EPS207 Computer Laboratory II – Generalized Rays

Introduction

This exercise applies the GRT ray code to model a transverse seismogram recorded at Berkeley for a M4.6 earthquake located near San Jose 08/11/1993 22:33:04.1UTC (Figure 1). The event was located at 37.313N 121.670W at a depth of 8.0 km. In this exercise you will compute and apply the radiation pattern weights (see the A coefficients in Helmberger, 1983) to produce a synthetic seismogram with the focal mechanism reported in the UCB Seismic Moment Tensor Catalog (http://www.seismo.berkeley.edu/~dreger/mtindex.html). Given the reported focal mechanism the velocity structure along the path from the earthquake to the Berkeley station will be modeled.

Copy the eps207_lab2_2016.tar file from bcourses and unpack. The file contains a new version of the run_suaveddscript, b2s.par, and the SUAVEDIN file from Lab1, a README file with instructions, a matlab script for incorporating a focal mechanism and convolving a source time function (see Helmberger, 1983), and the instrument corrected displacement data (cm) file, alumdata.

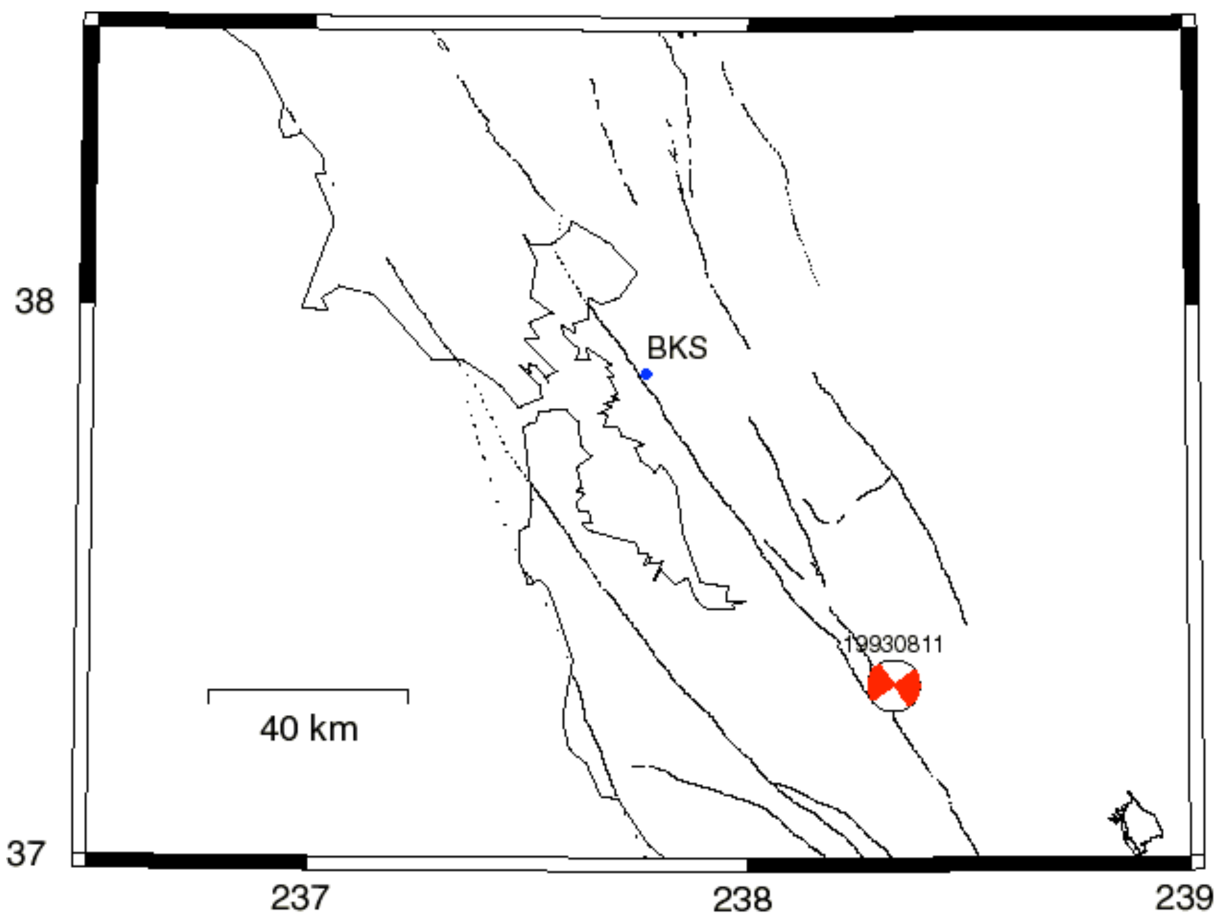


Figure 1. Location of the Mw5.1 event and the Berkeley BDSN station (BKS).

Figure 2 shows what the transverse component ground displacement seismogram should look like. Your mission will be to account for the source focal mechanism and model the complete record for crustal structure along the east bay path and to identify the major seismic phases.

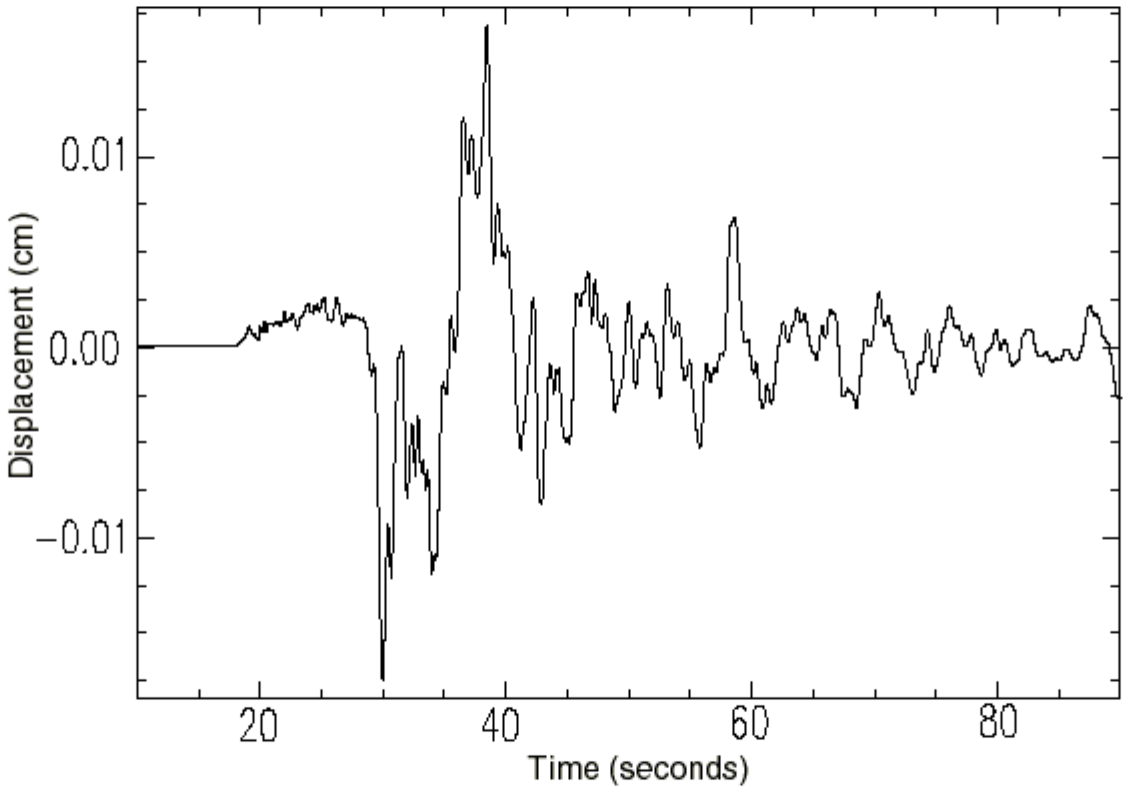
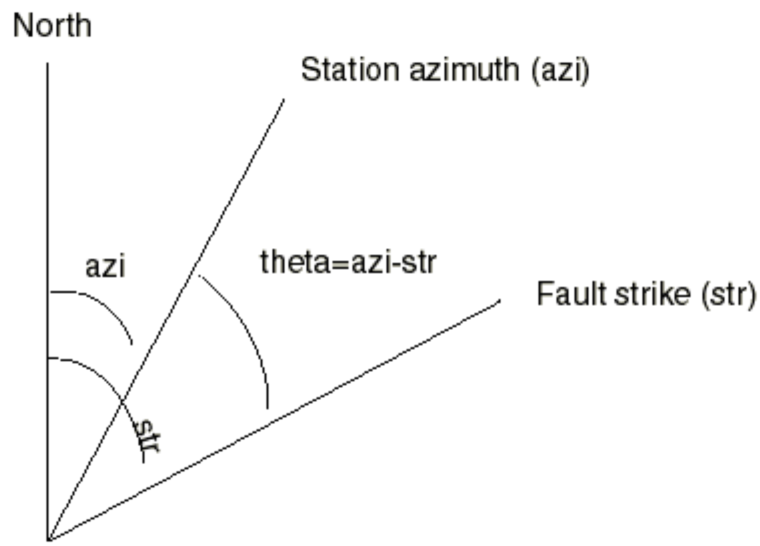


Figure 2. Transverse component of displacement recorded at BKS for the 08/11/1993 event. Amplitude is given in cm.

Exercises

1. We want to use the GRT code to model an actual earthquake record and to do this we must account for both the radiation pattern (focal mechanism) and the source time history. In Helmberger 1983 the radiation pattern coefficients for SH, A4 and A5 are defined. These coefficients are trigonometric functions of the azimuth, strike, dip and rake (slip angle). The total response of the transverse synthetic seismogram is then equal to $U_{SH}(t)=M_0*[A4*tss(t)+A5*tds(t)]/(4\pi\rho)$, where M_0 and ρ are the scalar seismic moment and the source media density, respectively. You can use $4\pi\rho=33.55$ for all of the calculations in this lab, which assumes a density of 2.67 g/cc. The A4 and A5 coefficients describe the relative weight of the transverse vertical strike-slip (tss) and dip-slip (tds) fundamental-faults, respectively, and depend on the fault dip (δ), rake (λ) and the angle between the station and the strike of the fault (θ). See diagram below for convention. The scalar seismic moment is in units of dyne cm, and the default moment in the GRT code is 10^{20} dyne cm. Therefore when applying the scalar seismic moment you will be multiplying by $M_0/10^{20}$. The included MatLab code, mksyn_grt.m performs all of the necessary operations.



   The file event_readme.txt gives two focal mechanism for the event one based on surface wave amplitude and phase information and the other on long-period waveforms. Compare the synthetics for the two focal mechanisms in terms of synthetic time series and their amplitude spectra.

2. Use the GRT code (run_suaveddscript) to iteratively forward model the 1D velocity structure between the source and Berkeley just as you did in Laboratory 1. Compare the fit in terms of broadband velocity, and an acausal Butterworth bandpass filter with

corner frequencies of 0.02 to 0.2 Hz (as shown in Figure 3). To present your modeling results prepare a macro that enables you to plot all of the seismograms (or at least the iterations that provided the most significant change to the synthetic seismograms) on a single plot (Figure 3 is an example of what I mean). Provide supporting documentation and sensitivity calculations illustrating the influence of the layer velocity and layer thickness perturbations on the synthetics. What components of your resulting velocity model are the most well constrained and the most poorly constrained?

3. For your preferred model examine the sensitivity of the time series and amplitude spectra in terms of the assumed rise time of the source time function. Consider rise times in the 0.25 to 3.0 seconds range. You will probably find the frequency domain comparison the easiest to use to determine a best fitting rise time.

4. Keeping the rise time fixed examine how much the scalar moment can change and still effectively model the data.

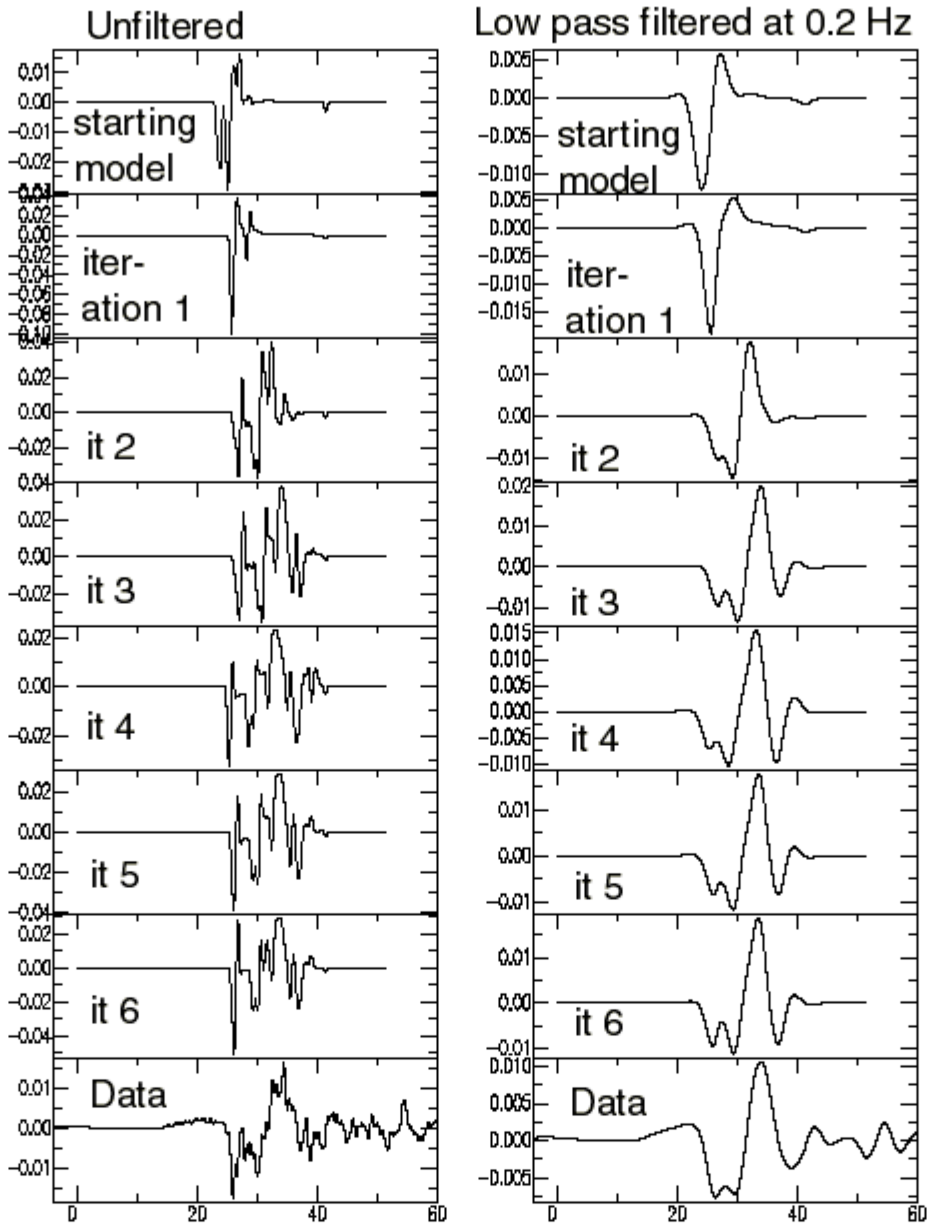


Figure 3. Example of iterative forward modeling approach. Left column compares transverse component synthetics and data. The synthetics are for a vertically dipping strike-slip mechanism and show several iterations in generalized ray modeling. The right column shows the same after a low pass butterworth filter with a corner frequency of 0.2 Hz was applied.