

TOPIC # 13

GLOBAL WARMING & ANTHROPOGENIC FORCING (cont.)

Part B

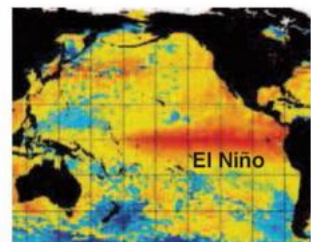
RADIATIVE FORCING



Earthweek: Diary of a Changing World

Week ending Friday, November 20, 2015

By Steve Newman



Sea-surface temperature anomalies on Nov. 16, 2016
Image: NOAA

Record El Niño

The intensity of El Niño peaked at a record level during the second week of November, leaving scientists wondering how much warmer the tropical Pacific could become during the current outbreak.

Analysis by the U.S. agency NOAA revealed a stretch between South America and Indonesia reaching a weekly average temperature of 3.0 degrees Celsius (5.4 F) above normal — a record.

Despite the peak, the current El Niño has yet to wield the same impacts as previous outbreaks in 1982-83 and 1997-98.

The ability to predict the effects of El Niño on worldwide weather patterns has greatly improved in recent years, but the warming is still likely to inflict considerable damage and even fatalities, according to the U.N.

Colorful Recovery

North America's iconic monarch butterflies could quadruple in numbers this year, thanks to joint conservation efforts by Canada, the United States and Mexico.

Populations of the orange-and-black insects plunged almost 90 percent two years ago, reaching only 35 million compared with a peak of about 1 billion during the 1990s.

The destruction of milkweed by agriculture was a leading cause of the decline.



Monarchs wintering in western Mexico
Photo: Jim Lovett / Monarch Watch

Ozone Hole Alert

An ultraviolet radiation alert was issued for Argentina's Tierra del Fuego as a near-record ozone hole over Antarctica threatened to brush the archipelago.

The "violet" or extreme alert meant there was an acute risk to unprotected skin and eyes.

The ozone hole has remained at a size greater than the North American continent since early October.

Tierra del Fuego, at the far southern tip of South America, has been frequently grazed by passing lobes of the hole, which typically surrounds only Antarctica.

Invasive Disease

A mosquito-borne disease once limited to Africa and Asia is spreading across parts of the Americas.

Zika joins dengue and chikungunya as invasive diseases carried by the *Aedes aegypti* and *Aedes albopictus* mosquitoes. It threatens public health and tourism from the Caribbean to South America.

Zika first appeared in Brazil last April, with local authorities linking it to foreign visitors attending the FIFA World Cup competition. Six cases of the disease have now been confirmed in neighboring Suriname.

Earthquakes

Two women were killed when a 6.5 magnitude temblor struck the western Greek island of Lefkáda.

• Earth movements were also felt in southwestern Japan, southern New Zealand, Trinidad and along the Oklahoma-Kansas border.

Typhoon

Tropical Storm In-fa formed from an area of disturbed weather near the Micronesian island of Pohnpei.

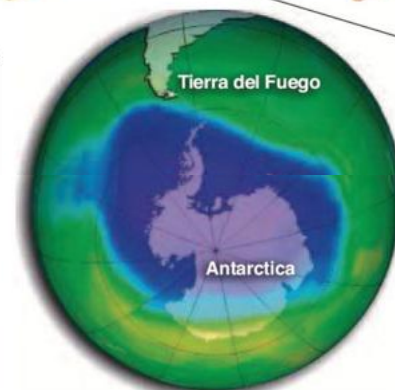
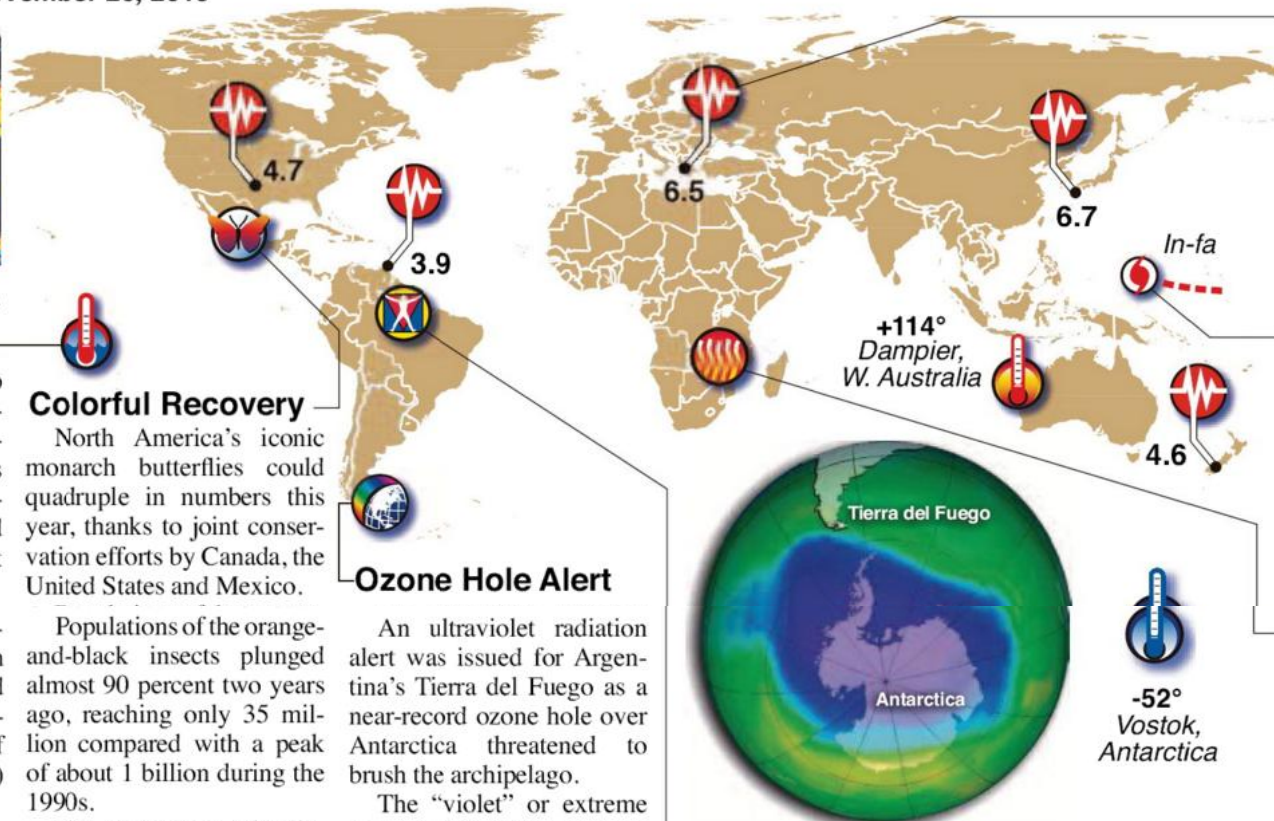
The storm later reached typhoon (hurricane) force on a path that would take it to the south of Guam.

Grounded by Heat

A string of days with the hottest temperatures in the world disrupted a commercial flight in Zimbabwe.

Temperatures soaring to 111 degrees Fahrenheit in the south of the country forced an Air Zimbabwe turboprop airliner traveling from Harare to Kariba to divert to Victoria Falls.

Such high temperatures make it very difficult or impossible for some aircraft to land safely or take off, especially on short runways.



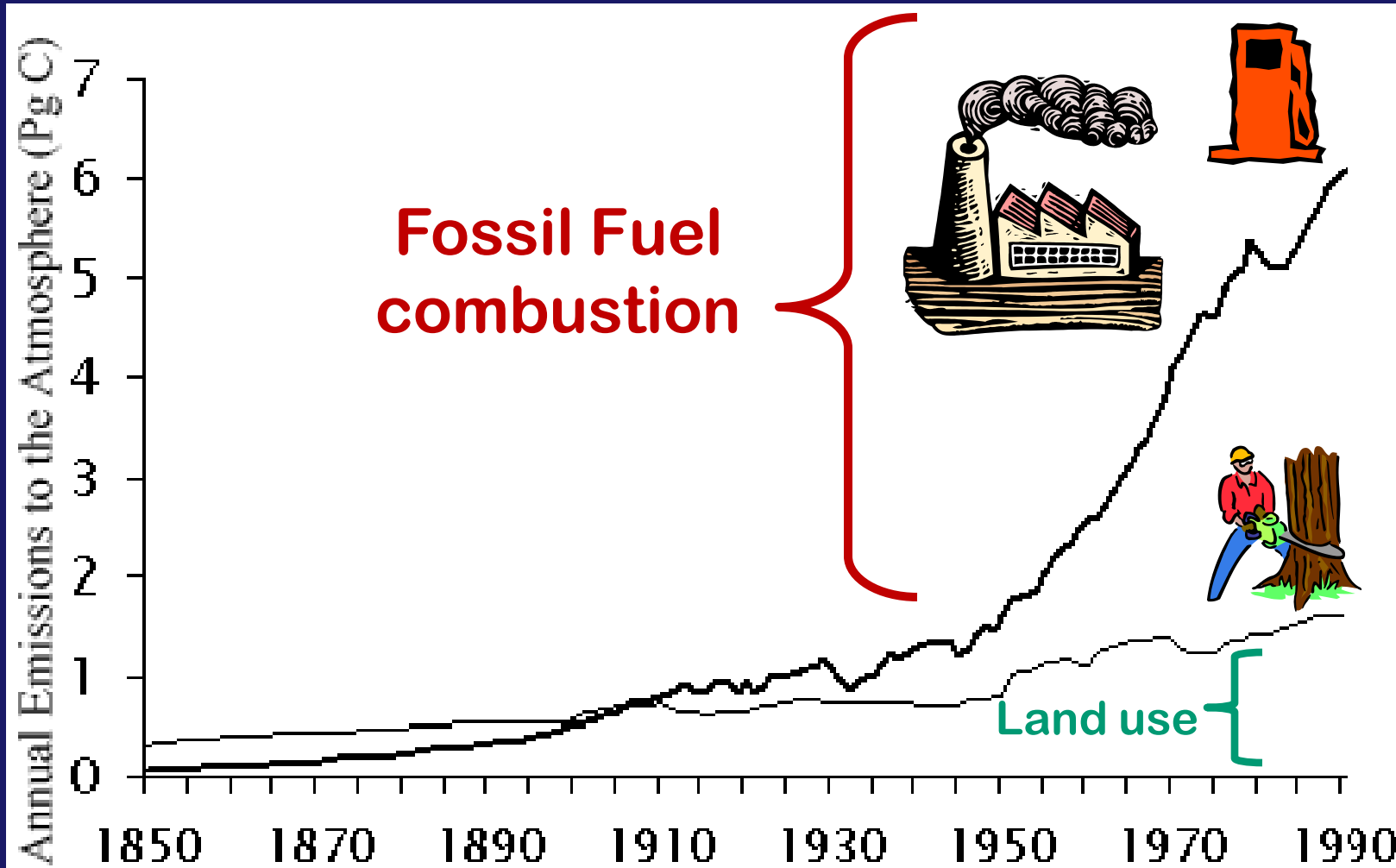
Ozone hole on Nov. 16, 2015
Image: NASA



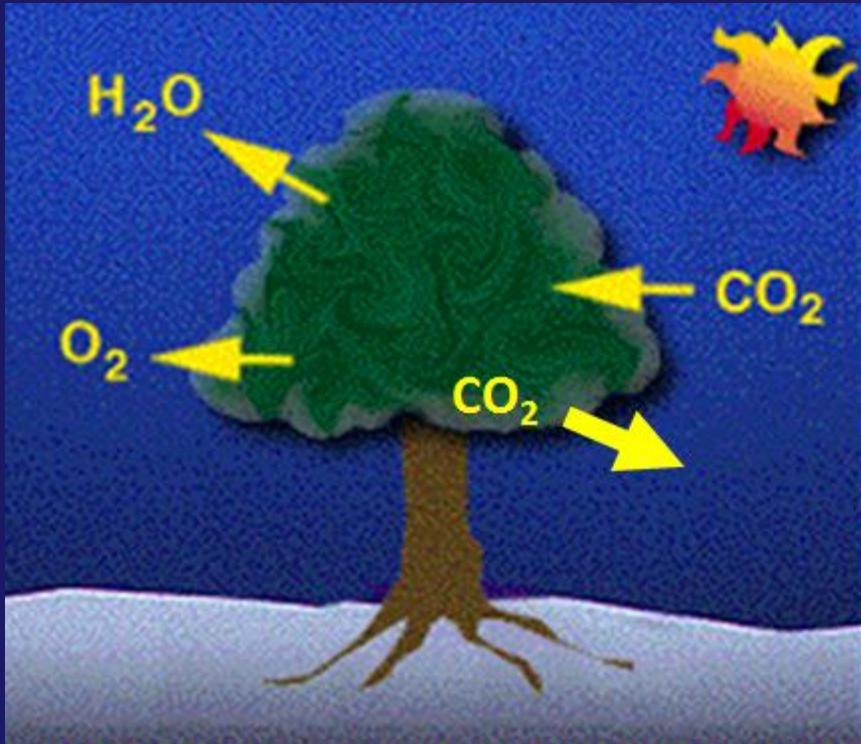
-52°
Vostok,
Antarctica

Recap:

CARBON DIOXIDE: Two big sources

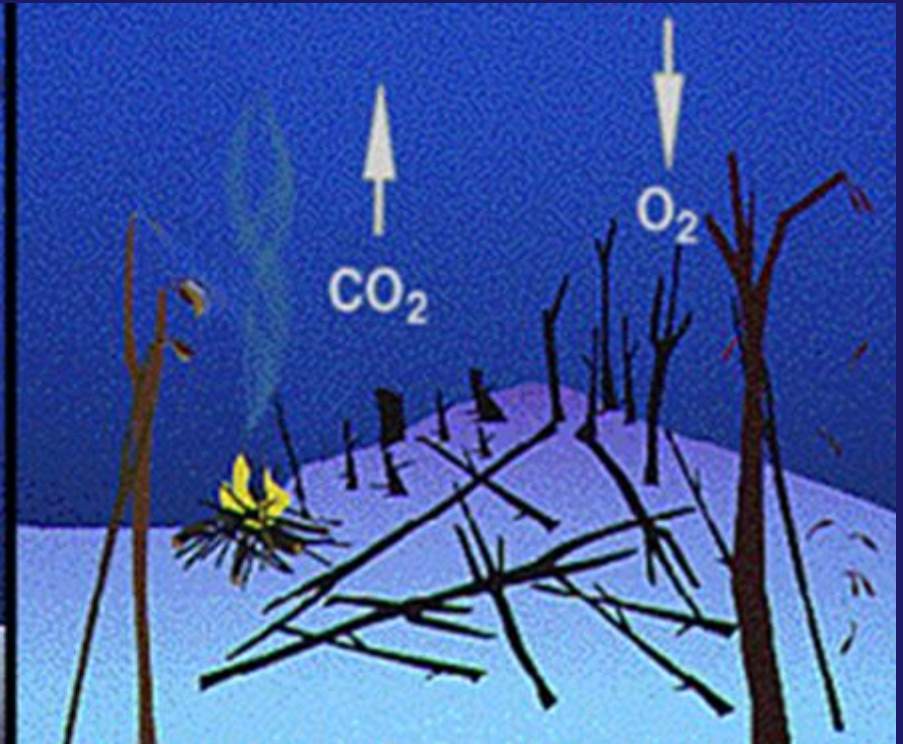


Photosynthesis & Respiration



Steady State

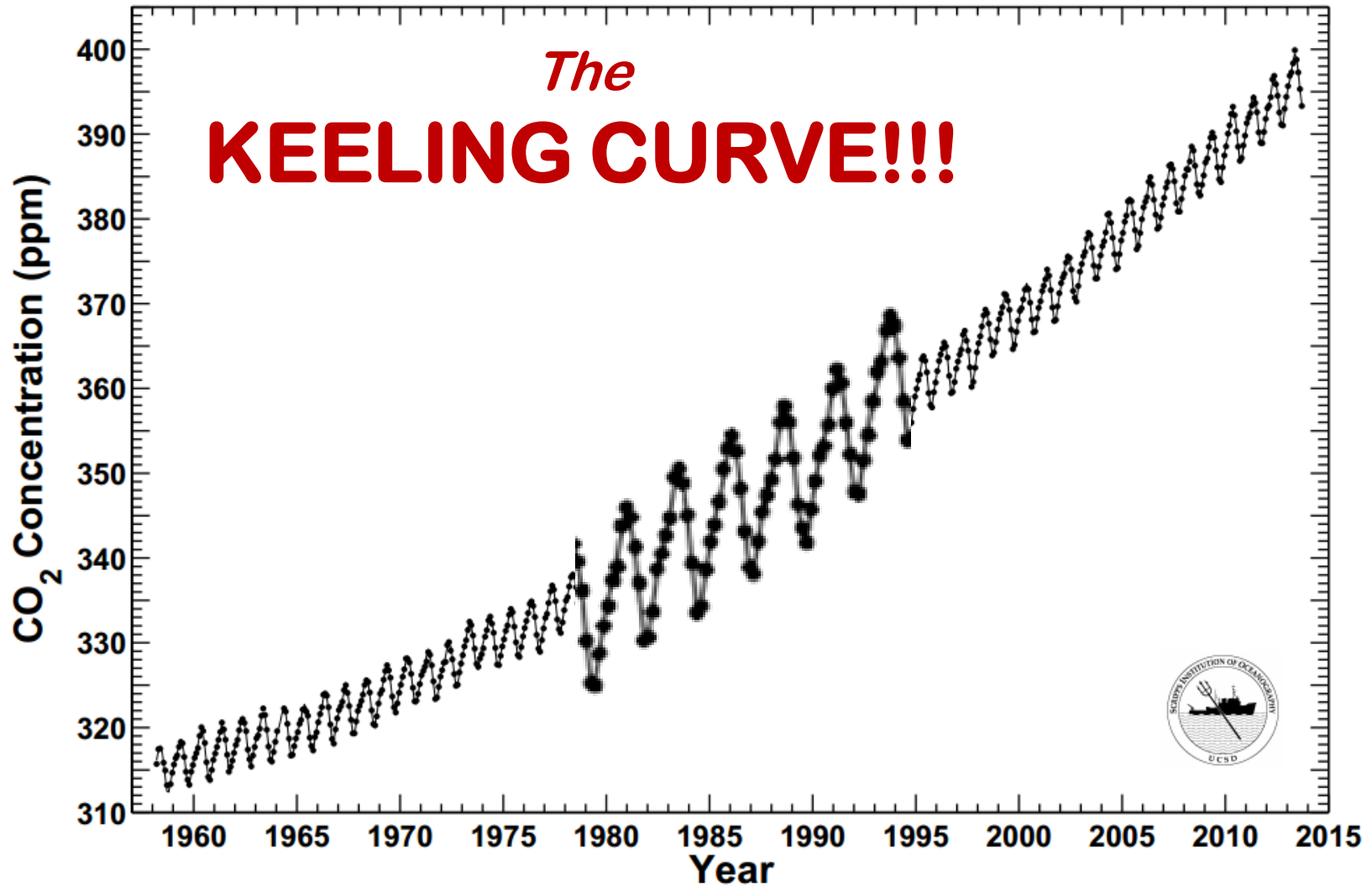
Respiration, Burning of Biomass, & Decomposition



Disruption of Steady State

Mauna Loa Observatory, Hawaii Monthly Average Carbon Dioxide Concentration

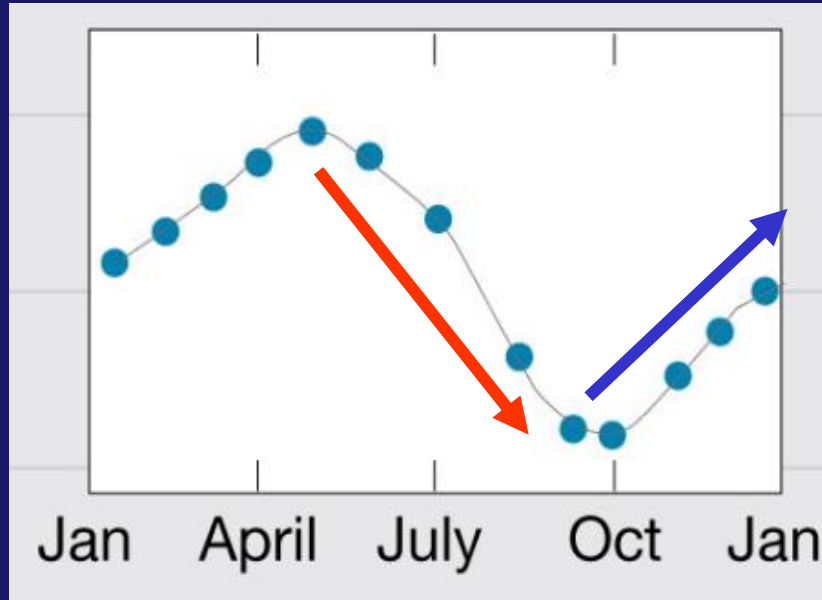
Data from Scripps CO₂ Program Last updated November 2013





Photosynthesis > Respiration

(CO₂ goes down in SUMMER as forests “breathe in” more CO₂)



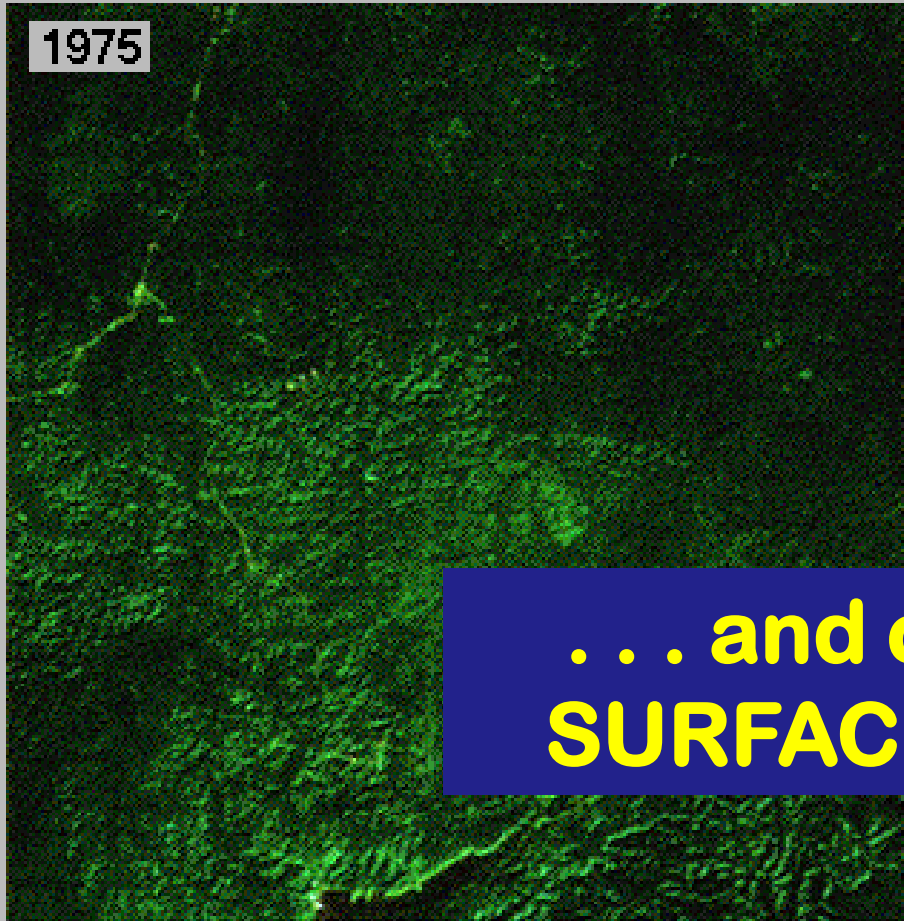
Respiration > Photosynthesis

(CO₂ levels rise in FALL/WINTER as forests “breathe out” more CO₂)

LAND USE CHANGES:

Deforestation practices increase burning & decomposition of large areas of forest

1975

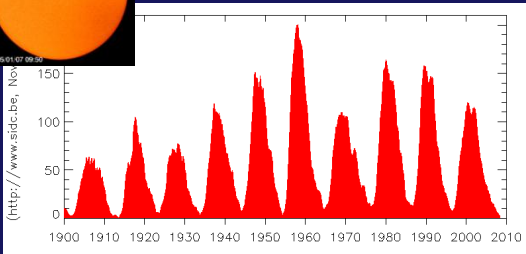
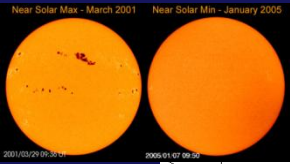


1986

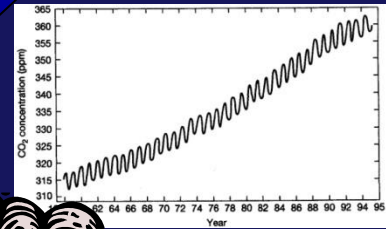


... and change the
SURFACE ALBEDO!

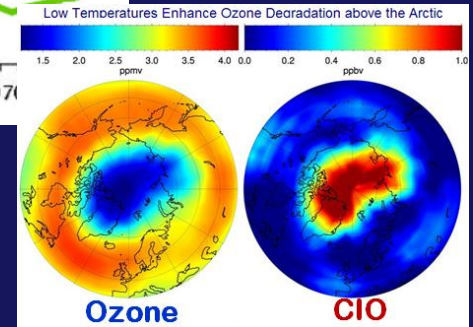
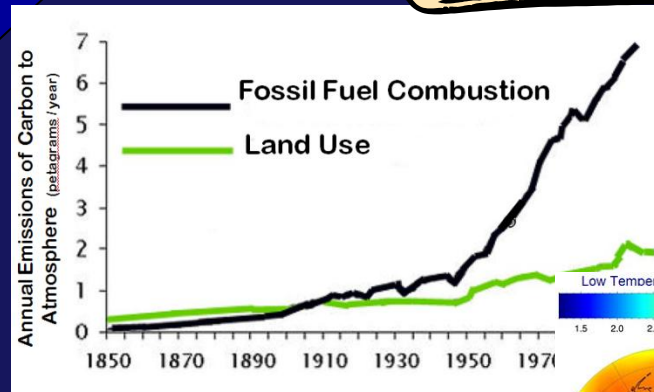
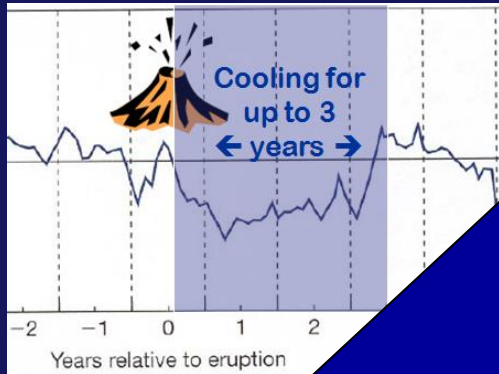
NATURAL FORCING



Solar output variations, sunspots



GHG's, soot, SO₂



Volcanic eruptions

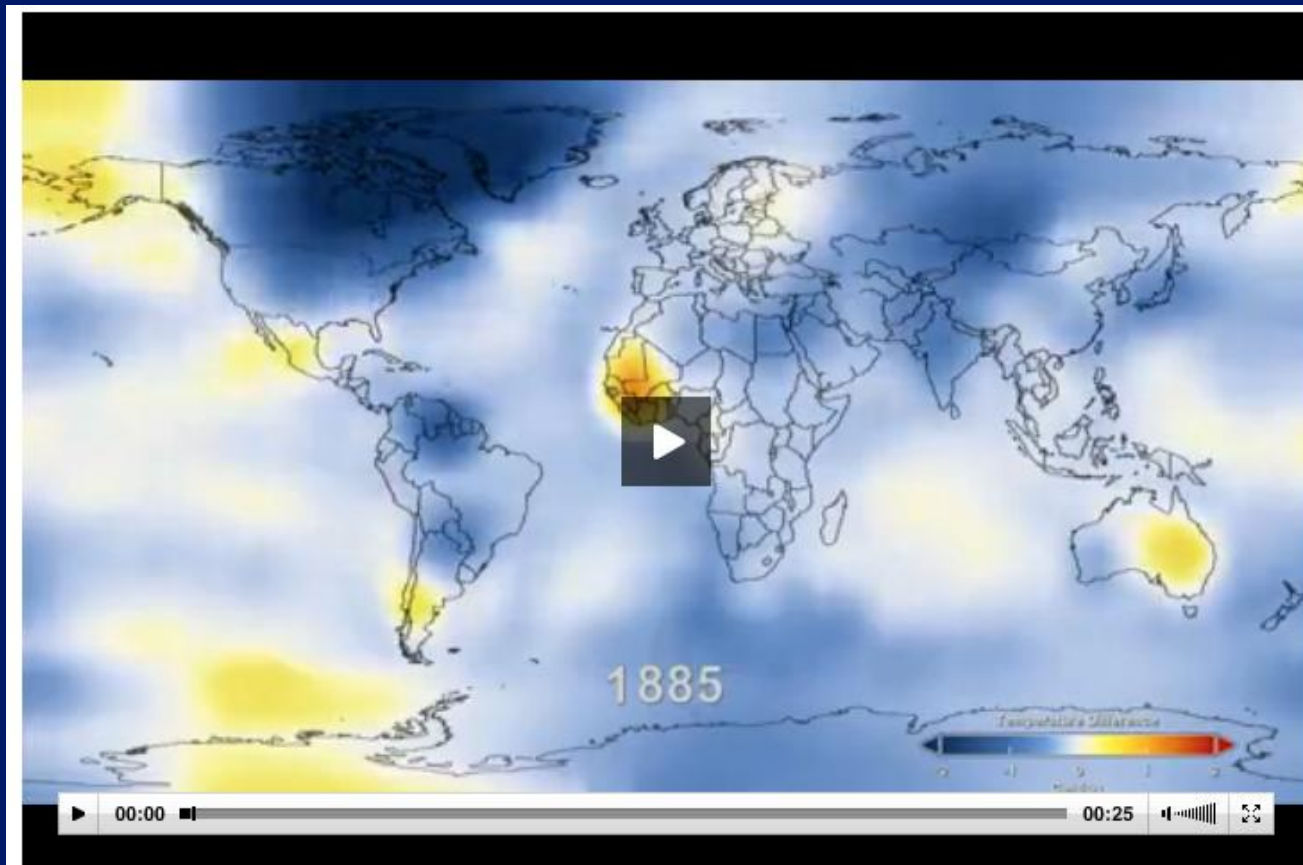


Surface Albedo Changes

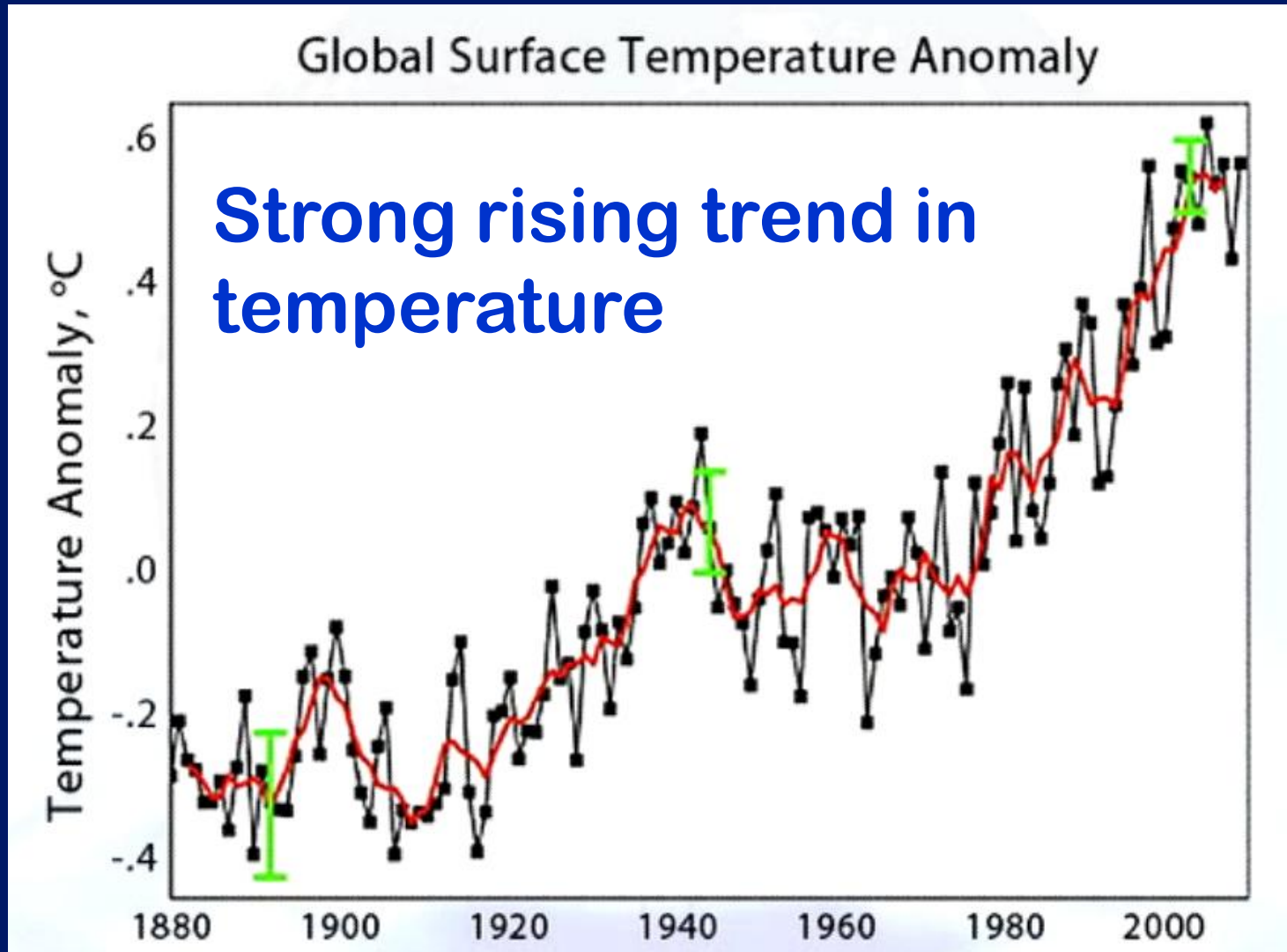
ANTHROPOGENIC FORCING

ALL THIS LEADS TO → GLOBAL WARMING

(watch a century in 26 seconds)



<http://www.biologicaldiversity.org/news/center/articles/2012/nasa-01-19-2012.html>



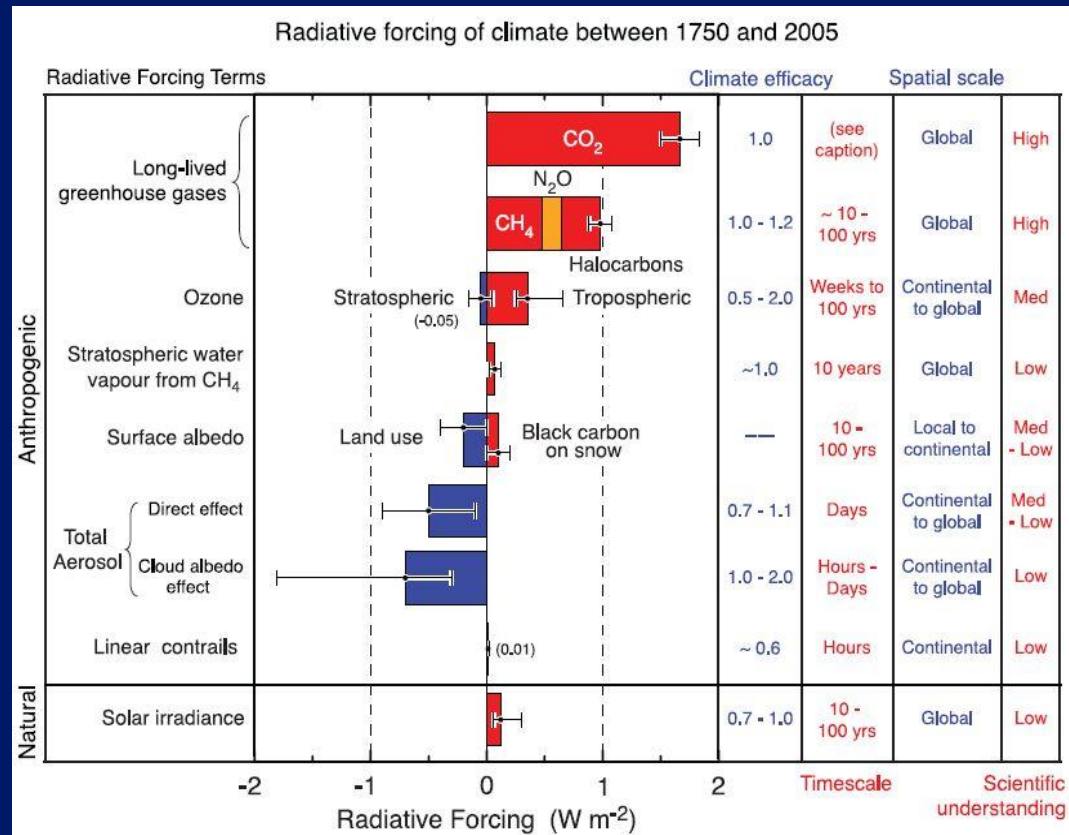
HOW do we SORT OUT
which
“FORCING FACTORS”

increase **WARMING**
and which
increase **COOLING**

as these “forcing factors”
CHANGE
due to natural and human
processes??

The Key To It All:

RADIATIVE FORCING OF CLIMATE



THE KEY TO IT ALL:

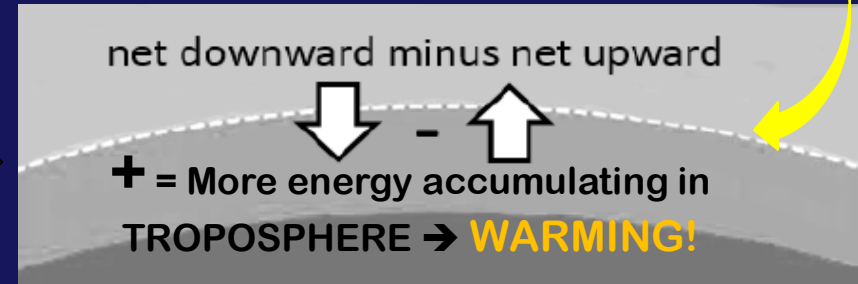
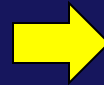
RADIATIVE FORCING

(linked to the Radiation / Energy Balance!)

$$R_{\text{NET}} = \begin{array}{ccccccc} & \text{SW} & & \text{SW} & & \text{SW} & & & & \text{LW} \\ & \downarrow & + & \downarrow & - & \nearrow & - & \updownarrow & + & \downarrow \\ R_{\text{NET}} = & & & & & & & \text{LW} & & \end{array}$$

Radiative Forcing is based on the ENERGY BALANCE at the TROPOPAUSE!

$$R_{NET} = \begin{array}{c} \text{SW} \\ \downarrow \\ \text{+} \\ \text{---} \\ \text{SW} \\ \downarrow \\ \text{-} \\ \text{---} \\ \text{SW} \\ \searrow \\ \text{-} \\ \text{---} \\ \text{LW} \\ \uparrow \\ \text{+} \\ \text{---} \\ \text{LW} \\ \downarrow \end{array}$$



an index of the degree to which different factors (like GHG's) INCREASE or DECREASE the amount of energy that accumulates in the TROPOSPHERE!

RADIATIVE FORCINGS ARE THE KEY TO WHAT'S GOING ON!

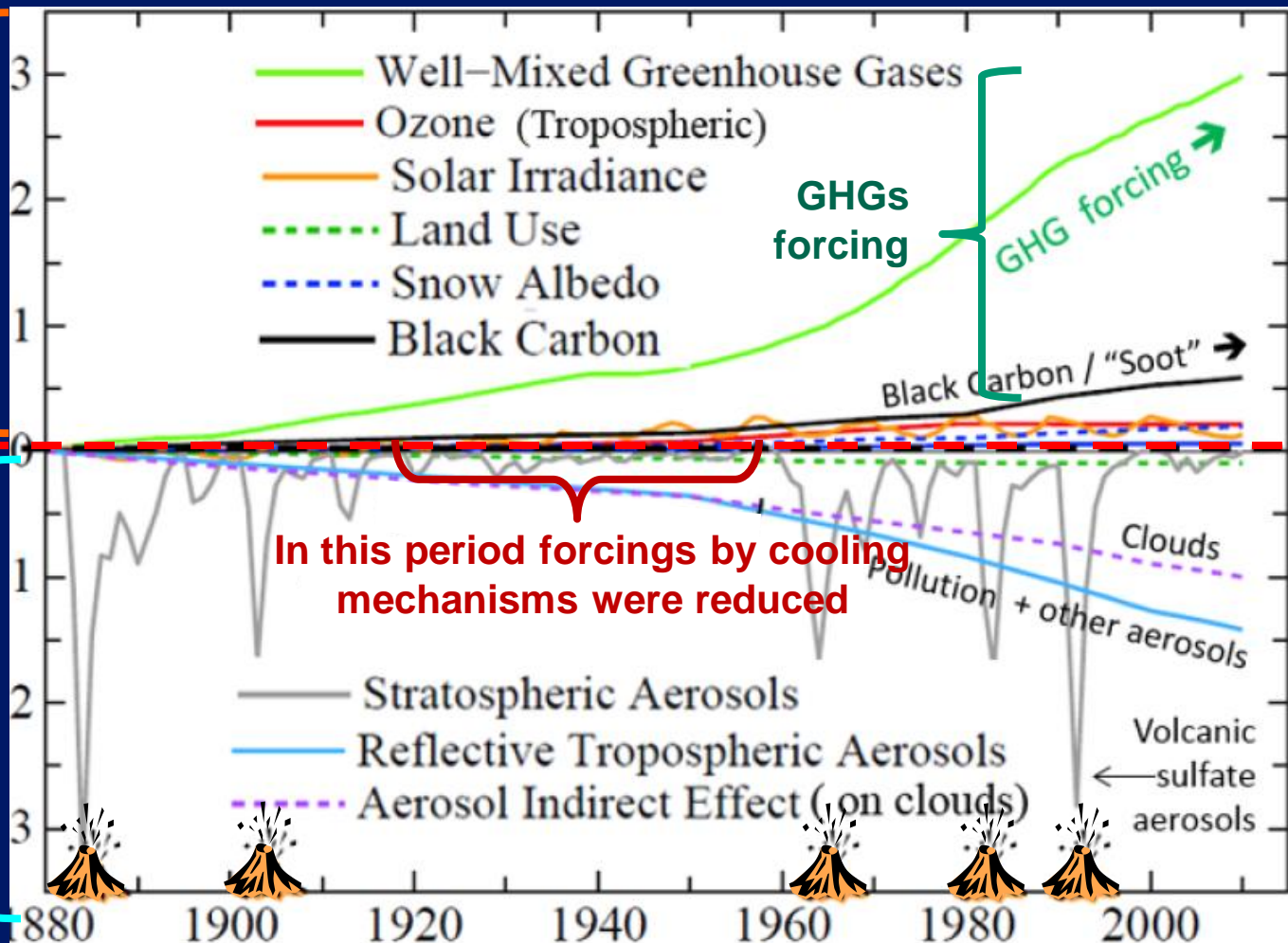
ABOVE THE 0 LINE:

Forcing by mechanisms that cause warming in the troposphere

0 line = 1880 value

BELOW THE 0 LINE:

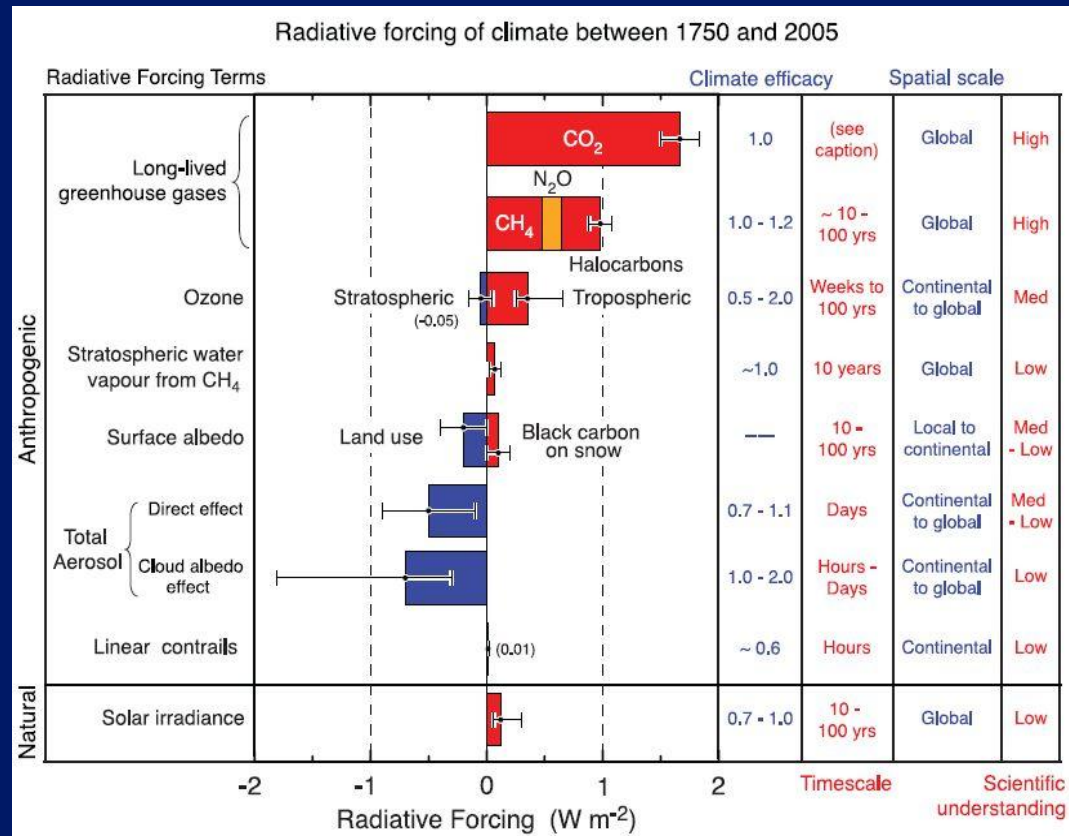
Forcing by mechanisms that cause cooling in the troposphere



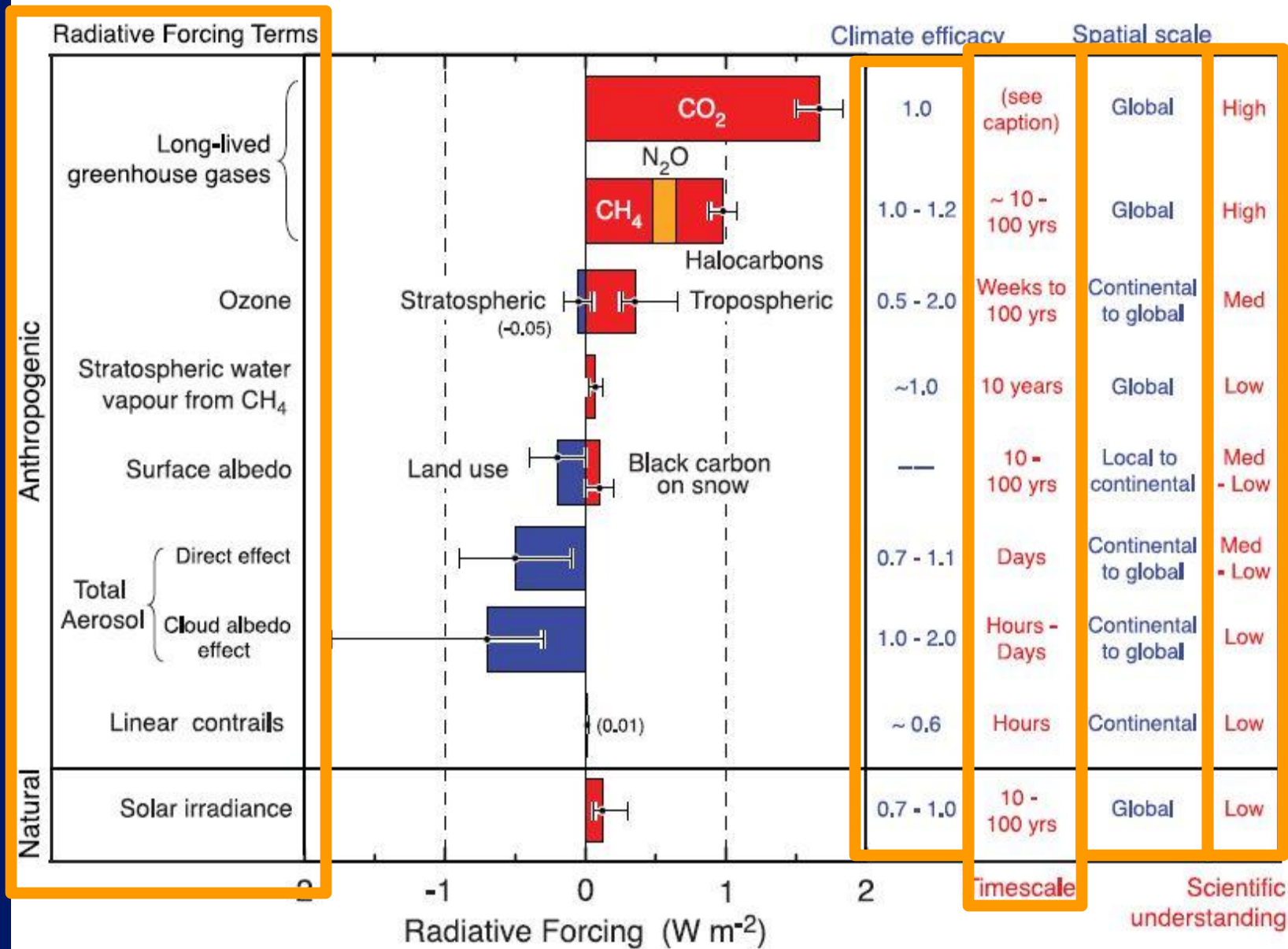
Effectiveness of various global climate forcings (in W/m^2)
relative to their 1880 value

(figure from NASA GISS <http://data.giss.nasa.gov/modelforce/>)

Reading the RADIATIVE FORCING GRAPH:

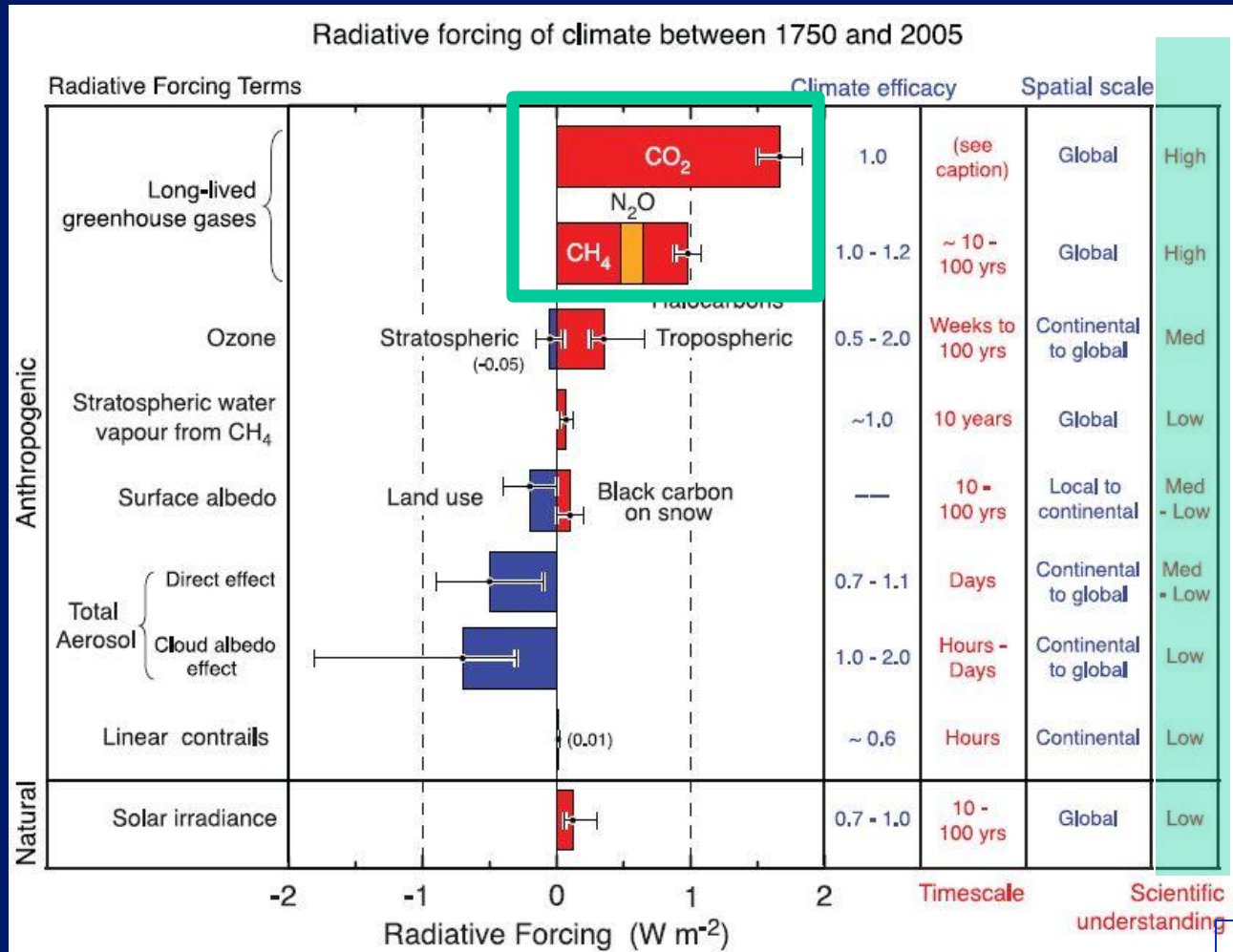


Radiative forcing of climate between 1750 and 2005



The figure shows that the forcing mechanism that is BEST understood by scientists is also the one that leads to the greatest climatic impact.

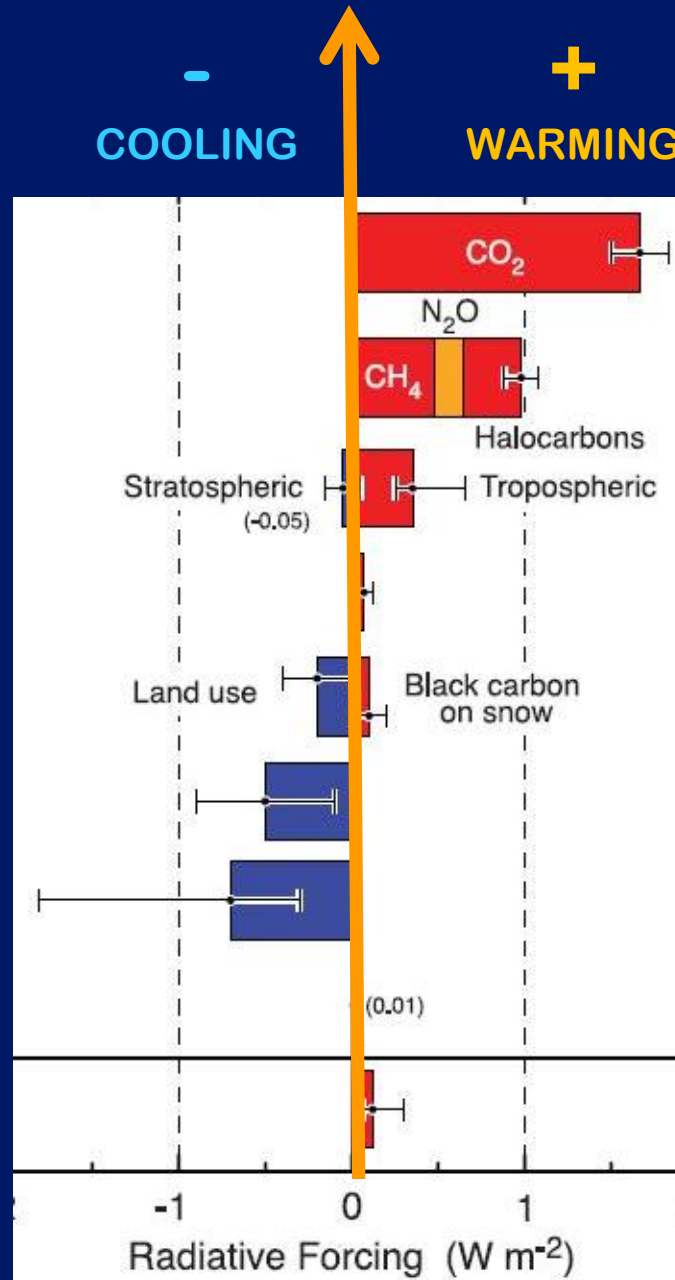
1. TRUE
2. FALSE



WHAT TO KNOW:

If the forcing is **NEGATIVE** (to left of line)

it means that an increase in that gas or factor contributes to **COOLING** in the troposphere.

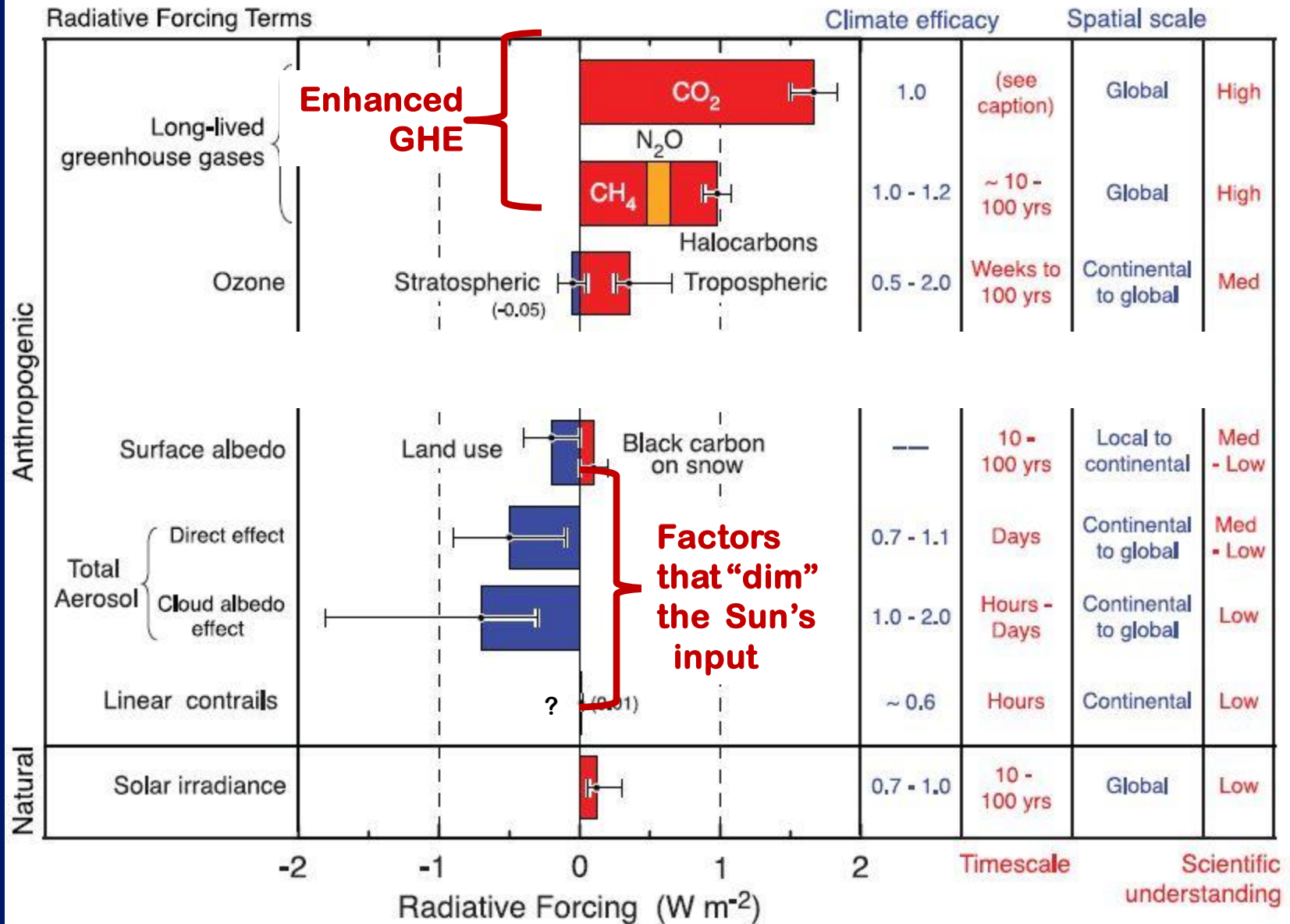


If the forcing is **POSITIVE** (to right of line)

it means that an increase in that gas or factor contributes to **WARMING** in the troposphere.

Top graph on p 83 from 2007 IPCC report

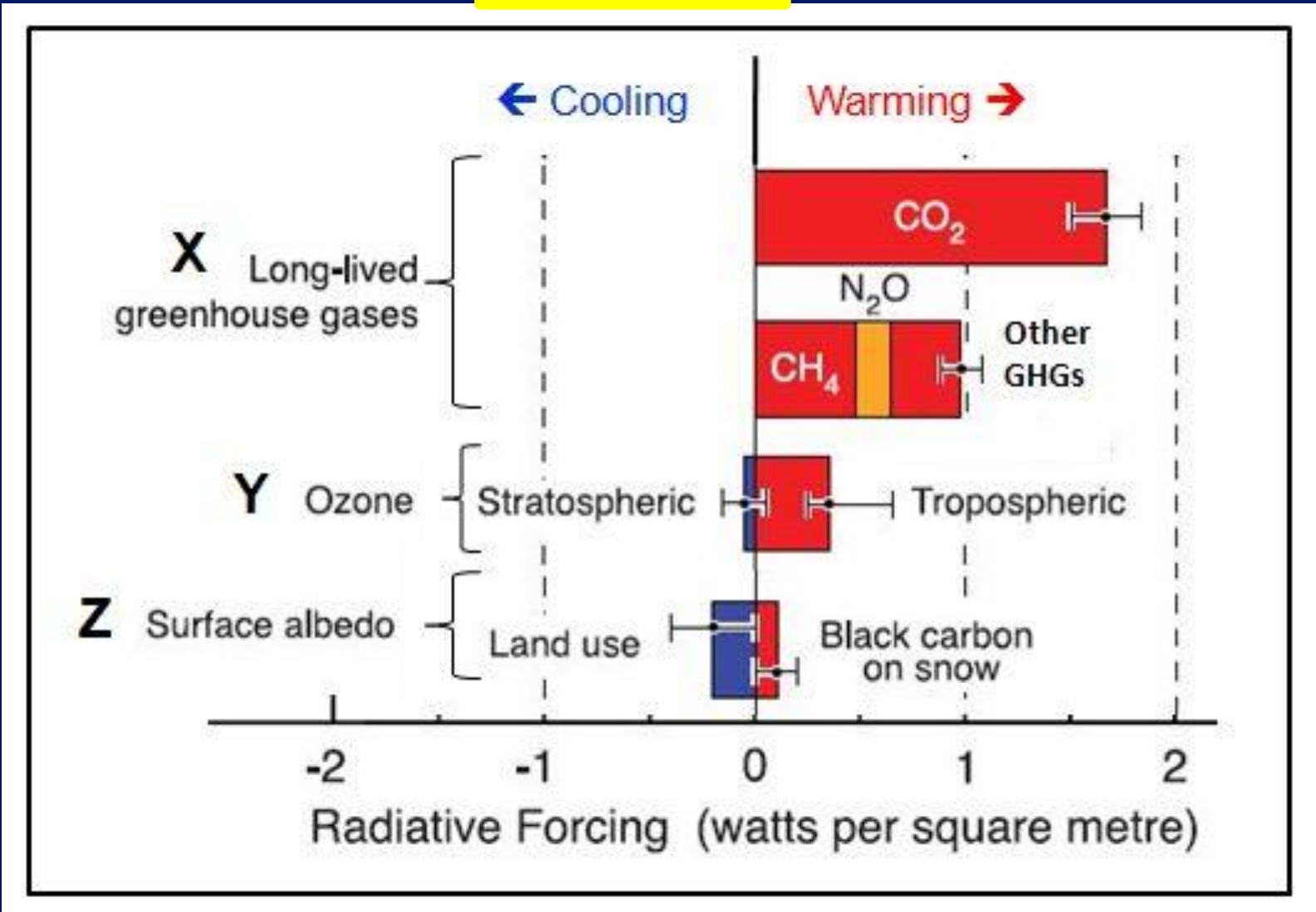
Radiative forcing of climate between 1750 and 2005



ALL of the forcing mechanisms shown here (X, Y, & Z) are linked to anthropogenic activity in some way:

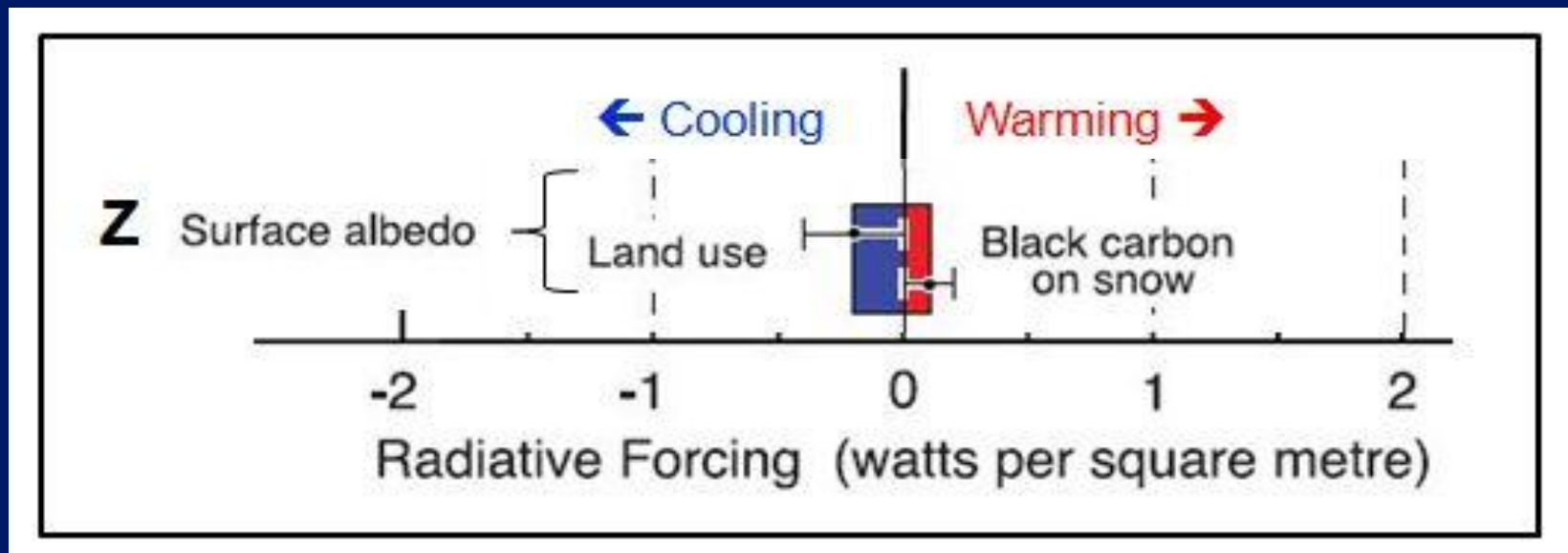
1. TRUE

2. FALSE



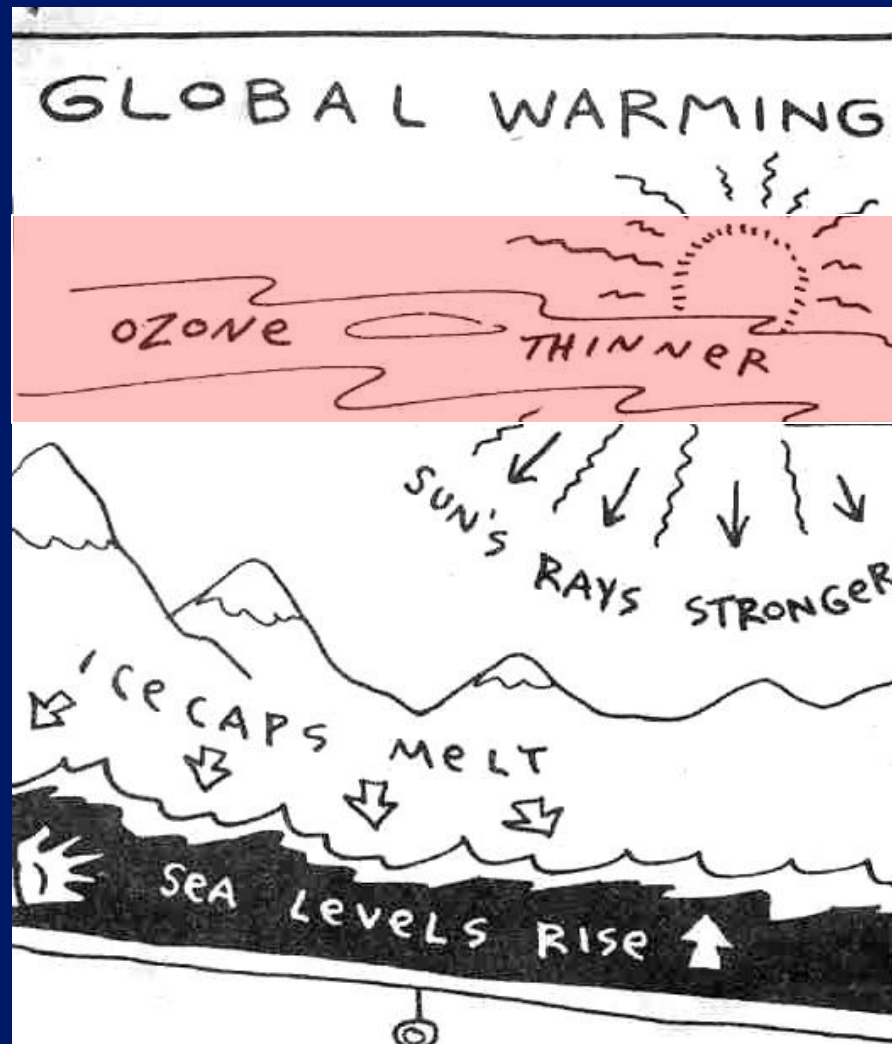
The figure shows that **Forcing Z (surface albedo changes)** leads to **COOLING** The reason for this is that **cooling** occurs when surface albedo **increases** and hence **MORE** energy is **absorbed**.

TRUE or **FALSE?**



LESS energy is absorbed!

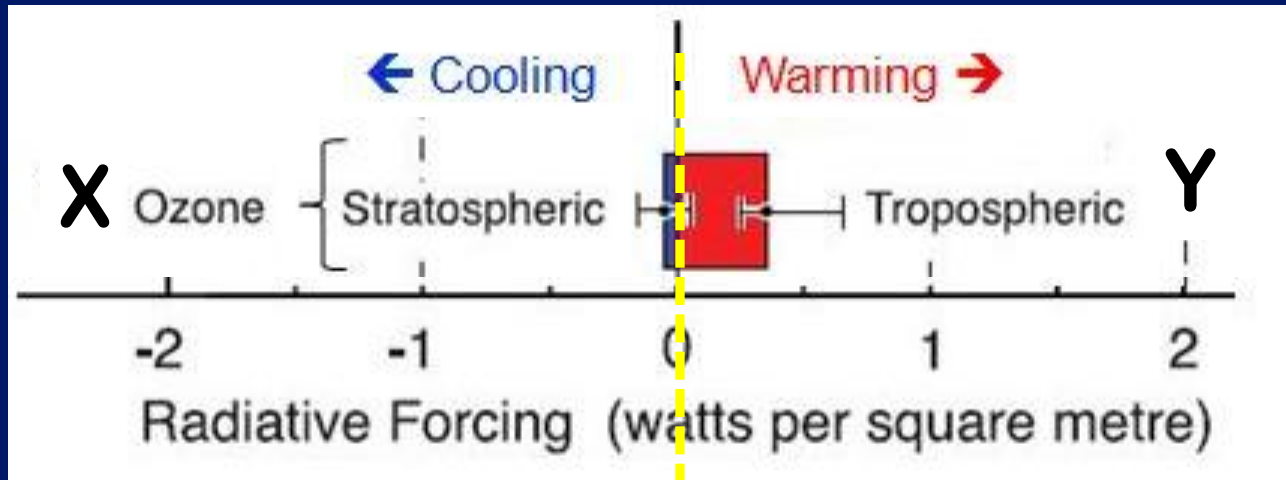
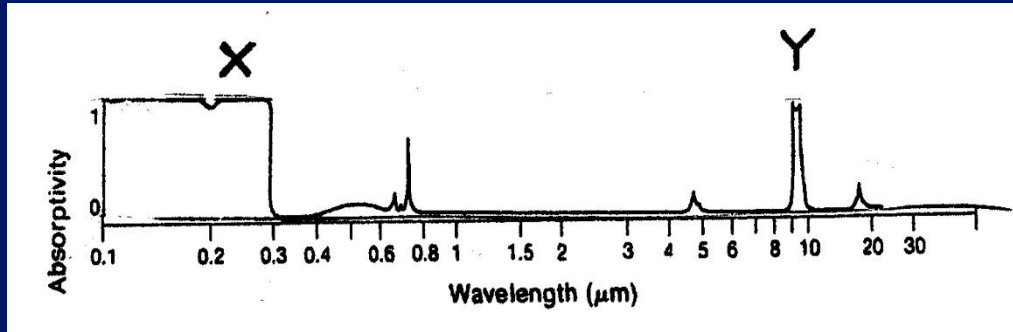
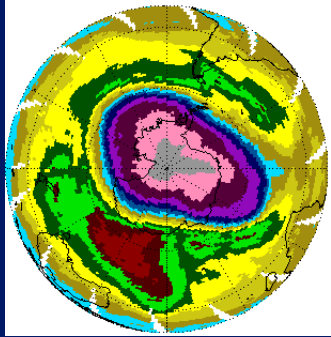
REVIEW OF THIS COMMON MISCONCEPTION!



Is the depletion of STRATOSPHERIC OZONE
(in the OZONE HOLE and elsewhere)
an **IMPORTANT**
CAUSE
of **GLOBAL WARMING?**

YES or NO ?

OZONE'S DUAL PERSONALITY!



An INCREASE of Stratospheric Ozone will absorb more UV in the stratosphere → less UV getting into the troposphere → a COOLER Troposphere

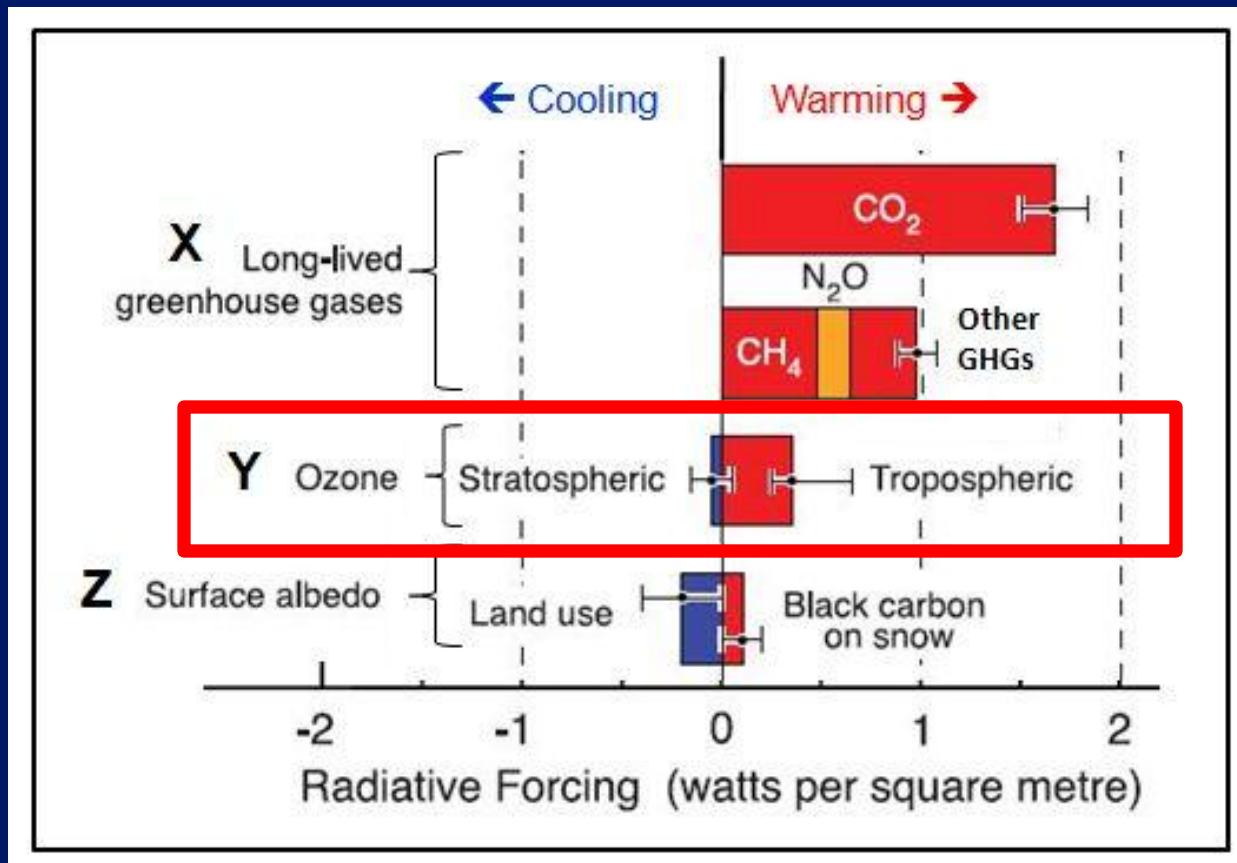
An INCREASE of Tropospheric (ground-level) Ozone will add to the Greenhouse Effect → more IR staying in the troposphere → a WARMER Troposphere

According to the figure which forcing mechanism has a GREATER influence on global temperature?

Stratospheric OZONE

OR

Tropospheric OZONE



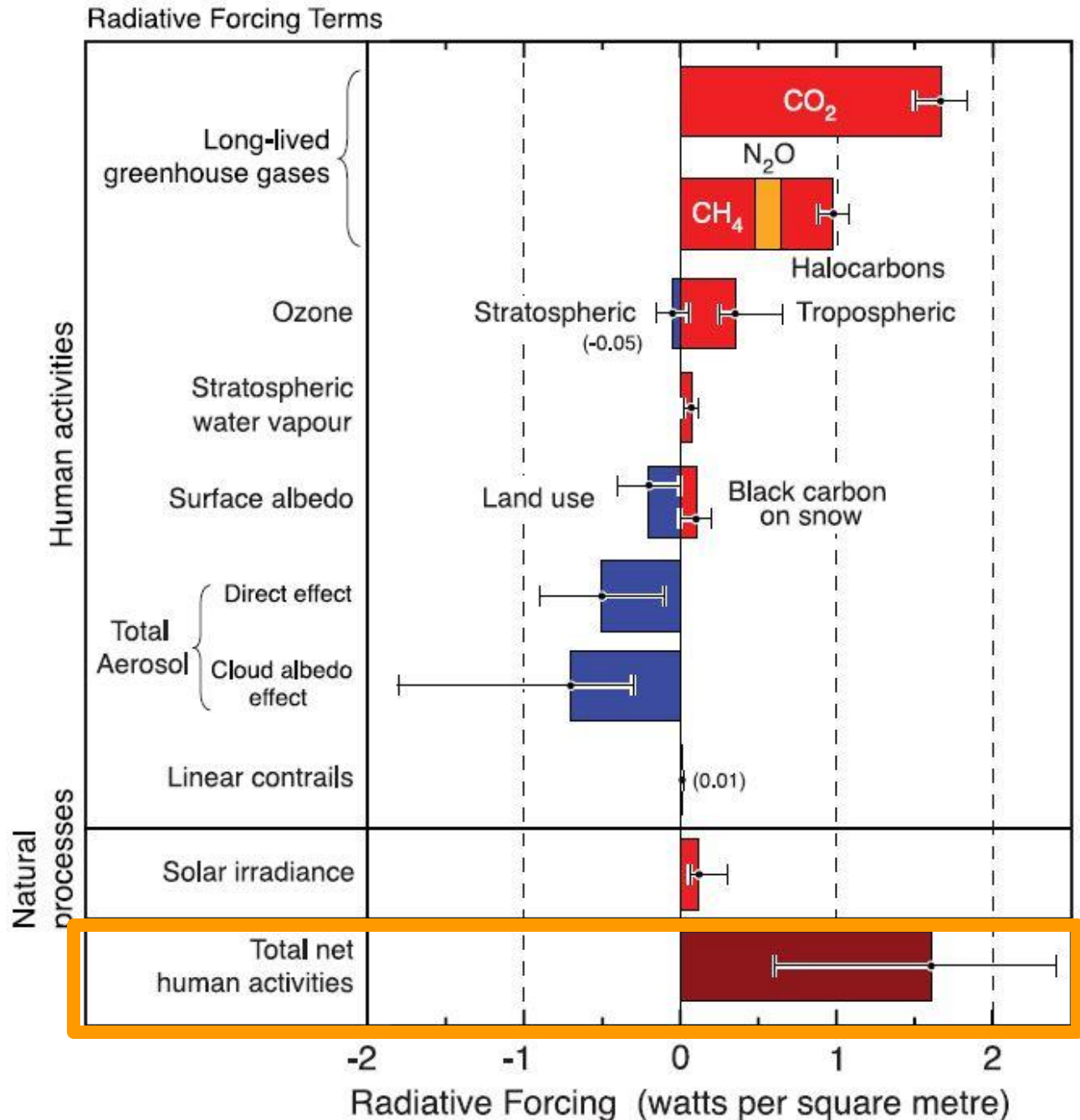
The **STRATOSPHERIC** OZONE HOLE IS NOT THE MAIN CAUSE FOR GLOBAL WARMING!

FAQ 2.1

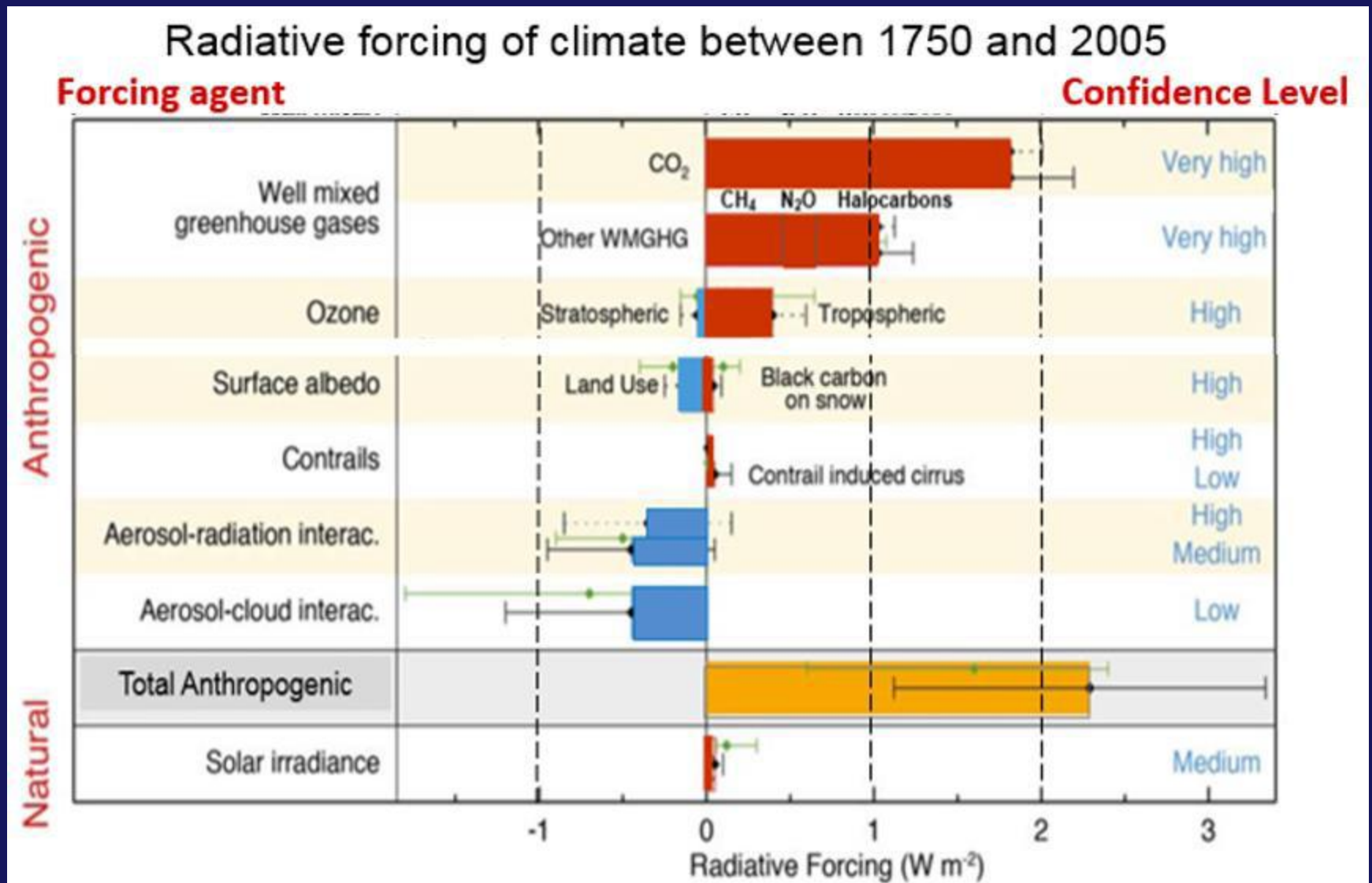
How do Human Activities Contribute to Climate Change and How do They Compare with Natural Influences?

Climate Change 2007 - IPCC
The Physical Science Basis
Working Group 1
Report

Radiative forcing of climate between 1750 and 2005



BOTTOM graph on p 83 from the most recent (2013) IPCC:



WHAT DIFFERENCES DO YOU SEE?



MOVIE TIME!

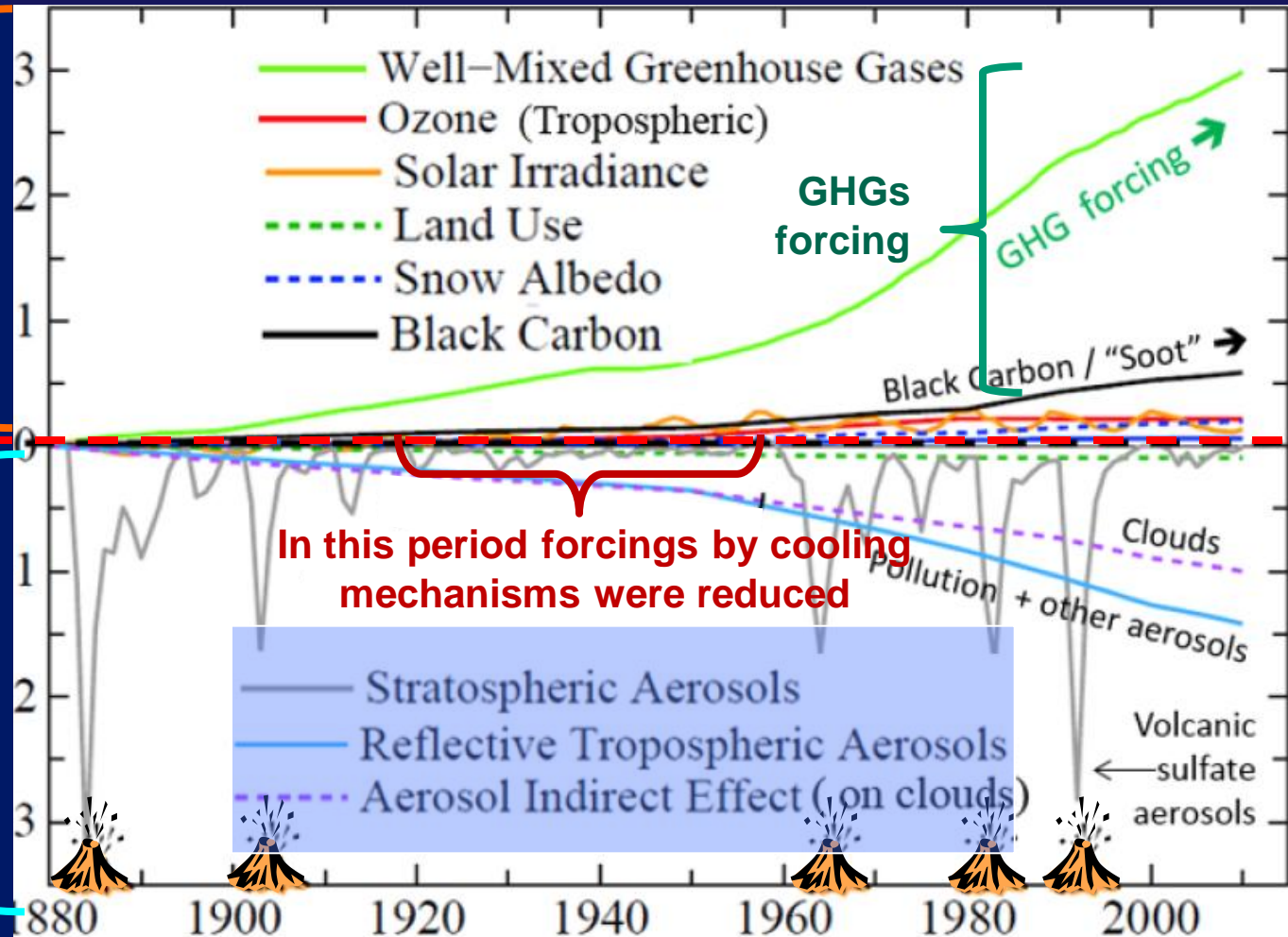
**A LINKING-TO LIFE
VIDEO**

How pollution & other human influences affect **RADIATIVE FORCINGS** . . .

Forcing by mechanisms that cause warming in the troposphere

0 line = 1880 value

Forcing by mechanisms that cause cooling in the troposphere





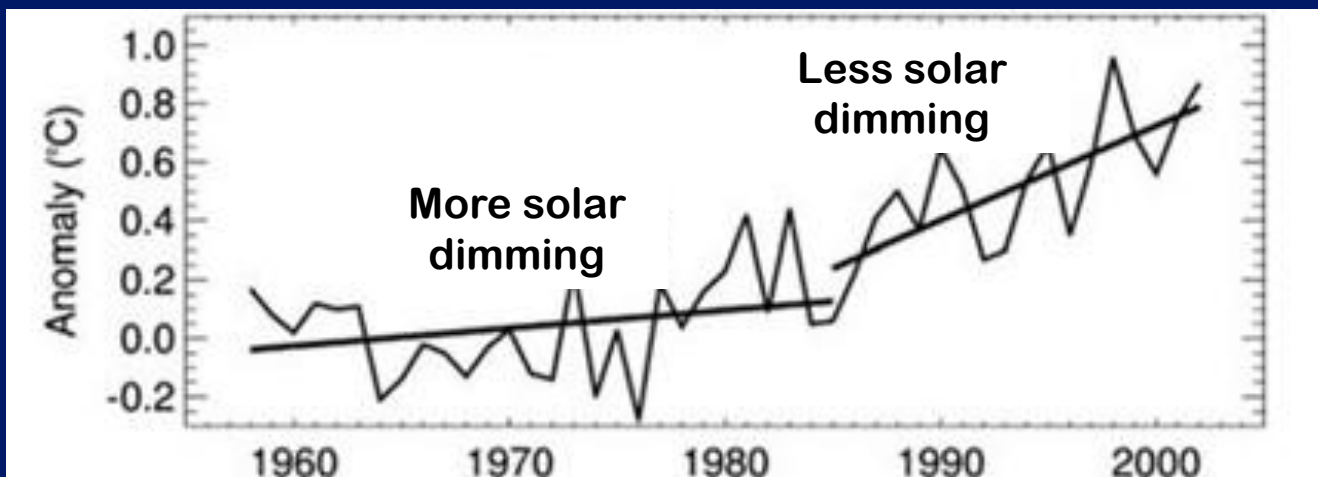
11,000 jet trails in 8 hours
33,000 in 24 hours

Jet Trails, 2007

Photographic artist, Chris Jordan

Solar Dimming may have “masked” the intensity of warming from the Enhanced GH Effect . . . until recently!

Average Temperature Change
over Global Land Surfaces (1958 – 2002)



*Thick-cloud
air pollution common;
health problems, deaths*



**Clean Air
Act of 1970**
*stronger law;
EPA established
later that year*

**Clean Air
Act of 1990**
*EPA more implementation +
enforcement authority;
increased emphasis on
cost-effectiveness*

Clean Air Act of 1963
*funding to study health effects; federal
+ state laws promote clean air*



Curious? Learn more in this interesting film



“New evidence that **AIR POLLUTION** has masked the full impact of global warming suggests the world may soon face a heightened climate crisis.”

NOVA

http://www.pbs.org/wgbh/nova/transcripts/3310_sun.html

LINKING TO LIFE PART B

PEER REVIEW

PROCESS EXPLAINED



For more details, see the posted
LTL- Part B directions under
Assignments

NO CLASS ON WEDNESDAY
Nov 25th



**Use the cancelled class time to work on your
Linking-to-Life Part B Assignment**

**If you haven't yet watched your film or video, all can
still be watched virtually in D2L**

See the LTL PART B directions for more details.

See you Monday November 30th!