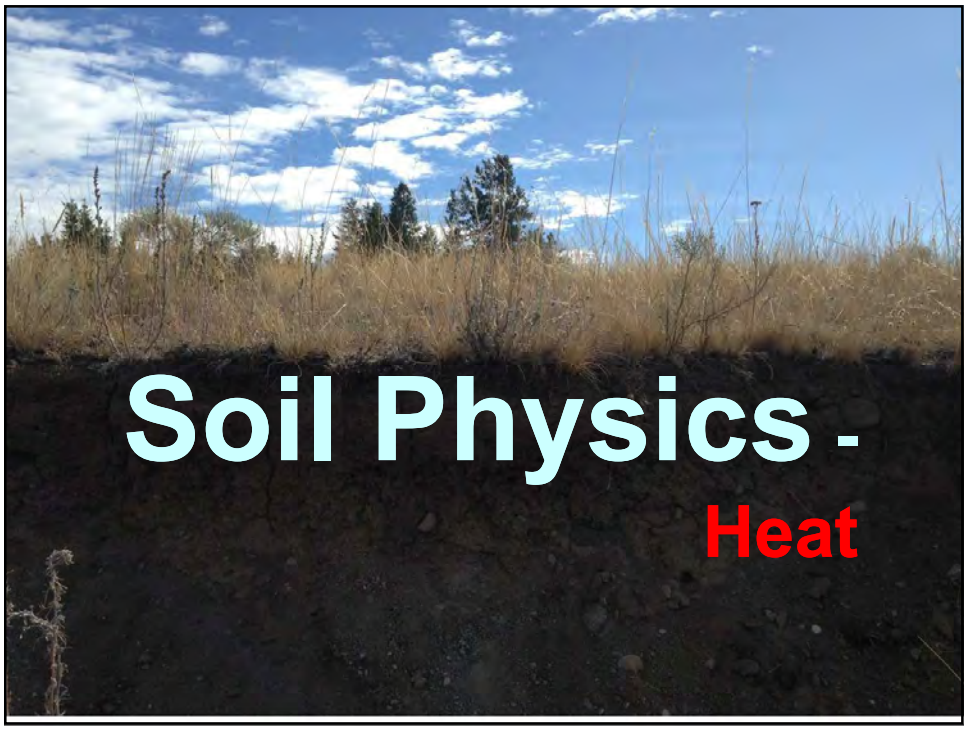

APBI 200
SOIL COMPONENTS


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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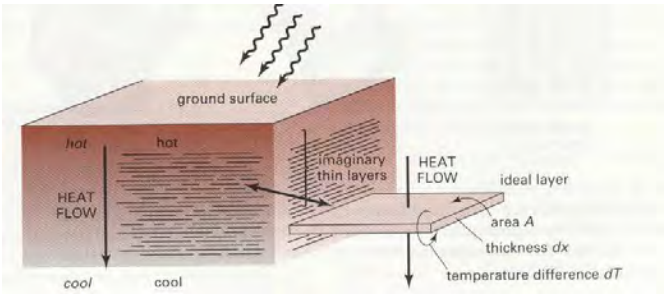
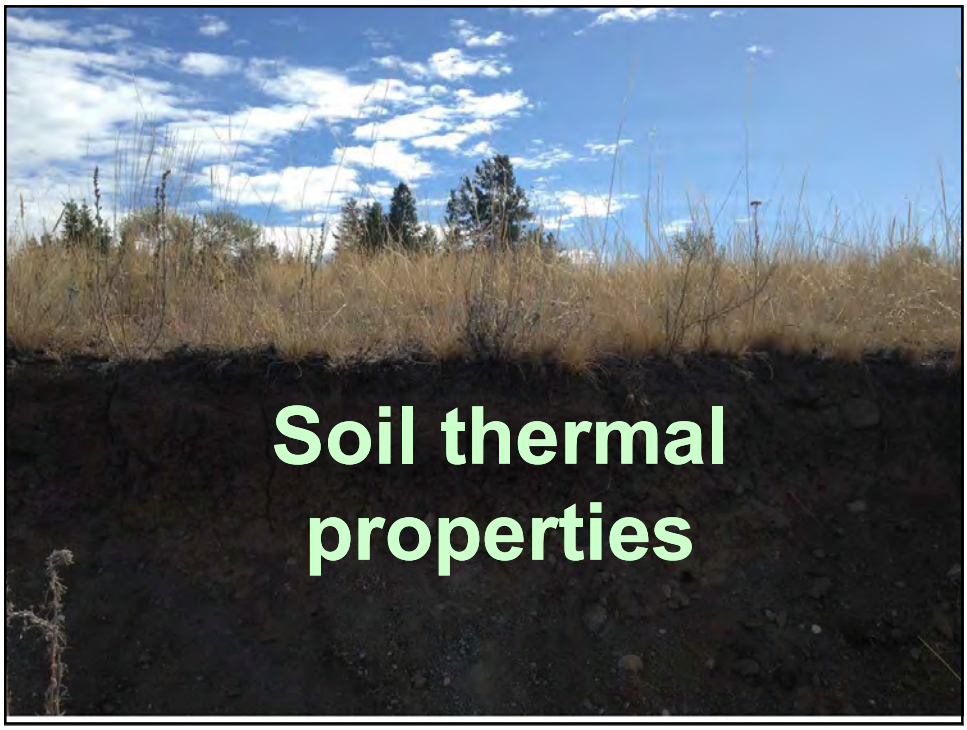


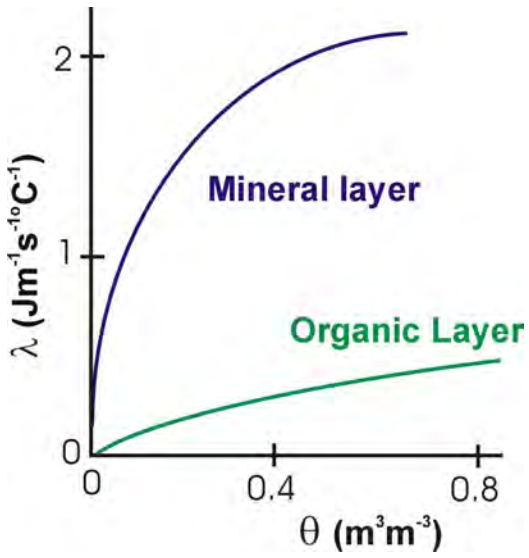
Heat flux density (G) is the rate of heat flow crossing the plane in unit time [J/m^{2}s].
The plane is always perpendicular to the axis of heat flow.



Thermal conductivity (λ)

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

Thermal conductivity



Heat conductor

versus

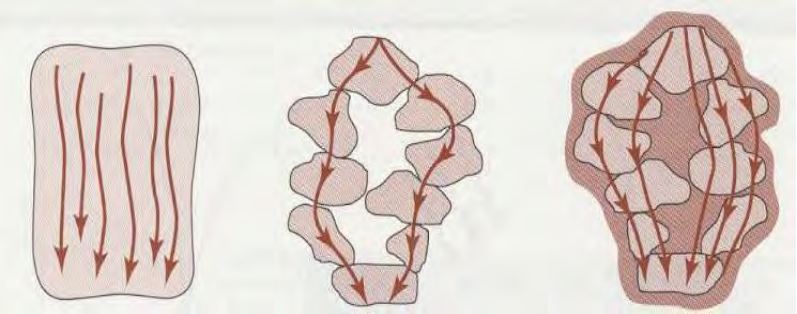
heat insulator

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

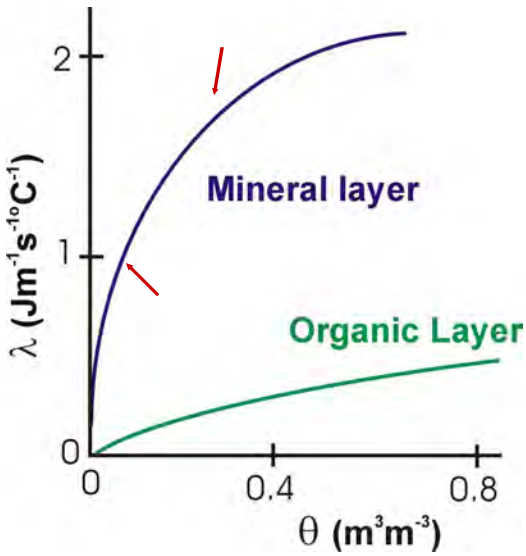
From van Wijk & deVries, 1963

Heat flow paths



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

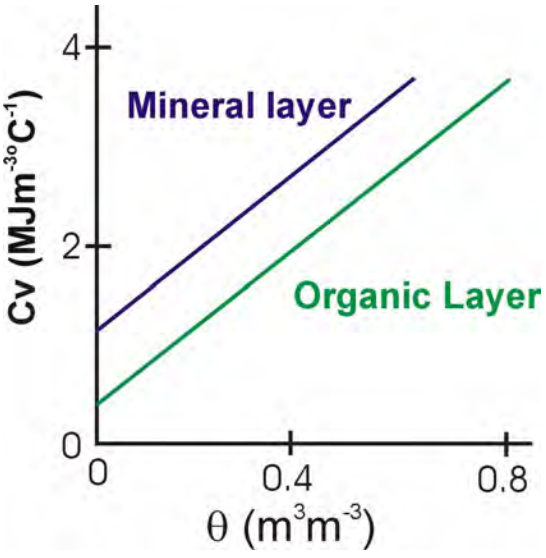
Thermal conductivity



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



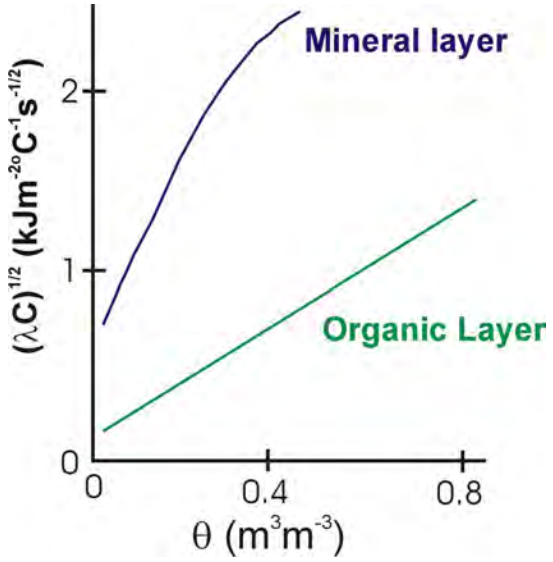
Water has **HIGH** heat capacity

Air has **low** heat capacity

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

represents ability of soil to accept and release heat [kJ/m^2°Cs]

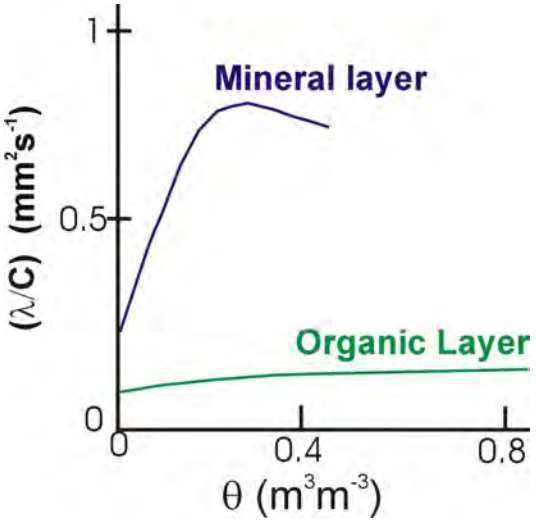
Thermal admittance



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?

Practices that can increase admittance and diffusivity

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