Geowissenschaftliches Zentrum
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Ability of Single-Well Injection-Withdrawal Experiments to Estimate Ground Water Velocity

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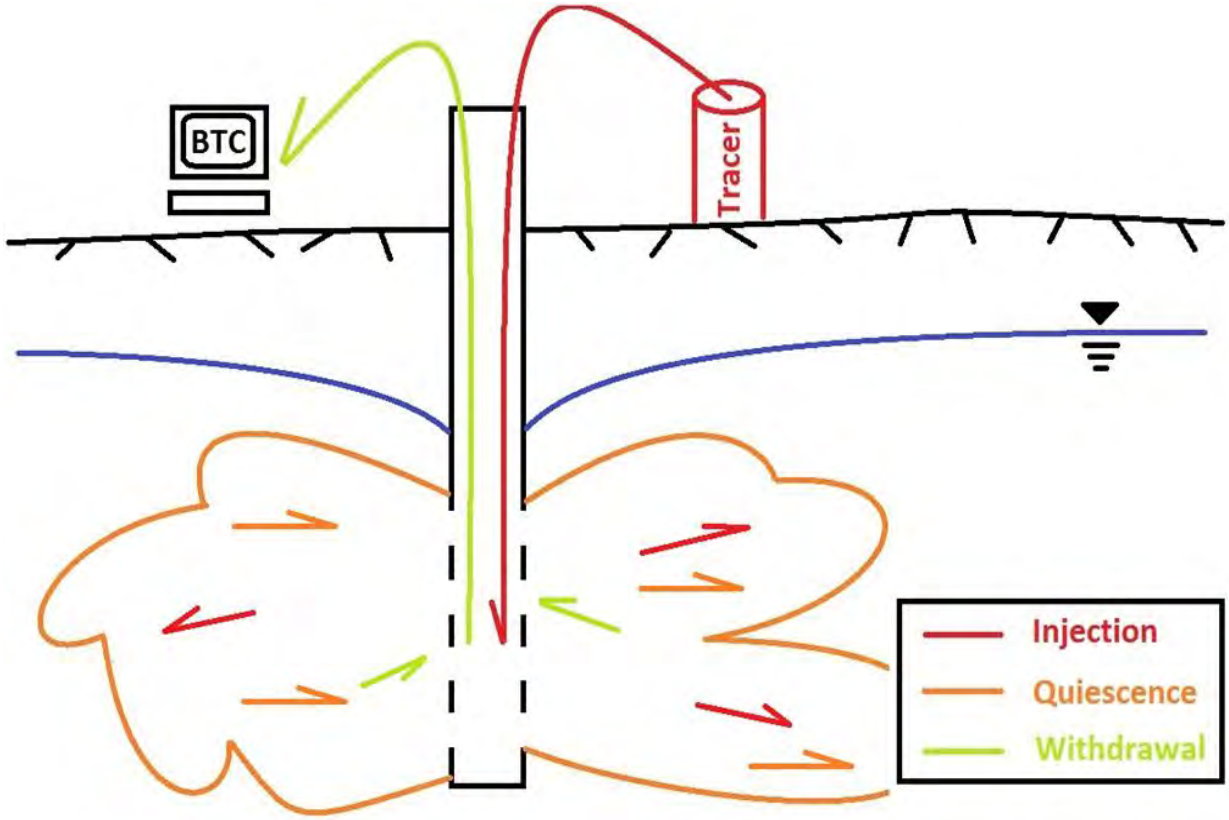
Objective



Experiments

- Interwell
- Intrawell
- SWIW (Push-Pull)

Tracers

- conservative
- reactive
- sorbing

Quantities

- ambient groundwater velocity
- residence times
- inter-/surfaces

etc.

Governing Equations

Dispersion-advection-equation:

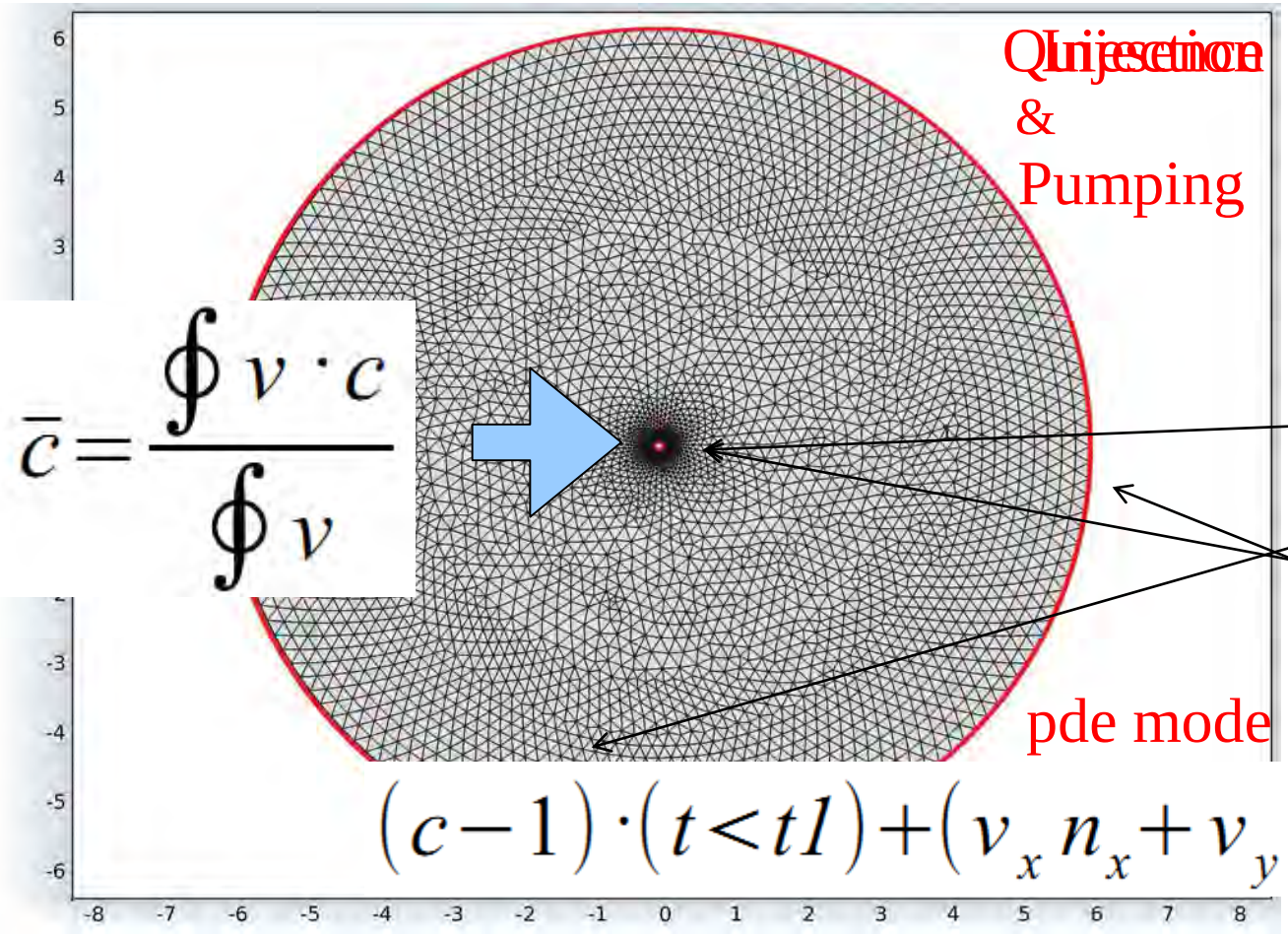
$$\phi_{eff}\frac{\partial c}{\partial t}-\nabla\left(\left(D_{disp}+D_{diff}\right)\nabla c\right)+v\nabla c=0$$

$$D_{xx}=\alpha_l v_x^2+\alpha_t v_y^2/(v)+D_{diff}$$

$$v=\frac{-K}{\rho_W g}\nabla p$$

or analytical solution

Model approach



$$\bar{c} = \frac{\oint v \cdot c}{\oint v}$$

Initial condition

$$c = 0$$

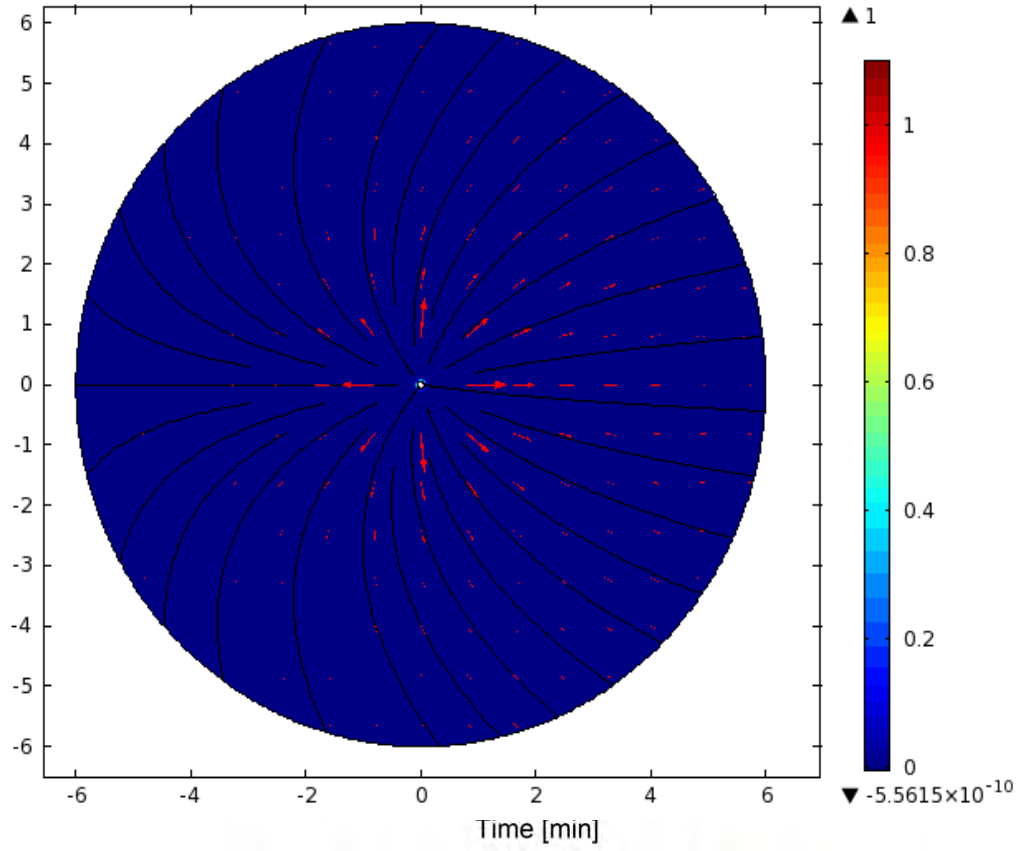
Boundary condition

$$c = 1$$

$$v_x n_x + v_y n_y = 0$$

$$(c-1)\cdot(t<t1) + (v_x n_x + v_y n_y)\cdot(t>t1) = 0$$

Model approach – Modes



DI & esst:
Solution transfer
Intermediate time stepping

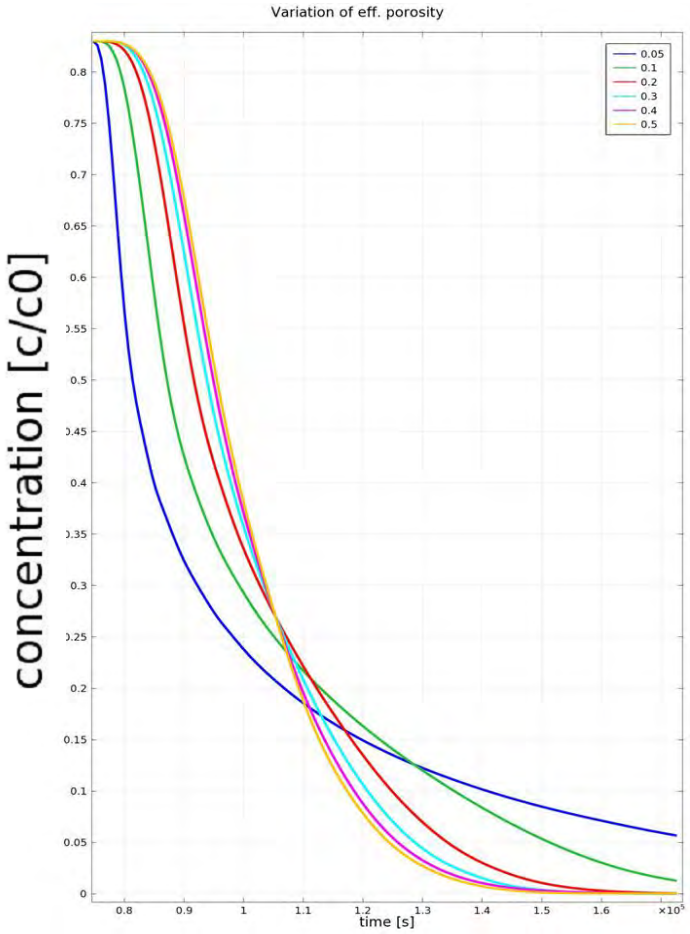
Esst:
Solution transfer

Pde:
Boundary condition change

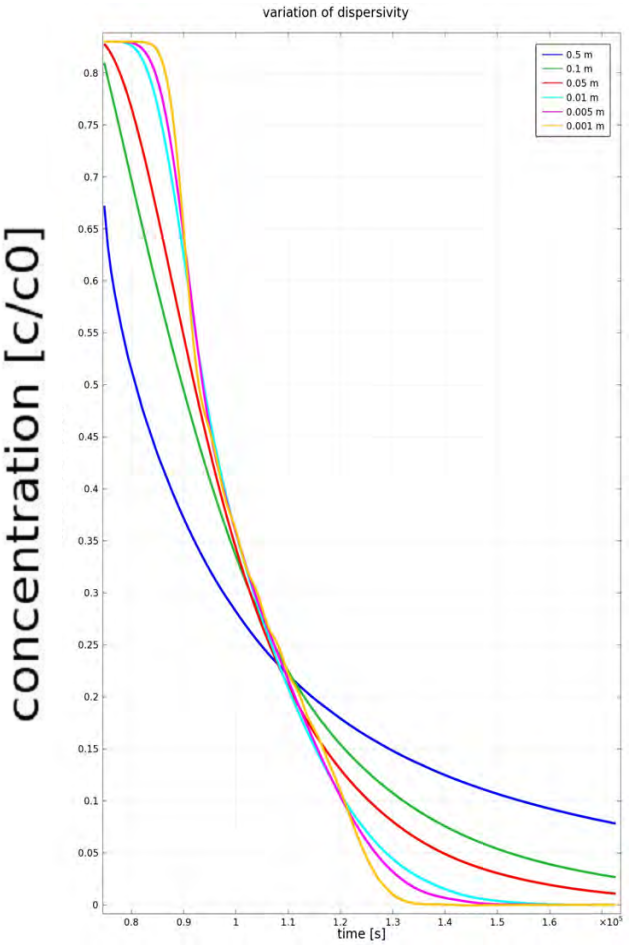
MODEL	*DOF*	*TIME [s]*
dl + esst	32896	277
esst	16448	76
pde	16448	88

Results - Sensitivity

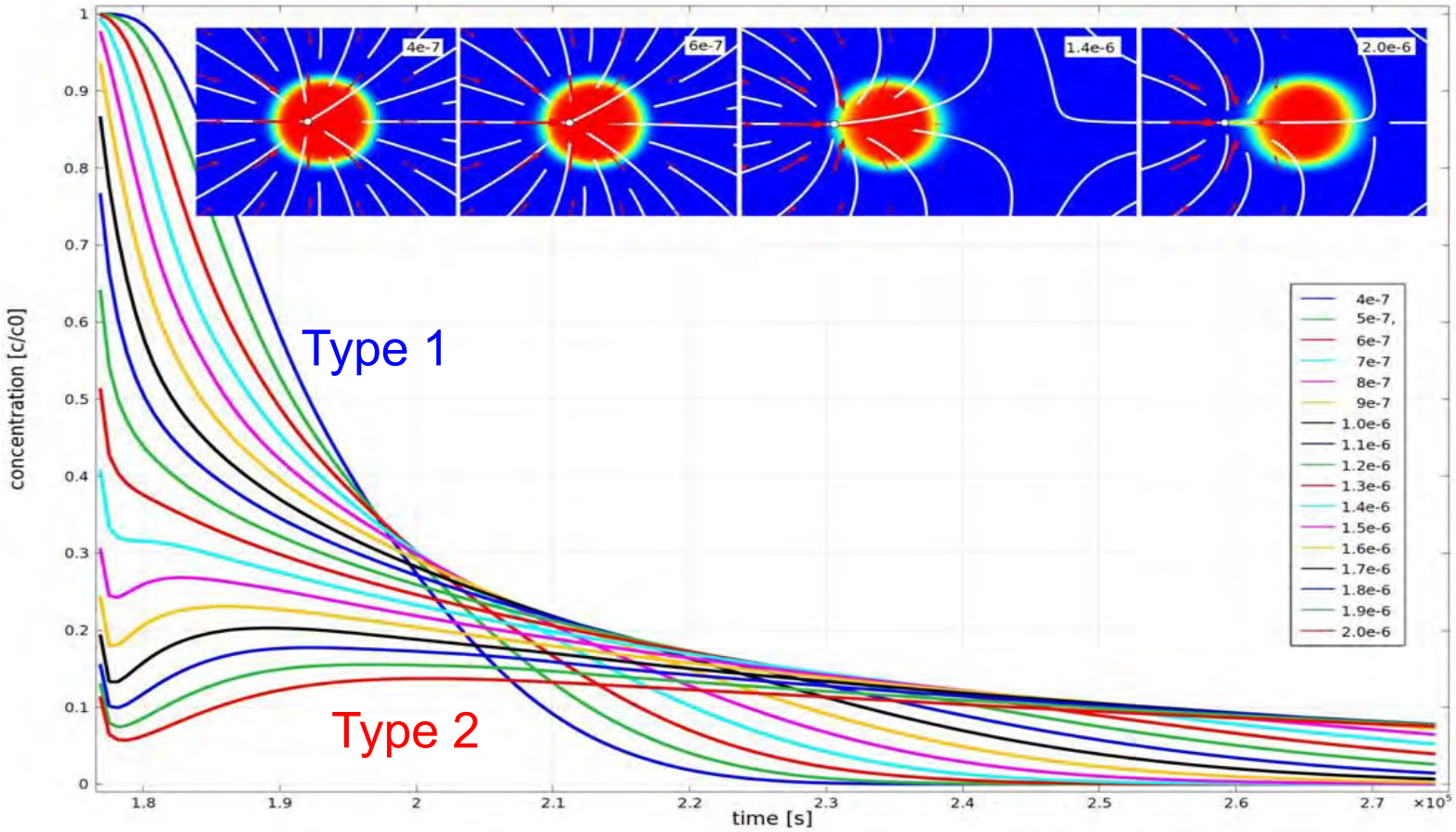
$$\phi_{eff}\frac{\partial c}{\partial t}-\nabla\left(\left(D_{disp}+D_{diff}\right)\nabla c\right)+v\nabla c=0$$



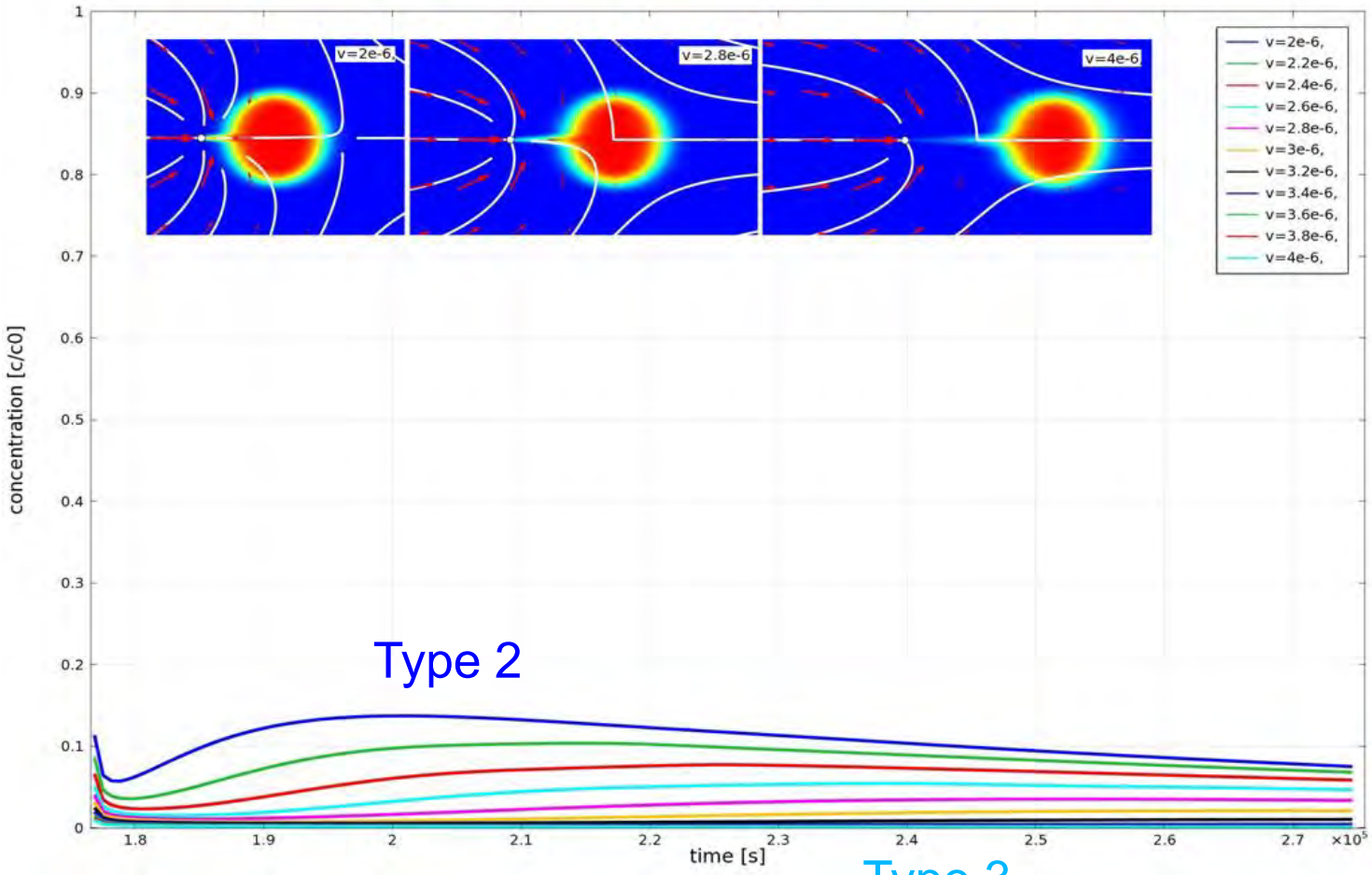
$$sp+D_d$$



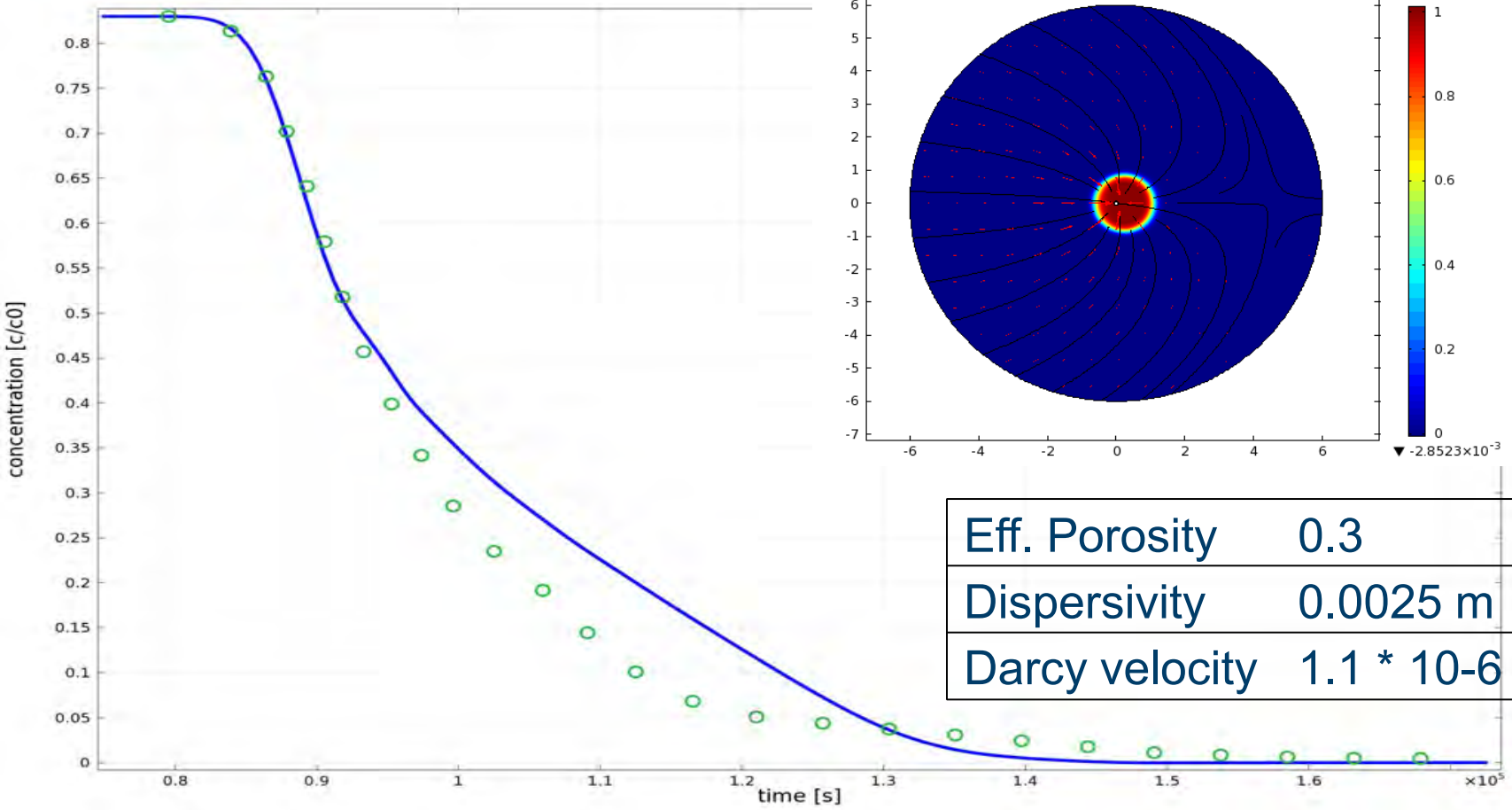
Results – Ambient Groundwater Velocity



Results – Ambient Groundwater Velocity



Results – SWIW



Eff. Porosity	0.3
Dispersivity	0.0025 m
Darcy velocity	1.1 * 10-6 m/s

Conclusions

- High sensitivity on dispersivity
- Lower sensitivity in eff. porosity
- In dependence on the ambient ground water velocity we get three main type-curves shapes

- Good fit of the measured BTC with the modeled BTC for a homogenous aquifer

- Change of the boundary-type is possible

Outlook

- Implementation of well effects (e.g. skin effect)
- Considering of inhomogeneities (e.g. fracture flow)
- Tracer effects like sorption and reaction

Thank you for your attention!

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