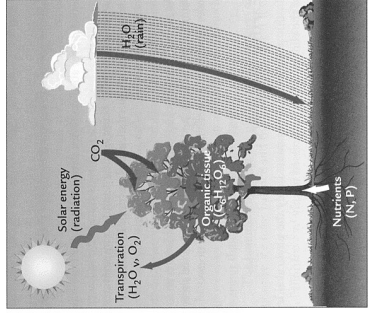


Lecture 5: Land Surface and Cryosphere (Outline)



(from *Our Changing Planet*)

- Climate Roles
- Surface Energy Balance
- Surface Water Balance
- Sea Ice
- Land Ice

Climate Roles of Land Surface

- greenhouse gas emissions
→ affects global energy and biogeochemical cycles
 - creation of aerosols
→ affects global energy and water cycles
- surface reflectivity (albedo)
→ affects global energy cycle
 - impacts on surface hydrology
→ affect global water cycle
- {
 Vegetation
 Soil Moisture
 Snow/Ice Cover

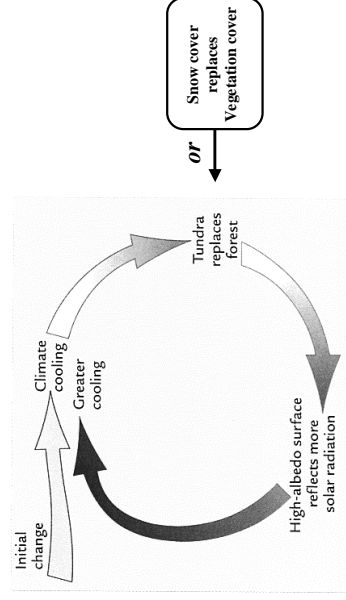
Surface Albedo

TABLE 2-1 Average Albedo Range of Earth's Surfaces

Surface	Albedo range (percent)
Fresh snow or ice	60–90%
Old, melting snow	40–70
Clouds	40–90
Desert sand	30–50
Soil	5–30
Tundra	15–35
Grasslands	18–25
Forest	5–20
Water	5–10

Adapted from W. D. Sellers, Physical Climatology (Chicago: University of Chicago Press, 1965), and from R. G. Barry and R. J. Chorley, Atmosphere, Weather, and Climate, 4th ed. (New York: Methuen, 1982).

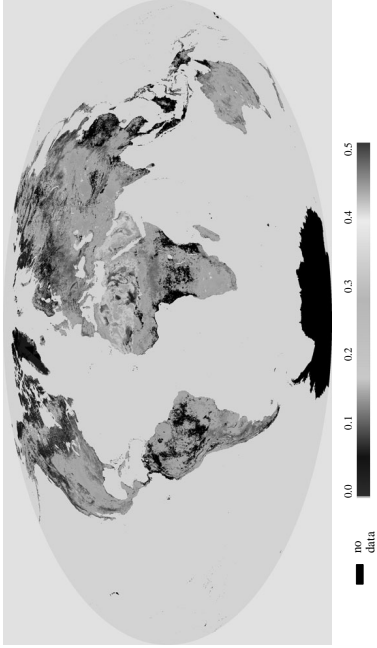
Climate Role 1: Albedo → Energy Cycle



(from *Earth's Climate: Past and Future*)

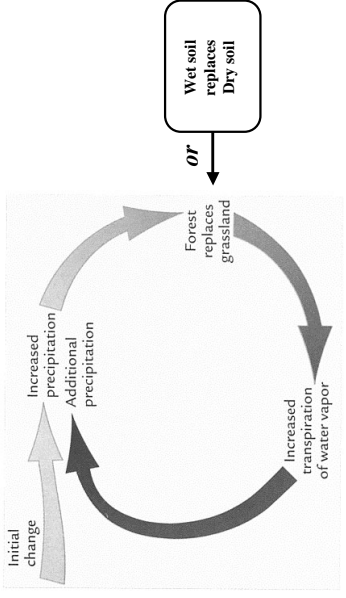
Global Broadband White-Sky Albedo (0.3-5.0µm)

Sept. 29 - Oct. 30, 2000



(from NASA-MODLAND Strabler et al.)

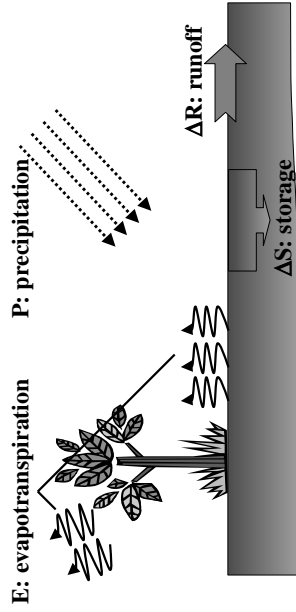
Climate Role 2: Transpiration → Water Cycle



(from Earth's Climate: Past and Future)

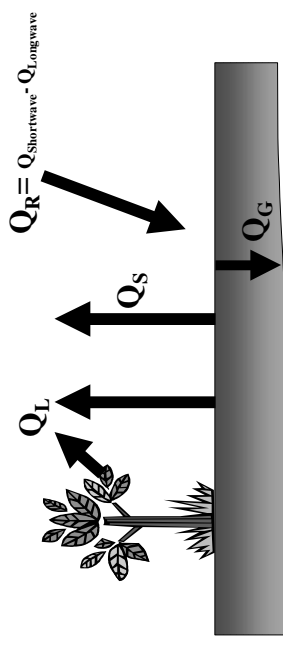
Surface Moisture Balance

$$P = E + \Delta R + \Delta S$$

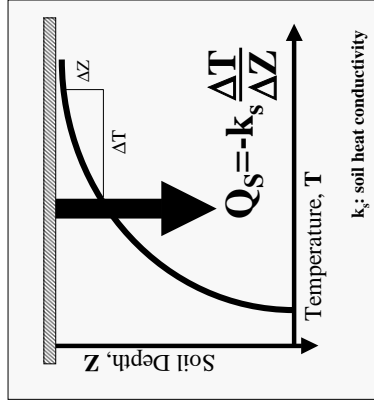


Surface Energy Balance

$$Q_{\text{Radiative}} = Q_{\text{Sensible}} + Q_{\text{Latent}} + Q_{\text{Ground}}$$

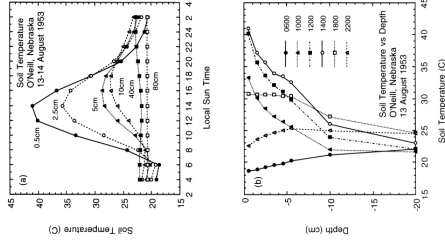


Heat Storage in Soil



Penetration Depth

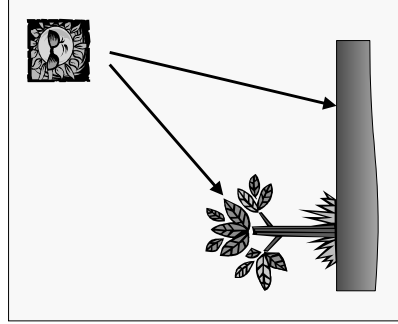
- **Diurnal Forcing of Q_s**
Penetration Depth ~ 10 cm
- **Annual Forcing of Q_s**
Penetration Depth ~ 1.5 m



(from *Global Physical Climatology*)

Land Surface Properties

- **Vegetation Properties**
Type and density
- **Soil Properties**
Depth and physical properties
(e.g., moisture)

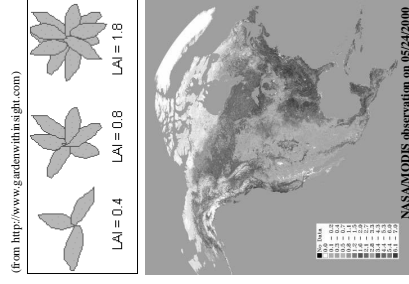


Characteristics of Vegetation Canopy

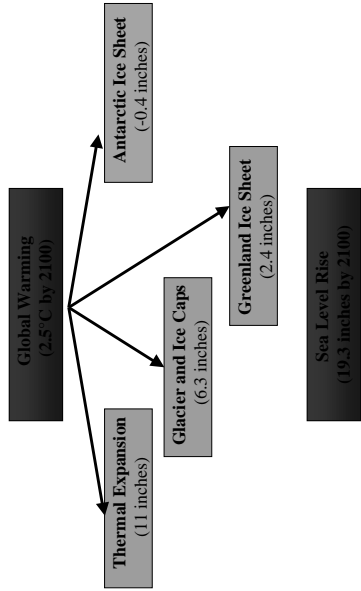
- **Typical Height**
- **Leaf Area Index (LAI)**

Leaf area index (LAI) is ratio of the total area of all leaves (one-side) on a plant to the area of ground covered by the plant.

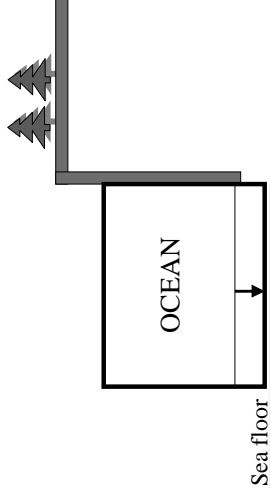
It defines the area that interacts with solar radiation and that is responsible for carbon absorption and exchange with the atmosphere.



Global Warming and Sea-Level Change

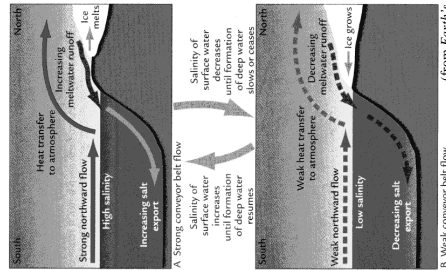


Sea Level Rise .vs. Sea Floor Sink



After a certain amount of land-supported ice melts, in stead of saying the sea level will rise "so much", we should say the oceans will get "so much" deeper.
 -- (Kivioja 2003; EOS)

Interactions between Ice and Ocean



- This hypothesis argues that millennial oscillations were produced by the internal interactions among various components of the climate system.
- One most likely internal interaction is the one associated with the deep-water formation in the North Atlantic.
- Millennial oscillations can be produced from changes in northward flow of warm, salty surface water along the conveyor belt.
- Stronger conveyor flow releases heat that melts ice and lowers the salinity of the North Atlantic, eventually slowing or stopping the formation of deep water.
- Weaker flow then causes salinity to rise, completing the cycle.

(from *Earth's Climate: Past and Future*)