DOES MACROPORE FLOW IN NO-TILL SYSTEMS FLUSH OR BYPASS MOBILE SOIL NITROGEN AFTER HARVEST?

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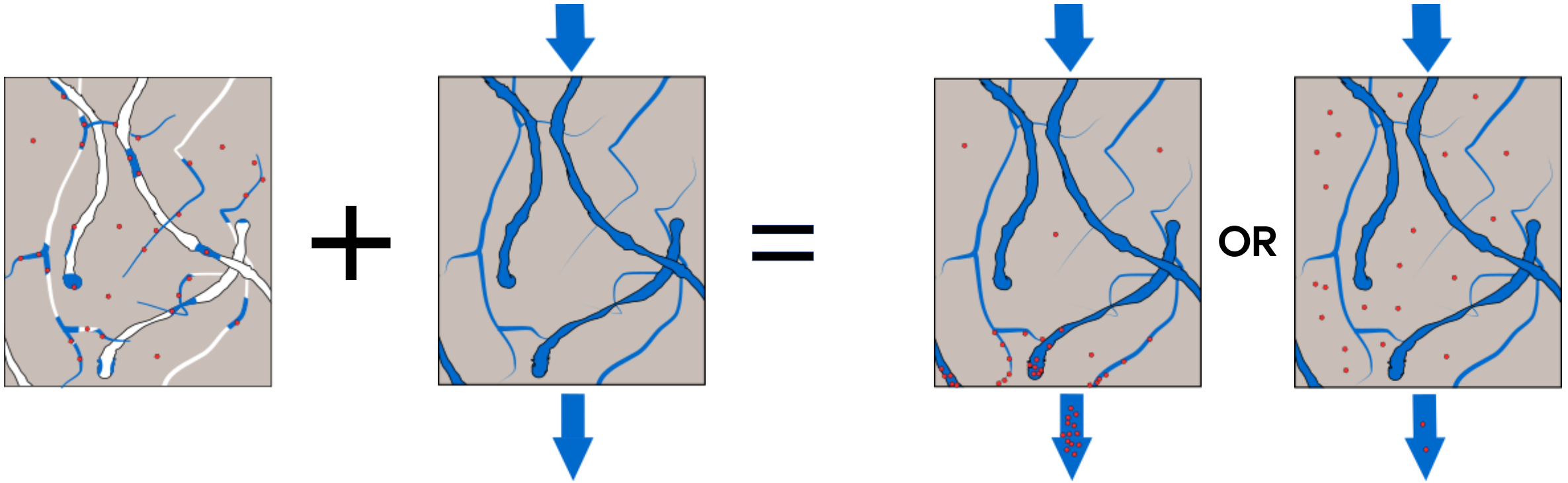
Background

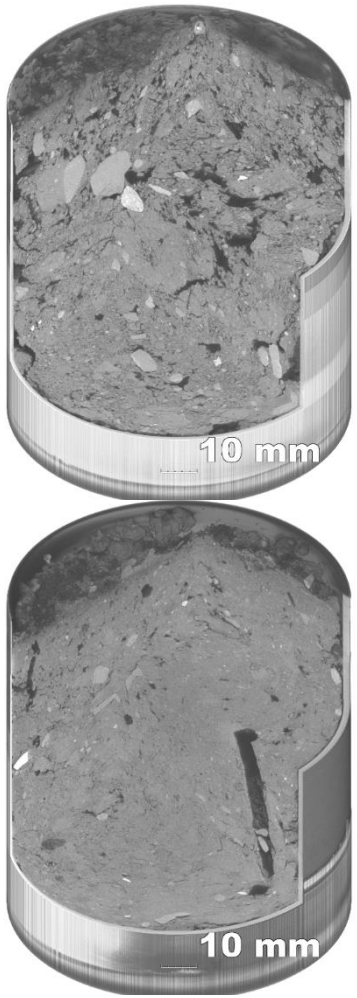
Mobile N after harvest

Macropore flow

Increased or reduced leaching?



The study in very few words:



CT

NT

Intact soil cores, 20x20 cm

Saturation in Ca^{2+} 0.05M + Br^- 0.01M for 7 days

Simulated rain: 10 mm/h for 20 hrs.

10-minute ^3H_2O pulse

Air suction equivalent to -10 cm

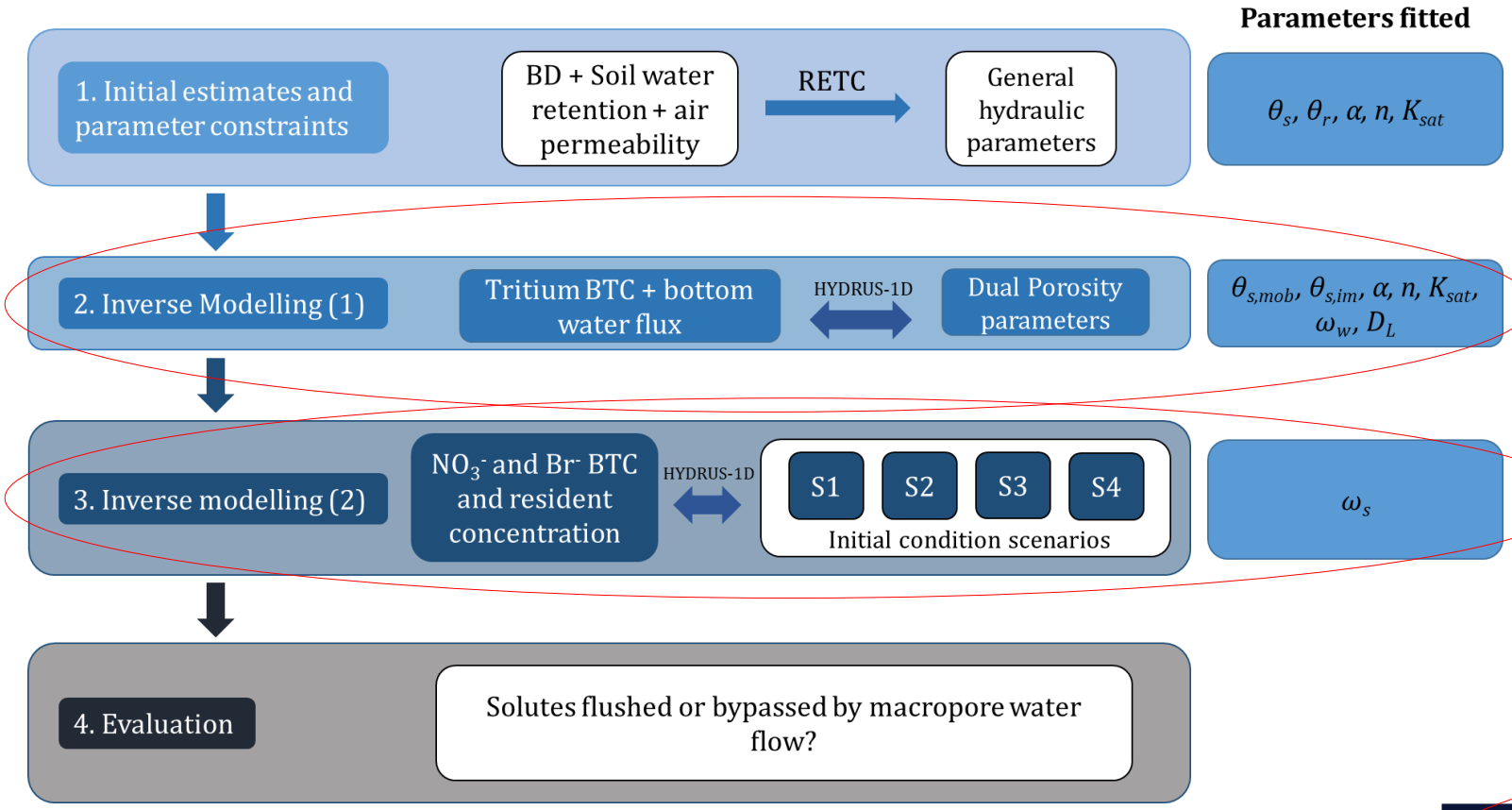
Sample collection: Every 10 minutes for 1 hr. and hourly up to 20 hrs.

2 Tillage treatments:
- Conventional Till (CT)
- No-till (NT)

2 Sets of intact cores
- Reference (only soaking)
- Experimental (soaking + simulated rain)

3 tracers:
- Tritium pulse
- Bromide added by soaking
- Native NO_3^- (from the field)

2 main analyses:
- BTCs (^3H, Br^-, NO_3^-)
- Dissection at 4 depths



Modelling work distributed over several rounds of inverse modelling

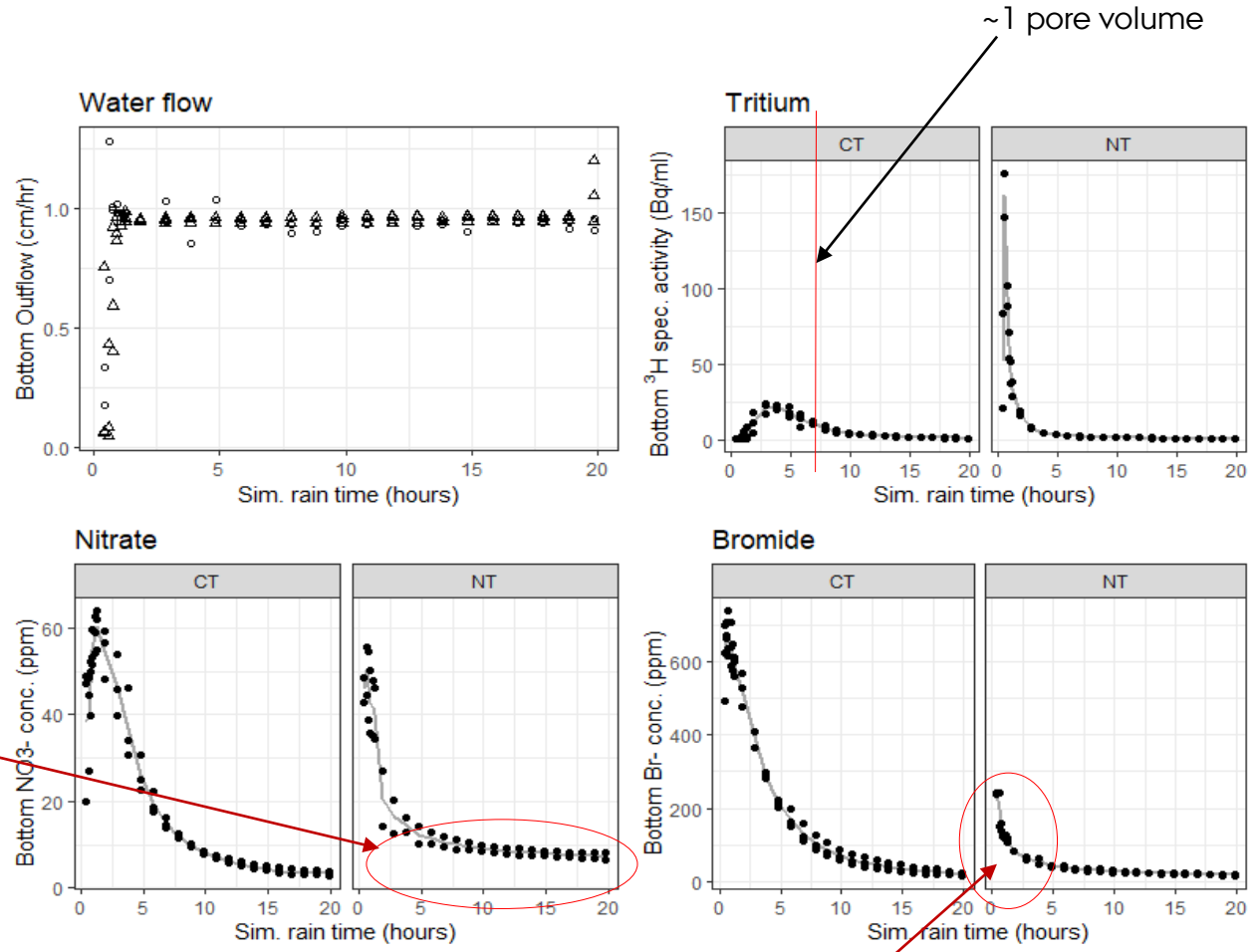
Inverse modelling in HYDRUS-1D:

- Dual porosity (mobile-immobile) water flow
- Dual porosity (mobile-immobile) solute transport
- Van Genuchten-Mualem theory
- Richard's equation and advection dispersion functions in the mobile phase
- No vertical flow or solute movement in immobile phase
- 1st-order kinetics mass transfer of water and solutes between phases (horizontal movement)

Four initial solute distribution scenarios:			
S1	S2	S3	S4
$c_{mob} = c_{im}$	$c_{im} = 0$	$c_{mob} = 0$	Manually adjusted

Breakthrough curves

- Rapid initiation of drainage
- Quick pulse leaching of Tritium in NT
- Some degree of macropore flow in CT
- Earlier leaching of bromide and nitrate
- “Tail” of leached nitrate in NT only
- Limited infiltration of bromide in NT



Nitrate “tail”

Minimal Br⁻ intrusion

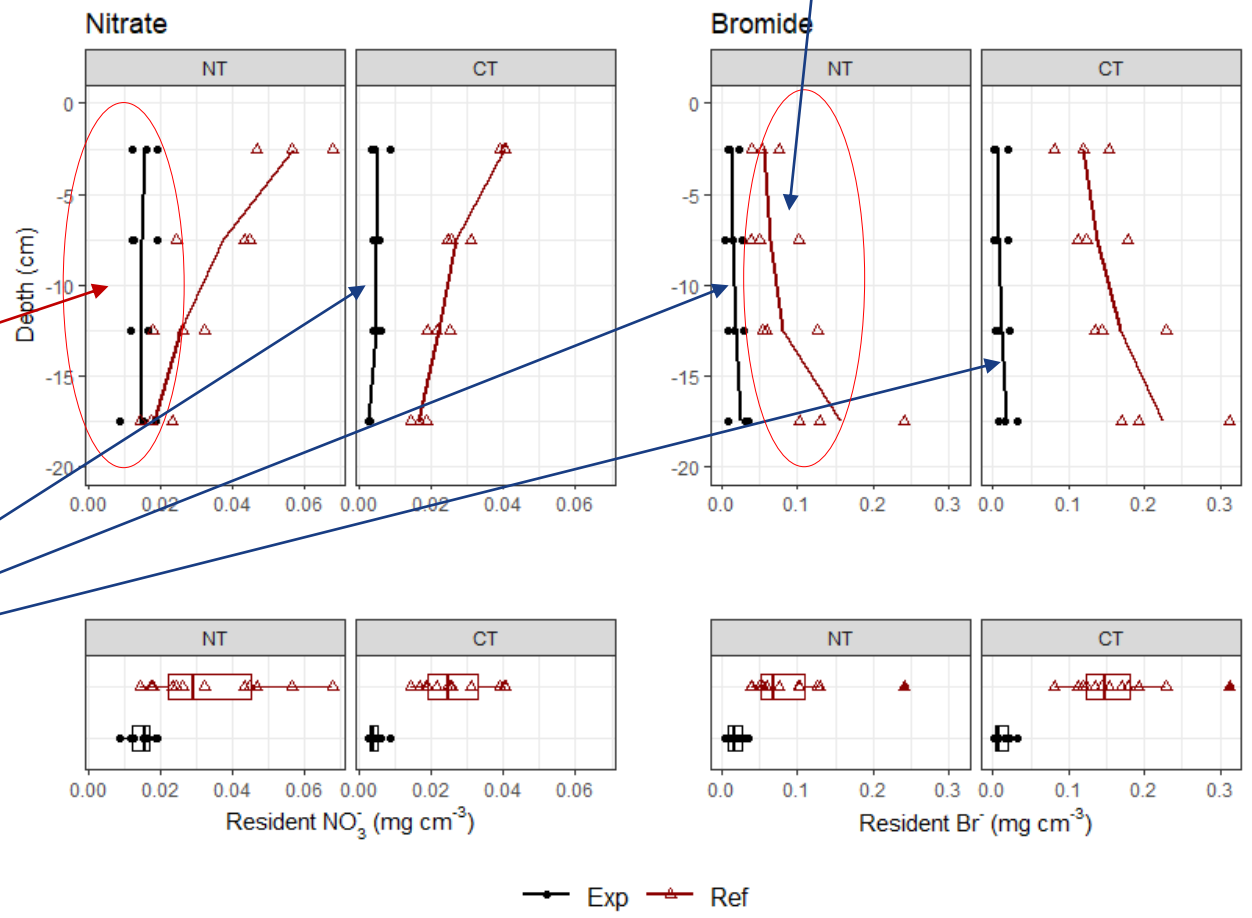
Resident concentrations

- Lower initial Br^- conc. in NT
- Higher **final** NO_3^- in NT

Less Br^- intrusion in NT

Bypass of nitrate by macropore flow

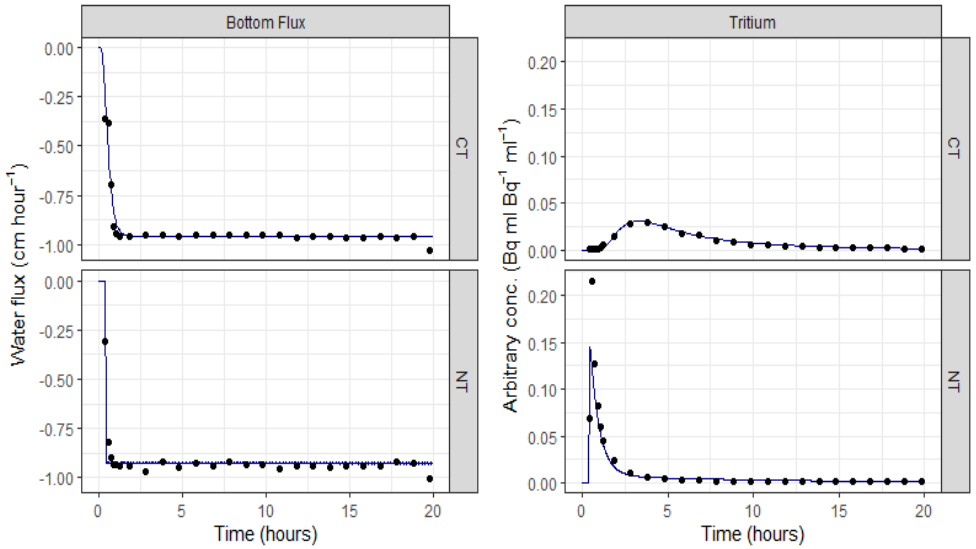
No bypass (thorough leaching)

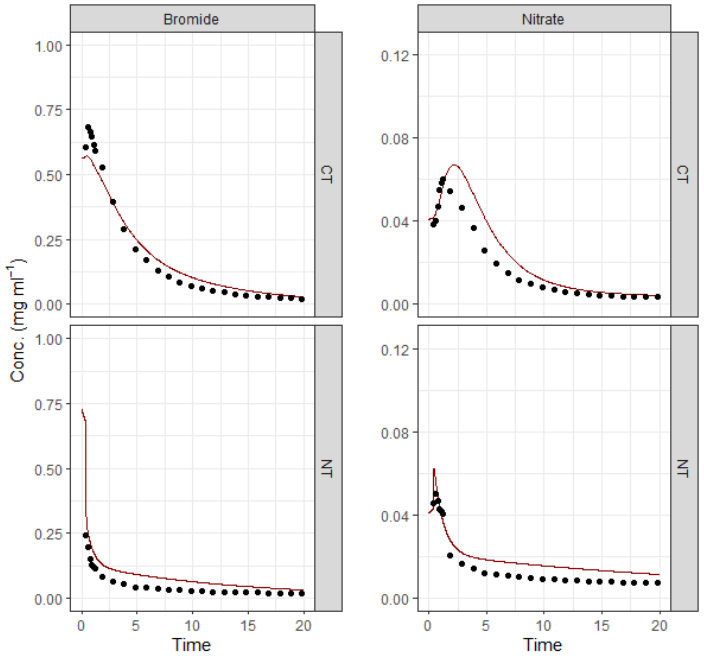


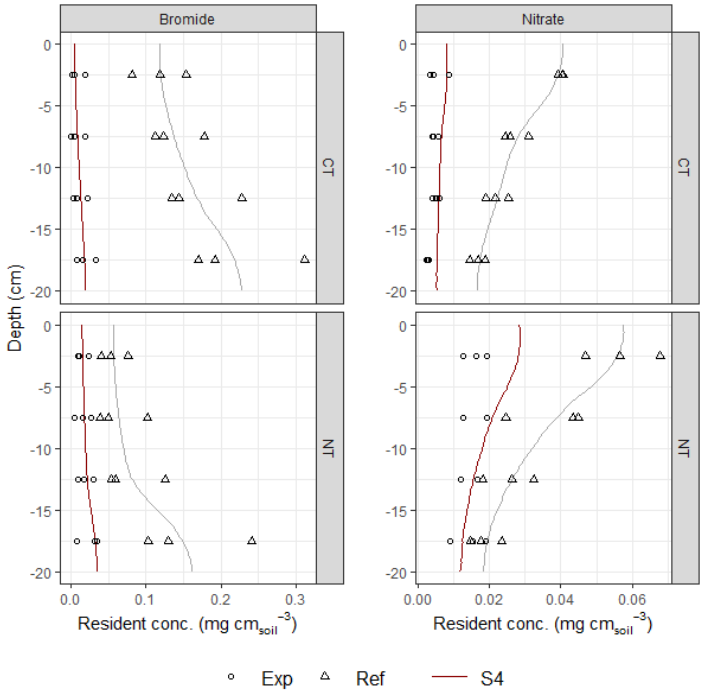
HYDRUS modelling

- $\theta_{sat,mob}$ = 0.35 in CT and $\theta_{sat,mob}$ = 0.05 in NT
- Greater solute transfer coefficients for Br^- than NO_3^-
- Solute distribution close to equilibrium (but not quite)
- The model simulated a bypass effect for NO_3^- in NT.

		Nitrate		Bromide	
	Scenario	ω_s [T^{-1}]	RMSE	ω_s [T^{-1}]	RMSE
CT	S4	0.003	0.0076	0.015	0.0495
NT	S4	0.0075	0.0063	0.025	0.0447







Biopore model in Daisy (1-D)

- Biopores modelled as cylinders
- Sink-source approach
- Biopores activated near saturation
- Critical pressure for deactivation of biopores

Matrix flow and transport

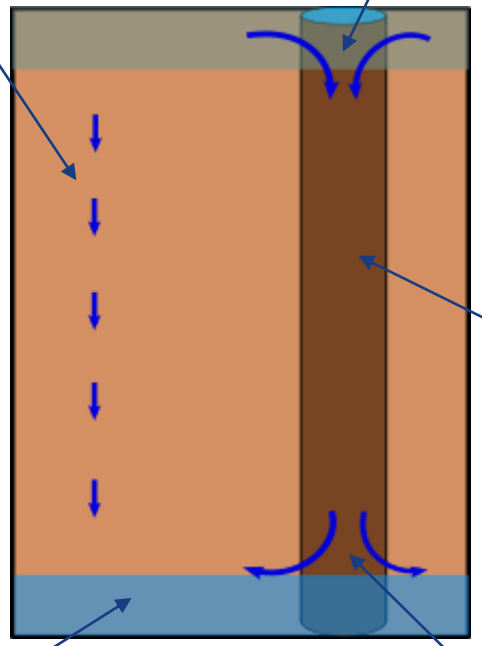
$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z}\left[K(h)\left(\frac{\partial h}{\partial z} + 1\right)\right] + \Gamma_w$$

$$\frac{\partial \theta c}{\partial t} = \frac{\partial}{\partial z}\left[\theta D\left(\frac{\partial c}{\partial z}\right)\right] - \frac{\partial qc}{\partial z} + \Gamma_s$$

Biopore sink/source

Matrix flow: Idealized Richard's equation

Biopore sink

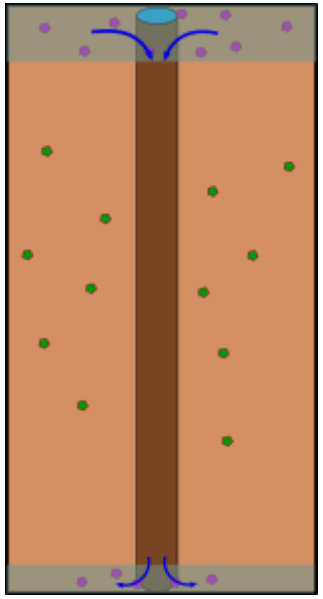


Instantaneous transfer

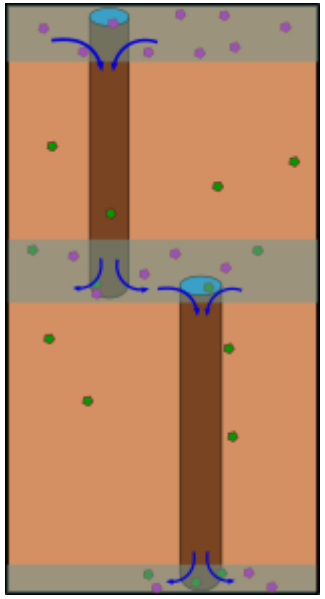
(evt.) saturated matrix

Biopore source

Bypass of matrix by surface solutes and bypass of resident solutes by macropore flow

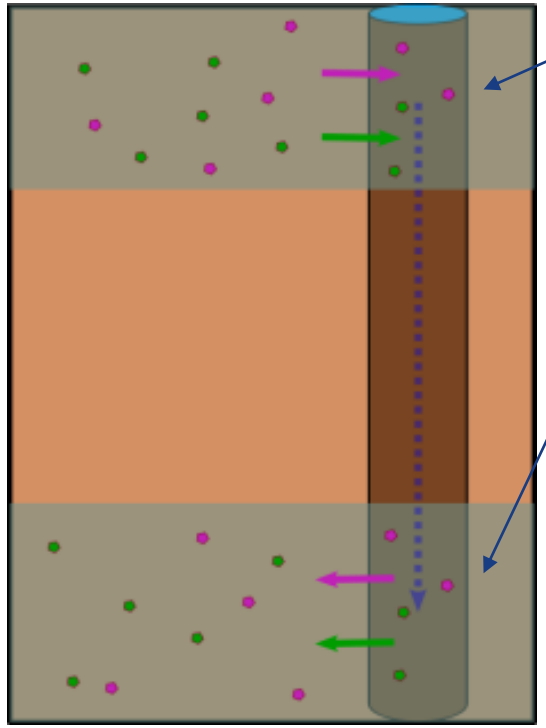


Biopore-matrix interaction at sinks and sources



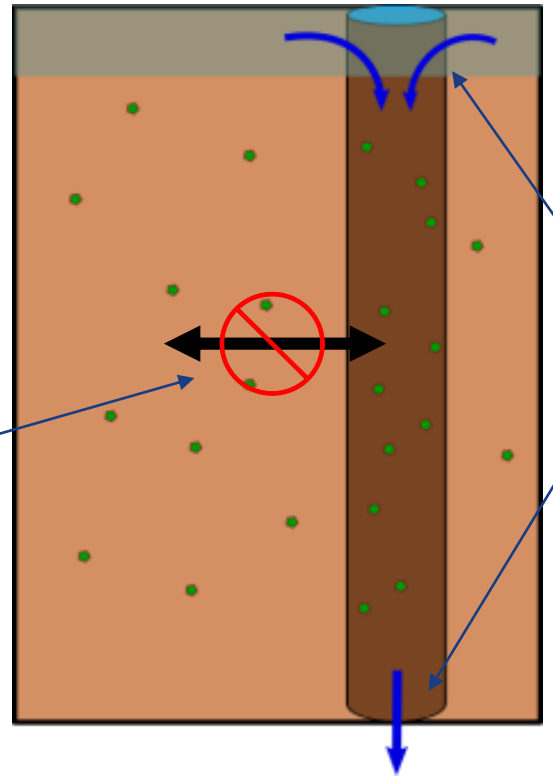
Biopore model in Daisy (1-D) (cont.)

- Water (and) storage



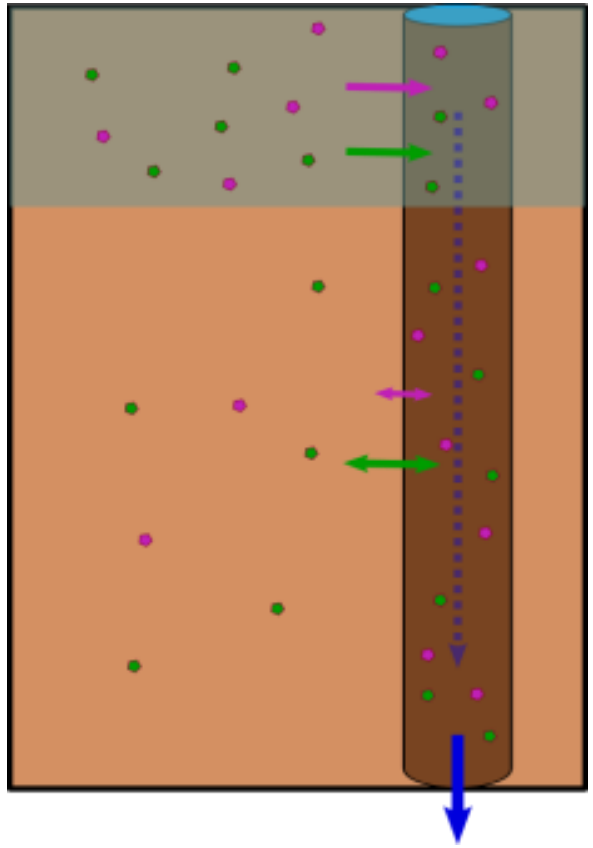
Equal advective transport for all solute species in the matrix

No matrix-biopore solute transport along the biopores



On/Off biopore flow, limited chance for "mild" preferential flow

An extended Daisy-like macropore model?



Sink/source and dual-domain hybrid?

- Multiple macropore flow regimes (e.g. different longitudinal dispersivities)
- Matrix-macropore solute transfer along active biopores
- Equilibration of solute concentrations between inactive biopores and matrix

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