# Using the VSoil software platform in a forestry context

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**EMMAH unit, Avignon, 4 mai 2022**

Program of the day:

| | | |
|---|---|---|
| 9h – 10h | Presentation of the Virtual Soil project (VSoil) | Nicolas Beudez |
| 10h - 12h | The steps for building a model based on vsoil-forest (model from the VSoilForOAD project) | Manon Martin and Nicolas Beudez |
| 12h - 13h | Lunch break | |
| 13h - 15h | Using the vsoil-forest model | Manon Martin and Nicolas Beudez |
| 15h - 16h | Discussion | |

# Presentation of the Virtual Soil (VSoil) project

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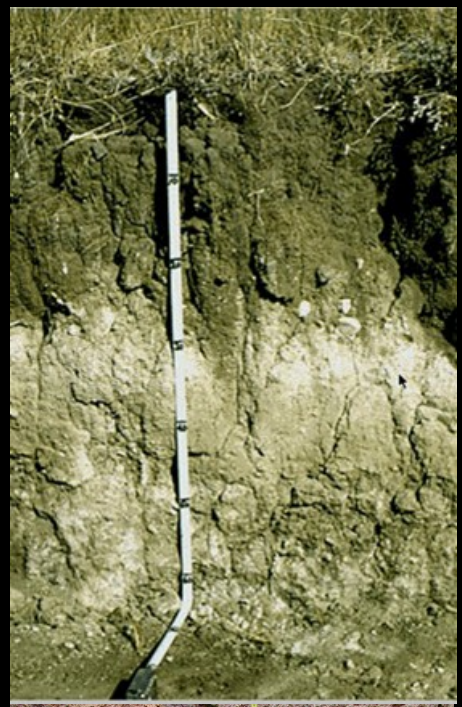
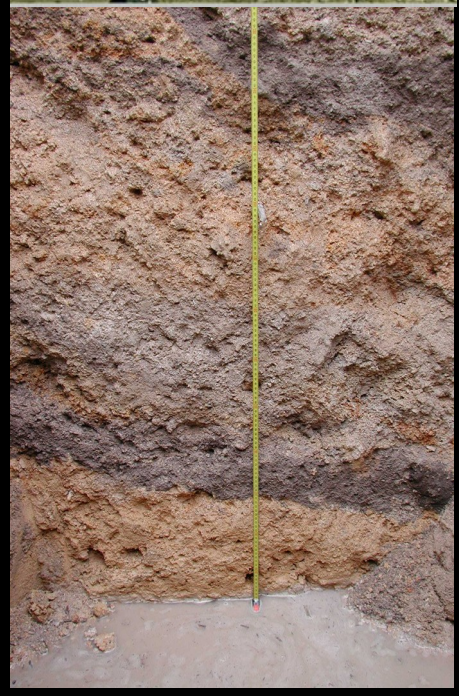
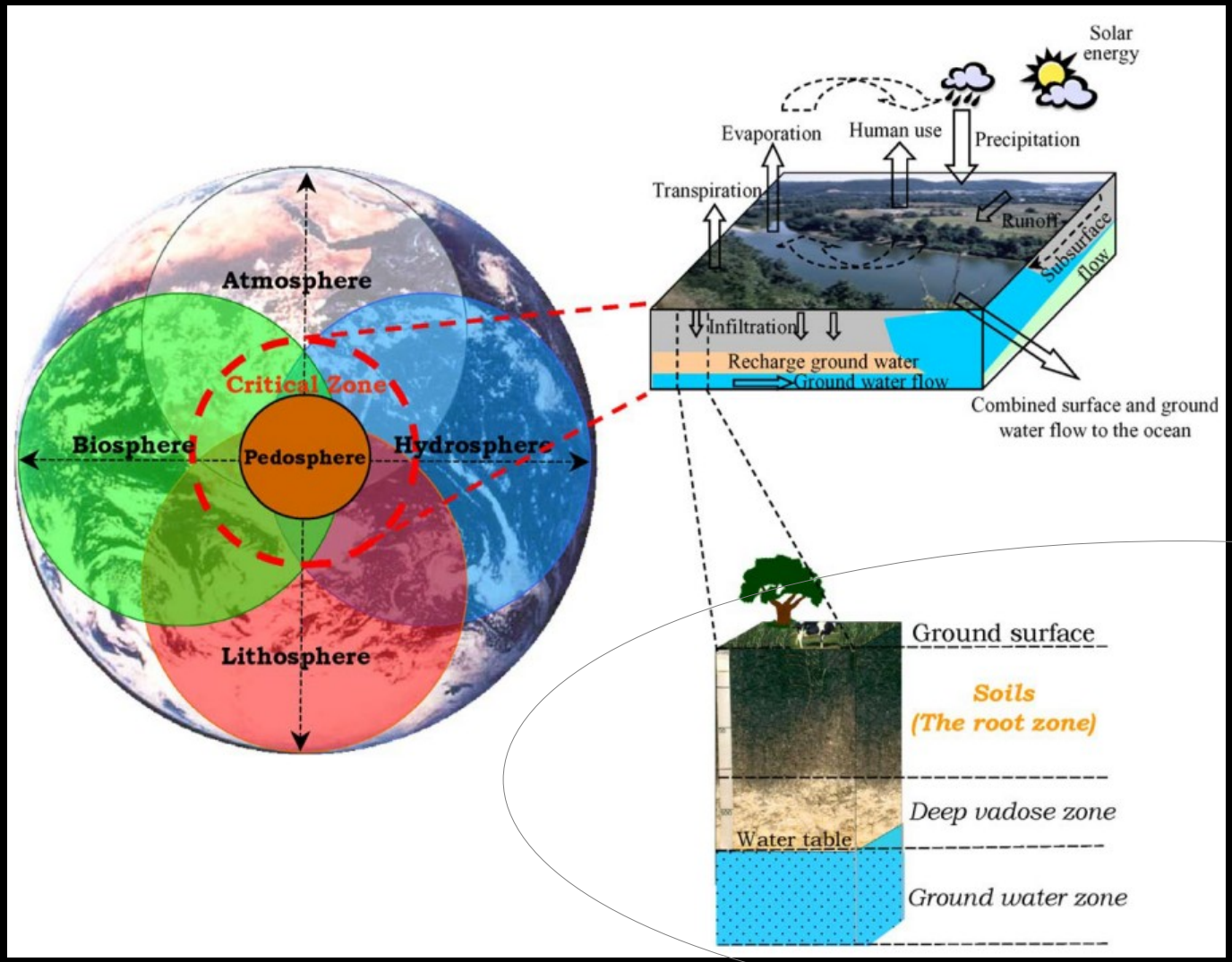
EMMAH unit, Avignon, 4 mai 2022



# Context: soil

**Climate change.**
**Changement of use.**
**Evolution ?**




**The soil is at the heart of the critical zone** of exchange of water and solutes, gases, solids, energy and organisms that extends from the upper canopy to the satured soil zone.

**Pedon**

- Local scale (a few m²).
- Soil profile from the surface to the groundwater or bedrock including the root exploration zone.

# Modelling requirements


**Survey** conducted between 2006 and 2008 within the Environment and Agronomy department of INRA

➡ Develop models that **couple mechanisms**:

- at different scales of time and space

- of different natures

➡ key point to understand the functioning and predict the evolution of soils

➡ Models should be developed **easily** et **quickly**: use what is available and / or develop new parts

➡ The development of new models should be accessible to all: **coding reduced as much as possible**

# Technical barriers


Difficulties in appropriating the **modelling**:

chain: experiments → model → computer code

➡ **need for support**

**Different computer languages** (Fortran, C, C++, Java, Python, …) 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

➡ Expectations ⇒ to have a structure that:
- allows to host and share models
- facilitates the development of new models
- allows to analyse the properties of these models

# Objectives


Create a structure to:

- **facilitate** the use of existing tools
- **reuse** and **capitalise** on the existing
- have a **modular modelling** approach
- accept **several representations** of a phenomenon
- **manage the coupling** of mechanisms
- **assist** in the development of new modelling approaches
- **facilitate interactions** between « modellers » and « experimenters »
- **facilitate communication** between scientists from different fields
- **share** and **make** innovations **« immediately » usable** for all users of the structure

# The VSoil software platform


VSoil is a **modelling software platform** supported by the INRAE Agroecosystems department and hosted in EMMAH unit on the Avignon site (developed since 2009)

It is a tool to **assist in the development of numerical models** describing the **physical, chemical and biological processes** of the soil in interaction with climate, plants and human actions

VSoil **facilitates the coupling** between these processes and makes it possible to develop complex models from the **assembly of existing or new source codes**

Space for **animation** and **scientific collaboration**

# Basic concepts


The **processes** that take place in the soil can be « described » and knowledge can be shared

Several representations of a process are possible through **modules**

A **model** is an assembly of modules

The modeller / user must be able to **concentrate on his core business**:

- making bricks (the modules)
- assembling the bricks
- analysing the results

→ modeller / user should be **relieved** of all tasks that are not its speciality

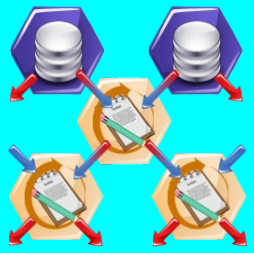
# Architecture


## From concepts...

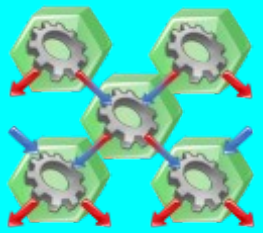
Processes

...encoded in modules,

...form squeletons,



...to create models



...and run simulations

vsoil-processes

vsoil-modules

vsoil-models

vsoil-player

## ...to softwares

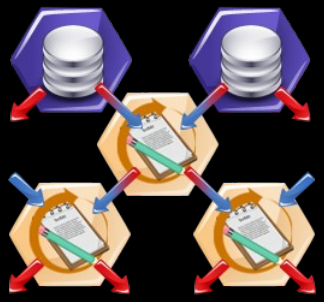
# The VSoil software components


## 1) vsoil-processes :

Phenomena are called **processes**

Some processes are **external**

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



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

demonstration !

**vsoil-processes**

**Open lists of variables and processes**

**Guide for naming variables**

**Tool for exploring content**

**Automatic creation of skeletons**

**Provide information for coding and assembly of modules**

# The VSoil software components


## 2) 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**

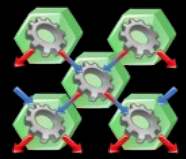
**Graphs**

**Non-invasive (standardised languages)**

demonstration !

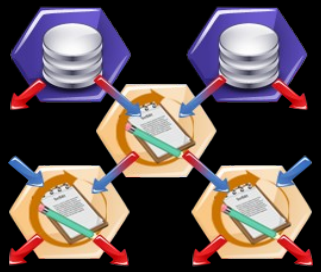
# The VSoil software components


## 3) vsoil-models :

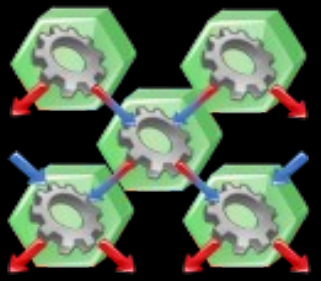


For each process...

… a module is selected



A **model** is based on a skeleton



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

**vsoil-models**

**Module selection**

**Generation of the main**

**Generation of the GUI**

**Execution**

**Visualization**

**Backup**

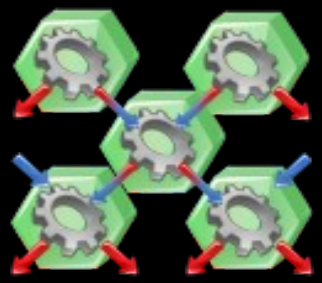
**Modification**



demonstration !

# The VSoil software components


## 4) vsoil-player :



A model already built

Simulations, visualisation of results, ...

**vsoil-player**

**Use available models**

**Run simulations**

**Archive simulations**

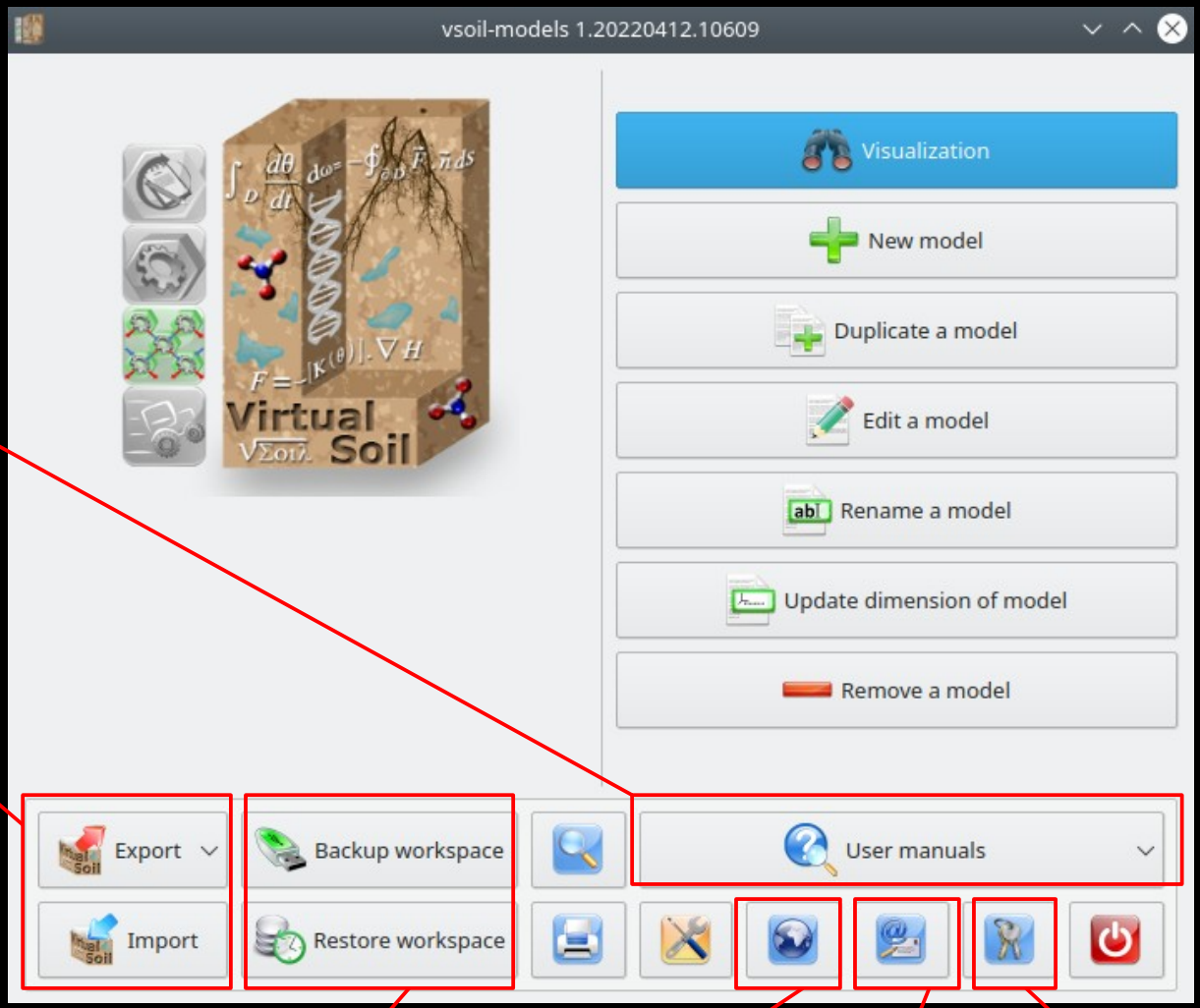
**View saved results**

**Compare simulation results**

**Perform sensitivity analysis and parameter estimation**

demonstration !

# A collaborative tool




online documentations (softwares and tutorials)

exchange of « user » objects

backup and restoration

access to the website

contact and support

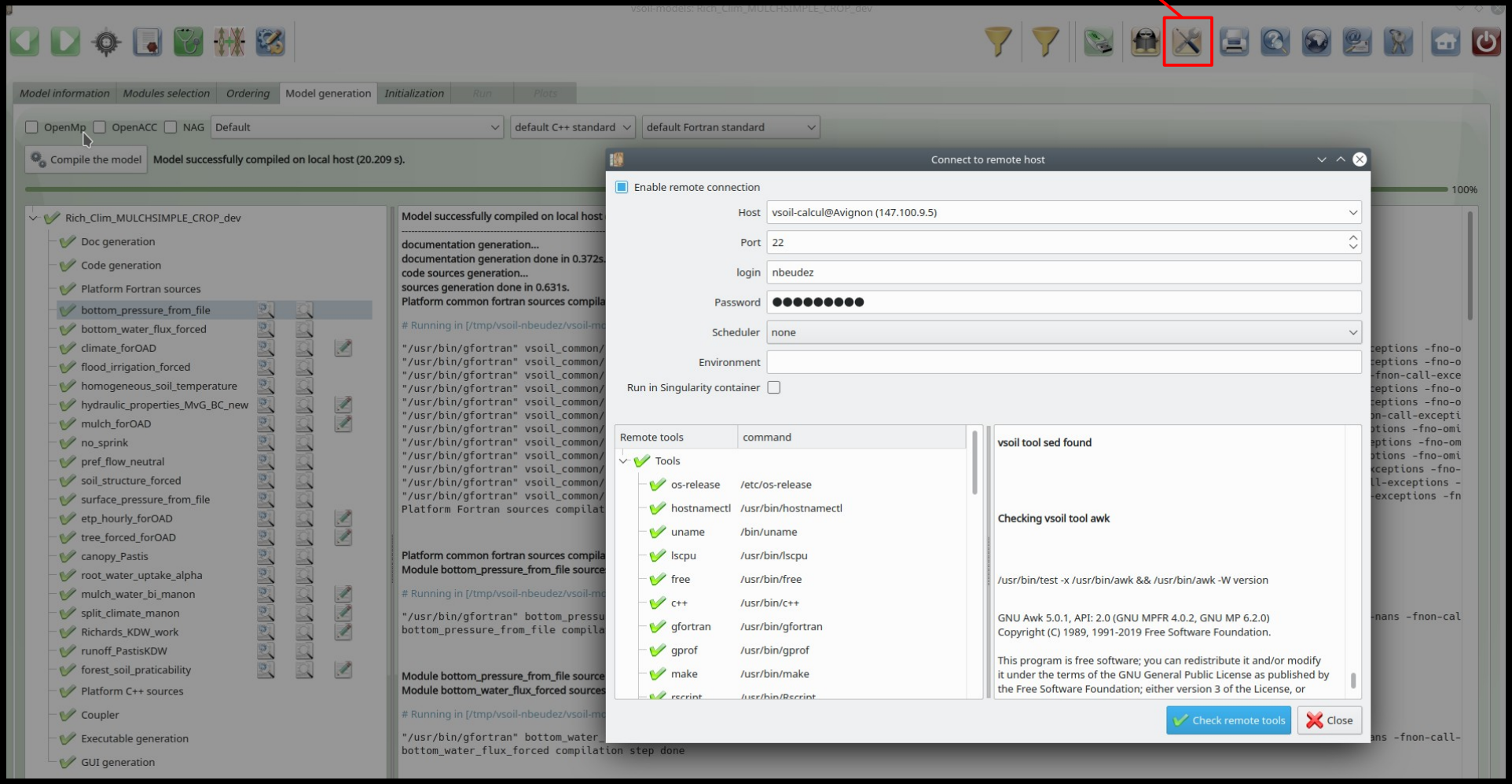
licence and charter

# Advantages of VSoil

1) Ability to **run calculations** on **remote** servers:

- « vsoil-calcul » Linux server : Ubuntu 20.04, 56 cores, RAM 92 Go
- compatible clusters

activation of remote connection



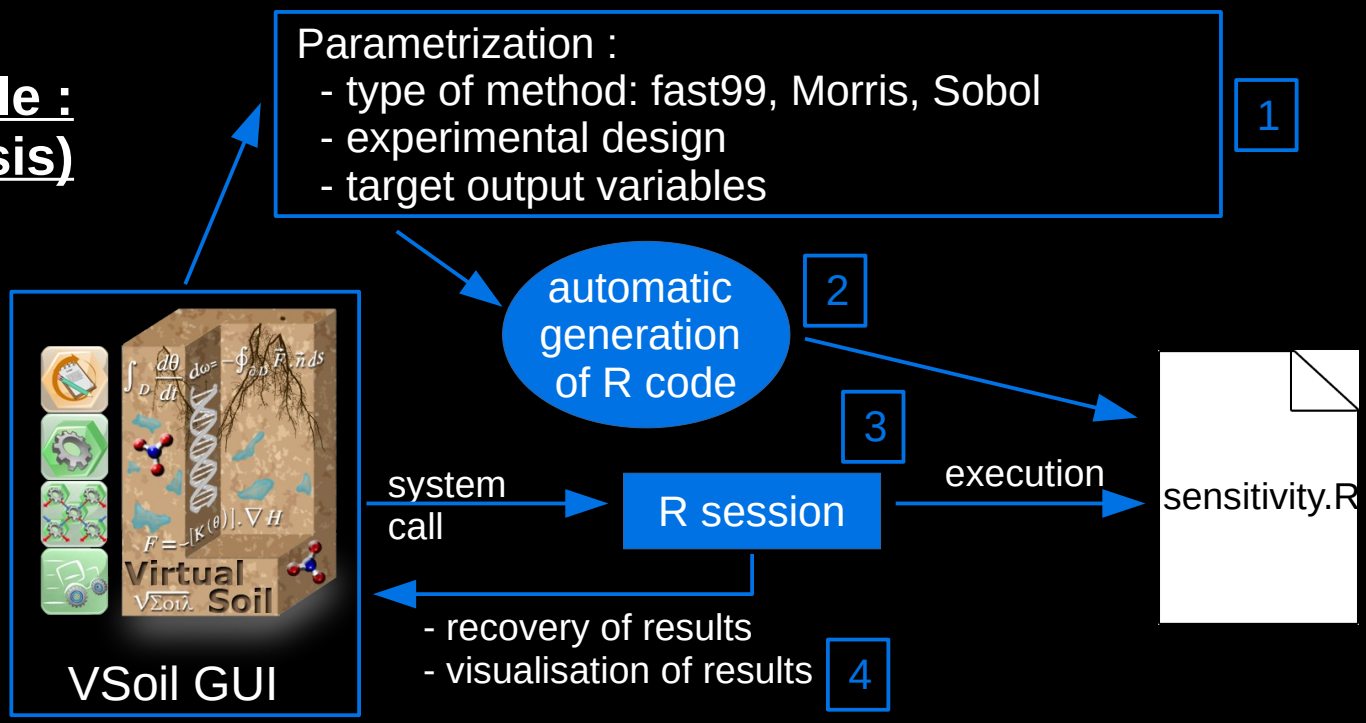
# Advantages of VSoil


2) **Model exploration** tools: VSoil models interfaced to dedicated **R packages**

⇒ several methods of **sensitivity analysis**: fast99, Morris, Sobol

⇒ different algorithms for **parameter estimation**:
- Levenberg-Marquardt
- SCE-UA (Shuffle Complex Evolution – Uncertainty Analysis)
- DREAM (Differential Evolution Adaptative Metropolis)
- DREAMzs (Differential Evolution Adaptative Metropolis)

**Scenario (example : sensitivity analysis)**



# Advantages of VSoil


3) Connections to **databases**


web-services

agro-climatic databases
(Climatik: Agroclim unit, Avignon)

soil databases (ACBB SOERE)

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

# Resources

Website: https://www6.inrae.fr/vsoil/


news

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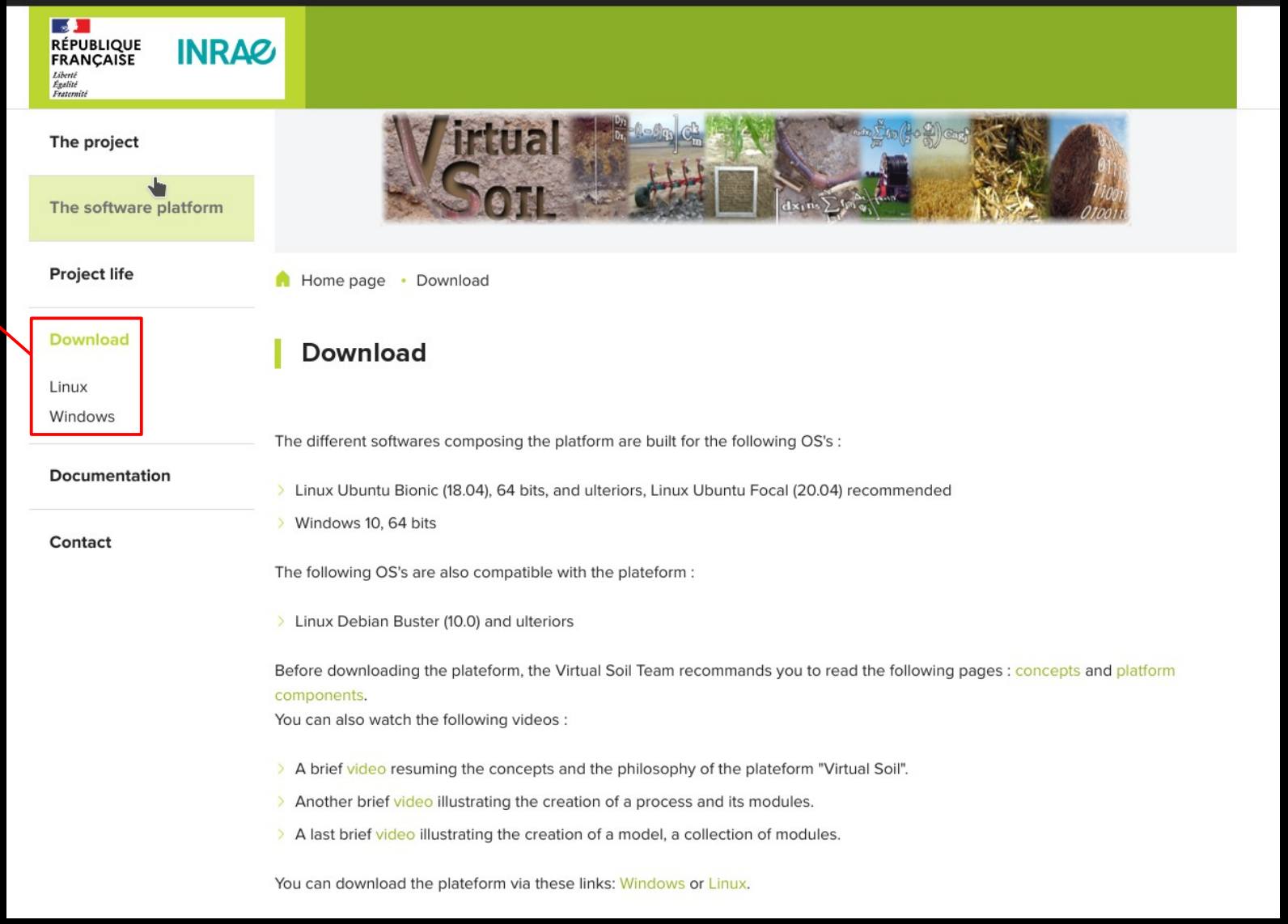
Website: https://www6.inrae.fr/vsoil/

download



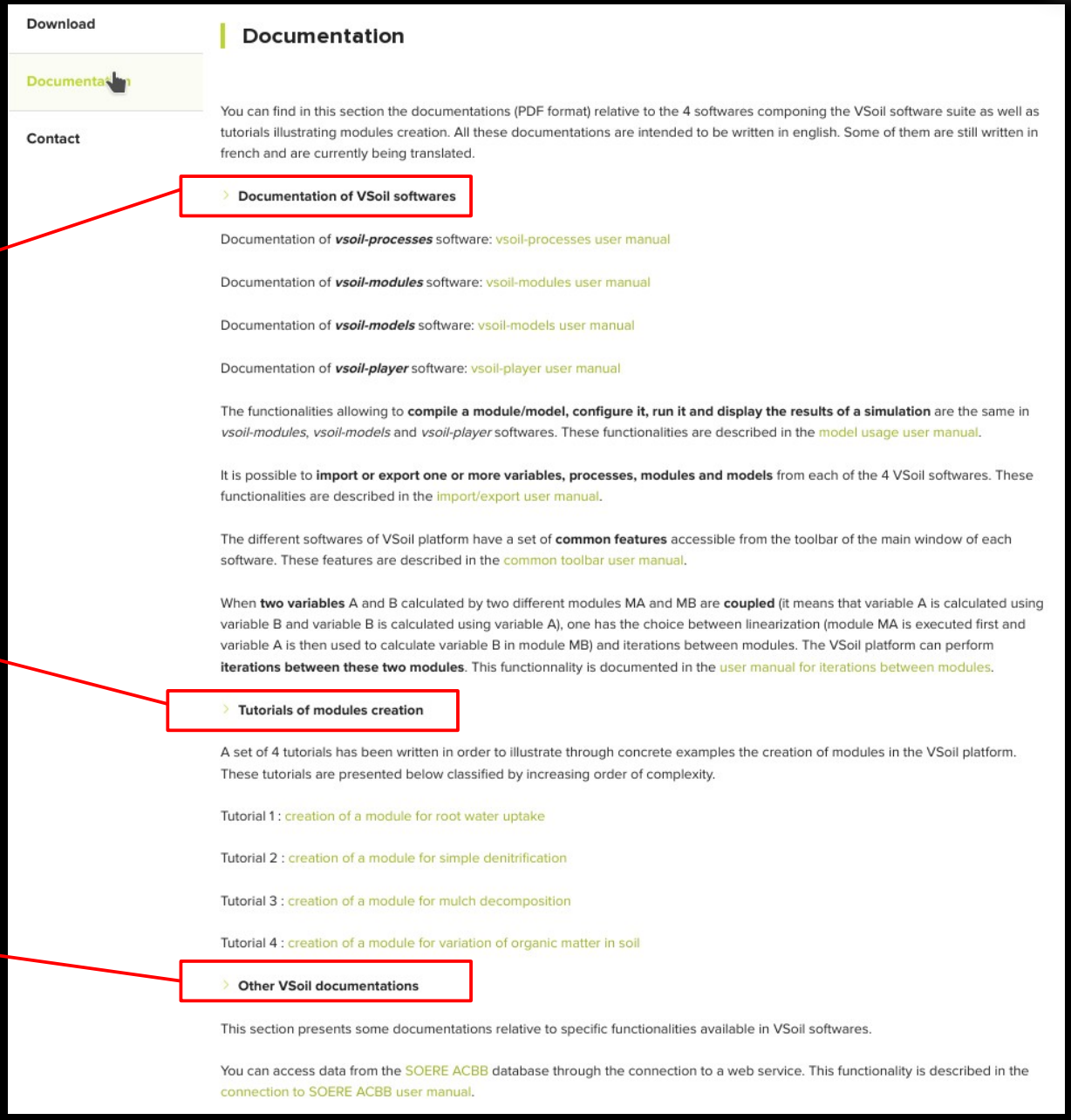
# Resources

Website: https://www6.inrae.fr/vsoil/

documentations of the different softwares:
- vsoil-processes
- vsoil-modules
- vsoil-models
- vsoil-player

tutorials for creating modules

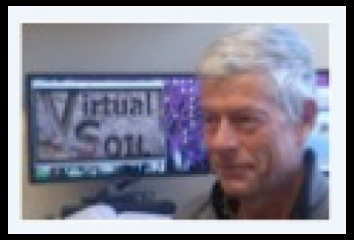
other documentations: connection to databases



# The VSoil team

Team members:

- <u>scientific team</u>:




François Lafolie
(research fellow – scientific leader of the project)

Nicolas Beudez
(design engineer – scientific computing)

- <u>development team</u>:

Nicolas Moitrier
(research engineer – IT project manager)

Nathalie Moitrier
(design engineer – software engineering)

Cédric Nouguier
(design engineer – software engineering)

To contact us:

- vsoil@inrae.fr → scientific team
  vsoil-support@inrae.fr → development team

- Discord server


# Thank you for your attention