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NetMOD Version 2.0 User's Manual

B. John Merchant

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Albuquerque, New Mexico 87185 and Livermore, California 94550

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Abstract

NetMOD (Network Monitoring for Optimal Detection) is a Java-based software package for conducting simulation of seismic, hydracoustic, and infrasonic networks. Specifically, NetMOD simulates the detection capabilities of monitoring networks. Network simulations have long been used to study network resilience to station outages and to determine where additional stations are needed to reduce monitoring thresholds. NetMOD makes use of geophysical models to determine the source characteristics, signal attenuation along the path between the source and station, and the performance and noise properties of the station. These geophysical models are combined to simulate the relative amplitudes of signal and noise that are observed at each of the stations. From these signal-to-noise ratios (SNR), the probability of detection can be computed given a detection threshold. This manual describes how to configure and operate NetMOD to perform detection simulations. In addition, NetMOD is distributed with simulation datasets for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) International Monitoring System (IMS) seismic, hydroacoustic, and infrasonic networks for the purpose of demonstrating NetMOD's capabilities and providing user training. The tutorial sections of this manual use this dataset when describing how to perform the steps involved when running a simulation.

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NOMENCLATURE

dB	Decibel
CDF	Cumulative Distribution Function
GUI	Graphical User Interface
JVM	Java Virtual Machine
NetMOD	Network Monitoring for Optimal Detection
PDF	Probability Density Function
PSD	Power Spectral Density
SNR	Signal to Noise Ratio

1 INTRODUCTION

1.1 Overview

Network simulations have long been used to study network resilience to station outages and to determine where additional stations are needed to reduce monitoring thresholds. Since the early 1990s, the standard tool for such simulations has been the NetSim package (Sereno, 1990). With correct parameters for the network, sources, and paths through the Earth, such a modeling tool can produce high-quality event detection simulations.

SNL has developed NetMOD (Network Monitoring for Optimal Detection), a new Java based open-release software package designed to assess the performance of ground-based waveform sensor networks (Heck et al., 2012). As designed, NetMOD has several clear advantages:

- Coded in a modern object-oriented language that is inherently multi-platform.
- Takes advantage of modern computing capabilities (e.g. multi-core processors, an easy-to-use graphical user interface).
- Modularity to easily allow incorporation of ground-based monitoring techniques other than seismic.
- Includes a new, well documented and well-validated default parameter set including information for all the IMS stations corresponding to technologies implemented in each software release.
- Support for empirical site noise files that do not assume a normal-distribution and allow for variations in time of day and day of year.

The NetMOD Graphical User Interface (GUI) is designed to give users the ability to easily set up simulations, navigate the results and answer many "what-if" questions in an easy manner. Notable features of the GUI include:

- The ability to create and modify the simulation configuration – Setting up a simulation run is by far the most difficult part and can take many days or even weeks due to the large numbers of parameter files that must be created and reviewed. The NetMOD GUI provides a display that guides the user through the various major portions of setting up a simulation.
- An integrated map for displaying configuration and results – Simulation outputs are fundamentally geographic in nature, as are many of the input parameters. Thus NetMOD includes an integrated map for both parameter set up and simulation analysis.
- A differencing tool for quickly assessing the differences between two simulations – Often simulations are calculated to ask specific questions about the effect of making a small change in the network, e.g. leaving out a station or adding a station. The differences in output between simulations, however, can be subtle. NetMOD provides a differencing tool that calculates and displays the differences directly, making analysis much easier.
- An introspection tool to drill down into the results in order to track how the simulation input affects the output – Network simulations are very complex calculations, involving numerous intermediate calculations and hundreds of input parameters. Trying to understand why a particular result was calculated is sometimes desirable, particularly

when there is any question about the validity of a simulation. NetMOD Introspection provides an easy way to quickly find out why a particular result was obtained.

The need for a new simulation tool is driven primarily by the desire to improve upon the implementation of simulation algorithms, not in the algorithms themselves. Thus the simulation methods used in NetMOD will be taken from the well-vetted models from literature and/or existing simulation tools. For example, for seismic detection NetMOD performs much the same calculations as NetSim (Sereno et al., 1990).

NetMOD is designed to be highly configurable by utilizing a modular plugin-based architecture. This software design pattern provides flexibility by allowing for the addition or removal of new software features via plugins without affecting other functionality. Version 2.0 of the NetMOD software supports the detection simulation of seismic, hydroacoustic, and infrasonic networks.

1.2 License

The following notices are required for the third party libraries that
are provided with NetMOD.

World Wind:

Sandia provides you with the NASA World Wind software (version 1.5)
unmodified and in object code only. Your use of the NASA World
Wind software is subject to and governed by the NASA OPEN SOURCE
AGREEMENT, which is provided herewith and available at
http://worldwind.arc.nasa.gov/worldwind-nosa-1.3.html.
The source code for the NASA World Wind software may be obtained at
http://worldwind.arc.nasa.gov/java. NASA requests that each recipient
of World Wind software register with NASA at
http://opensource.arc.nasa.gov to cooperate with their effort to track
usage and maintain accurate records of usage of World Wind.

JFreeChart:

NetMOD utilizes JFreeChart (version 1.0.15), which is shipped herewith and linked to NetMOD. NetMOD is a Combined Work under the LGPL version 3, and as such is not subject to the GPL or LGPL as a whole. However, JFreeChart is subject to the LGPL version 3. As required by the LGPL, the LGPL license and the GNU GPL are provided herewith. Nothing included with NetMOD is subject to the terms of the GNU GPL.

The LGPL V3 is available at http://www.gnu.org/licenses/lgpl.html.
The GPL V2 is available at http://www.gnu.org/licenses/gpl-2.0.html.

NetCDF:

NetMOD utilizes NetCDF (version 4.3.0), which is shipped herewith and linked to NetMOD. NetCDF is available at http://www.unidata.ucar.edu/software/netcdf/.

HPPC:

NetMOD utilizes HPPC (version 0.5.2), which is shipped herewith and linked to NetMOD. HPPC is available at http://labs.carrotsearch.com/hppc.html.
HPPC is subject to the Apache 2.0 license. As required by the Apache license, the Apache 2.0 license is provided herewith and available at http://www.apache.org/licenses/LICENSE-2.0.html.

Colt:

NetMOD utilizes Colt (version 1.2.0), which is shipped herewith and linked to NetMOD. Colt is available at http://acs.lbl.gov/software/colt/. As required by the Colt license, the following statement is provided herewith.

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Oxygen:

NetMOD utilizes the Oxygen icon package, which is shipped herewith and linked to NetMOD. Oxygen is available at http://www.oxygen-icons.org under the Creative Common Attribution-ShareAlike 3.0 License.

1.3 Typographic Conventions

This manual uses the following typographical conventions:

Italics	Book titles, names of sections in the manual, computer files and directories.
Bold	Key names, module names, menu names, button names, selectable items

When indicating an option of a pull down menu, we use the notation:

Menu → Option

If there is an option within a submenu you may see:

Menu → Submenu → Suboption

Selection commands for displayed objects assume that the user has a standard 3-button mouse. “Left-click”, “Center-click”, or “Right-click” means a single click with the left, center, or right button, respectively. “Double-click” means two clicks in rapid succession. “Two-single- clicks” means two separate clicks, in moderate succession. If no left, center, or right is specified for a click, assume left.

2 NETMOD VERSION HISTORY

2.1 Version 1.0

NetMOD Version 1.0 is written to run seismic detection simulations. This version of NetMOD implements the same basic simulation algorithms at NetSim. However, there are some differences between the two implementations either due to new features available in NetMOD or corrections of issues that were identified in NetSim:

- Path Attenuation Standard Deviation
  At teleseismic distances between a given source and receiver, NetSim evaluates the path attenuation curves specified in the reference path media for the distance and frequency that are being simulated. However, when obtaining the standard deviation for the teleseismic path attenuation, instead of using the value specified in the reference path media, NetSim obtains the standard deviation value from the path media type at the source location.

  NetMOD corrects this so that both the attenuation and standard deviation are consistently obtained from the reference path media type when at teleseismic distances. If a project file has a different path attenuation standard deviation value between the various media types, then there will be a noticeable difference in the outputs of NetSim and NetMOD.

  NetMOD has a parameter that may be specified at the command line to enable this behavior, if desired, for performing validation:

  NETSIM_PATH_SD=[true | false]

  Unless specified otherwise, this option defaults to false. If this option is true, then NetMOD will revert to being compatible with NetSim.

- 1-D Interpolation method
  NetSim makes use of an interpolation algorithm to evaluate the one dimensional curves that specify the receiver site noise, receiver array gain, and coda decay. The purpose of this interpolation algorithm is to determine the desired value of these curves for the simulated frequency or distance from the set of points that define the curve.

  NetSim has been observed to make use of different interpolation algorithms, depending upon the specific version, which can impact the results of the simulation. The original versions of NetSim coded in Fortran use a quadratic interpolation algorithm (*dquaint.f*). Later versions of NetSim, updated in the late 2000's when portions of the code were converted from Fortran to C, make use of a cubic spline algorithm for evaluating the site noise and a linear interpolation algorithm for evaluating the receiver array gain and coda decay.

  NetMOD has a parameter that may be specified at the command line to enable this behavior, if desired for performing validation:

NETSIM_C_INTERP=[true | false]

Unless specified otherwise, this option defaults to false. If this option is false, then NetMOD will use the quadratic interpolation algorithm as implemented in the Fortran version of NetSim. If this option is true, then NetMOD will use the interpolation algorithms consistent with version 2.4.1 of NetSim in which portions of the code were converted to C.

Note that all observed versions of NetSim make use of the original quadratic interpolation method for the 2-D interpolation of values from the source spectra and path attenuation. NetMOD uses the same algorithm for evaluating these quantities.

- Monte Carlo
  NetMOD adds the ability to perform Monte Carlo simulations. Monte Carlo simulations, when performed using a sufficiently large number of iterations, provide for a more accurate representation of the probability distributions without any assumption of parameters having a Normal distribution.

- Non-parametric site noise
  NetMOD adds support for station site noise definitions that are stored within NetCDF files and are defined as a cumulative distribution function that can vary with frequency, time of day, and day of year.

2.2 Version 1.0.1

NetMOD Version 1.0.1 is a minor update to Version 1.0 that includes the following changes:

- Flag to control whether the standard deviation value in the site noise files is in log10 or 10log10 units to allow for enabling a NetSim bug.
- User Interface fixes for better cross-platform appearance.
- Added two additional map options ('None' and 'Basic') for better support for computers that lack 3-D graphics.

2.3 Version 2.0

NetMOD Version 2.0 is a major revision that includes the following changes:

- Support for Hydroacoustic simulations.
- Support for Infrasonic simulations.
- Support for site noise cumulative distribution functions stored in an ASCII text file.
- Support for an alternate method of computing noise amplitudes that honors the properties of the amplitude probability distributions.
- Numerous user interface enhancements.

3 SYSTEM SETUP

Platform Requirements

NetMOD is supported on Windows, Mac OSX, Linux, and Solaris platforms. NetMOD was written entirely in Java, a platform independent programming language, and should be able to run on any platform that has Java installed. The only software needed is a copy of the Java Virtual Machine version 6 or greater, which is freely available from Oracle.

The map that NetMOD uses is based upon WorldWind (http://worldwind.arc.nasa.gov/java/). WorldWind, although primarily a Java library, does make use of native libraries that are architecture specific for the purpose of utilizing OpenGL. NetMOD provides these libraries for the Windows (x86 and x86-64), Mac OSX (PPC and x86-64), Linux (x86 and x86-64), and Solaris (Sparc, Sparc v9, x86, and x86-64) systems. NetMOD is able to dynamically self-load the required native library at runtime, eliminating any need for re-compilation or installation on the system on which the executable is located.

3.2 Command Line Options

To run NetMOD, the user may simply execute the file *NetMOD.jar*, which contains all of the compiled code needed for the application, by double clicking the file. Note that the operating system file association must be configured appropriately for this to work. Alternatively, the following command may be typed at the command line:

java [JVM Parameters] -jar NetMOD.jar [Parameters]

NetMOD may be started from any location, so long as the file reference to NetMOD.jar is updated to reflect the installed location.

Because NetMOD is a Java application, any of the Java Virtual Machine (JVM) runtime parameters may be specified prior to the "*-jar NetMOD.jar*" portion of the command. See the relevant JVM documentation for a description of the available JVM parameters.

Note that Java by default only allocates 64 megabytes of memory for its applications. It may be necessary to increase that amount depending upon the size of the simulation to be loaded within NetMOD. The following virtual machine setting may be specified to increase the allocated memory:

-Xmx???m

Where ??? is the amount of memory of megabytes. In typical use, an amount of 1000 megabytes has worked well. This virtual machine setting may either be included in the command line, by configuring the operating system's file type association, or added to the runtime operations using JVM Options within the Windows Control Panel.

NetMOD command line parameters may also be specified at application startup to define the tool's initial state. Many of the options are geared towards preloading, and potentially running, a simulation on NetMOD startup.

CONFIG=<file> Specify a properties file that contains the configuration settings. The NetMOD configuration file defaults to a file named "NetMOD.cfg" within the startup directory.

PAR=<file> Specify a project file that will be automatically loaded.

GUI=[true | false] Specify whether or not to display the graphical user interface. If the user interface is not displayed, then the simulation defined by the provided parameter file will be run automatically and the application will then exit upon completion. Defaults to 'true'.

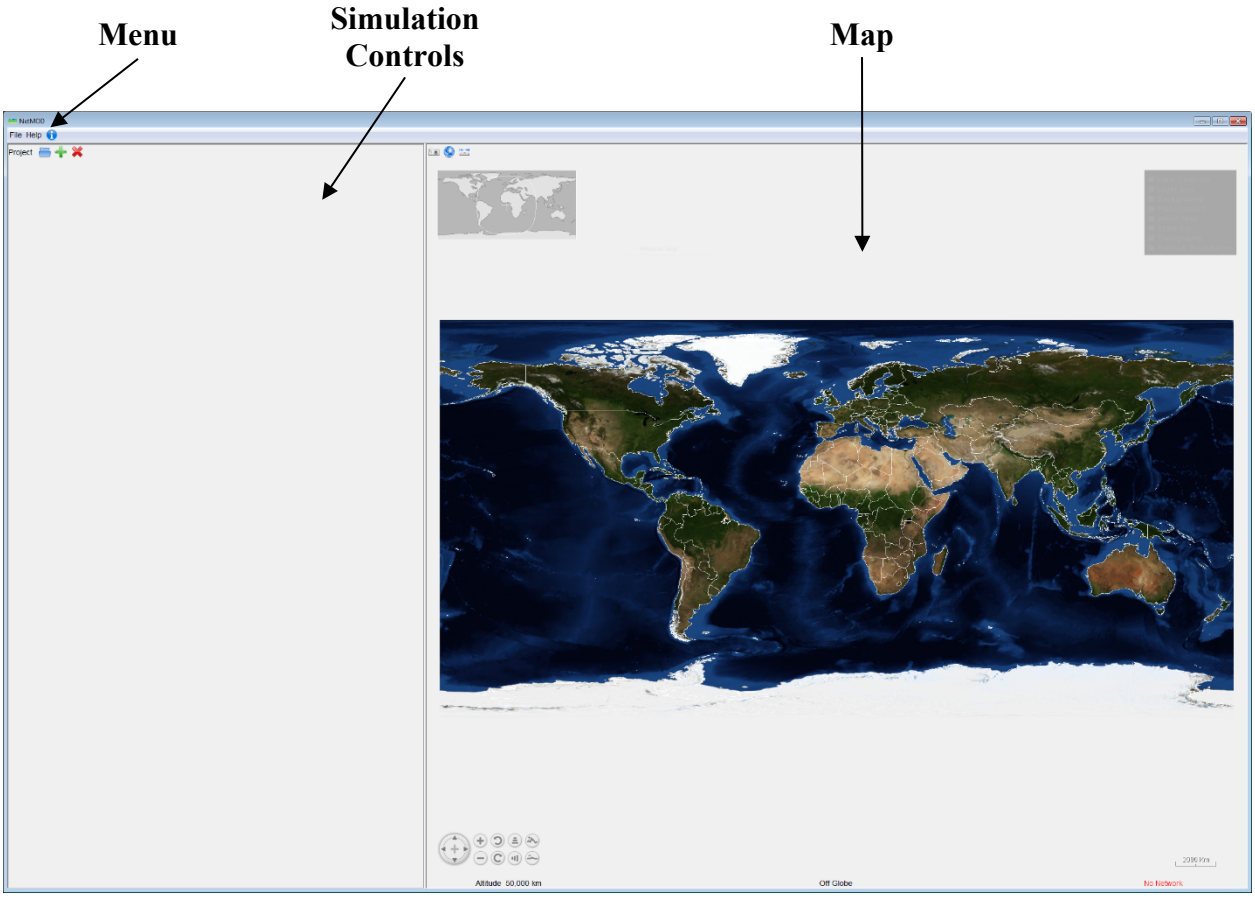
Parameters Any of the parameters defined within the NetMOD Parameters document.

The command-line output from NetMOD has one line for each source location specifying the longitude, latitude, number of iterations to converge at a solution, the magnitude, and the probability. An example of the output is shown below:

```
  epilon        epilat    iter     epi_size   net_prob
-180.00000    -80.00000     8       3.6381     0.9001
-180.00000    -76.00000     6       3.6999     0.9001
-180.00000    -72.00000     6       3.8309     0.9000
-180.00000    -68.00000    10       3.9492     0.8999
-180.00000    -64.00000    15       3.9940     0.9157
-180.00000    -60.00000     8       4.0684     0.9000
-180.00000    -56.00000    14       4.0832     0.8999
-180.00000    -52.00000    15       4.1611     0.9081
-180.00000    -48.00000    16       4.0892     0.8997
-180.00000    -44.00000     7       4.0651     0.9001
-180.00000    -40.00000    13       4.0292     0.8998
-180.00000    -36.00000     4       3.9845     0.9001
-180.00000    -32.00000    11       3.9641     0.9000
-180.00000    -28.00000    14       3.9489     0.9001
...
```

4 USER INTERFACE

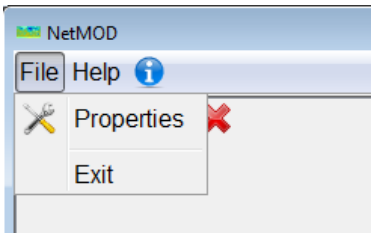
When the user starts the NetMOD application, they are presented with the main application desktop shown below. The primary components that make up the application are the **Menu**, **Simulation Controls**, and **Map**. The **Menu** provides the user with access to additional menu items and controls for interacting with NetMOD. The **Simulation Controls** display a hierarchical representation of the simulation parameters that are to be executed. The **Map** is where the various geophysical parameters and simulation outputs may be visualized. Additional information about each of these application components is provided in subsequent sections of this manual.



Menu

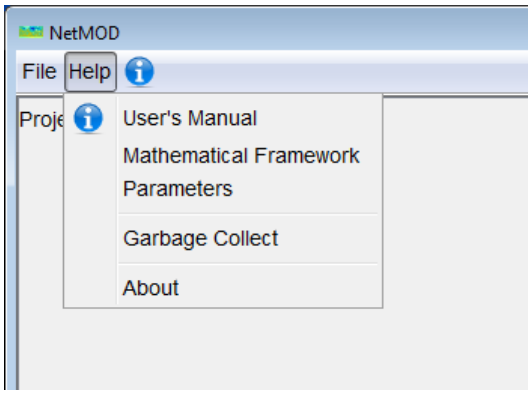
The **Menu** controls within NetMOD provide some basic user interface controls. The menu items are divided into File and Help sub-menus.

4.1.1 File



File → Properties	View and edit the NetMOD configuration properties. See section *0 Configuration* Properties.
File → Exit	Exit the application.

4.1.2 Help



Help → User's Manual	Display the User's Manual.
Help → Mathematical Framework	Display the Mathematical Framework reference.
Help → Parameters	Display the Parameters reference.
Help → Garbage Collect	Perform a Java "Garbage Collection" and display usage information about the allocated memory space.
Help → About	Display a dialog containing version information and relevant copyright and licensing disclaimers.

4.1.3 User's Manual

Display User's Manual.

4.2 Simulation Controls

The **Simulation Controls** pane contains user interfaces for visualizing and modifying the input parameters and outputs for any simulation that has been loaded into NetMOD. The specifics of the user interfaces are dependent upon the type of simulation. However, they all follow some common conventions that should make interaction with the interfaces consistent across the application.

The controls are laid out in a hierarchical structure that can be expanded or collapsed with a click of a button. The button to expand or collapse the sub-pane of the control is located in the upper left corner of the sub-pane. Clicking the button will toggle between the expanded or collapsed state.

Control sub-pane is expanded, clicking will collapse.

Control sub-pane is collapsed, clicking will expand.

A common button appearance and behavior is used throughout the controls:

Create a new entity within the control pane. A dialog will be presented to the user to enter a name.

Remove an existing entity within the control pane.

Toggle button to control visibility within the map.

Toggle button to enable selection within the map.

Browse for a file to open. The file dialog that appears will default to the last location that was previously accessed. If the file dialog is accompanied by a text field, then the location will default to the same path as is defined within the text field.

Browse for a file to save. The file dialog that appears will default to the last location that was previously accessed. If the file dialog is accompanied by a text field, then the location will default to the same path as is defined within the text field.

Visualize a quantity, such as source spectra, path attenuation, sensor response, site noise, etc, within a **Chart Viewer**.

At the top of the **Simulation Controls** pane are buttons to open a project file containing a simulation, create a new simulation, or remove an existing simulation:


Browse for a simulation file to open.

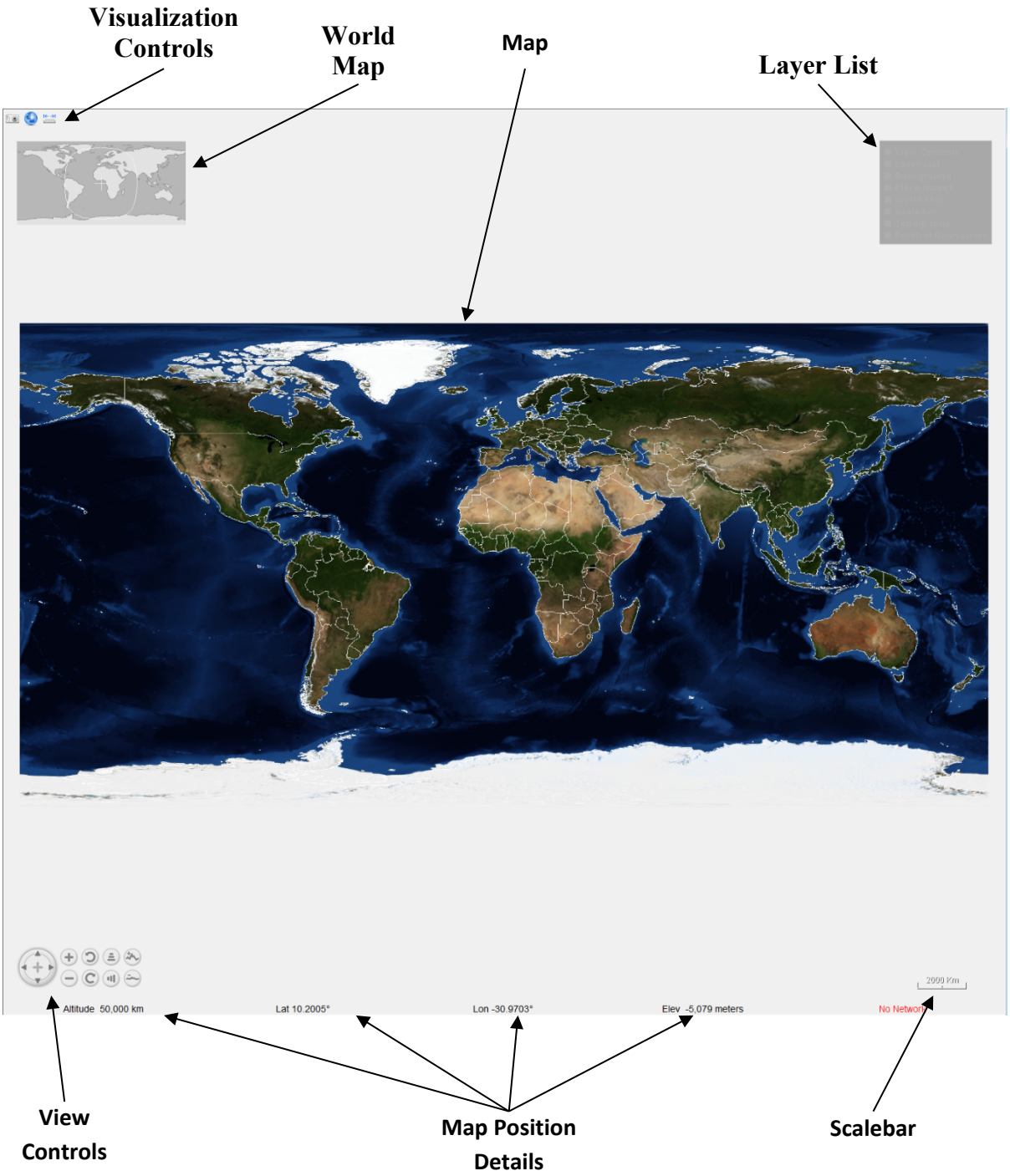

Create a new simulation chosen from a dialog listing the available simulation types.


Remove an existing simulation.

4.3 Map

The **Map** is where the various geophysical parameters and simulation outputs may be visualized. The map within NetMOD is implemented using WorldWind by default. No map and a basic map are also options that are available.

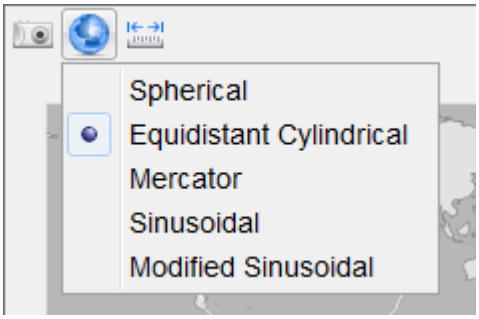
4.3.1 WorldWind



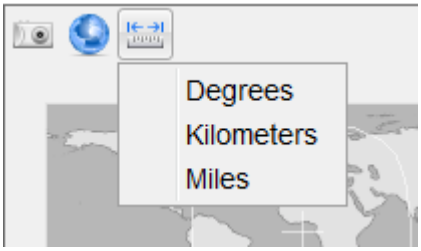
The **Visualization Controls** in the upper-left corner of the map provide the following actions for the user:

Take a screenshot of the map and save to a file on disk. A file dialog will be presented that will allow the user to select the file to be saved to, the image type, and the resolution of the image.

Change the map projection to one of the following options:



Measure radial distance on the map in one of the following options:



The **World Map** in the upper-left corner highlights the region of the globe that the map display is located at. The **Layer List** in the upper-right corner displays the layers of data within the map and allows the user to rearrange the layers by dragging the layer name or to toggle the layer visibility by clicking on the checkbox to the left of the layer name. The **View Controls** in the lower-left corner provide the ability to navigate on the map, in addition to the mouse controls native to World Wind. From the WorldWind documentation, the map mouse controls are:

Mouse with scroll wheel:

Pan	Left mouse button click & drag - all directions
Zoom	Use the scroll wheel on the mouse or Left & Right mouse (both buttons) click & drag - up and down
Tilt	Right mouse button click & drag - up and down or use "Page Up" and "Page Down" on the keyboard.
Rotate	Right mouse button click & drag - left and right Note: Crossing the top and bottom half of the screen while rotating will change direction.
Stop	Spacebar

Reset Heading	N
Reset all	R

Single button mouse:

Pan	Left mouse button click & drag - all directions L left mouse button click once to center view.
Zoom	Hold "Ctrl" on the keyboard and Left mouse button click & drag - up and down
Tilt	Hold "Shift" on the keyboard and Left mouse button click & drag - up and down or use "Page Up" and "Page Down" on the keyboard.
Rotate	Hold "Shift" on the keyboard and Left mouse button click & drag - left and right
Stop	Spacebar

The **Map Position Details** at the bottom describe the elevation of the view point and the latitude, longitude, and ground elevation at the location of the mouse cursor. The **Scalebar** in the lower-right corner provides a distance scale for the current zoom level of the map.

4.3.2 None

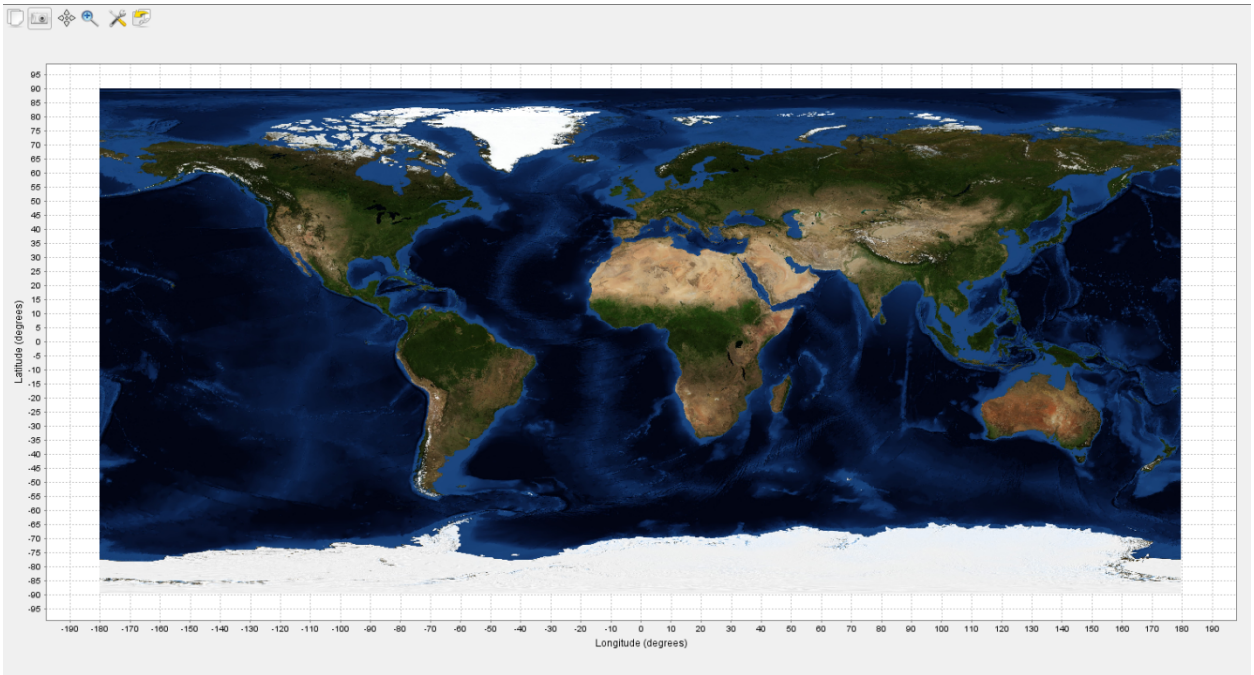
NetMOD can operate without any map by selecting **None** for the map plugin. See section *0*

Configuration Properties. Without a map, the simulation controls to display content on the map within NetMOD will have no effect.

4.3.3 Basic

NetMOD can operate with a very basic 2-D map by selecting **Basic** for the map plugin. See section *0*

Configuration Properties. The basic map supports a very limited set of display functionality. There are limited user controls for zooming. However, there is no support for changing projections or measuring distance. The basic map does support the display and selection of geophysical data using the simulation controls within NetMOD. The basic is intended for use on computers whose limited graphics capabilities do not supports 3-D visualization.



The **Visualization Controls** in the upper-left corner of the map provide the following actions for the user:

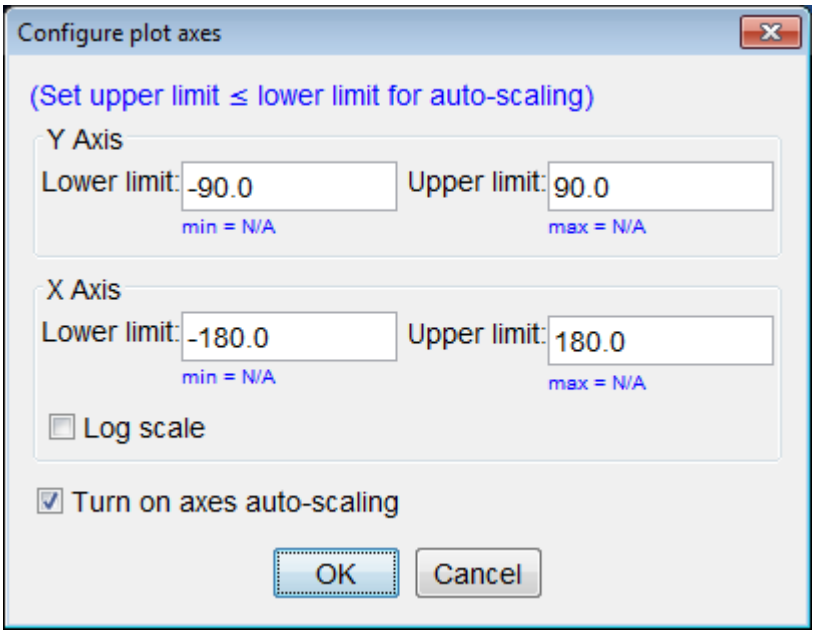

Copy a screenshot of the plot into the clipboard so that it may be pasted elsewhere.


Save a screenshot to an image file on disk.


Button to toggle panning on the plot.


Button to toggle zooming on the plot.


Open a dialog to configure the plot axes bounds:



Toggle the visibility of the individual dataset on the plot.

5 CONFIGURATION PROPERTIES

NetMOD contains a set of configuration parameters that control some of the appearance and behavior of the GUI. These parameters are loaded at application startup from a configuration file and may be modified by the user from within the GUI.

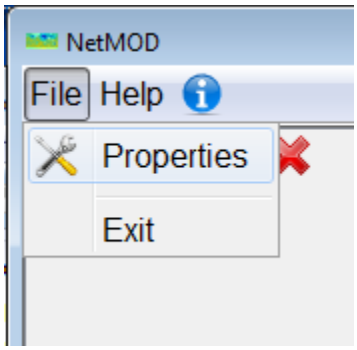
NetMOD will automatically create a file called *NetMOD.cfg* within the user's current working directory upon startup. Any configuration changes made to NetMOD will be automatically stored in this file and used whenever the application is run the next time.

The NetMOD configuration file is stored as an ASCII text file with the general format:

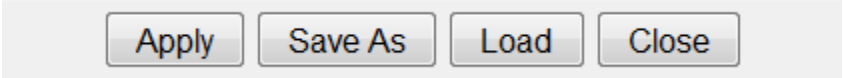
<parameter> = <value>

The parameters accessible through the GUI dialog are stored within their respective parameter names below. Note that the parameter definitions may be subject to change in future versions of NetMOD. See the NetMOD Parameters document for a description of the behavior of each of the parameters.

To access the dialog controlling the properties, select the **File → Properties** menu item.



The Properties Editor dialog will be displayed with the five tabs appearing as in the examples shown below. Changes to the properties may be made effective and saved to the configuration file by clicking on the "Save" button. The dialog may be closed by clicking on the "Close button.



Apply Save the current properties to the *NetMOD.cfg* file within the user's current working directory and update the user interface.

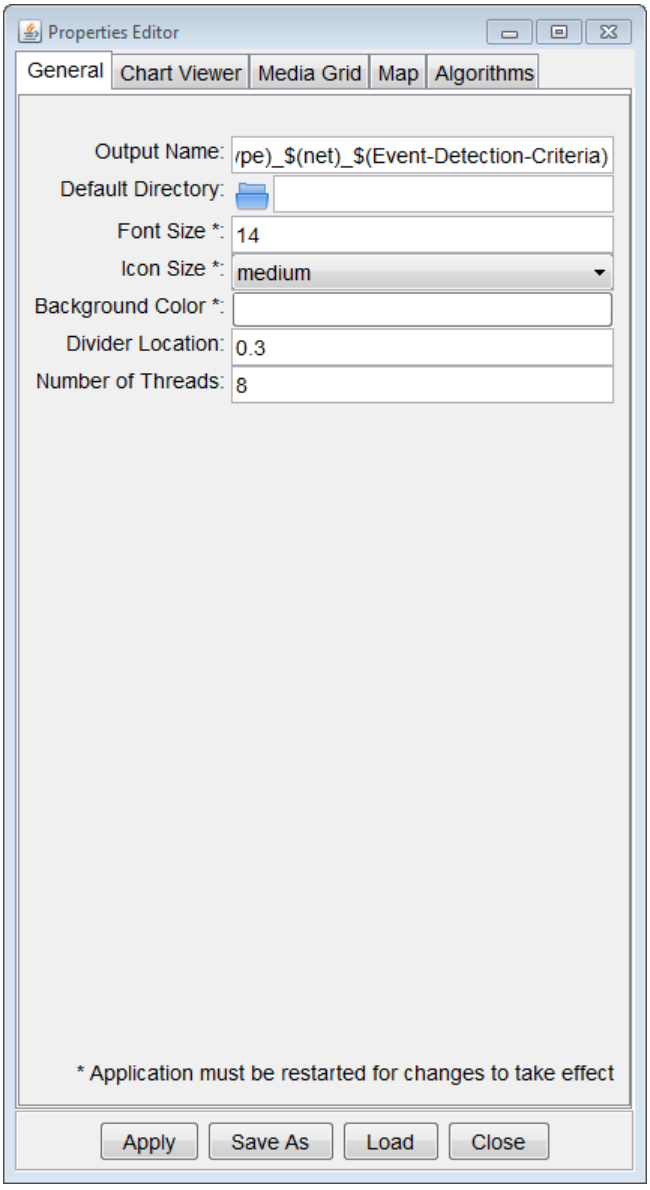
Save As Save the current properties to a user selected file. Note that the selected file will be an export of the active properties. NetMOD will continue to maintain the *NetMOD.cfg* file for the current active settings

Load Load a user selected file as the current properties. Note that the selected file will be used to import the active properties. NetMOD will continue to maintain the *NetMOD.cfg* file for the current active settings

Close Close the Properties Editor dialog without retaining any changes to the properties.

General

The **General** tab contains parameters that apply throughout NetMOD.



Output Name A string representing how any generated simulation output files

	are to be named. See the *OUTPUT_NAME* configuration parameter in the NetMOD Parameters document for a description of the syntax.
Default Directory	The directory that the file selection dialog defaults to when opened. This parameter is updated dynamically to always be the most recent directory that the user was browsing in.
Font Size	Font size of the text.
Icon Size	Size of the icons within the GUI, select from small, medium, or large.
Background Color	Background color of the GUI
Divider Location	Location of the divider between the Table of Contents and the Map. The value is a fraction between 0 and 1 of the application width.
Number of Threads	The number of threads used in the execution of simulations. If set to 0, then the number of simulation threads will be equal to the number of available processors. Otherwise, the number of threads will be limited to be no more than the number of available processors.

5.2 Chart Viewer

The **Chart Viewer** tab contains parameters that apply to the charts and graphs that are used to represent quantities defined in the simulations, such as source spectra, path attenuation, sensor response, site noise, etc.

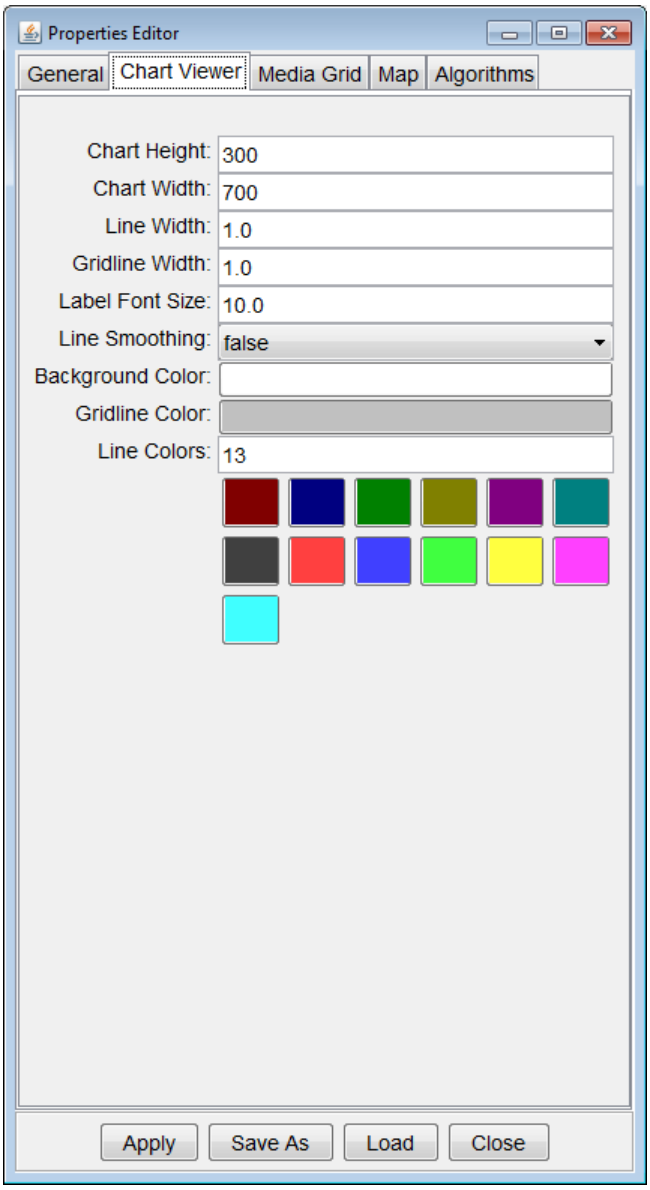


Chart Height The height of the chart in pixels.

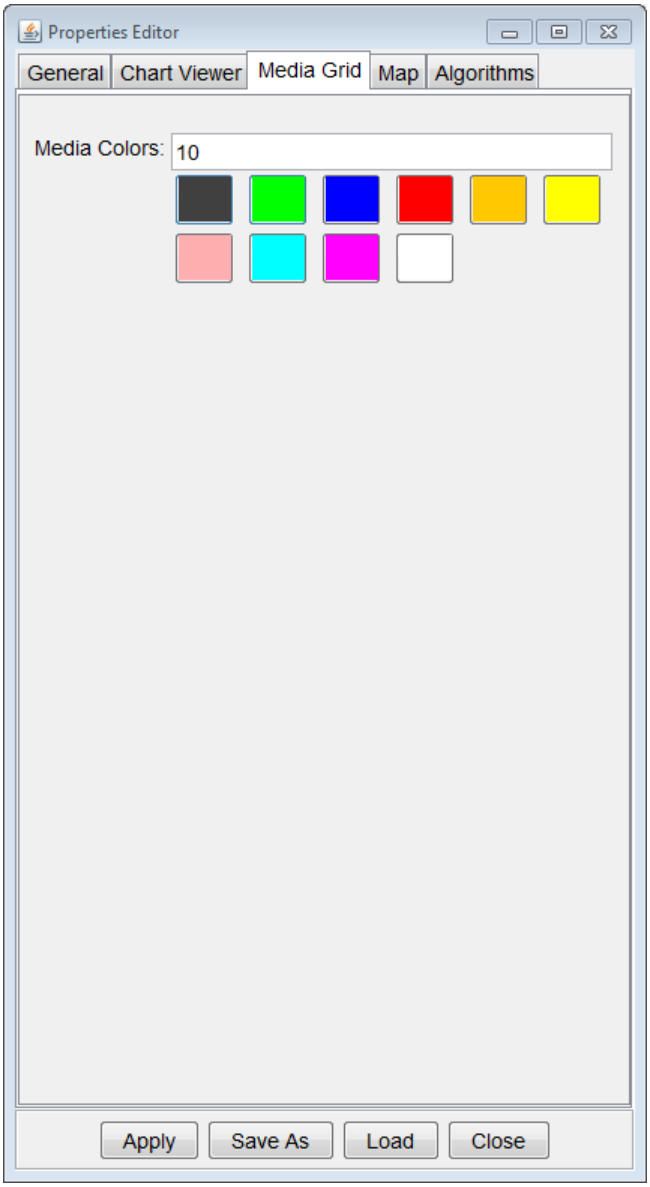
Chart Width The width of the chart in pixels.

Line Width The width of the data lines in points.

Gridline Width	The width of the gridlines in points.
Label Font Size	The font size of the chart labels in points.
Line Smoothing	Enable anti-alias smoothing of the data lines.
Background Color	The background color of the chart. Click on the color swatch to select a color.
Gridline Color	The color of the gridlines. Click on the color swatch to select a color.
Line Colors	The palette of colors available to plot data lines. The data lines cycle through the available colors in the order in which they are defined. Enter the desired number of colors in the text box. Click on the corresponding color swatch to select the color for each of the palette entries.

5.3 Media Grid

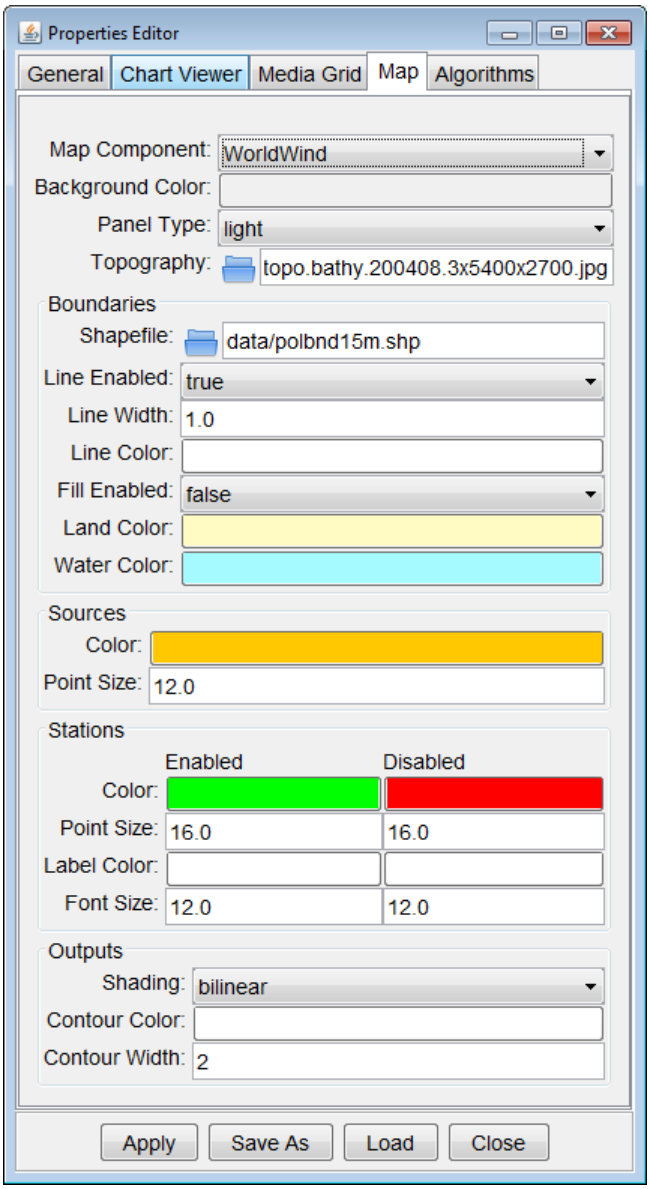
The **Media Grid** tab contains parameters that apply to the display of the source and path media grids within the map.



Media Colors The palette of colors available to plot the media grid regions. The regions cycle through the available colors in the order in which they are defined. Enter the desired number of colors in the text box. Click on the corresponding color swatch to select the color for each of the palette entries.

5.4 Map

The **Map** tab contains parameters that apply to the display of the map.

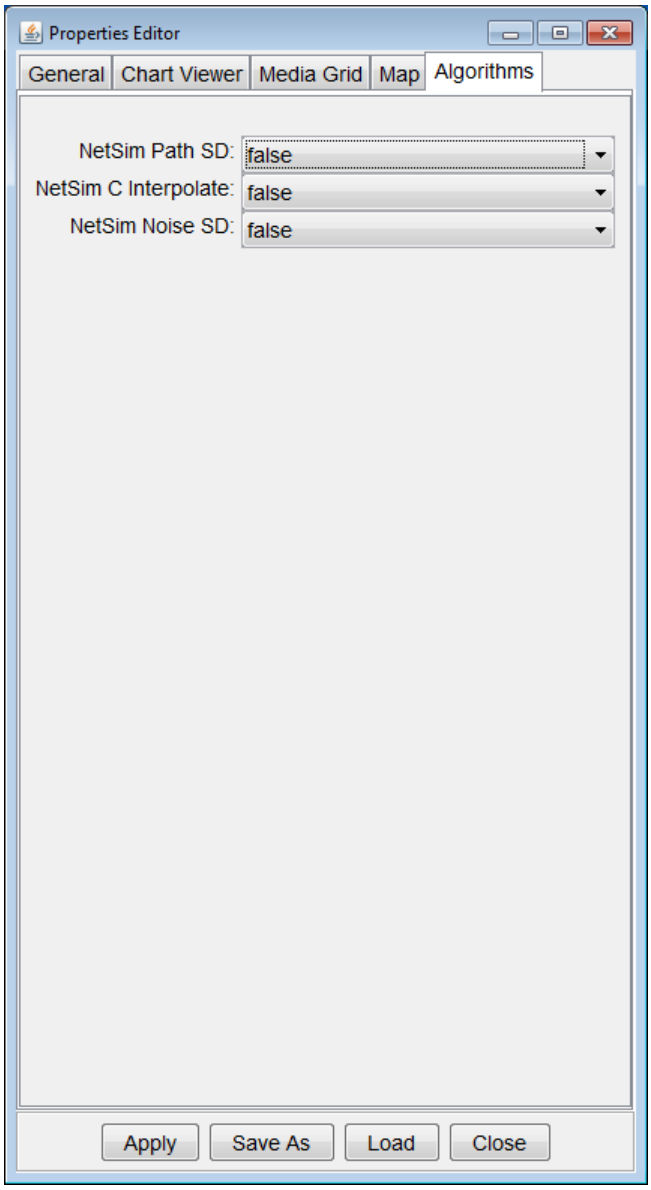


Map Component	Select the desired map component from the available map plugins. Defaults to WorldWind.
Map Background Color	The background color of the map. Click on the color swatch to select a color.
Panel Type	The "type" of Java Panel that the map uses: light weight or heavy weight. This setting should only be modified if there are operating system incompatibilities present.

	Defaults to light.
Topography	The image file used for topography, relative to the NetMOD installation directory. Note that if the image is too high of a resolution for the ability of the computer graphics, then the topography may not appear. Selecting a lower resolution image should resolve this issue.
Boundaries Shapefile	The shape file used for political boundaries, relative to the NetMOD installation directory.
Line Enabled	Enable display of the political boundaries.
Line Width	The line width of the political boundaries in points.
Line Color	The line color of the political boundaries. Click on the color swatch to select a color.
Fill Enabled	Enable display of the political boundaries fill.
Land Color	The fill color of the political boundaries land. Click on the color swatch to select a color.
Water Color	The fill color of the political boundaries water. Click on the color swatch to select a color.
Source Color	The color of the epicenter source locations. Click on the color swatch to select a color.
Source Size	The size of the epicenter source locations in points.
Station Color	The color of enabled and disabled stations. Click on the color swatch to select a color.
Station Point Size	The size of the enabled and disabled stations in points.
Station Label Color	The color of the enabled and disabled station labels. Click on the color swatch to select a color.
Station Font Size	The font size in points of the enabled and disabled station labels.
Output Shading	Select the visualization interpolation method for the output surfaces: flat or bilinear.
Contour Color	The line color of the contours. Click on the color swatch to select a color.
Contour Width	The line width of the contours in points.

5.5 Algorithms

The **Algorithms** tab contains parameters that control some of the algorithms used within NetMOD. These parameters are primarily intended for enabling compatibility with various versions of NetSim.



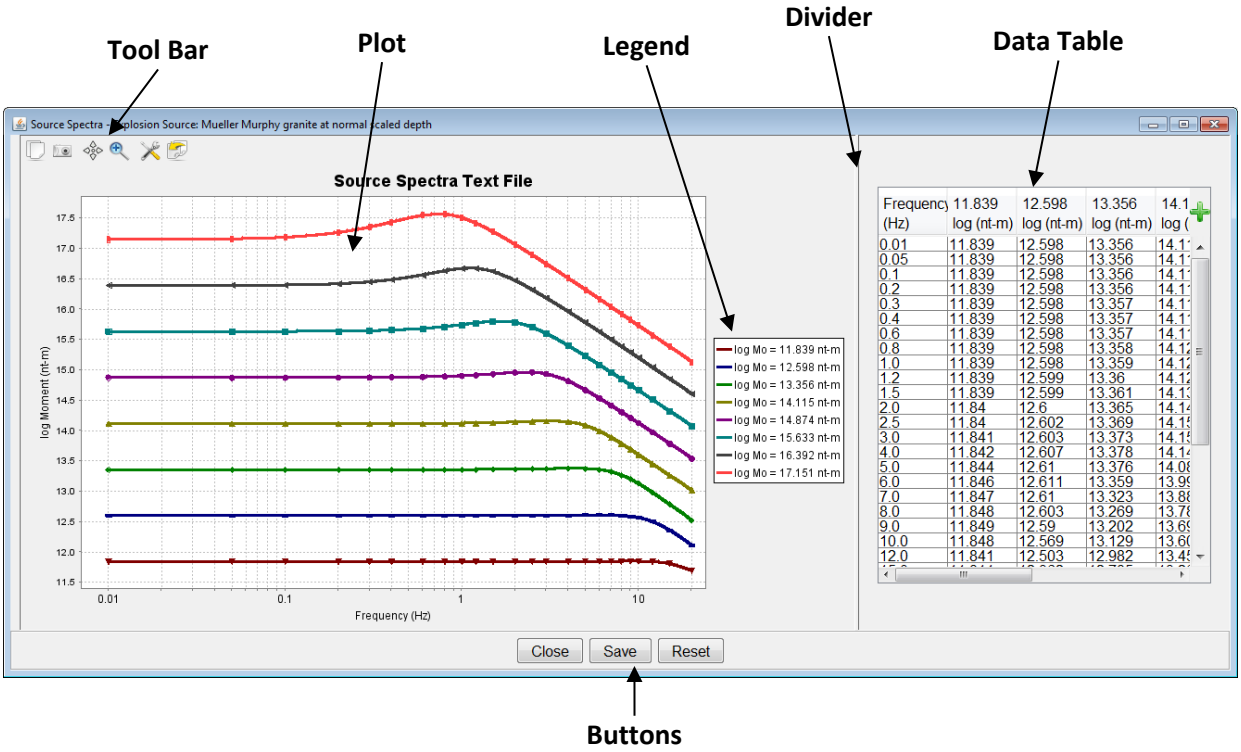
NetSim Path SD If true, enable compatibility with the method by which NetSim obtains the teleseismic path attenuation standard deviation from the media type at the source location. If false, obtain the attenuation standard deviation from the reference media type, which is where the mean attenuation is obtained.

NetSim C Interpolate If true, use a spline interpolation algorithm for evaluating the site noise and a linear interpolation algorithm for evaluating the site response and coda decay rate. These methods are compatible with version 2.4.1 of NetSim in which portions of the code were migrated to C. If false, maintain compatibility with the original Fortran versions of NetSim which uses a quadratic hermitian interpolation algorithm for the evaluation all parameter curves.

NetSim Noise SD If true, treat the standard deviation values contained within the site noise files (*noi*) as dB (10 · log10) instead of log10. This option replicates a bug observed in some versions of NetSim.

6 CHART VIEWER

A **Chart Viewer** is a component within NetMOD to represent the quantities defined in the simulations, such as source spectra, path attenuation, sensor response, or site noise within a plot. As an example, a **Chart Viewer** representing source spectra is shown below. All **Chart Viewers** possess common elements that may be used in a consistent manner.



The **Plot** displays the individual datasets being represented along with an appropriately labeled X-axis, Y-axis, and title. Each dataset is display as a line with a marker at the location of the defined data point. The line between the data points is drawn consistent with the method of interpolation that is being used. As the mouse passes over a dataset, a tooltip is shown that displays the X and Y values of the dataset at that mouse location.

The **Legend** identifies the colors assigned to each of the datasets. The color assignments are driven by the settings within the **Configuration Parameters**.
The **Tool Bar** at the top of the Chart Viewer contains the following button controls:

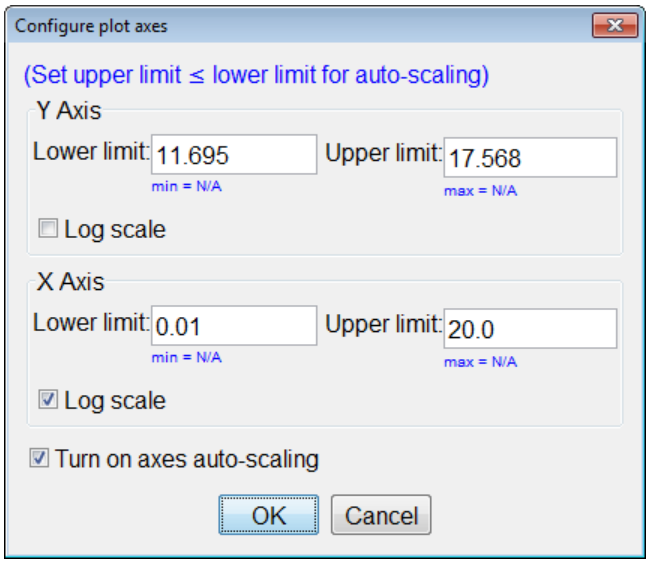

Copy a screenshot of the plot into the clipboard so that it may be pasted elsewhere.


Save a screenshot to an image file on disk.


Button to toggle panning on the plot.


Button to toggle zooming on the plot.

Open a dialog to configure the plot axes bounds:



Toggle the visibility of the individual dataset on the plot.

The **Divider** location can be dragged with the mouse to allocate more or less space to the **Plot** and the **Data Table**. The **Data Table** displays the numeric values that are displayed within the **Plot**. Depending upon the supported data file format, the **Chart Viewer** may allow users to edit values within the table and save the updated values back to the data file.

Some subset of the following **Buttons** may be available at the bottom of the dialog:

Close	Close the dialog without modifying the file.
Save	Save the quantities to the file.
Reset	Reload the quantities from the file.

7 PROJECT FILES

NetMOD project files store all of the input parameters, parameter tables, and formatted data files in a libpar-type format. This format is described in the NetMOD Parameters reference

Reading

NetMOD is capable of reading in a simulation project file by two different mechanisms:

- Application Startup

  A project file may be specified at the command-line when NetMOD is started. The project file will then be loaded automatically. See *3.2 Command Line Options* for a more detailed description.

- Read Button

  A project file may be loaded using the file browse button at the top of the simulation controls pane.

Once the project file is read, a new entry within the simulation controls pane will appear representing the simulation loaded from the project file.

The NetSim libpar-type format allows for the use of hierarchical references to other parameter files to allow for an arbitrary structural organization of the parameters. NetMOD can read project files that have been organized in this manner. NetMOD must be directed to the top most parameter file within such a hierarchy.

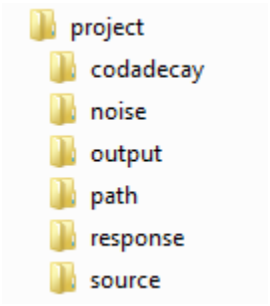
Also, the libpar-type format assumes that there is an external definition of a NS_CONFIG variable that contains the top level directory for all input files. Unless this parameter is defined by the user, NetMOD makes the assumption that the top level project file resides in this top level directory. Prior to reading in a project file, NetMOD assigns the NS_CONFIG variable to be equal to the directory in which the project file is located if the NS_CONFIG variable is undefined.

7.2 Writing

The user may make modifications to a simulation that is loaded within NetMOD. However, none of these changes are stored to a project file until the user explicitly saves the simulation to a project file. At the top of the simulation controls for a given simulation, there is a button that may be clicked to save the project file:

Clicking this button will open a file dialog to select the desired file and path to save the simulation project to. The file dialog also contains a checkbox indicating whether the formatted data files are to be exported as well. If the checkbox is unselected, then the project file will contain references to the existing formatted data files. However, no changes will be written out to those files. If the checkbox is selected, then the contents of the existing formatted data files will be written out to new files in a hierarchy along-side the indicated project file.

An example directory structure is shown below:



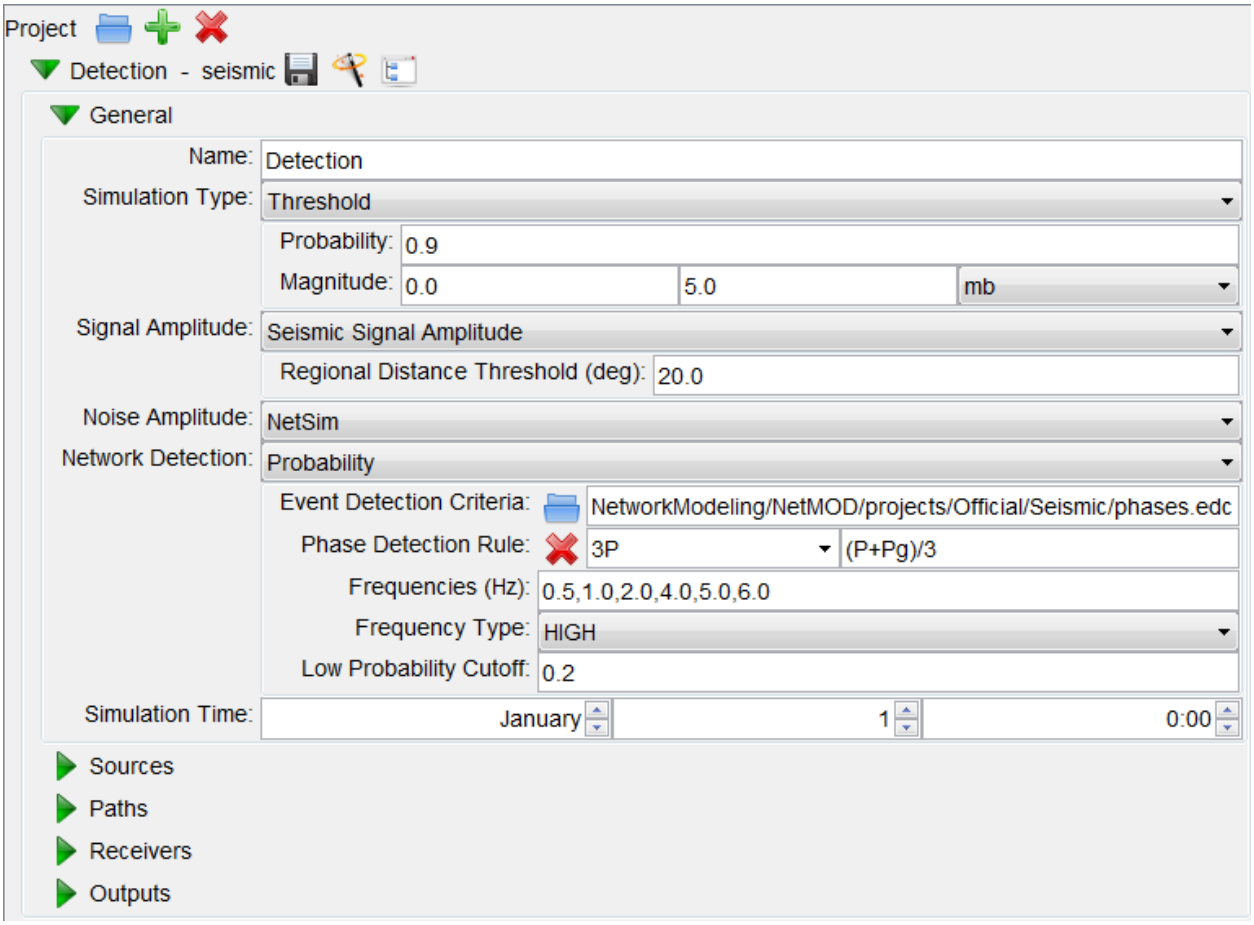
The formatted data files are stored within directories that are consistent with the type of data file.

8 SEISMIC DETECTION SIMULATION

The following sections detail NetMOD's seismic detection module and contain a description of all GUI components. For a general description of the algorithms, see the NetMOD Mathematical Framework document. The user controls for seismic simulations will be described in depth. The controls for hydroacoustic and infrasonic are nearly identical and will only be described where they are different from the seismic controls.

General Simulation Parameters

The top level controls for a Seismic Detection Simulation are shown below:



The buttons at the top of the simulation provide the following functionality:

Save the simulation to a project file.

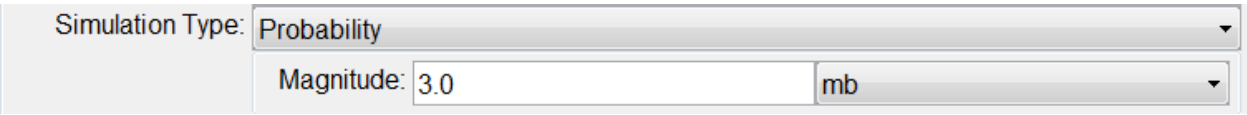
Execute the simulation

Execute the simulation with Introspection enabled. See section *0* Introspection for additional descriptions.

8.1.1 Simulation Type

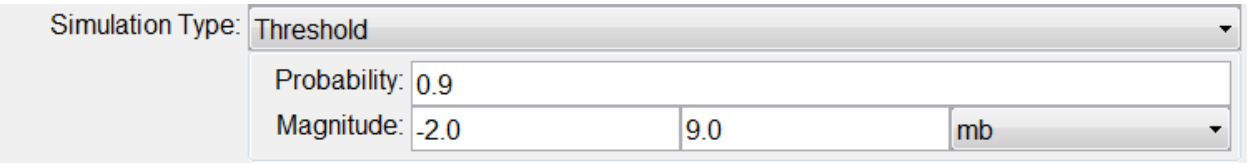
Seismic Detection Simulations support two different types of simulations: **Probability** and **Threshold**.

A **Probability** simulation computes the probability of a network to detect events of a fixed magnitude.



The user can enter the magnitude value and the value's corresponding unit from within the GUI controls.

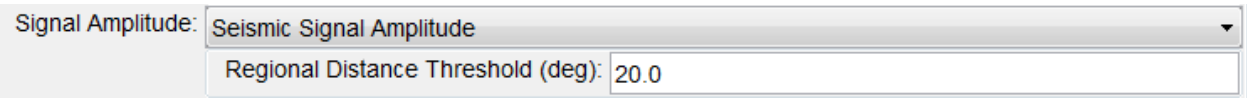
A **Threshold** simulation computes minimum magnitude for which the network can detect events at a fixed probability.



The user can enter the probability (between 0 and 1), minimum magnitude, maximum magnitude, and corresponding unit. NetMOD will then perform a search across the range of magnitudes to determine the magnitude at each source location that results in the desired probability of detection for the network.

8.1.2 Signal Amplitude Estimation

NetMOD provides support for different methods of estimating signal amplitude at the receiver. Currently, only the default method of computing bodywave signal amplitude is supported.

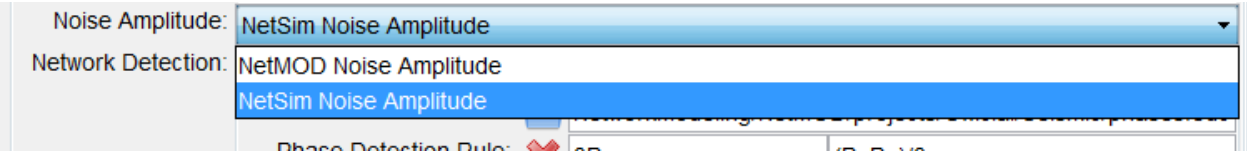


The user can enter a **regional distance threshold** in degrees that is used in determining whether the regional or teleseismic method of path attenuation is used between the source and receiver.

If the distance is greater than or equal to the threshold, then the path attenuation is looked up from the reference path media type. If the distance is less than the threshold, then the total path attenuation is computed from a weight combination of the path media types that the great circle path between the source and receiver passes through.

8.1.3 Noise Amplitude Estimation

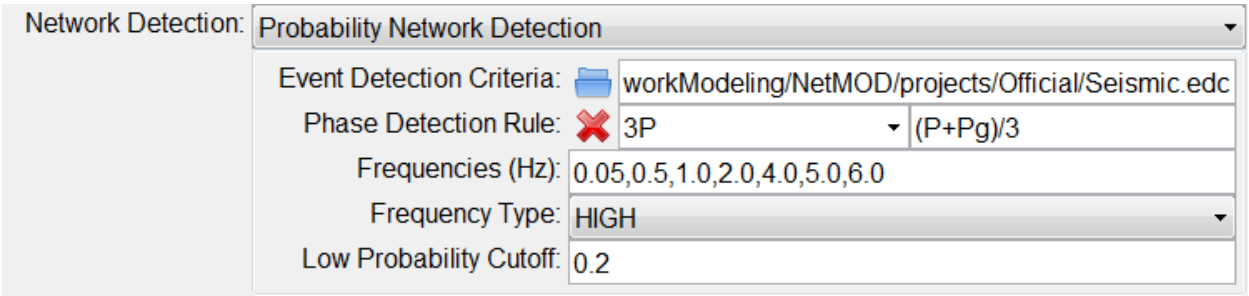
NetMOD provides support for different methods of estimating noise amplitude at the receiver. Currently there are two methods, NetMOD and NetSim, methods of computing noise amplitudes. They are very similar in concept, in which the noise at the receiver is equal to the ambient site noise plus any residual signal from an earlier phase, and vary only in their handling of how distributions of random variables are summed. The two methods are described in the NetMOD Mathematical Framework document.



8.1.4 Network Detection Method

Seismic Detection Simulations support two different types of network detection methods: **Probability** and **Monte Carlo**.

A **Probability** simulation assumes that all of the quantities being simulated are log-normal random variables and then estimates the mean and standard deviation of the signal to noise ratio from all of the components of the signal and noise amplitude distributions. The probability that the station detection occurred is simply the probability that the log-normal distributed SNR at the station and phase is greater than the detection threshold. The probability of a network detection is then determined from the probabilistic rule-set that combines the individual station detection probabilities.



The user can enter the following parameters:

Event Detection Criteria — File containing the set of labels and phase detection rules that are displayed below.

Phase Detection Rule — User readable labels and NetSim style phase detection rule that are used to combine the detections at individual stations to a probability of detection for the entire network. The user may select from a list of pre-defined detection rules from the pull down list or type in their own detection rule in the text field to the right. Clicking the delete button will remove the current detection

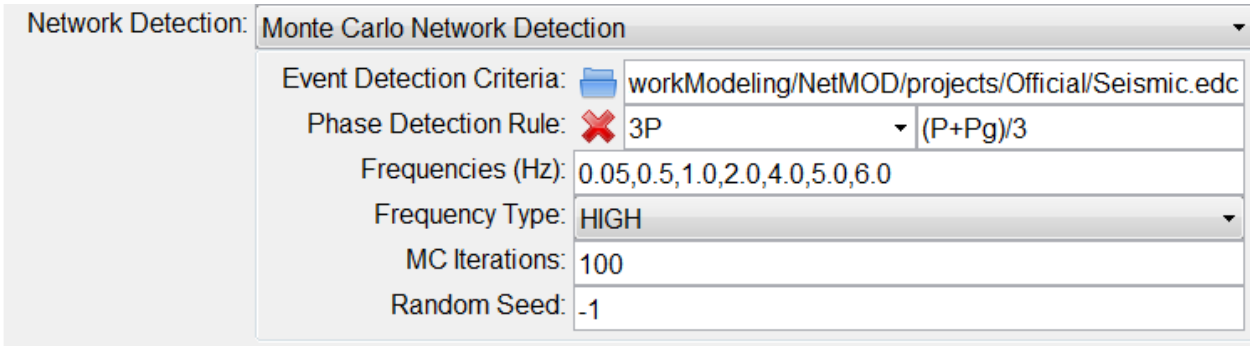
rule from the list.

Frequencies (Hz) — Individual frequencies or frequency bands at which signal to noise ratios are computed.

Frequency Type — Method by which signal to noise ratios at the individual frequencies are combined. **High** uses the SNR distribution from the frequency whose distribution of SNR values has the highest probability of detection for the chosen threshold. **Average** computes the statistical average of the SNR values at the frequencies and then computes a probability of detection for that average.

Low Probability Cutoff — Probability below which the station detections are set to 0.

A **Monte Carlo** simulation makes no assumption about the distributions of signal or noise. Instead, multiple iterations are performed in which random values are drawn from the underlying random distributions. These random values are combined to compute signal to noise ratios and then a binomial quantity of whether the event was detected or not. For each Monte Carlo iteration the network is determined to have detected or not based upon whether a sufficient number of stations detected the required set of phases. The probability of detection for the network is then computed as the ratio of the number of detections divided by the number of Monte Carlo iterations. Note that because Monte Carlo simulations are probabilistic in nature, the output of the simulation can vary from one execution to the next even if no parameters were modified.



The user can enter the following parameters:

Event Detection Criteria — File containing the set of labels and phase detection rules that are displayed below.

Phase Detection Rule — User readable labels and NetSim style phase detection rule that are used to combine the detections at individual stations to a probability of detection for the entire network. The user may select from a list of pre-defined detection rules from the pull down list or type in their own detection rule in the text field to the

right. Clicking the delete button will remove the current detection rule from the list.

Frequencies (Hz) — Individual frequencies or frequency bands at which signal to noise ratios are computed.

Frequency Type — Method by which signal to noise ratios at the individual frequencies are combined. **High** uses the set of Monte Carlo iterations from the frequency whose distribution of SNR values had the highest probability of detection for the chosen threshold. **Average** computes the statistical average of the SNR iteration values across the frequencies.

MC Iterations — Number of Monte Carlo iterations to perform. Larger numbers of iterations provide results that are statistically more stable and have greater precision.

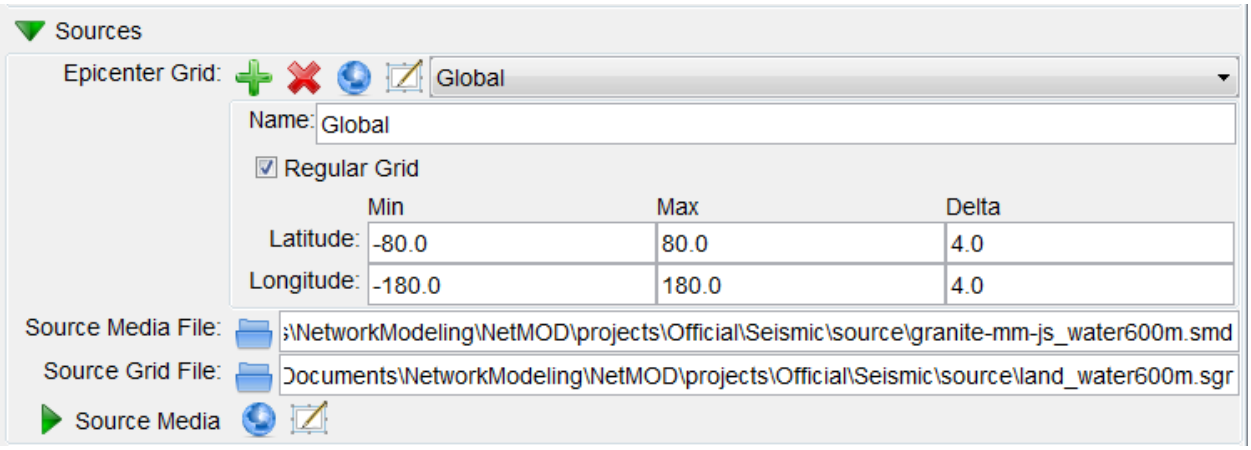
Random Seed — The seed value used in the random number generator. If the seed value is less than 0, then the current epoch time in milliseconds is used as the seed. The random number generator is reset with the specified seed for each combination of source location, station, and magnitude being simulated

8.1.5 Simulation Time

Simulation Time — Enter the month, day, and time of day when the events are to be simulated to have happened. The time of the event can impact the simulation if any of the geophysical parameters, such as site noise, vary with time.

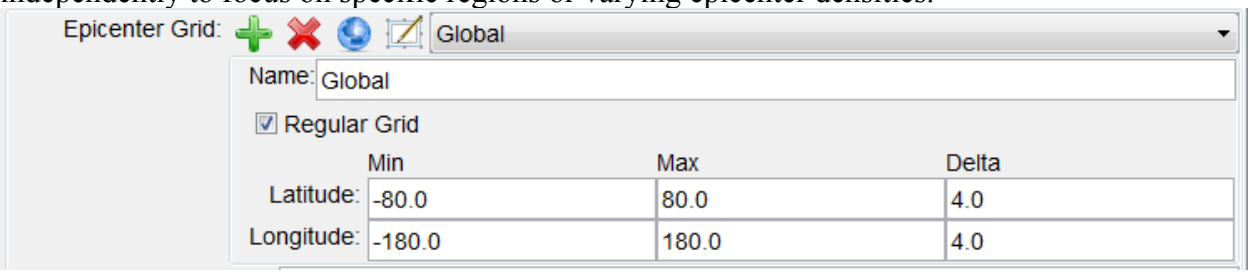
8.2 Sources

The **Sources** portion of the simulation provide for the definition of the characteristics of the sources that are to be simulated.



8.2.1 Epicenter Grid

The **Epicenter Grid** defines the locations of the sources that are to be simulated. Multiple epicenter grids may be defined within a simulation. Each epicenter grid may be defined independently to focus on specific regions or varying epicenter densities.



The buttons at the top of the **Epicenter Grid** controls support the following actions:


Create a new epicenter grid. A dialog will be presented to the user to enter a name.


Remove the existing epicenter grid. Note that if there is only one epicenter grid remaining, it cannot be removed


Toggle button to control visibility of the epicenter grid within the map.

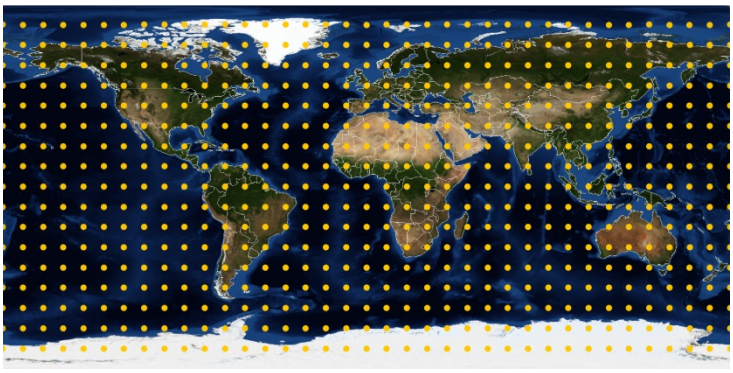

Toggle button to enable selection within the map. If enabled, the Min & Max range of the Latitude and Longitude will be dynamically updated based upon the user's selection of a region on the map.

The user can enter the following parameters:

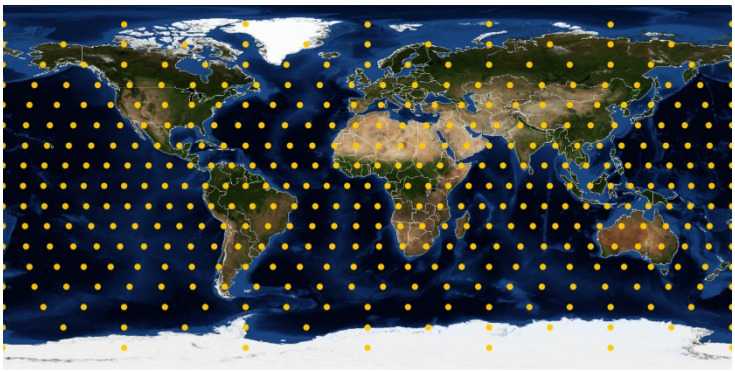
Name Name of the epicenter grid

Regular Grid Check box to control whether the epicenter grid is regularly spaced in latitude and longitude or evenly spaced in distance to prevent over sampling at the poles.

Regular:



Even:

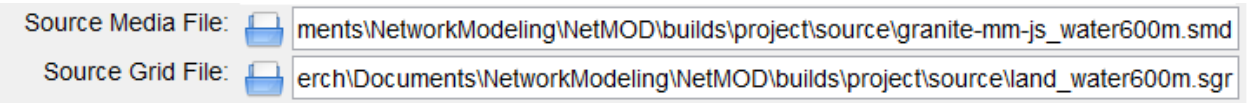


Latitude Enter the minimum, maximum, and delta spacing in degrees between latitude epicenters

Longitude Enter the minimum, maximum, and delta spacing in degrees between longitude epicenters.

8.2.2 Source Media

The **Source Media** defines the characteristics of the sources that depend upon their geophysical locations.

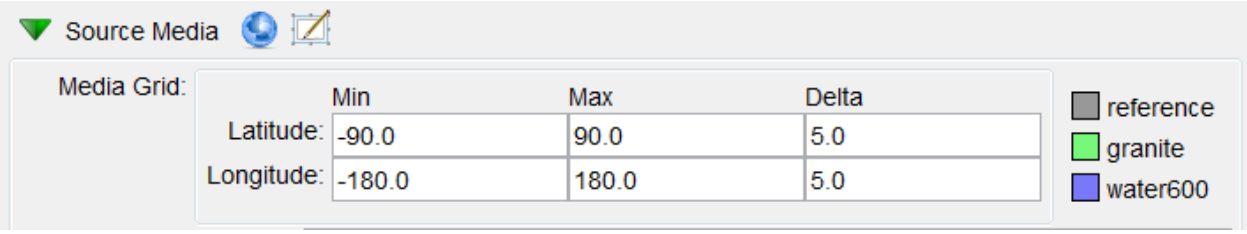


The source media file and source grid file jointly define the source media. The format of these files is consistent with the NetSim file definitions (SAIC-09/3007). The user may type in the location of these files or browse for them using the file browse button. If either of the files is

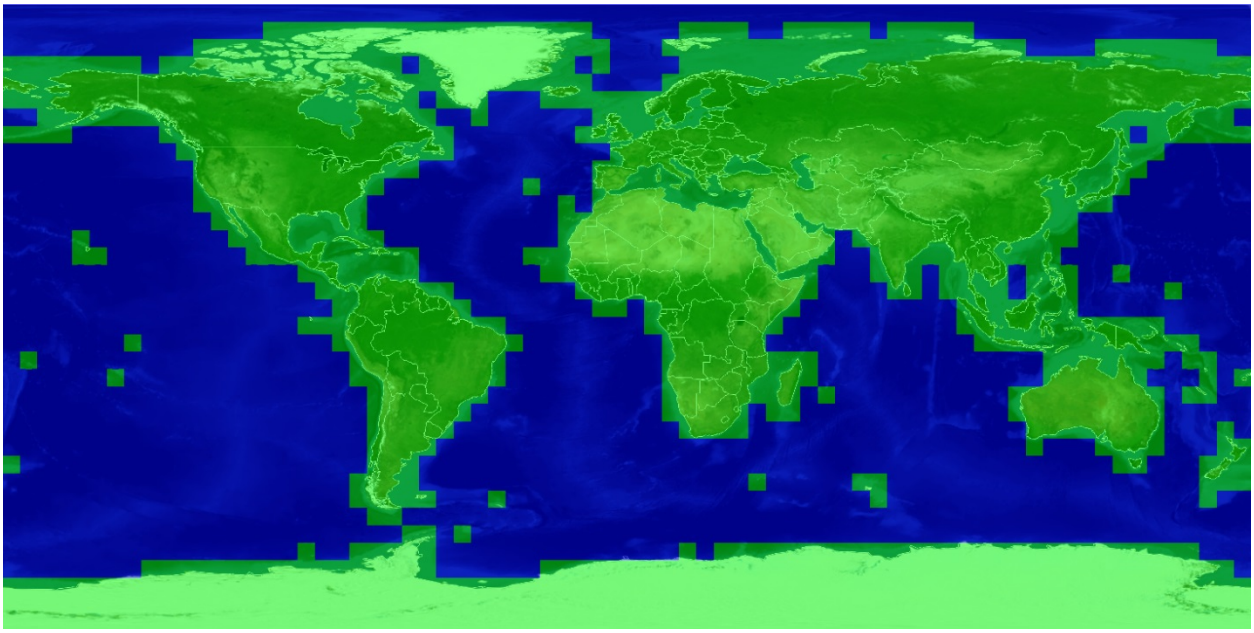
changed, NetMOD will automatically reload the contents of the files into the source media controls described below.

8.2.2.1 Media Grid

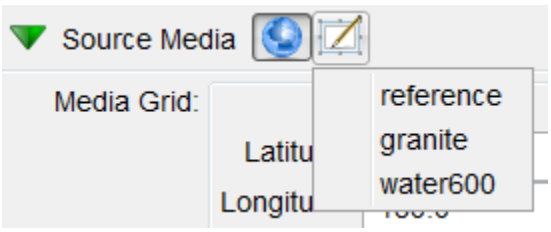
The **Media Grid** divides the globe into regularly spaced latitude and longitude bins. Each bin is assigned a media type.



The buttons at the top of the **Source Media** controls allow the user to toggle on and off the display of the media grid on the map or use the map to select the regions for each media type.



Clicking on the map selection button displays a popup containing the available media types:



Selecting a media type from the popup list enables map selection for that media type. Clicking on the map will set the selected bin to the chosen media type. Dragging a selection box on the map will set all of the bins within that selection box to the chosen media type. Clicking on the map selection button a second time will disable map selection.

The **Media Grid** also displays a legend showing the color used to represent each of the media types on the map. These color assignments may be modified using the Chart Viewer

Configuration Properties .

The user can enter the following parameters:

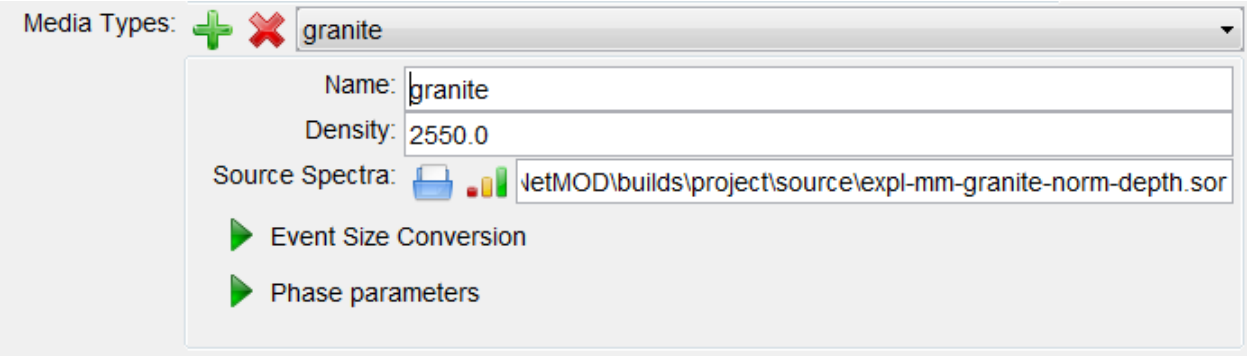
Latitude	Enter the minimum, maximum, and delta spacing in degrees between latitude bins
Longitude	Enter the minimum, maximum, and delta spacing in degrees between longitude bins.

Changing the latitude and longitude parameters for a previously defined media grid will cause the assigned media types to be spatially resampled as best as is possible.

Any region that is not assigned a media type will default to the reference media type.

8.2.2.2 Media Types

NetMOD can contain multiple **Media Types** for sources.



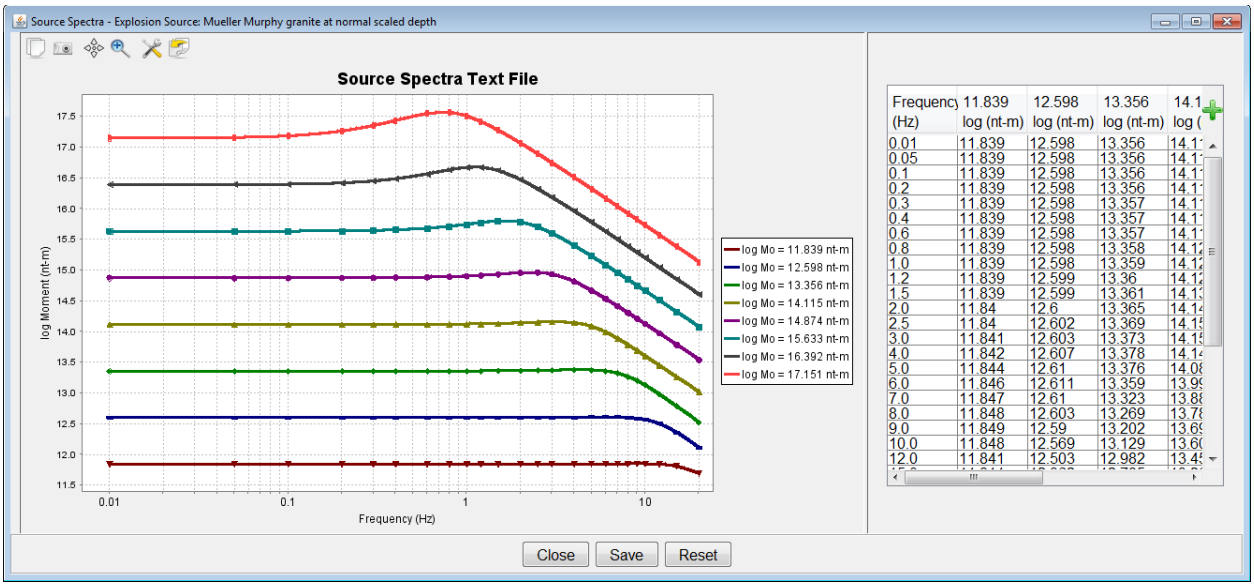
The buttons at the top of the **Media Types** controls allow the user to add a new media type or remove the existing media type.

The user can enter the following parameters:

Name	Identifying name of the media type.
Density	Density of the source media in kg/m^3.
Source Spectra	The location of the formatted data file containing the source spectra. Click on the file browse button to select a file or the visualize button to view the source spectra.

8.2.2.2.1 Source Spectra

The **Source Spectra** file defines the relationship between the simulated magnitude of the event, the simulated frequency, and the resulting log-Moment.



The user may use this viewer to simply visualize the source spectra curves or to also modify the values within the table and save them back to the file.

The following buttons are available at the bottom of the dialog:

Close	Close the dialog without modifying the file.
Save	Save the quantities to the file.
Reset	Reload the quantities from the file.

8.2.2.2.2 Event Size Conversion

The **Event Size Conversion** table provides the slopes and y-intercepts necessary to perform the linear conversions necessary between the defined magnitude unit and a log-Moment:

Event Size Conversion

log(Mo) vs	Slope	Y-intercept
log(KT):	0.76	14.874
mb:	0.99	10.51
Ms:	1.0	12.53
mlg:	1.0	10.214
ML:	0.0	0.0
Mw:	0.0	0.0

8.2.2.2.3 Phase Parameters

The Phase parameters allow the user to define parameters that are specific to each media type.

Phase parameters

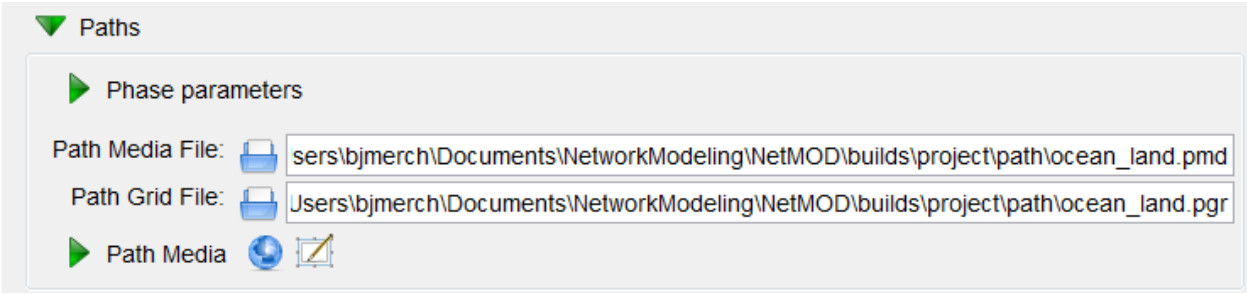
	Source excitation factor	Source media velocity (m/s)
P:	0.74	5500.0
pP:	0.0	0.0
Pg:	0.93	5500.0
S:	0.41	3175.0
Lg:	1.06	3175.0
LR:	0.19	3175.0

The user can enter the following parameters for each of the phases:

Source excitation factor	A fraction of the source energy that gets transmitted to the surrounding source media.
Source media velocity	Source media velocity in m/sec.

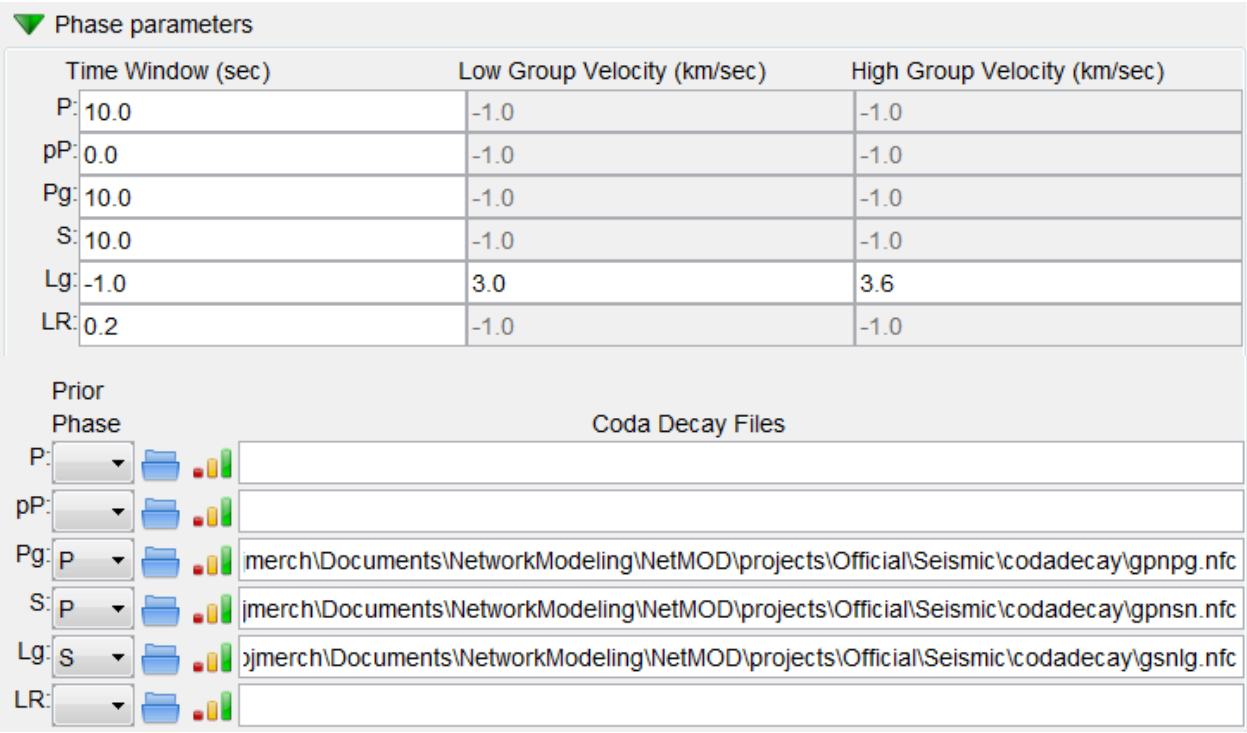
8.3 Paths

The **Paths** portion of the simulation provide for the definition of the characteristics of the paths that are to be simulated.



8.3.1 Phase Parameters

The general path related phase parameters determine how long of a time window to use when converting amplitude quantities between units of Power Spectral Densities and Spectral Amplitudes.



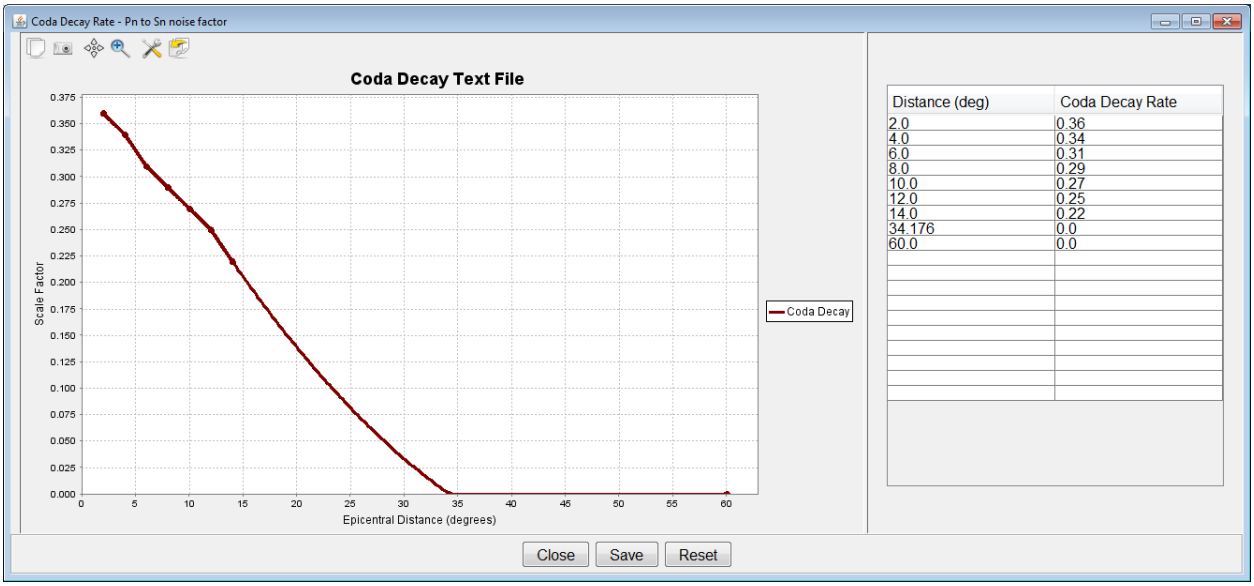
The user can enter the following parameters for each of the phases:

Time Window — Time window length in seconds for each of the phases. A value less than 0 will enable controlling the window length in terms of the group velocity.

Low Group Velocity	Low group velocity, in km/sec. The difference in propagation time between the low and the high velocity, for a given source to receiver distance, will determine the window length.
High Group Velocity	High group velocity, in km/sec.
Prior Phase	A phase that is defined as arriving at the station prior to each phase. The prior phase is used in determining the amount of noise present at the time the current phase arrives at the station. If no prior phase is defined, then the noise at the station is due to just site noise.
Coda Decay Files	Location of the formatted data file containing the coda decay may be specified for each phase. Click on the file browse button to select a file or the visualize button to view the coda decay.

8.3.1.1 Coda Decay

The **Coda Decay** file defines the relationship between the source to receiver distance and the rate by which the signal coda has decayed from one phase to the next (SAIC-09/3007).



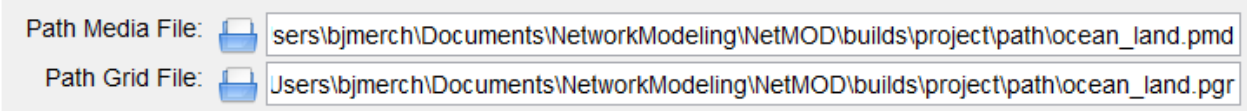
The user may use this viewer to simply visualize the coda decay rates or to also modify the values within the table and save them back to the file.

The following buttons are available at the bottom of the dialog:

Close	Close the dialog without modifying the file.
Save	Save the quantities to the file.
Reset	Reload the quantities from the file.

8.3.2 Path Media

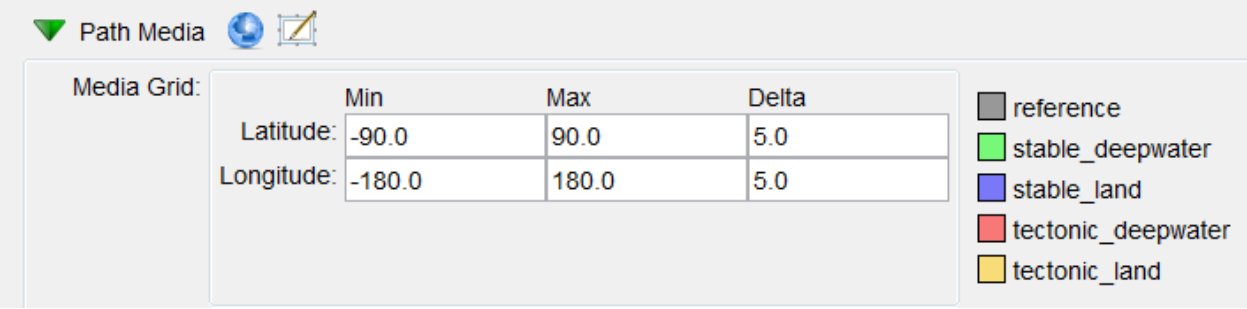
The **Path Media** defines the characteristics of the paths that depend upon their geophysical locations.



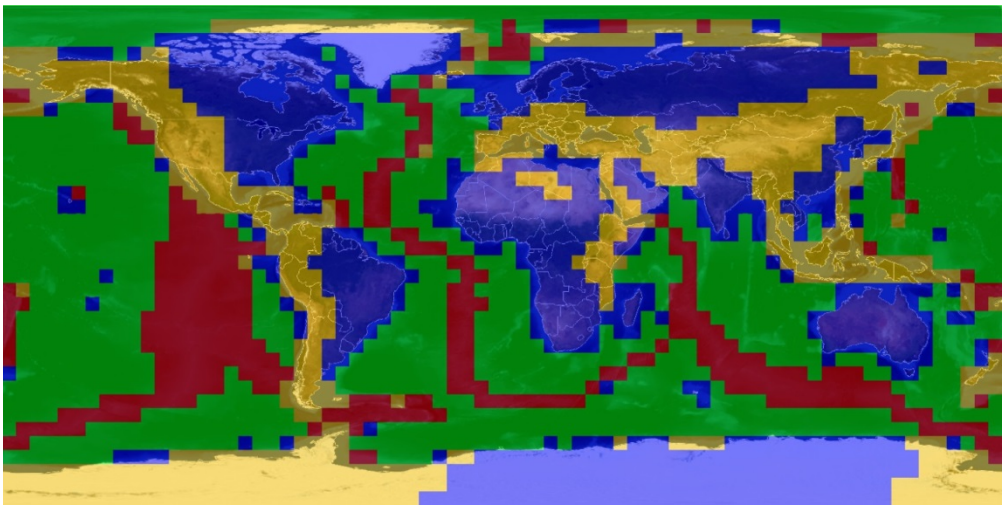
The path media file and path grid file jointly define the path media. The format of these files is consistent with the NetSim file definitions (SAIC-09/3007). The user may type in the location of these files or browse for them using the file browse button. If either of them is changed, NetMOD will automatically reload the contents of the files into the path media controls described below.

8.3.2.1 Media Grid

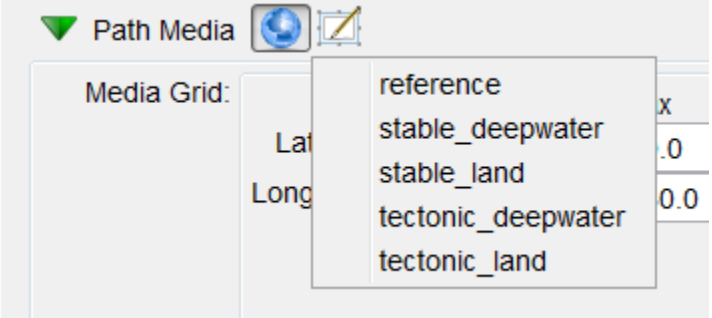
The **Media Grid** divides the globe into regularly spaced latitude and longitude bins. Each bin is assigned a media type.



The buttons at the top of the **Path Media** controls allow the user to toggle on and off the display of the media grid on the map or use the map to select the regions for each media type.



Clicking on the map selection button displays a popup containing the available media types:



Selecting a media type from the popup list enables map selection for that media type. Clicking on the map will set the selected bin to the chosen media type. Dragging a selection box on the map will set all of the bins within that selection box to the chosen media type. Clicking on the map selection button a second time will disable map selection.

The **Media Grid** also displays a legend showing the color used to represent each of the media types on the map.

The user can enter the following parameters:

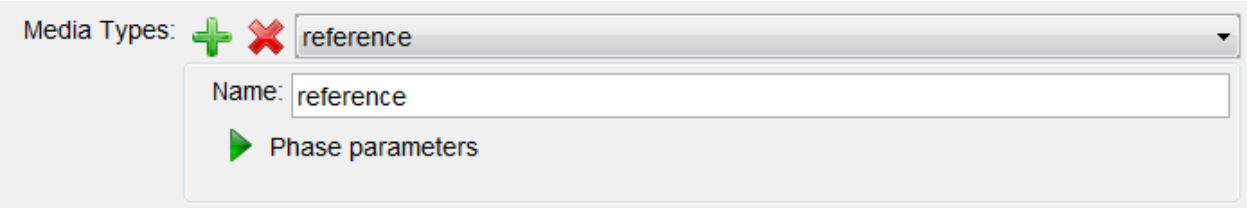
Latitude	Enter the minimum, maximum, and delta spacing in degrees between latitude bins.
Longitude	Enter the minimum, maximum, and delta spacing in degrees between longitude bins.

Changing the latitude and longitude parameters for a previously defined media grid will cause the assigned media types to be spatially resampled as best as is possible.

Any location that is not assigned a media type will default to the reference media type.

8.3.2.2 Media Types

NetMOD can contain multiple **Media Types** for paths.



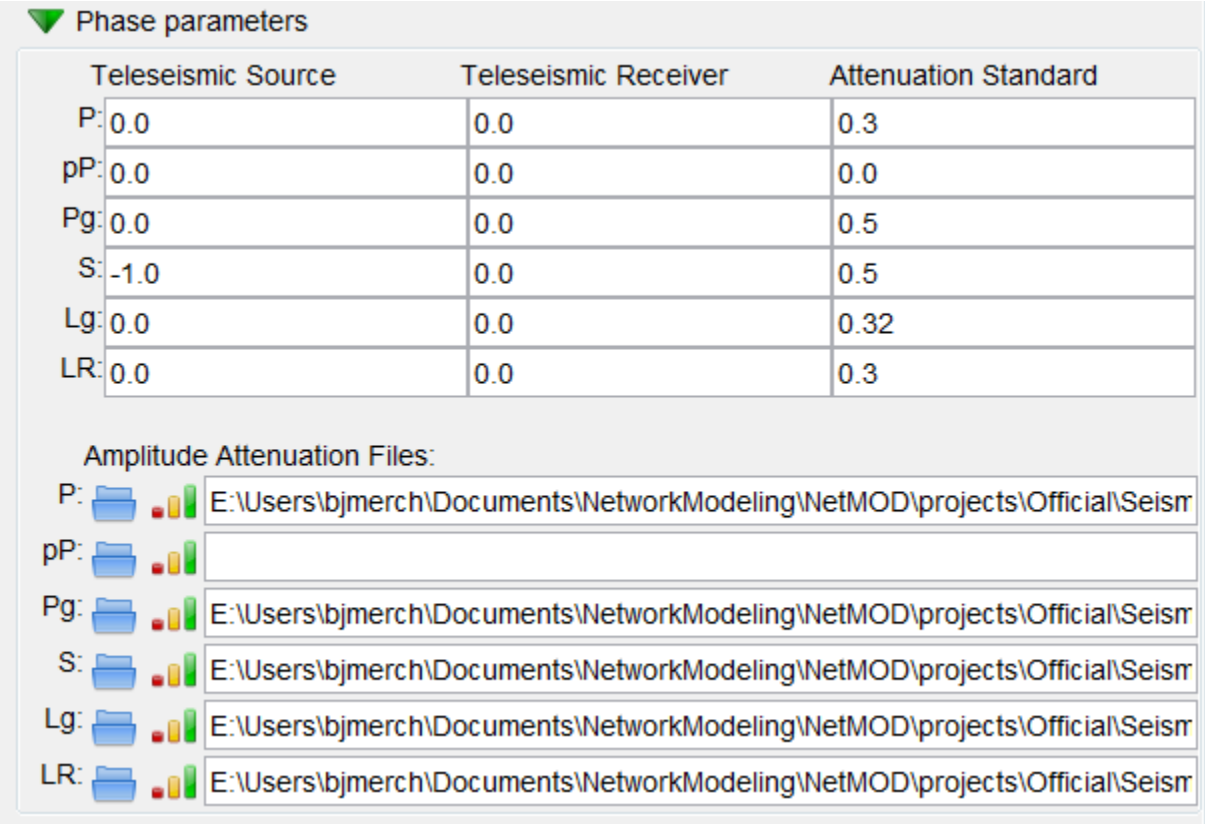
The buttons at the top of the **Media Types** controls allow the user to add a new media type or remove the existing media type.

The user can enter the following parameters:

Name Identifying name of the media type.

8.3.2.2.1 Phase Parameters

The Phase specific parameters define general parameters related to the paths that vary with phase but are specific to a particular path media type.

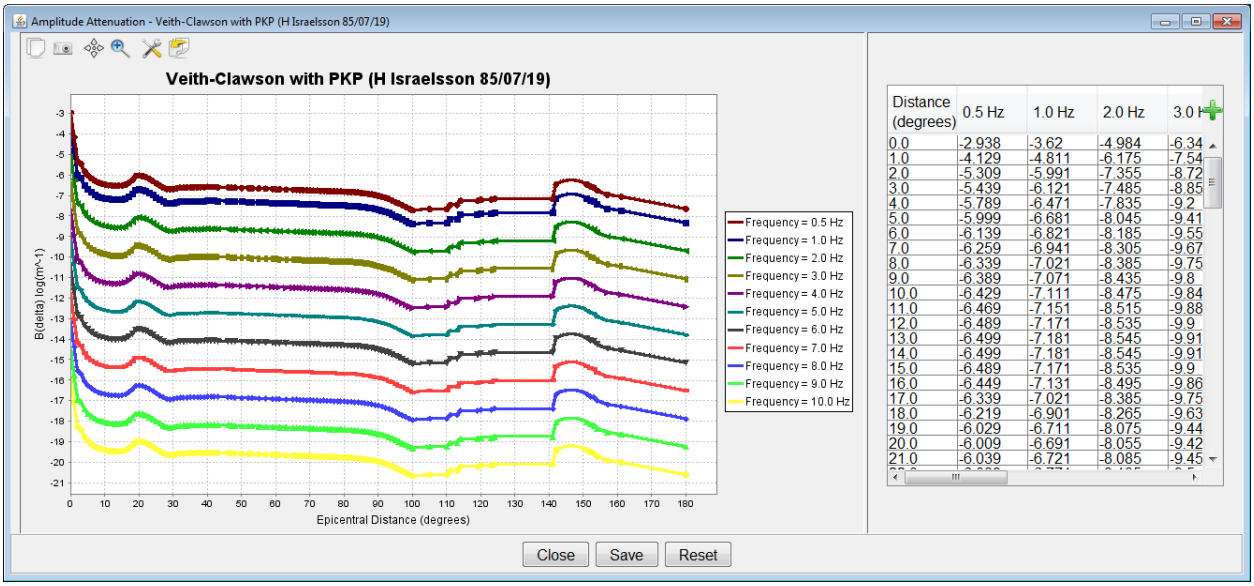


The user can enter the following parameters for each of the phases:

Teleseismic Source Correction	Teleseismic source correction term, in log10 spectral amplitude units.
Teleseismic Receiver Correction	Teleseismic receiver correction term, in log10 spectral amplitude units.
Attenuation Standard Deviation	Standard deviation of the amplitude attenuation, in log10 spectral amplitude units.
Amplitude Attenuation Files	Location of the formatted data file containing the amplitude attenuation may be specified for each phases. Click on the file browse button to select a file or the visualize button to view the amplitude attenuation.

8.3.2.2.2 Amplitude Attenuation

The **Amplitude Attenuation** file defines the relationship between the source to receiver distance, the frequency, and the amount of amplitude attenuation due to the path (SAIC-09/3007).



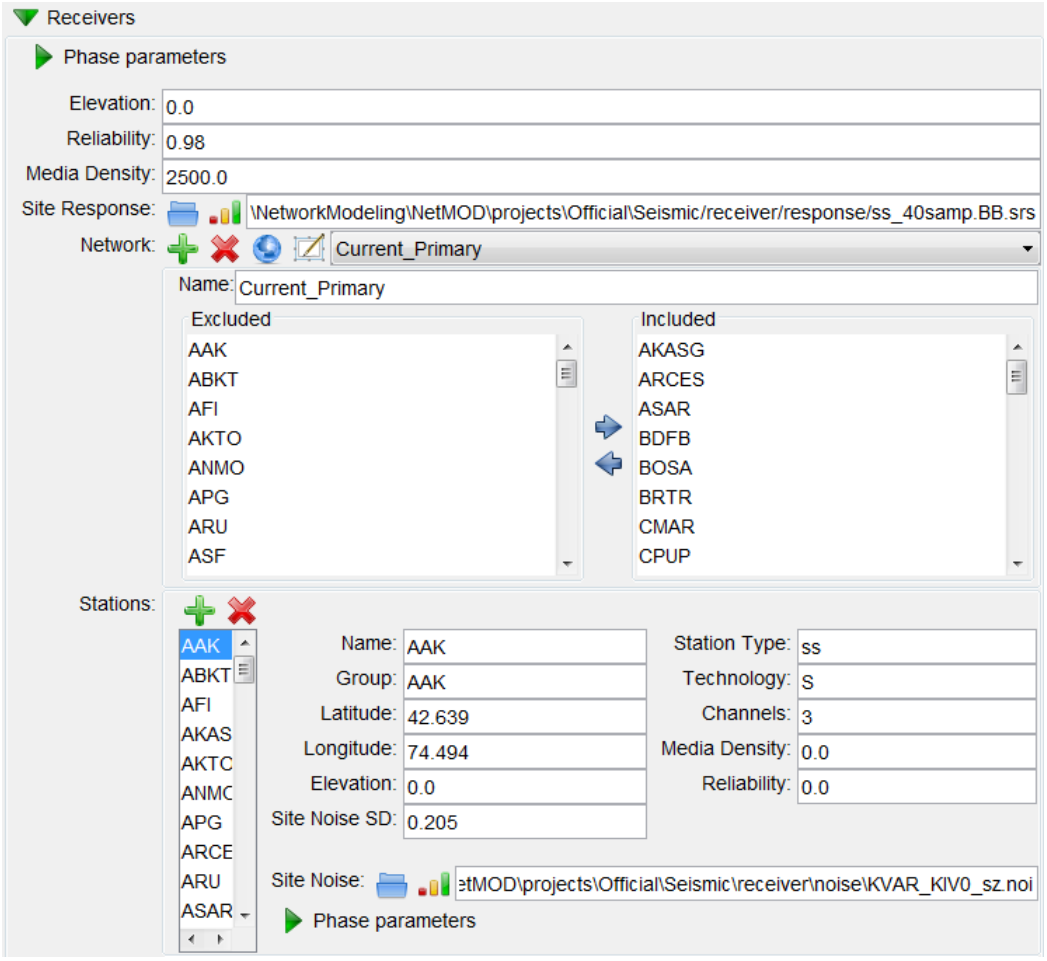
The user may use this viewer to simply visualize the amplitude attenuation curves or to also modify the values within the table and save them back to the file.

The following buttons are available at the bottom of the dialog:

Close	Close the dialog without modifying the file.
Save	Save the quantities to the file.
Reset	Reload the quantities from the file.

8.4 Receivers

The **Receivers** portion of the simulation provide for the definition of the characteristics of the stations that are to be simulated.



The user can enter the following parameters:

Elevation — Default elevation for any station that does not have a specified elevation, defined as being a value less than or equal to 0.

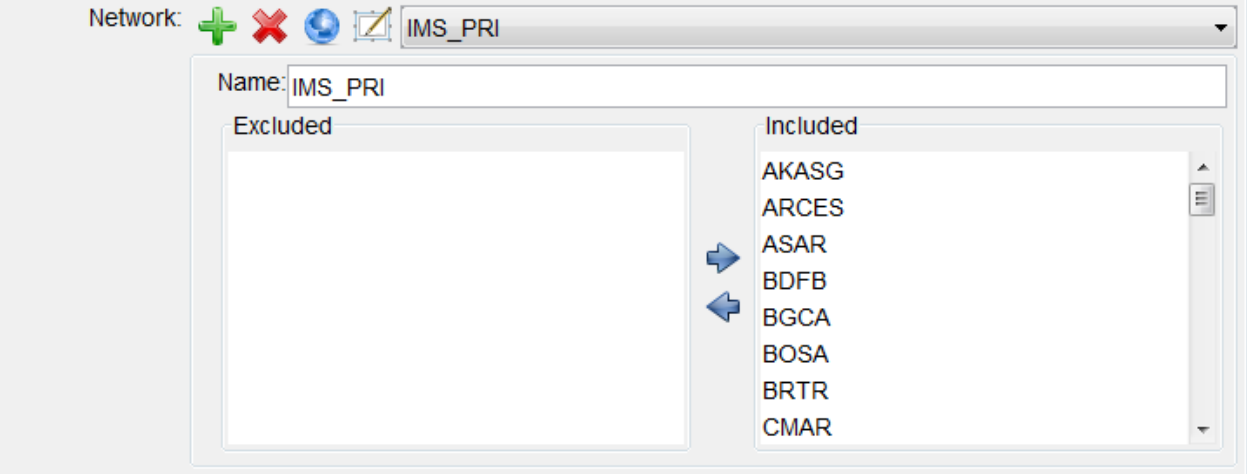
Reliability — Default station reliability, expressed as a probability between 0 and 1, for any station that does not have a specified reliability, defined as being a value less than or equal to 0.

Media Density — Default media density, expressed in kg/m^3, for any station that does not have a specified media density, defined as being a value less than or equal to 0.

Site Response — Default site response file for stations that do not have one defined.

8.4.1 Network

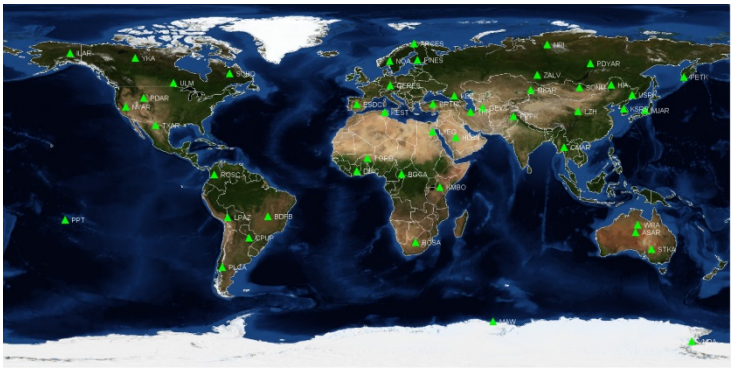
The stations defined within a simulation may be organized into networks. Version 1.0 of NetMOD comes with a data package of the International Monitoring System station locations that is used as a default and training set. Each station may be included in any number of networks. The selected network is then used to determine which stations should be used in the execution of the simulation.



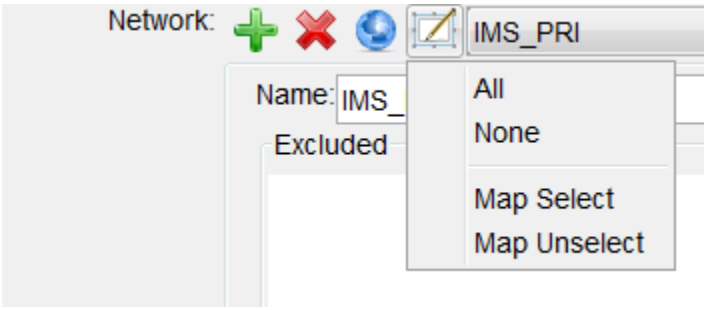
Create a new network. A dialog box will appear to prompt the user to enter a name for the network.

Remove the currently selected network.

Toggle button to control visibility of the stations on the map. Stations included or excluded from the network are assigned the colors as defined within the NetMOD properties.



Toggle button for selecting stations for a network on the map.



Clicking on **All** will include all of the stations within the network. Clicking on **None** will exclude all of the stations from the network.

Clicking on **Map Select** or **Map Unselect** will allow the user to use the mouse to interactively select or unselect stations on the map. Clicking on a station on the map will either select or unselect that station, depending on the chosen action. Dragging a selection box on the map will select or unselect all of the stations that are within that box, depending on the chosen action. Clicking on the map selection button a second time will disable map selection.

Move stations selected within the **Excluded** list into the **Included** list

Move stations selected within the **Included** list into the **Excluded** list

8.4.1.1 Phase Parameters

The Phase specific parameters define general parameters related to the receivers that vary with phase but are not specific to a particular station.

Phase parameters

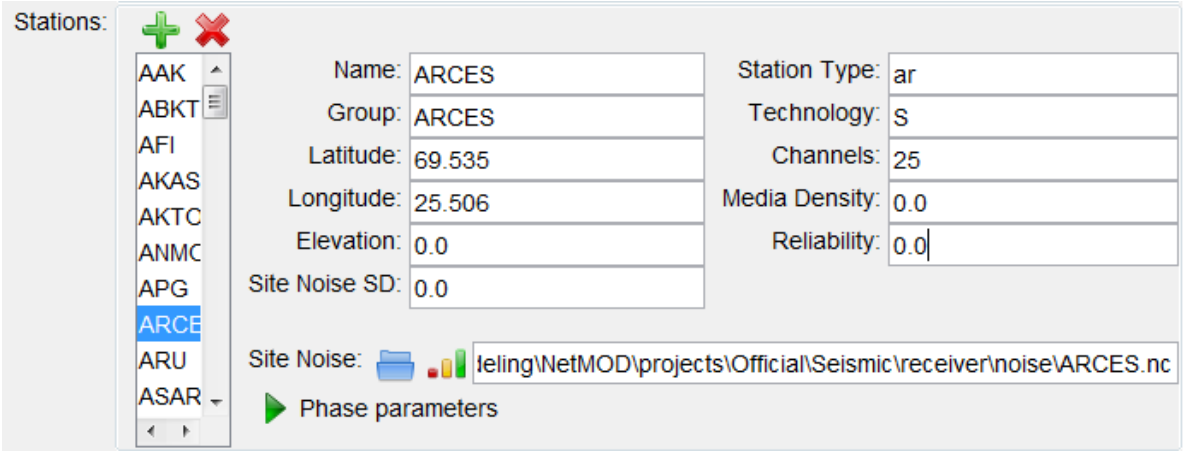
	Amplitude Correction	Standard Deviation	Media Velocity	Detection SNR
P:	0.0	0.4	5000.0	4.0
pP:	0.0	0.0	0.0	0.0
Pg:	0.0	0.0	5000.0	4.0
S:	0.0	0.0	3000.0	2.0
Lg:	0.0	0.0	3000.0	1.5
LR:	0.0	0.0	3000.0	1.5

The user can enter the following parameters for each of the phases:

Amplitude Correction Default mean value of the receiver amplitude correction, in log10 spectral amplitude units, for any station that does not have a specified amplitude correction, defined as being a value equal to 0.

Amplitude Correction Standard Deviation	Default standard deviation of the receiver amplitude correction, in log10 spectral amplitude units, for any station that does not have a specified amplitude correction standard deviation, defined as being a value equal to 0.
Media Velocity	Default receiver media velocity, in m/s, for any station that does not have a specified media velocity, defined as being a value less than or equal to 0.
Detection SNR	Default detection SNR, expressed as a ratio, for any station that does not have a detection SNR, defined as being a value less than or equal to 0.

8.4.2 Stations




Create a new station. A dialog box will appear to prompt the user to enter a name for the station.


Remove the selected stations.

The user can enter the following parameters:

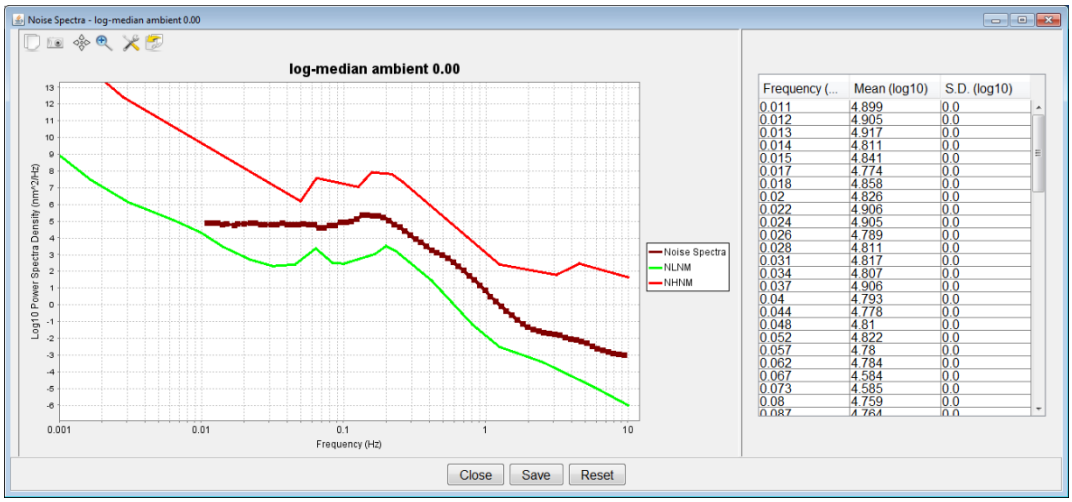
Name	Name of the station.
Group	Group name of the station. Typically equal to the station name unless there are a group of statistically dependent stations that share the same group name.
Latitude	Latitude of the station in decimal degrees.
Longitude	Longitude of the station in decimal degrees.
Elevation	Elevation of the station in meters. If the elevation is less than or equal to 0, then the default receiver elevation will be used.
Site Noise SD	The default standard deviation of the site noise, in log10 spectral amplitude units. This value is only used if the site noise file does not have a valid standard deviation defined, less than or equal to 0.
Station Type	Station type: 'ss' for single station or 'ar' for array.
Technology	Technology: 'S' for Seismic, 'H' for Hydroacoustic, or 'I' for Infrasound
Channels	The number of channels (or elements) of the array
Media Density	The media density in kg/m^3. If the media density is less than or equal to 0, then the default receiver media density will be used.
Reliability	Station reliability as a probability between 0 and 1. If the reliability is less than or equal to 0, then the default station reliability will be used.
Site Noise	Location of the formatted data file containing the site noise may be specified for each station. Click on the file browse button to select a file or the visualize button to view the site noise.

8.4.2.1 Site Noise

The **Site Noise** file defines the characteristics of the background noise present at a station. NetMOD supports several different noise file formats. Each of them is discussed in a section below.

8.4.2.1.1 Ambient Noise File

The standard **Ambient Noise File**, which ends with a "*.noi*", contains static measurements of the mean and standard deviation of the site noise in units of log10 power spectral density (see the NetMOD Parameters document). For seismic, the values are relative to nm^2/Hz. For hydroacoustic, the values are relative to uPa^2/Hz. For infrasound, the values are relative to $ubar^2/Hz$.



The user may use this viewer to simply visualize the noise values or to also modify the values within the table and save them back to the file.

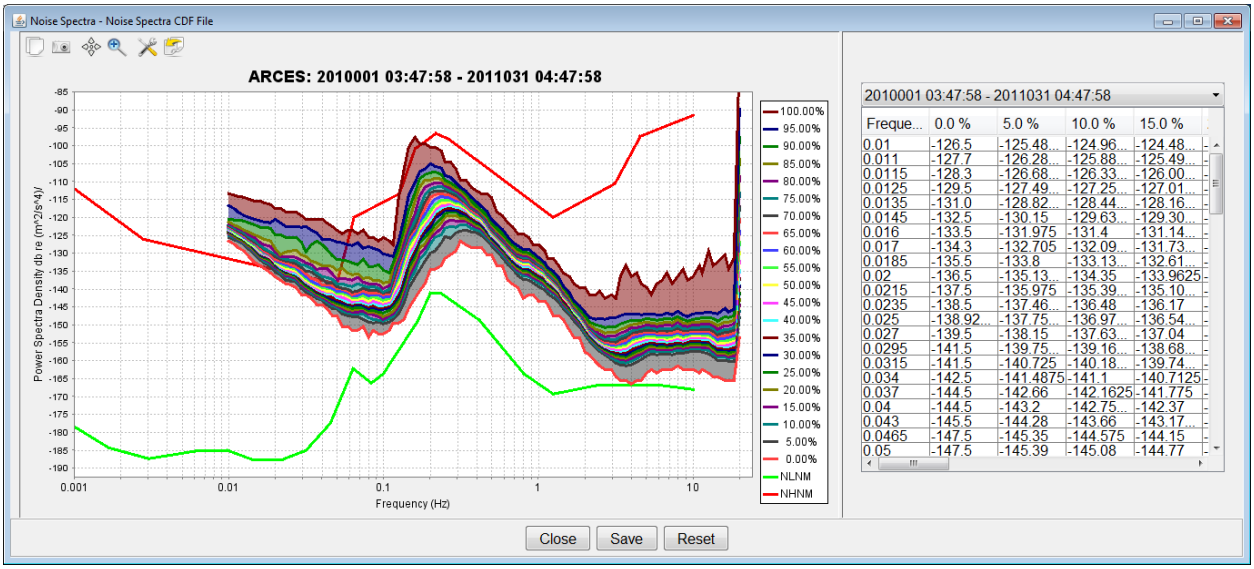
The following buttons are available at the bottom of the dialog:

Close	Close the dialog without modifying the file.
Save	Save the quantities to the file.
Reset	Reload the quantities from the file.

8.4.2.1.2 NetCDF Noise File

The **NetCDF Noise File**, which ends with "*.nc*", contains measurements of the Cumulative Distribution Function (CDF) of the noise for a range of frequencies. The noise values are expressed in dB relative to the power spectral density of acceleration. The noise file contains multiple CDF's for each station. There are CDF's for four times of day for each month of the year. The advantage of this format is that it does not assume that the site noise conforms to a Gaussian probability distribution and it does not assume that the site noise is constant throughout the day or the year.

Note that the CDF curves contained within the NetCDF Noise File are only able to be used when a Monte-Carlo simulation is being performed. The CDF curves are not used when a traditional NetSim style simulation is being performed. This is due to an assumption in the algorithms that the signal and noise amplitudes are log-normal random variables (SAIC-09/3006). When performing the traditional NetSim amplitude estimates, the mean and standard deviation values within the NetCDF files are used instead.



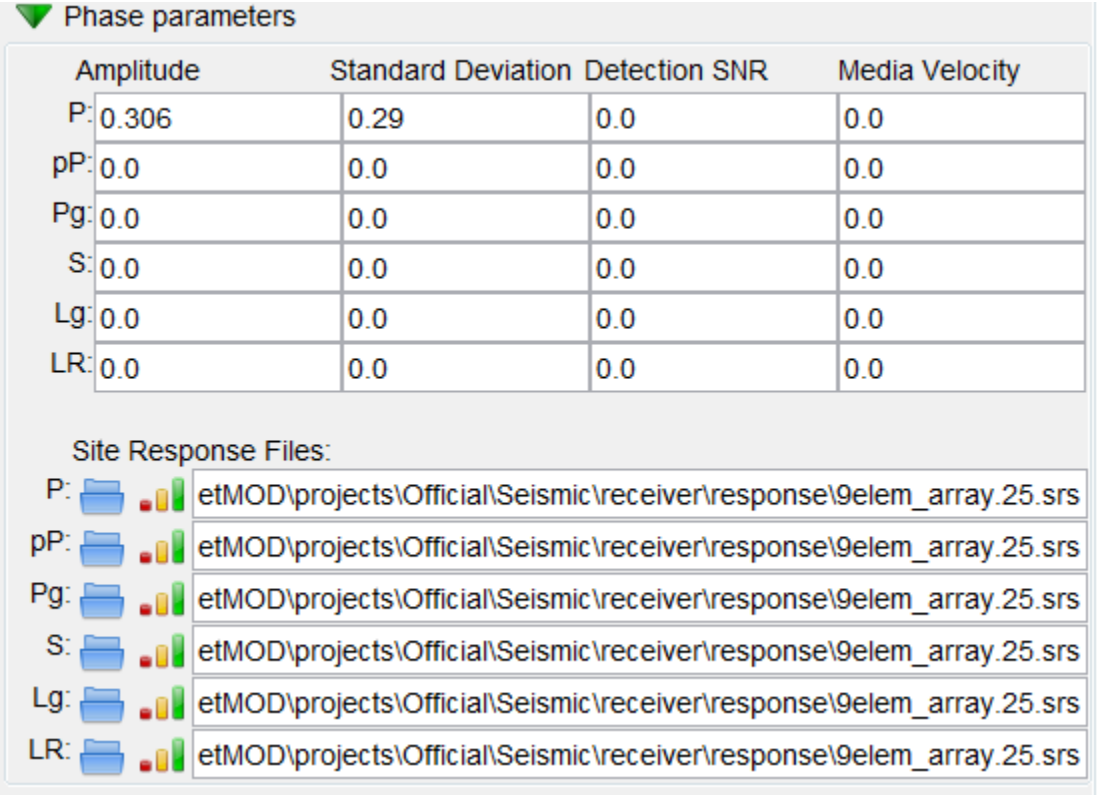
The user may use this viewer to simply visualize the noise values.

The following buttons are available at the bottom of the dialog:

Close	Close the dialog without modifying the file.
Save	NetMOD does not support the modification or saving of NetCDF files at this time.
Reset	Reload the quantities from the file.

8.4.2.2 Phase Parameters

The **Phase Parameters** define parameters that vary with phase and are specific to each station.



The user can enter the following parameters for each of the phases:

Amplitude Correction — Mean value of the receiver amplitude correction, in log10 spectral amplitude units. If the value is equal to 0, then the default receiver amplitude correction will be used.

Standard Deviation — Standard deviation of the receiver amplitude correction, in log10 spectral amplitude units. If the value is equal to 0, then the default receiver amplitude correction will be used.

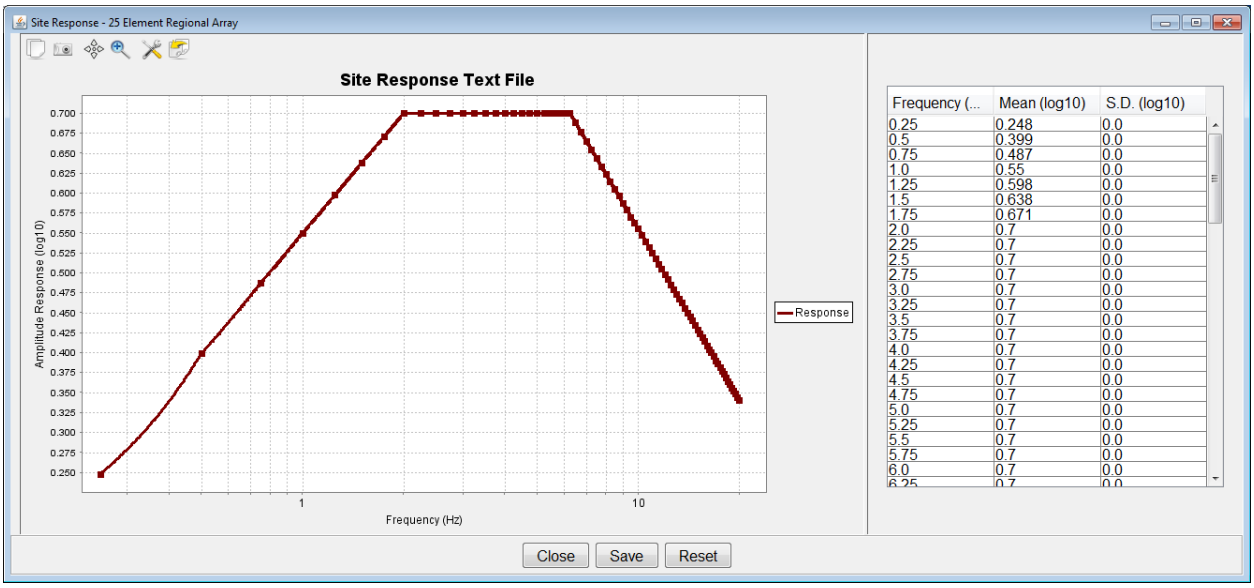
Detection SNR — Detection SNR, expressed as a ratio. If the value is less than or equal to 0, then the default receiver amplitude correction will be used.

Media Velocity — Receiver media velocity, in m/s. If the value is less than or equal to 0, then the default receiver amplitude correction will be used.

Site Response — Location of the formatted data file containing the site response may be specified for each station and phase. Click on the file browse button to select a file or the visualize button to view the site response.

8.4.2.2.1 Site Response

The **Site Response** file, which ends with a "*.srs*", contains the gain factor of the array in log10 units versus frequency (see the NetMOD Parameters document).



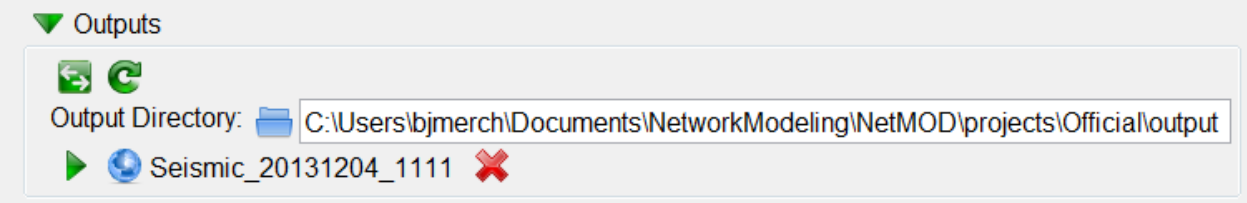
The user may use this viewer to simply visualize the response values or to also modify the values within the table and save them back to the file.

The following buttons are available at the bottom of the dialog:

Close	Close the dialog without modifying the file.
Save	Save the quantities to the file.
Reset	Reload the quantities from the file.

8.5 Output

The **Output** from the simulation runs are stored within sets of files contained within an output directory (SAIC-09/3007). NetMOD displays an entry in the control pane for each of the output file sets within the output directory.



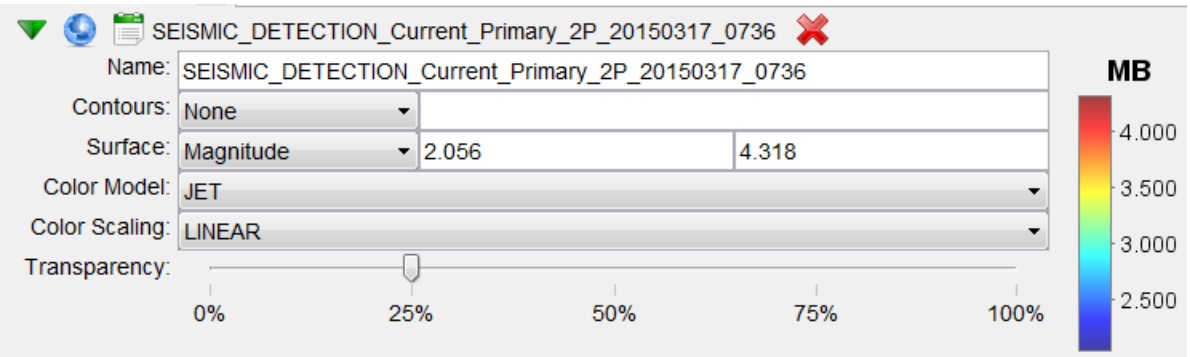
The user may enter a different output directory within the text field or use the file browser to select a directory. The set of displayed outputs will automatically update to reflect the contents of the updated directory.

Compute the difference between two outputs.

Refresh the set of outputs from the files on disk

8.5.1 Output Controls

Each output contains a set of individual output controls.

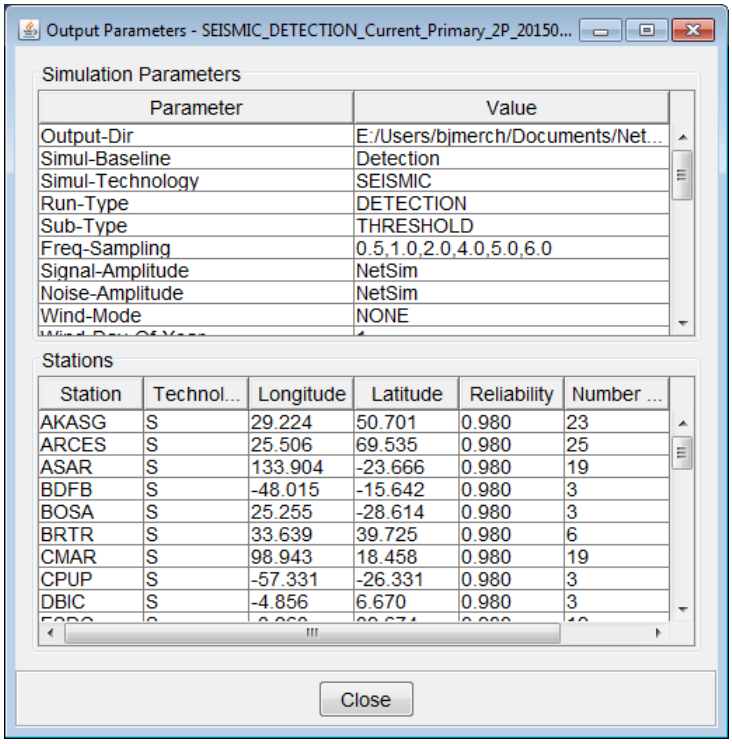


A color bar is displayed on the right hand size of the output controls. Within the map, as the mouse hovers over portions of the output surface, a tooltip will be displayed with the output value at that position.

The user can enter the following parameters for each of the phases:

Toggle button to control the visibility of the output on the map. Only one output may be displayed at a time. Selecting to display an output will automatically un-display all of the other outputs.

Display the output parameters that were used in generating the output.



Delete the output. This button will delete of the files on disk associated with this output and remove this output entry from the control pane.

Name Name of the output. Changing the name will result in the files on disk being renamed.

Contours Generate and display contour lines for the selected parameter in the adjacent pull down. A comma separate list of numeric values in the text field will specify the contour levels.

Surface Generate and display a surface image for the selected parameter in the adjacent pull down. The parameter from the output that is to be displayed. The parameter selection defaults to the first non-constant output parameter. The minimum and maximum data values that the color model is to span may be set. Note that when the parameter is changed, the data range is automatically reset to the range of available data.

Color Model Select the desired color model from the pull down list.

Color Scaling Select the desired color model will scale across the data range in a linear or log manner.

Transparency Select the desired surface transparency from 0 %, completely opaque, to 100 %, completely transparent.

8.5.2 Differencing Outputs

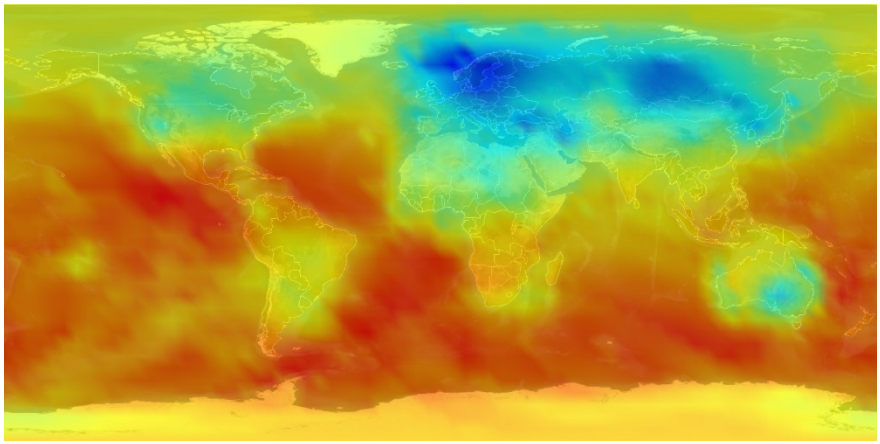
An important feature in NetMOD is the ability to determine the difference between two different simulation outputs. A user may perform this action by clicking on the difference button:

The user will be prompted to select the two outputs from selection dialogs that will appear. The only restriction is that the two simulation outputs must have been performed on the same set of source locations.

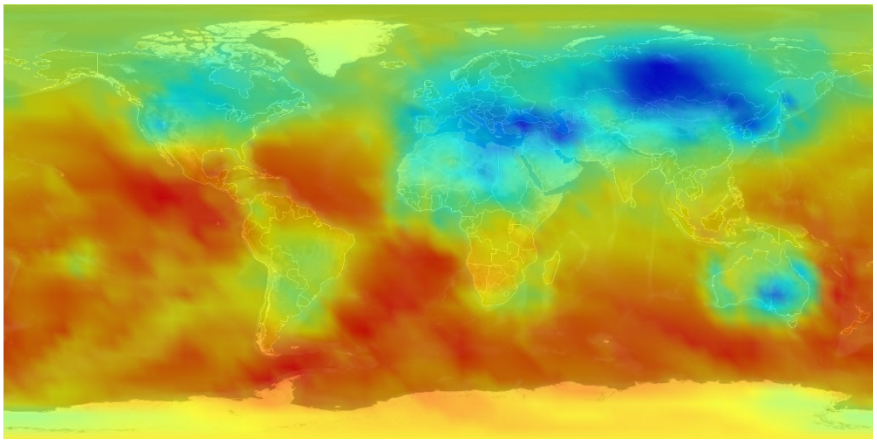
Once the difference is performed, a new output will be generated that has the name:

<first output name> - <second output name>

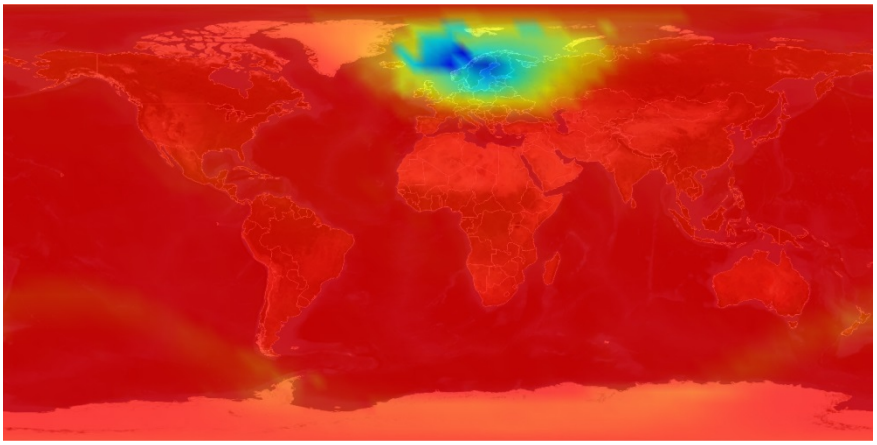
First output:



Second output:



Difference:

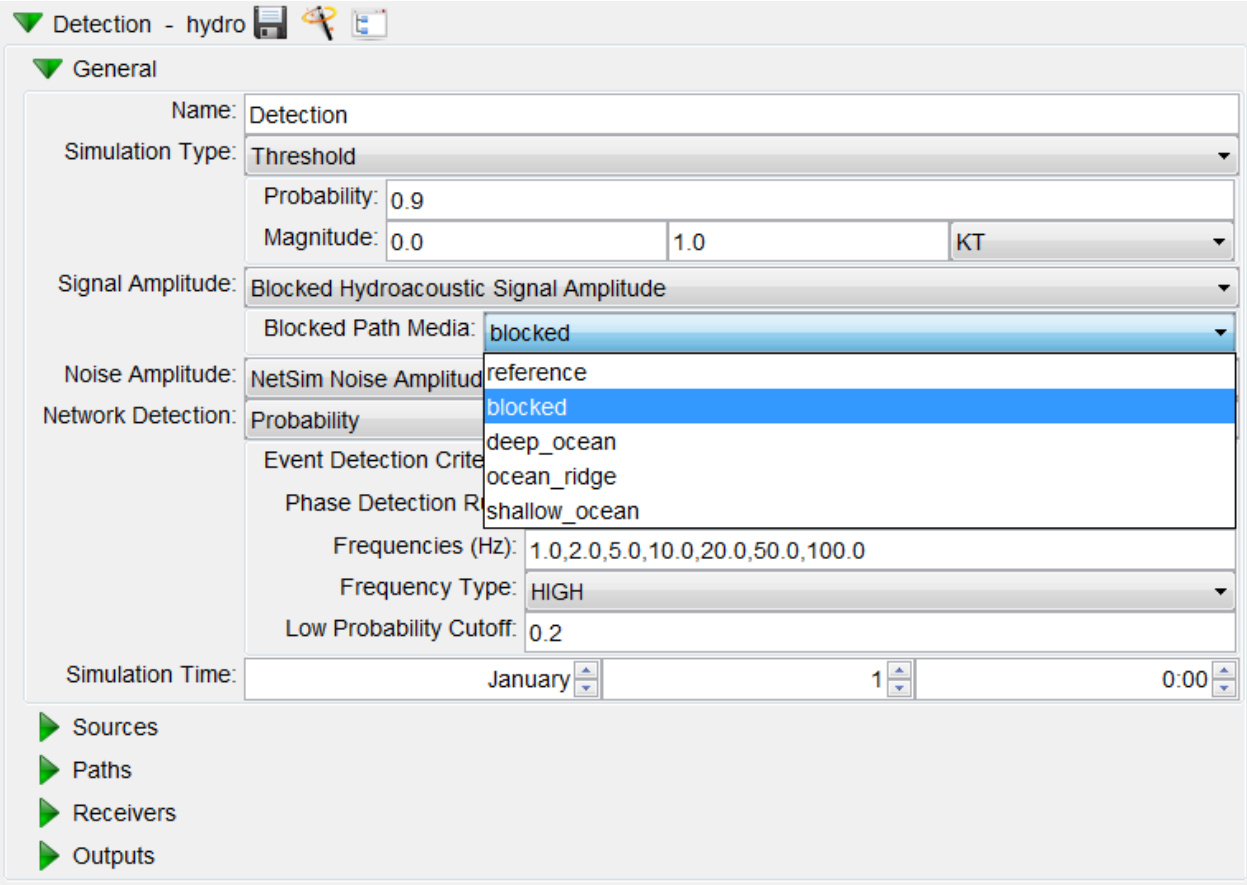


9 HYDROACOUSTIC DETECTION SIMULATION

The following sections detail NetMOD's hydroacoustic detection module and contain a description of the GUI components that are different from the seismic module. For a general description of the algorithms, see the NetMOD Mathematical Framework document.

General Simulation Parameters

The only difference in the Hydroacoustic **General** Simulation Parameters is in the method of computing signal amplitudes.



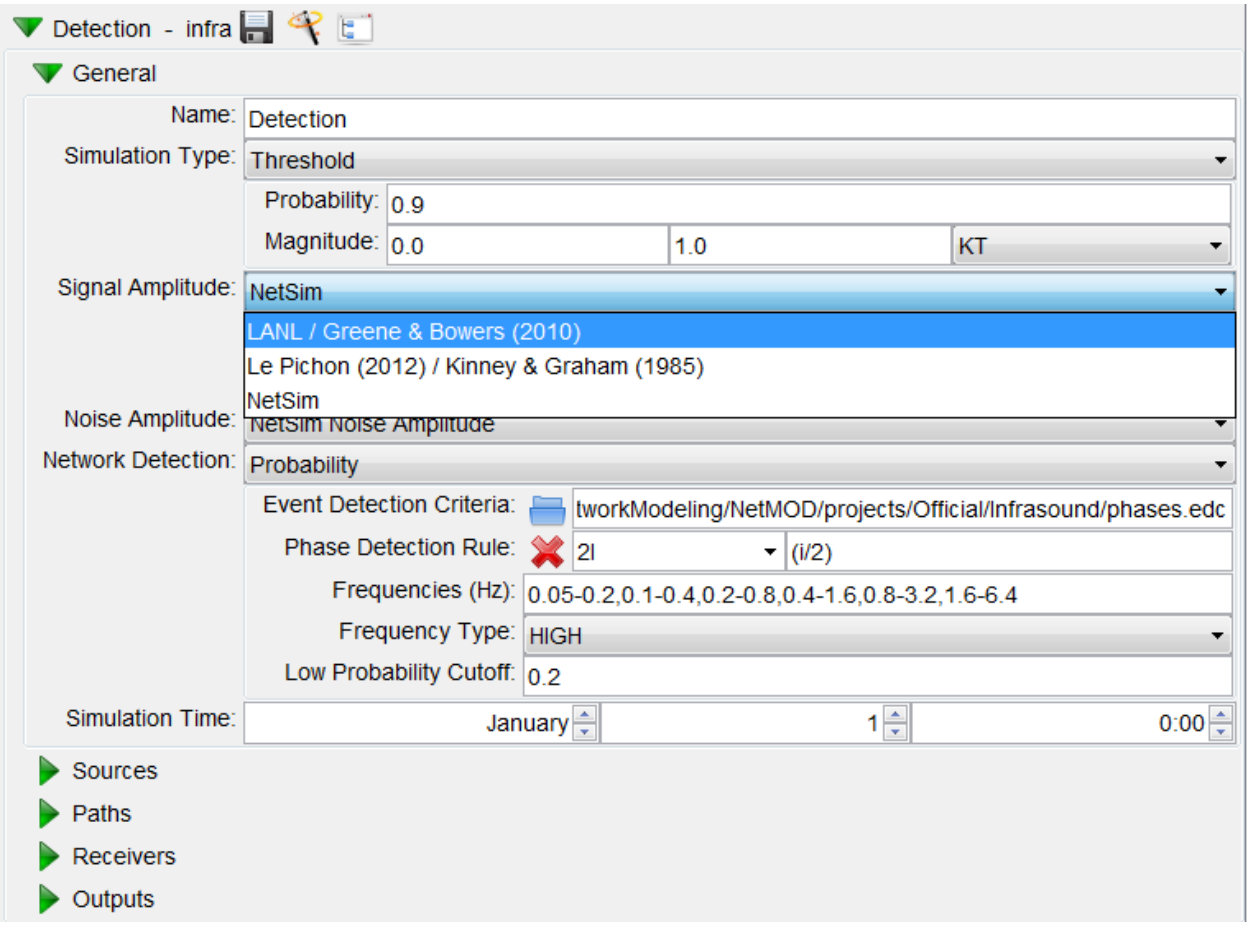
The only option for computing hydroacoustic signal amplitudes is to use a blockage method (see the NetMOD Mathematical Framework document) in which a defined path media type completely attenuates the signal if the source to receiver path intersection that media type. The blocked path media type may be selected from a list of the available media types.

10 INFRASONIC DETECTION SIMULATION

The following sections detail NetMOD's infrasonic detection module and contain a description of the GUI components that are different from the seismic module. For a detailed description of the algorithms, see the NetMOD Mathematical Framework document.

General Simulation Parameters

The only difference in the Infrasonic **General** Simulation Parameters is in the method of computing signal amplitudes.



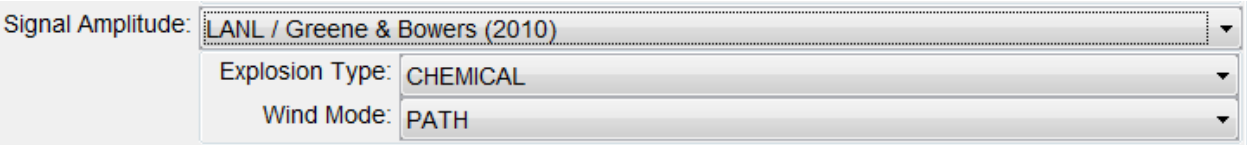
NetMOD provides three different methods for calculating signal amplitudes:

- LANL / Greene & Bowers (2010)
- LePichon (2012) / Kinney & Graham (1985)
- NetSim

See the NetMOD Mathematical Framework document for a detailed description of each method. The NetSim method utilizes the same text files for modelling the source spectra and path attenuation as the Seismic and Hydroacoustic simulation methods in their respective **Sources** and **Paths** sections. The other two methods, LANL and Le Pichon, directly implement the

referenced equations described in the NetMOD Mathematical Framework document, disregarding the contents of the **Sources** and **Paths** sections.

In addition, for each of the signal amplitude methods, the user may select from the options below:



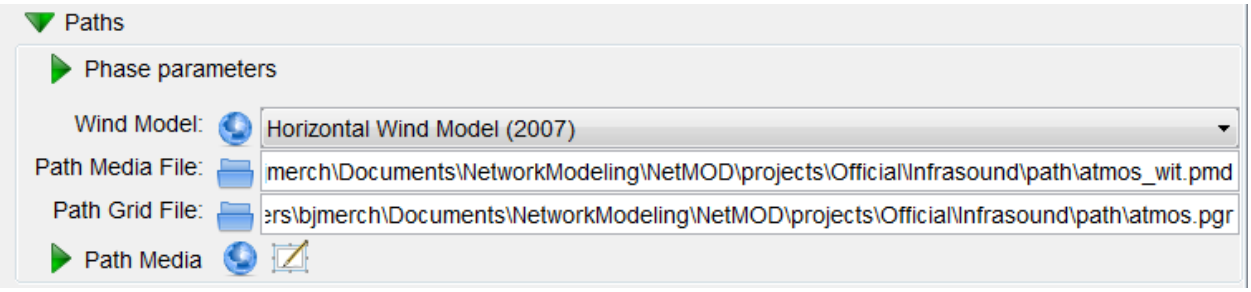
Explosion Type — Select whether to simulate the pressure from an above ground Chemical (Conventional) or Nuclear explosion.

Wind Mode — Select how discretely to sample the wind model between the source and receiver locations. The user may select:

NONE	No wind values are calculated. A value of 0 m/s is used in the calculations.
STA	Calculate the wind vector at the station location.
SOURCE	Calculate the wind vector at the source location.
SOURCE_STA	Calculate the wind vector as the average of the value at the source and station locations.
PATH	Calculate the wind vector along the great-circle bath from the source to the station, sampled at 50 km intervals.

10.2 Paths

The infrasonic simulation **Paths** section includes controls for selecting and displaying wind models.



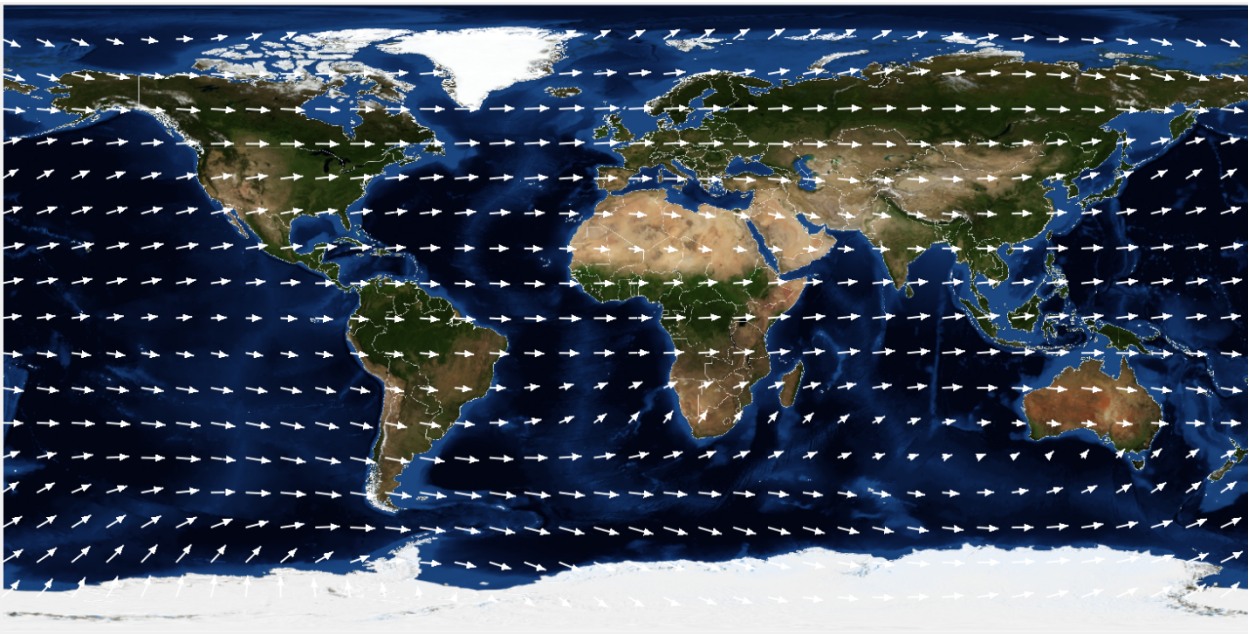
The user can enter the following parameters for each of the phases:

Wind Model

Select the desired wind model to be used in the infrasonic path attenuation calculations. At this time, the only option available is the Horizontal Wind Model (2007).

Toggle button to control the visibility of the wind model on the map. The wind model will be displayed as arrow vectors pointing in the wind direction and whose length is proportional to the wind speed.

The wind vectors will appear on the same similar to what is shown below.



11 INTROSPECTION

Validating the results of a network simulation can be challenging given the number of input parameters and calculations that must be performed. Fortunately, NetMOD has a feature called **Introspection** that allows a user to examine in depth how all of the results are obtained.

Introspection is based in part on how NetMOD has modularized the components that make up a simulation. The modular hierarchy of the components is reflected in the organization of the simulation controls within the GUI. Each of the components is able to log the details of the computation that it is performing. All that is necessary for the user to do is to click on the Execute Introspection button at the top of the simulation control pane:

The simulation will then begin running with the Introspection details appears in a dialog similar to the one shown below. The Introspection dialog has a number of color coded flags that may be displayed for each node to allow for the user to determine where any problems might occur. The color of each node represents the highest criticality of the results of that node's computation and that of the nodes below it.

Good: everything appeared to be fine with the simulation

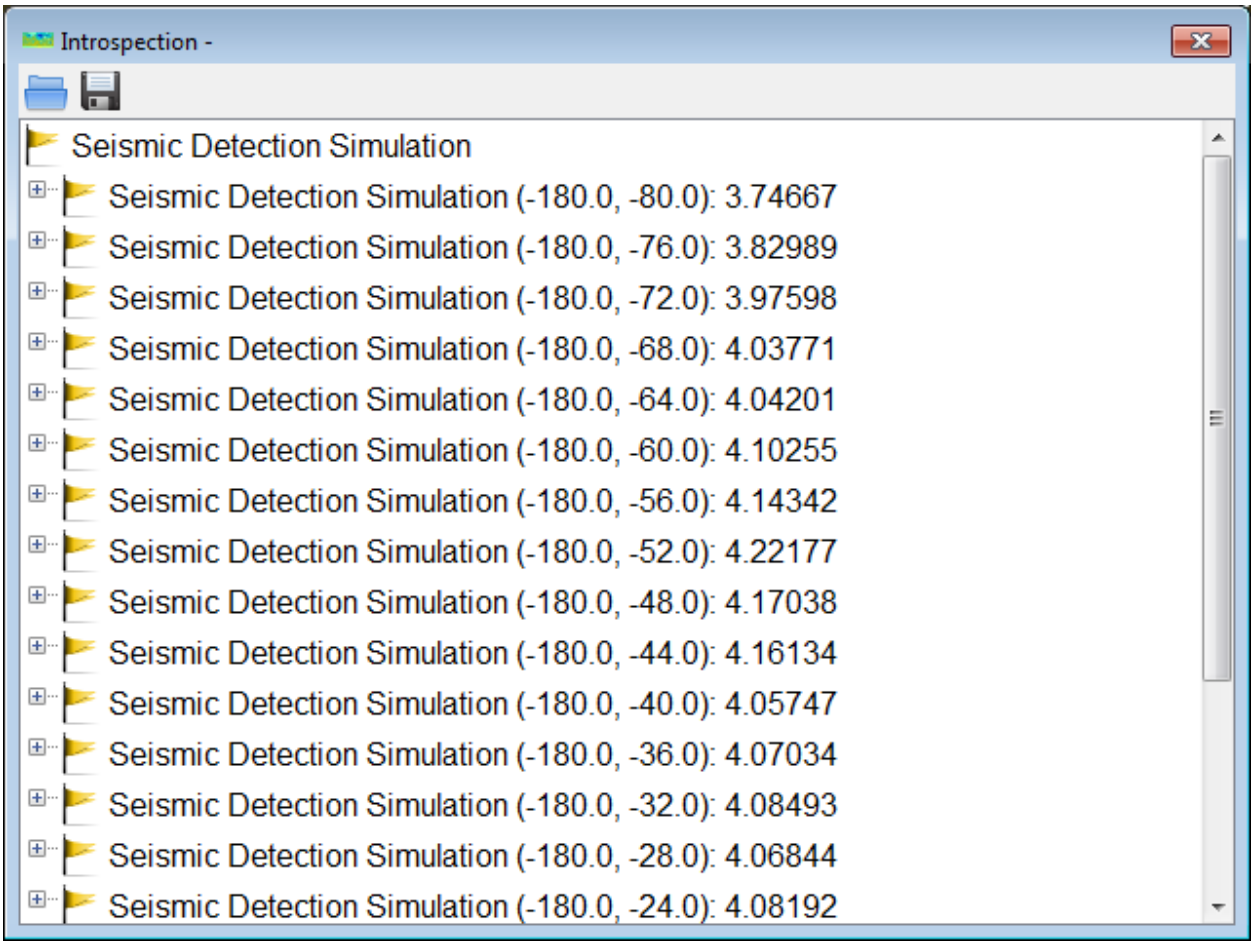
Warning: Some of the parameters may be out of range or missing, but the defaults should be sufficient. Examples could be a missing site response file (using a default array gain of 0), a missing site noise file (using a low noise model instead), or a non-critical out of range value (such as evaluating a path attenuation curve at a frequency outside the definition).

Error: Parameters are out of range or missing and the simulation results are suspect. An example of an error would be a missing path attenuation file.

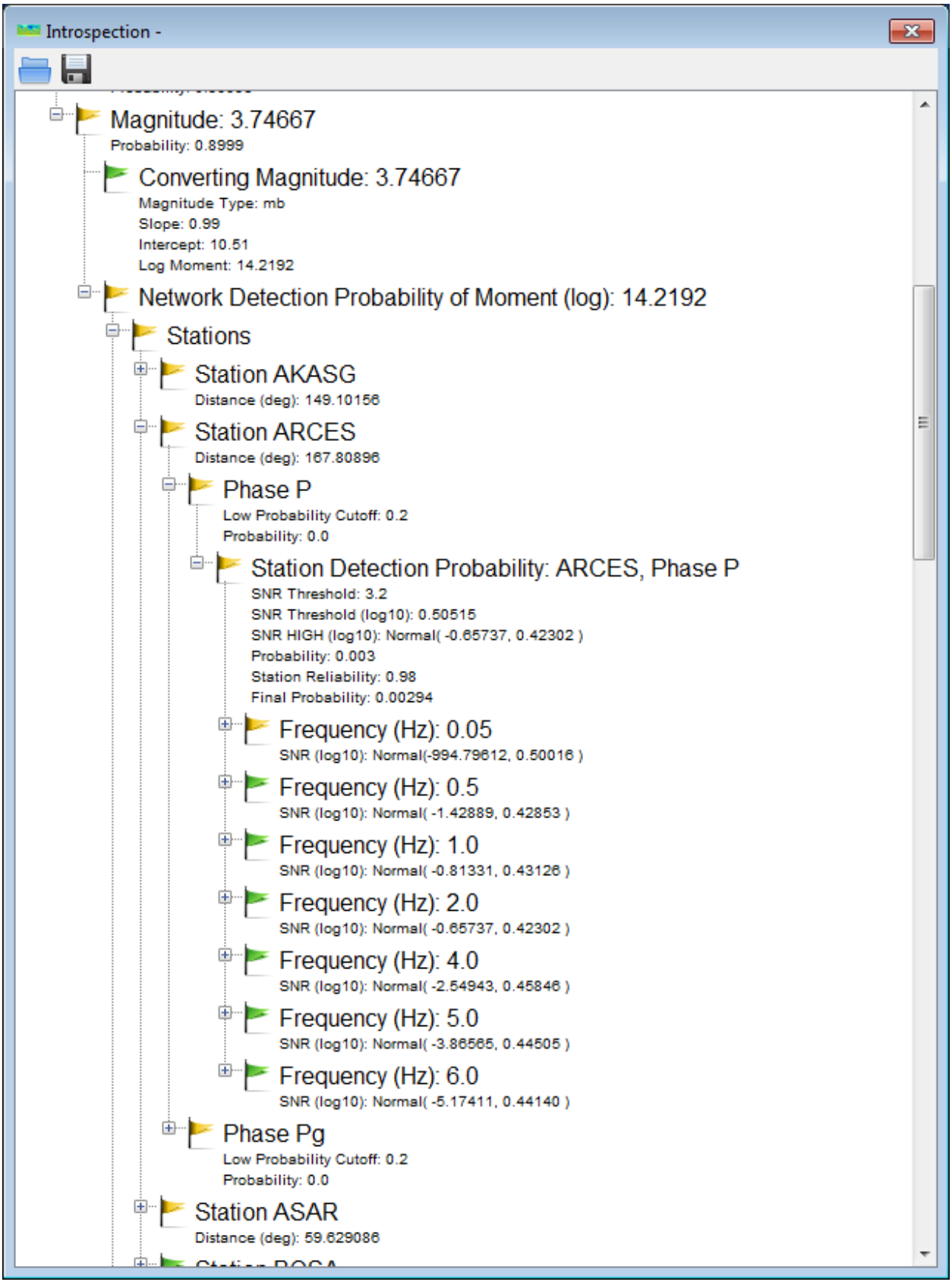
When the user has collected as much Introspection detail as they desire, they may cancel the execution of the simulation.

Note that executing the simulation with introspection again will bring up a new Introspection dialog and begin logging details to that new dialog. This allows for multiple Introspection dialogs to be open simultaneously for the purpose of comparing differences in simulations.

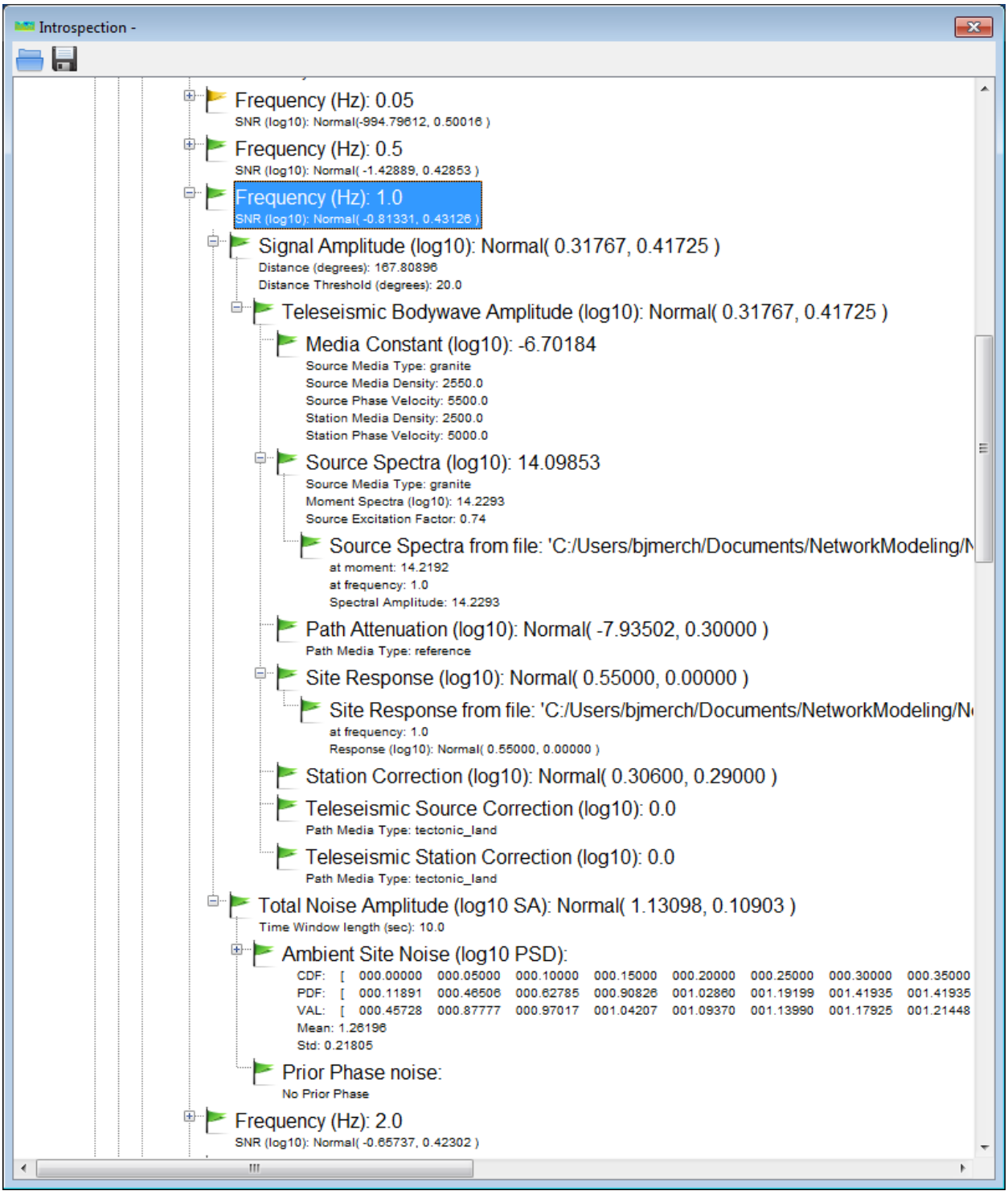
The results of Introspection are represented in a tree hierarchy that is verbose and fairly self-representative. At the top level, each source location is contained within a separate tree node:



Expanding down into each of the source locations, it is possible to examine how the simulation iterates over the magnitudes, stations, phases, and frequencies to be simulated:


Introspection -
Magnitude: 3.74667
Probability: 0.8999
Converting Magnitude: 3.74667
Magnitude Type: mb
Slope: 0.99
Intercept: 10.51
Log Moment: 14.2192
Network Detection Probability of Moment (log): 14.2192
Stations
Station AKASG
Distance (deg): 149.10156
Station ARCES
Distance (deg): 167.80896
Phase P
Low Probability Cutoff: 0.2
Probability: 0.0
Station Detection Probability: ARCES, Phase P
SNR Threshold: 3.2
SNR Threshold (log10): 0.50515
SNR HIGH (log10): Normal(-0.65737, 0.42302)
Probability: 0.003
Station Reliability: 0.98
Final Probability: 0.00294
Frequency (Hz): 0.05
SNR (log10): Normal(-994.79612, 0.50016)
Frequency (Hz): 0.5
SNR (log10): Normal(-1.42889, 0.42853)
Frequency (Hz): 1.0
SNR (log10): Normal(-0.81331, 0.43126)
Frequency (Hz): 2.0
SNR (log10): Normal(-0.65737, 0.42302)
Frequency (Hz): 4.0
SNR (log10): Normal(-2.54943, 0.45846)
Frequency (Hz): 5.0
SNR (log10): Normal(-3.86565, 0.44505)
Frequency (Hz): 6.0
SNR (log10): Normal(-5.17411, 0.44140)
Phase Pg
Low Probability Cutoff: 0.2
Probability: 0.0
Station ASAR
Distance (deg): 59.629086

Below each frequency, the Introspection results contain the details on how each specific signal amplitude, noise amplitude, and SNR is computed:



Reading and Writing

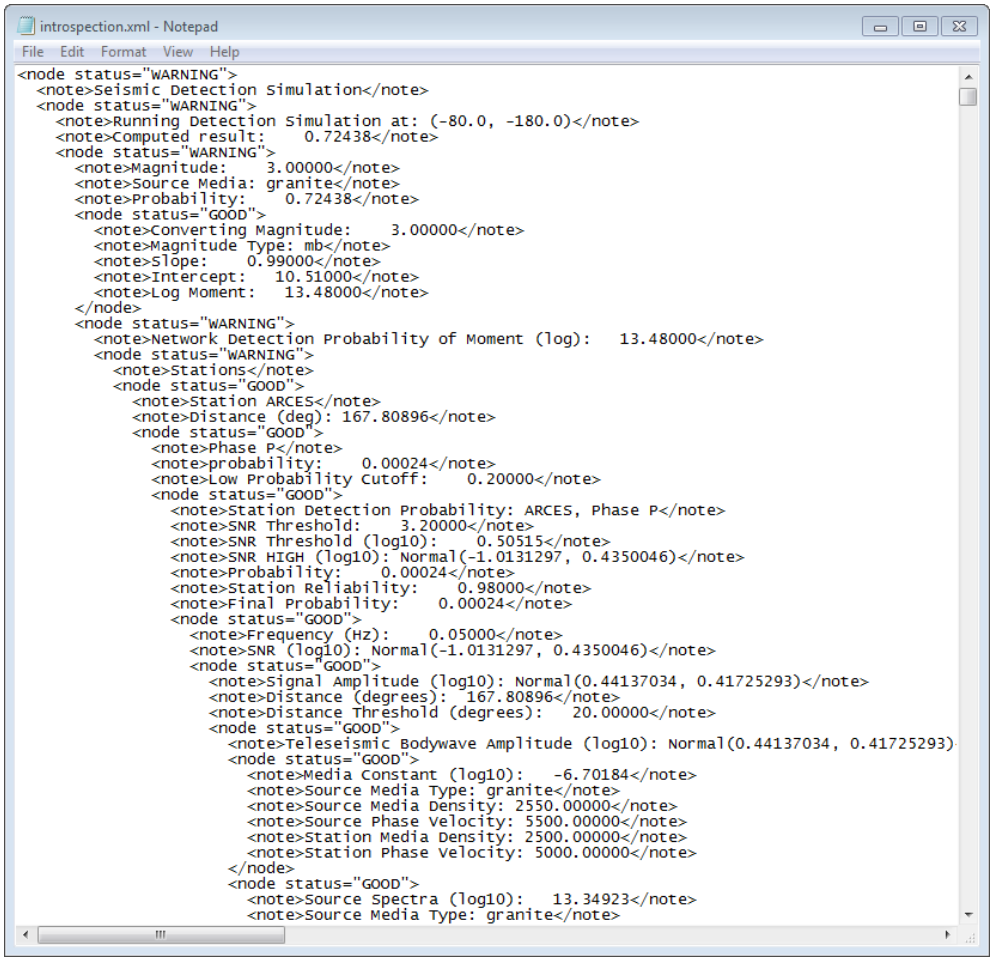
The Introspection log may be saved to a file on disk and then read back in at a later date. The intended purpose of being able to export and import the introspection logs is to allow users to document problems that they may come across when executing simulations and assist in communicating those problems to others.

The following buttons at the top of the Introspection dialog may be used for reading and writing:

Browse for an introspection log file to open from.

Browse for an introspection log file to save to.

The format of the Introspection log file is an ASCII XML file.



introspection.xml - Notepad

File Edit Format View Help

```
<node status="WARNING">
  <note>Seismic Detection Simulation</note>
  <node status="WARNING">
    <note>Running Detection Simulation at: (-80.0, -180.0)</note>
    <note>Computed result:    0.72438</note>
    <node status="WARNING">
      <note>Magnitude:    3.00000</note>
      <note>Source Media: granite</note>
      <note>Probability:    0.72438</note>
      <node status="GOOD">
        <note>Converting Magnitude:    3.00000</note>
        <note>Magnitude Type: mb</note>
        <note>Slope:    0.99000</note>
        <note>Intercept:   10.51000</note>
        <note>Log Moment:   13.48000</note>
      </node>
      <node status="WARNING">
        <note>Network Detection Probability of Moment (log):   13.48000</note>
        <node status="WARNING">
          <note>Stations</note>
          <node status="GOOD">
            <note>Station ARCES</note>
            <note>Distance (deg): 167.80896</note>
            <node status="GOOD">
              <note>Phase P</note>
              <note>probability:    0.00024</note>
              <note>Low Probability Cutoff:    0.20000</note>
              <node status="GOOD">
                <note>Station Detection Probability: ARCES, Phase P</note>
                <note>SNR Threshold:    3.20000</note>
                <note>SNR Threshold (log10):    0.50515</note>
                <note>SNR HIGH (log10): Normal(-1.0131297, 0.4350046)</note>
                <note>Probability:    0.00024</note>
                <note>Station Reliability:    0.98000</note>
                <note>Final Probability:    0.00024</note>
                <node status="GOOD">
                  <note>Frequency (Hz):    0.05000</note>
                  <note>SNR (log10): Normal(-1.0131297, 0.4350046)</note>
                  <node status="GOOD">
                    <note>Signal Amplitude (log10): Normal(0.44137034, 0.41725293)</note>
                    <note>Distance (degrees):  167.80896</note>
                    <note>Distance Threshold (degrees):   20.00000</note>
                    <node status="GOOD">
                      <note>Teleseismic Bodywave Amplitude (log10): Normal(0.44137034, 0.41725293)
                      <node status="GOOD">
                        <note>Media Constant (log10):   -6.70184</note>
                        <note>Source Media Type: granite</note>
                        <note>Source Media Density: 2550.00000</note>
                        <note>Source Phase Velocity: 5500.00000</note>
                        <note>Station Media Density: 2500.00000</note>
                        <note>Station Phase Velocity: 5000.00000</note>
                      </node>
                      <node status="GOOD">
                        <note>Source Spectra (log10):   13.34923</note>
                        <note>Source Media Type: granite</note>
```

12 TUTORIALS

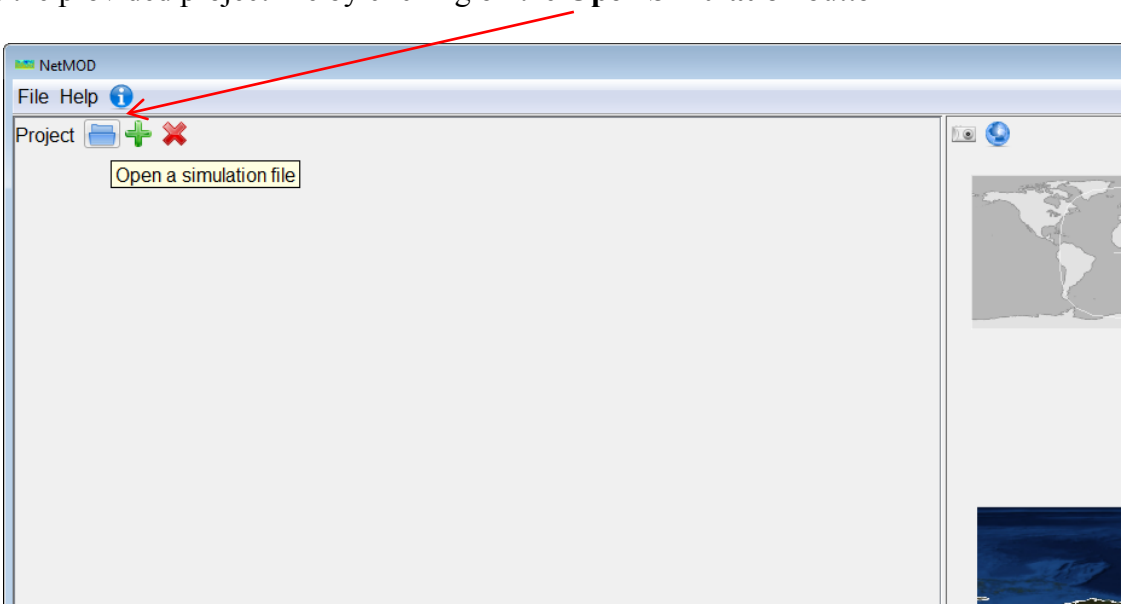
NetMOD is distributed with an example project file that includes the primary seismic stations for the CTBTO's IMS network. This project file is intended to serve as a starting point for users to begin using NetMOD. The tutorial sections below cover several common tasks that a user may wish to perform. Note that tutorials are written with the intent of progressing through some of the functionality in NetMOD with each tutorial building upon the features demonstrated in the prior tutorials.

There are two versions of the project file that are included. The first version (*Seismic.par*) references the standard site noise files that contain mean and standard deviation values that vary across frequency and are static across time. This version is included to provide a common project file with referenced data files that both NetSim and NetMOD can access for easy comparisons between the two programs. The second version (*Seismic_NetCDF.par*) references the updated site noise files that contain cumulative distribution functions that vary across frequency, time-of-day, and month-of-year. These files provide a more accurate estimate of the background noise present at each of the stations.

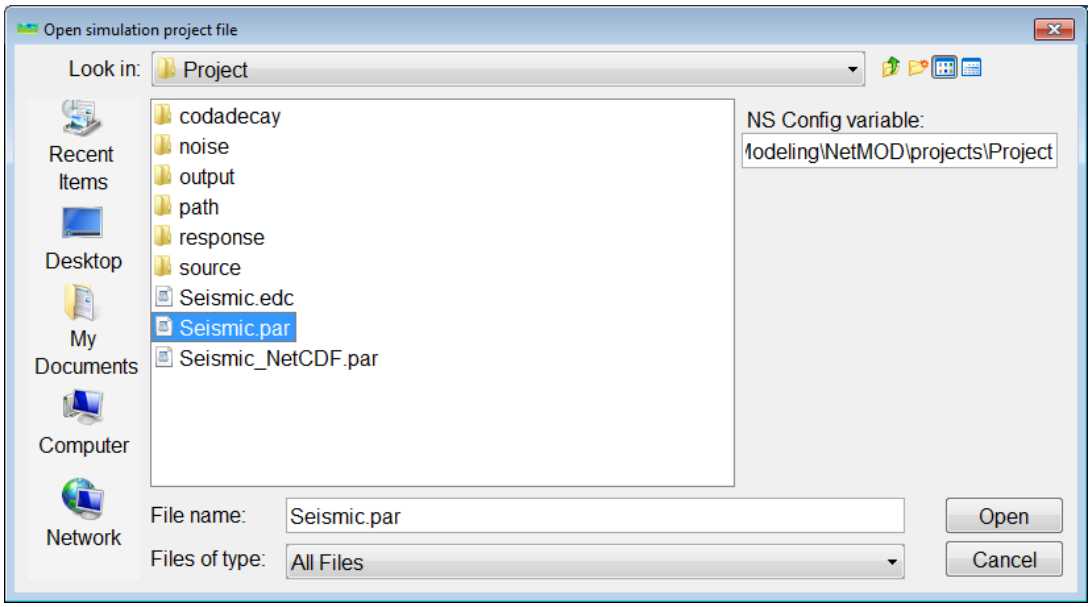
For all of these tutorial sections, the necessary initial step is to start NetMOD. Within the NetMOD application folder, there are startup scripts for Windows (*run_NetMOD.bat*) and Linux / MacOSX / Solaris (*run_NetMOD.sh*). NetMOD may be started by executing the appropriate startup script for the operating system being used. Alternatively, the user may modify and/or extract the contents of the startup script into a separate executable script.

Open a project file

Load the provided project file by clicking on the **Open Simulation** button

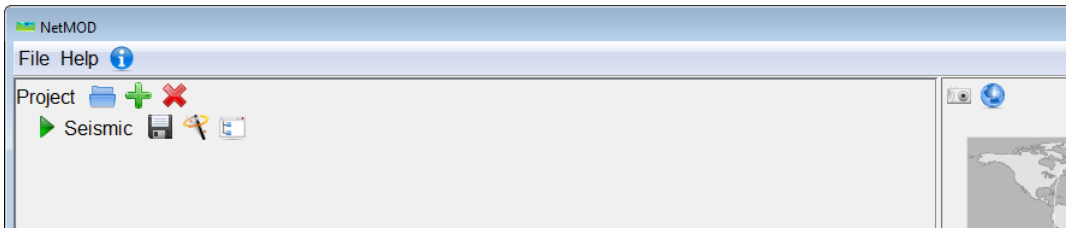


A file selection dialog will then appear:

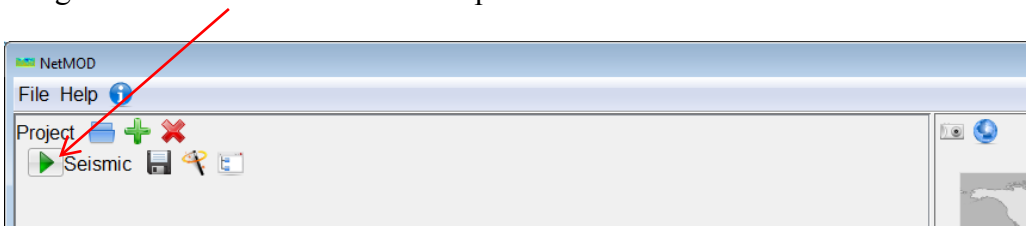


Use the dialog to navigate to the location of the project file and then select one of the provided project files, either *Seismic.par* or *Seismic_NetCDF.par*. The **NS Config** variable identifies the top-level folder of the project file structure. The content of the variable will automatically update to reflect the parent folder of the selected file, which is appropriate for the included project files. If the top-level folder for a project file is something different, update the variable definition to reflect that folder name.

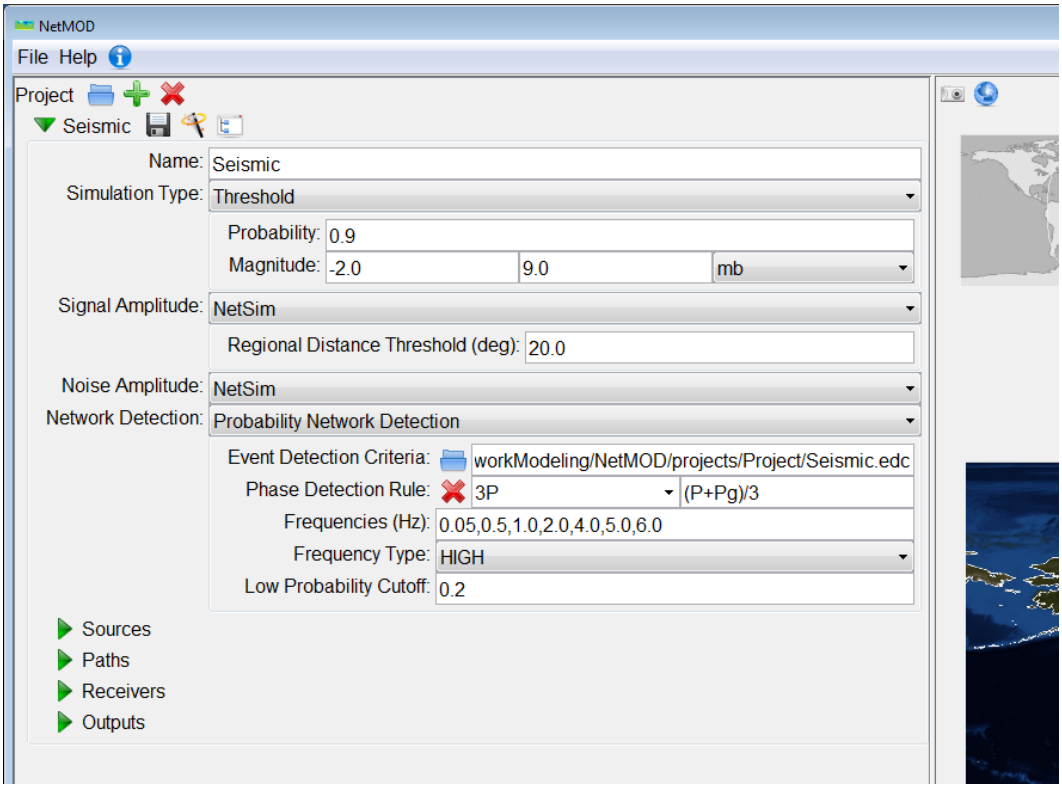
Click **Open** to read in the project file. Once the read has completed, there will now be an entry in the **Simulation Controls** for the project file:



Click on the green **Show Viewer** button to expand the viewer:



Additional details of the simulation are now visible:

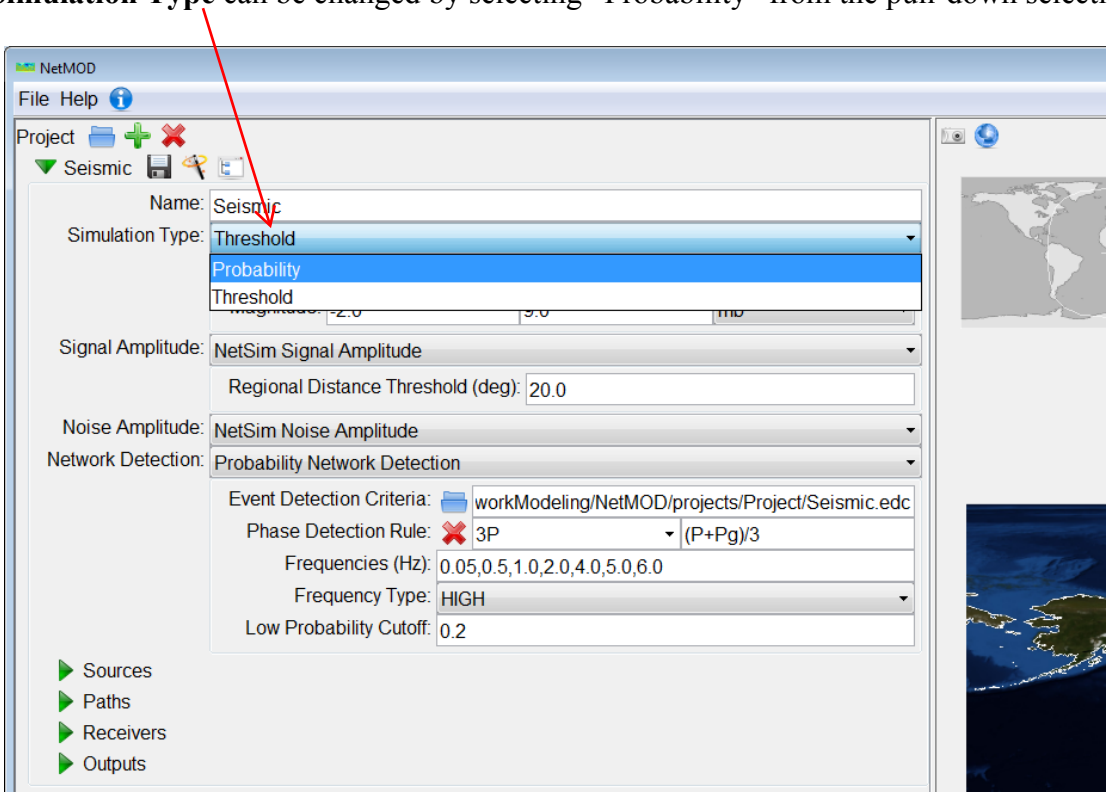


14.2 Run a probability simulation

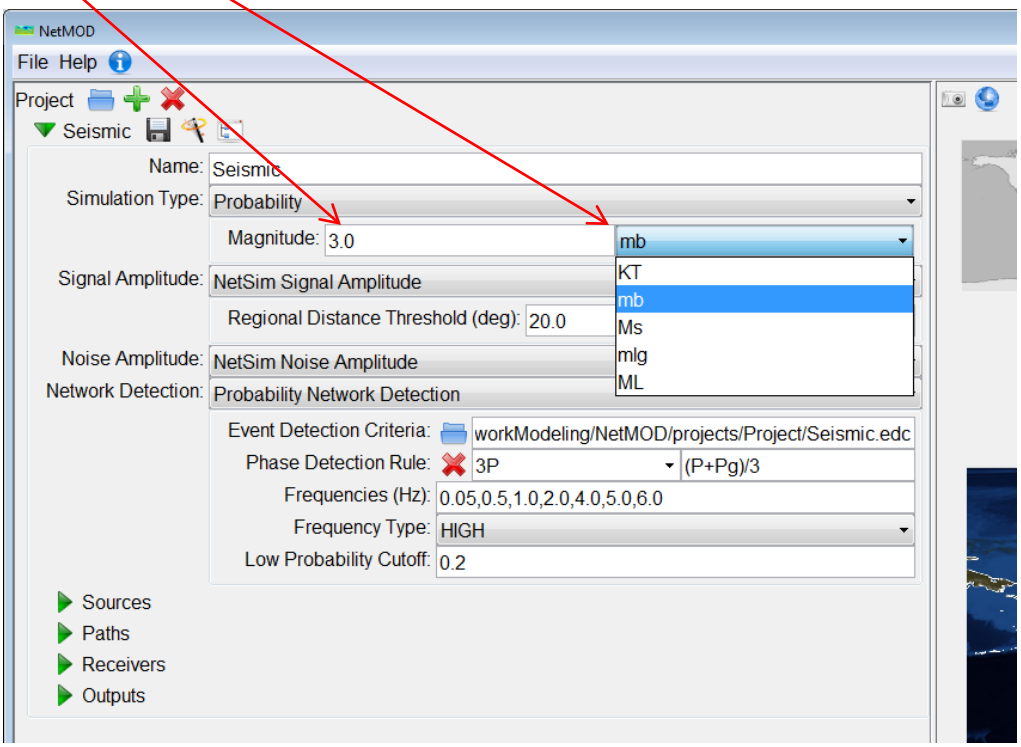
A probability simulation is one in which the probability of an event with a specific magnitude is computed at each of the source locations. The result is a map of the probabilities across some geographic region. The user may specify the magnitude of the event and the source locations that define the region.

Specify a "Probability" simulation type and magnitude. The included project file defaults to a "Threshold" simulation. It is necessary to switch to a "Probability" simulation.

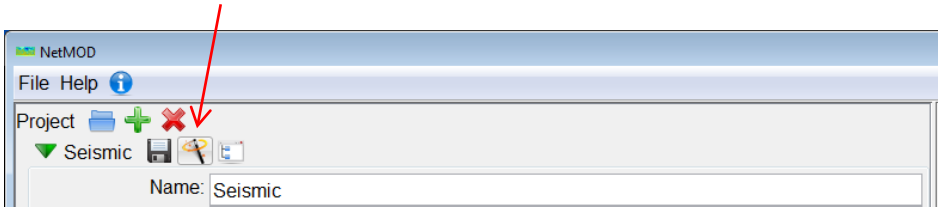
The **Simulation Type** can be changed by selecting "Probability" from the pull-down selection:



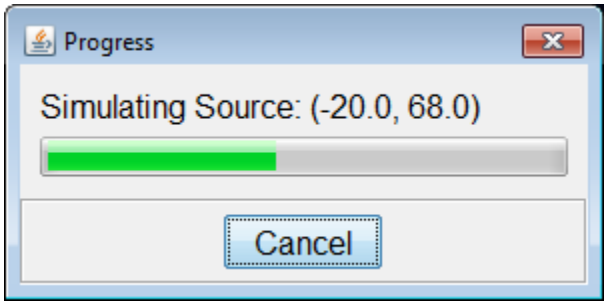
The details of the **Simulation Type** will update to reflect the chosen selection. Enter the desired **Magnitude** and **Unit** that are to be simulated in the provided controls:



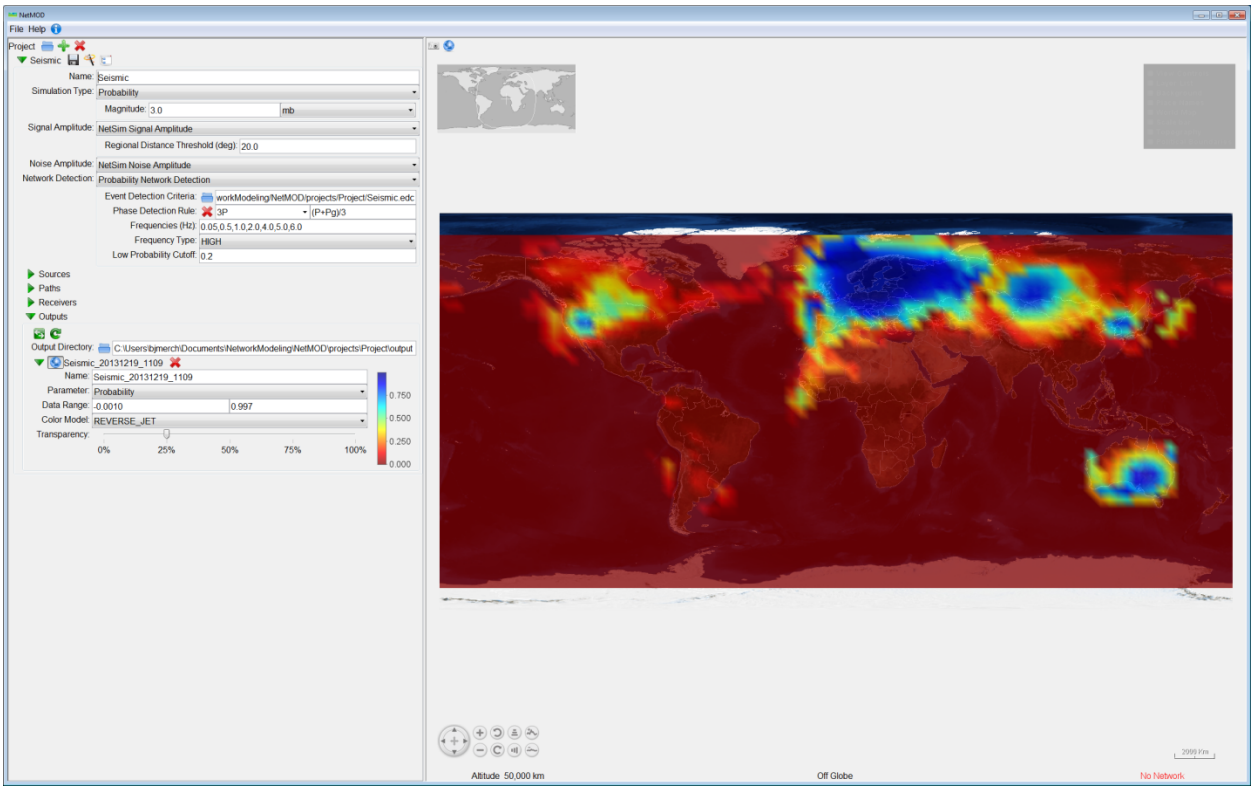
Run the simulation by clicking on the **Run Simulation** button at the top of the controls:



The simulation will execute with a progress dialog. Clicking **Cancel** will abort the simulation and discard any results that have been obtained thus far.



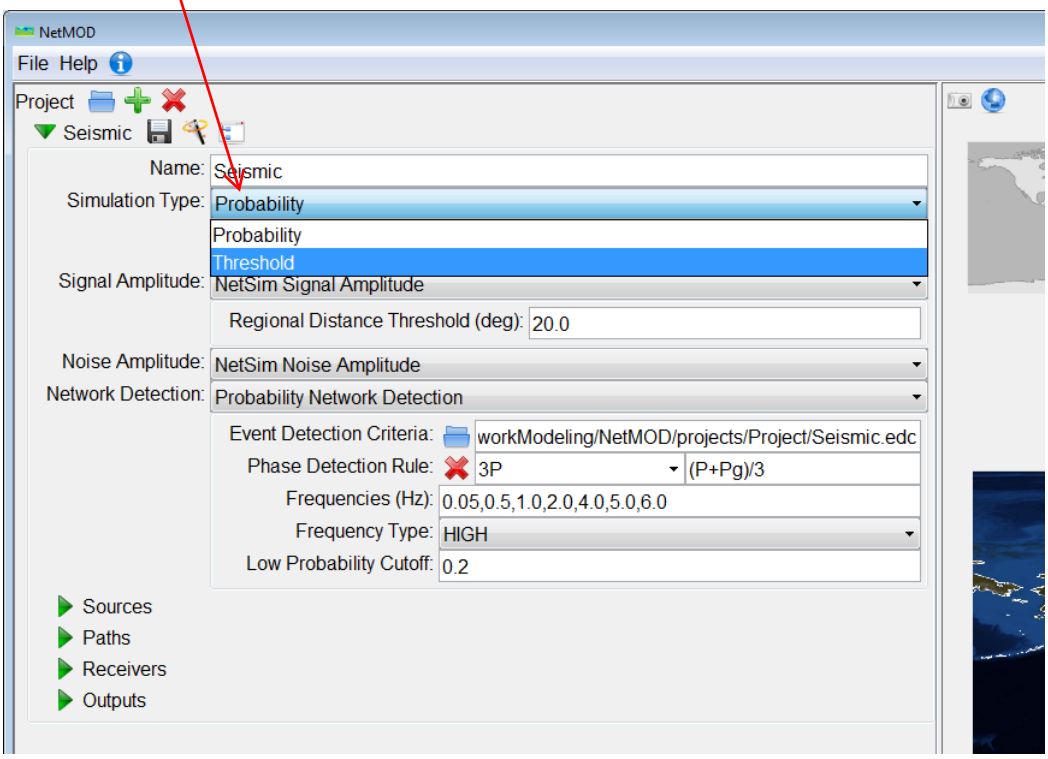
Once the simulation has successfully completed, the results of the simulation will be saved to a set of output files and automatically displayed on the map:



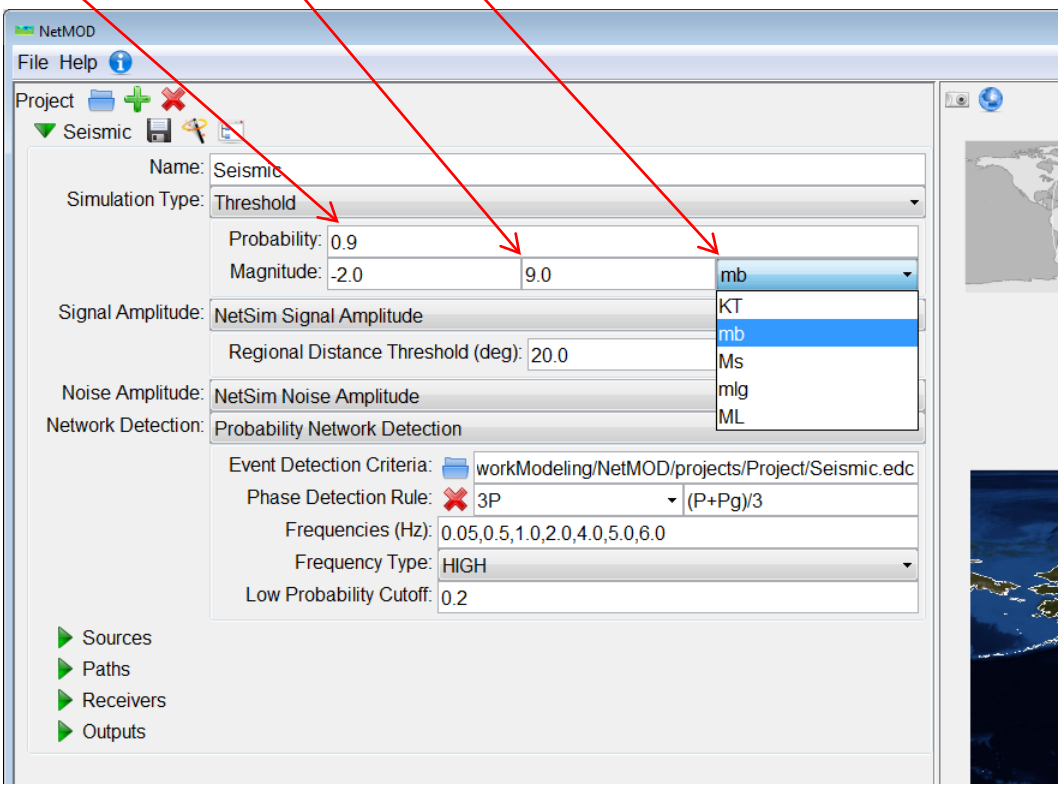
14.3 Run a threshold simulation

A threshold simulation is one in which the magnitude of an event with a specific probability is computed at each of the source locations. The result is a map of magnitudes across some geographic region. The user may specify the magnitude of the event and the source locations that define the region.

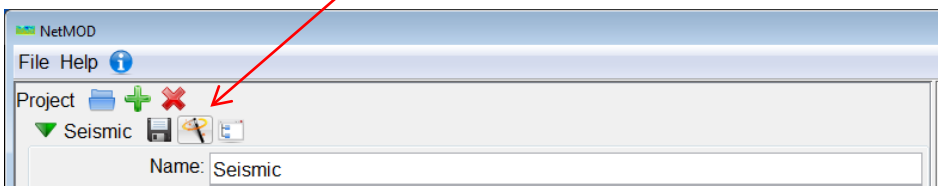
The **Simulation Type** can be changed by selecting "Threshold" from the pull-down selection:



The details of the **Simulation Type** will update to reflect the chosen selection. Enter the desired **Probability**, **Magnitude Ranges** and **Unit** that are to be simulated in the provided controls:

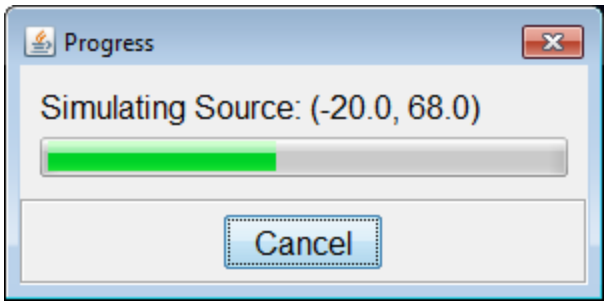


Run the simulation by clicking on the **Run Simulation** button at the top of the controls:

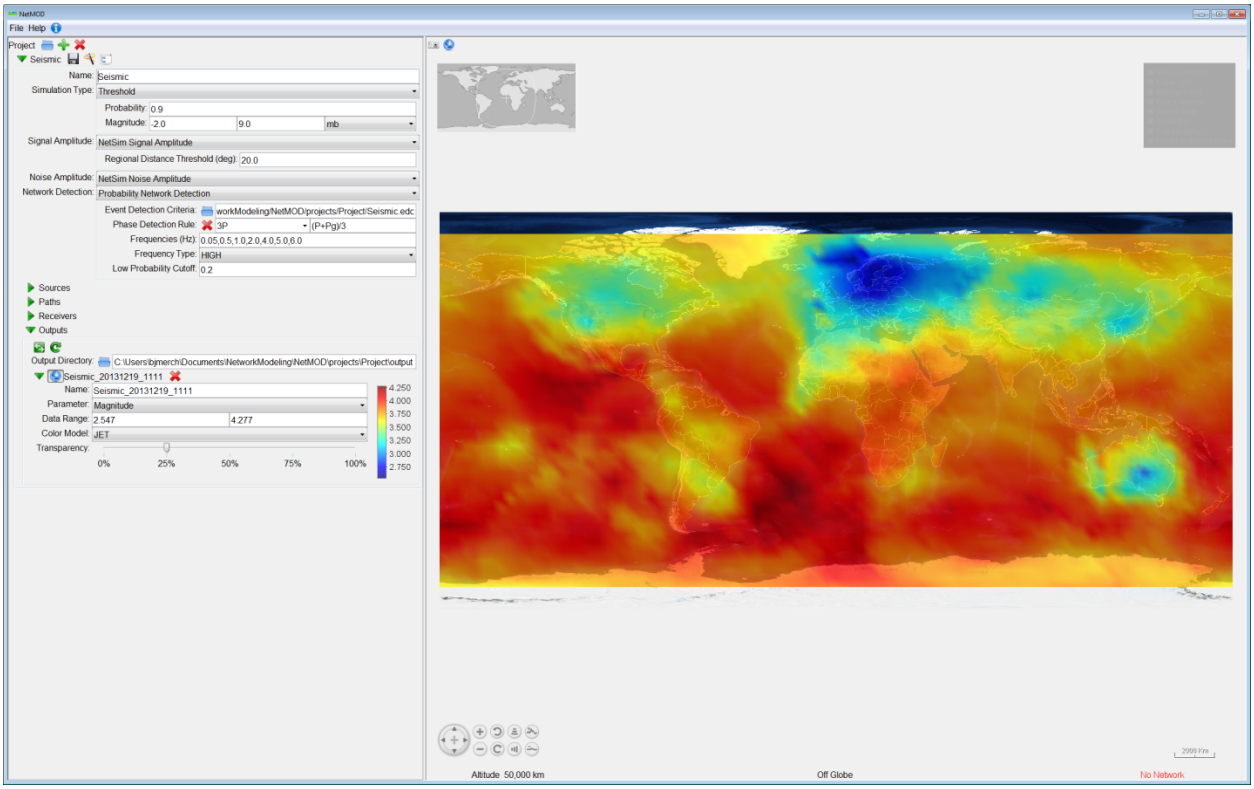


The simulation will execute with a progress dialog. Clicking **Cancel** will abort the simulation and discard any results that have been obtained thus far.

Note that a threshold simulation takes longer to compute than a probability simulation because rather than simulating the probability of a single magnitude, a range of magnitudes are simulated in order to narrow in on the magnitude that results in the desired probability.

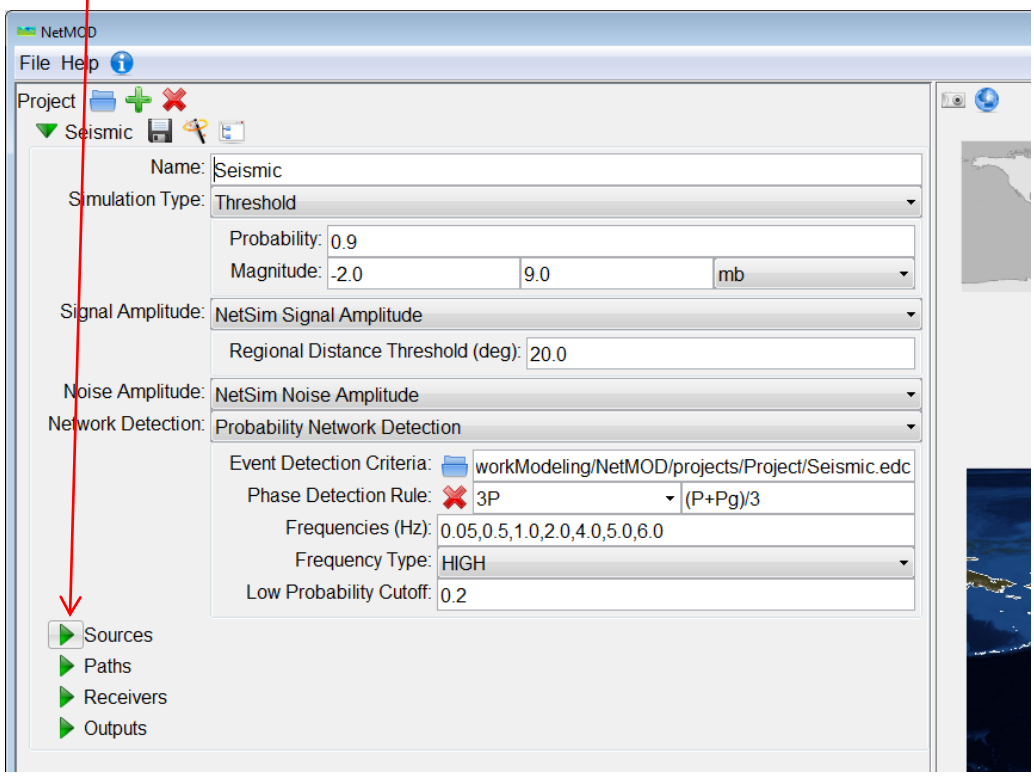


Once the simulation has successfully completed, the results of the simulation will be saved to a set of output files and automatically displayed on the map:

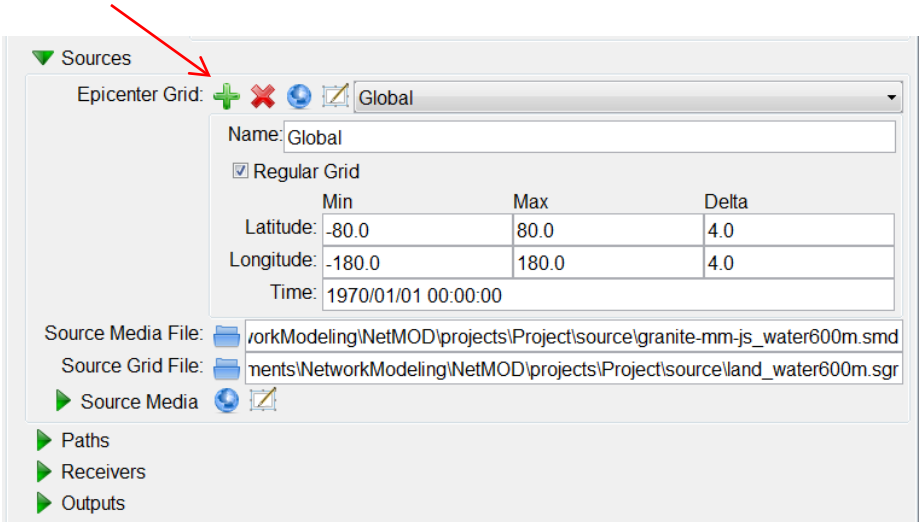


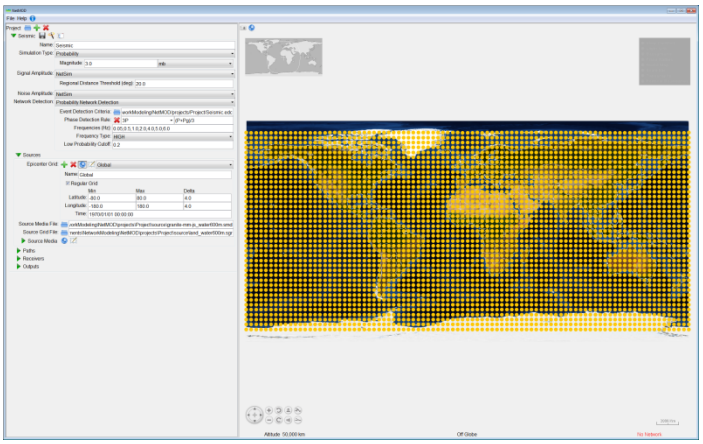
14.4 Change the simulation region

The provided NetMOD project file defaults to a geographic region that spans the entire globe with four degree source location spacing. If the user wishes, the project file may be expanded upon to simulate more specific regions of the earth or to modify the spatial resolution. To begin, expand the **Sources** viewer:



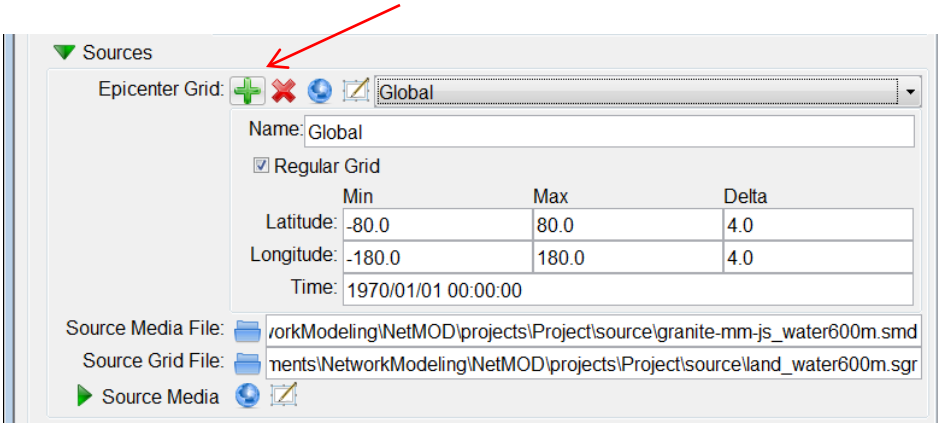
Select the desired geographic region to simulate from the **Epicenter Grid**. The source locations that make up the **Epicenter Grid** may be displayed on the map by click on the **Map Display** toggle button.



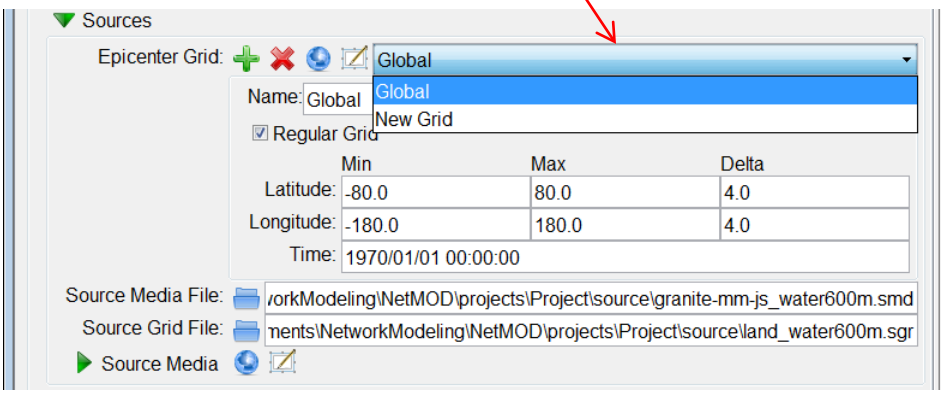


The **Epicenter Grid** may be specified using any combination of the methods below:

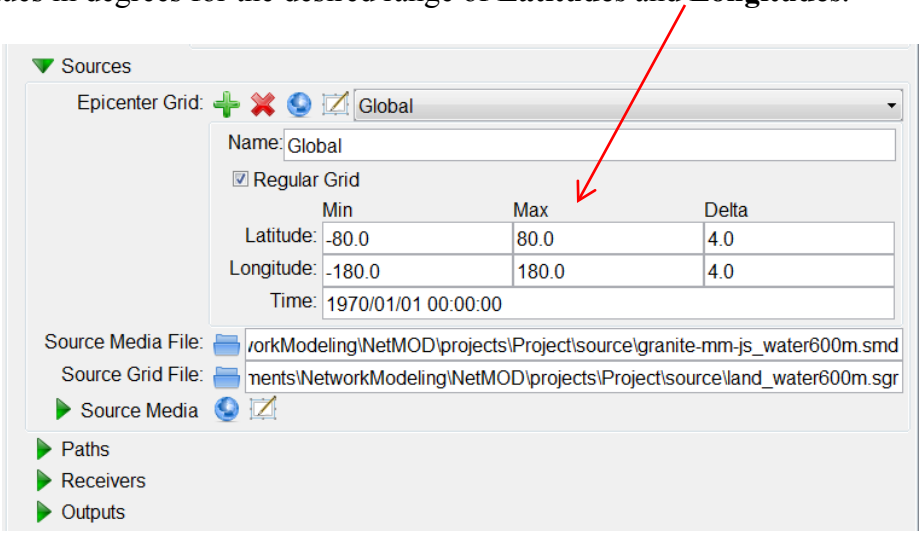
1. Create a new grid by clicking on the **Create New** button:



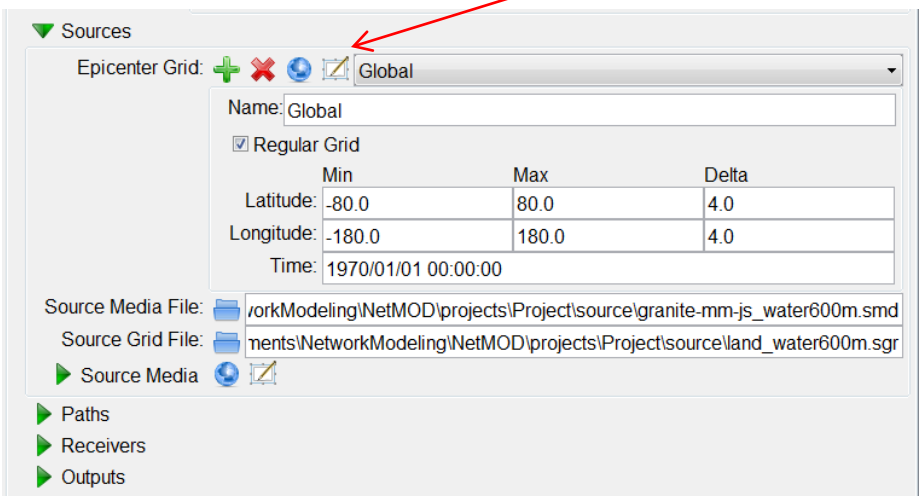
2. Select a pre-defined region from the pull-down selection:



3. Enter values in degrees for the desired range of **Latitudes** and **Longitudes**.



4. Select a region on the on the map using the mouse. Click on the **Map Select** button to enable map selection.

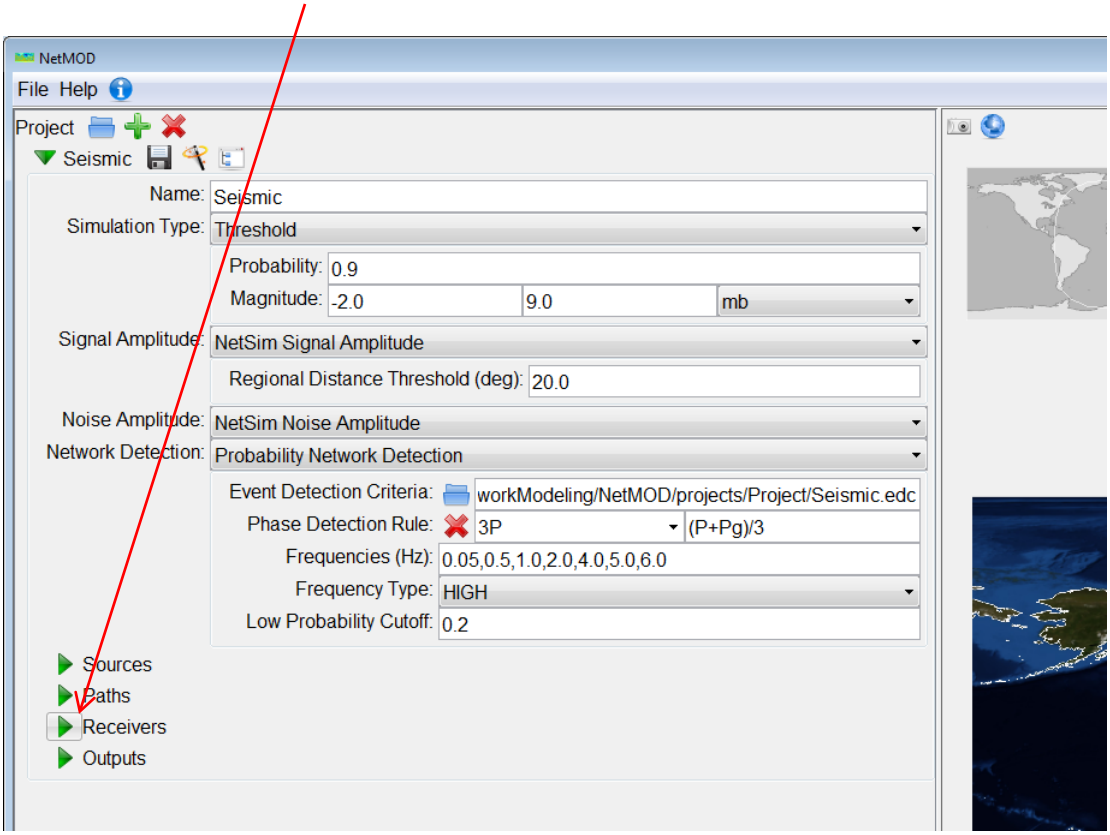


Drag a rectangle on the map. The Latitude and Longitude ranges will update to reflect the selected region. Update the **Delta** field to reflect the desired source location spacing in degrees.

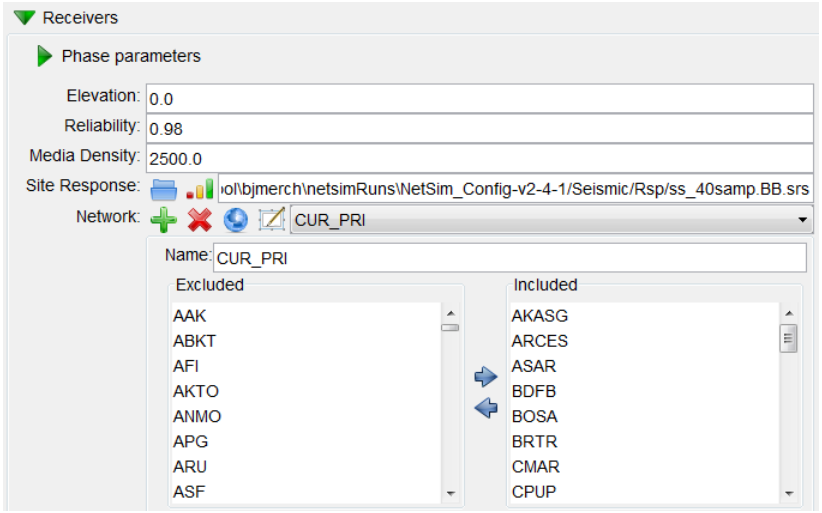
14.5 Add or remove stations from a network simulation

NetMOD performs simulations of the performance of an entire network. The results of any simulation that is performed depend heavily upon the set of stations that are contained within the network. NetMOD has the ability to define any number of "networks" and each station may belong to multiple networks.

The network definitions in NetMOD are contained within the **Receivers** section. Click on the green arrow to expand the **Receivers** viewer:

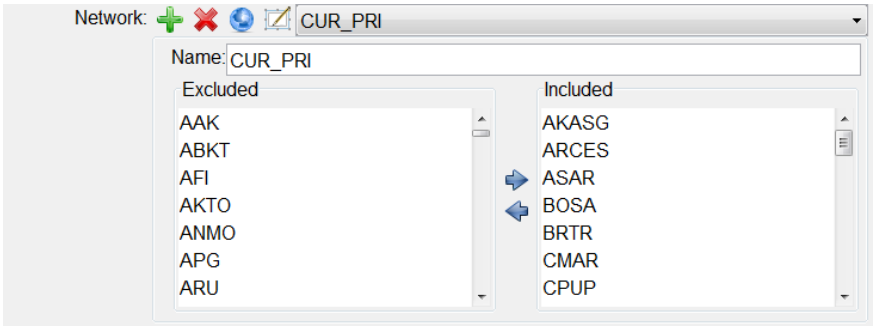


Additional details related to receiver parameters, including the network definitions, are now visible within the expanded viewer. All of the stations that have been defined for a given project file are listed within either the **Excluded** or **Included** lists in the user interface:

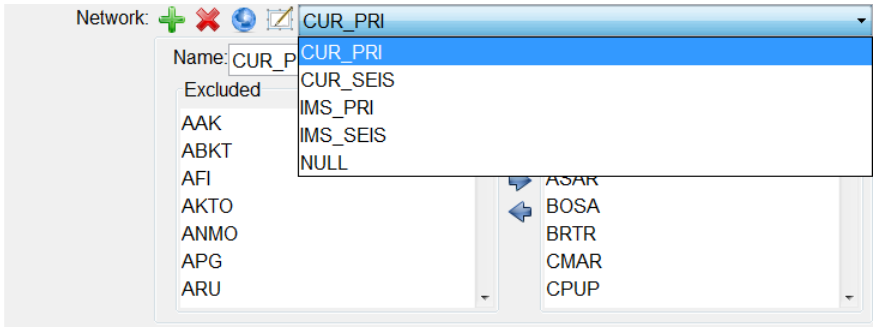


The **Network** definitions may be specified using any combination of the methods below:

1. Add or remove networks. Click on the **Add** or **Remove** button to either add a new network or remove the current network.

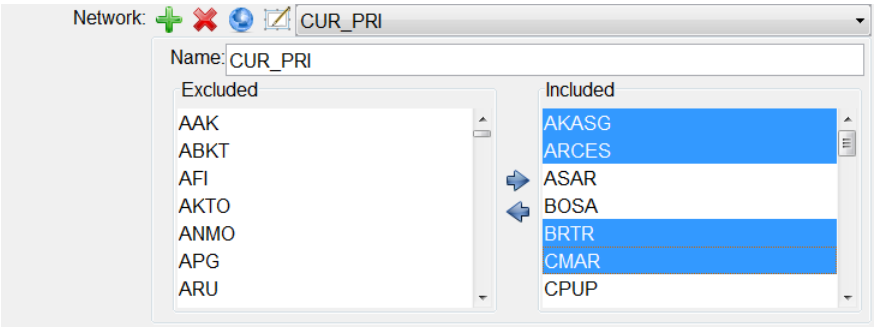


2. Select a network from the pull-down selection. The lists of **Excluded** and **Included** stations will update to reflect the network selection.

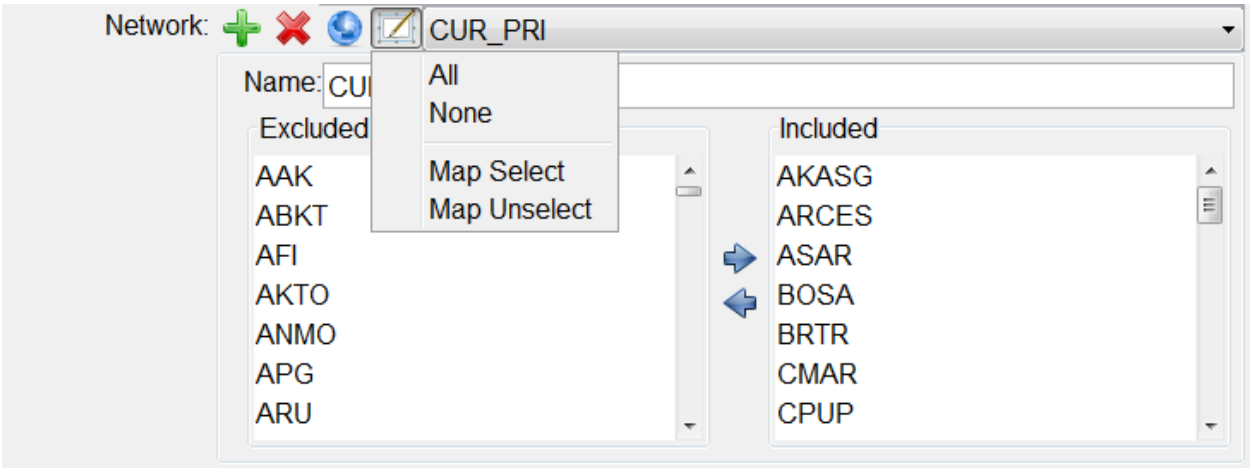


3. Manually move stations between **Excluded** and **Included** lists. Stations shown in either of the lists may be selected by clicking on their name. Clicking the **Right-arrow** button will

move selected stations from the **Excluded** list to the **Included** list. Clicking on the **Left-arrow** button will move selected stations from the **Included** list to the **Excluded** list.



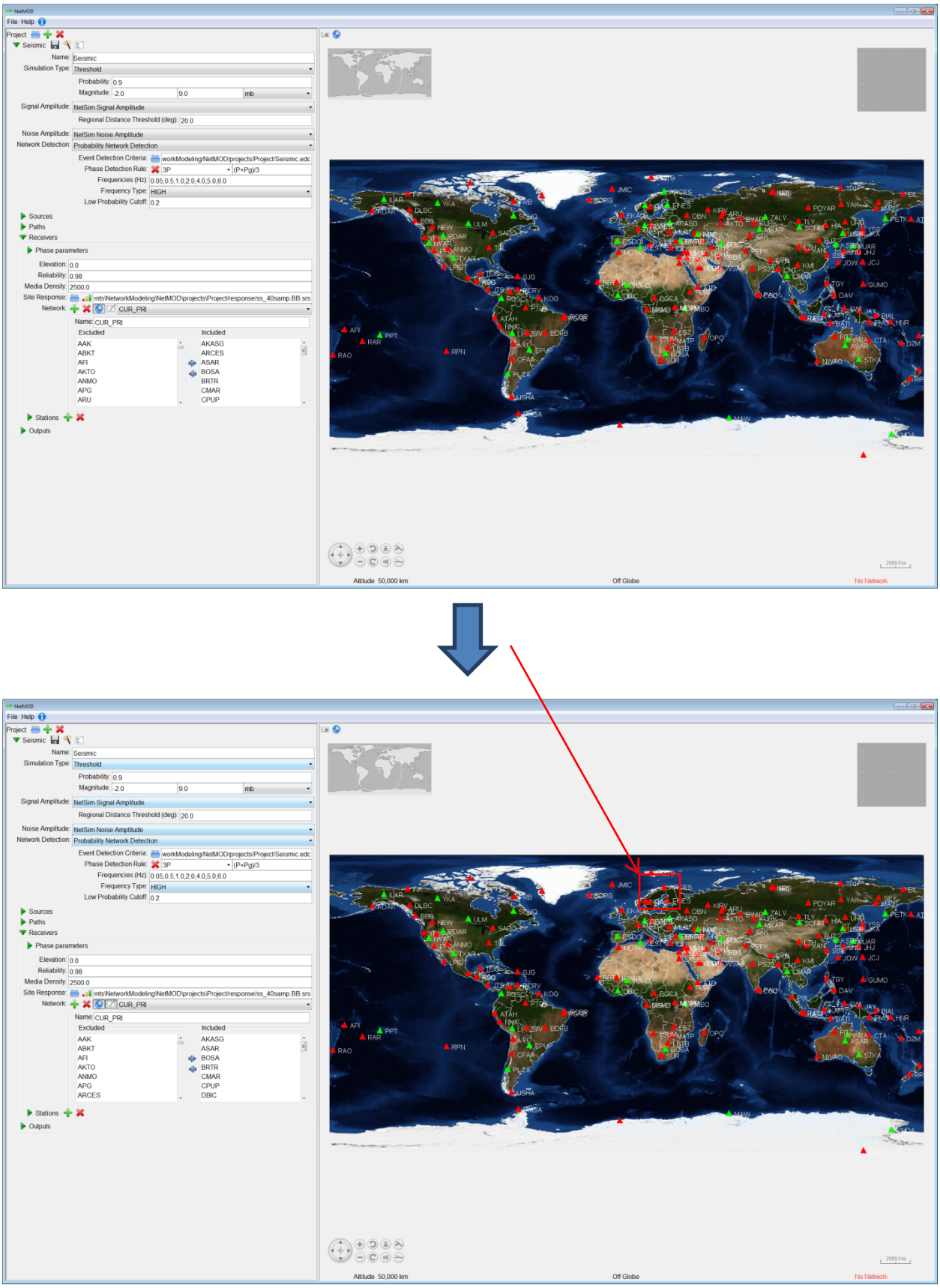
4. Select stations using the **Map**. First, click on the **Map Display** toggle button to display the stations with their selection status visible on the map. Next, click on the **Map Select** button to enable map selection. A popup menu will appear.



The popup menu options are

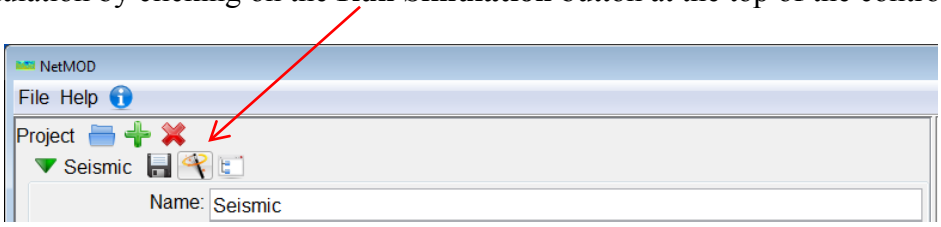
- **All** – All stations will be transferred to the **Included** list
- **None** - All stations will be transferred to the **Excluded** list
- **Map Select** – Users may drag a rectangle on the map to identify stations to add to the **Included** list.
- **Map Unselect** – Users may drag a rectangle on the map to identify stations to add to the **Excluded** list.

For the purpose of this tutorial, use one of the methods described above to exclude stations ARCES, FINES, and NOA from network CUR_PRI.

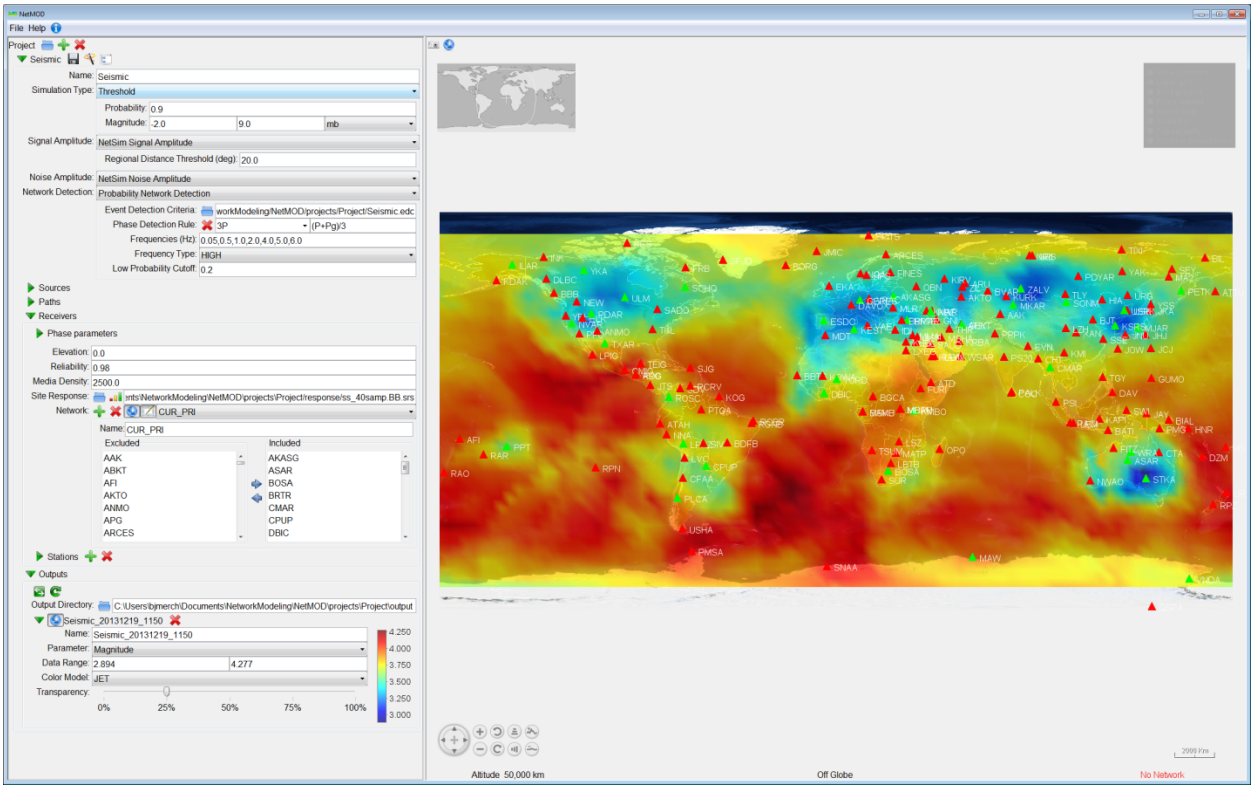

NetMOD
File Help
Project
Seismic
Name: Seismic
Simulation Type: Threshold
Probability: 0.9
Magnitude: -2.0 9.0 mb
Signal Amplitude: NetSim Signal Amplitude
Regional Distance Threshold (deg): 20.0
Noise Amplitude: NetSim Noise Amplitude
Network Detection: Probability Network Detection
Event Detection Criteria: workModeling/NetMOD/projects/Project/Seismic.edc
Phase Detection Rule: 3P (P+Pg)/3
Frequencies (Hz): 0.05,0.5,1.0,2.0,4.0,5.0,6.0
Frequency Type: HIGH
Low Probability Cutoff: 0.2
Sources
Paths
Receivers
Phase parameters
Elevation: 0.0
Reliability: 0.98
Media Density: 2500.0
Site Response: nts\NetworkModeling\NetMOD\projects\Project\response\ss_40samp.BB.srs
Network: CUR_PRI
Name: CUR_PRI
Excluded
AAK
ABKT
AFI
AKTO
ANMO
APG
ARU
Included
AKASG
ARCES
ASAR
BOSA
BRTR
CMAR
CPUP
Stations
Outputs
Altitude 50,000 km
Off Globe
No Network

NetMOD
File Help
Project
Seismic
Name: Seismic
Simulation Type: Threshold
Probability: 0.9
Magnitude: -2.0 9.0 mb
Signal Amplitude: NetSim Signal Amplitude
Regional Distance Threshold (deg): 20.0
Noise Amplitude: NetSim Noise Amplitude
Network Detection: Probability Network Detection
Event Detection Criteria: workModeling/NetMOD/projects/Project/Seismic.edc
Phase Detection Rule: 3P (P+Pg)/3
Frequencies (Hz): 0.05,0.5,1.0,2.0,4.0,5.0,6.0
Frequency Type: HIGH
Low Probability Cutoff: 0.2
Sources
Paths
Receivers
Phase parameters
Elevation: 0.0
Reliability: 0.98
Media Density: 2500.0
Site Response: nts\NetworkModeling\NetMOD\projects\Project\response\ss_40samp.BB.srs
Network: CUR_PRI
Name: CUR_PRI
Excluded
AAK
ABKT
AFI
AKTO
ANMO
APG
ARCES
Included
AKASG
ASAR
BOSA
BRTR
CMAR
CPUP
DBIC
Stations
Outputs
Altitude 50,000 km
Off Globe
No Network

Run the simulation by clicking on the **Run Simulation** button at the top of the controls:

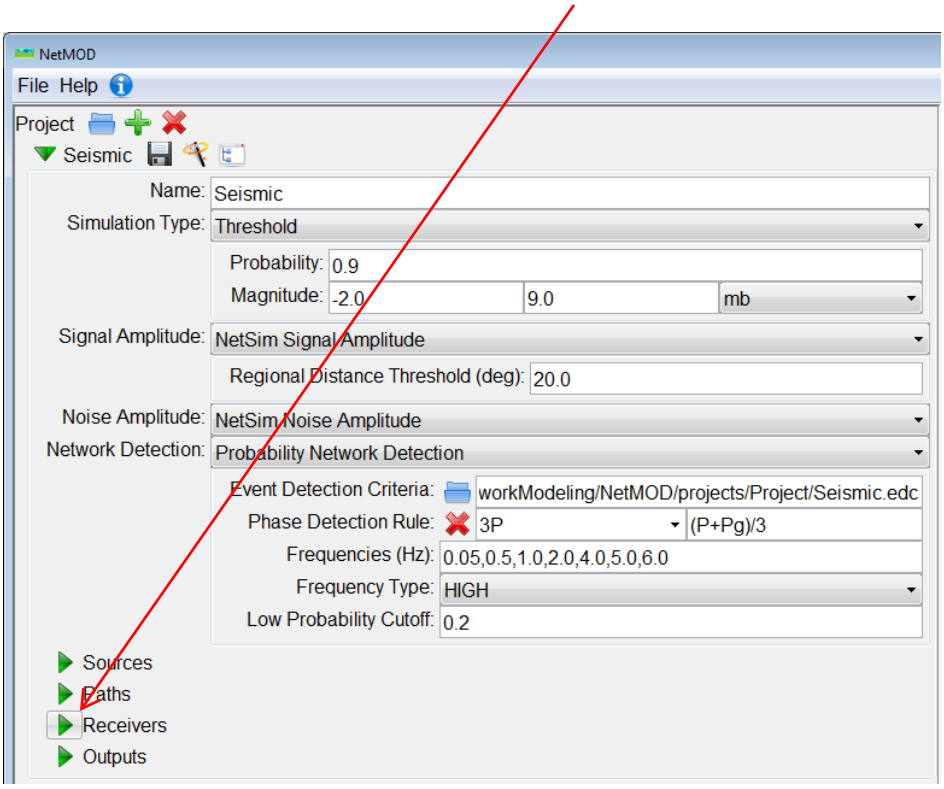


Once the simulation has successfully completed, the results of the simulation will be saved to a set of output files and automatically displayed on the map:

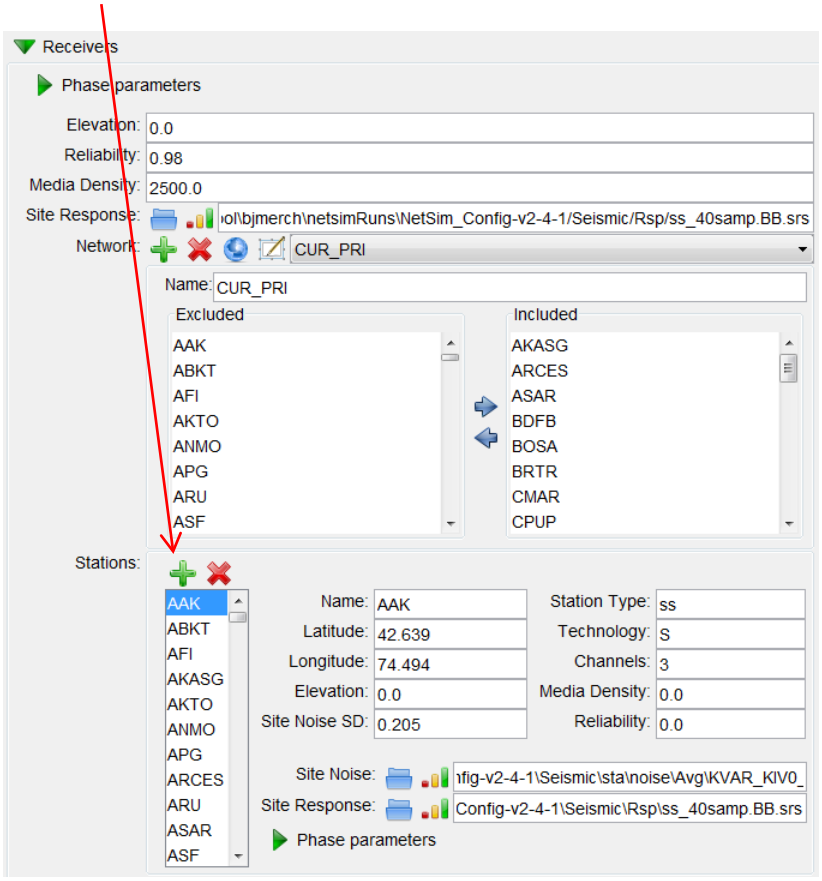


14.6 Add a new station

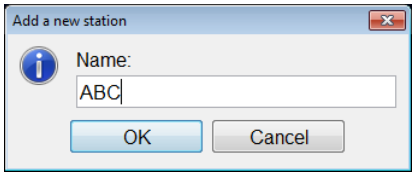
In addition to adding or removing existing stations from a given network to simulate, as was performed in the previous tutorial, a user may also wish to create a new station. The user may wish to do this if they would like to evaluate the possible improvement to the network performance if a new station were to be installed.The network definitions in NetMOD are contained within the **Receivers** section. Click on the green arrow to expand the **Receivers** viewer:



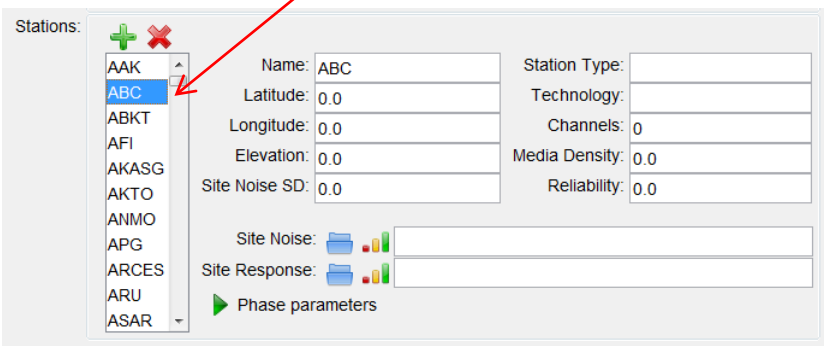
Next, click on the **Add Station** button to create a new station.



The user will be present with a dialog to enter the name of the desired station. For this example, the station is named "ABC".



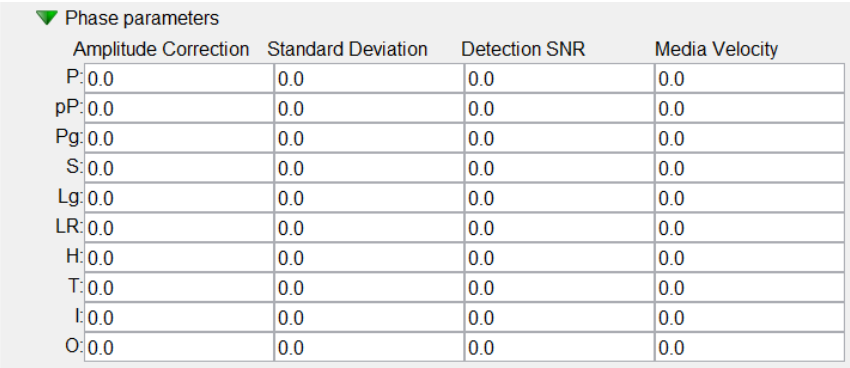
Next, the user will need to select station ABC within the stations:



It is now necessary to populate the metadata for that station. Enter the desired values for the Latitude (degrees), Longitude (degrees), Elevation (meters), Site Noise SD (log10 Spectral Amplitude , Station Type ("S": Seismic), Technology ("S": Seismic), Channels (integer count), Media Density (m/s, values <=0 will use the default), and reliability (values <= 0 will use the default).

It is also necessary to populate the site noise and site response file references. The user must either generate new noise and response files or select appropriate files from the existing files bundled with the project. See the NetMOD Parameters document for a description of the appropriate file formats.

The phase specific values for this station may also be populated by expanding the **Phase parameters** viewer for this station:



Once the station data has been fully entered, the station is now available for inclusion in any of the networks within the NetMOD project file. See section *14.5 Add or remove stations from a network simulation* for a description of how to include this new station in a simulation.

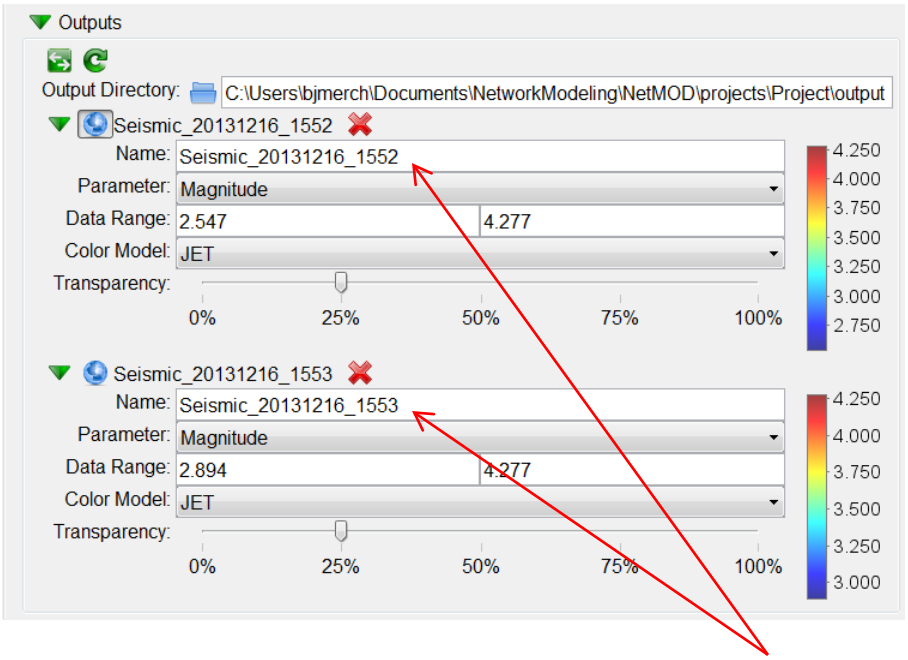
14.7 Compare results from two different simulation runs

Changes to the input parameters to a simulation have a definite impact on the results of the simulation. Gauging the scope of the change in the output is an important part of interpreting the results.

For the purpose of this tutorial, it is necessary to have the outputs from two different simulations. Before proceeding any further, generate output files as described in the following tutorial sections:

- *14.3 Run a threshold simulation*
- *14.5 Add or remove stations from a network simulation*

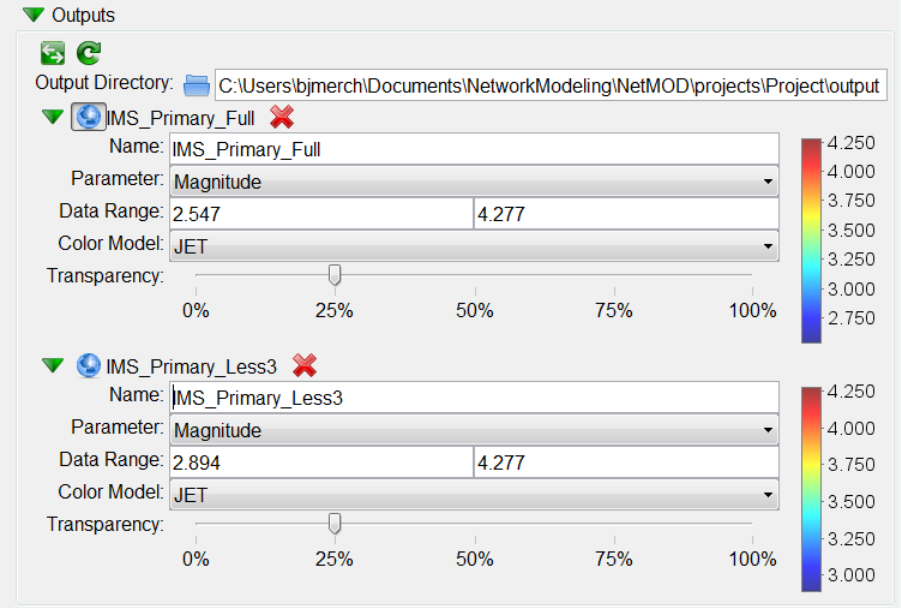
The two outputs should appear as shown below:



For the clarity, rename each of the outputs by typing a new name in the name fields for each output:

- *Seismic_20131216_1552 => IMS_Primary_Full*
- *Seismic_20131216_1553 => IMS_Primary_Less3*

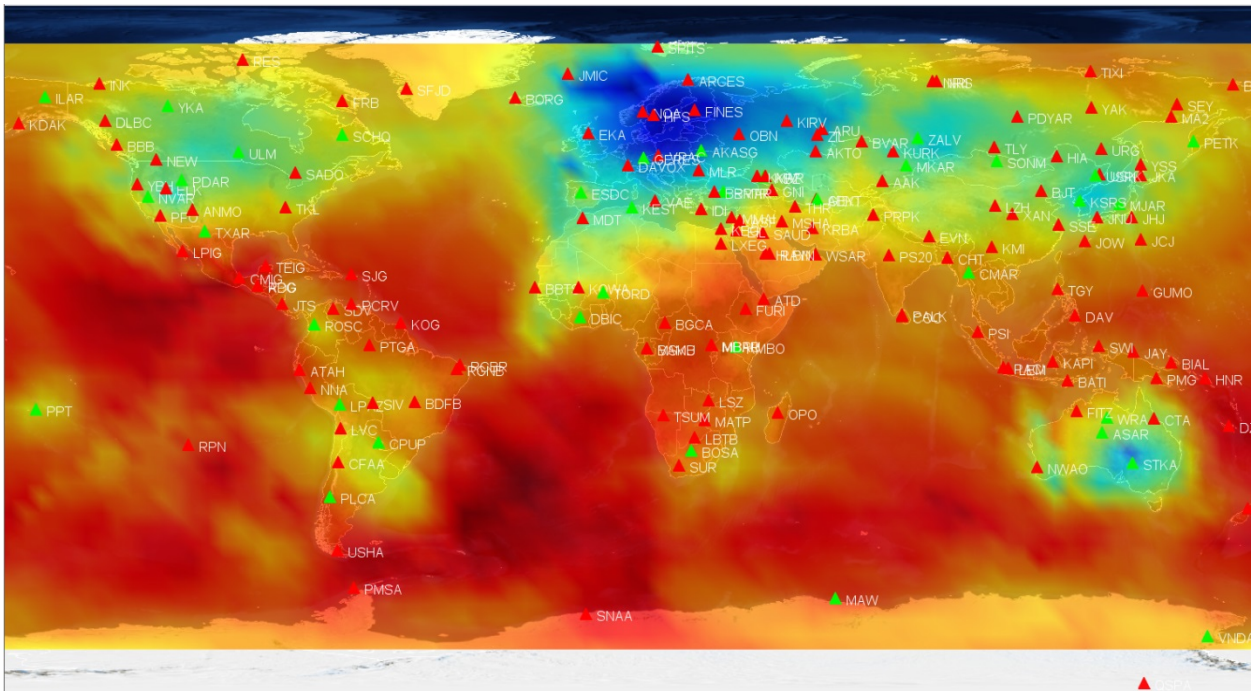
The outputs should now appear as shown below:



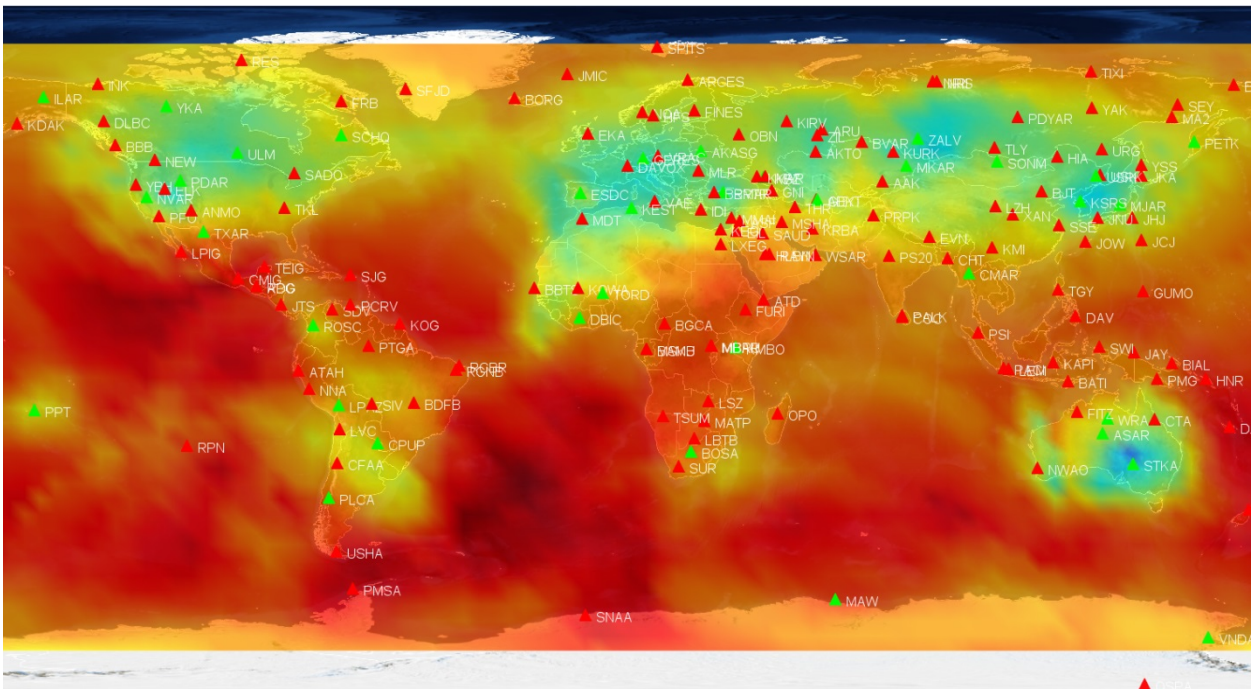
Each of the outputs has a data range that controls how the data values are mapped to the selected color model. The default data range for each of the outputs corresponds to the minimum and maximum values present in that output set.

If a user wishes to toggle the map display between two outputs, it is important to set the two data ranges to a common scale. Set the minimum data ranges to 2.5 and leave the maximum data ranges set to the common value of 4.277. The user can now toggle between displaying each of the outputs on the map by clicking on **Map Display** button on each of the respective outputs. The two outputs should be visible as shown below on a common color scale.

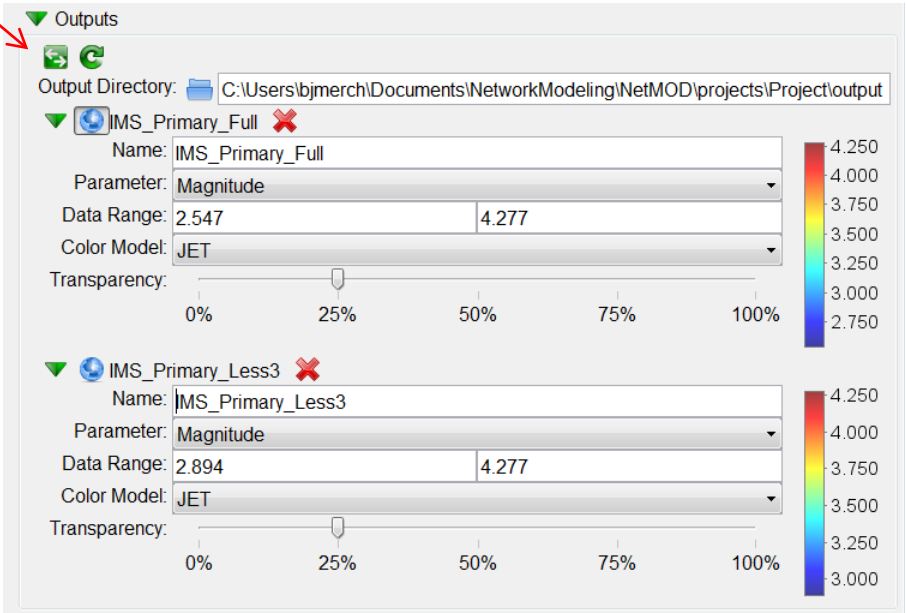
IMS_Primary_Full:



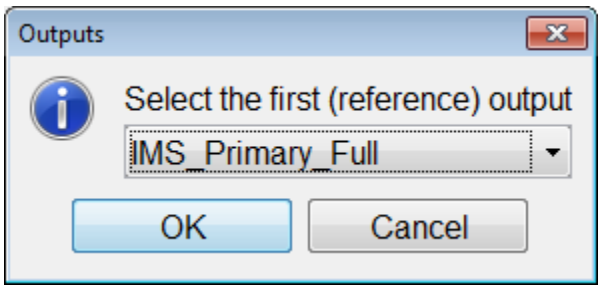
IMS_Primary_Less3:



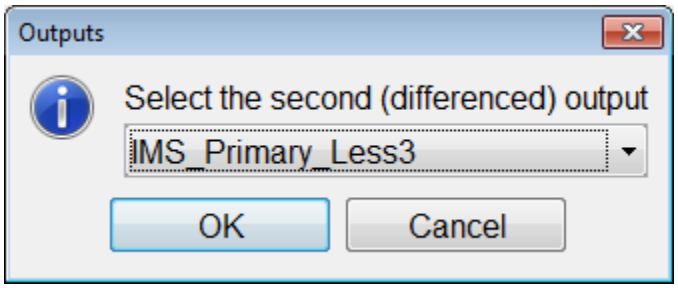
Alternatively, NetMOD can compute the difference between two outputs by clicking on the **Difference** button



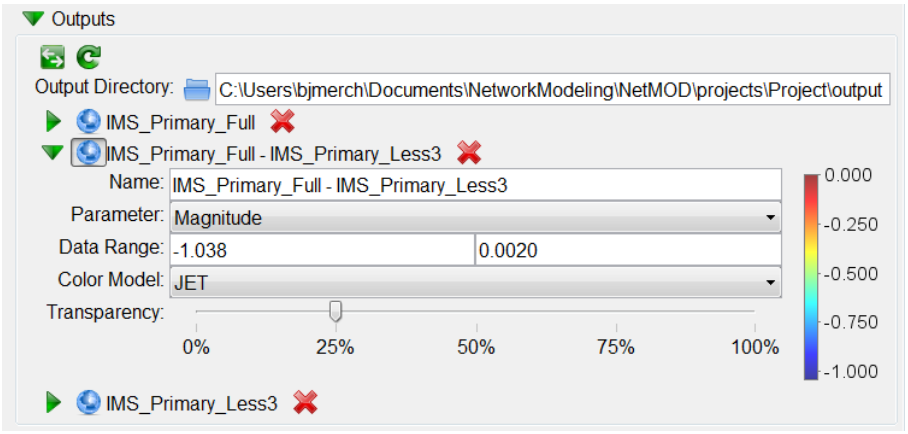
The user will then be prompted with two selection dialogs to select the first (reference):

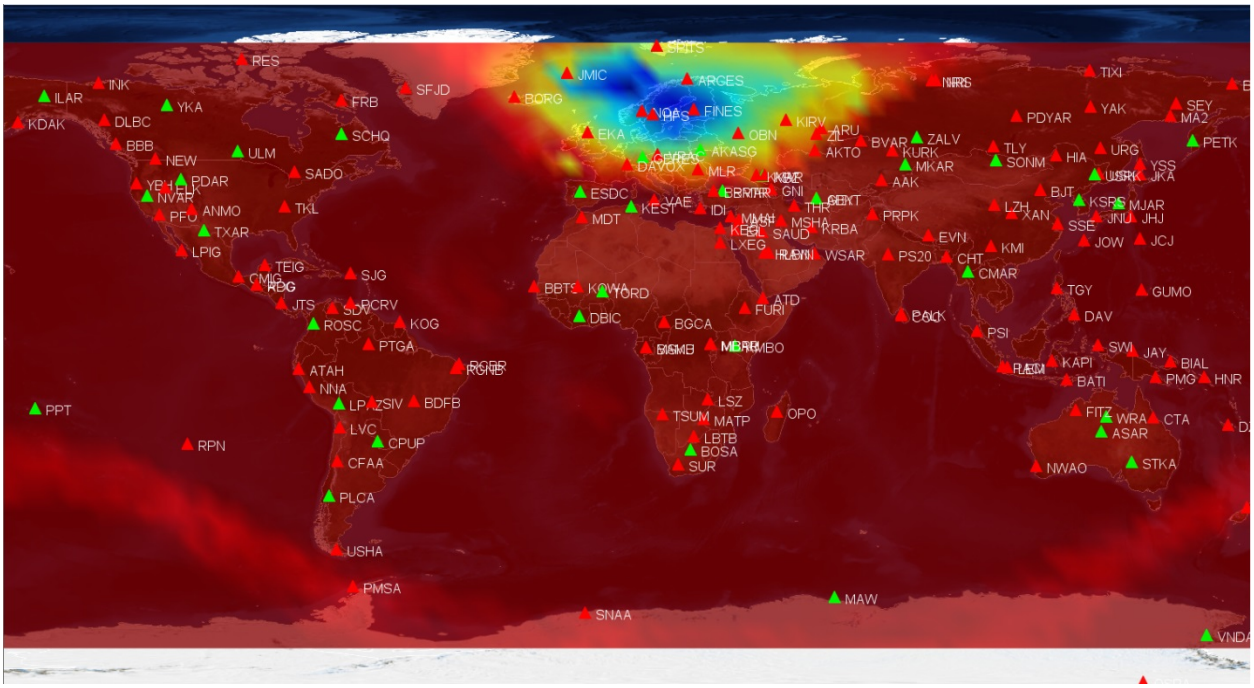


and second (difference) outputs to use:



The result of the differencing is then saved as an output file as shown below:





It can now be easily seen the impact of removing the three stations from the simulated network. As expected, the contribution of those stations is greatest in the immediate vicinity of the stations that were removed and returns to baseline beyond approximately 20 degrees.

14.8 Running NetMOD from the command line

NetMOD provides a graphical user interface (GUI) to allow users to easily configure and validate simulations. However, once a user has setup a project file, they may wish to execute multiple variations of the project file in a batch mode from the command line.

NetMOD supports the use of command line parameters to support the automatic execution of the simulation files without any GUI. See section *3.2 Command Line Options* for a more in-depth explanation of the available command line parameters. This tutorial provides some simple examples of how a command line execution of NetMOD might appear.

A simple case of executing a simulation exactly as defined within the project file:

java –jar NetMOD.jar GUI=false PAR=c:\NetworkModeling\project\Seismic.par

A case in which the name of the output files is overwritten:

java –jar NetMOD.jar GUI=false PAR=c:\NetworkModeling\project\Seismic.par
title=Seismic_run_ABC

A case in which the geographic region is over-ridden for a different area:

java –jar NetMOD.jar GUI=false PAR=c:\NetworkModeling\project\Seismic.par
Epi-Model=Region1

A case in which a different set of frequencies are simulated than are specified in the project file:

java –jar NetMOD.jar GUI=false PAR=c:\NetworkModeling\project\Seismic.par
Freq-Sampling=0.5,1.0,2.0,5.0

A case in which the network is over-ridden:

java –jar NetMOD.jar GUI=false PAR=c:\NetworkModeling\project\Seismic.par
net=Network_ABC

A case in which in which a custom list of station is used for the network:

java –jar NetMOD.jar GUI=false PAR=c:\NetworkModeling\project\Seismic.par
list-of-network-stations=ASAR,ARCES,ILAR,MKAR,TXAR

In all of these cases, any number of the NetSIM parameters may be used to override the parameters contained within the specified project file.

REFERENCES

Heck, S.L., B.R. Hamlet, E.P. Chael, C.J. Young, W.R. Walter, and D.N. Anderson (2012). A New Network Modeling Tool for the Ground-Based Nuclear Explosion Monitoring Community, in Proceedings of the 2012 Monitoring Research Review: Ground-Based Nuclear Explosion Monitoring Technologies, LA-UR-12-24325, Vol. I, pp. 247-253. http://www.osti.gov/bridge/servlets/purl/1050499/

Merchant, B.J., C.J. Young, E.P. Chael *NetMOD Version 2.0 Mathematical Framework*, SAND2015-6649, Sandia National Laboratories, Albuquerque, NM, August 2015

Merchant, B.J., *NetMOD Version 2.0 Parameters*, SAND2015-XYZ, Sandia National Laboratories, Albuquerque, NM, August 2015

Sereno, T.J., S.R. Bratt, and G. Yee (1990). NetSim: a computer program for simulating detection and location capability of regional seismic networks, SAIC Annual Technical Report SAIC90/1163.

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