vsoil-models user manual

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Introduction

The “vsoil-models” application is part of the “Vsoil” software platform. It is a computer tool that uses the objects defined in the scientific reflection phase (variables and processes of the “vsoil-processes” application) and developed in the computer design phase (modules of the “vsoil-modules” application). The “vsoil-models” application allows you to manage (view, create, modify, delete) models. This manual presents to you the functionalities of this application in detail.

The scientific data present in this manual (variables, processes, external factors, modules, models) may no longer correspond to the data contained in your “vsoil-models” application. The screenshots were taken on a version of the application at a given time and may not have been updated.

1 Home screen

The model creation/manipulation operations are accessible after launching the “vsoil-models” application (cf. figure 1).

Figure 1: Home screen: access to the main functions of the “vsoil-models” application

When launching the application, you have the choice to:

1. View an existing model.
2. Create a new model from scratch.
3. Create a new model from an existing model.
4. Modify an “user” model.
5. Rename an “user” model.
6. Destroy an “user” model.
7. Import processes, modules or models.
8. Export processes, modules or models.
9. Archive data.
10. Restore archived data.

11. Access user manuals.

12. Exit the application.

Import, export, restore and archive operations, unlike others, do not lead to the working environment (presented in Section 2): once these operations are completed, you return to the home screen (see figure 1).

1.1 Visualisation of a model

To view the content of a model, you can select the "Visualisation" function from the home screen (see figure 1). This function allows you to view the selected model, test it but not to modify it. In particular, the official models, by definition not modifiable, are accessible through this function.

1.2 Creation of a model

To create a process/module assembly, you can either create a model from scratch or modify an existing model.

1.2.1 Creation of a new model from scratch

After selecting the "New model" function from the home screen (see figure 1), the workspace appears (see Section 2). After choosing the dimension of the model from a drop-down list, three steps are required to create it:

1. "Model information": name, description and author of the model.

2. "Modules selection": selection of processes and modules to be integrated into the model.

3. "Ordering": if necessary, scheduling of the modules generating a cycle in the exchange of variables.

1.2.2 Creation of a new model from an existing model

It is possible to copy an assembly of modules already made, *i.e.* to copy an existing model. To do this, select the "Duplicate a model" function from the home screen (see figure 1). The list of available user and official models is displayed. All models (users and officials) can be copied for modification. Select the model to be copied then enter a new valid name for this model (see figure 2).

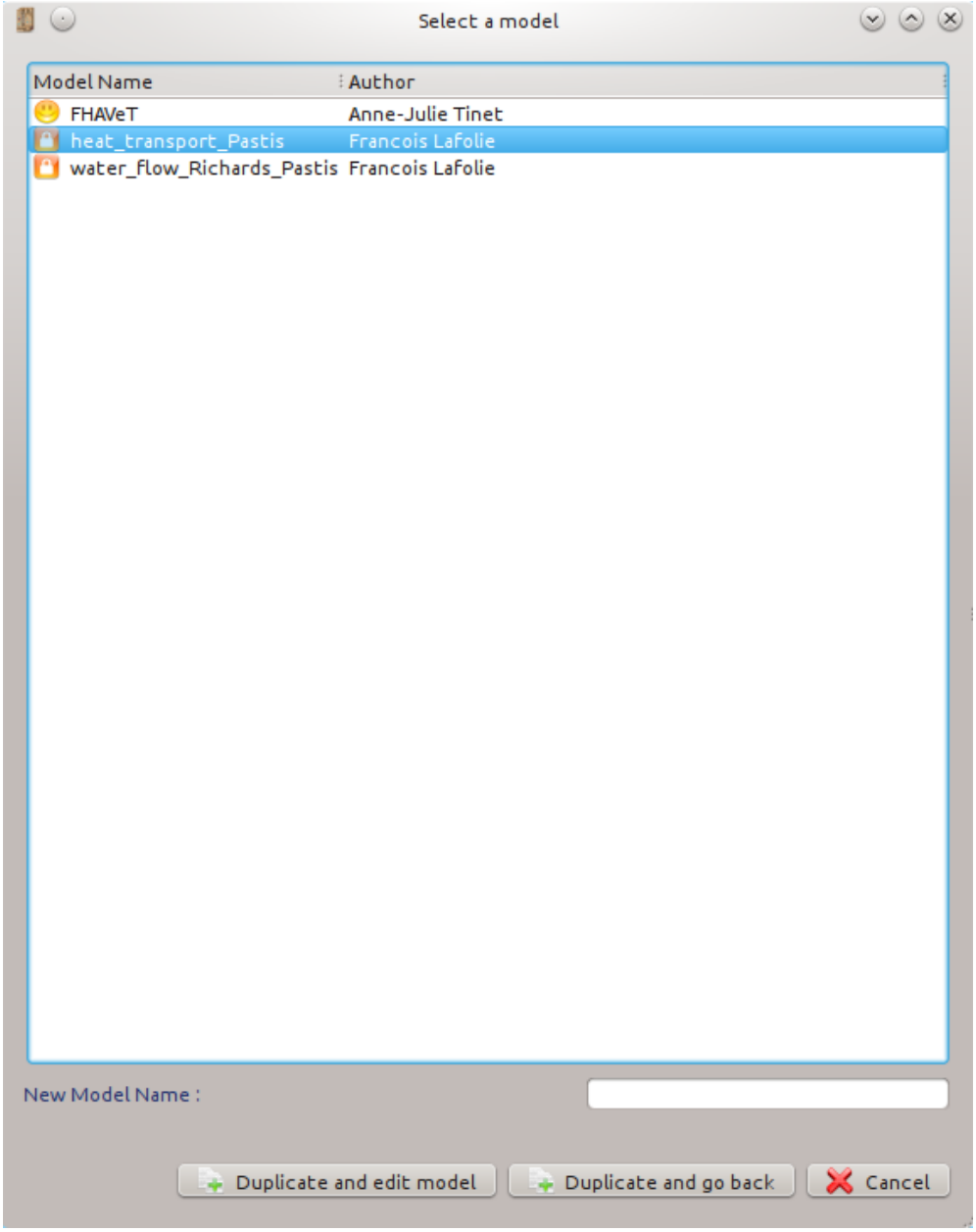


Figure 2: Creation of a new model from an existing model

Then you can either (see figure 2):

- perform the copy operation and edit the new model to modify it (“Duplicate and edit model”);
- perform the copy operation and return to the home screen (“Duplicate model”);
- cancel the copy operation and return to the home screen (“Cancel”).

1.3 Modification of a model

1.3.1 Renaming a model

The function for renaming a model is only accessible from the home screen via the “Rename a model” function (see figure 1). Official models cannot be renamed. Select the user model to be renamed and enter a new valid name for this model (see figure 3).

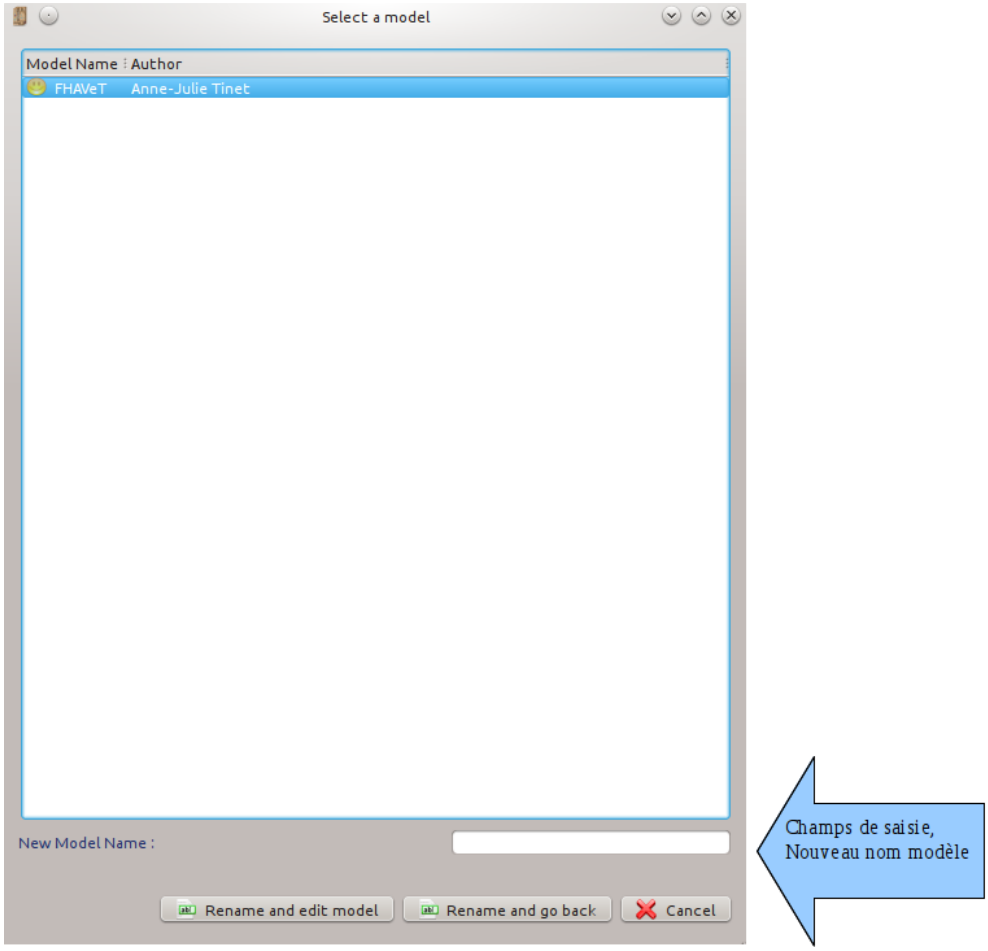


Figure 3: Renaming a model

Then you can either (see figure 3):

- rename this model and edit it immediately (“Rename and edit model”);
- rename this model and return to the home screen (“Rename model”);
- cancel the renaming operation and return to the home screen (“Cancel”).

1.3.2 Modification of the content of a model

Select the “Edit a model” function from the home screen (see figure 1). The list of official and user models appears. If you select an official model you will not be able to modify it but simply view it; this is the same as selecting “Visualisation” from the home screen (see figure 1) and selecting an official model (see Section 1.1). Select the desired model (user or official) (see figure 4).

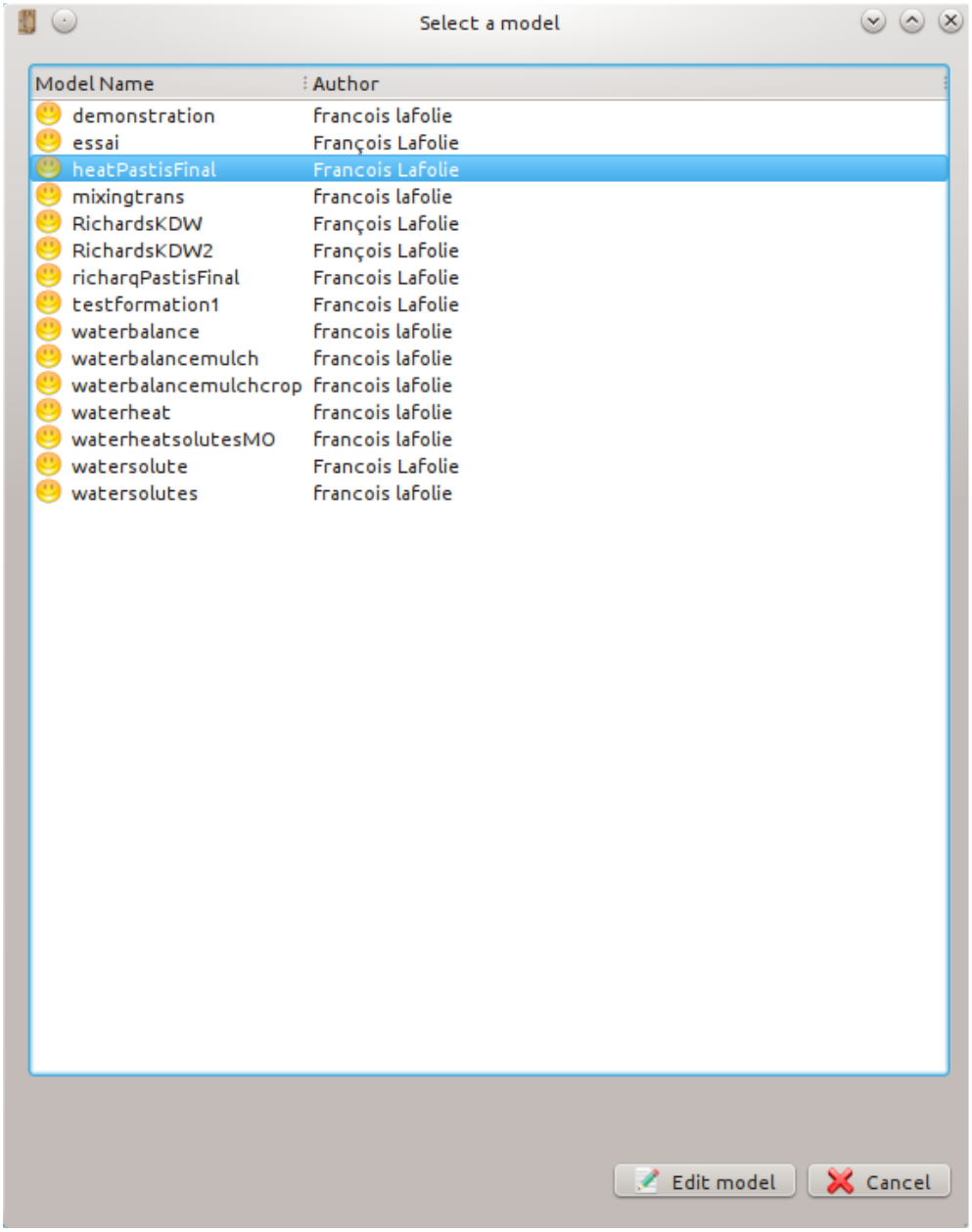


Figure 4: List of models to be edited (only user models here)

1.4 Destruction of a model

The destruction of a model is performed by the "Remove a model" function accessible from the home screen (see figure 1). The destruction of a model leads to the destruction of all its components (characteristics, source codes...). The modules composing the destroyed model are obviously not destroyed. Official models cannot be destroyed.

Select the model to be deleted from the list of user models. Then you can either:

- delete it and return to the home screen ("Remove model");

- cancel the delete operation and return to the home screen ("Cancel").

1.5 Functions for importing/exporting models and for restoring/archiving data

These functions are accessible from the home screen (see figure 1) and some of them from the workspace (in the common toolbar, see Section 2).

For the import and export functions, refer to the dedicated documentation (see the entry "Import/export user manual" from the list "User manuals" accessible from the home screen, see figure 1).

For the restore and archive functions, refer to the documentation of the general functions (see the entry "Common toolbar user manual" in the list "User manuals" accessible from the home screen, see the figure 1).

2 Synthetic presentation of the workspace

Access to the workspace is made after selecting one of the functions on the home screen, with the exception of the import, export, restore and archive functions (see figure 1). This workspace allows the user to design models from the platform's processes and modules. A model corresponds to a coherent arrangement of modules. All module inputs are fed by upstream modules. If you have selected the "Visualization" function from the home screen (see figure 1), then the working environment will be read-only, that is you will not be able to modify the model characteristics. In the end, the created models can be used immediately in the "vsoil-models" application or via the "vsoil-player" application.

The workspace is divided into two parts (see figure 7):

1. Part 1: toolbar (blue frame in the figure 7) divided into two parts:

   - the left part contains the access to the specific functionalities of the "vsoil-models" application (see figure 5): access to the previous and next steps, graphical visualisation of the model, textual visualisation of the model, model validity, model status and model change.

Figure 5: Left part of the toolbar specific to the "vsoil-models" application

   - the right part contains access to the functionalities common to the different applications of the "Vsoil" software platform: filtering, saving, remote connection, preferences, printing, access to the user manuals, access to the website, contact, licence, access to the home menu and exit from the application.

Figure 6: Right part of the toolbar common to all "Vsoil" applications

2. Part 2: access to the different steps to create, modify and use a model (green frame in the figure 7).

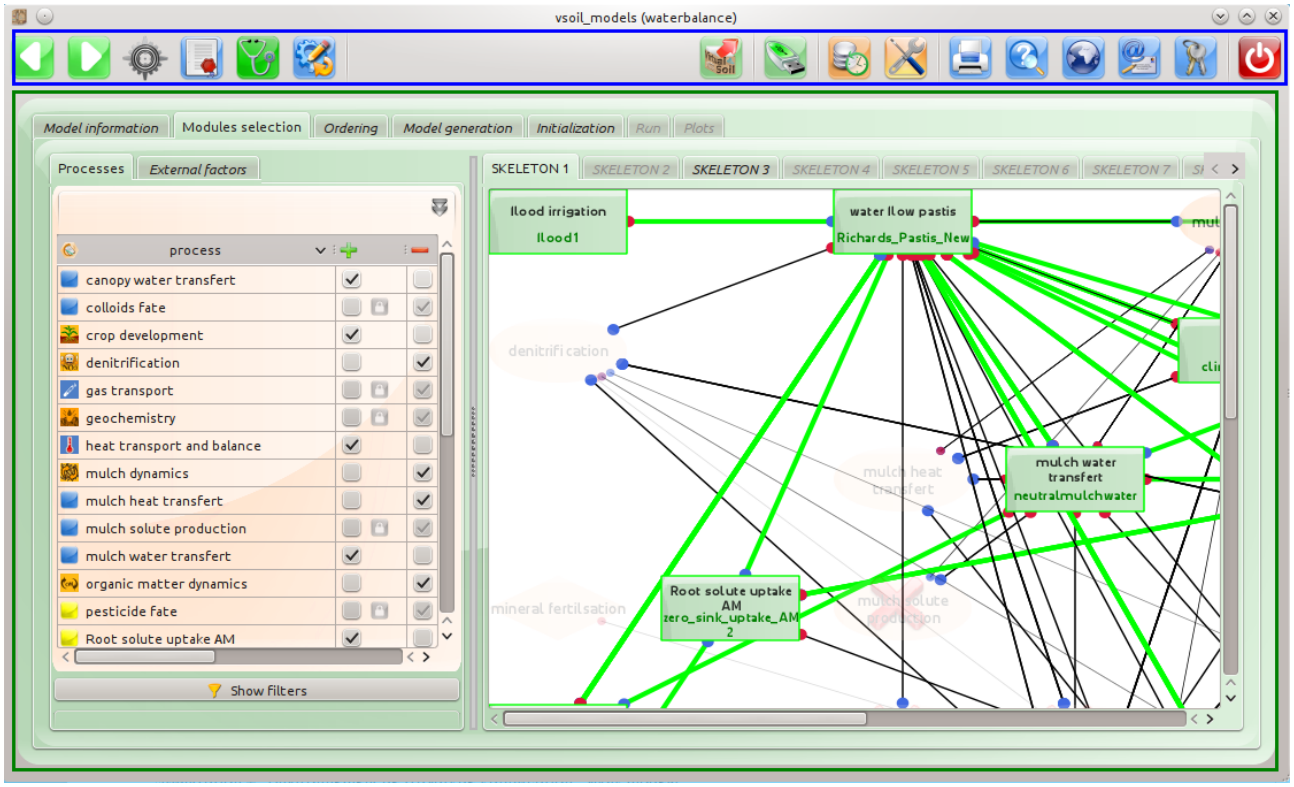


Figure 7: Main functions of the "vsoil-models" application

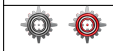
licence:

3 In-depth presentation of the workspace

3.1 Part 1: description of the toolbar

As we have seen in the Section 2, the toolbar contains a part specific to the "vsoil-models" application (left part) and functionalities common to all "Vsoil" applications (right part).

The functionalities specific to the "vsoil-models" application are as follows:

Icon	Meaning
	Go to next step.
	Go to previous step.
	View: • either all the processes and external factors of the "Vsoil" platform as well as the modules composing the model (target with a black background, default option); • either only the modules making up the model (target with a red background).
	View a status report that: • lists all the processes, external factors and modules making up the model; • lists all the processes, external factors and modules available in the "Vsoil" platform; • gives the reason why a process, an external factor or a module cannot be used in the model.
	View the content of the model (modules and their input and output variables) and consult the status (valid or invalid) of the model: • If the button has a red background: the model is invalid. • If the button has a green background: the model is valid.

For functionalities common to all "Vsoil" applications, refer to the general documentation (see the "Common toolbar user manual" entry from the "User manuals" list accessible from the home screen, see figure 1).

3.1.1 Graphical visualisation of the model or of the data set from the "Vsoil" platform

When the icon is displayed in the toolbar (icon displayed by default), not only all the modules making up the model and their connections, but also all the processes of the "Vsoil" platform and their connections are displayed for each skeleton (see figure 8).

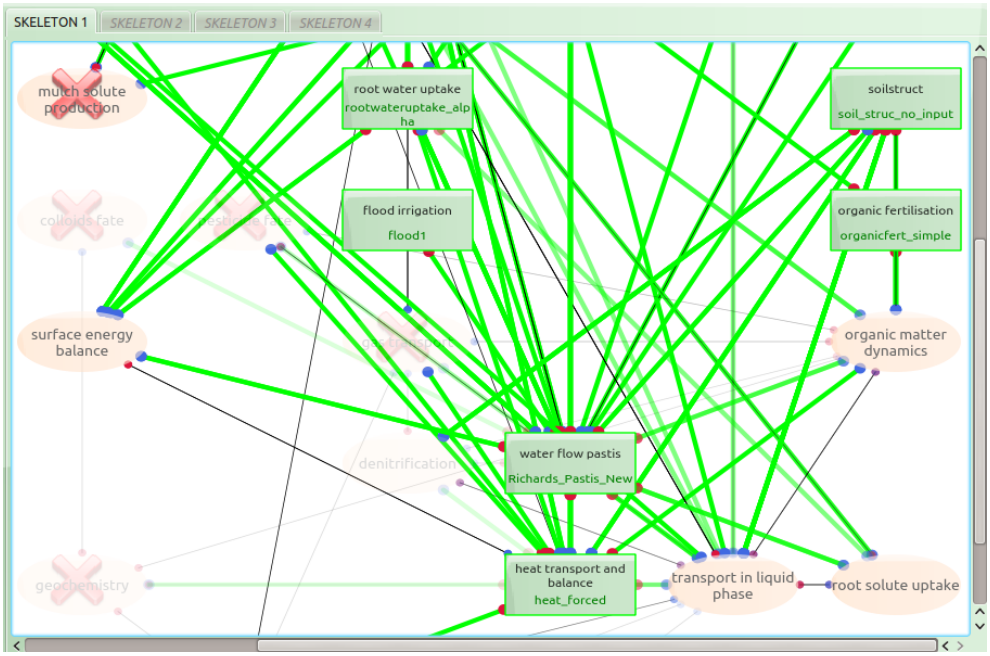


Figure 8: Visualisation of all the processes of the "Vsoil" platform and their connections as well as the modules composing the model and their connections

In order to view only the selected modules (*i.e.* composing the model), click on the button. The icon and the graphical visualisation then change appearance: the centre of the icon turns red (: symbolises targeting) and the processes and external factors not forming part of the model and their connections disappear from the graphical representation (see figure 9).

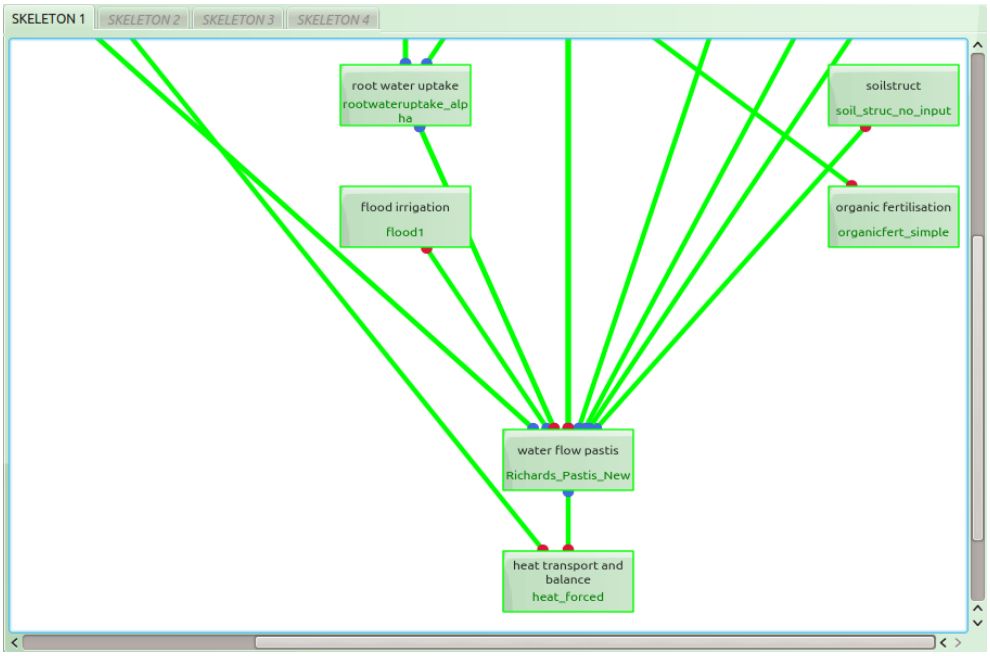


Figure 9: Visualisation of the selected modules and their connections

3.1.2 Status report

A click on the icon gives access to a textual report presenting all the processes and modules contained in the "Vsoil" platform, the processes and modules making up the model being highlighted (see figure 10).

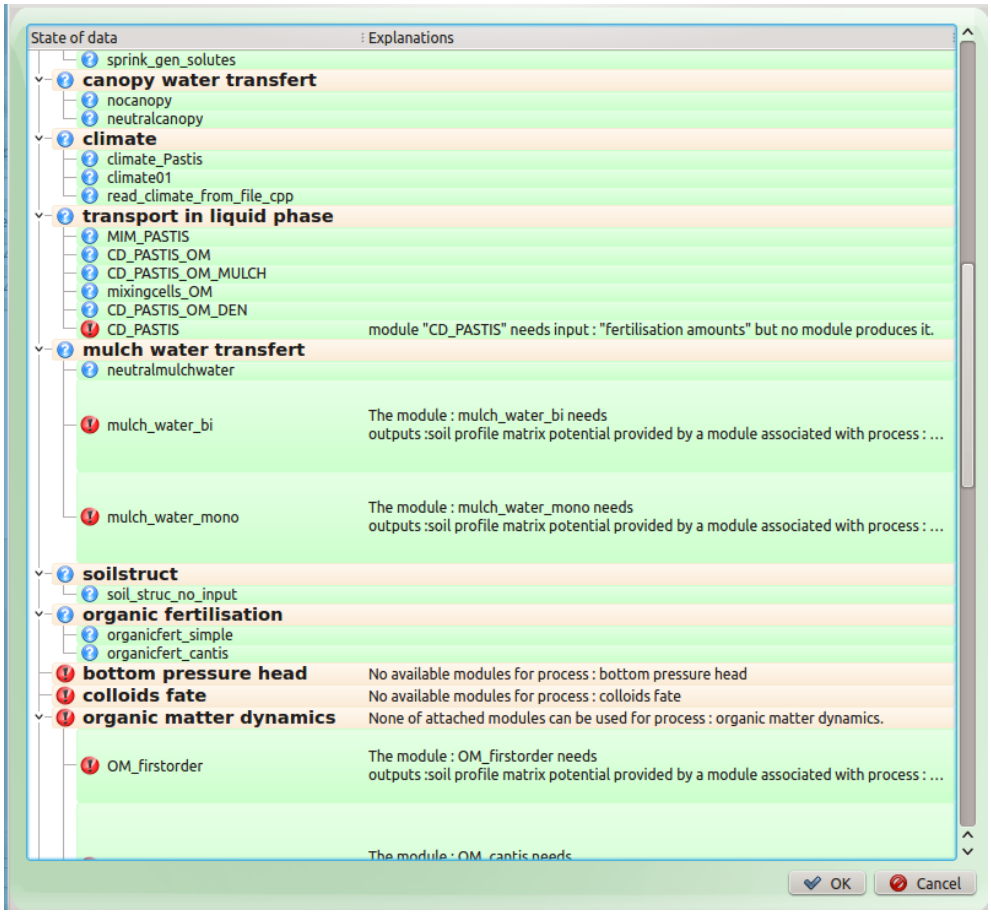


Figure 10: Status report

In this report, the processes have a salmon background and the modules have a green background. The icon preceding the processes and modules indicates their usability and use in the model.

Icon	Meaning
	The process or module has not been selected.
	The module has been selected for a process.
	The process or module is not usable. In this case, an explanatory text specifies the nature of the non-usability in the "Explanations" column.

If processes or modules are not usable (they are materialized by the icon positioned in front of their name), an explanation on the reason of the non-usability is proposed:

Associated texts	Explanation
No available modules for process: process name.	No module has been developed for the named process.
Module “module name” needs input: “input name” but no module produces it.	The named module needs an input that no other module of the “Vsoil” platform produces.
None of attached module can be used for process: process name.	The named process is not usable because all the modules that implement it are unusable.
The module is not available because another module is already selected for this process.	Only one module can be selected for a given process. Thus, as soon as a module is selected, the other modules implementing this process become non-selectable.

3.1.3 Validity of the constructed model

During the construction of a model, the system calculates the validity of the solution in real time. If it is considered valid, that is if all inputs of the selected modules can be fed, then the generation of the model executable is possible.

The background colour of the / icons indicates the validity of the constructed model:

- green background ( ): the model is valid;
- red background ( ): the model is not valid.

If you click on this icon (regardless of its green or red colour), you access different information about the model (see figure 11):

- the modules making up the model are listed with their inputs and outputs;
- the symbol precedes a valid entry (required by a module and provided by an upstream module) and the symbol precedes an invalid entry (required by a module but not provided by an upstream module);
- a green check mark precedes an output produced by a module.

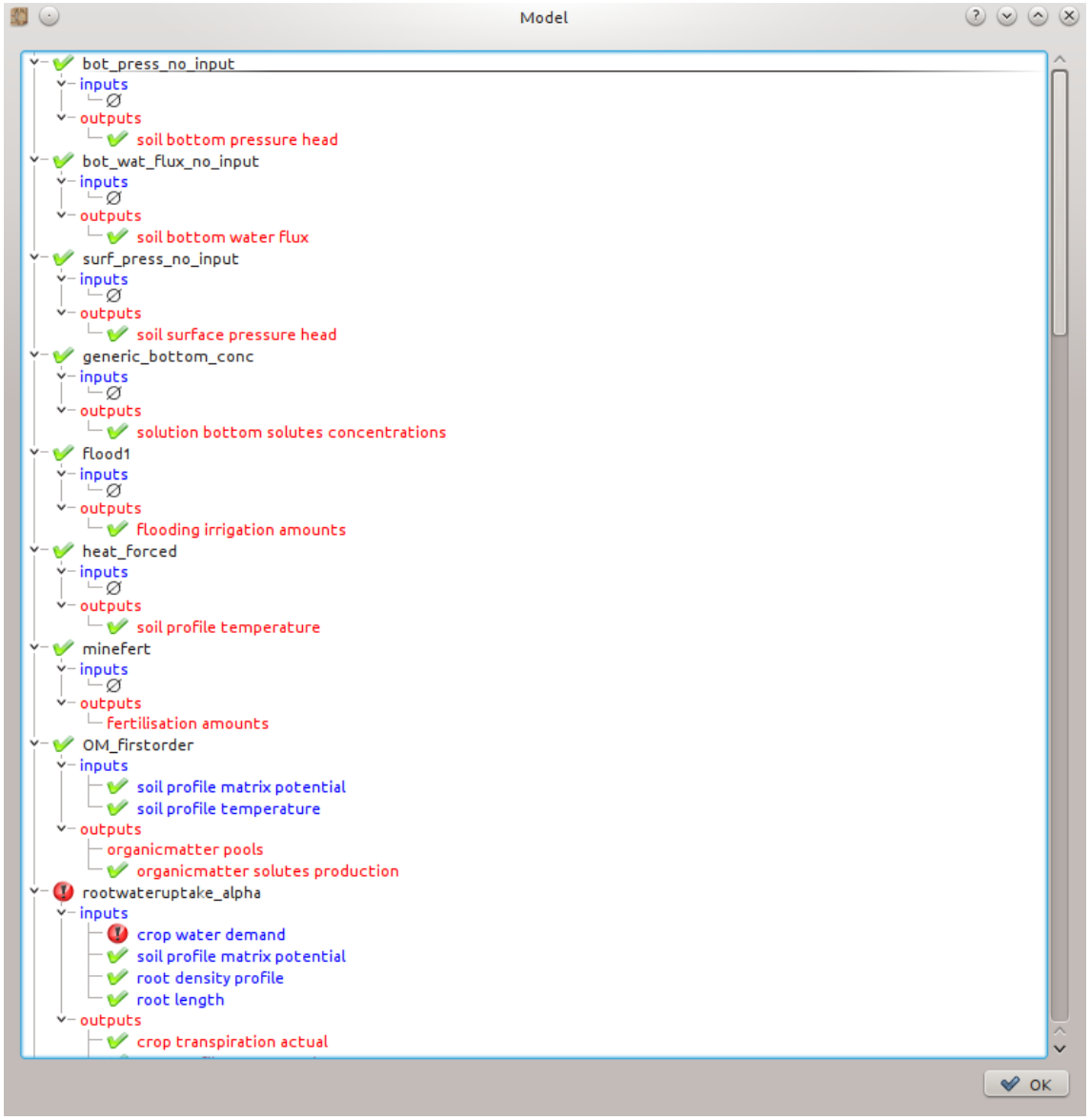


Figure 11: Solution status

Access to this report is not possible if the model does not contain any modules or if the model has not yet been created. Depending on the case, the following messages are displayed (see figures 12 and 13):

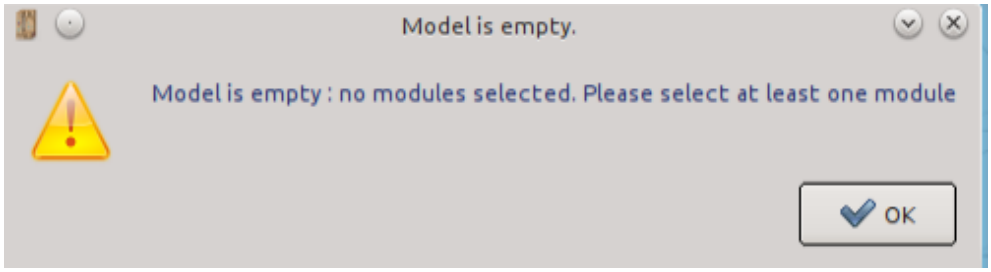


Figure 12: Unable to access solution status: message #1

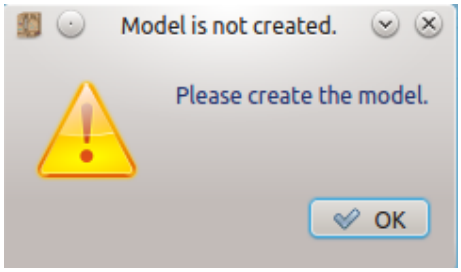


Figure 13: Unable to access solution status: message #2

3.2 Part 2: construction of a model

Three steps are necessary to build a model:

1. Associate information with the model.
2. Select the modules.
3. Organise these modules.

Each step corresponds to a tab (see figure 14) in the working environment (see green frame in figure 7).

Figure 14: Tabs representing the three steps required to create a model

When creating a model, the tabs to the right of the current tab are inaccessible as long as the information contained in the current tab is not validated (see figure 15).

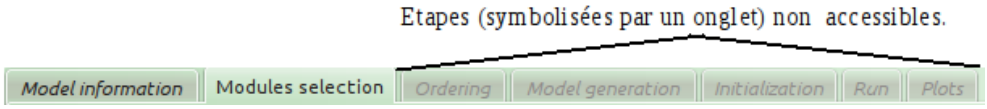
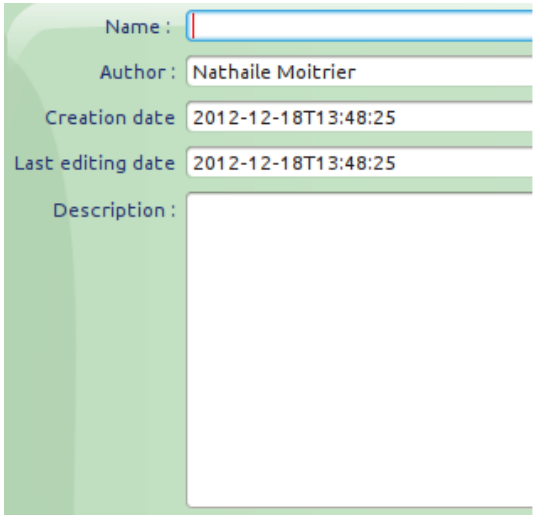


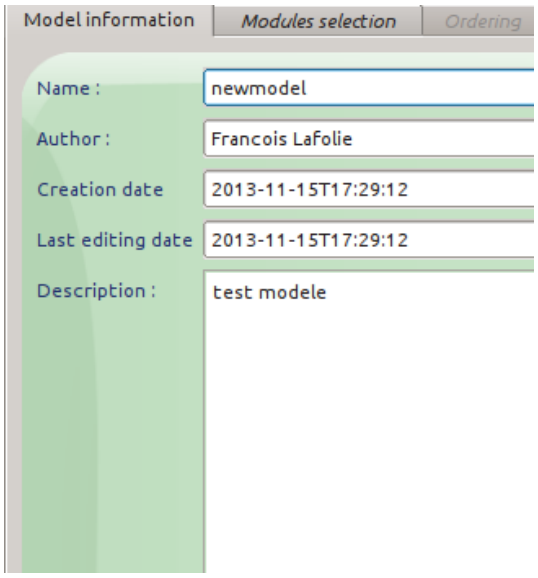
Figure 15: Inaccessible tabs

3.2.1 Step 1: associate information to the model

This step is performed in the "Model information" tab. Each model has a unique name, an initial author, a creation date, a modification date and a description. The content of this tab is filled or not with all the information depending on the function chosen from the home screen (see figure 1). In the case of the creation of a model, this tab is the one selected by default.



- "Name": model name.
- "Author": author's name.
- "Creation date" and "Last editing date": the creation and modification dates are pre-filled.
- "Description": free text field, allowing to give information about the model. The entry of this field is mandatory.



When creating a model, a set of information must be entered, including the name of the model. Once this information is validated (selection of to go to the next step), then the "Name" field is no longer modifiable. Renaming a model is only possible by using the "Rename a model" function accessible from the home menu of the "vsoil-models" application (see figure 1).

Enter:

1. **The name of the model** in the case of the creation of a model. It must be unique.
2. **The author**. The author's name is pre-filled with the registration information if it exists (name and surname) or the login identifier. You can change the contents of this field.
3. **A description**. Entering a description is mandatory. Without a functional description of the model, it can neither be effectively used in the future, nor even validated by the scientists of the project group. You can include any text you wish, there is no limitation in the number of characters.

Go to the next step: To do this click on the button in the toolbar (see the blue frame of the figure 7). If all the information is valid, you go to the next step. If an error is detected, then an error message appears. In the case of creating a model, if the information is valid, then the model is created.

Error case: If the information is invalid, the following message (see figure 16) appears when you click the button:

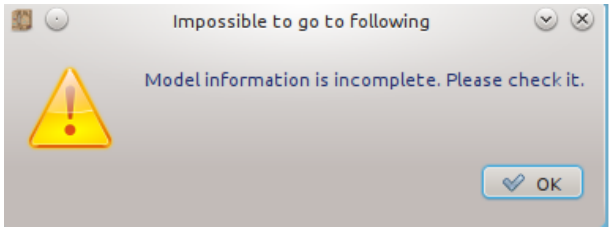


Figure 16: Error message: incomplete model information

For details on the type of error, refer to the message displayed above the information to be entered. Two types of error are handled.

1. The entered model name is not valid; it must consist of at least three characters and be distinct from other model names in the "vsoil-models" application.
2. None of the "Name", "Author" and "Description" fields must be empty (see figure 17).

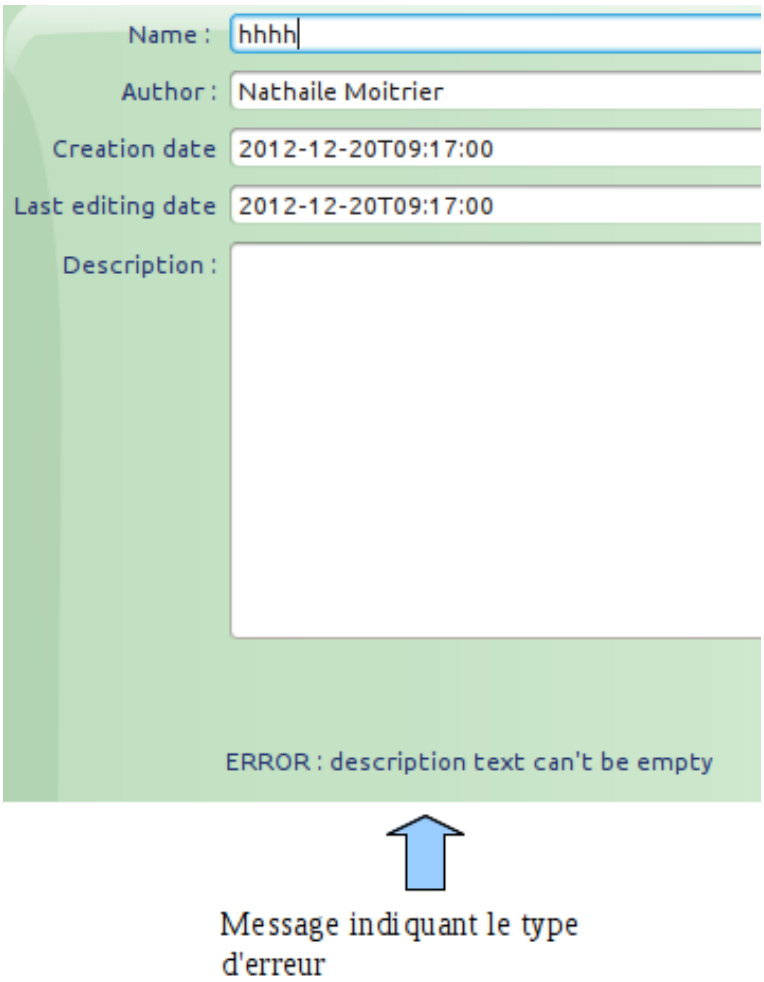


Figure 17: Contents of the "Model information" tab: case of a missing model description

3.2.2 Step 2: select the modules making up the model

This step is performed in the "Modules selection" tab (see figure 18).

Figure 18: “Modules selection” tab

A model consists of a sequence of modules selected by the user. In order to select these modules, the information contained in the “Modules selection” tab is arranged in two ways (see figure 19):

- in textual form on the left side;
- in graphic form on the right side.

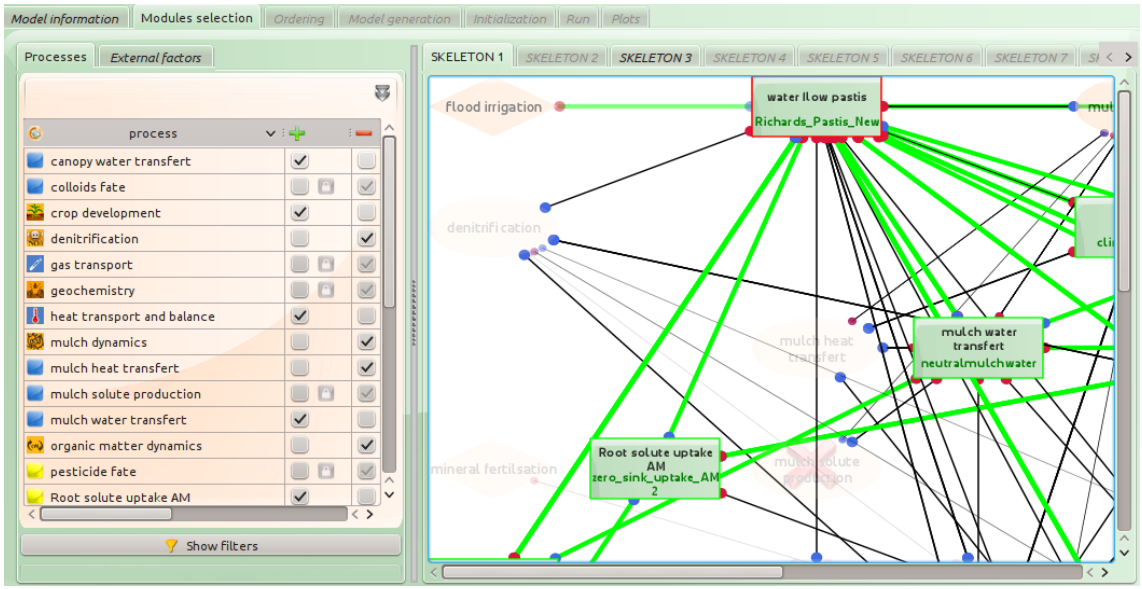


Figure 19: Contents of the “Modules selection” tab

Both of these layouts offer tools for adding or removing modules to the model.

1. Text part In the “Modules selection” tab, the list of processes and external factors (listed in alphabetical order) is accessible for their selection or deselection in the model being created or modified (see figure 20).

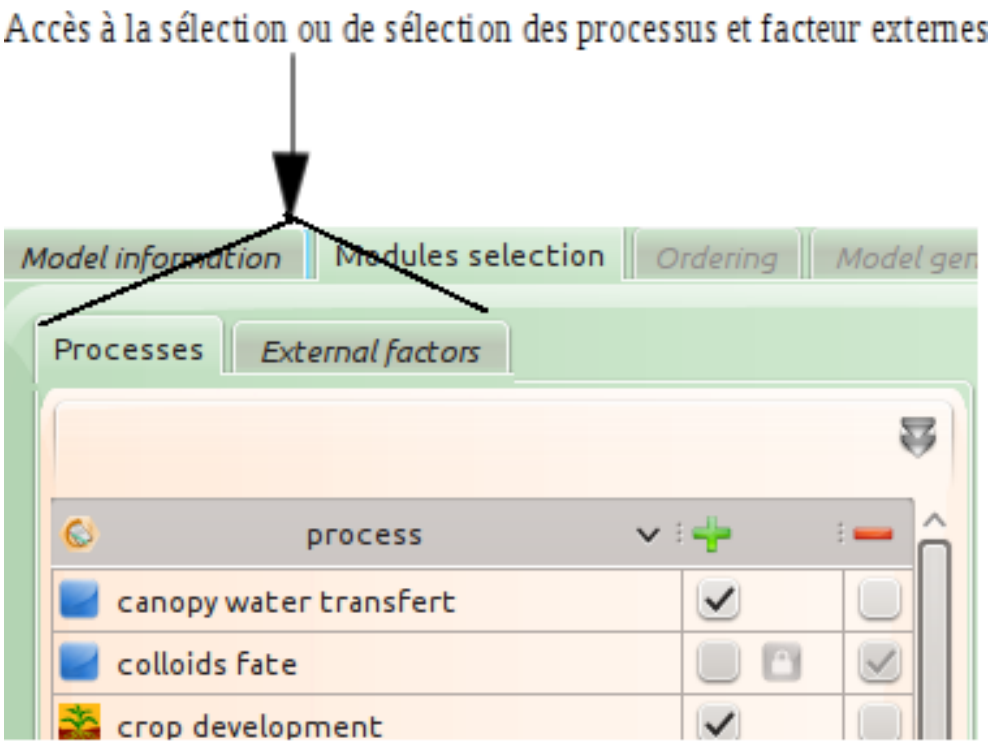
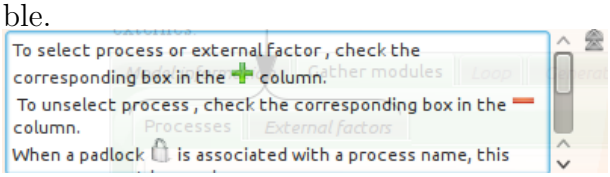


Figure 20: List of processes and external factors in the “Modules selection” tab

The structuring of the information presented in the “Processes” and “External factors” tabs is identical and consists of three parts:

- Part 1: the and icons allow you to show or hide contextual help.

	No text displayed.
	Display an explanatory text when using the table. 

- Part 2: a table contains the list of processes (if the “Processes” tab is active) or external factors (if the “External factors” tab is active) available in the “Vsoil” platform and for each of them a set of possible actions to perform (see figure 21).

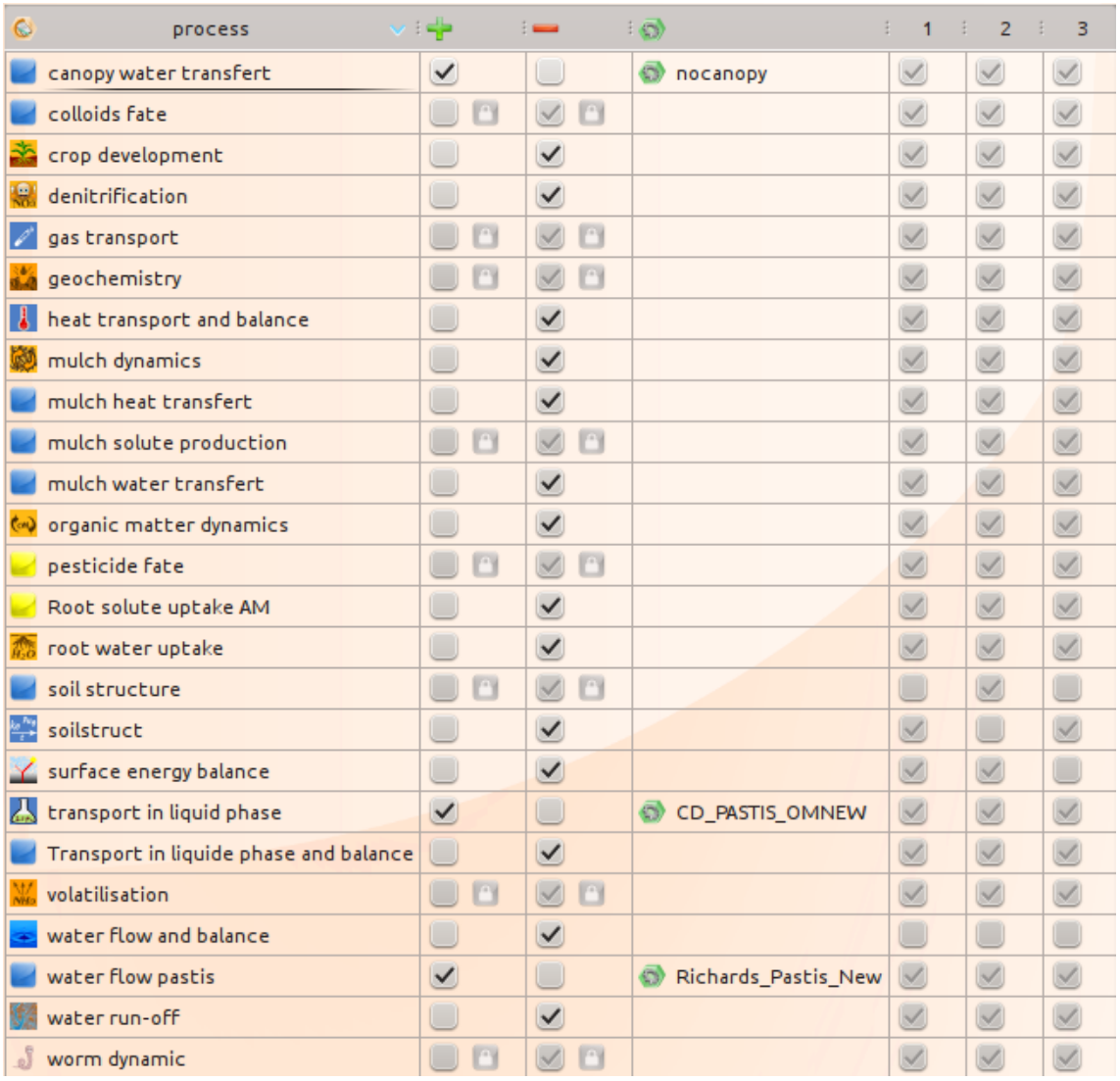


Figure 21: List of processes available in the "Vsoil" platform

Description of the function and type of access of each column of the table shown in the figure 21:

Column number	Function	Nature
1	Specifies either the process name if the “Processes” tab is active, or the external factor name if the “External factors” tab is active. To know the details of the process or the external factor, right click on its name, the window shown in the figure 22 appears.	Read-only.
2	Allows you to locate a process or an external factor in the active skeleton and to access its information (see figure 22).	Read-only.
3	Allows you to add the process or external factor to the model.	Read-only if the icon is present, otherwise modifiable. The selection (icon) leads to the module selection (see section 4.1.3).
4	Allows the process or external factor to be removed from the model.	Read-only if the icon is present, otherwise modifiable. The selection (icon) leads to the module selection (see section 4.1.3).
5	Specifies, in case the process or external factor is added to the model, the name of the selected module that implements it.	Read-only, unless the process or external factor has been added to the model. In this case, a left mouse click on the name of the module leads to the modification of the selected module (see section 4.1.3).
6 to x	Each column corresponds to a skeleton and specifies if the process or external factor is present (icon) or not (icon) in the skeleton.	In read-only mode.

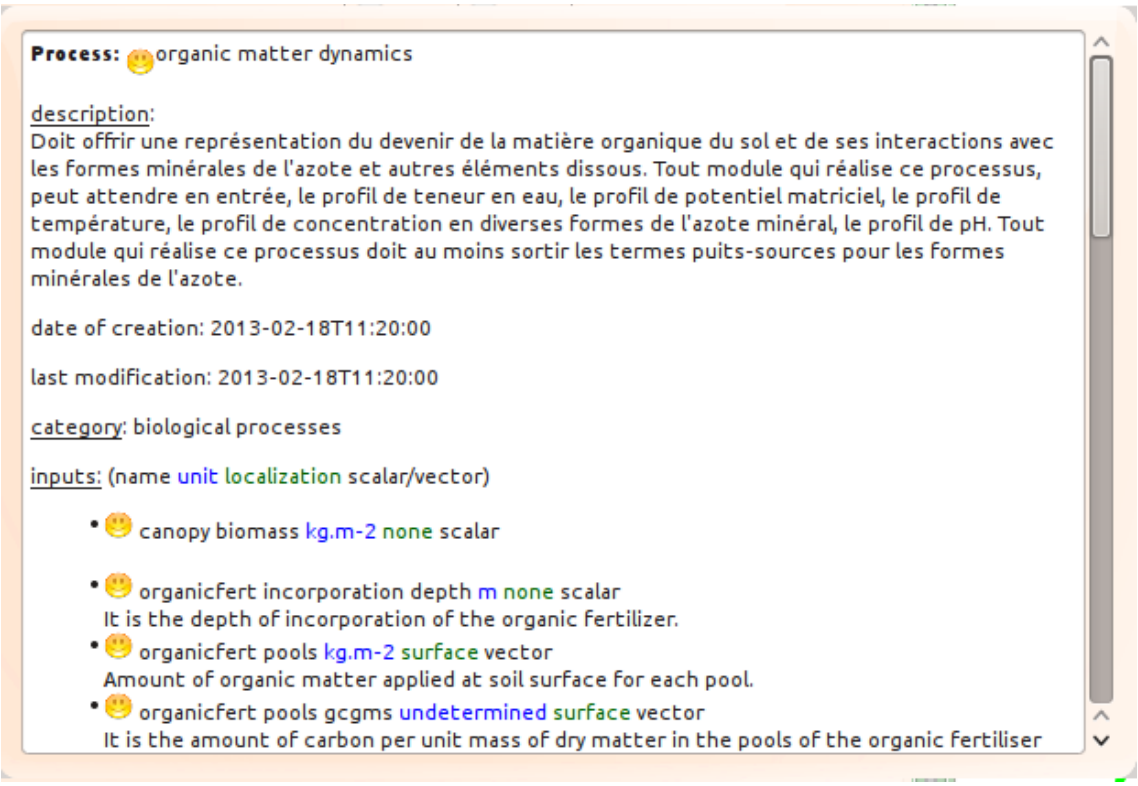


Figure 22: Access to process information.

Special case of the padlock : When the symbol accompanies the functions of adding or removing a process or an external factor to the model, it means that the process or the external factor can not be selected. This is due to the fact that the process or the external factor:

(a) has no associated module;

(b) has all of its associated modules that cannot be used. This case occurs when the module waits for inputs from upstream modules which do not exist. To find out the reason for the non-availability, place the cursor on the checkbox, a contextual help then appears indicating the nature of the error (see figure 23).

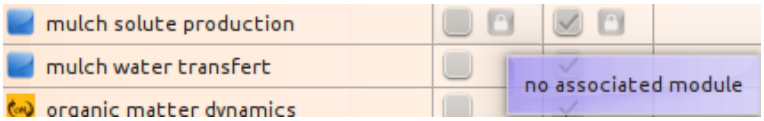


Figure 23: Process not selectable, accuracy of cause

- Part 3: Filtering
  Following the table, a filtering function is available, making it possible to search for processes or external factors using criteria. To use this function, click on the following button (see figure 24):

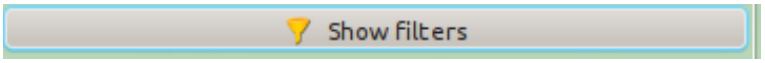


Figure 24: Access to filter criteria

The filtering criteria are displayed (see figure 25):

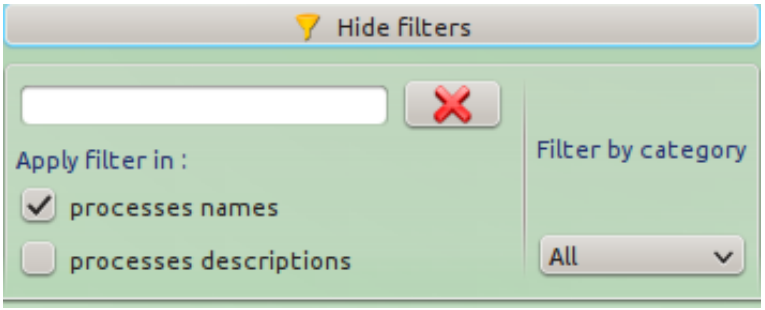


Figure 25: Filter criteria

Select the desired criteria, the list of displayed processes will then be modified taking these criteria into account. For example, enter the "mulch" term in the search box (see figure 26):

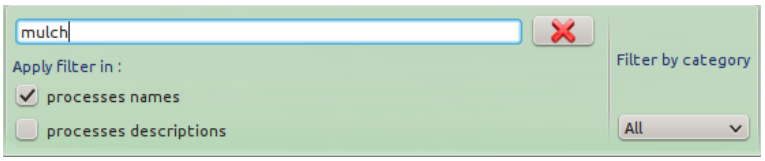


Figure 26: Entry in the filter search field

The list of displayed processes is reduced to the search term.

Remark: when the "Hide filters" button is clicked, only filtered processes are displayed in the table.

2. Graphic part In the "Modules selection" tab, graphical representations of processes / external factors are available on the right-hand side of the window. These representations are similar to those in the "vsoil-processes" application: different graphs represent the processes and external factors of the "Vsoil" platform and their connections.

When creating a model, the set of graphical symbols has a ghost appearance (see figure 27) to signify that no selection of processes or external factor has been made.

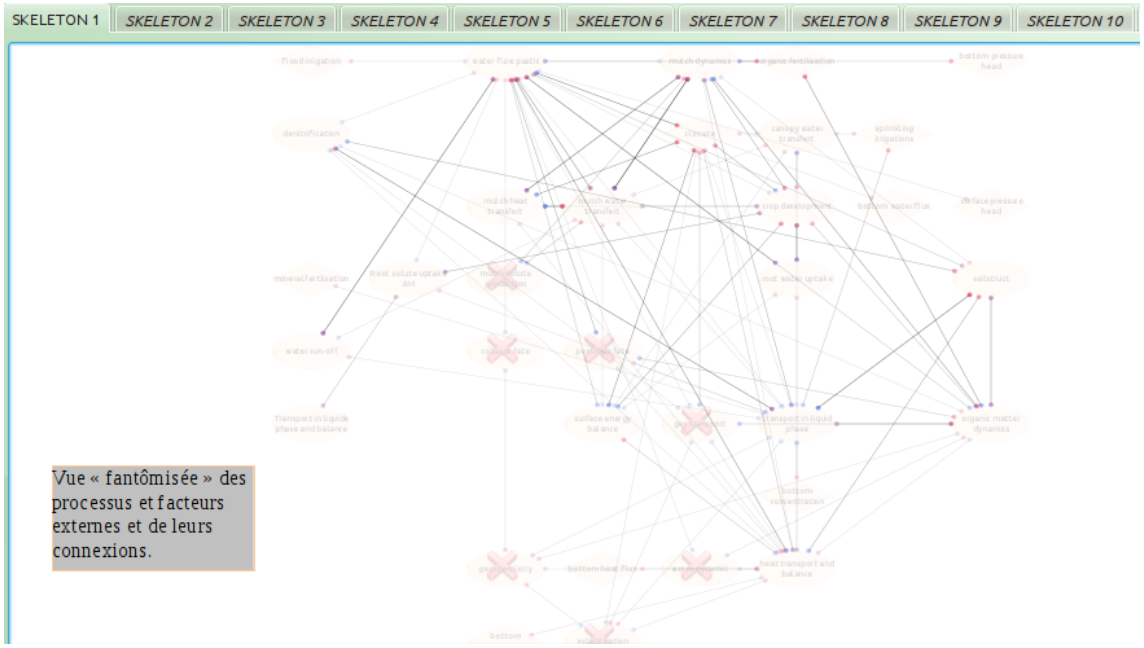


Figure 27: “Phantom” graphical representation of processes and external factors

When modules are selected and the built model is evaluated as correct, the stethoscope symbol changes to green. You can then proceed to the next step. If you try to go to the next step while the model is not valid, the following error message (see figure 28) appears:

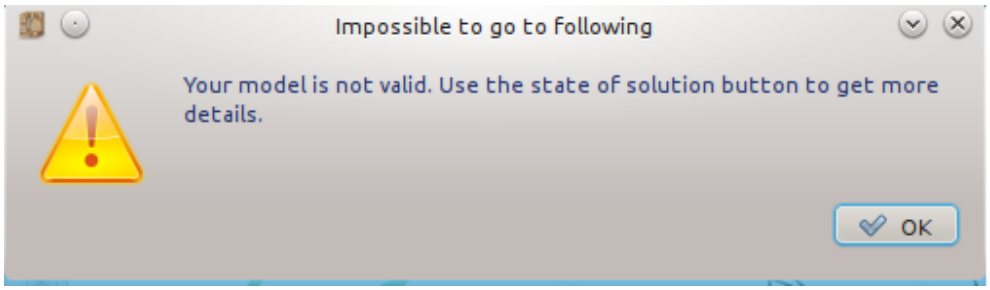


Figure 28: Error message appearing when the model is invalid

The model is in error, the symbol is present in the left part of the toolbar. Either it has no module, or at least one module is in error (materialised by a red rectangle in the graphic part of the window). To help you deal with this error, see section 3.1.3.

3.2.3 Step 3: order the modules

This step is performed in the “Ordering” tab (see figure 29).

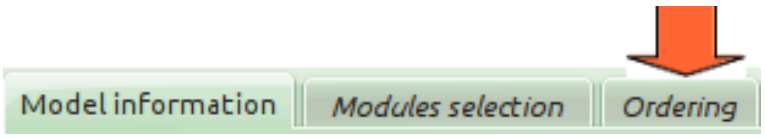


Figure 29: “Ordering” tab

The system determines *a priori* the order in which the modules are executed. If ambiguities remain, that is if there is a loop between modules, these modules will have to be ordered by you.

Case of non-ambiguity In this case, the content of the “Ordering” tab is pre-filled and cannot be changed (see figure 30). You can proceed to the next step.

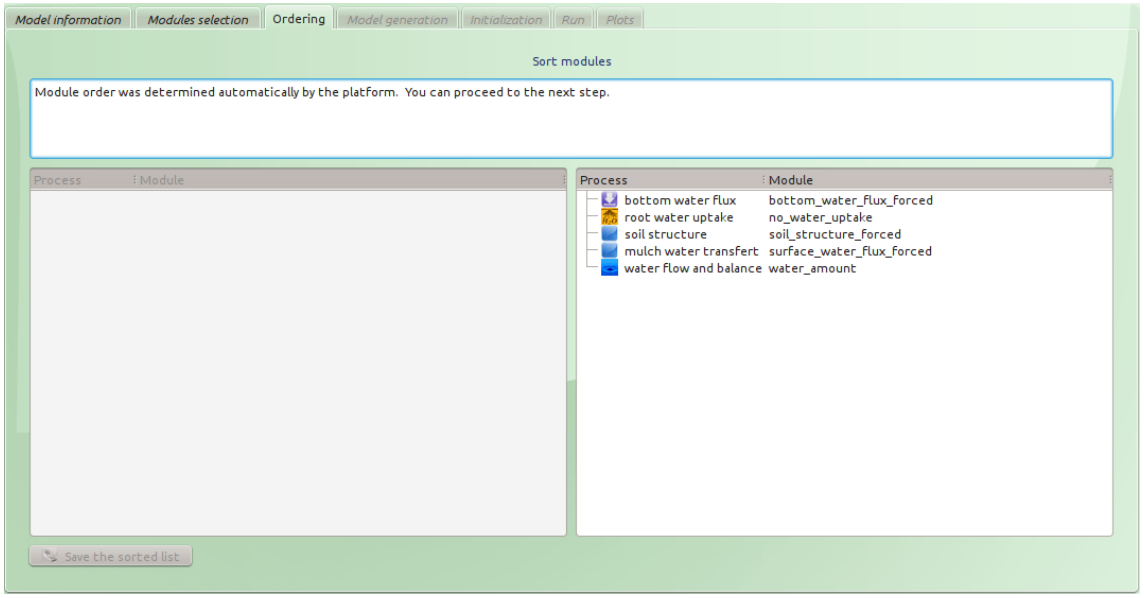


Figure 30: “Ordering” tab: case of the absence of looping between modules

Case of the presence of loops between modules In this case, an alert message appears when the “Ordering” tab is displayed (see figure 31).

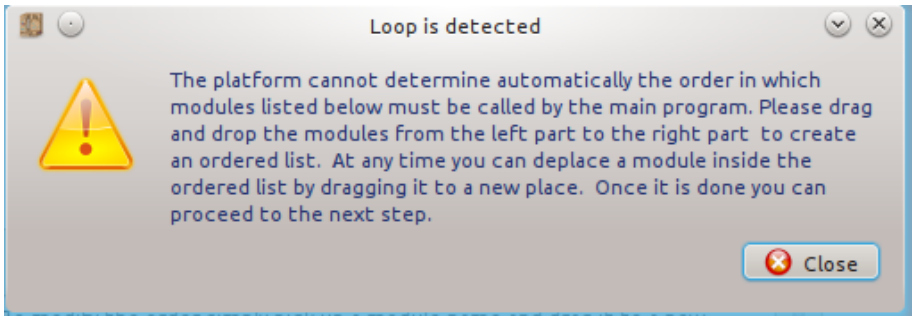


Figure 31: “Ordering” tab: warning message concerning the presence of a loop between modules

The content of the “Ordering” tab gives you the elements allowing you to schedule your modules (see figure 32).

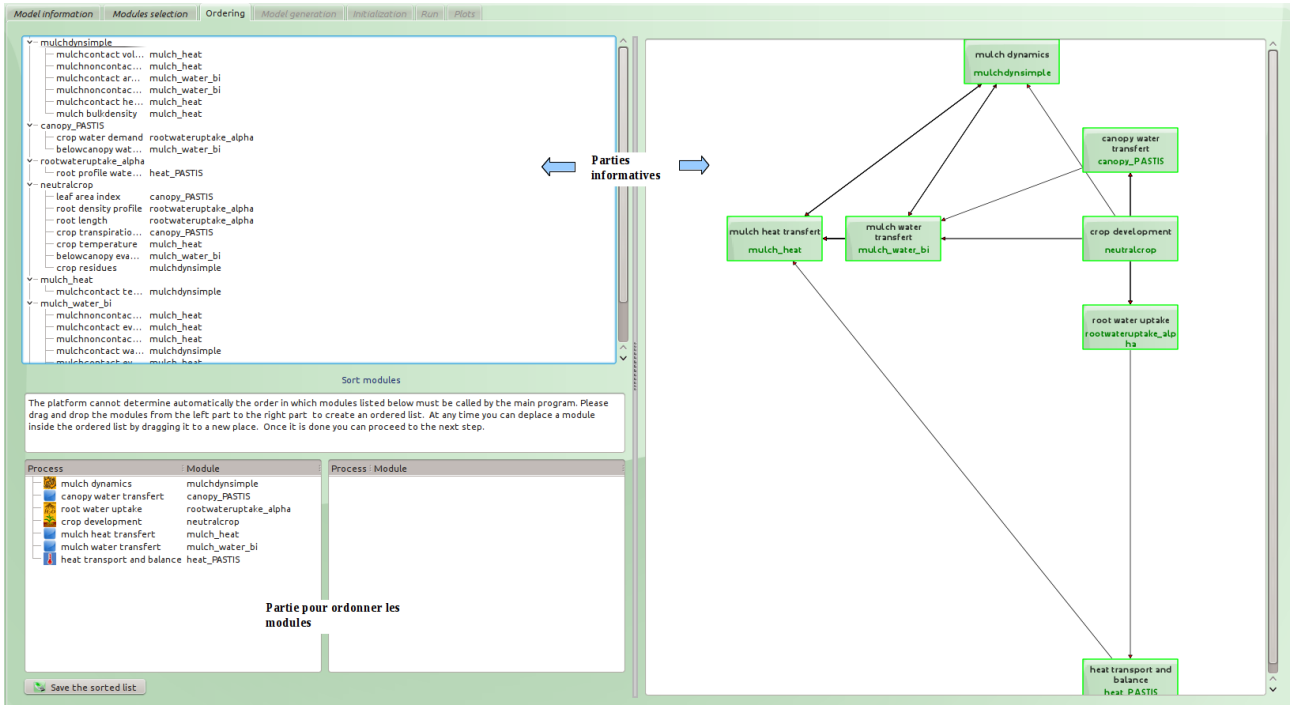


Figure 32: "Ordering" tab: case of the presence of a loop between modules

To help you schedule these modules, the list of modules is displayed in the text part (top left of the window) and a graphical representation of the modules and their interactions is provided in the graphical part (right of the window). Scheduling is done in the "Sort modules" part (bottom left of the window).

1. **Scheduling assistance** The informative parts are not modifiable.

2. **Text part** For each module are specified the variables it produces and for each variable is specified the module which uses it (see figure 33).

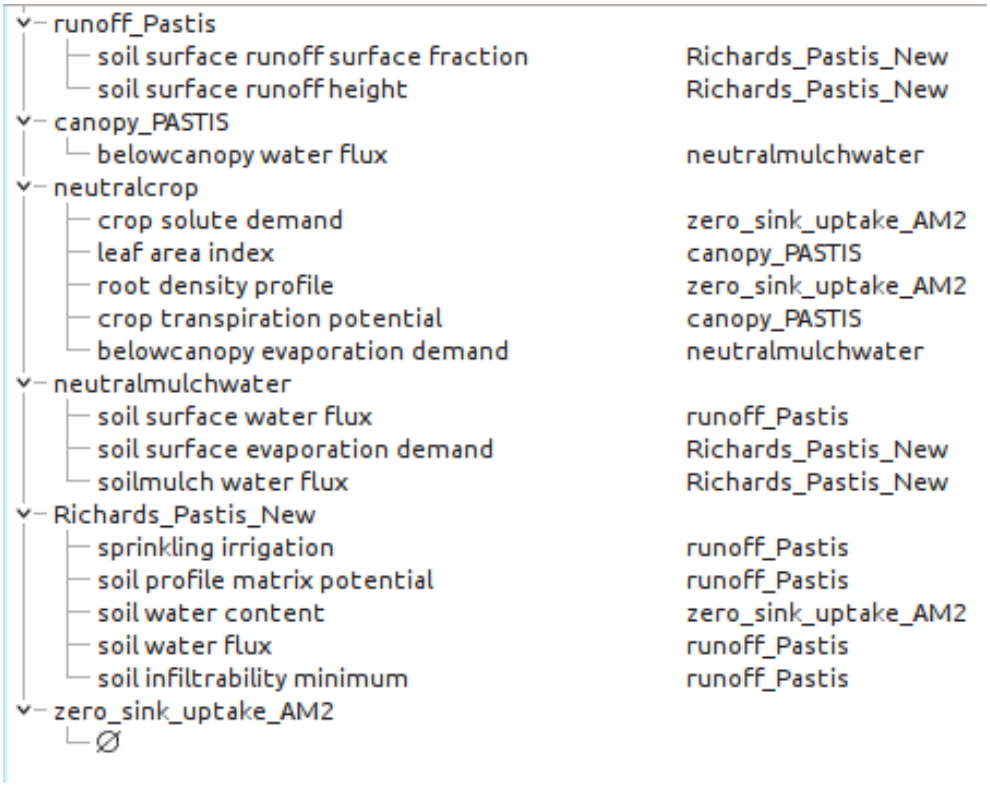


Figure 33: List of modules to be scheduled with produced variables and downstream modules

3. **Graphic part** The modules to be scheduled are shown graphically as well as their connections. An arrow indicates the direction of the connection. If a double arrow exists (case of the “runoff_Pastis” and “Richards_Pastis_New” modules in the example of the figure 34), it means that there is a direct loop between these two modules.

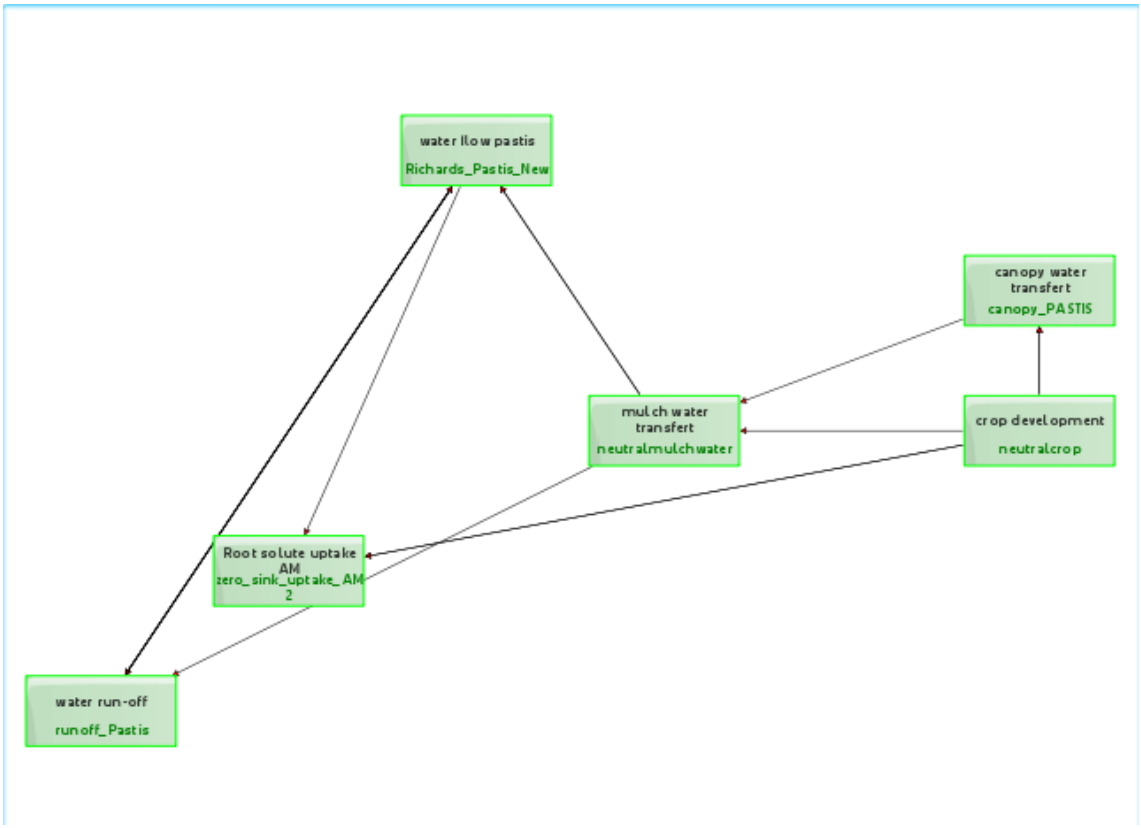


Figure 34: Graphic representation of a loop between modules

4. **Scheduling** The module scheduling is done in the "Sort modules" part (bottom left part of the window). Below the explanatory text, two lists are displayed. On the left is the list of modules to be scheduled, on the right the list of scheduled modules. The list on the right is initially empty. To schedule the modules, select them on the left side and drop them on the right side one after the other (see figure 35).

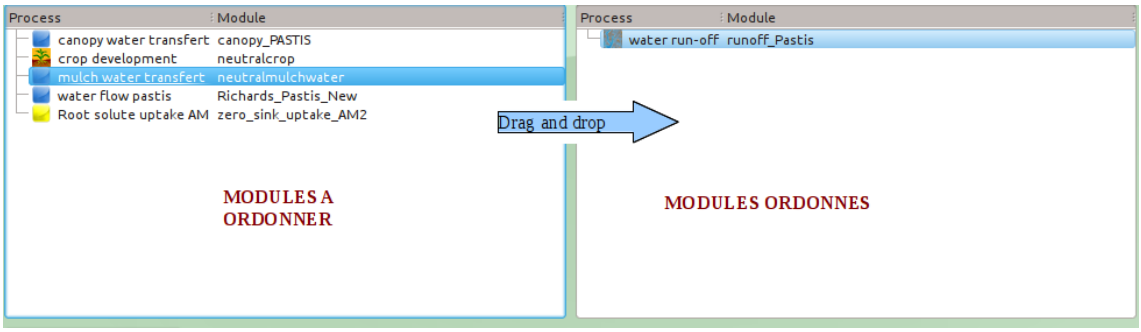


Figure 35: Area for scheduling modules

The list on the left must be empty in order to proceed to the next step (see figure 36). If you want to save the executed scheduling (knowing that the first executed scheduling is automatically saved), click on the "Save the sorted list" button (see figure 36).

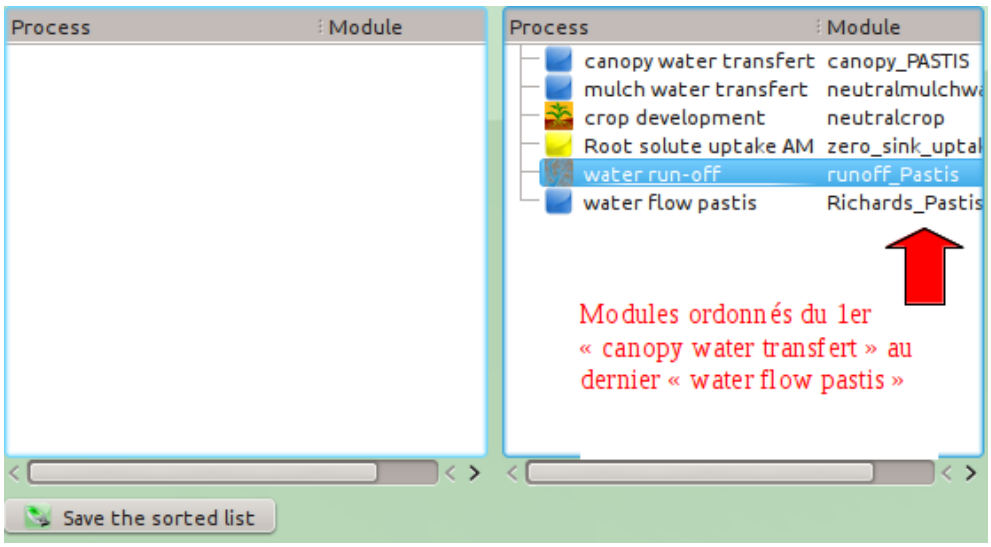


Figure 36: Scheduled modules and save schedule button

If you wish to change the order of the modules, drag and drop the module you wish to reposition in the list on the right. Example: you wish to position the “neutralmulchwater” module implementing the “mulch water transfer” process in the first position. Select this process from the list on the right and, while holding down the left mouse button, move it over the “canopy water transfer” process. Once this position is reached, release the left mouse button (see figure 37).

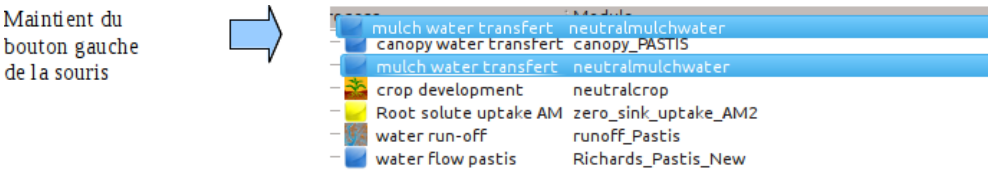


Figure 37: Changing the order of the modules

3.3 Part 3: execution of the created model

Once the model is created and valid, you can run it. The steps for executing a model are the steps in the tabs following the “Ordering” tab, namely “Model generation”, “Initialization”, “Run” and “Plots”. Since these steps are similar in the “vsoil-modules”, “vsoil-models” and “vsoil-player” applications, refer to the “model usage user manual”, accessible from the “User manuals” section of the “vsoil-models” application home screen (see figure 1), for a description of these steps.

4 Building a model

It is in the “Modules selection” tab that the construction of the model, that is the addition or removal of modules, is carried out (see presentation of this tab in the section 3.2.2).

4.1 Adding a module

The selection of modules is made through the processes or external factors attached to them. It is therefore necessary to first select a process or an external factor and then select the module implementing it. There are two possibilities for selecting processes/modules:

- through the “Processes” and “External factors” sub-tabs;
- through the graphical representation of processes and external factors by accessing the functions of a context menu.

4.1.1 Through the “Processes” and “External factors” sub-tabs

To add a module:

1. Search in the list for the process to which it is attached.
2. Then click on the checkbox in column #3 (column “+”).

A window then appears (see figure 41 and explanation of how this window works in the section 4.1.3) allowing you to select the desired module to implement the process you have just selected. Select the module and click on the “Add to model” button to validate your choice. The process and its associated module are added to the model. You then automatically return to the “Processes” or “External factors” tab and can see that the name of the selected module appears in the column #5 of the table (see figure 38).

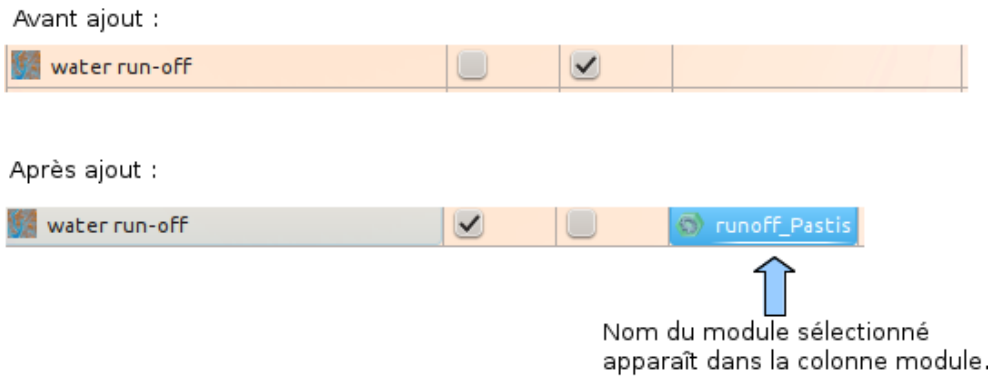


Figure 38: Changing the table in the “Processes and “External factors” tabs when adding a module to the model

4.1.2 Via la représentation graphique du processus ou facteur externe associé

The addition of a module can be done “graphically” directly from the graphical representation of the process on which it depends. To add a module:

1. Look for the graphic symbol of the associated process in one of the active skeletons (see section 5.3).

2. Position the mouse cursor on the desired process and right click. A pop-up menu appears (see figure 39).

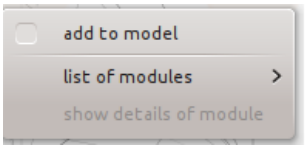


Figure 39: Access menu for selecting a module

There are then two ways to proceed:

1. The first way is to first add the process to the model under construction by checking the "Add to model" box of the contextual menu (see figure 39). A window then appears allowing you to select the desired module for this process (see figure 41 and explanation of the operation of this window in the section 4.1.3). Select the desired module and validate your choice by clicking on the "Add to model" button. You will then return to the graphical representation of the model. The graphic symbolisation of the process has been modified: a rectangle with green background appears containing the names of the selected process and corresponding module.

2. The second way is to select directly from the context menu the module in the list of modules implementing the selected process. To do this, select "List of modules" in the contextual menu and then check the box corresponding to the desired module (see figure 40). Once the module has been selected, you will notice that the graphic symbolisation of the process has been modified (see first way of proceeding above).

Figure 40: Direct access to the list of modules implementing the selected process

4.1.3 Selection of a module

The selection of a module for a given process can be made from the window of the figure 41 accessible from:

- the "Processes" and "External factors" sub-tabs (see section 4.1.1);

- the graphic representation of the process (see section 4.1.2).

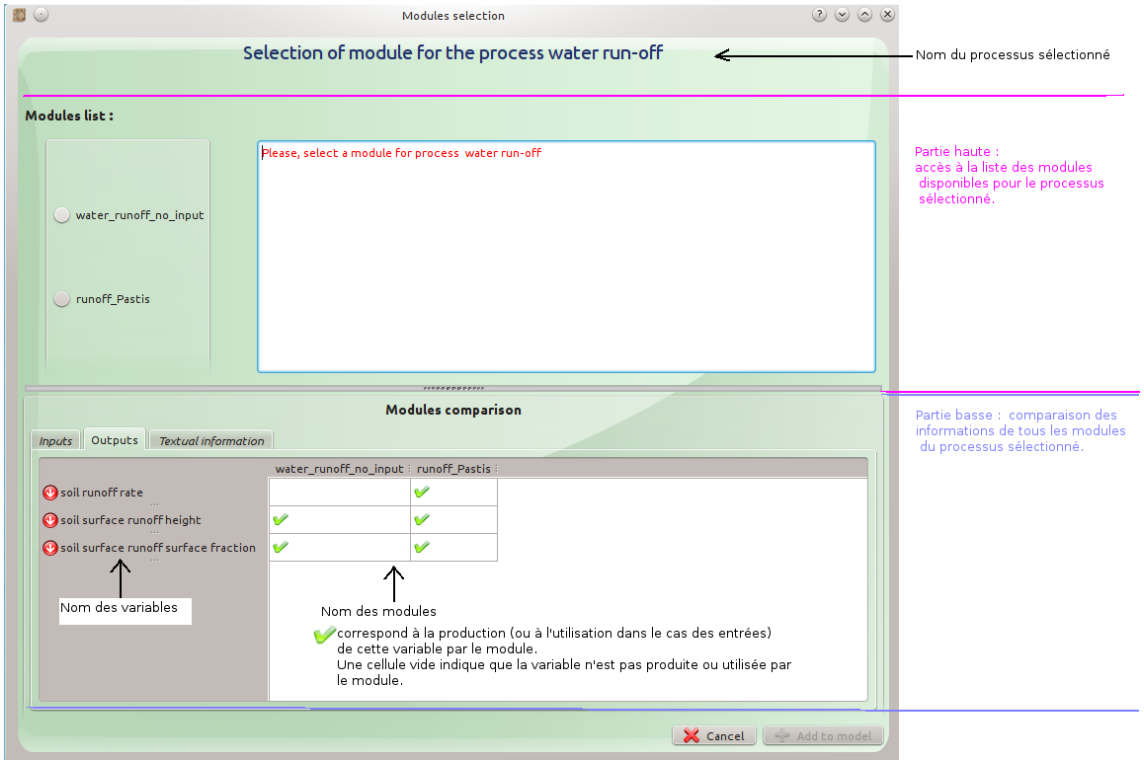


Figure 41: Window for selecting a module associated with the selected process

To help you select a module, a comparison of the inputs, outputs, description, keywords and parameters of each of the modules implementing the selected process is available in the lower part of the window entitled “Modules comparison”. This information is grouped in three tabs: “Inputs”, “Outputs” and “Textual information”, the last one gathering description, keywords and parameters (see figure 41). The structure of the information stored in the “Inputs” and “Outputs” tabs is identical. It is presented in the form of a table in which:

- the first column contains the list of input or output variables of the selected process;
- the following columns indicate which of these inputs and outputs are required (inputs) or produced (outputs) by the modules available for the selected process.

Once the module to be added to the model has been identified, select it in the upper part of the window then click on the “Add [module name] to model” button to validate your choice (see figure 42).

Figure 42: Choice of module from the list of available modules for the selected process

Special case of non-selectable modules in the list of available modules When selecting certain processes, the list of available modules may contain non-selectable modules. Their name is greyed out (see figure 43).

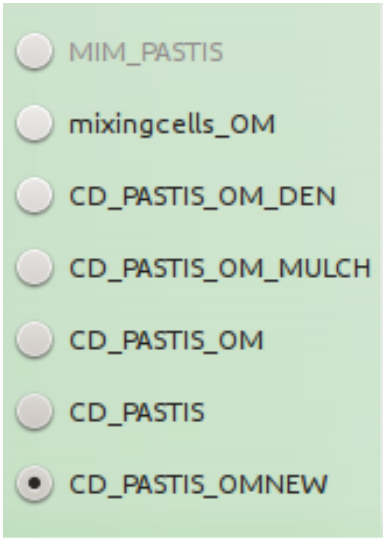


Figure 43: Presence of a non-selectable module in the list of available modules for the selected process

In the example in the figure 43, the “MIM_PASTIS” module is greyed out. It is not selectable. To find out why, position your mouse cursor over its name. A contextual help will then appear indicating the reason why the module is not selectable (see figure 44).

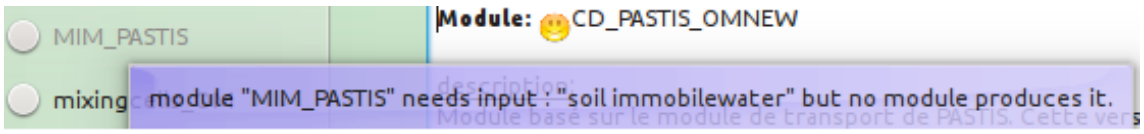


Figure 44: Non-selectable module

4.2 Modification of a module

It is possible to change the selected module for a given process or external factor. To do this, as in the case of adding a module, it is possible to go through:

- the “Processes” and “Externals factors” sub-tabs;
- the graphical representation of the process or external factor, by accessing the functions of the context menu.

4.2.1 Through the “Processes” and “External factors” sub-tabs

To modify the module associated with a process or an external factor:

1. Search in the list of processes or external factors the one to which the module to be modified is attached.
2. Click on the name of the module to be modified in the column #5 (see figures 21 and 45).

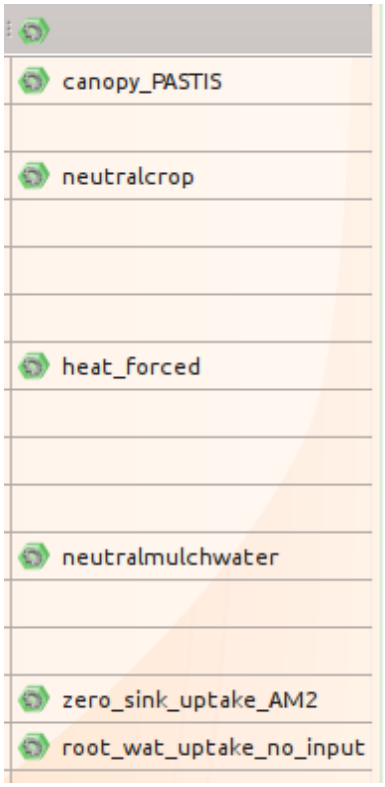


Figure 45: Column containing the modules selected for the different processes involved

The window for choosing a module then appears (see figure 41 and explanation of how this window works in the section 4.1.3), initialised with the currently selected module. Select

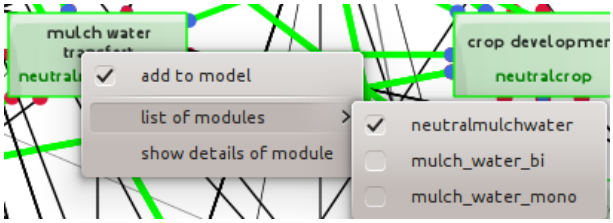
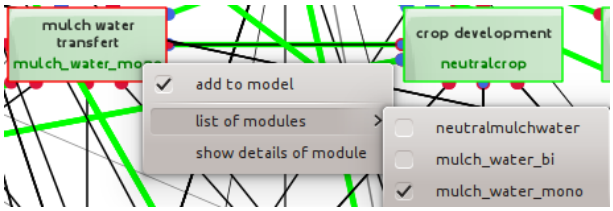
another module and validate your choice by clicking on the “Add [module name] to model” button. You will then return to the column #5 of the table of the “Processes” or “External factors” sub-tab and can see that the name of the module present in this column has changed.

4.2.2 Through the graphical representation of the associated process or external factor

The modification of the module can be made from the graphical representation of the associated process or external factor. To modify a module:

1. Look for the graphic symbol of the process associated with the module in one of the active skeletons.

2. Positionnez le curseur de la souris sur le processus et effectuez un clic droit. Un menu contextuel s’affiche. Positionnez-vous sur l’item “List of modules” puis cochez le nom du module souhaité (cf. figures de l’exemple ci-dessous). Position the mouse cursor on the process and right click. A context menu will appear. Position the mouse cursor on the “List of modules” item, and then check the name of the desired module (see the figures in the example below).

	The module initially selected for the “Mulch water transfer” process is the “neutralmulchwater” module.
	The selected module is modified: it is now the “mulch_water_mono” module.

Once the choice of module has been modified, you return to the graphical representation of the previously selected process or external factor.

4.3 Removing a process/module from the model

It is possible to remove a process, and therefore the associated module, from a model. This can be done from:

- the “Processes” and “External factors” sub-tabs;

- the graphical representation of the process or external factor, by accessing the functions of the context menu.

4.3.1 Through the “Processes” and “Externals factors” sub-tabs

In order to remove a process/module from a model:

1. Search in the list of processes or external factors for the one you wish to remove from the model.

2. Click on the box in column #4 (column “”) corresponding to the process to be removed (see figures 21 and 46).

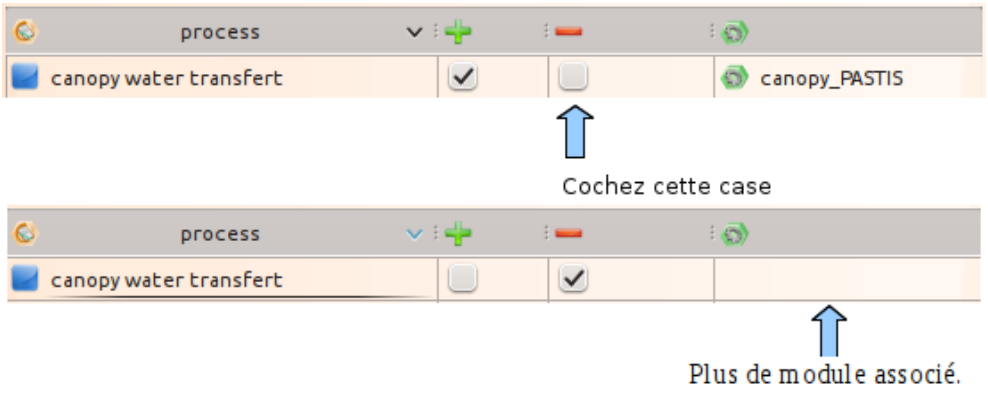


Figure 46: Removing a process/module from a model

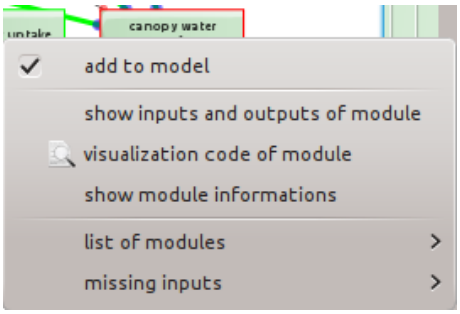
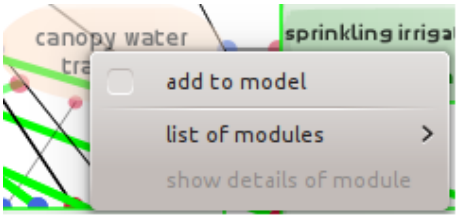
The process and its associated module are removed from the model. You can see that the name of the module initially present in the column #5 of the table in the “Processes” or “External factors” sub-tab has disappeared.

4.3.2 Through the graphical representation of the associated process or external factor

The removal of a process/module can be done from the graphical representation of the associated process or external factor. To remove a process/module:

1. Look for the graphic symbol of the process/module to be removed in one of the active skeletons.

2. Position the mouse cursor on the process and right click. A context menu will appear. Uncheck the “Add to model” box. The process and its associated module are then removed from the model (see figures of the example below).

	The “canopy water transfer” process is initially part of the model.
	The “canopy water transfer” process has been removed from the model.

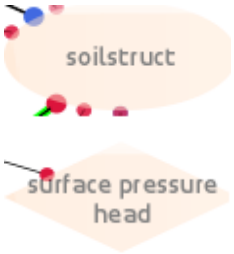
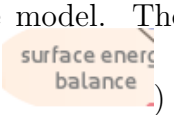
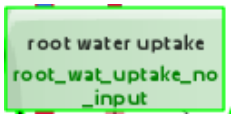
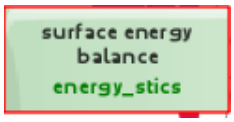
Once the process (or external factor) and its associated module have been removed from the model, you return to the graphical representation of this process (or external factor) and can see that it has been modified: the rectangle with a green background containing the names of the process (or external factor) and its associated module has been replaced by an ellipse (in the case of a process) or a diamond (in the case of an external factor) with a salmon background containing the name of the process (or external factor).

5 Visualisation strategy of the model construction

Symbols have been developed to help you build a coherent model.

5.1 Graphic symbolisation

A process is symbolised by an ellipse and an external factor by a diamond. Both have a salmon background. When a module has been selected for a process or external factor, then the symbolisation used is a rectangle with a green background. The table below shows the different symbols used in the graphical representation of a model and their explanation.

Graphic symbol	Nature	Explanation
	Process (ellipse) or external factor (diamond) not selected.	The level of transparency of the diamond or ellipse has a meaning. The very transparent level (example:) indicates that the process or external factor is not essential to the model. The visible level (example: ) indicates that the process or external factor is suggested.
	Process not selectable.	A red cross on a process or external factor indicates that no module or no valid module is available for this process or external factor. This process or external factor is therefore not usable by the model.
	Selected processes and modules without errors.	A green rectangle indicates that the module is consistent: its inputs are correctly supplied by upstream modules.
	Selected processes and modules with errors.	A red rectangle indicates that the module is in error because some of its inputs are not supplied by upstream modules. To help you correct the errors: see section 5.2.1.

5.2 Help in building the model

5.2.1 Error handling assistance

A model is valid when all the rectangles symbolising the selected modules/processes have a green outline and the symbol is displayed (see section 3.1).

In case of errors, the affected processes and modules are surrounded by a red rectangle and the symbol appears in the toolbar (see section 3.1).

Consultation of errors There are two ways to check for errors.

- From the toolbar The state of the solution (*i.e.* of the constructed model) can be accessed by clicking on the symbol on the toolbar (see section 3.1.3 for a detailed explanation of the contents of the displayed report).

- From the graphical representation of the module Position your mouse cursor on the graphical representation of the process/module in error (represented by a rectangle with a red outline) and display the context menu by right-clicking. Then select the "Show inputs and outputs of module" item (see figure 47).

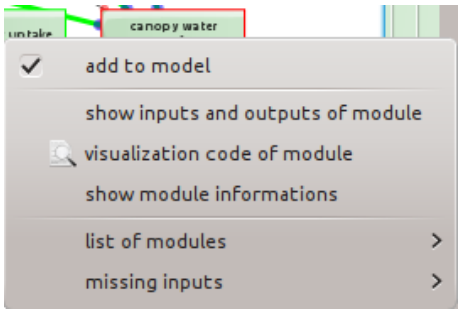


Figure 47: Consultation of errors from the graphical representation of a module

A window then appears containing the list of input and output variables of the module and the state of its input variables (see figure 48):

- The symbol in front of an input variable indicates that it is valid: it is provided by an upstream module.
- The symbol in front of an input variable indicates that it is not valid: it is not provided by any upstream module. Proposals of modules providing this variable are provided.
- The symbol in front of an output variable indicates that it is used by one or more downstream modules. The names of these modules are specified.

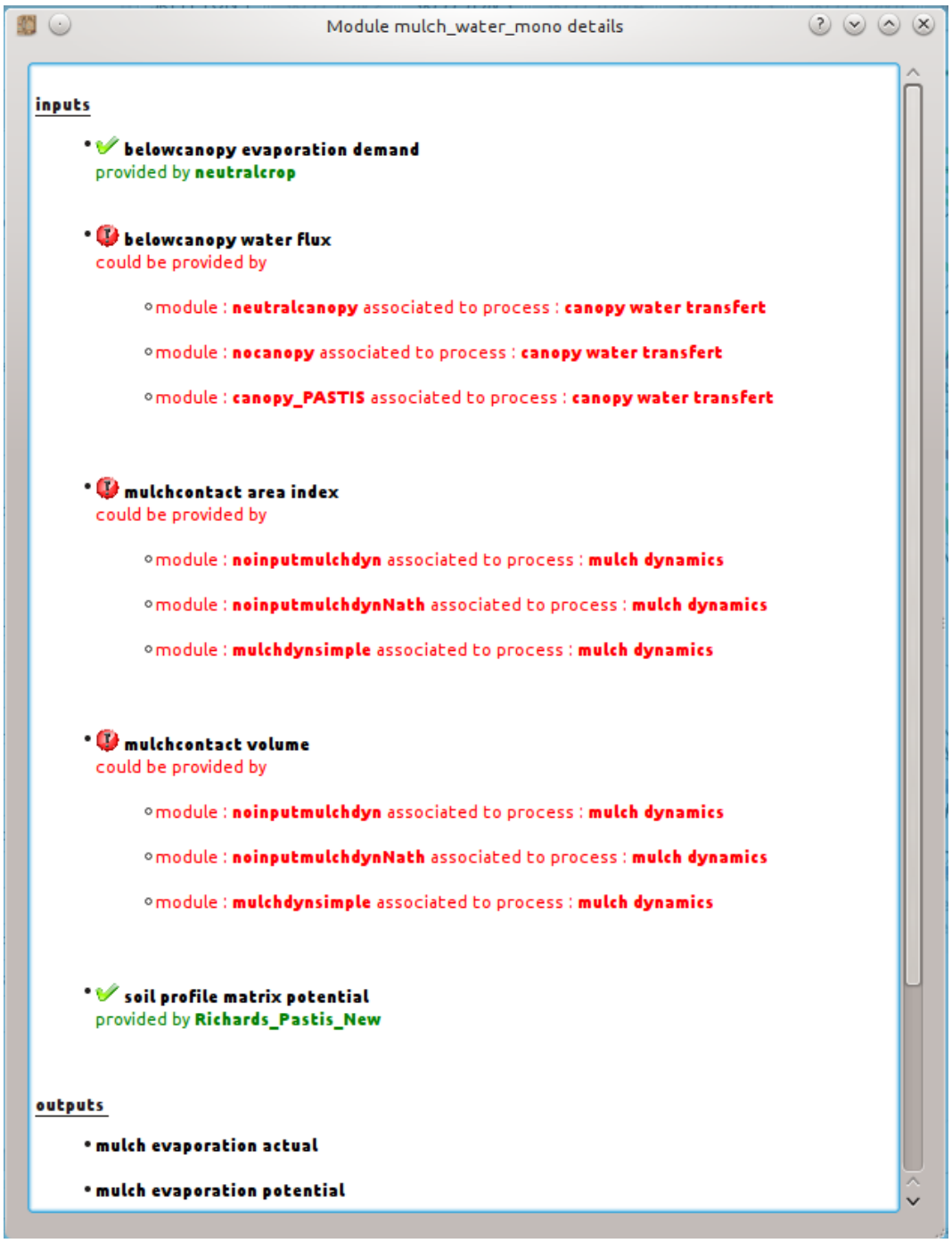


Figure 48: List of inputs (valid and invalid) and outputs of a module

In the example of the figure 48, the “belowcanopy evaporation demand” input variable required by the “mulch_water_mono” module is well provided by the “neutralcrop” upstream module. On the other hand, the “belowcanopy water flux” input, also required by the “mulch_water_mono” module, is not provided by any upstream module. It is noted that the “neutralcanopy”, “nocanopy” and “canopy_PASTIS” modules can provide this variable. For each of the input variables in error, one of the proposed modules should be selected.

Error resolution Position your mouse cursor on the graphical representation of the process/-module in error (represented by a red rectangle) and display the context menu by right-clicking. Then position the mouse cursor on the “Missing inputs” item to display the list of all inputs not provided by upstream modules (see figure 49).

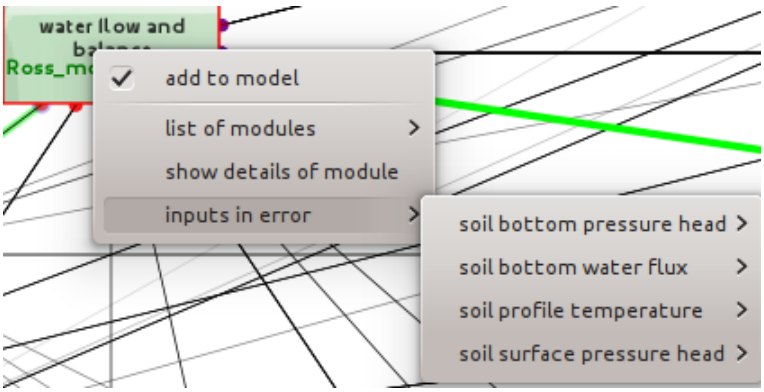


Figure 49: List of the inputs of a module not provided by upstream modules

From this list, select the name of the entry to be processed. A new sub-menu appears containing the names of the modules providing this variable (see figure 50).

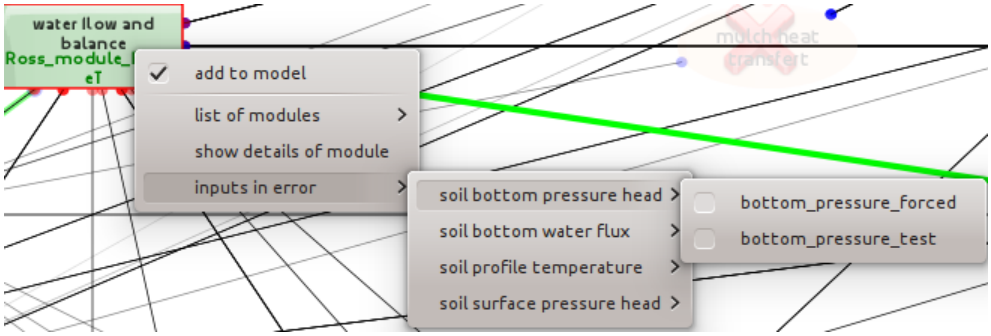


Figure 50: List of modules providing a missing entry

Then tick the box in front of the module you choose to provide this variable. This module and the process on which it depends are then added to the model. The list of missing entries to be processed is then modified: the one that has just been processed no longer appears (see figures 49 and 51).

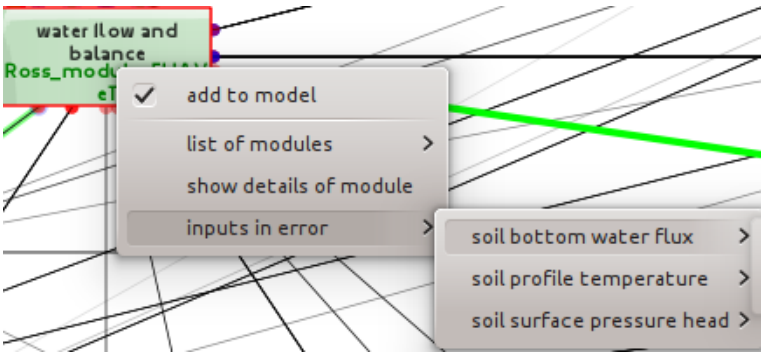


Figure 51: Updated list of module inputs not provided by upstream modules

In the example of the figures 49 and 51, it can be seen that the “soil bottom pressure head” entry no longer appears in the list of missing entries for the module implementing the “water flow and balance” process.

5.2.2 Help with the graphic interpretation of the solution

Let’s consider the graphical representation of an erroneous model proposed in the figure 52 below.

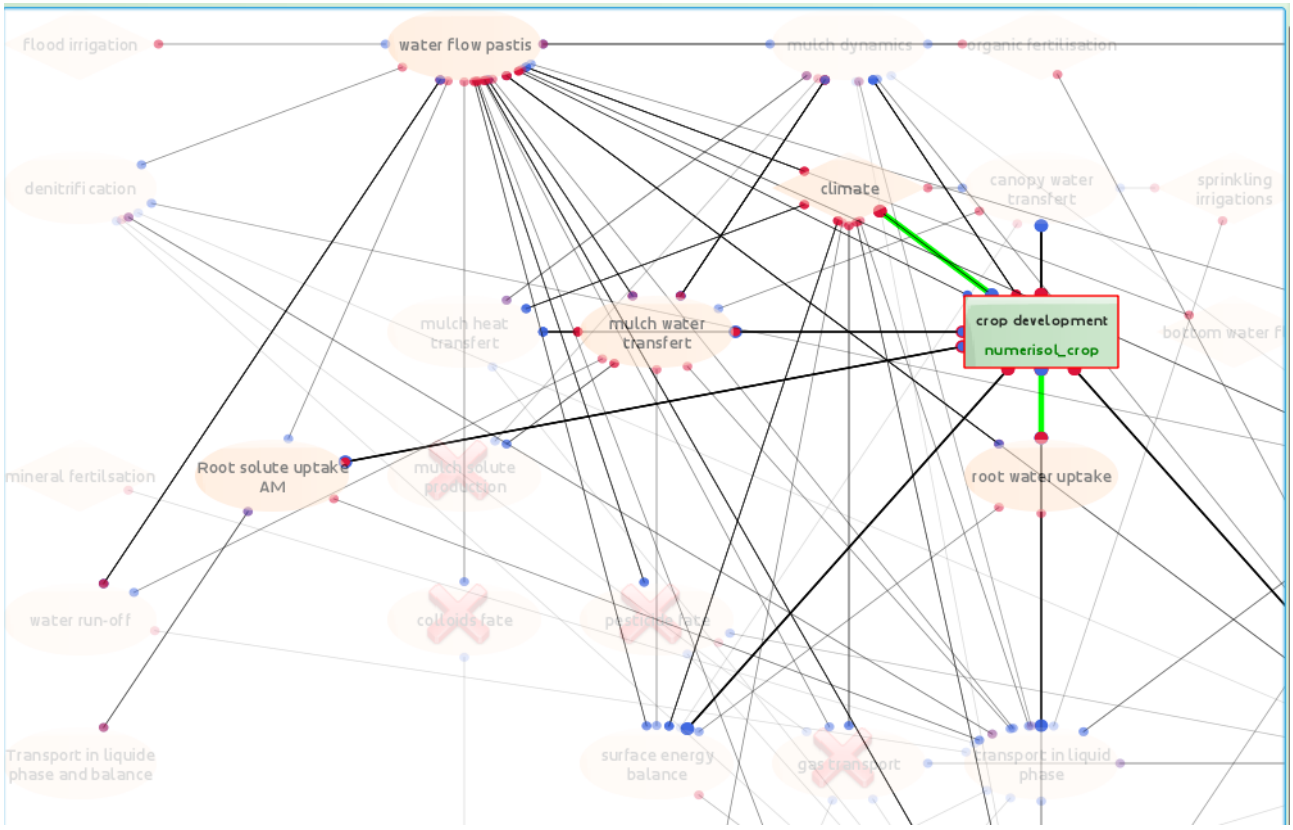


Figure 52: Graphical representation of a model in error

The “numerisol_crop” module implementing the “crop development” process is detected as being in error: the outline of its rectangle is red because some of its inputs are not provided by upstream modules.

The graphical appearance of certain processes and external factors, namely a salmon background and a visible level (the two “visible” and “very transparent” levels that a process or

external factor may have are presented in the table in the section 5.1), indicates that these processes and external factors produce variables that are input variables of the "crop development" process. This is the case for the "water flow pastis", "mulch water transfer", "root solutes uptake AM" and "root water uptake" processes, as well as the "climate" external factor. The links between the processes (through their inputs and outputs) are materialised by black segments.

If the segment linking a process to a module (and therefore also to the process or external factor it implements) is fluorescent green, it means that it produces at least one variable which is an input variable for this module (and therefore also for the process or external factor it implements). In the example of figure 52, the "numerisol_crop" module needs input variables produced by the "root water uptake" process and the "climate" external factor.

When adding (resp. removing) a module to (resp. from) the model, the graphical representation of the process on which it depends is modified:

- **Case of adding a module.** The process or external factor on which this module depends goes into "selected mode": its graphical symbol goes from an ellipse (case of a process) or a diamond (case of an external factor) to a rectangle (see table in section 5.1). The name of the module, written in green, is added in this rectangle under the name of the process which remains written in black. The colour of the outline of the rectangle indicates whether the module is in error (red outline) or not (green outline), see the table in section 5.1. If the module requires input variables produced by upstream processes (or external factors) or modules then the resulting links are highlighted (fluorescent green segments).

- **Case of removing a module.** The process or external factor on which this module depends goes into "unselected" mode: its graphical symbol changes from a rectangle to an ellipse (case of a process) or a diamond (case of an external factor) with a salmon background (see table in section 5.1). If the deleted module was feeding other modules then these modules are indicated to be in error: the outline of their rectangle turns red indicating missing entries for these modules. As in the case of adding a module, the left part of the window (text part) is automatically updated.

5.3 Skeleton selection

Depending on the processes/modules that you decide to add or remove from the model, the skeletons will automatically be accessible or not: the system automatically calculates, according to the choices made, the "viability" of the skeletons. If a process, in conflict with others because producing at least one common variable, is added to the model, then all the skeletons containing the conflicting processes become inaccessible (see figure 53).

Figure 53: Accessibility of the different skeletons

When selecting, through the “Processes” and “External factors” sub-tabs of the “Modules selection” tab, a process in conflict with another one, the following error message appears (see figure 54):

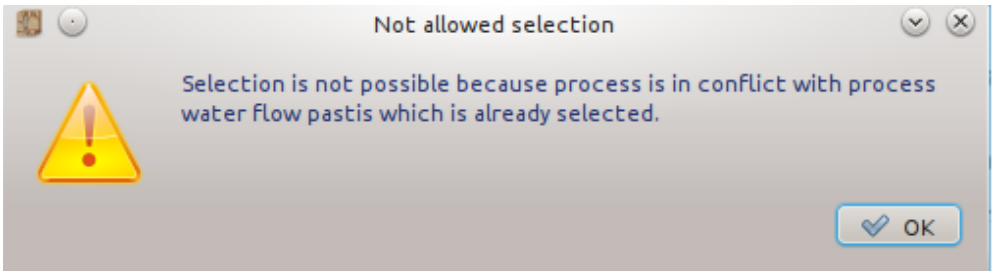


Figure 54: Process not selectable because it conflicts with a process already selected