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## Lab 1: Getting to know your data

*Your Name Here*

### ABSTRACT

This is a very simple exercise, the main purpose of which is to get you familiar with SEP's computer system and the commands you will be using for the labs.

### INTRODUCTION

In this exercise, you will generate some synthetic marine data, and will modify a simple Fortran program to generate common-midpoint gathers instead of common-source gathers. You will examine the effect of random shot amplitudes and time delays of the geophones. Subsequently, you will be able to apply what you learned in the synthetic world on real seismic sections.

The material for this exercise comes from BEI Chapter 1; however, I also recommend reading Chapters 12 and 13 as background before you start.

### GETTING STARTED

Welcome to the first homework for GP210. This homework (and the ones that follow) will require you to use the Linux operating system. If you find yourself fighting with the OS rather than the geophysics, please let me know. If anyone is unfamiliar with Linux (e.g. what does `ls` do?), please let me know.

You should do the assignment on a computer with an X-Windows environment. If you don't have access to such a computer, let me know and I will help you.

On your workstation, log onto `vostok.stanford.edu` using your assigned username and password (if you don't know how to do this, let me know) If this is the first time you are logging in to a SEP machine, change your password using the `passwd` command. We regularly run a program that tries to crack passwords, so make it difficult to guess (use a mix of capitals, symbols, numbers etc.). Once you are logged in to `vostok`, type: `ssh -Y sad` (or `mad` or `bad`. You will do your work on one of these computers).

Visit the BEI class webpage (<http://sep.stanford.edu/doku.php?id=sep:courses:gp210>). Here you will find an online copy of the BEI book. You will also find a link to additional class slides made by Bob, which contain many useful explanations of the class material.

The labs will be available on Coursework under “Materials”. You may also go to the BEI lab webpage ([http://sep.stanford.edu/doku.php?id=sep:courses:gp210\\_labs](http://sep.stanford.edu/doku.php?id=sep:courses:gp210_labs)). Download the source code for this lab, `Lab1_fortran.tar`. Copy this file to your home directory on `vostok` using `sftp` or `rsync` (or WinSCP if using Windows), then type `tar xf Lab1_fortran.tar` (once you’ve logged in to `vostok`) to create your `Lab1_fortran` directory.

Once you have done this, change to the directory corresponding to this lab (`cd Lab1_fortran`) and look around. There should be a subdirectory `Fig` where the figures are kept. There should also be various Fortran source files under the `Src` subdirectory (with the suffixes `.f90`), various parameter files under the subdirectory `Par` (with the suffixes `.par`), a Latex source file (`paper.tex`), a `Makefile` file and an `SConstruct` file.

To answer the questions, edit the Latex source file `paper.tex` and modify it accordingly. To build the latex file into a paper, you will need to have first generated all the included figures, and then type `make default`. To build the report file (`paper.pdf`), type `scons`. Later on in the lab, you will be asked to modify a code and to replace the corresponding figure.

Info about Makefiles can be found in the GNU Makefile manual (google it). They are used extensively at SEP, and this Makefile provides all the rules required to build the figures and generate postscript version of this lab from the latex source. General SEP makefile commands include

<code>make burn</code>	Destroys reproducible figures
<code>make default</code>	Builds them again
<code>make clean</code>	Cleans intermediate files
<code>make view</code>	Builds figures and displays them
<code>make *.pdf</code>	Builds a postscript and pdf version of whatever <code>*</code> is
<code>make *.x</code>	Builds an executable
<code>scons</code>	Builds the paper

## COMMON SHOT GATHER

Chapter 1 of Jon’s book *Basic Earth Imaging* (BEI) provides a subroutine `synmarine()` (page 7) which generates synthetic 2-D common-shot gathers. Figure 1 shows a single common-shot gather. You can generate a movie of common-shot gathers by entering the following commands on `sad`’s command line:

- `make movie.burn` – this deletes the existing figure
- `make movie.build` – this uses the rules in the makefile to create the figure
- `make movie.view` – this pops up a xtpen window that will flip through several common-shot gathers

The movie you generated is of common-shot gathers as the boat sails along. To make the movie run faster, put your mouse pointer in the xtpen window and press the `f` key. To slow it down, press the `s` key.

Feel free to “burn”, “build” and “view” the figure as much as you like. See if you can figure out how the rules in the `Makefile` that creates the figure work.

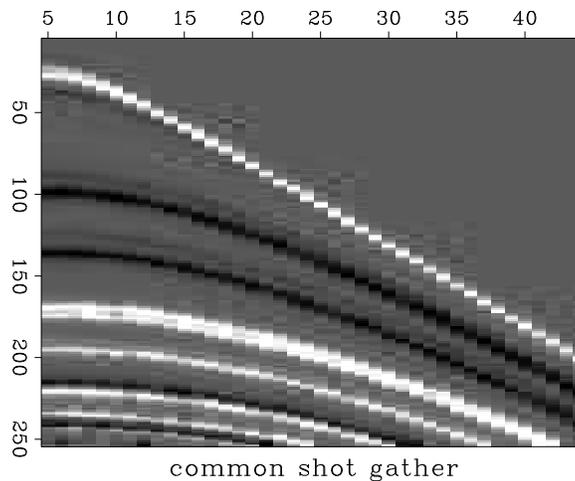


Figure 1: this is the movie

## COMMON MIDPOINT GATHER

The figure below should look the same as the one you just saw in the previous section. However, it is generated with `synmarine1` instead of `synmarine`.

Use your favorite text editor to edit `Src/synmarine1_mod.f90` so that it generates common-midpoint gathers that would be recorded from the same Earth instead of common-shot gathers. (Personally I use `vim`, some people use `gvim` or `gedit`.)

Once you have made the necessary changes, use the `burn` command (`make cmpMovie.burn`) and then `build`, and finally `view` to see the result of your changes, i.e. type `make cmpMovie.view` to see the movie.

If you are satisfied with the result, open the latex file `paper.tex` with a text editor. Change the name at the top of the document to correspond with your own and fill in the answers to the questions below.

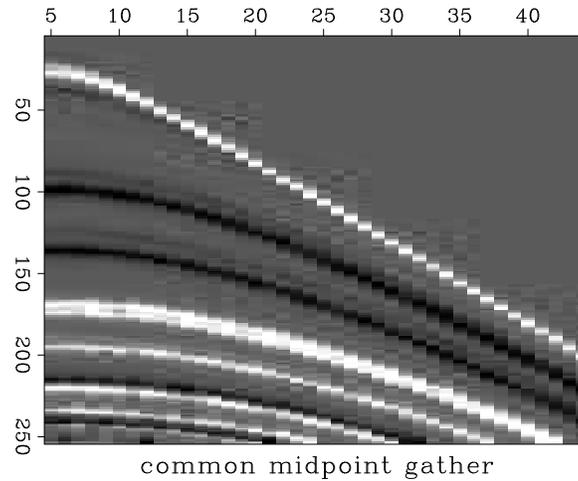


Figure 2: cmp movie

**Question 1:**

Describe the differences between the common-shot gather and common-midpoint gathers. Which represents a real physical experiment? Which tells you more about a particular subsurface location? Draw the geometry/raypaths for a common-shot gather, common-midpoint gather, and constant offset section (hint: see page 3 of the book).

**Your Answer:****Question 2:**

Include the lines you changed from `synmarine1` and explain why you did those changes.

## AT THE MOVIES

In this section you will be required to look at various movies of more complicated synthetic datasets and some real field data. Take a look at the movies and answer the questions that follow.

### Realistic CMP movie

In real seismic surveys, near-surface effects such as the irregularity of the soil layer can influence the geophone and shot behavior. The geophones may suffer time delay and the shots may not have the same strength.

In this section, you are required to work with 2-D common- midpoint gathers that contain random shot amplitude and random geophone delay time. You will have to change the maximum shot amplitude and the maximum time delay of the geophones, until you can see two different patterns in the CMP gathers: one moving to the right and one moving to the Left. Run `make realisticMovie.view` to build the movie.

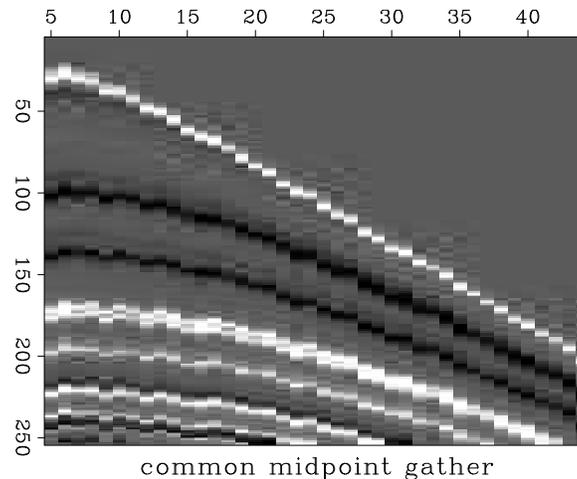


Figure 3: movie of realistic data

Edit the maximum shot amplitude and the maximum time delay at geophone in `complex.par`.

After setting those parameters, burn, build, and view to execute the program and see the resulting common-midpoint gathers movie. Your objective is to find a set of parameters which gives you both left-moving and right-moving patterns.

#### Question 3:

Your objective is to find a set of parameters which gives you both left-moving and right-moving patterns. Write down your choice below.

What causes the right moving pattern? What causes the left moving pattern?

**Your Answer:**

maxamp =

maxtimedelay =

## Statics

The synthetic data you saw in the previous section suffered from geophone time delays. This is an example of the problem of *statics*. Time delays such as these can be caused by near-surface irregularities and by the topography where the survey is done.

**Question 4:**

The problem of statics is often corrected by shifting each trace along the time axis depending on the geophone and source elevations and the near-surface velocity Yilmaz (1987). Why is this approach often acceptable? When would this not work?

**Your Answer:**

## SAGA movie

Run `make SAGAMovie.view` to see a movie of marine data:

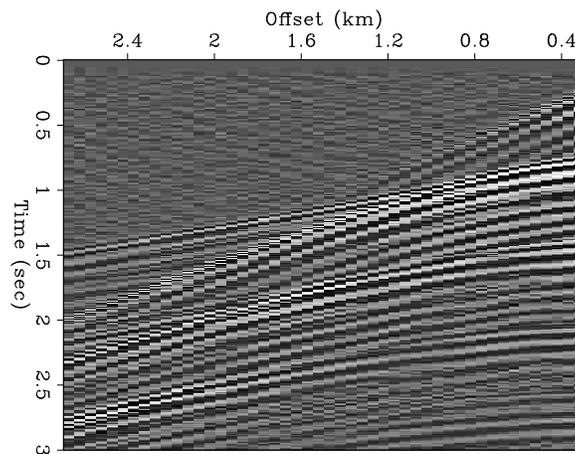


Figure 4: SAGA movie

**Question 5:**

Do you think you are looking at common-shot gathers or a common midpoint gathers? Why?

**Your Answer:**

**Question 6:**

This movie (Figure 4) has many events that cross each other at large offsets. What would cause this crossing behavior? (Hint: remember that the curvature is related to the subsurface velocity.)

**Your Answer:**

**Permafrost movie**

The next movie will show you a cube of seismic data recorded over permafrost in Alaska. Run `make permaMovie.view` and `tube Fig/permaMovie.v3`

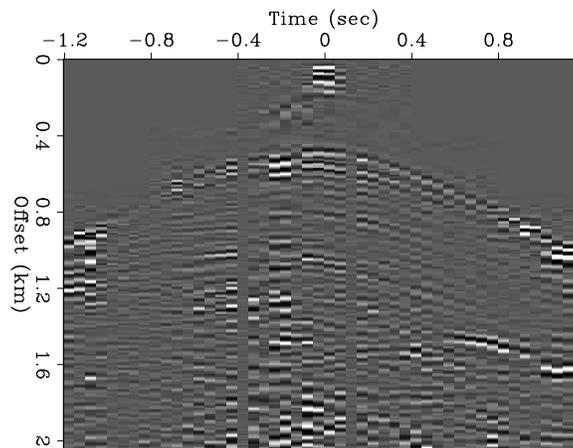


Figure 5: permafrost movie

**Question 7:**

By looking at the data, you will see that one of the gathers fades away. Which feature that appears in all gathers seems to be related to this fading? What is this feature?

**Your Answer:**

**Kiloseis movie**

This movie is one more example of how events move in common-shot gathers. Run `make kiloseisMovie.view` and `tube Fig/kiloseisMovie.v3`

**Question 8:**

Is this marine or land data? Give *several* reasons to justify your answer. (NOTE: the origin of the axis is not (0,0))

**Your Answer:**

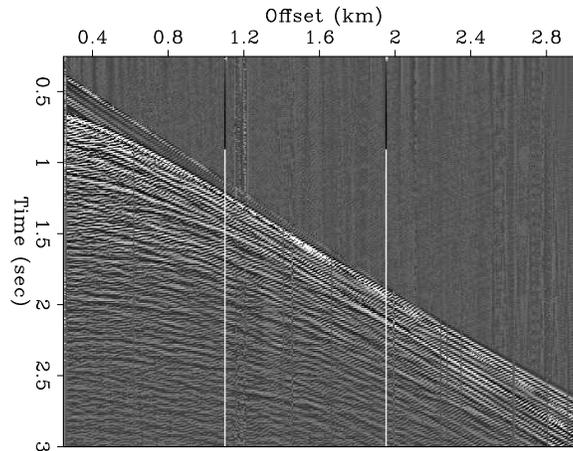


Figure 6: kiloseis movie

## Angle-domain gathers

So far you have been looking at data that has offset as the horizontal axis. If we are given a velocity model, it is simple to convert offset to reflection angle (or, equivalently, offset ray parameter). This movie shows data that is in reflection angle space. It has been depth migrated (that's Chapter 5, don't worry about it now) so that the events in the CMP gather are flat and the vertical axis is in depth. Run `make angleMovie.view`.

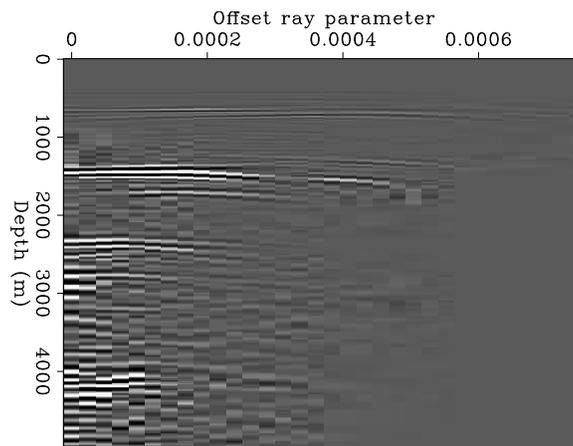


Figure 7: reflection angle domain gather

### Question 9:

Can you explain why the data appear the way they do? (Hint: remember our surveys are finite in size.)

### Your Answer:

## ASSORTED ODDITIES

The following figures and movies each display some kind of strange behavior that is not uncommon among real field data. View them and answer the accompanying questions. Run `make midpts.view`.

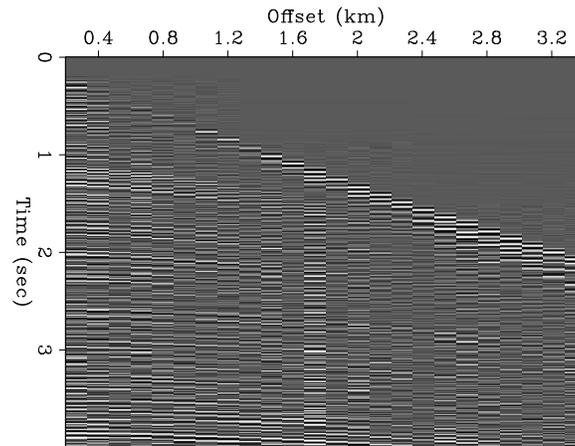


Figure 8: CMP gather

### Question 10:

This is a movie of several CMP gathers (Figure 8) for which the shot spacing is equal to the receiver spacing. What could cause the odd behavior between alternate gathers?

### Your Answer:

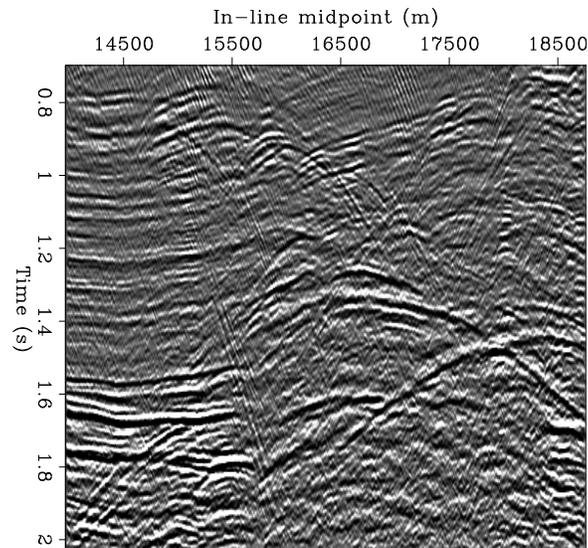


Figure 9: Common offset section

### Question 11:

This common-offset section (Figure 9) that is borrowed from Biondi (1998) has many odd, small hyperbolas throughout it. What are they? What causes them? Run `make coff.view`.

**Your Answer:**

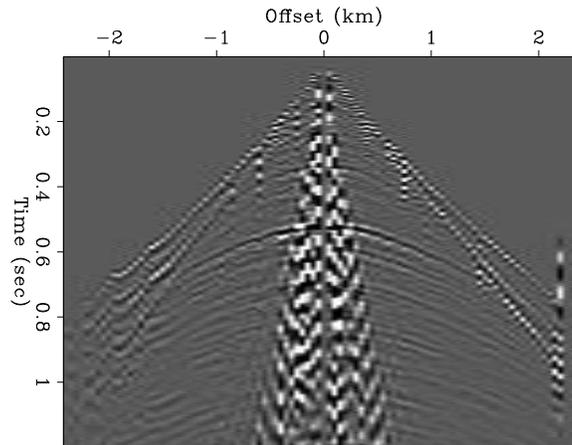


Figure 10: Shot gather

**Question 12:**

As you can tell from the ground roll, this shot gather (Figure 10) is from a land survey. How would you reduce the noise of the ground roll to see the data? Run `make shotgather1.view`.

**Your Answer:**

### 3D ACQUISITION GEOMETRY

Seismic data acquisition is called “3D” when the shots and receivers span an area, and are not just along a single line. It is not always easy to visualize what a particular survey geometry means for the data being acquired. In the following question, we will use a tool called “`qt_head`” that will enable us to see such acquisition geometry.

**Question 13:**

To answer this question, first login to `gertie`, `brooklyn` or `nanpu`. Go to your `Lab1_fortran` directory and run `make waz-bei.H`. This will copy a portion of a very large dataset to your directory. However, we will not be looking at the seismic data itself, but at its headers. These headers specify all the “data-about-the-data”, which in this case are the shot positions, receiver positions, CMP positions and offsets. We will look at these headers using the tool `qt_head`.

From your terminal on `gertie`, run `qt_head data=waz-bei.H`. In the main window you can crossplot the various headers one vs. the other. Begin by crossplotting the `s_x` and `s_y` coordinates, which are the shot coordinates. Select a small group of shot

points by windowing with the mouse. Now crossplot the `g_x` and `g_y` coordinates. These are the receiver positions that received data from the shot points you selected. Crossplot the `cmp_x` and `cmp_y` coordinates.

What are the characteristics of these geometry plots that tell you if this is a marine or land survey?

Create a histogram using the `cmp_x` and `cmp_y` coordinates. The histogram is just a count of the number of points in each interval. Why do the CMPs in the center have the highest values (or “fold”), while the ones on the perimeter have low values?

Crossplot the `cmp_x` and `off_x` coordinates. What was the sailing direction of the boats?

### Your Answers:

**Extra (no credit):** Test your idea on how to reduce ground-roll noise from Question 12 and include your best result in your assignment. This will help you figure out how to generate your own figures in the SEP environment. **Hint:** You might find the program `Bandpass` quite useful. Type `Bandpass` on the command line on `sad/mad/bad` for more details on this program. Good luck!

**Extra (no credit):** Carefully read section 1.3 of Yilmaz’s book *Seismic data analysis* (1987). Then answer questions 1.4, 1.5, 1.7 and 1.8 [for single-volume edition (1988)] or questions 1.7-1.10 [for double-volume edition (2001)] at the end of chapter 1 (you may want to read the entire chapter since it provides background information that will be useful for the rest of the course).

**Extra (no credit):** With a green pen mark all spelling and grammar errors in this lab. Also comment on confusing statements or other broken and outdated features/questions.

## ALL DONE?

Congratulations! You are done. At the shell prompt, type `scons` to compile a pdf of this lab’s paper. Copy the `paper.pdf` file and the program you edited for question 1 (`synmarine1_mod.f90`) back to your workstation. Upload these two files to your Drop Box on the Coursework website.

## REFERENCES

- Biondi, B., 1998, 3-D seismic imaging: SEP-Report, **98**, 1–204.  
Yilmaz, O., 1987, Seismic data processing: Soc. Expl. Geophys.