# The Effect of Open Inquiry on a Teacher-Student's Ability to Create a Poster

(see also: Longitudinal Speed Prediction with Limited Results due to Limited Available Data)

Jim Stith (Teacher at Newcastle High School, Newcastle, Wyoming)

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## Abstract

The purpose of this investigation was to use LIGO-provided information to determine the 2010 Baja California earthquake longitudinal wave velocity. This speed data was then used to investigate a similar disturbance of comparable magnitude, depth, and location present in the 2009 Baja California earthquake. This information was derived from LIGO information from Hanford and Livingston Observatories in Washington and Louisiana, respectively along with USGS earthquake data.

The results proved inconclusive due to, supposedly as to what the author can infer, anomalies in fore and aftershocks in the 2009 Baja California Earthquake. The velocities in the 2009 Baja California earthquake were far below the acceptable threshold given by the USGS. Given the small data set available, it is recommended by the author to gather a larger pool of information as well as investigate instances of other locations with more data available in the status quo.

## Introduction

The question first arose during a free investigation of the Baja California earthquake of 2010. Looking at data from the Hanford and Livingston Observatories, it was shown that there was an 85 second lag between when the Hanover Observatory and the Livingston Observatory detected the initial shock. The author assumed the distance fairly equidistant and therefore, the discrepancy was a matter of considerable interest.

Wondering if the rock structure density between the epicenter and two observatories would alter the speed of the seismic waves, the author began researching how density, maleability, and other factors will change the speed of said waves (http://earthquake.usgs.gov/learn/topics/seismology/keeping_track.php) . After calculating the actual distance (arc distance, not chord distance, the author assumes), There was a noticable discrepancy in the distances. This distance difference then began a new investigation.

## Procedures

1. Locate epicenter of 2010 Baja California Earthquake (via USGS site).

2. Locate Hanford (via their website) and Livingston (via Google Earth) observatory locations.

3. Using NOAA Latitude/Longitude Distance Calculator (http://www.nhc.noaa.gov/gccalc.shtml) determine the distance between the epicenter and two observatories. Be sure to properly format the datum (or convert via http://www.synnatschke.de/geo-tools/coordinate-

converter.php)

4. Log on to the LIGO E-Lab's Bluestone Project (http://www.i2u2.org/elab/ligo/bluestone/index.jsp).

5. In the data selection drop down menu, select HO Site, PEM Subsystem, EX Station, SEISX Sensor, and rms Sampling. On the left, click the plus sign under Add/Remove to add a second data set to the graph. Replicate the aforementioned data selection substituting the LO site for the HO site. Click on Plot.

6. Locate the 2010 Baja California earthquake (22:40:41 UTC on April 4, 2010). Highlight the date or manually select the date above the graph, hit "Zoom to Seletion" and click Plot again.

7. Repeat step 6 until the plot is similar to Figure 1.

8. Determine lag between Hanford Observatory (HO) and Livingston Observatory (LO) detecting the distrubance.

9. Subtract the difference between the distances (found in Step 3). Dividing by the time found in Step 8, calculate the speed of the wave in kilometers per second.

10. Using USGS earthquake information, determine if the speed is within an acceptable range of P-wave speed (if not, please recheck work).

11. Using the USGS and LIGO websites, locate the 2009 Baja California earthquake. Repeat steps 1-9 to determine distance between the disturbances and the stations, difference between those distances, lag between times each station detects the earthquake, and then calculate the speed of the wave.

12. Use distance between the two stations during the 2009 Baja California earthquake and divide this by the wave velocity for the 2010 Baja California earthquake (from Step 9).

13. Compare the derived speed of the 2009 Baja California earthquake from step 11 and the expected wave velocity from step 12 as well as comparing the lag difference between the two graphs.

# Results

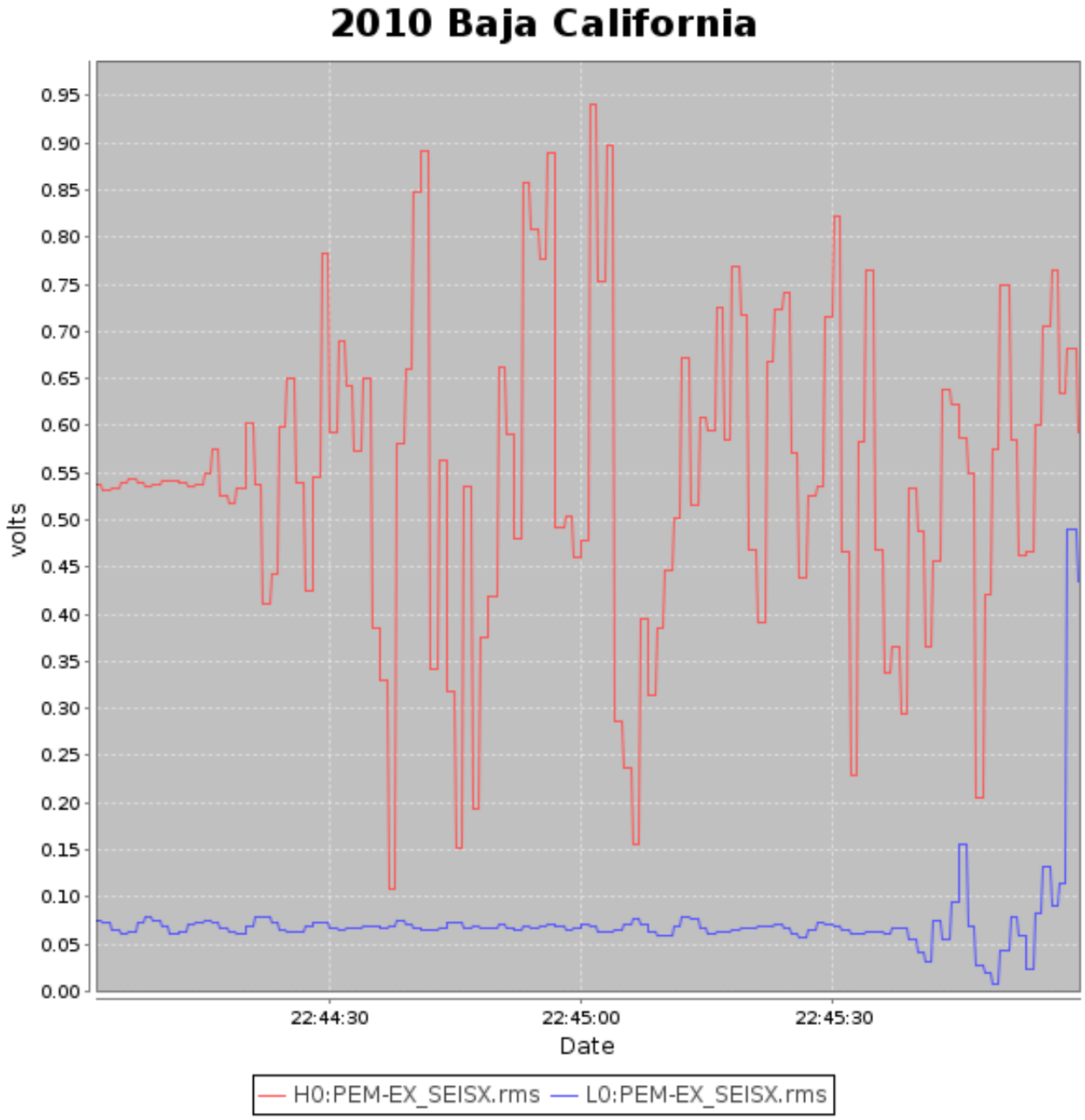
2010 Baja California Earthquake Stats
Magnitude: 7.2
Distance to Hanford (HO): 1630km
Distance to Livingston (LO): 2329 km
Distance difference between sites (HO-LO): 699km
Time lag between HO detection and LO detection: 85 seconds (which is 0.0235 hr)
699km/0.0235=29,744.68085km/hr= **8.26241135 km / s** (within acceptable speed http://earthquake.usgs.gov/learn/topics/seismology/keeping_track.php)

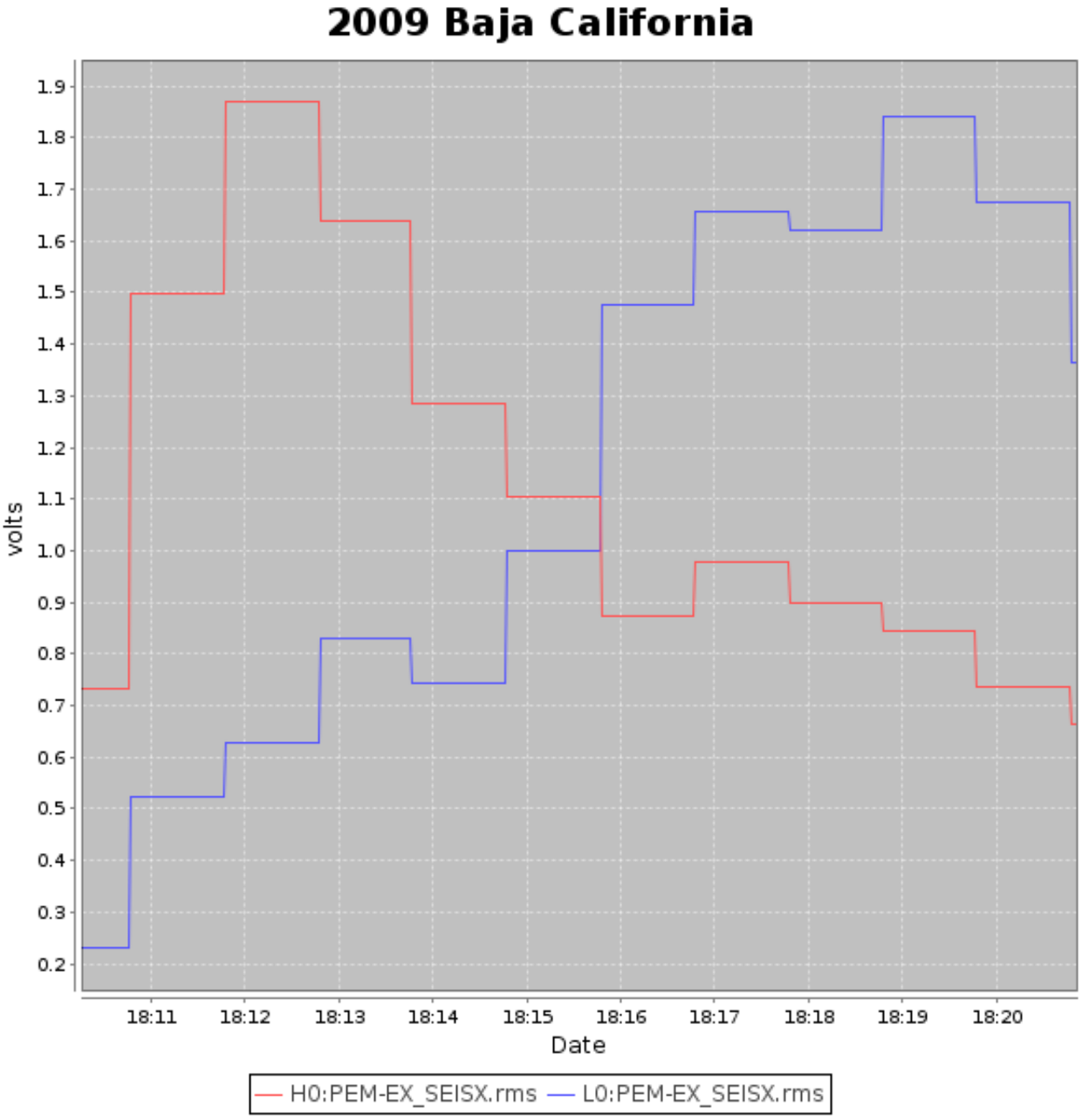
2009 Baja California Earthquake Stats
Magnitude: 6.9
Distance to Hanford (HO): 2014 km
Distance to Livingston (LO): 2133 km
Distance difference between sites (HO-LO): 119km
Time lag between HO detection and LO detection: approx 270 seconds (which is 0.075hr)
119km/0.075=1586.6667km/hr= **0.44074075 km / s** (NOT within acceptable speed http://earthquake.usgs.gov/learn/topics/seismology/keeping_track.php)

Expected Lag Interval:14.40257513 seconds (not found)

14.4 seconds does not equal 270 seconds (4.5 minutes).

# Figures






## Discussion and Conclusions

Results in this investigation were inconclusive. The predicted wave speed did not match the derived wave speed. The USGS Earthquake Hazard Site notes that there was a 5.8 magnitude foreshock that could have interfered with the results. The author would suggest one of two things:

1. Waiting for more, detectable disturbances in the targeted area (within a few hundred kilometers of the targeted area.

2. Select a new area (New Madrid, for example) that both detectors can be triggered. And a fairly active area could give a larger pool of data. The small sample size was detrimental to the investigation. A larger sample size will be less affected by anomalies.

# Bibliography

APA. Meh, do it yourself. I've got a video to do.

http://earthquake.usgs.gov/learn/topics/seismology/keeping_track.php

http://www.nhc.noaa.gov/gccalc.shtml

http://www.synnatschke.de/geo-tools/coordinate-converter.php

Google Earth

LIGO site

USGS Earthquake Site