Data Analysis in Geophysics (CERI 7104/8104)
Homework 4 – Due 11/10/17

In this homework we will use SAC to analyze seismograms that can be downloaded from the IRIS website. You can get pre-packaged data for the earthquakes below at `http://ds.iris.edu/wilber3/find_event` using the "Load Event Data:" option "Since 1990, M5.5+" to show the following events.

1. We will focus on four different events. Since there are four people in the class, each of you are assigned to a different event. You will need to consult with your classmates to compare your results. The events are as follows:

   - 11/19/2007 15:20:02 M_w 6.0 Loyalty Island – Hessam
   - 11/19/2007 00:52:12 M_w 6.3 Fiji Island – Hee
   - 07/12/2007 13:27:03 M_w 6.0 Western Brazil – Jabir
   - 04/13/2007 05:42:23 M_w 6.0 Guerrero, Mexico – Jiayan

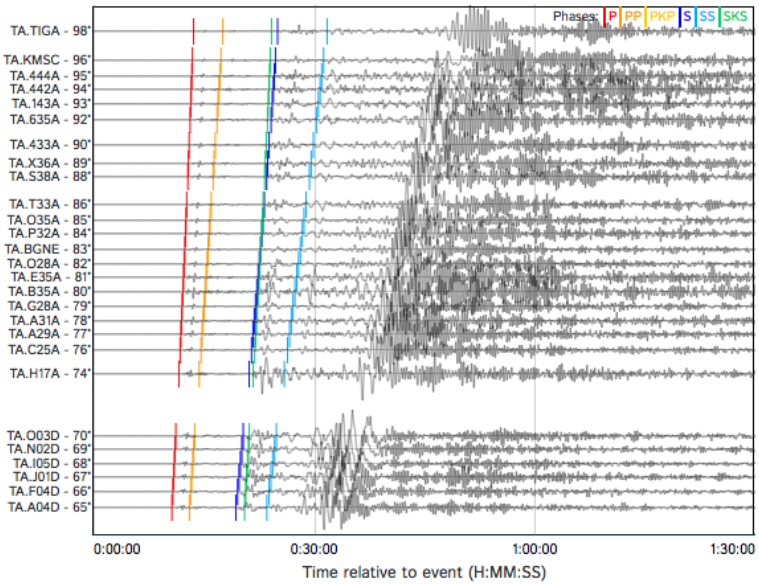
2. Download data for your event from IRIS for your event from the USArray Transportable Array (under "Networks" enter "TA"). You can preview the records using "Show Record Section," which will give you an approximate idea of what your final plot should resemble. You do not need to download the entire TA dataset, though you are welcome to do so if you want to pick your stations more carefully (it will be about 500 MB). Your plot should show a reasonable number of stations, at least 15, that are evenly spaced across the array (the "One Station Every" option is handy for this, though they likely will not all be along the same path). Your records should be long enough to see all of the different seismic phases from the earthquake.

3. We will make plots of what is known as a "record section" in this homework. Note that in SAC, you will need to write some intermediate results to file in order to do this. I find that the best way to effectively handle all file manipulations is through a shell script (a file holding shell commands), which copies the necessary files, performs the analysis in SAC, and cleans up any files at the end. This is a good technique for automating data processing and doing so reproducibly, though you are not required to do this.

   Your final homework will consist of three things: (a) your SAC macros with your commented code (you can do it in a single macro, though my preference is to break the work up into smaller subtasks), (b) plots of all three record sections (one for each component in a standard graphics format such as PDF, PNG, or (E)PS), and (c) a write-up with your answers to question 4.

(a) In seismology, it is conventional to plot seismograms with the horizontal components rotated so that one component points along the great circle path from the event to the station and the other component is orthogonal. This can be easily done in SAC using the `rotate` function. To use `rotate`, you need to load two horizontal components into memory, and then call `rotate` (the default settings on `rotate` is to rotate to the great circle path – see the help page for more details). Following the rotation, you will need to write the two rotated components to file. Do this for every station used in your analysis, either one at a time, or all at once (the files that you have in memory when you call `rotate` must be exclusively pairs of horizontal stations), writing the rotated components to disk.

(b) A common way to plot data in seismology is what is known as a "record section." In a record section, the traces are placed vertically within the plot based on their proximity to the event, which means that waves traveling across the network stations will be visible by eye. Here is an example from a data preview on the IRIS website:



While you do not need to include the different seismic phases on your record section plots, this does show the basic format: time on the horizontal, and distance relative to the event on the vertical (in this case in degrees, but this could also be kilometers). This can be done in SAC using the Signal Stacking Subprocess.

Within `sss` we can plot a record section using the `plotrecordsection` command. You can control the time window using `timewindow <min> <max>` (remember to re-plot the data to see the effect). `sss` also includes the ability to calculate the time axis relative to what would be expected

for a particular velocity model, but by default that is turned off and we do not need to use it for our analysis here.

The SAC record sections are a bit different from the one I showed above (the distance increases from top to bottom in SAC, which is opposite the one above, and the distances are in kilometers rather than degrees), but convey the same information.

(c) You may not be able to see all of the waves in the record section as it stands right now. This is because higher frequency signals are also present in the data which may be obscuring some of the lower frequency waves. The seismic phases we are interested in are below 0.1 Hz, so if you plot the spectra and find larger amplitudes at higher frequencies, you may need to further process your data.

There are two ways to improve the plot. We can either do a low pass filter on the data (`lowpass`, or `lp`), or we can decimate the data using `decimate`, which both filters and de-samples the data. The command syntax is `decimate <number>`, where `<number>` is an integer ranging from 2 to 7, which decimates the data by that factor. If you want to decimate the data further, apply the command repeatedly with appropriately chosen decimation factors until you reach the desired sampling rate. Either one will work equally well here, though since `decimate` reduces the number of data points, it will also make the final plots have a smaller file size.

Either by filtering or decimating your data, remove the higher frequencies so that you can see the appropriate seismic phases in your plot. You may need to experiment with this using different values to get the best results. You should clearly see several seismic phases on your record section propagating across the network if you have done this correctly.

(d) One technical note: I had trouble getting the SGF files to convert to PostScript in some cases when the labels for each trace were too long. I was able to avoid this problem by renaming the files to something shorter, which I did using a shell script when performing the analysis.

4. Once you have your record sections plots, share your plots with other members of the class to compare the four events. You will need to look at the header file to get information about the earthquake. What aspects of the earthquakes correlate with the observed differences in the seismograms? Explain – you are of course supposed to discuss these with your classmates, but the final write-up needs to be your own. Also note that just looking at the record sections on the IRIS website for the four events does not constitute "discussing" the event with your classmates – you actually need to talk to the other people in the class about this.