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Started on	Tuesday, July 19, 2022, 3:45 AM
State	Finished
Completed on	Tuesday, July 19, 2022, 6:47 AM
Time taken	3 hours 2 mins
Marks	28.67/36.00
Grade	**79.63** out of 100.00

Question 1
Correct
1.00 points out of 1.00
Flag question

SAC Tutorial on Filtering Real Seismograms

Digital Data and Sampling Rate

In today's activity we will revisit some ideas about frequency content and filtering using some real seismic data, including how continuous ground vibrations are digitized with a particular sampling rate when they are recorded into computer memory.

For this activity, we will revisit the September 12, 2007 Magnitude 8.5 earthquake in southern Sumatra that we examined in the earlier Earthquake Source Directivity assignment. We will learn how to request that data with the **dataselect** web service and then work on filtering the retrieved seismogram in SAC.

You can start with finding the details about this earthquake using the **event** web service. You can use the URL Builder like we did in the last assignment or you can modify the URL you used last time manually. The key information you will need to use to search for this event is the date (search from September 12 to September 13) and the magnitude (try a minimum magnitude of 5). What is the exact day and time information for this earthquake?

Select one:
- a. 2007-09-12T11:10:26 ✓
- b. 2007-09-12T01:55:40
- c. 2007-09-12T11:23:09
- d. 2007-09-12T14:40:07
- e. 2007-09-12T23:49:04

Check

Correct
Marks for this submission: 1.00/1.00.

Question 2
Correct
1.00 points out of 1.00
Flag question

Based on this information, how many aftershocks magnitude 5 and larger occurred on the same day as the mainshock?

Answer: 17 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 3
Correct
1.00 points out of 1.00
Flag question

What was the magnitude of the largest aftershock on the same day as the mainshock?

Answer: 7.9 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 4
Correct
1.00 points out of 1.00
Flag question

One of the stations we looked at during the Earthquake Source Directivity assignment was **SUR** in Sutherland, South Africa. In order to request data from this station, you will need to know the network and location code of this instrument. You can find this information with the **station** web service. Enter the formatted day and time information from the previous question for both the start and end time, and then SUR in for the name. What is the 2-character network code for this station?

Answer: II ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 5
Correct
0.67 points out of 1.00
Flag question

Which of the following location codes are available for recorded seismometer data (not synthetic seismograms)?

Select one or more:
- a. S3
- b. 10 ✓ 1 of 2 correct answers. This is for a STS-2 seismometer, often considered to be the next best thing relative to a STS-1.
- c. S1
- d. 00 ✓ 1 of 2 correct answers. This is for a STS-1 seismometer, often considered to be the best instrument available. You will want to use this location code when requesting data.

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 6
Correct
1.00 points out of 1.00
Flag question

When you request data, you will want to request the 3-character channel for broadband, high-gain, vertical component data. Which channel available for station SUR would match this?

Answer: BHZ ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 7
Correct
1.00 points out of 1.00
Flag question

You now have almost enough information to use the **dataselect** web service. However, we need to determine the start and end time of the seismogram we are requesting. I will ask that you request data from 640 seconds after the origin time to 830 seconds after the origin time to capture the P wave that we examined to determine the rupture directivity. Recall that you identified the origin time in Question 1, and that question also shows the proper format of year-month-dayThour:minute:second you will need for this question.

What is the exact day and time information for the start time you will input to **dataselect**?

Answer: 2007-09-12T11:21:06 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 8
Correct
0.33 points out of 1.00
Flag question

What is the exact day and time information for the end time you will input to **dataselect**? Review the previous question for how long the end time should be after the origin time. Make sure you use the properly formatted dateTtime format.

Answer: 2007-09-12T11:24:16 ✓

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.33/1.00**.

Question 9
Correct
1.00 points out of 1.00
Flag question

The last piece of information needed to make **dataselect** request is the data Format. Which option would allow you to receive the data in a format for use in SAC?

Answer: SAC zip ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 10
Correct
1.00 points out of 1.00
Flag question

Before we request the data, I would suggest you create a directory called **irisdmc** inside your home directory, and then create another directory called **filt** inside the **irisdmc** directory. What command should ensure that you are in the new **filt** directory?

Select one:
- a. cd ~/irisdmc/filt ✓
- b. cd ~/irisdmc/
- c. cd ~/filt
- d. cd ~/

Check

Your answer is correct.
Correct
Marks for this submission: 1.00/1.00.

Question 11
Correct
1.00 points out of 1.00
Flag question

Now you are ready to create the link for the **dataselect** request. You are welcome to use the URL Builder for **dataselect**, but note that you will need to use the link you build on your OSL desktop, not in your regular web browser. The reason is because submitting the link will result in data being immediately sent back to the application you submit it from. We do not want the data to return to your web browser, we want the data on your OSL desktop so we can open it up in SAC.

At the command line of the linux machine, you can use the command `wget` to retrieve the output of the http link. For this case, you should use the `wget` command with this format:

```
(iris) jupyter-[your username]:~/irisdmc/filt> wget "link" -O sac.zip
```

where the link you build with the URL Builder has quotation marks around it. The `-O` option tells `wget` to send the output to a file, *sac.zip* in this case. Is this the correct link to use? (the O is a Capital o)

http://service.iris.edu/fdsnws/dataselect/1/query?net=II&sta=SUR&loc=00&cha=BHZ&starttime=2007-09-12T11:21:06&endtime=2007-09-12T11:24:16&format=sac.zip&nodata=404

Select one:
- a. No
- b. Yes ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 12
Correct
1.00 points out of 1.00
Flag question

Once the sac.zip file downloads, you will need to unpack the SAC file using this command:

```
(iris) jupyter-[your username]:~/irisdmc/filt> unzip sac.zip
```

and then

```
(iris) jupyter-[your username]:~/irisdmc/filt> ls *SAC
```

What is the name of the file unpacked by unzip?

Answer: II.SUR.00.BHZ.M.2007.255.112106.SAC ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 13
Correct
1.00 points out of 1.00
Flag question

Once you are certain the .SAC file is in your current directory, go ahead and start sac, and then read the data file for station SUR. Which of the following commands would read the seismograms for station SUR?

Select one:
- a. r SUR*.SAC
- b. r *SUR*.SAC ✓ Correct, please run this command if you have not already.
- c. r *SUR*.SAC.*
- d. r *SUR.SAC
- e. r SUR.SAC

Check

Correct
Marks for this submission: 1.00/1.00.

Question 14
Correct
0.50 points out of 1.00
Flag question

Now plot this seismogram. You should notice that the data shows the earthquake prominently, but there is also some "noise" that is present before the earthquake begins. This noise makes it more difficult to see the initiation of the earthquake on the seismogram. In this activity we will work to remove this noise. We will start by learning how the seismogram is sampled to figure out the range of recorded frequencies in the recorded seismogram. Then we will investigate what the frequency content of the earthquake is and then what the frequency content of the noise is. With all that information, we will be able to determine a filter to remove the noise and preserve the earthquake signal.

We will start with learning how the seismogram is sampled. Since sac data files have a variety of information stored in a "header" at the beginning of the file, we can use the LISTHDR command to see this information, which can be abbreviated to lh. Let's run this command on the data file you just read into sac. Note that since there is a pretty long list of information about this data file, you will need to hit the enter key when sac gives you the "Waiting" prompt.

```
SAC> lh
```

Hopefully you can see there is a lot of metadata contained in a SAC file about how the data was recorded. Here is a list of what the different header variables represent:

```
NPTS = number of data points
B = begin time
E = end time
IFTYPE = file type
LEVEN = evenly sampled time series
DELTA = spacing in time of data points
IDEP = physical unit of the data
DEPMIN = minimum amplitude
DEPMAX = maximum amplitude
DEPMEN = mean amplitude
OMARKER = event origin marker
AMARKER = first arrival (P) marker
T0MARKER = t0 (S) marker
KZDATE = reference date
KZTIME = reference time
IZTYPE = type of reference time
KSTNM = station name
CMPAZ = component azimuth relative to north
CMPINC = component "incidence angle" reletive to the vertical
STLA = station latitude
STLO = station longitude
STEL = station elevation
STDP = station depth below surface (meters)
EVLA = event latitude
EVLO = event longitude
EVDP = event depth
DIST = source receiver distance in km
AZ = azimuth
BAZ = back azimuth
GCARC = great circle distance
LOVROK = TRUE if it is okay to overwrite this file on disk
NVHDR = Header version number. Current value is the integer 6.
SCALE = Multiplying scale factor for dependent variable
NORID = Origin ID (CSS 3.0)
NEVID = Event ID (CSS 3.0)
NWFID = Waveform ID (CSS 3.0)
LPSPOL = TRUE if station components have a positive polarity (left-hand rule)
LCALDA = TRUE if DIST, AZ, BAZ, and GCARC are to be calculated from station and event coordinates
KCMPNM = Component name
KNETWK = Network name
MAG = Event magnitude
```

Your output from the LISTHDR command will be shorter than this list since not all variables will be set in your file. Using the output of your LISTHDR command, what is the spacing between data points in the seismogram you read into SAC? Please include a unit. Make sure your unit is lowercase.

Please note that SAC may list numbers in an exponential format like 2.0e-04 for example. This example represents 0.0002 in traditional number format if you are not familiar with the exponential format.

Answer: 0.04999997 seconds ✓

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.50/1.00**.

Question 15
Correct
0.67 points out of 1.00

Based on the answer to the previous question (the number of seconds per sample), what is the sampling rate (the number of samples per second)?

Answer: 20.000012 ✓

Flag question

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 16
Correct
1.00 points out of 1.00
Flag question

What is the maximum frequency one can observe is this data? This is often referred to as the Nyquist frequency. If you are unfamiliar with the electronics term Nyquist frequency, you can read about how it is determined here: http://mathworld.wolfram.com/NyquistFrequency.html

Answer: 10.000006

Check

Correct
Marks for this submission: 1.00/1.00.

Question 17
Correct
0.67 points out of 1.00
Flag question

What is the unit for this frequency value?

Select one:
- a. Hz ✓
- b. nanometers
- c. cycles
- d. seconds
- e. samples

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 18
Correct
0.67 points out of 1.00
Flag question

Frequency Content of Earthquakes

Next we will examine the frequency content of this earthquake recording. Recall from our earlier SAC tutorial on frequency content that we use FFT command to perform the fast-fourier transform. Then the time series will be converted to the frequency domain, so the regular PLOT command will not work. Instead, we will use the PLOTSP to plot the frequency spectrum (abbreviation PSP). For this activity, we can use the AM and LOGLOG options to just plot the amplitude part of the frequency component and do a logarithmic X-axis and Y-axis.

```
SAC> fft
SAC> psp am loglog
```

What is the general trend in the amplitude vs. frequency plot?

Select one:
- a. Decreasing amplitude with increasing frequency, then increasing amplitude with increasing frequency
- b. Increasing amplitude with increasing frequency
- c. Decreasing amplitude with increasing frequency ✓
- d. Essentially no change in amplitude with increasing frequency
- e. Increasing amplitude with increasing frequency, then decreasing amplitude with increasing frequency

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 19
Correct
1.00 points out of 1.00
Flag question

At what frequencies do we see the largest amplitudes?

Select one:
- a. 1-10
- b. .01-.1 ✓
- c. 10-100
- d. .001-.01
- e. .1-1

Check

Correct
Marks for this submission: 1.00/1.00.

Question 20
Correct
1.00 points out of 1.00
Flag question

How big do the amplitudes get?

Select one:
- a. 1,000 – 10,000
- b. 1 – 10
- c. 100,000 – 1,000,000 ✓
- d. 10 – 100
- e. 10,000 – 100,000
- f. 100 – 1,000

Check

Correct
Marks for this submission: 1.00/1.00.

Question 21
Correct
0.67 points out of 1.00
Flag question

How might this frequency pattern differ from a smaller earthquake?
This concept was discussed in the lecture material so you should consider reviewing that.

Select one:
- a. A smaller earthquake would have the largest amplitudes at the same frequencies
- b. A smaller earthquake would have the largest amplitudes at higher frequencies ✓
- c. A smaller earthquake would have the largest amplitudes at lower frequencies
- d. It is impossible to predict whether the frequency pattern would differ because it depends entirely on the roughness of the fault.

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 22
Correct
1.00 points out of 1.00
Flag question

Frequency Content of Noise

Our next task is to figure out the frequency content of the noise that is recorded before the earthquake on the seismogram. First, you need to pick the arrival of the P wave. *Remember that after entering `FFT` you are in the frequency domain, and `PPK` only works in the time domain. To get back to time domain you need to either run `IFFT` (Inverse Fourier Transform), or read in the sac file again. Remember to save your pick with `WH` after you use `PPK` and the P key to pick the first arrival.*

To isolate the noisy part of the signal, we will use the `CUT` command to restrict the data to 30 seconds before the earthquake (A marks the first arrival of the earthquake waves) and then re-read the seismogram.

```
SAC> cut A -30 0
SAC> r *SUR*SAC
SAC> p
```

Which of the following describes this plot? Choose TWO answers that apply.
NOTE: If you receive a Warning about the cut values, it may be that you have not picked the P value and saved it. Review the instructions at the beginning of this question about using ppk and `wh` to pick the first arrival and then save it to the file.

Select one or more:
- a. There is a steep upward trend
- b. It looks like a boxcar function
- c. There is a slight upward trend
- d. There is a slight downward trend ✓
- e. It looks like an impulse function
- f. There is a steep downward trend
- g. It looks like a straight line
- h. It looks like a sine wave ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 23
Correct
0.67 points out of 1.00
Flag question

This trend in the shortened seismogram can unfairly influence our frequency determination, so we can use the RTREND command to remove this trend.

```
SAC> rtrend
SAC> p
```

Looking at the waves in the time domain of this seismogram, we will want to make an estimate of the dominant frequency of the noise. You may find it easiest to measure the period from peak to peak. What is the dominant period? Please make sure to include a unit.

Answer: 6 seconds

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 24
Correct
0.17 points out of 1.00
Flag question

Now convert the dominant period of the noise from the previous question to the dominant frequency of the noise. Please make sure to include a unit.

Answer: 0.16666666666 Hz

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.17/1.00**.

Question 25
Correct
1.00 points out of 1.00
Flag question

After making a time domain estimate, convert the time series to the frequency domain. Which command do we use to do that?

Answer: fft

Check

Correct
Marks for this submission: 1.00/1.00.

Question 26
Correct
1.00 points out of 1.00
Flag question

Now you should plot the results. Which command and options do we use to do that?

Select one:
- a. psp am loglin
- b. psp am loglog ✓
- c. psp am linlog
- d. plot am loglin
- e. plot am loglog
- f. plot am linlog

Check

Correct
Marks for this submission: 1.00/1.00.

Question 27
Correct
0.33 points out of 1.00
Flag question

At what frequency do you see the largest amplitudes? Please make sure to include a unit.

Answer: 0.2 Hz

Check

Correct
Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.33/1.00**.

Question 28
Correct
0.00 points out of 1.00
Flag question

How does the dominant noise frequency seen in the frequency domain (amplitude versus frequency plot) compare to the frequency you estimated in the time domain (seismogram peak-to-peak times)?

Select one:
- a. The frequency domain estimate was about three times smaller than the time domain estimate
- b. The frequency domain estimate was about the same as the time domain estimate ✓
- c. The frequency domain estimate was about ten times smaller than the time domain estimate
- d. The frequency domain estimate was about three times larger than the time domain estimate
- e. The frequency domain estimate was about ten times larger than the time domain estimate

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.00/1.00**.

Question 29
Correct
0.67 points out of 1.00
Flag question

How does the dominant noise frequency compare to the dominant earthquake frequency we found in the last section of this assignment?

Select one:
- a. The dominant noise frequency is higher than the dominant earthquake frequency ✓
- b. The dominant noise frequency is lower than the dominant earthquake frequency
- c. The dominant noise frequency is about the same as with the dominant earthquake frequency

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 30
Correct
1.00 points out of 1.00
Flag question

Before we move on to the next section, please make sure that you stop the CUT function from trimming the data to before the earthquake. In other words, we want to make sure that we can read in the entire seismogram that has the earthquake in it and the time frame before it. You may want to use the following to help figure it out:

```
SAC> help cut
```

Which command would prevent the cut function from operating on any new data read into SAC?

Select one:
- a. cut off ✓
- b. cut a 0 100
- c. read all *SUR*SAC
- d. cut stop
- e. read no cut *SUR*SAC

Check

Correct

Marks for this submission: 1.00/1.00.

Question 31
Correct
0.67 points out of 1.00
Flag question

Filtering Out the Noise

Now that you have an idea what the frequency content of the earthquake and the noise are, we should be able to construct a filter that can remove the noise and preserve the earthquake signal. We will use the BANDPASS command to perform the filtering, which can be abbreviated bp. We then need to specify the frequency corners for this filter, which means the beginning and the end of the frequency band that we want to pass through the filter. Frequencies less the first corner and greater than the second corner will be restricted. Which of the following is true about the filter we want to construct? Choose all that apply.

Select one or more:
- a. The first filter corner should be between the dominant earthquake frequencies and the dominant noise frequencies
- b. The first filter corner should be at the bottom edge of the dominant earthquake frequencies ✓
- c. The second filter corner should be at the bottom edge of the dominant earthquake frequencies
- d. The second filter corner should be between the dominant earthquake frequencies and the dominant noise frequencies ✓
- e. The first filter corner should be at the top edge of the dominant earthquake frequencies

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 32
Correct
1.00 points out of 1.00
Flag question

To properly filter the seismogram and compare it to the original, we need to re-read the seismogram, apply the filter (but you need to specify numbers for FREQ1 and FREQ2), and then read the original seismogram back in, and finally plot the filtered (at the top) and original (at the bottom) seismograms for comparison. Here are the commands you should use:

```
SAC> r *SUR*SAC
SAC> bp corner FREQ1 FREQ2
SAC> r more *SUR*SAC
SAC> p1
```

You can try several filters if you repeat this sequence of commands with different FREQ1 and FREQ2 values. This first time, try a FREQ1 of 0.01 and FREQ2 of 5. How do the filtered and original seismograms compare for this case?

Select one:
- a. The filtered seismogram has a smaller earthquake signal relative to the noise
- b. The filtered seismogram is about the same as the original seismogram ✓
- c. The filtered seismogram has smaller noise relative to the earthquake signal
- d. The filtered seismogram has larger noise relative to the earthquake signal

Check

Correct
Marks for this submission: 1.00/1.00.

Question 33
Correct
0.67 points out of 1.00
Flag question

Using your answers to earlier questions, which filter should we try if we want to focus on preserving the dominant earthquake frequencies and removing the dominant noise frequencies?

Select one:
- a. bp corner 0.16 0.25
- b. bp corner 0.001 0.01
- c. bp corner 0.01 0.1 ✓
- d. bp corner 0.1 1
- e. bp corner 1 10

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 34
Correct
0.67 points out of 1.00
Flag question

Using the series of commands from two questions ago, re-read the seismogram, apply the filter from the previous question, and then read the original seismogram back in, and plot the seismograms for comparison. How do the filtered and original seismograms compare for this case?

Select one:
- a. The filtered seismogram has smaller noise relative to the earthquake signal ✓
- b. The filtered seismogram has a smaller earthquake signal relative to the noise
- c. The filtered seismogram is about the same as the original seismogram
- d. The filtered seismogram has larger noise relative to the earthquake signal

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 35
Correct
0.67 points out of 1.00
Flag question

Using the same sequence of commands but with different FREQ1 and FREQ2 values, I would like you to experiment with the frequency range in your filter. Which of the following reduces the noise the most relative to the earthquake signal to improve our ability to pick the first arrival time?

Select one:
- a. bp corner .01 .09
- b. bp corner .01 .06
- c. bp corner .01 .03 ✓
- d. bp corner .01 .15
- e. bp corner .01 .12
- f. bp corner .01 .18

Check

Correct
Marks for this submission: 1.00/1.00. Accounting for previous tries, this gives **0.67/1.00**.

Question 36
Correct
1.00 points out of 1.00
Flag question

How does the filter that was the correct answer to the previous affect the earthquake signal?

Select one:
- a. It becomes smoothed out. ✓
- b. There is no longer an earthquake signal.
- c. It did not change.
- d. It becomes noisier.

Check

Your answer is correct.
Correct
Marks for this submission: 1.00/1.00.

Finish review