules out the possibility that global warming the industrial era is just a ..
2014-04-14T07:00:00+

Natural variability hypothesis was neglected by the scientific community



“substituto”

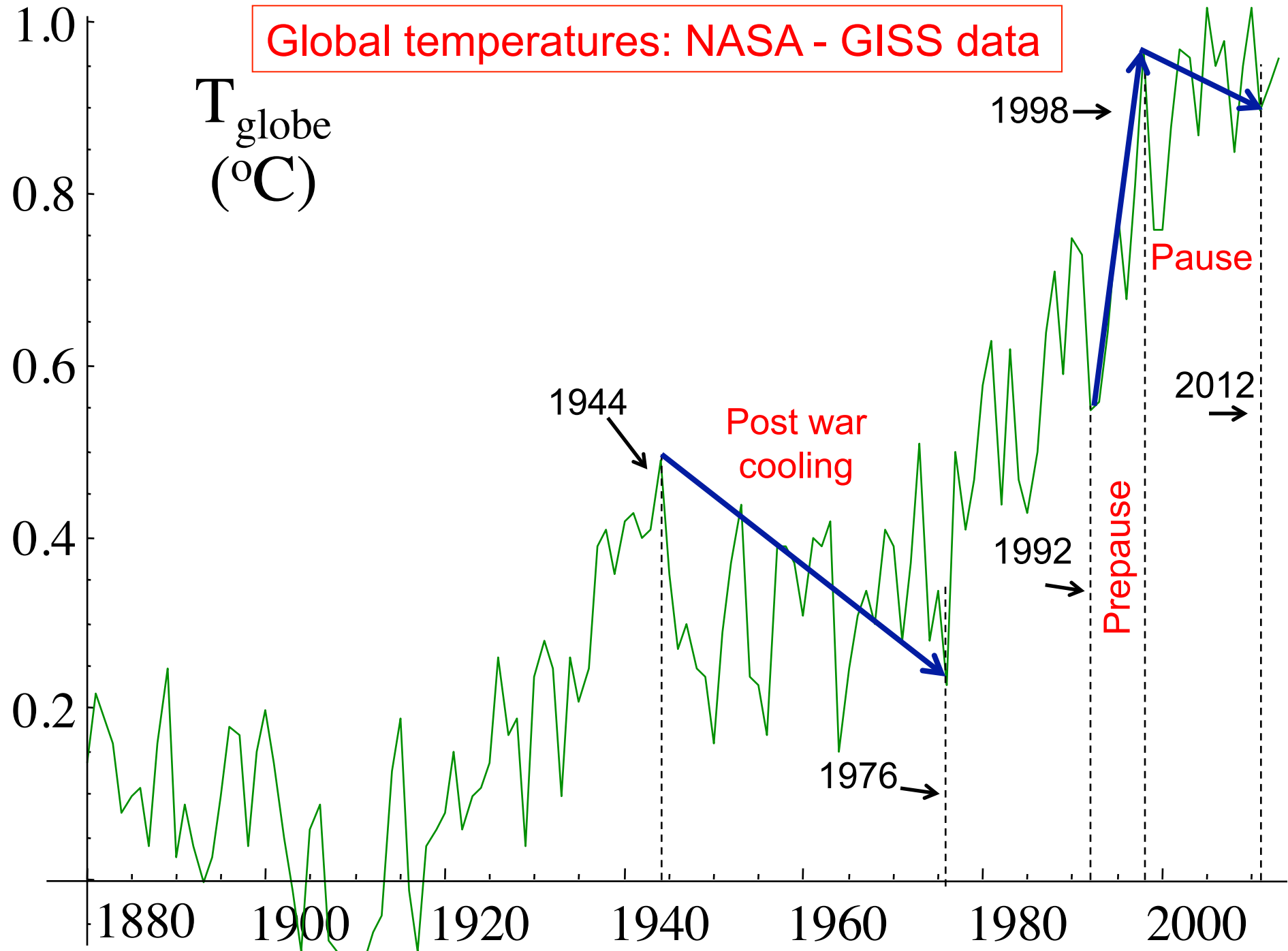
CO₂ forcing as surrogate for all anthropogenic effects

Roughly:

double the global economy, double the emissions, land use and other changes:

double the effects

Global temperatures: NASA - GISS data



T_{globe}
(°C)

1998 →

1944 →

Post war
cooling

2012 →

1992 →

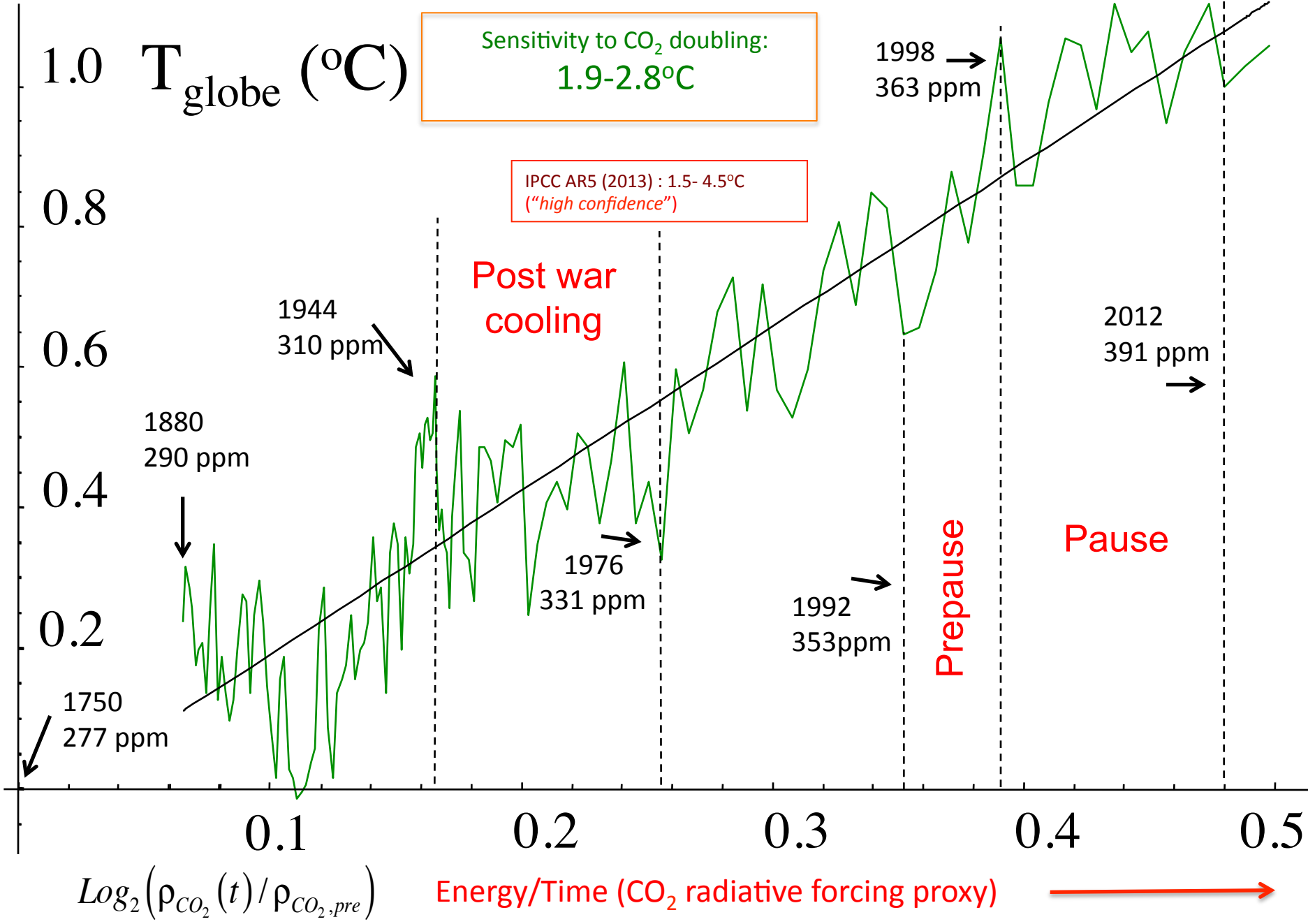
Prepause

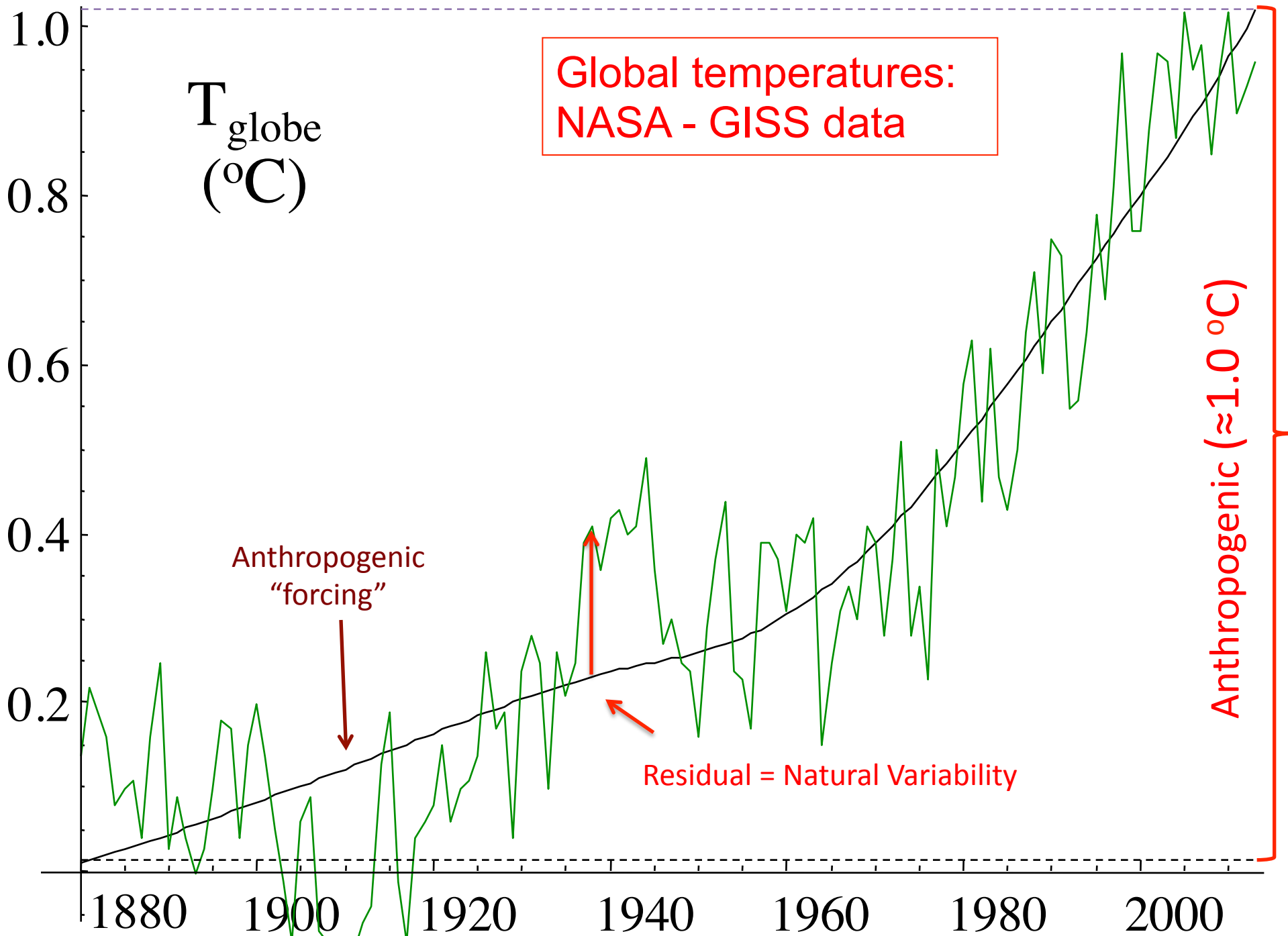
1976 →

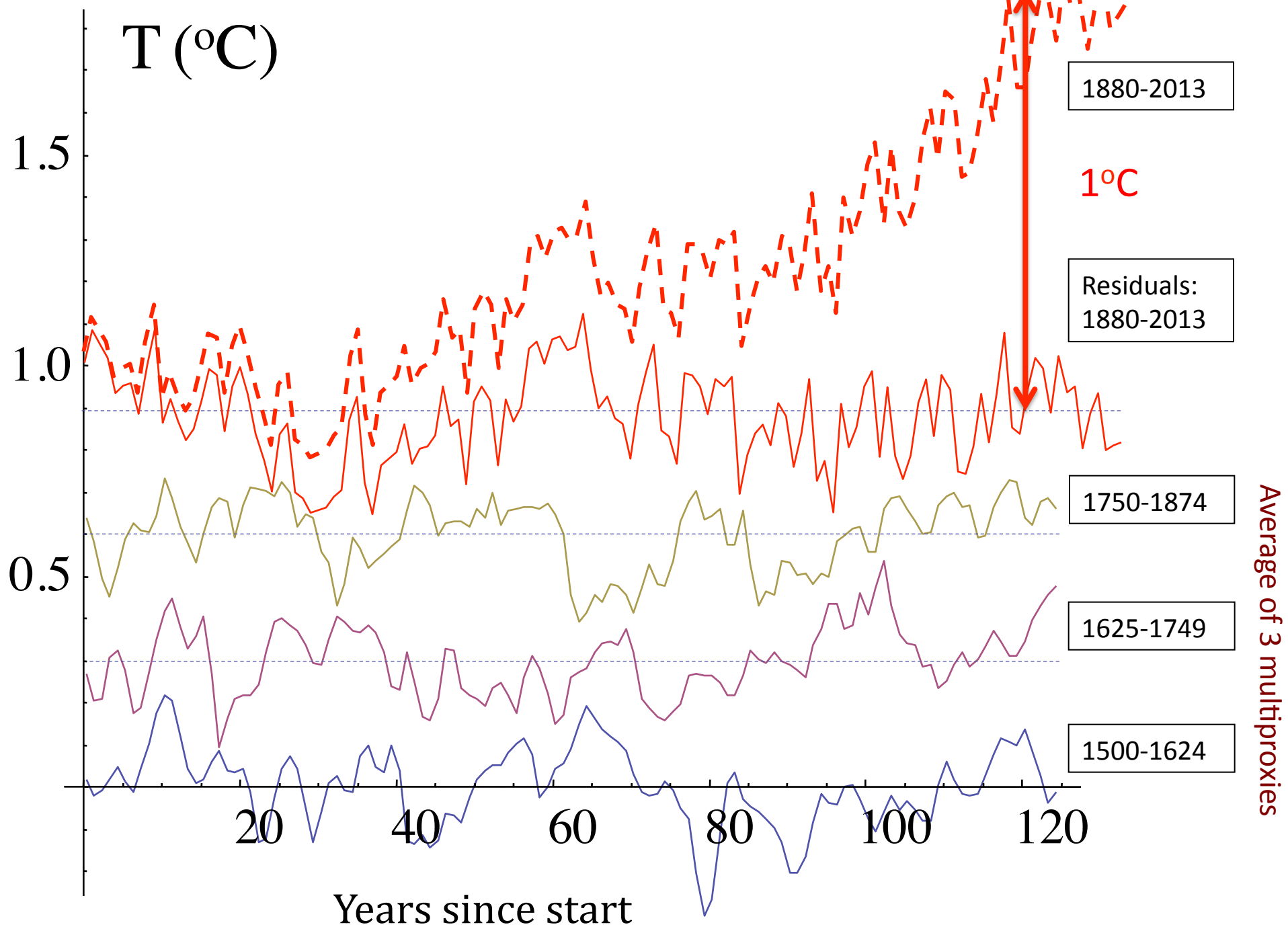
Pause

1880 1900 1920 1940 1960 1980 2000

Global temperatures: NASA - GISS data

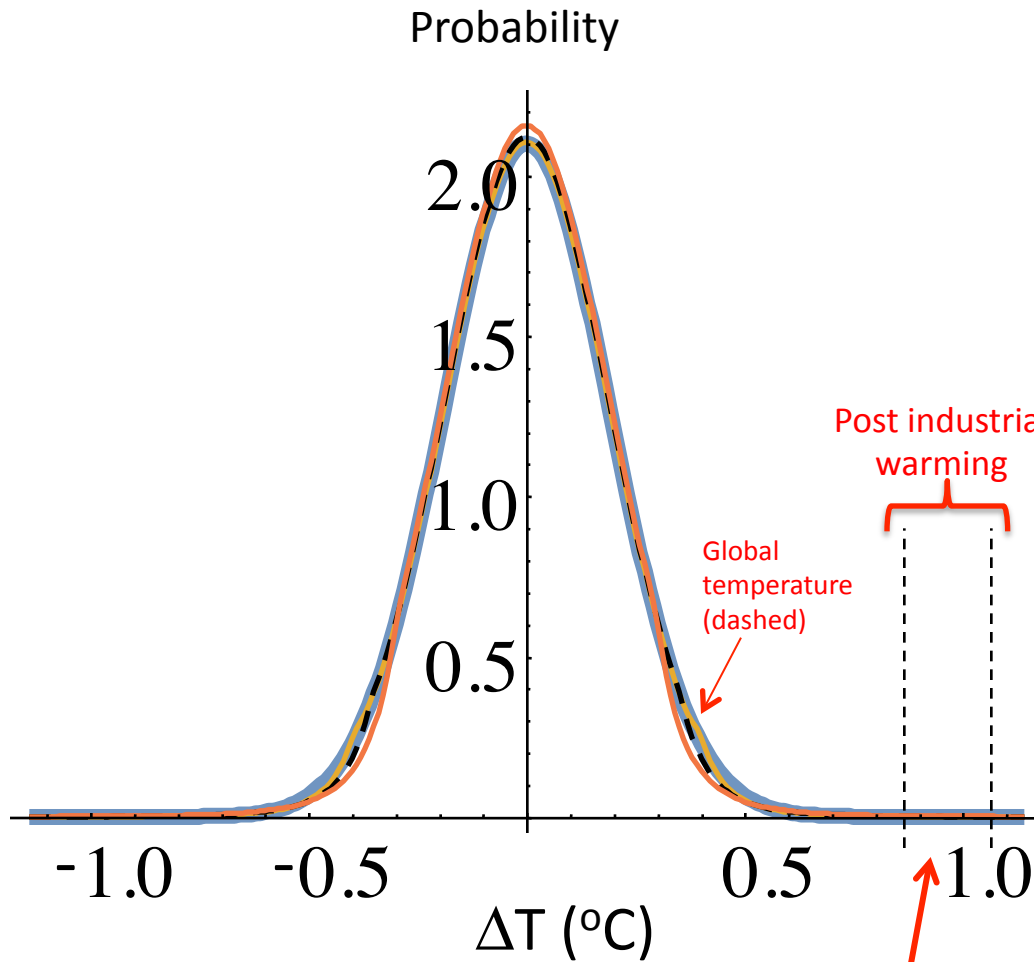






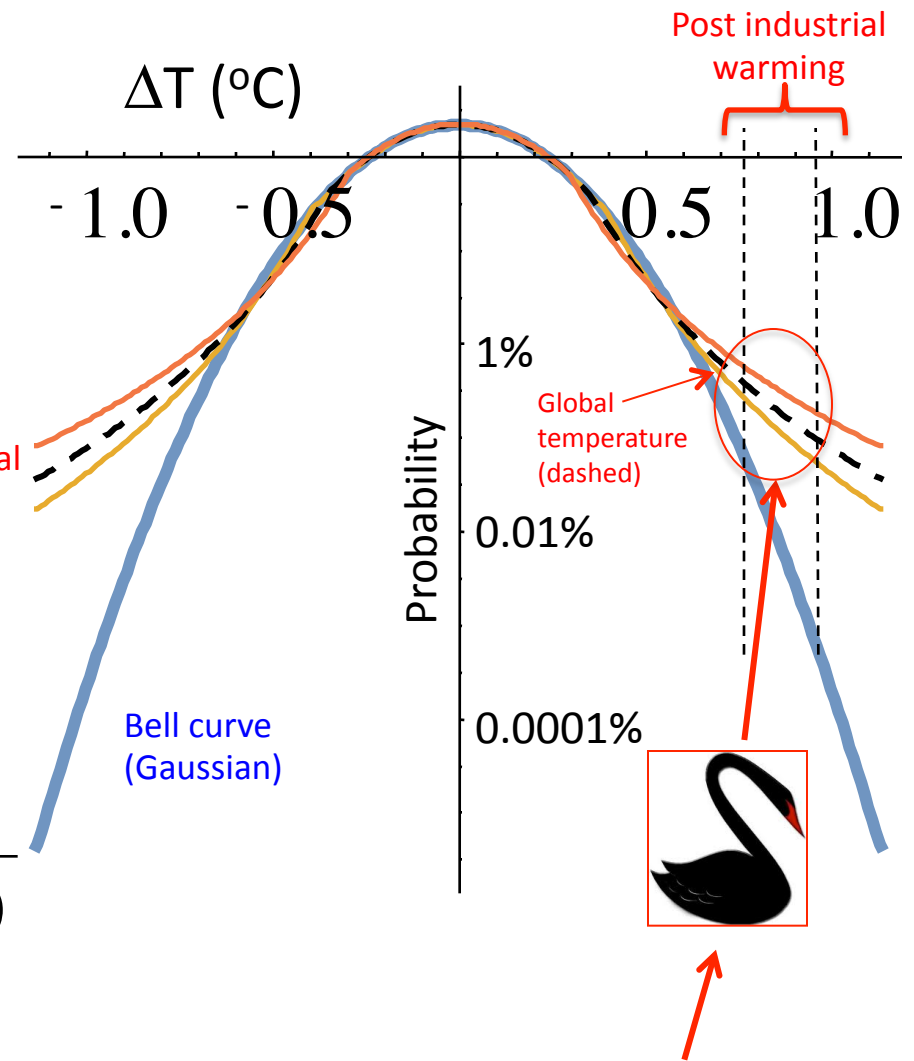
Probabilities of extremes: Bell Curve, Black Swans

Usual representation



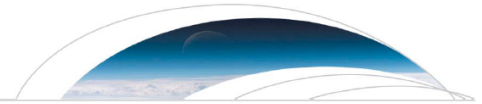
≈ 5 standard deviations: one in a million chance

Representation showing extremes



one in a thousand chance

The Pause



Geophysical Research Letters

RESEARCH LETTER

10.1002/2014GL060478

Key Points:

- The “pause” has a return period of 20–50 years (not unusual)
- Pre-pause (92–98) warming cancels the pause cooling
- The largest expected cooling event = 0.47 K; almost exactly the postwar cooling

Correspondence to:

S. Lovejoy,
lovejoy@physics.mcgill.ca

Citation:

Lovejoy, S. (2014), Return periods of global climate fluctuations and the pause, *Geophys. Res. Lett.*, 41, doi:10.1002/2014GL060478.

Return periods of global climate fluctuations and the pause

S. Lovejoy¹

¹Physics, McGill, Montreal, Canada

Abstract An approach complementary to General Circulation Models (GCMs), using the anthropogenic CO₂ radiative forcing as a linear surrogate for all anthropogenic forcings [Lovejoy, 2014], was recently developed for quantifying human impacts. Using preindustrial multiproxy series and scaling arguments, the probabilities of natural fluctuations at time lags up to 125 years were determined. The hypothesis that the industrial epoch warming was a giant natural fluctuation was rejected with 99.9% confidence. In this paper, this method is extended to the determination of event return times. Over the period 1880–2013, the largest 32 year event is expected to be 0.47 K, effectively explaining the postwar cooling (amplitude 0.42–0.47 K). Similarly, the “pause” since 1998 (0.28–0.37 K) has a return period of 20–50 years (not so unusual). It is nearly cancelled by the pre-pause warming event (1992–1998, return period 30–40 years); the pause is no more than natural variability.

CLIMATE CHANGE

Global warming slowdown just a ‘pause’

NATURAL COOLING FLUCTUATION

It can't be used to prove that temperature changes not man-made, McGill prof says

KAREN SEIDMAN

GAZETTE UNIVERSITIES REPORTER

McGill University physics professor Shaun Lovejoy, already a global warming denier's worst enemy, has done it again with his latest statistical analysis showing that a recent slowdown in global warming is merely a “pause” — and not any kind of proof that man-made global warming has waned.

Lovejoy already regularly gets hate mail from global

Lord Christopher Monckton of Brenchley, who referred to Lovejoy's work as an emanation “of the forces of darkness.”

That was Lovejoy's study which proved conclusively, he says, that there is such a tiny probability that what we are experiencing is natural warming — probably less than 0.1 per cent — that it can be dismissed.

He has followed it up with a statistical analysis of average global temperatures be-



ALLEN MANNING/THE GAZETTE

man-made.

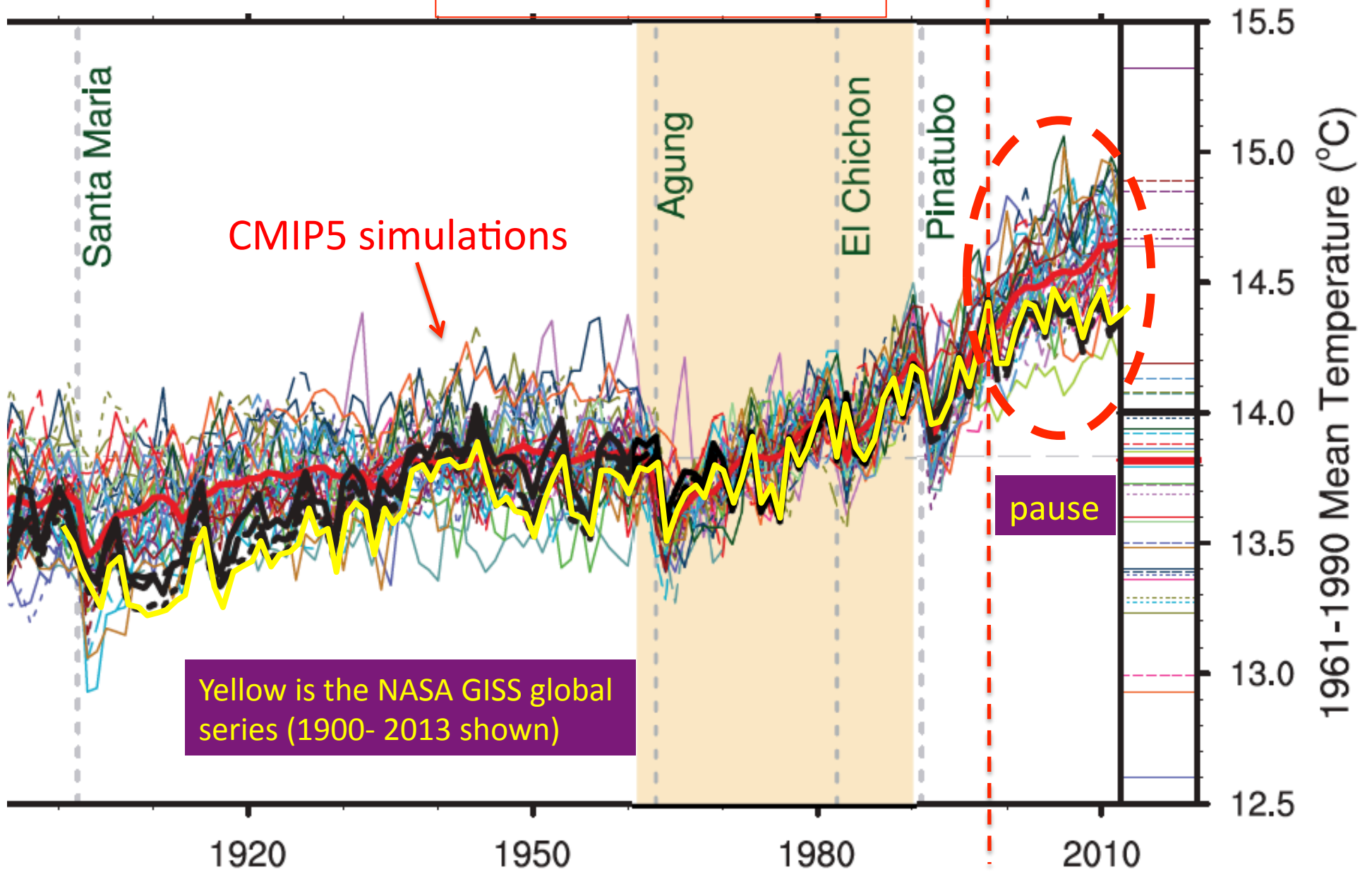
His most recent study addresses the argument raised by skeptics that, since greenhouse gases have continued to rise in the last 15 years while there has been a deceleration in rising temperatures, it must dispute the theory that global warming has been caused largely by man-made emissions.

But Lovejoy says his study concludes there has been a natural cooling fluctuation of about 0.28 to 0.37 C since 1998.

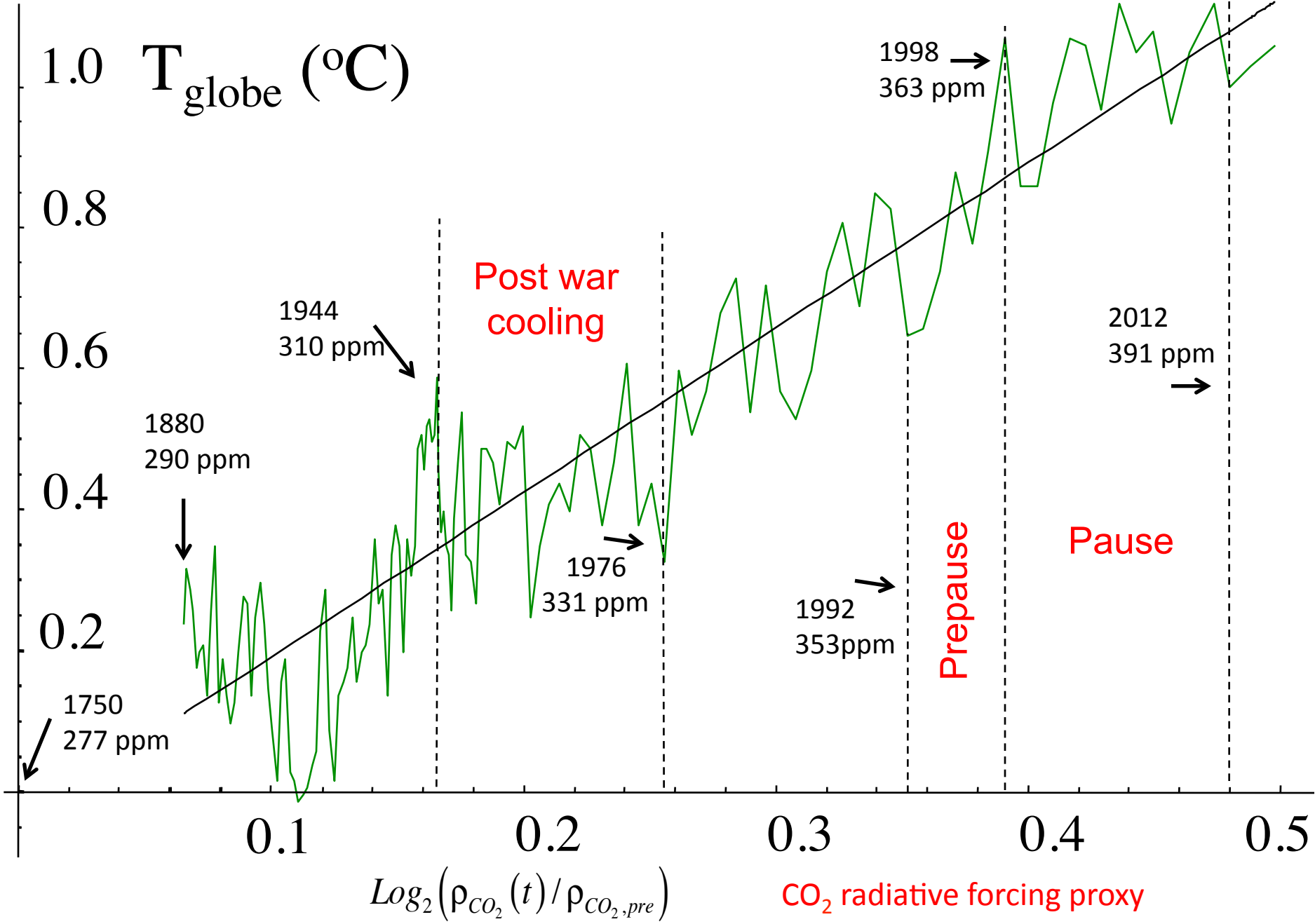
“Being based on climate records, this approach avoids any biases that might affect the sophisticated computer models that are commonly used for understanding global warming,” he said.

And while his new finding

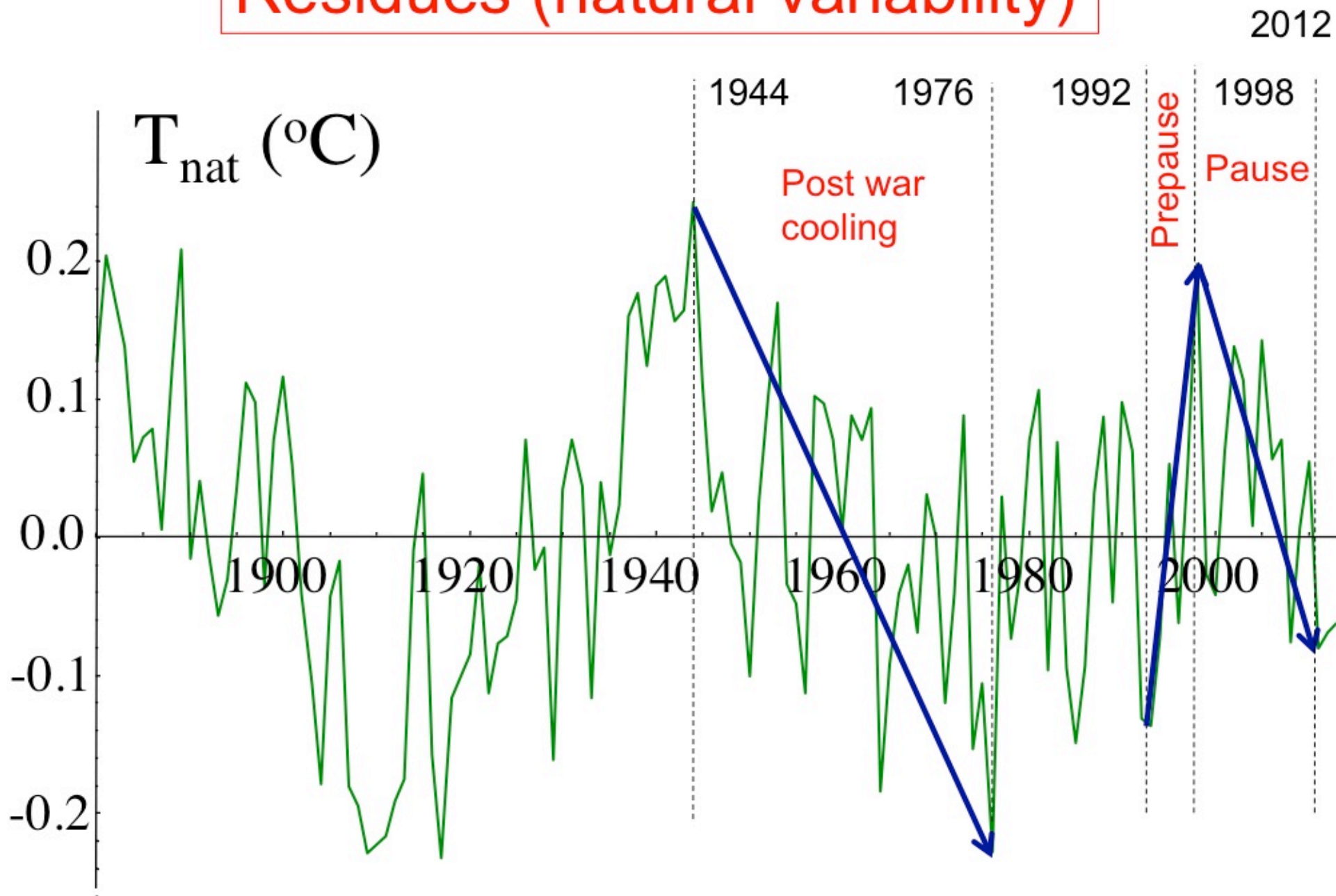
The Pause



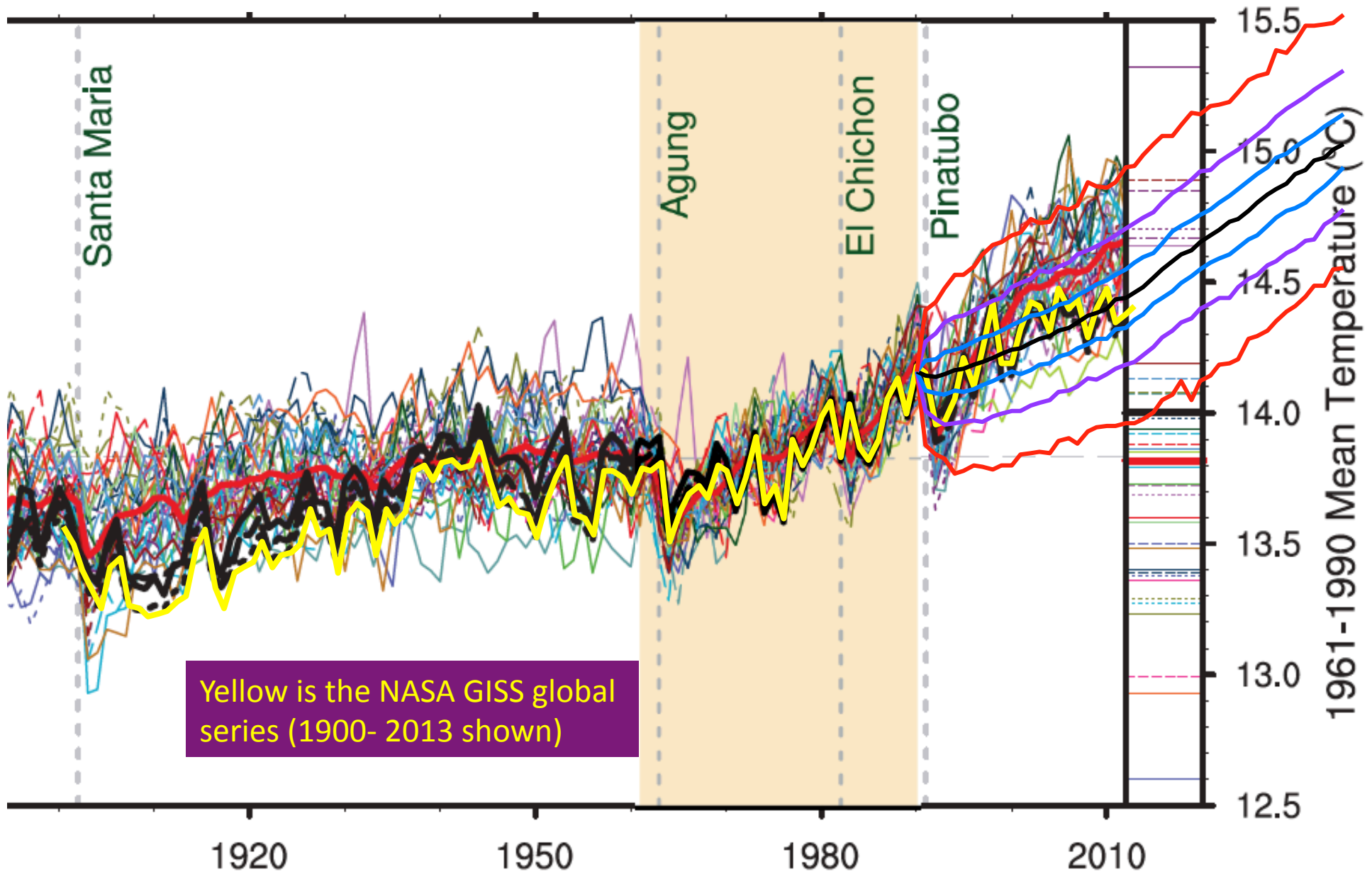
Global temperatures: NASA - GISS data



Residues (natural variability)



The pause with stochastic forecasts

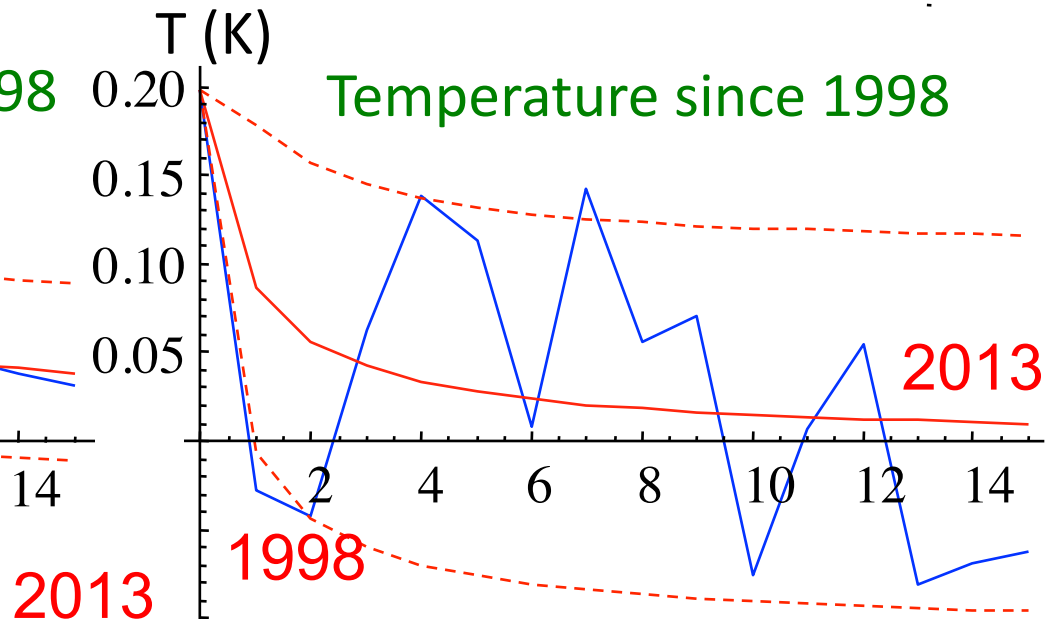
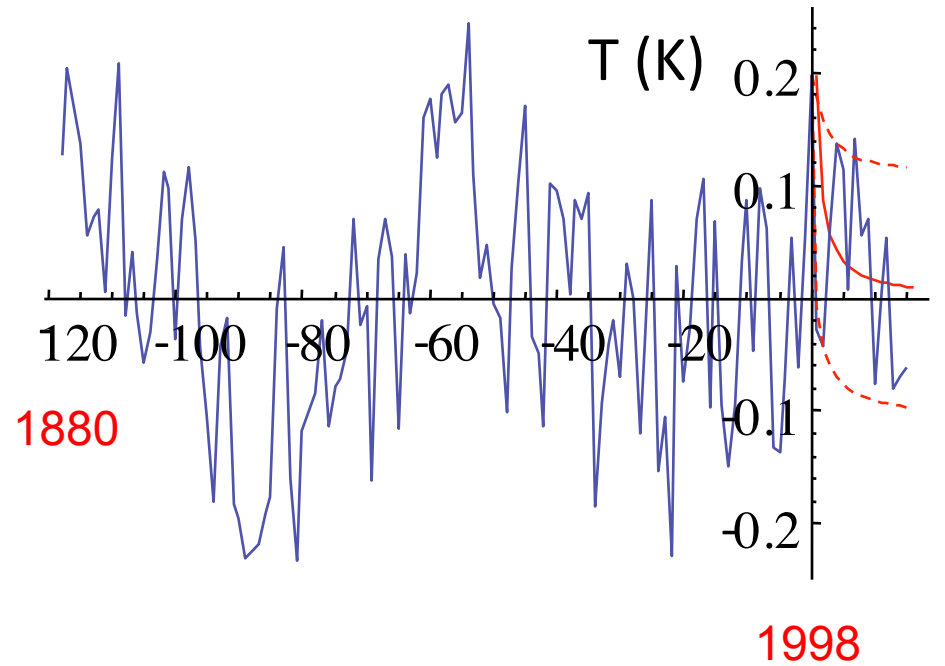
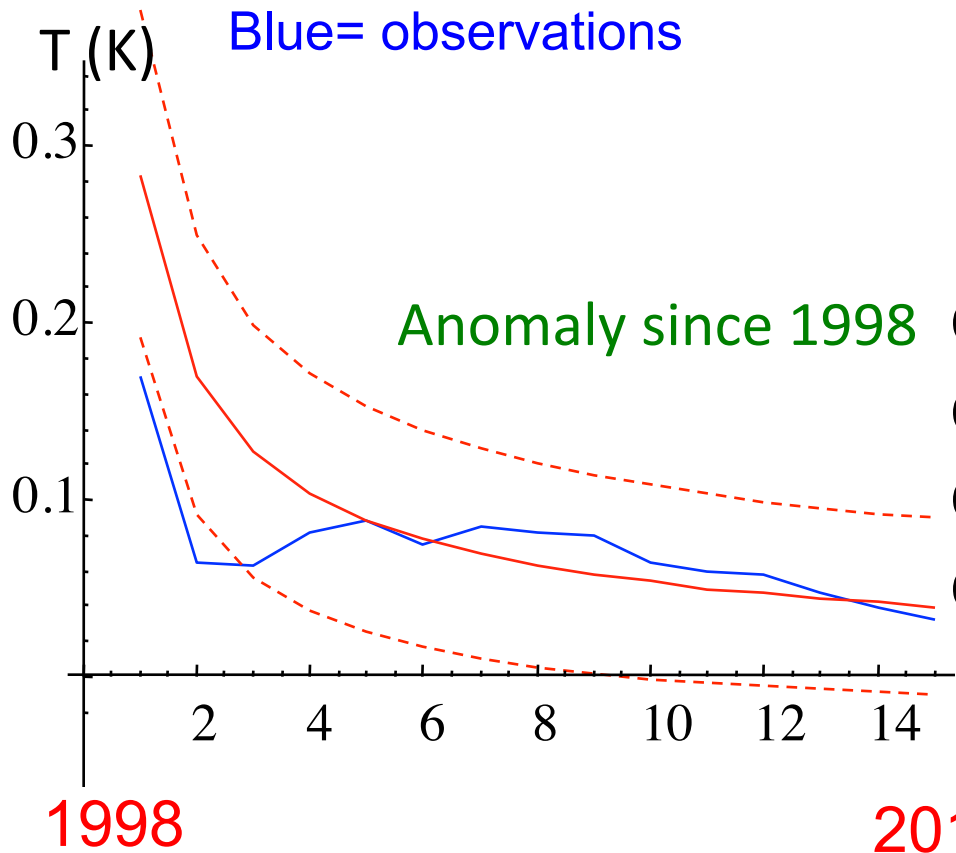


The "memory": Forecasting the Pause

(Global mean annual
Temperature since 1998,
natural variability only)

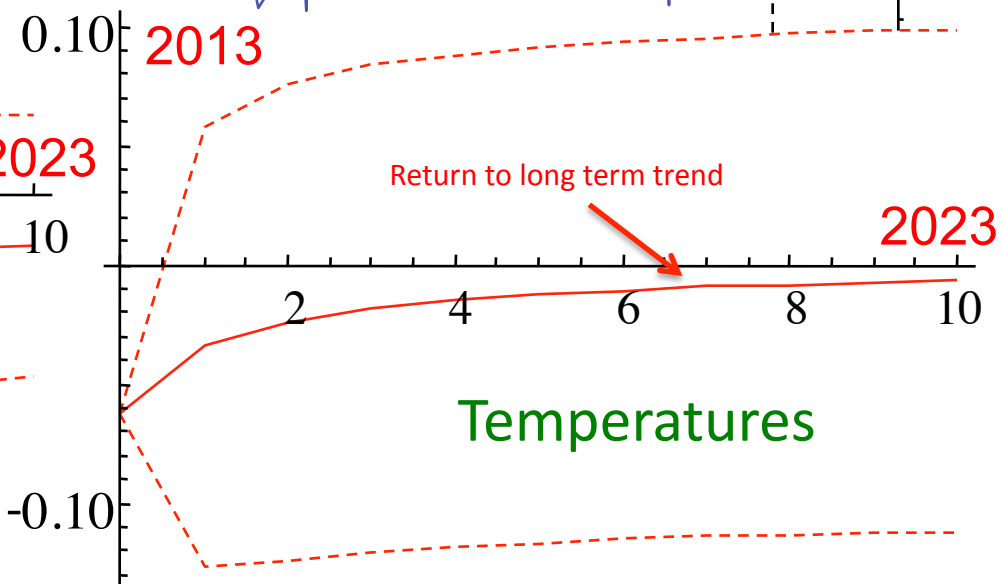
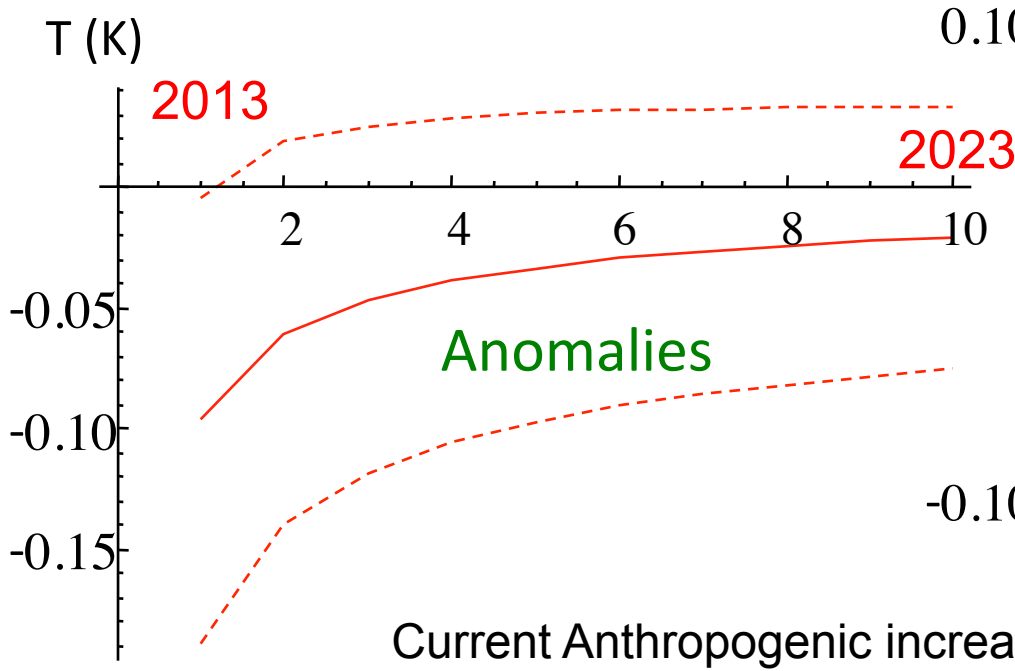
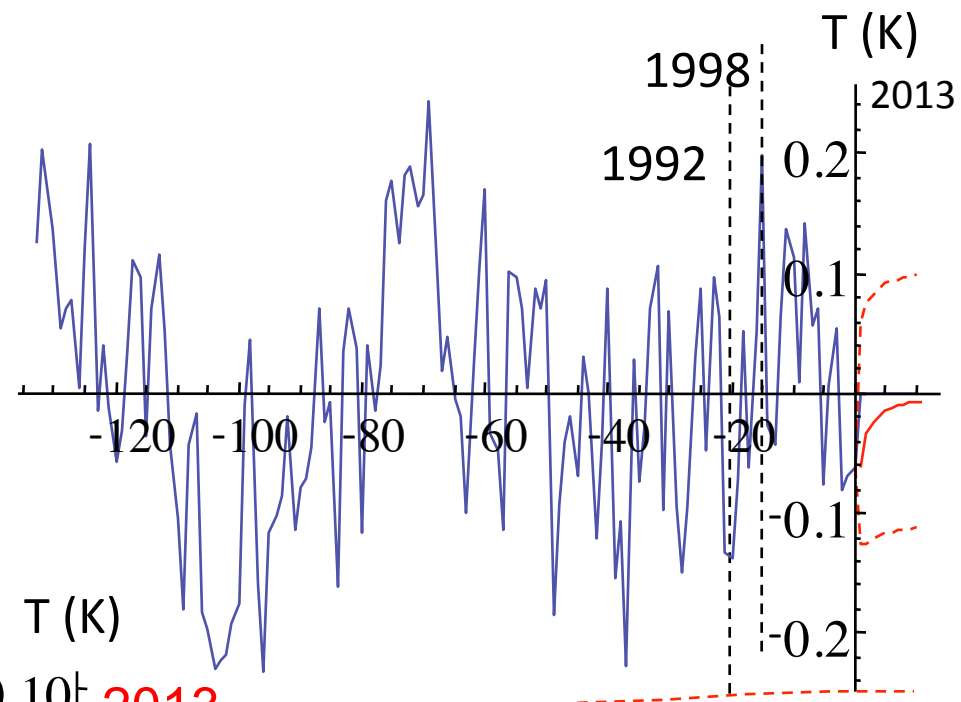
Red= forecast

Blue= observations



The Future

**The next 10 years, Global:
2014-2023**
(natural variability only)

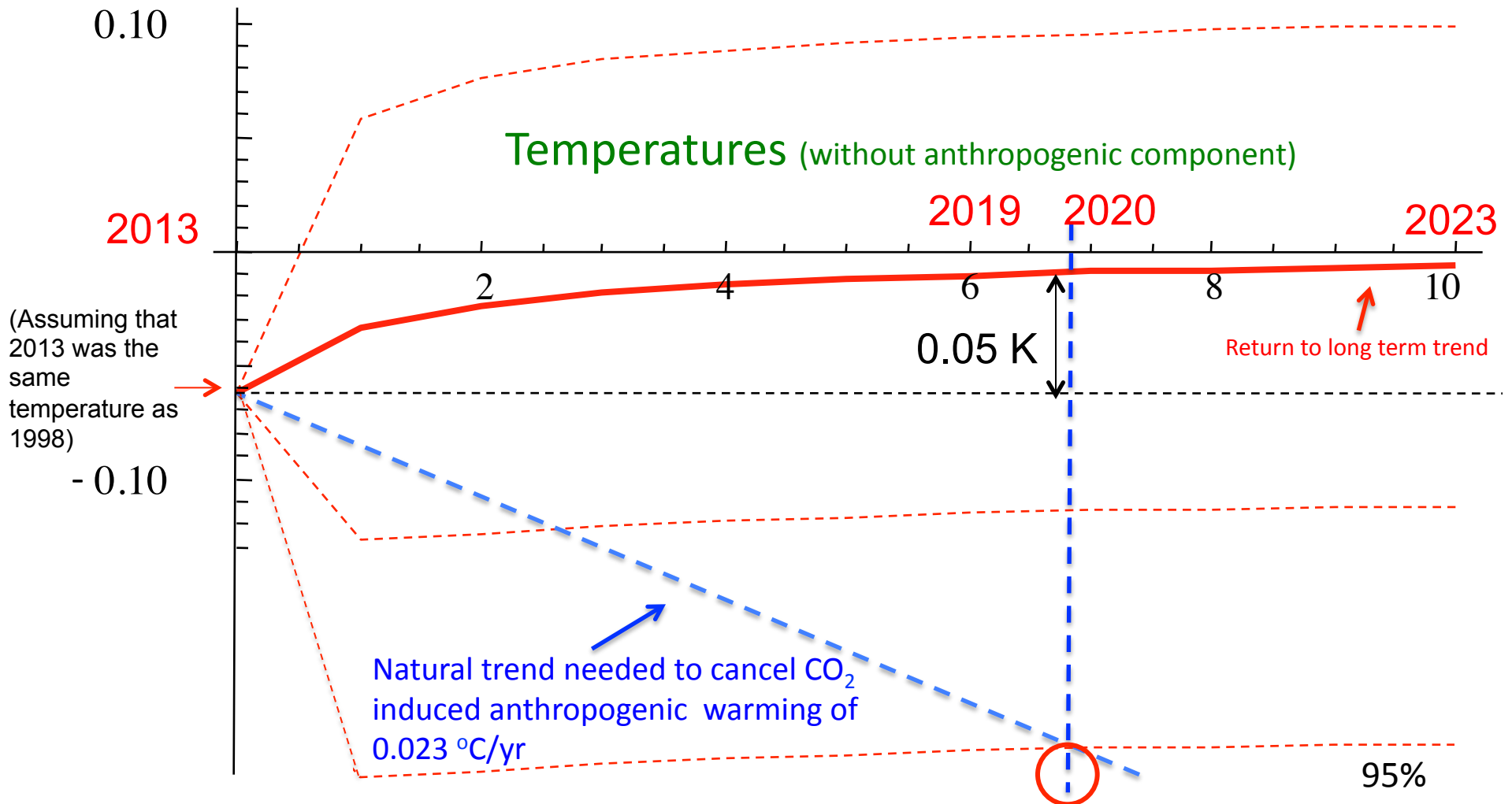


Current Anthropogenic increase: $\frac{d \log_2 CO_2}{dt} \approx 0.010 / yr$ $\frac{dT}{dt} \approx 0.023 / yr$

Forecast for 2023: $+0.05 \pm 0.10 K$ (natural) $+0.23 \pm 0.02 K$ (anthropogenic) = $0.28 \pm 0.11 K$ above 2013

Question: “How long must the pause continue before you admit that the warming is over?” – climate skeptic

Answer: About 6 years...



Current Anthropogenic increase:

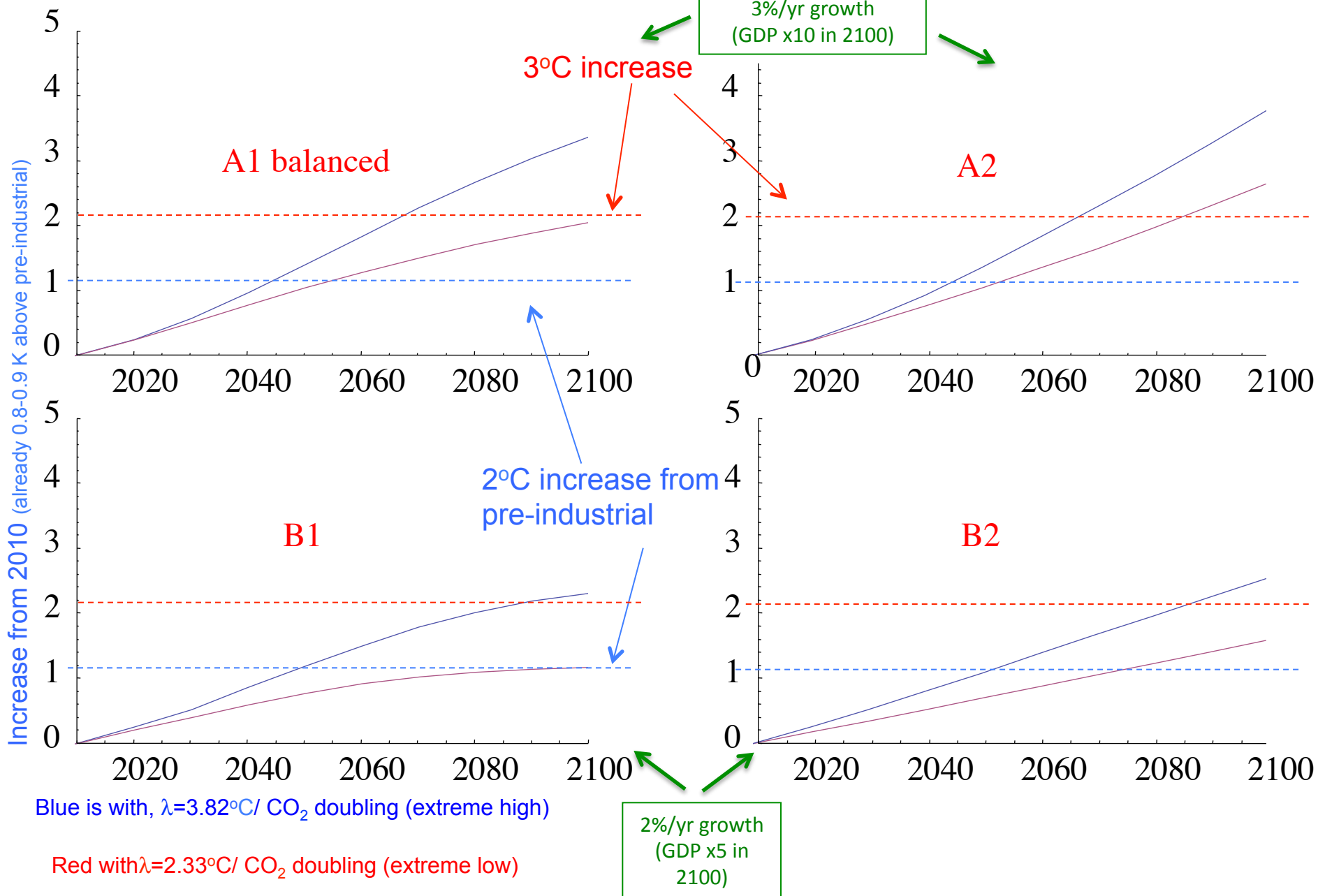
$$\frac{d \log_2 CO_2}{dt} \approx 0.010 / \text{yr}$$

$$\frac{dT}{dt} \approx 0.023 / \text{yr}$$

Forecast for 2023: +0.05±0.10°C (natural)+0.23±0.02°C (anthropogenic) =0.28±0.11°C above 2013

Future Projections

Based on SRES (Special Report on Emissions Scenarios, IPCC, AR2-4)



The skeptics reaction (1)



CALGARY, April 17, 2014 /Canadian News Wire/

Friends of Science (Calgary based group)

...Friends of Science are also calling up the Chancellor of McGill University to retract the McGill press release and issue an apology for the use of Lovejoy's quote
"This study will be a blow to any remaining climate-change deniers..."

"This is not the language of science or good taste that one expects from a Nobel Laureate university," says Gregory.

The skeptics reaction (2)

“A mephitic ectoplasmic emanation of the forces of darkness”

-Viscount Lord Christopher Monckton of Brenchley evaluating this work



A mephitic
ectoplasm



Common reactions.. and misconceptions:

-Use of historical information

Q: 800 years ago in medieval Europe *global* temperatures might have been warmer than today if so, doesn't this contradict the analysis?

A: Our conclusions are for **125 year periods** - there is nothing to prevent the same changes occurring much more slowly (i.e. over much longer periods).

-Use of unrepresentative paleo or instrumental sources, (the “Friends”):

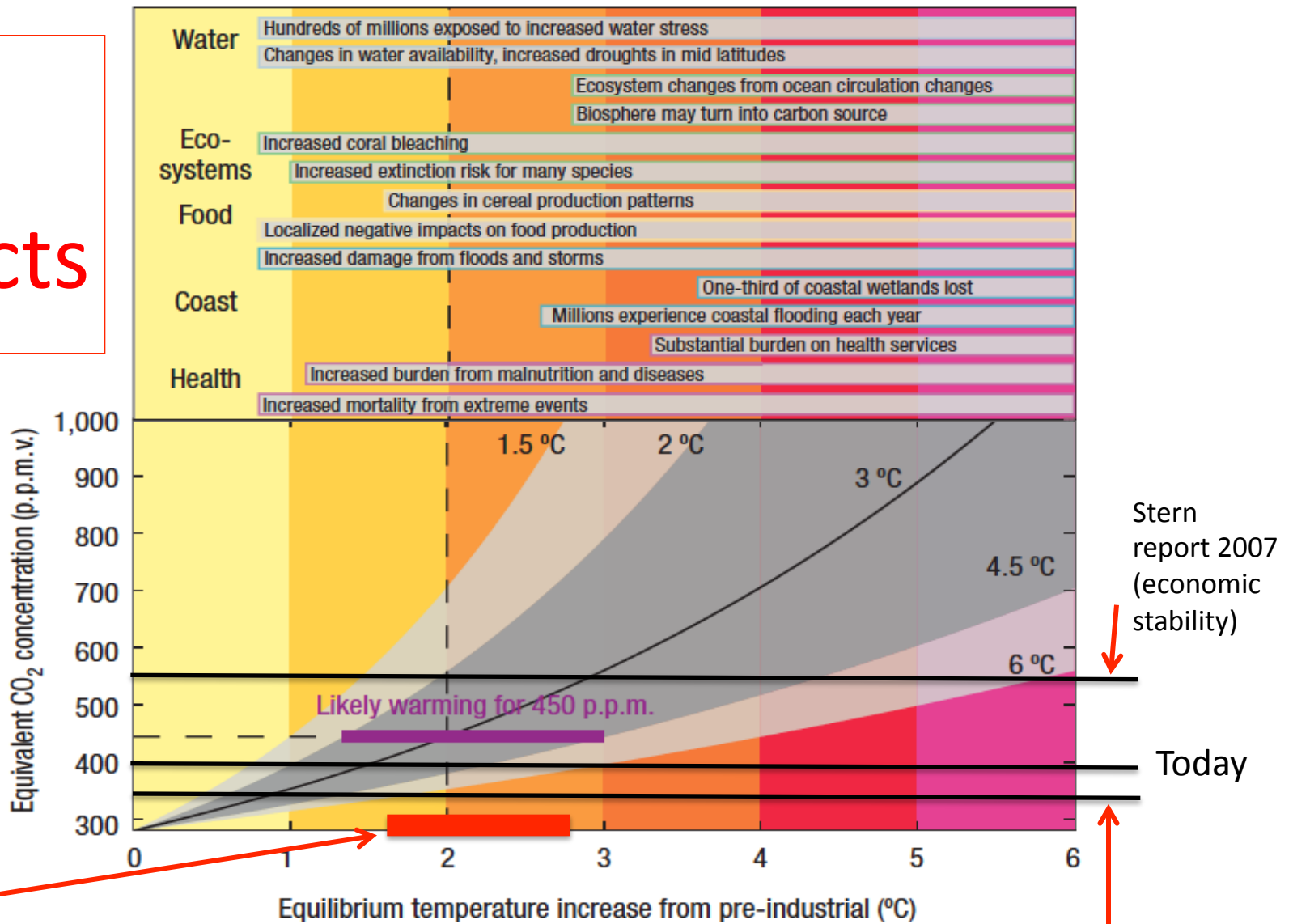
Q: The temperature change in central England from 1663-1762 was 0.90 °C, so such changes are not unusual.

A. England is only 0.04% of the earth's surface. The *global scale* temperature change was only 0.21±0.12 °C.

Impacts

The impacts

Knutti et al 2008



Our simple method:
doubling CO₂:
3.08±0.58 °C

For 450 ppm:
2.2±0.4 °C
(0.6±0.15 °C
more than in
2013)

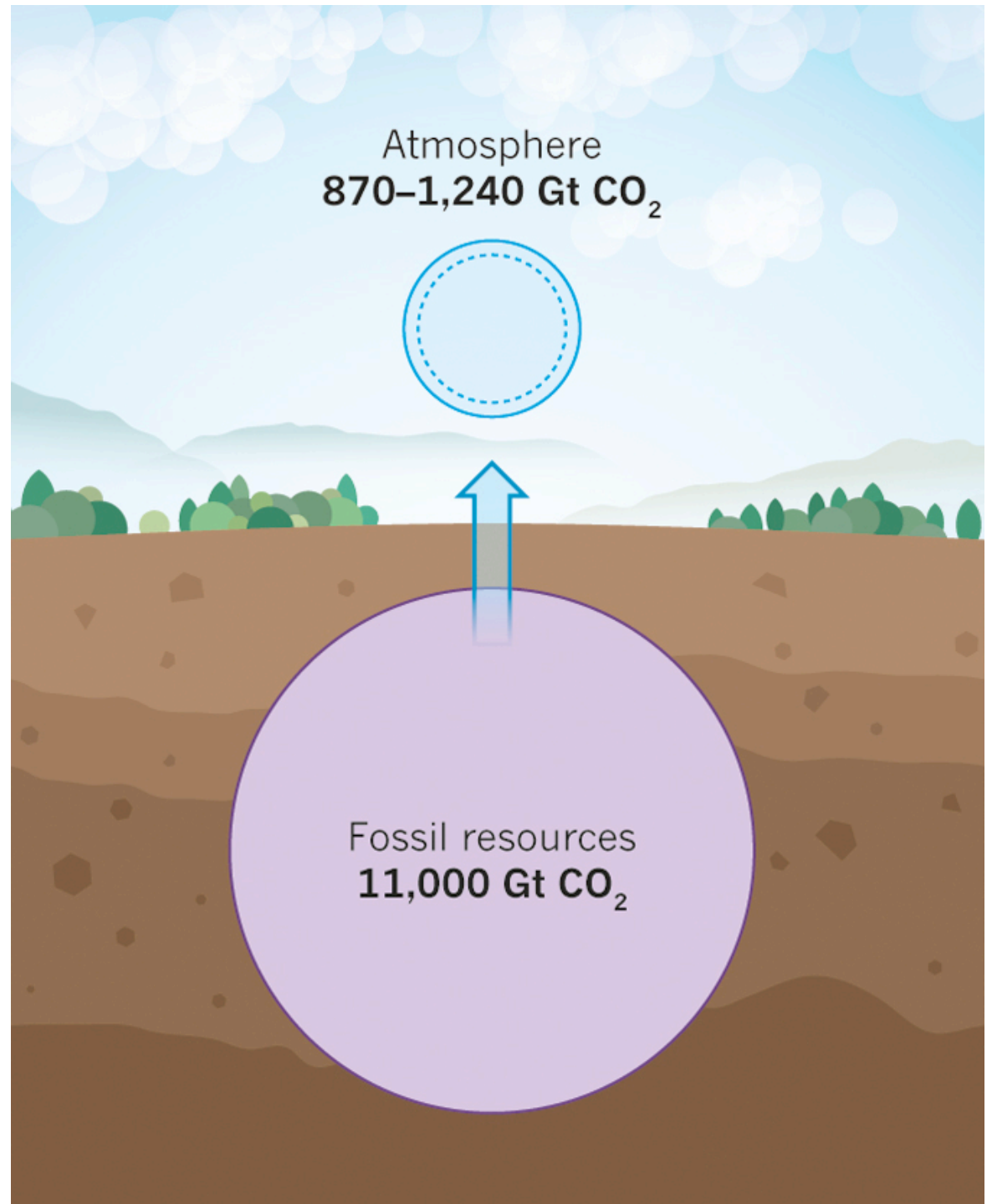
“Levels of CO₂ in excess of only 350 ppm are not compatible with the planet on which civilization developed or to which life on earth is adapted”:
Hansen et al 2008

What is to be done?

How much can we burn without roasting?

Proven reserves of fossil fuels are over 3 times the amount that can be burned while maintaining the temperature to within 2° of pre-industrial levels

Jakob & Hilaire 2015



The challenge: Decarbonize the economy

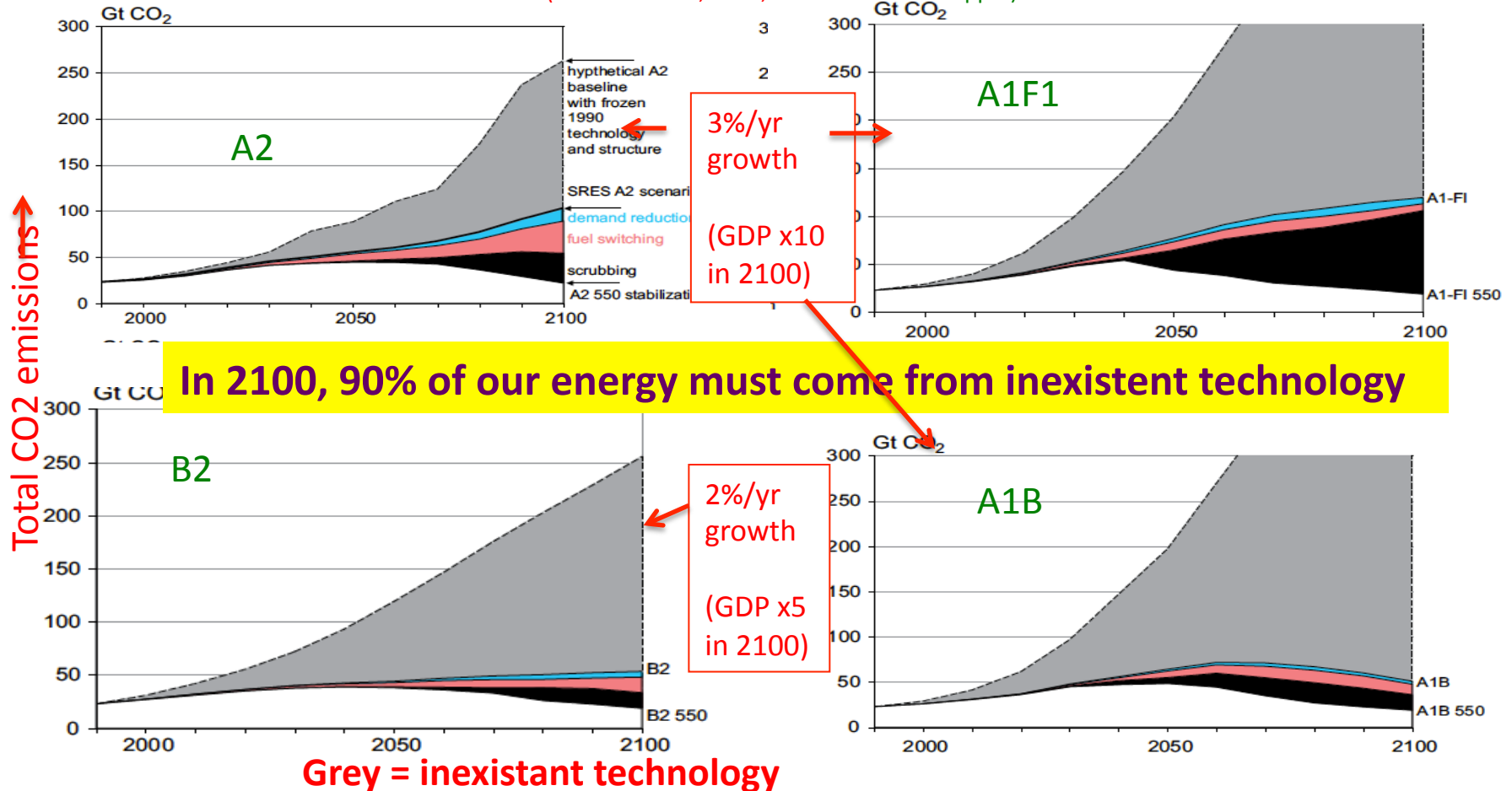
Can we break the link between economic growth
and CO₂ emissions?

Economists' magical thinking

No physical limits: if the price is right then technology can be conjured up to solve any problem...

The role of existent and new technologies

(IPCC scenarios, 2007; Stabilisation at 550ppm)



NEW!

IPCC 2014 (working group 3 on mitigation and adaptation)

A major role for Carbon Capture and Storage technology that doesn't exist...

IPCC 2014

(working group 3 on mitigation and adaptation)

In addition to carbon free energy:

A major role for **Carbon Capture and Storage** technology that doesn't exist...

Captura e
Armazenamento
de Carbono

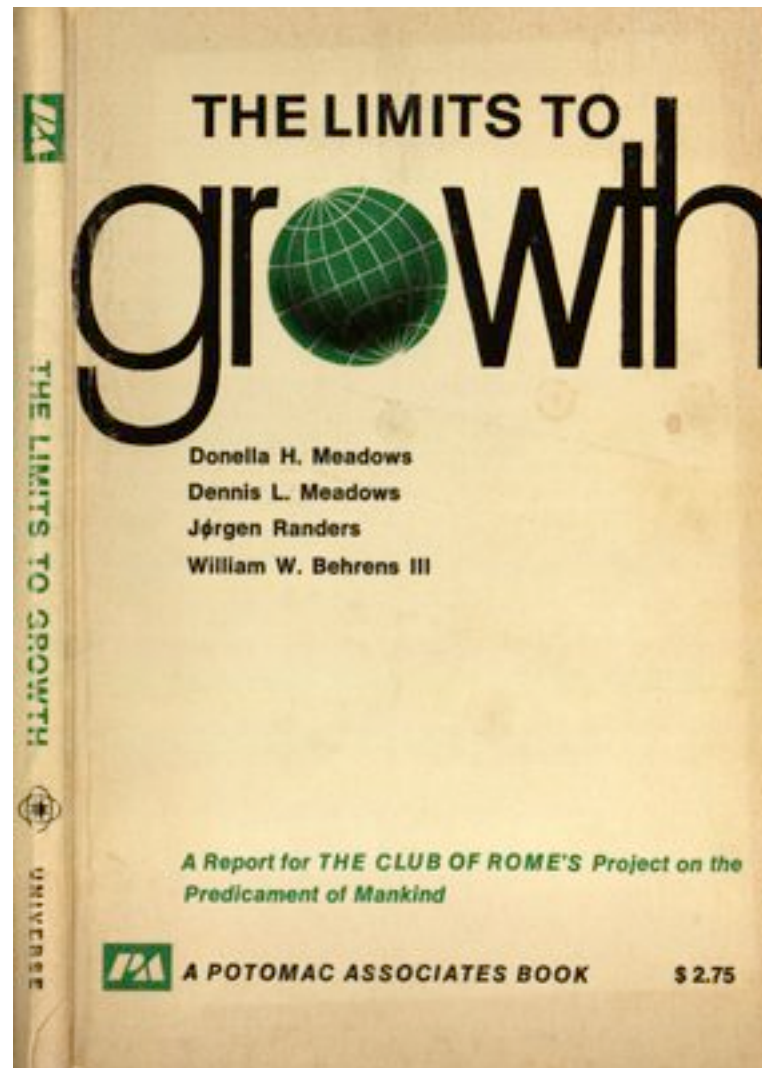
Is continued quantitative economic growth *possible*?

Limits to Growth: Overshoot and collapse

Superação e colapso

According to the 1972 “Business as Usual” projection, the last 40 years have tracked well and collapse will start around 2015 (G. Turner, 2014)

negócios como de costume

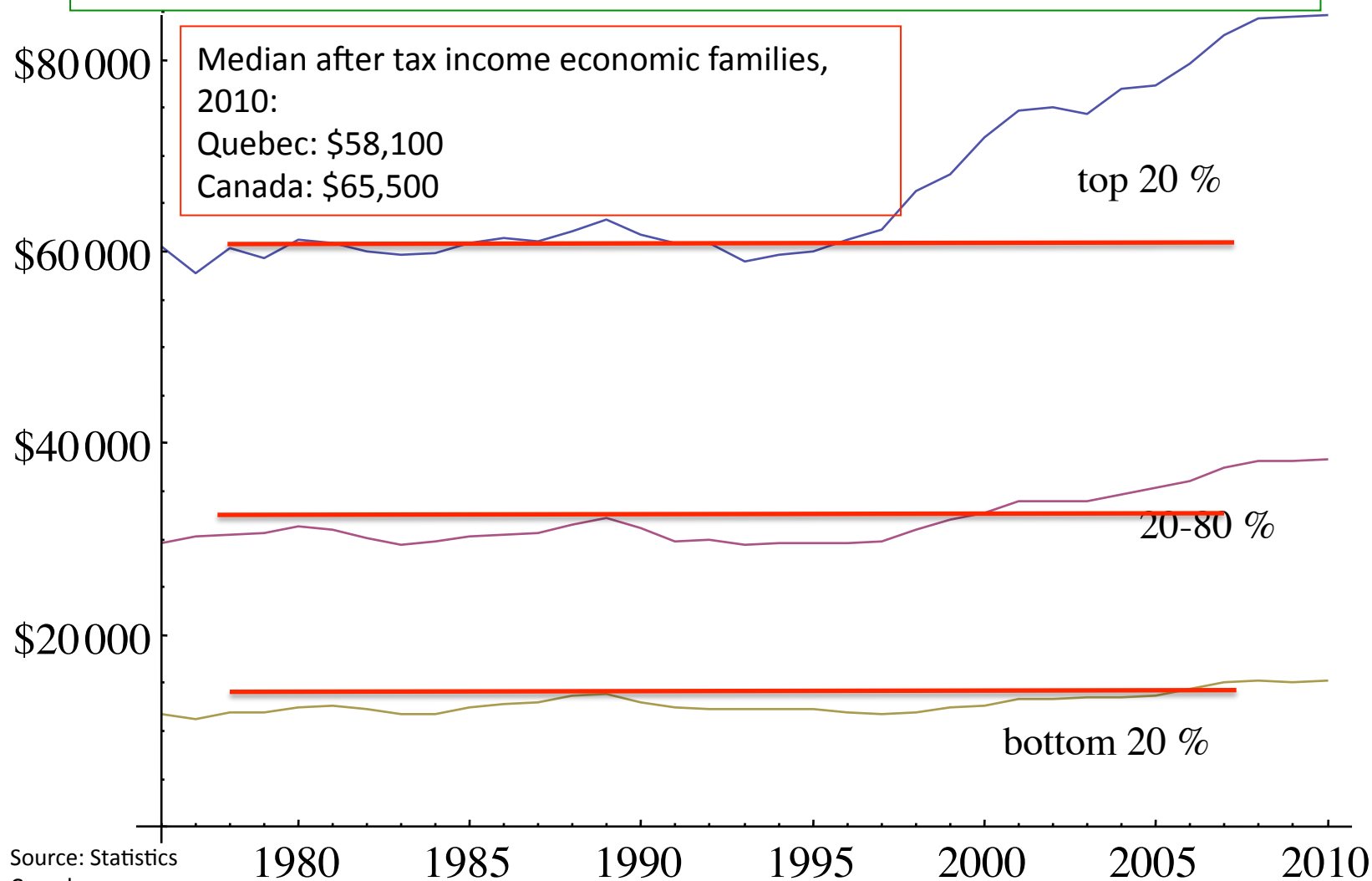


Note: The **nonlinear** model is completely based on physical (not financial inputs and outputs).

1972

Is continued quantitative growth *desirable*?

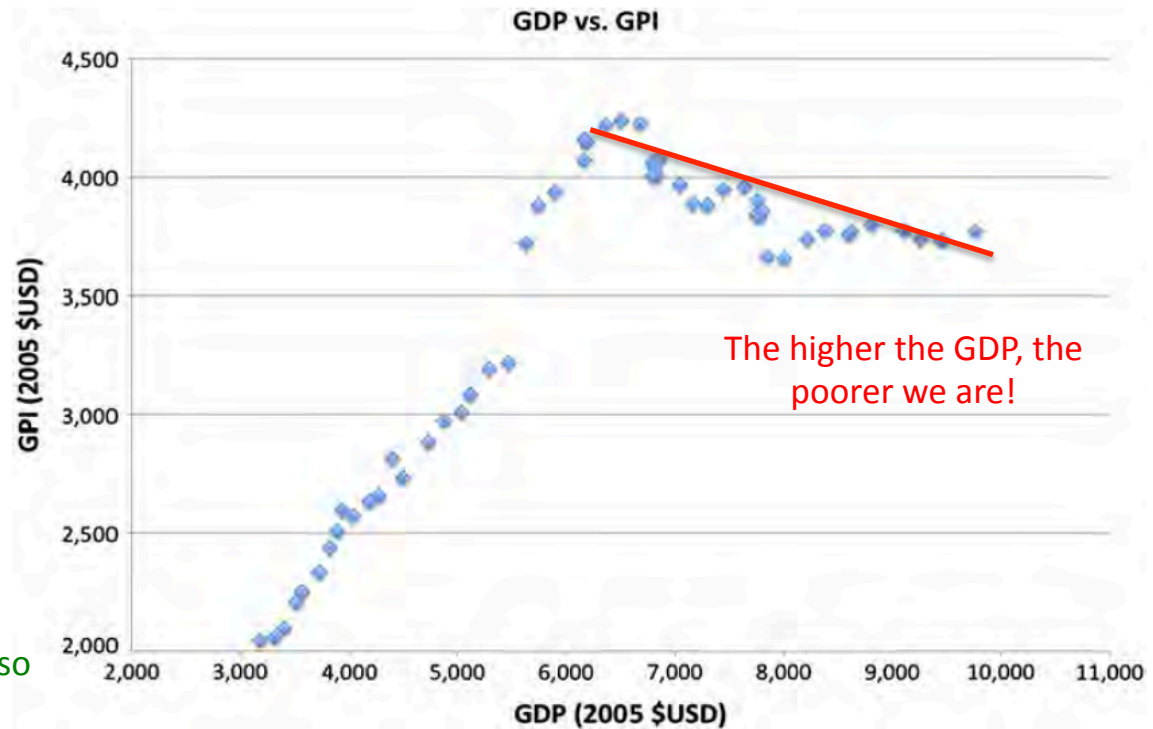
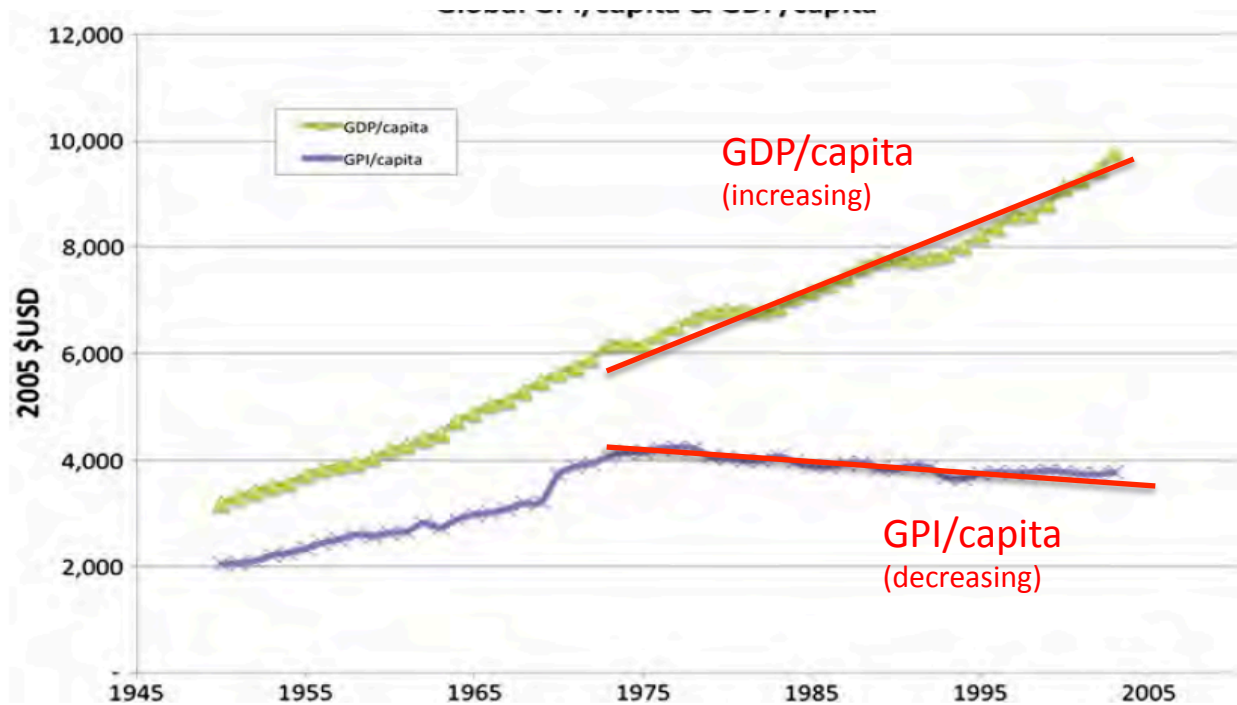
After - tax income, by family unit, Canada, 1976 – 2010
(2010 constant dollars, economic families)



GDP versus GPI

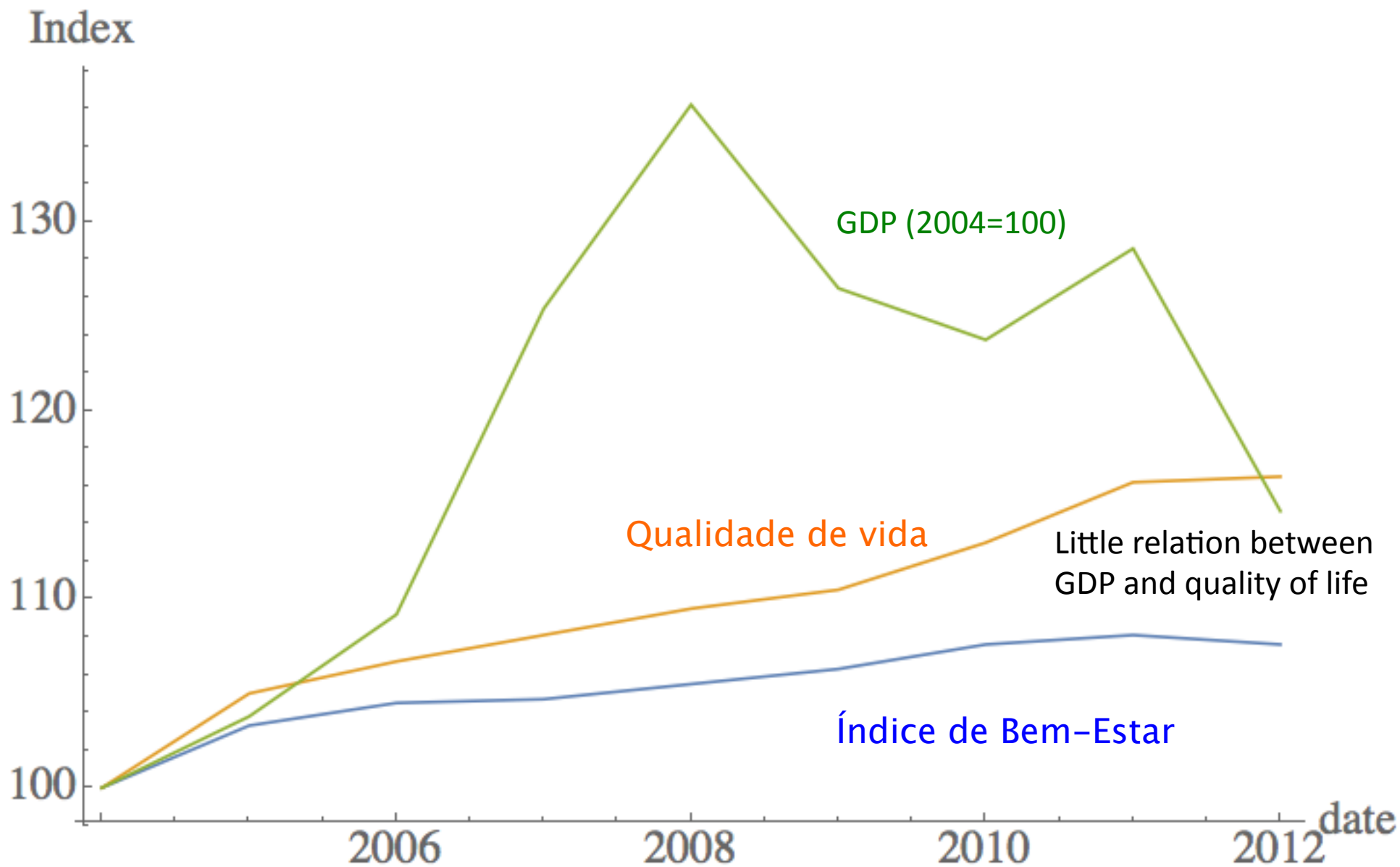
GDP=Gross Domestic Product
GPI=Genuine Progress Indicator

GDP=Produto Interno Bruto
GPI= Verdadeiro Indicador de Progresso



The higher the GDP, the poorer we are!

Portugal



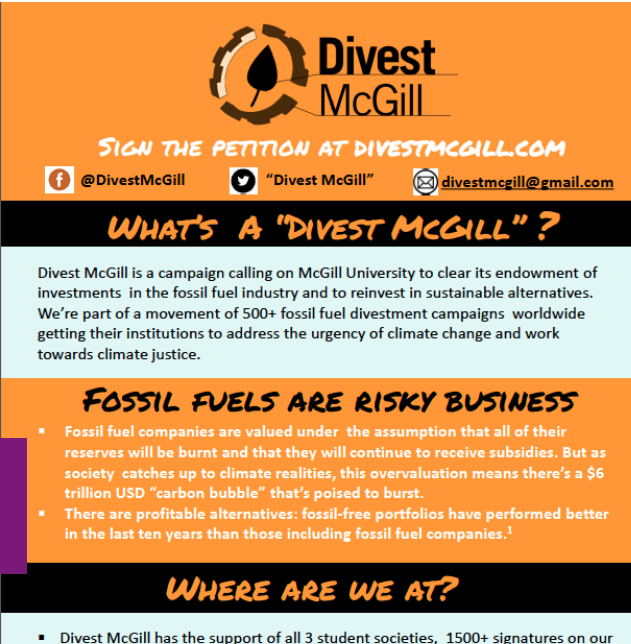
What is to be done?

- Global Warming is a global problem requiring global scale cooperation.
- Saving the climate is incompatible with the current triumph of the “free” market.

What is to be done?

McGill: divest from fossil fuels

Alienar combustiveis fósseis



Divest McGill

SIGN THE PETITION AT DIVESTMCGILL.COM

[@DivestMcGill](https://www.facebook.com/DivestMcGill) ["Divest McGill"](https://twitter.com/DivestMcGill) divestmcgill@gmail.com

WHAT'S A "DIVEST MCGILL" ?

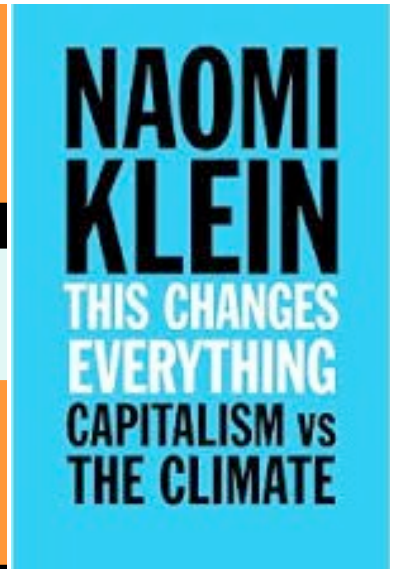
Divest McGill is a campaign calling on McGill University to clear its endowment of investments in the fossil fuel industry and to reinvest in sustainable alternatives. We're part of a movement of 500+ fossil fuel divestment campaigns worldwide getting their institutions to address the urgency of climate change and work towards climate justice.

FOSSIL FUELS ARE RISKY BUSINESS

- Fossil fuel companies are valued under the assumption that all of their reserves will be burnt and that they will continue to receive subsidies. But as society catches up to climate realities, this overvaluation means there's a \$6 trillion USD "carbon bubble" that's poised to burst.
- There are profitable alternatives: fossil-free portfolios have performed better in the last ten years than those including fossil fuel companies.¹

WHERE ARE WE AT?

- Divest McGill has the support of all 3 student societies, 1500+ signatures on our petitions, staff, faculty & alumni, and endorsements from a wide range of community organizations. We're challenging a May 2013 decision by McGill's Committee on Social Responsibility (CAMSR) in response to our petition to divest from fossil fuel companies. The campaign is filled with creative actions, speaking events, research briefs & meetings with students, alumni, professors & community.



Montreal: countering the "Friends of Science"



COULE PAS PAS CHEZ NOUS

“L'AVENIR N'EST PAS DANS LES PIPELINES!”

COULE PAS CHEZ NOUS!
EST UNE CAMPAGNE DE SENSIBILISATION CITOYENNE QUI DIFFUSE DE L'INFORMATION AFIN DE MIEUX COMPRENDRE L'ENJEU PÉTROLIER ET POURQUOI NOUS DEVONS DIRE NON AU TRANSPORT DE PÉTROLE SUR NOTRE TERRITOIRE

AGISSONS ENSEMBLE MAINTENANT!!

★★ DÉFILEZ JUSQU'EN BAS POUR NE RIEN MANQUER! ↓

Quebec: block the tar sands pipelines!



Conclusions

1. The climate is not what you expect.

O clima não é o que podemos esperar.

2. Legitimate versus illegitimate climate skepticism. It is much easier to disprove a theory (natural warming) than to prove one (anthropogenic warming).

“Ceticismo climático”: legítimo contra ilegítimo. É muito mais fácil refutar uma teoria (aquecimento natural) do que provar uma (aquecimento antropogénico).

3. The total anthropogenic warming since 1880 is about 1°C, for CO₂ doubling, 3.08±0.58°C.

O aquecimento antropogénico desde 1880 é de cerca de 1°C; para o dobro de CO₂, será de 3,08 ± 0.58°C.

4. The probability of the warming being natural is less than 0.1%.

A probabilidade de o aquecimento ser natural é inferior a 0,1%.

5. The pause is a natural cooling event.

A “pausa” é um evento natural de arrefecimento.

6. Impacts rise rapidly after 2°C of warming.

Os impactos do aquecimento aumentam rapidamente acima dos 2°C.

7. Decarbonizing unlikely with continued global economic growth (“magical thinking”).

A descarbonização é improvável face à continuação do crescimento económico global.

8. For many of us, continued economic growth is undesirable (lower GPI).

Para muitos, a continuação do crescimento económico é indesejável (menor “indicador de progresso”, GPI).

© Cartoonbank.com



Assim, apesar de cenários de fim-do-mundo repletos de horrores inimagináveis, acreditamos que o período precedente trará inigualáveis oportunidades lucrativas de negócios.