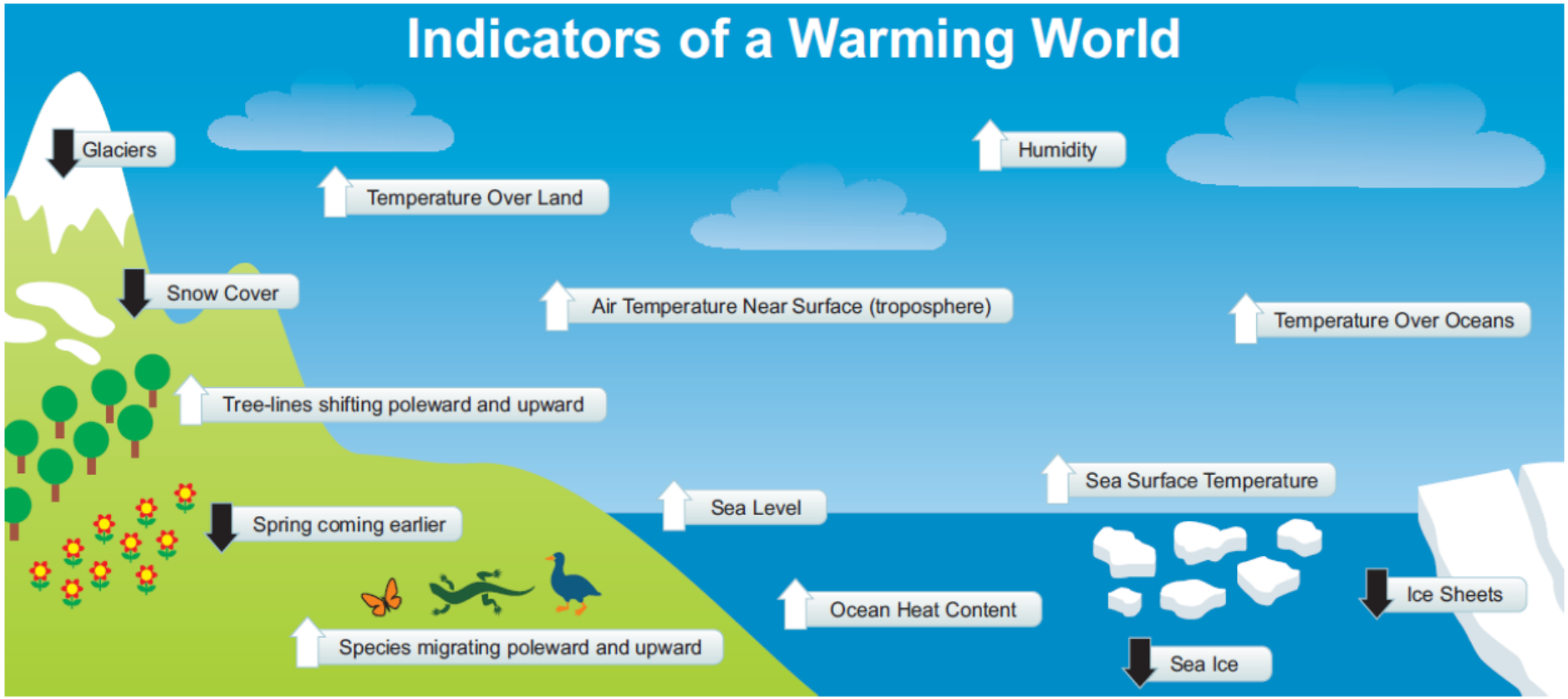
TOPIC #12

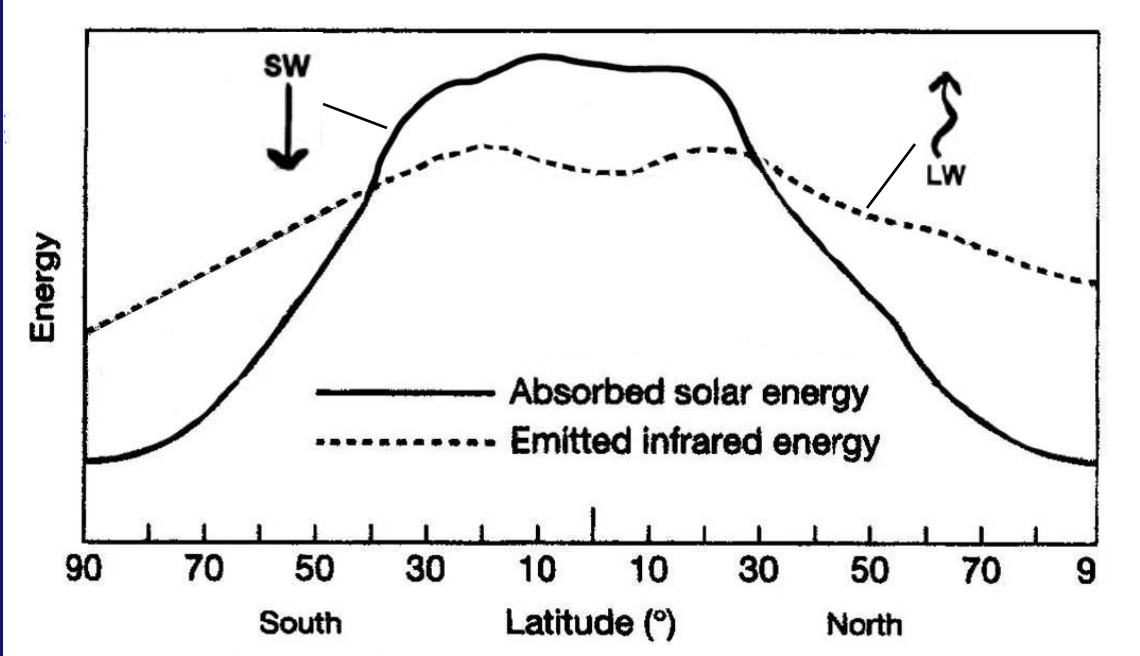
NATURAL CLIMATIC FORCING

(Start on p 67 in Class Notes)

RECAP: Can you explain how each of the processes involved in these climate change indicators would occur with a warming world?



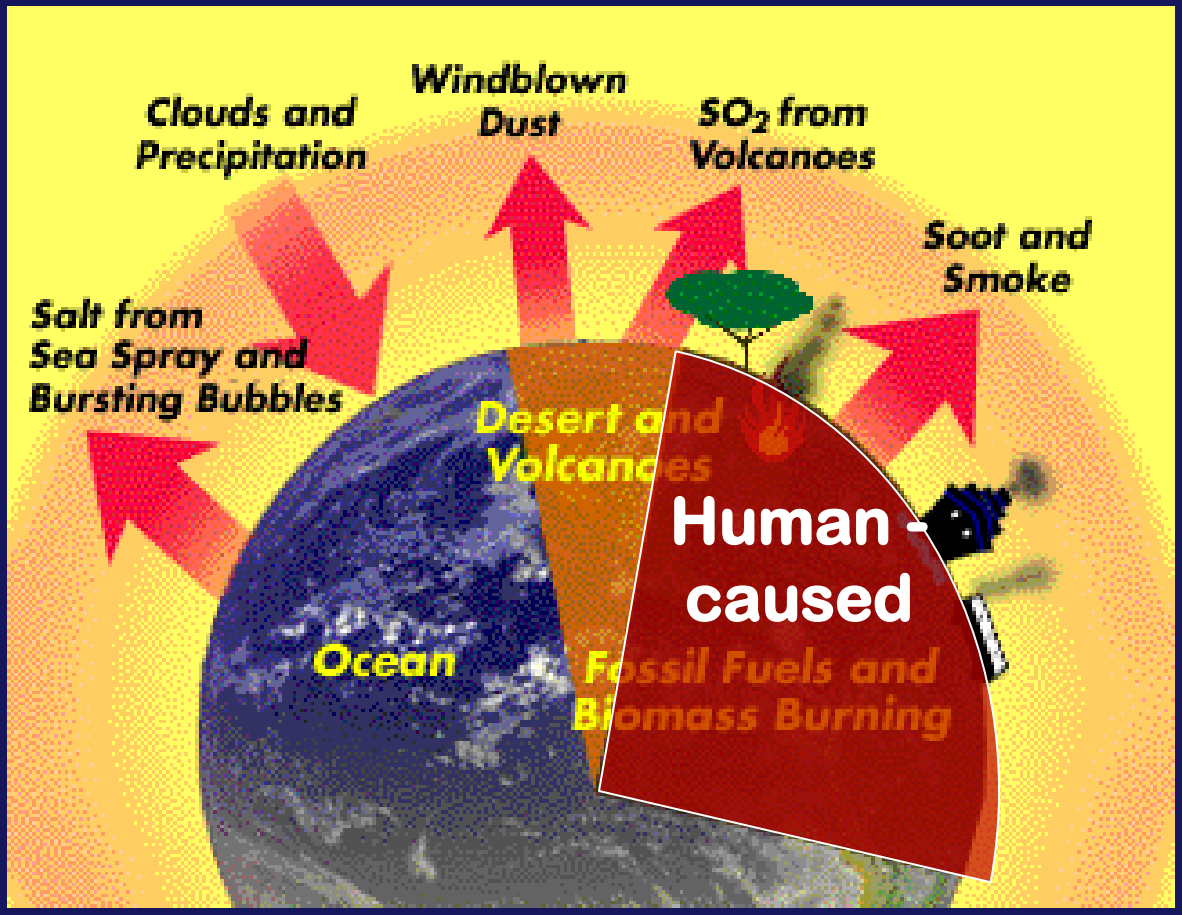
ENERGY BALANCE (review)



Global climate variability and change are caused by changes in the ENERGY BALANCE that are "FORCED"

review

FORCING = a persistent disturbance of a system



(a longer term disturbance than a perturbation)

NATURAL CLIMATIC FORCING

vs.

ANTHROPOGENIC FORCING

Natural Climatic Forcing = changes due to natural earth-atmosphere-sun processes

- Earth-Sun orbital relationships
- Solar variability
- Changing land-sea distribution
  (over long time scales: due to plate tectonics)
- Volcanic eruptions

also: internal atmosphere-ocean variability (i.e., ENSO)
clouds, dust, etc

Anthropogenic Climatic Forcing = changes due to human causes or enhancement of the processes involved

- Enhanced Greenhouse Effect due to fossil fuel burning
- Land use changes due to human activity (deforestation, urbanization, etc.)
- Soot and aerosols from industry
- Chemical reactions in stratosphere involving human-made compounds (ozone depletion)

All things are connected. Whatever befalls the earth, befalls the children of the earth.

~ Chief Seattle

The 3 main drivers of NATURAL CLIMATIC FORCING:

1) ASTRONOMICAL FORCING

2) SOLAR FORCING

3) VOLCANIC FORCING

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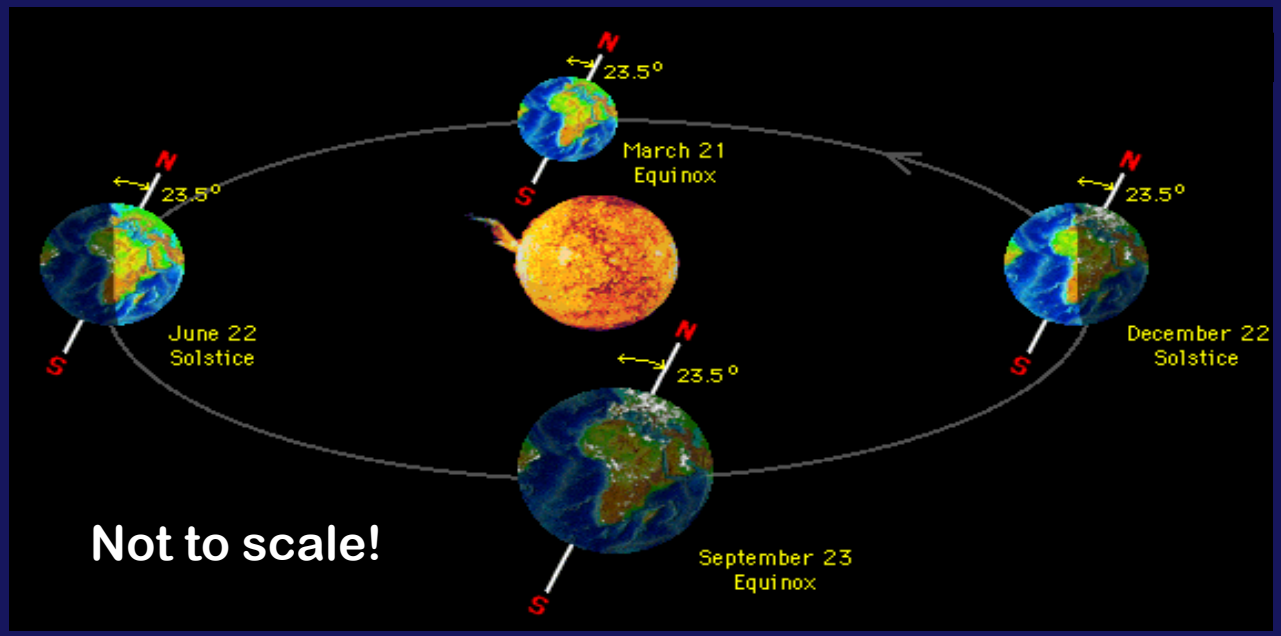
Remember EARTH-SUN Relationships? (p 61)



1) Earth orbits Sun in one year
2) Orbit is not a perfect circle (= an ellipse)
3) Earth's orbit around Sun can be "traced" on the "Plane of the Ecliptic")
4) Earth's axis tilts 23.5 ° ← at this point in time! from a ⊥ to the "Plane of The Ecliptic"

Changes in Solar "Astronomical" Forcing have driven natural climate variability (ice ages, etc.) on LONG time scales (5,000 to 1 million years)

What has varied over time?

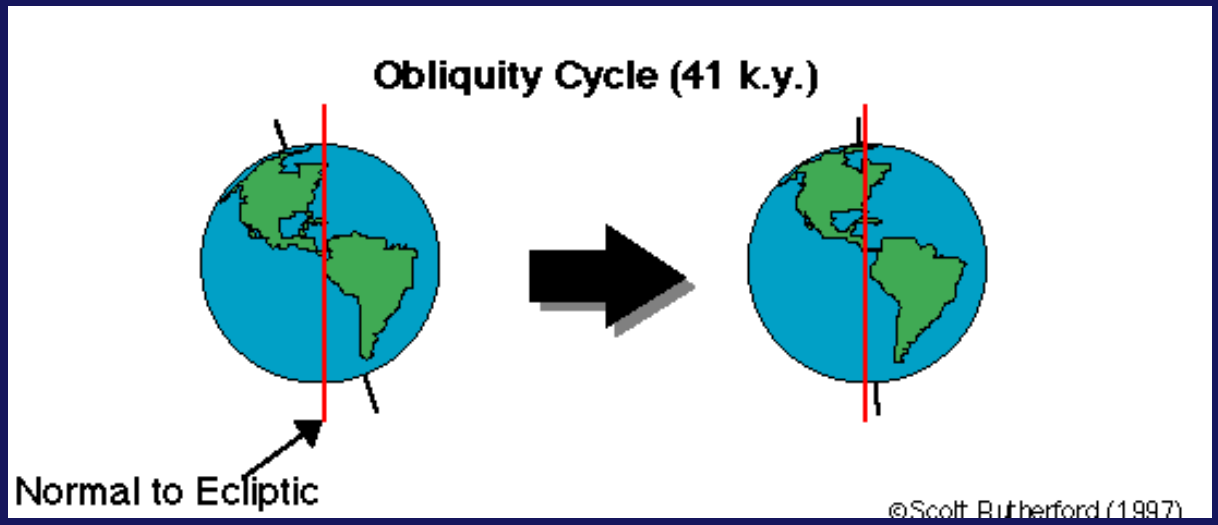
#1 OBLIQUITY OF EARTH'S AXIS

#2 ECCENTRICITY OF EARTH'S ORBIT

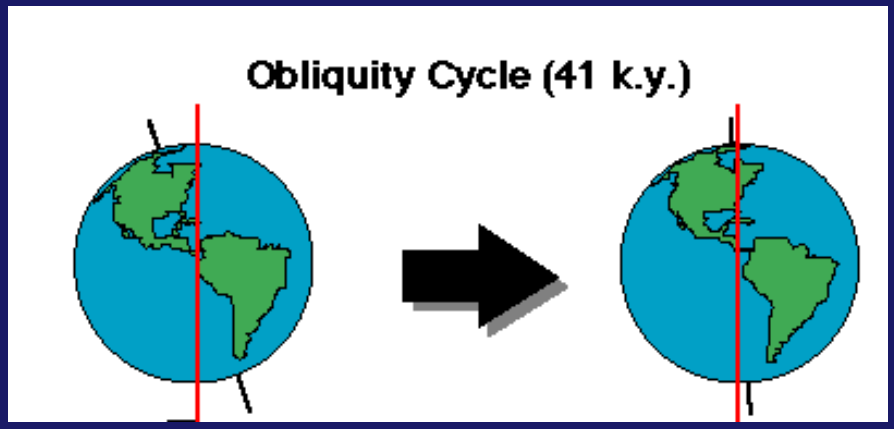
 # 3 Timing of Seasons in Relation to Orbit: "PRECESSION OF THE EQUINOXES"

1. OBLIQUITY OF EARTH'S AXIS

- axis "tilts" 23.5 degrees from plane of ecliptic
- causes the seasons
- has varied in the past from more "tilted" to more "vertical" (~24.5 ^{o} to ~ 22.5 ^{o})



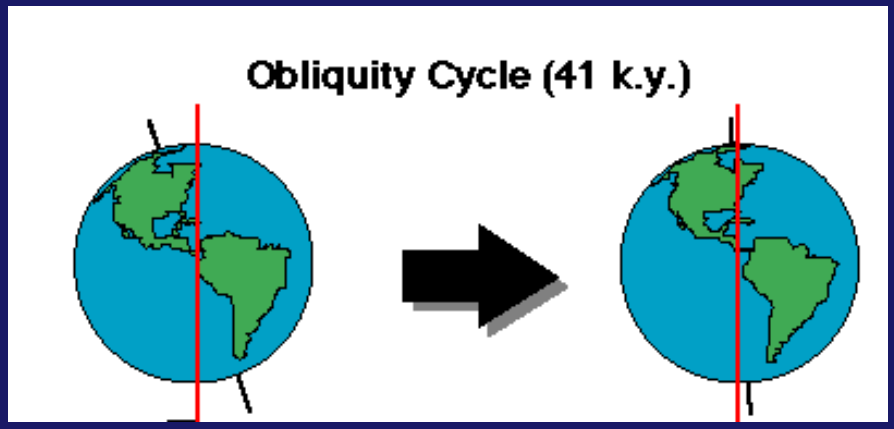
Q1 How do you think global climate would change with less of a tilt?



1 – The <u>difference</u> in annual temperature between polar and tropical latitudes would be GREATER

2 – The <u>difference</u> in annual temperature between polar and tropical latitudes would be LESS

Q1 How do you think global climate would change with less of a tilt?



1 – The <u>difference</u> in annual temperature between polar and tropical latitudes would be GREATER

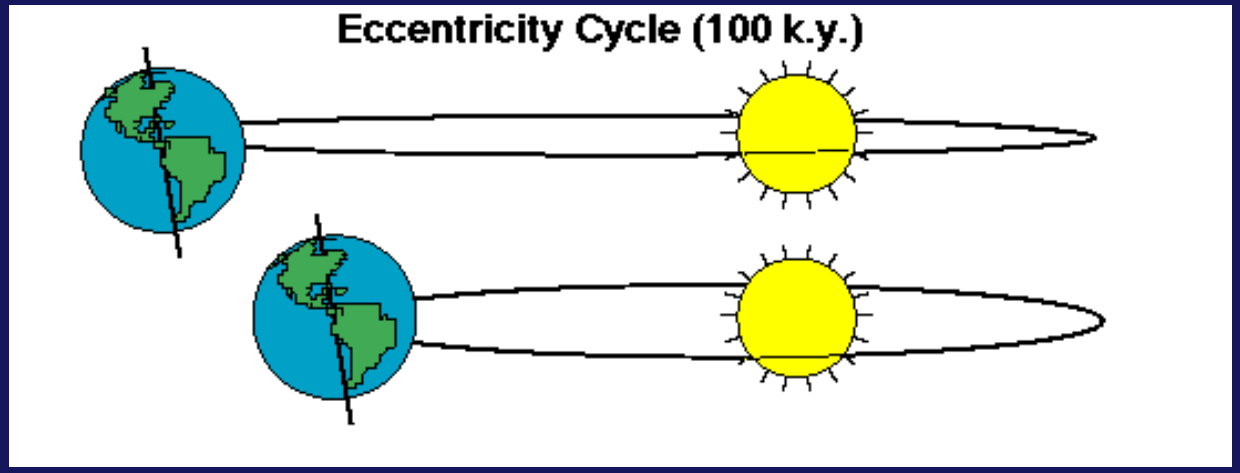
2 – The <u>difference</u> in annual temperature between polar and tropical latitudes would be LESS

2. ECCENTRICITY OF ORBIT

- Earth's orbit around sun is not symmetrical

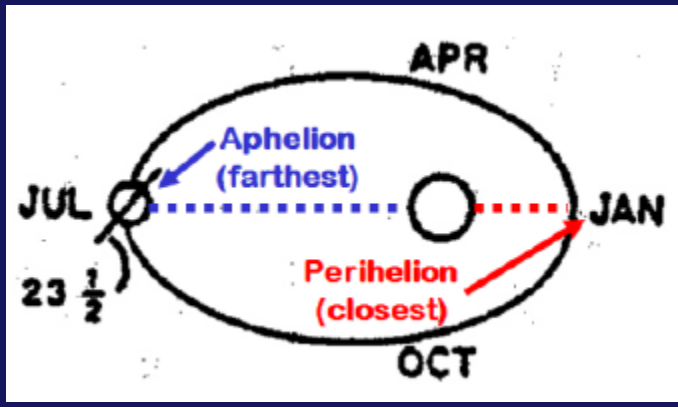
- Has varied in the past from more circular => elliptical shape

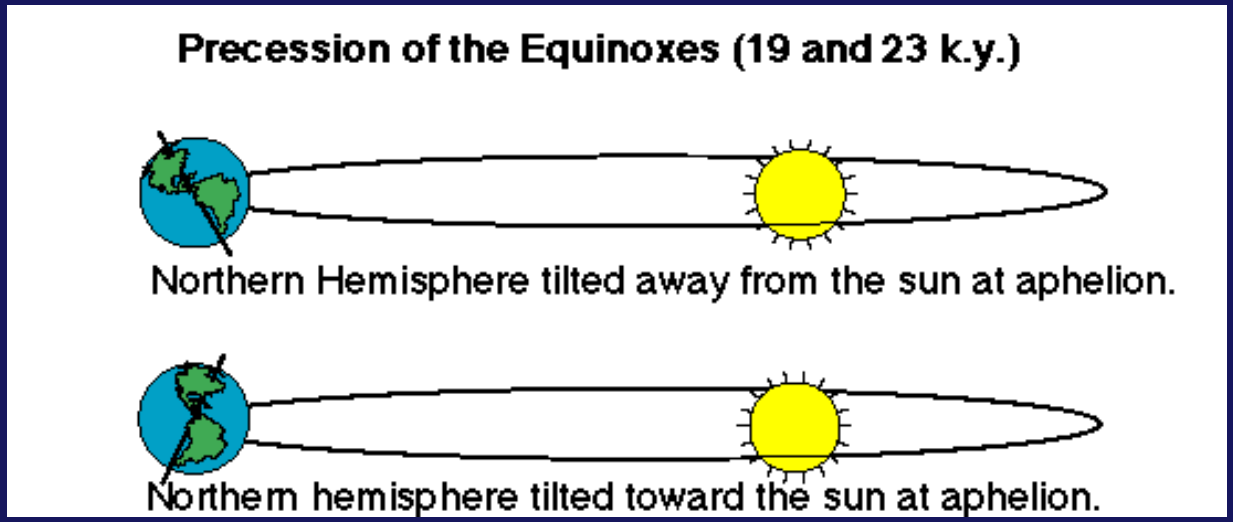
(more "eccentric!")



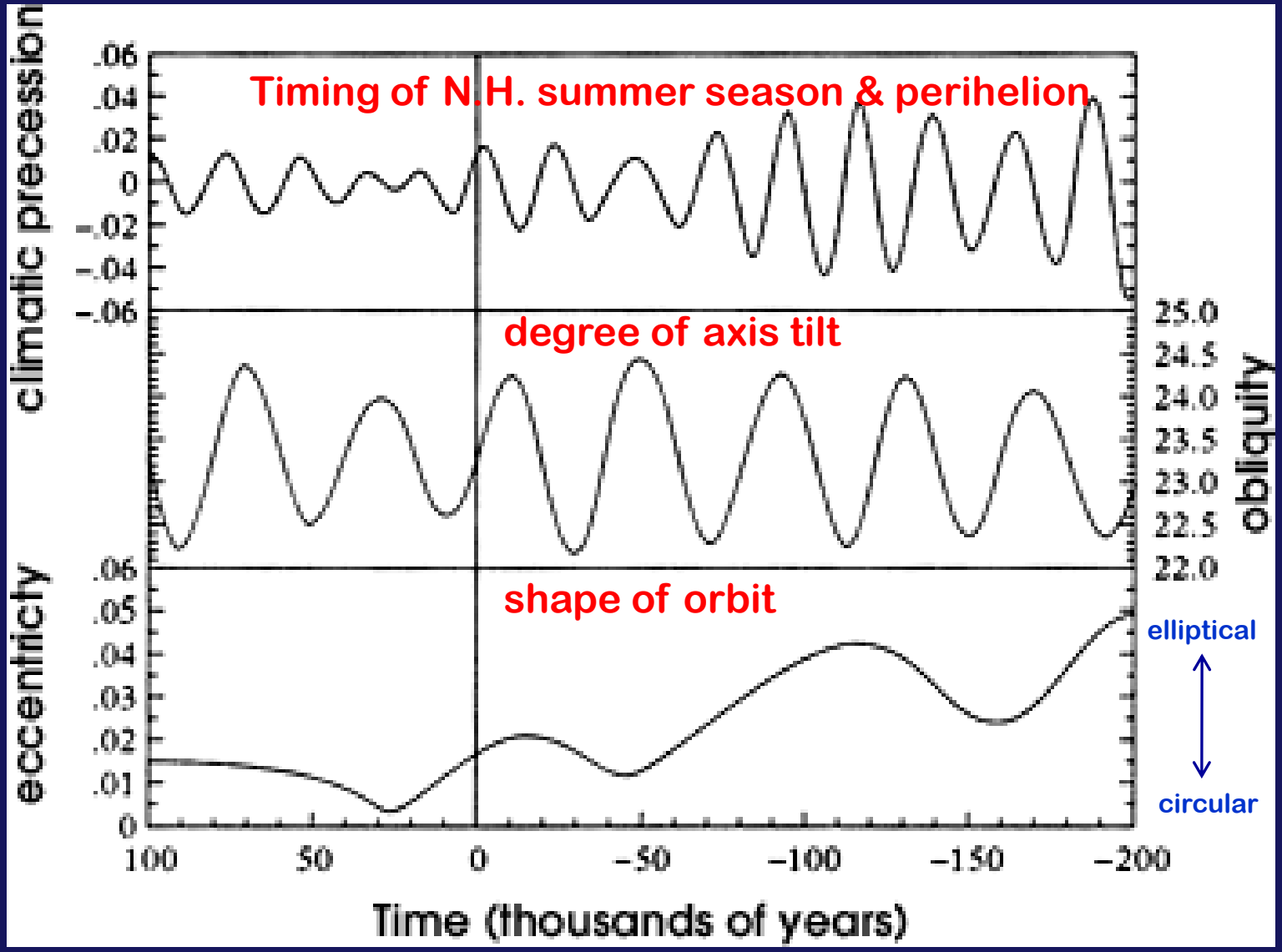
3. PRECESSION OF THE EQUINOXES
(Timing of Seasons in Relation to Orbit)

Currently the Earth is <u>closest to the Sun</u> (perihelion) in Jan & <u>farthest</u> (aphelion) in July. This has varied in the past.

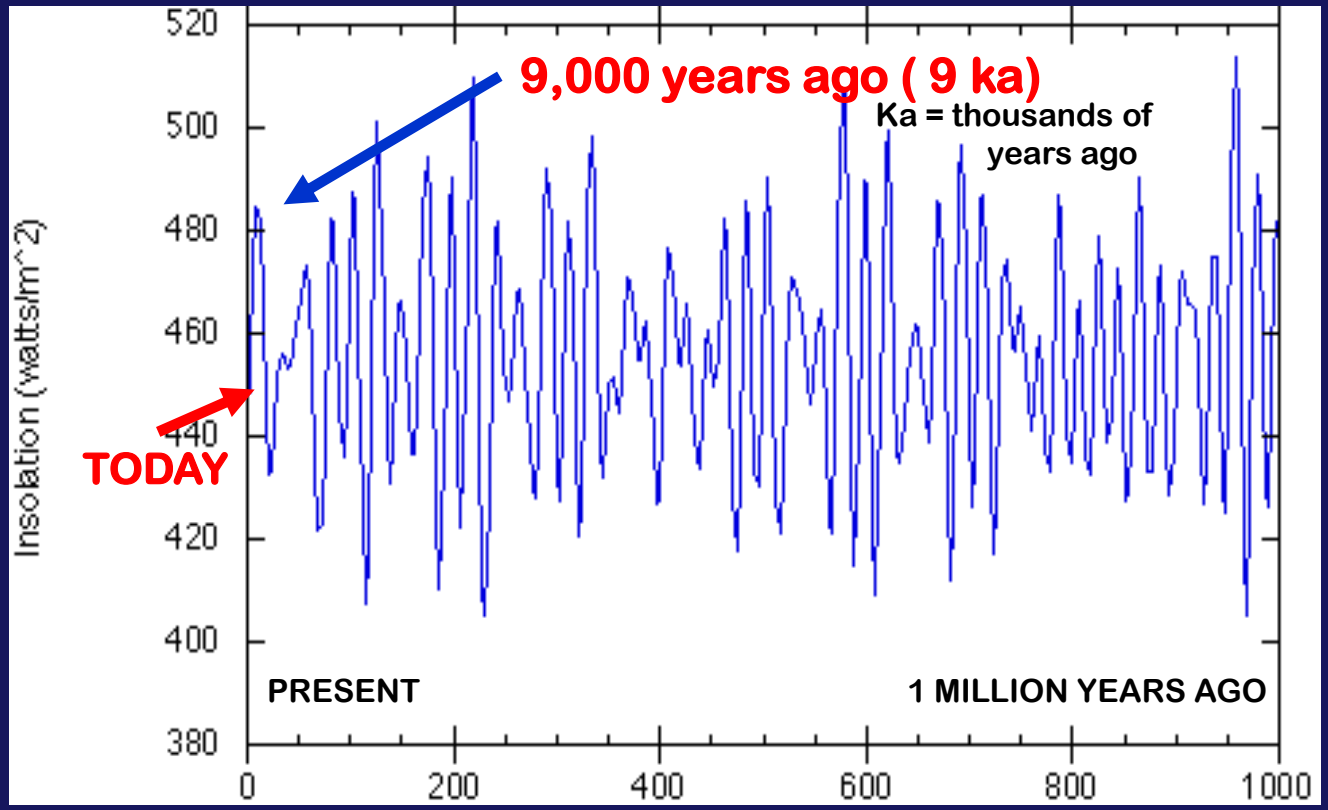




the Future ← TODAY → the Past *(in thousands of years)*



Summarizing graph of SOLAR INSOLATION calculated for 65 ° N latitude from the present to 1 million years ago based on "ASTRONOMICAL CLIMATE FORCING"



In the Northern Hemisphere, peak summer insolation occurred about 9,000 years ago when the last of the large ice sheets melted.

Since then N. H. summers have seen LESS solar radiation.

INDICATOR INTERLUDE

Denier Argument #1:

"Climate's changed before"

First discussed on p 21

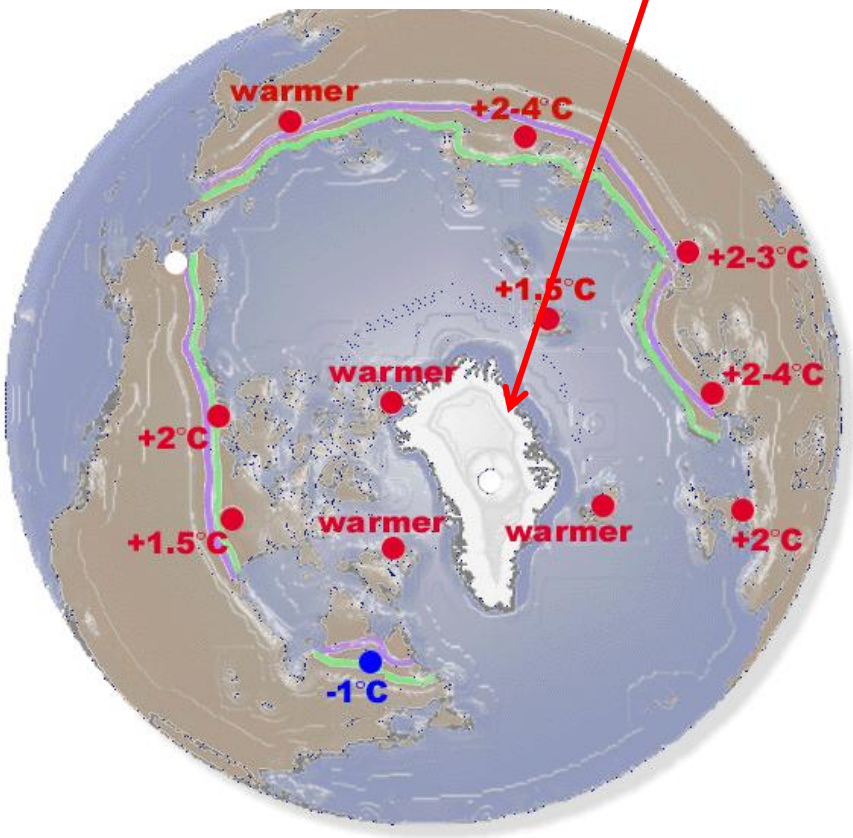
Mid-Holocene warm period
(~ 6,000 years ago)

Generally warmer than today, but only in summer and only in the northern hemisphere.

Cause =

"astronomical climate forcing"

Global warming "deniers" often point out how warm Greenland was in the past :

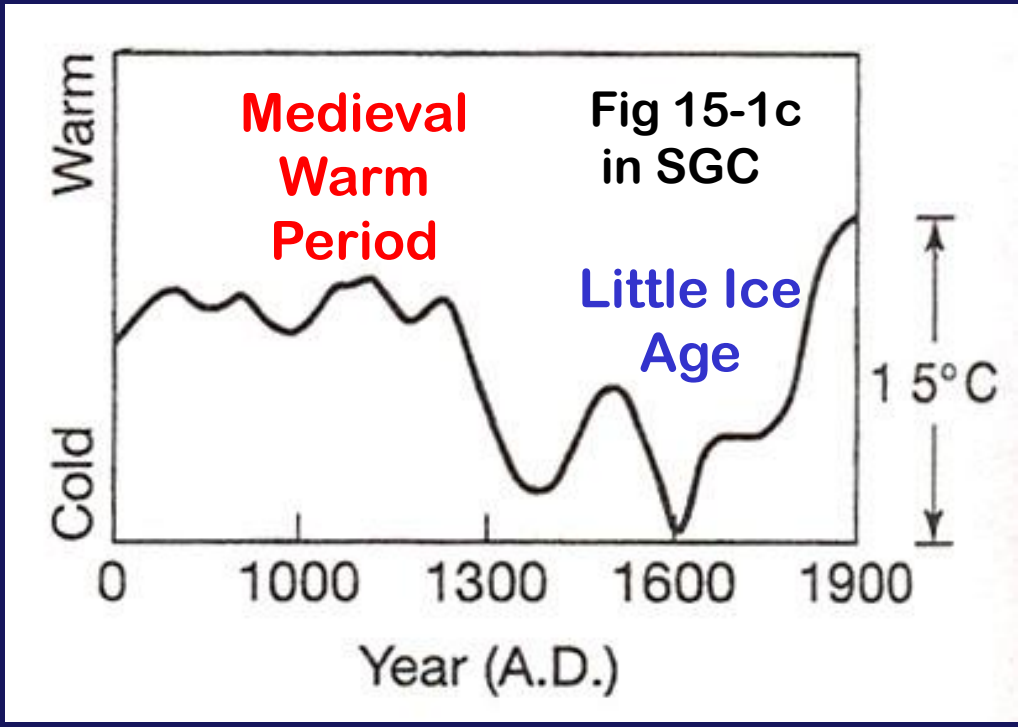


Top p 70

Other notable "naturally forced" climate changes of the more recent past:

Medieval Warm Period (MWP)

9th-14th centuries
(800-1300)
(regionally most evident in Europe)



Little Ice Age (LIA)

15th – 19th centuries
(1400-1800)
esp. 1600 -1800 (evidence found globally)

The 3 main drivers of NATURAL CLIMATIC FORCING:

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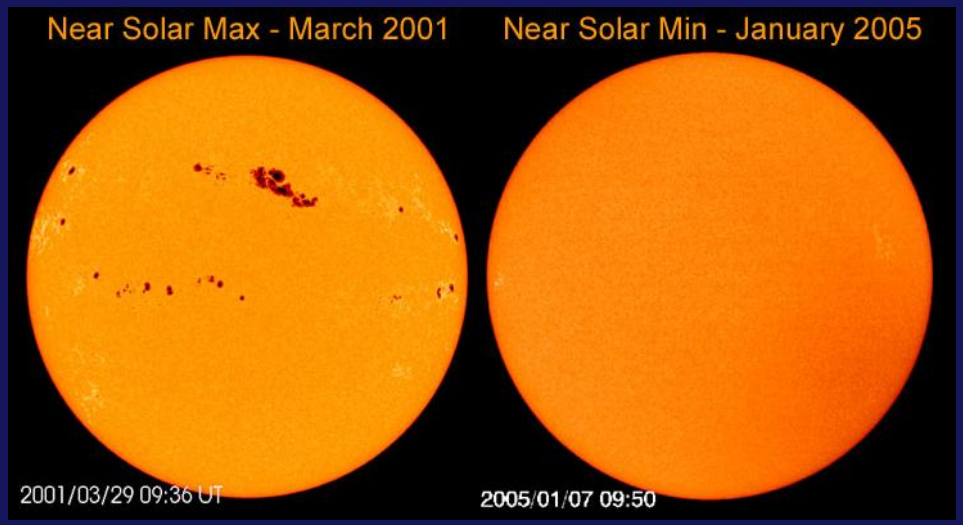
2) SOLAR FORCING ←

3) VOLCANIC FORCING

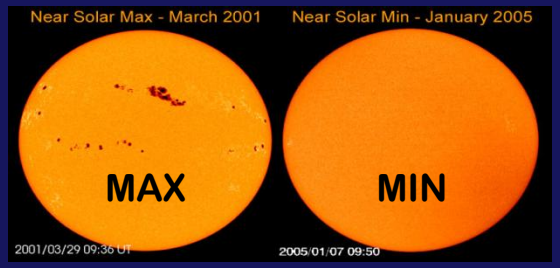
ANOTHER POSSIBLE NATURAL FORCING: SOLAR VARIABILITY

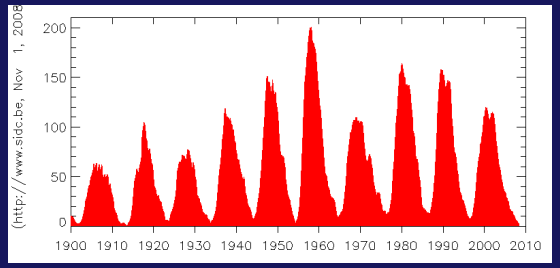


Sunspot maxima = MORE solar brightness (warmer temps)

Sunspot minima = LESS solar brightness (cooler temps)

ANOTHER POSSIBLE NATURAL FORCING: SOLAR VARIABILITY





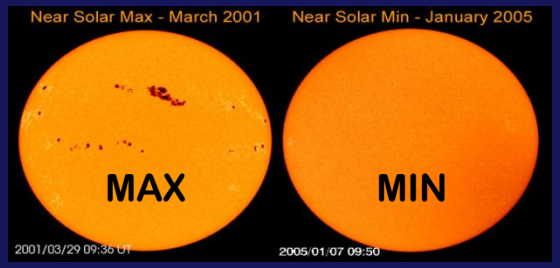
Q1 – During SUNSPOT Maximum periods:

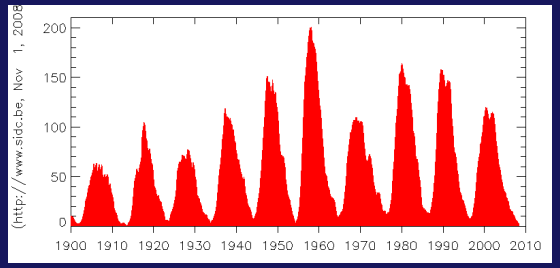
1. The sun is darker so it gives off less energy and global cooling is likely.

2. The sun sunspots indicate active solar flares and the sun gives off more energy leading to warmer periods.

3. There is no link between solar activity and global warming.

ANOTHER POSSIBLE NATURAL FORCING: SOLAR VARIABILITY



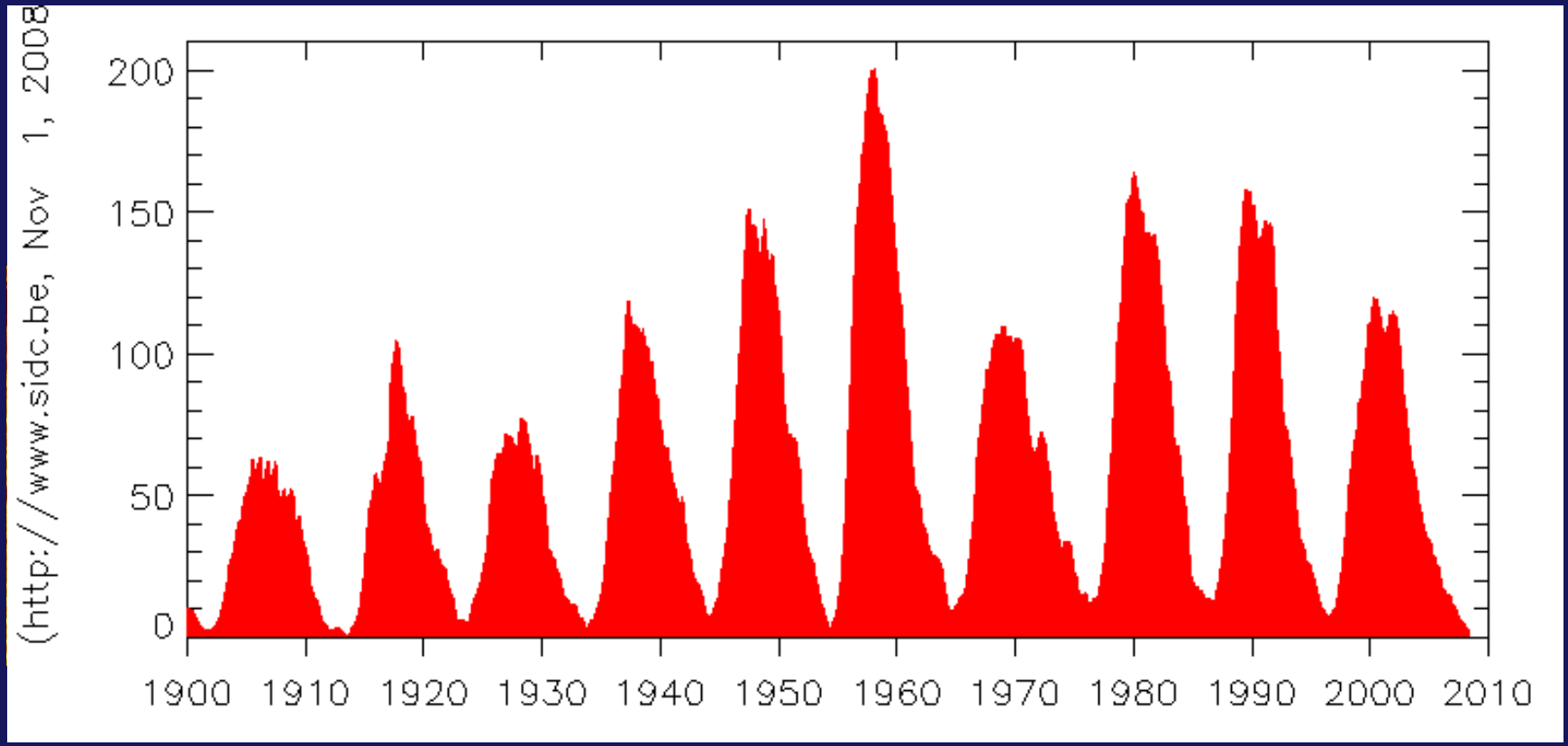


Q2 – During SUNSPOT Maximum periods:

1. The sun is darker so it gives off less energy and global cooling is likely.

2. The sun sunspots indicate active solar flares and the sun gives off more energy leading to warmer periods.

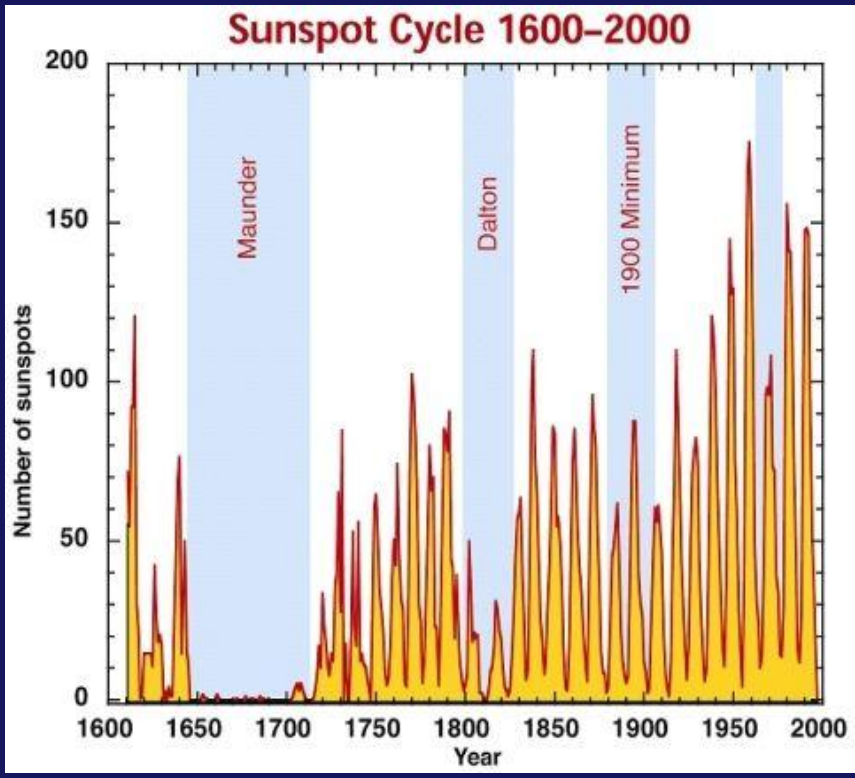
3. There is no link between solar activity and global warming.



Sunspot maxima = MORE solar brightness (warmer temps)

Sunspot minima = LESS solar brightness (cooler temps)

Maunder Minimum (cooler) (1645 -1715) linked to "Little Ice Age" (1600-1800)



But uncertainties remain!
What's the MECHANISM that links the Sun's drop in brightness to the lower temperatures on the Earth?

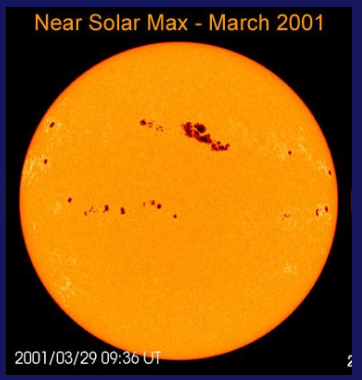
Dalton Minimum (1795 – 1825)

-- also cooler

-- lots of large volcanic eruptions then too

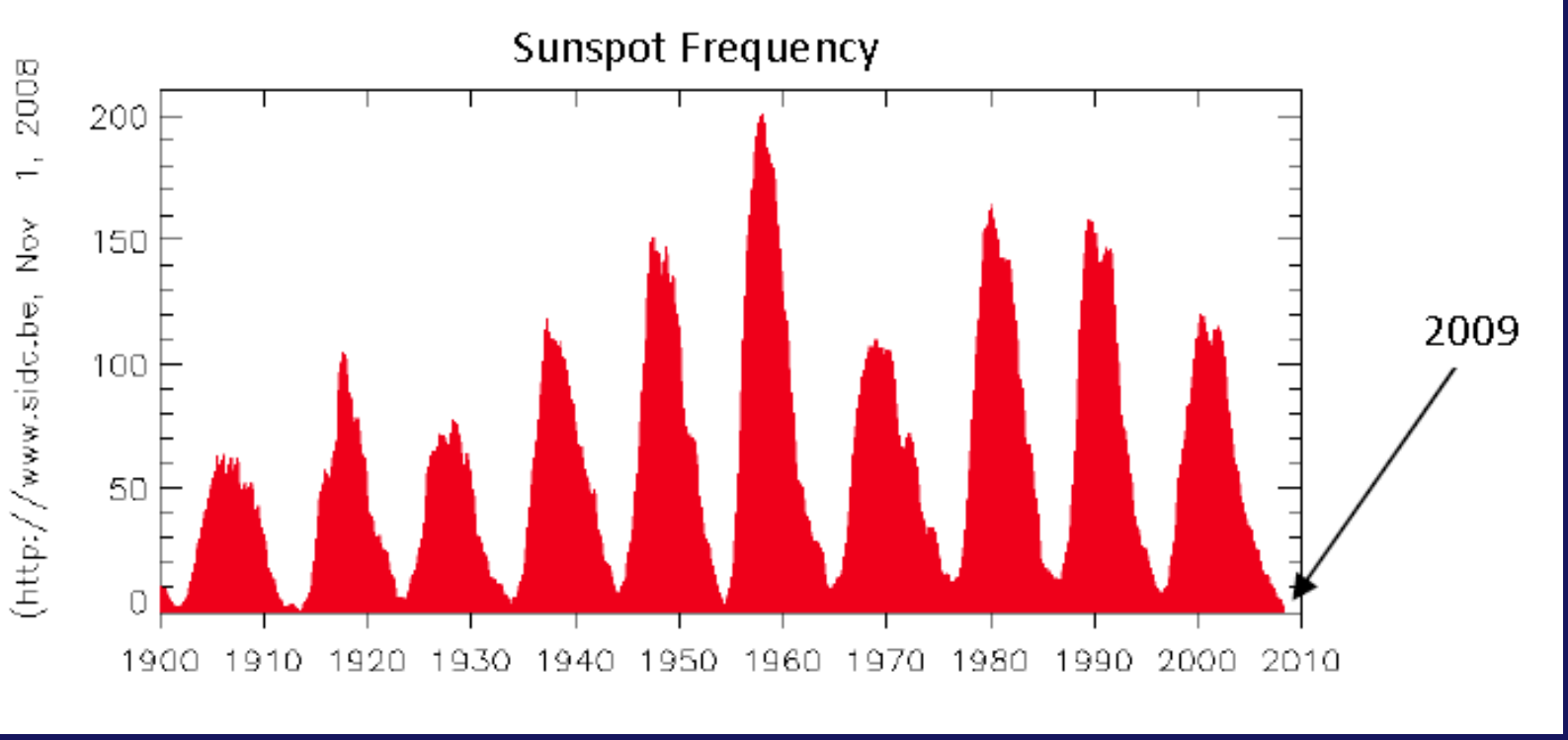
Since the Dalton Minimum, the Sun has gradually brightened – we just came out of a "Modern Maximum" (max in 2001)

BUT . . .
The increase in solar brightness during the recent "Modern Maximum" accounted for only:



- **about ½ of the temperature increase since 1860**, and
- **less than 1/3 since 1970**

The rest is attributed to greenhouse-effect warming by most experts in solar forcing.



Recently we were in a SOLAR MINIMUM

– ***this caused some (controversial) interest because:***

- minimum seemed unusually long
- number of "spotless" days has not been equaled since 1933
- the vigor of sunspots (in terms of magnetic strength and area) has greatly diminished
- Q: Are we going into another Maunder-like period? or
- Q: Will normal activity return within the year?

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Scientist Predicts Ice Age Within 10 Years

University of Mexico expert says lack of solar activity to cause significant cooling that will last over half a century

Paul Joseph Watson
Prison Planet
Tuesday, August 19, 2008

As evidence builds of the earth entering a dramatic cooling trend, another scientist has gone public with his conviction that we are about to enter a new ice age, rendering warnings about global warming fraudulent and irrelevant.

...h Of Sunspot Activity To Herald New Ice Age?

...legree drop in temperatures over next two decades

...g sun cycles for over 200 years predicts that global ... the next two decades as solar activity grinds to a halt ...ially heralding the onset of a new ice age.

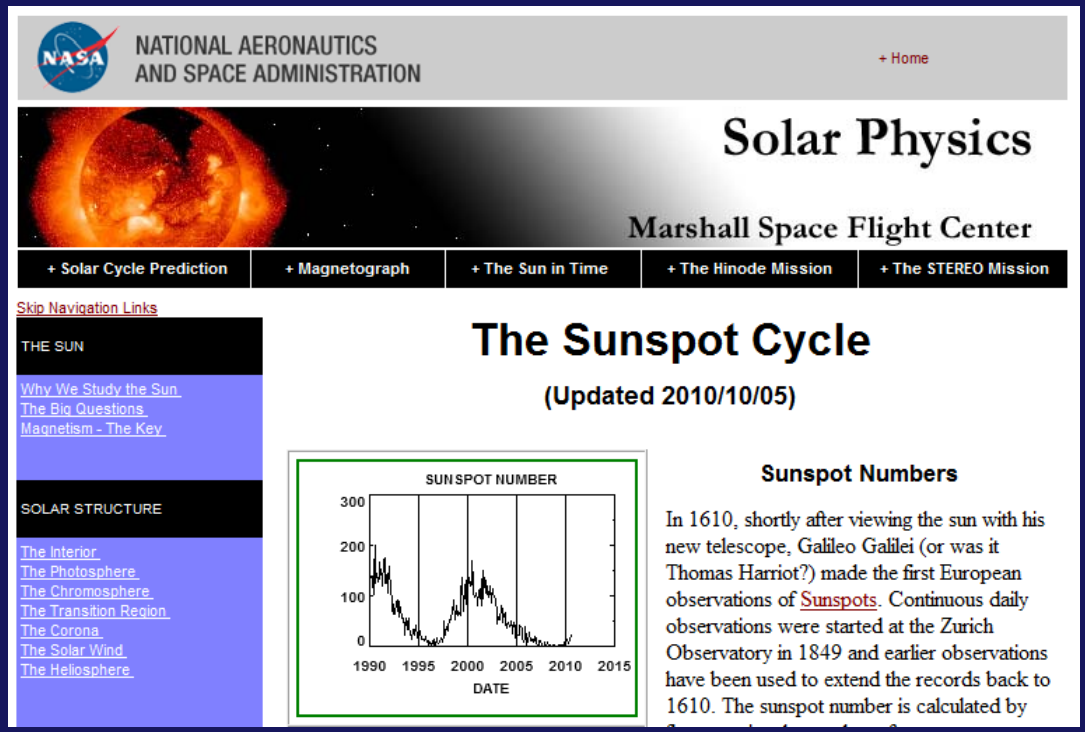
... bodies like the IPCC scaremonger about the ...d middle class pay CO2 taxes, both hard ...oints to a clear cooling trend.

...s most active period in over 11,000 years, the **last 10 years have ...cooling trend** as temperatures post-1998 leveled out and are now

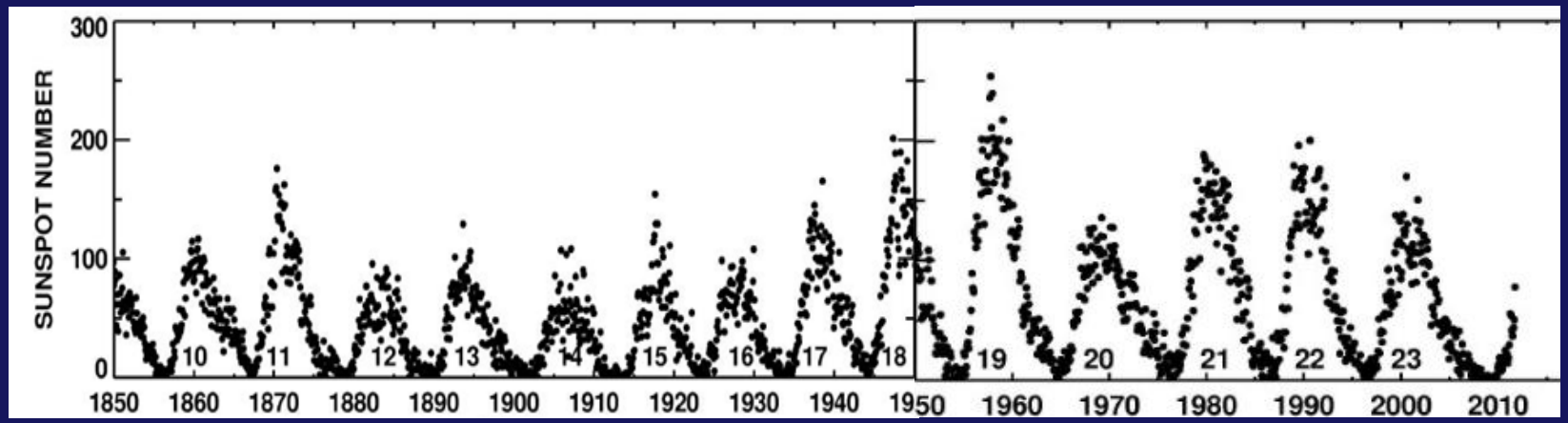
Not by Fire but by Ice

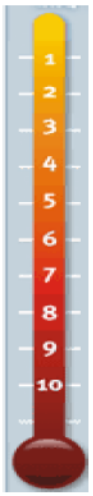
THE NEXT ICE AGE - NOW!

So what IS happening now?



http://solarscience.msfc.nasa.gov/SunspotCycle.shtml

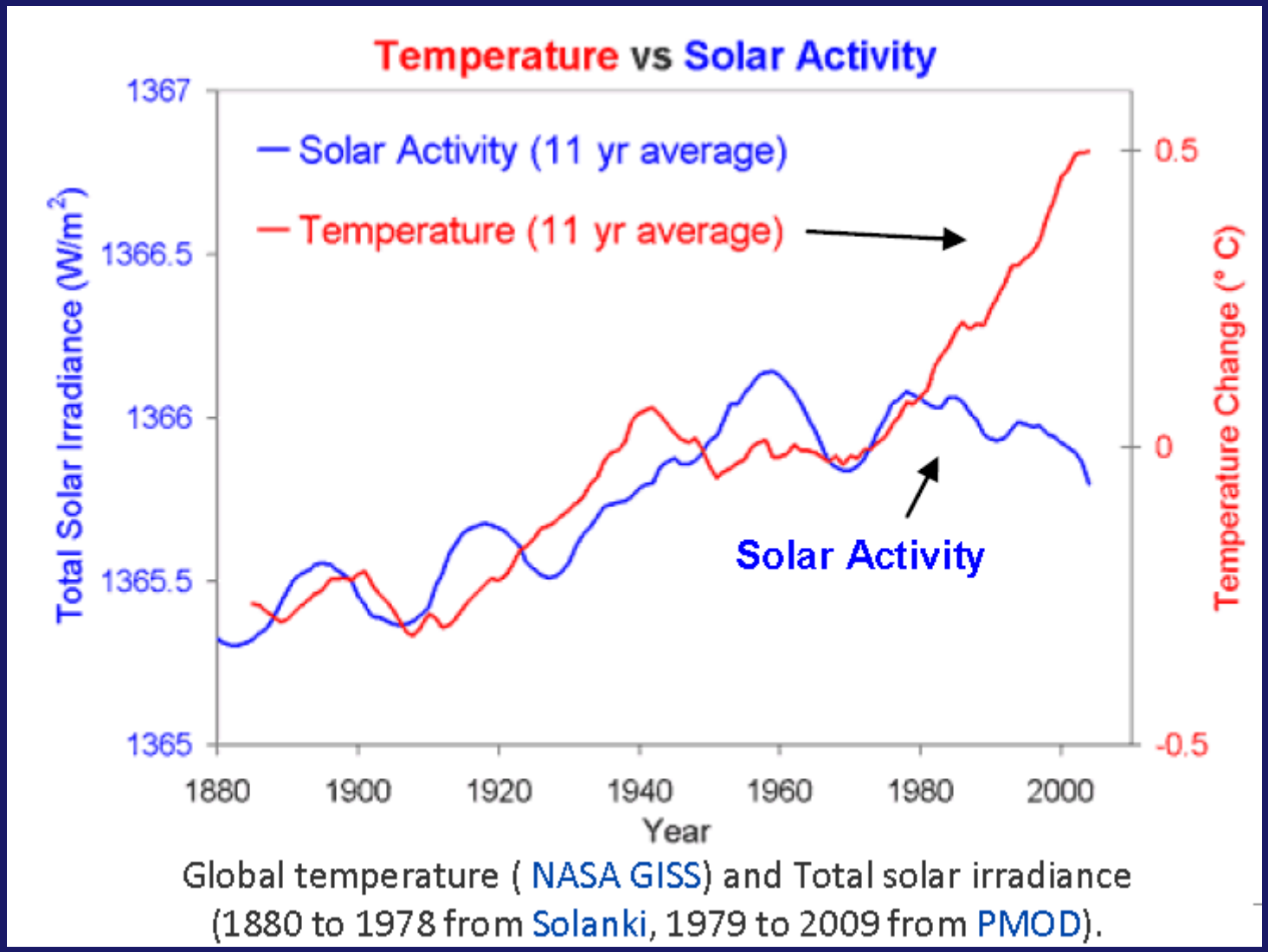




Indicator Interlude . . .

Denier Argument #2:

"It's the Sun"



Global temperature (NASA GISS) and Total solar irradiance (1880 to 1978 from Solanki, 1979 to 2009 from PMOD).

The Greenhouse Signature

What would a SOLAR Warming Signature look like?

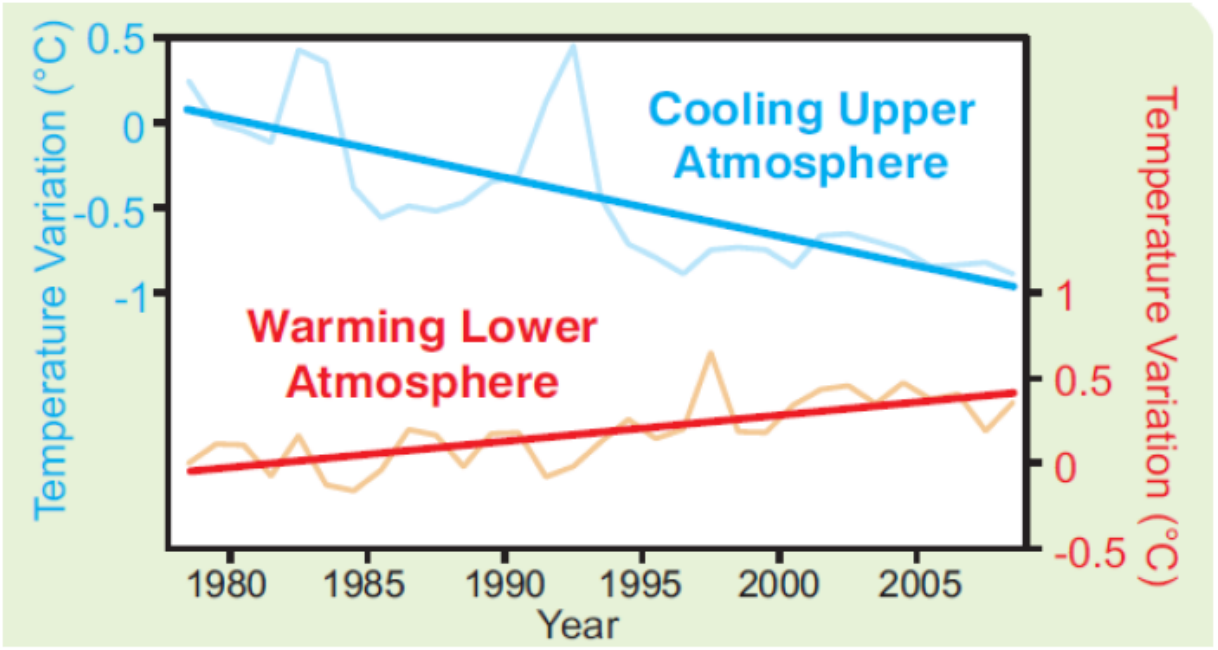
INDICATOR INTERLUDE . . .

The Greenhouse Warming Signature: *"Increasing CO2 warms the Troposphere and cools the Stratosphere"*

Solar Signature:
Warming in the upper atmosphere & cooling in the Troposphere . . .

From p 41

What has been observed since 1980:



Temperature variations (degrees C) in the upper (stratosphere) and lower (troposphere) atmosphere (measured by satellites)

Next short segment of: