

Contact: Tonian Robinson; tonianr@usf.edu

### An Interactive Seismic Refraction Plot using Obspy: graphSEG2

This project focuses on creating an interactive Seismic Refraction plot to save data points related to the direct and refracted wave returns. The use of seismic refraction datasets is crucial to Near-surface geophysical explorations and are often used to delineate depths to bedrock. This project will utilize the Obspy python framework to read SEG2 refraction datasets and plot interactive stream datasets using the [matplotlib.pyplot.ginput](#) function.

This document presents various ways to use the code provided and details supporting materials. Possible **errors** and how to address them are discussed at the end of the document.

### graphSEG2

graphSEG2 uses the [Obspy](#) framework to create an interactive plot of Seismic Refraction datasets. To begin use, make sure to install the Obspy framework using [pip](#) or [conda](#).

#### 1. Recommended installation:

- i. Add obspy to separate conda environment: `conda create -n obspy python=3.8.`
- ii. Initialize the environment using the command while in the anaconda command prompt: `conda activate obspy.`
- iii. Install obspy package: `conda install -c conda-forge obspy.`
- iv. Since this module works best with spyder in activated obspy environment install spyder using `conda install -c conda-forge spyder.`
- v. For missing dependencies e.g. pandas use `conda install pandas.`
- vi. To get started, activate spyder by typing `spyder` in open terminal.

#### 2. Importing function

To import the function, use the code:

```
from graphSEG2 import SEG2grapher
```

This allows the user script in use to have access to the graphSEG2 function and its executables. While in spyder highlight graphSEG2 in the script and press **CTRL + I** for a mini user guide.

#### 3. SEG2grapher.plot

SEG2grapher.plot allows the user to plot Seismic Refraction datasets by utilizing the [obsypy.read](#) SEG2 support function. To execute the SEG2grapher.plot, the user will need to input a *filename*, *gain*. The user will also use this function to make estimates on the best gain value to use for the input file.

```
SEG2grapher.plot(filename, gain)
SEG2grapher.plot('304.dat', 15)
```

Where:

- i. **Filename** (*str*) – should contain a string, e.g., '103.dat.'
- ii. **Gain** (*int*) – should be an integer, e.g., 1 for no gain or 10 to amplify the dataset by a factor of 10

#### 4. SEG2grapher.pick


SEG2grapher.pick allows the user to pick first arrivals for Seismic Refraction datasets by utilizing the [obspy.read](#) SEG2 support function. To execute the SEG2grapher.pick, the user will need to input a *filename*, *gain*, *nclicks*, *original name* and *startpicks*.

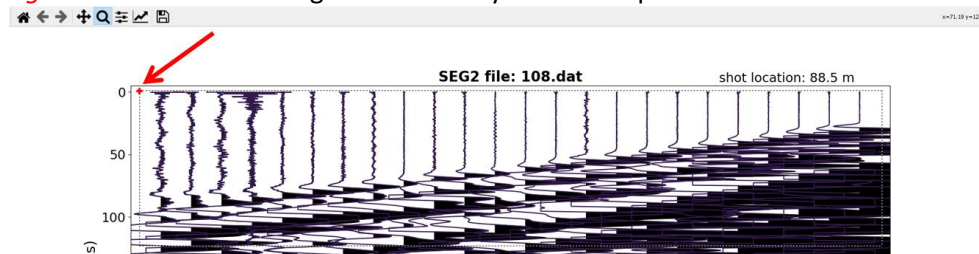
```
SEG2grapher.pick(filename, gain, originalname)
```

```
SEG2grapher.pick('300.dat', 15, 'false')
```

Where:

- i. **Filename (str)** – should contain a string, e.g., '103.dat.'
- ii. **Gain (int)** – should be an integer, e.g., 1 for no gain or 10 to amplify the dataset by a factor of 10
- iii. **Original name (str)** – program asks if the user wants to save the file's original name after completing the first arrival picks. 'true' indicates that the user would like to save picks with the file's original name while 'false' prompts in the python console the user to enter the desirable name after completing picks. The input filename should be *filename.txt*, with no quotations.

- **Important notice:** Zoom tool  in interactive figure window allows user to clearly see first arrivals for picking, however the user risks added an unwanted selection point. If the user decides to use the zoom tool, the user should click the **right mouse** after zooming to remove any unwanted point selections.



After running the above code, the user is prompted to read a mini guide and informed to press **ENTER** to continue or **CTRL+C** to end.

##### 4.1. Making First Arrival Picks

First arrival picking in the module utilizes [matplotlib.pyplot.ginput](#) for interactive selections. When picking points:

- selecting → **LEFT MOUSE**
- removing point → **RIGHT MOUSE**
- end selection → **ENTER** or **CENTER MOUSE**

Note that the user defined the maximum number of selections the user allowed is 96 (within the max time of 5 minutes) but one can exit the selection mode by simply pressing **ENTER** or **CENTER MOUSE**.

## 5. SEG2grapher.analyze

SEG2grapher.analyze allows the user to plot and analyze Seismic Refraction first arrival picks using a Slope Break method to find possible kinks in the plotted first arrivals that would represent the crossover point. To execute the SEG2grapher.analyze, the user will need to input a *pick file* and *show\_autocrossover*.

```
SEG2grapher.analyze(pckfilename, show_autocrossover)
SEG2grapher.analyze('300.txt', 'false')
```

Where:

- i. **Pckfilename** (*str*) – should contain a string of the text file, e.g., '103.txt.' This text file should have x,y dataset space or tab-separated. Where the x column is the distance, and the y column is the time.
- ii. **Show\_autocrossover** (*str*) – indicates whether the user would like to plot all the possible crossover points on the analysis plot; 'true' shows slope breaks while 'false' plots only the analysis and final crossover point.

### 5.1. Slope break method

The Slope Break method applies a single model (eqn.1) with the slope and intercept of two lines; this linear model is then fitted to each dataset (fig.1).

$$\text{eqn 1. } y = b_0 + b_1 + b_2D + b_3Dx$$

Slope breaks are identified by the location of the minimum slope uncertainty for slopes before and after a set kink, i.e., where both lines have a combination of the lowest slope uncertainties.

The equation is solved by computing a simple least-squares calculation and solving for the model parameters, which in this case is the b array:

$$y = Ab \text{ thus } b = A \backslash y$$

Where the A array is a combination of the x and the D arrays.

Example for 5-point array:

$$y = \begin{bmatrix} y \\ y \\ y \\ y \\ y \end{bmatrix} \quad A = \begin{bmatrix} 1 & x & D & D * x \\ 1 & x & D & D * x \\ 1 & x & D & D * x \\ 1 & x & D & D * x \\ 1 & x & D & D * x \end{bmatrix}; \quad b = \begin{bmatrix} b_0 \\ b_1 \\ b_2 \\ b_3 \end{bmatrix}$$

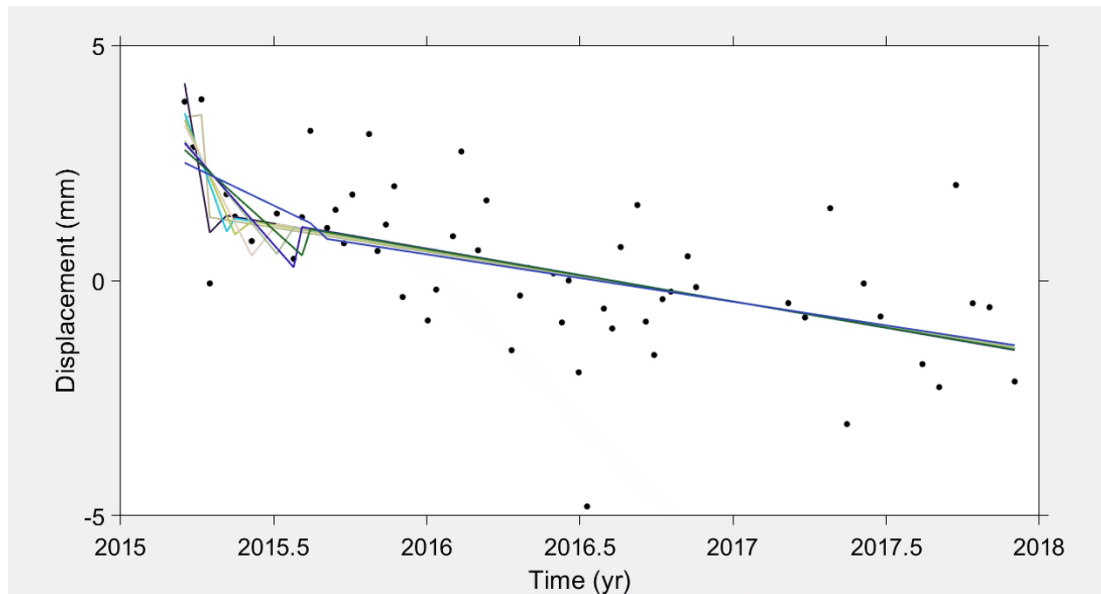


Fig.1.

## 5.2. Linestatistics.py

This function is implemented in the SEG2grapher.analyze function, and it is used to calculate line statistics parameters for each line before and after the Slope Break analysis has been applied. Linestatistics simply uses the input of x,y variables found in a workspace and uses matrix computations. Linestatistics returns the variables: ***m***, ***b***, ***m\_uncertainty***, ***b\_uncertainty***, ***R2***, which are the slope, intercept, slope uncertainty, and R-squared for a given linear dataset.

### 3.2.1 Running Linestatistics.py

To import the function, use the code:

```
from linearstatistics import linestatistics as lstats
```

Run e.g.

```
Statistics = lstats(x,y)
```

## 6. SEG2grapher.crossover

SEG2grapher.crossover allows the user to plot Seismic Refraction first arrival picks from text file and select desired crossover point. To execute the SEG2grapher.crossover, the user will need to input a *filename*.

```
SEG2grapher.crossover(filename, Show_autocrossover )
```

```
SEG2grapher.crossover ('300.txt', 'true')
```

Where:

- i. **Filename** (*str*) – should contain a string, e.g., ‘103.txt.’ This text file should have x,y dataset space or tab-separated. Where the x column is the distance, and the y column is the time.
- ii. **Show\_autocrossover** (*str*) – indicates whether the user would like to plot all the possible crossover points on the analysis plot; ‘true’ shows slope breaks while ‘false’ plots only the analysis and final crossover point.

### 6.1. Findclosestpoint.py

The callable module Findclosestpoint.py was created from a code found on the following forum: <https://codereview.stackexchange.com/questions/28207/finding-the-closest-point-to-a-list-of-points>

It is used to find closest point location within a list of points, it returns the index of the closest point. In SEG2grapher.crossover this code uses the user selected crossover location to find the index of the point in the input file.

#### 6.1.1. Running Findclosestpoint.py

To import the function, use the code:

```
from findclosestpoint import closestpoint
```

Run e.g.

```
Idx_closepoint = closestpoint(pt, pts)
```

Where:

**pt** (*array or list*)—should be a list or array with size **2**, it is a single (x,y) point dataset

**pts** (*array or list*)—should be a list or array with size (**n, 2**), where **n** is the total number of points, it is a series of datapoints

**Example code:**

```
from findclosestpoint import closestpoint
import numpy as np

x = [1,2,3,4,5,6,8]
y = [1,2,3,4,5,6,8]
a = np.stack((x,y))
a = a.T
pt = [3.12, 3.12]
w = closestpoint(pt,a)

print(w)
```

**\*\*Utilize numpy.stack to ensure your array is useable with code.**

## 6.2.

## 7. Other Information

### 7.1. Loading file from another folder

When loading file from folder make sure to source folder.

Example:

```
1 SEG2grapher.pick('./foldername/300.dat',15,'false')
```

OR

```
2 SEG2grapher.analyze('./foldername/102.txt','true')
```

OR

```
3 SEG2grapher.crossover('./foldername/102.txt',true')
```

### 7.2. Saving pick txt file to specified folder

When prompted to input output file name after picking first arrivals (SEG2grapher.pick original name set to 'false') user can add specific file location.

Example when prompted in console:

```
Write the output file's name as filename.txt:  
./foldername/103.txt
```

## 7.3.

## 8. Possible Hiccups

### 8.1. non-GUI Backend Error

**8.1.1. Error message in console:** *Matplotlib is currently using agg, which is a non-GUI backend, so cannot show the figure.*

Fix by changing IPython Console graphics backend to Qt5 in the Preferences window. Source: <https://stackoverflow.com/questions/36700083/in-spyder-plot-using-matplotlib-with-interactive-zoom-etc>

### 8.2. Spyder: rtree dependency missing >0.9.7