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Started on	Tuesday, August 2, 2022, 9:49 AM
State	Finished
Completed on	Tuesday, August 2, 2022, 2:14 PM
Time taken	4 hours 25 mins
Marks	36.33/38.00
Grade	**95.61** out of 100.00

Question 1

Correct

1.00 points out of 1.00

Flag question

Network Tutorial 3: Focal Mechanisms

10.1 Preparing to Determine Earthquake Focal Mechanisms

In our activity today, we will take a closer look at determining the focal mechanisms of earthquakes based on P wave polarities. The up or down motion observations of first arrivals will provide us with the key information about what the focal mechanisms is and we will use an inversion to calculate the best estimate of that fault plane solution. I have collected a set of seismograms that record the P waves for an earthquake from inland Northern California. This region marks the western end of the Basin and Range Province and the southern end of the Cascadia Subduction Zone, as well as being near the northern end of the San Andreas Fault. See the map below:

When an earthquake occurs in this region, it is important to determine what forces are causing them to occur and the orientation of the fault slip to interpret which of these tectonic regimes is generating the activity. Moreover, the hazard implications are different for each of these tectonic regimes.

To start looking at this example event, we will use `SAC`. Since we will be making some new files for this activity, you will need to login to your OSL desktop, and then create a new directory called **focmec** inside your home directory. What is the correct order of commands below to first make sure you are in your home directory (/home/jovyan or ~) and next create, check, and then enter this **focmec** directory?

pwd	1 ✓
cd focmec	4 ✓
ls focmec	3 ✓
mkdir focmec	2 ✓

Check

Your answer is correct.

The correct answer is: pwd – 1, cd focmec – 4, ls focmec – 3, mkdir focmec – 2

Correct

Marks for this submission: 1.00/1.00.

Question 2

Correct

1.00 points out of 1.00

Flag question

After you enter this new directory you will need to copy the seismograms for this Northern California earthquake. Those seismograms are in the following database directory: **/home/jovyan/iris_data/SSBWFiles/Seismograms/focmec** . Alternatively, you can obtain these seismograms from the IRIS WILBER3 site for the 2013-05-24 03:47:08 event in Northern California by specifying all networks, BHZ and HHZ channels, and distances from 0 to 3. On the OSL desktop, the seismograms are stored in files with filenames that end in .**SAC** that you can use when trying to copy them. Which command would you use to copy these files to your current **focmec** directory?

Select one:

- a. cp /home/jovyan/iris_data/SSBWFiles/Seismograms/focmec .
- b. copy /home/jovyan/iris_data/SSBWFiles/Seismograms/focmec/*.SAC
- c. copy /home/jovyan/iris_data/SSBWFiles/Seismograms/focmec .
- d. cp /home/jovyan/iris_data/SSBWFiles/Seismograms/focmec/*.SAC
- e. copy /home/jovyan/iris_data/SSBWFiles/Seismograms/focmec/*.SAC .
- f. cp /home/jovyan/iris_data/SSBWFiles/Seismograms/focmec/*.SAC . ✓

Check

The correct answer is: cp /home/jovyan/iris_data/SSBWFiles/Seismograms/focmec/*.SAC .

Correct

Marks for this submission: 1.00/1.00.

Question 3

Correct

1.00 points out of 1.00

Flag question

First, you should list the files to see what filenames copied over. How many SAC files are there?

Answer: 72 ✓

Check

The correct answer is: 72

Correct

Marks for this submission: 1.00/1.00.

Question 4

Correct

1.00 points out of 1.00

Flag question

Which components are included in the files that you copied over? Choose all that apply.

Select one or more:

- a. BHN
- b. HHE
- c. HHZ ✓ 1 of 2 correct answers
- d. BHZ ✓ 1 of 2 correct answers
- e. HHN
- f. BHE

Check

The correct answer is: BHZ, HHZ

Correct

Marks for this submission: 1.00/1.00.

Question 5

Correct

1.00 points out of 1.00

Flag question

What type of motion do these components record best? Choose all that apply.

Select one or more:

- a. S waves
- b. P waves ✓ 1 of 2 correct answers
- c. Vertical motion ✓ 1 of 2 correct answers
- d. Horizontal motion

Check

The correct answer is: Vertical motion, P waves

Correct

Marks for this submission: 1.00/1.00.

Question 6

Correct

1.00 points out of 1.00

Flag question

10.2 Using SAC to Pick P Wave Polarities

Now that we have collected some seismograms that contain the P wave arrivals, we need to pick the polarities in SAC. First, how do we start SAC?

Select one:

- a. chmod +X SAC
- b. sac ✓
- c. start sac
- d. chmod +x sac
- e. SAC
- f. start SAC

Check

The correct answer is: sac

Correct

Marks for this submission: 1.00/1.00.

Question 7

Correct

1.00 points out of 1.00

Flag question

Once inside SAC, how do we load those seismograms into SAC?

Select one:

- a. *.SAC
- b. load *.SAC
- c. l .SAC
- d. read .SAC
- e. .SAC
- f. r *.SAC ✓

Check

The correct answer is: r *.SAC

Correct

Marks for this submission: 1.00/1.00.

Question 8

Correct

1.00 points out of 1.00

Flag question

A key aspect of determining focal mechanisms is looking for patterns in the first motion polarities for recordings at different azimuths from the source. To help keep this in mind while looking at the seismograms, it would be a good idea to sort the seismograms by azimuth. What should we type into SAC to sort the seismograms by azimuth?

Answer: sort az ✓

Check

Correct, please run the command `sort az` now to successfully sort the files.

The correct answer is: sort az

Correct

Marks for this submission: 1.00/1.00.

Question 9

Correct

1.00 points out of 1.00

Flag question

Which command will plot seismograms and allow us to zoom in around the P arrival and pick the arrival times?

Select one:

- a. plot2
- b. p1
- c. ppk ✓
- d. plot

Check

The correct answer is: ppk

Correct

Marks for this submission: 1.00/1.00.

Question 10

Correct

1.00 points out of 1.00

Flag question

Which option would plot one seismogram per screen for picking?

Select one:

- a. prescreen one
- b. perplot 1 ✓ Correct, now run the command: ppk perplot 1
- c. perscreen 1
- d. ppk one
- e. perplot one
- f. ppk 1

Check

The correct answer is: perplot 1

Correct

Marks for this submission: 1.00/1.00.

Question 11

Correct

1.00 points out of 1.00

Flag question

What is the first station that you see?

Answer: TREE ✓

Check

The correct answer is: TREE

Correct

Marks for this submission: 1.00/1.00.

Question 12

Correct

1.00 points out of 1.00

Flag question

Over the next several questions, we will pick P-wave arrivals. But first, we must make sure we remember how to use the plot picking tool (ppk) in SAC. Please match each command with the key you would enter while your mouse is highlighting the plotting window (NOT the command window).

Mark the beginning and end of the X-axis range to zoom in	X ✓
Return to the old X-axis range to zoom out	O ✓
Stop picking	Q ✓
Move back to the previous seismograms	B ✓
Move on to the next seismograms	N ✓
Pick the P wave arrival time	P ✓

Check

Be careful to make sure you type these one letter keys in the plotting window. This is VERY IMPORTANT with the Q key, because if you type the Q key into the command window instead of your plot window by accident, it will not quit ppk and it might quit you from SAC instead once you do quit from ppk. This is a common issue for newbies with SAC and can be VERY frustrating if the arrival times you picked are not yet saved to the SAC files. If this happens, you will have to re-enter commands once you start SAC again and repick the seismograms, so BE CAREFUL.

The correct answer is: Mark the beginning and end of the X-axis range to zoom in – X, Return to the old X-axis range to zoom out – O, Stop picking – Q, Move back to the previous seismograms – B, Move on to the next seismograms – N, Pick the P wave arrival time – P

Correct
Marks for this submission: 1.00/1.00.

Question 13
Correct
1.00 points out of 1.00
Flag question

Now I would like you to start picking the polarities. You can do this when you pick the P arrival by specifying the polarity right before you pick the P arrival time. Move your cursor to where the P arrival is, then hit the U key for up or D key for down and then hit the P key to indicate it is a P arrival. This should store the information as IPU0 or IPD0 depending on up or down. (The I stands for Impulsive, the P stands for P wave, and the U/D stands for Up/Down.) Go ahead and pick the polarity and arrival time for the first station. Which label did SAC show once you made the pick?

Select one:
- a. IPD0
- b. None
- c. IPU0 ✓
- d. A
- e. P

Check

The correct answer is: IPU0

Correct
Marks for this submission: 1.00/1.00.

Question 14
Correct
1.00 points out of 1.00
Flag question

Use the N key in the ppk seismogram window to move to the next station seismogram and pick the polarity and arrival time. What is the station name and corresponding label you got once you picked the seismogram?

Select one or more:
- a. FS01B
- b. TREE
- c. WVOR ✓ 1 of 2 correct answers
- d. BMN
- e. IPU0 ✓ 1 of 2 correct answers
- f. FS02B
- g. IPD0

Check

The correct answer is: WVOR, IPU0

Correct
Marks for this submission: 1.00/1.00.

Question 15
Correct
1.00 points out of 1.00
Flag question

Go ahead and continue picking additional seismograms until you get to a seismogram that has a negative (down) P wave polarity. What is the station name?

Answer: PAH ✓

Check

The correct answer is: PAH

Correct
Marks for this submission: 1.00/1.00.

Question 16
Correct
1.00 points out of 1.00
Flag question

Go ahead and continue picking additional seismograms until you get to station BEK. What is the polarity of this station?

Select one:
- a. Up
- b. Down ✓

Check

The correct answer is: Down

Correct
Marks for this submission: 1.00/1.00.

Question 17
Correct
1.00 points out of 1.00
Flag question

Go ahead and continue picking additional seismograms until you get to station MOD. What is the polarity of this station?

Select one:
- a. Down ✓
- b. Up

Check

The correct answer is: Down

Correct
Marks for this submission: 1.00/1.00.

Question 18
Correct
1.00 points out of 1.00
Flag question

Go ahead and continue picking additional seismograms until you get to station DIX. What is the polarity of this station?

Select one:
- a. Up ✓
- b. Down

Check

The correct answer is: Up

Correct
Marks for this submission: 1.00/1.00.

Question 19
Correct
1.00 points out of 1.00
Flag question

You should not pick polarities and arrival times for stations that do not have clear P wave arrivals. It is common practice to zoom in to see the first motion polarity more clearly, but I have purposely chosen an example earthquake where the waveforms are relatively clear such that you should not need to zoom in really close to the first arrival to see what the first motion polarity is. However, if you encounter a station seismogram where you are not certain what the polarity is, then you should not record the polarity by not picking that seismogram. Go ahead and continue picking additional seismograms until you get to a seismogram that clearly does NOT have a P wave arrival above the noise level and hence no clear polarity information. What is the station name?

Reminder: if you're having trouble reading the station names, you can increase the size of or full screen the window containing the plots.

Answer: J09B ✓

Check

The correct answer is: J09B

Correct
Marks for this submission: 1.00/1.00.

Question 20
Correct
1.00 points out of 1.00
Flag question

It may take some time to go through and pick all of the good seismograms. And if you miss picking a seismogram or change your mind later, you can just run the `ppk perplot 1` again to go through the seismograms again. Once you are done picking, you should save the polarity picks into the SAC files. Which command do you use to store these polarity picks in the header of the SAC file?

Select one:
- a. save
- b. write header
- c. sh
- d. wh ✓
- e. write
- f. save header

Check

The correct answer is: wh

Correct
Marks for this submission: 1.00/1.00.

Question 21
Correct
1.00 points out of 1.00
Flag question

Which command will allow you to exit sac?

Answer: q ✓

Check

The correct answer is: quit

Correct
Marks for this submission: 1.00/1.00.

Question 22
Correct
1.00 points out of 1.00
Flag question

10.3 The focmec Program for Determining an Earthquake Source Location

Once you return to the linux command line you can download the focal mechanism inversion program called **focmec**. The program tries to find the best fitting fault plane solution to explain the P wave first motion polarities. I have complied a version of focmec in a zip file than can run on your OSL desktop. You can download it like this:

```
(iris) jupyter-[your username]:~/focmec> wget "http://www.users.miamioh.edu/brudzimr/classes/focmec_linux-binlib.zip"
```

Which of the following responses did you receive when you run your wget command?

Select one:
- a. No response
- b. ERROR 404: Not Found.
- c. wget all done
- d. A response that ends with a line that has "'focmec_linux-binlib.zip' saved" in it. ✓

Check

Your answer is correct.
The correct answer is: A response that ends with a line that has "'focmec_linux-binlib.zip' saved" in it.

Correct
Marks for this submission: 1.00/1.00.

Question 23
Correct
1.00 points out of 1.00
Flag question

After the .zip file has successfully transferred to your OSL desktop, you will need to unpack the zipped file with this command:

```
(iris) jupyter-[your username]:~/focmec> unzip focmec_linux-binlib.zip
```

After unpacking the .zip file, which of the following are listed in your **focmec** directory?

Select one or more:
- a. ONLY the focmec_linux-binlib.zip file and the SAC files are listed
- b. bin/ ✓ 1 of 4 correct.
- c. lib/ ✓ 1 of 4 correct.
- d. SV.sgf ✓ 1 of 4 correct.
- e. SAC files ✓ 1 of 4 correct.

Check

Your answer is correct.
The correct answer is: SAC files, bin/, lib/, SV.sgf

Correct
Marks for this submission: 1.00/1.00.

Question 24
Correct
1.00 points out of 1.00
Flag question

Now that you have the program **focmec** on your OSL desktop, there is one more step before you can run the program. You will need to download a simple script I have created called **focmec.csh** that takes the polarity information you have picked in the SAC files as input for **focmec**. My script uses the station distance and azimuth from the earthquake source that was stored in the SAC header and estimates the take off angle of the seismic waves. This is important for connecting your polarity observations with the focal sphere of the earthquake.

The focmec.csh script can be downloaded at http://www.users.miamioh.edu/brudzimr/classes/focmec.csh

What would you type on the command line to download the focmec.csh script?

Answer: wget "http://www.users.miamioh.edu/brudzimr/classes/focmec.csh" ✓

Check

The correct answer is: wget "http://www.users.miamioh.edu/brudzimr/classes/focmec.csh"

Correct
Marks for this submission: 1.00/1.00.

Question 25
Correct
0.67 points out of 1.00
Flag question

The script focmec.csh expects you to specify the SAC files you want to use as input on the command line when you run the program. Before you run the script, you need to make the script executable. Which two of the following commands would correctly make the script executable and then run the script on the files that have the polarity picks?

Select one or more:
- a. chmod +x focmec.csh *.SAC
- b. chmod +x focmec
- c. ./focmec
- d. ./focmec.csh
- e. ./focmec.csh *.SAC ✓ 1 of 2 correct. Yes, run this after you make the script executable.
- f. ./focmec *.SAC
- g. chmod +x focmec.csh ✓ 1 of 2 correct. Yes, run this first before you run the script.
- h. chmod +x focmec *.SAC

Check

The correct answer is: ./focmec.csh *.SAC, chmod +x focmec.csh

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

Question 26
Correct
1.00 points out of 1.00
Flag question

What happens when you correctly run the script?

Select one:
- a. Nothing
- b. A text file pops up
- c. A plot of a focal mechanism pops up ✓
- d. A SAC window pops up
- e. A plot of seismograms pops up

Check

The correct answer is: A plot of a focal mechanism pops up

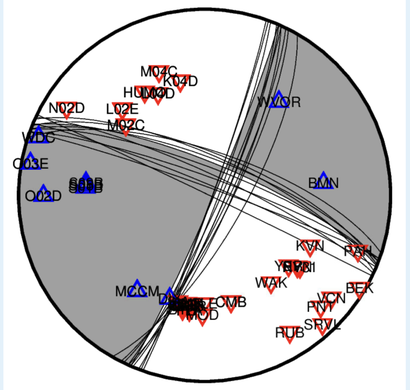
Correct
Marks for this submission: 1.00/1.00.

Question 27
Correct

Does your plot look similar to this? (*It doesn't have to be exact. If you have additional stations plotted then what is shown, it may be because you picked an arrival on a station we thought too noisy to determine the polarity*)

1.00 points out of 1.00

Flag question



Select one:

- a. Yes ✓
- b. No

Check

The correct answer is: Yes

Correct

Marks for this submission: 1.00/1.00.

Question 28

Correct

1.00 points out of 1.00

Flag question

What do you think the triangles represent? Choose all that apply.

Select one or more:

- a. regular blue triangles are up motions ✓ 1 of 2 correct answers
- b. inverted blue triangles are up motions
- c. inverted blue triangles are down motions
- d. inverted red triangles are down motions ✓ 1 of 2 correct answers
- e. inverted red triangles are up motions
- f. regular red triangles are up motions
- g. regular red triangles are down motions
- h. regular blue triangles are down motions

Check

The correct answer is: regular blue triangles are up motions, inverted red triangles are down motions

Correct

Marks for this submission: 1.00/1.00.

Question 29

Correct

1.00 points out of 1.00

Flag question

The thin, slightly curved lines in the plot are fault planes. Why do you think there are many fault planes?

Select one:

- a. The data are NOT consistent with a variety of potential fault planes.
- b. There were errors when picking the polarity.
- c. There is a solution for each station that you picked a polarity on.
- d. The data are consistent with a variety of potential fault planes. ✓

Check

Your answer is correct.

The correct answer is: The data are consistent with a variety of potential fault planes.

Correct

Marks for this submission: 1.00/1.00.

Question 30

Correct

1.00 points out of 1.00

Flag question

The fault planes are determined in part by what parameters are specified in the input for the `focmec` program. The parameters are described in the **focmec.csh** script file, which you can edit with a text editor like `gedit`. A very important parameter specified in this script is the number of allowable polarity errors. If this number is larger, then more possible fault plane solutions will likely be consistent with the data. Use the `head` command to look at the first part of the script file to see what this parameter is set to by default. What is the default number of allowable polarity errors.

Answer: 1 ✓

Check

The correct answer is: 1

Correct

Marks for this submission: 1.00/1.00.

Question 31

Correct

1.00 points out of 1.00

Flag question

Now use a text editor like `gedit` to change the number of allowable polarity errors to 0 and then re-run the focmec.csh script. What do you observe in the plot that results?

Select one:

- a. More potential fault planes are plotted
- b. No fault plane solution is plotted
- c. The same number of potential fault planes are plotted
- d. Less potential fault planes are plotted ✓ Correct, as fewer fault plane solutions can satisfy the data if less polarity errors are allowed.

Check

The correct answer is: Less potential fault planes are plotted

Correct

Marks for this submission: 1.00/1.00.

Question 32

Correct

1.00 points out of 1.00

Flag question

10.4 Interpreting the Earthquake Focal Mechanism

Let's go back to our focal mechanism generated using 1 allowed polarity error. In general, what type of fault does this resulting focal mechanism represent?

Select one:

- a. normal
- b. strike-slip ✓
- c. reverse

Check

The correct answer is: strike-slip

Correct

Marks for this submission: 1.00/1.00.

Question 33

Correct

0.67 points out of 1.00

Flag question

Is the type of focal mechanism consistent with the Cascadia Subduction Zone?

Select one:

- a. Yes
- b. No ✓

Check

The correct answer is: No

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

Considering the specific type of fault slip and the angle of the fault planes, is the focal mechanism potentially consistent with the San Andreas Fault? You may want to review the map from the beginning of this assignment to look at the orientation of the San Andreas Fault.

Select one:

- a. No ✓
- b. Yes

Check

The correct answer is: No

Correct

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

Question 35

Correct

1.00 points out of 1.00

Flag question

The Basin and Range Province consists of roughly north-south oriented normal faults bounded by roughly east-west oriented strike-slip faults. Is the focal mechanism potentially consistent with the Basin and Range? You may want to review the map from the beginning of this assignment to look at the orientation of the Basin and Range faults. Note the raised and lowered topography that are the ranges and basins created by normal faults.

Select one:

- a. No
- b. Yes ✓

Check

The correct answer is: Yes

Correct

Marks for this submission: 1.00/1.00.

Question 36

Correct

0.33 points out of 1.00

Flag question

The reported depth of this earthquake is less than 10 km. Is the depth of the earthquake consistent with your answer to the previous question?

Select one:

- a. Yes, it is relatively shallow and is consistent with deformation of extending crust. ✓
- b. Yes, it is relatively deep and is consistent with the trajectory of a subducting plate.
- c. No, it is relatively deep and is not consistent with the trajectory of a subducting plate.
- d. No, it is relatively shallow and is not consistent with deformation of extending crust.

Check

The correct answer is: Yes, it is relatively shallow and is consistent with deformation of extending crust.

Correct

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

Question 37

Correct

1.00 points out of 1.00

Flag question

Based on your answer to the previous questions, which potential fault plane do you think is the actual fault plane?

Select one:

- a. North-South
- b. Northeast-Southwest
- c. East-West ✓

Check

The correct answer is: East-West

Correct

Marks for this submission: 1.00/1.00.

Question 38

Correct

1.00 points out of 1.00

Flag question

So what type of fault slip does this focal mechanism represent?

Select one:

- a. thrust fault slip
- b. right-lateral strike slip ✓
- c. oblique fault slip
- d. high-angle normal fault slip
- e. left-lateral strike slip

Check

The correct answer is: right-lateral strike slip

Correct

Marks for this submission: 1.00/1.00.

Finish review