CERI 7104/8104 Homework 3 Solutions

Here are my solutions to Homework 3. I have included a set of SAC macros and a driver shell script for the Fiji event, but the analysis should be similar regardless of the event that you were assigned.
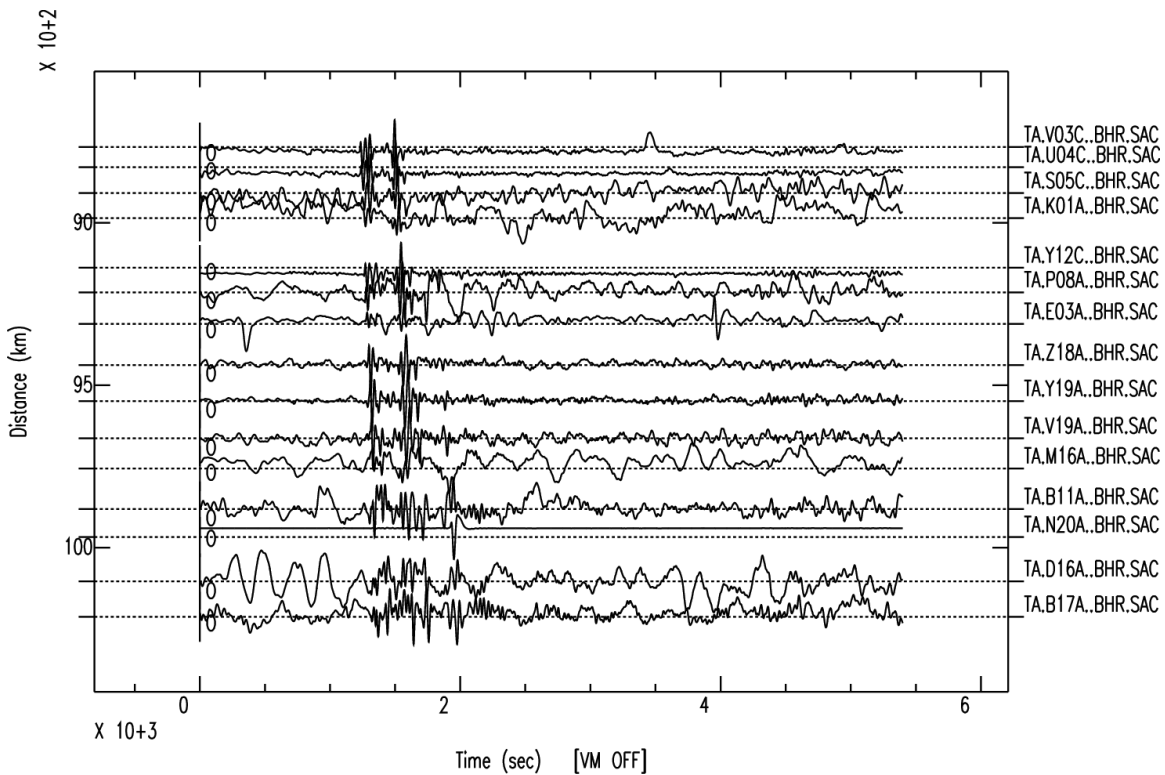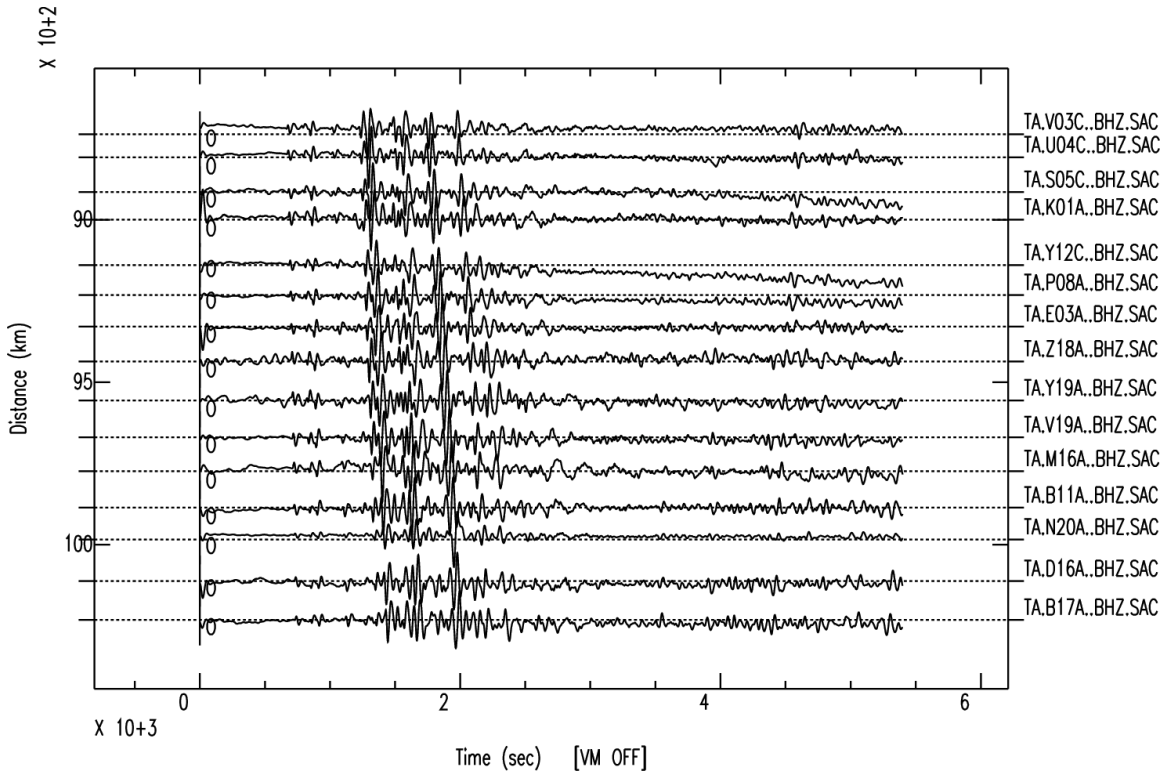
I chose to write out SAC macros for each processing step, as I found my SAC code ended up being long enough that I felt it was better managed in separate files and gave it more potential for re-use. I have included my shell script and two of the macros that I used (the one to rotate the data and the one to plot the record section). I also wrote a macro to read a seismogram, filter the data, and write the filtered data to disk, which I am not providing as you need to use your own in your final projects. However, you can see from my shell script how I used my macro for clues into how to best write your version (also see my example shell script from class on calling SAC from the shell).
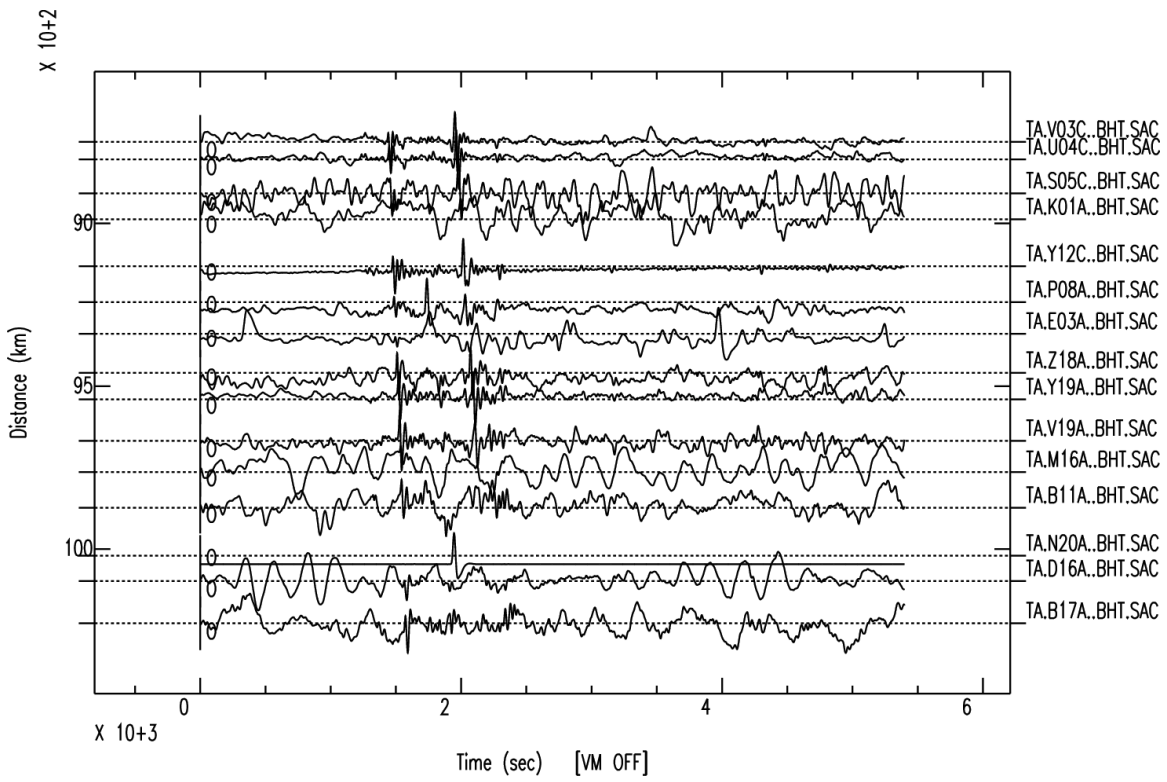
A few comments on your codes: I thought they were good for the most part. The biggest problem was that everyone hard coded the list of stations in their SAC macros instead of making the station list an input using a keyword. While your codes all worked correctly, they are only really useful for this particular problem, as you need to modify the station list in several places if you want to use the macros for a different problem. This makes your code difficult to maintain, as you need to rewrite several portions to handle a new problem. In my solution, I give examples of how you can avoid this problem, by either writing your macro to handle a single station at a time by putting the loop in the shell script (my rotate and filtering macros do this), or pass a large number of stations to use in a the loop inside the SAC macro (my record section macro does this). Notice how my macros can be re-used for other problem without too much trouble, because they all make use of input arguments in order to make them more adaptable in the future.

One other thing that I noticed was that all of you hard coded the number of points to include in the cut and your time window for the record section. While I didn't take off points, this would be best handled as an input to the macro. Additionally, in many cases people did not set the frequencies to be filtered using an input argument, which will require you to modify your code for use in your final project. You will need to fix this when revising your code for the final project.

A number of you downloaded the data relative to the p-wave time, rather than the event time. While this is fine in most cases, just remember that the velocities that you infer from the record section are relative to the p-wave velocity because there is an implicit move-out in the timing of the data.
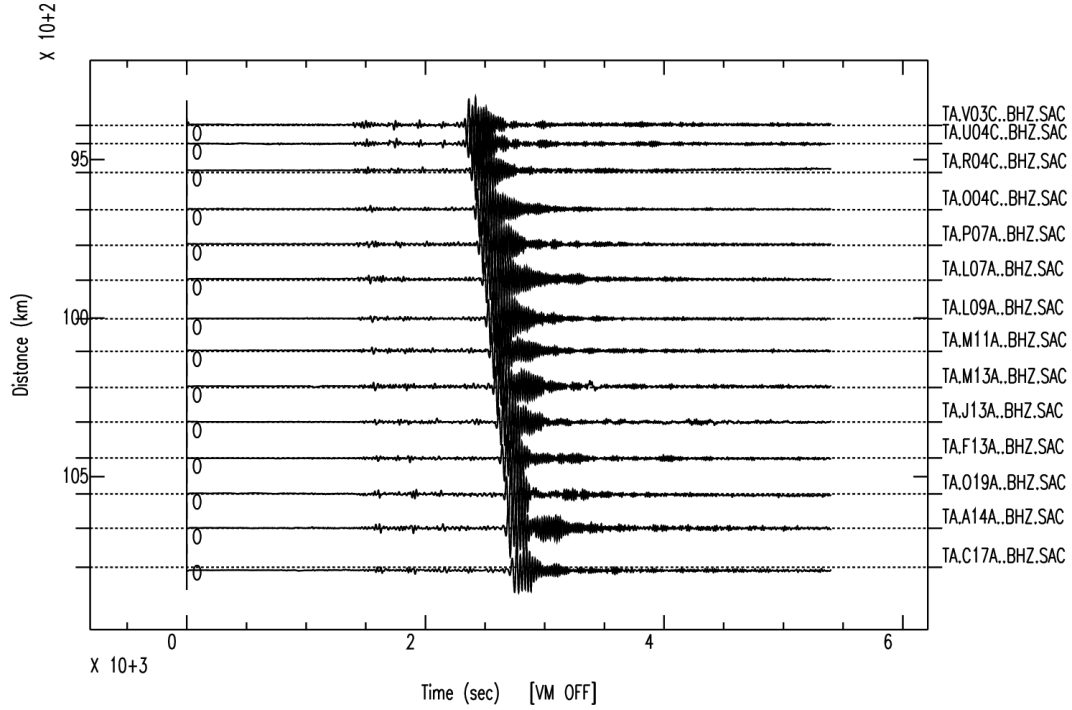
Here are my record sections for the Fiji event (vertical, radial, and transverse):

X 10+2

Distance (km)

TA.V03C..BHZ.SAC
TA.U04C..BHZ.SAC
TA.S05C..BHZ.SAC
TA.K01A..BHZ.SAC
TA.Y12C..BHZ.SAC
TA.P08A..BHZ.SAC
TA.E03A..BHZ.SAC
TA.Z18A..BHZ.SAC
TA.Y19A..BHZ.SAC
TA.V19A..BHZ.SAC
TA.M16A..BHZ.SAC
TA.B11A..BHZ.SAC
TA.N20A..BHZ.SAC
TA.D16A..BHZ.SAC
TA.B17A..BHZ.SAC

X 10+3

Time (sec)   [VM OFF]

X 10+2

Distance (km)

TA.V03C..BHR.SAC
TA.U04C..BHR.SAC
TA.S05C..BHR.SAC
TA.K01A..BHR.SAC
TA.Y12C..BHR.SAC
TA.P08A..BHR.SAC
TA.E03A..BHR.SAC
TA.Z18A..BHR.SAC
TA.Y19A..BHR.SAC
TA.V19A..BHR.SAC
TA.M16A..BHR.SAC
TA.B11A..BHR.SAC
TA.N20A..BHR.SAC
TA.D16A..BHR.SAC
TA.B17A..BHR.SAC

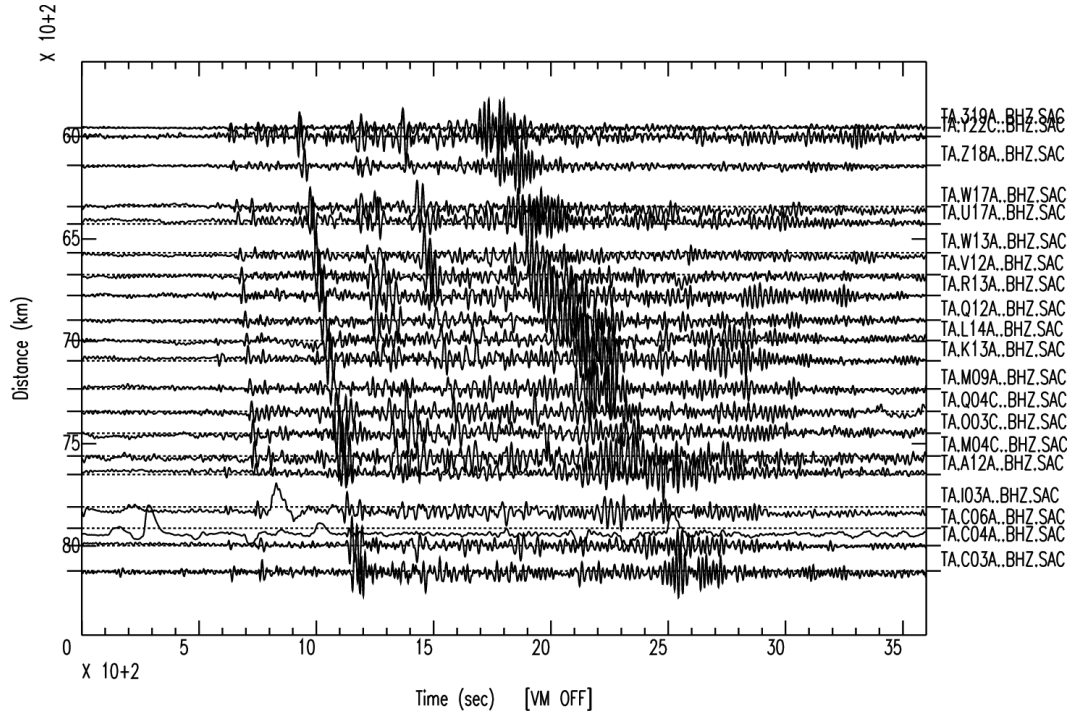X 10+3

Time (sec)   [VM OFF]

2

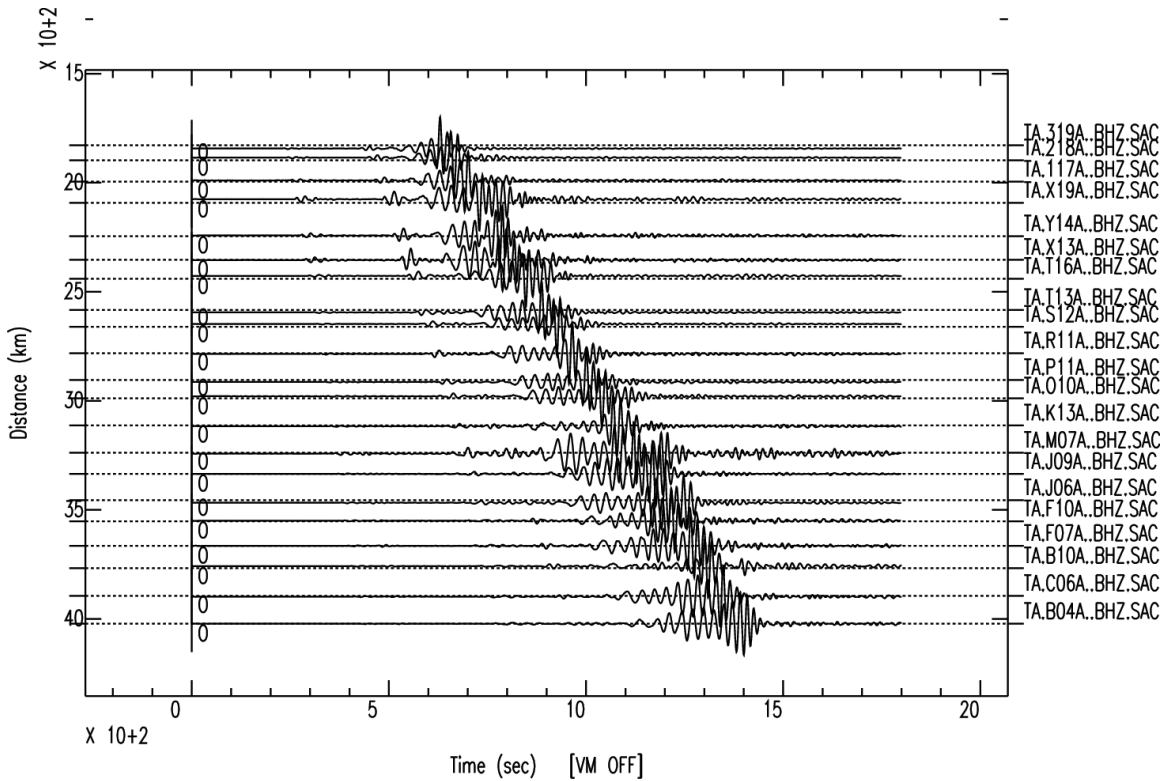Here are the vertical record sections for the other three events.

Loyalty Islands:

Western Brazil:

Mexico:

The main thing I noticed about these particular events are the differences in the surface wave amplitudes. Three of the events (Loyalty, Brazil, Mexico) show clear surface wave arrivals, while the Fiji event does not. Within the events that show surface waves, the Loyalty Islands event and the Mexico event are dominated by the surface waves (it is difficult to see any other seismic phases relative to the surface wave amplitudes). The Brazil event shows surface waves, but the amplitudes are similar to the amplitudes of the body wave phases.

There are some body wave phases that are easier to see on some records when compared to others, though that can be biased by the fact that the amplitudes are scaled to the height of the strongest wave, meaning that the shallow events (with their much larger surface wave amplitudes) are less likely to show the presence of body waves when compared to the deep events. Most of you nicely identified many different body wave phases from your record sections. Some of you also noticed that low pass filtering removes some of the body wave energies.

Why are the surface wave amplitudes different? The main difference between the events with the strong surface waves and the events with weak surface waves is the depth of the event. The Fiji event occurred at 559 km depth, while the Loyalty Islands event was only 1 km deep. Otherwise, the two events occurred at similar distances from the TA, so it is likely that the depth is the principal cause of the difference.

However, you might have noticed that the Brazil event also has a very large depth (634 km), yet it produced noticeable surface waves. Part of the reason for this could be the distance from the event is less than the Fiji event – we expect maximum geometrical spreading of the surface waves at a distance of 90°, which is approximately the distance for the Fiji event. The Brazil event is closer to the array, and so there should be less of a geometrical spreading effect. There may also be some additional effect from the type of faulting mechanism, but we do not have mechanism data in the SAC headers so we cannot determine if the faulting style plays a role from this data.