

Atmosphere and Surface Energy Balances

Geog101
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Atmosphere and Surface Energy Balances

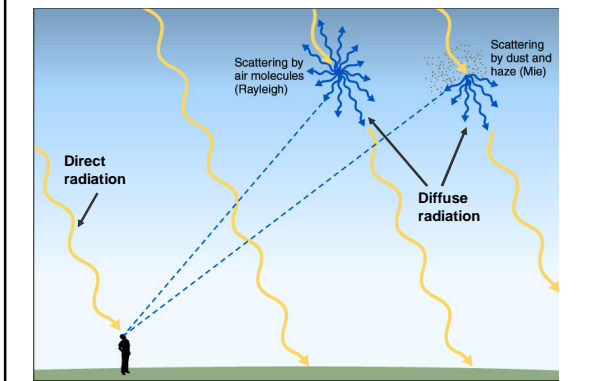
Reading: Chapter 4

- Energy pathways and principles
- Earths energy budget
- Other important forms of heat transfer
- Surface radiation and energy balances
- Urban climates

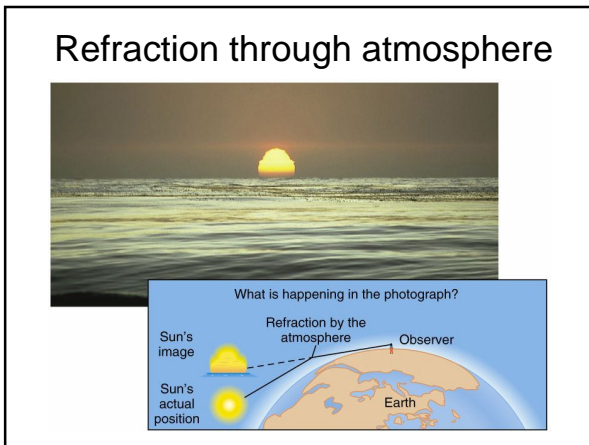
Atmospheric passage of shortwave radiation

- **Absorption**
 - Some energy is absorbed by atmosphere and reradiated as longwave radiation
- **Scattering**
 - Changing direction of light's movement, without altering its wavelengths
- **Refraction**
 - Change in speed and direction of light

Atmospheric scattering



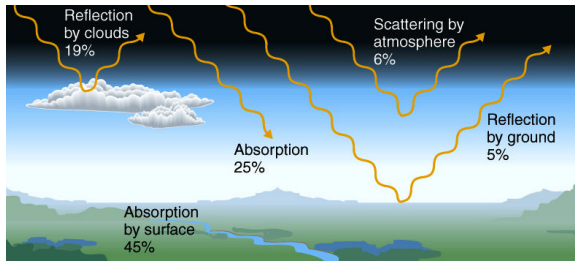
Refraction through atmosphere



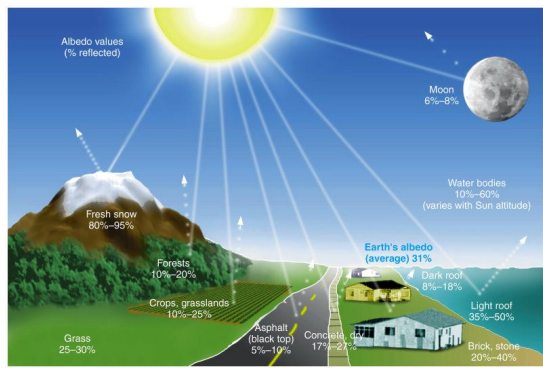
Refraction through raindrops



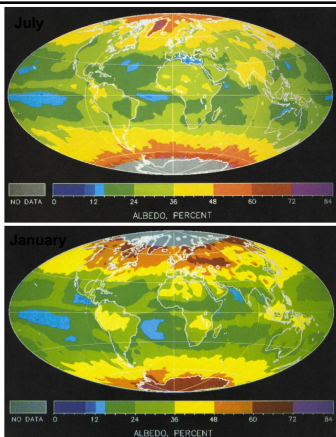
Earth's shortwave radiation budget

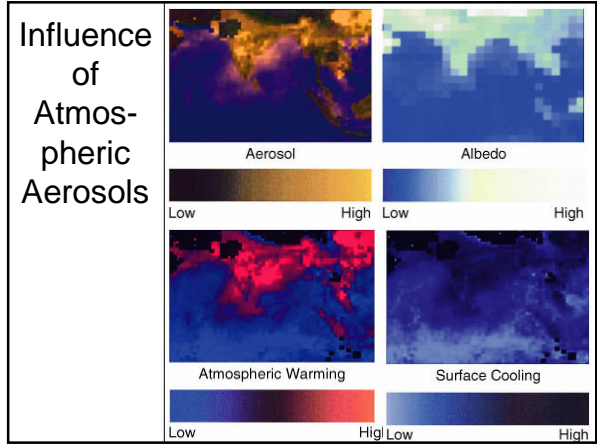


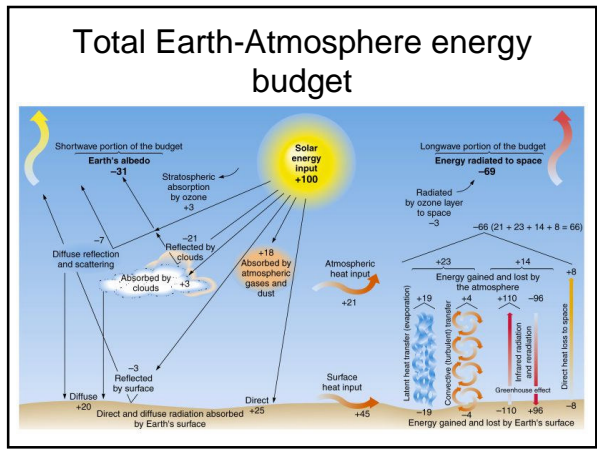
Surface albedo (reflectivity)

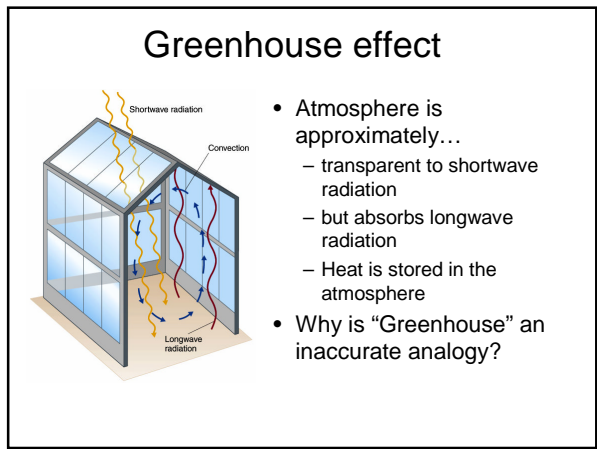


Seasonal variability of albedo





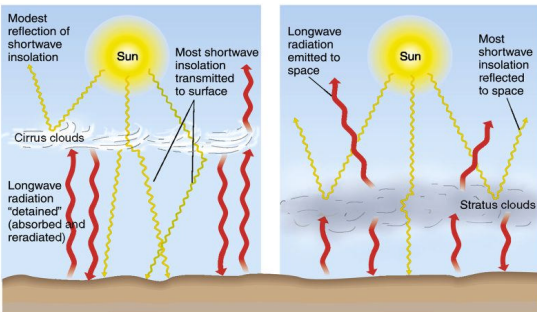




Greenhouse variables

- Gases
 - Carbon dioxide
 - Water vapor
 - Methane
 - Halocarbons
 - Nitrous oxides
- Greenhouse clouds

Greenhouse clouds

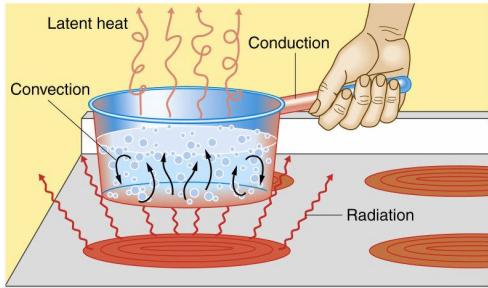


(a) High clouds: net greenhouse forcing and atmospheric warming
(b) Low clouds: net albedo forcing and atmospheric cooling

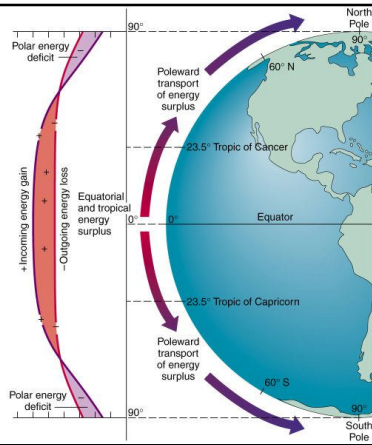
Heat transfer mechanisms

- **Conduction**
 - Molecule to molecule transfer
- **Convection**
 - Energy transferred by movement in fluids
- **Advection**
 - Horizontally dominant movement
- **Radiation**
 - Energy traveling through air or space

Heat transfer mechanisms



Spatial distribution of Earth's energy budget and advection



Energy Balance at Earth's Surface

- Surface Radiation Budget

$$QN = SW \downarrow - SW \uparrow + LW \downarrow - LW \uparrow$$

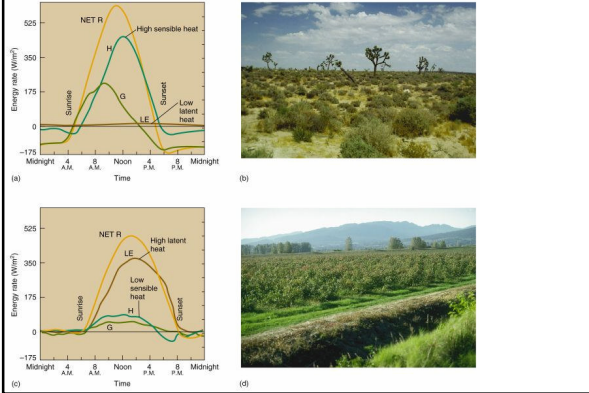
– QN = net radiation, SW = shortwave, LW = longwave

- Surface Energy Balance

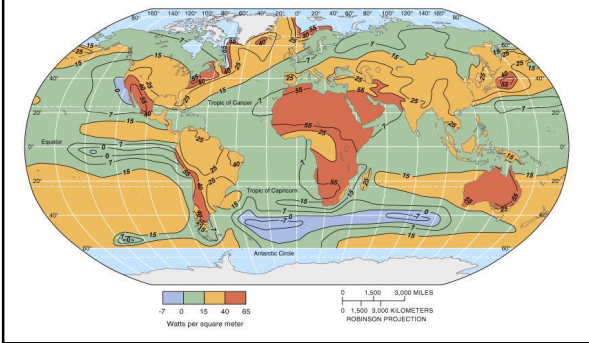
$$QN = H + LE + G$$

– H = sensible heat, LE = latent heat, G = ground heat

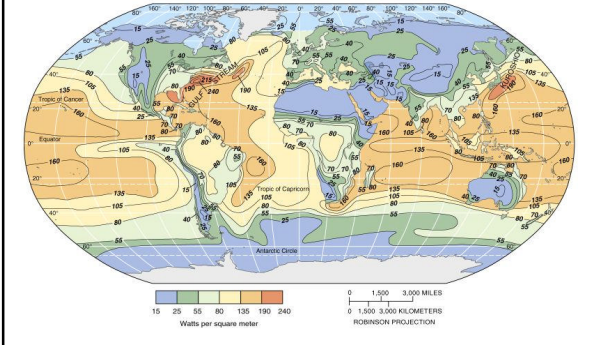
Surface energy balances



Global sensible heat flux



Global latent heat flux

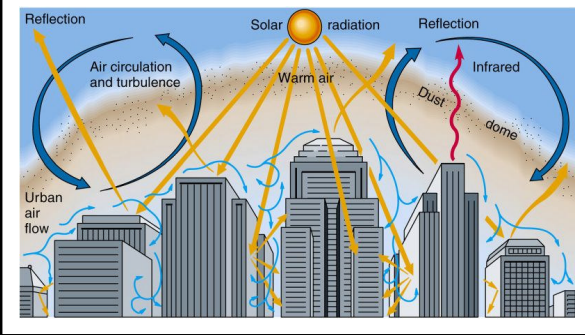


Urban climates



Urban heat island effect

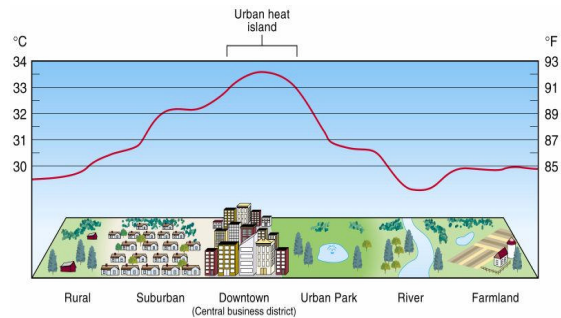
Properties of the urban environment



The Urban Environment

- Surfaces (concrete, asphalt etc)
 - Low albedo
 - high conduction
 - Impervious (less water present)
 - Irregular geometry
 - Multiple reflections
 - Lower winds
 - Anthropogenic heating
 - Burning of fossil fuels (cars, gas/oil)
 - Air Pollution
- } Urban heat-island effect

Rural-urban temperature transect



Question:

- Given the physical processes causing the urban heat island effect, what urban management practices could we employ to reduce its impact?
