MOHID Studio Quick Start Guide for MOHID Land

User Guide for setting up MOHID Land Projects with MOHID Studio Professional Edition

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This document is the MOHID Studio Quick Start Guide for MOHID Land. It contains a tutorial on how to create a MOHID Land project with MOHID Studio.

This document makes part of the MOHID Studio Documentation.

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1 Preface

1.1 Copyright

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1.3 Further Information

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2 Quick Start Tutorial for MOHID Land

This “Quick Start Tutorial for MOHID Land” is intended to help first-time users creating their first projects, following a sample project, an implementation in a small watershed, the Trancão Watershed, near Lisbon, Portugal.

It is suggested that you follow the tutorial, which progresses with increasing complexity, trying to replicate the provided sample project. After finished exploring all simulations with the samples, it is suggested that you revisit the tutorial applying the model examples to your own study site.

The tutorial starts with a preconfigured sample project, which is downloaded from Action Modulers’ web site, so you can get used to MOHID Studio’s environment, including projects and simulation structure, graphical visualization, running the model. All these tasks can be performed without any previous knowledge about using MOHID Studio / MOHID Land.

After the first play-around you are invited to independently create a simple hydrological project forced with rain, preparing the topography (include basin delineation), prepare the input files, run the model and explore results as previously.

The tutorial then shows how to access more complete example covering full 3D simulation with river discharges and meteorology, sediment transport, point sources and nutrient transport and transformation (full water quality simulation), resulting in a quite complete simulation that can be run with MOHID Land.

For each step, the require options to configure the model are explained in detail.

This is intended to be a step-by-step tutorial to implement in a straightforward way a MOHID Land project from simpler to complex simulations. Detailed description of the governing equations used by the model is not provided in this guide; neither a detailed description of the processes solved by the model is provided. For further information about these topics, you should explore the following MOHID related sources:

Action Modulers website – http://www.actionmodulers.com

MOHID website – http://www.mohid.com/

MOHID wiki – http://wiki.mohid.com/wiki

MOHID forum – http://www.mohid.com/forum/

MOHID code repository – https://github.com/Mohid-Water-Modelling-System/Mohid

It is assumed that you have installed already MOHID Studio (following MOHID Studio's Installation Guide) and that you understand the functioning of the different windows, environments and buttons (following MOHID Studio User Guide).

This manual applies to MOHID Studio 2016 (version 3.0).

In order to complete all steps in this document, you must have a Professional or an Evaluation License.

3 Exercise 1 - Explore a previously configured project

3.1 Introduction

The tutorial starts by providing a sample project so you can get familiarized to MOHID Studio. You will use a previously configured project and produce results with it.

3.2 Preparation

For Exercise 1, please prepare your PC the following steps:

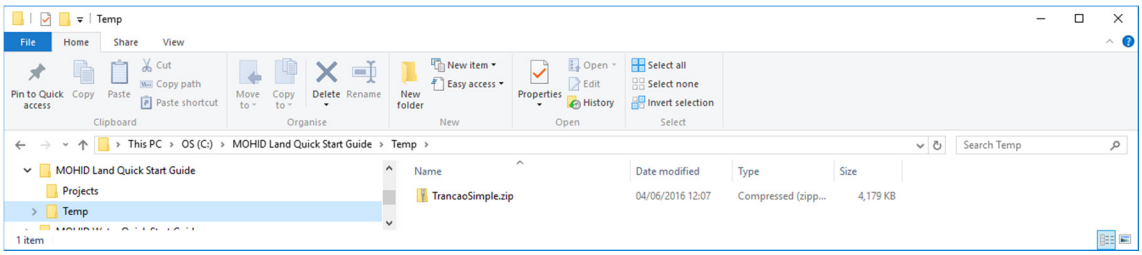
1. Create a directory C:\MOHID Land Quick Start Guide[1]
2. Create a directory C:\MOHID Land Quick Start Guide\Temp
3. Create a directory C:\MOHID Land Quick Start Guide\Projects

Download the demo project from the link below and store it in the "temp" directory created in 2.

- http://www.actionmodulers.com/Downloads/TrancaoSimple.zip

Please do **not** "unzip" this file, since MOHID Studio is expecting a ZIP file.

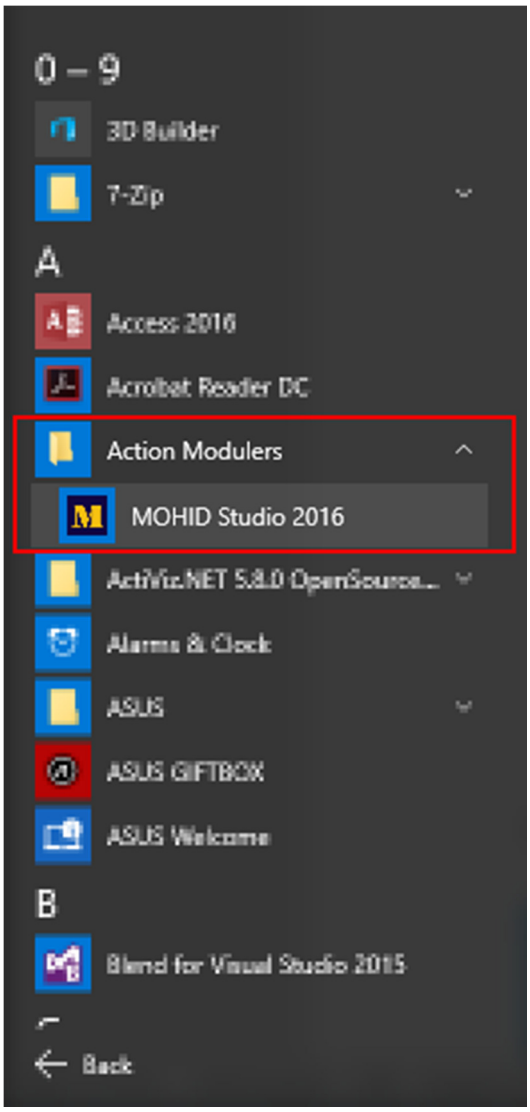
Now your directory should look like shown in the next figure.



[1] You can alternatively create this structure on a different disk (e.g. D:\)

3.3 Start MOHID Studio and import the preconfigured example

Start MOHID Studio by selecting Start -> Action Modulers -> MOHID Studio 2016.



You can alternatively use the icon on your desktop.

For this example, we have to create a new workspace. After MOHID Studio started, please select Home -> Workspace -> Open from MOHID Studio's main menu.

MOHID Studio's Workspace Manager Window appears which allows you to create a new work space. Choose "Start with an empty Workspace" and name it "MOHID Land Quick Start Guide".

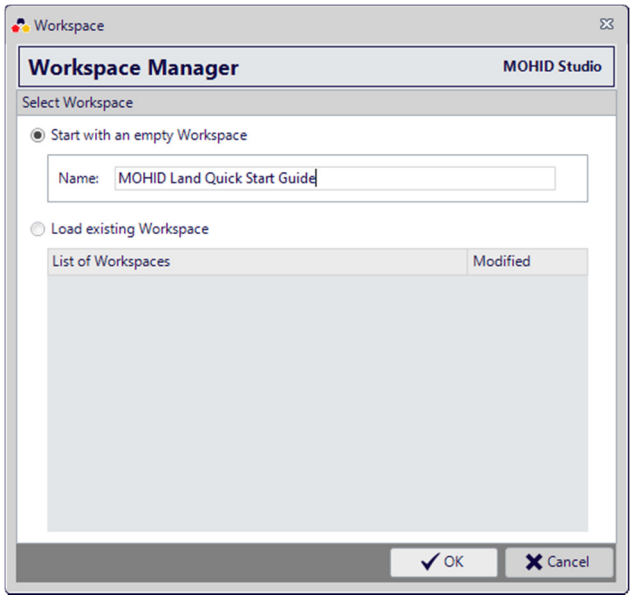
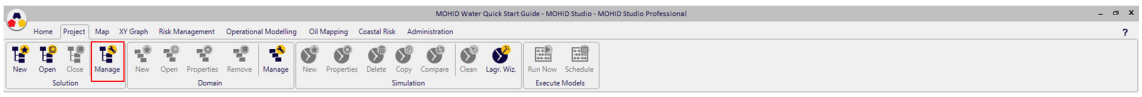


Figure 3.1: MOHID Studio Workspace Manager

Press ok to close the window.

Now we will import the previously configured example. Please select Project -> Solution -> Manage.



MOHID Studio's "Solution Management" window appears (Figure 3.2).

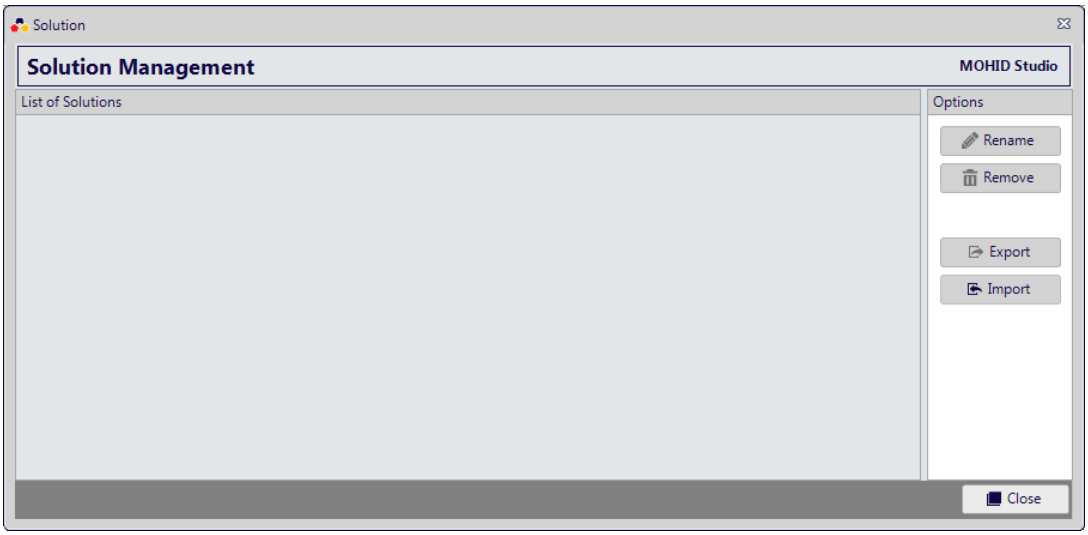


Figure 3.2: MOHID Studio Solution Management

In this window press the button "Import", located on right. The window "Import MOHID Solutions" will appear.

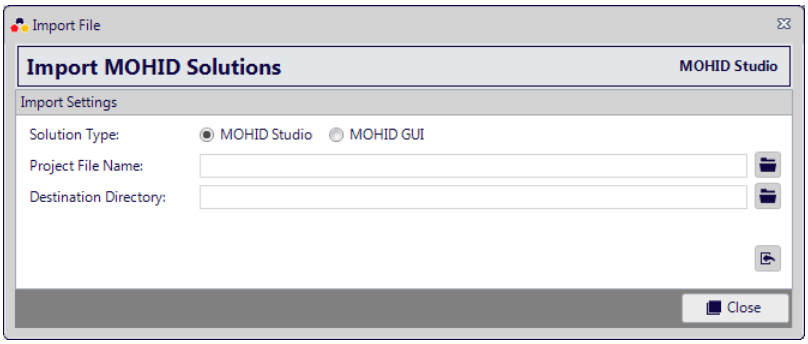


Figure 3.3: The Import MOHID Solution window

Select Solution Type “MOHID Studio” and under “Project File Name” browse for the file previously downloaded and stored in the “temp” directory (“C:\MOHID Land Quick Start Guide\Temp\TrancaoSimple.zip”).

The “Destination Directory” must be an empty directory. Please create a directory called “Trancao Simple” in “C:\MOHID Land Quick Start Guide\Projects”). You can to this after clicking the  button, as shown in the next figure.

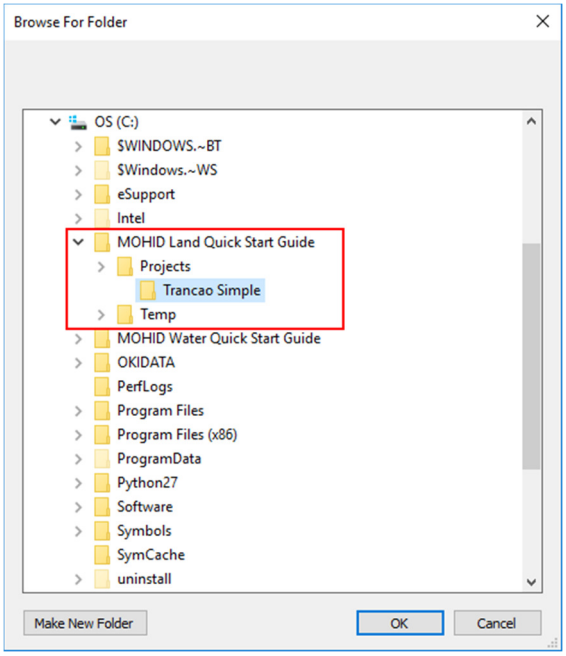


Figure 3.4: Creating the destination directory

Once you are done, the “Import MOHID Solutions” window should look like the one shown next.

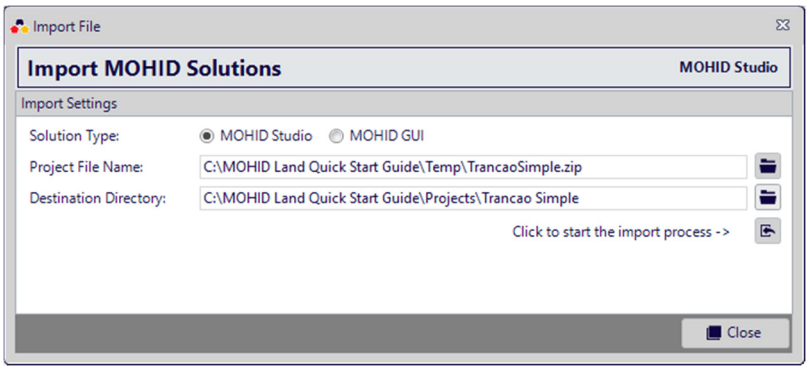


Figure 3.5: MOHID Studio Import Solution

Press the import button ( ) and wait until the import process is complete.

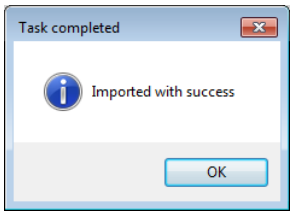


Figure 3.6: Message informing that the import process has finished

Close the message box and the "Import MOHID Solutions" window. In the "Solution Management Window" you should see now the imported solution, like shown next.

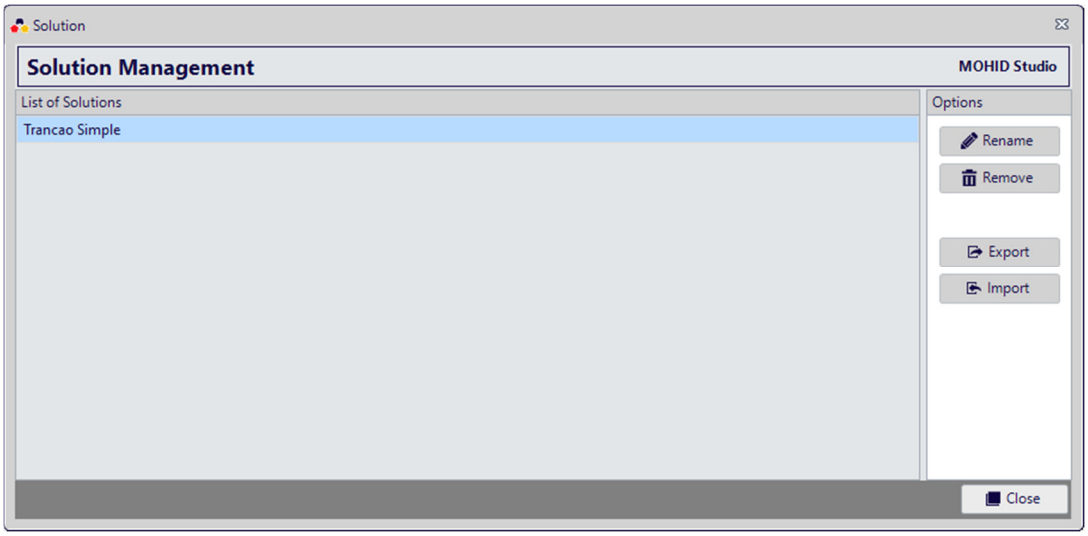
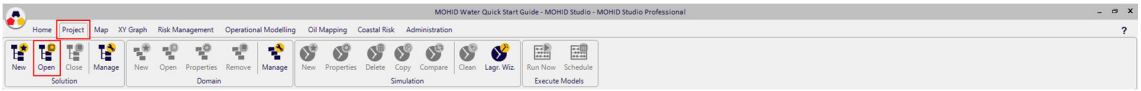


Figure 3.7: MOHID Studio Solution Management (after import)

NOTE: If a solution with the same name of the solution to import already exists, the newly imported solution is automatically renamed (example: Trancao Simple_1). Close this window also.

Now we have to open the solution we just imported and associate it to the current workspace, by selecting Project -> Solution -> Open.



The "Create or Open Solution" window appears with the solution "Trancao Simple", like shown in the next figure.

NOTE: The "Create or Open Solution" window looks very similar to the "Create Workspace window". The differences between workspaces and solutions are explained in the user manual.

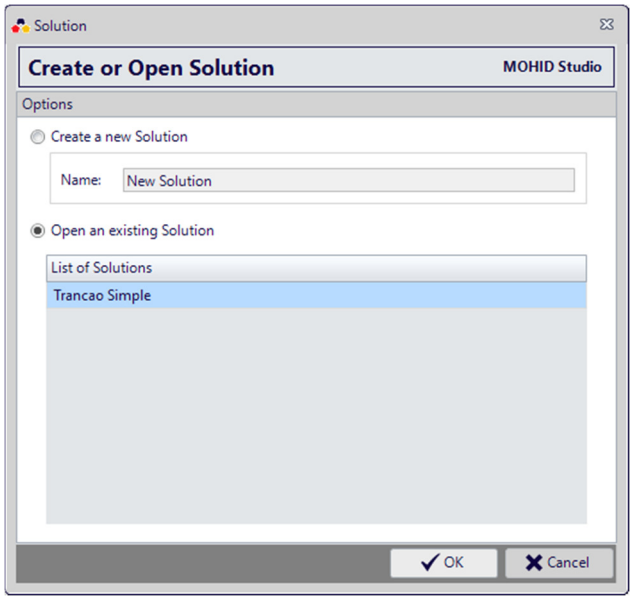


Figure 3.8: The "Create or Open Solution" window

In this window select "Open an existing solution" and select the "Trancao Simple". Press "OK" to close the window.

This action will open the "Trancao Simple" solution in "Explorer" tab. Press on the triangles (◢) to expand the tree view in the "Explorer". You screen should now look like shown in the next figure.

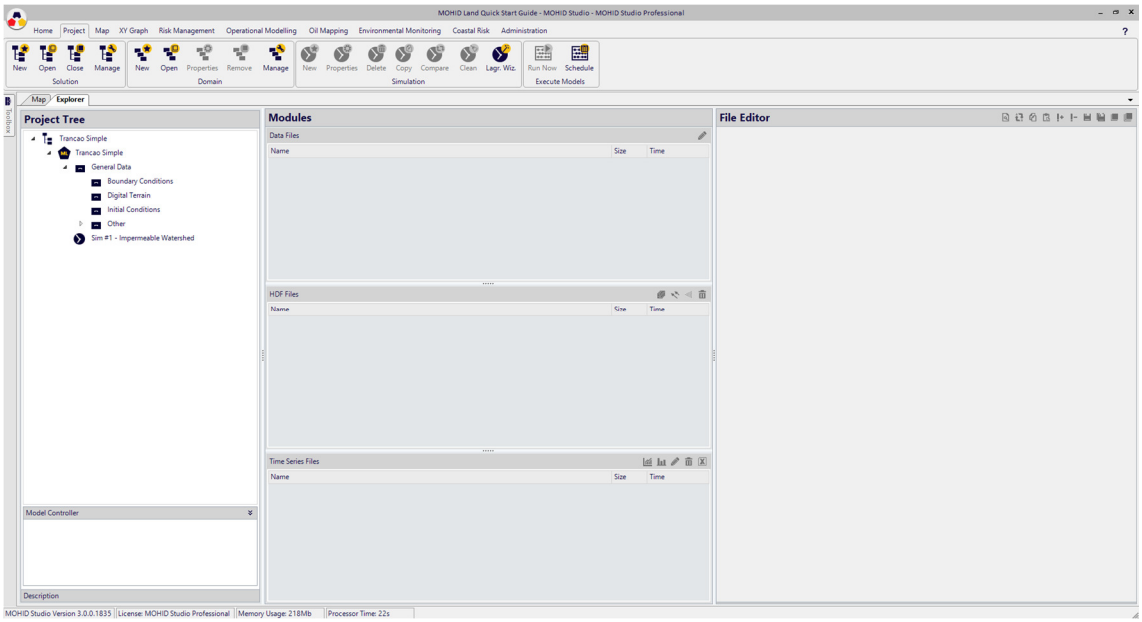


Figure 3.9: MOHID Studio's Explorer window after importing and opening the "Trancao Simple Project"

Step 2 – Navigating in the project structure

Like all MOHID Studio solutions, this solution is divided into the following items:

- the root element – the "Solution"
- one or more "Domains", in this case the "Trancao Simple".
- special folders for storing data common to all simulations
- simulations to run specific scenarios.

In the middle of the explorer window you will find the "Modules". By selecting any item in the "Project Tree", the "Modules" in the middle of the explorer window will be updated. For example, if you select the simulation "Sim #1 Impermeable Watershed", your window shows the data files associated with this simulation, as shown in the next figure.

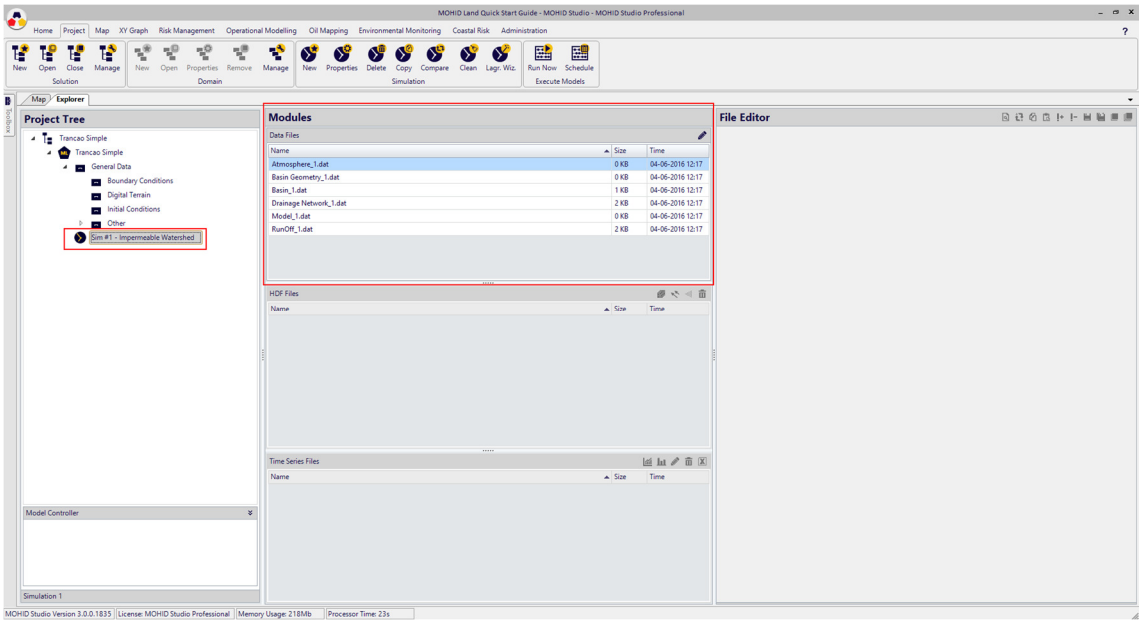


Figure 3.10: MOHID Studio's Explorer window – Data files

NOTE: The "Modules" are divided into 3 areas: Data Files, HDF Files and Time Series Files. Details about these file types are explained in the user manual.

The project management is one of the core features of MOHID Studio. Another feature is the internal GIS engine, which allows you to visualize all spatial data. Next we will show how to visualize the digital terrain of the Trancão Simple project.

3.4 Visualize the digital terrain of the Trancão Watershed

Adding layers to the GIS engine can be done directly from the "Explorer". To add the digital terrain of the Trancão Watershed, proceed in the following way:

In the Project Tree select the folder "Digital Terrain" (1). This will fill the Data Files under "Modules". Select the file "FinalDTM_160m_v4.dat" (2) and right click it. In the popup which appears select "Add to Map…" (3). Next screen shot shows these steps.

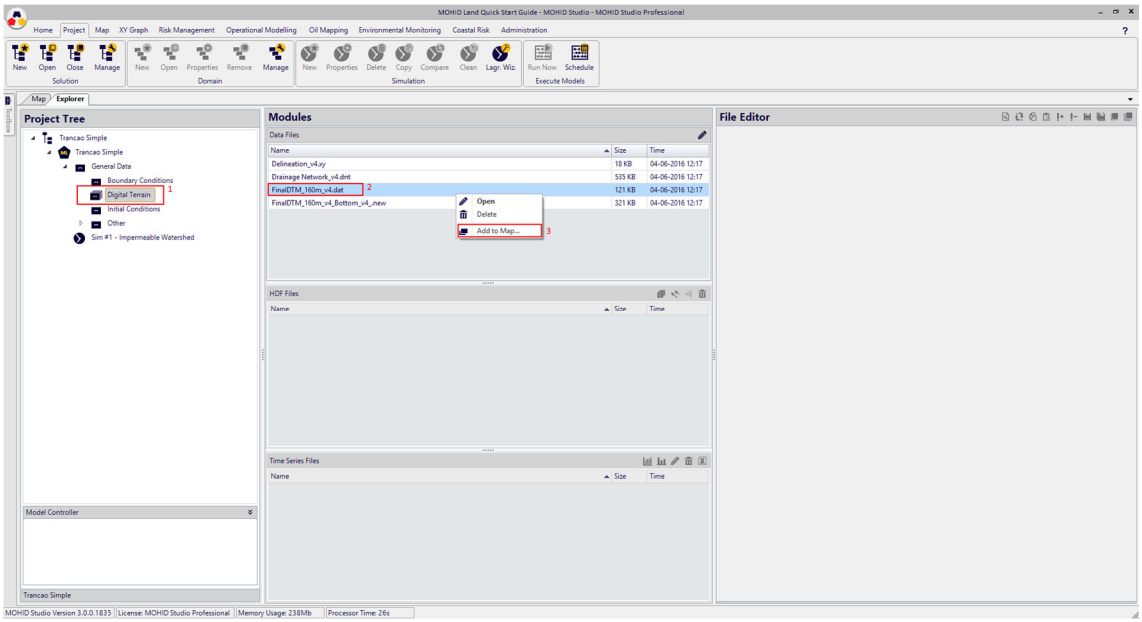


Figure 3.11: Selecting the bathymetry to be displayed in the map

The window “Add Vector Layer” appears.

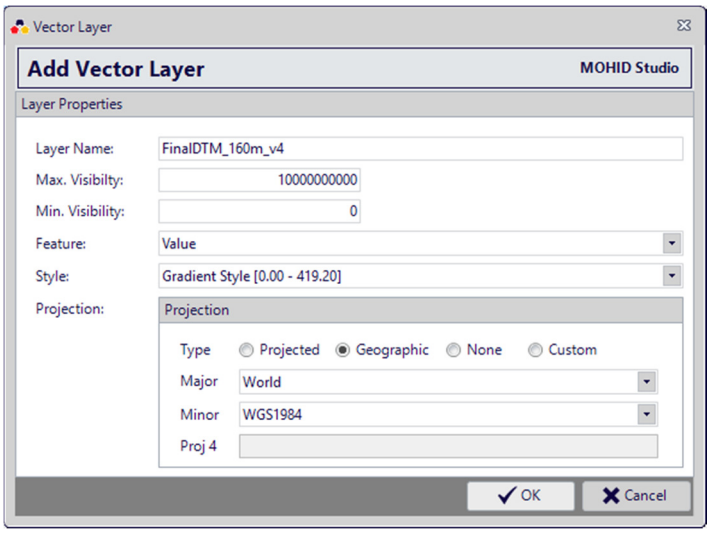


Figure 3.12: The “Add Vector Layer” window.

Just leave all default values as they are and press “OK”.

NOTE: If in this step appear a message complaining about the license, you don’t have a valid license to proceed (MOHID Studio Professional). We encourage you to request a temporary evaluation license. Check MOHID Studio’s Installation Guide for more information.

Now switch to the “Map” tab to see the digital terrain in the map window. Your screen should look like shown in the next figure.

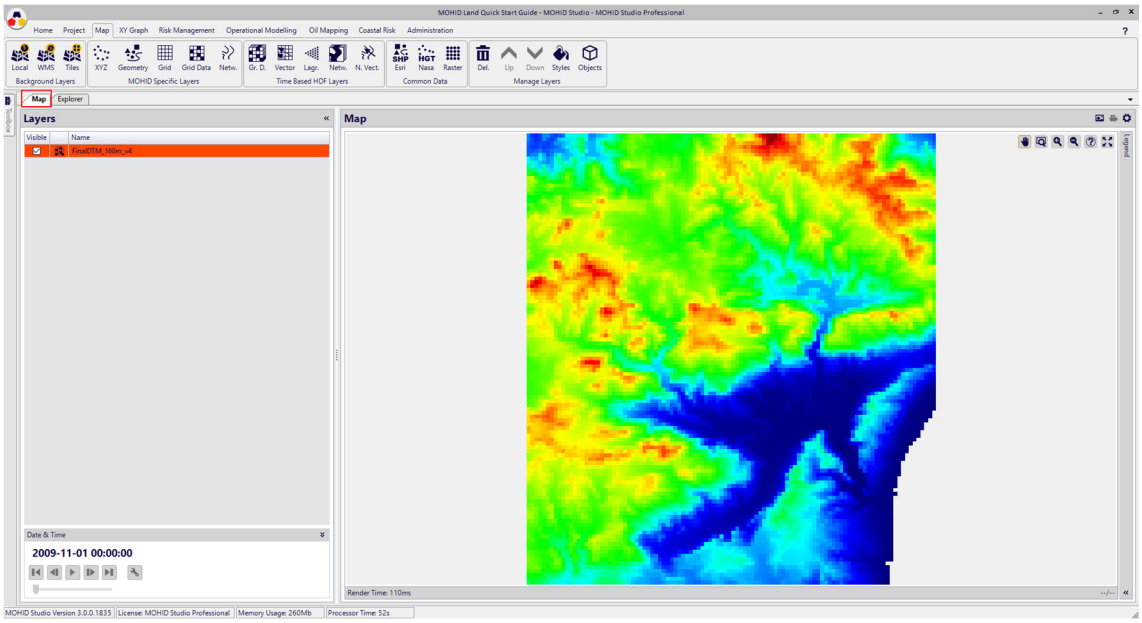


Figure 3.13: MOHID Studio Map Window with Trancão Watershed

To add a background map go to “Map” -> “Background Layers” -> “Tiles” (Figure 3.14).

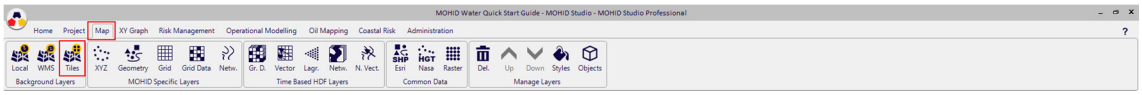


Figure 3.14: Add a background layer

A warning appears informing you that the coordinate system of the map has to be changed to “Web Mercator Projections” (Figure 3.15). Click “Yes” to continue.

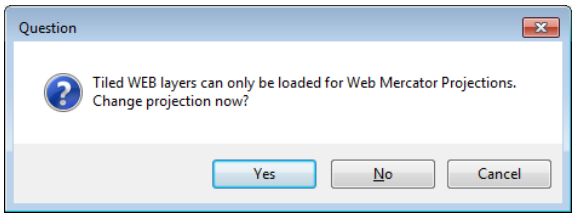


Figure 3.15: Changing the coordinate system

A window which lets you choose from a range of background layers will appear (Figure 3.16). Choose “Bing – Aerial” and OK to add the layer to the map.

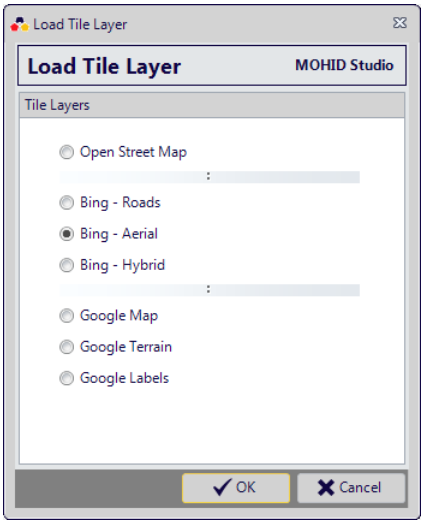


Figure 3.16: Selecting the type of background layer

Your main window now should look like the one in the next figure.

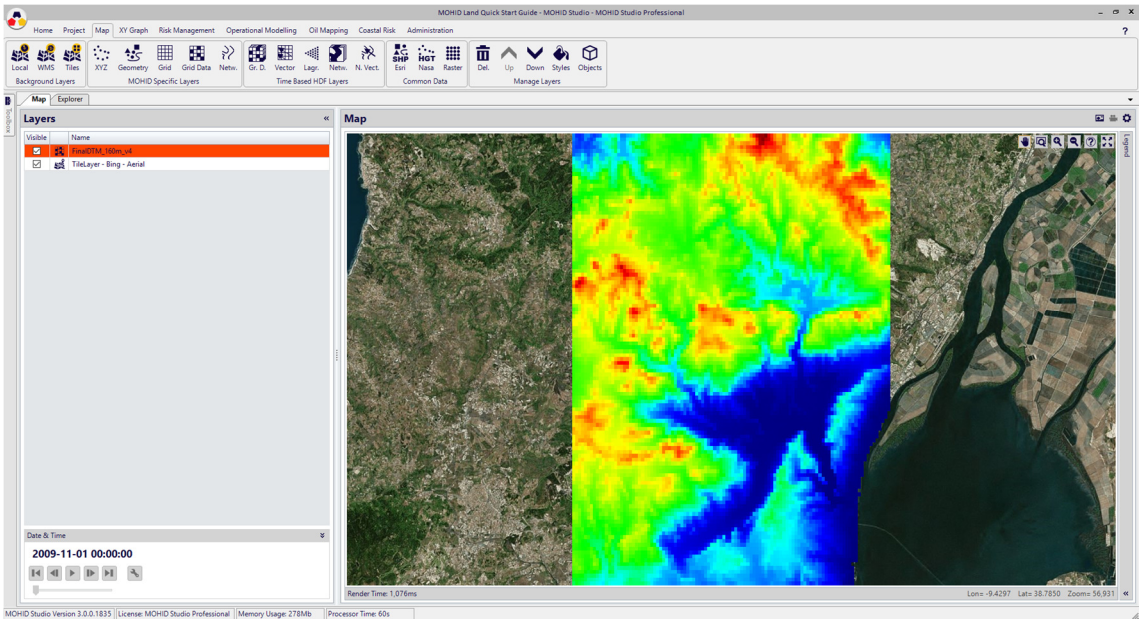


Figure 3.17: MOHID Studio with the Trancão Watershed and a background layer

3.5 Running a simulation

Now we will run a simulation of the sample project. Please switch back to the "Explorer" and in the "Project Tree" select the simulation "Sim #1 Impermeable Watershed" (1) and then select "Project" -> "Execute Models" -> "Run Now" (2). Figure 3.18 shows these two steps.

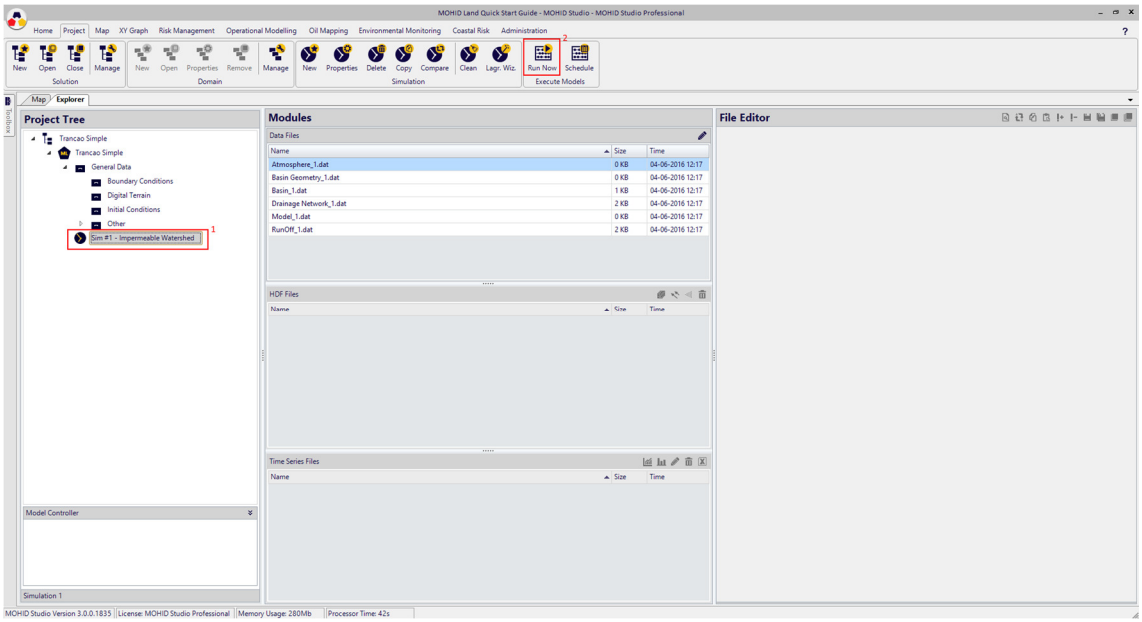


Figure 3.18: Running the simulation Sim #1

A window appears to confirm the execution of the model (Figure 3.19). Press “Yes” to continue.

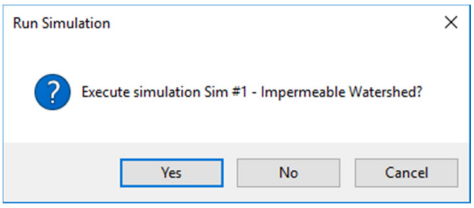


Figure 3.19: Confirm the execution of the simulation Sim #1

The box window called “Model Controller” below the domains and simulations is filled showing the progress bar of the simulation (Figure 3.20). To check more details on the simulation status press “Output” button to be able to see what is the current simulation time, the current computer time and the expected computer time when the simulation will end. The “Cancel” button in the window allows you to abort the simulation at any time.

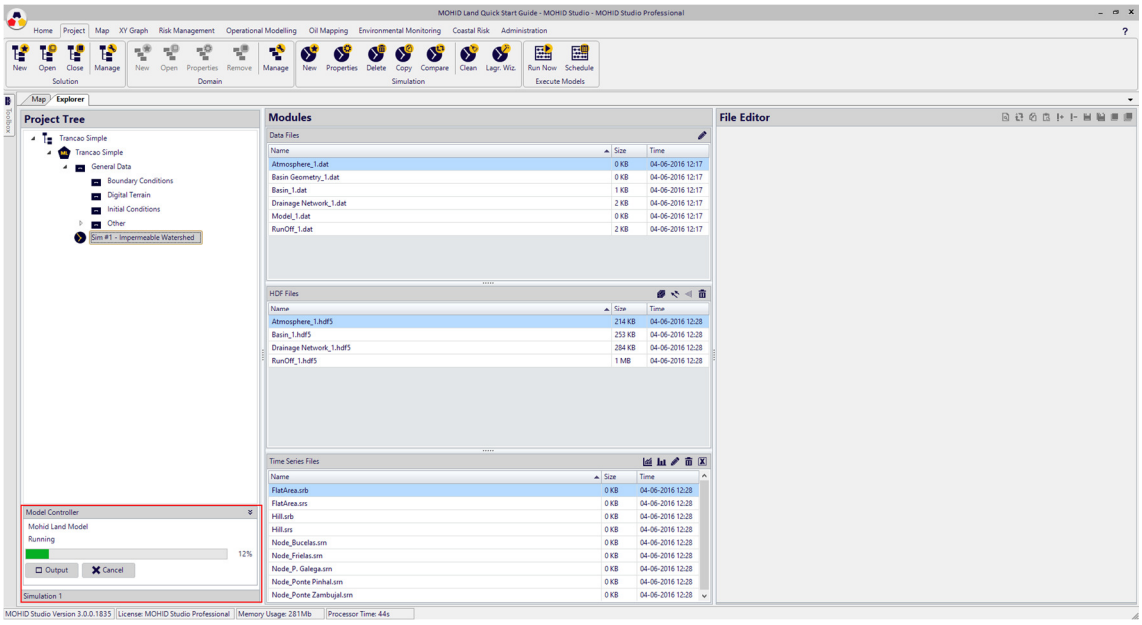


Figure 3.20: MOHID Studio Model Controller

At the end of the simulation a window notifies the user that the model has finished.

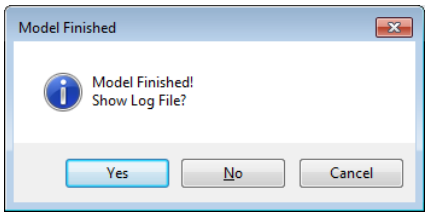


Figure 3.21: MOHID Studio Model Finished

To see the log file of the model run select “Yes”. A window with the log of the model run will appear.

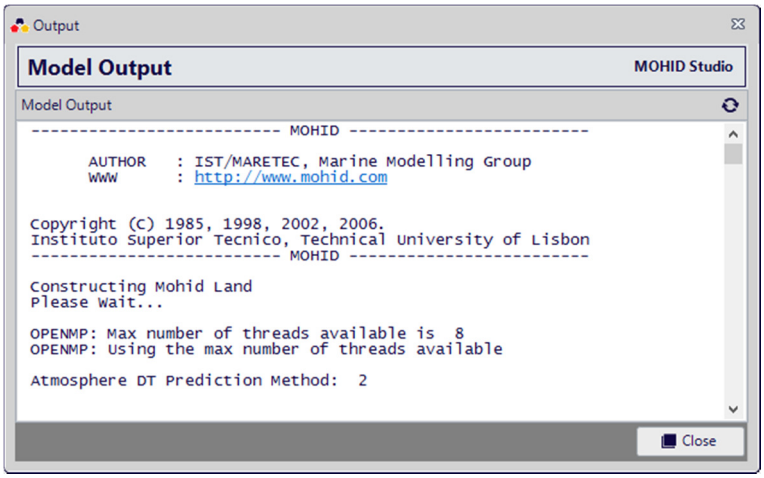


Figure 3.22: Model run log file

We recommend scrolling down this window until the end, so you can verify if the model did end successfully (Figure 3.23).

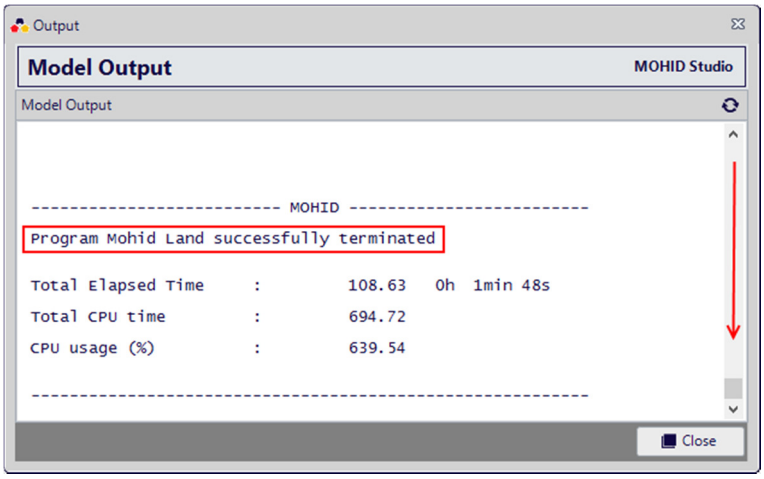


Figure 3.23: Model run log file (end of file)

3.6 Exploring the Results

During the simulation the model output files are created. When selecting the simulation that just finished running ("Sim #1 Impermeable Watershed"), the "Modules" section in the middle pane is filled with "HDF Files" and "Time Series Files" result data (Figure 3.24).

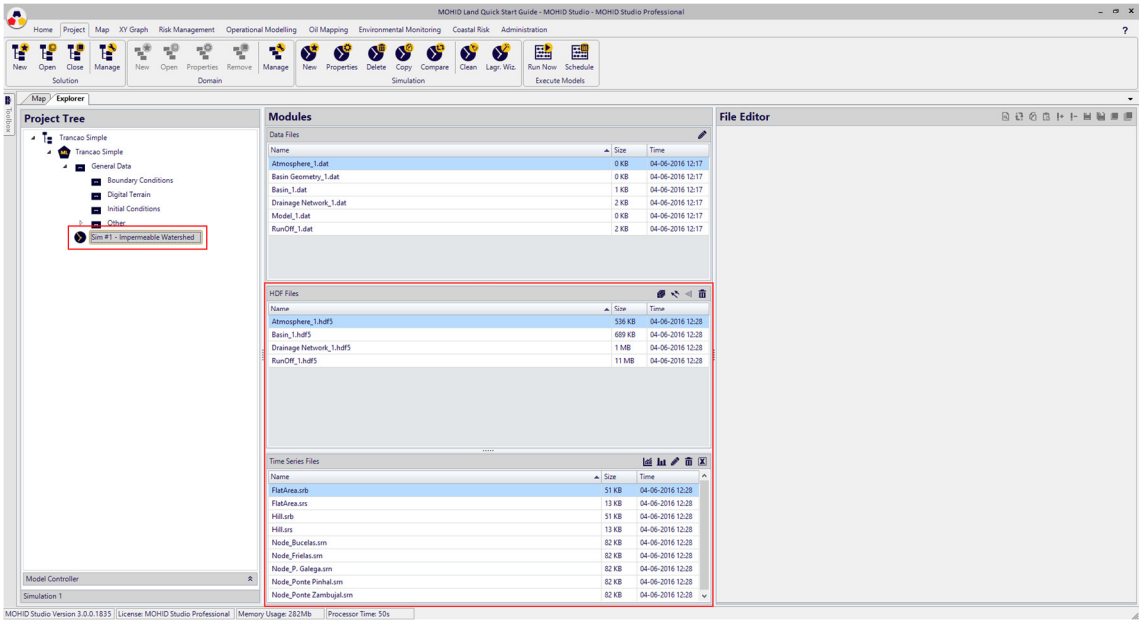


Figure 3.24: Result files of the simulation Sim #1

HDF files contain model results for the entire computational grid at different time instants of the simulation, similar to instantaneous snapshots of the study area. These results can be plotted as maps animated in time.

Time series files contain results for predefined computational grid points with high output frequency. These results can be plotter as time series graphs.

They way how these outputs can be configured will be explained later. More information on how to visualize results can be found in the "MOHID Studio User Guide".

We will start with creating a time series plot of the channel flow at a place called "Node_Ponte_Zambujal". For this we double click on the file "Node_Ponte_Zambujal.srn" in the "Time Series Files" list. This is the last of all files listed in this box. A window appears with a list of available time series. We choose "[channel flow] [MOHID Land Model] (Figure 3.25).

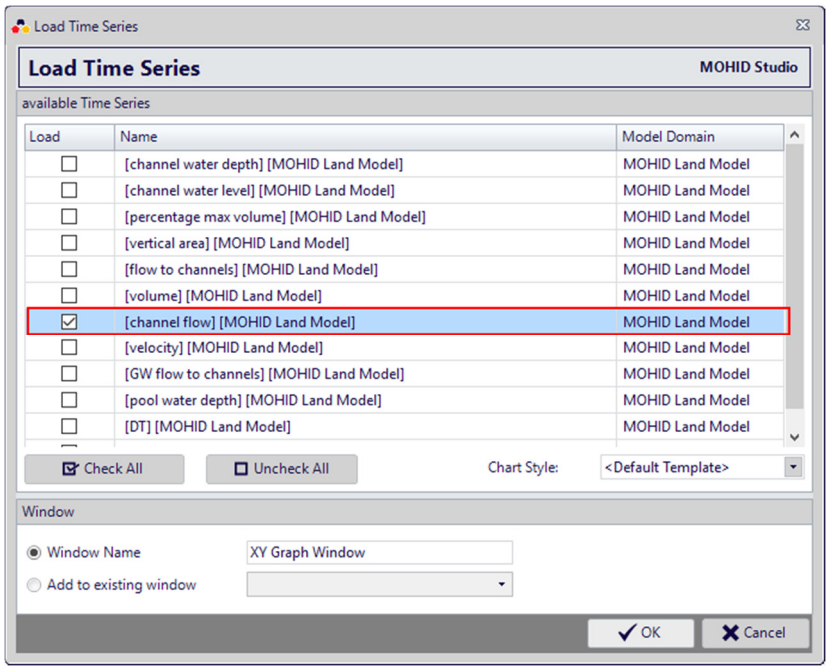


Figure 3.25: List of time series in the file "Node_Ponte_Zambujal.srn"

After pressing ok MOHID Studio creates a new XY Graph window with a plot of the selected series. Your screen should look like the one in the next figure.

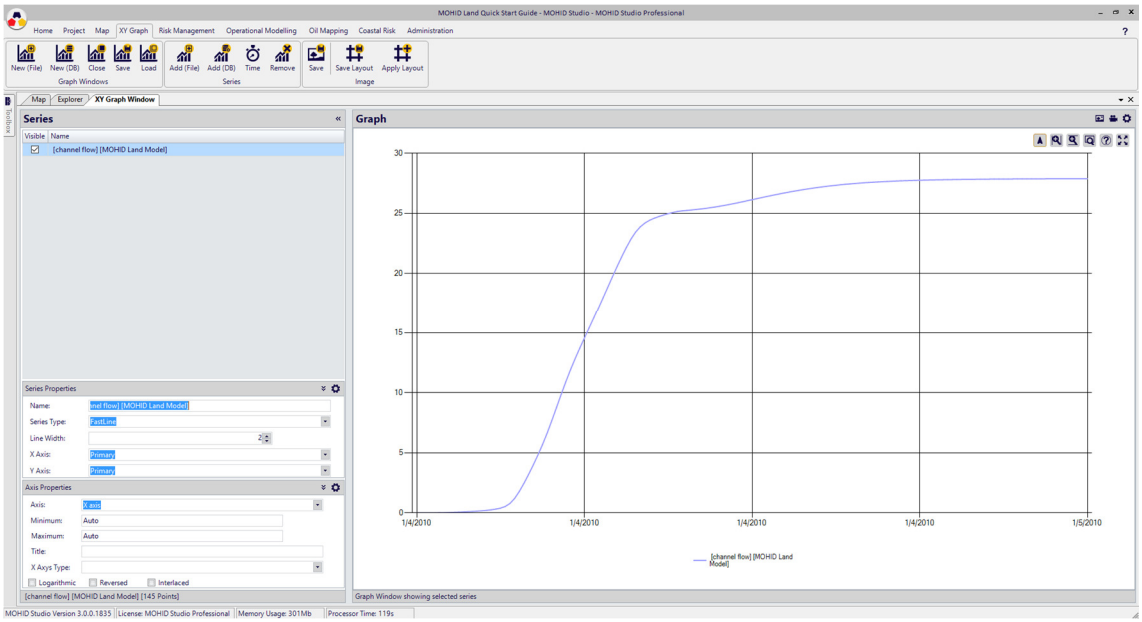


Figure 3.26: MOHID Studio time series of the channel flow (Sim # 1)

Now we will add the channel flow of the entire domain as animated layer to the map window.

First we switch back to the “Explorer Tab” and select the simulation “Sim #1 Impermeable Watershed” in the “Project Tree”. Then we double click on the file “Drainage Network_1.hdf5” in the HDF Files list. These steps are shown in the next figure.

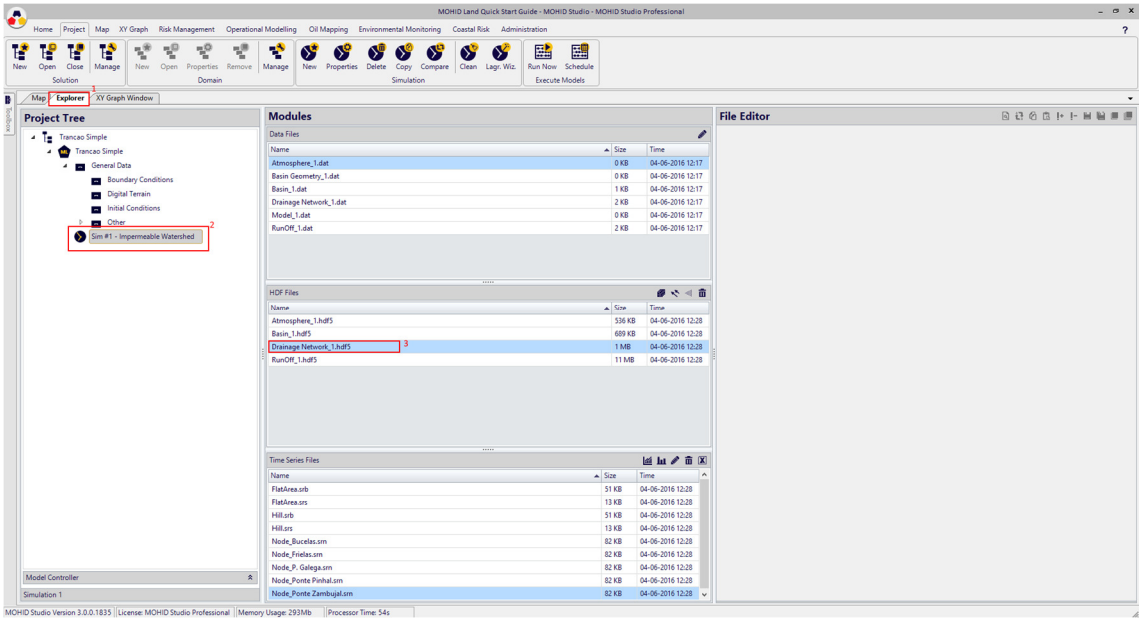


Figure 3.27: Displaying the channel water depth as animated layer – step 1

A window will appear which allows you to configure a set of options of what to display. Just leave all options unchanged (channel flow is the default property to display - Figure 3.28).

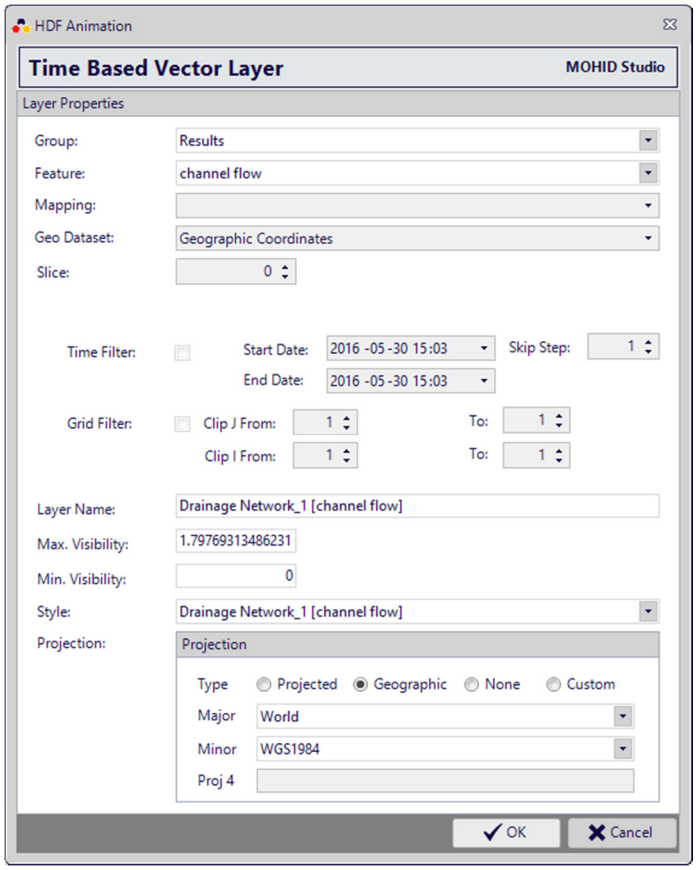


Figure 3.28: Displaying the channel flow as animated layer – step 2

Now you have to switch to the “Map” tab. On top of the digital terrain you now also see a layer which shows the flow in the channels. Your screen should look like the one shown in the next figure.

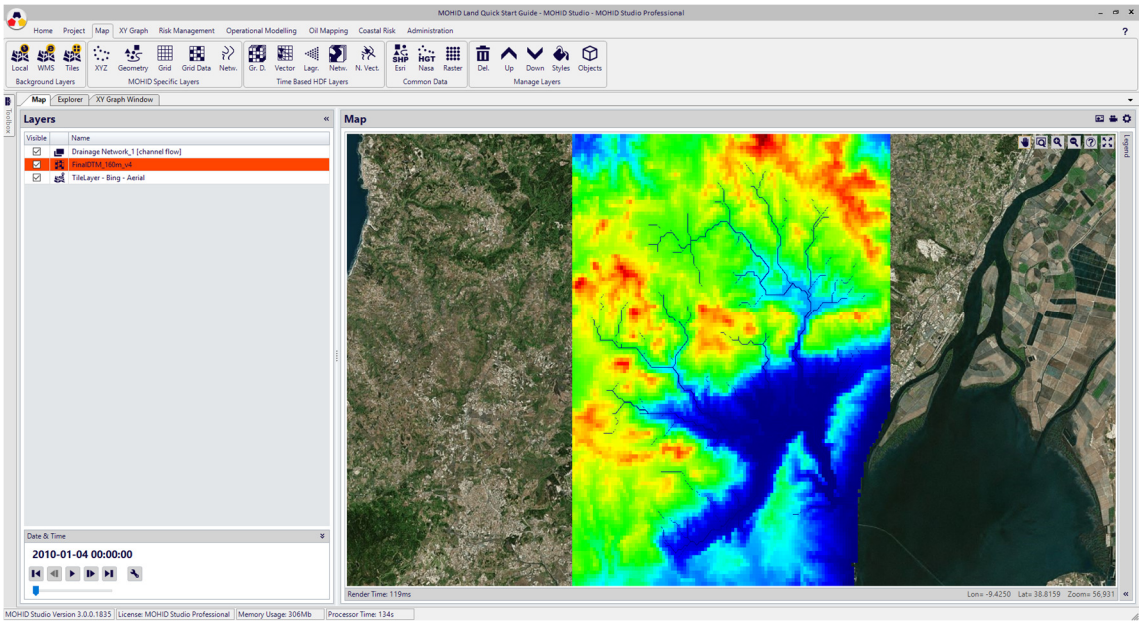


Figure 3.29: Displaying the velocity modulus as animated layer – step 3

You can now use the “Date & Time” controller, located in the lower left corner, to step forward and backward in time (Figure 3.30)

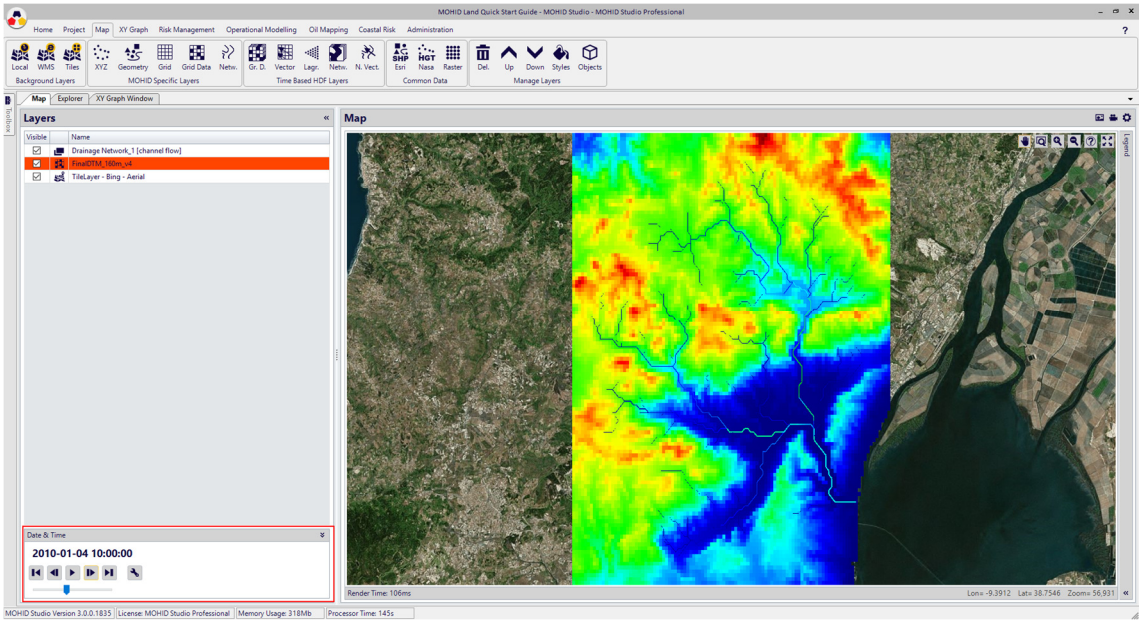
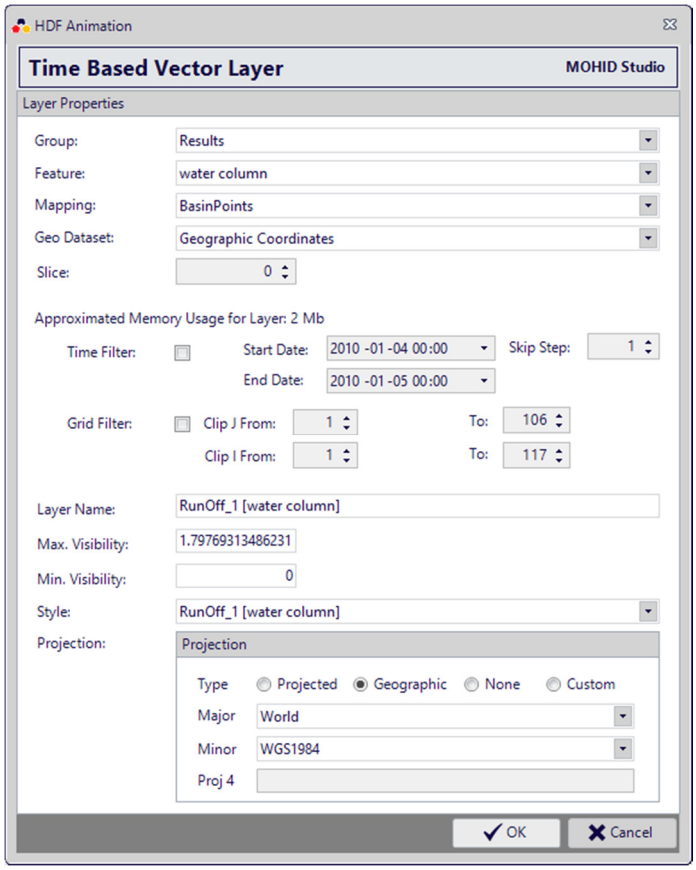


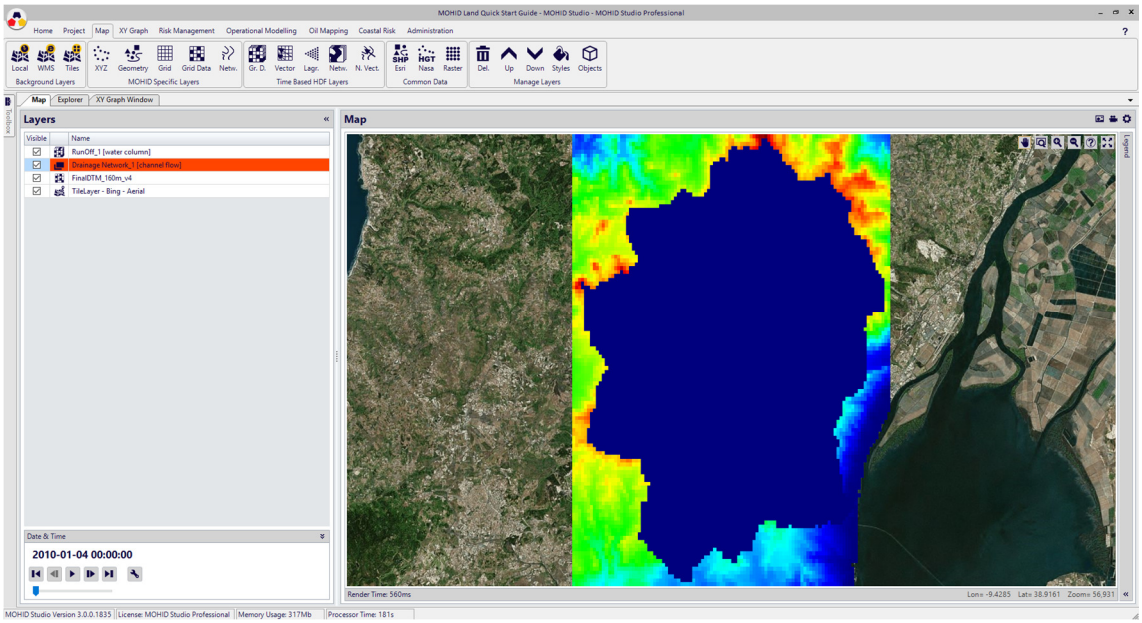
Figure 3.30: Displaying the velocity modulus as animated layer – step 4

Now we switch back to the “Explorer Tab” and select the simulation “Sim #1 Impermeable Watershed” in the “Project Tree”. Then we double click on the file “RunOff_1.hdf5” in the HDF Files list. The same dialog as shown previously appears, allowing us to select which type to load as layer.

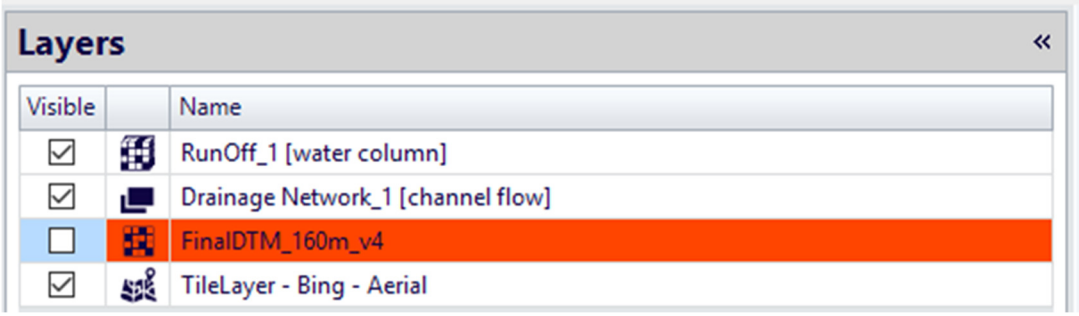


Just leave all options unchanged (this time water column is the default property to display) and press OK. Switch to the Map TAB.

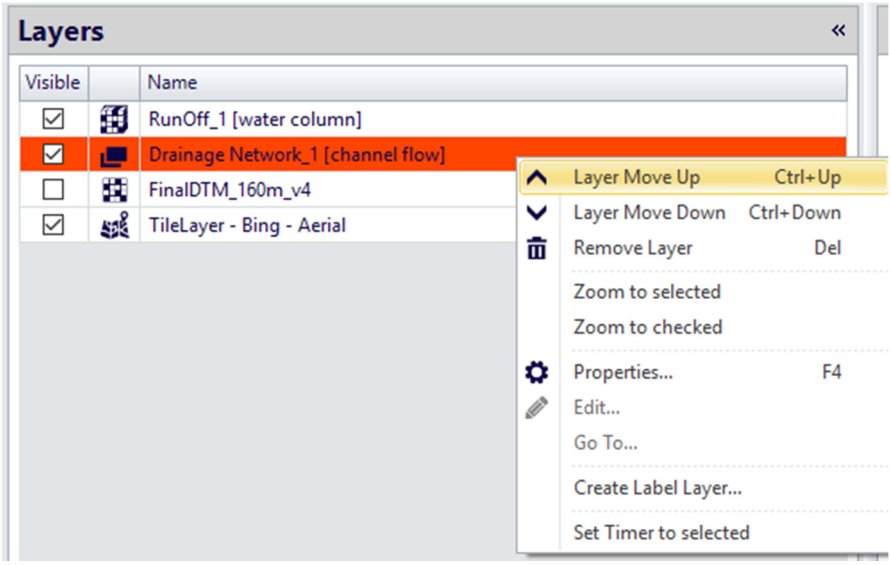
Now your display shows the water column, the flow in the channel, the DTM and a background layer and should look like the following figure.



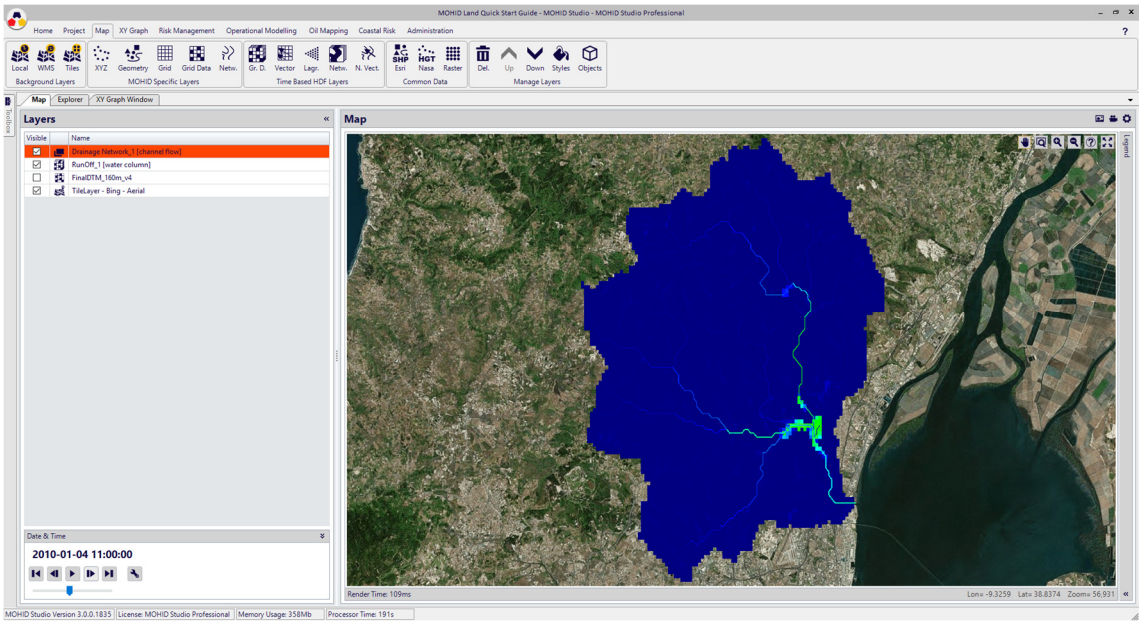
We will organize the display. First we switch off the DTM, by unselecting the check box in the layer list.



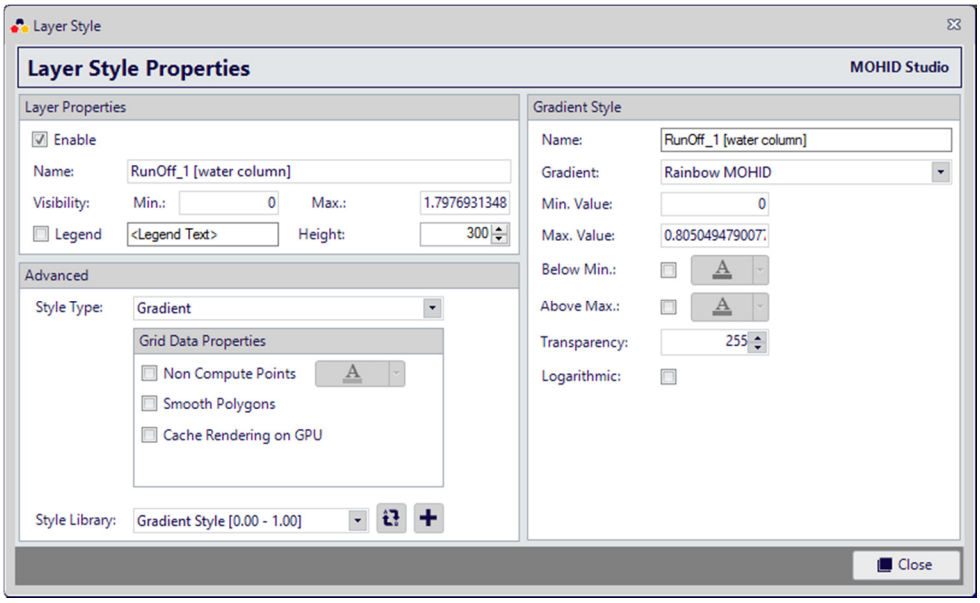
We also will move the “Channel Flow” layer on top of the “Water Column” layer by selecting it (left mouse button) and then using the context menu (right mouse button) to choose “Move Up”.



Using again the timer to step forward in time, you can now see the channel flow and the water column represented as colors, as shown in the next figure.



There are many ways to customize how these layers are displayed. You can access the properties of the current selected layer by pressing “F4”. For example, the next window shows the properties of the layer “Runoff_1 [water column]”.



To know more on how to customize the time series window (axis titles, series names and colors, etc.) and map images (color scale, horizontal scale, etc.) check the MOHID Studio User Guide.

With this we finished the first exercise. In the next exercise we will create a new project from scratch. Please close MOHID Studio.

4 Exercise 2 - Simulating rainfall runoff event

4.1 Introduction

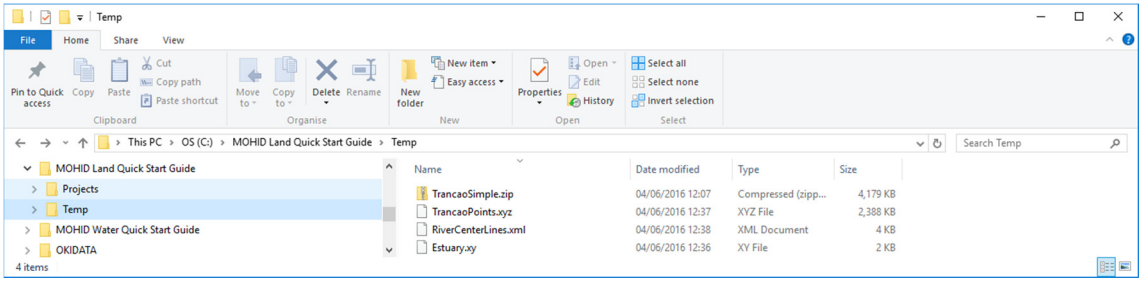
This section will show how to create a MOHID Land project to simulate a rainfall runoff event. We will simulate the same area as in the previous example, but rather than using a prepared project, we will go through all steps required to set up the model. The area we will simulate is the same as in the previous example.

4.2 Preparation

For Exercise 2, please download the files “Estuary.xy”, “TrancaoPoints.xyz” and RiverCenterLines.xml and store them in C:\MOHID Land Quick Start Guide\Temp (or any other directory created in 3.2)

- http://www.actionmodulers.com/Downloads/Estuary.xy
- http://www.actionmodulers.com/Downloads/TrancaoPoints.xyz
- http://www.actionmodulers.com/Downloads/RiverCenterLines.xml

Now your “temp” directory should look like shown in the next figure.



4.3 Step 1 – Creating a new Workspace, Solution and Domain

First we will create a new workspace for our project. Start MOHID Studio and select Home -> Workspace -> Open from the main menu. The Workspace Manager Window appears. Select “Start with an empty Workspace” and provide the name “My First Workspace”. Your window should look like the one shown in Figure 4.1.

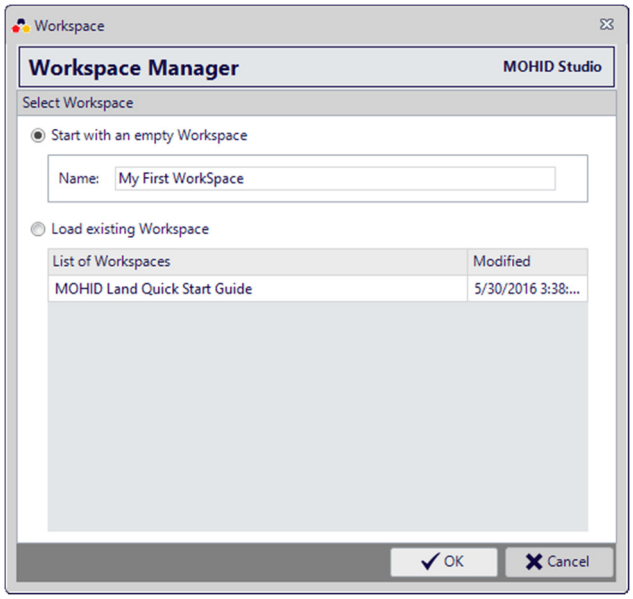
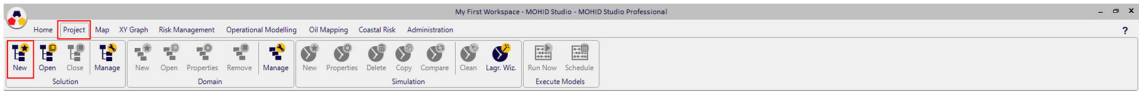


Figure 4.1: Workspace Manager Window – Creating a new Workspace

Click on "OK" to close the window.

Create a new solution by selecting Project -> Solution -> New from the main menu.



The Create or Open Solution Window appears. Select "Create a new Solution" and provide the name "My First Solution". Your window should look like the one shown in Figure 4.2.[2]

[2] Even in a first approach it seems that a "Workspace" and a "Solution" are the same, they aren't. You will later understand the differences.

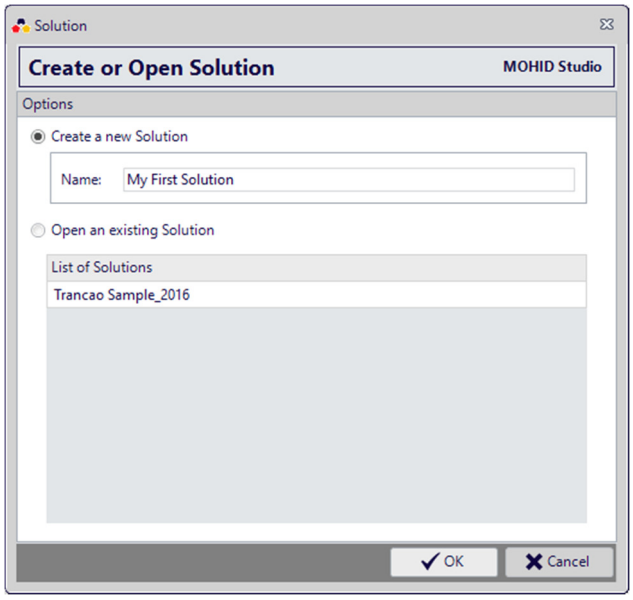


Figure 4.2: Create or Open a Solution – Creating a new Solution

Click OK to close the window. You should now see the solution in the Explorer Window -> Project Tree as shown in the next figure.

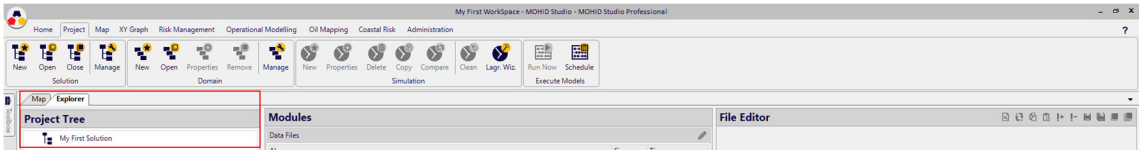


Figure 4.3: Explorer Window after creating a solution

Now we select the solution in the Project Tree and select Project -> Domain -> New from the main menu. The Domain window appears. As “Domain Name” use “Trancao Watershed” and for the root directory select the following directory:

C:\MOHID Land Quick Start Guide\Projects\Trancao Watershed

You can use the  button to browse for the Root Directory. Here you can browse for the directory where you like to store the files associated with the domain. In this example we created a subdirectory “Trancao Watershed” in the directory created in 3.2.

Also change the “Numerical Model” to “MOHID Land”.

Your window should now look like the one shown in Figure 4.4.

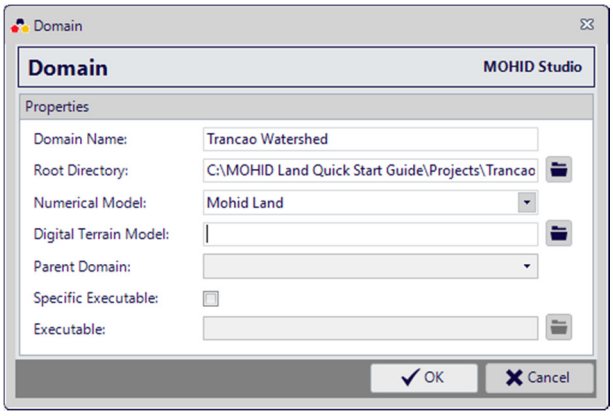


Figure 4.4: MOHID Studio create new domain

Leave all the other fields empty and press OK to close the window.

Now we have created the basic structure of the project (solution + domain). Your Explorer Window should look like shown in the next figure.

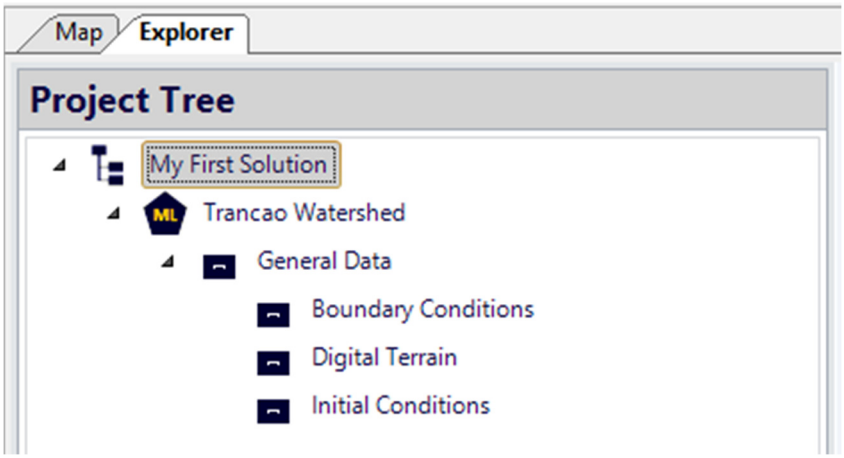


Figure 4.5: Explorer Window after creating workspace, solution and domain

More information on how to manage solutions and domains can be found in "MOHID Studio User Guide" in chapter 3.

4.4 Step 2 – Generate the Topography

4.4.1 Introduction

Now we will generate a topography file. This file defines the horizontal domain (computational grid and height values for each grid cell) and is the basic and most essential information need to run any MOHID Land simulation.

To create a topography file, the following is needed:

- **Digital terrain data** in point format (XYZ)
- **A polygon** defining the areas where the model will not calculate any values (water points).
- **The computational** grid for the model.

The **digital terrain data** can be obtained from many sources (e.g. ETOPO, SRMT, local data provider), but it must be formatted into MOHID's XYZ format. More information about MOHID's XYZ format can be found here:

http://www.mohid.com/wiki/index.php?title=XYZ_Points

For this exercise we downloaded already, during the preparation process, the file "TrancaoPoints.xyz". You can open this file with any text editor to check the format.

The polygon defining the areas where the model will not calculate any values can be provided in MOHID's XY format, MOHID Studio's XML format or as ESRI Shapefile. For this exercise we downloaded already, during the preparation process, the file "Estuary.xy". You can open this file with any text editor to check the format. More information about this XY format here:

http://www.mohid.com/wiki/index.php?title=Polygon

The computational grid will be constructed with a specific tool found inside MOHID Studio.

4.4.2 Importing the base data into the simulation

Even not strictly required, we will copy the two previously downloaded files into the directory structure of the solution we just created. Expand the "Project Tree" and select the folder "Digital Terrain". After selecting, right click it and choose "Import File…", as shown in the next figure.

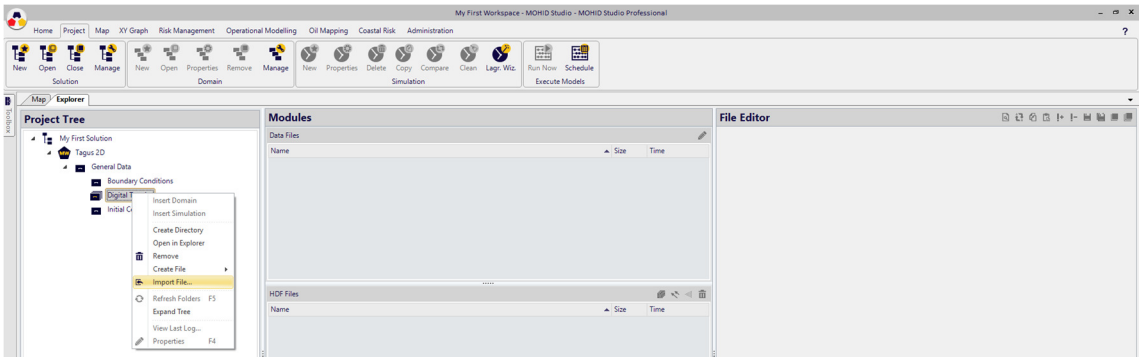


Figure 4.6: Importing the base data

Browse to the directory (C:\ MOHID Land Quick Start Guide\Temp) where you stored the files “TrancaoPoints.xyz”, “Estuary.xy” and “RiverCenterLines.xml”, select the three files and click Open. You should now see these files listed under Modules -> Data Files.

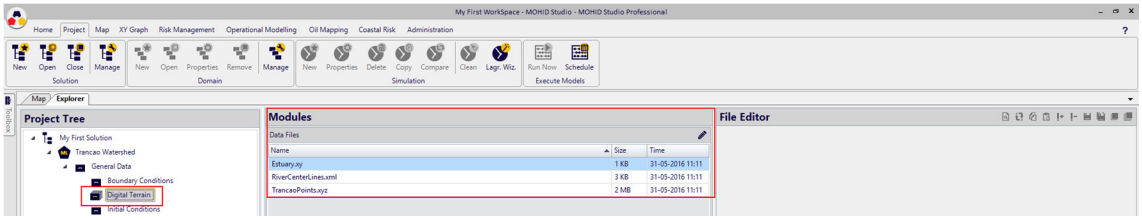


Figure 4.7: Files after importing

4.4.3 Adding the base data to the map

Under the Modules -> Data Files, select the file “TrancaoPoints.xyz” and select “Add to Map” from the context menu (Figure 4.8).

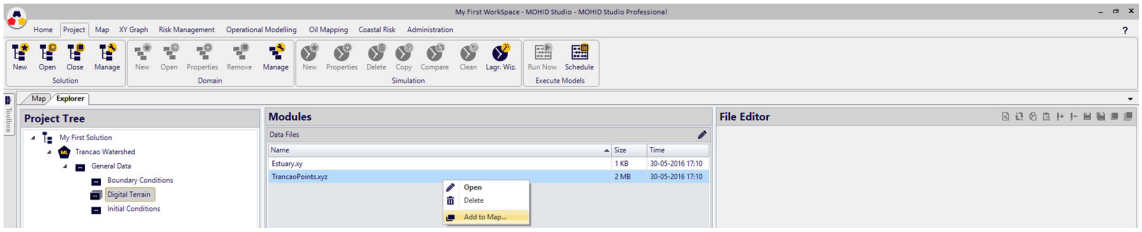


Figure 4.8: Adding the base data to the map 1/2

On the dialog which appears, just press OK to continue.

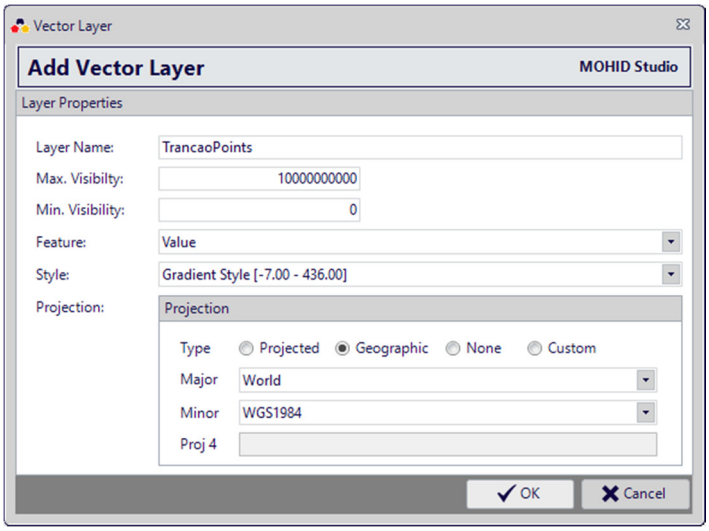


Figure 4.9: Adding the base data to the map 2/2

Repeat the steps above for the file “Estuary.xy” and the file “CenterRiverLines.xml”

Now, when switching to the “Map” you should see an image similar to the one shown in the next figure.

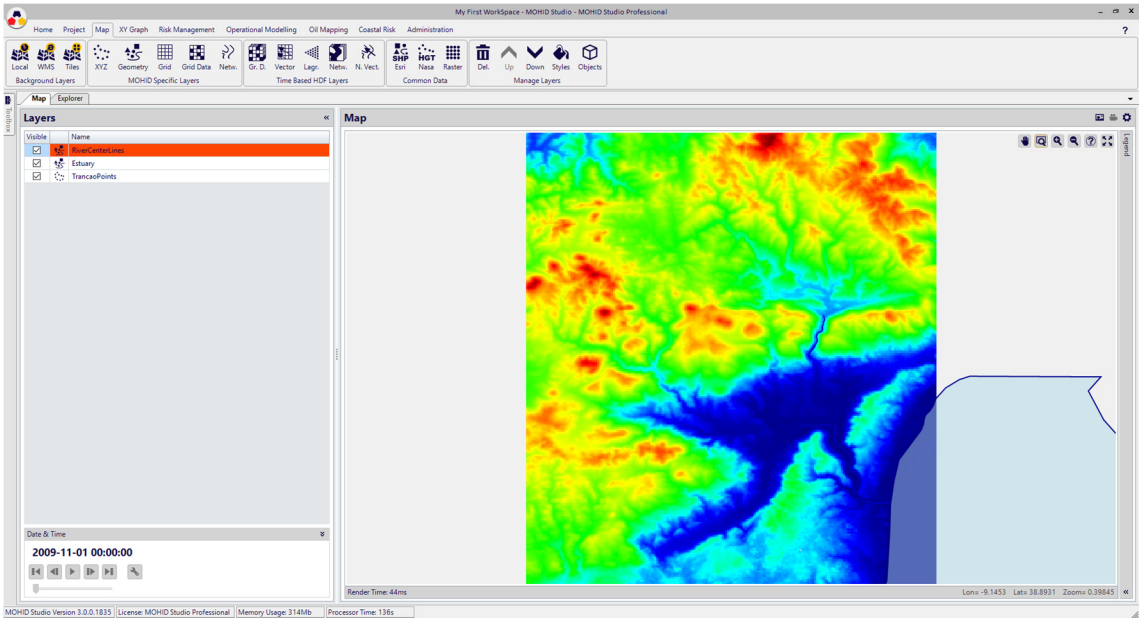


Figure 4.10: Map with base data

4.4.4 Generate the computational grid

Open the Tool Box and double click on Grid -> Constant Spaced Grid. This will open the “Constant Spaced Grid Tool” docked on the right of the main area. Your window should look like the one shown in the next figure.

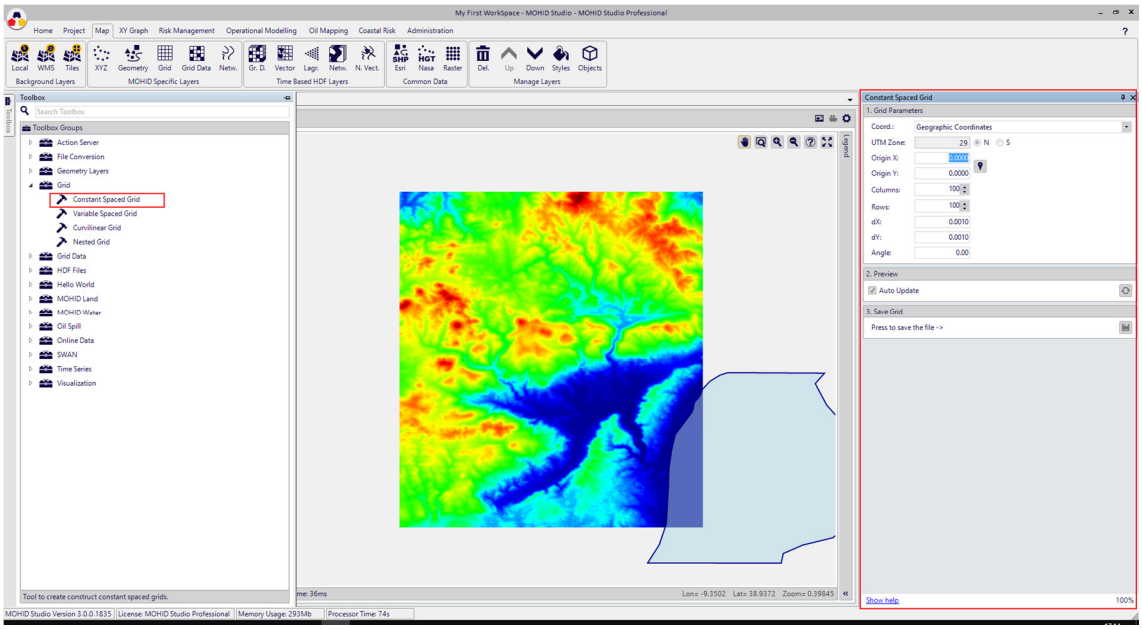


Figure 4.11: Create Constant Spaced Grid tool

We will create a constant spaced horizontal grid with the parameters indicated in the next table.

Parameter	Value	Description
Coordinate Type	Geographic Coordinates (the default)	Type of the coordinates to use. Options are geographic, UTM and metric (local) coordinates.
Origin X	-9.275	X coordinate of the lower left corner.
Origin Y	38.755	Y coordinate of the lower left corner.
Columns	205	Nº of columns of the grid
Rows	232	Nº of rows of the grid
dX	0.001	Size of the grid cells along the X axis. Given in units of the coordinate system (in this case º).
dY	0.001	Size of the grid cells along the Y axis. Given in units of the coordinate system (in this case º).
Angle	0.0	Rotation of the grid.

After filling this options, your window should look like shown in the next figure.

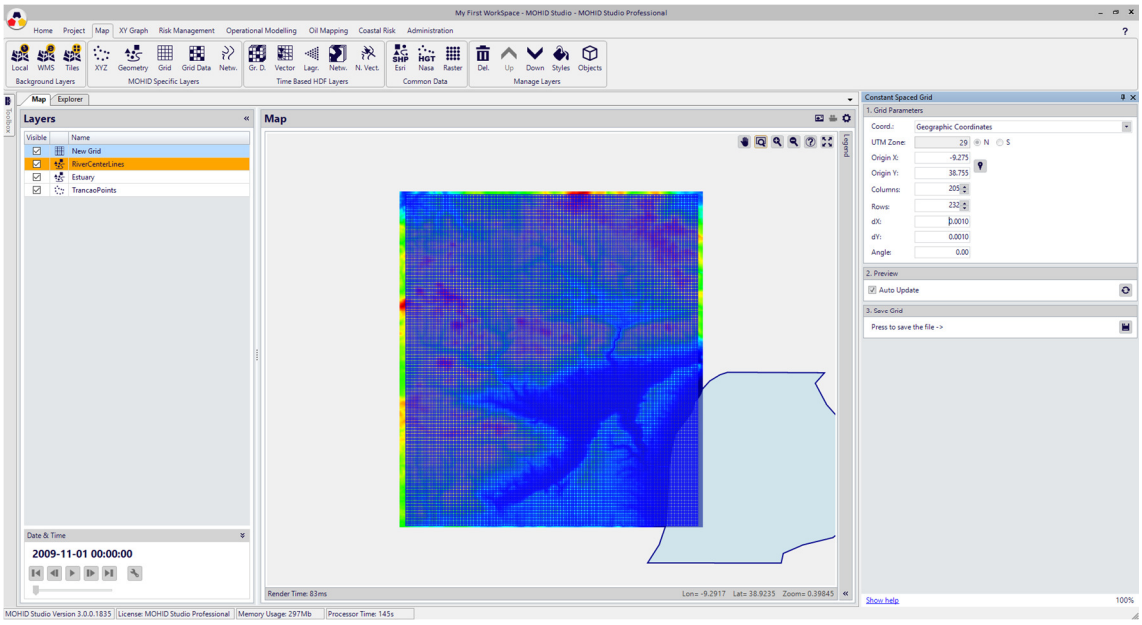


Figure 4.12: Create Constant Spaced Grid tool - 2

Press the save button ( ) in the lower right corner of the tool window and to save the grid file with the name "TrancaoGrid.grd" in the directory C:\MOHID Land Quick Start Guide\Projects\Trancao Watershed\General Data\Digital Terrain.

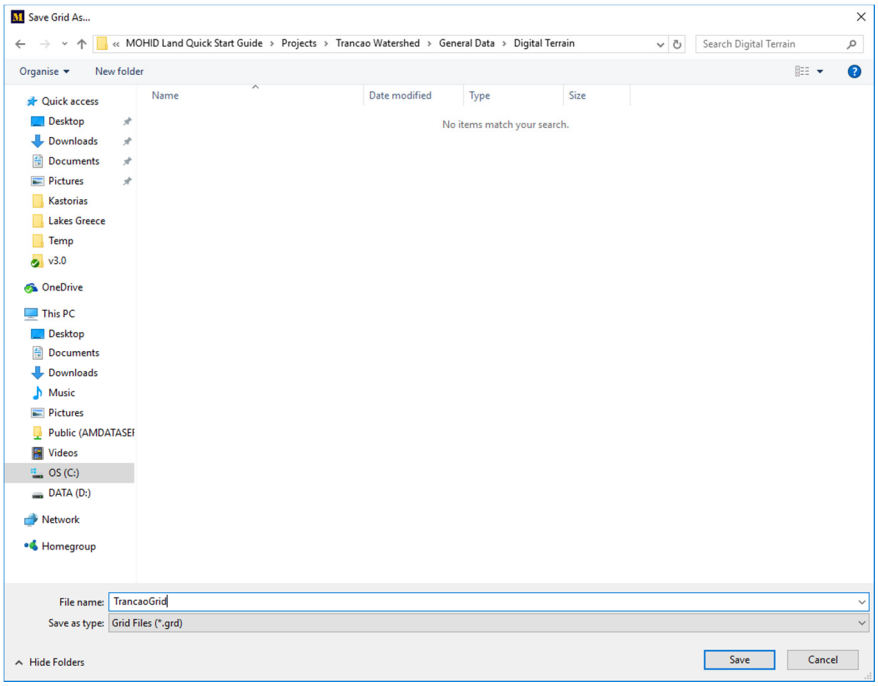


Figure 4.13: Selecting the destination of the grid file

When the tool closes, the grid remains loaded in the Map Window.

4.4.5 Generate the digital terrain

The base data for any MOHID Land model is the digital terrain (or topography), which is provided in form of a Grid Data file. More information about MOHID's Grid Data format can be found here:

http://www.mohid.com/wiki/index.php?title=Grid_Data

MOHID Studio contains several tools to create and manipulate grid data files.

Now, to create the topography we will need three data sets:

- XYZ points (TrancaoPoints.xyz - already loaded)
- Definition of the non-compute areas (Estuary.xy - already loaded)
- The computational grid (TrancaoGrid – created in the previous step)

To create the grid data we will use the "Grid Data" -> "Construct from Points" tool. Double click the tool to open it, as shown in the next figure:

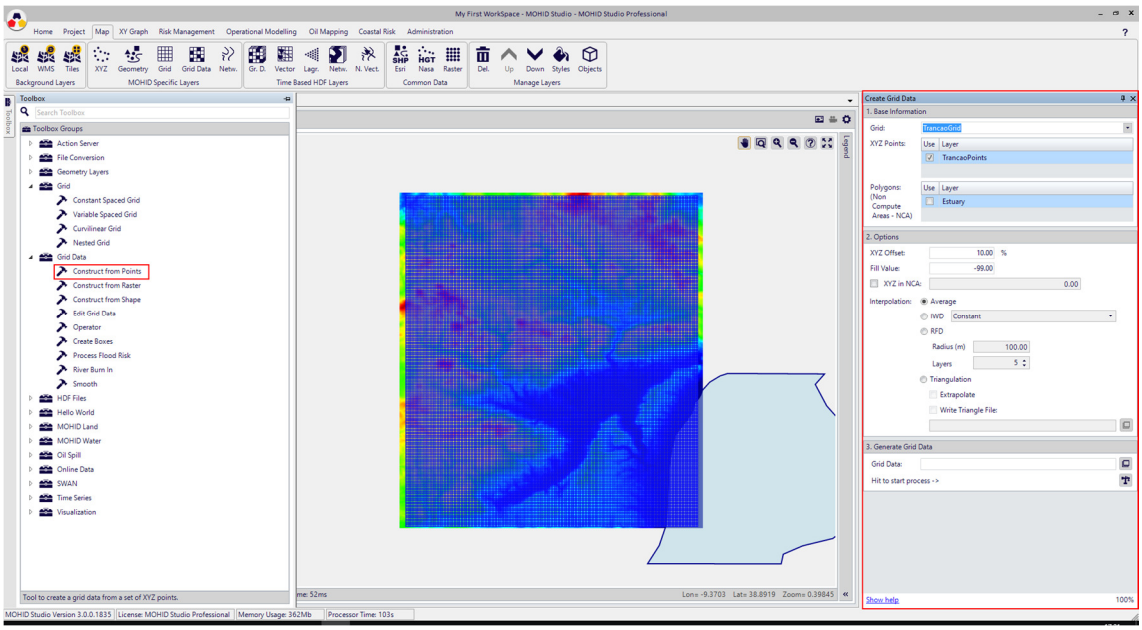


Figure 4.14: The Construct Grid Data Tool

We will now construct the topography with the following options indicated in the following table.

Parameter	Value	Description
Grid	Trancao Grid	The grid which is to be used to create the grid data.
XYZ Points	TrancaoPoints	The point dataset(s) which are to be used to fill the grid. In this example we only have one, but you can use multiple XYZ files.
Polygons	Estuary **(check it!)**	The polygon(s) which define non compute areas (water bodies in the case of MOHID Land). The model will not compute any values in the cell covered by these polygons.
XYZ Offset	10%	Offset from the grid, in percentage, of the maximum distance from the "XYZ Points" are considered when using interpolation algorithms.
Fill Value	-99.0	The value to be attributed in non-compute areas. You should not change this value unless you have a specific reason for.
XYZ in NCA	Leave uncheck	If you want to consider a specific height in the non-compute areas for the interpolation process near the land-water interface.
Interpolation	**Triangulation**	The interpolation method you want to use. If the density of points is smaller than the number of grid cell (not every cell contains a XYZ Point), then this option is the recommended one.
Grid Data	**C:\MOHID Land Quick Start Guide\Projects\Trancao Watershed\General Data\Digital Terrain\ TrancaoTopography_v01.dat**	The name of the file which will be created. It's recommended to place this file inside the folder General Data\Digital Terrain of your project.

After filling all data, choose the process button () to generate the topography. This process might take a couple of minutes and it finished with a status message.

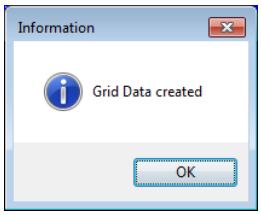


Figure 4.15: Status message of the Construct Grid Data Tool

Close the status message and the tool window (using the x). Your main window should now like the one in the following figure.

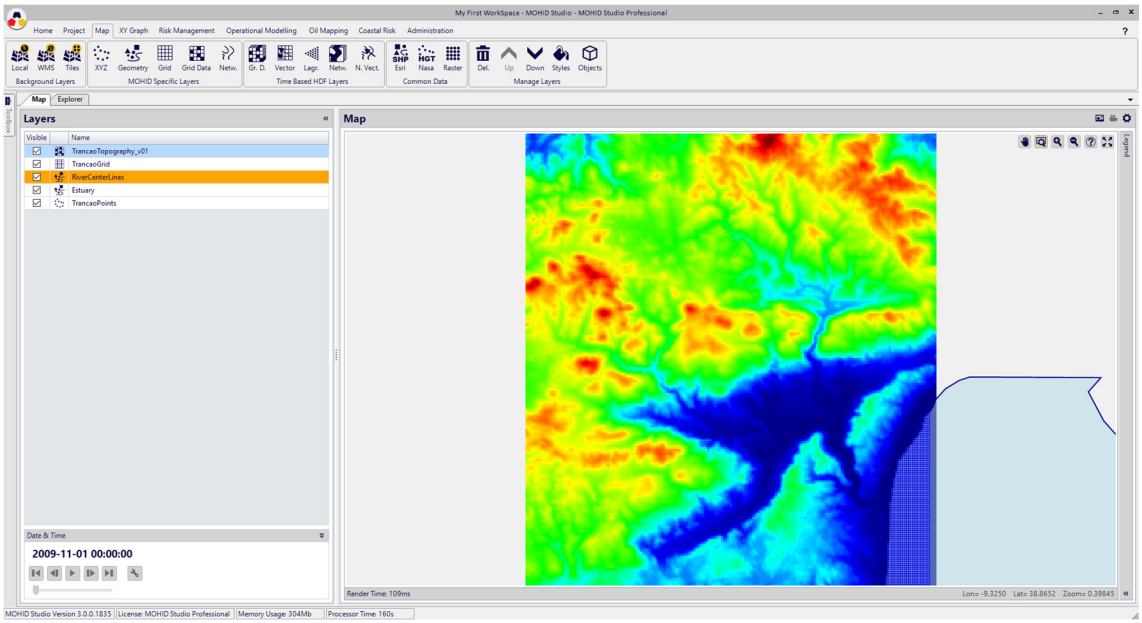
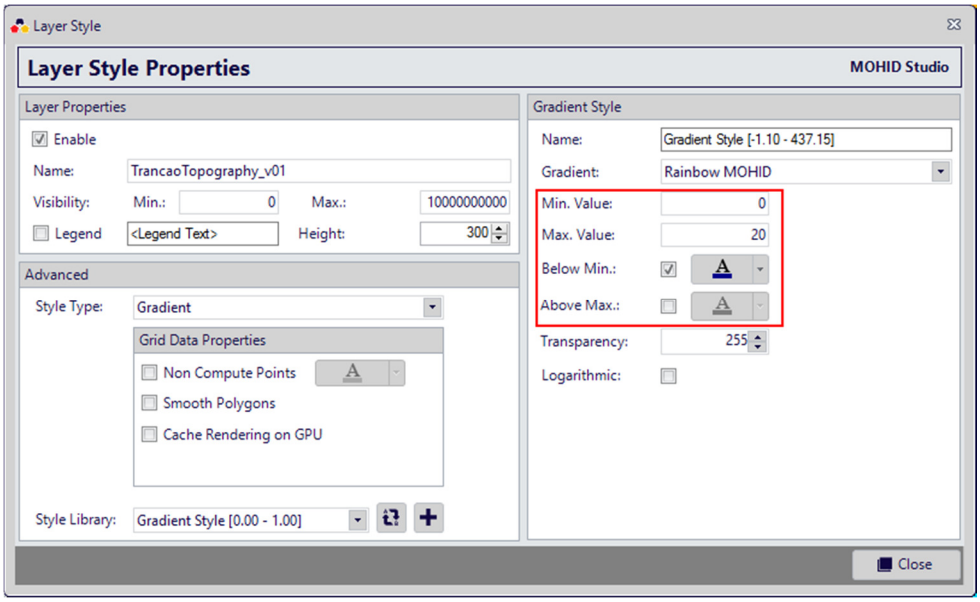


Figure 4.16: Window after creation of the topography

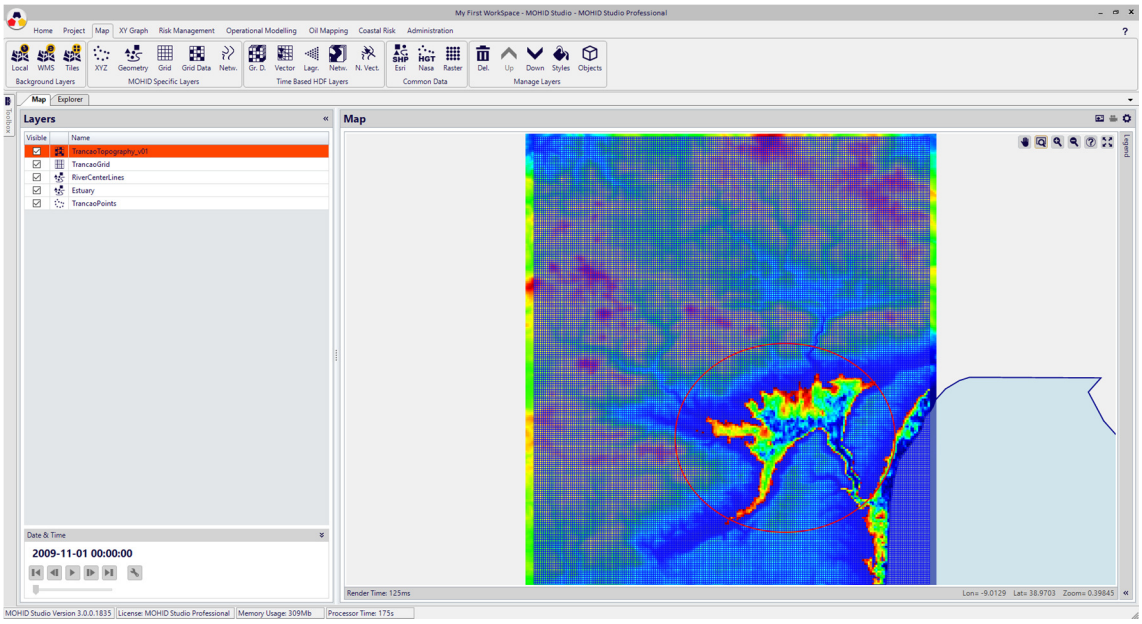
4.4.6 Smooth the digital terrain

After creating the topography, we should check it for noise, which sometimes appears especially in flat flood plains and/or when the source point data came from satellite imagery (e.g. SRTM). This step is optional and the user should check first if the digital terrain has “noise” and use this tool only if it exists and where it exists (the user may define to “denoise” all topography cells or only in a defined area).

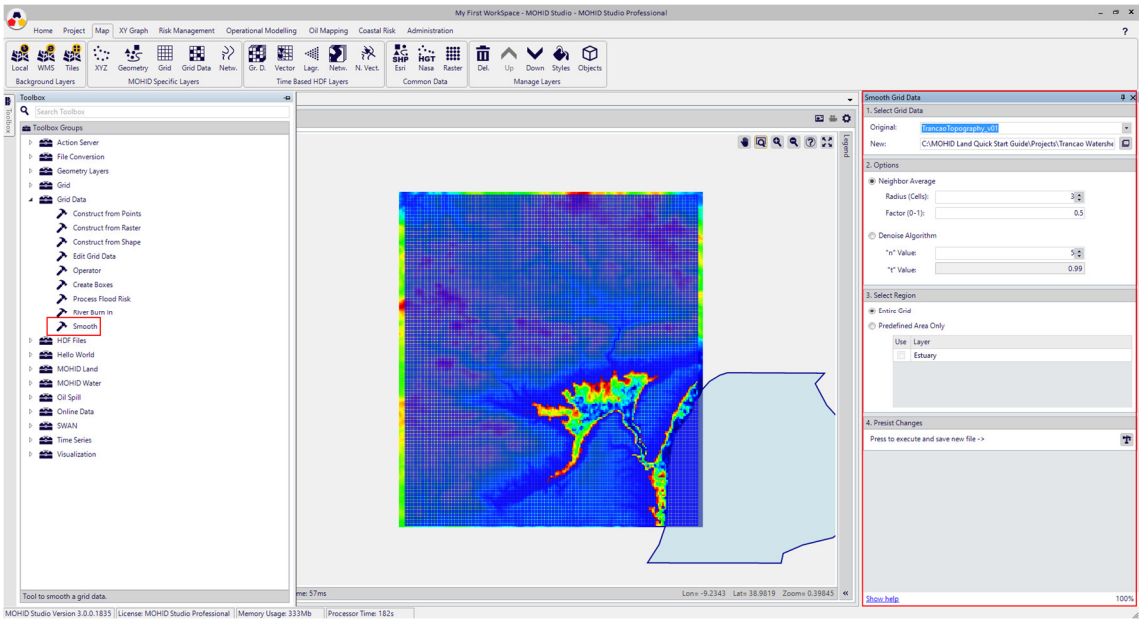
We now change the color range of the topography to values between 0 and 20 to check the downstream part (flat flood plain) where the “noise” exist. Under Map, select the layer “TrancaoTopography_01” and double click it to access the layers’ properties. In this window change the values “Min Value” to 0, “Max Value” to 20 and uncheck the “Above Max” option, as shown next.



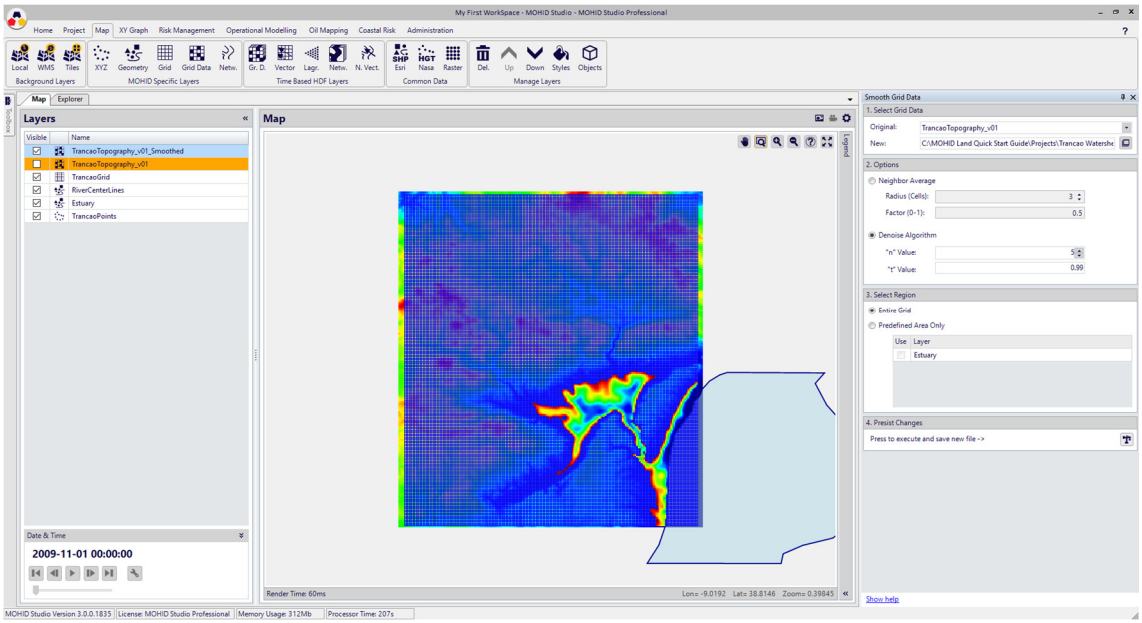
Press close to return to the map window. We now see, in the highlighted area in the next figure that the topography has a lot of noise.



We will now use the tool “Smooth Grid Data” to reduce this “noise”. From the tool box select “Grid Data” -> “Smooth”, as shown in the next figure.



Under the available option we select as original grid data the “Topography_v01” and as new grid data “TrancaoTopography_v01_Smoothed.dat”. These options are set by default. Under “2. Options” we check “**Denoise Algorithm**” and leave all other option with their default values. We press now the  button to generate a new grid data. Once done, close the tool. The new grid data is available in the list of layers. If we now select this layer in the layers’ list and double click it, we can set its properties has we have done previously (“Min Value” to 0, “Max Value” to 20 and uncheck the “Above Max” option) to with the original layer. You should now see the grid data with less noise in the “critical area”.

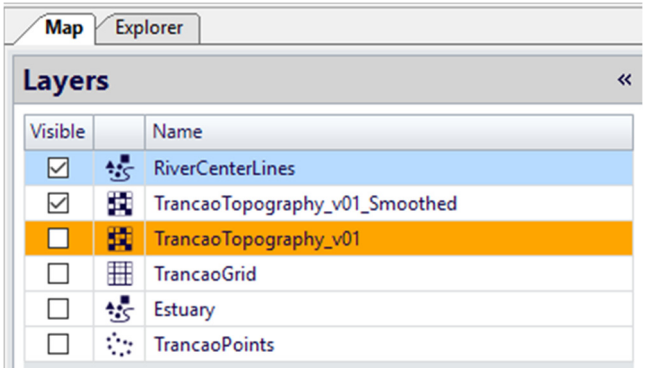


4.4.7 River “Burn In” the digital terrain

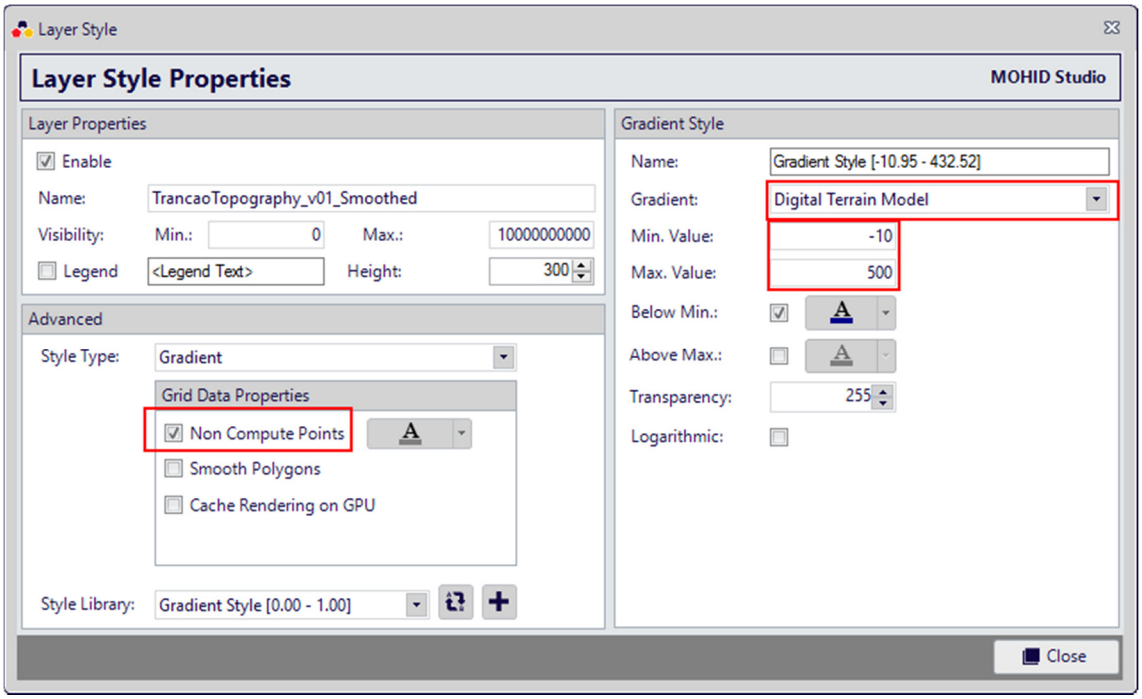
In order to further improve digital terrain, an optional step of “River Burn In” should be used. This process allows you to modify the grid data and “burn in” rivers. The user should check the model river network first (created in next steps) without “burn in” against actual river network and only use this tool if required and in the river stretches where automatically generated network locations is significant different from reality.

This step is not always required, but in our sample the watershed has some narrow valleys and a lot of flat flood plains where elevation data resolution is coarse to describe these features and previous river delineation showed that some river stretches would move aside from real position with automatic delineation without the “burn in”. So in this case the step of “burn in” is recommended.

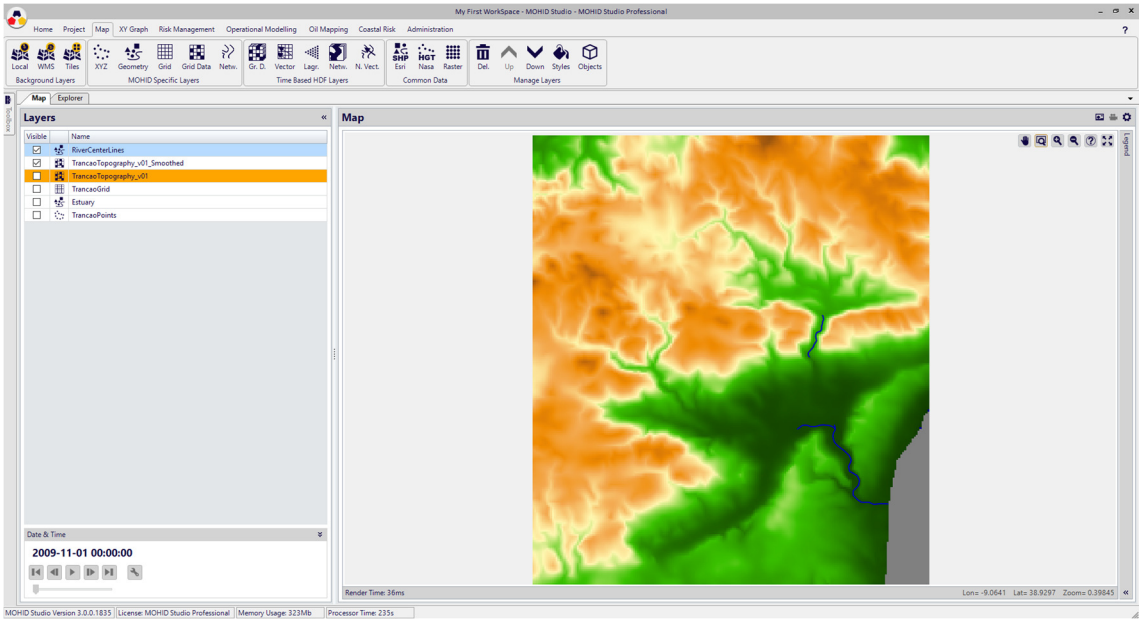
First we will arrange our layers in the map. Turn the layers “TrancaoPoints”, “Estuary”, “TrancaoGrid” and “TrancaoTopography_v01” off, by unchecking them in the Layer List window. Also move the layer “River Center Lines” to the top by using the context menu (right mouse button) to choose “Move Up”. Once done, you layer list should look like the one shown in the next figure.



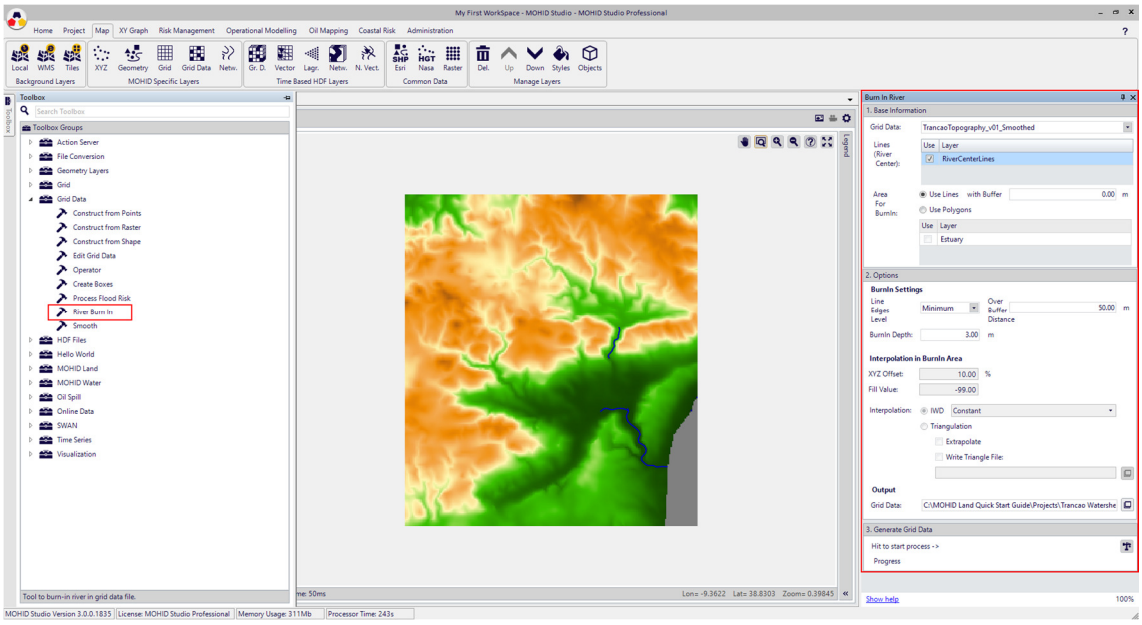
Now double click the layer “TrancaoTopography_v01_Smoothed” and reset the properties in a way that all values are visible. Use the options which are indicated in the next figure.



You window now should look like the one showing in the next figure.



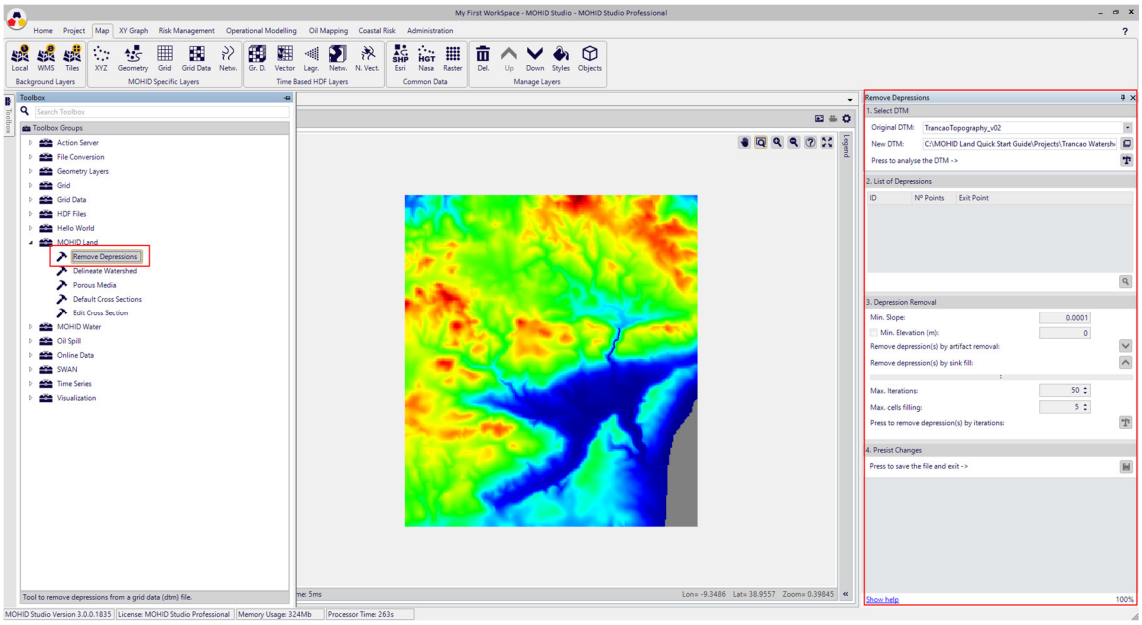
We now select “Grid Data” -> “River Burn In” from the tool box.



In the tool, under “Lines (River Center)”, check the layer “RiverCenterLines” and under output select as new output file for a file “TrancaoTopography_v02.dat” (in the same directory where are already the other files). Press the process button to perform the “Burn In” operation. Once done, the new topography is added as new layer. You can now close the tool.

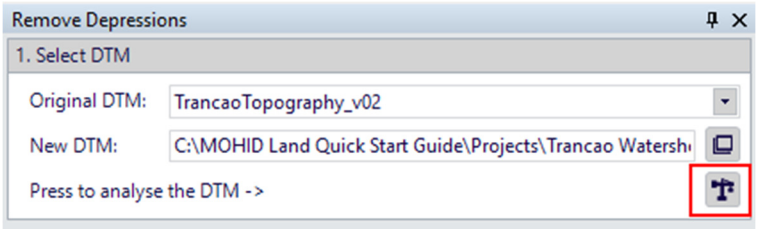
4.4.8 Remove depressions from the digital terrain

In the case you want to run MOHID Land with the module to simulate rivers explicitly, the topography needs to be free of depressions. We will now use the tool “MOHID Land” -> “Remove Depression” from the toolbox.

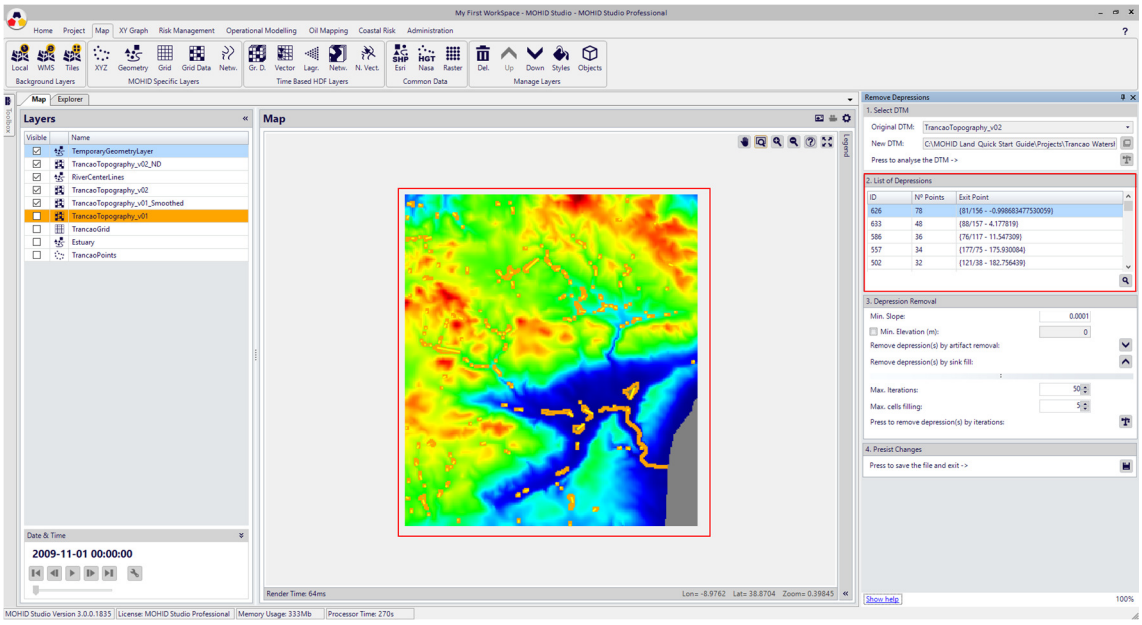


Under the available option we select as original grid data the “Topography_v02” and as new grid data “TrancaoTopography_v02_ND.dat”. These options are set by default and “ND” stands for “No Depression”

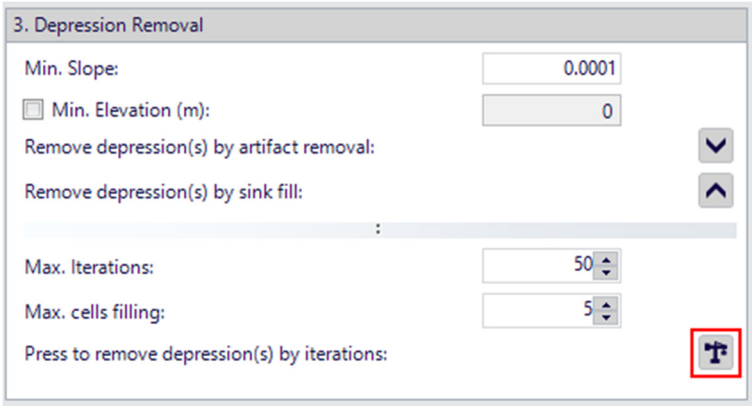
This tool works in two steps. First we need to find all depressions, by analyzing the DTM. This is done by using the process button ( ) in the “Select DTM” box.



Once this process is finished all depressions in the topography are highlighted in the map window and shown in the list of layers, as shown in the following figure.



This tool has many options to remove the depressions. We will use the default options and remove all depression by iterations. This is done by using the second process button.



Once concluded, all depressions of the topography disappear. You can now press the save button the save the topography and exit the tool.

NOTE: Some time the process of depression removal can take a long time. You should carefully check what happens and probably spend more time on the topography smoothing / river burn in options.

The process of preparing the topography is finished.

4.5 Step 3 – Associate the domain with the topography

In step 1 we created a new workspace, solution and a domain. In step 2 we created the topography. We will now associate the domain with the topography (this is needed because you may have more than one topography). To do so, please switch back to the Explorer Window, select the domain "Trancao Watershed", right click and choose "Properties".

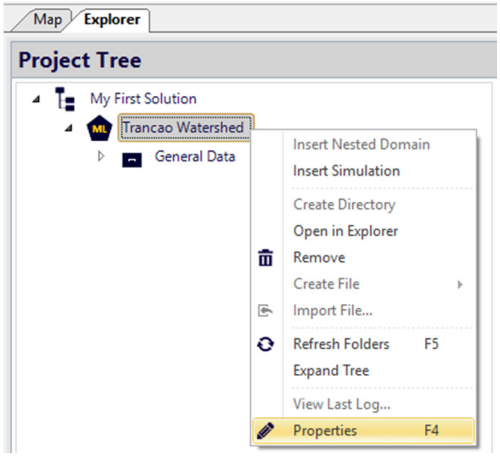


Figure 4.17: Accessing the properties of the domain

A window with the properties of the domain will show. Under "Digital Terrain", browse for the final, depression free, topography you created earlier C:\MOHID Land Quick Start Guide\Projects\Trancao Watershed\General Data\Digital Terrain\ TrancaoTopography_v02_ND.dat) as shown in the next figure.

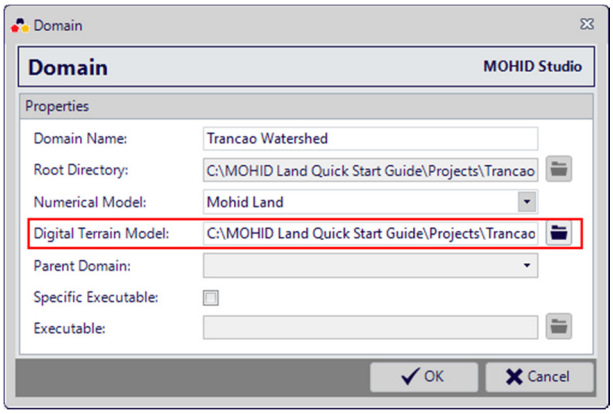


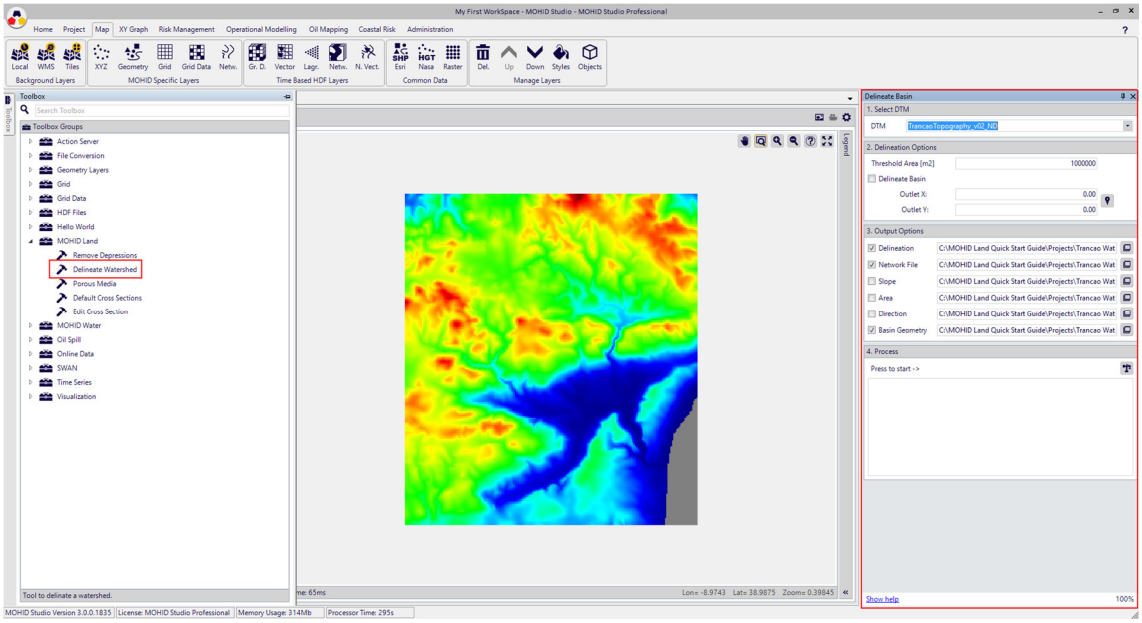
Figure 4.18: Associating the topography to the domain.

Now press OK to close the window.

4.6 Step 4 – Delineation of the watershed

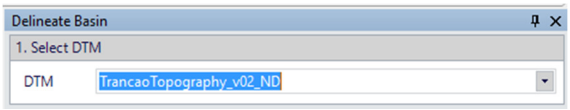
MOHID Land is prepared to run for a single watershed or for multiple watersheds at the same time. In the current case we will cover the option to run a single watershed, which requires that the watershed is delineated.

Watershed delineation requires that the topography is free of depressions, that's why we created in the previous step the layer ""TrancaoTopography_v02_ND.dat". We will now delineate the watershed using the "MOHID Land" -> "Delineate Watershed" tool.



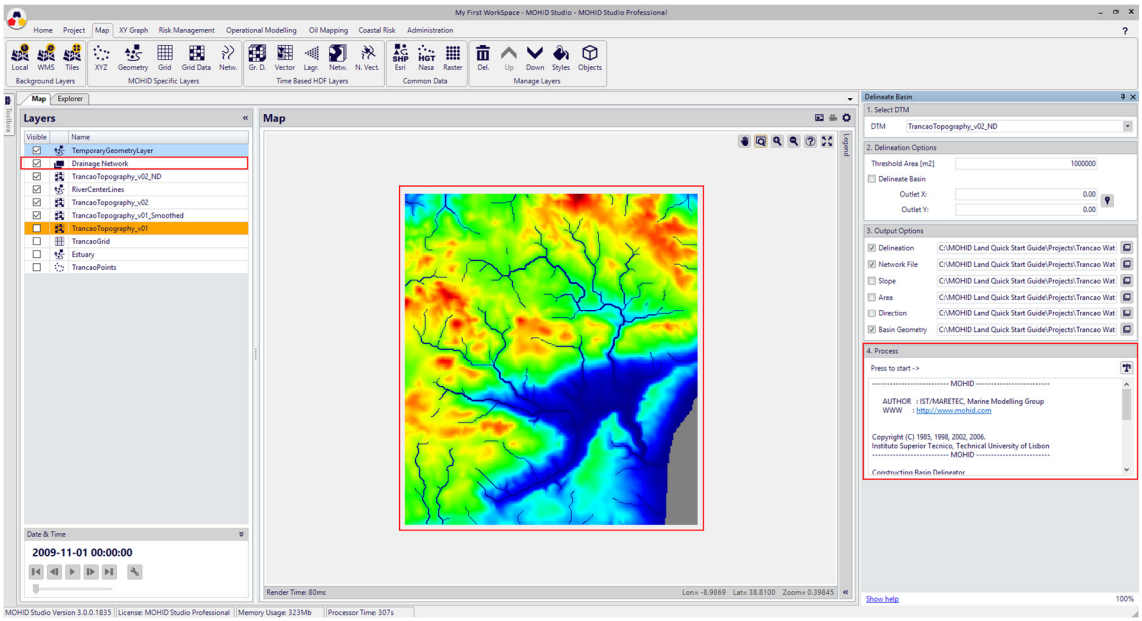
As the previous tool, this also requires generally two steps. Since we don't know where exactly the river passes, we will have to run the tool once to generate all rivers, select then an outlet and rerun the tool.

So, as a first step we select the digital terrain we want to process, in this case TrancaoTopography_v02_ND (should be selected by default).

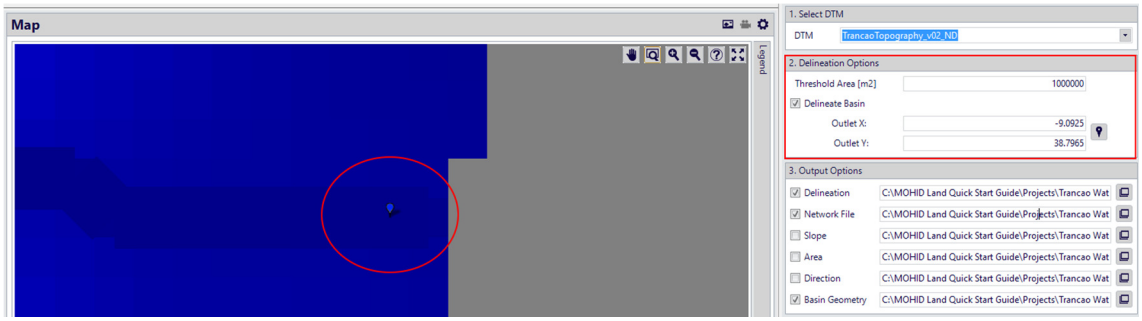


Leaving all other options with the default parameters we go straight to point "4. Process" and run the basin delineator tool by pressing the process button. Once done,

the status of the tool is display in the message box and a new layer with the drainage network is added to the map.

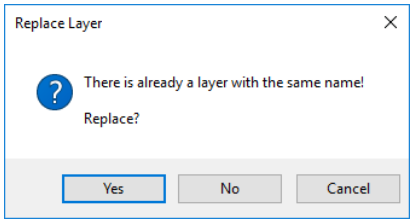


We now have to select the outlet and rerun the tool. This is done by the option “2. Delineation Option”. We check the option “Delineate Basin” and, for this example, specify “Outlet X” = -9.0925 and “Outlet Y” = 38.7965, as shown in the next figure. Once done a marker appears on the map, indicating the position of the outlet. Usually this is done by selecting the location with the mouse, by using the  button, on top of the drainage network built in the previous step (so that we choose an outlet in an existing model reach).

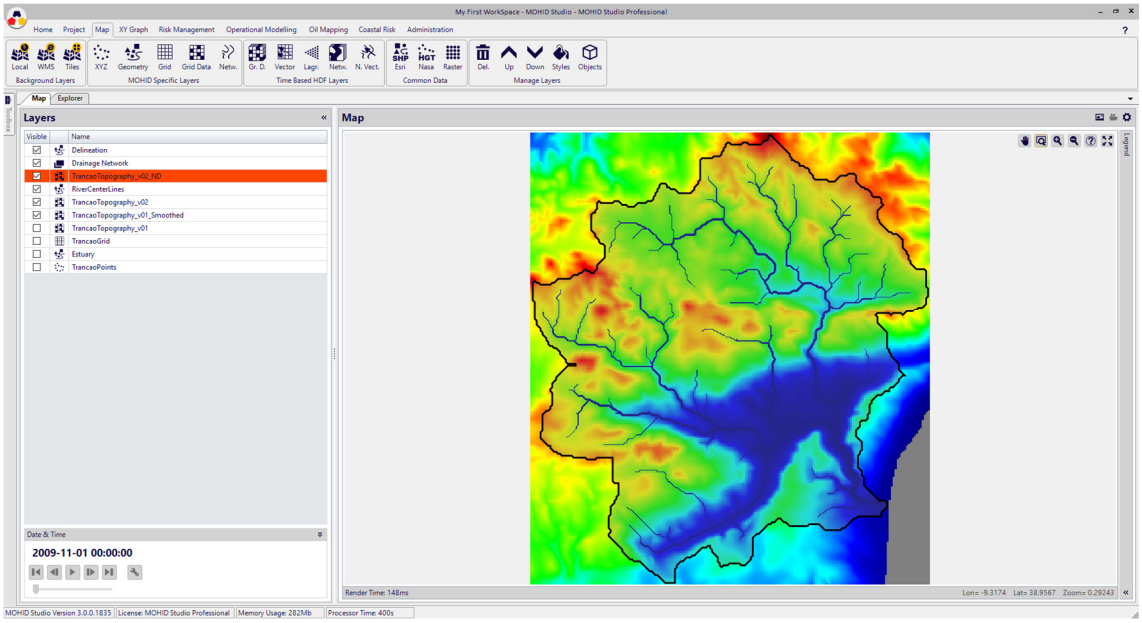


NOTE: The outlet location must be in a cell where the drainage network passes and cannot lie on the border of the watershed. If you look closer to the figure above, you will notice that there is one cell between the choose location and the border (grey area).

Once these options are set, press again the process button under 4. Once finished one or more warnings will appear asking you to replace the existing layers. Press “Yes” to continue and close the tool.



Your window will now look like the one shown in the following figure.

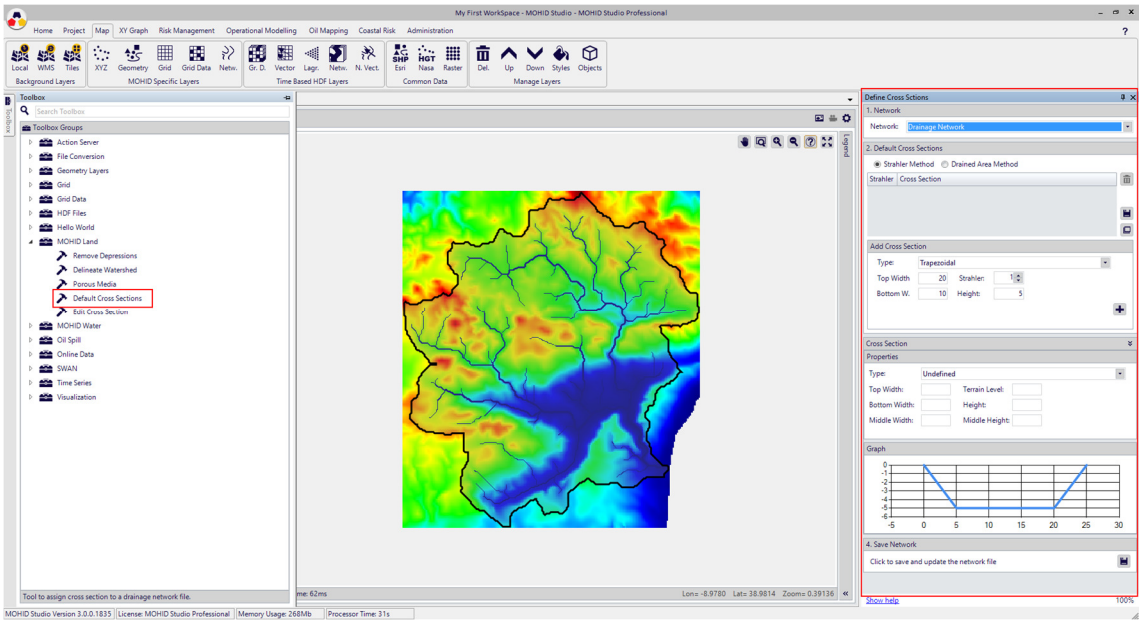


Now we finished the delineation of the watershed.

NOTE: Later on we will need to now the maximum Strahler order of the network. If we select the “Drainage Network” layer and use the query tool ( *), we can query information about a specific layer. Near the outlet the maximum Strahler order is 4.*

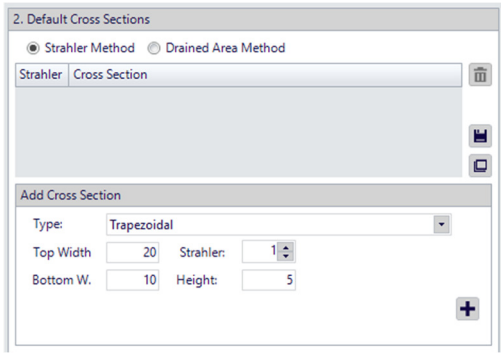
4.7 Step 5 – Define cross sections of the drainage network

In order to calculate the propagation of the flow, MOHID Land’s river module requires that the drainage network has cross sections defined for each node. This can be done using the tool “MOHID Land” -> “Default Cross Sections”.



This tool allows to define default cross sections for all river reaches, using one of the two methods: (i) cross sections in function of the Strahler order or (ii) cross sections in function of drained area. In this example we will use the first one.

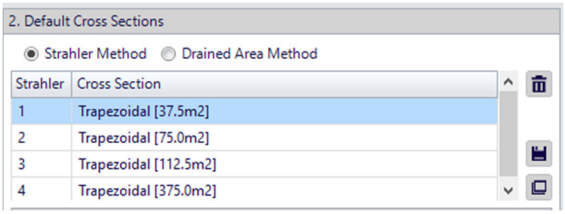
For each Strahler order we have to define a cross section and use the add button to add them to the list of cross sections, using “2. Default Cross Sections”



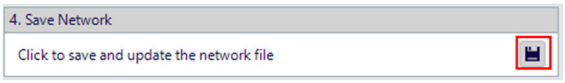
We will use the following values:

Order	Type	Top Width	Bottom Width	Height
1	Trapezoidal	10m	5m	5m
2	Trapezoidal	20m	10m	5m
3	Trapezoidal	30.0	15m	5m
4	Trapezoidal	50m	25m	10m

After adding these values, the box “2. Default Cross Sections” should look like shown in the following figure:



Once done click the save button under “4. Save Network”.



The tool will close and all nodes have a cross section defined.

4.8 Step 6 – Create a new simulation

So far we created the basic input files which are need to run any MOHID Land model. We will now create a simulation and fill the compute options for all modules.

In the Explorer Window select again the domain “Trancao Watershed” right click and select “Insert Simulation”. A window with the properties of a new simulation will appear. In the window you have to provide a name of the simulation, a small description and choose which modules you want to activate.

We will remove the modules “Geometry” and “PorousMedia” with the  button and they will move from the “Modules in Simulation” box to the “Available Modules” box as shown in Figure 4.19.

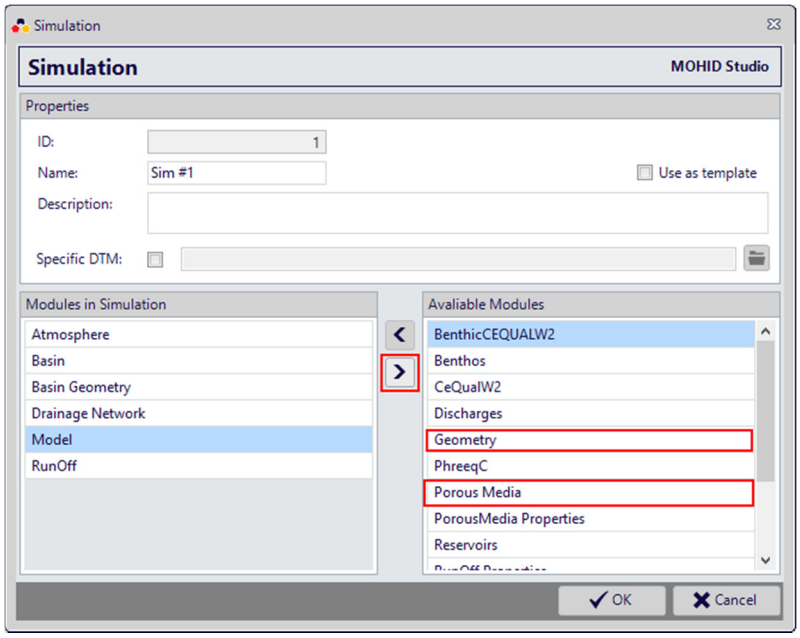


Figure 4.19: Creating a new simulation

Press OK to close the window. A new simulation is created and will appear in the project tree. When you select this simulation, the module data files will appear.

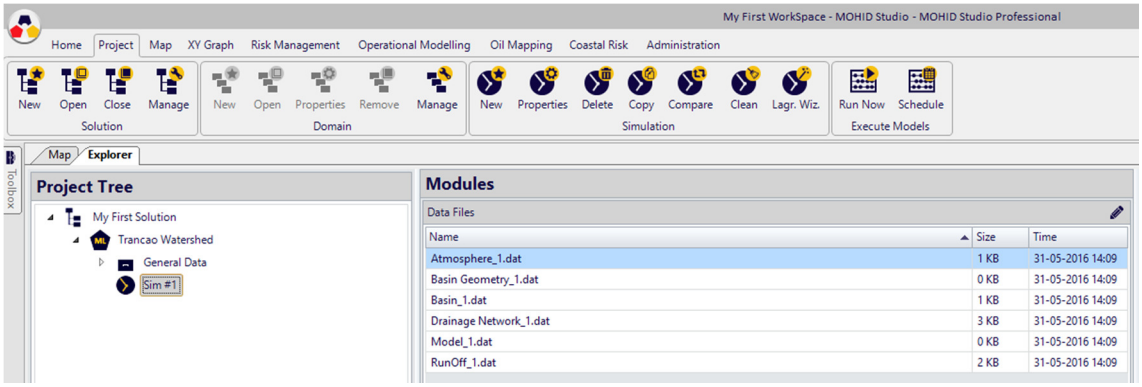


Figure 4.20: Explorer Window after creating a new simulation

4.9 Step 7 – Define the simulation properties

Selecting the simulation you just created shows that it has several input files listed in the “Modules” section under “Data Files”. In these files we have to specify the options for each module. Main files have already default options and here we will only change the files which require modification.

4.9.1 Step 6.1 – Time Options – Model_1.dat

The simulation start, end and time step is provided in the file Model_X.dat where is X is the simulation number (e.g. Model_1.dat). Under “Modules” double click the file “Model_1.dat”, which will open in the file editor.

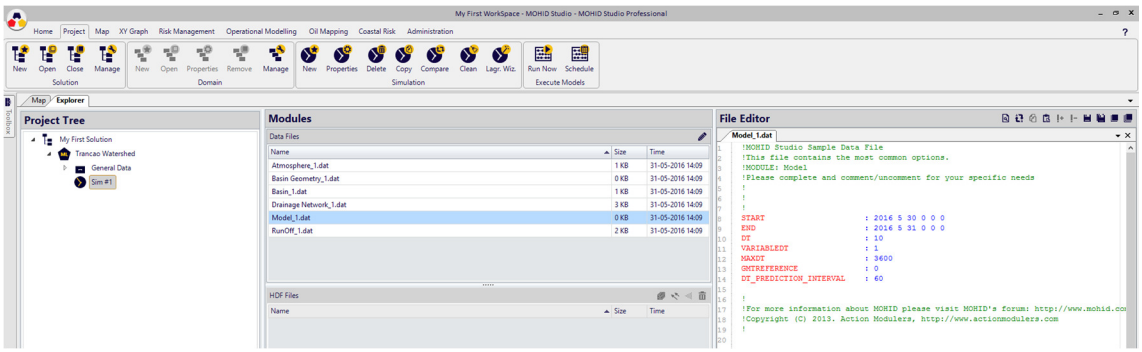


Figure 4.21: Model_1.dat in the File Editor

Change the values to the following options (**You should avoid using TABs).**

Parameter	Value	Description
START	2015 1 1 0 0 0	Start instant of the simulation. Values are year, month, day, hour minute and second.
END	2015 1 2 0 0 0	End instant of the simulation. Values are year, month, day, hour minute and second.
DT	10.0	(Initial) Time step of the model, in seconds.
VARIABLEDT	1	If a variable DT is to be used. 0 to switch off, 1 to switch on. For MOHID Land always use 1.
MAXDT	600.0	Maximum DT if variable time step is used.
GMTREFERENCE	0	Has the same as the time reference as in the tidal tool. If running the model in a place other than in GTM + 0 than need to edit accordingly (positive to east and negative to west).
DT_PREDICTION_INTERVAL	15.0	Interval, in seconds, when progress notifications are displayed.

After editing the file and changing the values as shown in the table above, save and close the file by pressing close button.

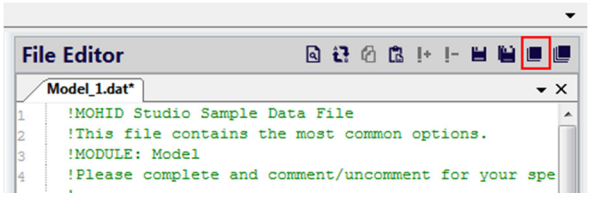
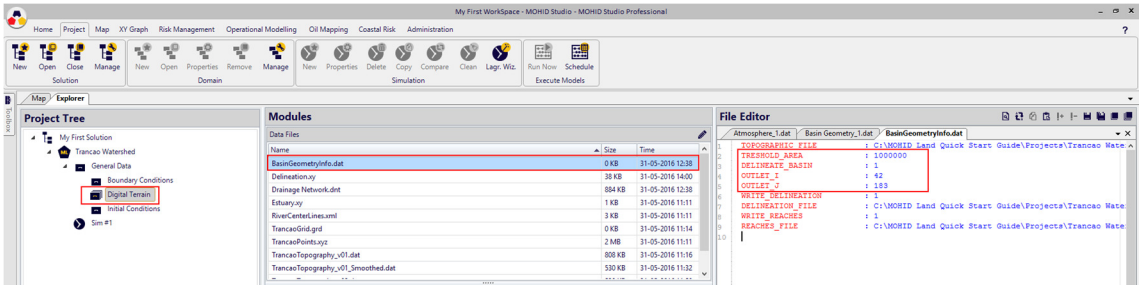


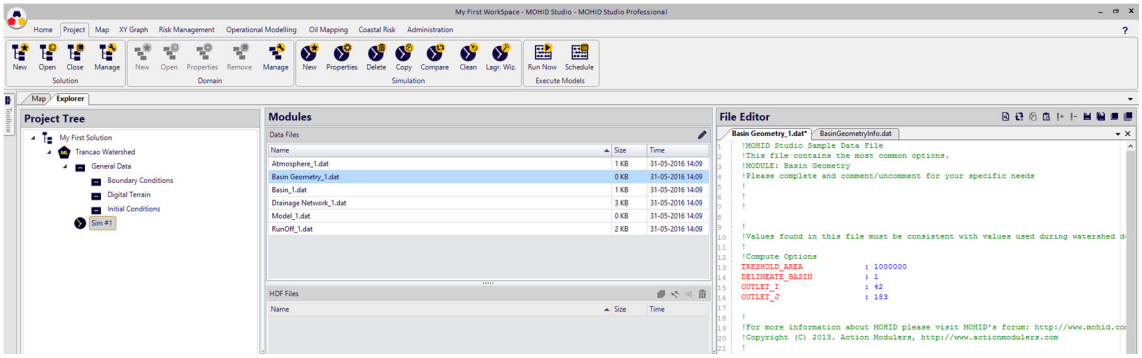
Figure 4.22: Saving and closing a file in the file editor

4.9.2 Step 4.3 – Watershed delineation – BasinGeometry_1.dat

The data file “BasinGeometry_1” must contain again the information about the outlet and the threshold area, which must be consistent with the options used during the basin delineation process. Open the file “Basin_Geometry_1.dat”. Now navigate in the Explorer to “Trancao Watershed -> General Data -> Digital Terrain” you will find a file called “Basin Geometry Info”. Open it also by a double click.



Copy the four marker lines (TRESHOLD_AREA, DELINEATE_BASIN, OUTLET_I and OUTLET_J) and switch back to the file “Basin_Geometry_1.dat” and replace these four lines.



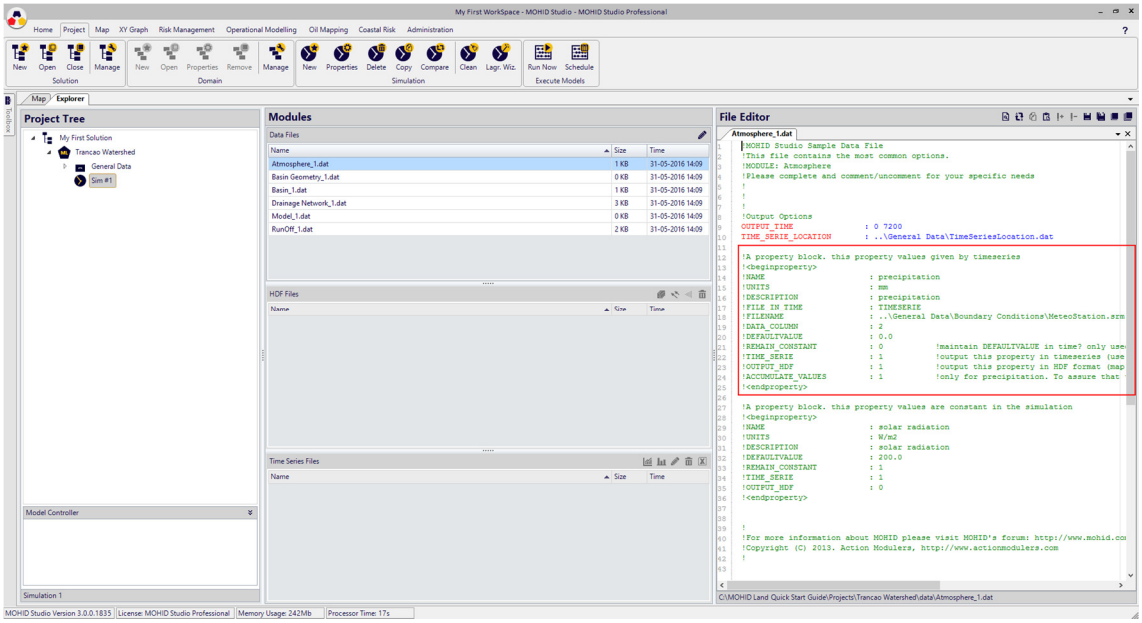
Now close and save the file BasinGeometry_1.dat and close the file BasinGeometryInfo.dat.

Under the Project Tree select again the simulation “Sim #1”.

4.9.3 Step 4.4 – Precipitation – Atmosphere_1.dat

The options related with the atmosphere module are provided in the file "Atmosphere_1.dat". In this example we will create a constant precipitation of 3mm/h.

When you open the file "Atmosphere_1.dat" MOHID Studio will generate a default file, containing a commented example.



We will uncomment the block "<beginproperty>" "<endproperty>" by removing the "!" from the beginning of the lines. You can do this line by line or by selecting all lines and you the button  at the top of the file editor. Inside the block we will change all lines so only lines indicated in the following table appear (remove all other lines).

Parameter	Value	Description
NAME	Precipitation	Name of the property to simulate. The names in MOHID are case sensitive.
UNITS	mm/hour	Units in which the property is given. Note that in most cases MOHID does NOT allow conversion of unit and all values must be specified in SI units. Precipitation is an exception, allowed values are mm and mm/hour.
DESCRIPTION	Constant rain	A description of the property.
DEFAULTVALUE	3	Value of the constant rain, in mm/h

REMAIN_CONSTANT	1	If the imposed value remains constant over time. 1- Yes, 0 – No
USE_ORIGINAL_VALUES	1	If the values are to be interpolated in time (1 – no interpolation)
TIME_SERIE	1	If to produce time series output of this property. 1- Yes, 0 – No
OUTPUT_HDF	1	If to produce map output of this property. 1- Yes, 0 – No

Once done, your file should look like the one shown below.

```
!A property block. this property values given by timeseries
<beginproperty>
NAME                    : precipitation
UNITS                   : mm/hour
DESCRIPTION             : constant rain
DEFAULTVALUE            : 3.0
REMAIN_CONSTANT         : 1           !maintain DEFAULTVALUE in time? only use
TIME_SERIE              : 1           !output this property in timeseries (use
OUTPUT_HDF              : 1           !output this property in HDF format (map
USE_ORIGINAL_VALUES     : 1
<endproperty>
```

Now save and close the file.

4.9.4 Step 4.5 – General basin options – Basin_1.dat

General option about the processes to simulate are defined in the file “Basin_1.dat”. Double click the file to open it in the File Editor.

Check the following options**.**

Parameter	Value	Description
ATMOSPHERE	1	If to use the atmosphere module. 1- Yes, 0 – No.
EVAPOTRANSPIRATION	0	If to calculate evapotranspiration. 1- Yes, 0 – No.
POROUS_MEDIA	0	If the porous media module is to be used. 1- Yes, 0 – No.
RUN_OFF	1	If the surface runoff module is to be used. 1- Yes, 0 – No.
DRAINAGE_NET	1	If the drainage network module is to be used. 1- Yes, 0 – No.
SCSCN_RUNOFF_MODEL	1	Calculate Infiltration using the Curve Number Method. 1- Yes, 0 – No.

Leave all the other options unchanged. Save and close the file.

4.9.5 Step 4.6 – River Flow – Drainage Network_1.dat

MOHID Studio created a default template file with a set of options for the drainage network. For this first example you can leave the default options unchanged.

4.9.6 Step 4.6 – Overland Flow – Runoff_1.dat

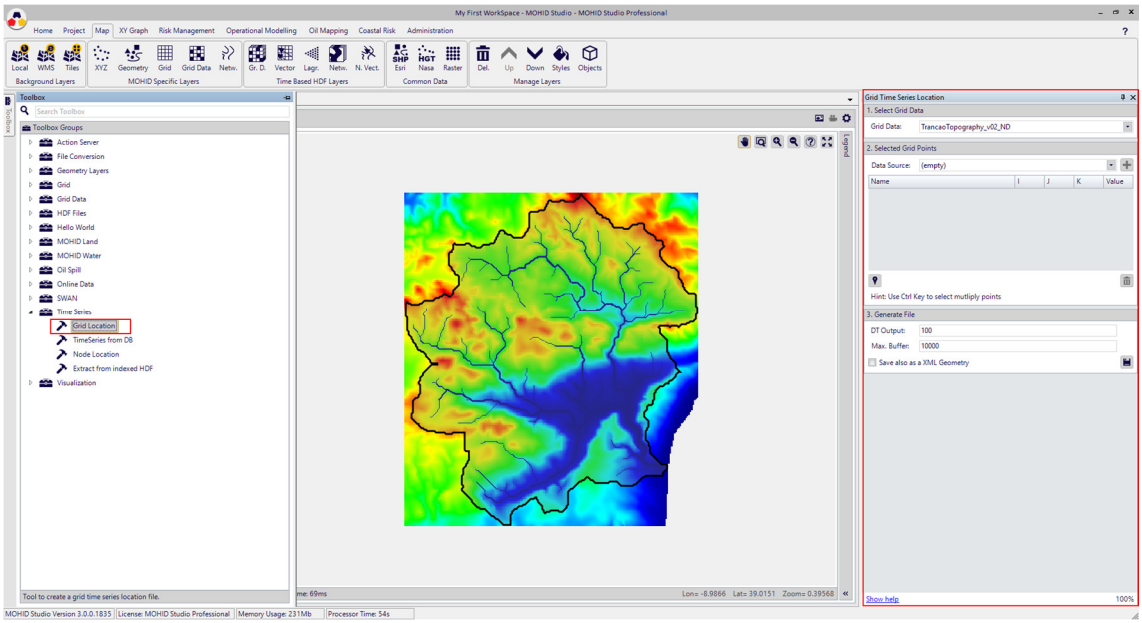
MOHID Studio created a default template file with a set of options for the surface runoff routing. For this first example you can leave the default options unchanged.

4.9.7 Time series output

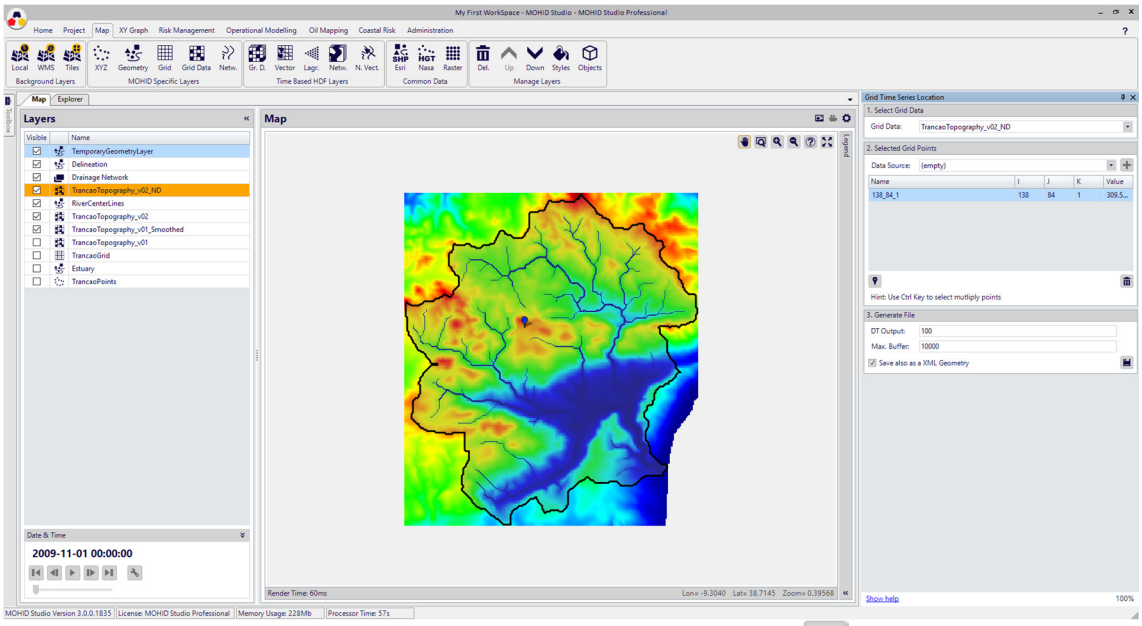
By default time series output is switched on in most modules, so we need to create a file which contains the locations of the places where time series are to be written. This has to be done for time series of specific grid locations (e.g. infiltration rate, precipitation rate) and for specific nodes of the drainage network (e.g. flow, channel water depth).

The link to the file which defines the place where time series are to be written is given by the keyword “TIME_SERIE_LOCATION”.

For grid time series this file can be create using the tool “Grid Location”.



With this tool use the “Add Points” button () to add new places. Select one place somewhere in the center of the watershed. Then also select the “Save also as XML Geometry” option. Your screen should now look like:

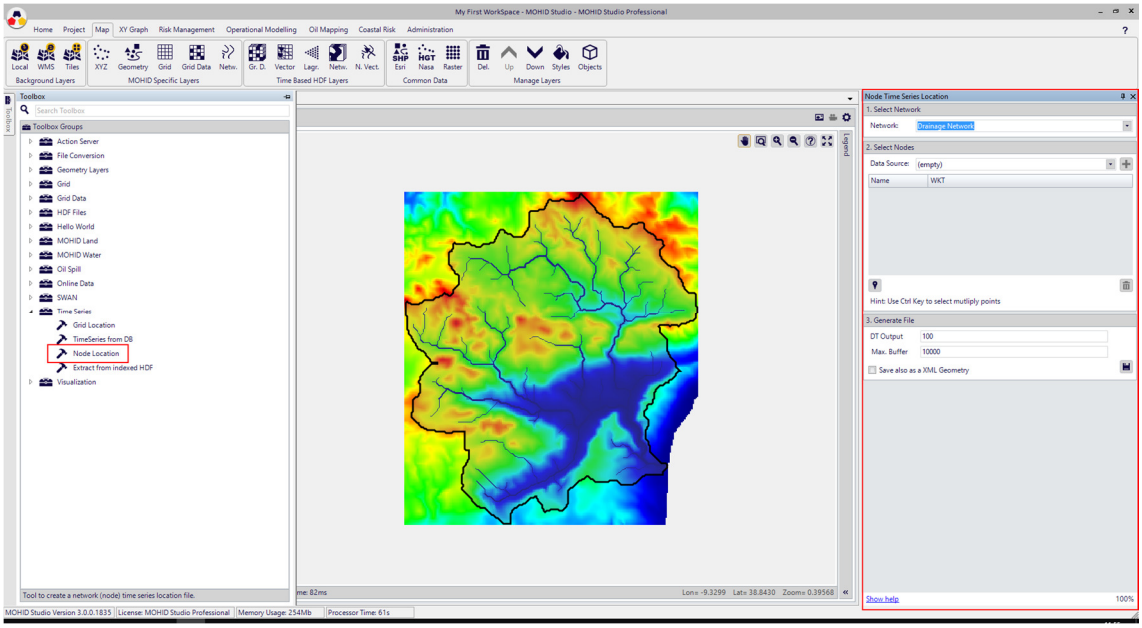


Now save all information, by pressing the “Save Button” (), using the following path:

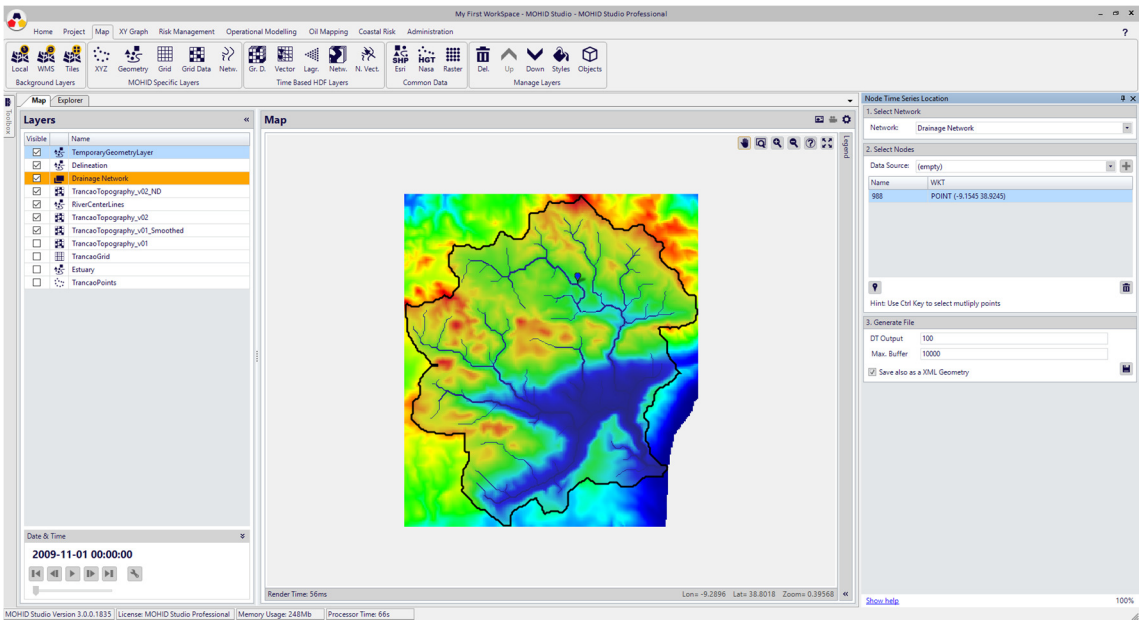
C:\MOHID Land Quick Start Guide\Projects\Trancao Watershed\General Data\TimeSeriesLocation.dat

After saving the tool window will close and the layer with the marks will be removed.

For node time series this file can be create using the tool “Node Location”.



Using again the “Add Points” button (), select a place over the drainage network. Then also select the “Save also as XML Geometry” option. Your screen should now look like:



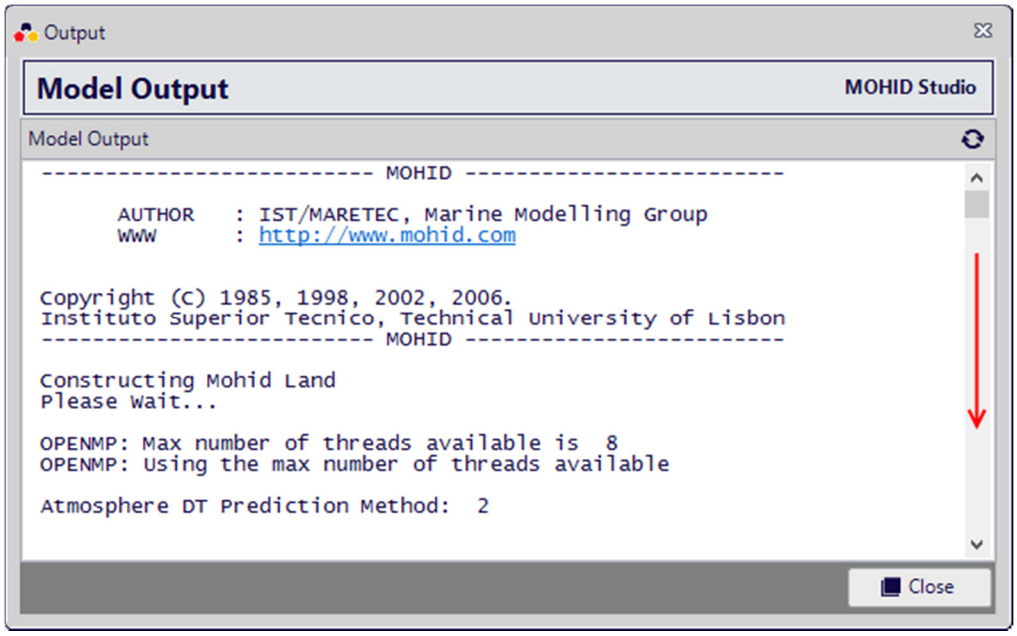
Now save all information, by pressing the “Save Button” (), using the following path:

C:\MOHID Land Quick Start Guide\Projects\Trancao Watershed\General Data\NodeTimeSeriesLocation.dat

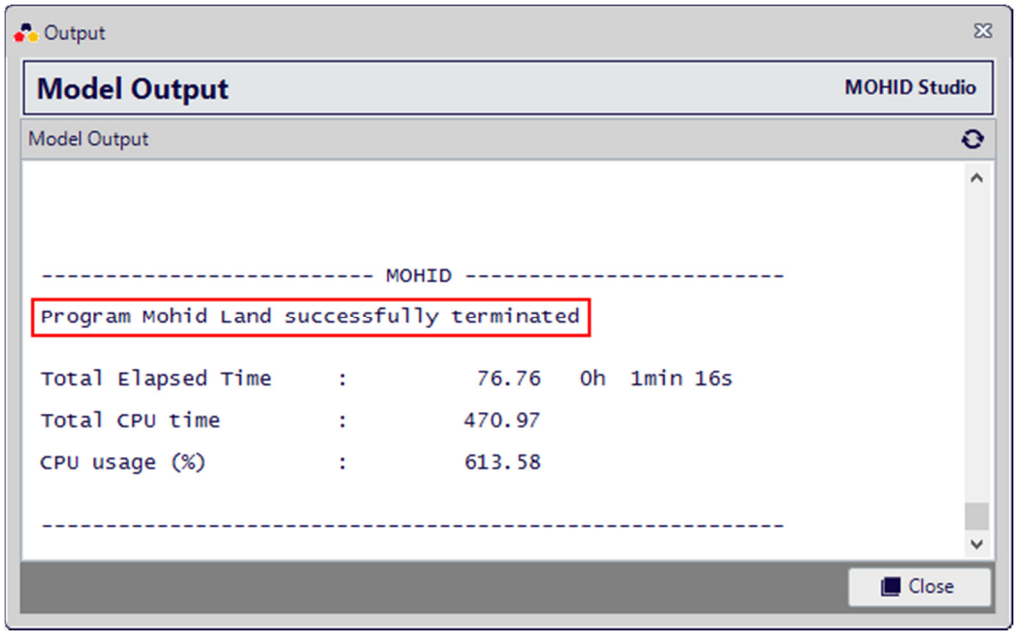
4.10 Step 8 – Run the simulation and explore results

Everything now is prepared to run the simulation. In the Explorer Window select the simulation Sim #1 and then select the option “Project” -> “Run Now” from the main menu (further details have been described earlier). In the message box which appears, click “Yes” to start the run. It will take some minutes to complete the simulation.

When the model finishes, a message box will pop, asking if you would like to see the model results. Click “Yes” and a window like the one shown in the next figure will be shown.



After any simulation, you should scroll down to the end of the window, checking the final status message, as shown in the next figure.



In this case the model log tells us that the model did finish successfully.

You can know explore the results by adding layers to the map or by creating time series graphs, as described in section 3.6.

5 Exercise 3 – Exploring Additional Examples

5.1 Introduction

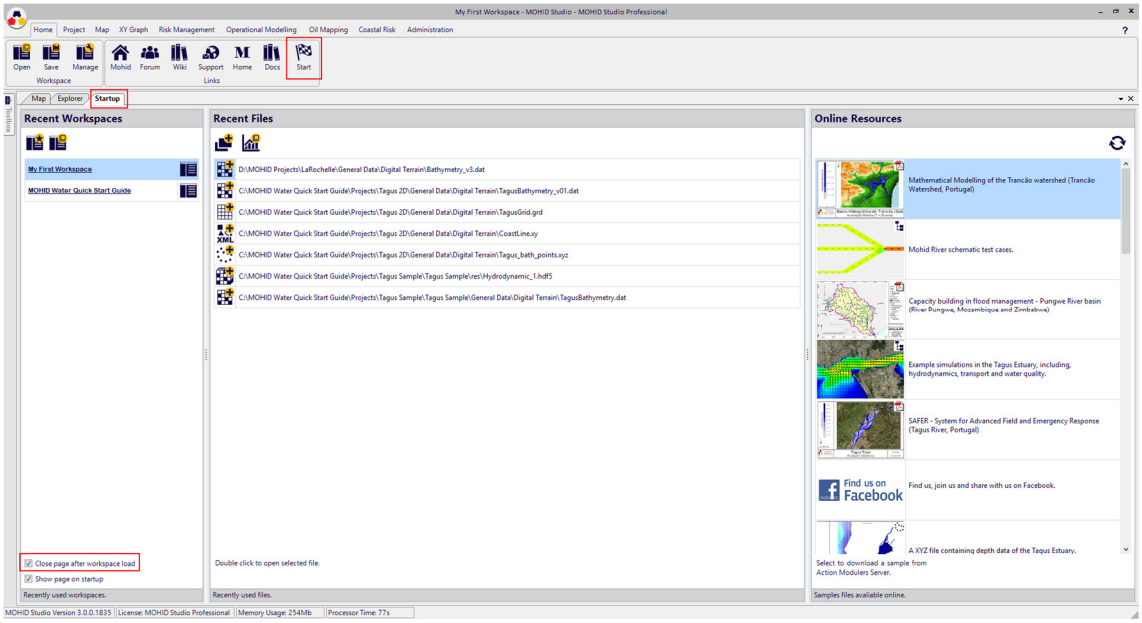
In Exercise 1 we downloaded a previously created model setup and imported it into MOHID Studio. The goal was to learn a little bit how MOHID Studio works.

In Exercise 2 we created a new model setup from scratch using some basic data files. The goal of the second exercise was to learn the basic steps you need to setup a simple MOHID Land simulation.

MOHID Land has hundreds of options, so sometimes it's tricky to find the right option for all the data files. In this exercise, Exercise 3, we will show how to open existing online resources which you can use as guidance to setup you own model.

5.2 Step 1 – Startup Page

MOHID Studio's Start-up page has on the right side a set of online resources, which ACTION MODULERS updates frequently. To access the start page, select Home -> Links -> Start.

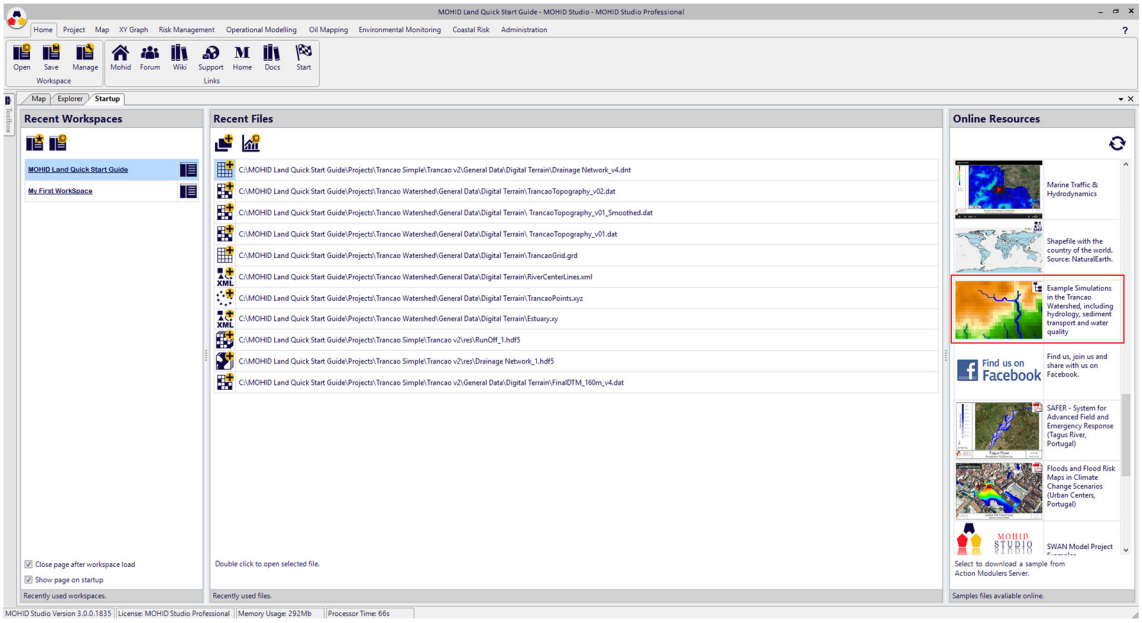


This page is allows shown after start up but, by default, it closes after opening a work space. You can change this behaviour in the lower left corner of the Start-up page.

We will now select a more advanced sample of the Trancão Watershed, which contains different types of simulations.

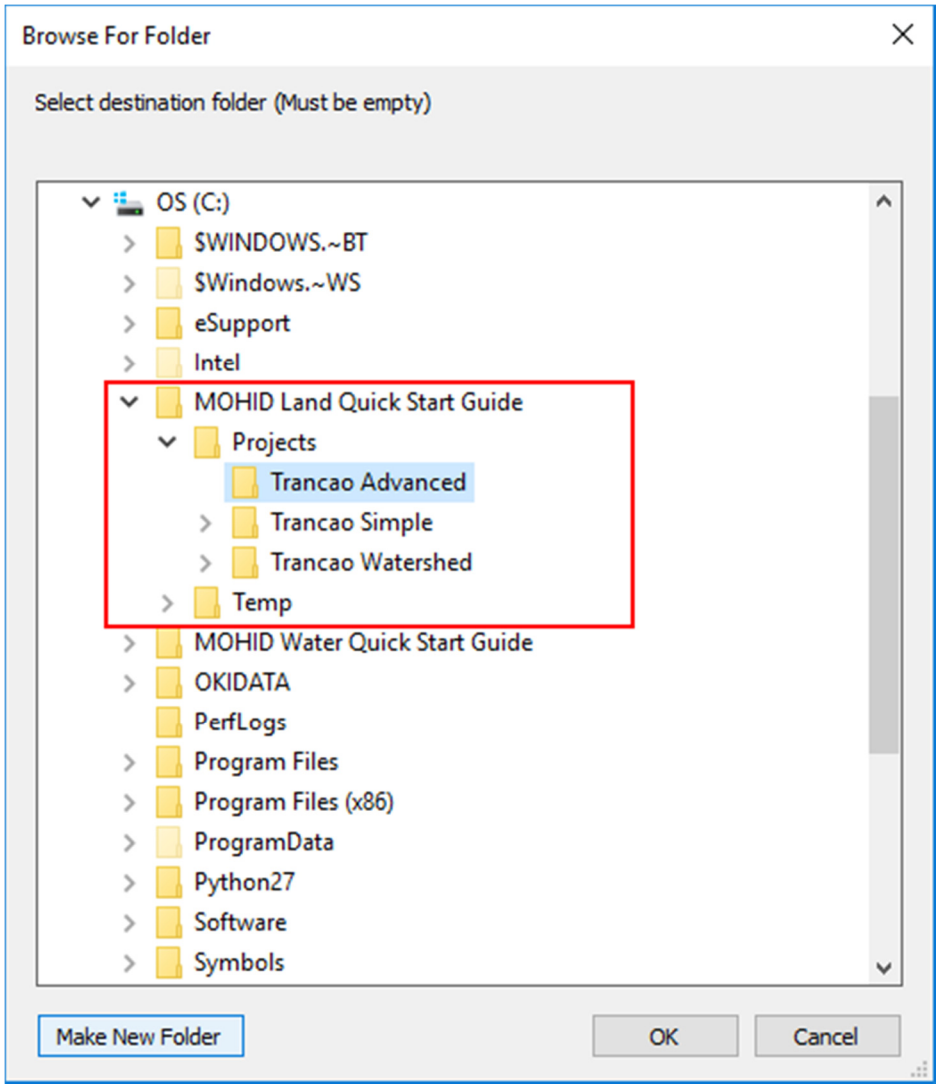
5.3 Step 2 – Download and open advanced examples

In the Startup Page check for the resource “Example Simulations in the Trancão Watershed, including hydrology, sediment transport and water quality”, as indicated in the figure below.

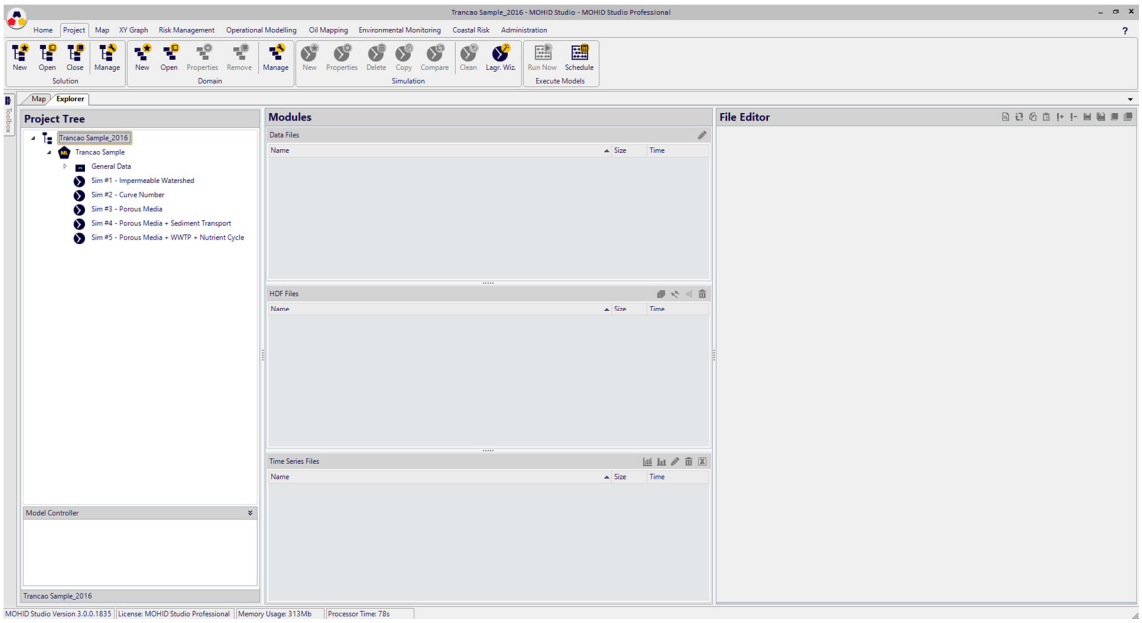


Click on this line. A popup window will appear which asks for where to store this example.

Create a directory in C:\MOHID Land Quick Start Guide\Projects called “Trancao Advanced” and press OK.



The download of the sample will start automatically. Once the download is completed (a message box informs you about this) your current workspace is closed and the download example is opened automatically. After expanding the project tree your window should now look like the one indicated next.



Inside this example you will find a set of simulations, showing different features of MOHID Land. We recommend that you run and explore these examples.

The first simulation is the same which we already explored in Exercise 1. Please check the following observations.

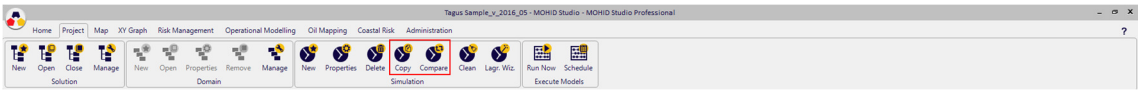
Name	Objective	Observations
Sim #1	Simple watershed simulation considering an impermeable watershed.	For demo purposes only. Be aware that impermeable watershed can generate huge floods, even for small rain events.
Sim #2	Watershed using Curve Number method to calculate infiltration. Atmospheric properties from time series and evaporation switched on.	Data files show how to implement Curve Number infiltration with MOHID Land. For real cases you should consider creating a Grid Data for real curve number values, changing the block “BeginCurveNumber> / “<EndCurveNumber>” inside the file Basin_2.dat. The tool Grid Data -> Construct from shape might be useful for this.
Sim #3	Complete hydrological simulation, including also interaction between surface water, groundwater and return flow.	Data files show how to implement some even more advanced features in MOHID Land. Module Porous Media and a vertical Geometry have been added. Infiltration is now calculated by module Porous Media, based on soil moisture.
Sim #4	Same as previous with sediment transport in surface waters added, including generation of sediments due to rain splash.	Sediment transport is characterized in the files Drainage Network and Runoff Properties.
Sim #5	Same as previous with point discharges from WWTP and the	Data files show how to activate the water quality module (WaterQuality_v5 and SedimentQaulity_v5)

	full nutrient cycle (phosphorus and nitrogen) to simulate the transport and transformation of properties in surface and subsurface waters.	and the transport in surface (Runoff Properties_v5 and DrainageNetwork_v5) and subsurface waters (Porous Media Properties_v5)

When setting up a MOHID Land model at your site, you can use these examples as guidance. Basic steps are:

1. Create a new domain, including computational grid and topography, as shown in Exercise 2;
2. Copy data files from the examples to the new created domain;
3. Adopt the data files where needed.

There are 2 features in MOHID Studio which you might find particularly interesting: the option to compare data files between simulations (Project -> Simulations -> Compare) and to copy data files from one Project/Simulation to another (Project -> Simulation -> Copy).



Please check MOHID Studio's User Guide for further information.

6 Final Remarks

This quick start-guide to implement MOHID Land intends to help first time users to quickly get the model running but may also be a starting point for every new implementation. The implementation of MOHID Land in these terms, with increasing complexity and processes added in cumulative way, gives user the sensibility to the major factors affecting circulation and water quality for each implementation site.

Any difficulties or need for more developed information should be addressed in the MOHID channels mentioned at the start of this document.

We appreciate all feed-back that you may give us on the implementation of MOHID Land projects with MOHID Studio so that this guide can improve with time.