Investigation of the induced seismicity in the Fox Creek region in first 3 months of 2016 using University of Calgary (DSA) and publicly available IRIS (RAVEN) local seismic arrays

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Objectives

Induced seismicity in the Fox Creek region has become a more pressing issue within the last 3 years due to multiple large scale events with magnitude over 4.0. As a response to the increased seismic activity in the area, the regulator has instituted subsurface order No. 2. Recent statistical analysis revealed that the sharp increase of seismicity in Western Canadian Sedimentary Basin mainly relates to hydraulic fracturing (HF) stimulation (Atkinson, G. M., et al. 2016).
Objective of this research is to investigate the induced seismicity and aftershock events of the HF triggered earthquake with magnitude Ml 4.7 on January 12, 2016 in the Fox Creek region. To accomplish this, I am developing an Obspy based workflow for quick detection and analysis of repeating and near-repeating seismicity that can be scaled up when more data becomes available.

Location and Available Data

University of Calgary local DSA seismic network was deployed South-East of the epicentre region of the January 12, 2016 Ml 4.7 shock from early January 2016. Moreover 5 stations from Alberta Geological Survey Regional Alberta Observatory for Earthquake Studies Network (RAVEN) has been operational at the time of event: "SWHSA","LGPLA","BDMTA", "STRPA" and "BRLDA". U of Calgary array is composed of 6 broadband stations, which record ground motion at a sample rate of 200Hz. RAVEN stations record ground motion at a sample rate of 100Hz.

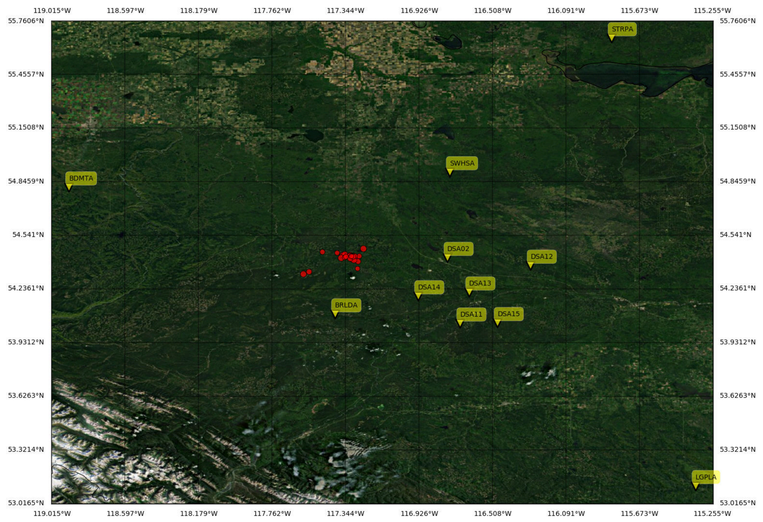

Figure 1: The distribution of the parent events and location of seismic stations. Yellow triangles are the University of Calgary (DSA) and IRIS (RAVEN) seismic stations. Red dots are events from TransAlta catalog between 1 January and March 31 2016

Catalog containing 36 events between January 1, 2016 and March 31, 2016 from Fox Creek area for the implementation of the template matching algorithm was extracted from TransAlta catalog.

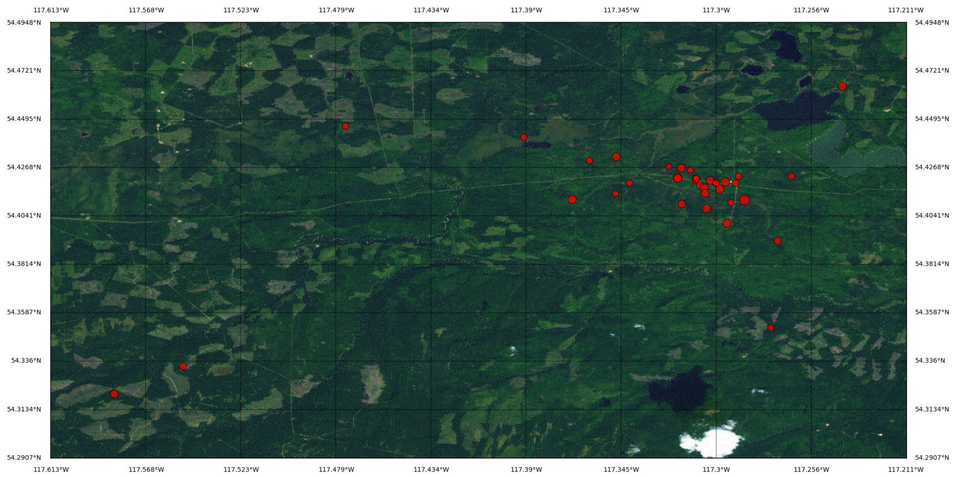

Figure 2: Red dots are events from TransAlta catalog between 1 January and March 31 2016

Proposed Method

Due to high degree of similarity of waveforms for closely located events with similar focal mechanisms, template matching algorithms approaches have been widely adopted to detect induced earthquakes (Oprsal et al., 2014). Matching filter algorithm can be described as a multi-component cross-correlation between a long pre-processed time series with a preconditioned parent signal. (Caffagni et al., 2015).

- The first step in applying the matched filter involves obtaining high signal-to-noise ratio template events. TransAlta catalog will be used for the initial templates. Templates for the MFA will include full waveform: pre-P noise (0.5 second), P and S waves, and S-coda.
- The generated after MFA waveforms are clustered into groups based on high degree of similarity, and these clusters characterize the different sources involved. Subsequently clusters are stacked and used as the new template events with a higher signal-to-noise ratio. Finally the process is repeated with a more conservative threshold utilized to detect more events.
- MFA detected events are located using local velocity model and HYPOSAT software (Schweitzer, 2001).
- Look for the spatial and temporal correlation between clusters of events and hydraulic fracturing in the Duvernay Shale.
- Perform interpretation

Proposed Method (Continued)

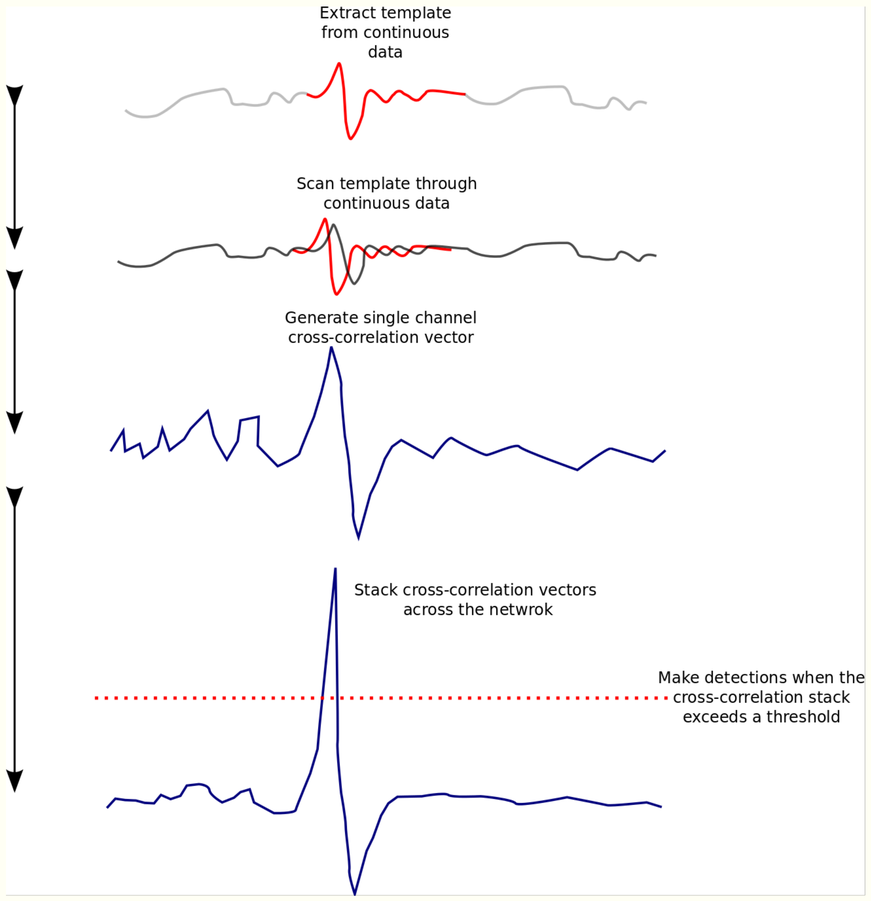

Figure 3: Shows proposed steps for the Matching Filter Algorithm. Source of the picture:http://eqcorrscan.readthedocs.io/en/develop/tutorials/matched-filter.html

Next Steps

- Develop an Obspy algorithm for the automatic generation of parent events for MFA.
- Utilise MFA within EQcorrscan package.
- Develop Catalog of "child" events.
- Calculate local magnitudes of the identified "child" events through a Richter scale approach.
- Locate "child" events using velocity model based on the local well log data and HYPOSAT software.
- Find wells that were undergoing HF operations at close proximity to the detected seismicity clusters (based on detections from MFA).
- Interpret findings.
- Repeat the process when more data becomes available.

References and Software used

- Bulletin 2015-07: Subsurface Order No. 2: Monitoring and Reporting of Seismicity in the Vicinity of Hydraulic Fracturing Operations in the Duvernay Zone, Fox Creek, Alberta
- Atkinson, G. M., et al. (2016), Hydraulic fracturing drives induced seismicity in the Western Canada Sedimentary Basin, Seismol. Res. Lett., 87(3), 631âĂŞ647.
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- Caffagni, E., Eaton, D.,W., Jones, J.P., Van der Baan, M., 2015, Detection and location of microseismic events using a matched filtering algorithm (MFA), Geophysical Journal International, submitted
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ObsPy
A Python Framework for Seismology

EQcorrscan
Correlation for earthquake detection in Python

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