

# Movement of water through snow

GEO 4430, snow hydrology  
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## Water movement through a snowpack

**cold content = the energy needed to bring the snow/ ice volume to 0°C**

How much water is needed to overcome the cold content?

$H_s = \Delta T m_s c_s$	(cold content)	density of snow, $\rho_s = 400 \text{ kg m}^{-3}$
$H_{rf} = m_w L$	(heat release while refreezing)	density of water, $\rho_w = 1000 \text{ kg m}^{-3}$
		specific heat of snow, $c_s = 2100 \text{ J kg}^{-1} \text{ K}^{-1}$
		latent heat of fusion, $L = 0.333 \times 10^6 \text{ J kg}^{-1}$

$H_s = H_{rf} = 840 \text{ kJ}$   
Solving for  $V_w = m_w \rho_w^{-1}$  yields  $V_w = 2.5 \text{ l}$

T distribution

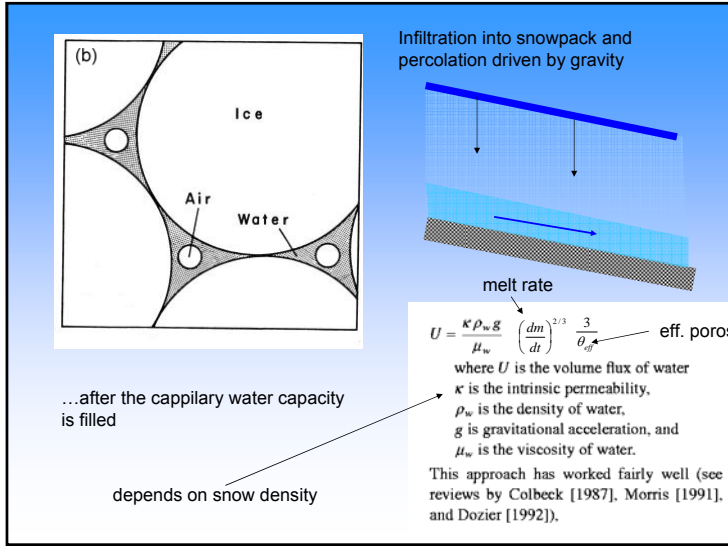
## Motion of water through a snowpack

Snow metamorphism

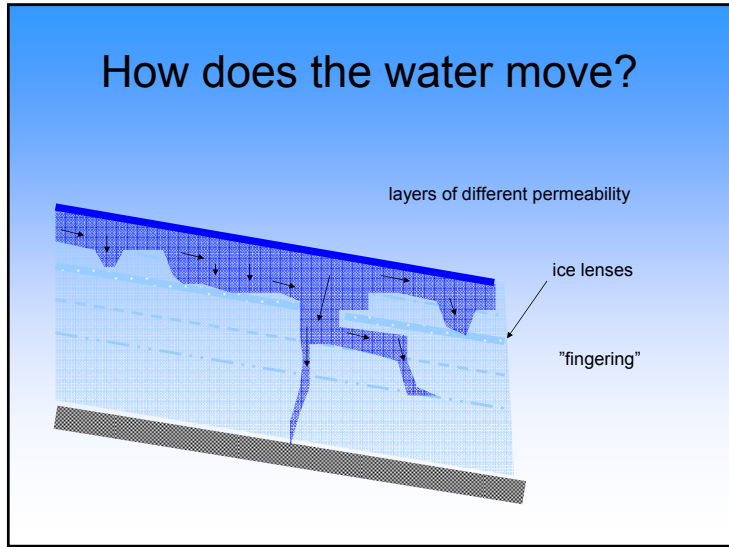
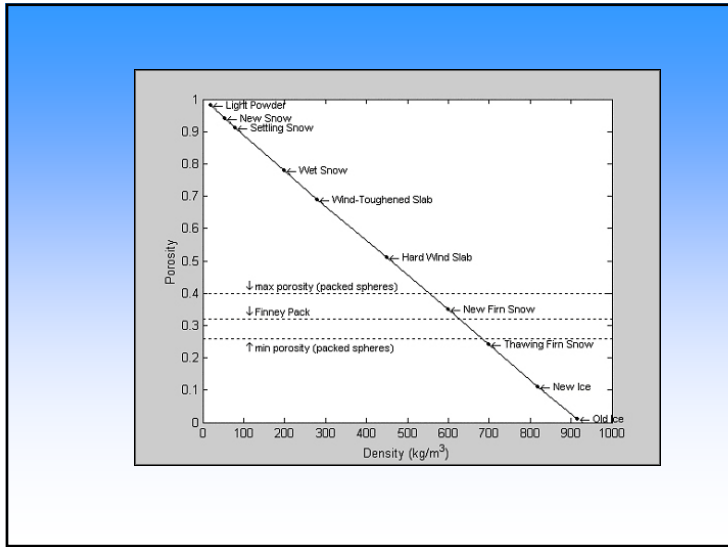
(a) Constructive metamorphosis (faceting),

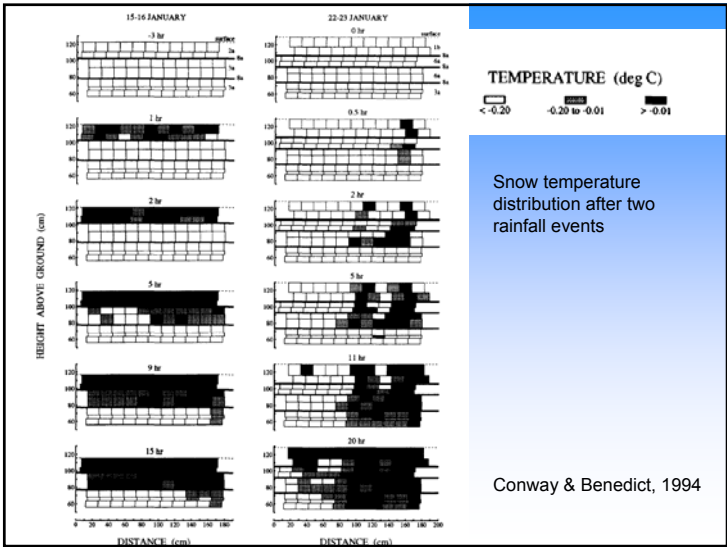
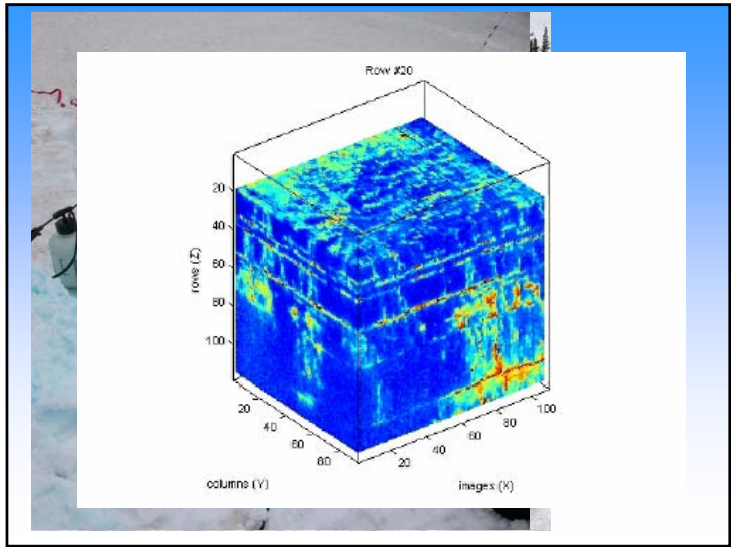
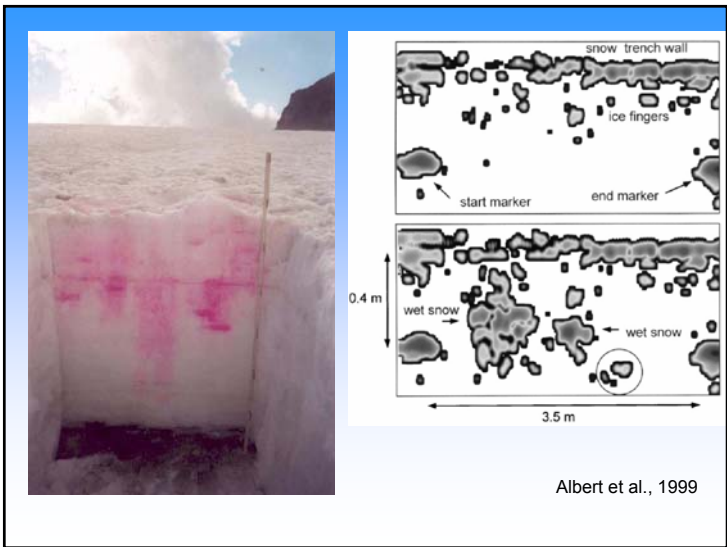
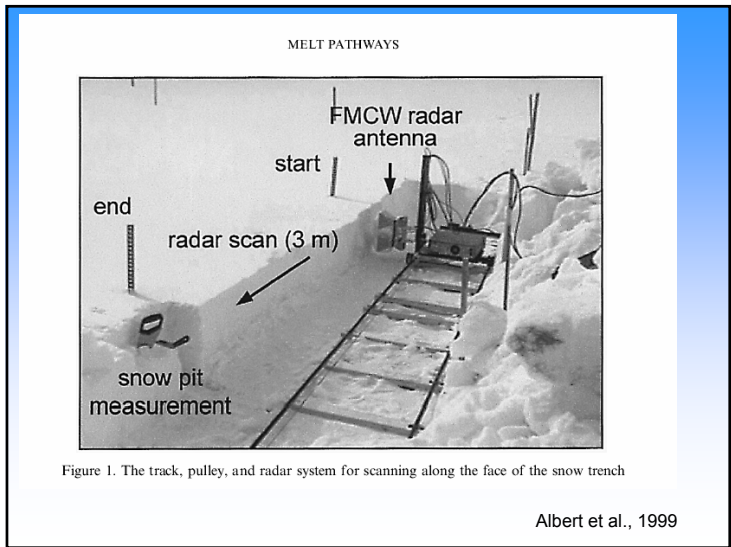
(b) Destructive metamorphosis (rounding),

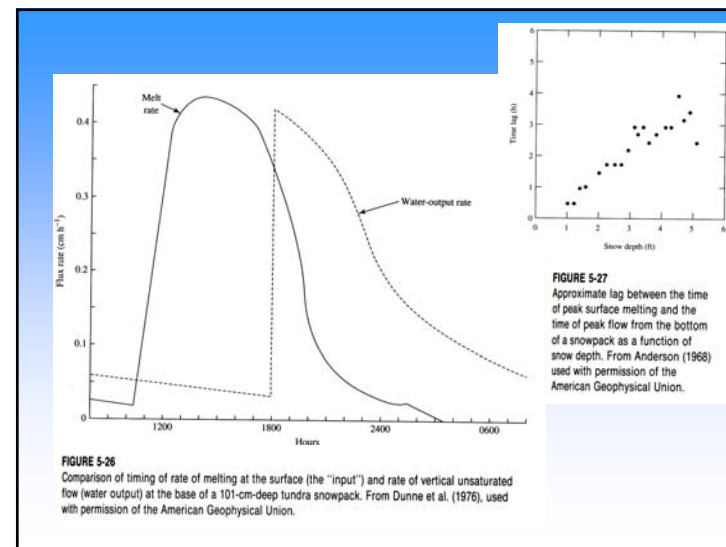
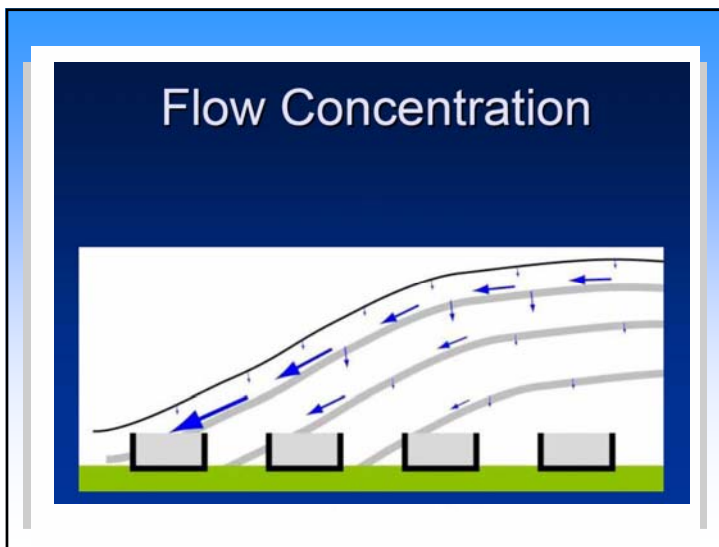
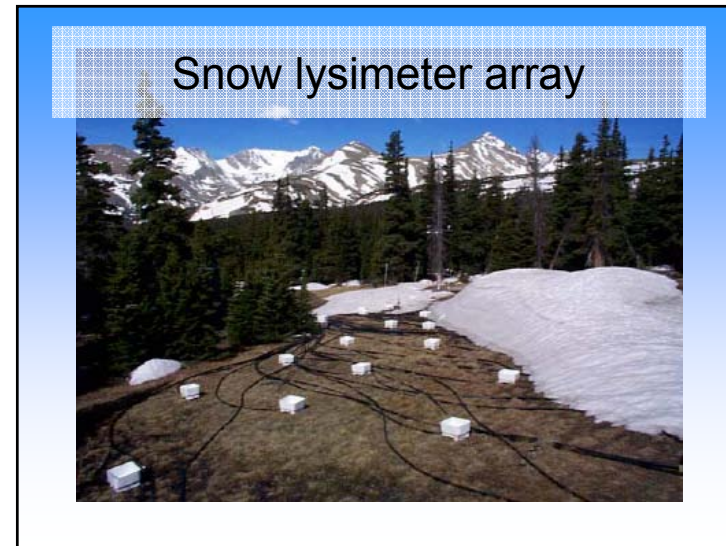
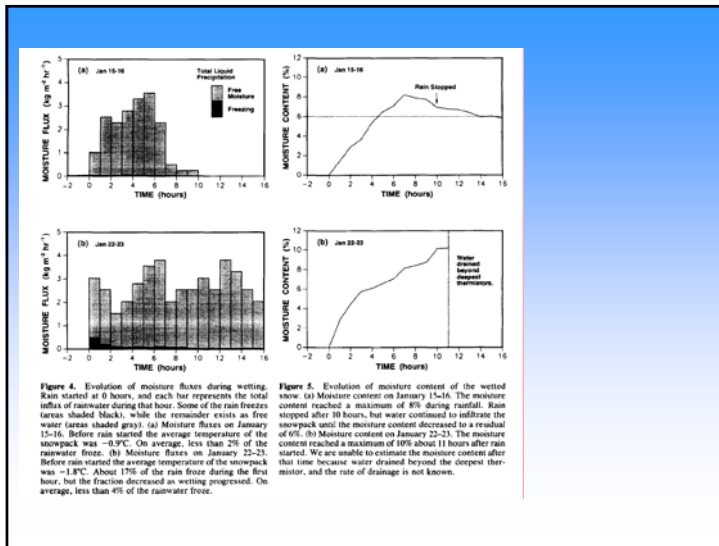
(c) Sintering

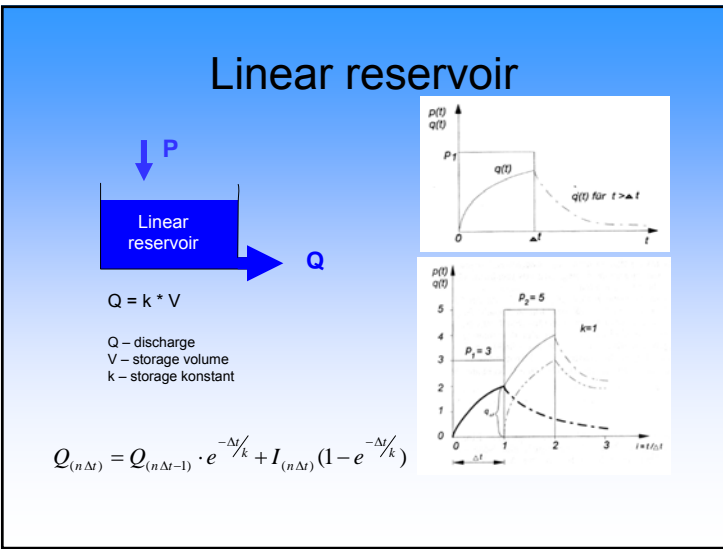
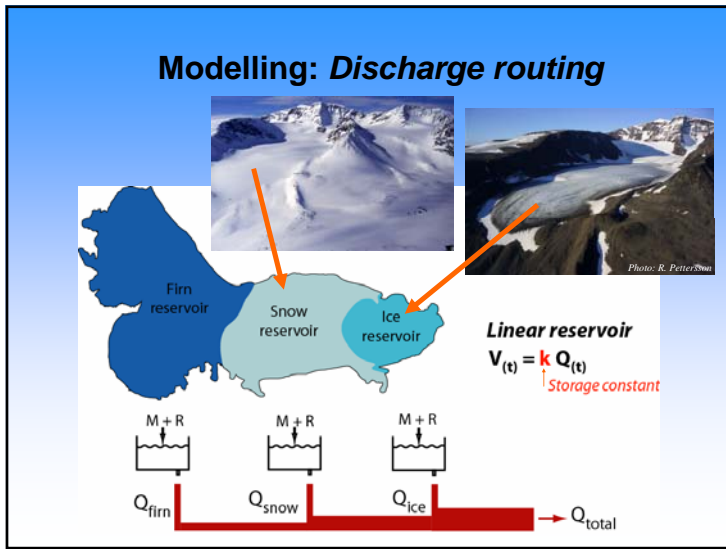
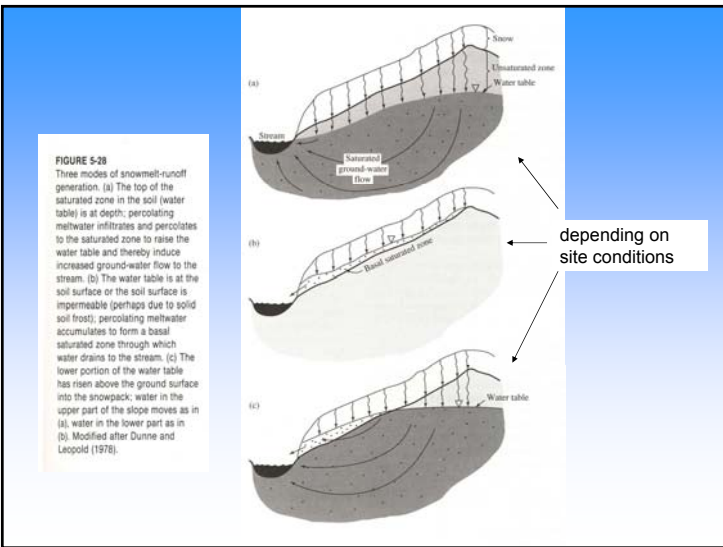
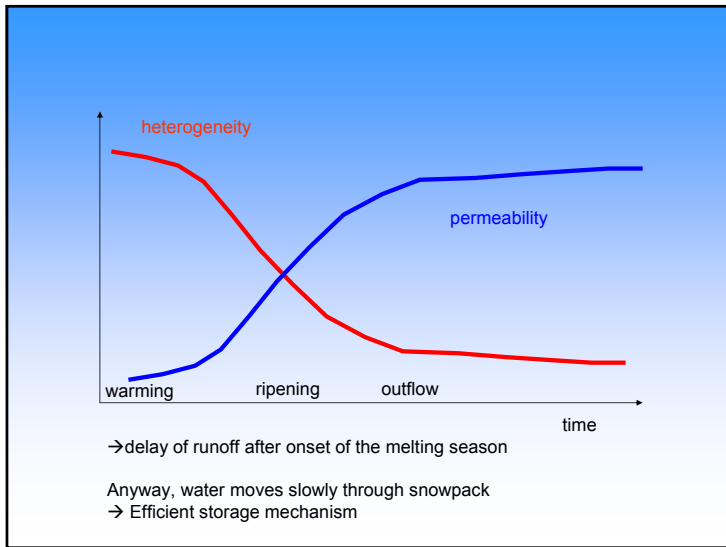


- ### Stages of snowpack evolution from a hydrological point of view
- Warming phase: increase T until isothermal conditions: T = 0 C
  - Ripening phase: filling the field capacity / retention capacity
  - Output phase: outflow from the snowpack occurs

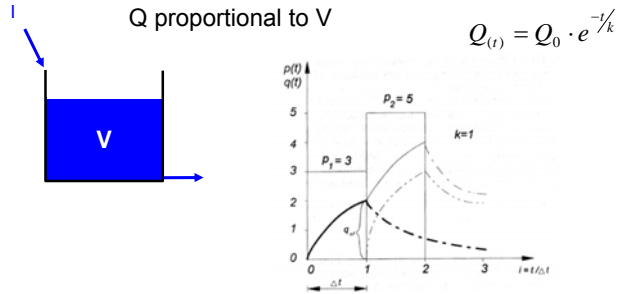








## Linear reservoir



$$Q_{(n\Delta t)} = Q_{(n\Delta t-1)} \cdot e^{-\Delta t/k} + I_{(n\Delta t)} (1 - e^{-\Delta t/k})$$

## Water movement: summary

- Snowpack similar to a porous aquifer after removal of cold content
- 3 stages of snowpack hydrological evolution: warming, ripening, outflow
- Snowpack permeability depends on density, grain size, temperature... → highly heterogeneous
- With maturing of the snowpack, the permeability becomes larger and more homogeneous