ATLANTIC AREA
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# ARCOPOL

**MOHID Desktop Spill Simulator:**

**Detailed User Manual**

**Activity 4**

Tasks 4.3.2

**ARCOPOL**

The Atlantic Regions' Coastal Pollution Response

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# Contents

# List of figures

# 1 Introduction

This manual aims to provide a full description about how to use the Mohid Desktop Oil Spill Simulator interface.

Mohid Desktop Spill Simulator is a fast oil and inert spill lagrangian simulator integrating offline metocean forecasts from several different institutions in the Atlantic Area, for the regions or ARCOPOL partners. This desktop client application allows end user to have control over model simulations. Parameters such as date and time of the event, location and oil spill volume are provided to the users; this interactive tool integrate best available metocean forecasts (waves, meteorological, hydrodynamics) from different institutions in the Atlantic Area. Metocean data are continuously gathered from remote THREDDS data servers (using OPENDAP protocol) or ftp sites, and then automatically interpolated and pre-processed to be available for the simulators. This simulation tool can also import initial data and export results from/to remote servers, using OGC WFS services.

Simulations are provided to end user in a matter of seconds, and thus, can be very useful in emergency situations. The backtracking modelling feature and the possibility of importing spill locations from remote servers with observed data (per example, from flight surveillance or remote sensing) allow the potential application to the evaluation of possible contamination sources. The numerical model used to simulate spill fate & behaviour in this application is the lagrangian component of MOHID water modelling system, including oil spill module (www.mohid.com).

The manual is arranged in 6 sections.

Section 2 explains the management of downloading Metocean Forecasting Systems.

Section 3 synthesizes lagrangian & oil spill modelling system used.

Section 4 presents Mohid Desktop Spill Simulator interface main features.

Section 5 describes in detail the process of creating Oil Spill simulations.

Lastly, section 6 describes some of the known limitations or bugs, and some proposals for future developments.

# 2 Management of Downloading Metocean Forecasting Systems

MOHID Desktop Spill Simulator makes use of several different data sources from institutions running metocean forecasting systems covering the Atlantic Area.

An additional application / background service (in the software installer, the name is "Spill Simulation Update Service" need to be installed prior to MOHID Desktop Spill Simulator – this service will be running on the computer, downloading the selected metocean properties everyday at midnight, and when application starts. Results are downloaded from ARCOPOL Server (managed by Instituto Superior Técnico), which is continuously collecting metocean results from different data sources on THREDDS servers, or ftp servers, and making the necessary conversions (This process of downloading is done with Model Download Manager[1]).

This ARCOPOL-integrated download service (that connects directly with ARCOPOL Server) is the recommended methodology to download metocean data in this tool, because minimum interaction with end-user is needed. As referred, metocean forecasting systems available for download from ARCOPOL Server cover the area of study of the ARCOPOL's partners (data providers include IFREMER, IST, Marine Institute, MERCATOR-ÓCEAN, MeteoGalicia, and NOAA (GFS)). However, if user wants to add additional data providers, and new metocean forecasting systems, this is possible to be done using Model Download Manager software locally. However, this is an advanced user option, since user will have to correctly set up the configuration of ModelDownloadManager, without forgetting conversion process needed.

[1] ModelDownloadManager is a software developed in the scope of EASYCO, and tested on ARCOPOL project, in order to download model data to feed MOHID Desktop Spill Simulator. This software product can be downloaded in http://www.project-easy.info/, under Members Area (registration is required)

# 3 Lagrangian & Oil Spill Modelling System

The numerical model used for computing the fate and behaviour of spilled substances in all the tools developed (MOHID lagrangian & oil spill model from MOHID Water modelling System – www.mohid.com) was also subject of several adaptations and updates, in order to increase its adaptability to the developed tools – horizontal velocity due to Stokes Drift, vertical movement of oil substances, modelling of floating containers, backtracking modelling and a multi-solution approach (generating computational grid on-the-fly, and using the available information from the multiple metocean forecasting solutions available) are some of the main features recently implemented.

MOHID framework has been built to comprise great flexibility and versatility, developed in such a way that can be used to study different types of applications at different environments.

MOHID lagrangian module has been widely used in different types of studies and applications, not only in oil spills, but also in sediments transport, harmful algal blooms (HAB's), fish larvae, residence time in estuaries, faecal contamination in bathing waters and plume diffusion and dispersion (near and far field) in water column from submarine outfalls and / or rivers. A list of MOHID / MARETEC references is attached at the end of this proposal.

Oil spill simulations have been used since Prestige Oil Spill (2002), with generation of oil spill trajectory forecasts. Forecasts were generated in the early stages of the oil spill, and predictions were initially validated in-situ by the response team, then, by remote sensing, and at last, by aerial observations. Since then, MOHID has been used operationally in other real accidents and in spill exercises performed by Portugal and Spain, always generating satisfactory results. The oil spill module is a trajectory and weathering model, with the ability to run integrated with hydrodynamic solution, or independently (coupled offline to metocean models), being this last one the option for the operational tools developed (to reduce computation time, taking advantage of metocean models previously run).

# 4 Main Window

The following picture shows the Mohid Desktop Spill Simulator interface main window.

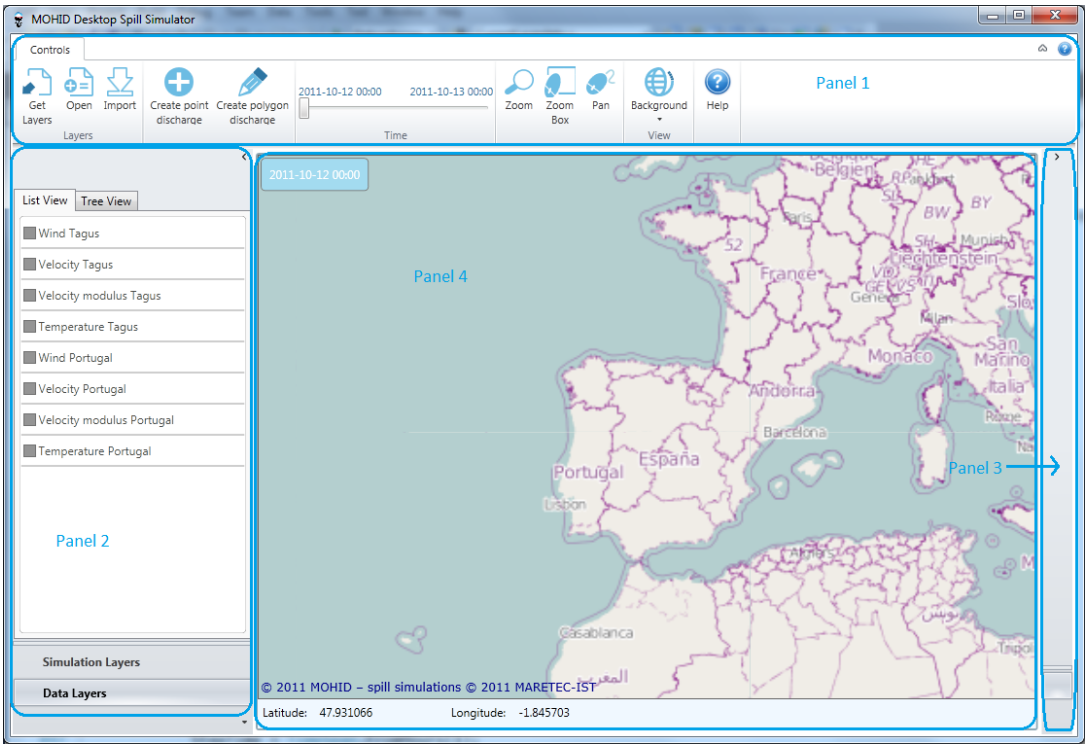


**Image 1 - Main window**

The image 1 gives a perspective of the smart-client main window. There are 4 distinct areas in the window:

- **Panel 1:** Application toolbar.
- **Panel 2:** Panel where the layers are displayed. In this panel user can switch between *Data Layers* and *Simulation Layers*.
- **Panel 3:** The panel 3 is closed by default. In this panel user can consult information about the selected Layer in panel 2 and also the results of the *Oil spill* simulations.
- **Panel 4:** Panel 4 presents a map where the layers can be viewed.

## 4.1 Main Window – Panel 1: Toolbar options

The panel 1 or the application toolbar is organized in 5 groups. Each group provides options that are related to each other.

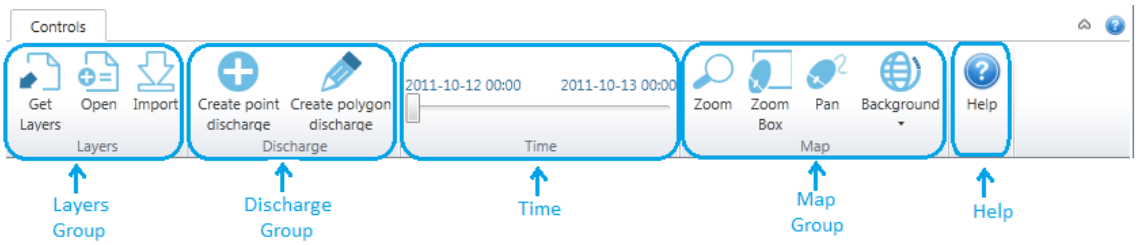


Image 2 - Panel 1 Buttons

Toolbar groups and its options:

- **Layers Group**:
  - **Get Layers:** Launch a wizard that allows user to select the metocean properties (layers) that he wants to download. The wizard is composed of 5 steps. Each step corresponds to one property: bathymetry, currents, wind, water salinity/temperature and waves. In each step, a list of files, where the step associated property is present, is displayed and the user can choose which files we want to download. When the wizard is completed, the client starts to download the selected files.

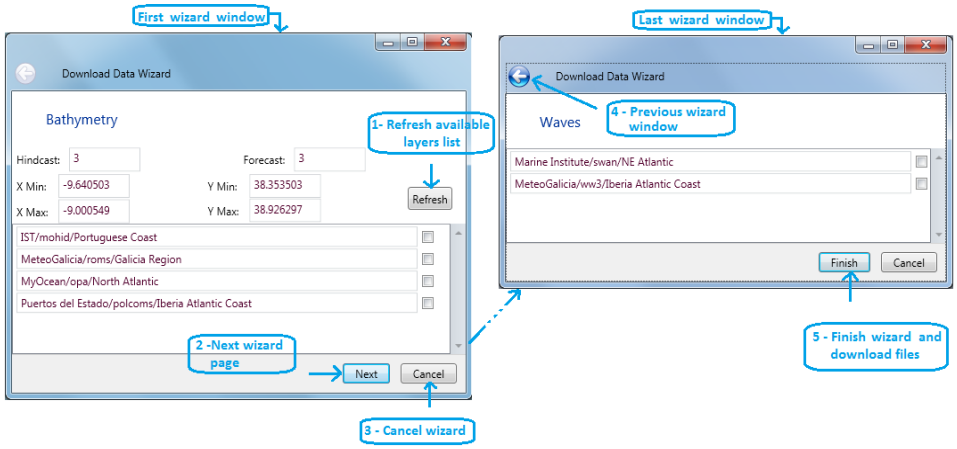


Image 3 - Download data wizard

Notice that the first wizard page is different from the others. That page allows user to define the basic options that will be used to search the available files on the server. The user can choose the hindcast and forecast time and the spatial window that he needs. Once the values have been entered, it is needed to click the *Refresh* button in order to update the list of available files. Data is downloaded to folder C:\Users\Public\Documents\Arcopol Client (MOHID Desktop Spill Simulator will pop-up the download data wizard when starting up application, and referred folder is empty). If user wants to restart the configuration of area and models to download, a "reset" is possible, simply by deleting C:\Users\Public\Documents\Arcopol Client folder, and restarting the application. Download data wizard will start again.

- **Open:** Opens a file dialog that allows users to import shape files or kml files. These files will be added to the *Data Layers* view in the Panel 2.

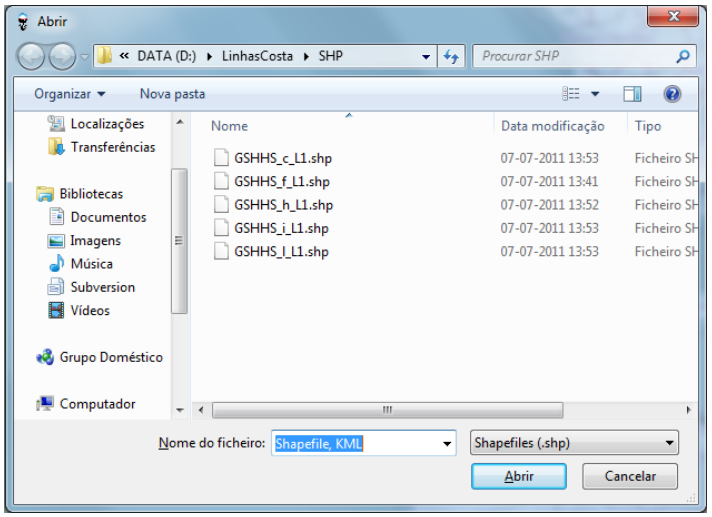


Image 4 – Open files dialog

- **Import:** Allows importing spills from a WFS server. The imported spill will be added to the *Simulation Layers* view in the Panel 2. For now this links only with the Intecmar (http://www.intecmar.org/ - Arcopol partner) GeoServer data base focus in oil observations.

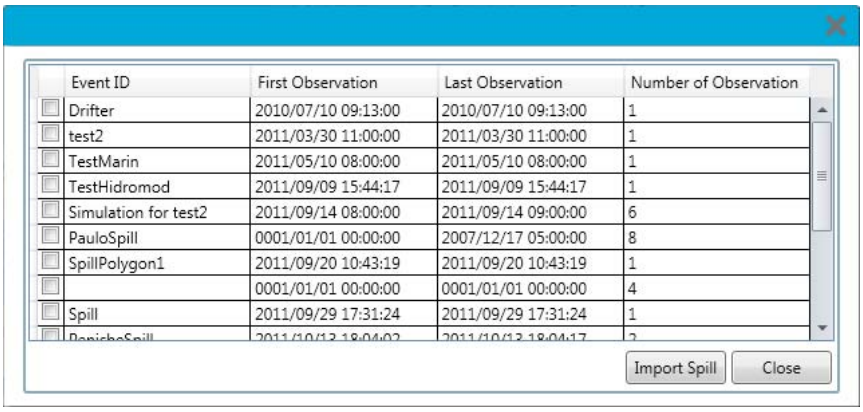


Image 5 – Import WFS spills dialog

- **Discharge Group**:
  - **Create point discharge**: Allows user to create a point discharge. After pressing the "Create point discharge" button, the user needs to click on the map to set the discharge point. Then a popup window shows up and let user configure the discharge options. In section 3 of this manual, this option will be fully explained.

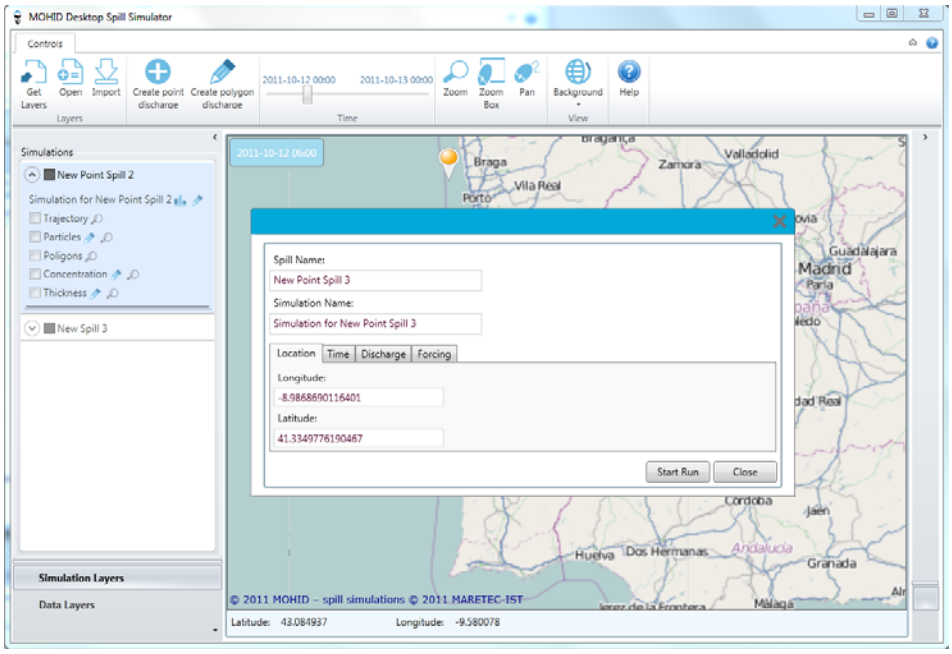


Image 6 – Create point discharge

- **Create polygon discharge**: This option lets user create a discharge based on polygon that he needs to draw on the map. This option is very similar to the *Create point discharge* one and will be explained to in the section 3.

- **Time**: A slide bar that is bounded to the common timeline of all the data layers. After selecting a data layer the user can move the slider and view the representation of the data layer property for a specific instant. As represented in the following image, the current value of the time slider is bounded to the clock displayed on top of the map.

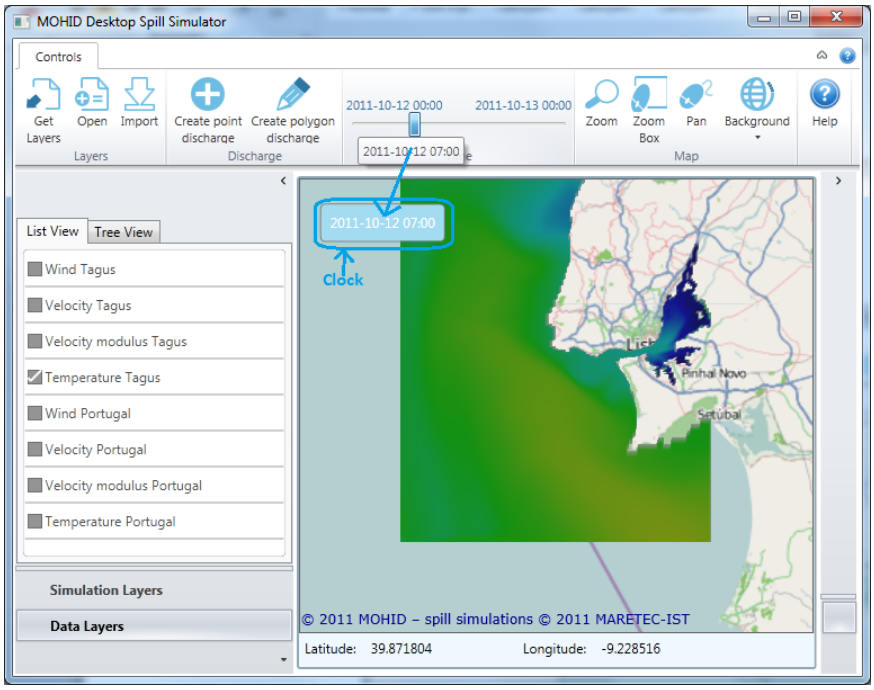


Image 7 – Time slider bounded to data layer

- **Map Group**:
  - **Zoom**: Zoom in or out the map;
  - **Zoom Box**: Allows user to draw a box upon the map and zoom in to that box;
  - **Pan**: After clicking on the *Zoom* option, it's requested to click on the *Pan* button in order to move the map;
  - **Background**: Allows choosing, from a list of options, the map background.
- **Help**: Displays a popup window with information about the Mohid Desktop Spill Simulator smart-client.

## 4.2 Main Window – Panel 2: Layers View

The *Panel 2* displays the available layers separated into *Data Layers* and *Simulation Layers.*

### 4.2.1 Data Layers

The image 8 shows the 2 possible views of the data layers: *List View* and *Tree View*.

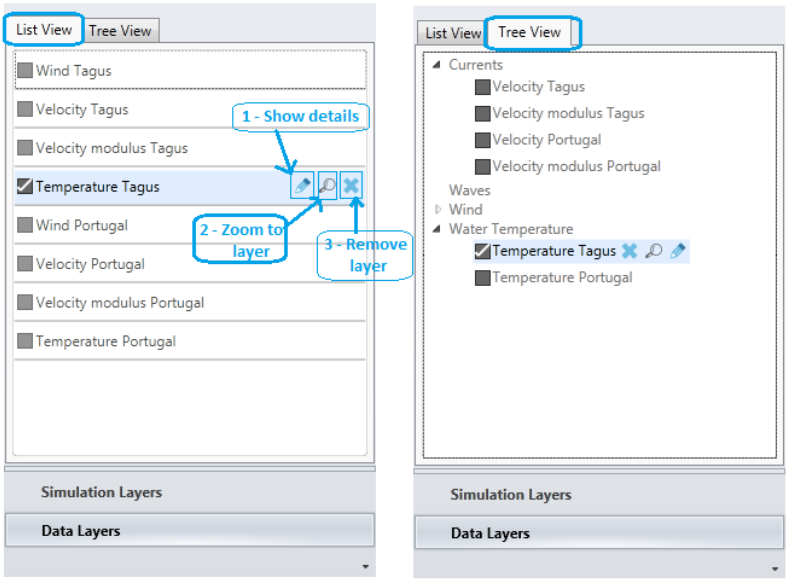


Image 8 – Data Layers view

The *List View* shows a plain list of the existing layers while the *Tree View* shows the same layers organized by properties. In order to display a layer on the map, check the checkbox on the left side of the layer name.

In addition to showing the layer on the map, the user has three more options: show layer details, zoom to layer on the map and delete the layer.

By clicking on the *Show details* button, the *Panel 3* of the main window becomes visible and shows information about the layer. By example, the next image shows the details of the "*Temperature Tagus*" layer (that is a scalar layer).

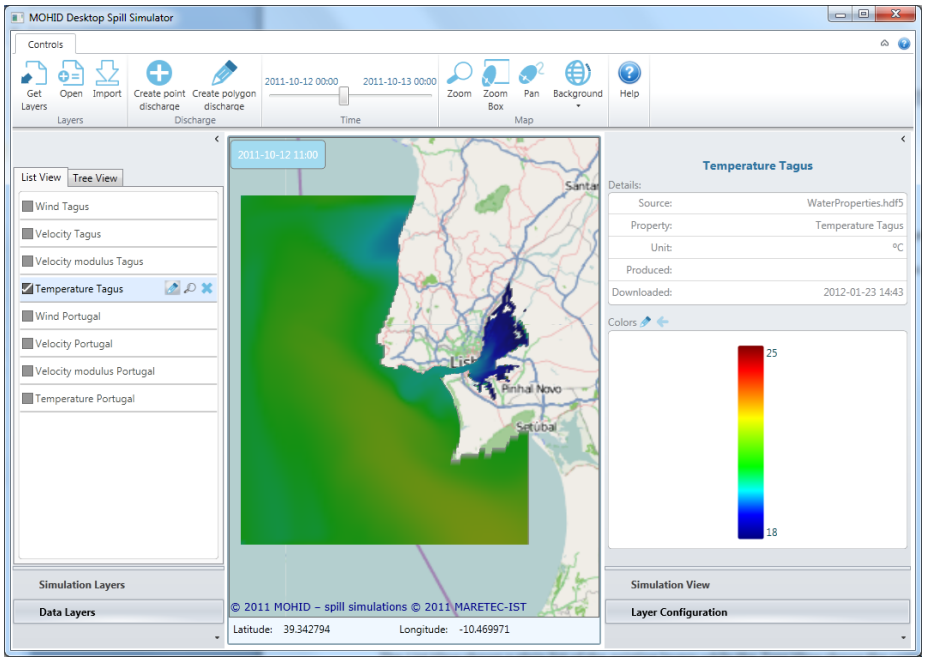


**Image 9 – Data layer details**

### 4.2.2 Simulation Layers

The other option in the P*anel 2* is the *Simulation Layers* view. That view presents a list of all the simulations performed by the user as well as the spills imported from the WFS server.

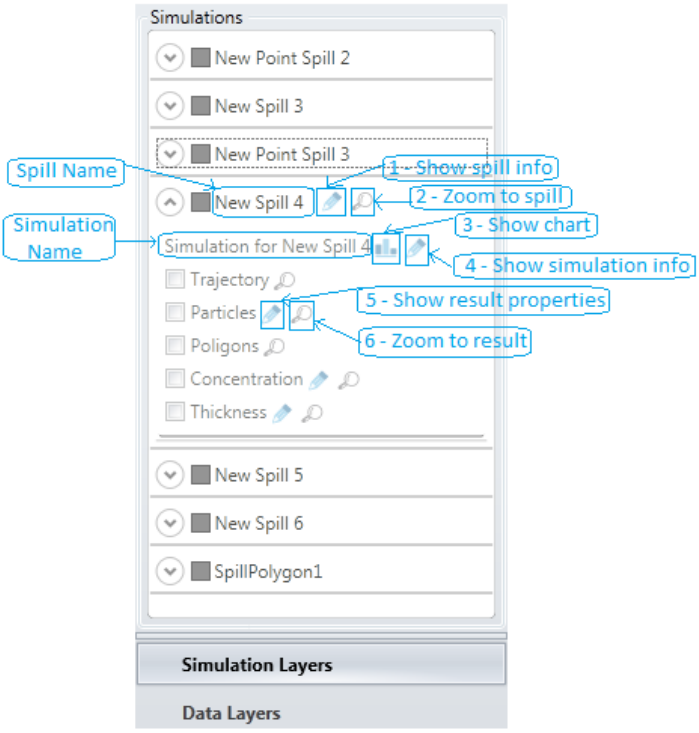


Image 10 – Simulation Layers view

In image 10 we can see an example of the *Simulation Layers* view. This view is basically a list where each item is an expander control and represents a spill (point or polygon). When the user expands the item, a list of the simulations that have been performed for that spill shows up. The user can view the original spill on the map as well as the results of the simulation.

In order to display the spill, check the checkbox on the left side of the spill name. Once the spill is selected user can zoom to spill on the map by clicking on the option 2 "*Zoom to spill*". The option 1 "Show spill info" will display information about the spill on the *Panel 3*, as well as give the option of make a new Oil Spill simulation, remove it or update it in case of that spill was been download from WFS server.

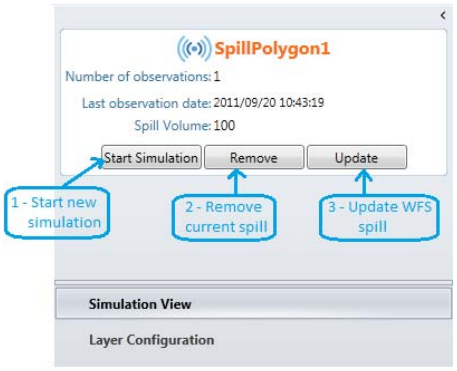


Image 11 – Spill information

Respecting the simulation, the user can view the resulting trajectory, particles, polygons, concentration and thickness on the map (just check the checkbox in the left side of the result property name). The user can also consult information about density, viscosity, evaporated fraction, dispersed fraction and water content volume by clicking on the option 3 "*Show chart*". This option will show on the *Panel 3* the results of the current simulation. This results can be consulted in a chart or/and in a table. The option 3 will also display information about the current simulation (start time, end time and exit status) and that information is also displayed when the user clicks on the option 4 "*Show simulation info*". The image 12 show an example of the *Simulation View* when the button "*Show chart*" is clicked.

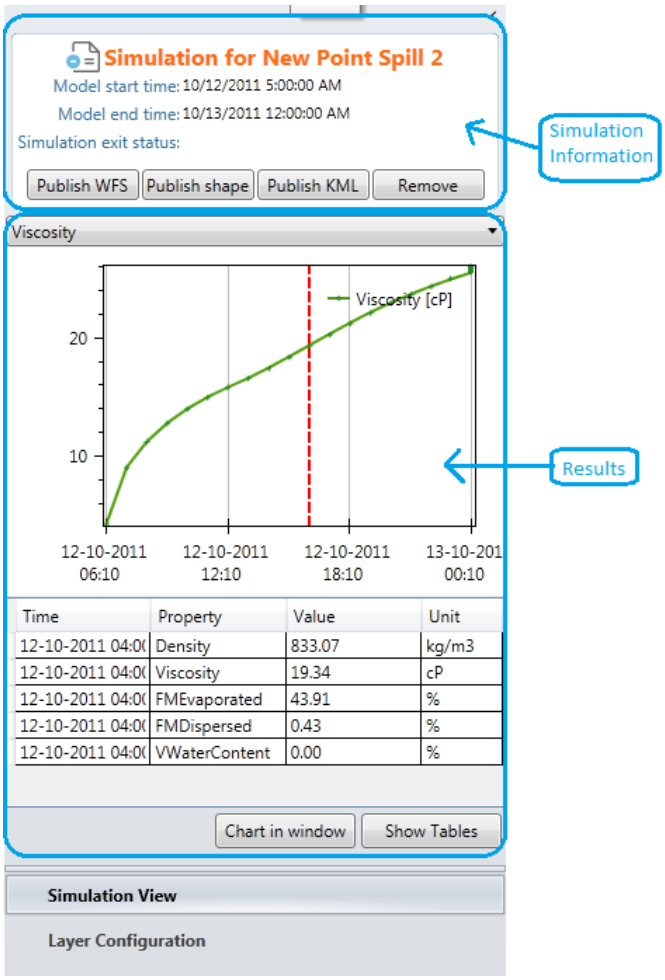


**Image 12 – Simulation View with simulation results**

## 4.3 Main Window – Panel 3: Simulation View and Layer Configuration

The *Panel 3* is composed of two components: *Simulation View* and *Layer Configuration*. The *Simulation View* displays the data corresponding to the spills (created or imported) and the Oil Spill simulations. The *Layer Configuration* displays data and allows configuring some properties of the layers.

### 4.3.1 Simulation View

This section will focus on the *Simulation View* component. This view is empty by default and only displays data once the user create (or import) at least one spill simulation. So, as seen before, the *Simulation View* is data bounded to the *Simulation Layers* of the *Panel 2.* Let's take a look at the possible "combinations" between the *Simulation Layers* and the *Simulation View*.

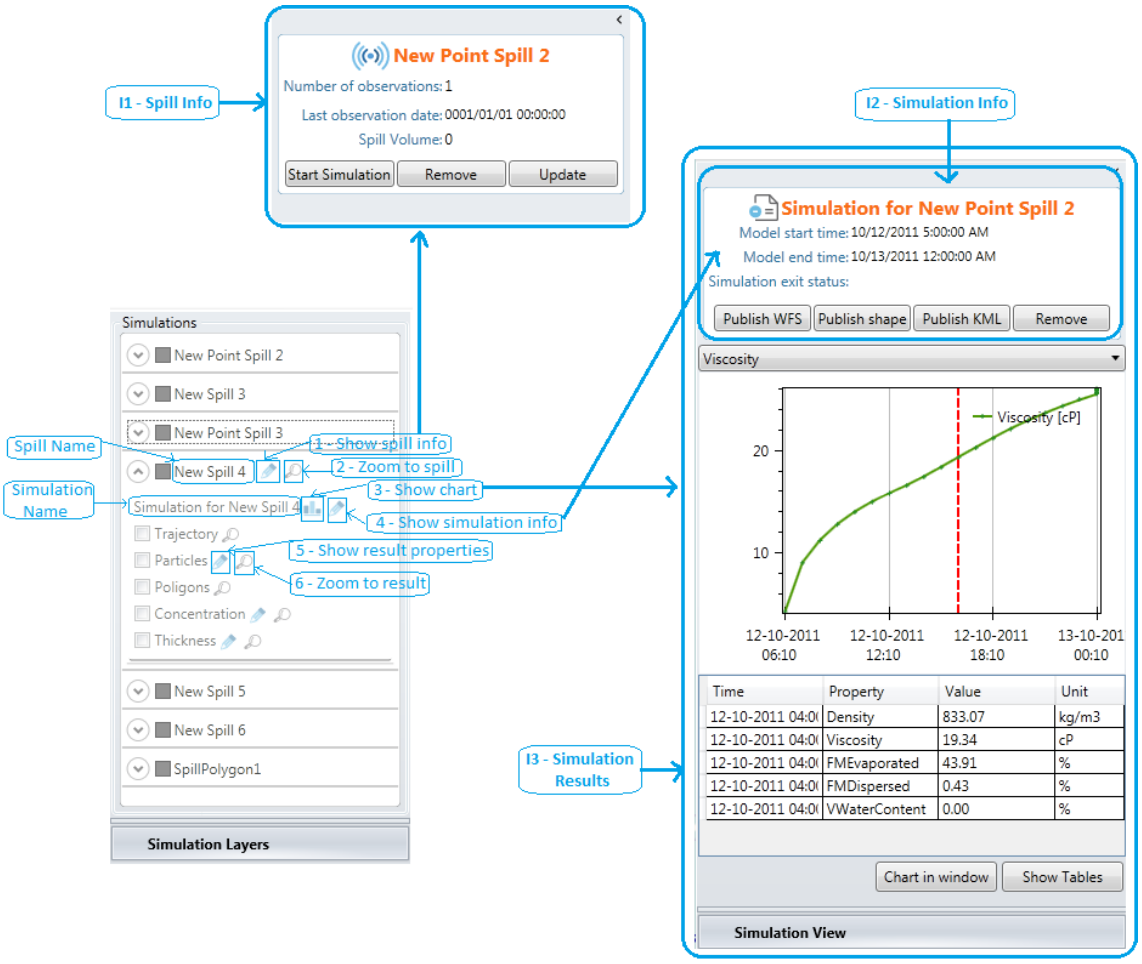


**Image 13 – Simulation View possible data**

The figure 13 shows all the possible displays of *Panel 3 Simulation View*. The component *"I1 – Spill info"* respects to the spill, and its option have already been explained in section 2.2.2 (see image 11).

The component *"I2 – Simulation info"* displays information about the spill langrangian simulation. If the users clicks on the option "*4 – Show simulation info*" in the left panel, the component *I2* will be the only-one displayed in the *Simulation View*. But if the user chooses the option "*3 – Show chart*" the component *I2* will be displayed integrated in the component *I3*.

Component *I2* presents 4 options to the user:

- **Publish WFS:** This option allows publishing the simulation results to the WFS server.
- **Publish shape:** Allows saving simulation results as a shape file (or multi files).

- **Publish KML:** Same as the previous option, but in this case the results will be saved as a KML file.
- **Remove:** Remove the current simulation from the *Simulation Layers* view.

All the previous options, excepting the last one, will make a popup window show up, and let user to choose which times of the resulting simulation he wants to save. The following image shows the popup window to publish the results as a shape file. The other two popup windows are similar to this one.

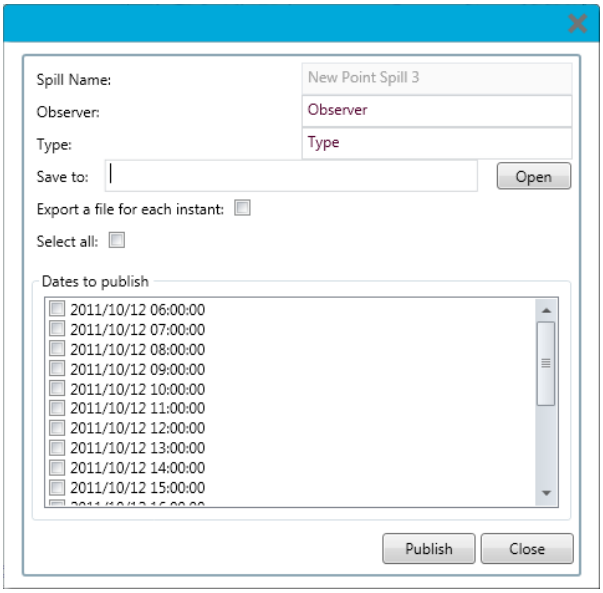


Image 14 – Publish simulation results

The component *I3* displays the panel *I2* and, more important, some results of the simulation. These results can be consulted in a chart or in tables. For consulting a specific result property pick it in the drop down list and then the chart automatically updates its values to the chosen property. Upon the chart there is a dotted red line. That line indicates the current time of visualization and it's bounded to the time slider of the toolbar. It's also bounded to the table on the bottom of the chart.

Just below the data table there are two buttons: *Chart in window* and *Show tables.* The *Chart in window* button allows displaying the chart in an independent window. *Show tables* button allows displaying, in an independent window, the results in tables for all the moments of the simulation.

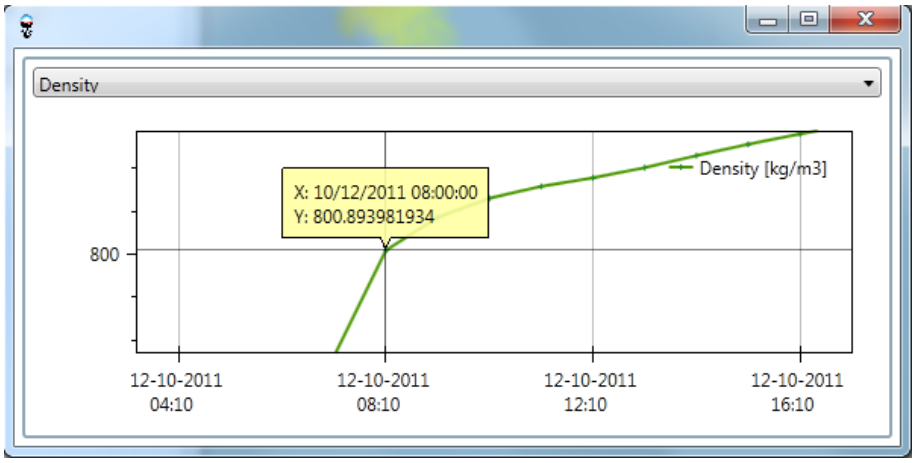


Image 15 – Independent chart window

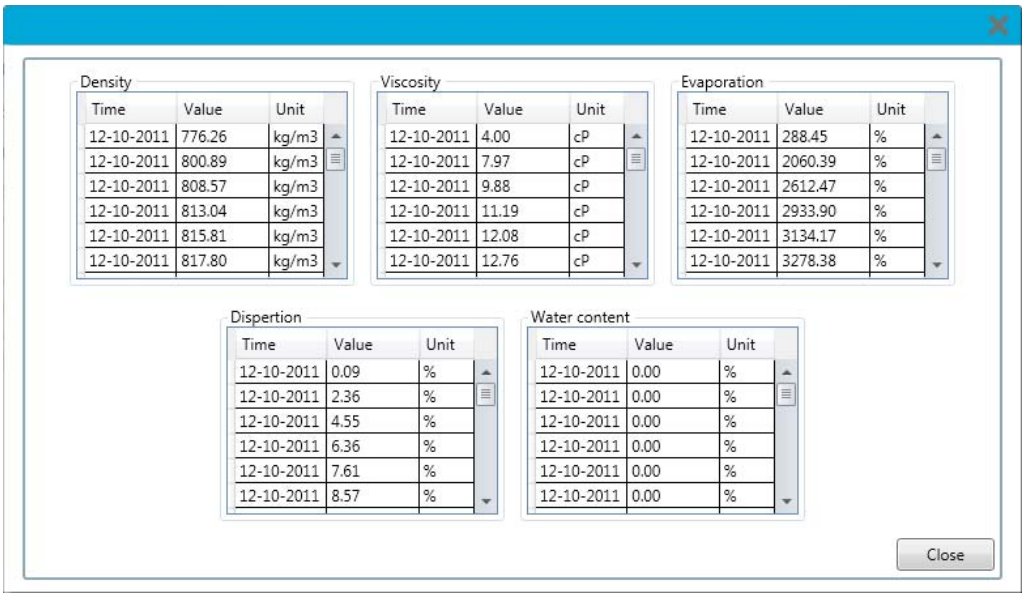


Image 16 – Independent data tables window

### 4.3.2 Layer Configuration

The *Layer Configuration* view shows information and let user configure some properties of the layers displayed in the *Data Layers* view of the *Panel 2*. Some results of the simulations can also be configured (display properties) in this view.

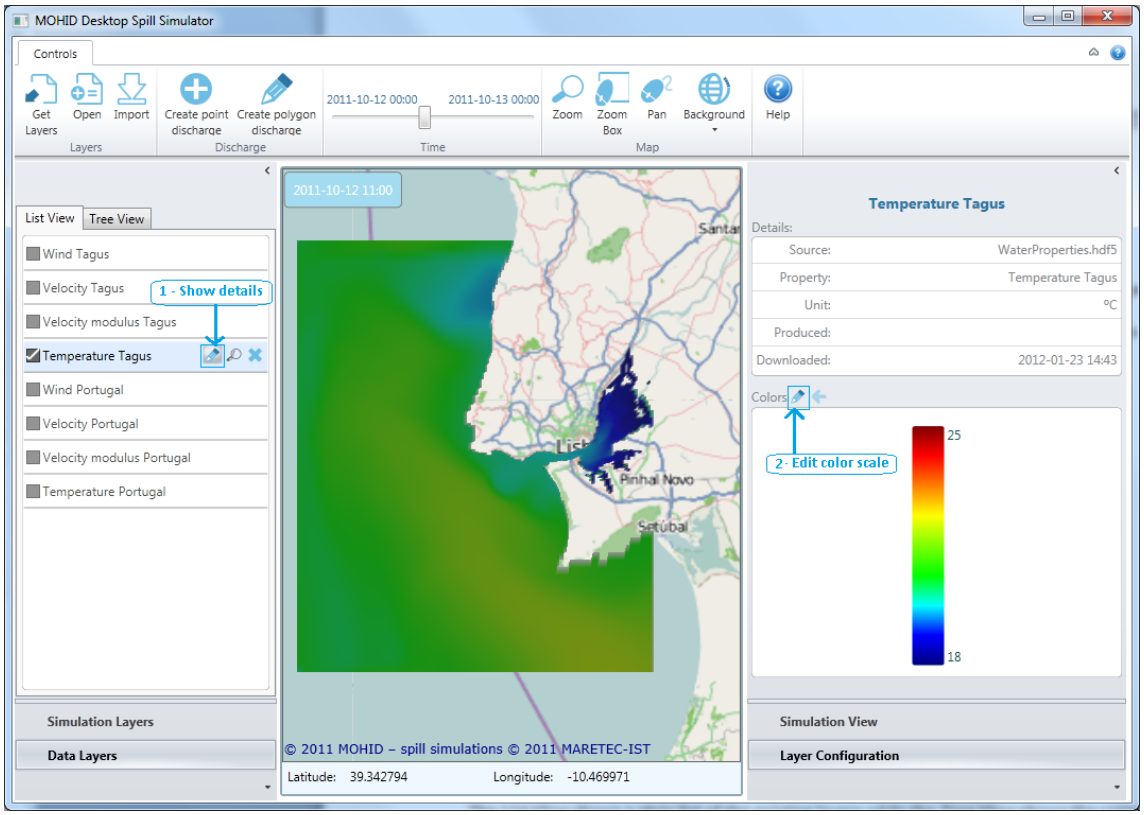


Image 17 – Scalar layer properties

In the image 17 we can see a full picture of information about a data layer. In order to access the *Panel 3 Layer Configuration* view, click in the option "*1 – Show details*". The *Layer Configuration* view is organized in two sections: *Details* and *Colors*. In the details sections, some basic information about the layer is displayed and in the *Colors* section the color scale, used to represent the layer on the map, is displayed. Notice that if the data layer selected is a vector layer the *Colors* section will be renamed to *Display* and will have a different representation, like showed in the image 18.

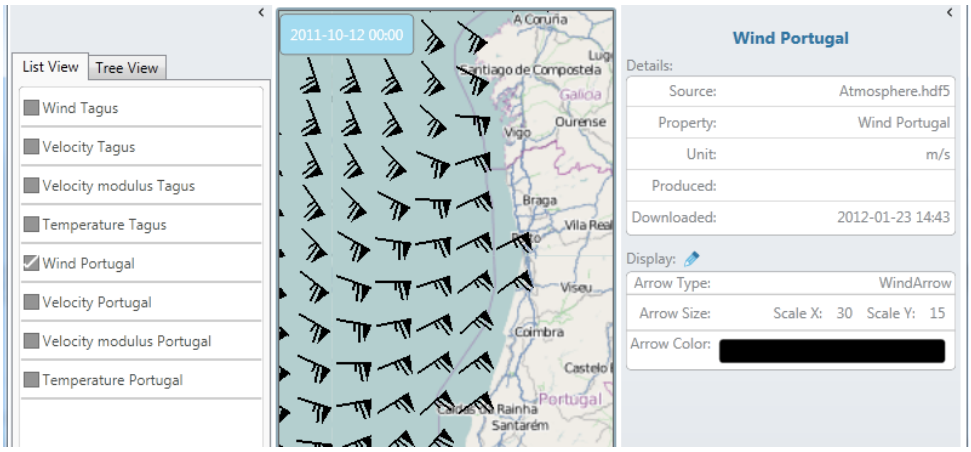


Image 18 – Vector layer properties

To edit the color scale (or the arrows properties) click on the button 2, in order to have access to the editor window. The image 19 shows the editor popup window for scalar layers and the image 20 for the vector layer. Change the pretended properties and then click "*OK*" to commit changes or "*Cancel*" to reject changes.

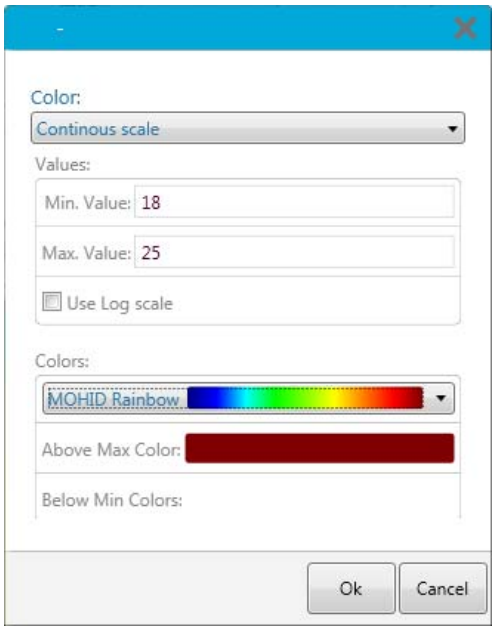


**Image 19 – Scalar layer editor**

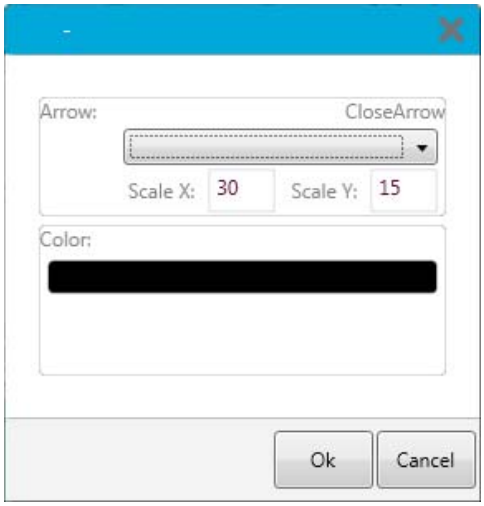


**Image 20 – Vector layer editor**

## 4.4 Main Window – Panel 4: Map view

The panel 4 is essentially the map view where the layers can be displayed. It's also the place where the spills for the simulations need to be created.

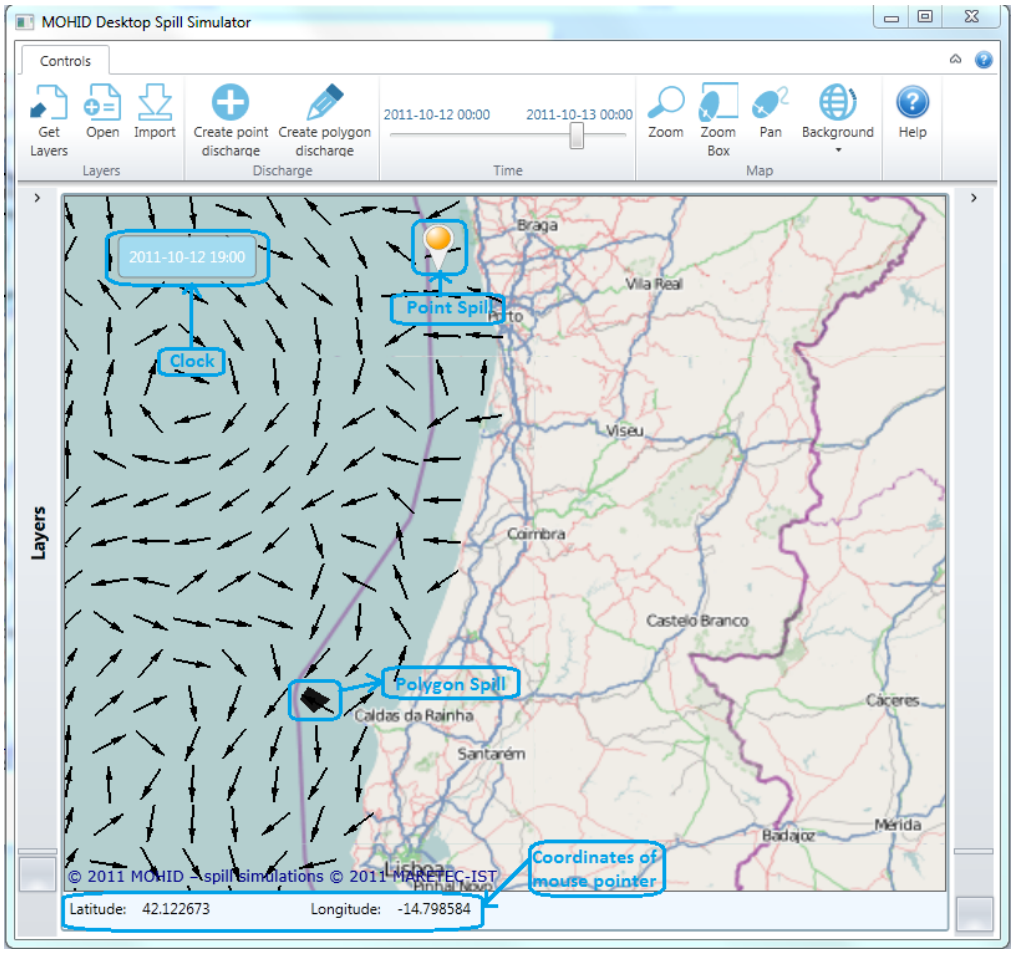


Image 21 – Panel 4: Map view

There are only two permanent items in the *Panel 4*: the clock and the coordinates of mouse pointer. All the other items that are marked in the image 21 can be added and removed. The background of the map can also be changed as well as turned off.

# 5 Creating Discharges

This section describes the task of creating discharges and run Oil Spill simulations. In section 5.1 we will describe the creation of a point discharge and in section 5.2 the creation of a polygon discharge.

## 5.1 Create Point Discharge

In order to create a point discharge, the first thing is to click on the "*Create point discharge*" button in the toolbar. Then click in the map in the place where you want to simulate the discharge. When clicked, a popup window will show up and let you configure the simulation options. Notice that all the options are filled with default options, so the simulation is ready to run and produce results.

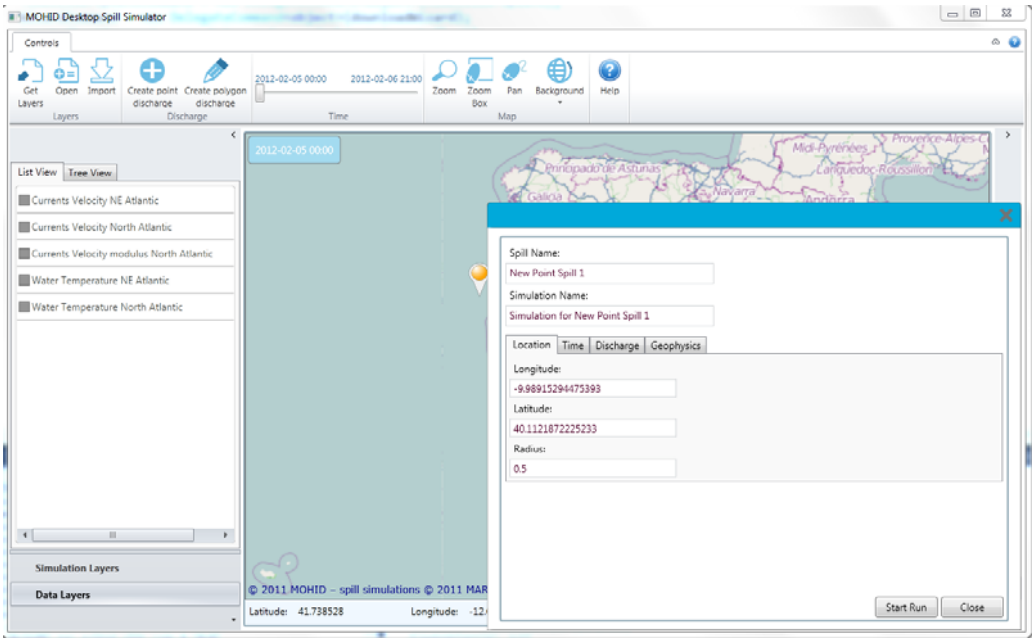


**Image 22 - Create point discharge**

Despite all the properties are set by default, user can change them all. So, in the first step, you can change: the spill name, the simulation name, the location (latitude and longitude) and the simulation radius (search area). The location is bounded to the pin point in the map.

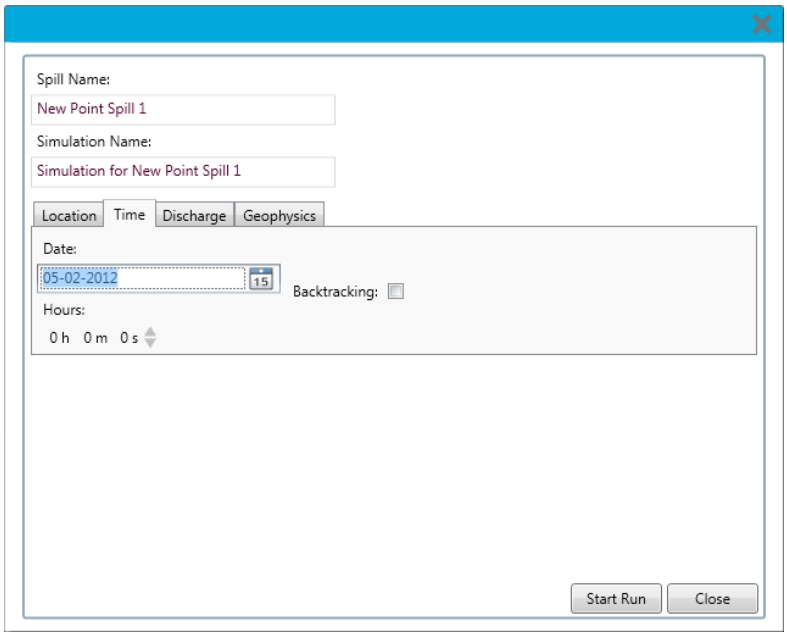


Image 23 - Set time for point discharge

User can change the time that is bounded by default to the value of the time slider in the toolbar. The user can also turn on the "*Backtracking*" option that allows running a "backward in time" simulation. That is, the displayed time becomes the end time of the simulation and the start date becomes the minimum available date in the current solution. This option is important when the user wants to locate possible origins of a specific spill.

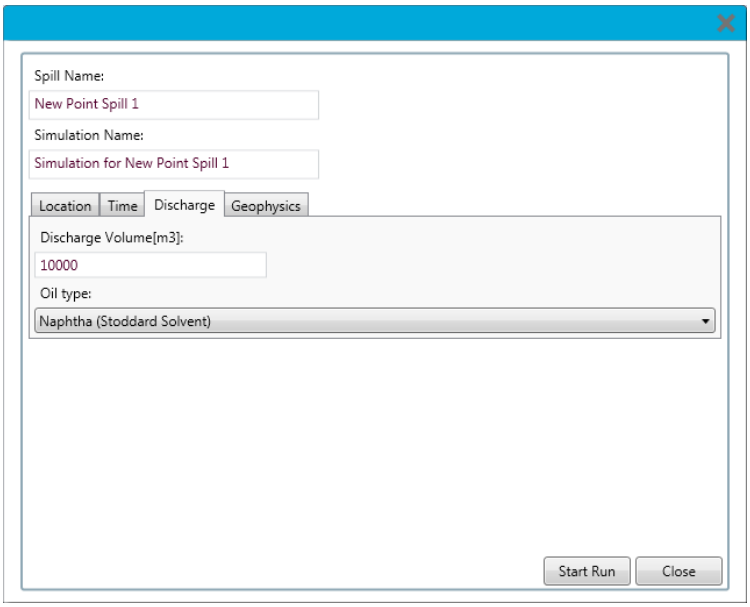


Image 24 - Set discharge volume and oil type for point discharge

In the "*Discharge*" tab the user can change the discharge volume and the oil type used to run the simulation.

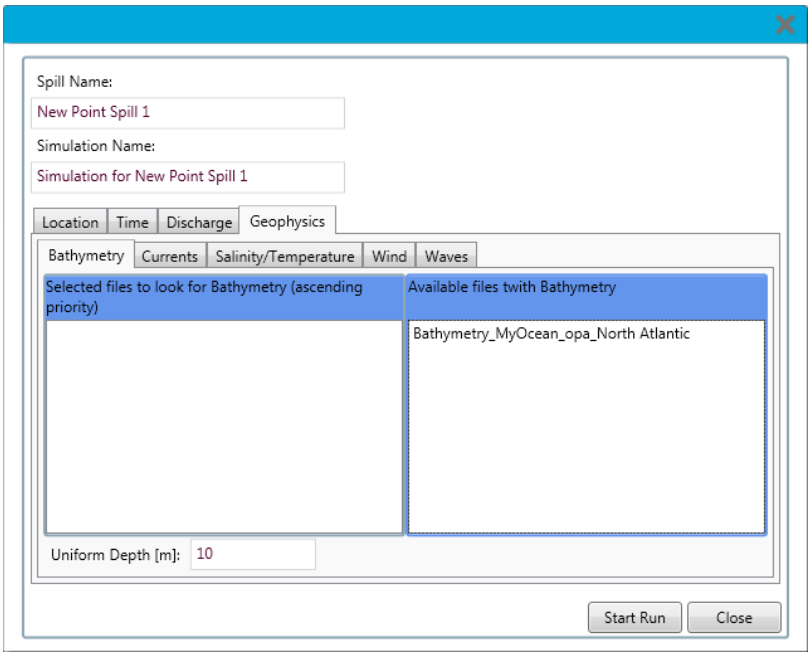


**Image 25 - Turn wind on/off for point discharge**

The "*Geophysics*" tab allows user to set values for geophysics properties. This tab makes another set of tabs visible and each one as a common section that is the two lists of files. The list on the right side shows all the available model solutions for each property. The user can select the solutions by just dragging in from the right side list to the left side list. The solutions are order by priority (top list - highest priority). Besides that the properties that user can manually set are:

- "*Bathymetry*" tab: depth;
- "*Currents*" tab: intensity and direction;
- "*Salinity/Temperature*" tab: salinity and temperature;
- "*Wind*" tab: wind drag, intensity and direction;
- "*Waves*" tab: enable Stokes drift, height, period and direction.

The point simulation is now ready to run. In order to do that, click on the "*Start Run*" button, the simulation will start immediately after. The popup window will be closed and the information about the simulation running status will be displayed in the *Panel 3* in the *Simulation View*. On the *Panel 2* in the *Simulation Layers* a new item will be added for this new spill and simulation. When the simulation finishes the *Trajectory* result of the simulation will be automatically displayed on the map and the *Panel 3* will display the details of this simulation.

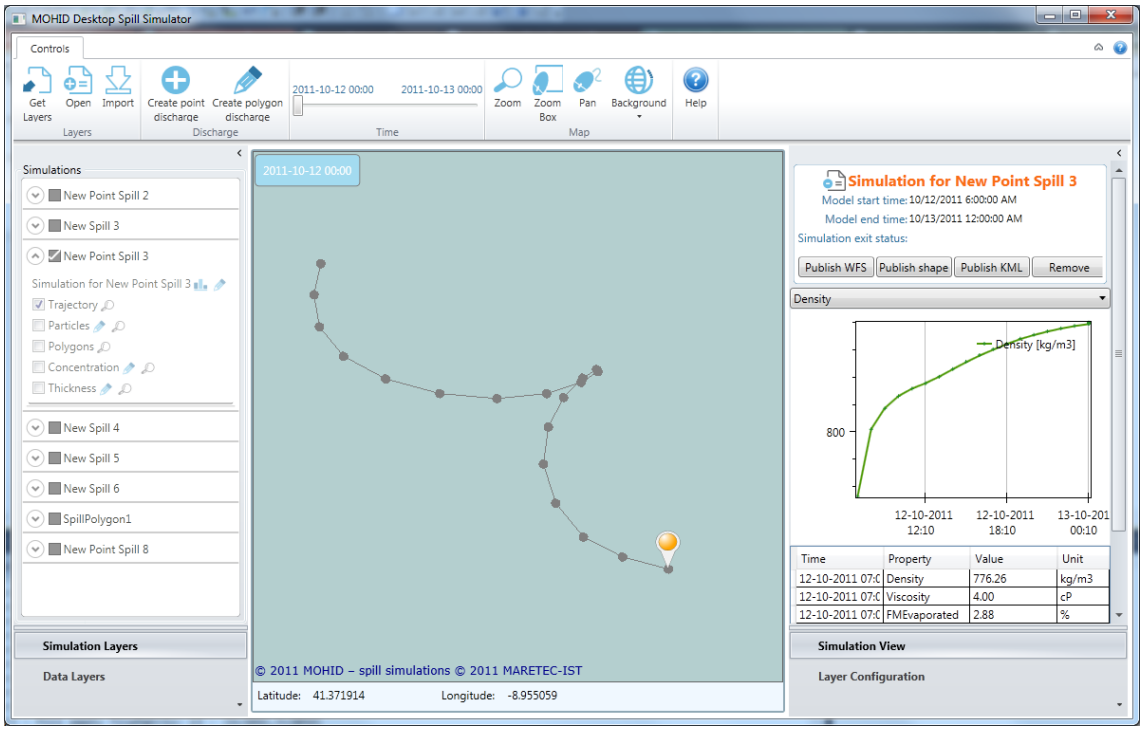


**Image 26 - Point discharge simulation completed**

The user can then explore the simulation results.

## 5.2 Create Polygon Discharge

The process of creating a polygon discharge simulation is similar to the process of creating a point discharge simulation. First click the button "*Create polygon discharge*", then draw a polygon on the map. Just click in a specific position then click on the next position and so on. To finish the polygon drawing make a double click and the polygon will auto close and a popup window will show up in order to let user provide the information that will be used to run the simulation.

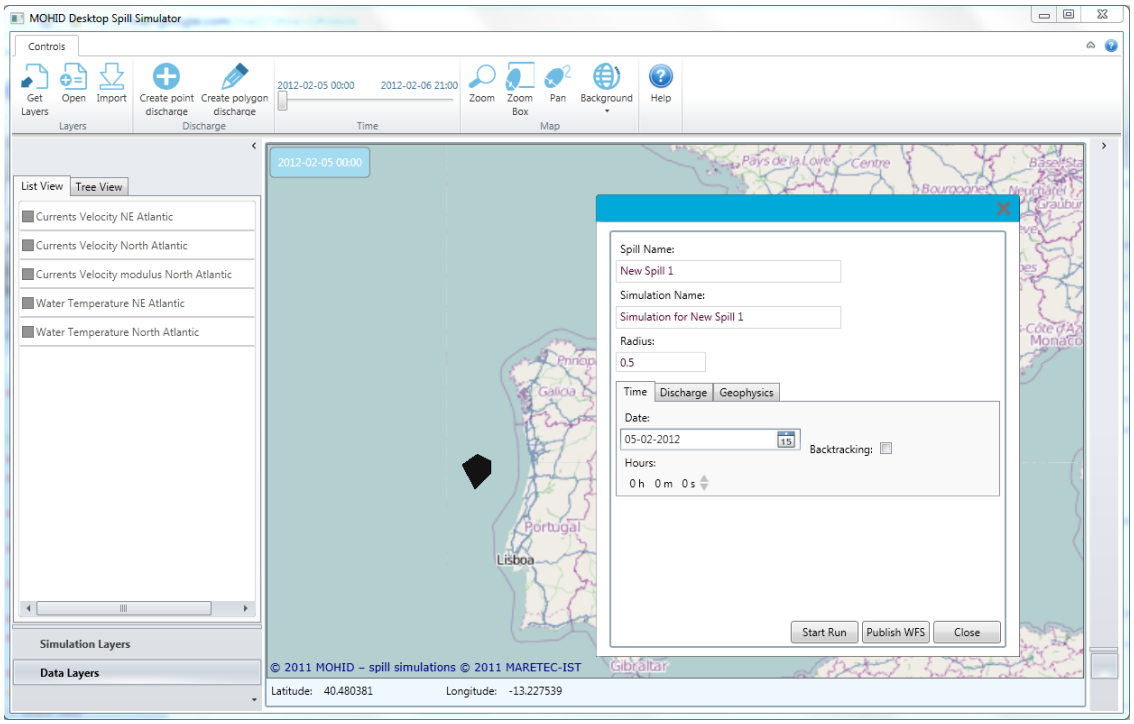


Image 27 - Creating polygon discharge simulation

The rest of the process is the same as seen for the creation of the point simulation discharge. The only two differences are that the configuration popup window doesn't have a "*Location*" tab and it has one more button that is "*Publish WFS*". This button allows user to publish the just created polygon to the WFS server. For starting the simulation click on the "*Start Run*" button so the popup window will be closed and the simulation will run immediately.

# 6 Known limitations or bugs; Future implementations

Users should be able to define the folder where to keep downloaded metocean model results, which is not possible in this version.

Bathymetry doesn't need to be downloaded (and should not be done, because model is crashing when using this).

More metocean forecasting systems are going to be integrated as data providers in the near future, allowing the application of this tool in more regions, and with better resolution in some specific zones (e.g. Tagus Estuary).

Another limitation in this version is related with the time window displayed: the time window available for simulations is the time horizon common to all the downloaded model data. This means that if one of the models only provides 1 day forecast and 1 day hindcast, time window available for simulations will be limited to that range of days, independently of having other model results downloaded for the area, and with a bigger time range. Next versions will solve this limitation.

MohidDesktop Spill Simulator seems to be sensitive to the computer's graphic card. Usually there is no problem with recent graphic cards. If problems are found, best solution is to close the tool and opening it again. A better diagnostic about this issue will be generated in the future.

The loading of background map layer is slower than is should be. To avoid this, the possibility of having an embedded shapefile with the background map and coastline is the solution proposed to the future. This is also interesting, because allows the possibility of seeing land information without internet connection.

Also the maps visualization for data layers (e.g. temperature, velocity modulus, etc.) needs to be improved in relation to the resolution, specially near shore. Similar process should be done for the coastline. In the future a high resolution coastline will be embedded by default, in the software tool.

Arrows density in the visualization of velocity layers is a bit low. In a future version, this should be customized by the end-user.

This software tool was also designed to accommodate and explore some additional data layers, like shapefiles, kml (Google Earth) files, etc. however, during the execution of the project, there was no possibility of releasing a stable version that accomplished complex operations when importing shapefiles or kml. The Portuguese Coastal Atlas is able to be imported, but several testing needs to be done.

When creating a new polygon discharge, polygons should not be bigger than the simulation radius (search area) – no warning is given to the end user if this happens.

In the exploration of simulation results, the fields "concentration" and "thickness" are presently grid-interpolated, providing "ugly" results. A future version will deactivate the

interpolation, providing grid concentration and grid thickness, but without interpolation. The field "particles" is representing the particle thickness

If user simulates a big time period, and if the search area / simulation radius defined is short, slicks can disappear.

A field with inert substances is missing in the discharge options (when running simulations on backtracking mode, inert should be the only substance used, since oil spill weathering and spreading processes are not computed backwards). This will issue will be corrected by the end of the first trimester of 2012.

Presently MOHID Desktop Spill Simulator is not simulating 3D processes for oil spills, neither floating containers (with this type of discharge, user only have to define the immersibility). A future version should include these features.

Beyond all of these limitations, bugs or updates already mentioned, other major developments are being considered:

- The online database of products generated by IST (task 4.3.4, http://arcopol.maretec.org) should be integrated with this software. Since database is able to provide contents in structured format (.xml), the incorporation with MOHID Desktop Spill Simulator wouldn't represent a big effort.
- Also taking advantage of ARCOPOL deliverables in Activity 4, the proposed recommendations and guidelines of data exchange between observation and software that predicts the movement of the spill should be further implemented, so that in the future this software can exchange more data input and output, naturally with other programs, either because it contains all necessary information or because it uses widely accepted standards (this report was generated by INTECMAR, entitled "Monitoring, Observations, Predictions & Communications – A Practical Guide"). Although MOHID Desktop Spill Simulator is already importing and exporting data with other systems (under OGC standards), much more standardization can be done.
- Following the philosophy mentioned above, the possibility of import satellite-detected oil slicks under EMSA's CleanSeaNet[2] operational service, and being able to run simulations forward and backwards, should be achievable without much effort, taking in account that CleanSeaNet delivers data in GML, under OGC standardization.

[2] CleanSeaNet is a near-real-time satellite-based oil spill and vessel monitoring service operated by EMSA. It entered into operation on 16 April 2007. The service is continually being expanded and improved and provides a range of different products to the Commission and to EU Member States, and to other governmental and institutional partners as appropriate.

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