Soilmu-3D

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EMERGING PROPERTIES OF MICROBIAL FUNCTIONS IN SOILS: IDENTIFYING SPATIAL DESCRIPTORS OF SOILS STRUCTURE FROM 3D MODELING AT MICROBIAL HABITAT SCALE

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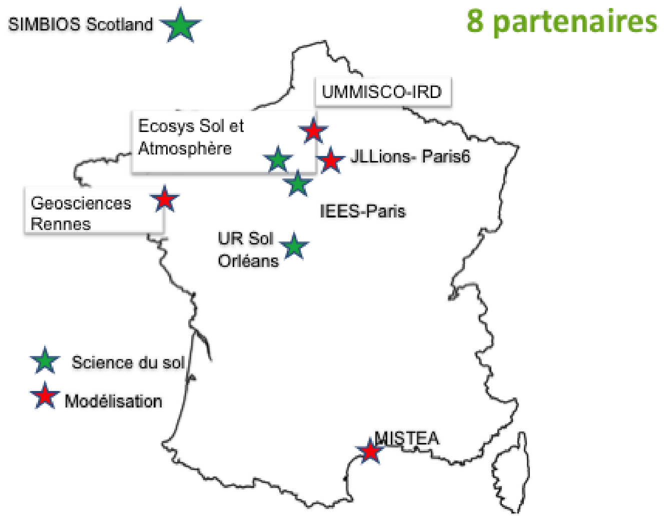
Project duration: 2016-2019

ObjectiVE: Use modeling as a tool for scale transfer from microbial habitat to soil profile.

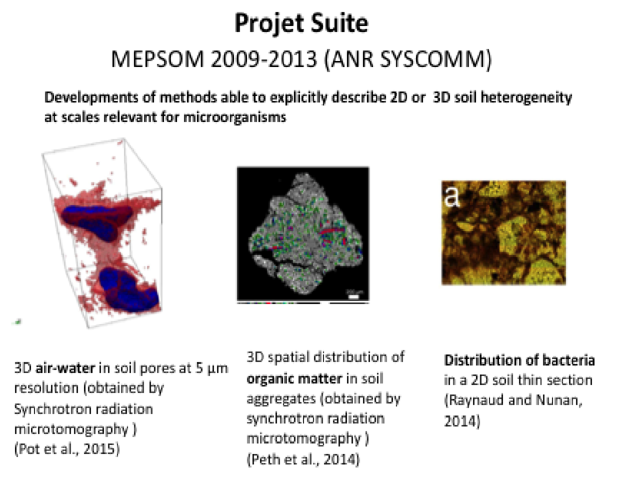
CONTEXT

The reduction of greenhouse gas (GHG) emissions by improving the efficiency of agricultural systems through robust ecologically-based management practices represents the most important challenge facing agriculture today. Models are needed to evaluate the effects of soil properties, climate, and agricultural management practices on soil carbon and on the nitrogen transformations responsible forGHG emissions. Models of Carbon and nitrogen cycles in soils like RothC, Century, or CERES need improvements so they can provide more accurate and robust predictions. They use empirical functions which account for the different environmental factors that affect microbial functions. However, these types of function have limitations because i) they don't consider the micro heterogeneity of soil at the scale of microorganisms and ii) they cannot describe processes that are connected to each other by complex interactions linked to soil structure. Mechanistic representation of small-scale processes was identified in literature as one of the priorities to improve these global soil organic matter dynamicsmodels. Our MEPSOM project (ANR, 2009-2013) showed the importance of the habitat of soil microorganisms, and especially how physical characteristics (pore sizes, connectivity) control the decomposition of organic substrates via experimental microcosm. MEPSOM project has developed a suite of methods and models to visualize in 2D or 3D soil heterogeneity at scales relevant for microorganisms. It has also contributed successfully to the development of three very complementary 3D models able to simulate for the first time the microbial degradation of organic matter at the scale of microhabitats in soil using real 3D images of soils.



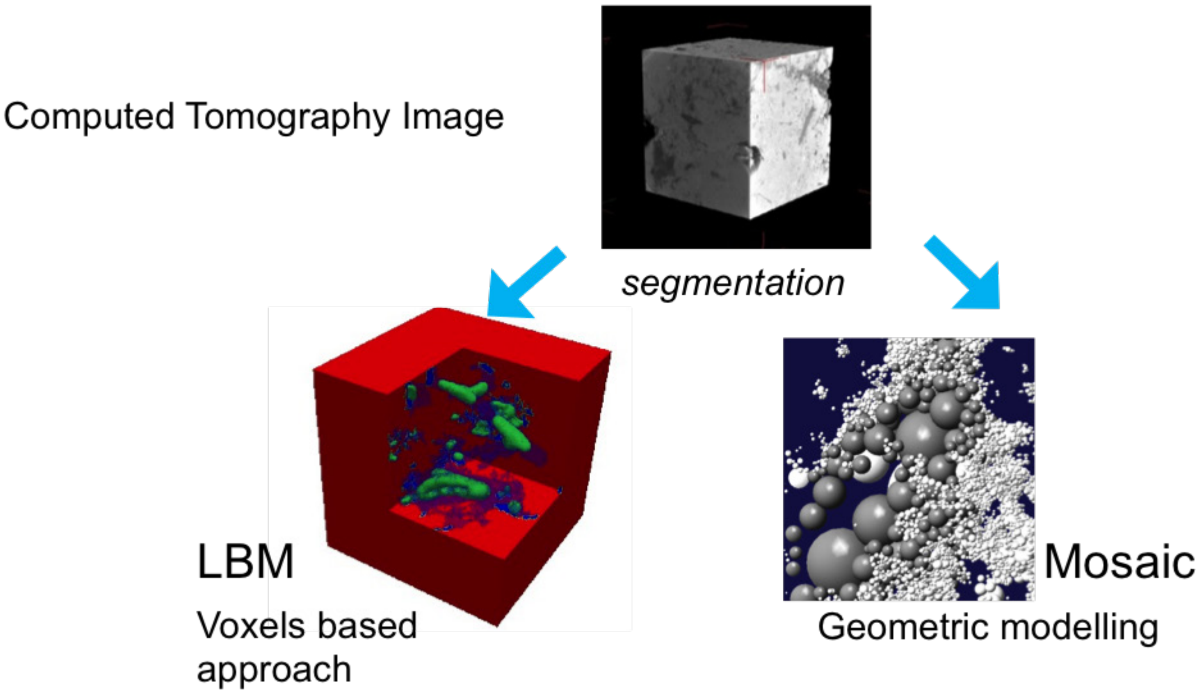
OBJECTIVES

The goal of this new project is now to go further by using the 3D models resulting from MEPSOM to upscale heterogeneities identified at the scale of microhabitats to the soil profile scale. The aims of the project are to: develop new descriptors of the pore scale 3D soil heterogeneity that explain the fluxes measured at the core scale, use our 3D models to connect the µ-scale heterogeneity and the measured macroscale fluxes, develop new simple models describing the soil micro-heterogeneity and integrating these micro-features into field-scale models.



APPROACH

The originality of our approach is to bring together scientists from soil science and scientists from applied mathematics and modelling. The interaction between these two populations of researchers will break with traditional modelling formalisms used in soil science.



ORGANIZATION

To start the project, partners will meet to establish and carry out scenarios from existing models of MEPSOM project. This first step will further define strategic experiments for measuring the emissions of CO2 and N2O under different micro-environmental conditions in WP1. 3D images of the pore-scale distribution of water, particulate organic matter, and microorganisms will be produced in WP2 from the samples provided by WP1. Descriptors of heterogeneity will also be calculated on these 3D images. The 3D pore scale models will upscale the 3D pore scale heterogeneity and simulate global CO2 and N2O fluxes at the core scale that could be tested against experimental data of WP1. Simulation scenarios exploring contrasted micro-environmental conditions will be carried out from these 3D models in WP3. Correlation between the descriptors calculated at the pore scale and the gas fluxes simulated at the core scale will serve as a basis for the production of functions or simple models which will relay the information to bring the microscopic heterogeneity to the soil profile. WP 5 will propose improvements in the models describing the process at field scale and a test of these improvements with existing field data.