

Land use change scenario generator in SIMILE

Isabelle Reginster, François Riguelle, Mark Rounsevell

reginster@geog.ucl.ac.be

Department of Geography, Université catholique de Louvain, Belgium

ALARM PARTNER 3 - WP1.1

Introduction

The purpose of creating a land use scenario generator is to provide a functional tool to automate the generation of annual time-series of spatially explicit and alternative scenarios of future land use in Europe. The generator aims to be flexible that new scenarios may be created in the future.

The resolution of the data is a 10' latitude/longitude grid, dividing Europe into 24024 cells. Different land use types are considered: urban, food crops, grassland, permanent crops, liquid biofuels, non-woody biofuels, woody biofuels and forests. The modelling approach also accounts for the competition between these land use types.

The Simile modelling environment

The scenario generator model, known as MOLUSC (Model Of Land Use SCenarios), is built in SIMILE. SIMILE is a declarative environment that allows the design of models in an intuitive diagram-based language. This language has the double advantage of being user-friendly for the modeller and providing a comprehensive representation of the system dynamics for the model user. The benefit of the latter advantage is that models can easily be exchanged between users.

The diagram-based language employs a widely-use notation for describing dynamics. Figure 1 shows the basic elements of a Simile model as used in the scenario generator. A description of the elements and additional information can be found within the Simile help, available online at <http://simulistics.com/help/index.htm>.

1 and 2: submodel envelopes

A model can contain many sub-models. These submodels can have various functions amongst which three are commonly used in MOLUSC. First, there is a visual function. When a model contains many elements, its complete structure becomes more apparent when the components are grouped into different submodels. Secondly, submodels can be used for disaggregation purposes. The same submodel is then applied to multiple “patches” that all have their own initial values and parameters. This is especially

useful in land use modelling when the same model is applied to multiple spatial units, such as the Alarm cells. This type of submodel is called a “multi-instance submodel” and is recognisable on the model diagram by the multiple lines on its left- and bottom-edges (see number 2). Finally, a submodel can be used to specify the conditional existence of a part of a model. Visually, we can recognise a conditional submodel both by the presence of a condition symbol (see number 10) and by a set of dots that go diagonally to the right from the submodel envelope.

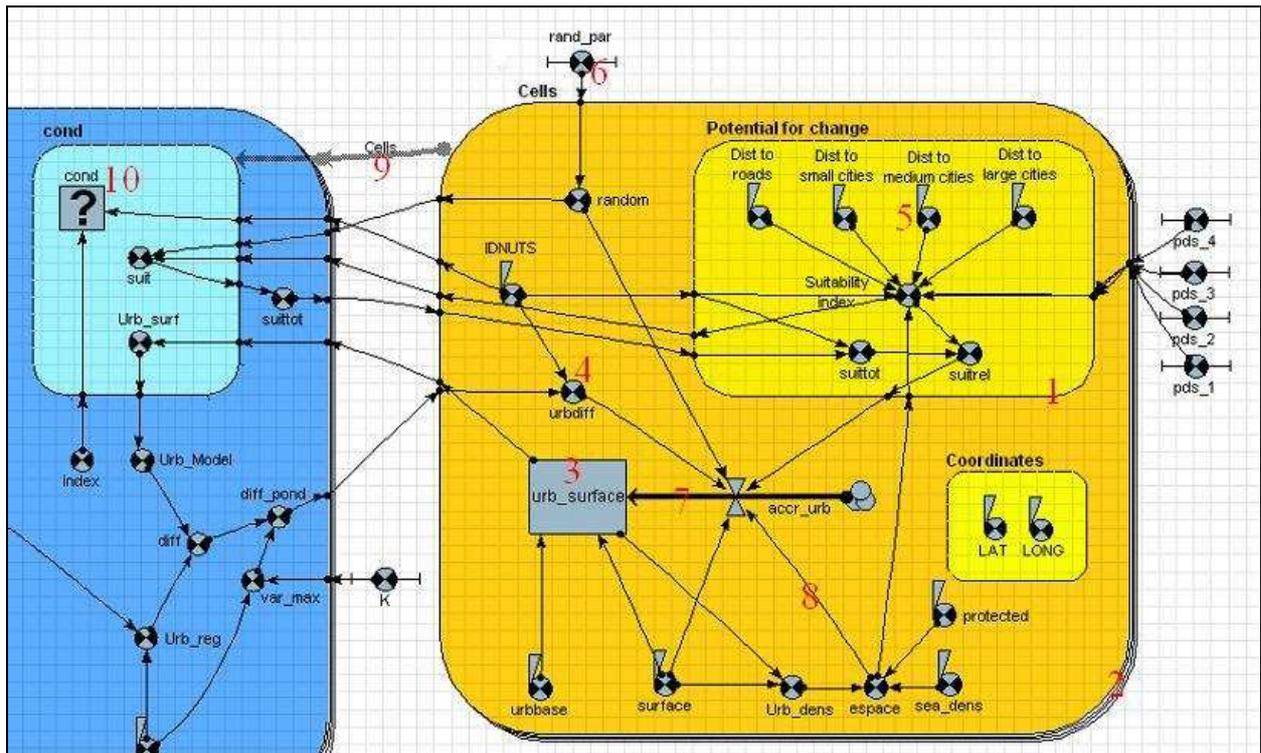


Figure 1 : Basic elements of a Simile model

3 : Compartment

The compartment symbol is used to represent a quantitative state variable. Notionally, we think of a compartment as containing an amount of some substance, though it can be used in other situations to represent the concept of state. A compartment value only varies due to the flows that move to and from it, but some variables can be linked to specify the initial value of the compartment.

4, 5 and 6 : variables

A variable is used to hold one or more values. There are three different kinds of variables in simile. Number 4 is the symbol for a variable whose value is calculated from a mathematical expression. This expression can be a simple number or a more complex expression including, for example, conditional elements. The value may vary during the course of a simulation, if it is calculated from other parts of the model that

change over time, or it may be constant. Number 5 represents “fixed parameters”. Its value must be entered when the model is run, either by manually entering the value or by referring to an external file. In MOLUSC, for example, this type of variable is used to import the initial value of each land use type in each cell stored in an external database. Number 5 is a “variable parameter”. A minimum and maximum value must be defined for this element, but when running the model, a slider can be used to vary the value. It is thus useful to study the sensitivity of a model to an element.

7 : Flow arrow

The flow arrow is used to specify a term contributing to the rate of change of a compartment. If the flow arrow enters a compartment, this specifies a positive contribution to the rate of change of that compartment. If a flow arrow leaves the compartment, this specifies a negative contribution to the rate of change. The units for a flow value must be the units of the corresponding compartment(s) to which it is linked, per unit of time

8 : Influence arrow

An influence arrow indicates that an element is used in the calculation of the value of another element. The arrow must be drawn from the influencing element towards the influenced element.

9 : « role arrow »

Role arrows join submodels that participate in some form of association, or where one is a satellite of the other. In MOLUSC, role arrows are used to indicate that each cell also forms part of a NUTS2 region and a country.

10 : Condition symbol

This element contains a boolean expression whose result (true or false) determines if a submodel, or a potential instance of a multiple-instance submodel actually exists.

The model

Figure 2 shows the basic structure of MOLUSC. The colours and the location of the compartments are the same as in the Simile model. Depending on the data sources, a total quantity of each land use is calculated at the NUTS2, country or European level. For each land use, an algorithm allocates this quantity of land use to each cell.

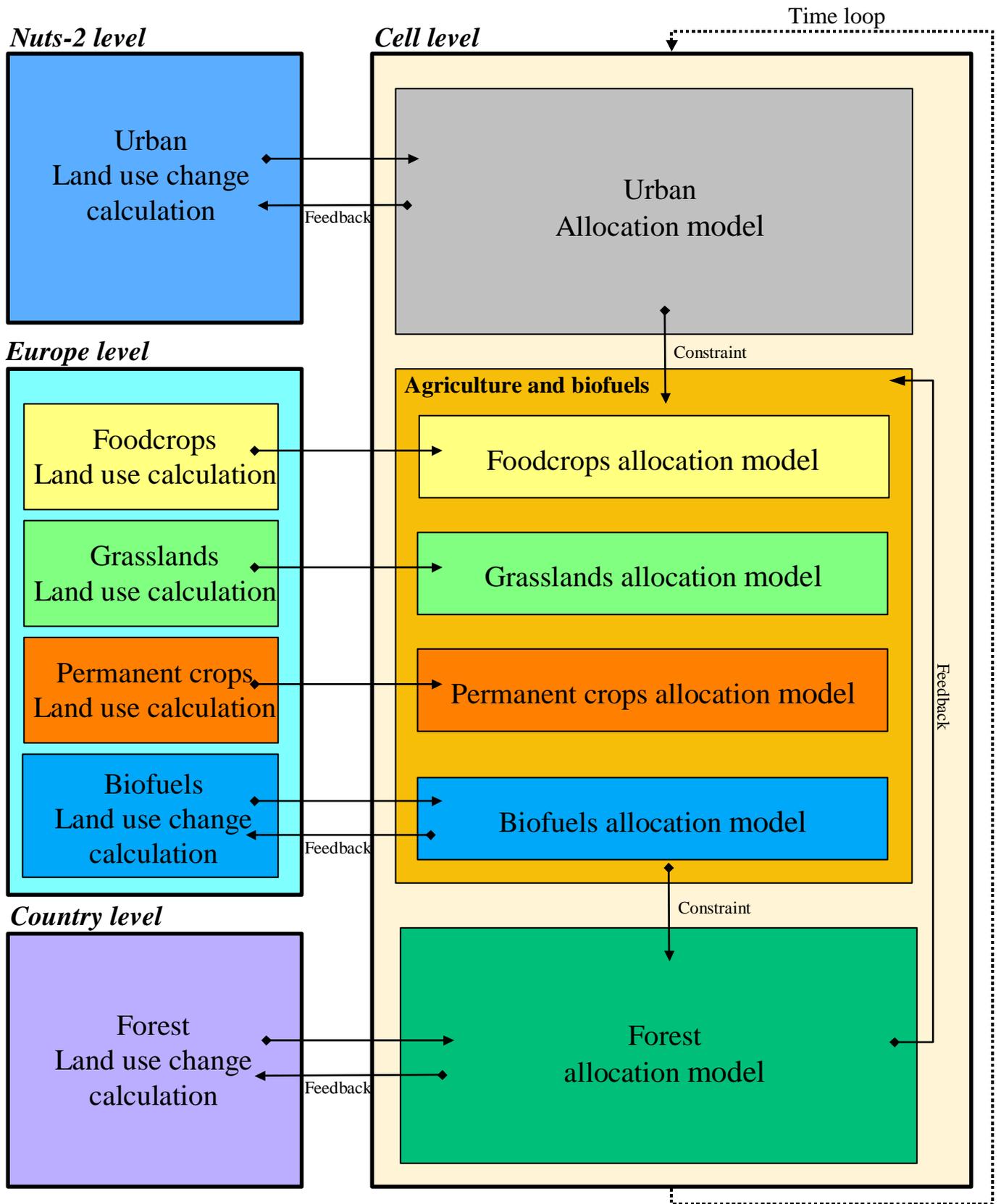


Figure 2 : Structure of the land use model

Memorandum – How to use the model?

You need a recent computer to use MOLUSC as 1G of RAM seems to be necessary.

Three folders are located on the CD. The data folder contains the data needed to run the model while the configuration folders contains configurations for the data. The third folder contains the MOLUSC model itself.

The first task in order to run the model is to download the Simile software. A free evaluation version can be found on <http://simulistics.com/products/simile.php>. This version will allow you to open and run MOLUSC, but not to save changes made to it.

You can now open the model by double-clicking on it. Remove the grid by clicking on  and use the zoom tools  to adjust the display to your preferences.

To inspect the model, use the select tool . Drag the cursor on an element of the model to see a pop up with the equation and a commentary on this element. Double clicking opens a dialogue box allowing modifications to the equation and the commentary. You can run the model with any change you make, but not save these changes when closing the model.

Use the  button to run the model. The model will be built in a few minutes and then a window will open asking for the file parameters. Click on the above  and then browse to the configuration folder. Choose which of the scenarios you want to test first and load the .spf file corresponding to this. The data will take a few minutes to load. Then click OK and wait again for some time.

A run environment window will open with the run control and settings on the left and the results on the right (initially blank). By clicking on file → parameters, you can re-open the file parameters window and load the data for another scenario if you want. Note that if you go back to the model window (without closing the run environment window), the values of the components will now pop up while dragging the select tool onto it.

On the run control panel, fix 'execute for' to 15 units if you need results until 2020 (the model is set to run between 2005 and 2080). On the 'run settings' panel, keep the time units and the integration method as default and fix the time step to a value equal to 1 or minus. The model is not very sensitive to the time step. A very small time step is thus not needed.

Select the displays you want to see.

The maps represent the land use density per Alarm cell. The range of values and the colours can be modified by clicking on the properties icon . All the variables of the ‘cells’ submodel can be shown on a map. To do this, select a blank tab, click on the  icon and select ‘spatial grid display’. Then click on the  icon, select the variable ‘IDcol’ to define the position of the columns of the grid and choose the variable you want to represent.

Other display tools are available. It is often useful to plot a variable against time. This option is available with the  icon. Be careful not to represent a variable of the ‘cells’ submodel on a plot as this would hardly be readable (the submodel has 58960 instances) and would take hours to be drawn. To remove a display, select the tab containing it and click on the  icon.

Some displays (such as the spatial grid) take time to be drawn. You can modify the ‘display interval’ option on the run control if the model takes too long to run because of the displays. When using the spatial grid display, a display interval bigger than 1 year allows a quick representation of the global evolution of the studied land use.

To output results for a variable that is not in the ‘cells’ submodel, the ‘data table’ helper  from the run environment window is fine. But do not use it to output time series for a variable of the ‘cells’ submodel as this would take ages to compute. The fastest way to output large dataset is to use the ‘inspect model variable’ tool. First initialise the model, click on the  icon and then on the variable you want to output. A new window will open. Use the save option of this window to export the data in csv format and then close the window. Then fix the ‘Execute for’ option of the run control to 1 (if you want annual times series) and run the model. Again use the  tool to export the data at year 1 and repeat the operation for 75 years. You will have different csv files that you can merge outside Simile. To use these data, you can also output the values of the variables ‘LAT’ and ‘LONG’ from the model. This gives you the coordinates of the centre of the cell. Cells that have (0; 0) as coordinates are cells that comprise entirely of the sea.