

The VSoil modelling software platform

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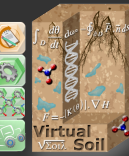
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INRAE, UMR EMMAH, Avignon

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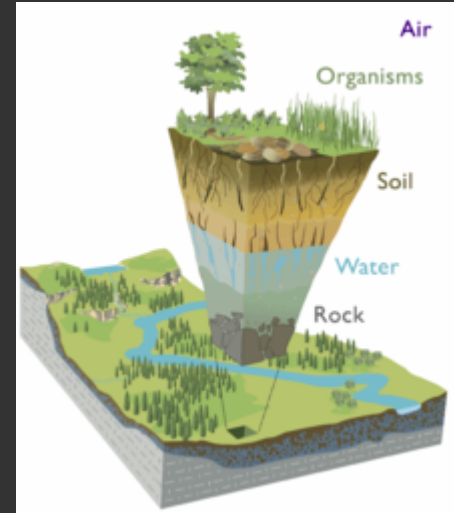
1) Context: the soil



The **soil** is at the heart of the ‘**critical zone**’.

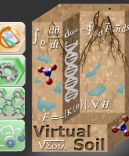
Critical zone:

- extends from the **atmosphere** to the **unaltered rock**;
- is the site of numerous **exchanges**: water, solutes, gas, solids, energy, organisms;
- is the place where processes that **sustain life on Earth** take place.



The ‘critical zone’

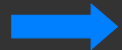
- ➔ It is essential to **understand** how the soil functions and **predict** its evolution for:
- sustainable agriculture,
 - biodiversity preservation,
 - water resource management,
 - climate change mitigation,
 - ...



2) Need to create models of soil functioning

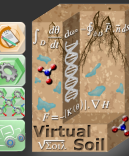
Digital models: powerful tools for reproducing and studying **soil functioning**

Survey (2006 – 2008) conducted within the 'Environment and Agronomy' department of INRA to identify the **needs** in terms of **soil functioning modelling**.



Scientists want:

- to develop models that **couple mechanisms**:
 - of different **natures**: water, solute, gas and heat transfers, earthworm dynamics, particle transport, ...;
 - at different **time** and **space** scales;
- models to be developed **easily** and **quickly**: use **available** and / or **new codes**;
- the development of models to be accessible to all: **coding reduced** as much as possible.



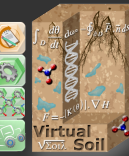
3) Technical barriers

Need for **assistance** in the modelling chain:



Different computer languages (Fortran, C, C++, Java, Python, R, ...) for programming whose lack of standards **restrains the coupling** of existing models.

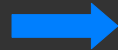
Lack of assistance and support for computer programming of simple and complex models.



4) VSoil: a powerful software platform to develop soil models

VSoil: a modelling software platform for developing digital 1D models describing the physical, chemical and biological processes of soil in interaction with climate, plants and human actions.

VSoil facilitates coupling between these processes.

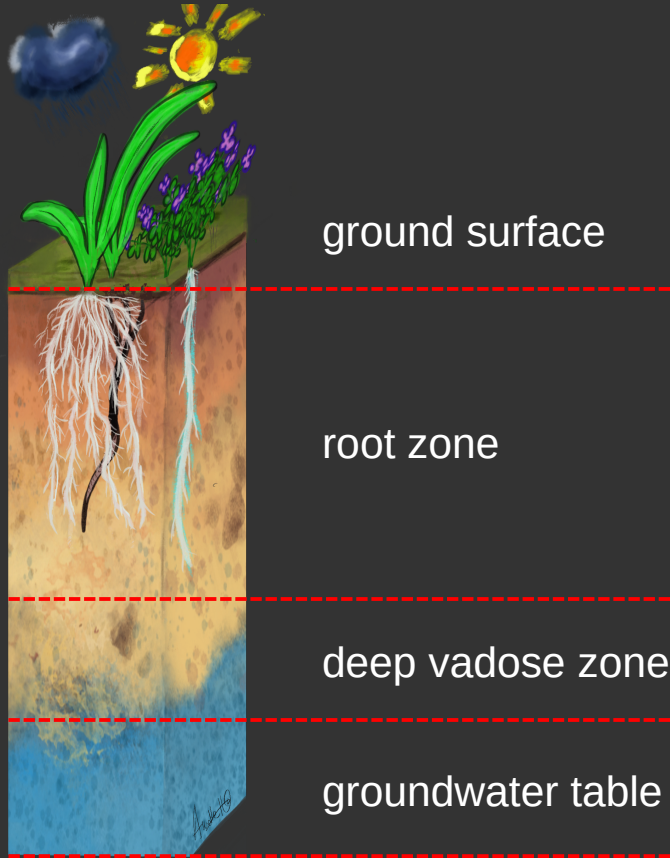


Creation of models of varying complexity from the assembly of existing or new computer codes.

VSoil is developed since 2009 at EMMAH (INRAE / Avignon University, France).



4) VSoil: a powerful software platform to develop soil models



ground surface

root zone

deep vadose zone

groundwater table

interest zone
in VSoil

Soil pedon considered in VSoil:

- local scale (a few m^2);
- soil profile from the surface to the groundwater table including the root exploration zone.

4) The architecture of VSoil



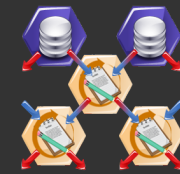
From **concepts**...



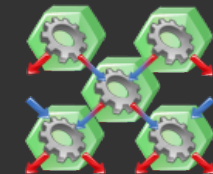
Phenomena (physical, chemical, biological) are called **processes** and are characterised by their **inputs** and **outputs**.



A **module** is a computer implementation of a process.



Processes and their inputs / outputs produce graphs called **skeletons**.



A **model** is an ordered set of modules.



A numerical simulation.



vsoil-processes



vsoil-modules



vsoil-models



vsoil-player

... to **software**.

4) The VSoil software components: **vsoil-processes**



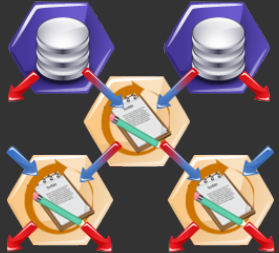
Phenomena are called **processes** (examples: bioturbation, evapotranspiration, heat transport and balance, organic matter dynamics, water flow and balance, ...). They are characterised by their **inputs** and **outputs**.



Some processes are **external**.



Interactions between processes are detected using **inputs** and **outputs**.



Processes with their inputs and outputs produce graphs: **skeletons**.

vsoil-processes

Open lists of variables and processes

Guide for naming variables

Automatic creation of skeletons

Provides information for coding and assembly of modules

60 official processes

4) The VSoil software components: vsoil-processes

The screenshot displays the VSoil software interface, titled "vsoil-processes". The interface is divided into several sections:

- Process Selection:** A "Processes" tab is active, showing a list of processes. The "water flow and balance" process is selected. The "Category" is set to "physical processes".
- Visualisation:** A "Visualisation" dropdown menu is set to "Outputs".
- Process Flow:** A set of navigation buttons includes "Upstreams", "Downstreams", "Inputs", and "Outputs". The "Outputs" button is highlighted with an orange circle.
- Output List:** A table lists various output parameters and their units. An orange arrow points from the "Outputs" button to a specific node in the network diagram.
- Network Diagram:** A complex network diagram showing the relationships between various processes. Nodes are represented by colored circles (blue, yellow, brown, purple) and diamonds (purple, blue). The diagram is organized into "Skeleton" sections (Skeleton 1 to Skeleton 8). A specific node in the network is circled in orange, corresponding to the "Outputs" button.

Outputs	Unit
root water volumetric uptake rate yearly	m3.m-2
soil air maximum volumetric content	m3.m-3
soil air volumetric content	m3.m-3
soil bottom water capillary flux	m.s-1
soil bottom water capillary flux time cumulated	m
soil bottom water capillary flux yearly	m
soil bottom water volumetric flux density time cumulated	m3.m-2
soil evaporation flux yearly	m
soil fluid bulk density	kg.m-3
soil fluid pore velocity	m.s-1
soil hydraulic conductivity values	m.s-1
soil immobile water volumetric content	m3.m-3
soil infiltrability minimum	m.s-1
soil infiltration cumulated	m
soil mobile water volumetric content	m3.m-3
soil pressure head gradient	NA
soil profile pressure head	m
soil root zone water amount	m
soil saturation index	ratio0-1
soil saturation index cell	ratio0-1
soil surface evaporation to maximum evaporation ratio	ratio0-1
soil surface evaporation volumetric flux density	m3.m-2.s-1

4) The VSoil software components: vsoil-processes

The screenshot displays the VSoil software interface for the 'vsoil-processes' component. On the left, a sidebar titled 'Processes' is active, showing a list of 'Upstream processes'. The process 'water flow and balance' is selected, and its icon is highlighted in the 'Upstreams' tab. An orange arrow points from this icon to a corresponding node in the main network diagram. The main diagram, titled 'General', shows a complex network of interconnected nodes representing various soil processes, with the selected node circled in orange. The nodes are color-coded and connected by lines, illustrating the relationships between different processes in the model.

Upstream processes list:

- bioturbation
- bottom boundary pressure head
- bottom boundary water flux
- climate
- crop development
- evapotranspiration
- flood irrigation
- heat transport and balance
- mulch water transfer
- preferential water flow
- root water uptake
- soil hydraulic properties
- soil tillage practices
- solid mineral balance
- sprinkling irrigations
- surface boundary pressure head
- volume change
- water runoff

4) The VSoil software components: vsoil-processes

The screenshot displays the vsoil-processes software interface, divided into two main panels. The left panel is the configuration area, and the right panel is a dependency graph.

Configuration Panel (Left):

- Process:** Inputs-outputs
- Visualisation:** (Dropdown menu)
- Name:** soil water volumetric content
- Unit:** m3.m-3
- Constraint:** none
- Location:**
 - radio buttons for: surface, profile (selected), layer, bottom, none, none (vector)
 - Visual representation of a soil profile with a vertical dashed line indicating the location.
 - Options: Single value (scalar), Arrays of values (tagged), Arrays of values (misc)
- List of processes using the selected variable as:**
 - Output (expanded)
 - water flow and balance
 - random_soil_moisture
 - Richards_Pastis
 - steady_water_flow
 - swf_dynamic_grid_example_cpp

Dependency Graph Panel (Right):

- Tabbed interface with tabs for General, Skeleton 1 through Skeleton 8.
- A complex network graph showing dependencies between various processes. Nodes are represented by colored circles (blue, yellow, brown, purple) and diamonds (purple).
- Nodes are interconnected by a dense web of lines, representing the flow of data and dependencies between different components of the software.

4) The VSoil software components: vsoil-modules



A **module** corresponds to a modelling, a numerical method, ...

It is a computer code (Fortran, C++).

A module is linked to a process.



Several modules may be available for a process.



A module uses some of the inputs of its process and must produce at least one output.

vsoil-modules

Parameters

Coding assistance

Compilation

Tests

Graphs

Standardised languages:
Fortran / C++

148 official modules

4) The VSoil software components: vsoil-modules

vsoil-modules: forest_soil_practicability

Process Module Inputs/outputs Parameters Code editor Upstream modules Initialisation Execution Plots

Module parameters

	Name	Desc.	Type	Unit	Min.	Max.	Pref. min	Pref. max	Default	Vector (array)	LD							
1	interest_layer_minimum_depth		real (decimal value)	m	-infinite	+infinite	0.0000000000000000 m	0.0000000000000000 m	0.0000000000000000 m	size 2								
2	interest_layer_intermediate_depth		real (decimal value)	m	-infinite	+infinite	0.0000000000000000 m	0.0000000000000000 m	0.2500000000000000 m	size 2								
3	interest_layer_maximum_depth		real (decimal value)	m	-infinite	+infinite	0.0000000000000000 m	0.0000000000000000 m	0.5999999999999998 m	size 2								
4	interest_period_starting_date		date (YYYY-MM-DD)	NA					2000-01-01	size 2								
5	interest_period_ending_date		date (YYYY-MM-DD)	NA					2000-01-01	size 2								
6	rainy_period_maximum_length		integer (signed)	NA	-infinite	+infinite	1	10	4	size 2								
7	dry_period_length		integer (signed)	NA	-infinite	+infinite	1	10	3	size 2								
8	daily_rainfall_threshold		real (decimal value)	m	-infinite	+infinite	0.0000000000000000 m	0.0000000000000000 m	0.0005000000000000 m	size 2								
9	cumulative_rainfall_threshold		real (decimal value)	m	-infinite	+infinite	0.0000000000000000 m	0.0000000000000000 m	0.0100000000000000 m	size 2								
10	saturation_index_threshold		ratio (range [0;1])	ratio0-1	0.000000	1.000000	0.000 ratio0-1	1.000 ratio0-1	0.750 ratio0-1	size 2								
11	cumulative_ET0_threshold		real (decimal value)	m	-infinite	+infinite	0.0000000000000000 m	0.0000000000000000 m	0.0060000000000000 m	size 2								
12	matrix_potential_threshold		real (decimal value)	m(H2O)	-infinite	+infinite	-500.0000000000000000 m	0.0000000000000000 m	-3.2999999999999998 m	size 2								

If you need external data files, you can add it here.

+ Add user external data file

Remove	Edit	Name

4) The VSoil software components: vsoil-modules

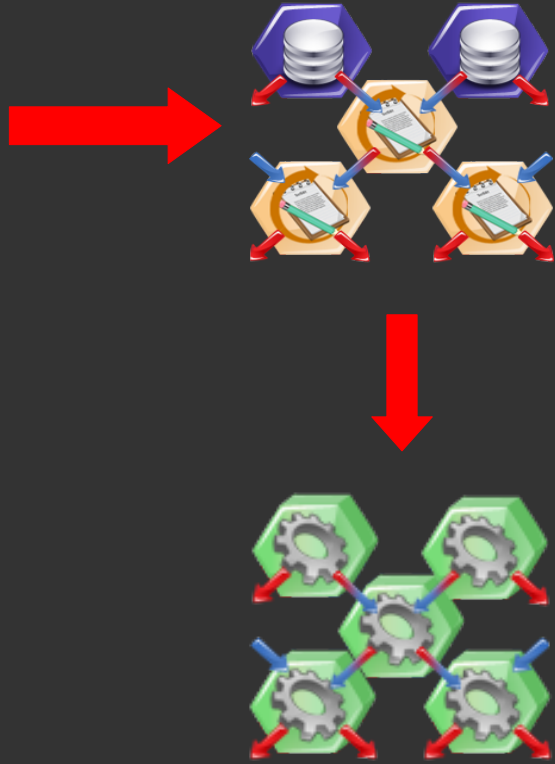
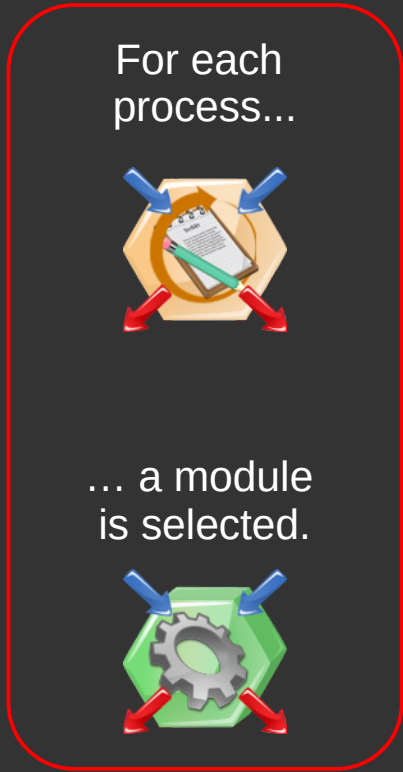
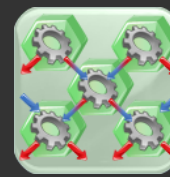
The screenshot displays the VSoil software interface, specifically the 'Code editor' tab for the 'vsoil-modules: forest_soil_practicability' project. The interface includes a top navigation bar with tabs for 'Process', 'Module', 'Inputs/outputs', 'Parameters', 'Code editor', 'Upstream modules', 'Initialisation', 'Execution', and 'Plots'. Below the navigation bar, there are buttons for 'Check code', 'Save source codes', and 'Language coding web resources'. The main area is divided into two panels: a left panel for 'Virtual soil global variables' and a right panel for the 'Code section'.

The 'Virtual soil global variables' panel shows a table with columns for 'Name' and 'Variable name'. The variables are categorized into 'Inputs', 'Inputs (previous time)', 'Outputs', and 'Outputs (previous time)'. A green circle highlights the 'Compute section' dropdown menu in the right panel.

Name	Variable name
Inputs	
crop maximum evapotranspiration volumetric flux density daily cumulated	pet_daily_cumulated
rain height daily cumulated	rain_height_daily_cumulated
soil hydraulic	soil_hydraulic
soil saturation index	soil_sat_index
soil water volumetric content	soil_water_vol_content
Inputs (previous time)	
valid_crop maximum evapotranspiration volumetric flux density daily cumulated	valid_pet_daily_cumulated
valid_rain height daily cumulated	valid_rain_height_daily_cumulated
Outputs	
interest soil layers drying slope time average	int_soil_layer_drying_slope_time_average
interest soil layers practicable days number	int_soil_layer_prac_days_number
interest soil layers practicable days percentage	int_soil_layer_prac_days_percentage
interest soil layers saturation index	int_soil_layer_sat_index
interest soil layers saturation index daily average	int_soil_layer_sat_index_daily_average
interest soil layers saturation ratio daily average	int_soil_layer_sat_ratio_daily_average
soil practicable days number	soil_prac_days_number
soil practicable days percentage	soil_prac_days_percentage
Outputs (previous time)	
valid_interest soil layers drying slope time average	valid_int_soil_layer_drying_slope_time_a...
valid_interest soil layers practicable days number	valid_int_soil_layer_prac_days_number
valid_interest soil layers practicable days percentage	valid_int_soil_layer_prac_days_percentage
valid_interest soil layers saturation index	valid_int_soil_layer_sat_index
valid_interest soil layers saturation index daily average	valid_int_soil_layer_sat_index_daily_aver...

```
1 // Force outputs to NAN value outside the period of interest.
2 initializeOutputs(grid, int_soil_layer_sat_index, int_soil_layer_sat_index_daily_average, int_soil_layer_sat_ratio_daily_average,
3                 int_soil_layer_prac_days_percentage, int_soil_layer_drying_slope_time_average, soil_prac_days_number, soil_
4
5 // Current simulation time is outside the period of interest.
6 if (!isSimulationTimeInInterestPeriod(t, vsoil_time->reference(), interest_period_starting_date, interest_period_ending_da
7
8 // Current simulation time is included in the period of interest.
9
10 interestPeriodAlreadyReached = validInterestPeriodAlreadyReached;
11
12 if (!interestPeriodAlreadyReached)
13 {
14     performInitializationsWhenFirstTimeInInterestPeriod(soil_sat_index, int_soil_layer_sat_index, int_soil_layer_sat_index_dail
15                                                         int_soil_layer_sat_ratio_daily_average, int_soil_layer_prac_days_nu
16                                                         int_soil_layer_drying_slope_time_average, soil_prac_days_number,
17
18     interestPeriodAlreadyReached = true;
19     return;
20 }
21 // Current simulation time is not the first simulation time to reach the period of interest. Updates calculations over the
22
23 // Time variables.
24 timeElapsedInDay = validTimeElapsedInDay + dt;
25 numberOfElapsedDays = validNumberOfElapsedDays;
26 if (day_changed) ++numberOfElapsedDays;
27
28 // True if soil is practicable (interest soil layers are simultaneously practicable), false otherwise.
29 bool soilIsPracticable = true;
30
31 // Loop over the interest soil layers.
32 for (InterestSoilLayer * const interestLayerPtr : orderedInterestSoilLayers)
33 {
34     const int interestLayerId = interestLayerPtr->getId();
35
36     // Calculates the space average saturation index of the current interest soil layer.
37     interestLayerPtr->calculateAverageSaturationIndex(soil_sat_index);
38     int_soil_layer_sat_index[interestLayerId] = interestLayerPtr->getAverageSaturationIndex();
39
```

4) The VSoil software components: vsoil-models



A **model** is an ordered set of modules.

- vsoil-models**
- Module selection**
- Generation of the main**
- Generation of the GUI**
- Execution**
- Visualisation**
- Backup**
- Modification**
- 20 official models**

4) The VSoil software components: vsoil-models

vsoil-models: forest_soil_practicability_previson_tool

Model Information | Modules selection | Ordering | Model generation | Initialisation | Run | Plots

Processes | External factors

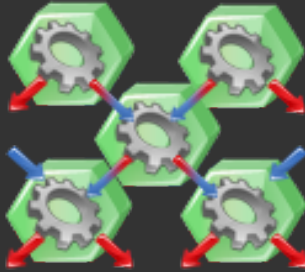
Process	☰	+	-
bioturbation	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
bottom boundary gas conditions	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
canopy water transfer	☰	<input checked="" type="checkbox"/>	<input type="checkbox"/>
chemical dispersion-coagulation	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
chemical weathering of primary minerals	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
complexation	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
crop development	☰	<input checked="" type="checkbox"/>	<input type="checkbox"/>
crop pesticides fate	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
denitrification	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
electrical transport	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
erosion	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
evapotranspiration	☰	<input checked="" type="checkbox"/>	<input type="checkbox"/>
gas transport and balance	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
geochemistry	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
heat transport and balance	☰	<input checked="" type="checkbox"/>	<input type="checkbox"/>
isotopic_geochemistry	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
molecules degradation	☰	<input type="checkbox"/>	<input checked="" type="checkbox"/>
mulch dynamics	☰	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Skeleton 1 | **Skeleton 2** | Skeleton 3 | Skeleton 4 | Skeleton 5 | Skeleton 6 | Skeleton 7 | Skeleton 8

Diagram illustrating the VSoil software components and their interactions. The central node is **water flow and balance** (Richards_KDW), which is circled in pink. It is connected to numerous other components, including:

- flood irrigation (flood_irrigation_forced)
- surface boundary pressure head (surface_pressure_from_fill_e)
- bottom boundary pressure head (bottom_pressure_from_fill)
- bottom boundary water flux (bottom_water_flux_forced)
- sprinkling irrigations (no_sprink)
- evapotranspiration (ET0_hourly_ASCE)
- time synchronisation (time_forced)
- surface energy balance (split_climate_basic)
- canopy water transfer (canopy_Pastis)
- mulch water transfer (mulch_water_bi)
- crop development (simple_tree)
- water runoff (runoff_PastisKDW)
- soil hydraulic properties (hydraulic_properties_from_PTF_classes)
- soil practiacability (forest_soil_practicability)
- mulch dynamics (mulch_forced)
- climate (climate_EMMAH_WS)
- root water uptake (root_water_uptake_alpha)
- heat transport and balance (homogeneous_soil_tempe_rature)
- solid mineral balance (soil_structure_forced)
- preferential water flow (pref_flow_neutral)

4) The VSoil software components: **vsoil-player**



A model already built.



Simulations, visualisation of results, ...

vsoil-player

Use available models

Run simulations

Archive simulations

View saved results

Compare simulation results

**Perform sensitivity analysis
and parameter estimation**

4) The VSoil software components: vsoil-player

vsoil-player: forest_soil_practicability_previson_tool

Compilation Initialisation Run Plots

Load configuration file Save configuration file Reset values Export run Prepare run

Time Grid Modules: time_forced Databases Statistical Miscellaneous

Layers definition

Load layers Save layers Reset values

Grid gap min 1.00000e-04 m max 1.00000e+00 m

Append layer Remove last layer

Layer and grid properties

Depth 1.00000e-01 m

Grid 10 point(s)

Distribution Linear

0.00000
0.10000
0.90000

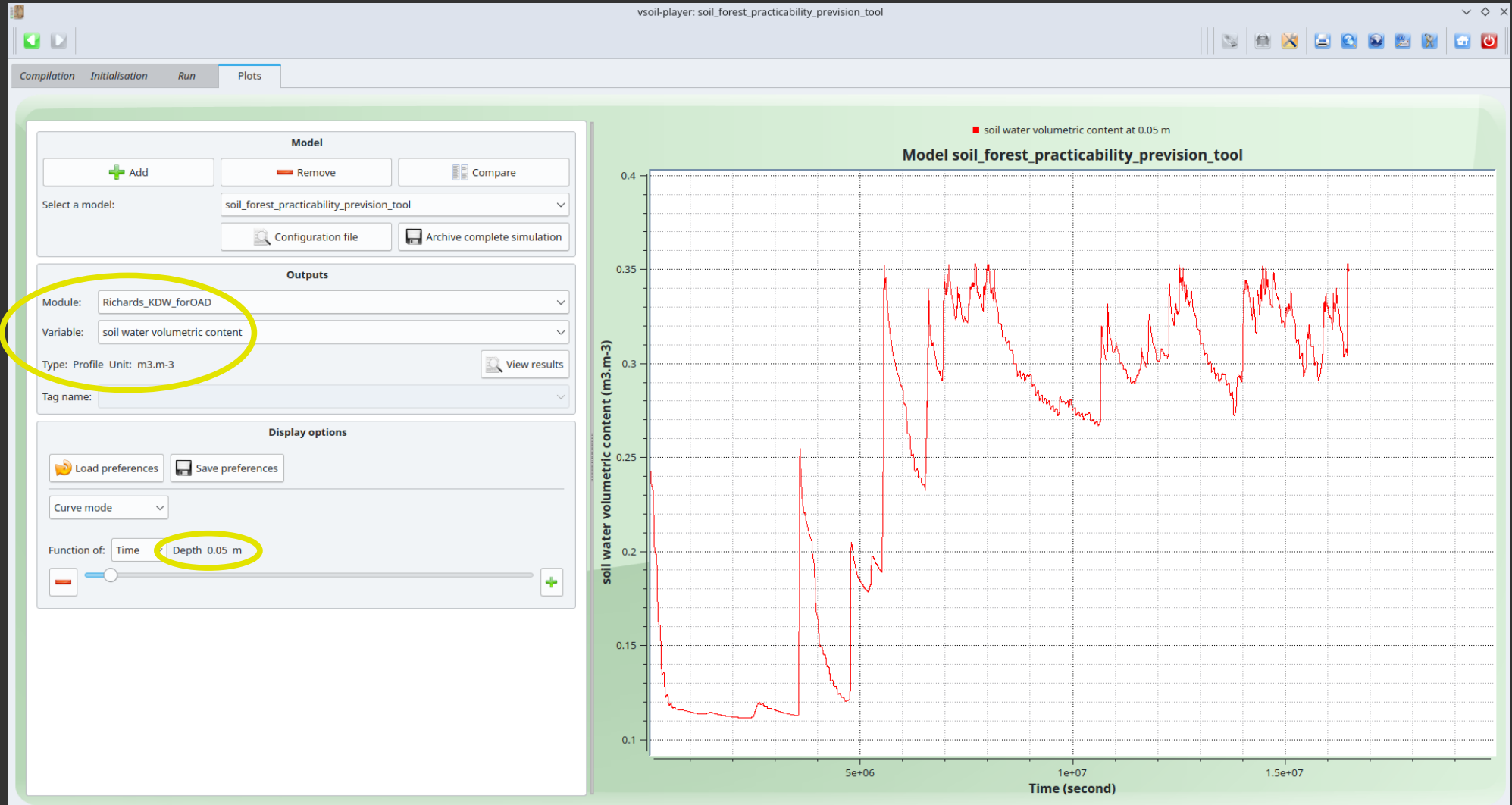
Layer 1 10 pts

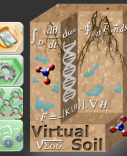
Layer 2 100 pts (+1)

layers depth (m) grid points

soil representation

4) The VSoil software components: vsoil-player





6) Particular features of VSoil

6.1) Interfacing with R software environment



- For using **model exploration** tools:
 - several **sensitivity analysis** methods: fast99, Morris, Sobol (*sensitivity*);
 - various algorithms for **parameter estimation**:
 - Levenberg-Marquardt (*minpack.lm*);
 - SCE-UA (Shuffle Complex Evolution – Uncertainty Analysis) (*rtop*);
 - DREAM (DiffeRential Evolution Adaptative Metropolis) (*dream*);
 - DREAMzs (Differential Evolution Adaptative Metropolis) (*BayesianTools*).
- For running **multi-simulations**.

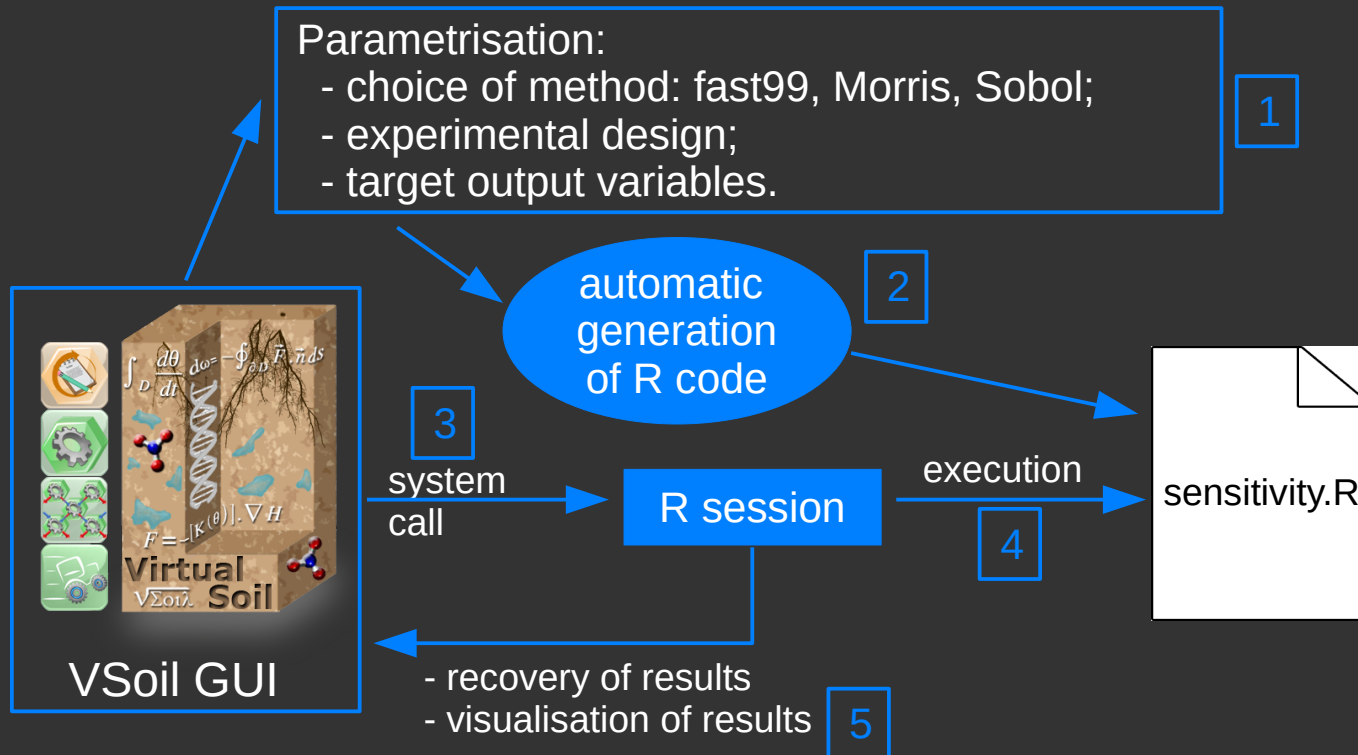
6) Particular features of VSoil



6.1) Interfacing with R software environment



- Example of scenario: **sensitivity analysis**

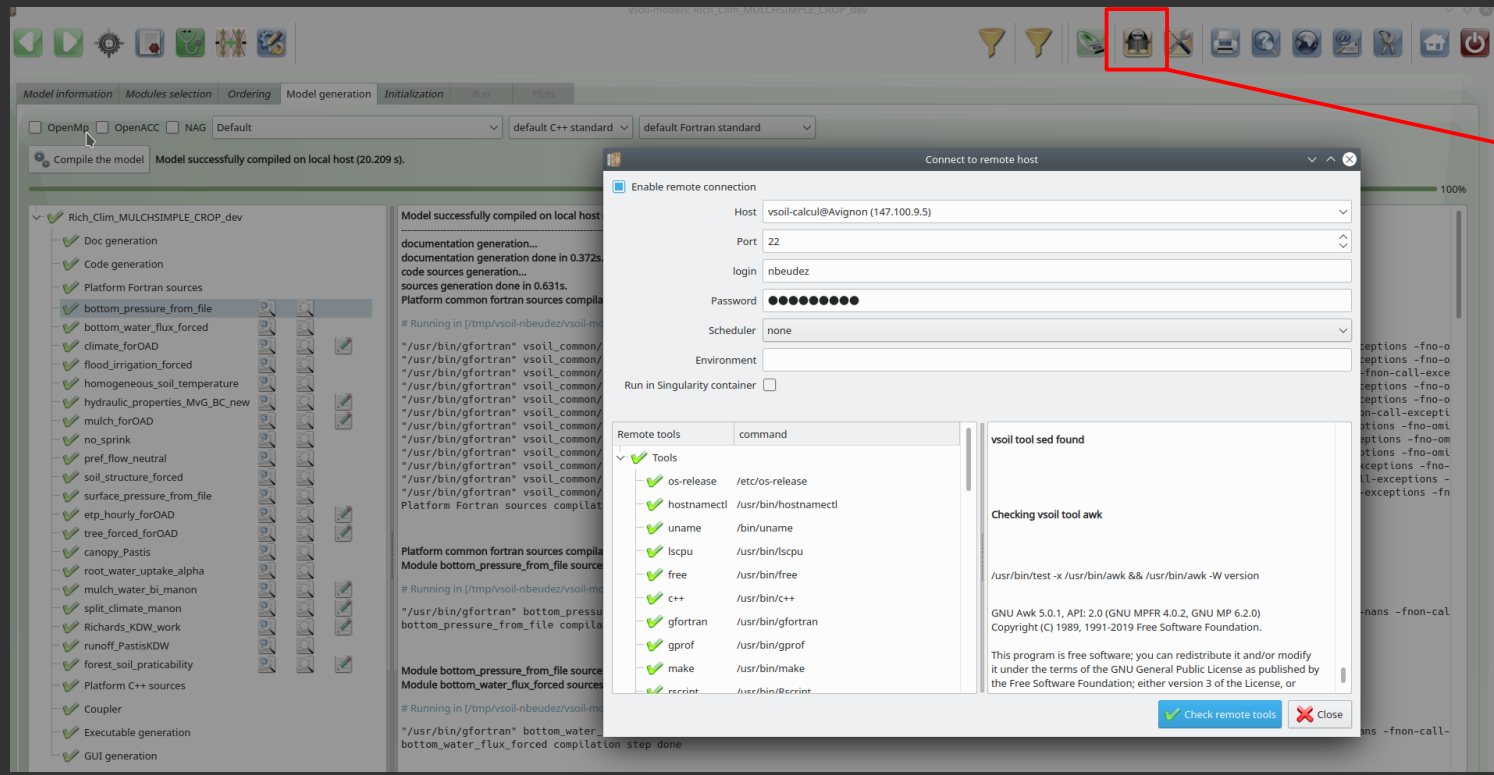


6) Particular features of VSoil



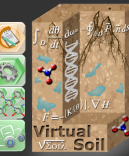
6.2) Ability to run calculations on remote servers

- Linux server 'vsoil-calcul': Ubuntu 24.04, 56 cores, 92 GB RAM;
- compatible with clusters;

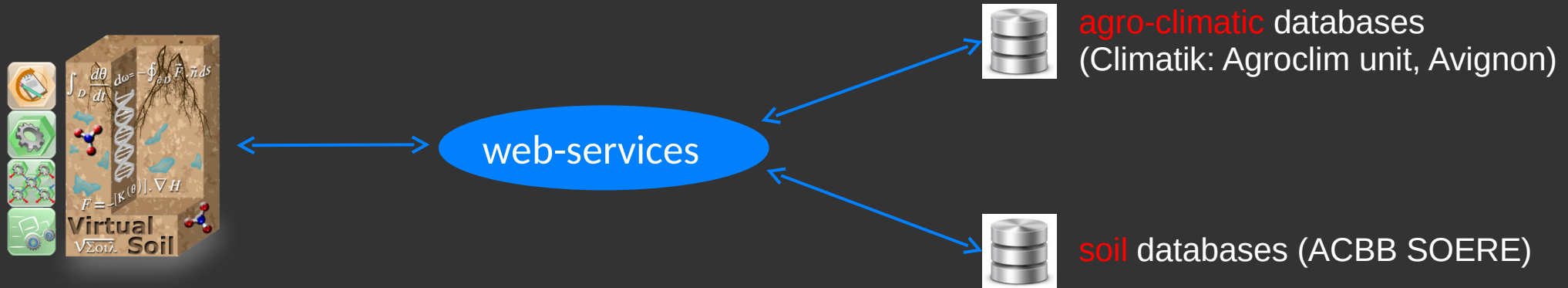


remote connection activation

6) Particular features of VSoil



6.3) Connecting to databases



SOERE: Long-term Observation and Experimentation System for Environmental Research (« Système d'Observation et d'Expérimentation sur le long terme pour la Recherche en Environnement »)

ACBB: Agro-ecosystem, Bio-geochemical Cycle and Biodiversity (« Agro-écosystème, Cycle Bio-géochimique et Biodiversité »)

6) Particular features of VSoil

6.4) Filter for exploring VSoil objects



Filter

Official & User | Input & output | All units
All locations | Array Tagged & Array misc & scalar | All constraints

potential evapotranspiration

Name Description

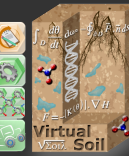
Criteria result: 1 / 1203 In/Out
Final result: 1 / 1203 In/Out

Show results for: In/Out | Display: Final results only

Name	Size
Inputs & Outputs	Total: 1 / 1203
crop maximum evapotranspiration volumetric flux density Penman	
Models	Total: 44 / 74
Modules	Total: 17 / 308
ETP_SGEN	
ETP_from_file	
ETP_from_file_debug	
MIPP_ETP	
MIPP_energy_fake	
Maize_STICS	
PET_hourly_ASCE	
etp_forced	
etp_from_file_hourly_work	
etp_hourly_forOAD_with_etp_calculated_or_read	
etr_from_file	
lec_etp	
no_evapotranspiration	
split_climate	
split_climate_SGEN	
split_climate_basic	
split_climate_new	
Processes	Total: 3 / 74
crop development	
evapotranspiration	
surface energy balance	

Criteria Criteria | Mode Filter everything | Ok

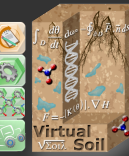
7) Additional information



- Some **technical specifications**:
 - Linux / Windows support;
 - Apache 2 licence (open source);
 - software versioning: Apache subversion;
 - continuous integration tool: Jenkins;
 - languages: C++ / Qt (software) and C++ / Fortran (modules);
 - 728 variables, 60 processes, 148 modules and 20 models;
 - naming of variables: OBOE ontology;
 - files format: XML (configuration files) and CSV (output files);
 - external libraries used in modules: Gimli (geophysics), LAPACK (numerical computation).

- **Distribution strategy**: 2 to 3 stable versions per year.

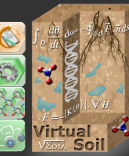
7) Additional information



- Examples of **collaborations**:

- **INRAE**: EMMAH (Avignon), CEREGE (Aix-en-Provence), LISAH (Montpellier), FARE (Reims), ECOSYS (Palaiseau), Info&Sols (Orléans);
- **ONF** (Chambéry);
- Gustave Eiffel University (Champs-sur-Marne), Ghent University (**Belgium**), National Autonomous University of Mexico (**Mexico**);
- **Groupe Roullier** (Saint-Malo).

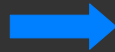
8) VSoil in summary



1. VSoil makes **modelling accessible** to people who are not comfortable with computer programming. The modeller:

focuses on his core business:

- manufacturing bricks (modules);
- assembling bricks graphically;
- analysing simulation results.



is **relieved** of all technical tasks that do not fall within his area of expertise.

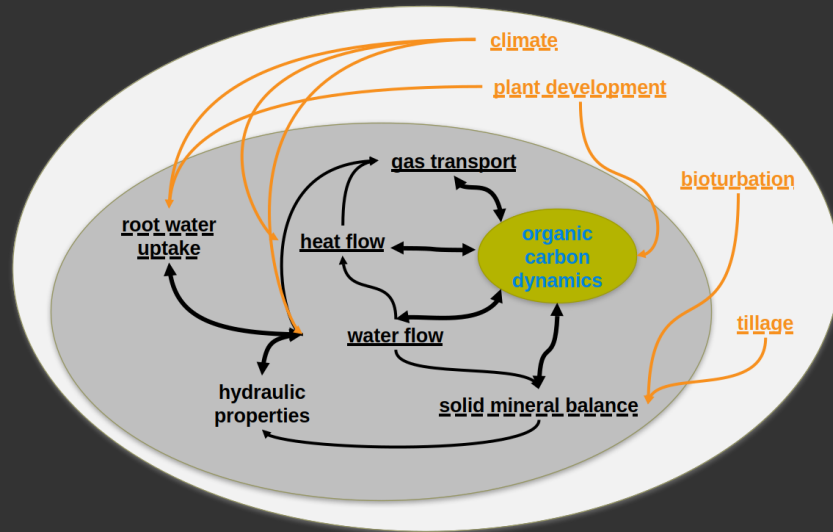
2. VSoil facilitates the **sharing** and **reuse** of **new developments** within the platform's user community (new features, distribution of VSoil objects, import / export system).

3. VSoil encourages **collaborations** between scientists from **different fields**.

9) Examples of realisations

- [OC_VGEN](#) (Keyvanshokouhi et al., 2019 and Chaif et al., 2025): model for simulating the **evolution of soil properties** at the **century scale** in a vertical soil profile.

Funding: INRAE, ADEME, partners: INRAE, ARVALIS.



Processes involved in the OC_VGEN model (H. Chaif)

Several **processes** are represented into dedicated **modules** adapted from [SoilGen](#) (Finke and Hudson, 2008) and [PASTIS](#) (Lafolie, 1991 and Findeling et al., 2007) models.

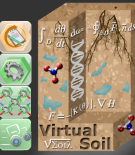
References:

- Lafolie (1991), DOI: 10.1007/bf01051129
- Findeling et al. (2007), DOI: 10.1111/j.1365-2389.2006.00826.x
- Finke and Hudson (2008), DOI: 10.1016/j.geoderma.2008.01.017
- Keyvanshokouhi et al. (2019), DOI: 10.1016/j.scitotenv.2018.10.236
- Chaif et al. (2025), DOI: 10.1016/j.geoderma.2025.117228

9) Examples of realisations

- [forest_soil_practicability_prevision_tool](#) (Martin et al., 2024 and Pousse et al., 2025): model for predicting the **risk of rutting** in **forest soils**.

Funding: ADEME, partners: ONF, CNPF-IDF, FCBA, INRAE.




Forestry machinery travels on dedicated tracks known as **skid trails**, whose **practicability** must be maintained over the long-term.

References:

- Martin et al. (2024), DOI: 10.1186/s13595-024-01265-4
- Pousse et al. (2025); <https://hal.science/hal-05198975>

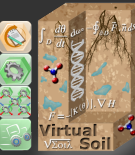
Ruts in Grand-Pays national forest (Meuse, France) – March 2021

Forestry machinery traffic test - 2018

 Development of a **climate service prototype** for real-time prediction of the water status of skid trails over the next 14 days:

observed and forecast **weather data** (ECMWF) + **model** to simulate the degree of **water saturation** of **skid trails** + ask minimum information to **forestry operator** = predicting the **risk of rutting**

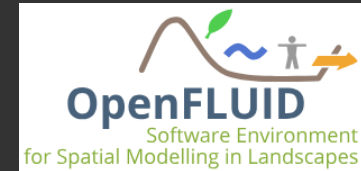
9) Examples of realisations



- **MIPP** ('Integrated Modelling of the fate of Pesticides in agricultural Landscapes'): model for predicting **pesticide concentrations** in soil, water and air compartments (Voltz et al., 2019):

- one brick = a **mechanistic 1D VSoil model**: transfers of water, heat and pesticides + fate of pesticides on leaves + penetration of pesticides into plant + partitioning of pesticide in soil (liquid, solid and gas phases);

- **integrative MIPP model** implemented in **OpenFLUID modelling platform**: pesticide transport in soil, air and surface waters over all units of a discretised landscape;



- **Ecophyto RIPP-Viti project**: adaptation to take into account **intra-field heterogeneities** encountered in **vineyards** (Dagès et al., 2024a et 2024b).



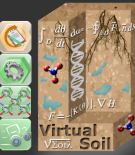
References:

- Voltz et al. (2019), <https://hal.inrae.fr/hal-02962223v1>
- Dagès et al. (2024a), <https://hal.inrae.fr/hal-04695079>
- Dagès et al. (2024b), <https://hal.inrae.fr/hal-04719108>

Funding: INRA département Environnement et Agronomie, Ecophyto Recherche & Innovation, OFB, partners: INRAE, Institut Agro, Agence de l'Eau Rhône-Méditerranée-Corse, Chambre Régionale d'Agriculture Occitanie, FREDON captages d'eau Occitanie, IFV, Réseau DEPHY-Vigne, EPT de bassin Orb et Libron, OFB

10) Resources

Website: <https://vsoil.hub.inrae.fr/>



[Project](#) [Software platform](#) [Project life](#) [Download](#) [Documentation](#) [Communications](#) [Contact](#)

All sections



Welcome to the VSoil project!

VSoil (for Virtual Soil), is a **modelling software platform** supported by the **"Agroécosystèmes" division of INRAE** and developed and hosted by **EMMAH laboratory**. It is a tool to **help develop numerical models** describing the **physical, chemical and biological processes of the soil** in interaction with the **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**.

We advise you to read the [What you can do with VSoil](#) page before using VSoil in order to know more about what VSoil is, the capabilities it has and the functionalities it offers.

Look also at the top of this page to access more informations about the VSoil project: description of the [project](#) and the [software platform](#), informations about the [project life](#), procedures to [download](#) the VSoil software suite (on Linux and Windows), access to [documentations](#) of the VSoil software suite (including some tutorials) and how to [contact](#) us.

You can find below all the **news about the VSoil project**: new stable versions of VSoil software suite, new collaborations (projects, thesis, ...).

News

- A **new stable version** of VSoil software suite (VSoil_20250929) is available. The main changes introduced in this version are: (1) several **modules** were translated into **C++ language**, (2) when a model is detected to need **time synchronisation** with calendar dates, then the **vsoil-models** software adds automatically the default time synchronisation module (that can be removed or changed), (3) modules can now ask **programmatically** to **save outputs** on current time step and (4) **'soil practicability'** was added to the list of available processes. See the [Technical news](#) page for more details about this version and the [Download](#) page to download and install it. 29/09/2025
- An article written by **Hamza Chaif et al.** was recently published in *Journal of hydrology*. See the [Communications](#) page for more details. 08/07/2025
- **Claude Doussan** (INRAE, EMMAH, Avignon) presented a poster entitled **'Caractérisation des propriétés hydrauliques du sol par inversion jointe électrique-hydrrique'** at the **GEOFAN 2025 symposium** (4-6 June 2025, Avignon, France). This poster illustrates the work done by **Ismail Djellouli** (Sorbonne University, Paris) and **Julien Arduin** (Savoie Mont Blanc University) during 2 master's internships he supervised and involving the VSoil platform (see [here](#) for more details about Ismail's and Julien's work). 10/06/2025
- **Nicolas Beudez** (VSoil team, INRAE, EMMAH, Avignon) presented the VSoil modelling software platform in a **poster** at the **EGU General Assembly 2025** (Vienna, Austria, 27 April to 2 May 2025). **Cécile Dagès** (INRAE, LISAH, Montpellier) also presented a **poster** illustrating the **MIPP model** and its application to estimate the environmental impact of pesticides in a Mediterranean wine-growing watershed. See the [Communications](#) page for more details. 06/05/2025



11) The VSoil team



Team members:

- scientific team:



Nicolas Beudez
scientific computing engineer
scientific co-director



Stéphane Ruy
research fellow
scientific co-director

- software team:



Nicolas Moitrier
research software engineer –
IT project manager



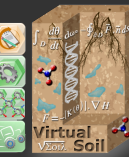
Nathalie Moitrier
software design
engineer



Cédric Nouguier
software design
engineer

To contact us:

- vsoil@inrae.fr ==> scientific team
- vsoil-support@inrae.fr ==> software team
- Discord server



Thank you for your attention