Teacher's Guide to

Introduction to the Global Earthquake Explorer (ver 2, 8/19/03]

OBJECTIVES:

1. The students will be able to access, view, and make measurements on earthquake data via the Global Earthquake Explorer.

2. The students will be able to describe wave characteristics (velocity, period, frequency, and amplitude) from observations of seismic waves.

3. Students will be able to use technology to conduct investigations with the Global Earthquake Explorer.

4. The students will be able to predict changes in the Earth surface based on real-time or near-real-time earthquake data.

5. The students will be able to locate the epicenter of an earthquake from seismic data and explain the location in terms of plate tectonics.

MATERIALS NEEDED:

Computer or Computer Laboratory equipped with the Global Earthquake Explorer.
If available, you may find that a computer-projector works well for this module.
Vertical-component seismograms from a classic earthquake will be available on line.
Seismogram from a recent earthquake recorded on local seismometer.
Student hand calculators.
Compasses for drawing circles on maps.

TEACHER INFORMATION:

1. Some detailed Background Information is available as on-line and print copies to help support teacher preparation for SCEPP exercises. It can be exported in PDF to your disk (along with other student materials) via a button on the Getting Started screen of this module.

2. This is probably the first SCEPP module that you will use in your classroom as most other modules utilize the Global Earthquake Explorer.

3. This lesson is intended to help students recall some basic concepts about waves and earthquakes learned in middle school and adjust to using technology to conduct investigations of earthquakes and earthquake data.

4. Prior to this lesson, students should have learned about P-waves and S-waves (in middle school earth science class).

5. Prior to this lesson, students should have learned in general terms about plate tectonics and the nature of the Earth's interior (again, probably in middle school earth science class).

6. Prior to this lesson, you must access Internet-based resources or use GEE to find an appropriate recent earthquake for the Engagement phase.

7. This lesson is based upon the premise that there might not be a very good seismogram available from your instrument. Therefore, we take the student first through the various steps using a classic seismogram. If in fact there is a good seismogram available from your instrument, you may disregard all references to the classic seismogram.

8. Students may work individually if sufficient computers exist. However, with new software, they may be more comfortable working in pairs or small groups.

9. A 'Student Instructional Guide' sheet (for students) has been provided for assistance in operating this program.

10. A 'How far away is the earthquake?' sheet has been provided for your assistance with the distance calculations. Teachers should modify in accordance with student abilities. This is available on-line at Help=>Teacher Info or in paper form.

ENGAGEMENT

1. Explain to students that there was an earthquake very recently and that they have a new software tool to look at recordings, or seismograms, of that earthquake right in their county/state.

2. Explain the main functions of the Global Earthquake Explorer (GEE). Using GEE, show the students the seismogram that was recorded on the instrument at your school or at a nearby school.

3. Explain that an instrument that is part of a statewide and worldwide network of instruments accessible through the Internet recorded the seismogram you are looking at.

4. Explain that a "seismogram" is a recording of ground motion at one point on the earth. The particular seismogram that you are looking at measures VERTICAL ground motion. Details of how this works will be covered in another lesson.

5. *Ask*: What can we learn from this seismogram?
   Explain: Depending on the quality of the seismogram and the intensity and location of the earthquake, the students should be able to determine the arrival times of the principal wave forms, the properties of the waves and the location of the earthquake. If the quality of the recording is bad or noisy, explain that the instrument records ALL ground motions, not just earthquakes so that activity around the school can sometimes disturb the instrument.

EXPLORATION PHASE

1. If the seismogram is too noisy, move students to the "classic" seismogram by suggesting you start by examining a seismogram that shows these waves very clearly, and then return to our seismogram. Explain how to access the Classic Earthquake.

2. Ask the students to load specific stations using GEE. Encourage them to use GEE in a guided exploration of those stations, mostly intended to get them comfortable with GEE functions. Explain the axes of the seismogram plots are TIME (x-axis) and AMPLITUDE (y-axis) and other GEE functions as appropriate.

CONCEPT DEVELOPMENT PHASE

1. Returning to one specific seismogram, explain: Remember from your 8th grade Earth Science class that an earthquake produces three kinds of waves – longitudinal (P), transverse (S) and surface waves.

2. Show the classic seismogram and ask: How are the waves on this seismogram distributed?
   (Answers will vary)

   Explain: Note that the seismogram is essentially flat up to this "blip" (point out P wave). After that there are several other " blips".

3. *Ask*: What are these "blips" on the seismogram?
   Explain: The blips are arriving waves, recorded on the seismometer that were generated by the earthquake. Seismologists call these "arrivals". Remind the students of P-waves and S-waves if necessary.

4. *Ask*: Why do these waves arrive at different times on the seismogram?
   Explain: Different types of waves travel at different speeds, or velocities. The velocity of a wave is property of that type of wave. It depends on the type of the

wave as well as the material that the wave is traveling through. We will use this later to find where the earthquake occurred.

5. *Ask*: How are these waves different from one another?
   Explain: Point out and identify P and S waves. The P wave and S wave look different. There are other characteristics that are different between these waves. In order to learn more about the properties of waves, let us first examine a simple wave.

6. Have students click on the button marked "simple wave" (a sine wave will be shown on the screen). Explain that using this simple wave will allow us to explain these properties. Click on the sine wave to help define its amplitude and period. Explain the amplitude and period of the wave. NOTE: The x-axis on seismograms is TIME, so what is being illustrated in one cycle of the wave is the PERIOD, not the wavelength. Many people fall into the trap of calling one cycle of this wave a "wavelength". Explain that the "frequency" of the wave is the inverse of the period.

7. *Ask*: Using these terms, describe the differences between the P wave and S wave?
   Explain: The P wave is shorter period (high frequency) than the S wave. Also, describe the difference in amplitude of the P wave and S wave (this will vary depending on the seismogram you are using).

APPLICATION PHASE

1. *Ask*: Again using the classic seismogram, which wave traveled at the higher velocity, the P wave or the S wave? Explain your answer.
   Explain: Since both waves were generated simultaneously, and the P wave arrived at the recording station first, the P wave traveled with the higher velocity. Develop simple time-distance relationships to explain this (time = distance/velocity, $T=X/V$; where X is the distance from the earthquake to the recording station).

2. Explain that the differences in the arrival times of the P wave and the S wave can also be used to determine the distance from the epicenter of the earthquake to the recording station.
   Point out that X, the distance is common in the time-distance relationships for both the P- and S-waves, so we can use these times to find out how far away the earthquake is to our station.

3. Using the classic seismogram, have students construct a data table of Station, P-wave arrival time, S-wave arrival time, arrival time difference, and distance to the earthquake. Have them use GEE to determine the P-wave and S-wave arrival times **for 3 stations**. They may remember this exercise from middle school.

4. Have the students calculate the distance to the earthquake at each station using the simple equations. You can either give the students the equations or help them

develop them on their own. Detailed equation development is given on the Equation Sheet.

5. Explain that this information gives us distance but not direction. *Ask*: What would be the possible locations of the earthquake epicenter?
   Explain: The earthquake focus could be in any direction, having a radius equal to the distance from the focus to the recording station.

6. Have the students use the calculated distances at each station to estimate the location of the earthquake on a map. This can be done on paper with compasses or, eventually, on the computer using an extension of GEE. Remind students that the earthquake focus is the point *within the Earth* where the earthquake actually took place. The earthquake epicenter is the position *on the surface of the Earth* directly above the focus.

7. Explain to the students that in most cases, seismologists do not know *where* an earthquake occurred, but that using the differences in P and S wave arrival times they can determine the distance from the earthquake epicenter to the recording station.

8. Have the computer show a map with the locations of the recording station at which the classic seismogram was recorded, and the earthquake epicenter.

POSSIBLE EXTENSIONS:

1. Have the students locate the recent earthquake or another classic earthquake on their own.

2. Relate the location of the classic or recent earthquake to Plate Tectonics.

3. Discuss in detail the fact that the intersection of the predicted locations was not a single point. Explore the possible ERRORS associated with locating earthquakes.

4. Find *when* the earthquake occurred: The Origin Time.