IDC/SA/SI
February, 2013

English only

CTBTO PREPARATORY COMMISSION | preparatory commission for the comprehensive nuclear-test-ban treaty organization

Geotool Software User Tutorial

This document contains the Geotool software user tutorial. The tutorial is divided into a set of exercises that can be followed individually. Together, the exercises cover the full functionality of the system.

Summary

Geotool is a software system that allows a user to interactively display and process seismoacoustic data from International Monitoring System (IMS) stations. The software can be customised and extended. This tutorial instructs users how to use the basic features of Geotool including data input, basic waveform handling, filters, and arrivals. Geotool has many other capabilities that are not covered here.

Document history

Version	Date	Author	Description
1.0	*13.07.2007.*	*Vera Miljanovic*	*Software User Tutorial*
2.0	*12.08.2009.*	*Vera Miljanovic*	*Updated Tutorial and rewrote Arrivals section*
3.0	*13.05.2010.*	*Vera Miljanovic*	*Updated Tutorial*
4.0	*12.10.2010.*	*Vera Miljanovic*	*Updated Tutorial*
5.0	*10.11.2011*	*Vera Miljanovic*	*Revisions based on the latest software version*
6.0	*07.03.2012*	*Vera Miljanovic*	*Revisions based on the latest software version*
7.0	*23.01.2013*	*Vera Miljanovic*	*Revisions based on the latest software version*
8.0	*08.02.2013*	*Vera Miljanovic*	*Added Add Station section*
9.0	*18.02.2013*	*Remmy Phiri*	*Added Print bulletin section*

Contents

1. SCOPE

1.1. Identification

This document applies to Geotool releases 2.0.0 and above.

1.2. System overview

Geotool is a software system that allows a user to interactively display and process seismoacoustic data from International Monitoring System (IMS) stations. The software can be customised and extended.

The original Geotool was developed in the 1990s at Alexandria Laboratories and the Center for Seismic Studies to allow researchers to easily and conveniently display and analyse data from seismic stations. During the course of GSETT-3, researchers also used the software to investigate hydroacoustic and infrasound data.

In 2006 and 2007, the software was nearly completely rewritten in C++. Geotool is available to all States Parties and is suitable for a wide range of users. It includes simple, easy to use functionality for novice users and additional features for advanced users.

1.3. Document overview

This document defines the Geotool software user tutorial.

This document is mainly intended for users to display and process seismoacoustic data.

This tutorial is designed primarily for users new to Geotool. It covers basic functions of the software menu options, mouse button functions, and Toolbar buttons. Other topics introduced include working with arrivals, filters, and component rotation. Additionally, this tutorial includes some new features that have been added to versions 2.0.0 and above.

2. INTRODUCTION

This tutorial introduces some of the fundamental functions of Geotool. It is not meant to be a comprehensive description of every option, but rather to be an overview of the software. The data used in this tutorial are included in the Geotool distribution, so you can follow along while reading.

A Note about the data sets: not all data sets are used in this tutorial, but are included for extra practice. The fixed data set for geotool was created expressly to show analysis examples of events at local (0-6 degrees), regional (6-20 degrees) and teleseismic distances (>= 20 degrees). Event selection criteria included being recorded by stations in the current IMS network over a good sampling of source-to-receiver distances, signal clarity and ability to locate using Geotool. In addition, the teleseismic event was chosen because it contains infrasound and hydroacoustic signals.

2.1. Getting Started with Geotool

Prior to running Geotool at your site, the Geotool software and the tutorial data must be installed as described in the Software Installation Plan [SIP].

This should report the path to the script. If the response is "`file not found`," seek advice from the person who installed Geotool at your site. Note that your `$PATH` may need to be changed for you to find the `geotool`.

Once you have verified that you can `geotool` you must make a local copy of the parametric tutorial data so that you can edit these data without disrupting the work of others. The data for this Tutorial are delivered in a file named tutorial_data_geotool++-3.0.tar.gz and you can copy it to your local directory. For example, it can be stored in the directory /$HOME/data/tutorial. Copy the file tutorial_data_geotool++-3.0.tar.gz from a directory containing the delivered source code, or from a CD, to that directory. Then uncompress the file.

Use the following commands:

```
mkdir -p $HOME/data/tutorial   (if the directory does not exist)
cd $HOME/data/tutorial
cp tutorial_data_geotool++-3.0.tar.gz .
zcat tutorial_data_geotool++-3.0.tar.gz | tar xf -
```

It is a set of files with the following prefixes:

```
DPRK  DPRK_reduced  DPRK_tutorial  KSRS  HYDRO  TURKEY_DATA  GERES
25454488 DPRK_20090525  korea2009/
```

Waveforms are stored in one level below, in the directory named tutorial.

Once the tutorial data is in the /tutorial directory, type the following commands to go to the directory containing data and start Geotool:

```
geotool
```

Once Geotool starts, the main waveform window of Geotool appears on the screen. It consists of the menu bar, toolbar, information (info) bar and main waveform window (see Figure 1). The toolbar is a convenient container for frequently used buttons. Buttons in the toolbar also appear as menu items.

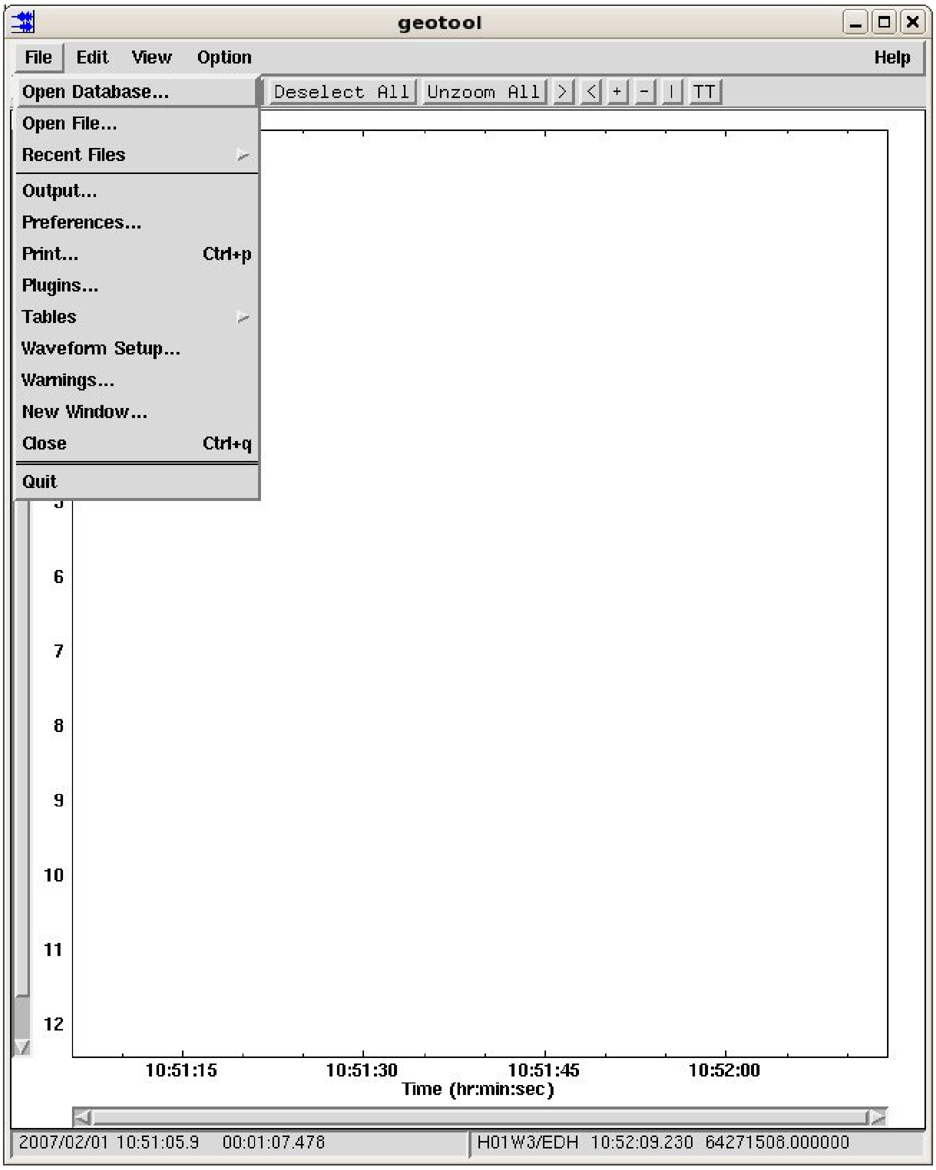


Figure 1. The main waveform window.

SECTION 1. BASIC FEATURES OF GEOTOOL

Exercise 1.1. Data Input

In this exercise, you will learn how to read data, and how to remove the amplitude scale from the waveforms.

Click on the **File→Open File** menu item in the main menu bar to activate the **Open file** popup (Figure 1). Note: the directory shown here (…/data/tutorial/) will be replaced with your own directory path. In this case you will have to navigate to the proper directory.

(1) Select the file named **DPRK_tutorial.wfdisc** in the **Files** column in the **Open file** popup and click on the **List Contents** button (Figure 2).

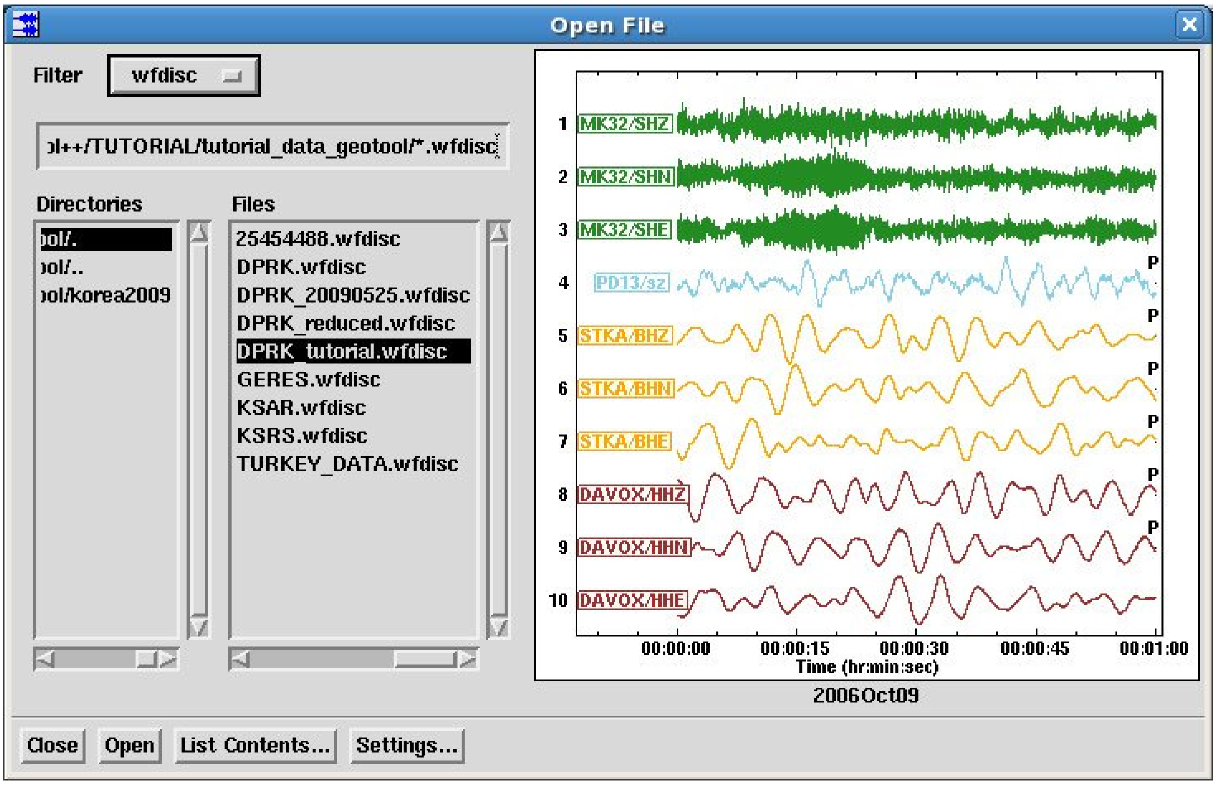


*Figure 2. The **Open file** popup.*

The **File Listing** popup appears (Figure 3).

(2) In the **File Listing** popup (or in DPRK_tutorial Listing popup) hold down the **Ctrl** key and select with **left** mouse button all waveforms

(3) Click on the **Display Waveforms** button.

After the waveforms are read, the waveforms referenced in the file **DPRK_tutorial.wfdisc** are displayed in the geotool window.

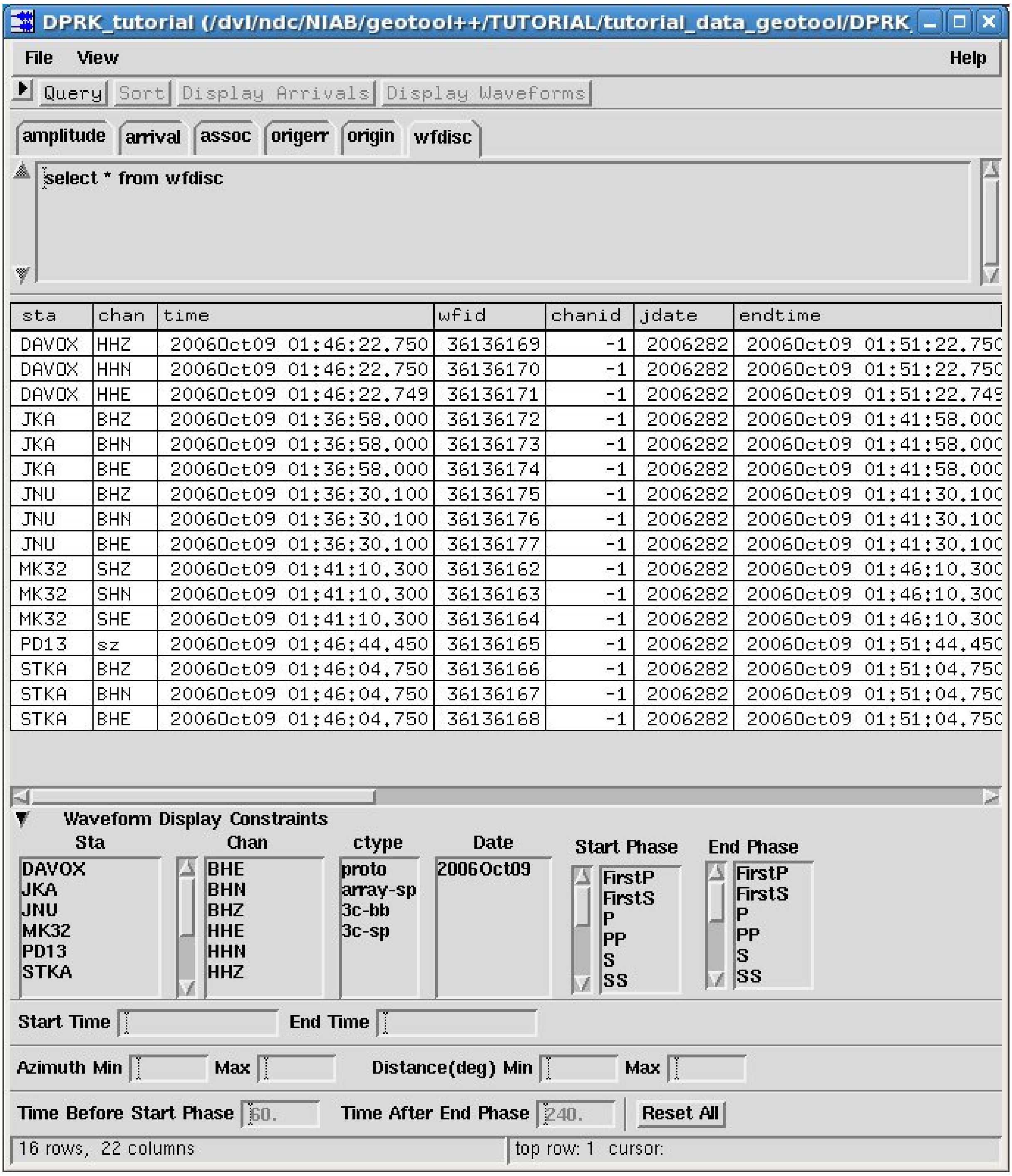


Figure 3. The File Listing popup (in this case of file DPRK_tutorial).

(4) Next, select the **Edit→Clear** menu option in the main waveform window to remove the waveforms from the display. Note: This does not remove data from the file system.

(5) Click with the left mouse button in the DPRK_tutorial Listing popup in order to deselect the waveforms.

(6) Select **BHZ** and **HHZ** in the **Chan** column (hold down the **Ctrl** key to select these channels and individually click on **BHZ** and **HHZ**). Click on the **Display Waveforms** button (Figure 4).

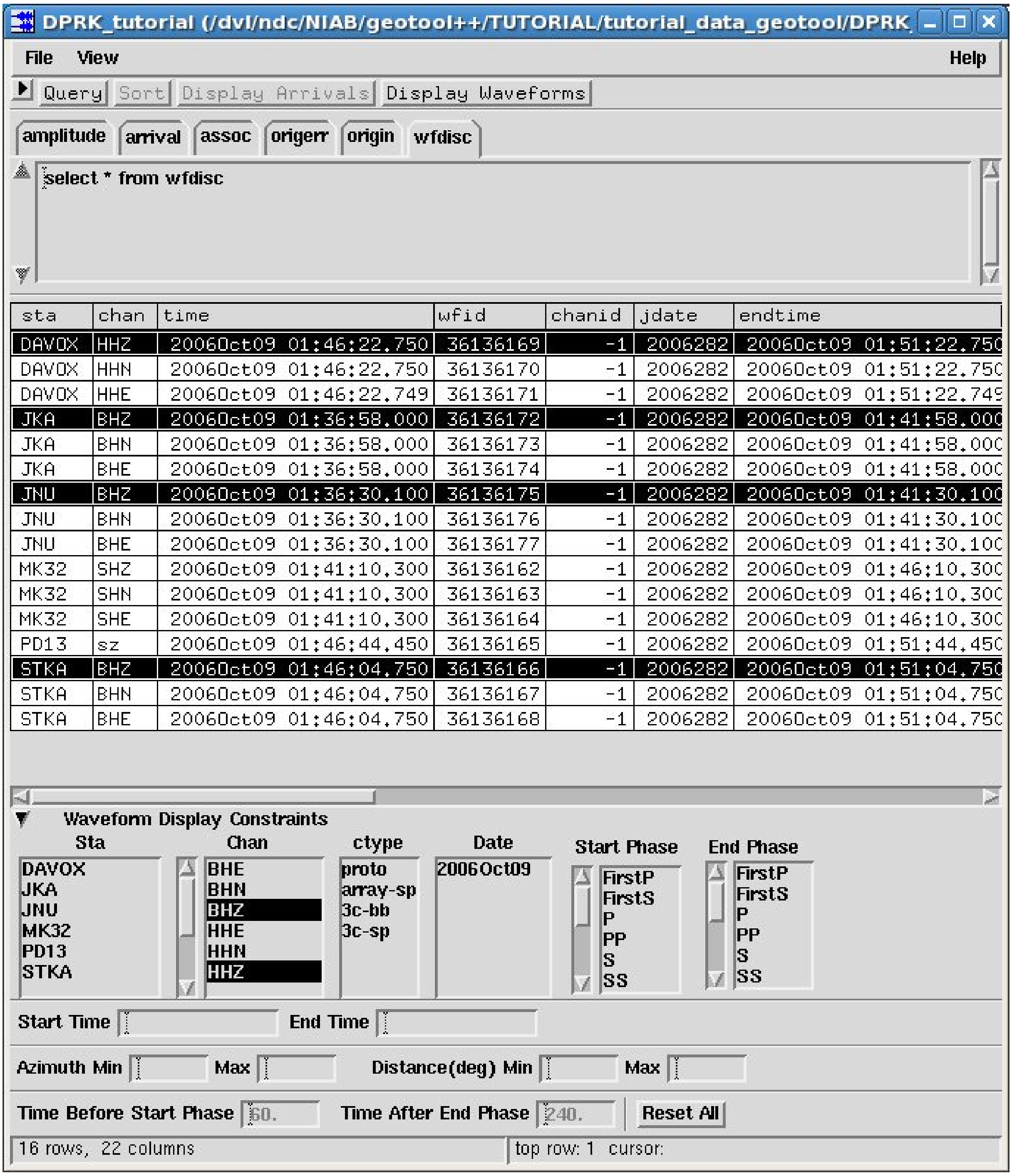


Figure 4. The DPRK_tutorial Listing popup
*with **BHZ** and **HHZ** channels selected.*

The main waveform window should now look like the left side of Figure 5. The waveforms are sorted by the order in which they appear in the **wfdisc** file.

The waveforms that are displayed by Geotool can be read from waveform files on disk or from the database. The amplitude values displayed by Geotool are the values read from the waveform file multiplied by the calibration factor read from the wfdisc table.

(7) Close the **Open** and **DPRK_tutorial Contents** popups by selecting **File->Close** in each popup. Note: closing windows that are not in use will keep workspace less cluttered.

To display/undisplay amplitude scales:

(8) Select **View→Display Amplitude Scale** (disposes of crowded amplitude values on y-axes of the waveforms). The main waveform window should now look like the right side of Figure 5.

Repeating the same procedure (i.e. selecting **View->Display Amplitude Scale**) will make amplitude scales again appear.

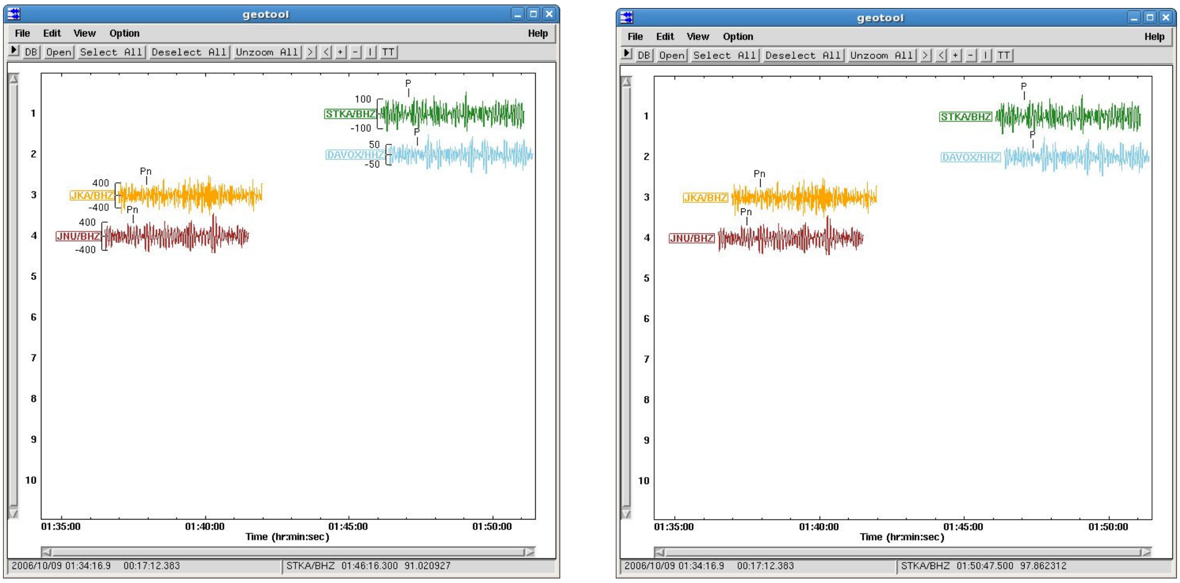


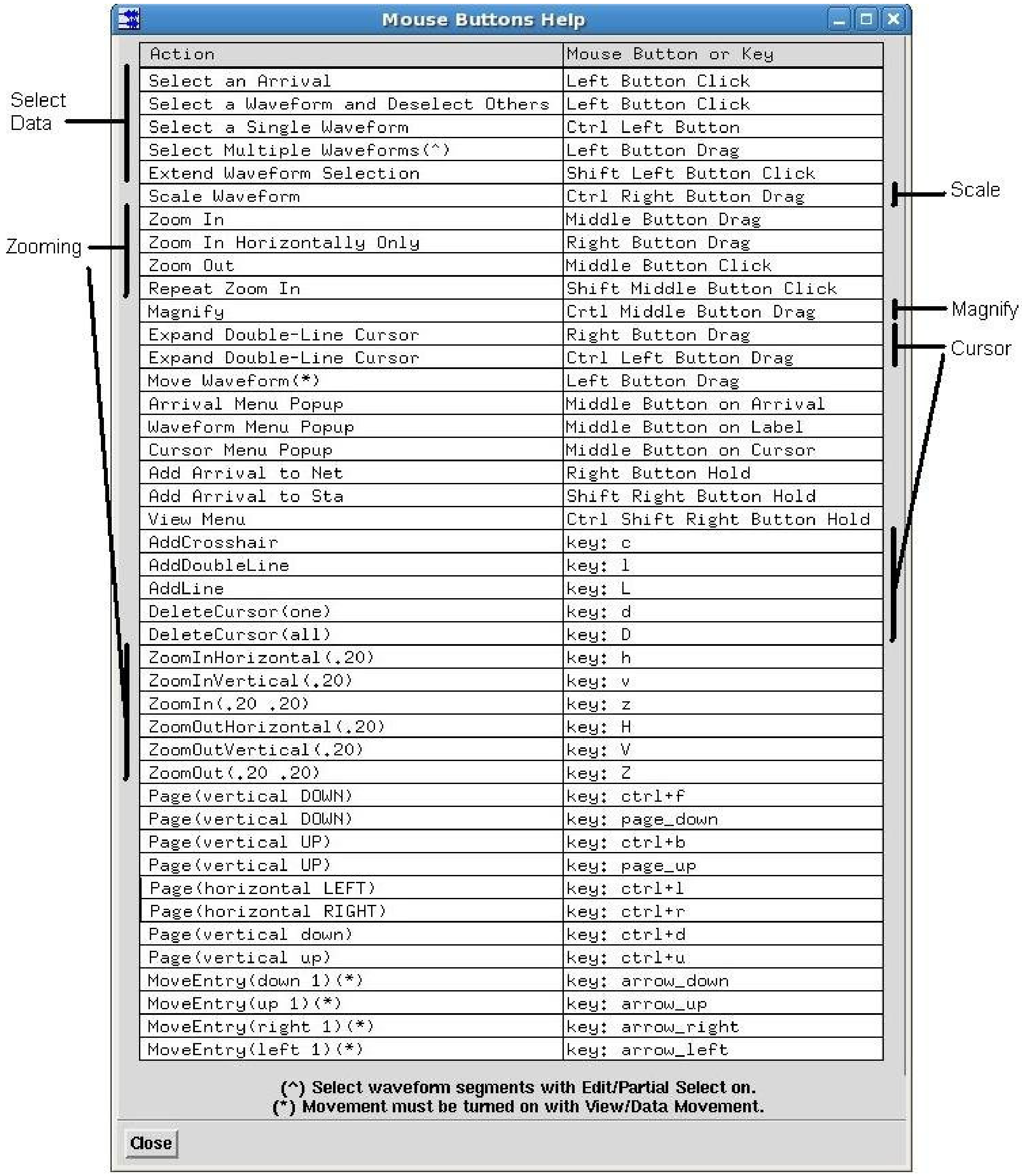
Figure 5. Main waveform window after loading the ***BHZ*** *and* ***HHZ*** *data channel (left picture) and after amplitude scale is removed (right picture).*

Exercise 1.2. Mouse Buttons Help.

In this exercise, you will be introduced to the Mouse Buttons Help menu, and learn how to select waveform data.

Mouse Button and keyboard functions are shown in the **Mouse Buttons Help** popup found by **Help→Mouse Buttons** menu item in the main menu bar.

Mouse button functions and keyboard shortcuts are displayed (Figure 6).



Action	Mouse Button or Key
Select an Arrival	Left Button Click
Select a Waveform and Deselect Others	Left Button Click
Select a Single Waveform	Ctrl Left Button
Select Multiple Waveforms(^)	Left Button Drag
Extend Waveform Selection	Shift Left Button Click
Scale Waveform	Ctrl Right Button Drag
Zoom In	Middle Button Drag
Zoom In Horizontally Only	Right Button Drag
Zoom Out	Middle Button Click
Repeat Zoom In	Shift Middle Button Click
Magnify	Crtl Middle Button Drag
Expand Double-Line Cursor	Right Button Drag
Expand Double-Line Cursor	Ctrl Left Button Drag
Move Waveform(*)	Left Button Drag
Arrival Menu Popup	Middle Button on Arrival
Waveform Menu Popup	Middle Button on Label
Cursor Menu Popup	Middle Button on Cursor
Add Arrival to Net	Right Button Hold
Add Arrival to Sta	Shift Right Button Hold
View Menu	Ctrl Shift Right Button Hold
AddCrosshair	key: c
AddDoubleLine	key: l
AddLine	key: L
DeleteCursor(one)	key: d
DeleteCursor(all)	key: D
ZoomInHorizontal(.20)	key: h
ZoomInVertical(.20)	key: v
ZoomIn(.20 .20)	key: z
ZoomOutHorizontal(.20)	key: H
ZoomOutVertical(.20)	key: V
ZoomOut(.20 .20)	key: Z
Page(vertical DOWN)	key: ctrl+f
Page(vertical DOWN)	key: page_down
Page(vertical UP)	key: ctrl+b
Page(vertical UP)	key: page_up
Page(horizontal LEFT)	key: ctrl+l
Page(horizontal RIGHT)	key: ctrl+r
Page(vertical down)	key: ctrl+d
Page(vertical up)	key: ctrl+u
MoveEntry(down 1)(*)	key: arrow_down
MoveEntry(up 1)(*)	key: arrow_up
MoveEntry(right 1)(*)	key: arrow_right
MoveEntry(left 1)(*)	key: arrow_left

*Figure 6. The **Mouse Buttons Help** popup.*

Waveforms must be "selected" before certain operations can be performed. Waveforms can be selected in the following ways:

To select a single waveform:

(1) **Left** button click over a waveform. This will select a waveform and deselect all other waveforms (Figure 7, left picture). Selected waveform appears in dark blue color.

To select many adjacent waveforms:

(1) Click the **left** mouse button over a waveform and drag the cursor over adjacent waveforms.

To select many non-adjacent waveforms:

(1) **Ctrl +Left click** over a waveform will select individual waveforms, and will not deselect other waveforms.

To select all waveforms:

(1) Select **View→Select→Select All** menu item or **Select All** toolbar button (Figure 7, right picture).

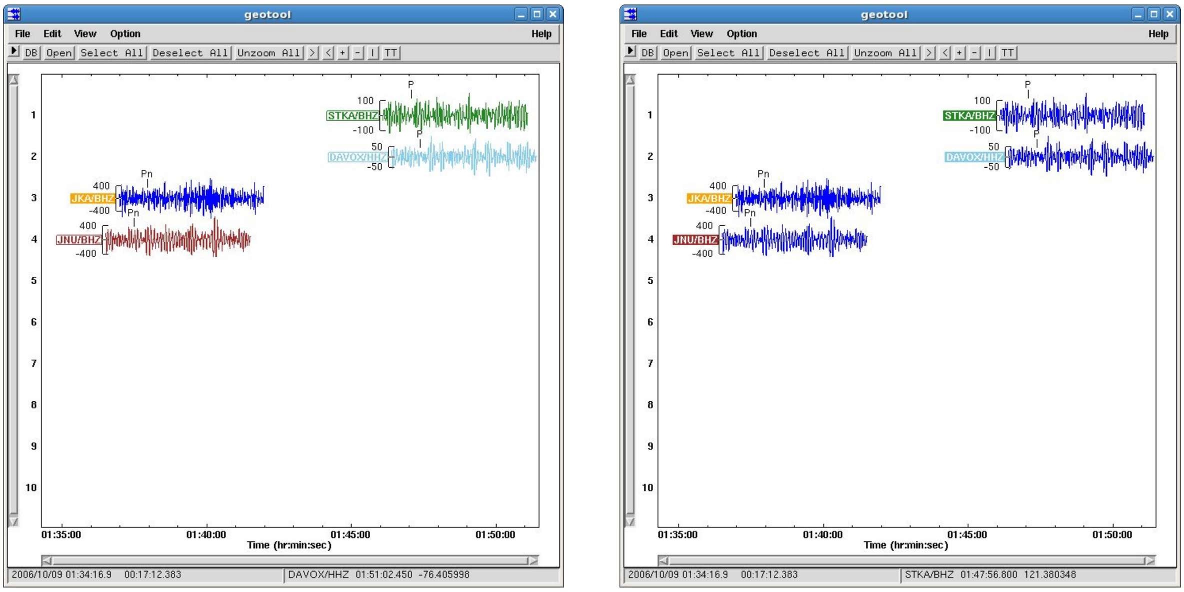


*Figure 7. The waveform window with a **single** waveform selected (left picture) and after clicking on **Select All** button from the main menu bar (right picture).*

To promote selected waveforms (i.e. move selected waveforms to the top of this display):

(1) Select **JKA/BHZ** by clicking it with **left** mouse button.
(2) Select **View->Promote Selected Waveforms** from main menu bar. This will place **JKA/BHZ** at the top of the waveform window (Figure 8).

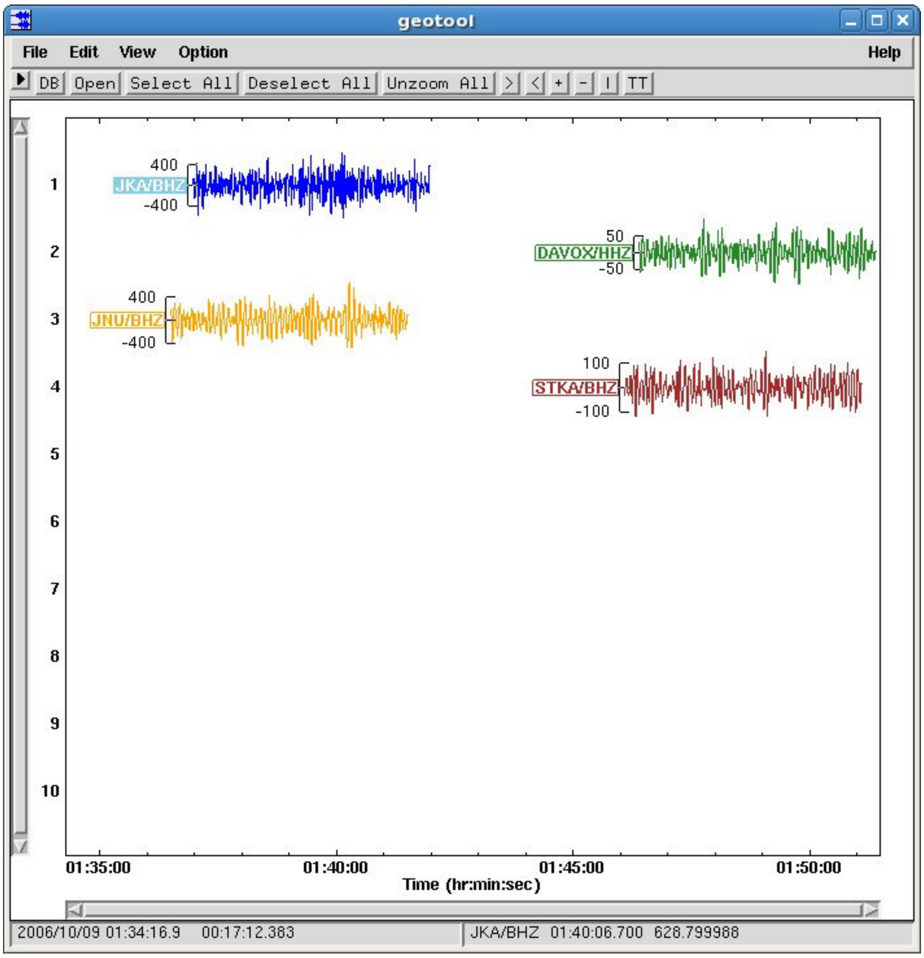


Figure 8. Promote selected waveform JKA/BHZ.

To deselect waveforms:
(1) Select **View→Select→Deselect All** menu item or **Deselect All** toolbar button.

Exercise 1.3. Toolbar buttons.

The toolbar buttons may be used as shortcuts for some of the file menu items or keyboard functions.

To scale a single waveform hold the **Ctrl key+ right** mouse button drag over the waveform.

Using the ">" button (**View →Scale→ Space More**) will increase the scale of all the waveforms, and fewer waveforms will appear in the main window. The vertical scroll bar will decrease in length.

Using the "< " (**View→Scale→Space Less**) will reverse the action, by decreasing the scale of the waveforms. The vertical scroll bar will increase in length (Figure 9).

In each case, the time duration (x axis) remains constant.

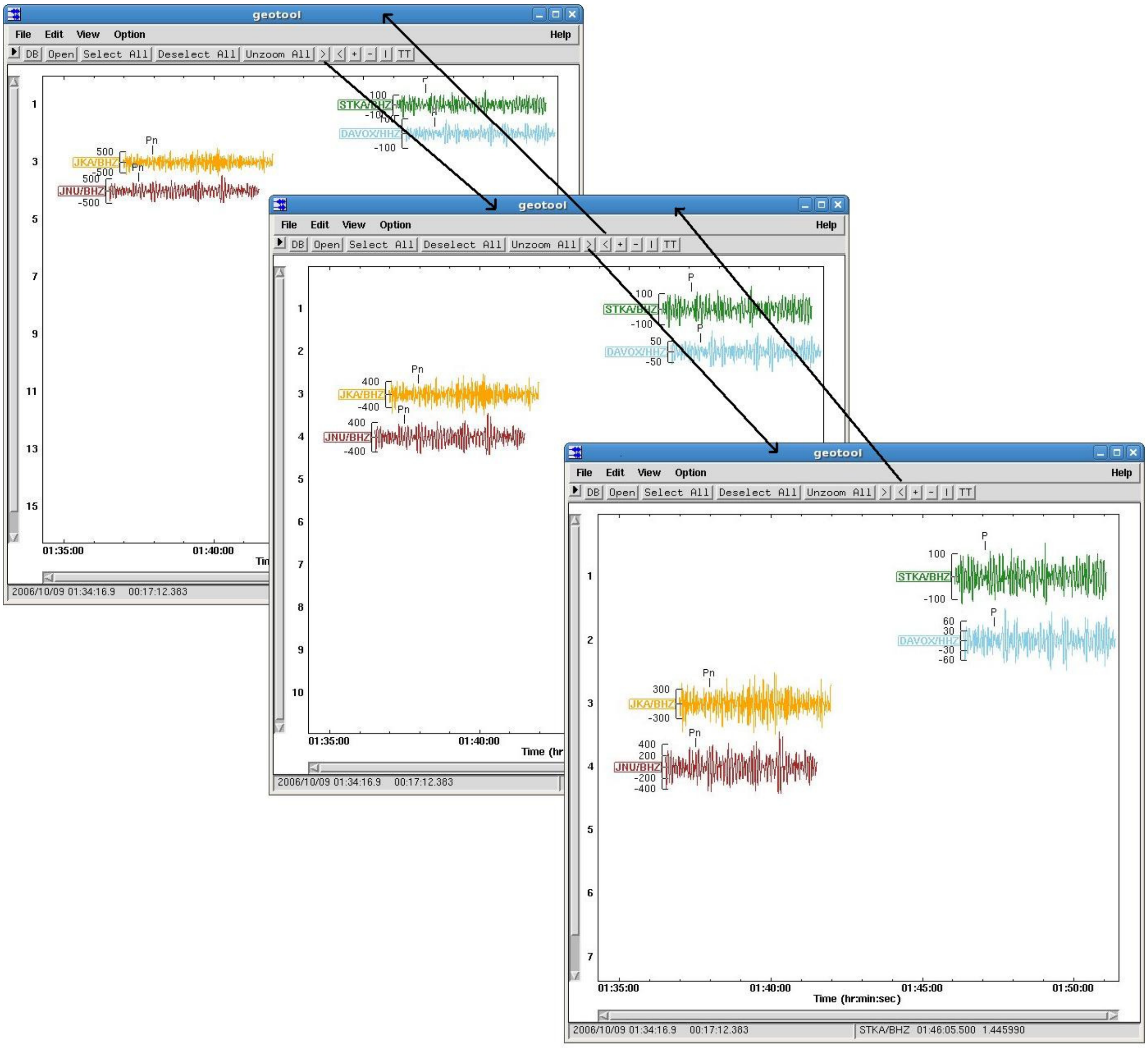


Figure 9. Changing the Y-axis using the " >"and "<" buttons.

Figure 10 illustrates the use of the “ **+** “ button which increases the amplitude scale of the waveforms (**View →Scale →Scale up**). Using the “ **–** “ button reduces the amplitude scale of the waveforms (**View →Scale → Scale down**).

In each case, the x and y axes remain fixed.

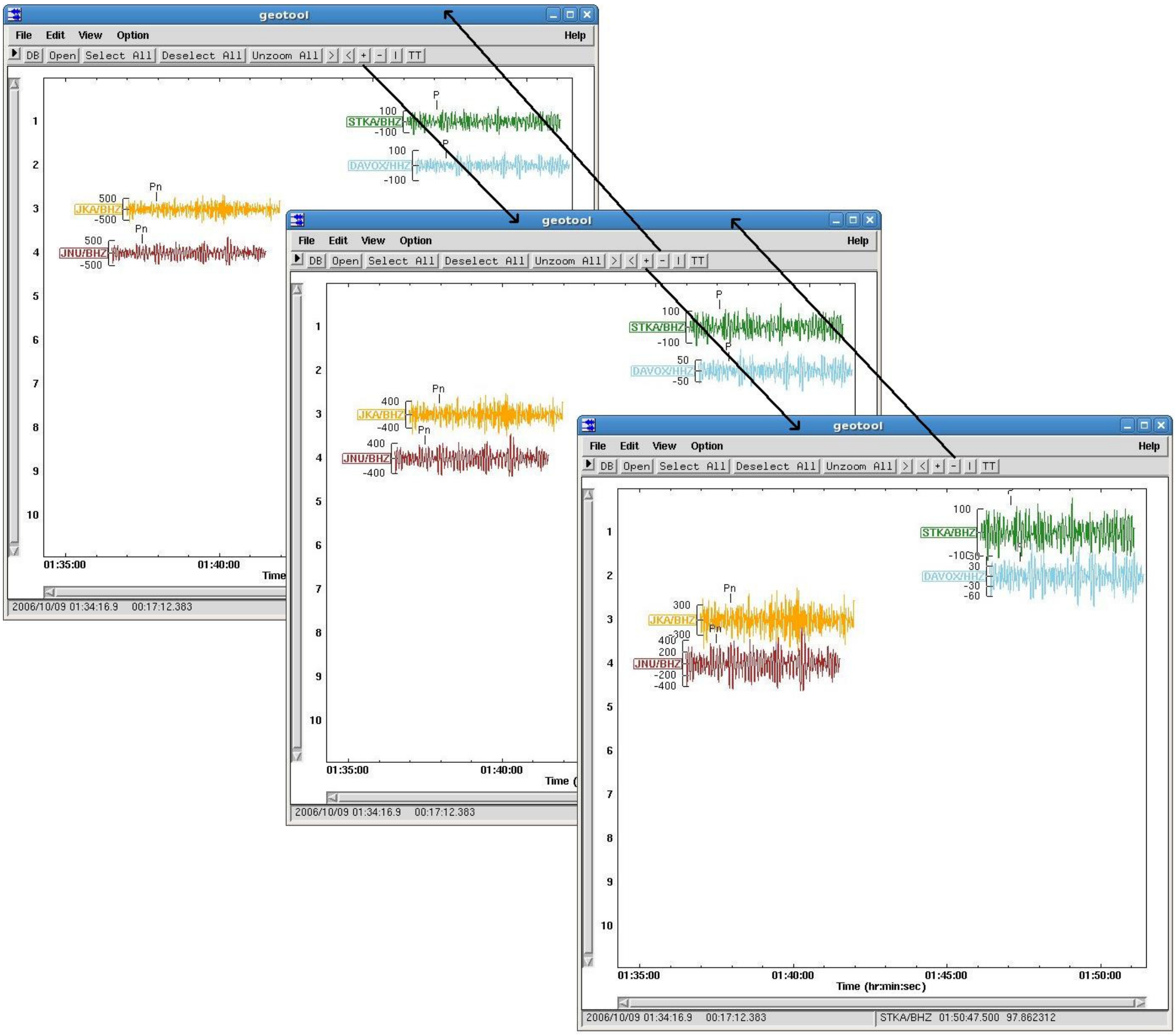


*Figure 10. Changing the amplitude scale using the “**+**” and “**-**“ buttons.*

Exercise 1.4. Cursors

Three types of cursors are used with Geotool, double-line cursor, single line cursor and crosshair cursor (Figure 11).

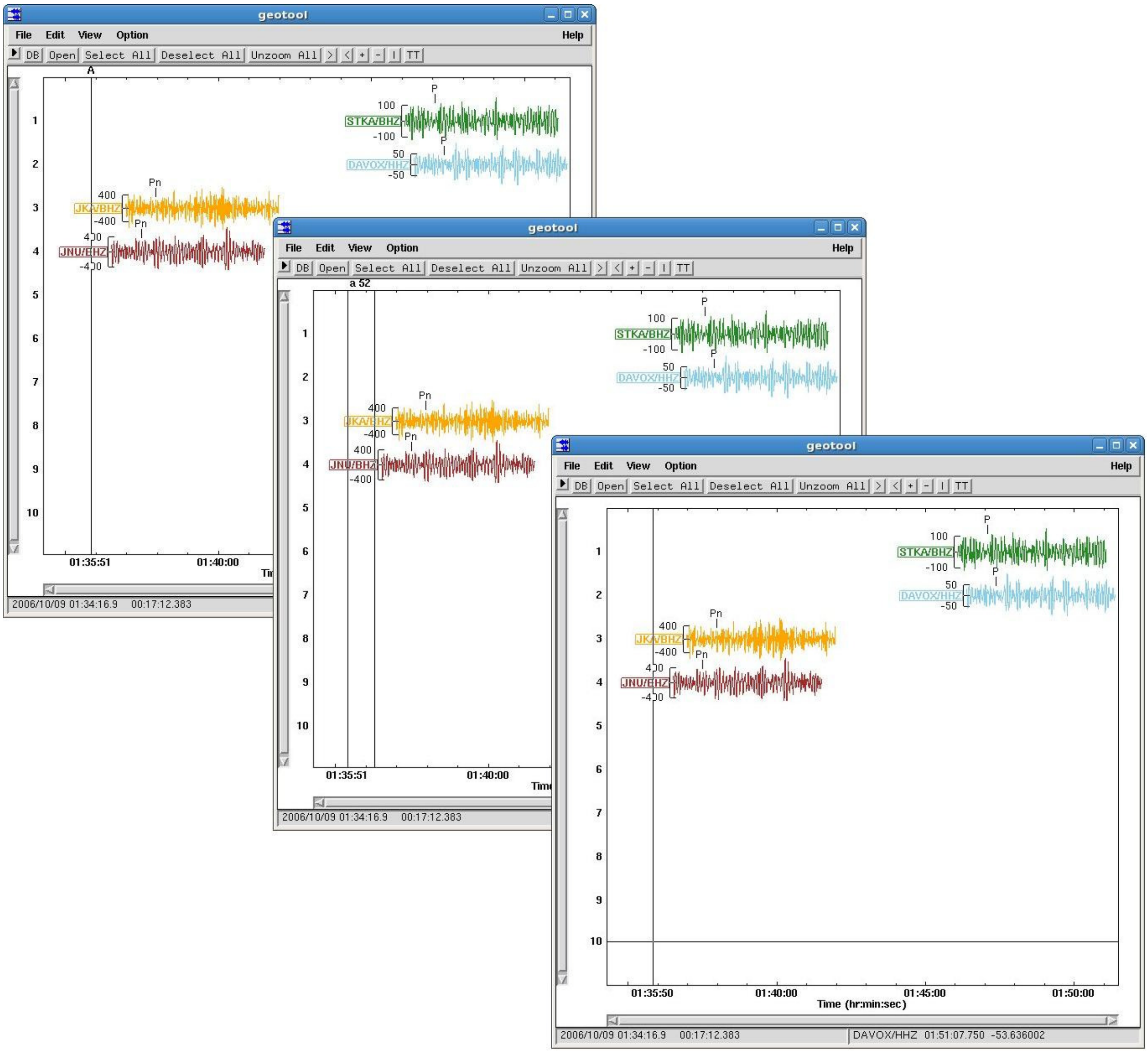


Figure 11. Waveform windows showing three types of cursors.

The double-line cursor is useful for specifying a time interval over a waveform.

(1) A double line cursor may be added to a waveform window to show time limits. It may be added by typing an l (small letter L) or by using the View menu **View→Cursors→Add Time Limits**.

(2) A double line cursor's time limits may be set by dragging one line of the cursor by pressing the **Ctrl +Left** mouse button or **Right** mouse button drag.

(3) To set the cursor width in seconds place the mouse over one of the cursor lines and click the middle mouse button. This will activate a cursor popup with the option to set the cursor width in seconds (Figure 12).

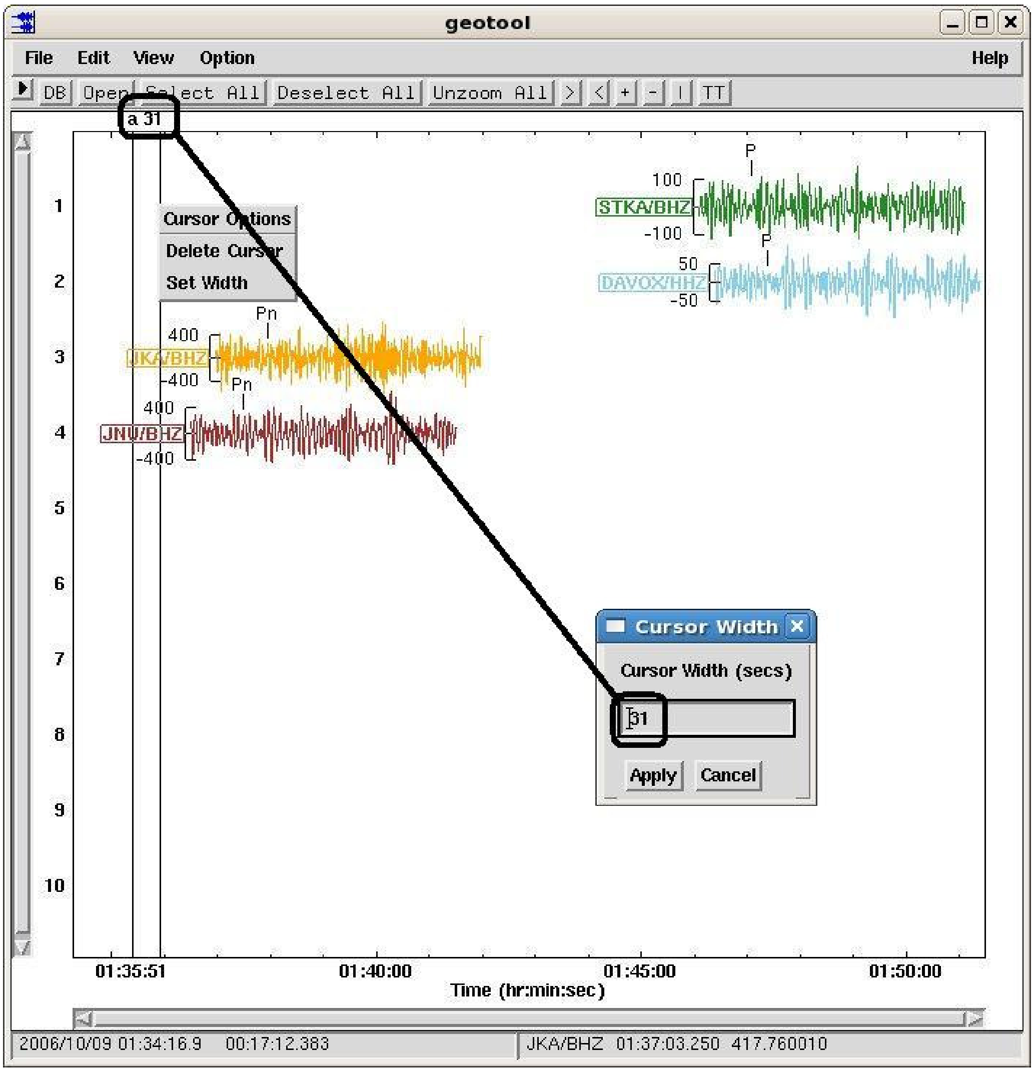


*Figure 12. Waveform window with the **Cursor Options** popup.*

A single line cursor is useful for specifying a single discrete point in time, for example, when measuring a phase arrival time.

(4) A single line cursor may be added to a plot by typing L (**Shift +L**) or by using the View menu **View→Cursors→Add Time Line**.

(5) A crosshair cursor is useful when both the x and y values of a plot should be displayed. For example, it is useful for identifying the coordinates on a map.

(6) A crosshair cursor may be added by using the View menu **View→Cursors→Add Crosshair** or by typing c (**lower case C**).

(7) All cursors may be removed by typing capital letter D (**shift+D**) or View menu **View→Cursors→Remove All**. A single line cursor may be removed by moving the mouse near a cursor, and type d (**lower case D**). The cursor closest to the mouse will be removed.

You may have up to 10 cursors present at any time on a single plot. Double line cursors are labelled with small letters (a, b, c, etc.). Single line cursors are labelled with capital letters (A, B, C, etc.).

Exercise 1.5. PostScript Output.

In this exercise, you will learn how to print the contents of the main Geotool window. The contents of most plot windows can be printed in a similar way.

To print the contents of the main waveform window:

(1) Select the **File→Print** menu item from the main menu bar. This activates the **Print** popup (Figure 13), used to create a PostScript file of the data currently displayed.

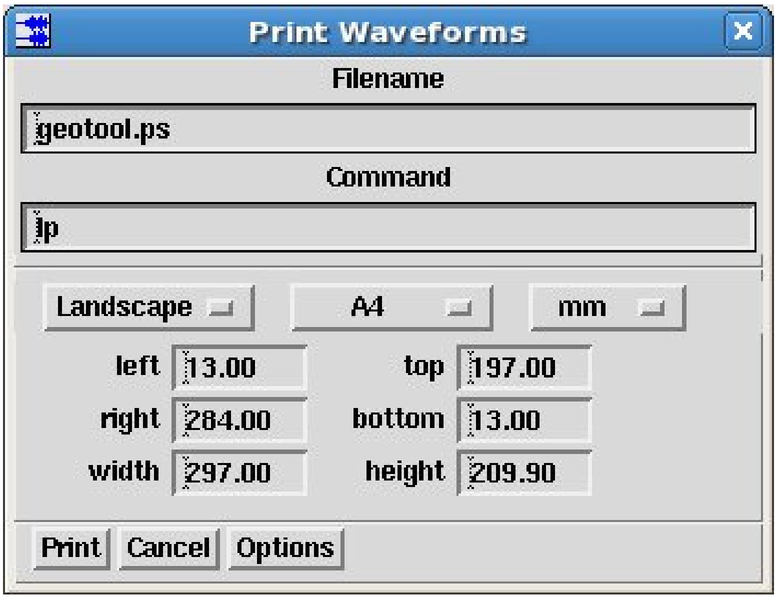


*Figure 13. The **Print Waveforms** popup (with default printer).*

(2) Click on the **Print** button to generate the PostScript file and send the file to the printer using the specified command. Since no printer name is specified, the default printer will be used. Note that the full path can also be given.

(3) Printer name can be specified by typing in the **Command** box of the **Print Waveforms** popup the following command: **lp –d <printer_name>** (Figure 14), where **<printer_name>** can be found after typing in the command line the following command: **lpstat –a**, i.e.

```
dlw003-109% lpstat -a
CLJ5-002 accepting requests since Mon Jun 27 13:22:35 2011
CXM24-001 accepting requests since Mon Jun 27 13:22:36 2011
CXM24-002 accepting requests since Mon Jun 27 13:22:37 2011
CXM24-003 accepting requests since Mon Jun 27 13:22:38 2011
CXM24-004 accepting requests since Mon Jun 27 13:22:39 2011
CXWC7228-001 accepting requests since Mon Jun 27 13:22:40 2011
CXWC7228-002 accepting requests since Mon Jun 27 13:22:41 2011
```

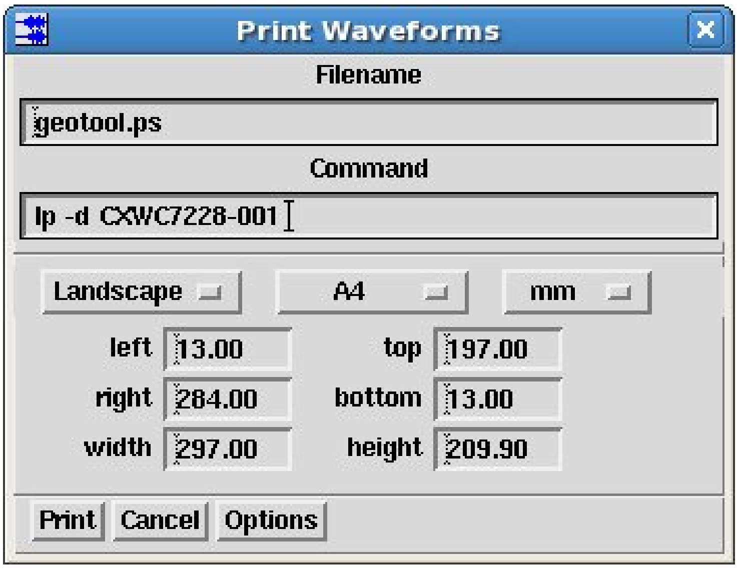


*Figure 14. The **Print Waveforms** popup (with specified printer).*

Note that if no command is given, the postscript file will be created, but it will not be sent to a printer. Each time the **Print** button is pressed in the **Print** window, a new postscript file is made with the specified file name. By default, any previously existing file of the same name is overwritten.

The **Filename** in the **Print** window is the name of the PostScript file that will be created when the **Print** button is pressed. The name of this file can be changed. This output file is created in the directory where geotool was started. However, it is also possible to enter a directory and a filename in the **Filename** window. For example, to write the output to a file named `fig0.ps` in the directory /tmp, the **Filename** can be specified as:

```
/tmp/fig0.ps
```

(4) Click Options button in the **Print Waveforms** popup

This activates **Print Options** popup.

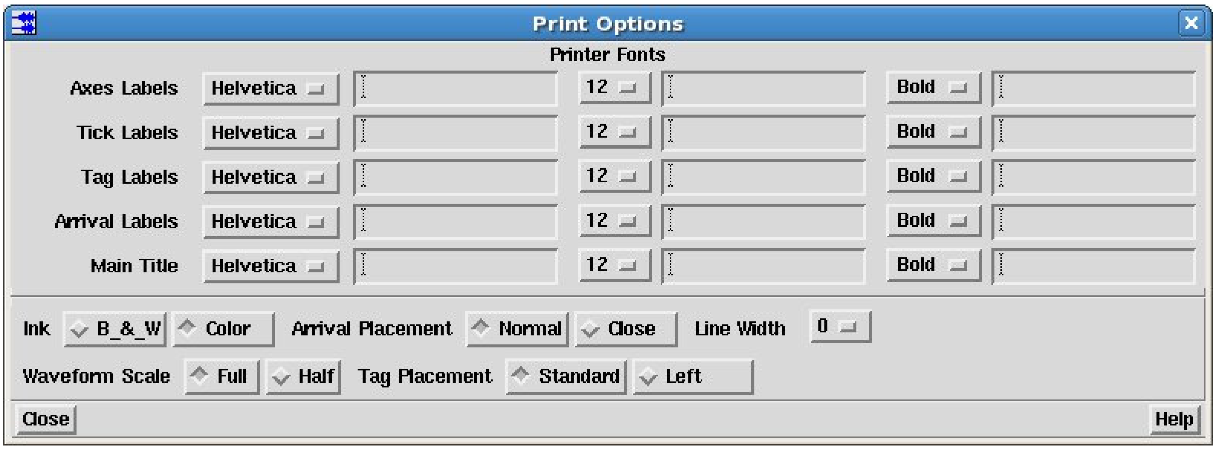


*Figure 15. The **Print Options** popup.*

For example choose the values for Waveform Scale or for Line Width as in Figure 15.
Click on the **Close** button in the **Print Options** popup. The values have now been set.

Click on the **Print** button in the **Print Waveforms** popup.
In the working directory you will find a new geotool.ps file (Figure 16).

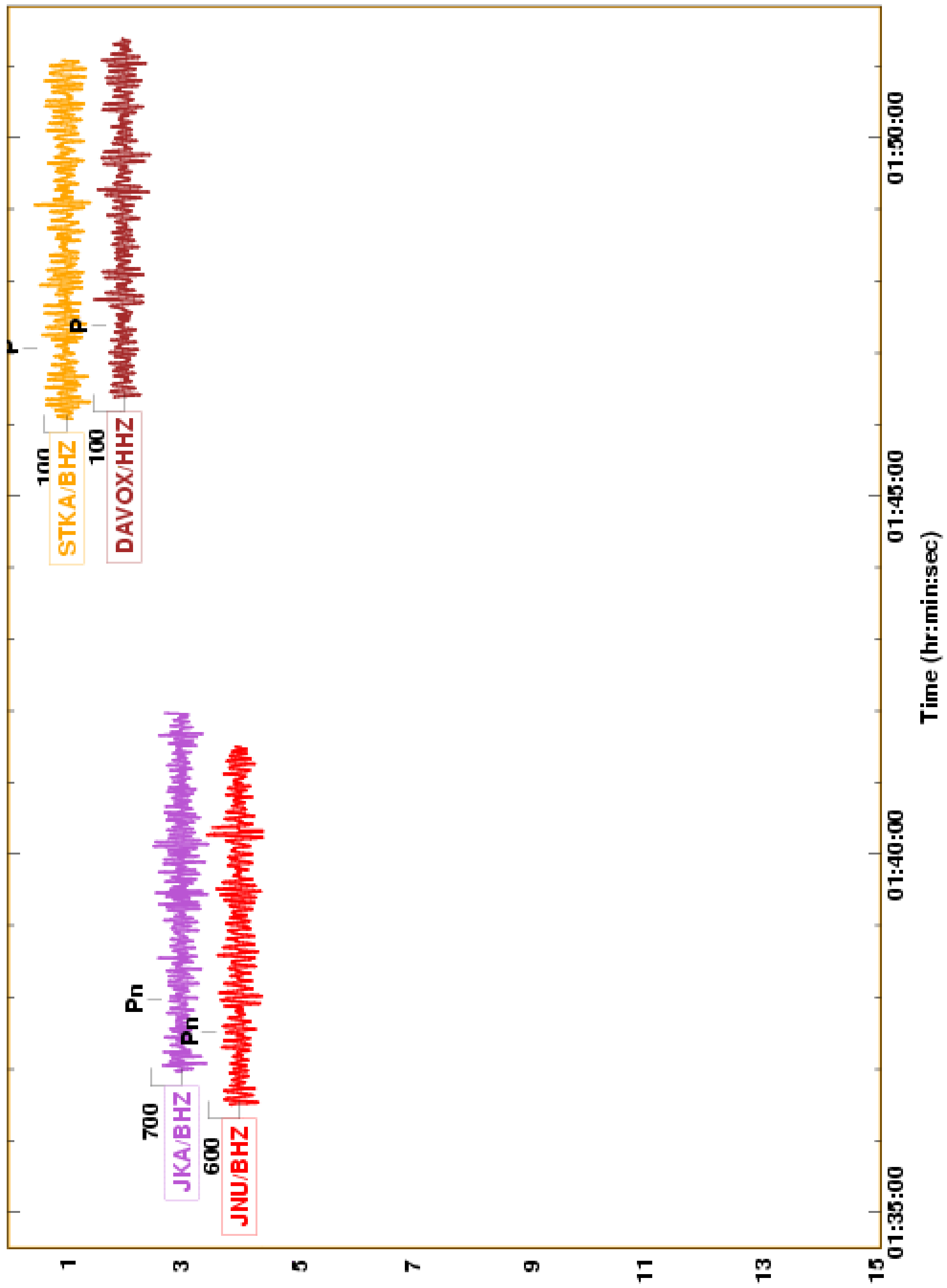


Figure 16. Example of geotool.ps.

(5) Click on the **Close** button to close the **Print** popup.

Exercise 1.6. Output of selected waveforms

In this exercise you will learn how to save waveforms and create a new file containing waveform data.

(1) Select **STKA/BHZ, DAVOX/HHZ** by clicking **Ctrl+Left** mouse button.

(2) Select **File->Output** from the main menu bar.

This activates **Output** popup (Figure 17).

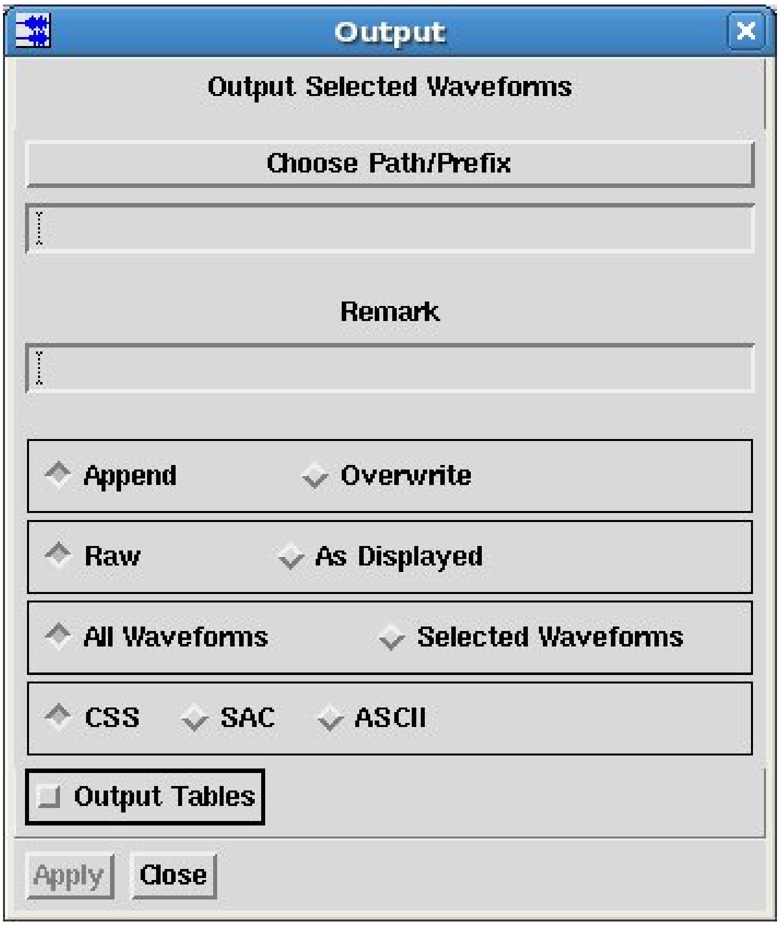


*Figure 17. The **Output** popup.*

(3) Click on the **Choose Path/Prefix** box in the **Output** popup.
This activates **Choose Prefix** popup.

(4) Scroll down in the **Directories** list in the **Choose Prefix** popup, and when you choose the correct directory click on it and it will appear in **Selection** list in the **Choose Prefix** popup.

(5) Type in **DPRK_2** in the **Selection** list in the **Choose Prefix** popup and click on the **Choose Prefix** box in **Choose Prefix** popup (Figure 18, left picture)

The chosen path/prefix will now appear in the Output popup (Figure 18, right picture).

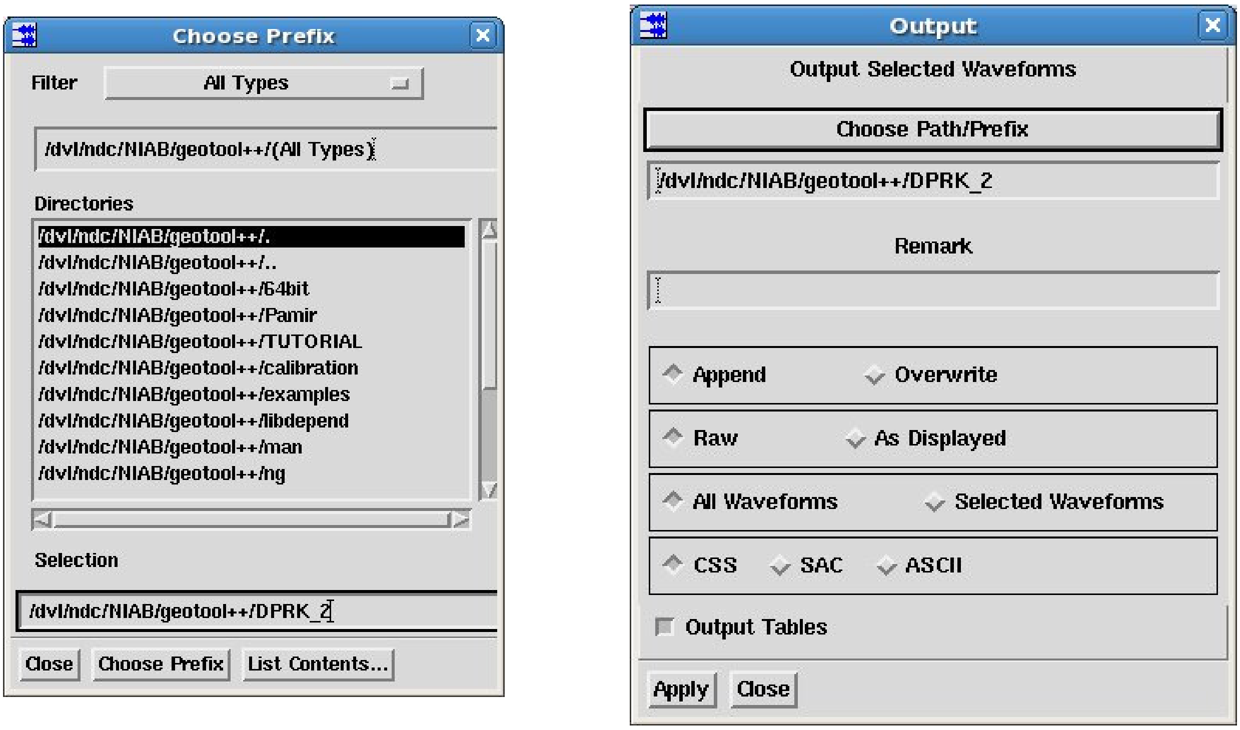


*Figure 18. The **Choose Prefix** popup(left picture), **Output** popup with chosen prefix (right picture).*

(6) Click on the **Output Tables** box in the **Output** popup.

(7) Click on the **Apply** button in the **Output** popup.

The new files **DPRK_2** have been created and saved. These files are **DPRK_2.wfidsc, DPRK_2.w**, **DPRK_2.arrival, DPRK_2.origin.**

Note: The default format for saving files is **CSS.** For saving files in **SAC, ASCII** format choose **SAC** or **ASCII** button in the **Output** popup and afterwards click on the **Apply** button in the **Output** popup.

Exercise 1.7. Waveform Tags

In this exercise you will learn two things: to display/undisplay the waveform tags, and to modify the waveform tags. A waveform tag is the label to the left side of each waveform.

To display/undisplay waveform tags:

(1)Select **View→Tags→Display Tags** menu item from the main menu bar. The main waveform window should now look like the right side of Figure 19.

After repeating the same procedure waveform tags will again appear.

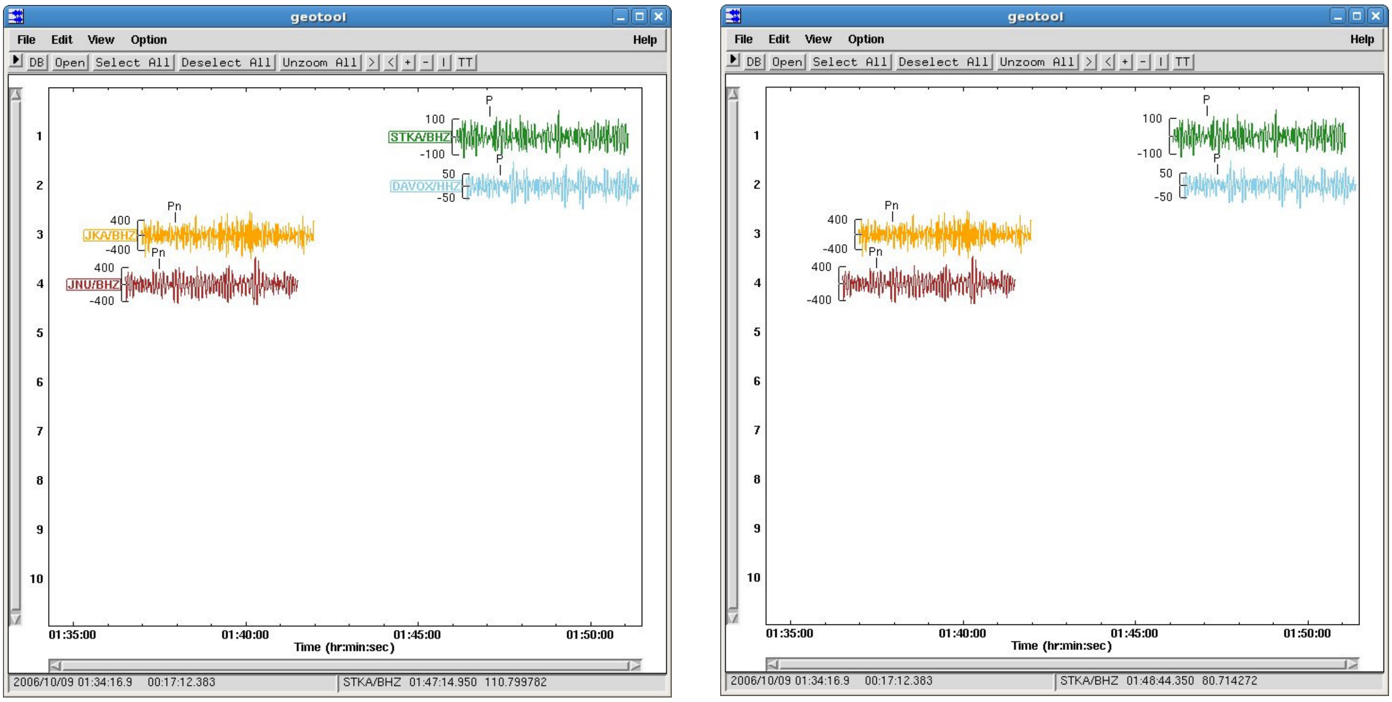


*Figure 19. Main waveform window after loading the **BHZ** and **HHZ** data channel (left picture) and after waveform tags are removed (right picture).*

To modify the waveform tags:

(1) Select all the waveforms with the **View→Select→Select All** menu item or **Select All** toolbar button.

(2) Click on the “**>**” button to increase the scale in the window. Click on it 2 times if needed.

(3) Select the **View→Tags→Tag Contents** in the main waveform window. This activates the **Tag Contents** popup.

(4) Station and Channel will already be selected by default. Select in addition the following items: **Distance (deg), YYMONDD, Text Input**. The check mark will appear next to the selected items. After selecting the item **Text Input** type **test** in the empty box in the **Tag Contents** popup. Click on the **Apply** button. Where applicable, each waveform tag now includes a value for distance in degrees from the event, year/month/day, and the typed text (Figure 20).

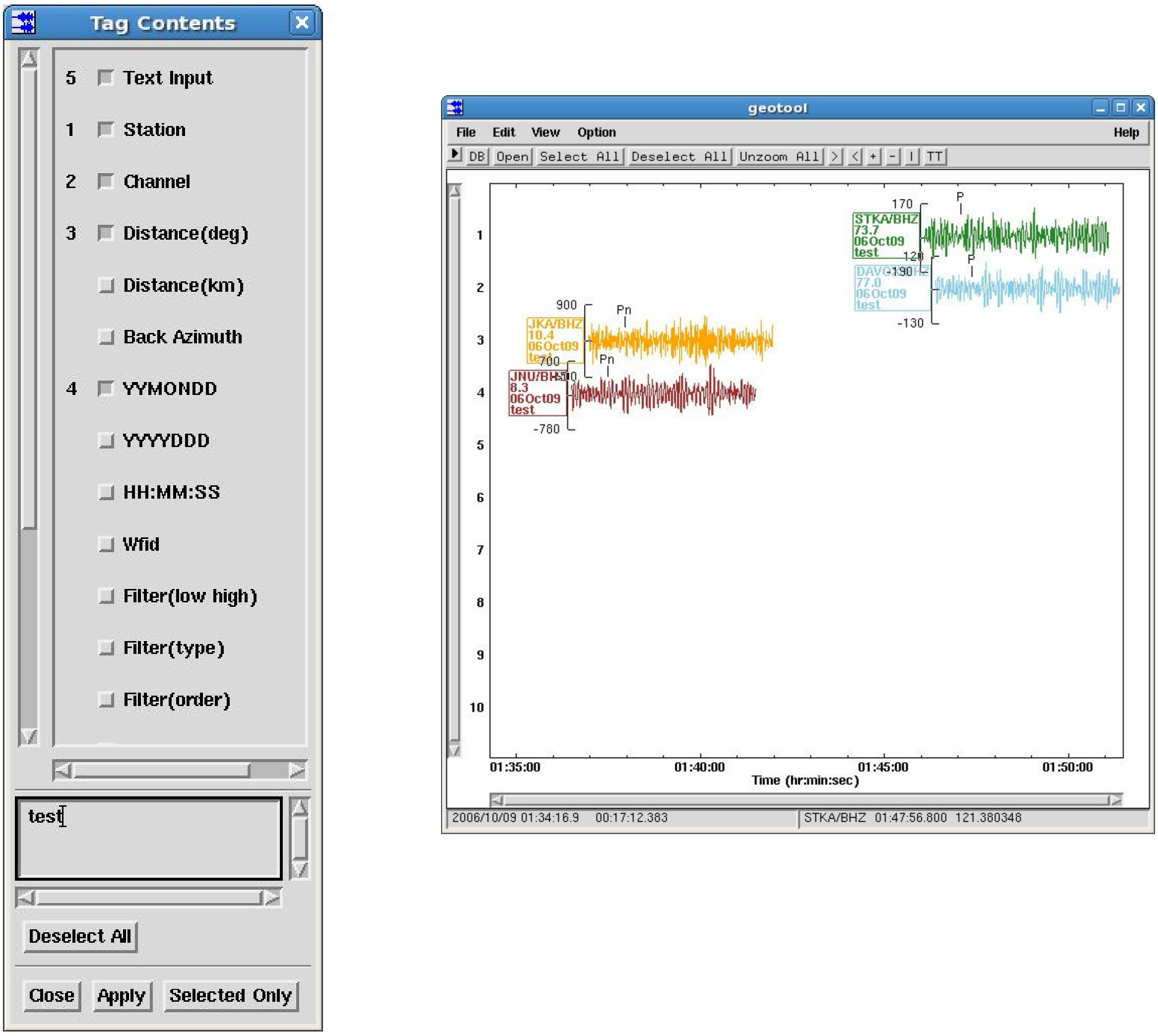


Figure 20. Waveform window with distance, date and text information added to each waveform tag.

(5) Select the **Distance (deg) YYMONDD, Text Input** items again.

(6) Select the **Apply** button. This will remove the check mark next to the items and will remove the distance, date, text attributes from the waveform tags for the selected waveforms.

(7) Click the **Close** button in the **Tag Contents** popup.

(8) Select **Edit→Clear** to remove the waveforms and prepare for the next exercise.

Exercise 1.8. The Butterworth Filter.

In this exercise, you will learn how to set accelerator key, and how to use the Butterworth filter in Geotool .

(1) Click with the **right** mouse button on the black arrow in the upper left information panel in the main window and select **Set Accelerator ->Edit->Filter->Butterworth filter** menu item (Figure 21, left picture).

(2) In the **Set Accelerator** popup click on the **Ctrl** box. Type f in the text window to the right of **Key**, and then click on the **Set Accelerator** box in the **Set Accelerator** popup (Figure 21, right picture).

This sets accelerator **Ctrl+f** for the Butterworth filter popup.

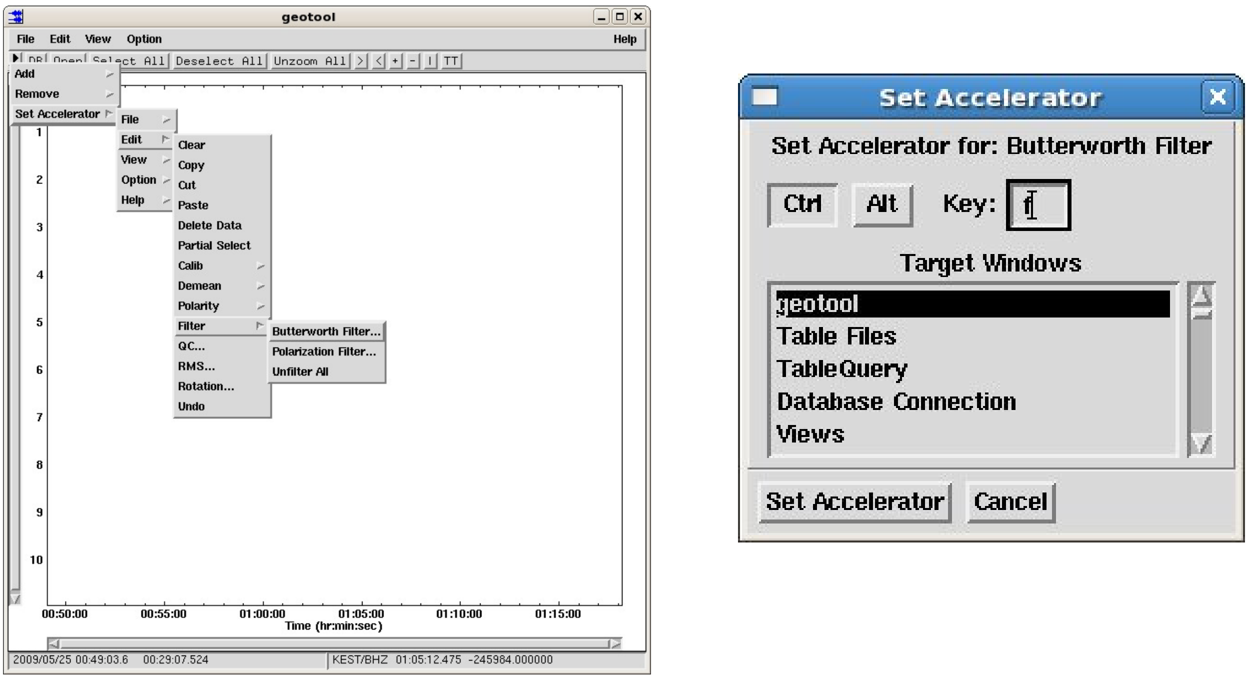


Figure 21. Set Accelerator Key for Butterworth Filter.

(3) Select the **File→Recent Files** menu item and select the top option which will open the same files used in the last exercise.

(4) Select the **Edit→Filter→Butterworth Filter** menu item (or now you can use the accelerator **Ctrl + f**) anywhere in the main window. This activates the **Butterworth Filter** popup, which is used for filtering waveforms.

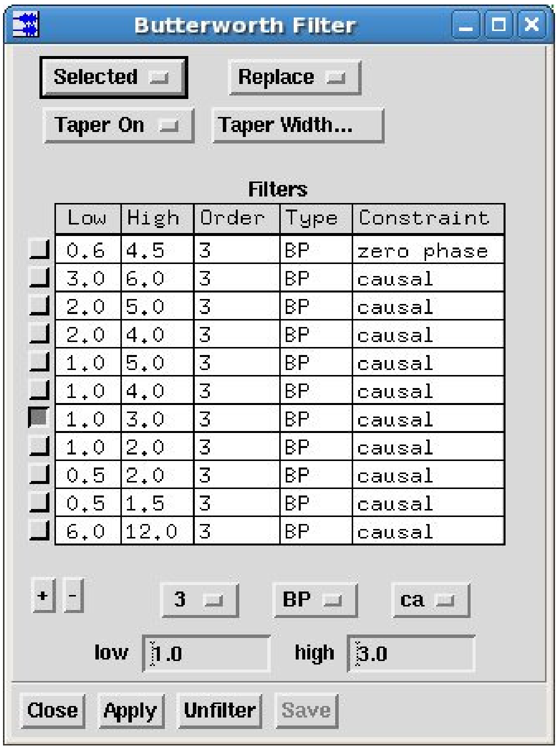


*Figure 22. The **Butterworth Filter** popup.*

(5) Select the waveforms **JKA/BHZ** and **JNU/BHZ**. Do this by **ctrl + left mouse click** over each waveform. Waveforms are displayed in dark blue when selected.

(6) In the **Butterworth Filter** popup, select a filter by clicking one of the boxes next to the filter you would like to apply (Figure 22). The selected filter is applied.

Please note that when a filter in the list is selected, it is immediately applied to the selected waveform(s). Try by selecting other filters in the list. You can change the values in the **Order**, **Type** or **Constraint** columns by clicking with the left mouse button on the box you want to modify. The value will automatically be changed. The **Low** and **High** attributes can be manually edited. Repeat it several times to become comfortable with changing filters. Then click on the **Apply** button. The new settings will be applied to the selected waveform(s).

Click on the **+** button if you want to add an additional filter and customize its attributes. Click on the **–** button if you want to remove the last filter from the list.

(7) Click the **Unfilter** button to restore the unfiltered waveforms.

(8) Click the **Close** button in the **Butterworth filter** popup to close the Butterworth filter.

Exercise 1.9. Warnings and Error Messages

Error messages and warnings may occur when using Geotool. For example, if the user attempts to filter a waveform and no waveforms are selected, the following will occur (Figure 23):

*Figure 23. **Warning** popup.*

If there have been several warnings during the course of a session, then the **More warnings** button will be active. Selecting the **More warnings** will activate the **Warnings** popup.

The **Warnings** popup lists all warning messages that have been recorded during a session.

(1) The Warnings popup is also accessible by selecting **File →Warnings** from the main menu bar.

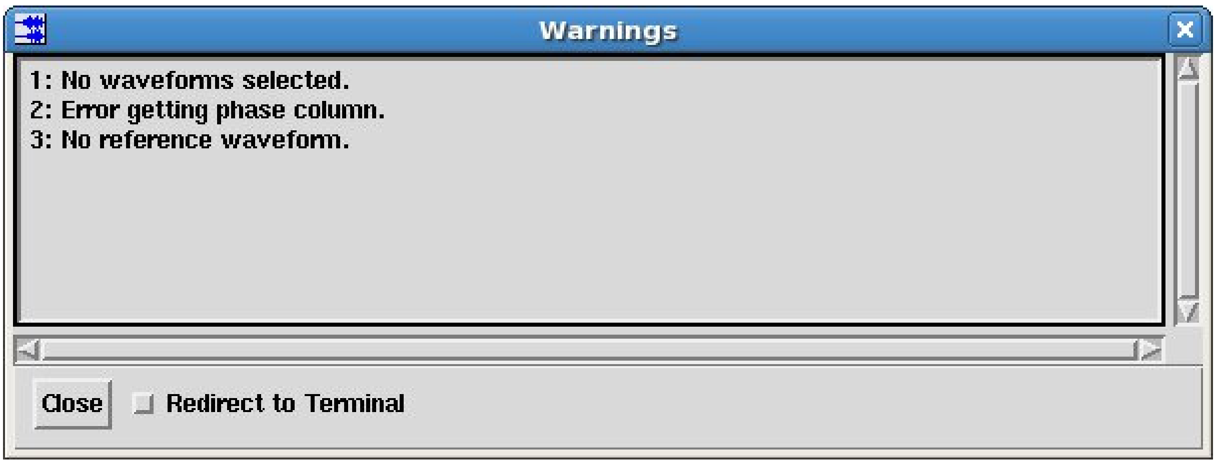


*Figure 24. **Warnings** popup.*

Warnings in the **Warnings** popup are not updated when the popup is displayed and should be closed after reading. In the case of many messages the number before the warning is significant. It is the sequence number of the message. If the same message is repeated consecutively, the sequence number will be increased but the message itself will not be repeated in the **Warnings** popup window. Therefore, if the sequence number of a message is greater than the sequence number of the previous message by more than one, it means that the last message is just being reissued. For example, (Figure 24) shows that the message "No reference waveform" with line number 3 has been issued three times in a row.

(2) Click on the **Redirect to Terminal** in the **Warnings** popup.

This redirects all warnings to also appear in the terminal from which geotool has started.

(3) Select **Edit → Clear** from the main menu bar to clear the data.

Exercise 1.10. Add and Remove Toolbar buttons

In this exercise, you will learn how to add and remove a new toolbar button in Geotool.

(1) Click with the **right** mouse button on the black arrow in the upper left information panel in the main window and select **Add ->Edit->Clear** menu item (Figure 25).

(2) Click on the **Add Button** box in the **Toolbar Button Label** popup (Figure 26).

This adds new toolbar button **Clear** in the main waveform window.

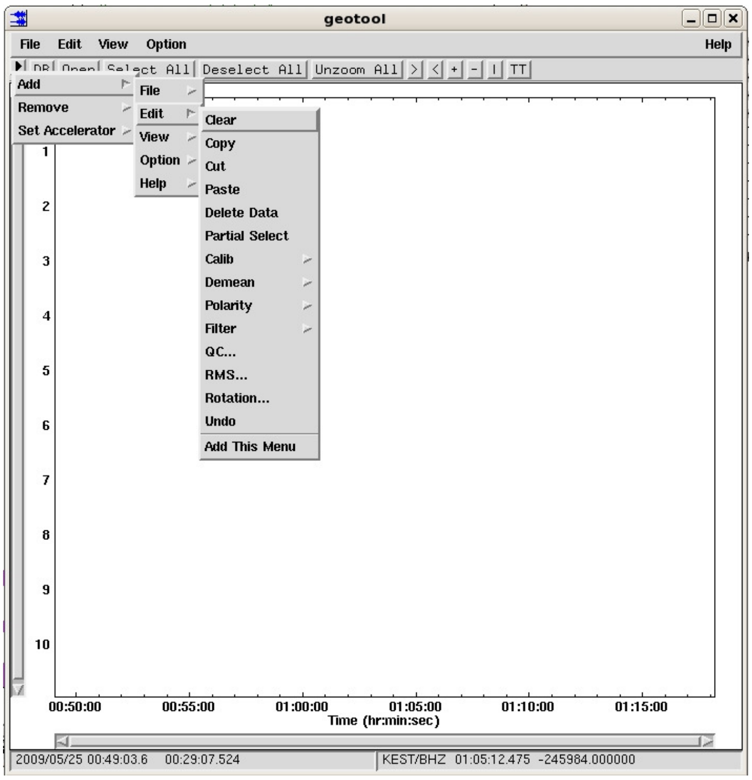


*Figure 25. Add new toolbar button **Clear** in the main waveform window bar.*

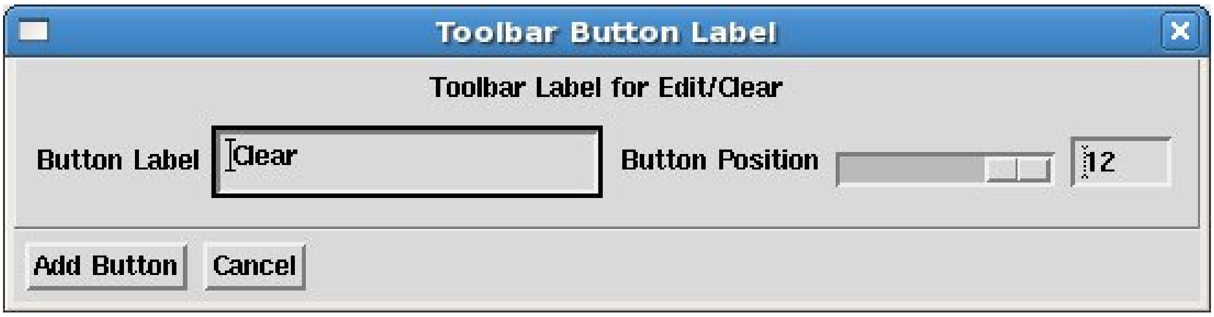


*Figure 26. **Toolbar Button Label** popup.*

(3) Click with the **right** mouse button on the black arrow in the upper left information panel in the main window and select **Remove->Clear** menu item (Figure 27).

This removes new toolbar button **Clear** in the main waveform window.

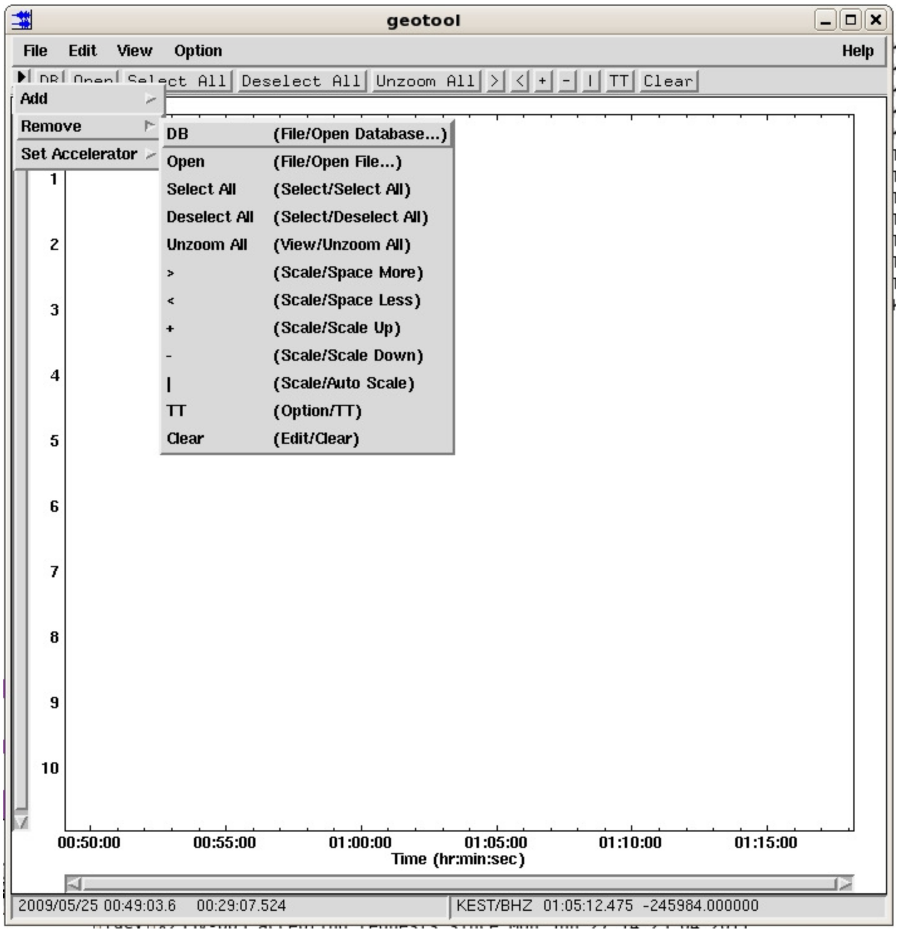


*Figure 27. Remove new toolbar button **Clear** in the main waveform window bar.*

Exercise 1.11. Table Viewer

In this exercise you will learn how to use the Table Viewer.

To open Table Viewer:

(1) Select **File->Tables->Table Viewer** from main menu bar. This activates **Table Viewer** popup.

(2) Select **File->Open** in the **Table Viewer** popup (Figure 28).

(3) This activates **Table Viewer Open** popup (Figure 29).

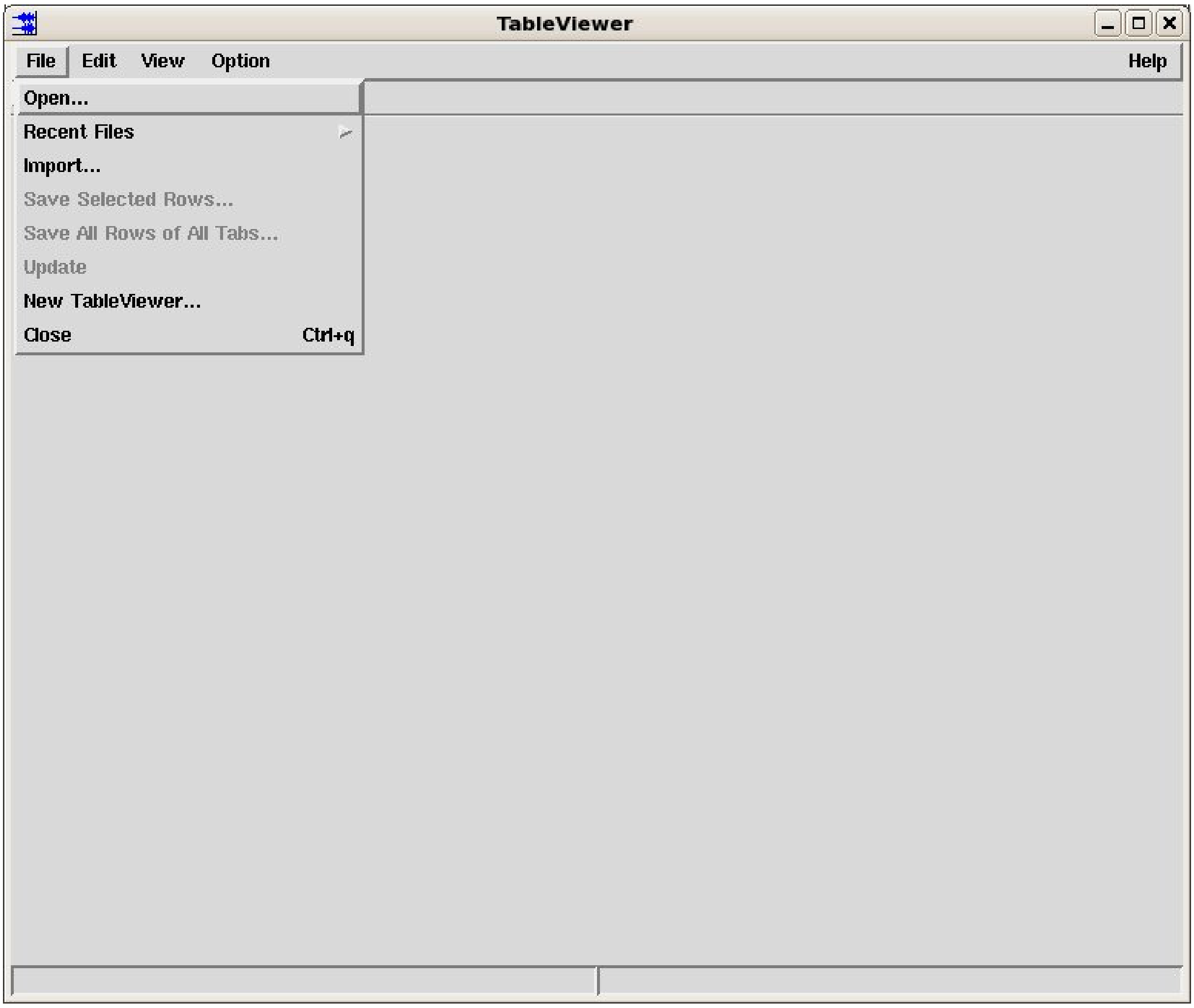


*Figure 28. **Table Viewer** popup.*

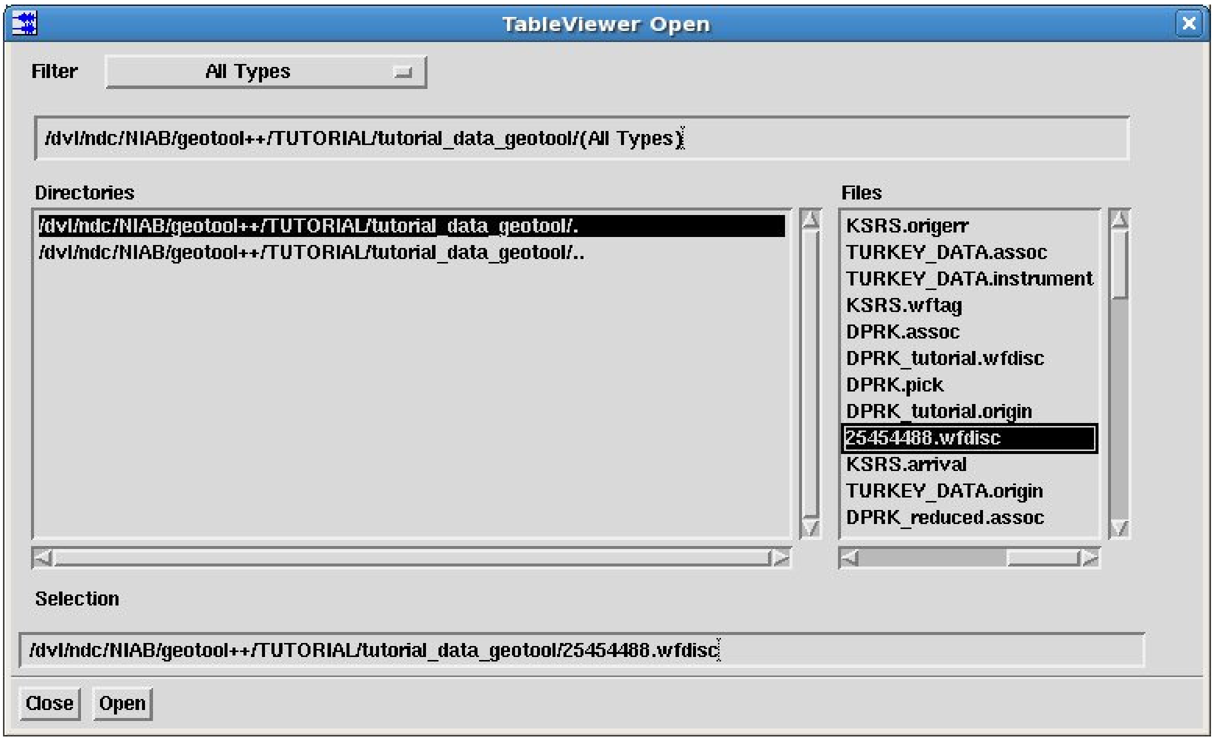
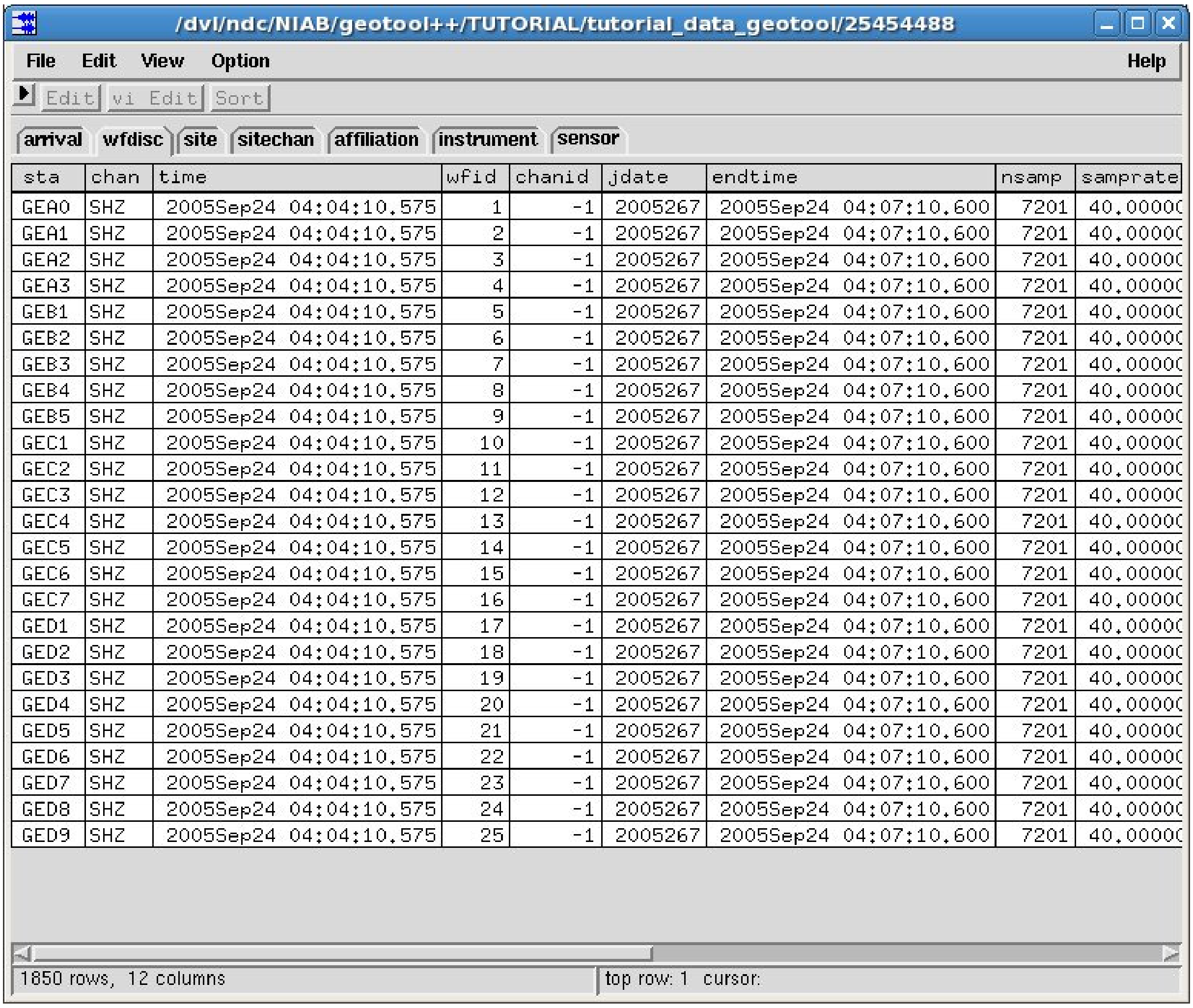


*Figure 29. **Table Viewer Open** popup.*

(4) Select file **25454488.wfdisc** in the **Table Viewer Open** popup by clicking on it with the left mouse button.
(5) Click on the **Open** button in the **Table Viewer Open** popup.

The **TableViewer** popup will be populated from the information of the wfdisc file, namely arrival, wfdisc, site, sitechan, affiliation, instrument, sensor (Figure 30 shows **wfdisc** information).



sta	chan	time	wfid	chanid	jdate	endtime	nsamp	samprate
GEA0	SHZ	2005Sep24 04:04:10.575	1	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEA1	SHZ	2005Sep24 04:04:10.575	2	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEA2	SHZ	2005Sep24 04:04:10.575	3	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEA3	SHZ	2005Sep24 04:04:10.575	4	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEB1	SHZ	2005Sep24 04:04:10.575	5	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEB2	SHZ	2005Sep24 04:04:10.575	6	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEB3	SHZ	2005Sep24 04:04:10.575	7	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEB4	SHZ	2005Sep24 04:04:10.575	8	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEB5	SHZ	2005Sep24 04:04:10.575	9	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEC1	SHZ	2005Sep24 04:04:10.575	10	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEC2	SHZ	2005Sep24 04:04:10.575	11	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEC3	SHZ	2005Sep24 04:04:10.575	12	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEC4	SHZ	2005Sep24 04:04:10.575	13	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEC5	SHZ	2005Sep24 04:04:10.575	14	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEC6	SHZ	2005Sep24 04:04:10.575	15	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GEC7	SHZ	2005Sep24 04:04:10.575	16	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GED1	SHZ	2005Sep24 04:04:10.575	17	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GED2	SHZ	2005Sep24 04:04:10.575	18	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GED3	SHZ	2005Sep24 04:04:10.575	19	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GED4	SHZ	2005Sep24 04:04:10.575	20	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GED5	SHZ	2005Sep24 04:04:10.575	21	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GED6	SHZ	2005Sep24 04:04:10.575	22	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GED7	SHZ	2005Sep24 04:04:10.575	23	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GED8	SHZ	2005Sep24 04:04:10.575	24	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000
GED9	SHZ	2005Sep24 04:04:10.575	25	-1	2005267	2005Sep24 04:07:10.600	7201	40.0000

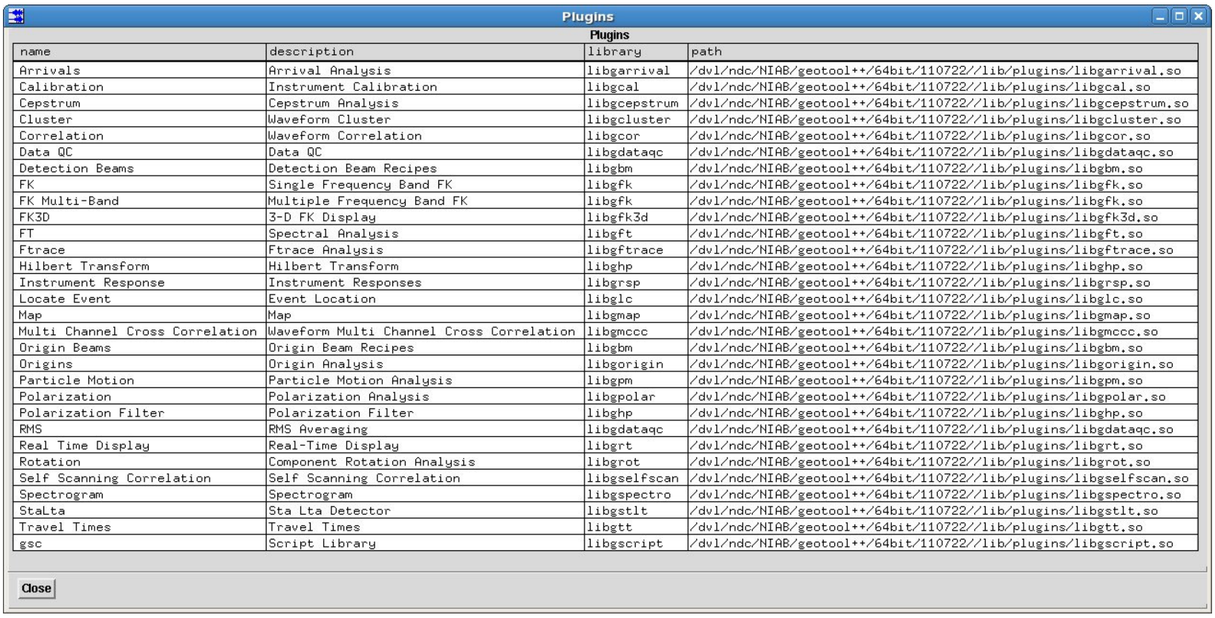
Figure 30. ***Table Viewer*** *popup with the values populated from* ***25454488.wfdisc****.*

Exercise 1.12. Plugins and Table Files

In this exercise you will learn to view plugins and table files.

(1) Select **File->Plugins** from the main menu bar.

This activates **Plugins** popup (Figure 31). You can view which plugins have been installed and where.



name	description	library	path
Arrivals	Arrival Analysis	libgarrival	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgarrival.so
Calibration	Instrument Calibration	libgcal	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgcal.so
Cepstrum	Cepstrum Analysis	libgcepstrum	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgcepstrum.so
Cluster	Waveform Cluster	libgcluster	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgcluster.so
Correlation	Waveform Correlation	libgcor	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgcor.so
Data QC	Data QC	libgdataqc	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgdataqc.so
Detection Beams	Detection Beam Recipes	libgbm	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgbm.so
FK	Single Frequency Band FK	libgfk	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgfk.so
FK Multi-Band	Multiple Frequency Band FK	libgfk	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgfk.so
FK3D	3-D FK Display	libgfk3d	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgfk3d.so
FT	Spectral Analysis	libgft	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgft.so
Ftrace	Ftrace Analysis	libgftrace	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgftrace.so
Hilbert Transform	Hilbert Transform	libghp	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libghp.so
Instrument Response	Instrument Responses	libgrsp	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgrsp.so
Locate Event	Event Location	libglc	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libglc.so
Map	Map	libgmap	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgmap.so
Multi Channel Cross Correlation	Waveform Multi Channel Cross Correlation	libgmccc	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgmccc.so
Origin Beams	Origin Beam Recipes	libgbm	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgbm.so
Origins	Origin Analysis	libgorigin	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgorigin.so
Particle Motion	Particle Motion Analysis	libgpm	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgpm.so
Polarization	Polarization Analysis	libgpolar	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgpolar.so
Polarization Filter	Polarization Filter	libghp	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libghp.so
RMS	RMS Averaging	libgdataqc	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgdataqc.so
Real Time Display	Real-Time Display	libgrt	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgrt.so
Rotation	Component Rotation Analysis	libgrot	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgrot.so
Self Scanning Correlation	Self Scanning Correlation	libgselfscan	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgselfscan.so
Spectrogram	Spectrogram	libgspectro	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgspectro.so
StaLta	Sta Lta Detector	libgstlt	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgstlt.so
Travel Times	Travel Times	libgtt	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgtt.so
gsc	Script Library	libgscript	/dvl/ndc/NIAB/geotool++/64bit/110722//lib/plugins/libgscript.so

*Figure 31. **Plugins** popup.*

If some packages are missing then not all plugins will be installed (i.e. if GSL is not installed, then Multi Channel Cross Correlation plugin will not be installed, if netCDF is not installed then Map plugin will not be installed). Please look for the details in the installation guide **NDC-in-a-Box_Wav_SIP_2011** on how to install all packages.

(2) Select **File->Tables->Table Files** from the main menu bar.

This activates **Table Files** popup (Figure 32). You can view tables which are used in Geotool and where are they installed.

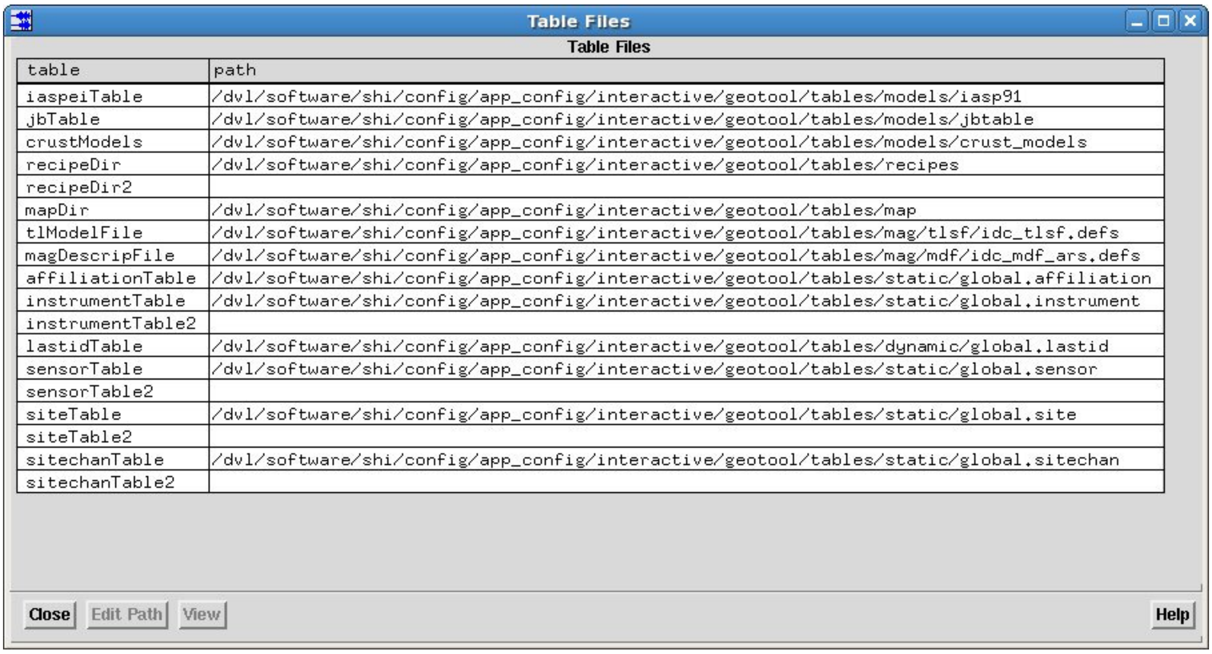


Table Files

table	path
iaspeiTable	/dvl/software/shi/config/app_config/interactive/geotool/tables/models/iasp91
jbTable	/dvl/software/shi/config/app_config/interactive/geotool/tables/models/jbtable
crustModels	/dvl/software/shi/config/app_config/interactive/geotool/tables/models/crust_models
recipeDir	/dvl/software/shi/config/app_config/interactive/geotool/tables/recipes
recipeDir2	
mapDir	/dvl/software/shi/config/app_config/interactive/geotool/tables/map
tlModelFile	/dvl/software/shi/config/app_config/interactive/geotool/tables/mag/tlsf/idc_tlsf.defs
magDescripFile	/dvl/software/shi/config/app_config/interactive/geotool/tables/mag/mdf/idc_mdf_ars.defs
affiliationTable	/dvl/software/shi/config/app_config/interactive/geotool/tables/static/global.affiliation
instrumentTable	/dvl/software/shi/config/app_config/interactive/geotool/tables/static/global.instrument
instrumentTable2	
lastidTable	/dvl/software/shi/config/app_config/interactive/geotool/tables/dynamic/global.lastid
sensorTable	/dvl/software/shi/config/app_config/interactive/geotool/tables/static/global.sensor
sensorTable2	
siteTable	/dvl/software/shi/config/app_config/interactive/geotool/tables/static/global.site
siteTable2	
sitechanTable	/dvl/software/shi/config/app_config/interactive/geotool/tables/static/global.sitechan
sitechanTable2	

*Figure 32. **Table Files** popup.*

IDC tables provide most input tables needed by the NDC software. Please look for the details in the installation guide **NDC-in-a-Box_Wav_SIP_2011** on how to install IDC tables (Annex I).

Exercise 1.13. Converting AutoDRM TXT to WFDISC file

Analysis cannot be done on the .txt files, so the files need to be converted to wfdisc.
In this exercise, data are read as follows:

(1) Select the **File→Open File** menu item to activate the **Open file** popup.

(2) Select all **.txt** files from the directory **tutorial_data_geotool/ korea2009/*.txt** in the **Files** column in the **Open file** popup and click on the **Open** button in the **Open file** popup (Figure 33).

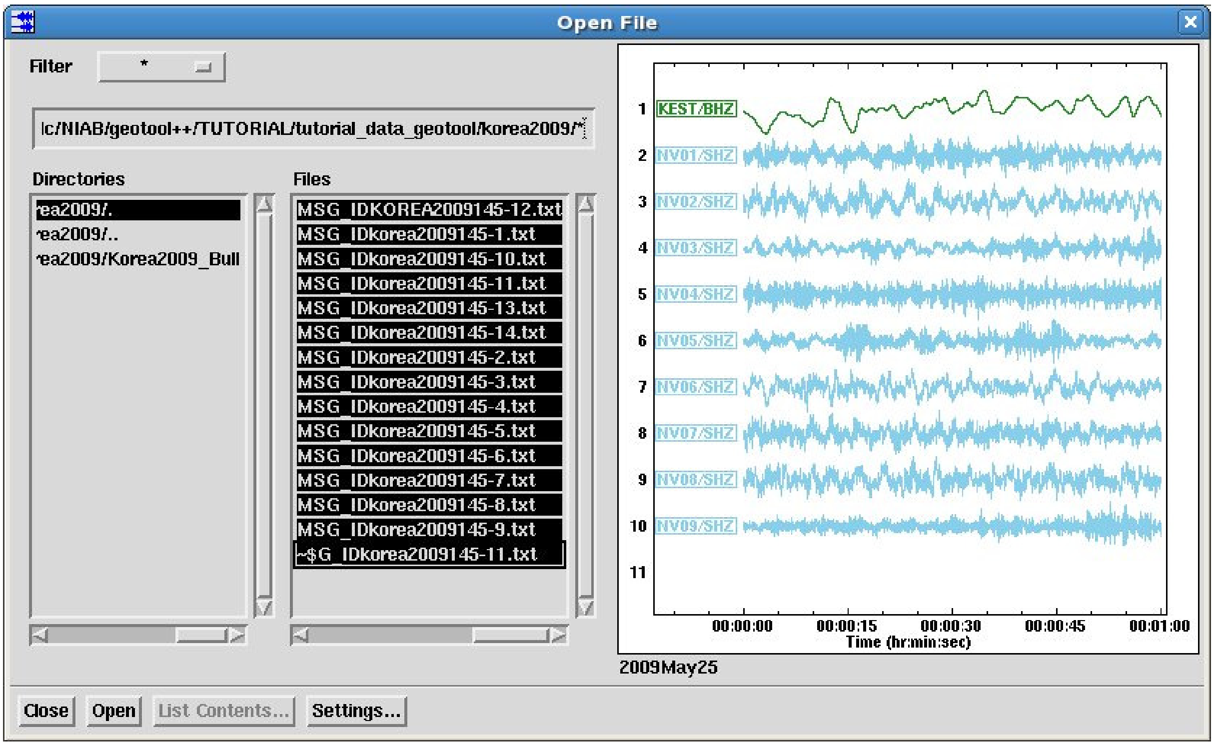


*Figure 33. The **Open file** popup with MSG_IDkorea2009*.txt files loaded.*

(3) After selecting the **Open** button the data will appear in the main waveform window (Figure 34).

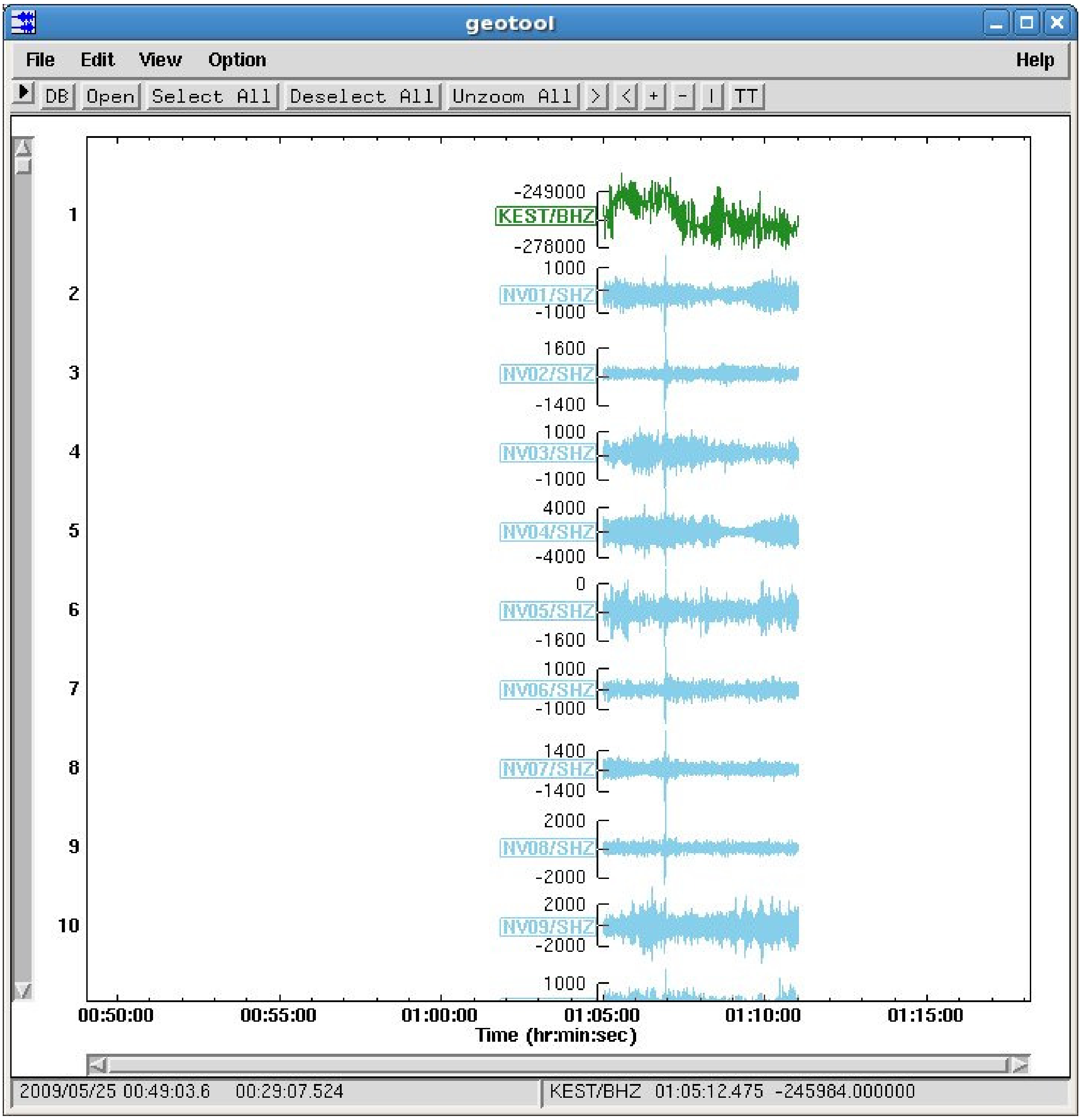


Figure 34. The main waveform window with TXT data loaded.

(4) Select **File->Output** from the main menu bar. This activates **Output** popup (see ***Exercise 1.6,*** Figure 17).

(5) Click on the **Choose Path/Prefix** in the **Output** popup. This activates the **Choose Prefix** popup.

(6) Type Korea2009 for the new chosen prefix in the selected path and click on the **Choose Prefix** box in the **Choose Prefix** popup (Figure 35).

The prefix Korea2009 will now appear in the **Output** popup.

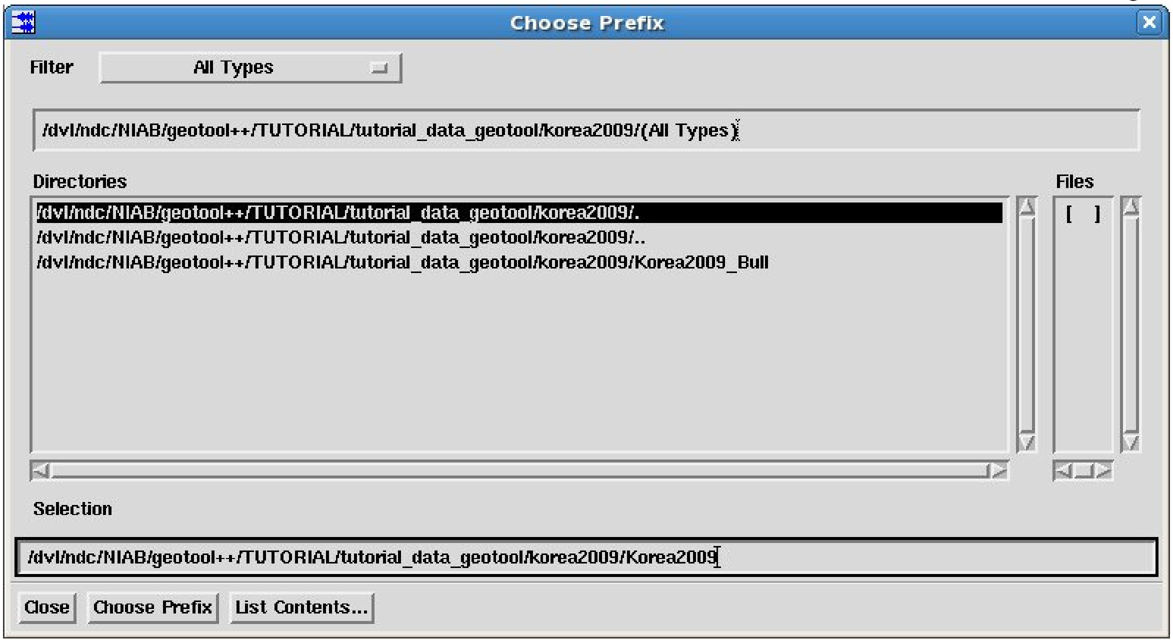


*Figure 35. The **Choose Prefix** popup with chosen prefix Korea2009.*

(7) Click on the **Output tables** box in the **Output** popup.
(8) Click on the Apply button in the Output popup (Figure 36).

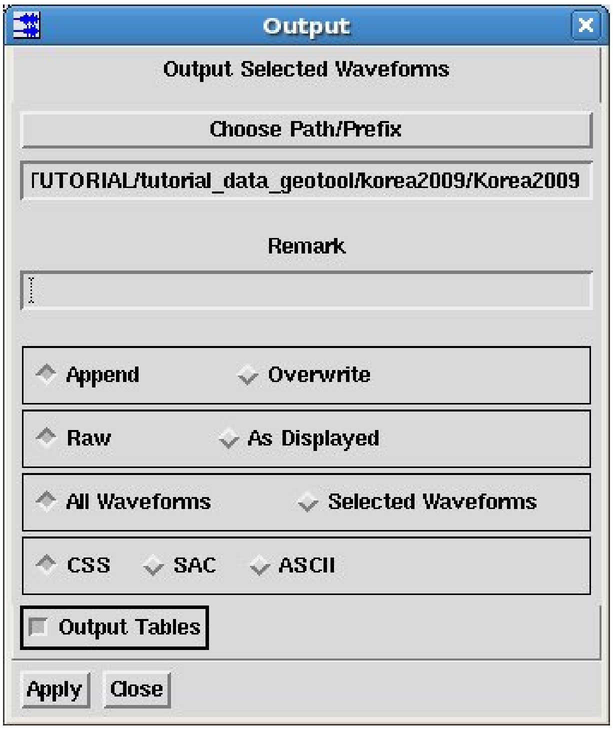


*Figure 36. **Output** popup with chosen prefix Korea2009.*

The new files **Korea2009** have been created and saved. These files are **Korea2009.w, Korea2009.wfdisc**.

(9) Select **Edit → Clear** from the main menu bar to clear the data.

SECTION 2. MORE BASIC WAVEFORM HANDLING

Exercise 2.1. Data Input.

In this exercise, data are read as follows:

(1) Select the **File→Open File** menu item to activate the **Open file** popup.

(2) Select the file named **DPRK_tutorial.wfdisc** in the **Files** column in the **Open file** popup and click on the **Open** button in the **Open file** popup.

Exercise 2.2. Aligning waveforms.

By default, waveforms are aligned on true time when they are loaded from wfdisc file.

To align waveforms on the first point:

(1) Select **View->Align->On First Point** from the main menu bar (Figure 37, left picture). In this view, the X axis represents the time after the first point of each waveform.

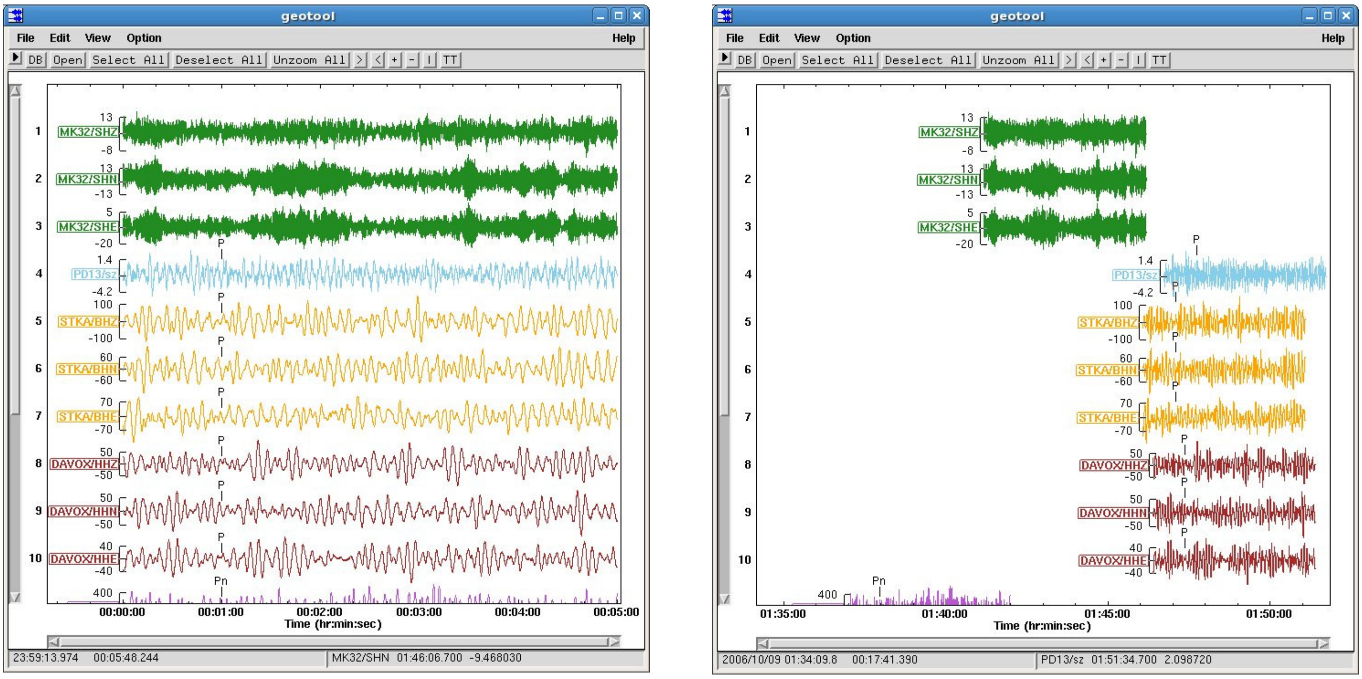


Figure 37. Main waveform window after aligning waveforms on first point (left picture) and after aligning waveforms on true time (right picture).

To align waveforms on true time:

(1) Select **View->Align->On True Time** from the main menu bar (Figure 37, right picture). In this view, the X axis represents the true time of when the data were recorded.

To align waveforms on **Time Minus Origin**, **Time Minus Predicted FirstP, Time Minus Observed FirstP** it is necessary to have waveforms associated to origin. More handling with Arrivals will be shown in Section 3.

Exercise 2.3. Selecting visible waveforms.

To select visible Z waveforms:

(1) Select **View->Select->Select Visible Z** from the main menu bar (Figure 38, left picture).

To select visible Horizontal component of waveforms:

(1) Select **View->Select->Select Visible Horz** from the main menu bar (Figure 38, right picture).

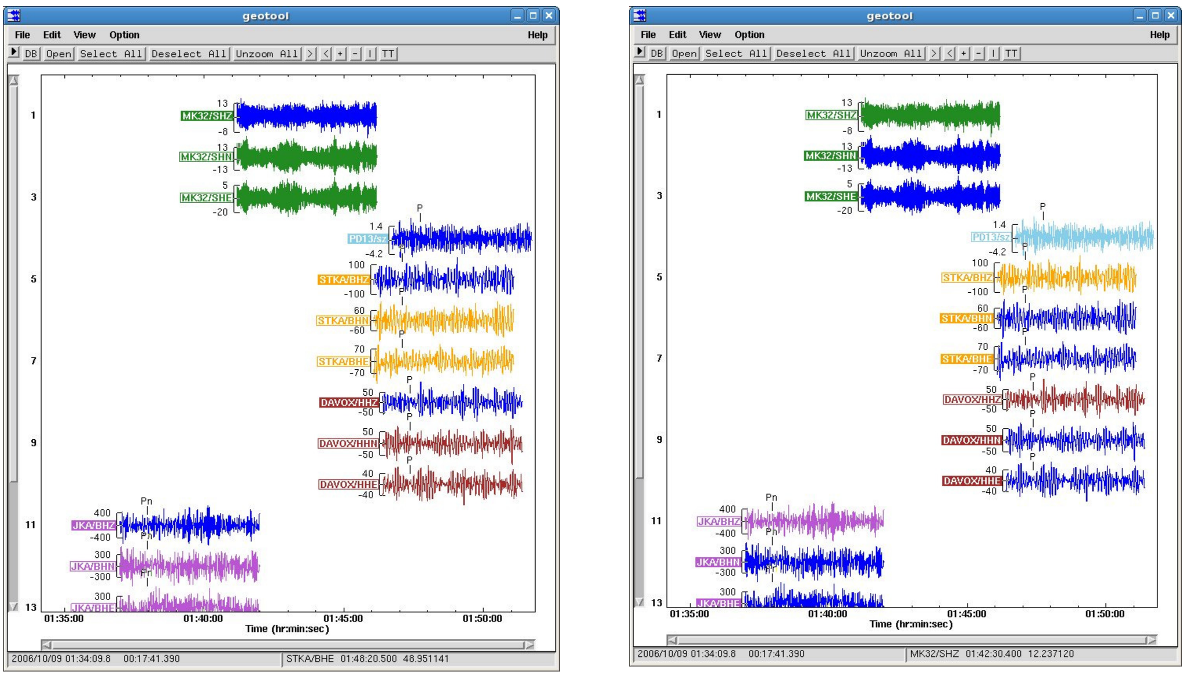


*Figure 38. Main waveform window after selecting **visible Z** waveforms (left picture) and after selecting **visible Horz** waveforms (right picture).*

To select visible waveforms:

(1) Select **View->Select->Select Visible** from the main menu bar.

This selects only visible waveforms in the current waveform window. Scroll down to see that the other waveforms have not been selected.
Before starting the new exercise click on the **Deselect All** toolbar button.

Exercise 2.4. Display of waveform components.

To view N and E waveform components:

(1) Select **View->Components->N and E Only** from the main menu bar (Figure 39a).

To view Z, N or E waveform components:

(1) Select **View->Components->Z Only, N Only, E Only** from the main menu bar (Figure 39b).

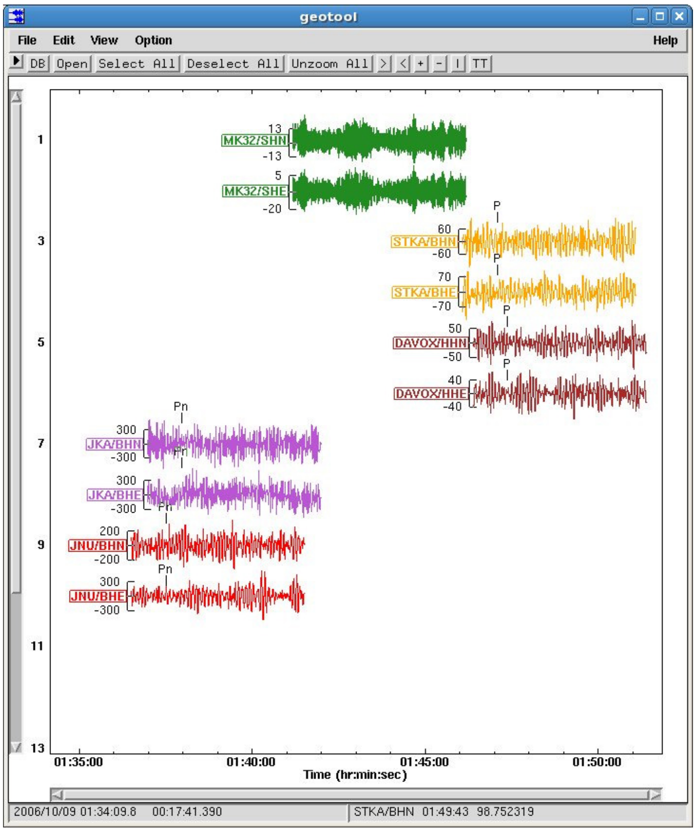


*Figure 39a. Waveform windows displaying **N and E Only** components of waveforms.*

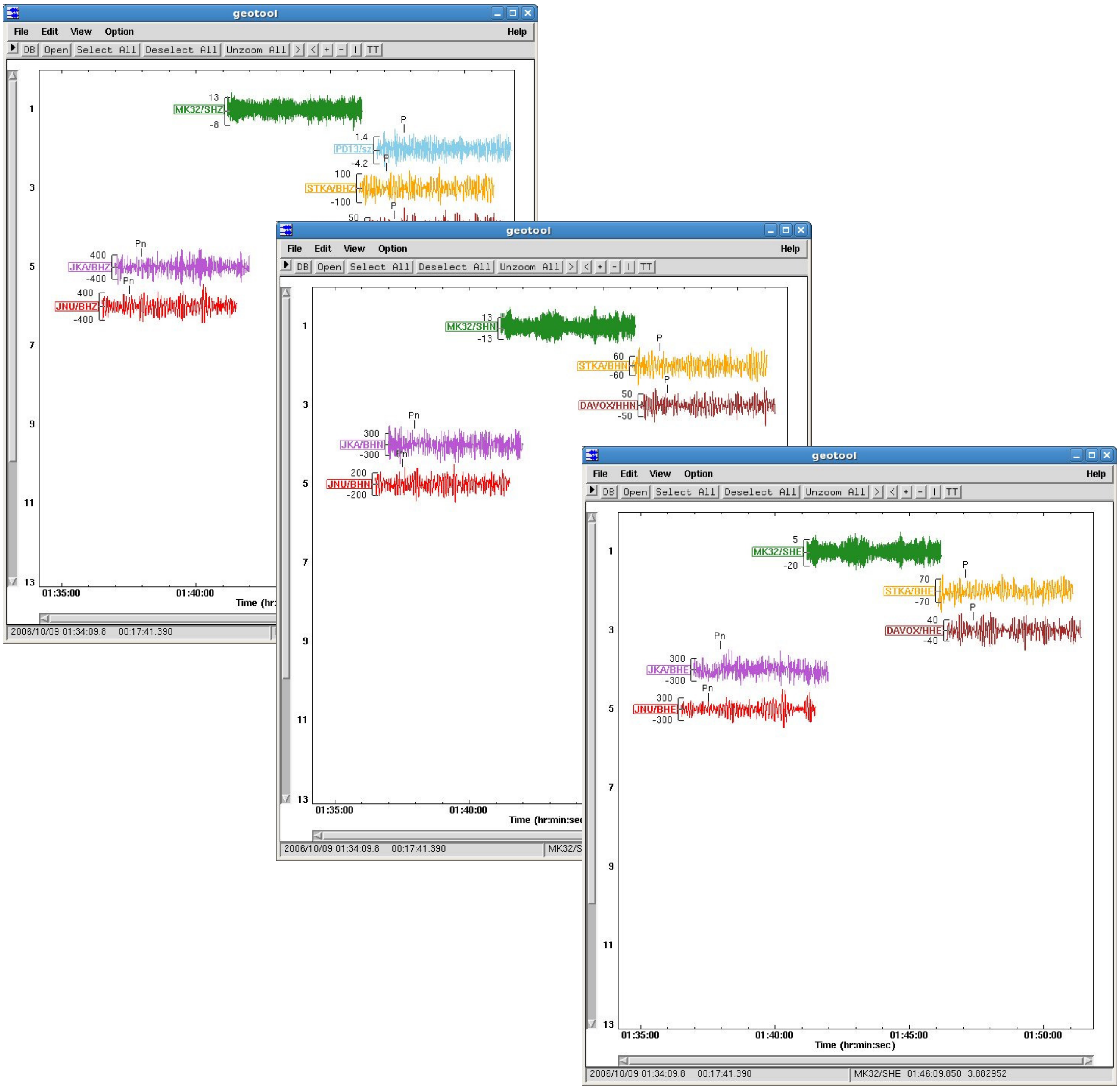


Figure 39b. Waveform windows displaying ***Z Only, N Only, E Only*** *components of waveforms.*

Exercise 2.5. Sorting of waveform order.

By default waveforms are sorted by Default Order (which is initially File Order).

To set the new Default Order:

(1) The Default Order can be changed by selecting some other waveform order as given below (Time/Sta/Chan, Sta/Chan,…,Back Azimuth).

(2) Select **View->Set Default Order** from the main menu bar

This saves the change and sets the new order as Default Order (instead of File Order).

To sort the waveforms by the file order:

(1) Select **View->Sort->File Order** from the main menu bar (Figure 40, left picture).

To sort the waveforms by distance from the associated event:

(1) Select **View->Sort->Distance** from the main menu bar (Figure 40, right picture).

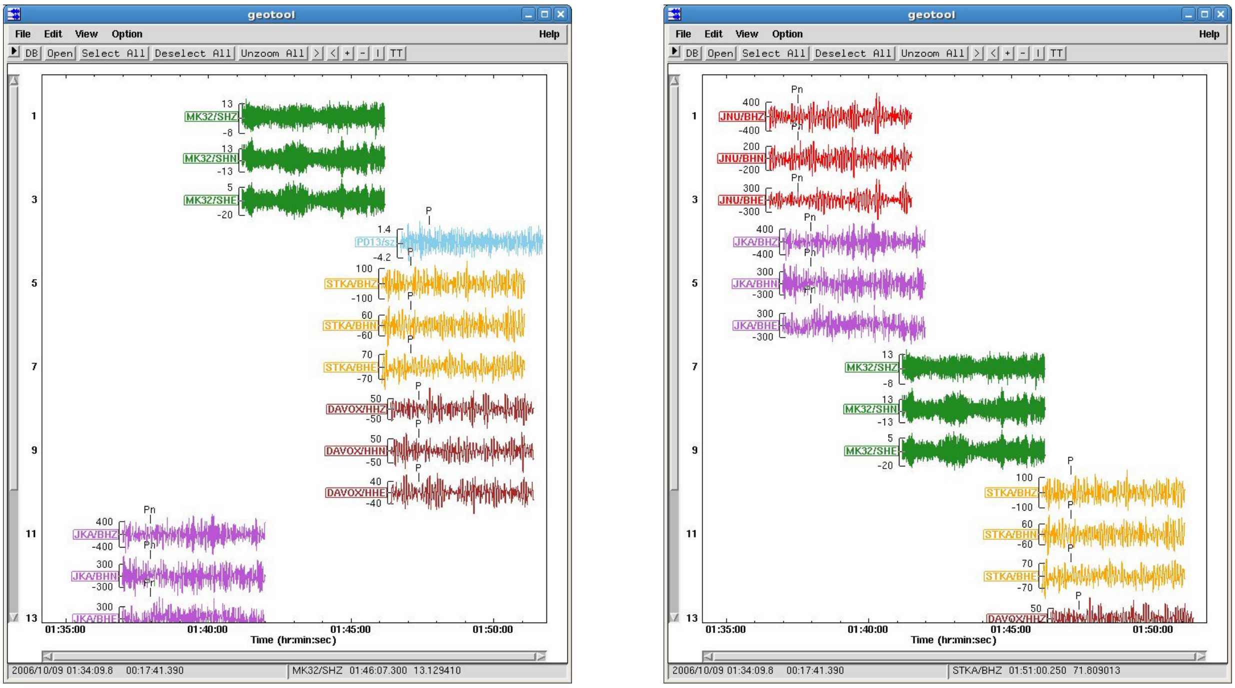


*Figure 40. Main waveform window after sorting waveforms by **File Order** (left picture) and by **Distance** (right picture).*

To sort the waveforms by Time/Station/ Channel (where Time is increasing start time):

(1) Select **View->Sort-> Time/Sta/Chan** from the main menu bar (Figure 41, left picture).

To sort the waveforms alphabetically by Station/Channel:

(1) Select **View->Sort->Sta/Chan** from the main menu bar (Figure 41, right picture).

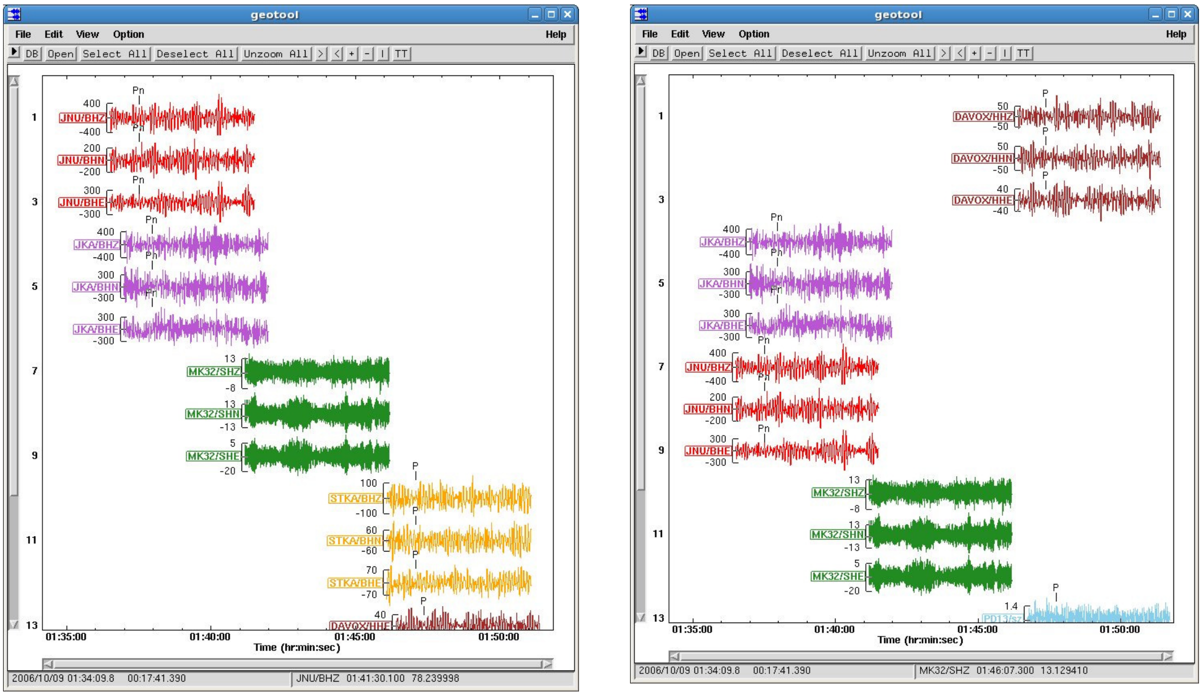


*Figure 41. Main waveform window after sorting waveforms by **Time/Sta/Chan** (left picture) and by **Sta/Chan** (right picture).*

To sort the waveforms by Channel/Station:

(1) Select **View->Sort-> Chan/Sta** from the main menu bar (Figure 42, left picture).

To sort the waveforms by increasing Back Azimuth from the associated event:

(1) Select **View->Sort-> Back Azimuth** from the main menu bar (Figure 42, right picture).

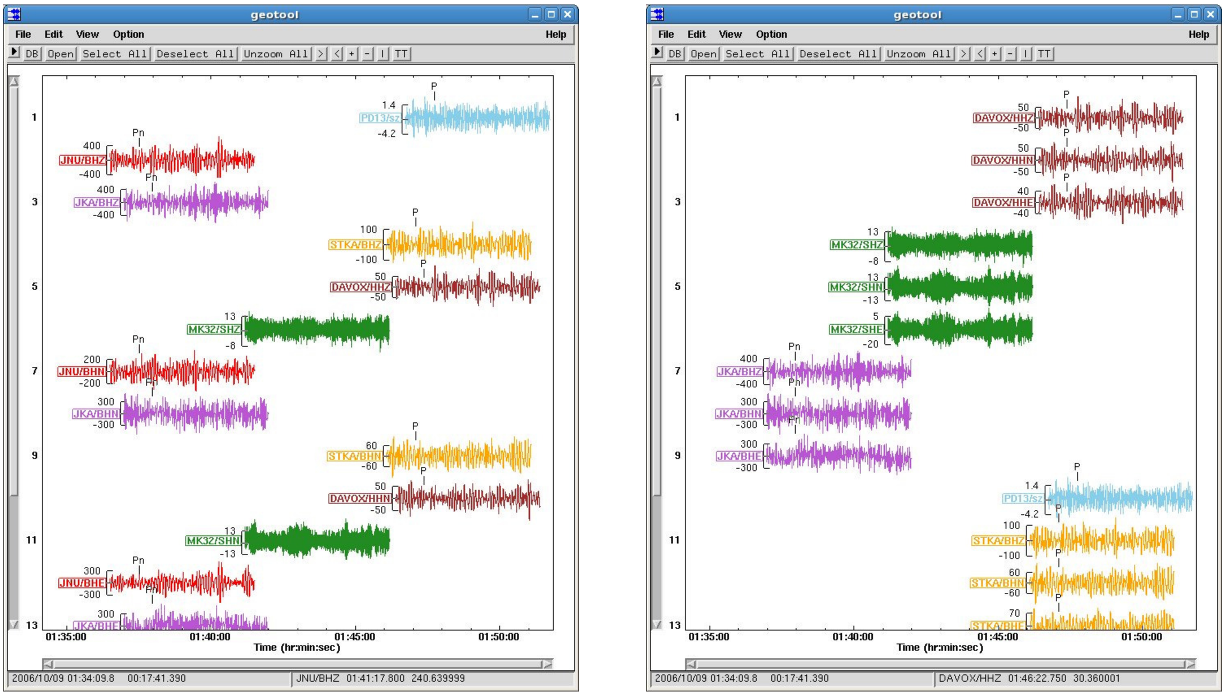


*Figure 42. Main waveform window after sorting waveforms by **Chan/Sta** (left picture) and by **Back Azimuth** (right picture).*

To sort the waveforms by Default Order:

(1) Select **View->Sort-> Default Order** from the main menu bar.

Exercise 2.6. Zooming on waveform(s).

In this exercise you will learn how to zoom in the main window. These actions can be applied to any geotool plot window.

(1) Hold down the **middle** mouse button and draw a rectangle over **PD13/sz**. Note that the edge of the box is **black**.
This will zoom in on a single waveform (Figure 43).

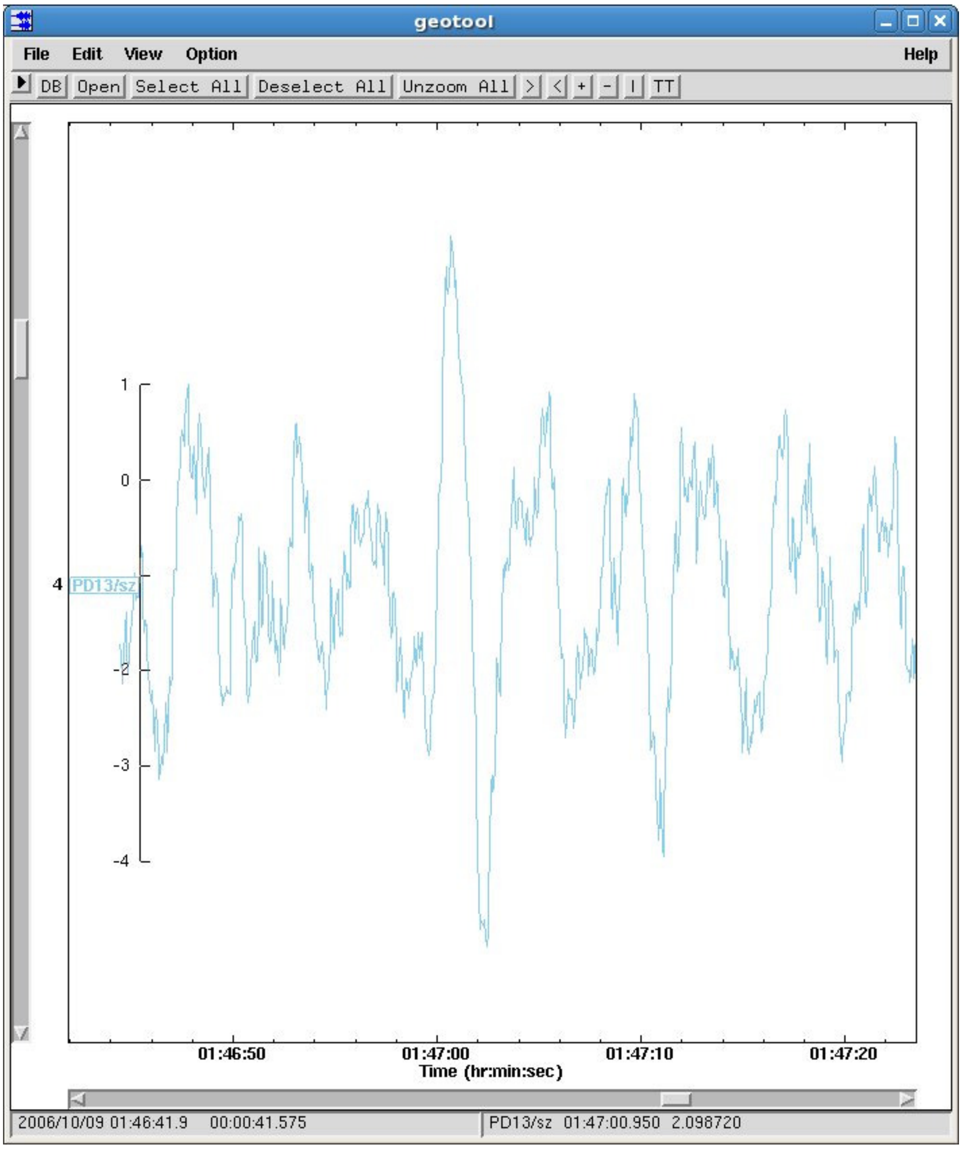


Figure 43. Zoom in on single waveform.

(2) Click on the **Unzoom All** button from the main menu bar.

(3) Select **View->Align->On First Point** in the main waveform window.

(4) Hold the **right** mouse button and drag over all waveforms.

This will zoom in on all waveforms (Figure 44, left picture).

(5) Repeat the step (4) several times until small red dot appears.

In the main window small red dot appears on the waveform nearest to the mouse button (Figure 44, right picture).

(6) Move the mouse along the waveforms.

The small red dot moves along the waveforms. Observe the changes of values of station+channel name, time of waveform, value of sample (at mouse cursor position) on the lower right information panel in the main window. The red dot represents each data sample. It only appears when you have zoomed in enough. Note that width is few seconds of data.

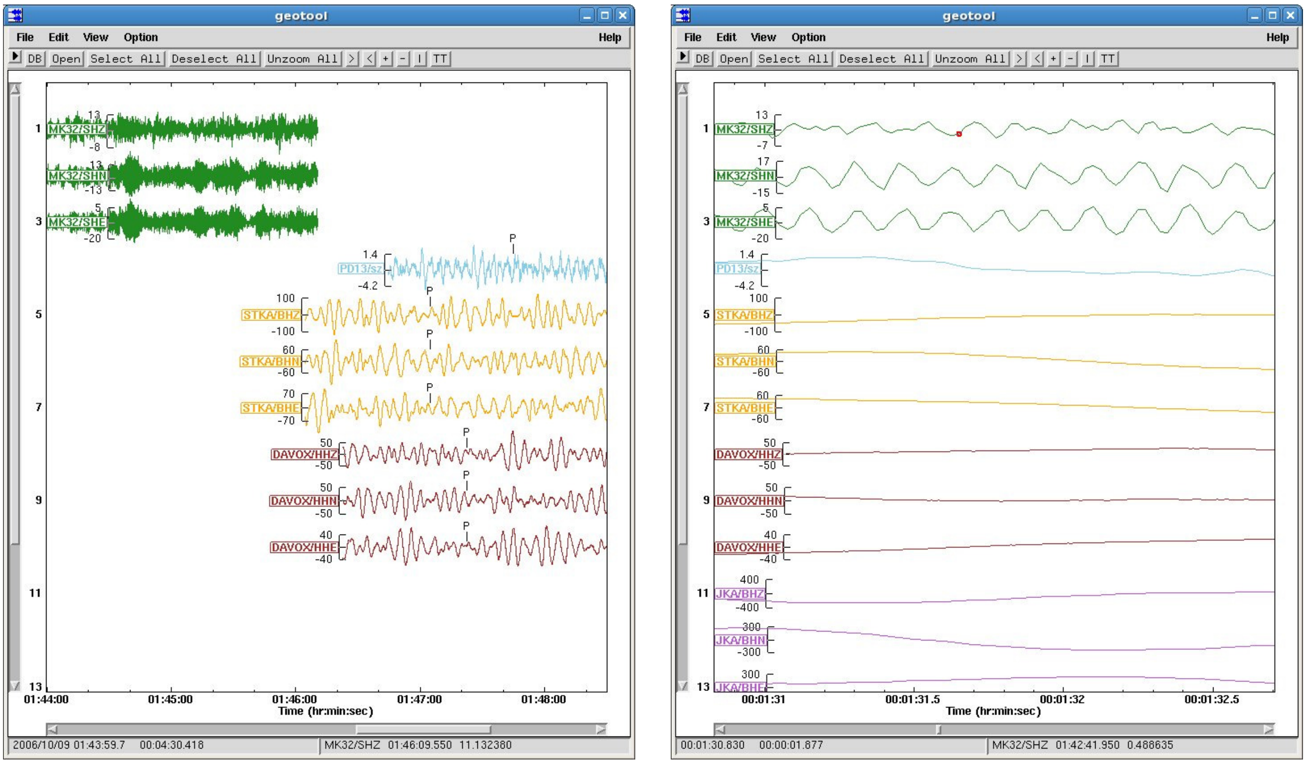


Figure 44. Zoom in on all waveforms (left picture) and with red dot moving along waveforms (right picture).

Exercise 2.7. Data Movement.

To move waveforms in x and y directions:

(1) Select **View->Data Movement->xy movement** from the main menu bar (Figure 45).

(2) Drag **PD13/sz** with the **left** mouse button in x and y directions.

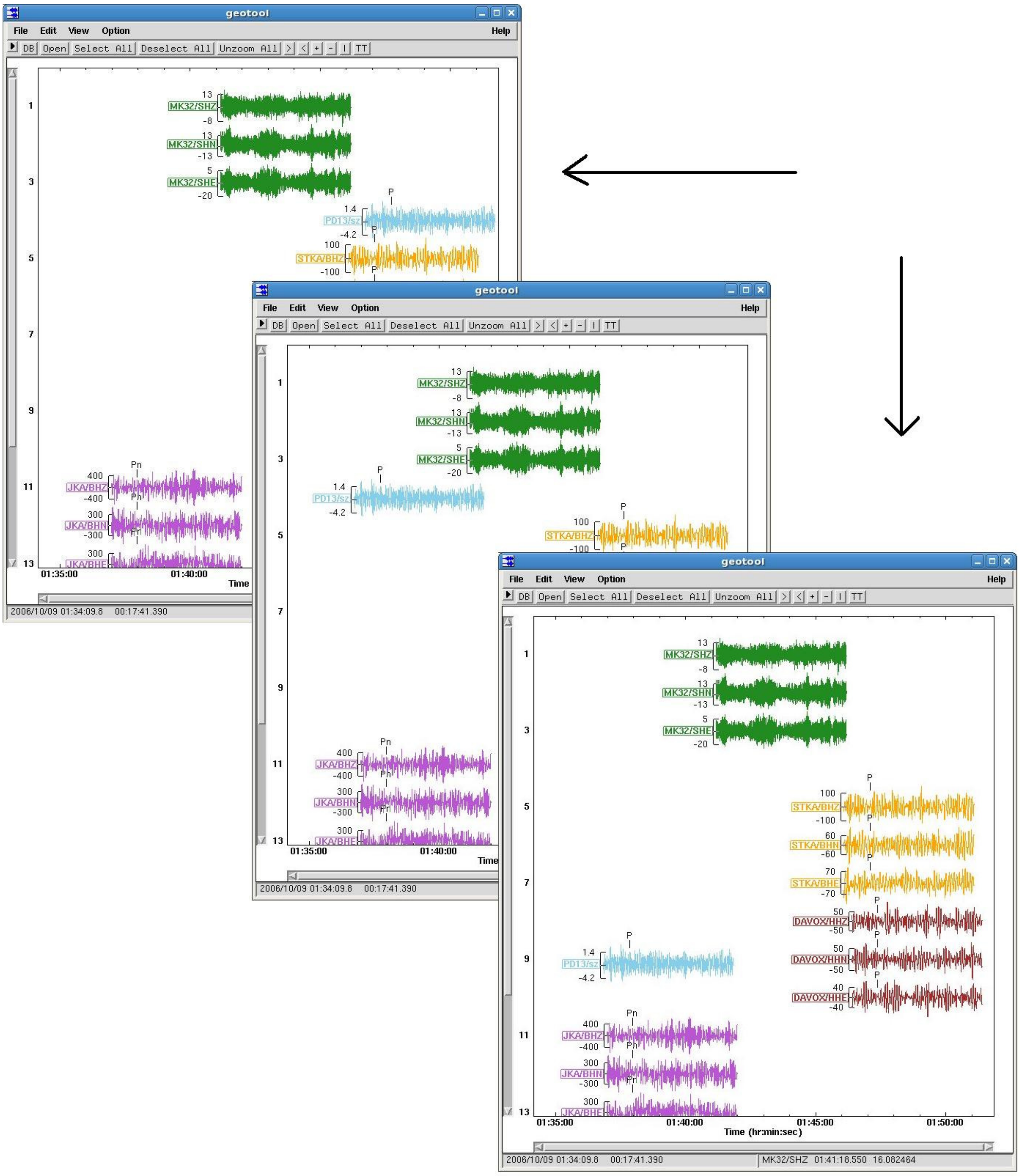


*Figure 45. Waveform windows showing **xy** data movement of **PD13/sz**.*

To move data in x direction:

(1) Select **View->Data Movement->x movement** from the main menu bar (Figure 46).

(2) Drag **PD13/sz** with the **left** mouse button in x direction (left and right).

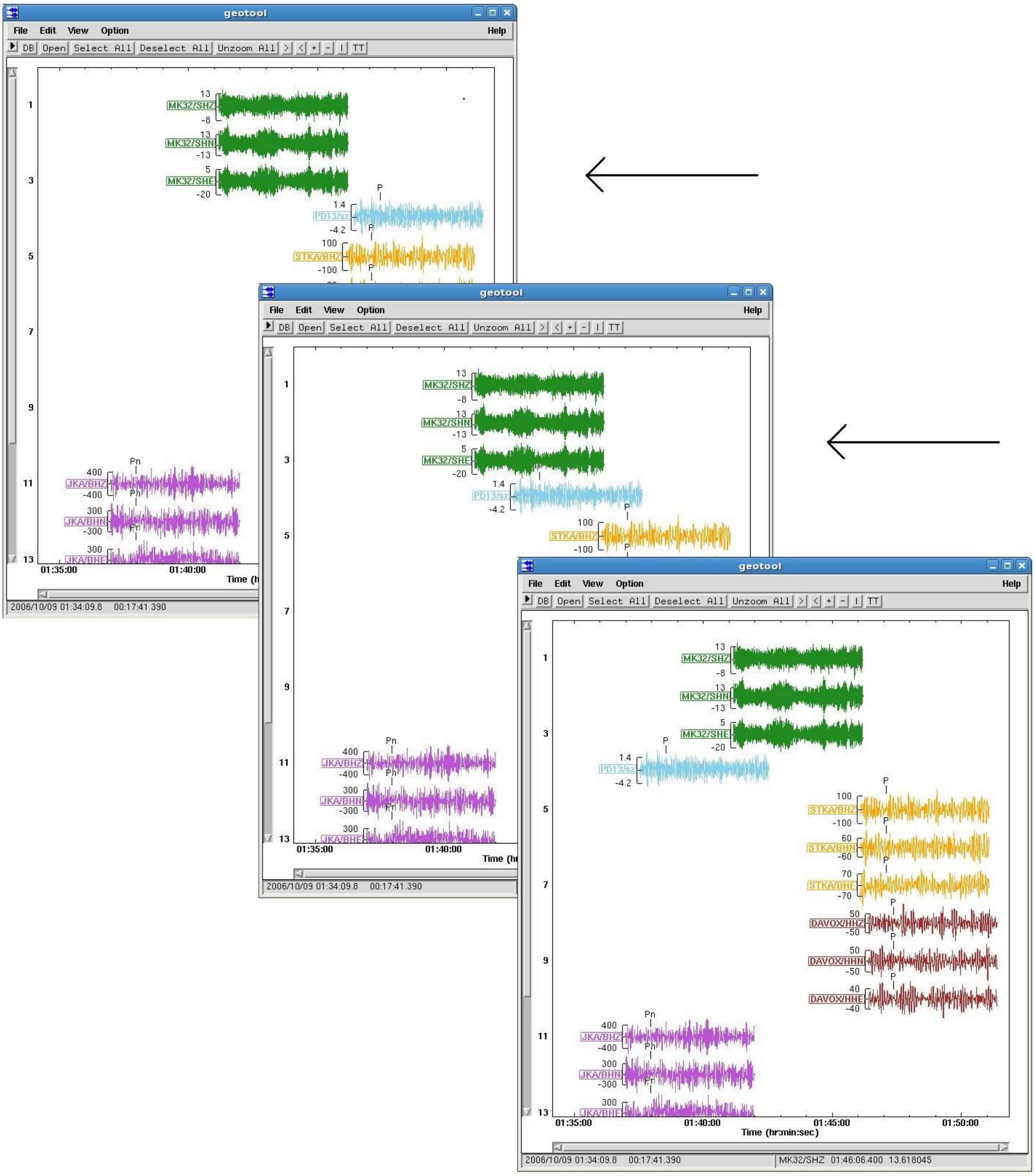


*Figure 46. Waveform windows showing **x** data movement of **PD13/sz**.*

To move data in y direction:

(1) Select **View->Data Movement->y movement** from the main menu bar (Figure 47).

(2) Drag **PD13/sz** with the **left** mouse button in y direction (up and down).

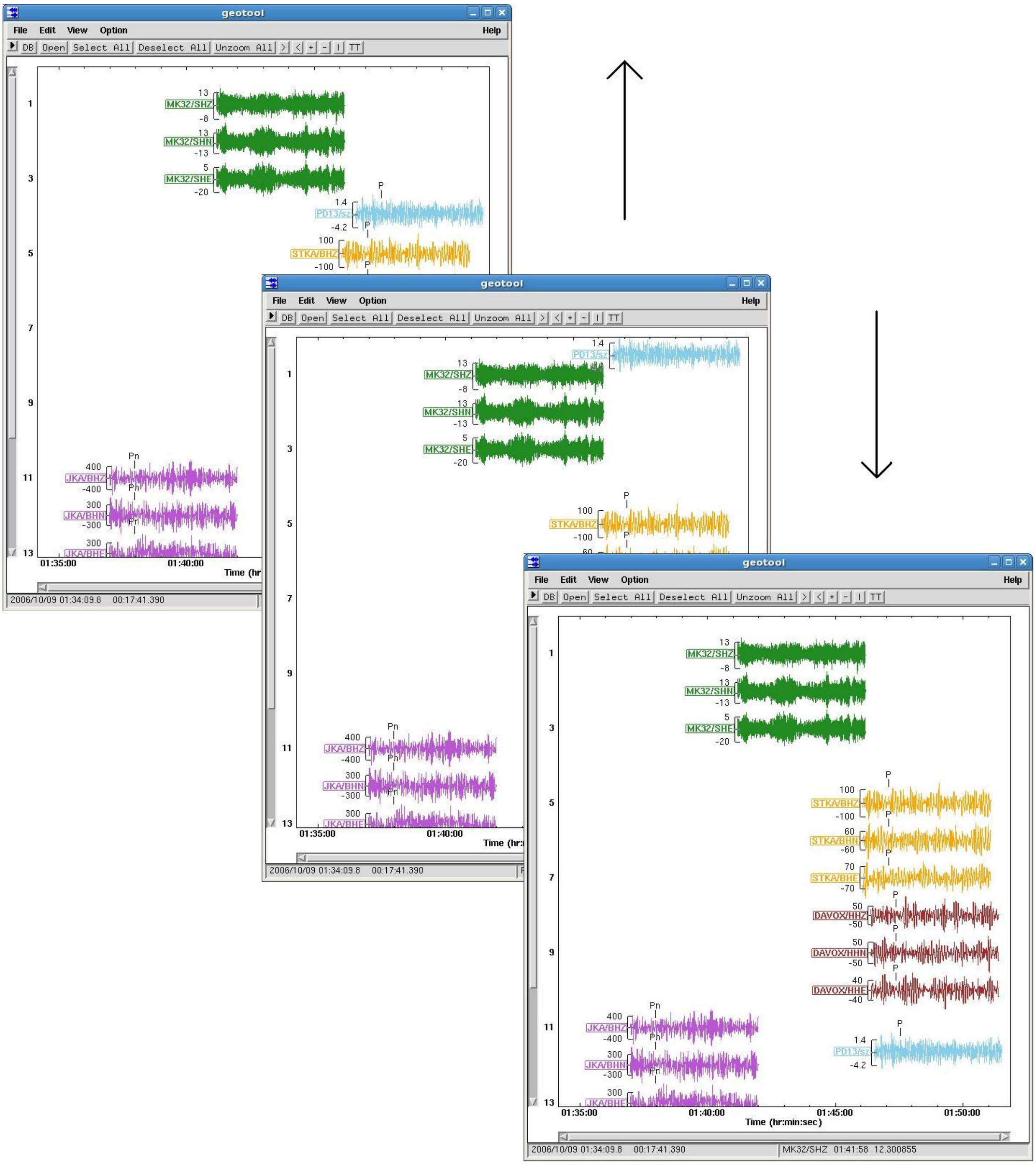


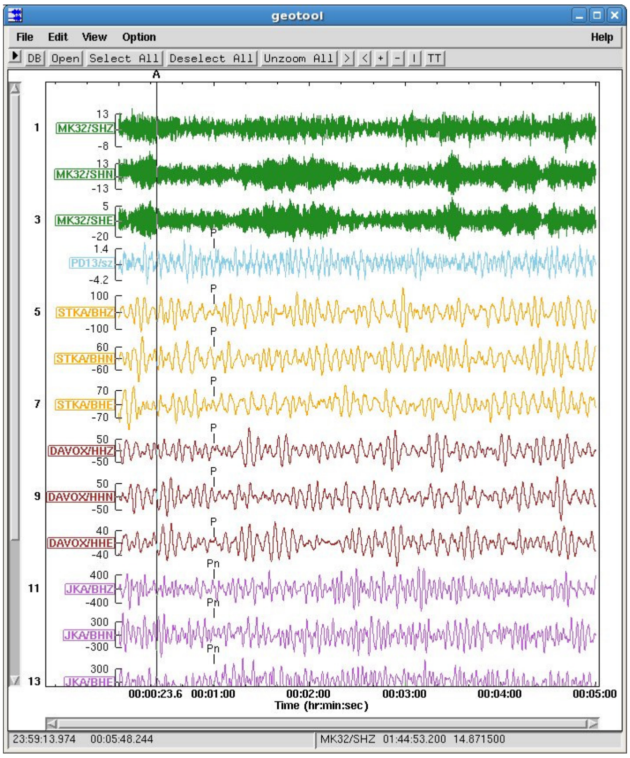
*Figure 47. Waveform windows showing **y** data movement of **PD13/sz**.*

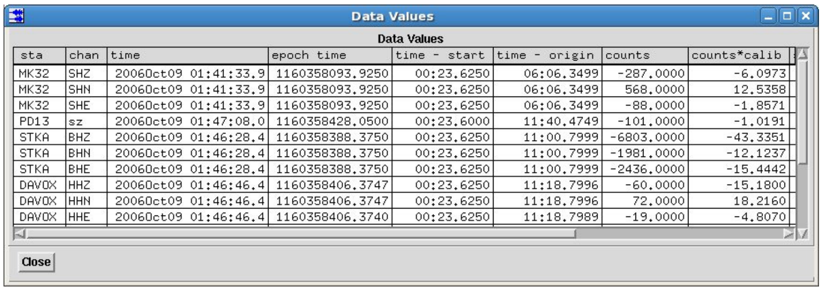
Exercise 2.8. Data Values.

(1) Select **View->Align->On First Point** from the main menu bar.

(2) Select **View->Data Values** from the main menu bar. In the main window the time line labelled **A** appears (Figure 48, left picture). This activates **Data Values** popup (Figure 48, right picture).

(3) Drag the **A** time line cursor with the left mouse button from the left to the right side of the main waveform window. This changes the values in the **Data Values** popup. The displayed values in the popup are those which intersect the time line labelled A.





Data Values

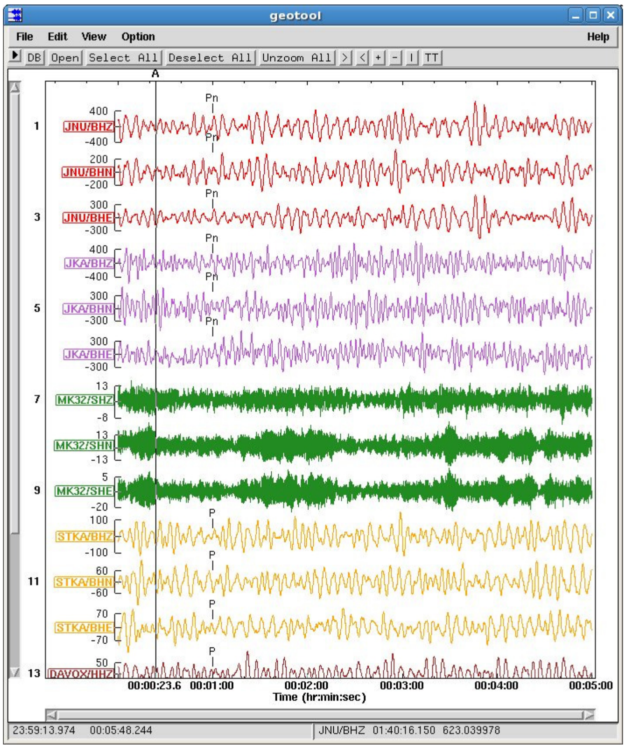
sta	chan	time	epoch time	time - start	time - origin	counts	counts*calib
MK32	SHZ	2006Oct09 01:41:33.9	1160358093.9250	00:23.6250	06:06.3499	-287.0000	-6.0973
MK32	SHN	2006Oct09 01:41:33.9	1160358093.9250	00:23.6250	06:06.3499	568.0000	12.5358
MK32	SHE	2006Oct09 01:41:33.9	1160358093.9250	00:23.6250	06:06.3499	-88.0000	-1.8571
PD13	sz	2006Oct09 01:47:08.0	1160358428.0500	00:23.6000	11:40.4749	-101.0000	-1.0191
STKA	BHZ	2006Oct09 01:46:28.4	1160358388.3750	00:23.6250	11:00.7999	-6803.0000	-43.3351
STKA	BHN	2006Oct09 01:46:28.4	1160358388.3750	00:23.6250	11:00.7999	-1981.0000	-12.1237
STKA	BHE	2006Oct09 01:46:28.4	1160358388.3750	00:23.6250	11:00.7999	-2436.0000	-15.4442
DAVOX	HHZ	2006Oct09 01:46:46.4	1160358406.3747	00:23.6250	11:18.7996	-60.0000	-15.1800
DAVOX	HHN	2006Oct09 01:46:46.4	1160358406.3747	00:23.6250	11:18.7996	72.0000	18.2160
DAVOX	HHE	2006Oct09 01:46:46.4	1160358406.3740	00:23.6250	11:18.7989	-19.0000	-4.8070

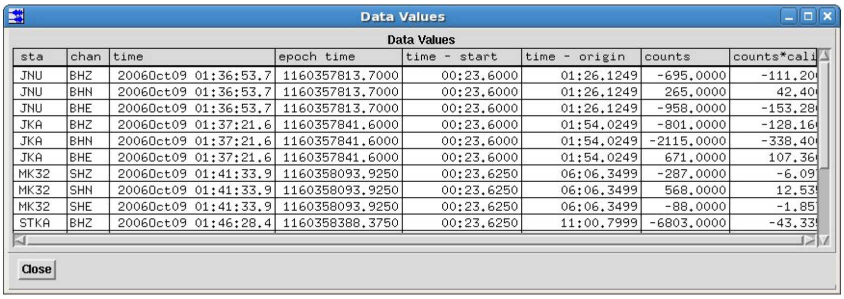
Close

Figure 48. Main waveform window with waveforms loaded on first point (left picture), ***Data Values*** *popup (right picture).*

(4) Select **View->Sort->Distance** from the main menu bar.
Waveforms are sorted in the main window and in the **Data Values** popup by the distance order (Figure 49, left picture).

(5) Drag the **A** time line cursor with the left mouse button and observe the changes of values in **Data Values** popup (Figure 49, right picture). Some of the values in the popup are: **time** is the time the event has occurred, **time start** is the time the waveform started, and **epoch time** is the arrival time.




Data Values

sta	chan	time	epoch time	time - start	time - origin	counts	counts*cali
JNU	BHZ	2006Oct09 01:36:53.7	1160357813.7000	00:23.6000	01:26.1249	-695.0000	-111.20
JNU	BHN	2006Oct09 01:36:53.7	1160357813.7000	00:23.6000	01:26.1249	265.0000	42.40
JNU	BHE	2006Oct09 01:36:53.7	1160357813.7000	00:23.6000	01:26.1249	-958.0000	-153.28
JKA	BHZ	2006Oct09 01:37:21.6	1160357841.6000	00:23.6000	01:54.0249	-801.0000	-128.16
JKA	BHN	2006Oct09 01:37:21.6	1160357841.6000	00:23.6000	01:54.0249	-2115.0000	-338.40
JKA	BHE	2006Oct09 01:37:21.6	1160357841.6000	00:23.6000	01:54.0249	671.0000	107.36
MK32	SHZ	2006Oct09 01:41:33.9	1160358093.9250	00:23.6250	06:06.3499	-287.0000	-6.09
MK32	SHN	2006Oct09 01:41:33.9	1160358093.9250	00:23.6250	06:06.3499	568.0000	12.53
MK32	SHE	2006Oct09 01:41:33.9	1160358093.9250	00:23.6250	06:06.3499	-88.0000	-1.85
STKA	BHZ	2006Oct09 01:46:28.4	1160358388.3750	00:23.6250	11:00.7999	-6803.0000	-43.33

Close

*Figure 49. Main waveform window with waveforms sorted by distance (left picture), **Data Values** popup (right picture).*

(6) Click on the **Close** button in the **Data Values** popup. Note that this also removes the **A** time line cursor.

(7) Select **Edit->Clear** from the main menu bar.

SECTION 3. WORKING WITH ARRIVALS

Exercise 3.1 Data Input.

In this exercise, data are read as follows:

(1) Select the **File→Open File** menu item to activate the **Open file** popup.

(2) Select the file named **DPRK_reduced.wfdisc** in the **Files** column in the **Open file** popup

(3) Click on the **Open** button in the **Open file** popup.

(4)After the waveforms are read, close the **Open file** popup by clicking on the **Close** button.

Exercise 3.2. Deleting and Adding an Arrival.

(5) Zoom in on the seismic phase signal '**Pn**' by positioning the mouse cursor above and to the left side of the signal on the **JNU/BHZ** channel.

- (i) Hold the middle mouse button down to the left and above the signal.
- (ii) Outline a rectangle that includes the signal, and release the mouse button (Figure 50).
- (iii) If there is a need to unzoom and try again, click the middle mouse button to unzoom.

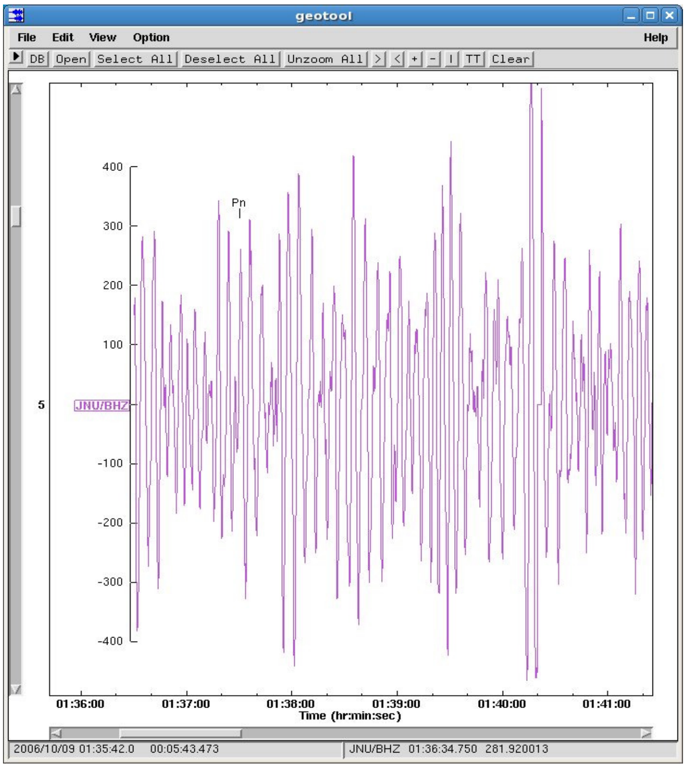


Figure 50. Zoomed in on the JNU/BHZ channel.

(6) Activate the **Arrivals** popup (Figure 51) by selecting the **Option→Arrivals** menu item from the main menu bar.
A list of phases, known as the phase list, is displayed on the left hand side of the **Arrivals** popup.

(iv) Select the existing arrival (click on the arrival entry in the **Arrivals** popup or click on the arrival tag in the main waveform window).

(v) Click on the **Delete** toolbar button in the **Arrivals** popup. This removes the arrival from this display and from the file where it was read.

(vi) In the Arrival popup, **Edit → Undo Delete Arrival** will restore the arrival which was just deleted. The delete action is undone both visually and is added back to the file.

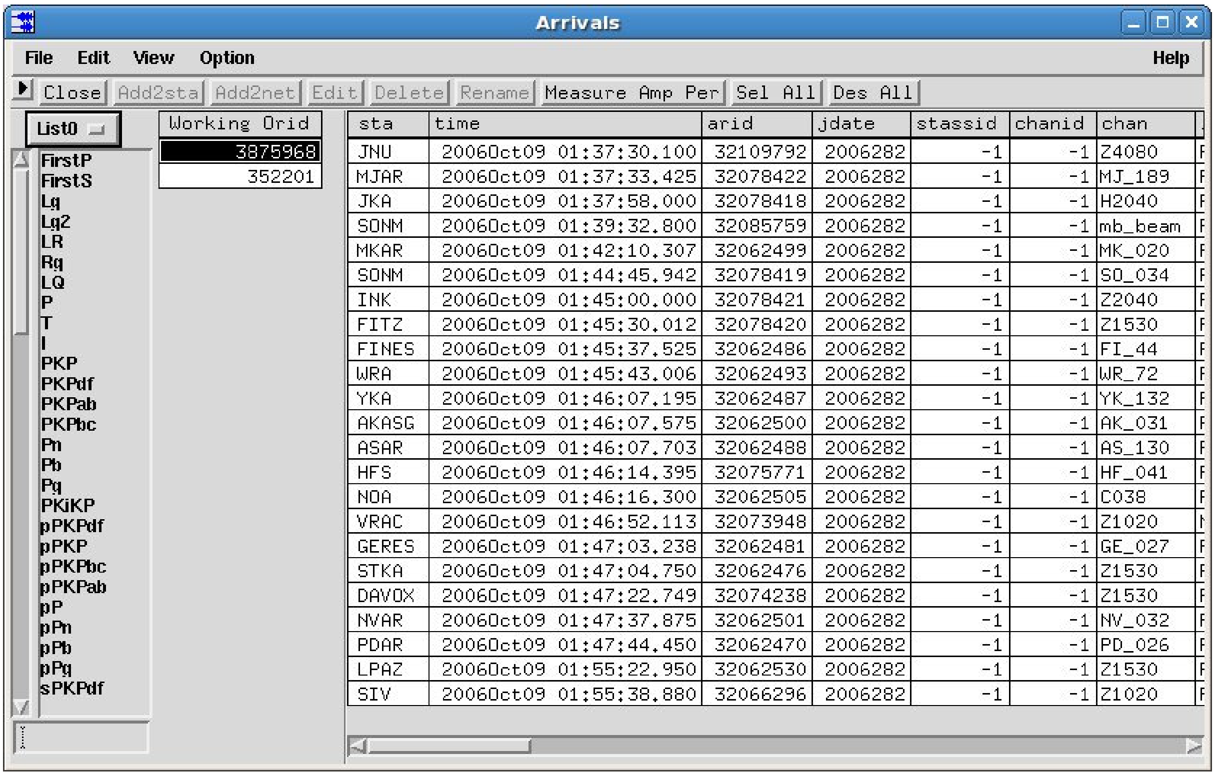


*Figure 51. The **Arrivals** popup.*

To add an arrival:

(vii) Select the **P** entry in the phase list (left hand side of the **Arrivals** popup) to add a vertical line (phase line) to the main waveform window. The name of the selected phase appears as a label above the phase line.

(viii) Drag the phase line to the position where you would like to add the arrival.

(ix) Select the waveform with a left mouse button click.

(x) From the Edit menu select **Edit→Add to sta** in the **Arrivals** popup or click on the **Add2sta** toolbar button in the **Arrivals** popup. This adds the arrival to the main window and adds a new record to the Arrivals window. An arrival record is also written to the arrival file.

(7) Click the **Unzoom All** toolbar button in the main waveform window.
(Left clicking on the highlighted **P** entry in the phase list in the **Arrivals** popup deselects this item to hide the **P** phase line drawn in the main waveform window.)

Exercise 3.3. Renaming an Arrival.

In this exercise a Pn arrival will be renamed to P. There are three methods of renaming arrivals.

As in the previous exercise, zoom in on the **Pn** arrival recorded at **JNU/BHZ** by moving the mouse cursor above and to the left of the arrival. Zooming in on the arrival is not required for editing, but does allow you to concentrate on this phase.

(8) Hold the middle mouse button down and drag the cursor below and to the right of the arrival. An outline of a rectangle appears (Figure 52).

(9) Once the box encloses the area of interest, release the mouse button and the main waveform window will be redrawn with the limits defined by the outlined box.

Select the **JNU/BHZ Pn** arrival by clicking on the arrival label in the waveform window. The arrival is highlighted when it is selected.

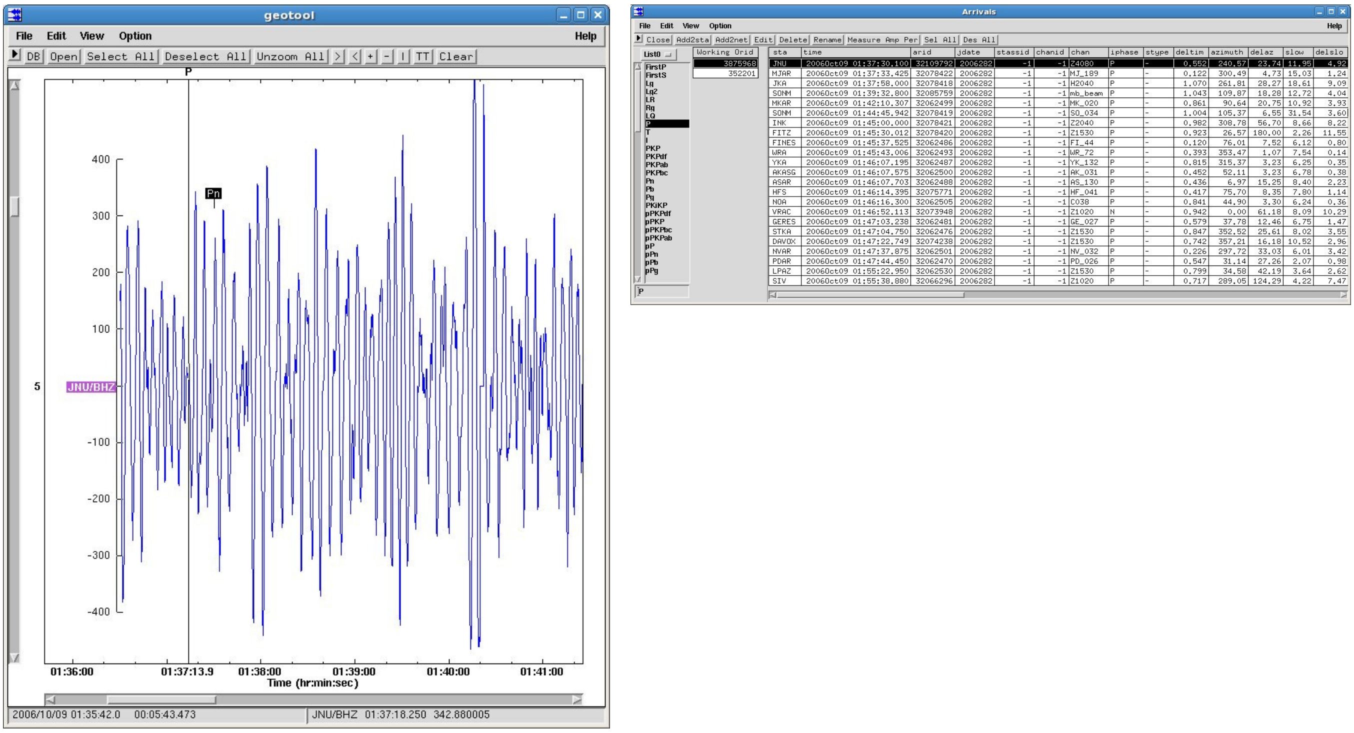


Figure 52. Middle mouse button released and arrival highlighted.

(10) Scroll down to select the **P** phase from the phase list on the left hand side of the **Arrivals** popup.
(11) Click on the **Rename** toolbar button in the Arrivals popup. **Rename Arrivals** popup will appear. Type **P** in the space in the **Rename Arrivals** popup and click on the **Apply** button. The selected arrival(s) will now be renamed **P.**

A second method is possible for renaming arrivals:

(12) Select the arrival.

(13) Click the **Edit** button in the Arrivals popup.

(14) Change the arrival manually on the phase column in the toolbar of the **Arrivals** popup.

(15) Click on the **Save** button.

When the **Edit** button is activated, fields in the selected row may be edited. Some fields are restricted to certain values. For example: the **qual** field may be edited with only {i ,e or w}. See IDC Database Schema for more detail. Also, see Appendix III for more information about the qual column in the Arrivals popup.

If an invalid attribute is entered, the pre-existing attribute will be automatically restored when the cursor leaves the attribute.

Another method for renaming an arrival is the following:

(12) Middle Mouse button **Click and hold** over an arrival will activate the **Edit Arrival** popup.
(13) Select **Edit Arrival→Rename Arrival** from the main menu bar (Figure 53).

(14) Change the name in the **Rename Arrival** popup. Note that the phase name is not checked for validity, and any text can be entered into the entry box, and that name will be used in the arrival tag.

(15) Click on the **Apply** button to save the edit.

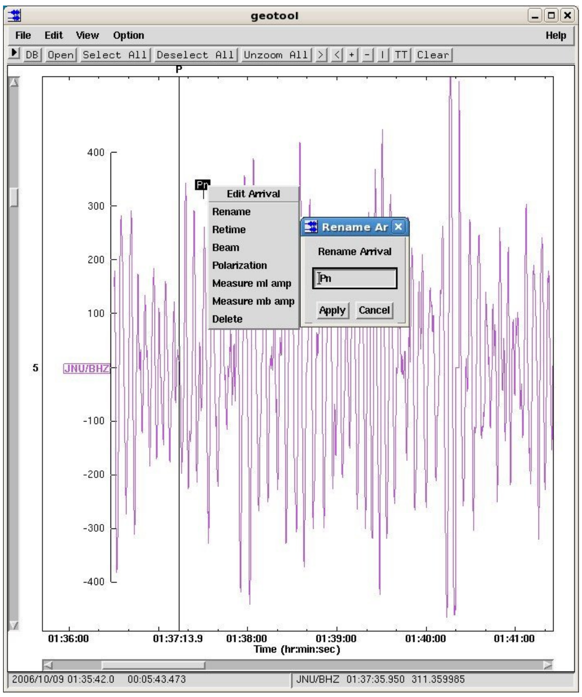


*Figure 53. The **Edit Arrival→Rename** Arrival popup.*

In each case, you may undo the phase name change by selecting **Edit → Undo** in the **Arrivals** popup.

Exercise 3.4. Re-timing an Arrival.

There are two methods for retiming arrivals, as described below.

(16) Open the **Arrivals** popup **Option→Arrivals.**

(17) Select the **JNU/BHZ Pn** arrival (click on the **Pn** label in the main waveform window or click on its entry in the **Arrivals** popup).

(18) Click on the **Edit** button in the toolbar of the **Arrivals** popup (Figure 54).

(19) Left click on the **Pn** label while holding down the mouse button and drag the **Pn** approximately 5 seconds earlier.

(20) Observe how the **Arrivals** popup entry for **JNU/BHZ Pn** updates in the time field as the cursor is dragged while holding down the left mouse button.

(21) Click on the **Save** button in the **Arrivals** popup to store the new arrival time. This action writes the value of the new time to a file.

You may undo the re-timing of the arrival by selecting **Edit→ Undo Edit Arrival** in the **Arrivals** popup.

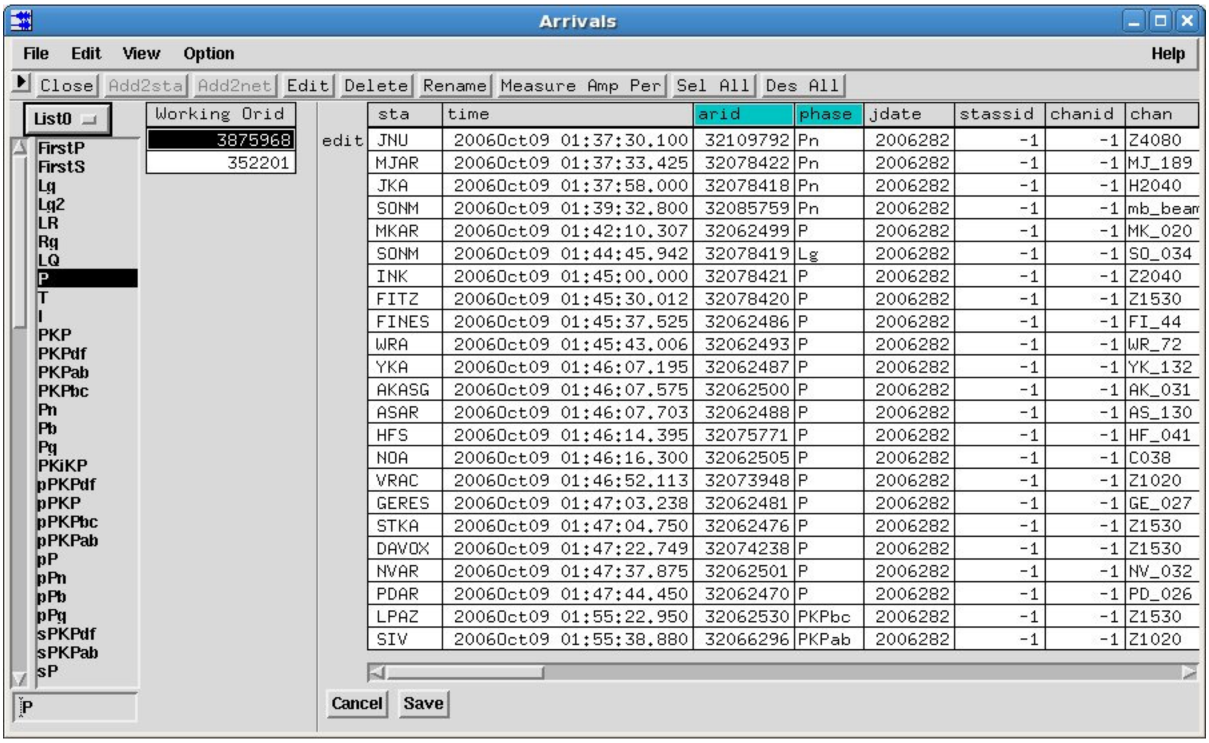


*Figure 54. The **Arrivals** popup with **Edit** button in use.*

(22) Alternately, middle mouse button **Click and hold** over an arrival will activate the **Edit Arrival** popup:

Edit Arrival→ Retime Arrival (Figure 55).

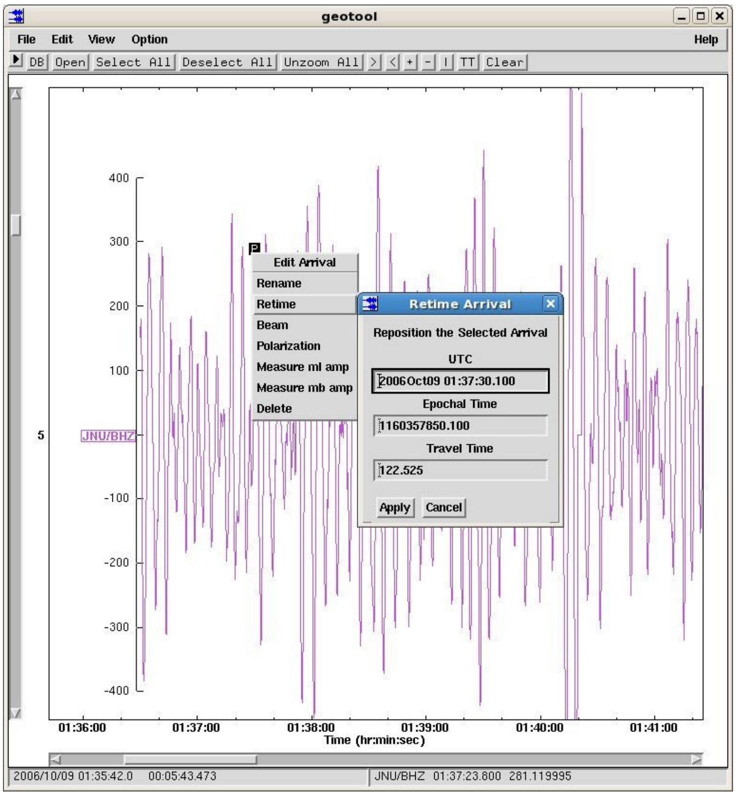


*Figure 55. The **Edit Arrival →Retime** Arrival popup.*

Note that any changes made can be undone by the **Edit → Undo** in the **Arrivals** popup.

(23) Close the **Arrivals** popup.

(24) In the main waveform window, click on the **Unzoom All** and **Deselect All** buttons in the toolbar.

(25) Then clear the data from the main window **Edit → Clear.**

Exercise 3.5. Measure, Create and Review Amplitude

To begin, from the file menu:

(1) Select the **File →Open File** menu item.

(2) Select the file named **DPRK_reduced.wfdisc** from the **Files** column in the **Open file** popup

(3) Select the **JNU/BHZ** waveform and filter it with Butterworth Filter (3.0, 6.0).

(4) Select **Option->Arrivals** from the main menu bar.

(5) Open the **Measure Amp Per** popup by clicking on the **Measure Amp Per** toolbar button in the **Arrivals** popup (Figure 56). Select **Help->Measure Help** in the **Measure Amp Per** popup to open **Measure Amp Per Help** popup.

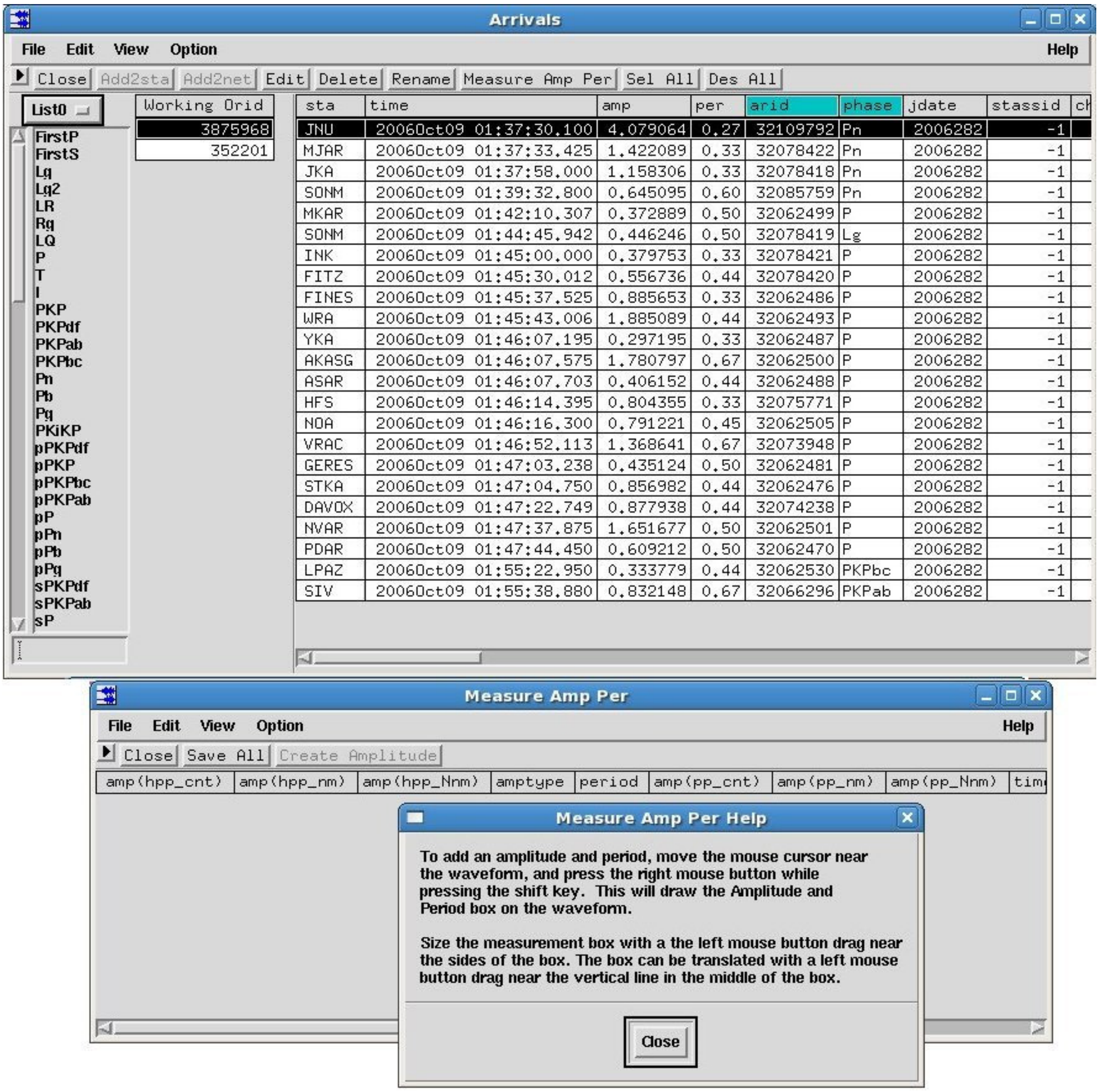


*Figure 56. The **Arrivals** popup and **Measure Amp Per** popup.*

(6) Zoom on the **JNU/BHZ** waveform.

(7) When the Measure Amp Per window is displayed, hold down the shift key and click the right mouse button (**Shift + Right mouse**) to draw the Amplitude and period box on the waveform (Figure 57).

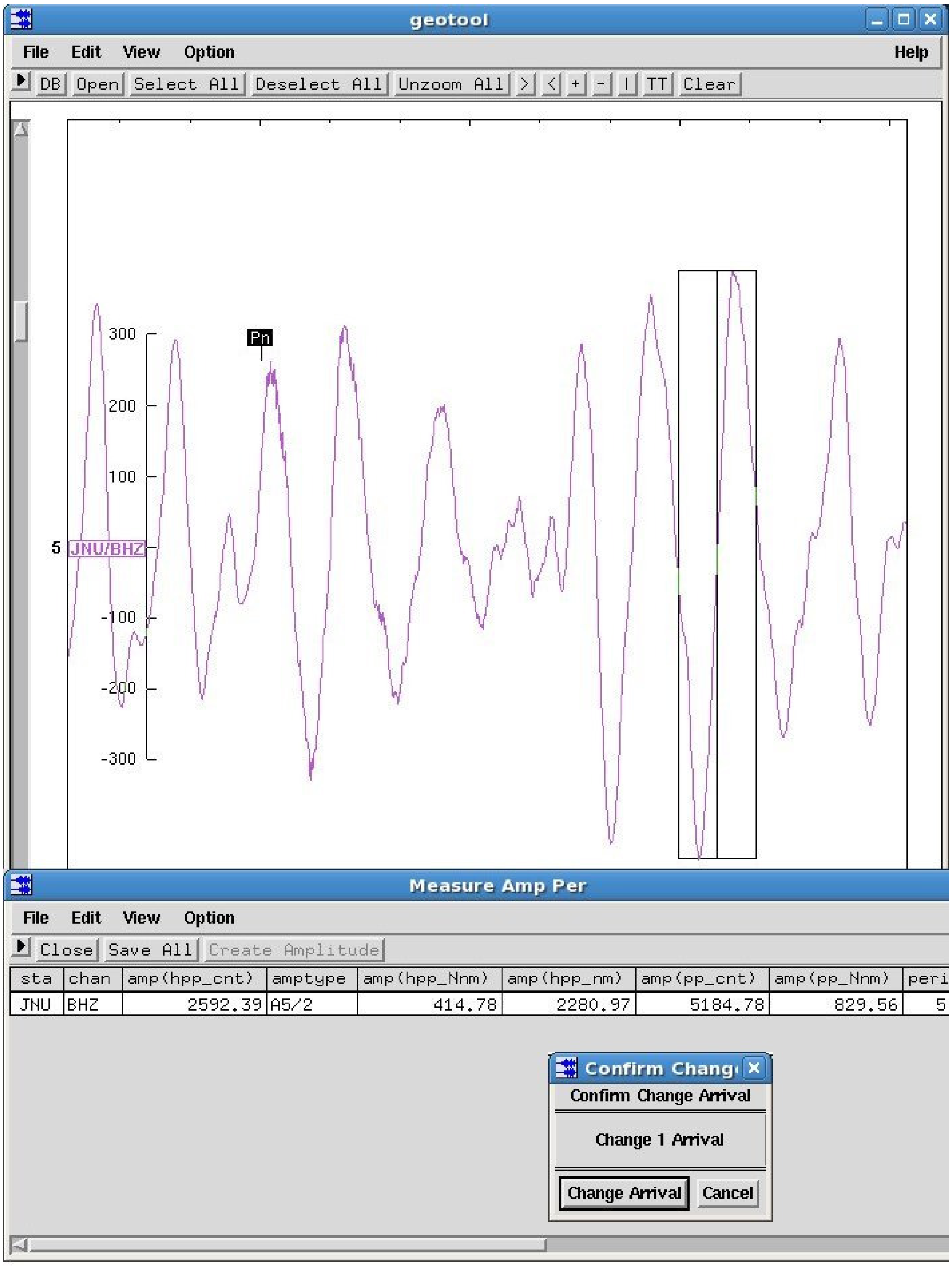


*Figure 57. Zoomed in on **JNU/BHZ** with Measure Amplitude and Period box added.*

(8) To resize the Amplitude and Period box, place the mouse cursor inside the box and drag the closest edge of the box with the right mouse button.

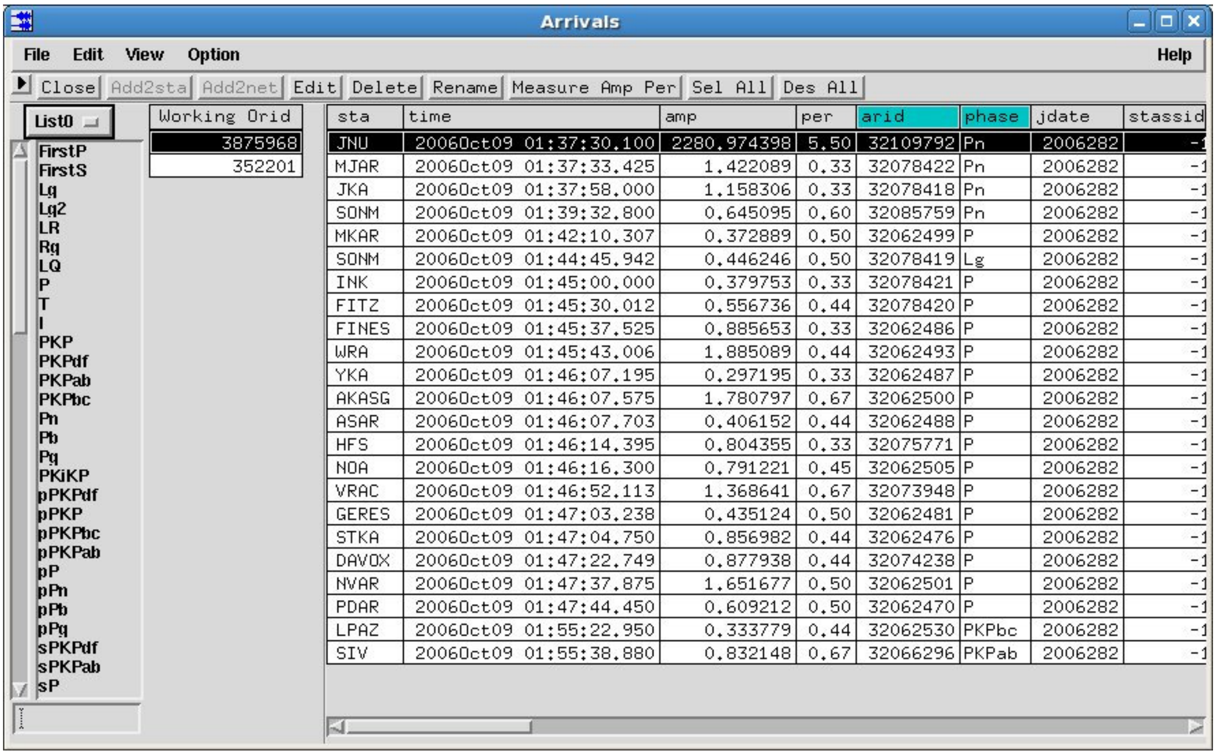
(9) Right mouse button drag with the cursor at the middle line of the box will drag the box along the waveform. Note the attributes changing in the **Measure Amp Per** as the box is moved.

To save amplitude and period measurement:

(1) Select the arrival label in the main window or the record in the **Arrivals** popup, and the corresponding Amplitude record in the **Measure Amp Per** popup.

(xi) Click the **Save All** button in the **Measure Amp Per** popup (Figure 58).

The amplitude/period of the new phase is similar to the existing P phase at JNU.



sta	time	amp	per	arid	phase	jdate	stassid
JNU	2006Oct09 01:37:30.100	2280.974398	5.50	32109792	Pn	2006282	-
MJAR	2006Oct09 01:37:33.425	1.422089	0.33	32078422	Pn	2006282	-1
JKA	2006Oct09 01:37:58.000	1.158306	0.33	32078418	Pn	2006282	-1
SONM	2006Oct09 01:39:32.800	0.645095	0.60	32085759	Pn	2006282	-1
MKAR	2006Oct09 01:42:10.307	0.372889	0.50	32062499	P	2006282	-1
SONM	2006Oct09 01:44:45.942	0.446246	0.50	32078419	Lg	2006282	-1
INK	2006Oct09 01:45:00.000	0.379753	0.33	32078421	P	2006282	-1
FITZ	2006Oct09 01:45:30.012	0.556736	0.44	32078420	P	2006282	-1
FINES	2006Oct09 01:45:37.525	0.885653	0.33	32062486	P	2006282	-1
WRA	2006Oct09 01:45:43.006	1.885089	0.44	32062493	P	2006282	-1
YKA	2006Oct09 01:46:07.195	0.297195	0.33	32062487	P	2006282	-1
AKASG	2006Oct09 01:46:07.575	1.780797	0.67	32062500	P	2006282	-1
ASAR	2006Oct09 01:46:07.703	0.406152	0.44	32062488	P	2006282	-1
HFS	2006Oct09 01:46:14.395	0.804355	0.33	32075771	P	2006282	-1
NOA	2006Oct09 01:46:16.300	0.791221	0.45	32062505	P	2006282	-1
VRAC	2006Oct09 01:46:52.113	1.368641	0.67	32073948	P	2006282	-1
GERES	2006Oct09 01:47:03.238	0.435124	0.50	32062481	P	2006282	-1
STKA	2006Oct09 01:47:04.750	0.856982	0.44	32062476	P	2006282	-1
DAVOX	2006Oct09 01:47:22.749	0.877938	0.44	32074238	P	2006282	-1
NVAR	2006Oct09 01:47:37.875	1.651677	0.50	32062501	P	2006282	-1
PDAR	2006Oct09 01:47:44.450	0.609212	0.50	32062470	P	2006282	-1
LPAZ	2006Oct09 01:55:22.950	0.333779	0.44	32062530	PKPbc	2006282	-1
SIV	2006Oct09 01:55:38.880	0.832148	0.67	32066296	PKPab	2006282	-1

*Figure 58. The **Arrivals** popup after the Measure Amplitude has been saved.*

Note that within the **Arrivals** popup, columns may be dragged by left mouse button to reorder attributes.

To view the list of arrival attributes, in the **Arrivals** popup, select **View → Attributes.**

Selected attributes will then be displayed in the popup. Attributes may be dragged to rearrange their order. The **Apply** button in the **arrival assoc Atributes** popup will change the display in the Arrivals popup. Use the horizontal scroll bar in the arrivals Attributes popup to view all available attributes. The values can be changed in each attribute box to control the precision of displayed values.

(xii)Click in the "per" box in the **arrival assoc Attributes** popup.

(xiii) Change the value in the box to %.4f, then click **Apply** in the **arrival assoc Attributes** popup.

Note the change in the **Arrivals** popup (Figure 59).

Attributes in other Geotool popups with this type of display can be changed using this same method. Attribute popups can be found under the file menu **View →Attributes**.

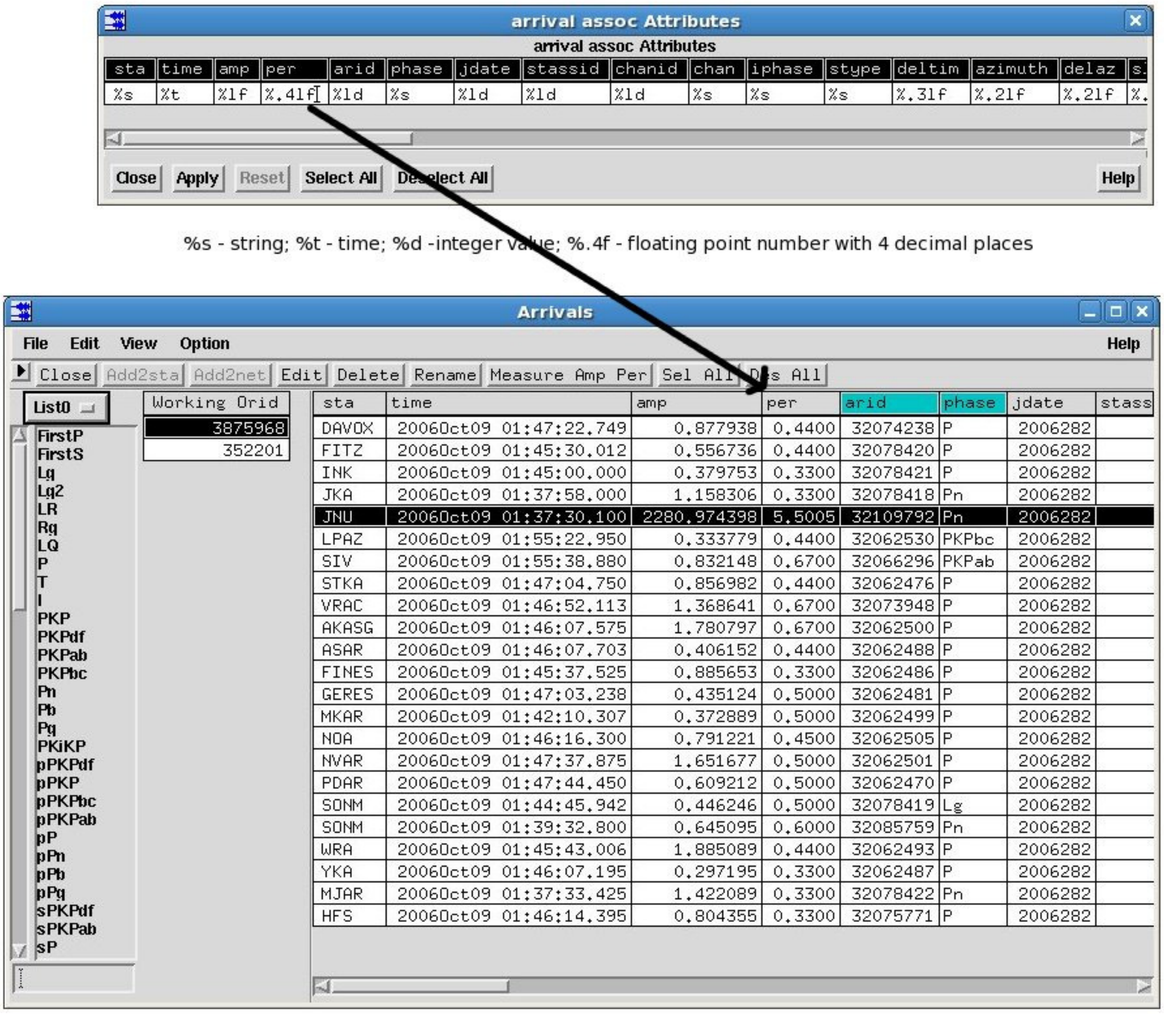


*Figure 59. **arrival assoc Attributes** and **Arrivals** popups.*

To create amplitude:

(2) Select the arrival label in the main window or the record in the **Arrivals** popup, and the corresponding Amplitude record in the **Measure Amp Per** popup.

(3) Select the **JNU/BHZ** waveform by **left** button click over a waveform.

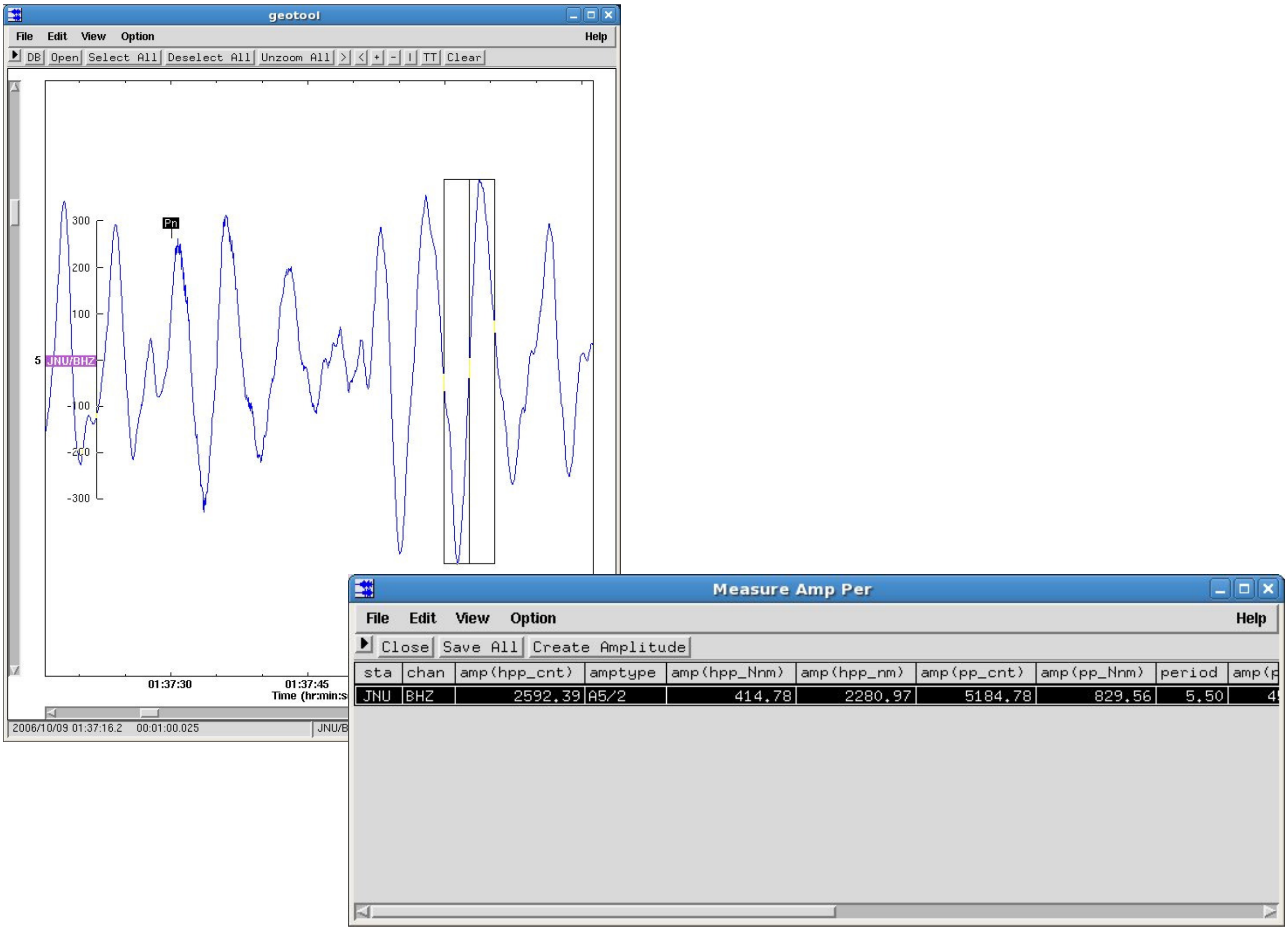


*Figure 60. **JNU/BHZ** waveform selected and amplitude selected in the Measure Amp Per popup.*

(4) Select the **Option-> Amplitudes/Magnitudes...** from the main menu bar of the geotool window. This will open the **Amplitudes/Magnitudes** popup.

(xiv) Click the **Create Amplitude** button in the **Measure Amp Per** popup (Figure 60).

This action will create the amplitude in the **Amplitudes/Magnitudes** popup.

(5) Select amplitude record and click on the **Review Amplitude** button in the **Amplitudes/Magnitudes** popup (Figure 61).

This action will display the amplitude in the **Amplitudes/Magnitudes** popup. Zoom in on the amplitude in the same way as zooming on the waveform (***Exercise 2.6***).

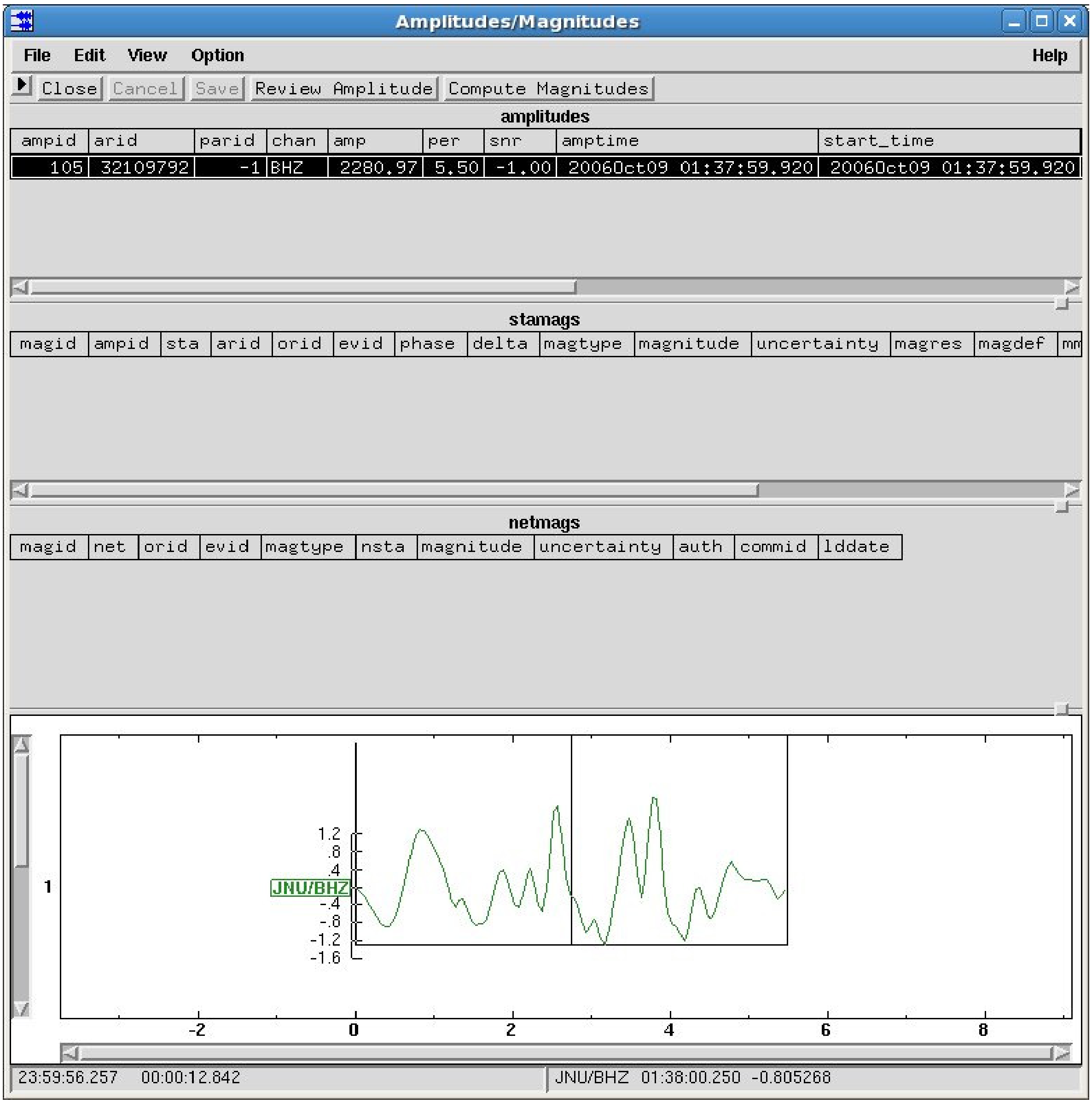


Figure 61. Review Amplitude in the Amplitudes/Magnitudes popup.

(xv) Close the **Measure Amp Per, Arrivals** and the **Amplitudes/Magnitudes** popups.

(xvi) Clear the data from the Geotool window by selecting **Edit →Clear** from the main menu bar.

SECTION 4. PARTICLE MOTION AND COMPONENT ROTATION

Exercise 4.1. Data Input.

(1) Select the file named **TURKEY_DATA.wfdisc** in the **Files** column in the **Open file** popup and click on the **Open** button.

The main waveform window should now look like Figure 62.

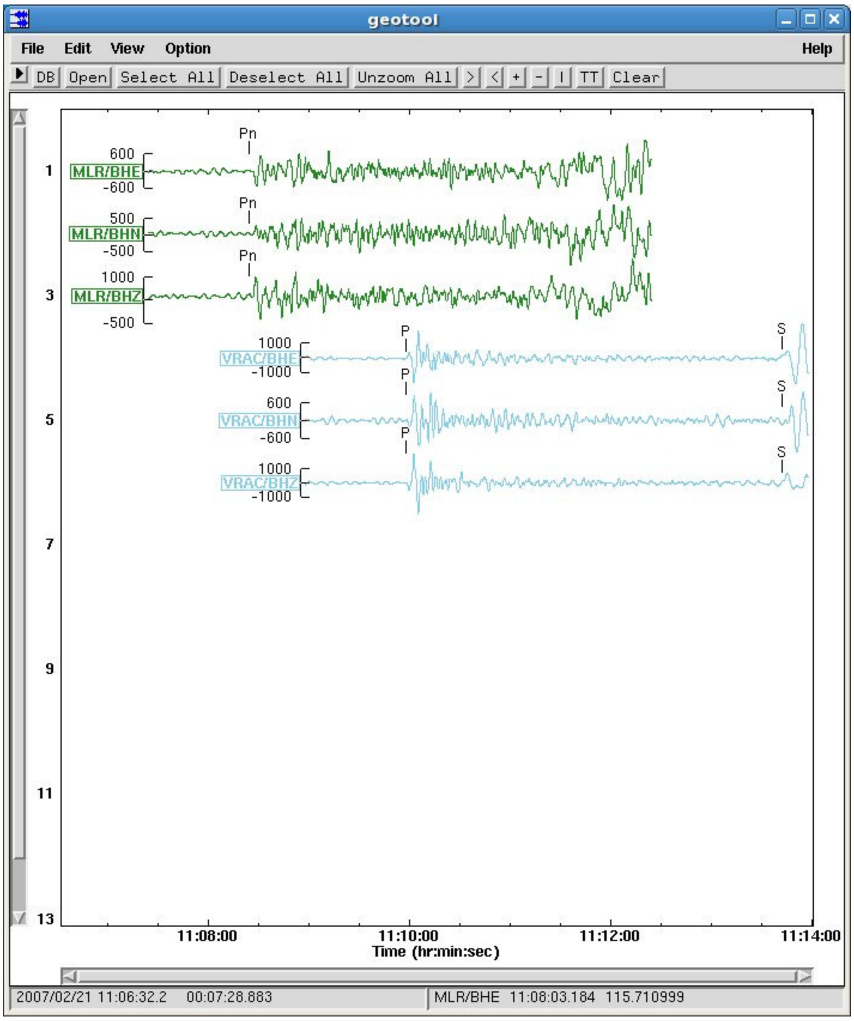


*Figure 62. Main waveform window with loaded waveforms from **MLR** and **VRAC** stations.*

Exercise 4.2. Particle Motion.

(2) Select **Option->Map** from the main waveform window; locations of both stations **VRAC** and **MLR** are shown in the map (Figure 63).

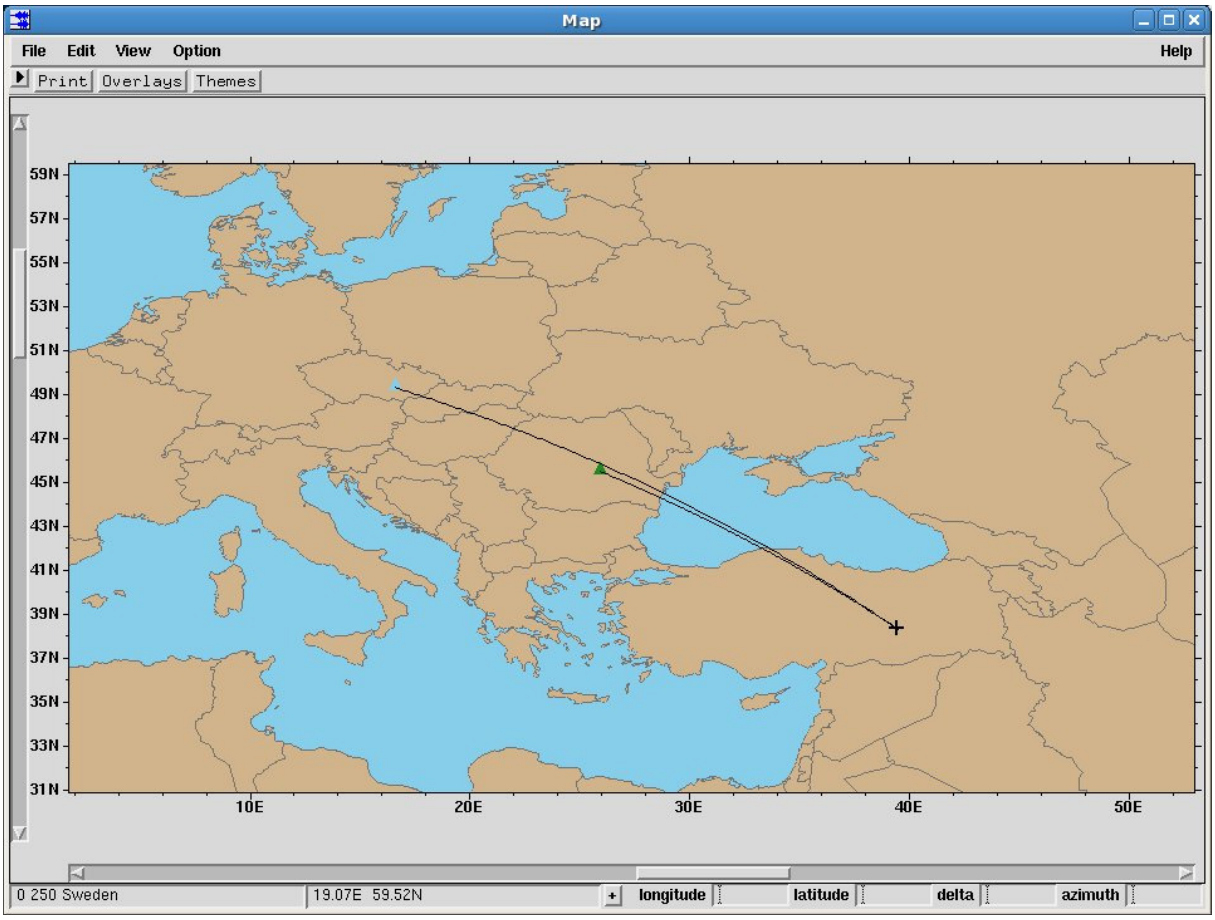


*Figure 63. Three component data from **MLR** and **VRAC.***

(3) Select **Option->Three-Component Analysis->Particle Motion** from the main waveform window. A double line cursor will be placed over the waveforms in the main window.

(4) Select the **N, E** and **Z** component waveforms for the station **VRAC** by clicking over the waveforms with the **left** mouse button and slide the double-line cursor to the phase arrival. (Figure 64). The particle motion interface draws an arrow at the coordinates of each (**N, E, Z**) data value inside the double-line cursor. Each arrow points to the base of the next arrow to give the direction of motion along the curve of motion.

The three-dimensional curve is projected onto two orthogonal planes. The plane on the left side of the display is considered to represent the plane that contains the signal source and receiver and the ray path. It is always vertical and can be rotated 360 degrees in azimuth. The plane on the right side of the display is always orthogonal to the source-receiver plane and shows the projection of the motion curve from the perspective of looking from the receiver along the ray path to the source.

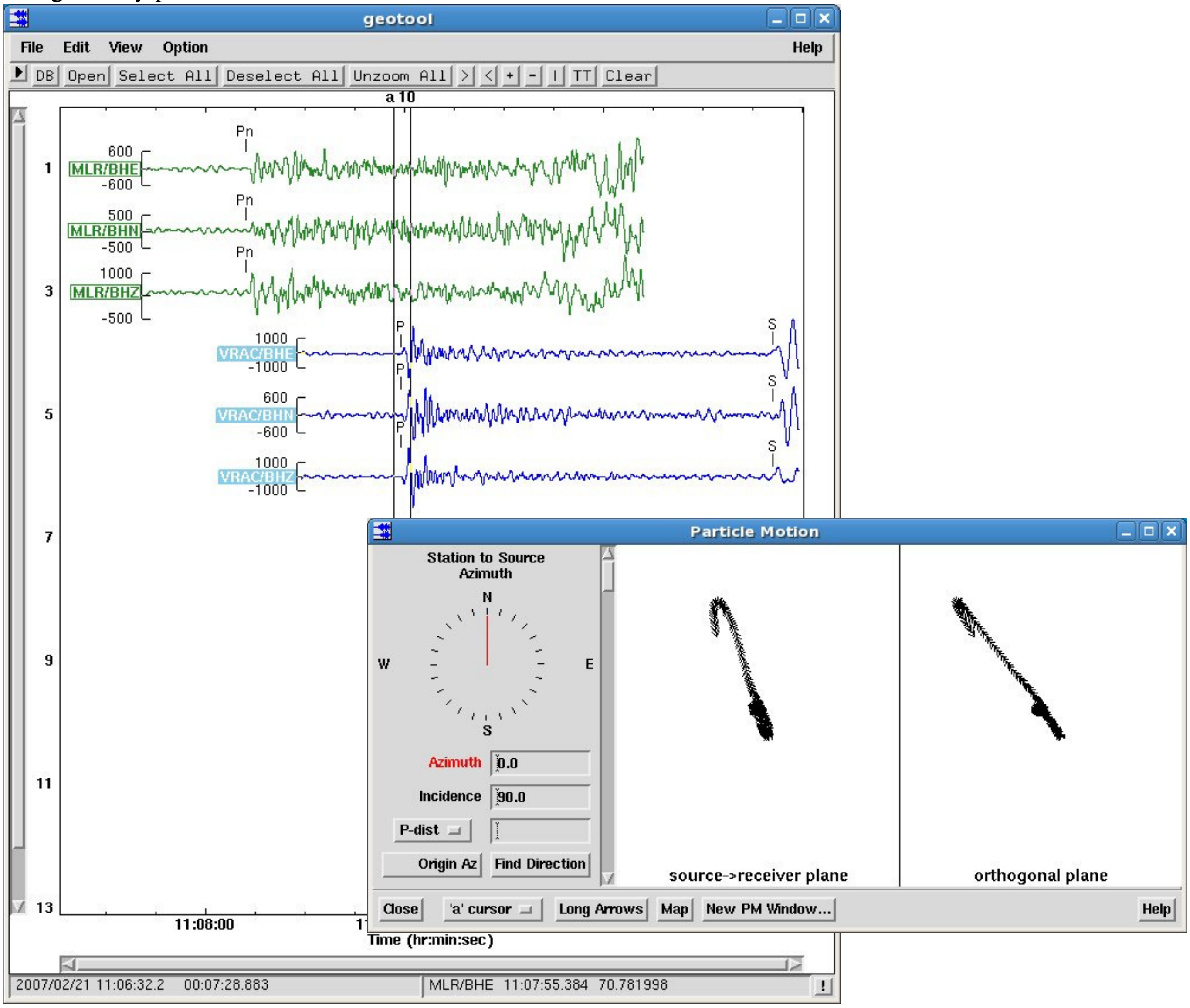


*Figure 64. Main waveform window with **N, E** and **Z** component waveforms for station **VRAC** selected (left picture), **Particle Motion** popup (right picture).*

Right picture of the Figure 64 shows the particle motion display for a ten second data window near the **P** arrival at station **VRAC**. The initial orientation of the source-receive plane is along the North-South axis. The azimuth of this plane can be set to any angle by moving the dial with a left mouse drag. The inclination of the orthogonal plane is initially vertical, 90 degrees. The inclination of the orthogonal plane is the same as the ray path incidence angle and can be adjusted from 90 to 0 degrees with the vertical scrollbar.

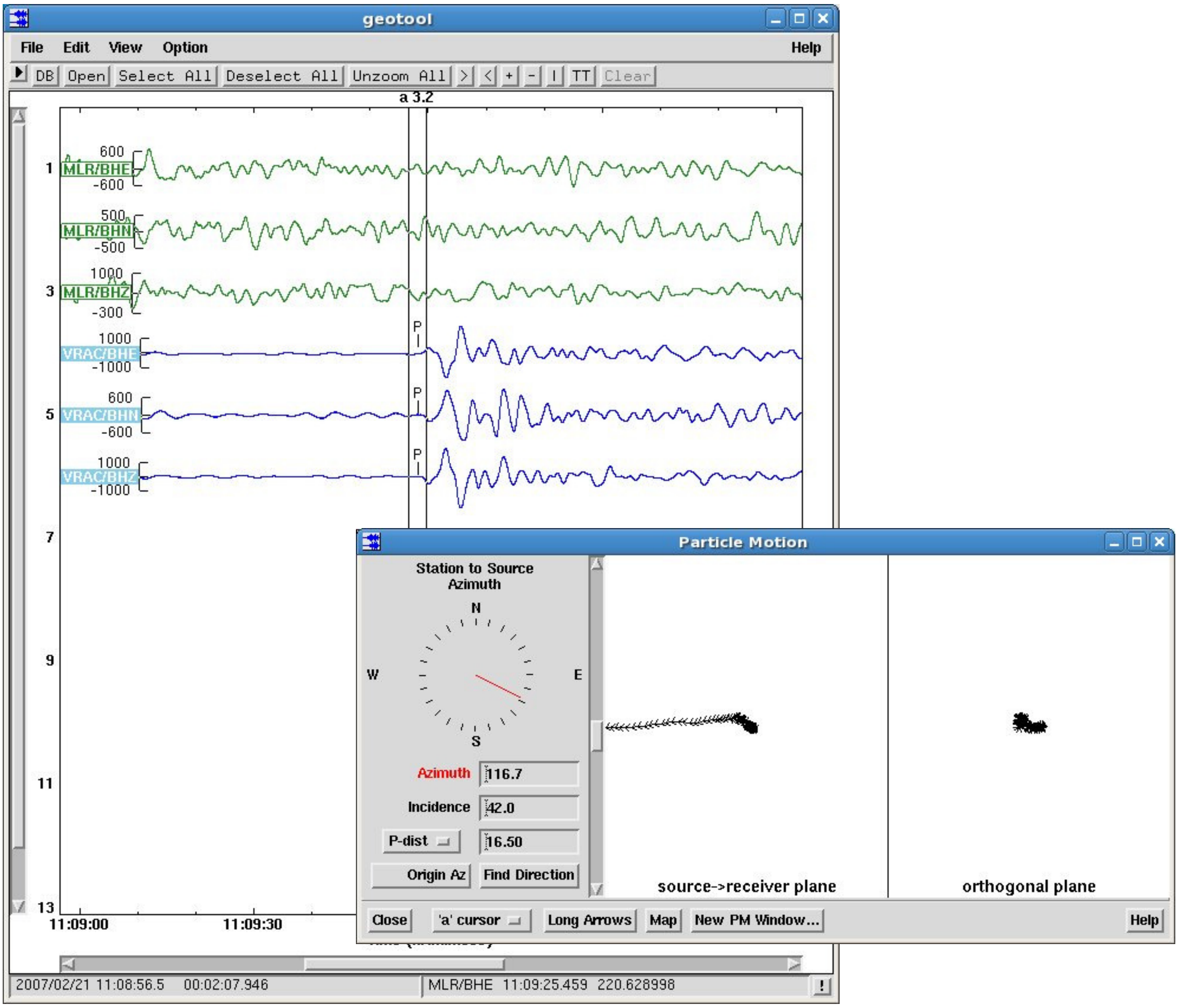


*Figure 65. Main waveform window with **N, E** and **Z** component waveforms for station **VRAC** selected and double-line cursor set to 3.2s (left picture), **Particle Motion** popup (right picture).*

Right picture of Figure 65 shows the particle motion display for a smaller 3 second data window positioned just at the onset of the **P** arrival. The motion curve is nearly a straight line. To determine the azimuth and incidence of the ray path, rotate the motion curve with the dial and scrollbar so that the arrows on the right side (orthogonal plane) are concentrated in a dot in the centre of the graph. This is the perspective of looking along the ray path towards the direction of the source.

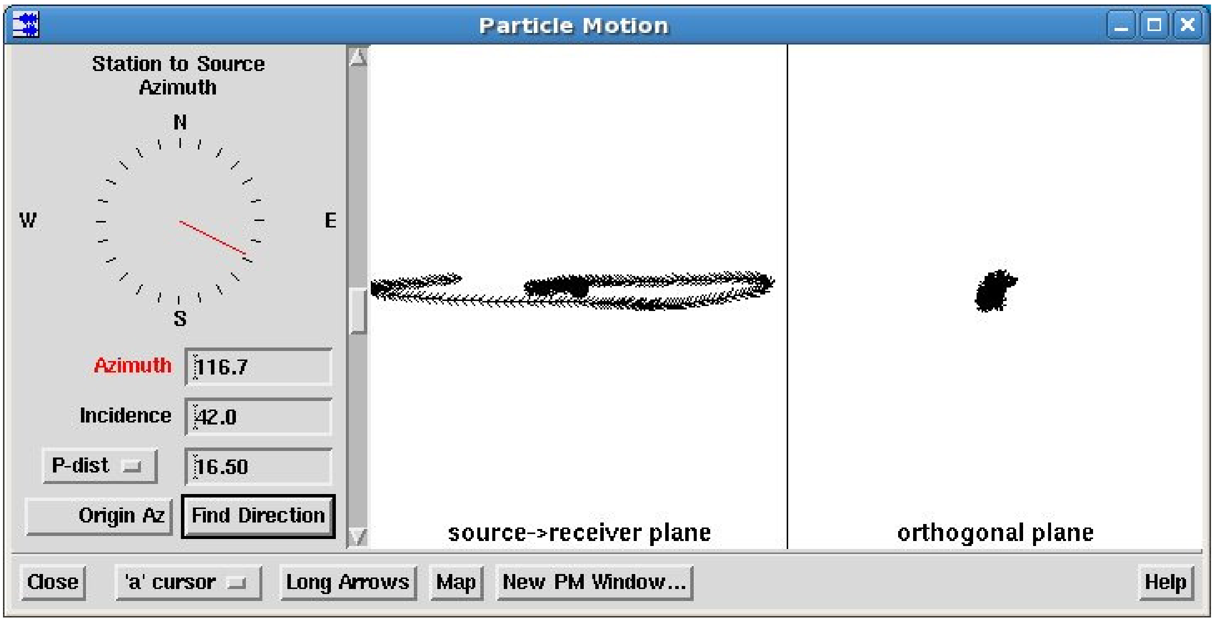


Figure 66. ***Particle Motion*** *display after the rotation to the direction of the ray path.*

(5) Click on the **Map** toggle button at the bottom of the Particle Motion (Figure 66) window to display the computed ray path arc on the map (Figure 67).

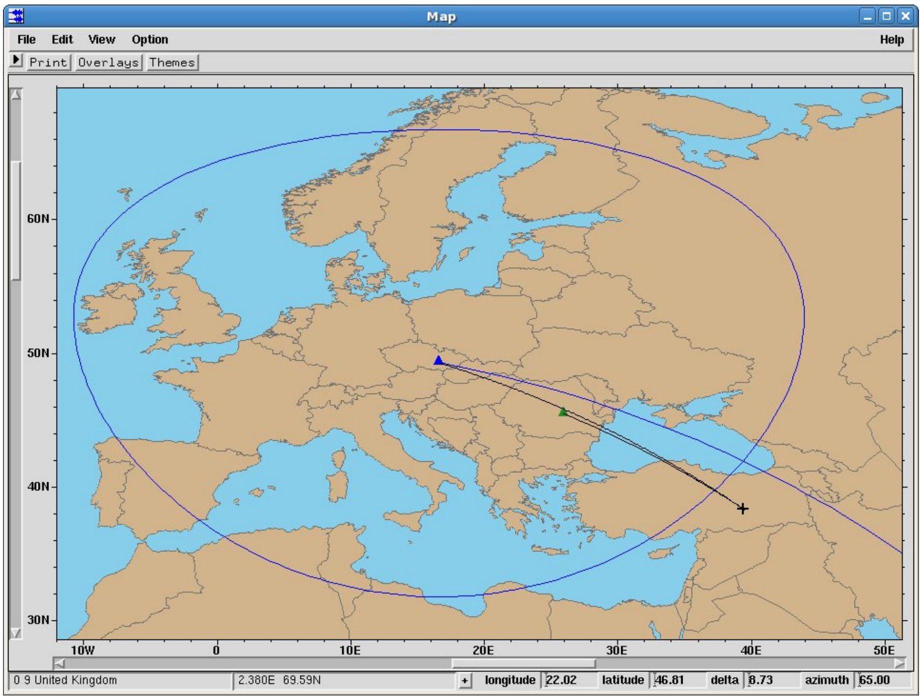


Figure 67. The map shows an arc with the computed azimuth and distance

The distance (16.59 degrees) is computed from the ray parameter of the IASPEI91 velocity model that corresponds to the incidence angle.

Repeat the same procedure to the data from station **MLR.** This results in the particle motion display are shown in Figure 68.

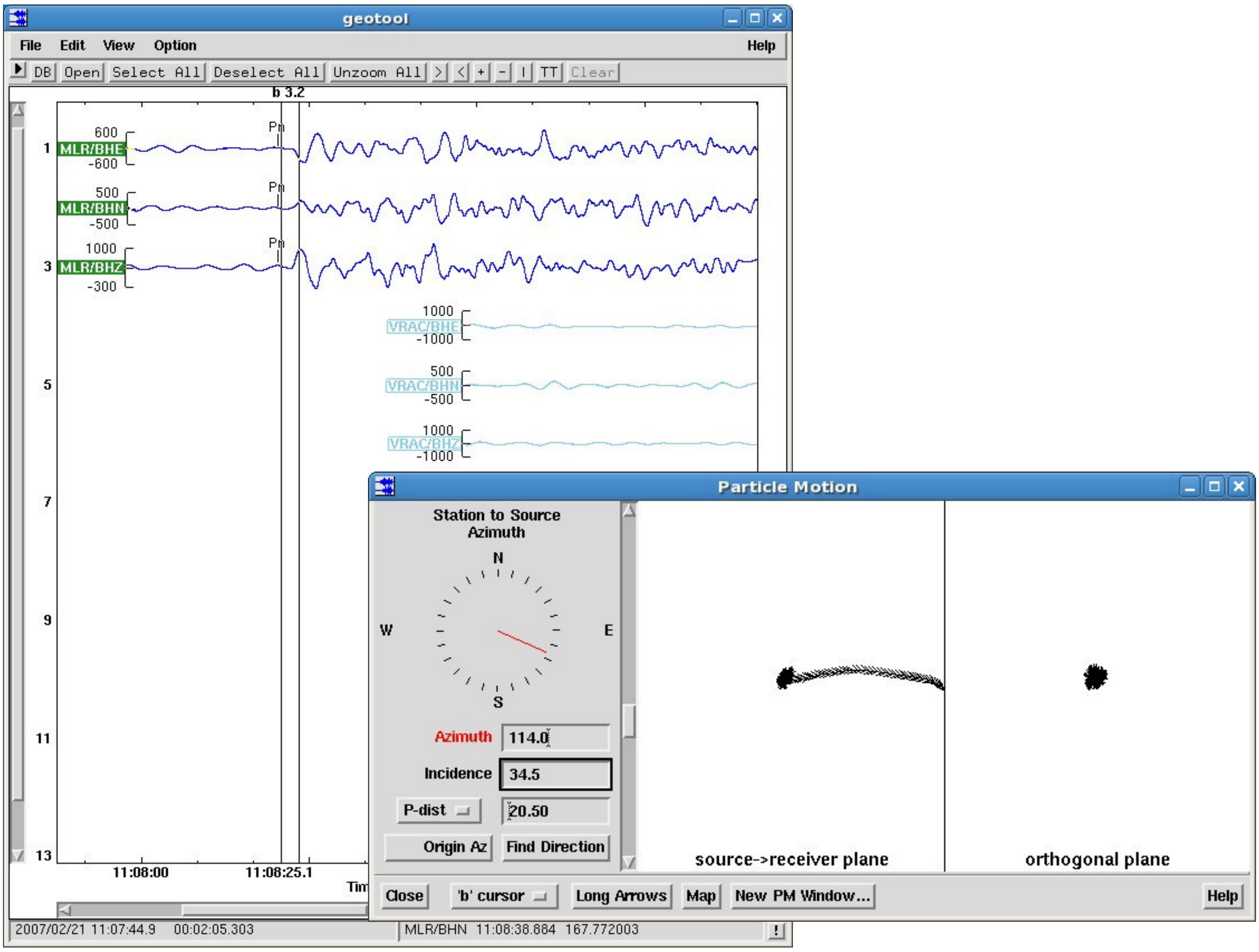


*Figure 68. Main waveform window with **N, E** and **Z** component waveforms for station **MLR** selected and double-line cursor set to 3.2s (left picture), **Particle Motion** popup (right picture).*

The "New PM Window" button at the bottom of the particle motion window will bring up a second particle motion display that is tied to a second double-line cursor labeled 'b' . This allows the results from the analysis of the data from both stations to be displayed on the map at the same time.

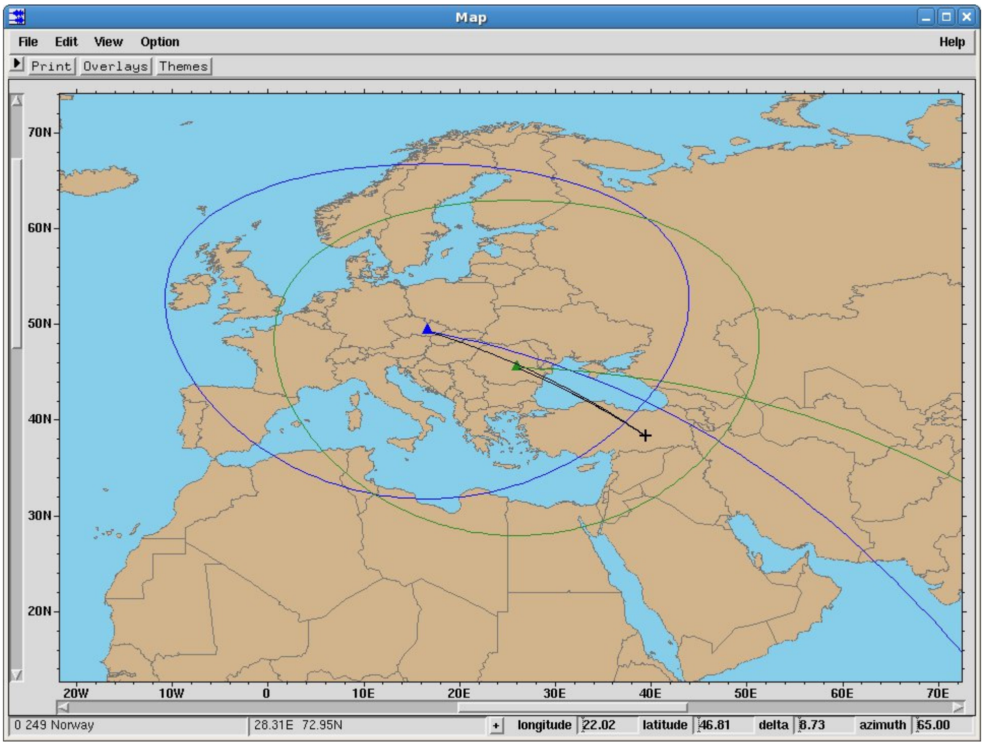


*Figure 69. Map arcs at both stations **VRAC** and **MLR** with computed azimuth and distance.*

The particle motion distance estimation is very sensitive to the incidence angle and also depends on the particular velocity model used. The azimuth estimation appears more reliable in this simple illustration of the tool. The **P** to **S** time separation is a more reliable estimate of distance when it is available. Figure 70 shows the **P** to **S** separation on the **VRAC/BHZ** waveform used to estimated the source-receiver distance.

Exercise 4.3. Travel Time Curves.

Travel time curves can only be used with waveforms that are associated with an origin. Waveforms are associated with an origin based on the data that are read in, or by actions done by a user to locate an event using waveform data. An example of locating an event is given in Section 10.

To leave the waveform position unchanged but to label theoretical arrivals:

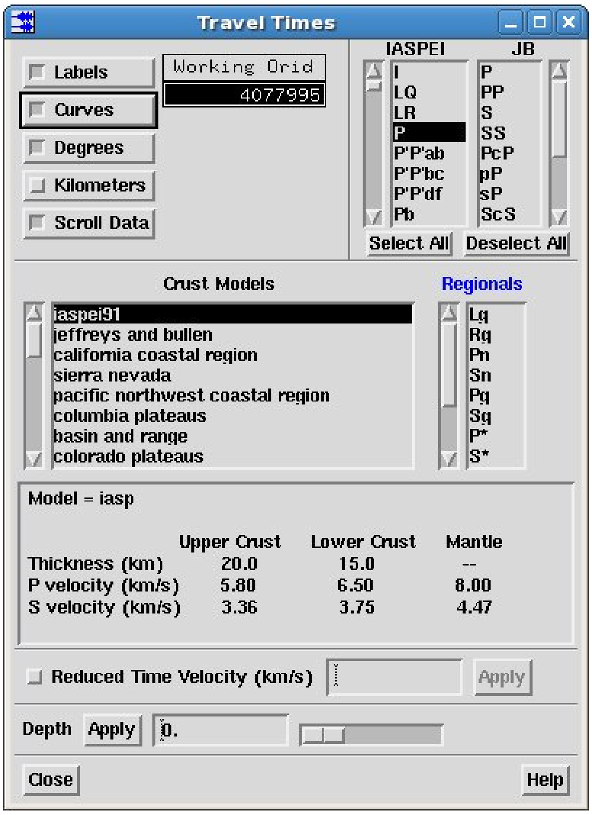
(6) Select the **Option→Travel Times** menu item to activate the **Travel Times** popup.

(7) Select the **P** and **S** in the **IASPEI** box, if they are not already selected.

(8) Click (check) the **Labels** button in the **Travel Times** popup (Figure 70, left picture).

To reposition waveforms based on distance and time from the origin and to draw travel time curves:

(9) Click the **Curve**s button in the **Travel Times** popup to add the **P, S** travel time curve. When the curves are activated, the units of the axis are changed. The y-axis represents distance from the associated origin. The x-axis represents time after the associated origin.



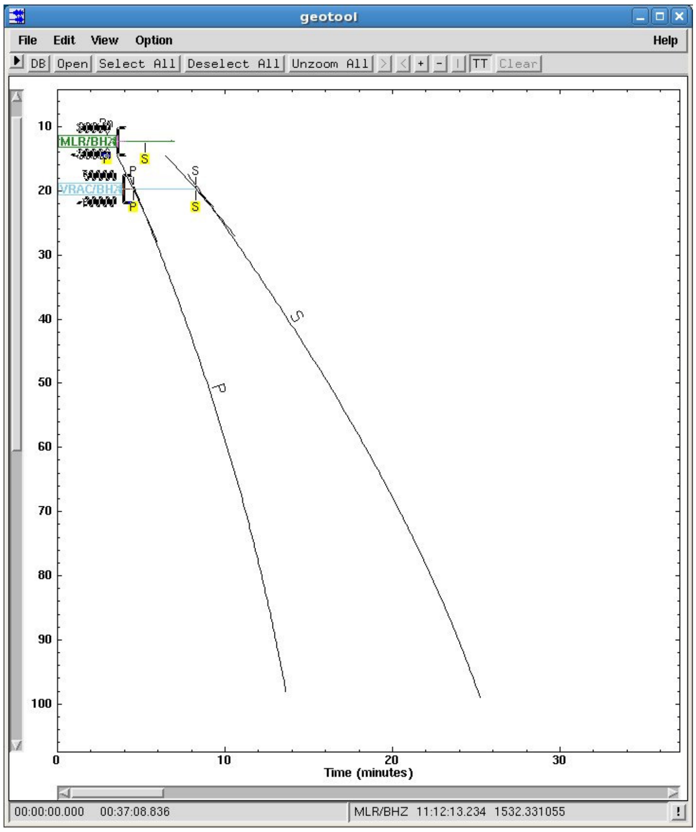


*Figure 70. **Travel Times** popu (left picture), waveforms with **Labels** and **Curves** buttons activated (right picture).*

(10) As needed, go to each waveform in the main waveform window and scale up the amplitude of each waveform manually by using the right mouse button while holding down the control (**Ctrl**) key; movingthe mouse up and down.

(11) The amplitudes of all waveforms can also be changed by clicking the **+** or **–** toolbar buttons.

In different circumstances a user may want to see different window limits when displaying Travel Time curves and waveform data. In one case, you may want the window to be sized based on the available data, while in another case you may want the window to be sized based on the Travel Time curves. It is possible to toggle between these two views:

(12) In the main window, click the **middle mouse button**. This will change the window limits so the Travel time curves are displayed .

(13) **Shift + middle mouse button click**, will return to the previous viewing limits.

Note: This zoom back feature (**shift + middle mouse button click**) is a general Geotool feature that can be used in any Geotool plot window.

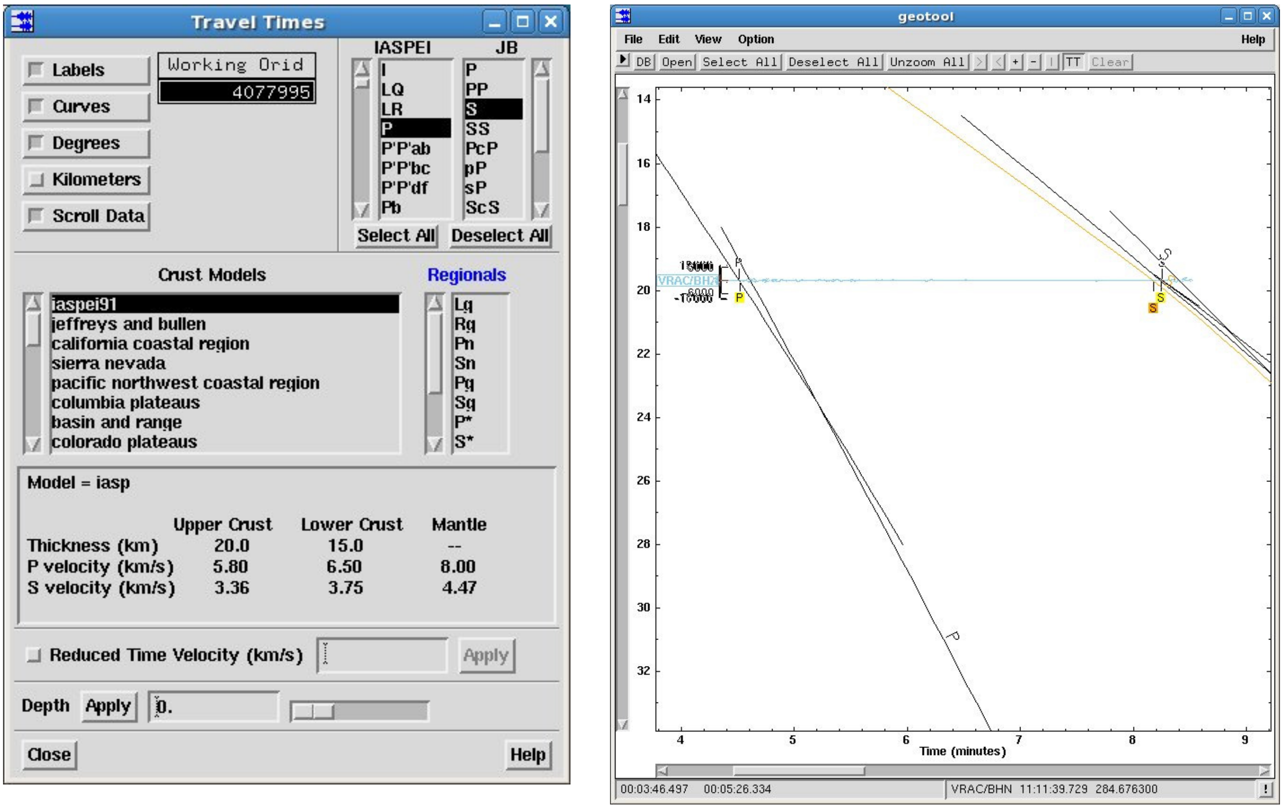


*Figure 71. **Travel Times** popup (left picture), **VRAC/BHZ** waveforms with **P** and **S** travel time curves activated (right picture*

An important difference must be pointed out concerning the times used for positioning the phase labels versus the times used for positioning the travel time curves. The depth of the associated origin is used to calculate the time of the predicted phase labels. The depth listed at the bottom of the **Travel Times** popup is used to calculate the time of the travel time curves. This distinction is made so different waveforms can be associated with different origins (and hence depths), but only one depth can be used when drawing the travel time curves since all the waveforms (which may have different associated depths) use the same travel time curve.

(14) Deselect the **Travel Times** Curves and Labels buttons.

(15) Close the **Travel Times** popup by clicking the **Close** button.

Note: Closing the **Travel Times** popup without deselecting the Travel Times (TT) curves button will allow the curves to remain in the waveform window. To remove the curves, use the **Travel Times** popup or the **TT** button in the toolbar.

Exercise 4.4. Magnify Window.

To see a detailed view while retaining an overview:

(16) Outline a box around the **VRAC/BHE S** arrival by dragging the middle mouse button while pressing the control key on the keyboard (**Ctrl + middle mouse button**). Note that the edge of the box is red rather than black (the box is black when zooming with no **Ctrl** key).

(17) To display the contents of the box just drawn, release the mouse button and the **Magnify** popup (right side of Figure 72) will be activated.

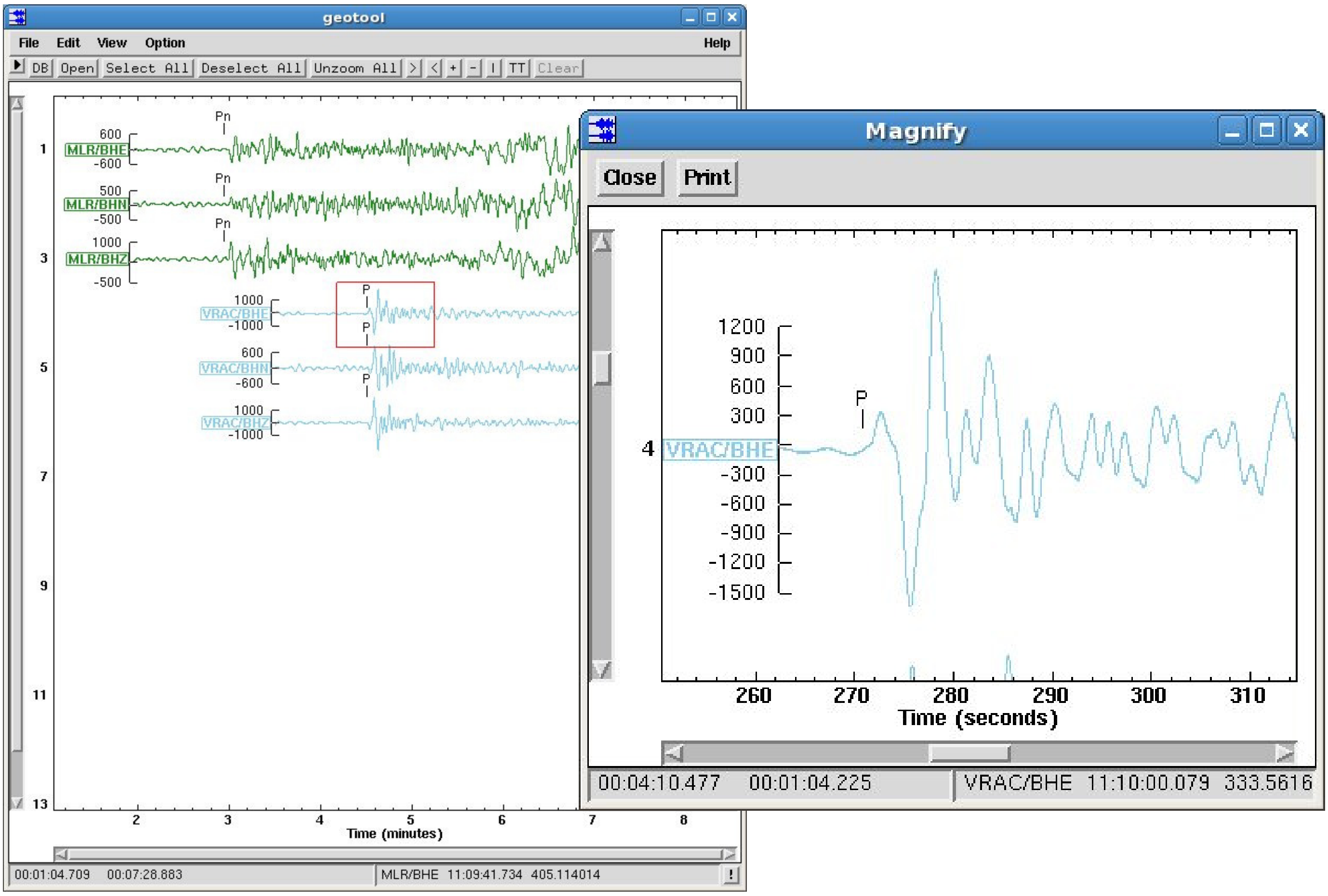


*Figure 72. The waveform window and **Magnify** popup.*

Use the vertical and horizontal scroll bars in the **Magnify** popup to reposition the **Magnify** window in the main waveform window.

(18) Pick up and drag the red box in the main window and observe the **Magnify** popup.

(19) When finished exploring, close the **Magnify** popup by clicking on the **Close** button in the **Magnify** popup.

Exercise 4.5. Component Rotation.

(20) In the main waveform window, select **VRAC/BHZ, VRAC/BHN, VRAC/BHE** by clicking **Ctrl+ left** mouse button.

(21) Zoom in near the **P** arrival to about a one minute window. This is done by moving the mouse cursor to the left of the arrival, and dragging the mouse cursor to the right with the right mouse button held down.

(22) Release the right mouse button after the cursor has passed the **P** arrival. As needed, recenter the **P** arrival using the horizontal scroll bar in the main waveform window.

(23) Select the **Edit→Rotation** menu item from the main menu bar. This activates the **Rotation** popup (Figure 73), which will be used for rotating horizontal components.

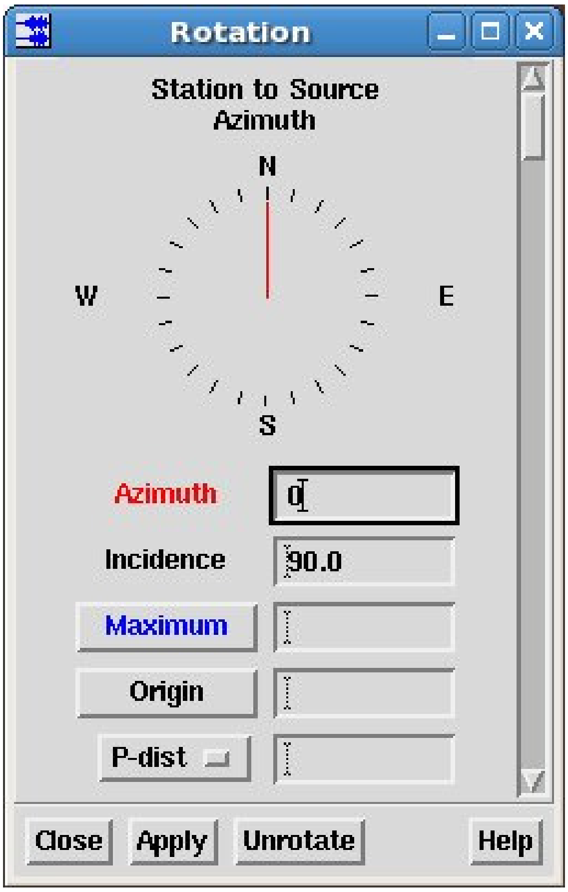


*Figure 73. The **Rotation** popup.*

The components will first be rotated to the azimuth of the associated origin.

(24) Rotate to the azimuth of the selected origin by clicking on the **Origin** button in the **Rotation** popup (Figure 74).

This azimuth is shown in the **Rotation** popup as a red line. In addition, a small black line is drawn in the azimuth indicator window that points towards the azimuth of the origin from the station. The black (origin) line will serve as a reference when other angles of rotation are used.

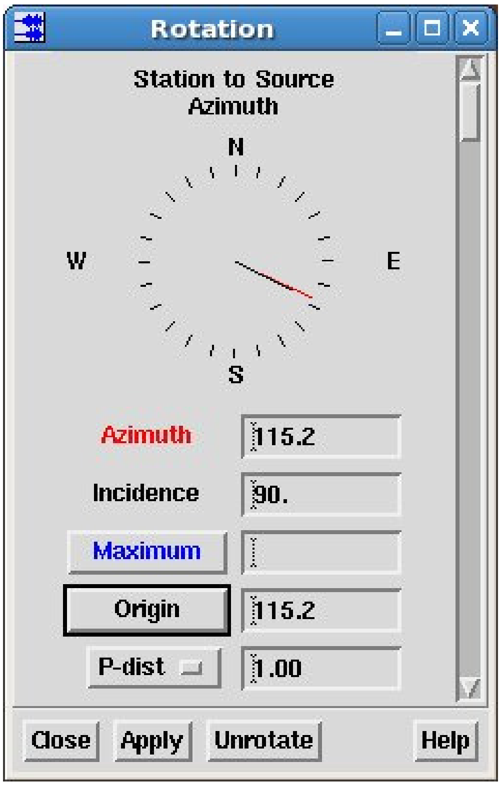


*Figure 74. The **Rotation** popup after selecting the **Origin** button.*

Exercise 4.6. Maximize Amplitude of the Radial Component.

(25) Add a double-line cursor by typing an l (a **low case L**) or (**View→Cursors→Add Time limits**) from the main menu bar, and position it over the P arrival.

(26) Drag one line of the double-line cursor (Ctrl) to make the width about 3 seconds (this can also be done with **middle** mouse button click over the double-line to activate the Cursor Options popup). Recall that the number above the double line cursor specifies the width in seconds.

(27) Click on the **Maximum** button in the **Rotation** popup (Figure 75).

This rotates the waveforms so the amplitude of the radial component is maximized.

In the ideal world, this maximum rotation angle computed from the onset of the P wave, will point towards the seismic source. Note that a blue line was drawn in the azimuth indicator window. Since there is 180 degree ambiguity in the angle that maximizes the radial horizontal component, the blue line is drawn to mark both possibilities.

The angles for both possibilities are listed next to the **Maximum** button.

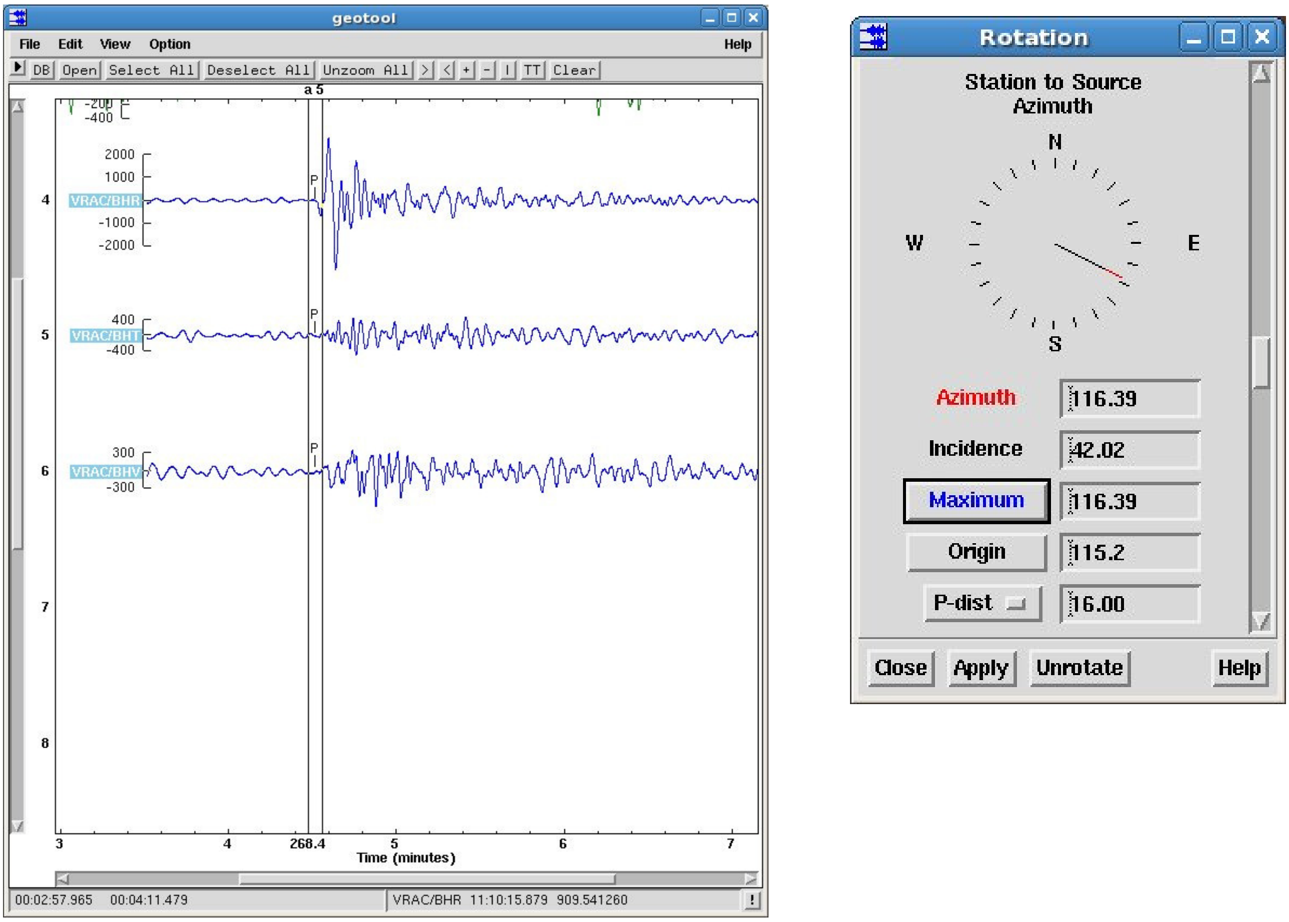


*Figure 75. The waveform window with **Rotation** popup.*

The components are rotated to maximize the amplitude of the radial component that will vary depending upon the window selection specified by the double line cursor.

Exercise 4.7. Save Rotation Azimuth

(28) In order to associate an arrival with the current rotation angle, select the arrival with a left click.

(29) Click the **Apply** button in the **Rotation** popup, and the current azimuth of rotation will be saved with the selected arrival.

(30) Deselect the arrival with another left click.

To prepare for the next exercises:

(31) Clear the display with the **Edit→Clear** menu item.

SECTION 5. WAVEFORM ANALYSIS

Exercise 5.1. Data Input.

(1) Select the file named **DPRK_reduced.wfdisc** in the **Files** column in the **Open file** popup and click on the **List Contents** button.

(2) Select **BHZ** and **HHZ** in the **Chan** column (hold down the **Ctrl** key to select these channels and individually click on **BHZ** and **HHZ**). Click on the **Display waveforms** button (Figure 76, left picture).

The main waveform window should now look like the right side of Figure 76.

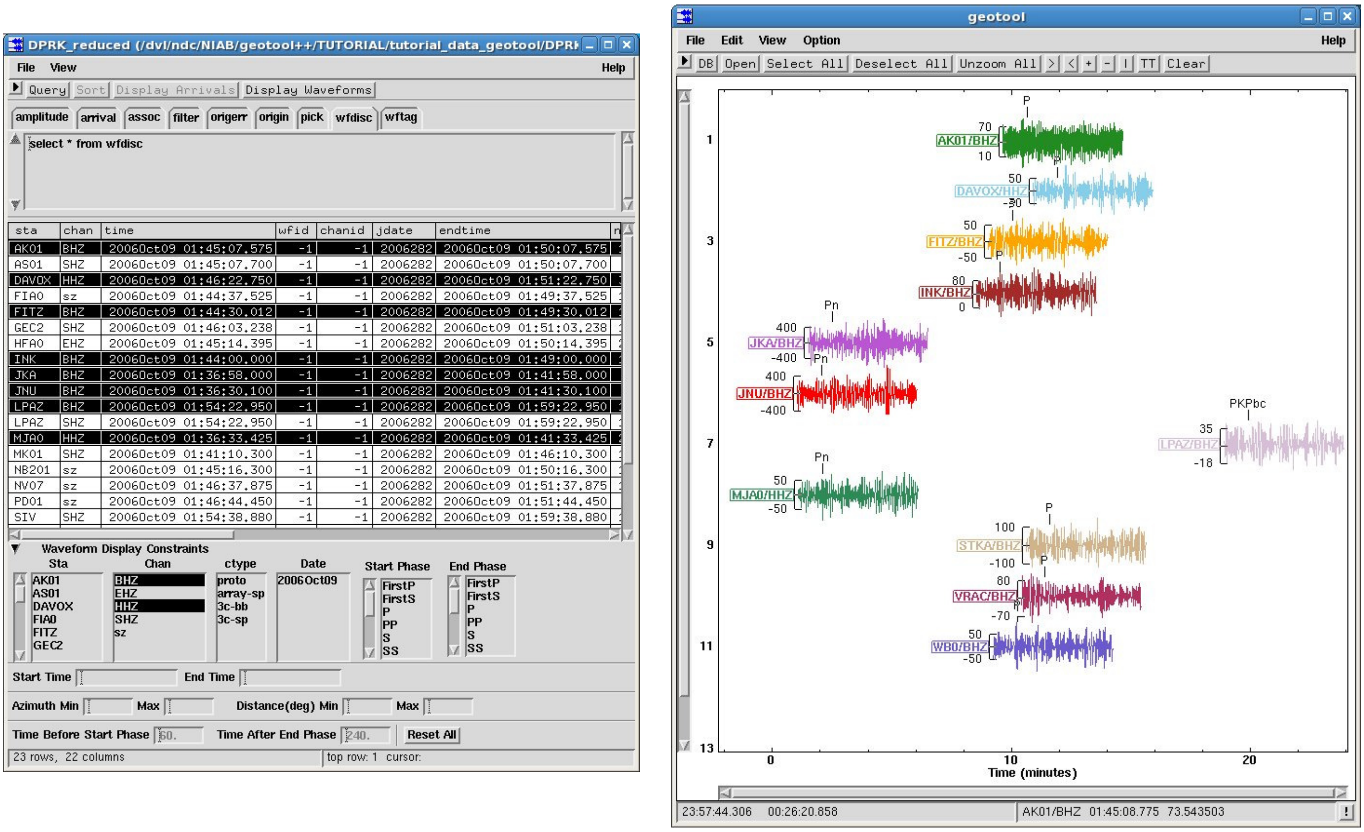


*Figure 76. The **DPRK_reduced** Listing popup with **BHZ** and **HHZ** channels selected (left picture) and main waveform window with loaded waveforms (right picture).*

Exercise 5.2. FT

(3) Click on the **Option→Spectral Analysis->FT** menu item from the main menu bar. This activates the **FT** popup, where spectra will be displayed (Figure 77).

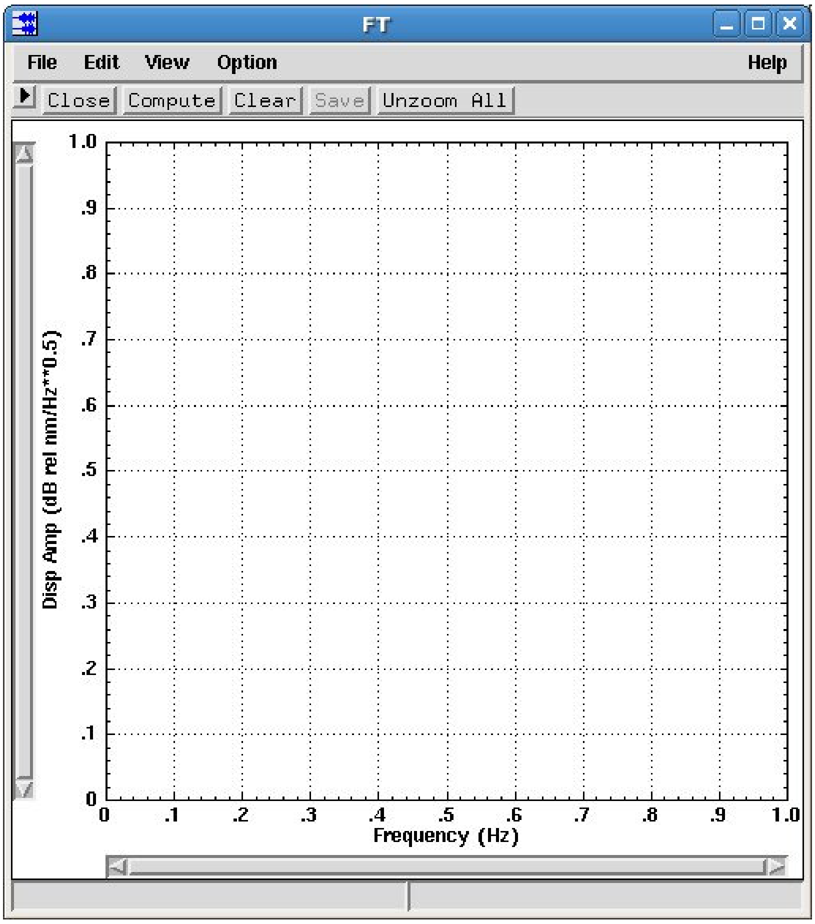


*Figure 77. The **FT** (**F**ourier **T**ransform) popup.*

To identify the waveform for calculating spectra:

(4) Select the **WBO/BHZ** waveform by clicking over the waveform with the **left** mouse button.

(5) Zoom in before and after the **P** arrival by holding down the middle mouse button and drawing a rectangle around the **P** arrival.

The main window will display the area around the **P** arrival of **WBO** after this action.

The objective is to compute the spectrum of the five seconds of background noise located just before the onset of the **P** arrival and a spectrum of five seconds that contains the **P** signal.

To specify the particular segment for spectrum calculation:

(6) Add a double-line cursor by moving the mouse cursor into the main waveform window.

Note: this can be done from the **View→Cursors→Add Time Limits** file menu or by typing the l (**lower case L**) on the keyboard.

(i) Drag the double-line cursor somewhere before and after the signal into the background noise. The number labelled above the cursor specifies the width of the double-line cursor in seconds.

(ii) Drag one line of the double-line cursor while pressing the control key (**Ctrl**) to change the width of the double-line cursor to be about 10 seconds, (or Right mouse button drag). If needed, zoom in on the waveform again to reduce the time scale so the two lines are not so close together and re-centre the signal as needed using the horizontal scroll bar (Figure 78).

(iii) Another method to set cursor width: with the mouse over the double-line cursor, **middle mouse button click and hold.** A popup will display a **Set Width** option, which can be used to accurately specify the cursor width.

(iv) Click on the **Apply** button in the **Set Width** popup

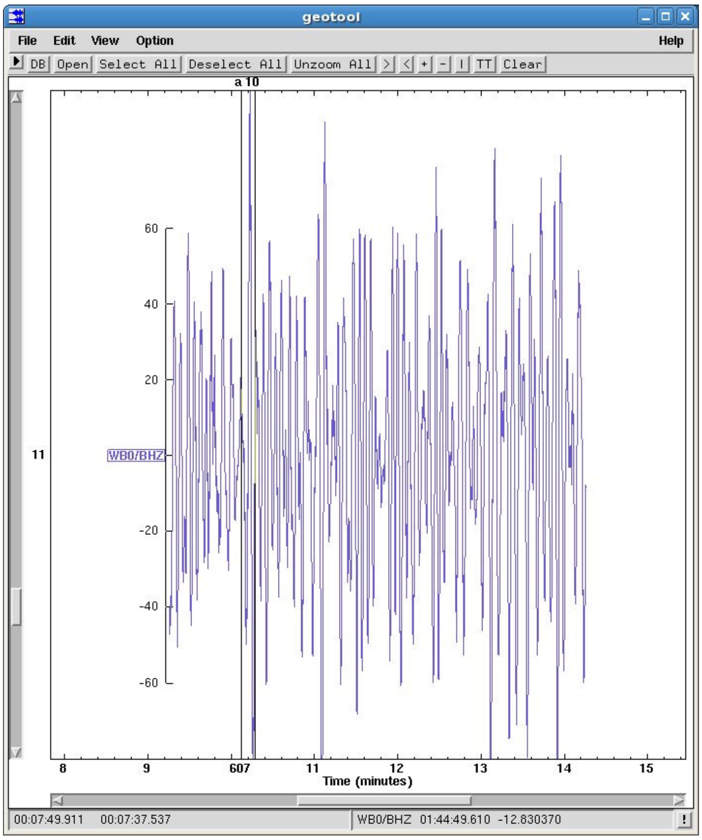


*Figure 78. Zoomed in after placing the double-line cursor on the **P** arrival of **WBO/BHZ**.*

(7) Drag the double-line cursor to overlay five seconds before the onset of the **P** arrival.

(8) Select the **File→Compute** menu item in the **FT** popup to calculate the spectrum of this segment of background noise. The spectrum should look similar to Figure 79. You can change the units of the X and Y axis by selecting one of the menu items under **View → X Axis** or **View → Y Axis**.

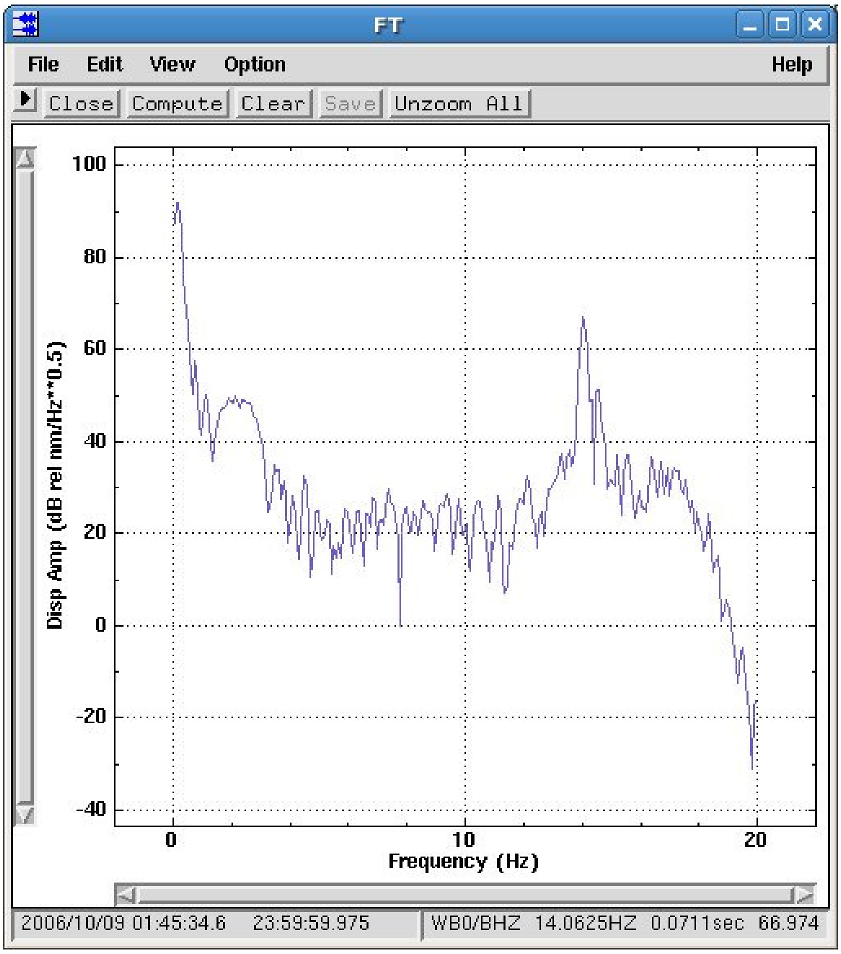


*Figure 79. The **FT** popup after compute.*

(xvii) Select the spectrum in the **FT** popup by left mouse click.

(xviii) Save the currently displayed spectrum on the screen by selecting the **Edit→Save Selected** menu item in the **FT** popup. (The spectrum will remain on the screen until it is cleared with the **Edit→Clear** menu item, which will be done later). Note: without selecting and preserving the spectrum it would be overwritten by the next calculated spectrum.

(10) To fill this noise spectrum in the popup **View→Fill/Unfill Selected** (Figure 80).

(11) Calculate the spectrum of the signal by dragging the double-line cursor so that the left line of the cursor is after the **P** label. The double-line cursor should be positioned to overlay five seconds of signal after the onset of the **P** arrival.

(12) Select the **File→Compute** menu item in the **FT** popup to compute the spectrum. It is plotted in the **FT** popup in addition to the spectrum for the background noise.

(13) Middle click in the **FT** popup will change scale so the whole signal is displayed.

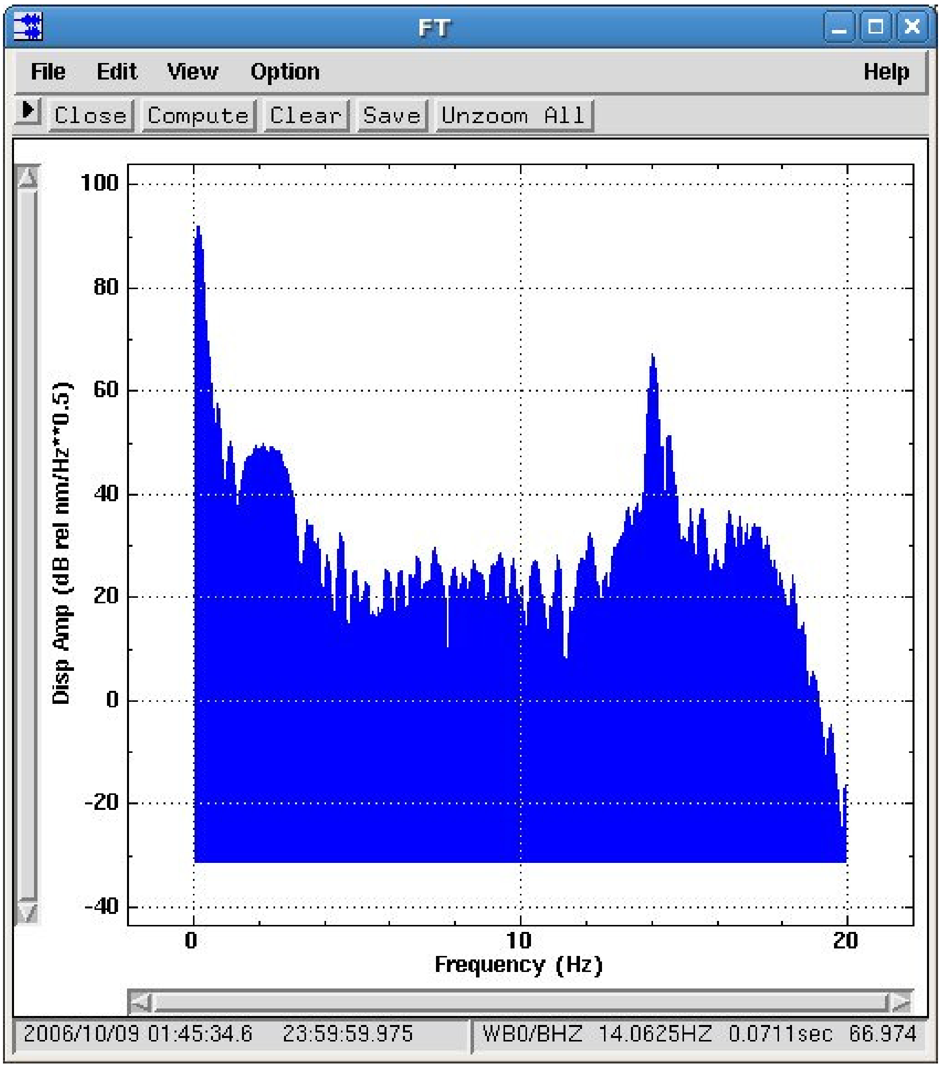


*Figure 80. Spectrum for signal from **WBO/BHZ** waveform displayed in the **FT** popup.*

To calculate spectra as the double-line cursor is dragged:

(14) Select the waveform with a left mouse click.

(15) Select the **Option→Auto Cursor** menu item in the **FT** popup.

(16) Drag the double-line cursor. Note that the spectrum is repeatedly recalculated and redisplayed as the cursor is dragged (Figure 81).

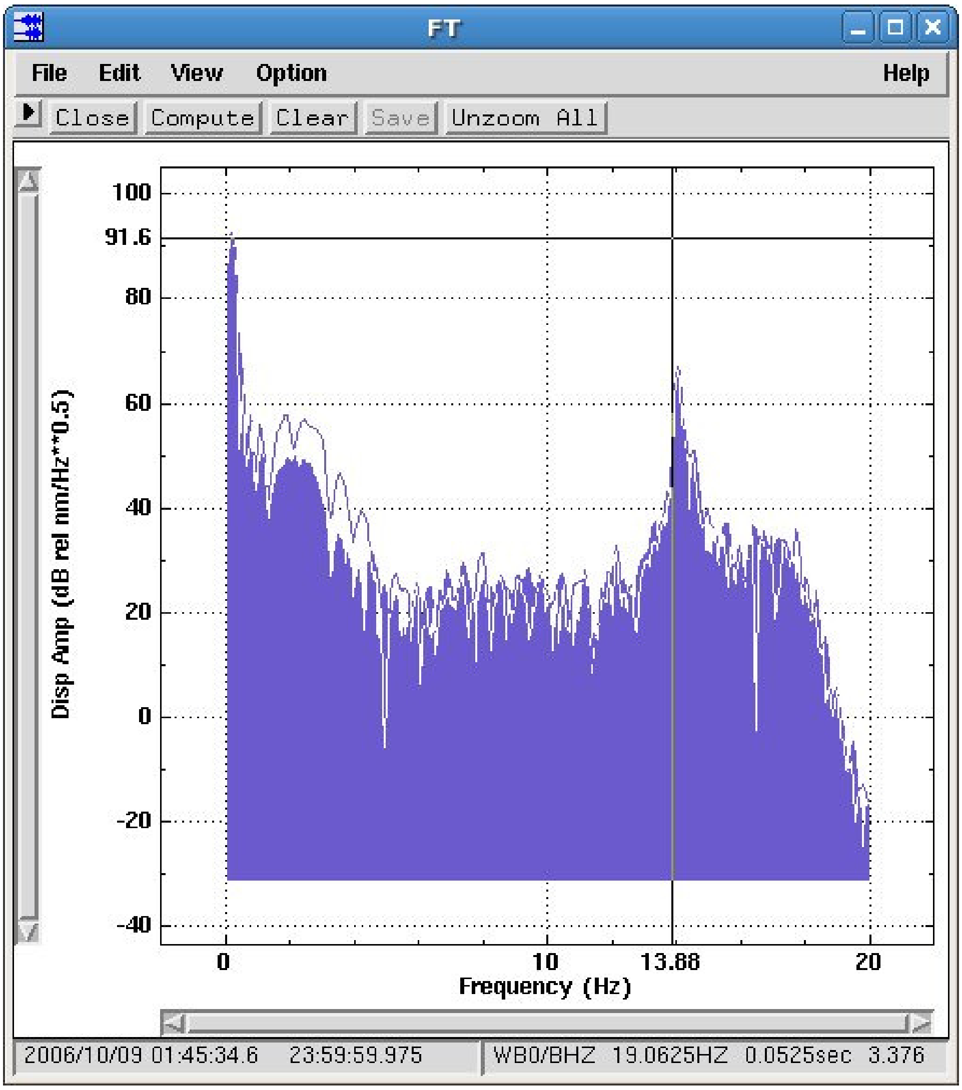


*Figure 81. **FT** popup with crosshair cursor.*

A crosshair cursor is useful for measuring values at a particular point on a plot. To add a crosshair cursor to the **FT** plot window:

(17) Move the mouse cursor into the **FT** plot window and type c (**lower case C**) on the keyboard.

(18) Drag the cursor to measure where the signal rises above and falls below the noise. These values can be used to select the best filter to enhance the signal.

(19) Select the **Option→Auto Cursor** menu item in the **FT** popup to deactivate recomputing spectra each time a double-line cursor is dragged over a selected waveform.

(20) Click on the **Close** button in the **FT** popup.

To cleanup for the next exercise:

(21) Select **Edit→Clear** from the main menu bar.

Exercise 5.3. Spectrogram

In the main Geotool window, open the DPRK_reduced.wfdisc data (**File→Open File**, select the **DPRK_reduced.wfdisc**, then **Open**).

(1) Select the waveform **WB0/BHZ**.

(2) Select **Option →Spectral Analysis->Spectrogram** from the main menu bar.

(3) Click on the **Compute** toolbar button in the Spectrogram.

A Spectrogram with a default color distribution will be displayed (Figure 82).

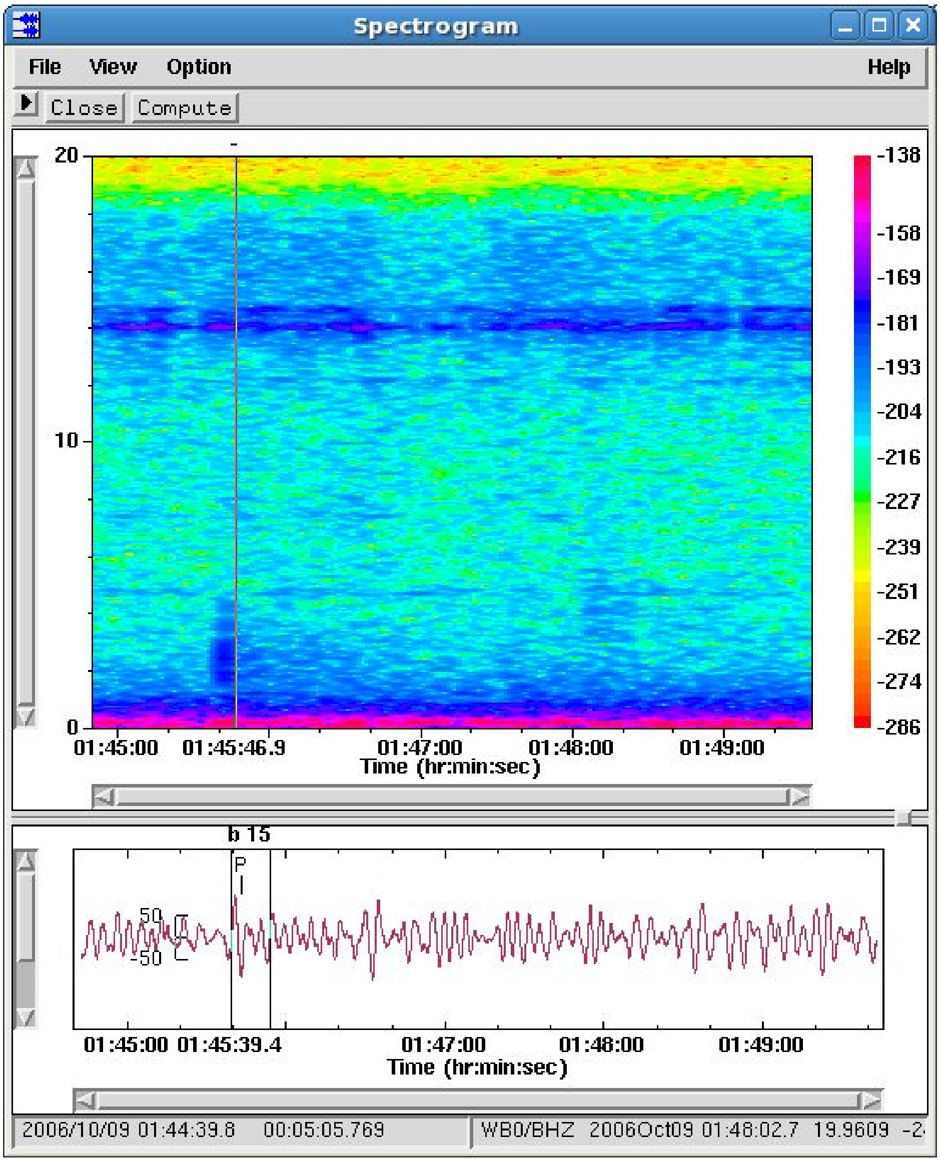


Figure 82. The Spectrogram.

In the **Spectrogram** window, the x axis represents time in seconds, while the y axis represents frequency in Hertz.

(4) Select **Option →Parameters** in the **Spectrogram** popup to activate the **Spectrogram Parameters** popup in order to view or to change the parameters used to compute the spectrogram (Figure 83).

The 'lo freq' and 'hi freq' values in the **Spectrogram Parameters** popup specify the frequency limits that are used to compute and display the Spectrogram. The default frequency limits are from 0.0 to the Nyquist frequency.

The window length specifies the length of the segment used in calculating each value of the Spectrogram.

The windows used to calculate in the Spectrogram are overlapping, and the window overlap field specifies the number of seconds adjacent windows are overlapping.

(5) All of the **Spectrogram Parameters** values are determined automatically by default. To change the values, click the '**Auto Window Parameters'** box, change the value(s), and click the **Compute** button in the **Spectrogram Parameters** popup.

Note that the window length determines the width of "b" cursor in the waveform of the **Spectrogram** popup.

The single cursor in the spectrogram is placed in the middle of the computational window.

It should be noted that the width of the pixels in the spectrogram is determined by the difference between the window length and the window overlap. As the difference between the window length and the window overlap increases, the pixels width used to display the spectrogram will also increase.

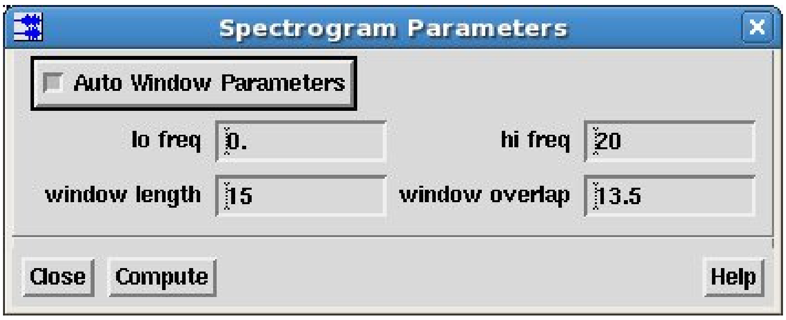


Figure 83. Spectrogram Parameter with the default setting.

(6) To work with the color distribution, open the **Spec Color Selection** popup, by selecting **View →Colors** in the **Spectrogram** popup (Figure 84).

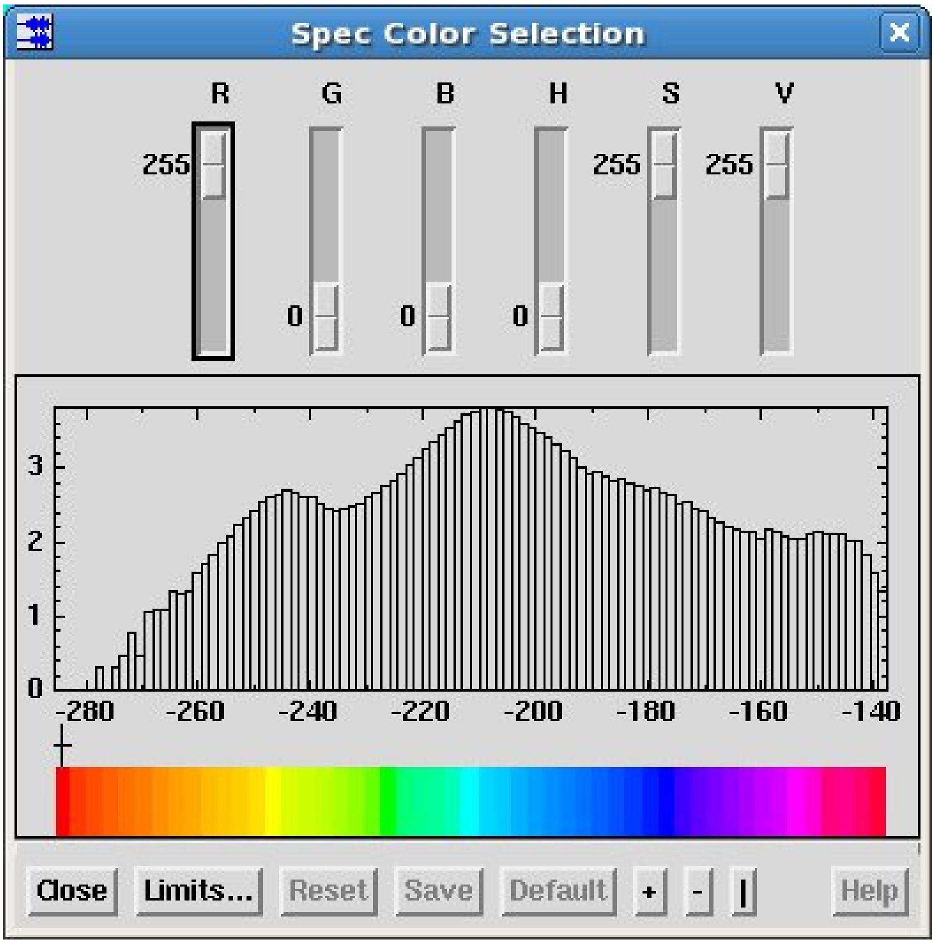


*Figure 84. **The Spectrogram Color** selection.*

This popup shows the distribution of color values displayed in the spectrogram. The minimum and maximum values displayed below in the histogram are the same as the values displayed to the right of the color scale in the **Spectrogram**.

(7) To redistribute the colors, grab and move either side of the colour bar by holding down the **Ctrl + left** mouse button (Figure 85).

When the color distribution is changed, it will also change the colors of some of the pixels. For example, compare the colors of the **Spectrograms** in figures 82 and 85. This technique can be used to accentuate signals in certain frequency bunds

.

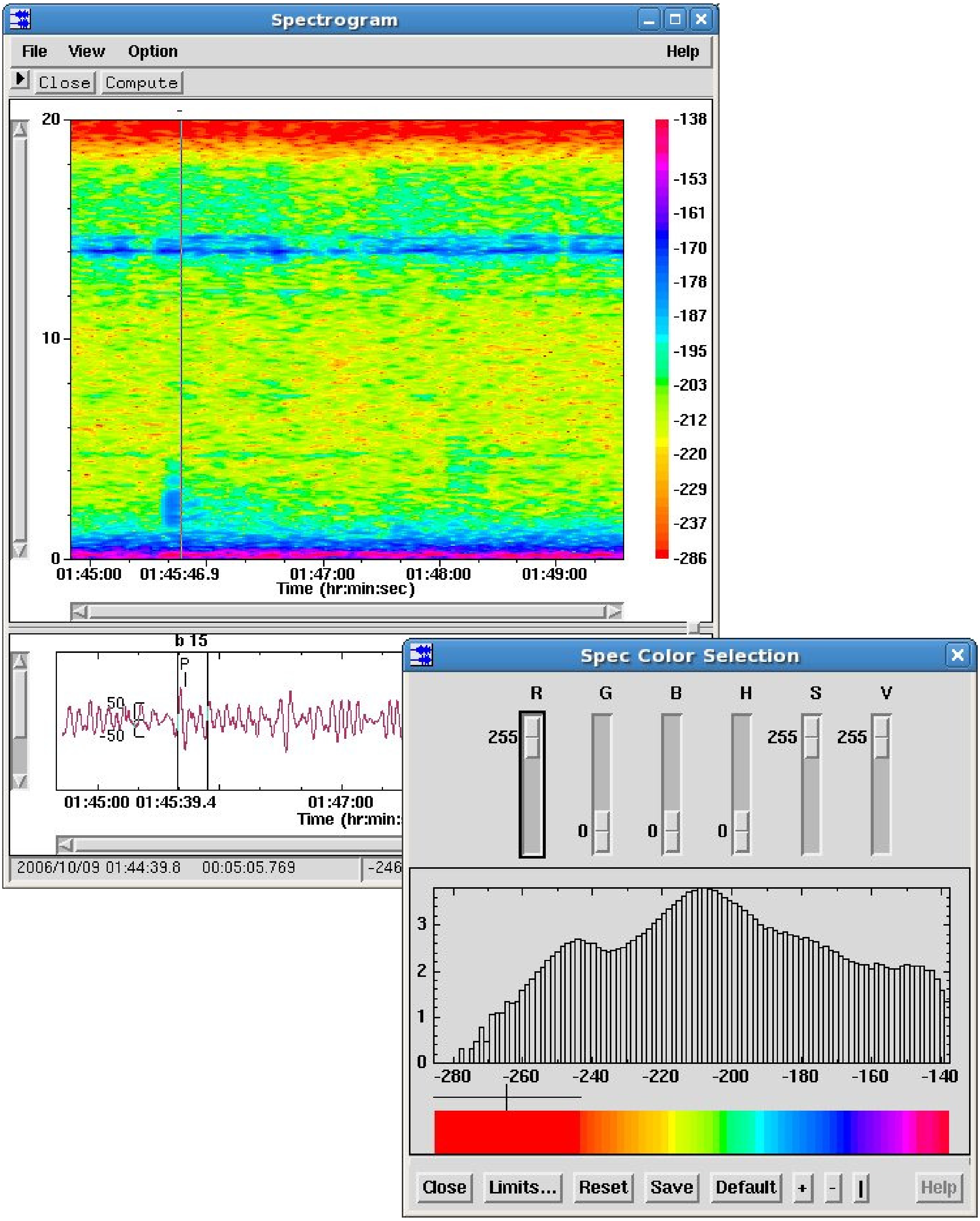


Figure 85. Spectrogram after making color changes.

Once a color in the color scale is selected, the RGB (red, green, blue) and the HSV (hue saturation value) values for the color are shown at the top of the **Spec Color Selection** popup. It is possible to change the selected color by moving any of the controls for the RGB/HSV values.
Note the black line above the red rectangle in the color bar in the popup. It is used as a visual aid to show mapping between the color and values in the histogram. Since the color scale in Figure 85 was changed, the red color rectangle towards the left edge covers different values, while each of the other colors cover a much narrower range.
It is also possible to zoom in the histogram plot for a more detailed view (zoom with middle mouse button).

(8) Select **File->Print** in the **Spectrogram** popup.
It activates the **Print Spectrogram** popup, where by clicking on **Print** button Spectrogram can be printed (Figure 86).

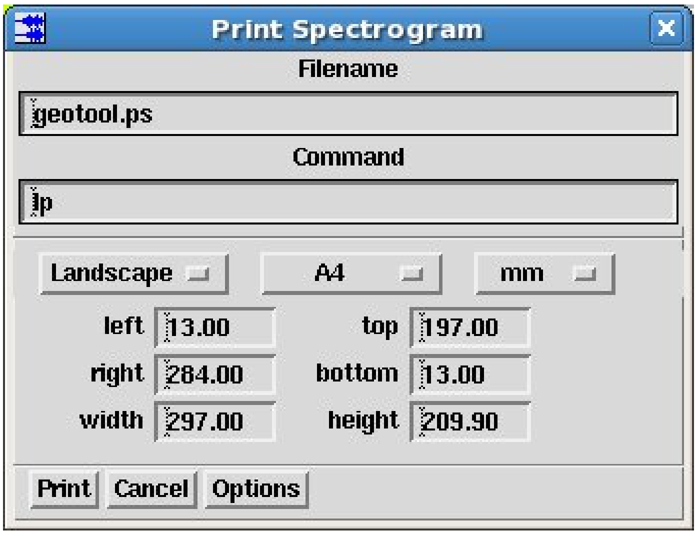


*Figure 86. **Print Spectrogram** popup.*

(6) When finished, close the popups and clear the data (**Edit →Clear** from the main menu bar).

Exercise 5.4. More Waveform Handling.

For the data input:

(1) Select the **Open File** toolbar button.

(2) Select the file named **DPRK_reduced.wfdisc** from the **Open file** popup. Then click on the **List Tables** button.

(3) Select the **BHZ** and **HHZ** files in the **Chan** column, then **Display Waveforms.**

(4) Select **View →Display Amplitude Scale** and turn on the Amplitude Scale.

(5) Zoom in on the waveform **JKA/BHZ**.

To view options for waveform handling:

(6) **Right mouse button** click over the waveform tag **JKA/BHZ**. Note the change in the appearance of the cursor when it is moved over the waveform tag.

This will activate the **Edit Waveform** popup with several options (Figure 87). These include options to change values of the waveform as it is displayed. This popup uses a pull right menu which means the user must hold down the mouse button and move it to the right to see other menu options.

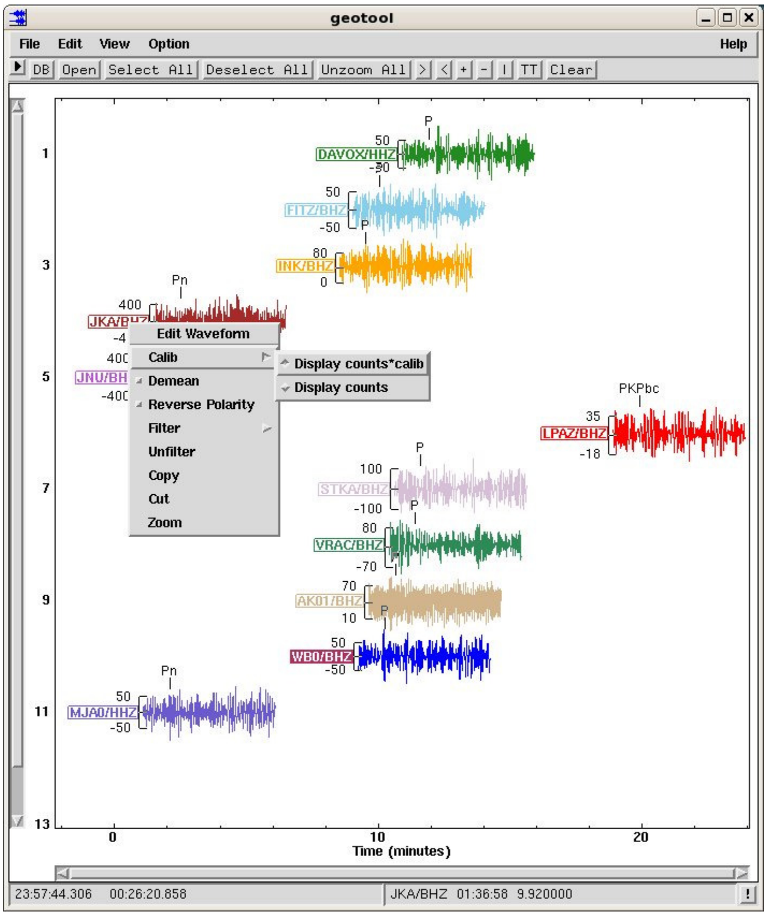


*Figure 87. The **Edit Waveform** popup.*

The Calib selection provides an option to display the wavefroms in units of counts (i.e., the values as read directly from the waveform file) or in counts multiplied by the calib (calibration factor read from the wfdisc file).

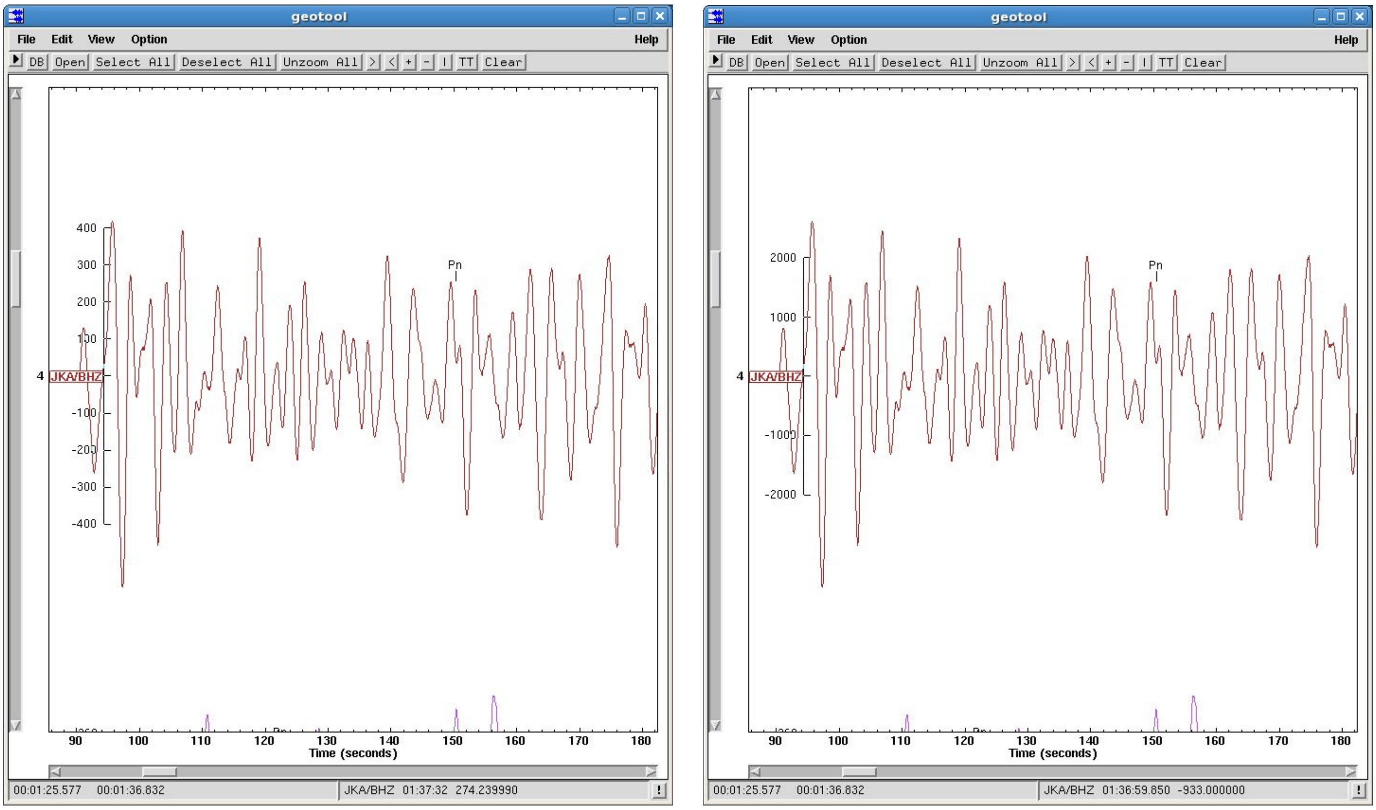


*Figure 88. Waveform window with waveform **JKA/BHZ** Display counts*calib (left picture) and **JKA/BHZ** Display counts (right picture).*

Figure 88 shows the same waveform. The waveform on the left side is displayed in units of counts multiplied by calib, while the waveform on the right is diplayed in units of counts.

Other options to change values of the waveform as it is displayed include removing the mean value from a waveform, filtering choices (Figure 89 and Figure 90), copying or cutting a waveform from the display.

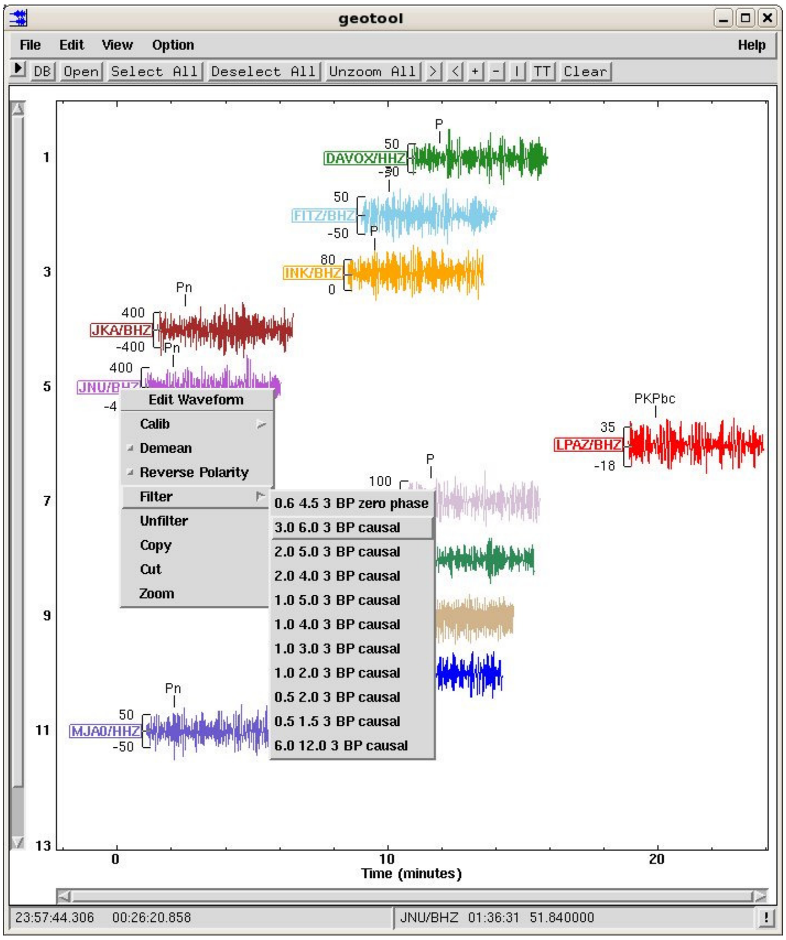


*Figure 89. The **Edit Waveform** popup with filtering option.*

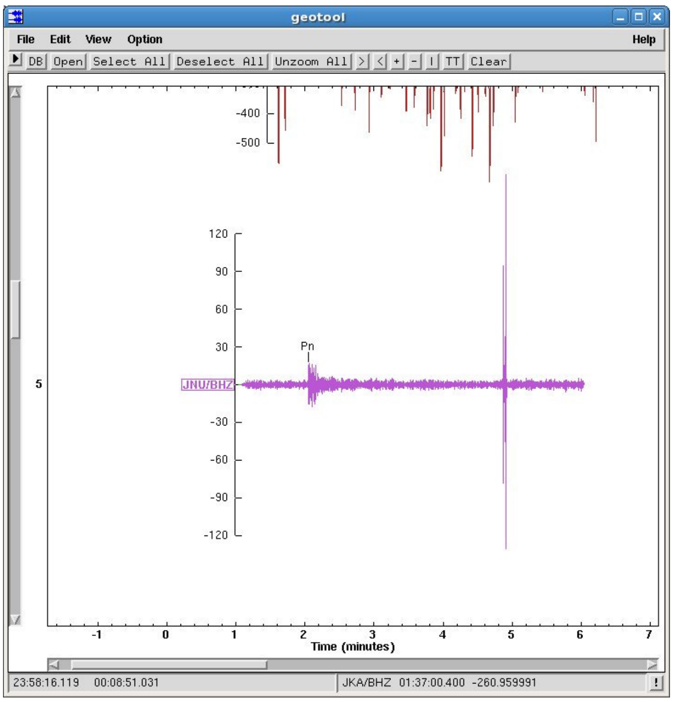


*Figure 90. Waveform **JNU/BHZ** after being filtered.*

After working with waveforms, it is possible to review the history of the methods applied to each waveform by selecting **Option →History** (Figure 91) from the main menu bar.

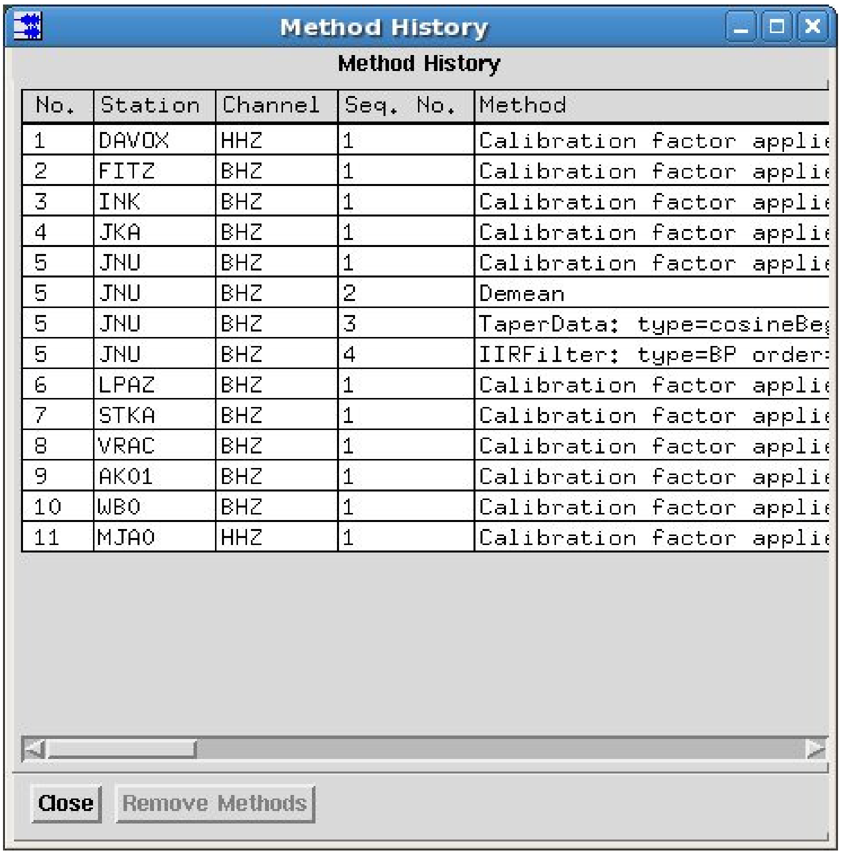


*Figure 91. The **Method History** popup.*

This popup allows the user to view each method history that has been applied to each waveform. From this window it is possible to remove items from the method history, which in turn will effect the waveform display.

To remove the filter applied to **JNU/BHZ**:

(1) Select the row in the **Method History** popup with the filter applied to **JNU/BHZ**. This is the Method line beginning with IIR.

(2) Click the **Remove Method** button. Notice the change to the waveform in the Main Geotool window.

When working with waveforms is completed, clear the data from the Geotool window with **Edit →Clear** from the main menu bar.

SECTION 6. MAP AND MAP OVERLAYS

Exercise 6.1. Data Input.

In the main Geotool window, open the DPRK.wfdisc data (**File→Open File**, select the **DPRK.wfdisc**, then **Open**).

Exercise 6.2. Map.

(1) Activate the map from the **Option→Map** menu item from the main menu bar.

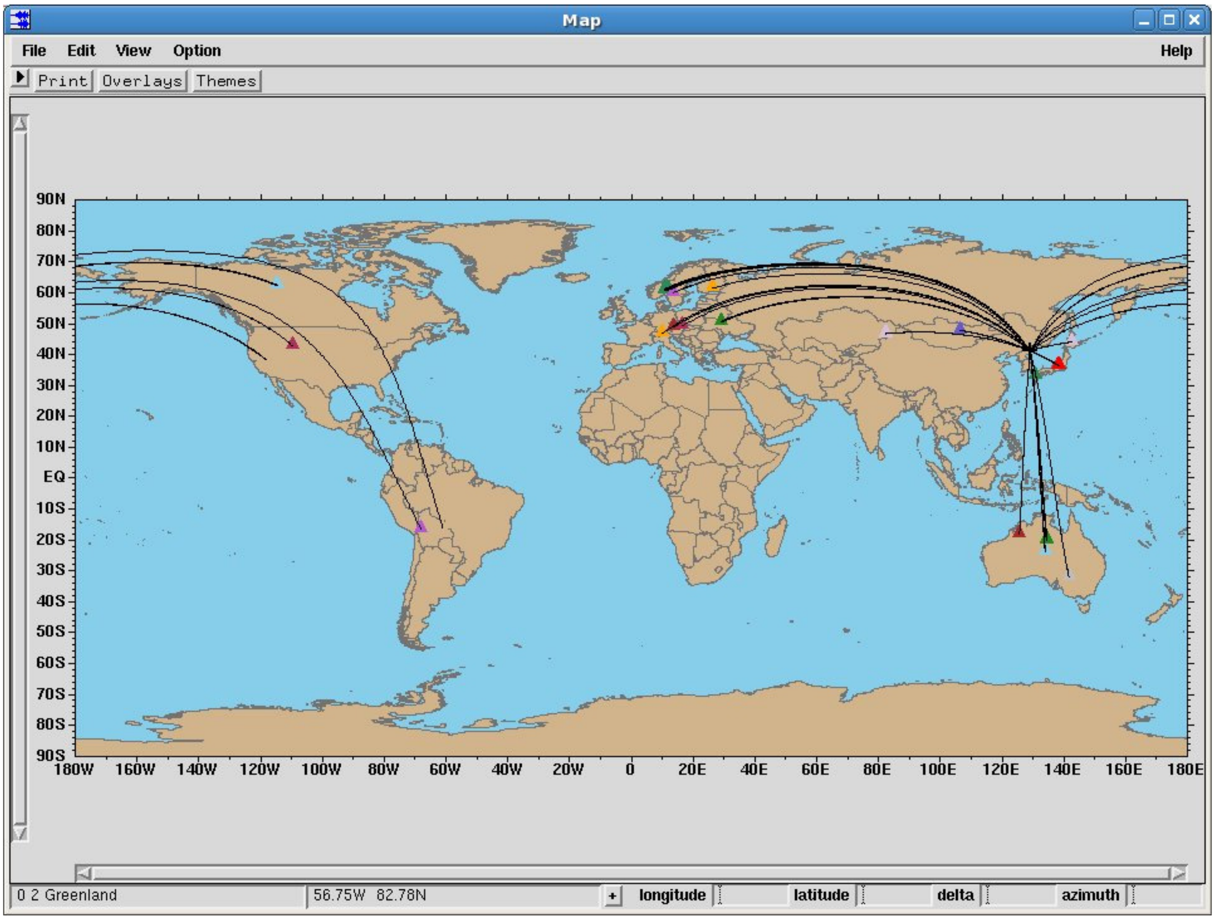


*Figure 92. The **Map** popup.*

The seismic source is plotted as a '+' symbol, the stations are plotted as triangles, the projection of the seismic ray path are drawn as a lines between the source and the station (Figure 92).

[To zoom in on an area, move the mouse cursor near an area of interest and drag the mouse cursor with the middle mouse button held down. Note that the zoom box preserves the aspect ratio of the map. To unzoom, click the middle mouse button.]

Exercise 6.3. Manual Rotation and Map Overlays.

To manually change the azimuth indicator direction:

(2) Select the vertical and the two horizontal channels of a three component station, i.e. **FITZ/BHV, FITZ/BHT, FITZ/BHR.**

(3) Select **Edit->Rotation** in the main waveform window. Click inside the azimuth indicator in the **Rotation** popup or click and drag the red indicator line.

Note that the waveforms are rotated and the red arc on the map is redrawn based on the new azimuth.

(4) Another method for rotating components is to type a value into the text window next to the **Azimuth** button then click on the **Azimuth** button.

(5) Clear the current data set from the display with the **Edit→Clear Rotation Azimuth** menu item in the **Map** popup.

(6) To remove the ray paths from the map, select the **View→Paths→Selected** menu item in the **Map** popup.

Click on the event ('+' symbol) to select the event. (If **View→Paths→None** menu item were chosen instead, the ray path would not be drawn when the event was selected.)

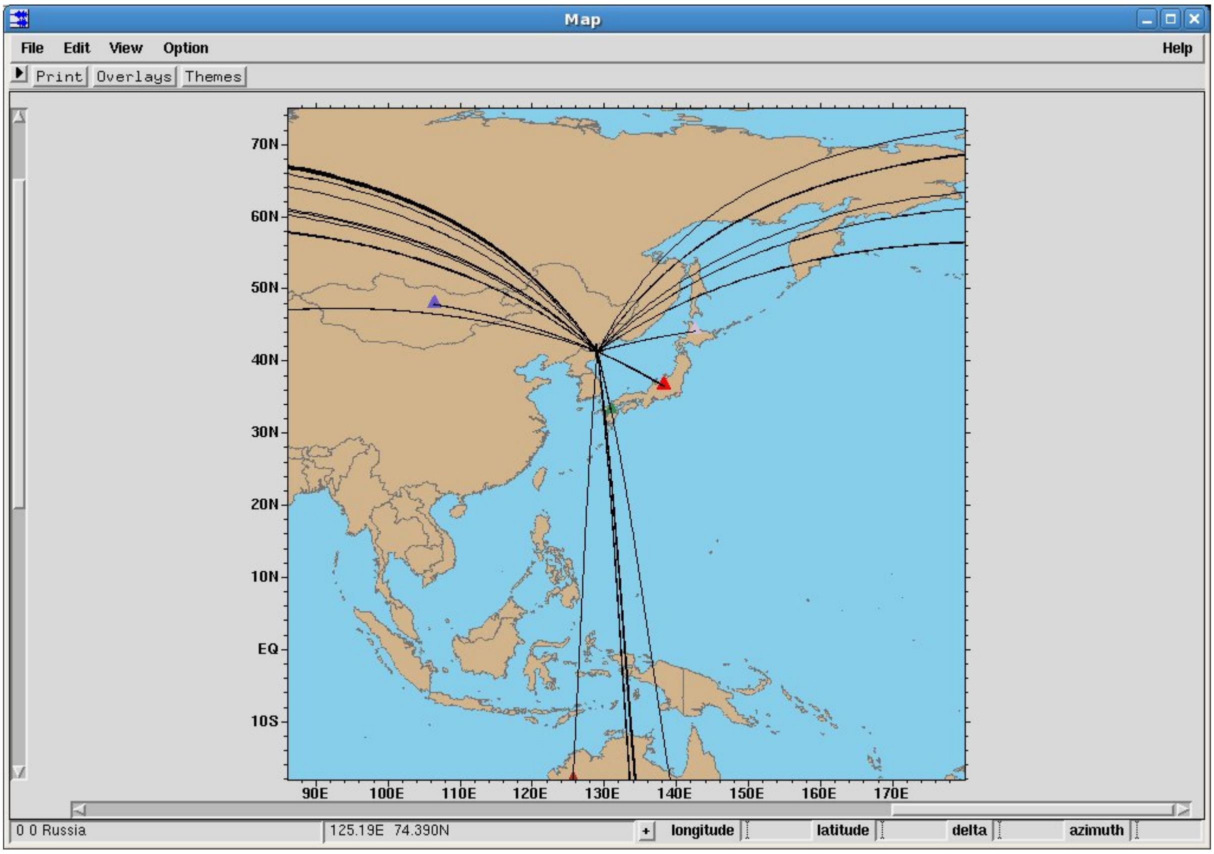


*Figure 93. **Map**, zoomed, with event selected.*

To choose a map overlay:

(7) Select the **File→Overlays** menu item (or click on the **Overlays** button) in the **Map** popup to activate the **Map Overlays** popup.

*Figure 94. **Map Overlays** popup.*

(8) Click with the **left** mouse button on the **seismic_regions** in the **Map Overlays** popup (Figure 94). This displays seismic regions in the **Map** popup (Figure 95). As you move the mouse over the map, the name of the seismic region appears in the lower left corner.

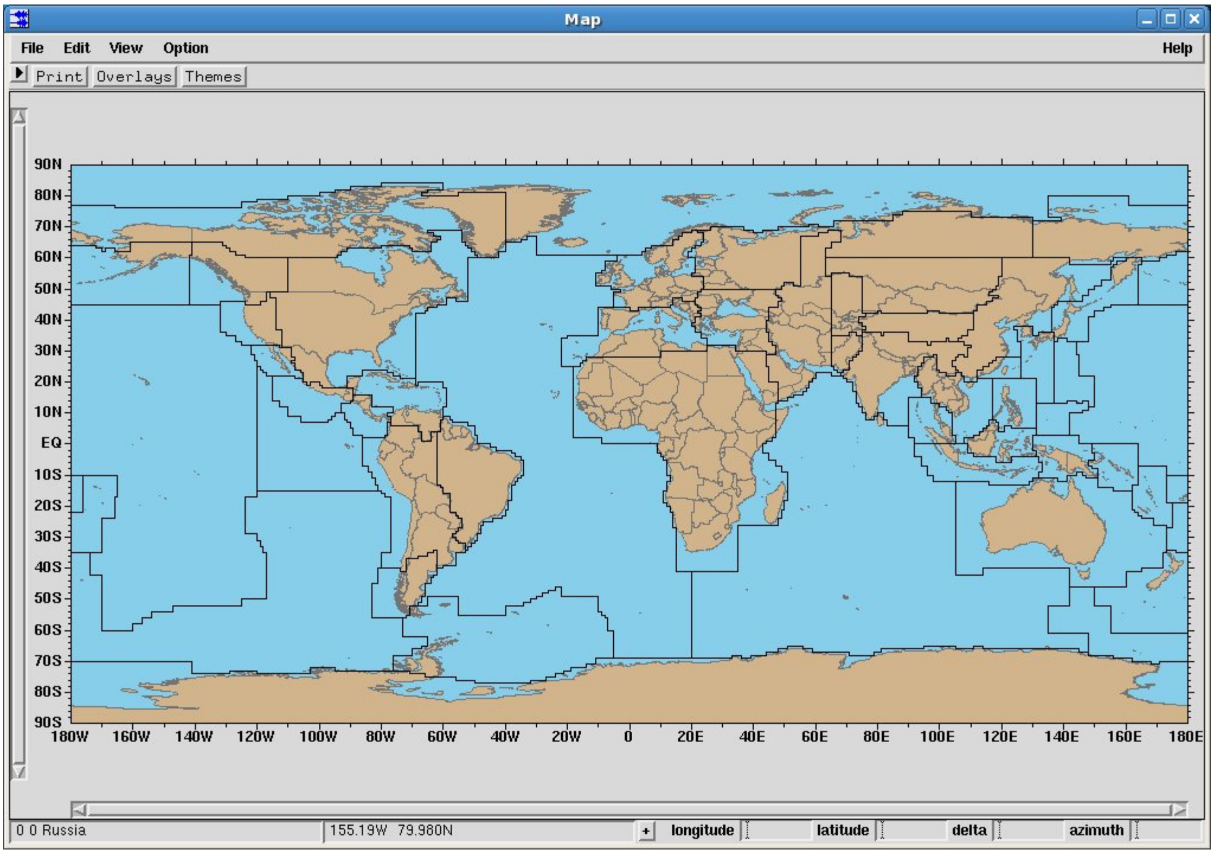


*Figure 95. Map with **seismic_regions** map overlay selected.*

(9) Unzoom the map by middle clicking in the **Map** popup if the map is zoomed.

(10) Unrotate the waveforms by clicking on the **Unrotate** button in the **Rotation** popup.

(11) Click on the **Close** button in the **Rotation** popup.

(12) Click on the **Close** button to close the **Map Overlays** popup.

(13) From the file menu of the map **File→Close**.

SECTION 7. FK ANALYSIS

Exercise 7.1 Data Input

FK is frequency (f) versus wavenumber (k) analysis that maps the power of seismic waves observed at an array as function of azimuth and slowness. [INM]
This exercise demonstrates reading array data, calculating an FK, and forming a beam based on the slowness and azimuth values measured from the FK. Note that FK analysis cannot be done using data from a single or three-component station.

(1) Select the **File→Open File** menu item from the main menu bar (or click on the **Open** toolbar button) to activate the **Open File** popup.

(2) Select the file named **KSRS.wfdisc** in the **Files** column in the **Open File** popup and click on the **List Contents** button.

(3) Click with the **right** mouse button on the **sta** table and select **Option->Sort** in the **Options** popup (Figure 96).

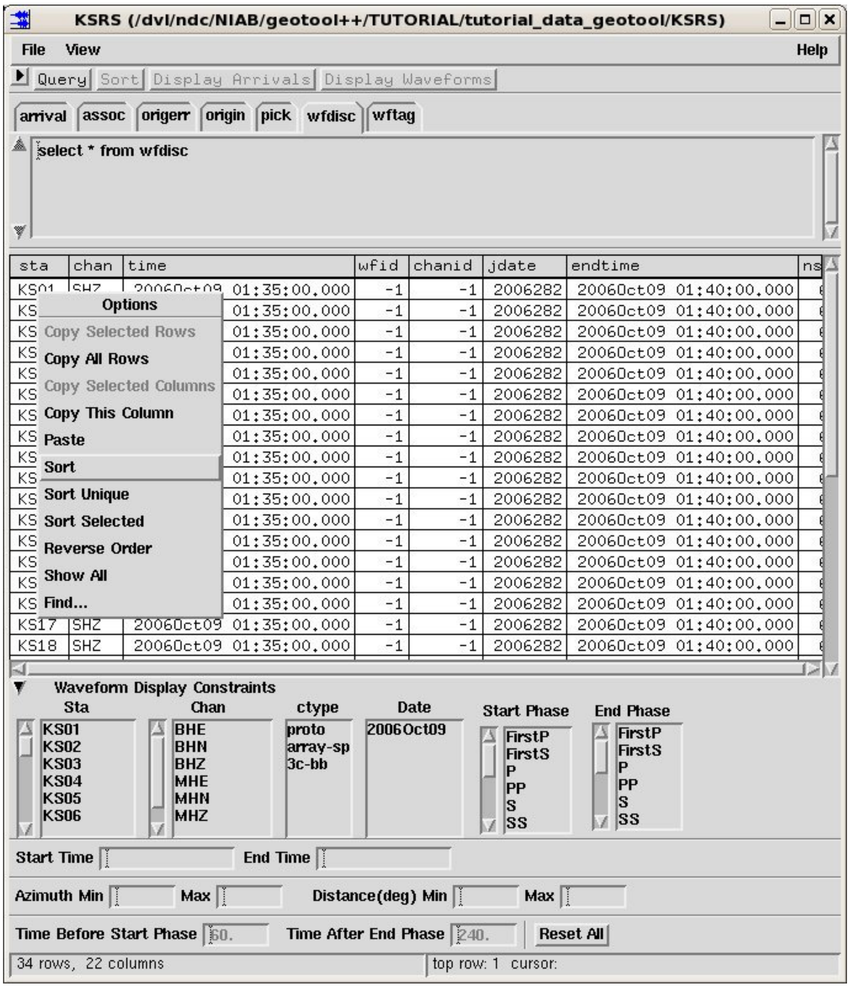


*Figure 96. **KSRS** file listing popup with sorting option.*

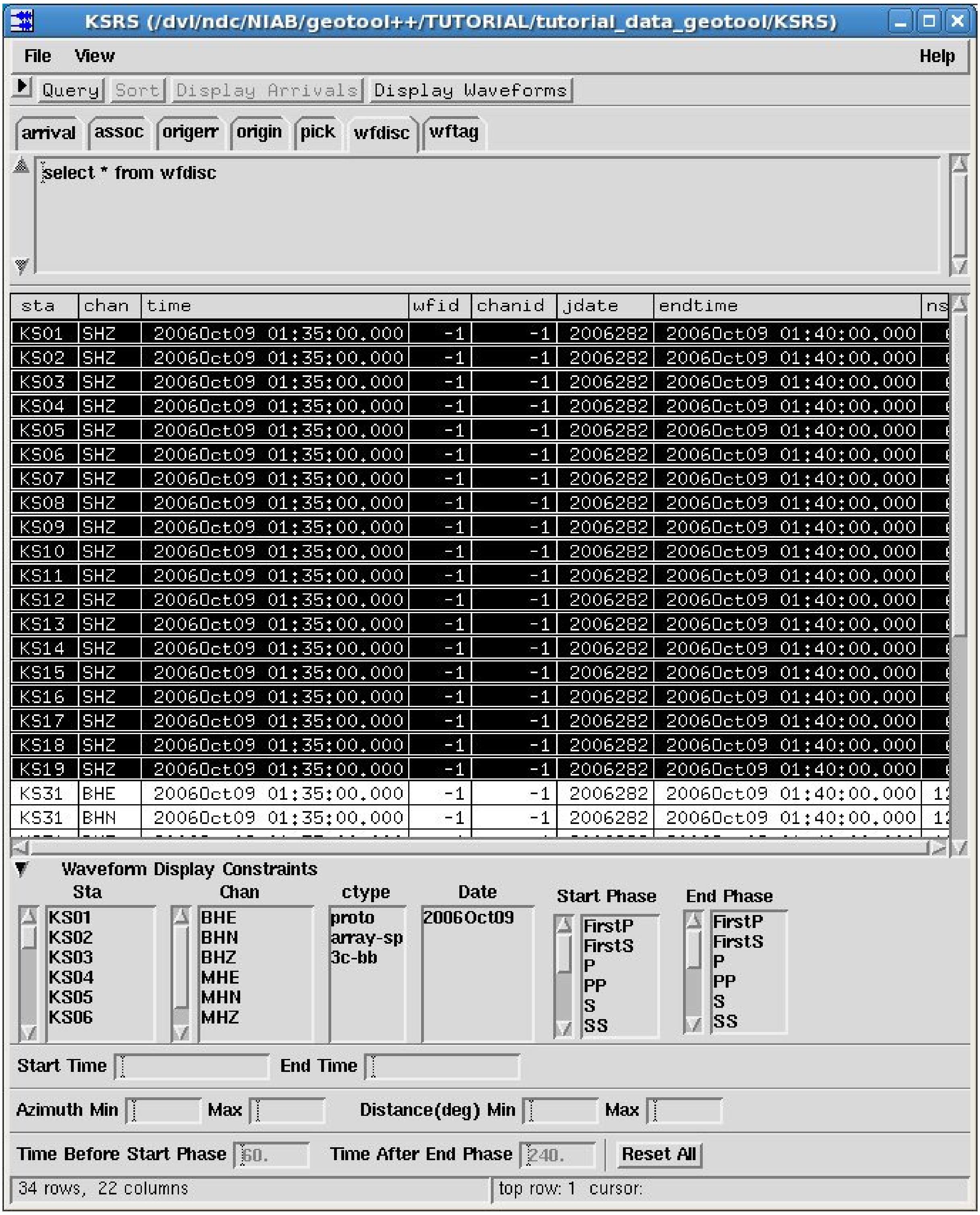


Figure 97. ***KSRS*** *file listing popup with* ***KS01-KS19*** *waveforms selected.*

(4) Now that waveforms are sorted, select with **left** mouse button **KS01-KS19** records (Figure 97).
(5) Click on the **Display Waveforms** button in the **KSRS** file listing popup.

Waveforms are now displayed in the main waveform window.

Exercise 7.2. FK Analysis.

(6) Click on the **Select All** toolbar button.

(7) Zoom in on the arrival by holding down a right mouse and drag from just before the **P** arrival to about 3 minutes after the arrival.

(8) Type keyboard l (**lower case L**) to add a double line cursor (or **View→Cursors→Add Double line**).

(9) Move the double line cursor to just after the **P** arrival.

(10) Adjust the width of the double line cursor to about 20 seconds (**Ctrl + left** mouse button or **Right** mouse button). Position the cursor just past the arrival (Figure 98).

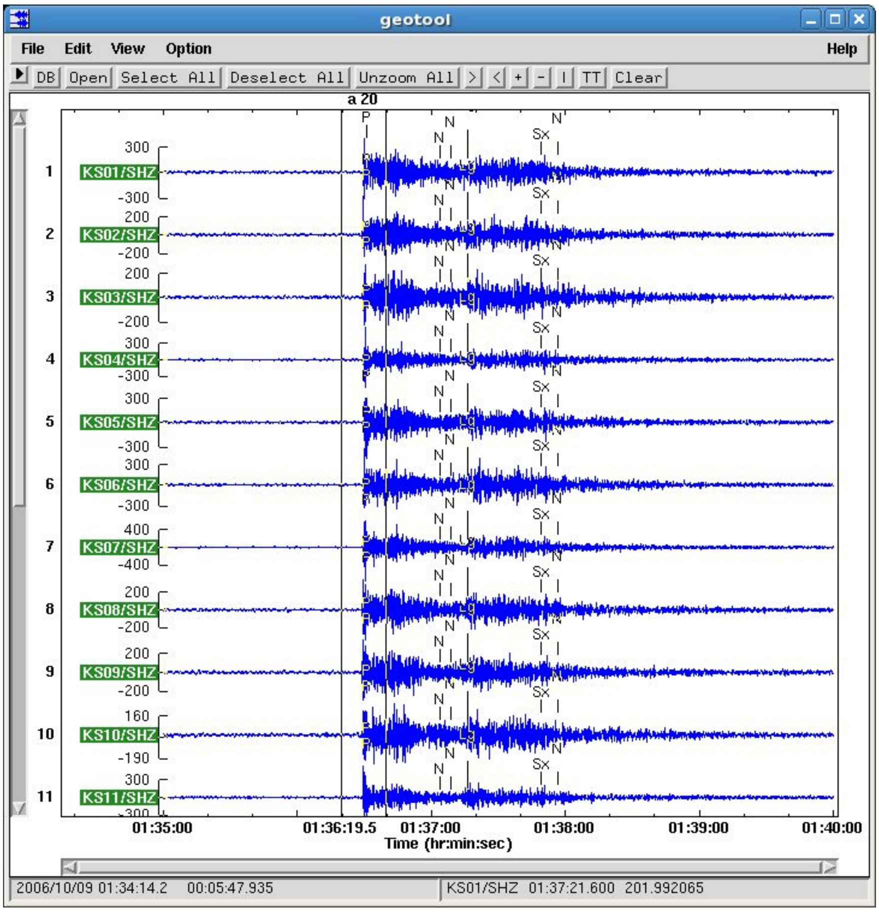


*Figure 98. Waveform window with double line cursor moved after **P** arrival.*

(11) Select the **Option→Array Analysis->FK** menu item from the main menu bar. This activates the **FK** popup.

(12) Select **File→Compute** (or click on the **Compute** toolbar button) in the **FK** popup

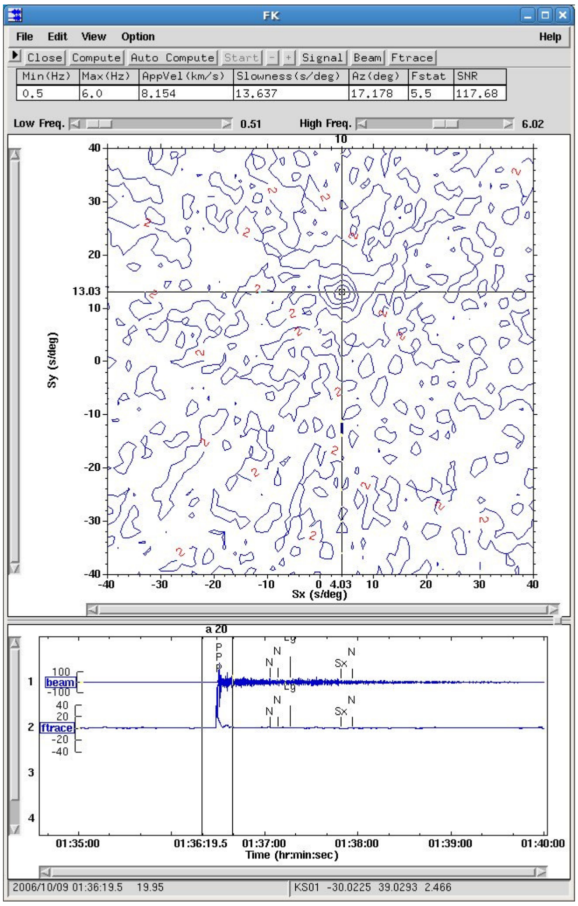
This computes the **FK**. The peak of the FK is marked by the position of the crosshair cursor in the **FK** popup. The corresponding slowness and azimuth values of the peak are displayed in the top portion of the **FK** popup (Figure 99, left picture).

(13) Select **Option->Signal Measurements** in the **FK** popup. This activates the **FK Signal Measurements** popup.

(14) Click on the **Auto Compute** button in the **FK Signal Measurements** popup (Figure 99, right picture).

(15) Click on the **Start** button in the **FK** popup (or on the **Start** button in the **FK Signal Measurements** popup).
Observe changes of values in the **FK** popup and in the **FK Signal Measurements** popup.

(16) Click on the **Stop** button in the **FK** popup (or on the **Stop** button in the **FK Signal Measurements** popup) or wait until the cursor comes till the end.



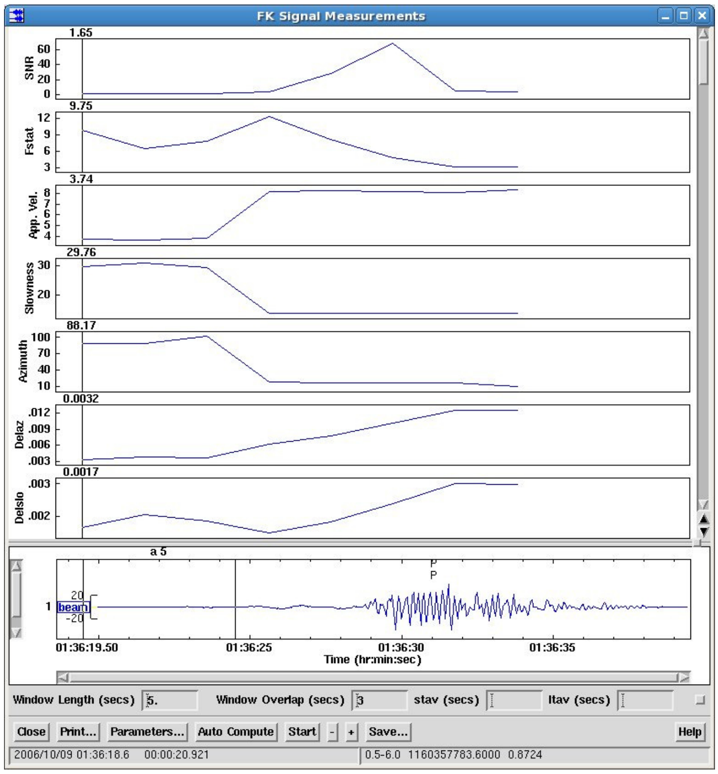


*Figure 99. **FK** popup (left picture) and **FK Signal Measurements** popup (right picture) after compute.*

To form a beam using the slowness and azimuth values reported in the **FK** popup:

(17) Click the **Beam** button in the **FK** popup. This will create a new waveform below all of the waveforms from the array.

(18) Scroll down to see the beam in the main window (Figure 100).

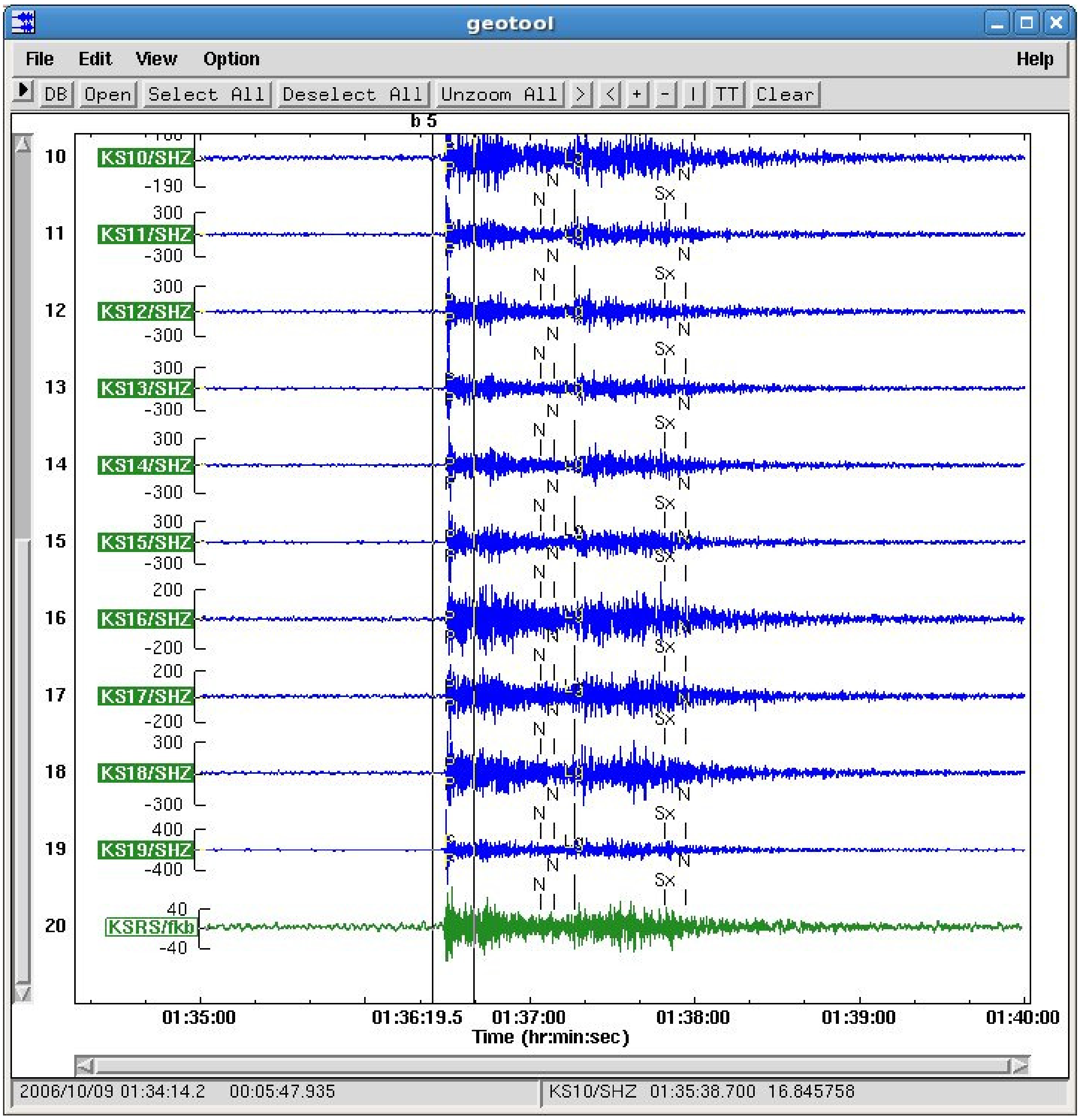


Figure 100. Beam is created below all the waveforms.

(19) Move the crosshair cursor in the **FK** popup. This changes the slowness and azimuth values in the **FK** popup.

(20) Click the **Beam** button in the **FK** popup. This replaces the previous beam using the new **FK** slowness and azimuth values.

(21) Click the **Ftrace** button in the **FK** popup. This will open **Ftrace** popup , where beam, F-trace, semblance, probability are already computed (Figure 101).

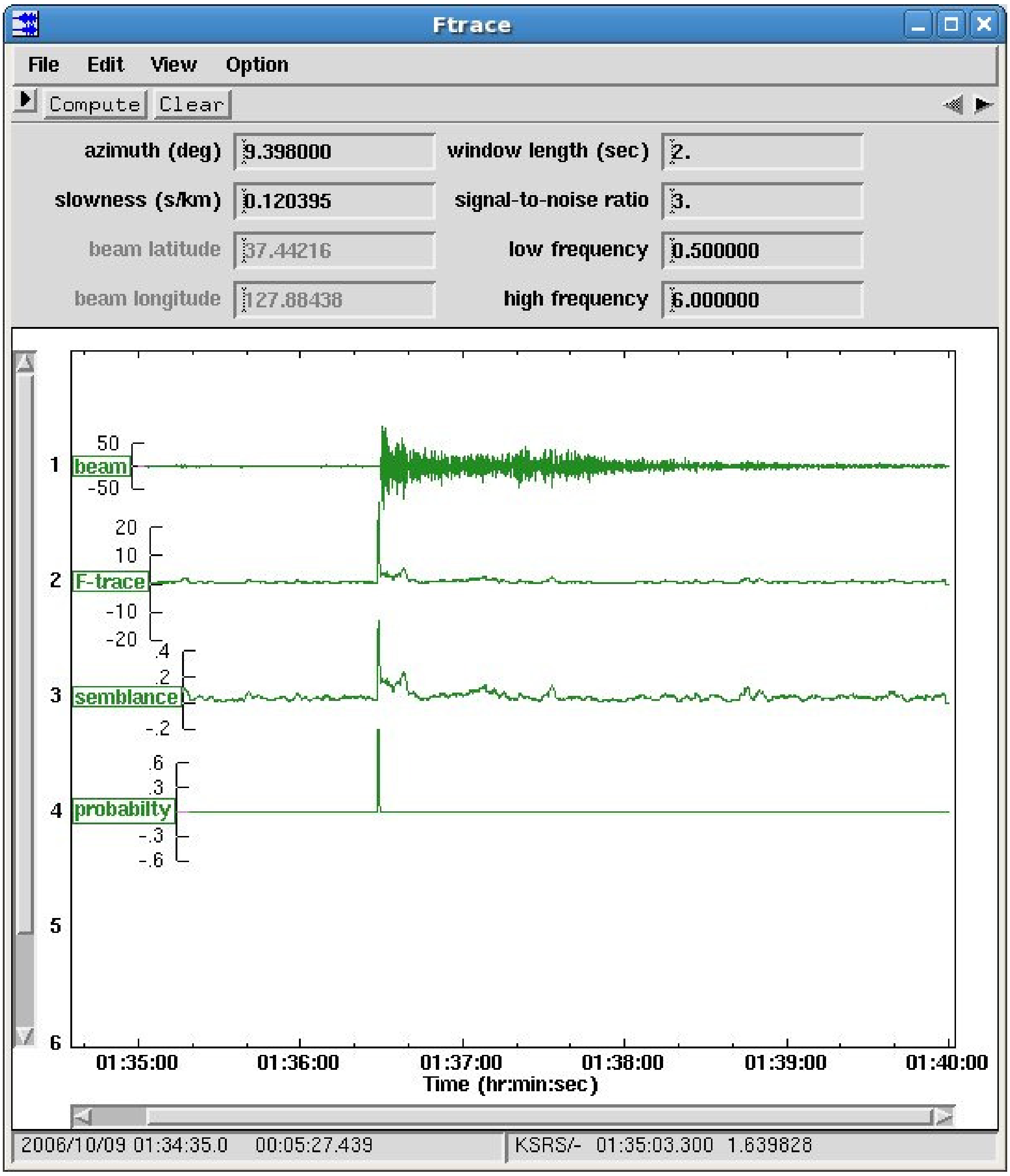


Figure 101. ***Ftrace*** *popup.*

(22) Now select **Option-> 3DView** in the **FK** popup.

This activates **3-D FK** popup (Figure 102).

(23) Push the keyboard arrow keys to move the **3-D FK** figure.

(24) Scroll with the **left** mouse button slider from the **3-D FK** popup.

This moves **3-D FK** figure along the y-axis.

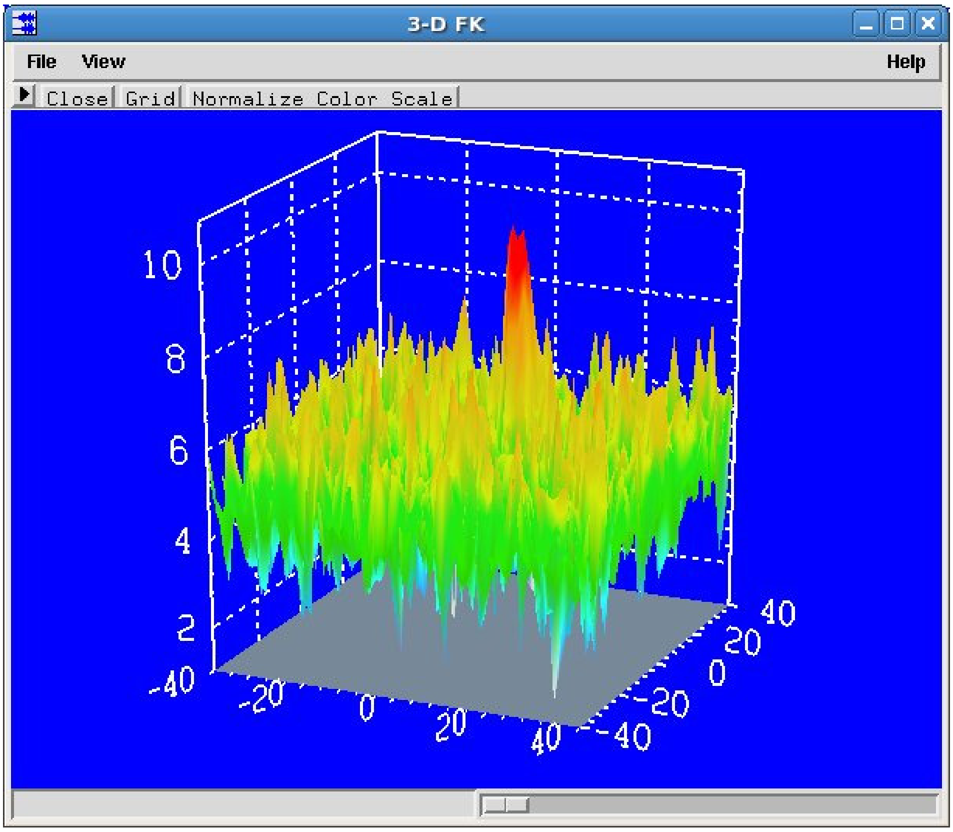


*Figure 102. **3-D FK** popup*

(25) Click on the **Close** button in the **3-D FK** popup.

(26) Click on the **Close** button in the **FK Signal Measurements** popup.

(27) Click on the **Close** button in the **FK** popup.

(28) To clear the display, select **Edit->Clear** from the main menu bar.

Exercise 7.3. FK Multi-Band Analysis.

(29) Follow the steps outlined in Exercise 7.1. Data Input, and continue until step (10) of Exercise 7.2. FK Analysis.
(30) Select **Option->Array Analysis->FK Multi-Band** from the main menu bar. This activates **FK Multi-Band** popup.
(31) Select **File→Compute** (or click on the **Compute** toolbar button) in the **FK Multi-Band** popup.

(32) Select **Option->Signal Measurements** in the **FK Multi-Band** popup. This activates the **FK Signal Measurements** popup.

(33) Click on the **Auto Compute** button in the **FK Signal Measurements** popup (Figure 103, right picture).
(34) Click on the **Start** button in the **FK Multi-Band** popup (or on the **Start** button in the **FK Signal Measurements** popup).
Observe changes of values in the **FK Multi-Band** popup and in the **FK Signal Measurements** popup (Figure 103, left picture).
(35) Click on the **Stop** button in the **FK Multi-Band** popup (or on the **Stop** button in the **FK Signal Measurements** popup) or wait until the cursor comes till the end.

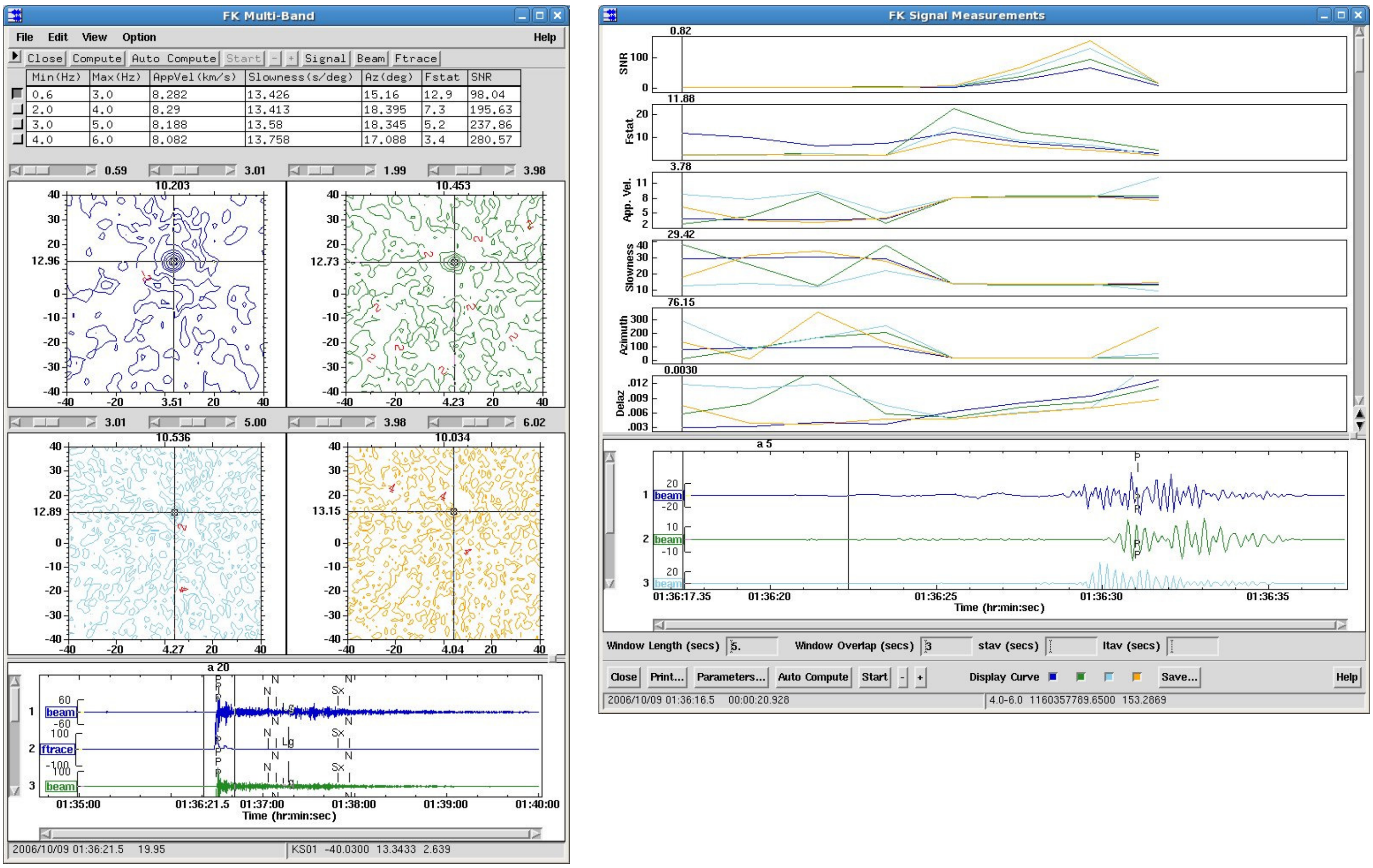


*Figure 103. **FK Multi-Band** popup (left picture) and **FK Signal Measurements** popup (right picture) after compute.*

To form a beam using the slowness and azimuth values reported in the **FK** popup:

(36) Click the **Beam** button in the **FK Multi-Band** popup. This will create a new beam below all of the waveforms from the array using the parameters for the selected FK in the **FK Multi-Band** popup.

(37) Scroll down to see the beam in the main window.

To activate **3-D FK Multi-Band** popup:

(38) Select **Option-> 3DView** in the **FK Multi-Band** popup.

This activates **3-D FK** popup (Figure 104).

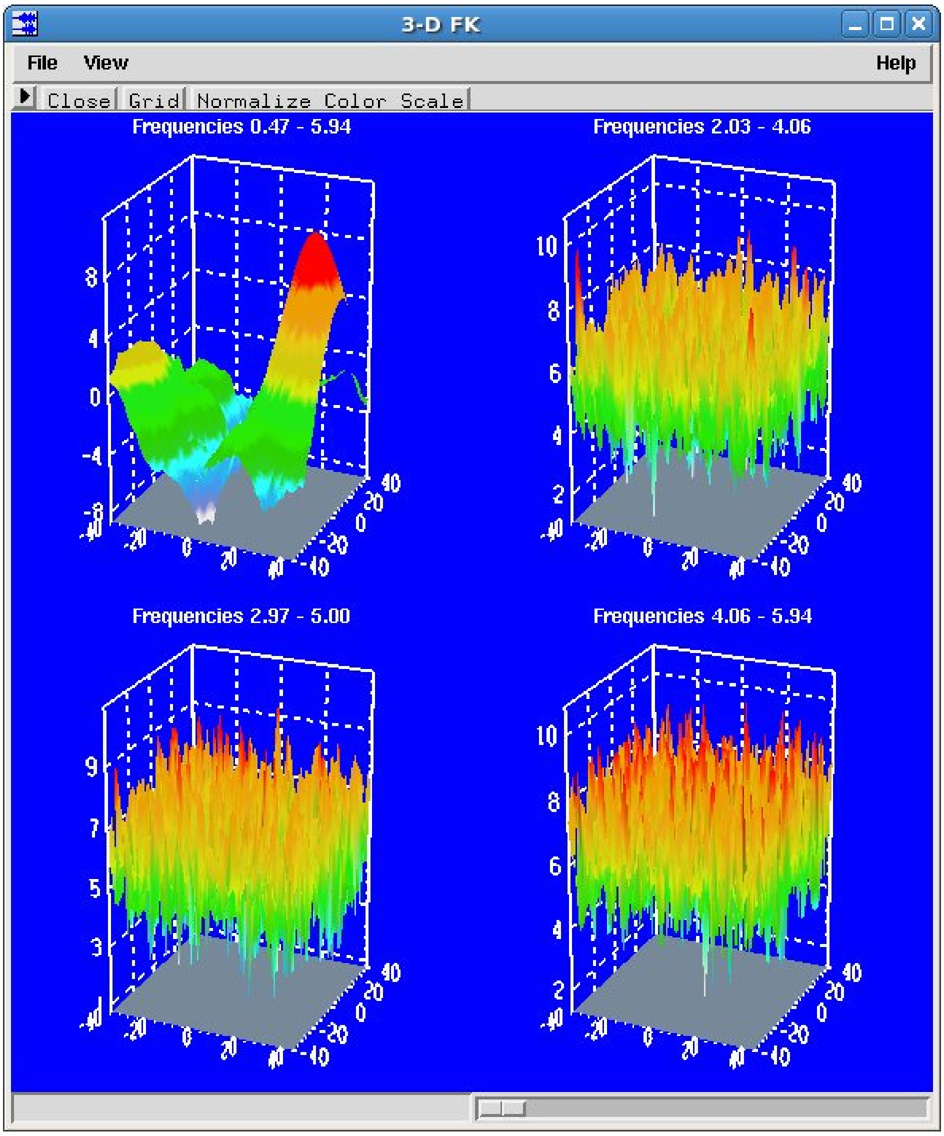
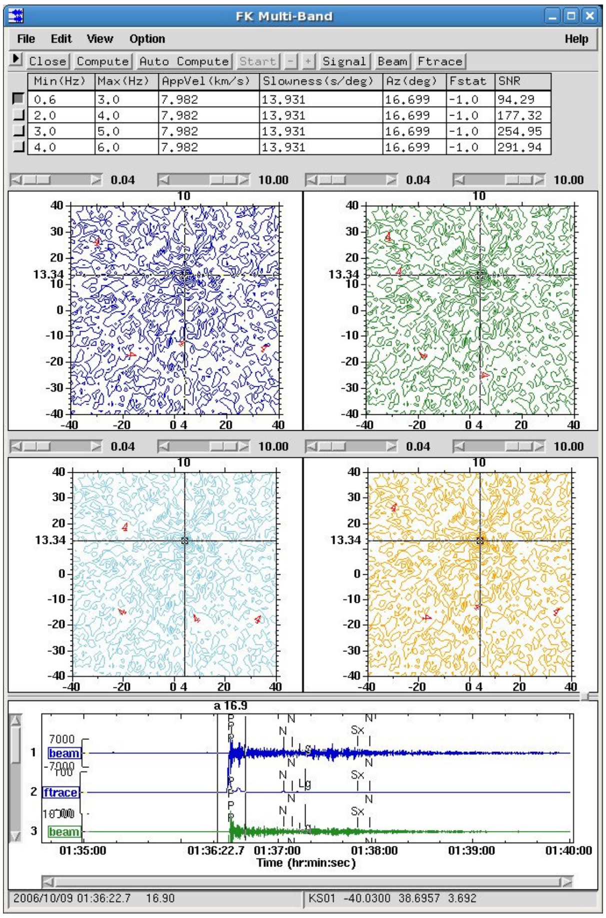


*Figure 104. **3-D FK Multi-Band** popup*

(39) Scroll with the **left** mouse button slider from **FK Multi-Band** popup as in the left picture of Figure 105.

(40) Push the keyboard arrow keys (up, down, left, right) in the **3D-FK** popup to move the **3-D FK** figures as in the right picture of Figure 105.



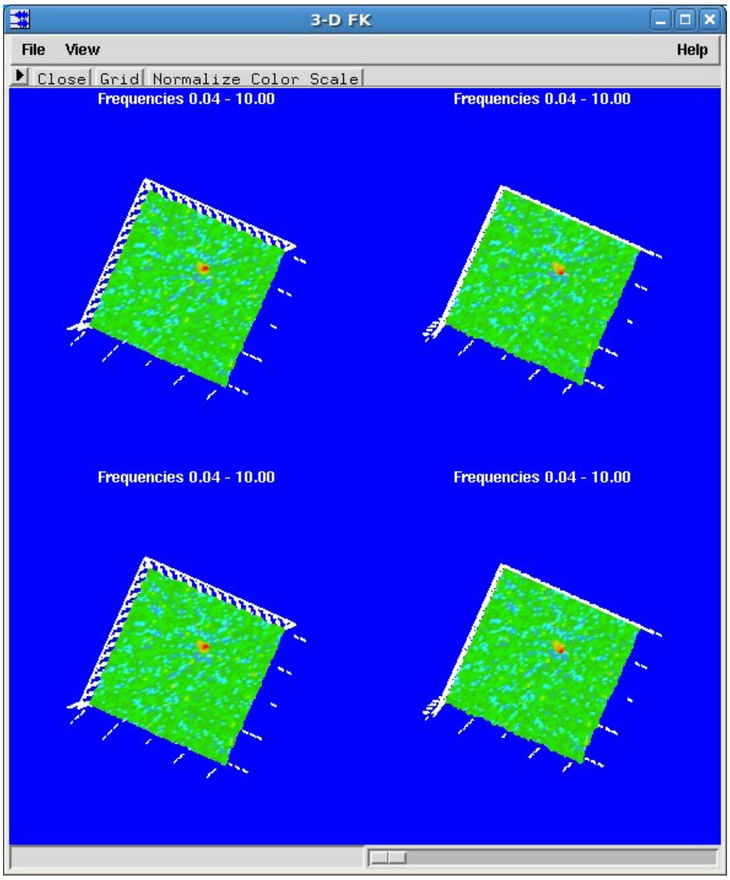


*Figure 105. **FK Multi-Band** popup (left picture) after moving the sliders and **3-D FK** popup (right picture) after moving the keyboard arrow keys.*

To print FK or to print FK Signal:

(41) Select **File->Print** from **FK Multi-Band** popup.

This activates **Print FK** popup (Figure 106, left picture).

(42) Click on the **Print** button in the **FK Signal Measurements** popup

This activates **Print FK Signal** popup (Figure 106, right picture).

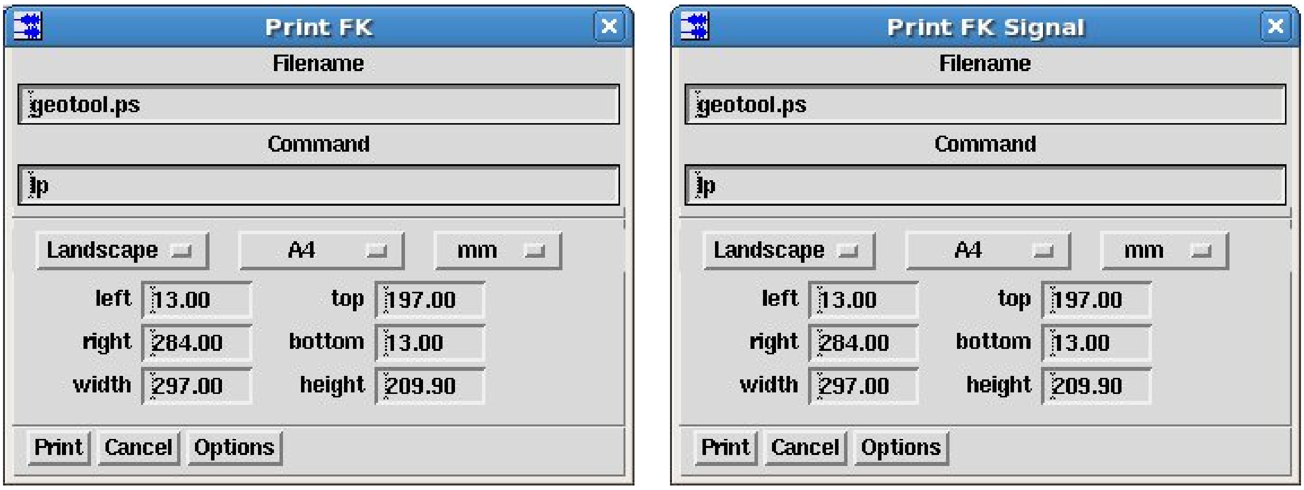


*Figure 106. **Print FK** popup (left picture), **Print FK Signal** popup (right picture).*

(43) By clicking on the **Print** button in both **Print FK** and **Print FK Signal** popups, printing is activated, whereas **Close** button closes the popups. Note that the files will be overwritten as they have the same filename geotool.ps.

(44) Click on the **Close** button in the **Reference Stations** popup.

(45) Click on the **Close** button in the **3-D FK** popup.

(46) Click on the **Close** button in the **FK Signal Measurements** popup.

(47) Click on the **Close** button in the **FK** popup.

(48) To clear the display, select **Edit->Clear** from the main menu bar.

SECTION 8. CEPSTRUM

Exercise 8.1. Data Input.

- Select **File->Open File** from main menu bar.
- Select the file named **HYDRO.wfdisc** in the **Files** column in the **Open file** popup and click on the **Open** button in the **Open file** popup (Figure 107).

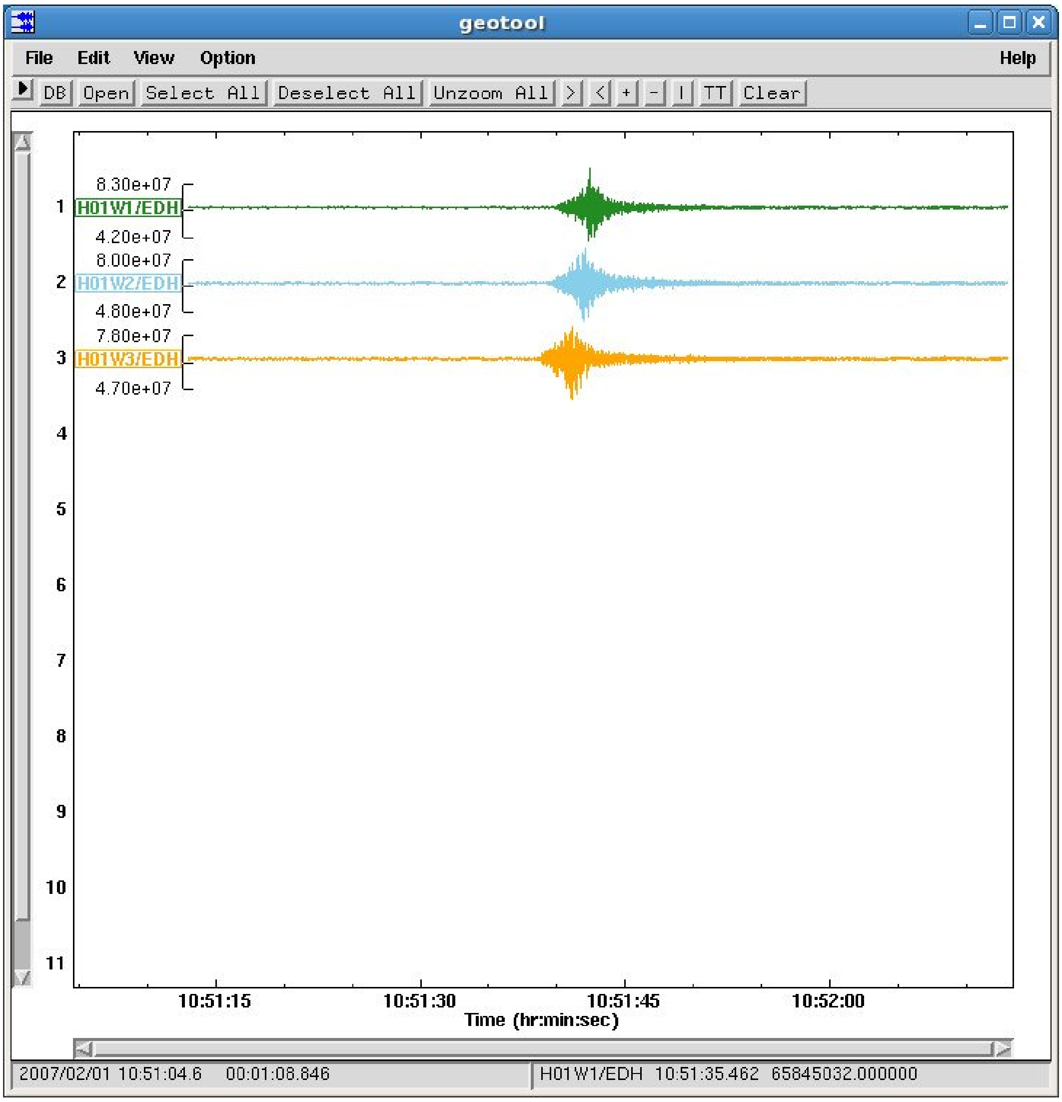


*Figure 107. Main waveform window after loading **HYDRO.wfdisc.***

Exercise 8.2. Spectrogram.

(3) Click with the left mouse button on **H01W1/EDH.**

(4) Select **Option->Spectral Analysis->Spectrogram** from the main menu bar, and click on the **Compute** button in the **Spectrogram** popup.

It computes the Spectrogram (Figure 108). Broadness of spectrum covers whole frequency range which means that it is of explosive nature (in-water explosive source). Scalloping in the frequency indicates there is bubble pulse in either spectrum or cepstrum.

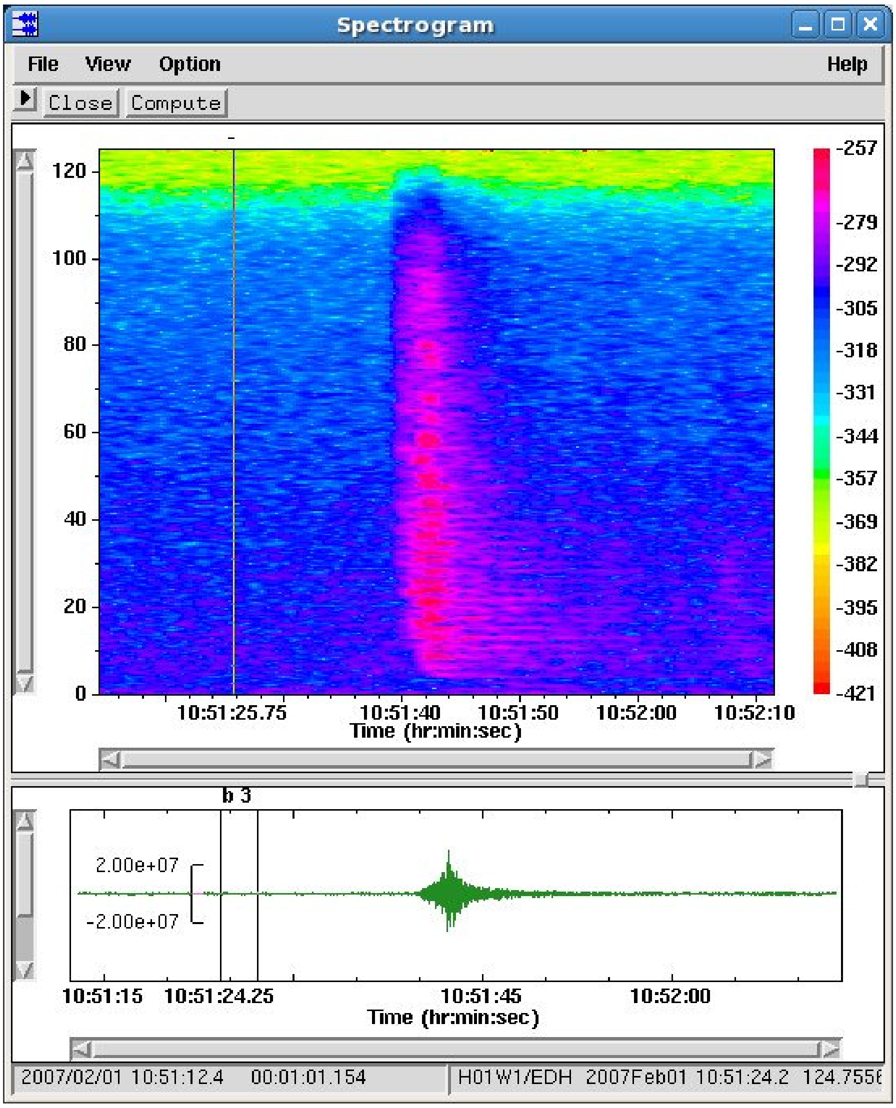


*Figure 108. Spectrogram computed for **H01W1/EDH.***

(5) Click on **Select All** button in the main waveform window.

(6) Hold the **middle** mouse button over selected waveforms in order to zoom in on selected waveforms.

(7) Select **View->Cursors->Add Time Limits** (or **lower case L**) from the main menu bar, and repeat it again (Figure 109).

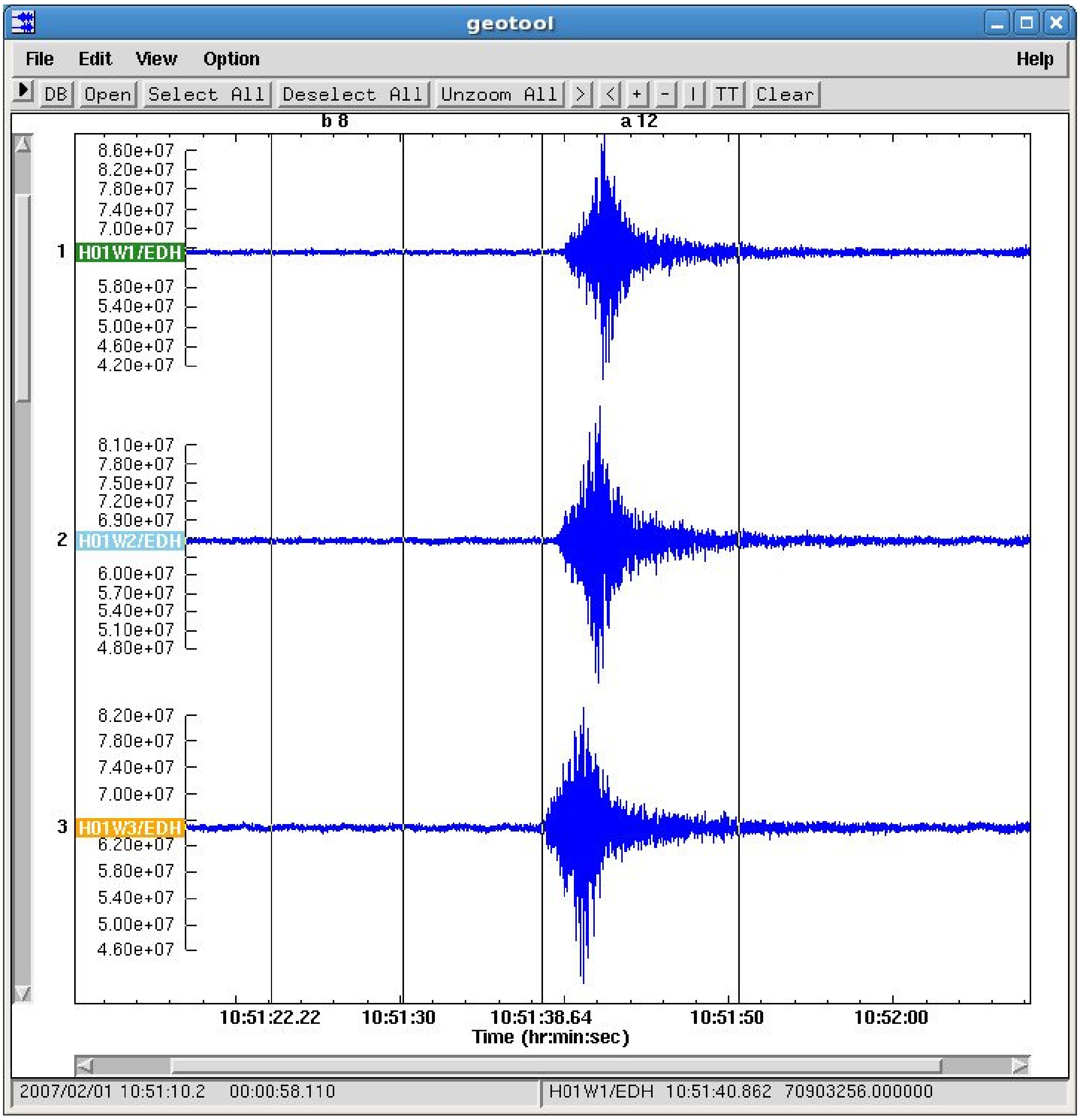


*Figure 109. Placing' **a'** and **'b'** double line cursors over signal and noise.*

Exercise 8.3. Cepstrum.

(8) Select **Option->Spectral Analysis->Cepstrum** from the main menu bar. It activates **Cepstrum** popup (Figure 110).

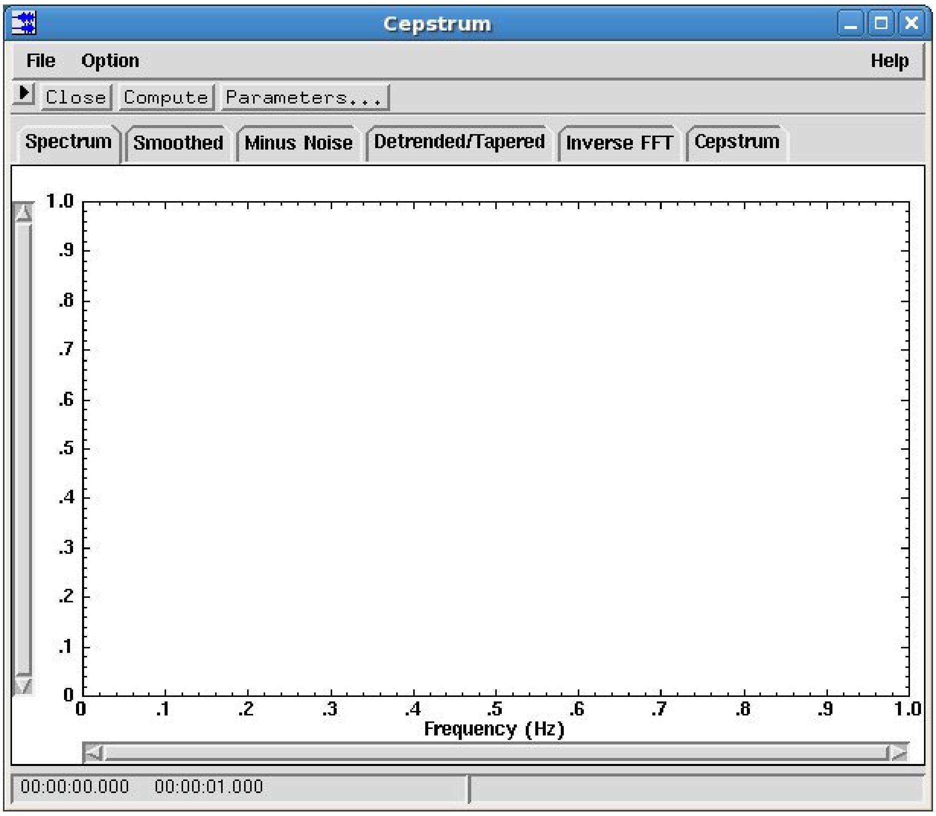


*Figure 110. **Cepstrum** popup.*

(9) Click on the **Parameters** button in the **Cepstrum** popup, where the default parameters are as in the Figure 111.

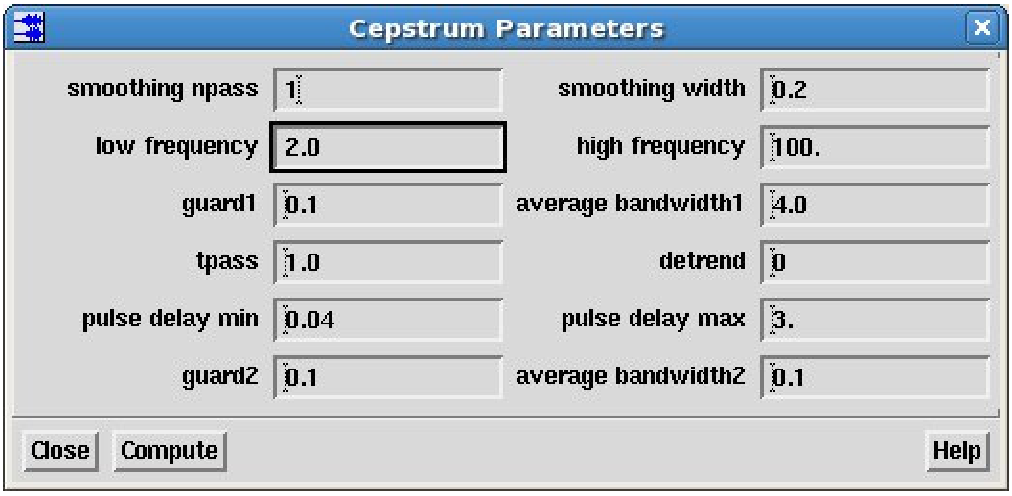


*Figure 111. **Cepstrum Parameters** popup.*

(10) Click on the **Compute** button in the **Cepstrum Parameters** popup.
It computes all the stages of cepstral analysis: Spectrum, Smoothed, Minus Noise, Detrended/Tapered, Inverse FFT, Cepstrum in the **Cepstrum** popup (Figures 112 -117).
Click on the **Spectrum** tab in the **Cepstrum** popup.

It shows raw waveforms of signal (black) and the preceding noise (red) (Figure 112).

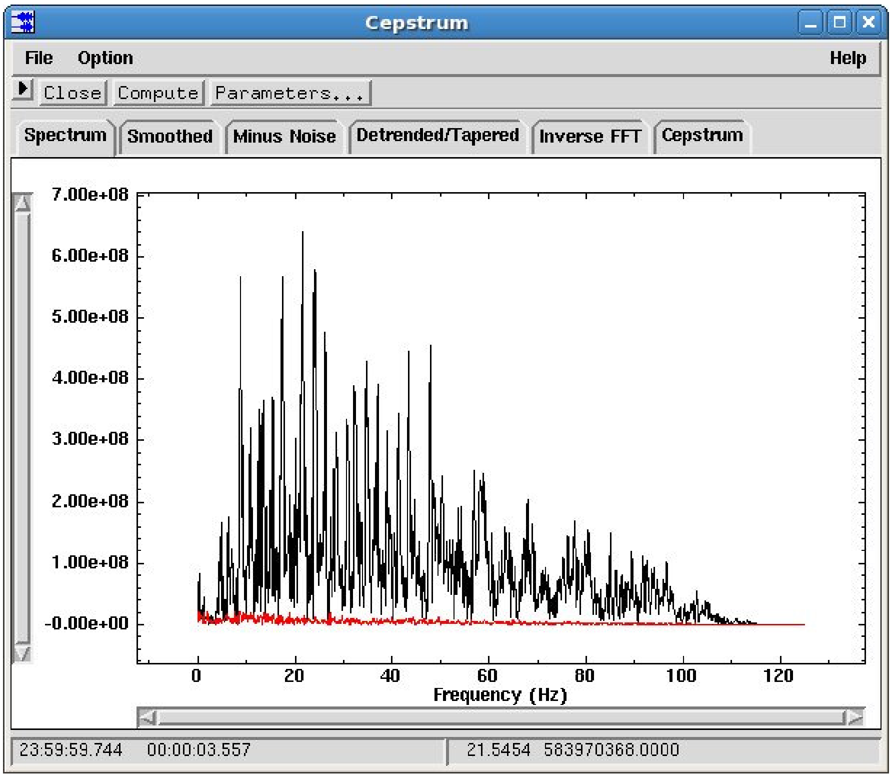


*Figure 112. Spectrum computed in the **Cepstrum** popup.*

(11) Click on the **Smoothed** tab in the **Cepstrum** popup.

It shows the amplitude spectrum of signal (black) and noise (red) (Figure 113).

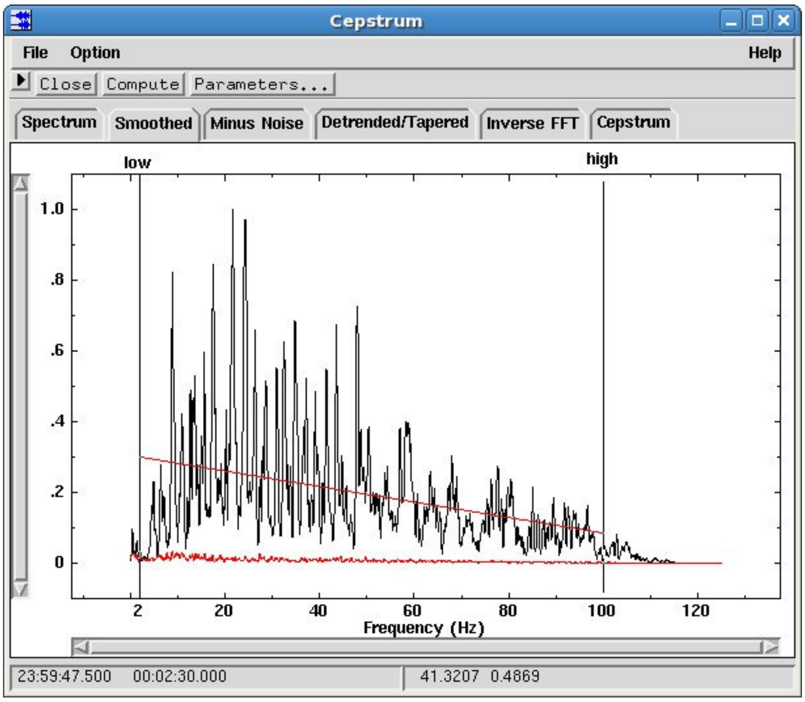


Figure 113. Smoothed computed in the ***Cepstrum*** *popup*

(12) Click on the **Minus Noise** tab in the **Cepstrum** popup.

It computes the smoothed spectrum of the signal (Figure 114).

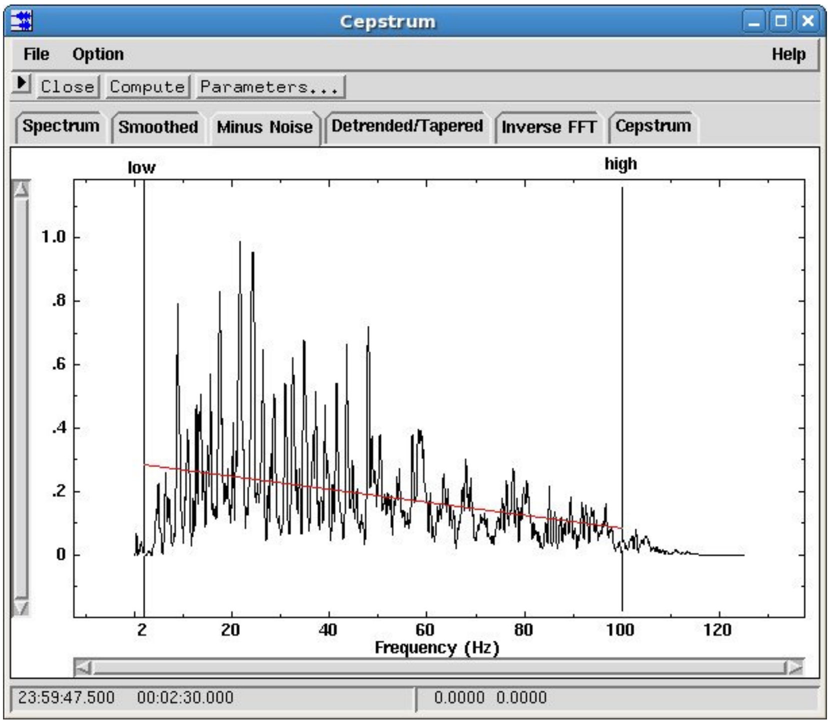


Figure 114. Minus Noise computed in the ***Cepstrum*** *popup.*

(13) Click on the **Detrended/Tapered** tab in the **Cepstrum** popup.

It computes detrended and tapered logarithm of smoothed spectrum (Figure 115).

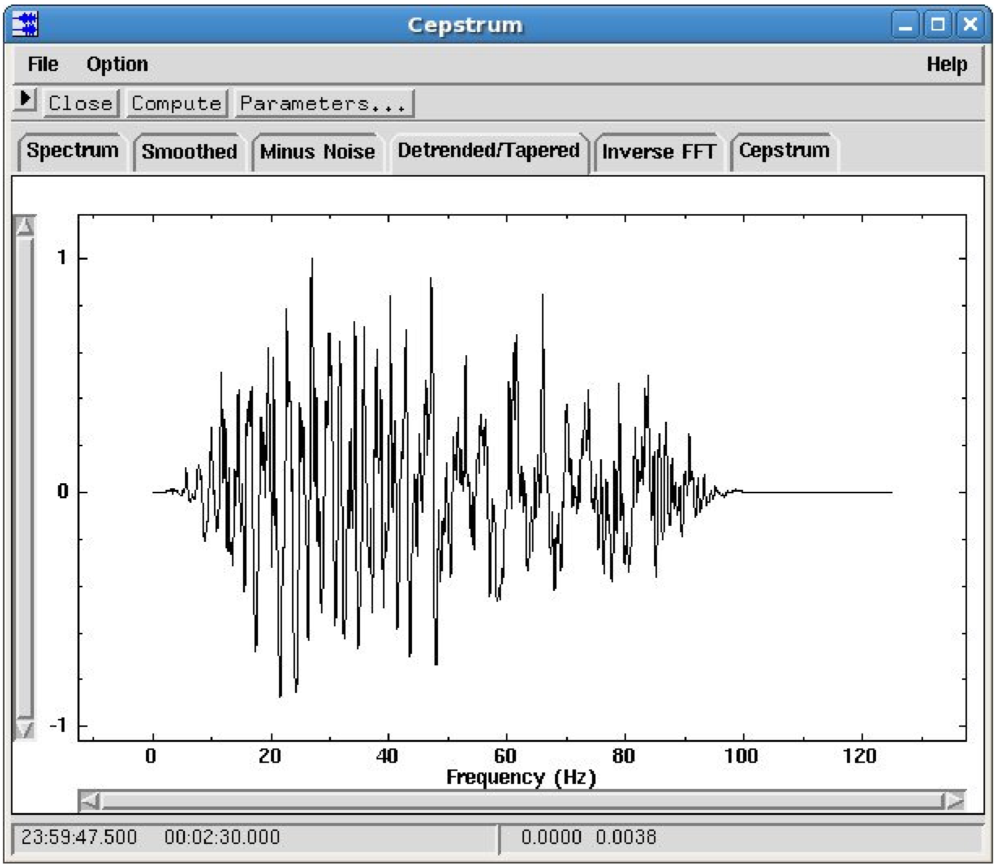


*Figure 115. Detrended/Tapered computed in the **Cepstrum** popup.*

(14) Click on the **Inverse FFT** tab in the **Cepstrum** popup.

It computes the inverse FFT of detrended spectrum (Figure 116).

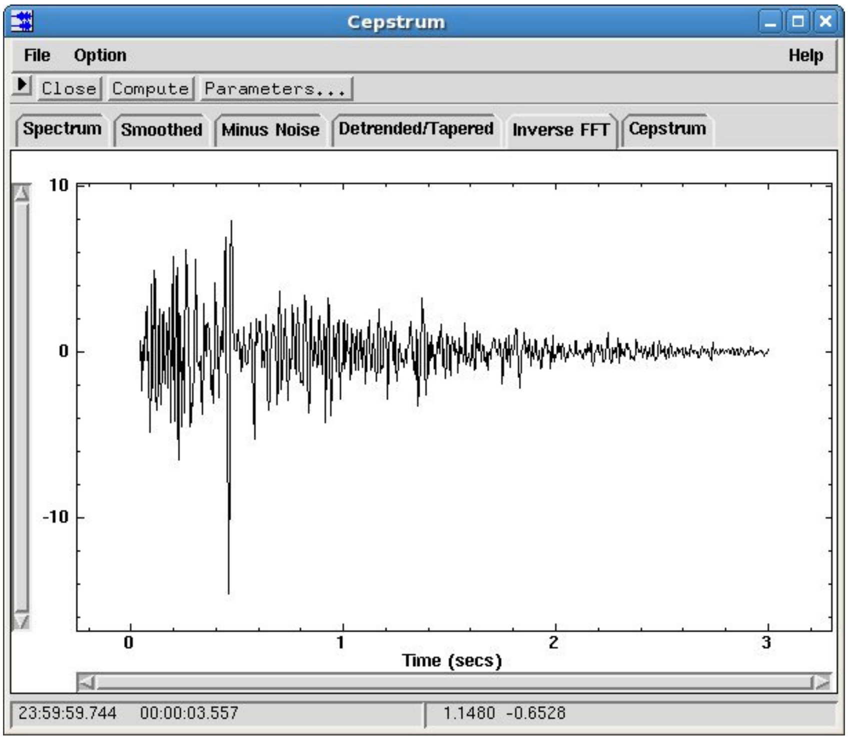


*Figure 116. Inverse FFT computed in the **Cepstrum** popup.*

(15) Click on the **Cepstrum** tab in the **Cepstrum** popup.

It shows cepstrum with clear peak showing the delay time (Figure 117).

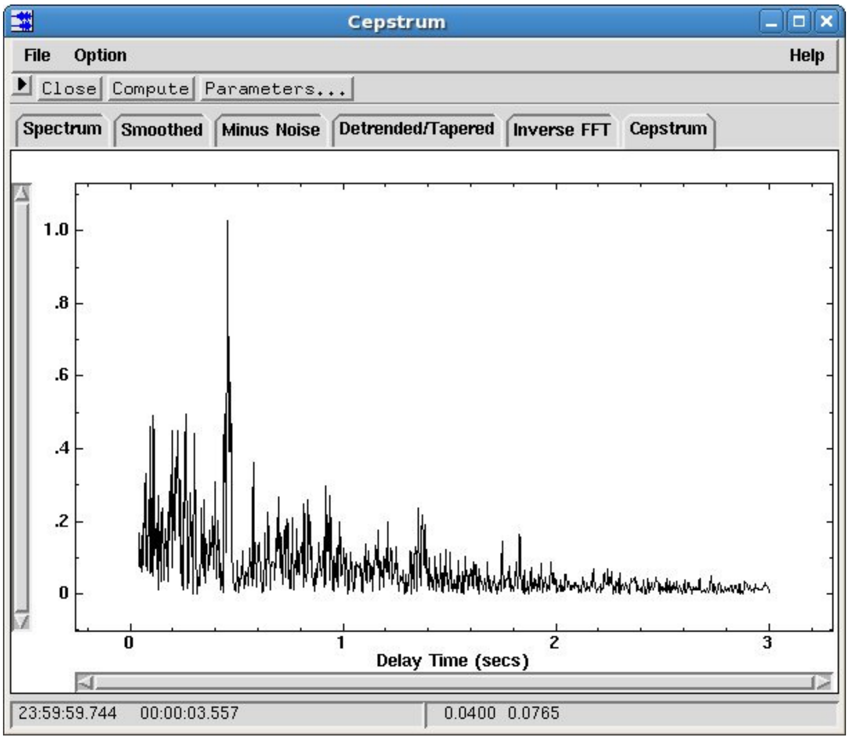


*Figure 117. Cepstrum computed in the **Cepstrum** popup*

(16) Clear the Display with the **Edit->Clear** menu item from the main menu bar.

SECTION 9. CORRELATION

Exercise 9.1 Data Input

(1) Follow the steps outlined in Exercise 7.1. Data Input for this exercise .

(2) Select **Edit->Partial Select** from the main menu bar.

(3) Drag **left** mouse button on the waveform **KS01/SHZ** in order to partially select it (Figure 118).

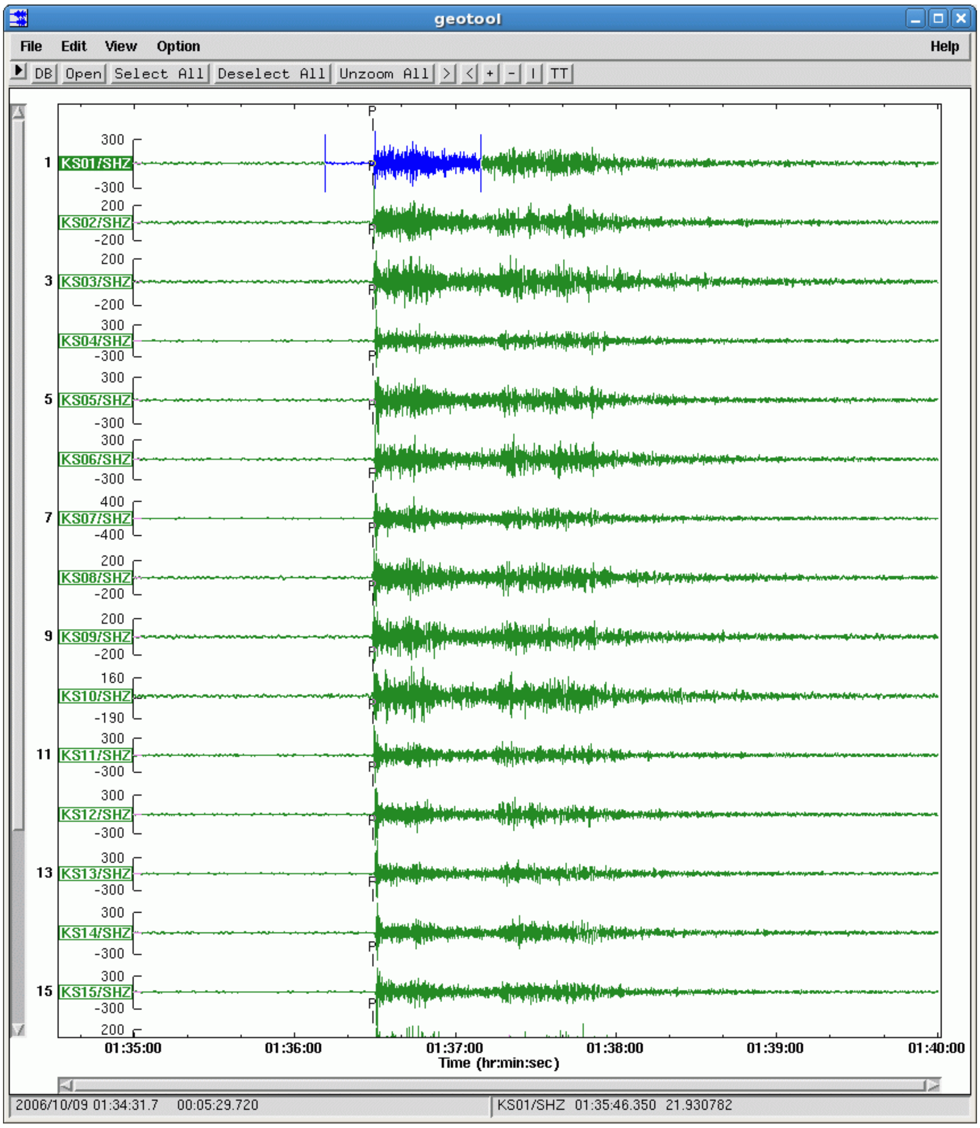


Figure 118. Partially selected waveform.

Exercise 9.2. Correlation

(4) Select **Option->Correlation->Basic Correlation** from the main menu bar.
This activates **Correlation** popup.
(5) Click on the **Set Reference** box in the **Correlation** popup.
This sets the selected part of the **KS01/SHZ** waveform as a reference.
(6) Click on the **Select All** toolbar button from the main menu bar.

(7) Click on the **Correlate** button in the **Correlation** popup.
This correlates the selected part of the first waveform with all the other selected waveforms (Figure 119, left picture).

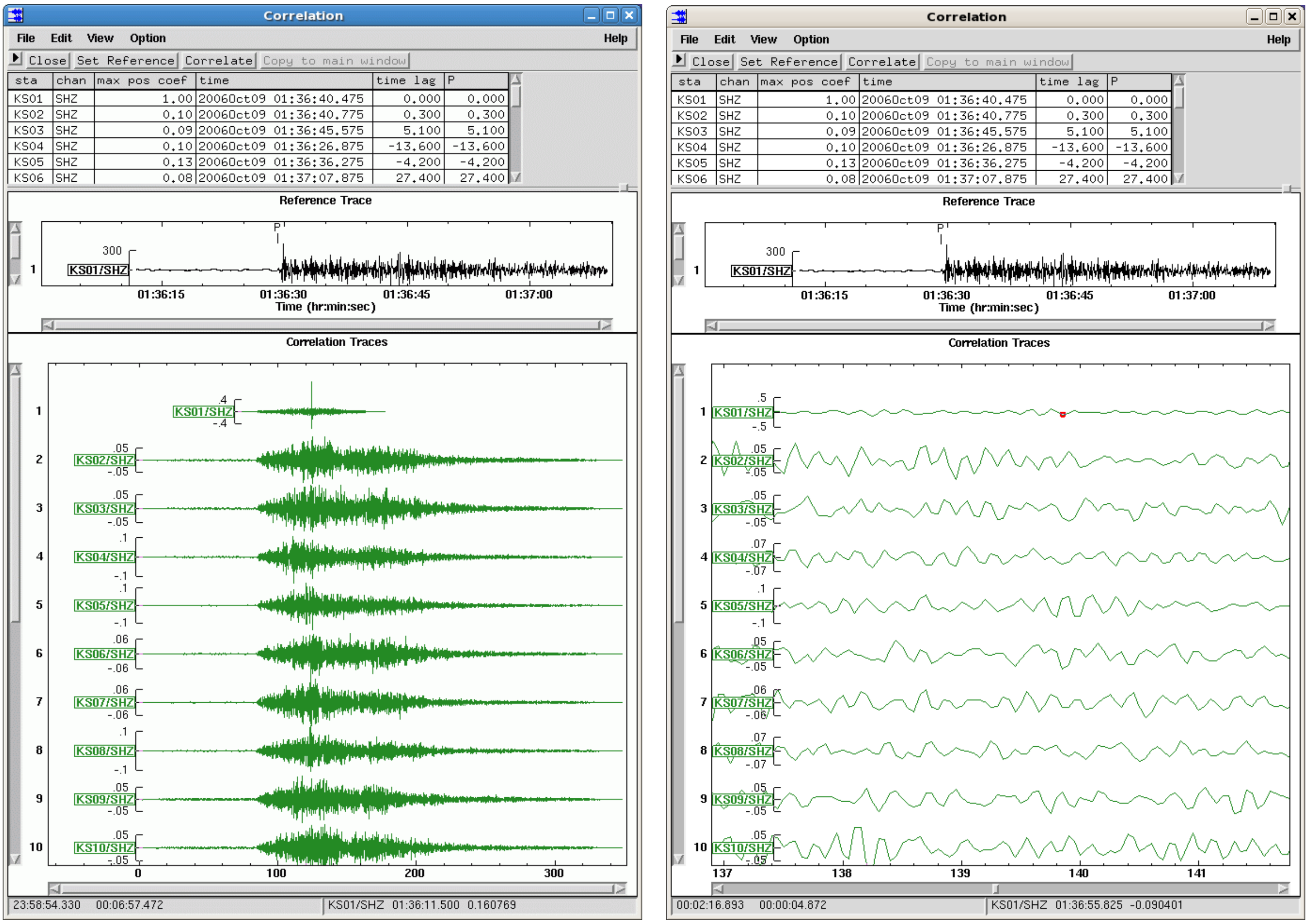


*Figure 119. **Correlation** popup (left picture) and **Correlation** popup where waveforms have been zoomed in (right picture).*

Note: You can zoom in with the right mouse button in the **Correlation Traces** box in **Correlation** popup so that the red dot appears (Figure 119, right picture).

(8) Select **Edit->Clear** from the main menu bar to clear the display.

SECTION 10. LOCATING AN EVENT

Exercise 10.1. Data Input.

(1) Click on the **File→Open File** menu item or the **Open** toolbar button.

(2) In the **Open file** popup, select the **DPRK_reduced.wfdisc** in the **Files** column.

(3) Click on the **Open** button at the bottom of the **Open file** popup. This will read in components of the selected wfdisc file.

Exercise 10.2. Obtaining a Location.

(4) Select **Option →Locate Event**. This activates the **Locate Event** popup (Figure 120).

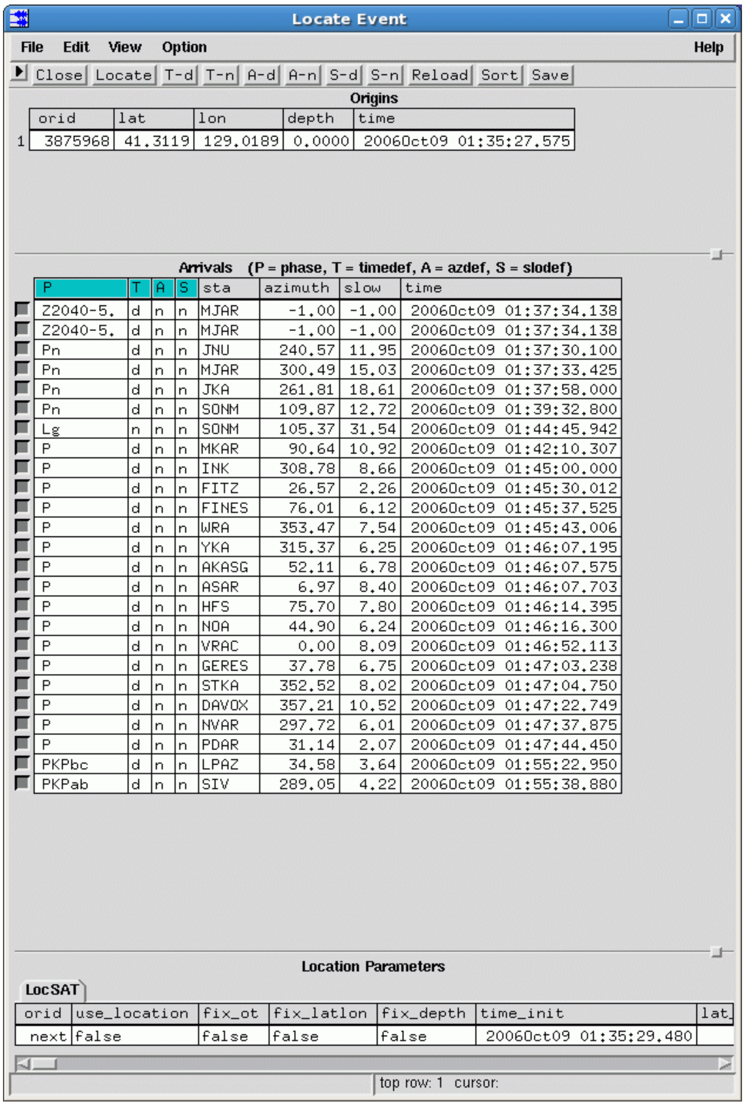


*Figure 120. The **Locate Event** popup.*

Values in the columns with Turquoise headings are inputs into the locations process. These columns are labelled:

P (phase)

T (phase to be time defining)

A (phase to be azimuth defining)

S (phase to be slowness defining)

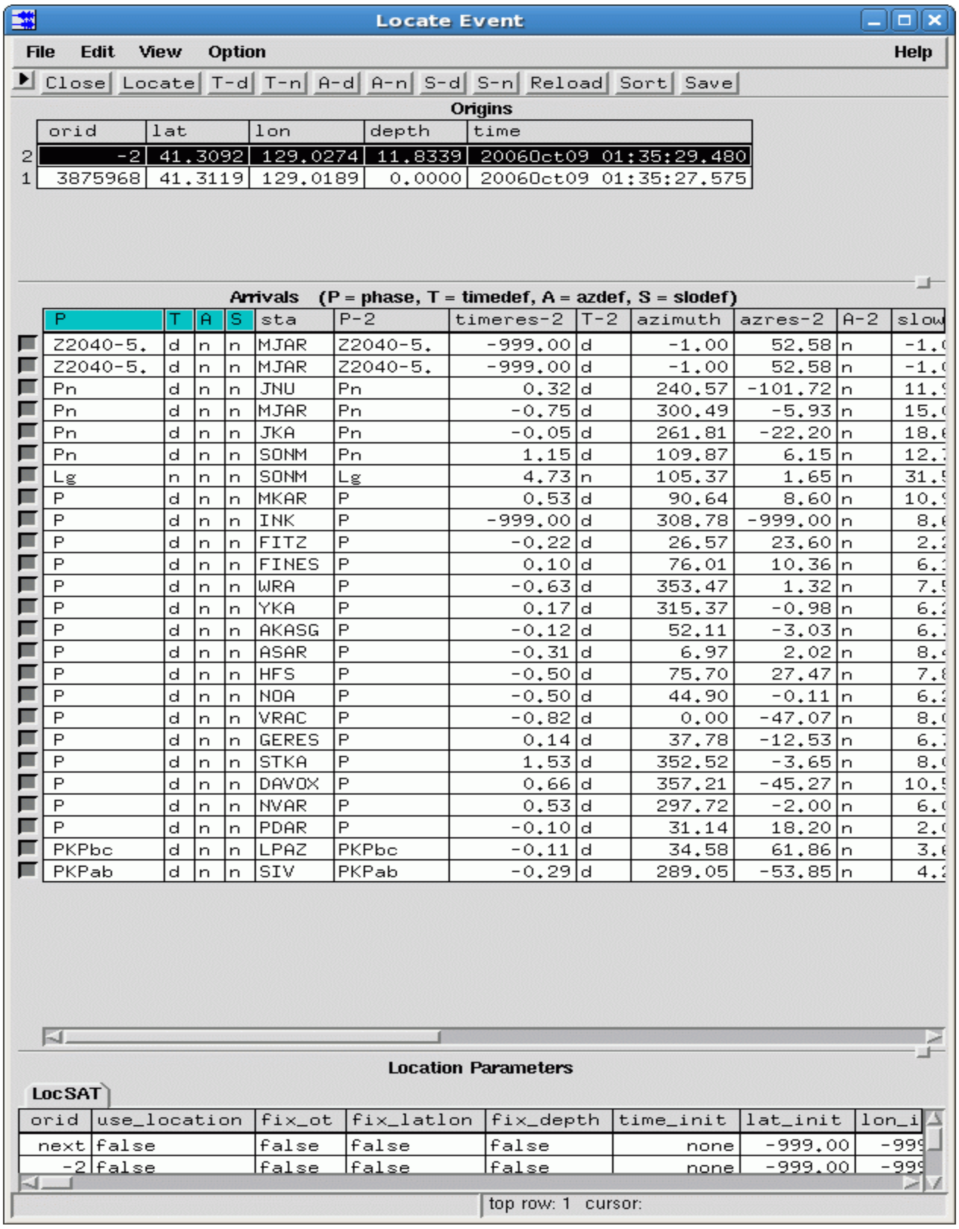
Clicking inside a T, A or S box of an associated arrival box will toggle the value between d (for defining) and n (for non-defining). The P (phase) entries can be edited by using the keyboard. Changing the values in this window only changes values for the location process. Changes made at this stage do not change Arrival labels in the main Waveform window, nor does it affect the **Arrival** popup.

Changing which attributes are defining can be accomplished with the toolbar buttons as well. For example, clicking on the Toolbar button **A-n** changes the azimuth defining value to be non-defining for all arrivals.

The **Location Parameters** values determine certain parameters used in the location process. Clicking within some of the parameter boxes will toggle values as well. Use the horizontal scroll bar to view other input parameters.

(5) Click on the **Locate** toolbar button in the **Locate Event** popup. A new origin is created with **orid: -2** (Figure 121 shows origin -2 selected).

Click on the origin with the **left** mouse button in order to select it. When an origin is selected, additional values related to the selected solution appear in the arrival listing. The columns represent the phase, residuals and defining flags for time, azimuth and slowness.



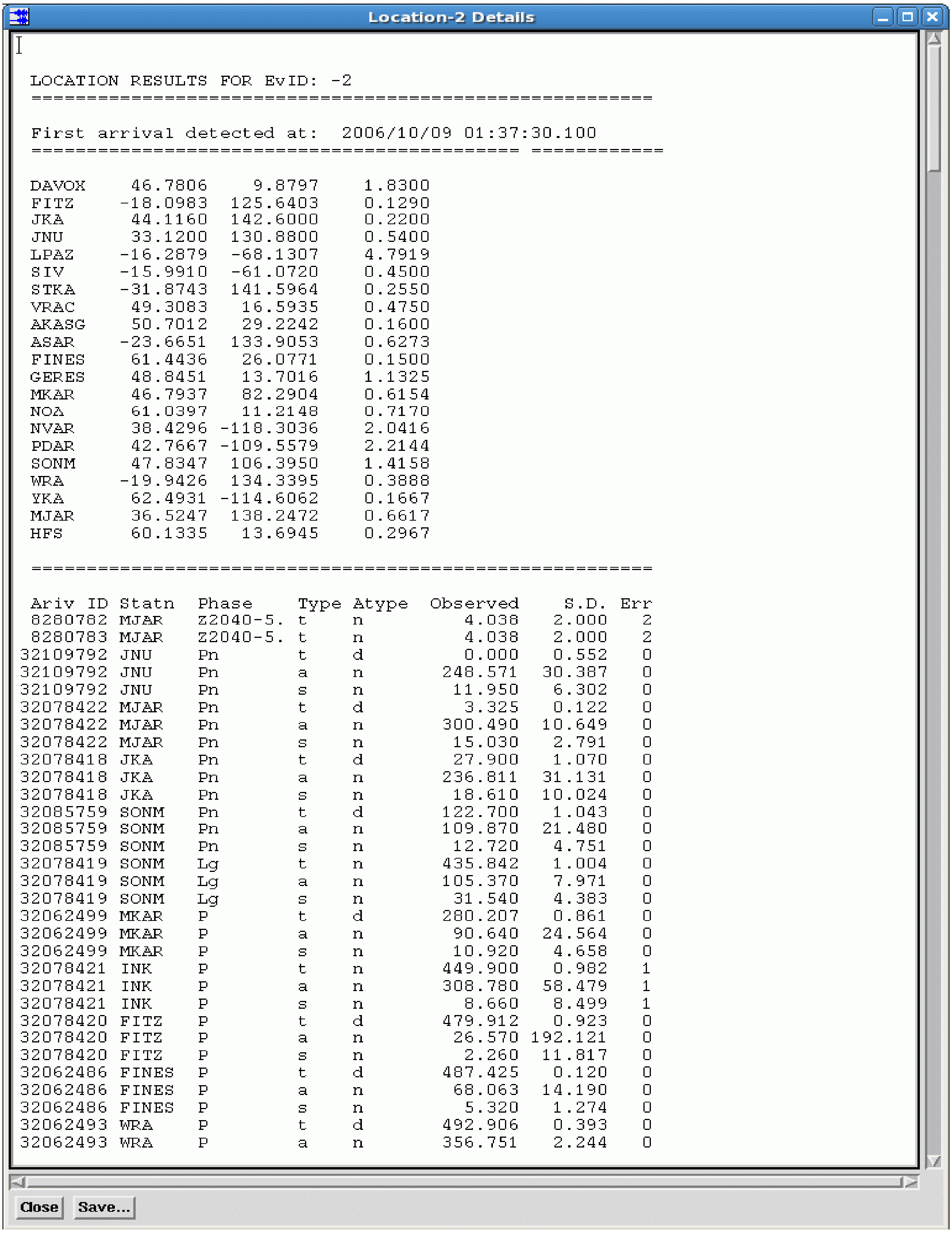
	orid	lat	lon	depth	time
2	-2	41.3092	129.0274	11.8339	2006Oct09 01:35:29.480
1	3875968	41.3119	129.0189	0.0000	2006Oct09 01:35:27.575

P	T	A	S	sta	P-2	timeres-2	T-2	azimuth	azres-2	A-2	slow
Z2040-5.	d	n	n	MJAR	Z2040-5.	-999.00	d	-1.00	52.58	n	-1.
Z2040-5.	d	n	n	MJAR	Z2040-5.	-999.00	d	-1.00	52.58	n	-1.
Pn	d	n	n	JNU	Pn	0.32	d	240.57	-101.72	n	11.
Pn	d	n	n	MJAR	Pn	-0.75	d	300.49	-5.93	n	15.
Pn	d	n	n	JKA	Pn	-0.05	d	261.81	-22.20	n	18.
Pn	d	n	n	SONM	Pn	1.15	d	109.87	6.15	n	12.
Lg	n	n	n	SONM	Lg	4.73	n	105.37	1.65	n	31.
P	d	n	n	MKAR	P	0.53	d	90.64	8.60	n	10.
P	d	n	n	INK	P	-999.00	d	308.78	-999.00	n	8.
P	d	n	n	FITZ	P	-0.22	d	26.57	23.60	n	2.
P	d	n	n	FINES	P	0.10	d	76.01	10.36	n	6.
P	d	n	n	WRA	P	-0.63	d	353.47	1.32	n	7.
P	d	n	n	YKA	P	0.17	d	315.37	-0.98	n	6.
P	d	n	n	AKASG	P	-0.12	d	52.11	-3.03	n	6.
P	d	n	n	ASAR	P	-0.31	d	6.97	2.02	n	8.
P	d	n	n	HFS	P	-0.50	d	75.70	27.47	n	7.
P	d	n	n	NOA	P	-0.50	d	44.90	-0.11	n	6.
P	d	n	n	VRAC	P	-0.82	d	0.00	-47.07	n	8.
P	d	n	n	GERES	P	0.14	d	37.78	-12.53	n	6.
P	d	n	n	STKA	P	1.53	d	352.52	-3.65	n	8.
P	d	n	n	DAVOX	P	0.66	d	357.21	-45.27	n	10.
P	d	n	n	NVAR	P	0.53	d	297.72	-2.00	n	6.
P	d	n	n	PDAR	P	-0.10	d	31.14	18.20	n	2.
PKPbc	d	n	n	LPAZ	PKPbc	-0.11	d	34.58	61.86	n	3.
PKPab	d	n	n	SIV	PKPab	-0.29	d	289.05	-53.85	n	4.

orid	use_location	fix_ot	fix_latlon	fix_depth	time_init	lat_init	lon_i
next	false	false	false	false	none	-999.00	-999
-2	false	false	false	false	none	-999.00	-999

Figure 121. Locate Event popup after origin-2 is located and selected

(6) Select **View->Location Details** from the **Locate Event** popup. It activates **Location -2 Details** popup (Figure 122).



```
Location-2 Details

LOCATION RESULTS FOR EvID: -2
========================================================

First arrival detected at:  2006/10/09 01:37:30.100
============================================ ============

DAVOX     46.7806    9.8797    1.8300
FITZ     -18.0983  125.6403    0.1290
JKA       44.1160  142.6000    0.2200
JNU       33.1200  130.8800    0.5400
LPAZ     -16.2879  -68.1307    4.7919
SIV      -15.9910  -61.0720    0.4500
STKA     -31.8743  141.5964    0.2550
VRAC      49.3083   16.5935    0.4750
AKASG     50.7012   29.2242    0.1600
ASAR     -23.6651  133.9053    0.6273
FINES     61.4436   26.0771    0.1500
GERES     48.8451   13.7016    1.1325
MKAR      46.7937   82.2904    0.6154
NOA       61.0397   11.2148    0.7170
NVAR      38.4296 -118.3036    2.0416
PDAR      42.7667 -109.5579    2.2144
SONM      47.8347  106.3950    1.4158
WRA      -19.9426  134.3395    0.3888
YKA       62.4931 -114.6062    0.1667
MJAR      36.5247  138.2472    0.6617
HFS       60.1335   13.6945    0.2967

========================================================

 Ariv ID Statn  Phase    Type Atype  Observed    S.D. Err
 8280782 MJAR   Z2040-5. t    n         4.038   2.000  2
 8280783 MJAR   Z2040-5. t    n         4.038   2.000  2
32109792 JNU    Pn       t    d         0.000   0.552  0
32109792 JNU    Pn       a    n       248.571  30.387  0
32109792 JNU    Pn       s    n        11.950   6.302  0
32078422 MJAR   Pn       t    d         3.325   0.122  0
32078422 MJAR   Pn       a    n       300.490  10.649  0
32078422 MJAR   Pn       s    n        15.030   2.791  0
32078418 JKA    Pn       t    d        27.900   1.070  0
32078418 JKA    Pn       a    n       236.811  31.131  0
32078418 JKA    Pn       s    n        18.610  10.024  0
32085759 SONM   Pn       t    d       122.700   1.043  0
32085759 SONM   Pn       a    n       109.870  21.480  0
32085759 SONM   Pn       s    n        12.720   4.751  0
32078419 SONM   Lg       t    n       435.842   1.004  0
32078419 SONM   Lg       a    n       105.370   7.971  0
32078419 SONM   Lg       s    n        31.540   4.383  0
32062499 MKAR   P        t    d       280.207   0.861  0
32062499 MKAR   P        a    n        90.640  24.564  0
32062499 MKAR   P        s    n        10.920   4.658  0
32078421 INK    P        t    n       449.900   0.982  1
32078421 INK    P        a    n       308.780  58.479  1
32078421 INK    P        s    n         8.660   8.499  1
32078420 FITZ   P        t    d       479.912   0.923  0
32078420 FITZ   P        a    n        26.570 192.121  0
32078420 FITZ   P        s    n         2.260  11.817  0
32062486 FINES  P        t    d       487.425   0.120  0
32062486 FINES  P        a    n        68.063  14.190  0
32062486 FINES  P        s    n         5.320   1.274  0
32062493 WRA    P        t    d       492.906   0.393  0
32062493 WRA    P        a    n       356.751   2.244  0

Close  Save...
```

Figure 122. Location -2 Details popup.

(7) When the user is finished and has a location to save, click on the **Save** toolbar button in the **Locate Event** popup. This saves the origin, origerr and assoc records (for more information on location algorithm see Chapter 6, Event Location in: IDC Processing of Seismic, Hydroacoustic and Infrasonic Data [IPSH]).

Location is now saved, and next time you press the **Locate** button in the **Locate Event** popup. Location 3 will have **orid: -3** (Figure 123).

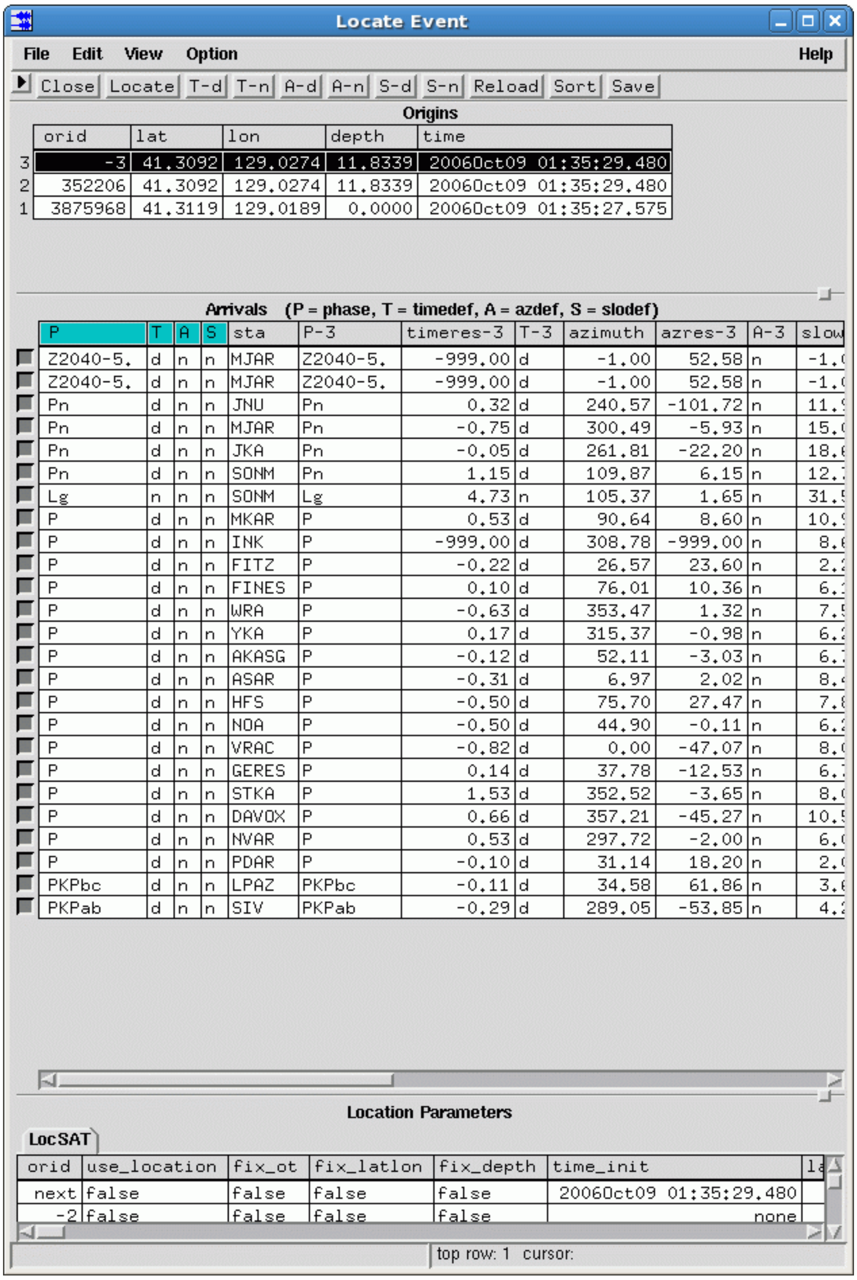


Figure 123. Locate Event popup after origin is saved

Exercise 10.3. Map in the Locate Event popup.

(8)Select **Option->Map** in the **Locate Event** popup. This activates **Map** popup (Figure 124).

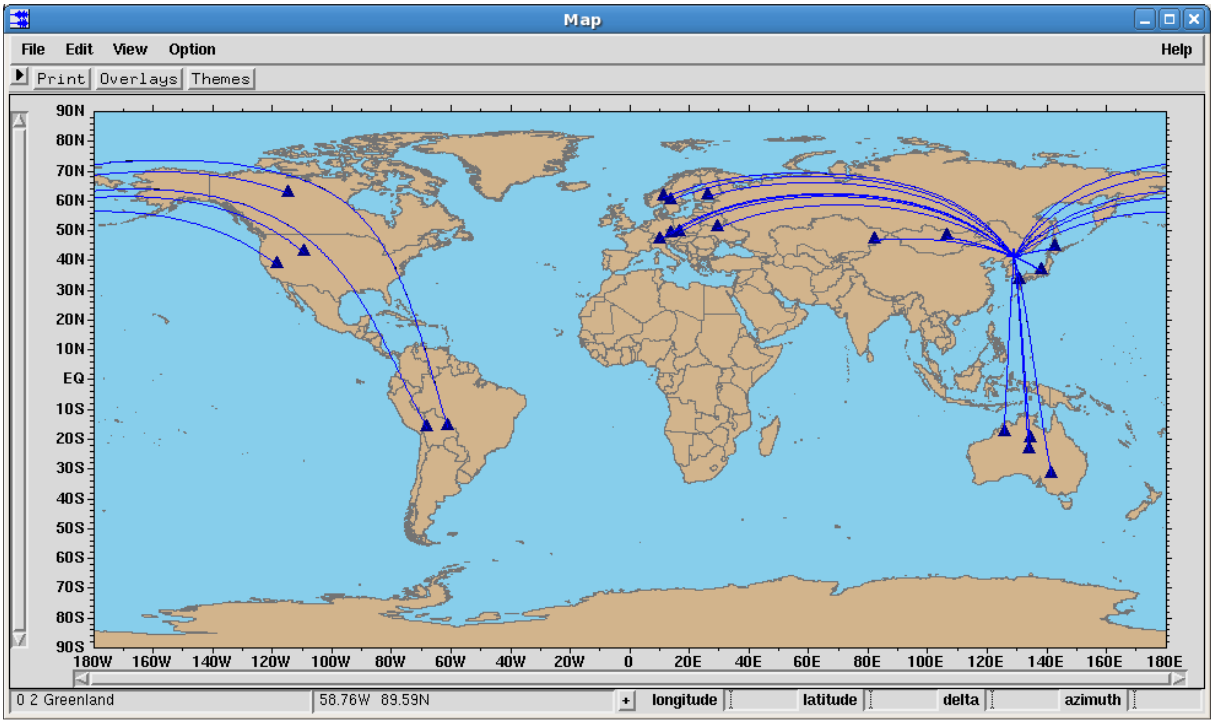


Figure 124. Map popup with location events.

(9) Select **Option->Map Cursor** in the **Map** popup. It activates **Map Cursor** popup (Figure 125) and adds crosshair to **Map** popup. You can drag the crosshair with the left mouse (Figure 126).

*Figure 125. **Map Cursor** popup.*

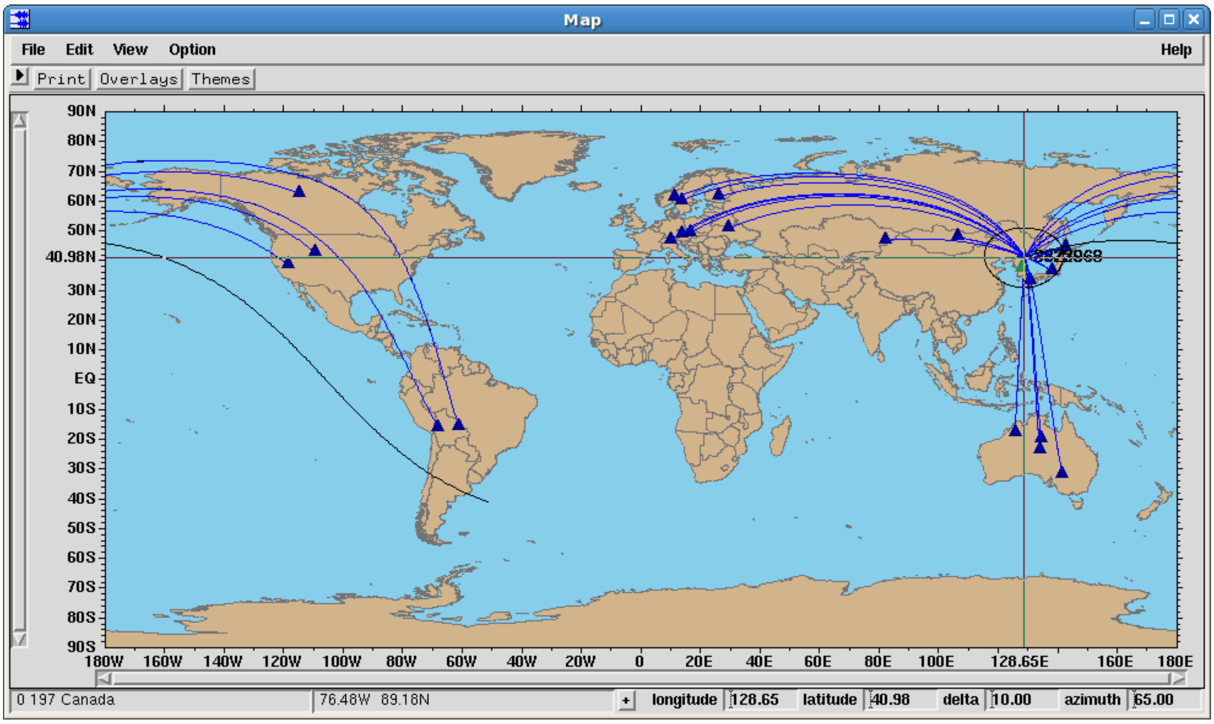


Figure 126. Map popup with Map Cursor crosshair.

(10) To label the seismic station, select the **View→Station Tags** menu item in the **Map** popup. You can zoom in the map by clicking the **middle** mouse button (Figure 127). You can move the circle and azimuth lines by dragging the **left** mouse button.

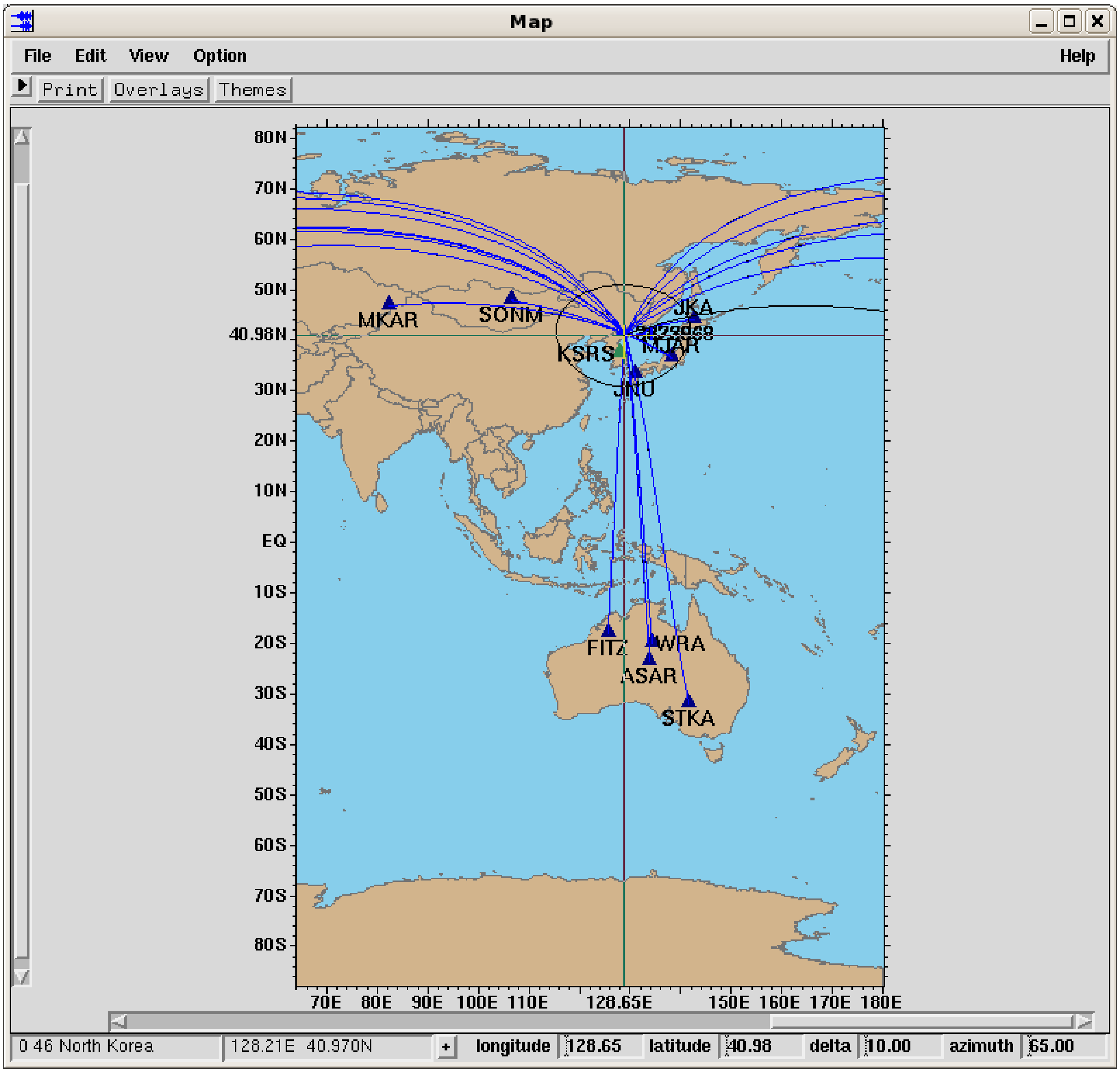


Figure 127. Zoom in the Map popup with Map Cursor crosshair.

SECTION 11. PRINT BULLETIN

Exercise 11.1. Save bulletin in current directory.

Ensure that you have saved an event according to ***Exercise 10.2. "Obtaining a Location".*** *When done locating, follow the outlined exercises below.*

To open Print Bulletin:

(1) Select **Option->Print Bulletin** from main menu bar. This activates **Print Bulletin** popup**.**
(2) In the **Origins** panel, select the origin row that you are interested in.

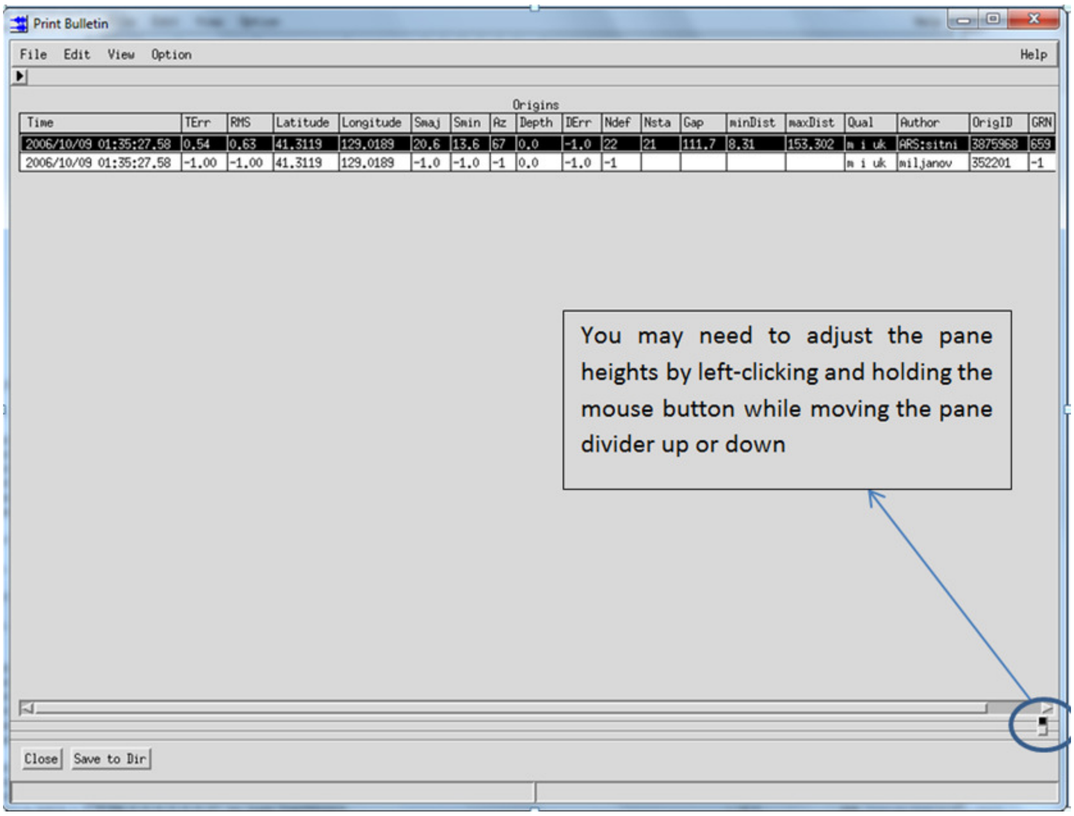


Figure 128. The ***Print Bulletin*** *popup*

You may need to adjust the pane divider as indicated in Figure 128. to show the **Magnitudes** and **Arrivals** panes. See Figure 129, below.

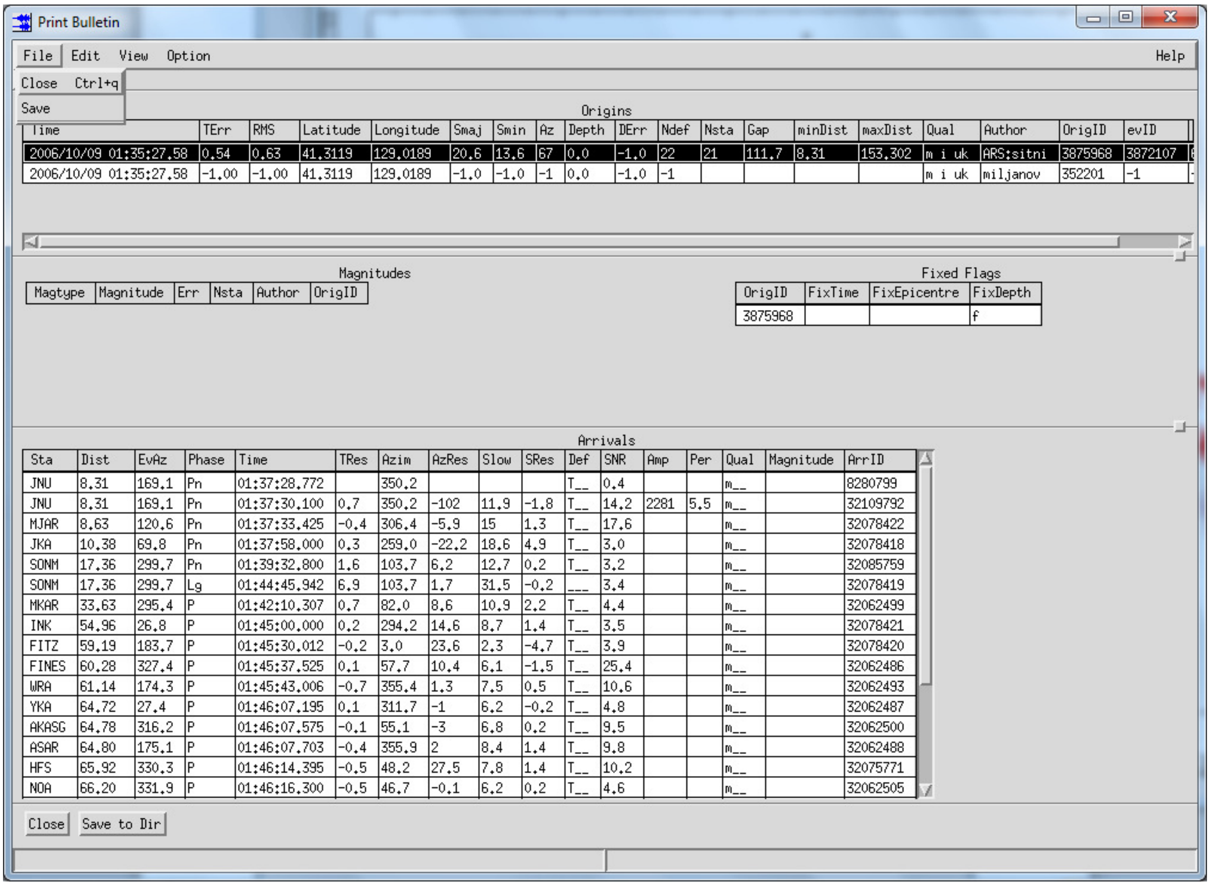


*Figure 129. The **Print Bulletin** popup showing the **Magnitude** and **Arrivals** panes for the selected event in the **Origin** pane*

(3) To save the bulletin file in the current directory, select **File -> Save** on the **Print Bulletin** menu

(4) The file, bulletin.txt, can be read using Unix commands like cat, less, more, vi, etc. You can also load it using common Unix editors.

Exercise 11.2. Save bulletin in any directory.

(1) To save the bulletin file in the current directory, click on **Save to Dir** button on the **Print Bulletin** popup at the left button. This activates a **Save File** popup, see Figure 130, below. Navigate to the desired directory and type in the file name into the **Selection** text box. Then click **Write File**.

(2) The file can be read using Unix commands like cat, less, more, vi, etc. You can also load it using common Unix editors. Note that you will need to navigate to the directory where the file was saved.

(3) Close the **Print Bulletin** popup by selecting **File -> Close** in the popup.

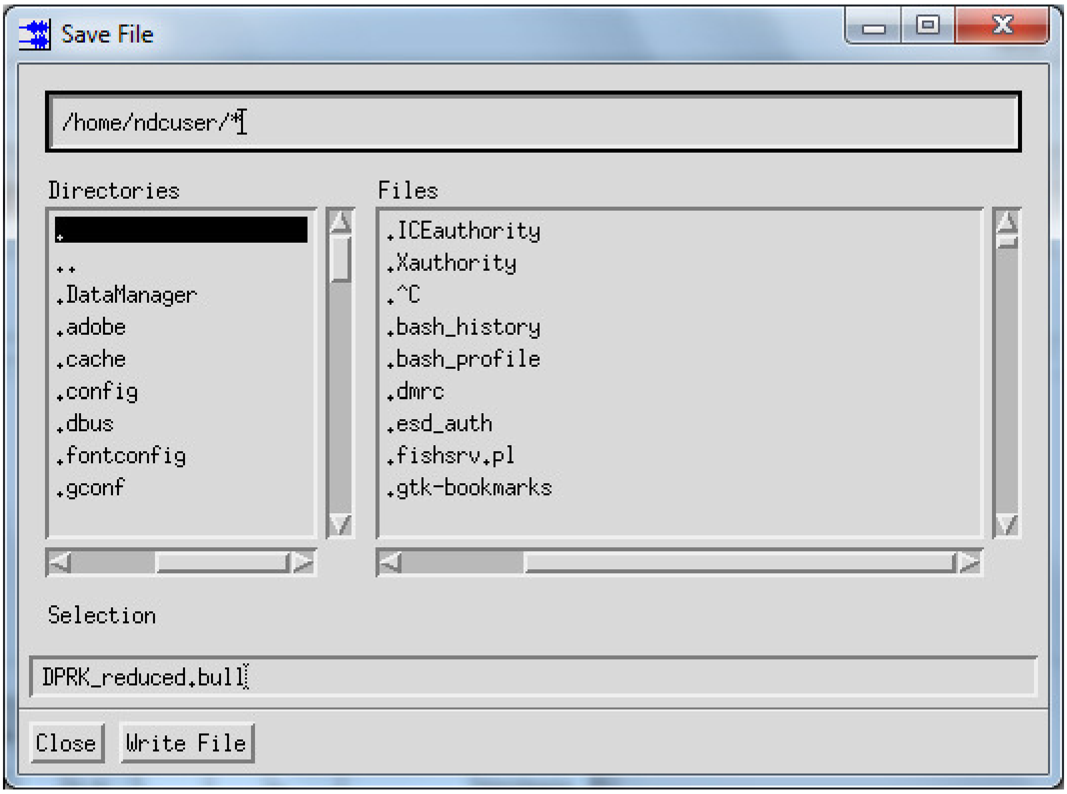


*Figure 130. **Save File** popup for **Print Bulletin***

SECTION 12. ADD STATION

Exercise 12.1. Data Input to Table Viewer.

To open Table Viewer:

(1) Select **File->Tables->Table Viewer** from main menu bar. This activates **Table Viewer** popup.

(2) Select **File->Open** in the **Table Viewer** popup. This activates **Table Viewer Open** popup (See Exercise 1.11).

(3) Scroll in the directories until you find the idc tables and the directory: ***/…/tables/static/global.site*** Select file **global.site** in the **Table Viewer Open** popup by clicking on it with the left mouse button.

(4) Click on the **Open** button in the **Table Viewer Open** popup.

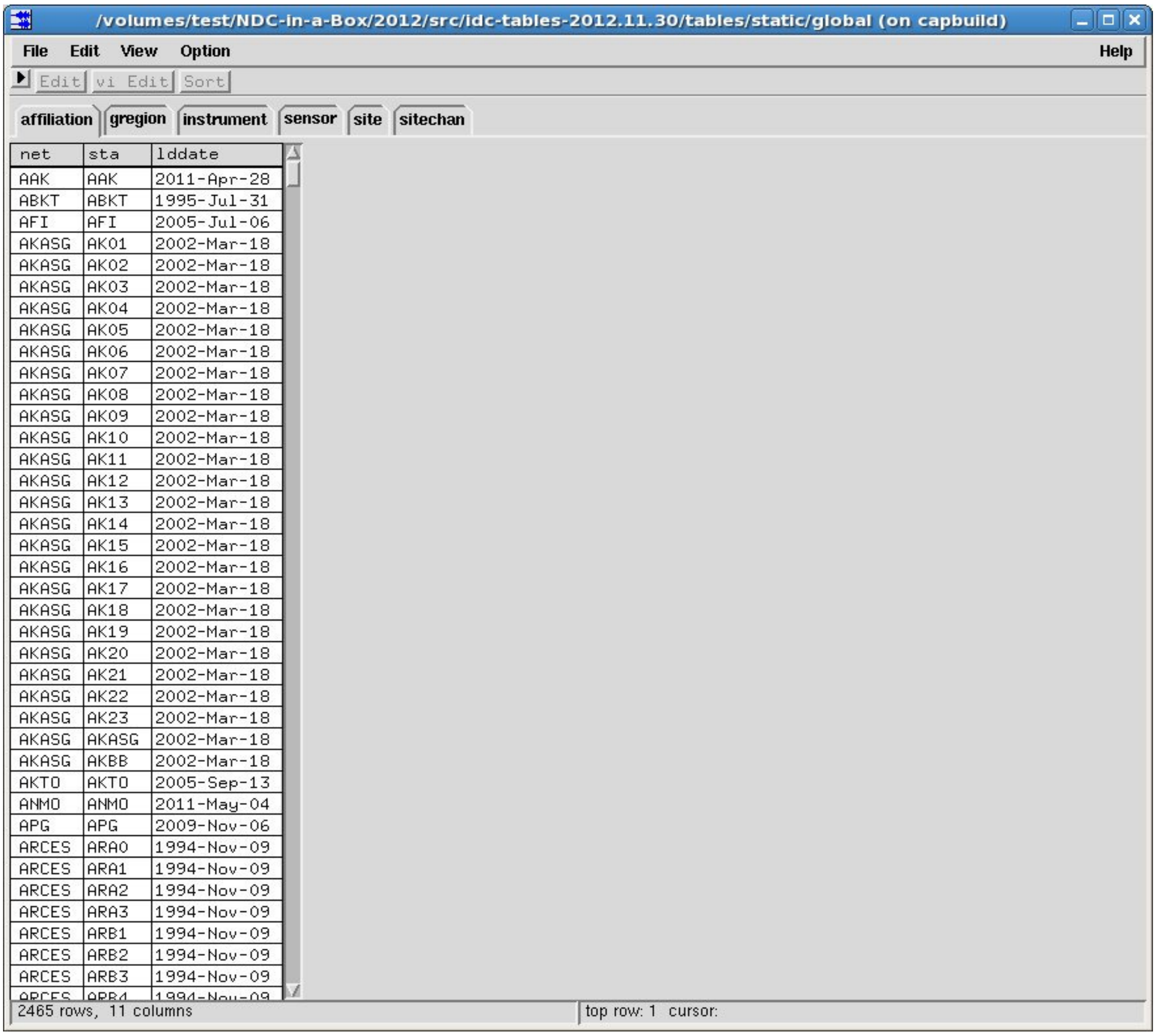


*Figure 131. **Table Viewer** popup with **global.site** loaded.*

The **TableViewer** popup will be populated from the information of the **global.site** file, and also shows other static tables: affiliation, gregion, instrument, sensor, sitechan (Figure 131 shows **site** information).
Add station plugin updates the information in the following tables: affiliation, site, sitechan, and this is the information which is used for location.

Exercise 12.2. Add Station to global.affiliation, global.site, global.sitechan

Once you have the information loaded in Table Viewer,

(5) Select **Option->Add Station** in the **Table Viewer** popupfrom main menu bar. This activates **Add Station** popup (Figure 132).

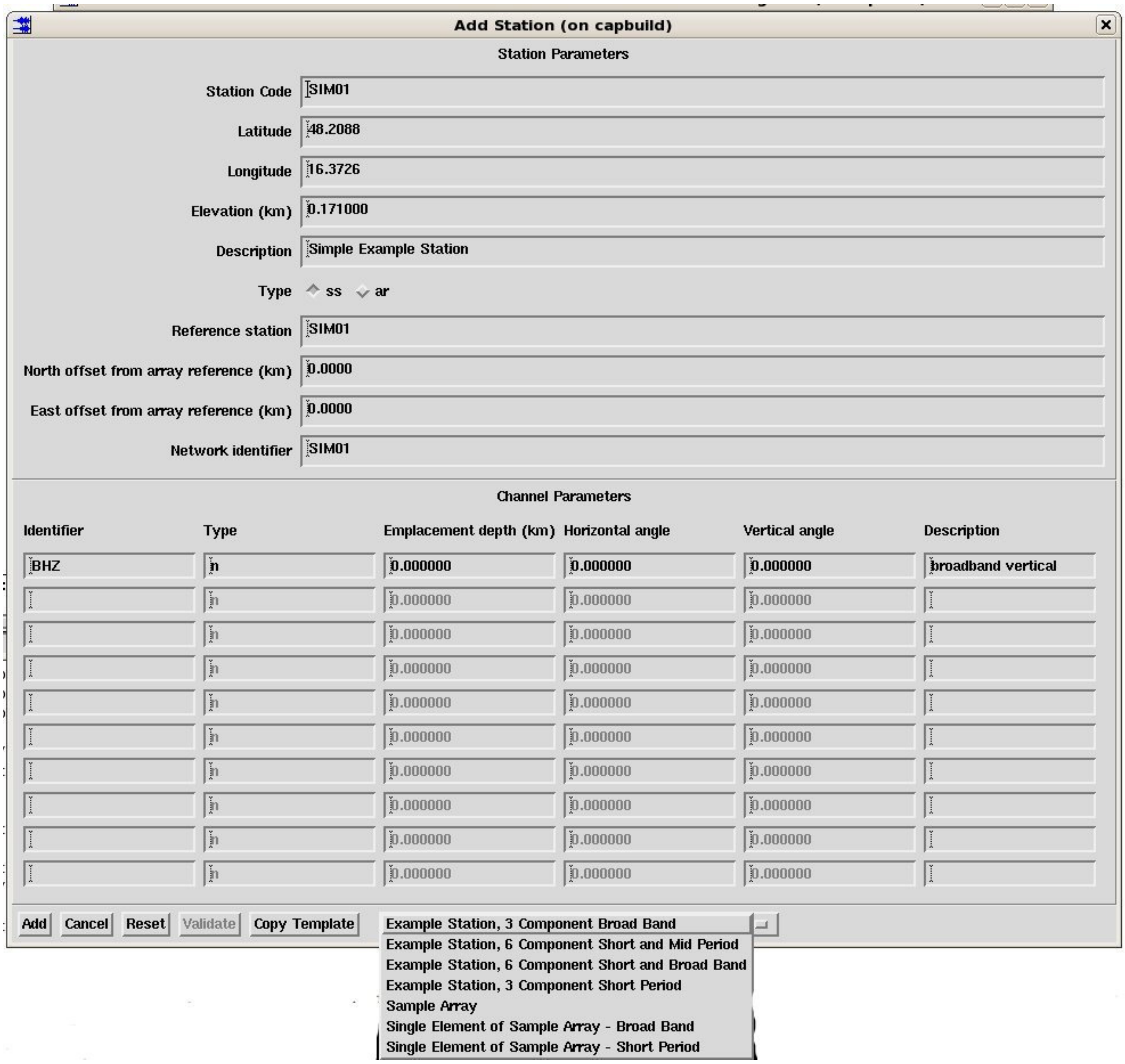


Figure 132. ***Add Station*** *popup.*

(6) In the templates, scroll to Example Station, **3 Component, Short Period** and click on the **Copy Template** button in the **Add Station** popup. The values of the template will appear in the **Add Station** popup (Figure 133).

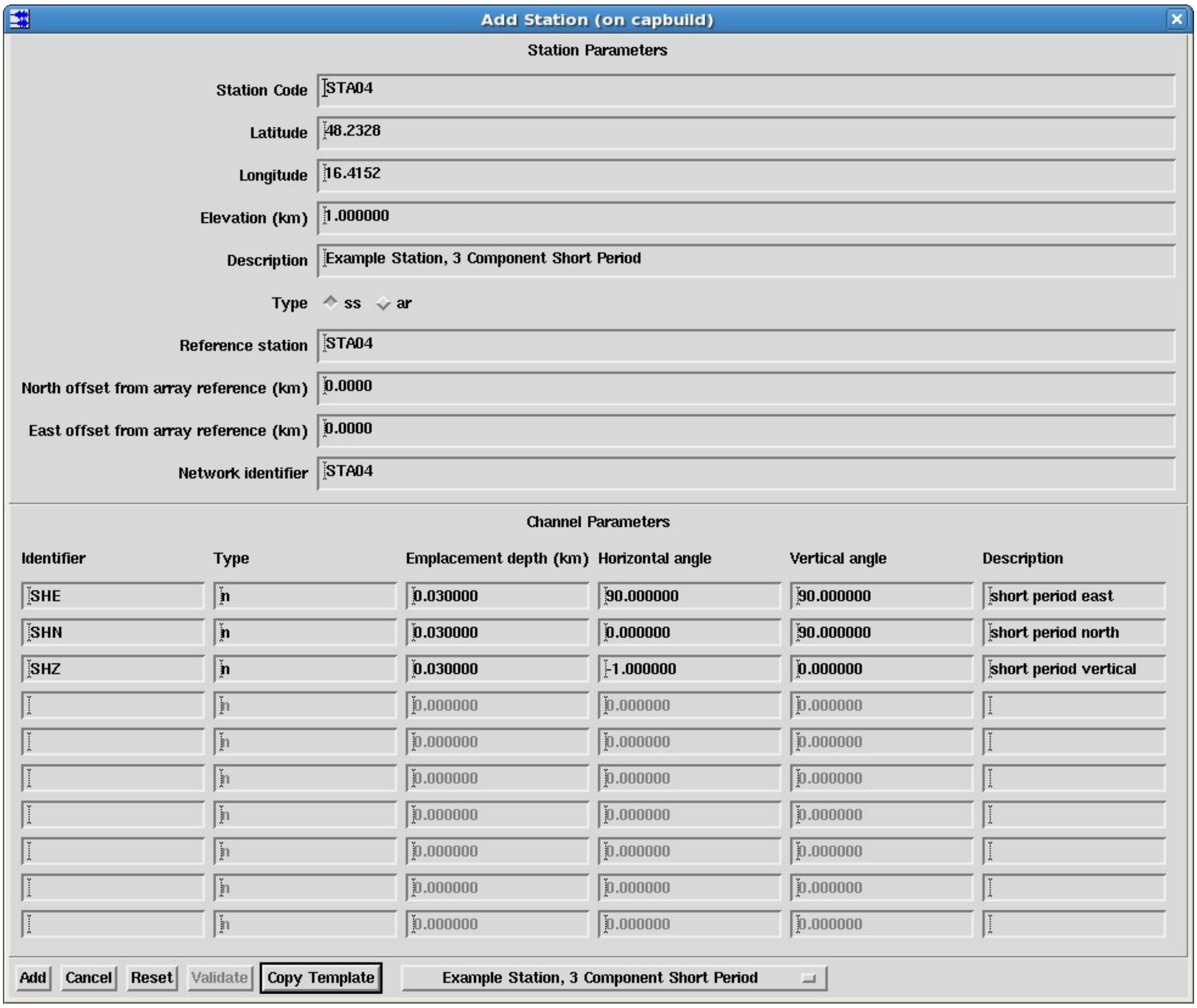
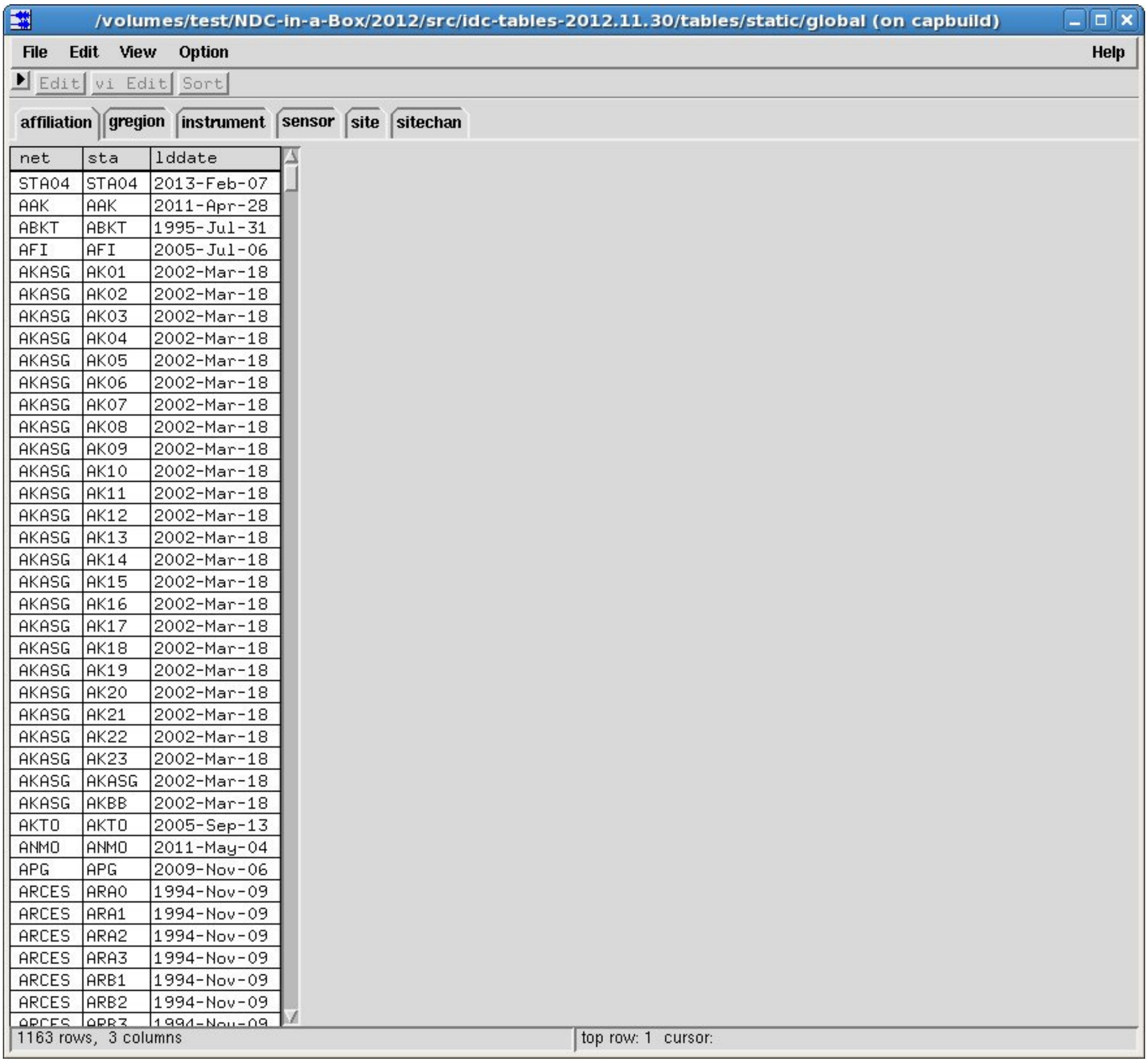


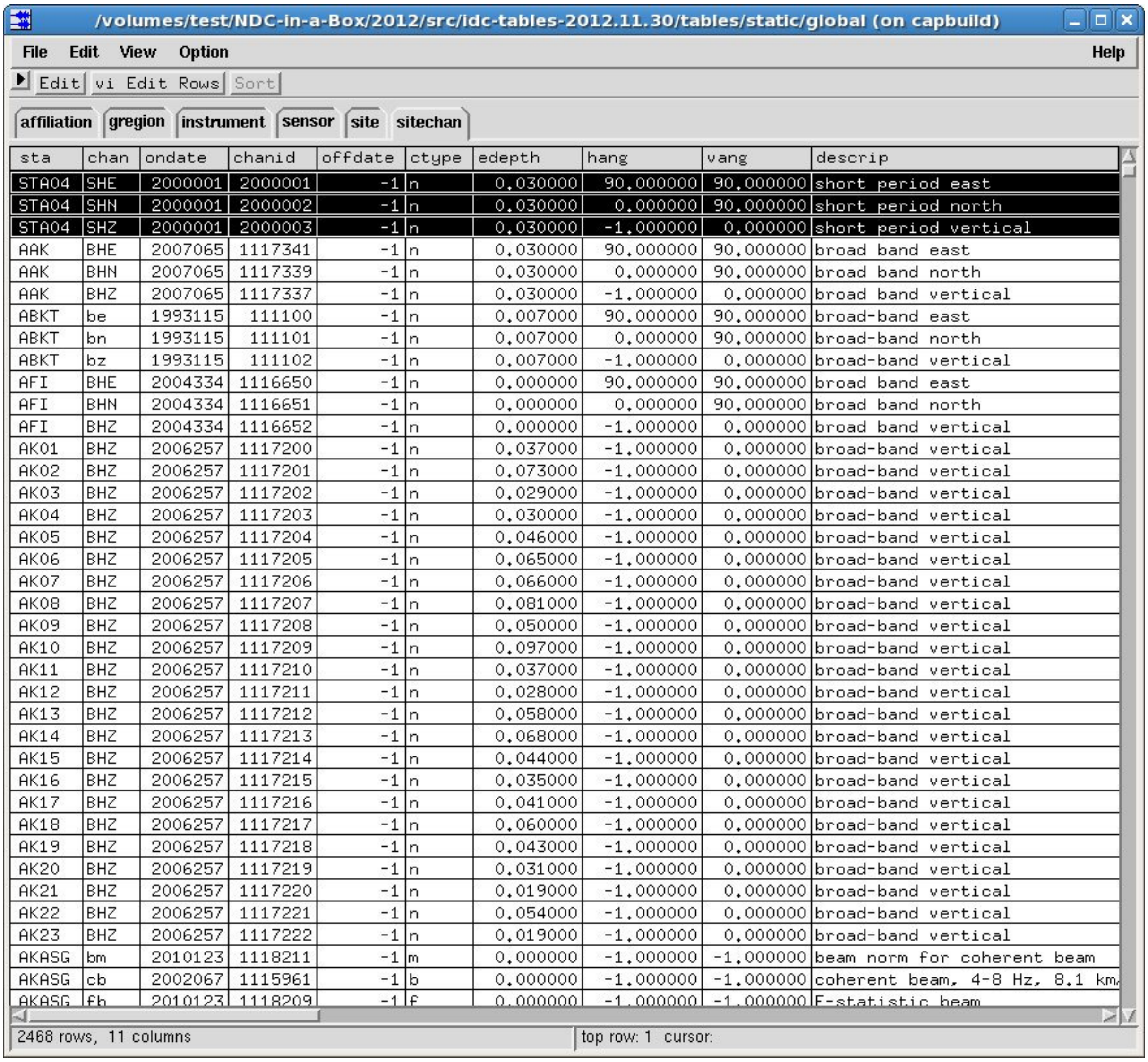
*Figure 133. **Add Station** popup, with template loaded.*

(7) Click on the **Add** button in the **Add Station** popup. The information of the template will appear on top in **Table Viewer** popup (note STA04), in affiliation, site and sitechan tables (Figure 134).



net	sta	lddate
STA04	STA04	2013-Feb-07
AAK	AAK	2011-Apr-28
ABKT	ABKT	1995-Jul-31
AFI	AFI	2005-Jul-06
AKASG	AK01	2002-Mar-18
AKASG	AK02	2002-Mar-18
AKASG	AK03	2002-Mar-18
AKASG	AK04	2002-Mar-18
AKASG	AK05	2002-Mar-18
AKASG	AK06	2002-Mar-18
AKASG	AK07	2002-Mar-18
AKASG	AK08	2002-Mar-18
AKASG	AK09	2002-Mar-18
AKASG	AK10	2002-Mar-18
AKASG	AK11	2002-Mar-18
AKASG	AK12	2002-Mar-18
AKASG	AK13	2002-Mar-18
AKASG	AK14	2002-Mar-18
AKASG	AK15	2002-Mar-18
AKASG	AK16	2002-Mar-18
AKASG	AK17	2002-Mar-18
AKASG	AK18	2002-Mar-18
AKASG	AK19	2002-Mar-18
AKASG	AK20	2002-Mar-18
AKASG	AK21	2002-Mar-18
AKASG	AK22	2002-Mar-18
AKASG	AK23	2002-Mar-18
AKASG	AKASG	2002-Mar-18
AKASG	AKBB	2002-Mar-18
AKTO	AKTO	2005-Sep-13
ANMO	ANMO	2011-May-04
APG	APG	2009-Nov-06
ARCES	ARA0	1994-Nov-09
ARCES	ARA1	1994-Nov-09
ARCES	ARA2	1994-Nov-09
ARCES	ARA3	1994-Nov-09
ARCES	ARB1	1994-Nov-09
ARCES	ARB2	1994-Nov-09
ARCES	ARB3	1994-Nov-09

Figure 134. ***Table Viewer*** *popup, with new station STA04 added at the top (affiliation table).*



sta	chan	ondate	chanid	offdate	ctype	edepth	hang	vang	descrip
STA04	SHE	2000001	2000001	-1	n	0.030000	90.000000	90.000000	short period east
STA04	SHN	2000001	2000002	-1	n	0.030000	0.000000	90.000000	short period north
STA04	SHZ	2000001	2000003	-1	n	0.030000	-1.000000	0.000000	short period vertical
AAK	BHE	2007065	1117341	-1	n	0.030000	90.000000	90.000000	broad band east
AAK	BHN	2007065	1117339	-1	n	0.030000	0.000000	90.000000	broad band north
AAK	BHZ	2007065	1117337	-1	n	0.030000	-1.000000	0.000000	broad band vertical
ABKT	be	1993115	111100	-1	n	0.007000	90.000000	90.000000	broad-band east
ABKT	bn	1993115	111101	-1	n	0.007000	0.000000	90.000000	broad-band north
ABKT	bz	1993115	111102	-1	n	0.007000	-1.000000	0.000000	broad-band vertical
AFI	BHE	2004334	1116650	-1	n	0.000000	90.000000	90.000000	broad band east
AFI	BHN	2004334	1116651	-1	n	0.000000	0.000000	90.000000	broad band north
AFI	BHZ	2004334	1116652	-1	n	0.000000	-1.000000	0.000000	broad band vertical
AK01	BHZ	2006257	1117200	-1	n	0.037000	-1.000000	0.000000	broad-band vertical
AK02	BHZ	2006257	1117201	-1	n	0.073000	-1.000000	0.000000	broad-band vertical
AK03	BHZ	2006257	1117202	-1	n	0.029000	-1.000000	0.000000	broad-band vertical
AK04	BHZ	2006257	1117203	-1	n	0.030000	-1.000000	0.000000	broad-band vertical
AK05	BHZ	2006257	1117204	-1	n	0.046000	-1.000000	0.000000	broad-band vertical
AK06	BHZ	2006257	1117205	-1	n	0.065000	-1.000000	0.000000	broad-band vertical
AK07	BHZ	2006257	1117206	-1	n	0.066000	-1.000000	0.000000	broad-band vertical
AK08	BHZ	2006257	1117207	-1	n	0.081000	-1.000000	0.000000	broad-band vertical
AK09	BHZ	2006257	1117208	-1	n	0.050000	-1.000000	0.000000	broad-band vertical
AK10	BHZ	2006257	1117209	-1	n	0.097000	-1.000000	0.000000	broad-band vertical
AK11	BHZ	2006257	1117210	-1	n	0.037000	-1.000000	0.000000	broad-band vertical
AK12	BHZ	2006257	1117211	-1	n	0.028000	-1.000000	0.000000	broad-band vertical
AK13	BHZ	2006257	1117212	-1	n	0.058000	-1.000000	0.000000	broad-band vertical
AK14	BHZ	2006257	1117213	-1	n	0.068000	-1.000000	0.000000	broad-band vertical
AK15	BHZ	2006257	1117214	-1	n	0.044000	-1.000000	0.000000	broad-band vertical
AK16	BHZ	2006257	1117215	-1	n	0.035000	-1.000000	0.000000	broad-band vertical
AK17	BHZ	2006257	1117216	-1	n	0.041000	-1.000000	0.000000	broad-band vertical
AK18	BHZ	2006257	1117217	-1	n	0.060000	-1.000000	0.000000	broad-band vertical
AK19	BHZ	2006257	1117218	-1	n	0.043000	-1.000000	0.000000	broad-band vertical
AK20	BHZ	2006257	1117219	-1	n	0.031000	-1.000000	0.000000	broad-band vertical
AK21	BHZ	2006257	1117220	-1	n	0.019000	-1.000000	0.000000	broad-band vertical
AK22	BHZ	2006257	1117221	-1	n	0.054000	-1.000000	0.000000	broad-band vertical
AK23	BHZ	2006257	1117222	-1	n	0.019000	-1.000000	0.000000	broad-band vertical
AKASG	bm	2010123	1118211	-1	m	0.000000	-1.000000	-1.000000	beam norm for coherent beam
AKASG	cb	2002067	1115961	-1	b	0.000000	-1.000000	-1.000000	coherent beam, 4-8 Hz, 8.1 km/
AKASG	fb	2010123	1118209	-1	f	0.000000	-1.000000	-1.000000	F-statistic beam

Figure 135. ***Table Viewer*** *popup, with new station STA04 added at the top (sitechan table).*

The first three rows show highlighted channels of STA04 in sitechan table (Figure 135).

Exercise 12.3. Save new station to the tables global.affiliation, global.site, global.sitechan

(8) Select **File->Save All Rows of All Tabs** in **Table Viewer** popup. This opens **Save all tables** popup. In the idc tables, scroll to /.../tables/static/global.site, and click on **Overwrite File** button in the **Save all tables** popup (Figure 136). This will update all three files: global.affiliation, global.site and global.sitechan, and save new station information.

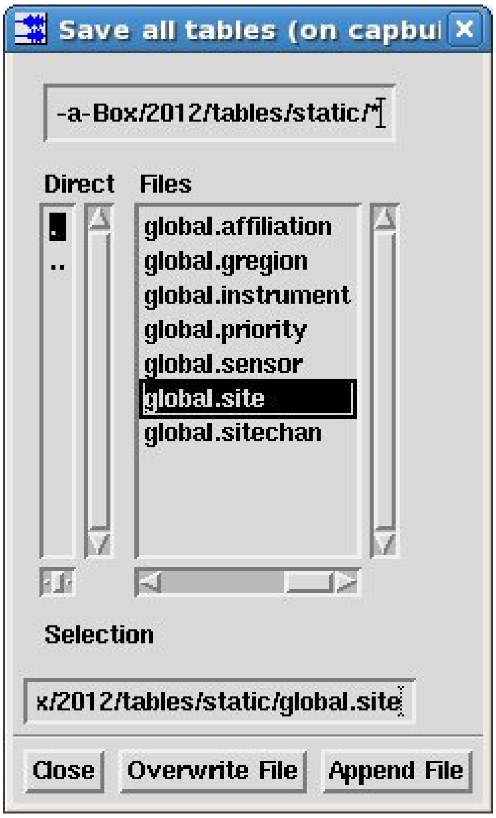


Figure 136. ***Save all tables*** *popup.*

SECTION 13. GEOTOOL SCRIPTS

Examples for scripts in geotool can be found in the directory /scripts.

Scripts in geotool can be ran from the command line, i.e.

```
$ geotool < dbdisplay1
```

where dbdiplay is a script which displays waveforms for an event:

```
alias tq=tablequery
alias db=tablequery.database connection
db.disconnect
db.data source=development
db.account=centre
db.password=data
db.connect

# query for an origin.
tq.query origin select * from origin where orid=2305214

# Display the waveforms
tq.select all
tq.display waveforms
```

This quit command will cause the program to exit only if this file
is input as the stdin. For example, the command
geotool < dbdisplay2
will exit. But if this file is input with the terminal command "parse file",
the "quit" is ignored.

```
$ geotool < dbdisplay2

# display waveforms for an event
alias tq=tablequery
alias db=tablequery.database connection
db.disconnect
db.data source=ORACLE
db.account=sel3
db.password=sel3
db.connect

# query for an origin.
tq.query origin select * from origin where orid=2305214

# get the other tables
tq.select all
tq.get aaow

# set some display constraints
alias wc=tablequery.waveform display constraints
wc.ctype=3c-bb
wc.start phase=FirstP
wc.end phase=FirstP

# display the waveforms
```

```
# select the wfdisc tab first, since the behavior of the Display Waveforms
# button depends on the tab.
tq.select tab=wfdisc
tq.display waveforms
```

this quit command will cause the program to exit only if this file
is input as the stdin. For example, the command
geotool < dbdisplay2
will exit. But if this file is input with the terminal command "parse file",
the "quit" is ignored.

```
$ geotool < dbread1

# save database records to a file
alias tq=tablequery
alias db=tablequery.database connection
db.disconnect
db.data source=ORACLE
db.account=sel3
db.password=sel3
db.connect
tq.query origin select * from origin where jdate=2004038
tq.select all
tq.save selected rows file=j.origin append=true
```

this quit command will cause the program to exit if only if this file
is input as the stdin. For example, the command
geotool < dbdisplay2
will exit. But if this file is input with the terminal command "parse file",
the "quit" is ignored.

```
$ geotool < dbread2

# save database records to a file
alias tq=tablequery
alias db=tablequery.database connection
db.disconnect
db.data source=ORACLE
db.account=sel3
db.password=sel3
db.connect

# query for an origin.
tq.query origin select * from origin where orid=2305214

# Get the associated origerr,arrival,assoc,wfdisc, etc records
tq.select all
tq.get aaow

#save all origin records to a file
tq.select tab origin
tq.select all
tq.save selected rows file=2305214.origin append=false

#save all origerr records to a file
tq.select tab origerr
tq.select all
```

```
tq.save selected rows file=2305214.origerr append=false

#save all arrival records to a file
tq.select tab arrival
tq.select all
tq.save selected rows file=2305214.arrival append=false

#save all assoc records to a file
tq.select tab assoc
tq.select all
tq.save selected rows file=2305214.assoc append=false

#save all wfdisc records to a file
tq.select tab wfdisc
tq.select all
tq.save selected rows file=2305214.wfdisc append=false
```

this quit command will cause the program to exit if only if this file
is input as the stdin. For example, the command
geotool < dbdisplay2
will exit. But if this file is input with the terminal command "parse file",
the "quit" is ignored.

```
$ geotool < fft1
```

read a waveform from a flat-file and compute the FT

```
read file=tutorial/DPRK_tutorial.wfdisc query="select * from wfdisc where
sta='MK32' and chan='SHZ'"

# add a time window
time window phase="P" lead=5 lag=20

# select the waveform
select all

# compute the FT
ft.compute

# print the FT

ft.print.layout=portrait
ft.print.height=100
ft.print.filename=fft1.ps
ft.print.command=
ft.print.print
```

this quit command will cause the program to exit only if this file
is input as the stdin. For example, the command
geotool < dbdisplay2
will exit. But if this file is input with the terminal command "parse file",
the "quit" is ignored.
quit

```
$ geotool < filter1
```

```
#read waveforms from a flat-file and filter
read file=tutorial/DPRK_tutorial.wfdisc query="select * from wfdisc where
sta='MK32'"
select all
butterworth filter.apply low=2.0 high=5.0 order=3 type=bp zp=0

# this quit command will cause the program to exit only if this file
# is input as the stdin. For example, the command
#       geotool < dbdisplay2
# will exit. But if this file is input with the terminal command "parse file",
# the "quit" is ignored.
```

CONCLUSION

The authors hope this tutorial has provided the user with useful instructions for the basic capabilities of Geotool. Suggestions for further exercises would be welcome.

As you work with Geotool, you will find you often have many windows open. Closing some popups when finished will help keep your workspace less cluttered.

As a general note: The main waveform window contains a “plot” but there are some other windows that contain a plot as well. Most mouse and keyboard functions that are used in the main waveform window will perform the same function in other plot windows.

Please contact support@ctbto.org with any comments, corrections or suggestions for further Geotool exercises.

APPENDIX I.

Static Tables Used in Geotool.

Note: The following pages describe some of the static tables used by Geotool. These pages have been taken from Database Schema Document [DS].

Affiliation, Stanet

The **affiliation** table groups stations into networks. The **stanet** table groups array sites into an array "network."

AFFILIATION (STANET)

	Column	Storage Type	Description
1	*net*	varchar2(8)	unique network identifier
2	*sta*	varchar2(6)	station identifier
3	*lddate*	date	load date

Keys: Primary *net,sta*

Instrument

The **instrument** table contains ancillary calibration information. This table holds nominal one-frequency calibration factors for each instrument and pointers to the nominal frequency-dependent calibration for an instrument. It also holds pointers to the exact calibrations obtained by direct measurement on a particular instrument (see **sensor**).

INSTRUMENT

Column		Storage Type	Description
1	*inid*	number(8)	instrument identifier
2	*insname*	varchar2(50)	instrument name
3	*instype*	varchar2(6)	instrument type
4	*band*	varchar2(1)	frequency band
5	*digital*	varchar2(1)	data type, digital (d), or analog (a)
6	*samprate*	float(24)	sampling rate in samples/second
7	*ncalib*	float(24)	nominal calibration (nanometers/digital count)
8	*ncalper*	float(24)	nominal calibration period (seconds)
9	*dir*	varchar2(64)	directory
10	*dfile*	varchar2(32)	data file
11	*rsptype*	varchar2(6)	response type
12	*lddate*	date	load date

Keys: Primary *inid*

Network

The **network** table contains general information about seismic networks (see **affiliation**).

NETWORK

Column	Storage Type	Description
1 *net*	varchar2(8)	unique network identifier
2 *netname*	varchar2(80)	network name
3 *nettype*	varchar2(4)	network type: array, local, world-wide, and so on
4 *auth*	varchar2(15)	source/originator
5 *commid*	number(8)	comment identifier
6 *lddate*	date	load date

Keys: Primary *net*

Foreign *commid*

Sensor

The **sensor** table contains calibration information for specific sensor channels. This table provides a record of updates in the calibration factor or clock error of each instrument and links a *sta/chan/time* to a complete instrument response in the table **instrument**. Waveform data are converted into physical units through multiplication by the *calib* field located in **wfdisc**. The correct value of *calib* may not be accurately known when the **wfdisc** record is entered into the database. The **sensor** table provides the mechanism (*calratio* and *calper*) to "update" *calib*, without requiring possibly hundreds of **wfdisc** records to be updated. Through the foreign key *inid,* this table is linked to **instrument**, which has fields pointing to flat files holding detailed calibration information in a variety of formats (see **instrument**).

SENSOR

Column		Storage Type	Description
1	*sta*	varchar2(6)	station code
2	*chan*	varchar2(8)	channel code
3	*time*	float(53)	epoch time of start of recording period
4	*endtime*	float(53)	epoch time of end of recording period
5	*inid*	number(8)	instrument identifier
6	*chanid*	number(8)	channel identifier
7	*jdate*	number(8)	Julian date
8	*calratio*	float(24)	calibration
9	*calper*	float(24)	calibration period
10	*tshift*	float(24)	correction of data processing time
11	*instant*	varchar2(1)	(y, n) discrete/continuing snapshot
12	*lddate*	date	load date

Keys: Primary *sta/chan/time/endtime*

Foreign *inid, chanid*

Site

The **site** table contains station location information. **Site** names and describes a point on the earth where measurements are made (for example, the location of an instrument or array of instruments). It contains information that normally changes infrequently, such as location. In addition, **site** contains fields that describe the offset of a station relative to an array reference location. Global data integrity implies that the *sta/ondate* in **site** be consistent with the *sta/chan/ondate* in **sitechan.**

SITE

Column	Storage Type	Description
sta	varchar2(6)	station identifier
ondate	number(8)	Julian start date
offdate	number(8)	Julian off date
lat	float(24)	latitude
lon	float(24)	longitude
elev	float(24)	elevation
staname	varchar2(50)	station description
statype	varchar2(4)	station type: single station, array
refsta	varchar2(6)	reference station for array members
dnorth	float(24)	offset from array reference (km)
deast	float(24)	offset from array reference (km)
lddate	date	load date

Keys: Primary *sta/ondate*

Sitechan

The **sitechan** table contains station-channel information. This table describes the orientation of a recording channel at the site referenced by *sta*. It provides information about the various channels that are available at a station and maintains a record of the physical channel configuration at a site.

SITECHAN

Column	Storage Type	Description
sta	varchar2(6)	station identifier
chan	varchar2(8)	channel identifier
ondate	number(8)	Julian start date
chanid	number(8)	channel identifier
offdate	number(8)	Julian off date
ctype	varchar2(4)	channel type
edepth	float(24)	emplacement depth
hang	float(24)	horizontal angle
vang	float(24)	vertical angle
descrip	varchar2(50)	channel description
lddate	date	load date

Keys:Primary *sta/chan/ondate*

Alternate *chanid*

APPENDIX II

Overview of IMS Stations

This Appendix provides an introduction to the types of Seismic, Hydroacoustic and Infrasound stations in the International Monitoring System (IMS). The station and channel names described here are also used by geotool. For more detailed information the reader is referred to the corresponding IMS Operational Manual [ISOP], [IHOP], [IIOP], or the IASPEI New Manual of Seismological Observatory Practice [INM].

Seismic Stations

Seismic Stations in the IMS network can be classified in two groups, three-component stations and arrays. At most three-component stations there is one broad-band sensor, which produces three data streams (time-series) of three orthogonal channels. These channels are typically named BHZ, BHN and BHE. The “Z” channel is vertically oriented, “N” channel is horizontally oriented towards North and the “E” channel is horizontally oriented towards East. The station name of the time series is the same name as the station itself. For example, data from the station MLR consists of time series with the names MLR/BHZ, MLR/BHN, MLR/BHE (Figure 3).

In cases where the horizontal channels are not oriented to the North or East, the channels are named BHZ, BH1 and BH2, where BH1 is the channel closest to North. The orientation is specified in the ?? field in the sitechan table.

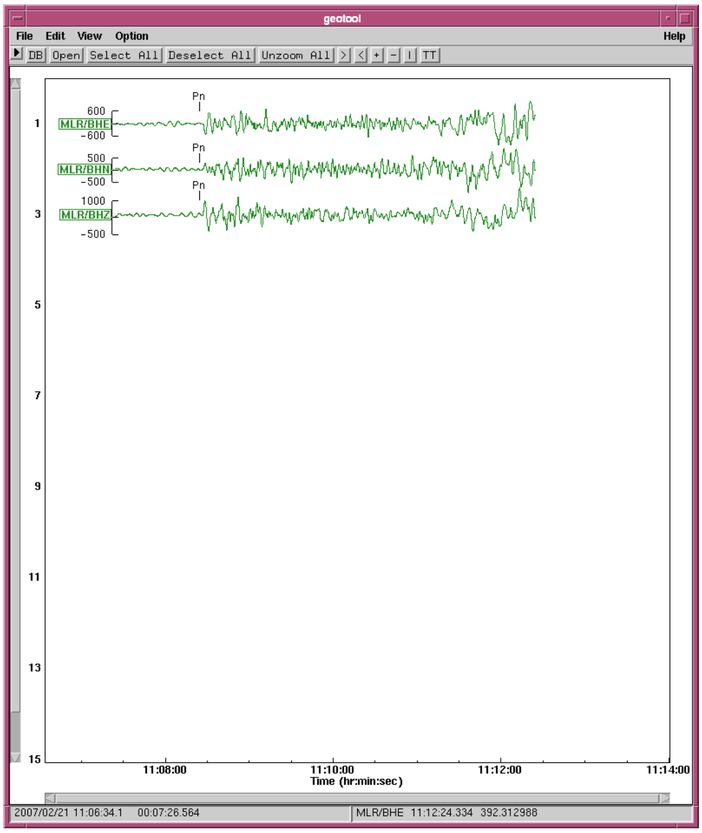


Figure 2. MLR time series.

A seismic array consists of many sites (or elements) which are geographically distributed over some area. For example, *Figure* shows a map of the sites of the KSRS array.

Typically at each site of the array there is at least one vertical sensor. For example, the vertical sensors at KSRS are:

KS01/SHZ	KS31/BHZ	KS32/MHZ
KS02/SHZ		KS33/MHZ
KS03/SHZ		KS36/MHZ
KS04/SHZ		KS37/MHZ

In addition to the vertical sensors, each IMS seismic array also contains at least one three-component station. The name of each time-series from an array is based on the sensor where the time-series was recorded.

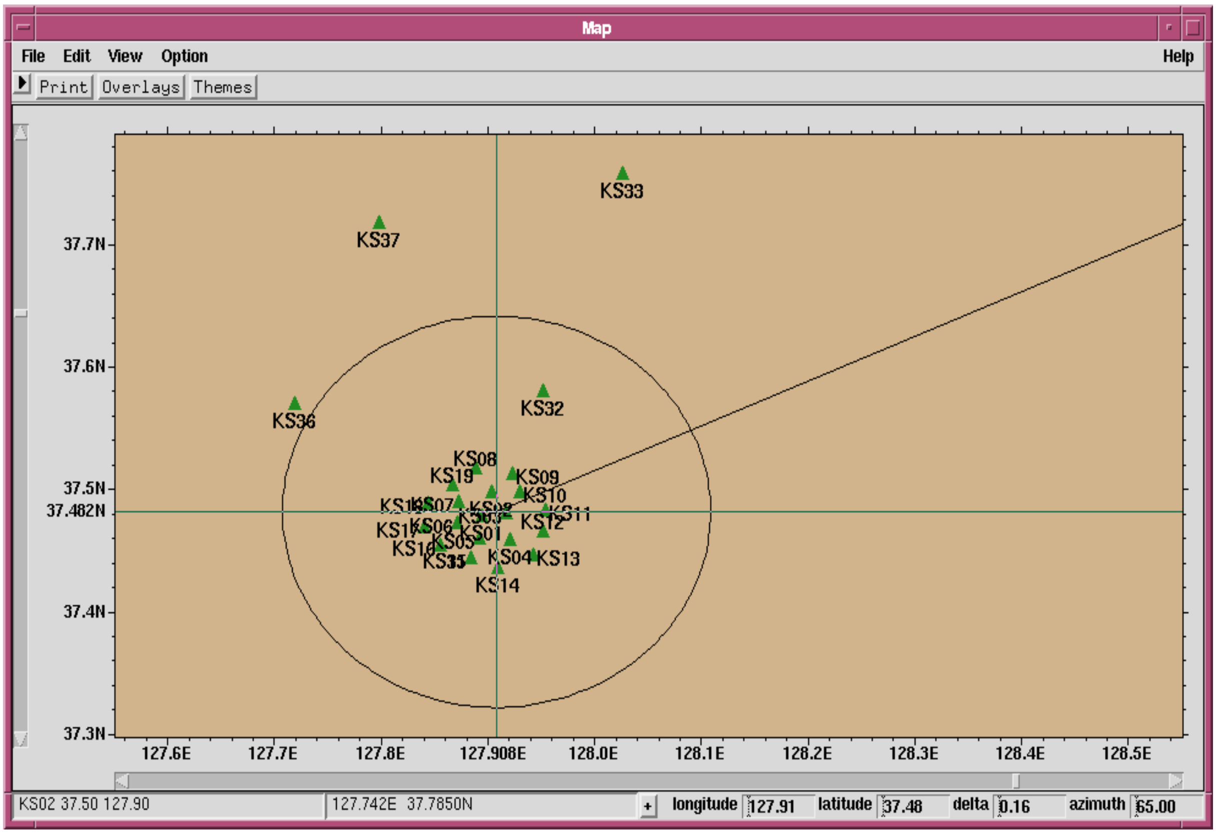


Figure 3. KSRS array

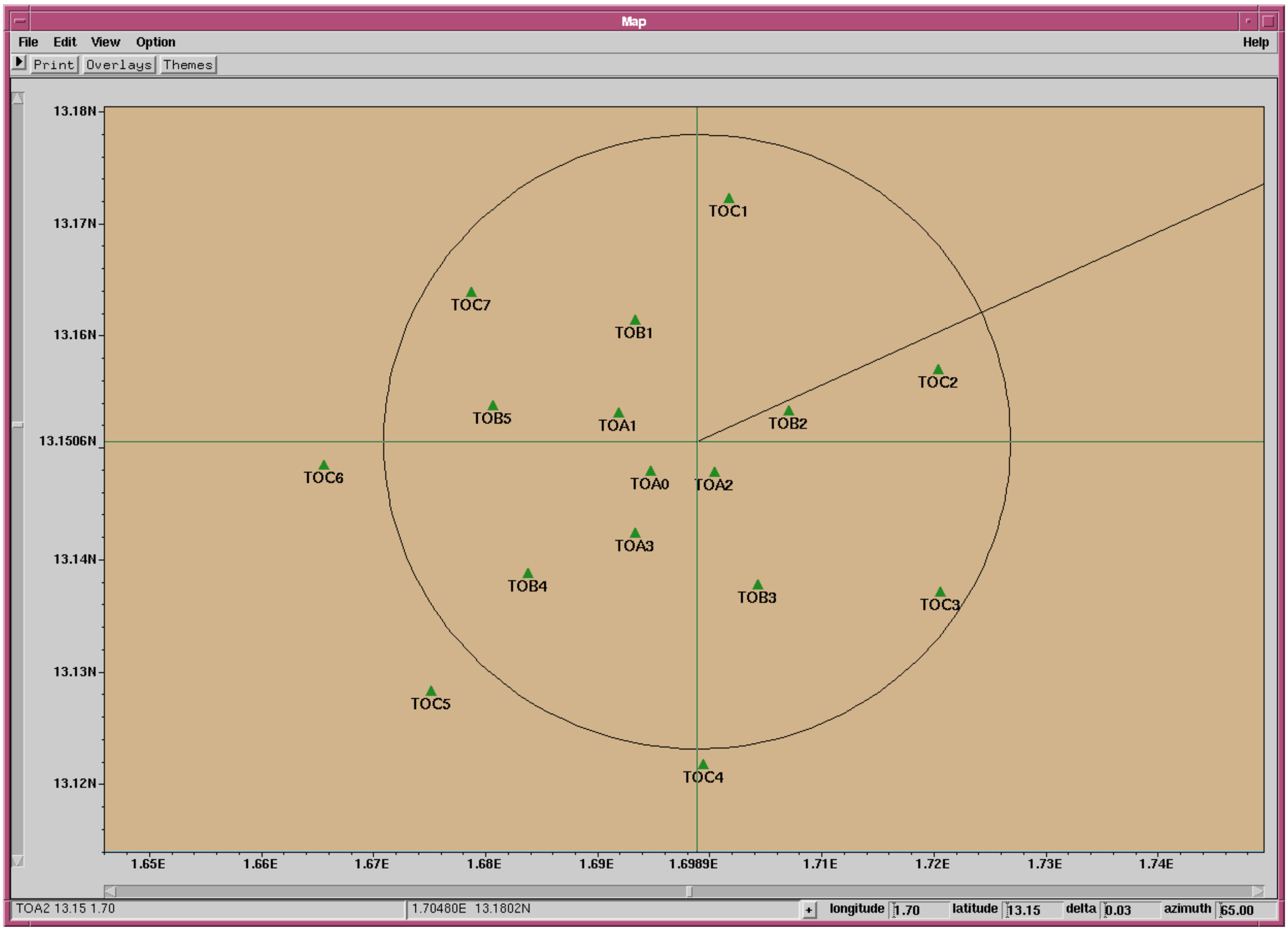


Figure 4. TOC array

When the vertical elements from an array are combined to form a beam, the beam is named for the array and not for any particular element. So the beams formed at the ARCES array are named ARCESS.

Hydroacoustic Stations

Hydroacoustic stations in the IMS network can be classified in two groups: T-phase stations and Hydroacoustic stations.

T-phase stations are based on land, and are similar to seismic three-component stations. The differences with seismic three-component stations are that T-phase stations typically have a higher sampling rate (to help distinguish between T-phases and H-phases), and T-phase stations are located very close to coastlines (in order to record T-phases).

Hydroacoustic stations consist of triplets of hydrophones placed in the SOFAR channel in the ocean. Each triplet has a triangular orientation. Depending on local bathymetry, each IMS Hydroacoustic station may have one or more triplets, where each triplet is used to monitor a different ocean basin.

Infrasound Stations

All infrasound stations in the IMS network are arrays. Typically there are between 4 and 9 elements, or sites, at each array. Each element produces a time series of the differential pressure. For example, one of the sites of the array I05AU is named I05H1, and the time-series from that element is named I05H1/BDF.

All names of infrasound stations in the IMS network begin with "I", followed by digit code from 01 to 60, followed by a two letter country name abbreviation. The numbers and country names are specified in Annex 1 of the Comprehensive Nuclear Test Ban Treaty. All infrasound channels currently used for processing at the IDC are named "BDF".

Automatic Processing at the IDC

After time-series data are received at the IDC, the data are automatically processed. The processing is done in different ways, depending on the type and configuration of the station. Detection processing is one of the initial processing steps.

During detection processing, arrivals are identified on the time-series. These arrivals are subsequently used to determine events.

During detection processing different configurations of parameters and sensors are used to identify detections at each station. For each station there are many different parameter configurations which are used, e.g., at seismic arrays, there can be hundreds of different beams formed during detection processing. Each of the configurations can be identified by a particular channel name

When a detection is made, this channel name is recorded as the channel name of the detected arrival. Consequently, when IDC arrivals are viewed in the Arrivals popup in geotool, the channel name of the arrival is not the channel name of the time series used to detect the arrival. Instead, the channel name refers back to the automatic processing configuration that was used to detect the arrival.

At three component stations, channel names recorded during detection processing often have a form like Z1030, which typically specifies that the Z (vertical) component was used, with a filter from 1.0 to 3.0 Hertz.

At arrays, channel names often have a form like AR_11, which specifies a beam formed with a specific slowness, azimuth and frequency band. In order to learn more, one must consult the beam recipe file for that station, and find configuration for that particular beam . For example, the following lines belong to a beam recipe file for ARCES. It can be seen that for AR-11 the beam is steered to the azimuth of 210º, with slowness of 0.1237 and is filtered from 0.75 to 2.25 Hz.

```
|name    |type|rot |std| snr   |azi    |slow    |phase   |flo | fhi | ford|zp|ftype|group  |
 AR_11    coh  no    0   3.90 210.0 0.1237   -        0.75 2.25   3   0  BP   a0-c-d
```

APPENDIX III

About the Qual column in Geotool's Arrival Popup

In the Geotool's Arrival popup there is a column "qual", which comes from the Arrival table in the IDC database. Traditional values in the qual column of the Arrivals popup are i, e and w. They denote onset quality i.e. the sharpness of the onset of a seismic phase. This relates to the timing accuracy as follows:

i (impulsive) - accurate to ±0.2 seconds

e (emergent) - accuracy between ± (0.2 to 1.0 seconds)

w (weak) - timing uncertain to > 1 second

Additional values are used in the qual column at the IDC, which come from the fkqual column of the detection table. These values record the result of automatic processing.

In this case qual is an integer quantifying the quality of the f-k spectrum. A value of 1 is high quality; value of 4 denotes low quality.

Default value '-' can belong to all types of phases and means that the qual value has not been specified.

An f-k quality measure (fkqual) is calculated to account for additional errors caused by noise, interfering signals, and deviation of the signal from the assumed plane-wave. When the amplitude of the second highest local maximum of the normalized spectral power is 6 dB or more below the absolute maximum over the f-k plane, fkqual is set to 1. In other words, fkqual=1 describes a situation where the difference from the highest to the next highest peak in the f-k plot is greater or equal 6 dB, which corresponds to a factor of 4. If this difference is below 6dB but greater or equal to 4 dB, fkqual is set to 2, and if it's below 4dB but greater or equal to 1 dB, or in case there is only one maximum, it is set to 3. In all other cases fkqual is set to 4.

APPENDIX IV

Seismic Phases

The following is an introduction to the types of phases detected by seismic, hydroacoustic and infrasound stations in the International Monitoring System (IMS).

SEISMIC PHASES

1. Local seismic events are detected by stations at distances of up to 6º. Typical phases associated with local events are listed in the table below :

PHASE TYPE	SUGGESTED FILTER RANGES (Hz)	SLOWNESS (seconds/degree)	COMMENTS
Pn	2-4 to 8-16	16 - 14	Typically impulsive, sharp arrival
Pg	2-4 to 8-16	~16	
Sn	unfiltered or 2-4	25 - 22	Difficult to find its onset time
Lg	1-2.5 to 2-4	33 - 20	Lg is most easily seen on the ib beam
Rg	0.5-2	40	Observed if the event is at or near the surface. Mining explosions can generate large Rg phases.

2. At source-to-receiver distances between 6º and 20º, events are called regionals.
They have (in most cases) the same phases as locals but with frequency differences, see the table below:

PHASE TYPE	SUGGESTED FILTER RANGES (Hz)	SLOWNESS (seconds/degree)	COMMENTS
Pn	1-2.5 to 2-4	14 - 10	Pn is more likely to be seen than Pg.
Pg	1-2.5 to 2-4	16 - 14	Determined by intervening crustal structure.
Sn	0.1-1 to 2-4	25 - 22	Often difficult to identify with F-k.
Lg	1-2 to 1.5-3	33 - 20	Typically large amplitude.

3. Events are called teleseisms when they are detected at distances beyond 20º.
The most prominent signals are body waves in their various forms of P, PcP,
ScP, PP, PkiKP, and PKP (and its branches). In general, the larger the event, the more phases (reflections and refractions) are produced.

PHASE TYPE	SUGGESTED FILTER RANGES (Hz)	Best Channel for Analysis	COMMENTS
P, PcP, ScP, PP, PKiKP, PKP	1-2.5 to 2-4	broadband vertical	Use the higher frequency band at regional distances
S, ScS, SS	1-2.5 to 2-4	broadband horizontal	ScS amd SS are often observed from deep, large events
PKKP, PKP2	1-2 to 1.5-3	broadband vertical	seen for mb > 4.2
Pdiff	1-2 to 1.5-3	broadband vertical	visible in the shadow zone as a low-frequency signal

HYDROACOUSTIC PHASES

T-phases

T-phases are ground-coupled hydroacoustic waves, which are most efficiently excited at sloping bathymetric features in the vicinity of epicenters.
T-phases are usually emergent and the maximum frequency rarely exceeds 30 Hz.
T-phases can have multiple peaks, depending on the size and complexity of the area of ground-to-water coupling.

H-phases

Often impulsive signals from in-water events (underwater explosions, airguns, volcanoes). H-phases are of short duration (< 20 sec, longer with reverberation coda) and cover a broad frequency range. Due to propagation effects the signal may become emergent at high latitudes and/or long ranges.
Once trapped in the deep sound channel, hydroacoustic waves propagate very efficiently over large distances at a speed of approximately 1.46-1.5 km/s. If two or more stations detect a hydroacoustic phase (T or H), the observed arrivals should be consistent in terms of (peak) arrival- time, back-azimuth and frequency content.

INFRASONIC PHASES

The phase “I” is a generic name given to an arrival picked on a coherent infrasound signal recorded by atmospheric pressure sensors. Infrasound waves are acoustic waves with frequencies below 15Hz. At the IDC, infrasound phases are commonly processed in the frequency band [0.04 - 4 Hz], and identified as I-phases when the horizontal velocity across the array is between 300 m/s and 450 m/s.
Strongly dependent on the temperature, pressure and wind profiles, infrasound waves propagate in the atmosphere and may return to the ground after reflection/refraction on various atmospheric layers at different altitudes. The turning height (height where the ray turns back to the ground) determines the type of I phase observed at the surface of the earth: Wave reflections in the troposphere (<10km), in the stratosphere (<50km), and in the thermosphere (<120km) are respectively identified as Iw, Is and It phases. This naming convention is not yet in routine at the IDC.

APPENDIX V

Open Database Connectivity

Open Database Connectivity (ODBC) is an open standard application programming interface (API) for accessing a database. By using ODBC statements in a program, you can access files in a number of different databases, including Oracle, Access, dBase, DB2, Excel and Text. In addition to the ODBC software, a separate module or driver is needed for each database to be accessed.

ODBC uses so called ini files to access configuration information. There are two types of ini files - system and user files. System ini files are designed to be accessible but not modifiable by any user. User files are private to a particular user and may be modified by that user.

The system files are odbcinst.ini and odbc.ini (note no leading dot).

The user file is ~/.odbc.ini in each user’s home directory (note leading dot).

odbcinst.ini

Holds information about the installed ODBC drivers and can only be modified by a system administrator (at the IDC this is done automatically while the driver package is installed).

Each driver has mandatory parameters that are specified here:

[oraodbc] (symbolic driver name used for referencing this driver in other configuration files)

Description= Open Source ODBC Driver for Oracle (textual description of the driver)

Driver=/opt/OSS/lib/liboraodbc.so (driver library implementing the ODBC interface)

Setup=/opt/OSS/lib/liboraodbcS.so (setup library knowing about specific driver parameters)

odbc.ini and .odbc.ini

Holds information about data sources (DSN = Data Source Name)

The system wide odbc.ini can only be changed by the system administrator and is searched when a DSN is not found in the users ~/.odbc.ini

Example DSN:

[idcdev_oraodbc] (Data Source Name (DSN) - symbolic name for the database connection)

Description=Dev Database, Open Source ODBC Driver for Oracle (textual description for the DSN)

Driver = oraodbc	(database driver name (as specified in odbcinst.ini))
DB=idcdev	(database name as specified in Oracle TNS)

The DSN parameters required largely depend on the driver used.

The only mandatory parameters are "Driver" and "Description".

In this case "DB" is a parameter that is specific to the "oraodbc" driver.

The "Oracle" driver calls the same parameter "Database".

If you do not have a system-wide ini file, each user must have one in his/her home directory. If you want to use different data sources from those in the system files, you must use your own .odbc.ini file too.

User names and passwords must be provided by the software/configuration files.

REFERENCES

Reference	Number	Title	Organisation	Revision/Date
DS	IDC-5.1.1Rev3	IDC Database Schema	CTBTO/PTS	November 2001
AISH	IDC.6.2.5	Analyst Instructions for Seismic, Hydroacoustic and Infrasonic Data		May 1998
SIP	CTBT/Geotool/SIP	Geotool Software Installation Plan, Version 0.5	CTBTO/PTS	3 October 2002
VI		Vibration Institute Terminology http://www.vibinst.org/vglos_a-e.htm	Vibration Institute	2001
CC		Cambridge Dictionary Online	Cambridge University Press	2002
WOP		Webopia, Online Encyclopedia http://www.webopedia.com/	Jupitermedia Corporation	2003
BR		Brian Robinson, brian@bec-kits.co.uk	Michigan Tech. Geological and Mining and Engineering Sciences	2000
INM	ISBN 3-9808780-0-7	IASPEI New Manual of Seismological Observatory Practice	Geo-Forschung-Zentrum Potsdam Potsdam, Germany Editor : Peter Bormann	2002
WI		http://whatis.techtarget.com/	TechTarget	2000-2004
ISOP		Draft Operational Manual for Seismological Monitoring and the International Exchange of the Seismological Data		2000
IHOP		Draft Operational Manual for Hydroacoustic Monitoring and the International Exchange of the Hydroacoustic Data		2000
IIOP		Draft Operational Manual for Infrasound Monitoring and the International Exchange of the		2000

		Infrasound Data		
IPSH	IDC-5.2.1Rev1	IDC Processing of Seismic, Hydroacoustic and Infrasonic Data	CTBTO/PTS	May, 2002

TERMINOLOGY

Glossary

Amplitude	The size of the wiggles on time series; more general the height of a wave-like disturbance (called waveform) from the medium (zero) level to its peak. In seismology ground motion amplitudes are usually measured in nanometers (10^{-9}m) or micrometers (10^{-6} m). Often the double amplitude (called peak-to-peak or peak-to-trough) is measured. [INM]
Array	An ordered arrangement of seismometers or other instruments, the data from which feeds into a central data acquisition and data processing unit. [INM]
Arrival	The appearance of energy on a time series record. [INM]
Associate	To assign an arrival to an event. [AISH]
Attribute (of arrivals)	A quantitative measure of an arrival such as onset time, (back)-azimuth, slowness, period and amplitude. [INM]
Azimuth	In general a direction measured clock-wise in degrees against north; used to measure the direction from a source to a station recording this event. [INM]
Background noise	Permanent movements of the Earth as seen on records caused by ocean waves, wind, rushing waters, turbulences in air pressure, etc. (ambient natural noise), and/or by traffic, hammering or rotating machinery, etc. (man-made noise). [INM]
Beam	A waveform created from array station elements that are specifically summed up for the direction of a specified backazimuth and apparent velocity (slowness). [INM]
Butterworth filter	The Butterworth filter is a long-established type of filter that is often used in electronics and geophysical data processing. It has the well-known and satisfactory characteristics of a very flat pass-band and is often used as an anti-alias filter. Sometimes it is called a maximally flat filter. [BR]
Channel	Channel identifier: the value is an eight character code that specifies a particular channel within a network (station), which, taken together with station and time, uniquely identifies time series data including the geographic location,

	spatial orientation, sensor, and subsequent data processing (beam channel descriptor). [DS]
Click	To press a mouse button, performing a particular function such as highlighting or selecting. [AISH]
CTBT	Comprehensive Nuclear Test-Ban Treaty [AISH]
CTBTO	Comprehensive Nuclear Test-Ban Treaty Organization; Treaty User group that consists of the Conference of States Parties (CSP), the Executive Council, and the Technical Secretariat. [AISH]
Event	S/H/I: Unique source of seismic, hydroacoustic, or infrasonic wave energy that is limited in both time and space. [DS]
FK	Frequency (f) versus wavenumber (k) analysis that maps the power seismic waves observed at an array as function of azimuth and slowness. [INM]
FT (Fourier Transform)	A transform is a mathematical operation that converts a function from one domain to another domain with no loss of information. For example, the Fourier transform converts a function of time into a function of frequency and vice versa. It is a mathematically rigorous operation, which transforms from the time domain to the frequency domain and vice versa. Jean-Baptiste Fourier was the famous many-talented French engineer, mathematician, and one time president of Egypt who devised the Fourier series and Fourier Transform. [VI]
Filter(ing)	Attenuation of certain frequency components of a signal and the amplification of others. For a recorded signal, the process can be accomplished electronically or numerically in a computer. Filtering also occurs naturally as energy passes through the Earth. [INM]
Foreign key	A foreign key, also called a foreign keyword, in a database table is a key from another table that refers to (or targets) a specific key, usually the primary key, in the table being used. A primary key can be targeted by multiple foreign keys from other tables. But a primary key does not necessarily have to be the target of any foreign keys. [WI]
Frequency	The number of times something happens in a certain period of time, such as the ground

	shaking up and down or back and forth during a seismic wave. The common unit of frequency is Hertz (Hz). [INM]
Hertz	The unit of frequency in the SI measurement system is the hertz, abbreviated Hz. One hertz is equal to one cycle per second. The name is in honour of Heinrich Hertz, an early German investigator of radio wave transmission [VI]
Hydroacoustic	Pertining to compressional (sound) waves in water, in particular in the ocean. Hydroacoustic waves may be generated by submarine explosions, volcanic eruptions or earthquakes.[INM]
IDC	International Data Centre [AISH]
IIR	Infinite Impulse Response (filters also referred to as recursive filters). [IPSH]
IMS	International Monitoring System [AISH]
Noise	Incoherent natural or artificial perturbations caused by a diversity of agent and distributed sources. One usually differentiates between ambient background noise and instrumental noise. The former is due to natural (ocean waves, wind, rushing waters, animal migration, ice movement, etc.) and/or man-made sources (traffic, machinery, etc.), whereas instrumental (internal) noise may be due to the "flicker" noise of electronic components and/or even Brownian molecular motions in mechanical components. Digital data acquisitions systems may add digitization noise due to their finite discrete resolution (least significant digit). Very sensitive recordings may contain all these different noise components, however, usually their resolution is chosen so that only signals and to a certain degree also the ambient noise are resolved. Disturbing noise can be reduced by selecting recording sites remote from noise sources, installation of seismic sensors underground) e.g., in boreholes, tunnels or abandoned mines.) or by suitable filter procedures (improvement of the signal-to-noise ratio). [INM]
Nyquist frequency	Half of the digital sampling rate. It is the minimum number of counts per second needed to define unambiguously a particular frequency. If the seismic signal contains energy in a frequency range above the Nyquist frequency the signal distortions are called aliasing. [INM]
Onset	The first appearance of a seismic or acoustic signal on a waveform. [AISH]

Origin	Place and time of a seismic, hydroacoustic, or infrasonic event. [AISH]
Phase	(1) A stage in periodic motion, such as wave motion or the motion of an oscillator, measured with respect to a given initial point and expressed in angular measure. (2) A pulse of energy arriving at a definite time, which passed the Earth on a specific path. (3) Stages in the physical properties of rocks or minerals under differing conditions of pressure, temperature, and water content.[INM]
P wave	A seismic body wave that involves particle motion (alternating compression and extension) in the direction of propagation. P waves travel faster than S waves and, therefore, arrive earlier in the record of a seismic event (P stands for “unda prima” = primary wave). [INM]
Primary key	A primary key, also called a primary keyword, is a key in a relational database that is unique for each record. It is a unique identifier. A relational database must always have one and only one primary key. Primary keys typically appear as columns in relational database tables. [WI]
S wave	A seismic body wave that involves a shearing motion in the direction perpendicular to the direction of wave propagation. When it is resolved into two orthogonal components in the plane perpendicular to the direction of the propagation, SH denotes the horizontal component and SV denotes the vertical component. [INM]
Save	To copy data from a temporary area to a more permanent storage medium. To record modifications to a file on to a disk or database. [WOP]
Seismology	The study of earthquakes and the structure of the Earth, by both naturally and artificially generated seismic waves. [INM]
Select	To choose a phase, station, or function in a user interface by clicking it with the mouse. [AISH]
Slowness	The inverse of velocity, in seconds/degree; a large slowness corresponds to low velocity. [INM]
Station	The site where geophysical instruments, e.g., seismographs or hydrophones, have been installed for observations. Stations can either be single sites or arrays. [INM]

Travel Time	The time required for a wave travelling from its source to a point of observation. [INM]
Travel time curve	A graph of arrival times, commonly of direct as well as multiply reflected and converted P or S waves, recorded at different points as a function of distance from the source. Seismic velocities within the Earth can be computed from the slopes of the resulting curves. [INM]
UNIX	An interactive, time-sharing operating system that originated at Bell Labs in 1969. In 1974, Unix became the first operating system written in the C language. Unix has since evolved into a powerful, stable open system that can be freely modified by anyone. Versions have been produced by companies, universities and individuals. Unix is widely used on workstations produced by Sun, IBM, Silicon Graphics and other companies. Unix, in the form of Linux is also becoming increasingly popular on personal computers. [WOP]
Waveform (data)	The complete analog or sufficiently dense sampled digital representation of a continuous wave group (e.g., of a seismic phase) or of a whole wave train (e.g.,seismogram). Accordingly, waveform data allow to reconstruct and analyse the whole record both in the time and frequency domain whereas parameter data describe the signal only be a very limited number of more or less representative measurement such as onset time, maximum signal amplitude and related period. [INM]
Wfdisc	Wave Form Disc. Waveforms are stored in ordinary disk files called wfdisc or “w” files. They are stored as a sequence of sample values (usually binary representation). [DS]

Abbreviations

CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organisation
IDC	International Data Centre
PTS	Provisional Technical Secretariat
SIP	Software Installation Plan
IMS	International Monitoring System

REFERENCES

Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) (2002). Editorial Manual.

International Data Centre (IDC) (2002). IDC Software Documentation Framework.