Earth's Energy Budget

The Greenhouse Effect

MODULE 3.4

3.4 The Greenhouse Effect

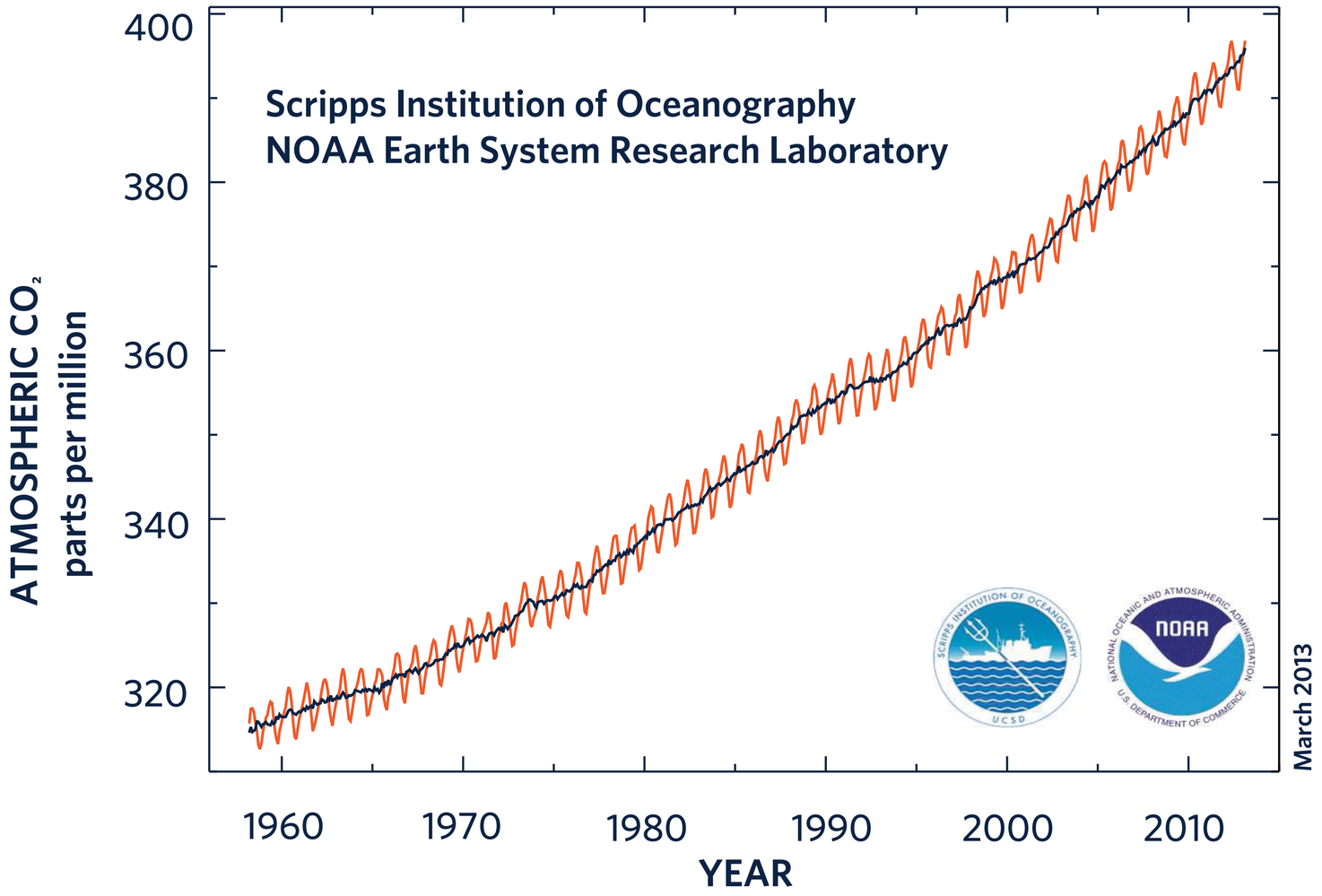
Lesson Goals:

» Contrast the molecular structure of greenhouse gases and non-greenhouse gases

» Describe how greenhouse gases themselves absorb and emit radiation, including what kinds of radiation (shortwave or longwave)

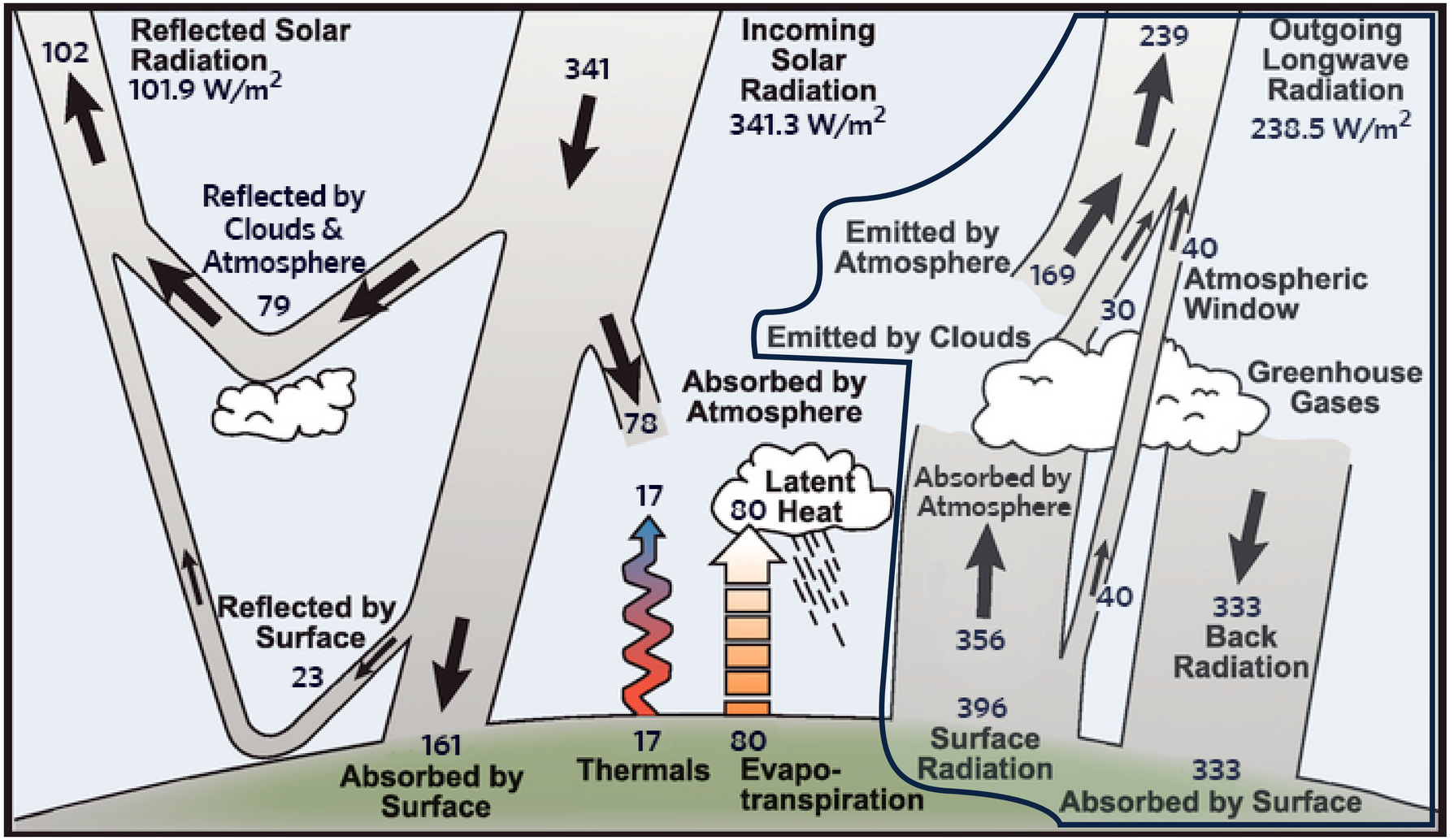
» Explain how the greenhouse effect warms Earth in terms of energy flows

Increasing stock of CO_2



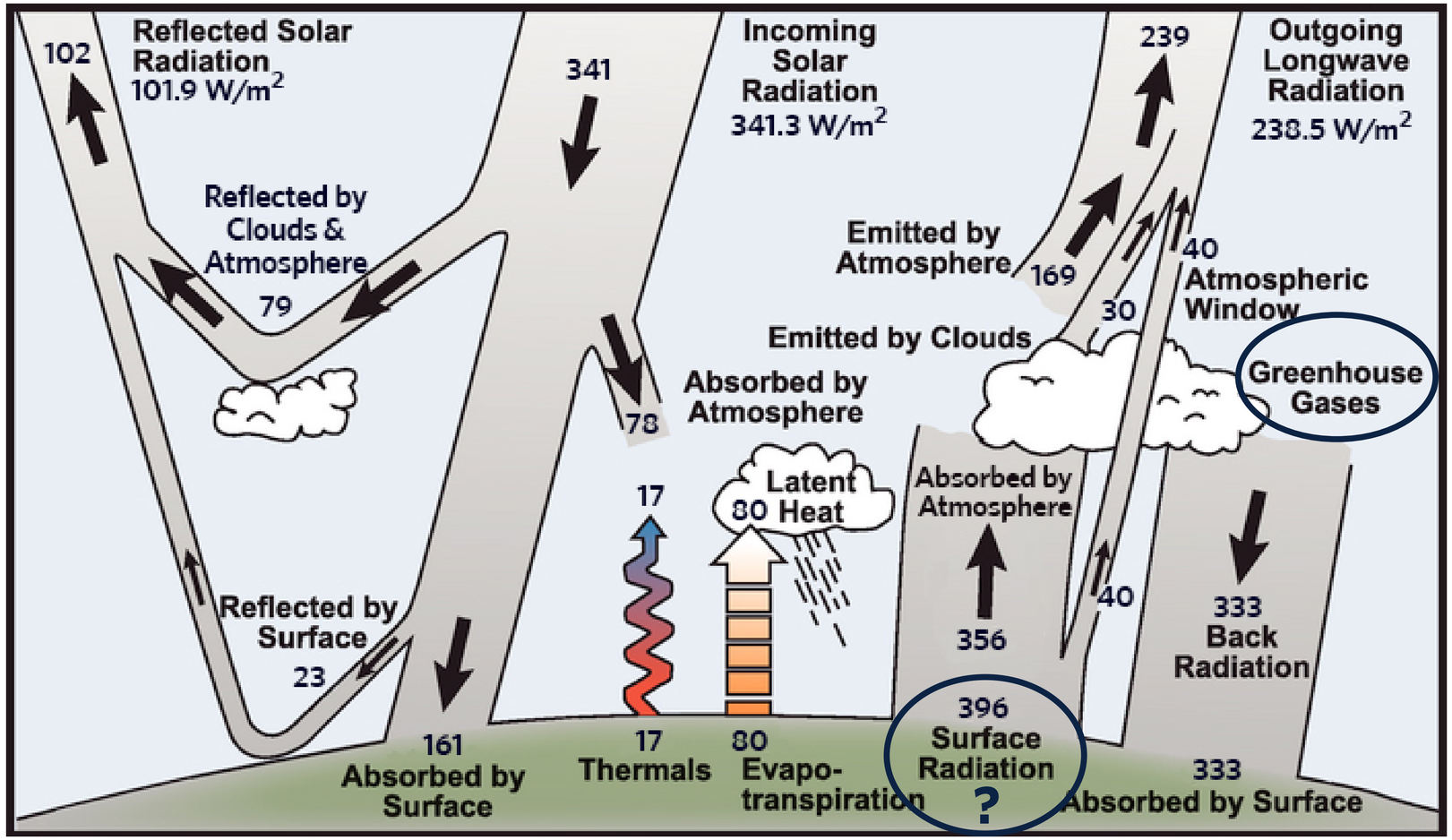
NOAA, EARTH SYSTEM RESEARCH LABORATORY

Earth's Annual Energy Budget



IPCC, 2007, UPDATED WITH TRENBERTH ET AL., 2009

What would happen to Earth's temperature if "Greenhouse gases" increased?



IPCC, 2007, UPDATED WITH TRENBERTH ET AL., 2009

"Surface Radiation" would...

A. Go up

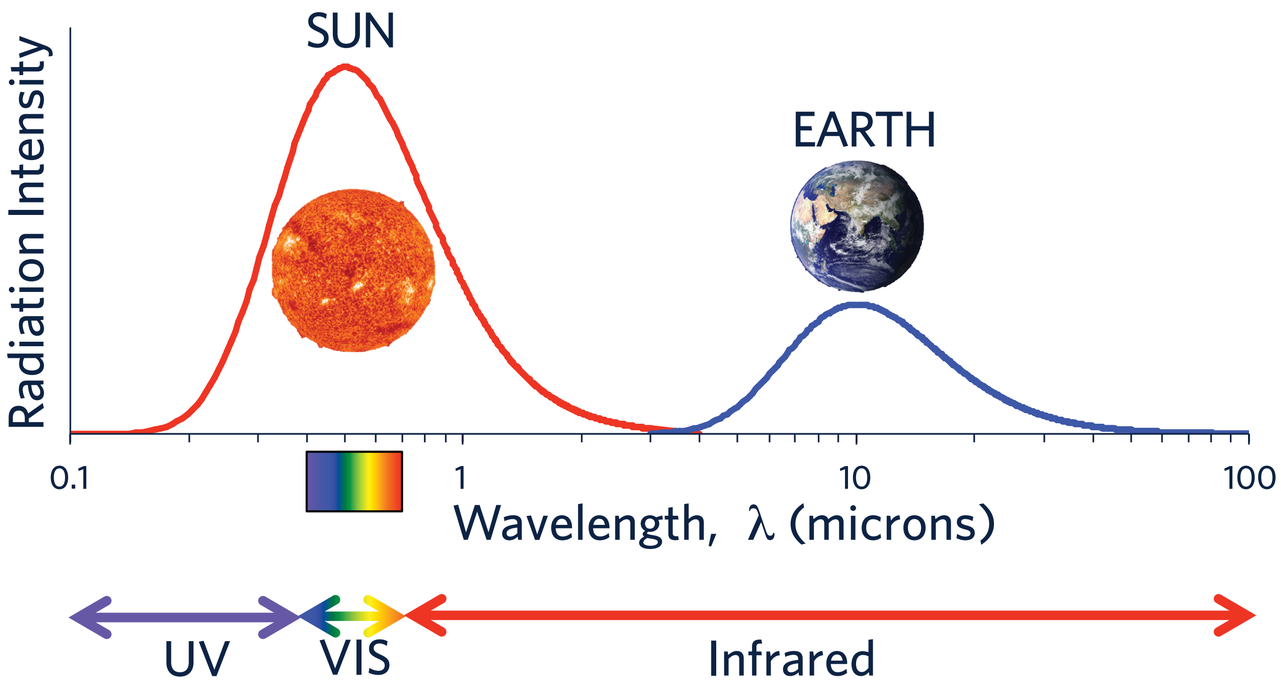
B. Go down

C. Stay the same

D. Go up at first, then back down to the original value

E. Go down at first, then back up to the original value

With what type of energy do greenhouse gases interact?



A. Visible radiation coming directly from the Sun

B. Visible radiation after it reflects off of Earth

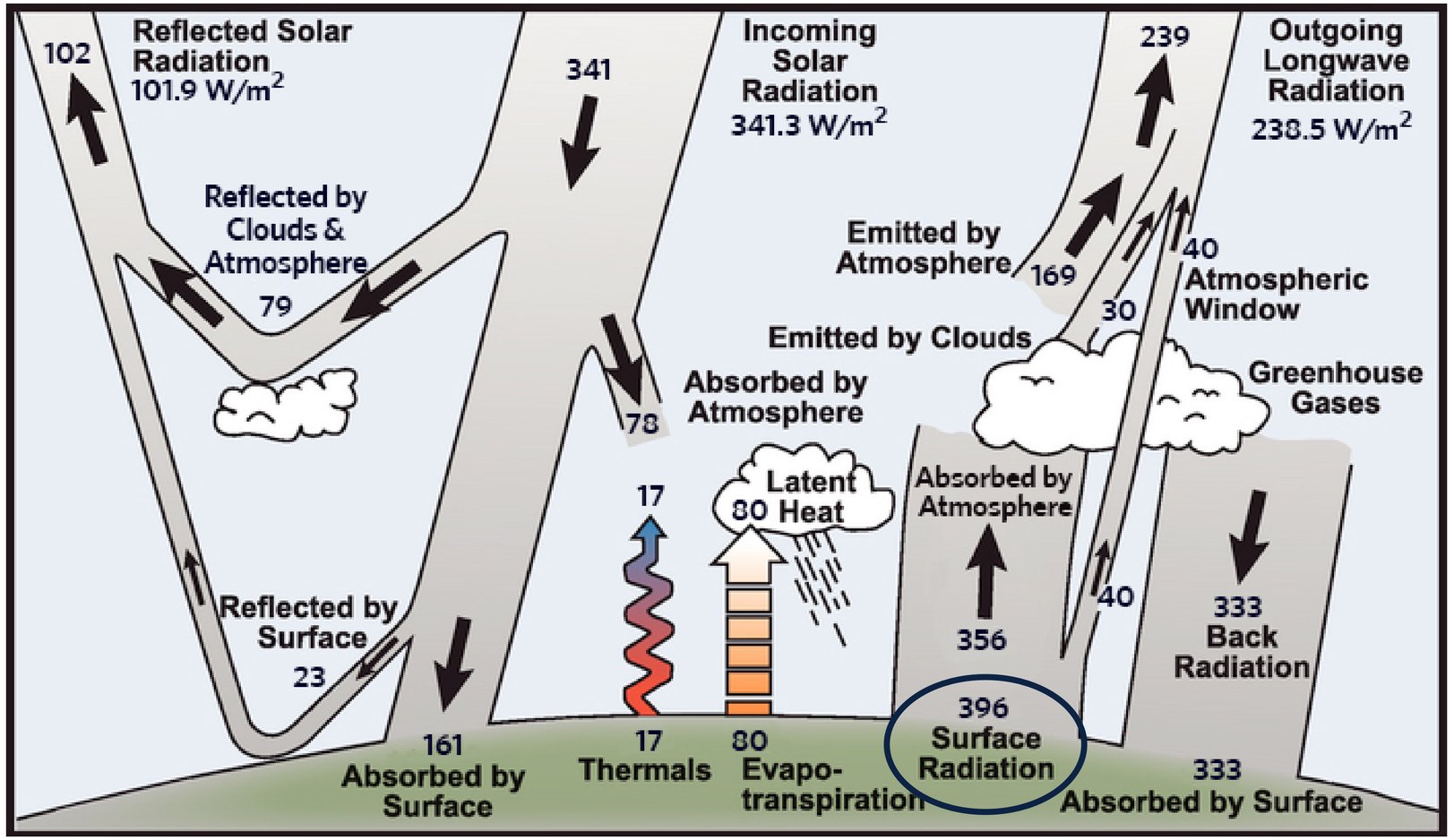
C. UV radiation coming directly from the Sun

D. Infrared radiation coming from Earth's surface

E. Visible radiation coming from Earth's surface

PLOTS BY S HARRIS. IMAGES FROM NASA

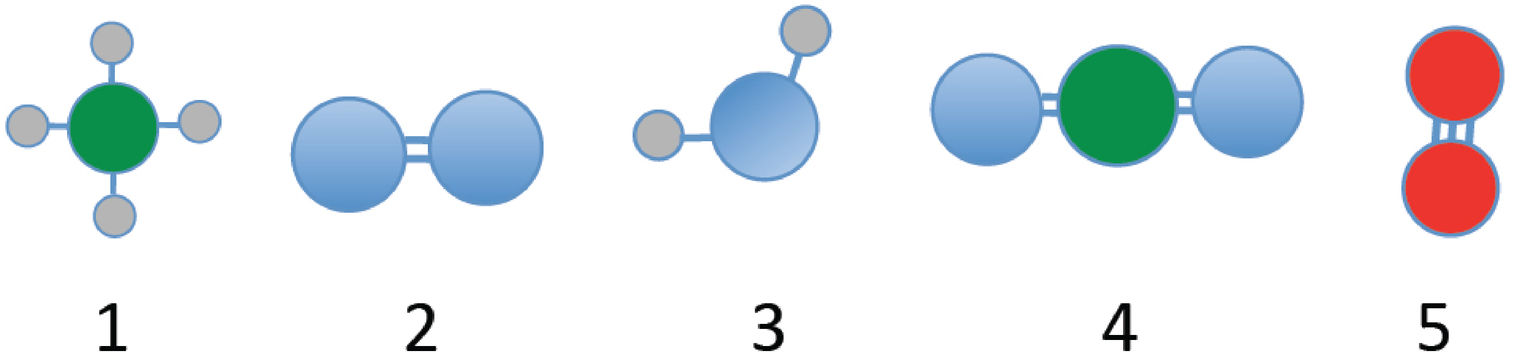
Greenhouse gases absorb longwave, infrared radiation emitted by Earth



IPCC, 2007, UPDATED WITH TRENBERTH ET AL., 2009

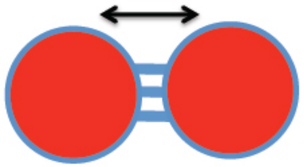
Which of these molecules do you think would be good greenhouse gases?

A. 1 and 3
B. 2, 4, and 5
C. 2 and 5
D. 1, 3 and 4
E. 2, 3 and 4



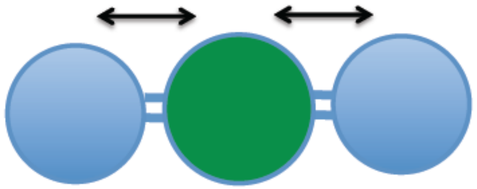
How many atoms?

Two atoms?



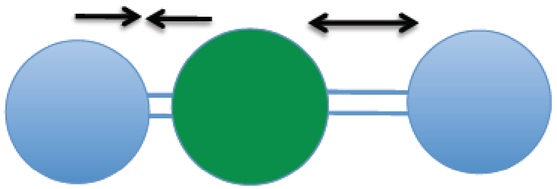
Symmetric Stretch

Three atoms?

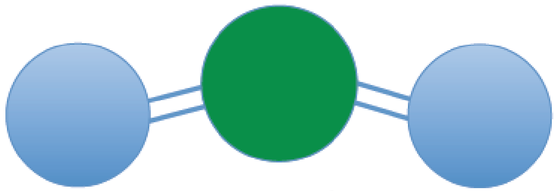


Symmetric Stretch

Interacts with infrared radiation



Asymmetric Stretch

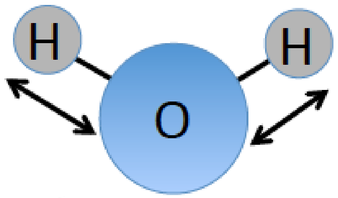


Bend

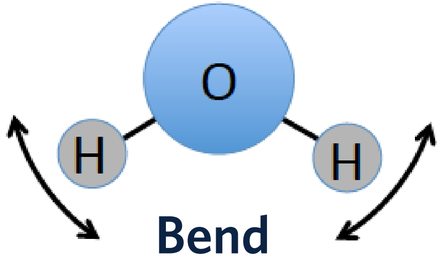
What do greenhouse gases do?

Vibrational modes for two greenhouse gases that interact with IR

H_2O

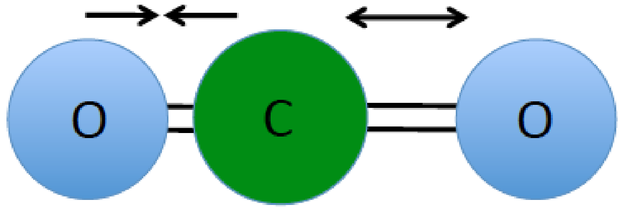


Stretch

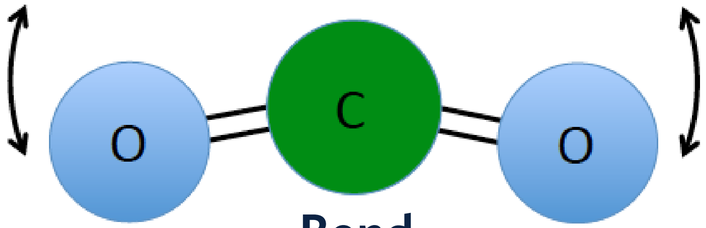


Bend

CO_2



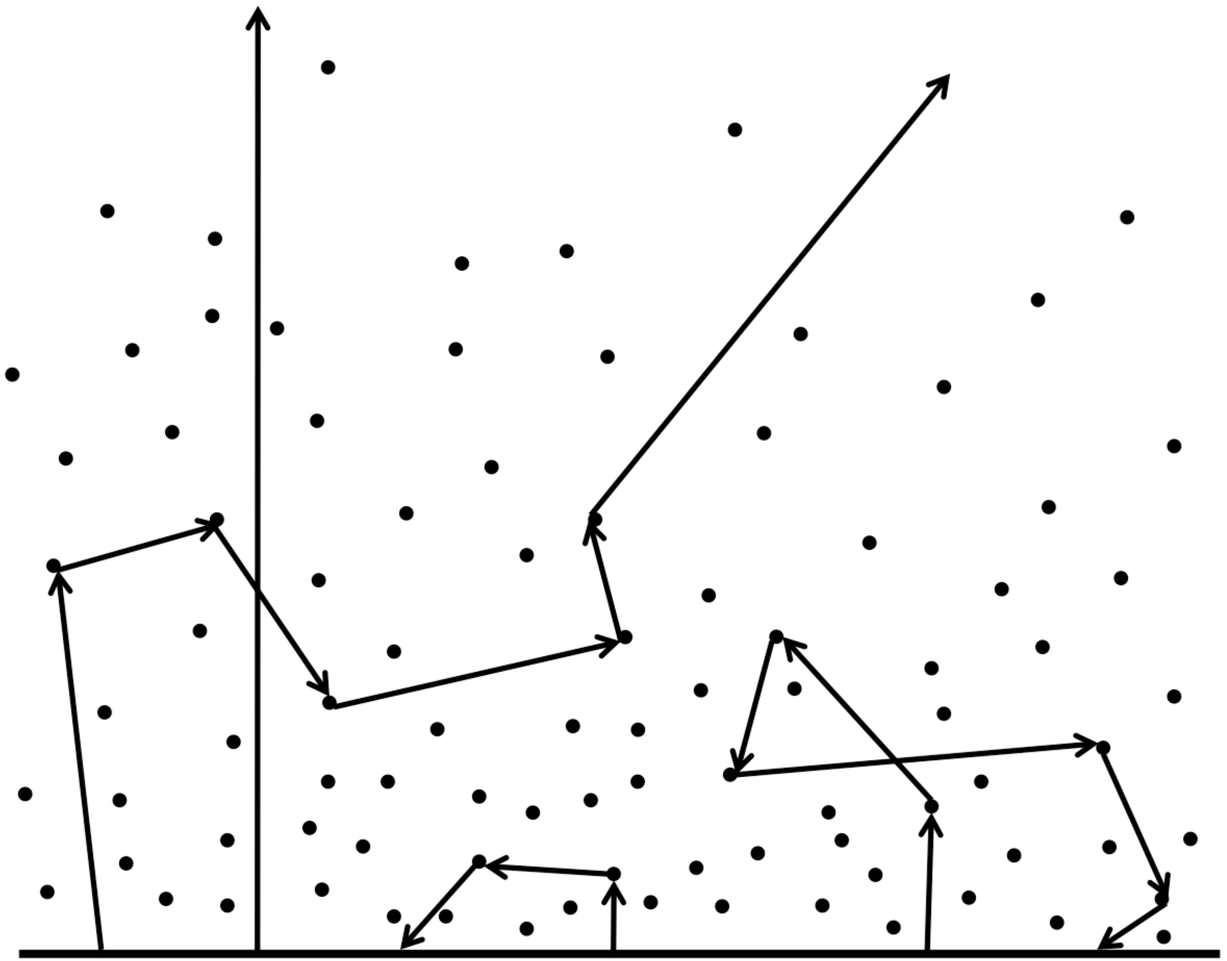
Asymmetric Stretch



Bend

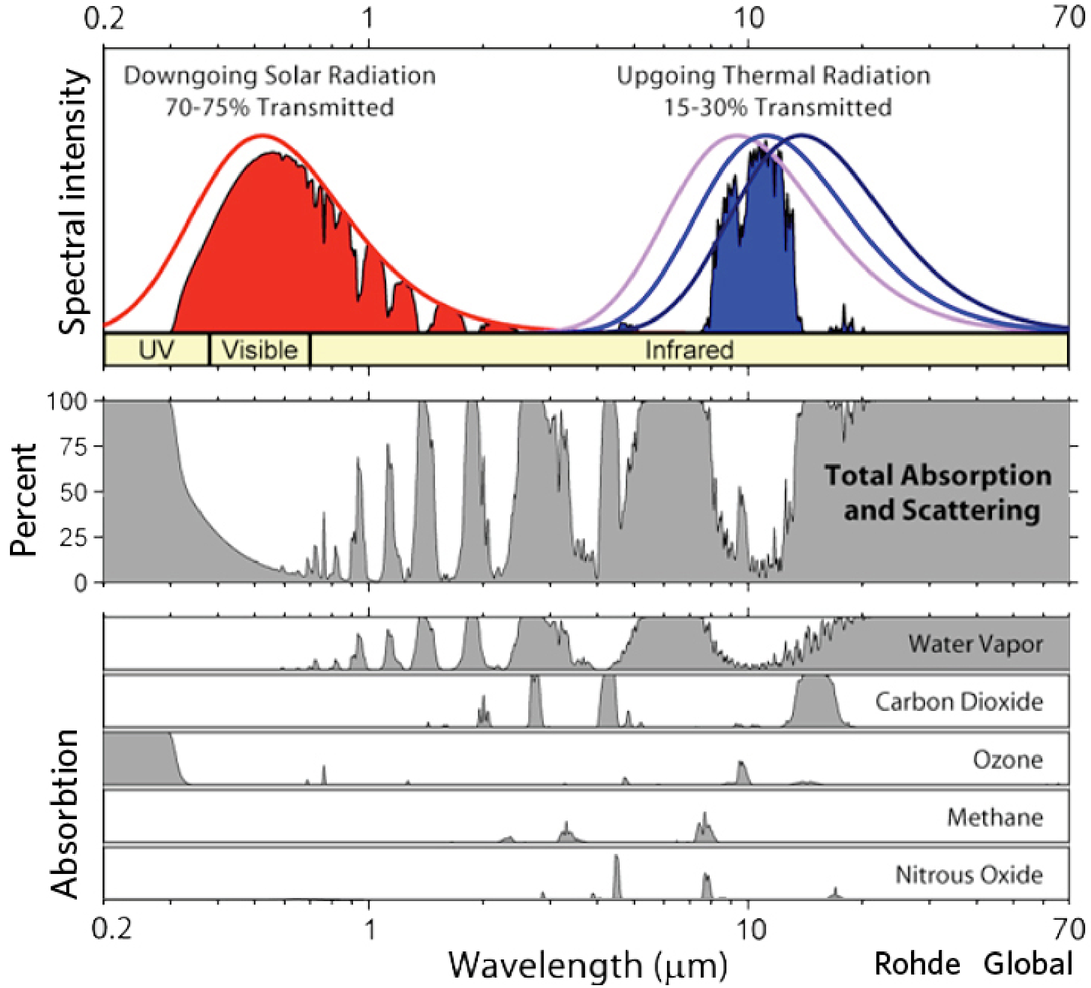
Symmetrical molecules with two atoms of the same element don't do this (e.g. N_2 & O_2)

Space



Earth’s surface

Radiation Transmitted by the Atmosphere



MODIFIED FROM ROHDE, GLOBAL WARMING ART, 2007

Which of these molecules do you think would be THE BEST greenhouse gas?

A. H_2O (water vapor)

B. CO_2 (carbon dioxide)

C. O_3 (ozone)

D. CH_4 (methane)

E. N_2O (nitrous oxide)

Key Points

» Greenhouse gases are those that can absorb and re-emit infrared radiation in the wavelength range of energy emitted by Earth's surface.

» The major constituents in our atmosphere, N_2 and O_2, are NOT greenhouse gases.

» When greenhouse gases emit infrared radiation, they emit it in random directions.

- Some goes back toward Earth's surface and gets re-absorbed
- Some goes toward space
- Some goes to another greenhouse gas molecule which repeats the absorption and re-emission and sends the energy in another random direction.

» Greenhouse gases slow the passage of infrared energy from Earth's surface to space, warming the planet.