Water and air distribution in 3D computed tomography images to use *in silico* studies of fungal resilience and biodiversity in soils

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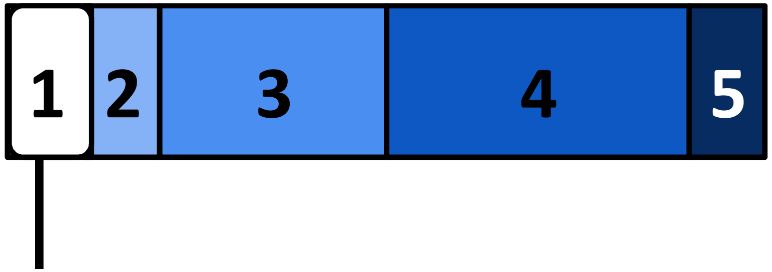
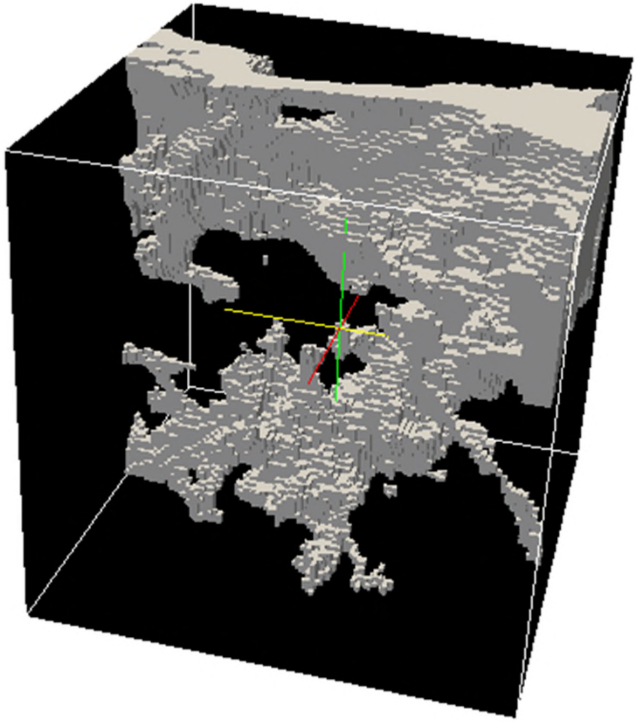
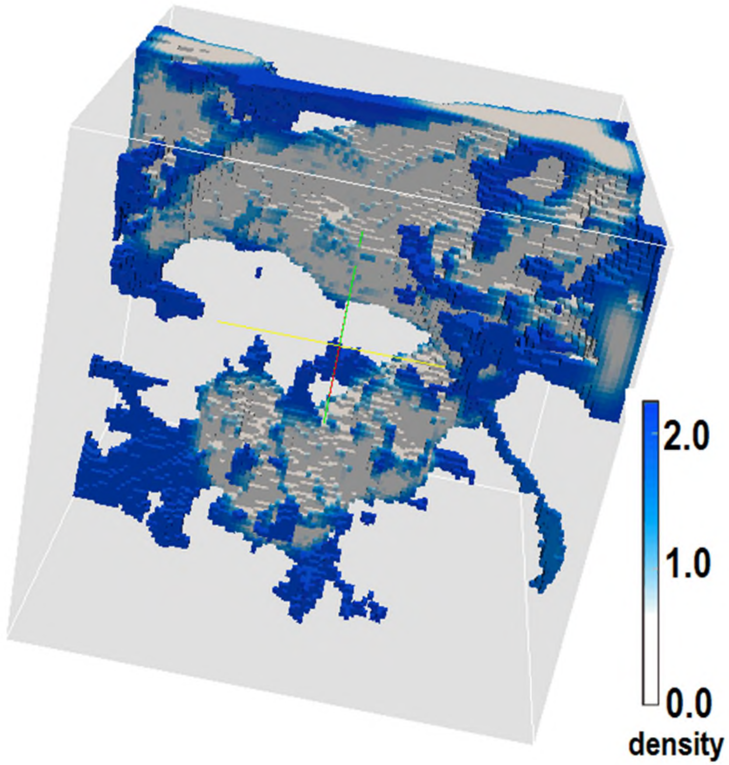


Introduction

Solid phase



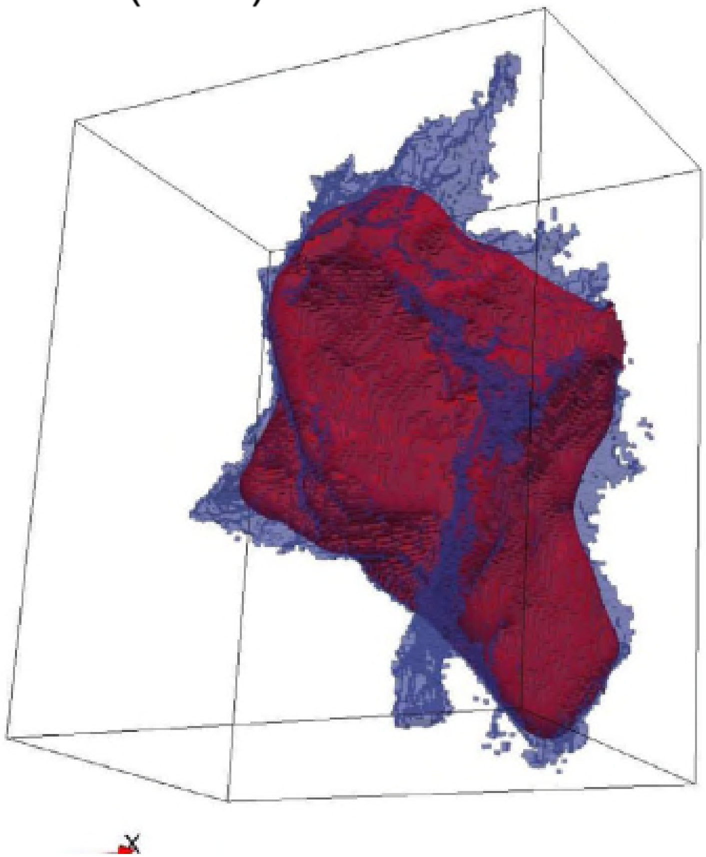
Solid-Liquid-Gas phases



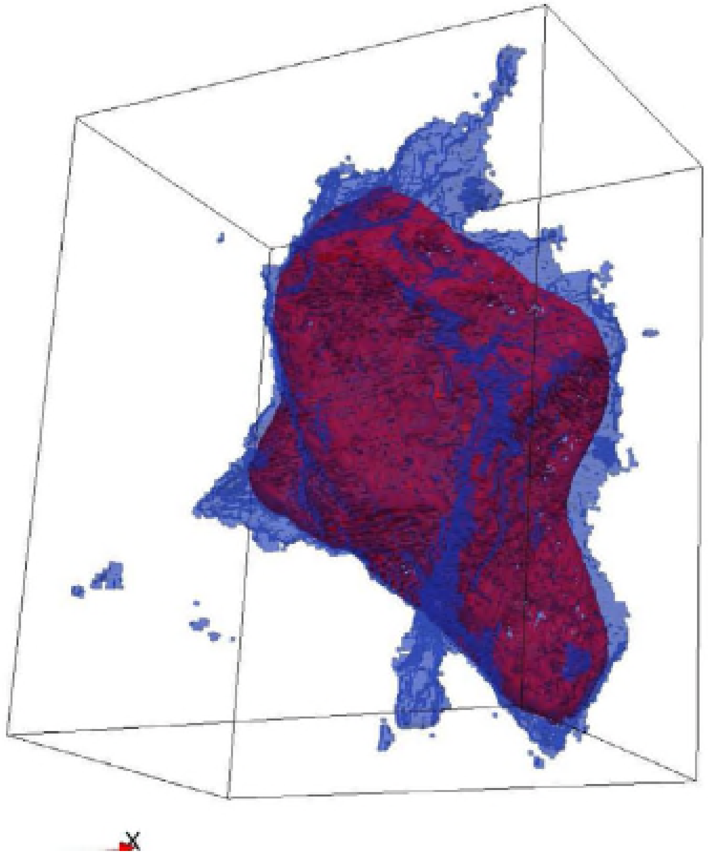
Modeling

The water and air filled fractions of the pore space can be obtained using apropriate models.

Pot et al. (2015)

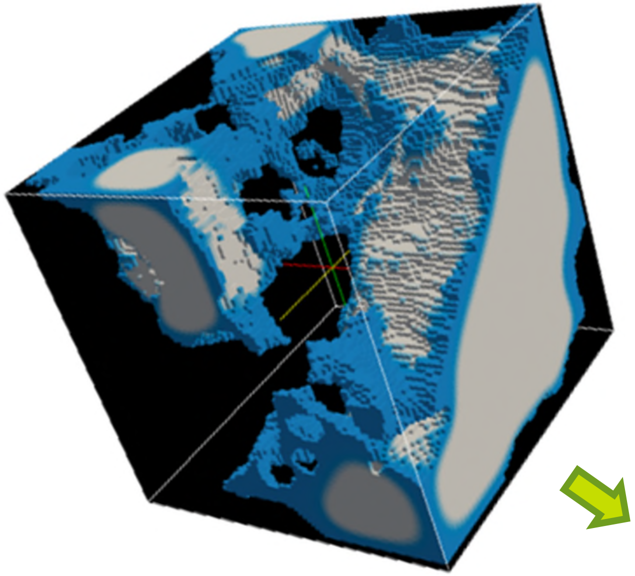


X-Ray CT Scans

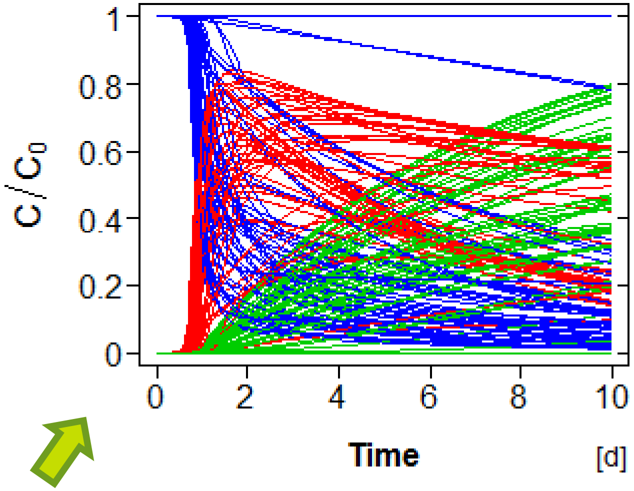


LB Model Output

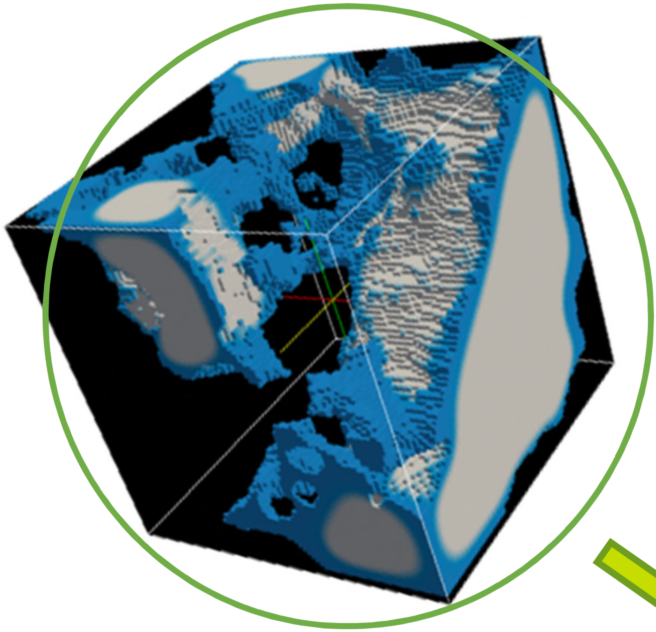
Lattice-Boltzmann modelling has shown to produce physically accurate water/air distributions in soil.



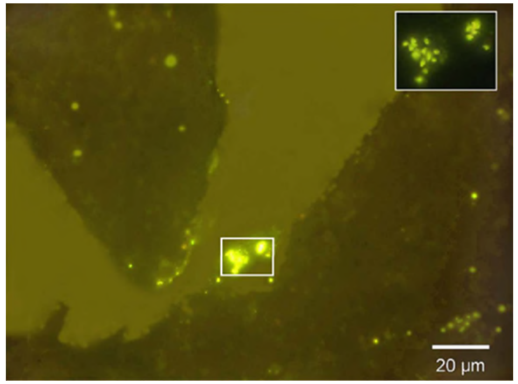
µbial pore scale models



3D CT Scans + Water/air distributions can be used by microbial pore scale models to untangle the effect of soil architecture on microorganismes.

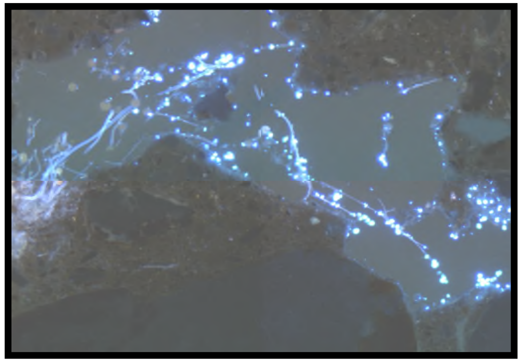


Bacteria need water

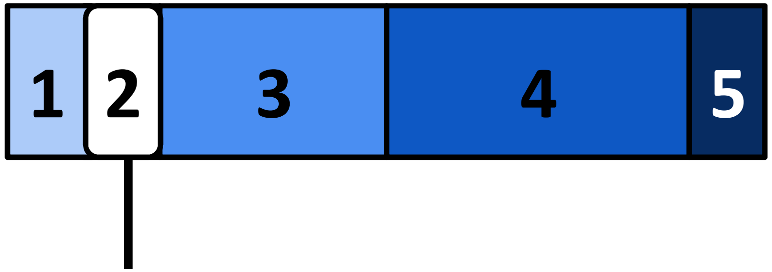


Eickhorst &Tippkötter, 2008

Fungi prefer air filled pores

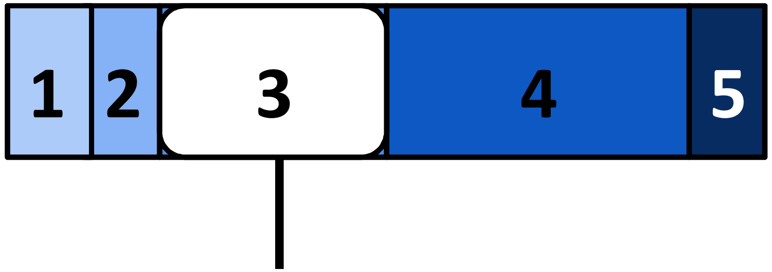


Different water contents will impact unevenly the soil microbial communities



Aim of the work

To obtain a **new set** of 3D images of **air-water interfaces** at **two water saturation levels** in a material constituted of soil aggregates repacked at **different densities**.



Material and methods

Lattice-Boltzmann simulations

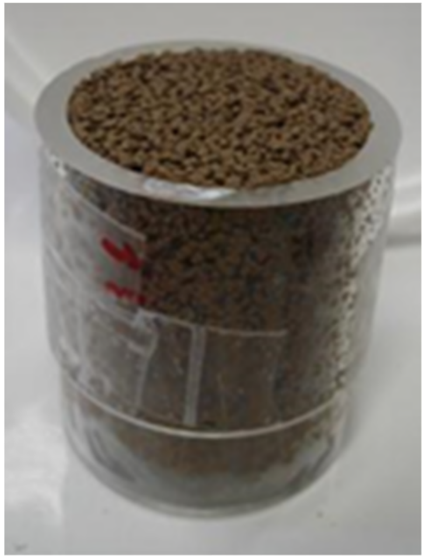
- **Soil:** Sandy loam at bulk densities 1.2, 1.3, 1.4, 1.5, and 1.6 g cm^{-3}.

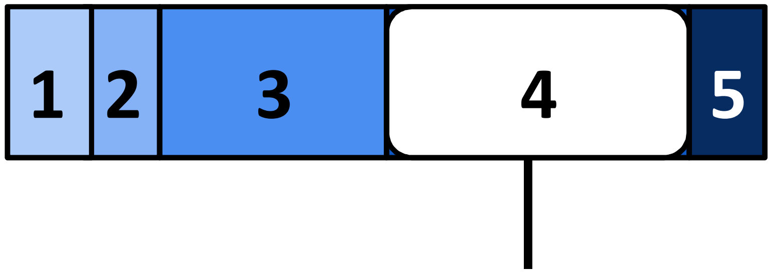
- **Model:** Two-phase Two Relaxation Times (Genty and Pot, 2013).

- **Two water contents** with the following hypothesis:
  - ✓ Sw=20% - Connected air and disconnected water space.
  - ✓ Sw=80% - Connected water and disconnected air space.

50 mm ø

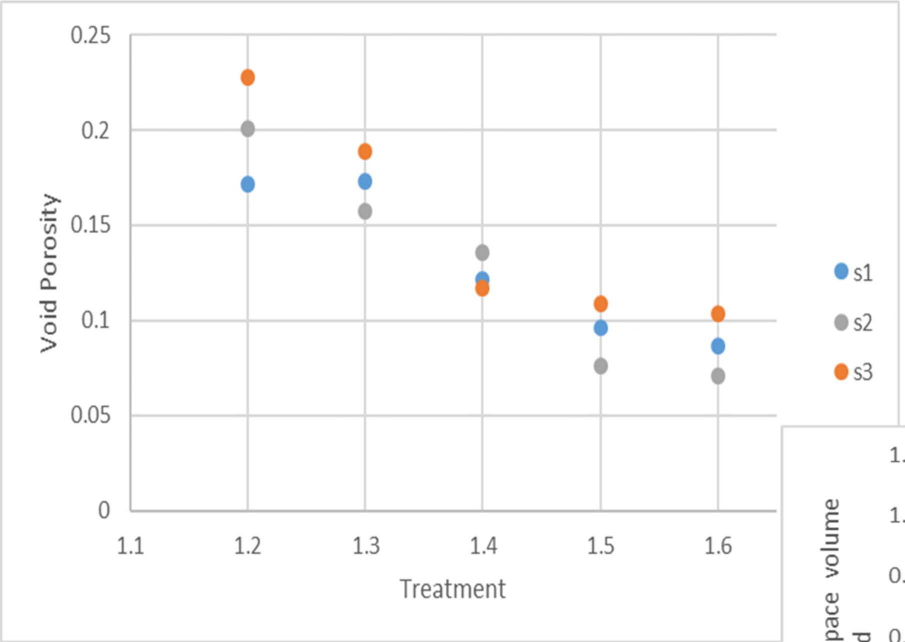
40 mm



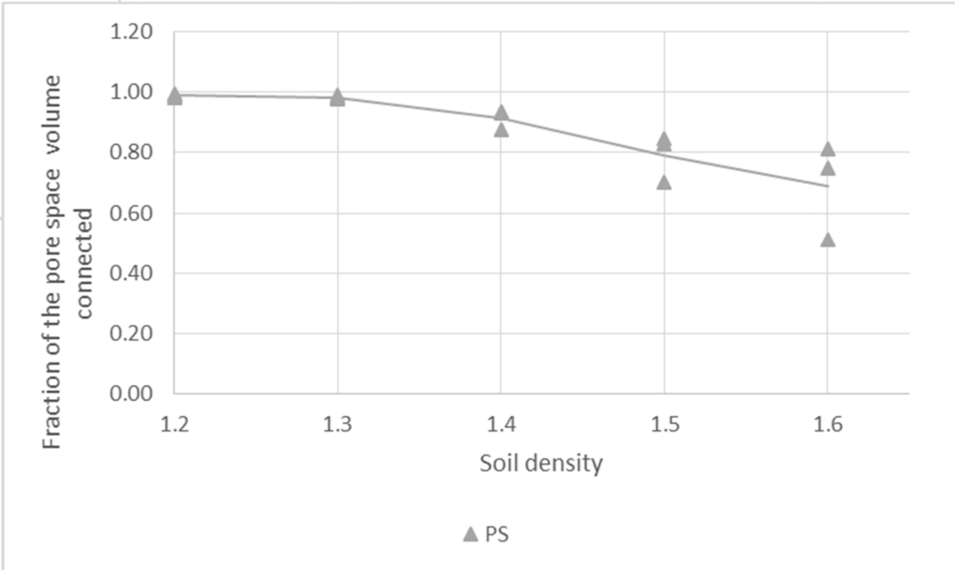


Results

First, total pore space



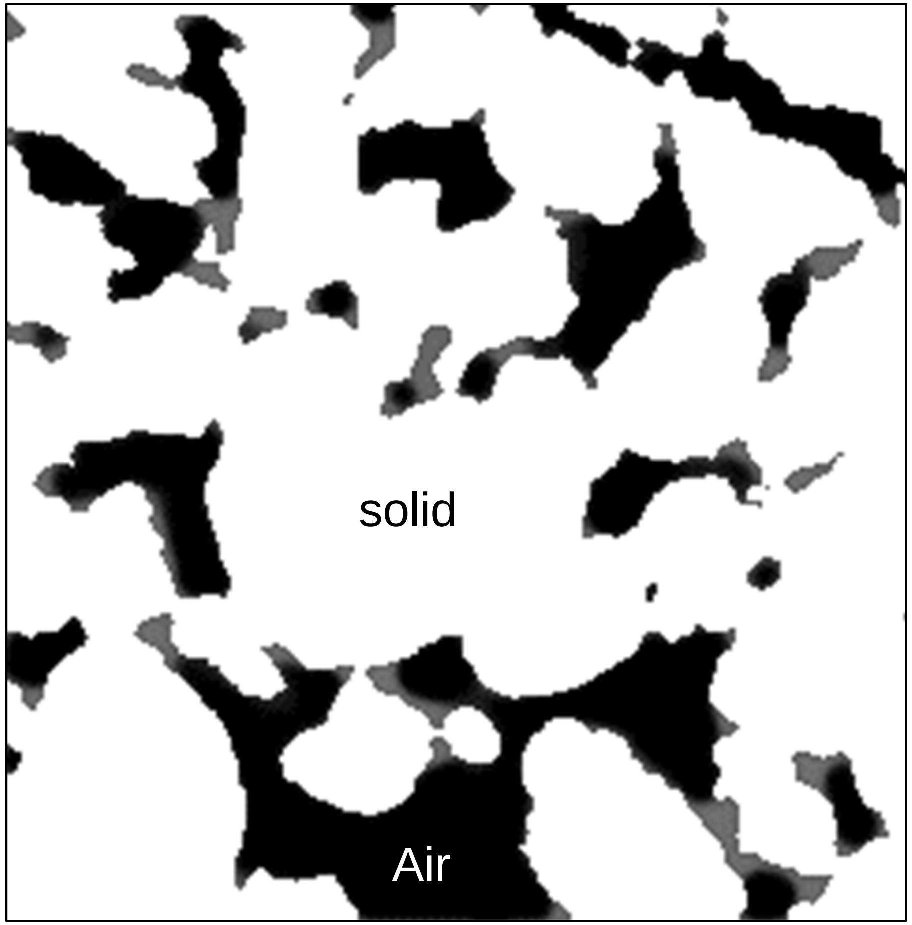
Porosity declines with soil density



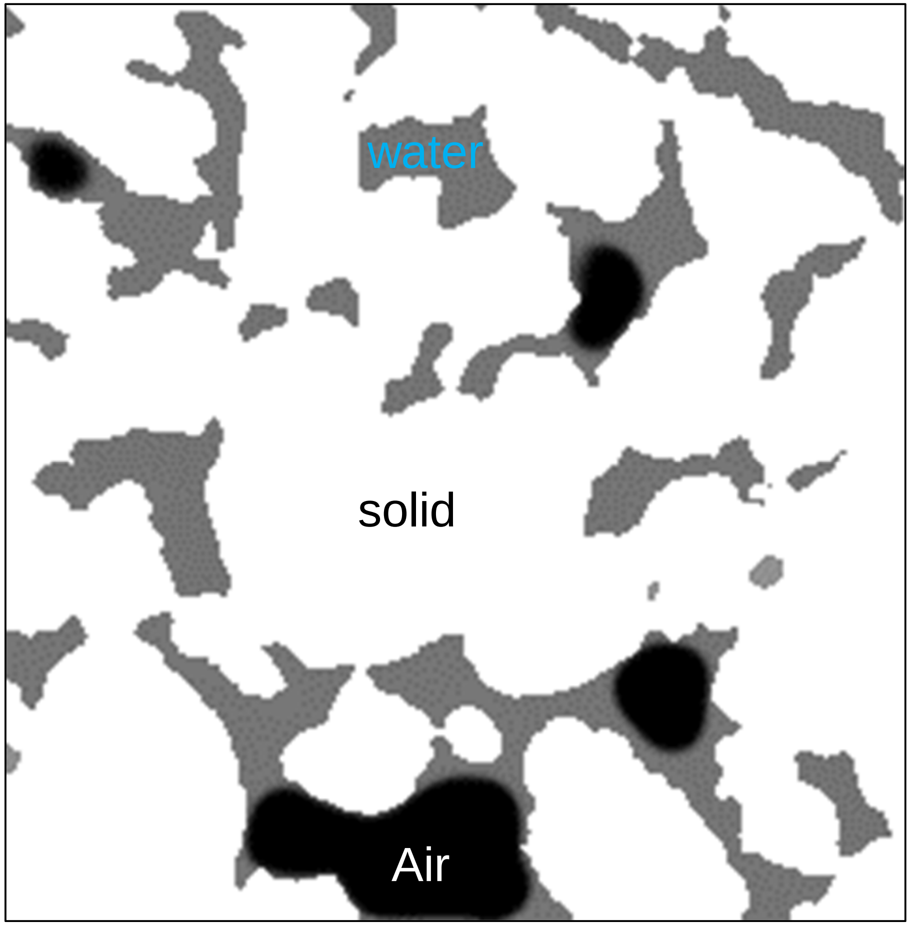
Pore space remains well connected for all densities

Let’s move on to the water/air distributions!

Image BD12 S1:



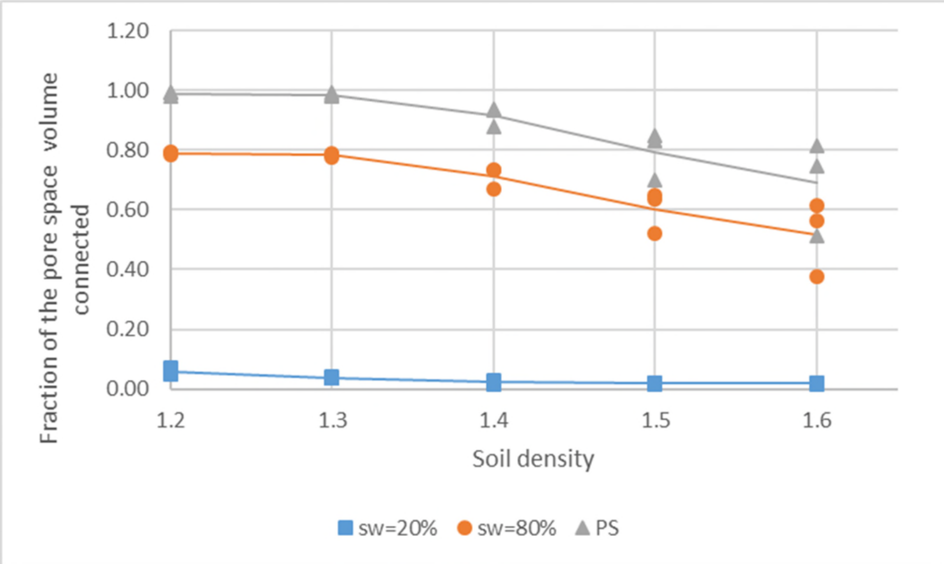
Sw=20%



Sw=80%

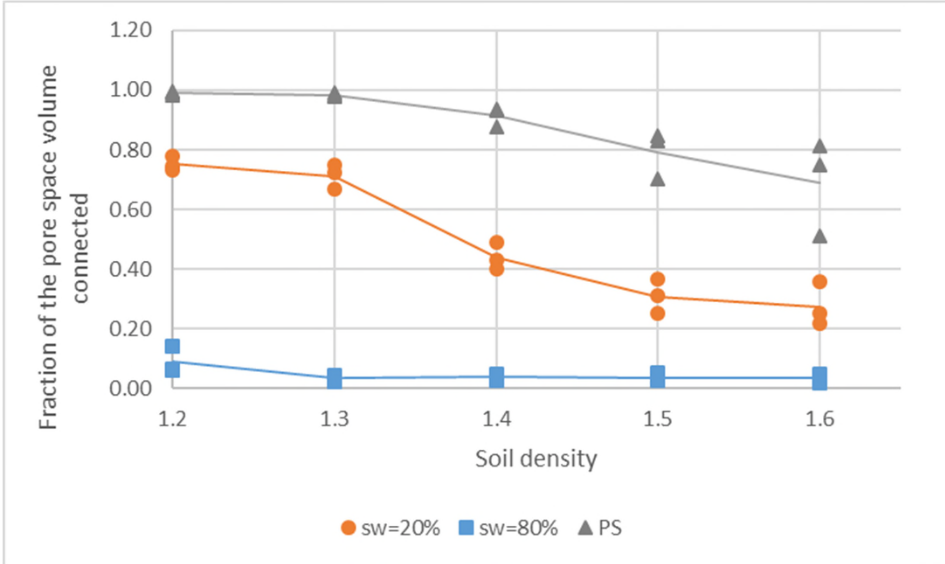
Let's move on to the water/air distributions!

Liquid phase connectivity



Water is connected at Sw=80±0.5% and disconnected at Sw=20±0.5%

Gas phase connectivity



Air is connected at Sw=20±0.5% and disconnected at Sw=80±0.5%

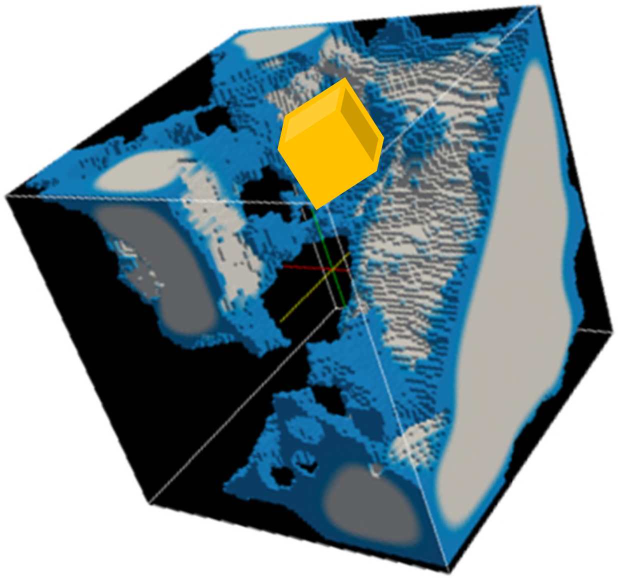
Application example *

Effect of the spatial distribution of organic matter on the bacterial growth

* Submitted to Frontiers in Microbiology.

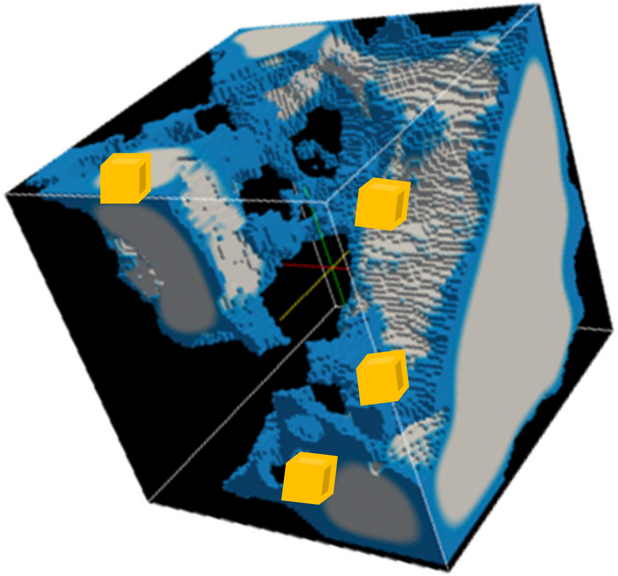
Organic matter placement

High heterogeneity



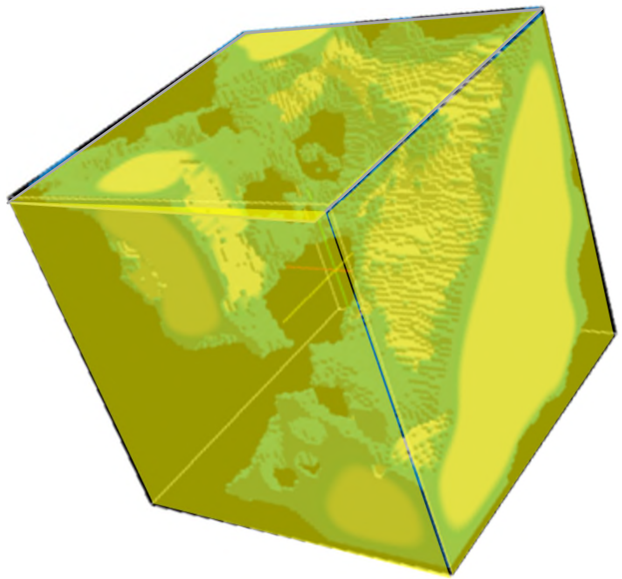
$1 \times 0.02^3\ cm^3$

Intermediate heterogeneity



$4 \times 0.01^3\ cm^3$

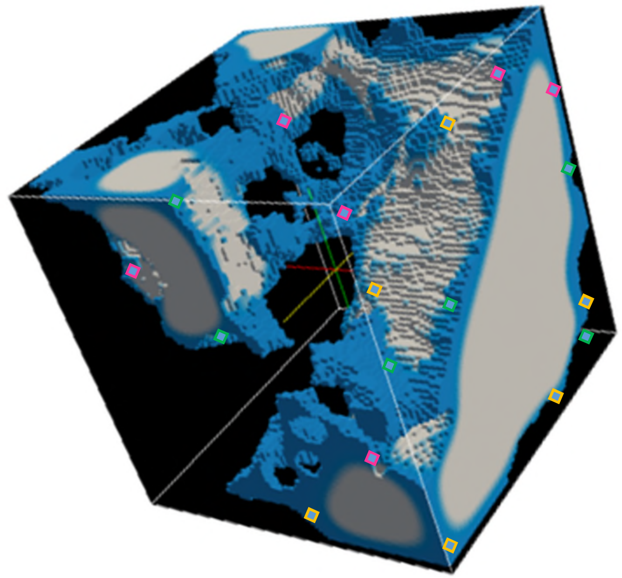
Low heterogeneity



C as DOC

10 repetitions changing POM position

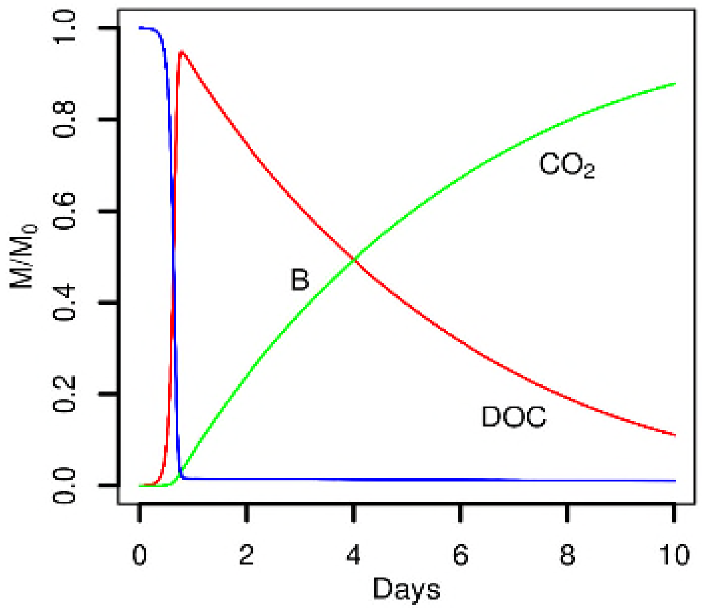
Bacterial placement and water level



690 (230x3) bacteria in 690 spots

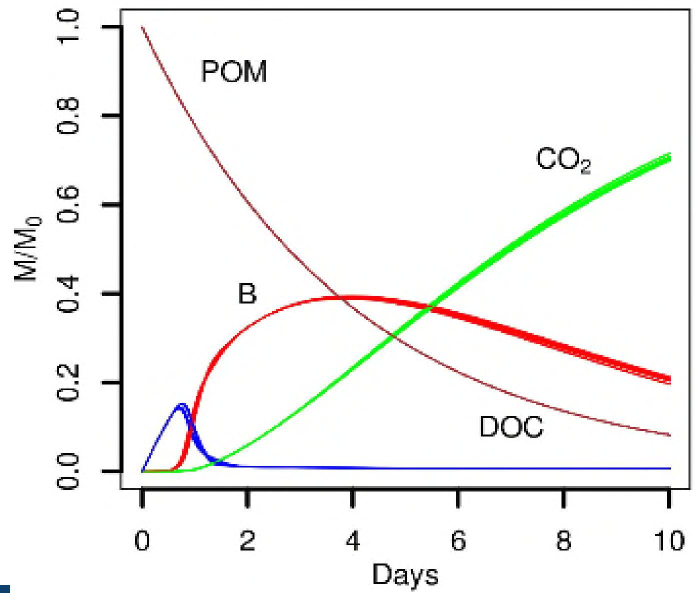
Three bacterial strains: competitive, generalist, poor competing

Low heterogeneity

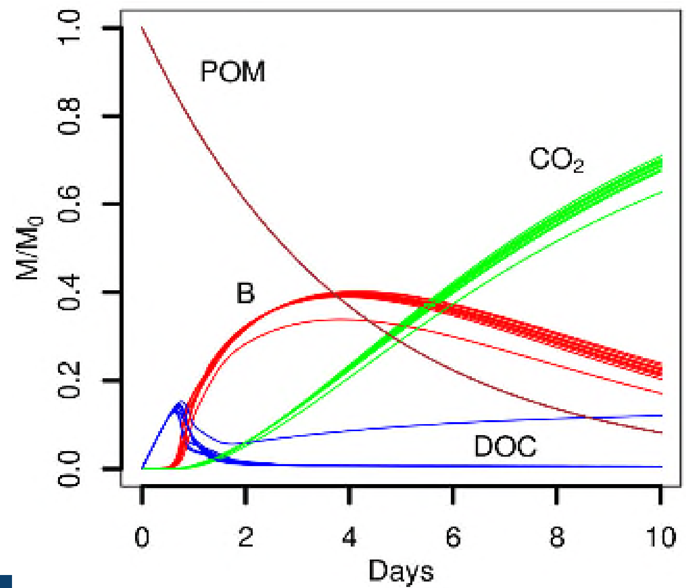


Faster growth when the C is available as DOC at the beginning of the simulation

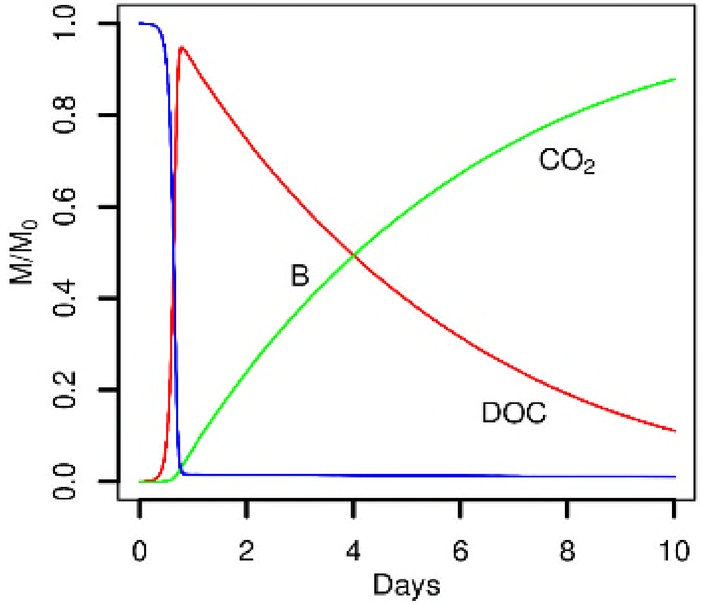
Intermediate heterogeneity



High heterogeneity

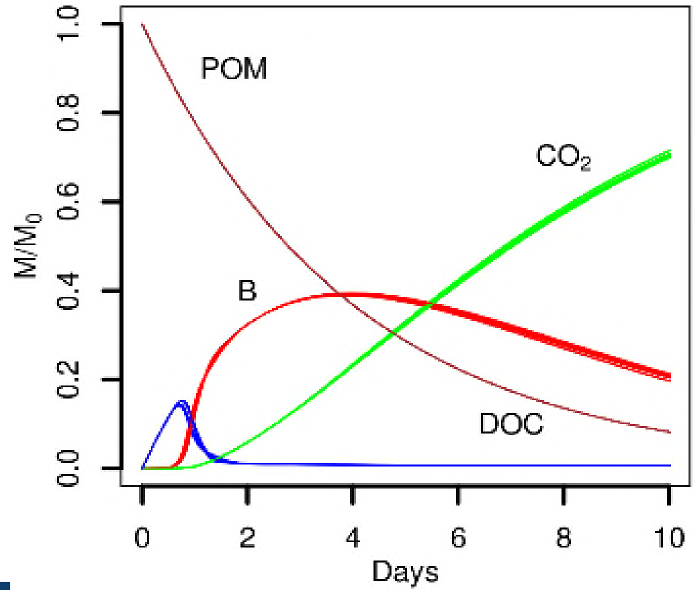


Low heterogeneity

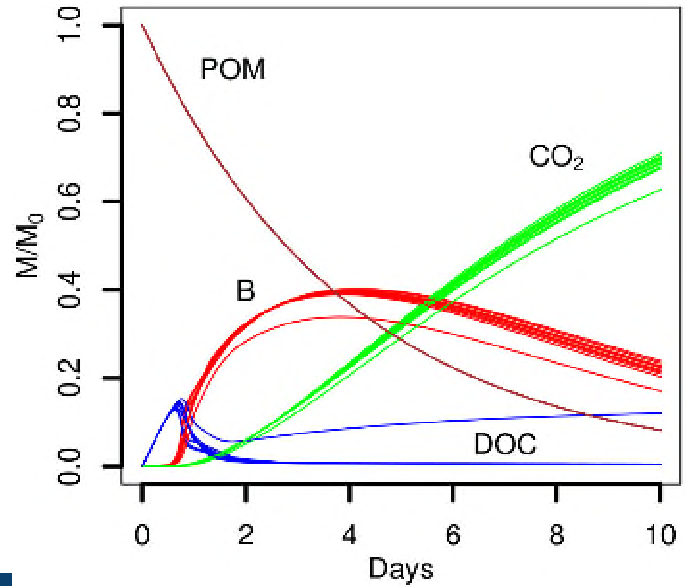


Similar kinetics when the OM is particulate

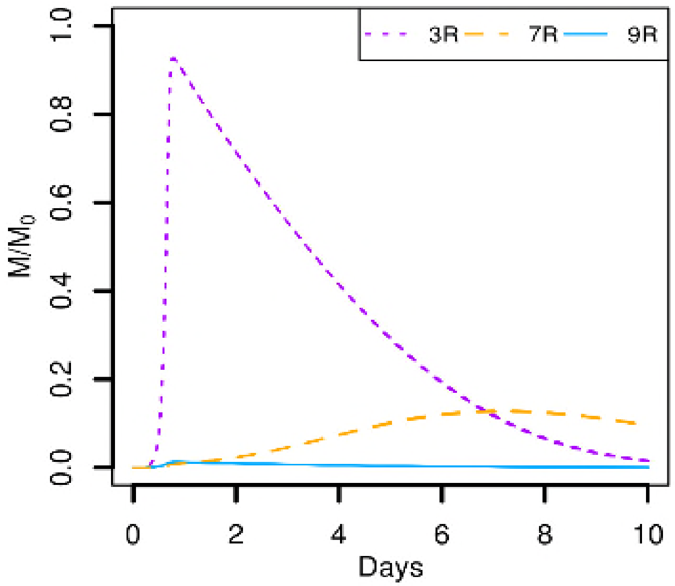
Intermediate heterogeneity



High heterogeneity

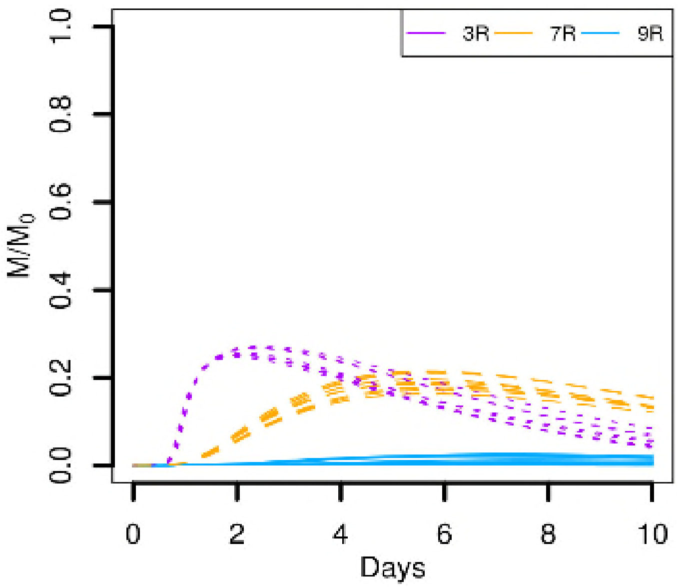


Low heterogeneity

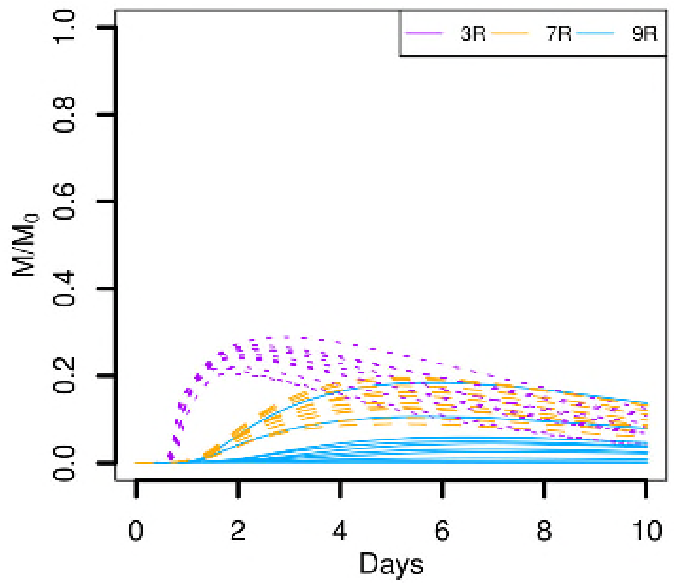


The high competing strain dominates clearly when all C is available at the beginning of the simulation

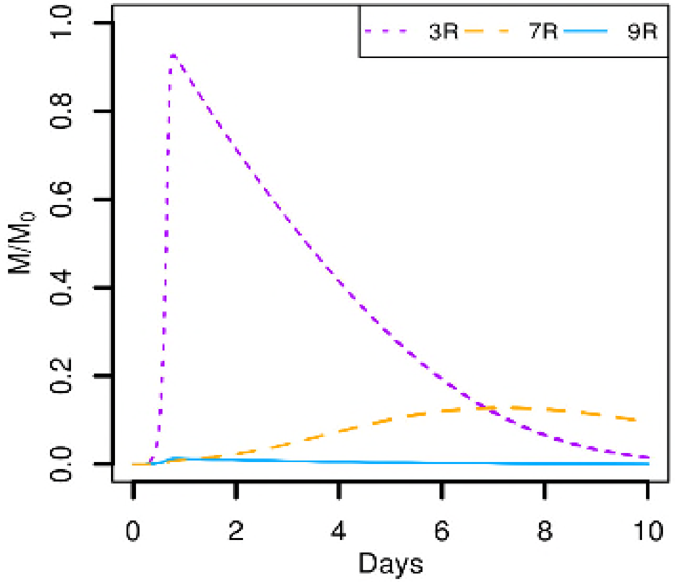
Intermediate heterogeneity



High heterogeneity

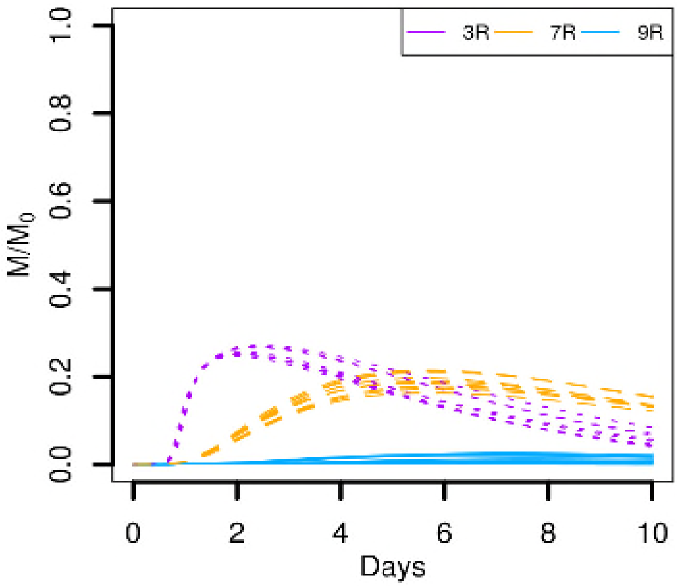


Low heterogeneity

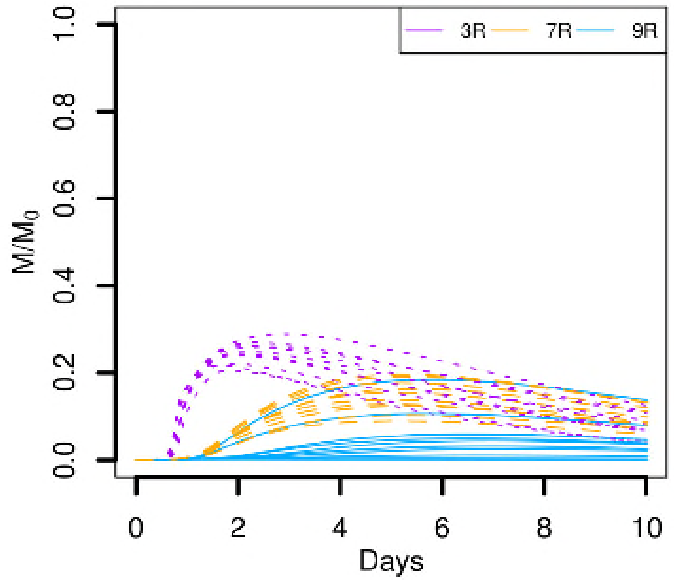


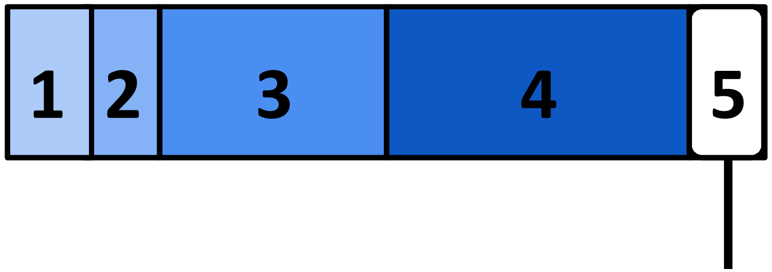
The low competing strain 9R is able to growth noticeably in the high heterogeneity scheme

Intermediate heterogeneity



High heterogeneity





Final remarks

Focusing on the LBM simulations…

Database of CT images:

- ✓ Five bulk densities (1.2, 1.3, 1.4, 1.5, 1.6 g/cm^3)
- ✓ Three replicates
- ✓ Four water contents (0, 20, 80, 100)

Images details:

- ✓**Size.** 512x512x512 Voxels (1.3x1.3x1.3 cm^3)
- ✓**Resolution.** 24 µm

A total of 60 images that differ in connectivity and geometry and that are available for microbial simulations.

Focusing on the bacterial simulations…

The **soil architecture** along with the **heterogeneity on the resource placement** can promote **bacterial biodiversity** in soils

Thank you very much for your attention!!!

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In depth enough?..........

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