Darcy's law

The water flux in a porous medium is proportional to the gradient of **hydraulic head (total water potential)**, with the proportionality given by the **hydraulic conductivity (depending on soil moisture)**

how tightly water is held by:
(1) the soil (matric potential) +
(2) elevation head (gravitational potential)

how easily water moves through the soil; in unsaturated conditions shrinks rapidly as the soil dries

Neglecting lateral fluxes....

$$q \;=\; -\,K(\theta)\left(\frac{\partial H}{\partial z}\right)$$

specific discharge (m/s)

hydraulic conductivity (m/s)

hydraulic gradient (adimensional)

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Neglecting lateral fluxes....

by discretizing the soil column, the vertical head gradient at interface between two adjaccent layers is approximated by a finite difference

$$q = -K(\theta)\left(\frac{\partial H}{\partial z}\right) \approx -K(\theta)\left(\frac{\Delta H}{\Delta z}\right)$$

specific discharge (m/s)

hydraulic conductivity (m/s)

soil moisture (m3/m3)

hydraulic gradient

soil water potential ($MPa = kgm^{-1}s^{-2}$)

gravitational potential (m)

$$q_{l+1/2} = -K^{effective}_{l+1/2}\left(\frac{H_{l+1}-H_{l}}{z_{l+1}-z_{l}}\right),\ H_{l} = \frac{\psi_{l}}{p_{w}g} + z_{l}$$

gravitational acceleration (ms^{-2})

the conductivity at the interface could be approximated using the harmonic mean of Ks values from the two adjacent layers

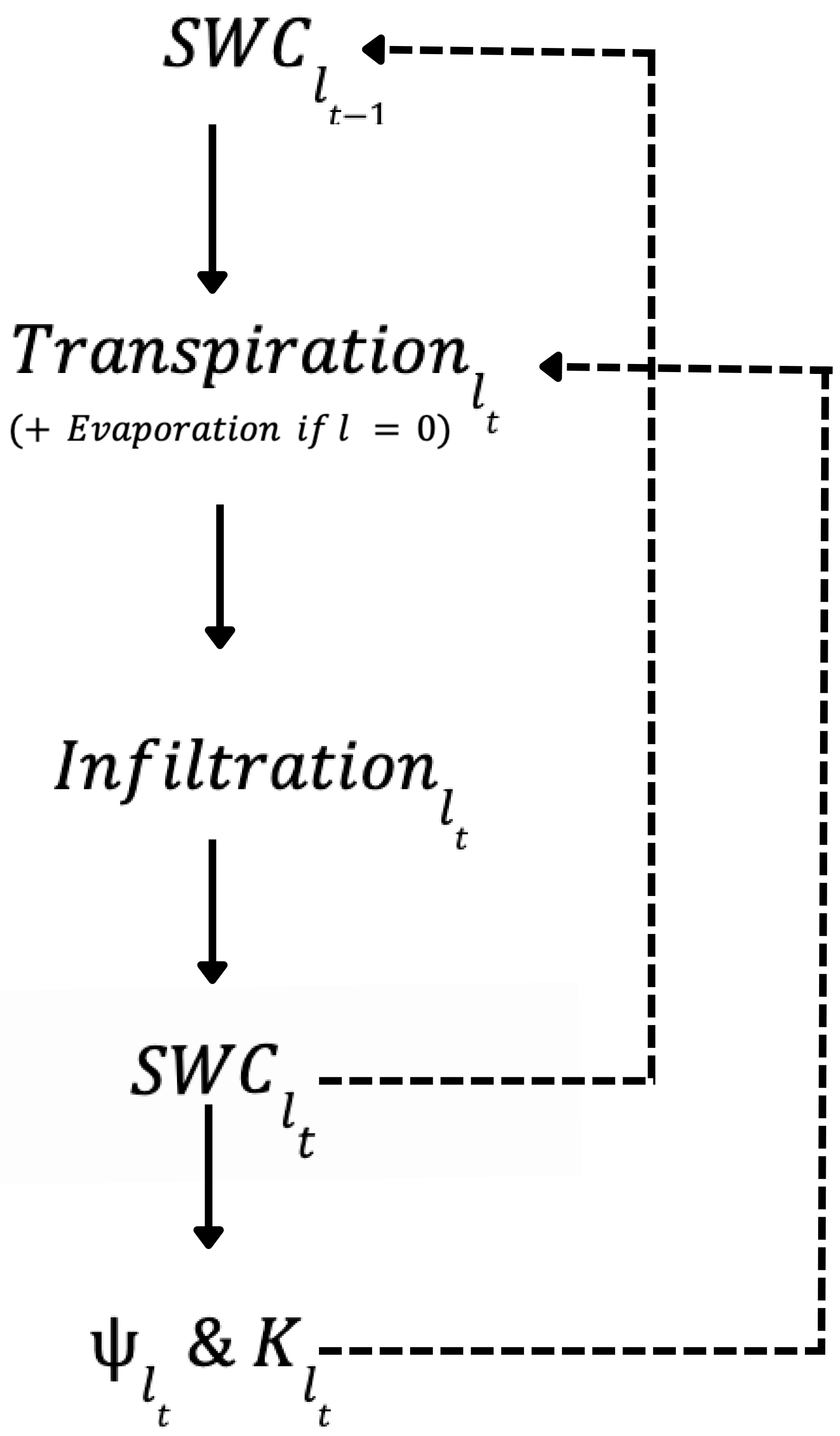
water density (kgm^{-3})

One possible simplification, based on Liu et al. 2017 (PNAS) and, is to calculate the upward flux by the simplified darcy's law equation and the downward flux by using the bucket model logic of percolation. [(**SPAC:** Liu et al., 2017 - PNAS); (**JULES:** Best et al., 2011 - Geosci. Model Dev)]

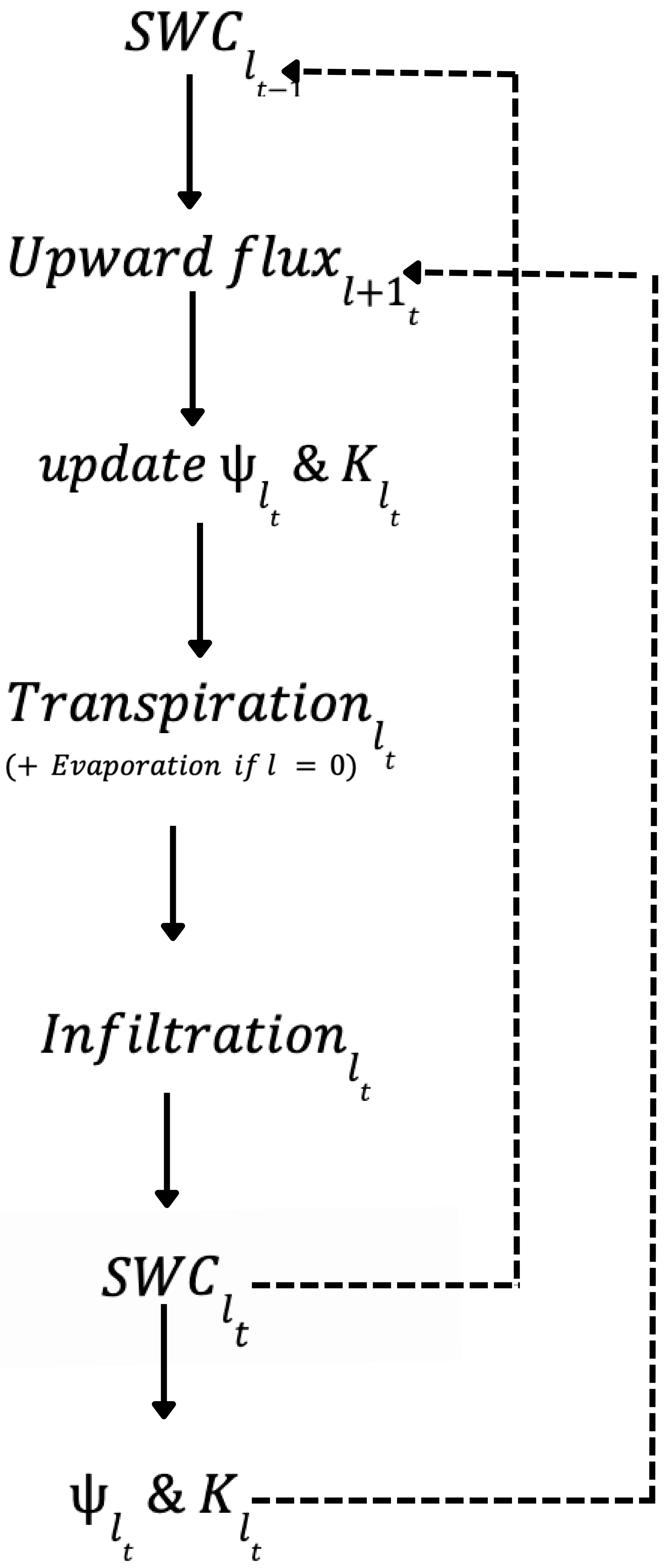
$$q_{l+1/2}^{cap} = -K_{l+1/2}^{effective}\left(\frac{\Psi_{l+1}-\Psi_{l}}{p_{w}g\Delta z} + 1\right)$$

To guarantee only upward flux:

$$q_{l+1/2}^{cap} = max(q_{l+1/2}^{cap},\ 0)$$



$SWC_{l_{t-1}}$
$Transpiration_{l_t}$
(+ Evaporation if $l = 0$)
$Infiltration_{l_t}$
SWC_{l_t}
ψ_{l_t} & K_{l_t}



$SWC_{l_{t-1}}$
$Upward\ flux_{l+1_t}$
update ψ_{l_t} & K_{l_t}
$Transpiration_{l_t}$
(+ Evaporation if $l = 0$)
$Infiltration_{l_t}$
SWC_{l_t}
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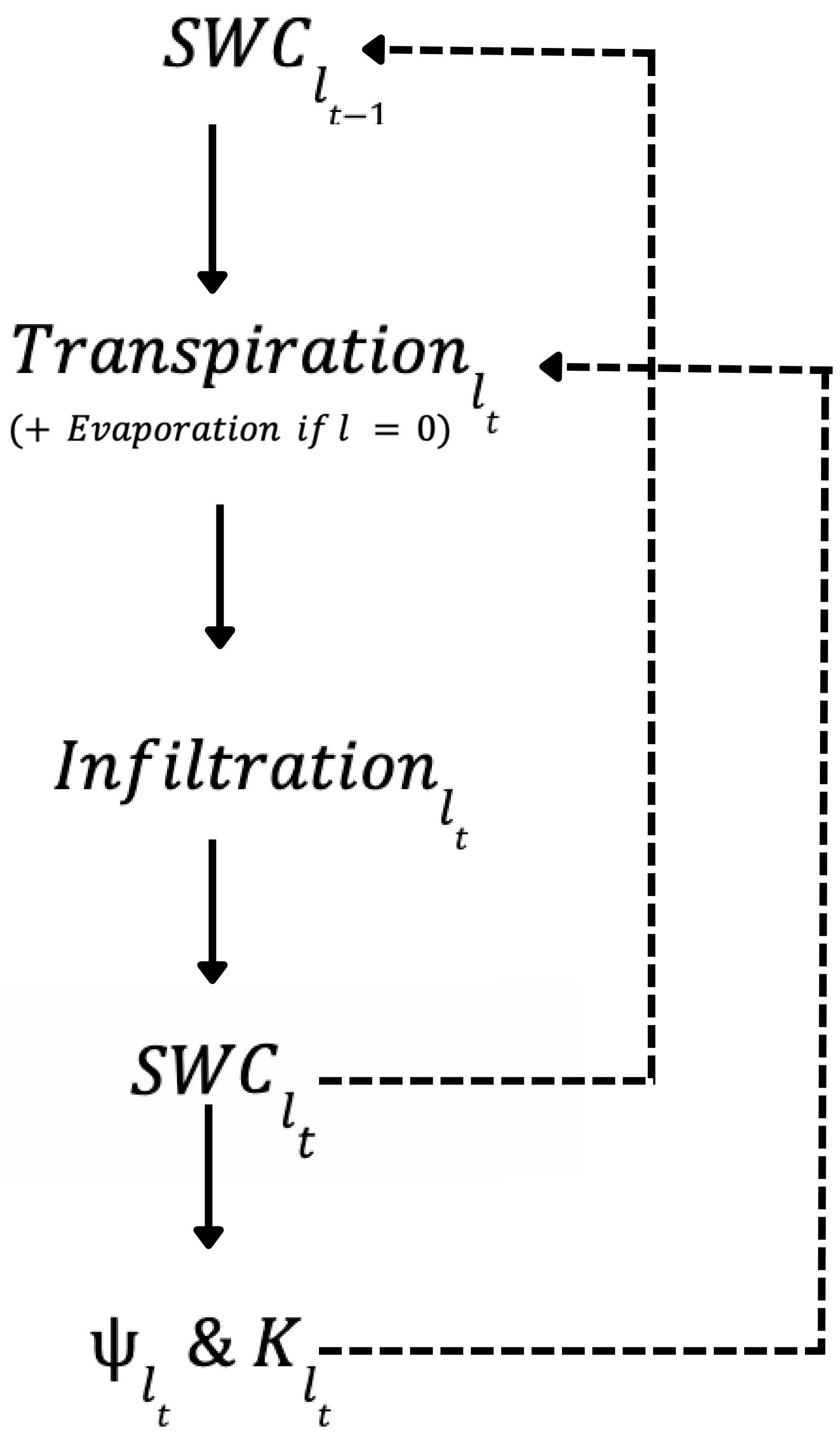
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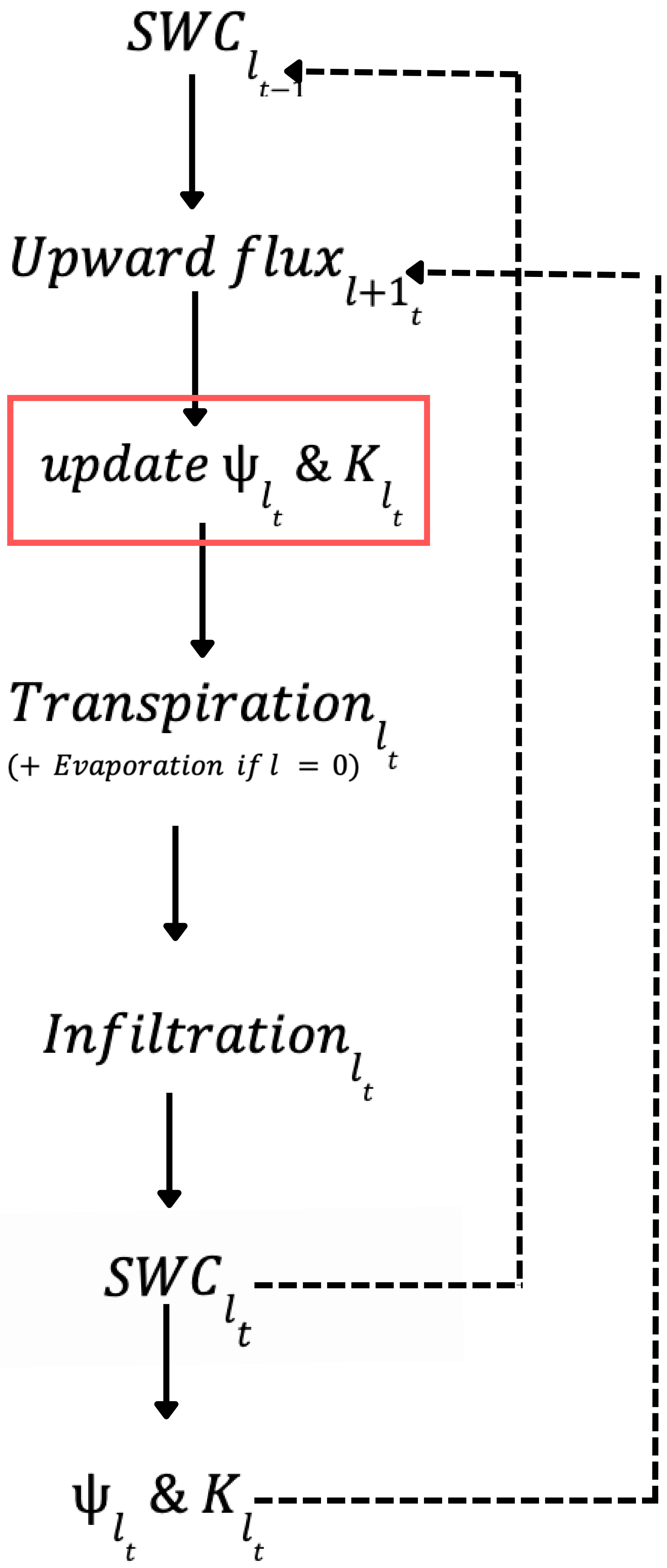
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