

Principles of the Global Climate System II



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Energy Transfers in 3 Ways

- **Conduction**

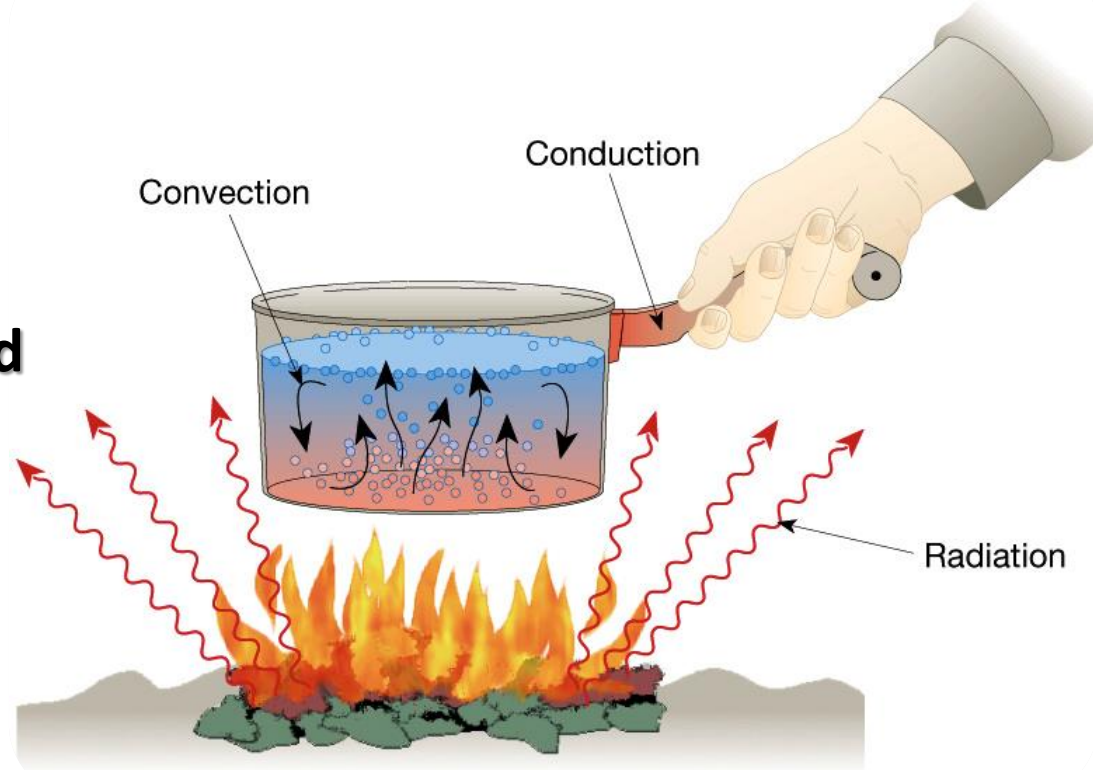
- Molecule-to-molecule transfer

- **Convection**

- Heat energy transferred by movement

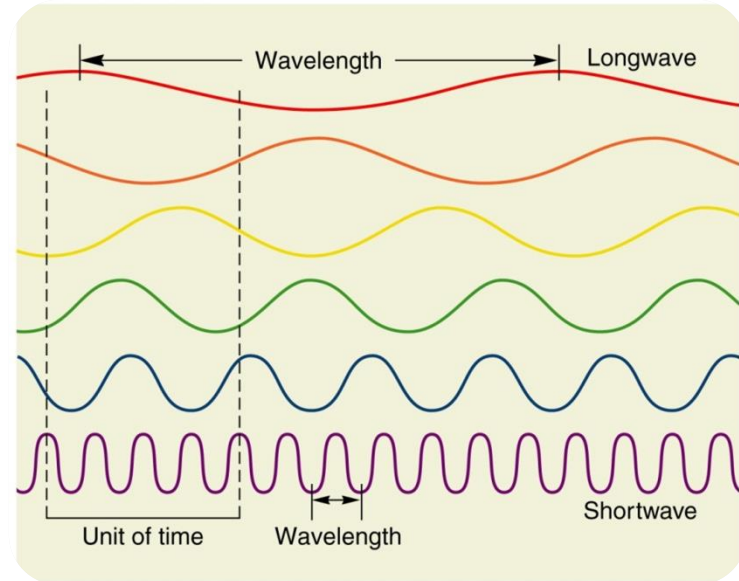
- **Radiation**

- The transfer of heat by the movement of electromagnetic waves
- Does not require a medium



Electromagnetic (EM) Radiation

All objects emit electromagnetic radiation



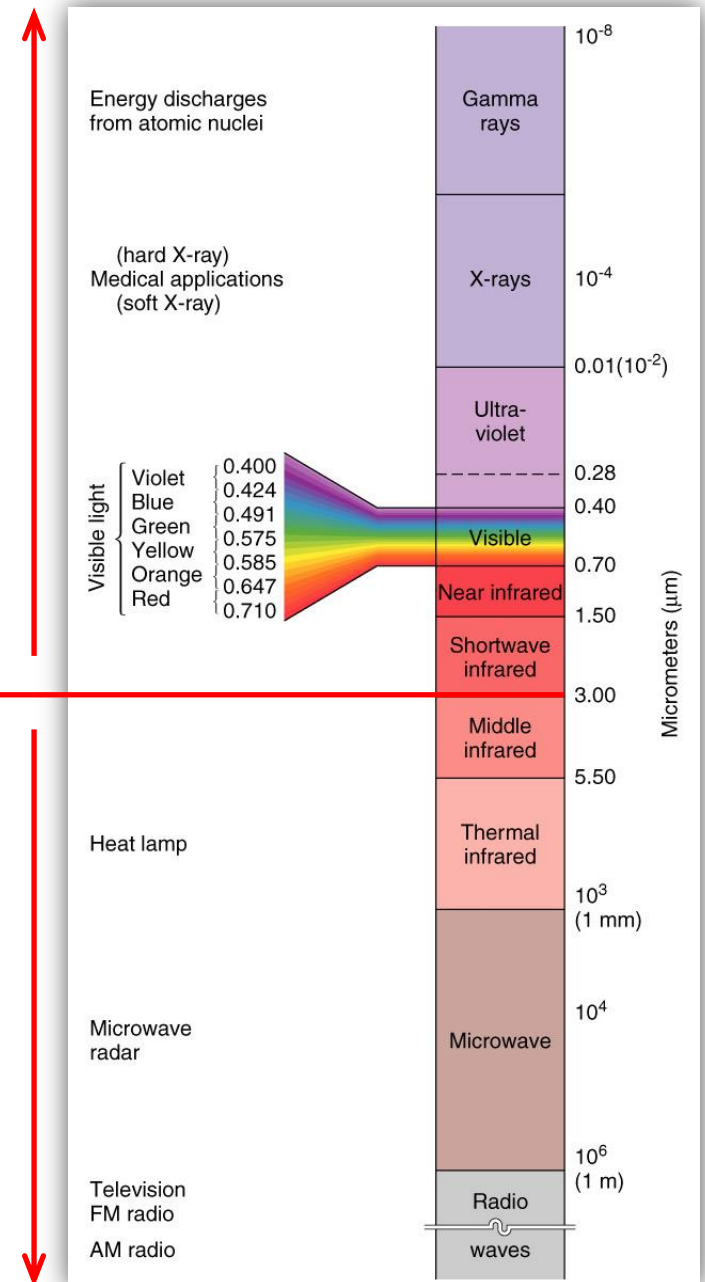
EM Spectrum

- **Shortwave Radiation**

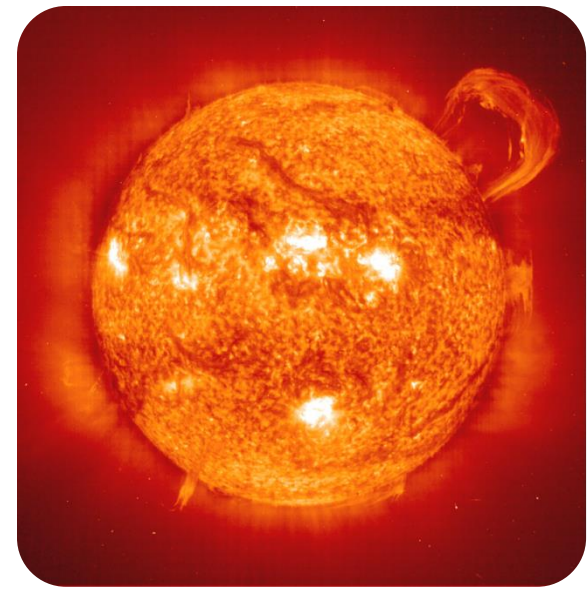
- Shorter than $3 \mu\text{m}$
- Visible, UV, x-rays, etc.
- Emitted from the Sun

- **Longwave Radiation**

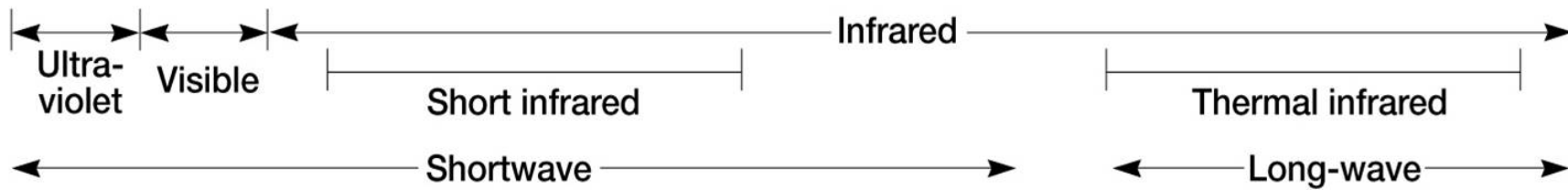
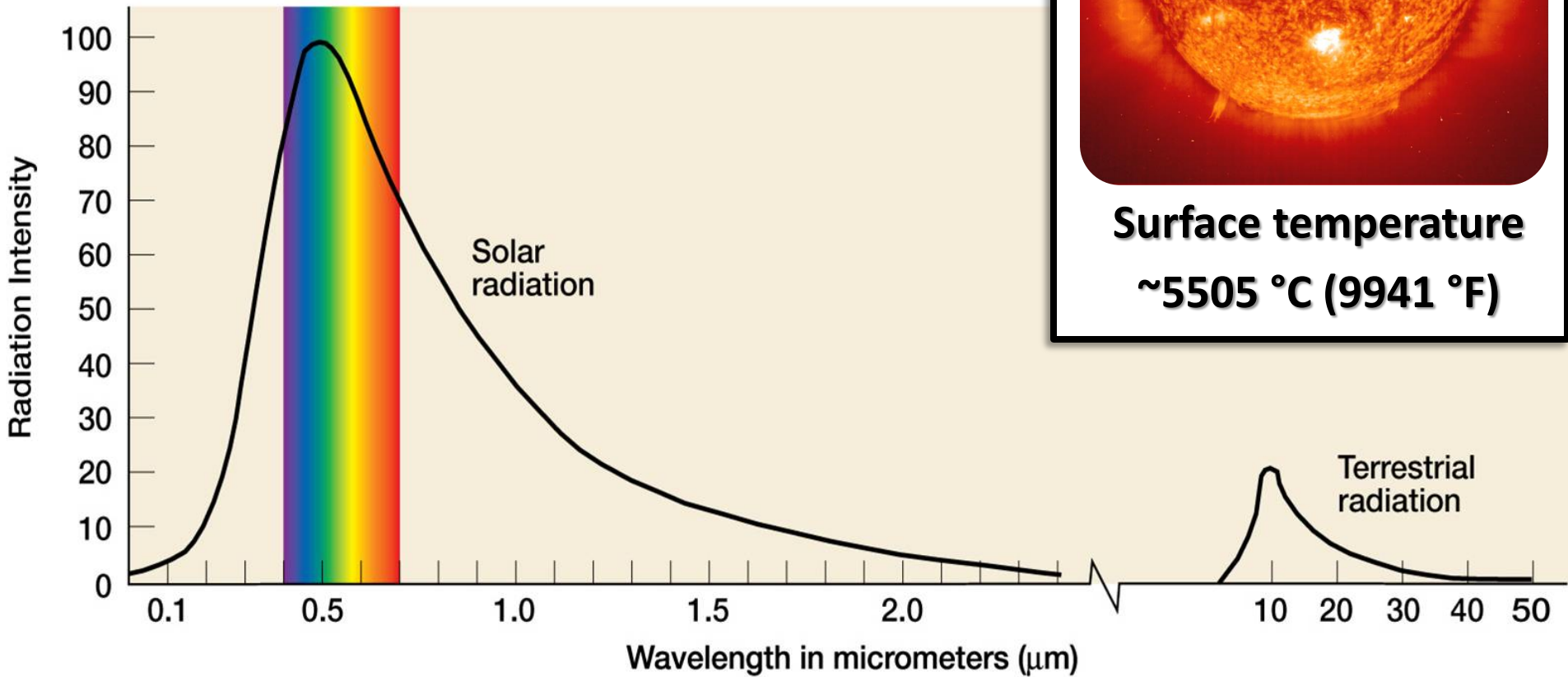
- Longer than $3 \mu\text{m}$
- Thermal, microwave, radar, etc.
- Emitted from Earth



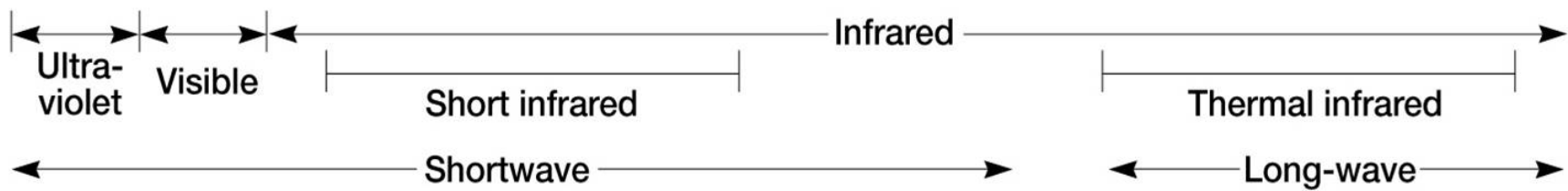
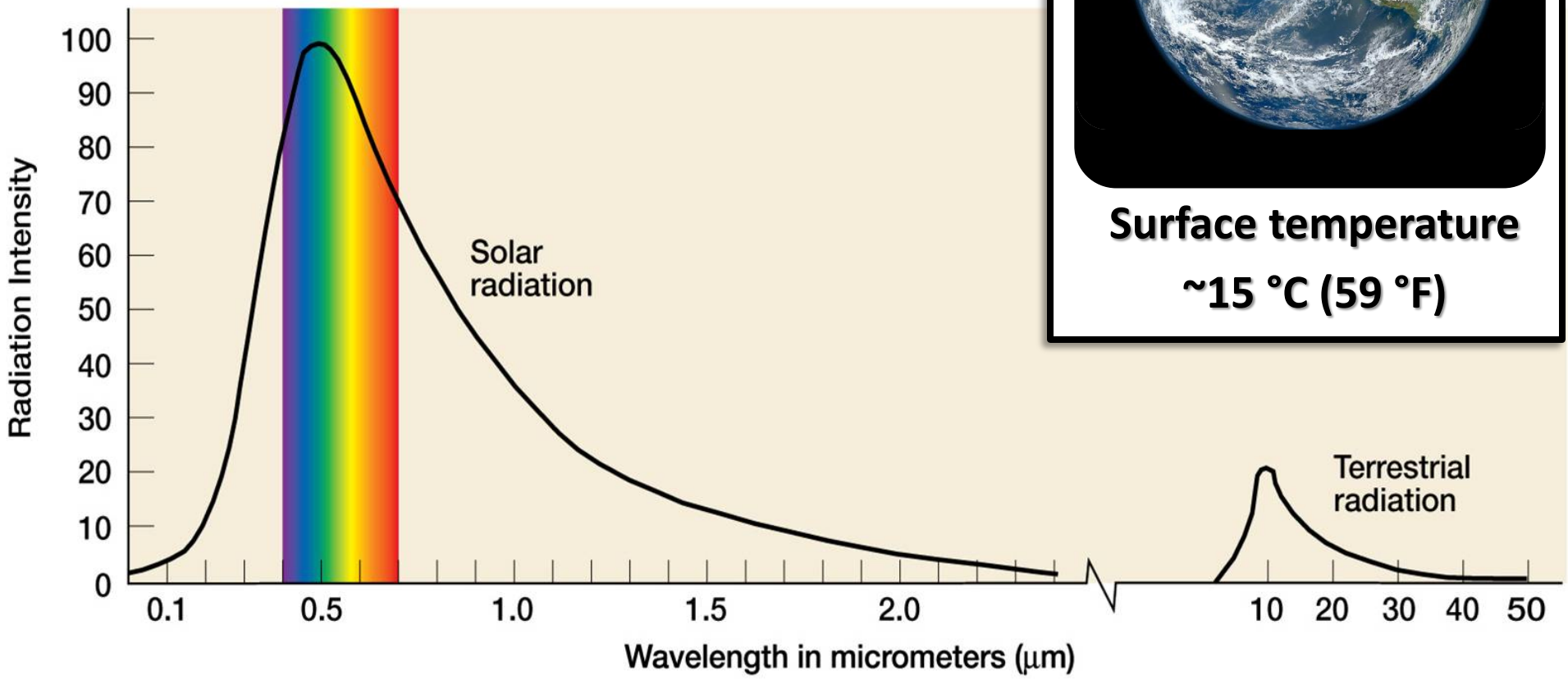
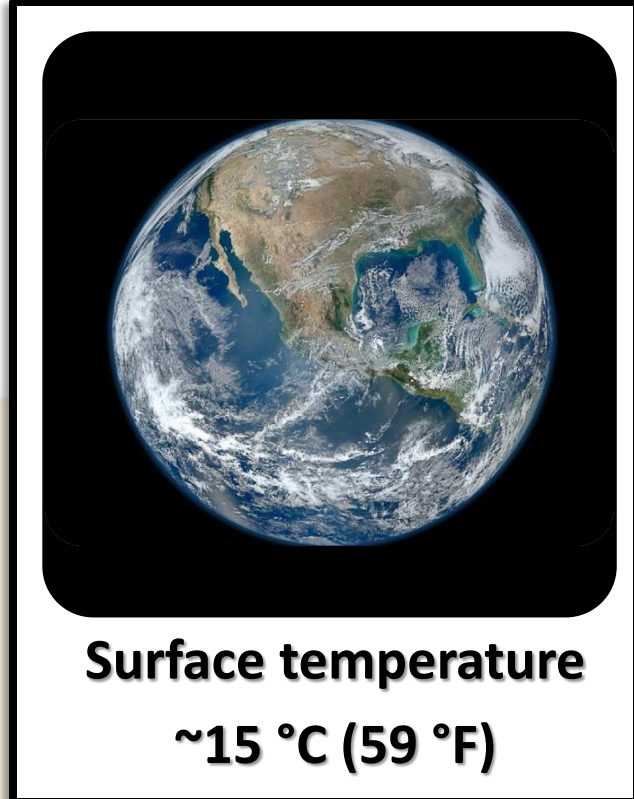
The Sun



**Surface temperature
~5505 °C (9941 °F)**



The Earth



Albedo

Albedo values
(% reflected)

Moon
6%–8%

Water bodies
10%–60%
(varies with Sun altitude)

Earth's albedo
(average) 31%

Fresh snow
80%–95%

Forests
10%–20%

Crops, grasslands
10%–25%

Grass
25–30%

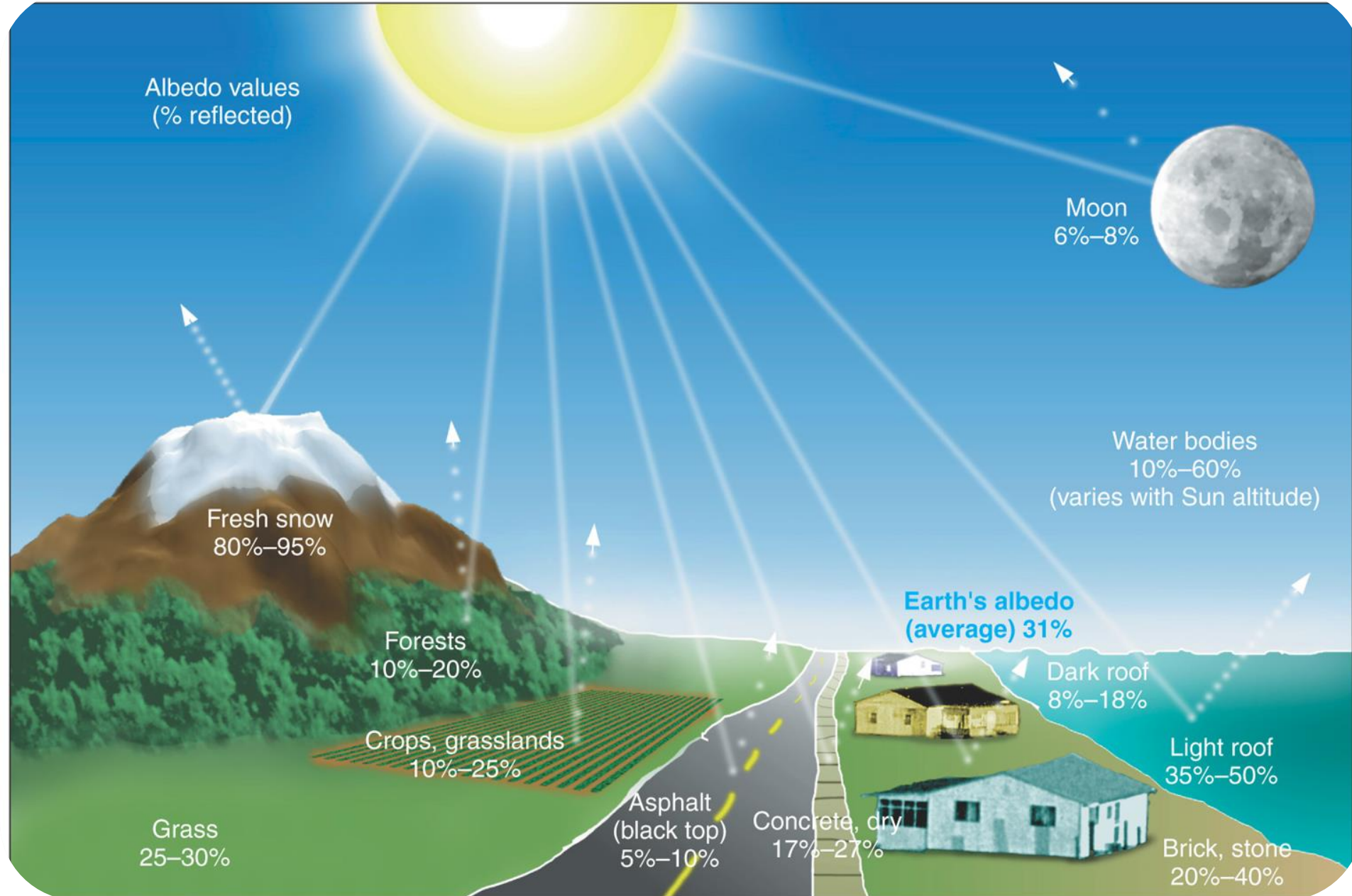
Asphalt
(black top)
5%–10%

Concrete, dry
17%–27%

Dark roof
8%–18%

Light roof
35%–50%

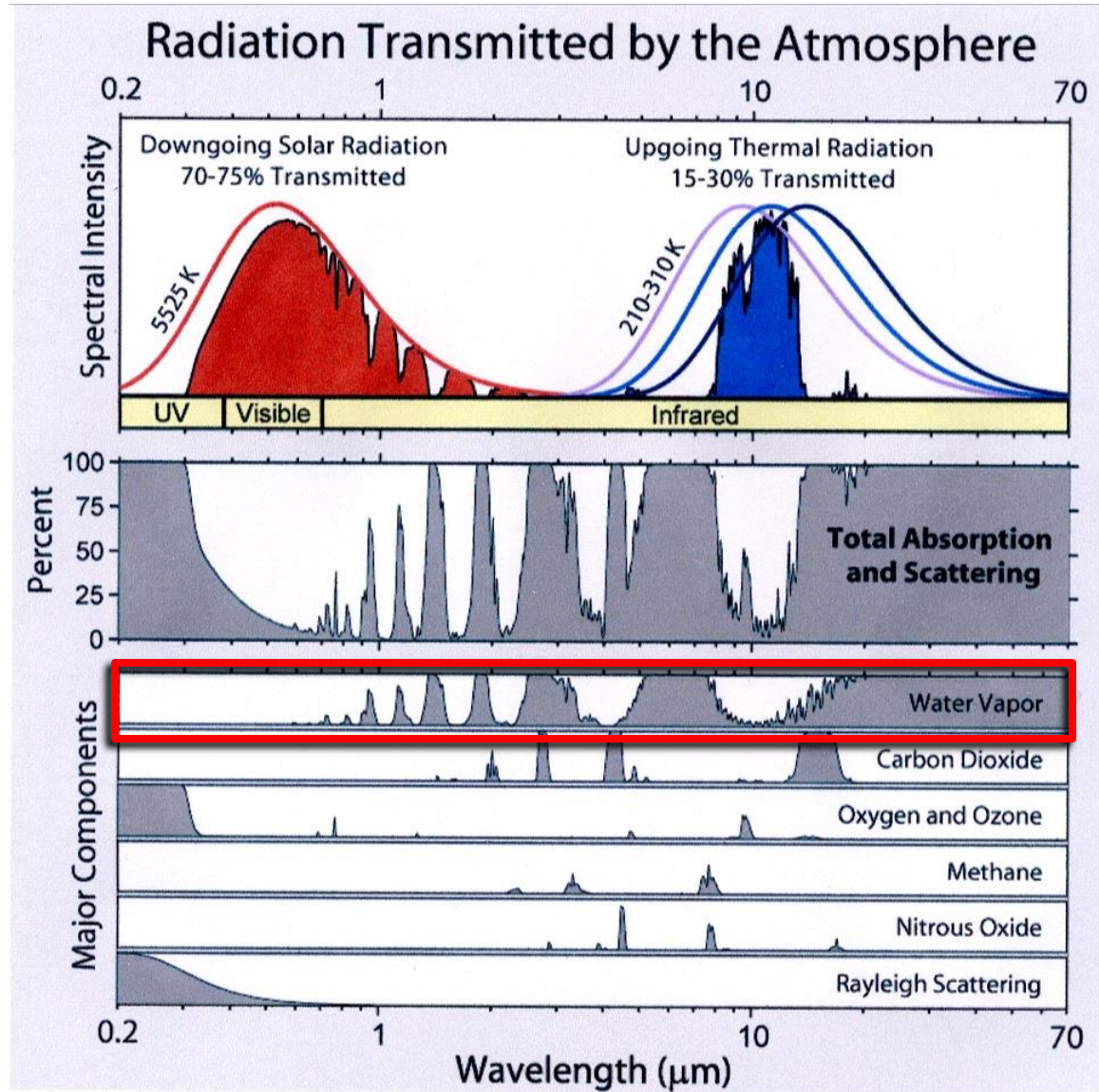
Brick, stone
20%–40%



Greenhouse Gases

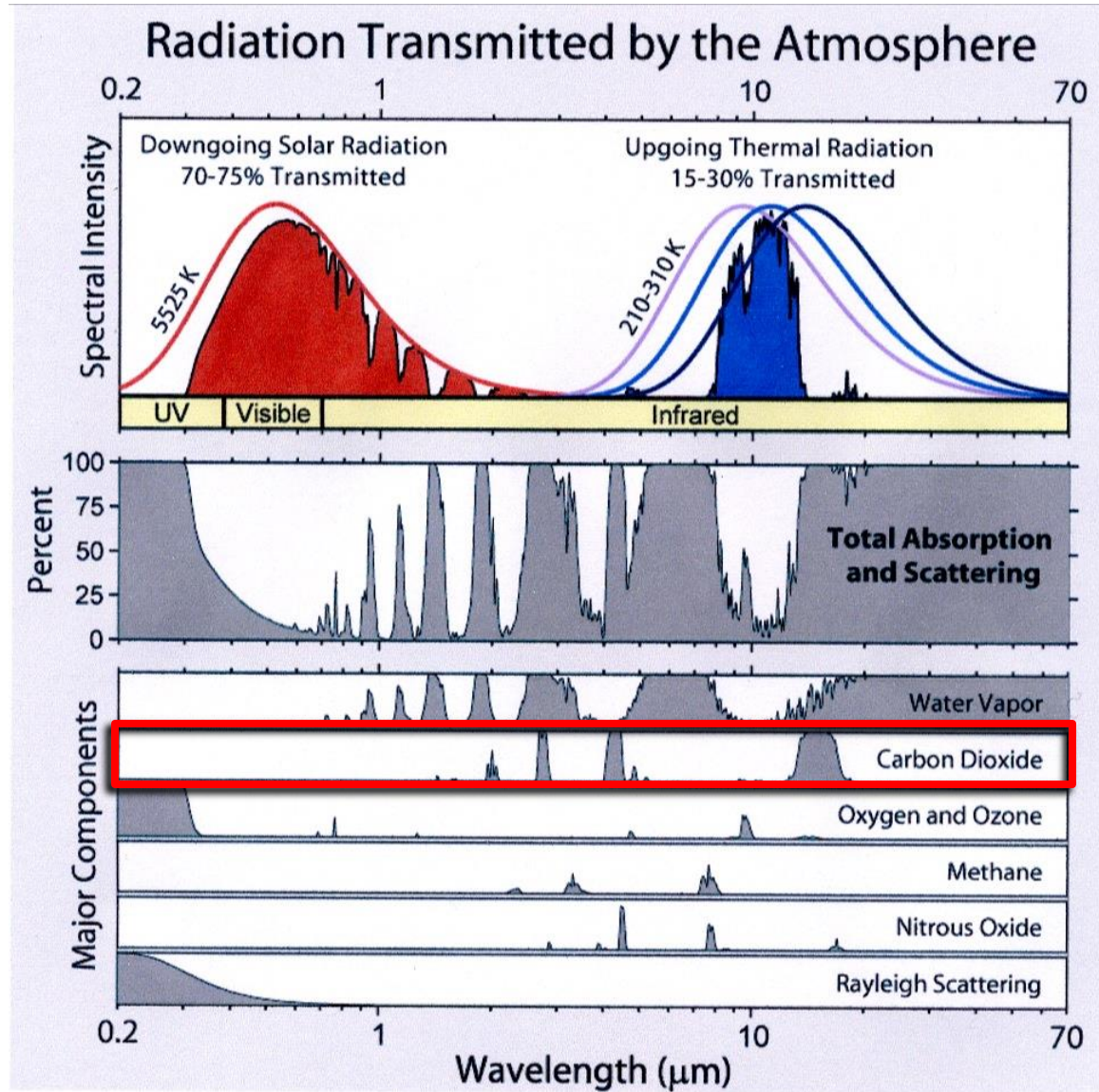
- **Water Vapor**

- ~3 pph maximum
- Most important GHG
- Equilibrium temp. -20 °C (-4 °F)
- Observed temp. 15 °C (59 °F)
- Only changing by about 1% / decade.



Greenhouse Gases

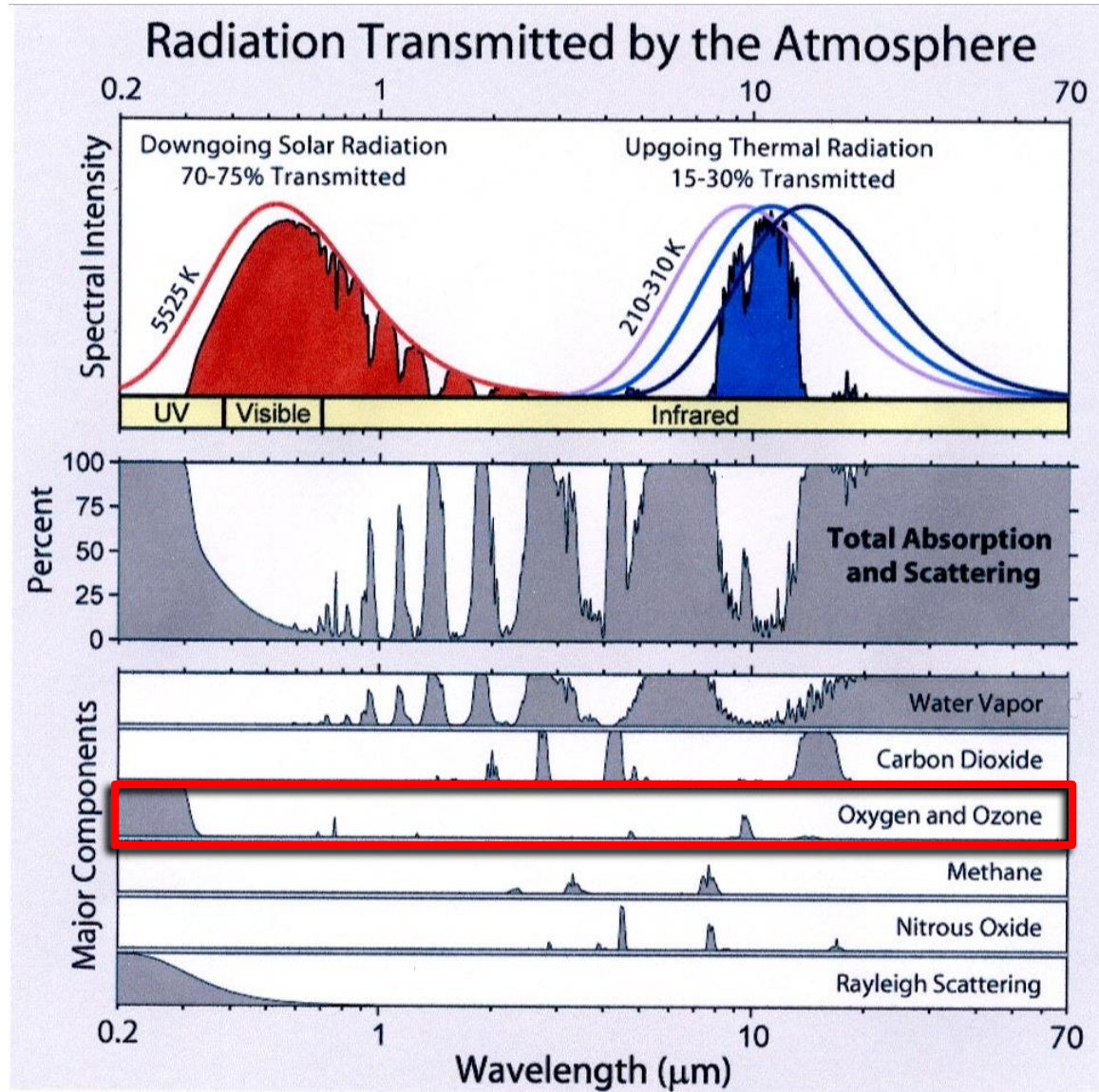
- **Carbon Dioxide**
 - ~394 ppm
 - 1-3 ppm annually
 - Produced by:
 - Fossil fuel combustion
 - Animal Respiration
 - Plant Respiration



Greenhouse Gases

- **Ozone**

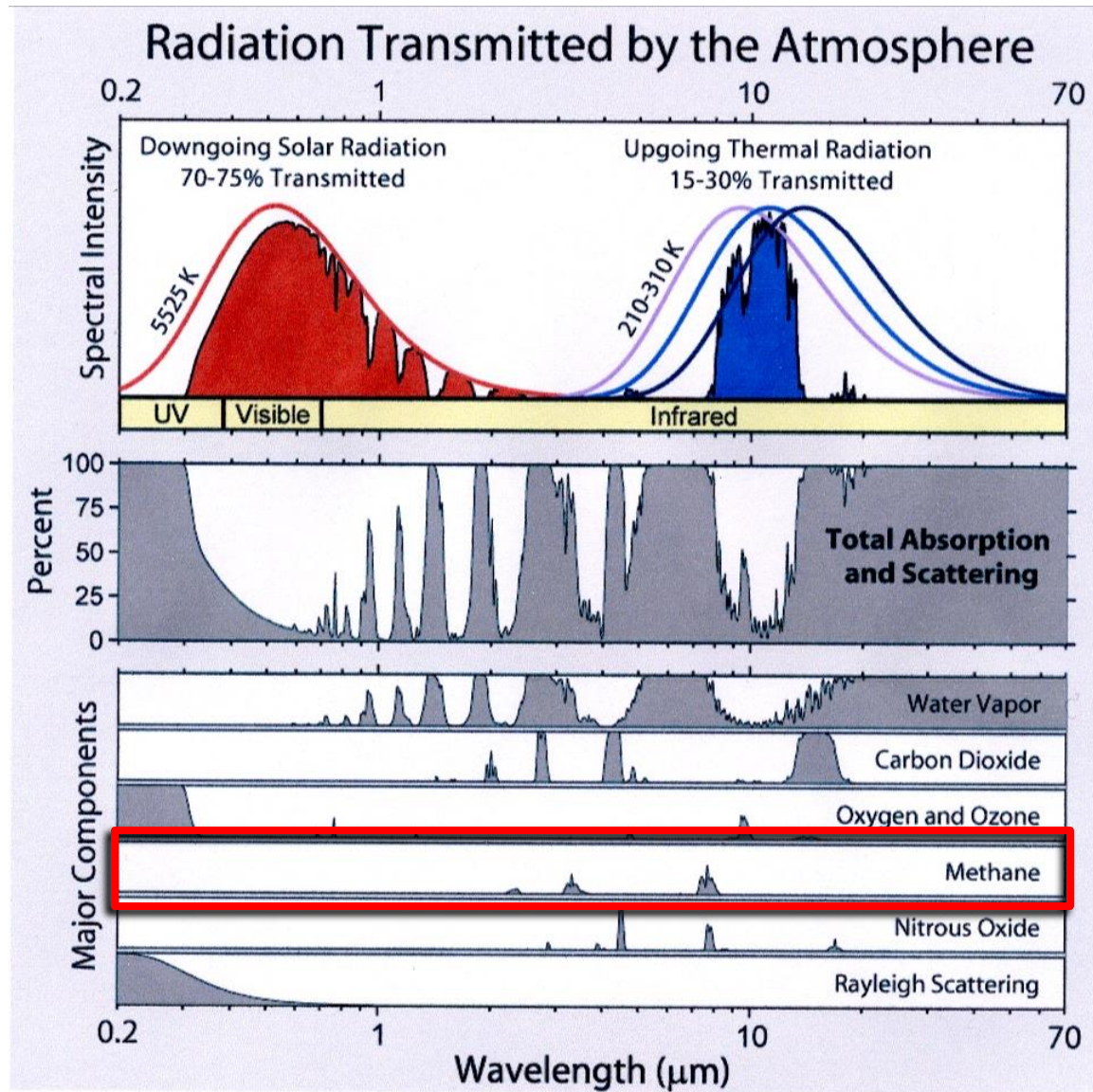
- ~34 ppb
- Forms only secondarily
- Roughly 34 ppb
- Global increase of roughly 30% since industrial revolution.



Greenhouse Gases

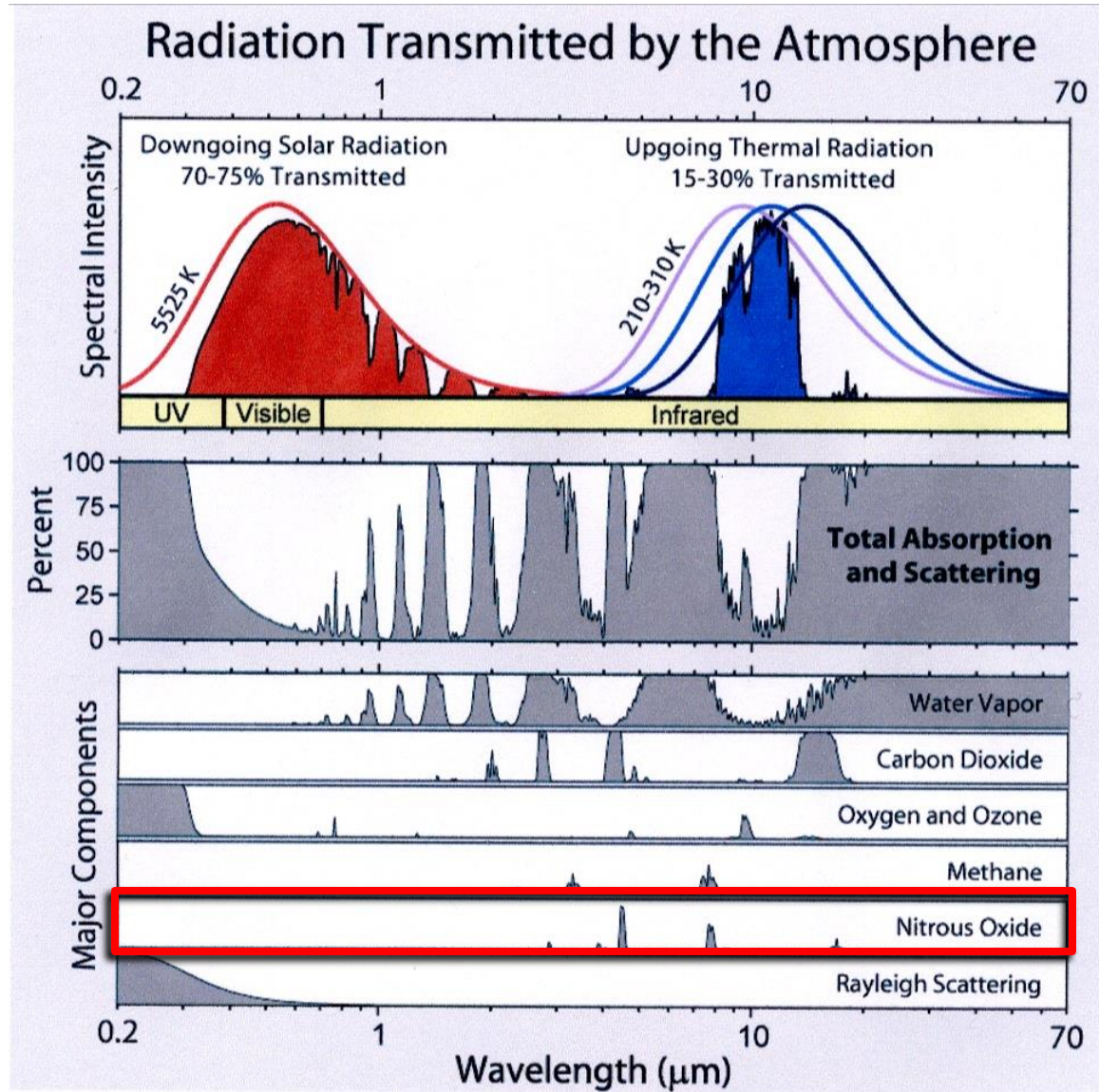
- **Methane**

- 2ppm
- A by-product of agriculture and farming, vehicles, factories, ...
- 25x more potent than CO₂
- 1/3 contribution to global warming relative to CO₂

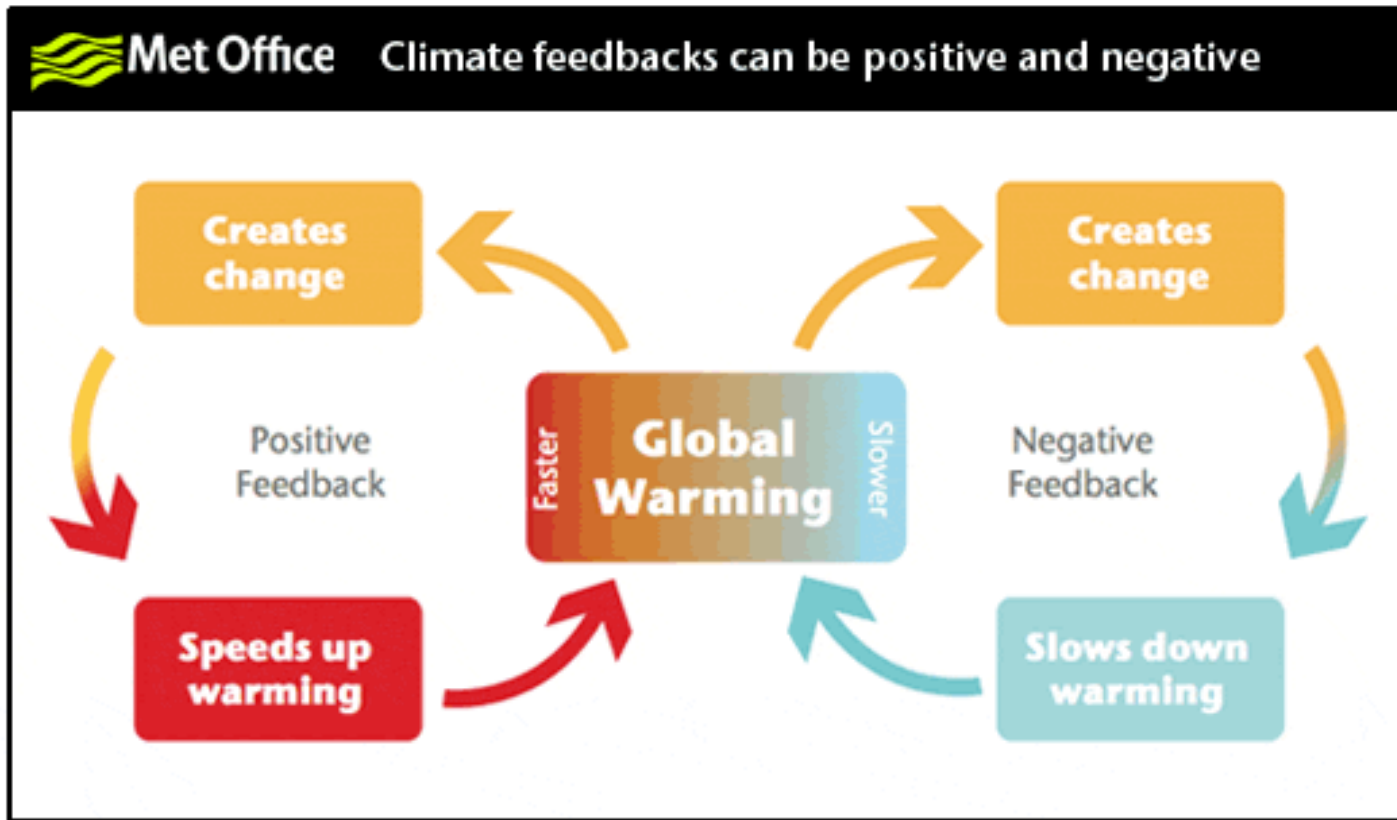


Greenhouse Gases

- **Nitrous Oxide**
 - 300 ppb
 - By product of agriculture and industry
 - 300x more potent than CO₂
 - Relatively long atmospheric residency time



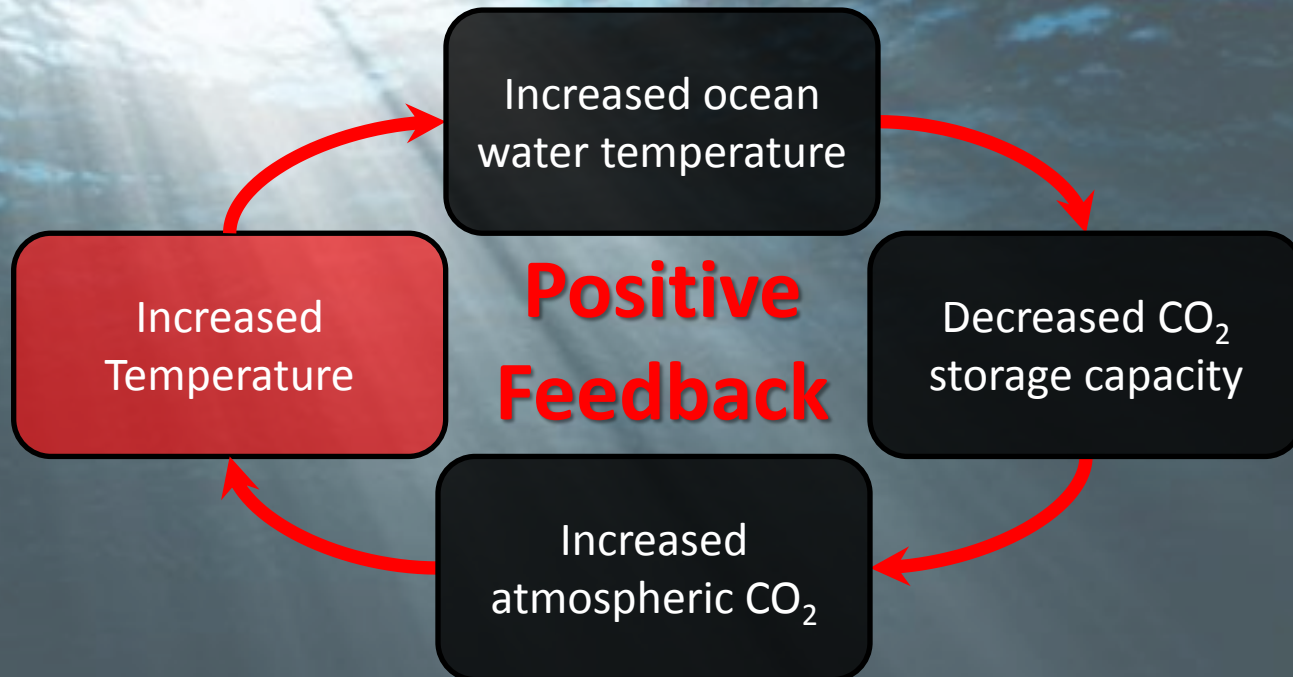
Climate Feedbacks



“An interaction mechanism between processes in the climate system is called a climate feedback, when the result of an initial process triggers changes in a second process that in turn influences the initial one. A positive feedback intensifies the original process, and a negative feedback reduces it.” [Open Source Systems, Science, Solutions](#)

An Example:

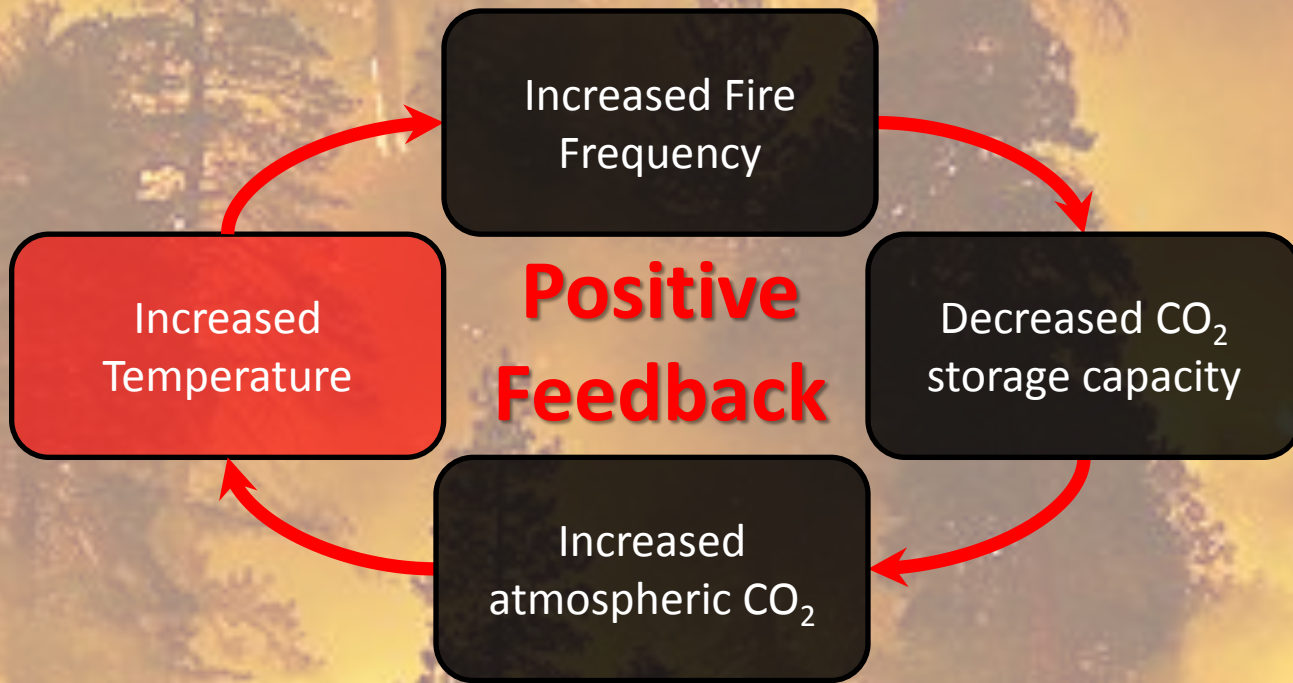
CO₂ in the oceans



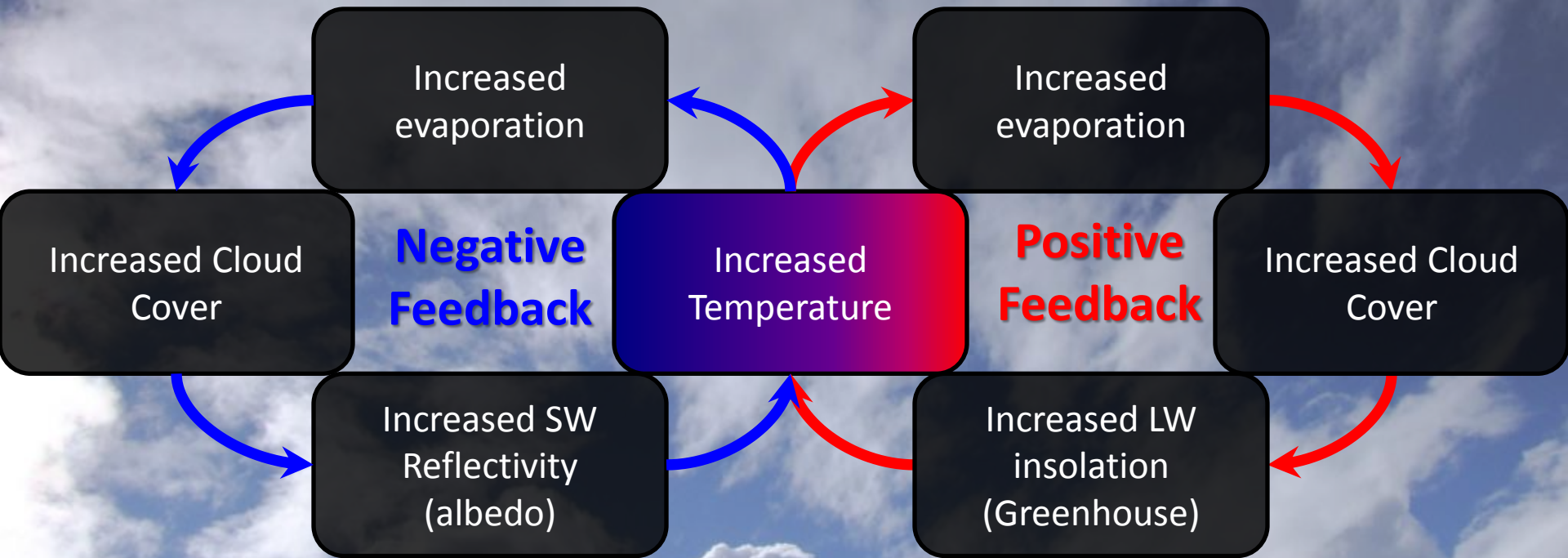
Group Work

- **Group 1: Forest Fires**
- **Group 2: Clouds**
- **Group 3: Snow/Ice**
- **Group 4: Water Vapor**
- **Group 5: Desertification**
- **Group 6: Growing Season Length**
- **Group 7: Permafrost**

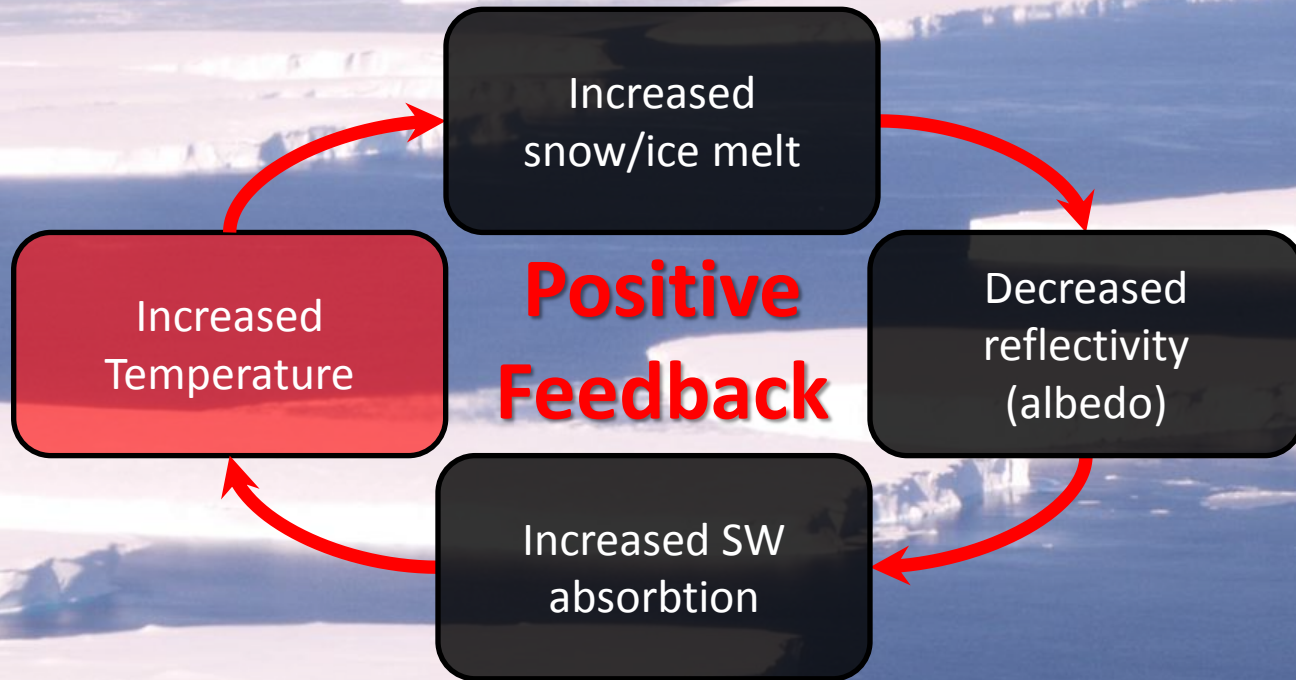
Forest Fires



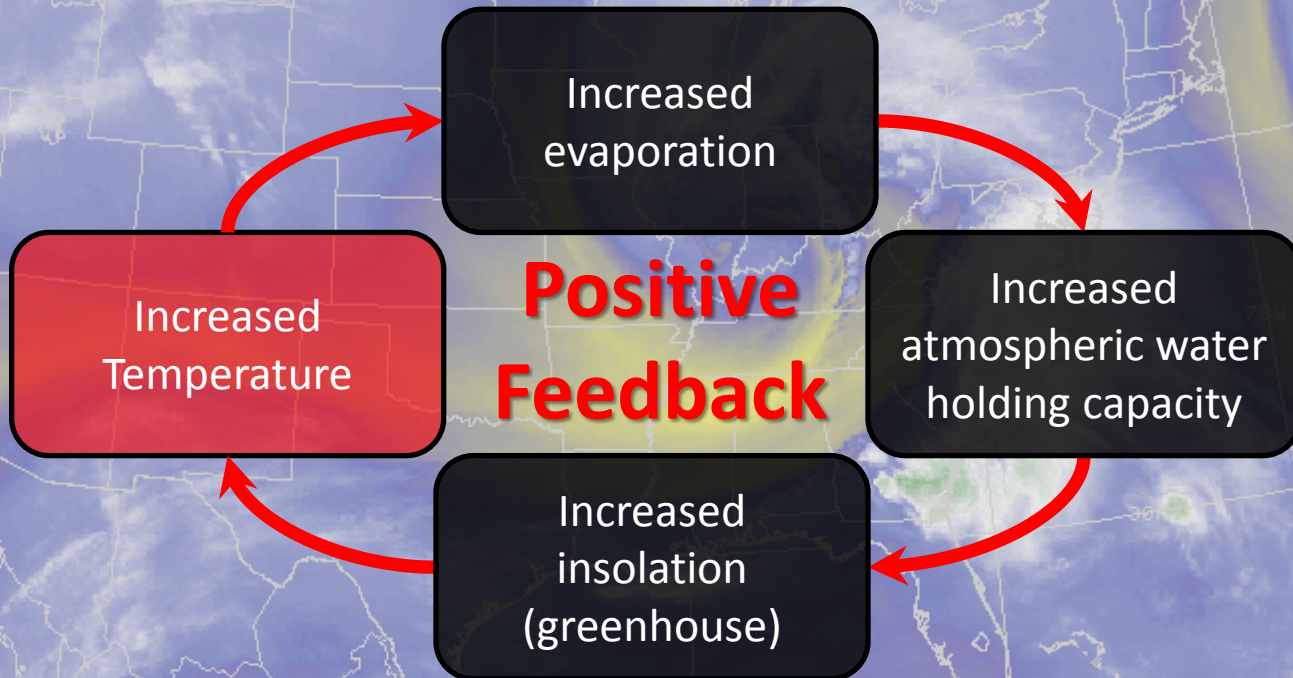
Clouds



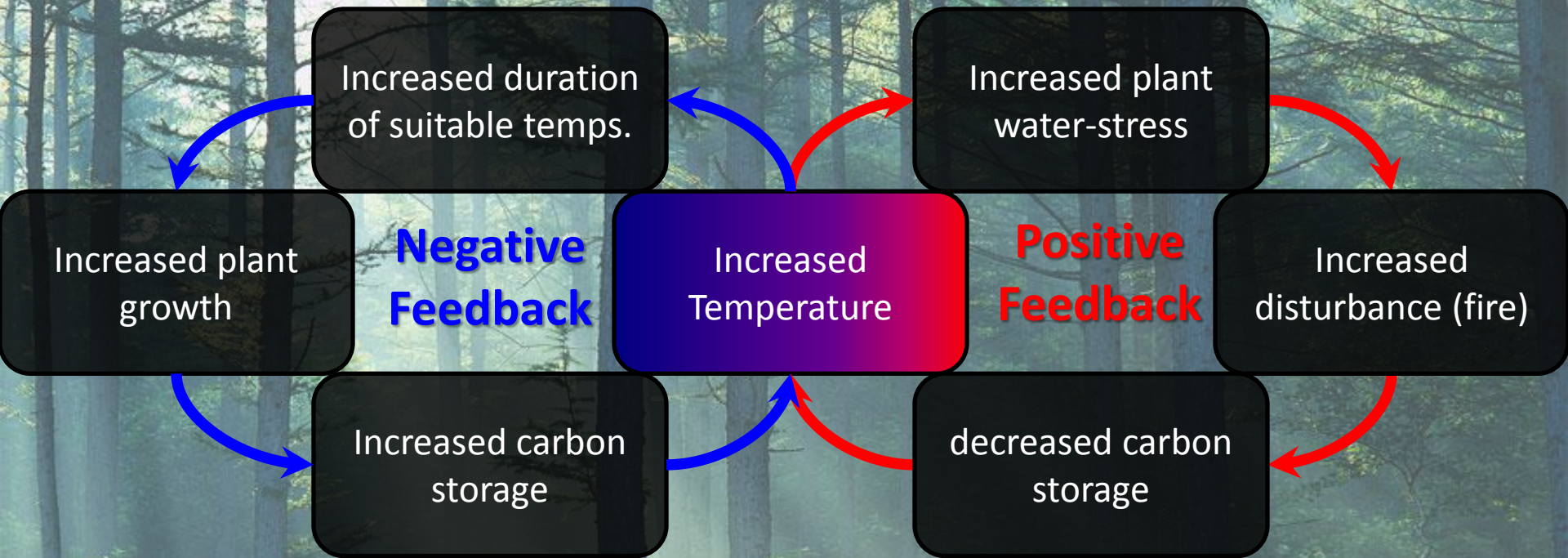
Snow/Ice



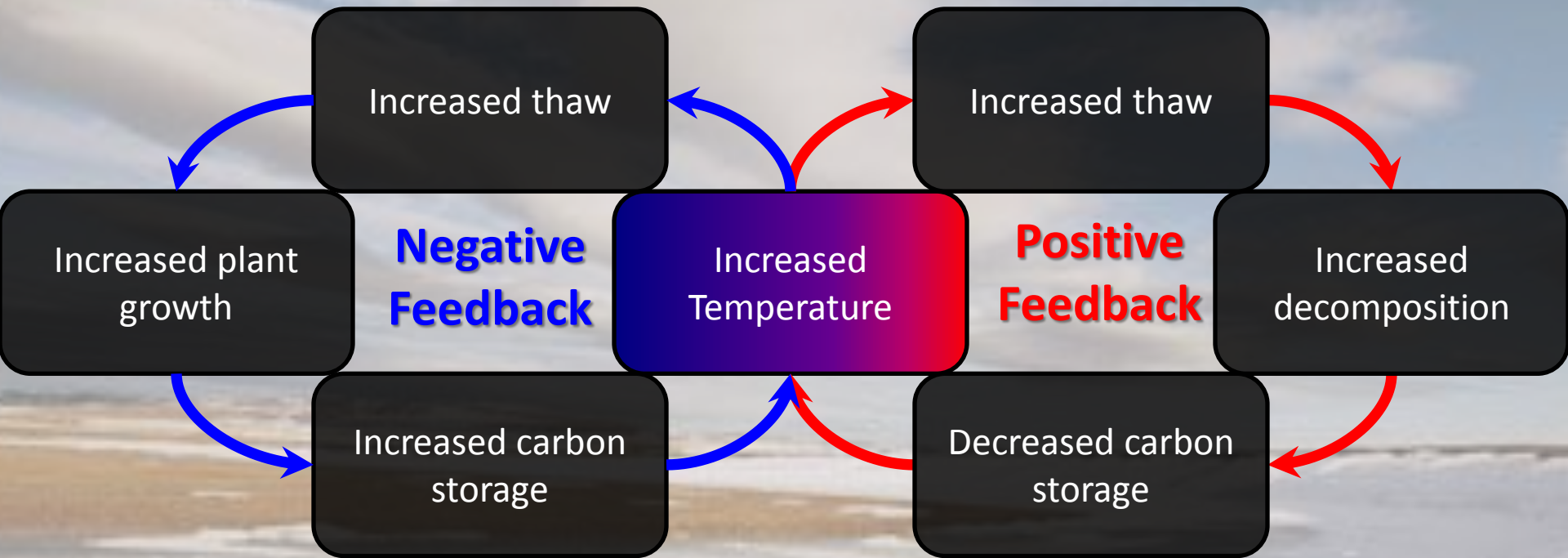
Water Vapor



Growing Season Length



Permafrost

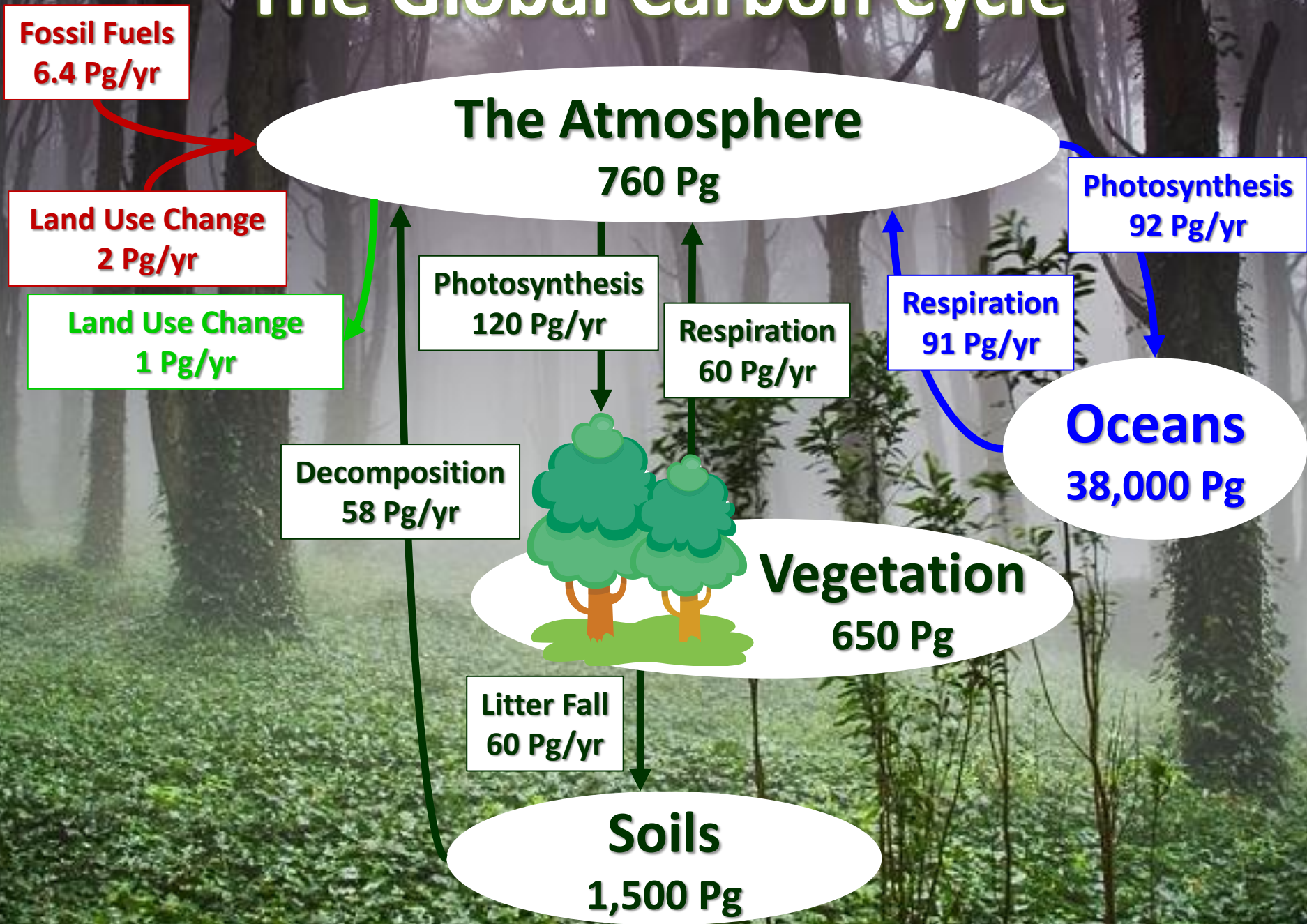


****Another positive feedback mechanism could be the release of large pockets of methane as permafrost thaws. This process is more commonly referred to as a tipping point due to the potential for drastic alteration of the insolation of the atmosphere.****

A photograph of a forest with sunlight streaming through the trees, creating a bright lens flare in the center. The sun is positioned behind a tree trunk, casting rays of light across the scene. The trees are tall and thin, with some green foliage visible. The overall atmosphere is bright and natural.

The Global Carbon Cycle

The Global Carbon Cycle



What Would Cause a Shift from Carbon Sink to Source??

The Atmosphere

A carbon sink can be converted to a carbon source when the amount of CO₂ respired to the atmosphere is greater than the amount fixed during photosynthesis (a net reduction of the source pool and a net increase in the atmospheric pool). Processes that can drive the conversion of a system from a sink to a source include wildfire, insect infestation, and drought.

Photosynthesis

Respiration



Vegetation

Soils

Decomposition

