EOSC 112: THE FLUID EARTH

EARTH'S ENERGY BUDGET AND CLIMATE FEEDBACKS

E3

Read: Kump et al. Chap.3, p. 44 (Atm. Comp.), p. 46-53. Check: Key Terms, Review Questions 5,6, 8-12, Problems 4, 5, 6.

Objectives:

1. **To describe the physical causes of the greenhouse effect**
2. **To describe the global energy budget and the role of clouds**
3. **To model radiative climate feedbacks**

1. Greenhouse Effect (Atm. Comp.)

- **Major constituents: (concentration by volume)**
  - **N_2 78%, O_2 21%, Ar 0.9 %**
  - **H_2O up to 4% (tropics), CO_2 0.037%**

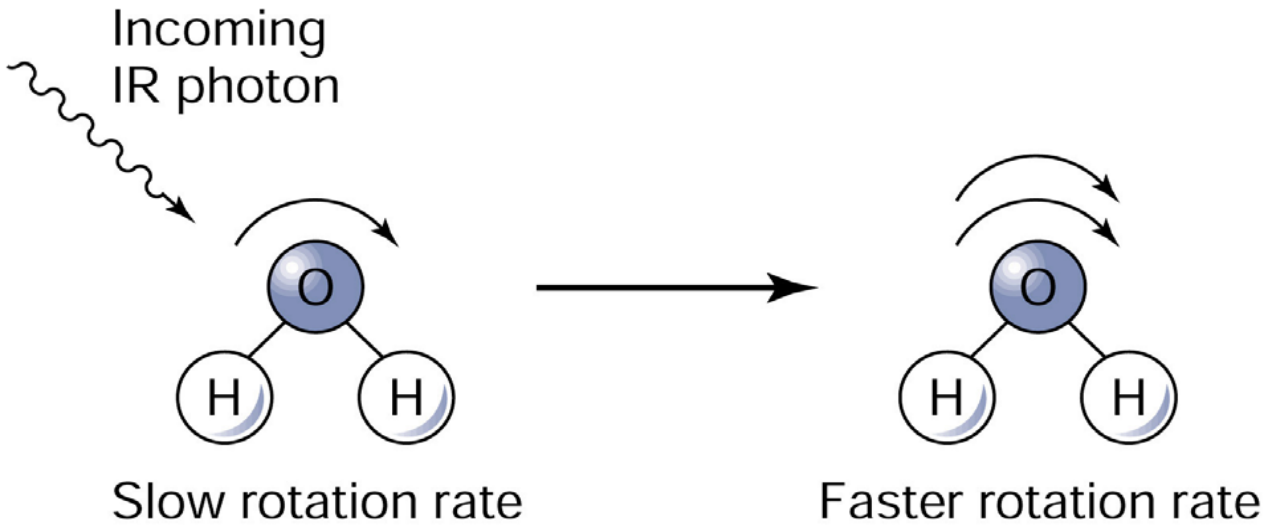
  A gas is called a "greenhouse gas" if it is able to absorb and emit infrared radiation.

- **Greenhouse gases:**
  - **H_2O, CO_2**
  - **Minor or "trace" constituents:**

    Methane CH_4, Nitrous oxide N_2O,

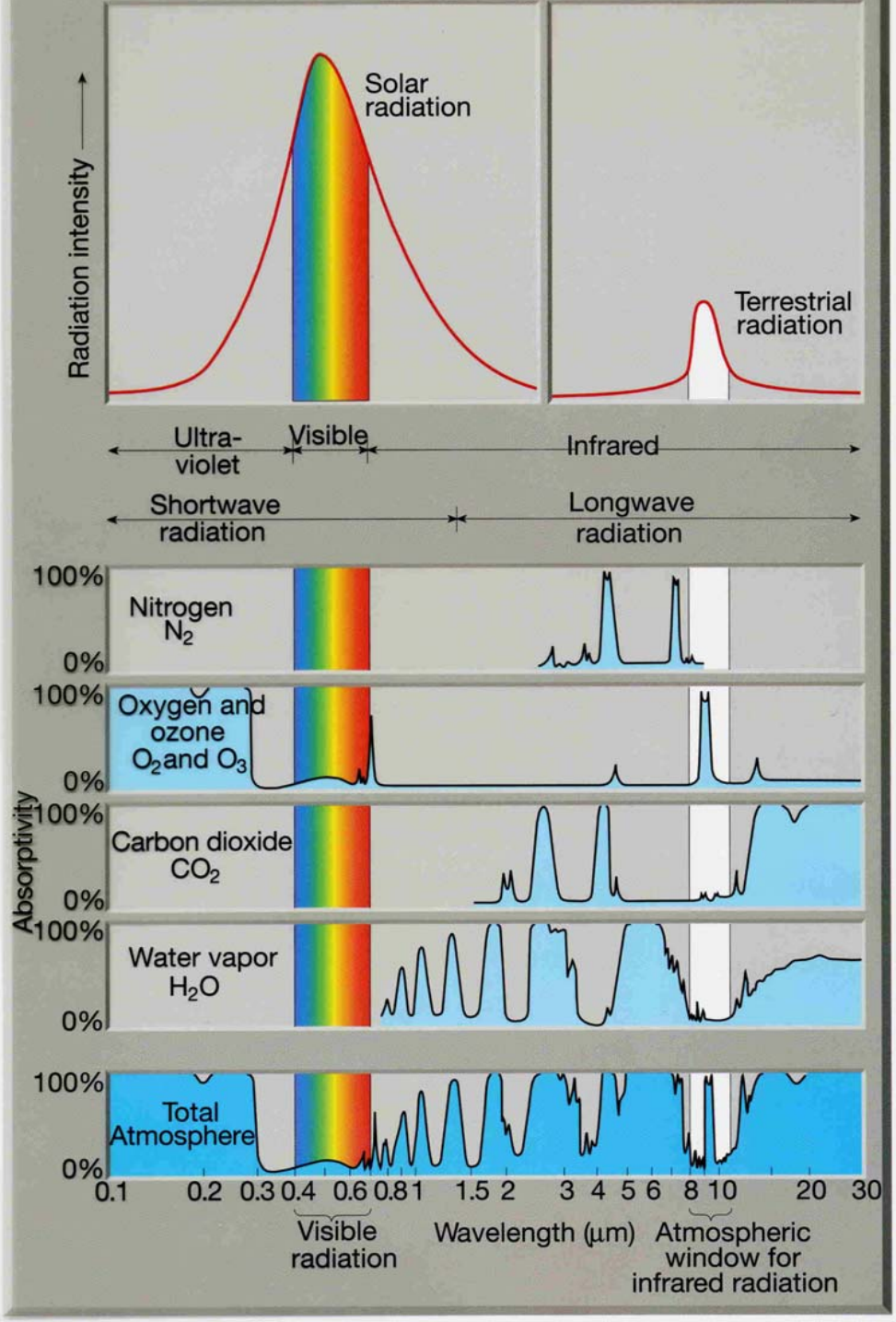
    Ozone O_3, Freon-11 CCl_3F, Freon-12 CCl_2F_2

Physical causes of the greenhouse effect



Molecules can only rotate at certain discrete frequencies.

Only a photon of the right frequency (wavelength) can be absorbed to increase a molecule's rotational frequency.

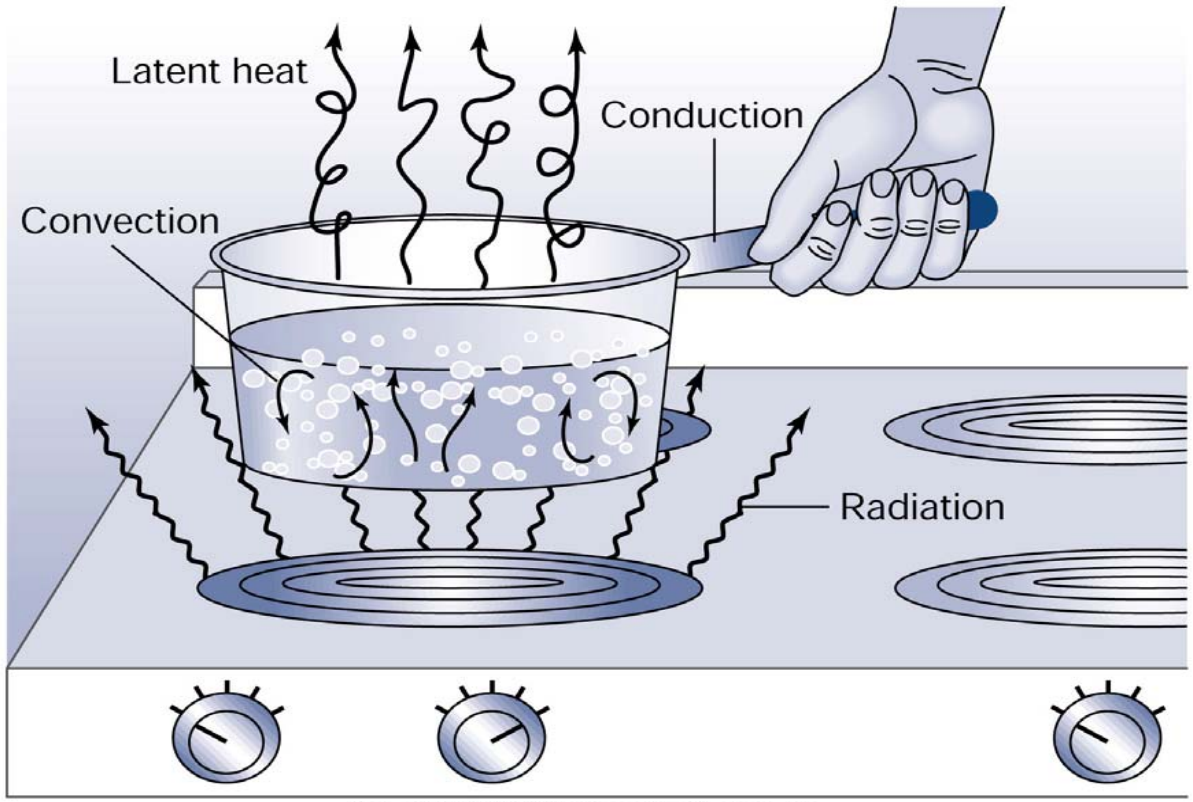

Radiation intensity
Solar radiation
Terrestrial radiation
Ultra-violet
Visible
Infrared
Shortwave radiation
Longwave radiation
Absorptivity
100%
0%
Nitrogen N_2
Oxygen and ozone O_2 and O_3
Carbon dioxide CO_2
Water vapor H_2O
Total Atmosphere
0.1 0.2 0.3 0.4 0.6 0.8 1 1.5 2 3 4 5 6 8 10 20 30
Visible radiation
Wavelength (μm)
Atmospheric window for infrared radiation

2. Mechanisms of Heat Transfer

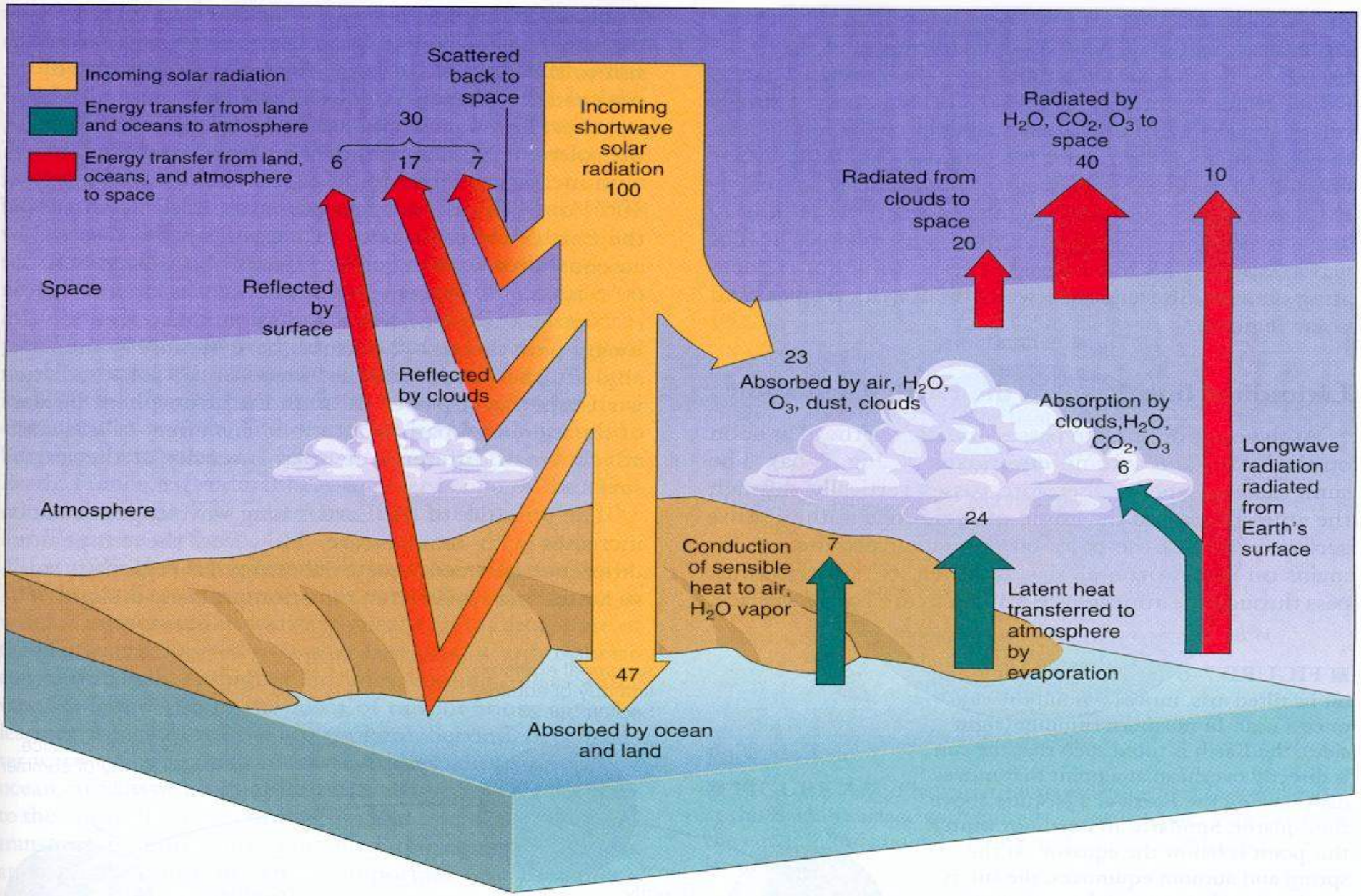
Radiation: can transfer heat over vacuum.

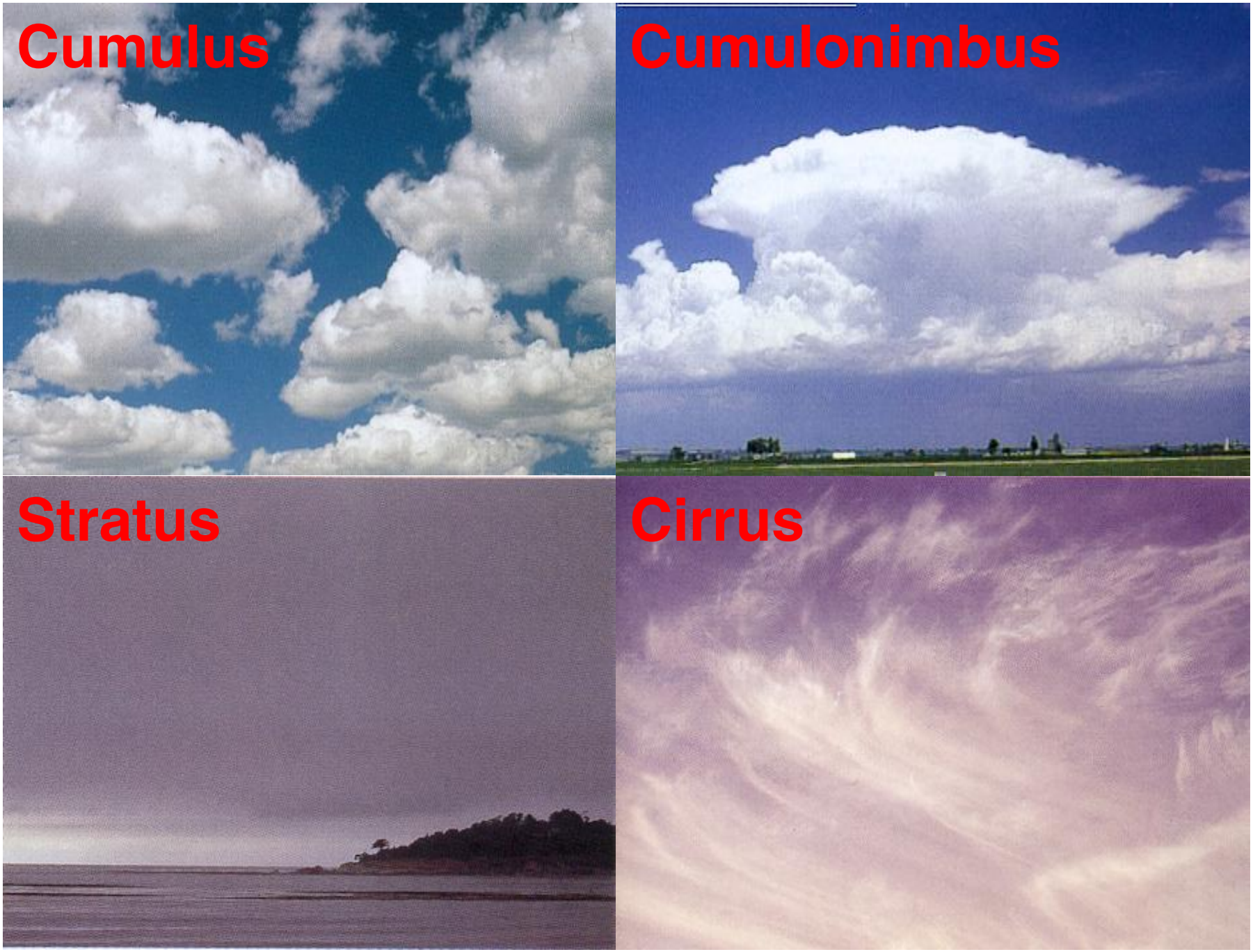
Conduction: … via neighboring molecules.

Convection: … by fluid movement, especially overturning. It is much stronger than conduction in atmosphere



Earth's Energy Budget

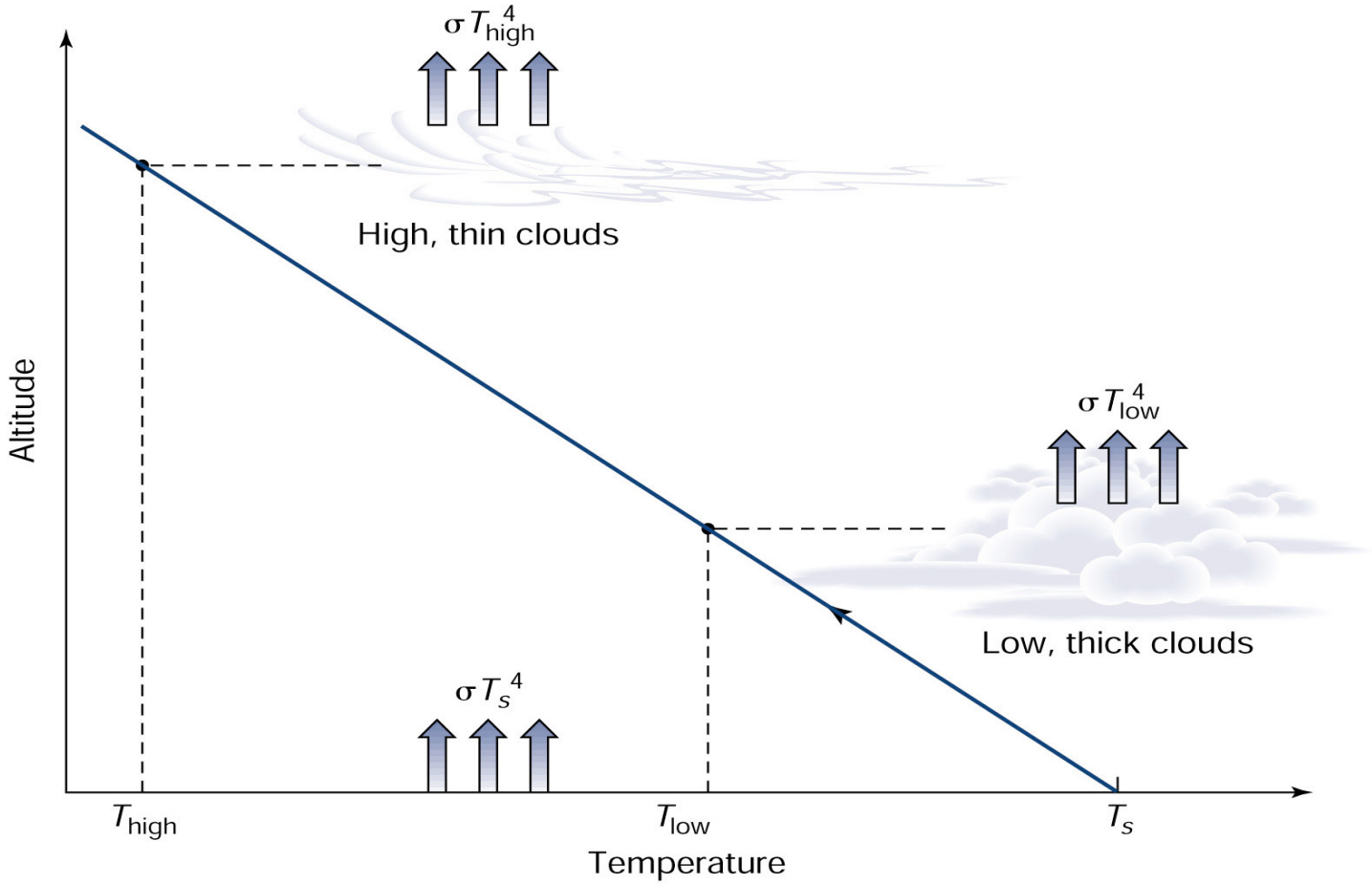



Cumulus
Cumulonimbus
Stratus
Cirrus

Role of Clouds

Low, thick clouds (stratus-type) cool the surface;

High, thin clouds (cirrus-type) warm the surface.



3. Radiative Climate Feedbacks

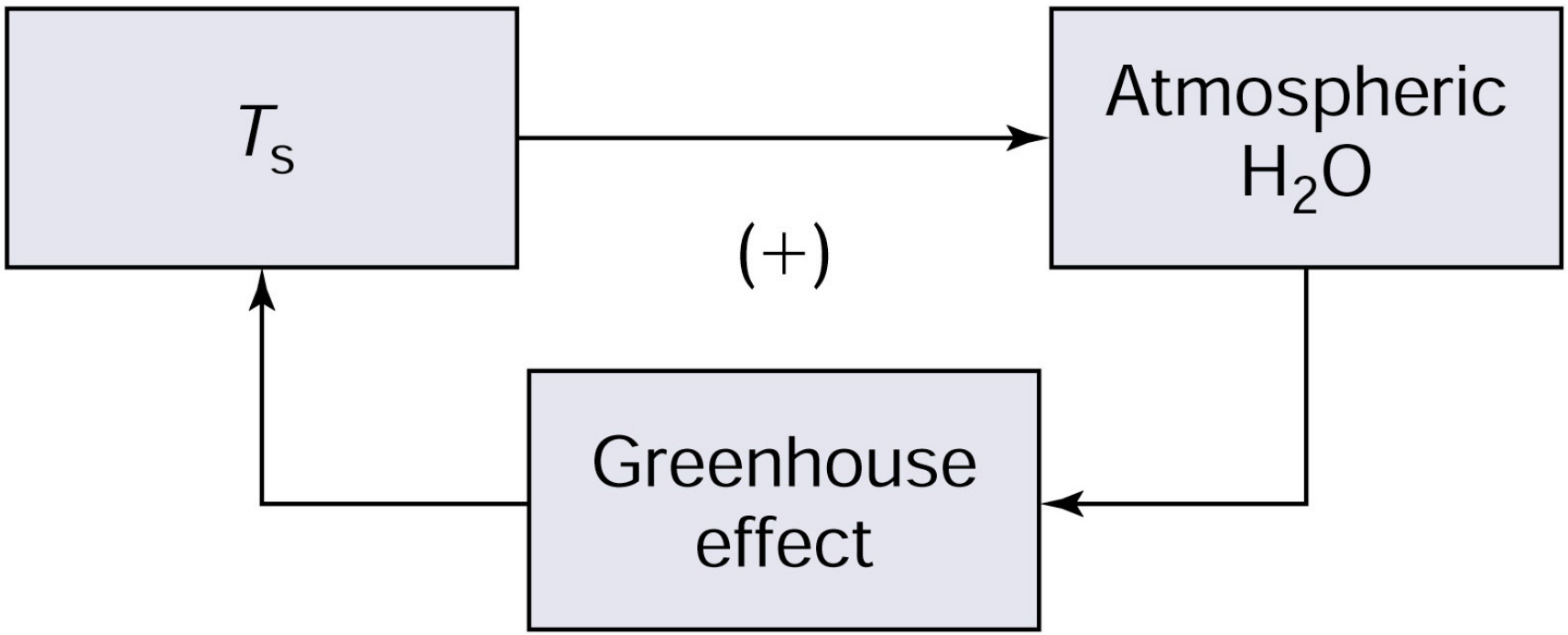
Water vapor feedback:

It is observed that for most regions of the planet, water vapor is close to its point of condensation.

Small changes in surface T will cause similar changes in atmospheric vapor H_2O concentrations and vice versa.

Result: 2 positive couplings $\Rightarrow$ positive feedback loop!

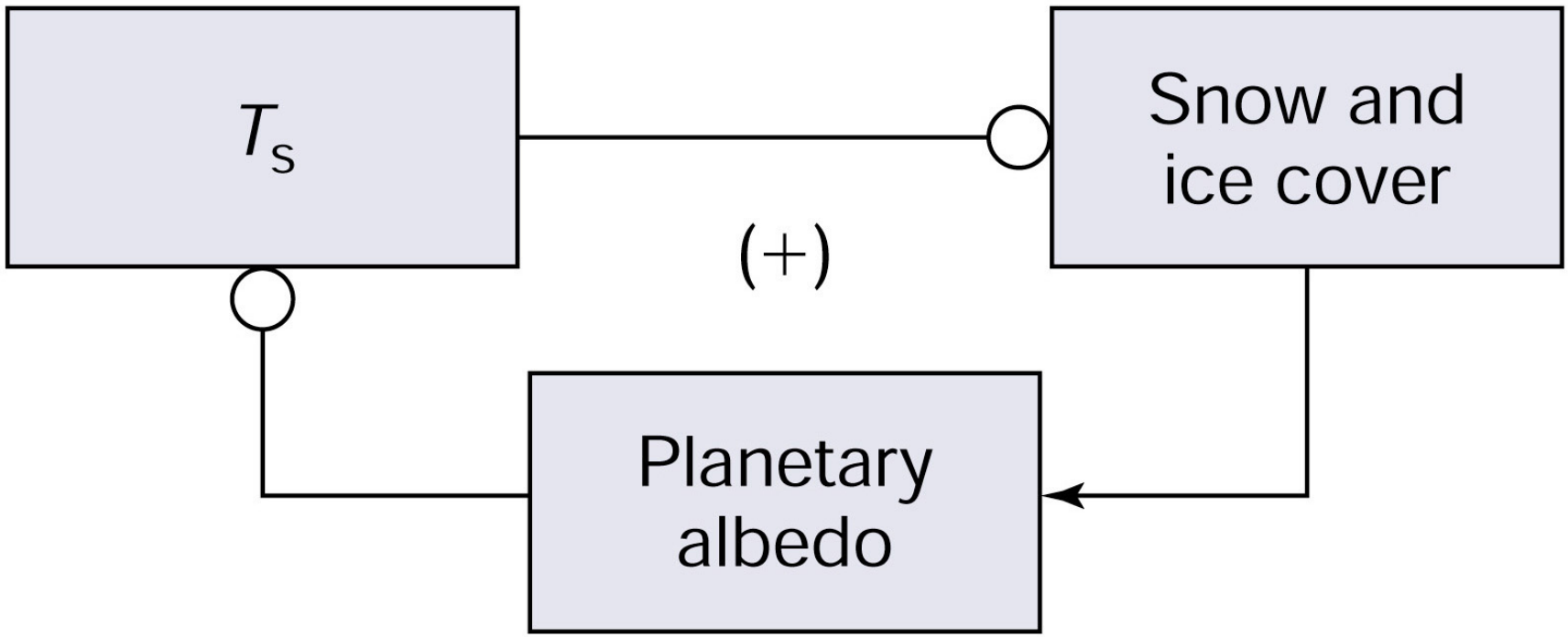
Unclear figure representing water vapor feedback



Snow/Ice Albedo Feedback:

Small changes in surface T will cause opposite changes in the extent of polar ice cover and vice versa.

Result: 2 negative couplings $\Rightarrow$ positive feedback loop!



Infrared Flux-T_s Feedback:

This feedback mechanism is responsible for the short-term stability of our climate.

Compare this feedback loop to that of our "Soot Planet"!