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Image-based modelling of the distribution and residence time of carbon in the rhizosphere at the pore-scale

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Motivation and Aims

- Development of a dynamic, **spatially explicit**, **data-based, pore scale model** supplementing and quantifying experimental insights
- Investigating the carbon sources POM and mucilage and their impact on the dynamic rearrangement of soil particles
- Evaluating scenarios to investigate distribution and residence time of carbon

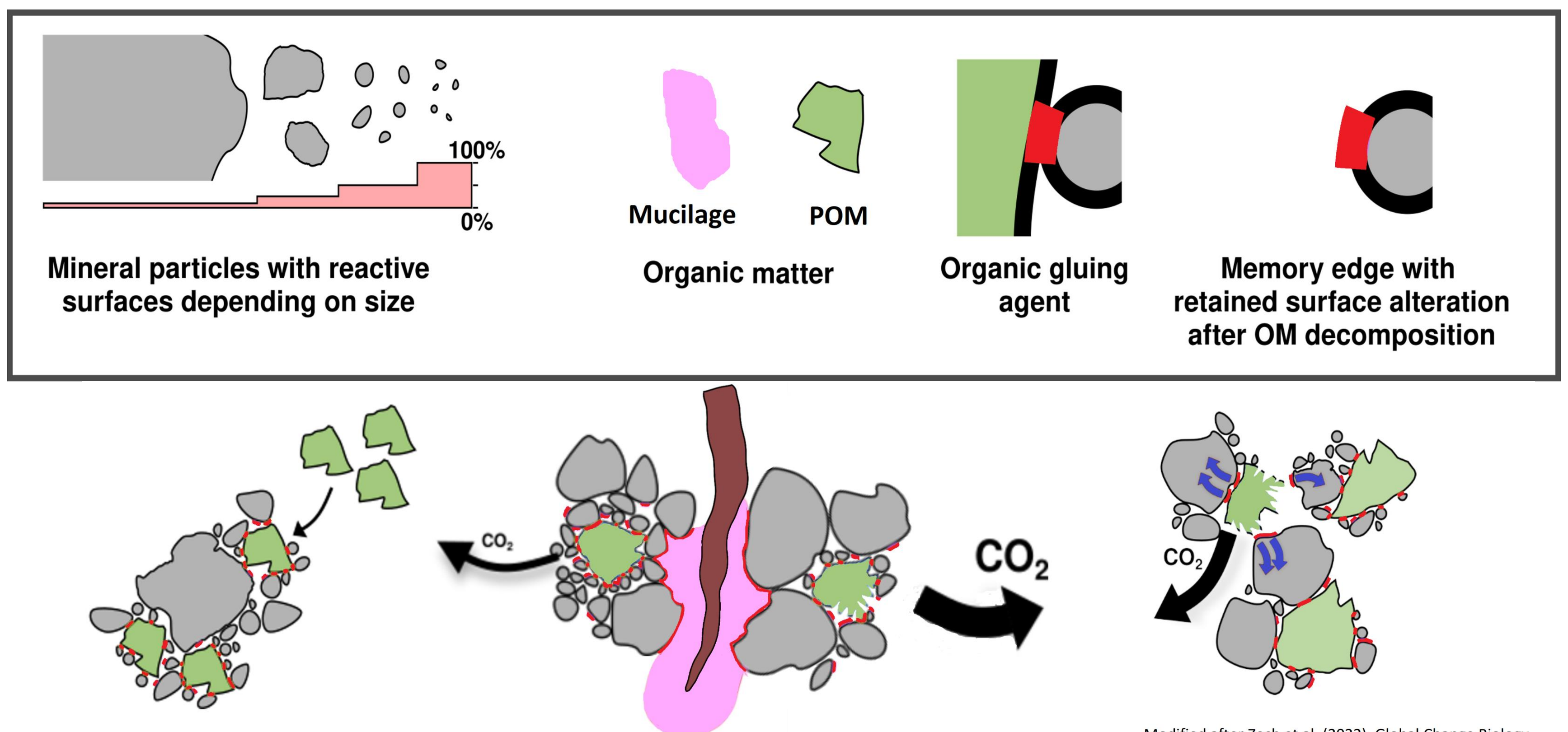
Mathematical Model

Virtual soil

- Computational domain: 500 µm x 500 µm with a resolution of 2 µm
- Digital twin of agriculture soils with different clay, silt and sand content

1. Dynamic structural reorganization of soil and POM particles

2. Carbon turnover model

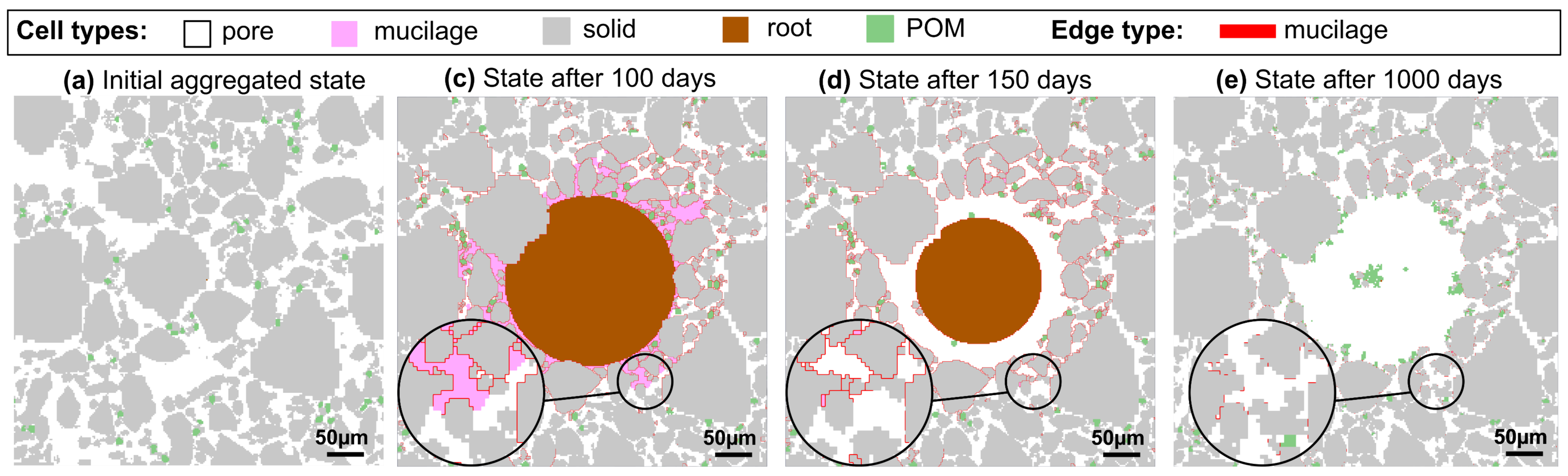


Modified after Zech et al. (2022), Global Change Biology

- Two C-sources: POM (slow: weeks-months) and mucilage (fast: days)
- Decomposition of OM depending on pore access
- Production of **organic gluing agent** by microbial OM turnover
- Enhancement of aggregate formation
- Without new input of carbon long term "**weathering" process** of microbially produced gluing agent (slow: months)

3. Root model

- Root growth/decay and exudation/distribution of mucilage

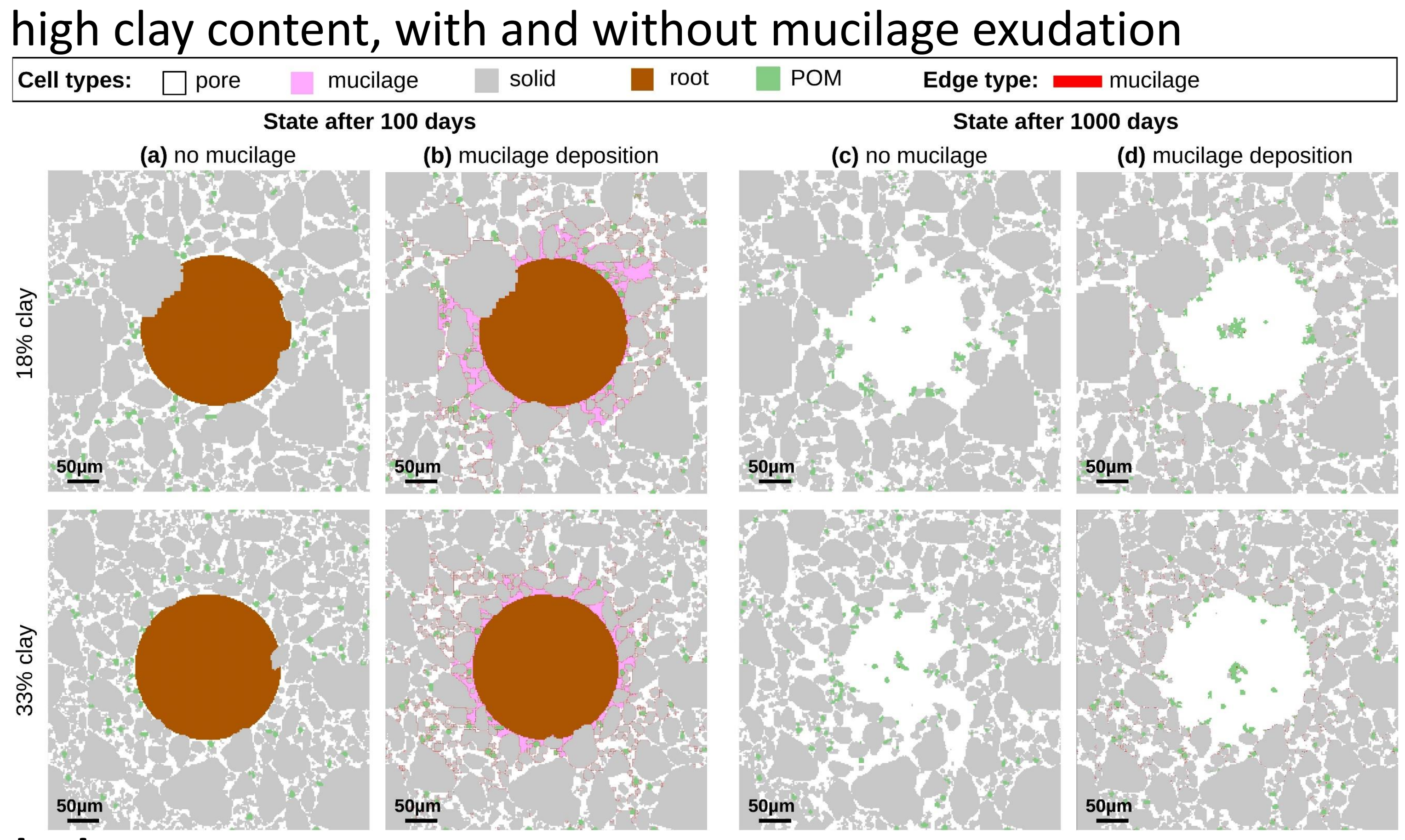


➢ **Dynamically changing surface properties leading to local (de-)stabilization of aggregates**

Rhizosphere study

Long-term behavior of the arrangement of soil particles

- Comparison of two digital twins of agriculture topsoils with low and high clay content, with and without mucilage exudation



High clay content

- Relocation process faster due to smaller, more mobile particles

Low clay content

- Higher stability of structures due to immobility of larger particles

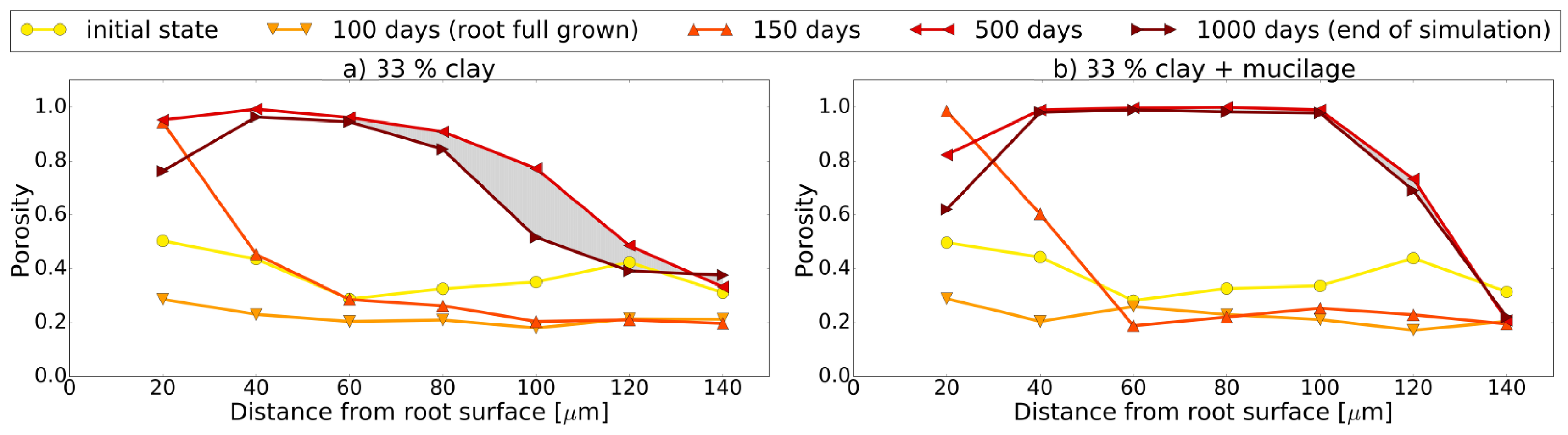
Mucilage exudation

- Fast degradation resulting in large amount of gluing agent, consequently persistent stabilization of the aggregated structures

No mucilage exudation

- Pronounced rearrangement of particles into the biopore

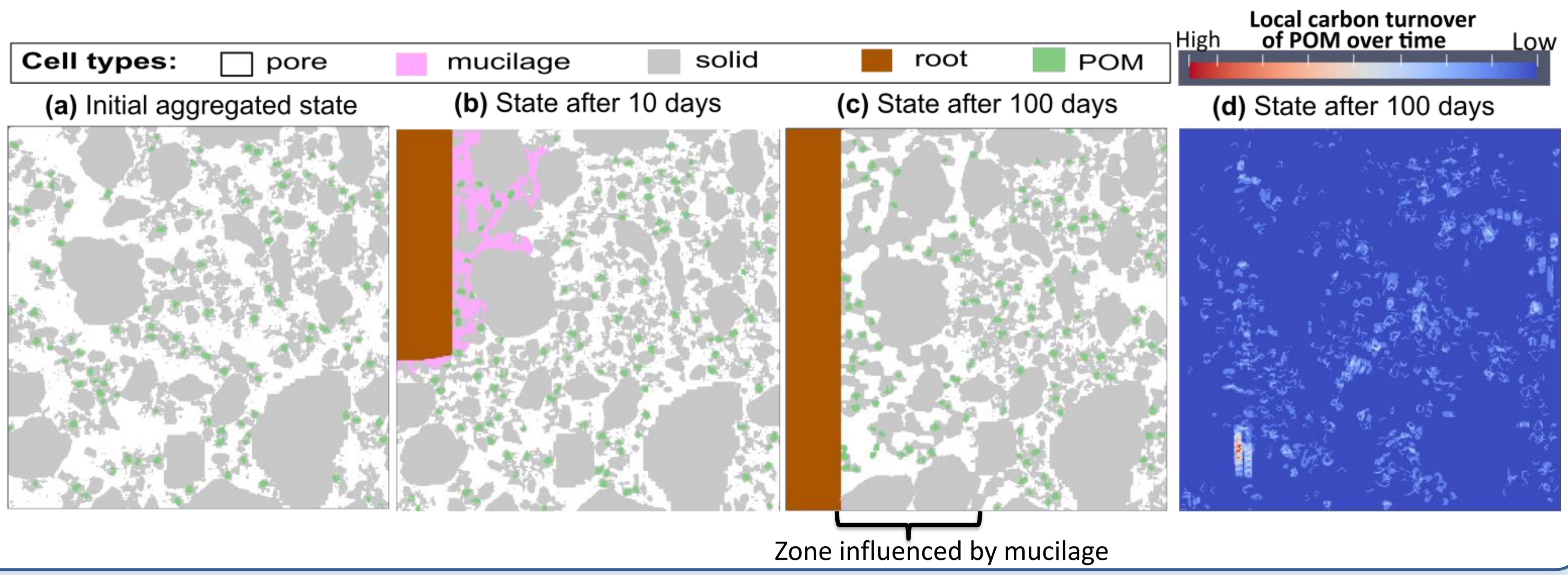
Quantification of local porosity



- Compaction (100 d), gap formation (150 d), biopore (500 d, 1000 d)
- **Long-term (in)stability** indicated by gray area

Distribution and residence of carbon

- Evaluating spatiotemporal carbon turnover (High turnover: hot spot)



Outlook

C:N-ratio relevant for microbial activity and growth of biomass

- Deficit of nitrogen: More respiration and less production of biomass

Combination of our current model of **spatial rearrangement** with an **extended carbon turnover model** adapting Kaiser et al. (2014)

- Dissolved nitrogen and carbon as nutrient sources
- **Growth and death** of microbial biomass
- Nitrogen as **additional required resource for microbial growth**

Simulation setting of a **rhizobox experiment**

- Hypothesis: **Spatial gradient** of carbon turnover (cold and hot spots)

References

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Don't miss following program point
Session SSS5.2
Coupling scales in process-based soil organic carbon modeling including dynamic aggregation
Alexander Prechtel, Simon Zech, and Nadja Ray
Wed, 17 Apr, 14:45–14:55 (CEST) | Room D2

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