Programme for the VSoil meetings
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INRAE PACA centre in Avignon
26 and 27 March 2026

Thursday 26 March (1.30 pm – 5.35 pm)

- 1.30 pm – 2 pm: welcoming participants
- 2 pm – 2.10 pm: overview of the programme and the aim of the VSoil meetings
- 2.10 pm – 2.35 pm: **Nicolas Beudez** and **Nicolas Moitrier** (INRAE UMR EMMAH)

The VSoil modelling platform.

VSoil (for Virtual Soil) is an open-source modelling software platform designed to help develop numerical models at the soil profile scale describing the physical, chemical and biological processes in soil and its interactions with climate, plants and anthropic actions. By facilitating the coupling between these processes, the platform makes it possible to develop complex models from assemblies of existing or new codes. VSoil currently offers key features, including: i) model exploration tools (sensitivity analysis and parameter estimation) along with the ability to run models on several sets of input data, ii) the possibility to run models on a remote computing environment (server or cluster), iii) the connection to INRAE's national agroclimatic database. VSoil fosters collaboration between scientists from various disciplines and facilitates the sharing and use of new developments within the platform's user community.

- 2.35 pm – 3 pm: **Eric Michel** (INRAE UMR EMMAH, Avignon, France)

Models of coupled matrix and preferential macropore flow in VSoil.

In this contribution, I will present two models already implemented the VSoil platform that can be used to simulate simultaneously preferential and matrix flow as well as the exchanges between theses two compartments. I will show how three-dimensional, time-lapse images recorded before and during rainfall experiments performed on undisturbed soil columns can be used to parametrize these models and test them at their very limits.

- 3 pm – 3.25 pm: **Noémie Pousse** (ONF – Research, Development and Innovation division, Chambéry, France)

Development of a prototype climate service: forest_soil_practicability_prevision_tool – a tool to help maintain the long-term practicability of forest skidding trails (VSoilForOAD project).

Increasing traffic is unavoidable in forests to harvest wood in the current socio-economical context. Traffic with heavy logging machinery often leads to irreversible damages to soil structure. In

French forests, concentration of machinery traffic on permanent skidding trails has developed as a solution to limit the surface affected by soil compaction and rutting. Yet, these skid trails, or any kind of harvesting and logging corridors, need to remain practicable in the long term to reduce permanently the surface affected by soil compaction and rutting. In that frame, soil water content is of paramount importance to select the appropriate dates of traffic. The aim of the VSoilForOAD project is to develop a prototype of a climate service predicting, in real time and for the next 14 days, the load-bearing capacity of skid trails. The prototype is based on an existing mechanistic water balance model adapted to forestry context, developed in the VSoil modelling platform (https://vsoil.hub.inrae.fr/), for which minor simplifications and modifications have been made to increase accessibility to forest managers and operators while limiting the loss of reliability.

- 3.25 pm – 3.50 pm: **Samuel Buis** (INRAE UMR EMMAH, Avignon, France)

Cluster-Based GSA: a clustering-based approach to global sensitivity analysis of models with dynamic and/or spatial outputs.

A new method, known as cluster-based GSA, is proposed to improve the sensitivity analysis of models that produce temporal or spatial outputs. It is based on a close coupling of Global Sensitivity Analysis (GSA) and clustering procedures. Clustering is used to characterise the different behaviours of the model outputs by grouping them into clusters. The method produces variance-based indices that quantify how the model inputs direct the outputs towards a given cluster or how they influence variations along a direction defined by two clusters. Aggregate indices are also proposed to summarise the overall influence of model inputs on changes in clusters. The method is applied to two models producing time-series outputs: a toy model and an environmental model simulating the decomposition of soil organic matter (CANTIS). In both cases, this approach effectively identifies the influence of model inputs on the different behaviours of the outputs.

- 3.50 pm – 4.20 pm: break

- 4.20 pm – 4.45 pm: **Cécile Dagès** and **David Crevoisier** (INRAE UMR LISAH, Montpellier, France)

Simulating pesticide fate in row-planted plots using the MIPP model (OpenFLUID x VSoil) – Application for evaluating strategies to reduce pesticide use in southern viticulture.

Vines are a major consumer of pesticides. Pesticide contamination has been reported for all environmental compartments in the wine-growing context, prompting the definition of more sustainable vine-growing methods. Intra-parcel heterogeneity in vineyard plots is high, due to the fact that vines are grown in rows, pesticides are applied mainly to these rows, and several soil management practices coexist within a plot (chemical weeding, tillage, grassing). To evaluate the environmental dispersion and fate of pesticides in vineyards, we have developed a new field plot model adapted to this intra-field heterogeneity and representing the main pesticide fate processes, spraying location and soil management practices. The model distinguishes between rows and inter-rows compartments so that different management practices can be applied. Concerning the processes, the model is based on the coupling of the following three sets of modules:

- a mechanistic soil fate module from the VSoil modelling software platform that simulates water, heat and pesticide transfers in dissolved or gaseous form. Physico-chemical equilibrium is assumed between the solid, liquid, gaseous phases in soil. Volatilisation is calculated from the soil and the vine leaves. Pesticide exchange rate between surface run-off water and soil surface layer is assumed proportional to the pesticide concentration gradient.

- a three sources energy balance module explicitly considering the proportions of plot area covered by bare soil, vine canopy and grass cover.

- a module simulating the evolution of surface conditions, which includes the simulation of the dynamics of spontaneous herbaceous cover in inter-row compartments considering water stress and the changes in soil hydraulic conductivity according to soil management.
This presentation will briefly describe the model, its evaluation and its application to evaluate vine-growing strategies. The model is part of the MIPP model of pesticide fate in agricultural landscapes developed in the modelling software platform OpenFLUID.

- 4.45 pm – 5.10 pm: **Hamza Chaif** (INRAE UR CEREGE, Aix-en-Provence)

Introducing a volume change function in process based modelling of soil evolution : a proof of concept.

Most process-based models of soil development are based on an assumption of constant soil volume over time. Nevertheless, the consequences of this simplification on model outputs are not negligible when used on a several decades to a century time scale. We propose in this study a new approach to considering volume change in a process-based model of soil evolution over short to medium time scales (10 to 70 years). To do so, we introduce in the model an estimation, by a pedotransfer function, of the bulk density that was then used to estimate soil volume in the model. The feasibility of this approach was demonstrated using a simple bulk density pedotransfer function based on soil organic carbon content for three long-term experiment sites with different scenarios of land use or tillage practices.

- 5.10 pm – 5.35 pm: **Rafael Márquez Caballé** (Universidad Nacional Autónoma de México, Mexico City, Mexico)

Use of VSoil to model the water retention and flow properties of a Mexican soil irrigated with wastewater.

In this presentation we will show the procedure and the creation of a model in VSoil, developed to study soil water flow and retention properties in soil with preferential flow at the lysimeter scale. We will present the results obtained from modelling mass balances and the work currently underway to model a water tracer application experiment.

Friday 27 March (8.30 am – 12.30 pm)

- 8.30 am – 9 am: welcoming participants

- 9 am – 9.25 am: **Valérie Pot** (INRAE UMR ECOSYS, Palaiseau, France)

Taking into account the multiple roles of organic matter in modelling the transport and fate of organic contaminants in soil.

Soil organic matter plays a key role in the transport and fate of organic contaminants in soil. It modulates the sorption properties of contaminants and can contribute to biodegradation processes through co-metabolism. It can also accelerate the transport of contaminants through co-transport. Results obtained using the PolDOC model, which accounts for co-transport processes through the association of organic contaminant molecules with dissolved organic matter, will be presented, along with work on the introduction into VSoil of a module describing the role of plant mulch in the fate of pesticides.

- 9.25 am – 9.50 am: **Agnès Grossel** (INRAE UR Info&Sols, Orléans, France)

Modelling nitrous oxide emissions and its isotopic composition with explicit representation of biochemical processes and fluid transfers in soil at fine scale.

Nitrous oxide (N_2O) emissions from soil are characterized by a large spatial and temporal variability which is still difficult to represent accurately into models. Biochemical processes producing N_2O (and, for denitrification, further reducing it) are dependent on reaction substrate (nitrogen and labile carbon) and soil oxygen status. Soil structure, which controls water movement and oxygen and N_2O diffusion, therefore affects emissions. The NOEpredhyr model was initially developed on the VSoil platform to simulate soil compaction and runoff effects on N_2O emissions induced by rain events in a laboratory-built model (10 m^2) under rain simulator (Poinçot, 2019). It coupled water, solutes and gas transfers along a 1D soil profile and denitrification and nitrification representation. Further development of this model is currently tested to more accurately represent gas diffusivity depending on soil structure and to include natural isotopic abundances of N_2O, which is affected by the type of production reaction and the reduction degree during denitrification. This new developments will be evaluated with different experiments. This work is still on going and only preliminary modelling results are available.

Poincot, F. (2019). *Le contrôle des émissions de N_2O par l'état structural des sols* (Doctoral dissertation, Université d'Orléans).

- 9.50 am – 10.15 am: **Claude Doussan** (INRAE UMR EMMAH, Avignon, France)

Characterisation of soil hydraulic properties using combined electrical-hydraulic inversion (poster).

Soil hydraulic properties are difficult to estimate, require site-specific measurements and are time-consuming. In contrast, geophysical measurements such as electrical resistivity tomography (ERT), which is sensitive to soil water, are relatively easy to deploy in the field and provide good spatial coverage. Here, we propose estimating hydraulic properties through a joint hydro-geophysical inversion. Implemented in VSoil, this inversion uses a soil hydrology model, an electrical current transport model imported from the GIMLi library (Rücker et al., 2017) to simulate electrical resistivity tomography measurements, and a petrophysical relationship (water content–resistivity). A sensitivity analysis (Morris) of the hydraulic parameters is carried out as a function of soil texture. The inversion, using the SCE-UA algorithm, demonstrates the effect of the number of ERT measurements over time, the contribution of joint hydraulic measurements, and that hydraulic parameters can be estimated by texture class.

Rücker, C., Günther, T., Wagner, F.M., 2017. pyGIMLi: An open-source library for modelling and inversion in geophysics, Computers & Geosciences, 109, 106-123, doi: 10.1016/j.cageo.2017.07.011.

- 10.15 am – 10.45 am: break

- 10.45 am – 12.20 pm: **discussion with the VSoil user community** (improvements and/or new features, new scientific topics to explore, etc.).

- 12.20 pm – 12.30 pm : afterword