Hi-sAFe
User GUIDE

Version 3.1

Isabelle LECOMTE

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1. Hi-sAFe overview

Hi-sAFe is a dynamic generic model simulating interactions between plants (trees and crops) in three dimensions, which account for the classical balance of materials and energy (water, nitrogen, light). Hi-sAFe is implemented under the **CAPSIS** modelling platform (De Coligny et al, 2002) which is portable software, freely available under a GNU license (http://capsis.cirad.fr/capsis/home). The Capsis project aims at integrating several types of forest growth and dynamic models and providing forest management tools to establish and compare different silviculture scenarios.

Hi-sAFe is designed to simulate scenes such as:

- Mixtures of trees and crops, whether trees are aligned, dispersed or isolated
- Perennial row crops with ground cover
- Mixtures of herbaceous crops, foot, row or strip
- Multi-species forests
- Isolated trees (urban trees, hedges) with or without ground vegetation
- Plots of pure crops with spatial heterogeneity
- Precision agriculture (technical itineraries adapted to the spatial heterogeneity of the stand)

A tree model has been specifically developed with 6 main modules:

- Phenology
- Light interception
- Water demand calculation
- C allocation
- Fine root growth
- Coarse root topology growth

STICS (Brisson et al, 2001) is the crop model embedded in Hi-sAFe. It has been in development at INRA-Avignon (France) since 1996 (http://www6.paca.inra.fr/stics). STICS simulates crop growth as well as soil water and nitrogen balances driven by daily climatic data. It calculates both agricultural variables (yield, input consumption) and environmental variables (water and nitrogen losses). One of the key elements of STICS is its adaptability to various crops. This is achieved by the use of generic parameters relevant for most crops and with options in the model concepts concerning both physiology and management, which have to be chosen for each crop.

The water and nitrogen repartition module between trees and crop also has been specially designed for HisAFe with a **minimisation of energy approach**. This simply means that the resources will be extracted where it is the easiest (plants are lazy). The model should be able to describe the opportunism of plants in heterogeneous environments, and especially when heterogeneity results from plant competition.

2. Hi-sAFe simulated scene

Usual agroforestry projects will take place at a variety of scales, but the Hi-sAFe belowground modules must operate at relatively small horizontal and vertical scales, over which local conditions can vary significantly. The following diagrams describe the process by which we move from the field scale through to the soil scale at which the Hi-sAFe belowground modules will operate.

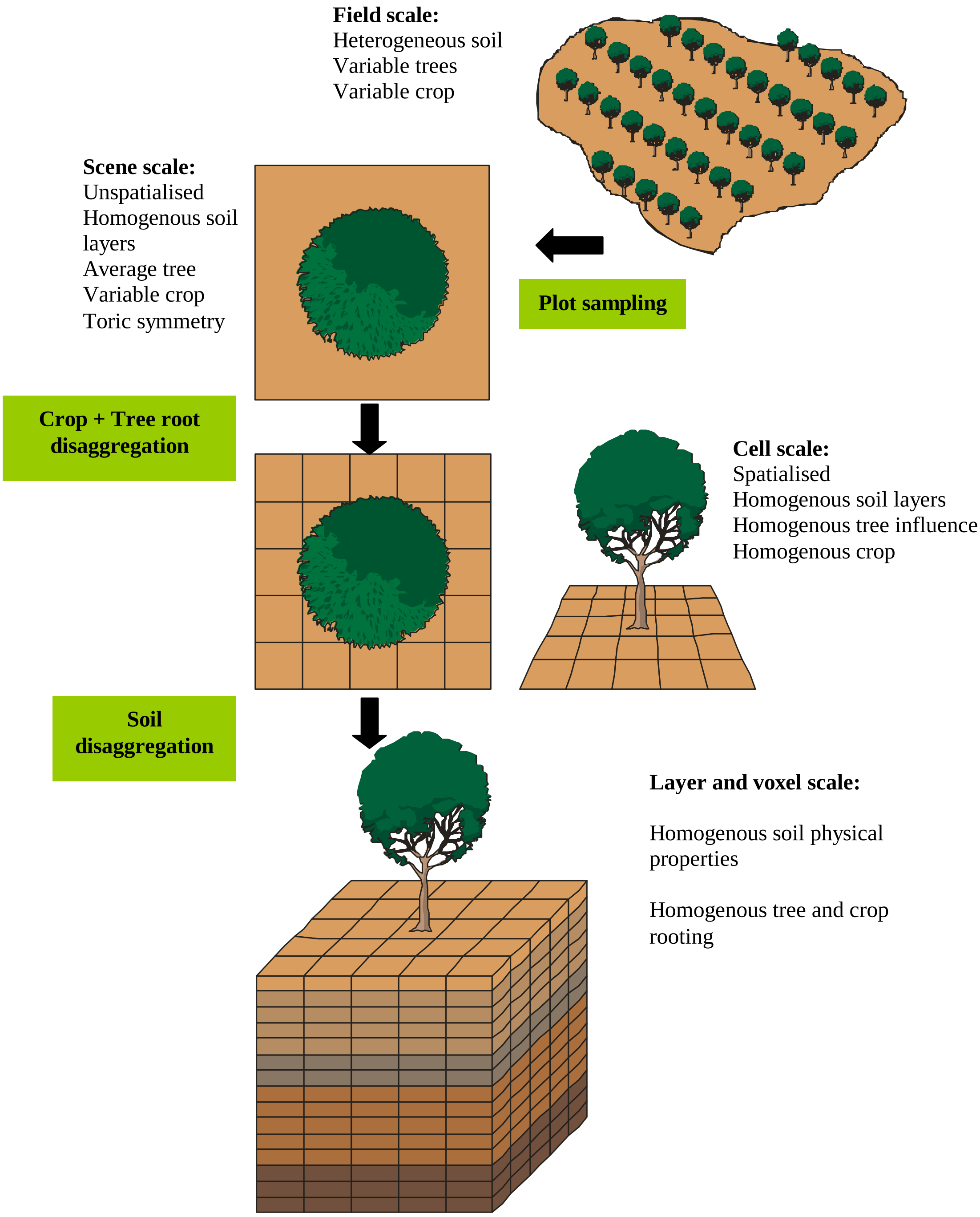


Figure 1: Spatial resolution – from the field scale to the voxel scale

The Hi-sAFe soil resolution is not only based on structural characteristics (pedologic layers) but also on a *maximum* thickness of soil suitable for the water extraction and the cellular automata module (for tree root growth) being simultaneously developed. The decision was reached to call these intermediate sub-layers "*voxels"*. The term is a contraction of "volume element" (by analogy with 'pixel'), and is commonly used in three-dimensional modelling. A voxel is defined as '"*the smallest distinguishable box-shaped part of a three-dimensional space*". The voxels will differ in terms of their water content, even if they share similar soil structural parameters. Further discussions centred on whether to consider only voxels of uniform dimensions (*e.g.* 1m X 1m X 1m), or whether it was necessary to be able to have non-cubic voxels. Eventually it was decided that the horizontal X-Y dimensions of voxels in Hi-sAFe would be uniform (*i.e.* square), but that the depth (Z-dimension) could vary. This was necessary in order to be able to divide the compartments (of variable depth due to the heterogeneity of the soil pedological layers) into discrete voxels.

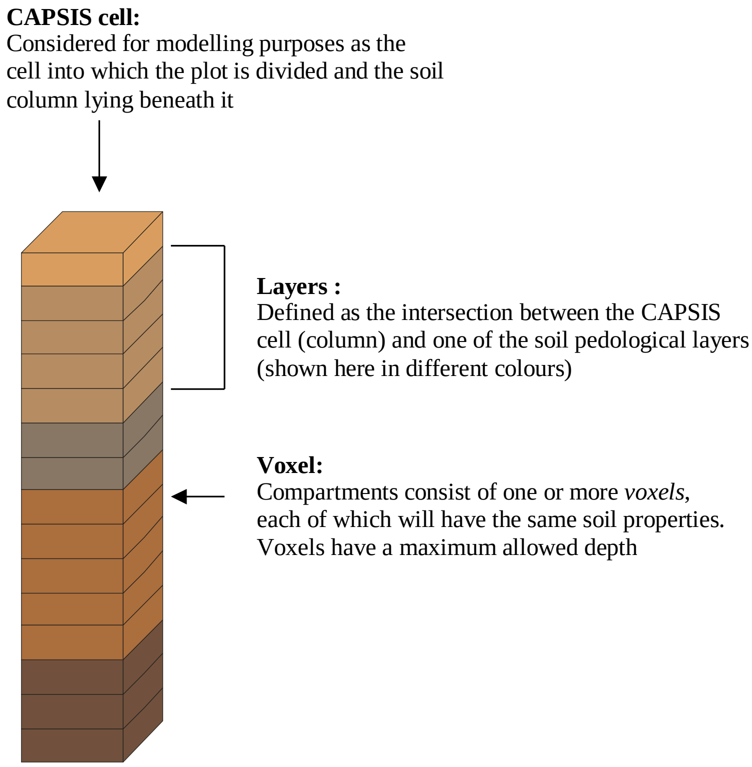


Figure 2: Definition of terms used in modules describing soil processes

Hi-sAFe includes toric symmetry algorithms that avoid generating artificial edge effects for heterogeneous stands (the scene is surrounded virtually by identical scenes)
Hi-sAFe can be used on simple scenes (for example centered on an average tree) or on complex scenes (eg including many trees with varying developments).

3. Running Hi-sAFe

Hi-sAFe installation creates a **capsis_install_folder\capsis4\data\safe** folder on your computer containing:

- cropSpecies: containing 23 crops species parameters files (*.plt)
- exportParameters: containing 10 export profiles (*.pro)
- generalParameters: containing 1 STICS general parameters file (tempopar.sti)
- itk: containing 23 crop intervention input files (*.itk)
- plotDescription: containing 10 example of plot description input file (*.pld)
- simSettings: containing 1 batch simulation folder example
- treeSpecies: containing 3 tree species parameters files (*.tree)
- weather: containing 1 weather input file (*.wth)

Each time you re-install or upgrade Hi-sAFe, this folder will be erased!
Copy this folder another part of your disk, and use this new folder to store your own simulation data.

3.1 Grafical User Interface (GUI) mode

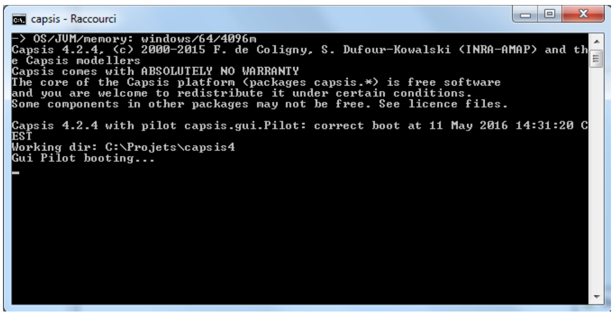
GUI mode is convenient to check plot configuration and run small simulations (1 or 2 years), but most of the time, BATCH mode is much more appropriate for multi-years simulations.

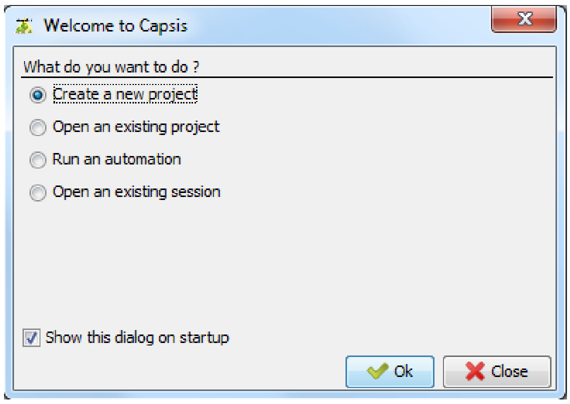
To run Hi-sAFe GUI, click on the Capsis desktop shortcut or open a DOS prompt and execute

```
c:\my_capsis_folder\capsis4 > capsis (in French)

c:\my_capsis_folder\capsis4 > capsis -l en (in English)
```

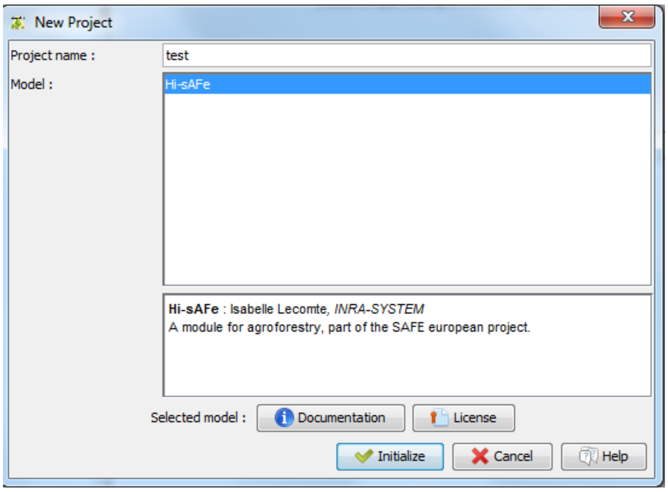
A DOS window and Capsis GUI will open simultaneously.



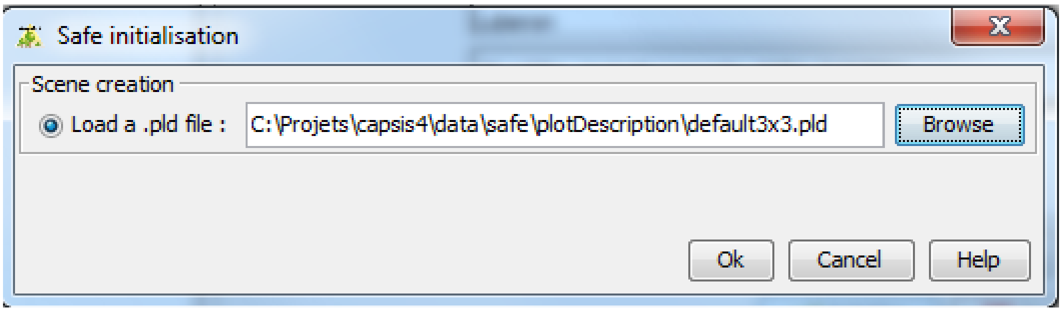


Choose “Create a new project” and click on **OK**

Give a name to the project, choose **Hi-sAFe** model and click on **Initialise**

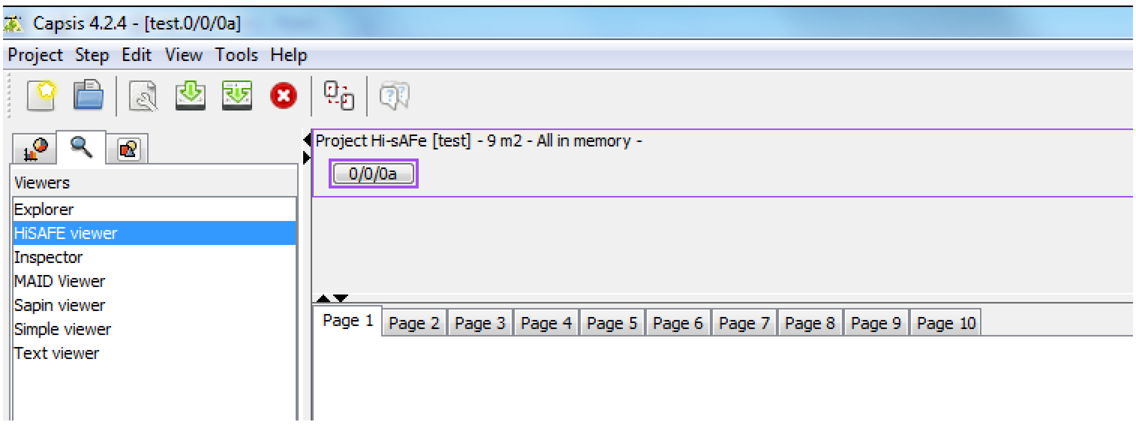


Initialise the project by giving a plot description file name. This file will contain all usefull information for designing the virtual scene (dimension, soil description and planted trees species). All details about the plot description file are in chapter 4.1.

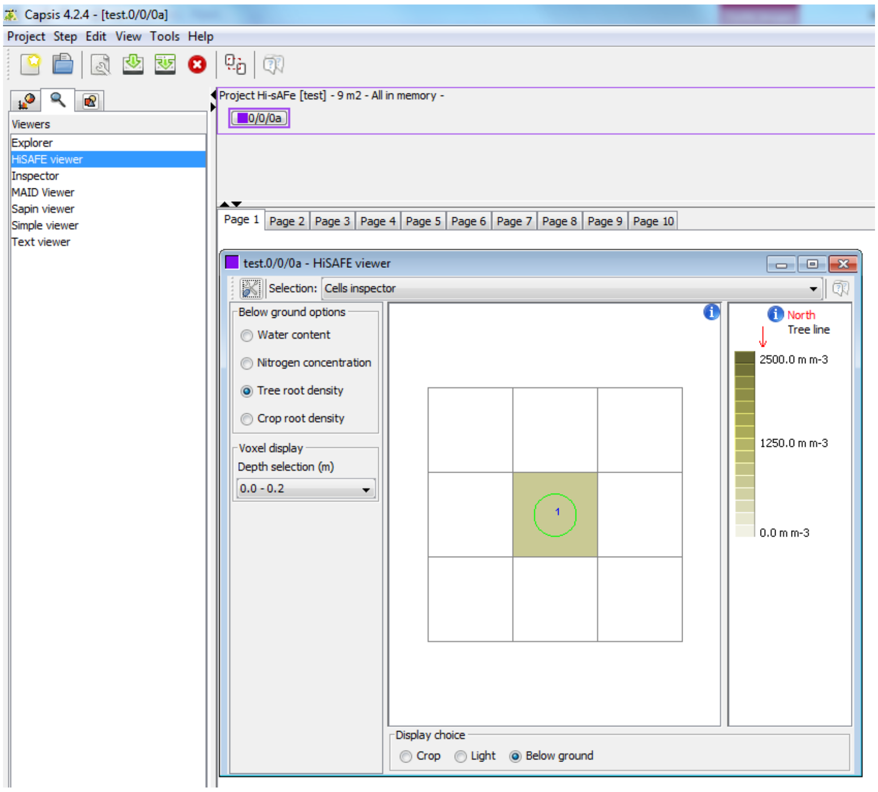


Click on the **Browse** button to choose a file on your computer, then **OK**

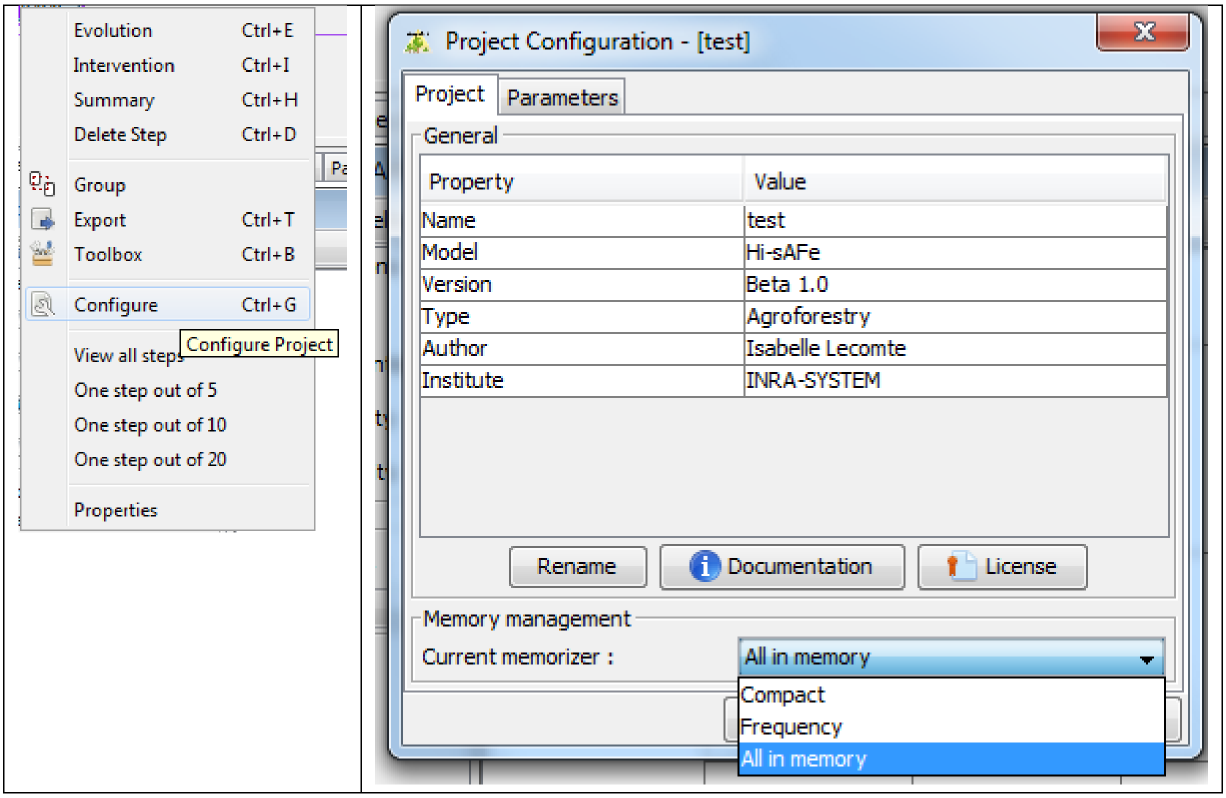
Click on the root step (**0/0/0a**) and then on **HiSAFE viewer** (on the left part of the screen)



You can check the plot design



Before running the simulation, it is possible to change the memory option to reduce the step that will be memorised in the CAPSIS project. Right-click on root step and choose "**Configure**"

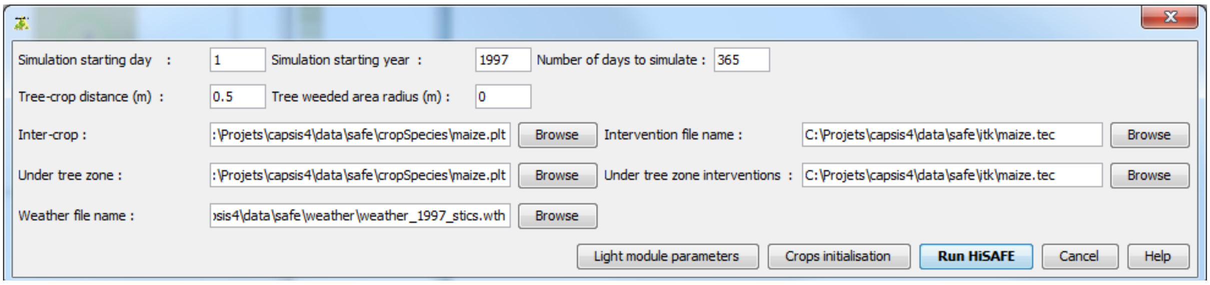


Memory options:

- All in memory : all steps are stored
- Compact : only the last step is stored

- Frequency : Only some steps are stored depending on the frequency defined

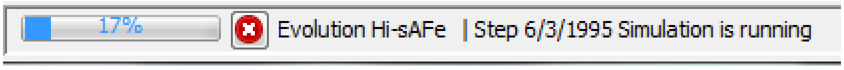
To run a Hi-sAFe simulation: right click on the root step (**0/0/0a**) of the project to choose "**Evolution**"



Fill in all simulation information:

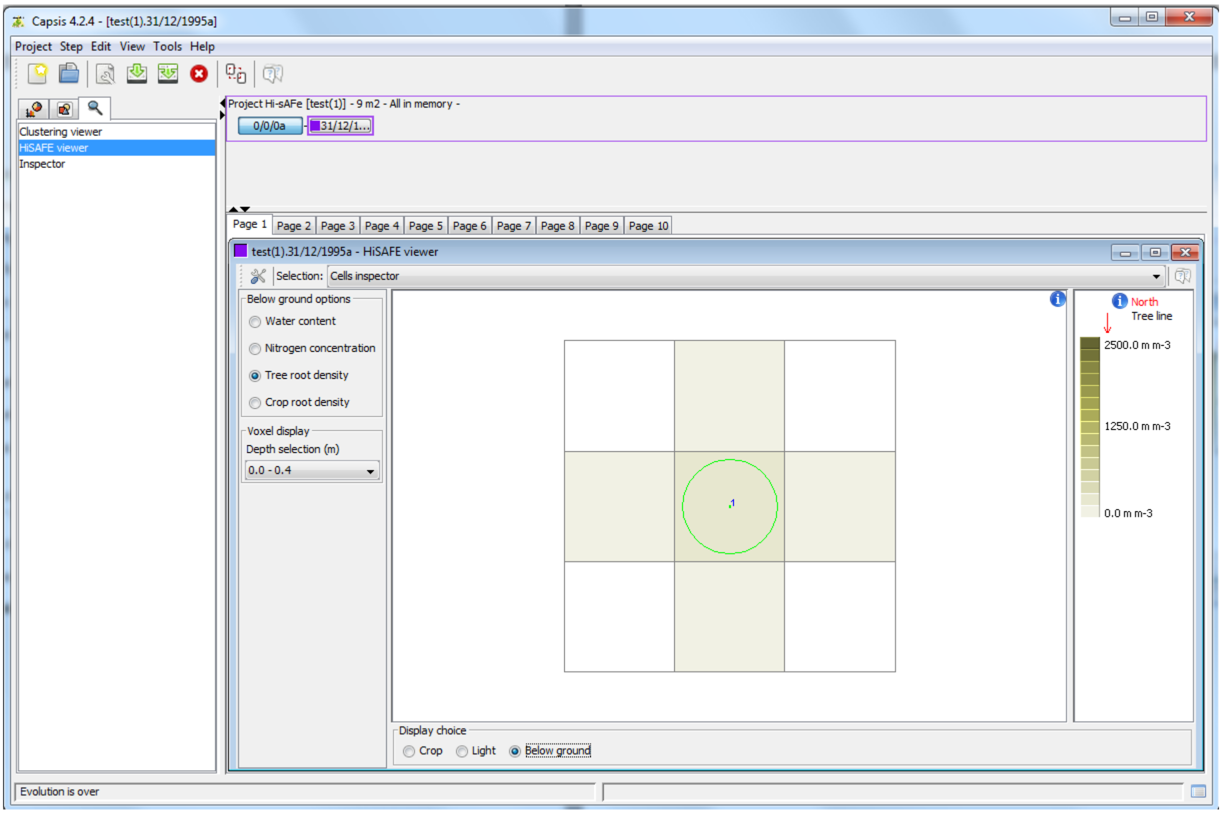
- Simulation starting date (in DOY)
- Simulation starting year
- Number of days for the simulation (1-365 max)
- Inter-crop species name and intenvention file
- Under tree zone species name and intenvention file
- Weather file name

Then click on "**Run Hi-sAFe**"

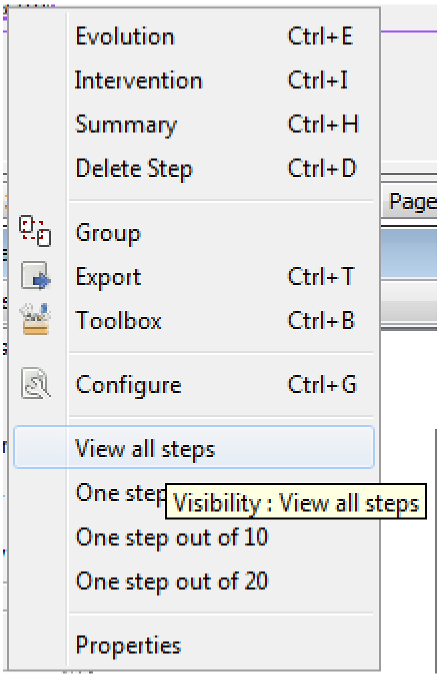


The progress bar at the bottom of the screen shows the evolution of the simulation.

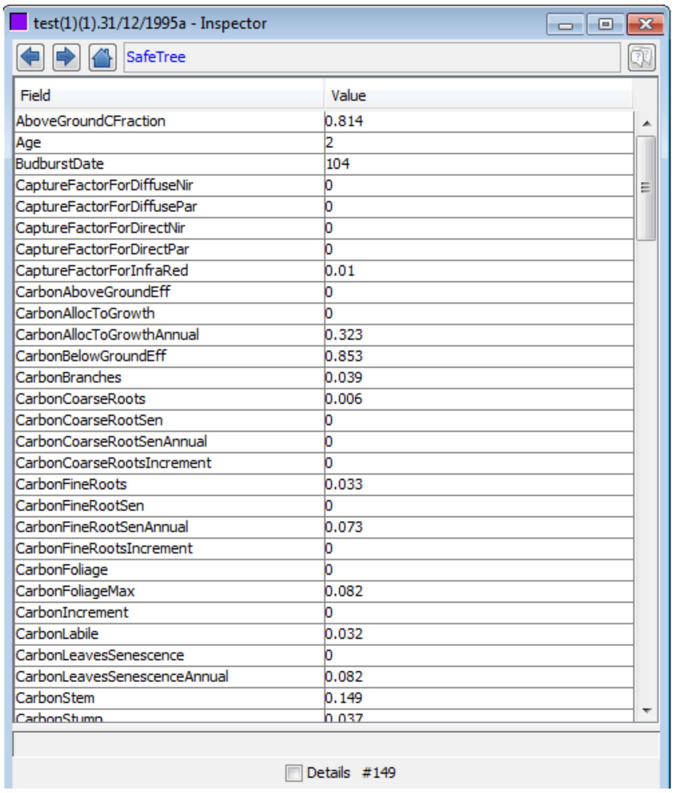
When the simulation is complete the last step appears next the root step.



To see other steps, right-click on a step and choose “**Configure**”



Results can be graphically explored using the **Inspector** or **HiSAFE viewer**



3.2 BATCH mode

Copy the capsis4/data/safe/ in a user simulation folder with

- **cropSpecies** : folder with all crop species file used in the simulation
- **exportParameters :** folder with all export profiles needed for the simulation
- **generalParameters** : folder with the temporar.sti general parameter fil
- **itk :** folder with all crop management files needed for the simulation
- **plotDescription :** folder with the plot description file
- **treeSpecies** : folder with all tree species parameters files needed for the simulation
- **weather** : folder with the weather file
- **test.sim :** simulation parameter file

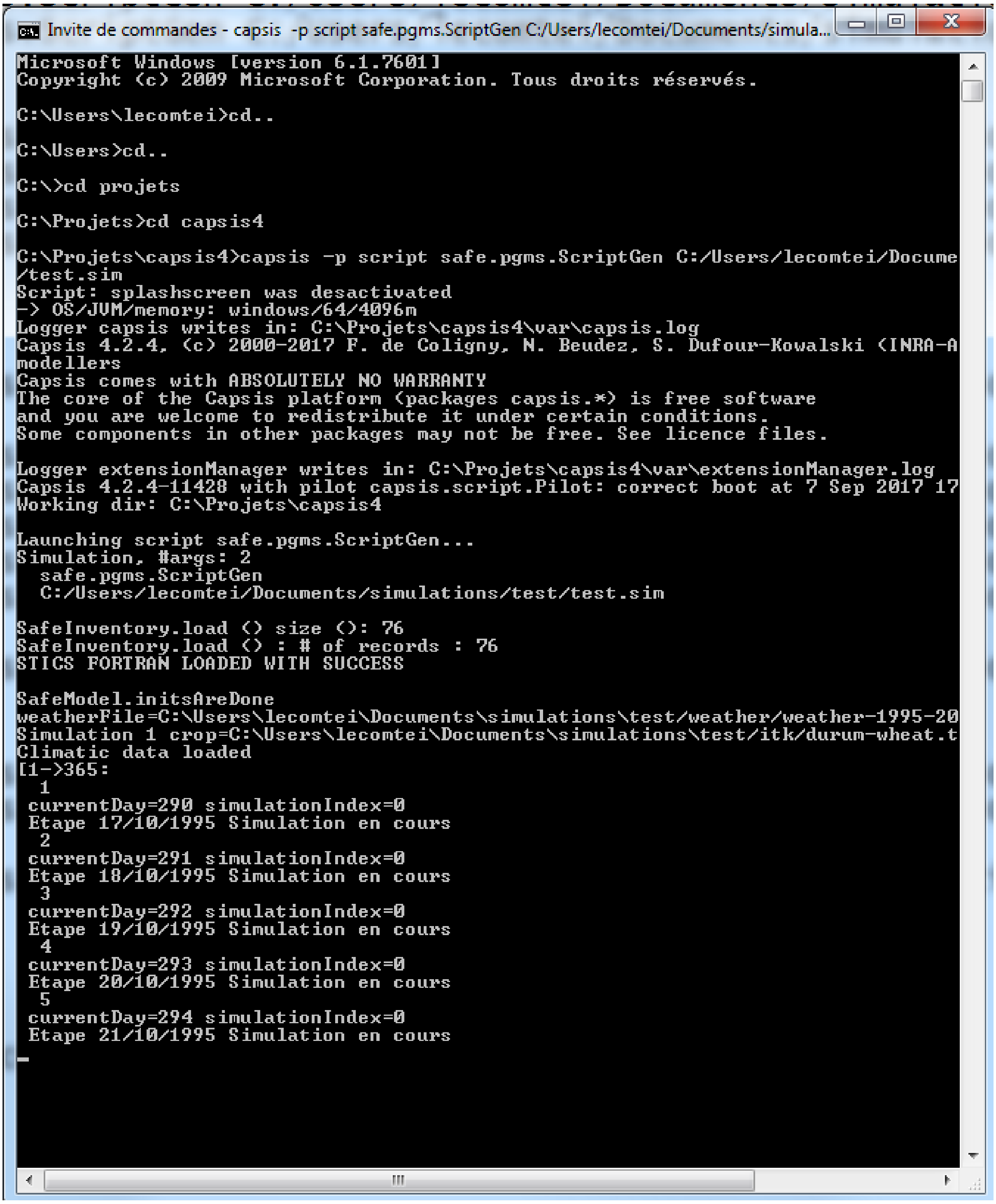
Be advised to choose a disk volume with enough space because a long simulation can generate large output files.

In this example simulation folder is **D:/simulations/test**

The simulation parameter file (test.sim) contains all information to run the simulation (this corresponding to the user entries in GUI mode)

Open a DOS prompt and execute

```
> capsis -p script safe.pgms.ScriptGen D:/simulations/test/test.sim
```



```
Invite de commandes - capsis  -p script safe.pgms.ScriptGen C:/Users/lecomtei/Documents/simula...
Microsoft Windows [version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. Tous droits réservés.

C:\Users\lecomtei>cd..

C:\Users>cd..

C:\>cd projets

C:\Projets>cd capsis4

C:\Projets\capsis4>capsis -p script safe.pgms.ScriptGen C:/Users/lecomtei/Docume
/test.sim
Script: splashscreen was desactivated
-> OS/JVM/memory: windows/64/4096m
Logger capsis writes in: C:\Projets\capsis4\var\capsis.log
Capsis 4.2.4, (c) 2000-2017 F. de Coligny, N. Beudez, S. Dufour-Kowalski (INRA-A
modellers
Capsis comes with ABSOLUTELY NO WARRANTY
The core of the Capsis platform (packages capsis.*) is free software
and you are welcome to redistribute it under certain conditions.
Some components in other packages may not be free. See licence files.

Logger extensionManager writes in: C:\Projets\capsis4\var\extensionManager.log
Capsis 4.2.4-11428 with pilot capsis.script.Pilot: correct boot at 7 Sep 2017 17
Working dir: C:\Projets\capsis4

Launching script safe.pgms.ScriptGen...
Simulation, #args: 2
  safe.pgms.ScriptGen
  C:/Users/lecomtei/Documents/simulations/test/test.sim

SafeInventory.load () size (): 76
SafeInventory.load () : # of records : 76
STICS FORTRAN LOADED WITH SUCCESS

SafeModel.initsAreDone
weatherFile=C:\Users\lecomtei\Documents\simulations\test/weather/weather-1995-20
Simulation 1 crop=C:\Users\lecomtei\Documents\simulations\test/itk/durum-wheat.t
Climatic data loaded
[1->365:
  1
 currentDay=290 simulationIndex=0
 Etape 17/10/1995 Simulation en cours
  2
 currentDay=291 simulationIndex=0
 Etape 18/10/1995 Simulation en cours
  3
 currentDay=292 simulationIndex=0
 Etape 19/10/1995 Simulation en cours
  4
 currentDay=293 simulationIndex=0
 Etape 20/10/1995 Simulation en cours
  5
 currentDay=294 simulationIndex=0
 Etape 21/10/1995 Simulation en cours
_
```

Starting messages for BATCH execution mode

Execution will automatically generate an output folder named **output-test.sim** containing**:**

- initialisation.sti : message from STICS initialisation
- mainplant.sti : message for STICS main plan initialisation
- secondplant.sti : message for STICS main plan initialisation
- one cvs file for each export described in the simulation parameter file

Name	Description	Unit
pldFileName	Name of the plot description file	
nbSimulations	Number of simulations	
simulationYearStart	Year start	Year
simulationDayStart	Day start	DOY
simulationNbrDays	Number of day to simulate	1-365
mainCropSpecies	Name of main crop species file	*.plt
mainCropItk	Name of main crop species intervention file	*.tec
interCropSpecies	Name of inter crop species file (under tree line)	*.plt
interCropItk	Name of inter crop species intervention file	*.tec
treeCropDistance	Tree – Crop distance	m
weededAreaRadius	Weeded or bare soil area (radius) under trees	m
weatherFile	Name of weather file name	*.wth
Paramètres optionnels		
saveProjectOption	Create a .pjr output file (can be re-opened with the graphical interface)	0=No, 1=Yes
profileNames	Name of profile to export	annualplot, annualtree, climate, plot etc..
exportFrequencies	Export frequencies for each profile	365 = every year 30 = every month 1 = every day
toreXp	Parameter for toric symmetry X positive	0 to desactivate
toreXn	Parameter for toric symmetry X negative	0 to desactivate
toreYp	Parameter for toric symmetry Y positive	0 to desactivate
toreYn	Parameter for toric symmetry Y negative	0 to desactivate
treePruningYears	Tree pruning years	1=First year
treePruningProp	Tree crown pruning proportion	ratio
treePruningMaxHeight	Tree pruning maximum height	m
treePruningDays	Tree pruning days (julian)	DOY
treeThinningIds	ID of tree for thinning	
treeThinningYears	Year for thinning trees	1=First year
treeThinningDays	Days for thinning trees	DOY
treeRootPruningYears	Year for root pruning	1=First year
treeRootPruningDays	Days for root pruning	DOY
treeRootPruningDistance	Root pruning distance from trees	m
treeRootPruningDepth	Root pruning depth	m
treePollardingMethod	Tree pollarding method	1=regular 2=threshold
treePollardingYears	Year for pollarding trees	
treePollardingDays	Days for pollarding trees	DOY
treePollardingHeight	Height after pollarding	m
treePollardingCanopyLeft	Heigth of canopy left after pollarding	m

Table 1: Format for simulation parameters file

```
# SIMULATION
pldFileName = Restinclieres_AF_A2.pld
nbSimulations = 10
simulationYearStart = 1995
simulationDayStart = 290
simulationNbrDays = 365

#CROP ROTATION
mainCropSpecies = durum-wheat-allur.plt
interCropSpecies = baresoil.plt
mainCropItk = durum-wheat.tec
interCropItk = baresoil.tec
treeCropDistance = 0.5
weededAreaRadius = 0

#WEATHER
weatherFile = restincl_A2-1995-2034-ex.wth

#EXPORTS
profileNames = annualplot,annualtree,climate,plot,trees,cells,voxels
exportFrequencies = 365,365,1,1,30,30

# toric symetry parameters
#toreXp = 0
#toreXn = 0
#toreYp = 0
#toreYn = 0

# tree pruning (values separated with ,)
treePruningYears = 2,4,6,8,10,12,14,16,18,20,22,24,26,28,30
treePruningProp = 0.3,0.3,0.3,0.3,0.3,0.3,0.3,0.3,0.3,0.3,0.3,0.3,0.3,0.3,0.3
treePruningMaxHeight = 4.0,4.0,4.0,4.0,4.0,4.0,4.0,4.0,4.0,4.0,4.0,4.0,4.0,4.0,4.0
treePruningDays = 365,365,365,365,365,365,365,365,365,365,365,365,365,365,365

# tree thinning (values separated with ,)
#treeThinningIds = 1
#treeThinningYears = 10
#treeThinningDays = 365
```

```
# tree root pruning (values separated with ,)
#treeRootPruningYears = 1
#treeRootPruningDays = 365
#treeRootPruningDistance = 1.5
#treeRootPruningDepth = 1.0


# tree pollarding (1=regular, 2=threshold)
treePollardingMethod = 1
treePollardingYears = 18,21,24,27,30,33,36,39
treePollardingDays = 365,365,365,365,365,365,365,365
treePollardingHeight = 4.0,4.0,4.0,4.0,4.0,4.0,4.0,4.0
treePollardingCanopyLeft = 0.5,0.5,0.5,0.5,0.5,0.5,0.5,0.5
```

Table 2 : Example of a simulation parameter file

Crop rotation examples :

Simulation parameter file can integrate crop rotations like:

```
nbSimulations = 10
mainCropSpecies = durum-wheat(3), rape(2)
interCropSpecies = baresoil, weed
treeCropDistance = 0.5(5),1.0(5)
```

For 10 years of simulation the rotation will be:

Main crop: durum-wheat / durum-wheat / durum-wheat / rape / rape / durum-wheat / durum-wheat / durum-wheat / rape / rape

Inter crop: Baresoil / Weed / Baresoil / Weed / Baresoil / Weed / Baresoil / Weed / Baresoil / Weed

Tree Crop distance: 0.5 / 0.5 / 0.5 / 0.5 / 0.5 / 1.0 / 1.0 / 1.0 / 1.0 / 1.0

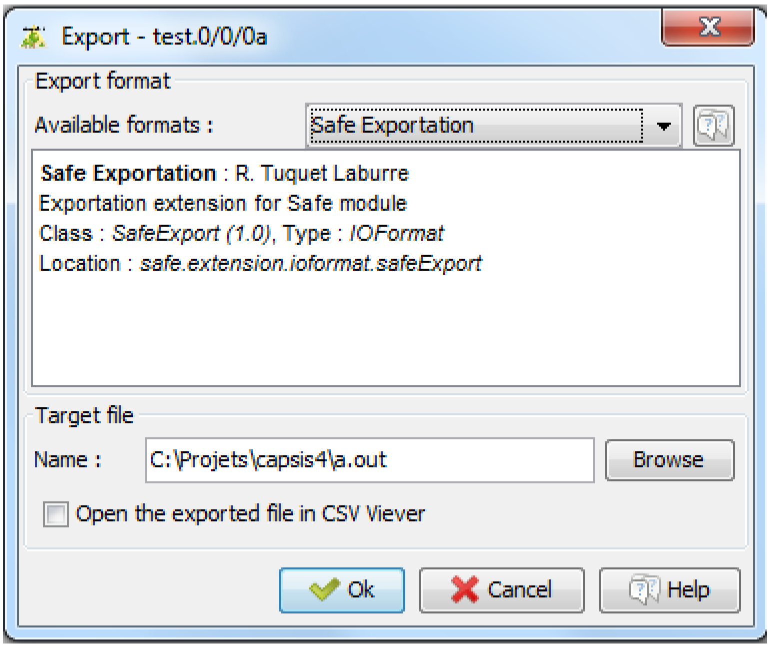
4. Exporting Hi-sAFe results

4.1 GUI mode

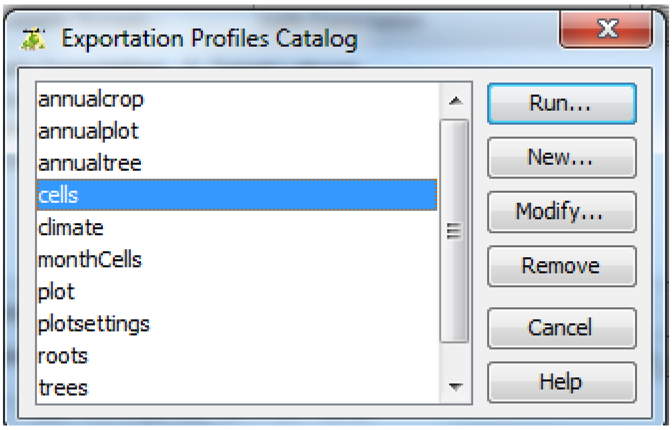
The best way to explore simulation results is to the export ASCII files output to be treated with EXCEL , R or any other data management software.

1) Right-click on the last step on the simulation and choose the "**Export**" option

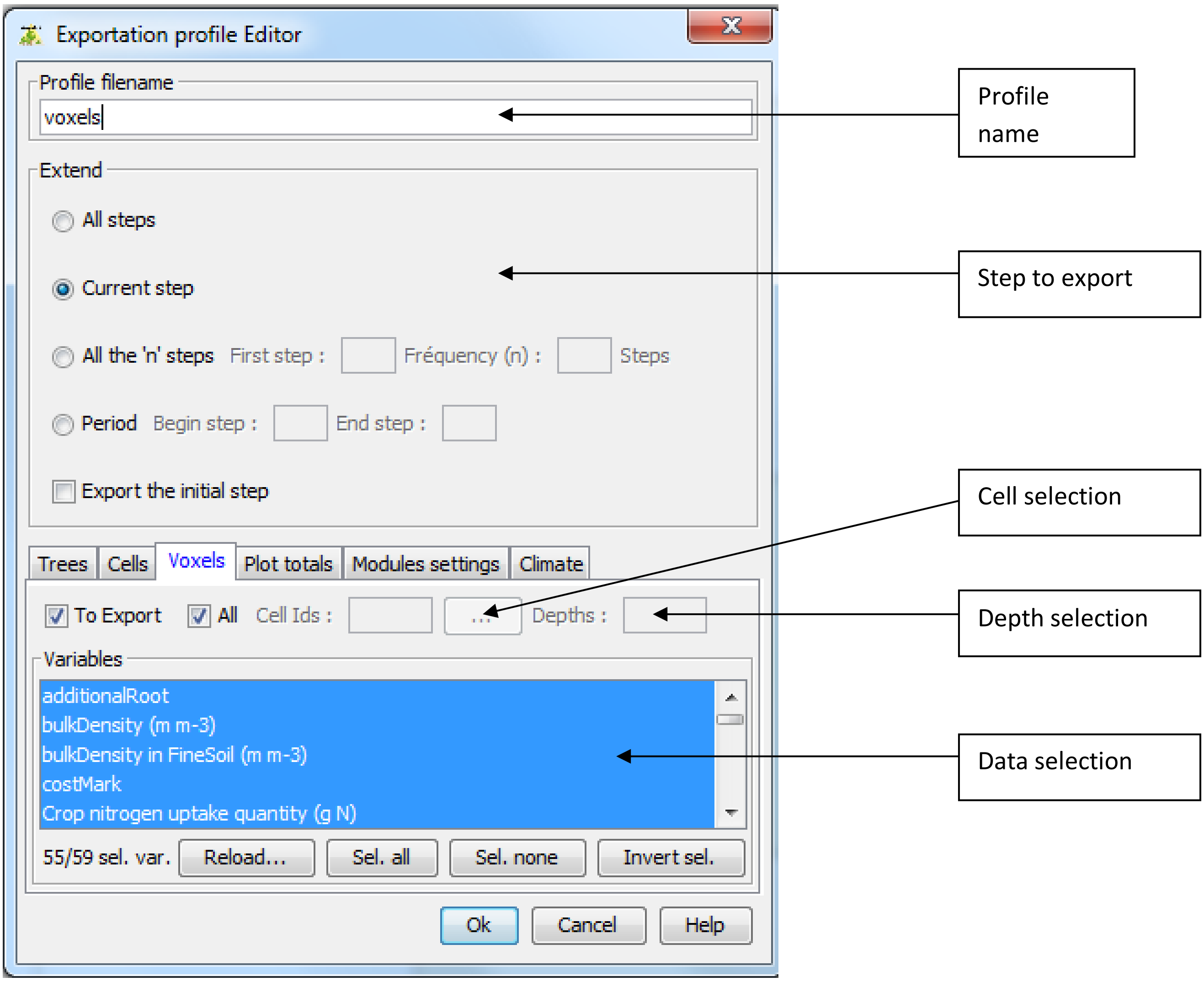
2) Choose the **SafeExportation** format and give the ASCII file a name



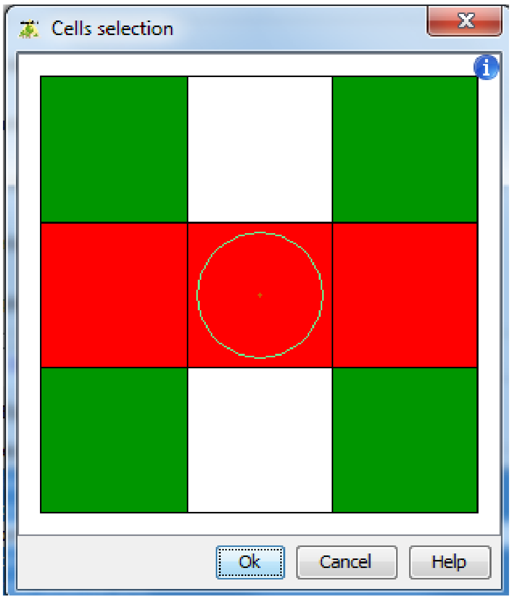
3) Choose an existing profile or create a new one if necessary



4) A profile contains all the information necessary to export data from the simulation.



5) A graphical selector is available for cell choice



6) When exportation process is running, a progress bar is displayed

7) Export ASCII file example

```
# Capsis 4.1.5 generated file - Thu Jul 20 11:47:09 CEST 2006
# Profil d'exportation
> Nom du fichier-profil : C:\capsis4\bin\safe\data\exportParameters\Cells
> Etendue : Toutes les étapes
> Exporter l'étape initiale : Oui
> Cellules : Tout (8 Variables)
> Variables :
Sujet   IdSujet NomVariable    Unité   Description
SafeCell        Cellules       waterDemand    liters  Eau demandée par la culture
SafeCell        Cellules       reducedWaterDemand     liters  Eau   demandée   par   la   culture
(reduction cambell)
SafeCell        Cellules       waterUptake    liters  Eau extraite par la culture
SafeCell        Cellules       rootDepth      m       Profondeur des racines
SafeCell        Cellules       waterStress    -       Stress hydrique culture
SafeCell        Cellules       sticsWaterTurgescenceStress    -       Stress hydrique de
turgescence
SafeCell        Cellules       sticsWaterStomatalStress       -       Stress hydrique stomatique
SafeCell        Cellules       sticsWaterSenescenceStress     -       Stress hydrique sur
senescence


# Cellules
Date    stepNum id      x       y       waterDemand     reducedWaterDemand      waterUptake
        rootDepth       waterStress     sticsWaterTurgescenceStress     sticsWaterStomatalStress
        sticsWaterSenescenceStress
27/10/2003      1 0     0.0     0.0     0.0     0.0     0.0     0.0     1.0     1.0     1.0     1.0
27/10/2003      1 1     0.0     0.0     0.0     0.0     0.0     0.0     1.0     1.0     1.0     1.0
28/10/2003      2 0     0.0     0.0     0.0     0.0     0.0     0.0     1.0     1.0     1.0     1.0
28/10/2003      2 1     0.0     0.0     0.0     0.0     0.0     0.0     1.0     1.0     1.0     1.0
29/10/2003      3 0     0.0     0.0     0.0     0.0     0.0     0.0     1.0     1.0     1.0     1.0
29/10/2003      3 1     0.0     0.0     0.0     0.0     0.0     0.0     1.0     1.0     1.0     1.0
30/10/2003      4 0     0.0     0.0     0.0     0.0     0.0     0.0     1.0     1.0     1.0     1.0
30/10/2003      4 1     0.0     0.0     0.0     0.0     0.0     0.0     1.0     1.0     1.0     1.0
31/10/2003      5 0     0.0     0.0     0.0     0.0     0.0     0.0     1.0     1.0     1.0     1.0
31/10/2003      5 1     0.0     0.0     0.0     0.0     0.0     0.0     1.0     1.0     1.0     1.0
```

4.2 Batch mode

In BATCH mode export files are automatically generated in the output folder according to rules written in the simulation file.

```
#EXPORTS
profileNames = annualplot,annualtree,climate,plot,trees,cells,voxels
exportFrequencies = 365,365,1,1,30,30
```

Be advised to create the export profile with the GUI interface and to copy the *.pro files in the simulation exportParameters folder.

More details about the export profile in chapter 5.4.

5. Hi-sAFe input files description

All files are in **CSV ASCII** format that can be edited with standard editing software such as NotePad, TextPad or Microsoft Excel.

Comments are always preceded by the special character # and most of the times are in capital letters

```
#PLOT DESCRIPTION
```

Single data are formatted as keyword = value with only a space (not tabulation) between them.

```
elevation = 130
```

Numbers are in US format

```
latitude = 43.7
```

String doesn't need to be notified with special quotation marks.

```
township = Montpellier
```

Boolean values are true or false

```
waterTable = true
```

List data are separated by tabulations with an identifying keyword in the first column. Lines of comment should always explain what the columns contain and their units.

```
#LAYER INITIALISATION
#           waterContent      n03Concentration  nh4concentration
#           %                 kg ha-1                 kg ha-1
LayerInit   0.10   32.0   0.0
LayerInit   0.10   12.0   0.0
```

The Hi-sAFe model loads input files before running a simulation. If a modification is done in one file, the user doesn't have to close Capsis and reload Hi-sAFe to take the modification into account. He or she will only need to run a new simulation.

These file names, extensions and physical locations can be changed but our advice is to give explicit names and extensions to easily recognise these files and their use.

5.1 Plot description (*.pld)

The plot description will give all information about the virtual scene (dimensions, orientation, tree spacing, soil characteristics etc.)
Name and extension can be changed, but our advice is to call these files with the real explicit name of your experimental plot and .pld extension (example: restincliere-A2.pld)

Parameter name	Description	Unit / Values
country	Country name	
townShip	Township name	

site	Site name	
name	Plot name	
latitude	Latitude	degrees
longitude	Longitude	degrees
elevation	Elevation	m
cellWidth	Cell width	m
geometryOption	Geometry of the tree stand	1 = square 3 = free
nbTrees	Number of trees	1 - 4 or 9 if geometryOption = 1
treeLineOrientation	Tree line orientation	0 = N – S 90 = E – W 180 = S - N 360 = W - E
spacingBetweenRows	Spacing between tree rows Needed if geometryOption = 1	m
spacingWithinRows	Spacing within tree rows Needed if geometryOption = 1	m
plotHeight	Plot Height Needed if geometryOption = 3	m
plotWidth	Plot Width Needed if geometryOption = 3	m
slopeIntensity	Slope intensity	degrees
slopeAspect	Slope aspect	0 = N – S 90 = E – W 180 = S - N 360 = W - E
Soil		
waterTable	Water table option	true/false
voxelThicknessMax	Voxel thickness max	m
humificationDepth	Humification Depth	m
organicNitrogen	Organic nitrogen content in humification profile	ratio
albedo	Albedo for dry bare soil	
evaporationValue	Evaporation value at the end of maximum evaporation stage	mm
rainRunOffFraction	Run off fraction in bare soil condition	
rootingObstance	Crop rooting obstacle	m
minNh4Concentration	NH4 soil minimum concentration	kgN ha-1 mm-1
ph	Soil Ph	
capillary	Capillary rise option	true/false
capillaryUptake	Capillary uptake values	mm j-1
minHumidity	Minimum humidity to activate capillary rise	g water g soil –1
drainage	Drainage option	true/false
impermeableLayerDepth	Impermeable layer depth	cm
spaceBetweenDrainagePipes	Space between drainage pipes	cm
drainagePipesDepth	Drainage pipes depth	cm
waterConductivity	Water conductivity for water transport in pipes	cm d-1
swellingClaySoil	Swelling Clay Soil option	true/false

nitrification	Nitrification option	true/false
macroporosity	Macro porosity option	true/false
stoneOption	Stone option	true/false
nitrogenDiffusionConstant	Nitrogen diffusion constant	
nitrogenEffectiveDiffusionA0	Nitrogen Effective Diffusion A0	
nitrogenEffectiveDiffusionA1	Nitrogen Effective Diffusion A1	
no3AbsorptionConstant	no3 Absorption Constant	
nh4AbsorptionConstant	nh4 Absorption Constant	
no3Fraction	Fraction of No3	
no3ConcentrationInWaterTable	no3 concentration in water table	g liter-1
nh4ConcentrationInWaterTable	nh4 concentration in water table	g liter-1
fmin1	Parameter for deep senescent roots mineralization	
fmin2	Parameter for deep senescent roots mineralization	
Fmin3	Parameter for deep senescent roots mineralization	
hopt		
hmin		
initCbio	Cbio initialisation in STICS	
initNbio	Nbio initialisation in STICS	
initCres	Cres initialisation in STICS	
Soil layers definition (5 max)		
thickness	Thickness	m
sand	Sand	%
clay	Clay	%
limeStone	Limestone	%
organicMatter	Organic Matter	%
partSizeSand	Particle size for sand	µm
stone	Stone	%
stoneType	Stone type	1=limestone B1, 2=limestone B2, 3=limestone L, 4=scree L, 5=gravel m, 6=flint, 7=granite a, 8=limestone J, 9=other1, 10=other2
infiltrability	Infiltrability with neighbour bottom layer	mm d-1
Soil layers initialisation (5 max)		
waterContent	Water content	ratio
no3Concentration	NO3 Concentration	kg ha-1
nh4concentration	NH4 Concentration	kg ha-1
Trees Initialisation		
species	Species name	
age	Age	years
height	Height	m
crownBaseHeight	Crown Base Height	m
truncatureRatio	Ellipsoïde troncature ratio	ratio
leafToFineRootsRatio	Leaf To fine roots ratio	ratio
crownRadius	Crown Radius	m
treeX	Tree position on X Axis	0

	if geometryOption = 3	
treeY	Tree position on Y Axis if geometryOption = 3	0
Tree roots Initialisation		
shape	Rooting shape	1=Sphere 2=Ellipsoid 3=Cone
repartition	Root repartition at initialisation	1=Uniform 2=Invert proportional to distance 3=Negative exponential
paramShape1	Parameter 1 for root initialisation	m
paramShape2	Parameter 2 for root initialisation	m
paramShape3	Parameter 3 for root initialisation	m
amount	Carbon quantity in fine roots	Kg C

Table 3: List of plot description input data

5.2 Crop interventions (*.tec)

This file will give all information about interventions planed for a crop on the virtual scene (sowing date, soil management, irrigation, fertilisation etc.)

Name and extension are free but one advice is to call these files with the name of the crop species - the real explicit name of your experimental plot with .tec extension (example: wheat-restincliere-A2.tec)

Name	Description	Unit
Soil management		
P_nbjtrav	Number of soil management item	
P_nbjres	Number of soil of residue incorporation	
jultrav	Date of soil management	DOY
julres	Date of soil residue incorporation	DOY
profres	minimum depth of residue incorporation	cm
proftrav	depth of tillage and/or incorporation of organic residues (max. 40 cm)	cm
coderes	type of residue	1=crop residues, 2=CI residues, 3=animal waste 4=OM compost, 5=SE mud, 6=grape waste, 7=horn, 8=other
P_qres	quantity of crop residues or organic inputs provided to the soil (fresh materials)	t MF ha-1
P_Crespc	proportion of carbon in residues	
P_CsurNres	C/N ratio of crop residues or organic inputs	
P_Nminres	mineral N content of organic residues	% fresh material
P_eaures	water content of organic residues	% fresh material
Sowing options		
iplt0	Date of sowing	DOY
profsem	Depth of sowing	cm
densitesem	Density of sowing	nb plants m-2
variete	Variety	1-n
codetradtec	description of crop structure with use of radiation transfer	1 =yes, 2 = no
interrang	width of the crop interrow	m
orientrang	direction of crop rows (relative to north)	rad
codedecisemis	option to activate the moisture effect on harvest decision	1 = yes, 2 = no
nbjmaxapressemis	maximal delay allowed for sowing (number of days) (if the soil compaction option is activated)	
nbjseuiltempref	number of days without frost for sowing (if sowing decision option is activated)	
Stage forcing		
codestade	option: forcing of one or more developmental stages	1=no 2=yes

ilev	Julian day of LEV stage (emergence) if this stage is observed (if not, 999)	DOY
iamf	Julian day of AMF stage (maximum acceleration of leaf growth, end of juvenile phase)	DOY
ilax	Julian day of LAX stage (maximum leaf index)	DOY
isen	Julian day of SEN stage (clear onset of senescence)	DOY
ilan	Julian day of LAN stage (no leaf index)	DOY
iflo	Julian day of flowering stage	DOY
idrp	Julian day of DRP stage (beginning of grain filling)	DOY
imat	Julian day of MAT stage (physiological maturity)	DOY
irec	Julian day of REC stage (harvest)	DOY
irecbutoir	latest date of harvest (imposed if the crop cycle is not finished at this date)	DOY
Irrigation		
nap	Number of irrigation item	
julapI	Irrigation date	DOY
qte	Quantity of water	mm
effirr	irrigation efficiency	
codecalirrig	code to activate the automatic calculation of irrigation requirements	1 = yes, 2 = no
ratiol	water stress index below which irrigation is started in automatic mode	0 in manual mode
dosimx	maximum water amount of irrigation authorised at each time step (mode automatic irrigation)	mm.d-1
doseirrigmin	minimal amount of irrigation	mm
codedateappH2O	irrigation application dates given as sum of temperatures	1 = yes, 2 = no
codlocirrig	code of irrigation localisation:	1= above the foliage, 2= below the foliage above the soil, 3 = in the soil
locirrig	soil depth at which irrigation is applied	cm
Fertilisation		
napN	Number of fertilisation item	
julapN	Fertilisation date	DOY
qte	Fertiliser quantity	Kg N ha-1
profmes	depth of measurement of the soil water reserve	cm
engrais	type of fertiliser	1= ammonium sulphate, 2=ammonium nitrate, 3= ammonium nitrate + calcium, 4= anhydrous ammonia, 5=urea, 6=di-ammonium phosphate, 7=solution, 8=other
concirr	concentration of mineral N (NH4+NO3-N) in irrigation water	kg.ha-1 mm-1

codedateappN	mineral fertilizer application dates given as sum of temperatures	1 = yes, 2 = no
codefracappN	option to activate splitting applications of N fertiliser	1 = absolute value, 2 = % of total value
Qtot_N	amount of total mineral N fertilizer applications	
codlocferti	option to code of fertilisation localisation	1= on soil surface, 2 = in soil
locferti	soil depth at which fertiliser is applied	cm
Harvest		
codrecolte	Option for triggered harvest	1=physiologic maturity 2=water content 3=sugar 4=nitrogen 5=oil
ressuite	Type of residue after harvest	1=crop 2=staw 3=chaumes 4=roots
codceuille	option of harvest type	1 =single harvest (cutting), 2 = multiple harvests (picking)
nbceuille	number of fruit harvestings	1= one at the end, 2 = many during the cycle
cadencerec	number of days between two harvests	
codeaumin	option to activate the harvest as a function of grain/fruit water content	1=minimum 2=maximum
h2ograinmin	min water content in fruits at harvest	g water g MF -1
h2ograinmax	max water content in fruits at harvest	g water g MF -1
sucrerec	min sugar content at harvest	g MF -1
CNgrainrec	nitrogen concentration in grains for harvest	0-1
huilerec	min oil content at harvest	g oil g MF -1
coderecolteassoc	option to harvest intercrop species simultaneously, at the physiological maturity date of the earliest one	1 = no, 2 = yes
codedecirecolte	option to activate moisture and frost effects on harvest decision	1 = yes, 2 = no
nbjmaxapresrecolte	maximal delay allowed for harvest (number of days) (if the soil compaction option is activated)	
Cuttings		
codefauche	option to activate cuts of forage crops	1=yes 2=no
mscoupemini	minimum value of aerial biomass required to make a cut of forage crop	
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
hautcoupedefaut	cut height for forage crops (calendar calculated)	m
stadecoupedf	stage of automatic cut for forage crops	
nbcoupe	Number of cuttings	1-10
julfauche	date(s) of each cut for forage crops	DOY
hautcoupe	cut height for forage crops (calendar fixed)	m
lairesiduel	residual LAI after each cut of forage crop	m2 leaves m-2 soil
msresiduel	Dry matter residual after each cut of forage	t ha-1

	crop	
anitcoupe	amount of mineral N added by fertiliser application at each cut of a forage crop	kgN ha-1
Others		
codepaillage	mulch option	1=no 2=plant 3=plastic
couvermulchplastique	fraction of soil covered by the plastic mulch	
albedomulchplastique	albedo of plastic cover	
codrognage	option of foliage control by trimming	1 = no, 2 = yes
largrogne	trimmed width	m
hautrogne	cutting height for trimmed plants	m
biorognem	minimal biomass to be removed when topping (automatic calculation)	t.ha-1
codcalrogne	option of calculation of tipping	1 = forced topping, 2 = automatic calculation
julrogne	day of plant trimming	
margerogne	topping occurs when plant height exceeds (hautrogne+margerogne) when automatic trimming is activated	
codeclaircie	option for the method of fruit removal	1 = no, 2 = yes for smallest fruits
juleclair	day of fruits removal	
nbinfloecl	number of inflorescences or fruits removed at fruit removal	nb.pl-1
codeffeuil	option to activate thinning	1 = no, 2 = yes
codhauteff	option of leaf removal height	1 = bottom of the canopy, 2 = top of the canopy
codcaleffeuil	option for the method to use for the calculation of leaf removal	1 = no, 2 =yes
laidebeff	LAI of the beginning of leaf removal	m2.m-2
effeuil	fraction of daily leaf removed at thinning	
juleffeuil	day of leaf removal	
codepalissage	option defining if the plant is fixed onto a vertical suuport (palissage)	1 = no, 2 =yes
hautmaxtec	maximal height of the plant allowed by the management	
largtec	technical width	m
codabri	option to activate cropping under shelter	1 = no, 2 = yes
transplastic	transmission coefficient of the plastic shelter	
surfouvre1	relative area of the shelter opened the first day of opening	
julouvre2	day (1/2) of opening the shelter	
surfouvre2	relative area of the shelter opened the second day of opening	
julouvre3	day (2/2) of opening the shelter	
surfouvre3	relative area of the shelter opened the third day	

	of opening	
codeDST	option to activate the variations in soil physical soil conditions due to tillage	1 = yes, 2 = no
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
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
codeDSTtass	option to activate the soil compaction at sowing and harvest	1 = yes, 2 = no
profhumsemoir	soil depth at which moisture is considered to allow sowing (if soil compaction is activated)	cm
dasemis	bulk density of soil after sowing	
profhumrecolteuse	soil depth at which moisture is considered to allow harvesting (if soil compaction is activated)	m
darecolte	bulk density of soil after harvest	
codeDSTnbcouche	number of compacted soil layers	1 = one layer, 2 = two layers

Table 4: List of crop intervention input data

5.3 Weather data (*.wth)

Hi-sAFe simulation in interactive mode cannot exceed 365 days, so weather data file doesn't need to be more than 365 days either. It is sometimes necessary to store several years of weather data in the same file to run winter cropped plots simulations (for example durum wheat seeded in October and harvested in June the next year)

For batch execution a weather file covering the whole simulation duration have to be provided. By default Hi-sAFe provides capsis4\data\safe\weather\weather-1995-2035.wth corresponding to 40 years of French Mediterranean climate. Last 20 years have been randomly generated with previous ones.

Name and extension are free but one advice is to call these files with the real explicit name of your weather station – start year – end year - with .wth extension (example: restinclieres-1996-2014.wth)

Name	Description	Unit
#STATION FILE VALUES		
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
altinversion	altitude of inversion of the thermal gradient	m
altisimul	altitude of simulated site	m
altistation	altitude of the input metorological station	m
bks	parameter of calculation of the energetic loss 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
codeclichange	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
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
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

NH3ref	NH3 concentration in the atmosphere	µg.m-3
ombragetx	change in air temperature in the northern hillslope of mountains (activated if codadret=2)	degreeC
patm	atmospheric pressure	mbar
ra	aerodynamic resistance (used in volatilization module when we use ETP approach)	s.m-1
zr	reference height of meteorological data measurement	m
#CLIMATIC DAILY VALUES		
julianDay	Number of the day in the year	1-720
year	Year	
month	Year	
day	Day	
minTemperature	Temperature min	degree
maxTemperature	Temperature max	degree
minRelativeHumidity	Relative humidity min	%
minRelativeHumidity	Relative humidity min	%
globalRadiation	Global radiation	MJ m-2
rain	Rain	mm
wind	Wind (at wind measure height)	m s-1
waterTableDepth	Water table depth (0 if none)	m
Co2	Co2 concentration	ppm

Table 5 : List of weather input data

5.4 Export profile (*.pro)

It is more convenient and secure to create and update the export profiles with the Hi-sAFe GUI interface. In BATCH mode, export profiles have to be in the exportProfile folder of the simulation.

Name	Description	Unit
allSteps	Export all steps (false/true)	
currentStep	Export current step (false/true)	
frequency	Frequency of exportation (false/true)	
frequencyBegin	Frequency of exportation begin	0-365
frequencyValue	Frequency of exportation value	0-365
period	Period of exportation (false/true)	
periodTo	Period of exportation (end)	0-365
periodFrom	Period of exportation (beginning)	0-365
rootStepToExport	Exporting root step (false/true)	
subject	Name of the subject to export	
variable	Name of the variable to export	

Table 6: List of export file parameters

Subject	Variable	Unit	Description
SafeCell	cropSpeciesName	-	aa-Species
SafeCell	activeNitrogenHumusStock	kg N ha-1	Humus nitrogen active for mineralisation
SafeCell	capillaryRise	liters	Water capillary rise
SafeCell	diffuseParIncident	Mol. m-2	Radiation daily diffuse incident PAR
SafeCell	directParIncident	Mol. m-2	Radiation daily direct incident PAR
SafeCell	diffuseParIntercepted	Mol. m-2	Radiation daily diffuse intercepted PAR
SafeCell	directParIntercepted	Mol. m-2	Radiation daily direct intercepted PAR
SafeCell	drainage	liters	Water drained
SafeCell	etpCalculated	mm	ETP calculated
SafeCell	nitrogenAmendement	kg N ha-1	Nitrogen amendement
SafeCell	nitrogenDenitrification	kg N ha-1	Nitrogen denitrification
SafeCell	nitrogenExportation	kg N ha-1	Nitrogen exportation
SafeCell	nitrogenFertilisation	kg N ha-1	Nitrogen fertilisation
SafeCell	nitrogenFixation	kg N ha-1	Nitrogen fixation
SafeCell	nitrogenHumusMineralisation	kg N ha-1	Nitrogen Humus mineralisation
SafeCell	nitrogenHumusStock	kg N ha-1	Humus nitrogen
SafeCell	nitrogenIrrigation	kg N ha-1	Nitrogen irrigation
SafeCell	nitrogenLixiviation	kg N ha-1	Nitrogen lixiviation
SafeCell	nitrogenOrganisation	kg N ha-1	Nitrogen organisation
SafeCell	nitrogenRain	kg N ha-1	Nitrogen rain
SafeCell	nitrogenResiduMineralisation	kg N ha-1	Nitrogen residu mineralisation
SafeCell	nitrogenRestitution	kg N ha-1	Nitrogen restitution
SafeCell	nitrogenVolatilisation	kg N ha-1	Nitrogen volatilisation
SafeCell	relativeDiffuseParIncident	%	Proportion of diffuse PAR incident
SafeCell	relativeDirectParIncident	%	Proportion of direct PAR incident

SafeCell	relativeGlobalRadIncident	%	Proportion of global radiation incident (PAR + NIR)
SafeCell	relativeTotalParIncident	%	Proportion of PAR incident (diffuse + direct)
SafeCell	runOff	mm	Water surface run off
SafeCell	soilEvaporation	mm	Water soil evaporation
SafeCell	surfaceRunOff	mm	Water run off
SafeCell	temperature	°C	Temperature
SafeCell	totalCapillaryRise	mm	Total capillary rise
SafeCell	totalDrainage	mm	Total drainage
SafeCell	totalIrrigation	mm	Total irrigations
SafeCell	totalRunOff	mm	Total run off
SafeCell	totalSoilEvaporation	mm	Total evaporation
SafeCell	totalSurfaceRunOff	mm	Total surface run off
SafeCell	totalWaterDemand	liters	Total water demad
SafeCell	totalWaterUptake	liters	Total water uptake
SafeCell	totalNitrogenDemand	kg N ha-1	Total nitrogen demad
SafeCell	totalNitrogenUptake	kg N ha-1	Total nitrogen extract
SafeCell	transmittedRain	mm	Water transmitted rain
SafeCell	transmittedStemflow	mm	Transmitted stemflow
SafeCell	visibleSky	%	Proportion of visible sky
SafeCell	waterExtractedInSaturationByTrees	liters	Water utake by trees in saturated voxels
SafeCell	waterExtractedInSaturationByCrops	liters	Water utake by crops in saturated voxels
SafeCell	waterProvidedBySaturation	liters	Water provided by water table to saturated voxels
SafeCell	waterTakenByDesaturation	liters	Water taken by water table to desaturated voxels
SafeCell	cropSpeciesName	-	Crop species
SafeCell	actualWaterPotential	cm	Crop water potential
SafeCell	yield	t.ha-1	Crop yield
SafeCell	lai	m2.m-2	Lai
SafeCell	eai	m2.m-2	Eai
SafeCell	sla	cm2.g-1	Sla
SafeCell	rootDepth	m	Crop root depth
SafeCell	yieldMax	t.ha-1	Crop yield max
SafeCell	laiMax	m2.m-2	Lai max
SafeCell	eaiMax	m2.m-2	Eai max
SafeCell	rootDepthMax	m	Crop root depth max
SafeCell	biomass	t.ha-1	Crop biomass
SafeCell	phenologicStage	-	phenologicStage
SafeCell	monthDirectPar	moles.m-2	month Direct Par
SafeCell	monthDiffusePar	moles.m-2	month Diffuse Par
SafeCell	monthDirectParIntercepted	moles.m-2	month Direct Par Intercepted
SafeCell	monthDiffuseParIntercepted	moles.m-2	month Diffuse Par Intercepted
SafeCell	monthDirectParIncident	moles.m-2	month Direct Par Incident

SafeCell	monthDiffuseParIncident	moles.m-2	month Diffuse Par Incident
SafeCell	monthRelativeDirectParIncident	%	month Relative Direct Par Incident
SafeCell	monthRelativeDiffuseParIncident	%	month Relative Diffuse Par Incident
SafeCell	monthRelativeTotalParIncident	%	month Relative Total Par Incident
SafeCell	monthVisibleSky	%	month Visible Sky
SafeCell	monthYield	t.ha-1	month Crop yield
SafeCell	monthLai	m2.m-2	month Lai
SafeCell	monthEai	m2.m-2	month Eai
SafeCell	monthBiomass	t.ha-1	month Crop biomass
SafeCell	waterDemand	liters	Crop water demand
SafeCell	waterUptake	liters	Crop water uptake
SafeCell	nitrogenDemand	kgN.ha-1	Crop nitrogen demand
SafeCell	nitrogenUptake	kgN.ha-1	Crop nitrogen uptake
SafeCell	hisafeWaterStress	-	Crop Water stress (hisafe)
SafeCell	hisafeNitrogenStress	-	Crop Nitrogen stress (hisafe)
SafeCell	sticsNitrogenStress	-	sticsNitrogenStress (inn)
SafeCell	sticsNitrogenBiomassStress	-	sticsNitrogenBiomassStress (inns)
SafeCell	sticsNitrogenLaiStress	-	sticsNitrogenLaiStress (innlai)
SafeCell	sticsNitrogenSenescenceStress	-	sticsNitrogenSenescenceStress (innsenes)
SafeCell	sticsWaterStomatalStress	-	sticsWaterStomatalStress (swfac)
SafeCell	sticsWaterSenescenceStress	-	sticsWaterSenescenceStress (senfac)
SafeCell	sticsWaterTurgescenceStress	-	sticsWaterTurgescenceStress (turfac)
SafeMacroClimat	minTemperature	°	Min temperature
SafeMacroClimat	maxTemperature	°	Max temperature
SafeMacroClimat	minRelativeHumidity	°	Min relative humidity
SafeMacroClimat	maxRelativeHumidity	°	Max relative humidity
SafeMacroClimat	precipitaions	mm	Precipitations
SafeMacroClimat	rain	mm	Rain
SafeMacroClimat	snow	mm	Rain turned to snow
SafeMacroClimat	meltedSnow	mm	Melted snow
SafeMacroClimat	snowStocked	mm	Snow stocked
SafeMacroClimat	rainCapacityInSnow	mm	Rain that can be still stocked in snow
SafeMacroClimat	etpPenman	mm	f-etpPenman
SafeMacroClimat	globalRadiation	MJ m-2	h-Global radiation
SafeMacroClimat	globalPar	Moles m-2	g-Global PAR radiation
SafeMacroClimat	directPar	Moles m-2	j-Direct PAR radiation
SafeMacroClimat	diffusePar	Moles m-2	i-Diffuse PAR radiation
SafeMacroClimat	airVapourPressure	mbar	q-Air vapour pressure
SafeMacroClimat	airVapourPressureSat	mbar	p-Air vapour pressure saturated
SafeMacroClimat	airVpd	mbar	o-Vapour pressure deficit of the air
SafeMacroClimat	dayLength	h	n-Day lenght
SafeMacroClimat	extraTerrestrialRadiation	MJ m-2	k-Extraterrestrial radiation

SafeMacroClimat	infraRedRadiation	W m-2	l-Infra-red radiation
SafeMacroClimat	sunDeclination	radian	m-Sun declination
SafeMacroClimat	waterTableDepth	m	r-Water table depth
SafeMacroClimat	windSpeed	m s-1	s-Wind speed
SafePlot	mainCropName	-	aa-Culture principale
SafePlot	cropBiomass	-	ab-Biomasse culture
SafePlot	minCropBiomass	-	ac-Biomasse culture min
SafePlot	maxCropBiomass	-	ac-Biomasse culture max
SafePlot	cropYield	-	ad-Rendement culture
SafePlot	minCropYield	-	ae-Rendement culture min
SafePlot	maxCropYield	-	ae-Rendement culture max
SafePlot	cropLai	-	af-Lai culture
SafePlot	minCropLai	-	ag-Lai culture min
SafePlot	maxCropLai	-	ah-Lai culture max
SafePlot	treeLai	-	ai-Lai arbres
SafePlot	treePhenologicStage	-	aj-Phenologie arbre
SafePlot	treeYield	t.ha-1	ak-Rendement arbres
SafePlot	treeWaterStress	-	TreeWaterStress
SafePlot	treeBiomassIncrement	kg/ha	treeBiomassIncrement
SafePlot	carbonBranches	kg/ha	carbonBranches
SafePlot	nitrogenBranches	kg/ha	nitrogenBranches
SafePlot	waterExtractedInSaturationByCrops	mm	waterExtractedInSaturationByCrops
SafePlot	waterExtractedInSaturationByInterCrops	mm	waterExtractedInSaturationByInterCrops
SafePlot	waterExtractedInSaturationByTrees	mm	waterExtractedInSaturationByTrees
SafePlot	nitrogenExtractedInSaturationByTrees	mm	nitrogenExtractedInSaturationByTrees
SafePlot	nitrogenExtractedInSaturationByCrops	mm	nitrogenExtractedInSaturationByCrops
SafePlot	waterStock	mm	WaterStock
SafePlot	maximalWaterStock	mm	MaximalWaterStock
SafePlot	waterStockAvalaibleForTrees	mm	WaterStockAvalaibleForTrees
SafePlot	waterStockAvalaibleForCrops	mm	WaterStockAvalaibleForCrops
SafePlot	waterStockAvalaibleForBoth	mm	WaterStockAvalaibleForBoth
SafePlot	waterStockInSaturation	mm	WaterStockInSaturation
SafePlot	waterTableDepth	m	WaterTableDepth
SafePlot	waterExtractedByTrees	mm	WaterExtractedByTrees
SafePlot	waterExtractedByCrops	mm	WaterExtractedByCrops
SafePlot	waterExtractedByInterCrops	mm	waterExtractedByInterCrops
SafePlot	waterFromSaturation	mm	WaterFromSaturation
SafePlot	waterToDesaturation	mm	WaterToDesaturation
SafePlot	rainTransmitted	mm	RainTransmitted
SafePlot	drainage	mm	Drainage
SafePlot	runOff	mm	RunOff

SafePlot	qngrain	mm	qngrain
SafePlot	qnplante	mm	qnplante
SafePlot	cngrain	mm	cngrain
SafePlot	cnplante	mm	cnplante
SafePlot	surfaceRunOff	mm	surfaceRunOff
SafePlot	parInterceptedByTrees	mol.(m2 of plot)-1	parInterceptedByTrees
SafePlot	parInterceptedByCrops	mol.(m2 of plot)-1	parInterceptedByCrops
SafePlot	parInterceptedByCropsCompetFree	mol.(m2 of plot)-1	parInterceptedByCropsCompetFree
SafePlot	parInterceptedByTreesCompetFree	mol.(m2 of plot)-1	parInterceptedByTreesCompetFree
SafePlot	parIncident	mol.(m2 of plot)-1	parIncident
SafePlot	parIncidentCrops	mol.(m2 of plot)-1	parIncidentCrops
SafePlot	parIncidentInterCrops	mol.(m2 of plot)-1	parIncidentInterCrops
SafePlot	cropWaterDemand	mm	cropWaterDemand
SafePlot	cropWaterDemandReduced	mm	cropWaterDemandReduced
SafePlot	cropWaterPotential	cm	cropWaterPotential
SafePlot	cropNitrogenDemand	kg.ha-1	cropNitrogenDemand
SafePlot	cropTotalRootLength	m	cropTotalRootLength
SafePlot	cropSla	-	cropSla
SafePlot	cropGrainNumber	-	cropGrainNumber
SafePlot	cropGrainWeight	-	cropGrainWeight
SafePlot	cropPhenologicStage	-	cropPhenologicStage
SafePlot	cropPlantDensity	-	cropPlantDensity
SafePlot	cropWaterStress	-	CropWaterStress
SafePlot	cropSenescenceWaterStress	-	CropSenescenceWaterStress
SafePlot	cropTurgescenceWaterStress	-	CropTurgescenceWaterStress
SafePlot	cropNitrogenStress	-	cropNitrogenStress
SafePlot	cropTemperature	-	cropTemperature
SafePlot	cropRootDepth	-	cropRootDepth
SafePlot	cropNitrogenLaiStress	-	cropNitrogenLaiStress
SafePlot	cropNitrogenBiomassStress	-	cropNitrogenBiomassStress
SafePlot	cropNitrogenSenescenceStress	-	cropNitrogenSenescenceStress
SafePlot	nitrogenExtractedByCrops	kg/ha	nitrogenExtractedByCrops
SafePlot	nitrogenExtractedByTrees	kg/ha	nitrogenExtractedByTrees
SafePlot	tmax	-	Tmax
SafePlot	tmin	-	Tmin
SafePlot	nitrogenHumification	kg/ha	nitrogenHumification
SafePlot	carbonHumification	kg/ha	carbonHumification
SafePlot	cMicroorgVariation	kg/ha	cMicroorgVariation
SafePlot	nMicroorgVariation	kg/ha	nMicroorgVariation
SafePlot	nitrogenRain	kg/ha	nitrogenRain

SafePlot	nitrogenIrrigation	kg/ha	nitrogenIrrigation
SafePlot	nitrogenFertilisation	kg/ha	nitrogenFertilisation
SafePlot	nitrogenFixation	kg/ha	nitrogenFixation
SafePlot	nitrogenHumusMineralisation	kg/ha	nitrogenHumusMineralisation
SafePlot	qLeafLitter	kg/ha	Biomasse of leaf litter
SafePlot	nLeafLitter	kg/ha	Nitrogen of leaf litter
SafePlot	leafLitterCn	-	Leaf litter C/N ratio
SafePlot	nminResCult	kg/ha	N mineralized from Crop Residus
SafePlot	nminLeaf	kg/ha	N mineralized from Leaf Litter
SafePlot	nminFineroot	kg/ha	N mineralized from Fine Roots in ProfHum
SafePlot	nminCoarseroot	kg/ha	N mineralized from Coarse Roots in ProfHum
SafePlot	nminTotal	kg/ha	N mineralized from All residus in ProfHum
SafePlot	coarserootSenCn	-	Coarse Roots Litter C/N ratio
SafePlot	finerootSenCn	-	Fine Roots Litter C/N ratio
SafePlot	nFineRootSenInProfHum	kg/ha	nFineRootSenInProfHum
SafePlot	nCoarseRootSenInProfHum	kg/ha	nCoarseRootSenInProfHum
SafePlot	qFineRootSenInProfHum	kg/ha	qFineRootSenInProfHum
SafePlot	qCoarseRootSenInProfHum	kg/ha	qCoarseRootSenInProfHum
SafePlot	totalCarbonFineRootSen	kg/ha	totalCarbonFineRootSen
SafePlot	totalNitrogenFineRootSen	kg/ha	totalNitrogenFineRootSen
SafePlot	totalCarbonCoarseRootSen	kg/ha	totalCarbonCoarseRootSen
SafePlot	totalNitrogenCoarseRootSen	kg/ha	totalNitrogenCoarseRootSen
SafePlot	nitrogenResiduMineralisation	kg/ha	nitrogenResiduMineralisation
SafePlot	inactiveNitHumusStock	kg/ha	inactiveNitrogenHumusStock
SafePlot	nitrogenResidus	-	nitrogenResidus
SafePlot	carbonResidus	-	carbonResidus
SafePlot	carbonImmobilisation	-	carbonImmobilisation
SafePlot	microorgBiomass	-	microorgBiomass
SafePlot	nitrogenImmobilisation	-	nitrogenImmobilisation
SafePlot	nitrogenDenitrification	kg/ha	nitrogenDenitrification
SafePlot	nitrogenExportation	t/ha	nitrogenExportation
SafePlot	totalNitHumusStock	kg/ha	totalNitrogenHumusStock
SafePlot	nitrogenRestitution	t/ha	nitrogenRestitution
SafePlot	biomassRestitution	t/ha	biomassRestitution
SafePlot	nitrogenLixiviationSTICS	kg/ha	nitrogenLixiviationSTICS
SafePlot	nitrogenLixiviationTOTAL	kg/ha	nitrogenLixiviationTOTAL
SafePlot	nitrogenOrganisation	kg/ha	nitrogenOrganisation
SafePlot	nitrogenVolatilisation	kg/ha	nitrogenVolatilisation
SafePlot	nitrogenAmendement	kg/ha	nitrogenAmendement
SafePlot	nitrogenAvalaibleForCrops	-	nitrogenAvalaibleForCrops
SafePlot	mineralNitrogenStock	kg/ha	mineralNitrogenStock
SafePlot	activeNitHumusStock	kg/ha	activeNitrogenHumusStock
SafePlot	nitrateStock	kg/ha	nitrateStock

SafePlot	cropResiduCn	-	cropResidu C/N ratio
SafePlot	totalCarbonHumusStock	t/ha	totalCarbonHumusStock
SafePlot	nminDeepRoots	kg/ha	nminDeepRoots
SafePlot	nRootSenStock	kg/ha	nRootSenStock
SafePlot	annualWaterExtractedByTrees	mm	annualWaterExtractedByTrees
SafePlot	annualWaterExtractedByCrop	mm	annualWaterExtractedByCrop
SafePlot	annualWaterExtractedByInterCrop	mm	annualWaterExtractedByInterCrop
SafePlot	annualWaterEvaporatedInCrop	mm	annualWaterEvaporatedInCrop
SafePlot	annualWaterEvaporatedInInterCrop	mm	annualWaterEvaporatedInInterCrop
SafePlot	annualWaterFromSaturation	mm	annualWaterFromSaturation
SafePlot	annualWaterToDesaturation	mm	annualWaterToDesaturation
SafePlot	annualRainTransmitted	mm	annualRainTransmitted
SafePlot	annualRunOff	mm	annualRunOff
SafePlot	annualSurfaceRunOff	mm	annualSurfaceRunOff
SafePlot	annualInterceptedRainByTrees	mm	annualInterceptedRainByTrees
SafePlot	annualInterceptedRainByCrops	mm	annualInterceptedRainByCrops
SafePlot	annualInterceptedRainByInterCrops	mm	annualInterceptedRainByInterCrops
SafePlot	annualDrainage	mm	annualDrainage
SafePlot	annualWaterExtractedInSaturationByTrees	mm	annualWaterExtractedInSaturationByTrees
SafePlot	annualWaterExtractedInSaturationByCrops	mm	annualWaterExtractedInSaturationByCrops
SafePlot	annualWaterExtractedInSaturationByInterCrops	mm	annualWaterExtractedInSaturationByInterCrops
SafePlot	annualParIncident	mol.(m2 of plot)-1	annualParIncident
SafePlot	annualParIncidentCrops	mol.(m2 of plot)-1	annualParIncidentCrops
SafePlot	annualParIncidentInterCrops	mol.(m2 of plot)-1	annualParIncidentInterCrops
SafePlot	annualParInterceptedByTrees	mol.(m2 of plot)-1	annualParInterceptedByTrees
SafePlot	annualParInterceptedByCrops	mol.(m2 of plot)-1	annualParInterceptedByCrops
SafePlot	annualParInterceptedByInterCrops	mol.(m2 of plot)-1	annualParInterceptedByInterCrops
SafePlot	annualTreesCarbonBranches	kg	annualTreesCarbonBranches
SafePlot	annualTreesCarbonCoarseRoots	kg	annualTreesCarbonCoarseRoots
SafePlot	annualTreesCarbonFineRoots	kg	annualTreesCarbonFineRoots
SafePlot	annualTreesCarbonLabile	kg	annualTreesCarbonLabile
SafePlot	annualTreesCarbonStem	kg	annualTreesCarbonStem
SafePlot	maxTreesCarbonFoliage	gk	maxTreesCarbonFoliage
SafePlot	maxTreesLeafArea	-	maxTreesLeafArea
SafePlot	treeHeight	m	Tree height
SafePlot	treeDbh	m	Tree diameter

SafeTree	aboveGroundCFraction	-	bh-aboveGroundCFraction
SafeTree	actualWaterPotential	cm	av-tree potential
SafeTree	captureFactorForDiffusePar	m	ce-captureFactorForDiffusePar
SafeTree	captureFactorForDirectPar	m	cf-captureFactorForDirectPar
SafeTree	captureFactorForDirectNir	m	cg-captureFactorForDirectNir
SafeTree	captureFactorForDiffuseNir	m	ch-captureFactorForDiffuseNir
SafeTree	carbonAboveGroundEff	-	bi-above ground carbon efficency
SafeTree	carbonAllocToGrowth	kg c	aw-CarbonAllocToGrowth
SafeTree	carbonBelowGroundEff	-	bj-below ground carbon efficiency
SafeTree	carbonBranches	kg	ba-Carbon branches pool
SafeTree	carbonCoarseRoots	kg	az-Carbon coarse roots pool
SafeTree	carbonCoarseRootSen	kg	bg-Carbon coarse roots daily senescent
SafeTree	carbonFineRoots	kg	bb-Carbon fine roots pool
SafeTree	carbonFineRootsIncrement	kg	be-Carbon fine roots daily allocated
SafeTree	carbonFineRootSen	kg	bf-Carbon fine roots daily senescent
SafeTree	carbonFoliage	kg	bc-Carbon foliage pool
SafeTree	carbonFoliageMax	kg	zz-Carbon foliage pool max
SafeTree	carbonIncrement	kg c	ax-carbone daily increment
SafeTree	carbonLabile	kg	bd-Carbon labile pool
SafeTree	carbonLeavesSenescence	kg	zz-carbonLeavesSenescence
SafeTree	nitrogenLeavesSenescence	kg	zz-nitrogenLeavesSenescence
SafeTree	carbonStem	kg	ay-Carbon stem pool
SafeTree	crownBaseHeight	m	bw-Crown base height
SafeTree	crownRadiusInterRow	m	bx-Crown radius inter row
SafeTree	crownRadiusTreeLine	m	by-Crown radius on tree line
SafeTree	crownRadiusVertical	m	bz-Vertical crown radius
SafeTree	crownVolume	m3	bv-Crown volume
SafeTree	dbh	cm	aa-tree diameter at breast height
SafeTree	diffuseParIntercepted	Moles	ap-diffuse PAR intercepted
SafeTree	directParIntercepted	Moles	aq-direct PAR intercepted
SafeTree	evaporatedRain	liters	zz-Water evaporated rain
SafeTree	globalRadIntercepted	MJ	ar-global radiation intercepted
SafeTree	height	m	ab-tree height
SafeTree	interceptedRain	liters	zz-Water intercepted rain
SafeTree	leafArea	m2	an-Leaf area
SafeTree	leafAreaMax	m2	ca-Leaf area max
SafeTree	lfrRatio	-	ao-leaf/fine roots ratio
SafeTree	lightCompetitionIndex	-	ah-Index of between trees light competition
SafeTree	nitrogenBranchesConc	kg	bk-Nitrogen branches pool
SafeTree	nitrogenCoarseRootsConc	kg	bl-Nitrogen coarse roots pool
SafeTree	nitrogenCoarseRootSen	kg	bp-Nitrogen coarse roots daily senescent
SafeTree	nitrogenDemand	kg	bj-Nitrogen demand
SafeTree	nitrogenFineRootsConc	kg	bm-Nitrogen fine roots pool

SafeTree	nitrogenFineRootSen	kg	bq-Nitrogen fine roots daily senescent
SafeTree	nitrogenFoliageConc	kg	bn-Nitrogen foliage pool
SafeTree	nitrogenLabile	kg	bo-Nitrogen labile pool
SafeTree	nitrogenSatisfaction	-	br-Nitrogen satisfaction
SafeTree	nitrogenSaturation	-	bs-Nitrogen saturation
SafeTree	nitrogenSinkStrength	-	zz-nitrogen Sink Strength
SafeTree	nitrogenStemConc	kg	bj-Nitrogen stem pool
SafeTree	nitrogenStress	-	ai-Nitrogen Stress
SafeTree	nitrogenStressSpring	-	aj-Nitrogen stress spring
SafeTree	nitrogenStressSummer	-	ak-Nitrogen stress summer
SafeTree	nitrogenUptake	kg	bk-Nitrogen uptake
SafeTree	nitrogenUptakeAnnual	kg	zz-Nitrogen uptake annual
SafeTree	phenologicalStage	-	al-Phenological stage
SafeTree	rootingDepth	m	ac-rooting depth
SafeTree	stemflow	liters	zz-Stemflow
SafeTree	stemVolume	m3	bu-Stem volume
SafeTree	storedRain	liters	zz-Water stored rain
SafeTree	targetLfrRatio	-	am-target leaf/fine roots ratio
SafeTree	totalOptiN	kg N	bt-totalOptiN
SafeTree	totalRootLength	m	cb-Total fine root lenght
SafeTree	waterDemand	liters	as-Water demand
SafeTree	waterDemandReduced	liters	at-Water demand reduiced
SafeTree	waterStress	-	ad-Water stress
SafeTree	waterStressSpring	-	af-Water stress spring
SafeTree	waterStressSummer	-	ag-Water stress summer
SafeTree	waterUptake	liters	au-Water uptake
SafeTree	waterUptakeAnnual	liters	zz-Water uptake annual
SafeTree	parInterceptedAnnual	Moles	zz-PAR intercepted annual
SafeTree	interceptedRainAnnual	liters	zz-Water intercepted rain annual
SafeTree	carbonAllocToGrowthAnnual	kg c	zz-CarbonAllocToGrowth annual
SafeTree	carbonLeavesSenescenceAnnual	kg	zz-carbonLeavesSenescence annual
SafeTree	carbonFineRootSenAnnual	kg	zz-Carbon fine roots annual senescent
SafeTree	carbonCoarseRootSenAnnual	kg	zz-Carbon coarse roots annual senescent
SafeTree	totalRootVolume	m3	zz-Total volume of rooted voxels
SafeTree	totalRootVolumePerLayer	m3	zz-Total volume of rooted voxels per layers
SafeTree	maxRootDistanceOnTreeLine	m	cc-Root extension on tree line
SafeTree	maxRootDistanceOnCropLine	m	cd-Root extension on crop line
SafeTree	budburstDate	-	zz-Date of budburst
SafeTree	leafExpansionEndingDate	-	zz-Date of leaf Expansion End
SafeTree	leafFallStartingDate	-	zz-Date of leaf Fall Start
SafeTree	leafFallEndingDate	-	zz-Date of leaf Fall End
SafeVoxel	cropNitrogenUptake	g N	ap-Crop nitrogen uptake quantity
SafeVoxel	nMinFromRootSen	g N	nMinFromRootSen

SafeVoxel	nitrogenRootSenStock	g N	nitrogenRootSenStock
SafeVoxel	treeCarbonCoarseRootSen	Kg	bl-tree carbonCoarseRootSen
SafeVoxel	treeNitrogenCoarseRootSen	Kg	bm-tree nitrogenCoarseRootSen
SafeVoxel	treeCarbonFineRootSen	Kg	bn-tree carbonFineRootSen
SafeVoxel	treeNitrogenFineRootSen	Kg	bo-nitrogenFineRootSen
SafeVoxel	nitrogenCropResiduMineralisation	Kg	bp-nitrogenCropResiduMineralisation
SafeVoxel	cropRootDensity	m m-3	an-Crop root density
SafeVoxel	cropWaterUptake	liters	ao-Crop water uptake quantity
SafeVoxel	evaporation	liters	aq-Evaporation
SafeVoxel	nitrogenAvailableForBoth	g	bq-nitrogenAvailableForBoth
SafeVoxel	nitrogenAvailableForTrees	g	br-nitrogenAvailableForTrees
SafeVoxel	nitrogenAvailableForCrops	g	bs-nitrogenAvailableForCrops
SafeVoxel	waterAvailable	mm	ar-waterAvailable
SafeVoxel	isSaturated	-	as-Saturated voxel
SafeVoxel	nitrogenNh4Stock	g N	ai-Nitrogen stock Nh4
SafeVoxel	nitrogenNo3Stock	g N	aj-Nitrogen stock No3
SafeVoxel	saturationDuration	days	at-Saturation duration
SafeVoxel	treeCoarseRootBiomass	kg C	bt-Tree coarse root biomass
SafeVoxel	treeNitrogenUptake	g N	am-Tree nitrogen uptake quantity
SafeVoxel	treeRootDensity	m m-3	ak-Tree fine root density
SafeVoxel	treeWaterUptake	liters	al-Tree water uptake
SafeVoxel	volume	m3	Volume
SafeVoxel	volumeFineSoil	m3	Volume FineSoil
SafeVoxel	sumEvaporation	liters	Sum Evaporation
SafeVoxel	sumTreeWaterUptake	liters	Sum Tree water uptake quantity
SafeVoxel	sumTreeNitrogenUptake	g N	Sum Tree nitrogen uptake quantity
SafeVoxel	sumCropWaterUptake	litres	Sum Crop water uptake quantity
SafeVoxel	sumCropNitrogenUptake	g N	Sum Crop nitrogen uptake quantity
SafeVoxel	fieldCapacity	m m-3	Field capacity
SafeVoxel	fieldCapacityFineSoil	m m-3	Field capacity in fine soil
SafeVoxel	fieldCapacityStone	m m-3	Field capacity in stones
SafeVoxel	wiltingPoint	m m-3	WiltingPoint
SafeVoxel	wiltingPointFineSoil	m m-3	WiltingPoint in fine soil
SafeVoxel	wiltingPointStone	m m-3	WiltingPoint in stones
SafeVoxel	bulkDensity	m m-3	bulkDensity
SafeVoxel	bulkDensityFineSoil	m m-3	bulkDensity in FineSoil
SafeVoxel	theta	m3 m-3	Water theta
SafeVoxel	thetaFineSoil	m3 m-3	Water theta in FineSoil
SafeVoxel	thetaStone	m3 m-3	Water theta in stones
SafeVoxel	waterPotentialTheta	cm	soil water potential
SafeVoxel	waterPotentialThetaFineSoil	cm	soil water potential in FineSoil
SafeVoxel	waterStock	liters	Water stock
SafeVoxel	waterStockFineSoil	liters	Water stock in FineSoil
SafeVoxel	waterEfficiency	-	waterEfficiency

SafeVoxel	nitrogenEfficiency	-	nitrogenEfficiency

Table 7: List of data that can be selected for exportation

6. Hi-sAFe parameters files description

Name and location of the parameters files have been fixed by the authors and cannot be modified without a complete recompilation of the model. There is no graphical interface for visualizing or modifying them. However it is possible to modify data in these files (to test different parameters values) using standard editing software.

Hi-sAFe loads these files once during the initialisation and all these data are unchanged as soon as Capsis is running. If a modification is made in a parameter file the user has to close Capsis and reload the whole Hi-sAFe model.

Neither names nor physical location of these parameter files can be modified!

6.1 Tree species parameters (*.tree)

3 species are available in Hi-sAFe model, these species are poplar, wild cherry and walnut hybrid.

Name	Description	Unit
treeCode	Tree code	
crownShape	Crown shape code	1=ellipsoid 2=paraboloid
heightDbhAllometricCoeffA		
heightDbhAllometricCoeffB		
crownDbhAllometricCoeffA		
crownDbhAllometricCoeffB		
stemDbhAllometricCoeffA		
stemDbhAllometricCoeffB		
stemDbhAllometricCoeffC		
stumpToStemBiomassRatio	Stump to stem biomass ratio	
# Phenology parameters		
phenologyType	Phenology type	1=ColdDeciduous 2=Evergreen
budBurstTempAccumulationDateStart	Date to start accumulation of temperature for budburst	DOY
budBurstTempThreshold	Threshold of effective temperature for cumulating degree day	degrees
budBurstAccumulatedTemp	threshold of accumulated temperature to trigger budburst	degrees
leafExpansionDuration	Usual duration of leaf expension	Number of days

budBurstToLeafFallDuration	BudBurst to leaf fall duration	Number of days
leafFallDuration	Usual duration of leaf fall	Number of days
leafFallFrostThreshold	Threshold for frost sensibility	degrees
woodAreaDensity	Virtual lad for winter interception by tree branches	m2 m-3
leafParAbsorption	Absorption coefficient for Par radiation	
leafNirAbsorption	Absorption coefficient for near infra-red radiation	
clumpingCoef	Correction parameter to account for leaf clumping	
stemFlowCoefficient	Coefficient of variation of the stemflow with the LAI	
stemFlowMax	Maximum stemflow fraction	
wettability	Wettability	mm lai-1
transpirationCoefficient	Transpiration coefficient	s m-1
# CAllocation parameters		
lueMax	Light use efficiency	g C MJ-1
leafAgeForLueMax	Leaf age for Lue Max	number of years
leafSenescenceTimeConstant		
leafAreaCrownVolCoefA	Target leaf area depends on crown volume : leafArea = a*crownVolume^b	
leafAreaCrownVolCoefB		
leafCarbonContent	Leaf carbon content	g C g total dry biomass
leafMassArea	Leaf dry mass per unit leaf area	kg m-2
woodDensity	Average branch and stem density (arbitrarily set to 500 kg per cubic meter)	kg m-3
branchVolumeRatio	Assuming a fixed ratio of branch volume to crown volume	cm3 cm-3
imbalanceThreshold	Level of imbalance above which remobilisation of reserves is triggered	
waterStressResponsiveness	governs amplitude of response in shoot root allocation to water stress	
nitrogenStressResponsiveness	governs amplitude of response in shoot root allocation to nitrogen stress	
rsNoStressResponsiveness		values between 0 and 1
maxTargetLfrRatioDailyVariation		
targetLfrRatioUpperDrift		
minTargetLfrRatio		
maxTargetLfrRatio		

optiNCBranch	Functional optimum N/C concentrations (branches)	
optiNCCoarseRoot	Functional optimum N/C concentrations (coarse roots)	
optiNCFineRoot	Functional optimum N/C concentrations (fine roots)	
optiNCFoliage	Functional optimum N/C concentrations (foliage)	
optiNCStem	Functional optimum N/C concentrations (stem)	
optiNCStump	Functional optimum N/C concentrations (stump)	
targetNCoefficient	Coefficient applied to optimum to defined target concentration	
luxuryNCoefficient	Coefficient applied to optimum to defined maximum concentration	
maxDailyNSC	Maximum daily NSC	
maxNSCFraction	Parameter to smoothen variation in NSC and avoid NSC to become 0	
targetNSCFraction	Target NSC Fraction	
leafNRemobFraction	Fraction of Nitrogen recovered from dying leaves	
rootNRemobFraction	Fraction of Nitrogen recovered from dying fine roots	
leafSenescenceRate	Leaf senescence rate	
cRAreaToFRLengthRatio	Coarse root to fine root lenght ratio	
coarseRootAnoxiaResistance	Number of days for coarse root deth in saturation	
specificRootLength	conversion of dry matter in meters of roots	m g-1 of dry matter
rootHalfLife	number of days for fine roots senescence calculation	
rootAnoxiaHalfLife	number of days for fine roots senescence calculation in case of anoxia (roots in saturated voxel of soil)	
colonisationThreshold	Threshold for root colonisation	m m-3
horizontalPreference	horizontal preference in root colonisation process	
geotropismFactor	geotropism factor	0=Inactive 1=Active
localWaterUptakeFactor	weighting factor for local water uptakes	
sinkDistanceEffect	effect of source sink distance	
localNitrogenUptakeFactor	weighting factor for local nitrogen uptakes	
coarseRootBiomassRatio	Ratio of total above ground perennial biomass (branch + trunk) for coarse root	

coarseRootTopologyType	Coarse roots topology type	1=spheric 2=elipsoïde 3=conic
rootDiameter	fine roots diameter	cm
rootConductivity	Root axial conductance	cm cm-1
alpha	Parameter for transpiration reduction factor following Campbell	
minTranspirationPotential	Min Transpiration Potential	cm
maxTranspirationPotential	Max Transpiration Potential	cm
bufferPotential	Potential drop needed to enter the root expressed as a % of soil water potential	cm
longitudinalResistantFactor	Longitudinal resistance factor for root sap	mm cm-1 m-1

Table 8 : List of tree species parameters

6.2 Crop species parameters (*.plt)

23 species are available in Hi-sAFe model, these species are:

- Alfalfa
- Banana
- Baresoil
- Barley
- Durum wheat
- Fescue
- Falx
- Grass
- Lettuce
- Maize
- Mustard
- Pea
- Potato
- Rape
- Ryegrass
- Sorghum
- Soybean
- Sugarbet
- Sugarcane
- Sunflower
- Tomato
- Vine
- Wheat

Name	Description	Unit
abscission	proportion of senescent leaves falling	
adens	parameter to compensate between the number of stems and the density of plants	
adfol	parameter for the evolution function of leaf density	m2m-3/m2m-2
adil	parameter for the critical dilution curve [Nplant]=adil MS^(-bdil)	N% MS
adilmax	parameter for the maximum dilution curve [Nplant]=adilmax MS^(-bdilmax)	N% MS
afpf	logistic parameter defining the fruit sink strength (undetermined growth): relative age of fruit where the rate of growth is maximum	
afruitpot	maximum number of set fruits per influorescence and by degree.day (undetermined growth)	nofruits °CJ-1
allocamx	maximum daily allocation of assimilates towards fruits	
ampfroid	thermal semi-amplitude of vernalising effect	°C
bdens	minimum density as from which there is competition between plants for leaf growth	plants m-2

bdil	paramètre for the critical dilution curve [Nplant]=adil MS^(-bdil)	
bdilmax	parameter for the maximum dilution curve [Nplant]=adilmax MS^(-bdilmax)	
belong	parameter for the elongation curve of the coleoptile	degree day -1
bfpf	logistic parameter defining the strength of the fruit sink (undetermined growth): rate of maximum growth as a proportion of maximum fruit weight	
celong	parameter for the elongation curve of the coleoptile	SD
cgrain	number of grains produced (per g MS/d) during the NBJGRAIN period which precedes the NDRP stage	grains gMS -1 day
cgrainv0	number of grains produced when the growth rate is nil	grains m-2
codazofruit	option: activation of direct effect of nitrogen status on the number of fruits	1=no 2=yes
codcalinflo	option: mode of calculation for number of influorescences	1=forced 2=trophic state
codebeso	option: calculation of water requirements	1=kept 2=resistive approach
codebfroid	option: calculation of requirements under cold conditions	1=no 2=vernalisation 3=dormancy
codedormance	option: calculation of dormancy	1=forced 2=Richardson 3=Bidabe
codegdh	hourly or daily calculation of development unit	1=daily 2=hourly
codegermin	option: passage through a germination phase	1=delay before initiation of the crop 2=direct initiation
codehypo	option: passage through growth phase	1=hypocotyledon growth phase 2=plantation of a plantlet
codeindetermin	option: simulation of leaf and fruit growth	1=determined 2=not determined
codeintercept	option: simulation of rain interception by foliage	1=yes 2=no
codeir	option: calculation of grain mass/total biomass ratio	1=proportional to time 2=proportion to summed temperatures
codelaitr	choice between a calculation of the rate of cover and the LAI	1=lai 2=cover rate
codelegume	leguminous option	1=no 2=yes
codemonocot	Plant code for monocotyledone	1=Monocotylédone 2=Dicotylédone
codeperenne	annual or perennial plant	1=annual 2=perennial
codephot	option: photoperiodicity of the plant	1=yes 2=no
codeplante	coded name of the plant in 3 letters	
coderacine	choice of module to estimate root growth in terms of volume	1=by typical profile 2=by true density
coderetflo	option: delayed action of water stress before the DRP stage	1=yes 2=no
codesymbiose	option: calculation of symbiotic uptake	1= critical nitrogen 2=activité nodosités

codetemp	option: mode of calculation for thermal time of the plant	1=air temperature 2=crop temperature
codetemprac	option: mode of calculation for thermal time of roots	1=crop temperature 2=soil temperature
codetransrad	option: simulation of radiation interception	1=Beer's law 2=radiation transfers
codetremp	option: thermal effect on grain filling	1=no 2=yes
codevar	Variety code	
codgelflo	activation of frost at flowering	1=no 2=yes
codgeljuv	activation of frost on LAI during juvenile stage	1=no 2=yes
codgellev	activation of frost on plantlet	1=no 2=yes
codgelveg	activation of frost on LAI during adult stage	1=no 2=yes
codlainet	option: calculation of LAI	1=net 2=gross
codtefcroi	option: use of threshold temperatures to calculate efficiency of growth	1=specific threshold 2= identical to those used for leaf index
coefamflax	multiplication coefficient for AMFLAX range to use the crop temperature	
coefdrpmat	multiplication coefficient for DRPMAT range to use the crop temperature	
coefflodrp	multiplication coefficient for FLODRP range to use the crop temperature	
coeflaxsen	multiplication coefficient for LAXSEN range to use the crop temperature	
coeflevamf	multiplication coefficient for LEVAMF range to use the crop temperature	
coeflevdrp	multiplication coefficient for LEVDRP range to use the crop temperature	
coefmshaut	ratio between biomass and useful cutting height on crops	t ha-1 m-1
coefsenlan	multiplication coefficient for SENLAN range to use the crop temperature	
concNnodseuil	maximum nitrogen threshold in soil for the setting of nodules	kg.ha-1.mm-1
concNrac0	nitrogen concentration preventing nodule activity	kg.ha-1.mm-1
concNrac100	nitrogen threshold concentration at full nodule activity	kg.ha-1.mm-1
contrdamax	maximum constraint on penetration	
croirac	growth rate of root front	cm degree.day-1
debsenrac	sum of degree.days defining the onset of root senescence (lifespan of a root)	degree days
deshydbase	rate of evolution of water content in fruits (>0 or <0)	% d-1
dfolbas	minimum foliage density in the plant form considered	m2 leaf m-3
dfolhaut	maximum foliage density in the plant form considered	m2 leaf m-3
dlaimax	maximum rate of production of net leaf surface area	m2 leaf plant-1 degree d-1
dlaimaxbrut	maximum rate of gross leaf surface area production	m2 leaf plant-1 degree d-1
draclong	maximum rate of production of root length	cm root plant-1 degree.day-1
dureefruit	duration of growth of a fruit from setting to	degree days

	physiological maturity	
durvieF	lifespan of a cm of adult leaf	Q10
durvieI	lifespan of a cm of young leaf as a proportion of DURVIEF	
durviesupmax	proportion of additional lifespan linked to overfertilisation with nitrogen	
efcroijuv	maximum growth efficiency during juvenile phase (LEV-AMF)	g MJ-1
efcroirepro	maximum growth effiicency during grain filling phase (DRP-MAT)	g MJ-1
efcroiveg	maximum growth efficiency during vegetative phase (AMF-DRP)	g MJ-1
elmax	maximum elongation of coleoptile or hypocotyledon in the dark	cm
envfruit	maximum proportion envelope/grain in mass	
extin	coefficient of extinction of PAR in plant cover	
fixmax	maximum symbiotic uptake	kgN ha-1 d-1
forme	form of leaf density profile of plant:	1=rectangle 2=triangle
h2ofeuiljaune	water content of yellow leaves	g water g MF -1
h2ofeuilverte	water content of green leaves	g water g MF -1
h2ofrvert	water content of green fruits (before water dynamics)	g water g MF -1
h2oreserve	water content of reserves	g water g MF -1
h2otigestruc	water content of structural stems	g water g MF -1
hautbase	height of plant base	m
hautmax	maximum plant height	m
hunod	humidity threshold for nodulation	mm cm soil-1
idebdorm	day of entry into dormancy	DOY
ifindorm	day of emergence from dormancy	DOY
inflomax	maximum number of influorescences per plant	nb pl-1
infrecouv	ulai at AMF stage (inflexion point of the rise in the cover rate)	
inngrain1	minimum inn for net maximum absorption of nitrogen	
inngrain2	maximum inn for net nil absorption of nitrogen	
INNmin	minimum INN value possible for the crop	
innsen	innsenes function passes through the point (innmin, innsen)	
innturgmin	innsenes function passes through the point (innmin, innturgmin)	
irmax	maximum harvest index	
julvernal	Julian day (between 1 and 365) of entry into vernalisation for perennial crops	DOY
jvc	number of days of vernalisation	DOY
jvcmini	minimum number of days of vernalisation	DOY
Kmabs1	constant of nitrate affinity by the absorption system 1 (high affility) of the roots	µmole. cm root-1

Kmabs2	constant of nitrate affinity by the absorption system 2 (low affinity) of the roots	µmole. cm root-1
kmax	maximum cultivation coefficient of the crop (= ETM/ETP)	
kstemflow	coefficient of extinction linking LAI and stemflow	
ktrou	coefficient of extinction of PAR through the plant (radiation transfers)	*
laicomp	LAI from which inter-plant competition starts	m2 m-2
laiplantule	LAI leaf index of plantlet at time of planting	m2 leaves m-2 soil
longsperac	specific length of roots	cm g-1
lvfront	root density at the rooting front	cm root.cm-3 soil
masecNmax	above-ground biomass from which the is dilution of nitrogen (critical and maximum curves)	t ha-1
mouillabil	maximum water retention on leaves	mm LAI-1
nbfeuilplant	initial number of leaves per plant at planting	nb pl-1
nbfgellev	number of leaves per plant at end of plantlet stage (sensitivity to frost)	nb pl-1
nbgrmax	maximum number of grains	grains m-2
nbgrmin	minimum number of grains	grains m-2
nbinflo	number of influorescences imposed	nb pl-1
nbjgrain	latency period before DRP for the setting of number of grains	days
nboite	number of boxes or age groups of fruits for fruit growth in undetermined plants	
nlevlim1		
nlevlim2		
parazofmorte	parameter for proportionality between C/N of dead leaves and INN	
pentinflores	parameter to calculate number of influorescences	
pentlaimax	parameter for LAI logistics	
pentrecouv	parameter for cover rate logistics	
pgrainmaxi	maximum weight of a grain (% water)	g
phobase	baseline photoperiod	hours
phosat	saturation photoperiod	hours
plastochrone	period separating the emission of two leaves on the main stem	°C Day
profnod	depth of nodulation	cm
psisto	absolute value for stomatic closure potential	bars
psiturg	absolute value for start of reduction in cell expansion	bars
q10	Q10 used to calculate Bidabe dormancy	
rapforme	ratio between thickness/breadth of plant shape (negative when the base of plant < summit)	
rapsenturg	definition of soil moisture threshold active to senesecence stress as a proportion of the turgescence threshold	
ratiodurvieI		

ratiosen	fraction of senescent biomass (with relation to the total biomass)	between 0 and 1
remobres	proportion of reserve which can be remobilised each day	
rsmin	minimum stomatic resistance	s m-1
sdrpnou	development range between DRP and NOU (end of setting)	°C day
sea	specific surface area of fruit envelopes	cm2 g-1
sensanox	sensitivity to anoxia (0 = insensitive)	
sensiphot	sensitivity to photoperiod (1 = insensitive)	
sensrsec	sensitivity of roots to soil dryness (1 = insensitive)	
slamax	maximum SLA of green leaves	cm2 g-1
slamin	minimum SLA of green leaves	cm2 g-1
spfrmax	threshold to calculate trophic stress on fruit development	
spfrmin	threshold to calcualte trophic stress on fruit development	
splaimax	threshold to calculate trophic stress on LAI	
splaimin	threshold to calculate trophic stress on LAI	
stamflax	cumulated development units between AMF and LAX stages	degree.days
stdnofno	development range between beginning and end of nodulation	degree.days
stdordebour	development range between emergence from dormancy and budding	degree.days
stdrpdes	development range between DRP and start of water dynamics	degree.days
stdrpmat	cumulated development units between DRP and MAT stages	degree.days
stdrpnou	cumulated development units between DRP and NOU stages (end of setting)	degree.days
stemflowmax	maximum fraction of rainfall running down stems	between 0 and 1
stflodrp	development range between FLO and DRP (indicative only)	degree.days
stfnofvino	development range between the end of nodulation and the end of nodule life	degree.days
stlaxsen	cumulated development units between the LAX and SEN stages	degree.days
stlevamf	cumulated development units between the LEV and AMF stages	degree.days
stlevdno	development range between emergence and the start of nodulation	degree.days
stlevdrp	cumulated development units between the LEV and DRP stages	degree.days
stoprac	stage of arrest of root growth (LAX or SEN)	*
stpltger	cumulated development units allowing germination	degree.days
stressdev	maximum delay authorised related to stress	

stsenlan	cumulated development units between the SEN and LAN stages	degree.days
tauxrecouvkmax	cover rate corresponding to maximum crop coefficient	m2 plant/m2 soil
tauxrecouvmax	maximum cover rate	m2 plant/m2 soil
tcmax	maximum temperature for growth	°C
tcmin	minimum temperature for growth	°C
tdebgel	temperature of frost onset	°C
tdmax	maximum threshold temperature for development	°C
tdmin	minimum threshold temperature for development	°C
temax	maximum threshold temperature for growth in biomass	°C
temin	minimum threshold temperature for growth in biomass	°C
tempdeshyd	increase in dehydration linked to increase in (Tcult-Tair)	% water °C-1
tempnod1	cardinal temperature for nodule activity	°C
tempnod2	cardinal temperature for nodule activity	°C
tempnod3	cardinal temperature for nodule activity	°C
tempnod4	cardinal temperature for nodule activity	°C
teopt	optimum temperature for growth in biomass	°C
teoptbis	optimum temperature for growth in biomass (if plateau between teopt and teoptbis)	°C
tfroid	optimum temperature for vernalisation	°C
tgelflo10	temperature corresponding to 10% of frost damage on flowers or fruits	°C
tgelflo90	temperature corresponding to 90% of frost damage on flowers or fruits	°C
tgeljuv10	temperature corresponding to 10% of frost damage on LAI (juvenile)	°C
tgeljuv90	temperature corresponding to 90% of frost damage on LAI (juvenile)	°C
tgellev10	temperature corresponding to 10% of frost damage on plantlet	°C
tgellev90	temperature corresponding to 90% of frost damage on plantlet	°C
tgelveg10	temperature corresponding to 10% of frost damage on LAI (adult)	°C
tgelveg90	temperature corresponding to 10% of frost damage on LAI (adult)	°C
tgmin	minimum threshold temperaure used for emergence phase	°C
tigefeuil	proportion between stem (structural) and leaf	
tletale	lethal temperature	°C
tmaxremp	maximum temperature for grain filling	°C
tminremp	minimum temperature for grain filling	°C
tustressmin	stress threshold (min(turfac,inns)) from which there is an effect on the LAI (supplementary senescence compared with natural senescence)	
udlaimax	ulai from which the rate of leaf emission diminishes	

vitirazo	rate of increase in the nitrogen harvest index	g grain g plant -1 day-1
vitircarb	rate of increase in the carbon harvest index	g grain g plant -1 day-1
vitircarbT	thermal rate of increase in the carbon harvest index	g grain g plant-1 degree.day-1
vitno	rate of installation of nodules as a proportion of fixmax by degree.days	nb degree.days-1
vitprophuile	rate of increase in oil harvest index	g oil g dry matter d-1
vitpropsucre	rate of increase in sugar harvest index	g sugar g dry matter d-1
vlaimax	ULAI at inflexion point of the DELTAI=f(ULAI) function	
Vmax1	maximum rate of nitrate absorption by absorption system 1 (high affinity) in roots	µmole cm-1 h-1
Vmax2	maximum rate of nitrate absorption by absorption system 2 (low affinity) in roots	µmole cm-1 h-1
zlabour	depth of tillage	cm
zpente	depth of level at which root density is reduced by half when compared with surface, for reference profile	cm
zprlim	maximum depth of root profile for reference profile	cm

Table 9: List of crop species parameters

6.3 STICS General parameters (tempopar.sti)

Name	Description	Unit
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
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
codeactimulch	option to activate the natural mulch effect i.e. drying out of soil surface	1 = yes, 2 = no
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
codeinitprec	option to activate reinitialization of initial conditions in case of chained simulations	1 = yes, 2 = no
codeinnact	option of activation of N stress effect on the crop	1 = yes, 2 = no
codemicheur	option of calculation of hourly microclimatic outputs	1 = yes, 2 = no
codeminopt	option to maintain a constant water content in bare soil during the simulation	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
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
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
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	code 1/2

	at the distance distdrain)	
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 nitrification rate constant (at temperature tnitopt)	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
irrlev	amount of irrigation applied automatically on the sowing day to allow germination when the model calculates irrigation	mm
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	*
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
mouillabilmulch	maximum wettability of crop mulch	mm.t-1.ha
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
pHmaxnit	soil pH above which nitrification is maximum	pH
pHmaxvol	soil pH above which NH3 volatilisation derived from fertiliser is maximum	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	fraction of N2O emitted per unit of N denitrified	SD
rationit	fraction of N2O emitted per unit of N nitrified	SD
rayon	average root radius	cm
rdrain	drain radius	cm
separateurrapport	column separator in rapport.sti file	SD
tnitmax	maximal temperature above which nitrification stops	degreeC
tnitmin	minimal temperature below which nitrification stops	degreeC

tnitopt	optimal temperature (1/2) for nitrification	degreeC
tnitopt2	optimal temperature (2/2) for nitrification	degreeC
trefh	reference temperature for decomposition of humified organic matter	degreeC
trefr	reference temperature for decomposition of organic residues	degreeC
Vabs2	N uptake rate at which fertilizer loss is divided by 2	kg.ha-1.d-1
voleng	maximal fraction of mineral fertilizer that can be volatilized	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
an_debut_serie_histo	beginning year for the calculation of moving average temperature on period_adapt_CC	y
an_fin_serie_histo	ending year for the calculation of moving average temperature on period_adapt_CC	y
code_adapt_MO_CC	option to activate adaptation of organic matter decomposition to climate change	1 = yes, 2 = no
code_adaptCC_denit	option to activate the impact of climate change on denitrification rate (trefdenit1 and trefdenit2)	1 = yes, 2 = no
code_adaptCC_miner	option to activate the impact of climate change on soil mineralisation rate (trefh and trefr)	1 = yes, 2 = no
code_adaptCC_nit	option to activate the impact of climate change on soil nitrification rate (tnitmin, tnitmax, tnitopt)	1 = yes, 2 = no
codecalferti	option to activate the automatic calculation of fertilisation rate	1 = yes, 2 = no
codemontaison	option to stop the reserve limitation after stem elongation in grassland	1 = yes, 2 = no
codeNmindec	option to activate the limitation of mineral N availability for residues decomposition in soil	1 = yes, 2 = no
codepluiepoquet	option to replace rainfall by irrigation at poquet depth in the case of poquet sowing	1 = yes, 2 = no
codeSWDRH	calculation of surface wetness duration	1 = yes, 2 = no
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
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
fNmindecmin	minimal fraction of mineral N available for residues decomposition (if codeNmindec is activated)	SD
humirac_decisemis	effect of soil moisture for sowing decision (from 0 to 1 : 0 = no sensitivity to drought, 1 = very sensitive)	SD
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	d

	soil after a sowing poquet	
param_tmoy_histo	mean temperature over the period of adaptation to climate change	degreeC
periode_adapt_CC	number of successive years used to calculate moving temperature average	SD
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
swfacmin	minimal value for drought stress index (turfac, swfac, senfac)	SD
trefdenit1	reference temperature for the soil denitrification (11 °C for temperate soils and 20 °C for tropical soils)	degreeC
trefdenit2	reference temperature for the soil denitrification (20 °C for temperate soils and 29 °C for tropical soils)	degreeC
vitreconspeupl	rate of regeneration of the tiller population	degreeC-1
codedyntalle	option to activate the module simulating tillers dynamics	1 = yes, 2 = no
coefracoupe	coefficient to define the proportion of dying roots after cut of forage crops	SD
maxtalle	maximum tillers density per soil area	nb.m-2
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
surfapex	equivalent surface of a transpiring apex	m2
tigefeuilcoupe	ratio stem (structural part)/leaf on the cutting day	SD

Table 10: list of STICS general parameters