

Seismology Instruction with AmaSeis

Installation and use of the AS-1 seismometer

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IRIS Seismographs in Schools Program
www.iris.edu



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Overview

Seismology offers unique opportunities to enrich earth science and physics curriculum. This document was created to assist teachers getting started in the exciting field of educational seismology. It provides a general overview of assembly, installation and configuration of the AS-1 educational seismometer using the AmaSeis software developed by Alan Jones.

As the educational seismology community continues to grow, resources are continually developed and refined, the AmaSeis software program is updated and improved. Additional software programs are under development to integrate with AmaSeis and AS-1 data. Today, there are many tools for teachers using real-time seismic data in the classroom.

This document will remain an introductory document to help teachers get started collecting and using real-time data in the classroom. Additional documents on advanced features in AmaSeis and other software packages are available on the SpiNet website. Web links to additional resources can be found in Chapter 6 of this document.

Acknowledgments

Assistance for production of the manual has been provided by IRIS as part of their Seismographs in Schools Program.

Additionally, we would like to thank Dr. Michelle Hall and Dr. Terry Wallace for their guidance on this project.

If you have questions or comments about this manual please email: spinet@scieds.com

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1 Getting Started

Introduction

The AS-1 seismometer 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 earthquakes as small as magnitude 3.5 at a distance of 150 km, and earthquakes magnitude 6.5 or larger that occur anywhere in the world.

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

Seismometer Location

There are two pieces of equipment for which a location must be selected, the seismometer and the computer display.

- 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. However, the seismometer can be out

on display in a public place so that students can see it in operation. The trade-off is that fewer small earthquakes may be detected because of increased local vibration, but students seeing the instrument is important. Often rooms have solid, built-in cabinets along the walls that can be a good spot for seismometer placement. The instrument should be shaded from direct sunlight, as a great deal of noise will be generated when sunlight strikes the instrument.

- 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) cable with one shielded pair. This cable length can be increased, allowing freedom of placement. We have purchased a 21.5 m (70 ft) cable from a local electronics store and used it without loss of signal. If a replacement cable is used, a connector end will need to be soldered to the replacement cable (also available from most electronics stores). In addition to a longer paired-shielded cable, some teachers have increased the length of the serial cable (cable to the computer). Ideally, place the computer display in a prominent location, either a classroom or public area, where data can be monitored.

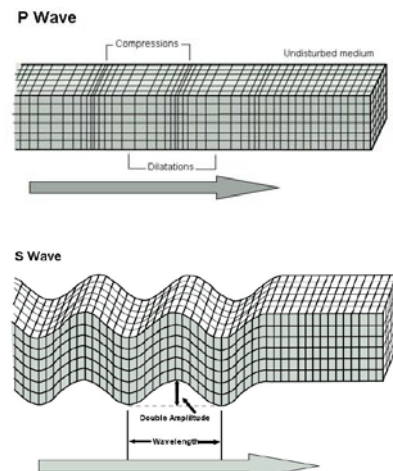
Two computers can be attached to one AS-1 black box. To do this, a serial splitter is used so that the serial data may be sent to two computers at the same time. For more information about this option email spinet@scieds.com.

Seismology Overview

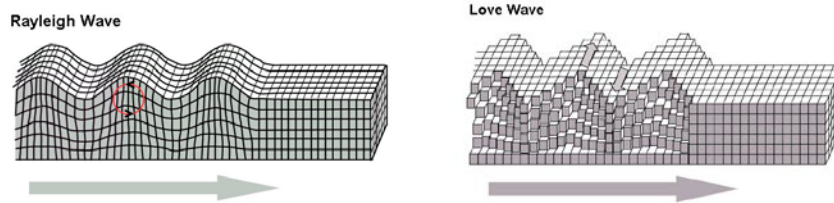
Earthquakes are caused by the sudden movement of blocks of the Earth's crust. Such movement involves the fracture of brittle rocks and the movement of rock along the fractures. A fracture in a rock along which movement occurs is called a fault.

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 S waves (**Love**). These waves are constrained to travel within the upper layers of the Earth.



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 they will not be recorded 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.

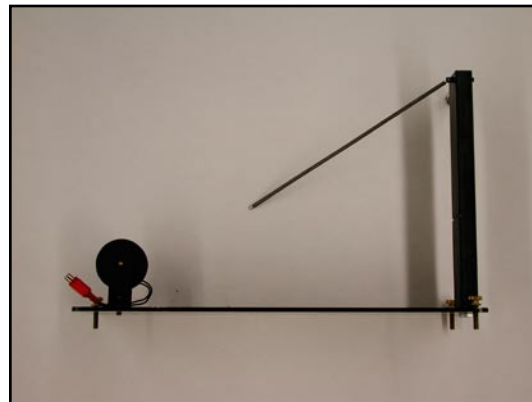
Seismometer Assembly

2

Packing List

The seismometer should arrive partially assembled with the following pieces.

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



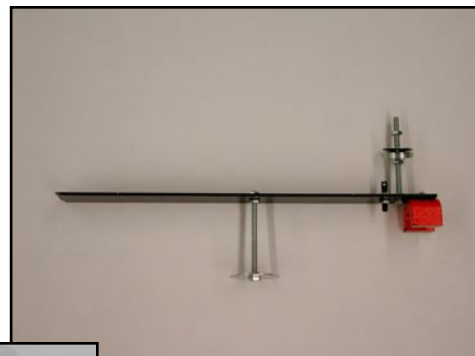
Base with coil and spring



Damping fluid container

Washers

Bubble level



Boom arm with attached damping washer, magnet, and washer post



Paired shielded coaxial cable



Power supply Box



Interface box (also known as the Black box)

Seismometer Assembly

1. Unpack the box completely and identify the parts from the packing list (p 2.1).
2. Tighten the coil to the base plate of the seismometer by turning the screw clockwise. The coil should be upright, perpendicular to the base, and may require tightening and/or gentle bending to orient correctly. Tighten the bolt that holds the magnet to the boom arm.

3. 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. Level the base, first across the short dimension and then along the long dimension.

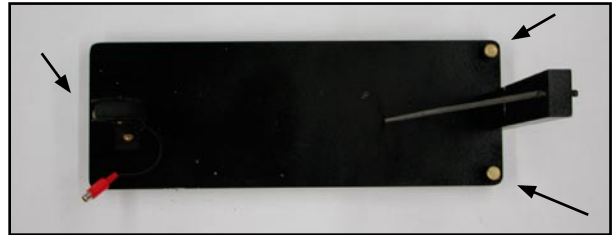


Figure 1

4. On the boom arm check that all of the nuts are tight that hold the damping washer, the magnet, and the washer post.

5. 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. Pour a small amount of oil in your damping cup and spread one drop on the knife edge. This oil is to lubricate the hinge only, the cup will be filled in a later step. Position the boom's knife-edge into the slot on the support post. The boom will rest at an angle. This is to be expected and will not damage the boom (Figure 2).

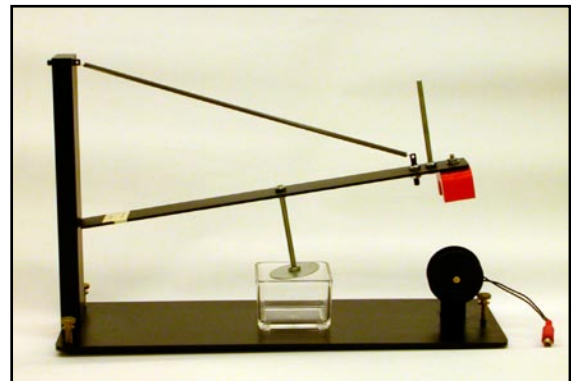


Figure 2

6. The washer post on the boom arm requires a stack of 5 to 30 washers (depending on the tightness of the spring) approximately 2.5 cm (1 inch) from the top of the bolt. Secure the stack between two hex nuts (Figure 3). Add washers until the boom arm is approximately level.

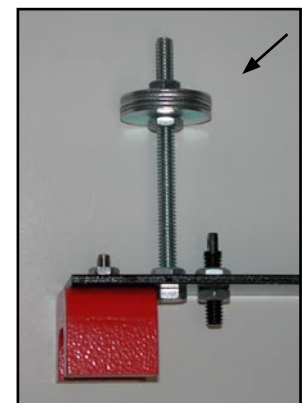


Figure 3

7. 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, and the magnet should not touch the coil. This may require additional adjustment of the coil so that it is vertical.

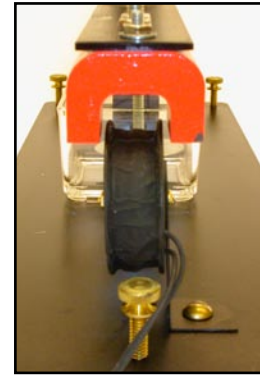


Figure 4

8. If you have a damping cup carefully swing the boom up until it is possible to position the partially filled damping fluid container under the damping vane. Do not completely fill the container before it is positioned correctly. If you have a magnetic damping unit no oil is necessary.

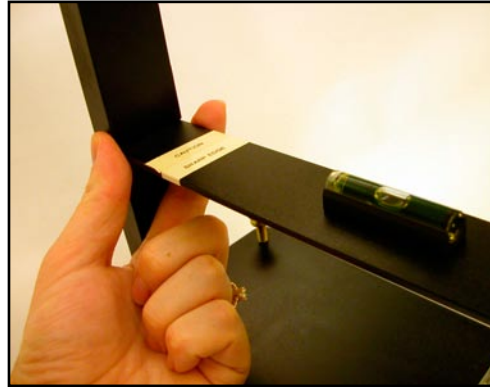


Figure 5

CAUTION: Do not release the boom arm abruptly. This will result in the magnet hitting the coil. The equipment is sensitive; handle and adjust the parts carefully and gently.

9. Add remaining fluid to the damping fluid container. Once finished, the fluid level should be about 1 cm (3/8 inch) below the top of the container. For proper damping, the fluid should be:

- 1/2 STP oil treatment and 1/2 10w40 synthetic motor oil for the thick spring units (spring diameter of 8 mm)
- 1/3 STP oil treatment and 2/3 10w40 synthetic motor oil for the thin spring units (spring diameter of 4 mm)

NOTE: Non-toxic mineral oil can also be used. The trade-off is that the system may be under-damped allowing a slight oscillation of the boom arm.

10. 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. Add or remove washers from the upright bolt, and if needed, add one or two washer(s) along the boom until the boom is level. Move the washers and the bubble level along the boom arm to fine tune the leveling. **The washer and bubble level must remain on the boom arm to keep it level.**

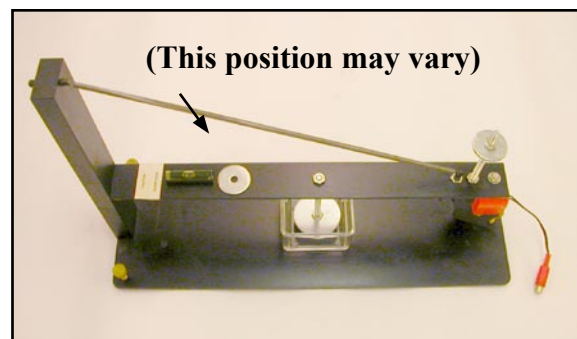


Figure 6

11. Check that the magnet is still centered above the coil. Center the magnet over the coil by sliding the knife edge at the support post (Figure 7). The boom arm should move freely up and down and the magnet **MUST NOT** touch the coil.

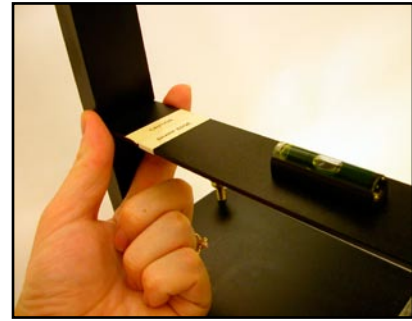


Figure 7

12. Attach the paired shielded coaxial cable to the interface box by inserting the two exposed wires one at a time to the posts. To attach a wire to a post the wire must pass through the hole in the post (Figure 8), then tighten the plastic knob. The wire insulation must not enter the screw terminal, as tightening the terminal cap may then not yield good contact between the metal wire and the post (Figure 9).

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 10). Tighten until snug.



Figure 9



Figure 8

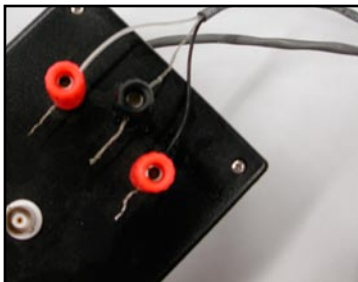
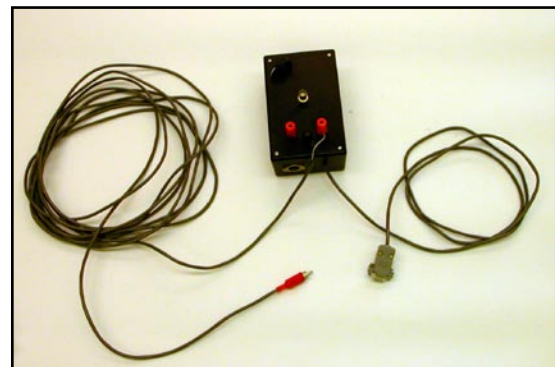


Figure 10

13. There are 2 cables leaving the interface box (Figure 12). The paired shielded coaxial cable (attached to the interface box in Step 12) has a 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. If your computer does not have a serial port, you can install the AS-1 through a USB port, a USB to serial adapter is needed (both adapters are available from Radio Shack or similar electronics store).



Black Box, cable with shielded pair, and serial cable

Figure 11

14. Plug the connector end of the paired shielded coaxial cable attached to the interface box to the matching connector on the seismometer cable.

15. Plug in the multi-pin cable from the power supply box to the multi-pin slot on the interface box. **Note the orientation of the pins to avoid damaging the connectors.** Plug in the power cord from the power supply to a surge protector (Figure 12).

NOTE: Plugging the power supply into a normal wall outlet can result in spikes on the helicorder screen during recording from power fluctuations.

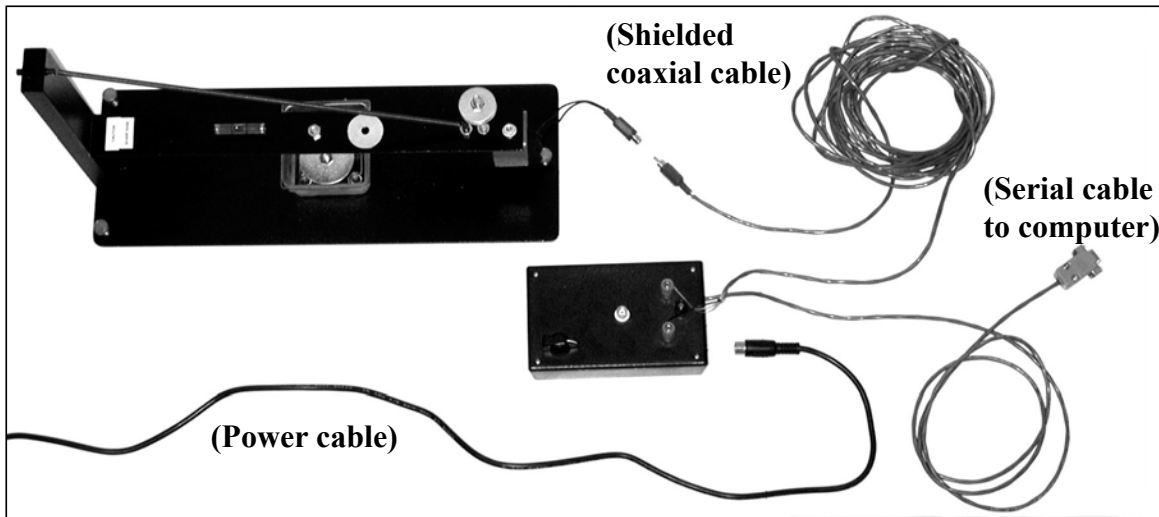


Figure 12

16. With a round file, make a groove in the base of the plexiglass cover so that the case will not rest on the coil wire. Cover the seismometer with the plexiglass display box. This will minimize motion of the boom due to air currents and keep dust off the instrument and oil.

CAUTION: If you should decide to move the seismometer, disconnect the boom arm to prevent damage to the knife edge and/or coil as a result of the boom arm swinging.

3 Software Installation and Configuration

Software Installation

a) Installing AmaSeis from CD

- Exit all windows programs before inserting the CD.
- Insert the disk in your CD drive. The setup program will automatically be launched. (If the program is not automatically launched, navigate to the CD and double click on **AmaSeisSetup.exe**)
- Install using the default settings

The standard installation will put files in **My Computer > Local Disk (C:) > AmaSeis**

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

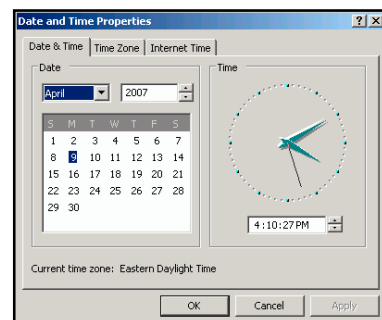
NOTE: Additional options for installing AmaSeis are described in Section 4.

Setting the Date and Time

Set the date, time, and time zone 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 > Control Panel > Date/Time**
- The current time is available from <http://www.time.gov>

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 more difficult to work with data.



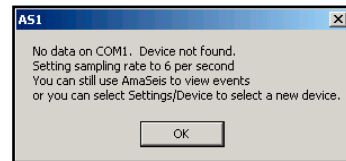
Automatic Time Synchronization

If the AmaSeis computer is connected to the Internet, it is highly recommended that a time synchronization program be run to reset the PC clock every hour. There are free programs available that will go out over the Internet to periodically synchronize a computer's clock to accurate UTC time.

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

Initial Program Launch

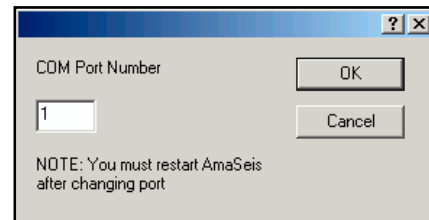
- To launch the software double click on the program icon
- The software assumes the AS-1 seismometer is attached to the communication port COM 1. If you receive a 'no data' error message, your computer is not receiving data from the seismometer. This will occur if the AS-1 is attached to a different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



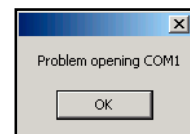
Changing the Port Setting - (Only if Necessary)

In AmaSeis from the Menu bar

- Select **Settings > COM port**
- Edit setting. Experiment with different COM ports (1-4).
- Quit and relaunch **AmaSeis**
- This is a trial and error process.



NOTE: If two copies of **AmaSeis** are launched an error will appear. Make sure to close all open copies of AmaSeis, then launch the software by double clicking on the program icon. More than one copy of AmaSeis can be run, but they must be located in different directories and use different COM ports.



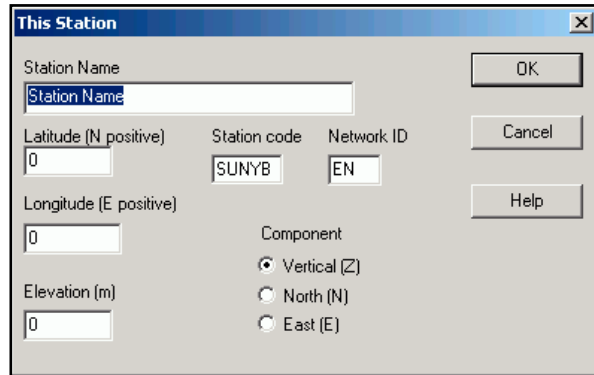
Launching the Program

- 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.

Setting Station Parameters

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

- **Station Name**
This is your school or organization name
- **Latitude / Longitude**
Enter in decimal degrees



NOTE: To determine the latitude and longitude of your school consult a topographic map, use a handheld GPS receiver, or use an online map. Maps are available online at <http://terraserver.homeadvisor.msn.com>. Type in the school address and select **Go**. Select an available image and record the latitude and longitude displayed under the address. Additional website for determining latitude and longitude are listed in the Additional Resources section.

HINT: Longitude in the United States (western hemisphere) is entered as a negative number.

- **Elevation**
Enter in meters
 - **Station Code**
A 4 letter code to uniquely identify your station. The first two letters represent your school or organization, the last two letters are your state abbreviation. To avoid duplicate codes, please check your choice at http://www.scieds.com/spinet/spinet_stations.php. If you have any questions, contact the network administrator at spinet@scieds.com to be assigned a code.
 - **Network ID**
Educational seismometers are part of the 'EN' (Educational Network).
 - **Component**
The AS-1 is a vertical component instrument
-
- Once the station parameters have been entered, this information is stored and does not need to be entered again.

Instrument Settings

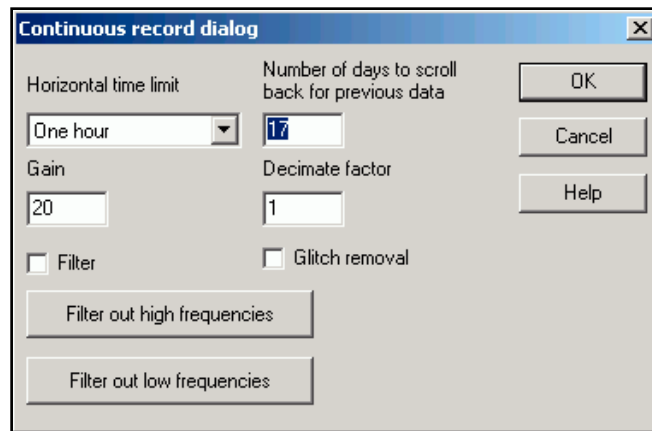
All settings in this section only effect the way the data is displayed on the computer screen. They do not effect the data values that are stored on disk.

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

- Horizontal Time Limit

The display can show anywhere from 24 minutes to 24 hours of data on the screen. This value defaults to **One hour**, 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 for earthquakes. If you change the horizontal time limit setting to 2 minutes, each line on the screen will show 2 minutes of data and shows details of the waveforms. This can be useful for in-class testing and demonstrations.



- Gain

The gain setting adjusts the amplification of the signal. An appropriate value for this setting varies with the location of the seismometer. The goal is to minimize noise, while highlighting any earthquakes that the AS-1 records. Choose a gain setting such that the background noise is just visible. For example, there should always be a little bit of up and down movement of the trace. A value between 25-50 is ideal. If the trace is too noisy, adjust the gain to a lower value. Any adjustment to the gain may require slight adjustments to the set zero level (discussed on p 3.7).

Often the best strategy is to watch carefully for the first earthquake, if the event is barely or not visible adjust the gain to a higher value. If the event seems to take over the screen, adjust the gain to a lower value. Since this setting only affects how data is displayed on the screen and does not effect the data values that are stored on disk, try different values to compare the earthquake signal with the background noise. Selecting an appropriate gain maximizes the instructional value of the instrument. A few examples are listed below to help select a starting value.

- **THAZ** - Gain 35

This instrument is located in a science storeroom in the back of a classroom at Tempe High School in Phoenix, Arizona. It is on the ground floor of a one-story building. This school is in downtown Tempe and the classroom is about 60 meters from a four-lane street.

- **WGCO** - Gain 50

This instrument is located on top of a small wooden cabinet which is situated in the back of the entry level conference room of the USGS National Earthquake Information Center in Golden, Colorado. This is a concrete-slab building with three floors above and one below the entry level.

- **PCAZ** - Gain 25

This instrument is located on the floor next to the wall in a classroom of Phoenix Country Day School in Paradise Valley, Arizona. The teacher had a small piece of carpet removed so that the AS-1 sits on concrete. The classroom is on ground floor of a one-story building. There is a small surface street 25 meters north of the instrument. The seismometer registers anyone who walks within three meters of it.

- **Number of days to scroll back for previous data**

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 does not affect the quality of the recording. While 21,600 data values are recorded for each hour, only a fraction can be displayed on the PC screen. The chosen value (proportion) effects the speed that AmaSeis is able to redraw the traces. Set the decimate factor to 10. If scrolling is very slow, adjust this setting higher to speed up scrolling.

- **Filter**

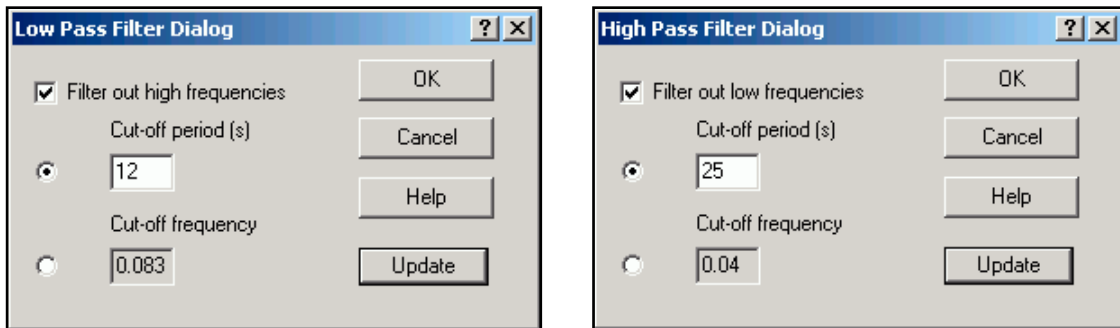
If the box is unchecked, there will be no filtering. If the box is checked, the parameters can be set by clicking on the **Filter out high frequencies** and **Filter out low frequencies** buttons. AmaSeis has two filters to select, a high-pass or low-pass filter. A high-pass filter is a filter that passes high frequencies (relative to a designated cutoff frequency) without change but attenuates (or reduces) lower frequencies. A low-pass filter is a filter that passes low frequencies

(relative to a designated cutoff frequency) without change but attenuates higher frequencies. A bandpass filter is a combination of a high-pass and a low-pass filter.

Filters can be used to enhance seismic waves or reduce noise. Set the cutoff frequencies either in frequency (Hz) or period (sec). Frequency is the inverse of period. For example, surface waves have a lot of energy in the range of .05 Hz. Converting to period: $1/0.05 = 20$ second period.

• Low Pass/High Pass Filter Dialogs

To enhance surface waves set a bandpass filter. This requires the low-pass filter cutoff period to be set to 12 seconds and the high-pass filter cutoff period to be set to 25 seconds. This passes waves in the 12 - 25 second range (.04 - .083 Hz).



The AS-1 samples the amplitude of the seismic signal approximately 6 times per second, which does not allow high frequencies to be well sampled. The highest frequency theoretically possible to record is one half the sample rate. Therefore, the cutoff frequency for the low pass filter should never be set to a frequency higher than 3 Hz.

- Glitch Removal

Some glitches are caused by the operating system losing data through the serial port. Selecting this setting smooths the spikes out of the displayed data. When AmaSeis discovers a glitch (defined by a signal 500 counts above or below the previous datapoint), the bad data point is replaced by the previous data point.

NOTE: All of the settings in the Helicorder dialog box only affect the way the data is displayed on the helicorder screen. These setting do not change the data stored on your hard drive.

Finding the Trace

- From the Menu Bar choose **Settings > Set Zero Level**
- Set the Zero Level at 2048 (This value centers the trace thus preventing clipping of the signal from a large event)
- From the Menu Bar choose **Settings > Helicorder**
- **Set the Gain to 25**



- At this point, the trace (visible wiggles) is commonly recording offscreen and will not be visible until adjusted. The goal is to line up the trace on the bottom (blue) hour line. To do this slowly move the potentiometer (black knob- Figure 12) on the AS-1 interface box until the trace is visible on the screen. **CAUTION:** The knob is very sensitive. Moving the potentiometer one direction will move the position of the trace up on the screen and the opposite direction will move the trace down on the screen. Each line represents one hour, so the trace moves slowly across the screen. **The current UTC time is the bottom hour line (in blue).** The screen will scroll up through the day, leaving the trace always recording on the bottom hour line.

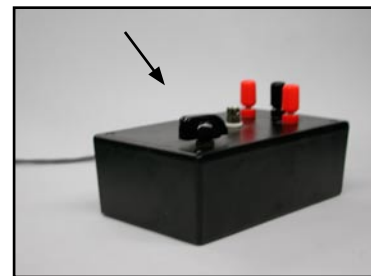
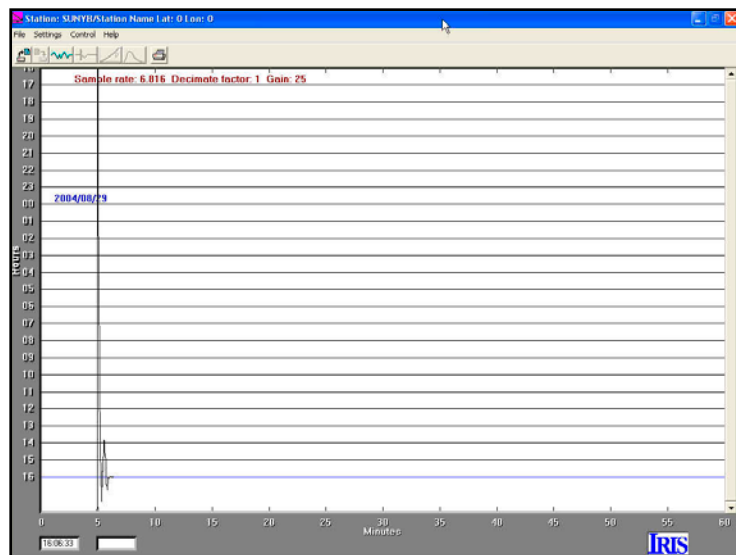


Figure 12

- Once the trace is visible on the screen moving it down to the current hour line requires gentle tapping of the potentiometer (use the end of a pencil). This is a difficult and slow process. Be patient and get the trace as close to the current UTC time (bottom line on screen) as possible.

- Be certain to check **Settings > Show Data Values** to make certain that the potentiometer is properly adjusted. The numbers should bounce equally above and below zero.



Centering the Trace

Once the trace is close to the correct hour line, fine tune adjustments can be made using the set zero level. Adjustments to this value are **RELATIVE** to the starting value of 2048.

- From the File Menu choose **Settings > Set Zero Level**
- To shift the trace to the correct hour line increase or decrease the value in the Set Zero Level pop-up window. Fine tuning of the trace position can include a relative change of +/- 5 or 10 units. This parameter **MUST ALWAYS BE** in the range 2038 to 2058. If the trace is still not centered, then tap the centering knob on the black box gently to make fine adjustments.



Registering the Station

- Register the new station online at <http://www.scieds.com/spinet>
- Select **Join the Network**
- SpiNet provides a site for teachers to share their AS-1 data with each other online. Additionally there are links to activities and other resources for teachers using seismic data in the classroom.

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 while using other programs.

Using AmaSeis

4

Software Installation

There are 3 options for installing AmaSeis. From the CD that ships with the AS-1, downloaded directly or downloaded on two disks to transfer to another computer.

Option 1) Installing AmaSeis from CD

- Exit all windows programs before inserting the CD.
- Insert the disk in your CD drive. The setup program will automatically be launched.
- If the program is not automatically launched, navigate to the CD and double click on **AmaSeisSetup.exe**.
- Install using the default settings.

Option 2) Downloading AmaSeis

- Go to: <http://www.geol.binghamton.edu/faculty/jones/AmaSeis.html>
- Click on the link labeled **AmaSeisSetup.exe**
- Save the file to the Desktop
- Double click to launch and install

Option 3) Installing AmaSeis without an Internet Connection

- The file is too large to fit on a single floppy disk, there is the option to create two installation disks to transfer the installation program
- From any computer connected to the Internet go to:
<http://www.geol.binghamton.edu/faculty/jones/AmaSeis.html>
- Click on the link labeled **AmaSeisDisk1.exe**
- Save the file to the Desktop
- Double click to launch. This will save the needed files to a diskette.
- Click on the link labeled **AmaSeisDisk2.exe**
- Save the file to the Desktop
- Double click to launch. This will save the needed files to a second diskette.

The standard installation will put files in **My Computer > Local Disk (C:) > AmaSeis**. It will also put an icon under the Start menu **Start > Programs > Seismology > AmaSeis**, and create a shortcut link on the computer desktop.

Upgrading AmaSeis

To upgrade AmaSeis go to: <http://www.geol.binghamton.edu/faculty/jones/AmaSeis.html>

- Click on the link labeled **AmaSeisUpgrade.exe**
- Save the file to the Desktop
- Double click the file. This will launch and install the upgraded program.

NOTE: Settings will be maintained even if the software is updated.

About AmaSeis

The AmaSeis program is used to record and archive data from the AS-1 Seismometer. Additionally, AmaSeis can be used to view, save, filter, analyze and interpret seismograms. The seismograms may be saved from the AS-1 data (continuous output of the seismometer) or imported from other sources (onto your computer whether or not an AS-1 seismometer is connected). Thus, AmaSeis can be used as a viewer for display, analysis, and interpretation of earthquake seismograms without an attached AS-1 seismometer. The AmaSeis program can analyze raw data from the AS-1 seismometer or a seismogram stored as a SAC file (see p. 4.5).

If data has already been collected on this PC but the AS-1 instrument is not attached at this time, an error message will be displayed after the AmaSeis program is launched. The program will still run and be able to scroll back to previously recorded data or open events that have been saved.

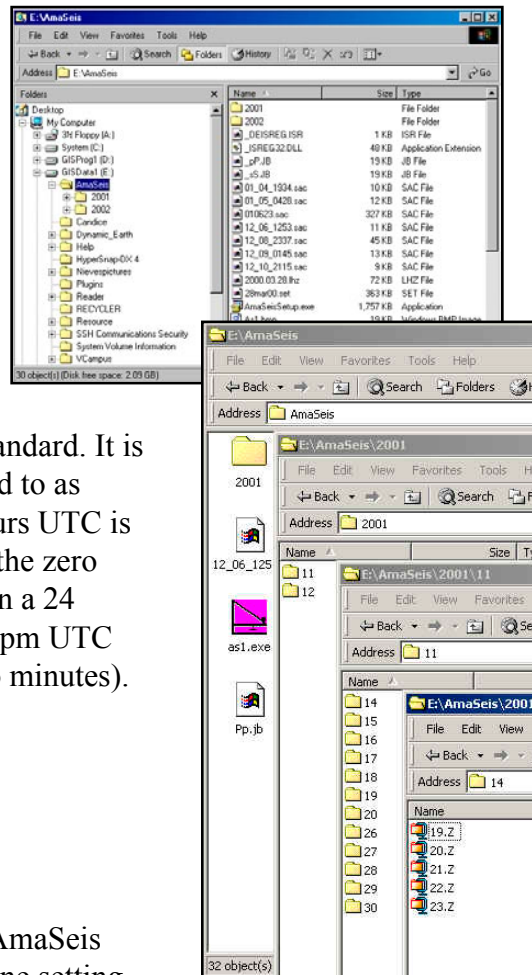


AmaSeis File Structure

AmaSeis stores data in a set of nested folders. A year's worth of data will take up about 388 megabytes. The data can be searched for events at any time using AmaSeis. Be aware of the amount of space the data will take so that you don't fill your hard drive. To erase old data, use the Windows Explorer. Remember, once it is deleted, you can not recover it.

The path to the AmaSeis directory (if you used a standard install) is **My Computer > Local Disk (C:) > AmaSeis**. The AmaSeis directory contains data folders, files, and the program.

- AmaSeis creates a series of nested folders to store data. The top level folders are divided by year. In each year folder, there will be a folder for each month, which contain subfolders for each day. The actual data files are saved with the naming convention hour.z. The z extension refers to the fact that the data is from a vertical component seismometer.
- AmaSeis references time in Coordinated Universal Time (UTC), the international time standard. It is the current term for what was commonly referred to as Greenwich Meridian Time (GMT). Zero (0) hours UTC is midnight in Greenwich, England, which lies on the zero longitudinal meridian. Universal time is based on a 24 hour clock, therefore, afternoon hours such as 4 pm UTC are expressed as 16:00 UTC (sixteen hours, zero minutes).



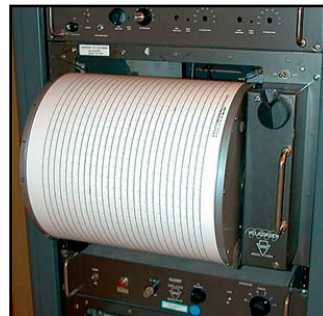
Conversions of UTC:

- Pacific Standard (Portland, OR) + 8 hours
- Mountain Standard (Santa Fe, NM) + 7 hours
- Eastern Standard (Washington DC) + 5 hours

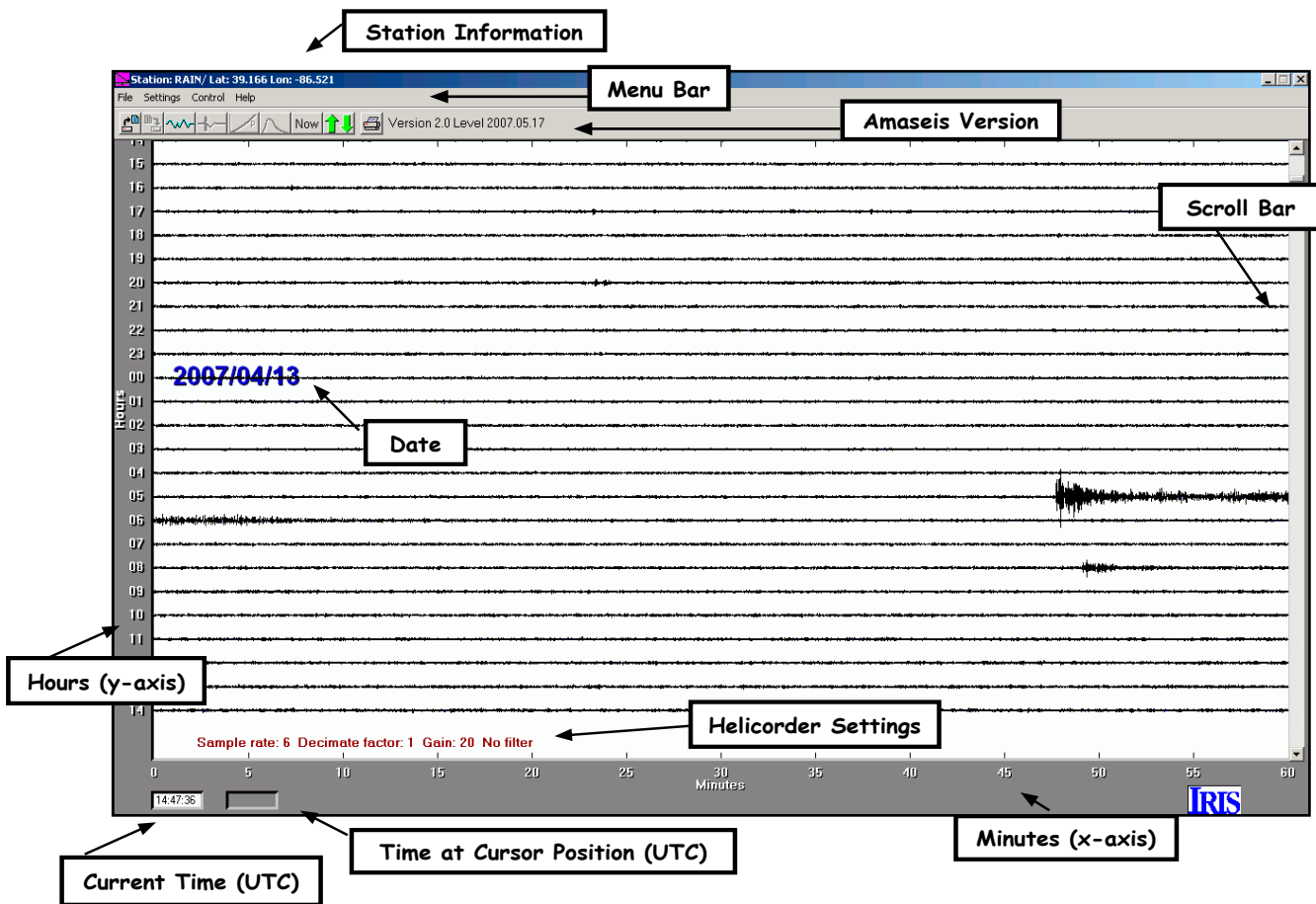
CAUTION: Keep your computer set to local time, AmaSeis makes the necessary adjustment based on the time zone setting of your computer.

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 (shown right).




- 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 the number of data values 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.

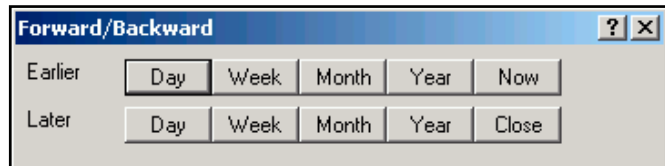



Searching for Events

In addition to using the scroll bar along the right side of the Helicorder screen to scroll back through the earlier recorded data it is possible to step back through the data to search for events.

- Click the Forward/Backward in time button below the menu bar 

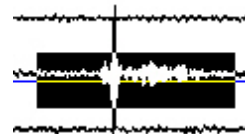
- Select in the dialog box the amount of time to step through the data.



- When finished, click the Now button in either the dialog box or below the menu bar to display the current recording. 

Saving an Event

- From the helicorder screen **highlight** an event by holding down the left mouse button and dragging over the event

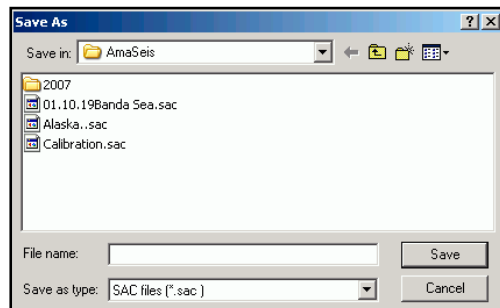


- Click the extract icon below the Menu Bar 

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, two digit minute (of first arrival), station code (**yymmddhhmmstcode.sac**)




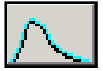
Example: Tempe High School (thaz) recorded an event at 04:41 on May 23, 2007
0705230441thaz.sac

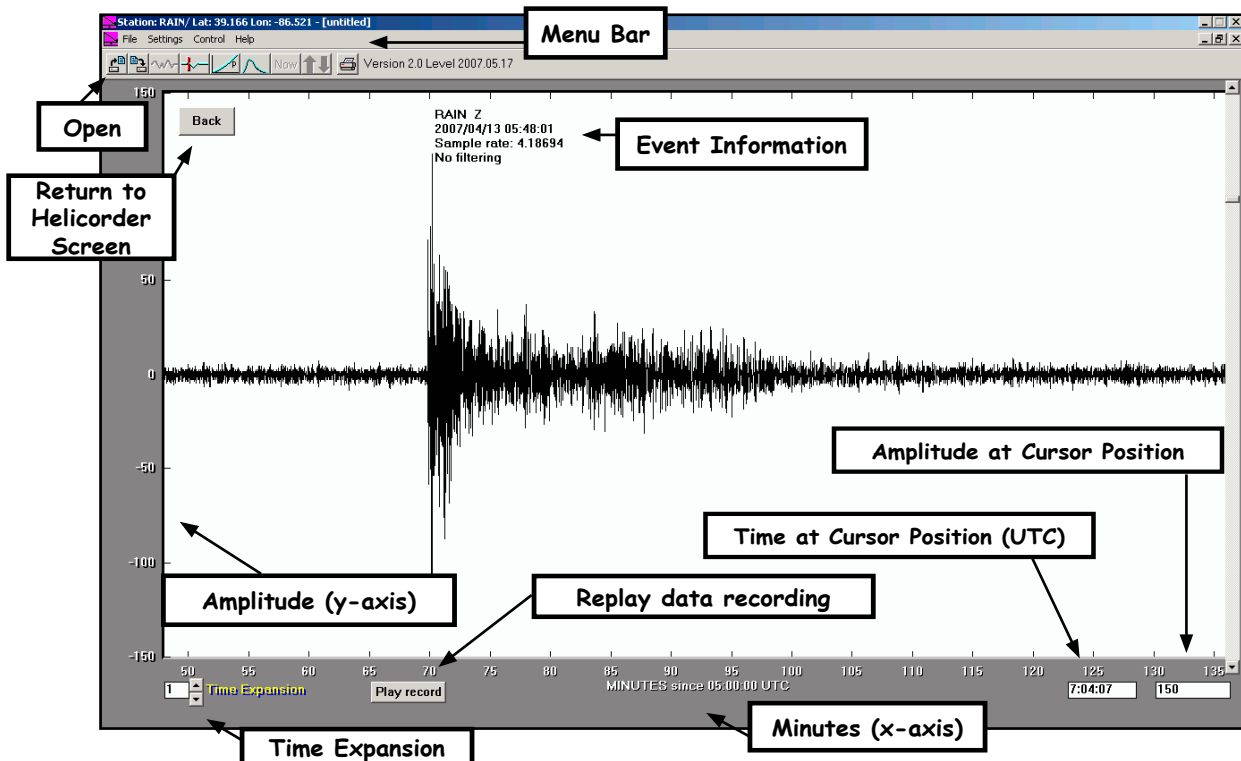


- In the bottom left hand corner, set the **Save as type** to **SAC**
- Click **Save**
- **Send us your event!** You can upload the SAC file through your internet browser at <http://www.scieds.com/spinet>

Extract Event Screen Overview

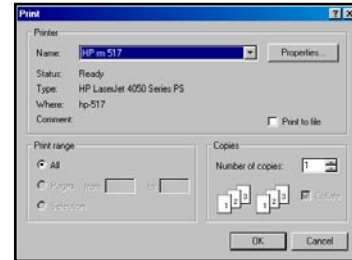
The highlighted portion of the trace from the helicorder screen is now displayed in this window. To zoom in again, highlight the record and click the extract icon button again.

- **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 the x-axis. In this case only the first half of the waveform is displayed on screen. To see more of the waveform use the scroll bar at the bottom of the screen.
- The cursor arrow position is linked to the time on the seismic record and the amplitude. This can be useful for determining periods and amplitude for seismic magnitude determination.
- **Play Record** replays the data recording. This is useful to point out when arrivals are coming in when reviewing an event with students.
- Load a previously saved event or a SAC file using the **Open Icon**. 
- The **Pick Arrivals** icon is used to mark wave arrivals. Mark either the P and S wave arrivals or the P and Surface 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 (see p. 5.4). 
- The **Fourier Transform** icon analyzes the frequency content of the seismogram. 



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 to print



An alternative way to save the screen for incorporation into a Microsoft Word™ document is to press the <alt> <print scrn> keys. Nothing will apparently happen, but you can open Microsoft Word™ and **Edit > Paste** to insert the image. Be sure to have **View > Toolbars > Drawing** and **Views > Toolbars > Picture** checked. The pasted image can be cropped and resized within Microsoft Word™.

Filtering

When a highlighted period of time is first viewed in the extract event window, no filtering is applied, even if the helicorder record is being viewed with a filter. Filter options are available by selecting **Control > Filter**. The filters are described below with further examples that follow.

- **Low-Pass / High-Pass**

A low-pass filter is a filter that passes low frequencies (relative to a designated cutoff frequency) without change, but attenuates (or reduces) higher frequencies.

A high-pass filter is a filter that passes high frequencies (relative to a designated cutoff frequency) without change, but attenuates lower frequencies.

For both the low- and high-pass filters, the cutoff frequencies can be specified in either frequency (Hz) or period (sec). Frequency is the inverse of period. For example, surface waves have a lot of energy in the range of .05 Hz. Converting to period: $1/0.05 = 20$ second period.

- **Bandpass**

A bandpass filter attenuates both low and high frequencies and can be created by using both a high-pass and a low-pass filter in combination.

- **Long period**

This is a specialized filter that enhances the long period surface waves. Additional documentation of this feature can be found in the AmaSeis help file.

Two additional filter commands can be found in the **Control** menu:

- **Median Filter**

The median filter is used to remove glitches (single bad data points) from the data. A seven-point filter is used. The program looks at the three points before the point of interest, the point itself, and the three points after. It then arranges these in sorted order and takes the median (the middle one).

- **Unfilter**

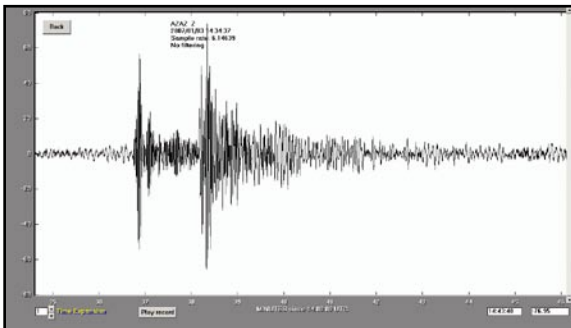
For a given event, try out various filter settings. If they don't enhance the signal use **Control > Unfilter** to return to the original seismogram and try again.

Investigating Earthquakes

5

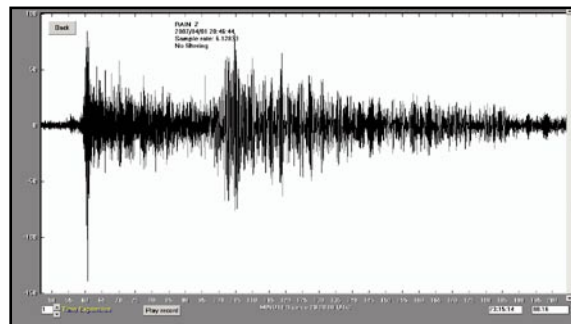
Filtering Earthquakes

The AS-1 System will record local earthquakes as small as magnitude 3.5 at a distance of 150 km, and earthquakes magnitude 6.5 or larger that occur anywhere in the world. The recordings of these earthquake will differ in frequency content, and different filters are useful for enhancing earthquake signals.



Magnitude 4.4 Earthquake in Colorado, recorded in Phoenix, Arizona at station AZAZ (Corona del Sol High School)

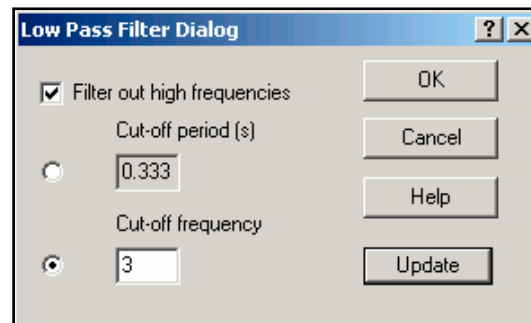
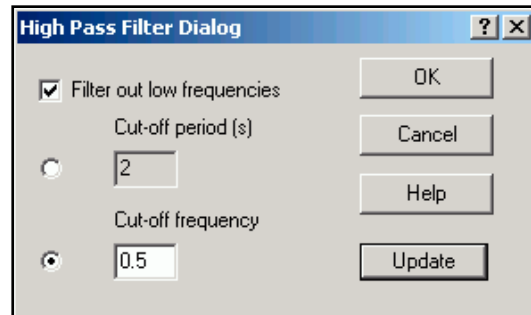
Magnitude 8.0 Earthquake in the Solomon Islands recorded in Bloomington, Indiana at station RAIN (Science Education Solutions)



Local and regional (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) seismograms 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 **Control > Filter**
- A useful filter is a bandpass filter with frequency cutoffs of 0.5 Hz and 3 Hz (isolating the short period energy: 2 - .333 s period).
- A bandpass filter can be created by using both the high pass and low pass filters. Enter the two cutoff frequencies, 0.5 in the **High Pass Filter Dialog Box** and 3 in the **Low Pass Filter Dialog Box**.



Global Events

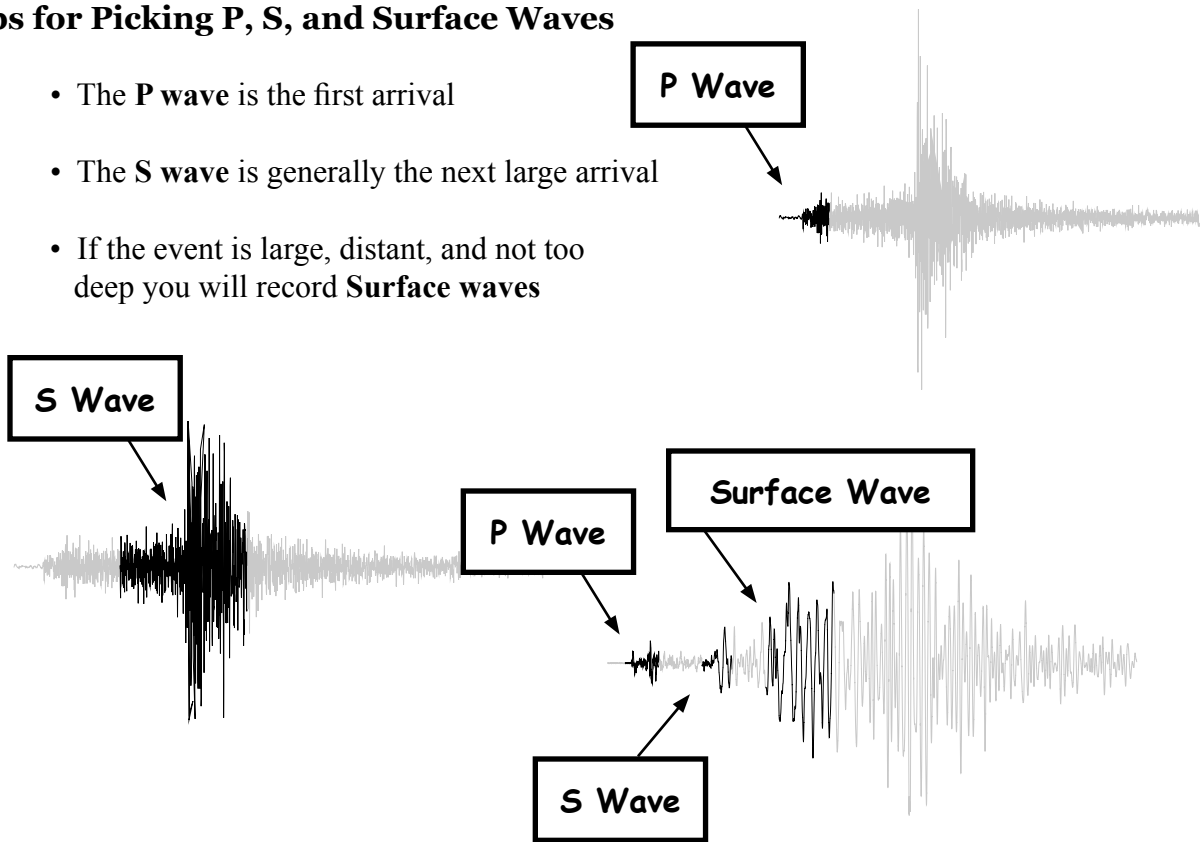
For teleseismic or distant earthquakes, lower frequency filtering often enhances the seismogram, especially the surface wave arrivals that are prominent for shallow depth (0 - 70 km) earthquakes.

- In the Extract Event Screen, from the File Menu Bar select **Control > 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). A bandpass filter can be created by using both the high pass and low pass filters. Enter the two cutoff frequencies, 0.1 in the **Low Pass Filter Dialog Box** and 0.0001 in the **High Pass Filter Dialog Box**.

NOTE: When filtering in the helicorder view in order to enhance certain frequencies, it may be necessary to increase the gain. To display the trace with less amplitude in the Extract Event screen the automatic scaling feature under **Control > Scale** can be turned off.

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**

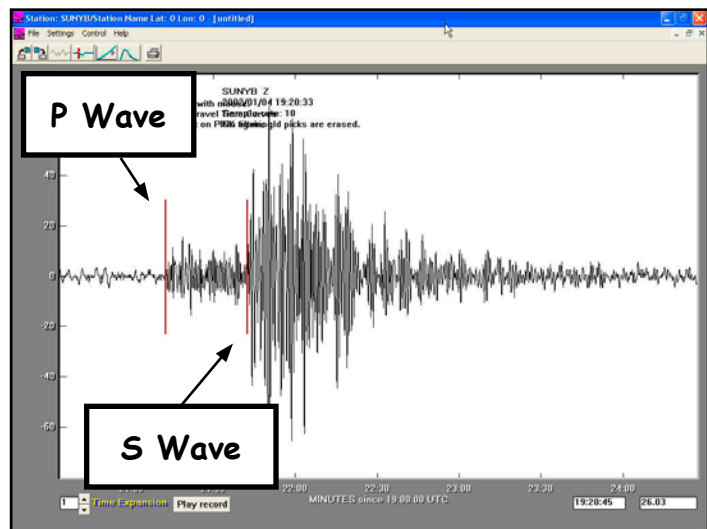


Picking Arrivals in AmaSeis

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

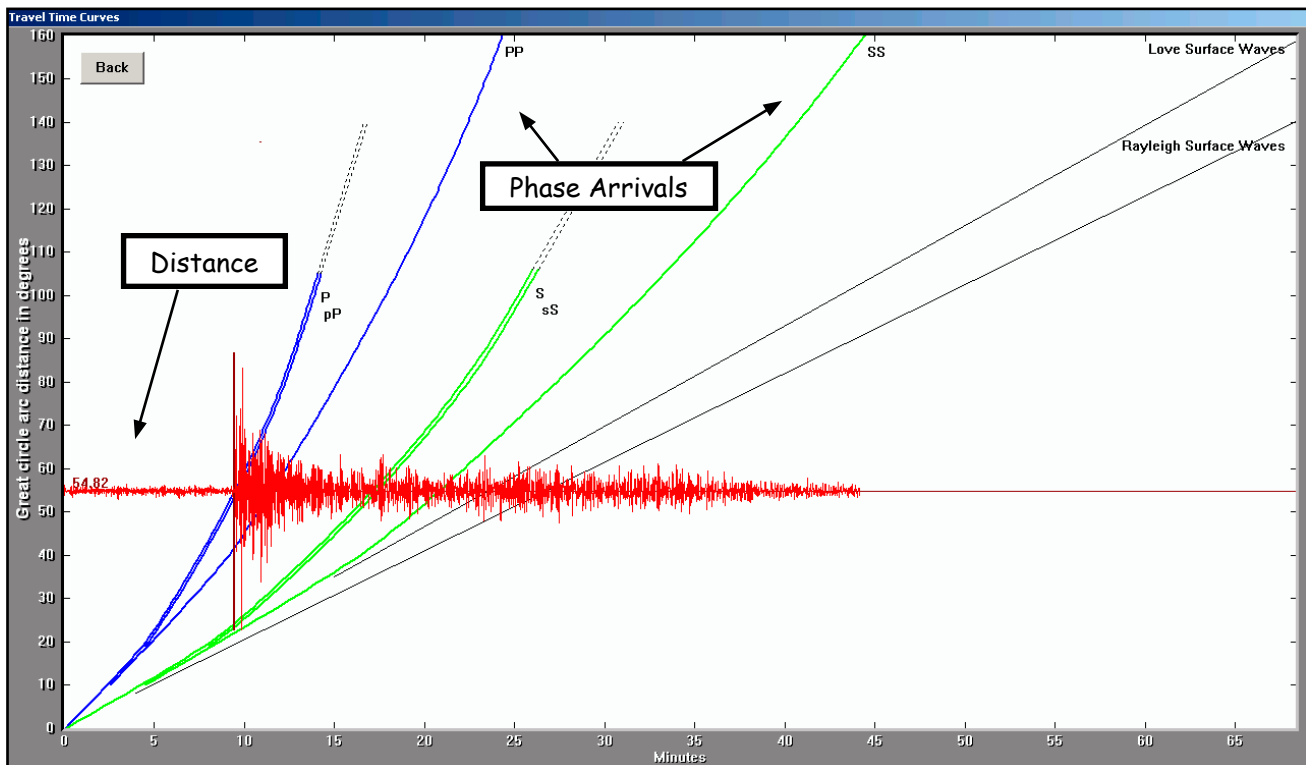


- Mark the arrival by positioning the mouse on the trace at the arrival and clicking with the **Left Mouse Button**.
- Mark either the P and S wave arrivals or the P and Surface wave arrivals.
- Picks will be marked with a vertical brown line. To repick, click on the **Pick Arrival Icon** again which will clear all previous picks.



Using the Travel Time Curve

- After picking arrivals in the **Extract Event Screen** click on the **Travel Time Curve Icon**.
- If the depth is known for the event, enter it in the **Depth Dialog** box, or leave the default 33 km. The depth is used to determine the correct travel time curve to use.
- 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 at the far left of 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 information about an event:

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

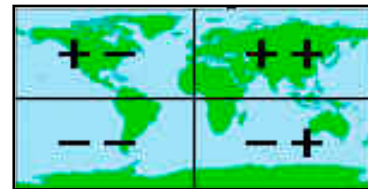
- On the **Extract Event Screen** select **Settings > Event**.

- Enter the event information in the **Event Dialog** box.

- The Seismogram Start time will be pre-filled and **should not** be changed.

- Earthquake Origin Time: AmaSeis will pre-fill part of this section. Use information from an NEIC or IRIS bulletin to fill in the event parameters of latitude, longitude, origin time, and depth.

- The latitude and longitude must be entered as signed numbers, negative for west longitude and negative for south latitude.



- Magnitudes
Record any magnitude reported by IRIS, NEIC, or if you calculated your own station magnitude report it here.

NOTE: Data from the AS-1 can be exported for use in Seismic Waves. See the SpiNet website for additional documentation on this feature.

Data Identification and Event Location

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

- Launch your browser and go to: <http://earthquake.usgs.gov/regional/neic/>
- Select **Current Worldwide Earthquake List**
- Events from the last 7 days will be displayed

Searching for events from the last month:

- Select from the left side menu
Recent Earthquakes: Last 8 - 30 days

Searching with NEIC

- Launch your browser and go to:
<http://earthquake.usgs.gov/regional/neic/>
- Select **Earthquake Catalog Search**.
- Scroll down and select **Global (Worldwide)**.
- 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.

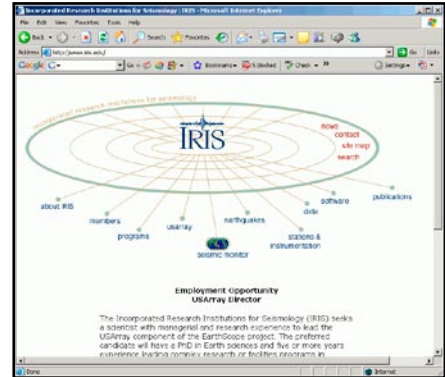
CAT	YEAR	MO	DA	ORIG	TIME	LAT	LONG	DEP	MAGNITUDE	IEFM	DTSVNWG	DIST
PDE-W	2001	06	23	2033	14.13	-16.26	-73.64	33	8.40	MwHRV	.C.G	.T.....

Labels with arrows pointing to the corresponding columns in the table:
 Catalog (CAT), Day (DA), Origin Time (ORIG TIME), Depth (DEP), Magnitude (MAGNITUDE), Month (MO), Latitude (LAT), Longitude (LONG).

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.edu>
- Select **Earthquakes**
- Select **Search Event Catalog > 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	LONG	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 the table fields:

- Month: points to the first part of the TIME field.
- Latitude: points to the LAT field.
- Depth: points to the DEP field.
- Magnitude: points to the MAG field.
- Day: points to the last part of the TIME field.
- Origin Time: points to the full TIME field.
- Longitude: points to the LONG field.
- Magnitude Type: points to the TYPE field.

Searching for Mining Seismicity

NEIC catalogs routine mining seismicity in the United States.

- Launch your browser and go to: <http://earthquake.usgs.gov/regional/neic/>
- Select **Routine U.S. Mining Seismicity** from the left side menu

[January 2001](#) | [February 2001](#) | [March 2001](#) | [April 2001](#) | [May 2001](#) | [June 2001](#) | [July 2001](#) | [August 2001](#) | [September 2001](#) | [October 2001](#) | [November 2001](#) | [December 2001](#) | [January 2002](#)

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

Labels pointing to the table fields:

- Date: points to the first part of the ORIGIN TIME field.
- Latitude: points to the LAT field.
- Longitude: points to the LONG field.
- Depth (km): points to the DEP field.
- Region: points to the F-E REGION field.
- Magnitude: points to the MAGNITUDE field.

ORIGIN TIME	GEOGRAPHIC COORDINATES		DEPTH	MAGNITUDE	SD	GAP	NO. STA USED	F-E REGION,	CONTRIBUTED MAGNITUDES AND COMMENTS
UTC	LAT	LONG		GS					
DAY HR MN SEC			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.

6 Additional Resources

Additional Resources and Information

AmaSeis Updates

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

Identifying Earthquakes or Mining Seismicity

- <http://earthquake.usgs.gov/regional/neic/>
- <http://www.iris.edu>
- <http://www.scec.org/earthquakes/>
(select **Recent California Earthquakes**)

Web Sites for Information and Curriculum Resources

- <http://www.scieds.com/spinet/>
- <http://jclahr.com/science/psn/as1/>
- <http://www.eas.purdue.edu/~braile/>
- <http://www.iris.edu/edu/AS1.htm>

Time

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

Latitude and Longitude

- <http://terraserver.homeadvisor.msn.com>
- <http://www.maptech.com/>
- <http://free.satellite.photos.googlepages.com/>
- <http://mapper.acme.com/>

AS-1 Information

- <http://jclahr.com/science/psn/as1/>

FAQ

- <http://jclahr.com/science/psn/as1/faq/index.html>
- <http://www.scieds.com/spinet/faq/faqkb.php>