ED51B-0750: An inquiry based seismology lesson for SeismicCanvas

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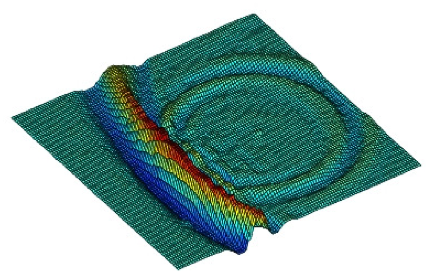
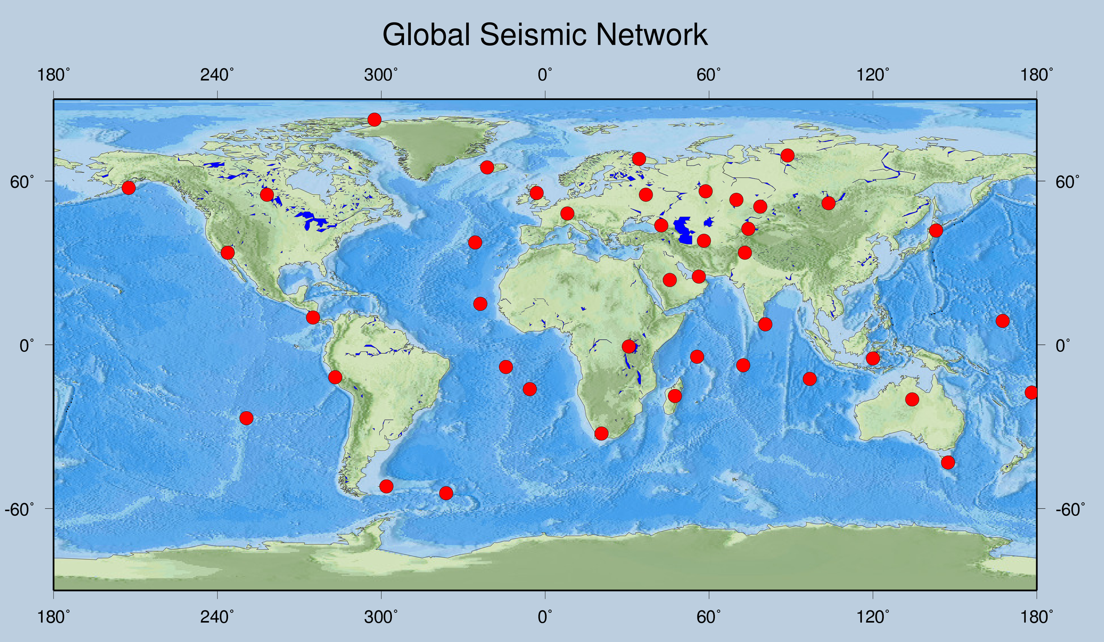


1. Introduction

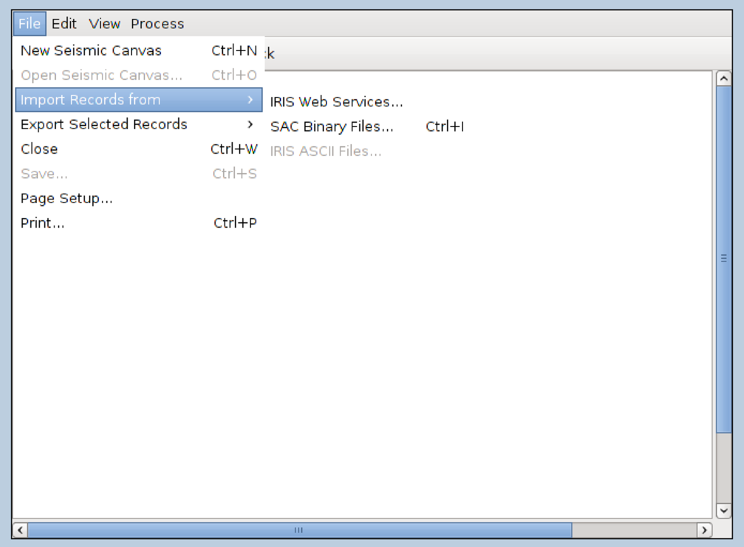
Incorporating technologies into science education to simplify the learning process and help students comprehend complex content more efficiently and accurately is highly desirable. We present a seismology lesson developed for high school and introductory undergraduate Earth science courses that utilizes the new seismic analysis software SeismicCanvas, a GUI application based in JAVA. The seismology lesson follows in the footsteps of previous seismic analysis lessons. However, by incorporating SeismicCanvas, we remove any command line knowledge requirement, while still giving the students hands on experience with digital signals, data processing, and inversion. The goal is to excite students about seismology using basic exercises such as this and eliminate the frustration common in beginning programmers. The benefit of SeismicCanvas is that is freely available and offers a GUI environment.

2. Global Seismic Network



Global seismic network stations. Data is freely available *http://www.iris.edu/data/*.

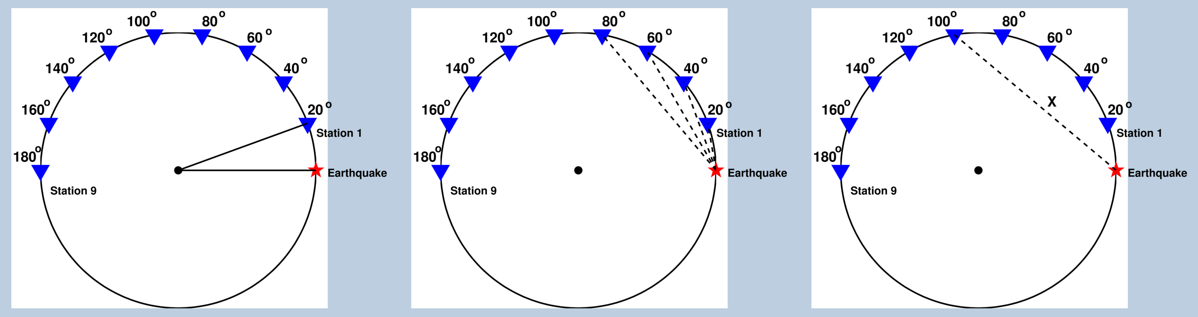
3. SeismicCanvas



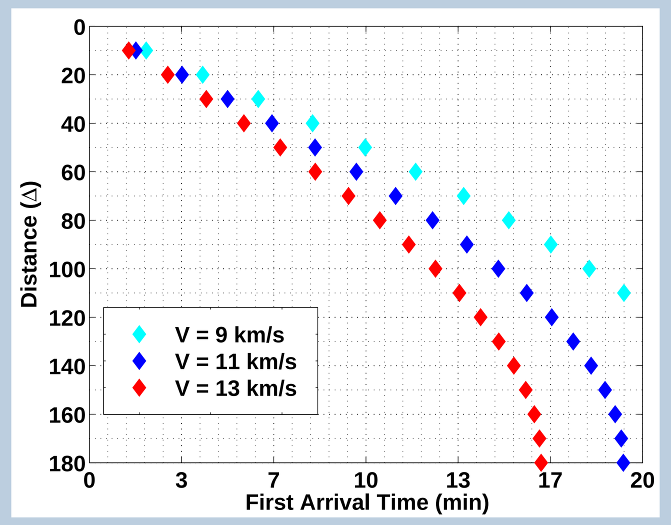
SeismicCanvas is freely available from Glenn Kroeger at Trinity University. See **ED51B-0749** in this session for details about new capabilities and project plans.

4. A Homogeneous Model

We have a good idea of Earth's dimensions. Therefore, students can compute synthetic arrival times (T = X/V) for P or S waves. In this example, we use a homogeneous sphere with a radius of 6371 km.

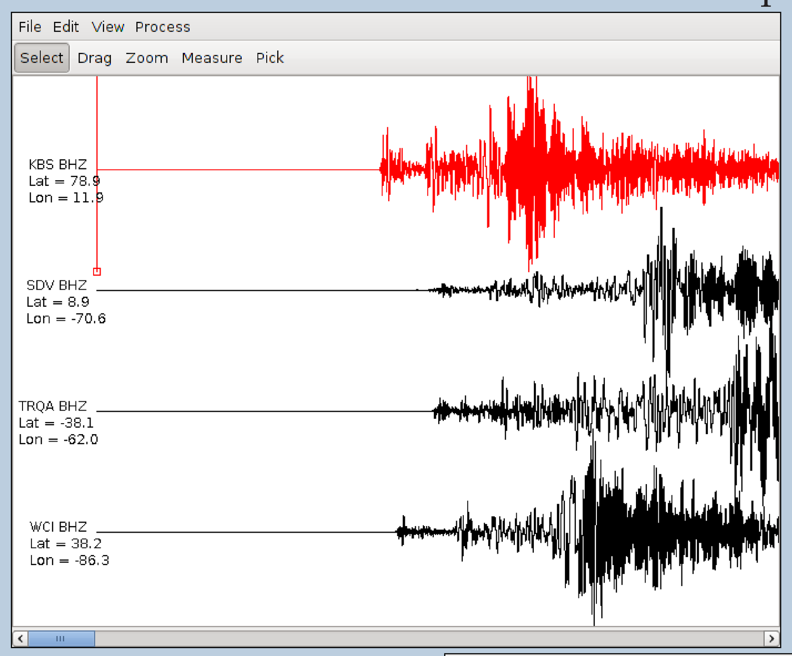


We compute X for stations at different degree distances (Δ) from an earthquake. Then we compute theoretical arrival times at different Δ for different P-wave velocities (right plot).

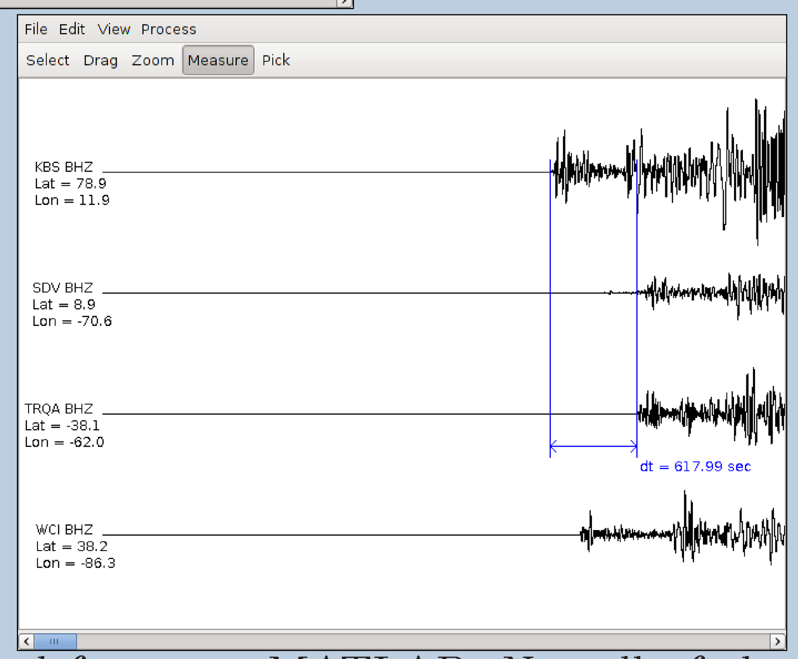


5. Analysis in Seismic Canvas

Using SeismicCanvas we let the students explore the effects of different data processing functions.



The waveforms on the left come from Honshu, Japan earthquake 11 March, 2011. The red waveform has been bandpass filtered.

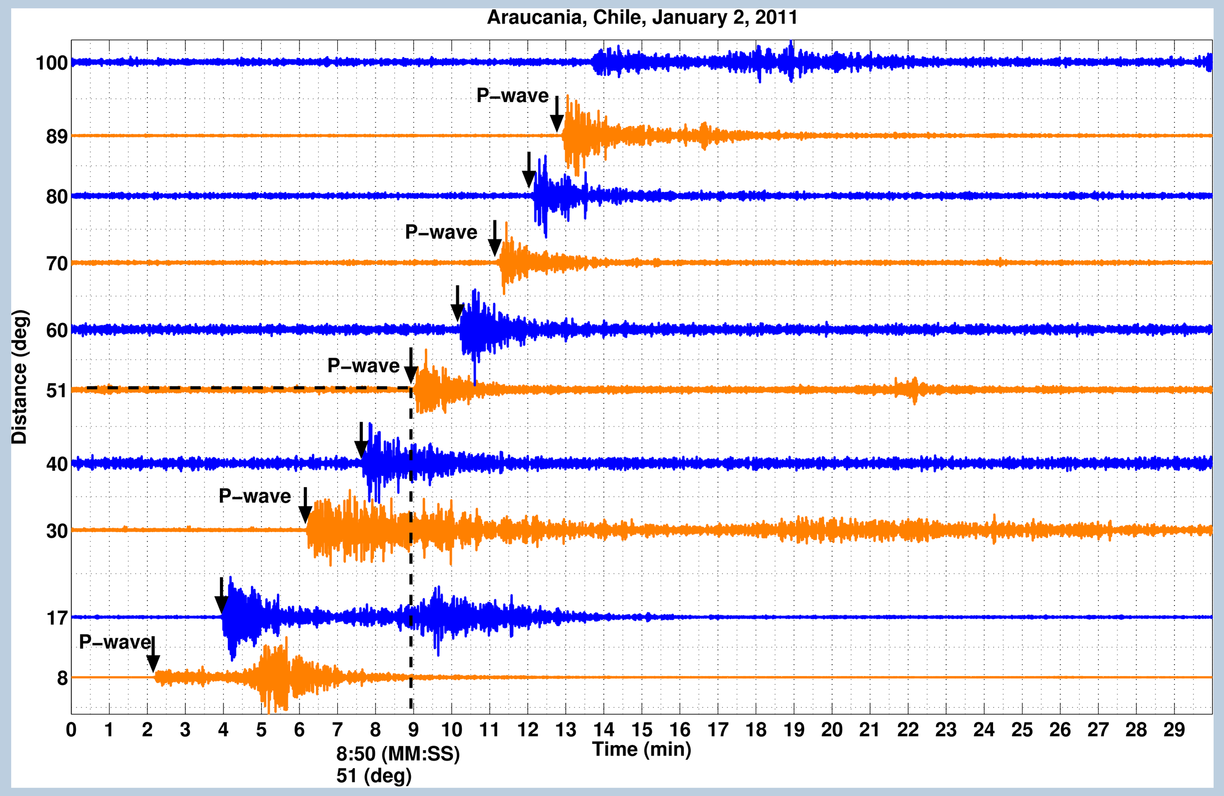


The left plot shows the bandpass filtered waveforms after zooming around the first P-wave arrival. Students can use the mouse to estimate a relative time shift dt from waveform to waveform.

From here on we are left to use MATLAB. Not all of the needed processing features available in SeismicCanvas yet. For instance, SeismicCanvas does not sort traces based on spatial information or set earthquake origin time.

6. Phase identification

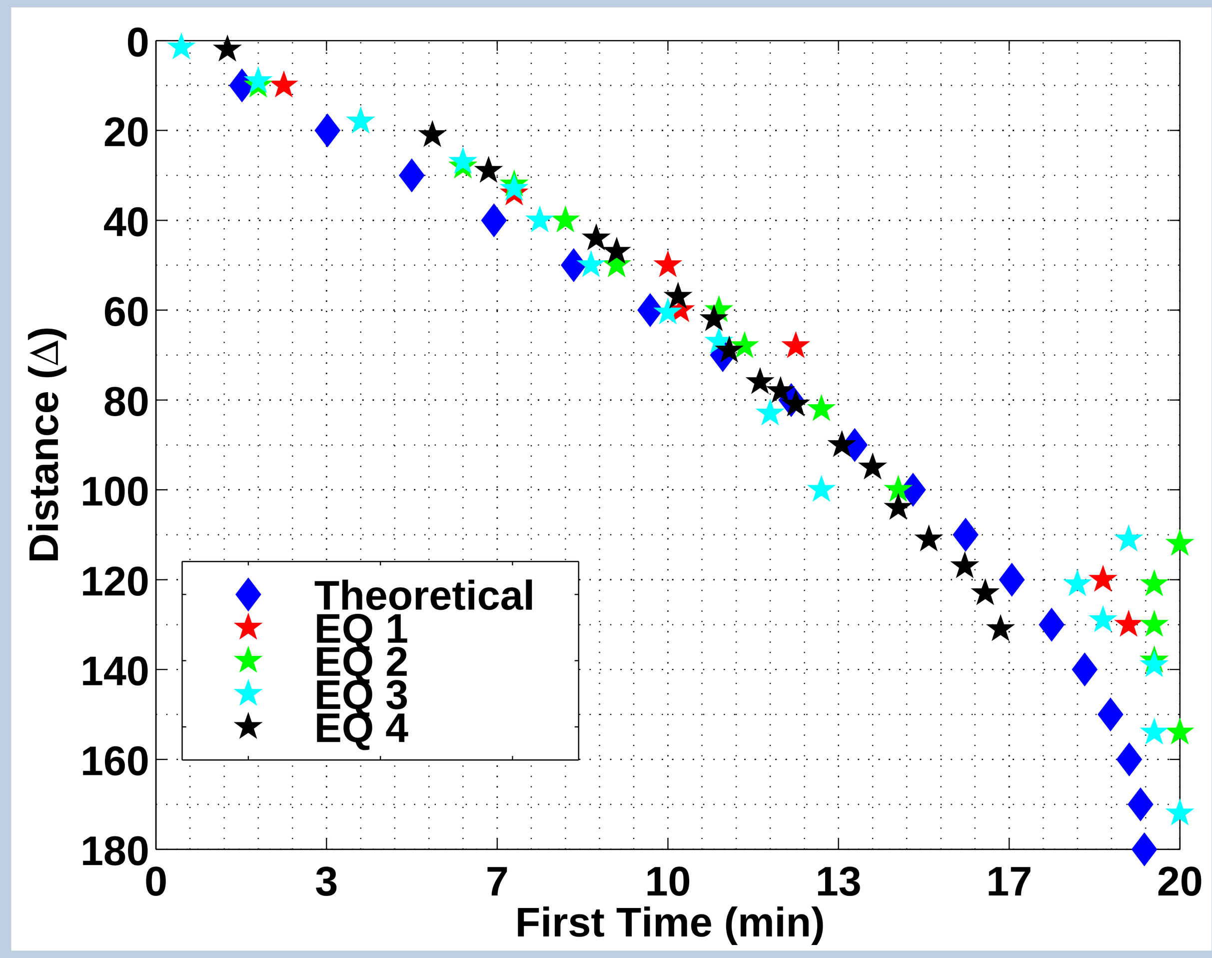
Once the data are correctly sorted by distance from the earthquake and the desired filter and gain have been applied, students begin to identify phase arrivals. In this example the direct P-wave is used.



Data are filtered between 0.5 to 19 Hz.

7. Inverse Modeling

Students can easily compare their picked earthquake arrival times to their synthetic arrivals. Plotting observations and synthetic data in this way leads to rather intuitive insights.



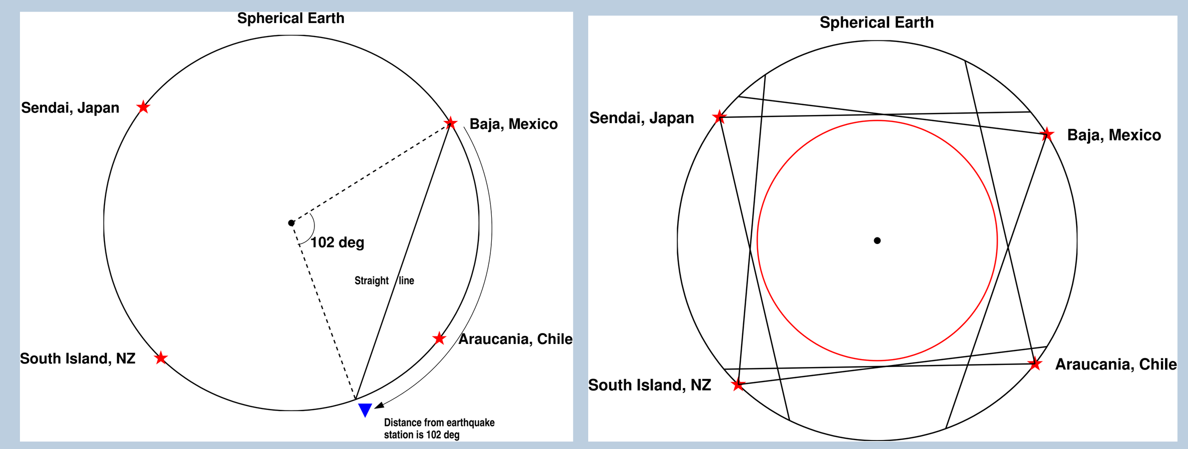
Questions for students:

- Are data from multiple earthquakes similar?
- If we changed the velocity, would the synthetic data match the observed data better?
- Should we add layers?
- Should we change the processing before we pick phases?

8. Multiple Earthquakes

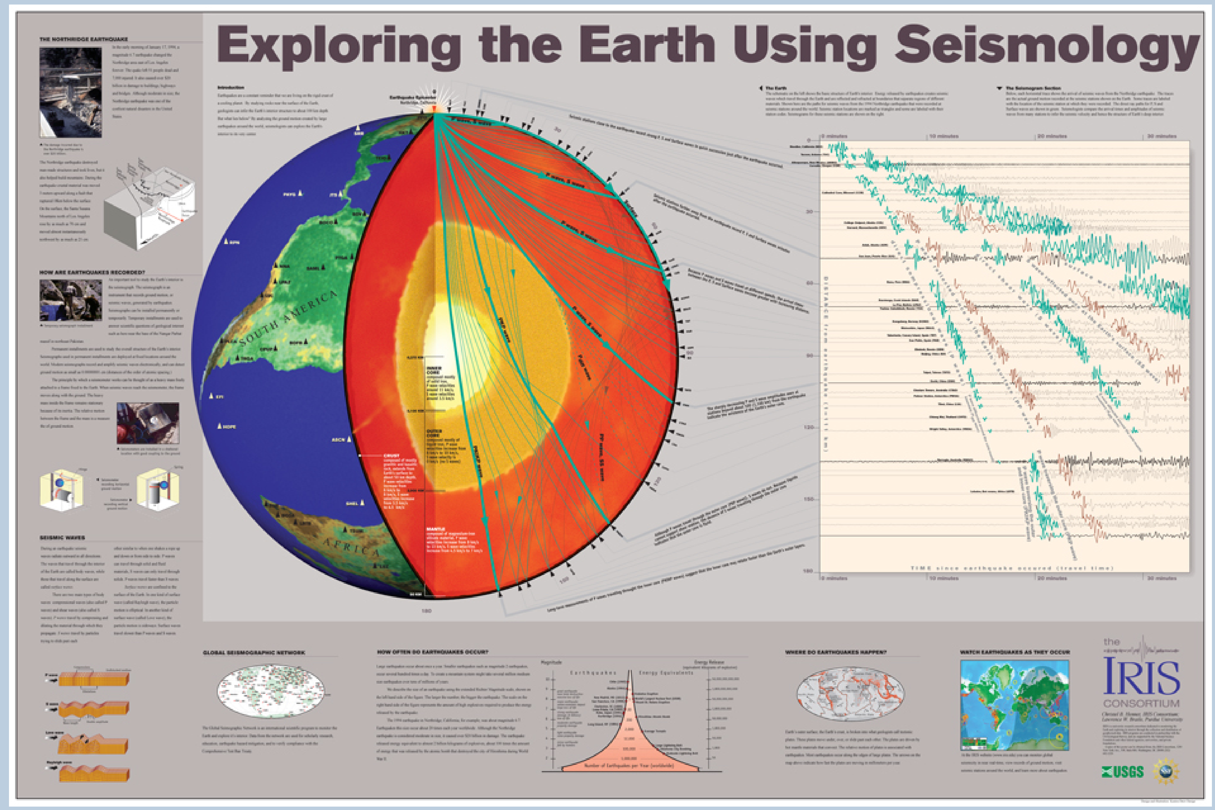
What can we learn from multiple earthquakes?

After students try to 'randomly' adjust their velocity model, either by changing the velocity or adding layers, it is worthwhile to let them try to repeat their results with many earthquakes. Investigating where the model and synthetics deviate can be enlightening, as illustrated below.



8. Further thoughts

- What does studying shear waves tells us that compressional waves do not?
- How can we tell the outer core is liquid?
- What features can we easily implement in SeismicCanvas besides data processing capabilities: 1D modeling, pick plotting, etc.?
- What other basic seismology (or other signal processing) lessons can we use this simple GUI applications for (e.g., microseismic data from a reservoir)?



Acknowledgments

We thank the facilities of the IRIS Data Management Center for the waveform data and Glenn Kroeger for SeismicCanvas. The backbone of this lesson, called Determining Earth's Internal Structure, comes from the IRIS Education and Outreach group (http://www.iris.edu/hq/resource/).