An aside about the recent period of “Global Warming”

Short-term Climate Variability and Global Warming

Important material to read

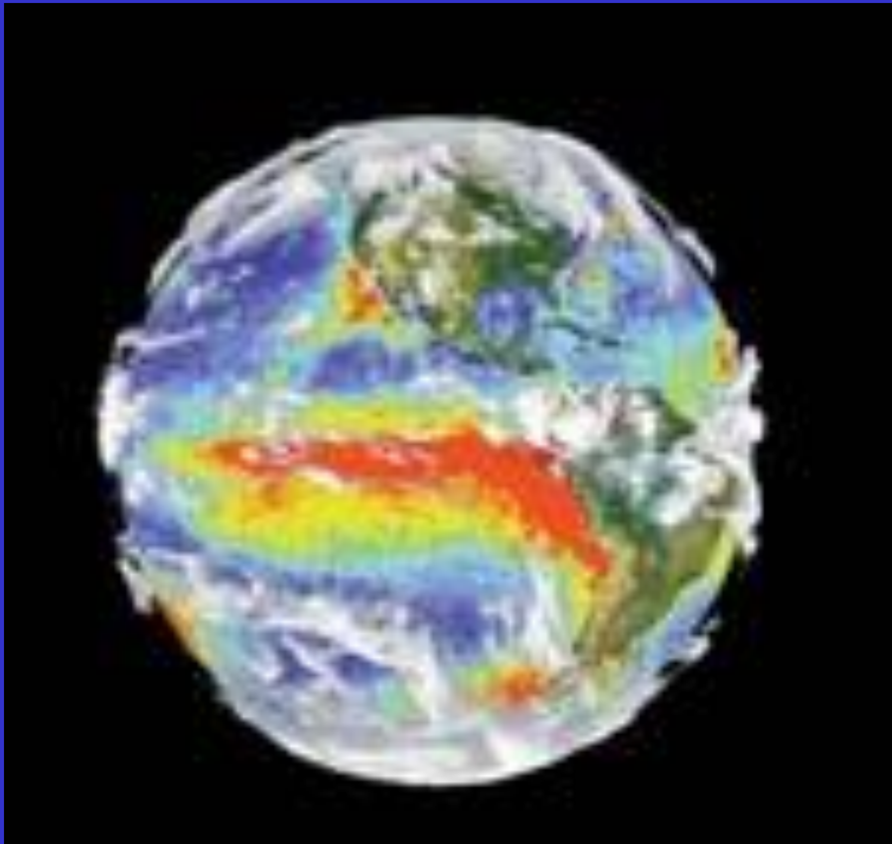
The temperature record over the past ~10, 100 and 1000 years (Chapter 1, and Chapter 15, p 295-297)

Proxy Climate Data (p 296)

Bore Hole records (not in textbook)

Abrupt climate change (p 288-289)

The Holocene Climatic Optimum (p 297-298)

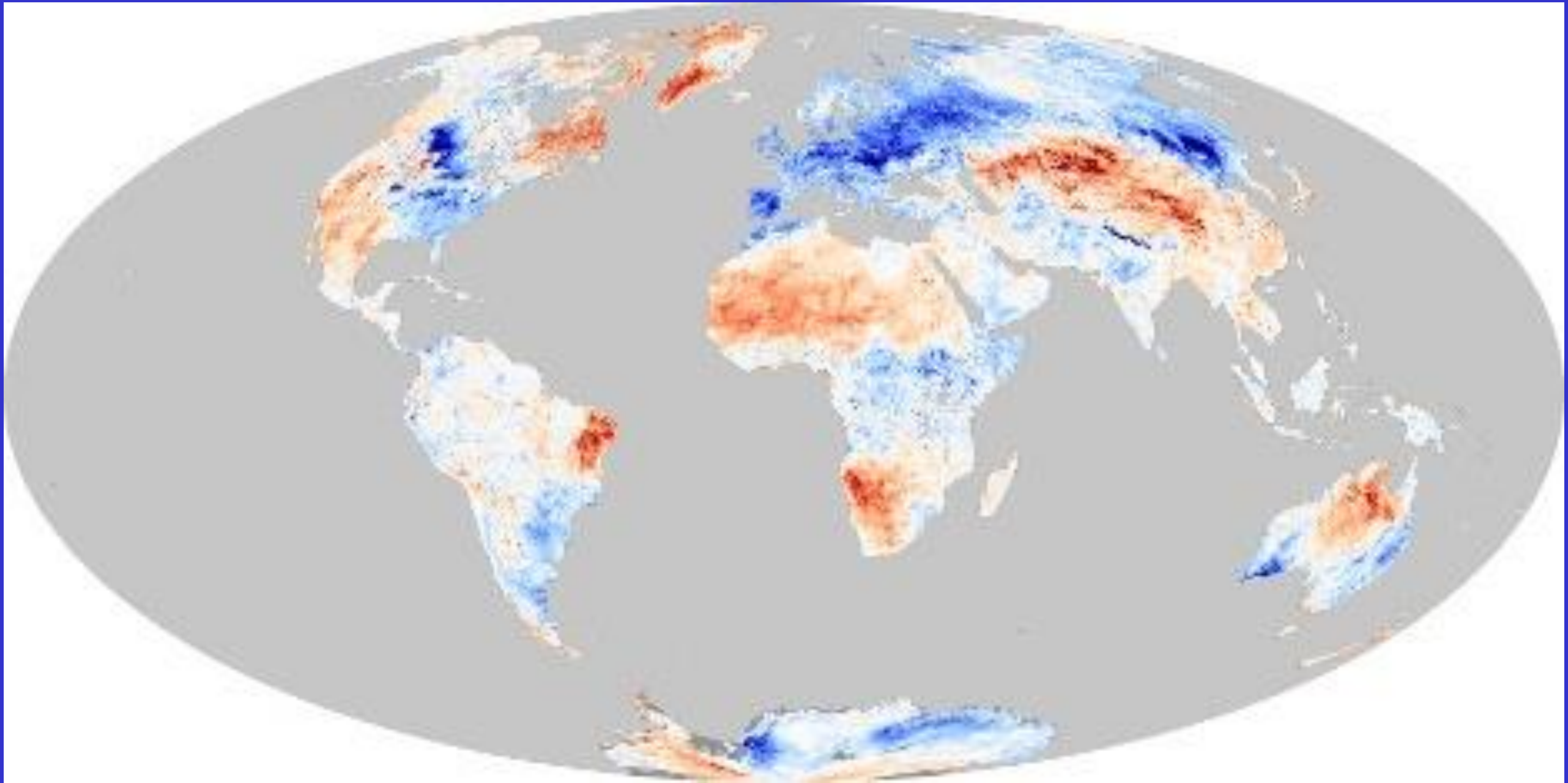


The Holocene

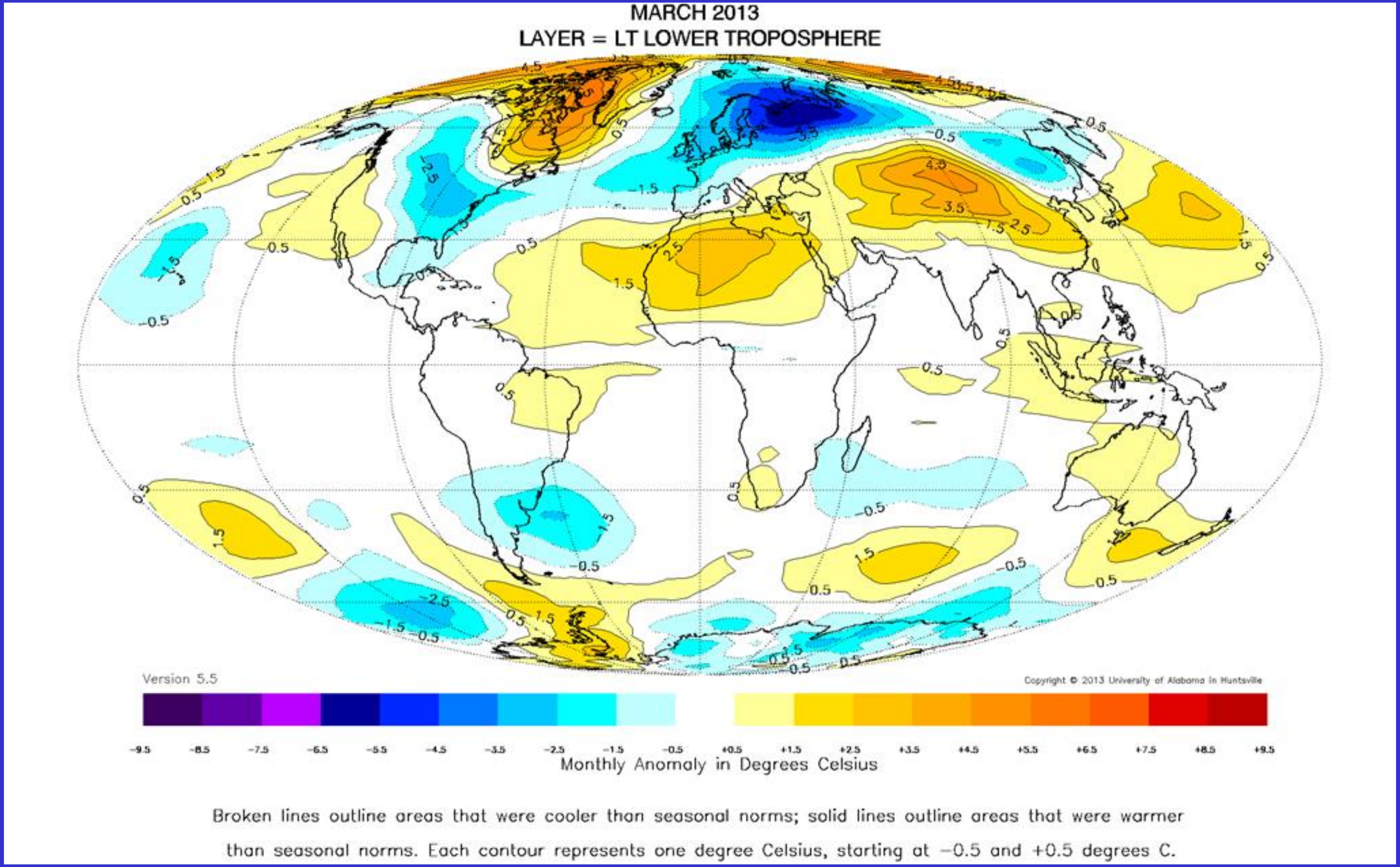
Let’s look at where we are today (and for the past ~20,000 years or so – “The Holocene”)

To observe a Holocene environment, simply look around you! The Holocene is the name given to the last ~10,000 years of the Earth's history -- the time since the end of the last major glacial epoch, or "ice age." Since then, there have been small-scale climate shifts -- notably the "Little Ice Age" between about 1200 and 1700 A.D. -- but in general, the Holocene has been a relatively warm period in between ice ages.

Last week I asked the question "given all this relatively cold weather we've been having, should we question the claim that Earth is getting warmer?" Here are two images of March temperature 'anomalies' (differences of March 2013 from historical climate averages). Note, we are in a 'blue' spot, but there are just as many 'red' zones where it has been warmer than usual.

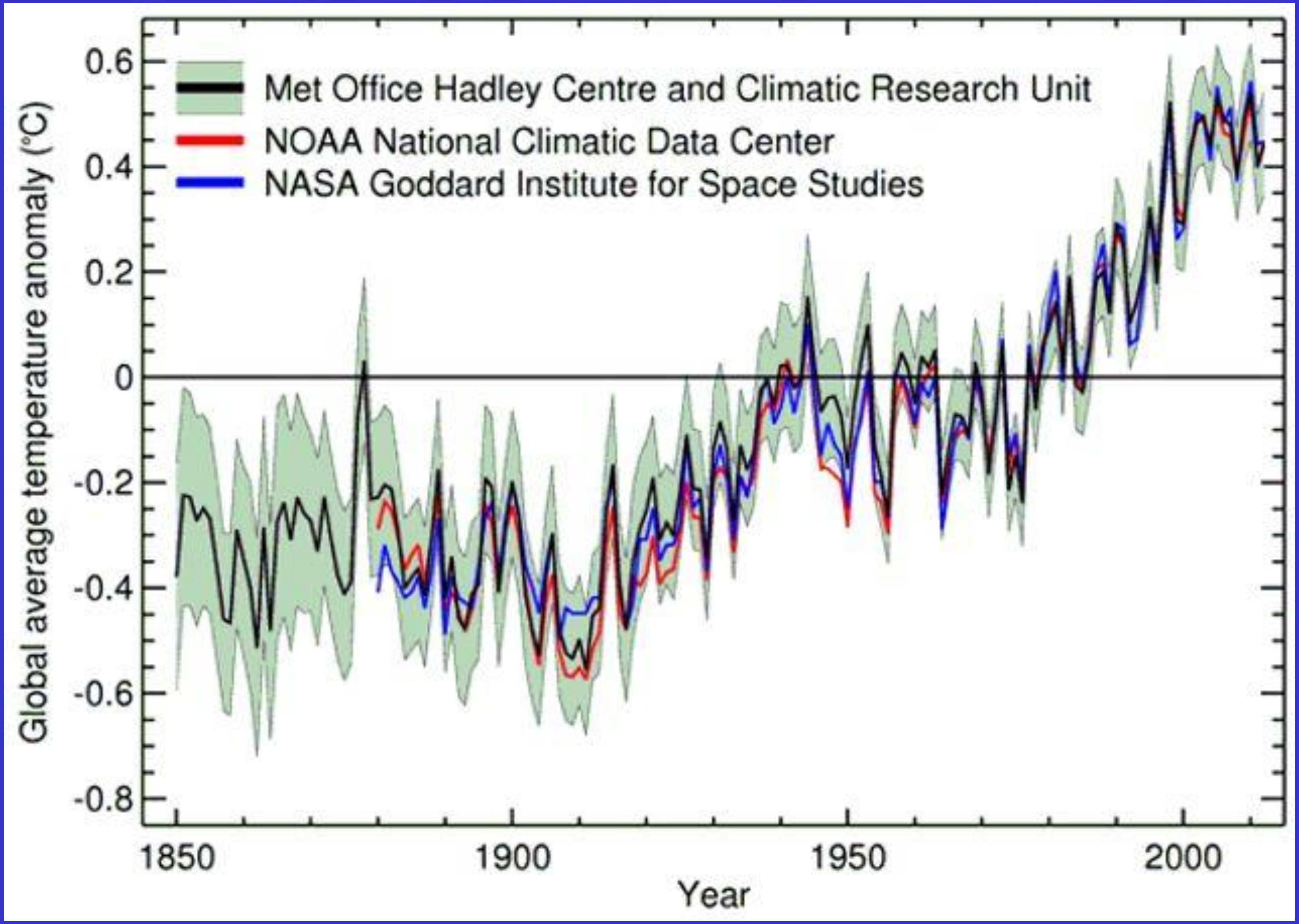


Note that ‘climate change’ is a better term than ‘global warming’ if you want to describe the way that the enhanced greenhouse effect impacts the weather. Some places may get colder at certain times, but most certainly other places will be warmer so that the global mean temperature will still be higher than normal.



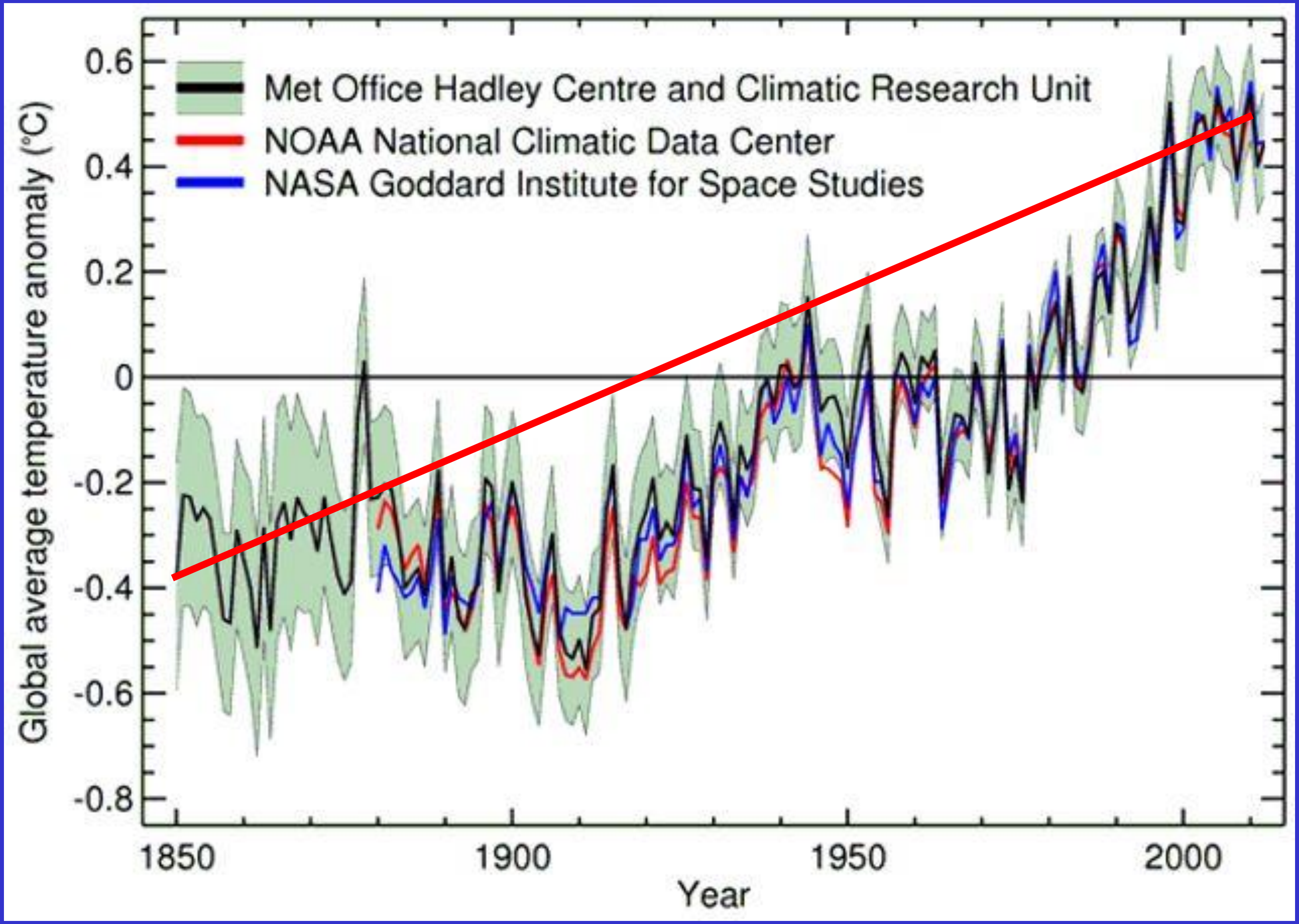
1998-2012 – So there hasn't been any global warming?

Let's look at this in the context of the past 100 years



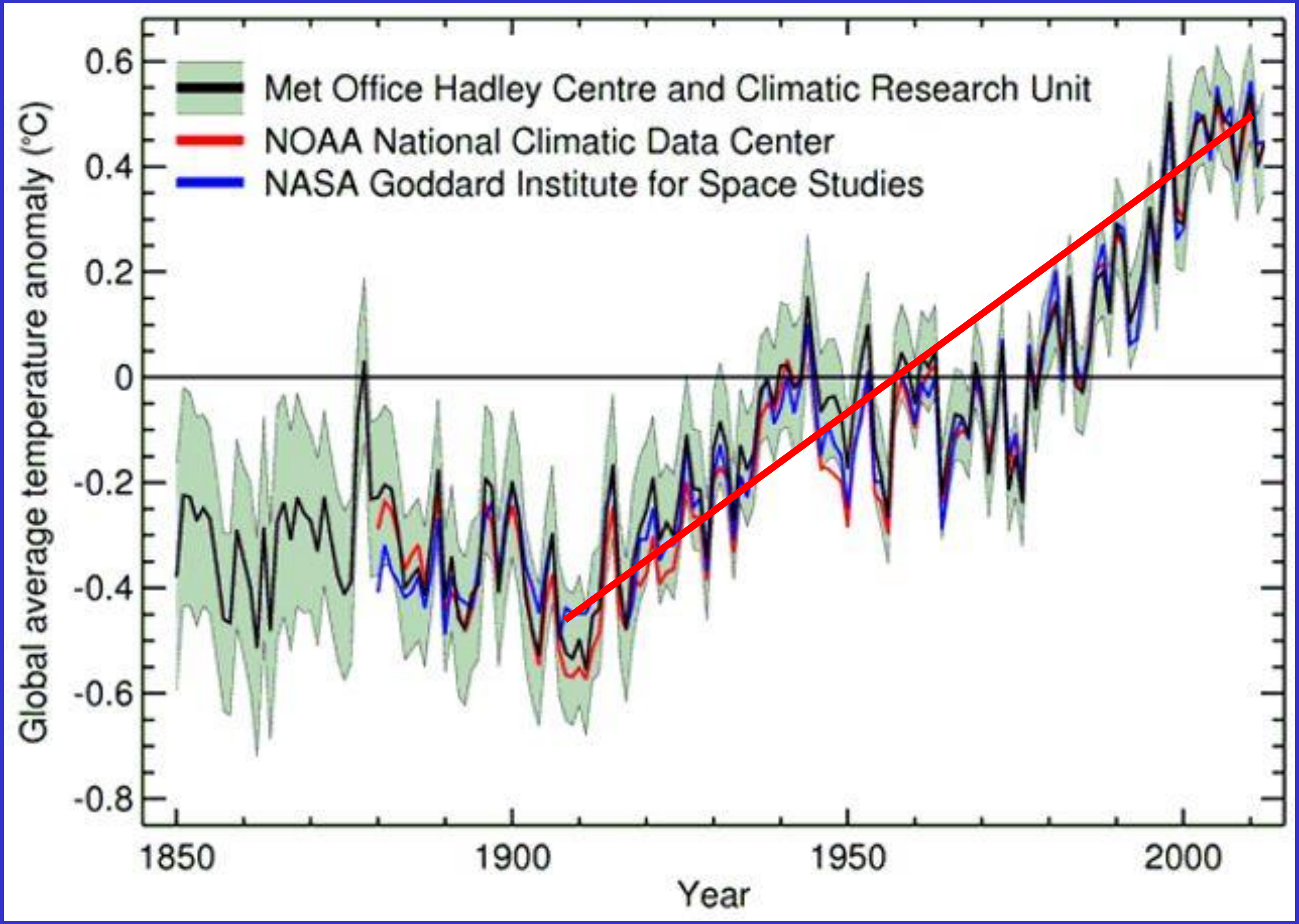
1998-2012 – So there hasn't been any global warming?

Start at 1850 → 0.9 °C/162 years = 0.06 °C per decade



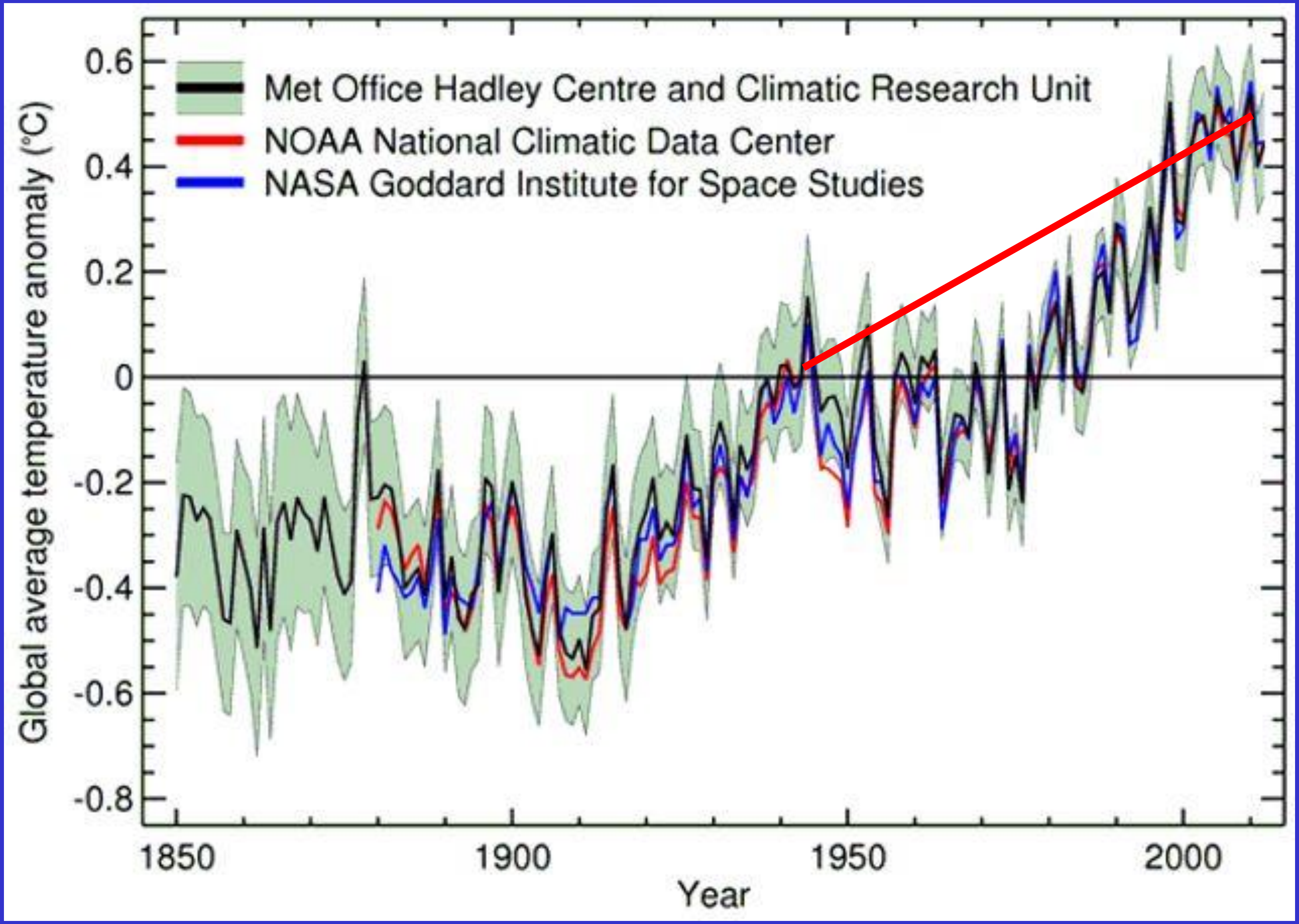
1998-2012 – So there hasn't been any global warming?

Start at 1910 → 1.0 ^{o}C/102 years = 0.1 ^{o}C per decade



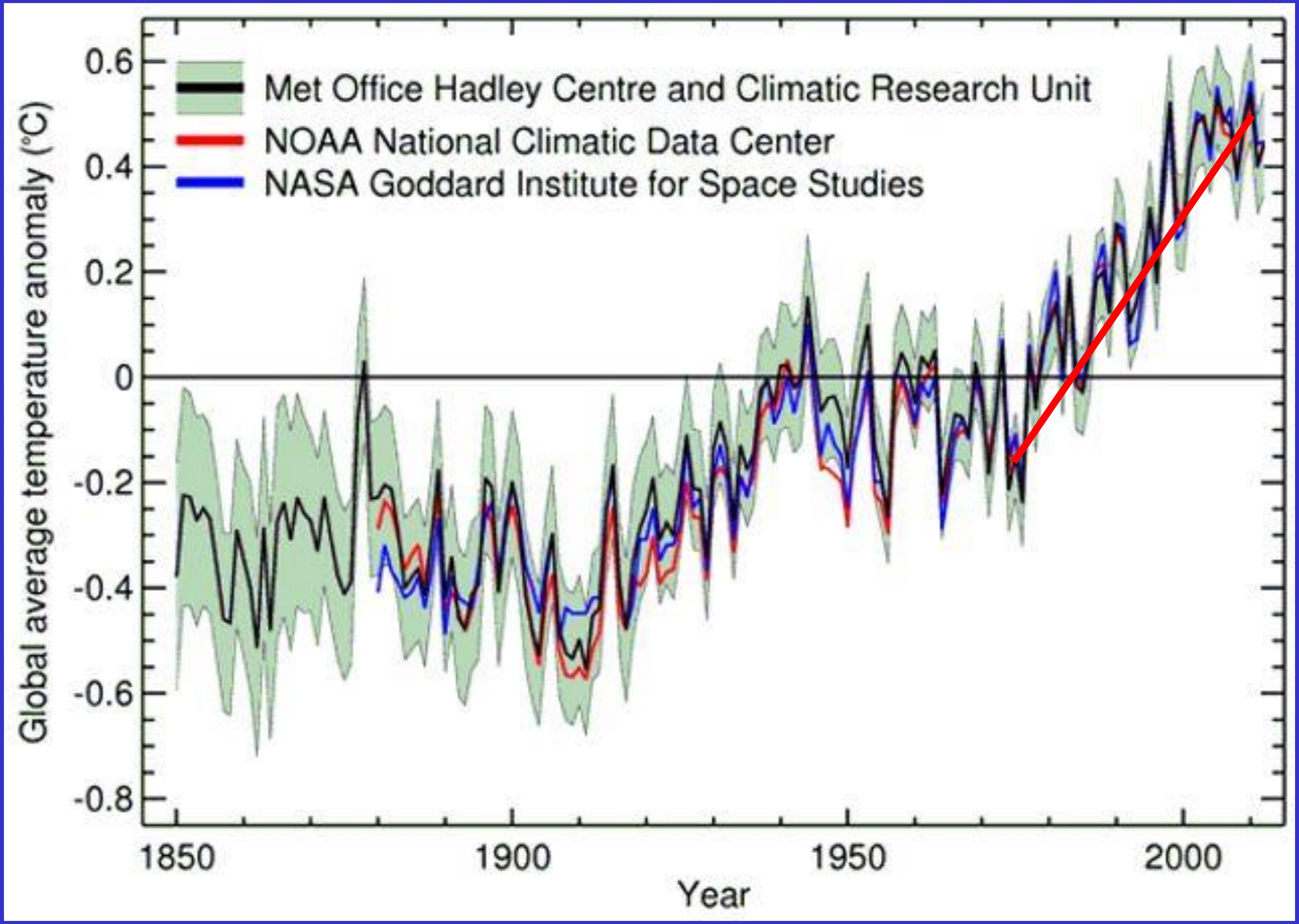
1998-2012 – So there hasn't been any global warming?

Start at 1940 → 0.5 ^{o}C/62 years = 0.08 ^{o}C per decade



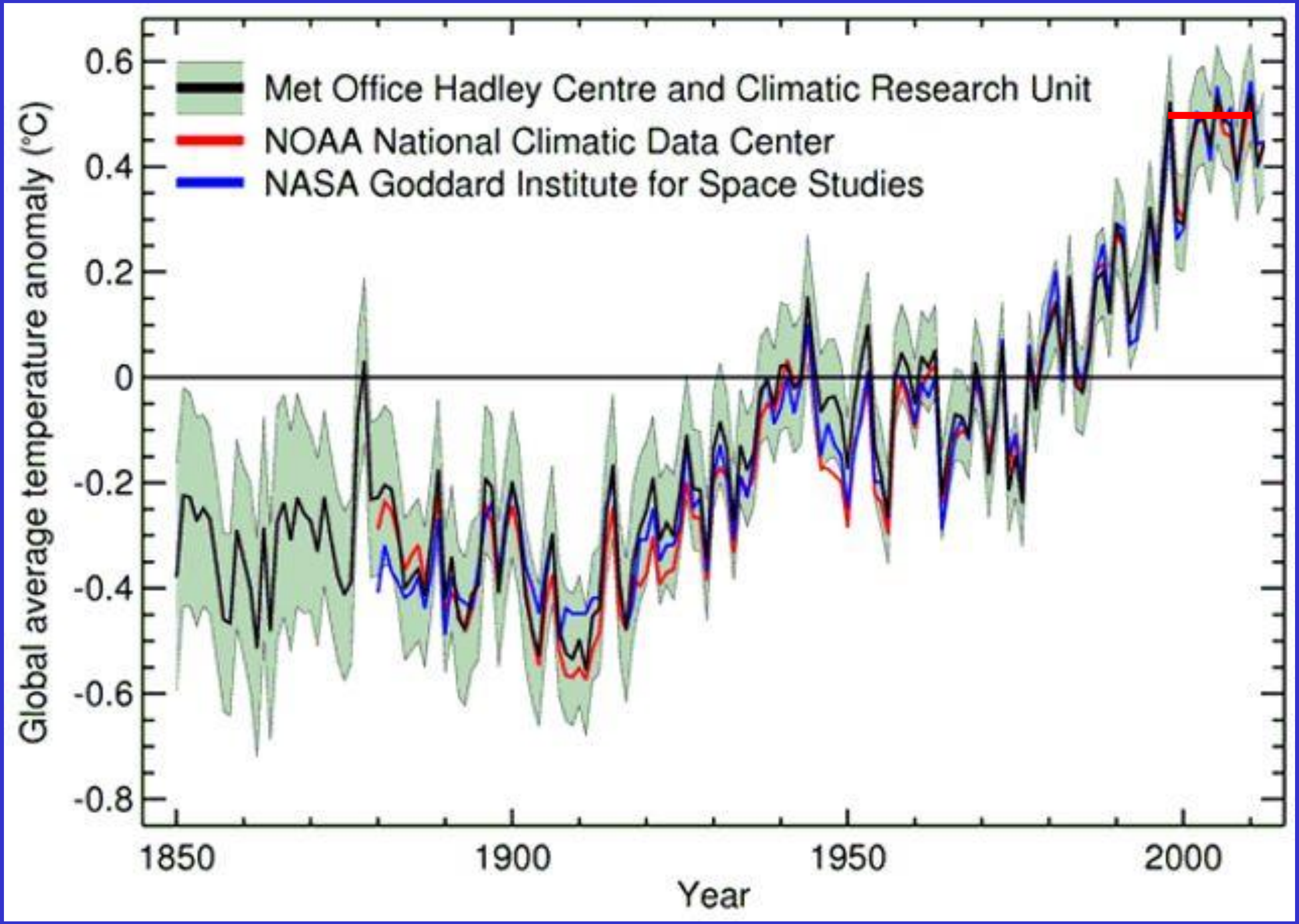
1998-2012 – So there hasn't been any global warming?

Start at 1970 → 0.7 ^{o}C/42 years = 0.17 ^{o}C per decade



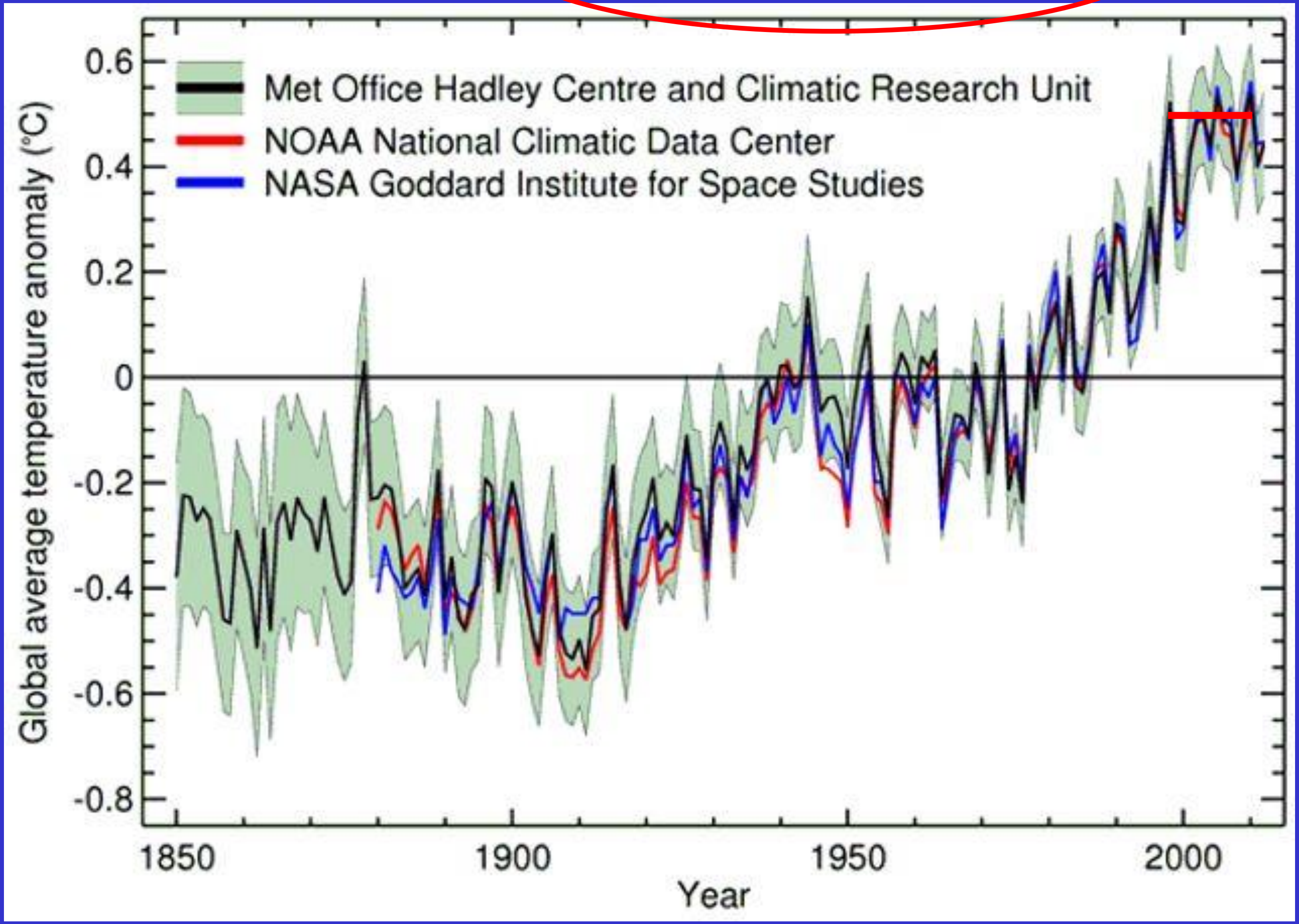
1998-2012 – So there hasn't been any global warming?

Start at 1998 → 0 ºC/15 years = 0 ºC per decade

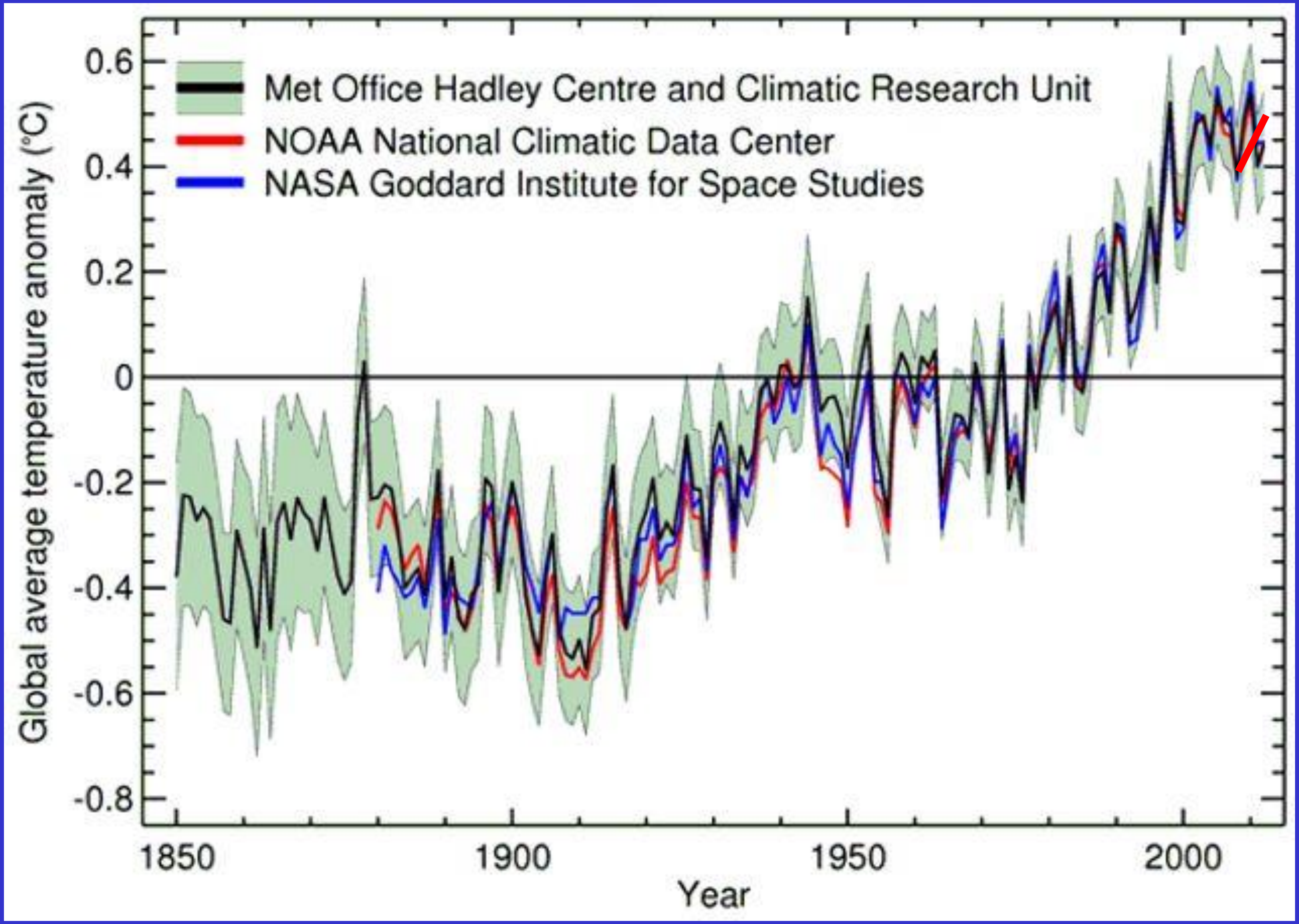


Oh Dear! Was George Will right?

Start at 1998 → 0 ºC/15 years = 0 ºC per decade



Wait, let's just take a few years!
Start at 2009 → 0.1 ºC/3 years = 0.33 ºC per decade



Note that as we examine a longer span of time the overall upward trend in temperature becomes more obvious – and larger than the year-to-year variations that represent the ‘natural’ variability of climate due to changes in weather patterns.

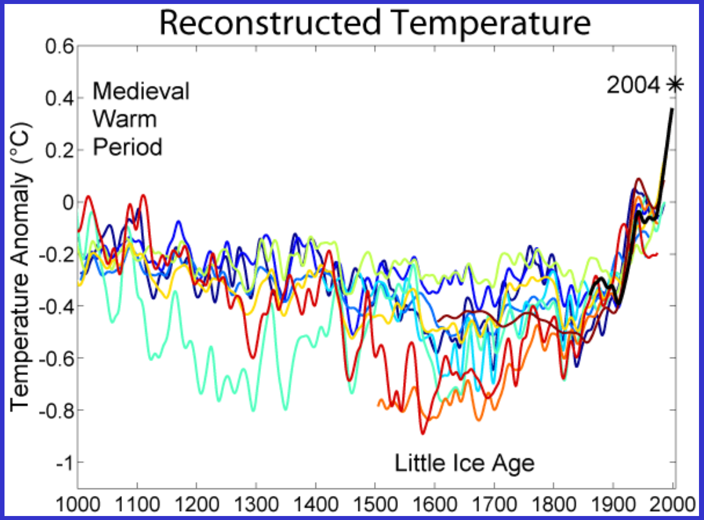
So, what can we say about the past 100 years? Remember Figure 1-4, and the exercise we carried out the first day of class?

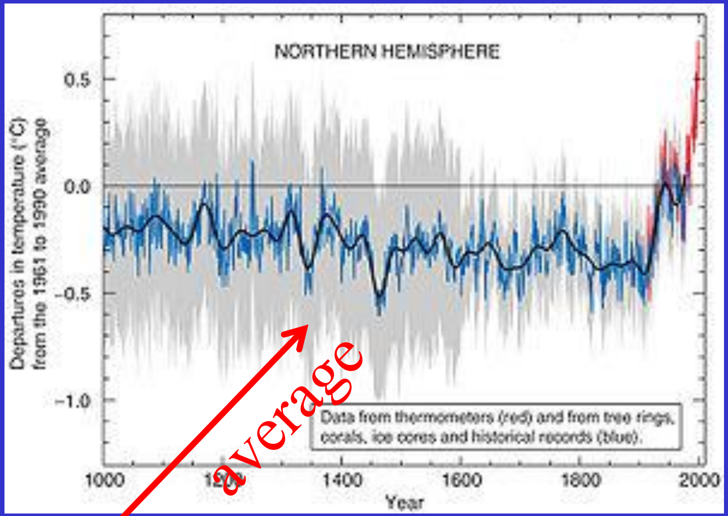
Over the past 100 years or so, Earth’s global mean temperature has increased by nearly 1 ^{o}C. This is clearly significant compared to year-to-year natural variability of 0.1 ^{o}C. But to understand whether this is just a natural shift in climate or something more ominous, we look at climate trends over the past 1000-10,000 years.

What is the hockey stick? It is a temperature record that is produced from ‘proxies’ of climate – things such as tree rings, corals, tree pollen, and other records left behind by living things that vary their behavior on the basis of climate. Based on how these records respond to climate today (e.g., ‘biomes’), these fossil records are interpreted to mean something about past climate.

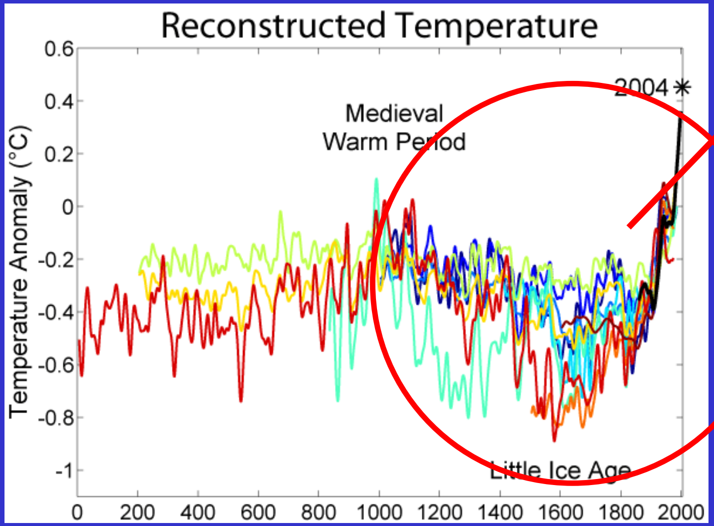
What is so important about this figure? It shows that different proxy records all indicate that temperatures today are warmer than in the previous 1000-2000 years.

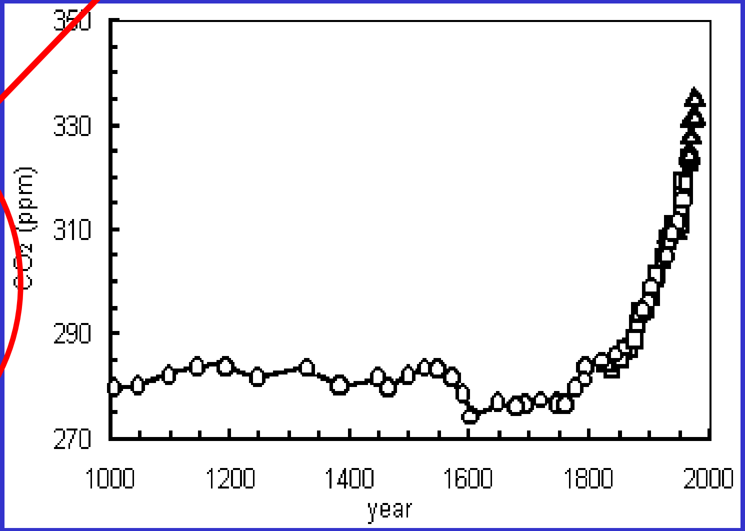
Past 1000 years



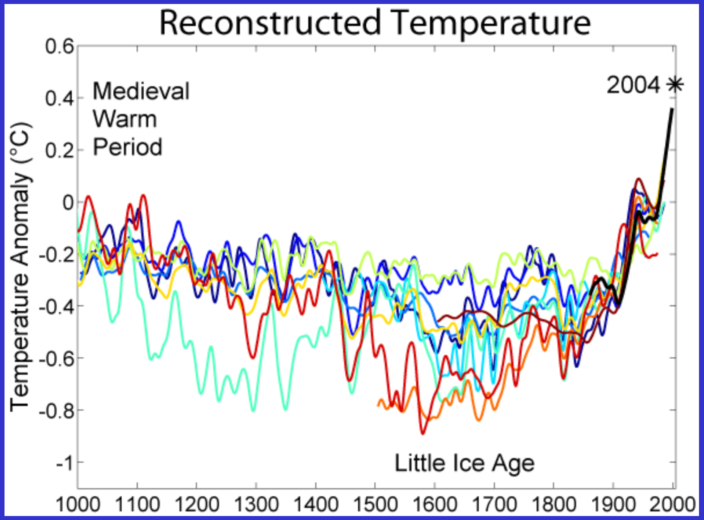


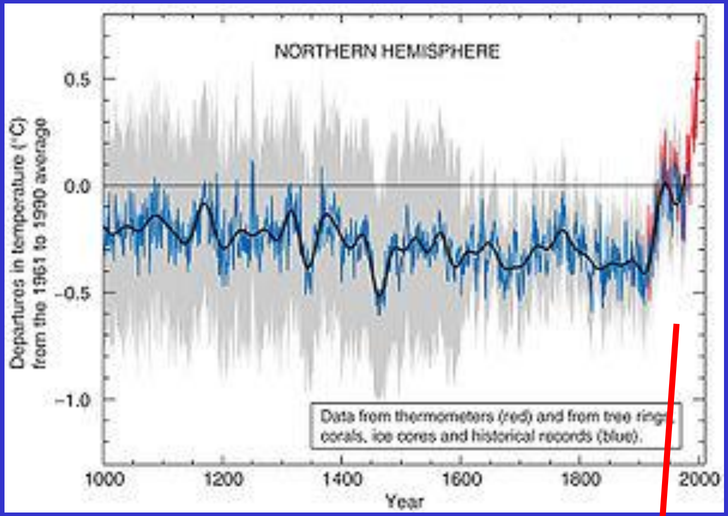
Past 2000 years

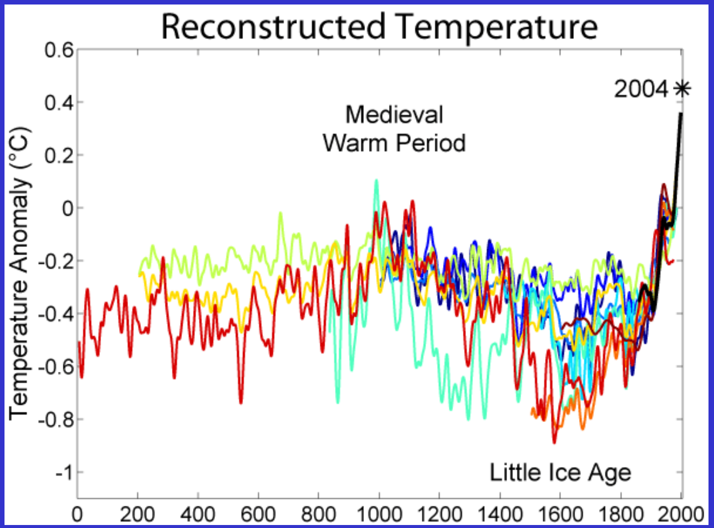


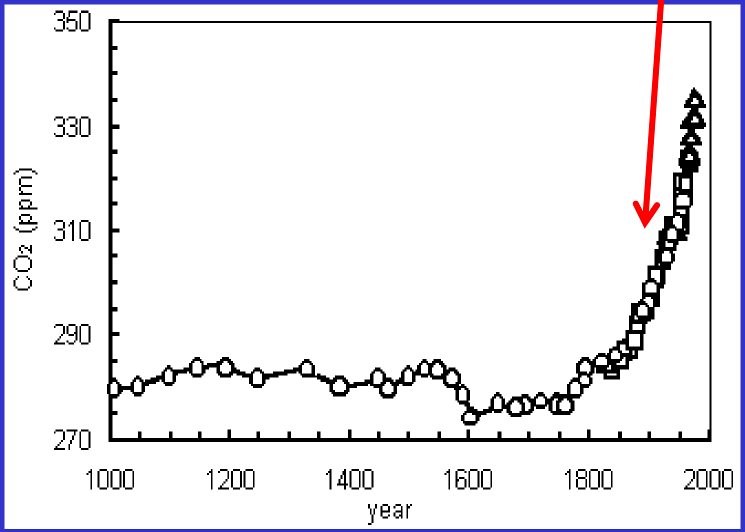


It also shows that climate took a dramatic turn from a slight cooling trend to a very rapid warming trend precisely at the time that human emissions of CO_2 starting increasing. Coincidence? Probably not.

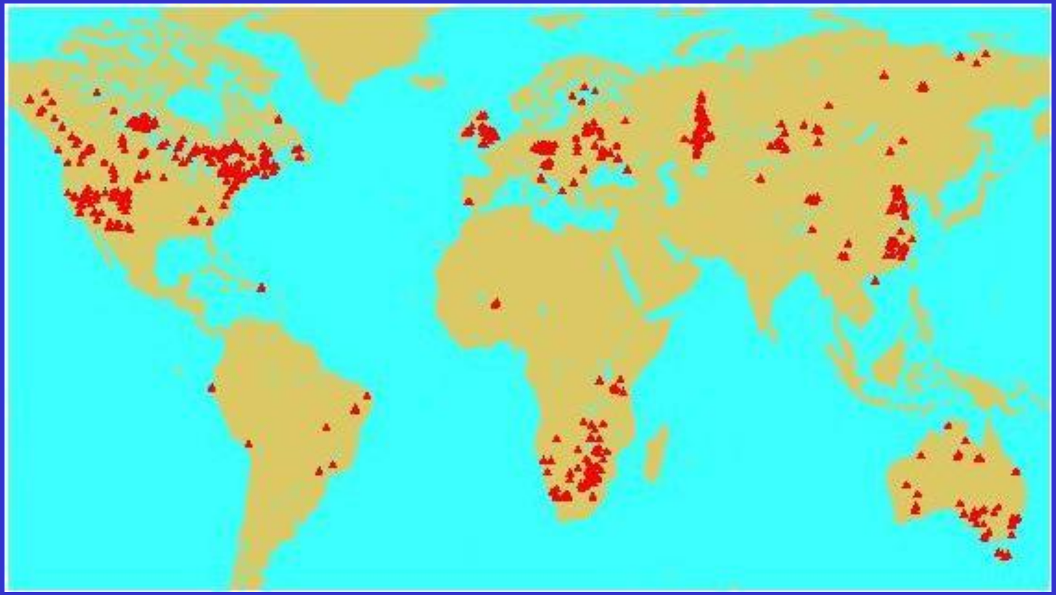


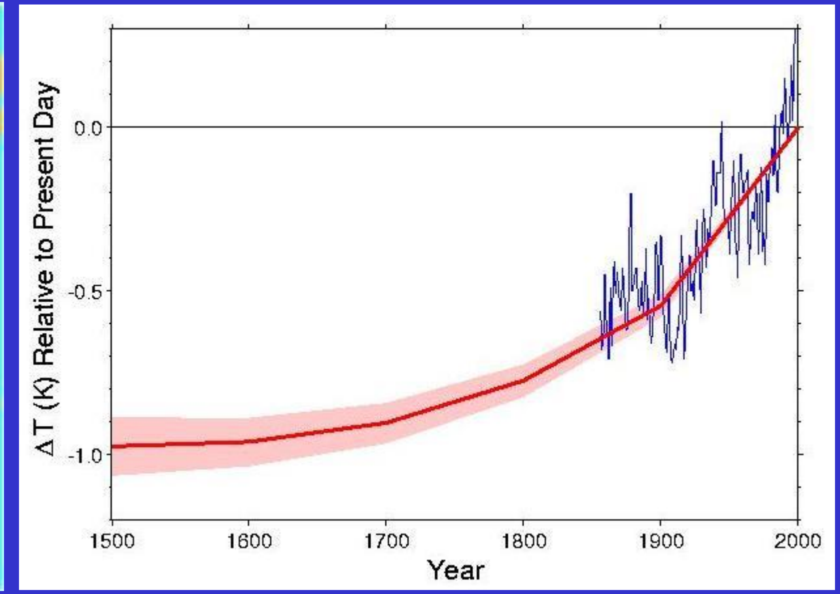






We now have actual temperature data going back 500+ years that show current temperatures are ~1.5 ^{o}C above values 500 years ago. These data come from holes dug deep in the ground where it takes many centuries for temperatures to equilibrate with the surface. Thus, by digging deep in the ground, scientists can probe historical temperatures (red line below – blue line represents surface thermometer records, or Figure 1-4 and)

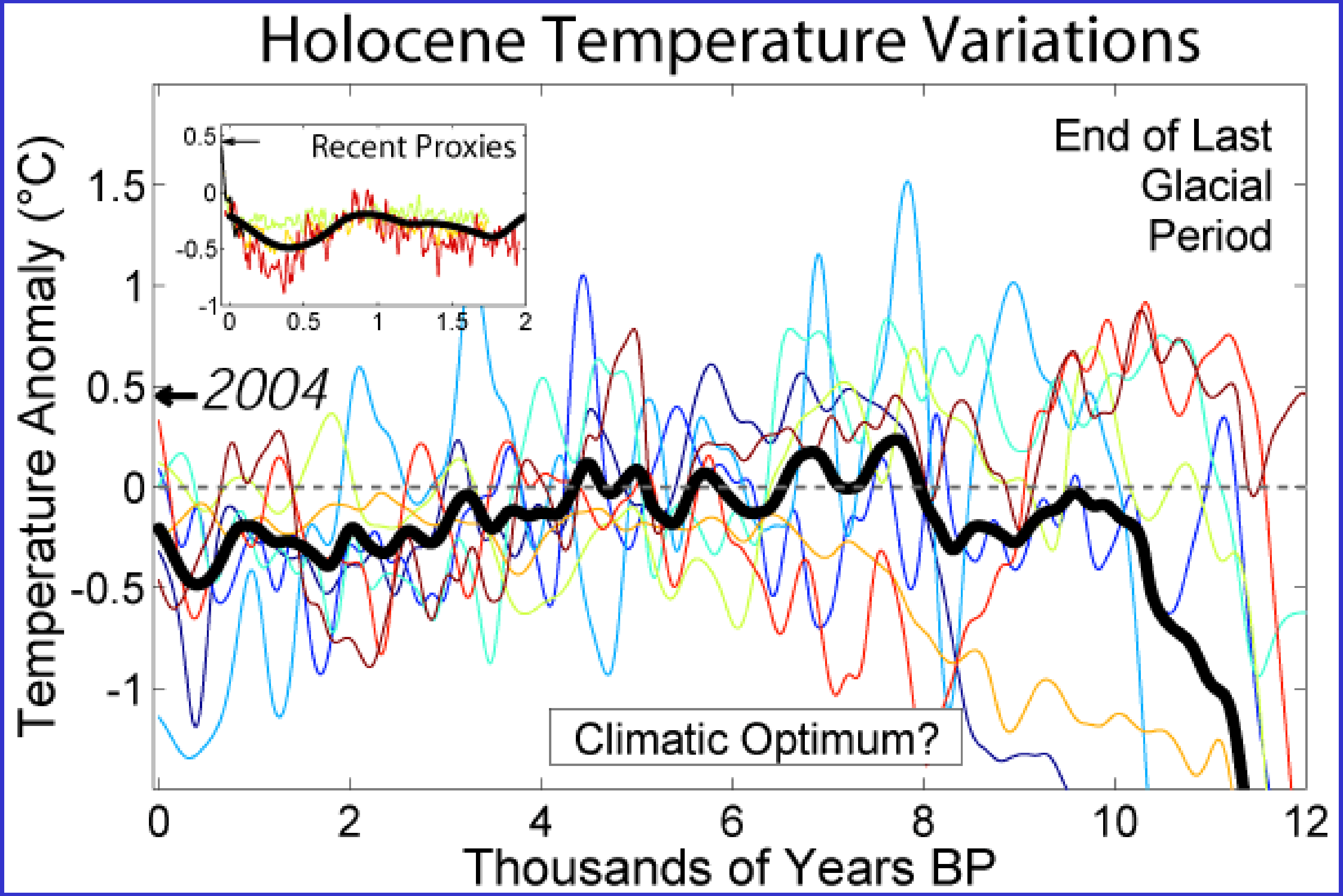




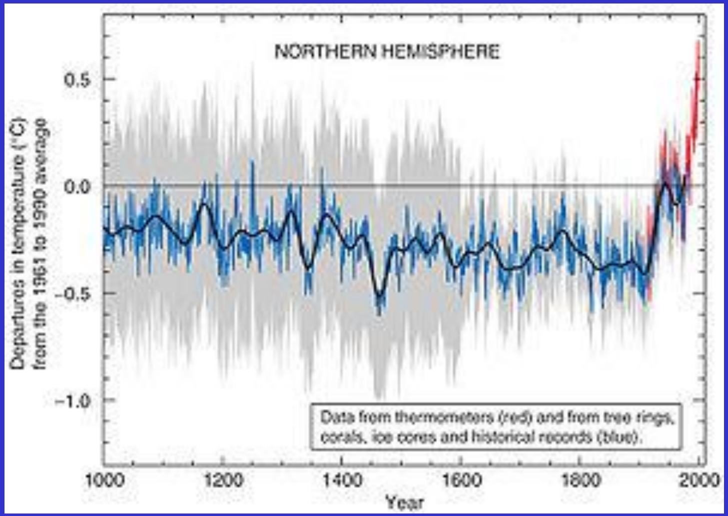
Locations of bore holes

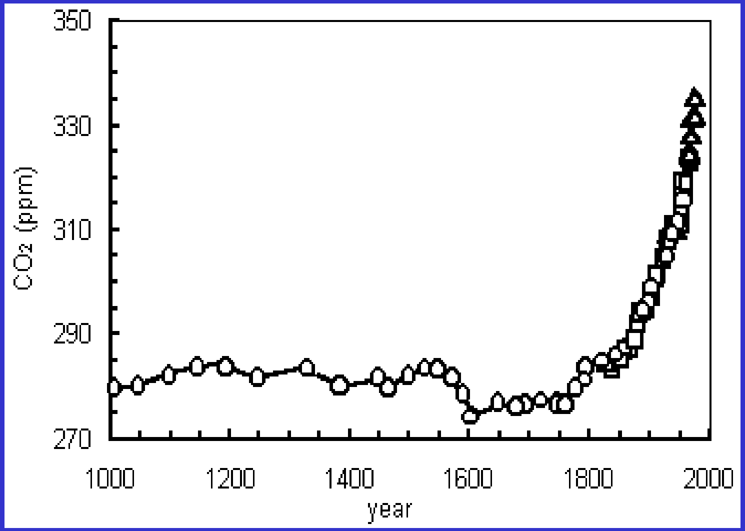
Temperature record

Here is what the proxies tell us going back 10-12,000 years – the Holocene Temperature record. The black line represents the average of the records, whereas the individual methods have more variability.



Back to our temperature/CO_2 records.





We note that global mean temperatures today are about 1 ºC higher than in the 1800s. Ice core records show that CO_2 abundances are about 100 parts per million higher today (380-390 ppm) compared to pre-industrial times. A correlation between two variables doesn't necessarily mean there is a cause-effect relationship.

But let's go back to Chapter 1 and look at the correlation between CO_2 and temperature over the past 400,000 years.

This simple comparison illustrates the importance of positive feedbacks in amplifying the climate warming due to changes in CO_2 that we discussed before the Fall Break. CO_2 changes alone cannot explain the differences between glacial and interglacial temperatures. Changes in Earth's albedo due to the changes in the ice sheet in the northern hemisphere are extremely important.

How does this compare to today? The only great ice sheet left in the NH is Greenland, and it's too small to make a large difference in Earth's albedo. Therefore, temperatures do not increase as much for a given change in CO_2. But ice-albedo feedbacks do have a disproportionately large impact on the high latitudes, where temperature changes over the past 20-30 years have been 3-4 times larger than the world's average.

So we know that temperatures today are warmer than they have been in ~150 years based on actual measurements of temperature.

Proxy records tell us that this is also true for the past 1000-2000 years.

Ice core data (water vapor isotopes) tell us that this is also true for the past 100,000 years.

We also know that climate tends to be unstable when cold, but much more stable when warm. Is this due to the influence of oceanic circulation? Probably, but scientists are still vigorously studying this – the implications are major (e.g., tipping points?!)