Communicating to Non-Scientists

Detection of Missing Earthquakes in Texas Using USAArray Data

Allante Harrison
IRIS Intern
July 25, 2013
Meet the USArray

A 400-seismic station array that is being moved across the United States.

Naturally occurring earthquakes aren’t as common in Texas as they are in the seismically active West Coast. Hydraulic fracturing is, however. USArray data has shown us that Texas is more seismically active than we’ve previously believed.

What is the relationship between hydraulic fracturing and seismicity in Texas?
What is Hydraulic Fracturing?

Hydraulic fracturing or “hydrofracking” is the injection of fluids into the ground to fracture rock in such a way as to gain access to previously inaccessible oil and gas reservoirs. While obviously beneficial, some side effects of fracking aren’t as favorable.

The injection of these fluids can increase pore pressure of rocks and relieve stress on suitably oriented faults causing them to slip, inducing earthquakes.
Importance

- USAarray data has increased the possibility of detecting smaller earthquakes.
- If these events prove to be induced events, possible damage from such earthquakes can be mitigated.

Project Goals

- To use Earthscope USAarray data to detect more events in Texas from 2009-2011.
- To use the newly found events to study possible interaction with hydrofracturing.
Overview

Step 1: Identify missing\textsuperscript{1} earthquake events to create a more complete catalog.

Step 2: Access and analyze injection well data.

Step 3: Find possible relationships between the injection well data and earthquake occurrence.

\textsuperscript{1} The term “missing earthquake” in this presentation refers to earthquakes that have occurred, but have not been recorded in earthquake catalogs.
The Waveform Cross-Correlation

- Takes the waveforms of an identified earthquake and compares them to waveforms collected over a period of time.
- Once a template event is scanned against the continuous data, it is assigned a Cross-Correlation value, which corresponds to the waveform's degree of similarity.
- Both types of waveforms are collected from the USArray.

<table>
<thead>
<tr>
<th>Cross Correlation (CC) value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perfectly identical</td>
</tr>
<tr>
<td>0</td>
<td>No relation</td>
</tr>
<tr>
<td>-1</td>
<td>Perfectly inverse</td>
</tr>
</tbody>
</table>
To the left is an example of an event with a 1.0 CC value. The red waveforms are those of the template event, while the grey waveforms are those of the continuous data.

Note that the template waveforms match up perfectly with the continuous waveforms. This is a characteristic of a self-detection, which is the template event basically finding itself in the continuous data.
A New and Improved Catalog

The cross correlation takes events that are similar enough to the template events and adds them to a new catalog.
Rate Increase?

• Now that the new catalog is generated, a very sharp increase in the rate of earthquakes is noticeable around the middle of the month.
• What are the trends in injection for this time of the month?
  – Is there a positive, negative, or no relationship between injection and earthquake increase?
  – Perhaps a critical rate of injection is reached on the date of earthquake rate increase?
Future Work

- Once a relationship is identified, improvements can be made to hydrofracking practices and the public can be made aware to take proper steps to lessen incurred damage.
- Repeat this process for other months to validate the relationship.