Planetary Atmospheres: Earth and the Other Terrestrial Worlds

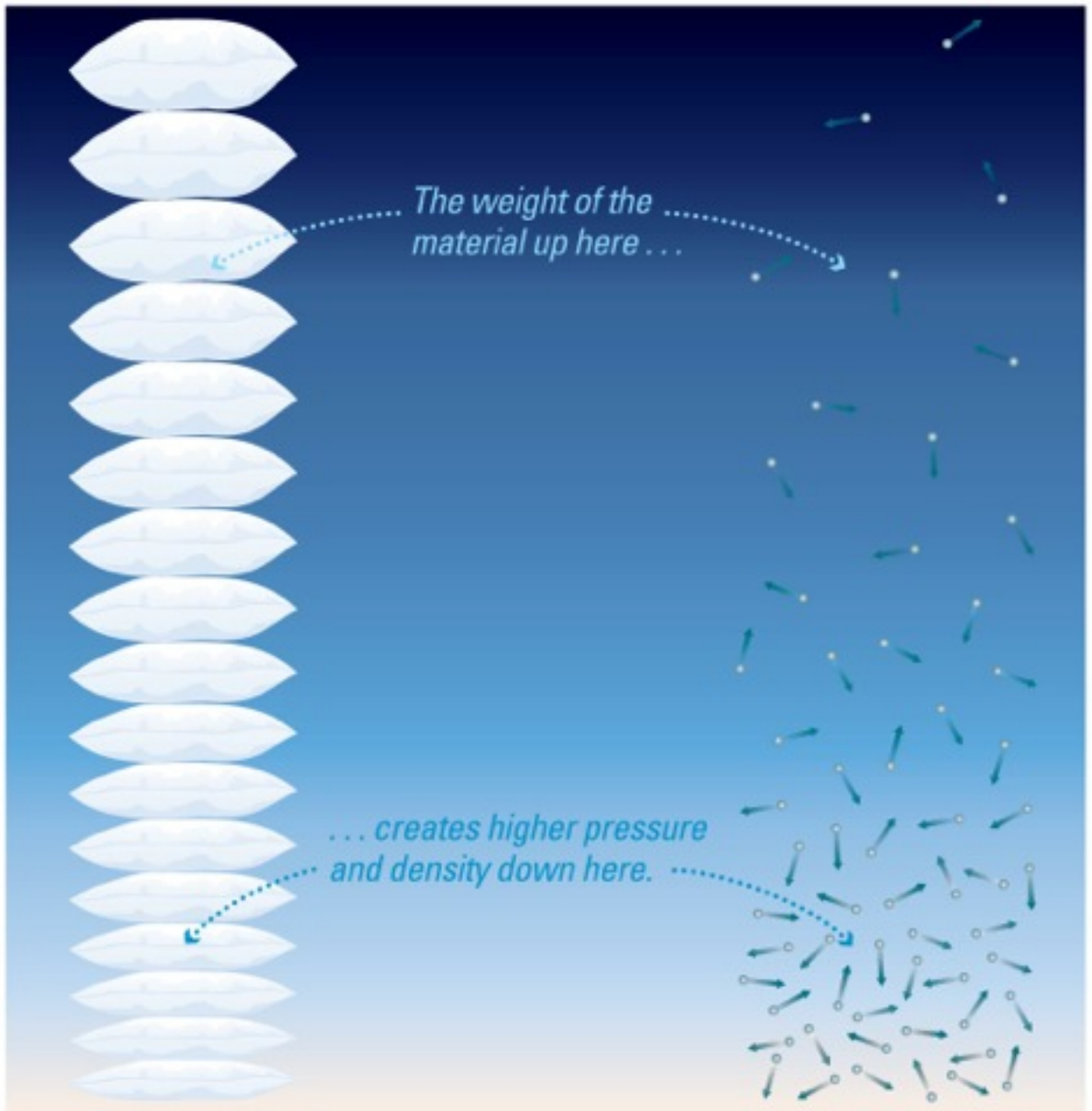
What is an atmosphere?

- An atmosphere is a layer of gas that surrounds a world.

Earth's Atmosphere

- About 10 kilometers thick
- Consists mostly of molecular nitrogen (N_2) and oxygen (O_2).

Where does an atmosphere end?

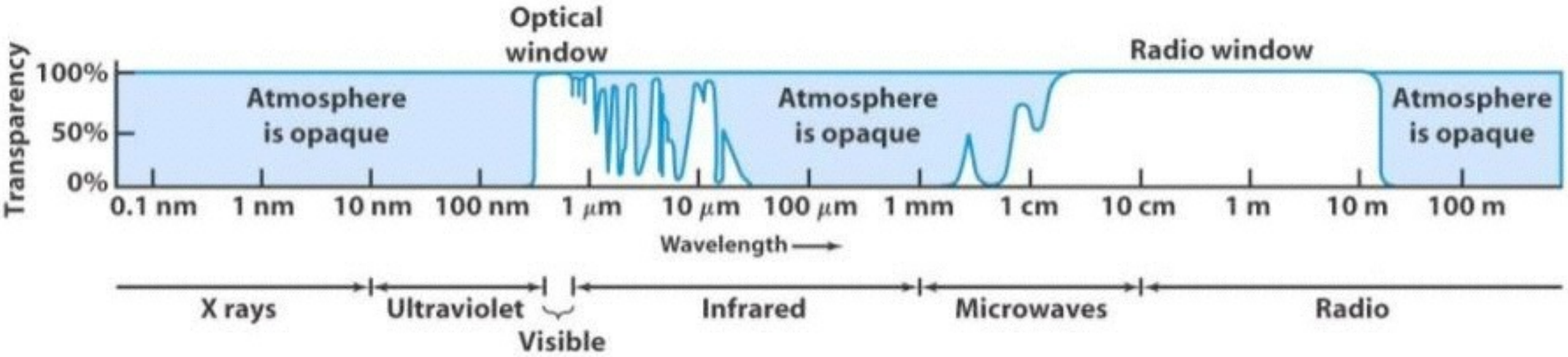


- There is no clear upper boundary.
- Most of Earth's gas is less than 10 kilometers from surface, but a small fraction extends to more than 100 kilometers.
- Altitudes more than 100 kilometers are considered "space."

Effects of Atmospheres

- They create pressure that determines whether liquid water can exist on surface.
- They absorb and scatter light.
- They create wind, weather, and climate.
- They can make planetary surfaces warmer through the greenhouse effect.

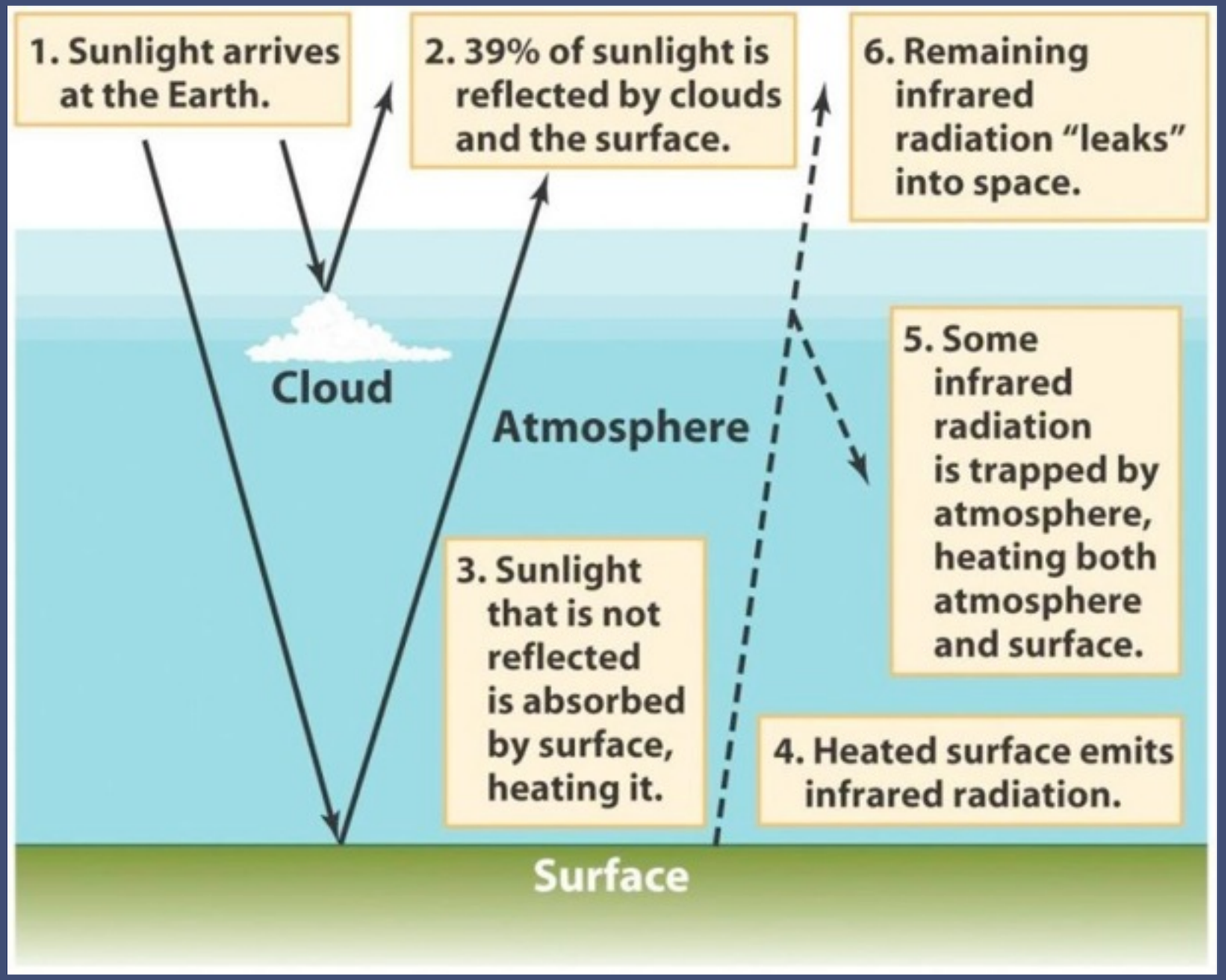
EM Protection of Atmosphere



- Earth's atmosphere is opaque to most harmful radiation from space
  - –X-rays and most UV

Greenhouse Effect

- Certain gases in the Earth's atmosphere act as a thermal blanket, insulating the Earth from the cold of space
- These gases are called greenhouse gases
  - primarily include H_2O (water vapor), CO_2 (carbon dioxide), and CH_4 (methane)



Venus' Atmosphere

- Much denser than Earth's
  - –surface pressure on Venus is 90 times higher than on Earth
  - –equivalent to diving 1 km below the surface of the ocean on Earth

Venus' Atmosphere

- Surface of Venus is covered by a perpetual layer of clouds
  - –cover the entire surface
  - –opaque
    - can't "see" the surface of Venus
    - by same token, couldn't see the Sun or stars from the surface of Venus
  - –have learned about the surface through
    - radar images
    - spacecraft landings

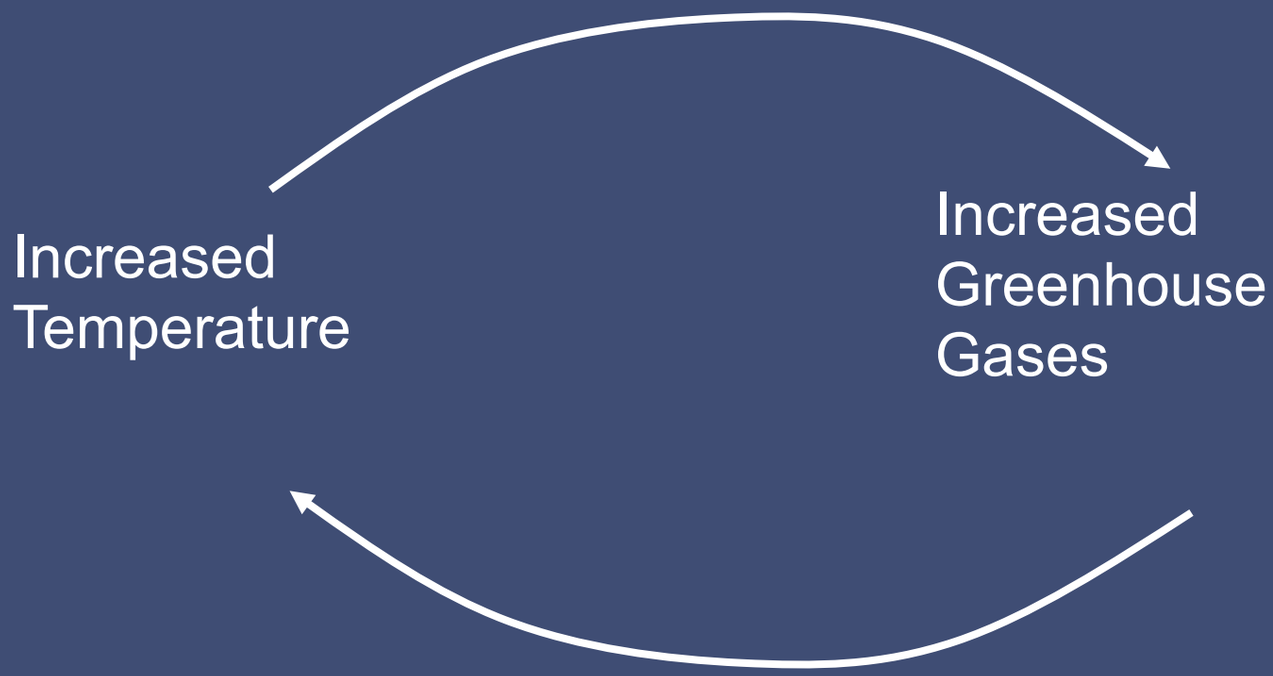
Atmosphere Comparison

- Venus
  - clouds are made of droplets of concentrated sulfuric acid
    - may rain acid
  - CO_2 : 96%
  - N_2 : 3%
- Earth
  - clouds are made of water vapor
    - rains water
  - N_2 : 78%
  - O_2 : 21%

Greenhouse Effect

- High CO_2 content in Venus' atmosphere has led to extreme greenhouse effect
  - –raises temperature of Venus 400° C (720 ° F) over what it would be without a greenhouse gases
  - –this in spite of the fact that the clouds in Venus' atmosphere reflect 59% of sunlight back into space (albedo=0.59)
- Leading theory is that Venus started out much more like Earth, but underwent runaway greenhouse effect

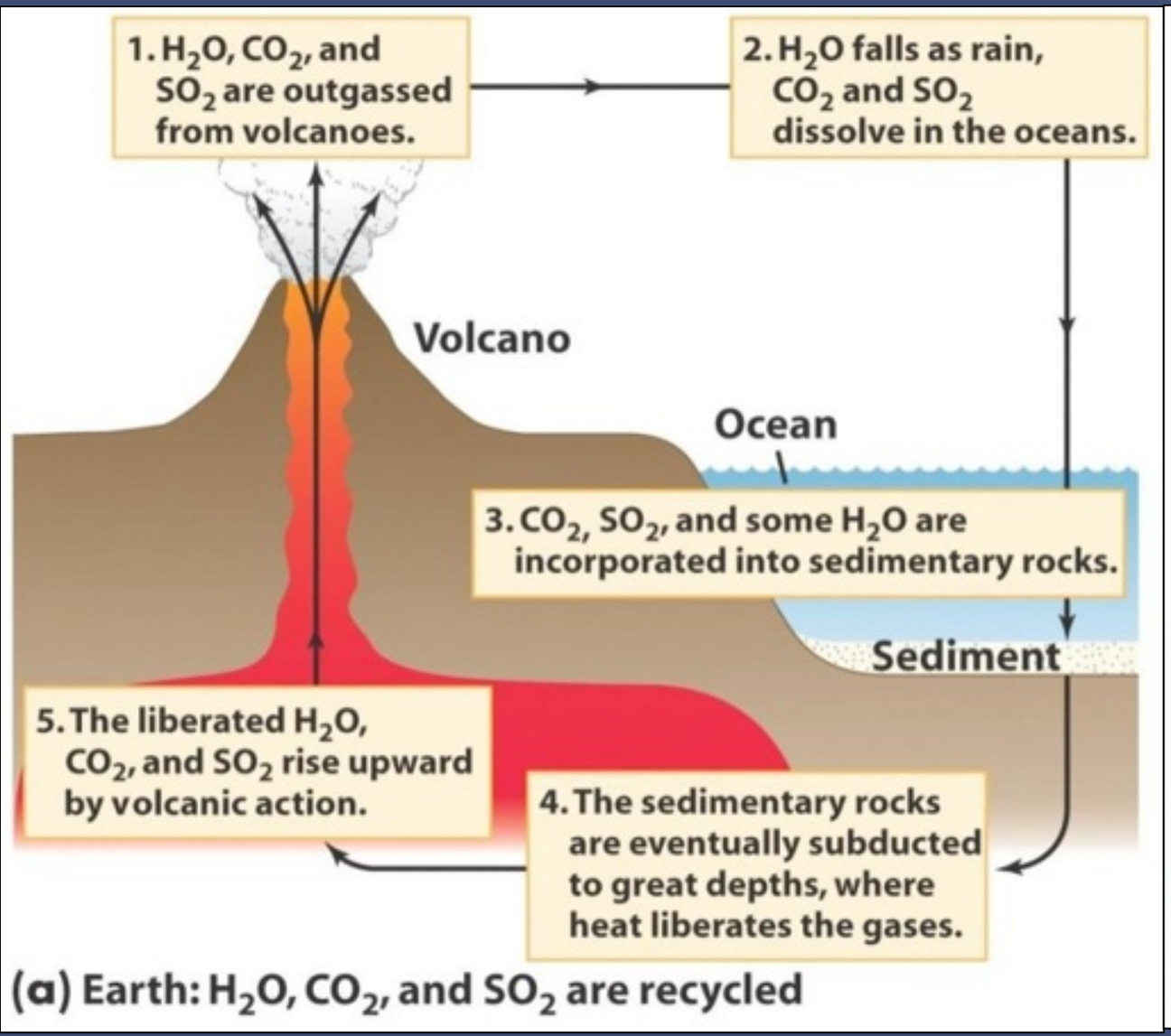
Runaway Greenhouse Effect



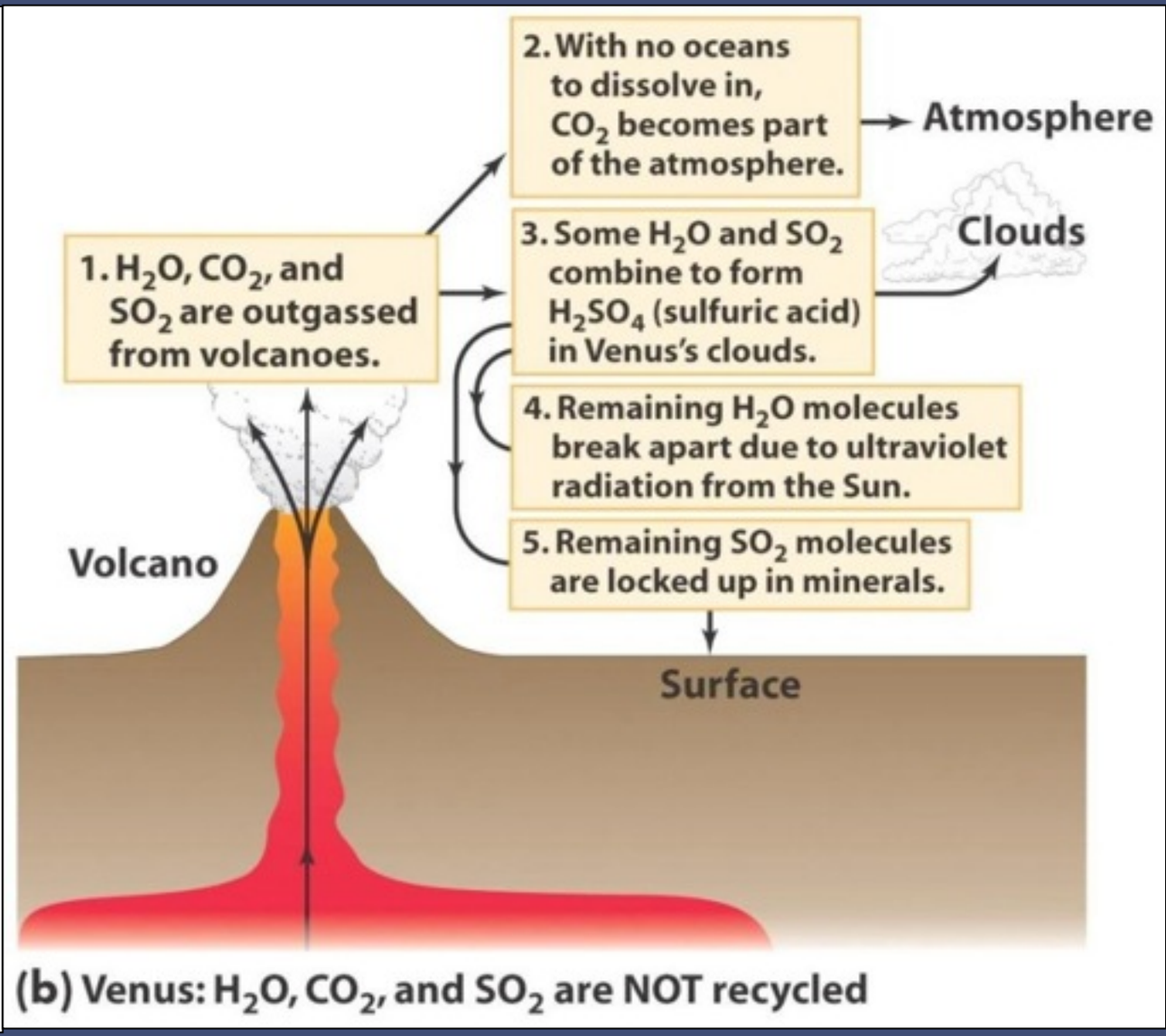
- Greenhouse gases increase because:
  - –water evaporates out of oceans
  - –CO_2 bakes out of rocks

Some scientists fear something similar could happen on Earth

Runaway Greenhouse Effect



(a) Earth: H_2O, CO_2, and SO_2 are recycled



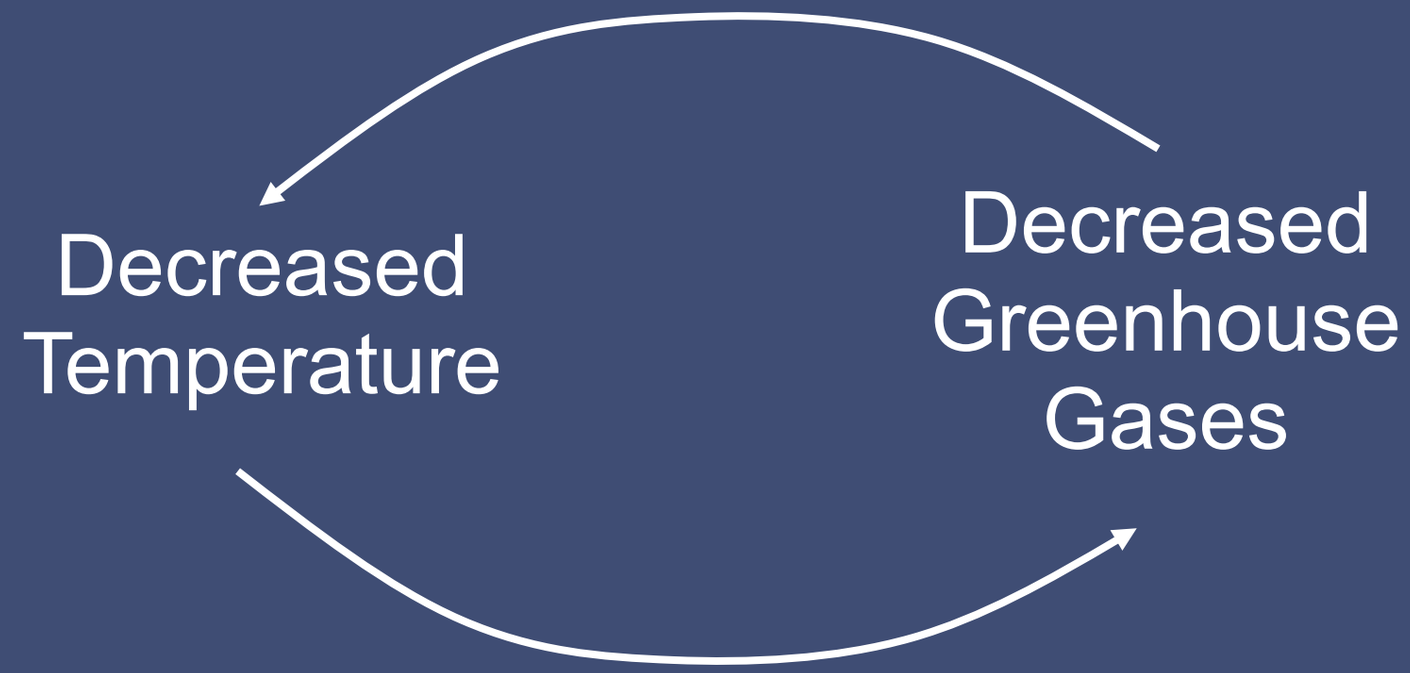
(b) Venus: H_2O, CO_2, and SO_2 are NOT recycled

Atmosphere Comparison

- Earth
  - Moderate temperature
  - Moderate pressure (1 atm)
  - N_2 : 78%
  - O_2 : 21%
  - H_2O: 1%
- Venus
  - Runaway greenhouse
  - Very high pressure (90 atm)
  - CO_2 : 96%
  - N_2 : 3.5%
- Mars
  - Runaway icehouse
  - Low pressure (0.01 atm)
  - CO_2 : 95%
  - N_2 : 3%

Even though Mars' atmosphere is still mostly CO_2, there isn't enough of it to raise the temperature significantly

Runaway Icehouse Effect



- Greenhouse gases decrease because:
  - –rain washed CO_2 out of atmosphere
  - –CO_2 locked into carbonate rocks
  - –little geologic activity on Mars meant CO_2 remained trapped

Runaway Icehouse Effect