# Helioseismology Tutorial: User Manual

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## 1 Requisites

In order to run this software, Python 3.x is required to run properly. If you do not have Python, you can:

- Go to https://www.python.org/ and find the instructions for your appropriate OS. There you can download the Python libraries for your OS.
- Go to https://www.anaconda.com/download/linux and download the Anaconda Python distribution. This option is the recommended due to Anaconda coming packaged with all the required libraries to run the tutorial and with an interpreter.

### 1.1 Python Libraries

The required libraries to run the application are:

- Scipy
- Numpy
- Matplotlib
- Astropy
- PyLab
- Tkinter
- Pillow

If you have Anaconda installed on your computer, you will most likely already have these, but it's good to check.

## 2 Installation

You can find the repository with the tutorial at the following link: https://github.com/softblooper/helioseismology_tutorial

There you can either download a compressed zip folder of the necessary files, or clone and pull the repository on to your local machine.

Once downloaded, you will have to execute the file "heliotut.py" with your Python interpreter.

# 3 User Guide

This section will give you a rundown of the different menus and functions of the tutorial, and how to manipulate images to your desire.

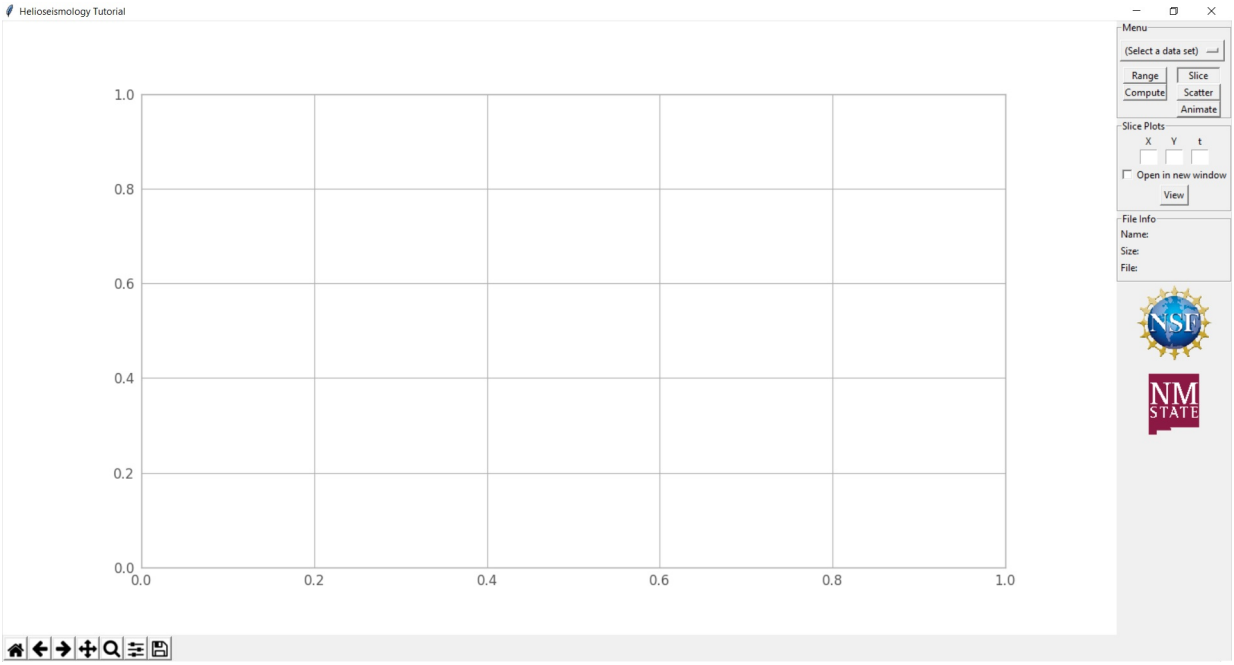


Figure 1: Main software window

This is the main window, where all of the function menus and main image display are available (Figure 1). This is the default view whenever you open the application.

## 3.1 Basic Viewing

The first thing you should know is how to select data to view. On the top left of the side menu, you will find the list of available data sets to choose from when clicked (Figure 2). Pressing view will then display the corresponding image on the main plot axis (Figures 3).

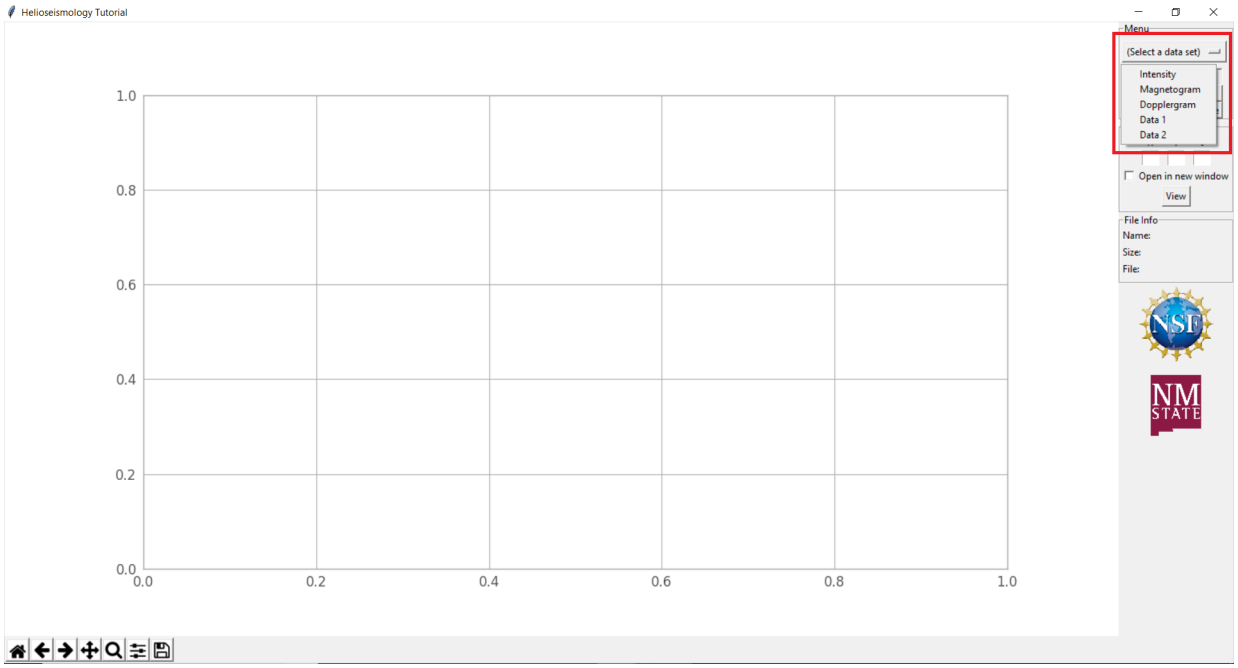


Figure 2: Data selection menu (in red)

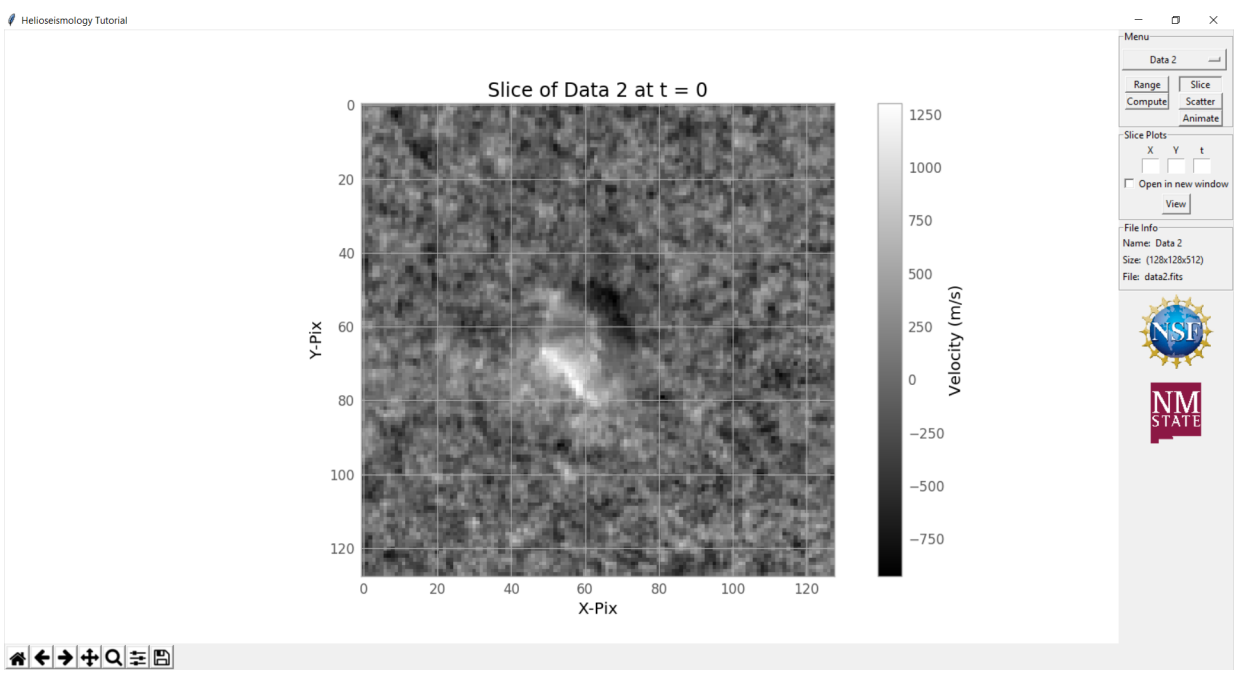


Figure 3: The selected data is displayed

## 3.2 Slice Menu

What was previously used to view the selected image is what's called the Slice menu. Pressing the View button with a 3-Dimensional data set selected will result in it showing the default selection (usually time at $t = 0$).

One can select different points at which to cut a data cube in order to view different "sides" of the cube (Figure 4 and 5).

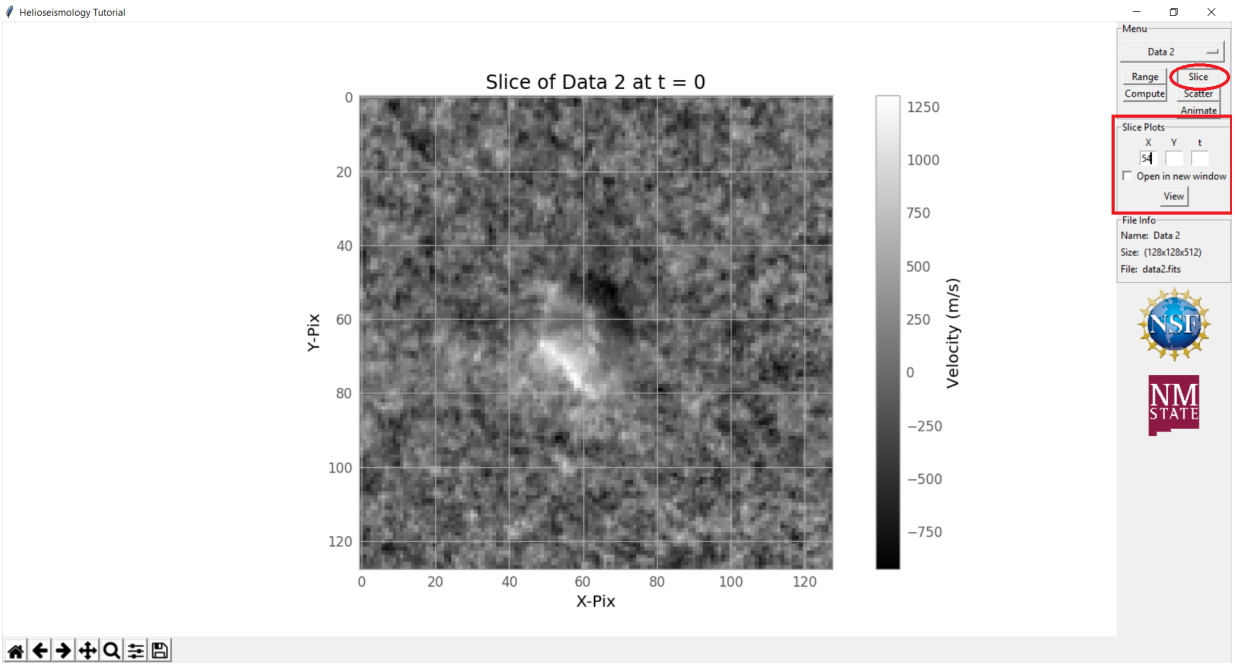


Figure 4: Example: Indicating a certain slice on an axis.

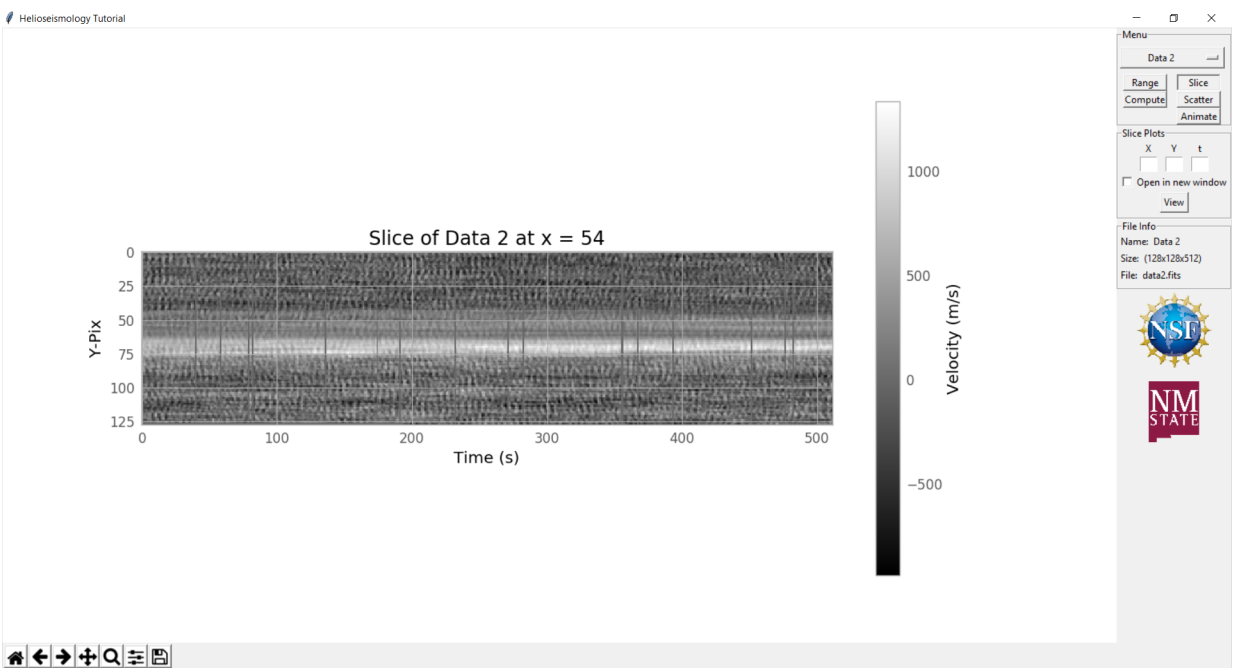


Figure 5: Example: The different slice can be seen.

Double slicing is also possible, allowing you to view how data varies at a certain point (Figure 6 and 7).

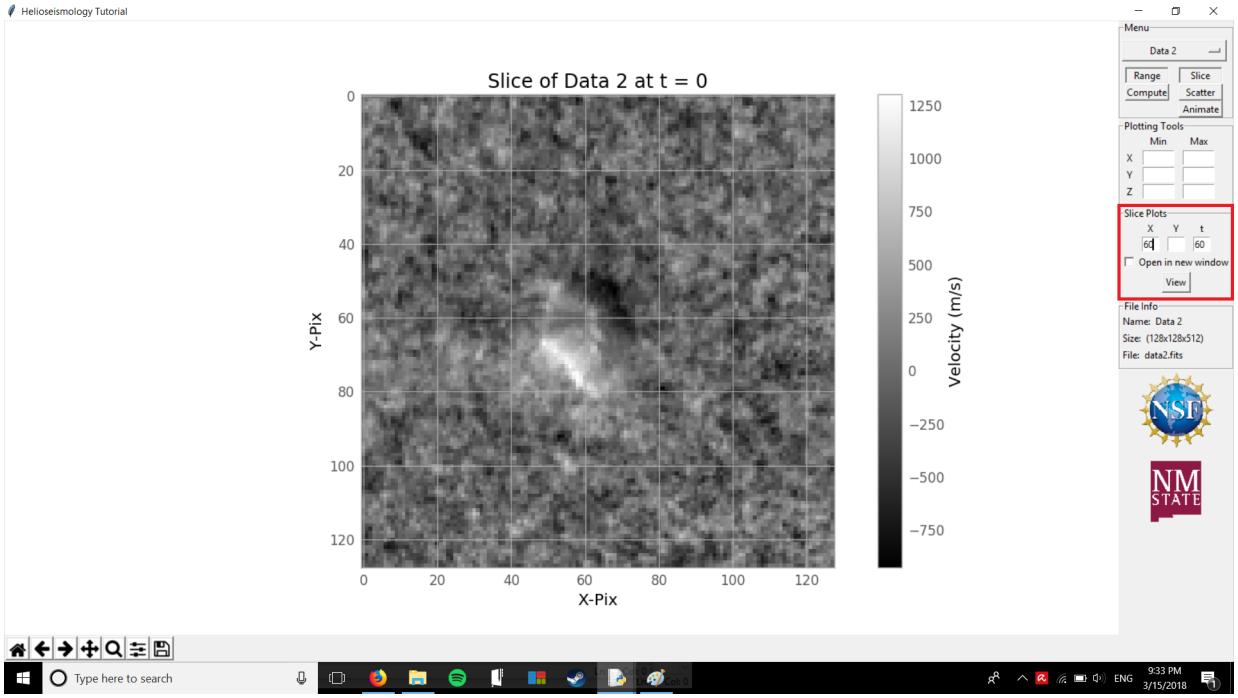


Figure 6: Example: Indicating slices at two different axes.

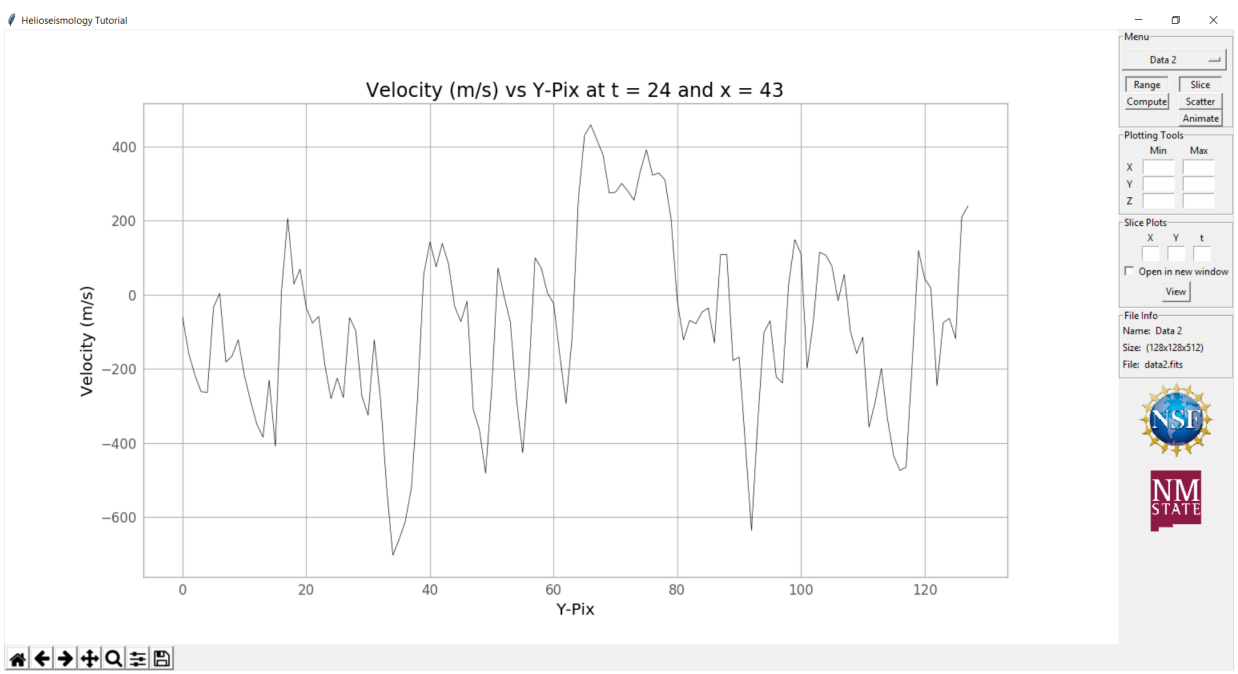


Figure 7: Example: Velocity as seen at the line $t = 24$, $x = 43$.

## 3.3 Computation Menu

The Computation menu allows you to generate new data sets from your selection (only valid for 3-D data set!). After marking the checkboxes of the desired computations, pressing the Compute button will generate new data sets and add them to the main menu selection.

- 2 Min. Average: Takes the average of the first and third image, which are 2 min apart.
- 2 Min. Difference: Subtracts the first image from the third.
- Mean: Takes the mean of the entire data set (along the time axis)
- Residuals: Subtracts the mean from every slice of the selected data set.
- Variance: Sums the square of the residuals, and divides it by the number of slices of the data set.
- Power Spectrum: Calculates the power spectrum of the selected data. (Caution: When viewing the calculated 3D Power Spectrum, the values for frequency and wavenumber seen in the title and used in the Range menu are not the actual values of these parameters, but indices that match that of their respective times and pixels)

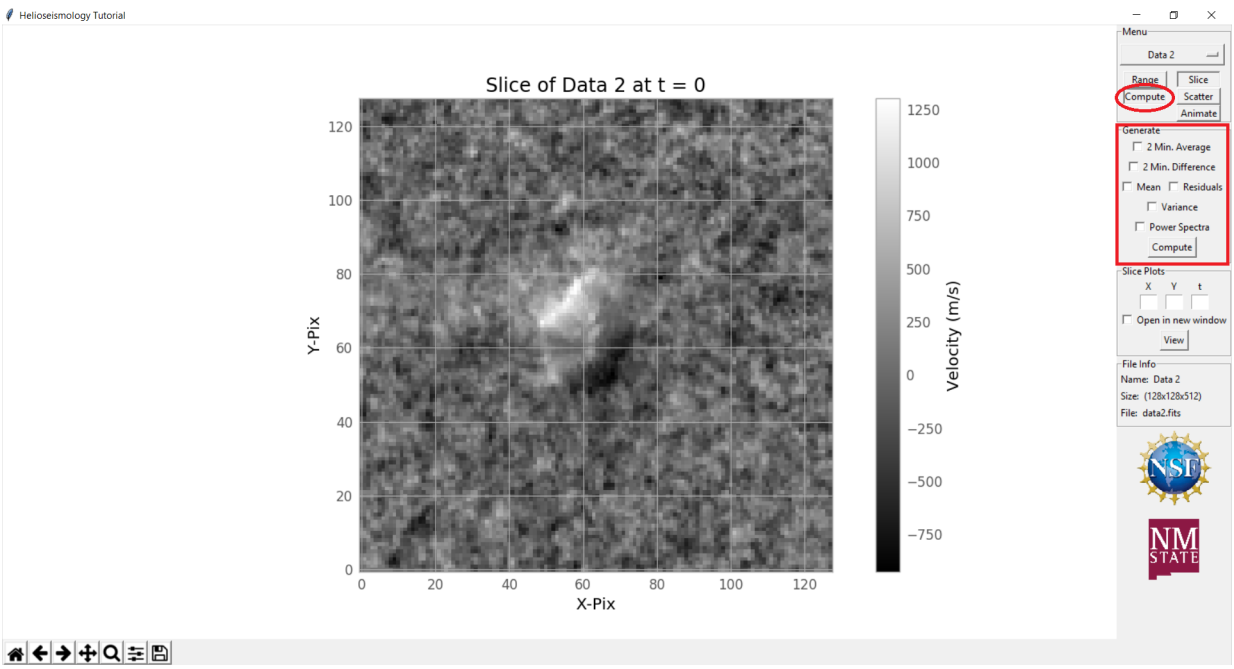


Figure 8: Computation Menu with its different options.

## 3.4 Scatter Plot Menu

A scatter plot to see the relationship between two different data sets can be done through the Scatter menu. Your main selection is considered to be your values for the X-Axis, and then a Y-Axis object must be chosen within the Scatter menu (Figure 9), allowing you to plot them against each other (Figure 10).

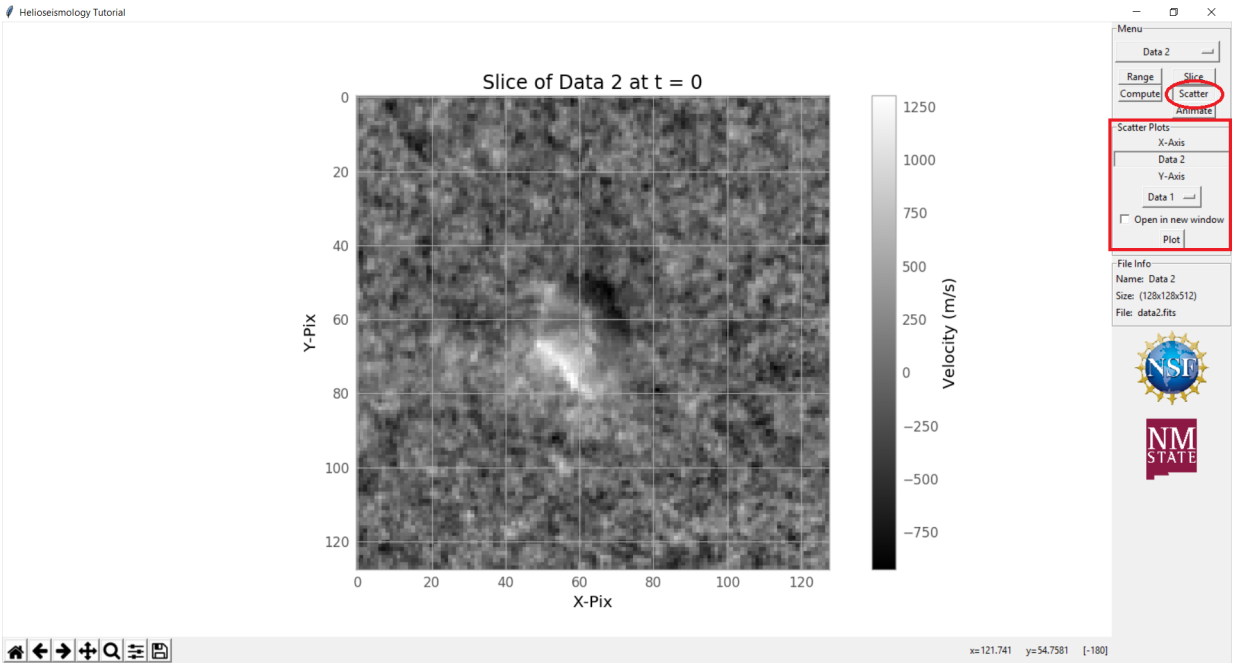


Figure 9: Caption

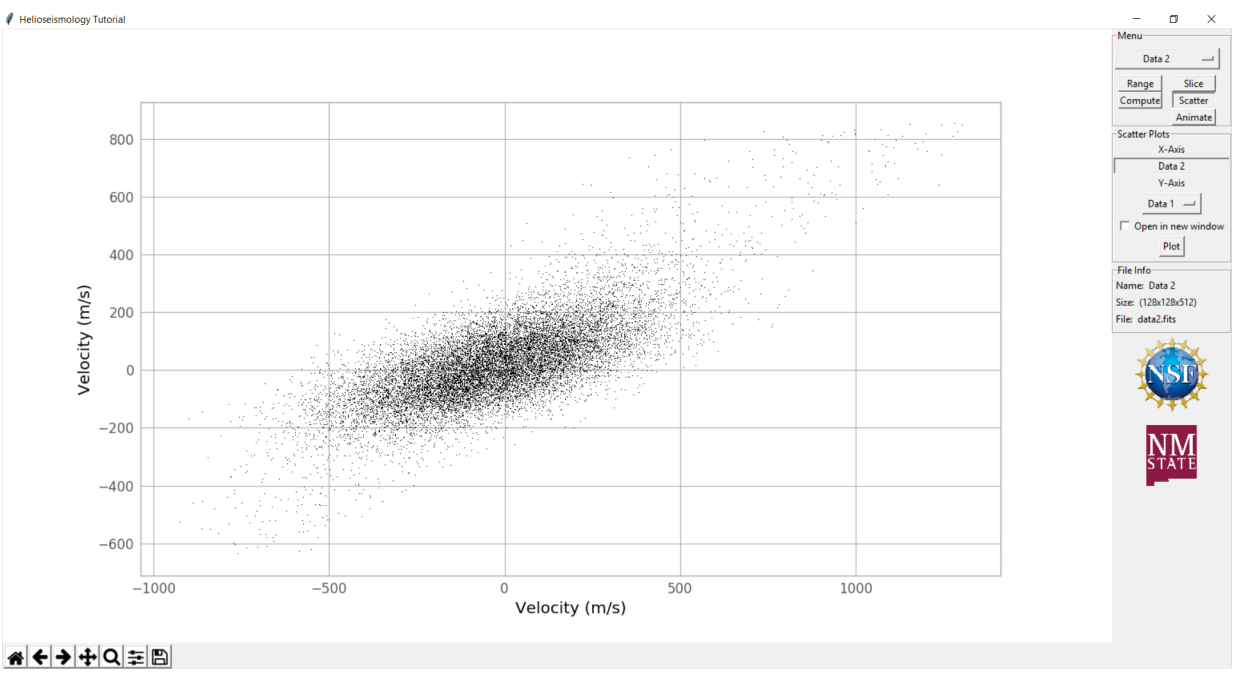


Figure 10: Caption

## 3.5 Animation Menu

The Animation menu allows you to play a sequence of the slices of the selected data set on one of its axis at a predetermined FPS (Figure 11). This will open a new window displaying the animation (Figure 12).

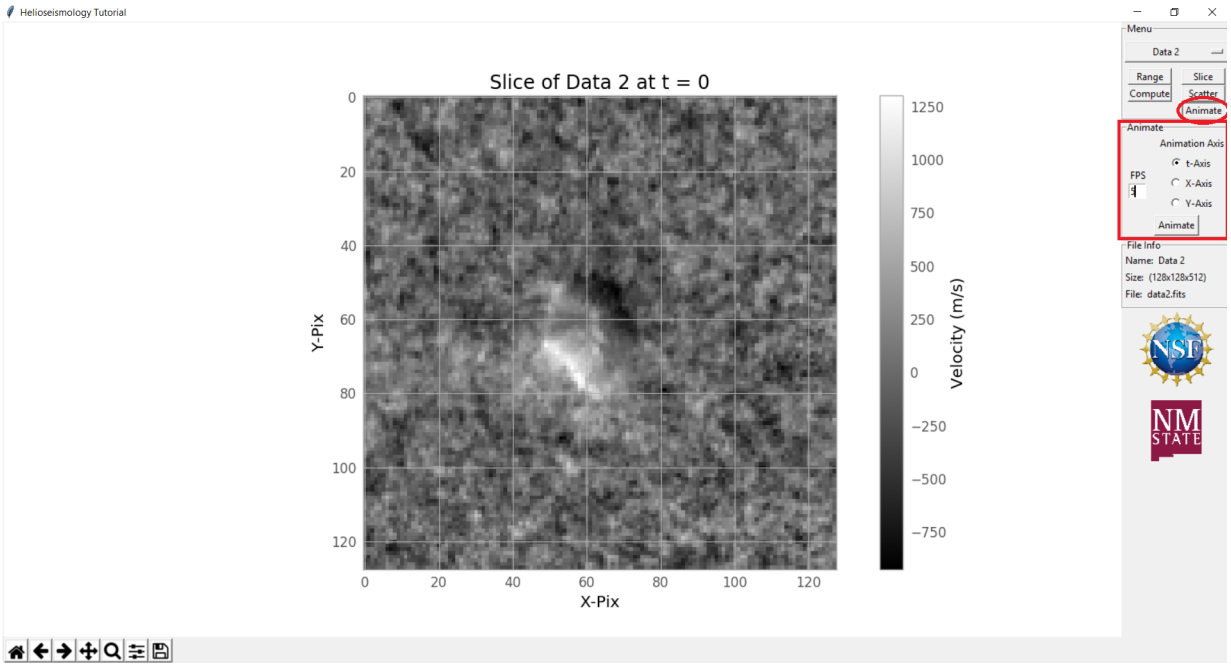


Figure 11: Caption

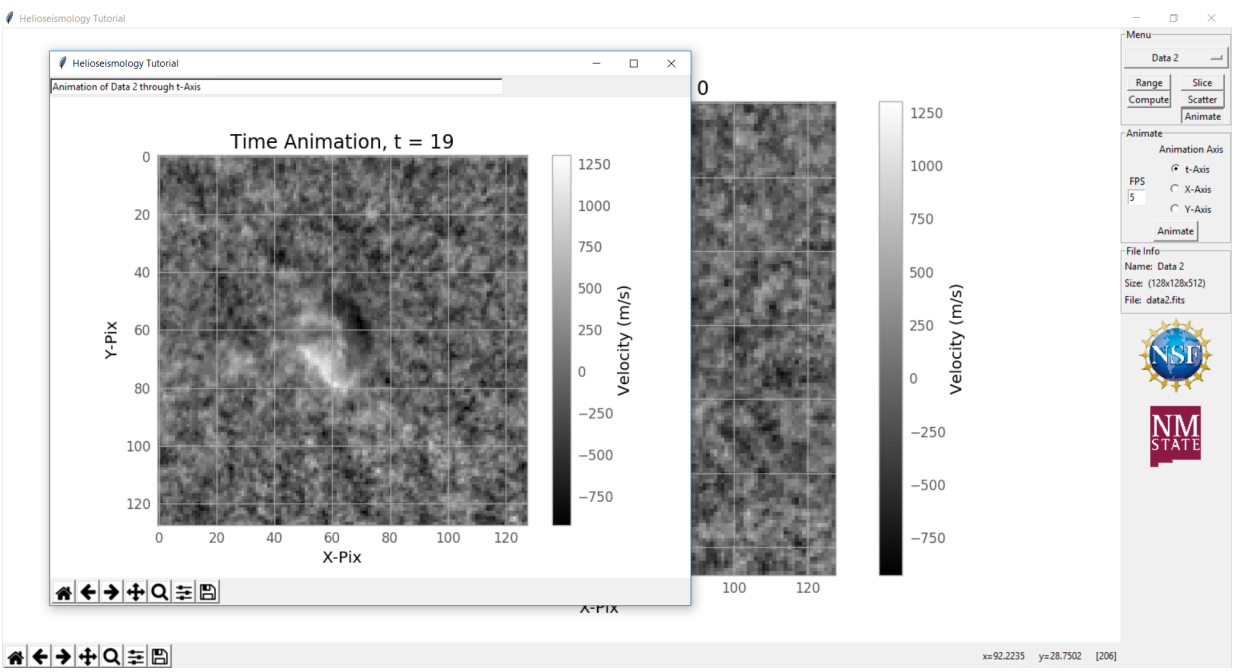


Figure 12: Caption

## 3.6 Range Menu

The Range menu allows the user to change the plotting limits on the different axes as to effectively "zoom in/out" or increase the "contrast" of an image (Figure 13 and 14). Both a minimum and a maximum must be indicated in order for this to work.

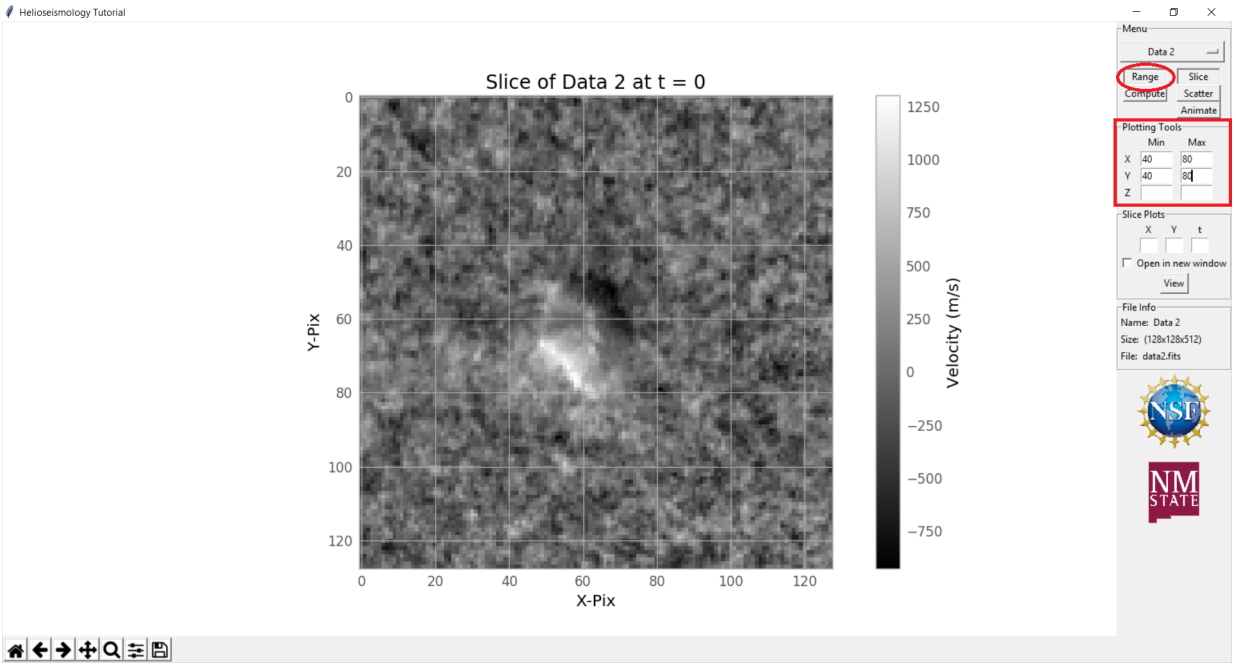


Figure 13: Example: Setting ranges for Data 2 of $x, y \in [40, 80]$

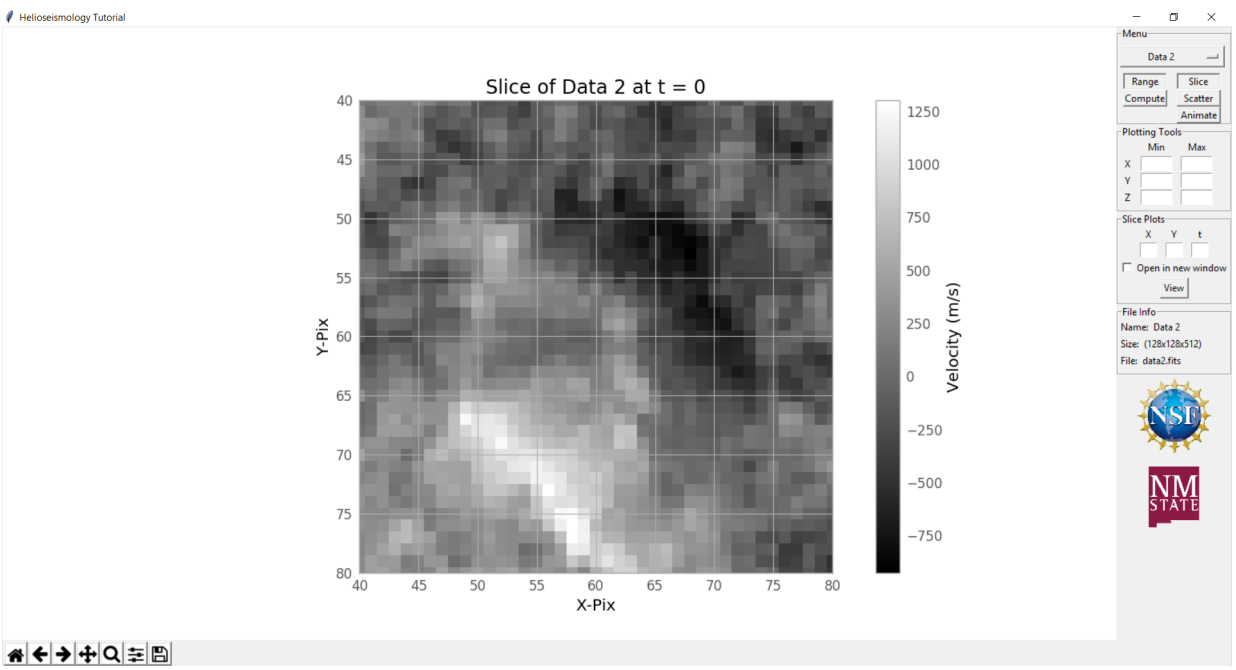


Figure 14: Example: Data 2 from $x, y \in [40, 80]$

## 3.7 New Window

While animations are forced to open in new windows, you have the option of viewing your desired image or scatter plot in either the main window or in a new window. By checking the "Open in new window" box (Figure 15), when plotting/viewing the selected data set, it will appear in a new window (Figure 16).

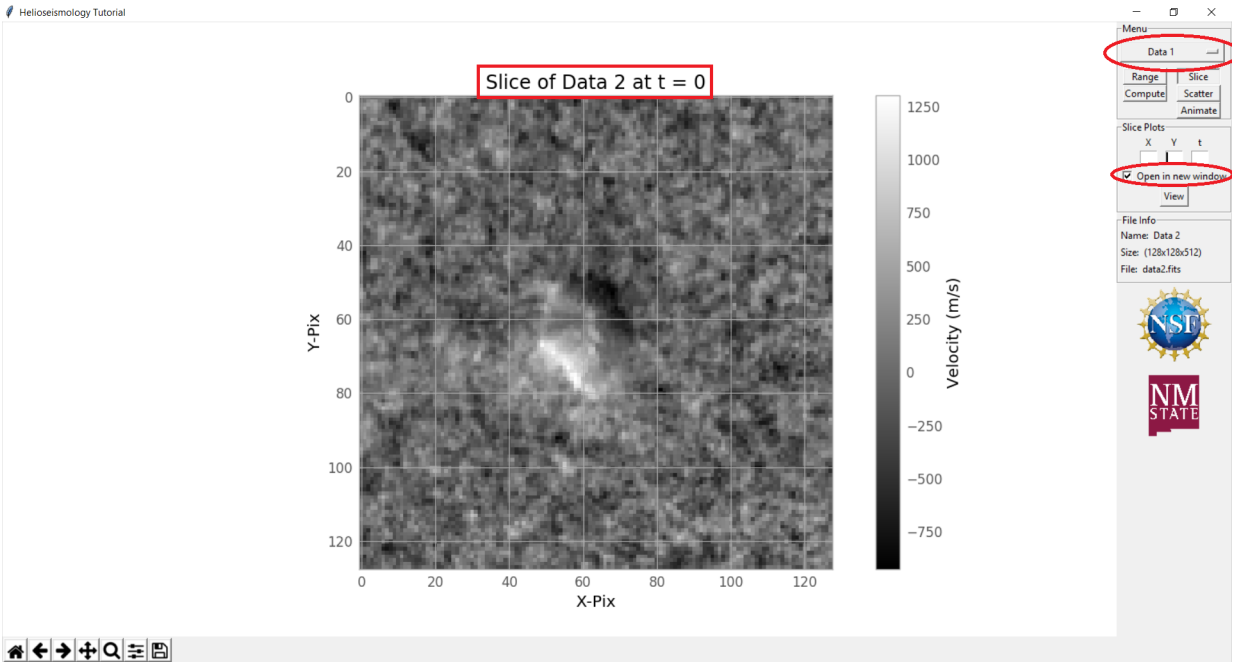


Figure 15: Caption

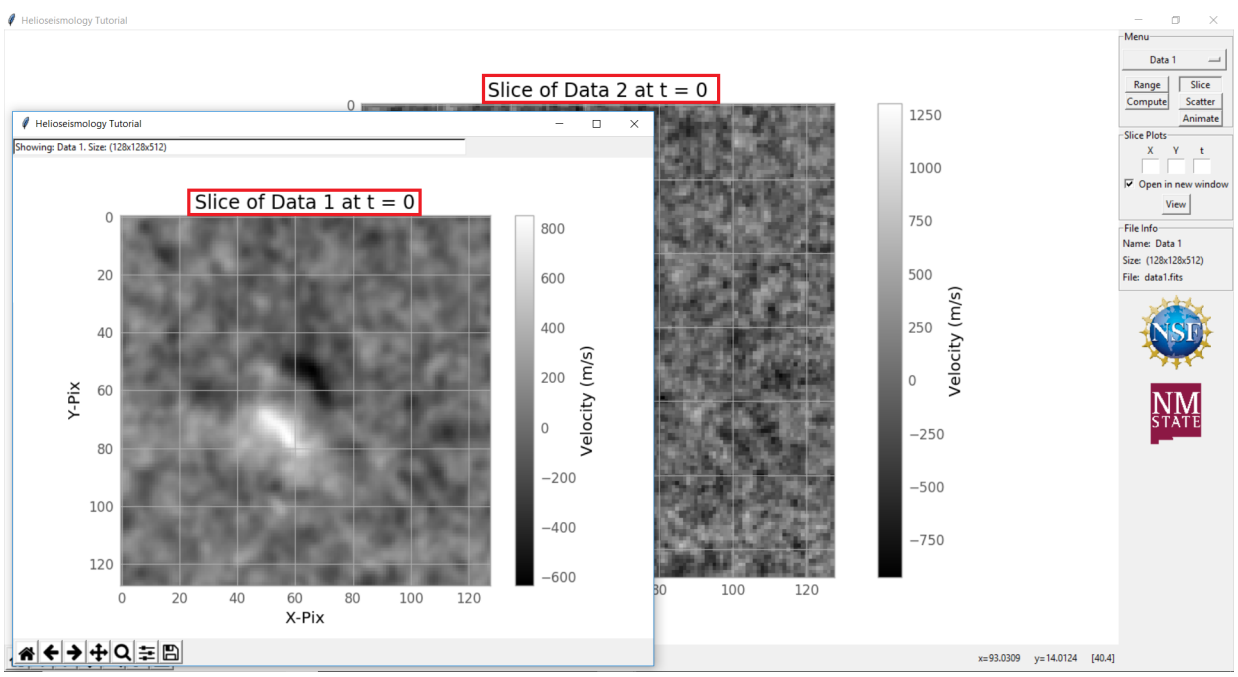


Figure 16: Caption

## 3.8 File Info Window

The File Info Window (Figure 17) displays some general information of the main data set selected.

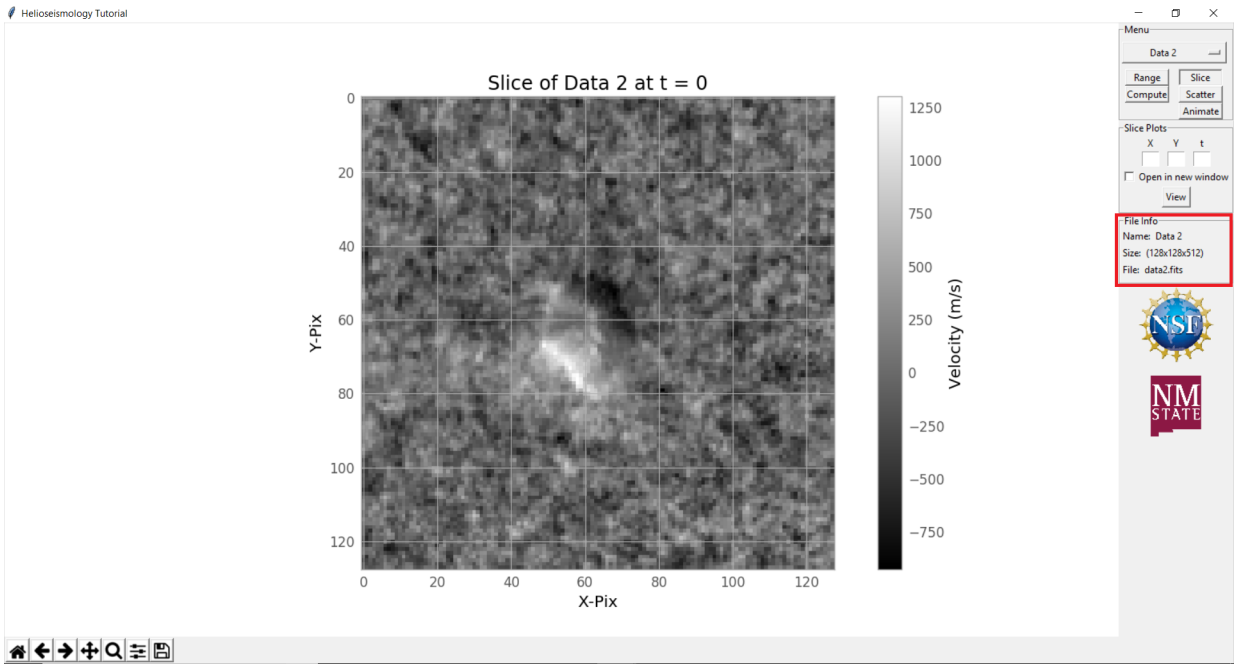


Figure 17: Caption

## 3.9 Save Image

If you want to save the displayed plot, matplotlib allows you to do so through the figure's own toolbar, by pressing the floppy disk icon (Figure 18).

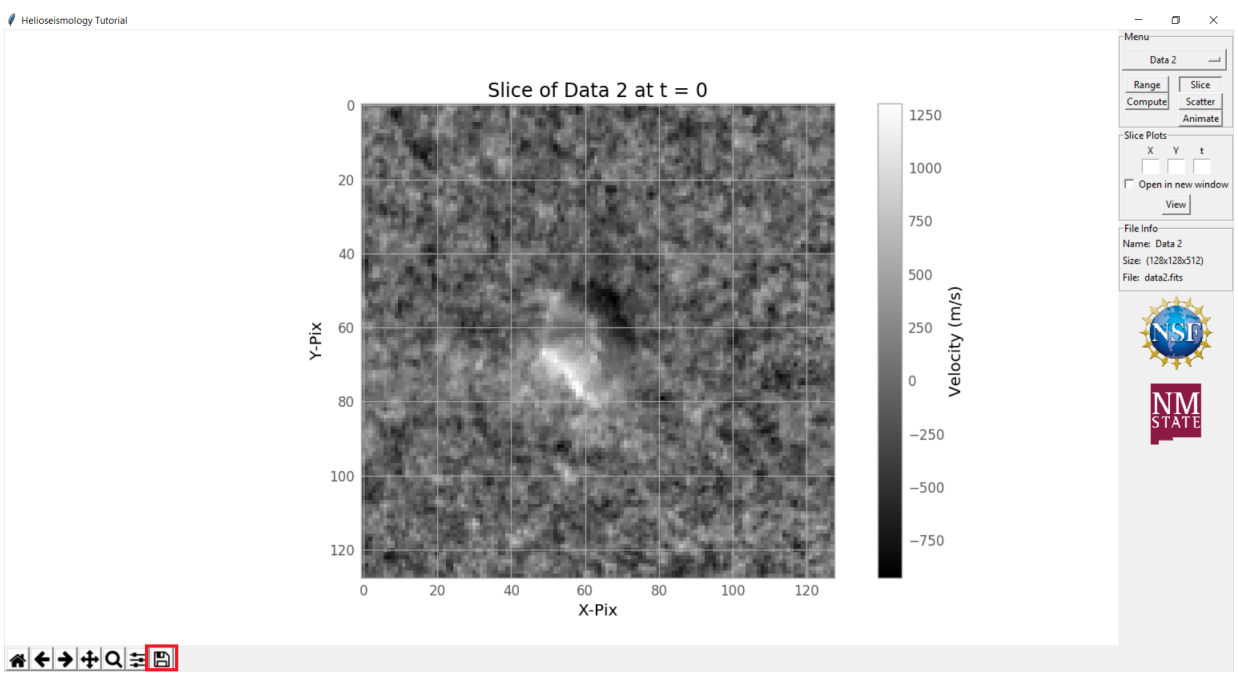


Figure 18: Caption