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Started on	Sunday, July 24, 2022, 7:15 AM
State	Finished
Completed on	Sunday, July 24, 2022, 1:37 PM
Time taken	6 hours 22 mins
Marks	34.33/41.00
Grade	**83.74** out of 100.00

Question 1
Correct
1.00 points out of 1.00
Flag question

Using Web Services and SAC to Investigate Surface Wave Seismograms and Speeds

Today we will examine some seismograms to look for basic patterns in surface waves and learn how we characterize their wave speeds and dispersion. In particular, we will look at differences in surface waves that travel through the western United States versus the eastern United States. To do so, we will choose an earthquake in the central United States and then examine the surface waves recorded at similar distances east and west of the earthquake.

To get started looking for an earthquake, what is the geographic center of the contiguous United States? BE CAREFUL: A web search will likely reveal many different choices depending on which United States territories are included. This question is asking for the center of the lower 48 states. Note that there are two correct answers, but either one will work in proceeding through this tutorial.

Select one:

- a. 37.0902, -95.7129
- b. 44.967243, -103.771556
- c. 39.8283, -98.5795 ✓ These are the coordinates for the actual site called "The Geographic Center of the United States"!
- d. 39.8333333, -98.585522
- e. 38.0000, -97.0000
- f. 31.51073, -96.4247

Check

Correct
Marks for this submission: 1.00/1.00.

Question 2
Correct
1.00 points out of 1.00
Flag question

Next, I would like you to identify the largest earthquake within 5 degrees (about 500 km) from this geographic center. To do this, you will need to build a web service request. Which web service is needed to accomplish this? You may want to review the choices at https://service.iris.edu/ .

Select one:

- a. event ✓
- b. traveltime
- c. station
- d. earthquake
- e. distaz

Check

Correct
Marks for this submission: 1.00/1.00.

Question 3
Correct
1.00 points out of 1.00
Flag question

Next you should build the link to use this web service. You can use the URL Builder to help with this. It should use the lat/lon radius option, inputting the latitude and longitude from the first question (be careful not to switch them) and 5 for the maximum radius. No need to set a start and end time as the default will be the entire duration of the catalog. To help identify the largest magnitude event, I would also recommend a minimum magnitude of 5, and to sort the results from largest magnitude to smallest. Remember to choose text file for the output format.

What is the magnitude of the largest event in this region?

Answer: 5.8 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 4
Correct
1.00 points out of 1.00
Flag question

Now I would like you to run this web service on your OSL desktop. Before doing so, I would suggest you create a directory called **surface** inside the **irisdmc** directory you would have made in the last assignment, and then `cd` into the new **surface** directory.

As we learned in our last assignment, you can use the command `wget` to retrieve the output of a web service http link. The command should have this format:

```
(iris) jupyter-[your username]:~/irisdmc/surface> wget "link" -O events.txt
```

where the link you built for the previous question has quotation marks around it. The `-O` option tells `wget` to send the output to a file (-O is a Capital O), *events.txt* in this case. Go ahead and run the `wget` command. After you run the full wget command to retrieve the file, which command would you run next to list the number of lines in this output file? Hint: It should have 3 parts, a command, an option, and an input file.

Answer: wc -l events.txt ✓

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 commands would print the line of the *events.txt* file that has the largest magnitude event?

Select one:

- a. awk 'NR==2' events.txt ✓
- b. awk 'NR==15' events.txt
- c. awk 'NR==14' events.txt
- d. awk 'NR==1' events.txt
- e. awk 'NR==3' events.txt

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

What is the latitude of the largest magnitude event?

Answer: 36.4251 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 7
Correct
1.00 points out of 1.00
Flag question

What is the longitude of the largest magnitude event?

Answer: -96.9291 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 8
Correct
1.00 points out of 1.00
Flag question

What is the formatted day and time value of the largest magnitude event? Use the reported format in your answer: yyyy-mm-ddThh:ii:ss where y-year, m-month, d-day, h-hour, i-minute, s-second as used in the text file.

Answer: 2016-09-03T12:02:44 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 9
Correct
1.00 points out of 1.00
Flag question

Next we will use the **station** web service to find a station near the east coast that is nearly due East of the earthquake. To find a station operating at the time of the earthquake, you use the answer from the previous question for both the starttime and endtime of this web service request.

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

Answer: BHZ ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 10
Correct
0.67 points out of 1.00
Flag question

You are almost ready to make the **station** web request. The other things to decide on are the Level of reporting (channel) and the Format (text), along with the location range. I would recommend 36 to 37 for the latitude range to be about the same latitude as the earthquake, and -78 to -75 for the longitude range to look for stations near the east coast.

Which station returned from this web service request is further east? This question is looking for the 4-character station name. Be careful with negative longitudes!

Answer: T59A ✓

Check

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

Question 11
Correct
0.00 points out of 1.00
Flag question

Next, we should try to identify a station that is approximately the same distance west of the earthquake. To approximate this, you can start by estimating the longitude difference between the earthquake and the eastern station in the previous question (simply subtracting one value from the other). Then you can use this longitude and subtract it from the earthquake location to get an approximate longitude of where you would want your western station to be located.

So based on the longitude difference between station and event, what is the longitude we should be looking for in the western United States to give us about the same distance?

Answer: -116.3041 ✓

Check

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

Question 12
Correct
0.67 points out of 1.00
Flag question

Now you should build a station web service request using the same parameters as before to find a station in the western United States, but changing the longitude range to be 0.2 west and 0.2 east of the answer to the previous question. Using these parameters, what is the name of the station you find at a similar distance?

Answer: TPNV ✓

Check

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

Question 13
Correct
0.67 points out of 1.00
Flag question

To get the waveforms, we need to decide on a time range. For this assignment, we can use the origin time of the earthquake for the start time, and 15 minutes later for the end time. What is the properly formatted End Time for the dataselect web service?

Answer: 2016-09-03T12:17:44 ✓

Check

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

Question 14
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 15
Correct
1.00 points out of 1.00
Flag question

Now we need to request the waveforms for the eastern and western stations with the **dataselect** web service. Which command do we use for this on the OSL desktop?

Answer: wget ✓

Check

Yes, just make sure you use the format: `wget "link" -O sac.zip`

NOTE: The two links you will need to use this command for and then unzip the downloaded sac.zip file are:

https://service.iris.edu/fdsnws/dataselect/1/query?sta=TPNV&cha=BHZ&starttime=2016-09-03T12:02:44&endtime=2016-09-03T12:17:44&format=sac.zip

https://service.iris.edu/fdsnws/dataselect/1/query?sta=T59A&cha=BHZ&starttime=2016-09-03T12:02:44&endtime=2016-09-03T12:17:44&format=sac.zip

Correct
Marks for this submission: 1.00/1.00.

Question 16
Correct
1.00 points out of 1.00
Flag question

When you unzip the file for the ***eastern*** station, what is the SAC file name?

Answer: N4.T59A..BHZ.M.2016.247.120244.SAC ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 17
Correct
1.00 points out of 1.00
Flag question

When you unzip the file for the ***western*** station, what is the SAC file name?

Answer: US.TPNV.00.BHZ.M.2016.247.120244.SAC ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 18
Correct
1.00 points out of 1.00
Flag question

Now you should use SAC to read in both files. The first thing I would recommend doing is to add the ***earthquake*** event latitude and longitude to the header of these files. You can find the earthquake location from questions earlier in this assignment. Which of the following commands in SAC would accomplish this?

Select one:

- a. lh evlo 36.9716 evla -77.5541
- b. ch evla 36.9716 evlo -77.5541
- c. lh evla 36.4251 evlo -96.9291
- d. ch evlo 36.9716 evla -77.5541
- e. lh evla 36.9716 evlo -77.5541
- f. ch evlo 36.4251 evla -96.9291
- g. lh evlo 36.4251 evla -96.9291
- h. ch evla 36.4251 evlo -96.9291 ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 19
Correct
0.67 points out of 1.00
Flag question

In a previous assignment we used the distaz web service to calculate distance between the source and the receiver. We could do that again here, but if we enter the event location into the SAC file header, then SAC will use the station location stored in the file to calculate the distance as well. SAC calculates this information in km in the DIST header variable, while the distance in degrees is stored in the GCARC header variable (stands for Great Circle ARC). To see the distance value in the SAC header, use the`lh`command.

What is distance to eastern station in km? Round to the nearest 0.01 km.

Answer: 1.729476e+03 ✓

Check

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

Question 20
Correct
1.00 points out of 1.00
Flag question

What is distance to western station in km? Again, round to the nearest 0.01 km.

Answer: 1.724795e+03

Check

Correct
Marks for this submission: 1.00/1.00.

Question 21
Correct
1.00 points out of 1.00
Flag question

You should find that the distances to each station are almost the same (only ~0.3% difference). The similar distances means that we should expect the arrival times to be similar if the seismic wave speeds are similar in the eastern and western United States. We will test this idea by examining P waves that travel through the earth and Rayleigh waves that travel along the surface of the earth. Let's start with the P waves. Go ahead and pick the P wave time for both stations.
A hint is that the P wave is easier to see on TPNV so start with that one, but the P wave arrives at a similar time for the other station.
Which of the following would be needed to pick the P wave and save it to the SAC file header?
Please note that there will be 4 steps necessary to pick and save the information, starting from the command window.

Select one or more:
- a. Typing wh in the plot window
- b. Typing q in the plot window ✓ 1 of 4 correct answers.
- c. Typing wh in the command window ✓ 1 of 4 correct answers.
- d. Typing ppk in the plot window
- e. Typing p in the plot window ✓ 1 of 4 correct answers.
- f. Typing p in the command window
- g. Typing q in the command window
- h. Typing ppk in the command window ✓ 1 of 4 correct answers.

Check

Correct
Marks for this submission: 1.00/1.00.

Question 22
Correct
0.67 points out of 1.00
Flag question

Now use the `lh` command to list the header and look for the P arrival time stored in the AMARKER variable. Fortunately, the waveform we downloaded starts at the origin time of the earthquake, so the pick times are in fact the time it takes for those phases to travel to the station. What is the travel time for the eastern station P wave?

Answer: 216.78

Check

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

Question 23
Correct
0.67 points out of 1.00
Flag question

What is the travel time of the western station P wave?

Answer: 216.9

Check

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

Question 24
Correct
0.50 points out of 1.00
Flag question

Using the distance between the event and the eastern station, what was the average speed of the P wave traveling through the eastern United States? Hint: speed = distance / time.

Answer: 7.98

Check

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

Question 25
Correct
1.00 points out of 1.00
Flag question

What was the average speed of the P wave traveling through the western United States?

Answer: 7.95

Check

Correct
Marks for this submission: 1.00/1.00.

Question 26
Correct
1.00 points out of 1.00
Flag question

Seismologists often talk about seismic wave speed differences in terms of percentages. Percentage differences are typically calculated using:
(a - b) / b * 100
What is the percent difference between the eastern and western United States based on the P wave speeds you estimated?
This question is looking for a percentage number, so no need to include the % sign in your answer.

Answer: 0.37

Check

Correct
Marks for this submission: 1.00/1.00.

Question 27
Correct
1.00 points out of 1.00
Flag question

If you were to use the TauP software that we learned about in one of the earlier assignments, you could plot the ray path of the P wave for the distance of the observations. You would find that much of the path of the P wave travels between 100 and 200 km depth. So what does the difference in P wave speeds suggest about the Earth structure? Seismic wave speed anomalies greater than 2% would be considered substantially different.

Select one:
- a. The upper mantle beneath eastern and western United States is substantially different.
- b. The upper mantle beneath eastern and western United States is not very different. ✓
- c. The crust beneath eastern and western United States is substantially different.
- d. The lower mantle beneath eastern and western United States is substantially different.
- e. The crust beneath eastern and western United States is not very different.
- f. The lower mantle beneath eastern and western United States is not very different.

Check

Correct
Marks for this submission: 1.00/1.00.

Question 28
Correct
1.00 points out of 1.00
Flag question

Next we will focus on the surface waves instead of the P wave. We will use a filter to focus on the ***lowest*** frequencies and remove the higher frequency energy that dominates the raw seismogram. Which type of filter would accomplish this?

Select one:
- a. band-pass
- b. high-pass
- c. low-pass ✓
- d. convolution
- e. Fourier transform

Check

Correct
Marks for this submission: 1.00/1.00.

Question 29
Correct
0.33 points out of 1.00
Flag question

When filtering, it is a good idea to remove the mean from your signal first, to avoid spikes at the beginning and end of the time series. Here are the commands I would recommend to accomplish the filtering of the surface waves below 0.03 Hz.

```
SAC> rmean
SAC> lp c .03 n 4
```

I am suggesting you use the `n 4` option which indicates the number of poles in the filter is doubled from the default 2 to 4, which represents a "stronger" reduction of energy above the corner of 0.03 Hz.
Next you should use ppk to pick the four largest peaks in the filtered time series. I would recommend using the t1, t2, t3, and t4 variables to store these arrival times. So when in the ppk window, place the cursor where you want to pick and type the "t" key and then the number key. When you are done picking both seismograms do not forget to type q in the plot window and then `wh` in the command window to save your picks. You can then use `lh` to see your pick times.
What is the time of the first peak (t1) for the eastern station?

Answer: 476.74

Check

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

Question 30
Correct
1.00 points out of 1.00
Flag question

What is the time of the fourth peak for the eastern station?

Answer: 572.52

Check

Correct
Marks for this submission: 1.00/1.00.

Question 31
Correct
0.50 points out of 1.00
Flag question

What is the time of the first peak for the western station?

Answer: 499.19

Check

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

Question 32
Correct
0.50 points out of 1.00
Flag question

What is the time of the fourth peak for the western station?

Answer: 590.51

Check

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

Question 33
Correct
1.00 points out of 1.00
Flag question

What is the surface wave speed associated with the first peak for the eastern station? Recall what the equation for speed is from an earlier question.
Round off to at least 3 decimal places.

Answer: 3.628

Check

Correct
Marks for this submission: 1.00/1.00.

Question 34
Correct
1.00 points out of 1.00
Flag question

What is the surface wave speed associated with the fourth peak for the eastern station?
Round off to at least 3 decimal places.

Answer: 3.020

Check

Correct
Marks for this submission: 1.00/1.00.

Question 35
Correct
1.00 points out of 1.00
Flag question

What is the surface wave speed associated with the first peak for the western station?
Round off to at least 3 decimal places.

Answer: 3.455

Check

Correct
Marks for this submission: 1.00/1.00.

Question 36
Correct
1.00 points out of 1.00
Flag question

What is the surface wave speed associated with the fourth peak for the western station?
Round off to at least 3 decimal places.

Answer: 2.920

Check

Correct
Marks for this submission: 1.00/1.00.

Question 37
Correct
1.00 points out of 1.00
Flag question

What is the percent difference in seismic wave speeds between the eastern and western United States for the first peak of the surface waves? You may want to review Question 26 since this question is similar to that one.

Answer: 5.00723589001

Check

Correct
Marks for this submission: 1.00/1.00.

Question 38
Correct
1.00 points out of 1.00
Flag question

Considering the surface waves mainly involve motion of the uppermost 50 km of the Earth, what does the difference in surface wave speeds suggest about the Earth structure? Seismic wave speed anomalies greater than 2% would be considered substantially different.

Select one:
- a. The lower mantle beneath eastern and western United States is not very different.
- b. The upper mantle beneath eastern and western United States is substantially different.
- c. The upper mantle beneath eastern and western United States is not very different.
- d. The crust beneath eastern and western United States is not very different.
- e. The lower mantle beneath eastern and western United States is substantially different.
- f. The crust beneath eastern and western United States is substantially different. ✓

Check

Correct
Marks for this submission: 1.00/1.00.

Question 39

Next you will use PPK to measure the wave period (the inverse of the frequency) of the first surface wave peak recorded at the eastern station. I will recommend picking the precise time of the trough immediately before the peak and the precise time of the trough immediately after the peak, and then subtracting the difference.

Correct

1.00 points out of 1.00

Flag question

I would recommend using the T5 variable to store the time of the trough before the first peak and the T6 variable for the trough after the first peak. Be careful to zoom in enough to make an accurate pick of the lowest part of the troughs.

In essence, we are estimating the wave period with a trough-to-trough time measurement. Using T6 minus T5, what wave period do you measure for the first surface wave peak recorded at the eastern station? Make sure your answer is a positive number.

Answer: 44.58

Check

Correct

Marks for this submission: 1.00/1.00.

Question 40

Partially correct

0.50 points out of 1.00

Flag question

Next you will use PPK to measure the wave period of the fourth surface wave peak recorded at the eastern station. I will recommend using the T7 variable to store the time of the trough before the fourth peak and the T8 variable for the trough after the fourth peak. Again, be careful to zoom in enough to make an accurate pick of the lowest part of the troughs. Using T8 minus T7, what wave period do you measure for the fourth surface wave peak recorded at the eastern station?

Answer: 20.03

Check

This is the time period for the fourth peak for the western station.

Partially correct

Marks for this submission: 0.50/1.00.

Question 41

Correct

0.33 points out of 1.00

Flag question

The phenomena of different periods of the surface wave traveling at different speeds is called dispersion. Dispersion happens for surface waves because the period of the surface wave is related to how deep the Earth is involved in the motion. Which of the following relationships explains our observations? You may want to review the lecture material to help with answering this question correctly.

Select one:

- a. shorter period surface waves travel faster than longer period surface waves, meaning that seismic wave speeds increase with depth
- b. longer period surface waves travel faster than shorter period surface waves, meaning that seismic wave speeds increase with depth
- c. longer period surface waves travel faster than shorter period surface waves, meaning that seismic wave speeds decrease with depth
- d. shorter period surface waves travel faster than longer period surface waves, meaning that seismic wave speeds decrease with depth

Check

Correct

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

Finish review