Lab 5: Earthquake Hypocenter Determinations

Objective: To pick and analyze digitally recorded earthquake data using one Utah earthquake, one Yellowstone earthquake, and the M 5.7 Draney Peak Idaho-Wyoming border earthquake recorded on the University of Utah Seismograph Station (UUSS) network. This lab will enable you to obtain an understanding of routine earthquake location techniques, errors, and limitations of the location method.

The local Utah and Yellowstone earthquakes range in quality and number of stations from excellent to good. The intent is to pick the 1st P and S wave arrivals and first P wave motions (direction of up or down) using uping (the standard digital interactive picking routine used by the UUSS). The user manuals for uping and hypoinverse (the location algorithm) are attached.

The primary purpose of picking the first motions is for a focal mechanism problem next week, so keep good records for them, i.e., print them out and store the prt and sum output files of the location program. Remember to rename the prt and sum files in between each run of hypoinverse or they will be overwritten.

The earthquake data are in the directory:
/home/jfarrell/GG5330/Lab4/DATA
In that directory you will find a separate subdirectory for each of the three earthquakes we will analyze in lab:

92031614423/ 94020309045/ 97122505552/

Within each of these directories are two data files which have the same prefix as the parent directory name and end in either D or d. For example, in the directory 92031614423/ you will find the files:
92031614423D and 92031614423d
You will need both files to run the picking program uping.

We will use two programs to find the hypocenter locations of these earthquakes. The first program, uping, displays the waveforms and saves locations of P and S wave picks. The codes are located in the directory /home/gpwaite/Progs/bin. You may want to set a path to these executables so you don't have to type in the full directory path name each time you want to run the code.

To set the path:

- Type: Edit /home/yourusername/.local/cshrc
Open your cshrc file in the text editor
- Add: Set path = ($path /home/gpwaite/Progs/bin)
Add this line after the line that begins path=/...
- Type: Source ~/.local/cshrc
Reconfigure the current window according to the cshrc file
To run \textit{uping}:

\begin{itemize}
  \item Type: \texttt{xtek} \hspace{1.5cm} To open a Tektronix emulation required by picking software.
  \item Type: \texttt{Uping -S ../stainv 92031614423d} \hspace{1cm} To start the analysis software.
\end{itemize}

After picking the P and S first arrivals in uping, a new file will be created. It will have the same numeric prefix but end in a "p" (for example 98010212213p). To run a location with just the Yellowstone stations and Yellowstone velocity model, use the script \textit{yploc}. Otherwise, use \textit{utloc} script. Both scripts call the location program \textit{hypoinverse}.

To run \textit{utloc}:

\begin{itemize}
  \item Type: \texttt{utloc -p 92031614423p} \hspace{1cm} To run \textit{hypoinverse} with Utah parameters
  \item Type: \texttt{cat prt} \hspace{1cm} To view the output from the solution of \textit{hypoinverse}
\end{itemize}

\begin{itemize}
  \item Repick the data as needed to reduce the RMS values for extraneous or outliers of individual stations.
\end{itemize}

Help manual page for the following are attached:

\begin{itemize}
  \item \textit{uping}: interactive phase picking algorithm
  \item \textit{eqphasefiles}: format of earthquake phase data
  \item \textit{hyp} (\textit{hypoinverse}): earthquake location program
\end{itemize}

\textbf{Assignment}: Pick (using the cross-hair fiducial marker) for each earthquake the P and S wave arrivals. As you pick make an estimate of the picking time accuracy on a separate sheet of paper. Note the quality of the pick by the appropriate weighting factors (zero through 4). Also pick whether the first motion is up or down or whether you can confidently pick the first motion. This will be important for next week’s lab.

List of earthquakes:

   This event is within the Utah network and has a $d_{\text{min}}$ near that of the focal depth which resolves this parameter better than most of our data. From these data can you say that this event was located on the Wasatch fault?
2. A $M_c$ (coda magnitude) 3.5 earthquake within Yellowstone, December 25, 1997. This event is within the augmented Yellowstone network. What is the focal depth resolution of this event compared to the SLC event. Also examine the individual traces from this earthquake for ray paths inside and outside the Yellowstone caldera. Can you any distinguishable differences?

3. The 1994 Draney Peak, Idaho-Wyoming border, (Mw 5.8) earthquake of February 3, 1994. This earthquake is an example of a larger event but it is located on the periphery of both the Utah and Yellowstone networks and illustrates the affect the epicenter outside the array geometry. Run the event using data from both networks separately, then together. What are the differences attributed to?

   Run the picks through utloc or yploc (whichever is more appropriate) for hypocenter determinations. The process is iterative, i.e., as you pick and run the location you will note residuals (Theoretical minus Observed) at each station. For large residuals you should re-pick the event to see if an error was made, otherwise the residual is likely related to deficiencies of the seismic velocity model.

   To get a feel for the accuracy of hypocenter determinations, remove some of the stations from the Yellowstone event to simulate variations in the proximity of stations to the hypocenter and variations in numbers of stations used.

Questions:

1. How does the distance of stations to the hypocenter effect the quality of the solution? To do this, systematically eliminate the nearby stations and examine the RMS, error in H and error in Z.

2. Is there a tradeoff between RMS and errors in H and Z? Test this out for distant vs. nearby stations as well as by the number of stations used in the solution. Do more stations necessarily improve the solution? Why and/or why not?.

3. Would you expect differences in the seismic character of phreatic vs. tectonic events for the Yellowstone environment? In what way?

4. How do you explain some of the larger residuals in your final solutions?

5. Was the epicenter/hypocenter for the 1994 Idaho-Wyoming border earthquake better or worse than the other solutions? Why?