Interactive Visualizations of Complex Seismic Data and Models

Chengping Chai\textsuperscript{1} (chai@psu.edu), Charles J. Ammon\textsuperscript{1} (charlesammon@psu.edu), Monica Maceira\textsuperscript{2} (maceinara@ornl.gov), Robert B. Herrmann\textsuperscript{2} (rbh@eas.slu.edu)

\textsuperscript{1}Department of Geosciences, The Pennsylvania State University; \textsuperscript{2}Oak Ridge National Laboratory; \textsuperscript{3}Department of Earth & Atmospheric Sciences, Saint Louis University

Introduction

The volume and complexity of seismic data and models have increased dramatically due to the expansion of seismic stations and deployments and advances in data modeling and processing. Seismic observations such as receiver functions and surface-wave dispersion are multidimensional: latitude, longitude, time, amplitude, and latitude, longitude, period, and velocity. Three- or four-dimensional seismic models are characterized with these three spatial dimensions and one additional dimension for the speed. In these circumstances, exploring the data and models and assessing the data fits is a challenge. A few professional packages are available to visualize these complex data and models. However, most of these packages rely on expensive commercial software or require a substantial time investment to master. Even when that effort is complete, communicating the results to others remains a problem.

Besides high cost and time investment of traditional high-dimensional visualization packages, these approaches are not effective in many ways. Most of these packages project 3D objects into 2D surfaces and use color to represent another dimension. Some user interaction to illustrate one more dimension. These approaches can summarize fine features but lose key information and beauty of visualizations created through these approaches can be hard to measure. Inspecting specific parameters may provide some measuring tools, but that too is out of reach most of the time due to the specific computational skills required.

The increasing popularity of Python and other scripting languages has led to the development of open-source packages, providing a platform for visualizing complex seismic data and models in a new interactive way. We show a few examples for both seismic data and models using two different approaches.

Interactive Visualizations

The two visualization approaches we present use HTML as the output format. HTML files can be viewed with a web browser. Like image viewers, a web browser is available for most computers. The products of our visualization have minimum requirements on users. Based on our tests, the resulting HTML files work for most modern web browsers such as Chrome, Safari, Firefox, Opera.

The first approach uses a Python package Boltok (http://bokeh.pydata.org) to convert data files into HTML files. The Boltok provides many plotting functions such as basic plotting interfaces, default interactive tools, and styling options. Creating an interactive plot with Boltok is similar to using other plotting packages (e.g., matplotlib). Using Python is the only requirement for generating HTML files with Boltok. For this approach, data are stored in the resulting HTML files. The HTML files are portable and ready to use.

The second approach uses a Javascript library D3 (d3.js). HTML language and CSS. The D3 have basic plotting functions such as lines and simple symbols. For this approach, developers will need to know how to use HTML, Javascript, and CSS languages. Generating a plot using D3 takes more efforts than using Boltok. However, developers have more design options for D3. Using D3 also gives us the ability to directly access data servers through the Internet, which means data downloading, processing and plotting can be achieved by one tool. Another advantage of using D3 is that users can visualize data on demand. Only the data of interest are plotted and shown to users. The HTML format also allows user inputs. Combining all of these options, we designed a seismogram and earthquake visualization tool using near real-time data.

Below the world map, a time history of recent earthquakes is shown. Earthquakes are also listed below the time history plot. Other options are available for selecting or specifying times of interest, changing filtering frequencies, and modifying the reference time. Changing the reference time provides us a quick way to visualize waveforms of previous earthquakes and global seismicity. B1 surface waves are highlighted in light gray color in the waveform plot for the most recent large event using automated grouping. Students can use this tool to make a Nexus connection between real seismic data and their theoretical implications.

Directions & Acknowledgments

The procedure of visualization for the tool shown in the Earthquakes & Seismograms section will be performed locally. Often more intuitive options are offered when developing an interactive tool, especially for lining a non-expert user. The D3 approach may take more time to learn at the beginning. However, the development time is reduced with the increase in experience using D3, HTML, and CSS.

References
