

PhD thesis: Operationalizing mechanistic soil function models



Background

Soils provides functions supporting ecosystem services and human well-being. Example of soil functions are the nutrient cycling or the primary productivity. The assessment of these functions is at the core of several recent national and international policies aiming at soil health. The recent proposal for a Directive on Soil Monitoring and Resilience of the European Commission, for example, aims to render all European soils healthy by 2050. While the institutional context is favourable, the quantification of such soil functions, however, is a scientific challenge, as these are difficult to measure. Usually, soil functions are estimated from soil properties used as indicators of the soil function supply, on which a threshold is used. An alternative approach is to use a mechanistic model with a biogeochemical model. Mechanistic modelling is the preferred approach as it does more justice to the underlying soil processed and pedological knowledge. To date, however, mechanistic models are seldom used for soil function assessment. This is because such models have often a very complex structure, have strong data requirement, and are slow and difficult to parametrize. Making these models operational are of importance so they can be applied at various spatial scale and support assessment of soil health in response to a change in farming practice.

In the framework of the EU-project [DeepHorizon](https://cordis.europa.eu/project/id/101156701) (<https://cordis.europa.eu/project/id/101156701>), we are therefore looking for an excellent PhD candidate to operationalize mechanistic soil function models. The PhD candidate will learn and apply newly developed mechanistic soil function models and investigate tools and general methodology developed in the field of uncertainty quantification for conducting a sensitivity analysis of input correlated variables, input dimension reduction (active subspace), uncertainty propagation, meta-modelling and calibration of the soil function models based on field data. The validation of the soil function models will also be carried out in order to test the ability of the models to generalize to different scenarios. The approaches developed will have to account for the relatively long computation time of the model. The candidate is expected to collaborate closely with other PhD candidates of the project consortium and with project partners in Germany and in the USA, for which temporary stay could be envisioned.

Tasks:

- 1- Evaluate the BODIUM or ECOSYS models developed at UFZ and Berkeley, respectively, in a context of reduced input data under various climate and land-use management scenarios in Europe. Calibrate and validate the models.

- 2- Co-build with the model developers a simplified mechanistic soil function model that account for the various uncertainty sources on the basis of the previous task.
- 3- Apply the models to a real-world case study in mapping soil functions at the landscape scale with a full account for uncertainty quantification and the limits of the models.

Each task corresponds approximately to one year of the PhD.

Expected profile:

We are looking for an ambitious, motivated and pro-active PhD candidate with a strong background in applied mathematics, applied statistics or soil/environmental modelling. Applicant should have a Master or equivalent in applied statistics/mathematics or environmental sciences with a strong background in modelling and skills in the following areas:

- Soil science, mechanistic modelling of soil, or interest in soil science
- Statistical modelling
- Proficiency in R or Python coding and familiarity with programming
- Good capacity for bibliographic analysis and synthesis
- Excellent writing and communication skills in English.

The contract will be for 3 years, starting in July 2025 or later. Salary and benefits are according to INRAE rules in France (monthly gross salary ~ 2,100 €).

The PhD will be supervised by Dr Alexandre Wadoux (INRAE), Prof Pierre Barbillon (AgroParisTech) and Dr David Makowski (INRAE) and hosted at the Mathematics and Applied Informatics Joint Unit in Saclay (France) <https://mia-ps.inrae.fr/>.

Interested candidates should send a CV and cover letter to Alexandre Wadoux (alexandre.wadoux@inrae.fr) and Pierre Barbillon (pierre.barbillon@agroparistech.fr). One to two references will be asked to the interviewed candidates.

Deadline for application is May 15, 2025.