Investigating faults using seismic interferometry

Eric Matzel
Christina Morency
Lawrence Livermore National Laboratory, matzel1@llnl.gov

In this study, we demonstrate the power of seismic interferometry for use in investigating tectonically active features. First, we apply ambient noise correlation (ANC) to seismic networks to create precise images of seismic velocity structure. We use a mix of instruments and networks to maximize resolution laterally and with depth. We invert for the best 1D models along each path and create 3D models based on those results. Synthetic seismograms calculated through the 3D models capture the complexity of the direct and scattered waves that are seen in recorded data.

Next we apply a second style of interferometry, the virtual seismometer method (VSM). In simple terms VSM involves correlating the waveforms from a pair of events recorded at an individual station and then stacking the results over all stations to obtain the final result. In the far-field, when most of the stations in a network fall along a line between the two events, the result is an estimate of the Green's Function (GF) between the two, modified by the source terms. In this geometry, each earthquake is effectively a virtual seismometer recording all the others. When this alignment is not met we need to address the effects of the geometry between the two earthquakes relative to each seismometer. VSM is very sensitive to the source parameters (location, mechanism and magnitude) and to the Earth structure in the source region. Using VSM, we are able to focus sharply on tectonically active regions such as faults. We can monitor the evolution of seismicity over time, measure changes in the style of faulting and sort earthquakes by location and magnitude.

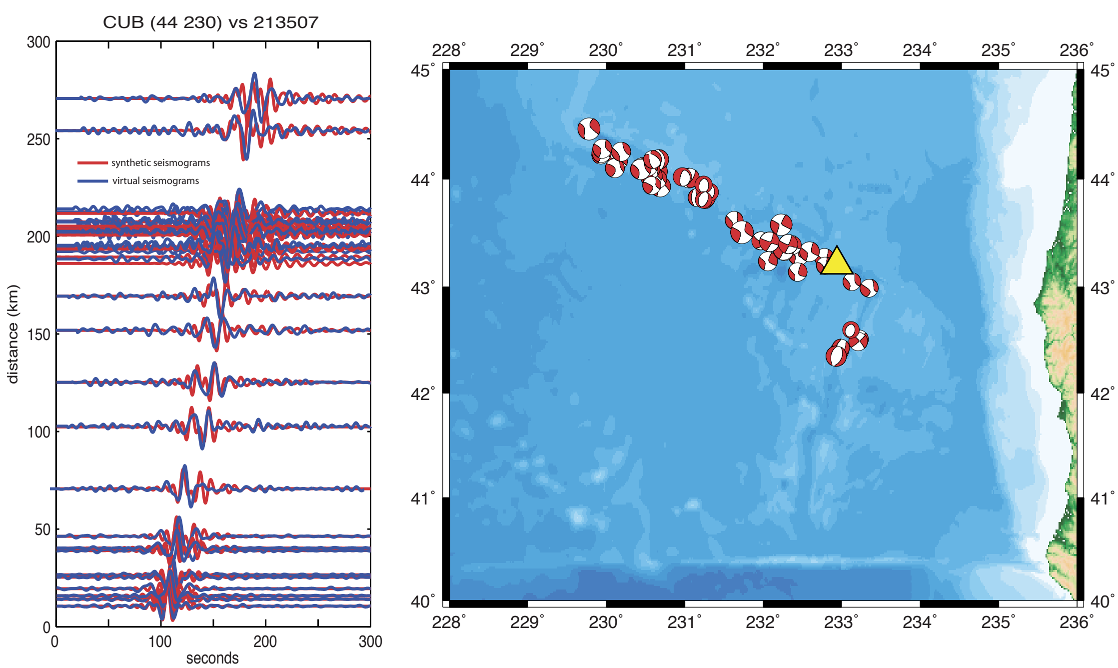

Figure 1. Proof of concept of the VSM. A profile of virtual seismograms (blue) for events located on the Blanco Fracture Zone, as recorded by a "virtual seismometer" (yellow triangle on the map). Synthetic seismograms calculated for those same paths (red).