



GOOD NEWS! AT THE CURRENT RATE OF GLOBAL WARMING WE SHOULD BE ABLE TO JUST SWIM OVER THERE AND EAT HIM IN UNDER FIVE YEARS...!



The layer of gas that surrounds most planets is called an **atmosphere**



- The removal of carbon dioxide is critical to Earth's history.
 - This is because an atmosphere rich in carbon dioxide can trap heat—by the **greenhouse effect**

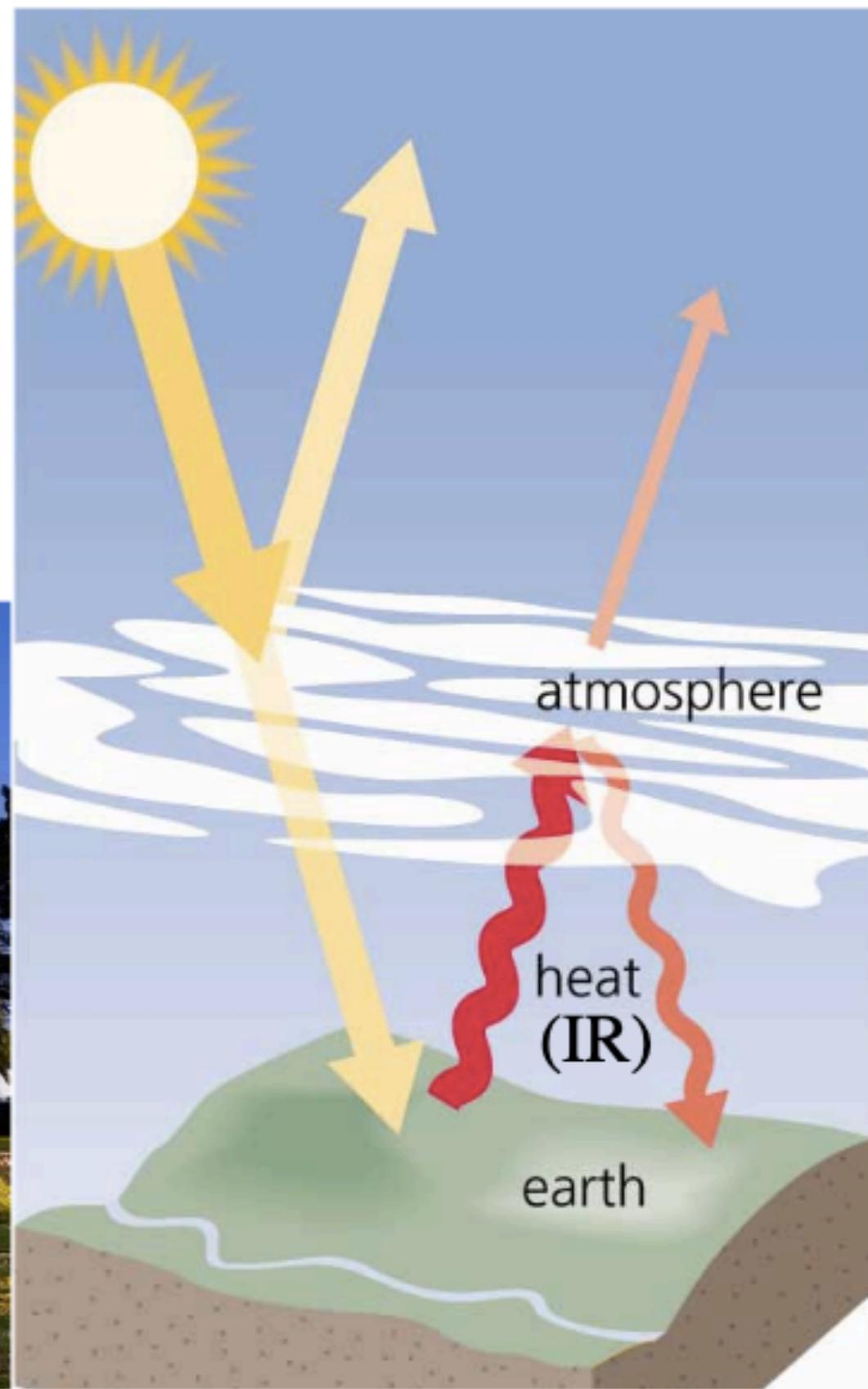


Three DIFFERENT Phenomena

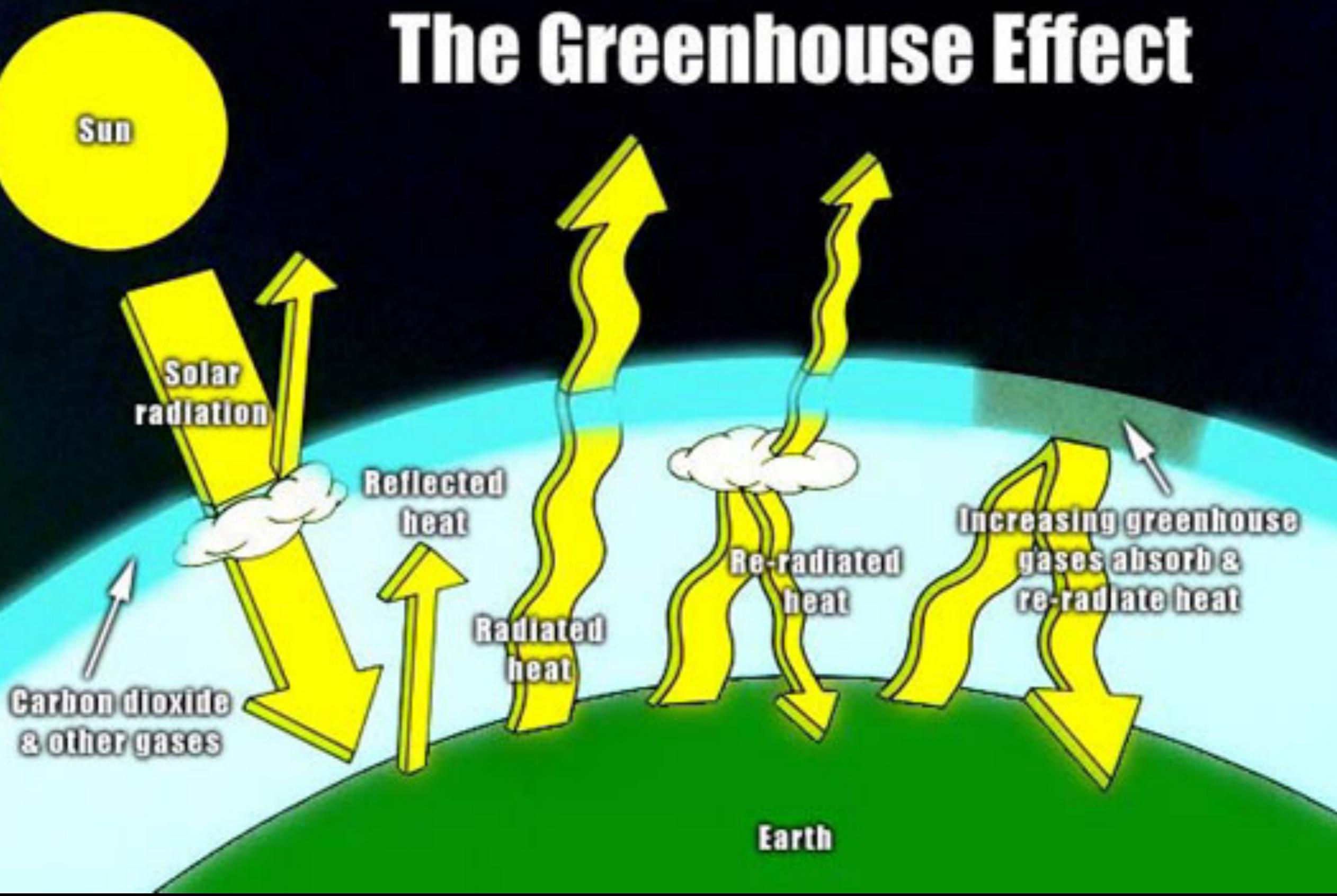
- Ozone Depletion
- Greenhouse Effect
- Global Warming

Greenhouse Effect

-happens when **infrared** light (heat) is trapped.
- In a greenhouse, it is trapped by glass walls.
- In the atmosphere, it is trapped by gases
- Important **Greenhouse Gasses:**
 - Carbon Dioxide (CO_2)
 - Methane (CH_4)
 - Water vapor



The Greenhouse Effect

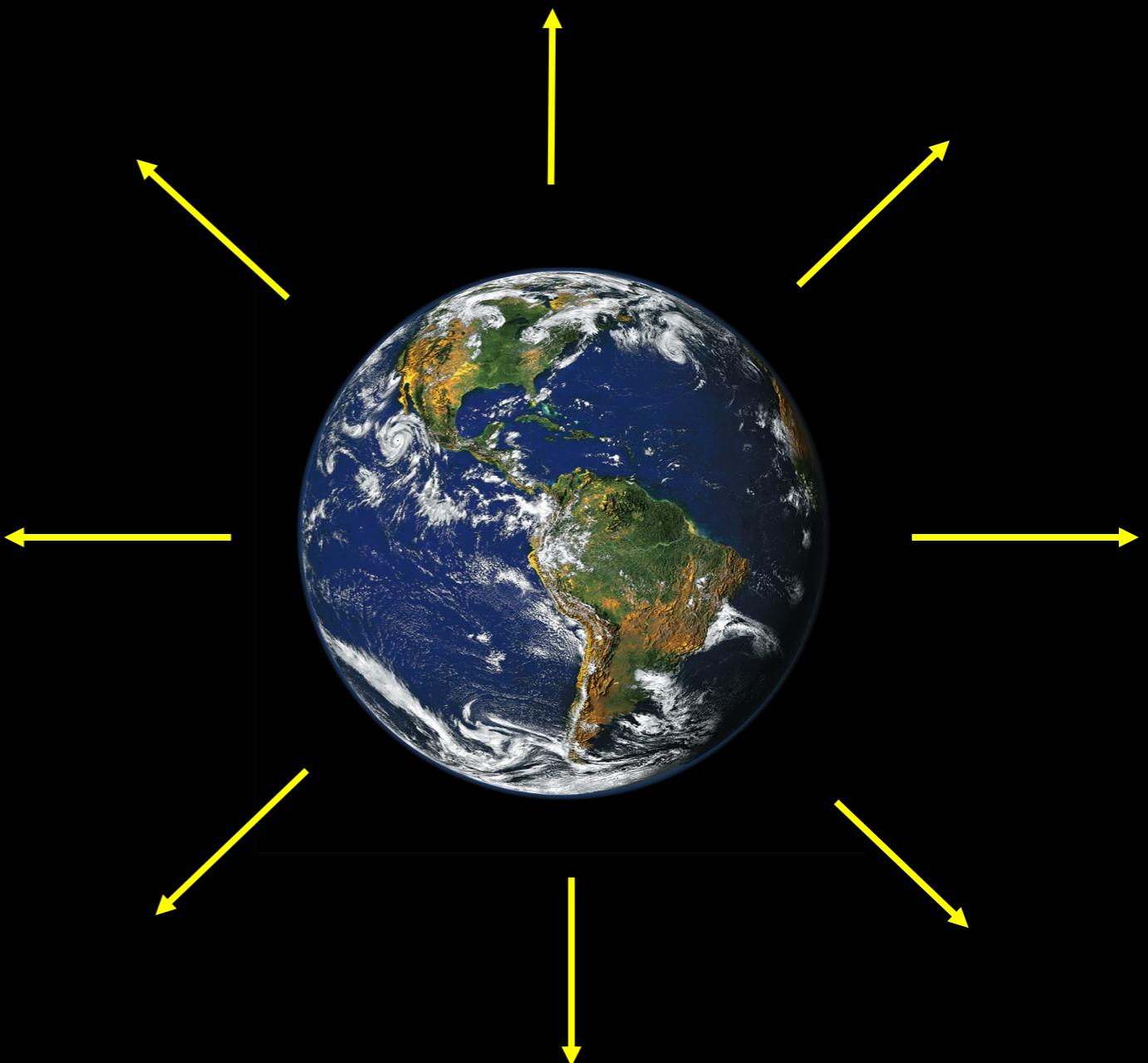
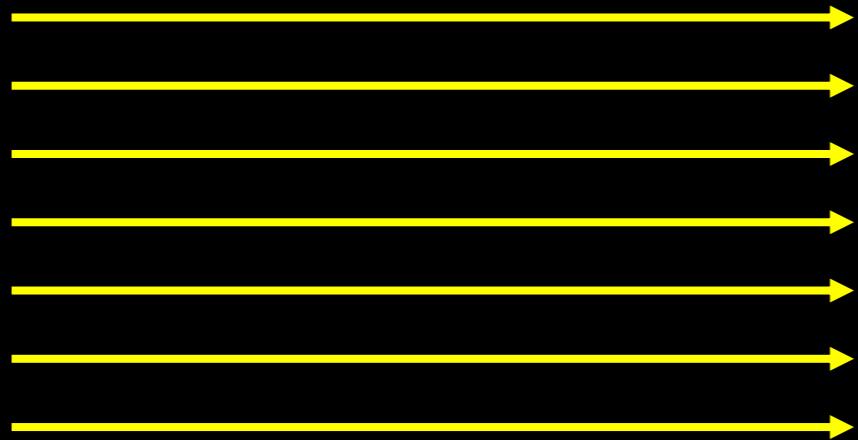


The sun drives the climate of Earth

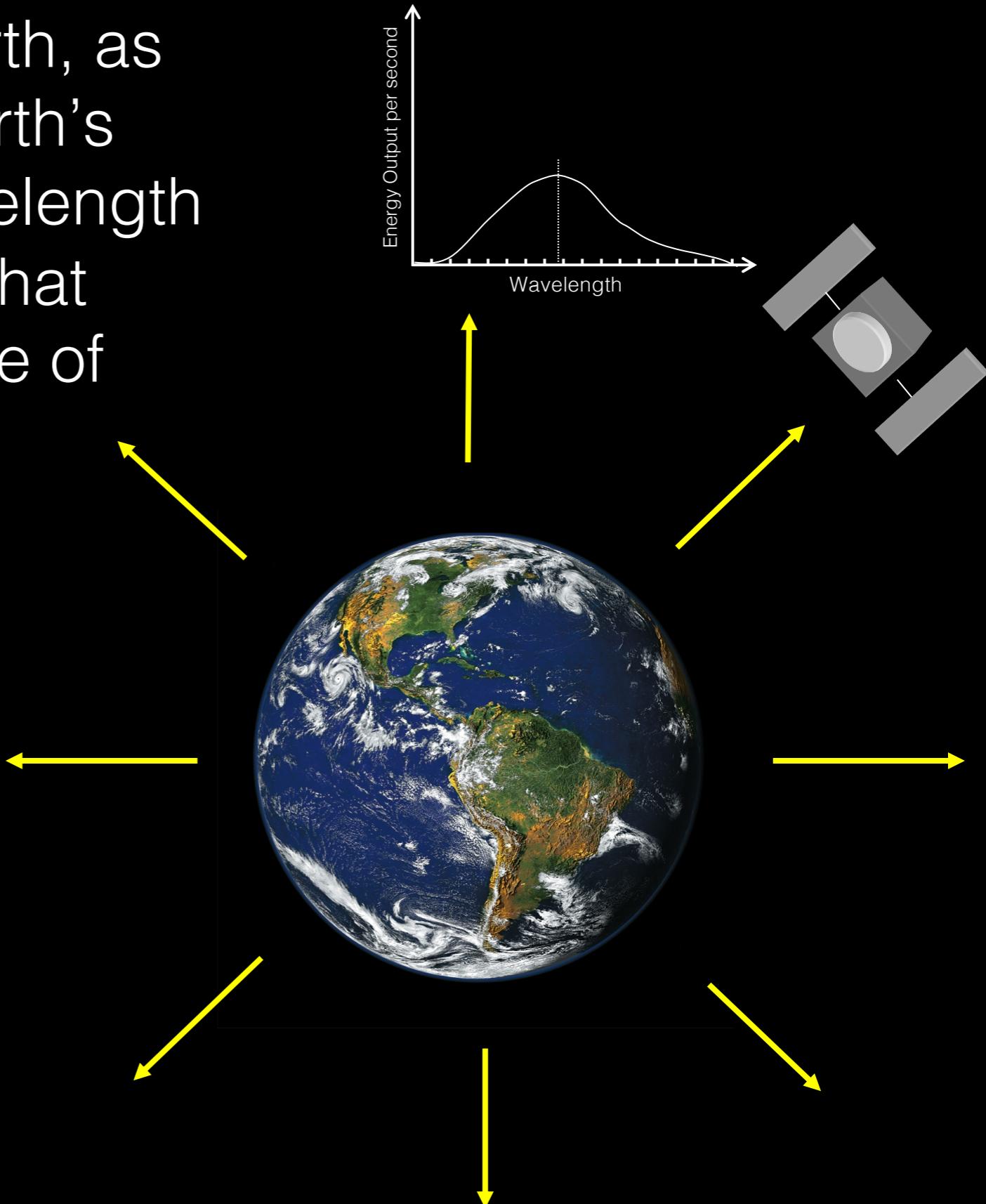
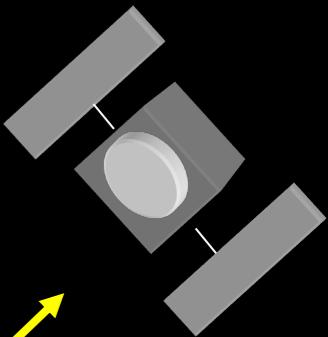
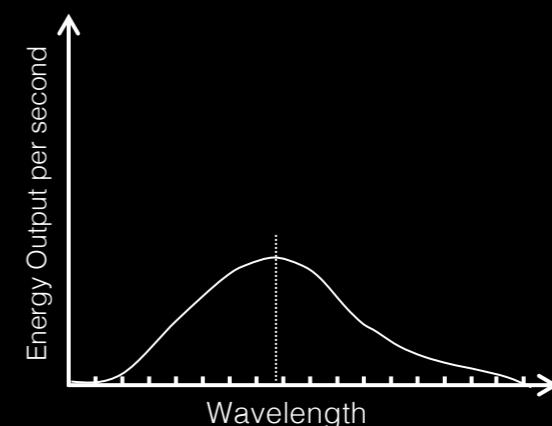


http://www.spaceweather.com/images2002/18mar02/cme_c3_big.gif

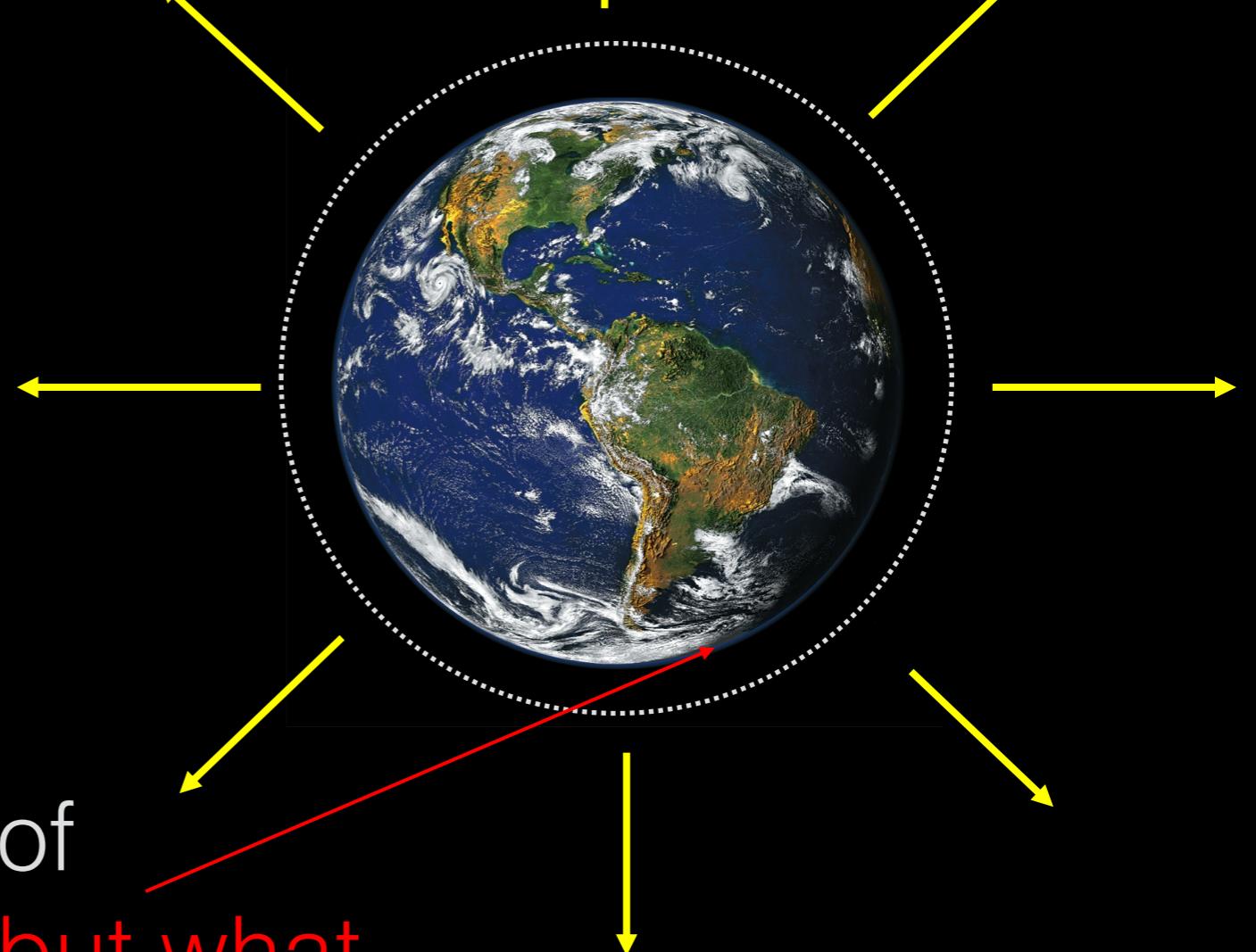
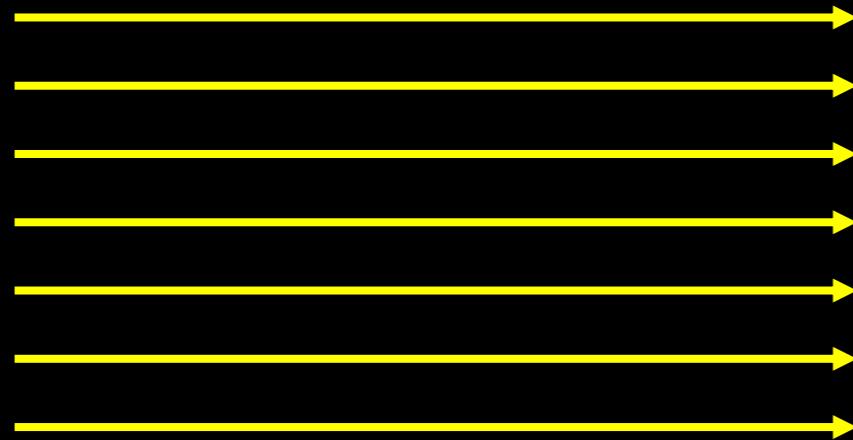
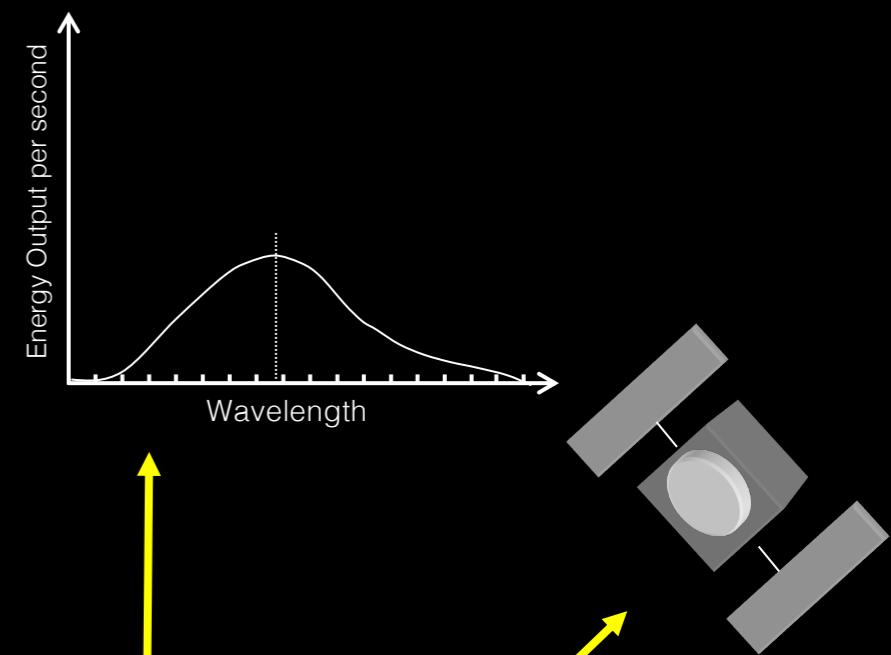
The amount of energy absorbed by Earth from the Sun is equal to the amount of energy given off by Earth.



The spectral curve of the Earth, as measured from far above Earth's atmosphere, peaks at a wavelength of approximately $10\mu\text{m}$ and that corresponds to a temperature of approximately 255 K (0°F).



How will the temperature measured by the spacecraft change if the earth is surrounded by an atmosphere?



Temperature seen at top of atmosphere is the same, **but what about the surface?**

“The Greenhouse Effect”

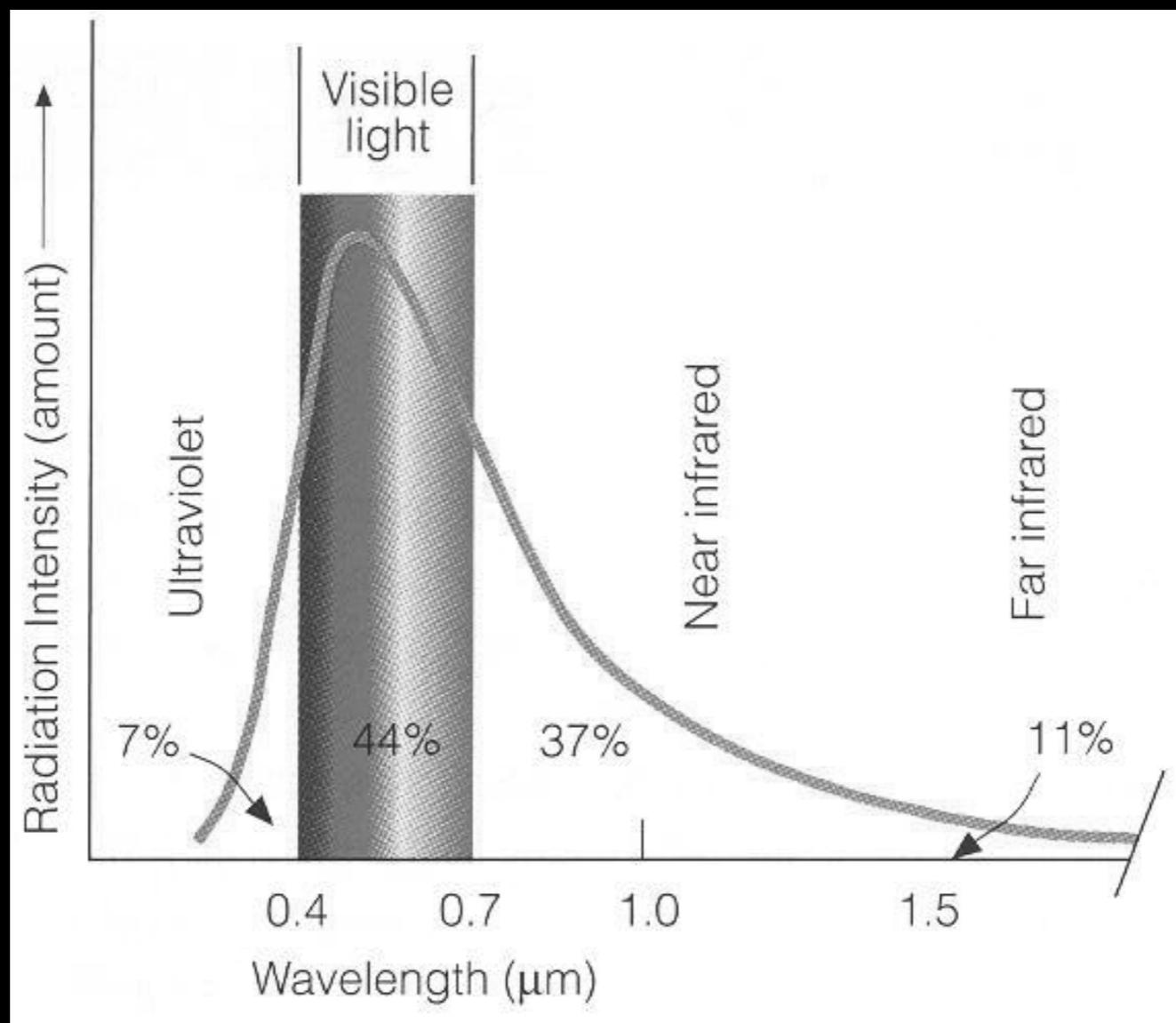
Which of the following appear to have a Greenhouse Effect?

Planet	Satellite Temperature	Surface Temperature
Venus	232K	740K
Earth	255K	288K
Mars	210K	210K
Titan	82K	94K

Wien's Law

SUNLIGHT

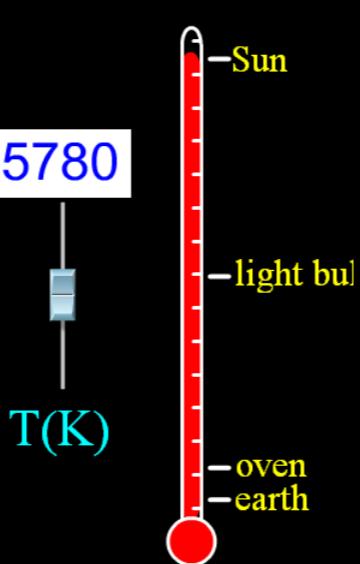
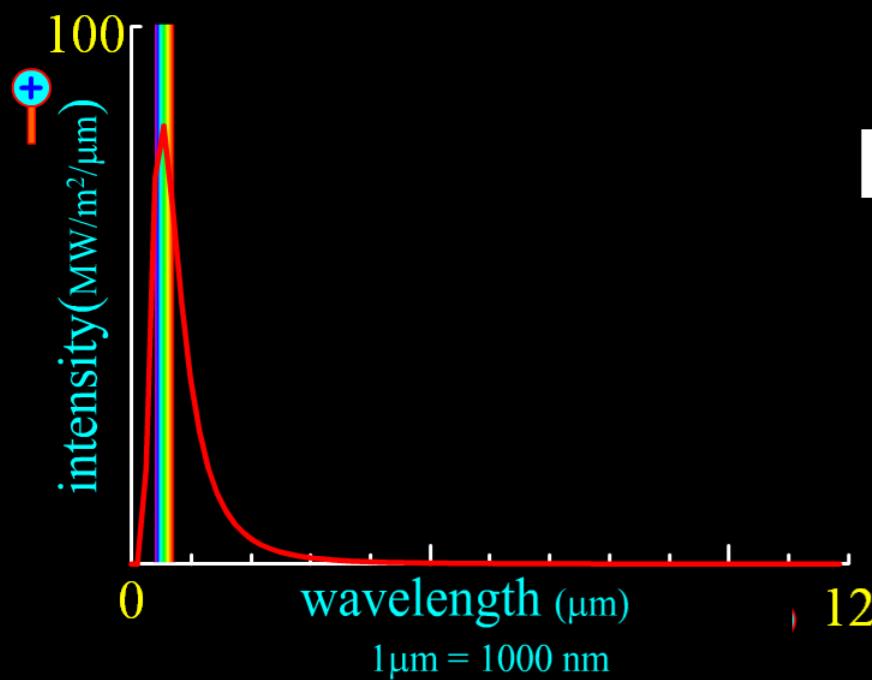
- Sun radiates mostly visible and IR



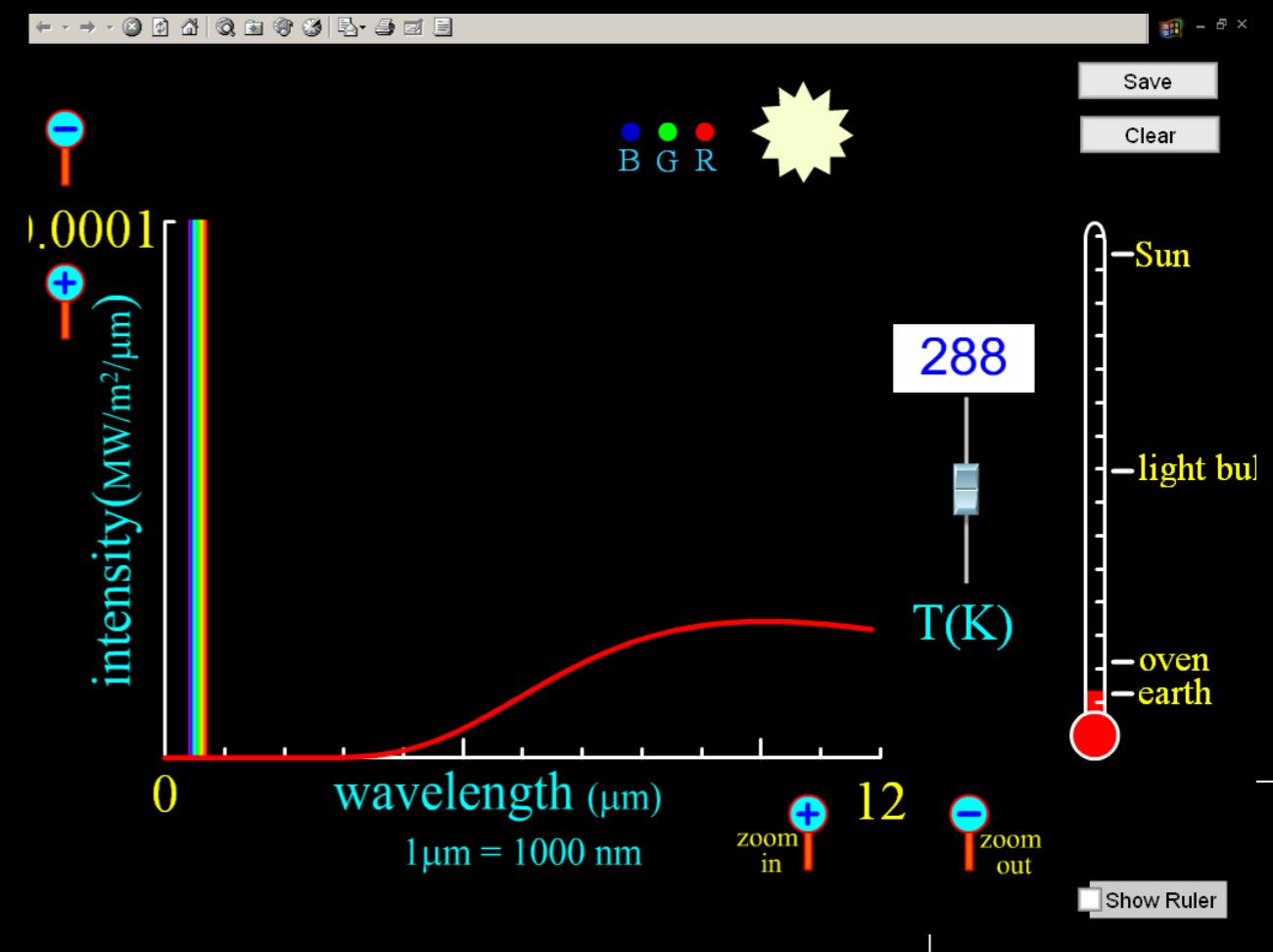
Wien's Law

- Sun radiates mostly visible and IR
- Earth radiates Mostly IR, its spectrum peaks in IR around 10 microns (.01mm)

SUNLIGHT

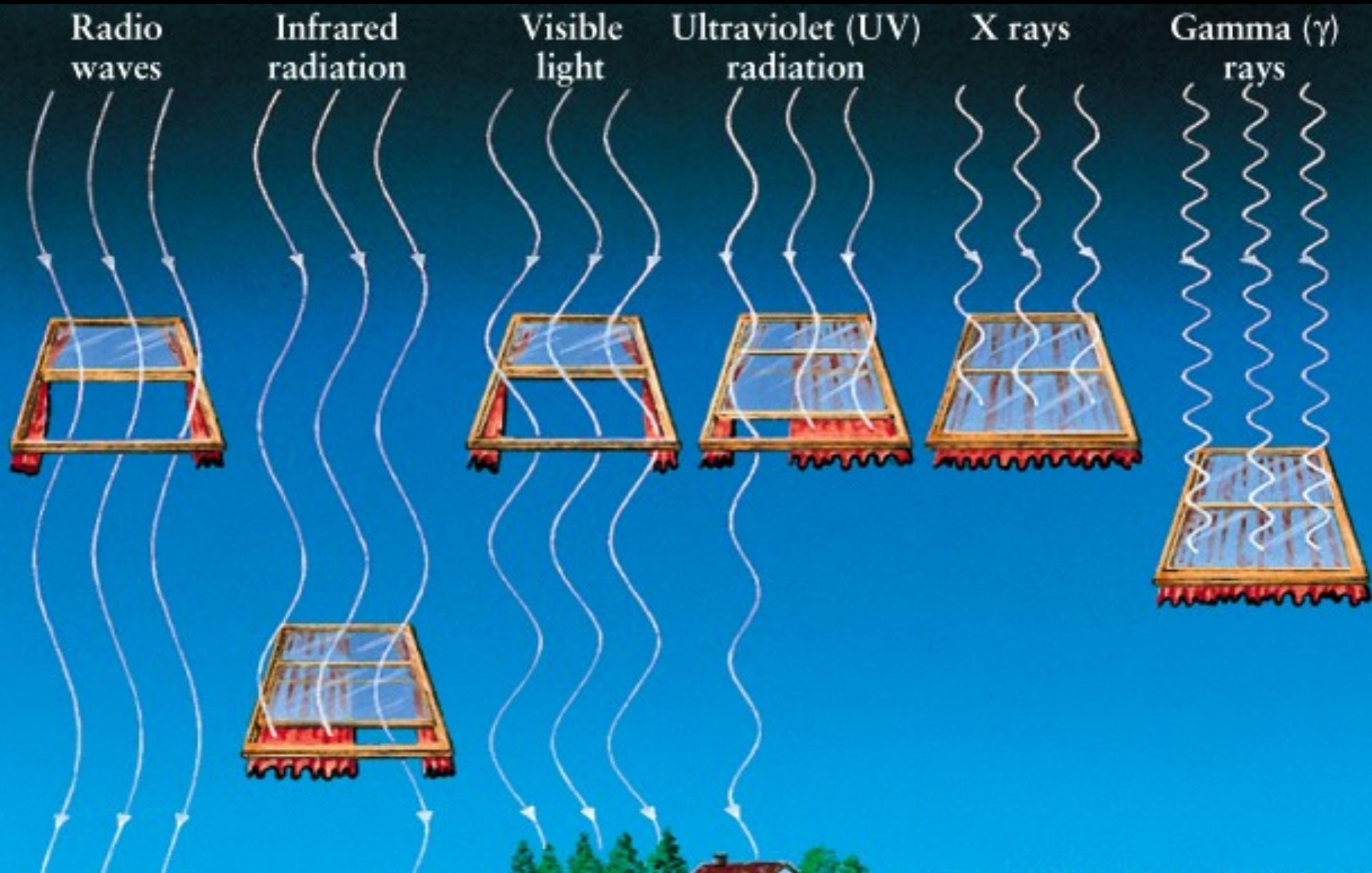


EARTHLIGHT



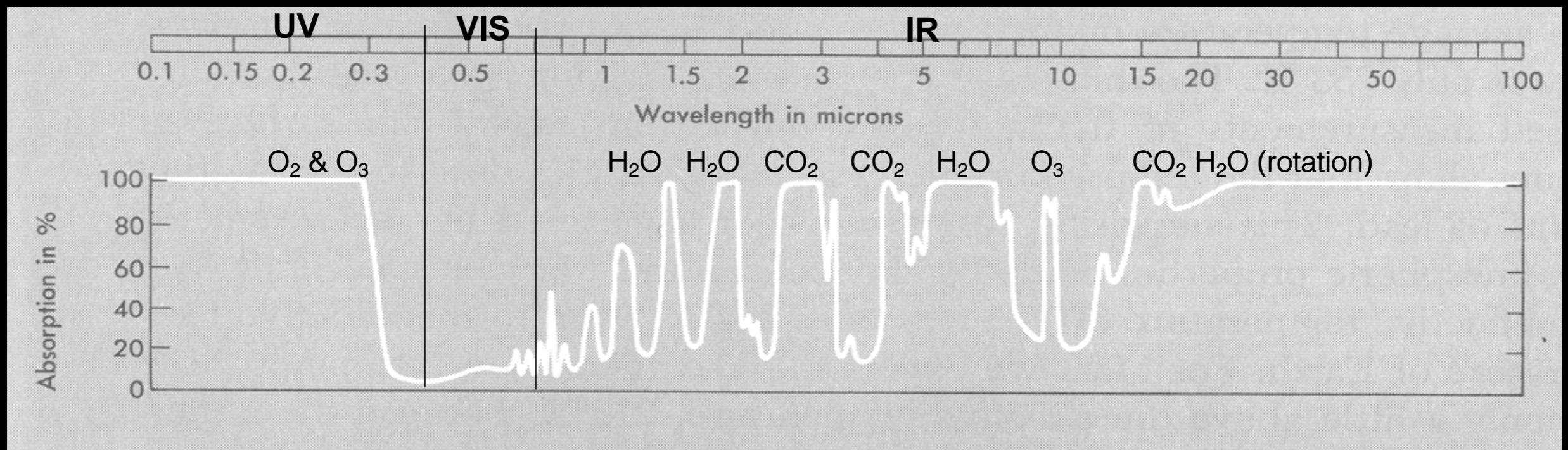
Show Ruler

Not all EM radiation can penetrate Earth's atmosphere.



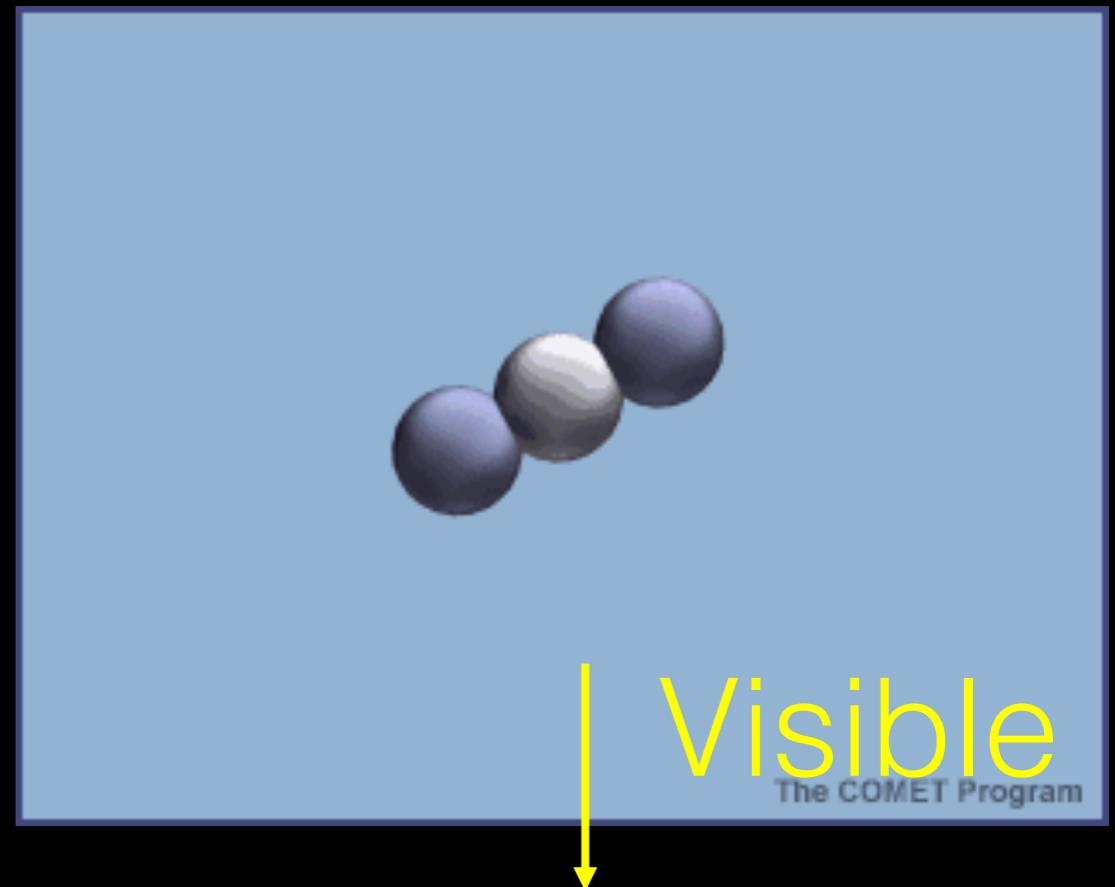
Atmosphere Absorption Spectrum

- Very little absorption at visible wavelengths
- Absorption of UV by ozone in upper atmosphere
- Absorption of IR by greenhouse gases in lower atmosphere



Interaction of Light and the Atmosphere

- Greenhouse gases (H_2O , CO_2 , CH_4 , other)
- Absorb different wavelengths of light
 - Absorb and re-emit IR
 - Are transparent to visible light



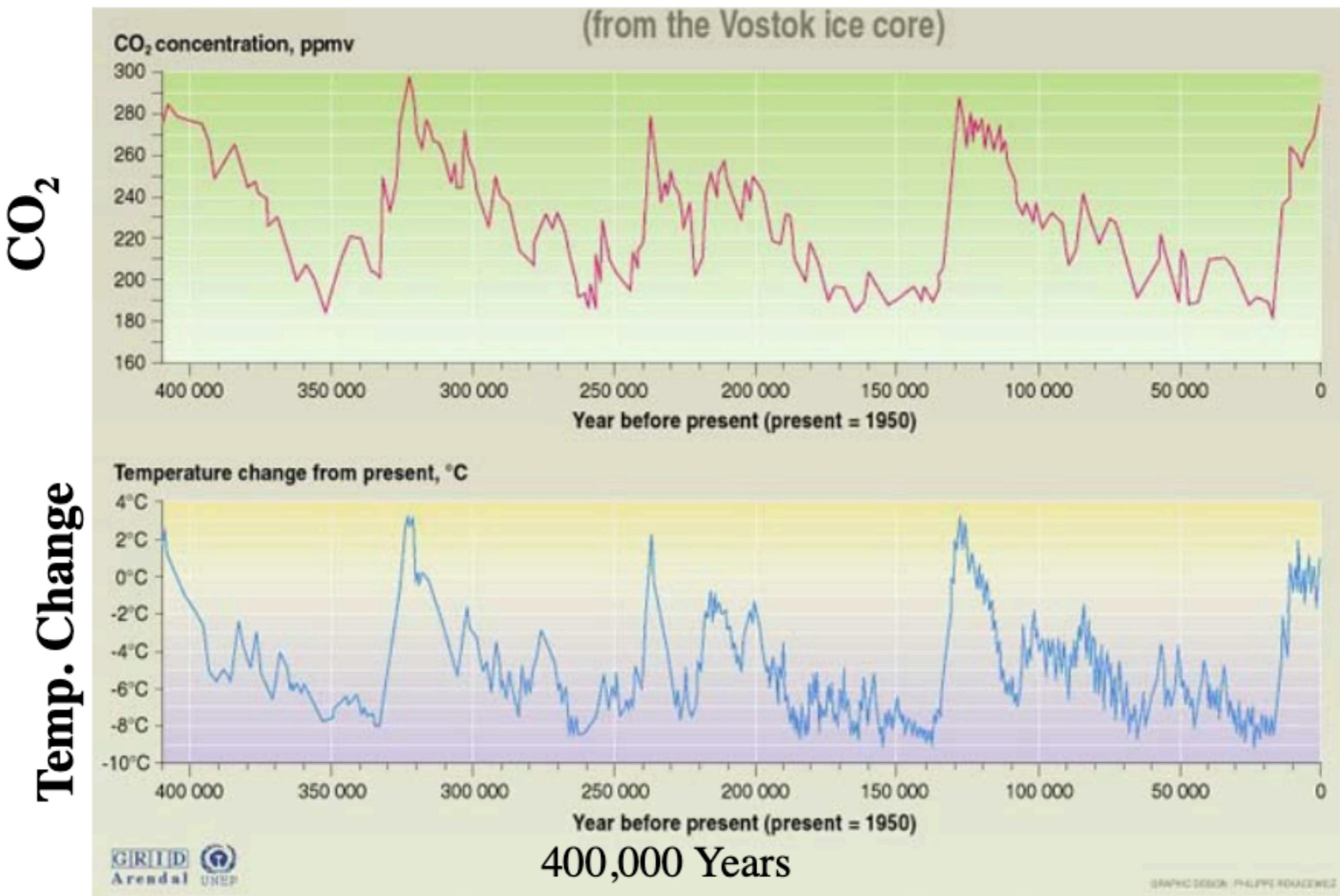
Understanding the Greenhouse Effect

- Spectra for Sun and Earth
 - Sun gives off mostly visible ; Earth gives off mostly IR
- Greenhouse gases absorb and re-emit IR but are transparent to Visible light.
 - H₂O, CO₂, CH₄
- Surface of planet is heated by energy (light) from the Sun AND from energy (IR light) re-radiated from the atmosphere
- GHE effect is a natural process and the surface of Earth would be much colder w/out GHE

Three DIFFERENT Phenomena

- Ozone Depletion
- Greenhouse Effect
- Global Warming

Temperature & CO₂ level are correlated throughout Earth's history.



Greenhouse Effect: Natural and “Anthropogenic”

- A small Greenhouse Effect warms Earth above the freezing point, making it **habitable**.
- But an **excessive** Greenhouse Effect can have catastrophic effects on life.
- Levels of CO₂ are now **increasing** as a result of burning fossil fuels (oil, coal, natural gas)
- We now dump over **10 billion tons of CO₂** into the atmosphere every year.
- (Natural sources, eg. volcanoes add up to 1%)

HOW THE GREENHOUSE EFFECT WORKS

About 30 percent
of infra-red radiation
escapes back
into space

Solar
energy

Carbon dioxide
released by aircraft

Solar
radiation
absorbed by earth

Ships burn
fossil fuel or oil

Oceans warm,
water evaporates
and vapour adds
to heat trap

Factories release
carbon dioxide

Burning of
fossil fuels
and vehicle
exhausts

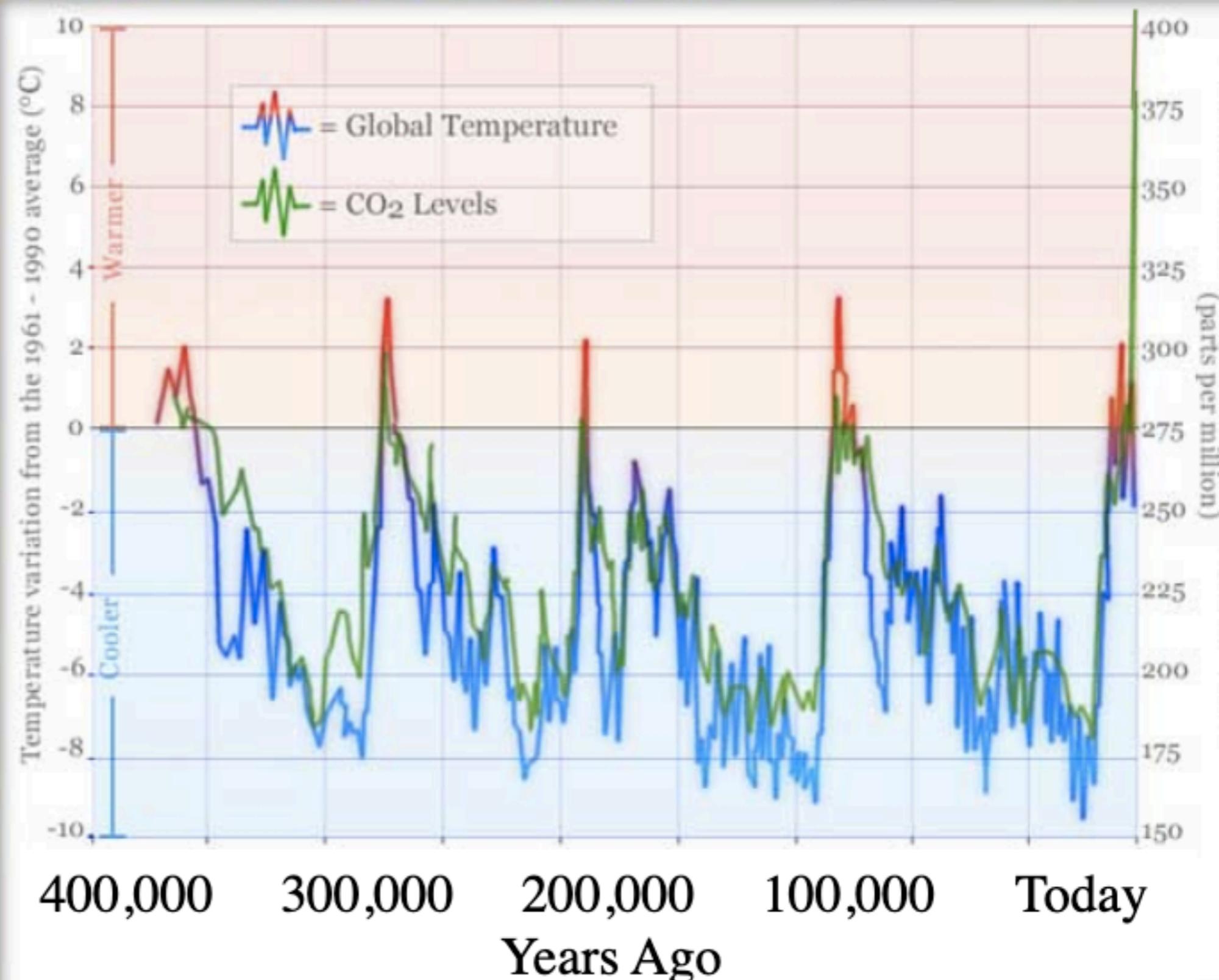
Heat trapped by excess carbon dioxide

Earth's
surface radiates
heat (infra-red
radiation) back
into atmosphere

Heat trapped
by excess
carbon dioxide

Recent CO₂ Increase is Huge!

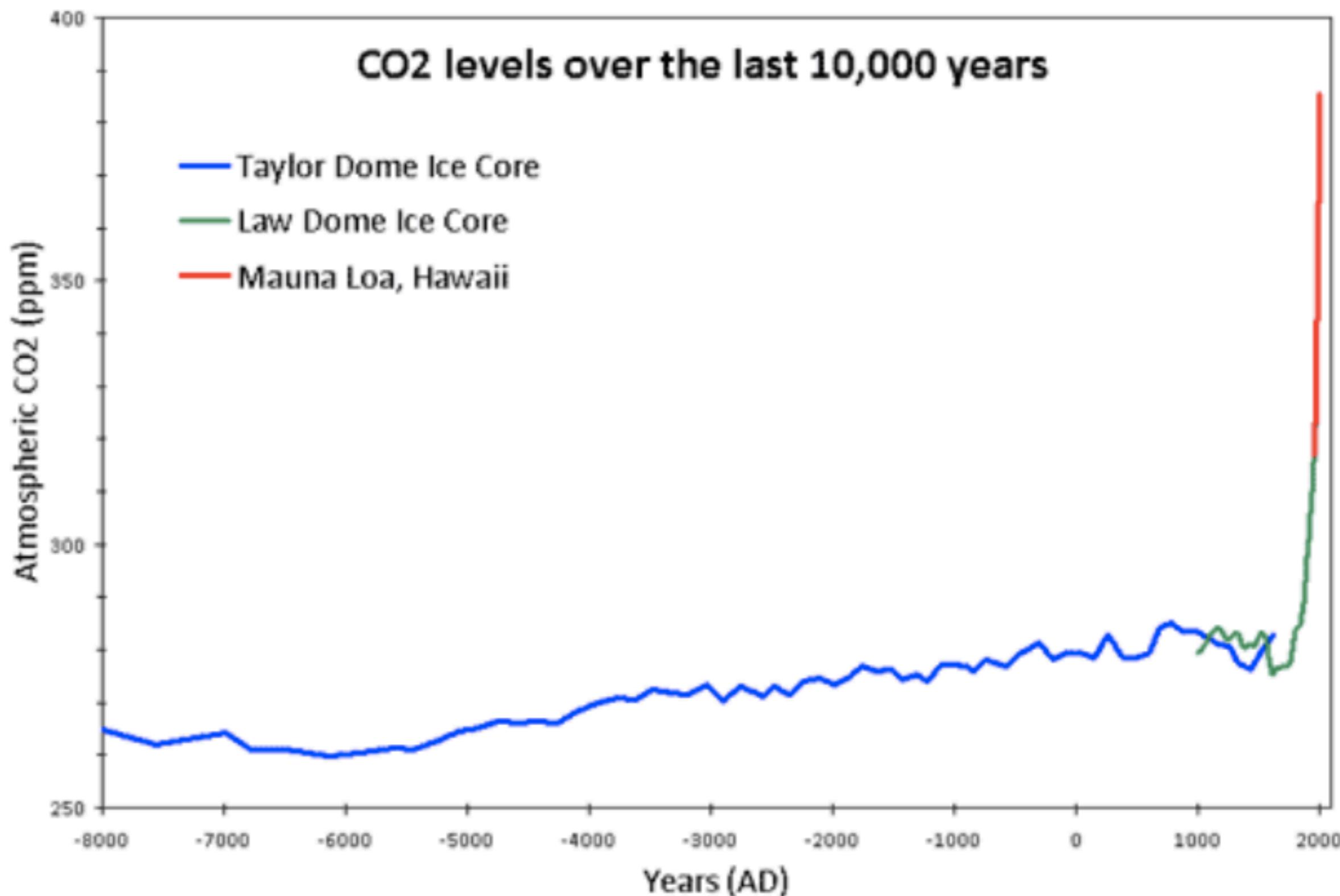
Carbon Dioxide Concentration

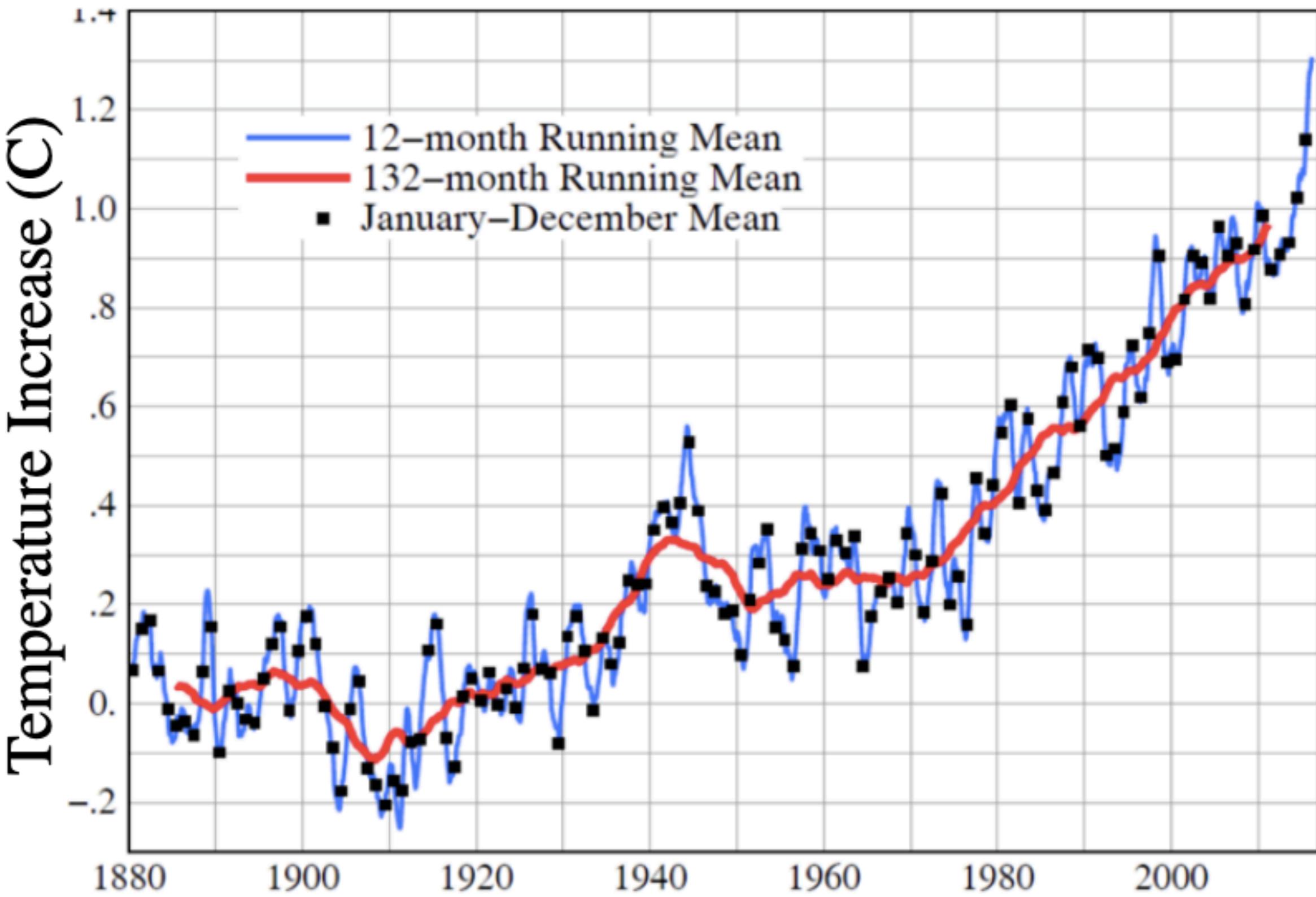


In the last half
million years...

CO₂ levels have
never been this
high.

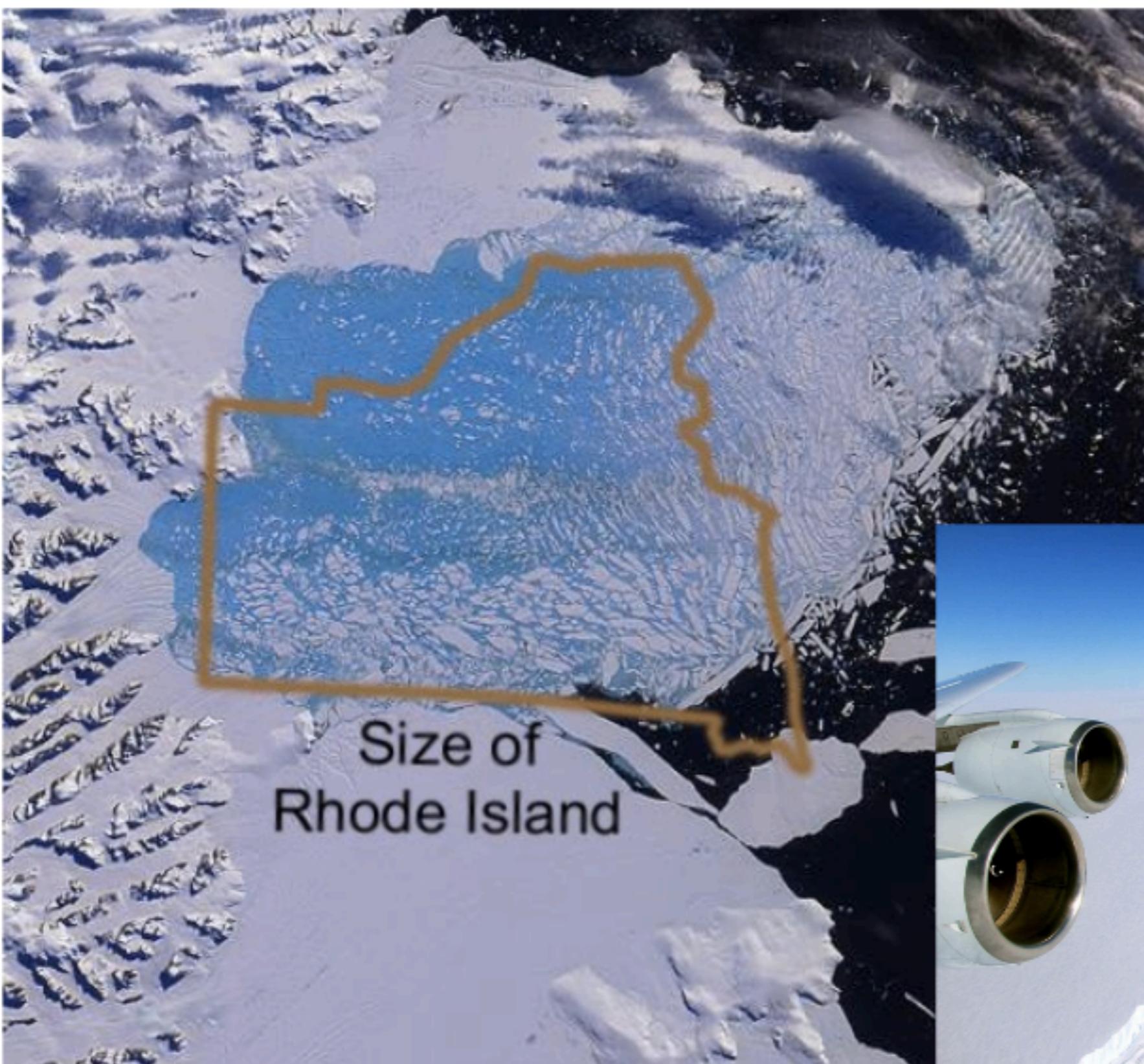
CO₂ Levels Have increased dramatically!





The effect of increased greenhouse gasses is easy to measure.
Earth's temperature is clearly rising, esp. in the last 20 years.

Global Warming Effects: Antarctica is Melting



Larson-B Ice Shelf existed for 12,000 years.

In 2002 it melted in 5 weeks!



The larger Larson-C has now cracked and begun to melt

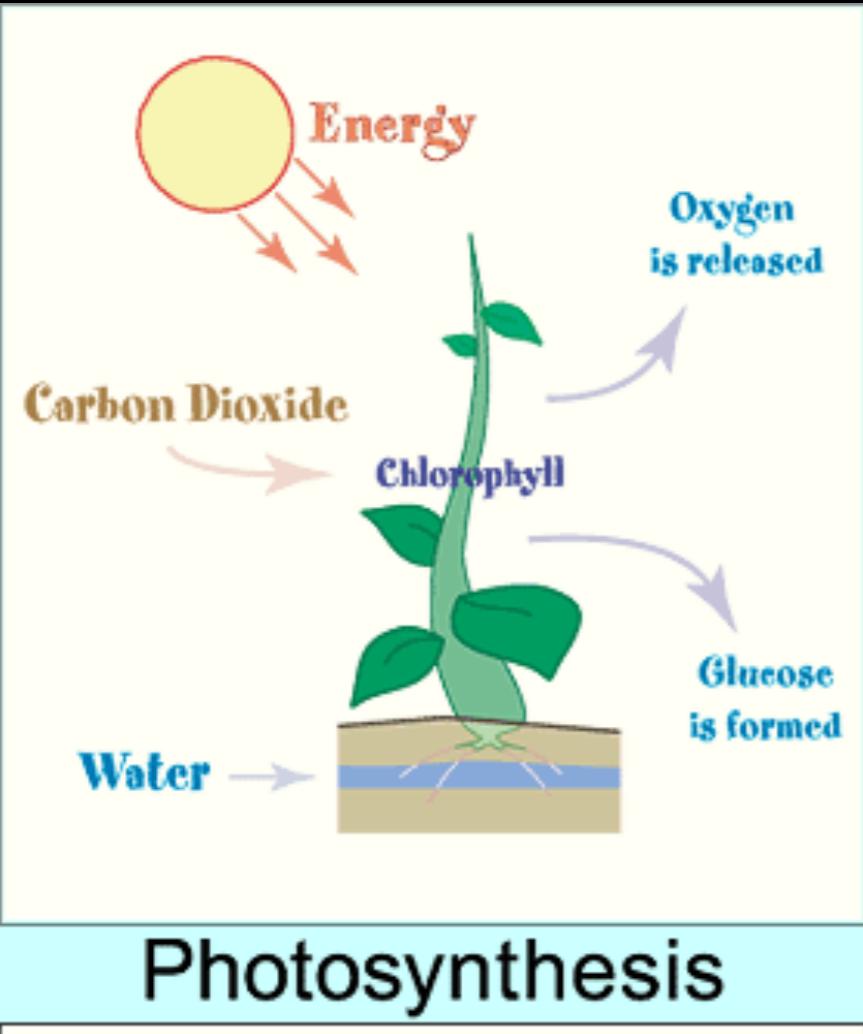
Sea levels may by a few feet...or up to 30 feet



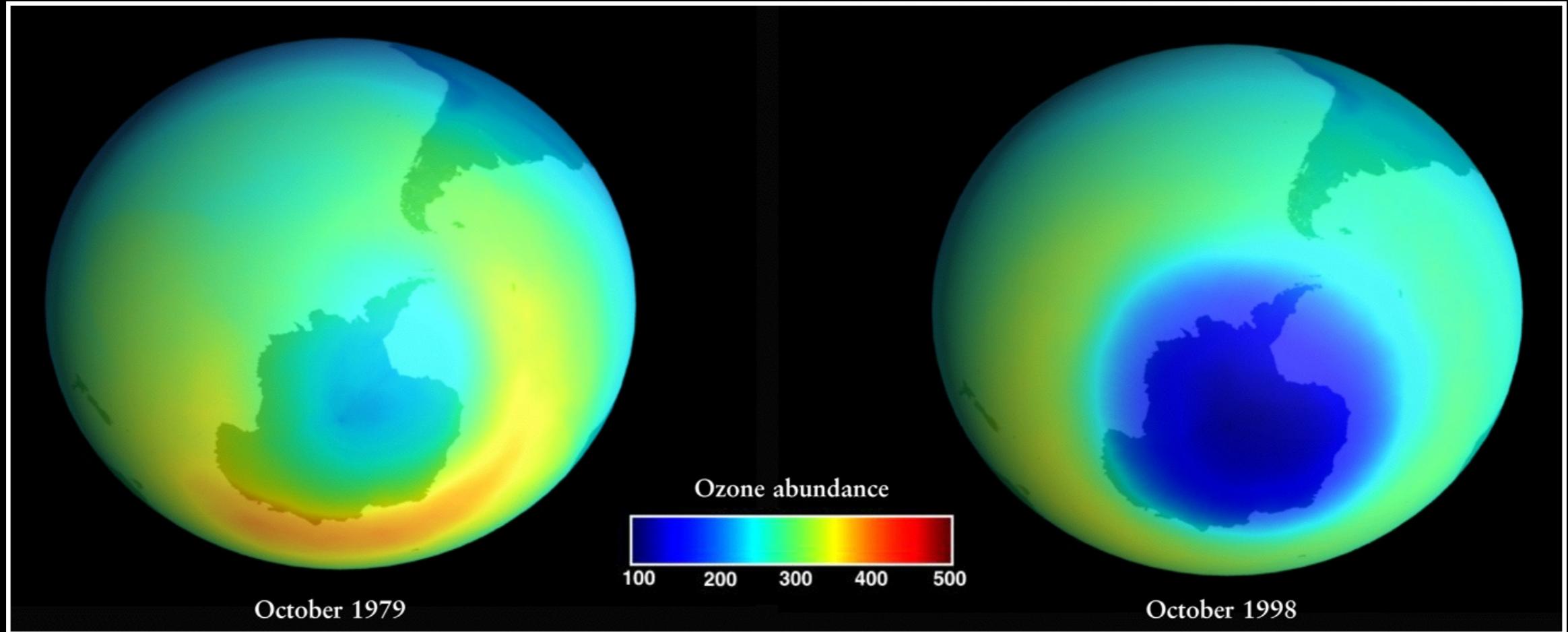
Three DIFFERENT Phenomena

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- Photosynthesis makes energy for the plants—by absorbing carbon dioxide and releasing free oxygen.
- As there is oxygen in the atmosphere now, there is also a layer of ozone (O_3) at altitudes of 15 to 30

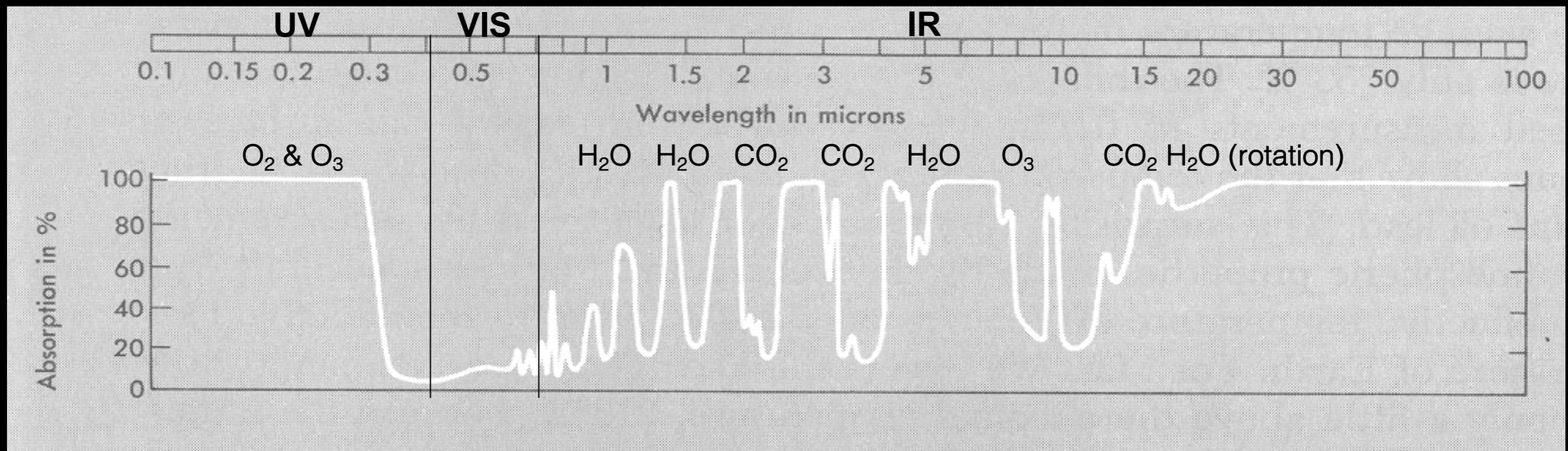
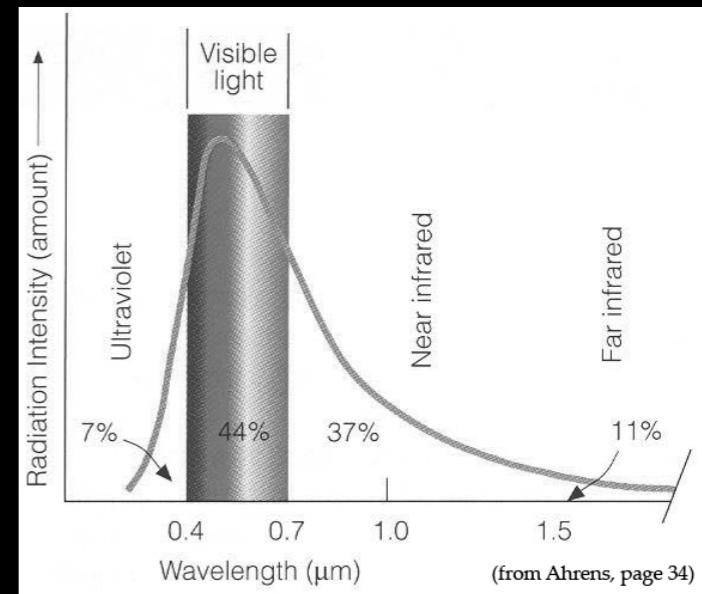
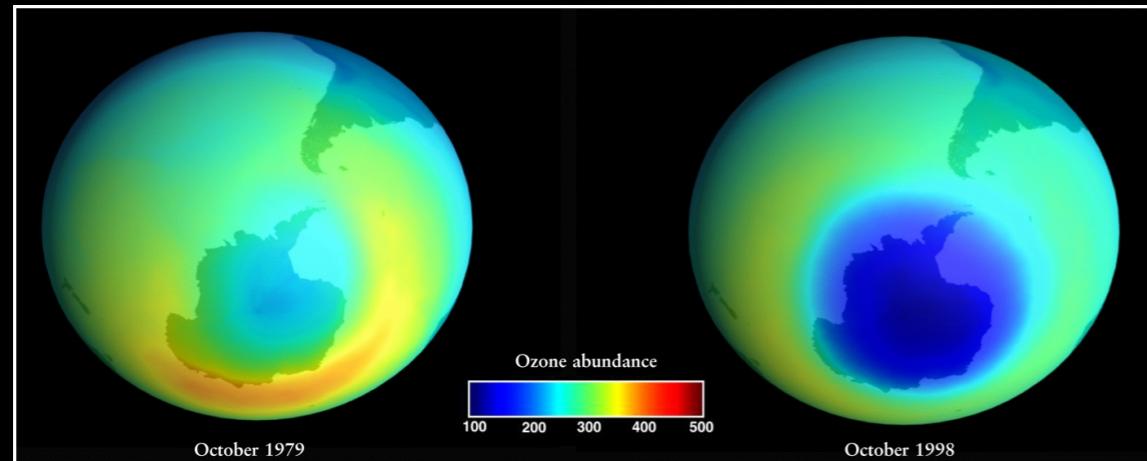


Ozone can be destroyed by synthetic CFC pollutants, such as freon



Two distributions of stratospheric ozone over Antarctic in October 1979 and October 1998. The data show that there has been a dramatic decrease in ozone over the Antarctic. But since we receive very little UV from the Sun, ozone depletion is not contributing to global warming – but could contribute to increased skin cancer where the hole exists

Ozone depletion does not lead to Global Warming



Since we receive very little UV from the Sun, ozone depletion is not contributing to global warming – but could contribute to increased skin cancer where the hole exists