Geophysics 130 Homework – Signal Processing

You have been provided with one hour of continuous waveform data, vertical component, recorded near the Calaveras Fault in California, southeast of San Jose. The seismogram includes several earthquakes between magnitude 0 and 4.1. The sampling rate is fs = 20 Hz (samples per second).

Please use MATLAB to do this homework, and turn in your MATLAB code with your answers.

1. Read in the seismogram data into MATLAB, using the `fget_sac.m` script:

```
[t,x,SAChdr] =
fget_sac('2011.008.00.00.00.deci5.1hr.NC.CCOB.EHZ.D.SAC');
```

The input is the name of the file containing the data. It is in SAC format, which is widely used by seismologists. There are 3 outputs. "t" contains the time (in seconds) for each data sample. "x" contains the seismogram amplitude (don't worry about units). "SAChdr" has other information associated with the data, which you don't need for now.

Make a plot of the seismogram amplitude as a function of time. The time axis should range from 0 to 3600 seconds, and the amplitude axis should range from -500 to 500. Label the axes and give the plot a title. Submit your plot and your MATLAB code. (Hint: use `xlim` and `ylim` to set the axis limits.)

2. What is the sampling time interval (Δt) in seconds? (You can use either the sampling rate fs, or look at the contents of the "t" array.)

3. To avoid aliasing, an anti-aliasing filter was applied to this data. What is the highest frequency (Nyquist) of the seismogram data? (Hint: you know the sampling rate fs.)

4. You will look at the frequency content of the seismogram data. Compute the Fourier transform of the seismogram amplitudes, using the MATLAB function `fft`. Then compute the amplitude spectrum (magnitude of the Fourier transform).

In this step, you will plot the amplitude spectrum as a function of frequency. You will only plot the amplitude spectrum at the positive frequencies (since the seismogram signal is real, the Fourier transform at the negative frequencies is symmetric).

First, set up the frequency spacing: $\Delta f = 1/T$, where T = length of data (seconds) = 3600 s (= 1 hour).

Next, set up an array with frequency values (in Hz), call it "freq". The original time (and seismogram amplitude) arrays have N = 72001 elements, so this frequency array should have fix(N/2)+1 = 36001 elements. The first element of freq should be 0, the last element of freq should equal your answer to Problem #3, and the difference between adjacent

elements should be Δf.

Now you are ready to plot the amplitude spectrum as a function of frequency. Plot it on a log-log scale (use the MATLAB function `loglog`). The frequency axis should range from 10^-3 to 10^1 Hz, and the amplitude spectrum axis should range from 10^-2 to 10^6. Label the axes and give the plot a title. Submit your plot and your MATLAB code.

5. Repeat Problem #1 and #4, but this time using the seismogram data that has been bandpass filtered 2-8 Hz:

```
[t,x,SAChdr] =
fget_sac('2011.008.00.00.00.deci5.1hr.NC.CCOB.EHZ.D.SAC.bp2to8');
```

You should only need to change the filename to use the version that is bandpass filtered. You don't need to make any other changes to your code.

a) Submit your plot of the seismogram amplitude as a function of time, and the amplitude spectrum as a function of frequency, for the bandpass filtered data.

(Hint: you can look at slides 45 and 46 of the "Seismograms as Signals" lecture to make sure you have the correct plots for this homework.)

b) What is the effect of the bandpass filter on the seismogram amplitude in the time domain?

c) What is the effect of the bandpass filter on the amplitude spectrum in the frequency domain?

d) What is one possible reason why you might want to apply a bandpass filter?

e) You have two other components (EHN: north horizontal, EHE: east horizontal). What can you do with three components?

f) Interpret the waveforms of the main (largest) earthquake. (hint: amplitude and/or frequency changes over the time, P or S waves, etc)

g) What else can you find from waves? (you can answer whatever you find.)