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iMUSH: The design of the Mount St. Helens high-resolution active source seismic experiment

Eric Kiser (1), Alan Levander (1), Steve Harder (2), Geoff Abers (3), Ken Creager (4), John Vidale (4), Seth Moran (5), and Steve Malone (4)

(1) Department of Earth Science, Rice University, Houston, TX, United States, (2) Department of Geological Sciences, University of Texas at El Paso, El Paso, TX, United States, (3) Lamont-Doherty Earth Observatory, Palisades, NY, United States, (4) Department of Earth and Space Sciences, University of Washington, Seattle, WA, United States, (5) USGS Cascade Volcano Observatory, Vancouver, WA, United States

Mount St. Helens is one of the most societally relevant and geologically interesting volcanoes in the United States. Although much has been learned about the shallow structure of this volcano since its eruption in 1980, important questions still remain regarding its magmatic system and connectivity to the rest of the Cascadia arc. For example, the structure of the magma plumbing system below the shallowest magma chamber under the volcano is still only poorly known. This information will be useful for hazard assessment for the southwest Washington area, and also for gaining insight into fundamental scientific questions such as the assimilation and differentiation processes that lead to the formation of continental crust.

As part of the multi-disciplinary imaging of Magma Under St. Helens (iMUSH) experiment, funded by NSF GeoPRISMS and EarthScope, an active source seismic experiment will be conducted in late summer 2014. The experiment will utilize all of the 2600 IRIS/PASSCAL/USArray Texan instruments. The instruments will be deployed as two 1000-instrument consecutive refraction profiles (one N/S and one WNW/ESE). Each of these profiles will be accompanied by two 1600-instrument areal arrays at varying distances from Mount St. Helens. Finally, one 2600-instrument areal array will be centered on Mount St. Helens. These instruments will record a total of twenty-four 500-1000 kg shots. Each refraction profile will have an average station spacing of 150 m, and a total length of 150 km. The stations in the areal arrays will be separated by $\sim$1 km.

A critical step in the success of this project is to develop an experimental setup that can resolve the most interesting aspects of the magmatic system. In particular, we want to determine the distribution of shot locations that will provide good coverage throughout the entire model space, while still allowing us to focus on regions likely to contain the magmatic plumbing system. In this study, we approach this problem by calculating Fréchet kernels with dynamic ray tracing.

An initial observation from these kernels is that waves traveling across the largest offsets of the experiment ($\sim$150km) have sensitivity below depths of 30km. This means that we may be able to image the magmatic system down to the Moho, estimated at $\sim$40 km. Additional work is focusing on searching for the shot locations that provide high resolution around very shallow features beneath Mount St. Helens, such as the first magmatic reservoir at about 3 km depth, and the associated Mount St. Helens seismic zone. One way in which we are guiding this search is to find the shot locations that maximize sensitivity values within the regions of interest after summing Fréchet kernels from each shot/station pair