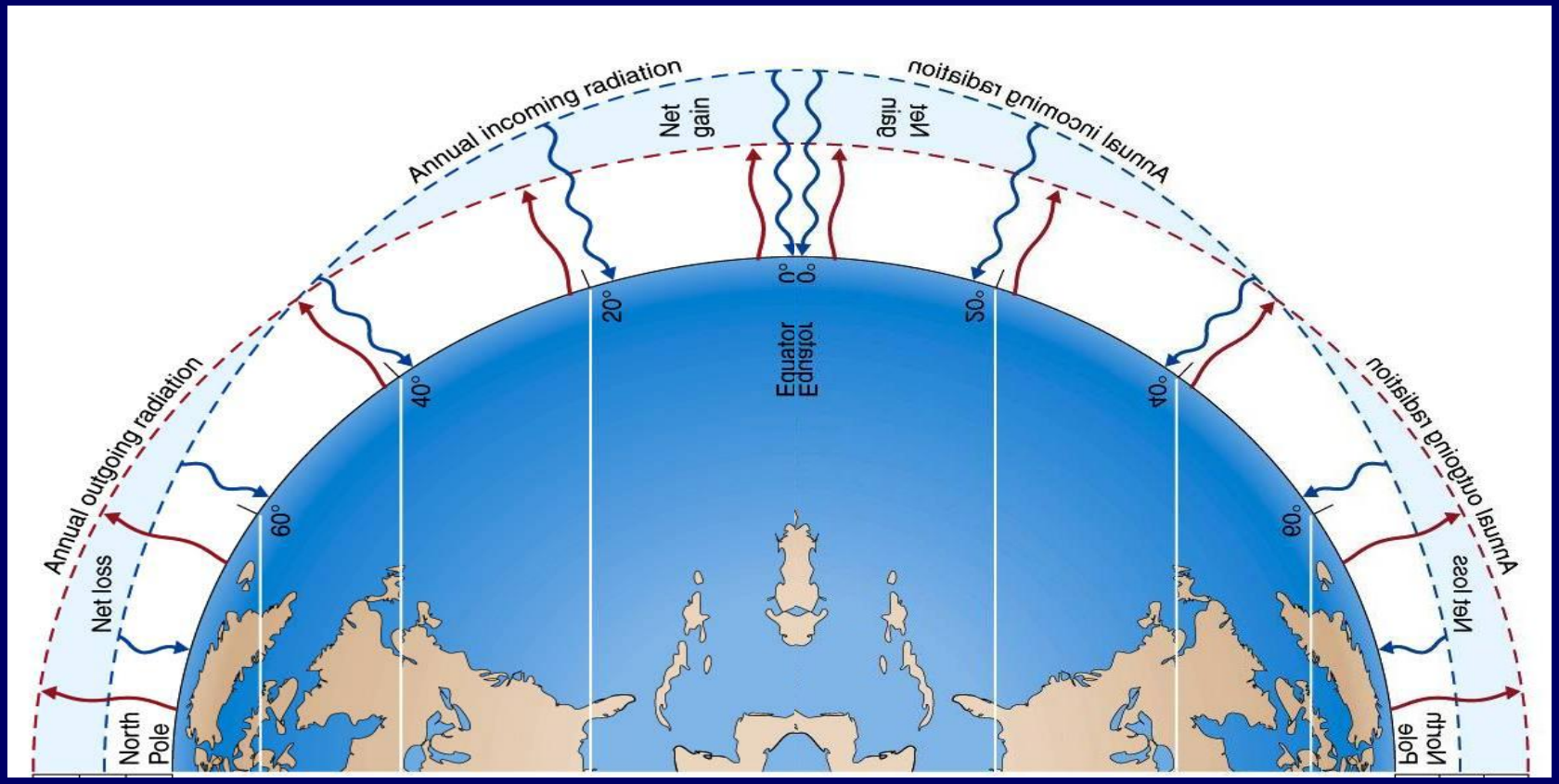
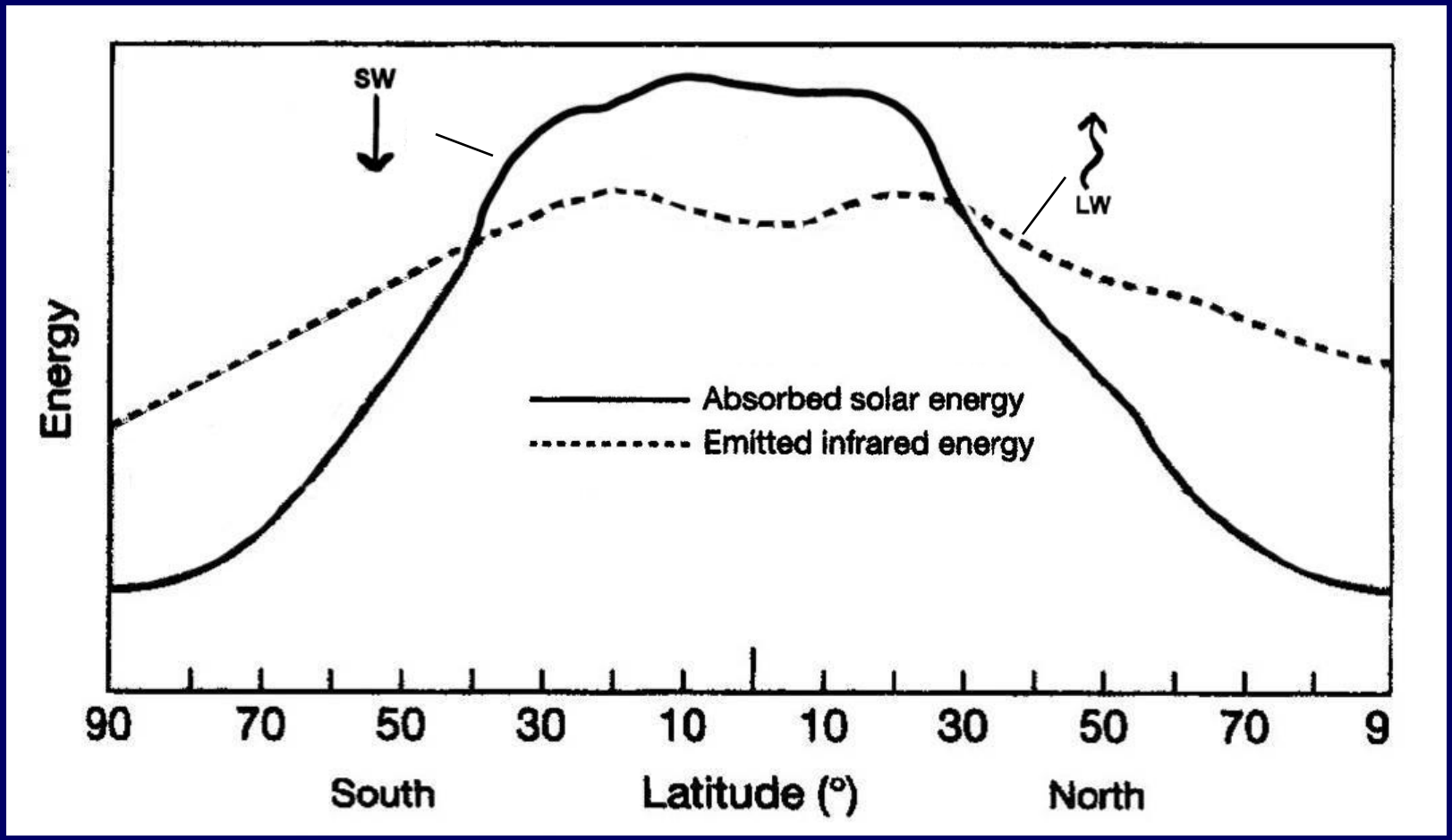
TOPIC #12

Wrap Up on GLOBAL CLIMATE PATTERNS



POLE **EQUATOR** **POLE**

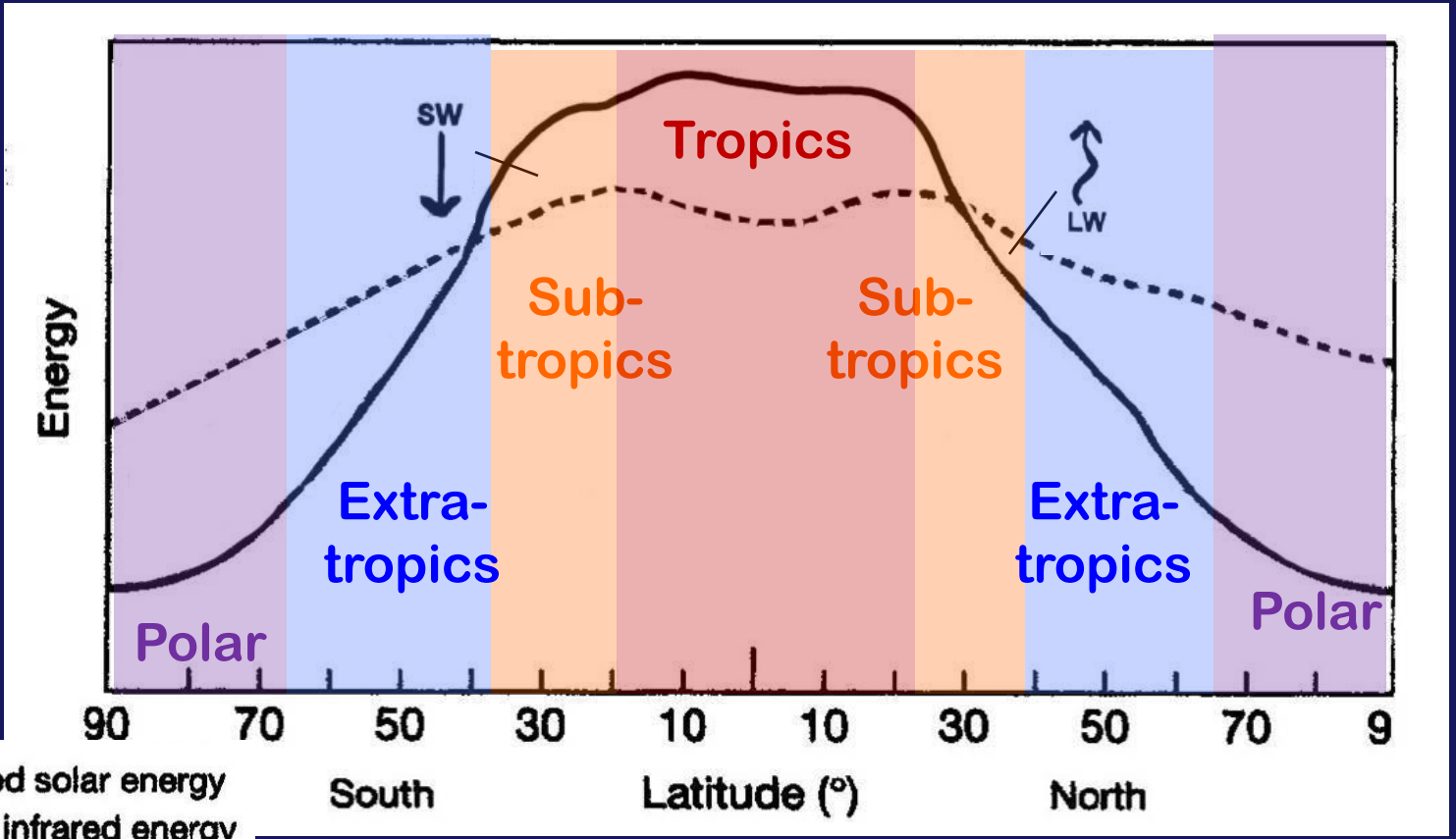
Now lets look at a Pole to Pole Transect


SW
LW
Energy
Absorbed solar energy
Emitted infrared energy
90
70
50
30
10
10
30
50
70
9
South
Latitude (°)
North

review

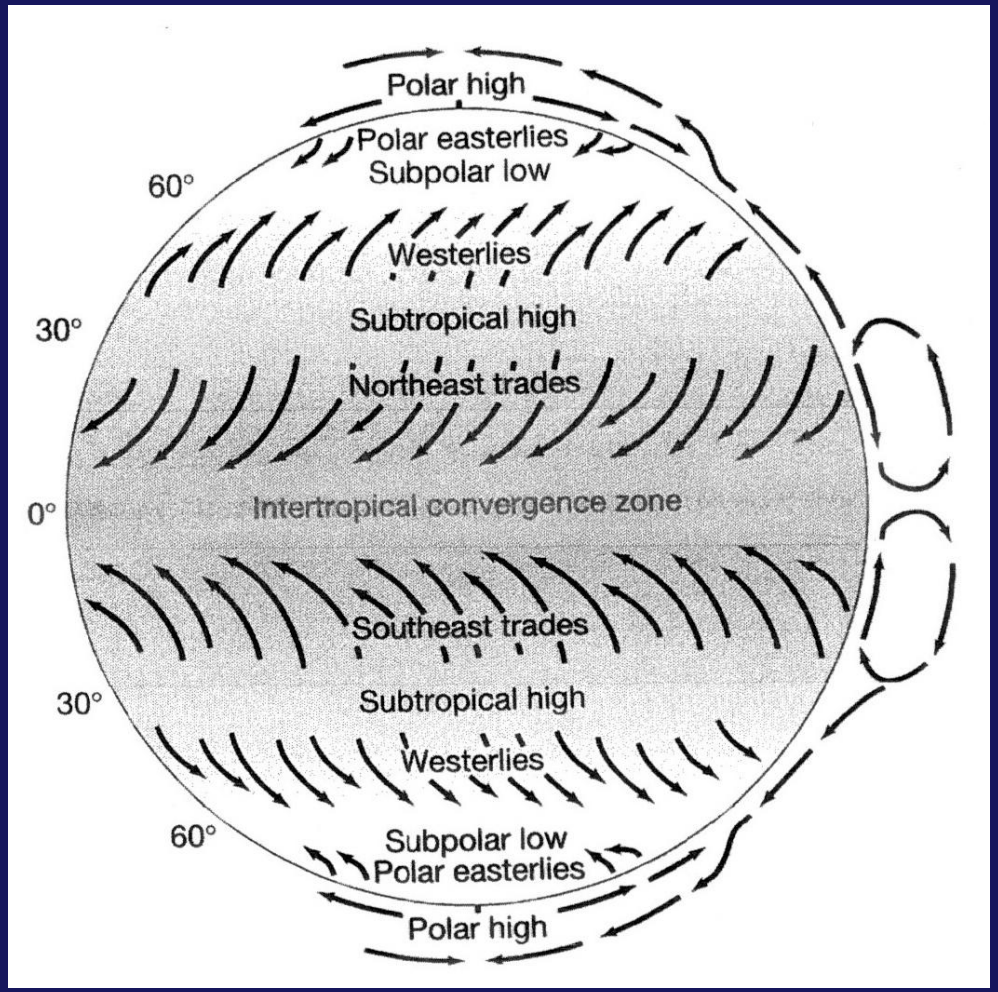
ENERGY BALANCE & CLIMATE REGIONS

(wrap up)



Global climate patterns are determined (in part) by regions of surplus and deficit in the ENERGY BALANCE

WHAT TO KNOW ABOUT THE GENERAL CIRCULATION: View 1

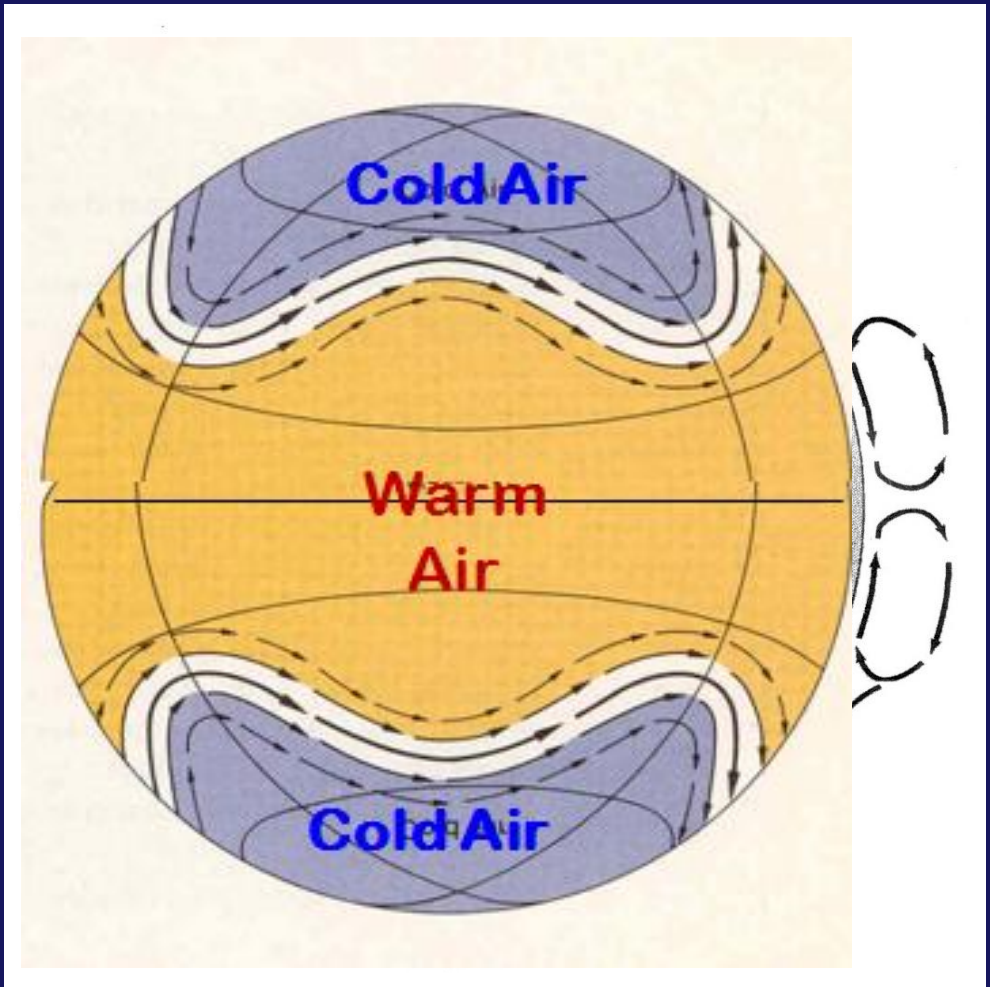


ROSSBY WAVES & JET STREAM = Key transport of Sensible Heat and exchange of cold air in the mid and high latitudes

HADLEY CELLS = key transport of Sensible Heat surplus in low latitudes!

ROSSBY WAVES & JET STREAM = Key transport of Sensible Heat and exchange of cold air in the mid and high latitudes

WHAT TO KNOW ABOUT THE GENERAL CIRCULATION: View 2



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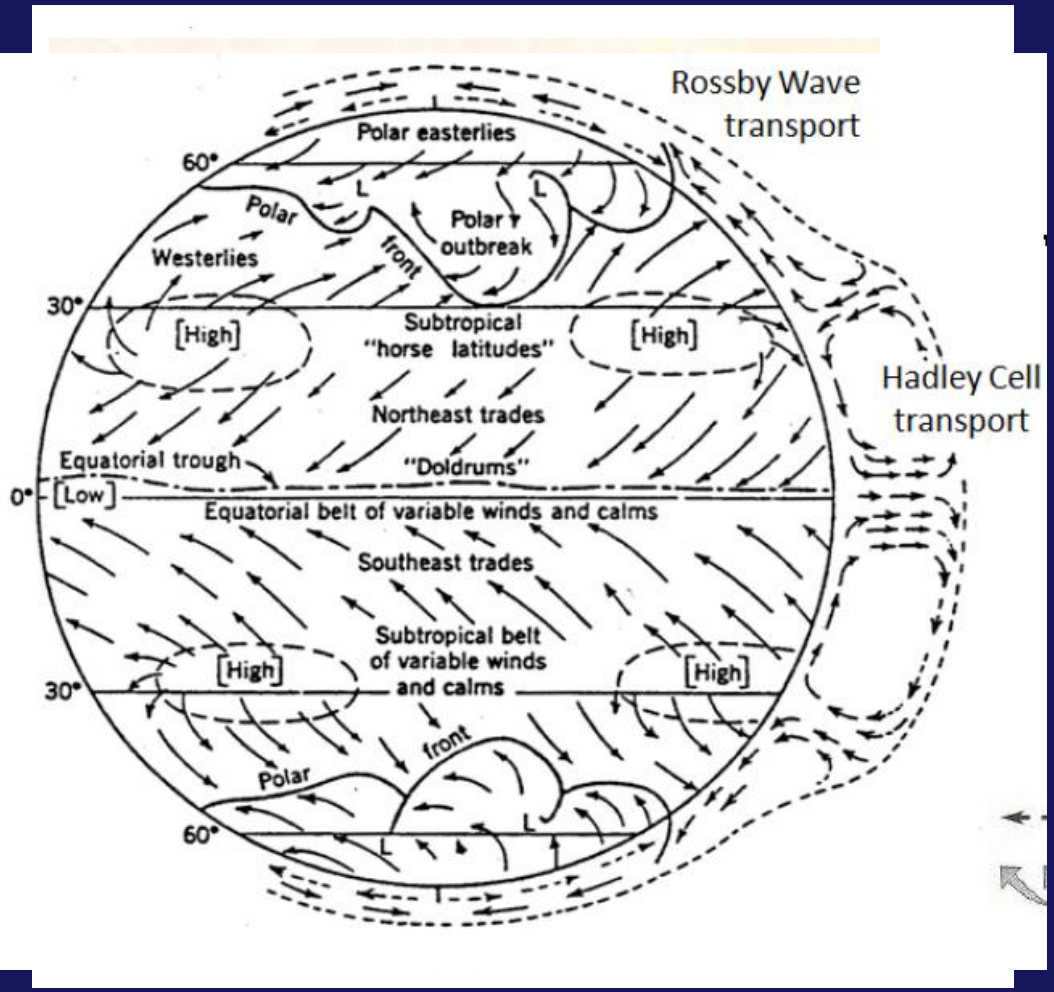
WHAT TO KNOW ABOUT THE GENERAL CIRCULATION: View 3



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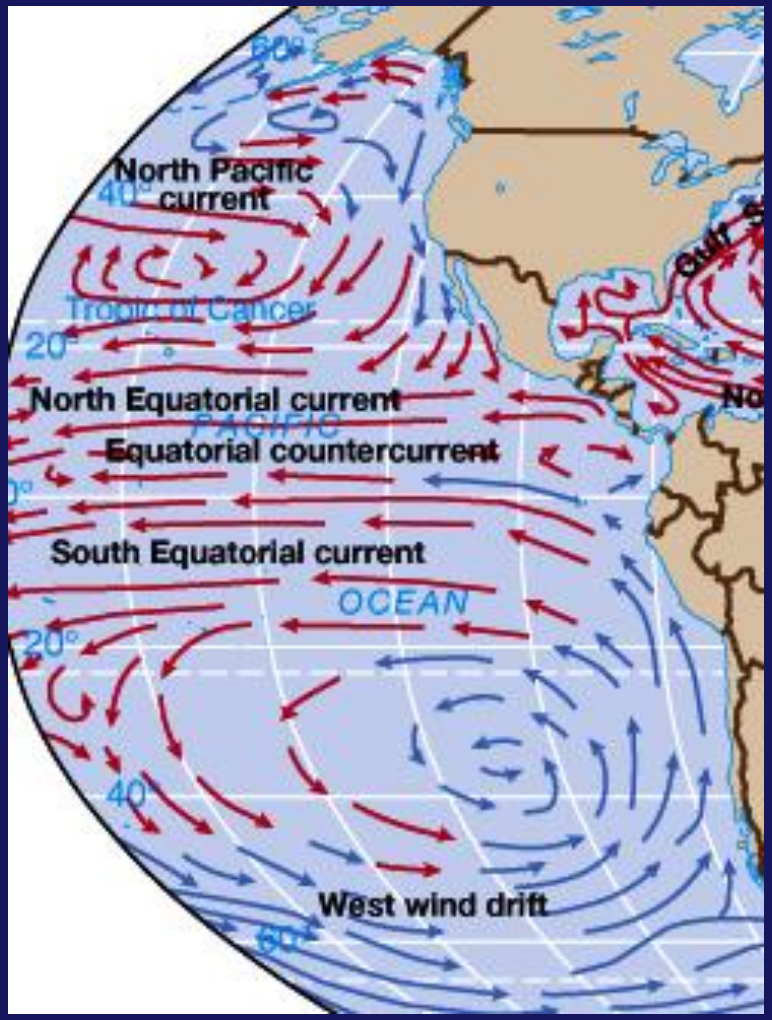
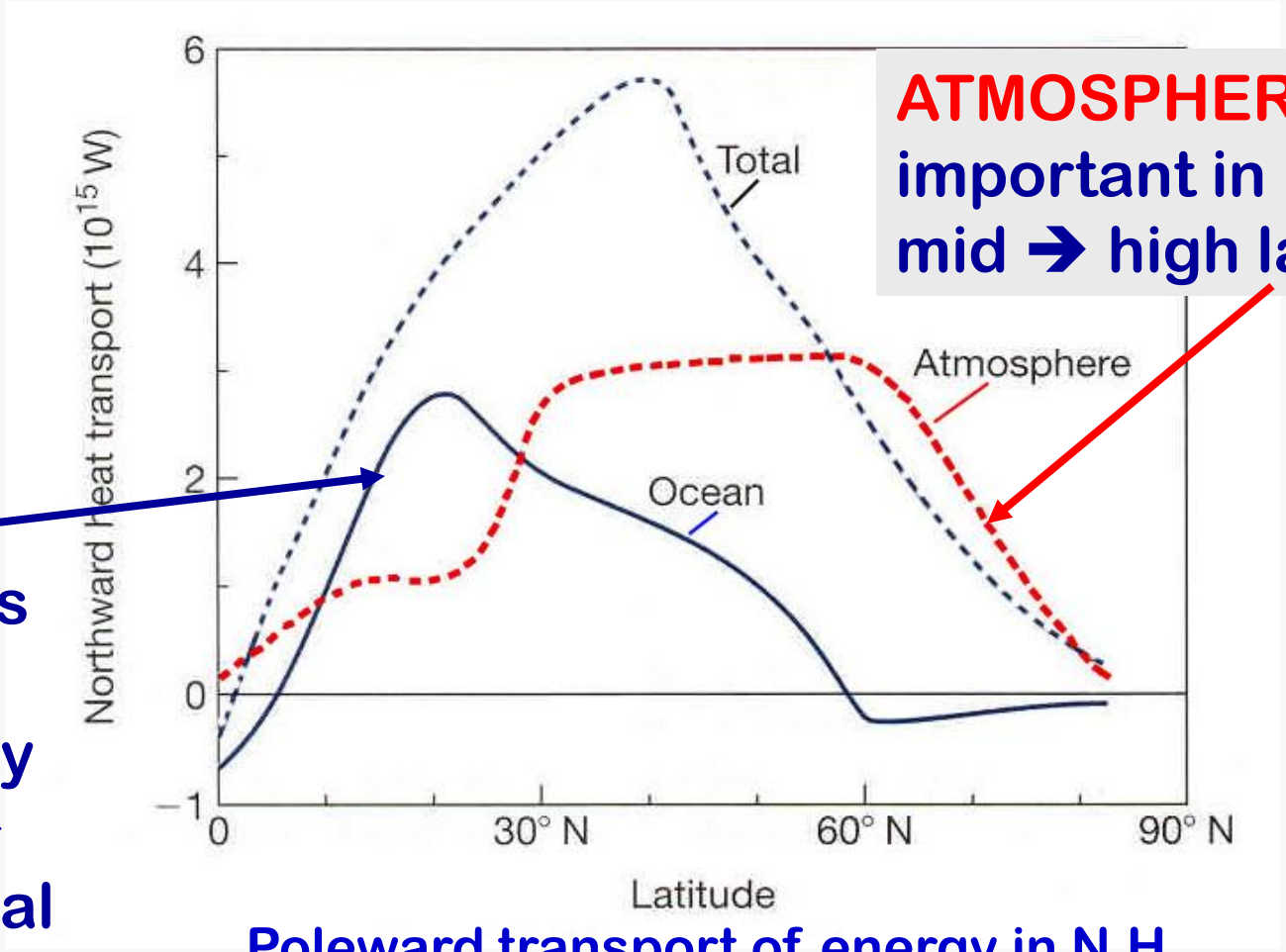


OCEAN CURRENTS are also important transporters of H (Sensible Heat)

Both ATMOSPHERE & OCEAN play important roles in BALANCING OUT ENERGY SURPLUS & DEFICIT AREAS:



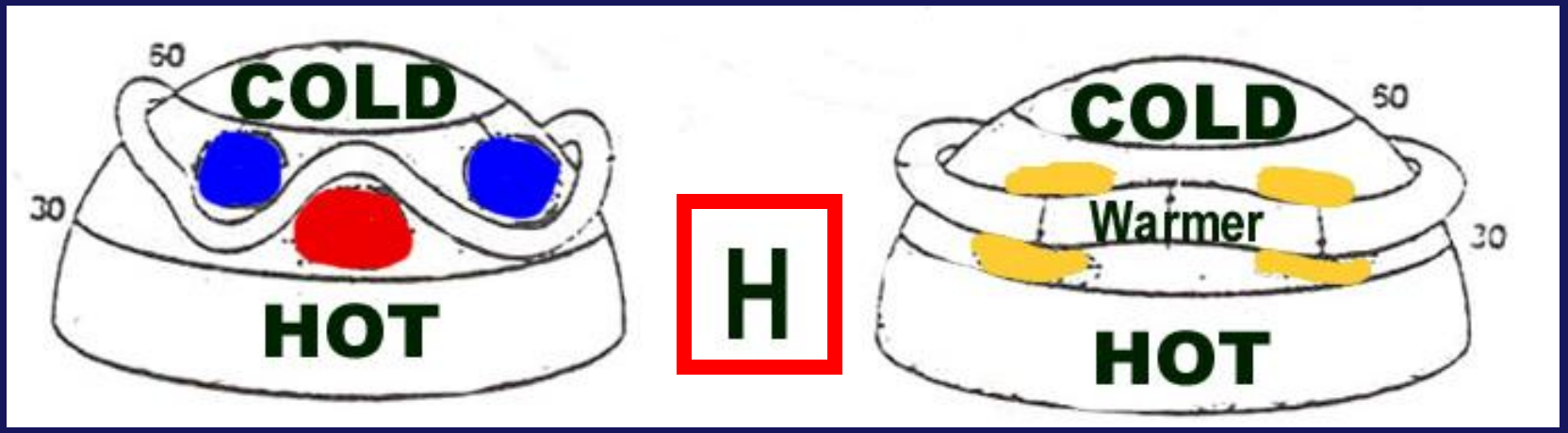
ATMOSPHERE more important in mid ➔ high latitudes

OCEAN transports MOST of the energy in LOW ➔ subtropical latitudes

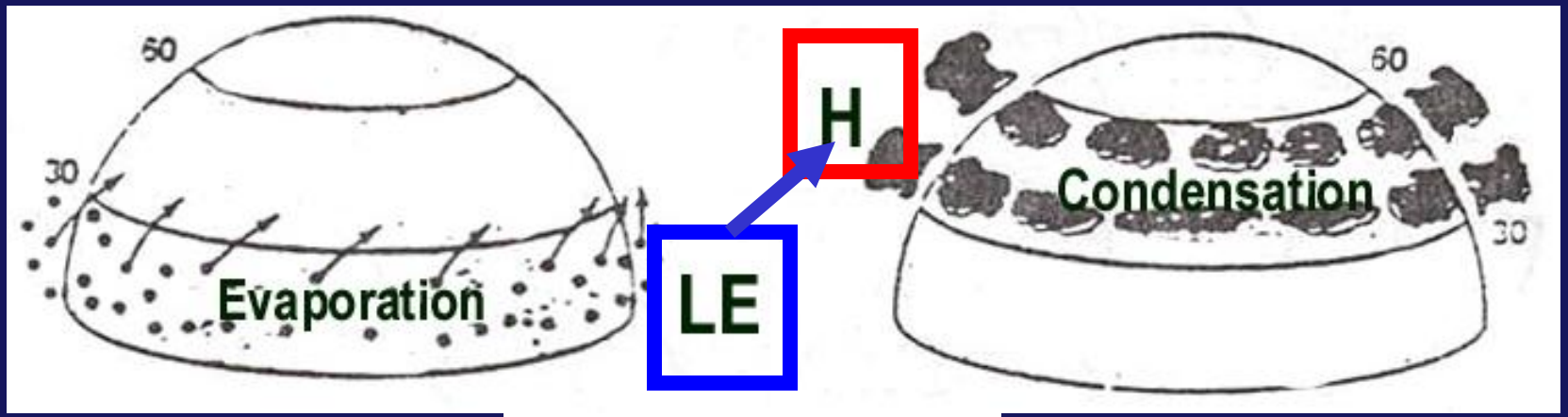
Poleward transport of energy in N.H.

Energy is transported from areas of surplus to deficit via:

H (sensible heat)



& LE (Latent Energy)



H + LE

TROPICAL

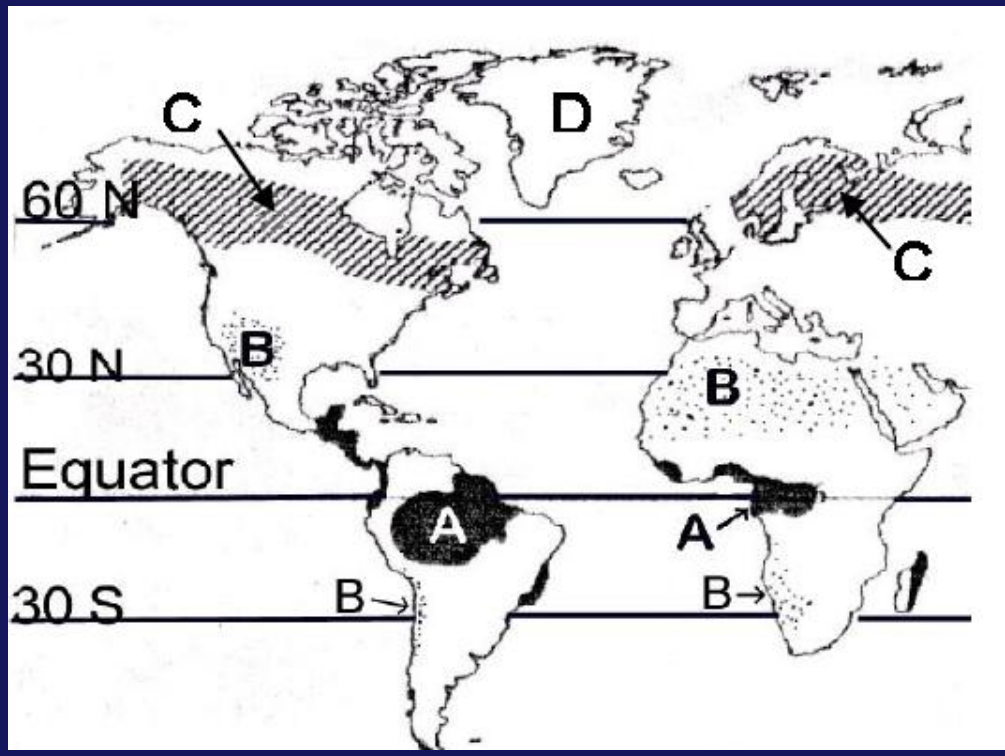
A-Tropical Forest

WHY? ITCZ, convergence + rising of warm, moist air)

SUBTROPICAL

B –Warm Desert

WHY? sinking air in STH (subtropical high) areas at 30° N + S)



EXTRATROPICAL / HIGH LATITUDE

p 67

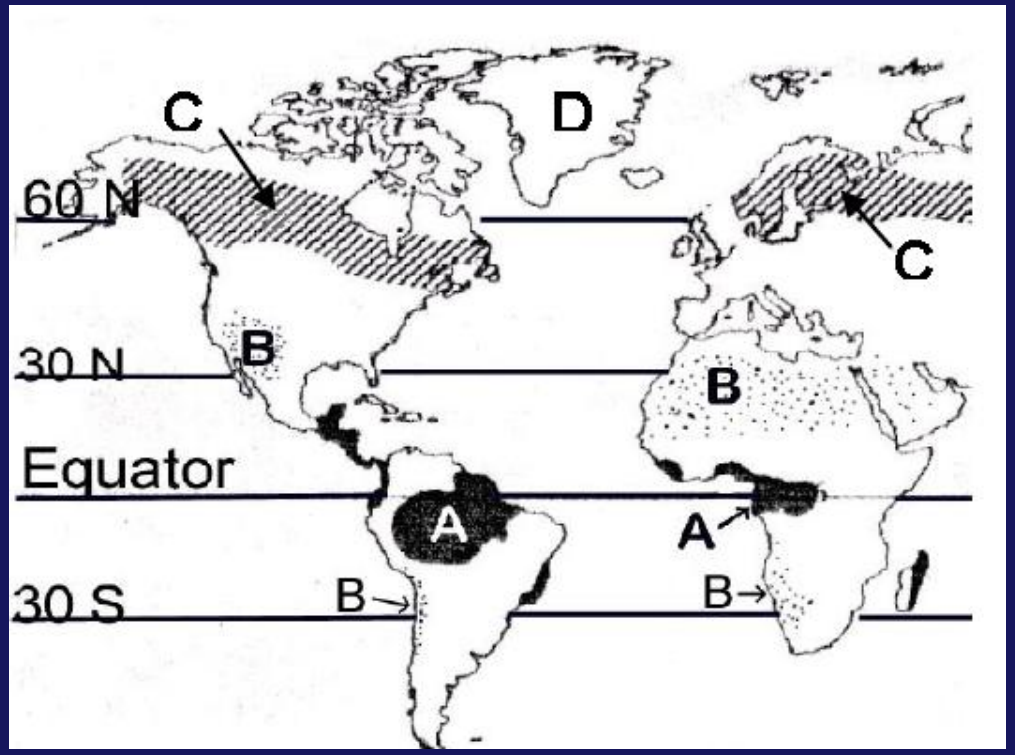
C – Evergreen Conifers / Boreal Forest (only in NH)

WHY? Low sun angle ➔ less insolation, Rossby Wave region ➔ cold polar air in winter + only a short growing season when warm air shifts poleward in summer; most successful species are "evergreen" and therefore always ready to photosynthesize when growing season begins

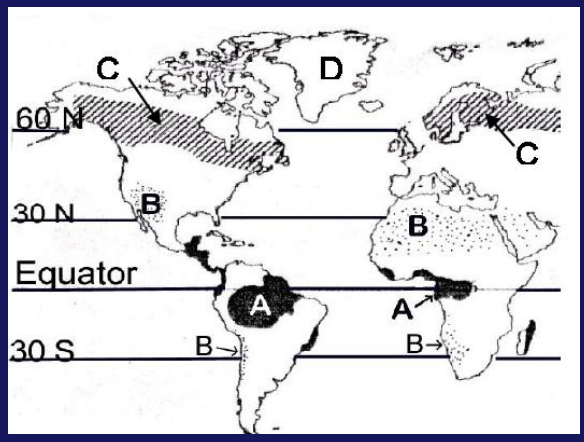
Between B + C =
Mid-latitude deciduous forests and other types of vegetation
WHY? Long, warm growing season, but cold winter (so trees drop their leaves)

Between C + D =
Tundra
WHY? too cold and too short a growing season for trees

D -No vegetation:
snow and ice!



Q. Most of the world's largest deserts (e.g., Sahara, Arabian, -- and even Arizona's Sonoran Desert) coincide with:



a) the polar front and Rossby wave zone

b) convergence of air in the Intertropical Convergence Zone (ITCZ)

c) sinking air at about 30° N and 30° S in the Hadley cell circulation that warms as it sinks

d) rising air at about 30° N and 30° S in the Hadley cell circulation that warms as it rises

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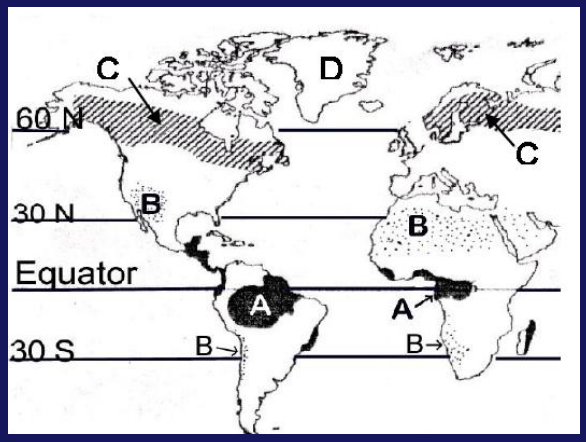

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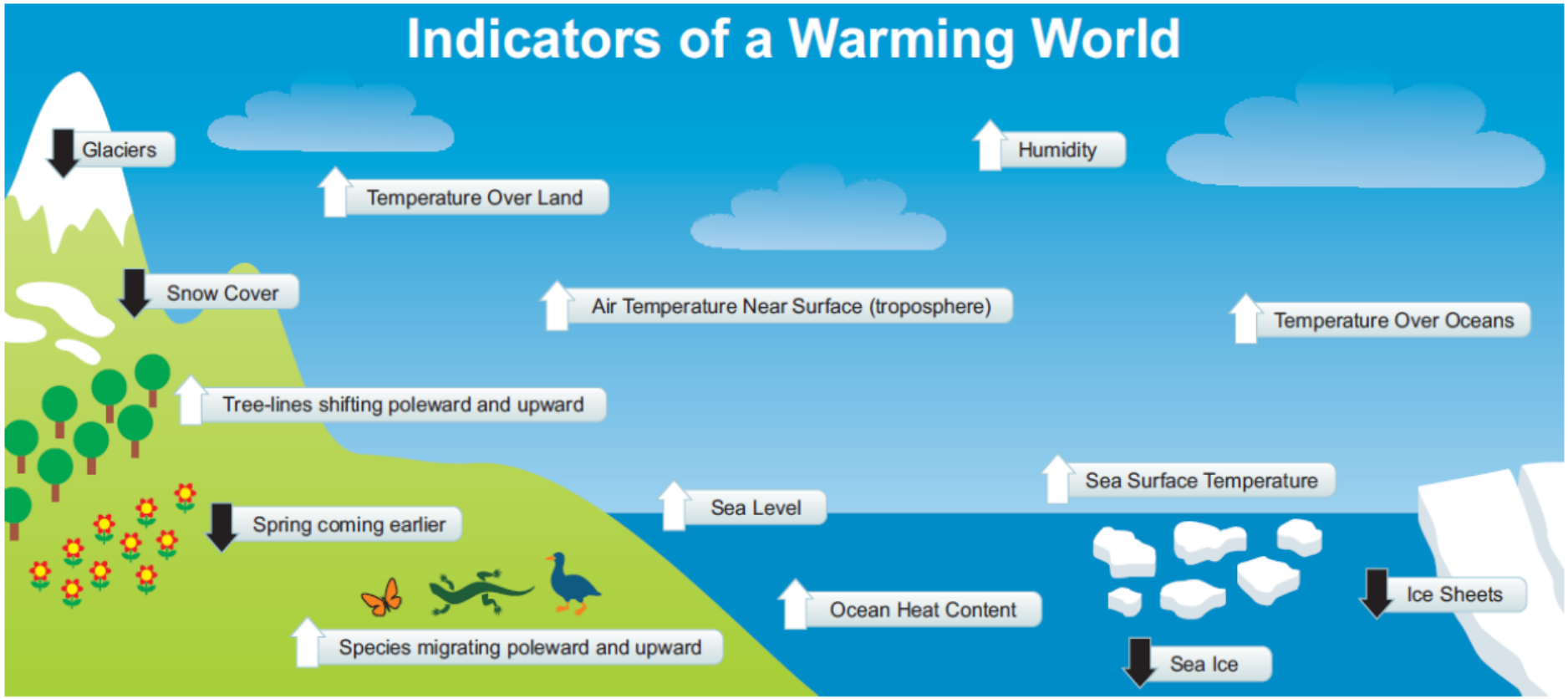
TOPIC #13

NATURAL CLIMATIC FORCING

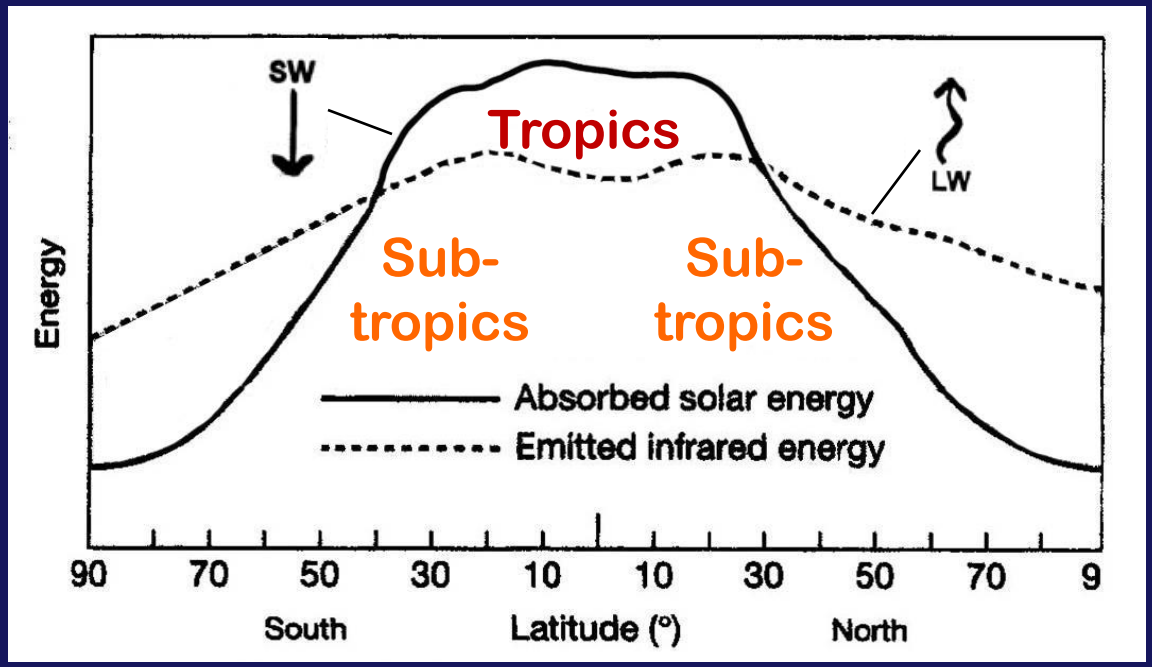
(Start on bottom of p 68 in Class Notes)

We will go over these in a future review lecture . . .

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



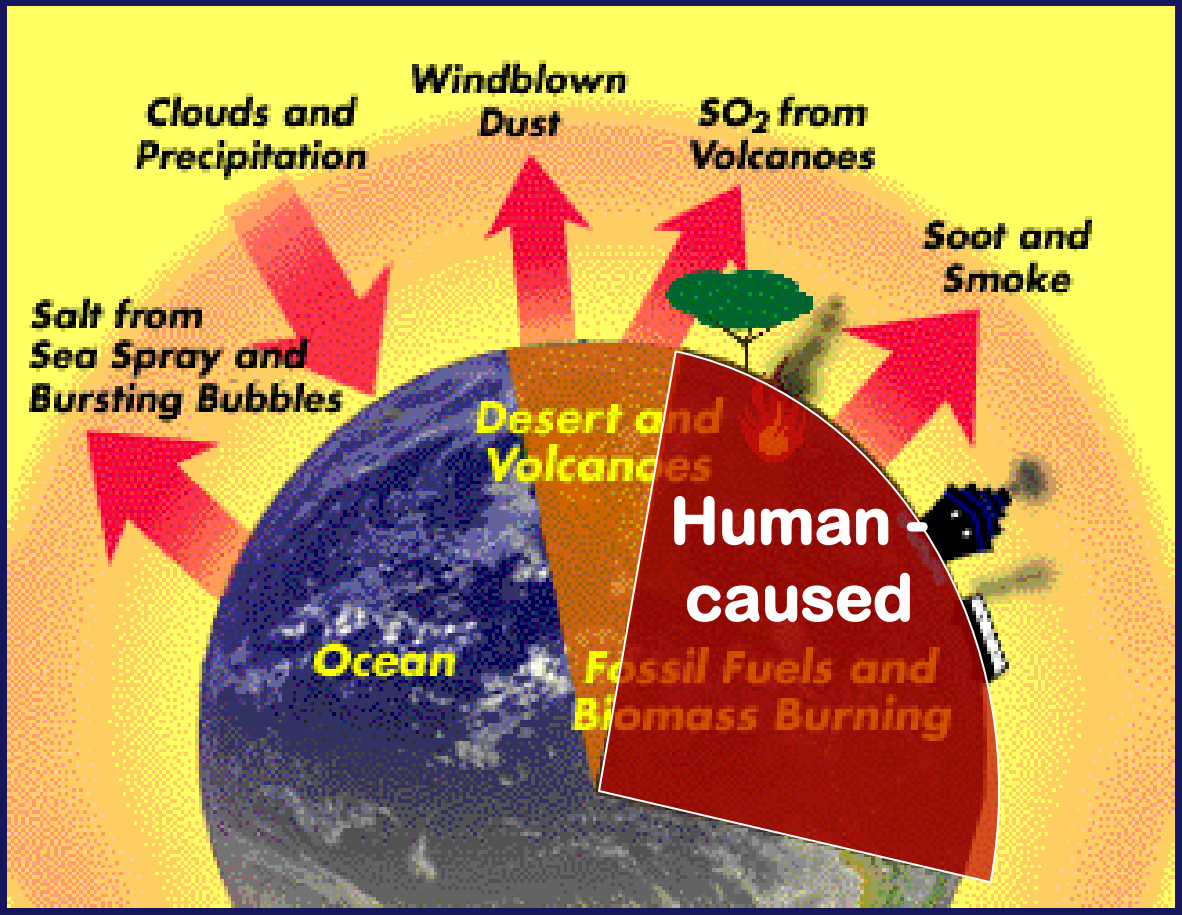
ENERGY BALANCE (review)



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

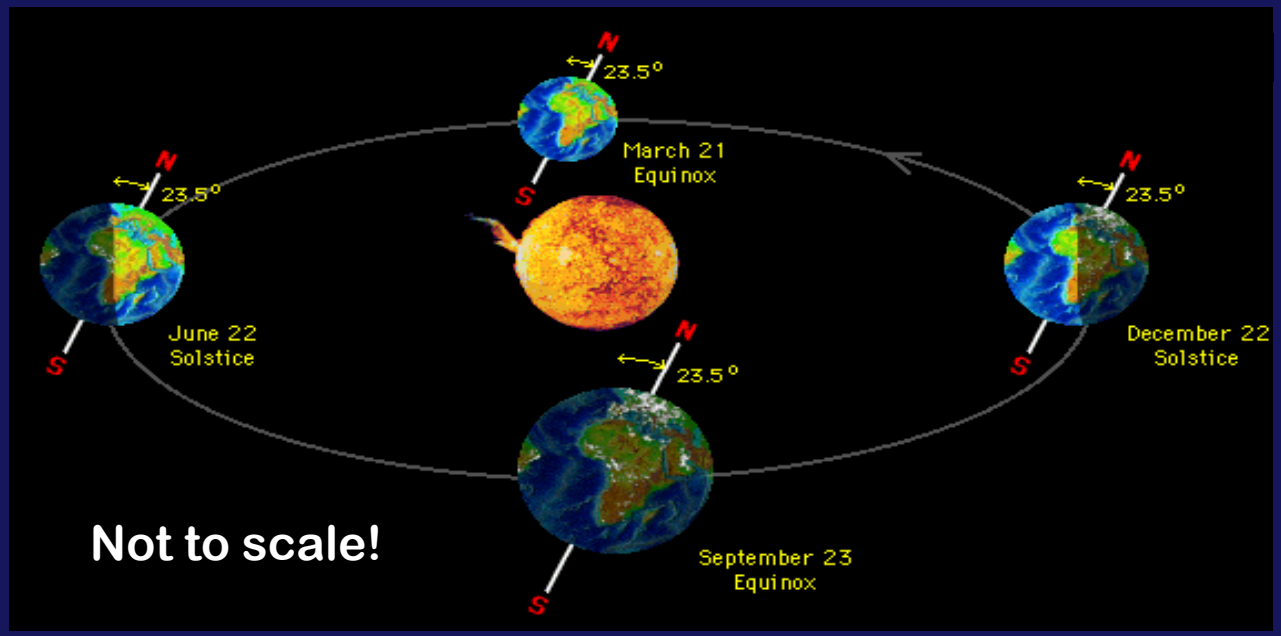
The 3 main drivers of NATURAL CLIMATIC FORCING:

1) ASTRONOMICAL FORCING ←

2) SOLAR FORCING

3) VOLCANIC FORCING

Remember EARTH-SUN Relationships?



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)

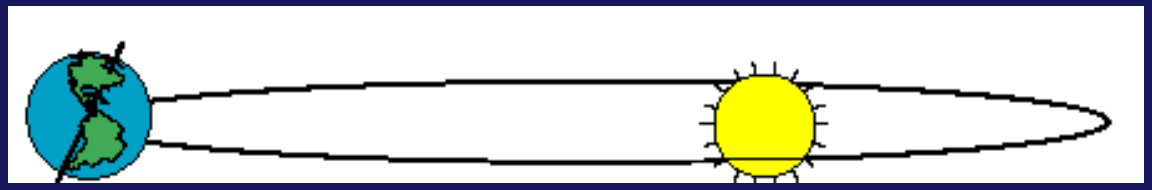
What has varied over time?

#1 OBLIQUITY OF EARTH'S AXIS

#2 ECCENTRICITY OF EARTH'S ORBIT

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

Q. What is being represented by this diagram ?

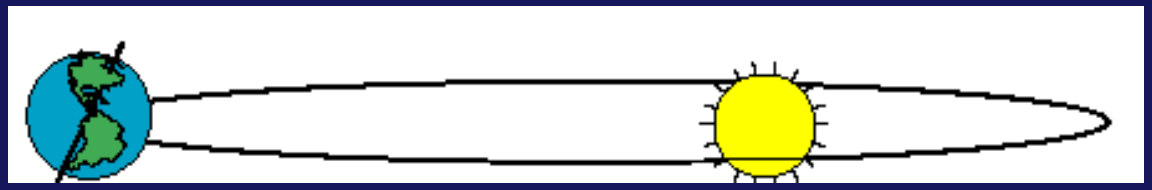


1 - One of the Equinoxes, where every latitude on Earth experiences 12 hours of daylight and 12 hours of darkness.

2 - Northern Hemisphere winter.

3 -Northern Hemisphere summer.

Q. What is being represented by this diagram ?



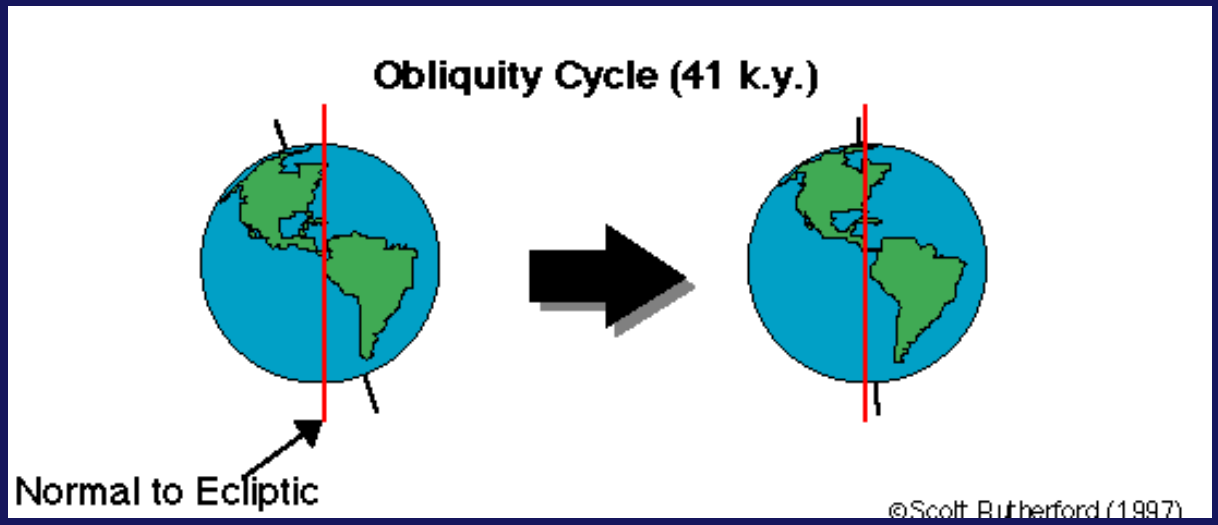
1 - One of the Equinoxes, where every latitude on Earth experiences 12 hours of daylight and 12 hours of darkness.

2 - Northern Hemisphere winter.

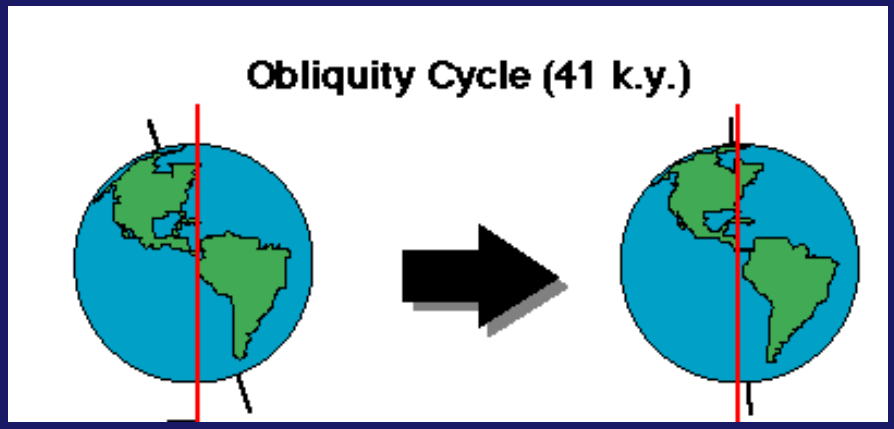
3 -Northern Hemisphere summer.

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})



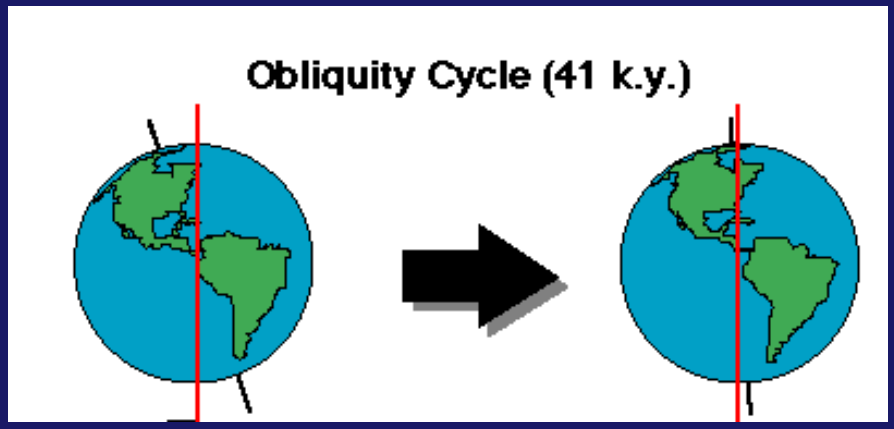
Q1 How do you think global climate would change with less of a tilt?



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

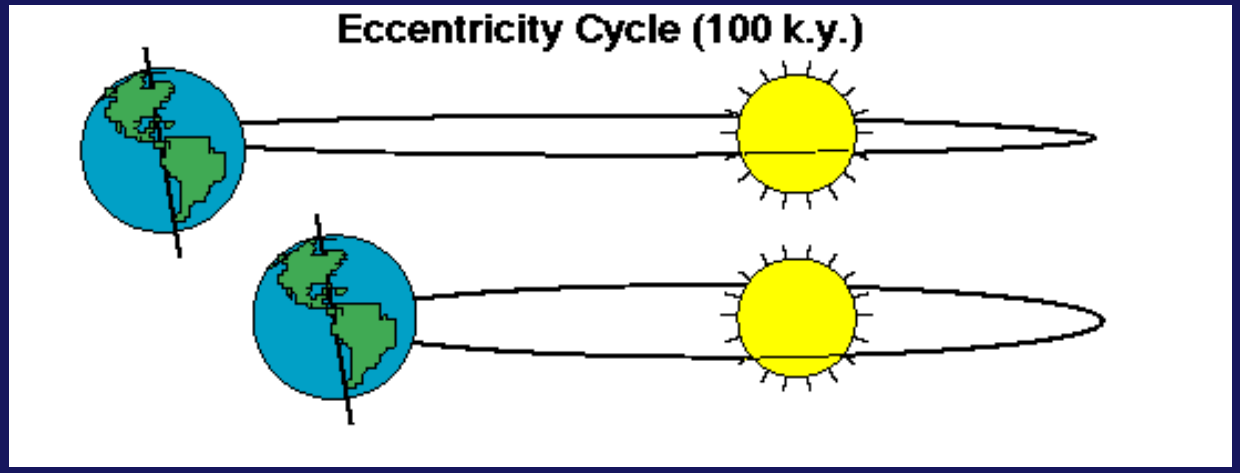
2 – The <u>difference</u> in annual temperature between polar and tropical latitudes would be LESS

2. ECCENTRICITY OF ORBIT

- Earth's orbit around sun is not symmetrical

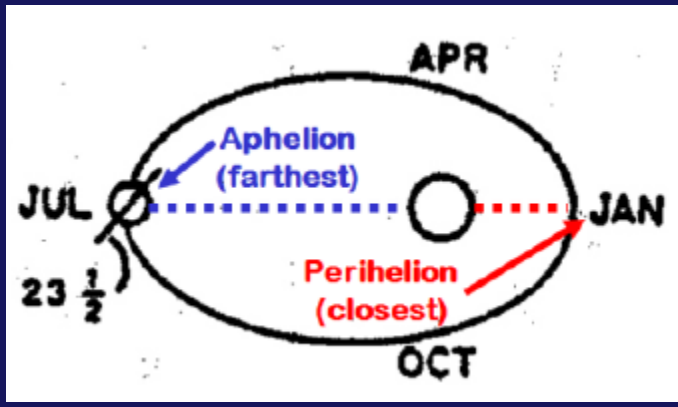
- Has varied in the past from more circular => elliptical shape

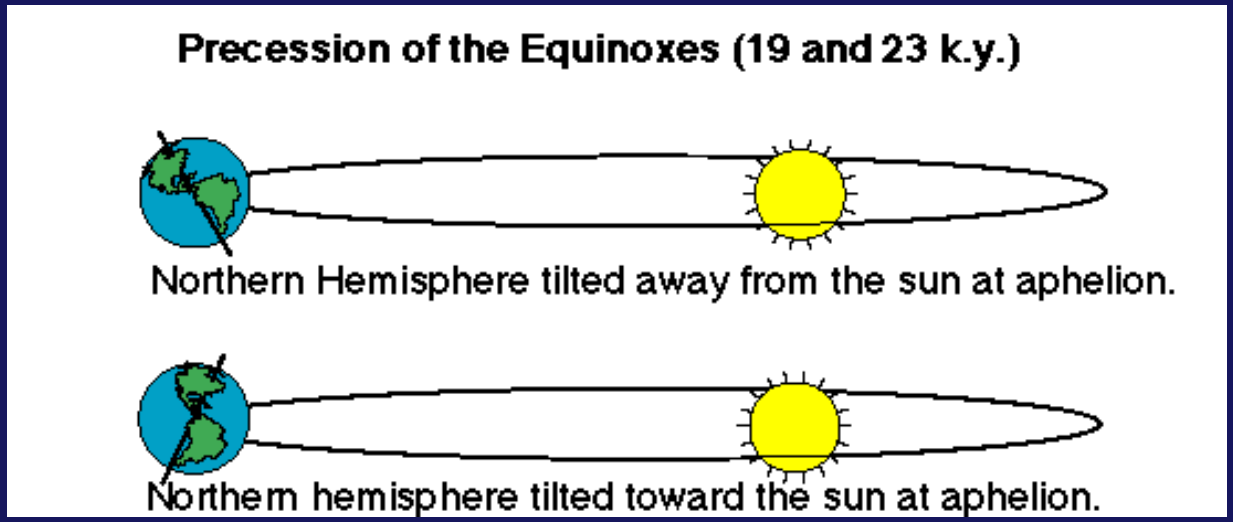
(more "eccentric!")



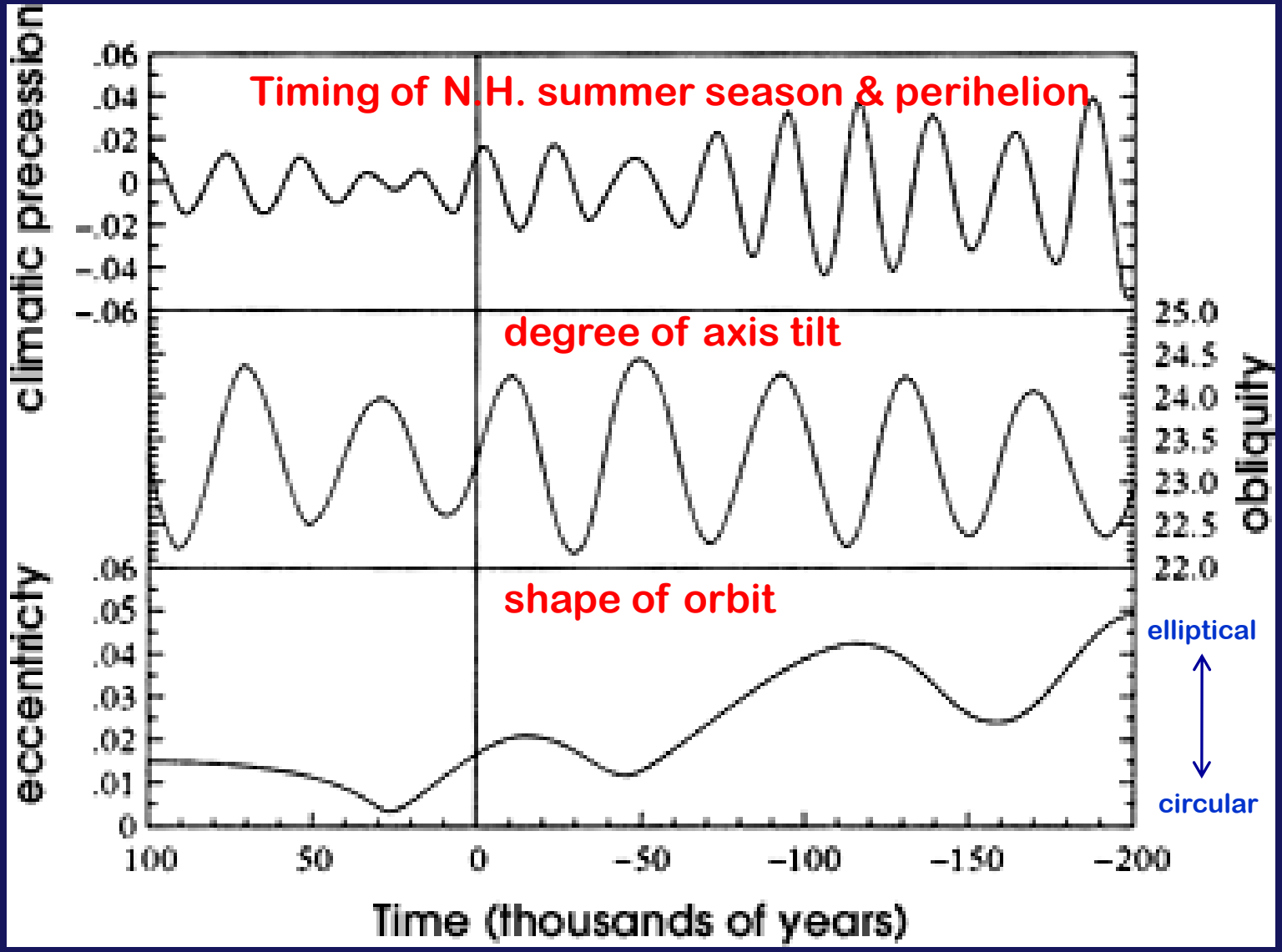
3. PRECESSION OF THE EQUINOXES
(Timing of Seasons in Relation to Orbit)

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.

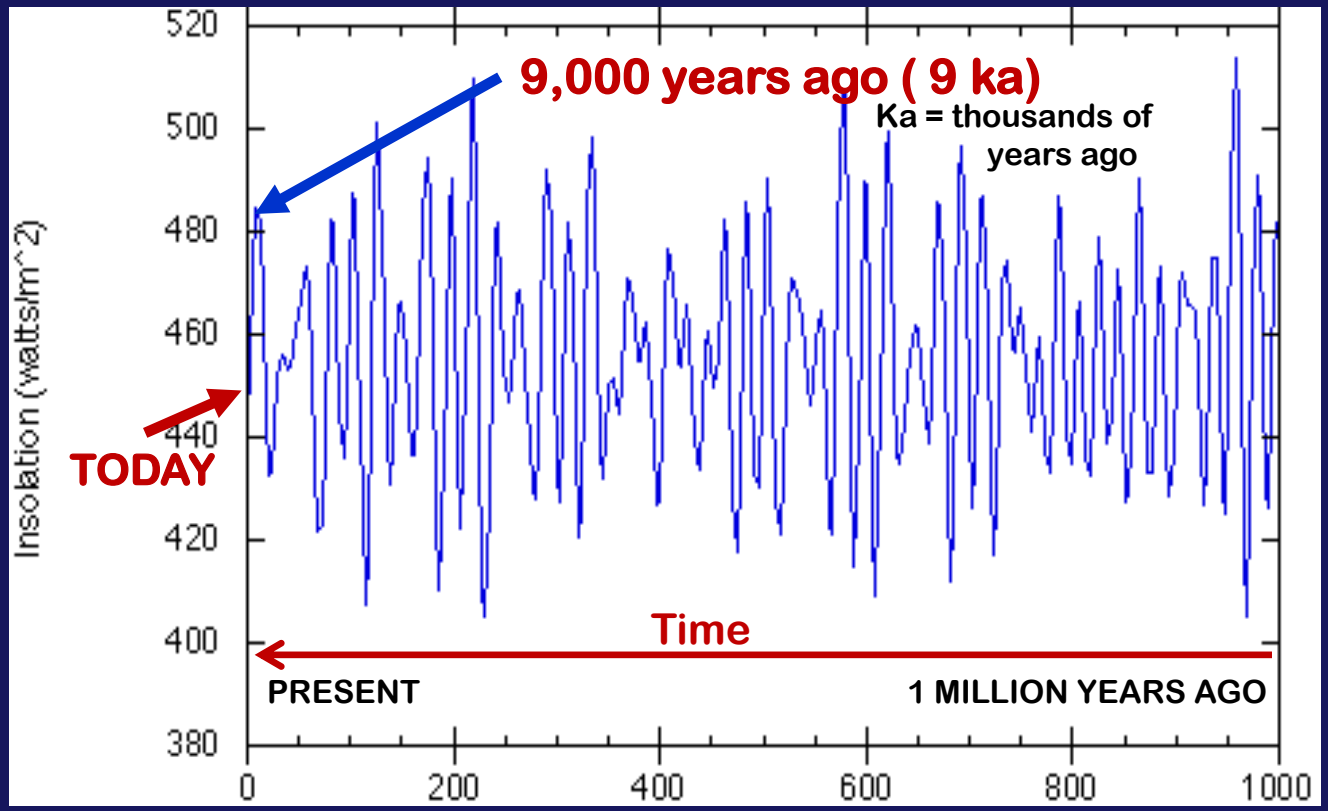




the Future ← TODAY → the Past *(in thousands of years)*



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



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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 17

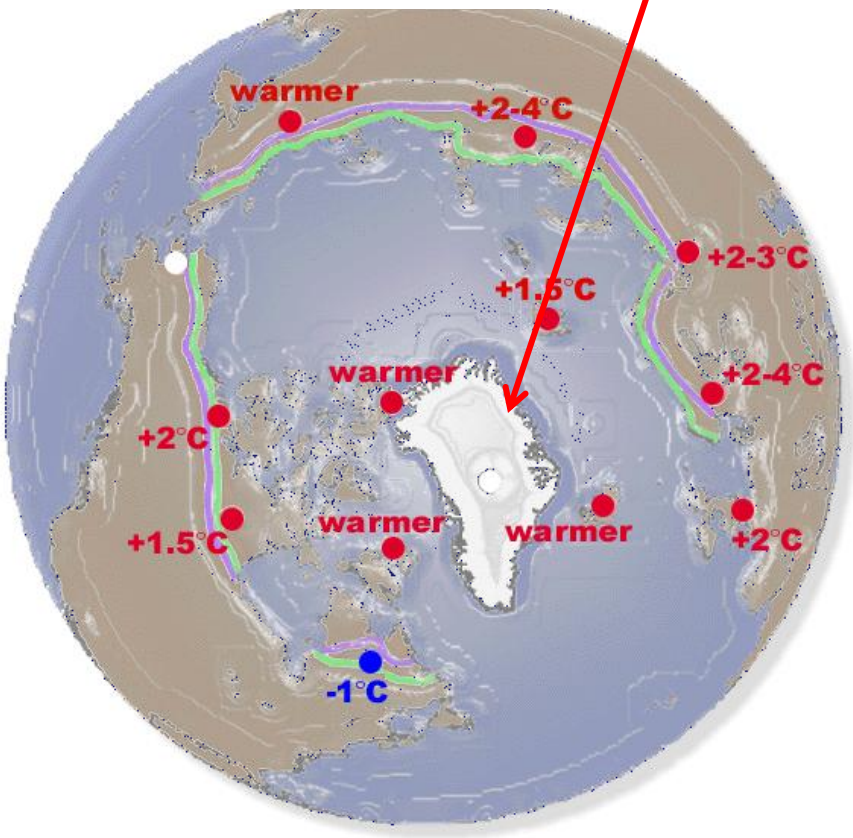
Mid-Holocene warm period
(~ 6,000 years ago)

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

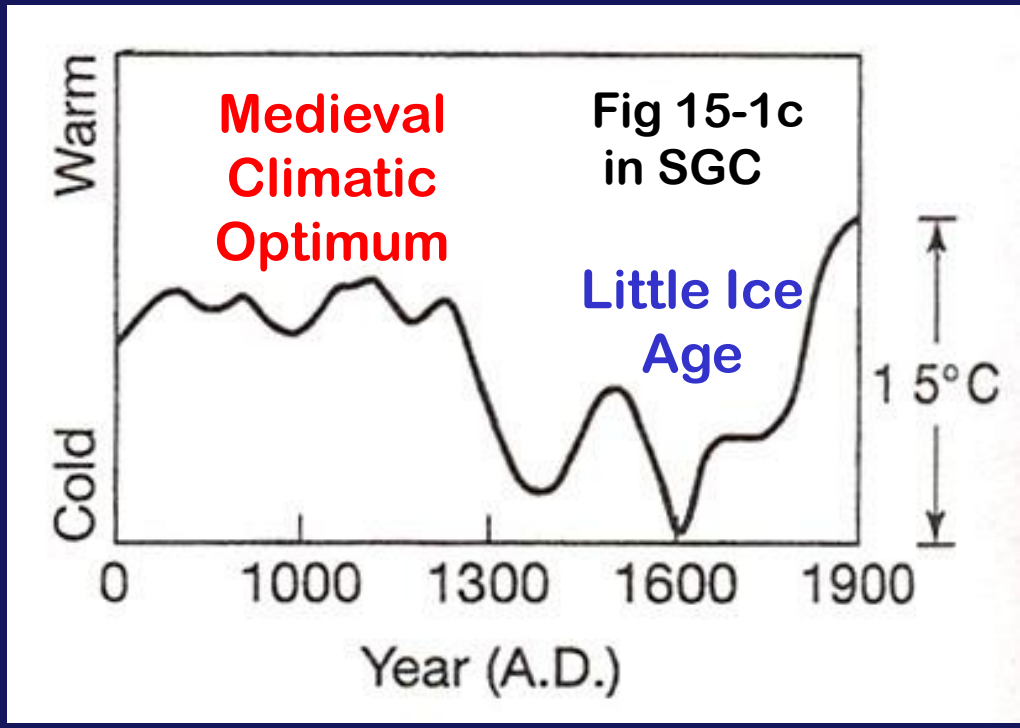
Other notable "naturally forced" climate changes of the more recent past:

Medieval Warm Period (MWP)

"Medieval Climatic Optimum"

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)

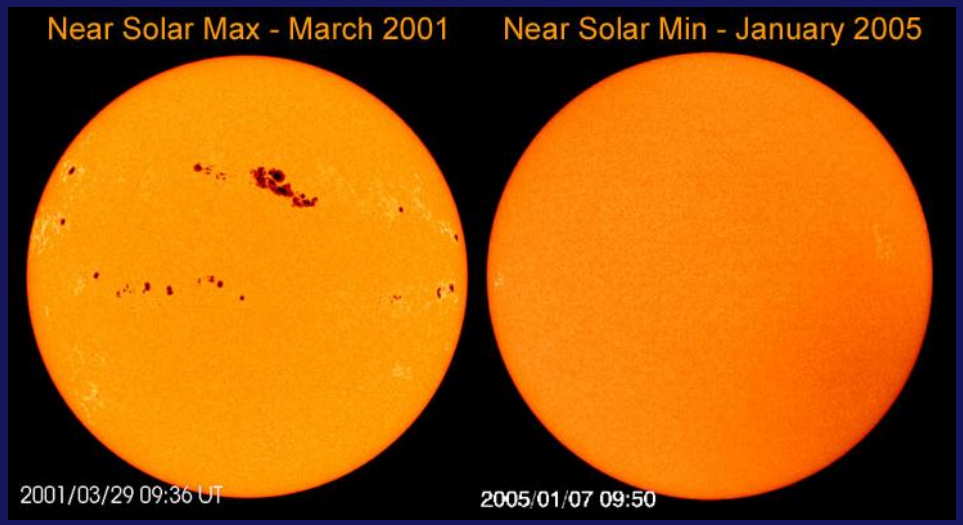
The 3 main drivers of NATURAL CLIMATIC FORCING:

1) ASTRONOMICAL FORCING

2) SOLAR FORCING ←

3) VOLCANIC FORCING

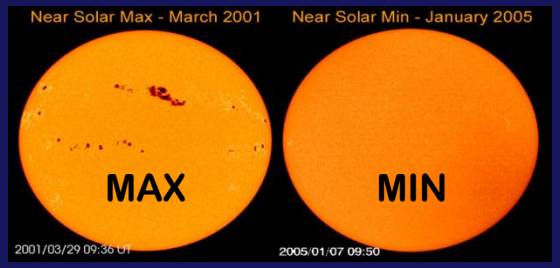
ANOTHER POSSIBLE NATURAL FORCING: SOLAR VARIABILITY

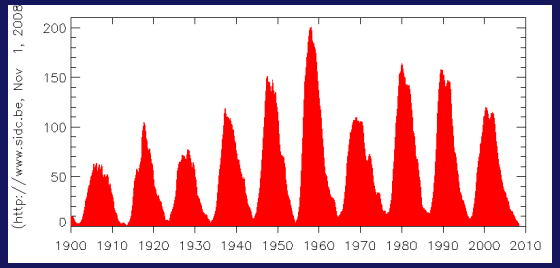


Sunspot maxima = MORE solar brightness (warmer temps)

Sunspot minima = LESS solar brightness (cooler temps)

ANOTHER POSSIBLE NATURAL FORCING: SOLAR VARIABILITY





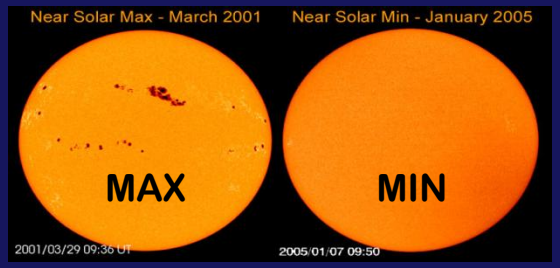
Q1 – During SUNSPOT Maximum periods:

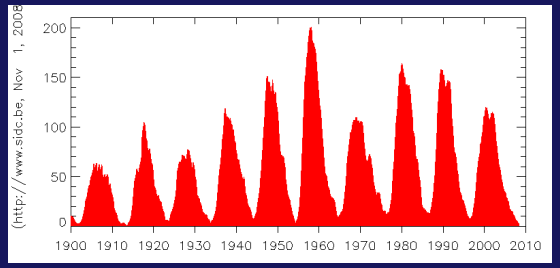
1. The sun is darker so it gives off less energy and global cooling is likely.

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:

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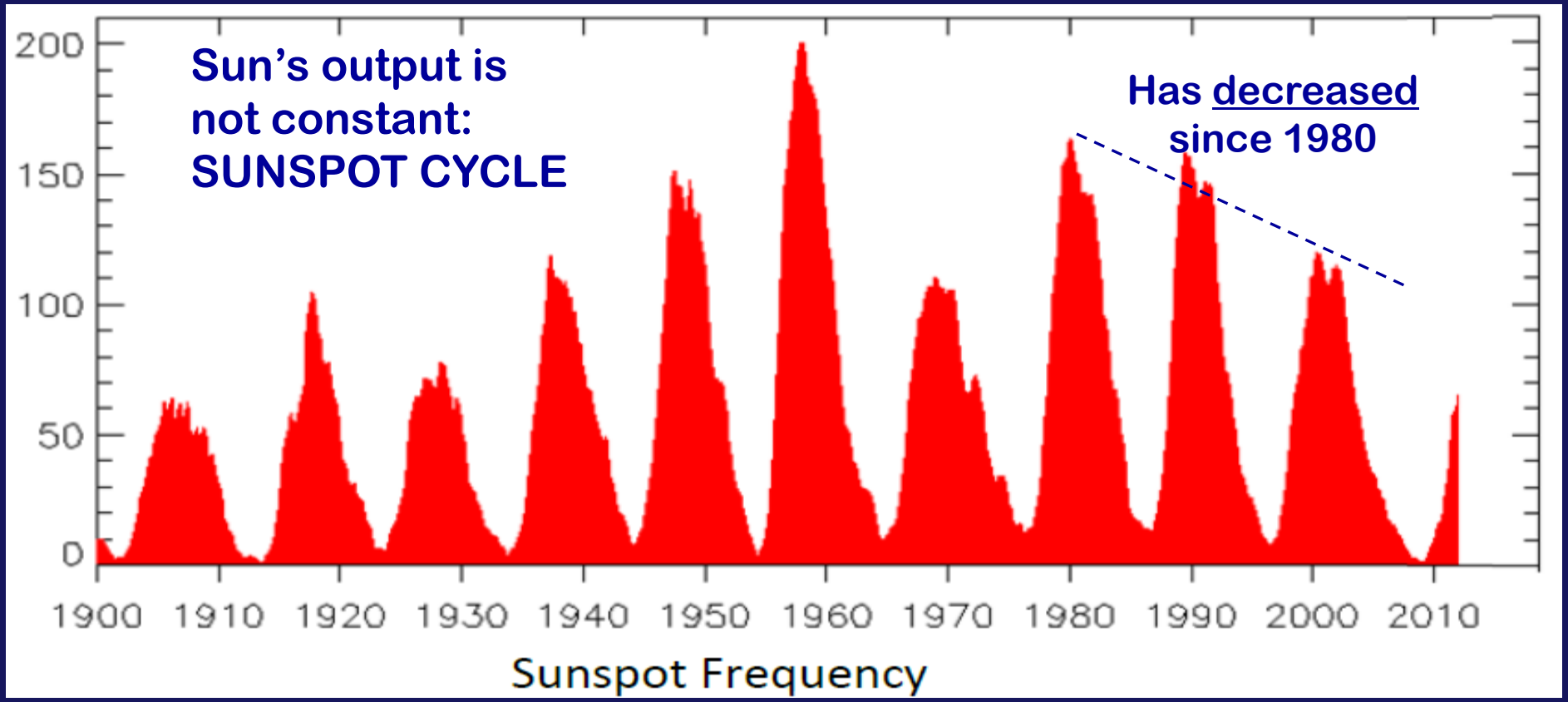
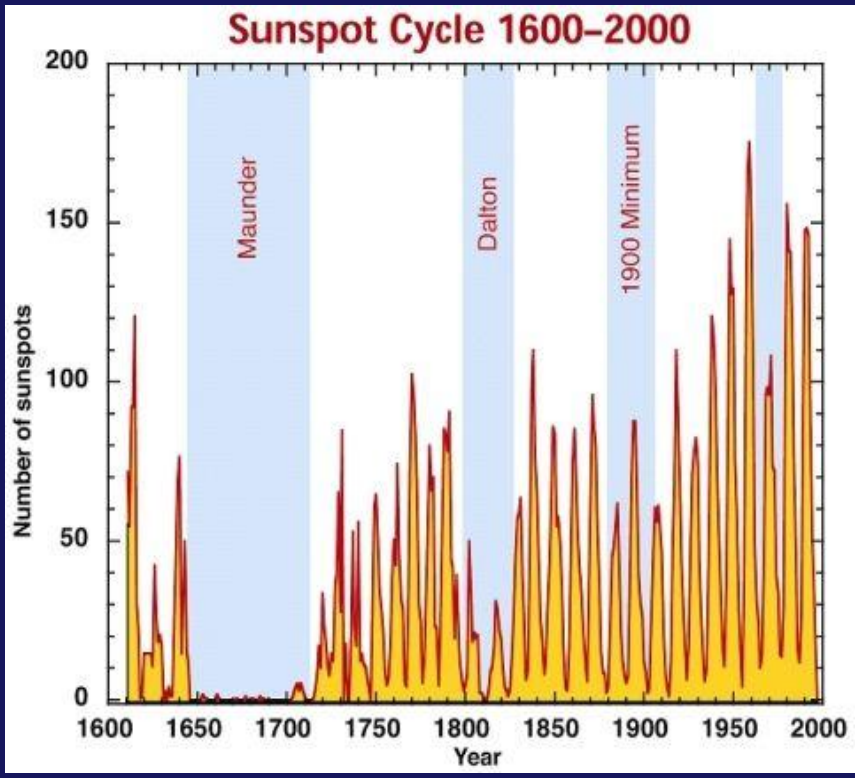


http://www.sidc.be/sunspot-index-graphics/sidc_graphics.php

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?

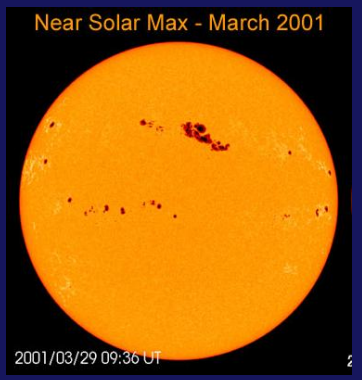
Dalton Minimum (1795 – 1825)

-- was also cooler

-- BUT, lots of large volcanic eruptions then too

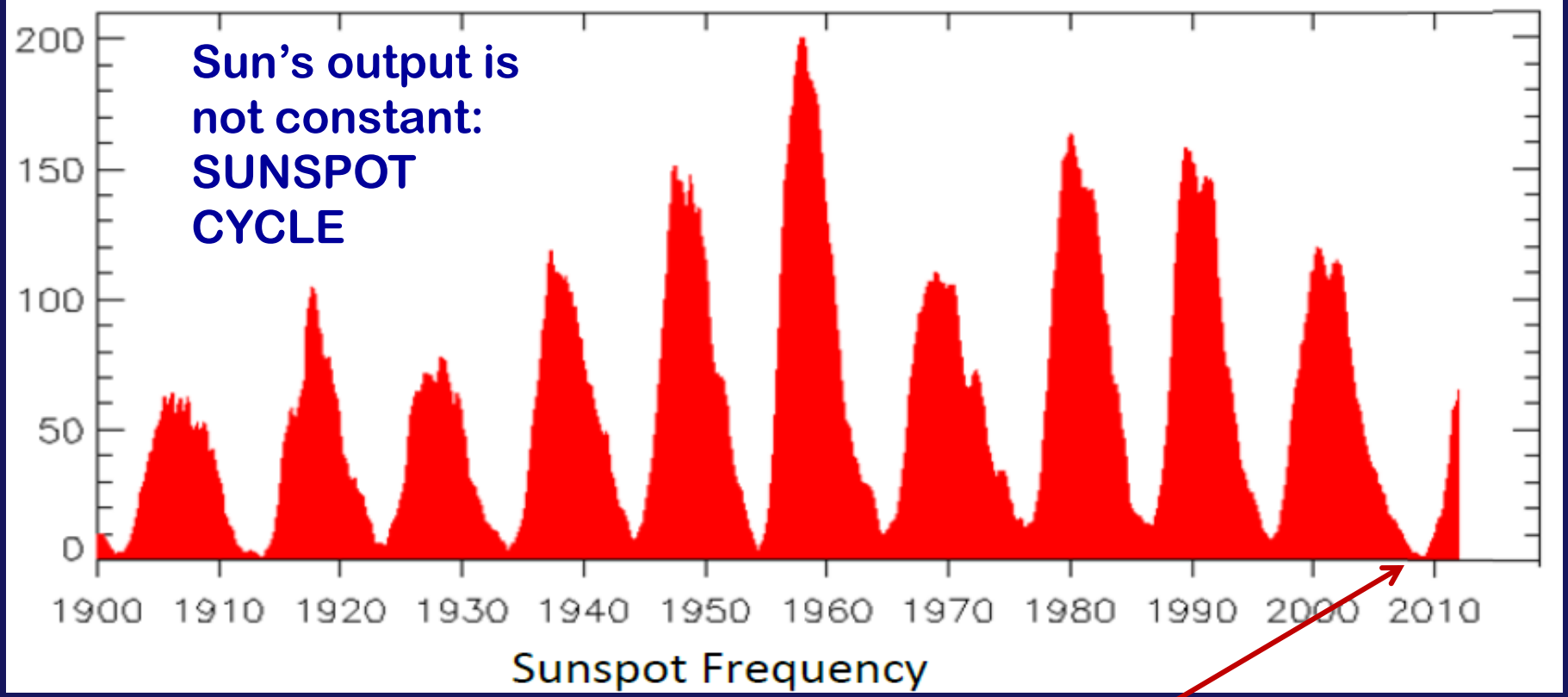
Since the Dalton Minimum, the Sun has gradually brightened , e.g., **"Modern Maximum"** (in 2001)

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
- Speculation: are we going into another Maunder-like period?

Or Will normal activity return within the year?

ALEX JONES' PRISONPLANET.com

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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.

Dearth Of Sunspot Activity To Herald New Ice Age

icts two degree drop in temperatures over next two decades
windles

en measuring sun cycles for over 200 years predicts that global
legrees over the next two decades as solar activity grinds to a halt
down, potentially heralding the onset of a new ice age.

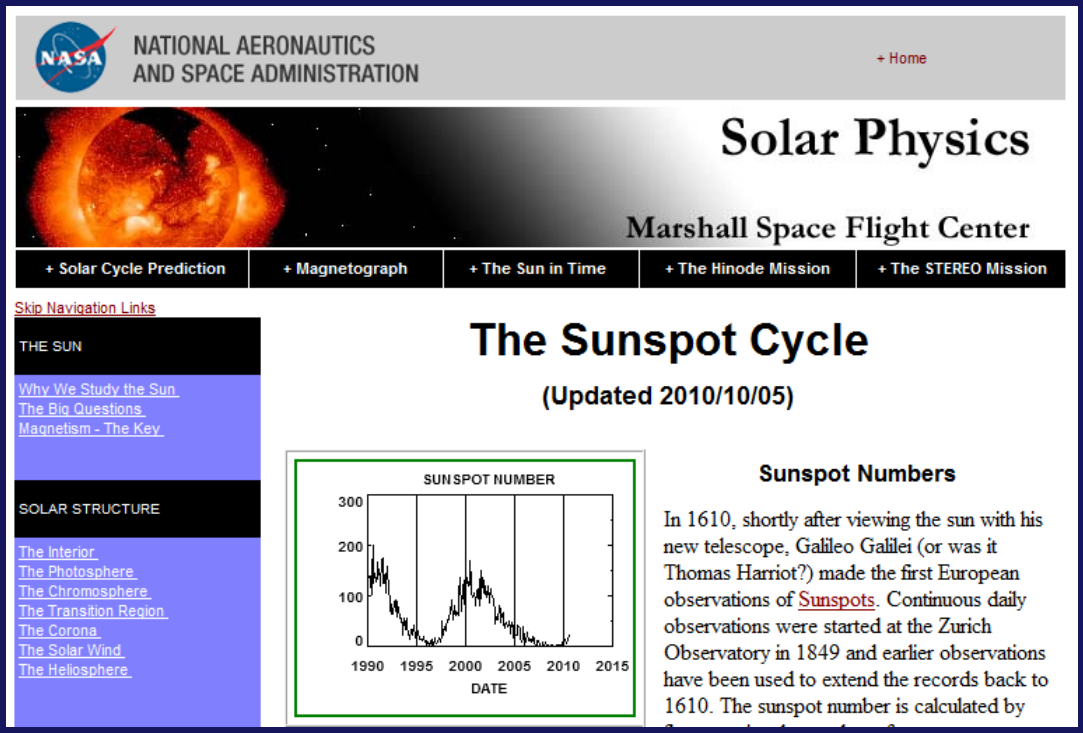
d politicized bodies like the IPCC scaremonger about the
the poor and middle class pay CO2 taxes, both hard
ence points to a clear cooling trend.

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

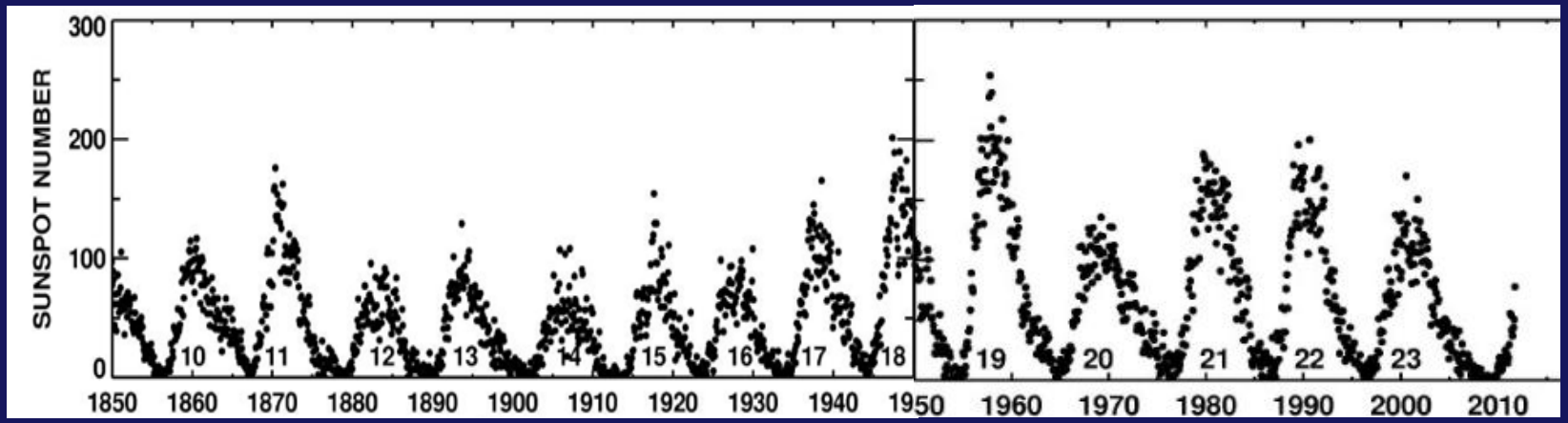
Not by Fire but by Ice

THE NEXT ICE AGE - NOW!

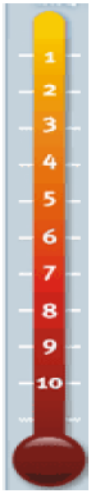
So what IS happening now?



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



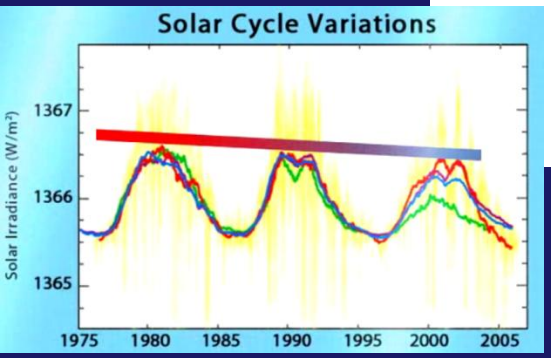
SEE ALSO: http://www.sidc.be/sunspot-index-graphics/sidc_graphics.php

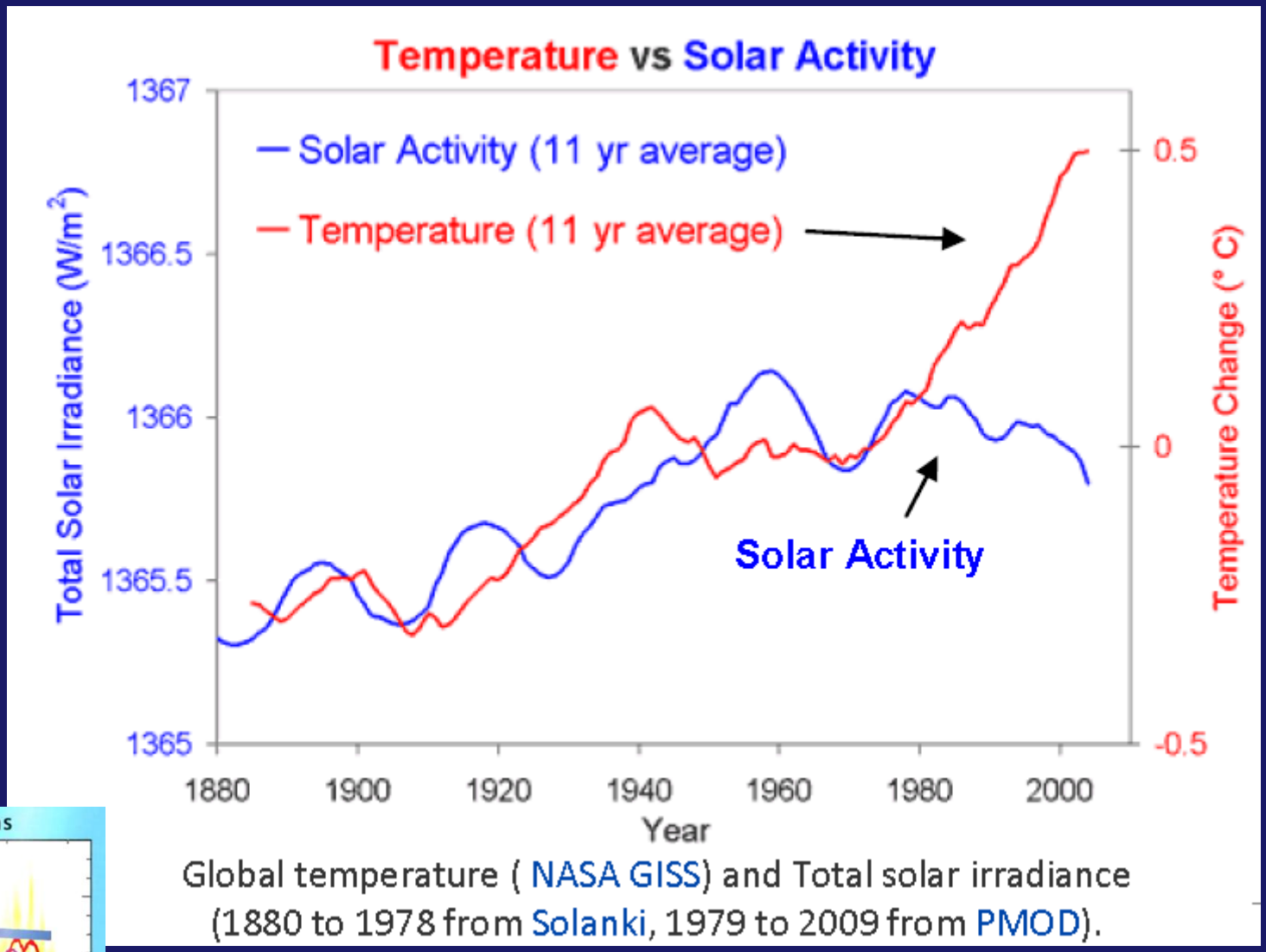


Indicator Interlude . . .

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).

← "Clearing the Air" in Lesson 2

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 . . .

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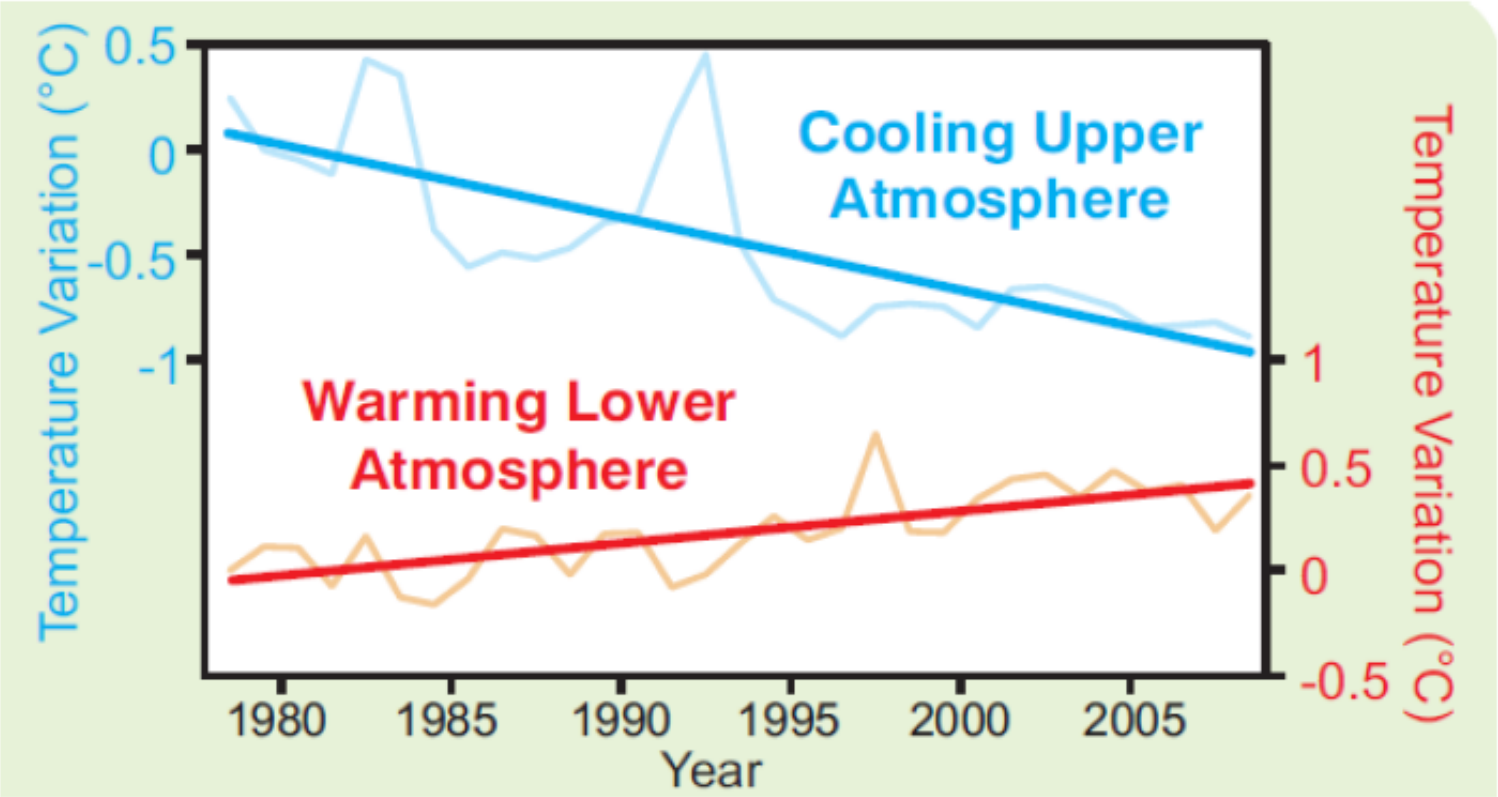
What has been observed since 1980?



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

SEE YOU ON WEDNESDAY!