

# Global Climate Change: Scales and Complexities



“Left” side of screen

“Right” side of screen

APRIL 9, 2007

**Living with Cancer**

The changing science



**Beyond Baghdad: Where The Enemy Has Its Own Surge**



**The Sopranos' Last Song: What Exit Will Tony Take?**

# TIME

SPECIAL DOUBLE ISSUE



## The Global Warming Survival Guide

51 Things You Can Do to Make a Difference

\$4.95US

15>



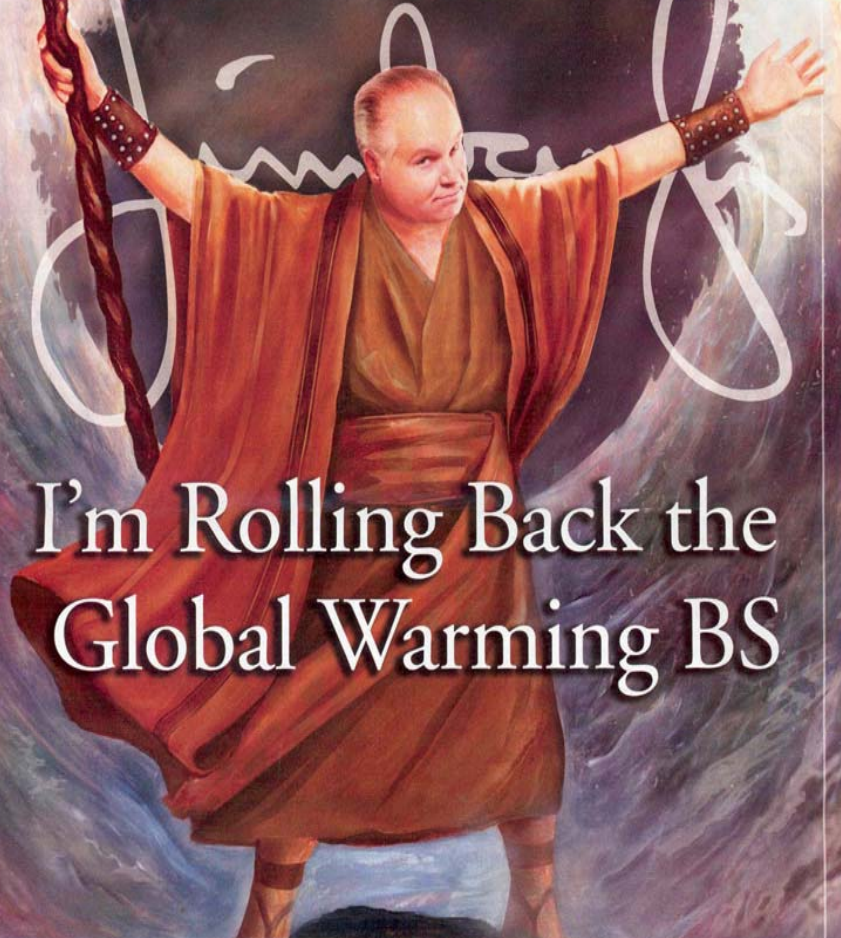
0 70989 10090 9

www.time.com

April 2007

Era of Limbaugh

### The Limbaugh Letter



## I'm Rolling Back the Global Warming BS

Subscription information and pricing details, including a price of \$354.

\$354



# Climate Change/Variability

☞ Earth's history (4.6 billion years) is filled with climate changes at all scales:

- warmer intervals, colder intervals
- changes in atmospheric composition
- intervals of different land, ocean, mountain distribution

☞ *Climatic variability* refers to fluctuations in the characteristic (expected!) elements-- mainly  $T_A$  and P





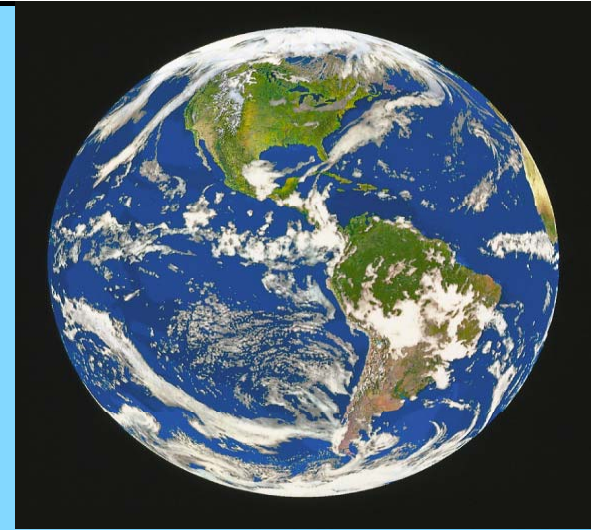
**HAVE YOU HUGGED  
A SKEPTIC TODAY?**

# MS Climate Controls:

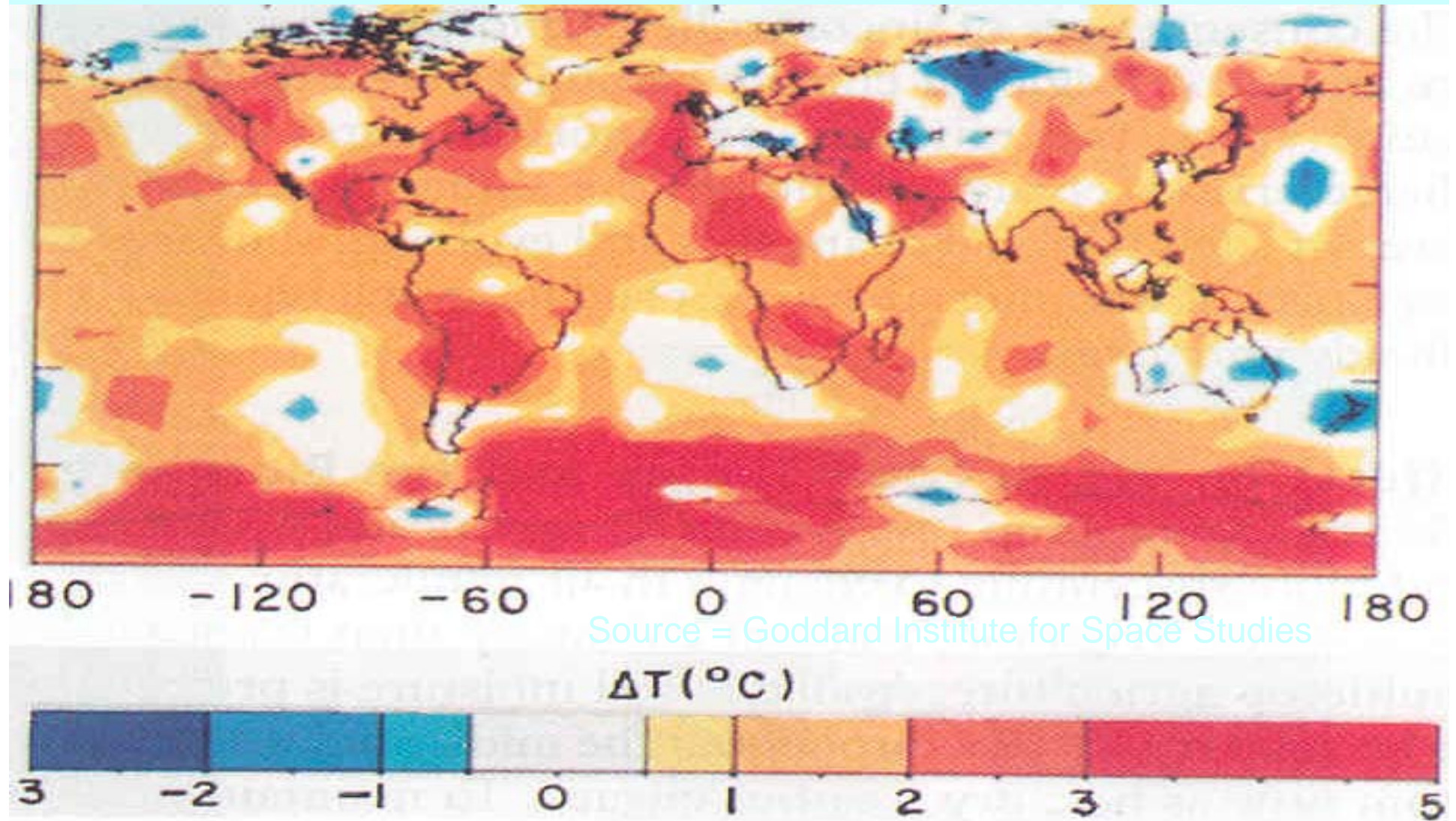
## ☞ Location

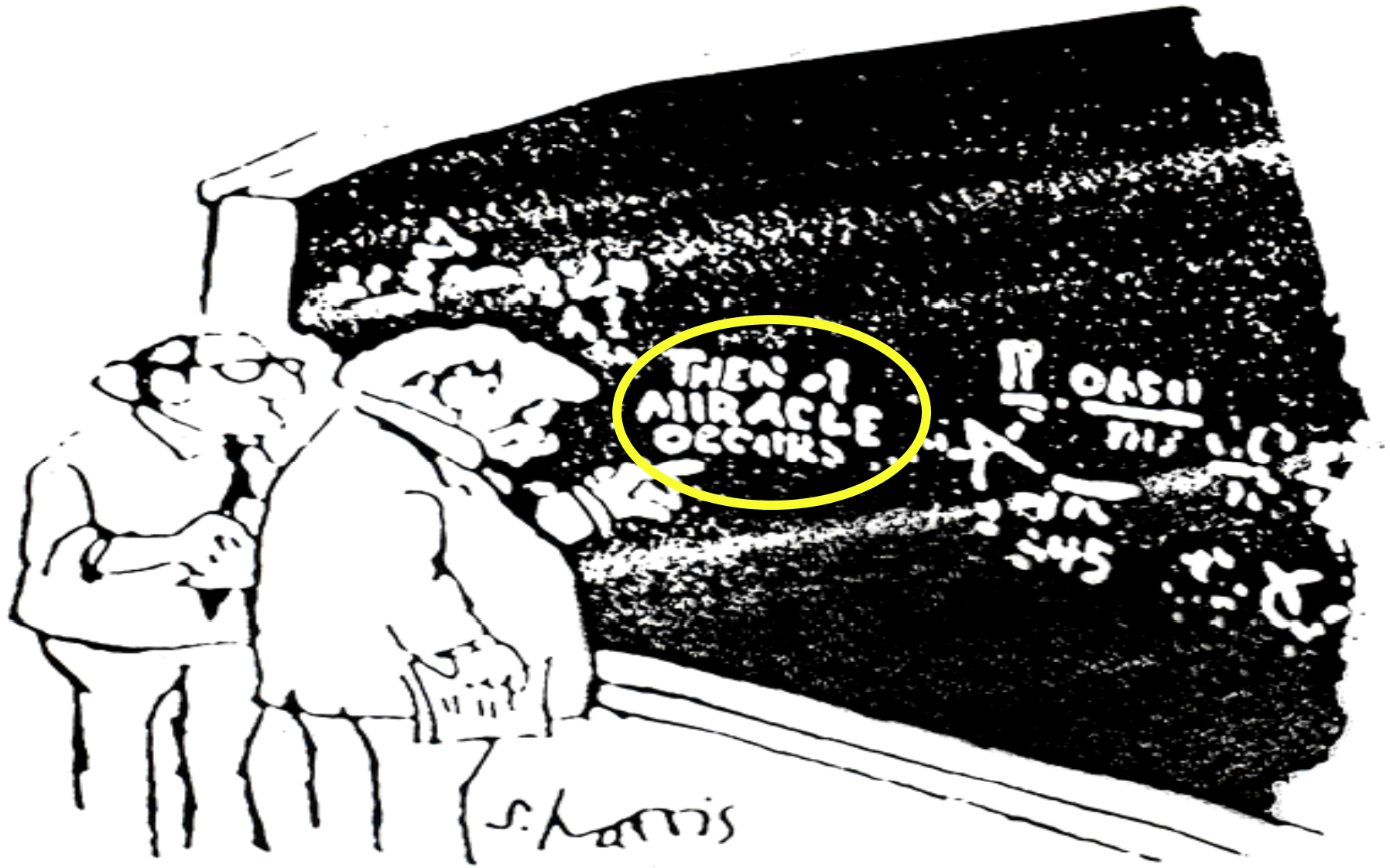
- Tropics to lower midlatitude
- Bermuda High
- Westerlies/trades
- Continent/Gulf of Mexico
- cP vs mT air masses
- Frontal passages, hurricanes, thunderstorms, tornadoes

☞ Result – humid subtropical climate (less than 8% of land surface)



**GCM forecast for July 2029 temp (mean change = +1.5°C) [notice geographic non-uniformity]**

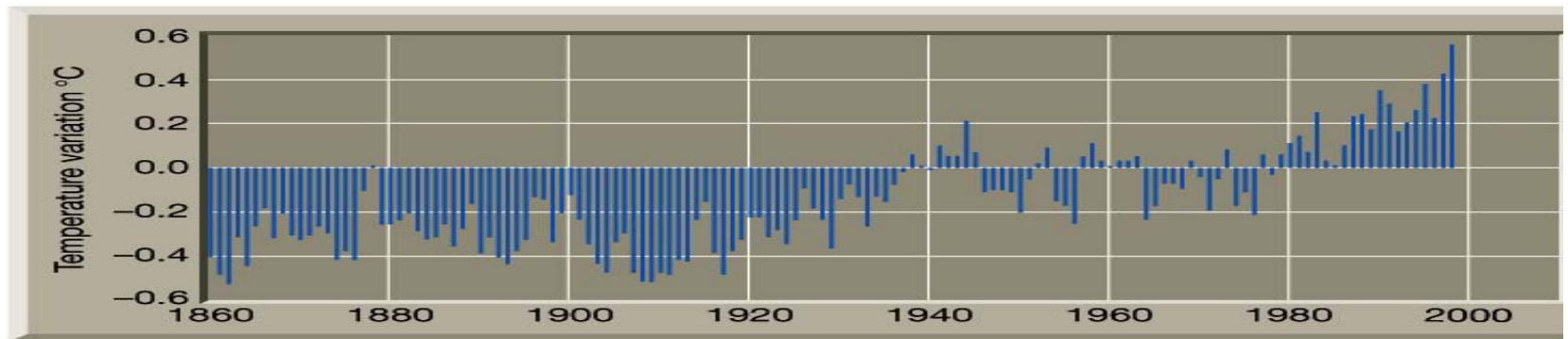
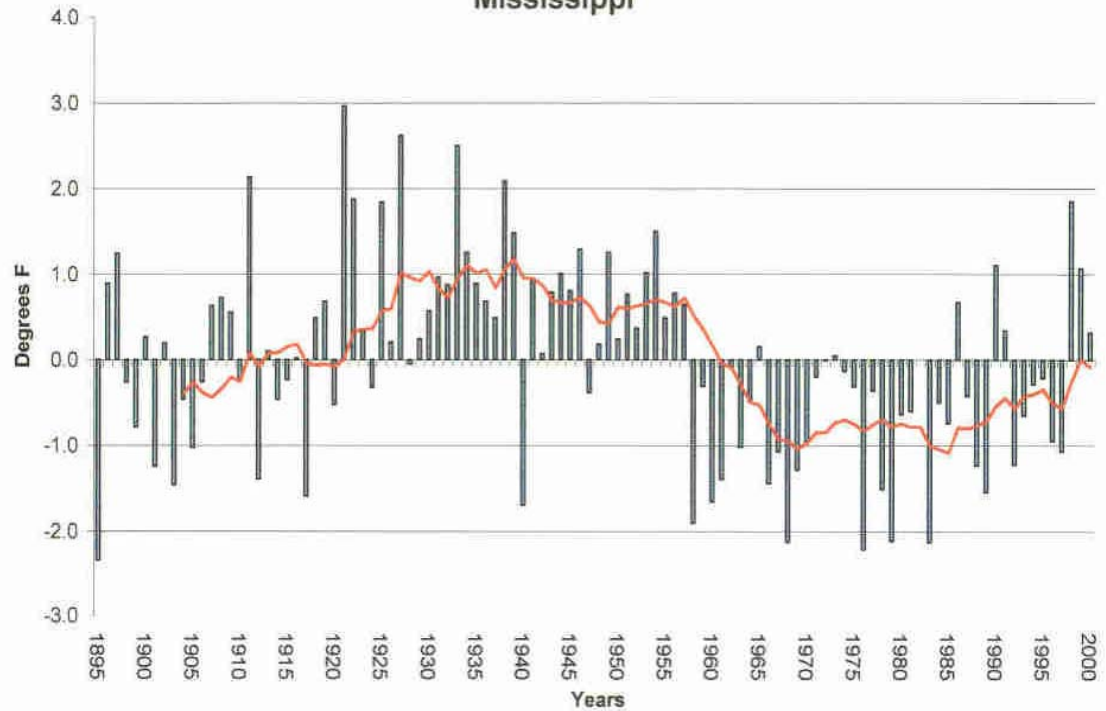




"I THINK YOU SHOULD BE MORE EXPLICIT  
HERE IN STEP TWO."

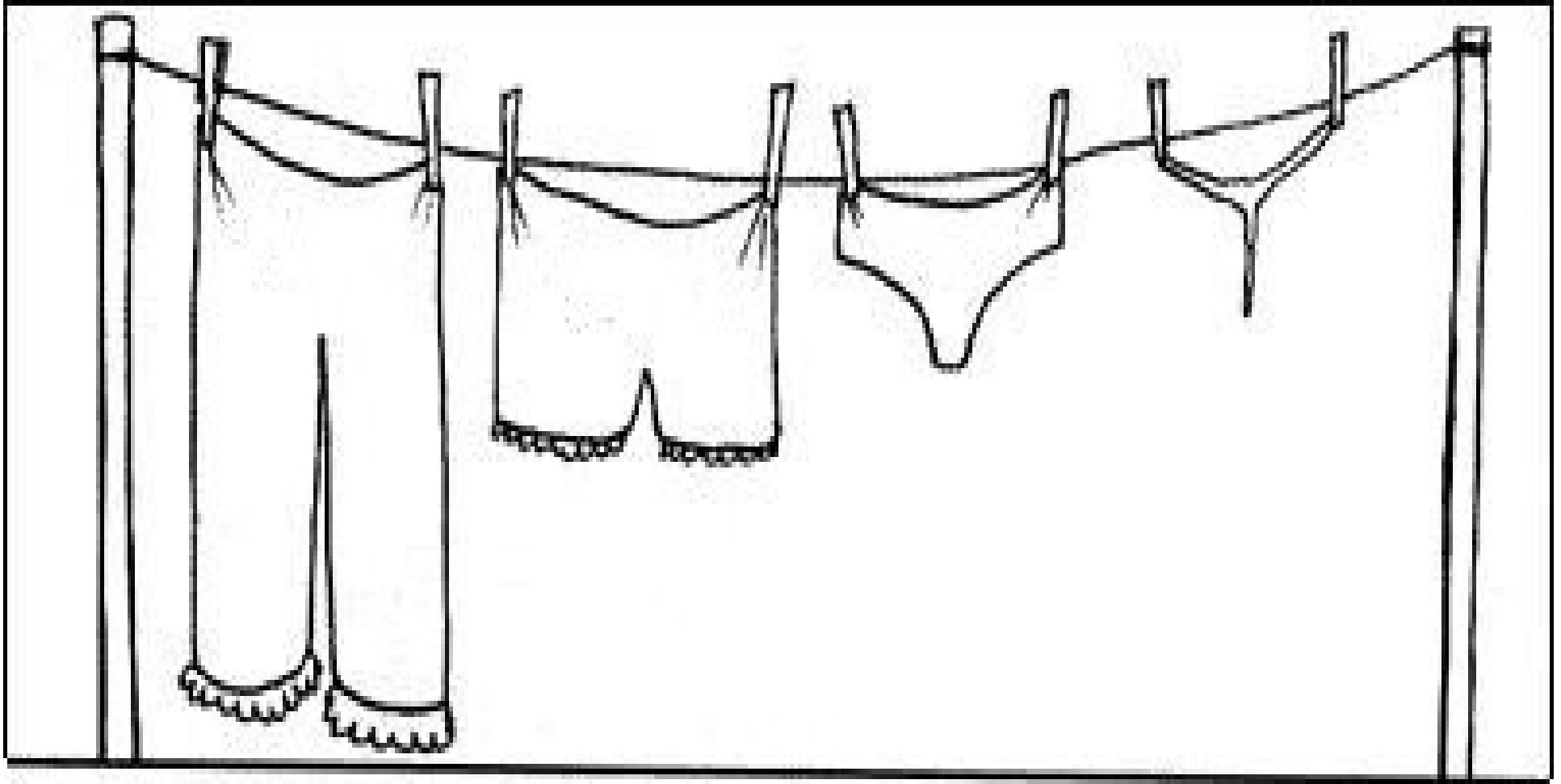
**Comparison:  
One state vs a  
hemisphere—  
geographic non-  
uniformity!!**

Statewide Annual Temperature Departure from Normal for  
Mississippi





# Proof of Global Warming!!



1920

1950

1980

2005

# What Is The Evidence for Past Global Changes in Climate?

- ☞ Instrument measurements--150 years at best
- ☞ Historical data--1000 years
- ☞ Proxy data:
  - Continental glaciation (landforms, etc.)
  - ice sheets: cores, isotope analysis, SL changes
  - sediments: lake/sea floor
  - fossils, pollen, tree rings
- ☞ These are used to reconstruct past climates



# What Are Possible Causes of Climate Changes on These Scales?

- Natural causes (in order of scale)
- Anthropogenic causes--CO<sub>2</sub>, O<sub>3</sub> ??



# Fox hunting



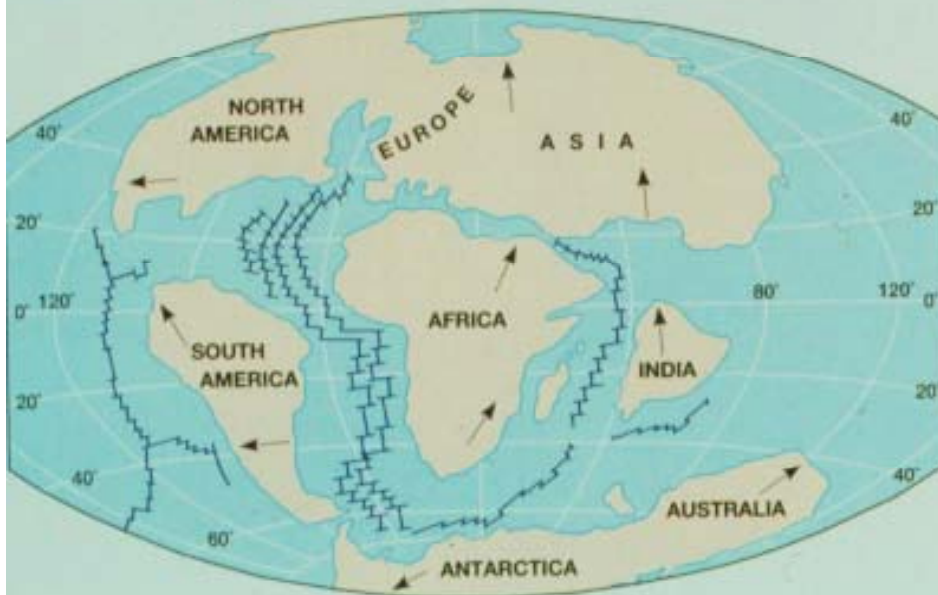
# Continental Drift



a) 225 million years before present



(b) 135 million years before present

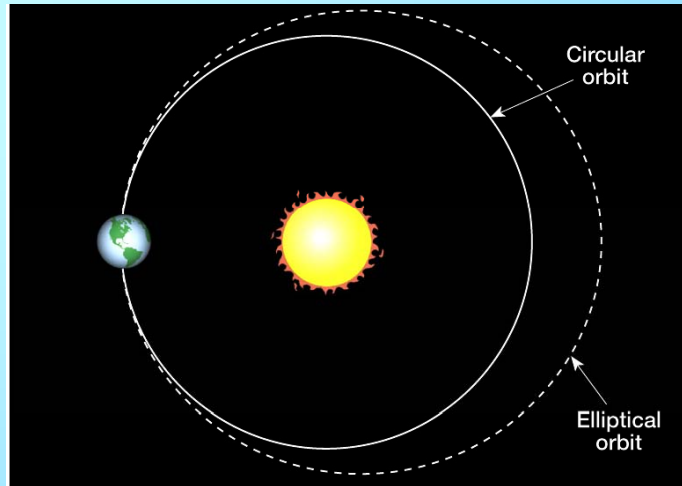


(c) 65 million years before present



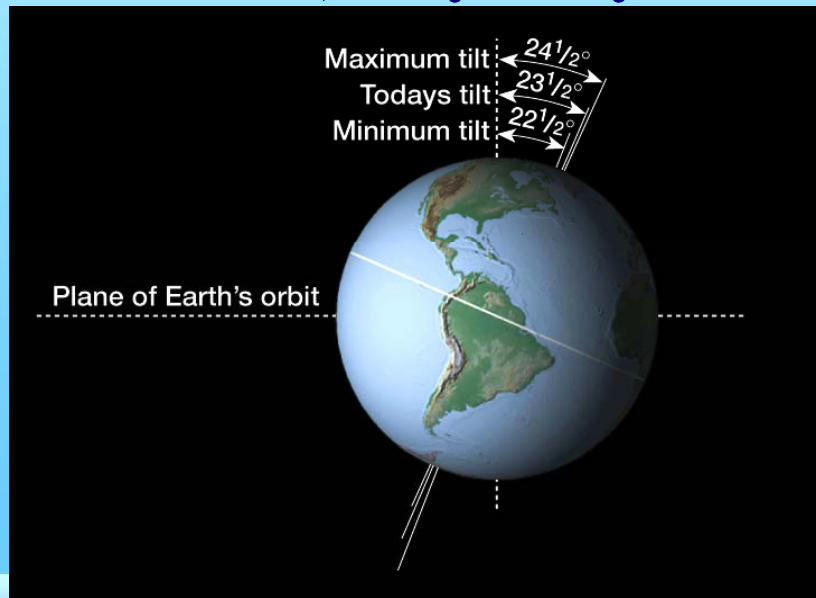
(d) Today

# Milankovitch Cycles: Orbital Eccentricities = Variations in Insolation??

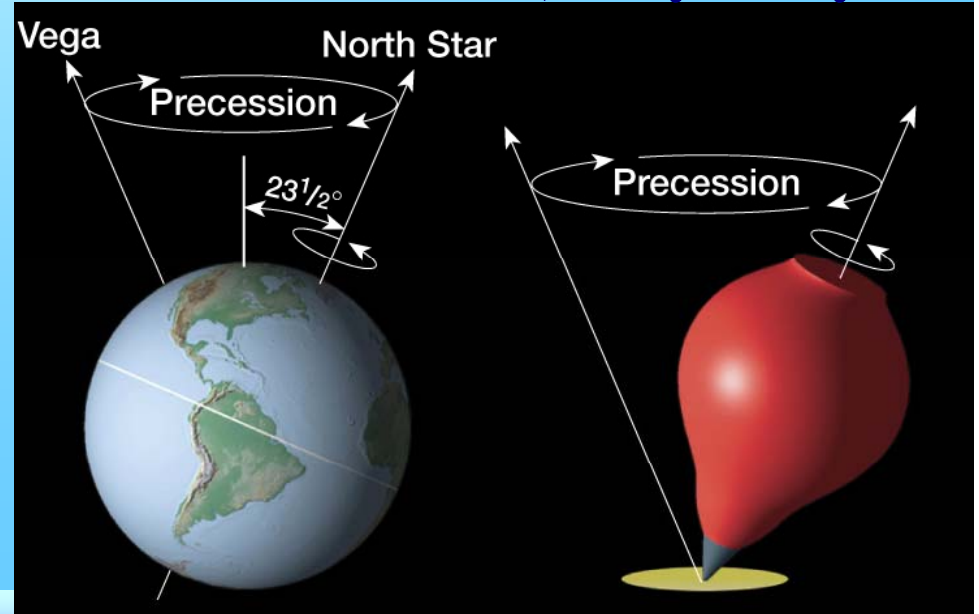


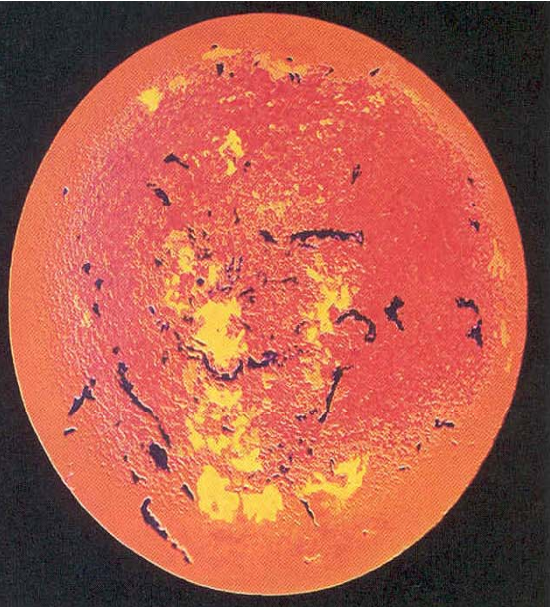
“Stretch”--100,000 year cycle

“Roll”--41,000 year cycle

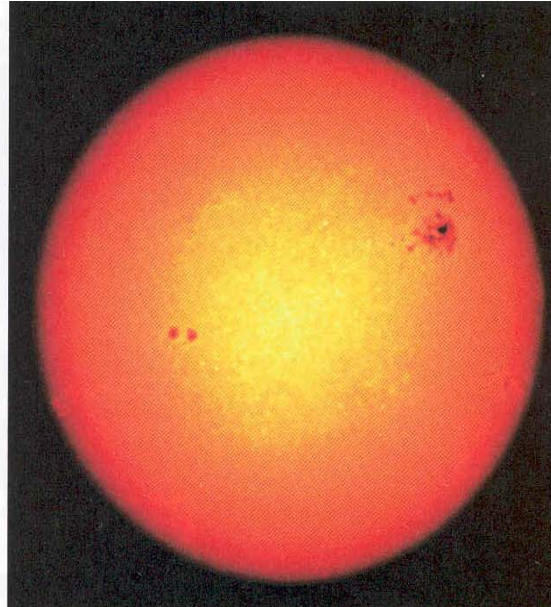


“Wobble”--26,000 year cycle





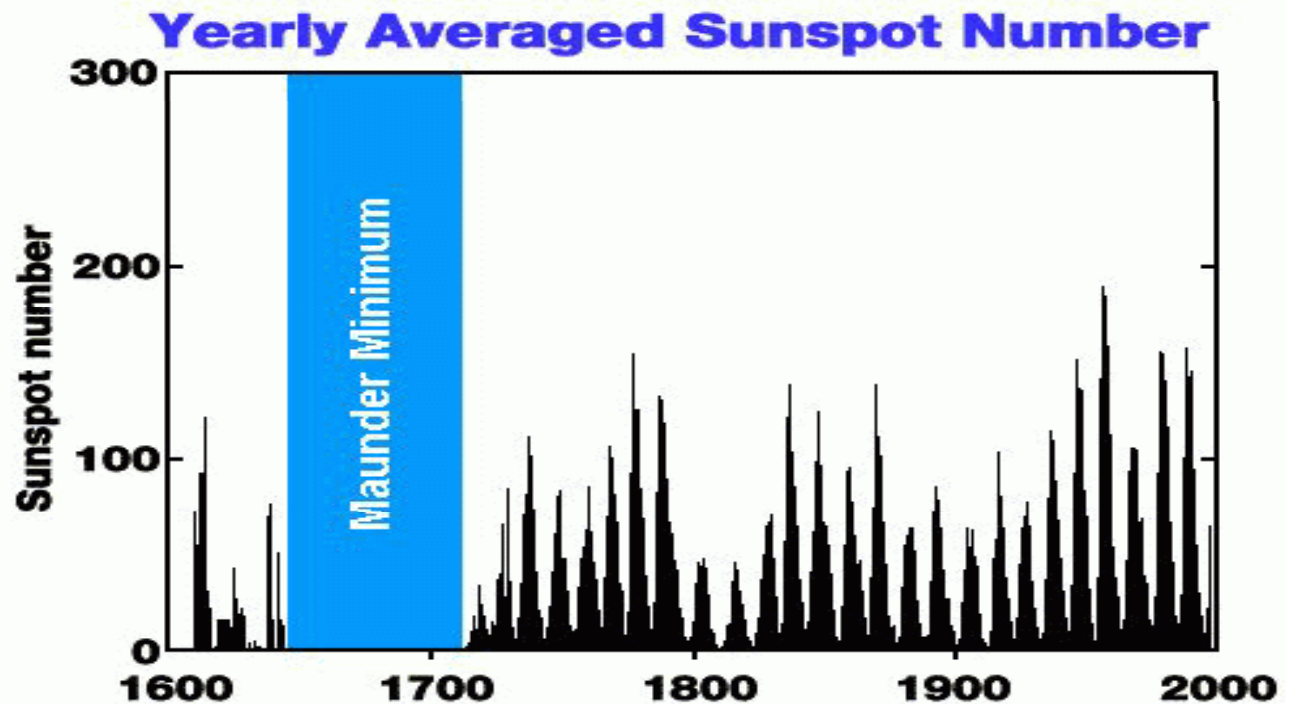
**Sunspot outbreak**

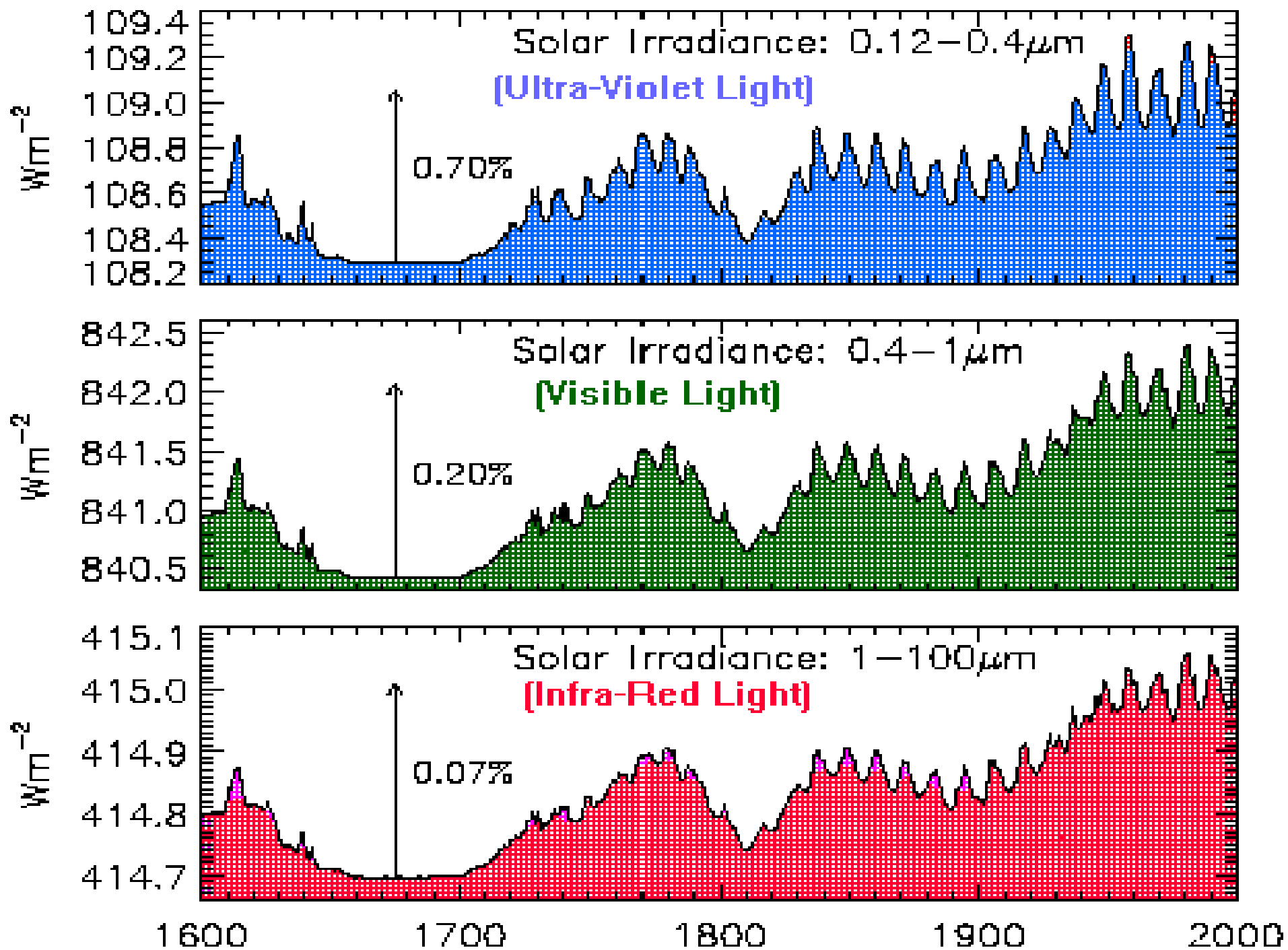


**normal**

## Sunspot activity

**Maunder Minimum: 1645-1715—less than one normal year's worth in a 70-yr period=coldest part of Little Ice Age**



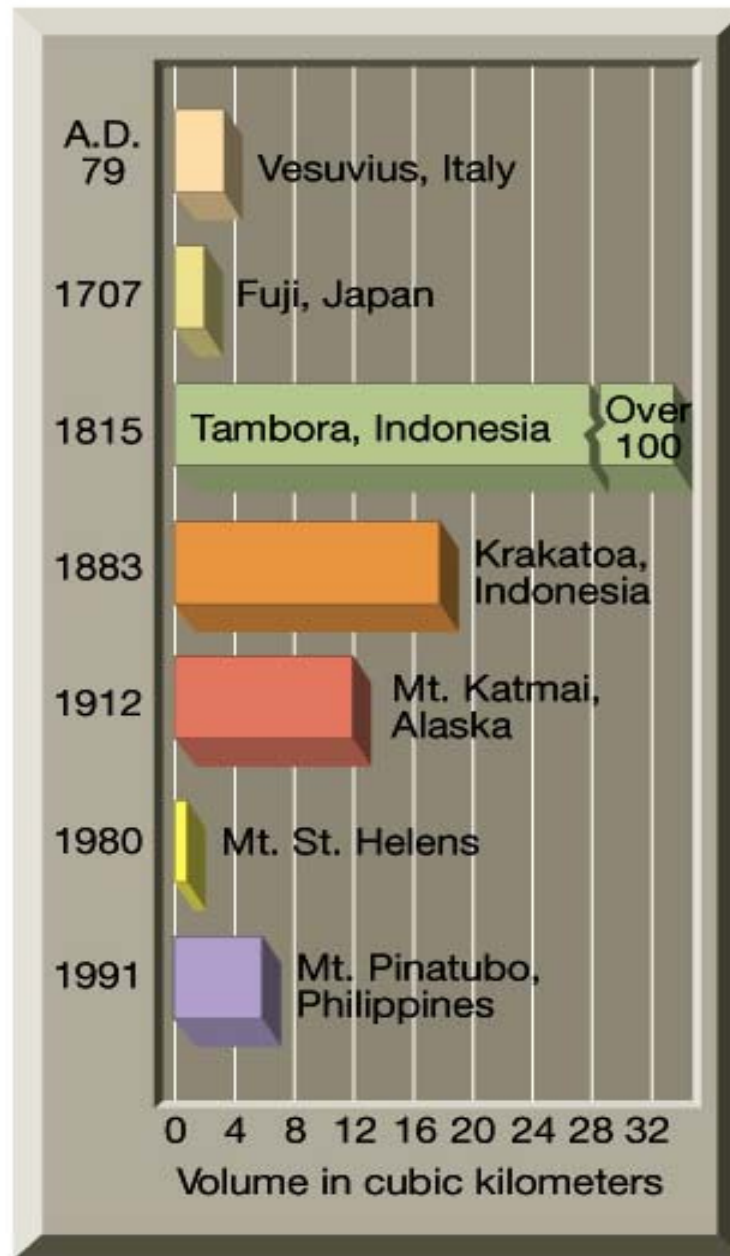




**Mount St. Helens Eruption--May 18, 1980  
(Volcanic Ash Blown into the Atmosphere)**

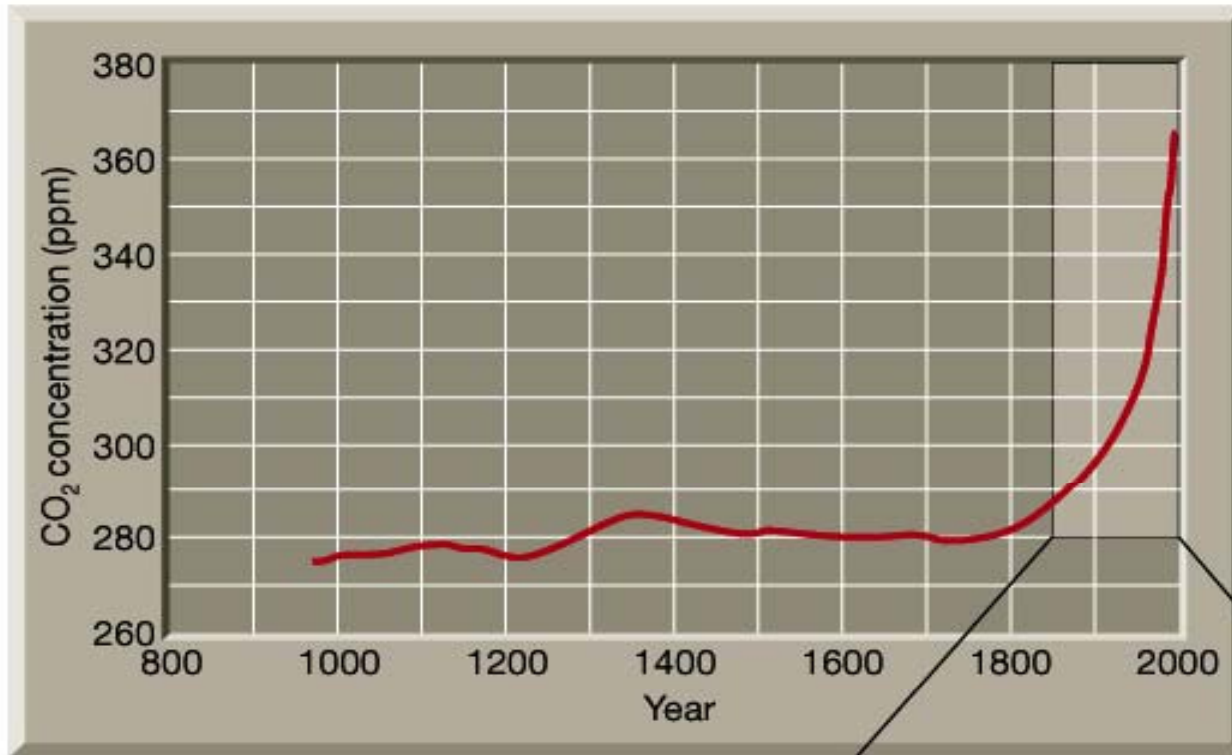


## Approximate volume of volcanic debris emitted during some well-known eruptions



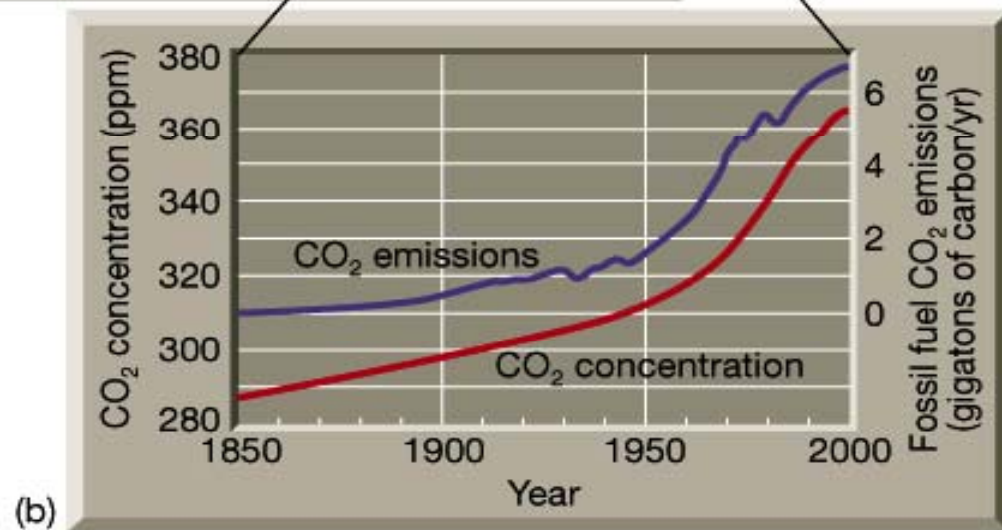
**Tambora ejected over 100 times more ash than did Mount St. Helens—  
1816=“year without a summer”**

# Carbon dioxide concentrations over the last 1000 years



(a)

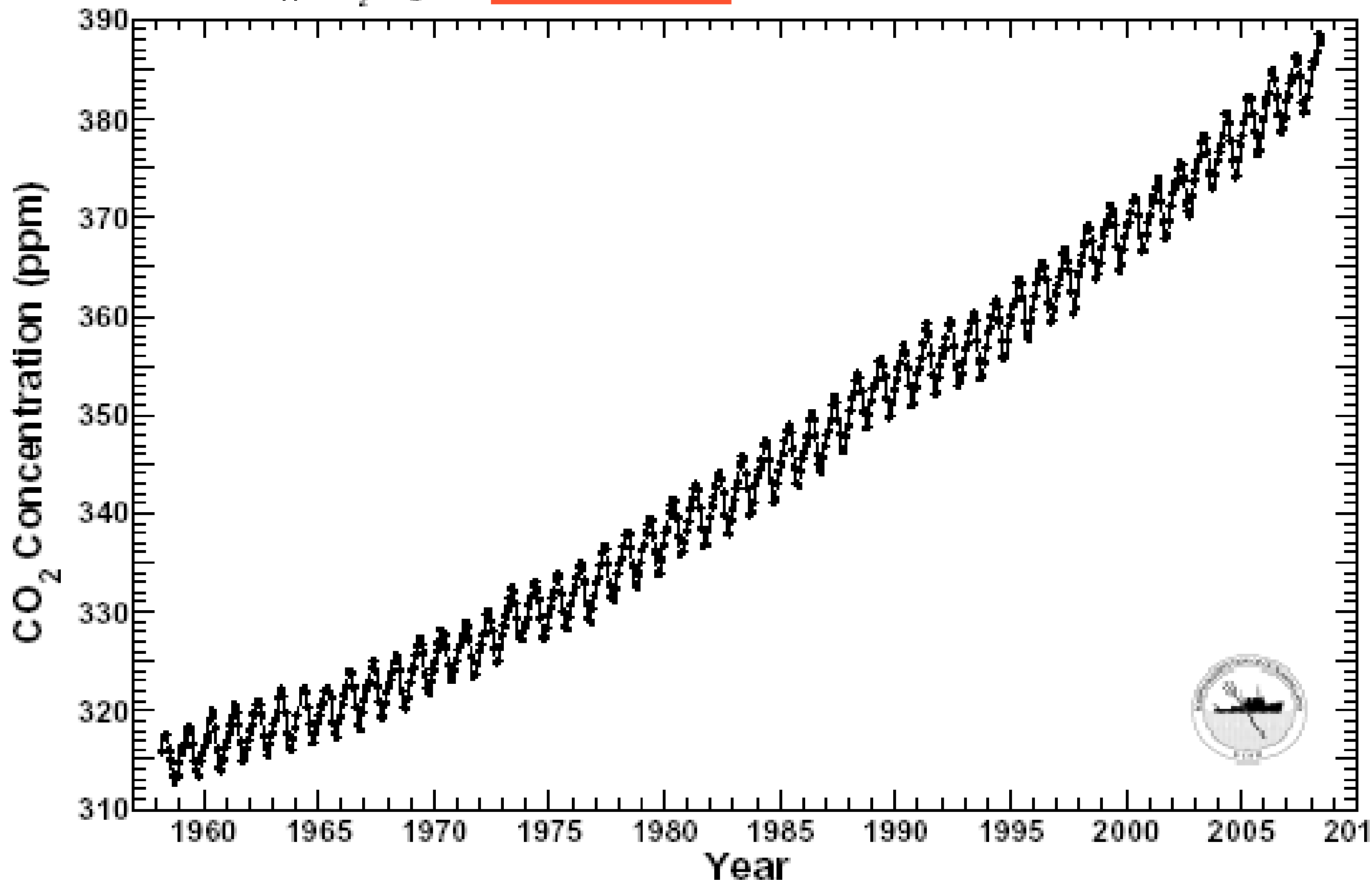
**Rapid increase since 1850 is tied to fossil fuel emissions**



(b)

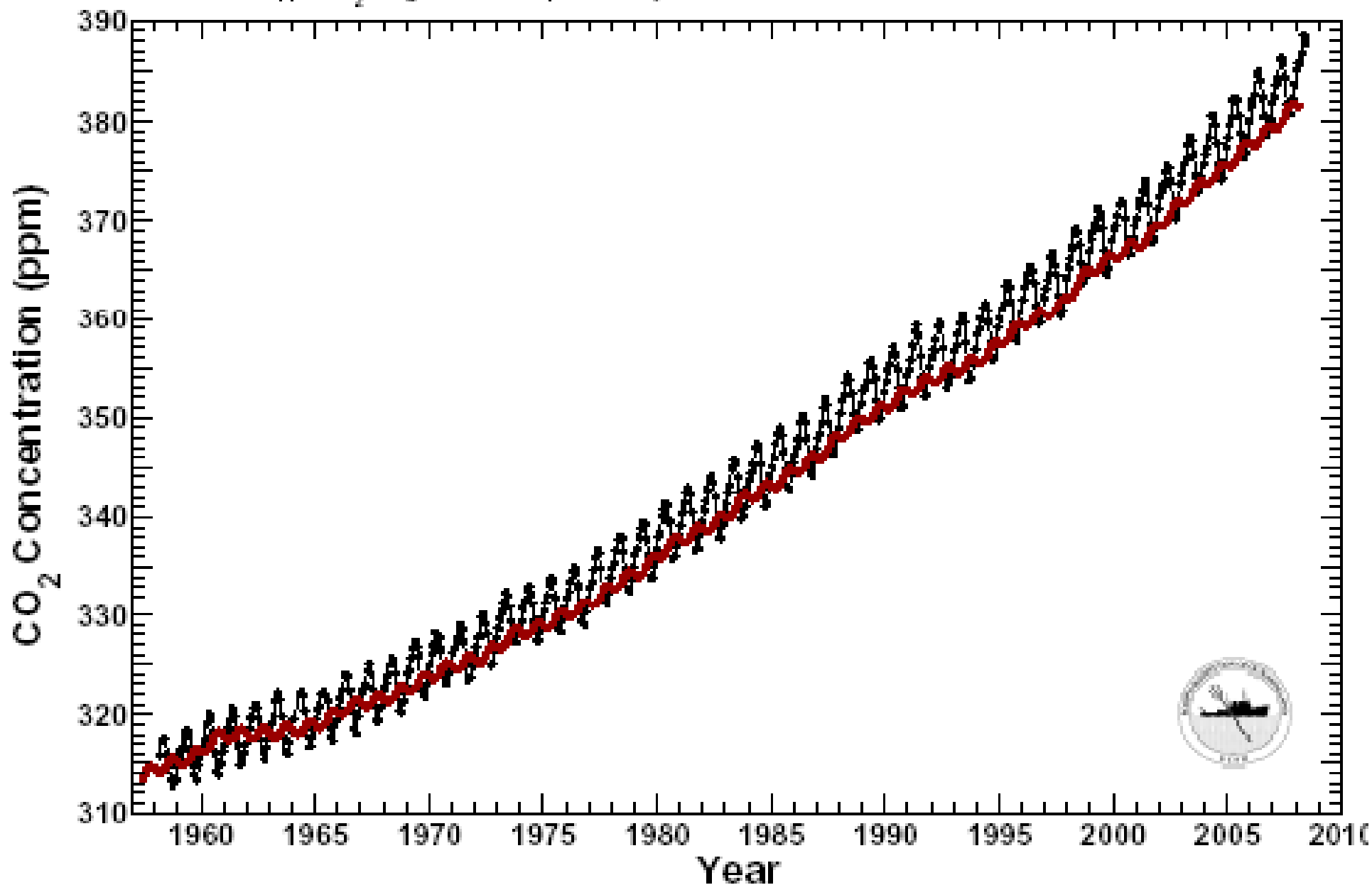
# Mauna Loa Observatory, Hawaii Monthly Average Carbon Dioxide Concentration

Data from Scripps CO<sub>2</sub> Program Last updated July 2008



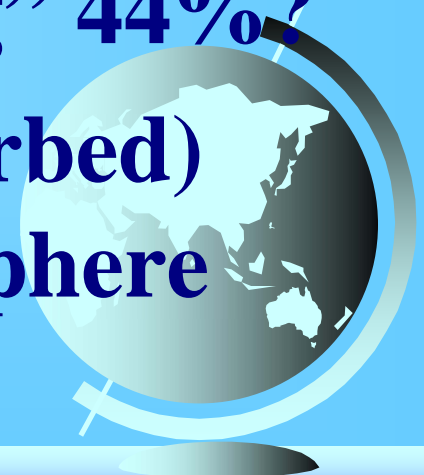
# Mauna Loa Observatory, Hawaii and South Pole, Antarctica Monthly Average Carbon Dioxide Concentration

Data from Scripps CO<sub>2</sub> Program Last updated July 2008



# **Calculate amount of CO<sub>2</sub> released by burning of fossil fuels since 1958 (260 b tons)**

- ☞ Emissions more than enough to cause the observed increases**
- ☞ But, measured rate of increase is 44% less than the total emissions**
- ☞ Puzzle—where is the “missing” 44%?**
- ☞ Answer—”mopped up” (absorbed) by oceans and terrestrial biosphere**



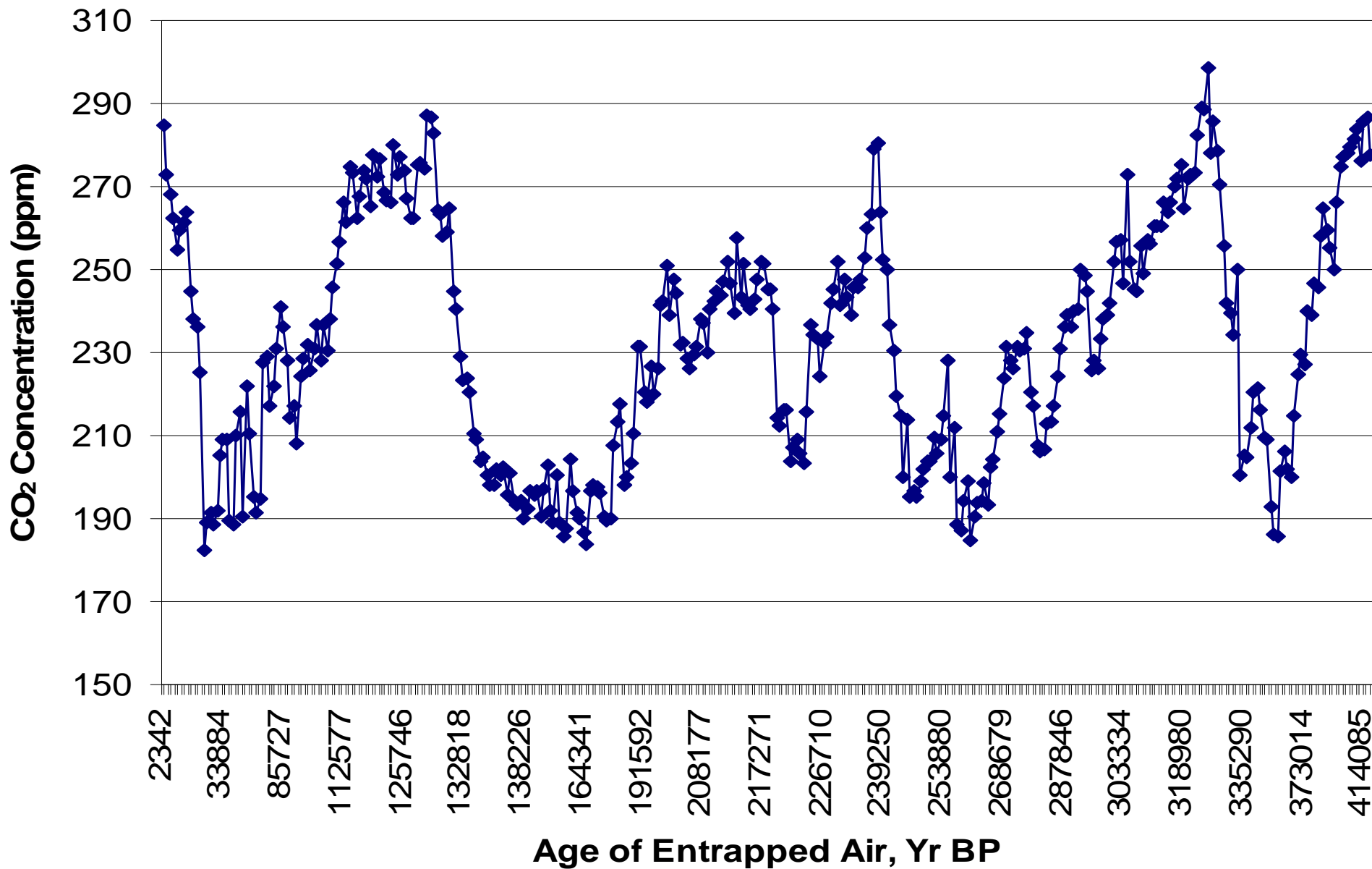


# The Balance of Nature



# Long-term Carbon Dioxide Atmospheric Concentration, Vostok Ice Sheet, Antarctica

400,000 years



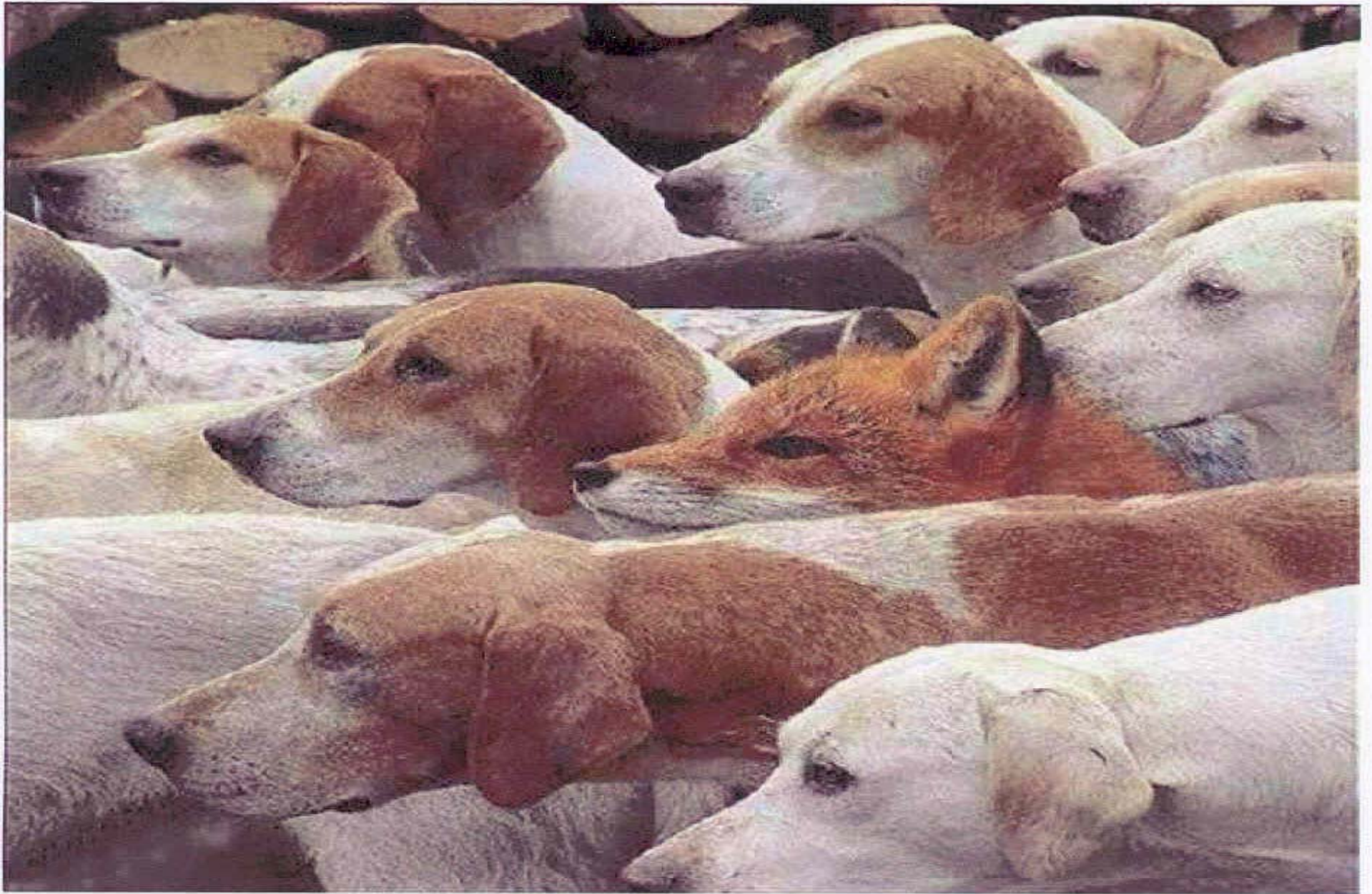


# Reconstruction of Past Climates

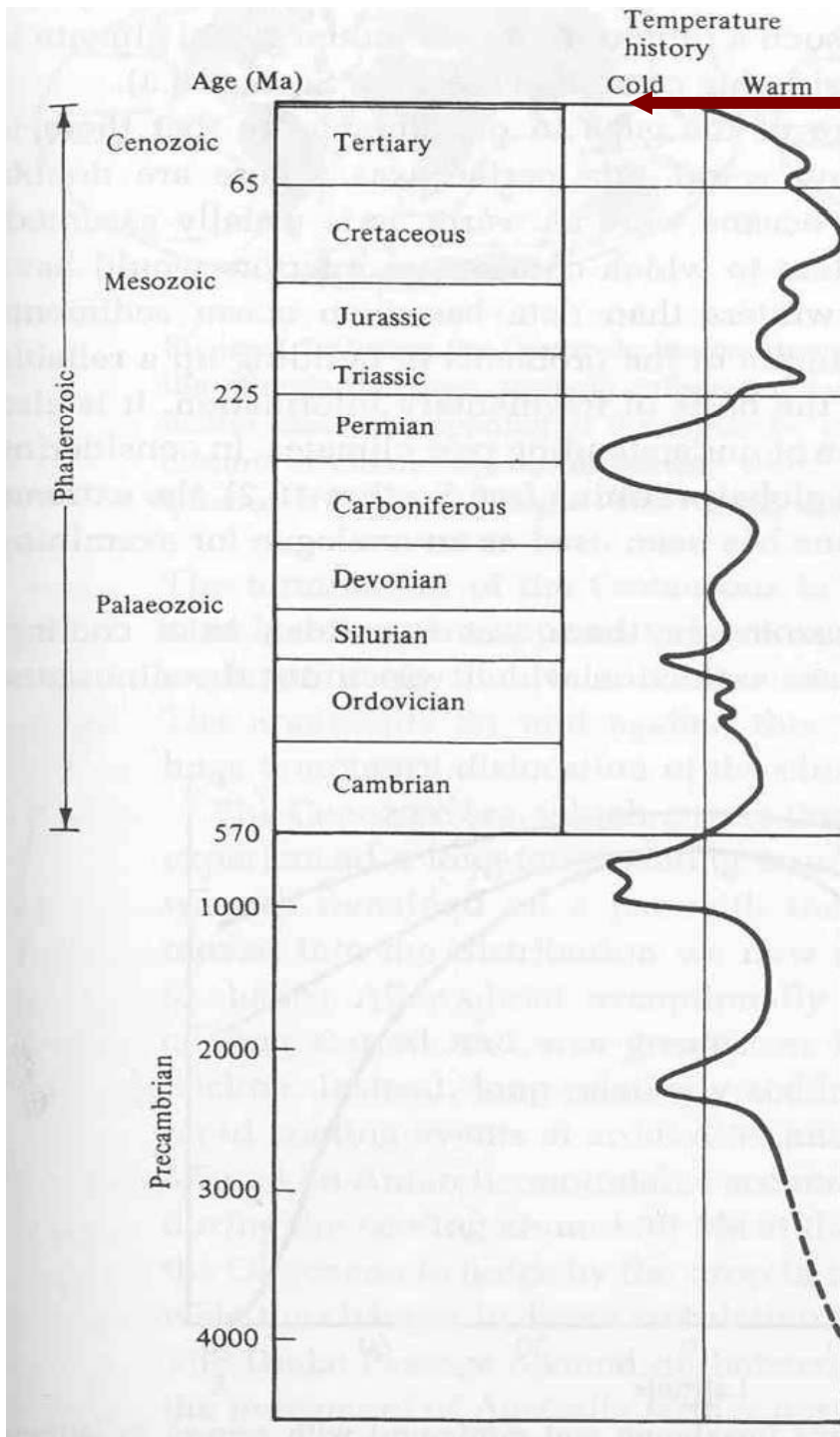
- ☞ Let's look at what is mostly accepted as the history of climate on earth
  - throughout geologic time
  - in historic times
  - in the most recent years
- ☞ Then look at causes of fluctuations we are experiencing today (measured!)







**When you are in deep trouble,  
say nothing, and try to look inconspicuous.**

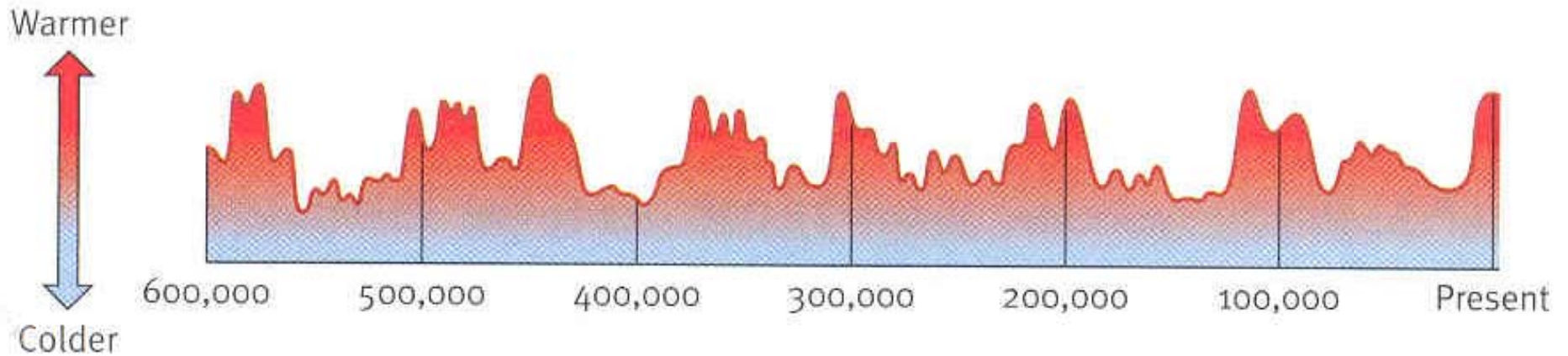


**Quaternary**

**Geologic  
perspective on  
climate  
change—4.5  
billion years**



# Last 600,000 years

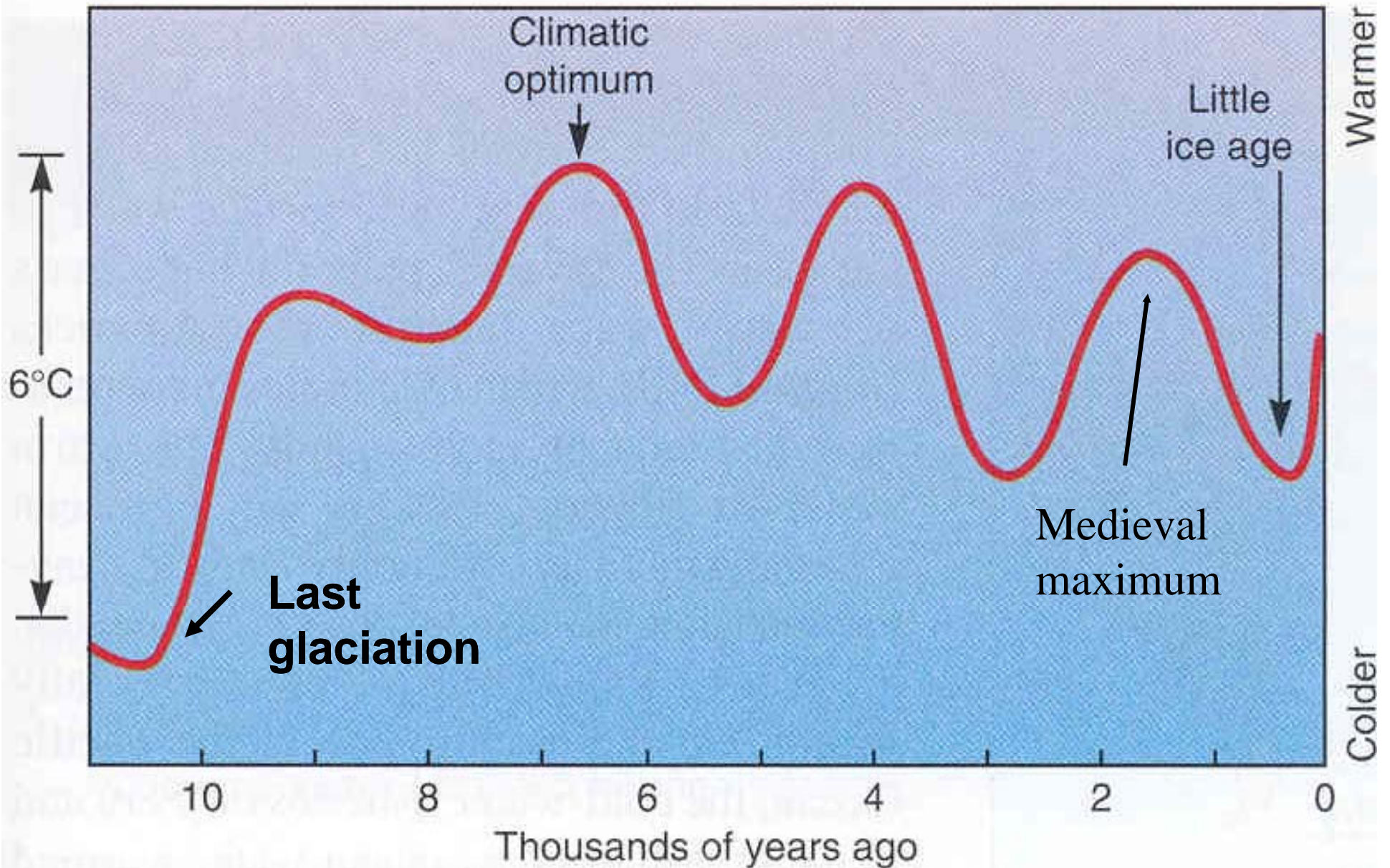


**100,000-year glaciations**

**10,000-year interglacials**

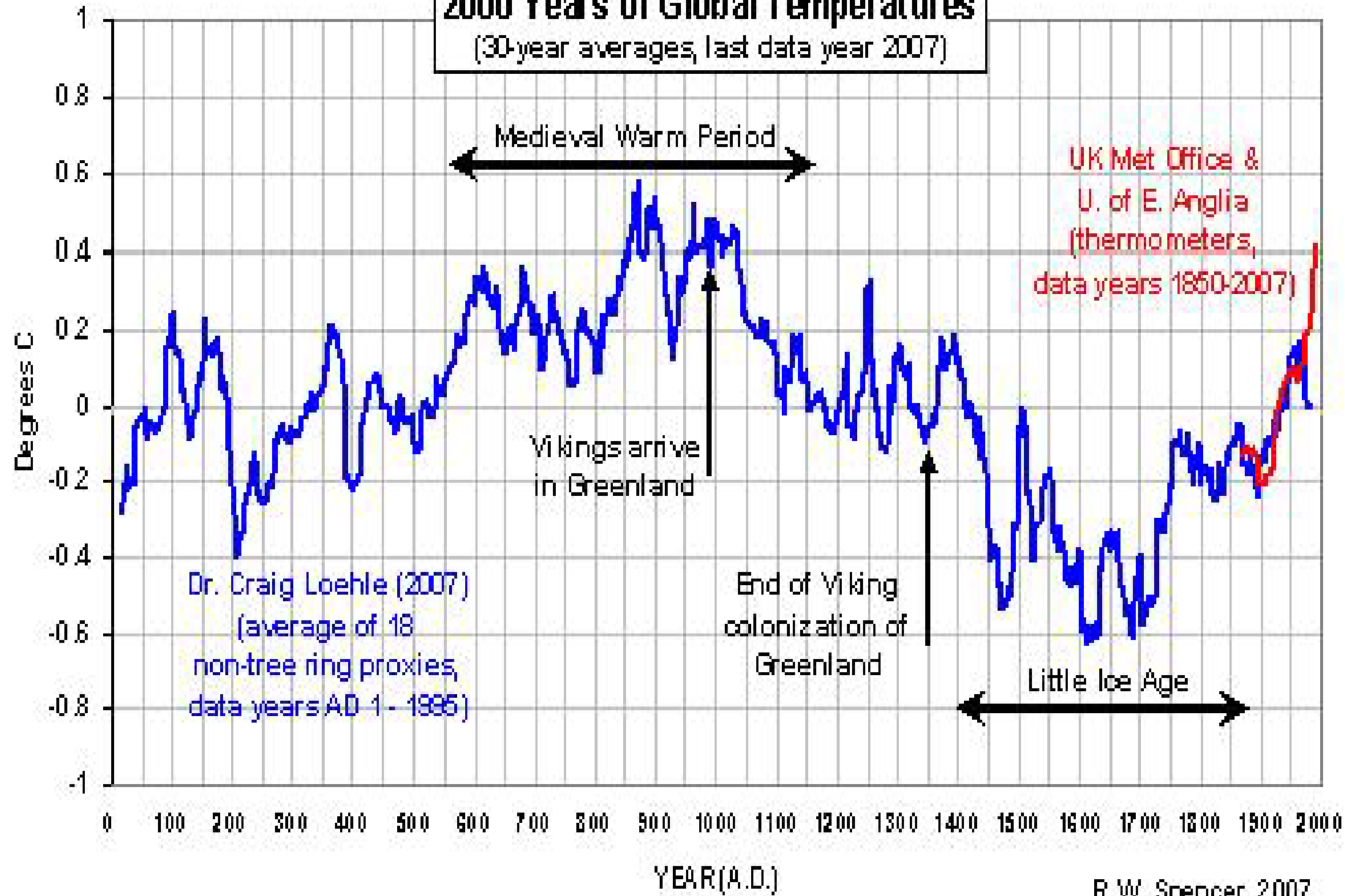


# Last 11,000 years



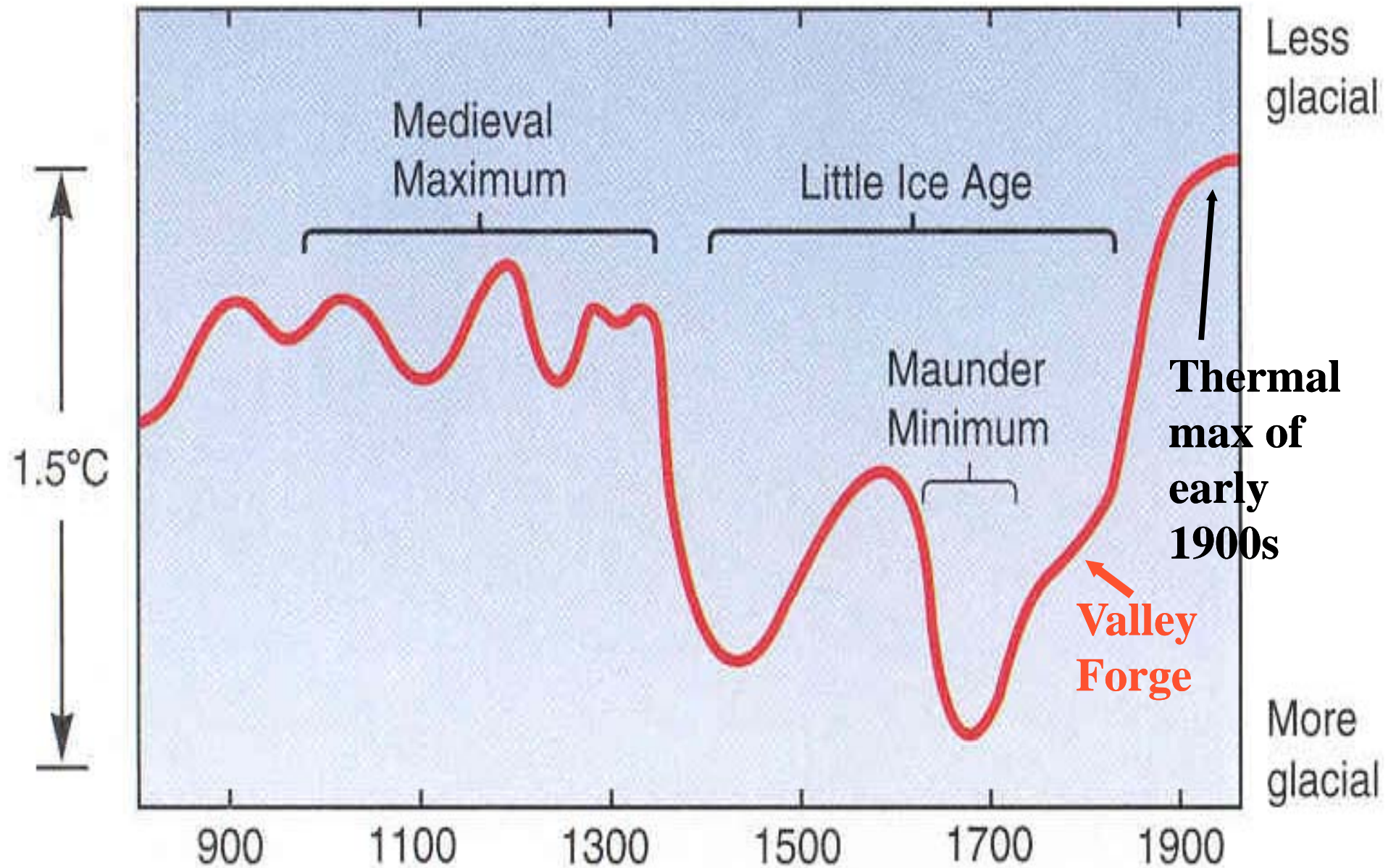
# 2000 Years of Global Temperatures

(30-year averages, last data year 2007)



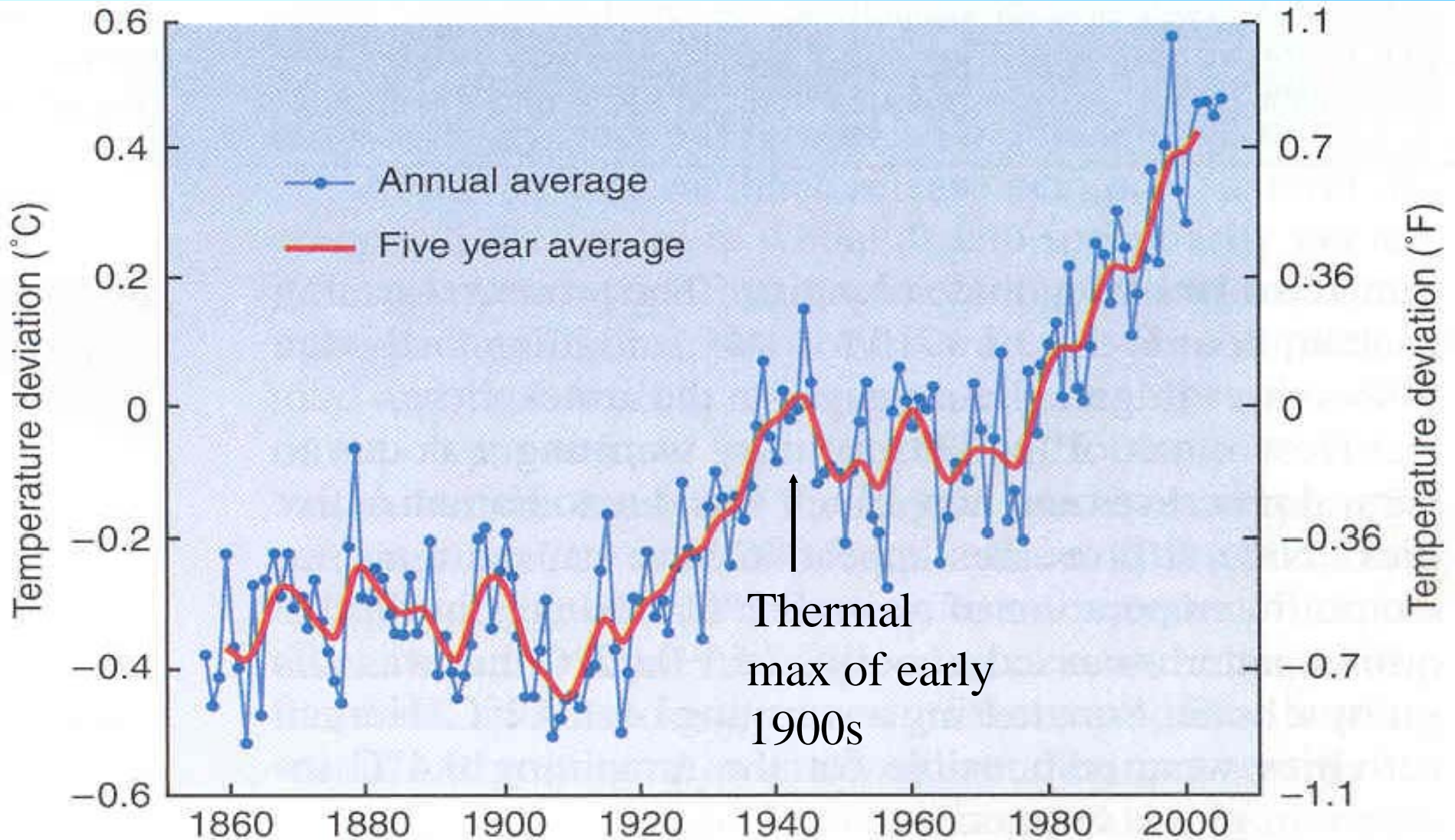
R. W. Spencer, 2007

# Historic records (1000 years)

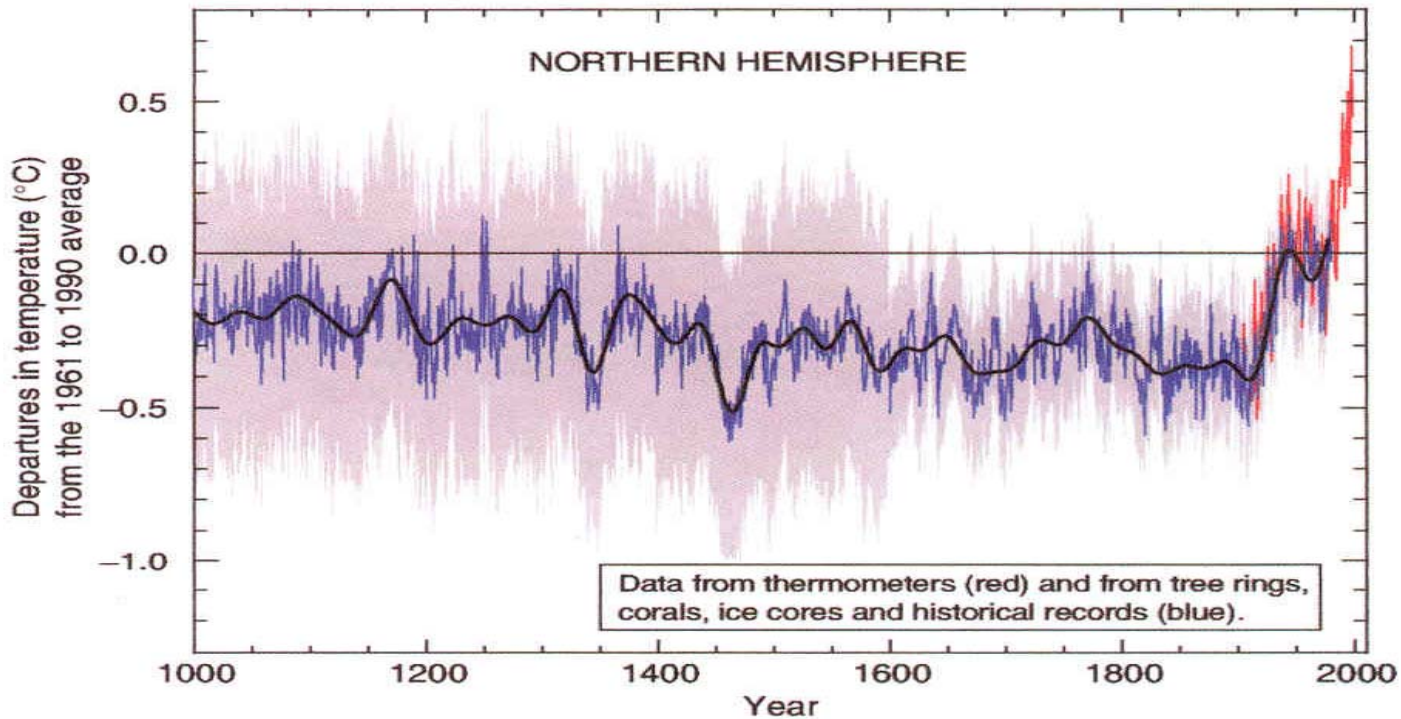




# Variation of Annual Mean Land Surface Temperature of the World, 1866-2005 (departures from 1951-80 mean)



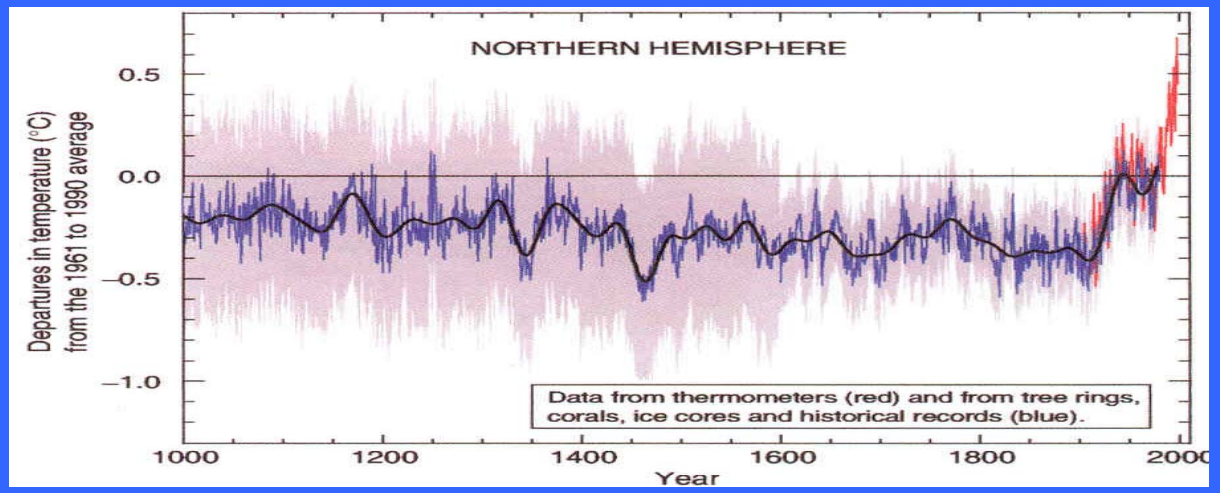
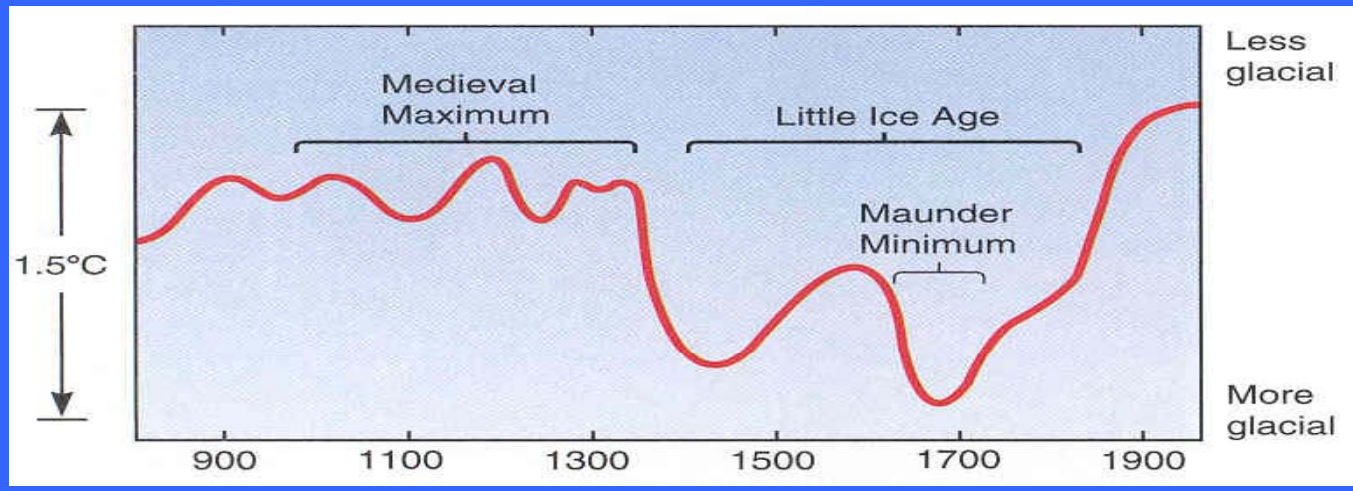
(b) the past 1,000 years



“Hockey  
Stick”  
graph

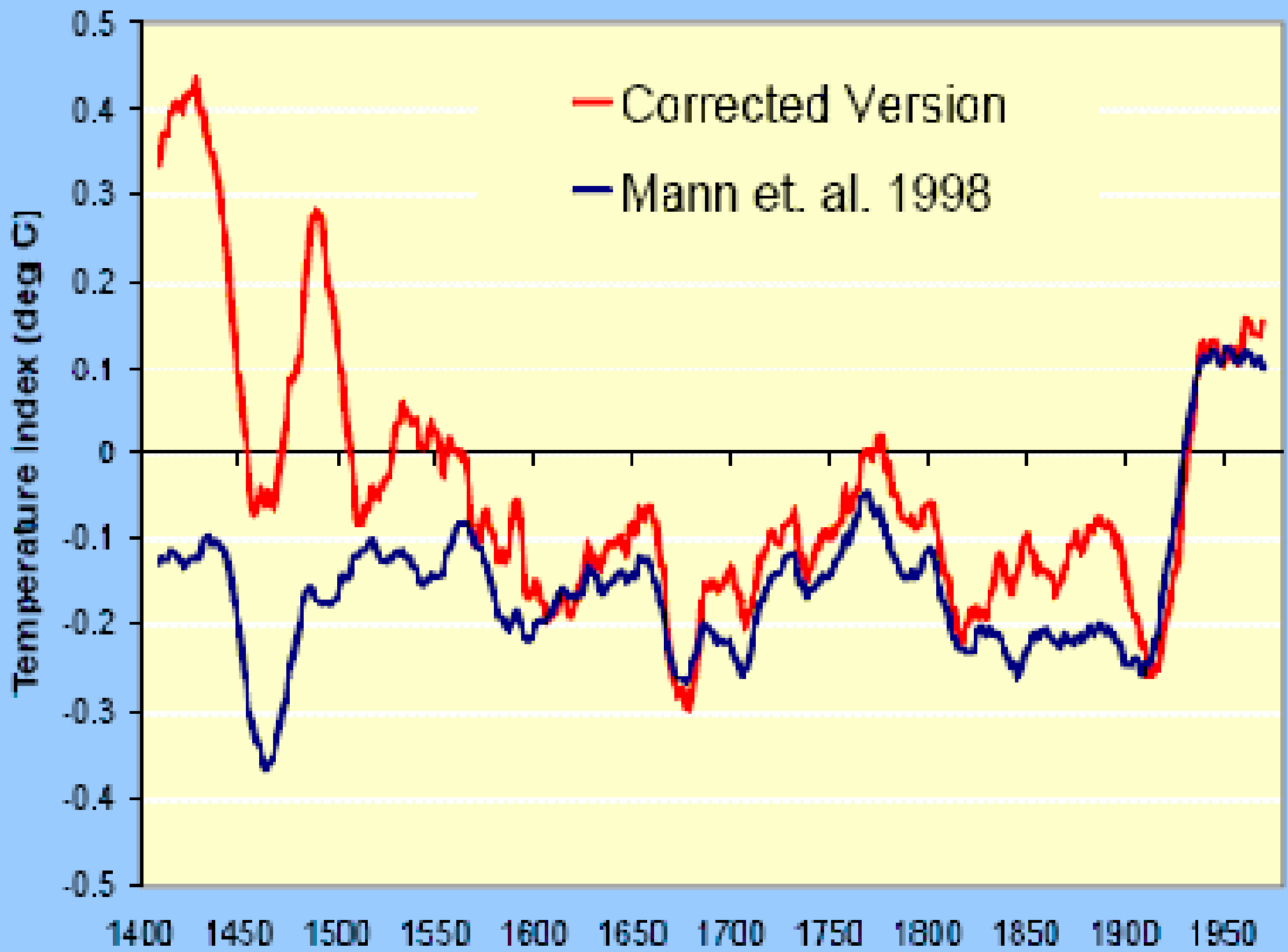
When did the instrumental  
record begin?!





**The analysis missed a couple of major, historic climate fluctuations —is it credible?**





HYPSTHERMAL

WARM

LITTLE CLIMATIC OPTIMUM

LITTLE ICE AGE

COLD

Within a trend of overall cooling, global temps can vary widely, creating warming trends like we are now experiencing

20k BP

10k BP

NOW

Wisconsin glaciation

Holocene interglacial

Remember, the "now" is the end of a very long story of ups and downs...





# Illustration of “perspective”

You may have seen this structure before, but it can still get your attention.

Did you know the world's tallest building is in Canada?

It's called the Canadian National Tower in Toronto and is used for telecommunications.

It's height is 553.3 meters or 1,815 feet so you know it's been photographed a lot.

I'm a big fan of architecture and have gone back and looked at this photo several times.

It's truly amazing. See for yourself....

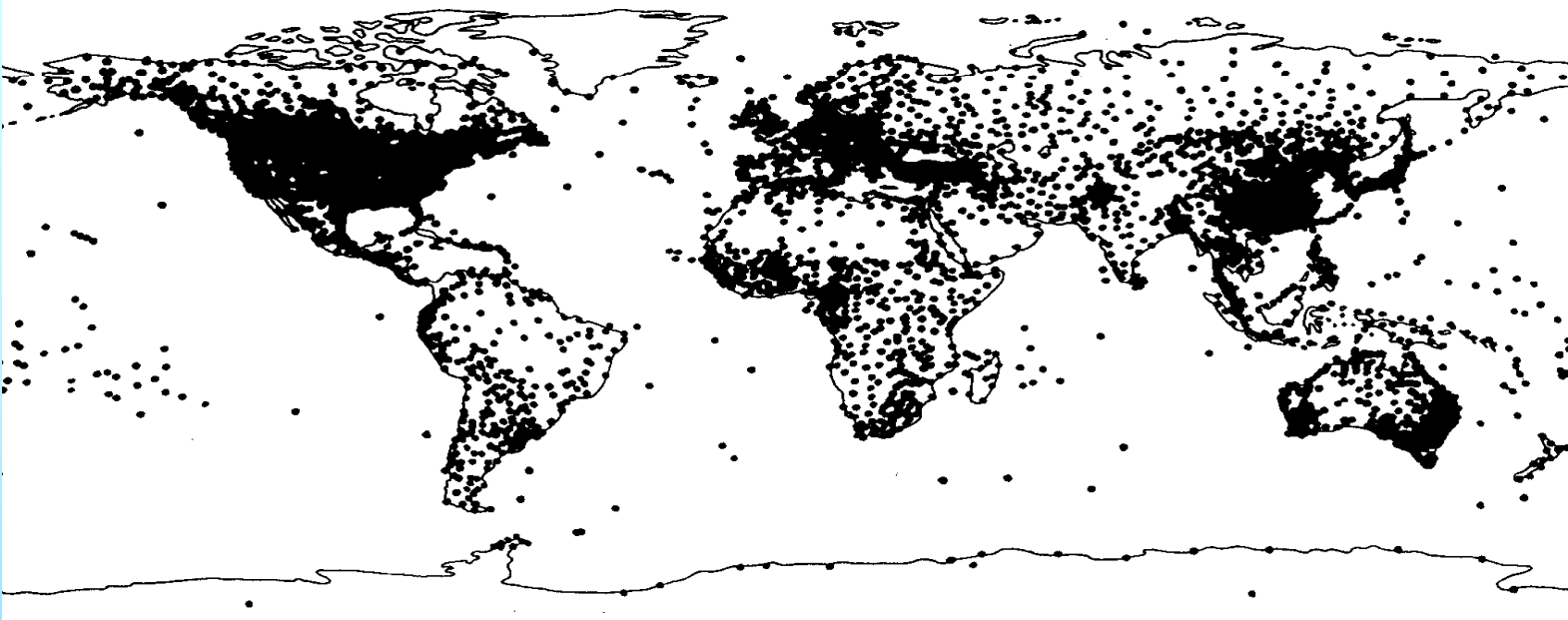




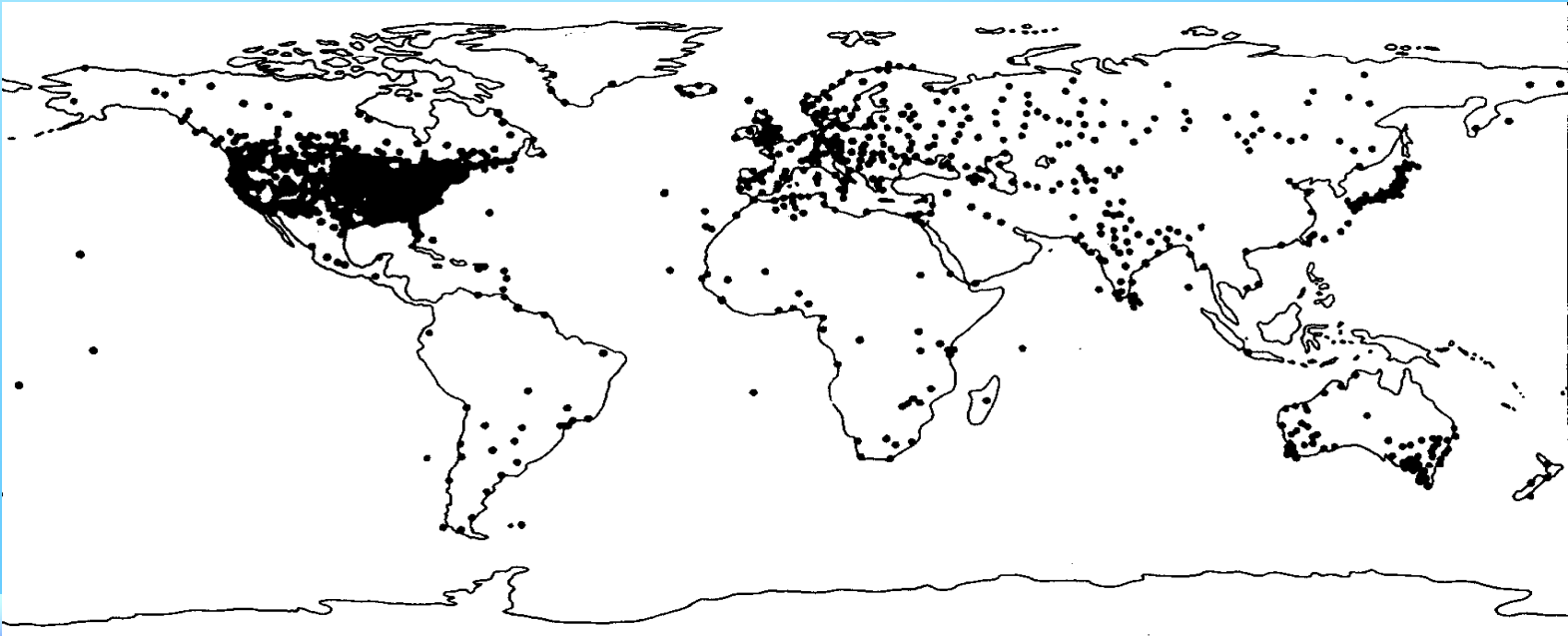


# Distribution of temperature stations (a) now (b) pre-1900

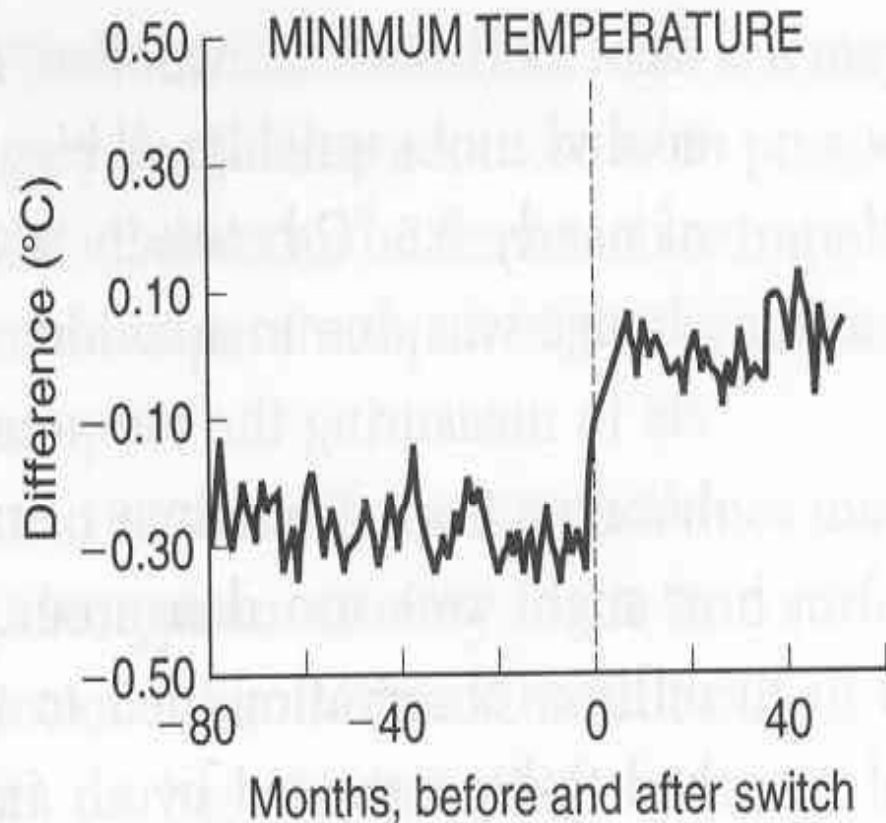
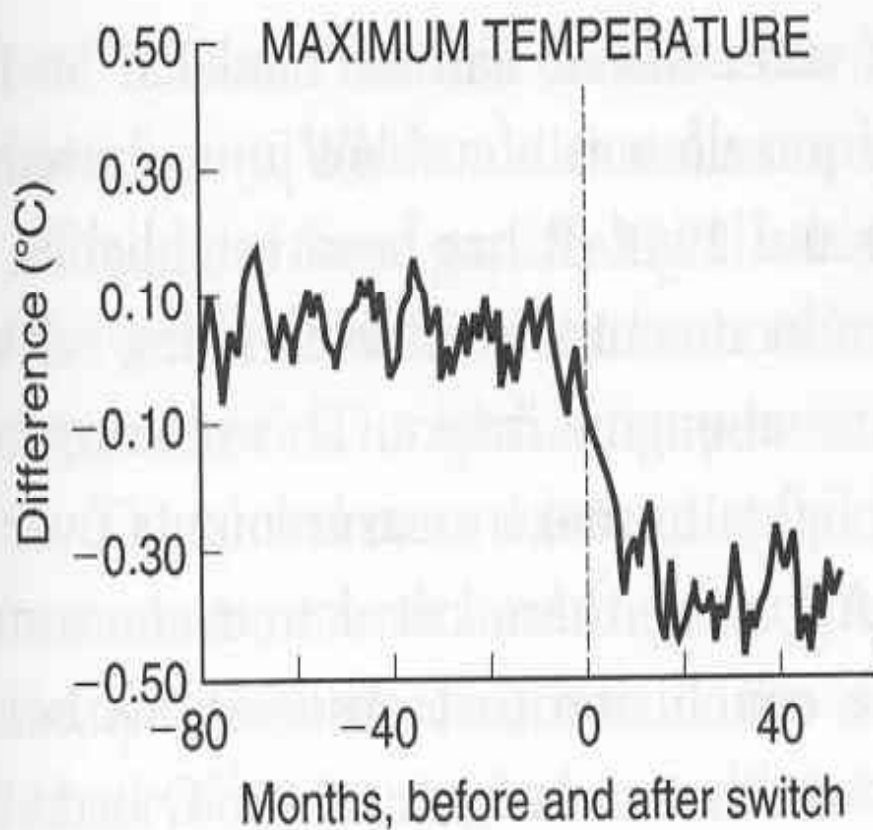
(a)



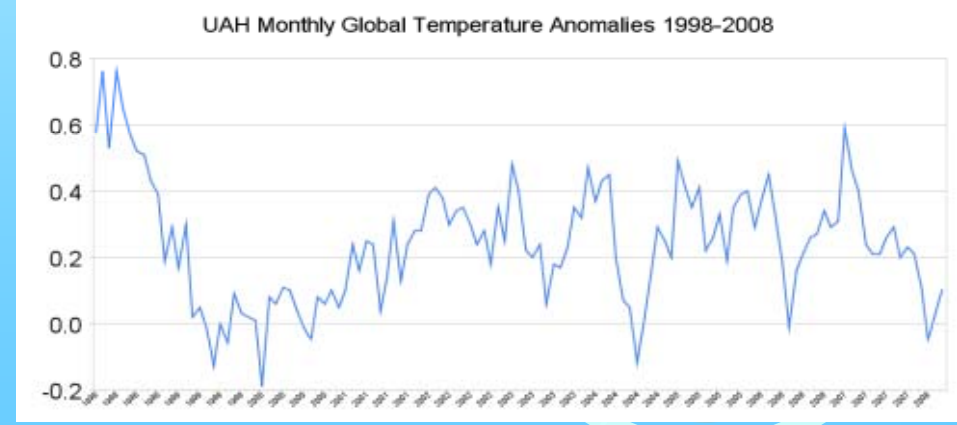
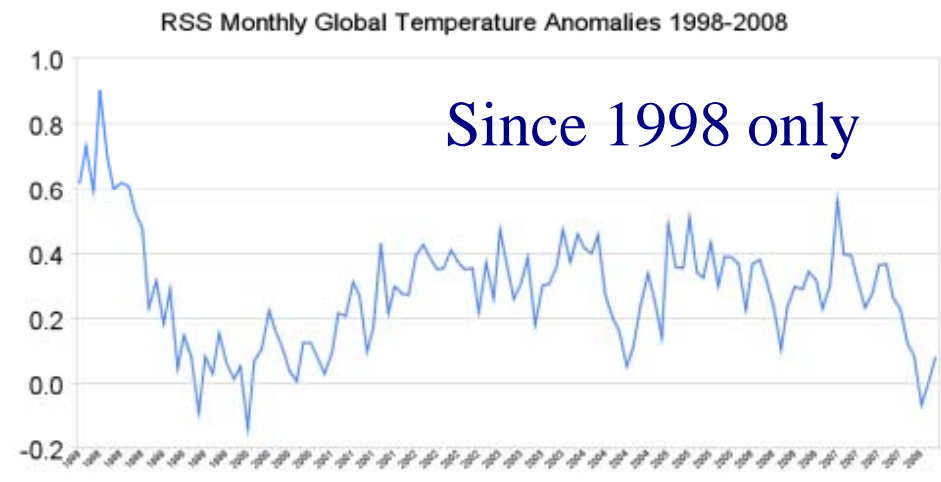
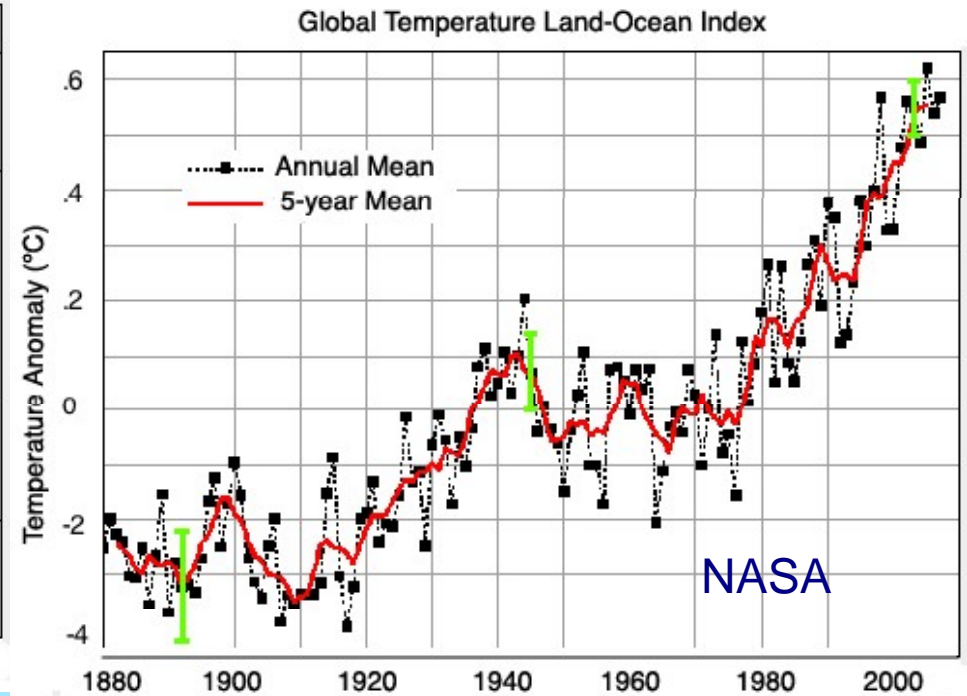
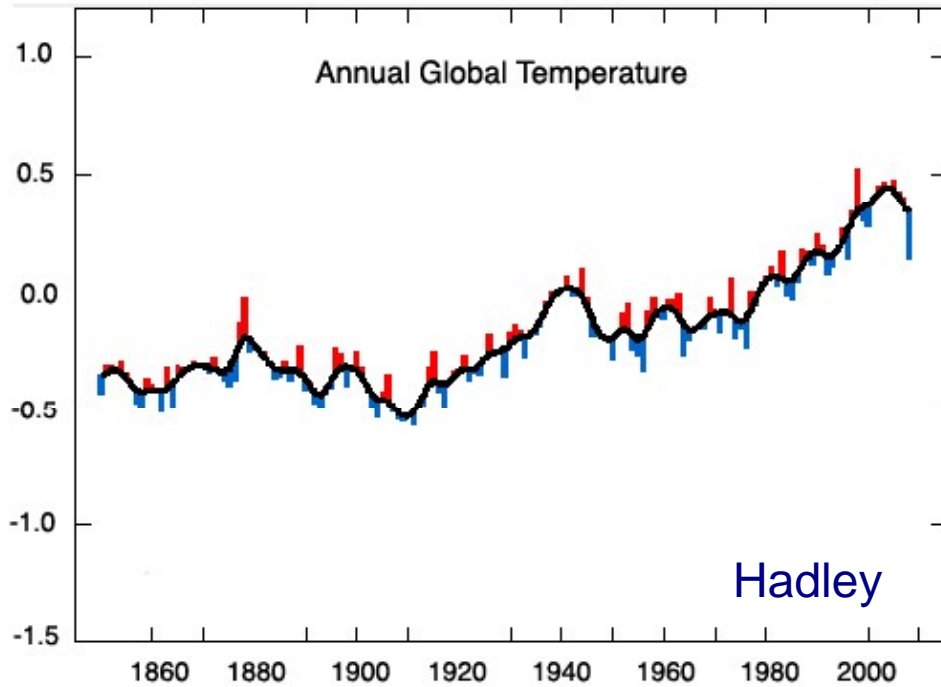
(b)



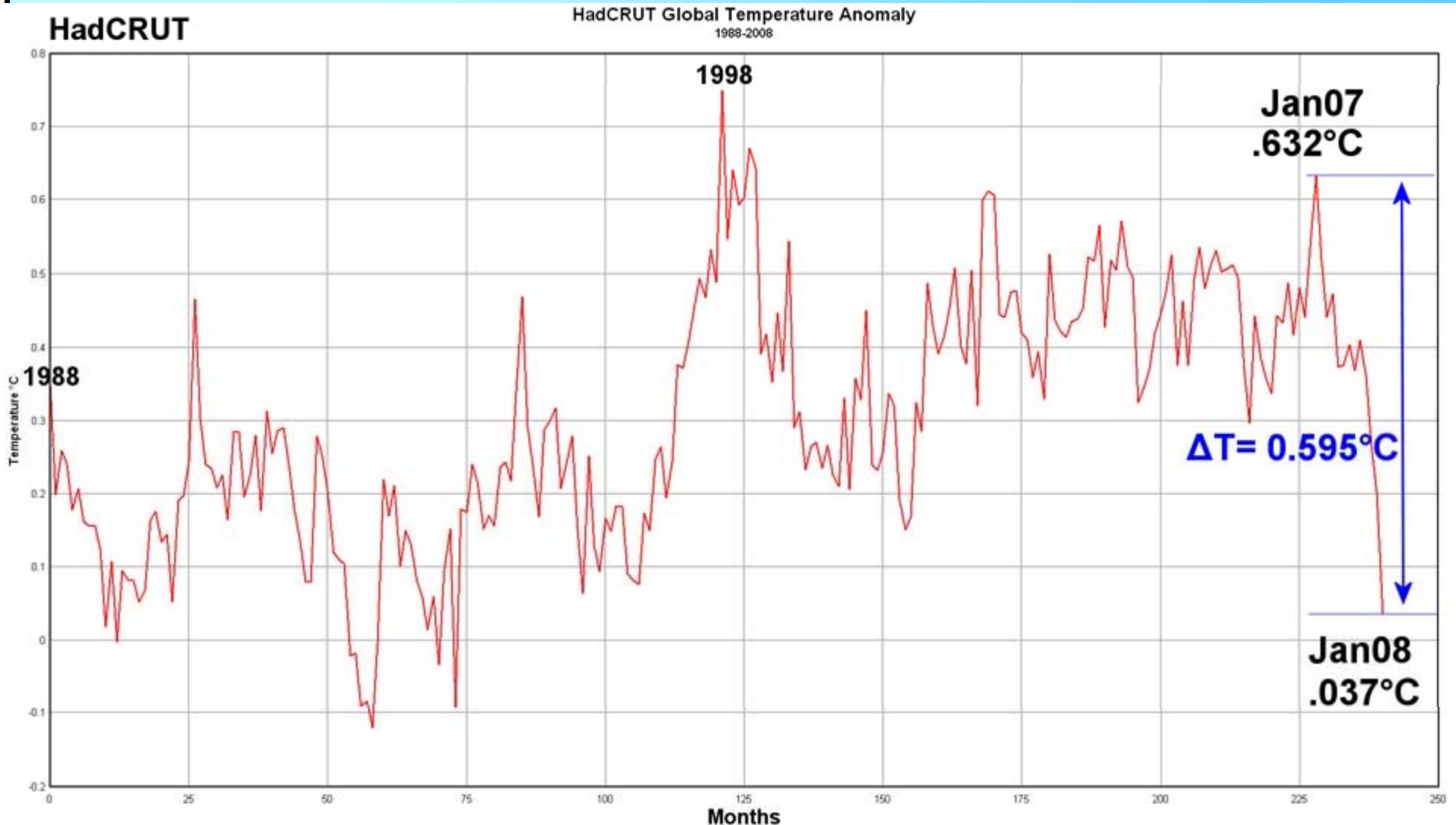
# Temperature measurements prior and subsequent to changing from old max/min liquid in glass thermometers to new electronic thermometers



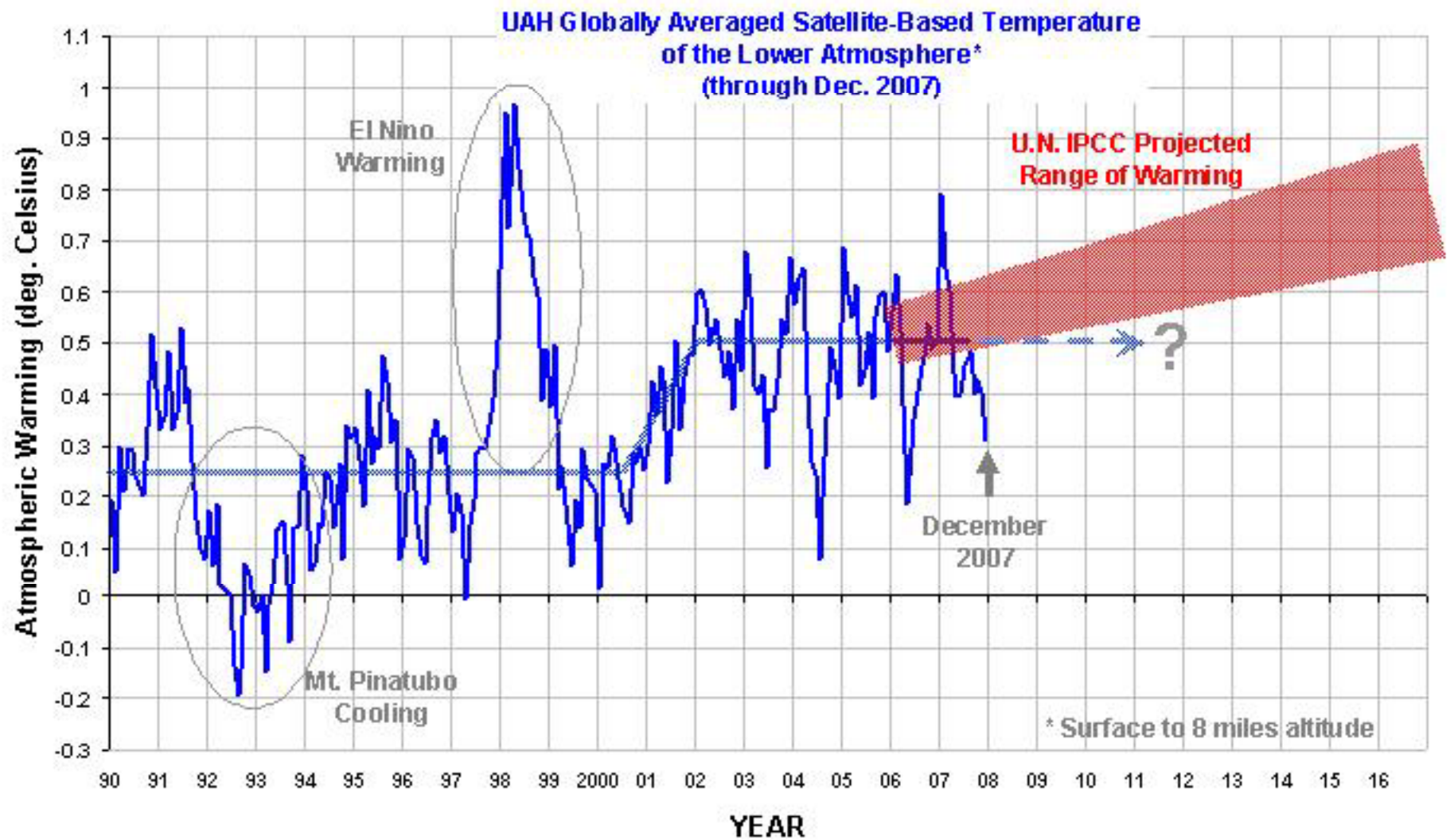
(Karl et al., 1995)



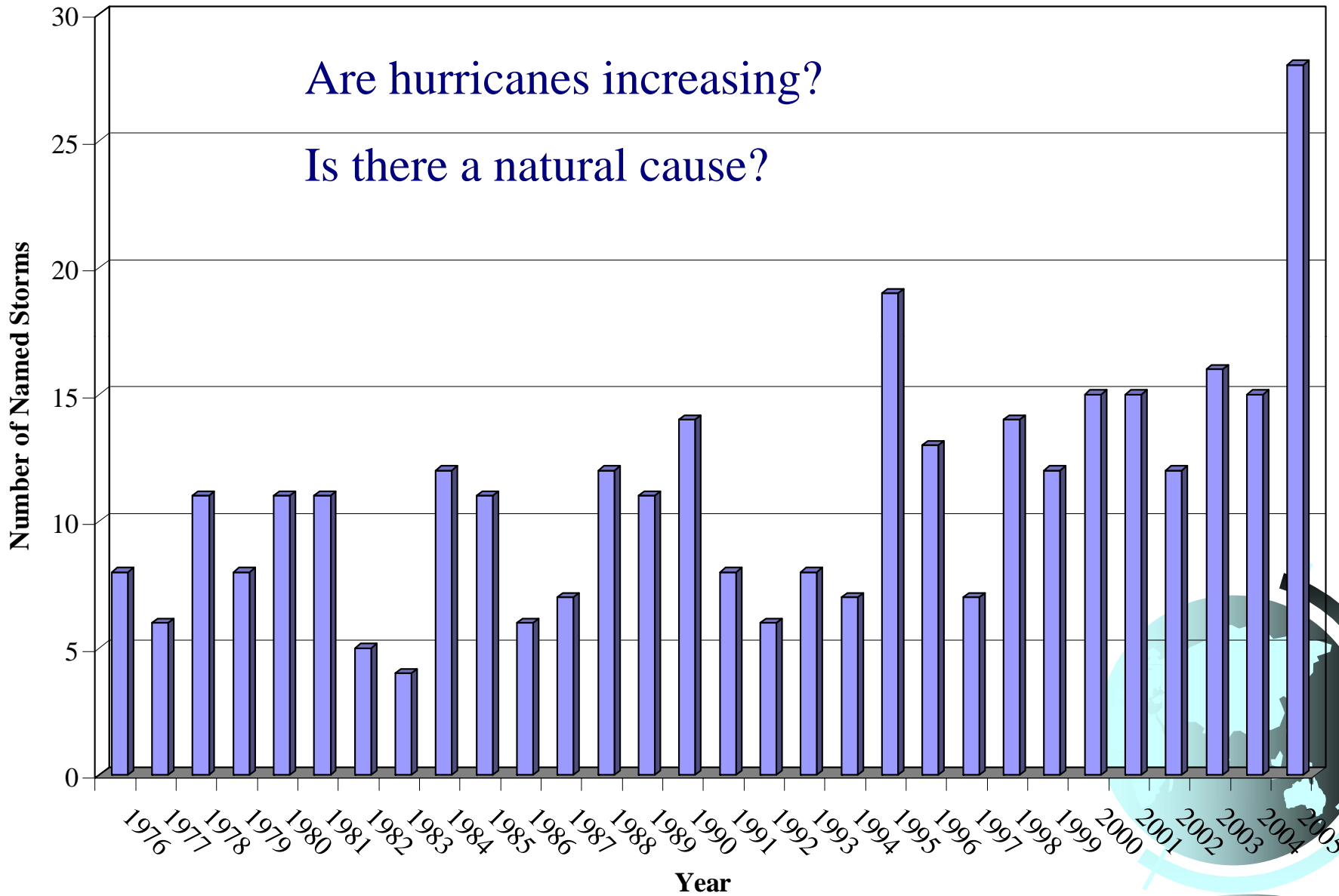
# Hadley Center for Climate Prediction—largest precipitous change ever measured, up or down



# Satellite-measured monthly globally averaged lower atmospheric temperature variations



# Hurricane Frequency

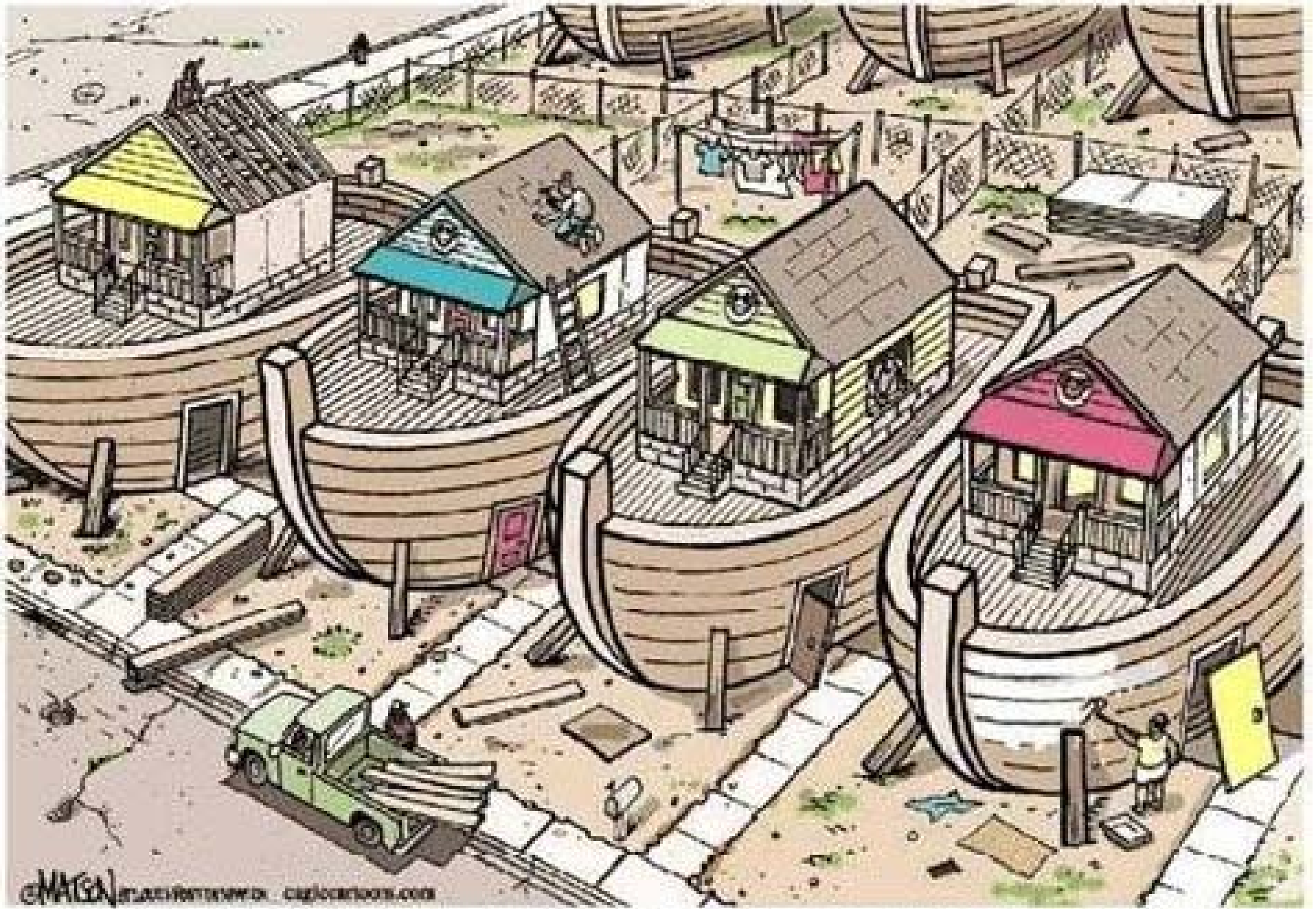




# Lots of FEMA trailers!



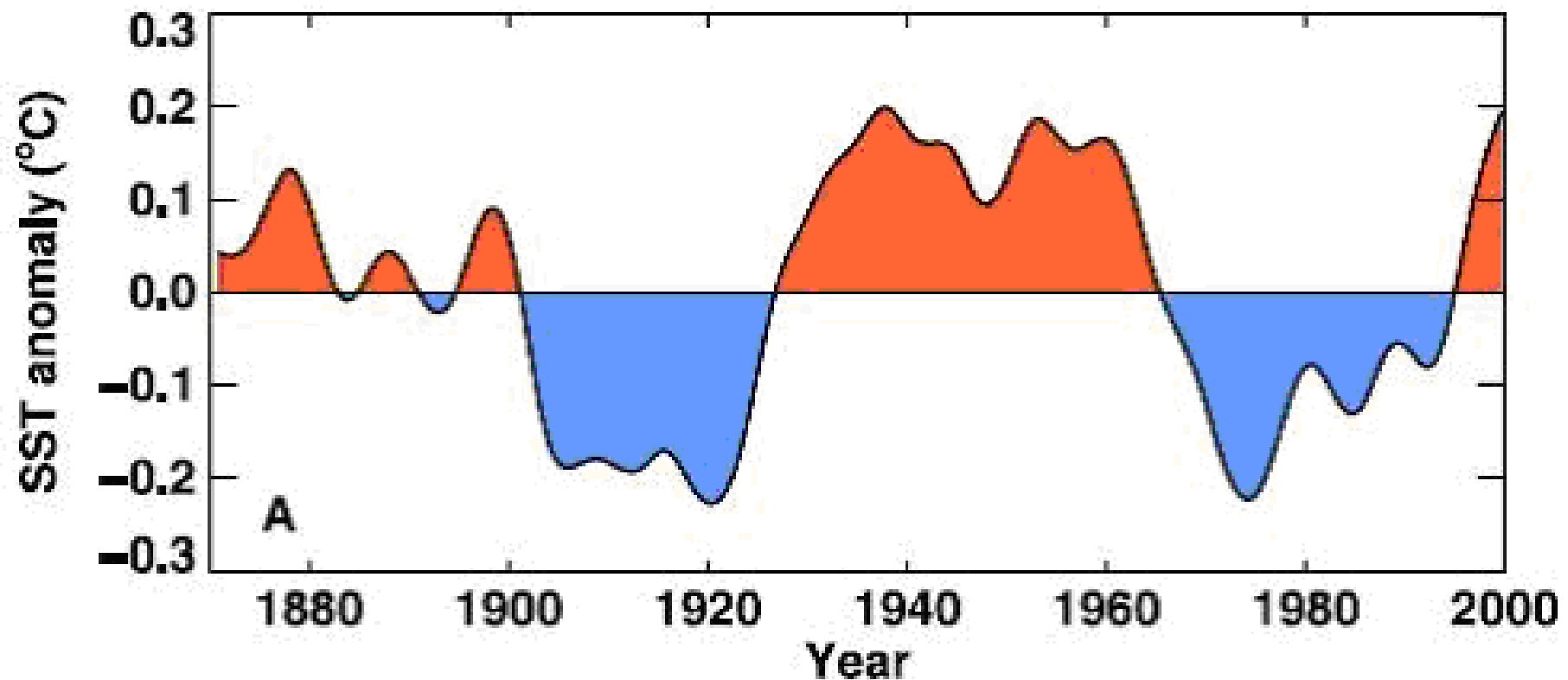




©MAYEN 1/14/11 11:11 AM C:\LOCAL001\001

**MORE REALISTIC FEMA. GUIDELINES FOR REBUILDING IN NEW ORLEANS**

The history of the *Atlantic Multidecadal Oscillation (AMO)* Index shows that positive and negative phases typically last for **20 to 40 years**. Since 1994, the AMO index has been positive, indicating that the United States might be headed into a prolonged period of increased hurricane activity.



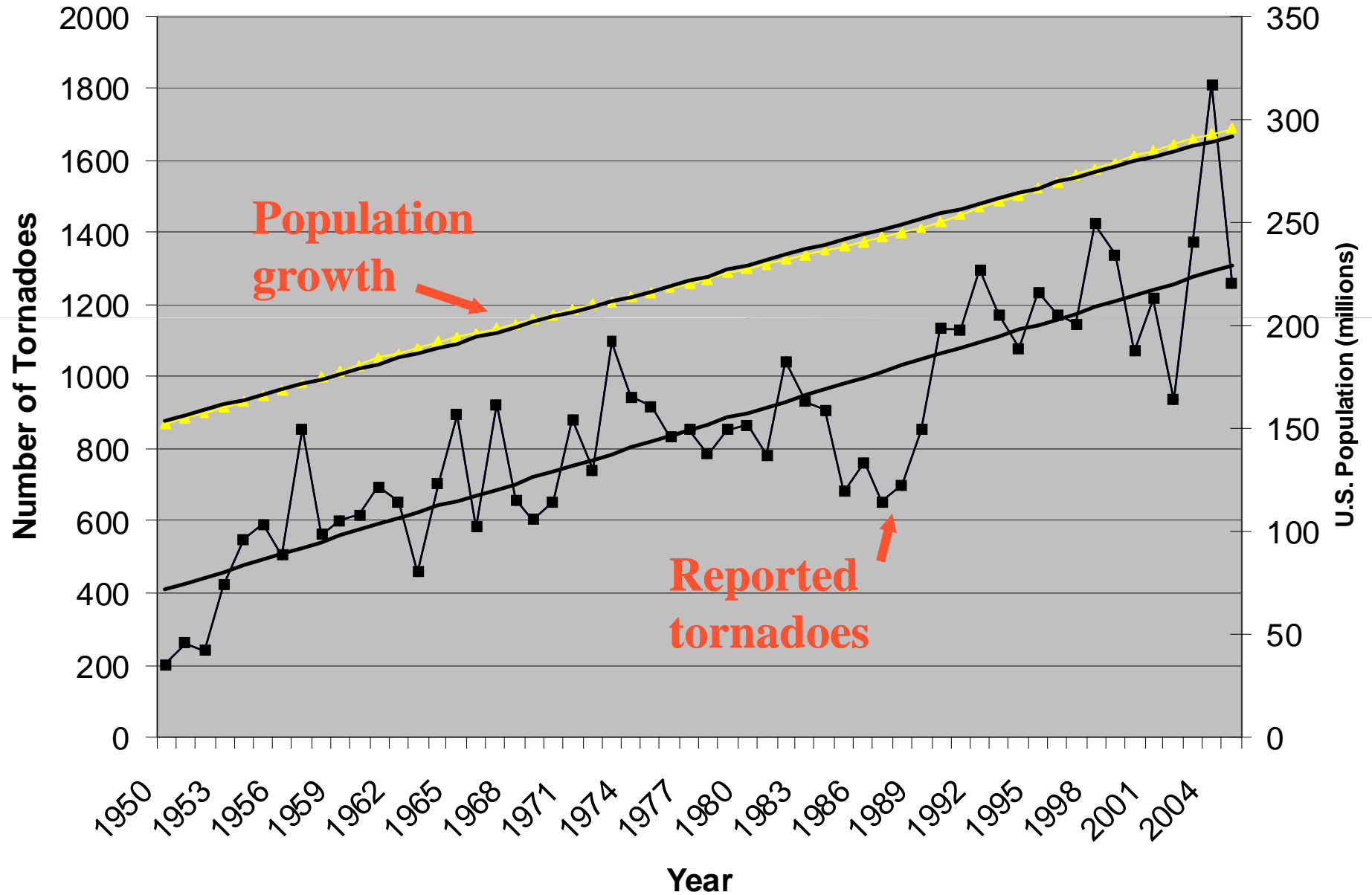
# Regional variation--Redneck hot tub!



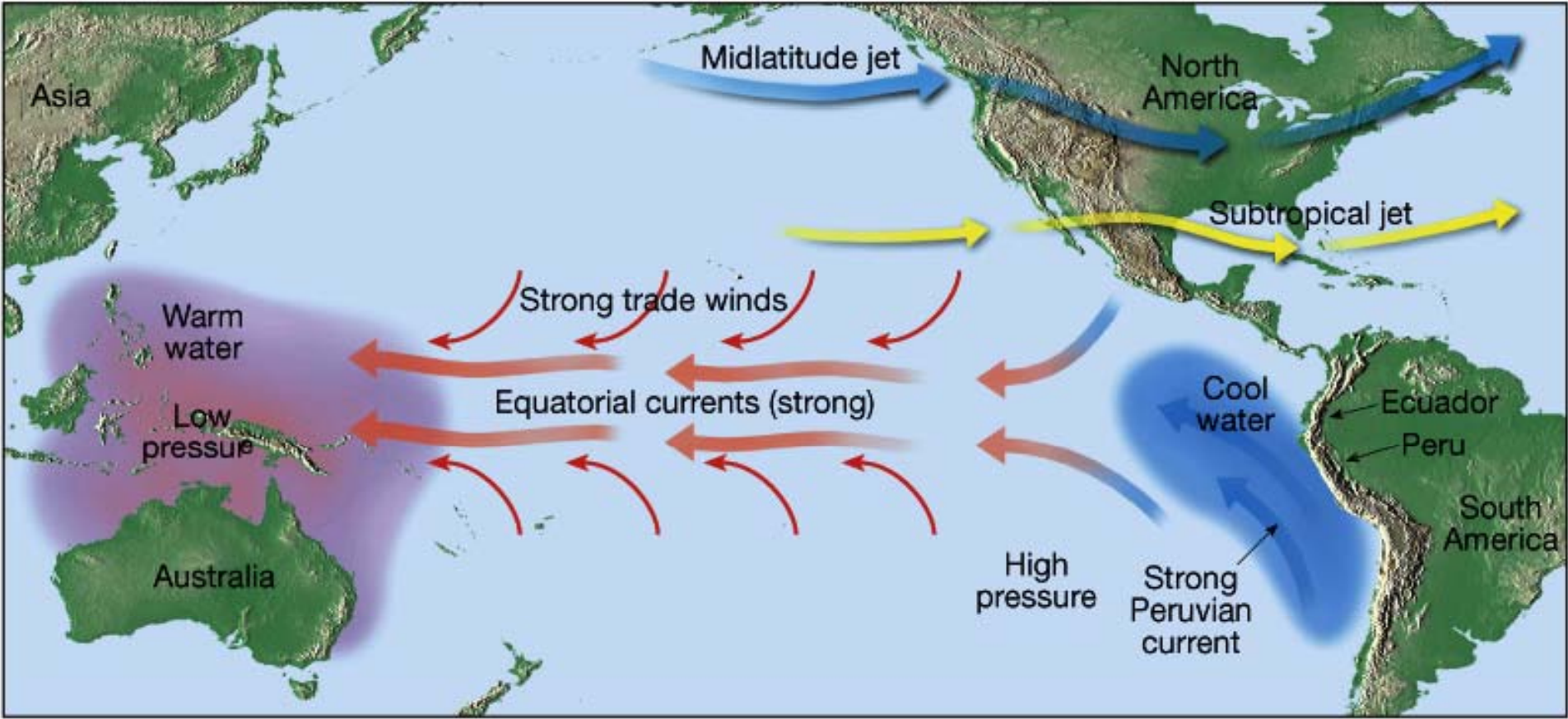
**Greensburg, KS EF-5  
May 2007**



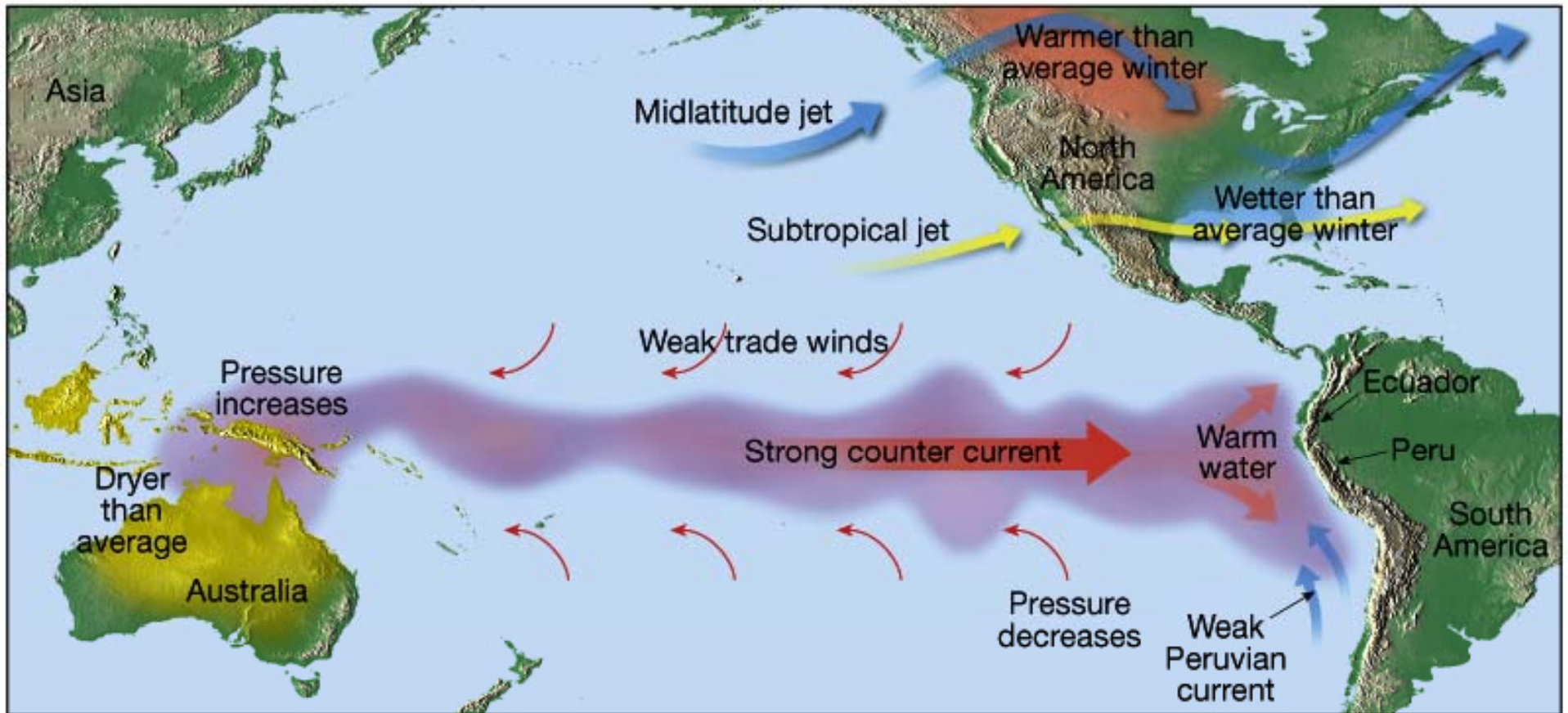
# Tornadoes Reported Per Year

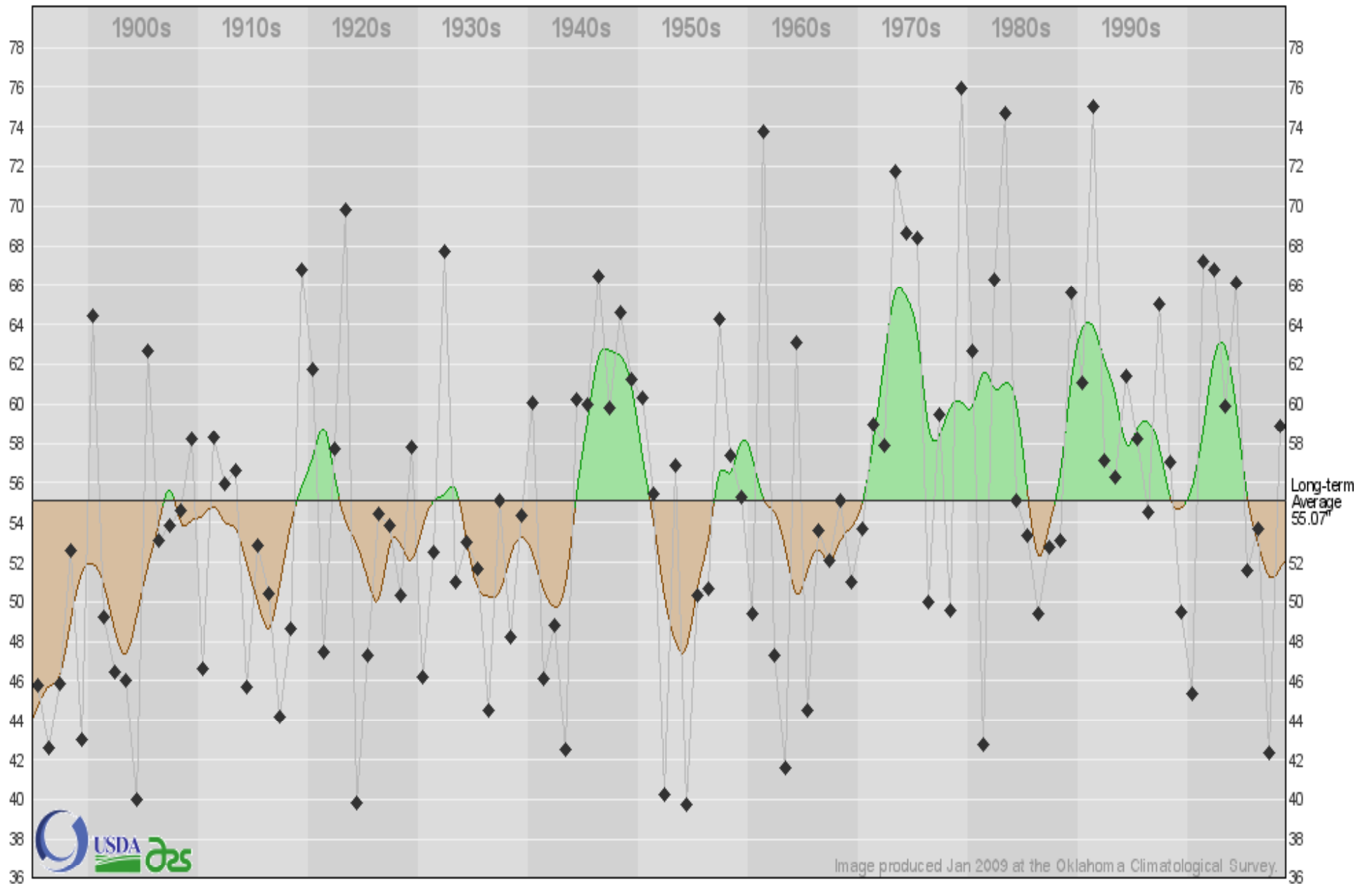


# Atmospheric Circulation--Normal Conditions



# Atmospheric Circulation--El Nino Conditions

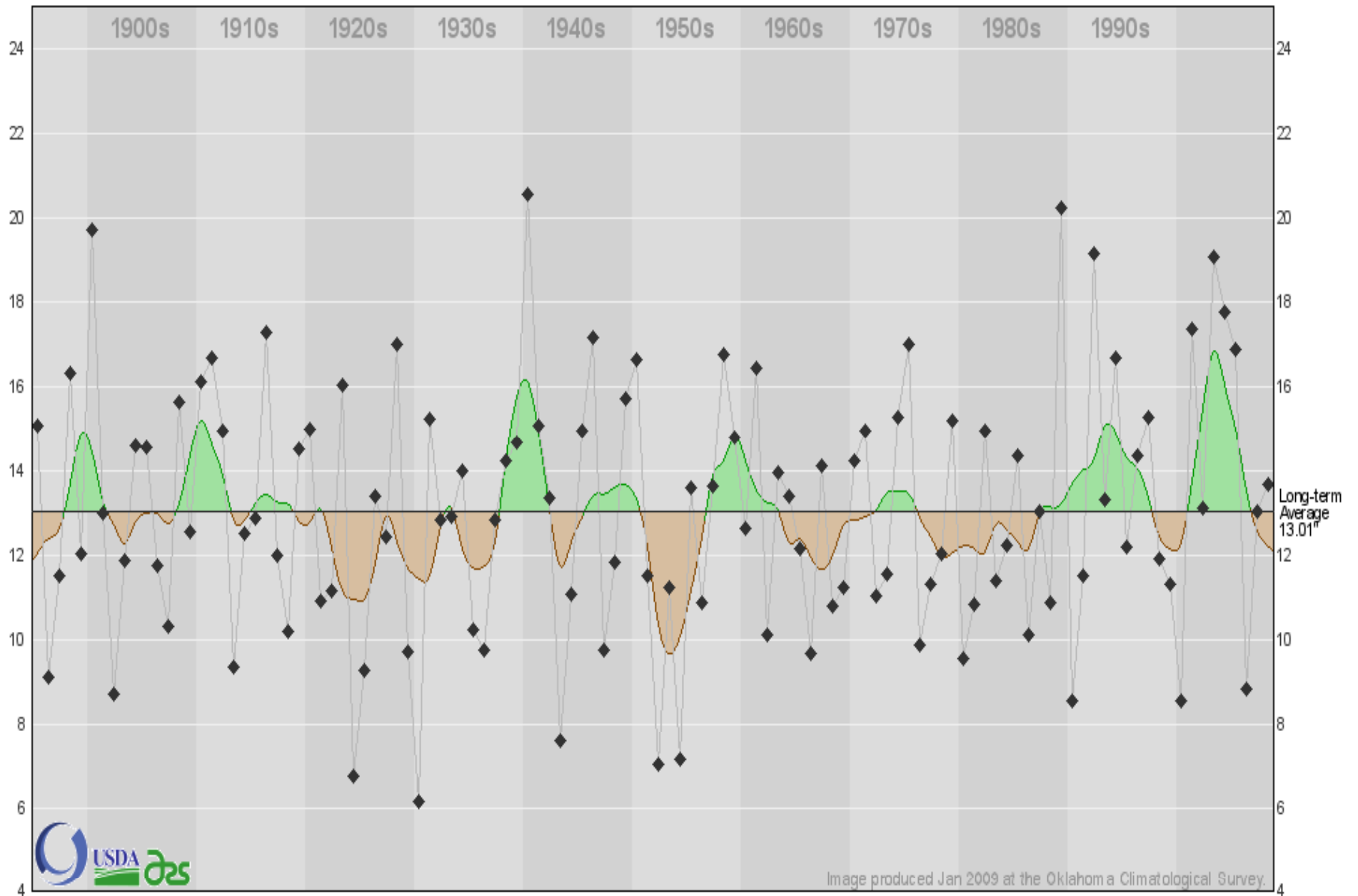




**Annual Precipitation History with 5-year Tendencies**  
Mississippi Statewide: 1895-2008

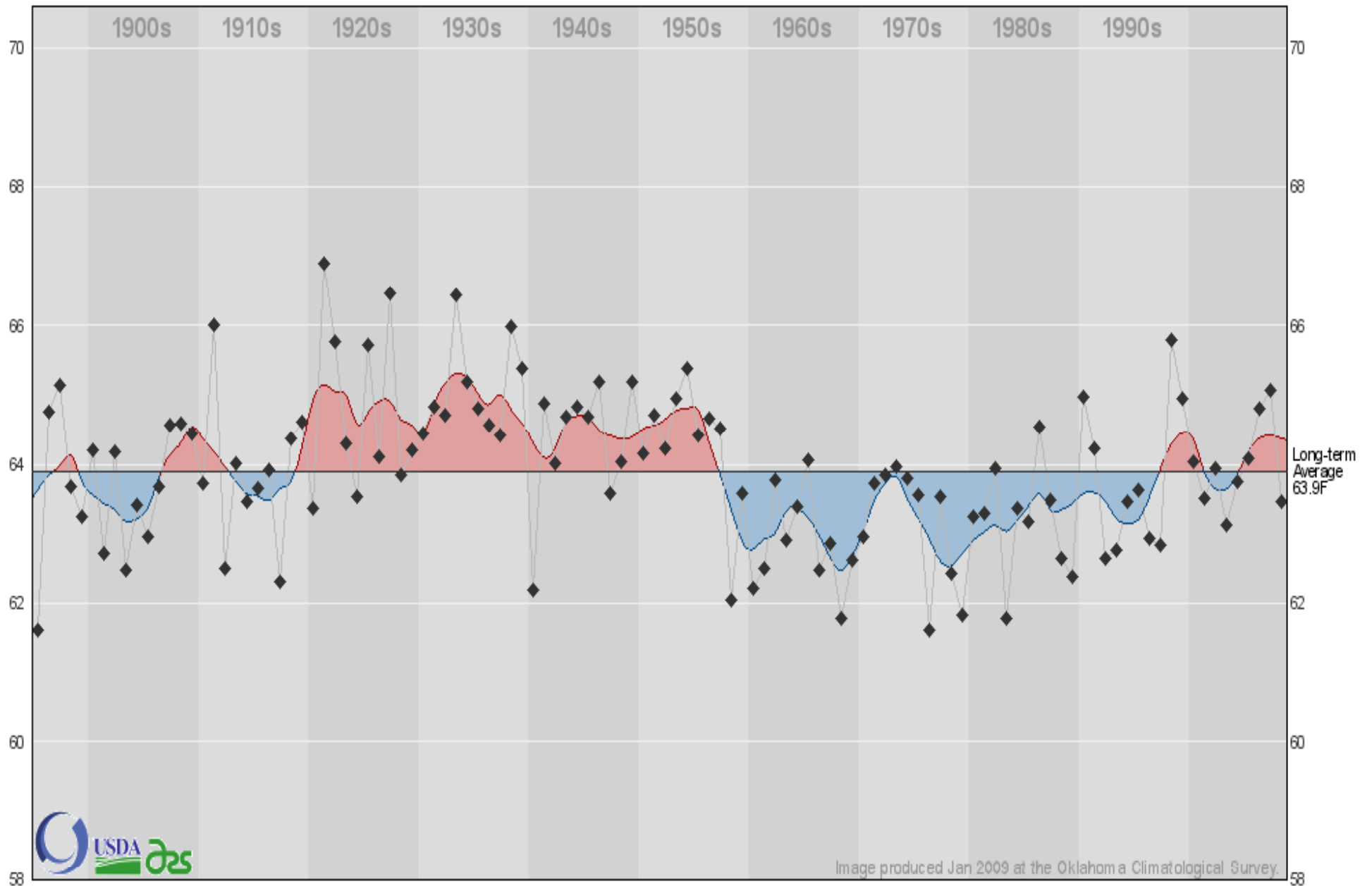
- Wetter historical periods
- Drier historical periods
- Individual Annual precipitation value





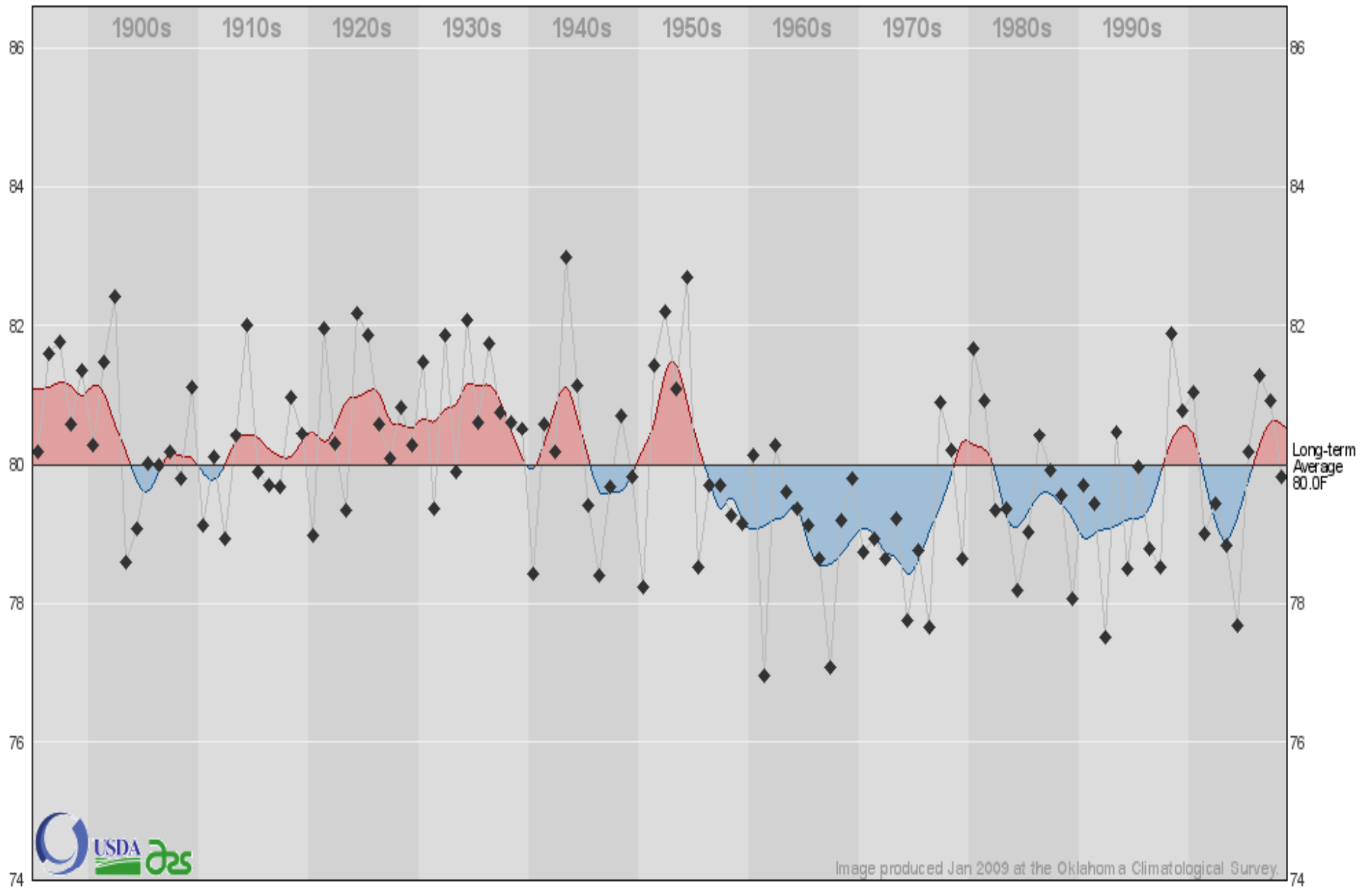
**Summer Precipitation History with 5-year Tendencies**  
Mississippi Statewide: 1895-2008

- Wetter historical periods
- Drier historical periods
- Individual Summer precipitation value



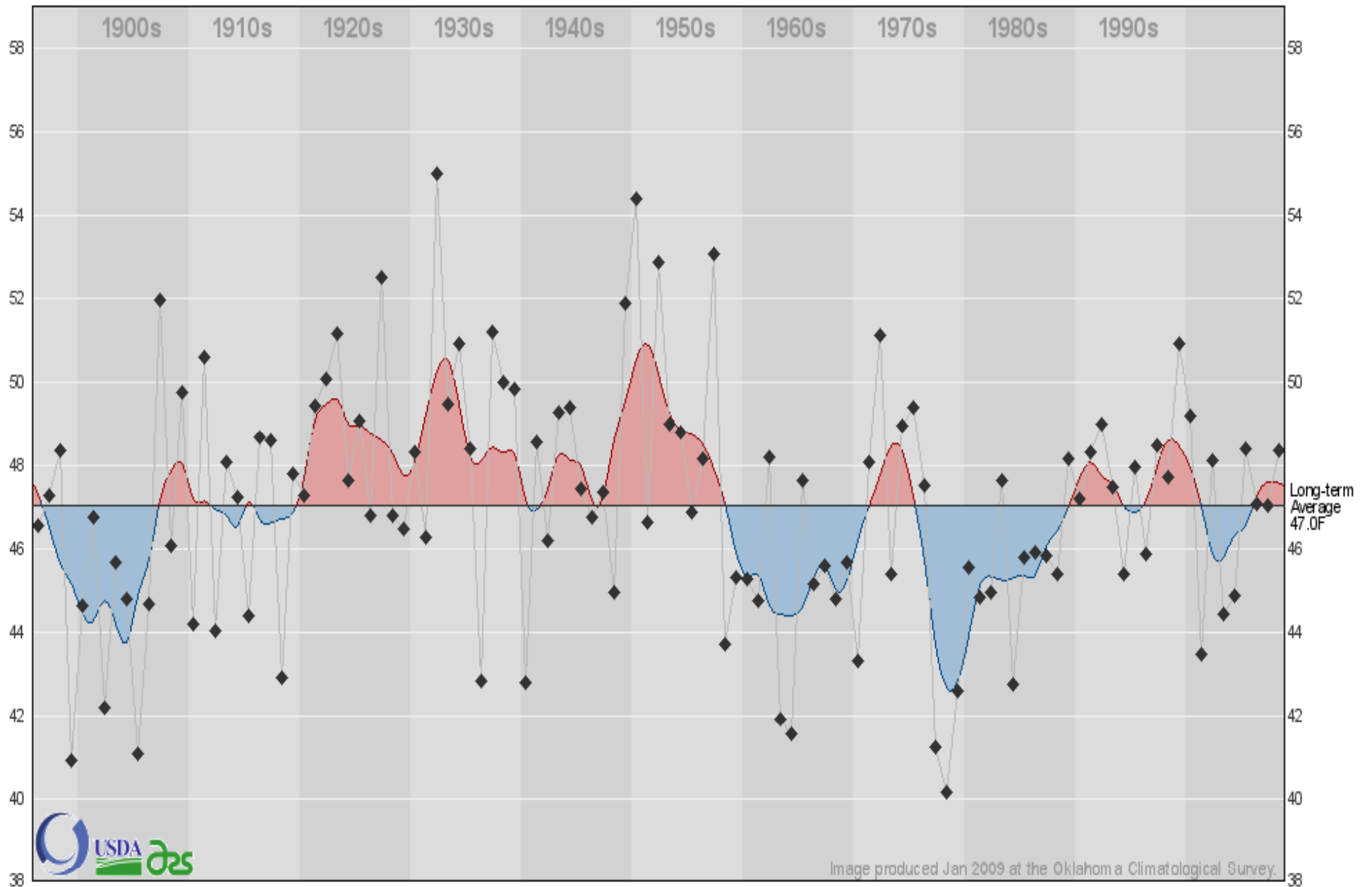
**Annual Temperature History with 5-year Tendencies**  
Mississippi Statewide: 1895-2008

- Warmer historical periods
- Cooler historical periods
- Individual Annual temperature value



**Summer Temperature History with 5-year Tendencies**  
Mississippi Statewide: 1895-2008

- Warmer historical periods
- Cooler historical periods
- Individual Summer temperature v a



**Winter Temperature History with 5-year Tendencies**  
 Mississippi Statewide: 1896-2008

- Warmer historical periods
- Cooler historical periods
- Individual Winter temperature value

# Light at the end of the tunnel



# Climate Change—Increased impacts on a more populous Earth

- Atlanta water supply 2007—distribution problem?
  - 9 million in GA
  - 7 million in north GA
  - 5 million in Atlanta!!
- MS Delta aquifer—water volume decline
  - Much more irrigation now
  - Drought increases demand, multiplies impact

# Controversy--Caution

- Scientific polarization
- Political/policy confusion
- Firing 3 State Climatologists
- Alarmism, "snake oil salesmen"





