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JavaStics 1.41 / STICS v9.0
User guide

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[1] APP : Agence pour la protection des programmes

Preface

JavaStics 1.40 is an interface for managing simulations with the STICS v8.50 crop model on Windows, Linux and Mac OS platforms.
This tool provides a user-friendly environment for managing input-output to and from the models and for their operational use.
This documentation is far from being exhaustive. It should be considered as a description summary of each menu, intended to guide the beginning user.

The STICS sources are available on demand to the Stics Project Team. The JavaStics sources are not supplied.

Please read this user license attentively before using the software.

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INTRODUCTION

Contributors to STICS formalisations

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Purpose

The aims of STICS (Simulateur mulTIdisciplinaire pour les Cultures Standard) are similar to those of a large number of existing models (Whisler *et al.*, 1986). It is a crop model with a daily time-step and input variables relating to climate, soil and the crop system. Its output variables relate to yield in terms of quantity and quality, and to the environment in terms of drainage and nitrate leaching. The simulated object is the crop situation for which a physical medium and a crop management schedule can be determined. The main simulated processes are crop growth and development as well as the water and nitrogen balances. A full description of crop models with their fundamental concepts is available in Brisson *et al.* (2006).

STICS has been developed since 1996 at INRA (French National Institute for Agronomic Research) in collaboration with other research (CIRAD[2], Irstea (ex-CEMAGREF)[3], Ecole des Mines de Paris, ESA[4], LSCE[5]) or professional (ARVALIS[6], Terres Inovia (ex-CETIOM)[7], CTIFL[8], ITV[9], ITB[10], Agrotransferts[11], etc.) and teaching institutes or organizations. For more than 10 years STICS has been used and regularly improved thanks to a close link between development and application, involving scientists and technicians from various disciplines.
When STICS began to be developed, many well-known models were available (CERES: Ritchie and Otter, 1984; ARCWHEAT: Weir *et al.*, 1984; EPIC: Williams *et al.*, 1989; SUCROS: van Keulen and Seligman, 1987, etc.) that were developed from the pioneer works by de Wit (1978) or Duncan (1971 cited in Baker, 1980). However new models appear regularly in the literature (Amir and Sinclair, 1991a,b; Brisson *et al.*, 1992a; Hunt and Pararajasingham,

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[6] ARVALIS, institut du végétal
[7] Terres Inovia
[8] Centre Technique Interprofessionnel des Fruits et légumes
[9] Institut technique de la vigne
[10] Institut technique de la betterave
[11] Agrotransferts for the regions Poitou-Charentes and Picardie

1995; Kanneganti and Fick, 1991; Maas, 1993; McMaster *et al.*, 1991; Teittinen *et al.*, 1994). As Sinclair and Seligman (1996) explained, this is because no one universal model can exist in the field of agricultural science and it is necessary to adapt system definitions, simulated processes and model formalisations to specific environments or to new problems (technical, genetic, environmental, etc.). These same authors emphasize the heuristic potential of modelling, a determining element in the development of STICS.

From a conceptual point of view, STICS is made up of a number of original parts compared with other crop models (e.g. simulation of crop temperature, simulation of many techniques) but most of the remaining parts are based on conventional formalisations or have been taken from existing models. Its strong points are the following:

- its "crop" generality: adaptability to various crops (wheat, maize, soybean, sorghum, flax, grassland, tomato, beetroot, sunflower, vineyard, pea, rapeseed, banana, sugarcane, carrot, lettuce, etc.)
- its robustness: ability to simulate various soil-climate conditions without too much error in the outputs (Brisson *et al.*, 2002). Yet, this robusness can jeopardise accuracy on a local scale.
- its "conceptual" modularity: the possibility of adding new modules or complementing the system description (e.g.: ammonia volatilisation, symbiotic nitrogen fixation, plant mulch, stony soils, many organic residues, etc.). The purpose of such modularity is to facilitate subsequent development.

Around 50 scientists of various disciplines participated in the STICS formalisations, most of them from INRA. Thus the model can be regarded as a synthesis of the French agronomic knowledge on the field and crop cycle scales. The formalisations of the STICS model (version 6.2) was presented in Brisson et al. (2008). They can be considered as references used in the framework of crop sciences, helping professionals and students in the partitioning and understanding of the complex agronomic system. The book arrangement relies on the way the model designs the crop-soil system functioning, each chapter being devoted to one important function such as growth initiation, yield onset, water uptake, transformation of organic matter etc. One chapter is devoted to the cropping system and long term simulations and the final chapter is about the involvement of the user in terms of option choices and parameterization. This notice will not present again these formalisations but only the way of using the software JavaStics and the model in a practical way. A summary of the main formalisms is described below. If the user wants to know more in detail about the formalisms, we recommend him to refer to Brisson et al. (2008).

Overall description of the system with its components

The system

STICS simulates the behaviour of the soil-crop system over one crop cycle, or several crop cycles to simulate rotations. The upper boundary of the system is the atmosphere, characterised by standard weather variables (radiation, minimum and maximum temperatures, rainfall, reference evapotranspiration and possibly wind and humidity) and the lower boundary corresponds to the soil/rock interface.
Crops are generally perceived in terms of their above-ground biomass and nitrogen content, leaf area index, and the number and biomass (and nitrogen content) of harvested organs. Vegetative organs (leaves, stems, branches or tillers, roots) are functionally separated in terms of radiation, water and nutrient sensors or reservoir role. Soil is described as a sequence of

horizontal layers, each of which is characterised in terms of its water content and mineral and organic nitrogen contents. Soil and crop interact via the roots, and these roots are defined in terms of root density distribution in the soil profile.

STICS can also simulate intercropping, i.e. two crops (annual or perennial) growing simultaneously as a mixture, each crop developing and growing with its own rhythm resulting from the resource partitioning. In this case the soil-plant-atmosphere system is divided into three sub-systems at the canopy level. There is the dominant canopy and the understorey canopy that is divided into two parts: a shaded part and a sunlit part, each of them being defined by a light microclimate that drives the different behaviour of the sub-systems.

Simulated processes

Crop growth is driven by the plant carbon accumulation (de Wit, 1978): solar radiation intercepted by the foliage and then transformed into aboveground biomass that is directed to the harvested organs during the final phase of the crop cycle. The crop nitrogen content depends on the carbon accumulation and on the nitrogen availability in the soil. According to the plant type, crop development is driven either by a thermal index (degree-days), a photothermal index or a photothermal index taking into account vernalisation. The development module is used to make the leaf area index and the roots evolve and define the harvested organ filling phase. Water stress and nitrogen stress, if any, reduce leaf growth and biomass accumulation. This reduction is based on stress indices that are calculated in water and nitrogen balance modules. Other stresses such as waterlogging and thermal stresses (frost or high temperatures) are also taken into account.

Particular emphasis is placed on the effect of crop management on the dynamics of the soil-crop-microclimate system, knowing that crop peculiarities influence both ecophysiology and crop management (e.g. accounting for the various forms of forage cutting, fertiliser composition, plastic or crop residue mulching, etc.).

Modules and options

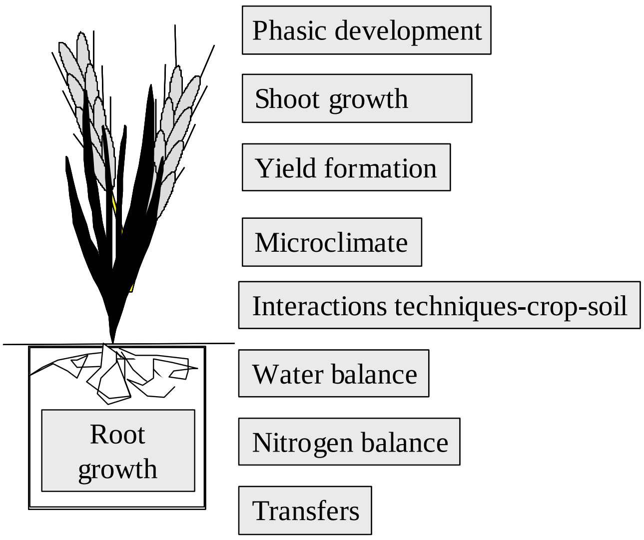


fig. 0.1 The main modules of the STICS crop model

The STICS model is organised into modules (*fig. 0.1*), composed of sub-modules dealing with specific mechanisms. A first set of three modules deals with the ecophysiology of above-ground plant parts (phasic development, shoot growth, yield formation). A second set of four modules deals with how the soil responds in interaction with underground plant parts (root growth, water balance, nitrogen balance, soil transfers). The crop management module deals with the interactions between the applied techniques and the soil-crop system. The microclimate module simulates the combined effects of climate and water balance on the temperature and air humidity within the canopy.

Within each module, different options can be chosen by the user to extend the scope of STICS to various crop systems. These options relate to ecophysiology and to crop management, for example:

- competition for assimilate between vegetative organs and reserve organs (hereafter referred to as trophic competition);
- considering the geometry of the canopy when simulating radiation interception;
- the description of the root density profile;
- using a resistive approach to estimate the evaporative demand by plants;
- the mowing of forage crops;
- plant or plastic mulching under vegetation

Some options depend on data availability. For example, the use of a resistive model is based on availability of additional climatic driving variables: wind and air humidity.

References

Whisler J.R., Acock B., Baker D.N., Fye R.E., Hodges H.F., Lambert J.R., Lemmon H.E., McKinion J.M., Reddy, V.R., 1986. Crop simulation models in agronomie systems, *Adv. Agron.* 40, 141-208.

Brisson, N. (Editeur) ; Launay, M. (Editeur) ; Mary, B. (Editeur) ; Beaudoin, N. (Editeur). Conceptual basis, formalisations and parameterization of the STICS crop model. Versailles (FRA): Editions Quae; 2008. 304 p.

de Wit C.T., 1978. Simulation of assimilation respiration and transpiration of crops. In Simulation Monographs. Pudoc, Wageningen, The Netherlands. pp. 141.

Brisson N., Ruget F., Gate P., Lorgeou J., Nicoullaud B., Tayot X., Plenet D., Jeuffroy M.H., Bouthier A., Ripoche D., Mary B., Justes E. 2002a. STICS: a generic model for the simulation of crops and their water and nitrogen balances. II. Model validation for wheat and corn. Agronomie, 22, 69-93.

INSTALLATION

Installation

The JavaStics interface and the STICS model are available on the STICS Web site through a registration procedure accessible at http://www6.paca.inra.fr/stics_eng/Download. The downloaded .zip file should be unzipped to an independent JavaStics directory. The model executables for **Windows**, **linux** and **Mac OS X** are all included in this zip.

If you already have an earlier version of JavaStics, unzip it to a new directory rather than to the existing one. Be carefull not to **install this JavaStics folder on the desktop and avoid folder names with blanks in the directory path.**

On linux and Mac OS X platforms Java JRE or SDK must be installed to run the JavaStics interface

- See instructions here for Mac : https://java.com/en/download/help/mac_install.xml
- See instructions here for Linux for installing one of these

Java Oracle: https://docs.oracle.com/javase/8/docs/technotes/guides/install/linux_jdk.html
OpenJDK: http://openjdk.java.net/install

On Mac OS X, Fortran libraries must be installed for running the Stics model. To do so, command line tools installation is needed.
Simply check if they are already installed by typing gfortran in a terminal. If they aren't installed, a window will appear to proceed to their installation after clicking on Install and accepting the licence.
We can check if command line tools are installed by typing **xcode-select –p** and enter, **/Library/Developer/CommandLineTools** will be displayed in the terminal.
Fortran installation can be checked by typing **gfortran** in the terminal. An error message will be displayed:

gfortran: fatal error: no iput files
compilation terminated.

Organisation of files and directories

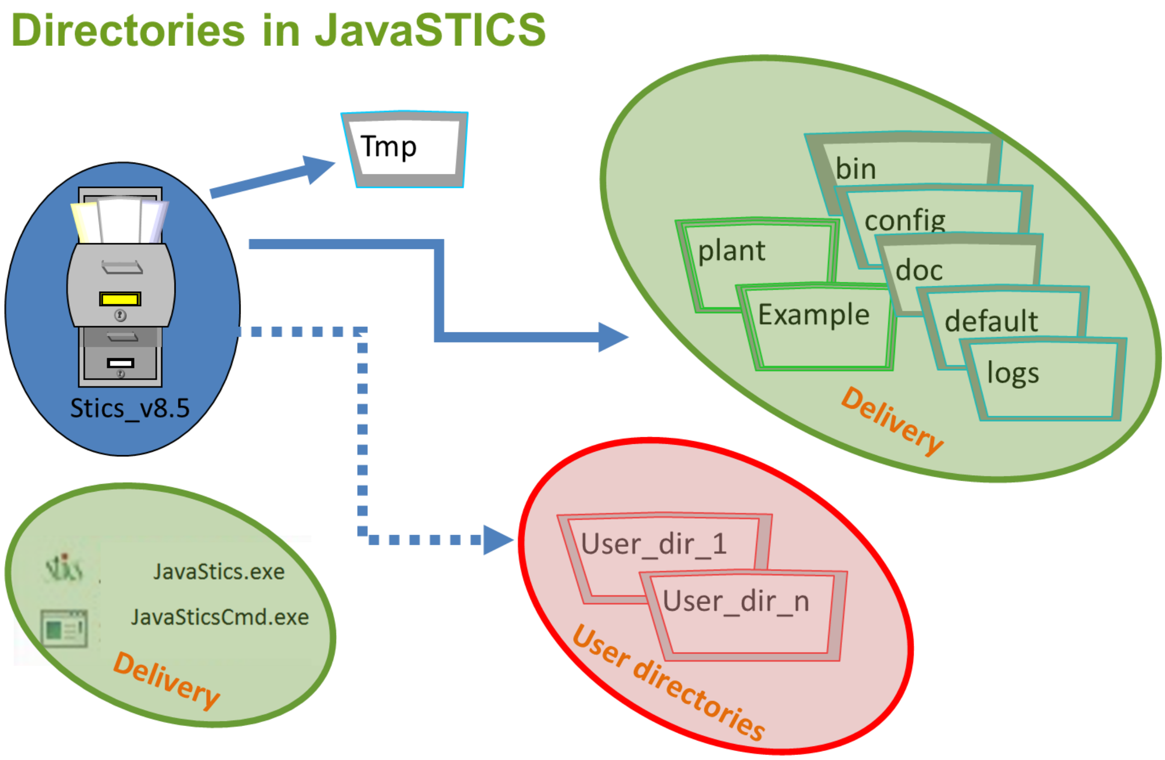
In the JavaStics directory, you will find a number of files and subdirectories:
We will point out the most important ones:

- **JavaStics.exe**: executable file for launching the JavaStics application
- **JavaSticsCmd.exe**: JavaStics command line tool
- the **config** directory: contains general settings files
- the **default** directory: contains the configuration for creating a new directory
- the **example** directory: contains examples that you can use to test the interface and the model
- the **bin** directory: contains the executables, the resources and the libraries needed by the interface
    - Windows executable: stics_modulo.exe (model), ajustJavaStics.exe and maf6versmod.exe (utilities)

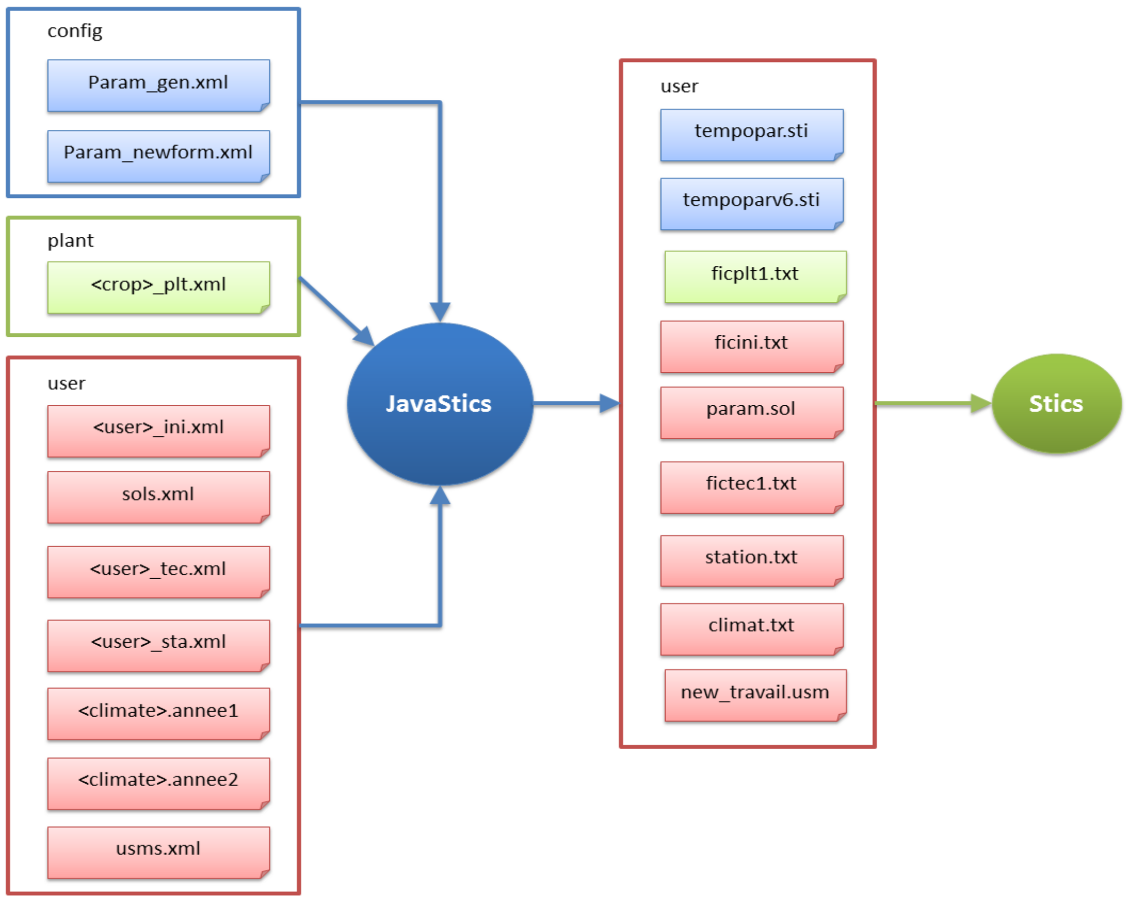
- Linux executable: stics_modulo (model), ajustJavaStics and maf6versmod (utilities)
- Mac OS executable: stics_modulo_mac (model), ajustJavaStics_mac and maf6versmod_mac (utilities)

- the **logs** directory: contains the log files (of user interventions and application)
- the **plant** directory: includes the settings files for each crop supported by the STICS model.
- the **tmp** directory: is a working directory generated only when first reformatting 6.x STICS version directories

User directories are workspaces that may be created either by adding a new working directory or by launching a reformatting process (for STICS older version files).



To perform a simulation, JavaStics is using different XML files located in two fixed directories: **config**, **plant** and **user defined workspace(s) directorie(s)**. JavaStics allows the user to modify these files and creates them as shown on the figure below. These input files are created in the user workspace(s).



The Stics model itself can be used directly without the JavaStics interface, but you must use the text files created by JavaStics as input files (.txt, .sti, .sol and .usm) and not the XML files. You can generate these txt files from XML ones as explained in the "**Using JavaStics command line tool**" section.

Launching JavaStics interface

For the Windows systems double-click on **JavaStics.exe** from the file manager. The main JavaStics window appears.

For the linux or Mac OS X systems, execute the following command in the JavaStics root directory from a terminal:

java -jar JavaStics.exe

You may use also an absolute path too:

java –jar /path/to/JavaStics/directory/JavasStics.exe

Using JavaStics command line tool

You can use JavaSticsCmd.exe to run the model from a terminal or command prompt.
The command options can be listed when executing only JavaSticsCmd.exe:

```
--run :
Use this command to run stics. The command should be launched in a JavaStics workspace.
      Ex : --run <workspace> <usm> or run <workspace>
--run-successive :
Use this command to run successive usms. The command should be launched in a JavaStics workspace.
      Ex : --run-successive <workspace> <usm1> <usm2> ...
--generate-txt :
Use this command to generate fortran binary input files from JavaStics input files.
      Ex : --generate-txt <workspace> <usm>
--generate-file-txt :
Use this command to generate fortran binary input files for a given JavaStics file.
      Ex : --generate-txt-file <file path>
--convert-files :
Use this command for converting a modulostics v69 workspace to a JavaStics workspace.
      Ex : --convert-files <workspace to convert>
```

Here are some use examples for the different options for running usms (USM stands for Unit of SiMulation) simulations or generating model input files:

1. To run **one usm or all the usms** of a directory
   a. one usm : JavaSticsCmd.exe --run <workspace> <usm>
      for example : JavaSticsCmd.exe --run example canne
   b. all the usms of a workspace : --run <workspace>
      for example : JavaSticsCmd.exe --run example
2. To run **successive usms**:
   JavaSticsCmd.exe --run-successive <workspace> usm1 usm2 ...
   for example:
   JavaSticsCmd.exe --run-successive C: \JavaStics\run\example demble1 demsnu2 demais3
3. To generate **fortran model inputs files** (.txt) from JavaStics input files (.xml)
   JavaSticsCmd.exe --generate-txt <workspace> <usm>
   For example: JavaSticsCmd.exe --generate-txt example canne
4. To generate specific **fortran model inputs files** (.txt) from JavaStics input files (.xml)
   JavaSticsCmd.exe --generate-file-txt <filepath> <soil name if filepath is a soil> or <usm name if filepath is an usm>
   For example:
   JavaSticsCmd.exe –generate-file-txt E:\example\Ble_tec.xml
   JavaSticsCmd.exe –generate-file-txt E:\example\sols.xml solcanne
   JavaSticsCmd.exe –generate-file-txt E:\example\usms.xml canne
5. To **convert a 6.9 directory** in a STICS v8.50 directory
   JavaSticsCmd.exe --convert-files <destination>
   for example:
   JavaSticsCmd.exe --convert-files E:\Home\stics_69

Notice: for usage on linux or Mac OS X, replace **JavaSticsCmd.exe** with **java -jar JavaSticsCmd.exe** in the command, for example:

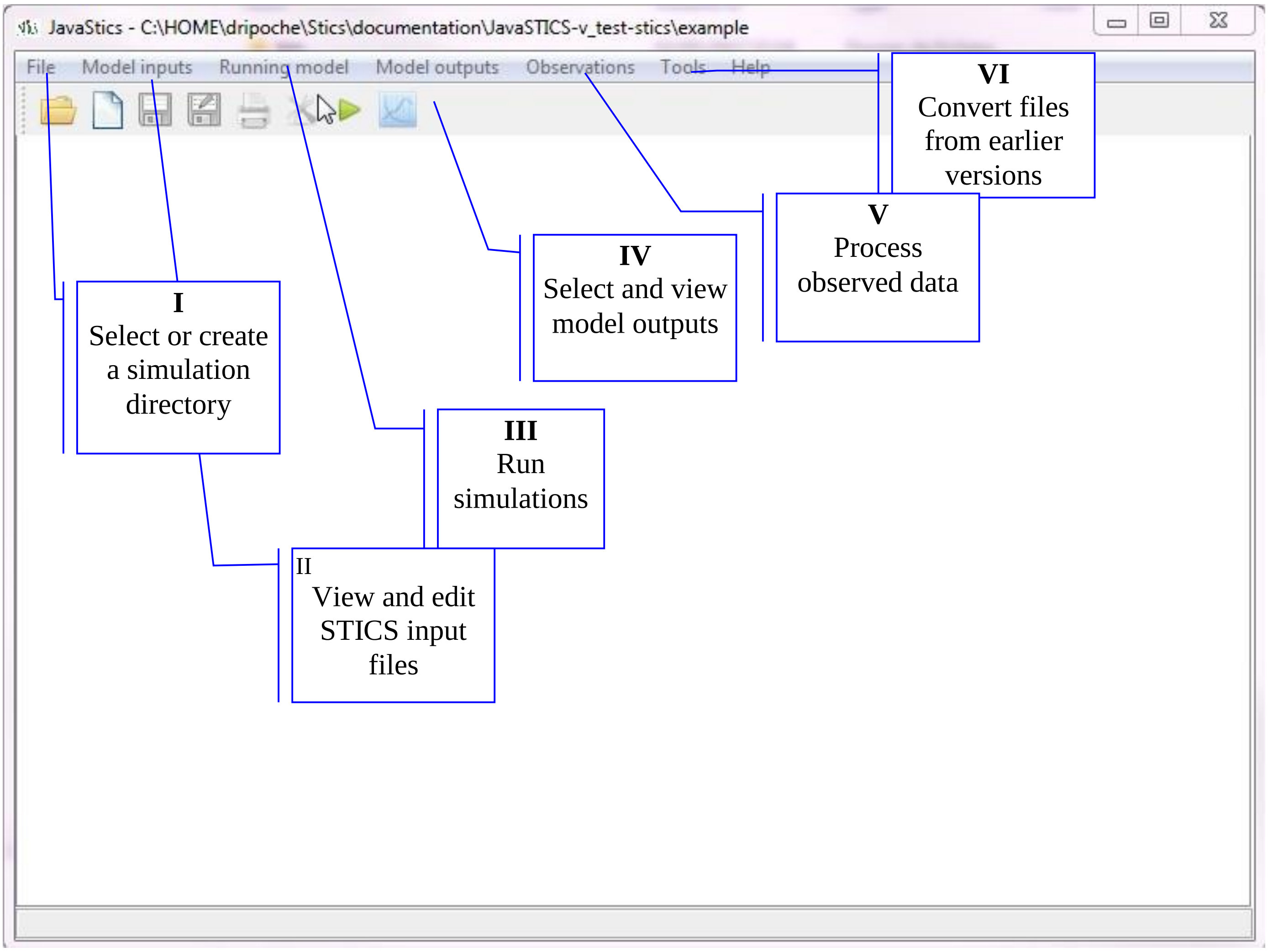
```
java -jar JavaSticsCmd.exe --run example canne
```

Sample batch files (example_batch.bat, for Windows or example_batch.sh, for linux/Mac OS) are available in the JavaStics root directory.

GENERAL MENU

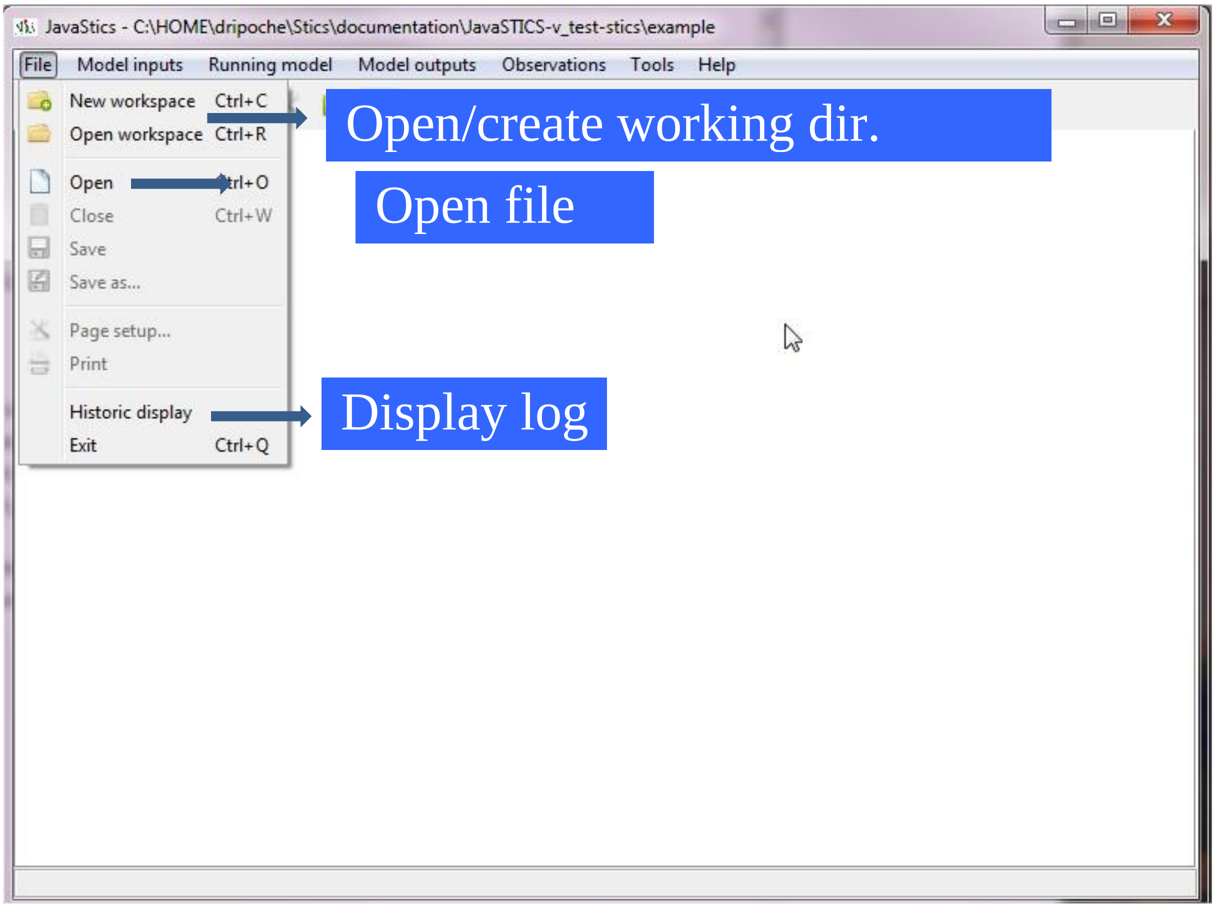
The main menu items of the JavaStics interface are organised as follows:

- **File**: select or create a simulation directory. The simulation directory contains the parameter files that can be edited by the user and also the STICS output files too.
- **Model inputs**: view and edit STICS input files
- **Running model**: launch simulations
- **Model outputs**: select outputs (before simulation) and view the model outputs when the simulation is done
- **Observations**: process observed data
- **Tools**: tools for converting files from earlier versions of STICS
- **Help**: display the application version



I - File

To perform simulations with the STICS model, you must first define simulation units (USMs) which correspond to a climate, a soil, a crop and a crop management. The parameter files describing the USMs are stored in a working directory called workspace in the interface.
The first stage for running a simulation is to define the workspace where are stored the input files. You can either create **a new workspace** (File → New workspace) or select an **existing one** (File → Open workspace).



Ia – File menu: New workspace

This menu lets you create a new working directory. This directory will contain only an example USM and a set of files corresponding to this usm.
The workspace directory can be located anywhere on your disk.
It can be an existing directory or you can create it by clicking on the "Create directory" Windows icon.
Choose the directory, and then click Open. JavaStics considers it a "blank" directory as far as the application is concerned. Therefore, it will create the files corresponding to an example USM.

Ib – File menu: Open workspace

This menu can also be invoked via the  icon
It lets you select a workspace directory. This directory will be the current user directory as long as it is not changed.
The workspace path is saved and reloaded as default workspace when the interface is launched again.
Choose the work directory, and then click Open.
The name and path of the selected workspace appears in the window title bar, so the user can verify that it is the workspace he wants to use.

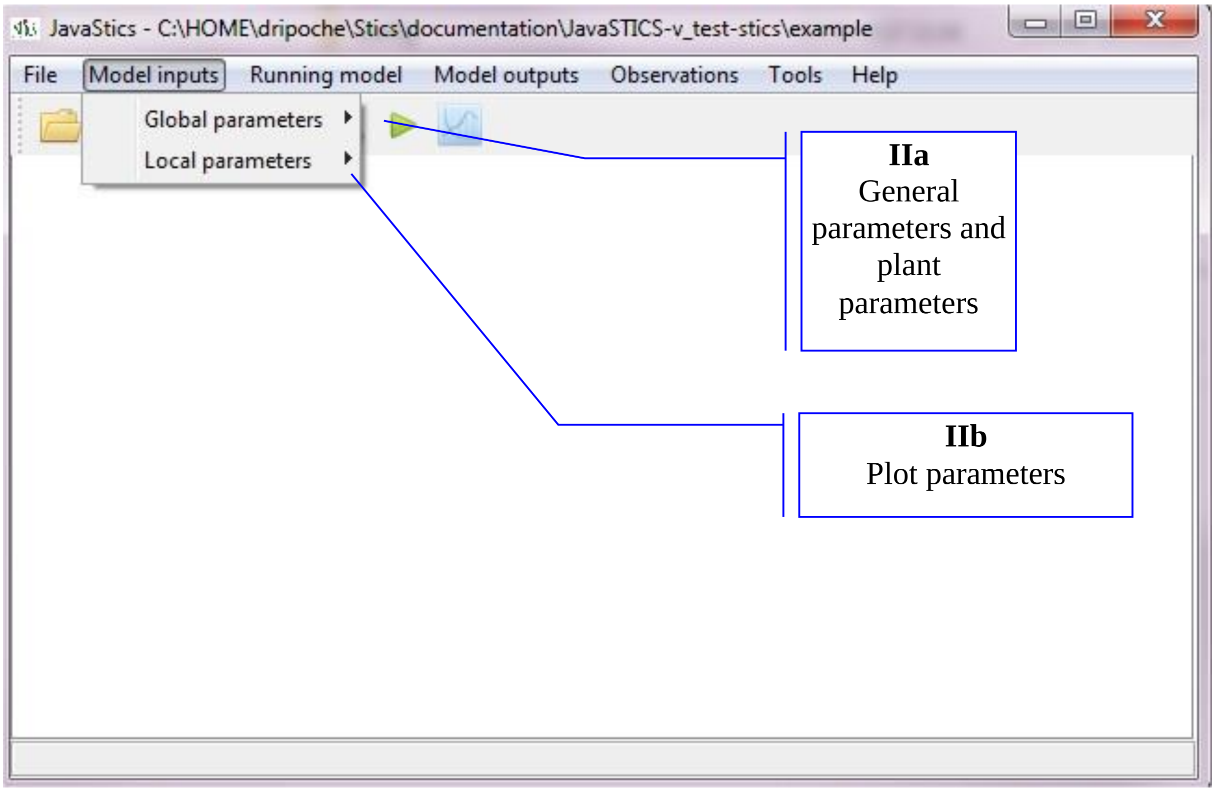
Ic – File menu: Historic display

This menu lets you view the log of your actions in the interface. This log file saves an history of all your interventions in the interface and is found in the file **logs** directory: user_log.txt. Until this file is deteted, it contains informations about all the JavaStics sessions.

II – Model Inputs: Creating input data

You can view or modify input files located in the working directory. The input parameters are subdivided into two categories accessibles through two submenus

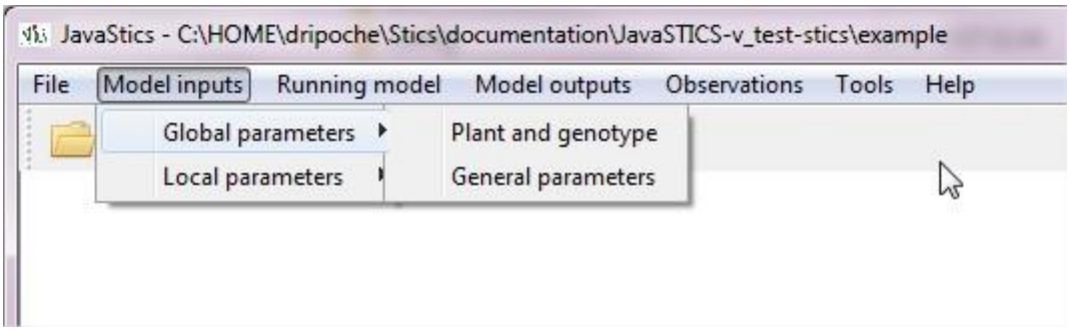
- **Global parameters**: access to general parameters and plant parameters files
- **Local parameters**: access to plot specific parameters files.



IIa – Model inputs: Global parameters

Used to view and edit the plant files and the general parameters file: param_gen.xml

The global parameters correspond to the general parameters and the model's plant parameters. The plant parameters files ***_plt.xml** are located in the **plant** directory. The general parameters are defined in the **param_gen.xml** file, located in the **config** directory.

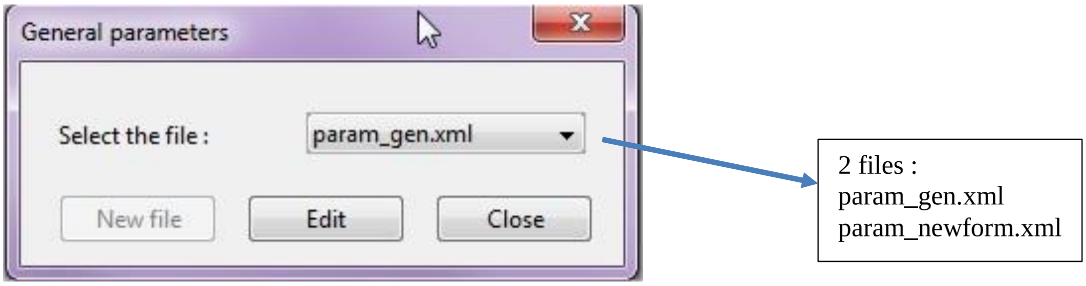


General parameters

To view or edit the general parameters, choose Model inputs →Global parameters → general parameters.

New general parameters files cannot be created.
Only one file proposed by the application can be edited: param_gen.xml is the standard general parameters file.

An other general parameter file param_newform.xml is used by the developers to introduce parameters linked to new formalisms .



In the view window, the general parameters are grouped into different categories displayed as a tree structure whose branches can be expanded by clicking on the +. The categories can be divided into sub-categories. These categories correspond to formalisms.

There are two types of parameters:

- **parameters corresponding to options**: In this case, a drop-down list shows the different possible values.
  The list of parameters or sub-options changes according to chosen options values. For example, (see the figure below), in the **Nitrogen fixation by legumes** option, if the nodule activity is selected, a choice through a drop-down list is proposed. Otherwise, if critical nitrogen is chosen, no sub-option is shown.

- **parameters for which a value has to be given**: In this case a value is entered in the box. The  icon calls up help on the parameter: its nature, type (numeric or alphanumeric), unit, bounds, and so on.

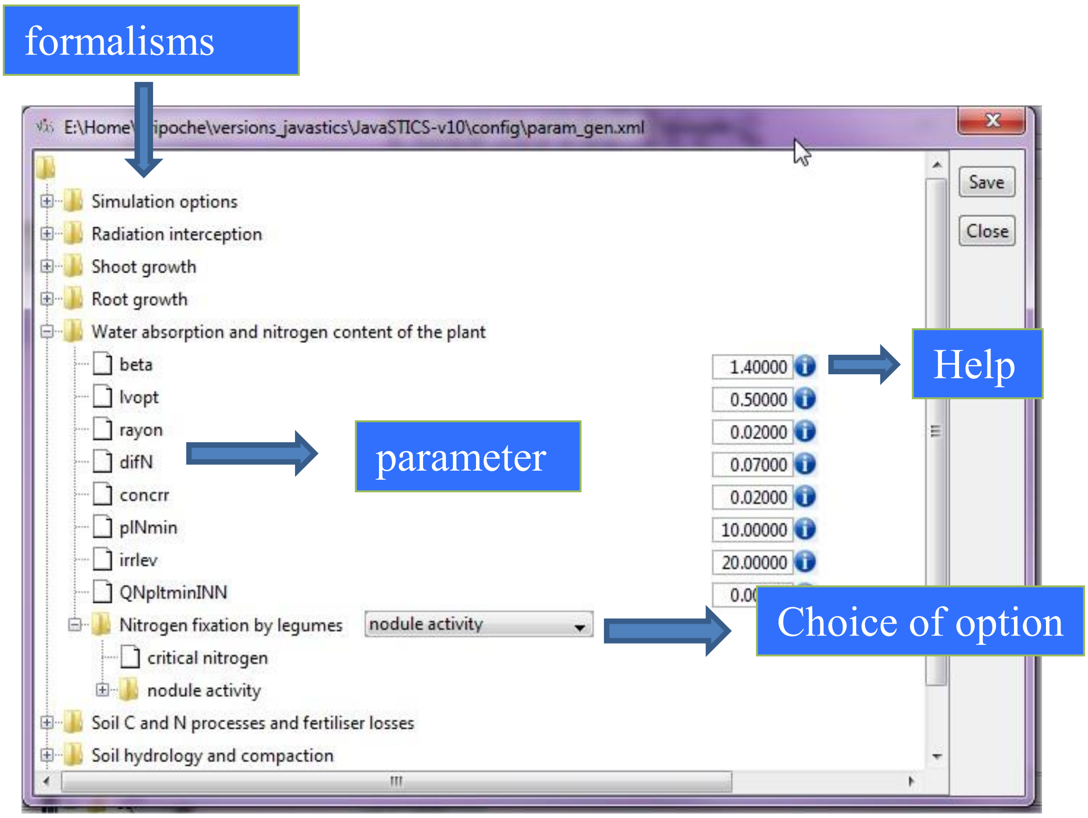


Table of parameters contained in the param_gen.xml file

ahres	parameter of organic residues humification: hres=1-ahres*CsurNres/(bhres+CsurNres)	g.g-1
akres	parameter of organic residues decomposition: kres=akres+bkres/CsurNres	d-1
albedomulchresidus	albedo of crop mulch	SD
alphapH	maximal soil pH variation per unit of inorganic N added with slurry	kg-1 ha
awb	parameter determining C/N ratio of biomass during organic residues decomposition: CsurNbio=awb+bwb/CsurNres	SD
beta	parameter of increase of maximal transpiration when a water stress occurs	SD
bformnappe	coefficient for the water table shape (artificially drained soil)	SD
bhres	parameter of organic residues humification: hres=1-ahres*CsurNres/(bhres+CsurNres)	g.g-1
bkres	potential rate of decomposition of organic residues: kres=akres+bkres/CsurNres	g.g-1
bwb	parameter determining C/N ratio of biomass during organic residues decomposition: CsurNbio=awb+bwb/CsurNres	g.g-1
cmax_pdenit	Corg value above which denitrification potential is constant and max	unknow n

cmin_pdenit	Corg value below which denitrification potential is constant and min	unknown
CNresmax	maximum value of C/N ratio of organic residue	g.g-1
CNresmin	minimum value of C/N ratio of organic residue	g.g-1
code_hourly_wfps_denit	choice of activating or not hourly WFPS calculation for denit (1 = yes, 2 = no)	code 1/2
code_hourly_wfps_nit	choice of activating or not hourly WFPS calculation for nit (1 = yes, 2 = no)	code 1/2
code_pdenit	choice of denitrification potential (1 = soil parameter or 2 = calculated from Corg)	code 1/2
code_ratiodenit	choice of constant (= 1) or variable(= 2) N2O ratio for denitrification	code 1/2
code_rationit	choice of constant or variable N2O ratio for nitrification (1 = constant, 2 = variable)	code 1/2
code_tnit	choice of temperature function for nitrification (1 = piecewise linear or 2 = gaussian)	code 1/2
code_vnit	choice of nitrification rate dependence on NH4 (1 = linear or 2 = Michaelis-Menten)	code 1/2
codeactimulch	option to activate the natural mulch effect i.e. drying out of soil surface (1 = yes, 2 = no)	code 1/2
codefrmur	code defining the maturity status of the fruits in the output variable CHARGEFRUIT (1 = including ripe fruits (last box N), 2 = excluding ripe fruits (first N-1 boxes))	code 1/2
codefxn	option defining the effect of soil nitrate on N fixation (1 = no effect, 2 = effect of nitrate amount , 3 = effect of nitrate concentration)	code 1/2/3
codeh2oact	option to activate water stress effect on the crop (1 = yes, 2 = no)	code 1/2
codeinitprec	option to activate reinitialization of initial conditions in case of chained simulations (1 = yes, 2 = no)	code 1/2
codeinnact	option of activation of N stress effect on the crop (1 = yes, 2 = no)	code 1/2
codemicheur	option of calculation of hourly microclimatic outputs (output file humidite.sti) (1 = yes, 2 = no)	code 1/2
codeminopt	option to maintain a constant water content in bare soil during the simulation (1 = yes, 2 = no)	code 0/1
codemsfinal	option defining the biomass and yield conservation after harvest (1 = yes (values maintained equal to harvest), 2 = no (values set at 0))	code 1/2
codeoutscient	option to write outputs files with scientific format (1 = yes, 2 = no)	code 1/2
codeprofmes	option of soil depth for calculating water and N stocks (1 = profmes, 2 = soil depth)	code 1/2
codesensibilite	option to activate the sensitivity analysis version of the model (1 = yes, 2 = no)	code 1/2
codeseprapport	option to select the column separator in the rapport.sti output file (1 = space separator, 2 = separator indicated in the separateurrapport parameter)	code 1/2

codesnow	option to activate the snow module use (1= yes,2= no)	code 1/2
codesymbiose	option for calculating symbiotic N fixation (1 = critical dilution curve, 2 = calculated N fixation)	code 1/2
codetycailloux	pebble type code	code 1 to 10
codetypeng	fertiliser type code	code 1 to 8
codetypres	organic residue type code	code 1 to 21
codhnappe	mode of calculation of watertable level (1 = mean height, 2 = height at the distance distdrain)	code 1/2
coefb	parameter defining radiation effect on conversion efficiency	SD
concrr	inorganic N concentration (NH4+NO3-N) in the rain	kg.ha-1 mm-1
CroCo	fraction of organic residue which is decomposable	SD
cwb	minimum ratio C/N of microbial biomass decomposing organic residues	g.g-1
dacohes	bulk density of soil below which root growth is reduced due to a lack of soil cohesion	g.cm-3
daseuilbas	bulk density of soil above which root growth is maximal	g.cm-3
daseuilhaut	bulk density of soil above which root growth becomes impossible	g.cm-3
deneng	maximal fraction of the mineral fertilizer that can be denitrified (used if codedenit is not activated)	SD
difN	diffusion coefficient of nitrate N in soil at field capacity	cm2.d-1
diftherm	soil thermal diffusivity	cm2.s-1
distdrain	distance to the drain to calculate watertable height	cm
dpHvolmax	maximal pH increase following the application of slurry	SD
engamm	fraction of ammonium in the N fertilizer	SD
fhminsat	relative soil mineralisation rate at water saturation	SD
finert	initial fraction of soil organic N inactive for mineralisation (= stable SON/ total SON)	SD
flagecriture	option for writing the output files (1 = mod_history.sti, 2=daily outputs,4= report outputs, 8=balance outputs,16 = profile outputs, 32= debug outputs, 64 = screen outputs, 128 = agmip outputs) add them to have several types of outputs	0-511
fmin1	relative potential mineralization rate: K2 = fmin1 * exp(-fmin2*argi) / (1+fmin3*calc)	d-1
fmin2	parameter defining the effect of clay on the potential mineralization rate: K2 = fmin1 * exp(-fmin2*argi) / (1+fmin3*calc)	-1%

fmin3	parameter defining the effect of CaCO3 on the potential mineralization rate: K2 = fmin1 * exp(-fmin2*argi) / (1+fmin3*calc)	-1%
fNCbiomin	minimal value for the ratio N/C of the microbial biomass when N limits decomposition	SD
fnx	potential proportion of NH4 nitrified each day if linear model	d-1
fredkN	reduction factor of decomposition rate of organic residues when mineral N is limiting	SD
fredlN	reduction factor of decomposition rate of microbial biomass when mineral N is limiting	SD
fredNsup	additional reduction factor of residues decomposition rate when mineral N is very limited in soil	SD
ftemh	parameter (1/2) of the temperature function on humus decomposition rate	K-1
ftemha	parameter (2/2) of the temperature function on humus decomposition rate	*
ftemr	parameter (1/2) of the temperature function on decomposition rate of organic residues	K-1
ftemra	parameter (2/2) of the temperature function on decomposition rate of organic residues	*
hcccx	gravimetric water content at field capacity of each type of pebble	% w
hminm	relative water content (fraction of field capacity) below which mineralisation rate is nil	SD
hminn	relative water content (fraction of field capacity) below which nitrification rate is nil	SD
hoptm	relative water content (fraction of field capacity) below which mineralisation rate is maximum	SD
hoptn	relative water content (fraction of field capacity) below which nitrification rate is maximum	SD
iniprofil	option of smoothing out the initial N and water profiles (spline function) (1 = yes, 2 = no)	code 0/1
irrlev	amount of irrigation applied automatically on the sowing day to allow germination when the model calculates irrigation	mm
Kamm	affinity constant for NH4 in nitrification if michaelis_menten option used	mg N/L
kbio	potential decay rate of microbial biomass decomposing organic residues	d-1
kcouvmlch	extinction coefficient connecting the soil cover to the amount of plant mulch	*
Kd	Affinity constant for NO3 in denitrification	mg N/L
kdesat	rate constant of de-saturation	d-1
khaut	extinction coefficient connecting LAI to crop height	*
lvopt	root length density (RLD) above which water and N uptake are maximum and independent of RLD	cm.cm-3
masvolcx	bulk density of each type of pebble	g.cm-3

max_pdenit	max value of denitrification potential	unknow n
min_pdenit	min value of denitrification potential	unknow n
mouillabilmulch	maximum wettability of crop mulch	mm.t-1.ha
nh4_min	minimum (fixed ?) NH4 concentration found in soil	mg N/kg
orgeng	maximal amount of fertilizer N that can be immobilized in the soil (fraction for type 8)	kg.ha-1
parsurrg	ratio of PAR to RG (global radiation)	SD
pHmaxden	pH beyond which the N2O molar fraction is minimum (<= ratiodenit)	pH
pHmaxnit	soil pH above which nitrification is maximum	pH
pHmaxvol	soil pH above which NH3 volatilisation derived from fertiliser is maximum	pH
pHminden	pH below which the N2O molar fraction is 100%	pH
pHminnit	soil pH below which nitrification is nil	pH
pHminvol	soil pH below which NH3 volatilisation derived from fertiliser is nil	pH
pHvols	parameter used to calculate the variation of soil pH after the addition of slurry	pH
plNmin	minimal amount of rain required to start an automatic N fertilisation	mm.d-1
pminruis	minimal amount of rain required to produce runoff	mm.d-1
primingmax	maximum priming ratio (relative to SOM decomposition rate)	SD
proflabour	minimal soil depth for ploughing (if soil compaction is activated)	cm
proftravmin	minimal soil depth for chisel tillage (if soil compaction is activated)	cm
prophumtassrec	soil moisture content (fraction of field capacity) above which compaction may occur and delay harvest	SD
prophumtasssem	soil moisture content (fraction of field capacity) above which compaction may occur and delay sowing	SD
proprac	ratio of root mass to aerial mass at harvest	g.g.-1
psihucc	soil water potential corresponding to field capacity	Mpa
psihumin	soil water potential corresponding to wilting point	Mpa
qmulchdec	maximal amount of decomposable mulch	t.ha-1
qmulchruis0	amount of mulch above which runoff is suppressed	t.ha-1
QNpltminINN	minimal amount of N in the plant required to compute INN	kg.ha-1
ratiodenit	constant value of N2O ratio for denitrification	SD
rationit	constant value of N2O ratio for nitrification	SD
rayon	average root radius	cm
rdrain	drain radius	cm
scale_tdenitopt	parameter related to the range of optimum temperature for denitrification	unknow n

scale_tnitopt	parameter related to the range of optimum temperature for nitrification	unknown
separateurrapport	column separator in rapport.sti file	SD
tdenitopt_gauss	optimum temperature for denitrification	degree C
tnitmax	maximal temperature above which nitrification stops	degree C
tnitmin	minimal temperature below which nitrification stops	degree C
tnitopt	optimal temperature (1/2) for nitrification	degree C
tnitopt_gauss	optimal temperature (1/2) for nitrification	degree C
tnitopt2	optimal temperature (2/2) for nitrification	degree C
trefh	reference temperature for decomposition of humified organic matter	degree C
trefr	reference temperature for decomposition of organic residues	degree C
Vabs2	N uptake rate at which fertilizer loss is divided by 2	kg.ha-1.d-1
vnitmax	maximum nitrification rate if michaelis_menten option used	mg N kg-1 d-1
voleng	maximal fraction of mineral fertilizer that can be volatilized	SD
wfpsc	wfps threshold beyond which denitrification occurs	SD
Wh	N/C ratio of soil humus	g.g-1
Xorgmax	maximal amount of N immobilised in soil derived from the mineral fertilizer	kg.ha-1
y0msrac	minimal amount of root mass at harvest (when aerial biomass is nil)	t.ha-1
yres	Carbon assimilation yield by the microbial biomass during crop residues decomposition	g.g-1

Table of parameters contained in the param_newform.xml file

codecalferti	option to activate the automatic calculation of fertilisation rate (1 = yes, 2= no)	code 1/2
codedate_irrigauto	to activate the beginning and the ending date (in date or in stage) in case of automatic irrigationÂ : dates (1),stages (2), no (3)	code 1/2/3
codedyntalle	option to activate the module simulating tillers dynamics (1 = yes, 2 = no)	code 1/2
codeFinert	option to activate the new functions to calculate proportion of inactive organic nitrogen (Finert) (1=Finert reading in the param_gen.xml file, 2 = calculated with the new functions)	code 1/2
codeFunctionFinert	option to activate the new functions to calculate proportion of inactive organic nitrogen (Finert) (1 : finert = finert1 * exp(-finert2*Corg), 2 : finert = finert1 * exp(-finert2*QCorg)	code 1/2
codemineralOM	option to activate the New mineralization of soil organic matter function (1=yes, 2=no)	code 1/2
codemineralR	option to activate the New mineralization of residues function (1=yes, 2=no)	code 1/2
codemontaison	option to stop the reserve limitation after stem elongation in grassland (1 = yes, 2 = no)	code 1/2
codemortalracine	kind of masec used to calculate dead roots at cutting dateÂ : masec (1), masectot (2)	code 1/2
codeNmindec	option to activate the limitation of mineral N availability for residues decomposition in soil (1 = yes, 2 = no)	code 1/2
codepluiepoquet	option to replace rainfall by irrigation at poquet depth in the case of poquet sowing (1 = yes, 2 = no)	code 1/2
coderes_pature	number ot the residue type in the param_gen.xml file used to parameterize bovine feces (1=crop residues, 2=residues of CI, 3=manure, 4=compost OM, 5=mud SE, 6=vinasse, 7=corn, 8=other)	code 1/10
codeSWDRH	calculation of surface wetness duration : 1=yes , 2 = no	code 1/2
codetempfauche	option of the reference temperature to compute cutting sum of temperatures (1 = upvt, 2 = udevair)	code 1/2
codetesthumN	option for automatic N fertilisation calculation (1 = based on rainfall, 2 = based on soil water content)	code 1/2
codetranspitalle	choice of the ratio used to calculate tiller mortality (1 = et/etm, 2 = epc2/eopC)	code 1/2
codetrosee	calculation of hourly dew temperature : 1=linear interpolation(actual calculation), 2=sinusoidal interpolation (Debele Bekele et al.,2007)	code 1/2
coef_calcul_doseN	N plant concentration under which there is no nitrogen return to the soil through animal urine (coefficient used to compute animal urine from animal grass dry matter intake and plant nitrogen concentration)c	g N k-1 dry weight

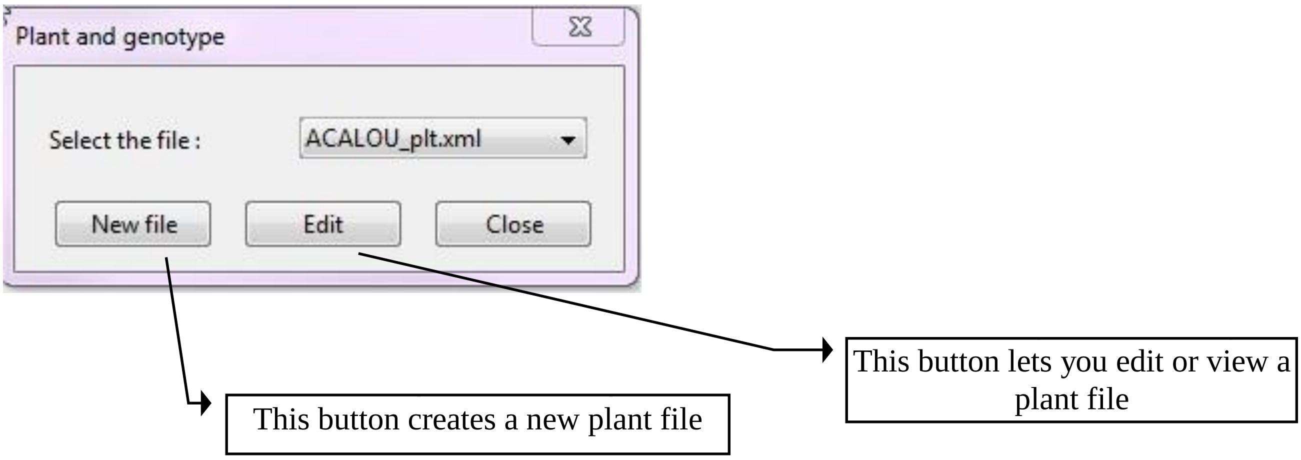
coef_calcul_qres	coefficient used to compute animal feces from animal grass dry matter intake, used as default	g N k-1 dry weight
coefracoupe	coefficient to define the proportion of dying roots after cut of forage crops	SD
Crespc_pature	C content in animal feces (fresh weight basis)	% fresh weight
datedeb_irrigauto	date of beginning automatic irrigations in julian day	julian day
datefin_irrigauto	date of ending automatic irrigations in julian day	julian day
dosimxN	maximum amount of fertiliser N applied on a given day (mode automatic fertilisation)	kg.ha-1
eau_mini_decisemis	minimum amount of rainfall to start sowing (when codesemis is activated)	mm
eaures_pature	Water amount of organic residues	%
engrais_pature	type of mineral fertilizer used to mimic urine excretion (used urea as default) : 1 =Nitrate.of ammonium ,2=Solution,3=urea,4=Anhydrous ammoniac,5= Sulfate of ammonium,6=phosphate of ammonium,7=Nitrateof calcium,8= fixed efficiency	*
Finert1	C/N soil factor 1 for function 2 to calculate proportion of inactive organic nitrogen	*
Finert2	C/N soil factor 2 for function 2 to calculate proportion of inactive organic nitrogen	*
fNmindecmin	minimal fraction of mineral N available for residues decomposition (if codeNmindec is activated)	SD
GMIN1	mineralization rate constant for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	day-1
GMIN2	clay content factor for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	-1%
GMIN3	CaCO3 content factor for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	-1%
GMIN4	pH factor 1 for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	pH-1
GMIN5	pH factor 2 for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	pH
GMIN6	C/N soil factor 1 for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. +	*

	gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	
GMIN7	C/N soil factor 2 for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	*
humirac_decisemis	effect of soil moisture for sowing decision (from 0 to 1 : 0 = no sensitivity to drought, 1 = very sensitive)	SD
maxtalle	maximum tillers density per soil area	nb.m-2
nbj_pr_apres_semis	number of days used to calculate rainfall requirement to start sowing (if codesemis is activated)	d
nbjoursrrversirrig	number of days during which rainfall is replaced by irrigation in the soil after a sowing poquet	d
Nminres_pature	N mineral content of animal feces (fresh weight basis)	%
option_engrais_multiple	enabling of using several kind of fertilizer yes(1),(no) 2	code 1/2
option_pature	enabling of pasture of grassland yes(1),(no) 2	code 1/2
option_thinning	enabling of several thinning yes(1),no(2)	code 1/2
pertes_restit_ext	proportion of animal feces and urine that are returned elsewhere than on grazed paddocks (e.g. in resting area, milking parlour, housing and paths/roads)	0-1
rapNmindec	slope of the linear relationship between the fraction of mineral N available for residue decomposition and the amount of C in decomposing residues (0.001)	g.g-1
ratiolN	nitrogen stress index below which fertilisation is started in automatic mode (0 in manual mode)	SD
resplmax	maximal reserve of biomass	t.ha-1
seuilLAIapex	maximal value of LAI+LAIapex when LAIapex is > 0	m2.m-2
seuilmortalle	relative transpiring threshold to calculate tiller mortality	mm
seuilreconspeupl	tiller density below which the entire population will not be regenerated	nb.m-2
sigmadistalle	parameter used for calculating tiller mortality (gamma law)	SD
stage_end_irrigauto	phenological stage of ending automatic irrigations (plt,ger,lev,amf,lax,drp,flo,sen,rec,mat,debdorm,findorm)	SD
stage_start_irrigauto	phenological stage of beginning automatic irrigations (plt,ger,lev,amf,lax,drp,flo,sen,rec,mat,debdorm,findorm)	SD
surfapex	equivalent surface of a transpiring apex	m2
swfacmin	minimal value for drought stress index (turfac, swfac, senfac)	SD
tigefeuilcoupe	ratio stem (structural part)/leaf on the cutting day	SD
vitreconspeupl	rate of regeneration of the tiller population	degree C-1

Plant parameters (*_plt.xml)

To view or edit the plant parameters, choose Model inputs → Global parameters → Plant and genotype.

To create a new plant parameter file, click the **New** file button. Then select the plant file you want to use as model, enter the prefix of the new file, and click on OK. A new plant file is created by using the plant file you selected as model.



To edit or view the plant file, select the plant file with the drop-down list, and then click Edit.

In the view window, the plant parameters are grouped into different categories arranged as a tree structure whose branches can be expanded by clicking on the +. The categories can be divided into sub-categories. These categories correspond to formalisms.

There are two types of parameters:

- **parameters corresponding to options**: in this case, a drop-down list shows the possible values.

  The list of parameters changes according to the chosen option. So, if the annual option is chosen in emergence and starting, some specific parameters will be displayed for defining the germination or latency parameters and the type of plant growth (see the figure below). If the perennial option is chosen, those parameters are no longer displayed.

- **parameters for which a value has to be given**: In this case the value is entered in the box. The  icon calls up help on the parameter: its nature, type (numeric or alphanumeric), unit, bounds, and so on.

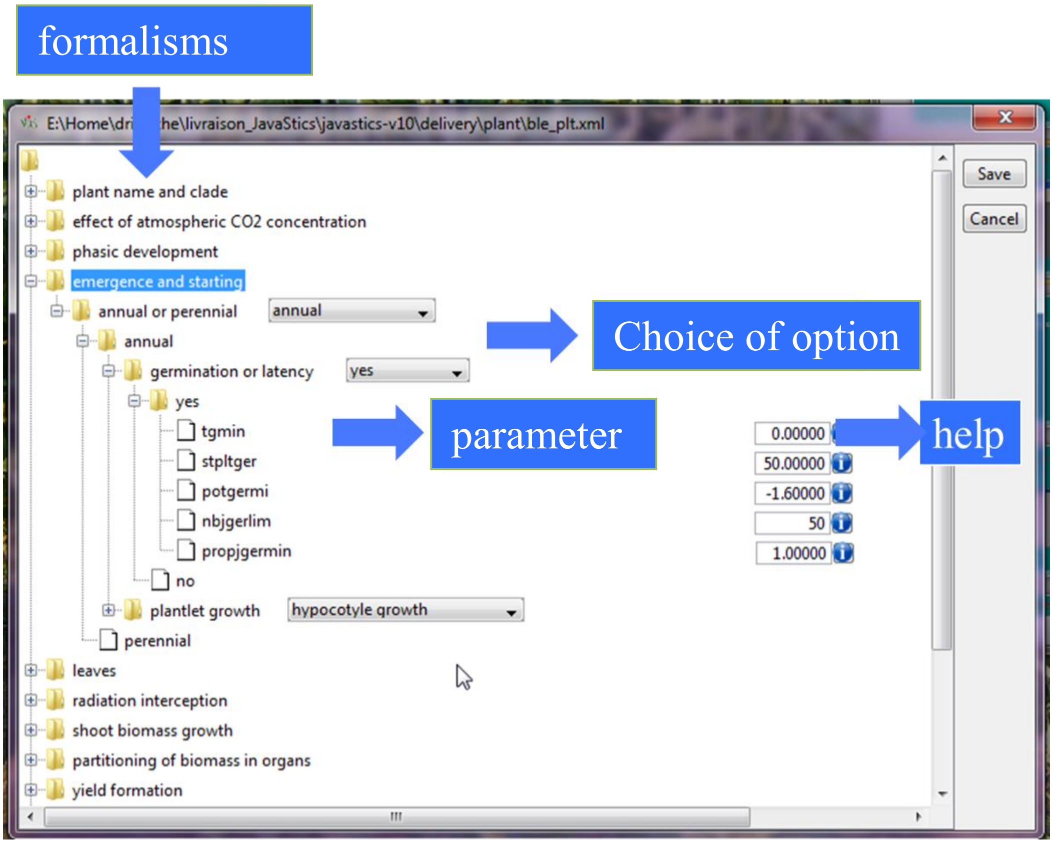


Table of parameters contained in the plant files

abscission	fraction of senescent leaves falling to the soil	SD
adens	Interplant competition parameter	SD
adfol	parameter determining the leaf density evolution within the chosen shape	m-1
adil	parameter of the critical dilution curve [Nplante]=adil MS^(-bdil)	% DM
adilmax	parameter of the maximum dilution curve [Nplante]=adilmax MS^(-bdilmax)	% DM
afpf	parameter of the logistic function defining sink strength of fruits (indeterminate growth) : relative fruit age at which growth is maximal	SD
afruitpot	maximal number of set fruits per degree-day (indeterminate growth)	degree-d-1
allocfrmax	maximal daily allocation to fruits	SD
alphaCO2	coefficient accounting for the modification of radiation use efficiency in case of atmospheric CO2 increase	SD
alphaphot	parameter of photoperiodic effect on leaf lifespan	SD
ampfroid	semi thermal amplitude for vernalising effect	degreeC
bdens	minimal density above which interplant competition starts	m-2
bdil	parameter of the critical dilution curve [Nplante]=adil MS^(-bdil)	SD
bdilmax	parameter of the maximum dilution curve [Nplante]=adilmax MS^(-bdilmax)	SD
belong	parameter of the curve of coleoptile elongation	degree-d-1
bfpf	parameter of the logistic curve defining sink strength of fruits (indeterminate growth): maximum growth rate relative to maximum fruit weight	SD
celong	parameter of the plantlet elongation curve	SD

cfpf	parameter of the first potential growth phase of fruit, corresponding to an exponential type function describing the cell division phase	SD
cgrain	slope of the relationship between grain number and growth rate	grains.g-1.d
cgrainv0	number of grains produced when growth rate is zero	grains.m-2
codazofruit	option to activate the direct effect of N plant status on the fruit/grain number (1 = no, 2 = yes)	code 1/2
codazorac	option to activate the N influence on root partitioning within the soil profile (1 = yes, 2 = no)	code 1/2
codcalinflo	option for calculating the inflorescences number (1 = read in param.par, 2 = calculated at the amf stage)	code 1/2
codebeso	option of computation water requirements (1 = k.ETP approach, 2= resistive approach)	code 1/2
codebfroid	option of chilling requirements (1 = no need, 2 = vernalising days, 3 = development stage)	code 1/2/3
codedormance	option for the calculation of dormancy and chilling requirements (1 = forcing, 2 = Richardson, 3 = Bidabe)	code 1/2/3
codefixpot	option of calculation of the maximal symbiotic fixation (1 = fixed, 2 =depending on growth rate)	code 1/2
codegdh	time step used for calculating development units (1 = hourly, 2 = daily)	code 1/2
codegdhdeb	option of time step used for calculating bud break date (1 = daily, 2 = hourly growing degrees)	code 1/2
codegermin	option of simulation of a germination phase or a delay at the beginning of the crop (1) or direct starting (2)	code 1/2
codehypo	option of simulation of a phase of hypocotyl growth (1) or planting of plantlets (2)	code 1/2
codeindetermin	option of simulation of the leaf growth and fruit growth (1 = determinate, 2 =indeterminate)	code 1/2
codeINN	option to compute INN (1 = cumulative, 2 = instantaneous)	code 1/2
codeintercept	option of simulation rainfall interception by leaves (1 = yes, 2 = no)	code 1/2
codeir	option of computing the ratio grain weight/total biomass: proportional to time (1), proportional to sum temperatures (2)	code 1/2
codelaitr	option used for calculating intercepted radiation (1 = LAI, 2 = soil cover)	code 1/2
codelegume	is the crop a legume fixing N ? (1 = yes, 2 = no)	code 1/2
codemonocot	type of plant: 1 = monocot, 2 =dicot	code 1/2
codeperenne	option defining the annual (1) or perenial (2) character of the plant	code 1/2
codephot	option of plant photoperiodism (1 = yes, 2 = no)	code1/2
codeplante	Name code of the plant in 3 letters	SD
codeplisoleN	code for N requirement calculations at the beginning of the cycle (1 = dense plant population, 2 = isolated plants)	code 1/2
coderacine	option of simulating root growth and extension (1 = standard profile, 2 = root length density)	code 1/2
coderetflo	option to activate the slow down effect of water stress on development before the stage DRP (starting date of filling of harvested organs) , (1 = yes, 2 = no)	code 1/2
codestrphot	option to activate the photoperiodic stress on lifespan (1 = yes, 2 = no)	code 1/2
codetemp	option to calculate thermal time for plant growth (1 = air temperature, 2 = crop temperature)	code 1/2
codetemprac	option to calculate thermal time for root growth (1 = crop temperature, 2 = soil temperature)	code 1/2
codetransrad	'option of simulating radiation interception (1 = Beer"s law, 2 = radiative transfer)'	code 1/2
codetremp	option to activate heat effect on grain filling (1 = yes, 2 = no)	code 1/2
codevar	cultivar name	SD

codgelflo	option to activate frost effect at anthesis (1 = no, 2 = yes)	code 1/2
codgeljuv	option to activate frost effect on LAI at the juvenile stage (1 = no, 2 = yes)	code 1/2
codgellev	option to activate frost effect on plantlet (1 = no, 2 = yes)	code 1/2
codgelveg	option to activate frost effect on LAI at adult stage (1 = no, 2 = yes)	code 1/2
codlainet	option of calculation of the LAI (1 : direct LAInet, 2 : LAInet = gross LAI - senescent LAI)	code 1/2
codtrophrac	trophic effect on root length growth (1 = permanent link, 2 = link by thresholds ,3 = no effect)	code 1/2/3
coefamflax	multiplier coefficient of the development phase AMF (maximum acceleration of leaf growth, end of juvenile phase) - LAX (maximum leaf area index, end of leaf growth)to use crop temperature	SD
coefdrpmat	multiplier coefficient of the development phase DRP (starting date of filling of harvested organs) - MAT to use crop temperature	SD
coefflodrp	multiplier coefficient of the development phase FLO (anthesis) - DRP (starting date of filling of harvested organs) to use crop temperature	SD
coeflaxsen	multiplier coefficient of the development phase LAX (maximum leaf area index, end of leaf growth) - SEN (beginning of leaf senescence) to use crop temperature	SD
coeflevamf	multiplier coefficient of the development phase LEV (emergence) - AMF (maximum acceleration of leaf growth, end of juvenile phase) to use crop temperature	SD
coeflevdrp	multiplier coefficient of the development phase LEV (emergence) - DRP (starting date of filling of harvested organs) to use crop temperature	SD
coefmshaut	ratio biomass/ useful height cut of crops	t.ha-1.m-1
coefsenlan	multiplier coefficient of the development phase SEN (beginning of leaf senescence) - LAN (leaf index nil) to use crop temperature	SD
concNnodseuil	maximal concentration of mineral N in soil for nodule onset	kg.ha-1.mm-1
concNrac0	nitrate-N concentration (if codefxN=3) or nitrate-N amount (if codefxN=2) above which N fixation is totally inhibited	kg.ha-1.mm-1 or kg.ha-1.cm-1
concNrac100	nitrate-N concentration (if codefxN=3) or nitrate-N amount (if codefxN=2) below which N fixation is maximum	kg.ha-1.mm-1 or kg.ha-1.cm-2
contrdamax	maximal reduction in root growth rate due to soil strengthness (high bulk density)	SD
croirac	elongation rate of the root apex	cm.degree-d-1
debsenrac	sum of degrees.days defining the beginning of root senescence (root life time)	degree-d
deshydbase	rate of change of fruit water content vs thermal time (>0 or <0)	g.g-1 FM.degree-d-1
dfolbas	minimal foliar density within the considered shape	m2 leaf.m-3
dfolhaut	maximal foliar density within the considered shape	m2 leaf.m-3
dfpf	parameter of the first potential growth phase of fruit, corresponding to an exponential type function describing the cell division phase	SD
dlaimax	maximum rate of the setting up of LAI	m2 leaf.plant-1.degree-d-1
dlaimaxbrut	maximum rate of the setting up of LAI	m2 leaf.plant-1.degree-d-1
dlaimin	accelerating parameter for the lai growth rate	SD
dltamsmaxsen	threshold value of growth rate from which there is no more photoperiodic effect on senescence	t.ha-1.d-1
dltamsminsen	threshold value of growth rate from which the photoperiodic effect on senescence is maximal	t.ha-1.d-1

draclong	maximum rate of root length production per plant	cm.plant-1.degree-d-1
dureefruit	total growth period of a fruit at the setting stage to the physiological maturity	degree-d
durvieF	maximal lifespan of an adult leaf expressed in summation of Q10=2 (2**(T-Tbase))	SD
durviesupmax	relative additional lifespan due to N excess in plant (INN > 1)	SD
efcroijuv	maximum radiation use efficiency during the juvenile phase(LEV=emergence - AMF= maximum acceleration of leaf growth, end of juvenile phase)	g.MJ-1
efcroirepro	maximum radiation use efficiency during the grain filling phase (DRP= starting date of filling of harvested organs - MAT= maturity)	g.MJ-1
efcroiveg	maximum radiation use efficiency during the vegetative stage (AMF = maximum acceleration of leaf growth, end of juvenile phase - DRP=starting date of filling of harvested organs)	g.MJ-1
elmax	maximum elongation of the coleoptile in darkness condition	cm
envfruit	fraction of envelop in grainmaxi (w:w)	SD
extin	extinction coefficient of photosynthetic active radiation in the canopy	SD
fixmax	maximal N symbiotic fixation rate	kg.ha-1.d-1
fixmaxgr	maximal N symbiotic fixation rate per unit of grain growth rate	kg.t-1
fixmaxveg	maximal N symbiotic fixation rate per unit of vegetative growth rate	kg.t-1
forme	option to define the shape of leaf density profile (1 = rectangle, 2 = triangle)	code 1/2
h2ofeuiljaune	water content of yellow leaves (relative to fresh matter)	g.g-1 FW
h2ofeuilverte	water content of green leaves (relative to fresh matter)	g.g-1 FW
h2ofrvert	water content of fruits before the beginning of dehydration (DEBDESHYD) (/fresh matter)	g.g-1 FW
h2oreserve	reserve water content (/fresh matter)	g.g-1 FW
h2otigestruc	structural stem part water content (/fresh matter)	g.g-1 FW
hautbase	basal height of crop	m
hautmax	maximum height of crop	m
idebdorm	day of the dormancy entrance	julian.d
ifindorm	day of dormancy break	julian.d
inflomax	maximal number of inflorescences per plant	SD
infrecouv	ulai at the stage AMF (maximal rate of leaf growth)	SD
inngrain1	minimal INN for net absorption of N during grain filling	SD
inngrain2	INN minimal for null net absorption of N during grain filling	SD
INNimin	INNI (instantaneous INN) corresponding to INNmin	SD
INNmin	minimum value of INN possible for the crop	SD
innsen	parameter of the N stress function active on senescence (INNsenes), bilinear function vs INN passing through the point (INNmin, INNsen)	SD
innturgmin	parameter of the N stress function active on leaf expansion (INNLAI), bilinear function vs INN passing through the point (INNmin, INNturgmin)	SD
irmax	maximum harvest index	SD
julvernal	day of initiation of vernalisation in perennial crops (between 1 and 365)	julian.d
jvc	number of vernalising days	d
jvcmini	minimum number of vernalising days	d
Kmabs1	affinity constant of N uptake by roots for the fast uptake system	µmole.L-1
Kmabs2	affinity constant of N uptake by roots for the low uptake system	µmole.L-1

kmax	maximum crop coefficient for water requirements (= MET/PET)	SD
krepracperm	parameter of biomass root partitioning : evolution of the ratio root/total (permanent trophic link)	SD
krepracseu	parameter of biomass root partitioning : evolution of the ratio root/total (trophic link by thresholds)	SD
kstemflow	extinction coefficient connecting LAI to stemflow	*
ktrou	extinction coefficient of PAR through the crop (used in the radiative transfer module)	*
laicomp	LAI above which competition between plants starts	m2.m-2
laiplantule	LAI of plantlet at the plantation	m2.m-2
longsperac	specific root length	cm.g-1
lvfront	root density at the root apex	cm.cm-3
masecmeta	biomass of the plantlet supposed to be composed of metabolic N	t.ha-1
masecNmax	aerial biomass above which N dilution occurs (critical and maximal curves)	t.ha-1
masecplantule	initial shoot biomass of plantlet	t.ha-1
maxazorac	mineral N concentration in soil above which root growth is maximum	kg.ha-1.cm-1
minazorac	mineral N concentration in soil below which root growth is reduced	kg.ha-1.cm-1
minefnra	reduction factor on root growth when soil mineral N is limiting (< minazorac)	SD
mouillabil	maximum wettability of leaves	mm.LAI-1
nbfeuilplant	leaf number per plant when planting	nb pl-1
nbfgellev	leaf number at the end of the juvenile phase (frost sensitivity)	nb pl-1
nbgrmax	maximum number of fruits per surface area	nb.m-2
nbgrmin	minimum number of fruits per surface area	nb.m-2
nbinflo	imposed number of inflorescences per plant	nb.pl-1
nbjgerlim	maximum number of days after grain imbibition allowing full germination	d
nbjgrain	number of days used to compute the number of viable grains	d
nboite	number of boxes or age classes of fruits used to calculate fruit growth for undeterminate crops	SD
nlevlim1	number of days after germination after which plant emergence is reduced	d
nlevlim2	number of days after germination after which plant emergence is impossible	d
Nmeta	proportion of metabolic N in the plantlet	%
Nreserve	maximal amount of N in plant reserves (difference between the maximal and critical dilution curves) (percentage of aerial biomass)	%
parazofmorte	parameter relating the C/N of dead leaves and the INN	SD
pentinflores	parameter used to calculate the inflorescences number	10*inflo*kg-1
pentlaimax	parameter of the logistic curve of LAI growth	SD
pentrecouv	parameter of the logistic curve of soil cover rate	SD
pgrainmaxi	maximum grain weight (at 0% water content)	g
phobase	basal photoperiod	hours
phobasesen	photoperiod under which the photoperiodic stress affects the lifespan of leaves	hours
phosat	saturating photoperiod	hours
phyllotherme	thermal duration between the apparition of two successive leaves on the main stem	degree-d
potgermi	soil water potential under which seed imbibition is impeded	MPa

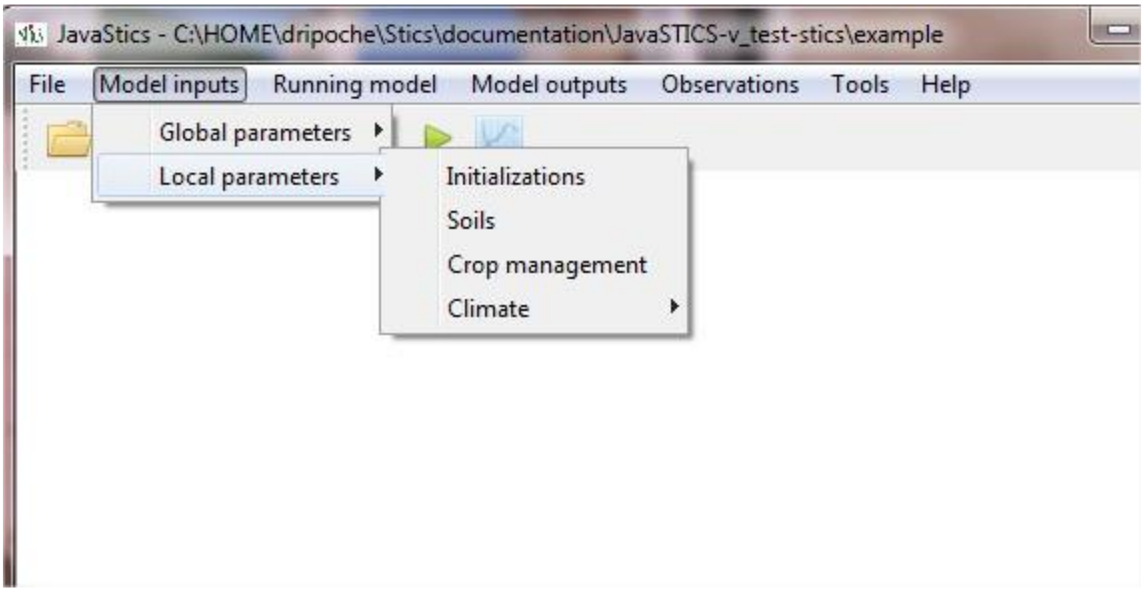
profnod	maximum depth of N2 fixation by legume crops	cm
propjgermin	minimal proportion of the duration nbjgerlim when the temperature is higher than the temperature threshold Tdmax	%
psisto	potential of stomatal closing (absolute value)	bars
psiturg	potential of the beginning of decrease of the cellular extension (absolute value)	bars
q10	Q10 used for the dormancy break calculation	SD
rapforme	ratio of thickness to /width of the crop shape (negative when the base of the form < top)	SD
rapsenturg	threshold soil water content active to simulate water senescence stress as a proportion of the turgor stress	SD
ratiodurvieI	life span of early leaves expressed as a fraction of the life span of the last leaves emitted DURVIEF	SD
ratiosen	fraction of senescent biomass (relative to total biomass)	SD
remobres	fraction of daily remobilisable C reserves	SD
repracpermax	maximum root biomass relative to total biomass (permanent trophic link)	SD
repracpermin	minimum root biomass relative to total biomass (permanent trophic link)	SD
repracseumax	maximum root biomass relative to total biomass (trophic link by thresholds)	SD
repracseumin	minimum root biomass relative to total biomass (trophic link by thresholds)	SD
rsmin	minimal stomatal resistance of leaves	s.m-1
sea	specific area of fruit envelops	cm2.g-1
sensanox	index of anoxia sensitivity (0 = insensitive)	SD
sensiphot	index of photoperiod sensitivity (1=insensitive)	SD
sensrsec	index of root sensitivity to drought (1=insensitive)	SD
slamax	maximum SLA (specific leaf area) of green leaves	cm2.g-1
slamin	minimum SLA (specific leaf area) of green leaves	cm2.g-1
spfrmax	maximal sources/sinks value allowing the trophic stress calculation for fruit onset	SD
spfrmin	minimal sources/sinks value allowing the trophic stress calculation for fruit onset	SD
splaimax	maximal sources/sinks value allowing the trophic stress calculation for leaf growing	SD
splaimin	minimal value of ratio sources/sinks for the leaf growth	SD
stadebbchamf	equivalent stage in BBCH-scale (amf= maximum acceleration of leaf growth, end of juvenile phase)	SD
stadebbchdebdes	equivalent stage in BBCH-scale (debdes= date of onset of water dynamics in harvested organs)	SD
stadebbchdrp	equivalent stage in BBCH-scale (drp = starting date of filling of harvested organs)	SD
stadebbchfindorm	equivalent stage in BBCH-scale (end of dormancy)	SD
stadebbchflo	equivalent stage in BBCH-scale (flowering)	SD
stadebbchger	equivalent stage in BBCH-scale (germination)	SD
stadebbchlax	equivalent stage in BBCH-scale (lax = maximum leaf area index, end of leaf growth)	SD
stadebbchlev	equivalent stage in BBCH-scale (emergence)	SD
stadebbchmat	equivalent stage in BBCH-scale (maturity)	SD
stadebbchnou	equivalent stage in BBCH-scale (fruit set)	SD
stadebbchplt	equivalent stage in BBCH-scale (sowing)	SD

stadebbchrec	equivalent stage in BBCH-scale (harvest)	SD
stadebbchsen	equivalent stage in BBCH-scale (senescence)	SD
stamflax	cumulative thermal time between the stages AMF (maximum acceleration of leaf growth, end of juvenile phase) and LAX (maximum leaf area index, end of leaf growth)	degree-d
stdnofno	cumulative thermal time between the beginning and the end of nodulation	degree-d
stdordebour	cumulative thermal time between the dormancy break and the bud break	degree-d
stdrpdes	cumulative thermal time between the DRP stage (starting date of filling of harvested organs) and DEBDES (date of onset of water dynamics in harvested organs)	degree-d
stdrpmat	cumulative thermal time between the stages DRP (starting date of filling of harvested organs) and MAT (maturity)	degree-d
stdrpnou	cumulative thermal time between the stages DRP (starting date of filling of harvested organs) and NOU (end of setting)	degree-d
stemflowmax	maximal fraction of rainfall flowing down along the stems	SD
stflodrp	cumulative thermal time between FLO (anthesis) and DRP (starting date of filling of harvested organs) (only for indication)	degree-d
stfnofvino	cumulative thermal time between the end of the nodulation and the end of the nodule life	degree-d
stlaxsen	cumulative thermal time between the stages LAX (maximum leaf area index, end of leaf growth) and SEN (beginning of leaf senescence)	degree-d
stlevamf	cumulative thermal time between the stages LEV (emergence) and AMF (maximum acceleration of leaf growth, end of juvenile phase)	degree-d
stlevdno	cumulative thermal time between emergence and the beginning of nodulation	degree-d
stlevdrp	cumulative thermal time between the stages LEV (emergence) and DRP (starting date of filling of harvested organs)	degree-d
stoprac	stage when root growth stops (LAX= maximum leaf area index, end of leaf growth or SEN=beginning of leaf senescence)	SD
stpltger	cumulative thermal time allowing germination	degree-d
stressdev	maximum phasic delay allowed due to stresses	SD
stsenlan	cumulative thermal time between the stages SEN (beginning of leaf senescence) et LAN	degree-d
tauxrecouvkmax	soil cover rate corresponding to the maximal crop coefficient for water requirement (plant surface / soil surface)	m2.m-2
tauxrecouvmax	maximal soil cover rate (plant surface / soil surface)	m2.m-2
tcmax	maximum temperature at which growth ceases	degreeC
tcmin	minimum temperature at which growth ceases	degreeC
tcxstop	temperature beyond which foliar growth stops	degreeC
tdebgel	temperature below which frost affects plant growth	degreeC
tdmax	maximum temperature above which development stops	degreeC
tdmaxdeb	maximal temperature for hourly calculation of phasic duration between dormancy and bud breaks	degreeC
tdmin	minimum temperature below which development stops	degreeC
tdmindeb	minimal thermal threshold for hourly calculation of phasic duration between dormancy and bud breaks	degreeC
temax	maximal temperature above which plant growth stops	degreeC
temin	minimum temperature for development	degreeC
tempdeshyd	increase in fruit dehydration rate due to the increase in crop temperature (Tcult-Tair)	% water.degreeC -1
tempnod1	temperature parameter (1/4) used to calculate N fixation by legumes	degreeC

tempnod2	temperature parameter (2/4) used to calculate N fixation by legumes	degreeC
tempnod3	temperature parameter (3/4) used to calculate N fixation by legumes	degreeC
tempnod4	temperature parameter (4/4) used to calculate N fixation by legumes	degreeC
teopt	optimal temperature (1/2) for plant growth	degreeC
teoptbis	optimal temperature (2/2) for plant growth	degreeC
tfroid	optimal temperature for vernalisation	degreeC
tgelflo10	temperature resulting in 10% of frost damages on flowers and fruits	degreeC
tgelflo90	temperature resulting in 90% of frost damages on flowers and fruits	degreeC
tgeljuv10	temperature resulting in 10% of frost damage on LAI (juvenile stage)	degreeC
tgeljuv90	temperature resulting in 90% of frost damage on LAI (juvenile stage)	degreeC
tgellev10	temperature resulting in 10% of frost damages on plantlet	degreeC
tgellev90	temperature resulting in 90% of frost damages on plantlet	degreeC
tgelveg10	temperature resulting in 10% of frost damage on LAI (adult stage)	degreeC
tgelveg90	temperature resulting in 90% of frost damage on LAI (adult stage)	degreeC
tgmin	minimum temperature below which emergence is stopped	degreeC
tigefeuil	ratio stem (structural part)/leaf	SD
tletale	lethal temperature for the plant	degreeC
tmaxremp	maximal temperature above which grain filling stops	degreeC
tminremp	minimal temperature below which grain filling stops	degreeC
tustressmin	water stress index (min(turfac,inns)) below which there is an extra LAI senescence	SD
udlaimax	ulai from which the rate of leaf growth decreases	SD
vigueurbat	plant vigor index allowing to emerge through a soil crust	SD
vitirazo	rate of increase of the N harvest index vs time	g grain.g-1.d-1
vitircarb	rate of increase of the C harvest index vs time	g grain.g-1.d-1
vitircarbT	rate of increase of the C harvest index vs thermal time	g grain.g-1.d-1
vitno	rate of nodule onset expressed as a proportion of fixmax per degree day	degree-d-1
vitprophuile	rate of increase of oil harvest index vs time	g oil.g-1.d-1
vitpropsucre	rate of increase of sugar harvest index vs time	g sugar.g-1.d-1
vlaimax	ulai at the inflexion point of the function DELTAI=f(ULAI)	SD
Vmax1	maximum specific N uptake rate with the low affinity transport system	µmole.cm-1 h-1
Vmax2	maximum specific N uptake rate with the high affinity transport system	µmole.cm-1 h-1
zlabour	depth of ploughing (reference profile)	cm
zpente	depth at which root density is 50% of the surface root density (reference profile)	cm
zprlim	maximum depth of the root profile (reference profile)	cm
zracplantule	initial depth of root apex of the plantlet	cm

IIb – Model inputs: Local parameters

To view or edit the local parameters, choose Model inputs menu → Local parameters.



The local parameters include five sets of files corresponding to:

- **Initialization** of the system at simulation start
- **Soils** parameterization
- **Crop management** parameterization
- **Climate data and weather station** parameterization

Initialization parameters

The initialization file follows the naming convention ***_ini.xml**. It is located in the workspace directory. It provides the initial state of the system at the simulation start.

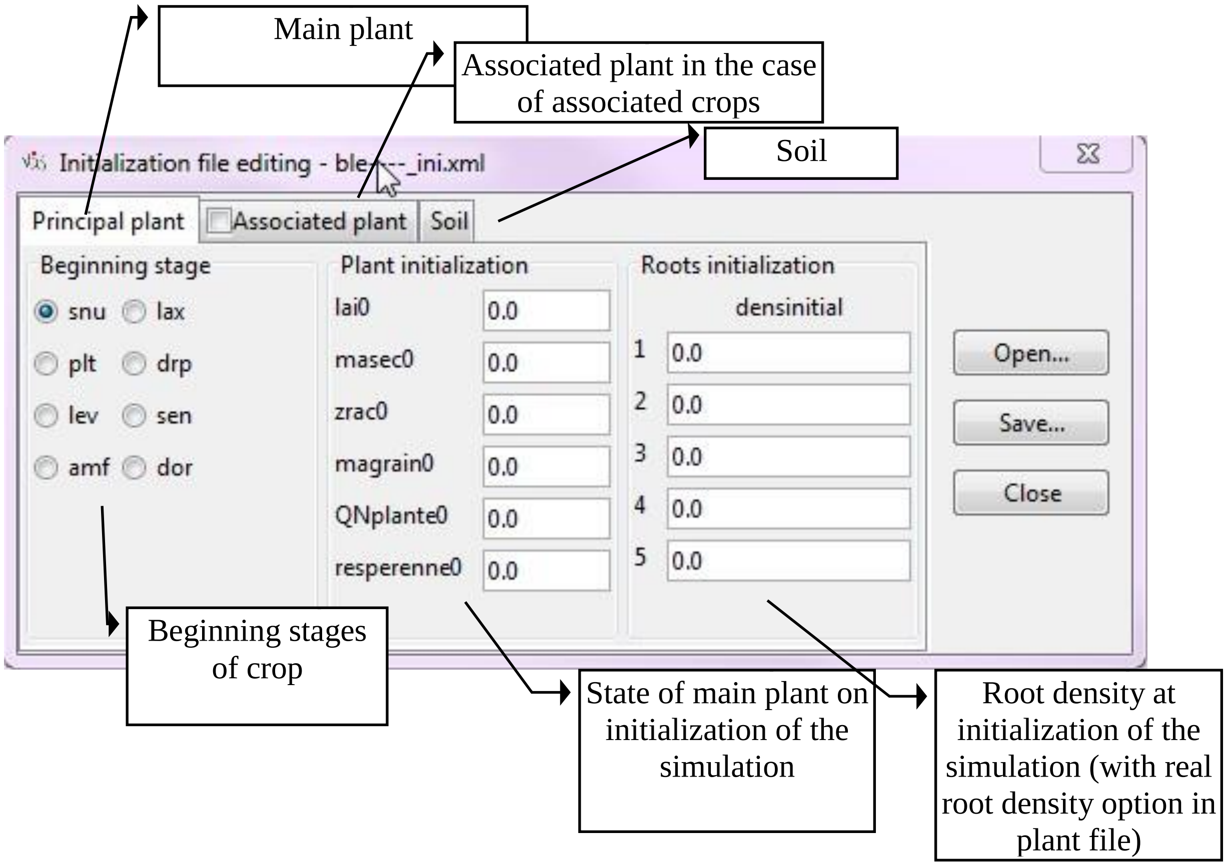
Choose **Model inputs** → **Local parameters** → **Initializations**, and then click Open to select an initialization file and click Open again. In a newly created workspace directory, you will find the default example file called **mais_ini.xml**.

The initialization parameters are presented in over three groups in separate tabs:

- The first tab corresponds to the initialization parameters for the main crop: development stage, status, and roots densities.
- The second tab corresponds to the initialization parameters for the associated crop, if there's any (check the box near tab title, if you are using associated crops)
- The third tab corresponds to the initial soil content state (water, nitrogen).

Simply change the values in the corresponding boxes, then save the changes by clicking Save.

Plants initialization



Even if you begin with a bare soil, you must fill in the plant initialization and the roots intialization with zero values.

The starting stages are described in the following table:

vegetative stages (leaf area index)	**harvested organs stages**
SNU: bare soil	
PLT: sowing or planting (annuals)	
LEV: emergence or budding	
DOR: beginning of dormancy (woody plants)	
AMF: maximum acceleration of leaf growth, end of juvenile phase	DRP: onset of filling of harvested organs
LAX: maximum leaf area index, end of leaf growth	
SEN: beginning of net senescence (LAInet option)	

List of the phenological stages of STICS

Table of parameters (Plants and roots) contained in initialization files

parameter name	Signification	Unit
densinitial	initial root density in each of the five soil layers	cm.cm-3
lai0	initial leaf area index	m2.m-2
magrain0	initial grain dry weight	g.m-2
masec0	initial aerial biomass	t.ha-1
QNplante0	initial N amount in the plant	kg.ha-1
resperenne0	initial reserve of biomass	t.ha-1
stade0	crop stage at the beginning of simulation	SD
zrac0	initial depth of root apex of the crop	cm

Soil initialization

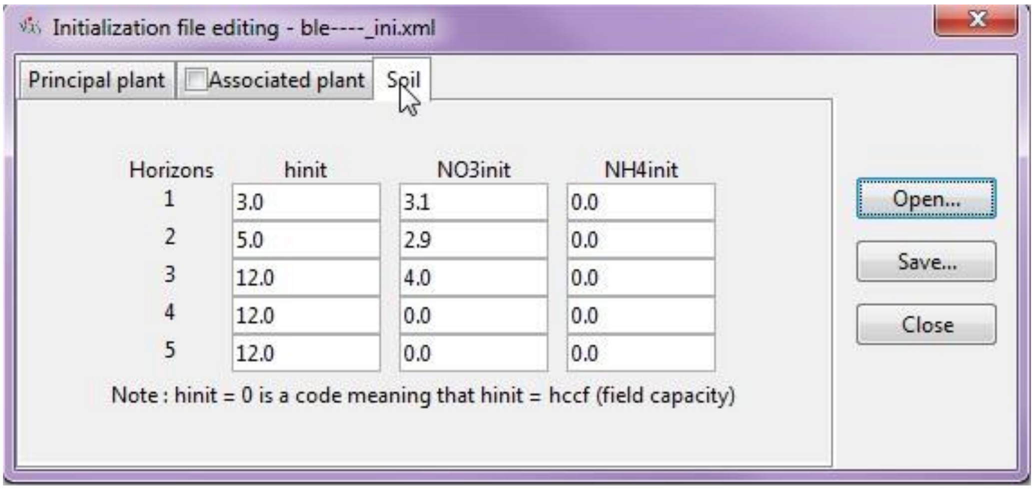


Table of soil parameters contained in initialization files

parameter name	Signification	Unit	Warnings
Hinit	initial gravimetric water content of each soil layer (/fine earth)	% w	Hinit=0 is a code meaning hinit = hccf (field capacity)
NO3init	initial amount of NO3-N in each of the soil layers (/fine earth)	kg.ha-1	
NH4init	initial amount of NH4-N in each of the soil layers	kg.ha-1	

The whole table must be filled in, even if the soil is described with less than 5 layers. If the soil has less than 5 layers, then put a value of zero for the parameters of the layers not present in the soil.
The NH4initf parameters are used by the model only if nitrification is activated (see the parameter codenitrif of the soil parameterization). If nitrification is not activated, then put NH4initf to zero for all layers.

Soil parameters

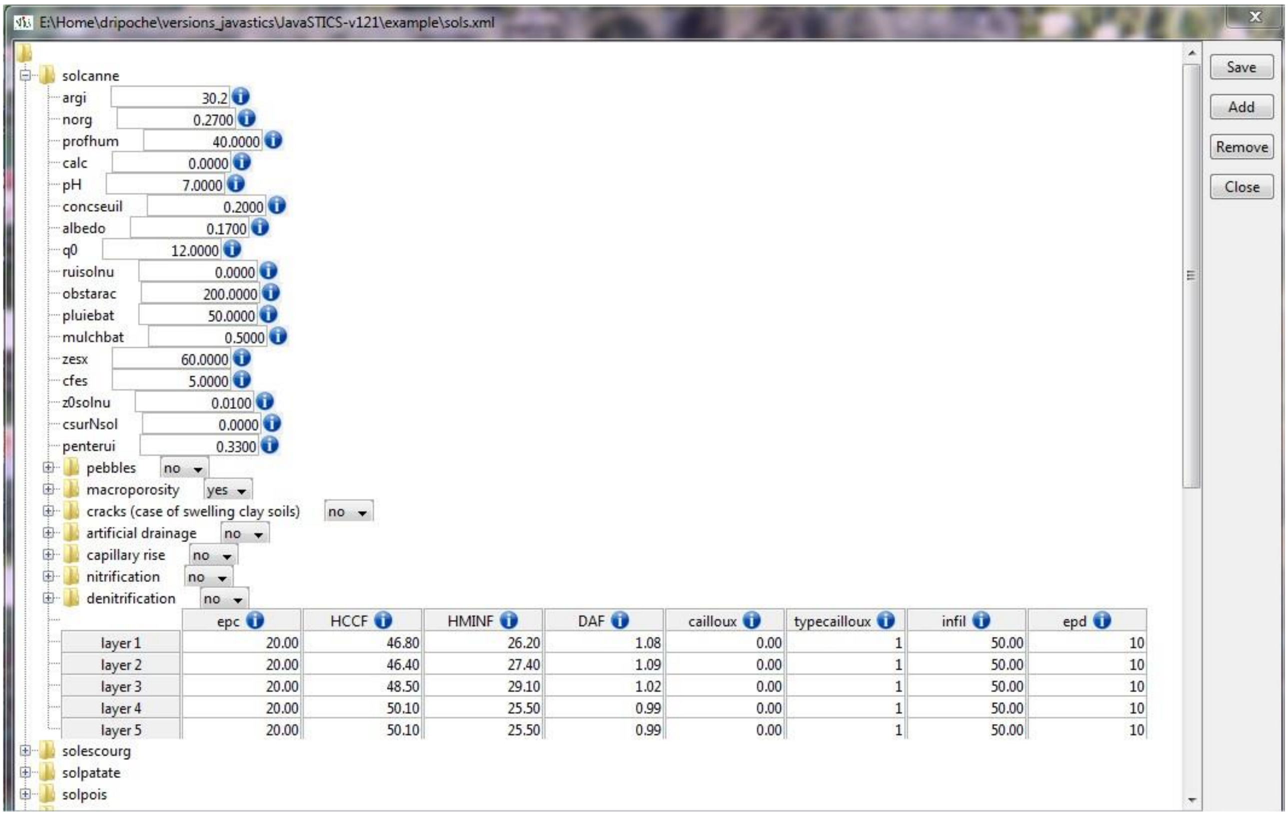
The file sols.xml includes parameters for all the soils in the current directory or workspace.

Choose **Model inputs menu → Local parameters → Soils**. In a newly created working directory, a default sols.xml file has been created. It contains a single soil.
In the view window, the soil parameters appear in the form of a tree structure whose branches can be expanded by clicking on the +.

There are two types of parameters:

- **parameters corresponding to options**: In this case, a drop-down list shows the different possible values.
- **The parameters for which a value must be set**: In this case the value is entered in the box. The icon calls up help on the parameter: its nature, type (numeric or alphanumeric), its unit, its limits, etc.

To add a new soil, click the Add button; enter its name (without any spaces). By default, its parameters are filled with the values of the first soil of the file (solcanne in example folder).
To delete a soil, select a soil by clicking on its name and then click Remove.
Click the Save button to save your changes.



A complete list of soil parameters is given in the table below.

Table of soil files parameters

aangst	'coefficient of the Angstrom''s relationship for extraterrestrial radiation'	SD
abscission	fraction of senescent leaves falling to the soil	SD
albedo	albedo of the bare dry soil	SD
argi	clay content after decarbonation	%
cailloux	volumetric content of pebbles per soil layer	m3.m-3
calc	total carbonate content	%
capiljour	capillary rise upward water flux	mm.d-1
cfes	parameter defining the soil contribution to evaporation versus depth	SD
codecailloux	option to take into account pebbles in the water and N balances (1 = yes, 2 = no,)	code 0/1
codedenit	option to activate the calculation of denitrification model (1 = yes, 2 = no)	code 1/2
codefente	option to activate an additional water compartment for swelling soils (1 = yes, 2 = no)	code 0/1
codemacropor	option to activate calculation of water flux in soil macroporosity (1 = yes, 2 = no)	code 0/1
codenitrif	option to activate nitrification rate model (1 = yes, 2 = no)	code 1/2
coderemontcap	option to activate capillary rise (1 = yes, 2 = no)	code 1/2
codrainage	option to simulate artificial drainage (1 = yes, no = 2)	code 1/2
concseuil	minimum concentration of HNO3 in soil	kg.ha-1 mm-1
CsurNsol0	Initial C to N ratio of soil humus	SD
DAF	bulk density of fine earth fraction in each soil layer	g.cm-3
ecartdrain	distance between mole drains	cm
epc	thickness of each soil layer	cm
epd	thickness of mixing cells in each soil layer (= 2 * dispersion length)	cm
hccf	gravimetric water content at field capacity of each soil layer (/fine earth)	% w
hminf	gravimetric water content at wilting point of each soil layer (/fine earth)	% w
humcapil	threshold of soil gravimetric water content under which capillary rise occurs	% w
infil	infiltrability rate at the base of each soil layer (if codemacropor = 1)	mm.d-1
ksol	soil hydraulic conductivity in the vicinity of mole drains	SD
mulchbat	mulch depth from which a crust occurs (a value must be given but if in the plt.xml the vigueurbat parameter is equal to 1 then the parameter is inactive)	cm

Norg	soil organic N content in the first soil layer (supposed constant down to the depth profhum), equal to total nitrogen (Kjeldahl method)	% dry soil
numsol	soil number	SD
obstarac	soil depth at which root growth is stopped due to physical constraints	cm
penterui	runoff coefficient taking account for plant mulch	SD
pH0	Initial soil pH (water solution)	pH
pluiebat	minimal amount of rain required to create a soil crust (a value must be given but if in the plt.xml the vigueurbat parameter is equal to 1 then the parameter is inactive)	mm.d-1
profdenit	soil depth on which denitrification is active (if codedenit is activated)	cm
profdrain	depth of mole drains	cm
profhum	maximum soil depth with an active biological activity (max.60 cm)	cm
profimper	Upper depth of the impermeable layer (from the soil surface). May be greater than the soil depth.	cm
q0	cumulative soil evaporation above which evaporation rate is decreased	mm
ruisolnu	fraction of runoff (relative to total rainfall) in a bare soil	SD
typecailloux	Pebbles type defined by a volumetric mass value (masvolx) and a field capacity moisture value (HCCCX) only used if codecailloux=1 . (typecailloux= 1:Beauce limestone1, 2:Beauce limestone2, 3:lutecian limestone, 4:Lutetian Brackish marl and limestone,5:Morainic gravels,6:Unweathered flint, sandstone or granite,7:weathered granite,8:Jurassic limestone,9:Pebbles from Magneraud,10:Other pebbles)	SD
typsol	soil type	SD
vpotdenit	potential rate of denitrificaion on profdenit (kg N/ha/day) (2 by default, or fonction of 5*Corg-4)	kg.ha-1.d-1
z0solnu	roughness length of bare soil	m
zesx	maximal soil depth affected by soil evaporation	cm

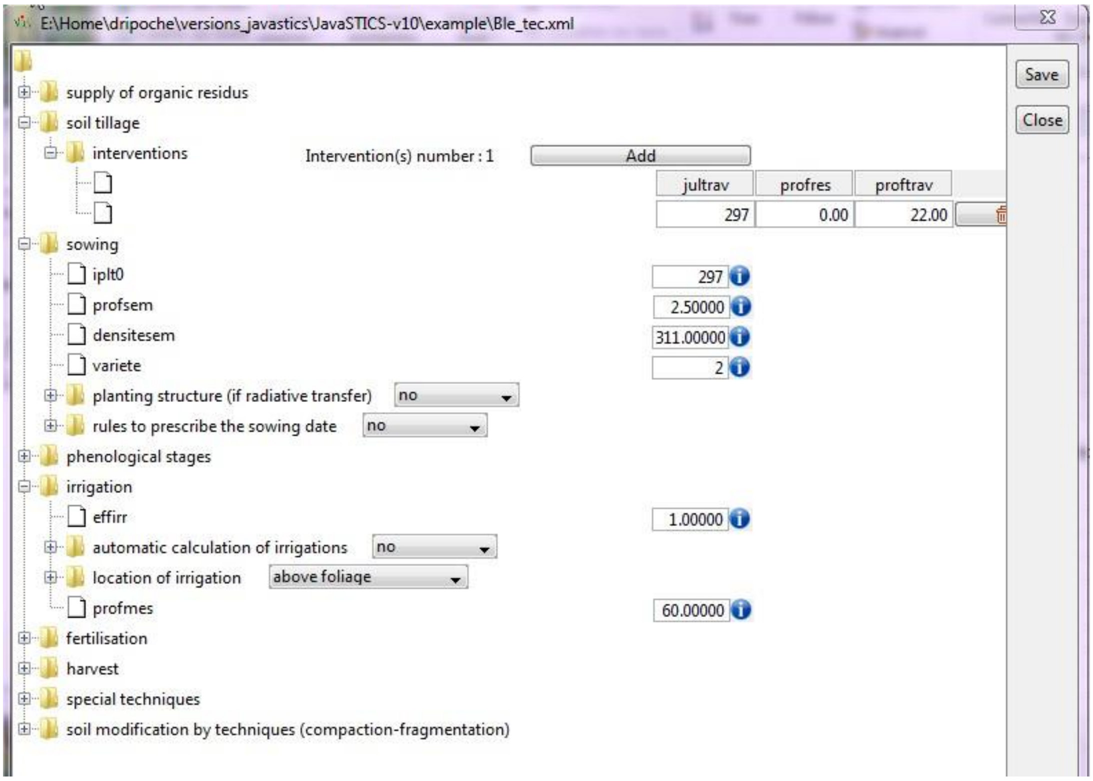
Crop management parameters

The crop management file folows the naming convention ***_tec.xml**. It is located in the workspace directory.

Choose **Model inputs menu → Local parameters → Crop management**. In a newly created working directory, a default **Mais_tec.xml** file has been created.

To create a new crop management parameter file, select the crop management file you want to use as model in the drop-box list, click on **New file** and enter the prefix of the new file, and click OK. A new crop management file is created using the crop management file you selected previously.

To edit or view the crop management file, select the file to view, then click **Open**.



The options and their parameters can be expanded (+) or closed in the tree structure.

The table below lists the crop management parameters:

Table of parameters contained in the crop management files

albedomulchplastique	albedo of plastic cover	SD
anitcoupe	amount of mineral N added by fertiliser application at each cut of a forage crop	kg.ha-1
biorognem	minimal biomass to be removed when topping (automatic calculation)	t.ha-1
cadencerec	number of days between two harvests	d
CNgrainrec	minimal N content of grain at harvest	SD
codabri	option to activate cropping under shelter (1 = no, 2 = yes)	code 1/2
codcaleffeuil	option for the method to use for the calculation of leaf removal (1 = no, 2 =yes)	code 1/2
codcalrogne	option of calculation of tipping (1 = forced topping, 2 = automatic calculation)	code 1/2
codcueille	option of harvest type (1 =single harvest (cutting), 2 = multiple harvests (picking))	code 1/2
codeaumin	option to activate the harvest as a function of grain/fruit water content	code 1/2
codecalirrig	code to activate the automatic calculation of irrigation requirements (1 = yes, 2 = no)	code 1/2
codeclaircie	option for the method of fruit removal (1 = no, 2 = yes for smallest fruits)	code 1/2
codedateappH2O	irrigation application dates given as sum of temperatures (1 = yes, 2 = no)	code 1/2
codedateappN	mineral fertilizer application dates given as sum of temperatures (1 = yes, 2 = no)	code 1/2
codedecirecolte	option to activate moisture and frost effects on harvest decision (1 = yes, 2 = no)	code 1/2
codedecisemis	option to activate the moisture effect on harvest decision (1 = yes, 2 = no)	code 1/2
codeDST	option to activate the variations in soil physical soil conditions due to tillage (1 = yes, 2 = no)	code 1/2
codeDSTnbcouche	number of compacted soil layers (1 = one layer, 2 = two layers)	code 1/2
codeDSTtass	option to activate the soil compaction at sowing and harvest (1 = yes, 2 = no)	code 1/2
codefauche	option to activate cuts of forage crops (1 = yes, 2 = no)	code 1/2
codeffeuil	option to activate thinning (1 = nos, 2 = yes)	code 1/2
codefracappN	option to activate splitting applications of N fertiliser (1 = absolute value, 2 = % of total value)	code 1/2
codemodfauche	option defining the cut mode (1 = automatic calculation depending on phenologic and trophic	code 1/2/3

	state, 2 = pre-established calendar in days, 3 = pre-established calendar in degree-days)	
codepaillage	option: 1 = no cover, 2 = plastic cover partly covering the soil	code 1/2
codepalissage	option defining if the plant is fixed onto a vertical suuport (palissage) (1 = no, 2 =yes)	code 1/2
coderecolteassoc	option to harvest intercrop species simultaneously, at the physiological maturity date of the earliest one (1 = no, 2 = yes)	code 1/2
coderes	residue type: 1=Main crop on surface, 2=Intermediate crop on surface, 3=Manure on surface, 4=Green compost on surface, 5=Sewage sludge on surface, 6=Vinasse on surface, 7=Horn on surface, 8=Grapevine shoots on surface, 9=Others.1 on surface, 10=Others.2 on surface, 11=Main crop ploughed in, 12=Intermediate crop ploughed in, 13=Manure ploughed in, 14=Green compost ploughed in, 15=Sewage sludge ploughed in, 16=Vinasse ploughed in, 17=Cattle horn ploughed in, 18=Grapevine shoots ploughed in, 19=Others.1 ploughed in, 20=Others.2 ploughed in, 21=Dead roots in soil	code 1 to 21
codestade	option to force one or several development stages (1 =yes, 2 = no)	code 1/2
codetaille	option to activate pruning (1 = no, 2 = yes)	code 1/2
codetradtec	description of crop structure with use of radiation transfer (1 =yes, 2 = no)	code1/2
codhauteff	option of leaf removal height (1 = bottom of the canopy, 2 = top of the canopy)	code 1/2
codlocferti	option to code of fertilisation localisation (1 = at soil surface, 2 = in the soil)	code 1/2
codlocirrig	code of irrigation localisation: 1= above the foliage, 2= below the foliage above the soil, 3 = in the soil	code 1/2/3
codrecolte	decision to harvest (1 = physiological maturity, 2 = water content, 3=sugar content, 4=nitrogen content, 5=oil content)	code 1 to 5
codrognage	option of foliage control by trimming (1 = no, 2 = yes)	code 1/2
concirr	concentration of mineral N (NH4+NO3-N) in irrigation water	kg.ha-1 mm-1
couvermulchplastique	fraction of soil covered by the plastic mulch	SD
Crespc	C content in organic residue	% FW
CsurNres	C/N ratio of organic fraction of residue	g.g-1
dachisel	bulk density of soil after soil tillage (Chisel)	g.cm-3
dalabour	bulk density of soil after full inversion tillage (plough)	g.cm-3
darecolte	bulk density of soil after harvest	g.cm-3
dasemis	bulk density of soil after sowing	g.cm-3

densitesem	plant sowing density	plants.m -2
doseI	irrigation amount	mm.d-1
doseirrigmin	minimal amount of irrigation	mm
doseN	daily amount of N added through fertilizers	kg.d-1
dosimx	maximum water amount of irrigation authorised at each time step (mode automatic irrigation)	mm.d-1
eaures	water content of organic residue (relative to fresh weight)	% FW
effeuil	fraction of daily leaf removed at thinning	0-1
effirr	irrigation efficiency	SD
engrais	fertilizer type (1=ammonium nitrate, 2=UAN solution, 3=urea, 4=anhydrous ammonia, 5=ammonium sulfate, 6=ammonium phosphate, 7=calcium nitrate, 8= fixed efficiency fertiliser)	*
fracN	proportion of fertiliser N applied at each application	%
h2ograinmax	maximal water content of fruits at harvest (/fresh matter)	g.g-1 FW
h2ograinmin	minimal water content of fruits at harvest (/fresh matter)	g.g-1 FW
hautcoupe	cut height for forage crops (calendar fixed)	m
hautcoupedefaut	cut height for forage crops (calendar calculated)	m
hautmaxtec	maximal height of the plant allowed by the management	m
hautrogne	cutting height for trimmed plants	m
huilerec	minimal oil content of fruits at harvest (/fresh matter)	g.g-1 FW
iamf	day of the stage AMF (maximal rate of leaf growth, end of juvenile phase) when the stage is observed (else 999)	julian.d
idrp	day of the stage DRP (beginning of grain filling) when the stage is observed (else 999)	julian.d
iflo	day of anthesis	julian.d
ilan	day of the stage LAN () if the stage is observed (else 999)	julian.d
ilax	day of the stage LAX (maximal leaf area index) when the stage is observed (else 999)	julian.d
ilev	day of the stage LEV (emergence) when the stage is observed (else 999)	julian.d
imat	day of the stage MAT (physiological maturity) when the stage is observed (else 999)	julian.d
interrang	width of the crop interrow	m
iplt0	date of sowing	julian.d
irec	date of harvest	julian.d
irecbutoir	latest date of harvest (imposed if the crop cycle is not finished at this date)	julian.d
isen	day of the stage SEN (beginning of net senescence) when the stage is observed (else 999)	julian.d

julapI	date(s) of irrigation	julian.d
julapN	date(s) of fertilizer application	julian.d
juleclair	day of fruits removal	julian.d
juleffeuil	day of leaf removal	julian.d
julfauche	date(s) of each cut for forage crops	julian.d
julouvre2	day (1/2) of opening the shelter	julian.d
julouvre3	day (2/2) of opening the shelter	julian.d
julres	date(s) of organic residue addition to soil	julian.d
julrogne	day of plant trimming	julian.d
jultaille	day of pruning	julian.d
jultrav	date(s) of soil tillage	julian.d
laidebeff	LAI of the beginning of leaf removal	m2.m-2
laieffeuil	LAI removed from the crop at day juleffeuil	m2.m-2
lairesiduel	residual LAI after each cut of forage crop	m2.m-2
largrogne	trimmed width	m
largtec	technical width	m
locferti	soil depth at which fertiliser is applied	cm
locirrig	soil depth at which irrigation is applied	cm
margerogne	topping occurs when plant height exceeds (hautrogne+margerogne) when automatic trimming is activated	m
mscoupemini	minimum value of aerial biomass required to make a cut of forage crop	t.ha-1
msresiduel	residual aerial biomass after a cut of a forage crop	t.ha-1
nbcueille	number of fruit harvestings (1= one at the end, 2 = many during the cycle)	code 1/2
nbinfloecl	number of inflorescences or fruits removed at fruit removal	nb.pl-1
nbjmaxapresrecolte	maximal delay allowed for harvest (number of days) (if the soil compaction option is activated)	d
nbjmaxapressemis	maximal delay allowed for sowing (number of days) (if the soil compaction option is activated)	d
nbjres	number of residue additions	d
nbjseuiltempref	number of days without frost for sowing (if sowing decision option is activated)	d
nbjtrav	number of tillage operations	SD
Nminres	proportion of N mineral content of organic residues (/fresh matter)	% FW
orientrang	direction of crop rows (relative to north)	rad
profhumrecolteuse	soil depth at which moisture is considered to allow harvesting (if soil compaction is activated)	cm
profhumsemoir	soil depth at which moisture is considered to allow sowing (if soil compaction is activated)	cm
profmes	depth of measurement of the soil water reserve	cm
profres	upper depth of organic residue incorporation	cm
profsem	depth of sowing	cm
proftrav	maximum depth of organic residue incorporation	cm

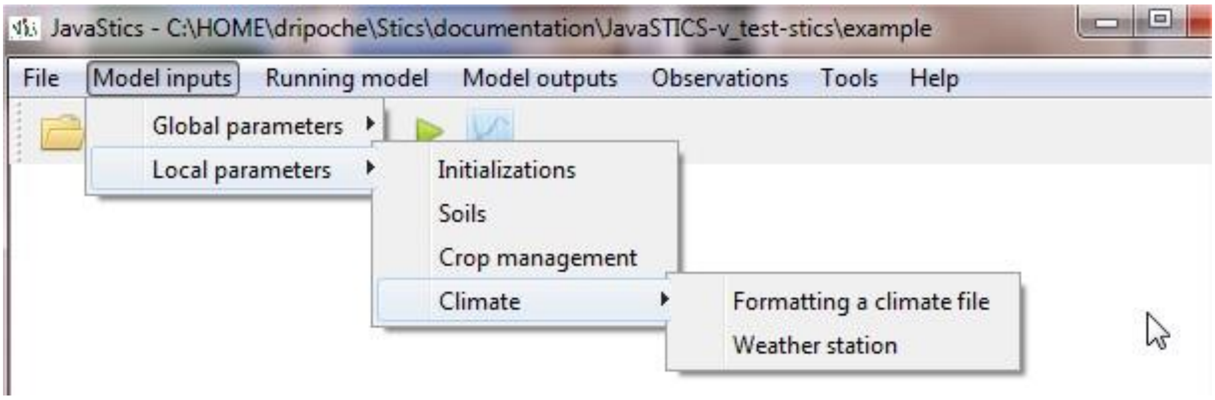
qres	mass of organic residues added to soil (fresh weight)	t.ha-1
Qtot_N	amount of total mineral N fertilizer applications	kg.ha-1
ratiol	water stress index below which irrigation is started in automatic mode (0 in manual mode)	SD
ressuite	type of crop residue (roots or whole_crop or straw+roots or stubble+roots or stubble_of_residu_type_9+roots or stubble_of_residu_type_10+roots ,prunings)	SD
rugochisel	roughness length of bare soil after chisel tillage (if soil compaction is activated)	m
rugolabour	roughness length of bare soil after mouldboard ploughing (if soil compaction is activated)	m
stadecoupedf	stage of automatic cut for forage crops	SD
sucrerec	minimal sugar concentration at harvest (/ fresh matter)	g.g-1 FW
surfouvre1	relative area of the shelter opened the first day of opening	SD
surfouvre2	relative area of the shelter opened the second day of opening	SD
surfouvre3	relative area of the shelter opened the third day of opening	SD
tempfauche	cumulative thermal time between two cuts of forage crops	degree-d
transplastic	transmission coefficient of the plastic shelter	SD
upvttapI	thermal time from emergence (UPVT units) driving irrigation	degreeC
upvttapN	thermal time from emergence (UPVT units) driving fertilization	degreeC
variete	cultivar number corresponding to the cultivar name in the plant file	SD

Climatic data

Climatic data are of two types:

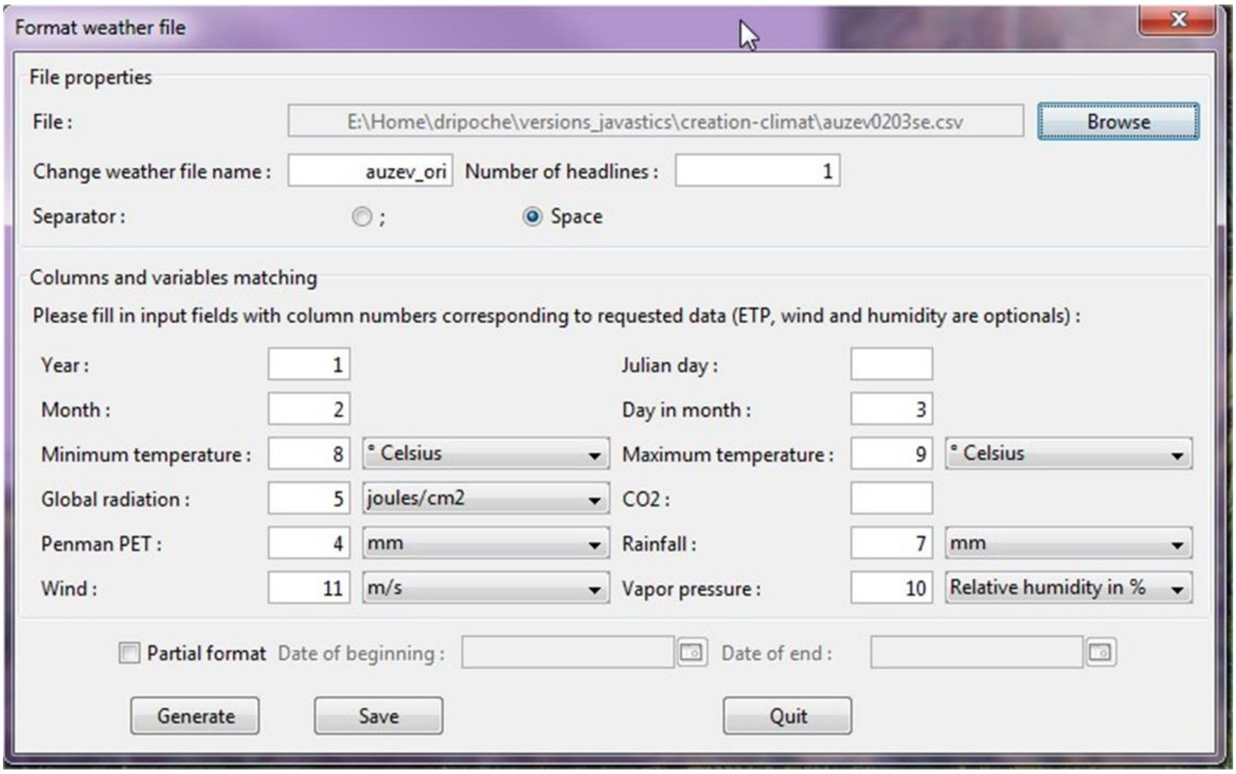
- **parameters:** defined in a weather station file, with the naming convention ***_sta.xml**,
- **Daily meteorological data**: file depending on the weather station.

The Climate submenu gives access to formatting a climate file or opening a wheater station file.



Formatting a climate file

The necessary daily data for the model must be written a specific file format. In order to write it correctly according to STICS format, use the formatting tool **Model inputs** → **Climate** → **Formatting a climate file**.



Select the input file to use by clicking the **Browse** button.

Give a name for the files to be created in the box **Change weather file name**, without any extension. Specify the **Number of headlines** in the source file.

Indicate the columns separator in the file by clicking the appropriate radio button. Only two types of separators are possible: “white space” for fixed format files and “semicolon” for free format files.

To indicate which variables are to be extracted, simply fill in to which column number they correspond in the input file, and also indicate their unit. For example, if the year is in the second column in the original file, then put 2 in the Year field box.
Then, the variables will be transformed having the following format with a space separator and the right units:

column 1: name of weather file
column 2: year
column 3: month
column 4: day in month
column 5: Julian day
column 6: minimum temperature (°C)
column 7: maximum temperature (°C)
column 8: global radiation (MJ.m-2. j-1)
column 9: Penman PET (mm.j-1)
column 10: rainfall (mm.j-1)
column 11: wind (m.s-1)
column 12: vapour pressure (mbars)
column 13: CO2 content(ppm).

Some variables are mandatory: year, month, day in month, minimum temperature, maximum temperature, global radiation, Rainfall.

Penman PET is optional. If Penman PET is not extracted, the value **-999.9** will be written in the output file. Then you will have to give the type of method to calculate PET in the station file (codeetp parameter).

Wind and **Vapor pressure** are also optional. If wind or vapour pressure is not extracted, the value **-999.9** will be written in the output file. But they are mandatory if you choose the “Shuttleworth and Wallace” method or the “Penman calculate” method to calculate PET in the station file (codeetp parameter).

CO2 is also optional. If CO2 values are not extracted, then the default value of **330 ppm** is written in the output file. If you want to use another value, click on the box use CO2 value and enter the value to use. Then all years will be filled with this value.

A climate file in STICS format corresponds to only one calendar year. If your input file contains several calendar years, then JavaStics will create as many output files as there are calendar years in the input file. Each of them will be suffixed with the year; ***. YYYY**.

If you want to extract only **a part of** the input file, then click on the box **Partial format** and give the beginning and end dates of the period to be extracted.

The **Generate button** will generate the output files.

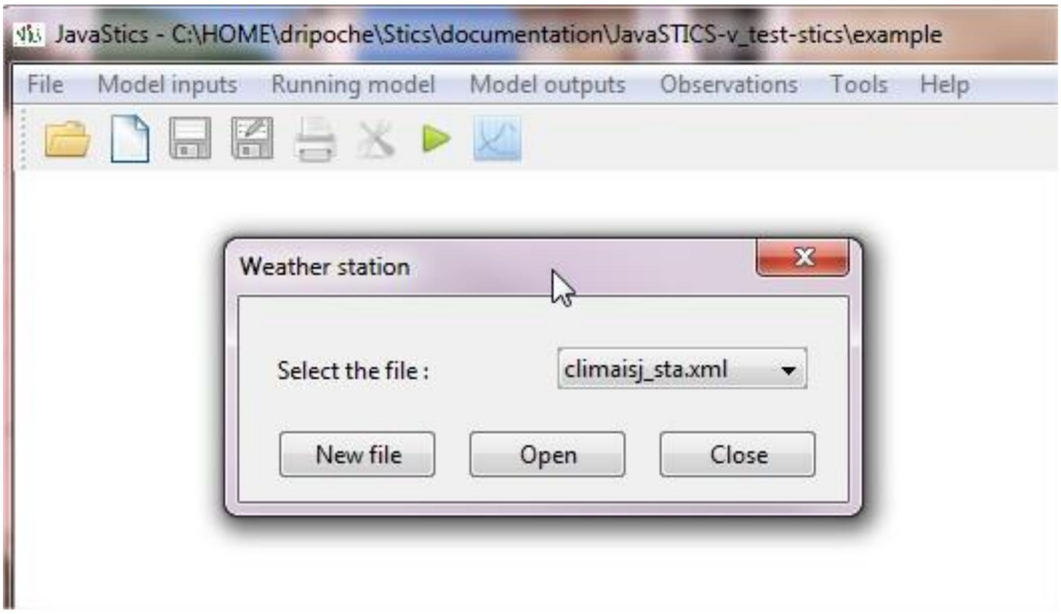
The **Save button** will save the parameterization of the climate file formatting for reusing it later with same kind of input files.

Weather station parameters file

To access to weather station files use **Model inputs → Climate → Weather station**

To create a new weather station file, select the station file you want to use as model in the drop-box list, click the **New file** button, enter a file name prefix, and then click OK. A new station file is created using the station file you selected previously as model.

To edit or view the station file, select the file to view, then click **Open**.



In the view window, the station parameters appear in the form of a tree structure whose branches can be expanded by clicking on the +.

There are two types of parameters:

- **parameters corresponding to options**: in this case, a drop-down list shows the different possible values.
- **The parameters for which a value has to be given**: in this case the value is entered in the box. The  icon calls up help on the parameter: its nature, type (numeric or alphanumeric), unit, bounds, and so on.

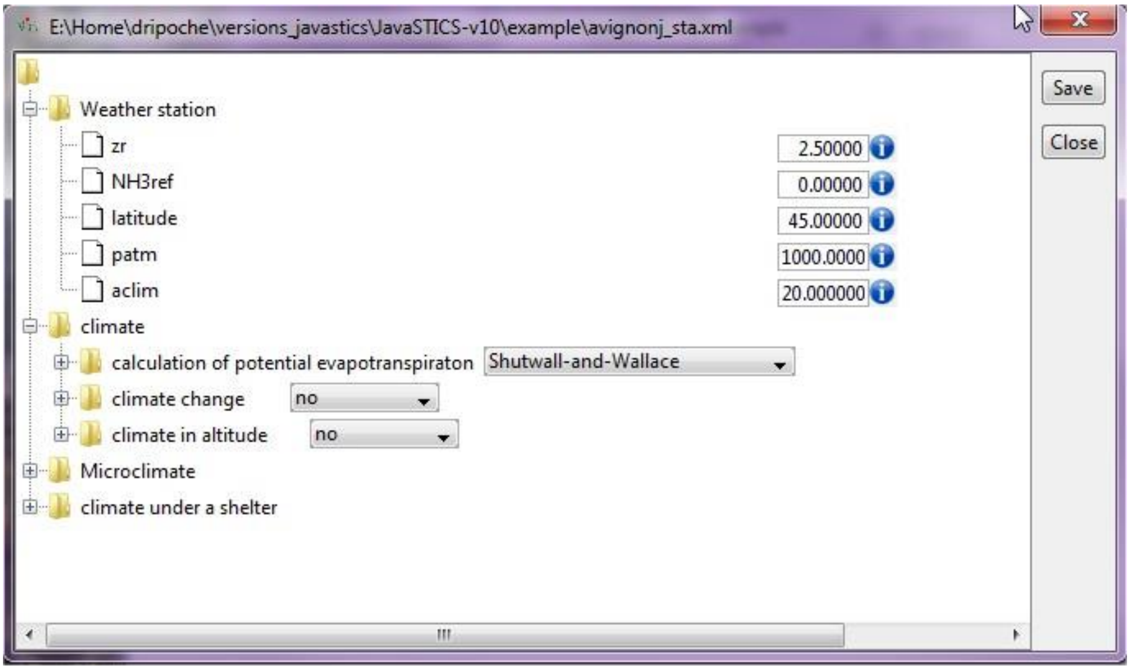


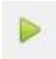
Table of parameters contained in the station files

aclim	climatic component of A to calculate actual soil evaporation	mm
aks	parameter of calculation of the energetic loss between the inside and the outside of a greenhouse	W.m-2.K-1
albveg	albedo of the vegetation	SD
alphapt	parameter of Priestley-Taylor formula	SD
altinversion	altitude of inversion of the thermal gradient	m
altisimul	altitude of simulated site	m
altistation	altitude of the input metorological station	m
bangst	'coefficient of the Angstrom''s relationship for extraterrestrial radiation'	SD
bks	parameter of calculation of the energetic lost between the inside and the outside of a greenhouse	W.m-2.K-1
cielclair	fraction of sunny hours allowing the inversion of thermal gradient with altitude	SD
codadret	option to calculate mountain climate taking into account the orientation (1 = south, 2 = north)	code 1/2
codaltitude	option to activate the calculation of the climate in altitude (1 = no, 2 = yes)	code 1/2
codecaltemp	option to activate the use of crop temperature for phasic development calculation (1 = empirical relation, 2 =energy balance)	code 1/2
codeclichang e	option to activate climate change (1 = no, 2 =yes)	code 1/2

codeetp	option for the method of calculating PET (1 = forced Penman, 2 = calculated Penman, 3= Shuttleworth & Wallace, 4 = Priestley & Taylor)	code 1/2/3/4
codemodlsnow	option for calculating snow variables (1 = Unused, 2 = Unused, 3 = Snow model 3)	code 1 to 3
codernet	'option of calculation of net radiation (1 = Brunt''s method, 2 = Cellier''s method)'	code 1/2
coefdevil	multiplier coefficient of the exterior radiation to compute PET inside of a greenhouse	SD
coefrnet	coefficient of calculation of the net radiation under greenhouse	SD
corecTrosee	temperature to substract to Tmin to estimate dew point temperature (in case of missing air humidity data)	degreeC
cvent	parameter of the climate calculation under the shelter	SD
DKmax	difference between the maximum and the minimum melting rates	mm.degreeC.d-1
E	snow compaction parameter	mm.mm-1.d-1
gradtn	thermal gradient in altitude for minimal temperatures	degreeC.m-1
gradtninv	thermal gradient in altitude for minimal temperatures under the inversion level	degreeC.m-1
gradtx	thermal gradient in altitude for maximal temperatures	degreeC.m-1
Kmin	minimum melting rate on 21 December	mm.degreeC.d-1
latitude	latitude of the site	degree
NH3ref	NH3 concentration in the atmosphere	Âµg.m-3
ombragetx	change in air temperature in the northern hillslope of mountains (activated if codadret=2)	degreeC
patm	atmospheric pressure	mbar
phiv0	parameter allowing the calculation of the climate under shelter	SD
Pns	density of the new snow	kg.m-3
prof	snow cover threshold for snow insulation	cm
ra	aerodynamic resistance (used in volatilization module when we use ETP approach)	s.m-1
SWrf	degree-day temperature index for refreezing	mm.degreeC.d-1
tmaxseuil	maximum temperature when snow cover is higher than prof	degreeC
Tmf	threshold temperature for snow melting	degreeC
tminseuil	minimum temperature when snow cover is higher than prof	degreeC
trmax	tmax above which all precipitation is assumed to be rain	degreeC
tsmax	maximum daily air temperature (tmax) below which all precipitation is assumed to be snow	degreeC
zr	reference height of meteorological data measurement	m

III – Running model: launching simulations

To launch a simulation, you first have to select a unit or units of simulation (USM). Several use cases are possible:

- you can define a single USM with **Running model menu → Create and run single USM** or click the icon 
- simulations can be launched for several independent USMs using **Running model → Run independent USMs**
- simulations can be launched for a crop rotation – that means, several successive USMs that are initialised with the data from the preceding USM. Use **Running model → Run successive USMs**
- one or several USMs can be launched for parameter optimization with **Running model menu → Run parameter optimization**.

IIIa – Running Model: Create and run single USM

The USM selection dialogue box is displayed. It lets you choose among the various simulation options.

In a newly created work directory, an example USM has already been created. It is called **maize**. All you need to do is to modify the parameters of the simulation.

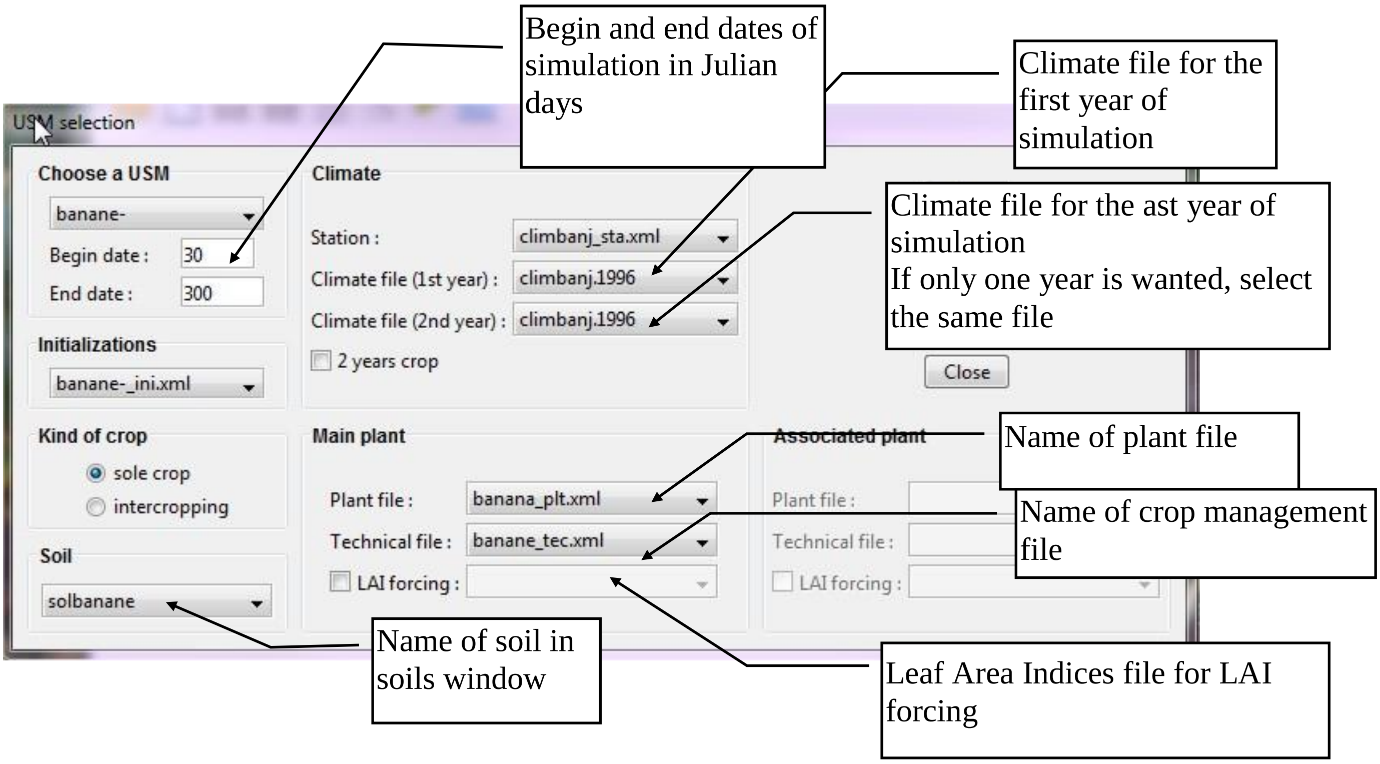
If simulation units have already been created, in **Choose an USM** drop-box list, simply select the USM name you want to use.

The choice of USM simulation options is done in the file selection dialogue box or by directly editing the input areas.
The options let you set the climate files, the type of plant, the crop parameters, the type of soil and the different initial states of the system; and finally the LAI file for forcing values with a daily profile instead of calculating them.

You can also create a new USM (new number in the USM identifier) or delete USMs.
Each USM represents one of the specific simulation options you have defined. A list of these USMs is stored between each call to STICS in the file usms.xml in the work directory.

When the different simulation options have been chosen, they can be saved by clicking Save. They can also be saved in a new USM file by clicking Save as…. Enter a new USM name (maximum of 20 characters). A USM can also be deleted by clicking Remove.

To launch the simulation, Click Run.



The different simulation options correspond to the following parameters:

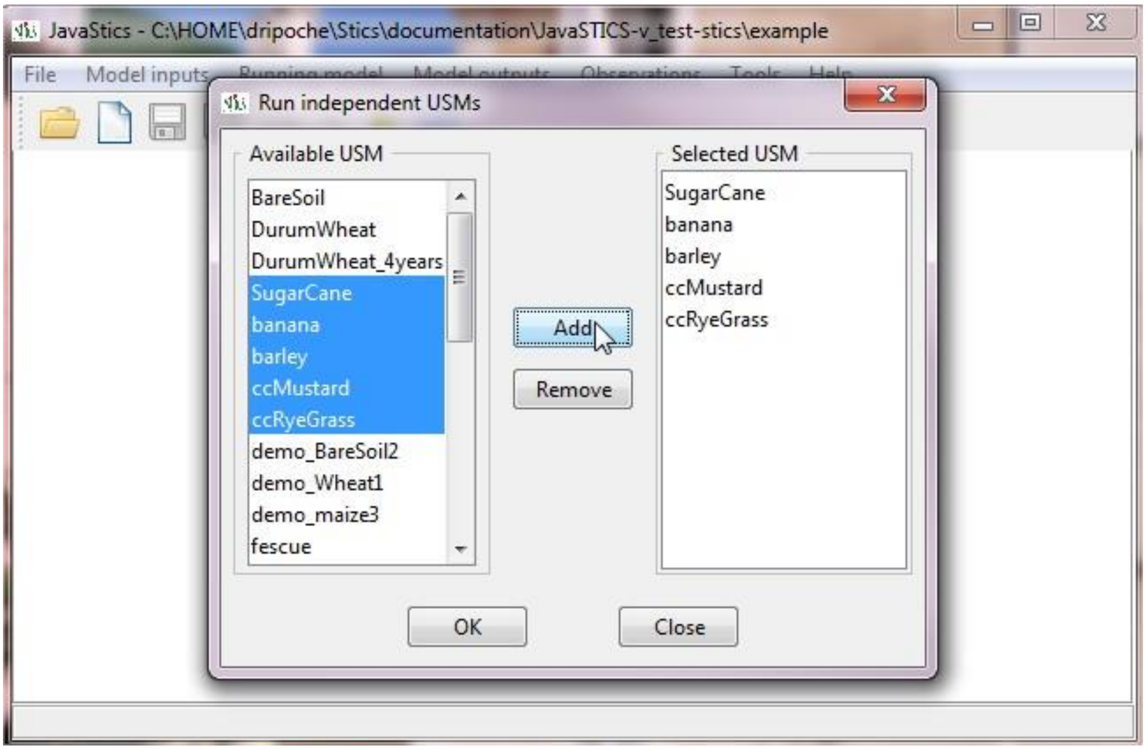
Table of parameters contained in the USM.xml file

Information to fulfill for usm description	parameter name	Signification	Unit
Name of the usm	usm	name of the USM	SD
Initializations	finit	name of the initialization file	SD
Station	fstation	name of the weather station file	SD
Soil	nomsol	name of the soil in the sols.xml file	SD
Begin date	datedebut	day of the beginning of the simulation	julian.d
Ending date	datefin	day of the end of simulation	julian.d
Climate file (1st year)	fclim1	name of the first climate file	SD
Climate file (2nd year)	fclim2	name of the last climate file	SD
2 years crop	culturean	number of calendar years involved in the crop cycle (1 = 1 year e.g. for spring crops, 0 = two years, e.g. for winter crops)	code 1/0
LAI forcing	codesimul	Type of LAI simulation : 0 = culture (LAI calculated by the model), 1 = feuille (LAI forced)	code 0/1
LAI forcing	flai	name of the LAI forcing file (null if none)	SD
Plant file	fplt	name of the plant file for main plant and if intercropping for associated plant	SD
Technical file	ftec	name of the technical file for main plant and if intercropping for associated plant	SD

Information to fulfill for usm description	parameter name	Signification	Unit
Kind of crop	nbplantes	number of simulated plants (sole crop=1; intercropping=2)	SD

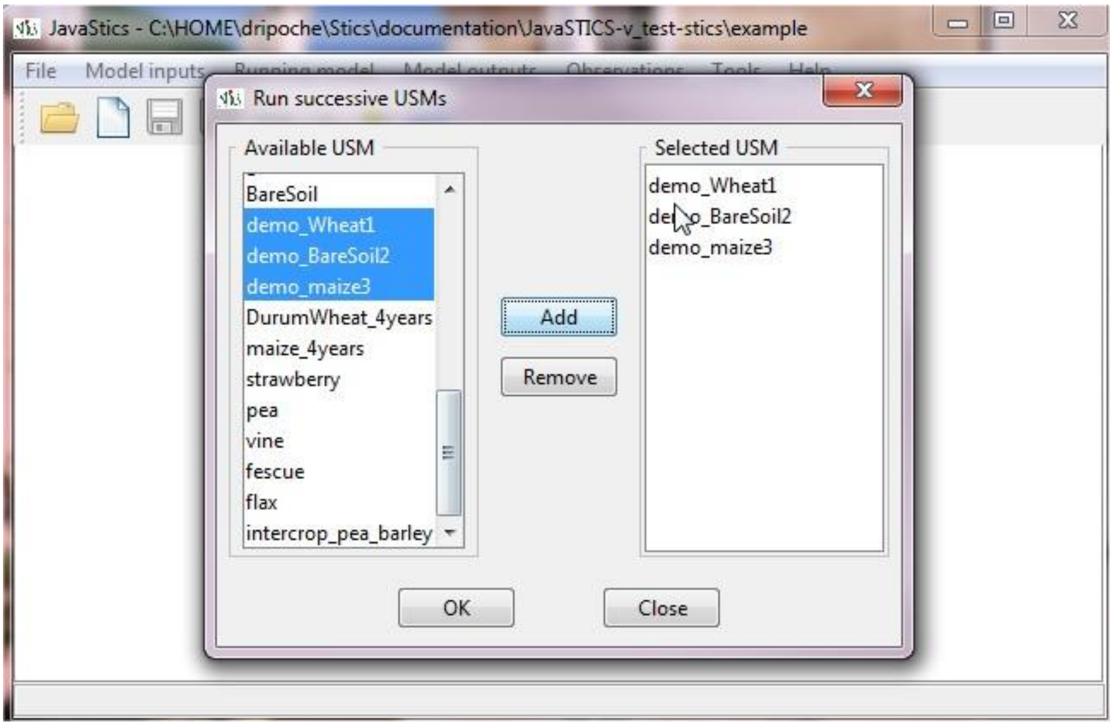
IIIb – Running Model: Run independent USMs

Independent USMs must have been already created with **Running model menu → Create and run single USM**. Then, using **Running model → Run independent USMs**, simply select in available USM list (on the left) those to be used, and then click Add.



IIIc – Running Model: Run successive USMs

Successive USMs must have been already created with **Running model menu → Create and run single USM**, being careful to set correct start and end dates. Then, using **Running model → Run successive USMs**, simply select in available USM list (on the left) those to be used, and then click Add.



<u>Constraints applying to successive simulations</u>:

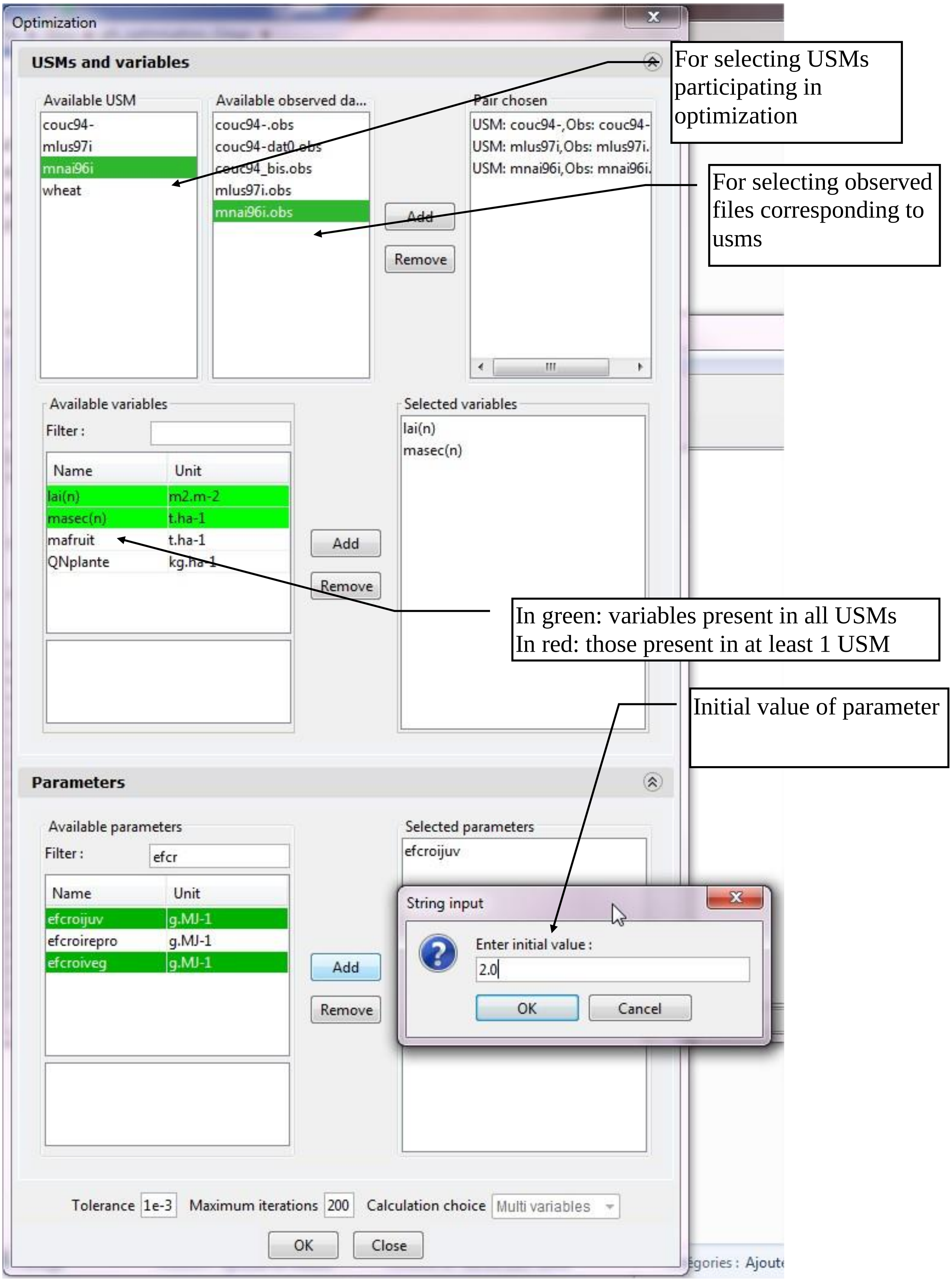
For successive simulations, the end and start day of the simulations need to be consistent between 2 successive USM.
If not, the model will stop running and an error will be logged in the modhistory.sti file (workspace directory).

The succession is done by passing variable values between the different USMs.

These variables are:
end date of the preceding simulation,
system state at the end of the preceding simulation:

- water, mineral nitrogen, and soil temperature profiles
- quantities and C/N ratio of residues
- stocks of organic nitrogen and carbon in the different pools (residues, humus, micro-organisms)

IIId – Running Model: Run parameter optimization



This STICS option lets you key your parameters to your observed-data sets. You can key the parameters of your choice (among those available in the input files) to one or several observed variable(s), existing in the corresponding ***.obs** file. The observation files names must be identical to usm names.
The algorithm used in the calculation is the simplex method based on least squares criterion.

$$f(x) = \sqrt{\frac{\sum_1^{n\_usms} \sum_1^{n\_variables} \sum_{n=1}^{n\_obs} \left(\frac{(x_{observed} - x_{calculated}) * n\_obs}{\sum_1^{n\_obs} x_{observed}} \right)^2}{nb\_obs\_tot}}$$

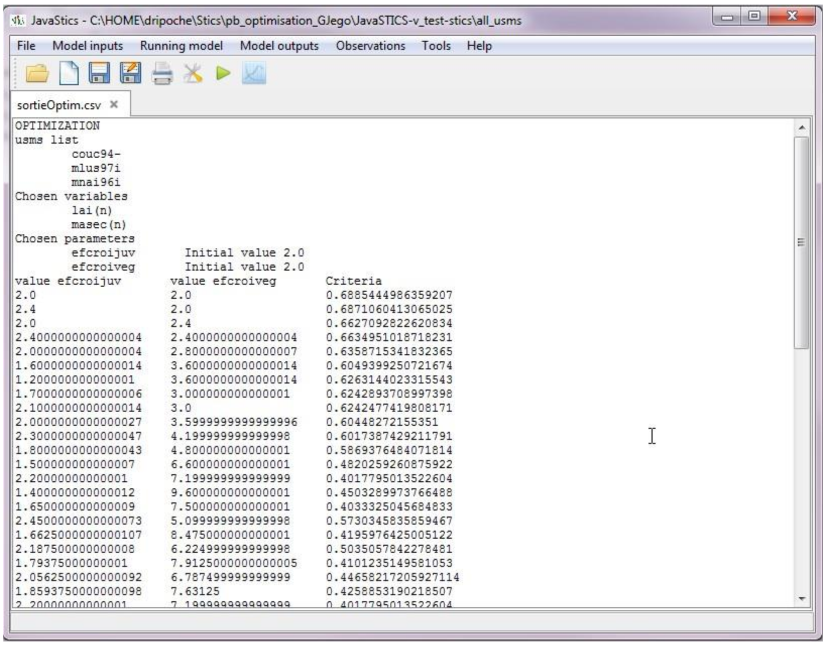
n_obs is the number of observed values for given variable and usm.

STICS gives the possibility of optimizing most of the model parameters according to observed data.
The parameters are those found in the 6 types of input files: general parameters, plant parameters, crop management parameters, soil parameters, station parameters, initialization parameters.

These parameters are specified in the Optimisable parameters appendix and may use bounds specified in each of the parameter files.

The outputs of the optimization are displayed on the screen and saved to the file sortieOptim.csv

Optimization stops when the spread between the criterion of each iteration has reached a minimum of 10^{-4} or after 1,000 iterations.



The output variables to which these parameters are keyed are those found in the daily output files **mod_s[usm].sti** (usm=usm name), and in the corresponding observation files (*.obs).

Warning 1: the parameters files are not modified by the optimization! You have to change the chosen parameter values in the file parameters and run the model to see the results.
Then you can view the results of the optimization using **Model outputs → Dynamic graphics** by comparing the simulated data (**mod_s[usm].sti** file) against the observed data (.obs file).

Warning 2 : if you want optimize together in the same time parameters from 2 plant files, then the 2 plant files must be in the same directory (in the plant directory of the workspace ou in the main plant directory) .

More complete and performing tools exist for optimizing: see part VI.

IIIe – Running Model: what to do when the simulation does not run

If you read the message: "The result file mod_b[usm].sti can't be found", this means that the simulation has failed ([usm]=usm name).
The first thing to do is to look in the history file: **modhistory.sti**, which is a log file giving the parameter values used and warning/error messages concerning the simulation.
This file is overwritten when launching a new simulation.

You can also post a question or look for more help on the STICS forum:
https://w3.avignon.inra.fr/forge/projects/stics_main_projecu/boards

As an overall recommendation, avoid the use of spaces in directory/file names, because it could generate problems with the JavaStics interface or JavaStics command line tool.

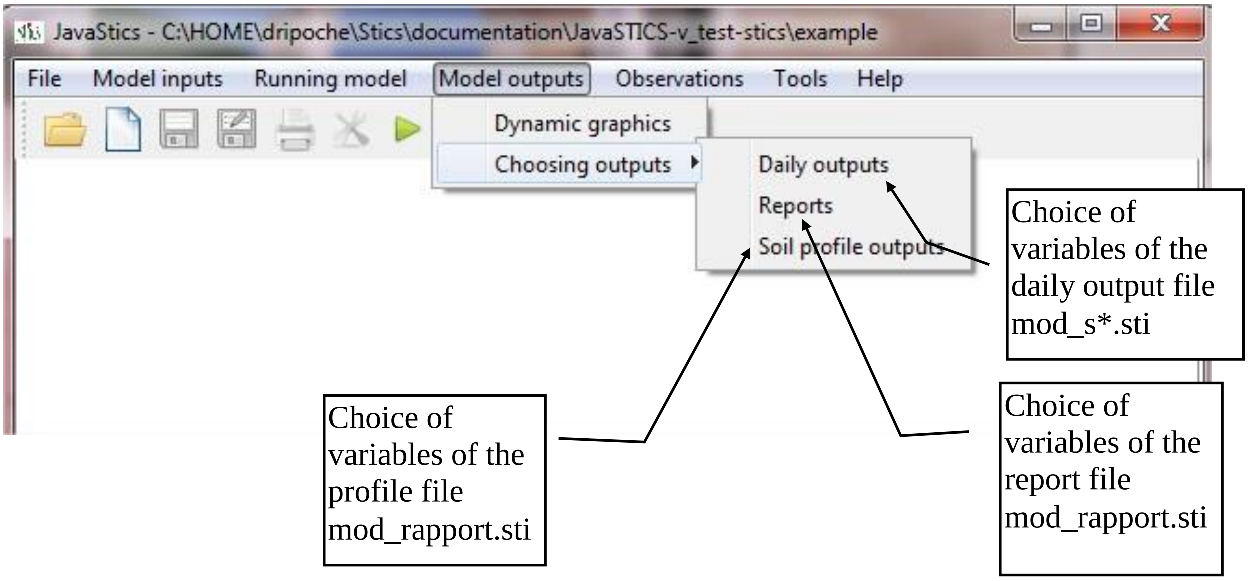
IV – Model outputs

This menu is used for:

- Choosing the type of outputs you want (choice of variables, etc.): **Model outputs → Choosing outputs**
- Viewing your outputs in the form of graphics, **Model outputs → Dynamic graphics**

IVa –Model outputs: Choosing output

This window lets you choose the type of outputs you want (choice of variables or time-step) before launching simulations.



Simulation outputs types are optional in STICS; you generate your own selection of outputs: The types of files are as follows:

- **Balance files**: mod_b'usm'.sti which describe the different stages of the simulated crop and balances.
- **history file**: **modhistory.sti**, which is a log file that gives you the parameter values used and warning or error messages concerning the simulation. This file is overwritten with each new simulation.
- **daily output files**: mod_s[usm].sti, containing the variables chosen within the state variables simulated by the model.
- **report file** (dates and/or stages): mod_rapport.sti, a file that gives a synthesis of the state variables chosen on a line corresponding to a date and/or stage. This file is written in an append mode, so it is incremented by one or several lines by each simulation.
- **profile file** (dates or frequency): profil.sti, which gives you a state variable of temperature or soil humidity along the depth of the soil and for a few chosen dates. This file is overwritten by each new simulation.

The user chooses the desired output files via the **flagecriture** parameter of the param_gen.xml file:

1 = modhistory.sti
2 = daily outputs
4 = report outputs
8 = balance outputs
16 = profile outputs
32 = debug outputs (currently not operational)
64 = screen outputs

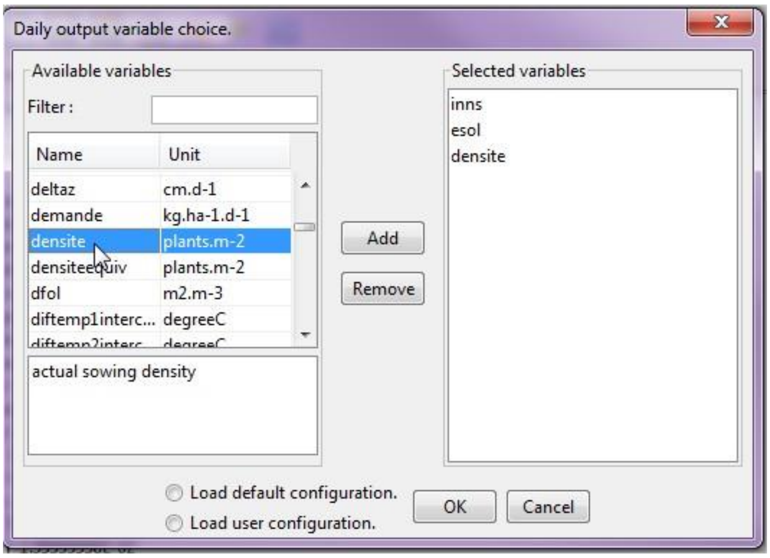
Here are a few standard combinations of outputs files, the resulting **flagecriture** numerical code is the sum of the individual chosen files code.

Value of flagecriture	modhistory.sti	daily outputs	report outputs	balance outputs	profile outputs	debug outputs	screen outputs
	1	2	4	8	16	32	64
1	x						
2		x					
4			x				
8				x			
16					x		
32						X (currently not operational)	
64							x
128							
Some examples							
31(standard outputs)	x	x	x	x	x		
13 (synthesis outputs)	x		x	x			
95 (detailed outputs)	x	x	x	x	x		x
Your outputs…							

The three dialogs for choosing the output variables are as follows and correspond to the three sub-menus of the window above:

Daily outputs: Configuring the daily output file mod_s[usm].sti ([usm]= usm name)

The daily output files mod_s[usm].sti give the daily values of output variables chosen among the 600 variables calculated by the model.
These variables are described in the output variables annex.



The user configuration can be used in each of the output selection dialogue boxes.
It operates as follows: Each time you define a new output configuration, it is used for all the subsequent simulations until you define a new one, and is identified as a user configuration.
Each configuration is specific to the current workspace or simulation directory.
Thus you have access to two configurations – the default configuration, which corresponds to the daily output for a fixed list of variables, and the user configuration, which is the one that is saved each time you Click OK.

You can also load an already existing user configuration or the default configuration again.

Report: configuration of the report file mod_rapport.sti

The file mod_rapport.sti gives the values of the variables you have selected at the dates and/or stages you have chosen.
Three options are possible:

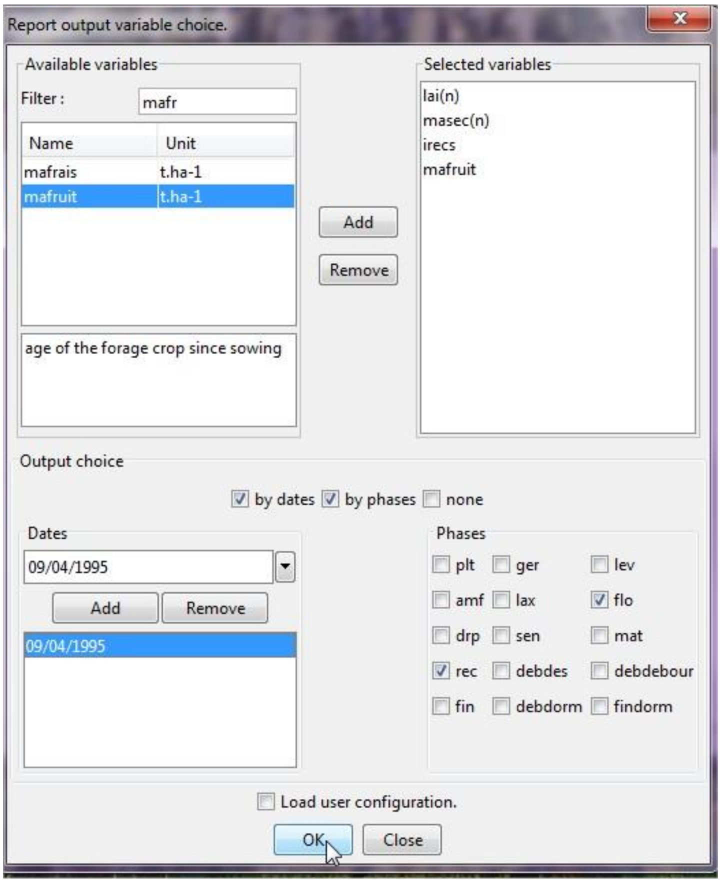
- at fixed dates, in which case you need to enter these dates in the same way as in the profile dialogue box (maximum 20 dates).
- at development stages dates you select by checking boxes.
- Combining the two preceeding options

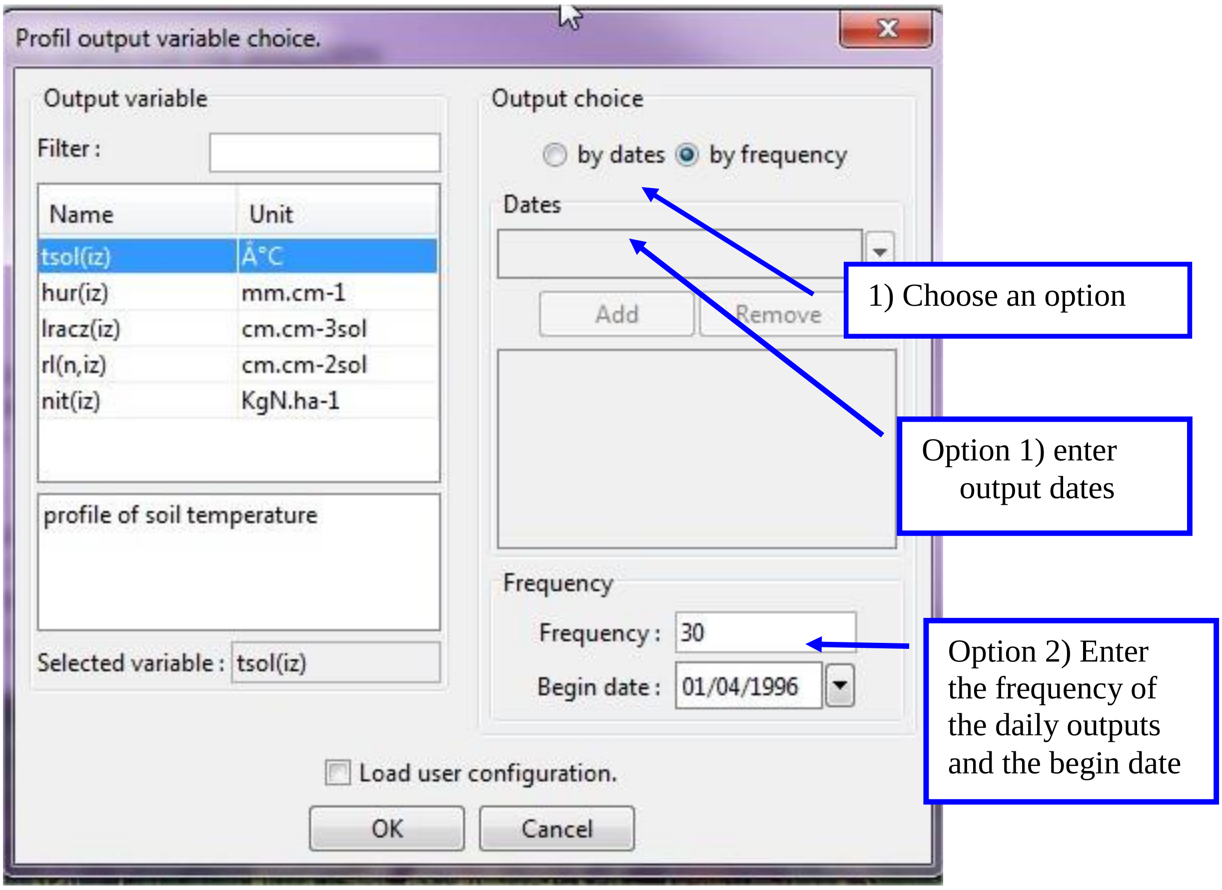
Be aware that this file has a particular status because it is not renewed for each simulation run, so it contains the results of one or several usms simulations until it’s deleted.

Soil profile outputs: The profile file mod_profil.sti

For the outputs in the profile file you may choose among five variables whose values will be given for each cm. of soil on 20 days chosen for the simulation.
You have two possible options for the dates:

- **option 1: At fixed dates, in which case you need to enter these dates (maximum 20 dates).**
- **option 2: At a certain frequency starting with a given date (maximum 20 dates)**





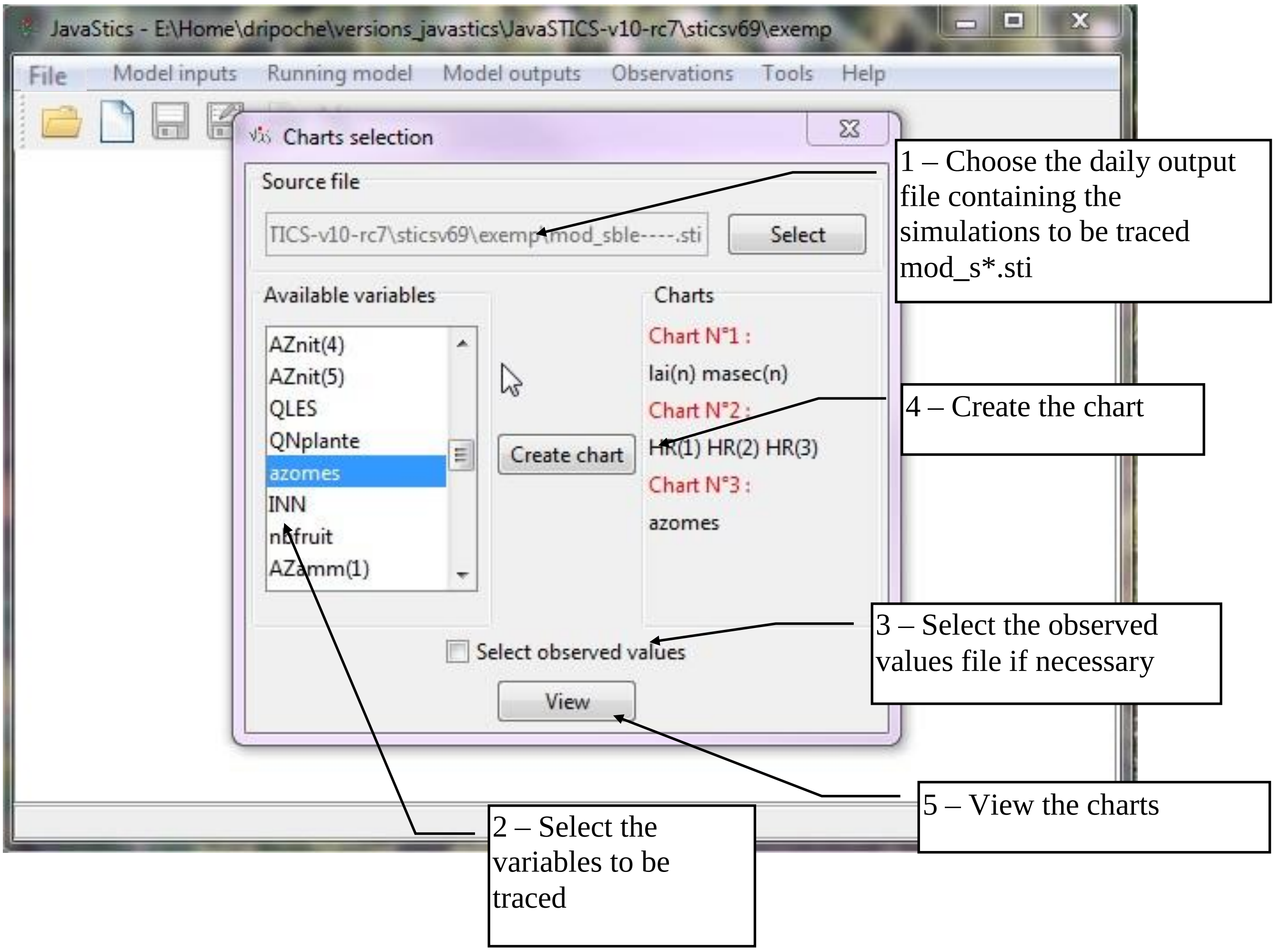
This file, **mod_profil.sti**, is overwritten at each simulation. If you want to keep it, you need to rename it.
The file can be displayed in a spreadsheet or graphics program.
Its format is as follows:

- 1 line for the name of the variable,
- 1 line with the chosen dates,
- 1 line per cm. of soil over 2 m. with the dates in columns.

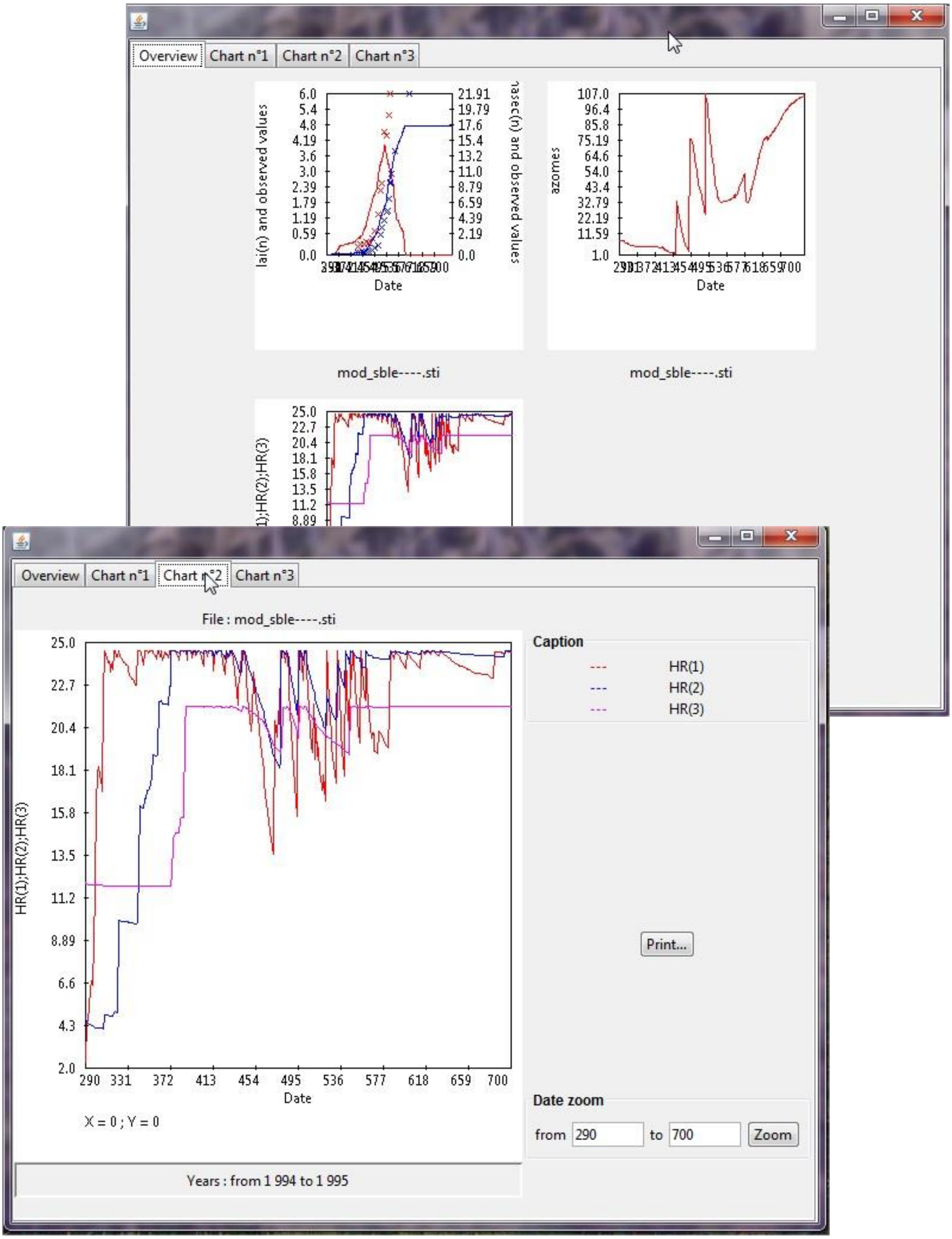
IVb –Model outputs: dynamics graphics

This dialog box lets you create charts (maximum 4 per page).

It can also be opened using the  button.



The display looks like this:

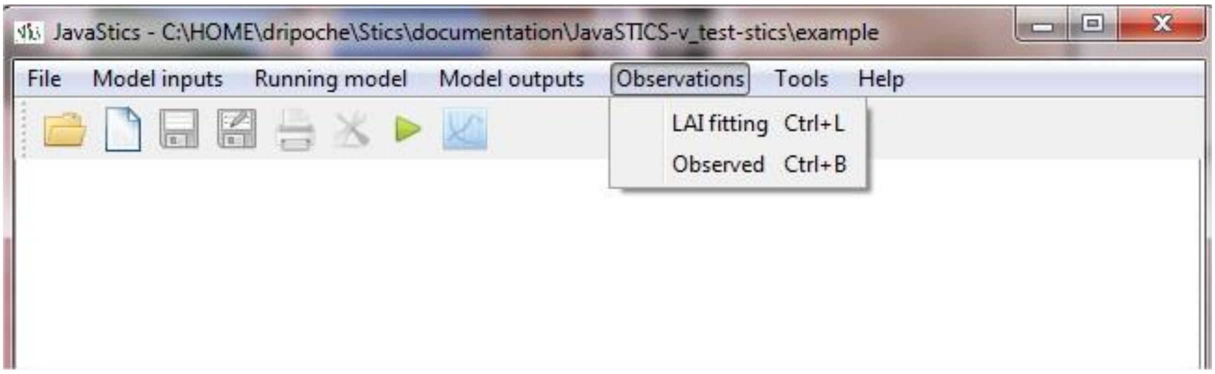


Charts can be printed by clicking the Print… button.
JavaStics lets you display 1 to 2 daily output variables and the corresponding observations (from the .obs file).As many variables as desired can be displayed in a chart, keeping in mind that there is one single scale per chart.

V – Observations

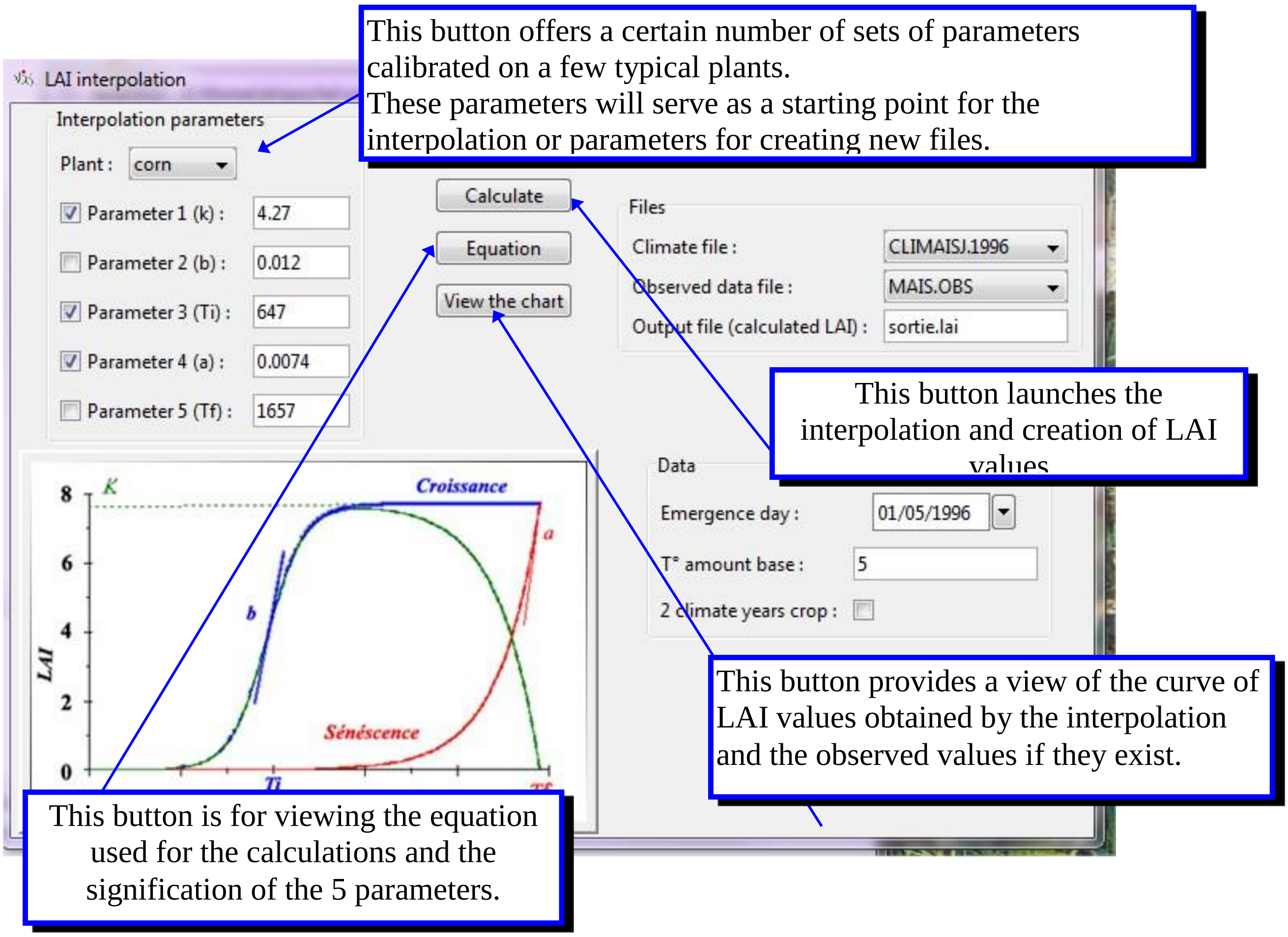
This menu is used for:

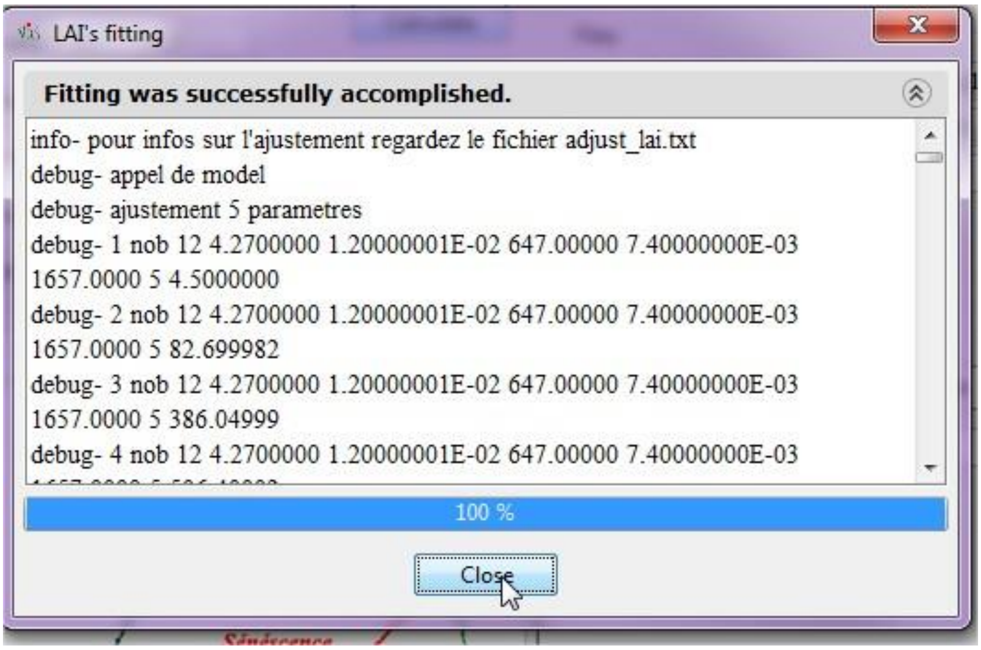
- generating a LAI file from a file containing observed data
- entering observed data in an .obs file (create or edit mode)



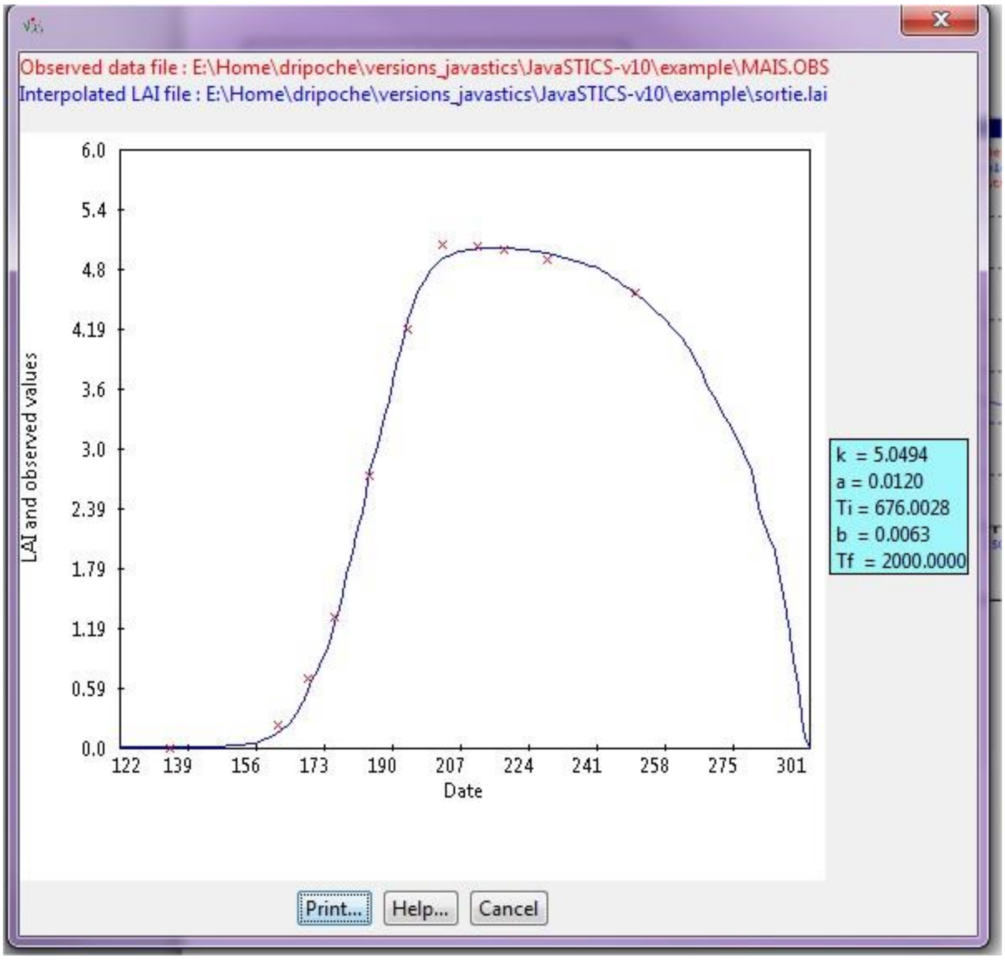
Va –Observations: LAI fitting

This STICS Module generates a continuous file of LAI values.
It can perform an interpolation from a file of observed values that is non-continuous in time.
It can also create a set of LAI values based on the 5 parameters of the LAI curve.
The only possibility at this stage in the development of STICS is creation of the LAI file.





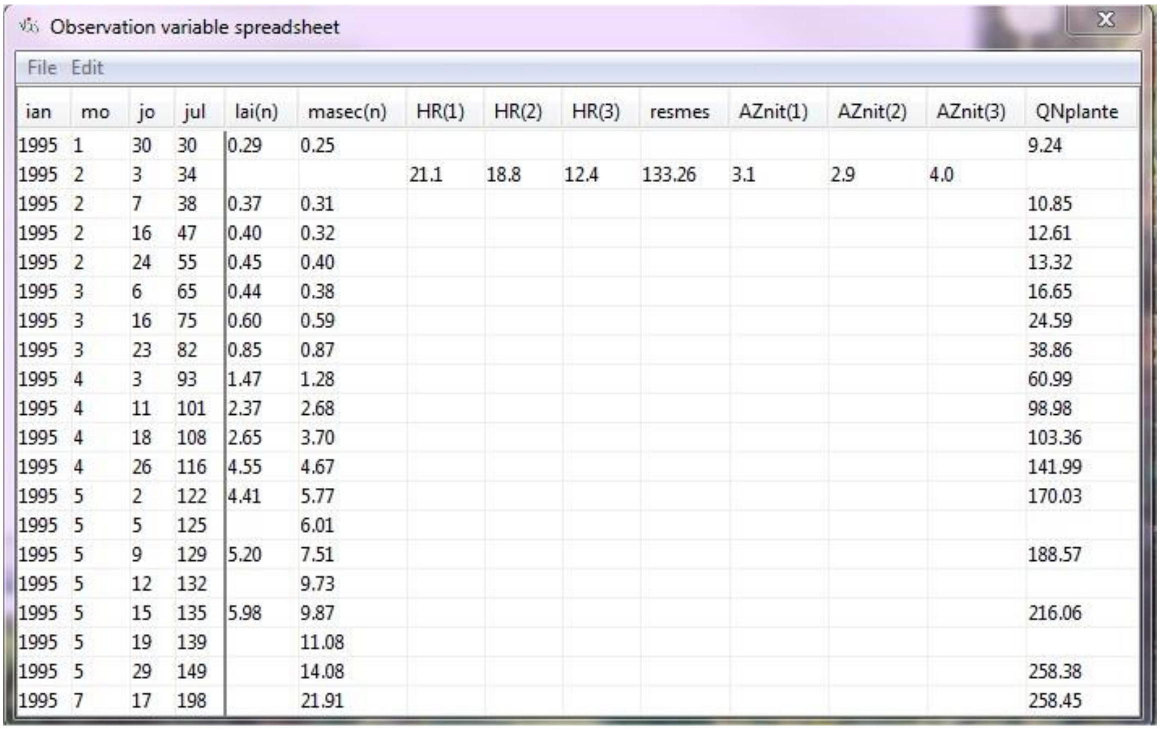
If the calculation is successful, you can call up a graphical display of the interpolation by clicking the View the chart button.



If the calculation seems not to run correctly (the LAI curve shows nothing or shows wrong parameters), you can:
1 - look in the HISTORY.STI file if you have no indications as to the problem.
2 - perform the calculation once imposing the interpolation parameters (don't check the boxes) to try to view the observed data and see if the emergence date and the basis for calculation sums of temperatures is correct.

Vb –Observations: Observed

This sub-menu launches a very simplified spreadsheet. It lets you enter or view observed data. These files, with the .obs extension, are the ones you will be able to compare with the output of your variables calculated by the models and stored at each simulation in the file mod_s*.sti. These files are also the ones that will let you key your parameters in the Optimization menu.



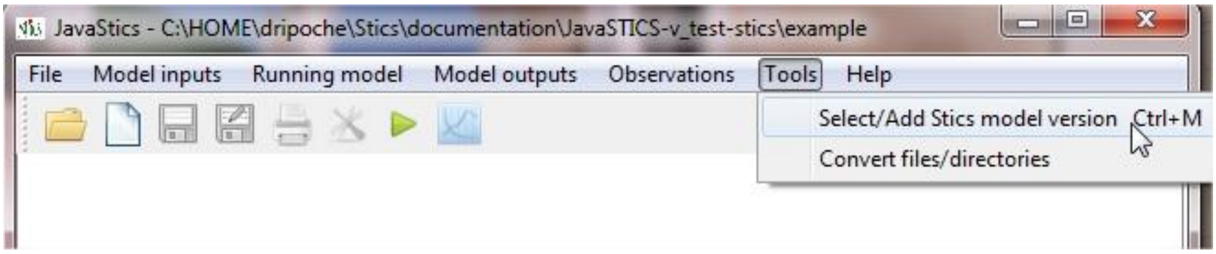
ian	mo	jo	jul	lai(n)	masec(n)	HR(1)	HR(2)	HR(3)	resmes	AZnit(1)	AZnit(2)	AZnit(3)	QNplante
1995	1	30	30	0.29	0.25								9.24
1995	2	3	34			21.1	18.8	12.4	133.26	3.1	2.9	4.0	
1995	2	7	38	0.37	0.31								10.85
1995	2	16	47	0.40	0.32								12.61
1995	2	24	55	0.45	0.40								13.32
1995	3	6	65	0.44	0.38								16.65
1995	3	16	75	0.60	0.59								24.59
1995	3	23	82	0.85	0.87								38.86
1995	4	3	93	1.47	1.28								60.99
1995	4	11	101	2.37	2.68								98.98
1995	4	18	108	2.65	3.70								103.36
1995	4	26	116	4.55	4.67								141.99
1995	5	2	122	4.41	5.77								170.03
1995	5	5	125		6.01								
1995	5	9	129	5.20	7.51								188.57
1995	5	12	132		9.73								
1995	5	15	135	5.98	9.87								216.06
1995	5	19	139		11.08								
1995	5	29	149		14.08								258.38
1995	7	17	198		21.91								258.45

It's possible to add dates and/or variables from among the 600 state variables calculated by the model.
These files are in .csv format (separator ;) and can be generated directly in a spreadsheet. They must contain a header line containing the STICS output variables name

* Notice: be carefull that the **jul** column must contain the day number within the year (between 1 and 365/366), as in daily output files (mod_s*.sti)
The other first 3 columns headers correspond to year (ian), month (mo), day of month (jo)

VI – Tools

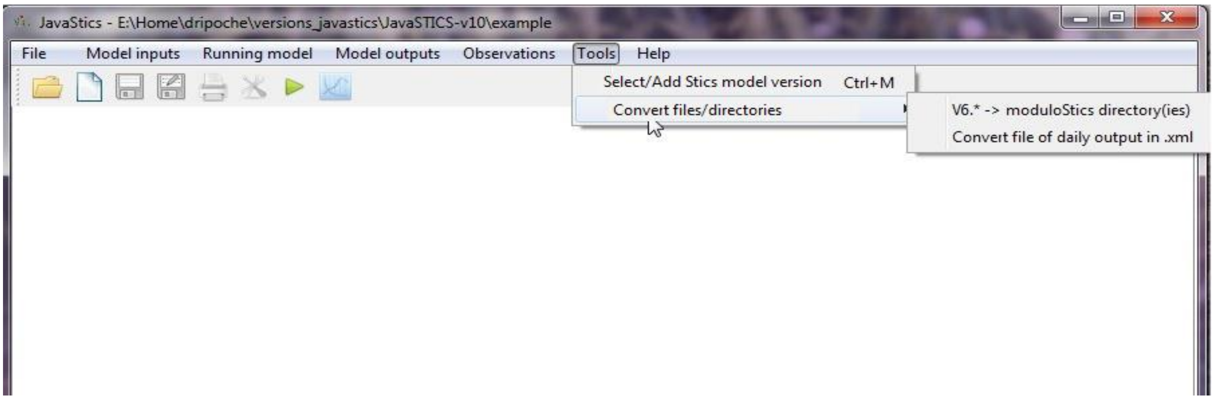
The **Select/Add Stics model version** allows to choose the version of STICS used.
By default only the current version (STICS 8.50, delivered with JavaStics) is available under this item. Users developing their own version of the executable will be able to choose it or add a new one.



In the **Convert files/directories** menu you will find two sub-menus:

- the **V6* -> moduloStics directory(ies)** menu: for reformatting your earlier versions described in the starting paragraph: Updating STICS version 6.X to the STICS v8.50 version.

If you already have an installed 6.9 version and you want to update the input files, the interface provides a sub-menu in Tools for transforming your existing data in the new format (STICS 8.50 with JavaStics format): V6.* → moduloStics directory(ies).

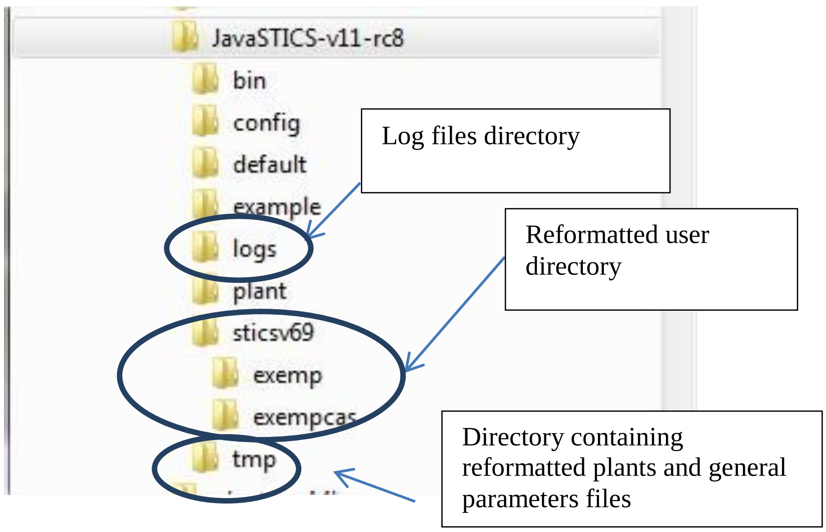


You must provide the access path to your existing STICS directory.

Following files are generated:

- The Plant files, and the general parameters files → in the tmp directory generated at the time of reformatting
- The user directories: (tec, sol, obs, climats, usms) → directory of the same name as your old directory

The description of the formatting process can be found in the file translate-tool-log.txt (switch parameters) of the logs directory.

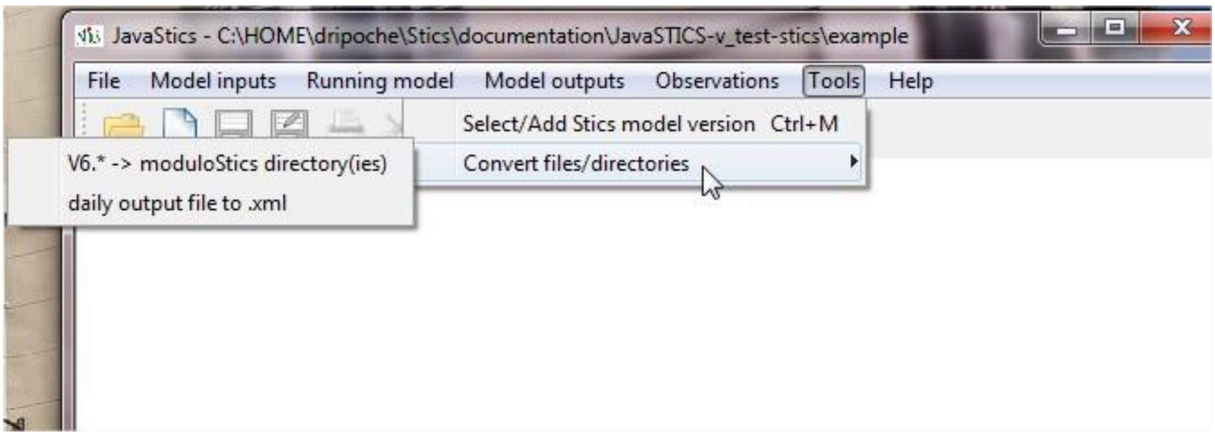


New plant files are provided in the plant directory and new general parameters files in the config directory.

Your plant files and general parameters will be taken into account by the interface if you copy them in the root directory of your formatted workspace – in the example a plant directory under sticsv69 for the plant files, and directly under the root of your workspace for the general parameters file.

Files can be updated individually. To do that, create an equivalent 6.9 workspace directory. It must contain a param.par file version 6.9, and a sub-directory containing your files (tec, sol, usm or climats) that you intend to update.
They will be converted in the same way as a complete directory.

- **daily output to .xml** sub-menu: for converting your output files (mod_s*.sti) to XML files format.



VII – External tools for analyzing/evaluating the model performances

OptimiStics

OptimiSTICS toolbox, developed under the Matlab environment is providing several methods for parameters estimation including the simplex method used in JavaStics. But, it also includes tools for sensitivity analysis based on multisimulations.
(http://www4.paca.inra.fr/emmah/Production-Documentation/Outils-et-modeles/MultiSimLib-OptimiSTICS).

R tools

A new STICS tool is available for download as a package archive **SticsEvalR** beside JavaStics distribution archive on STICS project forge
(https://w3.avignon.inra.fr/forge/projects/stics_main_projecv/files)

This package uses the XML package which must be installed from CRAN servers.

It provides for the moment only evaluation and evaluations comparison functions for STICS simulations results against observations data.

There package also contains tools functions for removing observations from files and for reducing evaluation output table.

VII – Additionnal documentations

Additional documentations are available :

- in the **doc** directory of JavaStics. They describe some specific formalisms added in the Stics lastest versions:

  - Documentation_N2O_formalism _STICS.html to describe nitrification, denitrification and N2O emissions

  - Documentation_Formalismes_Prairies_STICS.pdf to describe the grasslands specific formalisms (perennial crops harvested partially by cutting or grazing)

  - Documentation_snow_formalism _STICS.html to describe how a snow cover is simulated

  - Documentation_mineralization_formalism_STICS.html to describe the new functions of humus mineralization

- in the Stics forge :

- Adaptation to new crops : https://w3.avignon.inra.fr/forge/documents/36

Sorry but some of them are only in French by lack of time .

APPENDICES

Dates in STICS

The dates in the STICS input files are all in Julian days (between 1 and 731) – that is, calculated from 1 January of the year of the start of the simulation.

You can calculate it quickly using the table included here:

Non-Leap Year

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1	32	60	91	121	152	182	213	244	274	305	335
2	2	33	61	92	122	153	183	214	245	275	306	336
3	3	34	62	93	123	154	184	215	246	276	307	337
4	4	35	63	94	124	155	185	216	247	277	308	338
5	5	36	64	95	125	156	186	217	248	278	309	339
6	6	37	65	96	126	157	187	218	249	279	310	340
7	7	38	66	97	127	158	188	219	250	280	311	341
8	8	39	67	98	128	159	189	220	251	281	312	342
9	9	40	68	99	129	160	190	221	252	282	313	343
10	10	41	69	100	130	161	191	222	253	283	314	344
11	11	42	70	101	131	162	192	223	254	284	315	345
12	12	43	71	102	132	163	193	224	255	285	316	346
13	13	44	72	103	133	164	194	225	256	286	317	347
14	14	45	73	104	134	165	195	226	257	287	318	348
15	15	46	74	105	135	166	196	227	258	288	319	349
16	16	47	75	106	136	167	197	228	259	289	320	350
17	17	48	76	107	137	168	198	229	260	290	321	351
18	18	49	77	108	138	169	199	230	261	291	322	352
19	19	50	78	109	139	170	200	231	262	292	323	353
20	20	51	79	110	140	171	201	232	263	293	324	354
21	21	52	80	111	141	172	202	233	264	294	325	355
22	22	53	81	112	142	173	203	234	265	295	326	356
23	23	54	82	113	143	174	204	235	266	296	327	357
24	24	55	83	114	144	175	205	236	267	297	328	358
25	25	56	84	115	145	176	206	237	268	298	329	359
26	26	57	85	116	146	177	207	238	269	299	330	360
27	27	58	86	117	147	178	208	239	270	300	331	361
28	28	59	87	118	148	179	209	240	271	301	332	362
29	29		88	119	149	180	210	241	272	302	333	363
30	30		89	120	150	181	211	242	273	303	334	364
31	31		90		151		212	243		304		365

Leap Year

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1	32	61	92	122	153	183	214	245	275	306	336
2	2	33	62	93	123	154	184	215	246	276	307	337
3	3	34	63	94	124	155	185	216	247	277	308	338
4	4	35	64	95	125	156	186	217	248	278	309	339
5	5	36	65	96	126	157	187	218	249	279	310	340
6	6	37	66	97	127	158	188	219	250	280	311	341
7	7	38	67	98	128	159	189	220	251	281	312	342
8	8	39	68	99	129	160	190	221	252	282	313	343
9	9	40	69	100	130	161	191	222	253	283	314	344
10	10	41	70	101	131	162	192	223	254	284	315	345
11	11	42	71	102	132	163	193	224	255	285	316	346
12	12	43	72	103	133	164	194	225	256	286	317	347
13	13	44	73	104	134	165	195	226	257	287	318	348
14	14	45	74	105	135	166	196	227	258	288	319	349
15	15	46	75	106	136	167	197	228	259	289	320	350
16	16	47	76	107	137	168	198	229	260	290	321	351
17	17	48	77	108	138	169	199	230	261	291	322	352
18	18	49	78	109	139	170	200	231	262	292	323	353
19	19	50	79	110	140	171	201	232	263	293	324	354
20	20	51	80	111	141	172	202	233	264	294	325	355
21	21	52	81	112	142	173	203	234	265	295	326	356
22	22	53	82	113	143	174	204	235	266	296	327	357
23	23	54	83	114	144	175	205	236	267	297	328	358
24	24	55	84	115	145	176	206	237	268	298	329	359
25	25	56	85	116	146	177	207	238	269	299	330	360
26	26	57	86	117	147	178	208	239	270	300	331	361
27	27	58	87	118	148	179	209	240	271	301	332	362
28	28	59	88	119	149	180	210	241	272	302	333	363
29	29	60	89	120	150	181	211	242	273	303	334	364
30	30		90	121	151	182	212	243	274	304	335	365
31	31		91		152		213	244		305		366

A. The option codes

The table is present in this link : https://w3.avignon.inra.fr/forge/documents/88

General parameters (param_gen.xml) → new options in red

group	Option Name level 1	Code Name	val	nom	parameter's option	option name level 2	Code Name	val	nom	parameter's option
Simulation options	Nitrogen stress activation	codeinnact	1	yes						
			2	no						
	Water stress activation	codeh2oact	1	yes						
			2	no						
	Optimum mineralisation in bare soil	codeminopt	1	yes						
			2	no						
	Smoothing of initial profiles	iniprofil	1	yes						
			2	no						
	Depth for mineral N and water stocks calculation	codeprofmes	1	profmes						
			2	profsol						
	Climatic series	codeinitprec	1	reset						
			2	succession						
	Biomass and yield conservation after harvest	codemsfinal	1	yes						
			2	no						
	Take account of mulch (drying out of soil surface)	codeactimulch	1	yes						
			2	no						
	Fruit load	codefrmur	1	all fruits (including ripe ones)						
			2	growing fruits only						
	Hourly microclimate	codemicheur	1	yes						
			2	no						
	Scientific writing in st2 and report	codeoutscien	1	yes						
			2	no						
	Separator spaces in report	codeseprapport	1	yes	separateurrapport					
			2	no						
	Activation of model sensitivity analysis	codesensibilite	1	yes						
			2	no						
	Snow activation	codesnow	1	yes						
			2	no						

Water absorption and nitrogen content of the plant	Nitrogen fixation by legumes	codesymbiose	1	critical nitrogen						
			2	nodule activity		mineral nitrogen inhibition	codefxn	1	noeffect	
								2	nitrogen amount	
								3	nitrogen concentration	
Nitrification, denitrification and associated N2O emissions	Nitrification rate dependence on NH4	code_vnit	1	Linear	fnx					
			2	Michaelis_Menten	vnitmax, Kamm					
	Temperature function for nitrification	code_tnit	1	piecewise linear	tnitmin, tnitopt, tnitopt2, tnitmax					
			2	Gaussian	tnitopt_gauss , scale_tnitopt					
	Nitrification N20 ratio	code_rationit	1	constant	rationit					
			2	variable						
	Hourly WFPS calculation for nitrification	code_hourly_wfps_nit	1	yes						
			2	no						
	Denitrification potential	code_pdenit	1	Soil parameter						
			2	Soil carbon dependent	cmin_pdenit, cmax_pdenit, min_pdenit, max_pdenit					
	Denitrification N20 ratio	code_ratiodenit	1	constant	ratiodenit					
			2	variable						
	Hourly WFPS calculation for denitrification	code_hourly_wfps_denit	1	yes						
			2	no						
Soil hydrology and compaction	calculation of groundwater if drainage	codhnappe	1	average						
			2	interdrain localisation	distdrain					distdrain

Param newform parameters

group	Option Name level 1	Code Name	val	nom	parameter's option	option name level 2	Code Name	val	nom	parameter's option
Specificities of cut crops	reference thermal time to compute cutting dates	codetempfauche	1	in upvt						
			2	in udevair						
Specificities of Quinoa	Option to replace rainfall by irrigation at hole depth in the case of hole sowing	codepluiepoquet	1	yes	nbjoursrrversirrig					
			2	no						
Activation of the module simulating tiller dynamics	Activation for the main crop	codedyntalle(1)	1	yes	SurfApex(1), SeuilMorTalle(1), SigmaDisTalle(1), VitReconsPeupl(1), SeuilReconsPeupl(1), MaxTalle(1), SeuilLAapex(1), tigefeuilcoupe(1)					
			2	no						
	Activation for the associated crop	codedyntalle(2)	1	yes	SurfApex(2), SeuilMorTalle(2), SigmaDisTalle(2), VitReconsPeupl(2), SeuilReconsPeupl(2), MaxTalle(2), SeuilLAapex(2), tigefeuilcoupe(2)					
			2	no						
Calculation of the stem elongation stage for perenial grasslands	Activation for the main crop	codemontaison(1)	1	yes						
			2	no						
	Activation for the associated crop	codemontaison(2)	1	yes						
			2	no						
Fertilisation driving	Automatic calculation of fertilisation requirements	codecalferti	1	yes	ratioN, dosimxN,	soil moisture test	codetesthumN	1	minimum rainfall threshold	
			2	no				2	soil moisture threshold	
Residues decomposition	Limitation of N availability for residues decomposition in soil	codeNmindec	1	yes	rapNmindec, fNmindecmin					
			2	no						
coupling with pathogen models	calculation of hourly dew temperature	codetrosee	1	linear interpolation(actual calculation)						
			2	sinusoidal interpolation (Debele Bekele et al.,2007)						
	calculation of surface wetness duration	codeSWDRH	1	yes						
			2	no						
automatic irrigations (associated with the options of automatic irrigation in tec file)	dates to drive automatic irrigations	P_codedate_irrigauto	1	dates	datedeb_irrigauto, datefin_irrigauto					
			2	stages	stage_start_irrigauto, stage_end_irrigauto					
			3	no						

calculation of the root death at cutting date for grasslands	choice for dry matter	codemortalracine	1	masec		
			2	masectot		
option for several thinning (associated with the option thinning in the tec file)	activation of several thinning	option_thinning	1	yes		
			2	no		
option for several fertilizer type (associated with the option fertilisation in the tec file)	activation of several fertilizer type	option_engrais_multiple	1	yes		
			2	no		
option for pasture	activation of pasture	option_pature	1	yes	coderes_pature, pertes_restit_ext, Crespc_pature, Nminres_pature, eaures_pature, coef_calcul_qres, engrais_pature, coef_calcul_doseN	
			2	no		
option to activate the new functions of mineralization for organic matter	New mineralization of soil organic matter	codemineralOM	1	yes	gmin1,gmin2,gmin3,gmin4,gmin5,gmin6,gmin7	
			2	no		
special outputs AgMIP/Macsur (optional in the file)	specific project	type_project	1	nothing		
			2	AgMIP		
			3	Macsur		
	sowing rules wheat3 activation	rules_sowing_AgMIP	1	yes		
			2	no		
	report specific outputs	Flag_Agmip_rap	1	AgMIP Wheat		
			2	AgMIP Wheat Giacomo (HSC)		
			3	wheat Canopy temp		
			4	face_maize		
			5	new wheat3		
			6	ET		
			7	Wheat phase4		
			8	LowInputs_SmallFarmers		

Plant parameters

group	Option Name level 1	Code Name	val	nom	parameter's option	option name level 2	Code Name	val	nom	parameter's option
plant name and clade	plant name and clade	codeplante	char							
	monocot or dicot	codemonocot	1	monocotyledon						
			2	dicotyledon						
Phasic development	driving temperature	codetemp	1	air temperature		time.scale	codegdh	1	daily.scale	
								2	hourly.scale	
			2	temperature within canopy	coeflevamf, coefamflax, coeflaxsen, coefsenlan, coeflevdrp, coefdrpmat, coefflodrp					
	photoperiodic plant	codephot	1	yes	phobase,phosat					
			2	no						
	delay effect of stress	coderetflo	1	yes	stressdev					
			2	no						
	cold requirements	codebfroid	1	no						
			2	vernalisation	jvcmini,julvernal,tfroid,ampfr					
			3	dormancy (woody)	stdordebour, tdmindeb, tdmaxdeb	dormancy calculation	codedormance	1	forcing	ifindorm
								2	Richardson	
								3	Bidabe	q10,idebdorm
						post dormancy calculation	codegdhdeb	1	daily temperatures	
								2	hourly temperatures	
Emergence and starting	annual or perennial	codeperenne	1	annual		germination or latency	codegermin	1	yes	tgmin,stpltger,potgermi,nbjgerlim, propjgermin
								2	no	
						plantlet growth	codehypo	1	hypocotyle growth	belong,celo,ng,elmax,nlevlim1,nlevlim2,vigueurbat
								2	planting	laiplantule,nbfeuilplant,masecplantule,zracplantule
			2	perennial						
leaves	leaf dynamics	codelaitr	1	LAI	vlaimax, pentlaimax, udlaimax, ratiodurviel, tcmin, tcmax, ratiosen, abscission, parazofmorte, innturgmin, dlaimin	LAI calculation option	codlainet	1	direct LAInet	dlaimax,tustressmin
								2	LAInet=LAIbrut-senes	dlaimaxbrut,durviesupmax,innsen, rapsenturg
						effect of photoperiod on senescence	codestrphot	1	yes	phobasesen,dltamsmaxsen,dltamsminsen,alphaphot
								2	no	
			2	ground cover	tauxrecouvmax,tauxrecouvkmax,pentrecouv,infrecouv					
radiation interception	radiation interception	codetransrad	1	Beer's law	extin					
			2	radiation transfers	ktrou,forme,rapforme,adfol, dfolbas,dfolhaut					

Management parameters

Option Name level 1	Code Name	val	nom	parameter's option	option name level 2	Code Name	val	nom	parameter's option
planting structure (if radiative transfer)	codetradtec	1	yes	interrang,orientrang					
		2	no						
rules to prescribe the sowing date	codedecisemis	1	yes	nbjmaxapressemis,nbjseuiltempref					
		2	no						
forcing	codestade	1	yes	ilev,iamf,ilax,isen,ilan,iflo,idrp,imat,irec					
		2	no						
automatic calculation of irrigations	codecalirrig	1	yes	ratiol,dosimx,doseirrigmin					
		2	no		date of irrigation	codedateappH2O	1	in sum of upvt	sum_upvt,amount
							2	in julian days	julapI,amount
location of irrigation	codlocirrig	1	above foliage						
		2	under foliage						
		3	in the soil	locirrig					
date of fertilisation	codedateappN	1	sum of upvt						
		2	julian days						
splitting fertilisation	codefracappN	1	amounts in absolute value						
		2	amounts in % of the total value	Qtot_N					
location of mineral nitrogen inputs	codlocferti	1	at soil surface						
		2	below soil surface	locferti					
method of harvest	codceuille	1	cutting						
		2	picking		number of pickings	nbceuille	1	one at the end	
							2	many during the cycle	cadencerec
harvest decision	codrecolte	1	physiological maturity						
		2	water content		minimum.or.maximum	codeaumin	1	minimum	h2ograinmin
		3	sugar content	sucrerec			2	maximum	h2ograinmax
		4	nitrogen content	CNgrainrec					
		5	oil content	huilerec					
Decision of harvest for associated crops	coderecolteassoc	1	Maturity of the earliest						
		2	Maturity of the both (2 dates)						
rules of harvest/moisture status of the soil	codedecirecolte	1	yes	nbjmaxapresrecolte					
		2	no						

cut crop	codefauche	1	yes	mscoupemini	Method.of.cutting	codemodfauche	1	automatic	hautcoupedefaut,stadecoupedf
							2	calendar in days	julfauche,hautcoupe,lairesiduel,msresiduel,anitcoupe
							3	calendar in degree days	tempfauche,hautcoupe,lairesiduel,msresiduel,anitcoupe
mulch	codepaillage	1	no						
		2	plastic mulch	couvermulchplastique,albedomulchplastique					
topping	codrognage	1	no						
		2	yes	largrogne,hautrogne,biorognem	topping calendar (codrognage=yes)	codcalrogne	1	fixed date	julrogne
							2	autromatic calculation	margerogne
thinning	codeclaircie	1	no						
		2	yes	juleclair,nbinfloecl					
leaf removal	codeffeuil	1	no						
		2	yes		location of leaf removal	codhauteff	1	bottom of the canopy	
							2	top of the canopy	
					leaf.removal.calculation	codcaleffeuil	1	automatic calculation	laidebeff,effeuil
							2	fixed date	juleffeuil,laieffeuil
pruning	codetaille	1	no						
		2	yes	jultaille					
trellis system	codepalissage	1	no						
		2	yes	hautmaxtec,largtec					
greenhouse crop	codabri	1	no						
		2	yes	transplastic,surfouvre1,julouvre2,surfouvre2,julouvre3,surfouvre3					
activation fragmentation	codeDST	1	yes	dachisel,dalabour,rugochisel,rugolabour					
		2	no						
activation compaction sowing/harvest	codeDSTtass	1	yes	profhumsemoir,dasemis,profhumrecolteuse,darecolte					
		2	no						
nb of layers affected by the compaction	codeDSTnbcouche	1	1						
		2	2						

Soils parameters

group	Option Name level 1	Code Name	val	nom	parameter's option	option name level 2	Code Name	val	nom	parameter's option	comment
	pebbles	codecailloux	1	yes	cailloux,typecailloux						
			2	no							
	macroporosity	codemacropor	1	yes	infil						
			2	no							
	cracks (case of swelling clay soils)	codefente	1	yes							codemacropor=n
			2	no							
	artificial drainage	codrainage	1	yes	profimper, ecartdrain, ksol, profdrain						
			2	no							
	capillary rise	coderemontcap	1	yes	capiljour,humcapil						
			2	no							
	nitrification	codenitrif	1	yes							
			2	no							
	denitrification	codedenit	1	yes	profdenit,vpotdenit						
			2	no							

Station parameters

group	Option Name level 1	Code Name	val	nom	parameter's option	option name level 2	Code Name	val	nom	parameter's option
Climate	calculation of potential evapotranspiration	codeetp	1	Penman-reading						
			2	Penman-calculate						
			3	Shutwall-and-Wallace						
			4	Prestley-Taylor	alphapt					
	climate change	codeclichange	1	no						
			2	yes						
	climate in altitude	codaltitude	1	no						
			2	yes	altistation,altisimul,gradtn,gradtx,altinversion,gradtninv,cielclair	option.adret.or.ubac	codadret	1	adret(south)	
								2	ubac(north)	ombragetx
Microclimate	calculation of crop temperature	codecaltemp	1	empirical relation						
			2	energy balance						
	calculation of net radiation	codernet	1	Brunt						
			2	Brutsaert						

B. parameterization (issues from the Conceptual basis, formalisations and parametrization of the STICS crop model, N. Brisson, M. Launay, B. Mary, N. Beaudoin, éditions Quae 2008)

Numbers of equations in the text refer to the equation numbers given in the reference above.

Running the model without the proper parameter set makes it inoperative or leads to incorrect results, and yet this part is rarely documented in scientific literature because the parameterization is not regarded as novel. Expressing phenomena as equations is considered a much nobler task and is the object of many scientific papers. The actual parameter values are mostly only available in the technical documentation of crop models, or worse, in the code. Unlike statisticians for whom a model comprises equations and parameters, so that changing parameters brings about a change of the model, for crop scientists the model does not include the parameter values.

However the robustness of the model, as well as its ability to be extrapolated, is closely linked to the parameter values, mainly their spatial and temporal validity as well as their validity throughout various cropping systems. But spatial and temporal validity must not be mistaken for biophysical meaning. The closer the parameters are to the processes, the better their biophysical meaning. We can assume that such parameters can be arrived at independently from the model through experiments, especially those carried out in controlled environments. These parameters are valuable even though they can be strictly soil- or plant-dependent. On the other hand parameters that encompass many processes are difficult to measure by experiments and must be evaluated with the model by mathematical optimization techniques (Makowski *et al.*, 2006). Although not always the case, those parameters may be ones which confer robustness to the model, e.g. the maximal radiation use efficiency or the harvest index.

The number of parameters for a model is often a subject of discussion. A widely accepted idea is that the more the parameters, the more complicated the model. It is true that the number of parameters more or less reflects the number of processes simulated, which can be regarded as a source of complication. At the same time, parameters may be easy to access, so we prefer the notion of cost of availability of the parameters rather than their number. Readily available parameters are, for example, parameters of a biophysical nature connected to largely shared databases, such as soil parameters deduced from soil databases using soil transfer functions. It is very important to know the sensitivity of the model to the considered parameter in order to determine the required precision for its value (see for STICS Ruget *et al.*, 2002). Note that since each sensitivity analysis is applicable only to the soil and weather conditions explored.

In STICS we have adopted the commonly-used definitions for parameters and variables, i.e. parameters can be considered as constant throughout the simulation while variables vary over time. IN STICS, certain parameters were converted to variables as new processes were added.

The following paragraphs focus on the parameters characterizing the three parts of the cropping system, i.e. the plant, the soil and the cropping techniques, and attempt to recommend methodologies to assign them values.

I- Plant parameterization

Methodology

First is the choice of formalisations. Some formalisations are prescribed from agrophysiological knowledge of the plant, while others are chosen by the user as a function of his point of view concerning the output variables of interest. The most important processes should be as mechanistically simulated as possible, the available information on the plant or its cropping conditions providing default values.
The second element of the recommended methodology is the sensitivity analysis, which allows the parameters to be ranked according to their influence on the variable of interest and to quantify the magnitude of this influence. It also reveals the agricultural conditions which maximise this influence, such as nutrient availability, weather conditions etc. Some methods of applying sensitivity analysis to crop models are described in Monod *et al.* (2006).
Finally the inventory of available experimental data or published parameters for the considered plant or similar species should determine the means of specifying parameter values (tabl. 1). Some methods for estimating parameters are detailed in Makowsky *et al.* (2006).

tabl. 1 : Summary of the various means available for assigning parameter values according to the data available. [1] "parameter estimation" is used in its mathematical meaning, referring to statistical methods for finding the parameter giving the best fit between observed and simulated output variables.

parameter	High sensitivity	Low sensitivity
Available in literature for the plant of interest or for an analogous species Available as a parameter of another model	Estimation[1] recommended if the validity domain of available information does not match the pursued objective.	Use of available parameter values from literature or modelling documentation
Measured or calculated directly from available experimental data	Use of measurements compulsory	Use of measurements optional
Unavailable through the above-mentioned means	Estimation[1] compulsory using dedicated experimental data	Analogous species parameters (always possible with STICS)

Set of plant parameters for some species

In order to give some examples of plant parameterizations, we propose in tabl. 2 the plant parameter values for five different crops. Two perennial crops, forage (herbaceous) and grapevines (Vitis vinifera L., ligneous), and three annual crops, spring pea (Pisum sativum L.), sugar beet (Beta vulgaris L.) and winter wheat (Triticum aestivum L.) are taken as examples. In this table, some parameter values are not given if the equations for which they are needed have not yet been formulated for the species concerned. Others are given for different varieties when they are variety-dependent.
Commencement of growth for forage and vines is usually simulated after the winter rest (dormancy and budding having being parameterized for vines, Garcia de Cortazar, 2006), when perennial reserves are remobilised. The vine root system is considered to be already completely established (Garcia de Cortazar, 2006), whereas that of forage crops is partially established and will continue to grow during the cropping period. Forage crop parameterization was done for a grass

mixture with an ecophysiology similar to tall fescue (Festuca arundinacea Schreb.) and cocksfoot (Dactylis glomerata L.) (Ruget et al., 2006). Sugar beet is regarded as an annual crop by the model because of the way in which it is grown and despite the fact that it completes its vegetative cycle in two years (Launay and Brisson, 2004). parameters controlling the photoperiod slowing effect (PHOBASEP, PHOSATP and SENSIPHOTP) and vernalisation requirement (JVCMINIP, JULVERNALP, TFROIDP and AMPFROIDP) are activated for winter wheat only (Brisson et al., 2002a).
Shoot growth, and especially leaf production are unrestricted throughout the cropping period for forage and sugar beet, which is simulated by a high STLAMFLAXP parameter value (Graux, 2006 or Launay and Brisson., 2004). Considering the row-planting arrangement of vines and the need to simulate intercropping with peas, those two crops were parameterized in order to use the radiation transfer formalisation (see $3.2.2) and the associated resistive approach, involving the estimation of KTROUP, FORMEP, RAPFORMEP, ADFOLP, DFOLBASP, DFOLHAUTP and RSMINP parameters (tabl. 2).
Considering yield formation, forage, spring pea and winter wheat are simulated as determinate crops, whereas sugar beet and vines are simulated as indeterminate (see chapter 4). In the case of forage, the parameterization was not targeted on grain production but on the above-ground biomass prediction since this is the harvested part of the crop (Ruget et al., 2006). For sugar beet, we assumed that only one tuber (storage and harvested root) was set by each plant (NBINFLOP=1), and the trophic stress effects on tuber setting were cancelled by means of very low SPFRMINP and SPFRMAXP parameter values; storage root growth was assumed to be linear over the growth cycle (BFPFP=1) (Launay and Brisson., 2004).
Finally, root length growth was simulated as trophic-linked for spring peas, as shown in trials comparing sole and intercropped peas (Corre-Hellou et al., 2007). Symbiotic N uptake formalisation was also parameterized for this leguminous plant (Corre-Hellou et al., 2007). The nitrogen stress index relying on the daily accumulation of nitrogen rather than on the plant nitrogen concentration, named INNI (see eq.3.33 and $8.2), was chosen to avoid the notable inertia of the INN dynamics in the case of vines and winter wheat (Garcia de Cortazar, 2006 and Mary and Guerif 2005).

tabl. 2 : Plant parameter values for forage, spring pea, sugarbeet, two varieties of vine and two varieties of winter wheat (grey boxes correspond to the parameters that are not activated).

Chapter	parameter	Unit	Value						
			Forage	Pea	Sugar-beet	Vineyard		Winter wheat	
						Grenache	Chardonnay	Talent	Shango
CO2 effect	ALPHACO2$_P$	ND	1.2	1.2	1.2	1.2		1.2	
Development	TDMIN$_P$	°C	0	0	3	10		0	
	TDMAX$_P$	°C	25	25	25	37		28	
	STLEVAMF$_V$	degree·day	116	230	500	25		235	278
	STAMFLAX$_V$	degree·day	800	418	5715	1123	927	260	352
	STLEVDRP$_V$	degree·day	1000	900	1847	363	305	692	837
	STFLODRP$_V$	degree·day		216	0	50	51	0	0
	STDRPMAT$_V$	degree·day		490				700	700
	COEFLEVAMF$_P$	ND	1.0	1.0				1	
	COEFAMFLAX$_P$	ND	1.0	1.0				1	
	COEFLEVDRP$_P$	ND	1.0	1.0				1	
	COEFDRPMAT$_P$	ND	1.0	1.0				1	
	COEFFLODRP$_P$	ND	1.0	1.0				1	
	PHOBASE$_P$	h	6.3					6.3	

	PHOSAT$_P$	h	20.0					20	
	SENSIPHOT$_V$	ND						0	0
	STRESSDEV$_P$	ND	0.2					0.2	
	JVCMINI$_P$	day						7	
	JULVERNAL$_P$	julian day						274	
	TFROID$_P$	°C						6.5	
	AMPFROID$_P$	°C						10	
	STDORDEBOUR$_P$	degree day				9174	6577		
	TDMINDEB$_P$	°C				5.0			
	TDMAXDEB$_P$	°C				25.0			
	IFINDORM$_P$	julian day				1			
	Q10$_P$	ND				2.17			
	IDEBDORM$_P$	julian day				213			
	JVC$_V$	day				102	101.2	55	45
	TGMIN$_P$	°C	0.0	0	3			0	
	STPLTGER$_P$	degree day	50.0	60	45			50	
	POTGERMI$_P$	MPa		-1.6	-1.6			-1.6	
	NBJGERLIM$_P$	days		50	50			50	
	PROPJGERMIN$_P$	day.day^{-1}		1	1			1	
	BELONG$_P$	degree day		0.0115	0.0115			0.012	
	CELONG$_P$	ND		4.57	4.57			3.2	
	ELMAX$_P$	cm		7.21	7.21			8.0	
	NLEVLIM1$_P$	day		10	10			10	
	NLEVLIM2$_P$	day		50	50			50	
	VIGUEURBAT$_P$	ND		1	1			1.0	
	LAIPLANTULE$_P$	m2 leaf m^{-2} soil							
	NBFEUILPLANT$_P$	nb leaves plant^{-1}							
	MASECPLANTULE$_P$	t ha^{-1}							
	ZRACPLANTULE$_P$	m							
Shoot growth	PHYLLOTHERME$_P$	degree·day	200	120	120	25		120	
	ADENS$_V$	ND	-0.5	-0.45	-0.47	0.0		-0.6	-0.6
	BDENS$_P$	plants· m^{-2}	140.0	10.0	7.0	1.0		7.0	
	LAICOMP$_P$	m^2·m^{-2}	0.0	0.0	0.75	0.0		0.30	
	HAUTBASE$_P$	m	0.02	0.0	0.0	0.6	0.3	0.0	
	HAUTMAX$_P$	m	0.3	0.65	0.6	2.5		1.20	
	TCXSTOP$_P$	°C	30.0	100.0	100.0	100.0		100.0	
	VLAIMAX$_P$	ND	2.2	2.2	2.2	2.2		2.2	
	PENTLAIMAX$_P$	ND	5.5	5.5	5.5	5.0		5.5	
	UDLAIMAX$_P$	ND	3.0	3.0	3.0	3.0		3.0	
	RATIODURVIEI$_P$	ND	1.0	0.8	1.0	1.0		0.8	
	TCMIN$_P$	°C	0.0	0.0	3.0	10.0		0.0	
	TCMAX$_P$	°C	25.0	30.0	30.0	37.0		40.0	

	RATIOSEN$_P$	ND	0.8	0.25	0.87	0.8	0.8
	ABSCISSION$_P$	ND	0.8	0.0	0.56	1.0	0.0
	PARAZOFMORTE$_P$	ND	13.0	13.0	13.0	13.0	13.0
	INNTURGMIN$_P$	ND	0.3	0.3	0.3	0.3	-0.65
	DLAIMIN$_P$	m2 leaf m^{-2} soil	0.10	0.0	0.0	0.0	0.0
	DLAIMAXBRUT$_P$	m^2 leaf plant^{-1} degree day^{-1}	2.0·10^{-5}	3.5·10^{-4}	1.44·10^{-3}	0.015	4.4·10^{-4}
	DURVIEF$_V$	ND	78	160	60	400 400	200 205
	DURVIESUPMAX$_P$	ND	0.4	0.4	0.0	0.1	0.4
	INNSEN$_P$	ND	1.0	0.35	0.3	0.87	0.17
	RAPSENTURG$_P$	ND	0.0	0.5	0.5	0.05	0.5
	PHOBASESEN$_P$					12.0	
	DLTAMSMAXSEN$_P$					0.01	
	DLTAMSMINSEN$_P$					0.15	
	ALPHAPHOT$_P$					200.0	
	EXTIN$_P$	ND	0.55		0.58		0.5
	KTROU$_P$	ND		1.0		1.7	
	FORME$_P$	code		1		2	
	RAPFORME$_P$	ND		1.0		1.5	
	ADFOL$_P$	m-1		1.0		3.16	
	DFOLBAS$_P$	m^2 leaf·m^{-3}		5.0		1.5	
	DFOLHAUT$_P$	m^2 leaf·m^{-3}		5.0		11.5	
	TEMIN$_P$	°C	0.0	0.0	3.0	10.0	0.0
	TEMAX$_P$	°C	25.0	30.0	30.0	37.0	40.0
	TEOPT$_P$	°C	15.3	15.0	13.0	25.0	12.0
	TEOPTBIS$_P$	°C	25.0	20.0	30.0	25.0	17.0
Shoot growth	EFCROIJUV$_P$	g·MJ^{-1}	2.0	1.2	1.75	1.2	2.2
	EFCROIVEG$_P$	g·MJ^{-1}	2.5	2.7	4.9	1.04	4.25
	EFCROIREPRO$_P$	g·MJ^{-1}	2.2	3.3	3.98	2.25	4.25
	REMOBRES$_P$	ND	0.05	0.2	0.29	0.073	0.2
	COEFMSHAUT$_P$	ND	25.0				
	SLAMAX$_P$	cm^2·g^{-1}	280	350	250	235	350
	SLAMIN$_P$	cm^2·g^{-1}	180	180	70	100	180
	TIGEFEUILLE$_P$	ND	0.36	0.0	0.58	0.9	0.5
	ENVFRUIT$_P$	ND	0.0	0.1	0.0	0.0	0.10
	SEA$_P$	cm^2·g^{-1}	0.0	0.0	0.0	0.0	0.0
	TLETALE$_P$	°C	-25.0	-25.0	-25.0	-20.0	-25.0
	TDEBGEL$_P$	°C	-5.0	-4.0	-4.0	-1.5	-4.0
	NBFGELLEV$_P$	nb leaves plant^{-1}	2	2			2
	TGELLEV10$_P$	°C	-6.0	-4.0			-4.0
	TGELLEV90$_P$	°C	-20.0	-20.0			-20.0
	TGELJUV10$_P$	°C	-10.0	-10.0		-2.0	-10.0

	TGELJUV90$_P$	°C	-20.0	-20.0		-5.0		-20.0	
	TGELVEG10$_P$	°C	-4.5	-4.5		-2.0		-4.5	
	TGELVEG90$_P$	°C	-10.0	-10.0		-5.0		-10.0	
	TGELFLO10$_P$	°C	-4.5	-4.5		-2.0		-4.5	
	TGELFLO90$_P$	°C	-6.5	-6.5		-5.0		-6.5	
Yield Formation	NBJGRAIN$_P$	days		15				30	
	CGRAIN$_P$	nb grains· g^{-1} day		0.031				0.036	
	CGRAINV0$_P$	grains·m^{-2}		0.0				0.0	
	NBGRMIN$_P$	grains·m^{-2}		447				6000	
	NBGRMAX$_V$	nb grains		$3.5 \cdot 10^3$				$3 \cdot 10^5$	$2.25 \cdot 10^5$
	VITIRCARB$_P$	g grain· g plant $^{-1}$ day^{-1}		0.022				0.011	
	IRMAX$_P$	ND		0.65				0.55	
	PGRAINMAXI$_V$	g		0.35	1057	1.96	2.0	0.0388	0.0478
	NBOITE$_P$	ND			50	10			
	ALLOCFRMAX$_P$	ND			0.9	1			
	AFPF$_P$	ND			0.5	0.55			
	BFPF$_P$	ND			1.0	18.0			
	CFPF$_P$	ND			0.0	15.0			
	DFPF$_P$	ND			0.2	0.2			
Yield formation	AFRUITPOT$_V$	nb fruits degree.day^{-1}			0.004	1.15	2.12		
	DUREEFRUIT$_V$	degree·day			9850	1472	1280		
	STDRPNOU$_P$	degree.day			210	91	90		
	SPFRMIN$_P$	ND			$1 \cdot 10^{-5}$	0.75			
	SPFRMAX$_P$	ND			$2 \cdot 10^{-5}$	1.0			
	SPLAIMIN$_P$	ND			-0.84	0.63			
	SPLAIMAX$_P$	ND			1.08	1.0			
	NBINFLO$_P$	nb· plant^{-1}			1	15	22		
	INFLOMAX$_P$	nb· plant^{-1}				15	22		
	PENTINFLORES$_P$	ND				4.5			
	TMINREMP$_P$	°C		8.0		0.0		0.0	
	TMAXREMP$_P$	°C		40.0		37.0		38.0	
	VITPROPSUCRE$_P$	g sugar ·g DM^{-1}·day^{-1}		0.0	$8 \cdot 10^{-4}$	0.0029		0.0	
	VITPROPHUILE$_P$	g oil ·g DM^{-1}·day^{-1}		0.0	0.0	0.0		0.0	
	VITIRAZO$_P$	g grain ·g plant $^{-1}$·day^{-1}		0.022	0.0	0.004		$1.45 \cdot 10^{-2}$	
Root growth	CROIRAC$_V$	cm degree.day^{-1}	0.06	0.12	0.14			0.12	0.1381
	SENSANOX$_P$	SD	0.0	0.0	0.0	0.0		1.0	
	STOPRAC$_P$	stage	REC	LAX	SEN	LAX		SEN	

	SENSRSEC$_P$	SD	0.0	0.4	0.5	0.0		0.5	
	CONTRDAMAX$_P$	SD	0.3	0.34	0.3	0.3		0.3	
	ZLABOUR$_P$	cm	25.0		102				
	ZPENTE$_P$	Cm	25.5		119				
	ZPRLIM$_P$	Cm	40.0		150				
	DRACLONG$_P$	cm $\cdot pl^{-1}\cdot°.day^{-1}$		30		40		80.0	
	DEBSENRAC$_P$	degree·day		1000		2000		1000	
	LVFRONT$_P$	cm root.cm^{-3} soil		0.05		5·10-3		$5\cdot10^{-2}$	
	LONGSPERAC$_P$	$cm\cdot g^{-1}$		3300		1021		18182	
	MINEFNRA$_P$	SD							
	MINAZORAC$_P$	kg $N\cdot ha^{-1}\cdot mm^{-1}$							
	MAXAZORAC$_P$	kg $N\cdot ha^{-1}\cdot mm^{-1}$							
	KREPRACSEU$_P$	SD							
	REPRACSEUMAX$_P$	SD							
	REPRACSEUMIN$_P$	SD							
	KREPRACPERM$_P$	SD							
	REPRACPERMAX$_P$	SD							
	REPRACPERMIN$_P$	SD							
Water balance	PSISTO$_P$	bar	12.0	10.0	10.0	15.0		15.0	
	PSITURG$_P$	bar	1.0	2.0	10.0	6.0		4	
	H2OFEUILVERTE$_P$	g water$\cdot g^{-1}$ FW	0.9	0.9	0.9	0.75		0.9	
	H2OFEUILJAUNE$_P$	g water$\cdot g^{-1}$ FW	0.15	0.15	0.15	0.5		0.15	
	H2OTIGESTRUC$_P$	g water$\cdot g^{-1}$ FW	0.6	0.60	0.6	0.7		0.60	
	H2ORESERVE$_P$	g water$\cdot g^{-1}$ FW	0.7	0.70	0.8	0.7		0.70	
	H2OFRVERT$_P$	g water$\cdot g^{-1}$ FW	0.4	0.55	0.8	0.925		0.4	
	STDRPDES$_V$	degree·day		700	700	96	95	700	700
	DESHYDBASE$_P$	g water·g $FW^{-1}.°C^{-1}$		0.008	0.0	$1.59\cdot10^{-3}$	$1.32\cdot10^{-3}$	0.008	
	TEMPDESHYD$_P$	% eau$\cdot°C^{-1}$		0.005	0.0	$1.6\cdot10^{-4}$		0.005	
	KMAX$_P$	ND	1.0		1.4			1.0	
	RSMIN$_P$	$s\cdot m^{-1}$		100		250			
	MOUILLABIL$_P$	$mm\cdot LAI^{-1}$							
	STEMFLOWMAX$_P$	ND							
	KSTEMFLOW$_P$	ND							
Nitrogen transfor-mations	VMAX1$_P$	$\mu mole\cdot cm^{-1}\cdot h^{-1}$	$1.8\cdot10^{-3}$	0.012	$1.8\cdot10^{-3}$	$1.8\cdot10^{-3}$		$1.8\cdot10^{-3}$	
	KMABS1$_P$	µmole. cm $root^{-1}$	50	50	50	50		50	
	VMAX2$_P$	$\mu mole\cdot cm^{-1}\cdot h^{-1}$	$5\cdot10^{-2}$	0.12	$5\cdot10^{-2}$	$5.8\cdot10^{-3}$		$5\cdot10^{-2}$	
	KMABS2$_P$	µmole. cm $root^{-1}$	25000	20000	25000	25000		25000	
	ADIL$_P$	% DM	4.8	5.08	5.21	3.3		5.35	
	BDIL$_P$	ND	0.32	0.32	0.56	0.44		0.44	
	MASECNMAX$_P$	$t\cdot ha^{-1}$	1.0	1.0	1.0	1.6		1.54	

	INNMIN$_P$	ND	0.3	0.3	0.3		
	INNIMIN$_P$	ND				-0.49	-0.5
	INNGRAIN1$_P$	ND		0.3			0.03
	INNGRAIN2$_P$			0.9			1.2
	ADILMAX$_P$	% DM					8.5
	BDILMAX$_P$	ND					0.44
	NMETA$_P$	% DM	6.47	6.47	6.47	6.0	
	MASECMETA$_P$		0.04	0.04	0.04	0.04	
	NRESERVE$_P$		1.5	0.5	1.5	1.6	
Leguminous	STLEVDNO$_P$	degree·day		0.0			
	STDNOFNO$_P$	degree·day		2000			
	STFNOFVINO$_P$	degree·day		0.0			
	VITNO$_P$	degree·day^{-1}		1.0			
	PROFNOD$_P$	cm		30.0			
	CONCNNODSEUIL$_P$	kg ha^{-1} mm^{-1}		6.0			
	CONCNRAC0$_P$	kg ha^{-1} mm^{-1}		2.70			
	CONCNRAC100$_P$	kg ha^{-1} mm^{-1}		0.04			
	TEMPNOD1$_P$	°C		0.0			
	TEMPNOD2$_P$	°C		15.0			
	TEMPNOD3$_P$	°C		25.0			
	TEMPNOD4$_P$	°C		35.0			
	FIXMAX$_P$	kg ·ha^{-1}·day^{-1}		8.9			
	FIXMAXVEG$_P$	kg ·(t DM)$^{-1}$		30.0			
	FIXMAXGR$_P$	kg ·(t DM)$^{-1}$		9.5			
BBCH scale	CODEBBCHPLT$_P$	SD		00	00	00	00
	CODEBBCHGER$_P$	SD		05	05		05
	CODEBBCHLRV$_P$	SD		09	09	09	09
	CODEBBCHAMF$_P$	SD					35
	CODEBBCHLAX$_P$	SD					55
	CODEBBCHSEN$_P$	SD					85
	CODEBBCHFLO$_P$	SD		65		65	65
	CODEBBCHDRP$_P$	SD			49		71
	CODEBBCHNOU$_P$	SD					
	CODEBBCHDEBDES$_P$	SD				85	75
	CODEBBCHMAT$_P$	SD		89			89
	CODEBBCHREC$_P$	SD					99
	CODEBCHFINDORM$_P$	SD				01	

Table 11.5

II- *Soil parameterization*

The tabl. 3 summarises the various soil parameters and recommends some methods to assign them. The hydrodynamic parameters need to be discretized by layers, whose maximal number is 5.

tabl. 3 : List of soil parameters with help to assign them. PDT is soil transfer rules or functions. [1]signifies the optional character of the parameter. The sensitivity levels are just suggestions and depend on the purpose of the simulation

parameter	Recommended assigning method	Default value	Links between parameters	Sensitivity level
$ARGI_S$	Soil analysis	Fig. 1		**
$NORG_S$	Soil analysis	Vineyard soils = 0.06 Arable crop soils = 0.14 Pasture soils = 0.20	$PROFHUM_S$	***
$CALC_S$	Soil analysis	Non calcareous = 1 calcium carbonate = 10 Chalk = 60		**
$PROFHUM_S$	Depth of soil tilling	30 cm	$NORG_S$	**
[1]$CONCSEUIL_S$	Estimation by fitting to the mineral nitrogen content profile	0.01 in temperate soil 0.20 in tropical soil	EPD_s (Z)	*
[1]pH_S	Soil analysis	7		*
$ALBEDO_S$	Reflectance measurements	Tabl. 6		*
$Q0_S$	Estimation by fitting to bare soil water reserve measurements	Fig. 1	$DAF_S(1)$	***
EPDs(Z)	Estimation by fitting to soil nitrate contents during infiltration periods	10 cm	$CONCSEUIL_s$	**
Z0SOLNUs	Measurements by a roughness meter Estimated as the 1/10 of the average asperity height.	10^{-3} m for sowed soil 10^{-2} m for a ploughed soil	DAF_s (1)	***
CFESs	Estimation by fitting to water content profiles during evaporation periods	1		*
ZESXs		30 cm	DAF_s (1)	**
PLUIEBATs, MULCHBATs	Sensitivity to crusting estimated by fitting to emergence in terms of date and density	50mm, 3 cm : insensitive 3 mm, 0.5 cm : high sensitivity 10 mm, 1.5 cm : low sensitivity	$Q0_s$	**

RUISOLNU$_S$		Tabl. 5		*
OBSTARAC$_S$	Either mechanical constraint or chemical toxicity for roots	200 cm		*
EPC$_S$(Z)	Soil description	30 cm		
CSURNSOL$_S$	Initial C to N ratio of soil humus	0 (this value is recalculated by the model =1./Wh)		
PENTERUI$_S$	runoff coefficient taking account for plant mulch	0.33		
HCCF$_s$(Z)	Soil analysis or in situ measurements of water content in winter			***
HMINF$_S$ (Z)	Taken as wilting point : soil analysis or PDT	Tabl. 4		**
DAF$_S$ (Z)	In situ measurements or PDT		EPC$_s$(Z)	***
[1]CAILLOUX$_S$ (Z)	In situ estimation	0.0		***
[1]TYPECAILLOUX$_S$ (Z)		Tabl. 7		**
[1]INFIL$_S$ (Z)	Estimation by fitting to the water content profile during rainy events	Tabl. 4	DAF $_s$ (Z)	***
HUMCAPIL$_S$	Threshold of soil gravimetric water content under which capillary rises occur	0.0		*
CAPILJOUR$_S$	Capillary rises	0.0		**
PROFDENIT$_S$	Thickness of the denitrifying layer	20		*
VPOTDENIT$_S$	potential rate of denitrificaion **on profdenit** (kg N/ha/day) (2 by default, or fonction of 5*Corg-4)	2		**
PROFIMPER$_S$	Upper depth of the impermeable layer (from the soil surface). May be greater than the soil depth.	150		***
LDRAIN$_S$	Between drain ½ spacing	150		*
KSOL$_S$	Hydraulic conductivity in the soil above and below the drains	1		**
PROFDRAIN$_S$	Drain depth	80		**

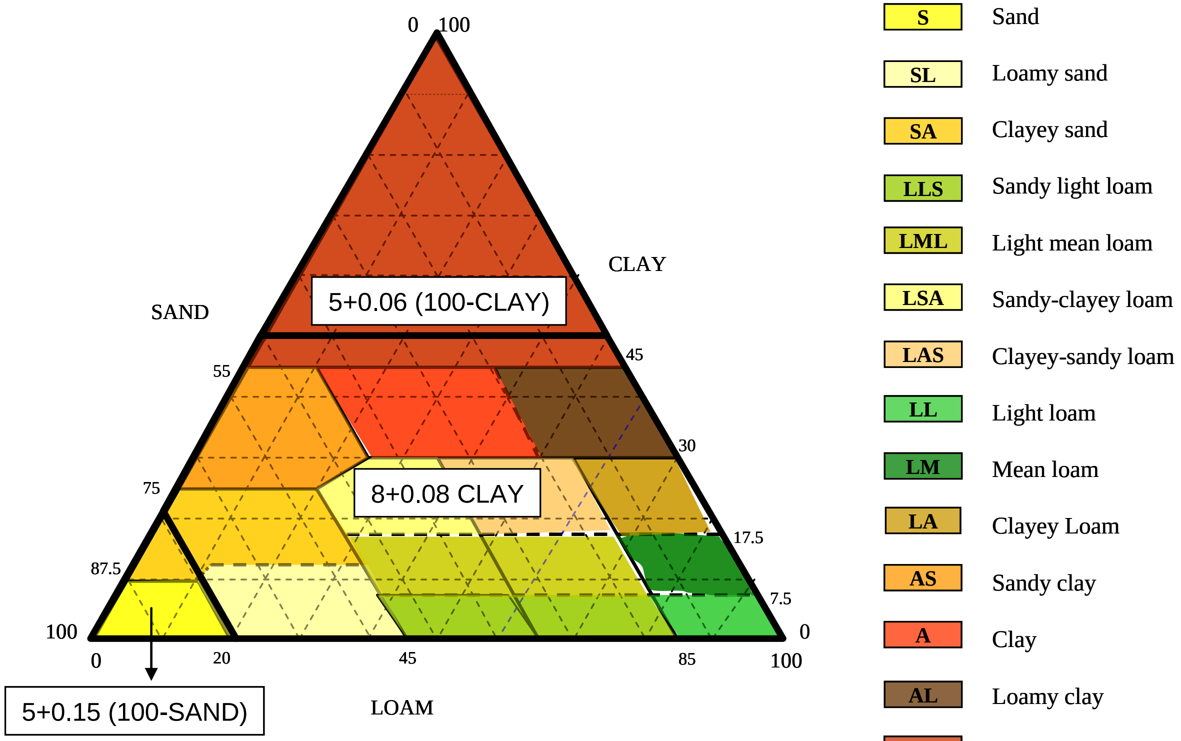
When soil information is missing, some soil parameters, considered as permanent characteristics, can be accessed by soil transfer functions or rules (Bruand et al., 2003, Wöesten et al., 1999), i.e. their values can be inferred from readily available soil data such as texture, particle size and organic matter content. It has been much used for field capacity and wilting point and to a lesser extent for bulk density. A review of the literature on the soil transfer function was carried out by Bastet et al. (1998) and many of them are available in the SOILPAR program by Acutis and Donatelli (2003 : http://www.isci.it/sipeaa/ASP/ASP2/SOILPAR.asp)

For approximate values for non-tilled layers, the pioneer work by Jamagne et al. (1977) can be used (tabl. 4). More recent works for French soils using the SOLHYDRO data base can also be used (Bruand et al., 2004; Al Majou et al., 2008a and 2008b; Roman Dobarco et al., 2019). Databases of hydraulic soil properties, such as HYPRES (Wösten *et al.*, 1999) or EU-HYDI (Toth et al., 2015) at the European scale, constitute another source of data to assign some soil parameters as well as databases of agricultural soil analyses, such the BDAT developed in France (http://www.gissol.fr/programme/bdat/bdat.php).

Yet some parameters closely associated with soil structure are difficult to assign with only database information and textural characteristics. This is the case for field capacity and bulk density values, especially for sub-surface layers whose hydrodynamic characteristics depend heavily on soil structure; - much more than on soil texture (Bruand *et al.*, 2003).

In order to enable STICS users to parameterize their soil, at least roughly for test runs, we have constructed soil transfer tables based on well-known literature. They mostly use textural information (see fig. 1) so that they are likely to change with soil structure and organic matter content.

fig. 1: Textural triangle and classification by Jamage *et al.* (1977). Soil transfer functions to assess the $Q0_S$ parameter as a function of clay or sand content (based on work from Ritchie and Crum (1989)



tabl. 4: Pedotransfer table to estimate hydrodynamic parameters as functions of textural classes (fig. 1) based on Jamagne et al. (1977) (*: for heavy clay soils air porosity is estimated taking into account the craks: eq. 9.5)
This link to the Saxton triangle calculator is an other way to estimate the hydraulic properties: http://resources.hwb.wales.gov.uk/VTC/env-sci/module2/soils/soilwatr.htm

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	Textural class	HCCFS (% dry soil)	HMINFS (% dry soil)	DAFS (g cm-3)	INFILS for various layer thickness											
					5 cm	10 cm	15 cm	20 cm	25 cm	30 cm	40 cm	50 cm	60 cm	80 cm	100 cm	120 cm
topsoil	coarse	13	5	1.3	50.00	50.00	50.00	50.00	50.00	45.93	34.48	27.59	22.99	17.24	13.79	13.69
	medium	22	12	1.3	22.69	12.66	8.54	6.42	5.13	4.28	4.18	4.18	4.18	4.18	4.18	4.18
	medium fine	25	10	1.3	8.17	4.29	2.87	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28

	fine	31	21	1.3	4.22	2.12	1.41	1.06	0.85	0.71	0.58	0.58	0.58	0.58	0.58	0.58
	very fine	38	26	1.3	1.81	0.91	0.60	0.45	0.36	0.30	0.27	0.27	0.27	0.27	0.27	0.27
subsoil	coarse	8	3	1.45	50.00	50.00	46.97	36.09	29.10	24.31	18.25	14.60	13.56	13.56	13.56	13.56
	medium	19	10	1.45	24.43	13.63	9.20	6.91	5.53	4.61	3.45	3.33	3.33	3.33	3.33	3.33
	medium fine	23	11	1.45	6.20	3.26	2.18	1.63	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48
	fine	28	20	1.5	1.04	0.52	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
	very fine	32	24	1.45	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27

In tabl. 4 the permeability classes proposed by Ritchie (1985) are arbitrarily associated with textural classes: they correspond to a percentage of the amount of water stored in the macroporosity that infiltrates from one day to the next. The calculations show that the effect of layer thickness on INFILS disappears with decreasing permeability.

The values of the RUISOLNUS (tabl.5) derived from the USDA Runoff Curve Number method are rather low because they represent only Hortonian (surface) runoff, which only depends on obstacles created by plants and on the water velocity on a sloppy field. The other component of runoff, i.e. resistance to infiltration, as well as the presence of a plant mulch, are taken into account by the model (see § 6.4).

tabl. 5: Values of the parameter $RUISOLNU_S$ as the proportion of Hortonian runoff to incoming precipitation minus the $PMINRUIS_G$ threshold, based on the USDA CN approach described in Chapman and Lake (2003)

soil cover	Slope classes			
	0-2 %	2-5%	5-10%	>10%
smooth soil	0.05	0.07	0.10	0.13
ploughed soil	0.00	0.03	0.06	0.08
row crop in direction of slope	0.05	0.07	0.10	0.13
row crop perpendicular to slope	0.00	0.03	0.06	0.09
homogeneous crop	0.00	0.03	0.07	0.10

The albedo parameter is for dry soil, there being a function to account for soil water content (**Erreur ! Source du renvoi introuvable.**). There are two criteria to assign this parameter, either texture or colour, the latter being read from a Munsell chart (**Erreur ! Source du renvoi introuvable.**).

tabl. 6 : Values of the dry soil albedo ($ALBEDO_S$) using either textural classes or colours, based on Richard and Cellier (1998), Jacquemoud and Baret (1992)

Soil type	$ALBEDO_S$
TEXTURE	
Limestone	0.31
Loamy sand	0.25
Clayey loam	0.18 – 0.22
Mean loam	0.22 – 0.23
Crusted mean loam	0.28
Clay	0.28
COLOUR	
Brown soil	0.27
Red soil	0.29
Black soil	0.17
Grey soil	0.29
Yellow soil	0.35

Relation between soil colour and albedo can be found in Post et al. (2000).
POST, D. F., FIMBRES, A., MATTHIAS, A. D., SANO, E. E., ACCIOLY, L., BATCHILY, A. K., & FERREIRA, L. G. (2000). Predicting soil albedo from soil color and spectral reflectance data. *Soil Science Society of America Journal*, *64*(3), 1027-1034.

Pebbles are characterized by their water retention ability. Some laboratory experiments were done to assess them for pebbles frequently encountered in French agricultural fields (tabl. 7).

tabl. 7 : Water retention characteristics of various pebbles, used as classes of stone types.

Stone type	Volumetric mass g cm^{-3}	Field capacity % in mass
Non-porous limestone	2.20	7
Porous limestone	1.80	16
Lutetian semi-porous limestone	2.00	11
Lutetian stones	2.30	7
Morainic gravel	2.60	3
Flints, sandstone or unaltered granite	2.65	0
Altered granite	2.30	10
Rendzinic porous limestone	1.20	28

For pebbles coming from sedimentary rocks, more information can be found in Tetegan et al. (2011).
TETEGAN, M., NICOULLAUD, B., BAIZE, D., BOUTHIER, A., & COUSIN, I. (2011). The contribution of rock fragments to the available water content of stony soils: Proposition of new pedotransfer functions. Geoderma, 165(1), 40-49.

III- *Crop management parameterization*

While management data are probably the easiest input to provide, the links between practices and the proper state variables in the model can require the implementation of transfer rules. For example, the interactions between the fertilizers and the soil-crop system depend very much on the type of fertilizer, of course either organic or mineral, but also within each of these types their proper biochemical and physical behaviour. As listed in the sanitary status of the crop.

tabl. 8, the practices accounted for in STICS concern bare soil and cropping periods for industrial crops as well as fruit crops and vegetables. There is no information about the sanitary status of the crop.

tabl. 8: list of techniques accounted for by the model and the corresponding parameters. [1] technique that can be either prescribed or partly calculated using some decision rules (see table 14). [2] Several cultivation operations can be planned to bury or mix in residues (of different types) in the soil. These operations include new residues or serve simply to modify the structural and moisture conditions of residues previously added.

technique	Compulsory parameters if the technique is applied	Optional parameters if the technique is applied	Typology: codification	Typology: dependant parameters
[2] supply of organic residues	$JULRES_T$		$CODERES_T$ (cf tabl 12)	$QRES_T$ $CSURNRES_T$ $CRESPC_T$ $NMINRES_T$ $EAURES_T$ all mineralization parameters (in param_gen.xml file)
[2] soil tillage	$JULTRAV_T$ $PROFRES_T$ $PROFTRAV_T$			
[1] sowing	$DENSITE_T$ $VARIETE_T$	if annual : $IPLT_T$, $PROFSEM_T$ if row crop : $INTERRANG_T$ $ORIENTRANG_T$ if sowing date is calculated : $NBJMAXAPRESSEMIS_T$, $NBJSEUILTEMPREF_T$,	$VARIETE_T$	all varietal parameters
[1] irrigation	$EFFIRR_T$	If prescribed by dates or by phasic stages: $JULAPI\_OR\_SUM\_UPVT_T$, DOSEIT If calculated : $RATIOL_T$, $DOSIMX_T$, $DOSIRRIGMIN_T$ If in the soil : $LOCIRRIG_T$		
[1] fertilisation	$DOSEN_T$ $ENGRAIS_T$	If fert-irrigation : $CONCIRR_T$ If prescribed by dates or by phasic stages: $JULAPN\_OR\_SUM\_UPVT_T$, If splitting fertilisation with amounts in % of the total value : $QTOT\_N_T$ If in the soil : $LOCFERTI_T$	$ENGRAIS_T$ (cf tabl. 9)	$ENGAMM_T$ $ORGENG_T$ $DENENG_T$ $VOLENG_T$

[1]harvesting	RESSUITE$_T$ (cf tabl. 11)	if non physiological : IRECBUTOIR$_T$ If water content dependent : H2OGRAINMIN$_T$ or H2OGRAINMAX$_T$ If sugar dependent : SUCREREC$_T$ If nitrogen dependent : CNGRAINREC$_T$ If oil dependent : HUILREC$_T$ If several pickings : CADENCEREC$_T$ if compaction dependent : NBJMAXAPRESRECOLTE$_T$	CODETYPERES (cf tab 10)	all mineralization parameters (in param_gen.xml file)
[1]forage cutting	MSCOUPEMINI$_T$	If prescribed cuts : HAUTCOUPE $_T$, LAIRESIDUEL $_T$, MSRESIDUEL $_T$, ANITCOUPE $_T$ If calendar prescription : JULFAUCHE$_T$ if phasic prescription : TEMPFAUCHE$_T$ If calculated : STADEFAUCHET, HAUTCOUPEDEFAUT $_T$		
[1]plastic mulching	COUVERMULCHPLASTIQUE$_T$ ALBEDOMULCHPLASTIQUE$_T$	ALBEDOMULCH $_T$		
trellising crops	HAUTMAXTEC$_T$, LARGTEC$_T$			
[1]tactical shape control	LARGROGNE$_T$, HAUTROGNE$_T$, BIOROGNEM$_T$	if prescribed : JULROGNE$_T$ If calculated : MARGEROGNE$_T$		
technique	**Compulsory parameters if the technique is applied**	**Optional parameters if the technique is applied**	**Typology**	
[1]leaf removal	CODHAUTEFF$_T$	if prescribed : JULEFFEUIL$_T$ LAIEFFEUIL$_T$ if calculated LAIDEBEFF$_T$ EFFEUIL$_T$		
fruit removal	JULECLAIR$_T$ NBFROTE$_T$			
pruning	JULTAILLE$_T$			
shelter	TRANSPLASTIC$_T$	if shelter punctually opened (3 times maximum) SURFOUVRE$_T$ JULOUVRE$_T$		

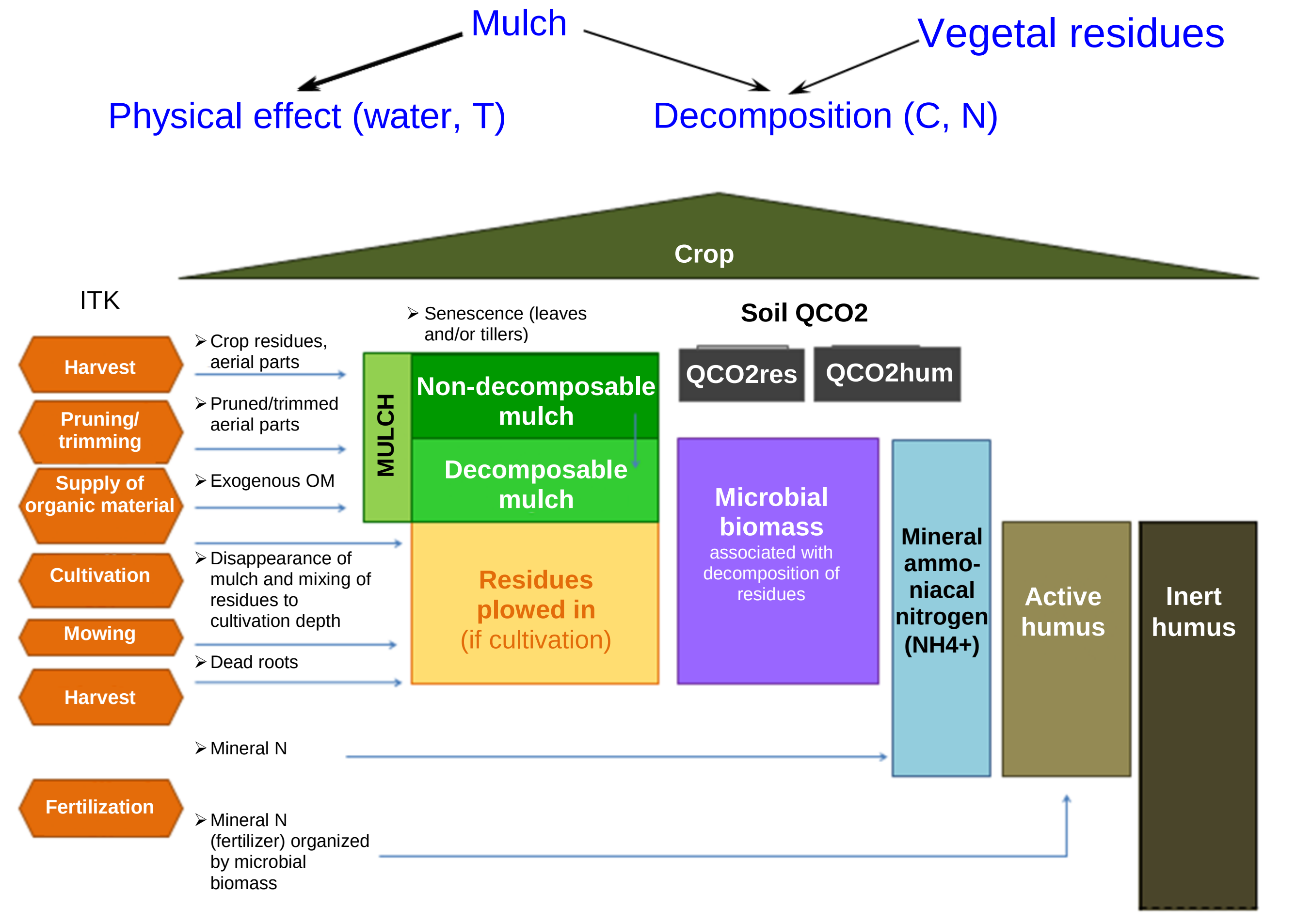
tabl. 9: list of available mineral fertilizers and corresponding parameters.
1 in the case of fixed efficiency, the DENENG, VOLENG and ORGENG values represent the proportion of fertilizer which is denitrified, volatilized and immobilized in soil, respectively.

CODE	1	2	3	4	5	6	7	8
TYPE	AMMONIUM NITRATE	UAN SOLUTION	UREA	ANHYDROUS AMMONIA	AMMONIUM SULFATE	AMMONIUM PHOSPHATE	CALCIUM NITRATE	Fixed efficiency[1]
ENGAMM$_T$	0.50	0.75	1.00	1.00	1.00	1.00	0.00	0.50
DENENG$_T$	0.11	0.13	0.10	0.10	0.10	0.10	0.20	0.05
VOLENG$_T$	0.12	0.30	0.35	0.35	0.25	0.25	0.00	0.05
ORGENG$_T$	30.0	33.8	37.7	37.7	37.7	37.7	25.0	0.20

1 With this option the DENENG, VOLENG and ORGENG values represent the proportion of fertilizer which is denitrified, volatilized and immobilized in soil, respectively.

Residues and mulching

fig. 2: Balance of organic matter in the soil and management of vegetal mulch



Accounting for mulching

For independent usm

Crop management file: Enter a supply of residue mulch with ressuite parameter corresponding to the mulch to be used with the corresponding qres etc.
The parameters relating to mulching with the chosen residue need to have been entered (in the param_gen.xml file).
Residues of type 9 and 10 (other.1 and other.2) are left free for specific settings you can enter.

tabl. 10: list of available residues for decomposition parameters.

codetypres	Type of residues for decomposition parameters	
1	**Main crop on surface**	**Relates to the surface of the soil**
2	**Intermediate crop on surface**	
3	**Manure on surface**	
4	**Green compost on surface**	
5	**Sewage sludge on surface**	
6	**Vinasse on surface**	
7	**Horn on surface**	
8	**Grapevine shoots on surface**	
9	**Others.1 on surface**	
10	**Others.2 on surface**	
11	**Main crop ploughed in**	**Relates to the residues ploughed in**
12	**Intermediate crop ploughed in**	
13	**Manure ploughed in**	
14	**Green compost ploughed in**	
15	**Sewage sludge ploughed in**	
16	**Vinasse ploughed in**	
17	**Horn ploughed in**	
18	**Grapevine shoots ploughed in**	
19	**Others.1 ploughed in**	
20	**Others.2 ploughed in**	
21	**Dead roots in soil**	

For rotation

usm 1

crop management file: Enter a ressuite parameter corresponding to the type of mulch to be used.

table. 11: list of available ressuite

	ressuite	Qressuite	QNressuite
1	'whole_crop'	masec	QNplante-Nrac
2	'straw+roots'	mspaille	QNveget-Nrac
3	'stubble_of_residu_type_9+roots'	mspaille	QNveget-Nrac
4	'stubble_of_residu_type_10+roots'	mspaille	QNveget-Nrac
5	'prunings'	Mabois	mabois * 0.5 * 10.
6	'stubble+roots'	0.35*mspaille	0.35*(QNveget-Nrac)
	The rest is managed separately, except for 'roots'		

The parameters relating to mulching with the chosen residue need to have been entered (in the param_gen.xml file).
Residues of type 9 and 10 (other.1 and other.2) are left free for specific settings you can enter.

usm2

Crop management file: Enter a supply of residue/mulch with the type of residues corresponding to the ressuite (see above); the quantity of residue/mulch will be calculated by the model from usm1.

tabl. 12: list of organic residues and corresponding default parameters. The $CODERES_T$ number refer to mineralization dynamics (§6.3.3)

	Residue code	Average rate	Carbon content	C/N ratio	Mineral N content	Water content	Reference (pers. com.)
		t FM ha^{-1}	% DM		% FM	% FM	
	$CODERES_T$	$QRES_T$	$CRESPC_T$	$CSURNRES_T$	$NMINRES_T$	$EAURES_T$	
RESIDUES OF MATURE CROPS							
Cereals (straw)	1	9	42	90	0	7	
sugarbeet (leaves and crowns)	1	40	42	22	0	90	J.M. Machet
grain maize (stalks)	1	12	43	60	0	25	
soybean (straw and roots)	1	5	44	75	0	10	B. Nicolardot
proteaginous pea (foliage and roots)	1	4	42	28	0	10	
rapeseed (roots, pods and straw)	1	6	44	45	0	10	E. Justes
RESIDUES OF CATCH CROPS							
wheat, rye (cereals)	2	8	42	15	0	80	J.M. Machet
mustard (cruciferous)	2	10	42	15	0	70	
phacelia (cruciferous)	2	15	42	20	0	80	
radish, oil seed (cruciferous)	2	10	42	16	0	80	E. Justes
ryegrass (grass)	2	18	40	25	0	80	
MANURE							
bovine manure	3	45	32	20	0	75	
ovine manure	3	45	45	20	0	75	T. Morvan
poultry manure	3		22			45	
COMPOSTS							
rubbish compost	4	10	25	19	0.08	44	
green waste compost	4	10	26	18	0.04	30	S. Houot
compost of sewage plant	4	10	37	19	0.04	50	
SEWAGE SLUDGE							
non processed sludge	5	60	30	8	0.12	90	
limed sludge	5	25	25	10	0.13	70	V. Parnaudeau
physico-chemical sludge	5	20	30	15	0.05	75	
CONCENTRATED VINASSE	6	3	40	8	0	50	J.M. Machet
GROUND HORN	7		40	3.8	0	10	B. Nicolardot
LIQUID MANURE							

porcine liquid manure	8	50	35	15	0.35	91	T. Morvan
bovine liquid manure	8	50	25	18	0.10	94	
FEATHER FLOUR	9	0.5	37	4	0	10	B. Nicolardot

tabl. 13 : Some plant mulches and corresponding parameters

Many of the techniques mentioned offer some possibility of calculation using simple decision rules (tabl.).

	DECOMPOSMULCH$_T$	QMULCHRUIS0$_T$	MOUILLABILMULCH$_T$	KCOUVMLCH$_T$	ALBEDOMULCH$_T$
maize stalk	0.0070	1.0	0.4	0.367	0.10
sugar cane	0.0070	1.0	0.4	0.367	0.50
vine stems	0.0070	1.0	0.0	0.050	0.08

tabl. 14 : Decision rules to help to implement practices

technique	**Possible decision rules**
sowing	**date** as a function of soil water status and temperature
irrigation	calendar **dates** or **phenological stages** and **amounts** as a function of water stress
fertilisation	calendar **dates** or **phenological stages** and **amounts** as a function of nitrogen stress and soil surface water status
harvesting	**date** as a function of plant physiology and soil water status
forage cutting	calendar **dates** or **phenological stages** with a minimum level of biomass
tactical shape control	**dates** and **amounts** as a function of the purposed shape
leaf removal	**dates** and **amounts** as a function of the leaf quantity to remove

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C. State variables calculated by the model

In grey the variables are not still available in this version, but tested for the next version.
It will be to zero if you choose them for your simulations

Name	Definition	Unit
abso(n)	N uptake rate by the crop	kg.ha-1.d-1
age_prairie	age of the forage crop since sowing	year
airg(n)	daily amount of irrigation water	mm.d-1
albedolai	albedo of the crop including soil and vegetation	SD
allocfruit	allocation ratio of assimilates to the fruits	0-1
amm_1_30	amount of NH4-N in the soil layer 1 to 30 cm	kg.ha-1
amm_31_60	amount of NH4-N in the soil layer 31-60 cm	kg.ha-1
amm_61_90	amount of NH4-N in the soil layer 61-90 cm	kg.ha-1
ammomes	amount of NH4-N in soil over the depth "profmes"	kg.ha-1
amptcultmat	mean daily temperature range (tcult) during the reproductive phase (stages lax - rec)	degreeC
anit_engrais(n)	Daily nitrogen provided by fertiliser	kgN.ha-1 j-1
anit_uree(n)	amount of animal urine returned to the soil	kgN.ha-1 j-1
anit(n)	daily amount of fertiliser-N added to crop	kg.ha-1.d-1
anoxmoy	index of anoxia over the root depth	0-1
AZamm(1)	amount of NH4-N in the soil layer 1	kg.ha-1
AZamm(2)	amount of NH4-N in the soil layer 2	kg.ha-1
AZamm(3)	amount of NH4-N in the soil layer 3	kg.ha-1
AZamm(4)	amount of NH4-N in the soil layer 4	kg.ha-1
AZamm(5)	amount of NH4-N in the soil layer 5	kg.ha-1
azlesd	daily amount of NO3-N leached in mole drains	kg.ha-1.d-1
AZnit(1)	amount of NO3-N in the soil layer 1	kg.ha-1
AZnit(2)	amount of NO3-N in the soil layer 2	kg.ha-1
AZnit(3)	amount of NO3-N in the soil layer 3	kg.ha-1

AZnit(4)	amount of NO3-N in the soil layer 4	kg.ha-1
AZnit(5)	amount of NO3-N in the soil layer 5	kg.ha-1
azomes	amount of NO3-N in soil over the depth "profmes"	kg.ha-1
bouchon	index showing if the shrinkage slots are opened (0) or closed (1)	0/1
Cb	amount of C in the microbial biomass decomposing organic residues mixed with soil	kg.ha-1
Cbmulch	amount of C in the microbial biomass decomposing organic residues at soil surface (mulch)	kg.ha-1
cdemande	cumulative amount of N needed by the plant (plant needs)	kg.ha-1
cEdirect	Total Evaporation (water evaporated by the soil + intercepted by leaves and mulch) integrated over the cropping season	mm
cEdirecttout	Total Evaporation (water evaporated by the soil + intercepted by leaves and mulch) integrated over the simulation period	mm
cep	cumulative transpiration over the cropping season	mm
ces	cumulative evaporation over the cropping season	mm
cestout	cumulative evaporation over the simulation period	mm
cet	cumulative evapotranspiration over the cropping season	mm
cet_from_lev	cumulative evapotranspiration over the cropping season (from emergence or budbreak)	mm
cet_from_plt	cumulative evapotranspiration over the cropping season (from planting or budbreak)	mm
cetm	cumulative maximum evapotranspiration over the cropping season	mm
Cetmtout	cumulative maximum evapotranspiration over the simulation period	mm
cetp	cumulative potential evapotranspiration (pet) over the cropping season	mm
chargefruit	number of filling grains or ripe fruits	m-2
Chuma	amount of active C in humified organic matter	kg.ha-1
Chumi	amount of inert C in humified organic matter	kg.ha-1
Chumt	amount of C in humified organic matter (active + inert fractions)	kg.ha-1
cintermulch	cumulative amount of rain intercepted by the mulch	mm
cinterpluie	cumulative amount of rain intercepted by the leaves	mm
Cmulch	amount of C in the whole plant mulch	kg.ha-1
Cmulchdec	amount of C in the decomposable mulch	kg.ha-1
Cmulchnd	amount of C in the non decomposable mulch	kg.ha-1
CNgrain	N concentration in fruits	% dry weight
Cnondec(1)	amount of C in the undecomposable mulch made of residues of type 1	kg.ha-1

Cnondec(10)	amount of C in the undecomposable mulch made of residues of type 10	kg.ha-1
Cnondec(2)	amount of C in the undecomposable mulch made of residues of type 2	kg.ha-1
Cnondec(3)	amount of C in the undecomposable mulch made of residues of type 3	kg.ha-1
Cnondec(4)	amount of C in the undecomposable mulch made of residues of type 4	kg.ha-1
Cnondec(5)	amount of C in the undecomposable mulch made of residues of type 5	kg.ha-1
Cnondec(6)	amount of C in the undecomposable mulch made of residues of type 6	kg.ha-1
Cnondec(7)	amount of C in the undecomposable mulch made of residues of type 7	kg.ha-1
Cnondec(8)	amount of C in the undecomposable mulch made of residues of type 8	kg.ha-1
Cnondec(9)	amount of C in the undecomposable mulch made of residues of type 9	kg.ha-1
CNplante	N concentration in the aboveground plant	% dry weight
co2(n)	atmospheric CO2 content above 330 ppm	ppm
CO2hum	daily amount of CO2-C emitted due to the mineralisation of soil humus	kg.ha-1.d-1
CO2res	daily amount of CO2-C emitted due to the mineralisation of organic residues	kg.ha-1.d-1
CO2sol	daily amount of CO2-C emitted due to soil mineralisation (humus and organic residues)	kg.ha-1.d-1
codebbch_output	code of the bbch stage (see plant file)	0-99
concNO3les	nitrate concentration in drained water	mg NO3.l-1
concNO3sol(1)	nitrate concentration in soil layer 1	mg NO3.l-1
concNO3sol(2)	nitrate concentration in soil layer 2	mg NO3.l-1
concNO3sol(3)	nitrate concentration in soil layer 3	mg NO3.l-1
concNO3sol(4)	nitrate concentration in soil layer 4	mg NO3.l-1
concNO3sol(5)	nitrate concentration in soil layer 5	mg NO3.l-1
condenit	ratio of actual to potential denitrifying rate	0-1
couvermulch	cover ratio of mulch	0-1
cpluie	cumulative amount of rain over the simulation period	mm
cprecip	cumulative water supply over the cropping season (precipitation + irrigation)	mm
cpreciptout	cumulative water supply over the simulation period (precipitation + irrigation)	mm
Cr	amount of C in organic residues mixed with soil	kg.ha-1
Crac	amount of C in roots at harvest	kg.ha-1
Cresiduprofil(1)	amount of C in residues over the soil depth "profhum" in the residue type 1	kg.ha-1

Cresiduprofil(10)	amount of C in residues over the soil depth "profhum" in the residue type 10	kg.ha-1
Cresiduprofil(2)	amount of C in residues over the soil depth "profhum" in the residue type 2	kg.ha-1
Cresiduprofil(3)	amount of C in residues over the soil depth "profhum" in the residue type 3	kg.ha-1
Cresiduprofil(4)	amount of C in residues over the soil depth "profhum" in the residue type 4	kg.ha-1
Cresiduprofil(5)	amount of C in residues over the soil depth "profhum" in the residue type 5	kg.ha-1
Cresiduprofil(6)	amount of C in residues over the soil depth "profhum" in the residue type 6	kg.ha-1
Cresiduprofil(7)	amount of C in residues over the soil depth "profhum" in the residue type 7	kg.ha-1
Cresiduprofil(8)	amount of C in residues over the soil depth "profhum" in the residue type 8	kg.ha-1
Cresiduprofil(9)	amount of C in residues over the soil depth "profhum" in the residue type 9	kg.ha-1
crg	cumulative global radiation over the cropping season	MJ.m-2
crgtout	cumulative global radiation over the simulation period	MJ.m-2
CsurNres_pature	C/N ratio of residues in case of pasture	g g-1
ctairtout	cumulative air temperature (tair) over the simulation period	degreeC
ctcult	cumulative crop temperature (tcult) over the cropping season	degreeC
ctculttout	cumulative crop temperature (tcult) over the simulation period	degreeC
ctetptout	cumulative potential evapotranspiration (pet) over the simulation period	mm
ctmoy	cumulative air temperature over the cropping season	degreeC
Ctousresidusprofil	amount of C contained in soil residues over the biologically active depth (profhum)	kg.ha-1
cum_et0	cumulative maximum evapotranspiration over the cropping season (eop+eos)	mm
cum_et0_from_lev	cumulative maximum evapotranspiration over the cropping season from germination or budbreak (eop+eos)	mm
cum_immob	cumulative amount of N immobilised by the microbial biomass decomposing residues	kg.ha-1
cum_immob_positif	cumulative amount of N immobilised by the microbial biomass decomposing residues (positive value)	kg.ha-1
cumlracz	cumulative length of active roots per soil surface	cm.cm-2
cumraint	cumulative intercepted radiation	MJ.m-2
cumrg	cumulative global radiation during the stage sowing-harvest	Mj.m-2
cumvminh	daily amount of N mineralised from humus	kg.ha-1.d-1
cumvminr	daily amount of N mineralised from organic residues	kg.ha-1.d-1
da(1)	bulk density of the layer 1 (recalculated by the model if codeDSTtass is 1)	g.cm-3
da(2)	bulk density of the layer 2 (recalculated by the model if codeDSTtass is 1)	g.cm-3

day_after_sowing	days after sowing or planting	day
day_cut	cut day	julian day
deltai(n)	daily increase in green leaf index per soil surface	m2.m-2.d-1
deltaz	rate of deepening of the root front	cm.d-1
demande	daily amount of N need of the plant	kg.ha-1.d-1
densite	actual sowing density	plants.m-2
densiteequiv	equivalent plant density for the understorey crop	plants.m-2
dfol	"within the shape" leaf density	m2.m-3
diftemp1intercoupe	mean difference between crop and air temperatures during the vegetative phase (emergence - maximum LAI)	degreeC
diftemp2intercoupe	mean difference between crop and air temperatures during the reproductive phase (maximum LAI - maturity)	degreeC
dltags	daily growth rate of the plantlets	t.ha-1.d-1
dltaisen	daily change in the senescent leaf area index	m2.m-2.d-1
dltams(n)	daily growth rate of the plant	t.ha-1.d-1
dltamsen	daily senescence rate of the plant	t.ha-1.d-1
dltaremobil	daily amount of perennial reserves remobilised	t.ha-1.d-1
dltmsrac_plante	pour sorties ArchiSTICS: biomasse journaliere allouee aux racines en g	mï¾²sol
drain	daily amount of water drained at the base of the soil profile	mm.d-1
drain_from_lev	cumulative amount of water drained at the base of the soil profile during the crop cycle(emergence or budbreak-harvest)	mm
drain_from_plt	cumulative amount of water drained at the base of the soil profile during the crop cycle (planting-harvest)	mm
drat	cumulative amount of water drained at the base of the soil profile during the simulation period	mm
drlsenmortalle	root biomass corresponding to dead tillers	t.ha-1.d-1
dtj(n)	thermal time for root growth	degreeC.d
dureehumec	number of hours which are "wet" (rainy days or days when tcult < dew point)	hour
dureeRH	number of night hours during which relative humidity exceeds a 90% threshold	hour
durvie(n)	actual life span of the leaf surface	degreeC
eai	equilvalent leaf area for ear	m2.m-2
ebmax	maximum value of radiation use efficiency	cg.MJ-1
ebmax_gr	Maximum radiation use efficiency during the vegetative stage (AMF-DRP)	g MJ-1
Edirect	daily amount of water evaporated by the soil + intercepted by leaves and mulch	mm.d-1

efda	reduction factor on root growth due to physical constraint (through bulk density)	0-1
efdensite	density factor on leaf area growth	0-1
efdensite_rac	density factor on root growth	0-1
efNrac_mean	reduction factor on root growth rate due to mineral N concentration	0-1
em_N2O	daily amount of N2O-N emitted from soil	kg.ha-1.d-1
em_N2Oden	daily amount of N2O-N emitted from soil by denitrification	kg.ha-1.d-1
em_N2Onit	daily amount of N2O-N emitted from soil by nitrification	kg.ha-1.d-1
Emd	daily amount of water directly evaporated after leaves interception	mm.d-1
Emulch	daily amount of water directly evaporated after mulch interception	mm.d-1
eo	intermediary variable for the computation of evapotranspiration	mm.d-1
eop	daily maximum transpiration flux	mm.d-1
eos	daily maximum evaporation flux	mm.d-1
ep	daily actual transpiration flux	mm.d-1
epc_recal(1)	thickness of the soil layer 1 (recalculated by the model if codeDSTtass is 1)	cm
epc_recal(2)	thickness of the soil layer 2 (recalculated by the model if codeDSTtass is 1)	cm
epc_recal(3)	thickness of the soil layer 3 (recalculated by the model if codeDSTtass is 1)	cm
epc_recal(4)	thickness of the soil layer 4 (recalculated by the model if codeDSTtass is 1)	cm
epc_recal(5)	thickness of the soil layer 5 (recalculated by the model if codeDSTtass is 1)	cm
epsib	radiation use efficiency	t.ha-1.MJ-1.m2
esol	daily actual soil evaporation flux	mm.d-1
et	daily evapotranspiration (esol + ep)	mm.d-1
et0	daily maximun evapotranspiration flux (transpiration + soil evaporation)	mm
etm	daily maximum evapotranspiration (esol + eop)	mm.d-1
etpp(n)	'daily potential evapotranspiration as given by Penman"s formula'	mm.d-1
exces(1)	amount of water in the macroporosity of the layer 1	mm
exces(2)	amount of water in the macroporosity of the layer 2	mm
exces(3)	amount of water in the macroporosity of the layer 3	mm
exces(4)	amount of water in the macroporosity of the layer 4	mm
exces(5)	amount of water in the macroporosity of the layer 5	mm

exobiom	reduction factor on biomass growth due to water excess	0-1
exofac	waterlogging index	0-1
exofac1moy	mean value of the waterlogging index during the vegetative stage (emergence - fruit establishment)	0-1
exofac2moy	mean value of the waterlogging index during the reproductive stage (fruit establishment - maturity)	0-1
exolai	reduction factor on leaf growth due to water excess	0-1
fapar	proportion of the radiation intercepted	0-1
fco2	specie-dependant CO2 effect on radiation use efficiency	SD
fco2s	specie-dependant CO2 effect onstomate closure	SD
fgelflo	reduction factor on the number of fruits due to frost	0-1
fixmaxvar	maximal rate of BNF (symbiotic fixation)	kg.ha-1.d-1
fixpot	potential rate of BNF (symbiotic fixation)	kg.ha-1.d-1
fixreel	actual rate of BNF (symbiotic fixation)	kg.ha-1.d-1
flurac	daily amount of N taken up by the plant when N uptake is limited by the plant capacity absorption	kg.ha-1.d-1
flusol	daily amount of N taken up by the plant when N uptake is limited by the transfer from soil to root	kg.ha-1.d-1
fpari	radiation effect on conversion efficiency	g.MJ-1
fpari_gr	radiation factor on the calculation of conversion efficiency	g MJ-1
fpft	daily sink capacity of fruits	g.m-2.d-1
fpv(n)	daily sink capacity of growing leaves	g.m-2.d-1
FsNH3	daily amount of NH3-N emitted from soil by volatilisation	micro g.m-2.d-1
fstressgel	reduction factor on leaf growth due to frost	0-1
ftemp	reduction factor on biomass growth due to temperature-related epsibmax	0-1
fxa	reduction factor on BNF (symbiotic fixation) due to soil anoxia	0-1
fxn	reduction factor on BNF (symbiotic fixation) due to mineral N concentration	0-1
fxt	reduction factor on BNF (symbiotic fixation) due to soil temperature	0-1
fxw	reduction factor on BNF (symbiotic fixation) due to soil water content	0-1
gel1	proportion of leaves damaged by frost before amf stage (end of juvenile phase)	0-1
gel1_percent	proportion of leaves damaged by frost before amf stage (end of juvenile phase)	%
gel2	proportion of leaves damaged by frost after amf stage (end of juvenile phase)	0-1
gel2_percent	proportion of leaves damaged by frost after amf stage (end of juvenile phase)	%

gel3	proportion of flowers or fruits damaged by frost	0-1
gel3_percent	proportion of flowers or fruits damaged by frost	%
grain_dry_weight_ mg	Grain unit dry weight	mg
H2Orec	water content of harvested organs	0-1
H2Orec_percent	water content of harvested organs	% fresh weight
hauteur	height of canopy	m
Hmax	maximum height of water table between drains	cm
Hnappe	height of water table affecting plant growth	cm
Hpb	minimum depth of perched water table	cm
Hph	maximum depth of perched water table	cm
HR_mm_1_30	water content of the layer 1-30 cm	mm
HR_mm_31_60	water content of the layer 31-60 cm	mm
HR_mm_61_90	water content of the layer 61-90 cm	mm
HR_vol_1_10	water content of the layer 1-10 cm	mm-3.mm-3
HR_vol_1_30	water content of the layer 1-30 cm (table)	mm-3.mm-3
HR_vol_121_150	water content of the layer 121-150 cm (table)	mm-3.mm-3
HR_vol_151_180	water content of the layer 151-180 cm (table)	mm-3.mm-3
HR_vol_31_60	water content of the layer 31-60 cm (table)	mm-3.mm-3
HR_vol_61_90	water content of the layer 61-90 cm (table)	mm-3.mm-3
HR_vol_91_120	water content of the layer 91-120 cm (table)	mm-3.mm-3
HR(1)	water content of the soil layer 1	% dry weight
HR(2)	water content of the soil layer 2	% dry weight
HR(3)	water content of the soil layer 3	% dry weight
HR(4)	water content of the soil layer 4	% dry weight
HR(5)	water content of the soil layer 5	% dry weight
huile	oil content of harvested organs	0-1
huile_percent	oil content of harvested organs	% fresh weight
humair	air moisture content	0-1

humair_percent	air moisture content	% saturation
humidite	air moisture content in the canopy	0-1
humidite_percent	air moisture content in the canopy	% saturation
humirac_mean	reduction factor on root growth due to soil water content (mean value over the root profile)	0-1
hur_10_vol	soil water content in the soil at 10 cm	cm/cm
iamfs	date of amf stage (maximum acceleration of leaf growth, end of juvenile phase)	julian day
idebdess	date of onset of water dynamics in harvested organs	julian day
idebdorms	date of entry into dormancy	julian day
idrps	starting date of filling of harvested organs	julian day
ifindorms	date of emergence from dormancy	julian day
iflos	date of flowering	julian day
igers	date of germination	julian day
ilans	date of lan stage (leaf index nil)	julian day
ilaxs	date of lax stage (leaf index maximum)	julian day
ilevs	date of emergence	julian day
imats	date of start of physiological maturity	julian day
imontaisons	date of start of stem elongation	julian day
infil_recal(1)	infiltrability parameter at the base of the layer 1	mm.d-1
infil_recal(2)	infiltrability parameter at the base of the layer 2	mm.d-1
infil_recal(3)	infiltrability parameter at the base of the layer 3	mm.d-1
infil_recal(4)	infiltrability parameter at the base of the layer 4	mm.d-1
infil_recal(5)	infiltrability parameter at the base of the layer 5	mm.d-1
inn	nitrogen nutrition index (NNI)	0-2
inn1intercoupe	average NNI during the cut (cut crop vegetative phase: emergence to maximum LAI)	0-2
inn1moy	average NNI during the vegetative stage	0-2
inn2intercoupe	average NNI during the cut (cut crop reproductive phase: maximum LAI to maturity)	0-2
inn2moy	average NNI during the reproductive stage	0-2
innlai	reduction factor on leaf growth due to NNI (nitrogen deficiency)	innmin to 1
inns	reduction factor on biomass growth due to NNI (nitrogen deficiency)	innmin to 1

innsenes	nitrogen stress index affecting leaves death	innmin to 1
inous	ending date for setting of harvested organs	julian day
intermulch	daily amount of water intercepted by the mulch (vegetal)	mm.d-1
interpluie	daily amount of water intercepted by leaves	mm.d-1
iplts	date of sowing or planting	julian day
irazo(n)	nitrogen harvest index	0-1
ircarb(n)	carbon harvest index	0-1
irecs	date of harvest (first if several)	julian day
irrigjN	amount of mineral N added by irrigation	kg.ha-1
irrigN	cumulative amount of mineral N added by irrigation	kg.ha-1
isens	date of begninning leaf senescence stage	julian day
izrac	water excess stress index on roots	0-1
lai_mx_av_cut	LAI before cut (for cut crops , for others = lai(n))	SD
lai(n)	leaf area index (table)	m2.m-2
laimax	maximum leaf area index	m2.m-2
laisen(n)	leaf area index of senescent leaves (table)	m2.m-2
largeur	width of the plant shape	m
leaching_from_lev	cumulative amount of NO3-N leached at the base of the soil profile during the crop cycle (emergence or budbreak-harvest)	kg.ha-1
leaching_from_plt	cumulative amount of NO3-N leached at the base of the soil profile during the crop cycle	kg.ha-1
leai	Leaf+ear area index = lai +eai	m2.m-2
lessiv	daily amount of NO3-N leached at the base of the soil profile	kg.ha-1.d-1
LRACH(1)	root length density in soil layer 1	cm.cm-3
LRACH(2)	root length density in soil layer 2	cm.cm-3
LRACH(3)	root length density in soil layer 3	cm.cm-3
LRACH(4)	root length density in soil layer 4	cm.cm-3
LRACH(5)	root length density in soil layer 5	cm.cm-3
lracsentot	cumulative length of senescent roots	cm root.cm -2 soil
mabois	biomass removed by pruning	t.ha-1

maenfruit	biomass of harvested organ envelops	t.ha-1
mafeuil	biomass of leaves	t.ha-1
mafeuil_kg_ha	Dry matter of leaves	kg.ha-1
mafeuiljaune	biomass of yellow leaves	t.ha-1
mafeuiltombe	biomass of fallen leaves	t.ha-1
mafeuilverte	biomass of green leaves	t.ha-1
mafrais	aboveground fresh matter	t.ha-1
mafruit	biomass of harvested organs	t.ha-1
mafruit_kg_ha	Dry matter of harvested organs	kg.ha-1
masec_kg_ha	Aboveground dry matter	kg.ha-1
masec_mx_av_cut	Aboveground dry matter before cut(for cut crops , for others = masec(n))	t.ha-1
masec(n)	biomass of aboveground plant (table)	t.ha-1
masecneo	biomass of newly-formed organs	t.ha-1
masectot	dry matter	t.ha-1
masecveg	biomass of vegetative organs	t.ha-1
matigestruc	biomass of stems (only structural parts)	t.ha-1
matigestruc_kg_ha	Dry matter of stems (only structural parts)	kg.ha-1
matuber	biomass of harvested organs, tuber weight only calculated for sugarbeet	t.ha-1
mortalle	daily number of dying tillers	d-1
mortmasec	cumulative biomass of dead tillers	t.ha-1
mortreserve	biomass of reserves corresponding to dead tillers	t.ha-1.d-1
MSexporte	cumulative amount of harvested biomass	t.ha-1
msjaune	Senescent dry matter	t.ha-1
msneojaune	newly-formed senescent dry matter	t.ha-1
msrac(n)	biomass of roots	t.ha-1
msrec_fou	Dry matter of harvested organs for forages	t.ha-1
MSrecycle	cumulative amount of biomass returned to soil (unexported at harvest + fallen leaves)	t.ha-1
msresjaune	senescent residual dry matter	t.ha-1
N_mineralisation	cumulative amount of N mineralized from humus and organic residues	kg.ha-1

N_volatilisation	cumulative amount of N volatilised from fertilizer and organic inputs	kg.ha-1
Nb	daily amount of N in the microbial biomass decomposing organic residues mixed with soil	kg.ha-1
nbfeuille	number of leaves on main stem	SD
nbinflo_recal	number of inflorescences	SD
nbj0remp	number of shrivelling days	d
nbjechaudage	number of shrivelling days between lax and rec	d
nbjgel	number of frosting days active on the plant	d
nbjpourdecirecolte	number of days until harvest is launched when it is postponed by the "harvest decision" option	d
nbjpourdecisemis	number of days until sowing is launched when it is postponed by the "sowing decision" option	d
Nbmulch	cumulative N in microbial biomass decomposing the decomposable mulch	kg.ha-1
NCbio	n/c ratio of biomass decomposing organic residues	SD
Ndenit	daily denitrification rate in soil (if option "denitrification" is activated)	kg.ha-1.d-1
Nexporte	cumulative amount of N removed by crop harvests	kg.ha-1
nfruit(1)	number of fruits in box 1	SD
nfruit(2)	number of fruits in box 2	SD
nfruit(3)	number of fruits in box 3	SD
nfruit(4)	number of fruits in box 4	SD
nfruit(5)	number of fruits in box 5	SD
nfruit(nboite-1)	number of fruits in last but one box	SD
nfruit(nboite)	number of fruits in last box	SD
nfruitnou	number of set fruits	fruits.m-2
Nhuma	amount of N in active soil organic matter	kg.ha-1
Nhumi	amount of N in inert soil organic matter	kg.ha-1
Nhumt	amount of N in humus soil organic matter (active + inert fractions)	kg.ha-1
nit_1_30	amount of NO3-N in the soil layer 1 to 30 cm	kg.ha-1
nit_31_60	amount of NO3-N in the soil layer 31 to 60 cm	kg.ha-1
nit_61_90	amount of NO3-N in the soil layer 61 to 90 cm	kg.ha-1
nitetcult(n)	number of iterations to calculate tcult	SD
nitrifj	daily nitrification rate in soil (if option "nitrification" is activated)	kg.ha-1

Nmineral_from_lev	cumulative amount of N mineralized during the crop cycle (emergence or budbreak-harvest)	kg.ha-1
Nmineral_from_plt	cumulative amount of N mineralized during the crop cycle (sowing-harvest)	kg.ha-1
Nmulchdec	amount of N in the decomposable mulch	kg.ha-1
Nmulchnd	amount of N in the non decomposable mulch	kg.ha-1
Nnondec(1)	amount of N in the undecomposable mulch derived from residues type 1	kg.ha-1
Nnondec(10)	amount of N in the undecomposable mulch derived from residues type 10	kg.ha-1
Nnondec(2)	amount of N in the undecomposable mulch derived from residues type 2	kg.ha-1
Nnondec(3)	amount of N in the undecomposable mulch derived from residues type 3	kg.ha-1
Nnondec(4)	amount of N in the undecomposable mulch derived from residues type 4	kg.ha-1
Nnondec(5)	amount of N in the undecomposable mulch derived from residues type 5	kg.ha-1
Nnondec(6)	amount of N in the undecomposable mulch derived from residues type 6	kg.ha-1
Nnondec(7)	amount of N in the undecomposable mulch derived from residues type 7	kg.ha-1
Nnondec(8)	amount of N in the undecomposable mulch derived from residues type 8	kg.ha-1
Nnondec(9)	amount of N in the undecomposable mulch derived from residues type 9	kg.ha-1
nodn	reduction factor on nodulation establishment (potential BNF) due to mineral N stress	0/1
Norgeng	daily amount of N immobilized from fertiliser	kg.ha-1.d-1
Nr	amount of N in the decomposing organic residues mixed with soil	kg.ha-1
Nrac	amount of N in roots at harvest	kg.ha-1
Nrecycle	cumulative amount of N returned to soil (unexported at harvest + fallen leaves)	kg.ha-1
Nresiduprofil(1)	amount of N in residues over the soil depth (profhum) derived from residues type 1	kg.ha-1
Nresiduprofil(10)	amount of N in residues over the soil depth (profhum) derived from residues type 10	kg.ha-1
Nresiduprofil(2)	amount of N in residues over the soil depth (profhum) derived from residues type 2	kg.ha-1
Nresiduprofil(3)	amount of N in residues over the soil depth (profhum) derived from residues type 3	kg.ha-1
Nresiduprofil(4)	amount of N in residues over the soil depth (profhum) derived from residues type 4	kg.ha-1
Nresiduprofil(5)	amount of N in residues over the soil depth (profhum) derived from residues type 5	kg.ha-1
Nresiduprofil(6)	amount of N in residues over the soil depth (profhum) derived from residues type 6	kg.ha-1
Nresiduprofil(7)	amount of N in residues over the soil depth (profhum) derived from residues type 7	kg.ha-1
Nresiduprofil(8)	amount of N in residues over the soil depth (profhum) derived from residues type 8	kg.ha-1
Nresiduprofil(9)	amount of N in residues over the soil depth (profhum) derived from residues type 9	kg.ha-1

Ntousresidusprofil	amount of N in all organic residues over soil depth (profhum)	kg.ha-1
numcoupe	cut number	SD
numcult	crop season number	SD
Nvolat_from_lev	cumulative amount of N volatilised during the crop cycle(emergence or budbreak-harvest)	kg.ha-1
Nvolat_from_plt	cumulative amount of N volatilised during the crop cycle (planting-harvest)	kg.ha-1
Nvoleng	daily amount of N volatilised from fertiliser	kg.ha-1.d-1
offrenod	daily amount of N fixed symbiotically (BNF)	kg.ha-1.d-1
p1000grain	1000 grains weight	g
pdsfruit(1)	weight of fruits in box 1	g.m-2
pdsfruit(2)	weight of fruits in box 2	g.m-2
pdsfruit(3)	weight of fruits in box 3	g.m-2
pdsfruit(4)	weight of fruits in box 4	g.m-2
pdsfruit(5)	weight of fruits in box 5	g.m-2
pdsfruit(nboite-1)	weight of fruits in last but one box	g.m-2
pdsfruit(nboite)	weight of fruits in last box	g.m-2
pdsfruitfrais	weight of fresh fruits	g.m-2
penfruit	ratio of fruit envelops to plant biomass	0-1
pfeuil(n)	ratio of leaves to plant biomass	0-1
pfeuiljaune	ratio of yellow leaves to plant biomass	0-1
pfeuilverte(n)	ratio of green leaves to non-senescent plant biomass	0-1
phoi	photoperiod	hour
pHvol	pH of soil surface as affected by organic residues application (slurry)	SD
pousfruit	number of fruits transferred from one box to the next	SD
poussracmoy	mean reduction factor on the root growth due to soil constraints (option "true density")	0-1
precip	daily amount of water added to soil (precipitation + irrigation)	mm.d-1
precipjN	daily amount of mineral N added to soil due to precipitation	kg.ha-1.d-1
precipN	cumulative amount of mineral N added to soil due to precipitation	kg.ha-1
preciprec(n)	recalculated daily precipitation	mm.d-1
preserve	proportion of reserve in total plant biomass	0-1

profexteau	average depth of water absorption by plant	cm
profextN	average depth of N absorption by plant	cm
profnappe	depth of water table	cm
psibase	predawn leaf water potential	MPa
ptigestruc	proportion of structural stems in total plant biomass	0-1
QCapp	cumulative amount of organic C added to soil	kg.ha-1
QCO2hum	cumulative amount of CO2-C emitted due to mineralisation of humus	kg.ha-1
QCO2mul	cumulative amount of CO2-C emitted due to mineralisation of residues in the mulch	kg.ha-1
QCO2res	cumulative amount of CO2-C emitted due to mineralisation of residues (including residues in mulch)	kg.ha-1
QCO2sol	cumulative amount of CO2-C emitted due to heterotrophic respiration (QCO2res + QCO2hum)	kg.ha-1
QCplantetombe	cumulative amount of C added to soil by fallen leaves due to senescence	kg.ha-1
QCprimed	cumulative amount of C mineralised by priming effect	kg.ha-1
QCrac	cumulative amount of C added to soil by dead roots	kg.ha-1
QCresorg	cumulative amount of C added to soil through organic exogenous residues	kg.ha-1
QCressuite	cumulative amount of C added to soil due to aerial residues at harvest	kg.ha-1
QCrogne	cumulative amount of C added to soil by fallen leaves due to trimming	kg.ha-1
Qdrain	water flow rate in mole drains	mm.d-1
Qdraincum	cumulative amount of water flowing in mole drains	mm
Qem_N2O	cumulative amount of N2O-N emitted from soil	kg.ha-1
Qem_N2Oden	cumulative amount of N2O-N emitted from soil by denitrification	kg.ha-1
Qem_N2Onit	cumulative amount of N2O-N emitted from soil by nitrification	kg.ha-1
Qfix	cumulative amount of N fixed symbiotically (BNF)	kg.ha-1
Qles	cumulative amount of NO3-N leached at the base of the soil profile	kg.ha-1
Qlesd	cumulative amount of NO3-N leached into mole drains	kg.ha-1
Qminh	cumulative amount of mineralized N derived from humus mineralisation	kg.ha-1
Qminr	cumulative amount of mineralized N derived from organic residues mineralisation	kg.ha-1
qmulch	biomass of plant mulch	t.ha-1
QNapp	cumulative amount of organic N added to soil (from straw, roots, leaves, organic amendments,)	kg.ha-1
QNdenit	cumulative amount of N denitrified during the simulation period	kg.ha-1

QNdenit_from_lev	cumulative amount of N denitrified during the crop cycle (emergence or budbreak-harvest)	kg.ha-1
QNdenit_from_plt	cumulative amount of N denitrified during the crop cycle	kg.ha-1
QNexport	Amount of nitrogen exported at harvest (harvested and removed parts)	kgN.ha-1
QNgrain	amount of N in harvested organs (grains / fruits)	kg.ha-1
Qnitrif	cumulative amount of N nitrified in soil (if option "nitrification" is activated)	kg.ha-1
QNorgeng	cumulative amount of N immobilized from fertiliser	kg.ha-1
QNplante	amount of N taken up by the plant	kg.ha-1
QNplante_mx_av_cut	Amount of nitrogen taken up by the plant before cut(for cut crops , for others = Qnplante(n))	kgN.ha-
QNplantetombe	cumulative amount of N added to soil by fallen leaves due to senescence	kg.ha-1
QNprimed	cumulative amount of N mineralised by priming effect	kg.ha-1
QNrac	cumulative amount of N added to soil by dead roots	kg.ha-1
QNresorg	cumulative amount of organic exogenous N added to soil	kg.ha-1
QNressuite	cumulative amount of N added to soil by aerial residues at harvest	kg.ha-1
QNrogne	cumulative amount of N added to soil by fallen leaves due to trimming	kg.ha-1
QNvoleng	cumulative amount of N volatilised from fertiliser	kg.ha-1
QNvolorg	cumulative amount of N volatilised from organic inputs	kg.ha-1
qres_pature	amount of animal feces returned to the soil (fresh weight basis)	t MF ha-1
Qressuite	biomass of residues from the previous crop returned to soil at harvest	t.ha-1
Qressuite_tot	amount of total harvest residues (aerials + roots)	t.ha-1
ra_recal	aerodynamic resistance between the canopy and the reference level zr	s.m-1
raint	photosynthetic active radiation intercepted by the canopy	MJ.m-2
ras	aerodynamic resistance between the soil and the canopy	s.m-1
Ratm	atmospheric radiation	MJ.m-2
rc	resistance of canopy	s.m-1
rdif	ratio of diffuse radiation to global radiation	0-1
remobilj	daily amount of biomass remobilized for growth	kg.ha-1.d-1
remontee	capillary uptake from the base of the soil profile	mm.d-1
rendementsec	dry biomass of harvested organs	t.ha-1

resmes	amount of soil water integrated on the measurement depth	mm
resperenne	biomass of perennial reserves which can be remobilized	t.ha-1
resrac	soil water reserve in the root zone	mm
rfpi	reduction factor on plant development due to photoperiod	0-1
rfvi	reduction factor on plant development due to vernalization	0-1
rlj	rate of root length growth	m.d-1
rltot	total root length (accounting for senescent roots)	cm.cm-2
rmaxi	maximum water reserve used	mm
rnet	net radiation	MJ.m-2
rnetS	net radiation at the soil surface	MJ.m-2
rombre	fraction of the total radiation in the shade	0-1
rsoleil	fraction of the total radiation in the full sun	0-1
RsurRU	fraction of plant available water over the soil profile	0-1
RsurRUrac	fraction of plant available water over the root profile	0-1
RU	maximum plant available water content over the soil profile	mm
ruissel	daily amount of water in total runoff (surface + overflow)	mm.d-1
ruisselsurf	daily amount of water in runoff at soil surface	mm.d-1
ruisselt	cumulative amount of water in total runoff (surface + overflow)	mm
runoff_from_lev	cumulative amount of water in runoff (surface + overflow) during the crop cycle (emergence or budbreak-harvest)	mm
runoff_from_plt	cumulative amount of water in runoff (surface + overflow) during the crop cycle (sowing-harvest)	mm
RUrac	maximum plant available water content over the root profile	mm
saturation	amount of water in the soil macroporosity	mm
Sdepth(n)	snow cover depth	m
senfac	reduction factor on leaf life span due to water stress (increasing senescence rate)	0-1
sla	specific leaf area	cm2.g-1
Snowaccu(n)	daily snowfall accumulation (mm water equivalent)	mm.d-1
Snowmelt(n)	daily snowmelt (mm water equivalent)	mm.d-1
SoilAvW	amount of plant available water in soil over the depth "profmes"	mm
SoilN	amount of mineral N in soil over the depth "profmes"	kg.ha-1

SoilNM	amount of NO3-N in soil over the depth "profmesN"	kg.ha-1
SoilWatM	amount of plant available water in soil over the depth "profmesW"	mm
som_HUR	cumulative water content of the soil microporosity	mm
som_sat	cumulative amount of water in the soil macroporosity	mm
somcour	cumulative units of development (upvt) between two stages	degreeC.d
somcourdrp	cumulative units of development (upvt) between two reproductive stages	degreeC.d
somcourfauche	sum of temperature beetwen 2 cuts of forage crop	degreeC.d
somcourmont	cumulative units of development from the start of vernalisation	degreeC.d
somdifftculttair	cumulative temperature difference (tcult-tair) during the simulation period	degreeC
somtemp	sum of temperatures (expressed in Q10 =sum (2.0 ** (udevair ou udevcult / 10.))	degreeC.d
somudevair	sum of air temperature (udevair) from sowing to harvest	degreeC
somudevcult	sum of crop temperature (udevcult) from sowing to harvest	degreeC
somupvtsem	sum of development units (upvt) from sowing to harvest	degreeC
sourcepuits	source to sink ratio of assimilates in the plant	SD
spfruit	reduction factor on the fruits number due to trophic stress	0-1
splai	source to sink ratio of assimilates in the leaves	SD
stemflow	daily amount of water runoff along the stem	mm.d-1
str1intercoupe	average stomatal water stress index during the vegetative phase (emergence - maximum LAI) of forage crops	0-1
str2intercoupe	average stomatal water stress index during the reproductive phase (maximum LAI - maturity) of forage crops	0-1
stu1intercoupe	average turgescence water stress index during the vegetative phase (emergence - maximum LAI) of forage crops	0-1
stu2intercoupe	average turgescence water stress index during the reproductive phase (maximum LAI - maturity) of forage crops	0-1
sucre	sugar content of harvested organs	0-1
sucre_percent	sugar content of harvested organs	% fresh weight
surf(ao)	fraction of the soil surface in the shade	0-1
surf(as)	fraction of the soil surface in the sun	0-1
swfac	stomatic water stress index	0-1
swfac1moy	average stomatic water stress index over the vegetative stage	0-1
swfac2moy	average stomatic water stress index over the reproductive stage	0-1
tairveille	mean air temperature at the previous day	degreeC

tauxcouv(n)	cover rate of the canopy	SD
tcult	crop surface temperature (daily average)	degreeC
tcult_tairveille	difference between canopy temperature and air temperature	degreeC
tcultmax	crop surface temperature (daily maximum)	degreeC
tcultmin	crop surface temperature (daily minimum)	degreeC
tempeff	efficient temperature for growth	degreeC
tetp(n)	efficient potential evapotranspiration (entered or calculated)	mm.d-1
tetstomate	threshold of soil water content limiting transpiration and photosynthesis	% vol
teturg	threshold of soil water content limiting the growth of leaves (in surface area)	% vol
tmax(n)	maximum active temperature of atmosphere	degreeC
tmaxext(n)	maximum temperature of external atmosphere	degreeC
tmaxrec(n)	recalculated daily maximum temperature (with presence of a snow cover)	degreeC
tmin(n)	minimum active temperature of atmosphere	degreeC
tminext(n)	minimum temperature of external atmsphere	degreeC
tminrec(n)	recalculated daily minimum temperature (with presence of a snow cover)	degreeC
tmoy(n)	mean active temperature of atmosphere	degreeC
tmoyext(n)	mean temperature of external atmosphere	degreeC
tmoyIpltJuin	mean temperature from sowing or planting (iplt stage) until June 30	degreeC
tmoyIpltSept	mean temperature from sowing or planting (iplt stage) until September 30	degreeC
tncultmat	average of minimum crop temperatures (tcultmin) between the stages lax and rec	degreeC
tnhc	cumulative "normalized" time for the mineralisation of humus	d
tnrc	cumulative "normalized" time for the mineralisation of organic residues	d
totapN	cumulative amount of mineral N added by mineral fertilisers and organic fertilisers	kg.ha-1
totapNres	cumulative amount of mineral N added by organic fertilisers	kg.ha-1
totir	cumulative amount of water inputs by irrigation	mm
tpm(n)	water vapour pressure in air	hPa
trg(n)	active radiation (entered or calculated)	MJ.m-2
trgext(n)	exterior radiation	MJ.m-2
trr(n)	daily rainfall	mm.d-1

TS(1)	mean soil temperature (in layer 1)	degreeC
TS(2)	mean soil temperature (in layer 2)	degreeC
TS(3)	mean soil temperature (in layer 3)	degreeC
TS(4)	mean soil temperature (in layer 4)	degreeC
TS(5)	mean soil temperature (in layer 5)	degreeC
tsol(10)	temperature in the soil at 10 cm	degrees
turfac	turgescence water stress index	0-1
turfac1moy	average turgescence water stress index during the vegetative stage	0-1
turfac2moy	average turgescence water stress index during the reproductive stage	0-1
tustress	reduction factor on leaf growth due to the effective water stress (= min(turfac,innlai))	0-1
tvent(n)	mean daily wind speed at 2 m high above soil	m.s-1
udevair	effective temperature for crop development, computed with tair	degreeC.d
udevcult	effective temperature for crop development, computed with tcult	degreeC.d
ulai(n)	relative development unit for LAI	0-3
upvt(n)	development unit	degreeC.d
vitmoy	mean canopy growth rate	g.m-2.d-1
xmlch1	thickness of the dry layer created by evaporation from the soil and mulch	cm
zrac	maximum depth reached by root system	cm

D. Optimizable parameters

Name	description	unit	Parameter type		Value type	min	max

aangst	'coefficient of the Angstrom''s relationship for extraterrestrial radiation'	SD	STATION	1	real	0	0.9
abscission	fraction of senescent leaves falling to the soil	SD	PARPLT	1	real	0	100
aclim	climatic component of A to calculate actual soil evaporation	mm	STATION	1	real	4	25
adens	Interplant competition parameter	SD	PARPLT	1	real	-2	0
adfol	parameter determining the leaf density evolution within the chosen shape	m-1	PARPLT	1	real	-10	10
adil	parameter of the critical dilution curve [Nplante]=adil MS^(-bdil)	% DM	PARPLT	1	real	1	7
adilmax	parameter of the maximum dilution curve [Nplante]=adilmax MS^(-bdilmax)	% DM	PARPLT	1	real	3	10
afpf	parameter of the logistic function defining sink strength of fruits (indeterminate growth) : relative fruit age at which growth is maximal	SD	PARPLT	1	real	0.01	1
afruitpot	maximal number of set fruits per degree-day (indeterminate growth)	degree-d-1	PARPLT	1	real	0.5	20
ahres	parameter of organic residues humification: hres=1-ahres*CsurNres/(bhres+CsurNres)	g.g-1	PARAM	21	real	0	500
akres	parameter of organic residues decomposition: kres=akres+bkres/CsurNres	d-1	PARAM	21	real	0	1000
aks	parameter of calculation of the energetic loss between the inside and the outside of a greenhouse	W.m-2.K-1	STATION	1	real	0.01	100
albedo	albedo of the bare dry soil	SD	PARSOL	1	real	0.05	0.6
albedomulchplastique	albedo of plastic cover	SD	PARTEC	1	real	0.05	0.8
albedomulchresidus	albedo of crop mulch	SD	PARAM	21	real	0.05	0.8
albveg	albedo of the vegetation	SD	STATION	1	real	0.05	0.3
allocfrmax	maximal daily allocation to fruits	SD	PARPLT	1	real	0.05	1
alphaCO2	coefficient accounting for the modification of radiation use efficiency in case of atmospheric CO2 increase	SD	PARPLT	1	real	1	2
alphapH	maximal soil pH variation per unit of inorganic N added with slurry	kg-1 ha	PARAM	1	real	0.001	0.02
alphaphot	parameter of photoperiodic effect on leaf lifespan	SD	PARPLT	1	real	0	1000
alphapt	parameter of Priestley-Taylor formula	SD	STATION	1	real	1	2
altinversion	altitude of inversion of the thermal gradient	m	STATION	1	real	0	2000

altisimul	altitude of simulated site	m	STATION	1	real	0	2000
altistation	altitude of the input metorological station	m	STATION	1	real	0	2000
ampfroid	semi thermal amplitude for vernalising effect	degreeC	PARPLT	1	real	1	30
anitcoupe	amount of mineral N added by fertiliser application at each cut of a forage crop	kg.ha-1	PARTEC	20	real	0	400
argi	clay content after decarbonation	%	PARSOL	1	real	0	60
awb	parameter determining C/N ratio of biomass during organic residues decomposition: CsurNbio=awb+bwb/CsurNres	SD	PARAM	21	real	0	500
bangst	'coefficient of the Angstrom''s relationship for extraterrestrial radiation'	SD	STATION	1	real	0	1
bdens	minimal density above which interplant competition starts	m-2	PARPLT	1	real	1	200
bdil	parameter of the critical dilution curve [Nplante]=adil MS^(-bdil)	SD	PARPLT	1	real	0.01	0.8
bdilmax	parameter of the maximum dilution curve [Nplante]=adilmax MS^(-bdilmax)	SD	PARPLT	1	real	0.01	0.8
belong	parameter of the curve of coleoptile elongation	degree-d-1	PARPLT	1	real	0.005	0.04
beta	parameter of increase of maximal transpiration when a water stress occurs	SD	PARAM	1	real	1	2
bformnappe	coefficient for the water table shape (artificially drained soil)	SD	PARAM	1	real	0	1
bfpf	parameter of the logistic curve defining sink strength of fruits (indeterminate growth): maximum growth rate relative to maximum fruit weight	SD	PARPLT	1	real	0	30
bhres	parameter of organic residues humification: hres=1-ahres*CsurNres/(bhres+CsurNres)	g.g-1	PARAM	21	real	0	10000
biorognem	minimal biomass to be removed when topping (automatic calculation)	t.ha-1	PARTEC	1	real	0	10
bkres	potential rate of decomposition of organic residues: kres=akres+bkres/CsurNres	g.g-1	PARAM	21	real	-5	1000
bks	parameter of calculation of the energetic lost between the inside and the outside of a greenhouse	W.m-2.K-1	STATION	1	real	0	100
bwb	parameter determining C/N ratio of biomass during organic residues decomposition: CsurNbio=awb+bwb/CsurNres	g.g-1	PARAM	21	real	-2500	0
cadencerec	number of days between two harvests	d	PARTEC	1	integer	1	30
cailloux	volumetric content of pebbles per soil layer	m3.m-3	PARSOL	5	real	0	100
calc	total carbonate content	%	PARSOL	1	real	0	100

capiljour	capillary rise upward water flux	mm.d-1	PARSOL	1	real	0.1	20
celong	parameter of the plantlet elongation curve	SD	PARPLT	1	real	1	10
cfes	parameter defining the soil contribution to evaporation versus depth	SD	PARSOL	1	real	0.5	4
cfpf	parameter of the first potential growth phase of fruit, corresponding to an exponential type function describing the cell division phase	SD	PARPLT	1	real	0.1	100
cgrain	slope of the relationship between grain number and growth rate	grains.g-1.d	PARPLT	1	real	0.01	1
cgrainv0	number of grains produced when growth rate is zero	grains.m-2	PARPLT	1	real	0	15000
cielclair	fraction of sunny hours allowing the inversion of thermal gradient with altitude	SD	STATION	1	real	0	1
cmax_pdenit	Corg value above which denitrification potential is constant and max	unknown	PARAM	1	real	3	40
cmin_pdenit	Corg value below which denitrification potential is constant and min	unknown	PARAM	1	real	0	3
CNgrainrec	minimal N content of grain at harvest	SD	PARTEC	1	real	0	1
CNresmax	maximum value of C/N ratio of organic residue	g.g-1	PARAM	21	real	3	200
CNresmin	minimum value of C/N ratio of organic residue	g.g-1	PARAM	21	real	3	200
codabri	option to activate cropping under shelter (1 = no, 2 = yes)	code 1/2	PARTEC	1	integer	1	2
codadret	option to calculate mountain climate taking into account the orientation (1 = south, 2 = north)	code 1/2	STATION	1	integer	1	2
codaltitude	option to activate the calculation of the climate in altitude (1 = no, 2 = yes)	code 1/2	STATION	1	integer	1	2
codazofruit	option to activate the direct effect of N plant status on the fruit/grain number (1 = no, 2 = yes)	code 1/2	PARPLT	1	integer	1	2
codazorac	option to activate the N influence on root partitioning within the soil profile (1 = yes, 2 = no)	code 1/2	PARPLT	1	integer	1	2
codcaleffeuil	option for the method to use for the calculation of leaf removal (1 = no, 2 =yes)	code 1/2	PARTEC	1	integer	1	2
codcalinflo	option for calculating the inflorescences number (1 = read in param.par, 2 = calculated at the amf stage)	code 1/2	PARPLT	1	integer	1	2
codcalrogne	option of calculation of tipping (1 = forced topping, 2 = automatic calculation)	code 1/2	PARTEC	1	integer	1	2
codcueille	option of harvest type (1 =single harvest (cutting), 2 = multiple harvests (picking))	code 1/2	PARTEC	1	integer	1	2

code_hourly_wfps_denit	choice of activating or not hourly WFPS calculation for denit (1 = yes, 2 = no)	code 1/2	PARAM	1	integer	1	2
code_hourly_wfps_nit	choice of activating or not hourly WFPS calculation for nit (1 = yes, 2 = no)	code 1/2	PARAM	1	integer	1	2
code_pdenit	choice of denitrification potential (1 = soil parameter or 2 = calculated from Corg)	code 1/2	PARAM	1	integer	1	2
code_ratiodenit	choice of constant (= 1) or variable(= 2) N2O ratio for denitrification	code 1/2	PARAM	1	integer	1	2
code_rationit	choice of constant or variable N2O ratio for nitrification (1 = constant, 2 = variable)	code 1/2	PARAM	1	integer	1	2
code_tnit	choice of temperature function for nitrification (1 = piecewise linear or 2 = gaussian)	code 1/2	PARAM	1	integer	1	2
code_vnit	choice of nitrification rate dependence on NH4 (1 = linear or 2 = Michaelis-Menten)	code 1/2	PARAM	1	integer	1	2
codeactimulch	option to activate the natural mulch effect i.e. drying out of soil surface (1 = yes, 2 = no)	code 1/2	PARAM	1	integer	1	2
codeaumin	option to activate the harvest as a function of grain/fruit water content	code 1/2	PARTEC	1	integer	1	2
codebeso	option of computation water requirements (1 = k.ETP approach, 2= resistive approach)	code 1/2	PARPLT	1	integer	1	2
codebfroid	option of chilling requirements (1 = no need, 2 = vernalising days, 3 = development stage)	code 1/2/3	PARPLT	1	integer	1	3
codecailloux	option to take into account pebbles in the water and N balances (1 = yes, 2 = no,)	code 0/1	PARSOL	1	integer	0	1
codecalferti	option to activate the automatic calculation of fertilisation rate (1 = yes, 2= no)	code 1/2	PARAMV6	1	integer	1	2
codecalirrig	code to activate the automatic calculation of irrigation requirements (1 = yes, 2 = no)	code 1/2	PARTEC	1	integer	1	2
codecaltemp	option to activate the use of crop temperature for phasic development calculation (1 = empirical relation, 2 =energy balance)	code 1/2	STATION	1	integer	1	2
codeclaircie	option for the method of fruit removal (1 = no, 2 = yes for smallest fruits)	code 1/2	PARTEC	1	integer	1	2
codeclichange	option to activate climate change (1 = no, 2 =yes)	code 1/2	STATION	1	integer	1	2
codedate_irrigauto	to activate the beginning and the ending date (in date or in stage) in case of automatic irrigationÂ : dates (1),stages (2), no (3)	code 1/2/3	PARAMV6	1	integer	1	3
codedateappH2O	irrigation application dates given as sum of temperatures (1 = yes, 2 = no)	code 1/2	PARTEC	1	integer	1	2

codedateappN	mineral fertilizer application dates given as sum of temperatures (1 = yes, 2 = no)	code 1/2	PARTEC	1	integer	1	2
codedecirecolte	option to activate moisture and frost effects on harvest decision (1 = yes, 2 = no)	code 1/2	PARTEC	1	integer	1	2
codedecisemis	option to activate the moisture effect on harvest decision (1 = yes, 2 = no)	code 1/2	PARTEC	1	integer	1	2
codedenit	option to activate the calculation of denitrification model (1 = yes, 2 = no)	code 1/2	PARSOL	1	integer	1	2
codedormance	option for the calculation of dormancy and chilling requirements (1 = forcing, 2 = Richardson, 3 = Bidabe)	code 1/2/3	PARPLT	1	integer	1	3
codeDST	option to activate the variations in soil physical soil conditions due to tillage (1 = yes, 2 = no)	code 1/2	PARTEC	1	integer	1	2
codeDSTnbcouche	number of compacted soil layers (1 = one layer, 2 = two layers)	code 1/2	PARTEC	1	integer	1	2
codeDSTtass	option to activate the soil compaction at sowing and harvest (1 = yes, 2 = no)	code 1/2	PARTEC	1	integer	1	2
codedyntalle	option to activate the module simulating tillers dynamics (1 = yes, 2 = no)	code 1/2	PARAMV6/PLT	2	integer	1	2
codeetp	option for the method of calculating PET (1 = forced Penman, 2 = calculated Penman, 3= Shuttleworth & Wallace, 4 = Priestley & Taylor)	code 1/2/3/4	STATION	1	integer	1	4
codefauche	option to activate cuts of forage crops (1 = yes, 2 = no)	code 1/2	PARTEC	1	integer	1	2
codefente	option to activate an additional water compartment for swelling soils (1 = yes, 2 = no)	code 0/1	PARSOL	1	integer	0	1
codeffeuil	option to activate thinning (1 = nos, 2 = yes)	code 1/2	PARTEC	1	integer	1	2
codeFinert	option to activate the new functions to calculate proportion of inactive organic nitrogen (Finert) (1=Finert reading in the param_gen.xml file, 2 = calculated with the new functions)	code 1/2	PARAMV6	1	integer	1	2
codefixpot	option of calculation of the maximal symbiotic fixation (1 = fixed, 2 =depending on growth rate)	code 1/2	PARPLT	1	integer	1	3
codefracappN	option to activate splitting applications of N fertiliser (1 = absolute value, 2 = % of total value)	code 1/2	PARTEC	1	integer	1	2
codefrmur	code defining the maturity status of the fruits in the output variable CHARGEFRUIT (1 = including ripe fruits (last box N), 2 = excluding ripe fruits (first N-1 boxes))	code 1/2	PARAM	1	integer	1	2
codeFunctionFinert	option to activate the new functions to calculate proportion of inactive organic nitrogen (Finert) (1 : finert = finert1 * exp(-finert2*Corg), 2 : finert = finert1 * exp(-finert2*QCorg)	code 1/2	PARAMV6	1	integer	1	2

codefxn	option defining the effect of soil nitrate on N fixation (1 = no effect, 2 = effect of nitrate amount , 3 = effect of nitrate concentration)	code 1/2/3	PARAM	1	integer	1	3
codegdh	time step used for calculating development units (1 = hourly, 2 = daily)	code 1/2	PARPLT	1	integer	1	2
codegdhdeb	option of time step used for calculating bud break date (1 = daily, 2 = hourly growing degrees)	code 1/2	PARPLT	1	integer	1	2
codegermin	option of simulation of a germination phase or a delay at the beginning of the crop (1) or direct starting (2)	code 1/2	PARPLT	1	integer	1	2
codeh2oact	option to activate water stress effect on the crop (1 = yes, 2 = no)	code 1/2	PARAM	1	integer	1	2
codehypo	option of simulation of a phase of hypocotyl growth (1) or planting of plantlets (2)	code 1/2	PARPLT	1	integer	1	2
codeindetermin	option of simulation of the leaf growth and fruit growth (1 = determinate, 2 =indeterminate)	code 1/2	PARPLT	1	integer	1	2
codeinitprec	option to activate reinitialization of initial conditions in case of chained simulations (1 = yes, 2 = no)	code 1/2	PARAM	1	integer	1	2
codeINN	option to compute INN (1 = cumulative, 2 = instantaneous)	code 1/2	PARPLT	1	integer	1	2
codeinnact	option of activation of N stress effect on the crop (1 = yes, 2 = no)	code 1/2	PARAM	1	integer	1	2
codeintercept	option of simulation rainfall interception by leaves (1 = yes, 2 = no)	code 1/2	PARPLT	1	integer	1	2
codeir	option of computing the ratio grain weight/total biomass: proportional to time (1), proportional to sum temperatures (2)	code 1/2	PARPLT	1	integer	1	2
codelaitr	option used for calculating intercepted radiation (1 = LAI, 2 = soil cover)	code 1/2	PARPLT	1	integer	1	2
codelegume	is the crop a legume fixing N ? (1 = yes, 2 = no)	code 1/2	PARPLT	1	integer	1	2
codemacropor	option to activate calculation of water flux in soil macroporosity (1 = yes, 2 = no)	code 0/1	PARSOL	1	integer	0	1
codemicheur	option of calculation of hourly microclimatic outputs (output file humidite.sti) (1 = yes, 2 = no)	code 1/2	PARAM	1	integer	1	2
codemineralOM	option to activate the New mineralization of soil organic matter function (1=yes, 2=no)	code 1/2	PARAMV6	1	integer	1	2
codemineralR	option to activate the New mineralization of residues function (1=yes, 2=no)	code 1/2	PARAMV6	1	integer	1	2
codeminopt	option to maintain a constant water content in bare soil during the simulation (1 = yes, 2 = no)	code 0/1	PARAM	1	integer	0	1

codemodfauche	option defining the cut mode (1 = automatic calculation depending on phenologic and trophic state, 2 = pre-established calendar in days, 3 = pre-established calendar in degree-days)	code 1/2/3	PARTEC	1	integer	1	3
codemodlsnow	option for calculating snow variables (1 = Unused, 2 = Unused, 3 = Snow model 3)	code 1 to 3	STATION	1	integer	1	3
codemonocot	type of plant: 1 = monocot, 2 =dicot	code 1/2	PARPLT	1	integer	1	2
codemontaison	option to stop the reserve limitation after stem elongation in grassland (1 = yes, 2 = no)	code 1/2	PARAMV6	2	integer	1	2
codemortalracine	kind of masec used to calculate dead roots at cutting dateÂ : masec (1), masectot (2)	code 1/2	PARAMV6	1	integer	1	2
codemsfinal	option defining the biomass and yield conservation after harvest (1 = yes (values maintained equal to harvest), 2 = no (values set at 0))	code 1/2	PARAM	1	integer	1	2
codenitrif	option to activate nitrification rate model (1 = yes, 2 = no)	code 1/2	PARSOL	1	integer	1	2
codeNmindec	option to activate the limitation of mineral N availability for residues decomposition in soil (1 = yes, 2 = no)	code 1/2	PARAMV6	1	integer	1	2
codeoutscient	option to write outputs files with scientific format (1 = yes, 2 = no)	code 1/2	PARAM	1	integer	1	2
codepaillage	option: 1 = no cover, 2 = plastic cover partly covering the soil	code 1/2	PARTEC	1	integer	1	2
codepalissage	option defining if the plant is fixed onto a vertical suuport (palissage) (1 = no, 2 =yes)	code 1/2	PARTEC	1	integer	1	3
codeperenne	option defining the annual (1) or perenial (2) character of the plant	code 1/2	PARPLT	1	integer	1	2
codephot	option of plant photoperiodism (1 = yes, 2 = no)	code1/2	PARPLT	1	integer	1	2
codeplisoleN	code for N requirement calculations at the beginning of the cycle (1 = dense plant population, 2 = isolated plants)	code 1/2	PARPLT	1	integer	1	2
codepluiepoquet	option to replace rainfall by irrigation at poquet depth in the case of poquet sowing (1 = yes, 2 = no)	code 1/2	PARAMV6	1	integer	1	2
codeprofmes	option of soil depth for calculating water and N stocks (1 = profmes, 2 = soil depth)	code 1/2	PARAM	1	integer	1	2
coderacine	option of simulating root growth and extension (1 = standard profile, 2 = root length density)	code 1/2	PARPLT	1	integer	1	2
coderecolteassoc	option to harvest intercrop species simultaneously, at the physiological maturity date of the earliest one (1 = no, 2 = yes)	code 1/2	PARTEC	1	integer	1	2
coderemontcap	option to activate capillary rise (1 = yes, 2 = no)	code 1/2	PARSOL	1	integer	1	2
coderes	residue type: 1=Main crop on surface, 2=Intermediate crop on surface, 3=Manure on surface, 4=Green compost on surface,	code 1 to 21	PARTEC	11	integer	1	10

	5=Sewage sludge on surface, 6=Vinasse on surface, 7=Horn on surface, 8=Grapevine shoots on surface, 9=Others.1 on surface, 10=Others.2 on surface, 11=Main crop ploughed in, 12=Intermediate crop ploughed in, 13=Manure ploughed in, 14=Green compost ploughed in, 15=Sewage sludge ploughed in, 16=Vinasse ploughed in, 17=Cattle horn ploughed in, 18=Grapevine shoots ploughed in, 19=Others.1 ploughed in, 20=Others.2 ploughed in, 21=Dead roots in soil						
coderes_pature	number ot the residue type in the param_gen.xml file used to parameterize bovine feces (1=crop residues, 2=residues of CI, 3=manure, 4=compost OM, 5=mud SE, 6=vinasse, 7=corn, 8=other)	code 1/10	PARAMV6	1	integer	1	10
coderetflo	option to activate the slow down effect of water stress on development before the stage DRP (starting date of filling of harvested organs) , (1 = yes, 2 = no)	code 1/2	PARPLT	1	integer	1	2
codernet	'option of calculation of net radiation (1 = Brunt''s method, 2 = Cellier''s method)'	code 1/2	STATION	1	integer	1	2
codesensibilite	option to activate the sensitivity analysis version of the model (1 = yes, 2 = no)	code 1/2	PARAM	1	integer	1	2
codeseprapport	option to select the column separator in the rapport.sti output file (1 = space separator, 2 = separator indicated in the separateurrapport parameter)	code 1/2	PARAM	1	integer	1	2
codesnow	option to activate the snow module use (1= yes,2= no)	code 1/2	PARAM	1	integer	1	2
codestade	option to force one or several development stages (1 =yes, 2 = no)	code 1/2	PARTEC	1	integer	1	2
codestrphot	option to activate the photoperiodic stress on lifespan (1 = yes, 2 = no)	code 1/2	PARPLT	1	integer	1	2
codesuite	option to simulate several successive USM (0 = no, 1 = yes)	code 0/1	USM/USMXML	1	integer	0	0
codeSWDRH	calculation of surface wetness duration : 1=yes , 2 = no	code 1/2	PARAMV6	1	integer	1	2
codesymbiose	option for calculating symbiotic N fixation (1 = critical dilution curve, 2 = calculated N fixation)	code 1/2	PARAM	1	integer	1	2
codetaille	option to activate pruning (1 = no, 2 = yes)	code 1/2	PARTEC	1	integer	1	2
codetemp	option to calculate thermal time for plant growth (1 = air temperature, 2 = crop temperature)	code 1/2	PARPLT	1	integer	1	2
codetempfauche	option of the reference temperature to compute cutting sum of temperatures (1 = upvt, 2 = udevair)	code 1/2	PARAMV6	1	integer	1	2

codetemprac	option to calculate thermal time for root growth (1 = crop temperature, 2 = soil temperature)	code 1/2	PARPLT	1	integer	1	2
codetesthumN	option for automatic N fertilisation calculation (1 = based on rainfall, 2 = based on soil water content)	code 1/2	PARAMV6	1	integer	1	2
codetradtec	description of crop structure with use of radiation transfer (1 =yes, 2 = no)	code1/2	PARTEC	1	integer	1	2
codetranspitalle	choice of the ratio used to calculate tiller mortality (1 = et/etm, 2 = epc2/eopC)	code 1/2	PARAMV6	1	integer	1	2
codetransrad	'option of simulating radiation interception (1 = Beer''s law, 2 = radiative transfer)'	code 1/2	PARPLT	1	integer	1	2
codetremp	option to activate heat effect on grain filling (1 = yes, 2 = no)	code 1/2	PARPLT	1	integer	1	2
codetrosee	calculation of hourly dew temperature : 1=linear interpolation(actual calculation), 2=sinusoidal interpolation (Debele Bekele et al.,2007)	code 1/2	PARAMV6	1	integer	1	2
codetycailloux	pebble type code	code 1 to 10	PARAM	1	integer	1	10
codetypeng	fertiliser type code	code 1 to 8	PARAM	1	integer	1	8
codetypres	organic residue type code	code 1 to 21	PARAM	1	integer	1	8
codgelflo	option to activate frost effect at anthesis (1 = no, 2 = yes)	code 1/2	PARPLT	1	integer	1	2
codgeljuv	option to activate frost effect on LAI at the juvenile stage (1 = no, 2 = yes)	code 1/2	PARPLT	1	integer	1	2
codgellev	option to activate frost effect on plantlet (1 = no, 2 = yes)	code 1/2	PARPLT	1	integer	1	2
codgelveg	option to activate frost effect on LAI at adult stage (1 = no, 2 = yes)	code 1/2	PARPLT	1	integer	1	2
codhauteff	option of leaf removal height (1 = bottom of the canopy, 2 = top of the canopy)	code 1/2	PARTEC	1	integer	1	2
codhnappe	mode of calculation of watertable level (1 = mean height, 2 = height at the distance distdrain)	code 1/2	PARAM	1	integer	1	2
codlainet	option of calculation of the LAI (1 : direct LAInet, 2 : LAInet = gross LAI - senescent LAI)	code 1/2	PARPLT	1	integer	1	2
codlocferti	option to code of fertilisation localisation (1 = at soil surface, 2 = in the soil)	code 1/2	PARTEC	1	integer	1	2
codlocirrig	code of irrigation localisation: 1= above the foliage, 2= below the foliage above the soil, 3 = in the soil	code 1/2/3	PARTEC	1	integer	1	3
codoptim	optimisation code (0 = no, 1 = yes main plant, 2 = yes associated plant)	code 0/1/2	USM	1	integer	0	2
codrainage	option to simulate artificial drainage (1 = yes, no = 2)	code 1/2	PARSOL	1	integer	0	1

codrecolte	decision to harvest (1 = physiological maturity, 2 = water content, 3=sugar content, 4=nitrogen content, 5=oil content)	code 1 to 5	PARTEC	1	integer	1	2
codrognage	option of foliage control by trimming (1 = no, 2 = yes)	code 1/2	PARTEC	1	integer	1	2
codtrophrac	trophic effect on root length growth (1 = permanent link, 2 = link by thresholds ,3 = no effect)	code 1/2/3	PARPLT	1	integer	1	3
coef_calcul_doseN	N plant concentration under which there is no nitrogen return to the soil through animal urine (coefficient used to compute animal urine from animal grass dry matter intake and plant nitrogen concentration)c	g N k-1 dry weight	PARAMV6	1	real		
coef_calcul_qres	coefficient used to compute animal feces from animal grass dry matter intake, used as default	g N k-1 dry weight	PARAMV6	1	real		
coefamflax	multiplier coefficient of the development phase AMF (maximum acceleration of leaf growth, end of juvenile phase) - LAX (maximum leaf area index, end of leaf growth)to use crop temperature	SD	PARPLT	1	real	1	2
coefb	parameter defining radiation effect on conversion efficiency	SD	PARAM	1	real	0.05	0.15
coefdevil	multiplier coefficient of the exterior radiation to compute PET inside of a greenhouse	SD	STATION	1	real	0.3	1.2
coefdrpmat	multiplier coefficient of the development phase DRP (starting date of filling of harvested organs) - MAT to use crop temperature	SD	PARPLT	1	real	1	2
coefflodrp	multiplier coefficient of the development phase FLO (anthesis) - DRP (starting date of filling of harvested organs) to use crop temperature	SD	PARPLT	1	real	1	2
coeflaxsen	multiplier coefficient of the development phase LAX (maximum leaf area index, end of leaf growth) - SEN (beginning of leaf senescence) to use crop temperature	SD	PARPLT	1	real	1	2
coeflevamf	multiplier coefficient of the development phase LEV (emergence) - AMF (maximum acceleration of leaf growth, end of juvenile phase) to use crop temperature	SD	PARPLT	1	real	1	2
coeflevdrp	multiplier coefficient of the development phase LEV (emergence) - DRP (starting date of filling of harvested organs) to use crop temperature	SD	PARPLT	1	real	1	2
coefmshaut	ratio biomass/ useful height cut of crops	t.ha-1.m-1	PARPLT	1	real	2	50
coefracoupe	coefficient to define the proportion of dying roots after cut of forage crops	SD	PARAMV6/PLT	2	real	0.001	1
coefrnet	coefficient of calculation of the net radiation under greenhouse	SD	STATION	1	real	0.001	1

coefsenlan	multiplier coefficient of the development phase SEN (beginning of leaf senescence) - LAN (leaf index nil) to use crop temperature	SD	PARPLT	1	real	1	2
concirr	concentration of mineral N (NH4+NO3-N) in irrigation water	kg.ha-1 mm-1	PARTEC	1	real	0	0.2
concNnodseuil	maximal concentration of mineral N in soil for nodule onset	kg.ha-1.mm-1	PARPLT	1	real	0	10
concNrac0	nitrate-N concentration (if codefxN=3) or nitrate-N amount (if codefxN=2) above which N fixation is totally inhibited	kg.ha-1.mm-1 or kg.ha-1.cm-1	PARPLT	1	real	0	10
concNrac100	nitrate-N concentration (if codefxN=3) or nitrate-N amount (if codefxN=2) below which N fixation is maximum	kg.ha-1.mm-1 or kg.ha-1.cm-2	PARPLT	1	real	0	2
concrr	inorganic N concentration (NH4+NO3-N) in the rain	kg.ha-1 mm-1	PARAM	1	real	0	3
concseuil	minimum concentration of HNO3 in soil	kg.ha-1 mm-1	PARSOL	1	real	0	0.5
contrdamax	maximal reduction in root growth rate due to soil strengthness (high bulk density)	SD	PARPLT	1	real	0	1
corecTrosee	temperature to substract to Tmin to estimate dew point temperature (in case of missing air humidity data)	degreeC	STATION	1	real	-5	5
couvermulchplastique	fraction of soil covered by the plastic mulch	SD	PARTEC	1	real	0	1
Crespc	C content in organic residue	% FW	PARTEC	11	real	0	100
Crespc_pature	C content in animal feces (fresh weight basis)	% fresh weight	PARAMV6	1	real	0	100
CroCo	fraction of organic residue which is decomposable	SD	PARAM	21	real	0	1
croirac	elongation rate of the root apex	cm.degree-d-1	PARPLT	1	real	0	0.5
CsurNres	C/N ratio of organic fraction of residue	g.g-1	PARTEC	11	real	6	200
CsurNsol0	Initial C to N ratio of soil humus	SD	PARSOL	1	real	8	20
culturean	number of calendar years involved in the crop cycle (1 = 1 year e.g. for spring crops, 2 = two years, e.g. for winter crops)	code 1/2	USM/USMXML	1	integer	0	0
cvent	parameter of the climate calculation under the shelter	SD	STATION	1	real	0.001	1
cwb	minimum ratio C/N of microbial biomass decomposing organic residues	g.g-1	PARAM	21	real	5	60
dachisel	bulk density of soil after soil tillage (Chisel)	g.cm-3	PARTEC	1	real	0.8	2
dacohes	bulk density of soil below which root growth is reduced due to a lack of soil cohesion	g.cm-3	PARAM	1	real	0.001	1.4
DAF	bulk density of fine earth fraction in each soil layer	g.cm-3	PARSOL	5	real	0.8	2

dalabour	bulk density of soil after full inversion tillage (plough)	g.cm-3	PARTEC	1	real	0.8	2
darecolte	bulk density of soil after harvest	g.cm-3	PARTEC	1	real	0.8	2
dasemis	bulk density of soil after sowing	g.cm-3	PARTEC	1	real	0.8	2
daseuilbas	bulk density of soil above which root growth is maximal	g.cm-3	PARAM	1	real	1	1.4
daseuilhaut	bulk density of soil above which root growth becomes impossible	g.cm-3	PARAM	1	real	1.4	2.5
datedeb_irrigauto	date of beginning automatic irrigations in julian day	julian day	PARAMV6	1	integer	1	731
datedebut	date of the beginning simulation	julian day	USMXML	1	integer	0	730
datefin	date of the end of the simulation	julian day	USMXML	1	integer	0	730
datefin_irrigauto	date of ending automatic irrigations in julian day	julian day	PARAMV6	1	integer	1	731
debsenrac	sum of degrees.days defining the beginning of root senescence (root life time)	degree-d	PARPLT	1	real	0	2000
deneng	maximal fraction of the mineral fertilizer that can be denitrified (used if codedenit is not activated)	SD	PARAM	8	real	0	1
densinitial	initial root density in each of the five soil layers	cm.cm-3	INIT	5	real	0	10
densitesem	plant sowing density	plants.m-2	PARTEC	1	real	0.05	2000
deshydbase	rate of change of fruit water content vs thermal time (>0 or <0)	g.g-1 FM.degree-d-1	PARPLT	1	real	-0.02	0.02
dfolbas	minimal foliar density within the considered shape	m2 leaf.m-3	PARPLT	1	real	1	10
dfolhaut	maximal foliar density within the considered shape	m2 leaf.m-3	PARPLT	1	real	1	10
dfpf	parameter of the first potential growth phase of fruit, corresponding to an exponential type function describing the cell division phase	SD	PARPLT	1	real	0.01	5
difN	diffusion coefficient of nitrate N in soil at field capacity	cm2.d-1	PARAM	1	real	0.01	0.1
diftherm	soil thermal diffusivity	cm2.s-1	PARAM	1	real	0.001	0.01
distdrain	distance to the drain to calculate watertable height	cm	PARAM	1	real	0	25000
DKmax	difference between the maximum and the minimum melting rates for snow	mm.degreeC.d -1	STATION	1	real	1	2
dlaimax	maximum rate of the setting up of LAI	m2 leaf.plant-1.degree-d-1	PARPLT	1	real	0.000005	0.5
dlaimaxbrut	maximum rate of the setting up of LAI	m2 leaf.plant-1.degree-d-1	PARPLT	1	real	0.000005	0.5
dlaimin	accelerating parameter for the lai growth rate	SD	PARPLT	1	real	0	1

dltamsmaxsen	threshold value of growth rate from which there is no more photoperiodic effect on senescence	t.ha-1.d-1	PARPLT	1	real	0.01	0.2
dltamsminsen	threshold value of growth rate from which the photoperiodic effect on senescence is maximal	t.ha-1.d-1	PARPLT	1	real	0.01	0.2
doseI	irrigation amount	mm.d-1	PARTEC	30	real	0	500
doseirrigmin	minimal amount of irrigation	mm	PARTEC	1	real	0	500
doseN	daily amount of N added through fertilizers	kg.d-1	PARTEC	20	real	0	500
dosimx	maximum water amount of irrigation authorised at each time step (mode automatic irrigation)	mm.d-1	PARTEC	1	real	10	500
dosimxN	maximum amount of fertiliser N applied on a given day (mode automatic fertilisation)	kg.ha-1	PARAMV6	1	real	5	500
dpHvolmax	maximal pH increase following the application of slurry	SD	PARAM	1	real	0	3
draclong	maximum rate of root length production per plant	cm.plant-1.degree-d-1	PARPLT	1	real	1	1000
dureefruit	total growth period of a fruit at the setting stage to the physiological maturity	degree-d	PARPLT	1	real	10	2000
durvieF	maximal lifespan of an adult leaf expressed in summation of Q10=2 (2**(T-Tbase))	SD	PARPLT	1	real	10	500
durviesupmax	relative additional lifespan due to N excess in plant (INN > 1)	SD	PARPLT	1	real	0	1
E	snow compaction parameter	mm.mm-1.d-1	STATION	1	real	0	0.05
eau_mini_decisemis	minimum amount of rainfall to start sowing (when codesemis is activated)	mm	PARAMV6	1	integer	0	40
eaures	water content of organic residue (relative to fresh weight)	% FW	PARTEC	11	real	0	99
eaures_pature	Water amount of organic residues	%	PARAMV6	1	real	0	100
ecartdrain	distance between mole drains	cm	PARSOL	1	real	100	5000
efcroijuv	maximum radiation use efficiency during the juvenile phase(LEV=emergence - AMF= maximum acceleration of leaf growth, end of juvenile phase)	g.MJ-1	PARPLT	1	real	1	7
efcroirepro	maximum radiation use efficiency during the grain filling phase (DRP= starting date of filling of harvested organs - MAT= maturity)	g.MJ-1	PARPLT	1	real	1	10
efcroiveg	maximum radiation use efficiency during the vegetative stage (AMF = maximum acceleration of leaf growth, end of juvenile phase - DRP=starting date of filling of harvested organs)	g.MJ-1	PARPLT	1	real	1	10
effeuil	fraction of daily leaf removed at thinning	0-1	PARTEC	1	real	0	1

effirr	irrigation efficiency	SD	PARTEC	1	real	0.2	1
elmax	maximum elongation of the coleoptile in darkness condition	cm	PARPLT	1	real	2	40
engamm	fraction of ammonium in the N fertilizer	SD	PARAM	8	real	0	1
engrais	fertilizer type (1=ammonium nitrate, 2=UAN solution, 3=urea, 4=anhydrous ammonia, 5=ammonium sulfate, 6=ammonium phosphate, 7=calcium nitrate, 8= fixed efficiency fertiliser)	*	PARTEC	10	integer	0	8
engrais_pature	type of mineral fertilizer used to mimic urine excretion (used urea as default) : 1 =Nitrate.of ammonium ,2=Solution,3=urea,4=Anhydrous ammoniac,5= Sulfate of ammonium,6=phosphate of ammonium,7=Nitrateof calcium,8= fixed efficiency	*	PARAMV6	1	integer	1	10
envfruit	fraction of envelop in grainmaxi (w:w)	SD	PARPLT	1	real	0	0.5
epc	thickness of each soil layer	cm	PARSOL	5	real	1	1000
epd	thickness of mixing cells in each soil layer (= 2 * dispersion length)	cm	PARSOL	5	integer	1	50
extin	extinction coefficient of photosynthetic active radiation in the canopy	SD	PARPLT	1	real	0.1	1.5
fhminsat	relative soil mineralisation rate at water saturation	SD	PARAM	1	real	0	1
finert	initial fraction of soil organic N inactive for mineralisation (= stable SON/ total SON)	SD	PARAM	1	real	0	1
Finert1	C/N soil factor 1 for function 2 to calculate proportion of inactive organic nitrogen	*	PARAMV6	1	real	0	1
Finert2	C/N soil factor 2 for function 2 to calculate proportion of inactive organic nitrogen	*	PARAMV6	1	real	0	1
fixmax	maximal N symbiotic fixation rate	kg.ha-1.d-1	PARPLT	1	real	2	12
fixmaxgr	maximal N symbiotic fixation rate per unit of grain growth rate	kg.t-1	PARPLT	1	real	0	50
fixmaxveg	maximal N symbiotic fixation rate per unit of vegetative growth rate	kg.t-1	PARPLT	1	real	0	50
flagecriture	option for writing the output files (1 = mod_history.sti, 2=daily outputs,4= report outputs, 8=balance outputs,16 = profile outputs, 32= debug outputs, 64 = screen outputs) sum them to have several types of outputs	0-511	PARAM	1	integer	0	511
fmin1	relative potential mineralization rate: K2 = fmin1 * exp(-fmin2*argi) / (1+fmin3*calc)	d-1	PARAM	1	real	0	1

fmin2	parameter defining the effect of clay on the potential mineralization rate: K2 = fmin1 * exp(-fmin2*argi) / (1+fmin3*calc)	-1%	PARAM	1	real	0	1
fmin3	parameter defining the effect of CaCO3 on the potential mineralization rate: K2 = fmin1 * exp(-fmin2*argi) / (1+fmin3*calc)	-1%	PARAM	1	real	0	1
fNCbiomin	minimal value for the ratio N/C of the microbial biomass when N limits decomposition	SD	PARAM	1	real	0.01	0.1
fNmindecmin	minimal fraction of mineral N available for residues decomposition (if codeNmindec is activated)	SD	PARAMV6	1	real	0	1
fnx	potential proportion of NH4 nitrified each day if linear model	d-1	PARAM	1	real	0.01	1
forme	option to define the shape of leaf density profile (1 = rectangle, 2 = triangle)	code 1/2	PARPLT	1	integer	1	2
fracN	proportion of fertiliser N applied at each application	%	PARTEC	10	real	5	100
fredkN	reduction factor of decomposition rate of organic residues when mineral N is limiting	SD	PARAM	1	real	0.1	1
fredlN	reduction factor of decomposition rate of microbial biomass when mineral N is limiting	SD	PARAM	1	real	0.2	1
fredNsup	additional reduction factor of residues decomposition rate when mineral N is very limited in soil	SD	PARAM	1	real	0	1
ftemh	parameter (1/2) of the temperature function on humus decomposition rate	K-1	PARAM	1	real	0.05	0.5
ftemha	parameter (2/2) of the temperature function on humus decomposition rate	*	PARAM	1	real	10	50
ftemr	parameter (1/2) of the temperature function on decomposition rate of organic residues	K-1	PARAM	1	real	0.05	0.5
ftemra	parameter (2/2) of the temperature function on decomposition rate of organic residues	*	PARAM	1	real	5	30
GMIN1	mineralization rate constant for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	day-1	PARAMV6	1	real	0	1
GMIN2	clay content factor for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	-1%	PARAMV6	1	real	0	1
GMIN3	CaCO3 content factor for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-	-1%	PARAMV6	1	real	0	1

	gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)						
GMIN4	pH factor 1 for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	pH-1	PARAMV6	1	real	0	1
GMIN5	pH factor 2 for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	pH	PARAMV6	1	real	3	11
GMIN6	C/N soil factor 1 for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	*	PARAMV6	1	real	0	1
GMIN7	C/N soil factor 2 for new function (Clivot et al,2017) k2hum=gmin1 * exp(-gmin2*argi) / (1. + gmin3*calc)*exp(-gmin4*(pH-gmin5)**2) * (0.8*exp(-gmin6*(CsurNsol-gmin7)**2)+0.2)	*	PARAMV6	1	real	5	35
gradtn	thermal gradient in altitude for minimal temperatures	degreeC.m-1	STATION	1	real	0.1	3
gradtninv	thermal gradient in altitude for minimal temperatures under the inversion level	degreeC.m-1	STATION	1	real	0.1	3
gradtx	thermal gradient in altitude for maximal temperatures	degreeC.m-1	STATION	1	real	0.1	3
h2ofeuiljaune	water content of yellow leaves (relative to fresh matter)	g.g-1 FW	PARPLT	1	real	0.05	1
h2ofeuilverte	water content of green leaves (relative to fresh matter)	g.g-1 FW	PARPLT	1	real	0.5	1
h2ofrvert	water content of fruits before the beginning of dehydration (DEBDESHYD) (/fresh matter)	g.g-1 FW	PARPLT	1	real	0.1	1
h2ograinmax	maximal water content of fruits at harvest (/fresh matter)	g.g-1 FW	PARTEC	1	real	0.05	1
h2ograinmin	minimal water content of fruits at harvest (/fresh matter)	g.g-1 FW	PARTEC	1	real	0.05	1
h2oreserve	reserve water content (/fresh matter)	g.g-1 FW	PARPLT	1	real	0.5	1
h2otigestruc	structural stem part water content (/fresh matter)	g.g-1 FW	PARPLT	1	real	0.5	1
hautbase	basal height of crop	m	PARPLT	1	real	0.1	2
hautcoupe	cut height for forage crops (calendar fixed)	m	PARTEC	20	real	0.01	0.5
hautcoupedefaut	cut height for forage crops (calendar calculated)	m	PARTEC	1	real	0.01	0.5
hautmax	maximum height of crop	m	PARPLT	1	real	0.1	5
hautmaxtec	maximal height of the plant allowed by the management	m	PARTEC	1	real	0.5	3
hautrogne	cutting height for trimmed plants	m	PARTEC	1	real	0.2	2

hcccx	gravimetric water content at field capacity of each type of pebble	% w	PARAM	10	real	10	110
hccf	gravimetric water content at field capacity of each soil layer (/fine earth)	% w	PARSOL	5	real	10	110
Hinitf	initial gravimetric water content of each soil layer (/fine earth)	% w	INIT	5	real	5	110
hminf	gravimetric water content at wilting point of each soil layer (/fine earth)	% w	PARSOL	5	real	2	25
hminm	relative water content (fraction of field capacity) below which mineralisation rate is nil	SD	PARAM	1	real	0.1	1
hminn	relative water content (fraction of field capacity) below which nitrification rate is nil	SD	PARAM	1	real	0.1	1
hoptm	relative water content (fraction of field capacity) below which mineralisation rate is maximum	SD	PARAM	1	real	0.1	1
hoptn	relative water content (fraction of field capacity) below which nitrification rate is maximum	SD	PARAM	1	real	0.1	1
huilerec	minimal oil content of fruits at harvest (/fresh matter)	g.g-1 FW	PARTEC	1	real	0.1	1
humcapil	threshold of soil gravimetric water content under which capillary rise occurs	% w	PARSOL	1	real	2	10
humirac_decisemis	effect of soil moisture for sowing decision (from 0 to 1 : 0 = no sensitivity to drought, 1 = very sensitive)	SD	PARAMV6	1	real	0	1
iamf	day of the stage AMF (maximal rate of leaf growth, end of juvenile phase) when the stage is observed (else 999)	julian.d	PARTEC	1	integer	1	999
ichsl	soil number in the param.soil file	SD	USM	1	integer	1	999
idebdorm	day of the dormancy entrance	julian.d	PARPLT	1	integer	1	999
idor	day of the dormancy entrance	julian.d	java	1	integer	1	999
idrp	day of the stage DRP (beginning of grain filling) when the stage is observed (else 999)	julian.d	PARTEC	1	integer	1	999
ifindorm	day of dormancy break	julian.d	PARPLT	1	integer	1	999
iflo	day of anthesis	julian.d	PARTEC	1	integer	1	999
ifwater	day of the end of simulation	julian.d	USM	1	integer	1	731
ilan	day of the stage LAN () if the stage is observed (else 999)	julian.d	PARTEC	1	integer	1	999
ilax	day of the stage LAX (maximal leaf area index) when the stage is observed (else 999)	julian.d	PARTEC	1	integer	1	999
ilev	day of the stage LEV (emergence) when the stage is observed (else 999)	julian.d	PARTEC	1	integer	1	999

imat	day of the stage MAT (physiological maturity) when the stage is observed (else 999)	julian.d	PARTEC	1	integer	1	999
infil	infiltrability rate at the base of each soil layer (if codemacropor = 1)	mm.d-1	PARSOL	6	real	0.1	100
inflomax	maximal number of inflorescences per plant	SD	PARPLT	1	real	0	100
infrecouv	ulai at the stage AMF (maximal rate of leaf growth)	SD	PARPLT	1	real	0	3
iniprofil	option of smoothing out the initial N and water profiles (spline function) (1 = yes, 2 = no)	code 0/1	PARAM	1	integer	0	1
inngrain1	minimal INN for net absorption of N during grain filling	SD	PARPLT	1	real	0.3	2
inngrain2	INN minimal for null net absorption of N during grain filling	SD	PARPLT	1	real	0.3	2
INNimin	INNI (instantaneous INN) corresponding to INNmin	SD	PARPLT	1	real	0	1
INNmin	minimum value of INN possible for the crop	SD	PARPLT	1	real	0	1
innsen	parameter of the N stress function active on senescence (INNsenes), bilinear function vs INN passing through the point (INNmin, INNsen)	SD	PARPLT	1	real	-2	1
innturgmin	parameter of the N stress function active on leaf expansion (INNLAI), bilinear function vs INN passing through the point (INNmin, INNturgmin)	SD	PARPLT	1	real	-2	1
interrang	width of the crop interrow	m	PARTEC	1	real	0	10
iplt	date of sowing	julian.d	java	1	integer	1	731
iplt0	date of sowing	julian.d	PARTEC	1	integer	1	731
irec	date of harvest	julian.d	PARTEC	1	integer	1	731
irecbutoir	latest date of harvest (imposed if the crop cycle is not finished at this date)	julian.d	PARTEC	1	integer	1	731
irmax	maximum harvest index	SD	PARPLT	1	real	0.2	1
irrlev	amount of irrigation applied automatically on the sowing day to allow germination when the model calculates irrigation	mm	PARAM	1	real	0	50
isen	day of the stage SEN (beginning of net senescence) when the stage is observed (else 999)	julian.d	PARTEC	1	integer	1	731
isnu	bare soil	julian.d	java	1	integer	1	731
iwater	day of the beginning of the simulation	julian.d	USM	1	integer	1	731
julapI	date(s) of irrigation	julian.d	PARTEC	30	integer	1	731
julapN	date(s) of fertilizer application	julian.d	PARTEC	20	integer	1	731

juleclair	day of fruits removal	julian.d	PARTEC	10	integer	1	731
juleffeuil	day of leaf removal	julian.d	PARTEC	1	integer	1	731
julfauche	date(s) of each cut for forage crops	julian.d	PARTEC	20	integer	1	731
julouvre2	day (1/2) of opening the shelter	julian.d	PARTEC	1	integer	1	731
julouvre3	day (2/2) of opening the shelter	julian.d	PARTEC	1	integer	1	731
julres	date(s) of organic residue addition to soil	julian.d	PARTEC	11	integer	1	731
julrogne	day of plant trimming	julian.d	PARTEC	1	integer	1	731
jultaille	day of pruning	julian.d	PARTEC	1	integer	1	731
jultrav	date(s) of soil tillage	julian.d	PARTEC	11	integer	1	731
julvernal	day of initiation of vernalisation in perennial crops (between 1 and 365)	julian.d	PARPLT	1	integer	1	731
jvc	number of vernalising days	d	PARPLT	1	real	0	70
jvcmini	minimum number of vernalising days	d	PARPLT	1	real	0	20
Kamm	affinity constant for NH4 in nitrification if michaelis_menten option used	mg N/L	PARAM	1	real	1	100
kbio	potential decay rate of microbial biomass decomposing organic residues	d-1	PARAM	21	real	0	250
kcouvmlch	extinction coefficient connecting the soil cover to the amount of plant mulch	*	PARAM	21	real	0	150
Kd	Affinity constant for NO3 in denitrification	mg N/L	PARAM	1	real	10	500
kdesat	rate constant of de-saturation	d-1	PARAM	1	real	1	20
khaut	extinction coefficient connecting LAI to crop height	*	PARAM	1	real	0.2	2
Kmabs1	affinity constant of N uptake by roots for the fast uptake system	µmole.L-1	PARPLT	1	real	20	200
Kmabs2	affinity constant of N uptake by roots for the low uptake system	µmole.L-1	PARPLT	1	real	4000	40000
kmax	maximum crop coefficient for water requirements (= MET/PET)	SD	PARPLT	1	real	0.5	4
Kmin	minimum snow melting rate on 21 December	mm.degreeC.d -1	STATION	1	real	1.5	2.5
krepracperm	parameter of biomass root partitioning : evolution of the ratio root/total (permanent trophic link)	SD	PARPLT	1	real	0.0001	1
krepracseu	parameter of biomass root partitioning : evolution of the ratio root/total (trophic link by thresholds)	SD	PARPLT	1	real	0.0001	1
ksol	soil hydraulic conductivity in the vicinity of mole drains	SD	PARSOL	1	real	0.0001	1

kstemflow	extinction coefficient connecting LAI to stemflow	*	PARPLT	1	real	0.1	2
ktrou	extinction coefficient of PAR through the crop (used in the radiative transfer module)	*	PARPLT	1	real	0.1	2
lai0	initial leaf area index	m2.m-2	INIT	1	real	0	10
laicomp	LAI above which competition between plants starts	m2.m-2	PARPLT	1	real	0	1
laidebeff	LAI of the beginning of leaf removal	m2.m-2	PARTEC	1	real	1	10
laieffeuil	LAI removed from the crop at day juleffeuil	m2.m-2	PARTEC	1	real	0.05	10
laiplantule	LAI of plantlet at the plantation	m2.m-2	PARPLT	1	real	0	8
lairesiduel	residual LAI after each cut of forage crop	m2.m-2	PARTEC	20	real	0	2
largrogne	trimmed width	m	PARTEC	1	real	0.1	2
largtec	technical width	m	PARTEC	1	real	0.1	2
latitude	latitude of the site	degree	STATION	1	real	-90	90
locferti	soil depth at which fertiliser is applied	cm	PARTEC	1	integer	0	30
locirrig	soil depth at which irrigation is applied	cm	PARTEC	1	integer	0	30
longsperac	specific root length	cm.g-1	PARPLT	1	real	250	25000
lvfront	root density at the root apex	cm.cm-3	PARPLT	1	real	0.02	1
lvopt	root length density (RLD) above which water and N uptake are maximum and independent of RLD	cm.cm-3	PARAM	1	real	0.2	1
magrain0	initial grain dry weight	g.m-2	INIT	1	real	1	5
margerogne	topping occurs when plant height exceeds (hautrogne+margerogne) when automatic trimming is activated	m	PARTEC	1	real	0.01	1
masec0	initial aerial biomass	t.ha-1	INIT	1	real	0	10
masecmeta	biomass of the plantlet supposed to be composed of metabolic N	t.ha-1	PARPLT	1	real	0.1	1
masecNmax	aerial biomass above which N dilution occurs (critical and maximal curves)	t.ha-1	PARPLT	1	real	0.05	5
masecplantule	initial shoot biomass of plantlet	t.ha-1	PARPLT	1	real	0.002	4
masvolcx	bulk density of each type of pebble	g.cm-3	PARAM	10	real	0.5	5
max_pdenit	max value of denitrification potential	unknown	PARAM	1	real	0	100
maxazorac	mineral N concentration in soil above which root growth is maximum	kg.ha-1.cm-1	PARPLT	1	real	0.1	5
maxtalle	maximum tillers density per soil area	nb.m-2	PARAMV6/PLT	2	real	0	10000

min_pdenit	min value of denitrification potential	unknown	PARAM	1	real	0	2
minazorac	mineral N concentration in soil below which root growth is reduced	kg.ha-1.cm-1	PARPLT	1	real	0	5
minefnra	reduction factor on root growth when soil mineral N is limiting (< minazorac)	SD	PARPLT	1	real	0	1
mouillabil	maximum wettability of leaves	mm.LAI-1	PARPLT	1	real	0.05	3
mouillabilmulch	maximum wettability of crop mulch	mm.t-1.ha	PARAM	5	real	0.05	5
mscoupemini	minimum value of aerial biomass required to make a cut of forage crop	t.ha-1	PARTEC	20	real	1	10
msresiduel	residual aerial biomass after a cut of a forage crop	t.ha-1	PARTEC	20	real	0	5
mulchbat	mulch depth from which a crust occurs (a value must be given but if in the plt.xml the vigueurbat parameter is equal to 1 then the parameter is inactive)	cm	PARSOL	1	real	0	2
nbcueille	number of fruit harvestings (1= one at the end, 2 = many during the cycle)	code 1/2	PARTEC	1	integer	1	2
nbfeuilplant	leaf number per plant when planting	nb pl-1	PARPLT	1	integer	0	10
nbfgellev	leaf number at the end of the juvenile phase (frost sensitivity)	nb pl-1	PARPLT	1	integer	1	5
nbgrmax	maximum number of fruits per surface area	nb.m-2	PARPLT	1	real	0	1000000
nbgrmin	minimum number of fruits per surface area	nb.m-2	PARPLT	1	real	0	10000
nbinflo	imposed number of inflorescences per plant	nb.pl-1	PARPLT	1	real	1	100
nbinfloecl	number of inflorescences or fruits removed at fruit removal	nb.pl-1	PARTEC	10	real	0	10
nbj_pr_apres_semis	number of days used to calculate rainfall requirement to start sowing (if codesemis is activated)	d	PARAMV6	1	integer	1	20
nbjgerlim	maximum number of days after grain imbibition allowing full germination	d	PARPLT	1	integer	1	50
nbjgrain	number of days used to compute the number of viable grains	d	PARPLT	1	integer	5	40
nbjmaxapresrecolte	maximal delay allowed for harvest (number of days) (if the soil compaction option is activated)	d	PARTEC	1	integer	0	90
nbjmaxapressemis	maximal delay allowed for sowing (number of days) (if the soil compaction option is activated)	d	PARTEC	1	integer	0	90
nbjoursrrversirrig	number of days during which rainfall is replaced by irrigation in the soil after a sowing poquet	d	PARAMV6	1	integer	0	0
nbjres	number of residue additions	d	PARTEC	1	integer	0	8

nbjseuiltempref	number of days without frost for sowing (if sowing decision option is activated)	d	PARTEC	1	integer	1	60
nbjtrav	number of tillage operations	SD	PARTEC	1	integer	0	8
nboite	number of boxes or age classes of fruits used to calculate fruit growth for undeterminate crops	SD	PARPLT	1	integer	1	20
nbplantes	number of simulated plants	SD	USM/USMXML	1	integer	0	0
NH3ref	NH3 concentration in the atmosphere	Âµg.m-3	STATION	1	real	0	10
nh4_min	minimum (fixed ?) NH4 concentration found in soil	mg N/kg	PARAM	1	real	0	20
NH4initf	initial amount of NH4-N in each of the soil layers (/fine earth)	kg.ha-1	INIT	5	real	0	200
nlevlim1	number of days after germination after which plant emergence is reduced	d	PARPLT	1	integer	1	100
nlevlim2	number of days after germination after which plant emergence is impossible	d	PARPLT	1	integer	1	100
Nmeta	proportion of metabolic N in the plantlet	%	PARPLT	1	real	0	100
Nminres	proportion of N mineral content of organic residues (/fresh matter)	% FW	PARTEC	11	real	0	30
Nminres_pature	N mineral content of animal feces (fresh weight basis)	%	PARAMV6	1	real	0	100
NO3initf	initial amount of NO3-N in each of the soil layers (/fine earth)	kg.ha-1	INIT	5	real	0	200
Norg	soil organic N content in the first soil layer (supposed constant down to the depth profhum), equal to total nitrogen (Kjeldahl method)	% dry soil	PARSOL	1	real	5.00E-02	0.5
Nreserve	maximal amount of N in plant reserves (difference between the maximal and critical dilution curves) (percentage of aerial biomass)	%	PARPLT	1	real	0	100
numsol	soil number	SD	PARSOL	1	integer	0	1000
obstarac	soil depth at which root growth is stopped due to physical constraints	cm	PARSOL	1	real	10	1000
ombragetx	change in air temperature in the northern hillslope of mountains (activated if codadret=2)	degreeC	STATION	1	real	-5	5
option_engrais_multiple	enabling of using several kind of fertilizer yes(1),(no) 2	code 1/2	PARAMV6	1	integer	1	2
option_pature	enabling of pasture of grassland yes(1),(no) 2	code 1/2	PARAMV6	1	integer	1	2
option_thinning	enabling of several thinning yes(1),no(2)	code 1/2	PARAMV6	1	integer	1	2

orgeng	maximal amount of fertilizer N that can be immobilized in the soil (fraction for type 8)	kg.ha-1	PARAM	8	real	0	100
orientrang	direction of crop rows (relative to north)	rad	PARTEC	1	real	0	6.28
parazofmorte	parameter relating the C/N of dead leaves and the INN	SD	PARPLT	1	real	10	20
parsurrg	ratio of PAR to RG (global radiation)	SD	PARAM	1	real	0.4	0.6
patm	atmospheric pressure	mbar	STATION	1	real	800	1200
penterui	runoff coefficient taking account for plant mulch	SD	PARSOL	1	real	0	5
pentinflores	parameter used to calculate the inflorescences number	10*inflo*kg-1	PARPLT	1	real	0	10
pentlaimax	parameter of the logistic curve of LAI growth	SD	PARPLT	1	real	0	10
pentrecouv	parameter of the logistic curve of soil cover rate	SD	PARPLT	1	real	0	10
pertes_restit_ext	proportion of animal feces and urine that are returned elsewhere than on grazed paddocks (e.g. in resting area, milking parlour, housing and paths/roads)	0-1	PARAMV6	1	real	0	1
pgrainmaxi	maximum grain weight (at 0% water content)	g	PARPLT	1	real	0	5
pH0	Initial soil pH (water solution)	pH	PARSOL	1	real	4	9
phiv0	parameter allowing the calculation of the climate under shelter	SD	STATION	1	real	0	0.01
pHmaxden	pH beyond which the N2O molar fraction is minimum (<= ratiodenit)	pH	PARAM	1	real	6	10
pHmaxnit	soil pH above which nitrification is maximum	pH	PARAM	1	real	5	9
pHmaxvol	soil pH above which NH3 volatilisation derived from fertiliser is maximum	pH	PARAM	1	real	6	9
pHminden	pH below which the N2O molar fraction is 100%	pH	PARAM	1	real	3	6.5
pHminnit	soil pH below which nitrification is nil	pH	PARAM	1	real	3	6
pHminvol	soil pH below which NH3 volatilisation derived from fertiliser is nil	pH	PARAM	1	real	3	6
phobase	basal photoperiod	hours	PARPLT	1	real	0	24
phobasesen	photoperiod under which the photoperiodic stress affects the lifespan of leaves	hours	PARPLT	1	real	1	12
phosat	saturating photoperiod	hours	PARPLT	1	real	0	24
pHvols	parameter used to calculate the variation of soil pH after the addition of slurry	pH	PARAM	1	real	5	9
phyllotherme	thermal duration between the apparition of two successive leaves on the main stem	degree-d	PARPLT	1	real	10	150

plNmin	minimal amount of rain required to start an automatic N fertilisation	mm.d-1	PARAM	1	real	5	30
pluiebat	minimal amount of rain required to create a soil crust (a value must be given but if in the plt.xml the vigueurbat parameter is equal to 1 then the parameter is inactive)	mm.d-1	PARSOL	1	real	5	100
pminruis	minimal amount of rain required to produce runoff	mm.d-1	PARAM	1	real	2	50
Pns	density of the new snow	kg.m-3	STATION	1	real	0.000005	100
potgermi	soil water potential under which seed imbibition is impeded	MPa	PARPLT	1	real	-4.2	-0.1
primingmax	maximum priming ratio (relative to SOM decomposition rate)	SD	PARAM	1	real	1	5
prof	snow cover threshold for snow insulation	cm	STATION	1	real	8	12
profdenit	soil depth on which denitrification is active (if codedenit is activated)	cm	PARSOL	1	real	10	40
profdrain	depth of mole drains	cm	PARSOL	1	real	20	200
profhum	maximum soil depth with an active biological activity (max.60 cm)	cm	PARSOL	1	real	10	150
profhumrecolteuse	soil depth at which moisture is considered to allow harvesting (if soil compaction is activated)	cm	PARTEC	1	real	0	100
profhumsemoir	soil depth at which moisture is considered to allow sowing (if soil compaction is activated)	cm	PARTEC	1	real	0	100
profimper	Upper depth of the impermeable layer (from the soil surface). May be greater than the soil depth.	cm	PARSOL	1	real	50	200
proflabour	minimal soil depth for ploughing (if soil compaction is activated)	cm	PARAM	1	real	0	100
profmes	depth of measurement of the soil water reserve	cm	PARTEC	1	real	10	1000
profnod	maximum depth of N2 fixation by legume crops	cm	PARPLT	1	real	10	50
profres	upper depth of organic residue incorporation	cm	PARTEC	11	real	0	30
profsem	depth of sowing	cm	PARTEC	1	real	0	10
proftrav	maximum depth of organic residue incorporation	cm	PARTEC	11	real	0	50
proftravmin	minimal soil depth for chisel tillage (if soil compaction is activated)	cm	PARAM	1	real	0	100
prophumtassrec	soil moisture content (fraction of field capacity) above which compaction may occur and delay harvest	SD	PARAM	1	real	0.8	1.8
prophumtasssem	soil moisture content (fraction of field capacity) above which compaction may occur and delay sowing	SD	PARAM	1	real	0.8	1.8

propjgermin	minimal proportion of the duration nbjgerlim when the temperature is higher than the temperature threshold Tdmax	%	PARPLT	1	real	0	1
proprac	ratio of root mass to aerial mass at harvest	g.g.-1	PARAM	1	real	0.05	0.5
psihucc	soil water potential corresponding to field capacity	Mpa	PARAM	1	real	-5	-0.1
psihumin	soil water potential corresponding to wilting point	Mpa	PARAM	1	real	-5	-0.1
psisto	potential of stomatal closing (absolute value)	bars	PARPLT	1	real	1	25
psiturg	potential of the beginning of decrease of the cellular extension (absolute value)	bars	PARPLT	1	real	1	15
q0	cumulative soil evaporation above which evaporation rate is decreased	mm	PARSOL	1	real	0	50
q10	Q10 used for the dormancy break calculation	SD	PARPLT	1	real	1.5	3.5
qmulchdec	maximal amount of decomposable mulch	t.ha-1	PARAM	21	real	0	5
qmulchruis0	amount of mulch above which runoff is suppressed	t.ha-1	PARAM	21	real	0	5
QNplante0	initial N amount in the plant	kg.ha-1	INIT	1	real	0	200
QNpltminINN	minimal amount of N in the plant required to compute INN	kg.ha-1	PARAM	1	real	0	50
qres	mass of organic residues added to soil (fresh weight)	t.ha-1	PARTEC	11	real	0	200
Qtot_N	amount of total mineral N fertilizer applications	kg.ha-1	PARTEC	1	integer	0	200
ra	aerodynamic resistance (used in volatilization module when we use ETP approach)	s.m-1	STATION	1	real	10	70
rapforme	ratio of thickness to /width of the crop shape (negative when the base of the form < top)	SD	PARPLT	1	real	-5	5
rapNmindec	slope of the linear relationship between the fraction of mineral N available for residue decomposition and the amount of C in decomposing residues (0.001)	g.g-1	PARAMV6	1	real	0	0.01
rapsenturg	threshold soil water content active to simulate water senescence stress as a proportion of the turgor stress	SD	PARPLT	1	real	0.5	1.5
ratiodenit	constant value of N2O ratio for denitrification	SD	PARAM	1	real	0	1
ratiodurvieI	life span of early leaves expressed as a fraction of the life span of the last leaves emitted DURVIEF	SD	PARPLT	1	real	0	1
ratiol	water stress index below which irrigation is started in automatic mode (0 in manual mode)	SD	PARTEC	1	real	0.2	1
ratiolN	nitrogen stress index below which fertilisation is started in automatic mode (0 in manual mode)	SD	PARAMV6	1	real	0.2	1
rationit	constant value of N2O ratio for nitrification	SD	PARAM	1	real	0	0.05

ratiosen	fraction of senescent biomass (relative to total biomass)	SD	PARPLT	1	real	0	1
rayon	average root radius	cm	PARAM	1	real	0.005	0.07
rdrain	drain radius	cm	PARAM	1	real	1	100
remobres	fraction of daily remobilisable C reserves	SD	PARPLT	1	real	0	0.5
repracpermax	maximum root biomass relative to total biomass (permanent trophic link)	SD	PARPLT	1	real	0.1	0.9
repracpermin	minimum root biomass relative to total biomass (permanent trophic link)	SD	PARPLT	1	real	0.1	0.9
repracseumax	maximum root biomass relative to total biomass (trophic link by thresholds)	SD	PARPLT	1	real	0.1	0.9
repracseumin	minimum root biomass relative to total biomass (trophic link by thresholds)	SD	PARPLT	1	real	0.1	0.9
resperenne0	initial reserve of biomass	t.ha-1	INIT	1	real	0	5
resplmax	maximal reserve of biomass	t.ha-1	PARAMV6	2	real	0	100
rsmin	minimal stomatal resistance of leaves	s.m-1	PARPLT	1	real	20	500
rugochisel	roughness length of bare soil after chisel tillage (if soil compaction is activated)	m	PARTEC	1	real	0.01	0.2
rugolabour	roughness length of bare soil after mouldboard ploughing (if soil compaction is activated)	m	PARTEC	1	real	0.01	0.2
ruisolnu	fraction of runoff (relative to total rainfall) in a bare soil	SD	PARSOL	1	real	0	1
scale_tdenitopt	parameter related to the range of optimum temperature for denitrification	unknown	PARAM	1	real	10	40
scale_tnitopt	parameter related to the range of optimum temperature for nitrification	unknown	PARAM	1	real	5	30
sea	specific area of fruit envelops	cm2.g-1	PARPLT	1	real	0	300
sensanox	index of anoxia sensitivity (0 = insensitive)	SD	PARPLT	1	real	0	1
sensiphot	index of photoperiod sensitivity (1=insensitive)	SD	PARPLT	1	real	0	1
sensrsec	index of root sensitivity to drought (1=insensitive)	SD	PARPLT	1	real	0	1
seuilLAIapex	maximal value of LAI+LAIapex when LAIapex is > 0	m2.m-2	PARAMV6/PLT	2	real	0	10
seuilmortalle	relative transpiring threshold to calculate tiller mortality	mm	PARAMV6/PLT	2	real	0	10
seuilreconspeupl	tiller density below which the entire population will not be regenerated	nb.m-2	PARAMV6/PLT	2	real	0	4000

sigmadistalle	parameter used for calculating tiller mortality (gamma law)	SD	PARAMV6/PLT	2	real	0	0.5
slamax	maximum SLA (specific leaf area) of green leaves	cm2.g-1	PARPLT	1	real	50	500
slamin	minimum SLA (specific leaf area) of green leaves	cm2.g-1	PARPLT	1	real	50	500
spfrmax	maximal sources/sinks value allowing the trophic stress calculation for fruit onset	SD	PARPLT	1	real	0.7	2
spfrmin	minimal sources/sinks value allowing the trophic stress calculation for fruit onset	SD	PARPLT	1	real	0	1
splaimax	maximal sources/sinks value allowing the trophic stress calculation for leaf growing	SD	PARPLT	1	real	0.7	2
splaimin	minimal value of ratio sources/sinks for the leaf growth	SD	PARPLT	1	real	0.01	1
stamflax	cumulative thermal time between the stages AMF (maximum acceleration of leaf growth, end of juvenile phase) and LAX (maximum leaf area index, end of leaf growth)	degree-d	PARPLT	1	real	0	6000
stdnofno	cumulative thermal time between the beginning and the end of nodulation	degree-d	PARPLT	1	real	0	500
stdordebour	cumulative thermal time between the dormancy break and the bud break	degree-d	PARPLT	1	real	0	20000
stdrpdes	cumulative thermal time between the DRP stage (starting date of filling of harvested organs) and DEBDES (date of onset of water dynamics in harvested organs)	degree-d	PARPLT	1	real	0	900
stdrpmat	cumulative thermal time between the stages DRP (starting date of filling of harvested organs) and MAT (maturity)	degree-d	PARPLT	1	real	0	2000
stdrpnou	cumulative thermal time between the stages DRP (starting date of filling of harvested organs) and NOU (end of setting)	degree-d	PARPLT	1	real	0	6000
stemflowmax	maximal fraction of rainfall flowing down along the stems	SD	PARPLT	1	real	0	1
stflodrp	cumulative thermal time between FLO (anthesis) and DRP (starting date of filling of harvested organs) (only for indication)	degree-d	PARPLT	1	real	0	500
stfnofvino	cumulative thermal time between the end of the nodulation and the end of the nodule life	degree-d	PARPLT	1	real	0	500
stlaxsen	cumulative thermal time between the stages LAX (maximum leaf area index, end of leaf growth) and SEN (beginning of leaf senescence)	degree-d	PARPLT	1	real	0	6000
stlevamf	cumulative thermal time between the stages LEV (emergence) and AMF (maximum acceleration of leaf growth, end of juvenile phase)	degree-d	PARPLT	1	real	0	6000

stlevdno	cumulative thermal time between emergence and the beginning of nodulation	degree-d	PARPLT	1	real	0	500
stlevdrp	cumulative thermal time between the stages LEV (emergence) and DRP (starting date of filling of harvested organs)	degree-d	PARPLT	1	real	0	6000
stpltger	cumulative thermal time allowing germination	degree-d	PARPLT	1	real	0	100
stressdev	maximum phasic delay allowed due to stresses	SD	PARPLT	1	real	0.1	0.9
stsenlan	cumulative thermal time between the stages SEN (beginning of leaf senescence) et LAN	degree-d	PARPLT	1	real	0	6000
sucrerec	minimal sugar concentration at harvest (/ fresh matter)	g.g-1 FW	PARTEC	1	real	0.0001	0.5
surfapex	equivalent surface of a transpiring apex	m2	PARAMV6/PLT	2	real	0	0.0001
surfouvre1	relative area of the shelter opened the first day of opening	SD	PARTEC	1	real	0.1	0.8
surfouvre2	relative area of the shelter opened the second day of opening	SD	PARTEC	1	real	0.1	0.8
surfouvre3	relative area of the shelter opened the third day of opening	SD	PARTEC	1	real	0.1	0.8
swfacmin	minimal value for drought stress index (turfac, swfac, senfac)	SD	PARAMV6	1	real	0	1
SWrf	degree-day temperature index for snow refreezing	mm.degreeC.d-1	STATION	1	real	0	0.01
tauxrecouvkmax	soil cover rate corresponding to the maximal crop coefficient for water requirement (plant surface / soil surface)	m2.m-2	PARPLT	1	real	0.5	1
tauxrecouvmax	maximal soil cover rate (plant surface / soil surface)	m2.m-2	PARPLT	1	real	0.5	1
tcmax	maximum temperature at which growth ceases	degreeC	PARPLT	1	real	10	50
tcmin	minimum temperature at which growth ceases	degreeC	PARPLT	1	real	-10	15
tcxstop	temperature beyond which foliar growth stops	degreeC	PARPLT	1	real	0	100
tdebgel	temperature below which frost affects plant growth	degreeC	PARPLT	1	real	-5	5
tdenitopt_gauss	optimum temperature for denitrification	degreeC	PARAM	1	real	0	60
tdmax	maximum temperature above which development stops	degreeC	PARPLT	1	real	15	40
tdmaxdeb	maximal temperature for hourly calculation of phasic duration between dormancy and bud breaks	degreeC	PARPLT	1	real	0	40
tdmin	minimum temperature below which development stops	degreeC	PARPLT	1	real	-10	15
tdmindeb	minimal thermal threshold for hourly calculation of phasic duration between dormancy and bud breaks	degreeC	PARPLT	1	real	0	40
temax	maximal temperature above which plant growth stops	degreeC	PARPLT	1	real	15	40
temin	minimum temperature for development	degreeC	PARPLT	1	real	-10	15

tempdeshyd	increase in fruit dehydration rate due to the increase in crop temperature (Tcult-Tair)	% water.degreeC -1	PARPLT	1	real	0.0001	0.05
tempfauche	cumulative thermal time between two cuts of forage crops	degree-d	PARTEC	20	real	0	2000
tempnod1	temperature parameter (1/4) used to calculate N fixation by legumes	degreeC	PARPLT	1	real	-10	40
tempnod2	temperature parameter (2/4) used to calculate N fixation by legumes	degreeC	PARPLT	1	real	-10	40
tempnod3	temperature parameter (3/4) used to calculate N fixation by legumes	degreeC	PARPLT	1	real	-10	40
tempnod4	temperature parameter (4/4) used to calculate N fixation by legumes	degreeC	PARPLT	1	real	-10	40
teopt	optimal temperature (1/2) for plant growth	degreeC	PARPLT	1	real	10	30
teoptbis	optimal temperature (2/2) for plant growth	degreeC	PARPLT	1	real	10	30
tfroid	optimal temperature for vernalisation	degreeC	PARPLT	1	real	-5	10
tgelflo10	temperature resulting in 10% of frost damages on flowers and fruits	degreeC	PARPLT	1	real	-25	0
tgelflo90	temperature resulting in 90% of frost damages on flowers and fruits	degreeC	PARPLT	1	real	-25	0
tgeljuv10	temperature resulting in 10% of frost damage on LAI (juvenile stage)	degreeC	PARPLT	1	real	-25	0
tgeljuv90	temperature resulting in 90% of frost damage on LAI (juvenile stage)	degreeC	PARPLT	1	real	-25	0
tgellev10	temperature resulting in 10% of frost damages on plantlet	degreeC	PARPLT	1	real	-25	0
tgellev90	temperature resulting in 90% of frost damages on plantlet	degreeC	PARPLT	1	real	-25	0
tgelveg10	temperature resulting in 10% of frost damage on LAI (adult stage)	degreeC	PARPLT	1	real	-25	0
tgelveg90	temperature resulting in 90% of frost damage on LAI (adult stage)	degreeC	PARPLT	1	real	-25	0
tgmin	minimum temperature below which emergence is stopped	degreeC	PARPLT	1	real	-10	15
tigefeuil	ratio stem (structural part)/leaf	SD	PARPLT	1	real	0	3
tigefeuilcoupe	ratio stem (structural part)/leaf on the cutting day	SD	PARAMV6/PLT	2	real	0	3
tletale	lethal temperature for the plant	degreeC	PARPLT	1	real	-30	-1
tmaxremp	maximal temperature above which grain filling stops	degreeC	PARPLT	1	real	10	40

tmaxseuil	maximum temperature when snow cover is higher than prof	degreeC	STATION	1	real	-0.5	0.5
Tmf	threshold temperature for snow melting	degreeC	STATION	1	real	0	1
tminremp	minimal temperature below which grain filling stops	degreeC	PARPLT	1	real	0	20
tminseuil	minimum temperature when snow cover is higher than prof	degreeC	STATION	1	real	-1	0
tnitmax	maximal temperature above which nitrification stops	degreeC	PARAM	1	real	30	50
tnitmin	minimal temperature below which nitrification stops	degreeC	PARAM	1	real	-10	20
tnitopt	optimal temperature (1/2) for nitrification	degreeC	PARAM	1	real	10	40
tnitopt_gauss	optimal temperature (1/2) for nitrification	degreeC	PARAM	1	real	0	50
tnitopt2	optimal temperature (2/2) for nitrification	degreeC	PARAM	1	real	20	45
transplastic	transmission coefficient of the plastic shelter	SD	PARTEC	1	real	0.3	0.9
trefh	reference temperature for decomposition of humified organic matter	degreeC	PARAM	1	real	-10	20
trefr	reference temperature for decomposition of organic residues	degreeC	PARAM	1	real	-10	20
trmax	tmax above which all precipitation is assumed to be rain	degreeC	STATION	1	real	0.5	1.5
tsmax	maximum daily air temperature (tmax) below which all precipitation is assumed to be snow	degreeC	STATION	1	real	-1	-0.5
tustressmin	water stress index (min(turfac,inns)) below which there is an extra LAI senescence	SD	PARPLT	1	real	0.3	1
typecailloux	Pebbles type defined by a volumetric mass value (masvolx) and a field capacity moisture value (HCCCX) only used if codecailloux=1 . (typecailloux= 1:Beauce limestone1, 2:Beauce limestone2, 3:lutecian limestone, 4:Lutetian Brackish marl and limestone,5:Morainic gravels,6:Unweathered flint, sandstone or granite,7:weathered granite,8:Jurassic limestone,9:Pebbles from Magneraud,10:Other pebbles)	SD	PARSOL	5	integer	1	10
udlaimax	ulai from which the rate of leaf growth decreases	SD	PARPLT	1	real	1	3
upvttapI	thermal time from emergence (UPVT units) driving irrigation	degreeC	PARTEC	30	integer	0	200
upvttapN	thermal time from emergence (UPVT units) driving fertilization	degreeC	PARTEC	20	integer	0	200
Vabs2	N uptake rate at which fertilizer loss is divided by 2	kg.ha-1.d-1	PARAM	1	real	0.5	5
variete	cultivar number corresponding to the cultivar name in the plant file	SD	PARTEC	1	integer	1	200
vigueurbat	plant vigor index allowing to emerge through a soil crust	SD	PARPLT	1	real	0.0001	1

vitirazo	rate of increase of the N harvest index vs time	g grain.g-1.d-1	PARPLT	1	real	0.001	0.04
vitircarb	rate of increase of the C harvest index vs time	g grain.g-1.d-1	PARPLT	1	real	0.001	0.02
vitircarbT	rate of increase of the C harvest index vs thermal time	g grain.g-1.d-1	PARPLT	1	real	0.00005	0.002
vitno	rate of nodule onset expressed as a proportion of fixmax per degree day	degree-d-1	PARPLT	1	real	0.001	0.01
vitprophuile	rate of increase of oil harvest index vs time	g oil.g-1.d-1	PARPLT	1	real	0.001	0.01
vitpropsucre	rate of increase of sugar harvest index vs time	g sugar.g-1.d-1	PARPLT	1	real	0.001	0.01
vitreconspeupl	rate of regeneration of the tiller population	degreeC-1	PARAMV6	2	real	0	0.1
vlaimax	ulai at the inflexion point of the function DELTAI=f(ULAI)	SD	PARPLT	1	real	1.5	2.5
Vmax1	maximum specific N uptake rate with the low affinity transport system	µmole.cm-1 h-1	PARPLT	1	real	0.0002	0.01
Vmax2	maximum specific N uptake rate with the high affinity transport system	µmole.cm-1 h-1	PARPLT	1	real	0.002	0.1
vnitmax	maximum nitrification rate if michaelis_menten option used	mg N kg-1 d-1	PARAM	1	real	0	100
voleng	maximal fraction of mineral fertilizer that can be volatilized	SD	PARAM	8	real	0	1
vpotdenit	potential rate of denitrificaion on profdenit (kg N/ha/day) (2 by default, or fonction of 5*Corg-4)	kg.ha-1.d-1	PARSOL	1	real	0.3	10
wfpsc	wfps threshold beyond which denitrification occurs	SD	PARAM	1	real	0.3	1
Wh	N/C ratio of soil humus	g.g-1	PARAM	1	real	0.05	0.14
Xorgmax	maximal amount of N immobilised in soil derived from the mineral fertilizer	kg.ha-1	PARAM	1	real	100	500
y0msrac	minimal amount of root mass at harvest (when aerial biomass is nil)	t.ha-1	PARAM	1	real	0	5
yres	Carbon assimilation yield by the microbial biomass during crop residues decomposition	g.g-1	PARAM	21	real	0.3	0.7
z0solnu	roughness length of bare soil	m	PARSOL	1	real	0.01	0.2
zesx	maximal soil depth affected by soil evaporation	cm	PARSOL	1	real	10	150
zlabour	depth of ploughing (reference profile)	cm	PARPLT	1	real	0	100
zpente	depth at which root density is 50% of the surface root density (reference profile)	cm	PARPLT	1	real	10	200
zprlim	maximum depth of the root profile (reference profile)	cm	PARPLT	1	real	10	200
zr	reference height of meteorological data measurement	m	STATION	1	real	2	10

zrac0	initial depth of root apex of the crop	cm	INIT	1	real	0	200
zracplantule	initial depth of root apex of the plantlet	cm	PARPLT	1	real	0	200