Activity #1-HS

What is a Seismometer?
High School Level

Objective

Students will learn that a seismometer detects 3 components of motion and that a seismogram is the record of an earthquake.

Background

Prior to this activity, students should be introduced to the basics of earthquakes. Curriculum for this can be found at http://www.redcross.org/disaster/masters/
This curriculum is designed for 9-12 grade levels. Other good activities can be found at http://www.dlese.org/ or http://web.ics.purdue.edu/~braile/.

Materials

QCN Demo installed on laptop
LCD projector or monitor
internet access to view video
slinky

Activity

1. Begin with the computer on a level surface.

2. Let students observe the seismic sensor for a few minutes. Encourage them to jump up and down or bang on the table with a fist or drop books.

3. Have students explain what they observe on the screen. What does each graph mean? What is the horizontal axis and the vertical axis? (You may want to avoid using x and y since the directions of the sensor are described by x, y, and z). Where on the graph is the time now? Why does the picture move to the left? Any ideas about the Earthquake Significance graph? What about the trigger line? Let students wonder about the Earthquake Significance for now.

4. Begin to lead students to think about what the purpose of the software is. What do you think this program is designed for? Why? The purpose of the Quake Catcher Network is to detect earthquakes and record the seismic activity on many internet-connected computers to rapidly detect earthquake activity.

5. Review earthquake basics with students. Show video clips of a real earthquake. Video from the 2001 Earthquake in Seattle, WA was captured by serveral security cameras and can be see at http://www.classzone.com/books/earth_science/terc/content/visualizations/es1005/es1005page01.cfm?chapter_no=visualization or several on Youtube.com.

Earthquake Review

Earthquakes happen because of a sudden slip on a fault in the earth's surface where the rock on one side moves up, down, or sideways relative to the other side. An earthquake is felt as a sudden, rapid shaking on the surface of earth. This shaking can last a few seconds or even a few minutes. The motion causes waves that moves through Earth. The first waves are compressional waves, also known as primary or P waves, travel fastest, at speeds between 1.5 and 8 kilometers per second in the Earth's crust. Shear waves, also known as secondary or S waves, travel more slowly, usually at 60% to 70% of the speed of P waves.

Earthquakes are detected with instruments that measure and record the seismic waves. In general, seismologists now use seismometers and digital recorders, rather than the older seismographs (drum of paper spinning with a needle) which are only used for show on TV when there is a big earthquake because the TV channels like to show them. The record or graph is called a seismogram.

6. There are a few kinds of waves generated by earthquakes. A good way to explain P- and S- waves is with a slinky. Have two students sit opposite each other with a slinky pulled taught across the floor between them. When one student pushes their end of the slinky toward the other, it creates a wave like a P wave. When the student pushes the end of the slinky to the right or left, it creates a wave like an S wave.

7. Demonstrate how different motions of the computer are recorded by the sensor. Move the computer in the different directions as shown in the figure. X is the motion from left to right (east to west). Y is the direction from front to back (north to south) and z is the motion up and down (vertical component). Earthquake Significance is a calculated value based on the X, Y, and Z over the last minute. It helps distinguish noise from a real earthquake signal.
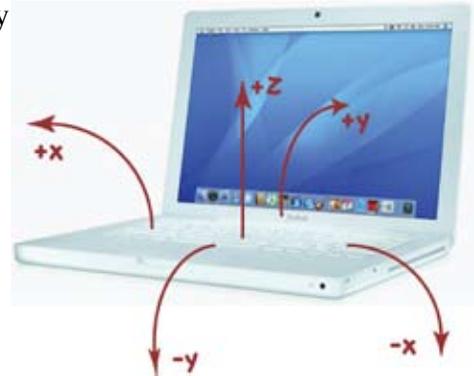
Explanation for the Teacher

One way to think about the different directions is to image a boat floating at the surface floating at the surface of the ocean. It moves with the ocean waves, up and down, and side to side. The pitch of the boat is the angle from bow to stern (front to back), measured here as the Y component. The roll of the boat is the angle from port to starboard (left to right), measured here as the X component. The sensor measures angular rotation which is a bit more complex than just measuring a linear distance, which is how the vertical component Z is measured.

8. Pass out the Siesmogram Worksheet to al students. Remind students that the first waves are compressional waves, also known as primary or P waves, which travel fastest. Shear waves, also known as secondary or S waves, travel more slowly, usually at 60% to 70% of the speed of P waves.
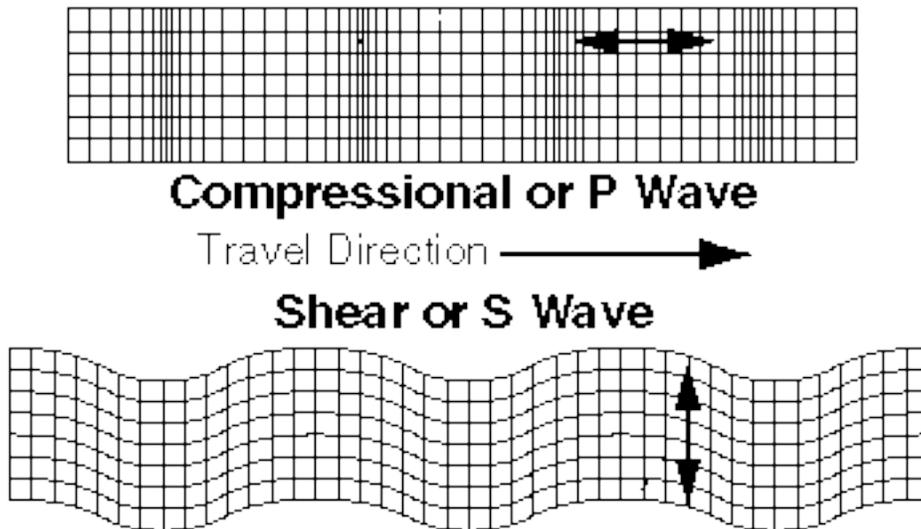
9. Bring groups of students up to the computer to experience the changing of the measured motion as they move the computer. This give each student a chance to experience this 3 component system of the motion themselves.   Challenge each group to figure out what the EQ Significance and triggers are.

10. Ask students what they learned from their experience with moving the computer. How are the records similar for the computer and the Tonga siesmogram? What is the EQ Significance? How does that change? What sources of error are there in the classroom? (doors slamming, table shaking, etc)

11. Describe the Quake Catcher Network and how the computer will always be running the program in the background to detect earthquakes. Discuss EQ Significance graph.

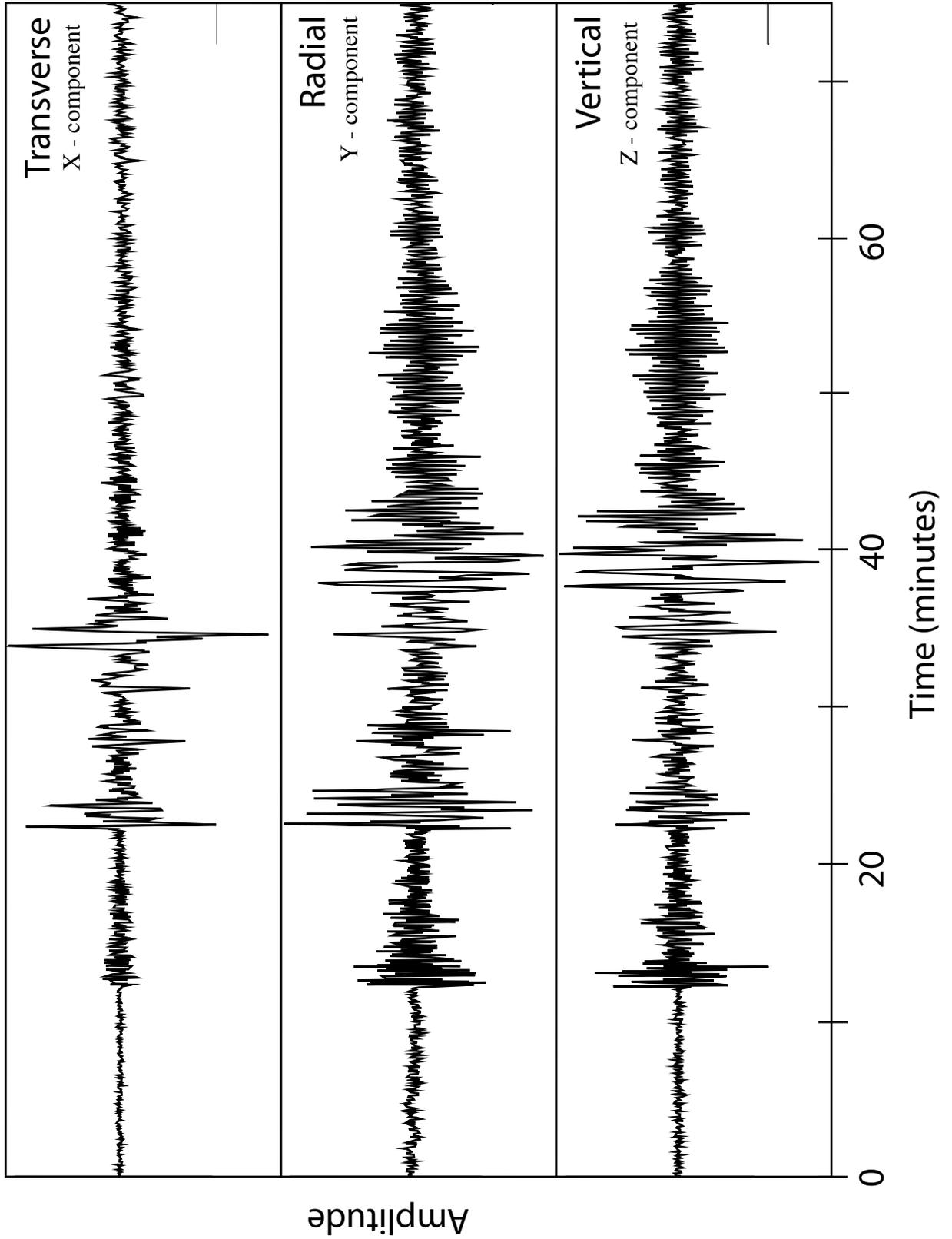
Explanation for the Teacher: Earthquake Significance

The Earthquake Significance is a calculated value based on the last 60 seconds to detect significant signals. It helps detect strong new vibrations measured by the laptop's sensor. If EQ Sig is above some level, the laptop informs the QCN server that it has detected a new vibration. It sends the time, amplitudes (x, y, and z) and the EQ Sig. If many laptops tell the server there is a strong shaking all at once, we know it is an earthquake. The QCN server evaluates triggers from 100s to 1000s of laptops. If the QCN server suddenly receives more triggers than expected from a particular area, we know there is an earthquake. If only a few laptops produce triggers in an area, we know that it is probably people bumping their laptops. If successful, it may be possible for anyone participating to learn of a large earthquake before they feel it and take safety precautions.

Seismogram Worksheet

1. Examine the seismogram. When and where did this earthquake occur?

2. Find the beginning of the record where the time is zero. When did the first wave of the earthquake reach this station?
   Label this with a P on each of the 3 components of motion.

3. The first wave is called the P wave, P for primary.
   a. Which direction of motion has the largest disturbance by the P wave?
   b. P waves are compressional waves. Using the diagram of the slinky below, which direction does the slinky move when the P wave goes by?

4. The second wave is called the S wave.
   a. Label the S wave on the seismogram.
   b. Which direction of motion has the largest disturbance by the S wave?
   c. S waves are shear waves. Using the diagram of the slinky, which direction does the slinky move when the S wave goes by?

Compressional or P Wave

Travel Direction ⟶

Shear or S Wave

12/09/2007 M 7.8 Tonga Earthquake
Recorded in San Diego

Transverse
X - component

Radial
Y - component

Vertical
Z - component

Amplitude

Time (minutes)

0   20   40   60

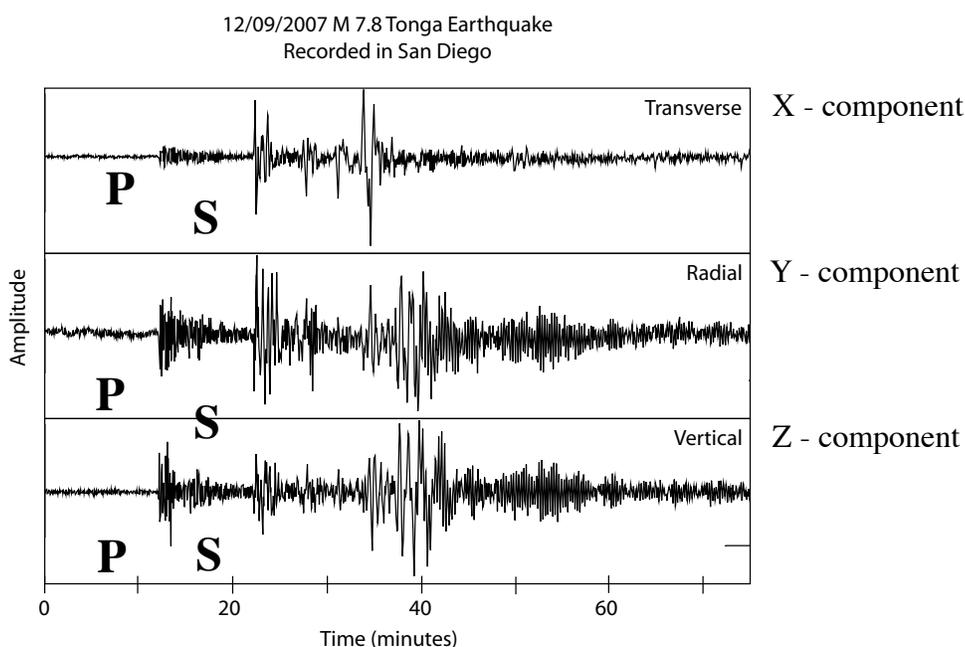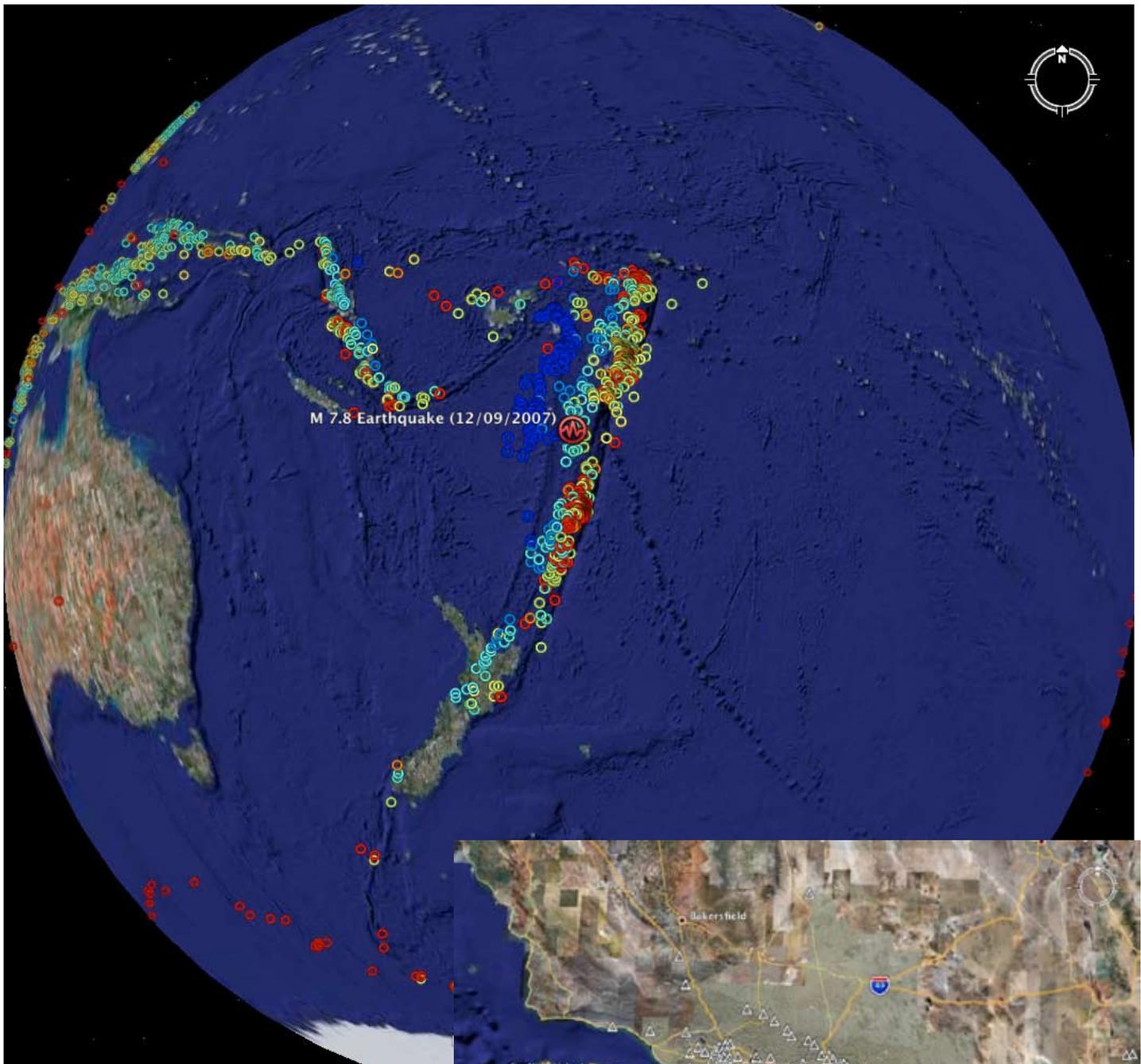*Quake Catcher Network - Activity #1 for High School - as of 2/27/08*

Seismogram Worksheet Teacher Answers

Answers in bolded italics.

1. Examine the seismogram. When and where did this earthquake occur?
in Tonga on December 9, 2007. This was recorded in San Diego.

2.   Find the beginning of the record where the time is zero. When did the first wave of the earthquake reach this station? *9 minutes from the start*
Label this with a P on each of the 3 components of motion.

3. The first wave is called the P wave, P for primary.
    a.   Which direction of motion has the largest disturbance by the P wave? *Z, although Y is pretty close*
    b.   P waves are compressional waves. Using the diagram of the slinky below, which direction does the slinky move when the P wave goes by?   *left to right*

4. The second wave is called the S wave.
    a.   Label the S wave on the seismogram.
    b.   Which direction of motion has the largest disturbance by the S wave?   *X and Y*
    c.   S waves are shear waves. Using the diagram of the slinky, which direction does the slinky move when the S wave goes by? *up and down*

Slinky image from http://www.seismo.unr.edu/ftp/pub/louie/class/100/seismic-waves.html

12/09/2007 M 7.8 Tonga Earthquake
Recorded in San Diego

M 7.8 Earthquake (12/09/2007)

The earthquake was located on Tonga, a south Pacific Island. The record is from a seismic station in San Deigo, California.