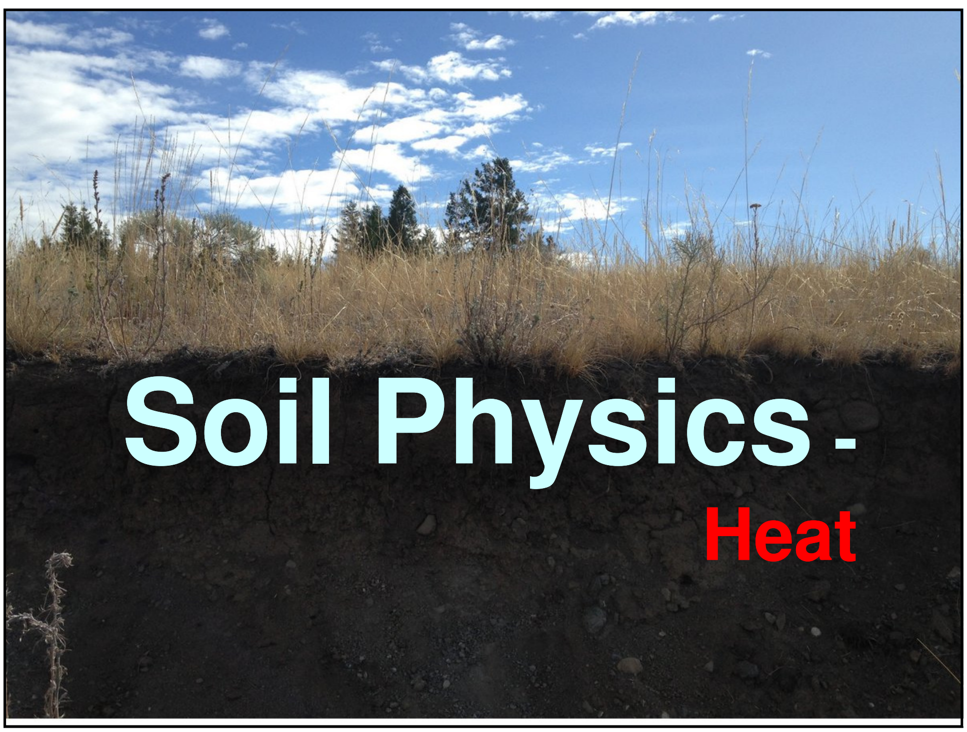
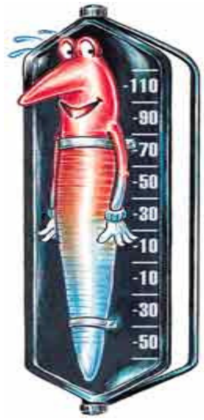

APBI 200
SOIL COMPONENTS


Soil Physics -
Heat

Lecture outline

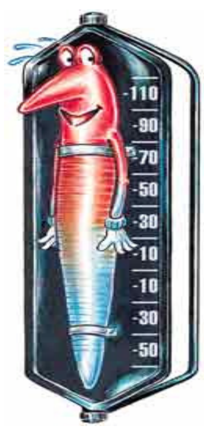
A. Soil thermal behavior

B. Soil thermal properties



What is heat?

- **Heat** represents transfer of energy from one body to another, due to the difference in temperature



What is temperature?

- **Temperature** is a measure of kinetic energy of individual molecules

Heat transfer is due to:

- **Conduction**
  (through molecular collisions)
- **Convection**
  (by mass movement of molecules)
- **Radiation**
  (by electromagnetic waves)

Fourier's Law of Heat Conduction

$$G = -\lambda \frac{dT}{dx}$$

G = heat flux density [J/m^{2}s]
λ = thermal conductivity [J/ms°C]
dT/dx = temperature gradient [°C/m]

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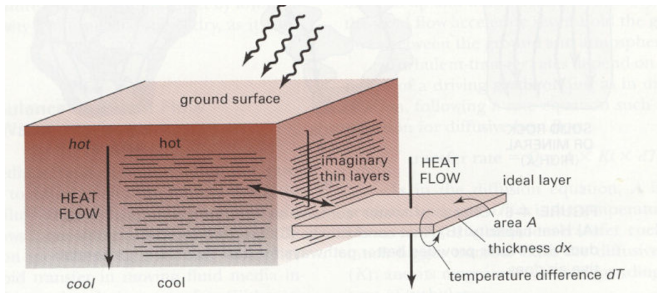
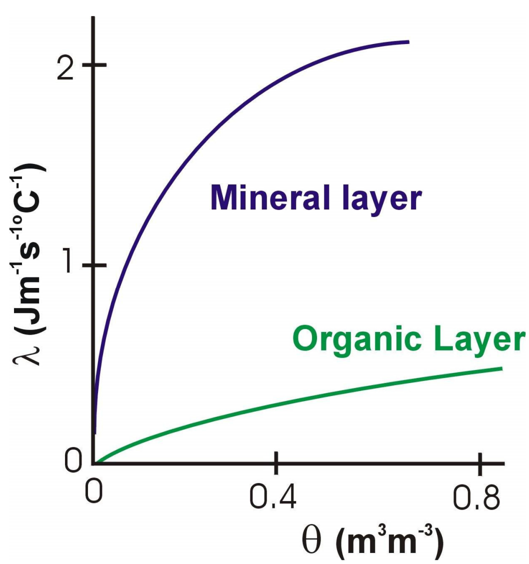


Heat flux density (G) is the rate of heat flow crossing the plane in unit time [J/m^{2}s].
The plane is always perpendicular to the axis of heat flow.

Thermal conductivity (λ)

describes heat flow in response to a temperature gradient [J/ms°C]

Thermal conductivity



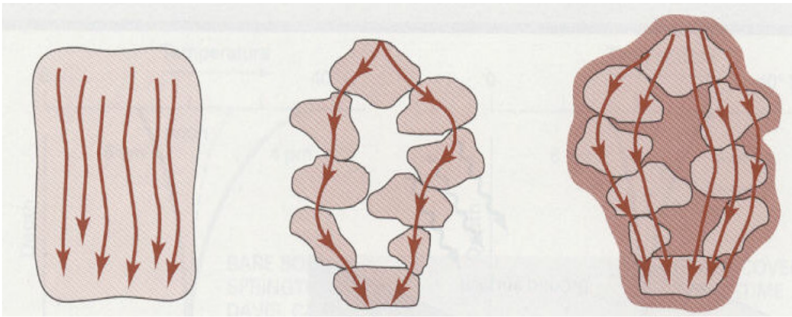
Heat conductor
versus
heat insulator

Thermal conductivity (λ) of soil components

Soil component	λ (J/msK°)
Quartz	8.368
Various soil minerals	2.930
Organic matter	0.251
Water	0.594
Air	0.026

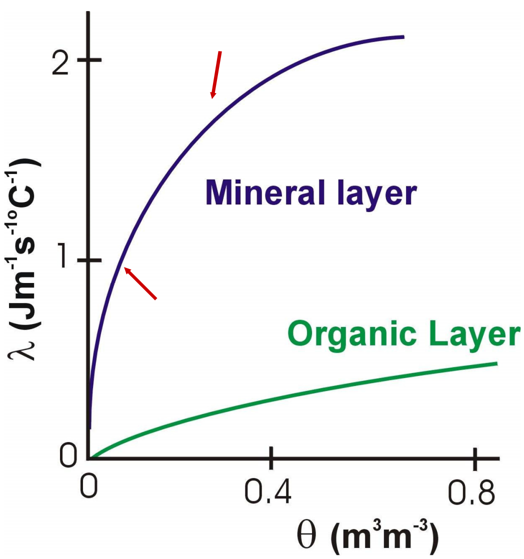
From van Wijk & deVries, 1963

Heat flow paths



Solid rock (high λ) Dry soil (low λ) Wet soil (high λ)

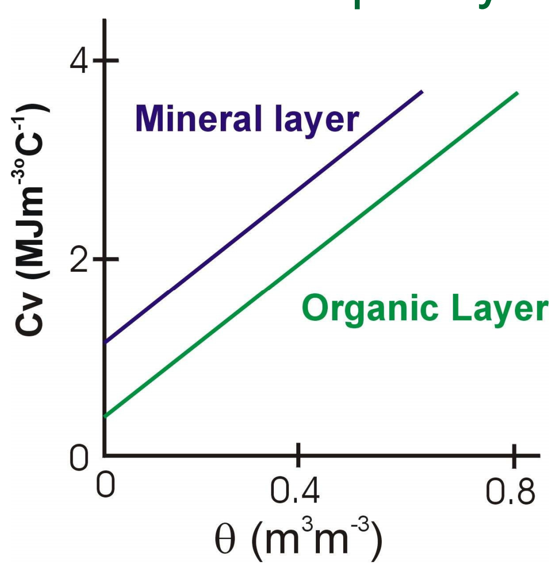
Thermal conductivity



Soil heat capacity (C_v)

represents the amount of heat needed to cause a 1°C change in temperature of a unit volume of soil [J/m^3°C]

Soil heat capacity



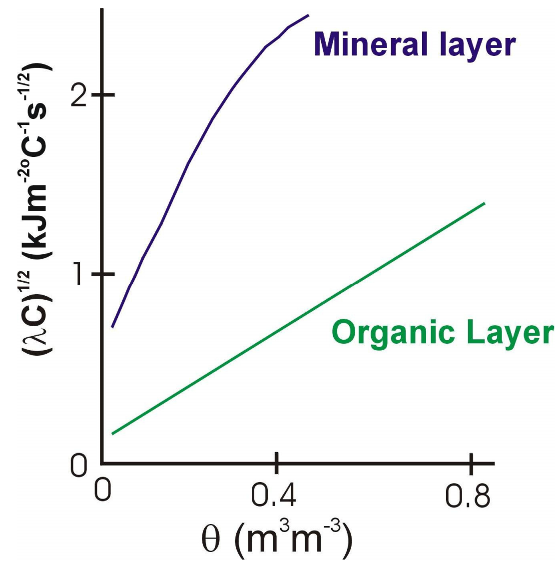
Water has **HIGH** heat capacity

Air has **low** heat capacity

Thermal admittance $(\lambda C_v)^{1/2}$

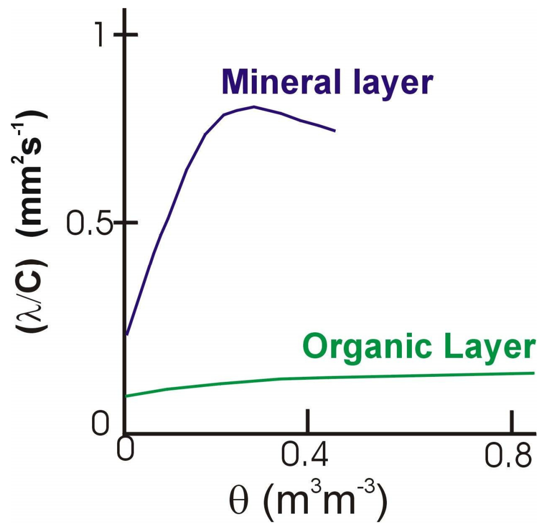
represents ability of soil to accept and release heat [kJ/m²°Cs]

Thermal admittance



Thermal diffusivity (λ / C_v) is an indication of **subsurface** temperature response to surface temperature change [m^2/s]

Thermal diffusivity



Why are soils with low thermal admittance subject to extreme surface temperature fluctuations?

Why does high thermal diffusivity result in large and rapid subsurface temperature responses to surface temperature change?

Practices that can increase admittance and diffusivity

- Adding sand to organic soil
- Cultivation
- Adding water to dry soil
- Removal of organic surface layers