Le 5 octobre 2016

L'influence de l'hétérogénéité physique des microenvironnements du sol sur les transformations microbiennes du carbone : Exploration à l'aide d'un modèle de Boltzmann sur réseau.

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Thèse co-encadrée par Patricia GARNIER et Valérie POT

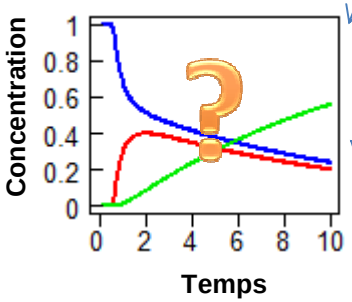
ANR-MEPSOM: Multiscale Modeling and Emergent Properties of microbial degradation of Soil Organic Matter

Effets de la structure du sol sur l'activité microbienne?

Carbone atmosphérique

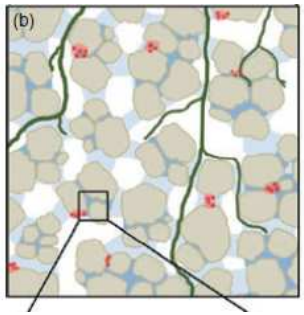
Dégradation microbienne

Matière organique du sol



Hétérogénéité spatiale

- Morphologie de la porosité
- Distribution de l'eau et l'air
- Distribution des microorganismes / substrats organiques

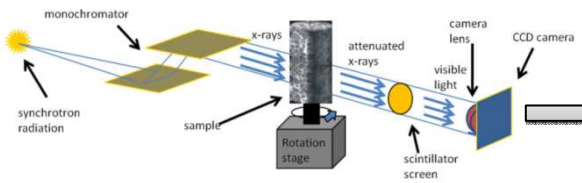


Transport

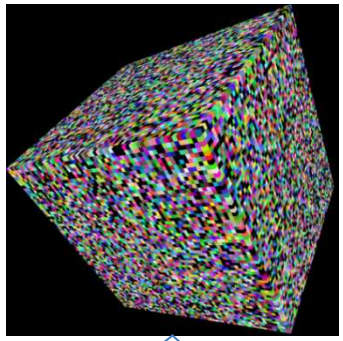
- Eau / air
- Microorganismes
- **Substrats carbonés**

Un outil d'exploration : le modèle LBioS

Microtomographie aux rayons X

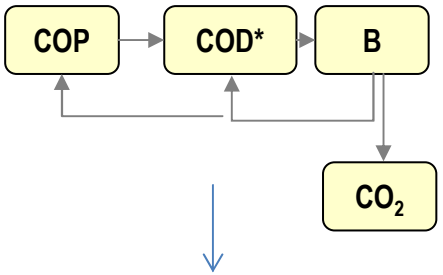


Modèle de Boltzmann sur réseau



Séparation de phases **Diffusion**

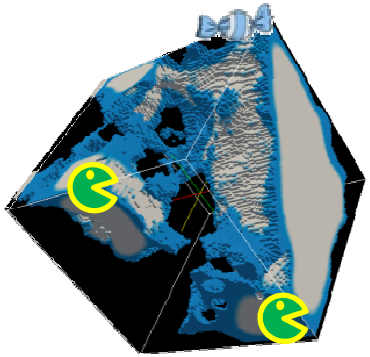
Modèle de décomposition de la MOS

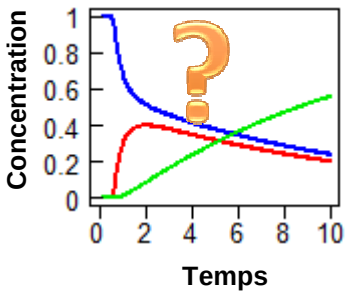


Biodégradation

*COD: carbone organique dissous

- *Géométrie de la porosité*
- *Saturation en eau*
- *Localisation des décomposeurs / substrats*

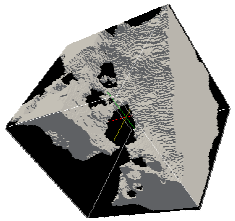




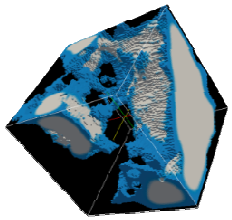
Une méthode pour quantifier les effets de la structure

Plan d'expérience factoriel

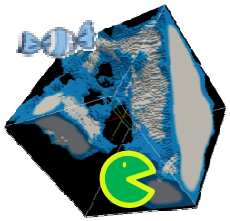
Géométrie de la porosité
(G)



Saturation en eau
(S)



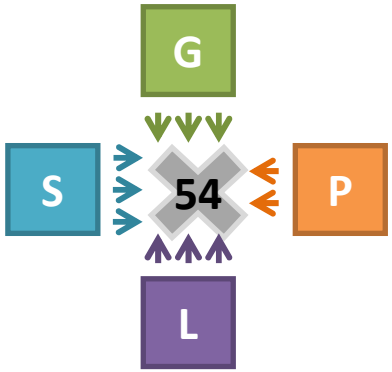
Localisation des bactéries
(L)



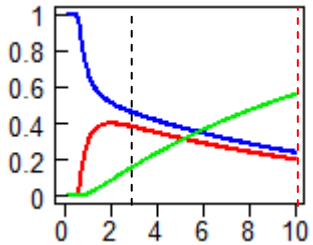
Physiologie bactérienne
(P)

Paramètre du modèle biogéochimique

54 scénarios

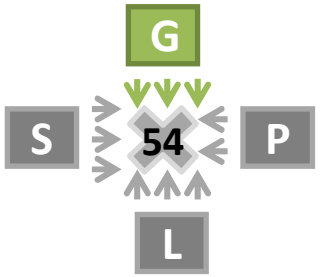


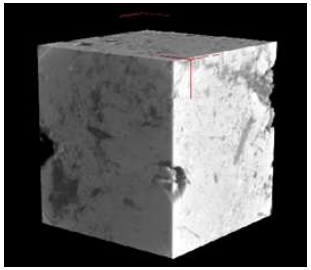
Cinétique de biodégradation



Analyse de la variabilité

Complete factorial design: Geometry



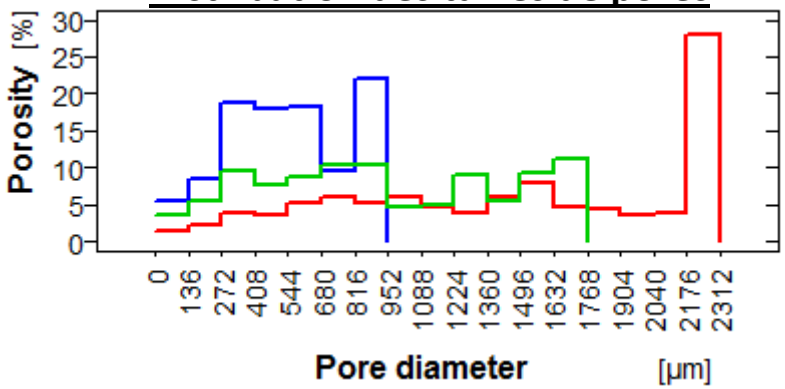


Résolution: 68 µm
Taille : 100^3 voxels (6.8^3 = 314 mm^3)

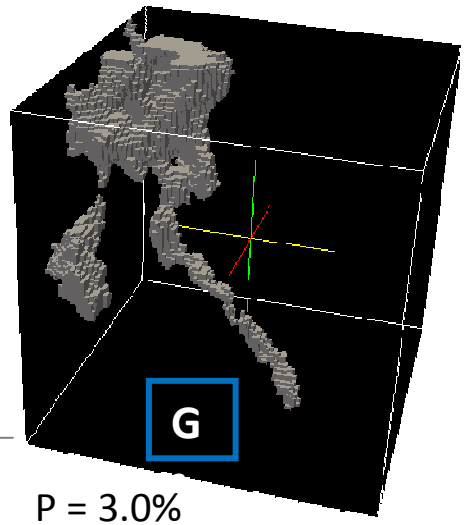
Sélection de 3 images contrastées

Indicateurs morphologiques
PSD, Tortuosité($\tau = \frac{L_e}{L_g}$)

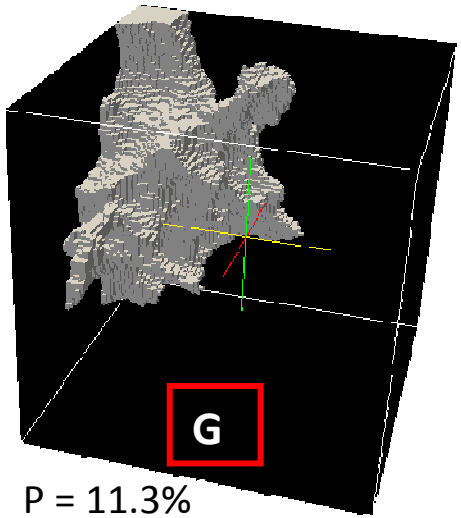
Distribution des tailles de pores



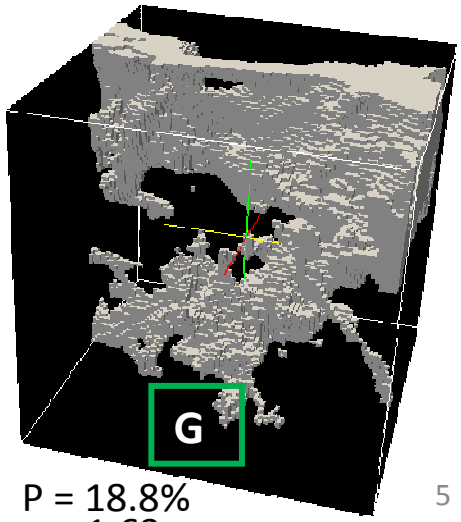
100 voxels
6.8 mm



P = 3.0%
τ = 1.72

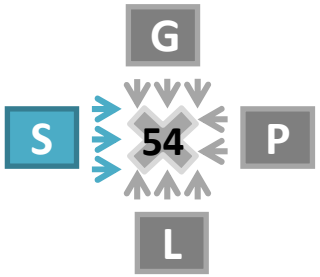


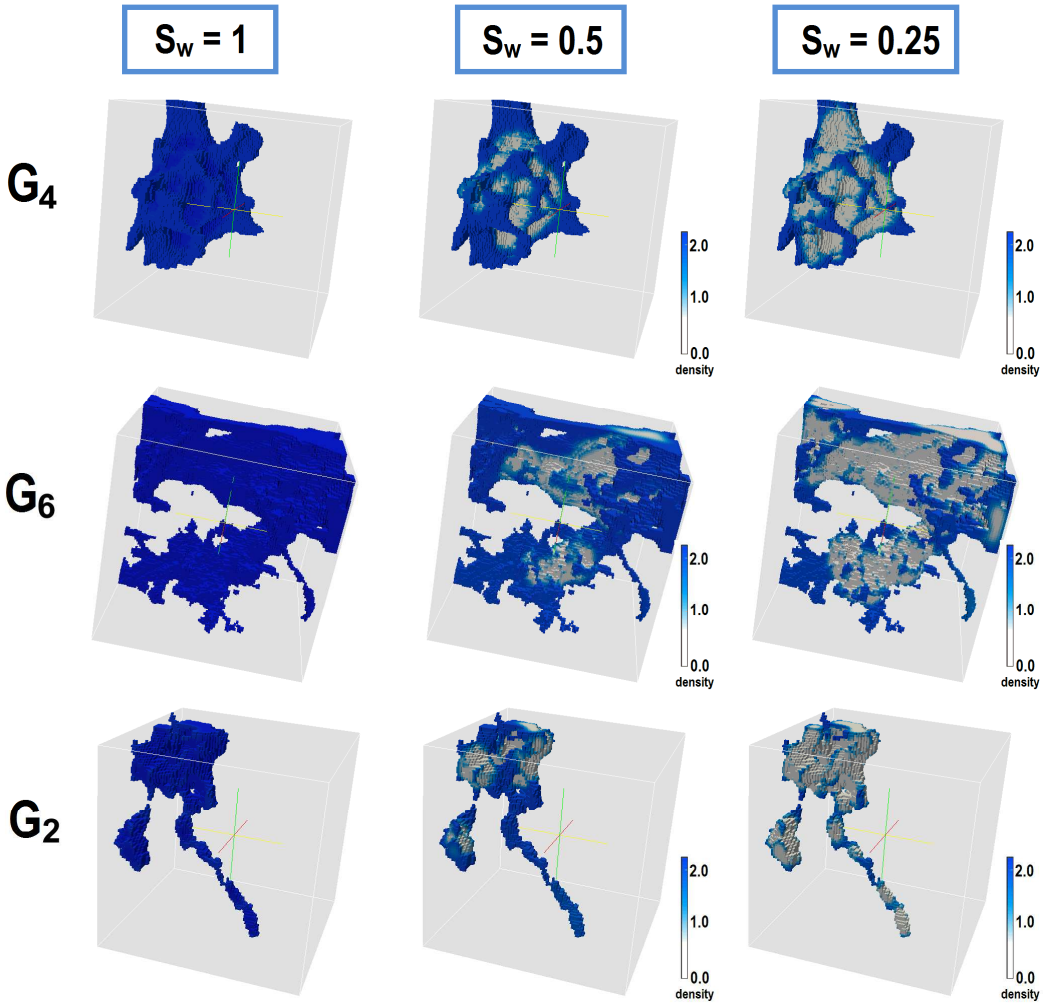
P = 11.3%
τ = 1.09



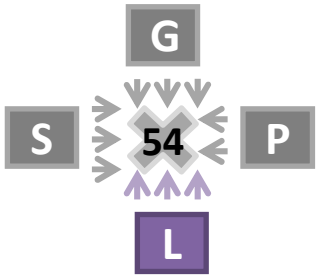
P = 18.8%
τ = 1.63

Plan d'expérience factoriel: Saturation en eau



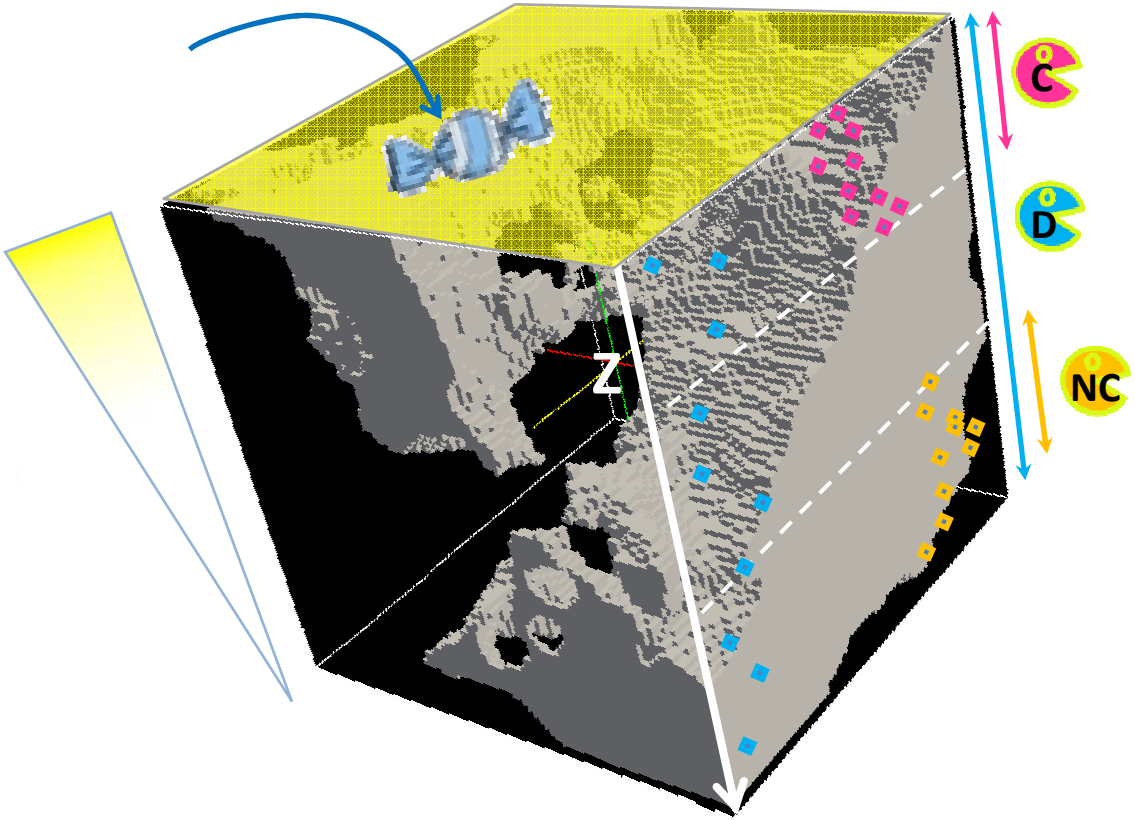


Complete factorial design: Location



Substrat:
Carbone organique dissous

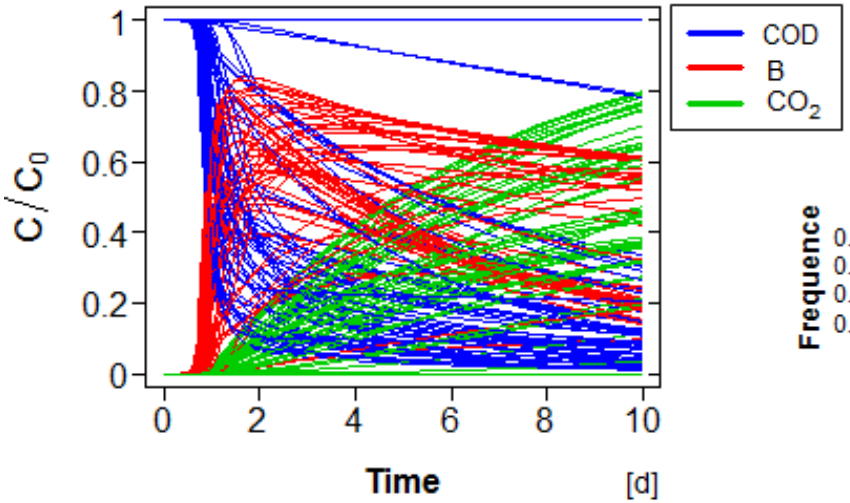
Distribution des bactéries :
10 hot-spots de masse égale

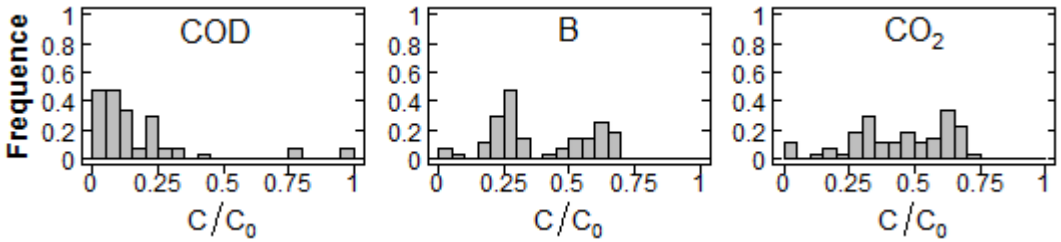


Distribution des bactéries / source de substrat :

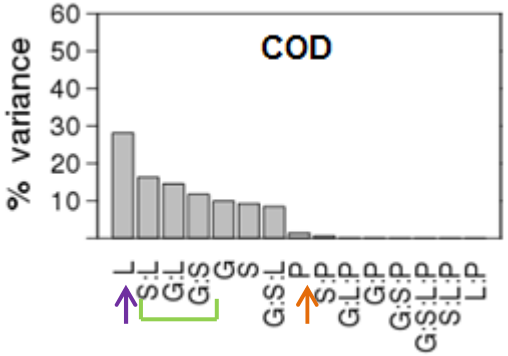
- Co-localisée **(C)**
- Dispersée **(D)**
- Non co-localisée **(NC)**

Résultats





Dispersion des résultats cinétiques après 10 jours:

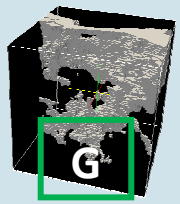


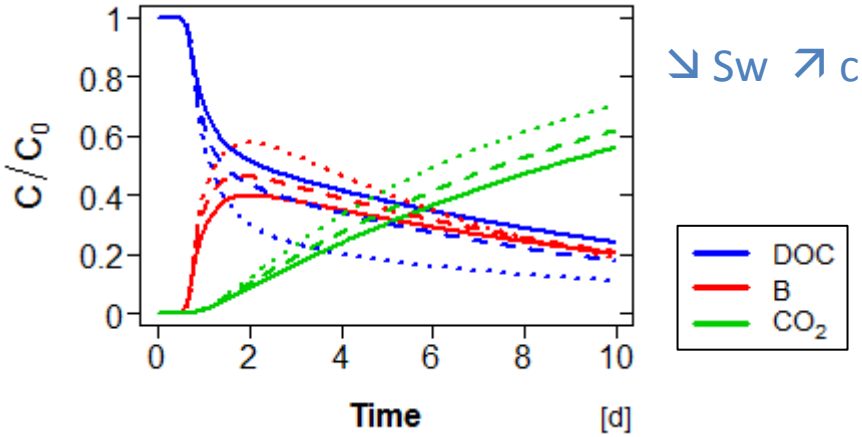
Contribution des facteurs à la variabilité:

- *Faible influence du facteur Physiologie*
- *Importance des facteurs physiques*
  - → *Localisation (28%)*
  - → *Interactions entre facteurs (51%)*

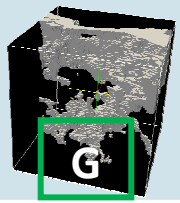
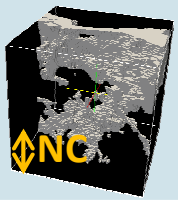
Results of the sensitivity analysis (ANOVA), at 10 days

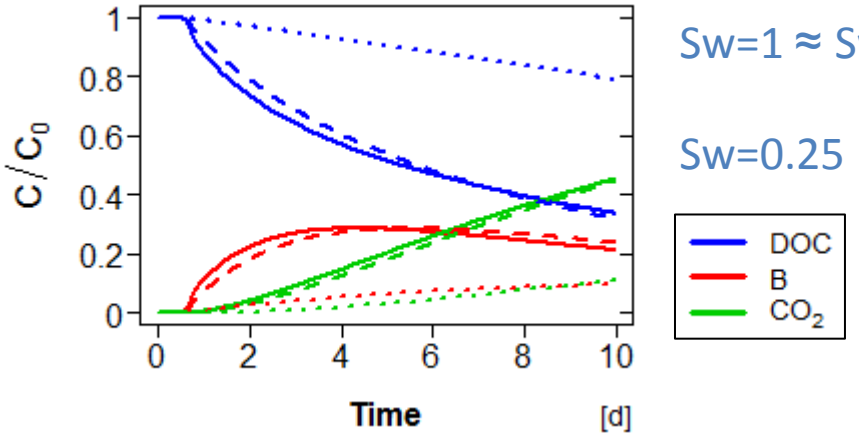
Effets des interactions entre facteurs:
Saturation en eau x Localisation

Géometrie	Saturation	Localisation
	Sw=1 Sw=0.5 Sw=0.25	



↘ Sw ↗ cinétique

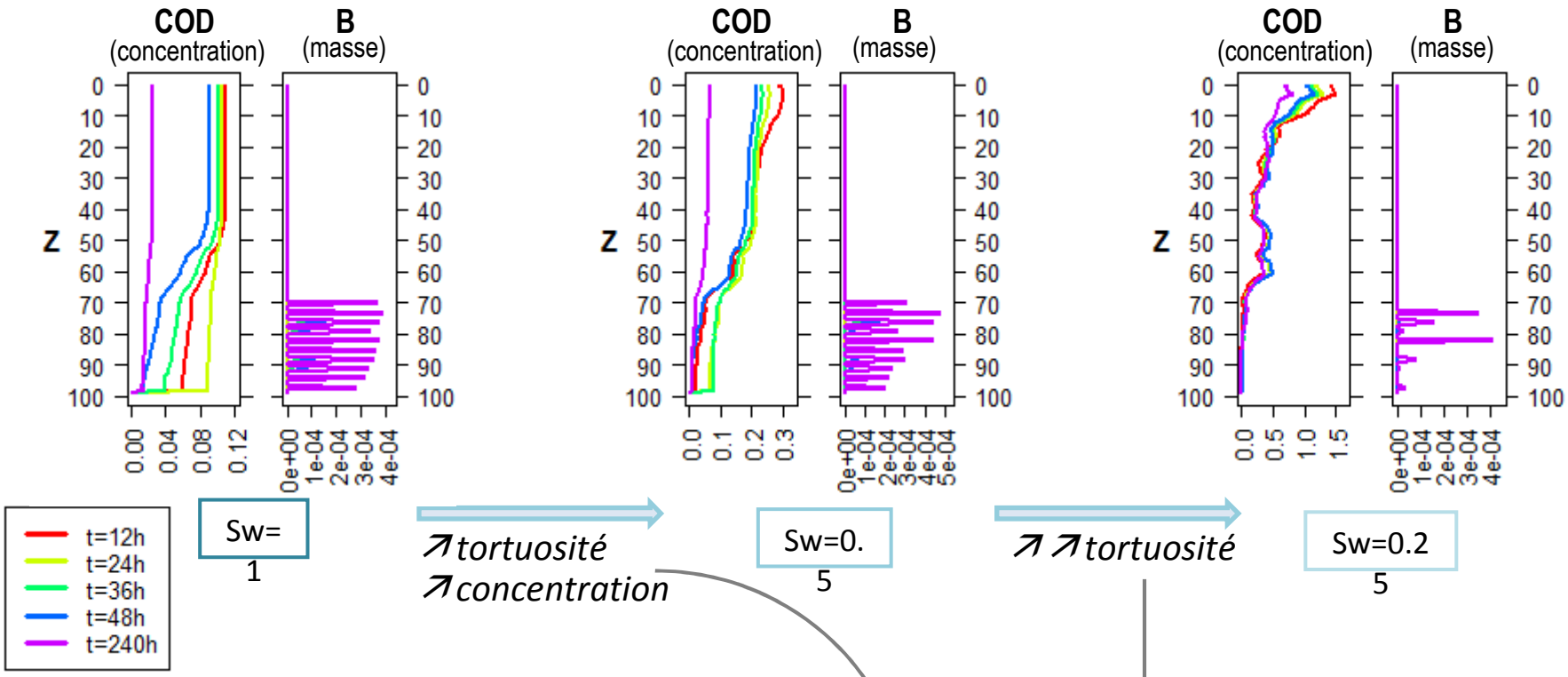
Géométrie	Saturation	Localisation
	Sw=1 Sw=0.5 Sw=0.25	

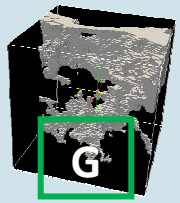
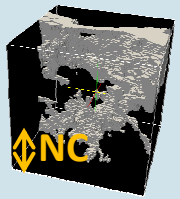


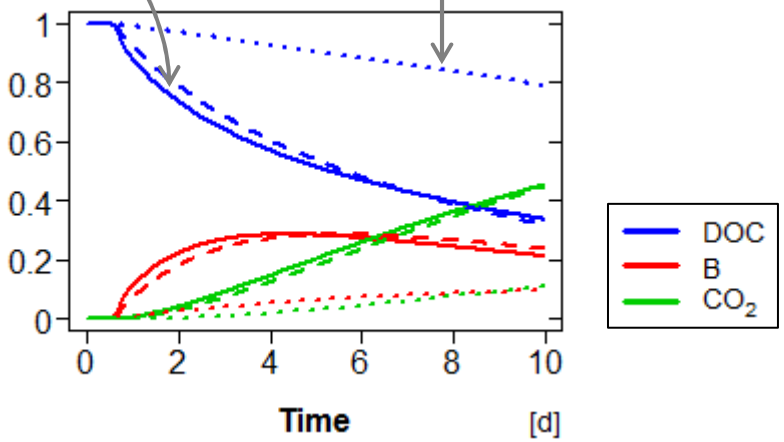
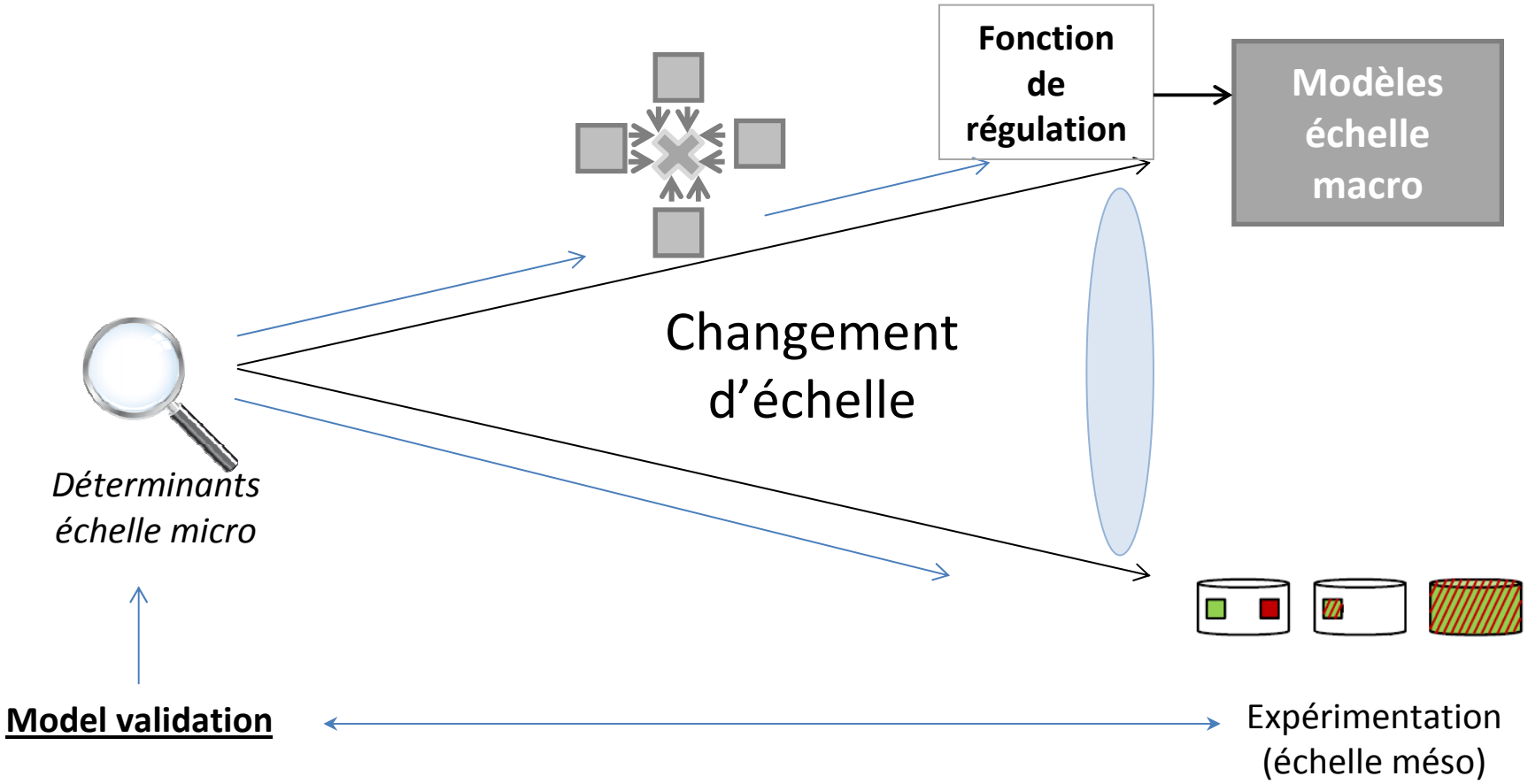
Sw=1 ≈ Sw=0.5

Sw=0.25 ↘ ↘

Pore-scale view



Géométrie	Saturation	Localisation
	Sw=1 Sw=0.5 Sw=0.25	



Perspectives