

Detection Threshold of the Seismic Stations and the Magnitude of Completeness in Alberta

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Overview

1. Seismic Stations and RAVEN.
2. Magnitude of Completeness:
 - Part 1: Station Performance,
 - Part 2: Synthetic M_c ,
 - Part 3: Statistical Variability in M_c ,
 - Part 4: Cluster Correlation.
3. Conclusion.

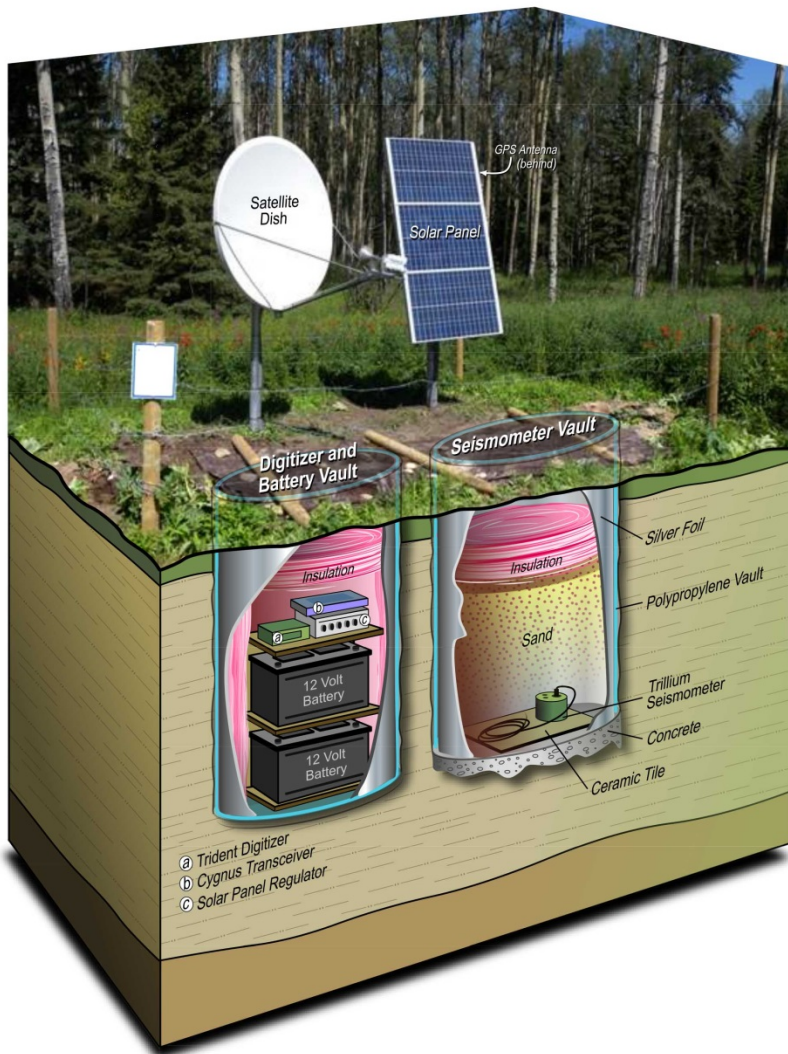


Chapter 1:

Seismic Stations and RAVEN



Seismic Stations



» Satellite based seismic stations:

- First installed Summer 2013,
- 16 stations in the province.

Seismic Stations



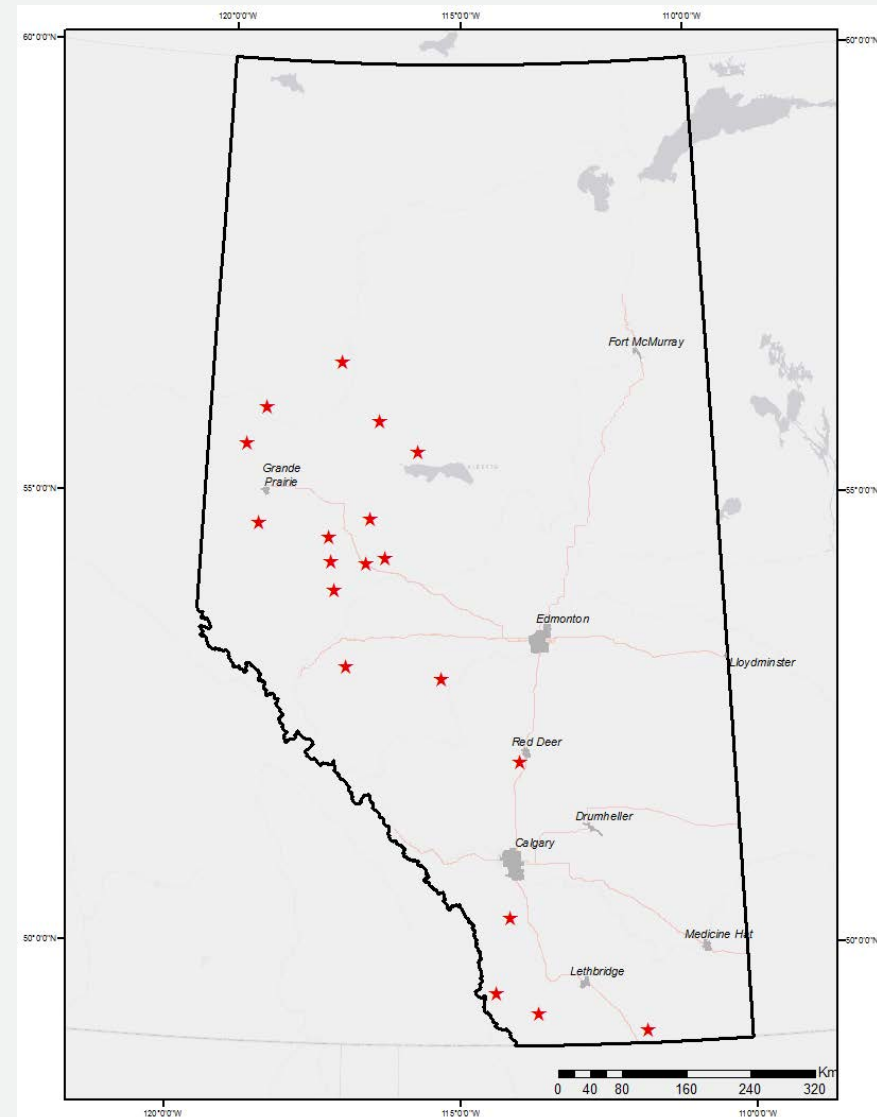
» Cellular based seismic stations:

- First installed Summer 2018,
- 4 stations in the province.

Regional Alberta Observatory for Earthquake Studies Network

» RAVEN (Regional Alberta ObserVatory for Earthquake Studies Network) [Shultz & Stern, 2015]:

- Established in 2013 as a provincial backbone for earthquake monitoring,
- Total of 20 stations,
- Locations have been targeted based on detection deficiencies, azimuthal gaps, known areas of quarrying or blasting, or areas of clustered seismicity.

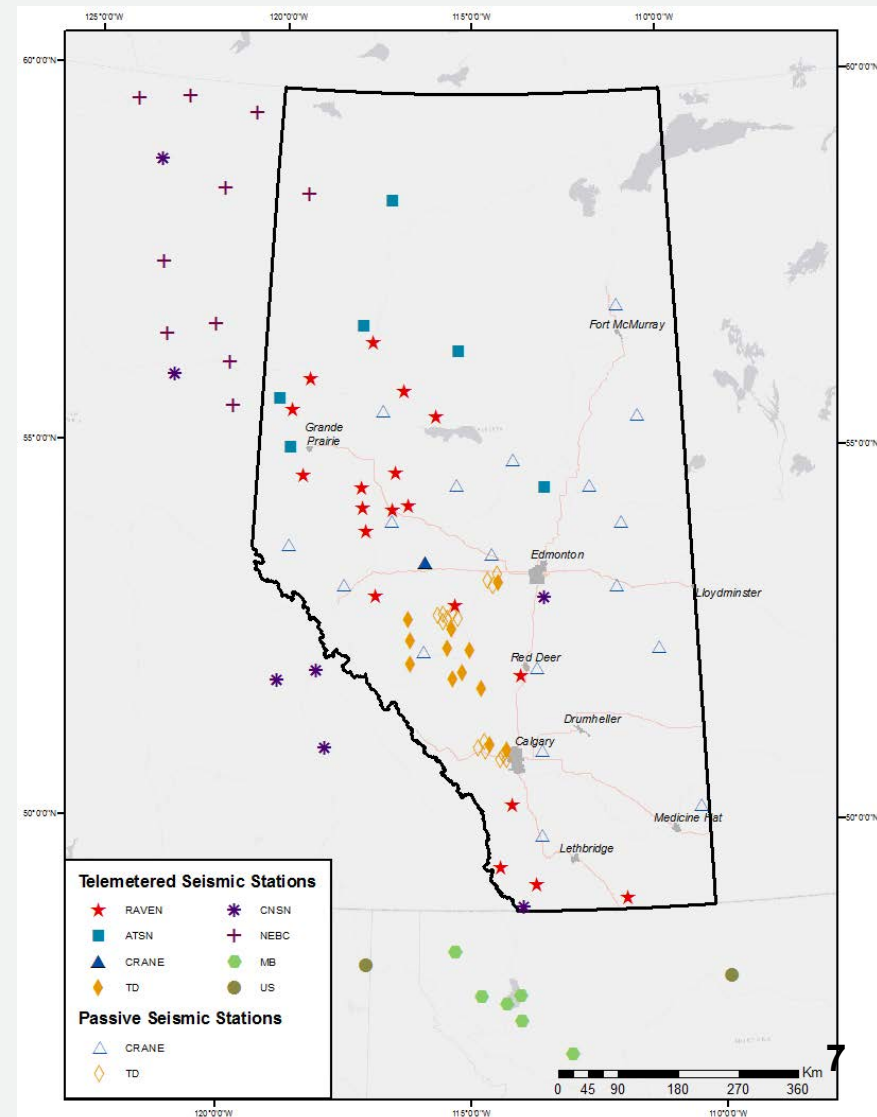


AGS Earthquake Catalogue

» Seismic data comes from multiple agencies:

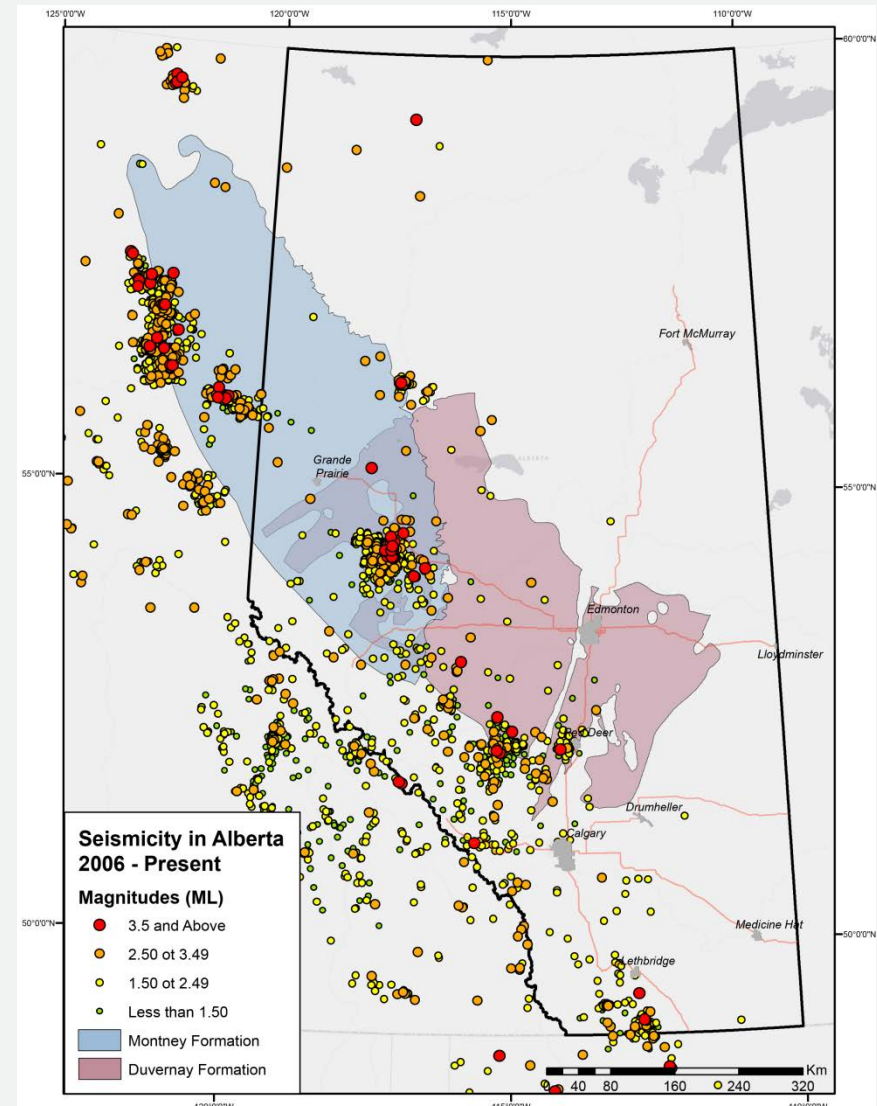
- University of Alberta, University of Calgary, Western University, Geological Survey of Canada, British Columbia Geological Survey, Montana Bureau of Mines and Geology, and US Geological Survey.

» Over 50 stations are used to monitor ground motion in the province.



AGS Earthquake Catalogue

- › Seismicity in Alberta is sparse and relatively quiescent.
- › Over 1500 earthquakes have been detected since 2006.
- › Earthquakes in Alberta happen in clusters and account for the majority of the seismicity in the province.



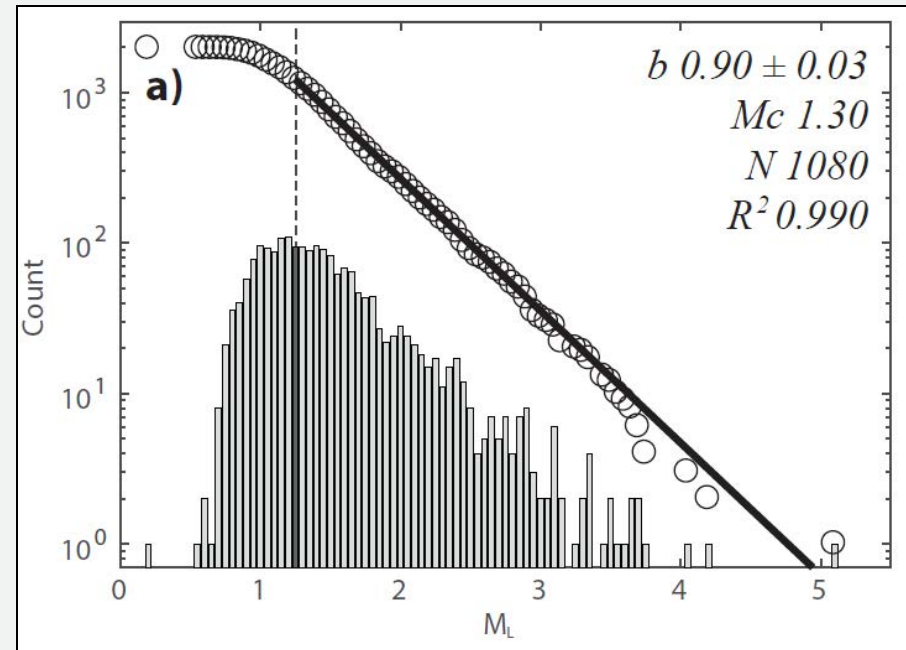


Chapter 2: Magnitude of Completeness

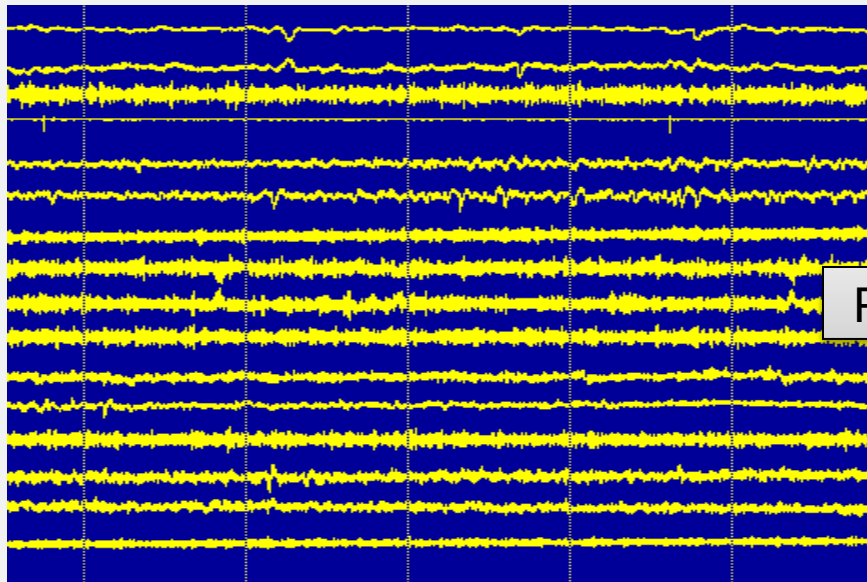


Gutenberg-Richter Law

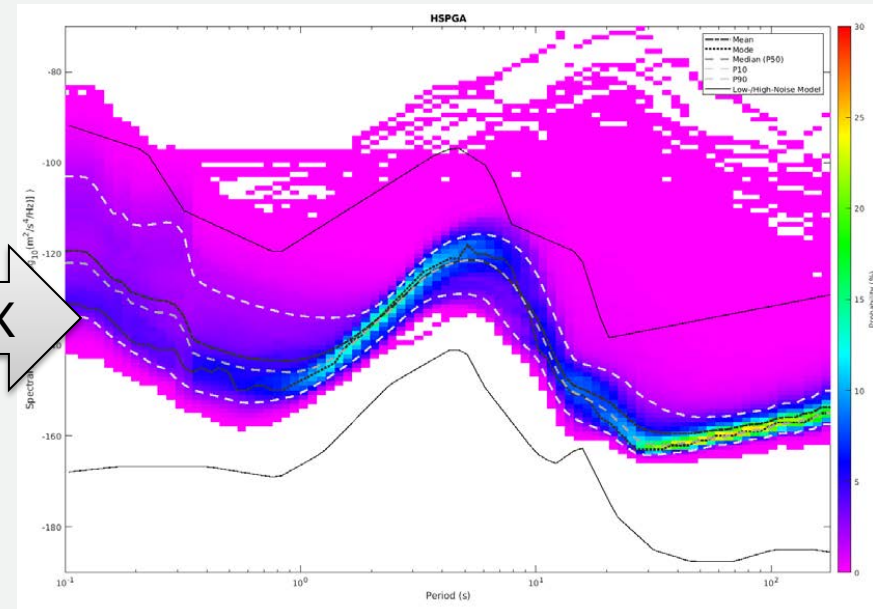
- › Earthquake counts follow a log-linear scaling distribution.
- › Magnitude of Completeness, M_c , is characterized as the departure point from the log-linear scale. (Gutenberg and Richter, 1942)
- › Not enough data points in Alberta to determine empirically; synthetic tests are used.



Part 1: Station Performance



PQLX



- › Continuous waveform data in the time domain as collected by the AGS.

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- › Waveform data in the frequency domain – Probability Distribution Functions (PDFs) [McNamara & Boaz, 2011].

Part 1: Station Performance

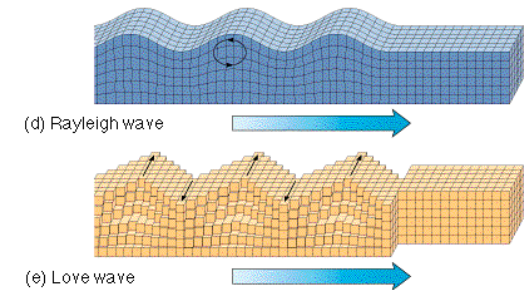
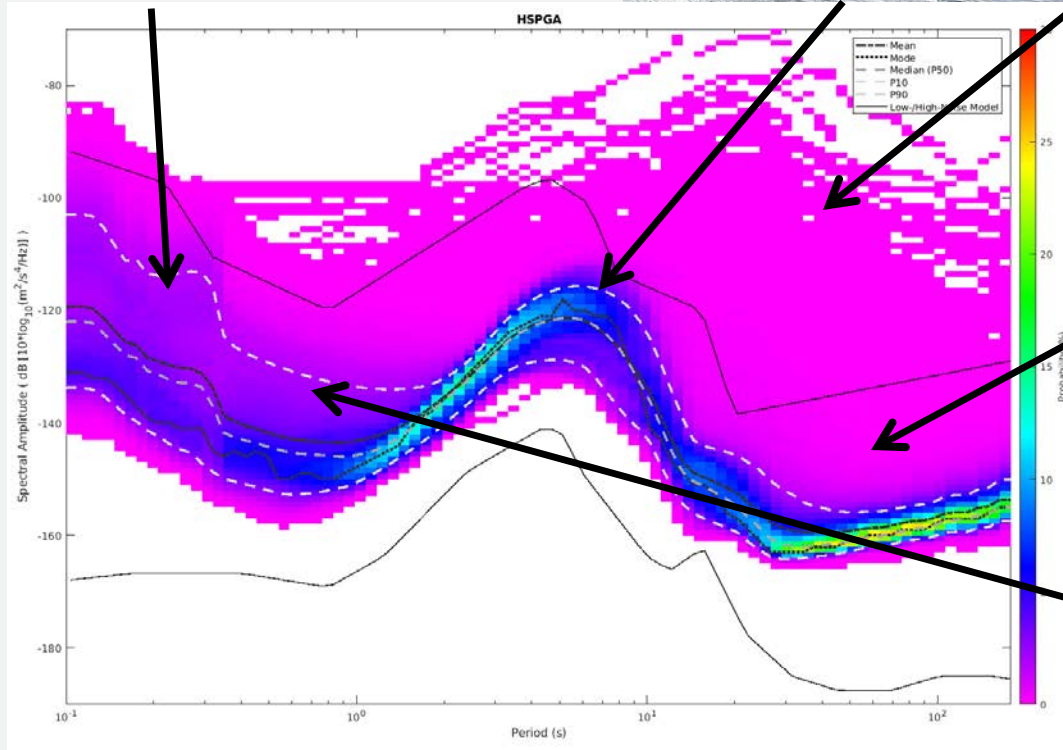


Cultural Noise

Seismic Energy from the Ocean Waves

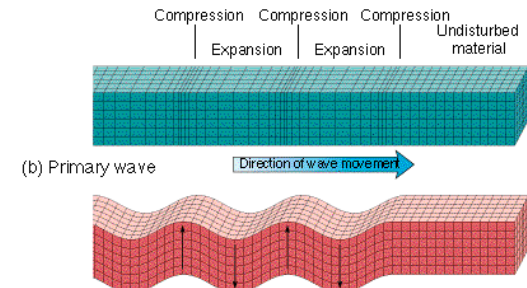


Instrument Self-noise

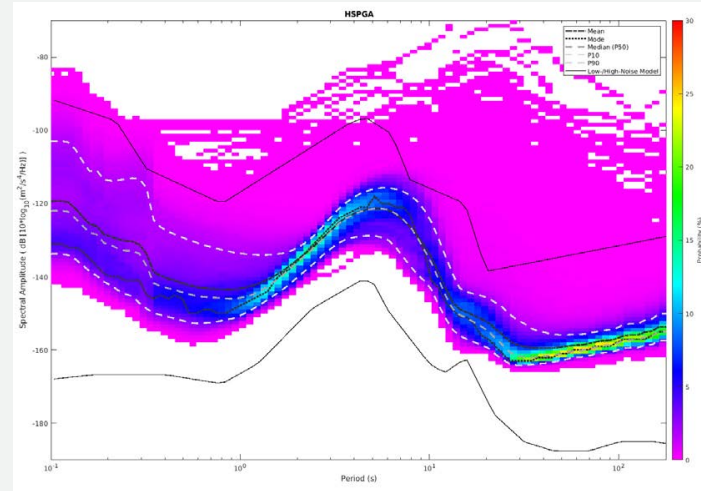
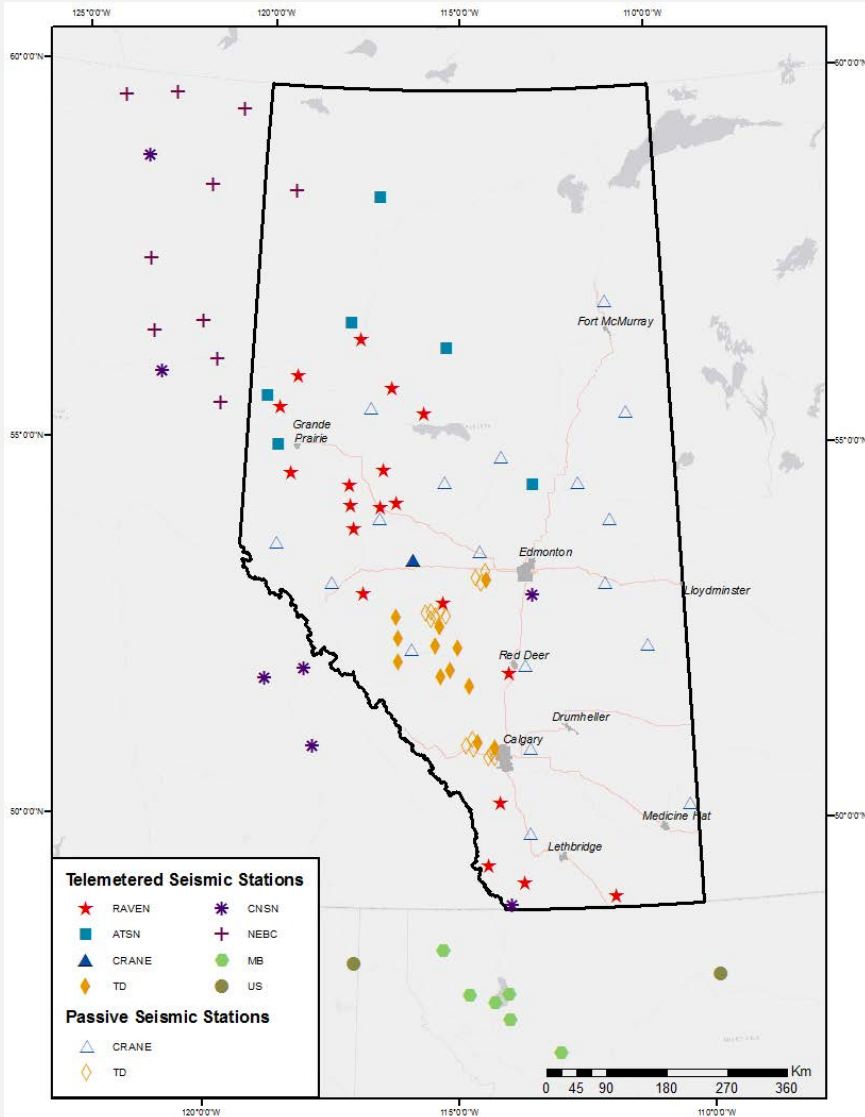


Surface Waves

Body Waves



Part 1: Station Performance



➤ PDF's of live stations, with minimum of one year of data, are combined with simulations of earthquake frequency amplitudes, to compute the lowest detectable magnitude at given distances (Schultz et al., 2015b).

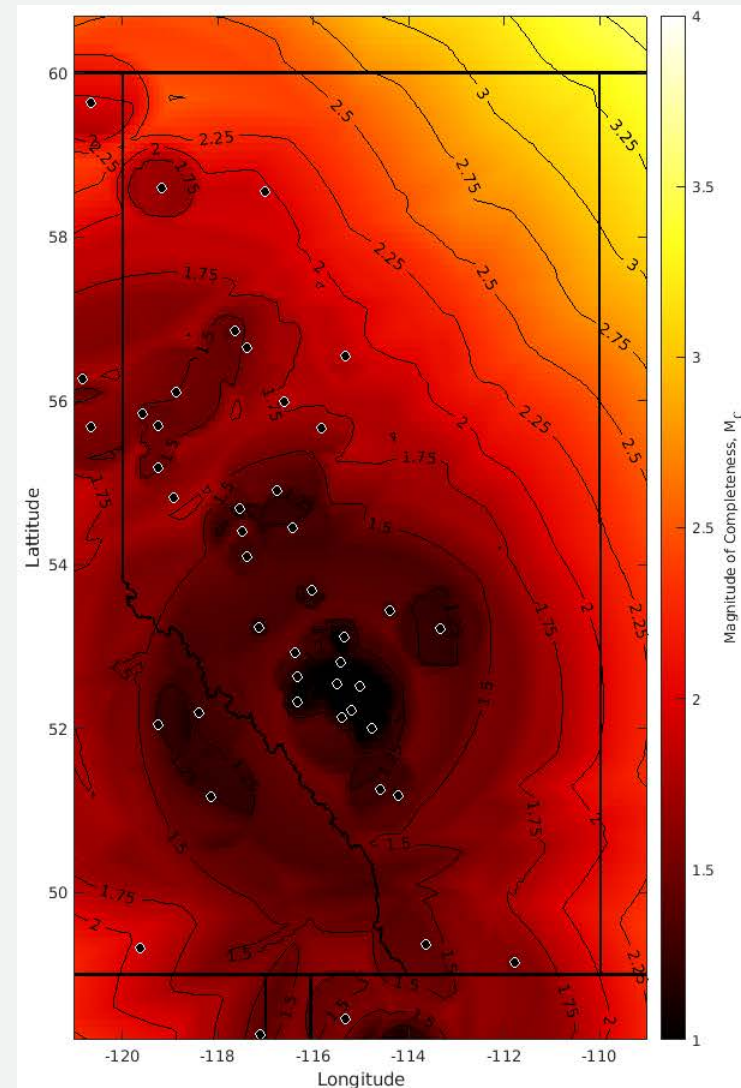
Part 2: Synthetic Mc

» Definition of M_c :

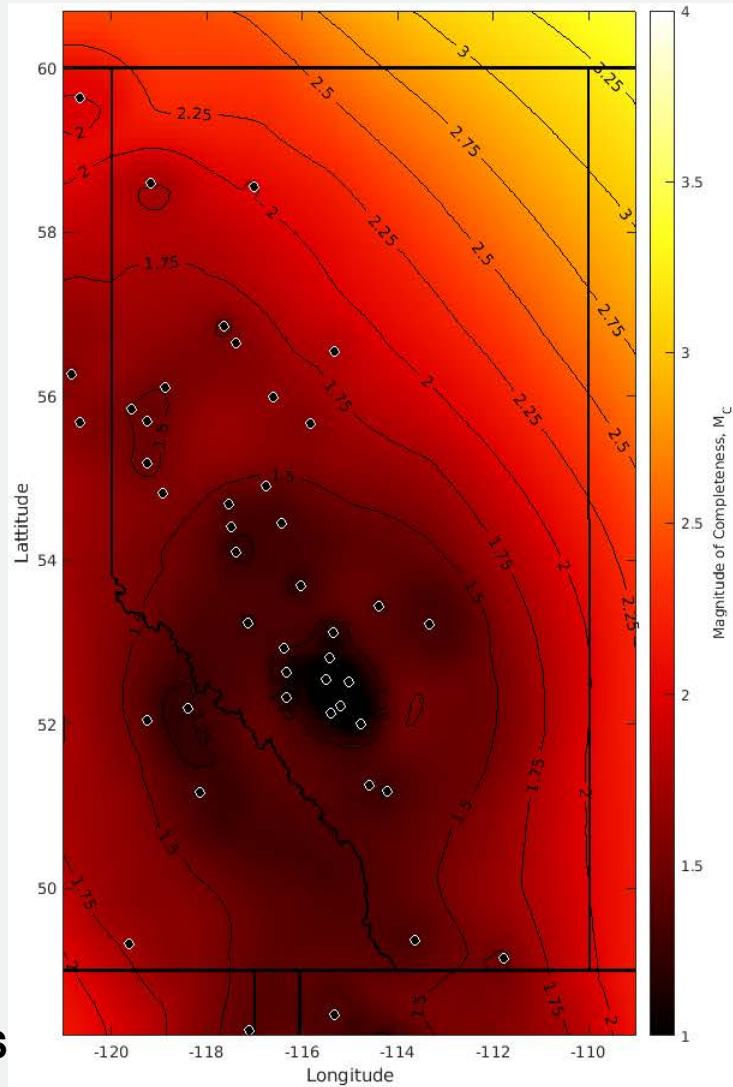
- The magnitude above which 100% events are detected.

» Assumptions in M_c :

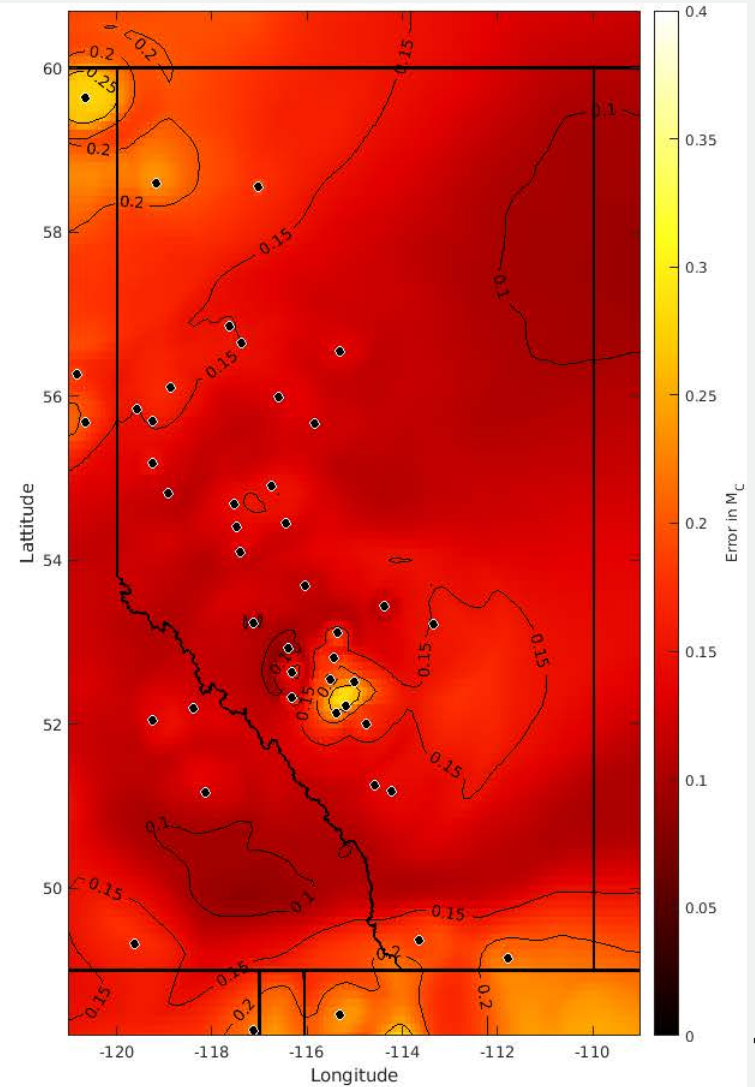
- Station operational time,
- Station noise levels.



Part 3: Statistical Variability in M_C (Varying Noise Levels)

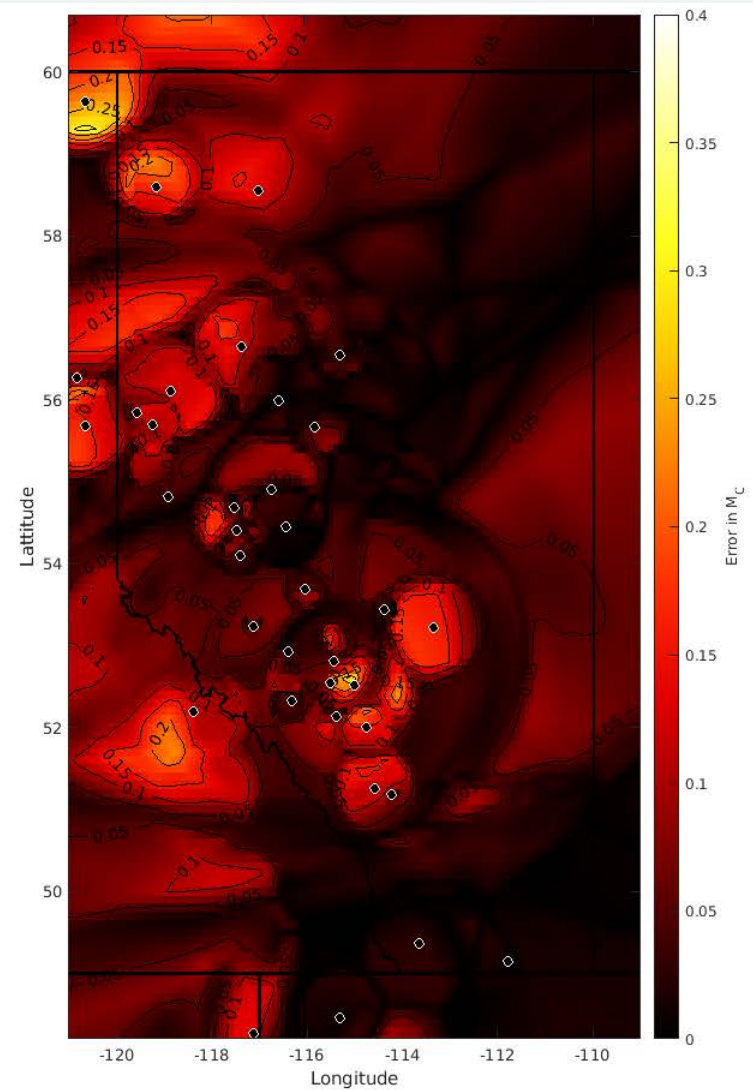
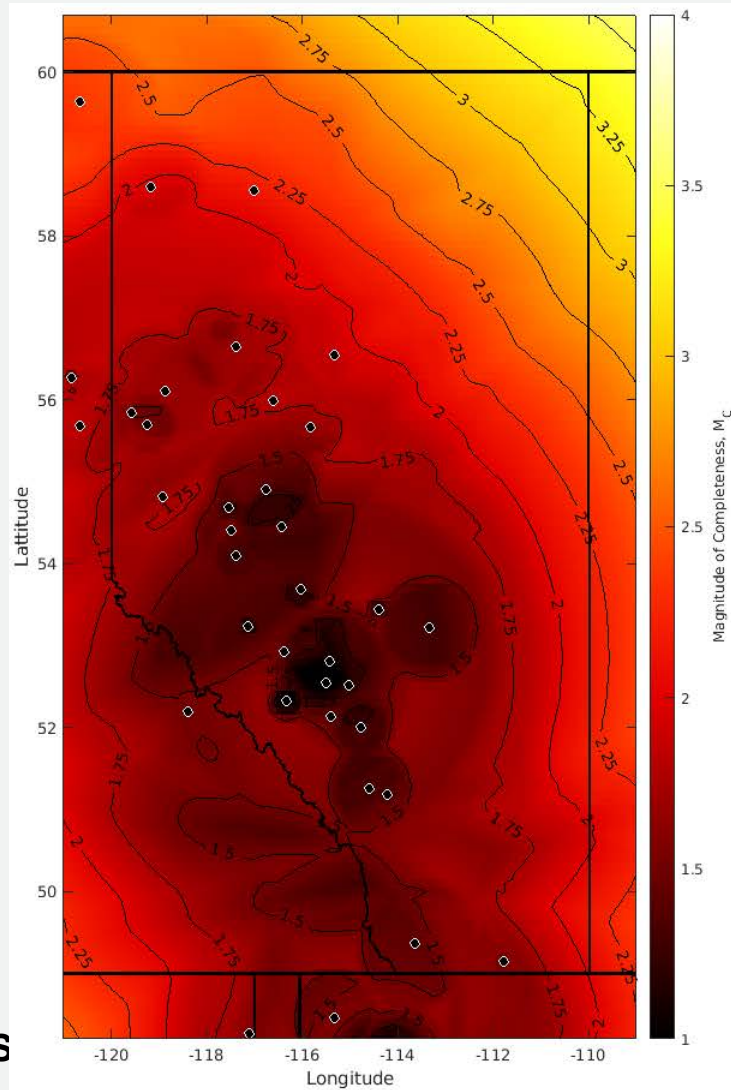


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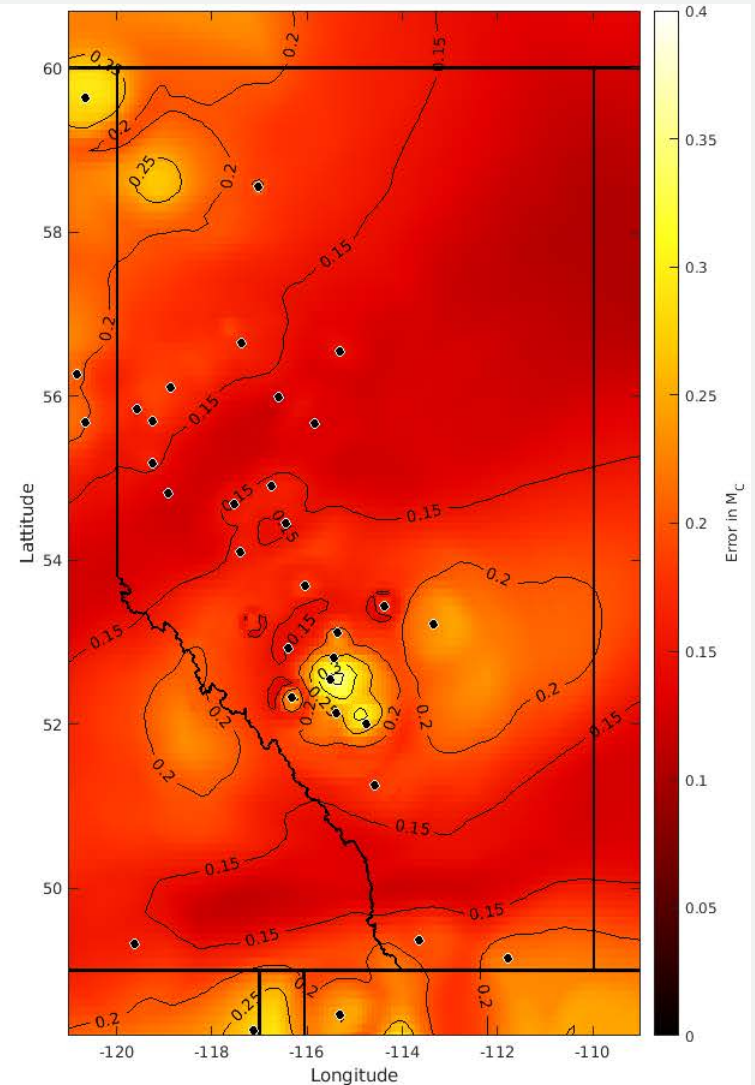
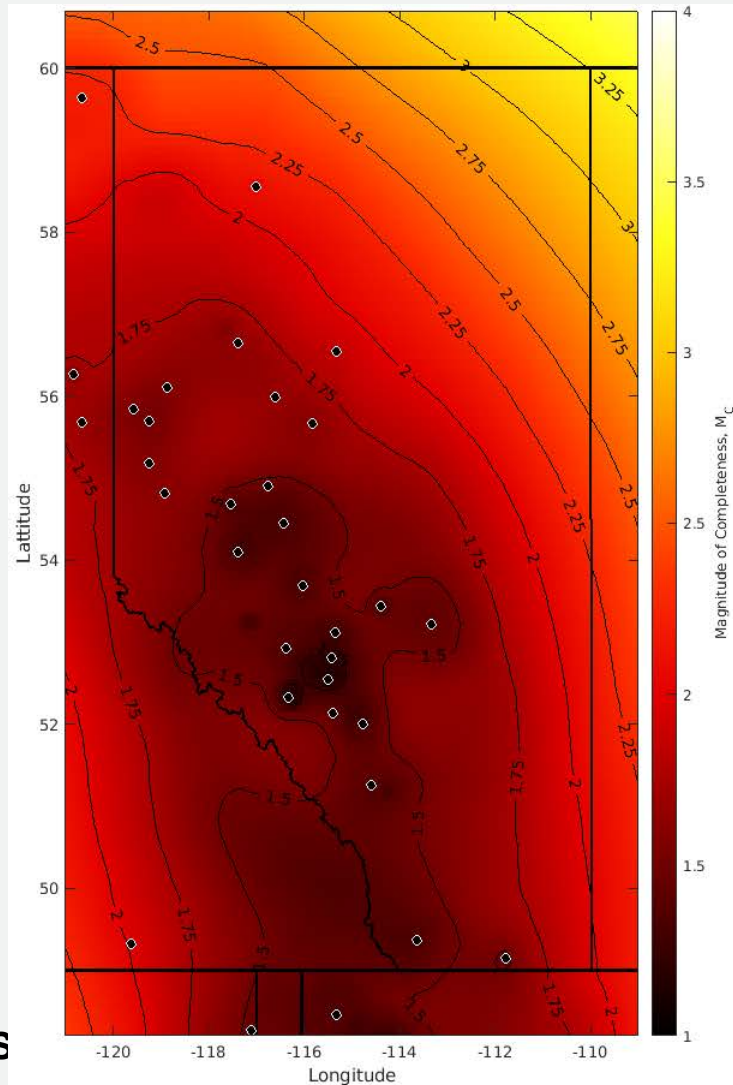


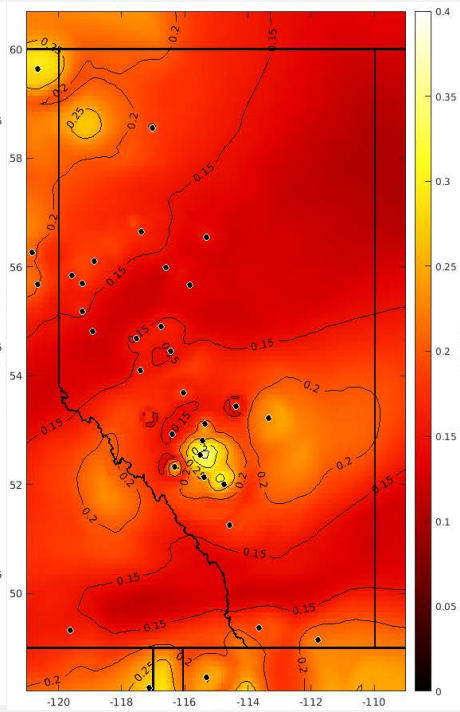
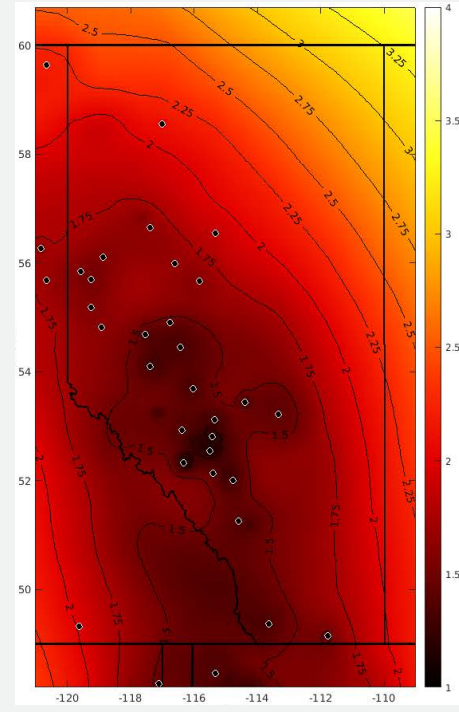
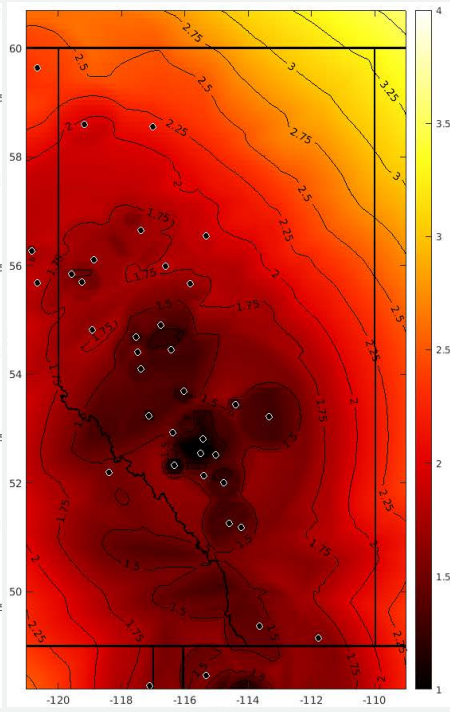
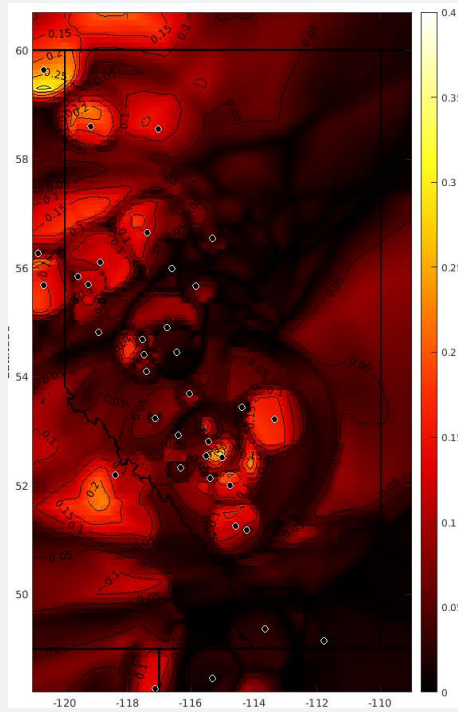
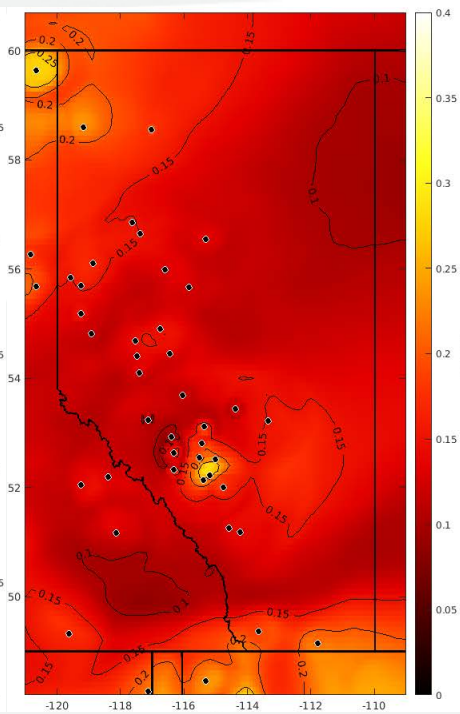
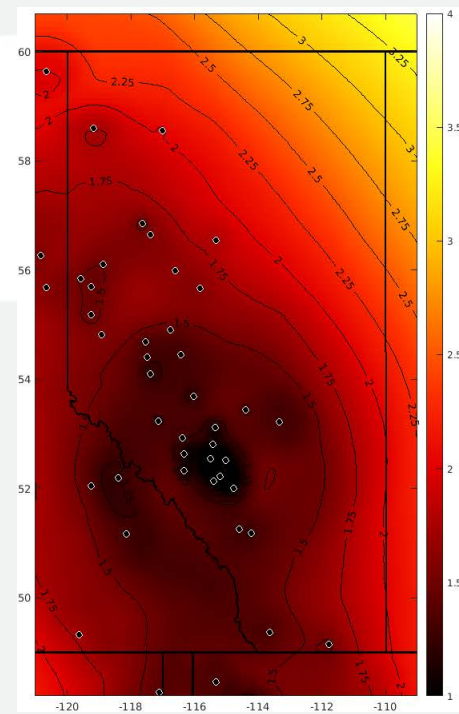
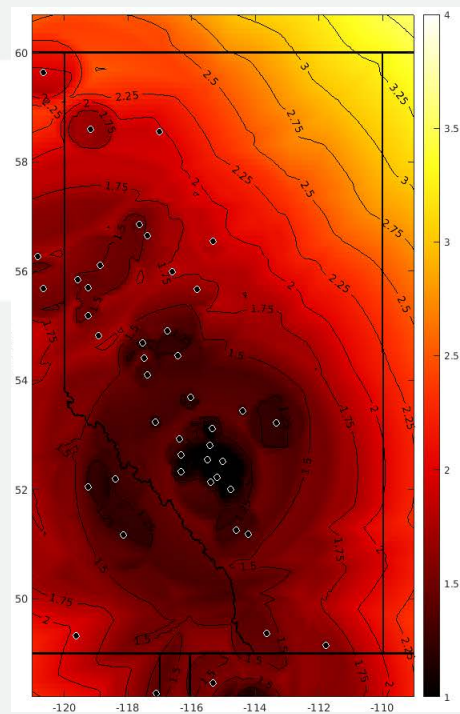
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Part 3: Statistical Variability in M_C (Varying Station Operational Time)



Part 3: Statistical Variability in M_c

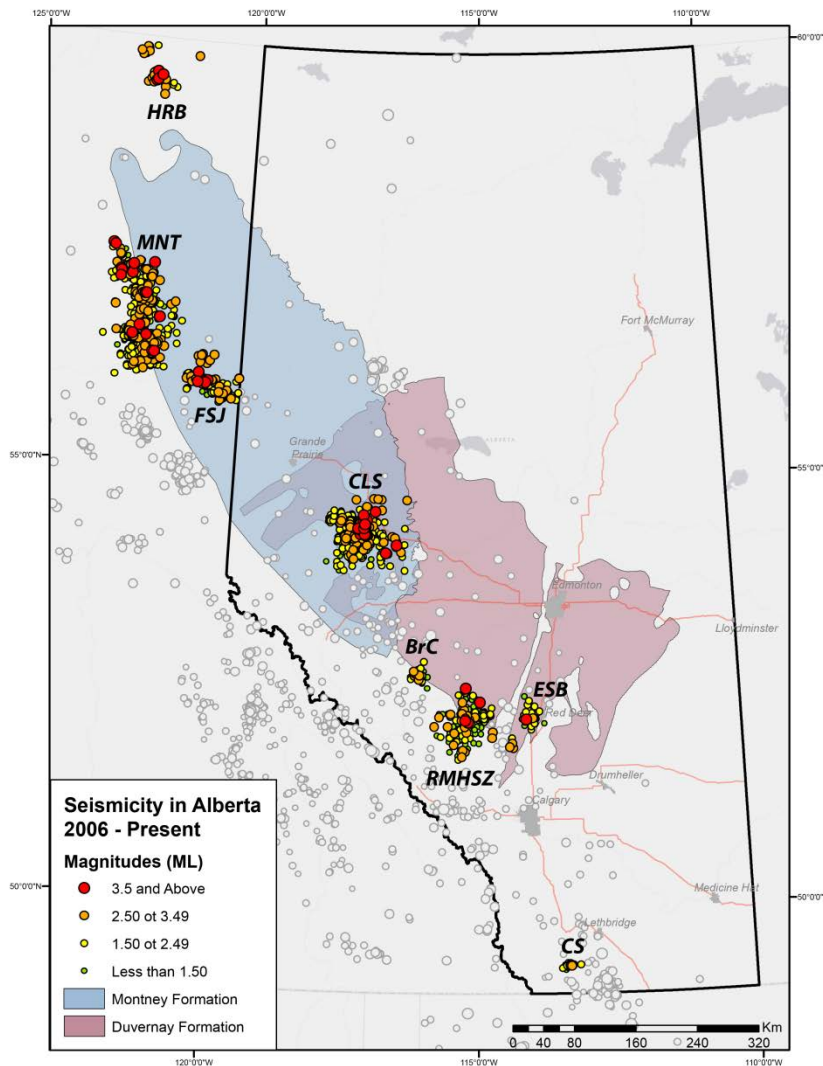




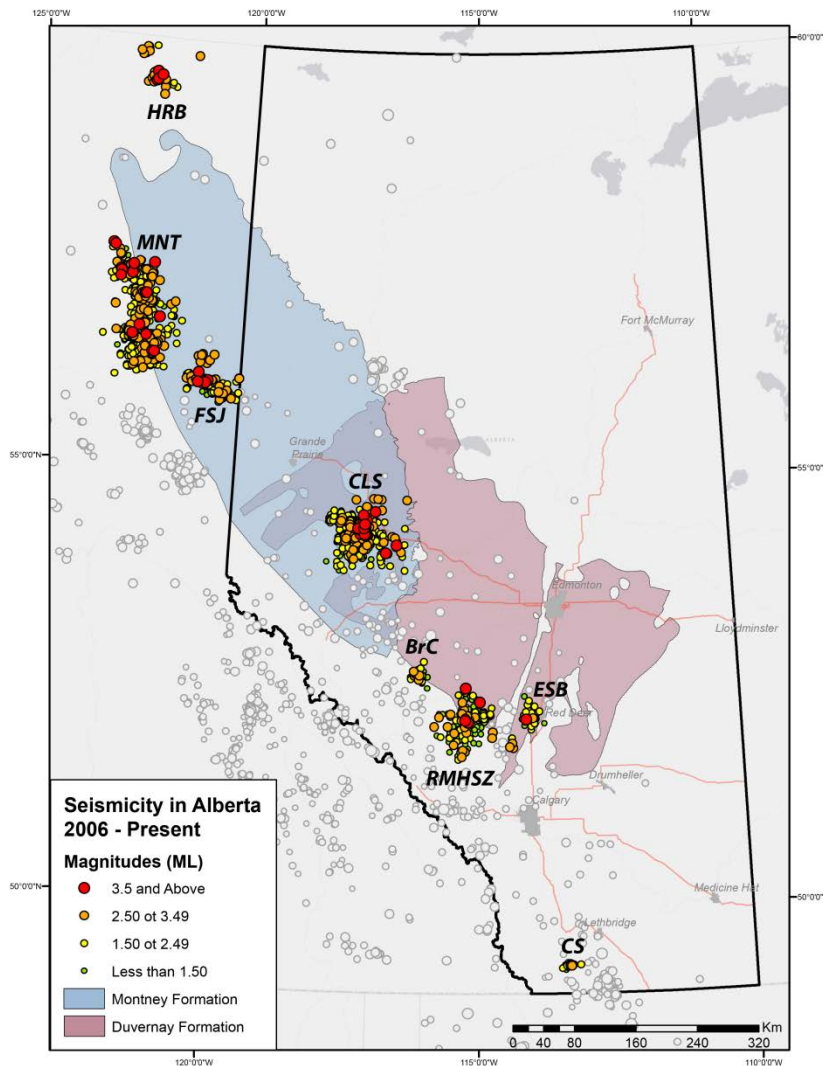
Part 4: Cluster Correlation

» There are five predominant clusters in Alberta:

1. Fox Creek Cluster (CLS),
2. Brazeau River Cluster (BrC),
3. Red Deer Cluster (ESB),
4. Rocky Mountain House Seismogenic Zone (RMHSZ),
5. Cardston Earthquake Swarm (CS).



Part 4: Cluster Correlation

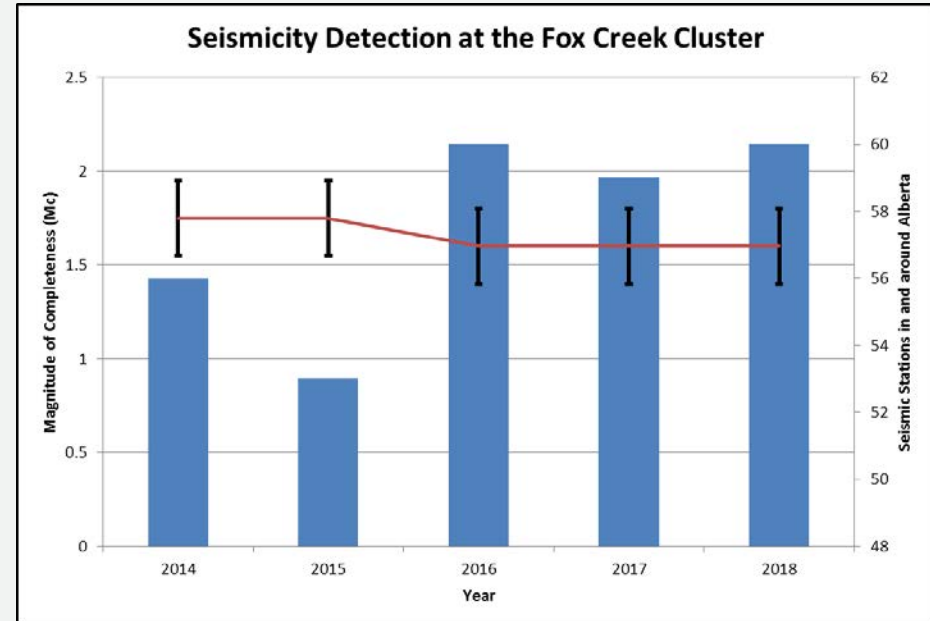
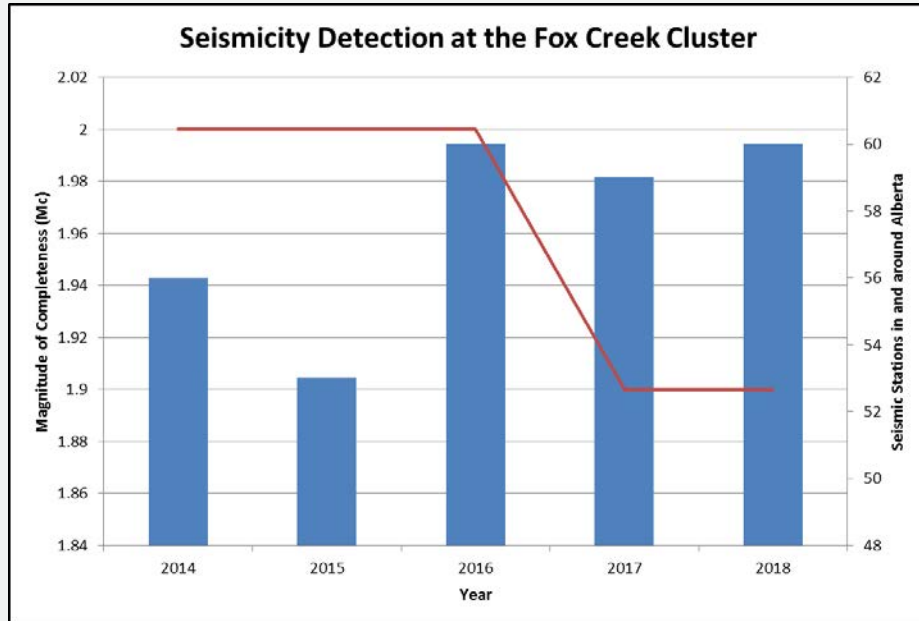


» CLS cluster:

- First started in December 2013 (2.7 – 3.7 M_L),
- Strongest event on January 12, 2016 (4.8 M_L),
- Traffic light protocol was created to manage these events (Alberta Energy Regulator, 2015).

» ZMAP catalog analysis package is used to determine M_c (Weimer, 2001).

Part 4: Cluster Correlation



» Theoretical magnitudes match the empirically determined values within an error ($\pm 0.20 M_L$).

Conclusion

- 》 Magnitude of Completeness can be calculated synthetically, in relatively quiescence areas of Alberta,
 - Model can be compared to the seismogenic clusters; results comply with observed numbers within the margin of error.
- 》 Model is used at AGS as a blueprint for improvements to the regional seismic monitoring and analysis in WCSB.



Questions





Thank you

