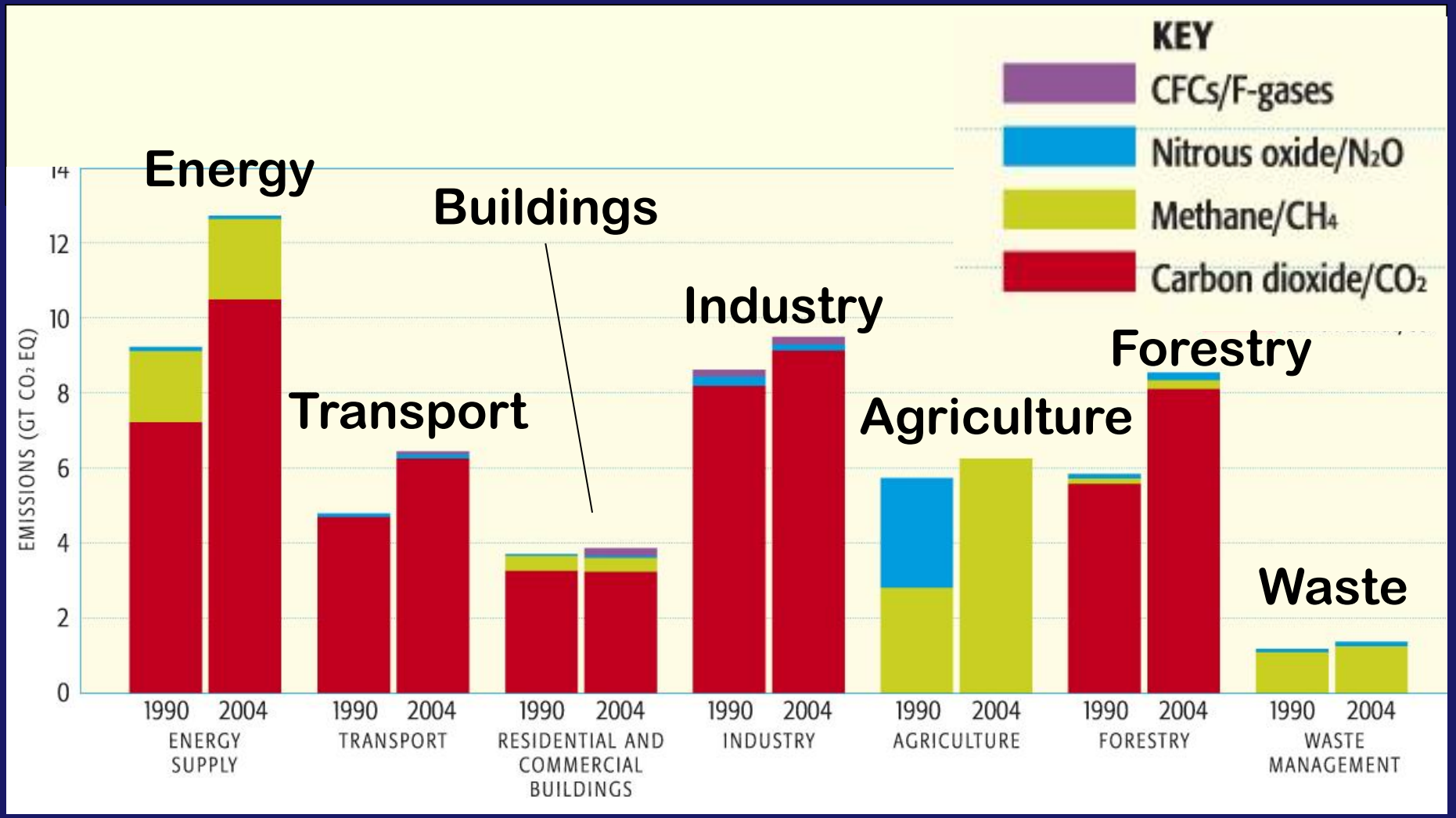
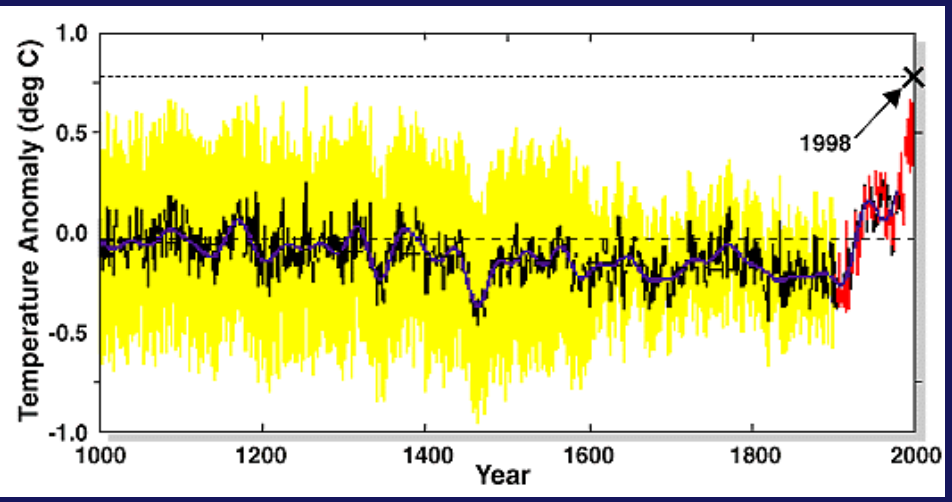
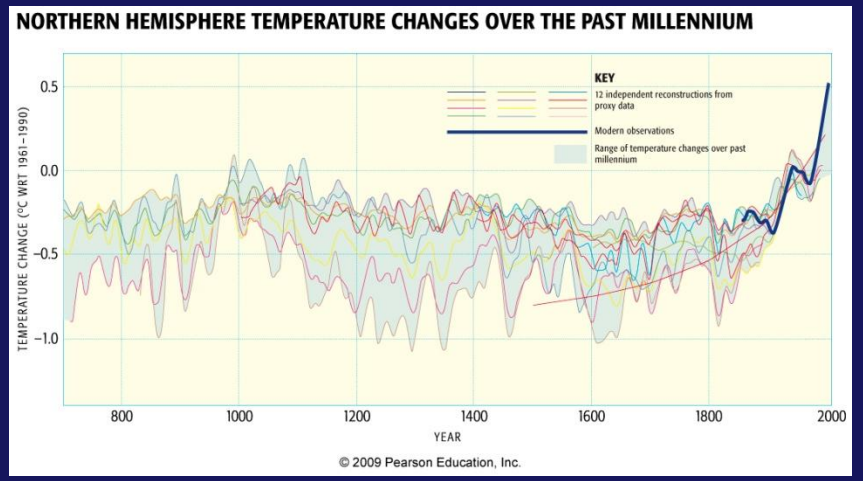
WRAP- UP of TOPIC #14 on ANTHROPOGENIC GLOBAL WARMING

GREENHOUSE GAS EMISSIONS BY SECTOR IN 1990 AND 2004



TOPIC # 14, PART B:
Evidence from Natural Archives

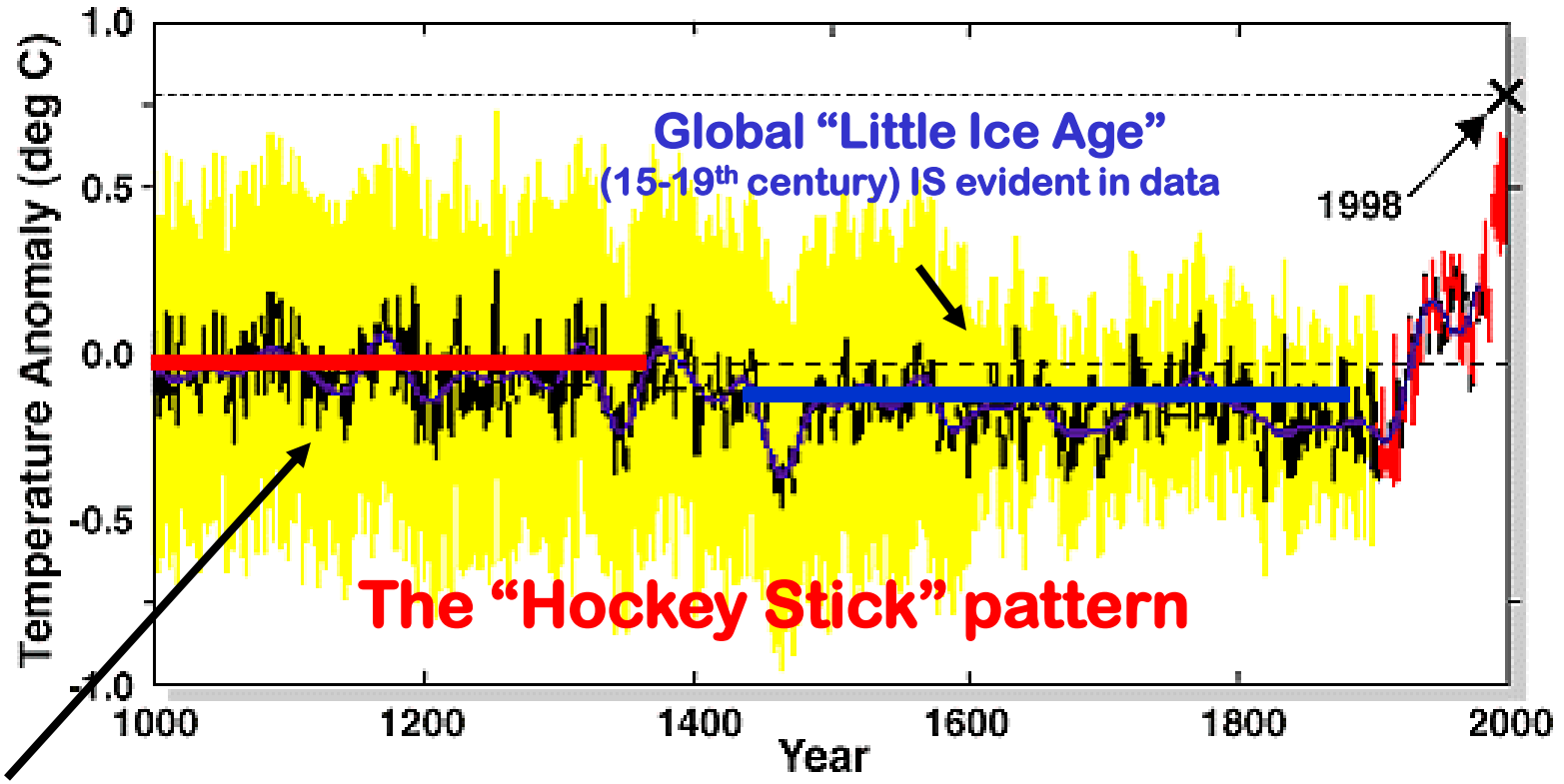




Class Notes pp 78

KEY GRAPH! Temperature change over the last 1000 years from multi-proxy records: shows there is NO period of global or hemispheric temperatures warmer than the 20th century

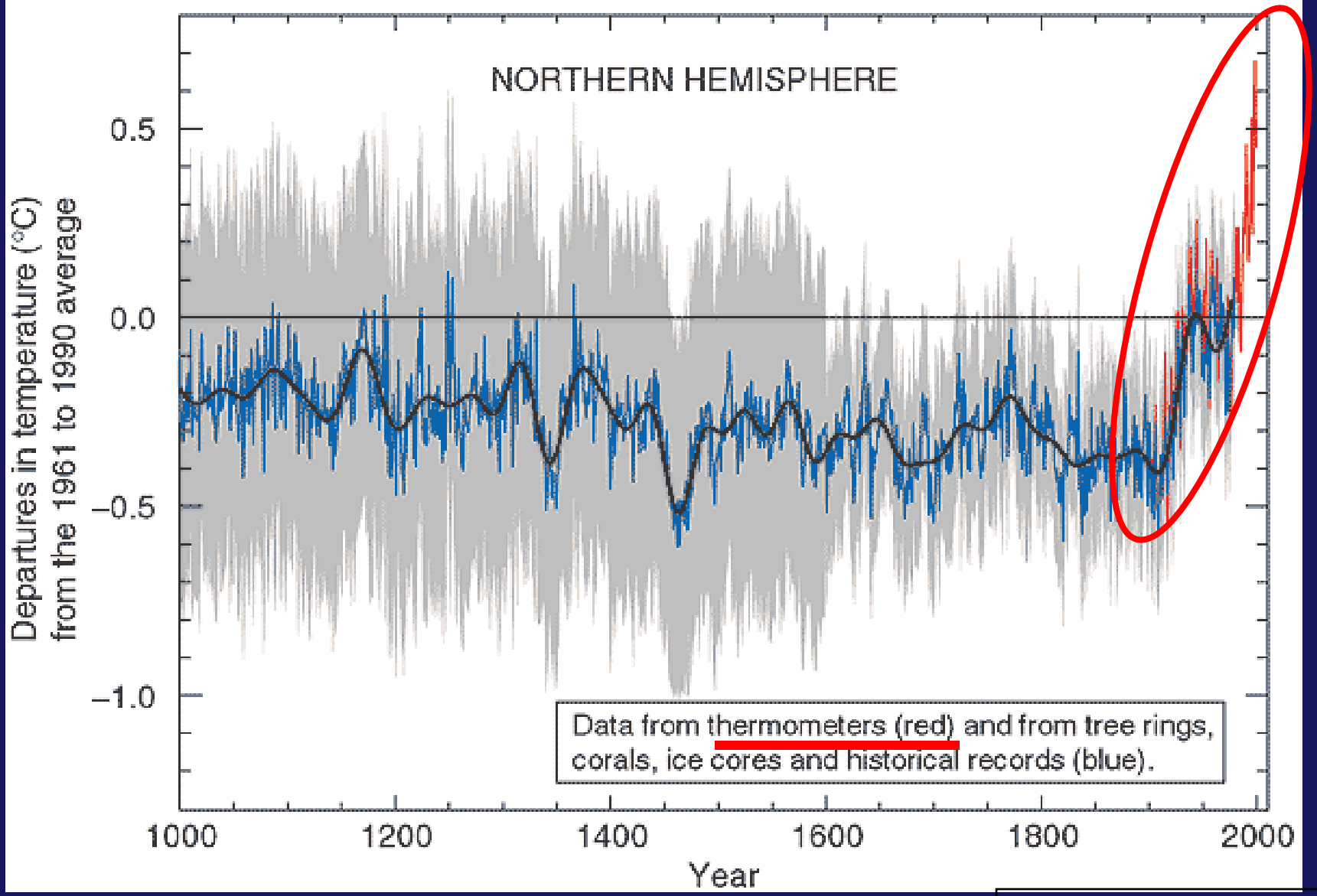
1902 -80 global mean



"Medieval Warm Period" (9-14th century) is a regional phenomenon only -- not globally warmer than 20th century!

Another view of the "HOCKEY STICK" GRAPH

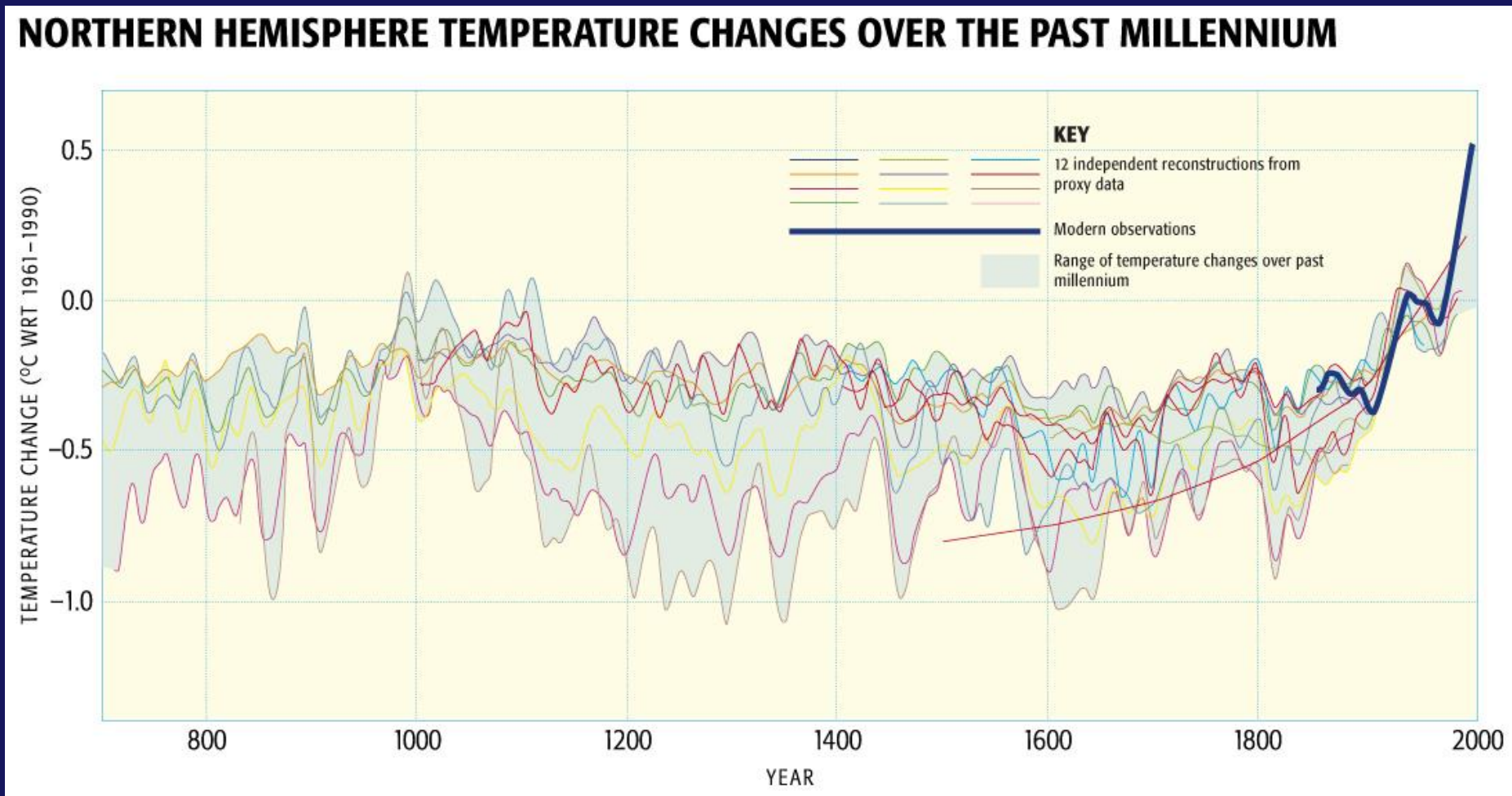
"proxy" data added to thermometer records



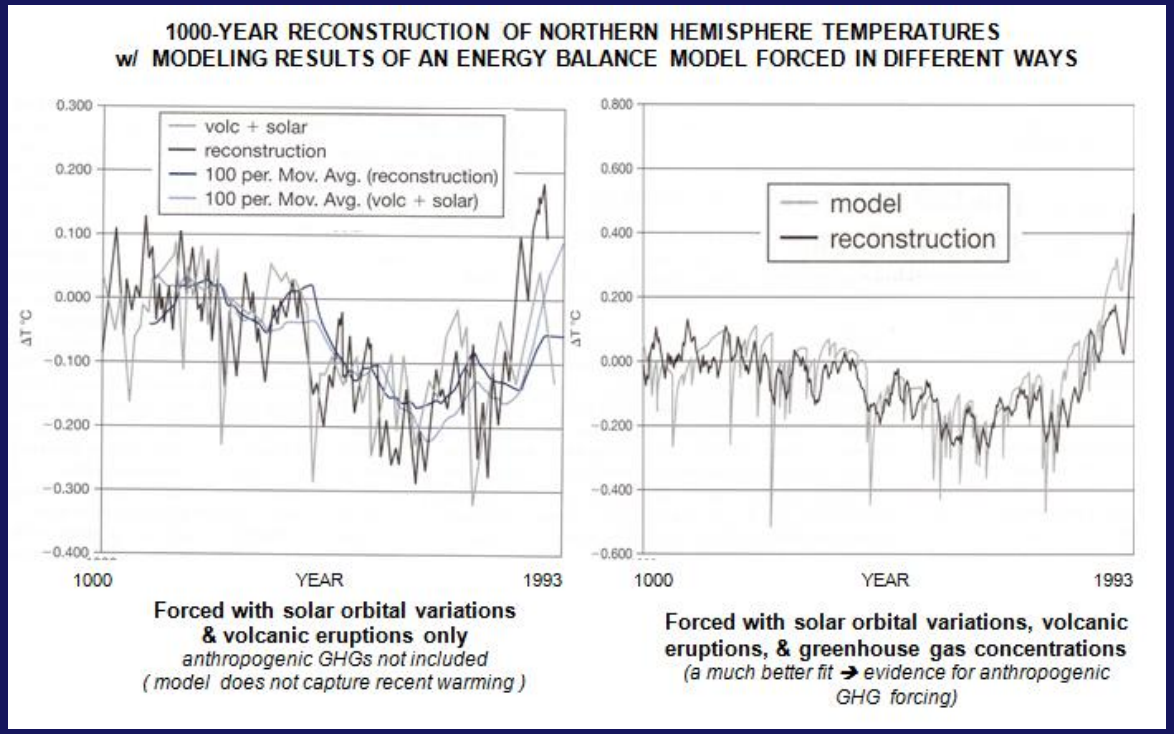
Like p 78

Has stood the test of time, despite intense scrutiny and debunking attempts:

Converging evidence of basic shape based on 12 independent reconstructions:



TOPIC # 14, PART C:
Evidence from Model Comparisons
Natural vs. Anthropogenic



Class Notes pp 79

DIFFERENT TYPES OF MODELS:

Increasing complexity

Energy Balance Model

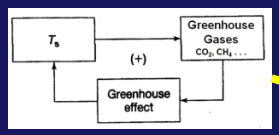
$$R_{NET} = SW\downarrow + SW\downarrow - SW\uparrow - LW\uparrow + LW\downarrow$$

Radiative Convective Model

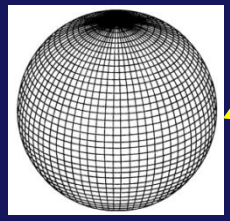
$$R_{NET} = SW\downarrow + SW\downarrow - SW\uparrow - LW\uparrow + LW\downarrow = H + LE + G$$

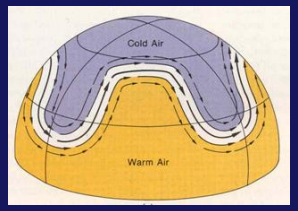
H & LE fluxes added

General Circulation Model (GCM)



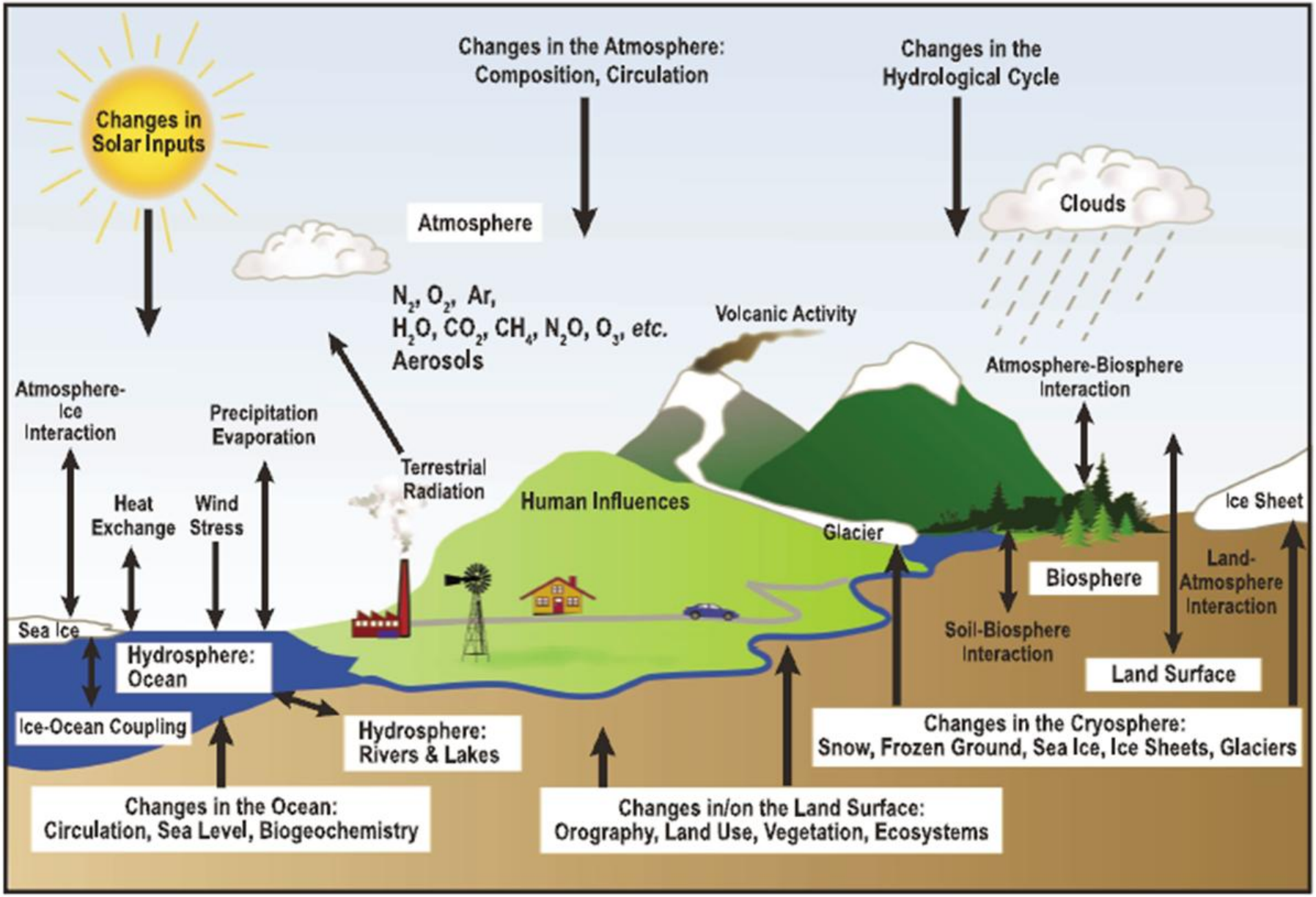
Feedbacks



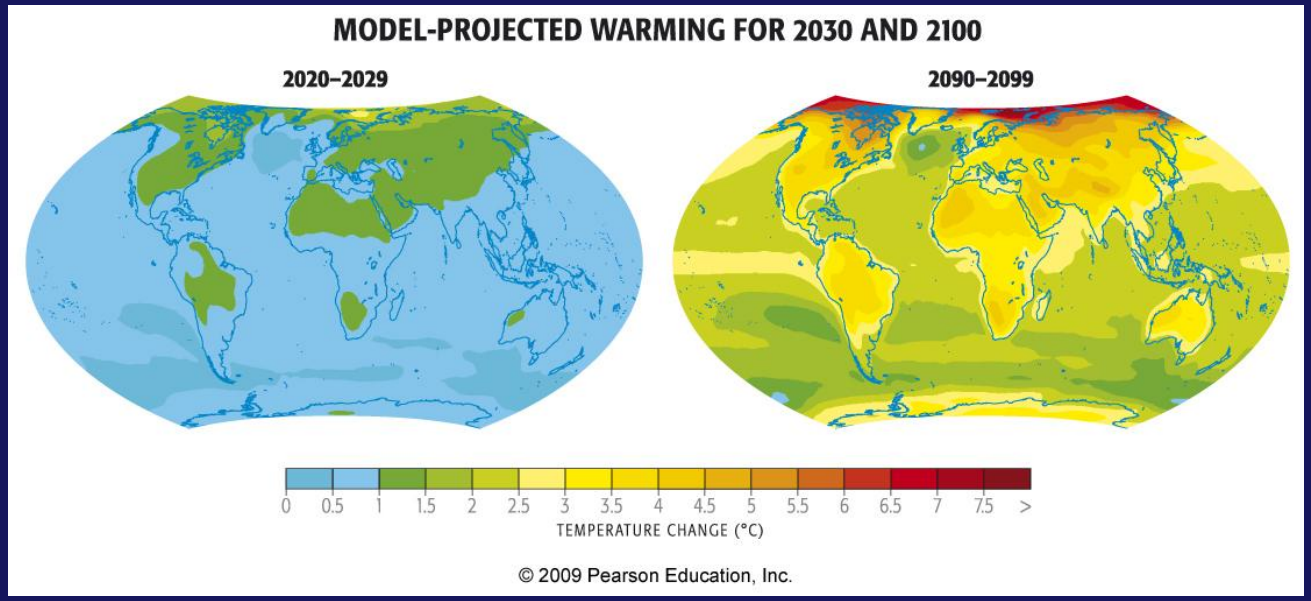


Atmospheric Circulation

Modeling The Climate System



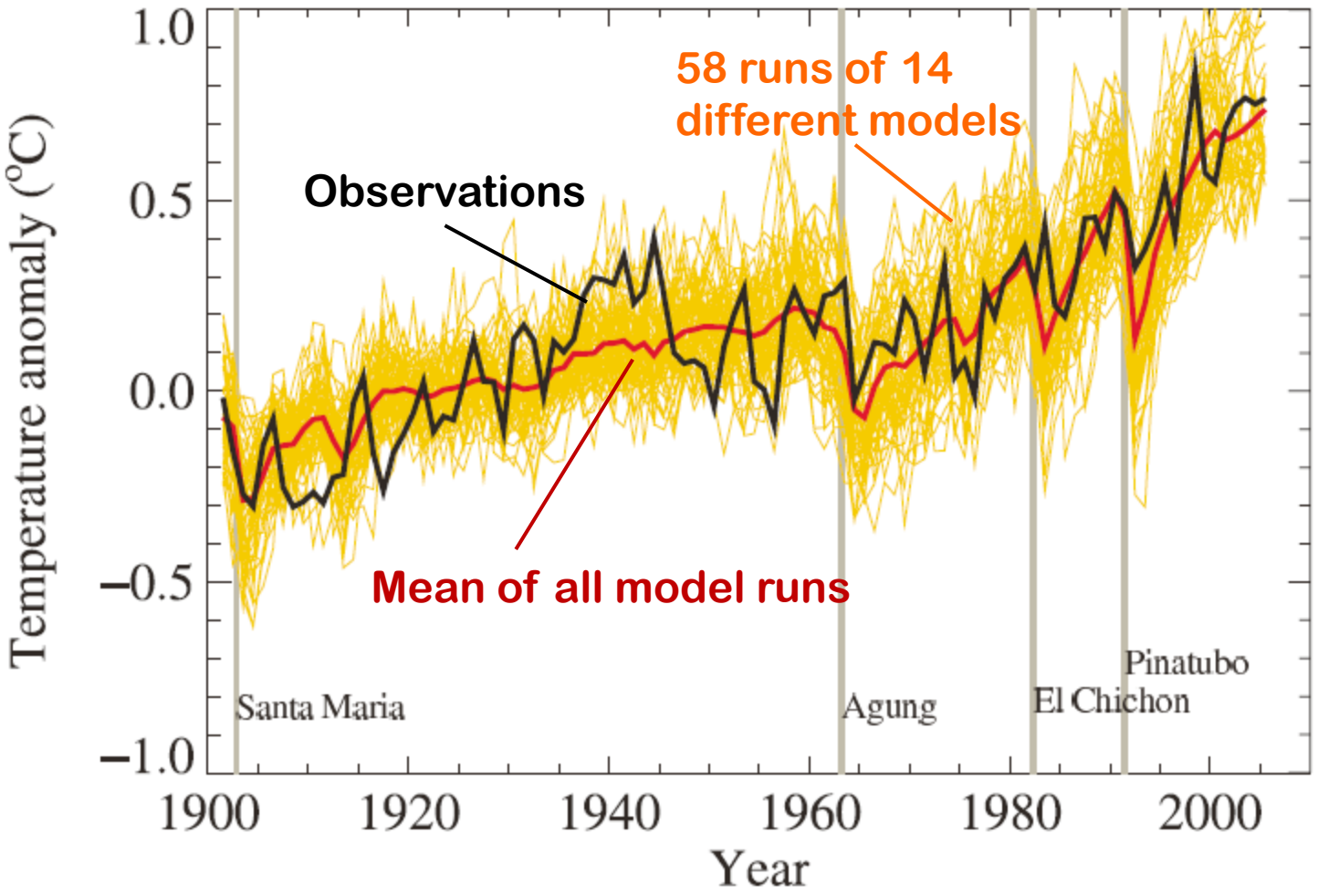
GCM's can predict not only **HOW MUCH CHANGE IN TEMPERATURE** might occur due to an enhanced greenhouse effect



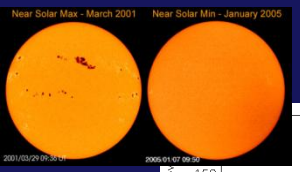
but also ***WHERE*** the changes are likely to manifest themselves.

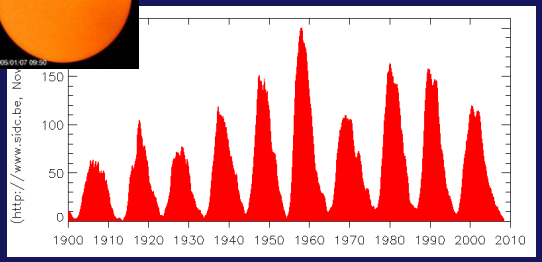
How Good are the Models?

MODELED GLOBAL MEAN TEMPERATURE:

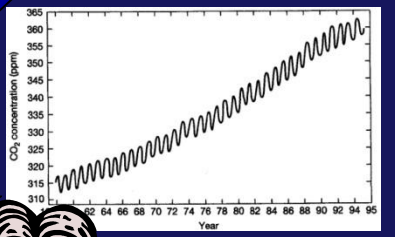


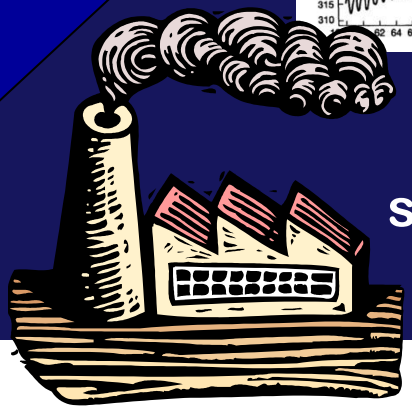
NATURAL FORCING



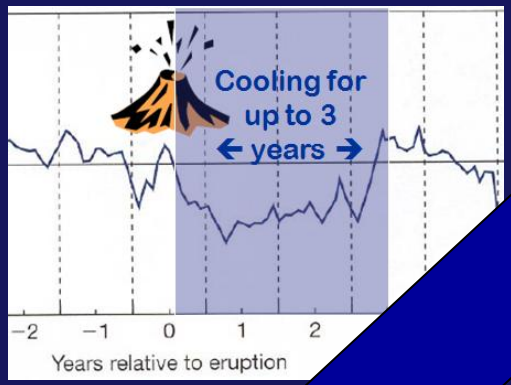


Solar output variations, sunspots

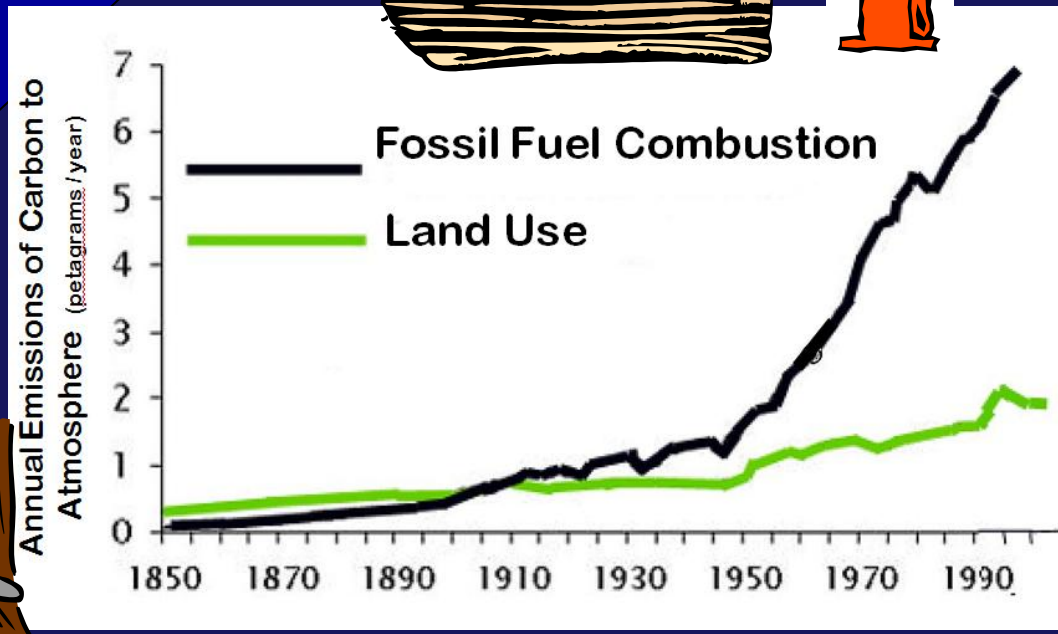


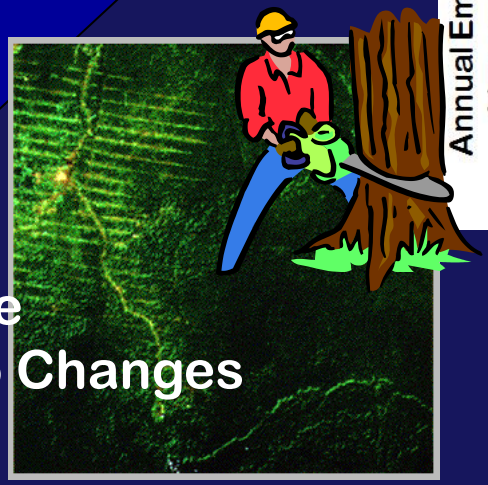


GHG's, soot, SO_2



Volcanic eruptions

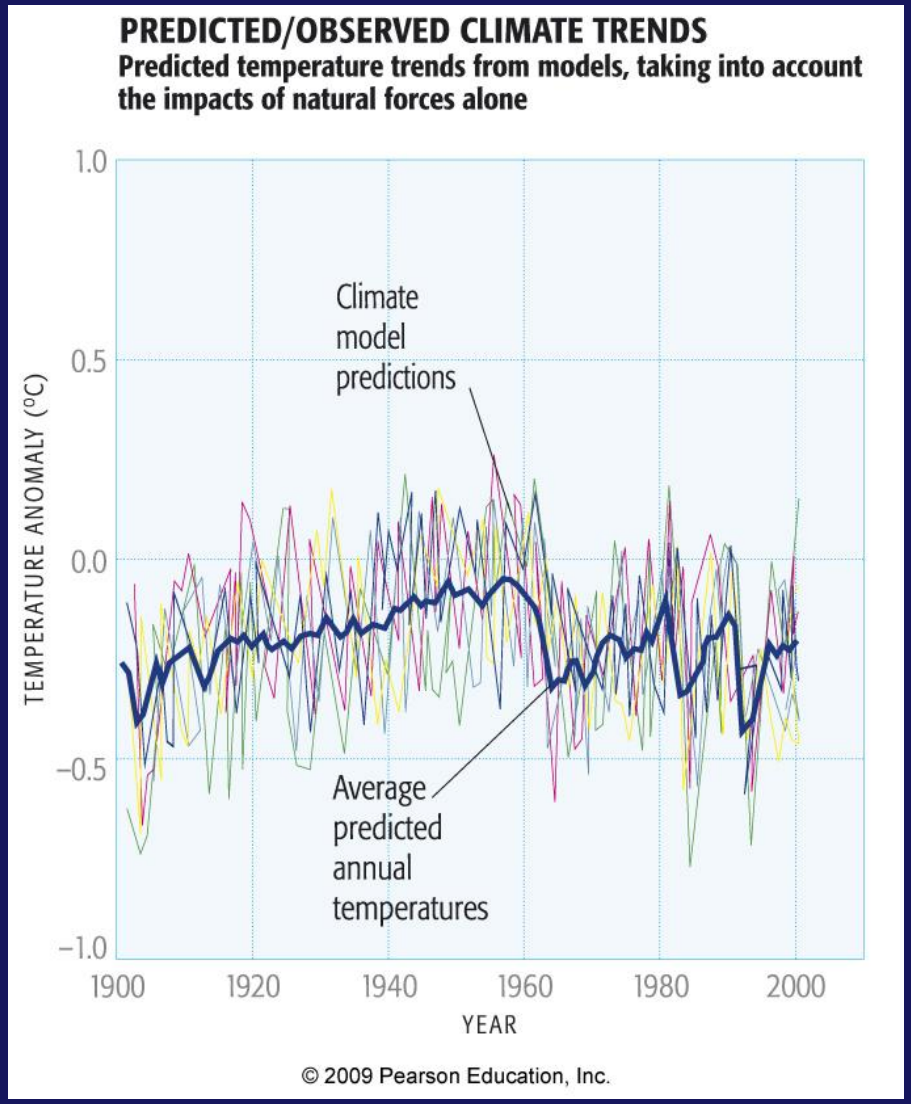


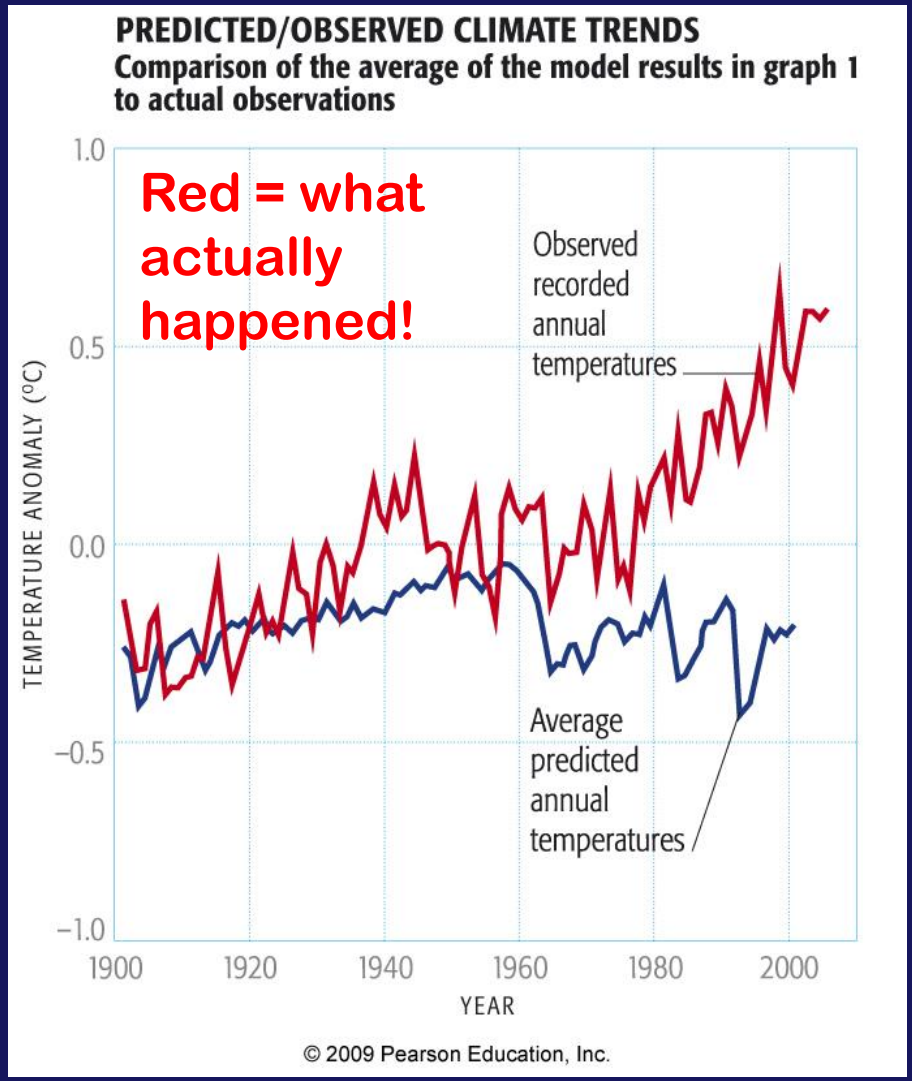


Surface Albedo Changes

ANTHROPOGENIC FORCING

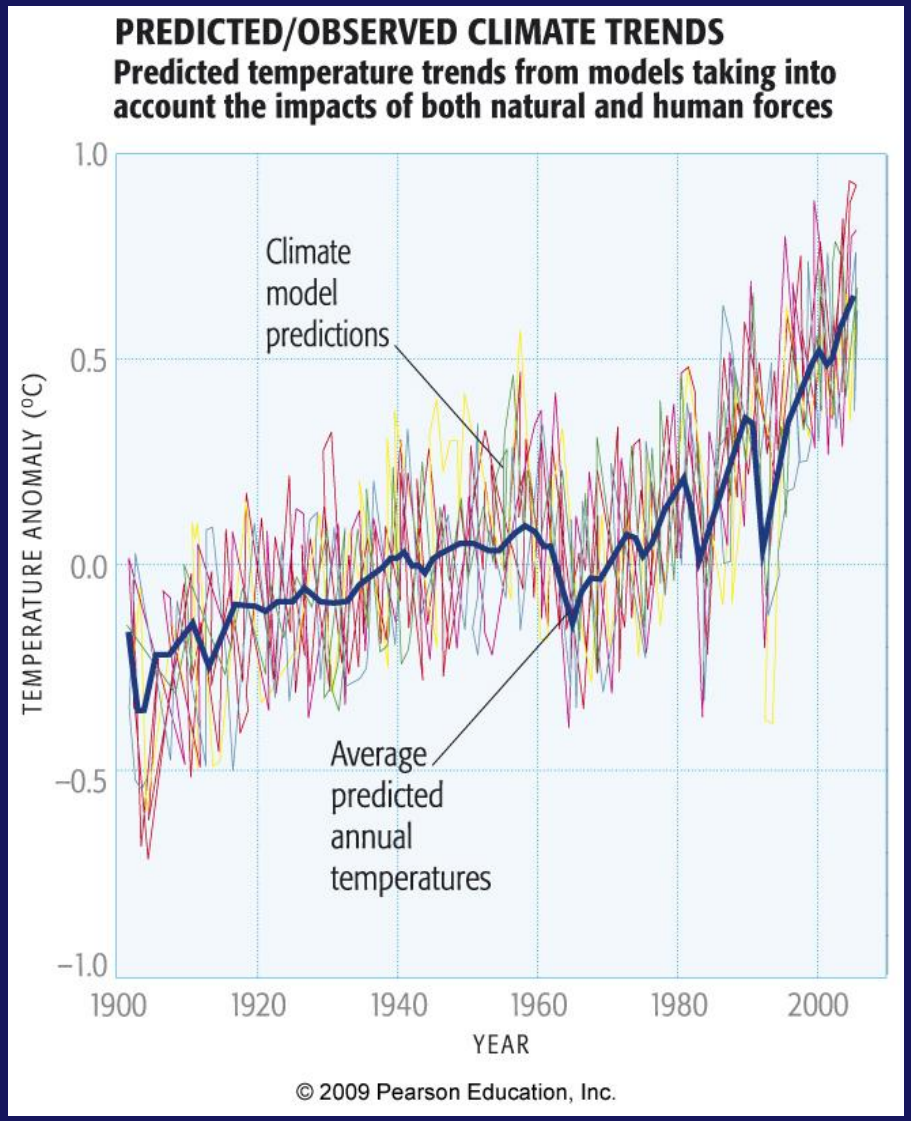
Modeled Temperature with Natural Forcing Only:

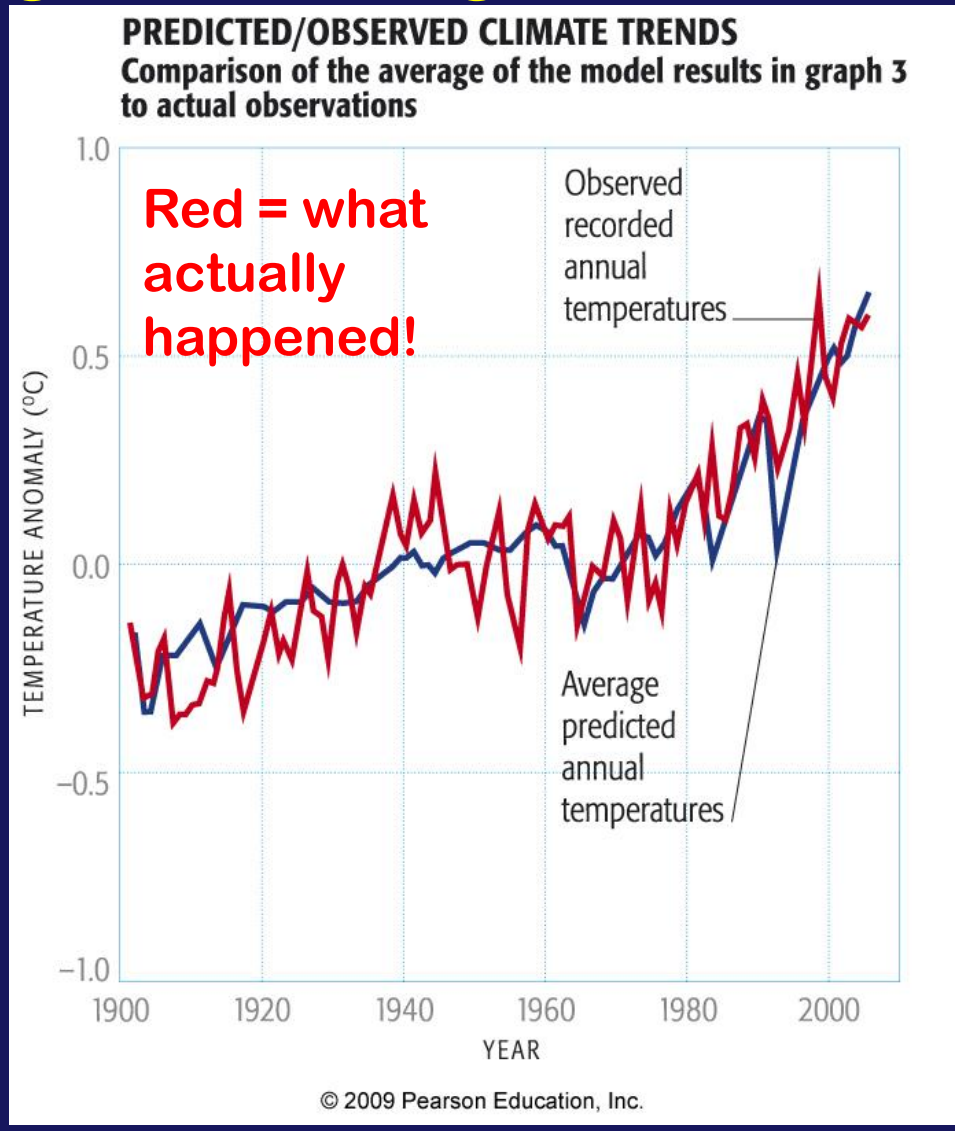




From Dire Predictions pp 68-69

Modeled Temperature with Natural AND Anthropogenic Forcing



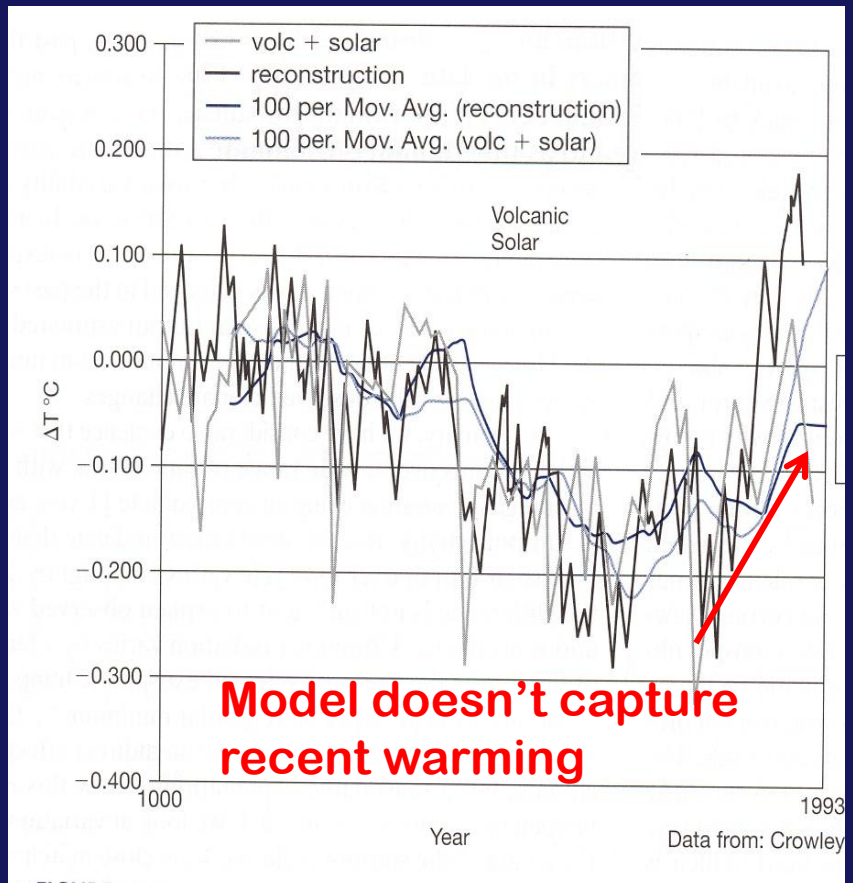


From Dire Predictions pp 68-69

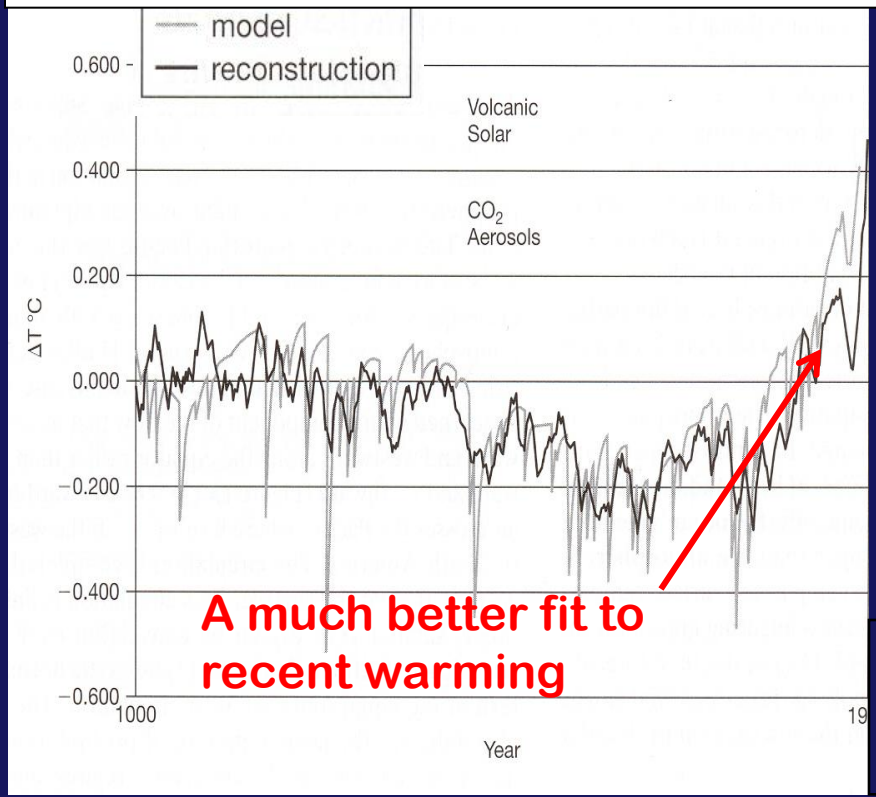
COMPUTER MODEL "FORCING" EXPERIMENT OF PAST CLIMATE

1000-year Reconstruction of Northern Hemisphere temperatures w/ Modeling Results of an Energy Balance Model Forced in Different Ways

Forced with orbital variations & volcanic eruptions

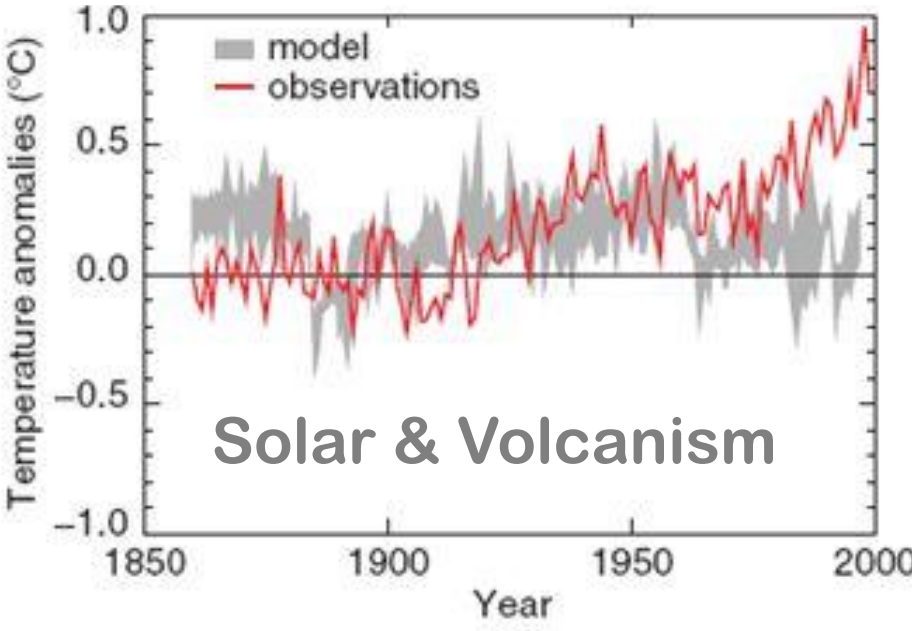


Forced with orbital variations, volcanic eruptions, & greenhouse gas concentrations



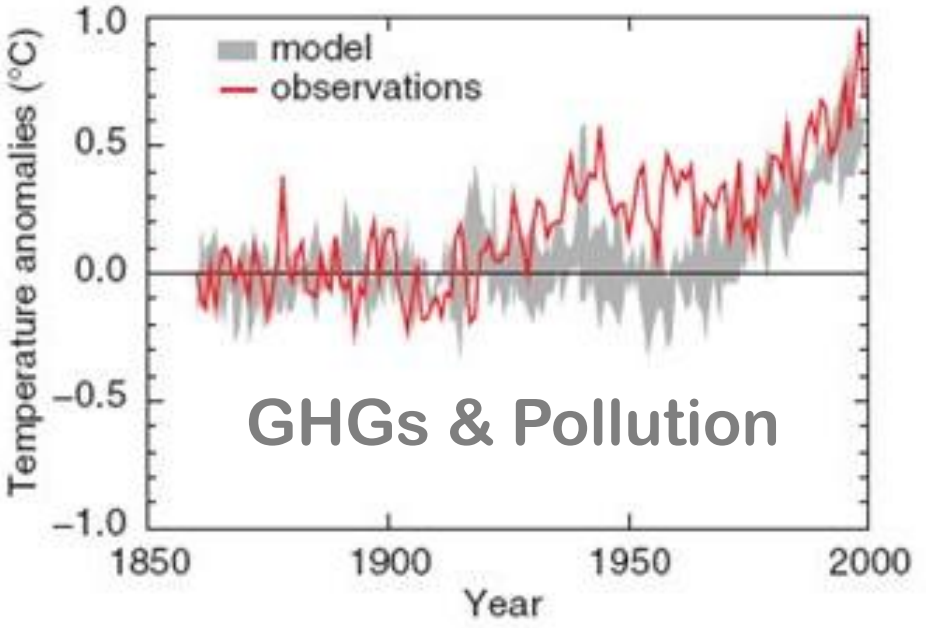
SEPARATING OUT NATURAL vs. ANTHROPOGENIC FORCING

NATURAL FORCING ONLY



Gray = Model-derived temperatures based on forcing by **solar variations and volcanism** only
Red = Observed temperatures

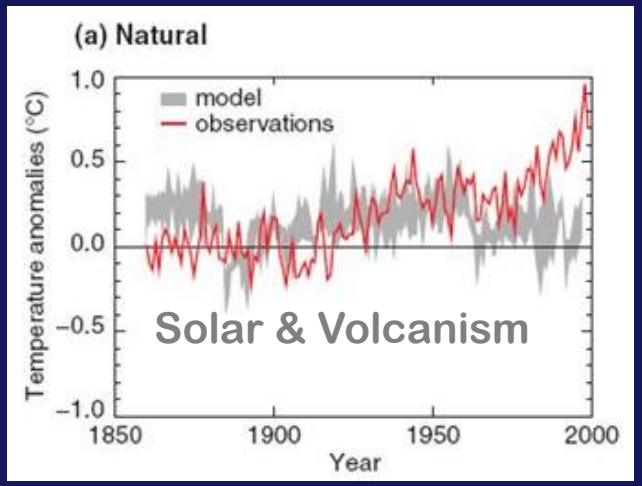
ANTHROPOGENIC FORCING ONLY



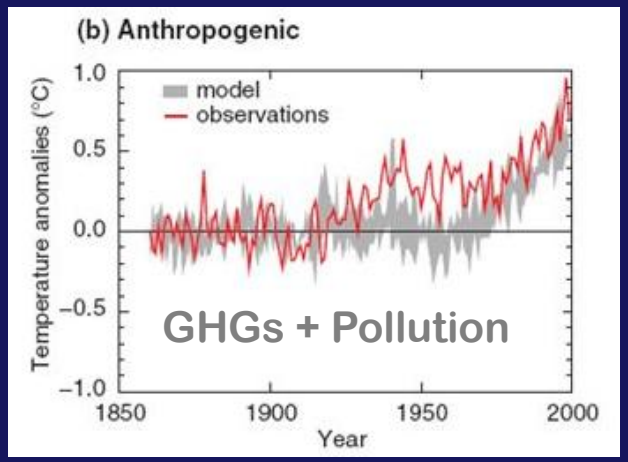
Gray = Model-derived temperatures based on forcing **by human emissions of GHGs** and **pollution** only
Red = Observed temperatures

From SGC-II Ch. 9

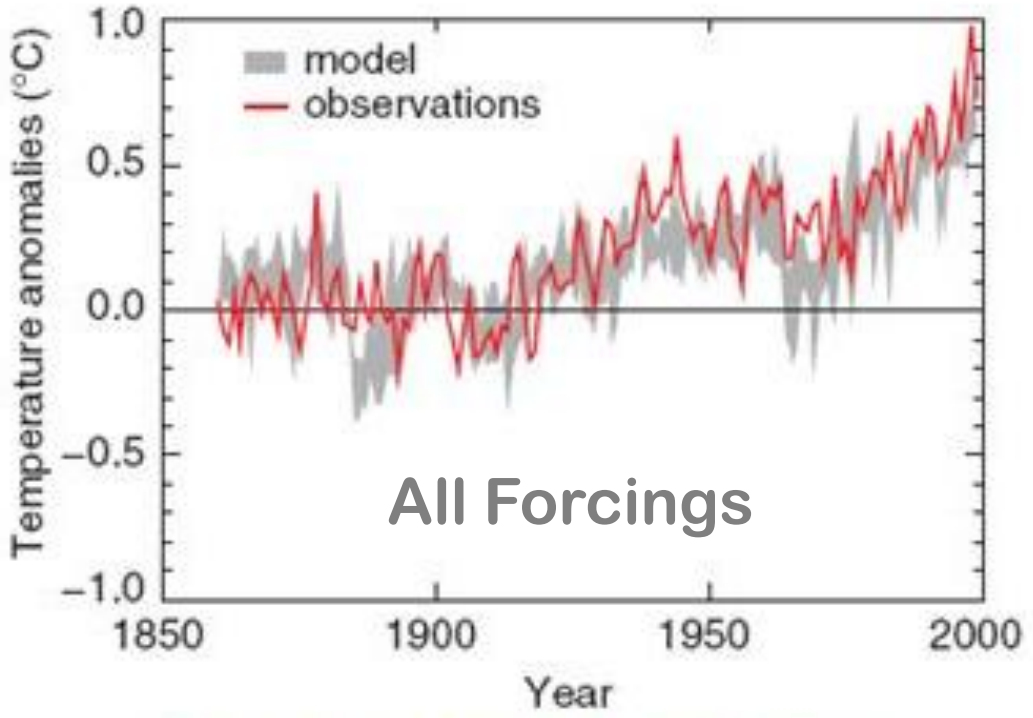
SEPARATING OUT NATURAL vs. ANTHROPOGENIC FORCING



+



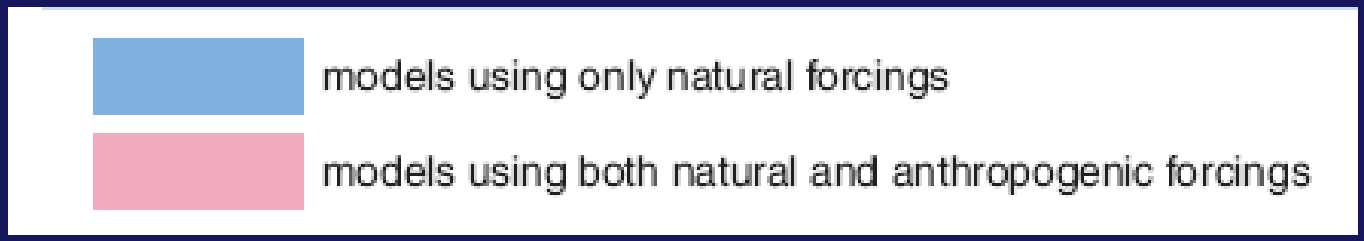
NATURAL + ANTHROPOGENIC FORCING COMBINED

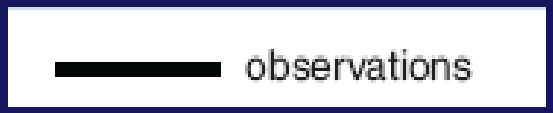


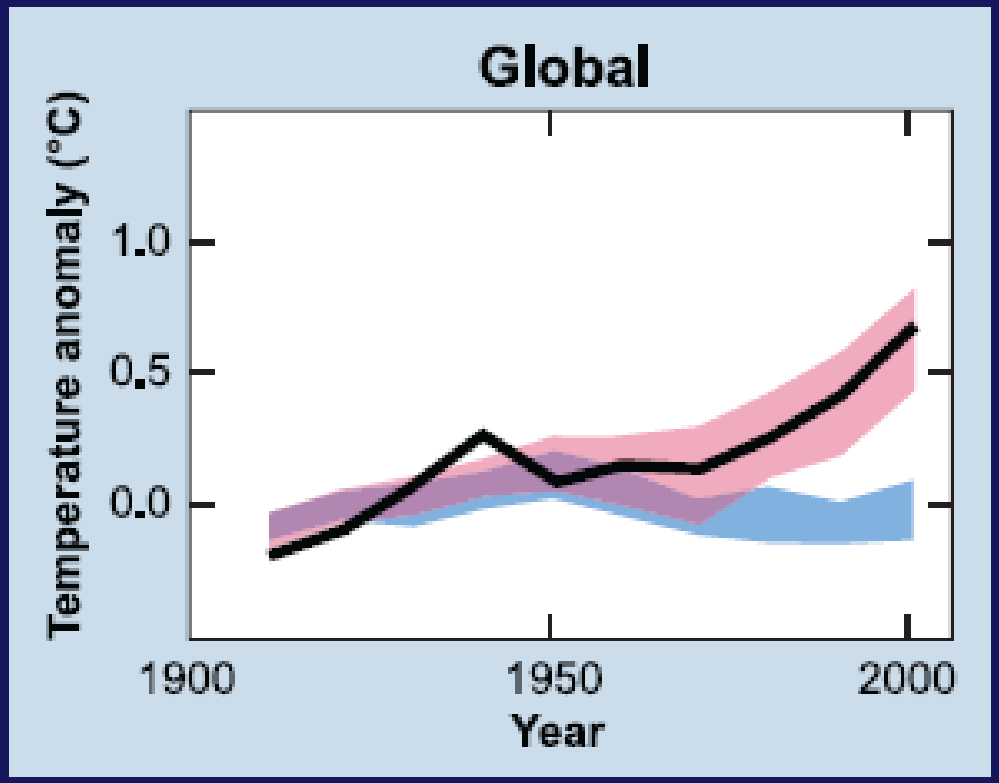
Gray = Model-derived temperatures based on forcing by BOTH **natural and anthropogenic** factors

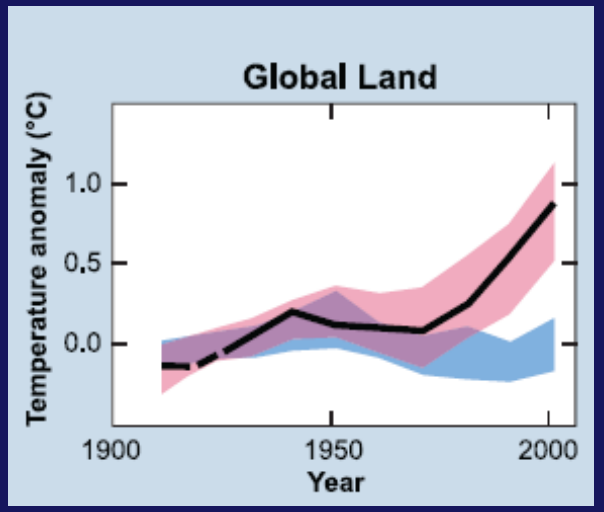
Red = Observed temperatures

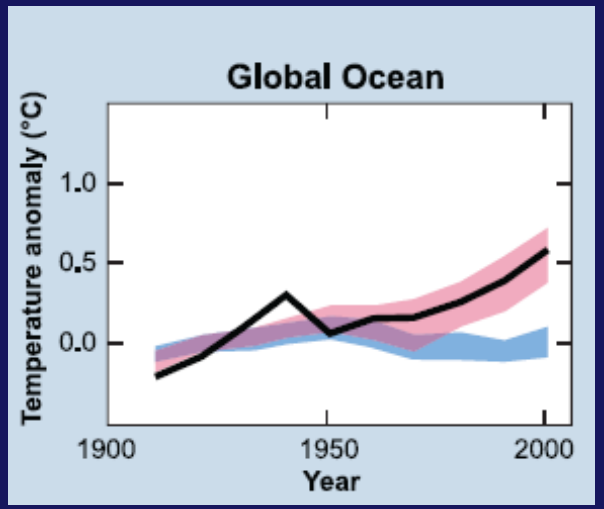
From SGC-II Ch. 9





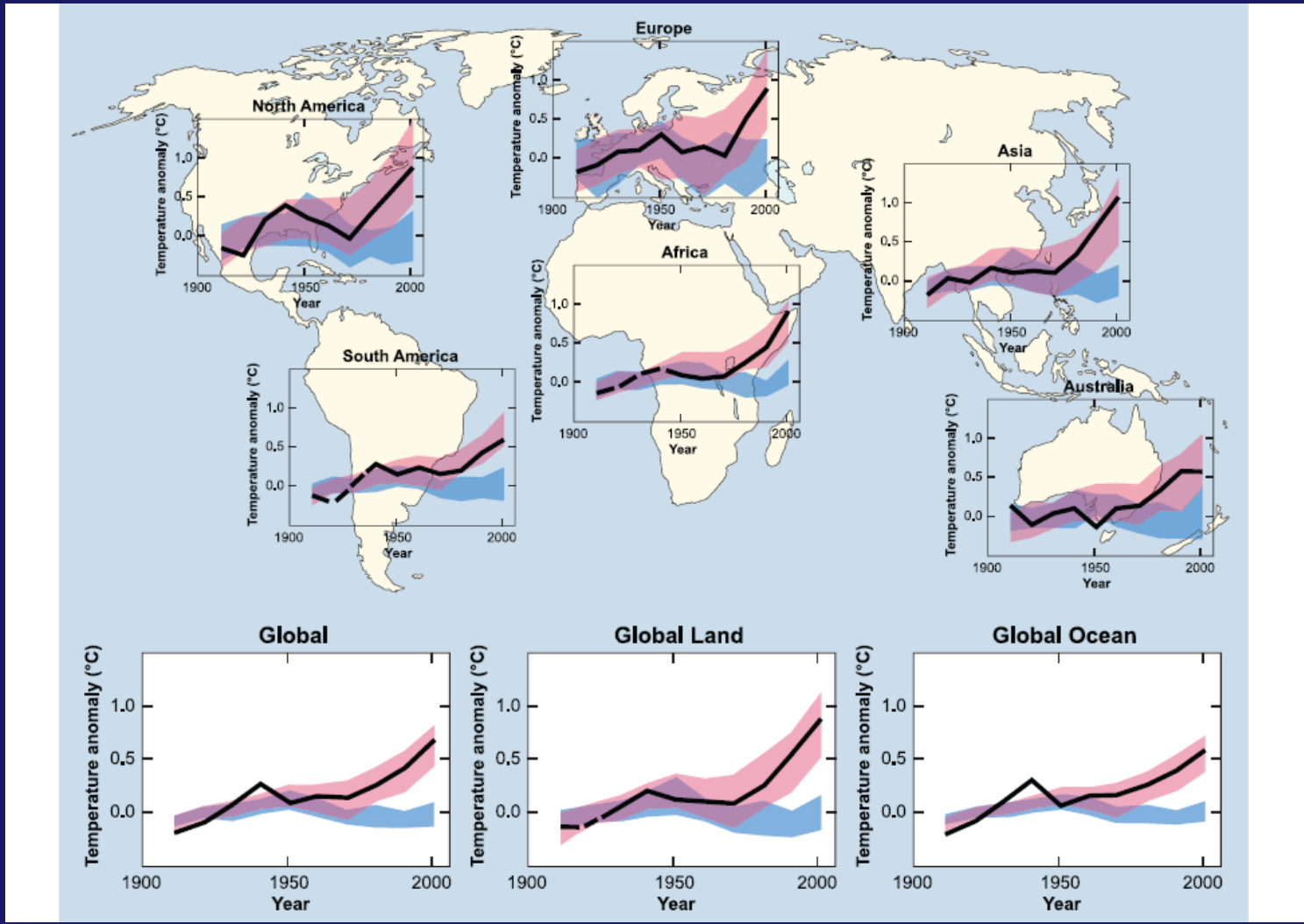






SOURCE: IPCC 2007 WG-1 Synthesis Report Summary for Policymakers

Individual Region Model Runs showed the same results!



observations

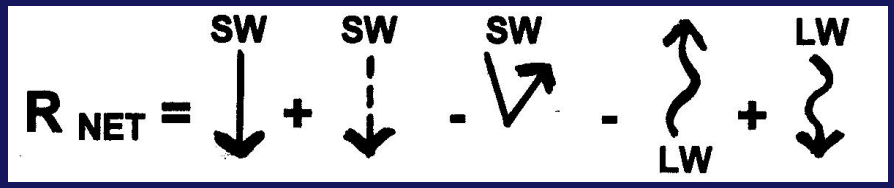
models using only natural forcings

models using both natural and anthropogenic forcings

Now we will focus on:

RADIATIVE FORCING

(linked to Radiation Balance!)



(expressed in Watts per square meter (Wm^{-2})

(def) a measure of the influence a factor has in altering the balance of **incoming & outgoing energy** in the Earth-atmosphere system

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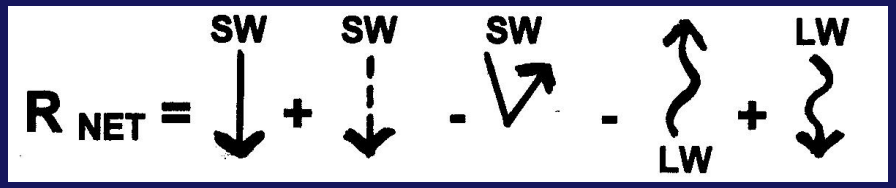
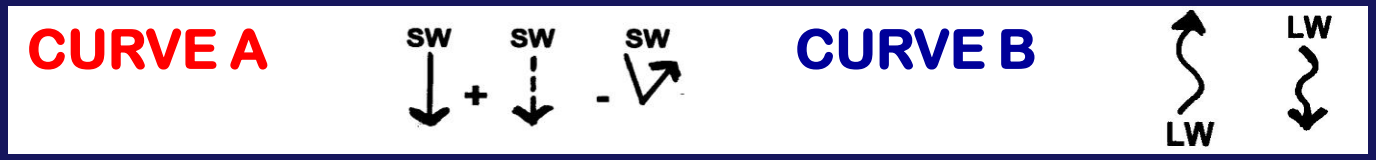
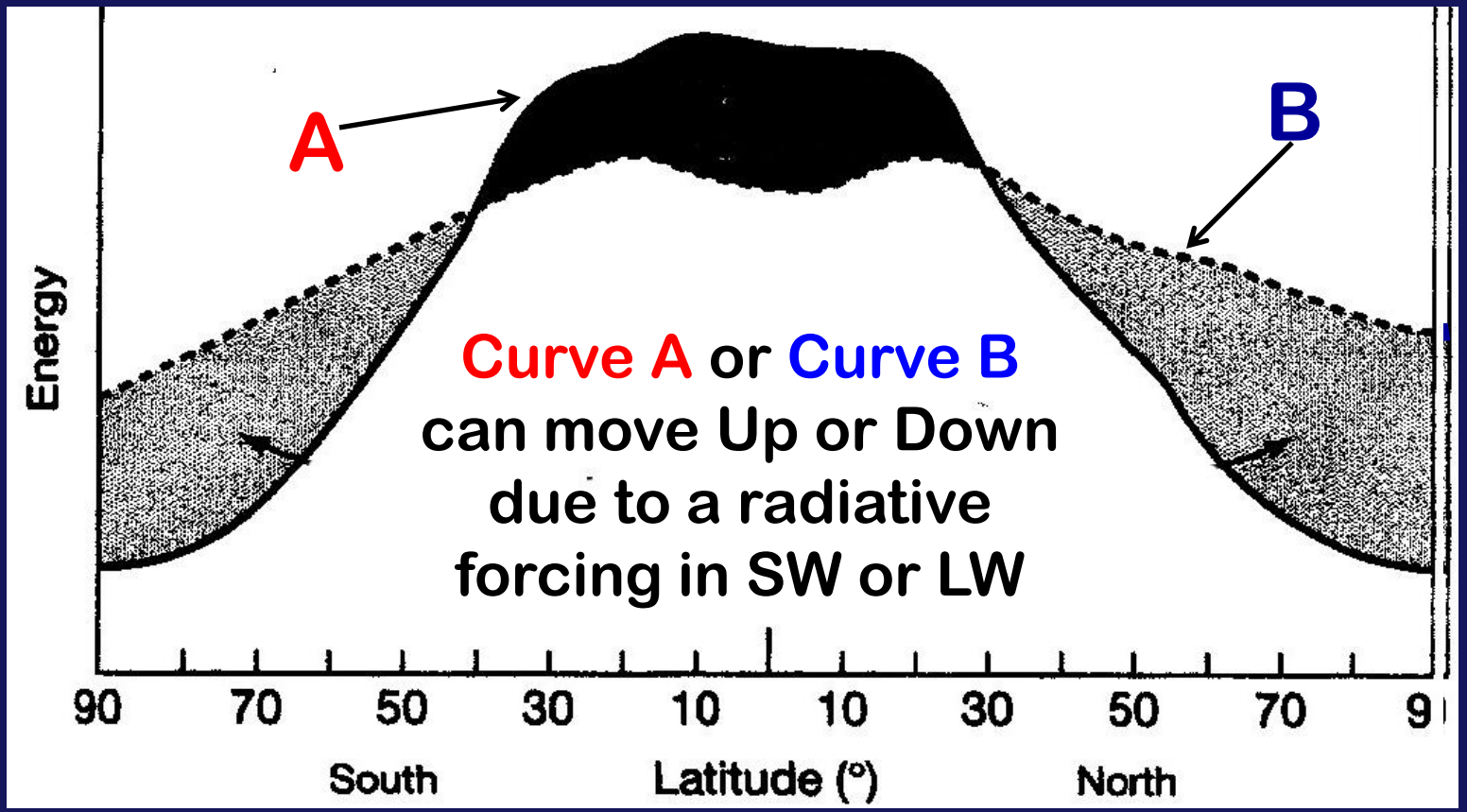
RADIATIVE FORCING

(linked to Radiation Balance!)



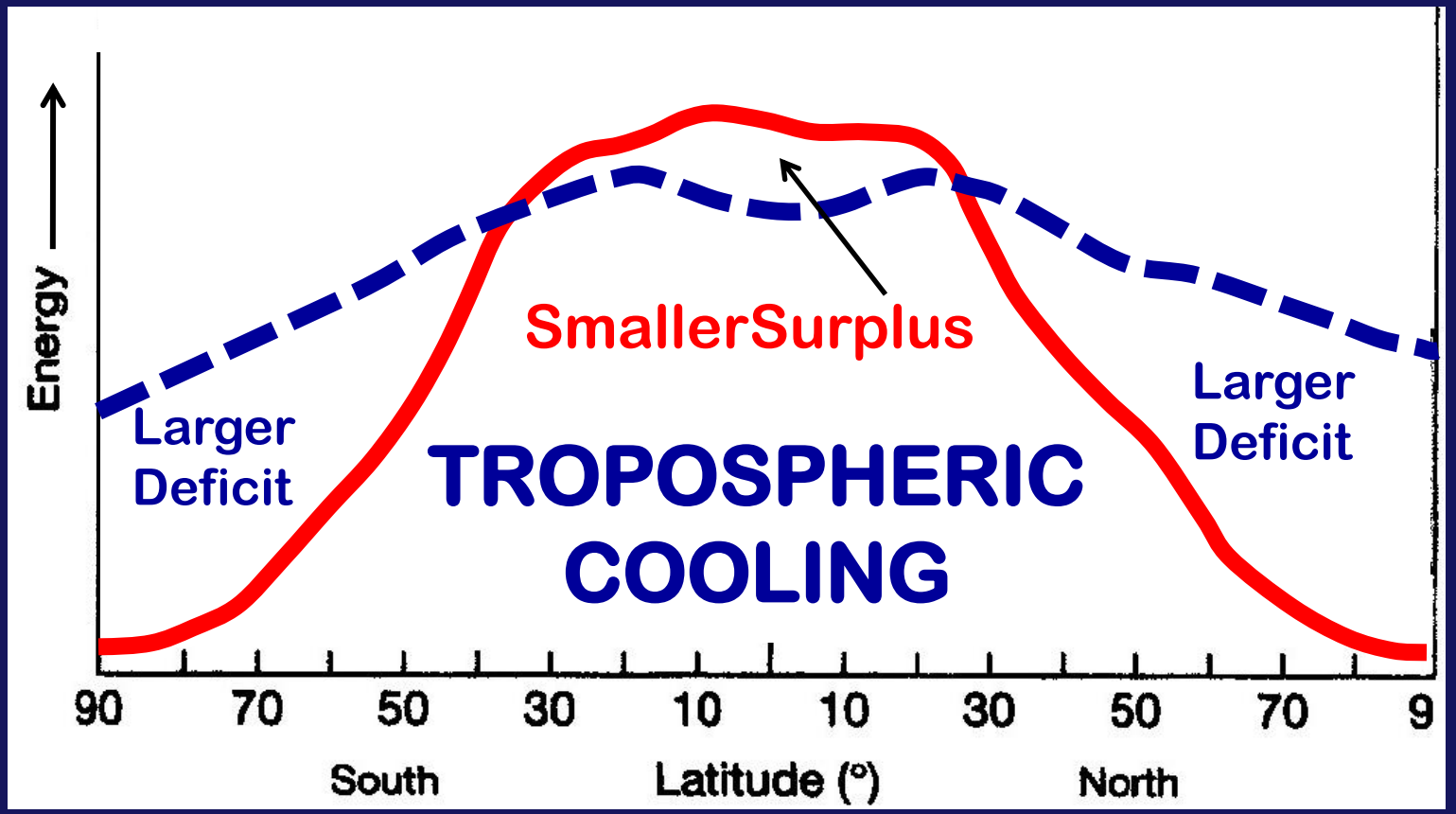
It's an index of the importance of the factor as a potential climate change mechanism!





ENERGY BALANCE CHANGES IN THE TROPOSPHERE

IF CURVE A moves down: SW ↓ + SW ↓ - SW ↗



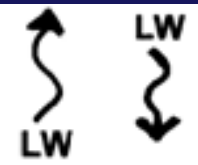
SW ↓ + SW ↓ - SW ↗ If incoming energy represented by Curve A is reduced (A curve goes down)

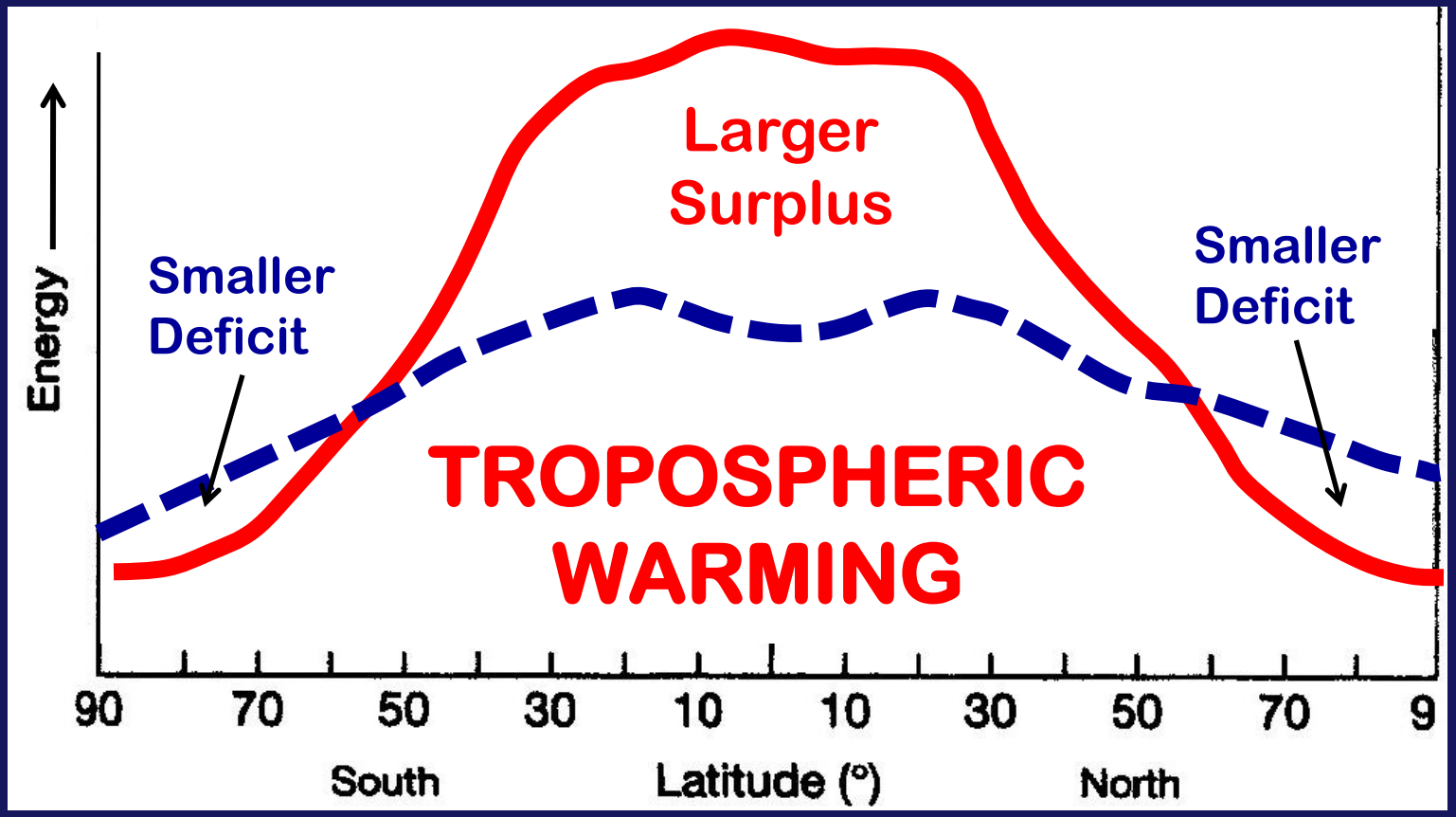
SW ↓

HOW? Albedo increases due to Eruption, Deforestation, Sulfur Aerosols, etc.

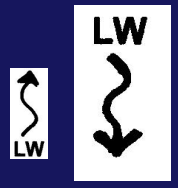
SW ↗

If CURVE B moves down



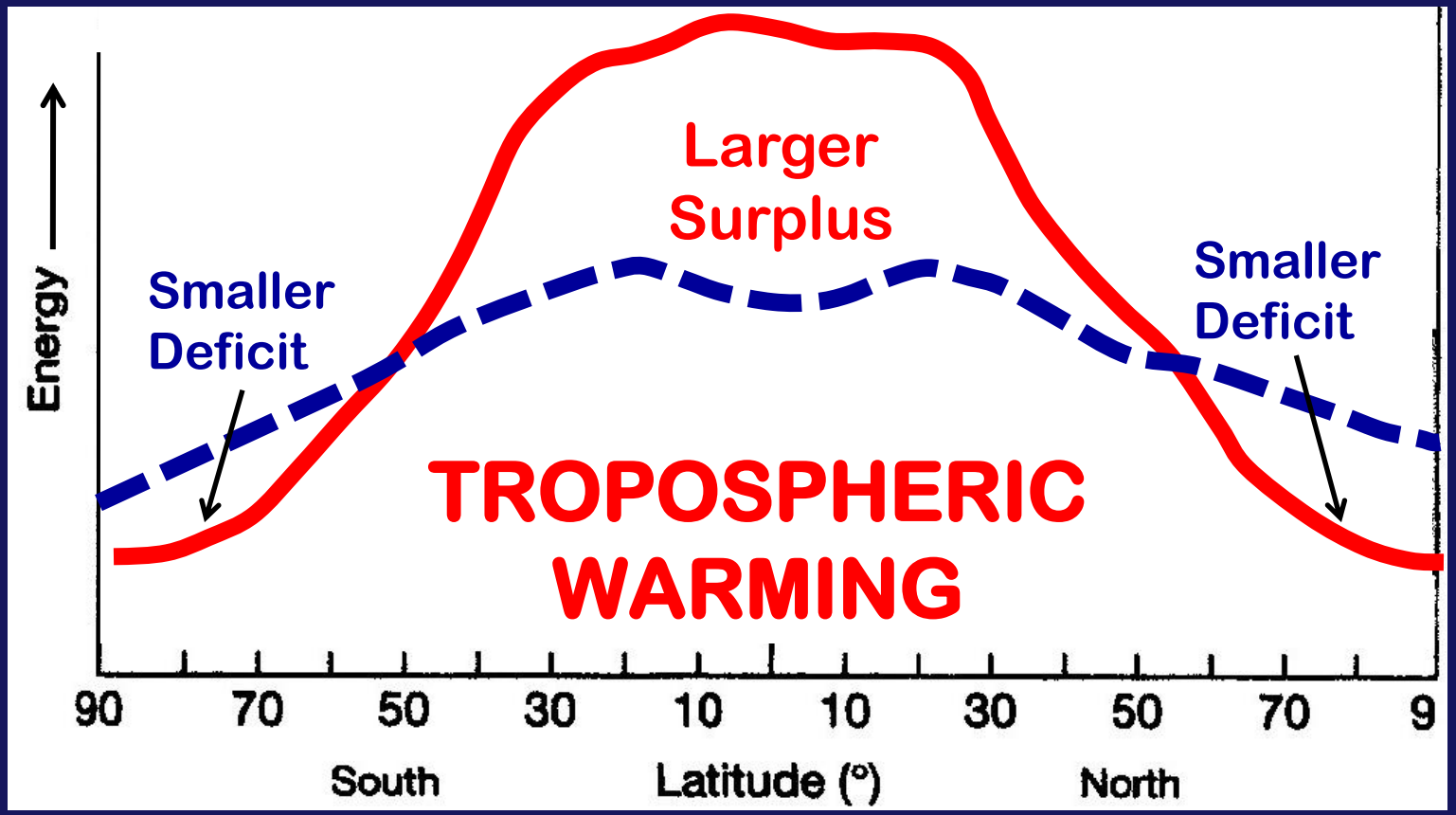


If outgoing energy represented by Curve B is reduced (B curve goes down)



HOW?
GHG's increase & keep more LW in!

IF CURVE A moves up: SW ↓ + SW ↓ - SW ↗



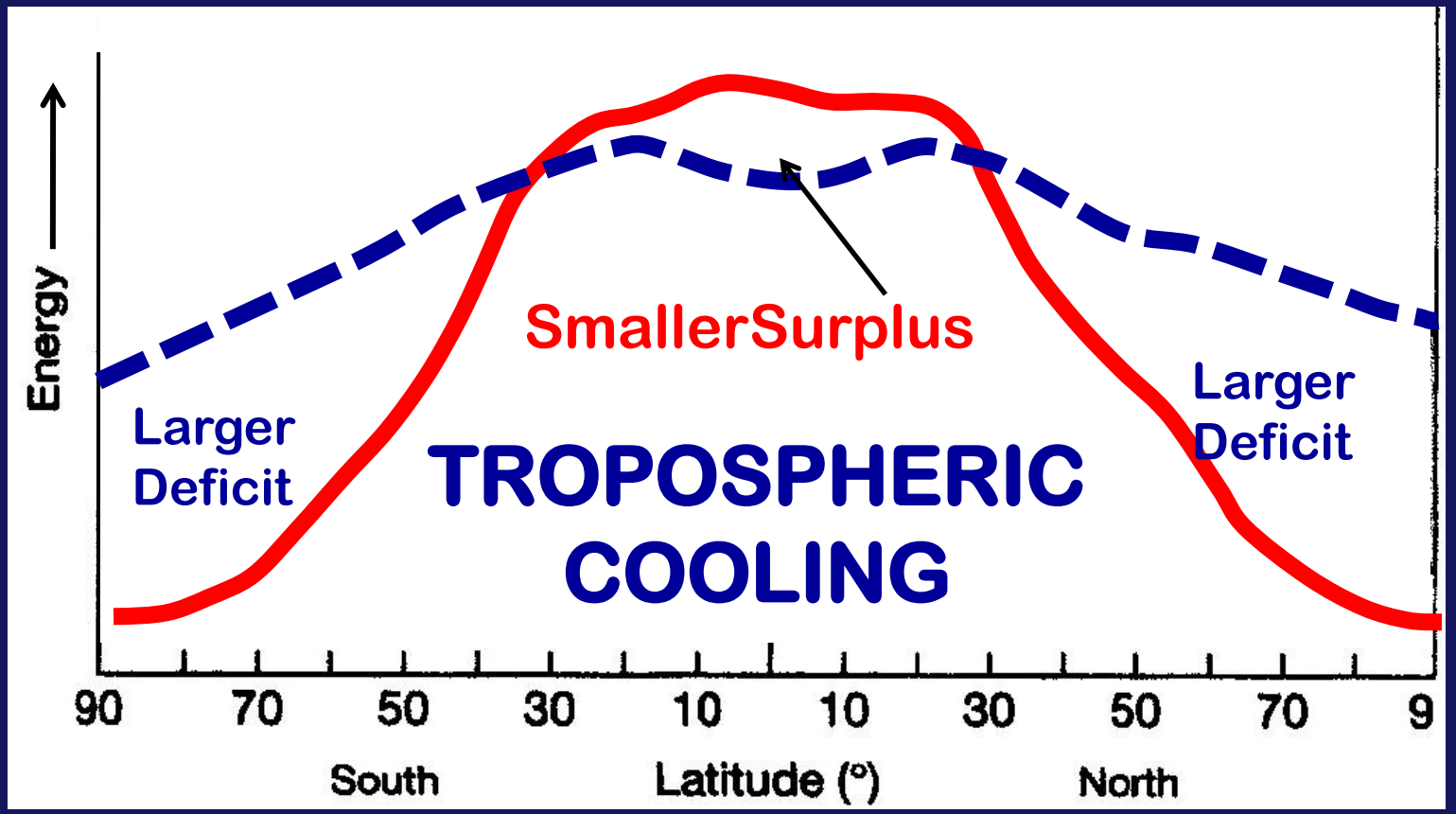
SW ↓ + SW ↓ - SW ↗

If incoming energy represented by Curve A is increased (A curve goes up)

HOW? Albedo decreases and / or solar input increases

SW ↓ SW ↗

If CURVE B moves up:

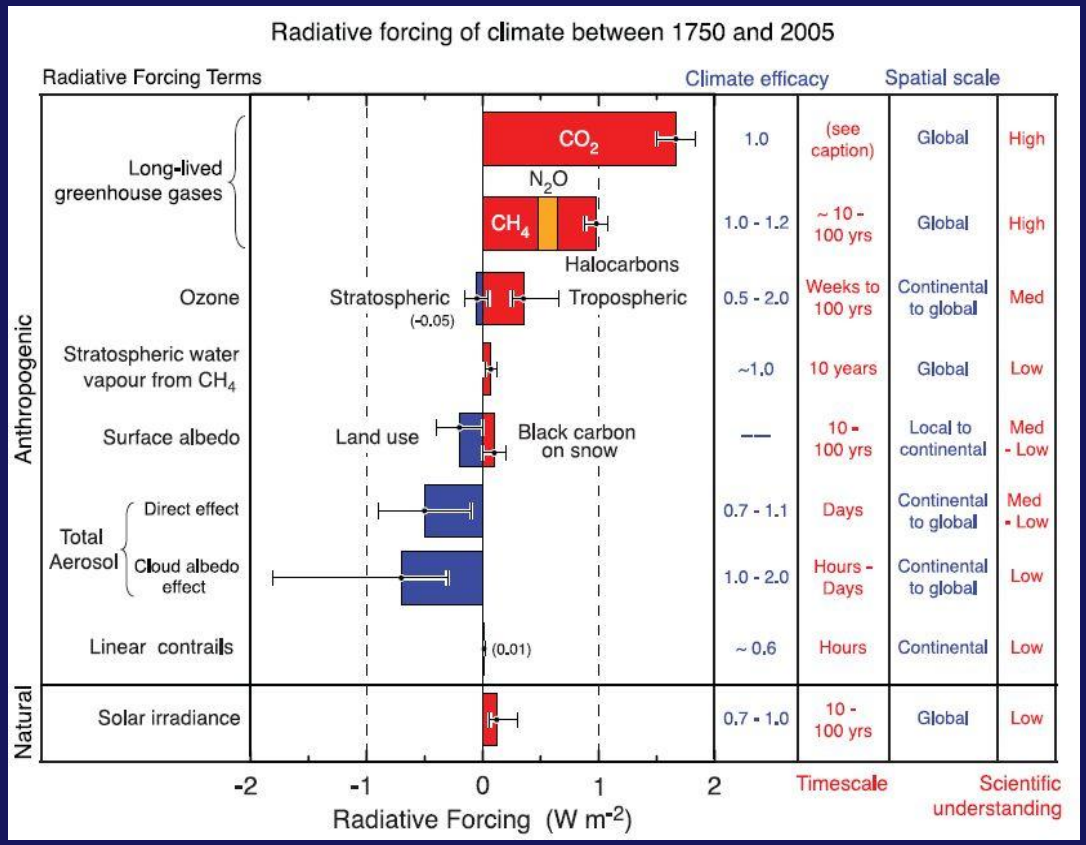


If outgoing energy represented by Curve B is increased (B curve goes up)

HOW?
GHG's decrease & allow more LW out!

The Key To It All:

RADIATIVE FORCING OF CLIMATE



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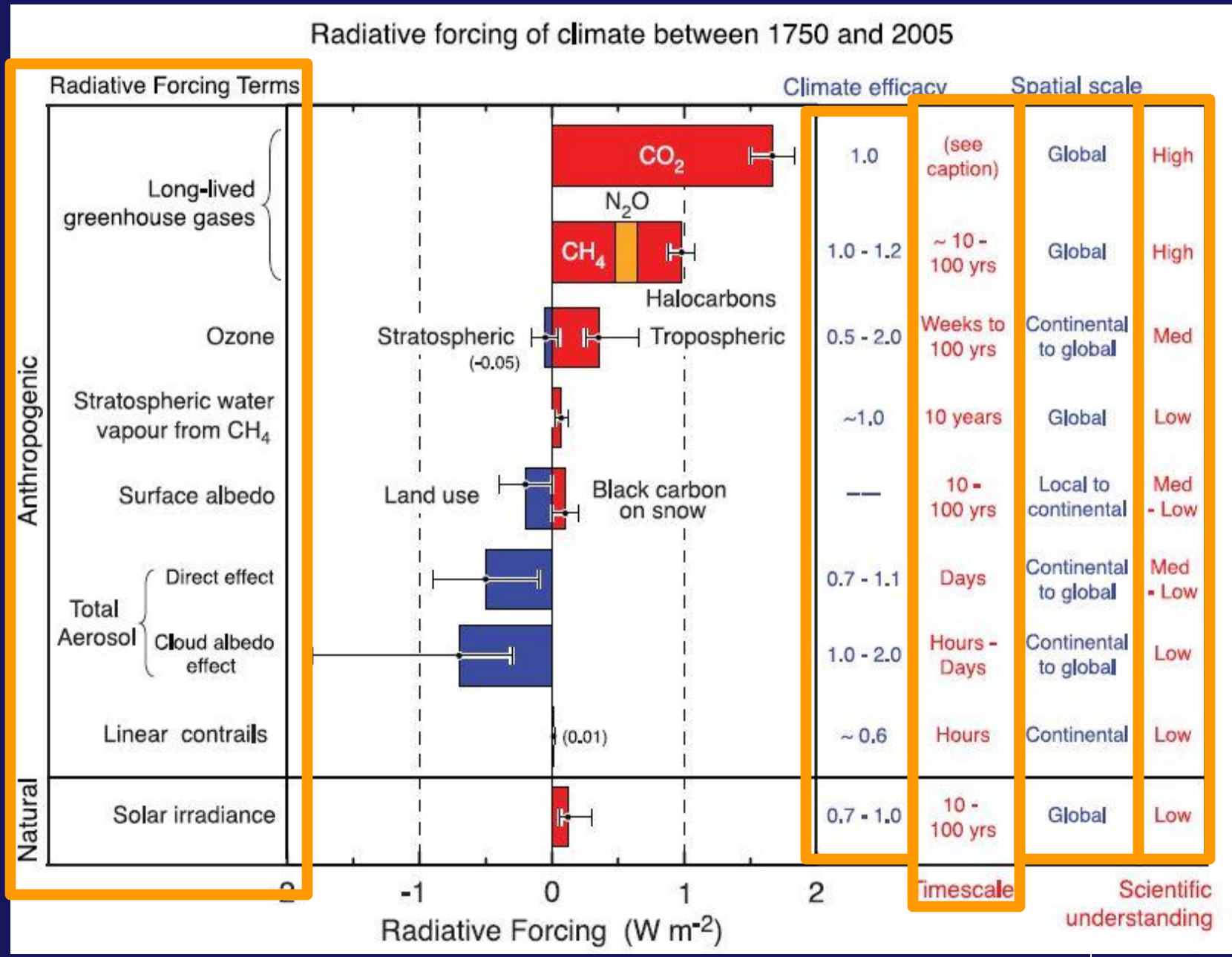
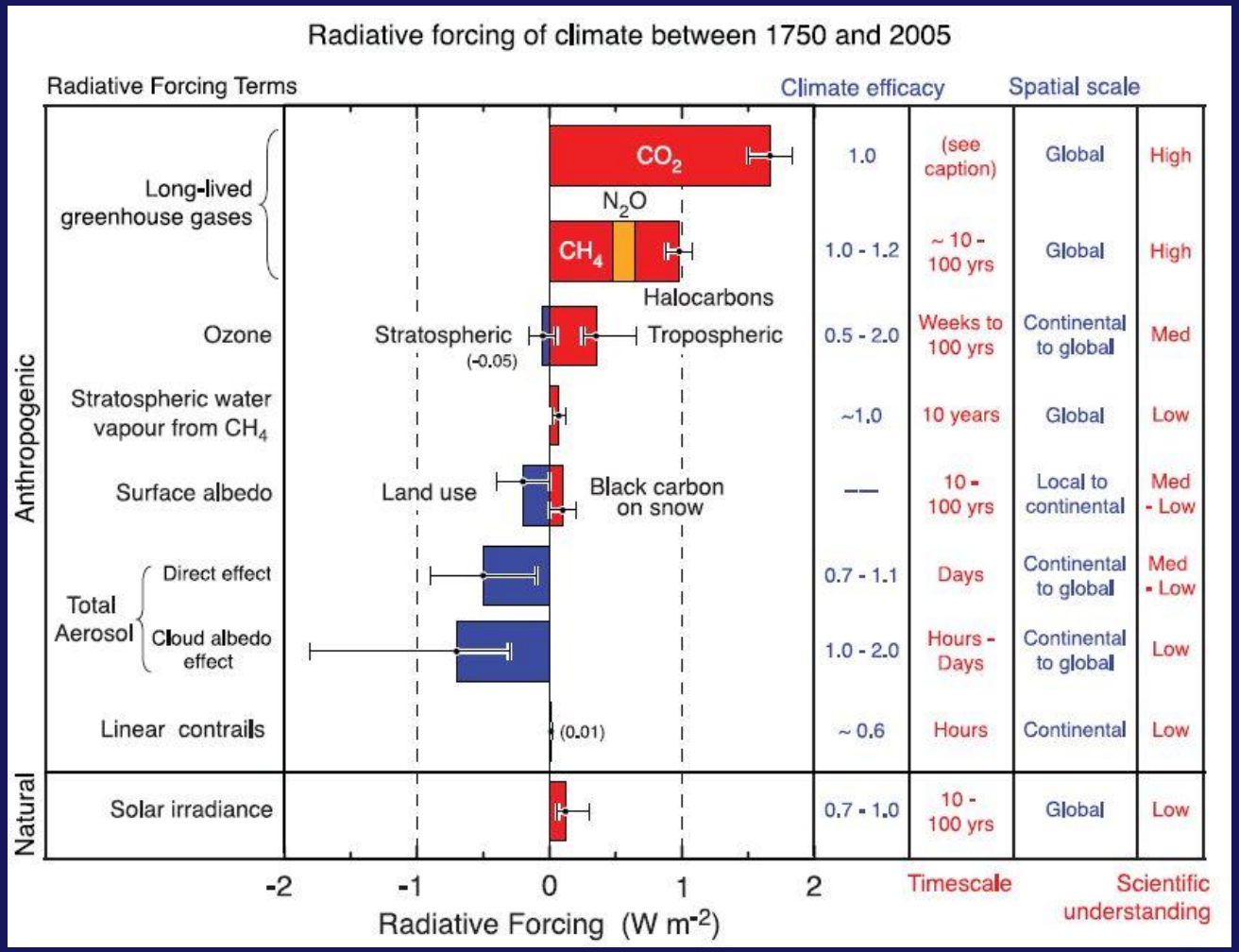


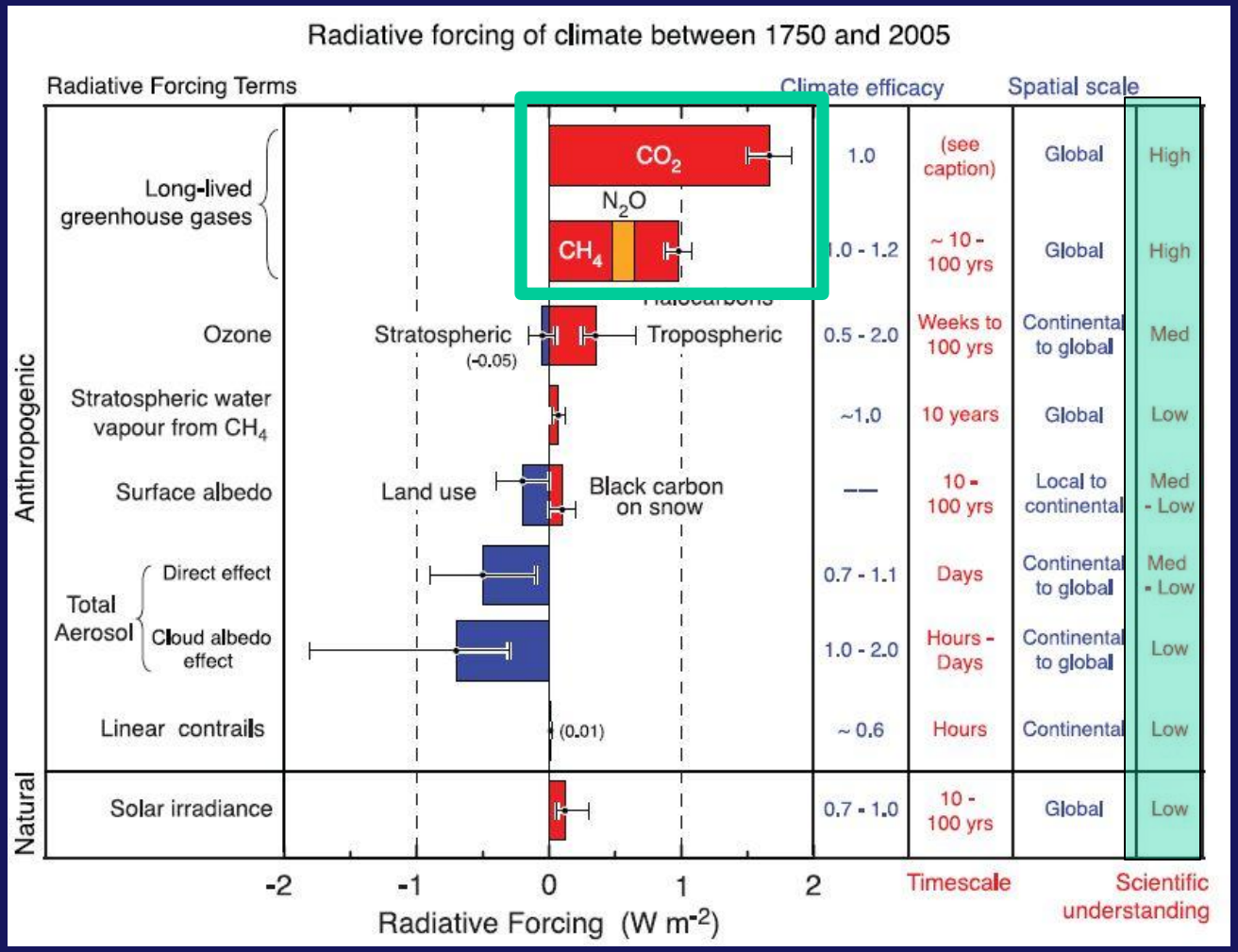
SOURCE: IPCC 2007 WG-1 Synthesis Report Summary for Policymakers

Q1. 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

Q1. The figure shows that the forcing mechanism that is *BEST* understood by scientists is also the one that leads to the greatest climatic impact.

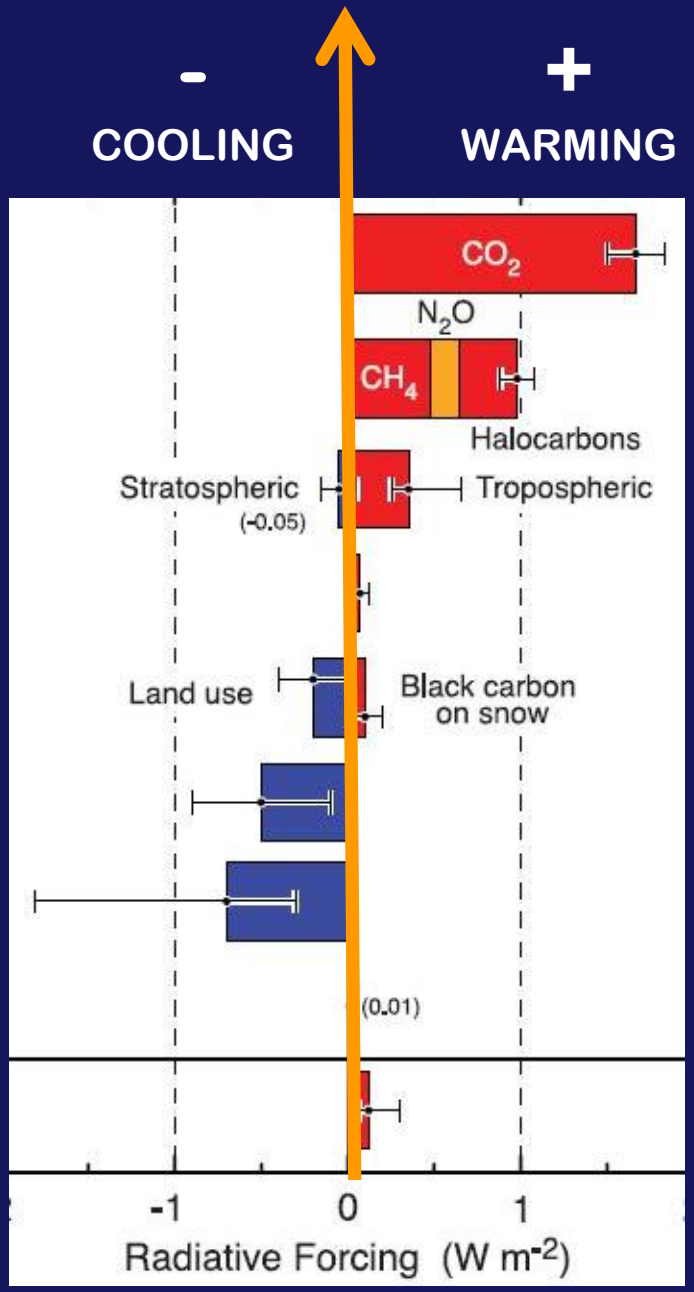


1.TRUE

2. FALSE

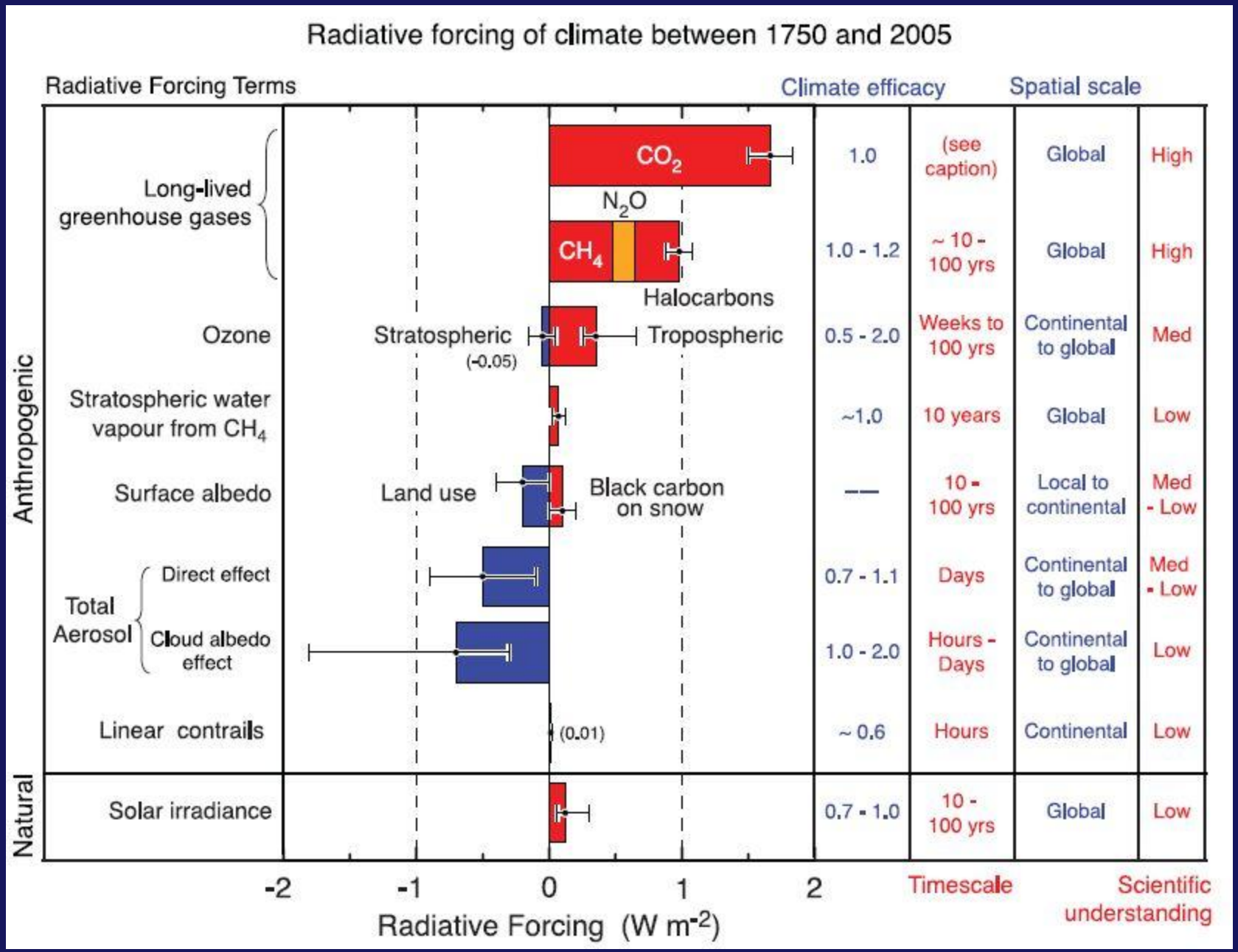
If the forcing is **NEGATIVE (-)** (to **left** of line)

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)

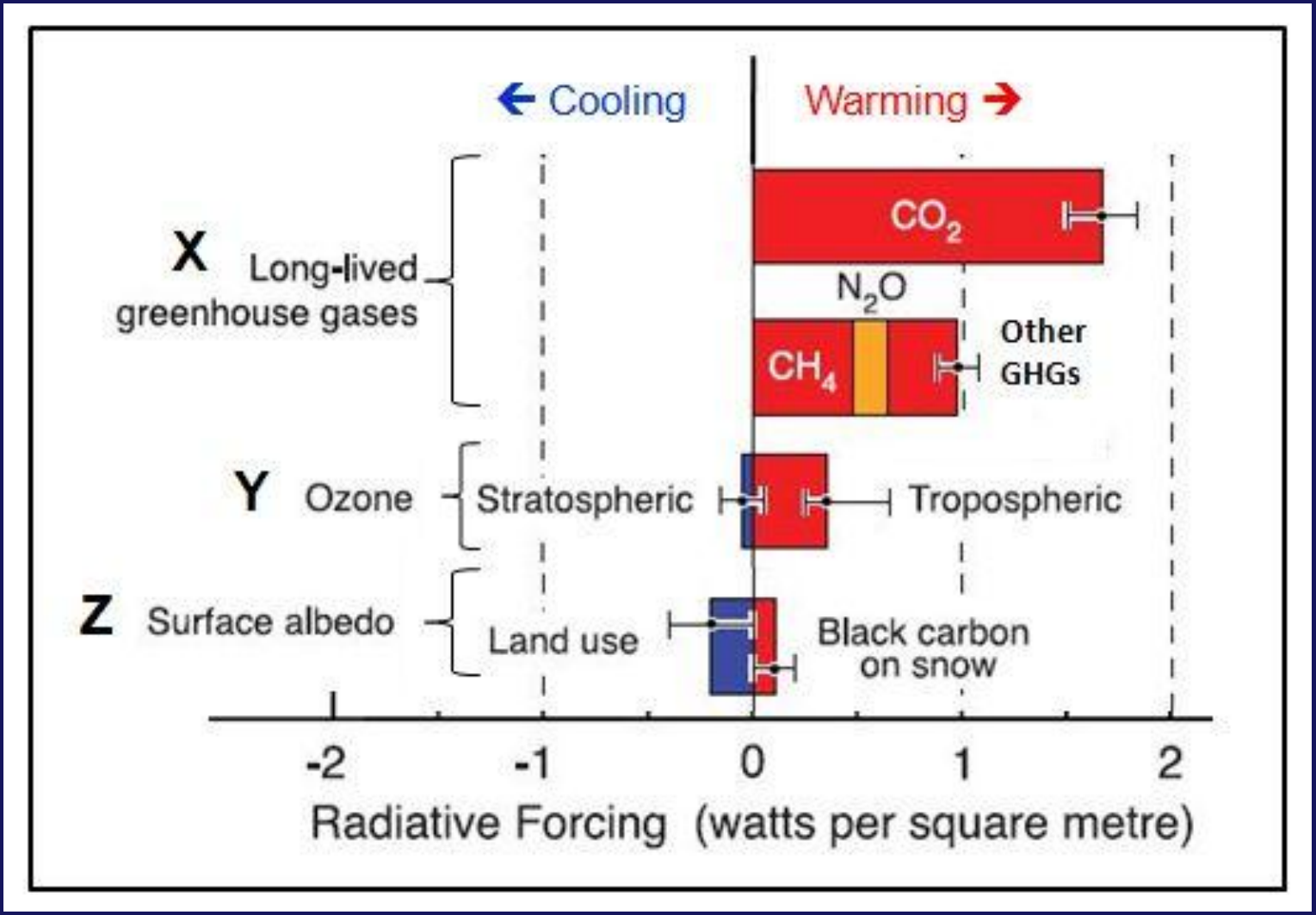
it means that an increase in that gas or factor contributes to **WARMING** in the troposphere.



SOURCE: IPCC 2007 WG-1 Synthesis Report Summary for Policymakers

Q2. ALL of the forcing mechanisms shown here (X, Y, & Z) are linked to anthropogenic activity in some way:

1. TRUE 2. FALSE



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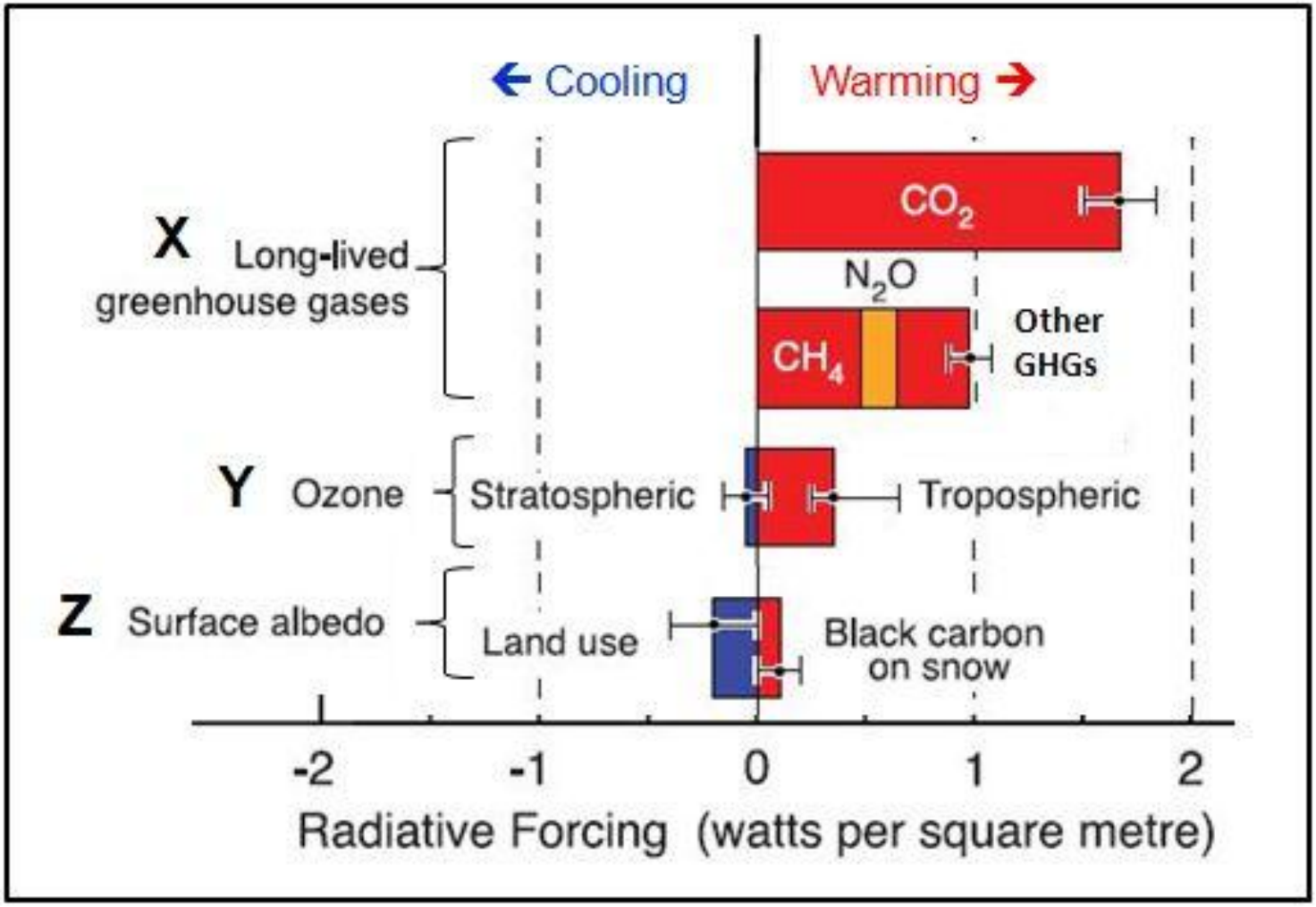


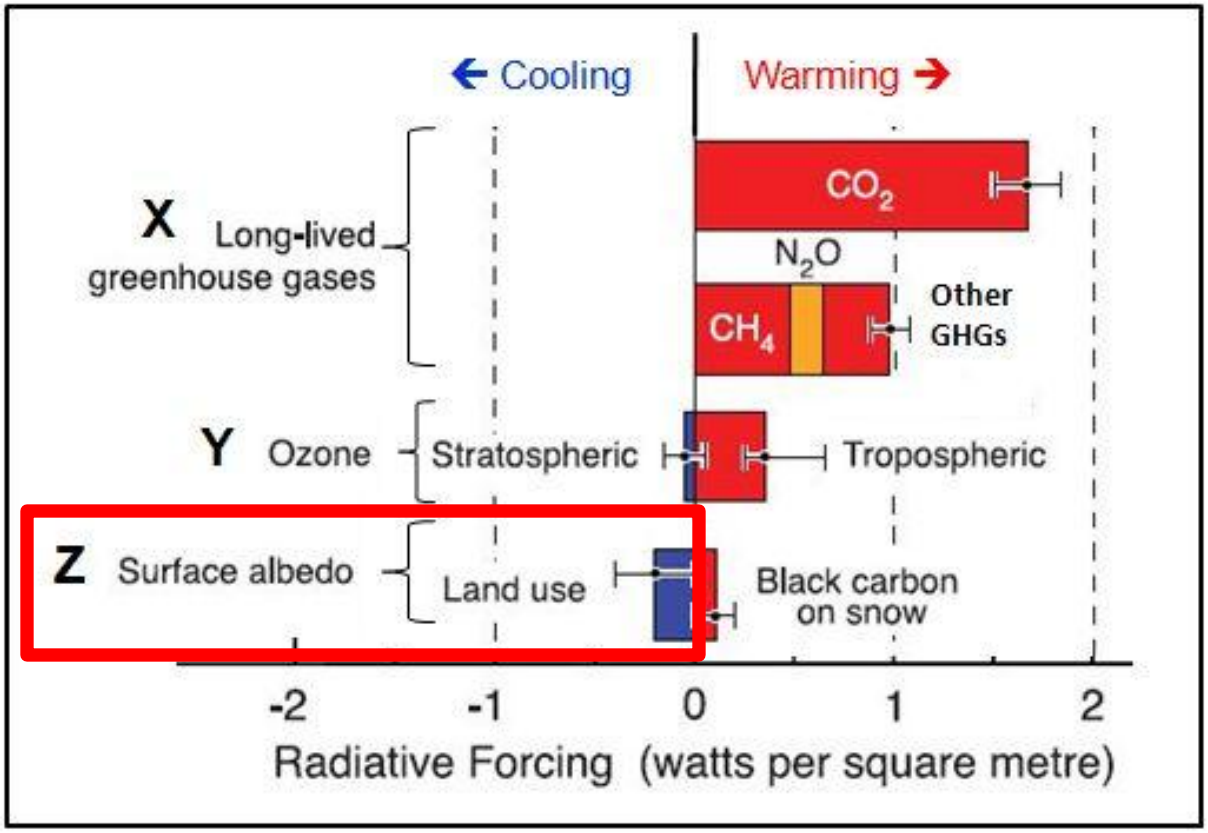
Q3. The figure shows that forcing mechanism Z (Land-use as indicated by albedo) leads to COOLING. . . This is correct.

1. TRUE
2. FALSE

BUT WHY?

. . . The reason for this is that cooling occurs when surface albedo *increases* and hence MORE energy is absorbed.

TRUE or FALSE?



Q3. The figure shows that forcing mechanism Z (Land-use as indicated by albedo) leads to COOLING. . . This is correct!

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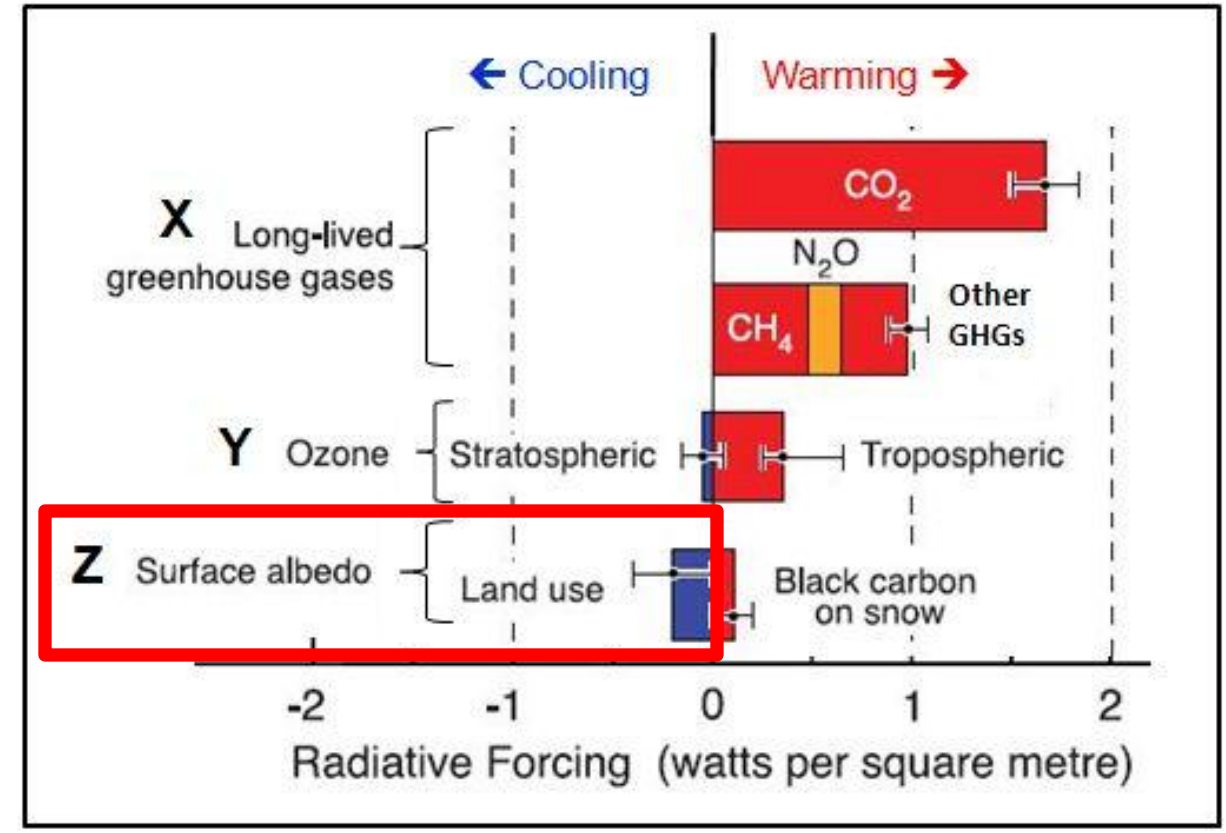
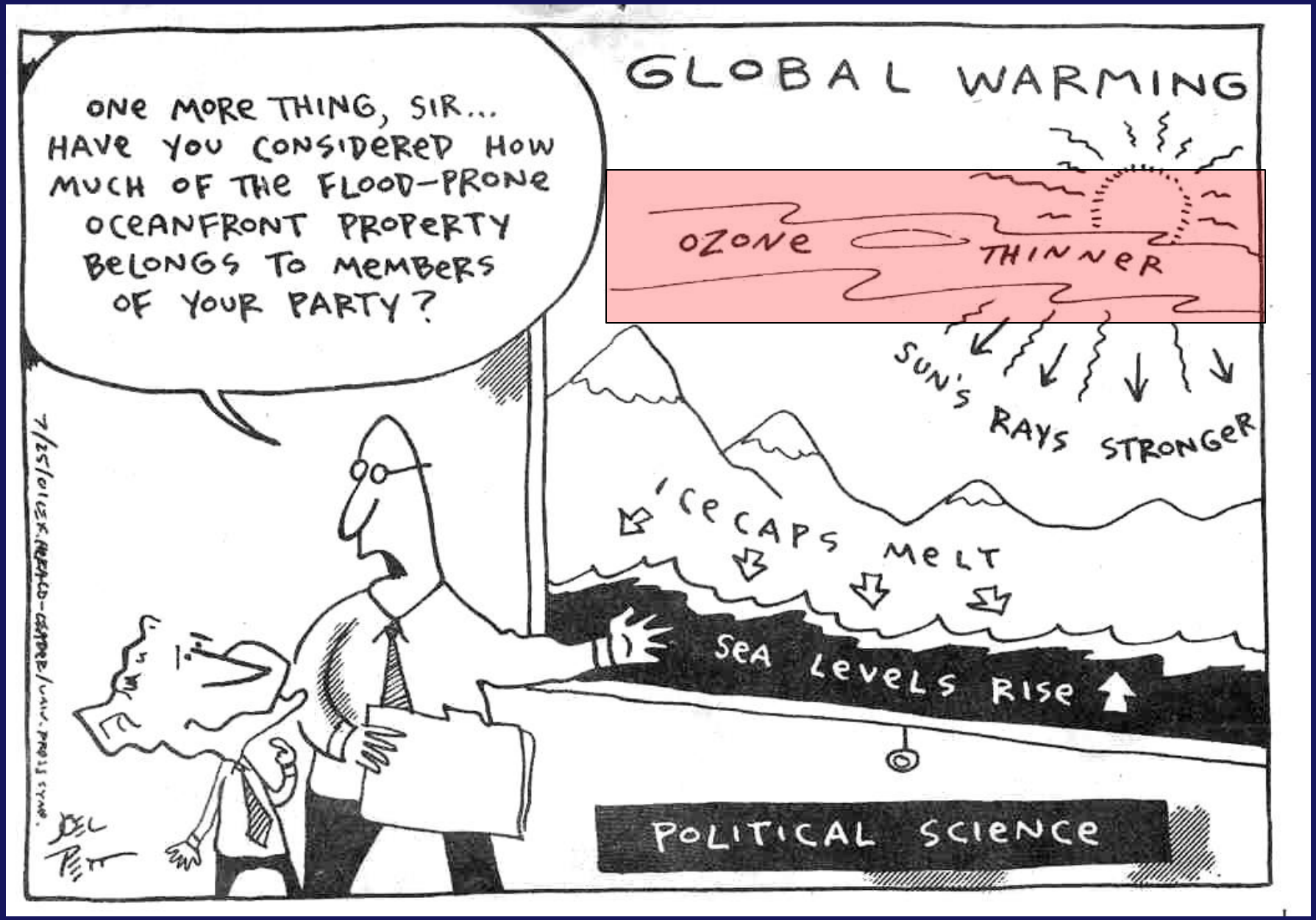
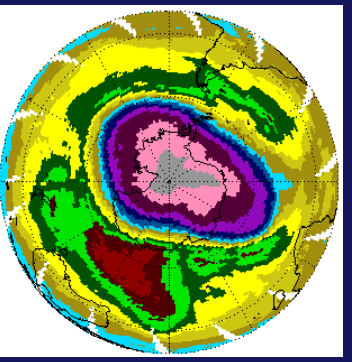


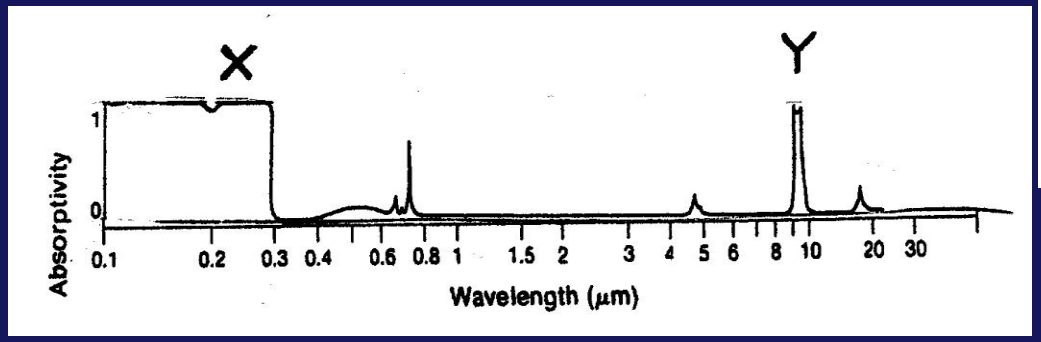
LESS energy is absorbed!

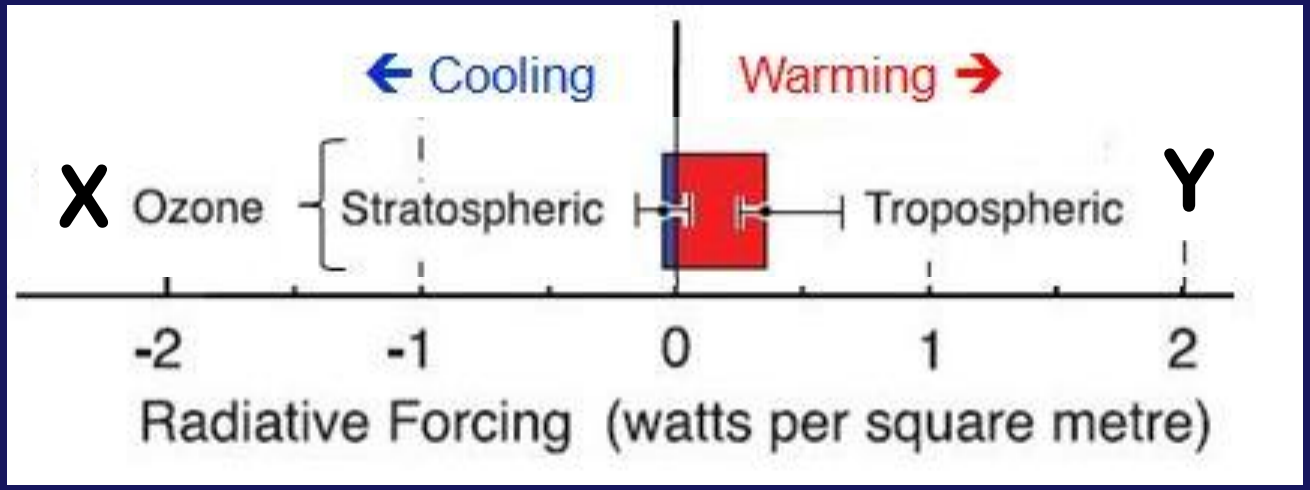
A COMMON MISCONCEPTION!



OZONE'S DUAL PERSONALITY!

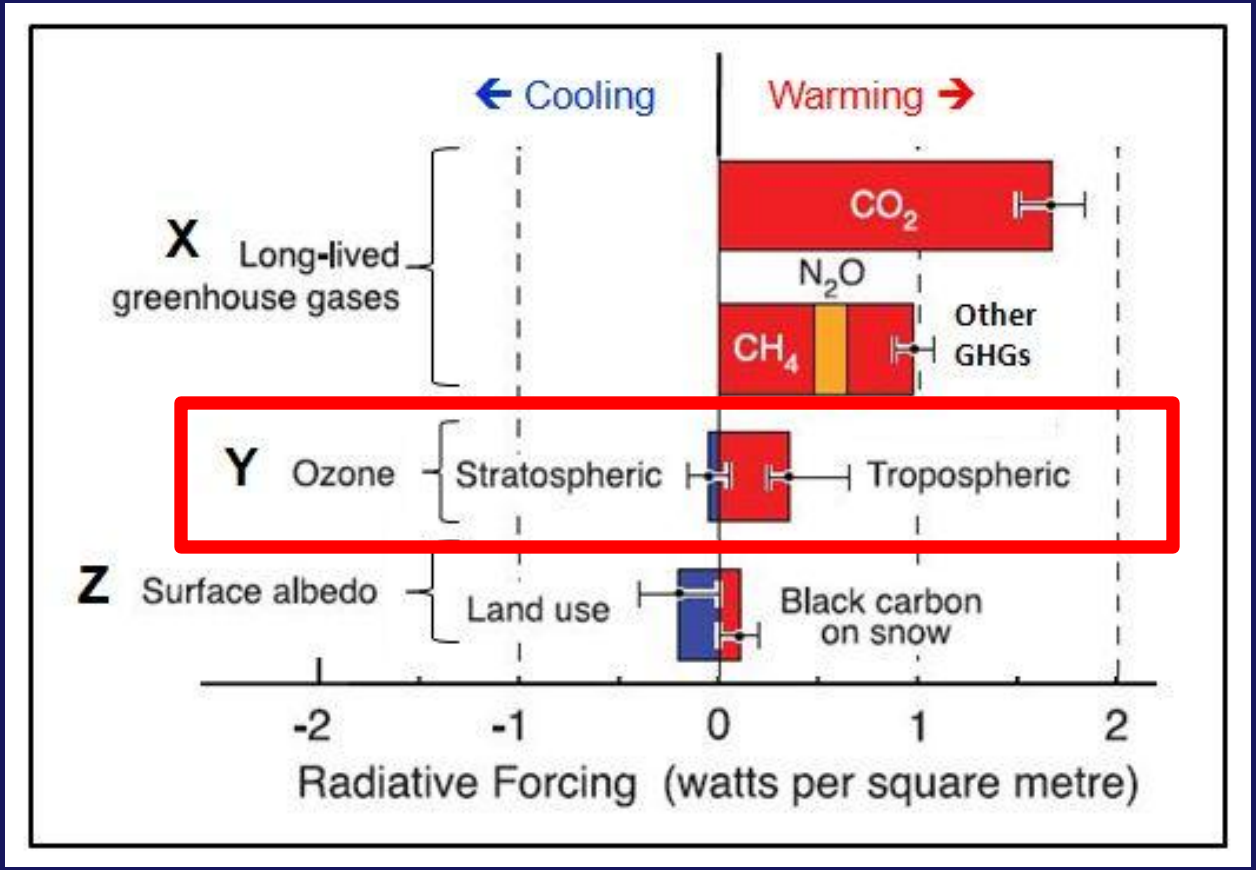






According to the figure which forcing mechanism has a GREATER influence on global temperature?

Stratospheric OZONE OR **Tropospheric OZONE**



The 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