



Update on Summer Research on Induced Seismicity
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Tools

- Linux, Bash Shell Script, Obspy, F-K & gCAP packages, SAC tools

Location

- Central Oklahoma, U.S

Event characteristics:

- Magnitude greater than 3.0 throughout 2016-2017.
- Notice there was an earthquake on Sep 3 of magnitude 5.8

Signal Processing

- Waveforms are obtained and compiled into SAC files to remove instrument response.
- Rotation of three-component seismograms to great circle, removal of mean and linear trend in waveforms & unit conversions are involved.

Velocity Model:

- Velocity model is determined (cross-referenced with values obtained from Crustal 1.0).
- Apply F-K package to compute Green's function (Synthetics)

Inversion Method:

- Apply Generalized "Cut-and-Paste" method (developed by Dr. Lupei Zhu) to combine both the observed data and synthetic data to produce inversion.
- gCAP performs grid search over the source mechanism parameters (strike, dip, rake, depth, magnitude) within the search range and step size.

Inversion Result (Example):

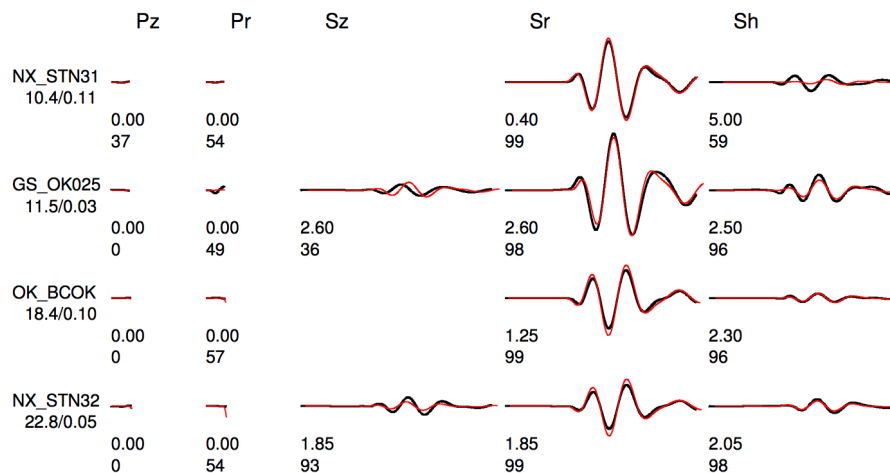
- The inversion result only shows event on 1-1-2016.
- The upper left hand corner shows the moment tensor solution of the seismic event.
- A close-enough strike-slip fault of strike 123, dip 79 and rake 19. This fault plane (unlike the auxiliary plane) is more likely to be responsible for the induced seismic activity.
- The focal depth for this case is 4km (where fluid injection is usually of depth around 1-2km). This is quite a reasonable result (as long as variance reduction is well above 50) ; however, a more reliable result is likely to show a shallower depth. (with a close-to-zero misfit)
- Observed data in black. Synthetics in red.
- Phase segments from left to right are vertical Pnl, radial Pnl, vertical surface waves, radial surface waves and transverse surface waves.
- Output shows station name and epicentral distance/constant shift.



Event 2016172 Model and Depth vmn_4

FM 123 79 19 Mw 4.86 rms 8.271e-04 453 ERR 1 1 4 ISO 0.00 0.00 CLVD 0.00 0.00

Variance reduction 82.4



Future works:

- More inversions (for other events) to obtain much better results.
- Inversion is required for different depths to check if there are better fits.
- Check consistency with surrounding geological settings & injection activity details.

Comments:

This methodology using source mechanism inversion can be applied for Canada's Western Sedimentary Basin (however fewer stations than in US) to investigate induced seismic activity. This method could produce quite reliable result; however, there are other methodologies (probabilistic/statistical models) which are of interest to me.