A New Network Modeling Tool for the Comprehensive Test Ban Treaty Organization

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Introduction

Network simulations have long been used to assess the performance of monitoring networks to detect events for such purposes as planning station deployments and network resilience to outages. The standard tool has been the NetSim package, developed in the ealry 1990s. With correct parameters, NetSim can produce high-quality simulations; however, the package has several shortcomings: an older language (FORTRAN), an emphasis on seismic monitoring with limited support for other technologies, limited documentation, and a limited parameter set. Thus, we are developing NetMOD (Network Monitoring for Optimal Detection), a Java-based tool designed to assess the performance of ground-based networks. NetMOD's advantages include: coded in a modern language that is multi-platform, utilizes modern computing performance (e.g. multi-core processors), incorporates monitoring technologies other than seismic, and includes a well-validated default parameter set for the IMS stations.

Design and Implementation

NetMOD is highly configurable by utilizing a plugin-based architecture. Plugins are independent components that provide a set of functionality. In the context of NetMOD, plugins will represent different monitoring tasks such as the type of simulation being formed, the method of estimating signal and noise amplitudes, and the data formats for obtaining the geophysical properties.
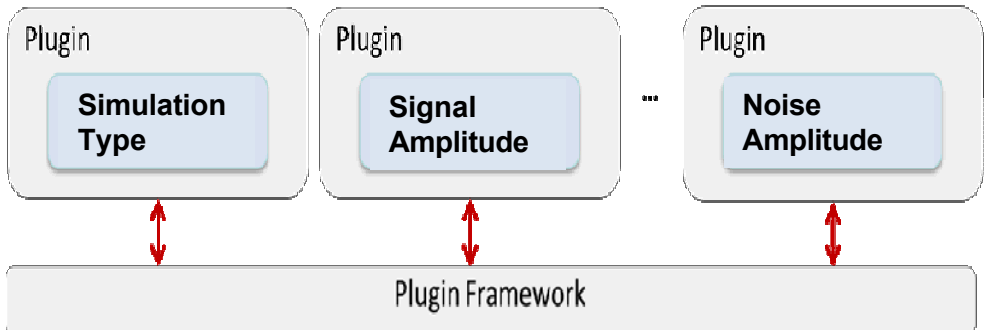
NetMOD is designed to be highly configurable by utilizing a plugin-based architecture. This software design pattern provides flexibility by allowing the addition or removal of new software features via plugins without affecting other functionality.

Configuration File Format

NetMOD uses the libpar file format developed by Robert Clayton of Caltech and widely used by the seismological research community. This format can accommodate comments, as well as the inclusion of the names of the parameters that are being set, making the files much easier to understand and modify. The control parameter, geophysical model, and output file formats used by NetMOD are consistent with the CTBTO libpar simulation configuration files.

```
par=$(NS_CONFIG)/BaselineDesc.par
# Model Declarations
conf=0.95                          # Default: 0.90
# Three mode parameters
Run-Type=detection                 # Default: detection
Sub-Type=threshold                 # Default: threshold
# Output-Dir=
Verbose-Level=0
Apply-Time-Dependent-Features=0
#!BeginTable EventSizeDesc
units
        type   | size  | Min-Simul | Max-Simul | Min-GUI | Max-GUI |
@mb    mb      4.0      0.5         9.0         -1.0      9.0       MU
@Ms    Ms      3.0      -2.0        6.0         -4.0      7.0
MU#!EndTable
Low-Prob-Cutoff=0.3                # Default: 0.2
```

User Interface

The NetMOD User Interface is designed to give users the ability to easily set up simulations, navigate results and answer many "what-if" questions with minimal effort. Notable features include:
- The ability to create and modify the simulation configuration.
- An integrated map for displaying configuration and results.
- A comparison tool for quickly assessing the differences between two simulations
- An introspection ability to examine the specific details at all levels of the simulation calculations.
- A command-line mode to support the batch execution of simulations from saved configuration files.
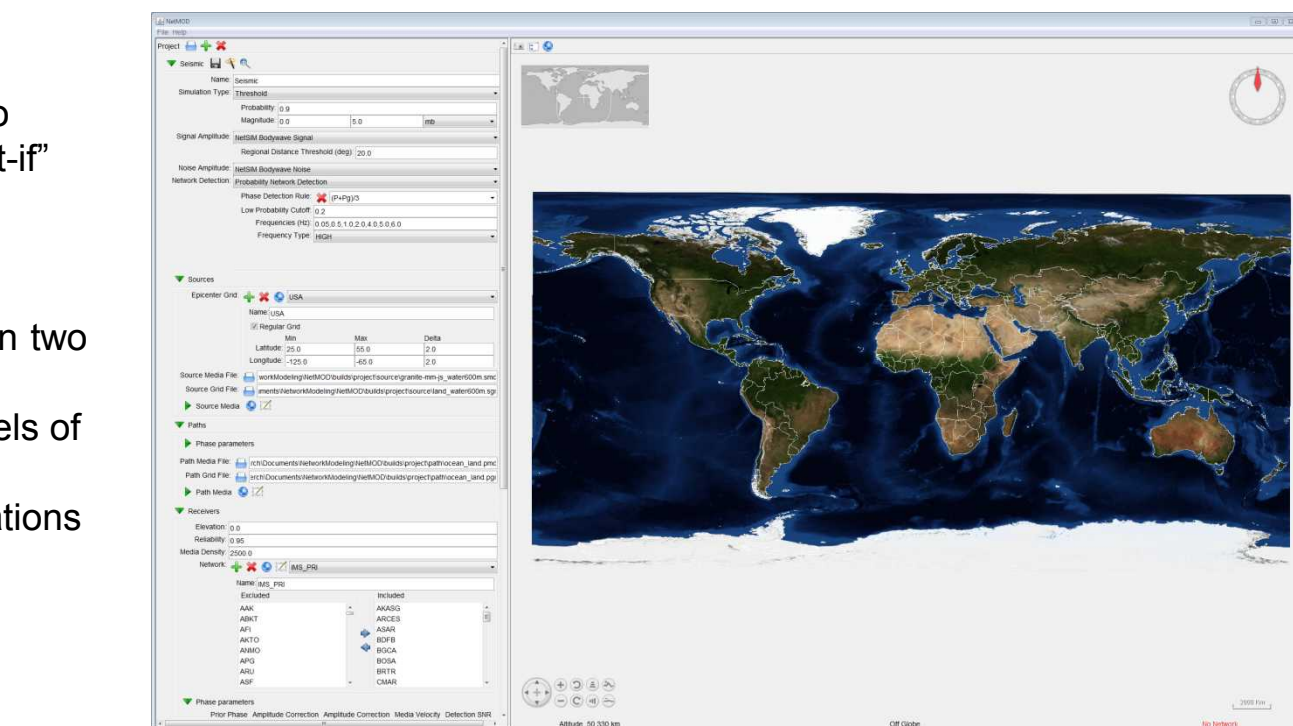

Project Overview

The project configuration panel shows the parameters controlling the overall simulation. The user may interactively visualize, configure, or execute the simulation directly from this panel.


Stations

The Stations configuration shows the relevant simulation parameters for each station in the network: ambient noise, secondary phase noise levels, station array gain and amplification corrections, etc.


Source and Path Models

The geophysical models for the source and path effects are represented within NetMOD. The source and path regions may be displayed and assigned on the map.

reference	
stable_deepwater	
stable_land	
tectonic_deepwater	
tectonic_land	
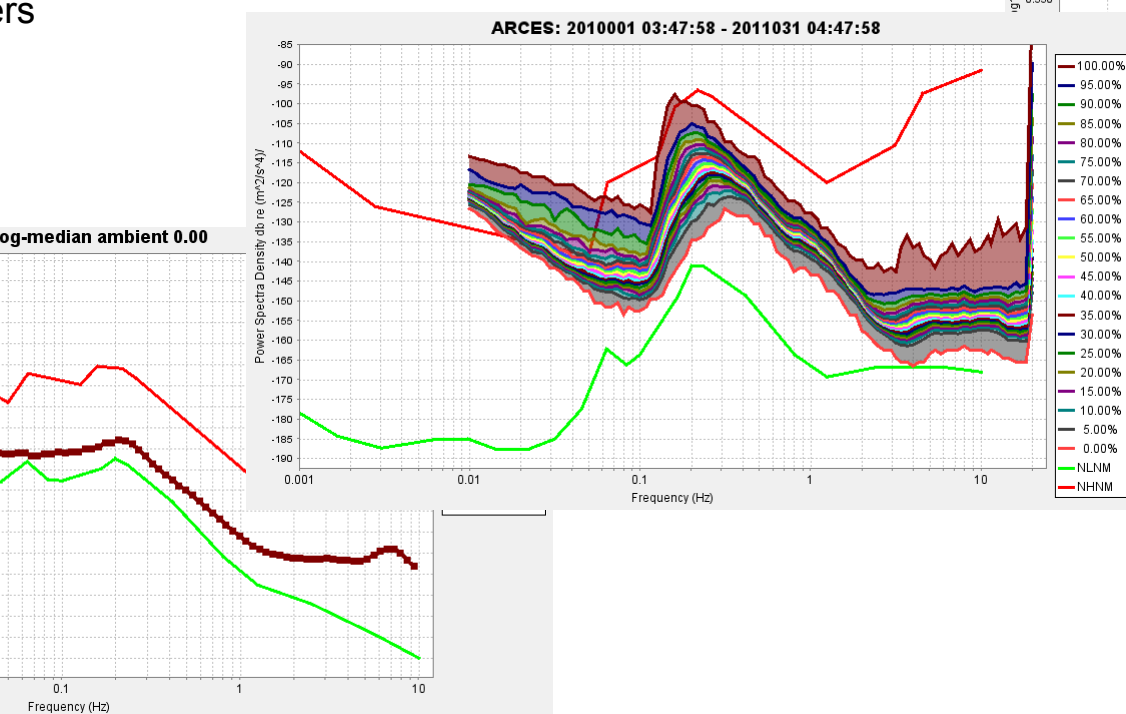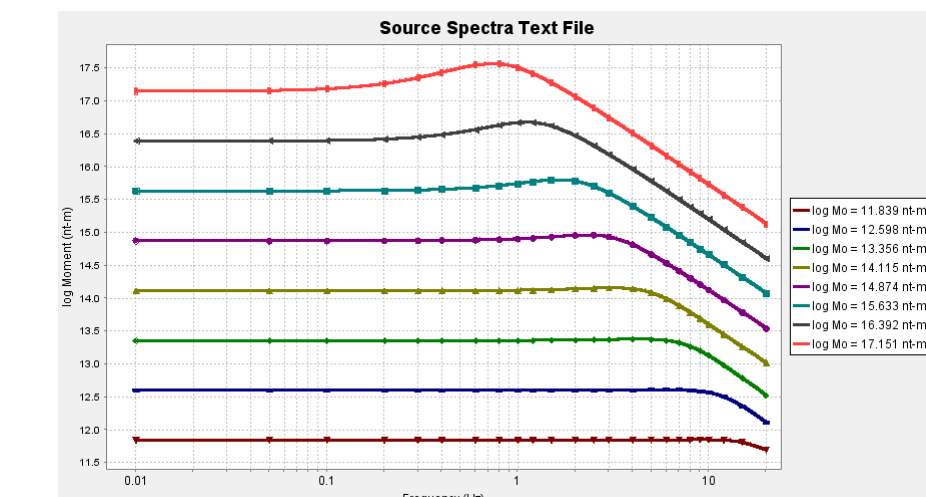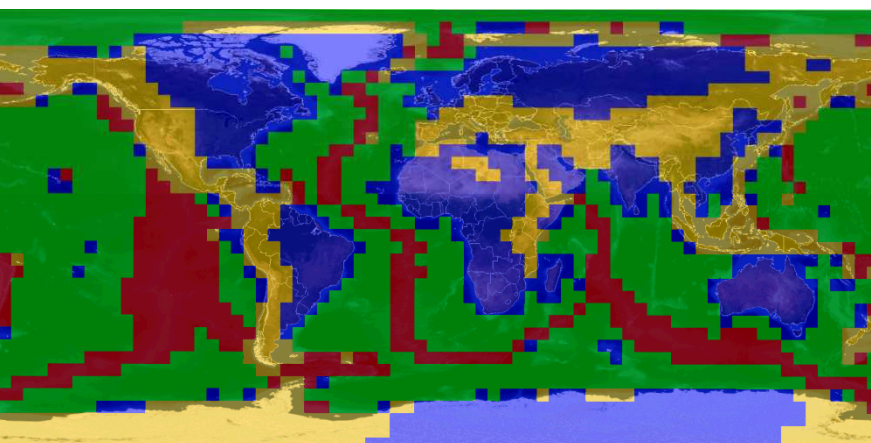
Simulation Type

Probability Simulation computes the probability of the network detecting a seismic event of a specific magnitude at each source location.

Probability	
Magnitude: 3.0	mb

Threshold Simulation computes the magnitude of the event that the network has a specified probability of detecting at each source location.

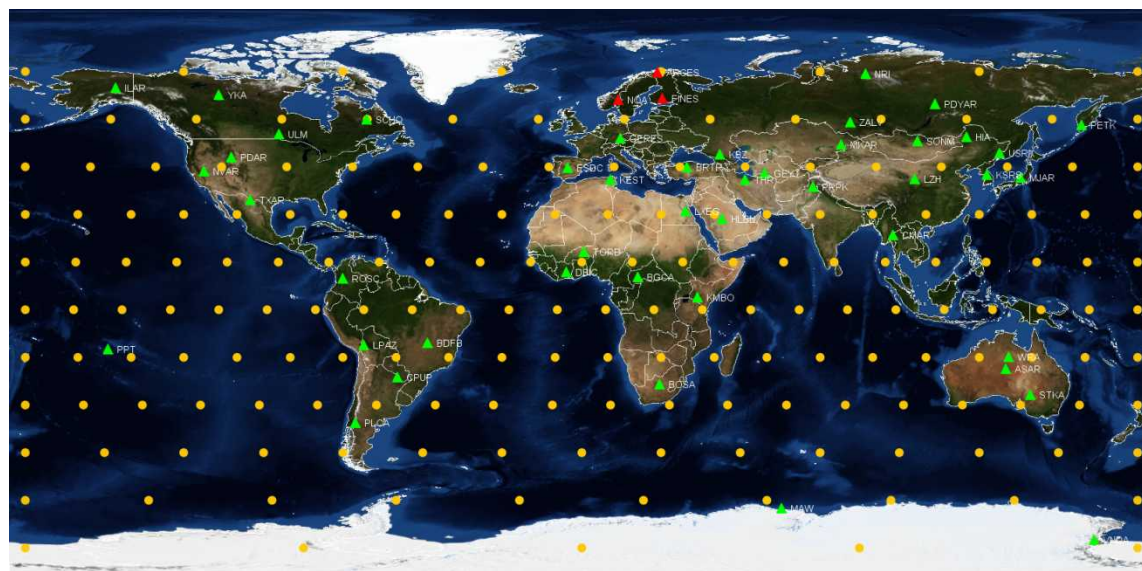| Threshold		
Probability: 0.9		
Magnitude: -2.0	9.0	mb
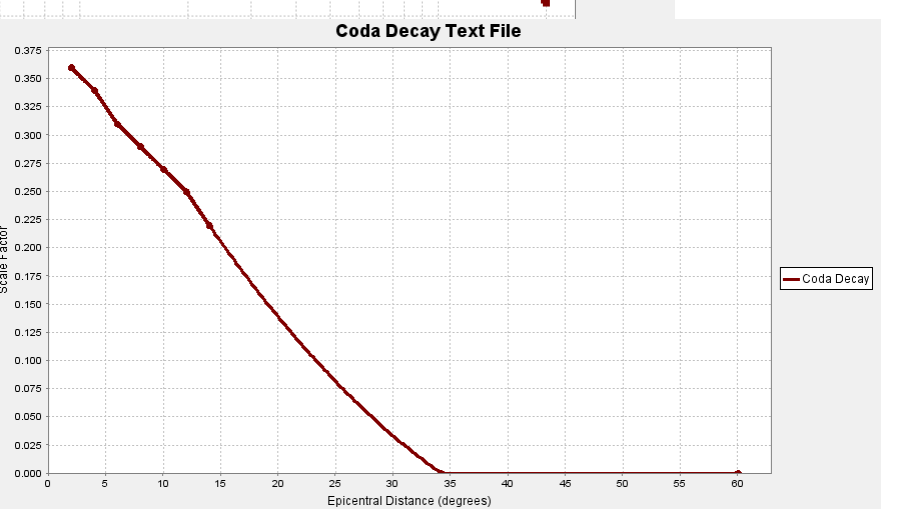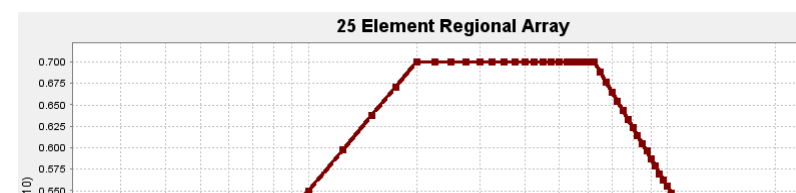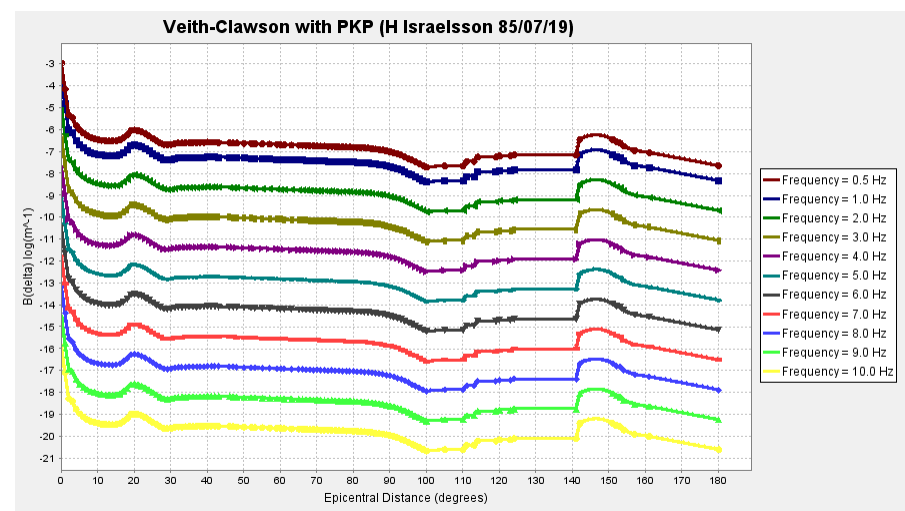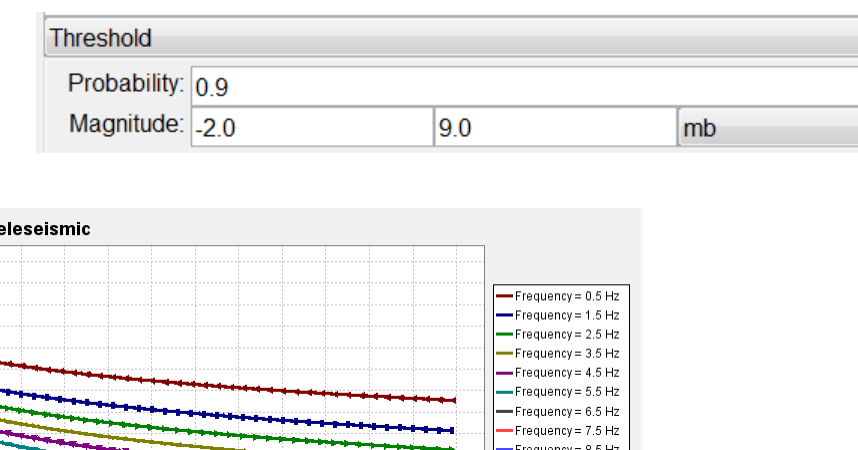
Introspection *(Calculation Details)*

Trying to determine why a simulation result was calculated can be difficult. NetMOD provides the capability to hierarchically examine the calculation details at each station for a selected source position
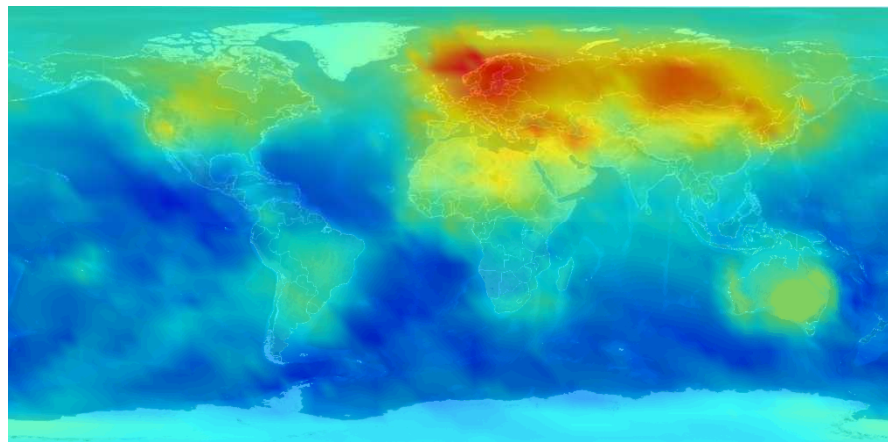

Sensor Networks & Source Locations

The integrated map in NetMOD shows station and source locations. In this figure the stations are represented by green or red triangles, depending on whether they are selected, while event epicenters are represented by orange circles.
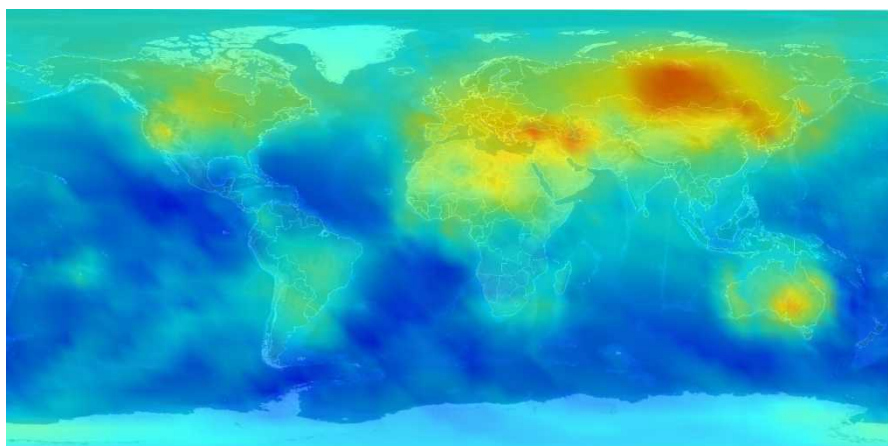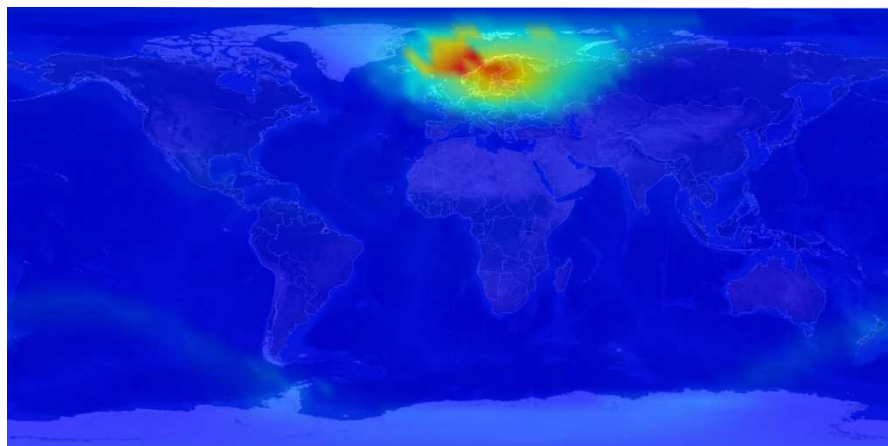

Simulation Results

90% Threshold Detection, Full Network

90% Threshold Detection, Less 3 Stations

90% Threshold Detection, Difference

Simulation results are shown as a color overlay on an interactive map (zoom, pan, etc.). The cursor can be used to find the value at a given position. Various types of reference information (station locations, political boundaries, etc.) can also be shown to facilitate the interpretation. The map allows the user to toggle between overlays for multiple simulations and also has the capability to display the differences between simulations.

Status & Release Schedule

- Development of the NetMOD software is nearly complete. An initial version with functioning seismic detection simulation capability has been completed, has passed internal validation at Sandia, and is undergoing external review for release. It is intended that NetMOD will be made available to the CTBTO, pending final U.S. approval.
- In parallel with the software development, we are developing a baseline parameter set for the IMS primary network that will be included with the software release. This will include improved station noise models, source models, and attenuation models (both regional and teleseismic).