TUTORIAL 3

test case 1: *vallecamonica_160m.grd*

The third case described in this tutorial regards the Oglio river, upstream of its entrance into Lake Iseo, northern Italy. The watershed is discretised with a space resolution of 160x160 m. The geometrical features of the DEM are automatically specified in the header of the input *.grd file that is read by the program

```
ncols      272
nrows      414
xllcorner    1578620.000000
yllcorner    5068220.000000
cellsize    160
NODATA_value  -9
```

This DEM has been enhanced using a GIS by eliminating all the depressions and flat areas inside it. This task is very important, otherwise it would not be possible to create a single connected path that goes from any cell inside the watershed to the watershed outlet. Typically, this is done by recursively filling the depressed cells up to the elevation of the lowest surrounding cell, and then by tilting the resulting flat areas, adding a small quantity to the local elevation.

In any case this is an ordinary pre-processing that is routinely accomplished by most GIS. Another important requirement is that the watershed outlet (i.e., the lowest cell in the watershed) must be located along the watershed boundary (i.e., it can't be an inner point of the DEM). Also this requirement is quite reasonable. A visual ispection of the *vallecamonica_160m.grd* file should be self-esplicative.

Run the Q2T program by clicking on the *Q2T.exe* icon.

Select command In/Out: the following panel appears
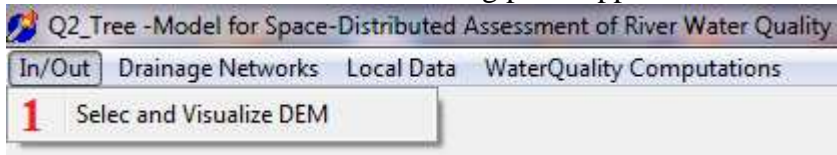
Using command 1 above, select the file *vallecamonica_160m.grd*. Upon selection, a panel shows up where the magnification ratio for the DEM visualization on the screen can be selected. In order to make the DEM visible on the screen, we select a magnification ratio = 2 and then we select the SHOW DEM button. The Watershed Visualizer panel below will show up on the screen, where the DEM (in this case a line of cells) is represented with color scaling from brown (highest elevation in the watershed) down to blue (lowest elevation). The shading of the watershed is actually shown under the action of an oriented light source, using the slope and of the orientation of each cell in the watershed, provided by two additional files that the program creates in the input directory (with extension *.rad* and *.esp*)
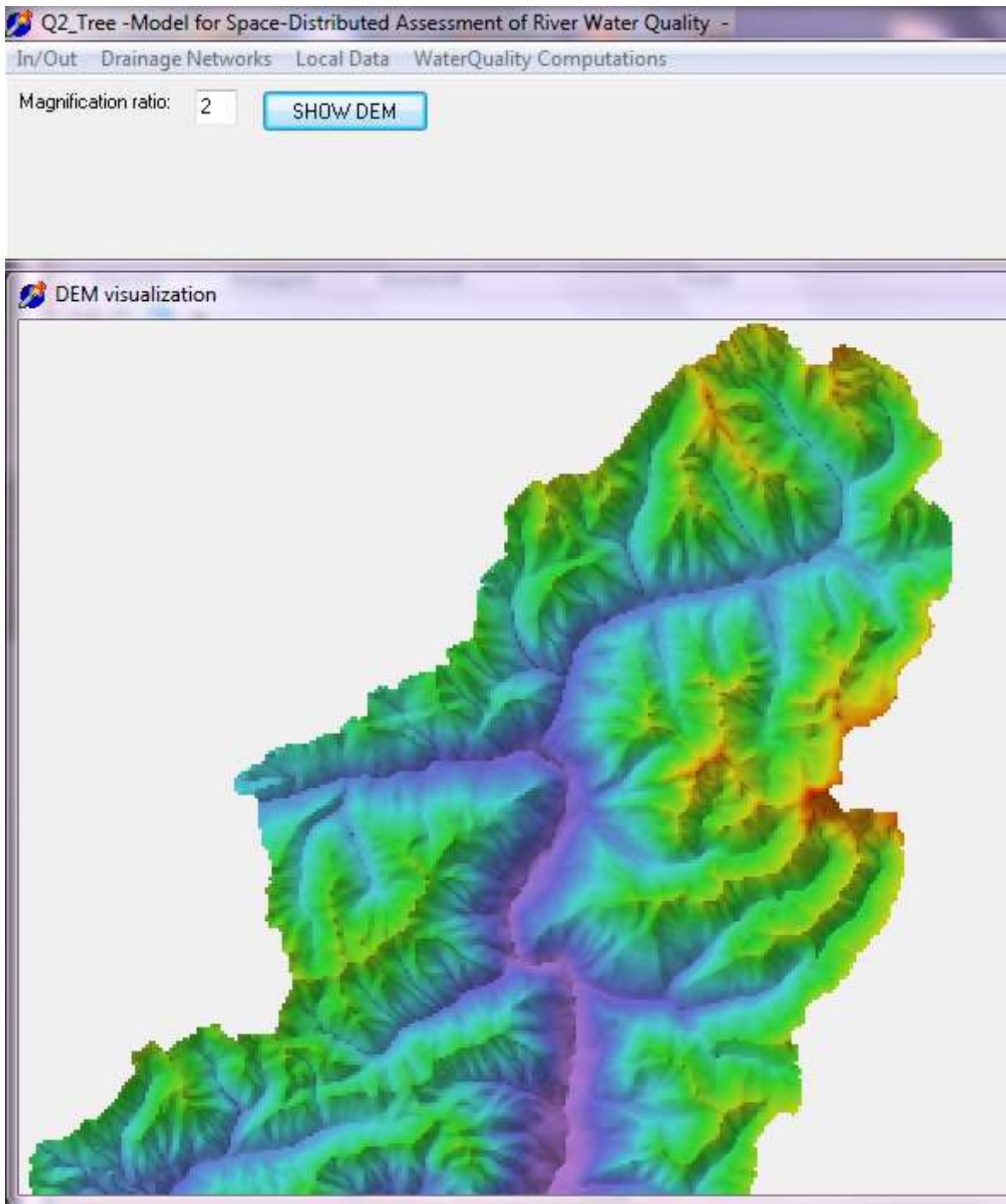
The actual local elevation of each cell can be known by using the Local Data commands.
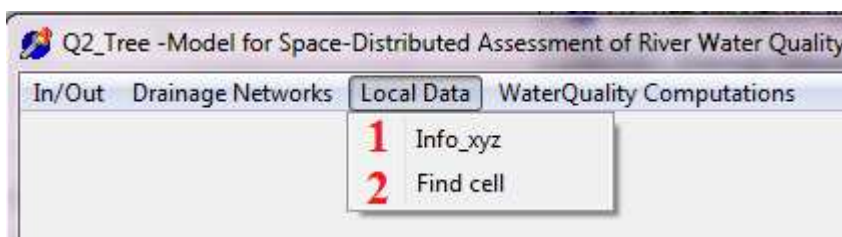

By selecting Info_xyz and clicking on a cell of the DEM, the local elevation is shown (value in the blue ellipse below) surrounded by the elevation of the 8 surrounding cells. Also the coordinates of
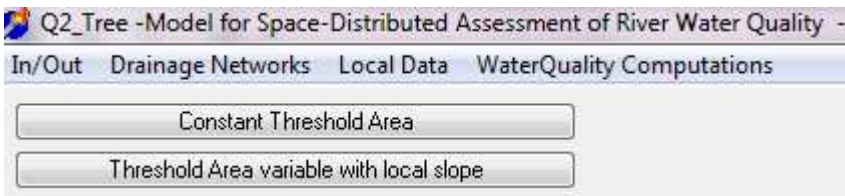
the point are shown (round ellipse), either in the matrix reference frame (row, column) or by its UTM coordinates. The Find cell command can be used in a similar way. By selecting the row and column of the cell to be serched, it is shown on the screen as a yellow square.
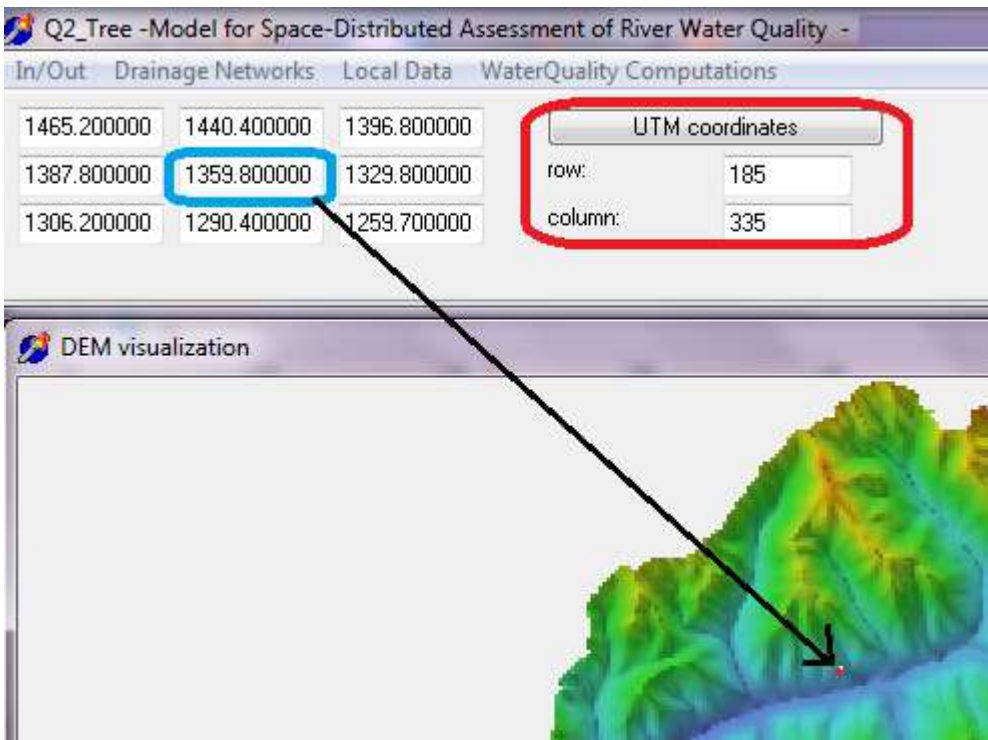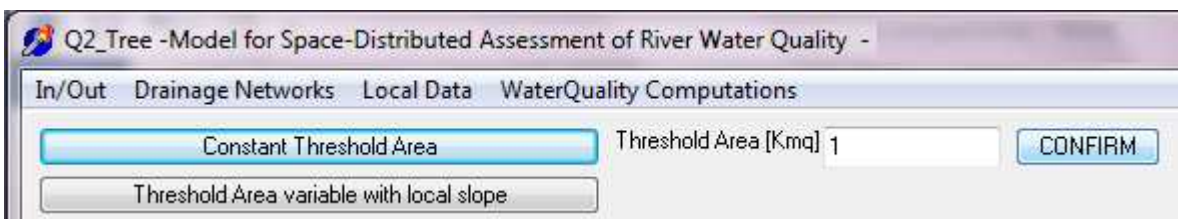

Now select the Command Drainage Networks
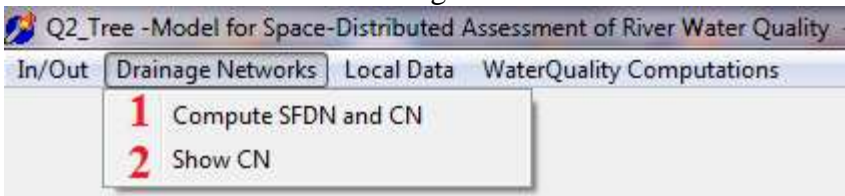
Here select command 1: Compute SFDN and CN.
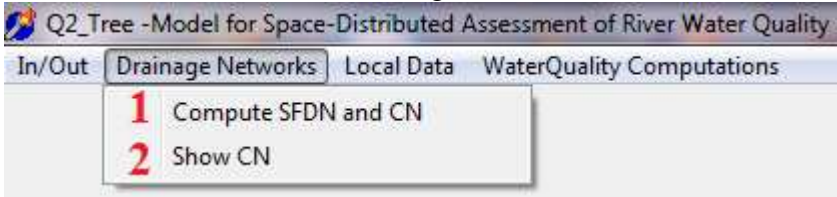The panel will appear

On the basis of this choice, the CN will be obtained by the automatically computed SFDN using either a constant Threshold Area or a Threshold Area that changes with the local slope. Let us select the first option, and insert 1 (km^2) as threshold area

Press CONFIRM

Now select the Command Drainage Networks

Here select command 2: Show CN.
The panel will appear

By this command the CN can be shown, filtered according to Horton's ratio. Simply press SHOW
CN and the CN will appear as a red line superimposed on the DEM. If one selects the Activate
Reading of Drained Area button, one can browse the drained area at each point along the CN simply
by pressing the mouse left key on the cell. At this stage both the SFDN and CN have been
computed and the CN is the red line shown on the screen.
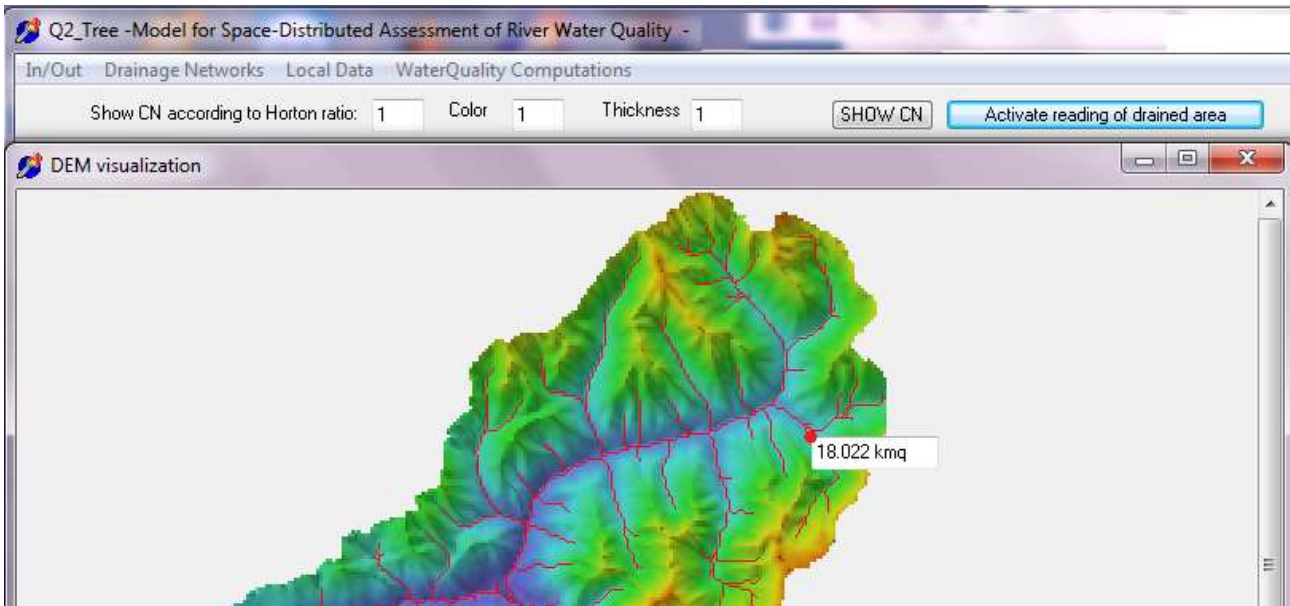
The outlet of the watershed is always marked by a red dot on the DEM and in this case is located at
the DEM southern tip. The point can be found by using one of the scroll bars of the panel
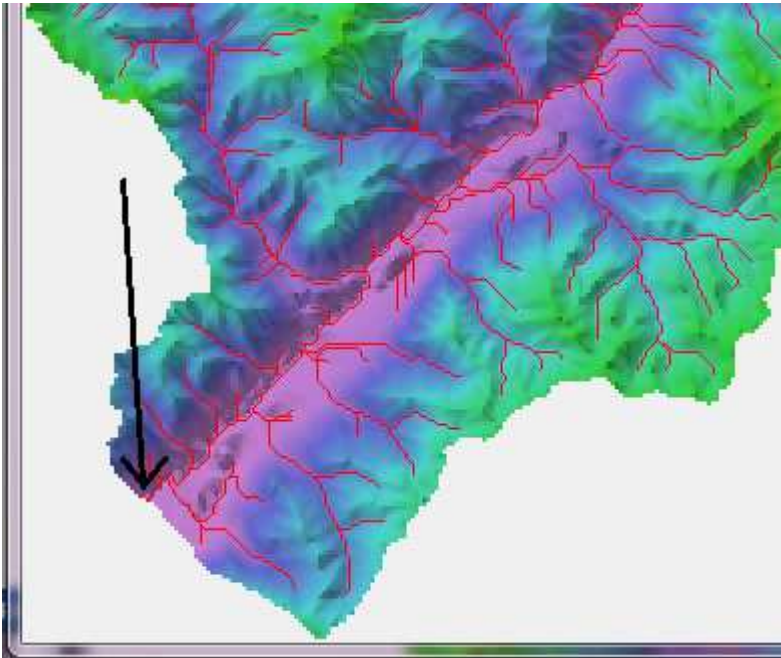
Now it is time to go to the Water quality Model. Select the Command Water Quality Computations
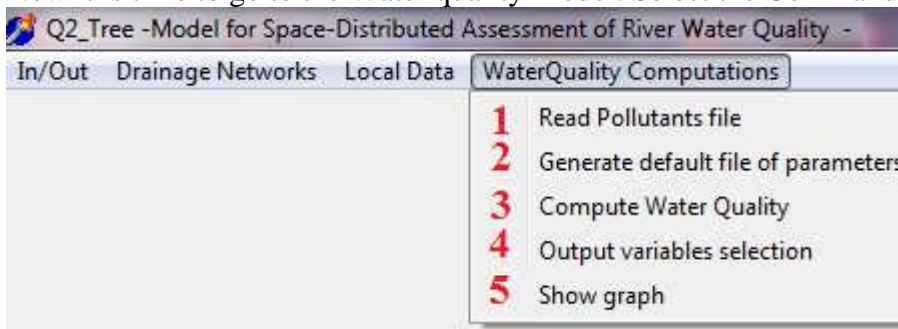

Select Command 1 to read the user-defined list of pollutant sources and water diversions. Here select the file valcamonica_160m.inp. This file is an unformatted ASCII file that contains the following information:

r	c	Q_immission	T	Ci_imm i=1..5					Q_diversion
86	174	0.1244	25	500.0	16.7	26.7	0.0	3.3	0
129	155	0.0265	25	500.0	16.7	26.7	0.0	3.3	0
145	163	0.0045	25	500.0	16.7	26.7	0.0	3.3	0
171	144	0.0187	25	500.0	16.7	26.7	0.0	3.3	0
188	157	0.0061	25	500.0	16.7	26.7	0.0	3.3	0
198	162	0.0101	25	500.0	16.7	26.7	0.0	3.3	0
227	160	0.0072	25	500.0	16.7	26.7	0.0	3.3	0
242	159	0.0165	25	500.0	16.7	26.7	0.0	3.3	0
290	121	0.1241	25	500.0	16.7	26.7	0.0	3.3	0
296	113	0.0191	25	500.0	16.7	26.7	0.0	3.3	0
376	34	0.2500	25	500.0	16.7	26.7	0.0	3.3	0
315	60	0.0173	25	500.0	16.7	26.7	0.0	3.3	0

The meaning of this file can be easily understood by comparison with the pollutant loads summarized in Table 5 of the Companion paper.
When this file is read, immission or withdrawal points are marked along the CN with yellow points, as shown in the panel below.
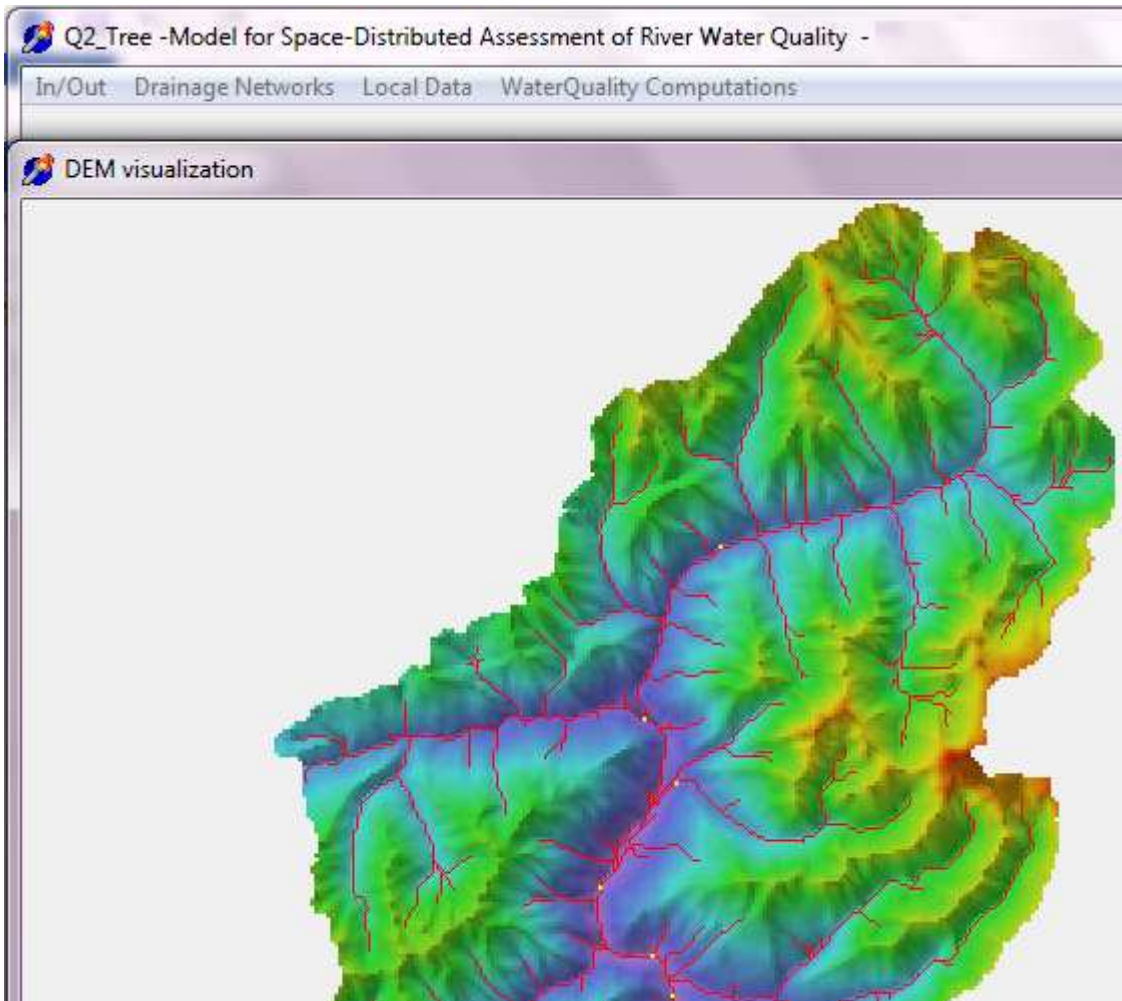
Now Select Command 2: Generate Default File of Parameters. This command generates the list of parameters used by the solver. Initially all the cells are blank and the mask looks like the following

Press Select Default Values and the default values for all the parameters will be loaded as in the following panel.

The red line above encircles the parameters for controlling the river width as a function of the drained area (eq. 2 of the paper). In our case we have made the assumption that the width of the cross-sections can be computed with the value of the parameters $\varepsilon = 0.2$ and $\delta = 3.482$, that corresponds to a width varying between 4 m (when the drained area is 1 km^2) and 15 m (at the basin outlet). Insert these values in the corresponding cells.

The green line is related to the variation of the Manning's coefficient as a function of the drained area. For simplicity sake, a constant Manning coefficient n = 0.04 m$^{-1/3}$s has here been used, that is obtained by selecting the same value for the minimum and the maximum.

The variation of the temperature of the local contribution from the groundwater is controlled by the minimum and maximum values within the yellow line. Here we have made the assumption of a linear variation between 0+ °C at the maximum elevation in the watershed and 11 °C at the watershed outlet.The pink line encompass the unitary flow contribution from the watershed. In this test case, as described in the paper, it will be = 0.0097 m^3/s/km^2. Here we made the assumption that the unitary flow contribution is fully oxygen saturated at the point of emergence according to its temperature and elevation (see Eq. in Table 2 of the paper) and that the associated pollutant loads are 0.

As observed above, the depitting algorithm that has produced the pre-processed DEM has left some cells where the gradient is unrealistically flat. In order to deal with this problem, that is an artefact of the quality of the original DEM, a user-specified minimum slope has been introduced in the program. When the local slope in the DEM is lower than this threshold, the threshold is used. In our case this minimum slope was set to 0.001 m/m.

The blue line encompasses the value for all the chemical parameters. Their value will not be changed in the following.

As one can observe within the black line, the user can select both a variable reareation coefficient and a variable oxygen pressure saturation, as a function of T and atmospheric pressure. These two options can be activated by selecting the checkbox on their left. Otherwise, if constant values are selected throughout the CN, these can be specified on the right. In this test case the oxygen saturation varies as a function of water temperature and altitude, according to the equations shown in Table 2 of the paper (check the checkbox on the left), whereas, the reaeration coefficient has been kept constant and equal to 20 d^{-1} (so, do not check the corresponding checkbox on the left but insert 20 on the right).

In this example we solve the complete energy balance of Eq. (9) considering the terms of Eq. (10). Accordingly the "detailed Energy balance" option is selected and the following parameters are specified. First of all, we have made the assumption of a linear variation of the daily average air temperature as a function of elevation. Considering the Julian day 225 in the summer, here it varies between 2+ °C at the maximum elevation in the watershed and 23 °C at the watershed outlet. Then some data are required in order to estimate the average daily short wave radiation in the watershed: the reference latitude of the watershed, the cloud factor and a pollution index ranging from 2 (clean sky) to 5 in case of strong pollution (see Chapra, 2008). By pressing the "compute SW" button, the shortwave value shows up on the right. However, if more detailed data are available, such a measured average value, this can be substituted in the corrisponding cell and will be used by the code.

Finally, the relative humidity and the wind velocity at 7 m above the river water surface are required (Chapra, 2008).
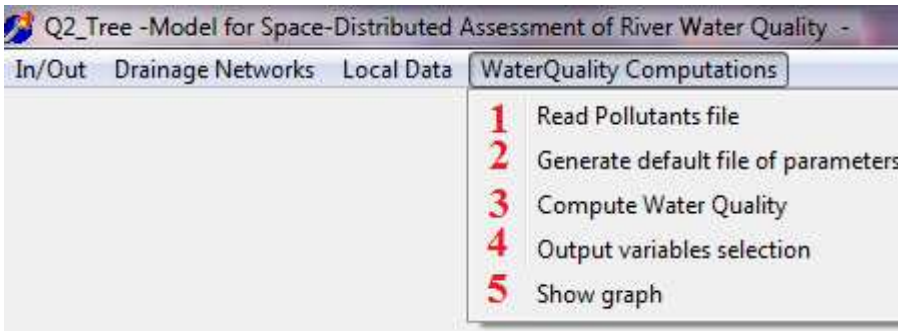
Accordingly, the panel should be modified as follows
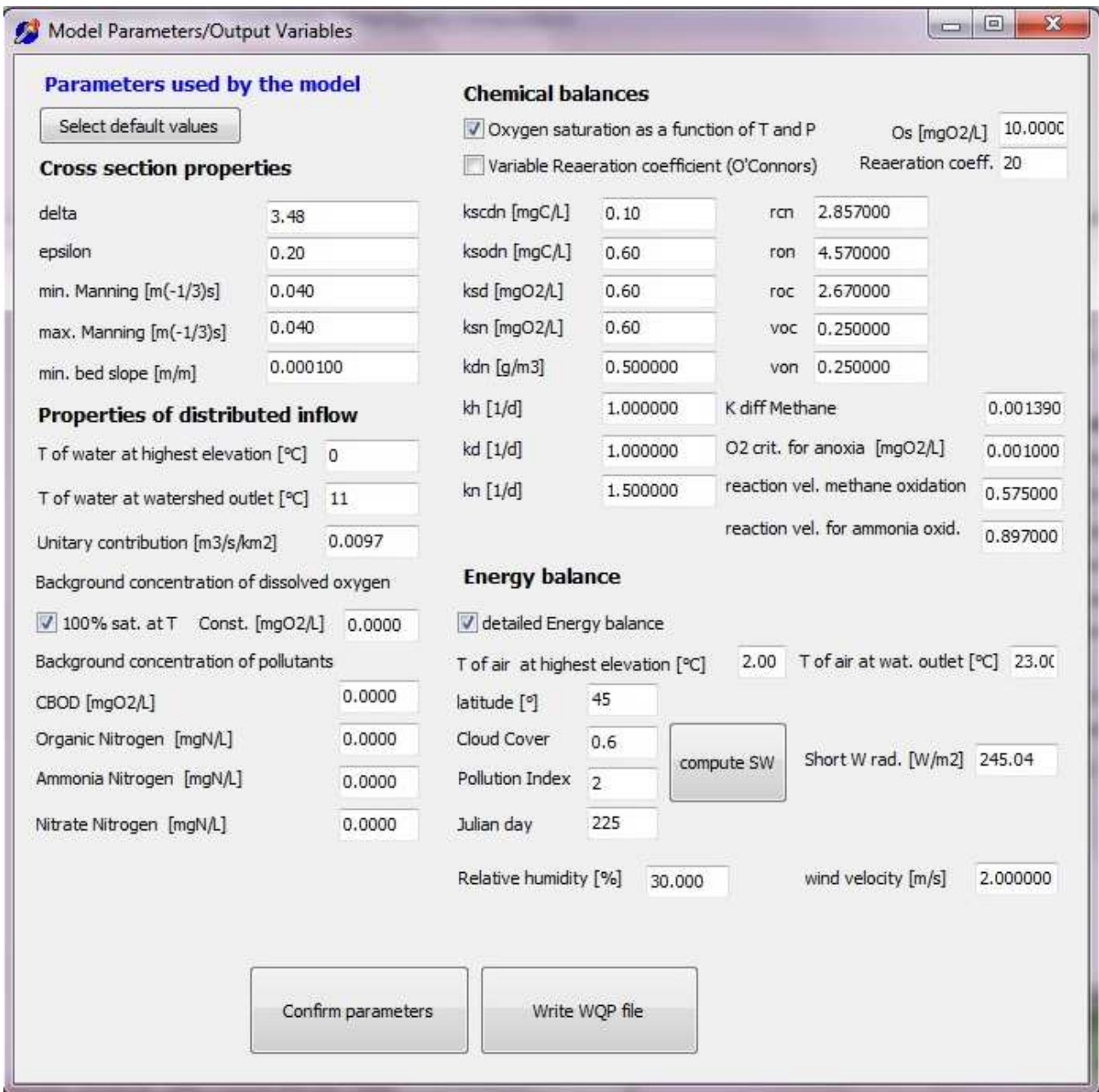
Now the user can press the Confirm Parameters and then the Write WQP file. At this point the WQP file, that is one of the outputs of the program, is written on disk and the mask is automatically closed.
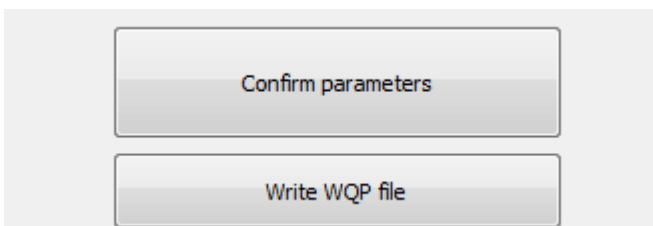

Now it is time to run the Solver. Select the Compute Water Quality command 3 below

Upon selecting this command, the set of equations are solved moving according to the post-order algorithm along the CN. In order to show the progression of the computation, a DOS window is opened where for each cell the vector of solutions x_i i= 1..6 along with the corresponding value of the balanced functions is shown. When the "End of computations" line appears at the bottom, the solver has come to the end and the results are ready to be written on disk.
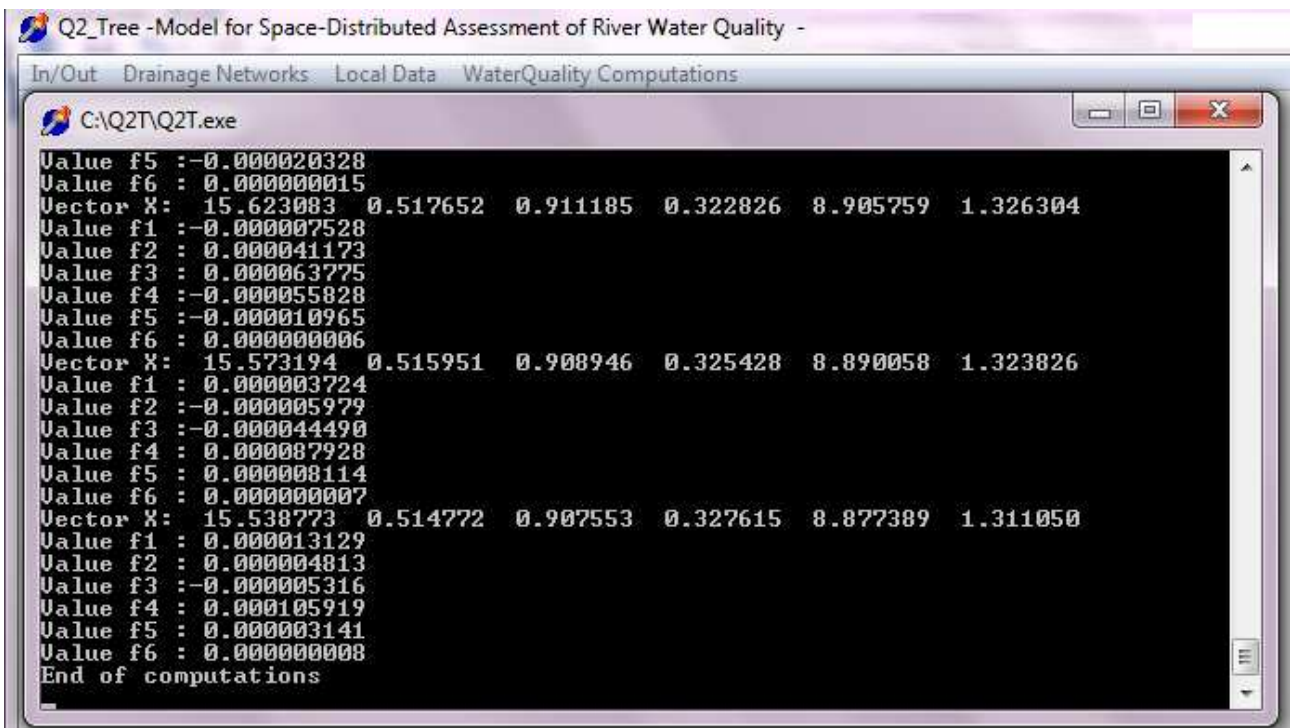

Now select the Output Variables Selection command 4 below
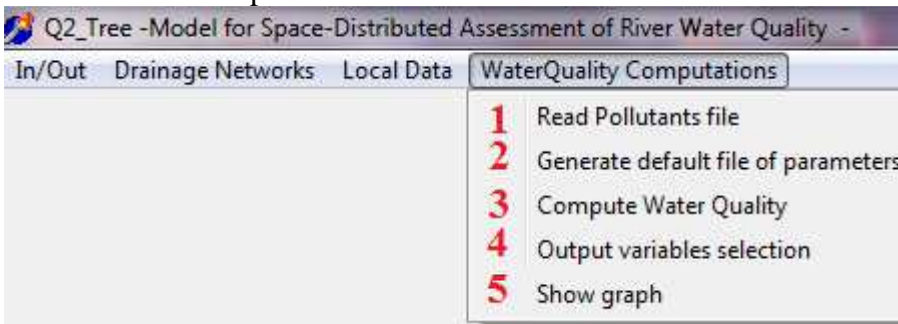
The panel below will show up. The idea behind this panel is that of selecting a point along the CN and printing on disk the computed quantities from that point downward as far as the outlet. In particular, by selecting each check box the user can customise the variables to print as well as can activate the writing of the MATLAB output file described in the user manual.

In the following we will "Select all" the variables
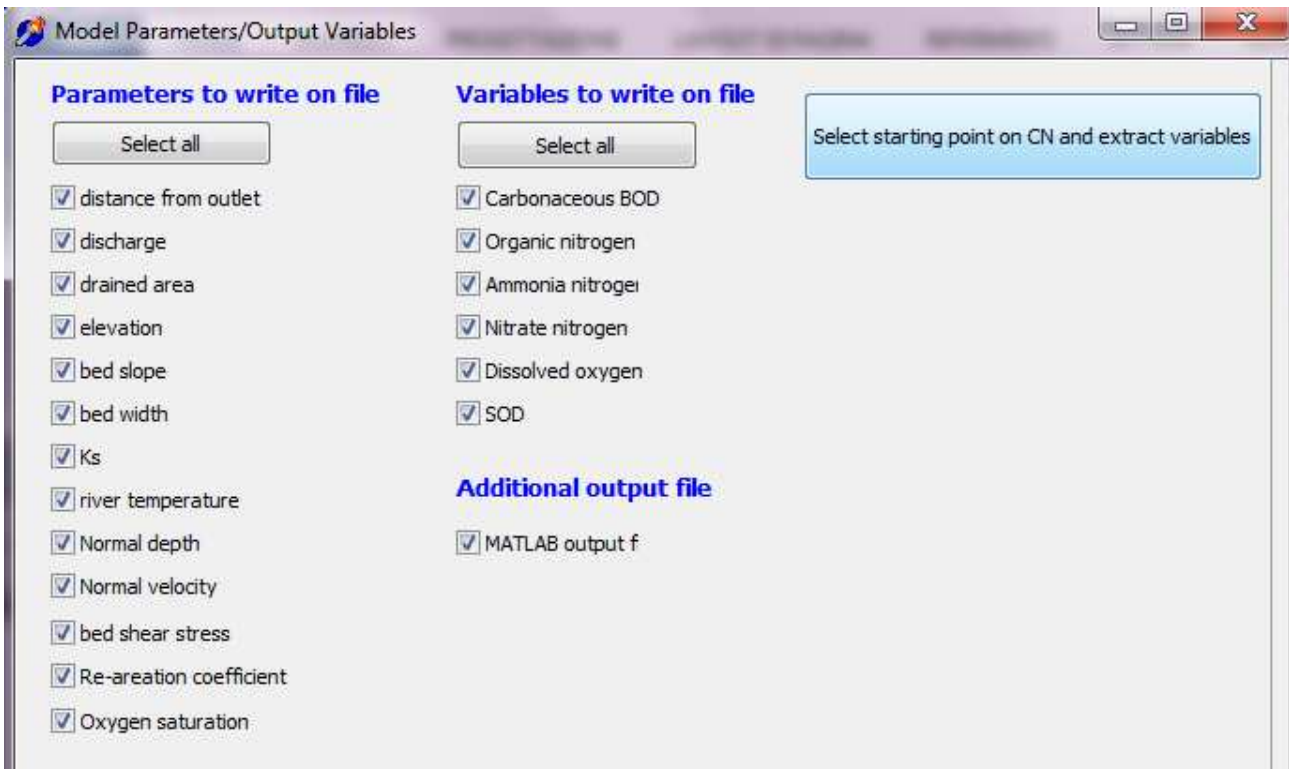
and we will press the "Select Starting Point on CN" button. By doing this the panel will automatically close and it will be possible to select the starting point on the CN in the "DEM visualization" panel. In order to do this, the user has to click with the left key of the mouse in correspondence of a node on the visualised outline of the CN. When the selected point as been recognised as being part of the CN (a point can erroneously be selected outside of the CN), a blue square shows up on the CN and a beep is heard.
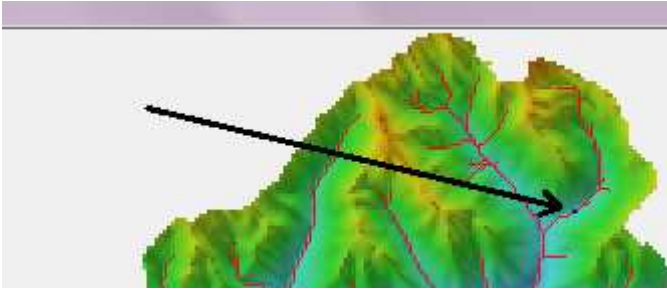
Moreover, a message appears in the "List of Tasks" panel (see last message below) documenting that a file vallecamonica_160m53_241.out has been written on file, where 53_241 means starting from the cell whose row is 53 and column is 241 in the DEM. If a different cell is selected, the name will change accordingly.
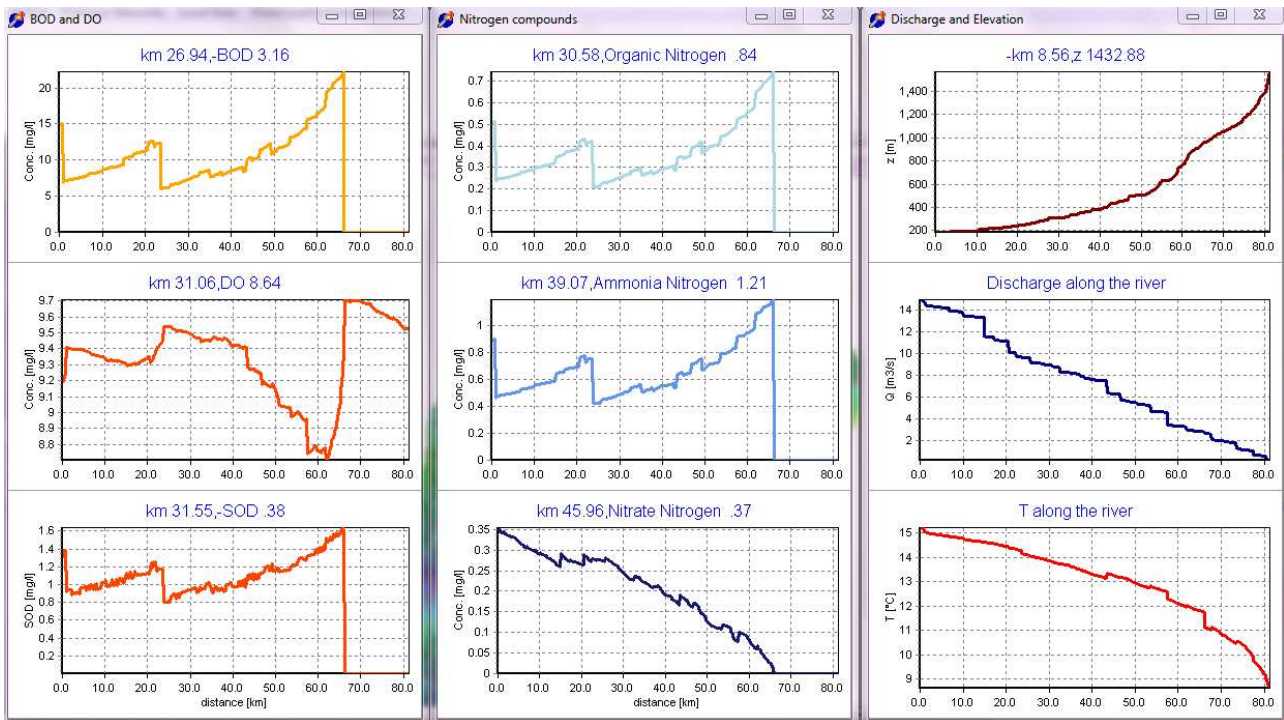

Eventually, by selecting the Show Graph 5 below
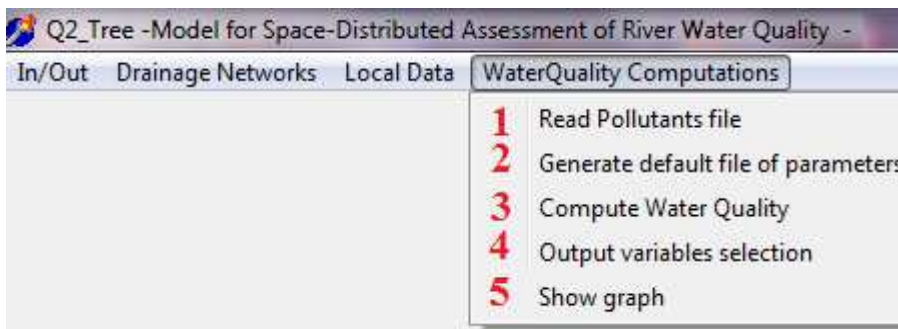
the space pattern along the selected path of the 6 computed variables is shown as below

Finally, in order to quit the program, click on the white cross at the upper right corner of the DOS panel.