

EGU2018-17675

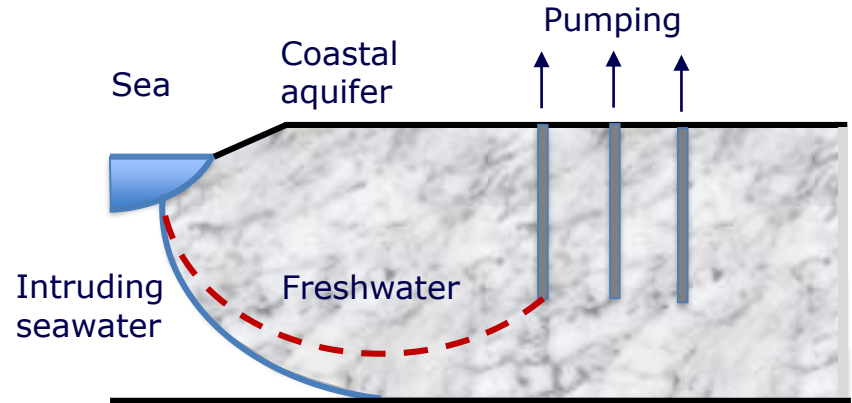
**Seawater intrusion in a randomly-heterogeneous coastal aquifer under multiple pumping scenarios**

Martina Siena and Monica Riva

Politecnico di Milano

# Problem statement

Seawater intrusion (SWI) phenomena threaten groundwater resources in coastal aquifers



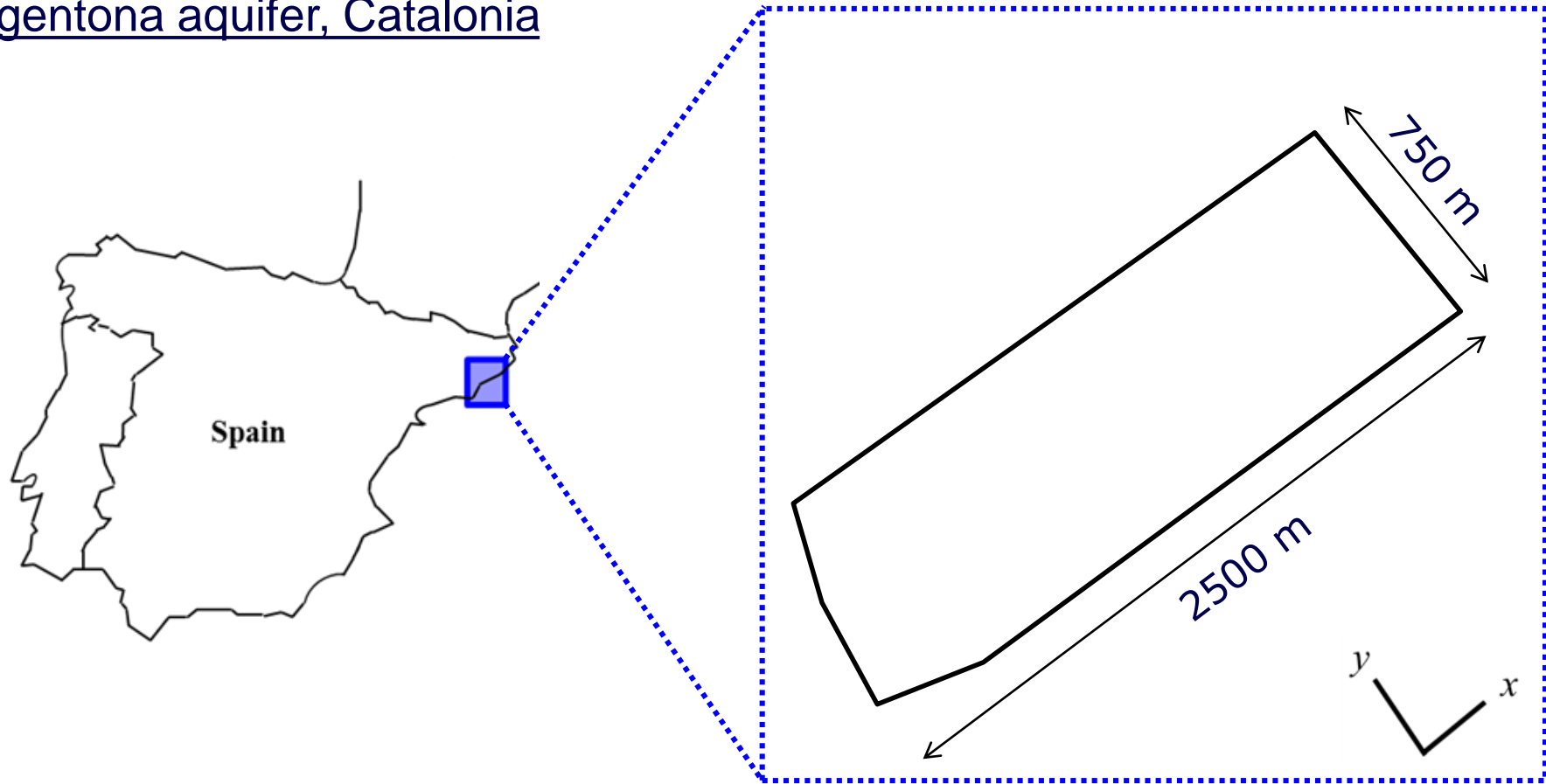
An effective risk assessment must deal with several sources of uncertainty

## GOAL

Quantitative effects on SWI of random **heterogeneity of permeability** in the presence of **groundwater withdrawal**

# Case study

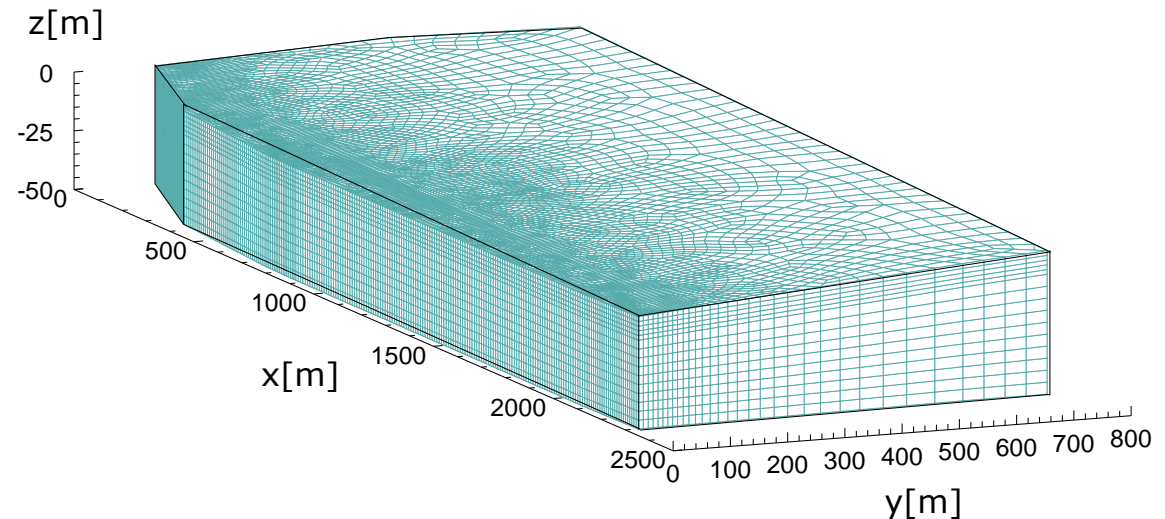
## Argentona aquifer, Catalonia



# Numerical model

## Variable-density simulation of flow and transport

- 3D domain (2500 x 750 x 50 m<sup>3</sup>)
- Unstructured grid of 101632 elements
- Preliminary simulation over 8 years (2006 - 2013) with transient BC
- 8-month simulations with pumping
- Heterogeneous permeability field  $k$

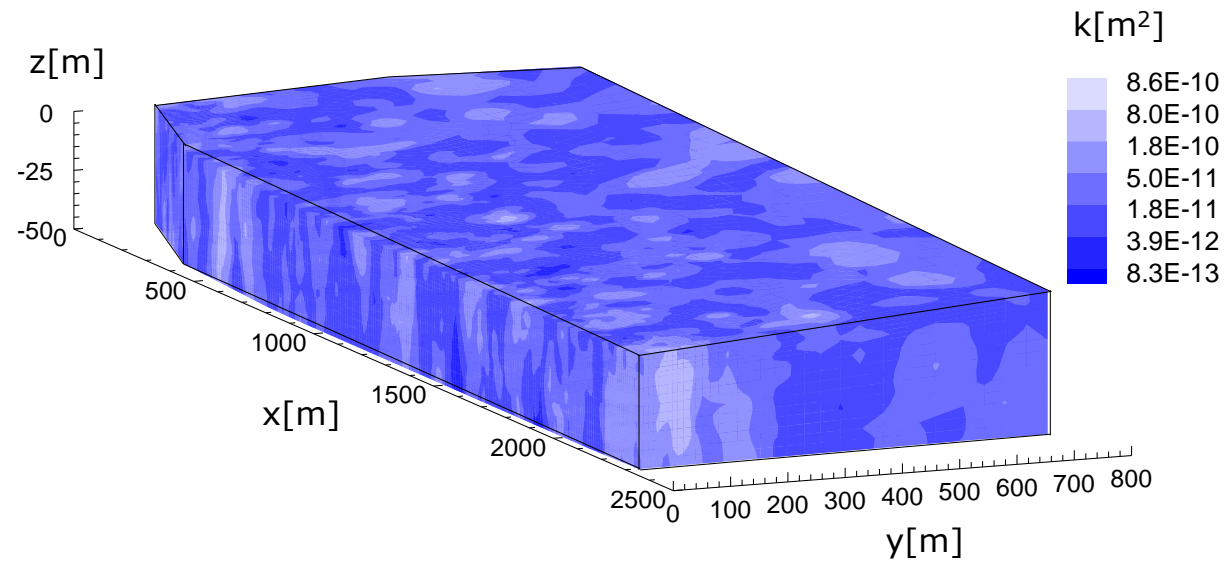


# Monte Carlo framework

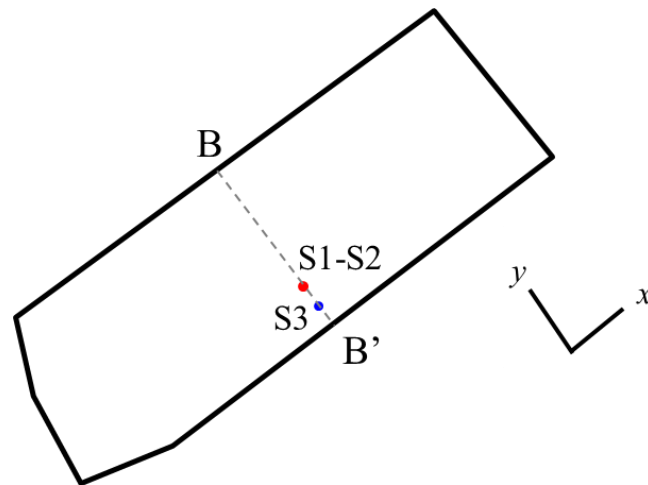
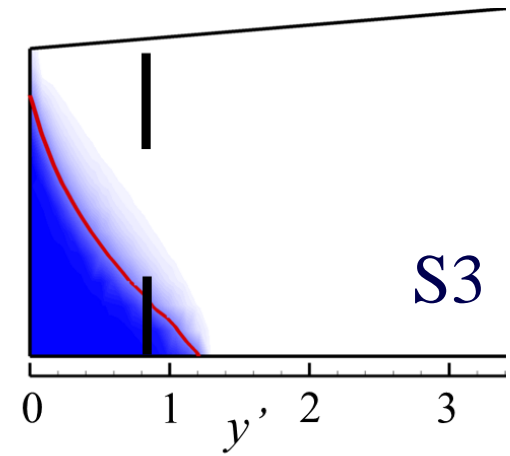
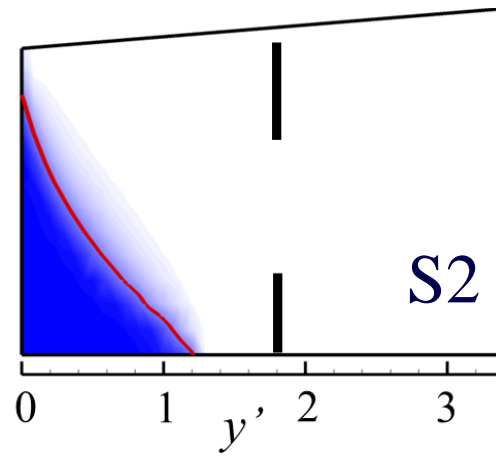
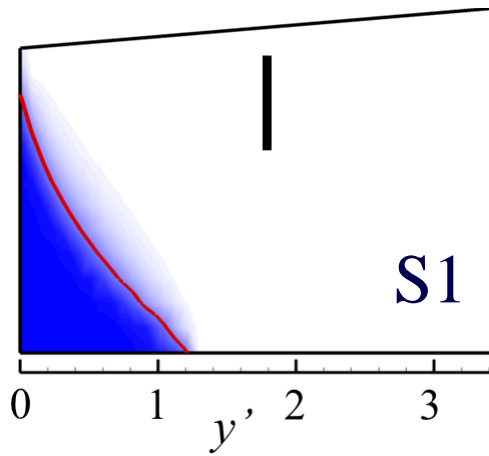
## Unconditional random distributions of $Y = \ln k$

Sequential Gaussian algorithm:

- variance  $\sigma^2 = 1$
- isotropic correlation scale  $\lambda = 100$  m

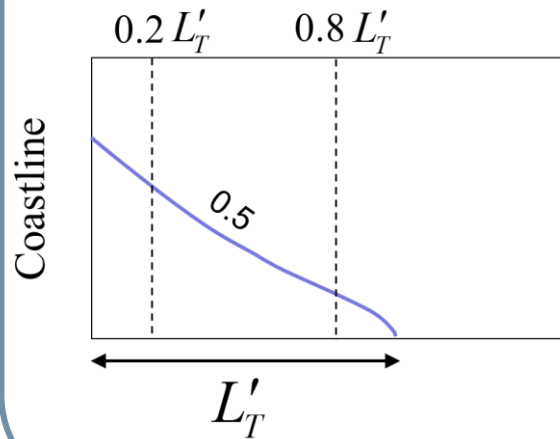


# Pumping schemes

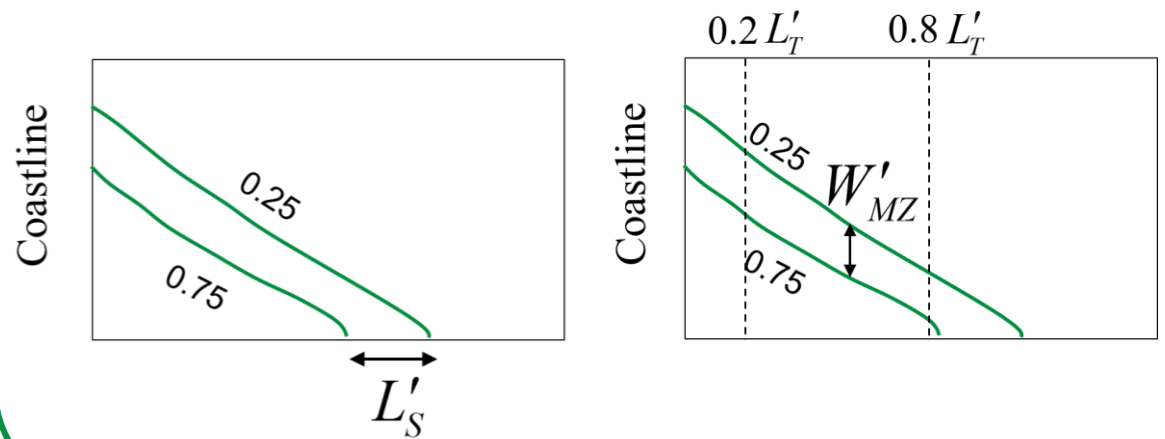


# SWI metrics: single cross section

## Toe penetration

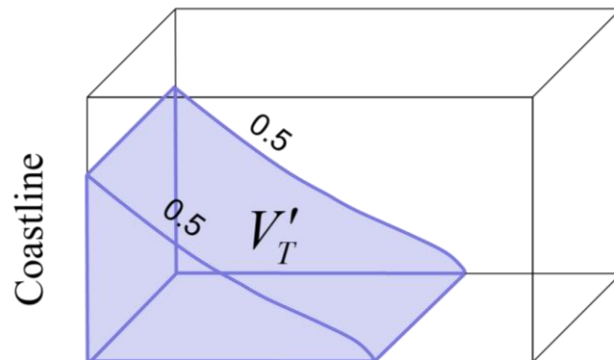
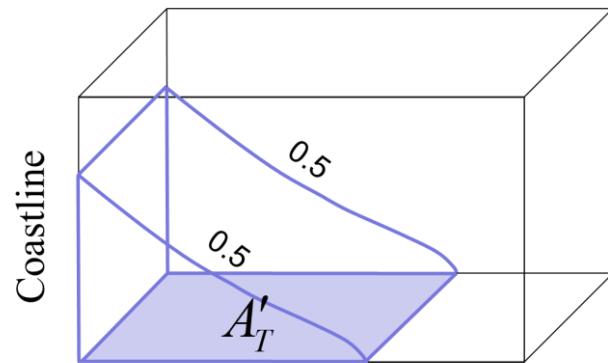


## Transition zone width

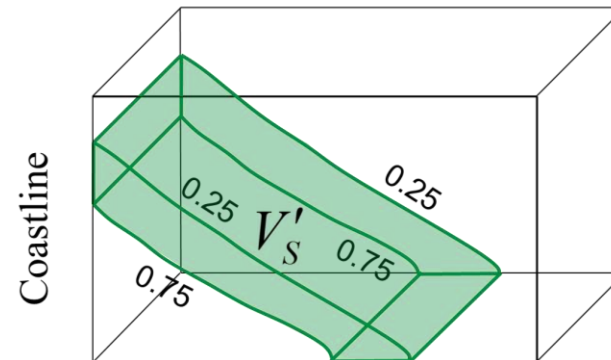
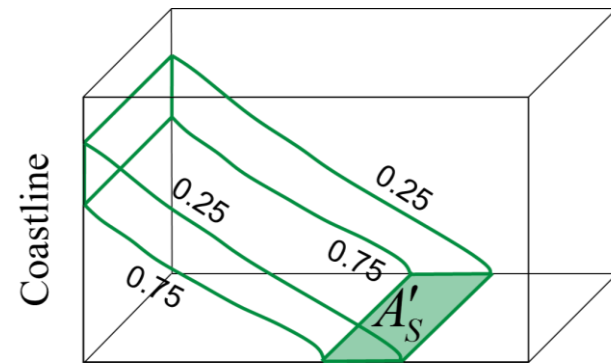


# SWI metrics: areal and volumetric extent

## Toe penetration

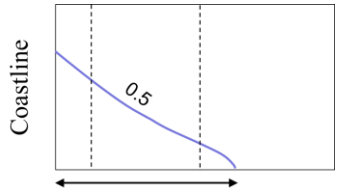


## Transition zone width

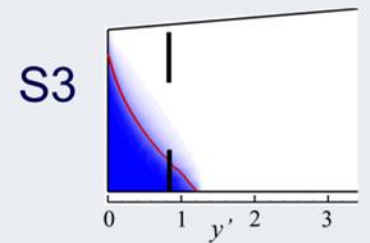
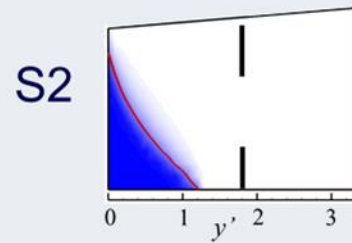
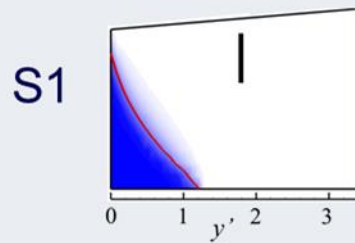
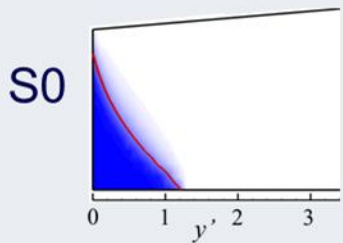
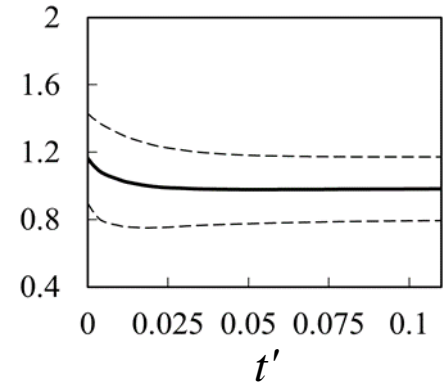
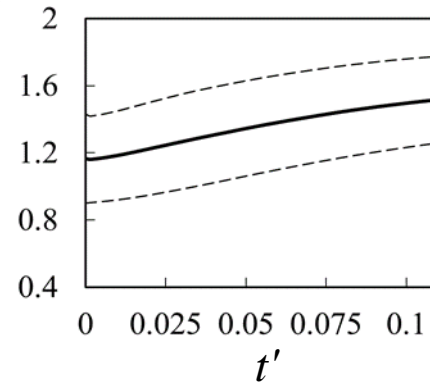
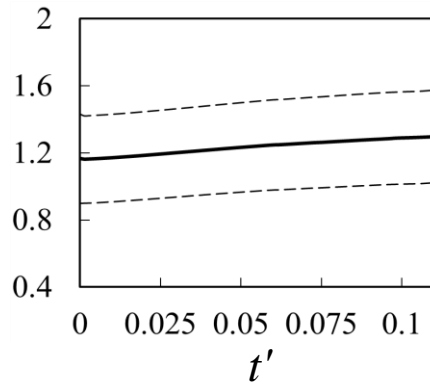
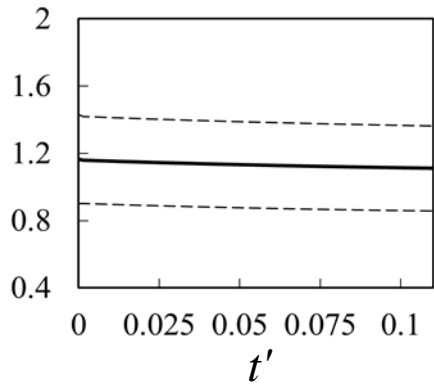
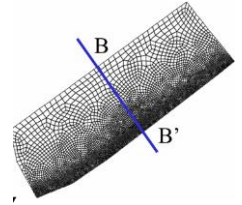




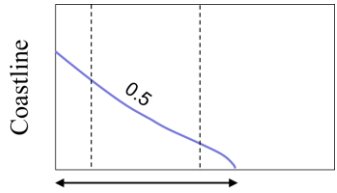
# Results: linear SWI metrics



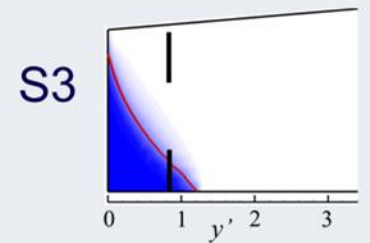
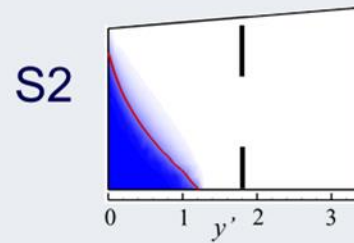
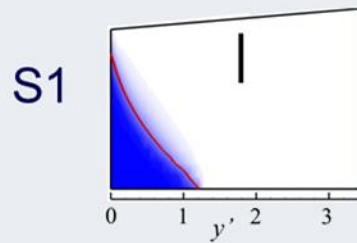
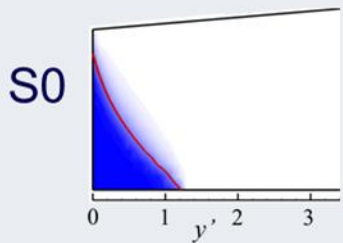
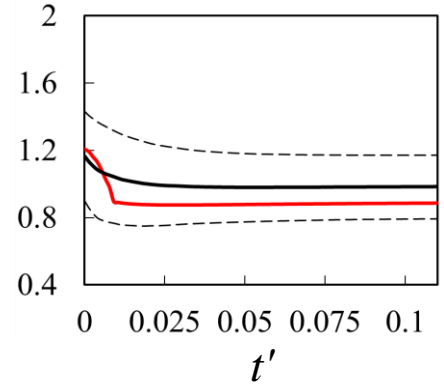
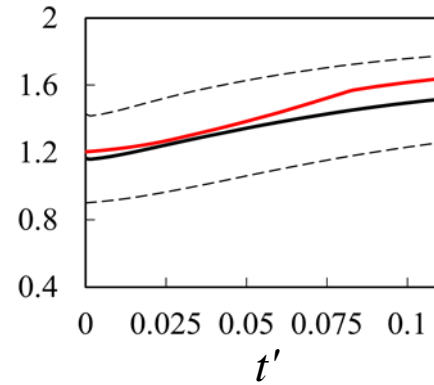
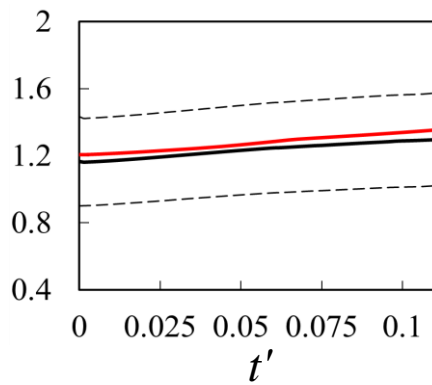
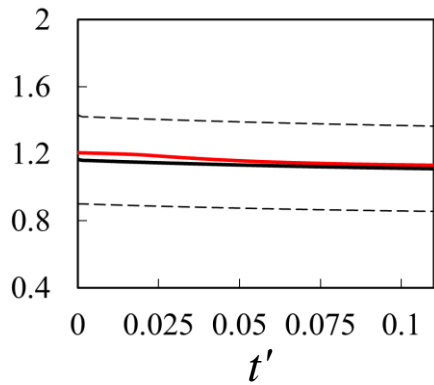
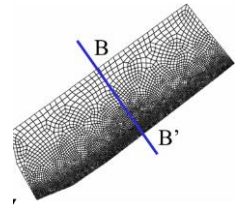
$$\text{---} \langle L'_T \rangle \pm \sigma_{L'_T}$$



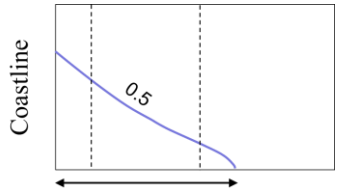
# Results: linear SWI metrics



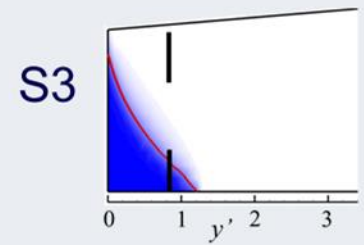
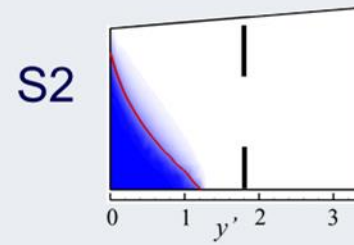
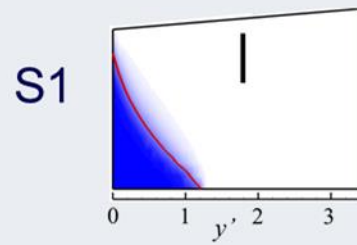
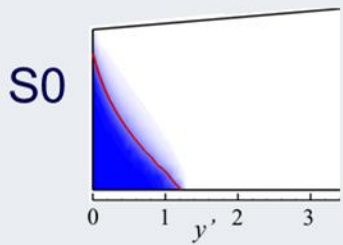
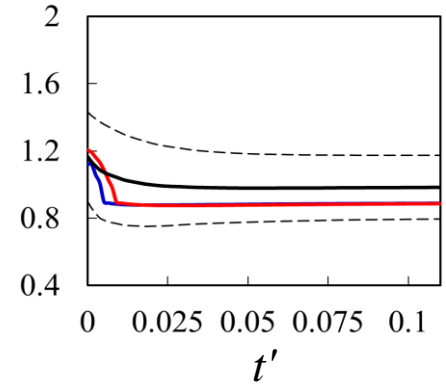
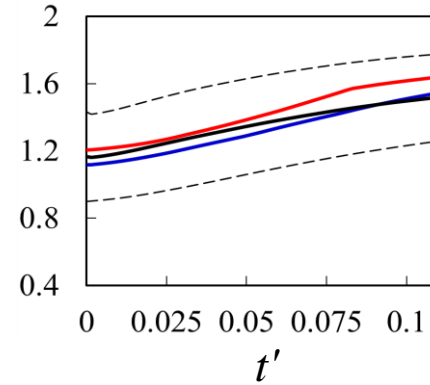
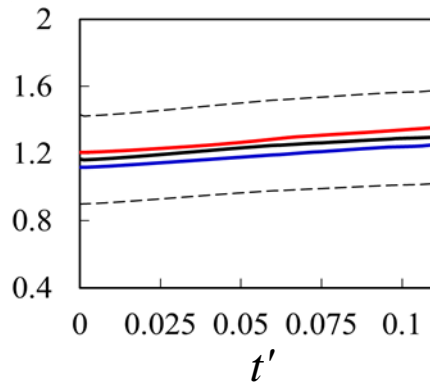
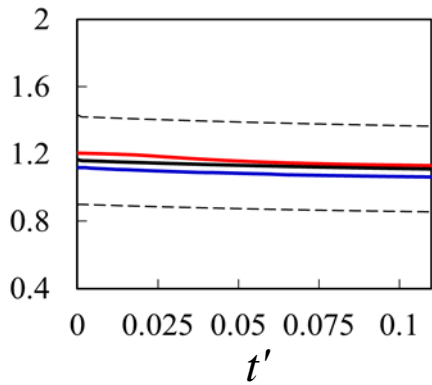
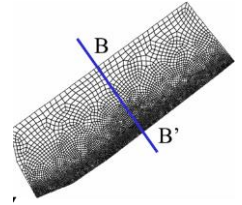
$$\text{---} \langle L'_T \rangle \pm \sigma_{L'_T} \quad \text{---} L'_T{}^{HOM}$$



# Results: linear SWI metrics

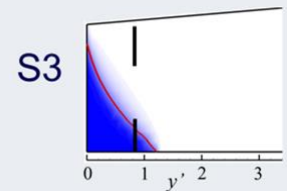
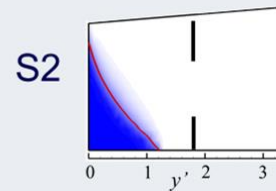
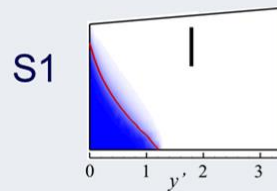
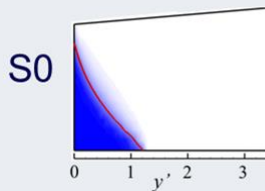
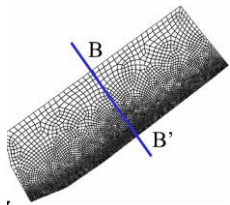
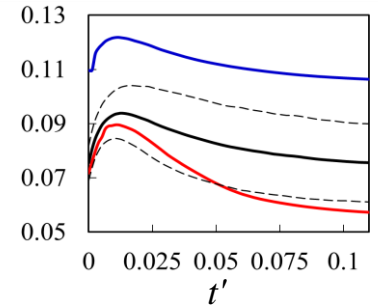
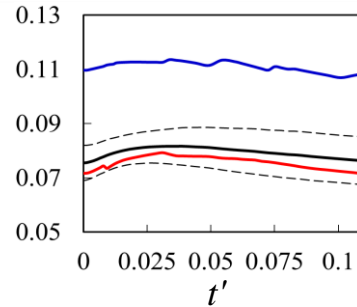
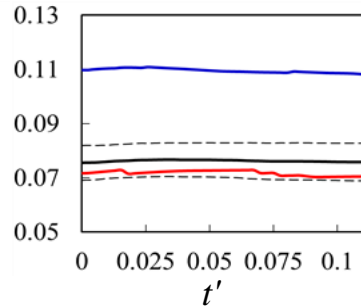
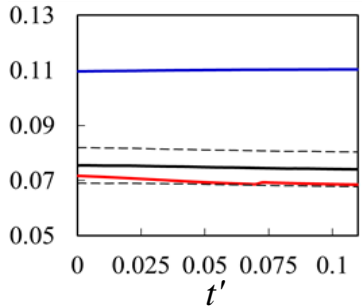
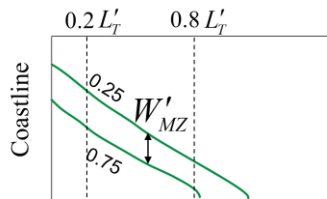
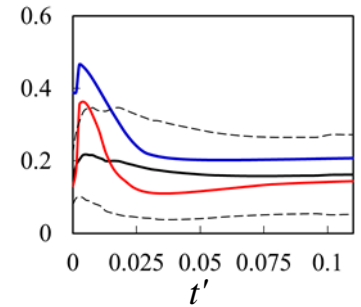
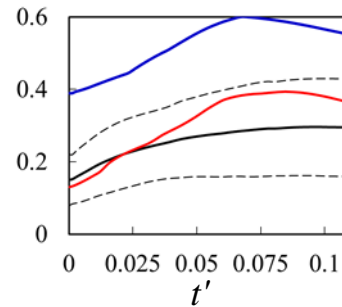
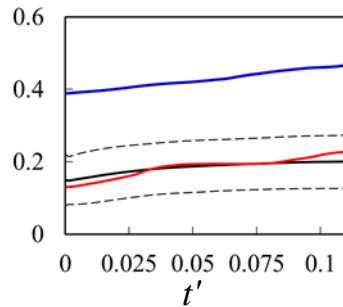
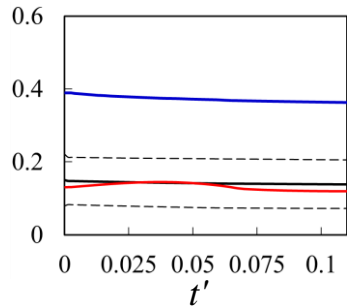
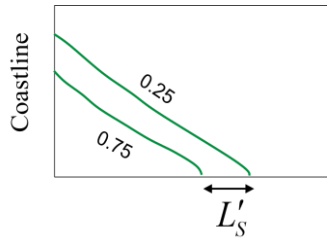


$$\begin{array}{c} \text{---} \\ \text{---} \end{array} \langle L'_T \rangle \pm \sigma_{L'_T} \quad \text{---} L'_T{}^{HOM} \quad \text{---} L'_T{}^{ENS}$$

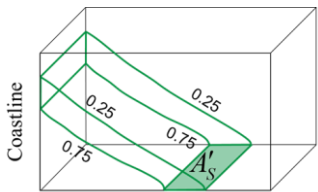
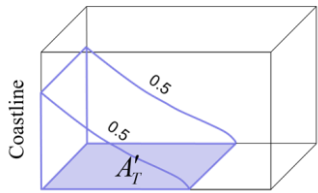


# Results: linear SWI metrics

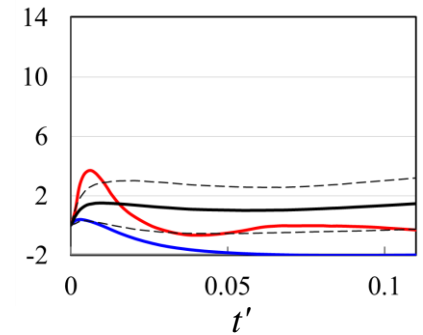
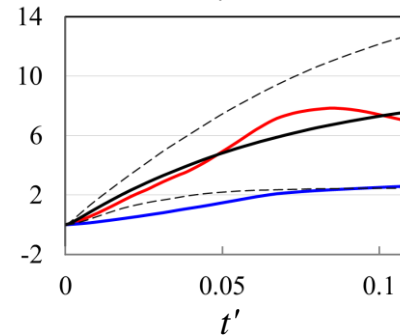
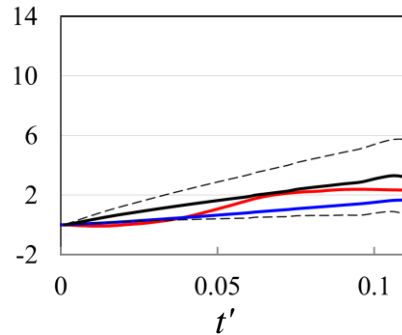
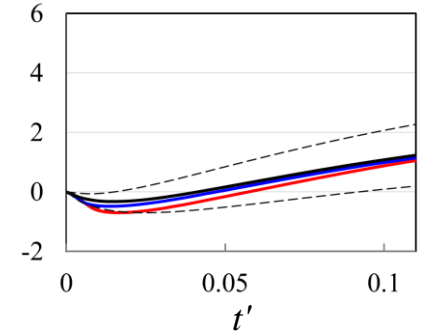
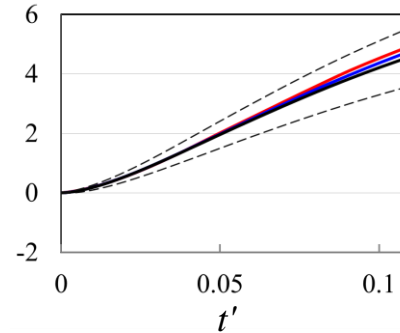
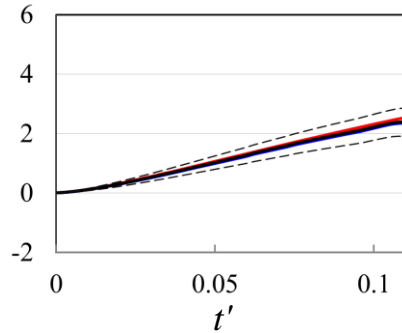
$\text{---} \langle \xi' \rangle \pm \sigma_{\xi'}$      $\text{---} \xi'_{HOM}$      $\text{---} \xi'_{ENS}$



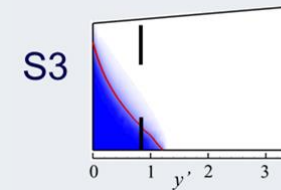
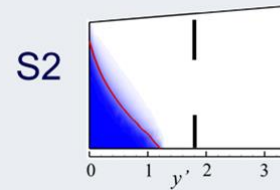
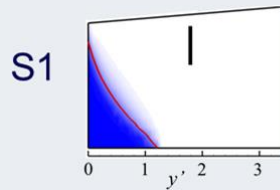
# Results: areal SWI metrics



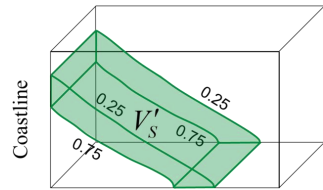
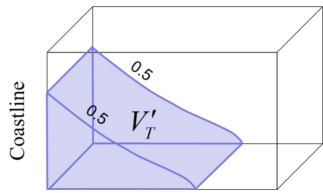
$$\begin{array}{l} \text{---} \langle \xi^* \rangle \pm \sigma_{\xi^*} \\ \text{---} \end{array} \quad \text{---} \xi^*_{HOM} \quad \text{---} \xi^*_{ENS}$$



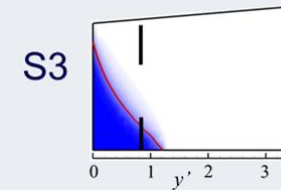
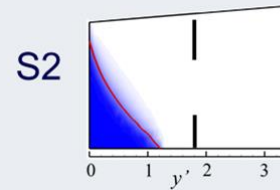
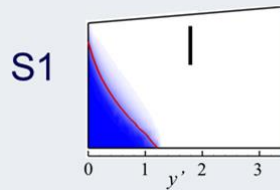
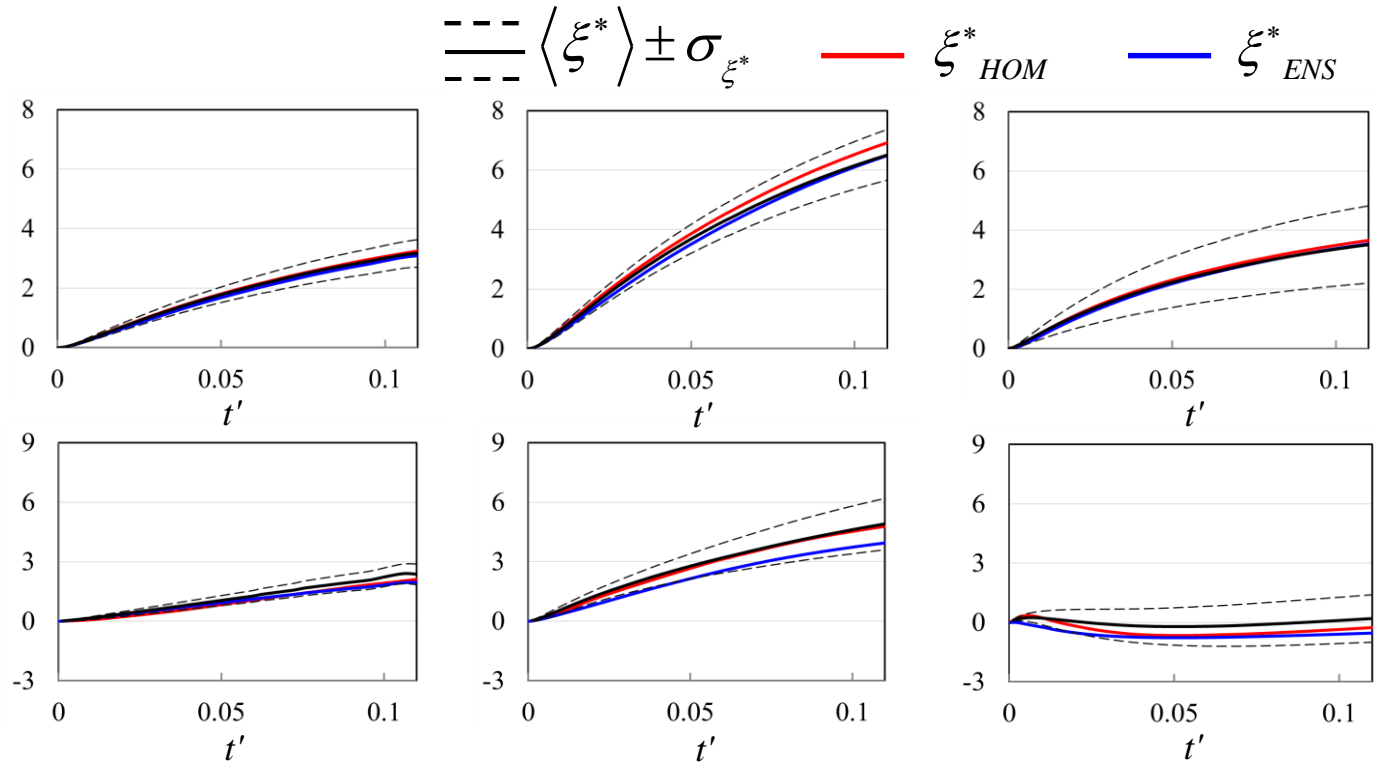
$$\xi^*_{S0} = \frac{\xi' - \xi'_{S0}}{\xi'_{S0}}$$



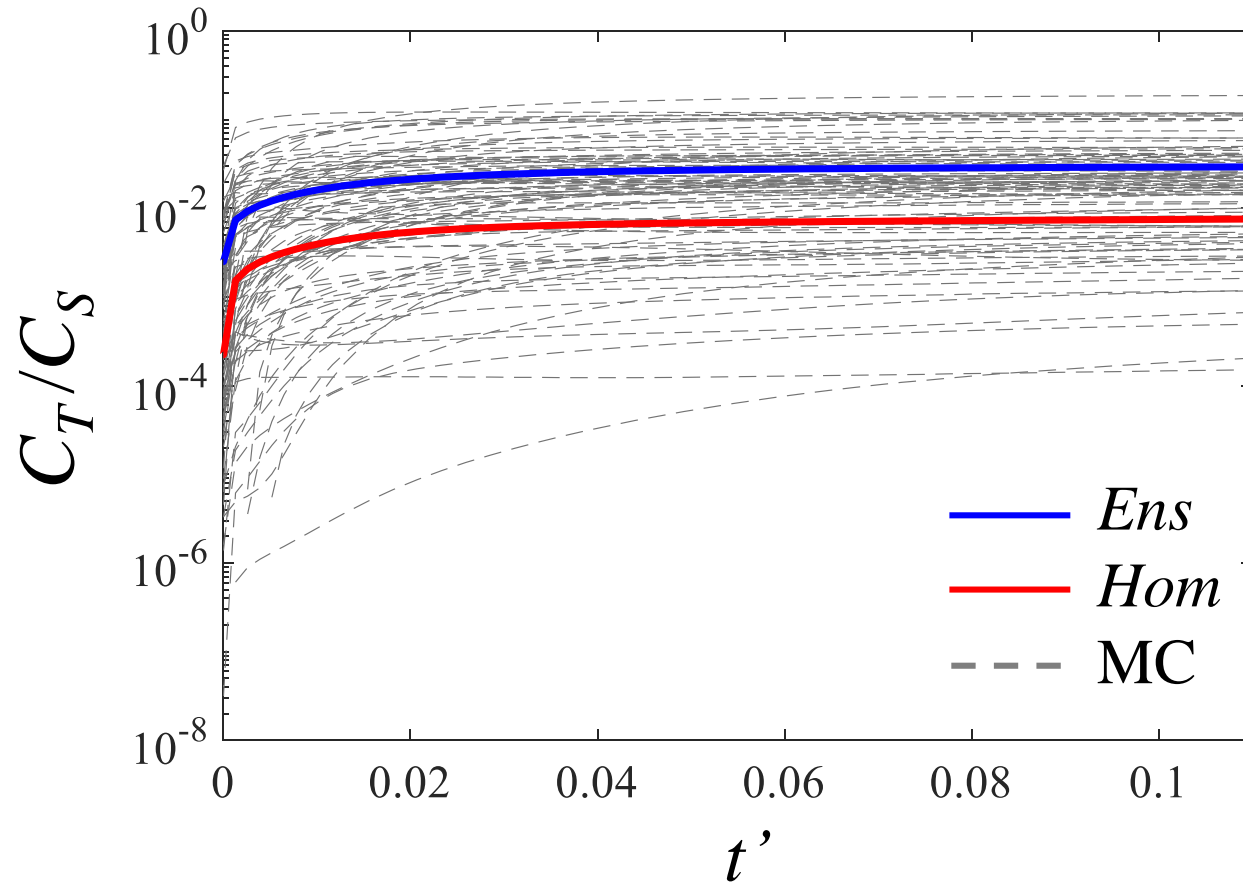
# Results: volumetric SWI metrics



$$\xi^* = \frac{\xi' - \xi'_{S0}}{\xi'_{S0}}$$



# Local concentration at the FW well



# Final remarks

- Monte Carlo investigation on the combined effects on SWI of random heterogeneity and groundwater pumping in terms of linear, areal and volumetric extent of wedge penetration and mixing zone.
- Heterogeneous system has penetration and mixing length respectively smaller and larger compared to the equivalent homogeneous case.
- Effects of withdrawal are sensitive to the relative position of the wellbore with respect to the wedge prior to pumping.
- Mild degree of permeability heterogeneity causes a significant uncertainty in local salt concentrations.

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