
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..!
SEA-LEVEL RISE

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

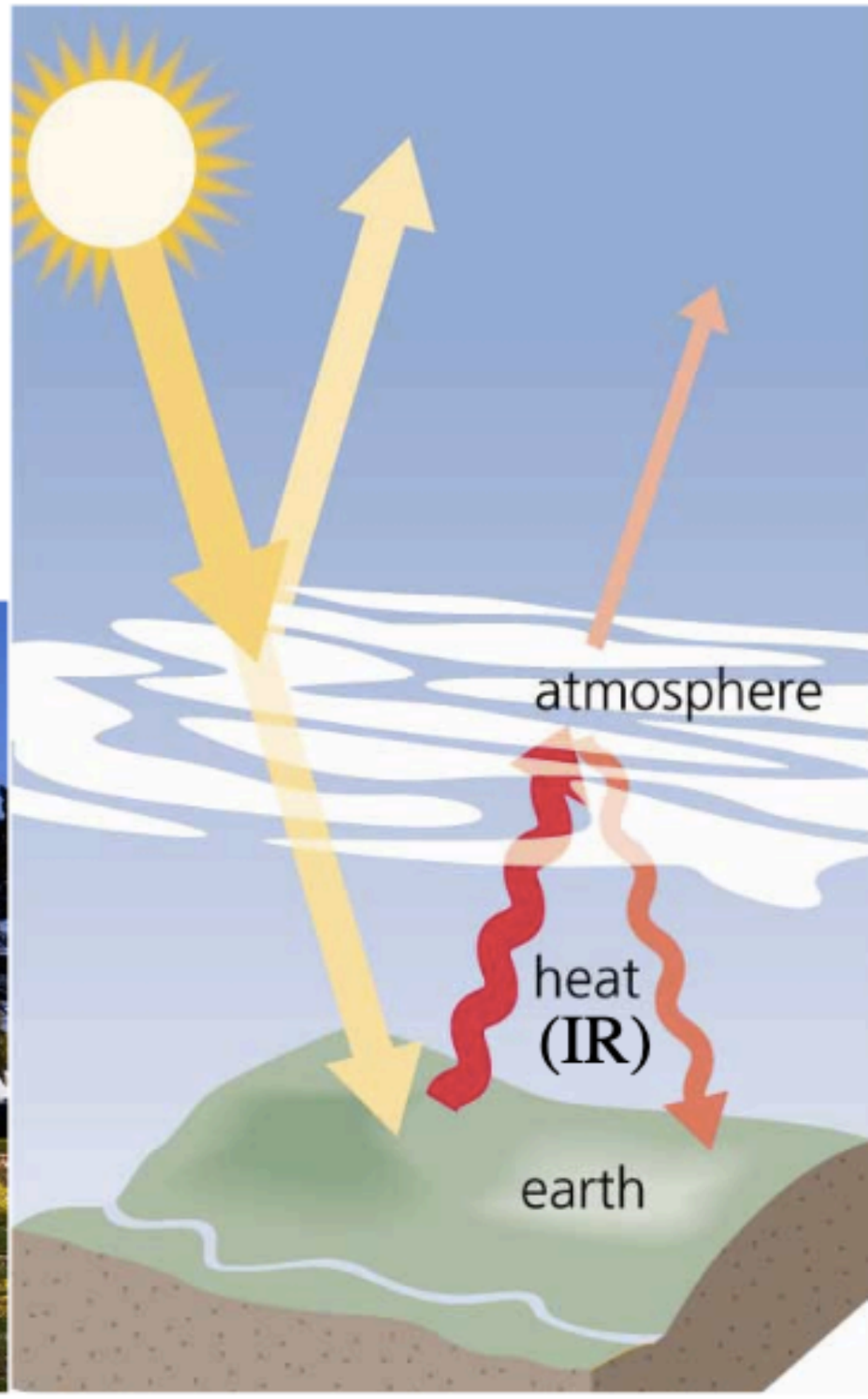
Three DIFFERENT Phenomena

- Ozone Depletion
- Greenhouse Effect
- Global Warming

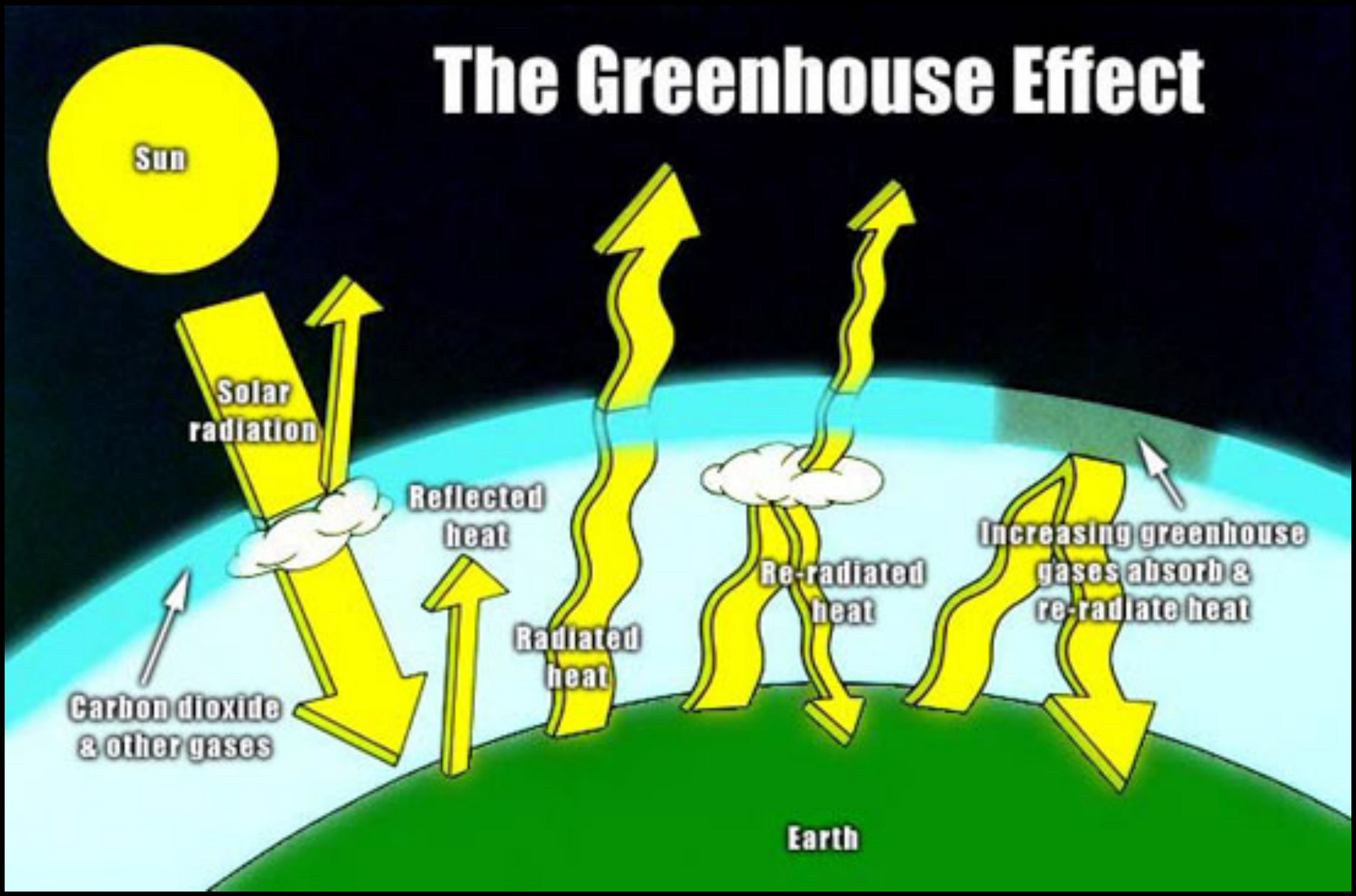
Greenhouse Effect

- ....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



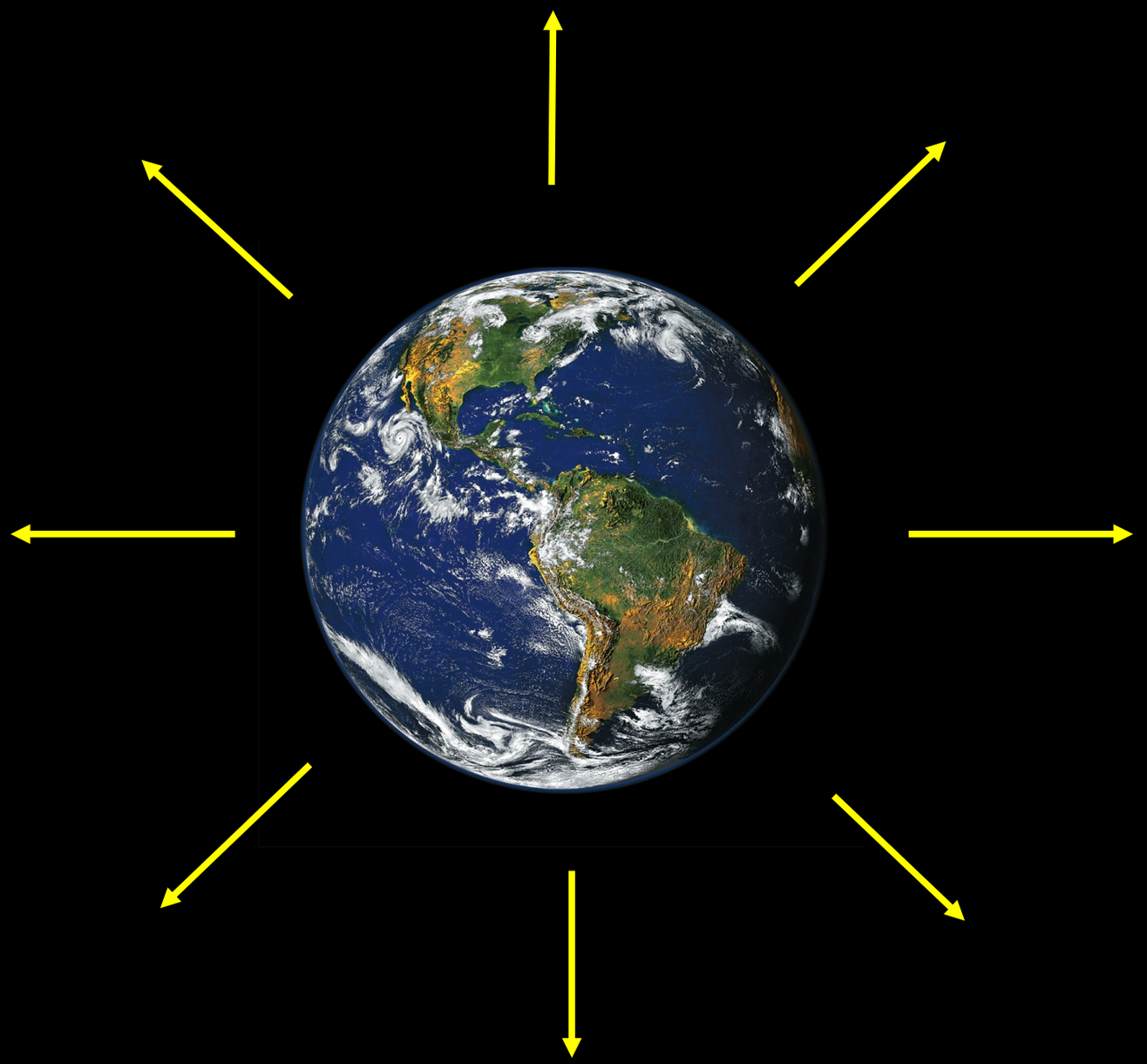
The Greenhouse Effect



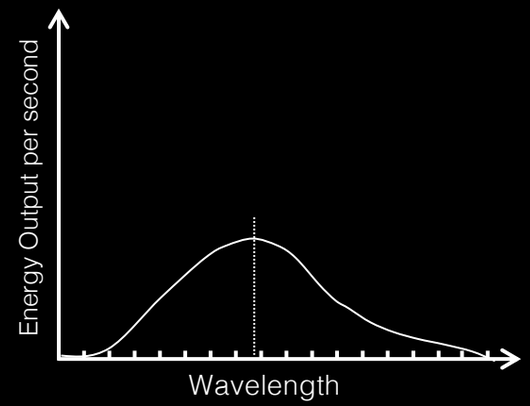
The sun drives the climate of Earth

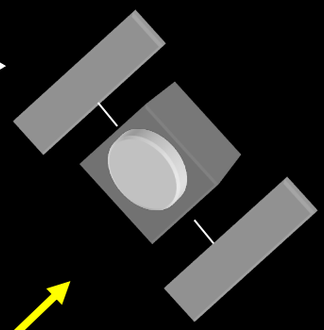
http://www.spaceweather.com/images2002/18mar02/cme_c3_big.gif

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

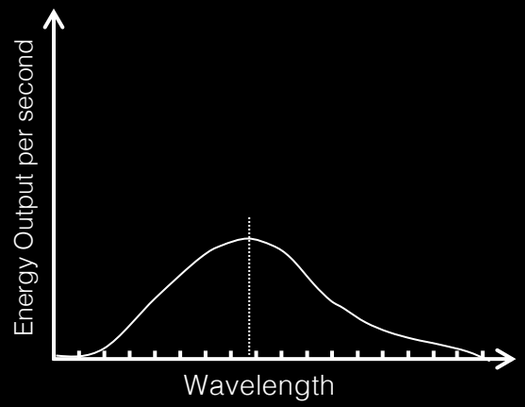


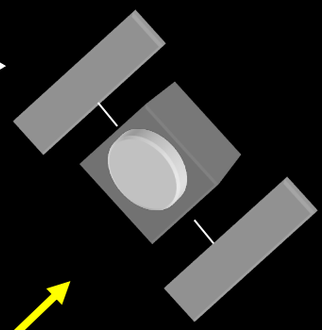
The spectral curve of the Earth, as measured from far above Earth's atmosphere, peaks at a wavelength of approximately 10μm and that corresponds to a temperature of approximately 255 K (0°F).

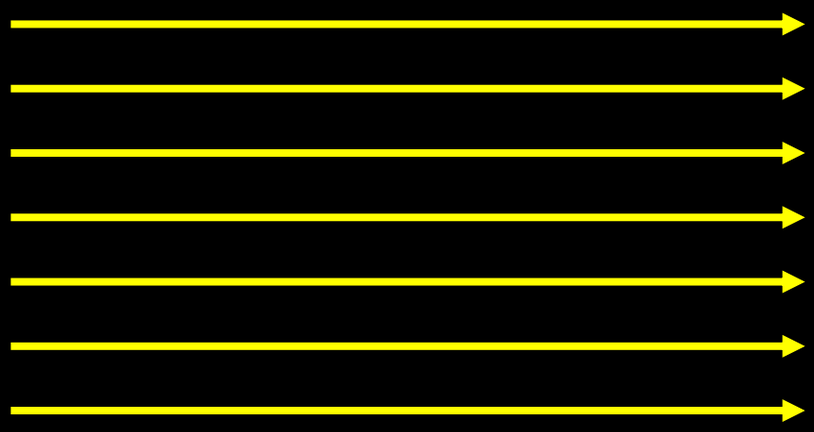


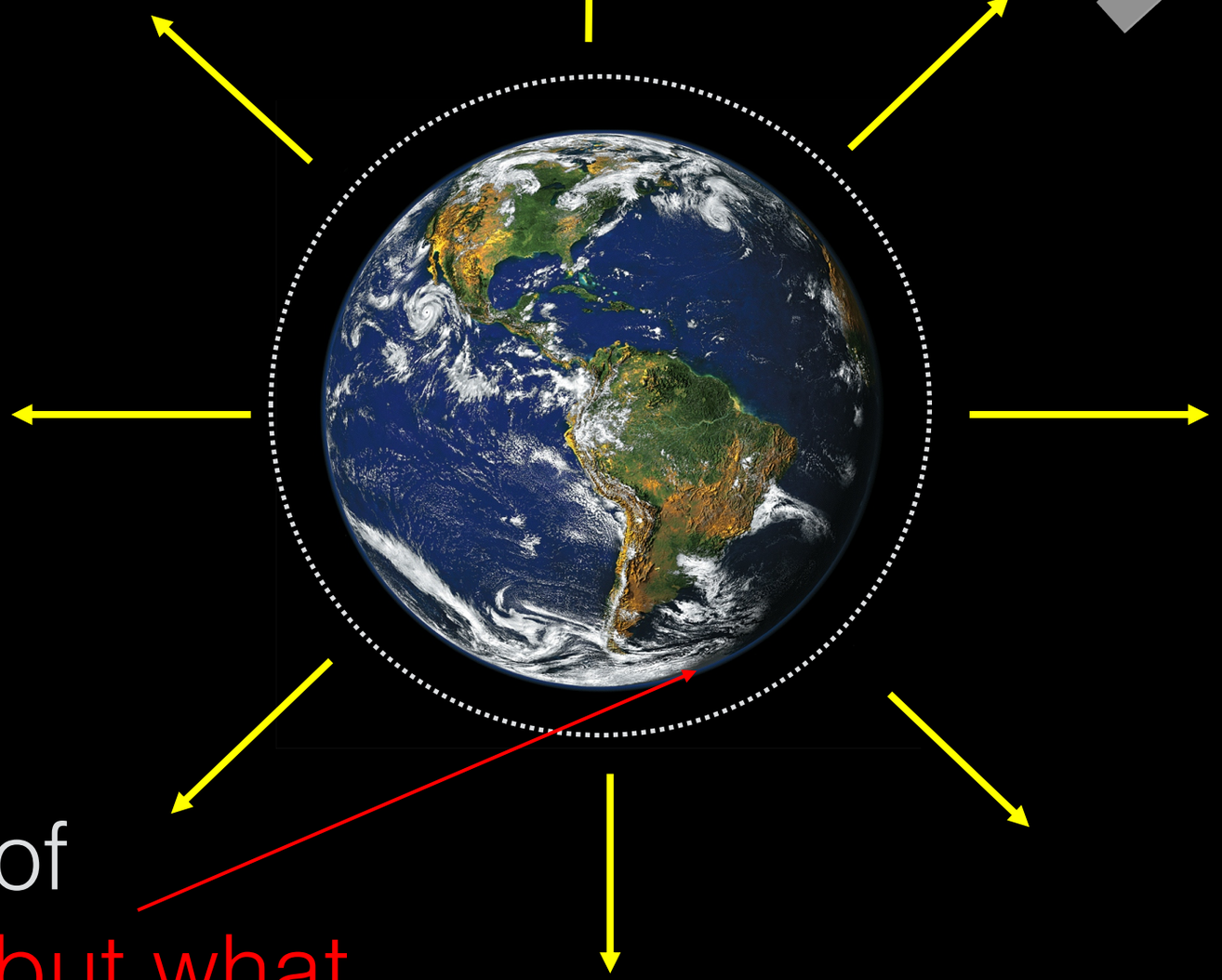


How will the temperature measured by the spacecraft change if the earth is surrounded by an atmosphere?









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

"The Greenhouse Effect"

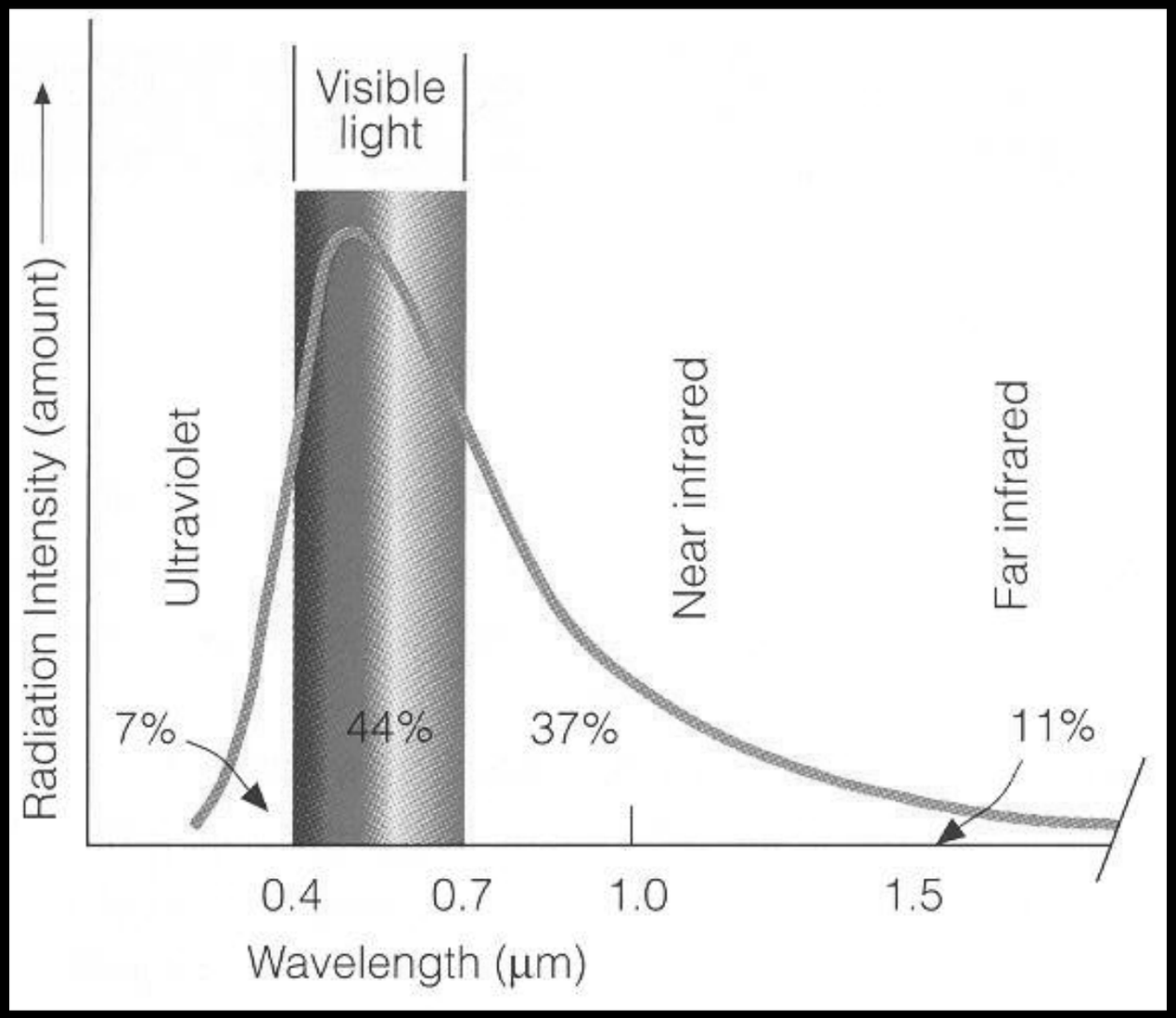
Which of the following appear to have a Greenhouse Effect?

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

Wien's Law

SUNLIGHT

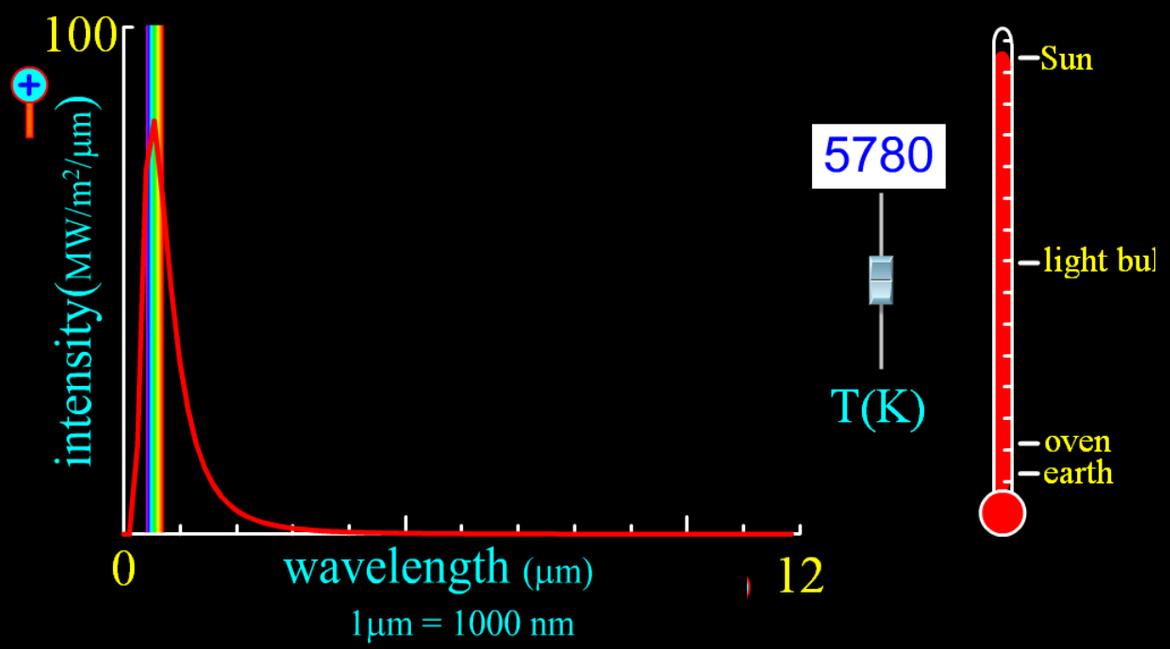
- Sun radiates mostly visible and IR



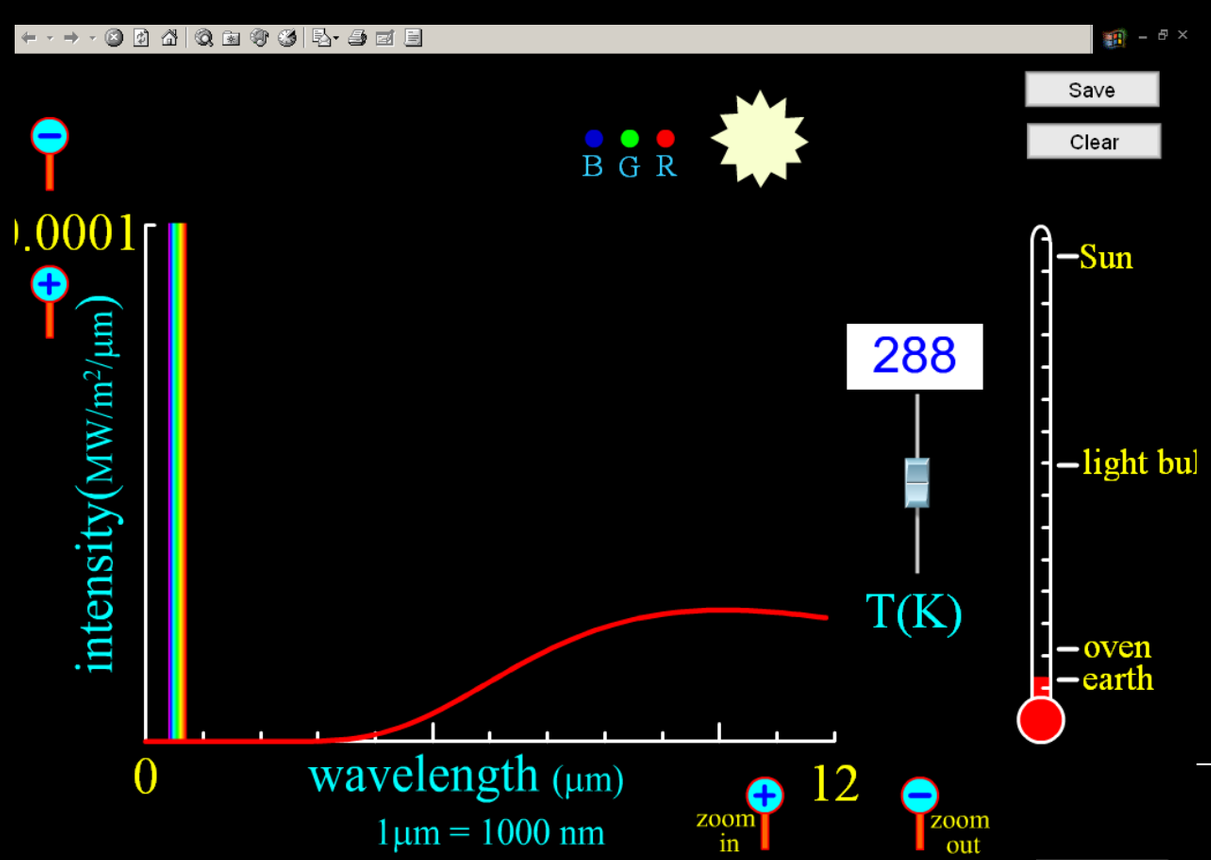
Wien's Law

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

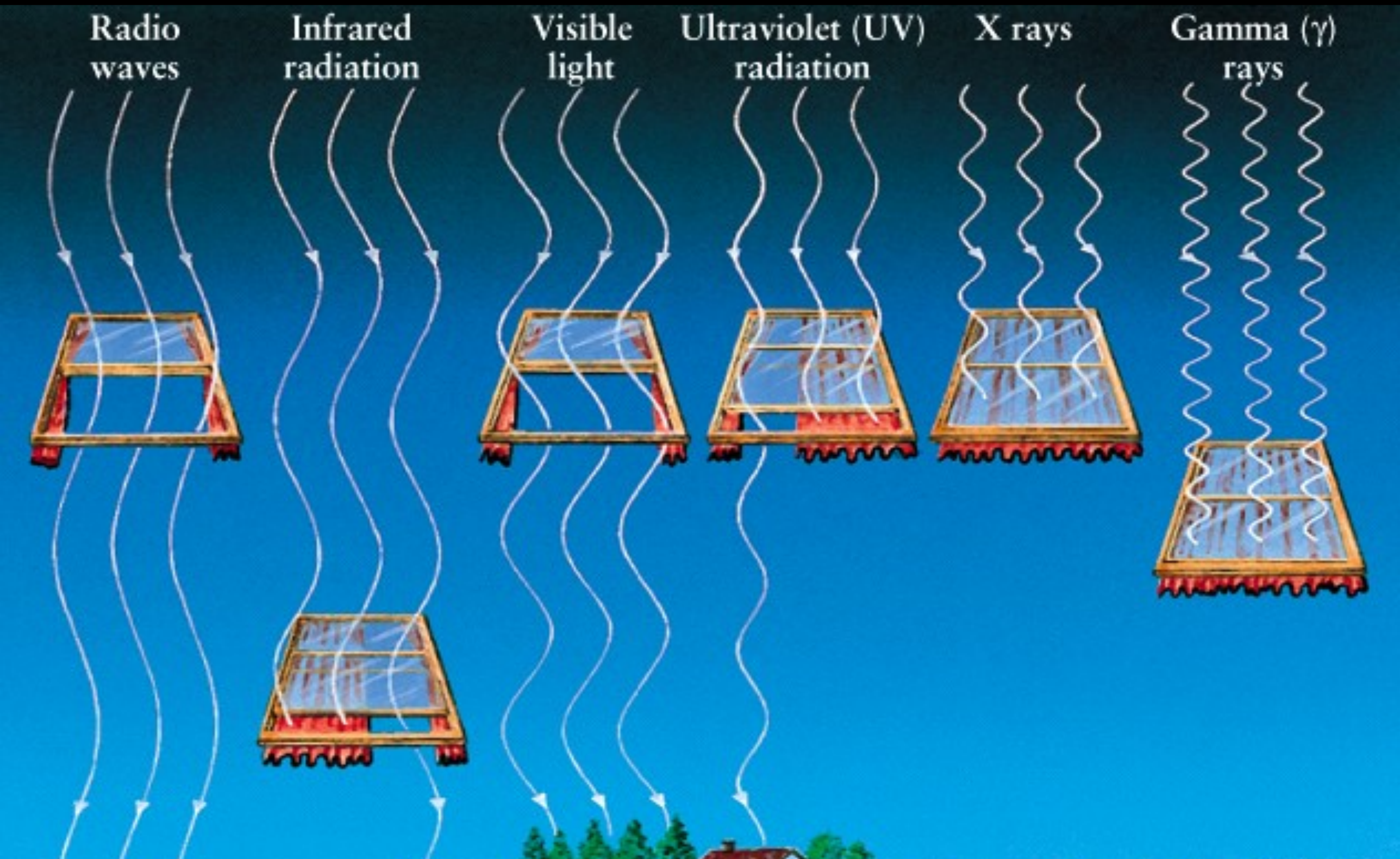
SUNLIGHT



EARTHLIGHT

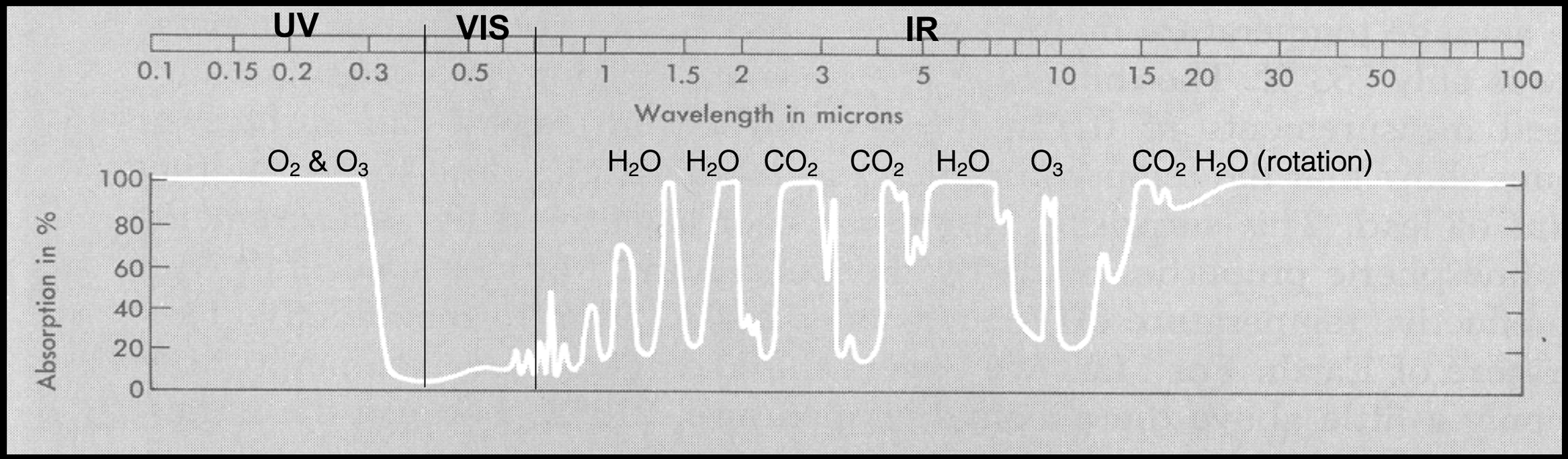


Not all EM radiation can penetrate Earth's atmosphere.



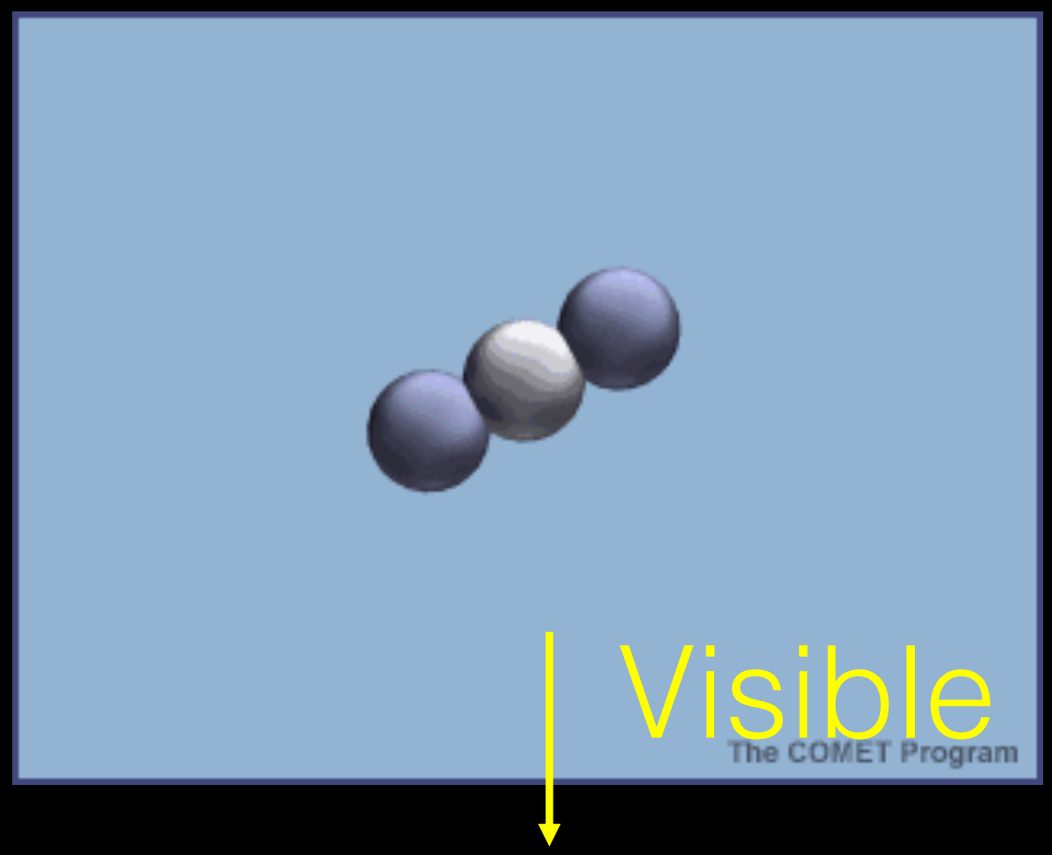
Atmosphere Absorption Spectrum

- 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_20, CO_2, CH_4, other)
- Absorb different wavelengths of light
  - Absorb and re-emit IR
  - Are transparent to visible light



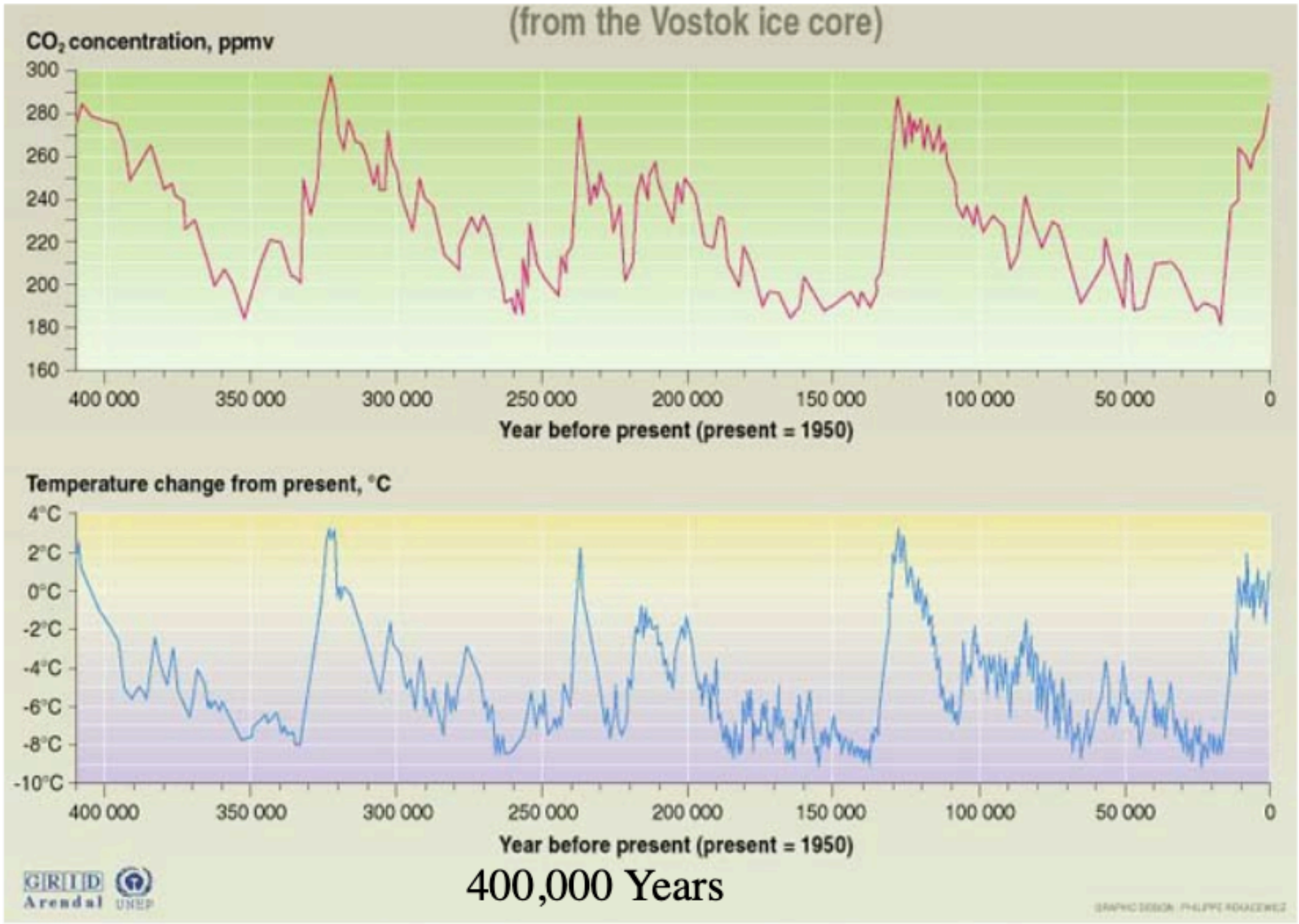
Understanding the Greenhouse Effect

- Spectra for Sun and Earth
  - Sun gives of mostly visible ; Earth gives of mostly IR
- Greenhouse gases absorb and re-emit IR but are transparent to Visible light.
  - H_20, CO_2, CH_4
- 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 & CO_2 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 CO_2 are now **increasing** as a result of burning fossil fuels (oil, coal, natural gas)
- We now dump over **10 billion tons of CO_2** into the atmosphere every year.

- (Natural sources, eg. volcanoes add up to 1%)

HOW THE GREENHOUSE EFFECT WORKS

Solar energy

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

Heat trapped by excess carbon dioxide

Carbon dioxide released by aircraft

Solar radiation (heat) absorbed by earth

Forests cut down

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

Factories release carbon dioxide

Heat trapped by excess carbon dioxide

Ships burn fossil fuel or oil

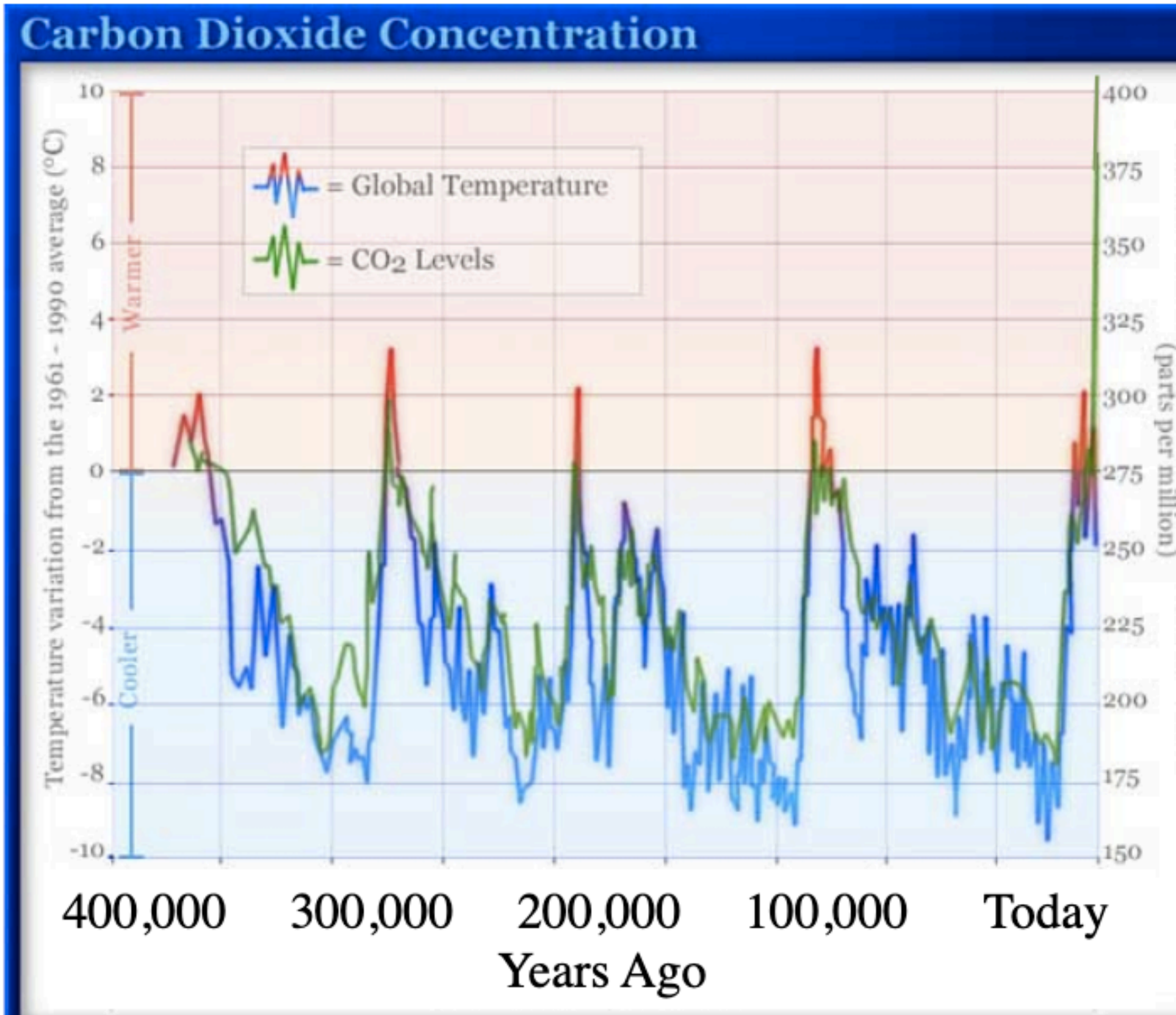
Oceans warm, water evaporates, and vapour adds to heat trap

Burning of fossil fuels and vehicle exhausts

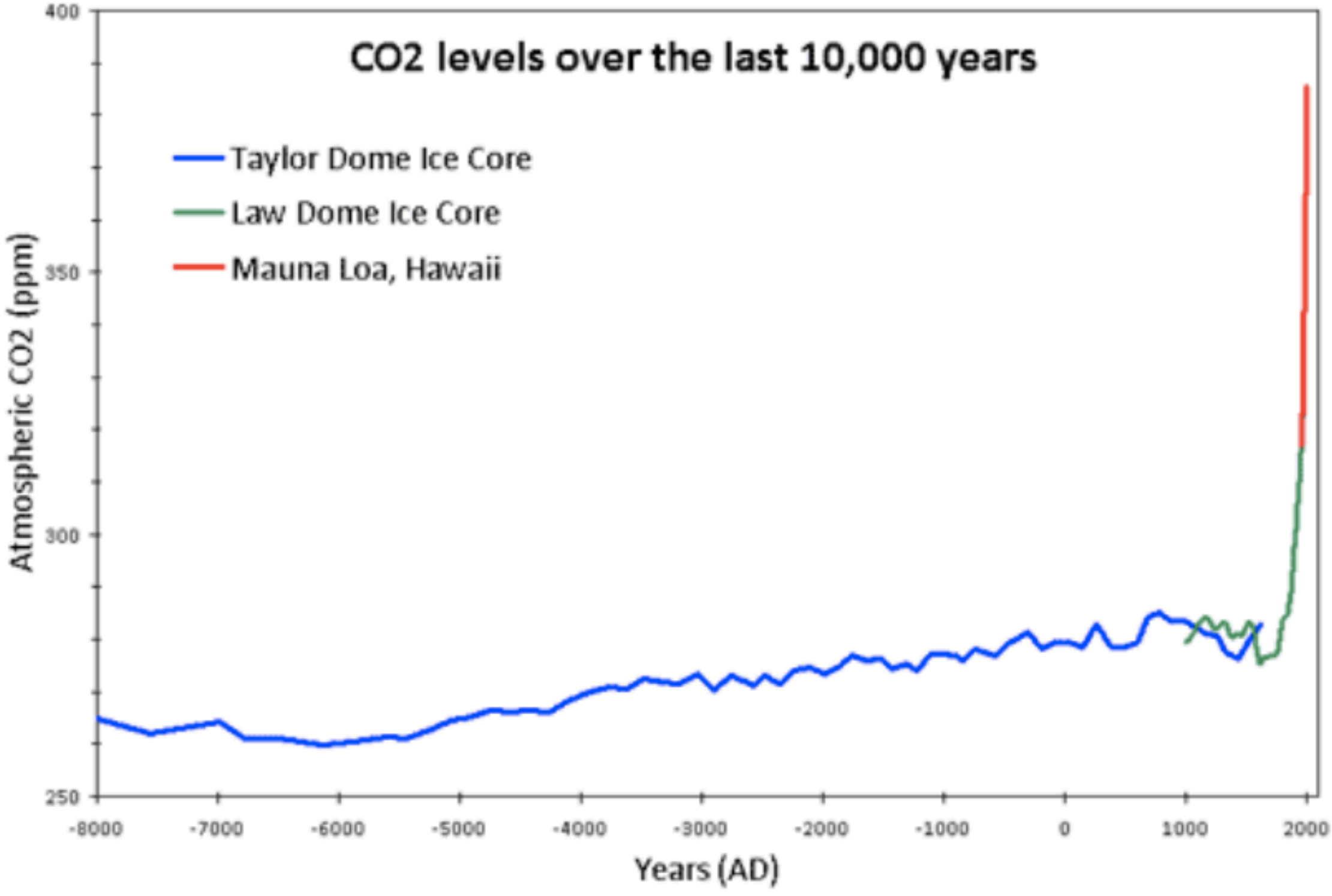
Recent CO_2 Increase is Huge!

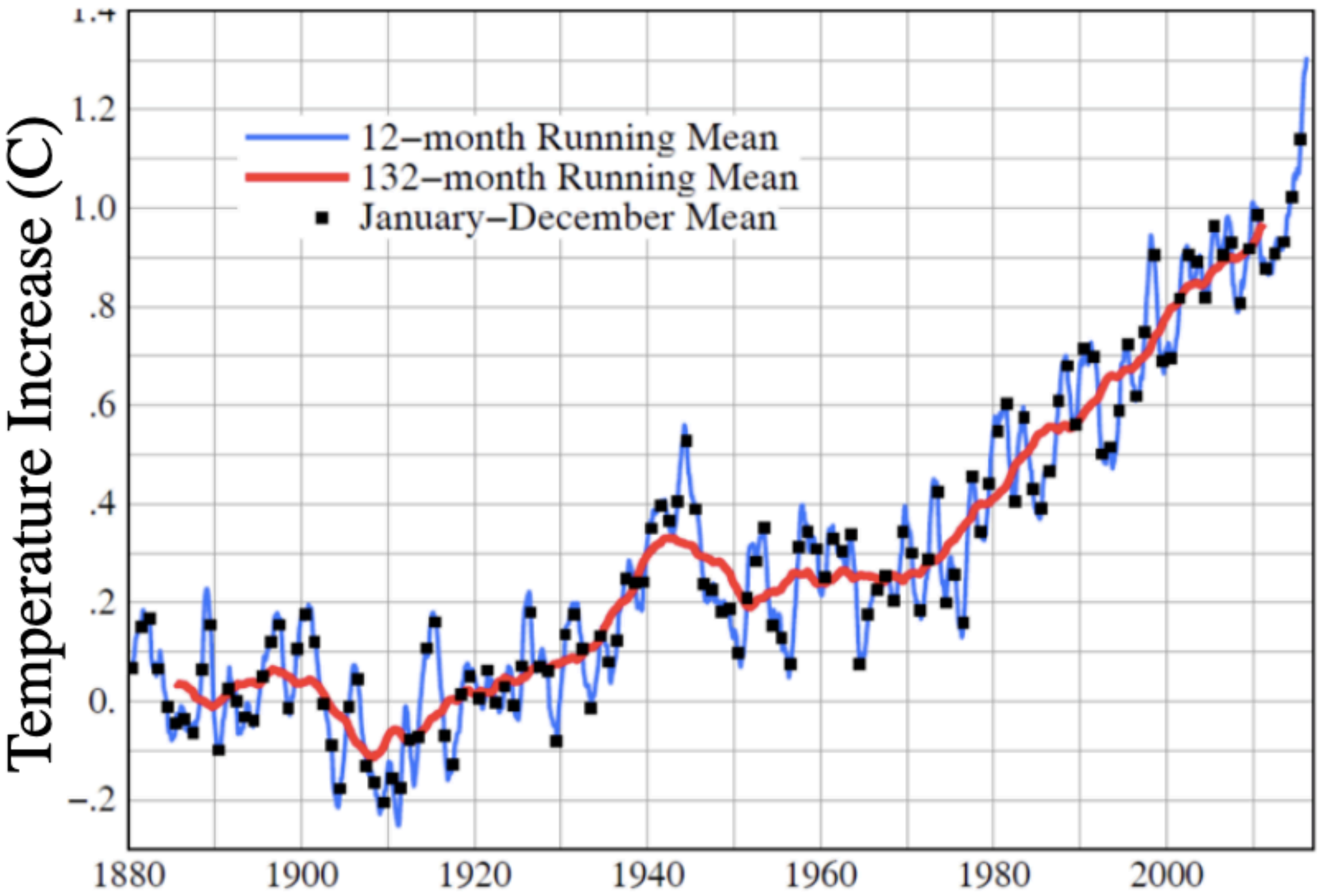
In the last half million years…

CO_2 levels have **never** been this high.



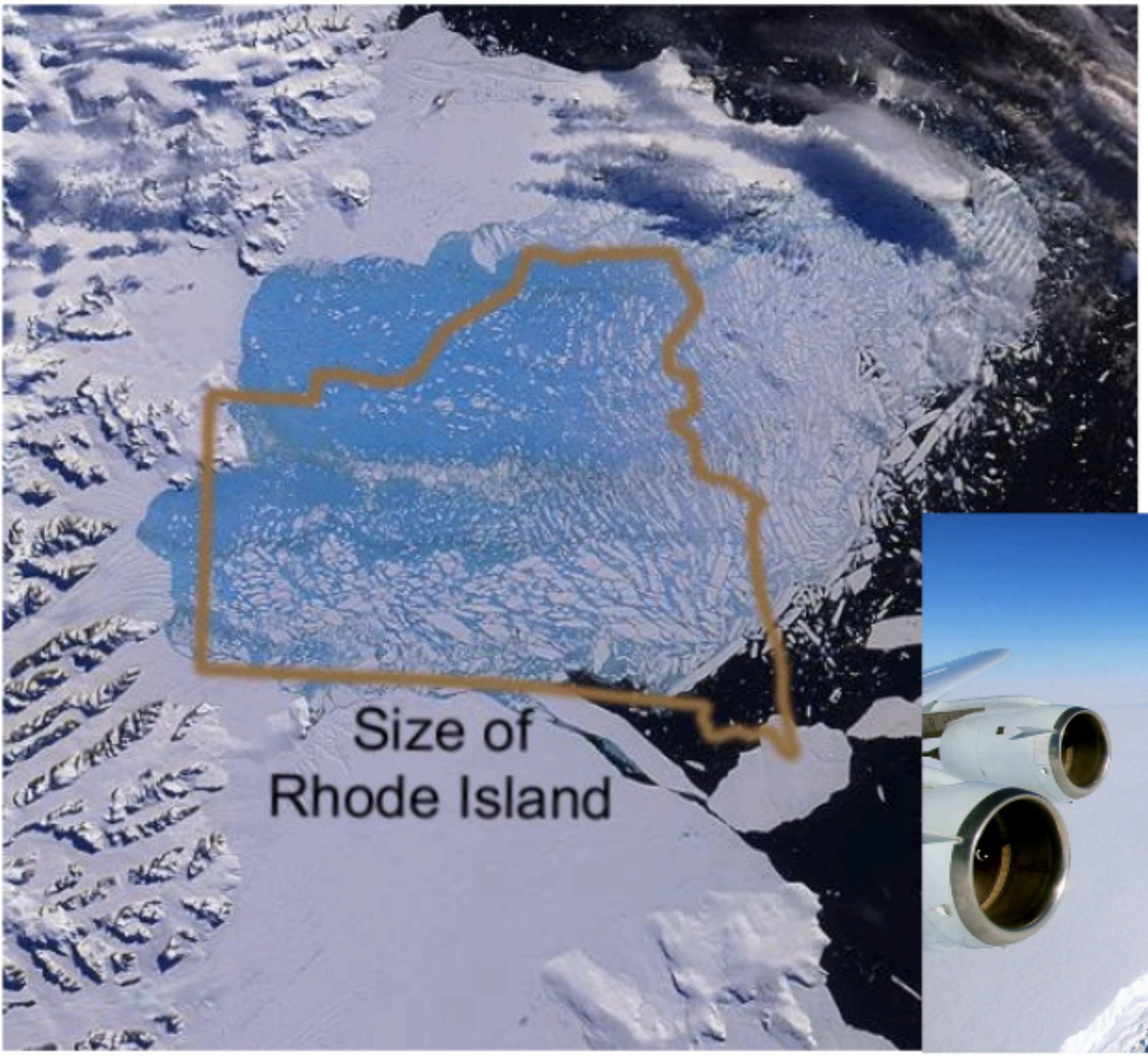
CO_2 Levels Have increased dramatically!





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

S.F. Bay Area after only 5 feet sea level rise

Three DIFFERENT Phenomena

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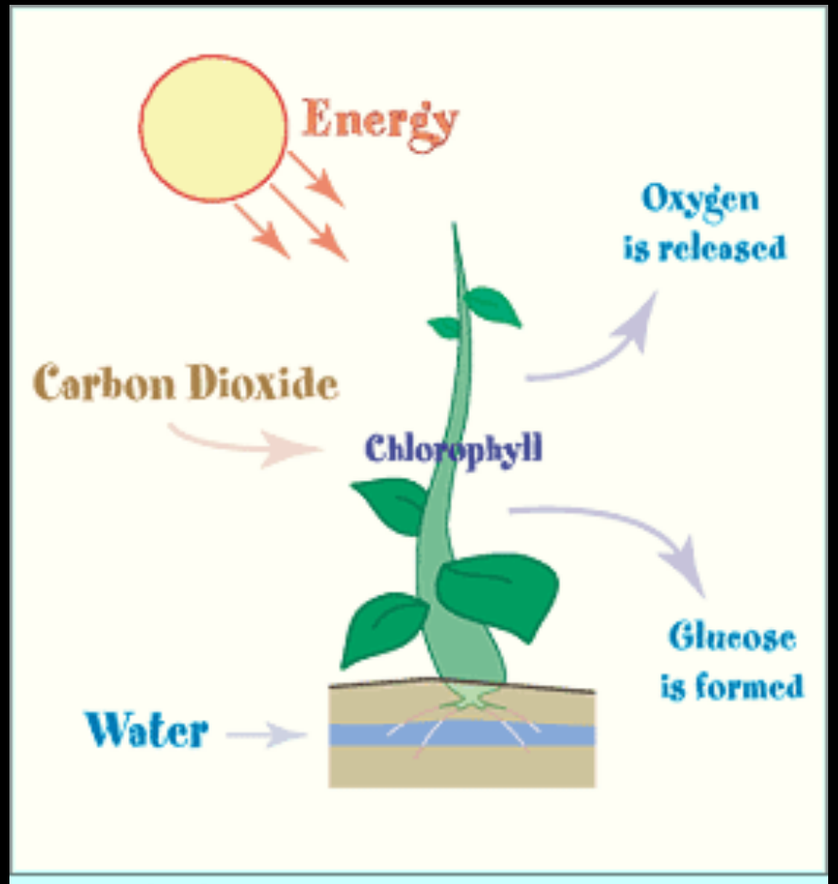
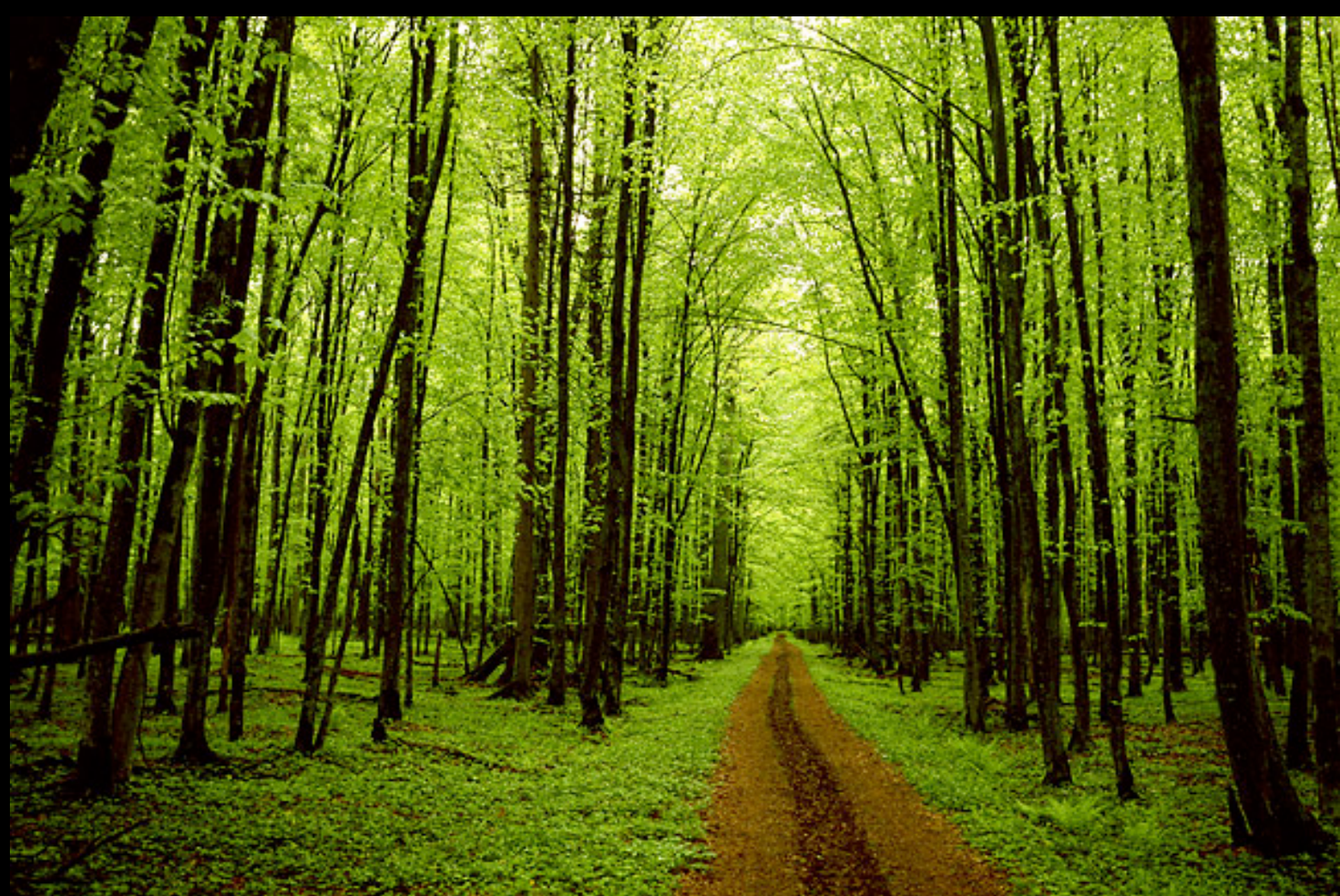
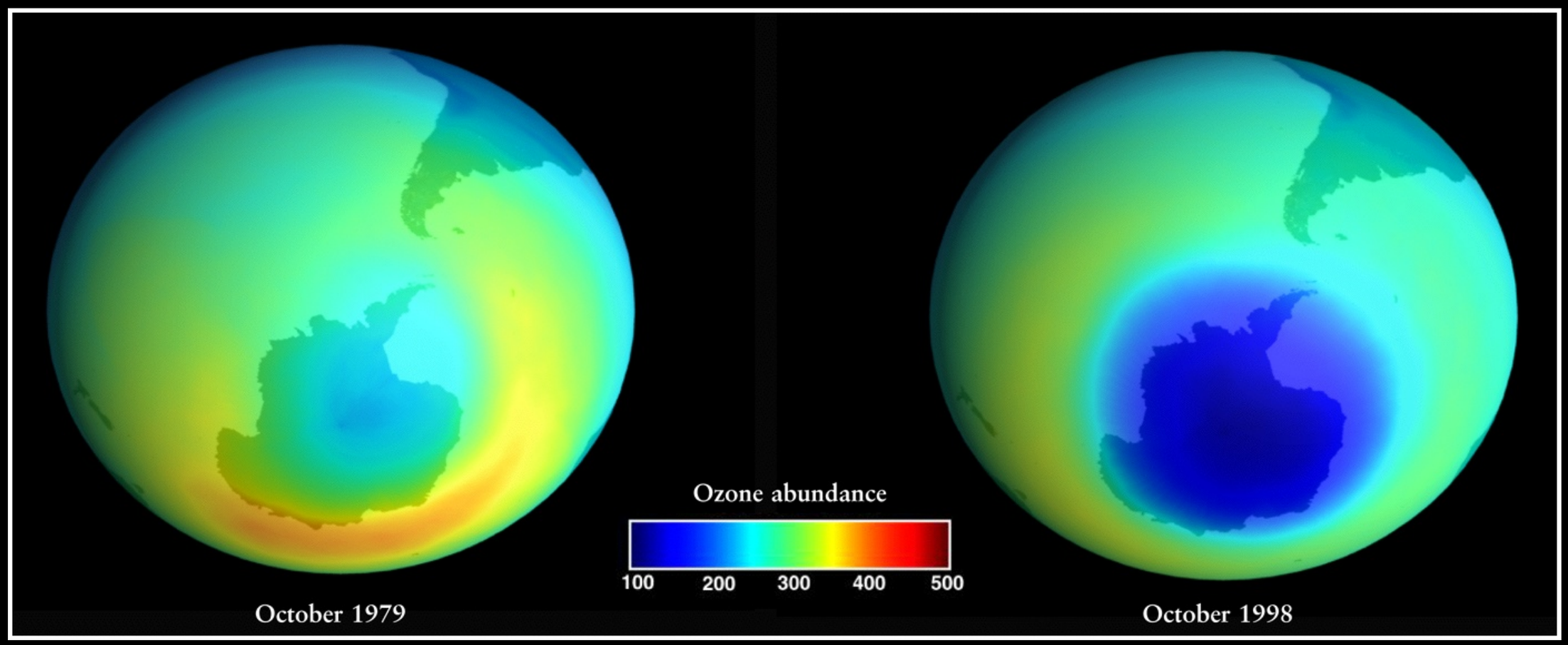
- Photosynthesis makes energy for the plants—by absorbing carbon dioxide and releasing free oxygen.
- As there is oxygen in the atmosphere now, there is also a layer of ozone (O_3) at altitudes of 15 to 30



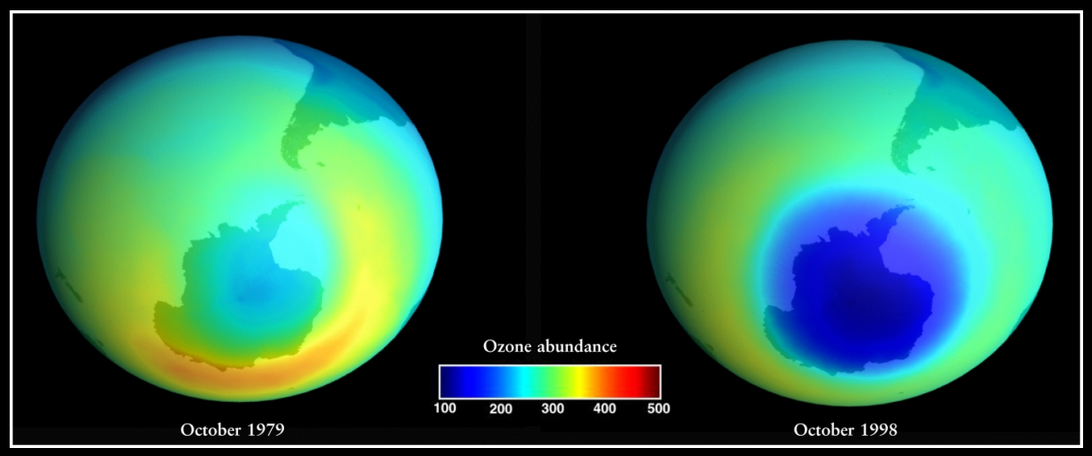


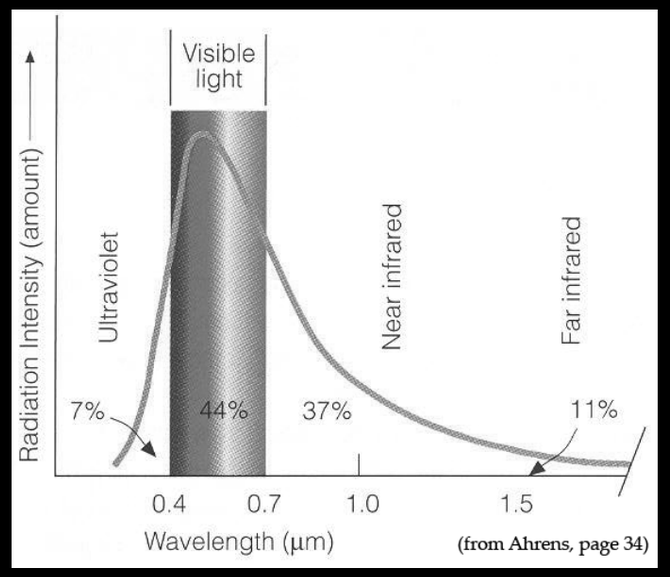
Ozone can be destroyed by synthetic CFC pollutants, such as freon

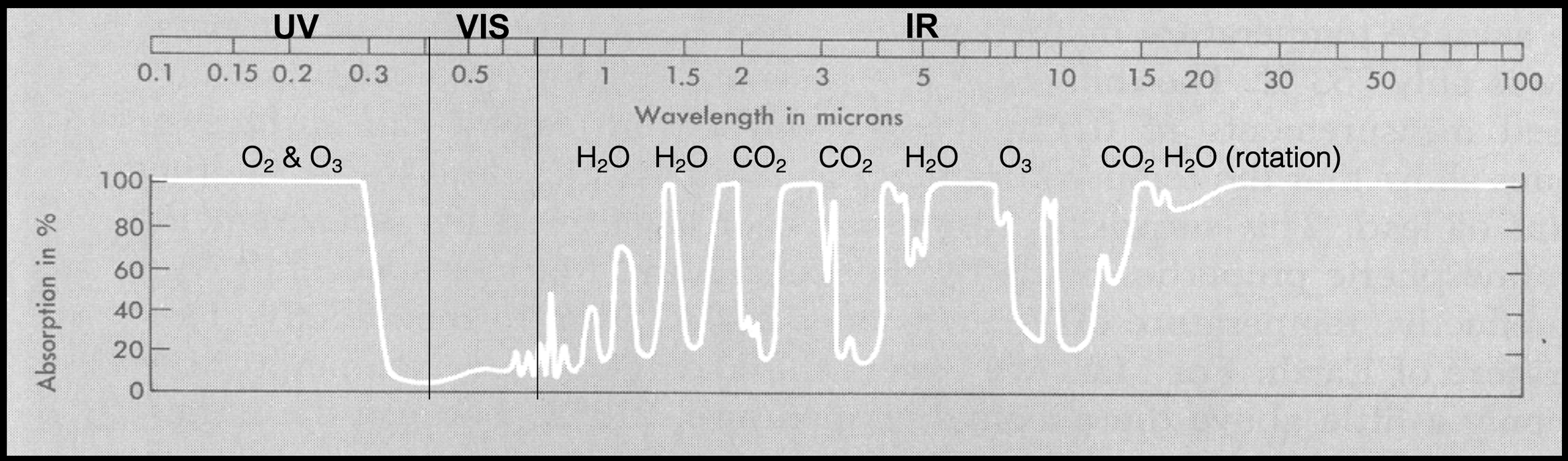


Two distributions of stratospheric ozone over Antarctic in October 1979 and October 1998. The data show that there has been a dramatic decrease in ozone over the Antarctic. But since we receive very little UV from the Sun, ozone depletion is not contributing to global warming – but could contribute to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

Ozone depletion does not lead to Global Warming



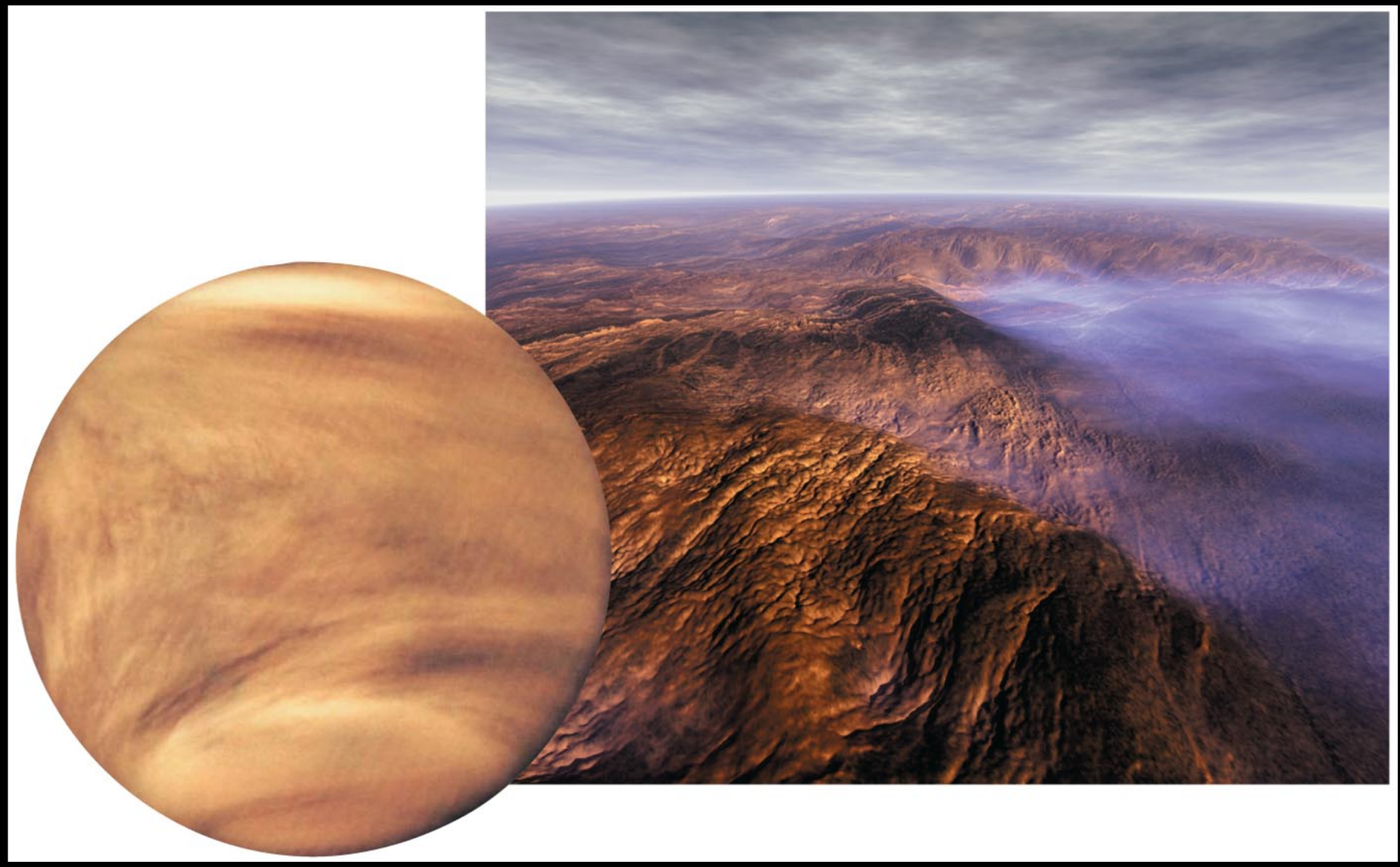




Since we receive very little UV from the Sun, ozone depletion is not contributing to global warming – but could contribute to increased skin cancer where the hole exists

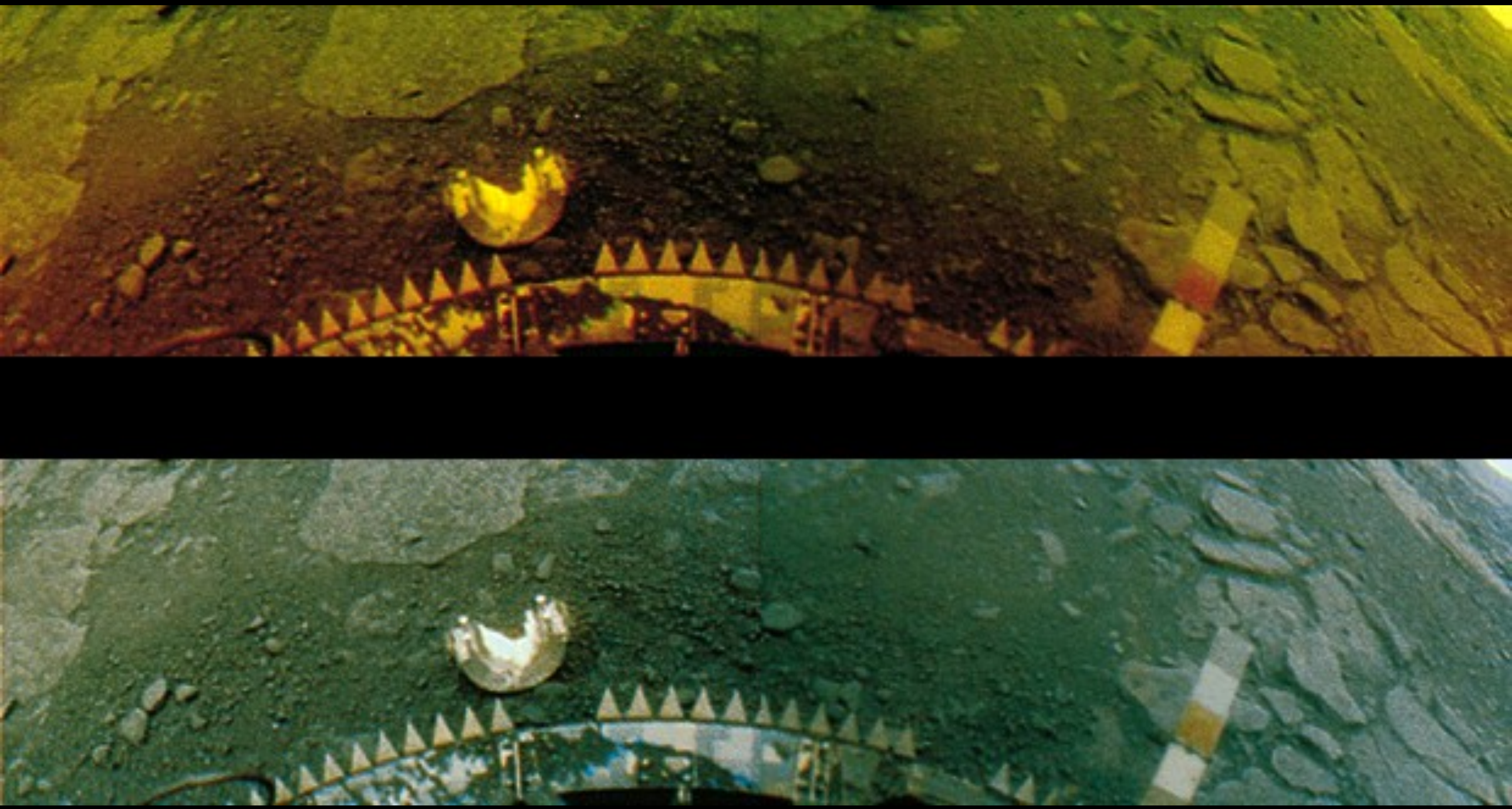
The surface of Venus is completely hidden beneath permanent cloud cover

Venus



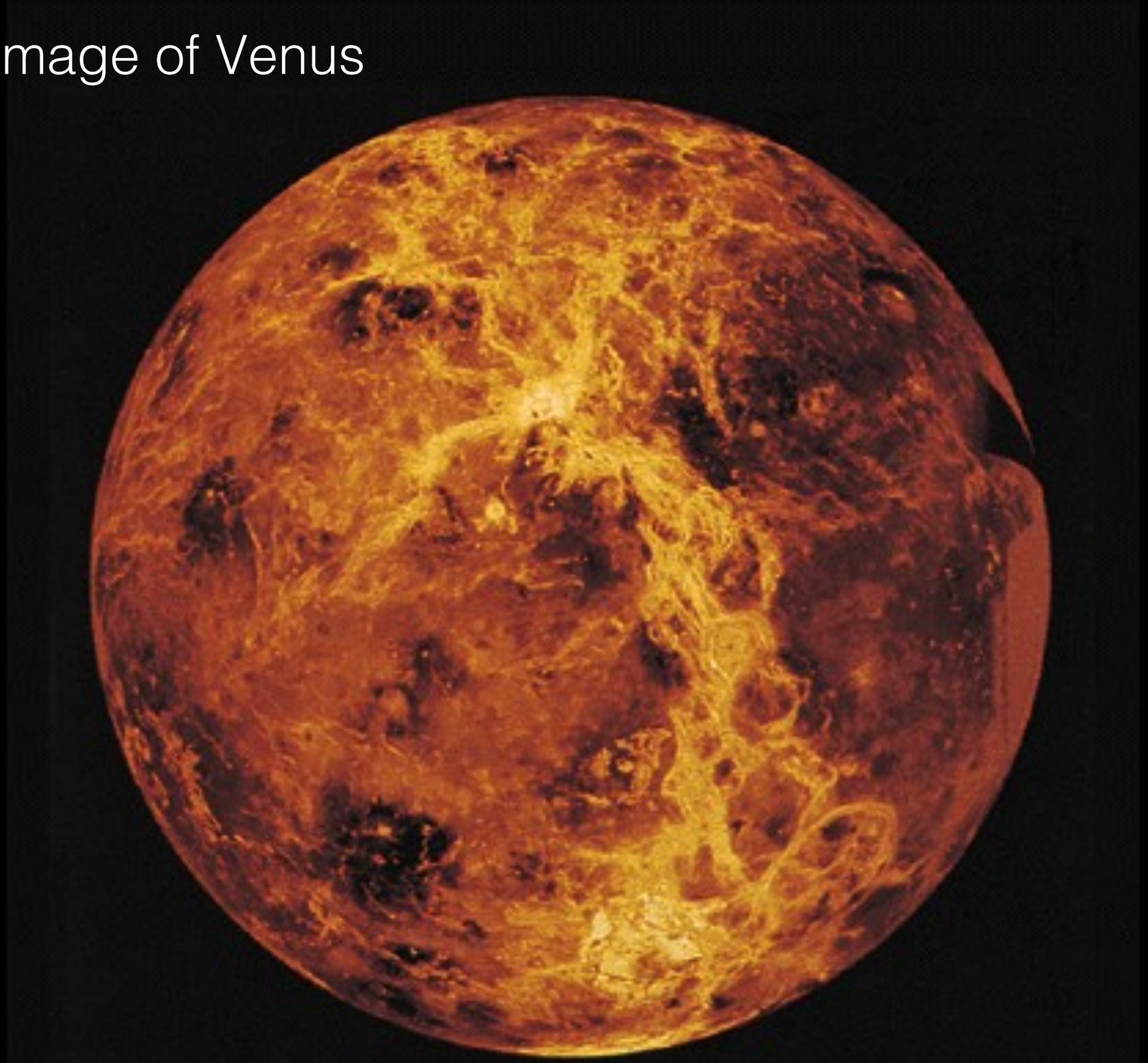
- Nearly identical in size to Earth
- Hellish conditions due to an extreme **greenhouse effect**
- Even hotter than Mercury: 470°C, day and night

The Venusian Surface

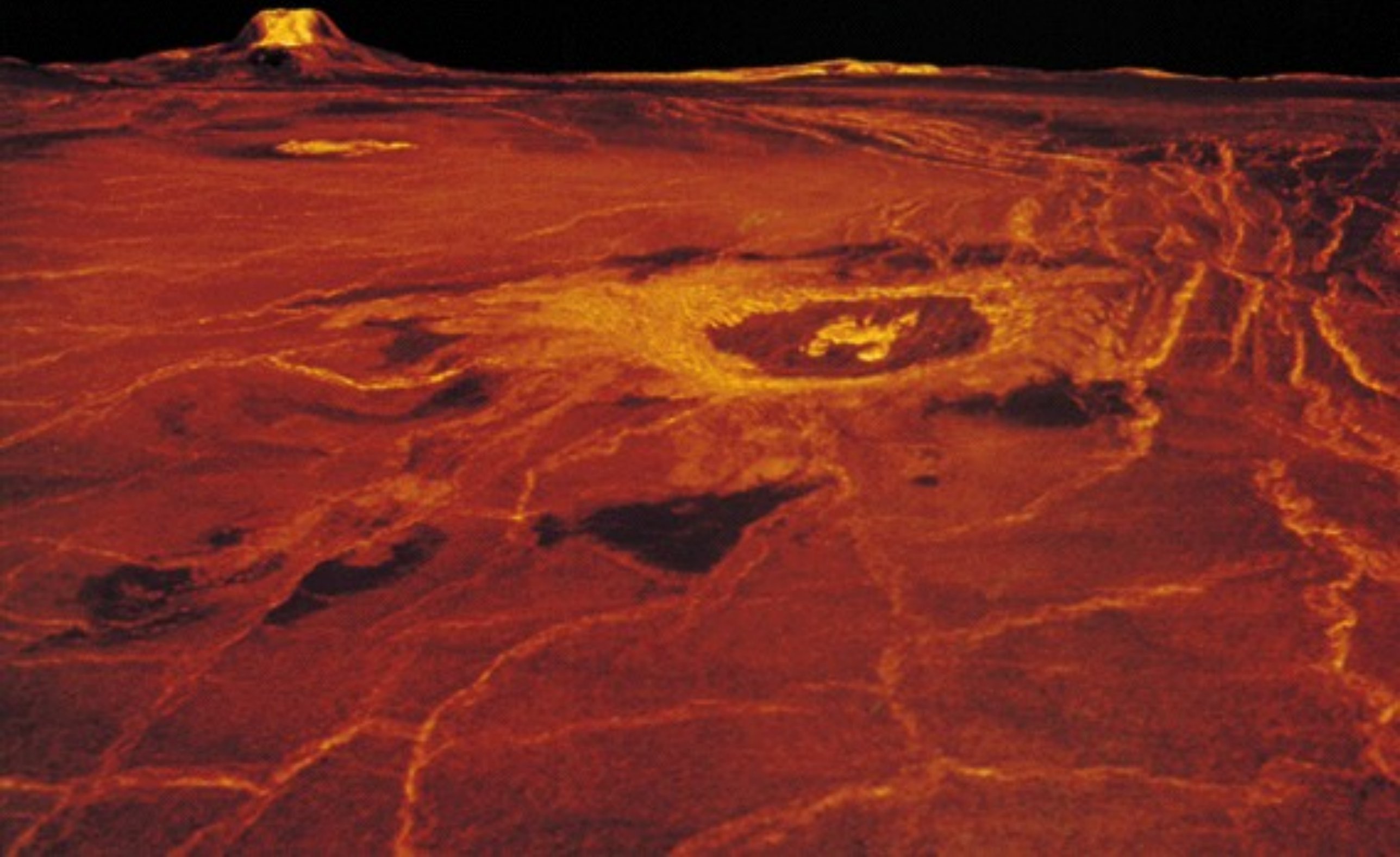


View from the Venera 13 lander on Venus

Radar image of Venus



Venus is covered with gently rolling hills and numerous volcanoes



Top 6 things to know about Venus

1) Nearly identical in size to Earth; surface hidden by clouds

2) Hellish conditions due to an extreme, runaway **greenhouse effect**

3) Even hotter than Mercury: 878F, day and night

4) Visited by Soviet Venera 13 which lasted a few hours and Magellan

5) It ROTATES BACKWARDS compared to other planets

6) Its atmosphere is 96% CO_2 with trace elements of N_2, with some Ar, sulfur dioxide, and small amounts of sulfuric acid, hydrochloric acid, and hydrofluoric acid. It is 90 times MORE dense than Earth's.