

Seismology Instruction with AmaSeis installation and use of the AS-1 seismometer

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Introduction

The AS-1 System was designed and built to make the science of seismology accessible to individuals and schools at a reasonable cost. With the AS-1 seismometer, you will be able to record and analyze earthquakes. In the classroom, the instrument will allow students to watch a quake roll in as it is occurring. Students will be able to watch a current event unfold, long before the media reports begin.

The AS-1 seismometer combined with the AmaSeis software allows real-time recording of seismic events and simplifies data analysis. The AmaSeis software automatically stores the ground movements so that the earthquake can be extracted and analyzed at a later time. The AS-1 System will record local quakes as small as magnitude 3.5 at a distance of 150 km, and larger quakes that occur anywhere in the world.

This manual will take you through the setup, software installation, and use of your AS-1 System. It will also give you an introduction to seismogram interpretation and analysis.

Seismometer Location

There are two important location considerations:

Seismometer

- Find a suitable location for the seismometer, preferably where local vibrations from people or machinery are at a minimum. Vibrations can be caused by air conditioning units, traffic, construction, or weather. The vibrations, called seismic noise, can hide seismic signals from smaller events. The best surface for the seismometer is a concrete or stone floor, in a location free of extreme temperature variations. A back room or storage closet out of the way is an ideal location for the instrument for optimal recordings. The seismometer can be out on display in a public place so that students can see it in operation, but the tradeoff is that fewer earthquakes may be detected because of increased local vibration.

Computer Display

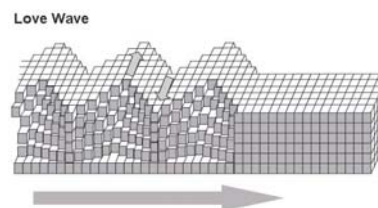
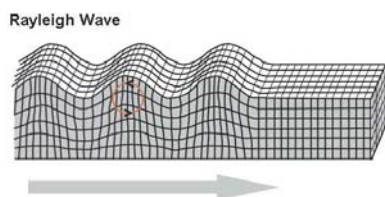
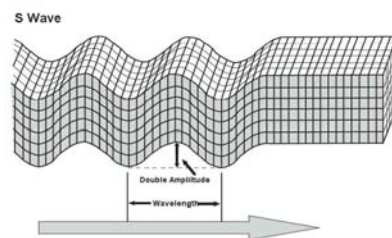
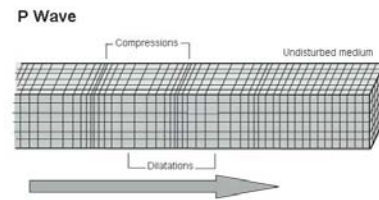
- The computer display showing the real-time data does not need to be close to the seismometer. The AS-1 is shipped with a 7 m (22 ft) paired shielded coaxial cable. The cable can be extended, allowing freedom of placement. We have purchased 21.5 m (70 ft), without loss of signal. Ideally, place the computer display in a prominent location either a classroom or public area where data can be monitored.

Seismology Overview

Earthquakes are caused by the sudden movement of blocks of the Earth's crust. Such movement involves the fracture of brittle rocks and the movement of rock along the fractures. A fracture in a rock along which movement occurs is called a fault.

When an earthquake occurs, it releases energy in the form of waves that radiate from the earthquake source in all directions. The different types of energy waves shake the ground in different ways and also travel through the earth at different velocities.

- The fastest waves, and therefore the first to arrive at a given location, are **P waves** (Primary waves) or compressional waves. Like sound waves, they move by alternately compressing and expanding material in the direction of motion.
- The next significant waves to arrive are the **S waves** (Secondary waves). They travel through the earth moving material up and down and side to side perpendicular to the direction of motion.
- The last to arrive are **Surface waves**, which travel slower than P and S waves and move the ground like a rolling ocean wave (**Rayleigh**) or side to side like a S wave (**Love**).



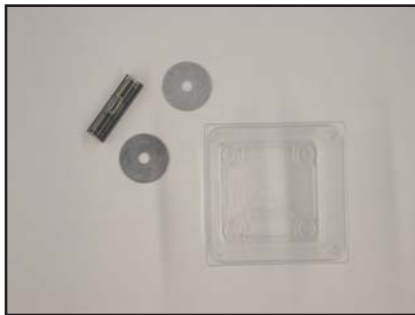
The distinction between types of wave motions is important because it determines what will be recorded on a seismometer. The AS-1 is a vertical component seismometer, which means that it records waves that displace the ground in a vertical direction only. Thus, we can expect to record P, S, and Rayleigh waves. Since Love waves move horizontally we will not be able to record them on this seismometer.

What can you expect to see in the AS-1 recording? Often the quality of the record will allow you to pick out each of the waves, but other times there may be noise on the seismogram that makes it difficult to distinguish the arrivals. See the **Tips for Picking P, S, and Surface Waves** section for examples of picking wave arrivals.

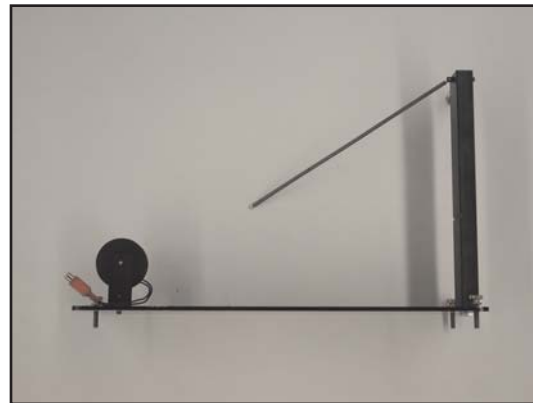
Packing List

The seismometer should arrive partially assembled.

- 1 Boom arm
- 1 Base with support post and attached spring and pickup coil
- 1 Damping fluid container
- 1 Interface box with 9-pin signal cable
- 1 Paired shielded coaxial cable
- 1 Power supply box
- 8 1 ½ inch diameter washers
- 1 Bubble level



**Damping Fluid Container
Washers
Bubble Level**



Base



Boom Arm



Paired shielded coaxial cable



Power Supply Box



Interface Box

Seismometer Assembly

1. Unpack the box completely and identify the parts from the packing list.

2. Place the base of the seismometer on a level surface. The base contains three leveling screws (Figure 1). Use the bubble level and adjust the leveling screws as needed. Check the level of the base both front-to-back and side-to-side.

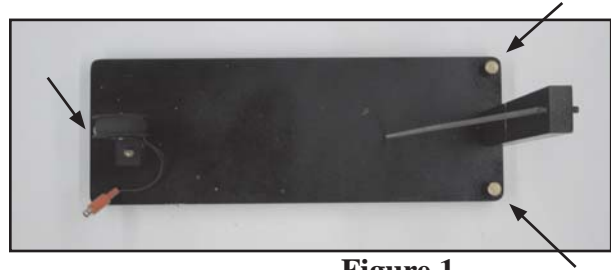


Figure 1

3. Remove the tape from the knife-edge at the end of the boom. **CAUTION:** The knife-edge is sharp, be careful not to cut your hand or damage the knife-edge. One end of the spring should be already connected to the upright support post. Attach the other end of the spring to the boom. Position the boom's knife-edge into the slot on the support post. The boom will be positioned at an angle, this is to be expected and will not damage the boom (Figure 2). **CAUTION:** Before moving the seismometer, disconnect the boom to prevent damage to the knife edge.



Figure 2

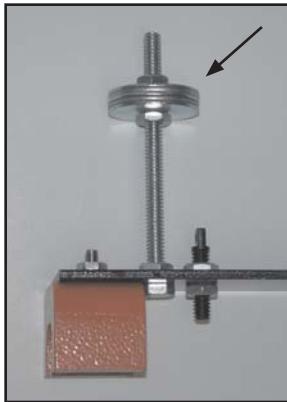


Figure 3

4. The upright bolt on the boom arm requires a stack of five washers approximately 2.5 cm (1 inch) from the top. Secure the stack between hex nuts (Figure 3)

With the added weight of the washer stack the boom arm should now be suspended over the coil. Center the magnet over the coil (Figure 4) by sliding the knife edge at the support post (Figure 5). The boom arm should move freely up and down, but the magnet should not touch the coil.

5. Carefully swing the boom up until it is possible to position the damping fluid container under the damping vane. Do not fill the container before it is positioned correctly.

CAUTION: Do not release the boom arm abruptly and allow the magnet to hit the coil. The equipment is sensitive, handle and adjust the parts carefully and gently.



Figure 4



Figure 5

6. Add fluid to the damping fluid container with either mineral oil or synthetic 10-40 motor oil. The fluid level should be 1 cm (3/8 inch) below the top of the container.

7. The boom arm must be level to accurately record vertical motion. Begin by positioning the bubble level on the boom, as shown in Figure 6. If needed, add one or two washer(s) along the boom until the boom is level. The positioning of the washers and the bubble level will vary. The bubble level and the balance washer(s) stay on the boom arm to keep it level.



Figure 6

8. Rotate the bubble level 90 degrees on the boom. Adjust the base leveling screws until the bubble is again centered. Rotate the bubble level 90 degrees back to its starting position.

9. Check that the magnet is still centered above the coil. The boom can be horizontally adjusted by pushing the boom at the support post (Figure 7). The boom arm should move freely up and down, but the magnet should not touch the coil.



Figure 7

10. Attach the paired shielded coaxial cable to the interface box. To attach a wire to a post the wire must pass through the hole on the post (Figure 8), then tighten the plastic knob. The center conductor of the signal cable (uninsulated wire) should be connected to the ground terminal (black post) on the interface box. The remaining two insulated wires should be connected to the two red posts. (Figure 9)

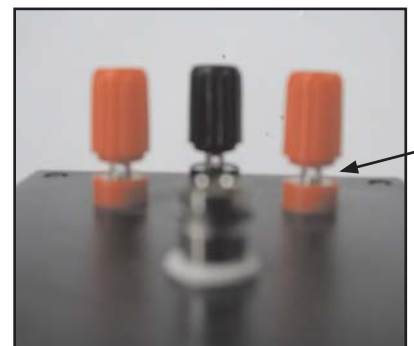


Figure 8

11. There are 2 cables leaving the interface box (Figure 10). The paired shielded coaxial cable (attached to the interface box in Step 10) has a red plug connector on the end. The other cable has a gray 9-pin connector. Install the 9-pin connector from the interface box to the serial port on your personal computer. If your serial card has a 25-pin connector, you will need to purchase a 9- to 25- pin adapter (available at Radio Shack).

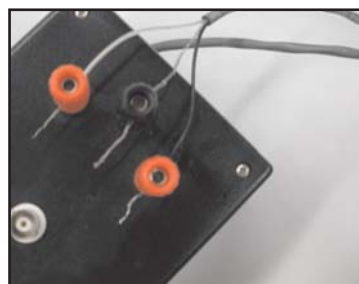


Figure 9



Figure 10

12. The paired shielded coaxial cable attached to the interface box has a red connector end. Plug it into the matching red connector on the seismometer base.

13. Plug in the 5-pin cable from the power supply box to the 5-pin slot on the interface box. Plug in the power cord from the power supply to an outlet (Figure 10).

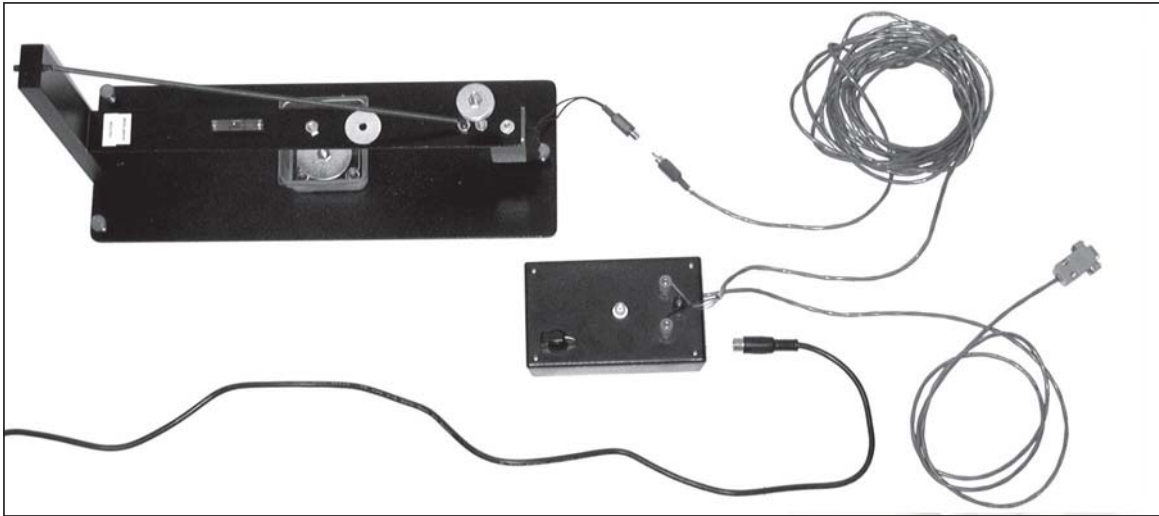


Figure 10

14. Cover the seismometer with the plexiglass display box. This will minimize motion of the boom due to air currents.

Software Installation

a) Installing from CD

- Exit all windows programs before inserting the CD.
- Insert the disk in your CD drive. The setup program will automatically be launched.
- Install using the default settings

b) Downloading AmaSeis

- Go to: <http://www.geol.binghamton.edu/faculty/jones/as1.html>
- Click on the link labeled **AmaSeisSetup.exe**
- Save the file to the **Desktop**
- Double click on the **amaseissetup.exe** on the desktop. This will launch the setup program

The standard installation will put files in **My Computer > System C > AmaSeis**

It will also put an icon under the Start menu **Start > Programs > Seismology > AmaSeis**

Installing a New Version of AmaSeis

Once AmaSeis is installed you will need to check for program updates every few months.

To upgrade your version go to:

<http://www.geol.binghamton.edu/faculty/jones/as1.html>

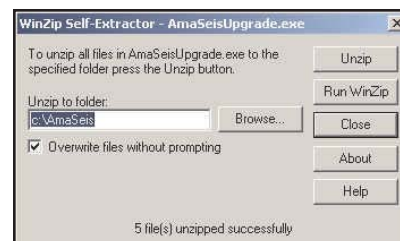
- Click on the link labeled **AmaSeisUpgrade.exe**

If prompted save the file to the **Desktop**

- Double click on the **amaseisupgrade.exe** file on the desktop

This will open the **WinZip Self Extracting Dialog Box**

- Click on **UnZip** to upgrade AmaSeis
- If your computer does not have the WinZip software, a copy is included on the AmaSeis CD.



Once the extraction is complete a message box will appear saying the upgrade was successful. The AmaSeisUpgrade.exe file can be deleted from the desktop.

Setting the Date and Time

Set the date and time on your computer before you launch **AmaSeis**. The software will record data based on these settings, and it is crucial that the time is as accurate as possible.

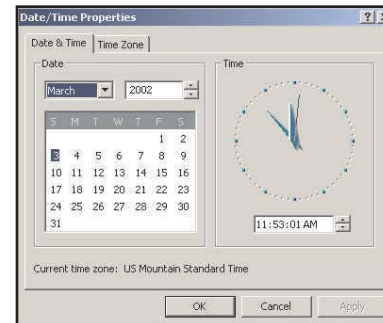
- Select **Start Menu > Settings > Date/Time**

Time is available from:

- <http://www.time.gov>

or you can also download a program to automate time updates over the internet (set to update hourly) from

- <http://www.boulder.nist.gov/timefreq/service/its.htm>



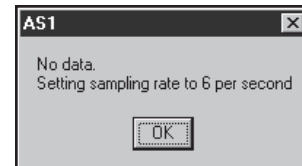
CAUTION: It is highly recommended that the time setting be checked on a monthly basis. Some systems lose accuracy as time passes, and even a discrepancy of a minute or two makes it very difficult to identify events.

Launching the Program

- To launch the software Double Click on the program icon
- The software assumes the AS-1 seismometer is attached to the communication port COM 1. If you receive a 'no data' error message, your computer is not receiving data from the seismometer. This will occur if the AS-1 is attached to a different port. To fix this error change the port setting.

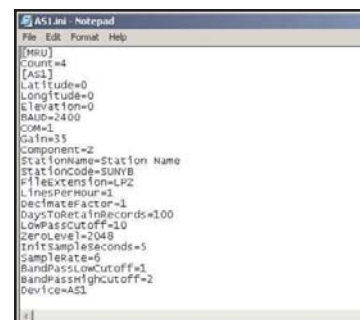


as1.exe



Changing the Port Setting


- Select **My Computer > System C > AmaSeis**
- Double click on **AS1.INI**
- Edit the **COM=1** line to match the computer settings
- Choose **File > Save** to save the changes
- Quit and relaunch **AmaSeis**
- This is a trial and error process. Experiment with different COM ports (1-4).



NOTE: If more than one version of **AmaSeis** is open an error will appear. Make sure to close all open programs, then launch the software by double clicking on the program icon.



Launching the Program

- To launch the software double click on the program icon 
- An introductory screen will display for approximately 5 seconds. After that time, the helicorder screen will appear. On the first launch of the software, the station parameters need to be set.

as1.exe

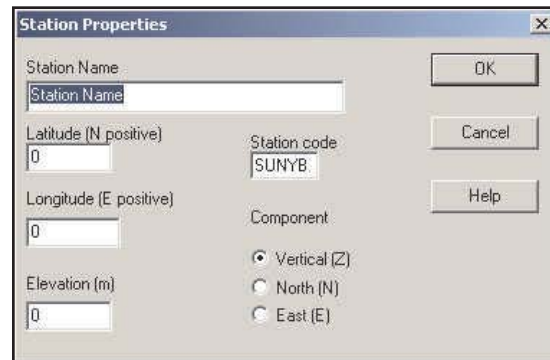
Setting Station Parameters

- From the Menu Bar choose **Settings > Station**
- Edit the station properties

- **Station Name**
- **Latitude**
- **Longitude**
- **Elevation**
- **Station Code**

This is assigned to the instrument by the network administrator
contact: braile@purdue.edu

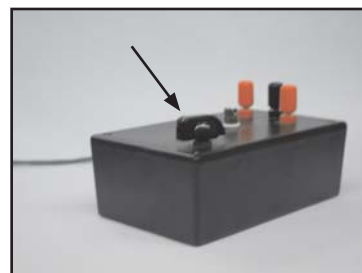
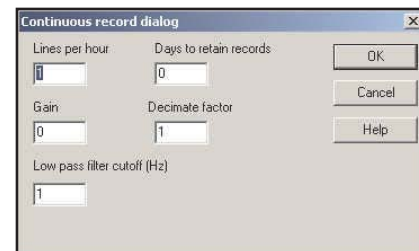
- **Component**
The AS-1 is a vertical component instrument



- To determine the latitude and longitude of your school consult a topographic map or online at <http://terraserver.homeadvisor.msn.com>
- Once the station properties have been entered, this information is stored and does not need to be entered again.

Finding the Trace

- From the Menu Bar choose **Settings > Helicorder**
- **Set the Gain to 25**
- The trace will now be drawn on the screen, and it may be visible. Or, more commonly, it is recording off the screen. Slowly move the potentiometer (black knob) on the AS-1 interface box until the trace is visible approximately at the center of the screen.



Centering the Trace

The trace is the actual recording of the seismometer. Each line on the screen represents one hour, so the trace moves slowly. The trace for the current hour should be displayed on the bottom line on the screen. Sometimes the trace is not centered on its hour line. To center the trace:

- From the File Menu choose **Settings > Set Zero Level**
- To shift the trace down to the correct hour line increase the value in the Set Zero Level pop-up window. Large jumps to the bottom of the screen require shifts in the 100s; fine-tuning of the trace positions requires shifts of less than 20.

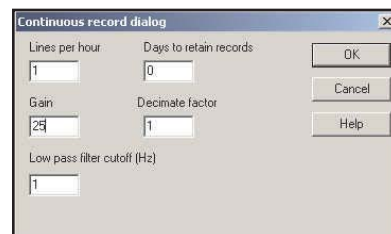


Instrument Settings

- From the File Menu choose **Settings > Helicorder**

- **Lines Per Hour** The display can show anywhere between 1 and 24 hours of data on the screen. This value defaults to 1, which means that the width of the screen represents one hour. The data for one day is contained on one screen, this can be useful in searching

If you change the lines per hour setting to 3, one hour of recording will take up three lines and 8 hours of recording will be seen on one screen rather than 24 hours. The value can be increased up to 60 to show details of the waveforms. This can be useful for in-class testing and demonstrations.



- **Gain** This setting adjusts the amplification of the signal and varies with the location of the seismometer. Choose a gain setting such that the background noise is just visible. For example, there is always a little bit of up and down movement of the trace. A values between 25-50 is suggested. If the trace is too noisy, adjust the gain to a lower value.
- **Low pass filter cutoff** Set to 3 Hz.
- **Days to retain records** This setting controls how many days are available to scroll back through when looking for events. All data will be stored by the system until it is deleted by the user, this setting just controls how much is available to display.
- **Decimate Factor** This setting controls the number of plotted points when the trace is redrawn, but it does not affect the quality of the recording. Leave this setting at the default setting of 1.

Congratulations!

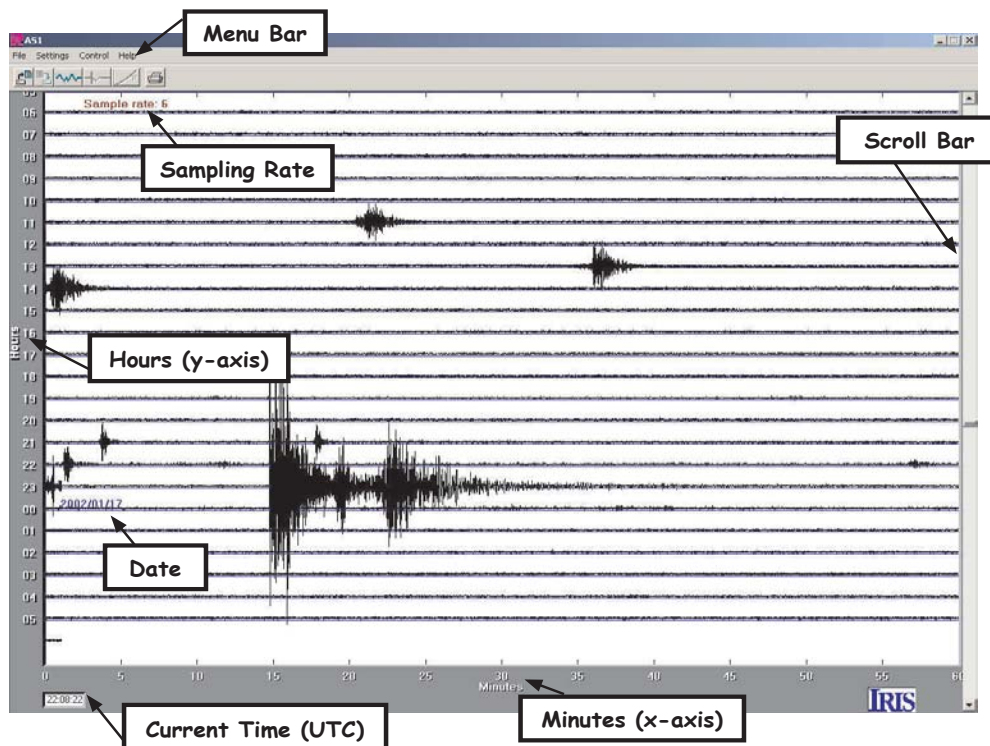
By reaching this point, your seismometer is accurately recording and will store any events that it is able to detect. The AmaSeis program needs to be running at all times in order to collect data, however the display window can be minimized and the program will still record.

Helicorder Screen Overview


The window that appears when the program is launched is called the helicorder screen. The recording emulates what appears on a drum recorder.

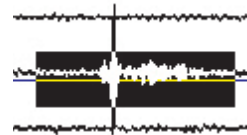


- Using default settings each horizontal line represents an hour. The current time (UTC) is found in the bottom left corner of the screen. The trace should be recording along the bottom hour line.
- The date is posted on the 00 hour line. The scroll bar along the right side of the window can be used to scroll back through the earlier recorded data.
- The sampling rate is shown near the top left of the screen and is the data per second that are sent from the seismometer to the computer. It should be a number between 6.1 and 6.2 samples per second for the AS-1. This rate is determined when the introduction screen is visible, by counting the number of data points that arrive in 5 seconds.



Saving an Event

- From the helicorder screen **highlight** an event by holding down the left mouse button and scrolling over the event
- Click the extract icon below the Menu Bar 

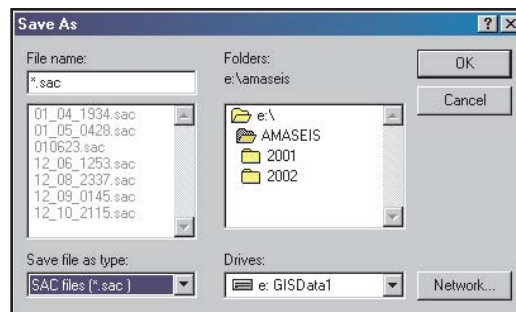


This will open the **Extract Event Screen**


- To save the data in a file select **File > Save As**
- In the upper left corner of the **Save As Dialog Box** name the file (change the * in front of .sac to your filename). Please use the following naming convention: two digit year, two digit month, two digit day, two digit hour, station code (**yymmddhhstcode**)

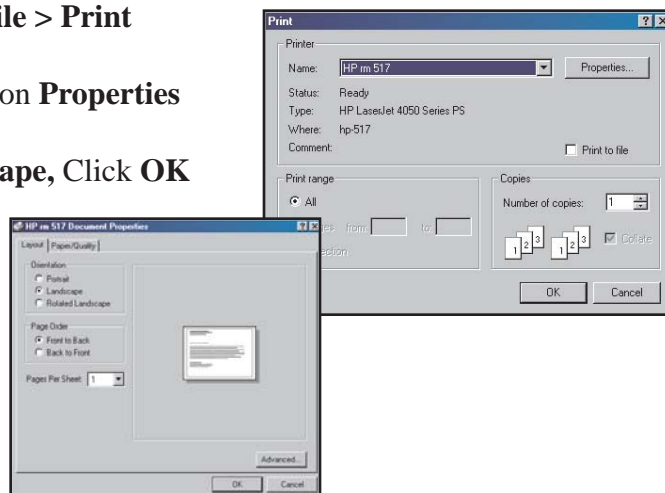
Example: Tempe High School (thaz)
recorded an event at 19:30 on June 23, 2001
01062319thaz.sac

- In the bottom left hand corner, set the **File Type** to **SAC**
- **Send us your event!** You can upload the SAC file through your internet browser at <http://www.geo.arizona.edu/geod/spinet>



Printing an Event

- From the Extract Event screen click on the print icon  or from the Menu Bar choose **File > Print**
- At the Print Dialog Box click on **Properties**
- Set the Orientation to **Landscape**, Click **OK**
- Click the **OK** button



Extract Event Screen Overview

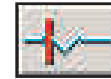
The highlighted portion of the trace is displayed in this window.

- Time Expansion expands the x axis. For example, when the time expansion is 2, the time axis is doubled in length allowing you to zoom in. In this case only the first half of the waveform is displayed. To see more of the waveform use the scroll bar at the bottom of the screen.

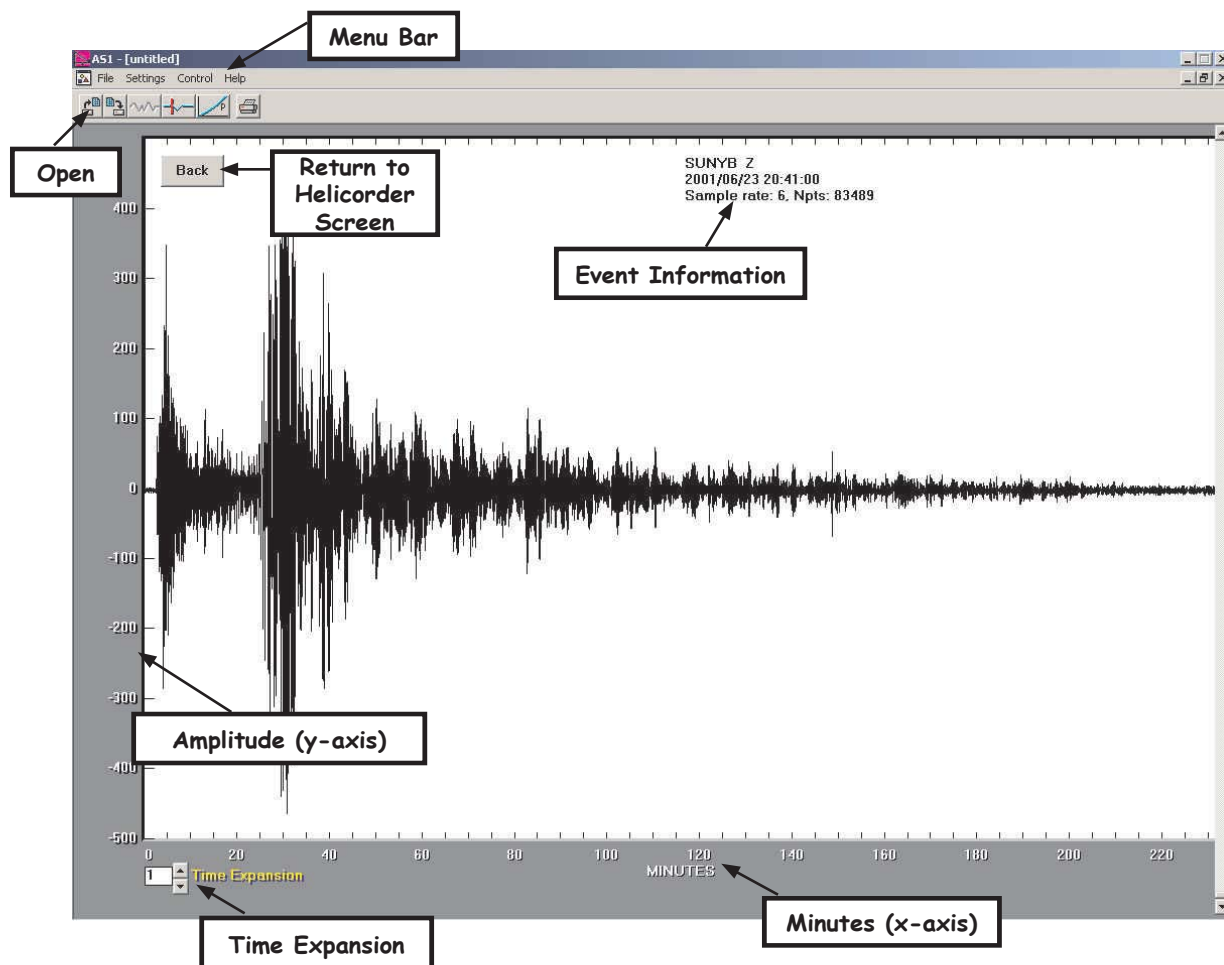
- Load a previously saved event using the **Open Icon**.



- The **Pick Arrivals Icon** is used to mark wave arrivals. For regional events it is sometimes easier to mark the P wave and Surface wave arrivals. For global events, mark the P and S wave arrivals.

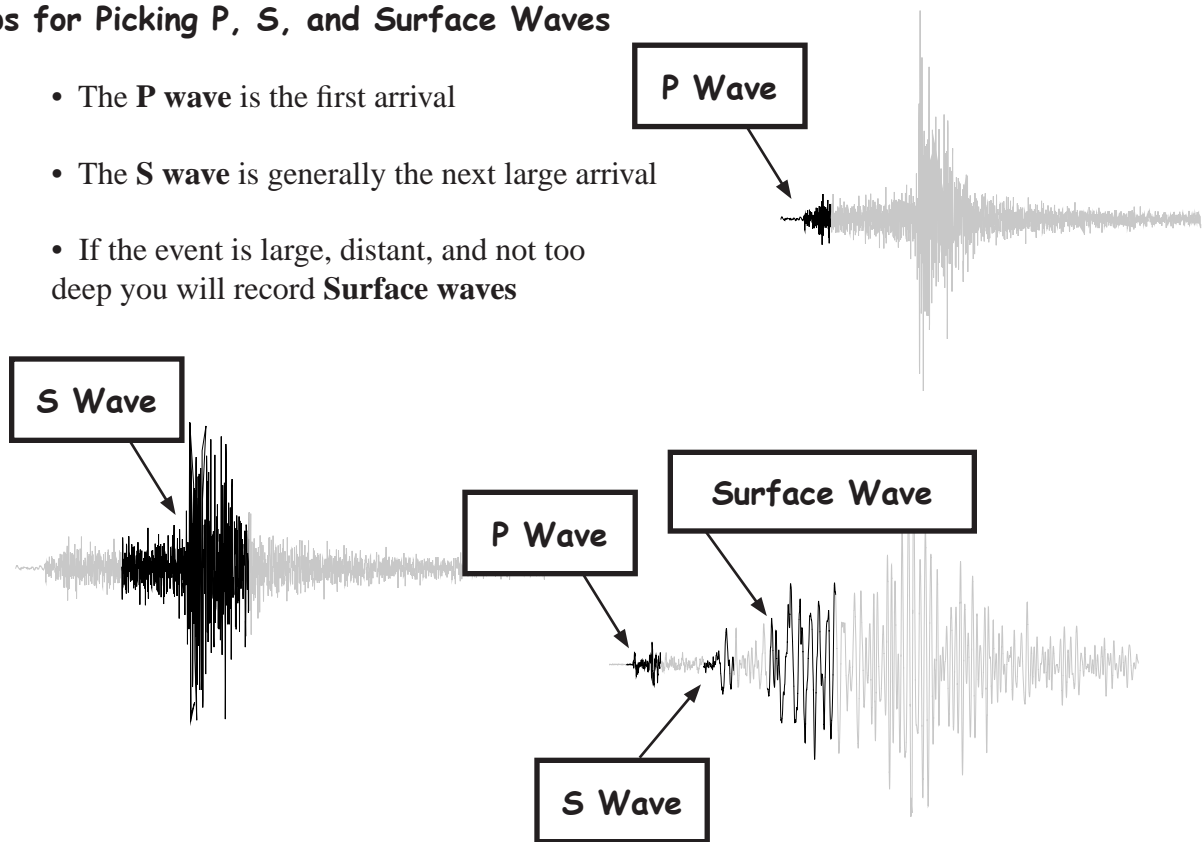


- The **Travel Time Curves Icon** is used to determine the distance from the event to your station using the time delay between wave arrivals.



Tips for Picking P, S, and Surface Waves

- The **P wave** is the first arrival
- The **S wave** is generally the next large arrival
- If the event is large, distant, and not too deep you will record **Surface waves**



Picking Arrivals in AmaSeis

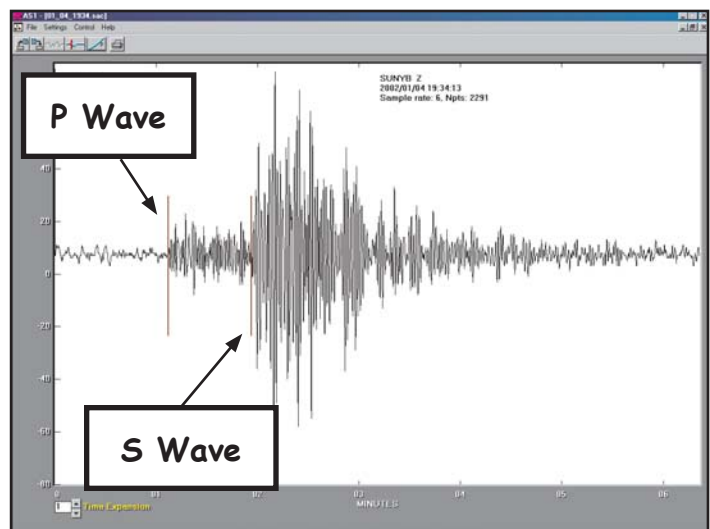
- On the **Extract Event Screen** click on the **Pick Arrivals Icon**.



- Mark the arrival by positioning the mouse on the trace at the arrival and clicking with the **Left Mouse Button**.

- For regional events, mark the P wave and Rayleigh wave arrivals. For global events, mark the P and S wave arrivals.

- Picks will be marked with a vertical brown line. To repick, click on the **Pick Arrival Icon**.

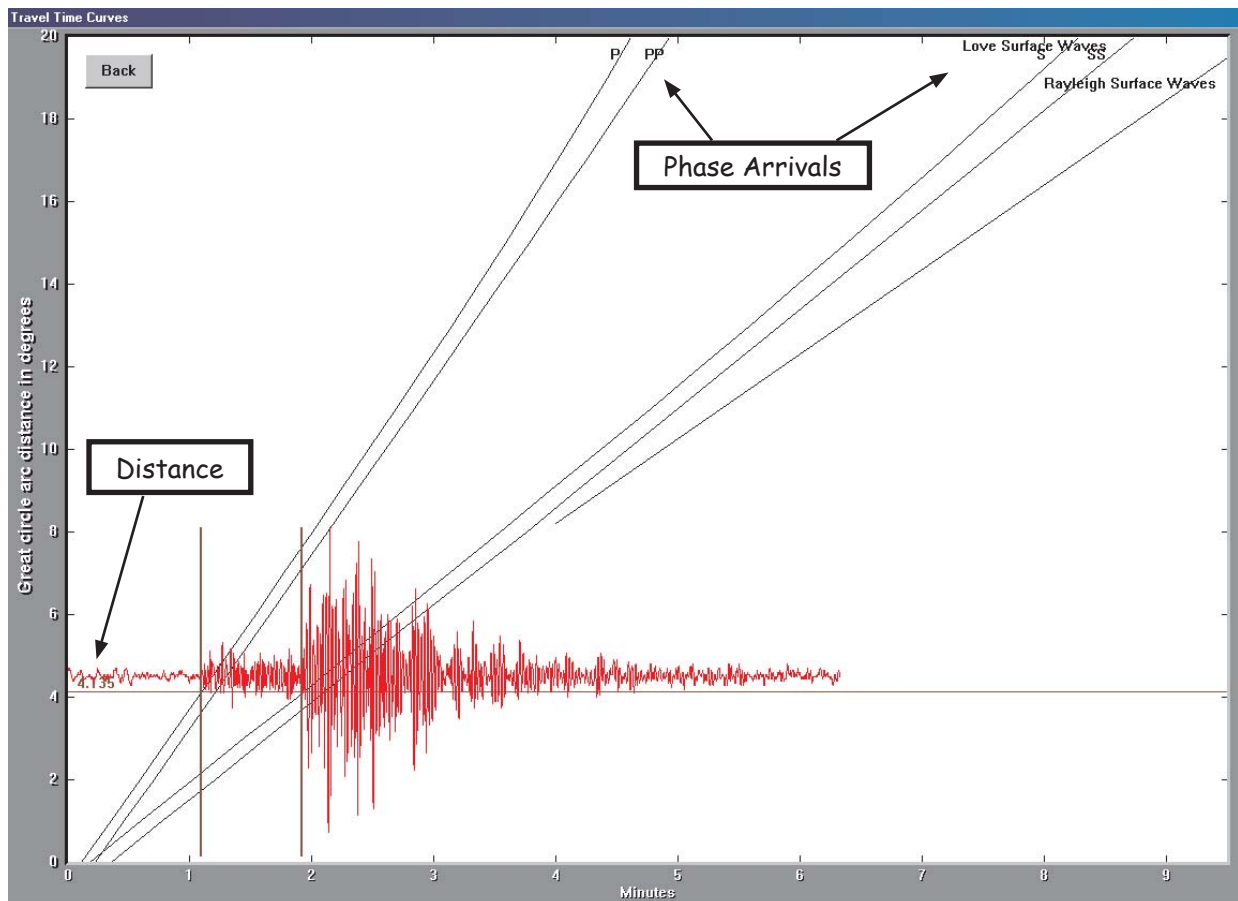


Using the Travel Time Curve

- After picking arrivals in the **Extract Event Screen** click on the **Travel Time Curve Icon**



- Using the Mouse, drag the trace up or down along the vertical axis to align the **Arrival Picks** with the corresponding **Phase Arrival Lines**.
- Once the record is aligned with the travel time curve, the distance to the event is reported on the left under the trace.
- The distance is reported in degrees. To convert from degrees to kilometers:
1 degree = 111 kilometers

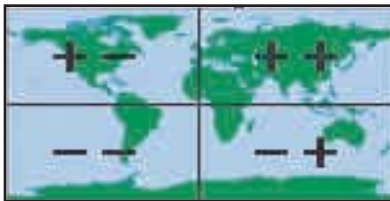


Storing Event Information

Once you have identified an event that your AS-1 has recorded, you can store information about it for future instructional use. There are many applications for using real-time seismic data in the classroom.

To store data about an event:

- On the **Extract Event Screen** select **Settings > Event**
- Enter the event information in the **Event Dialog** box.
- The latitude and longitude must be entered as signed numbers, negative for west longitude and negative for south latitude.



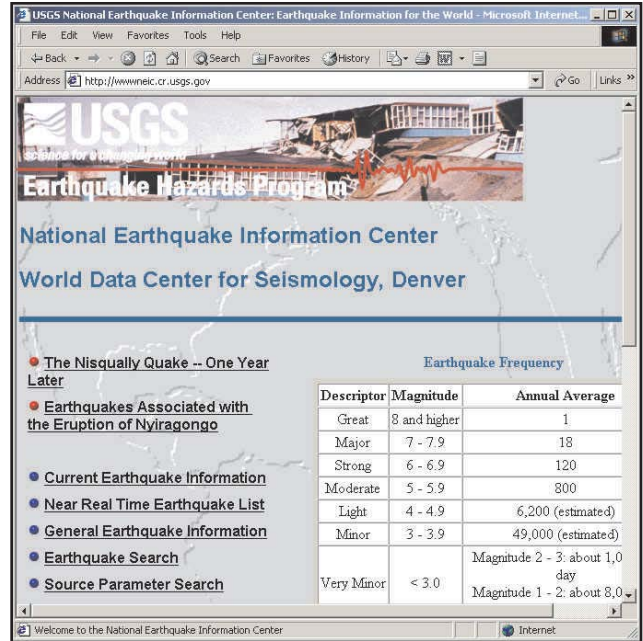
Event name			Magnitudes			
Name			MB:	0		
Year	Month	Day	MS:	0		
2001	12	18	ML:	0		
Hour	Minute	Second	MW:	0		
21	33	10.66				
Latitude (N positive)		Longitude (E positive)		OK		
0		0		Cancel		
Depth (km)		Time from event time to beginning of record (s)		Help		
0		0				

NOTE: Using internet earthquake databases is described in the next section. Use these databases to gather the above information about the event.

Data Identification and Event Location

Searching for Current Events in NEIC (National Earthquake Information Center)

- Launch your browser and go to: <http://wwwneic.cr.usgs.gov>
- Select **Near Real Time Earthquake List**
- The 20 most recent events will be displayed



Searching for events from the last month:

- Scroll down and click on **Last 30 Days of Earthquake Activity**

Searching with NEIC

- Launch your browser and go to <http://wwwneic.cr.usgs.gov>
- Select **Earthquake Search**.
- Scroll down and select **Global Search Area**.
- Use the default selection for the **Output File Type** and **Database**.
- In the **Optional Search Parameters** fill in a date range to narrow down the records. It is not necessary to fill in all the fields. NOTE: If you enter a minimum magnitude, the site requires a value for the maximum magnitude.
- Click on **Submit Search**

Optional Search Parameters:

Date
 Starting Year Starting Month Starting Day
 Ending Year Ending Month Ending Day

Magnitude
 Minimum Magnitude Maximum Magnitude

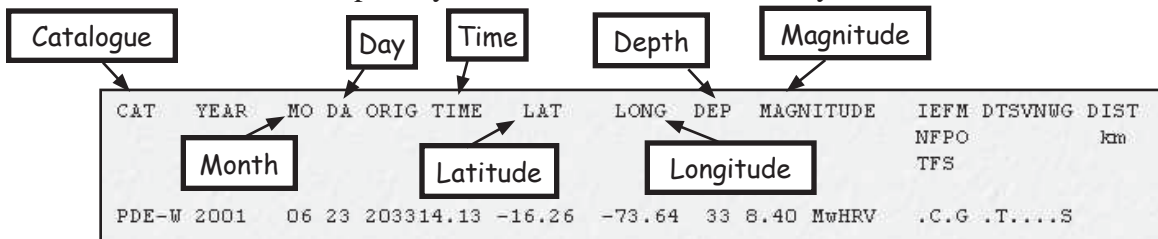
Depth
 Minimum Depth Maximum Depth

Intensity
 Minimum Intensity Maximum Intensity

Submit Search Clear form

Site Output:

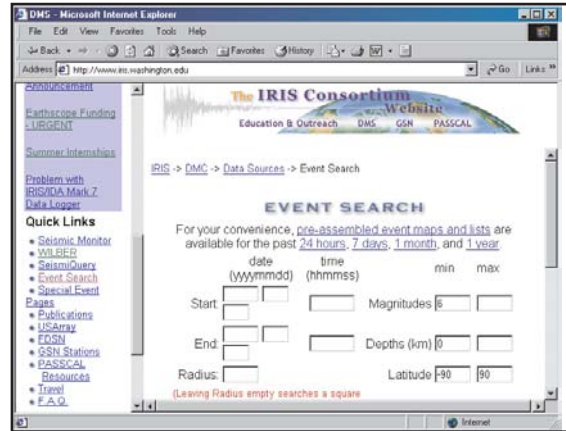
When the search is complete, you will see a table of data in your browser window.



Searching the IRIS Earthquake Database

The IRIS event search is very similar to the NEIC event search. However, IRIS also provides a geographical location in addition to the latitude and longitude.

- Launch your browser and go to <http://www.iris.washington.edu>
- **Scroll down in the left frame** and choose **Event Search**.
- Enter a date range in the search form.
- This site does not require all fields to be filled in.
- Click on **Submit Search**



Site Output

When the search is complete, you will see a table of data in your browser window.

TIME	LAT	LON	DEP	MAG	TYPE	CATALOG	REGION
2001/01/26 03:16:40.5000	23.419	70.232	16	8.0	MS	MHDF	INDIA

Labels pointing to table columns: Month (TIME), Day (TIME), Time (TIME), Latitude (LAT), Longitude (LON), Depth (DEP), Magnitude (MAG), Magnitude Type (TYPE).

Searching for Mining Seismicity

NEIC catalogues routine mining seismicity in the United States.

- Launch your browser and go to: <http://wwwneic.cr.usgs.gov>
- Select **Routine U.S. Mining Seismicity**



- Scroll down through the catalogues and click on the month of interest.

Site Output

ORIGIN TIME UTC	GEOGRAPHIC COORDINATES	DEPTH	MAGNITUDE GS	SD	GAP	NO. STA USED	F-E REGION, CONTRIBUTED MAGNITUDES AND COMMENTS
DAY HR MN SEC	LAT LONG	mb MS					
01 21 05 29.2*	43.614 N 105.532 W	0 G		0.9	242	10	WYOMING. ML 3.3 (GS). 40 miles ENE of Midwest.
03 21 07 54.8*	43.725 N 105.319 W	0 G		0.6	246	13	WYOMING. ML 3.3 (GS). 40 miles SSE of Gillette.
04 21 21 48.8	36.378 N 110.343 W	0 G		0.6	176	8	EASTERN ARIZONA. ML 2.4 (GS). 25 miles SSW of Kayenta.
04 22 00 16.8*	33.213 N 109.262 W	0 G		0.7	257	8	EASTERN ARIZONA. ML 3.4 (GS). 35 miles NE of Safford.

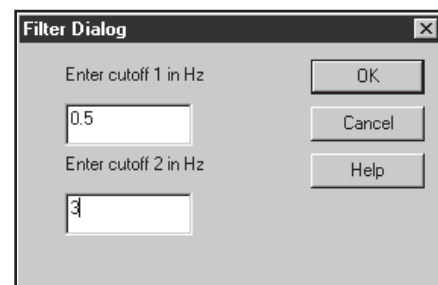
Labels pointing to table columns: Date (ORIGIN TIME UTC), Latitude (GEOGRAPHIC COORDINATES), Longitude (GEOGRAPHIC COORDINATES), Depth (DEPTH), Region (F-E REGION), Magnitude (MAGNITUDE GS).

Filtering

Local and regional event (less than 10 degrees distance) earthquake seismograms are usually dominated by short period (near 1 s period) energy. Teleseismic (distant earthquakes, 10 to 180 degrees) recordings usually consist of lower frequency (longer period) energy and often have prominent surface wave arrivals of 12 - 30 s period. The AS-1 seismometer has a natural period of oscillation of about 1 s. To make the seismometer more useful for recording distant earthquakes, the long period (greater than 10 s) response of the instrument is enhanced. Because background noise is always present, filtering of the records is often desirable to enhance the earthquake signals.

Local and Regional Events

- In the Extract Event Screen, from the File Menu Bar select **Settings > Filter**
- A useful filter is a bandpass filter with frequency cutoffs of 0.5 Hz and 3 Hz (isolating the short period energy: 2 s - .333 s period).

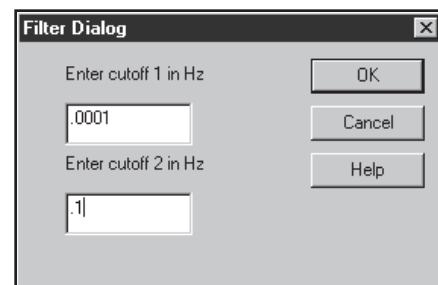


- Enter the two frequencies in the **Filter Dialog Box**.

Global Events

For teleseismic or distant earthquakes, lower frequency filtering often enhances the seismogram, especially the surface wave arrivals that are prominent for shallow focal depth (0 - 70 km) earthquakes.

- In the Extract Event Screen, from the File Menu Bar select **Settings > Filter**
- Suggested filter cutoffs for lower frequency (longer period) signal enhancement are 0.0001 Hz and 0.1 Hz (isolating the longer period energy: 10,000 s - 10 s period).



- Enter the two frequencies in the **Filter Dialog Box**.

Default Low Pass Filter

- AmaSeis's default low pass filter is a display filter that removes high frequency noise. We recommend that this be set to 3 Hz.

Acknowledgements

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If you have questions or comments about this manual please email:
spinet@geo.arizona.edu

Additional Resources and Information

AmaSeis Updates

- <http://www.geol.binghamton.edu/faculty/jones/as1.html>

Identifying Earthquakes or Mining Seismicity

- <http://wwwneic.cr.usgs.gov>
- <http://www.iris.washington.edu>

Web Sites for Information and Curriculum Resources

- <http://www.eas.purdue.edu/~braile/>
- <http://www.geo.arizona.edu/geoed/spinet>

Time

- <http://www.time.gov>
- <http://www.boulder.nist.gov/timefreq/service/its.htm>

Latitude and Longitude

- <http://teraserver.homeadvisor.msn.com>

California Earthquake Information

- <http://www.scec.org/earthquakes/>
(select **Recent California Earthquakes**)