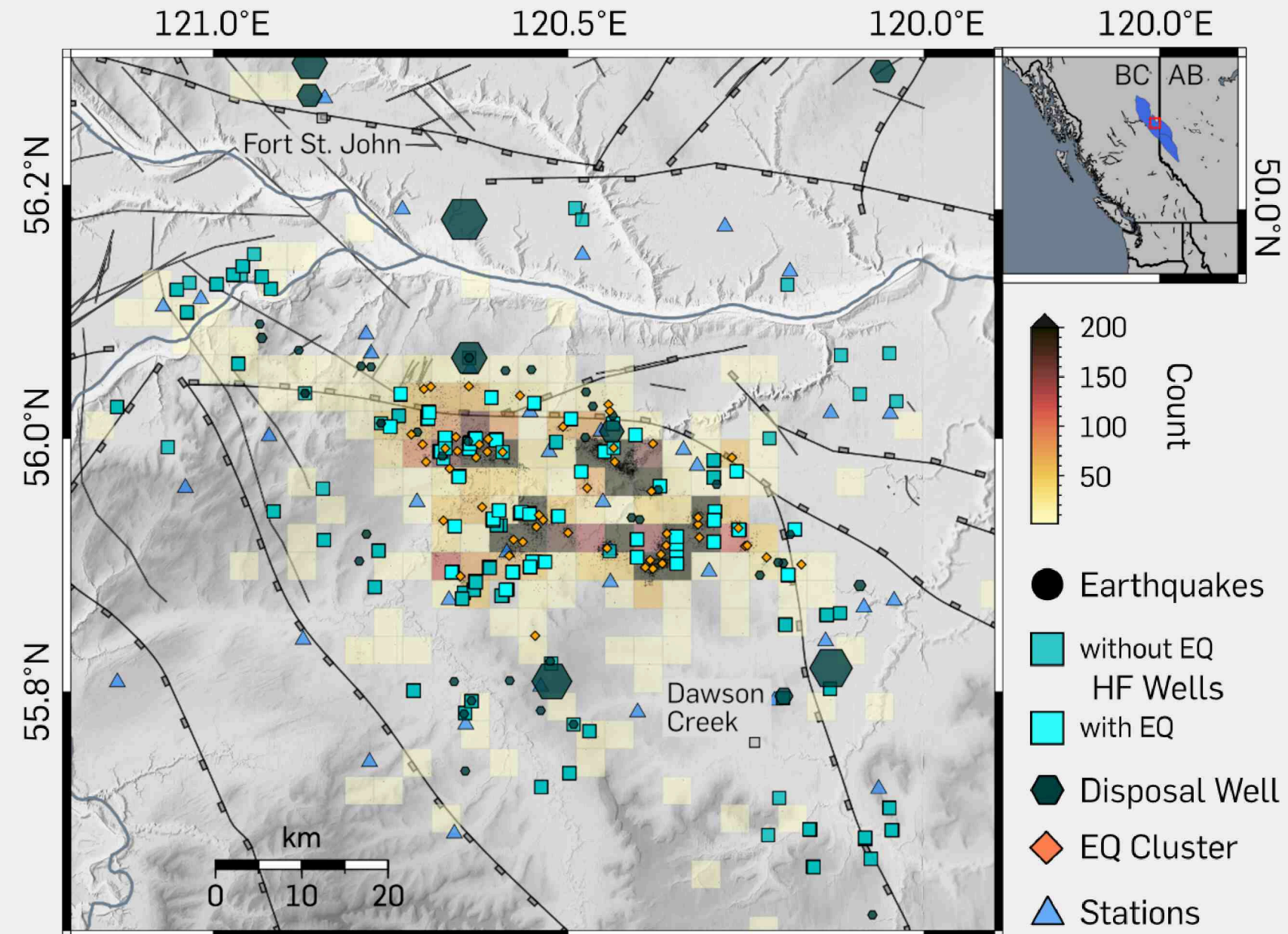


The relevance of small-magnitude earthquakes in detailing the spatiotemporal correlation between hydraulic fracturing related injection and seismicity - Additional Information

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 - Ricarda M. Wache¹
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- 1) Ruhr University Bochum, Bochum, Germany
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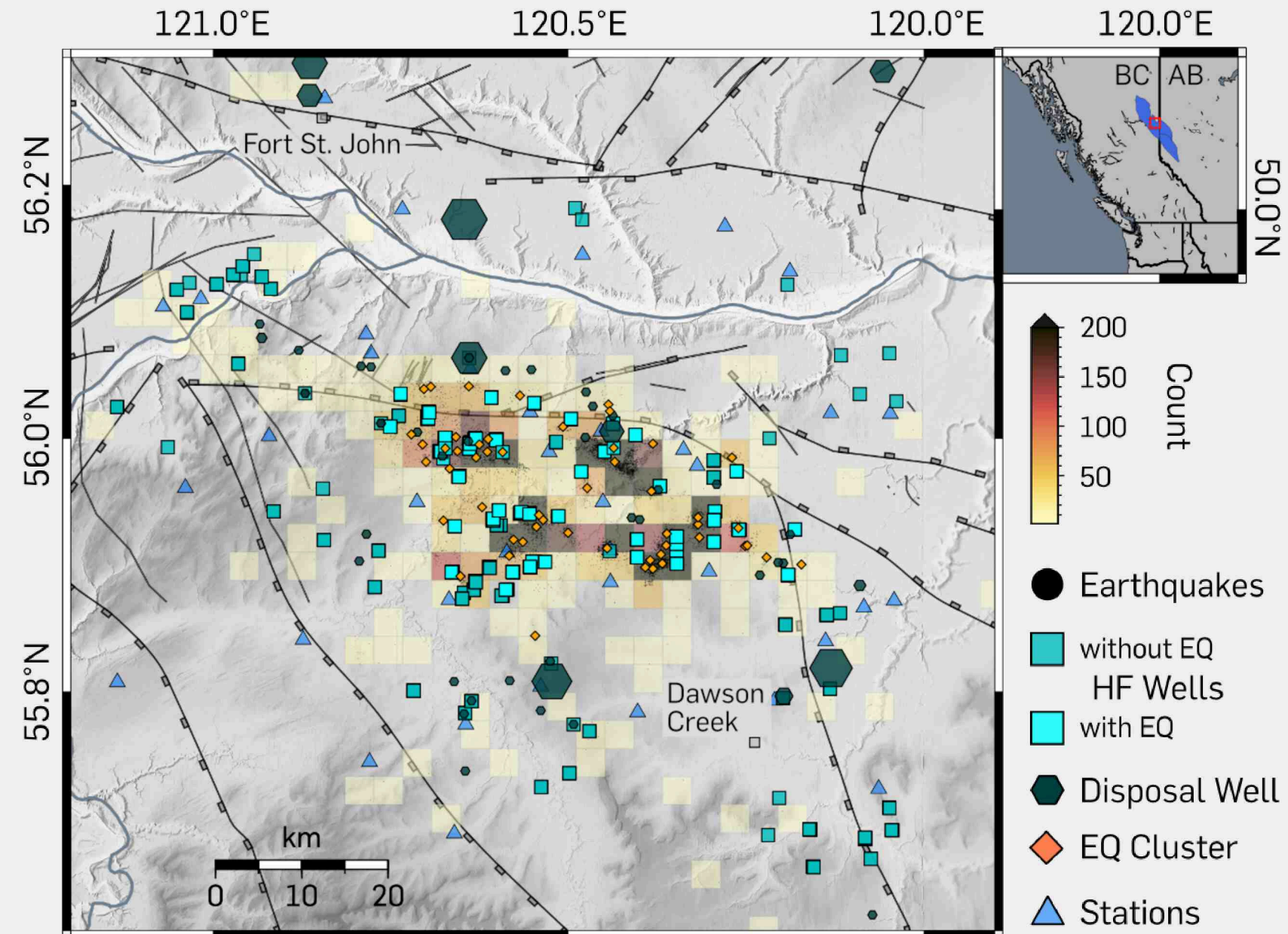
Where?

- Western Canadian Sedimentary Basin (WCSB) near Dawson Creek, British Columbia, Canada
- Area with hydraulic fracturing (HF) induced seismicity
- Enhance STA/LTA earthquake catalog from Roth et al. (2020)



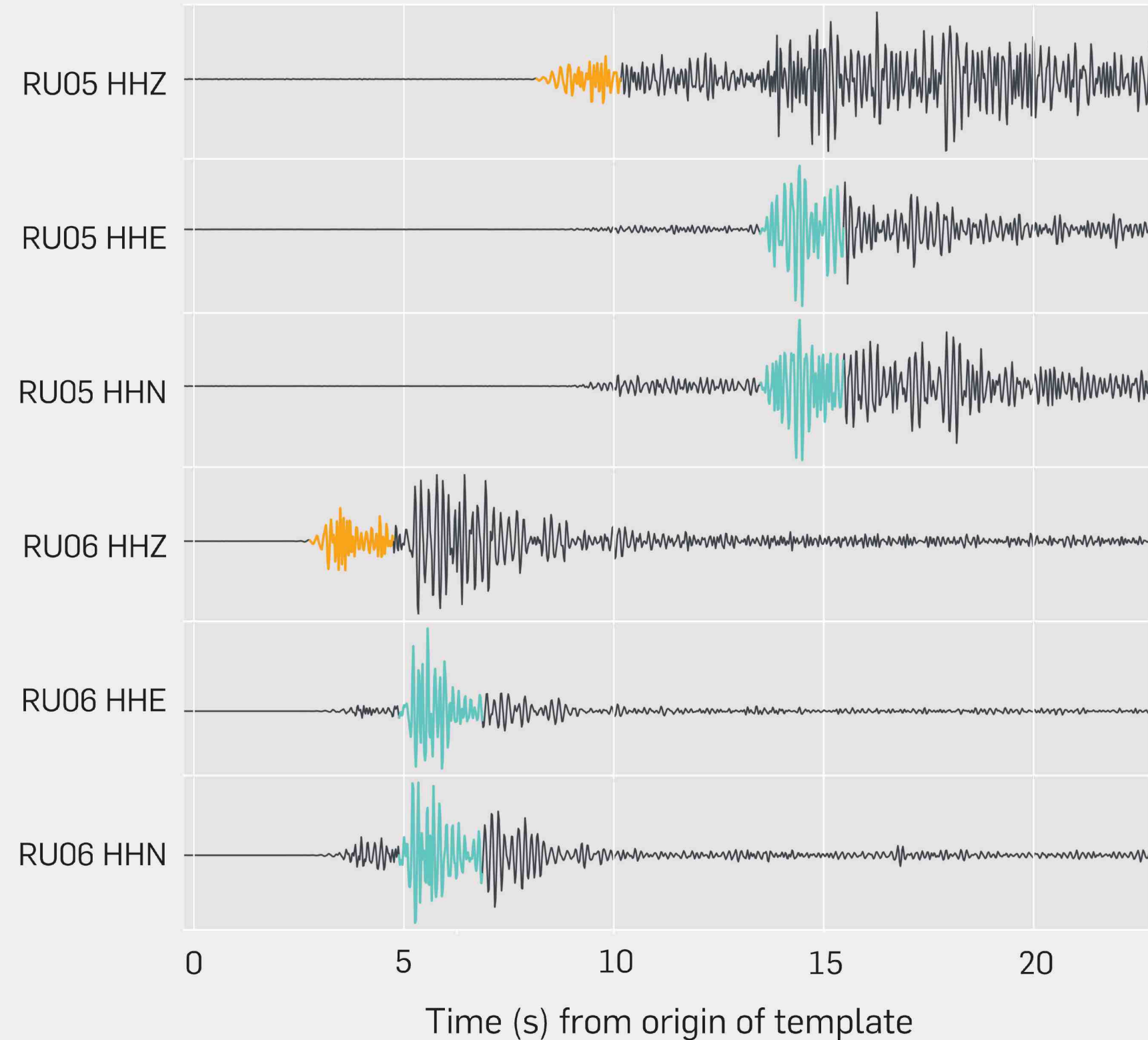
Multi-station Matched Filter

- All STA/LTA detections as templates (Roth et al., 2020)



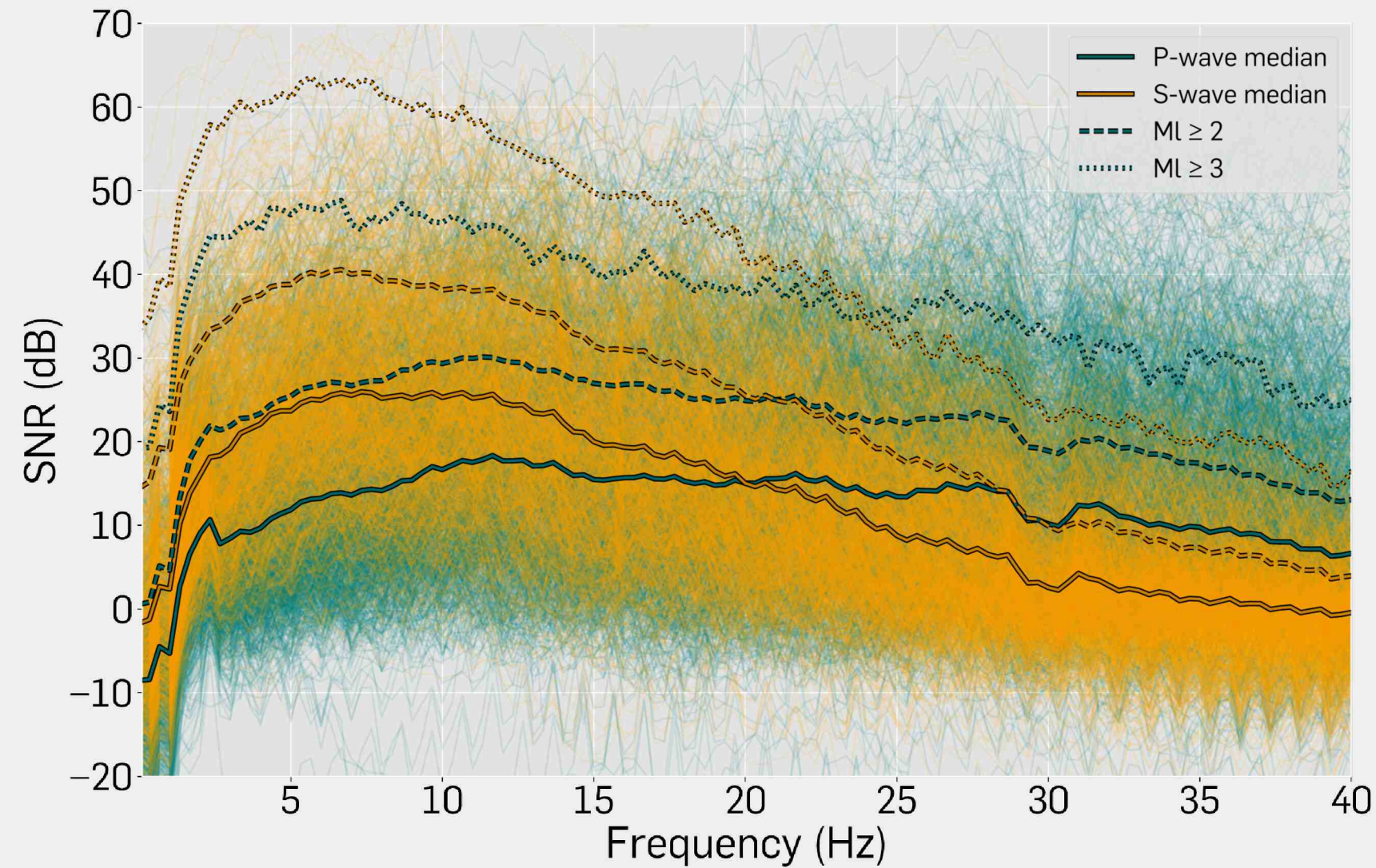
Multi-station Matched Filter

- All STA/LTA detections as templates (Roth et al., 2020)
 - $\text{SNR} > 5$, > 4 picks
 - 8,013 templates
 - 2 sec time long



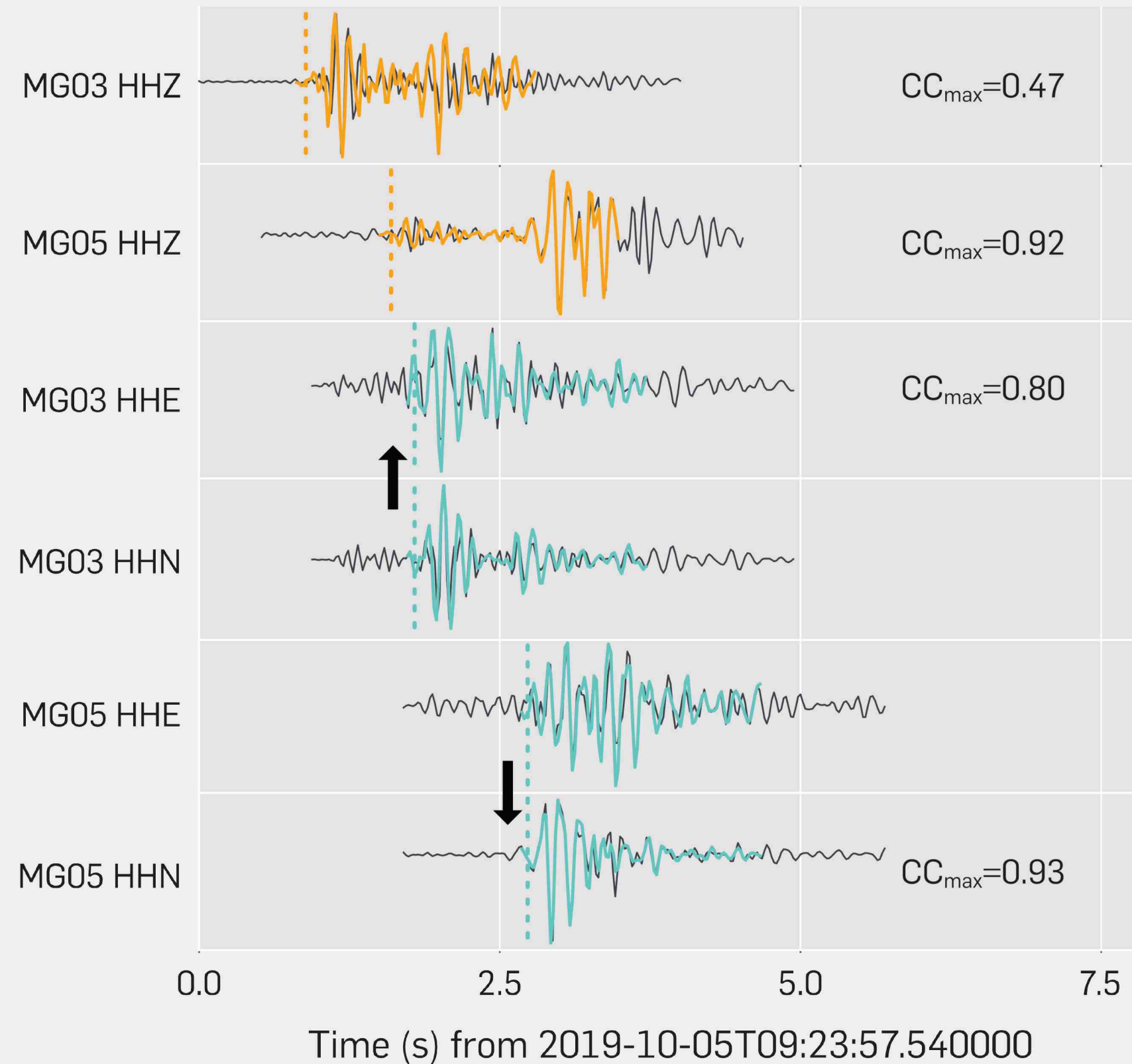
Multi-station Matched Filter

- All STA/LTA detections as templates (Roth et al., 2020)
- Filter 5 - 15 Hz



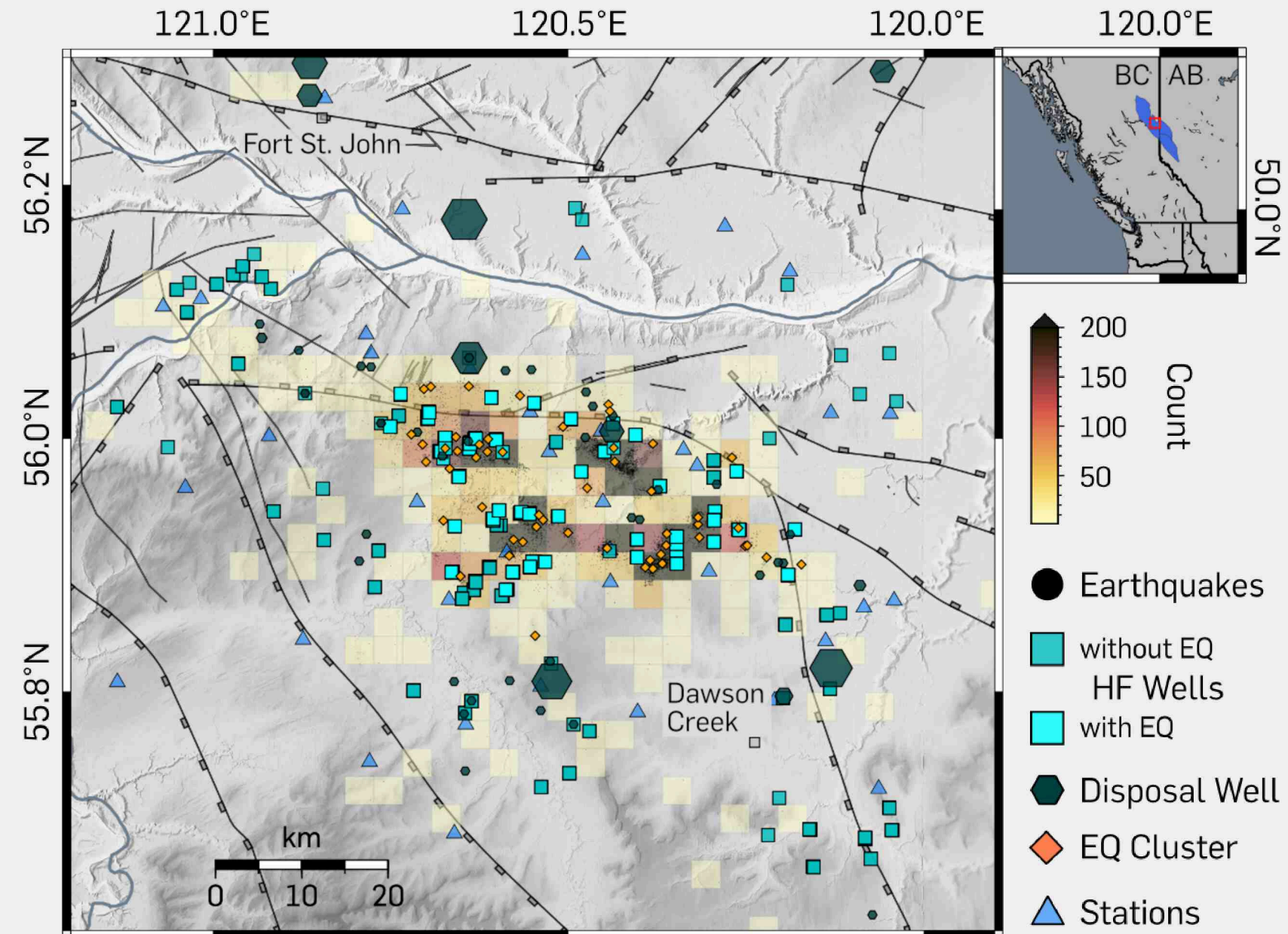
Multi-station Matched Filter

- All STA/LTA detections as templates (Roth et al., 2020)
- 2017-07-12 to 2020-12-31
 - Using EQcorrscan (Chamberlain et al., 2018)
 - MAD 10
 - Cross-correlation phase arrivals (0.4)
 - Location + Magnitude as for the STA/LTA Catalog



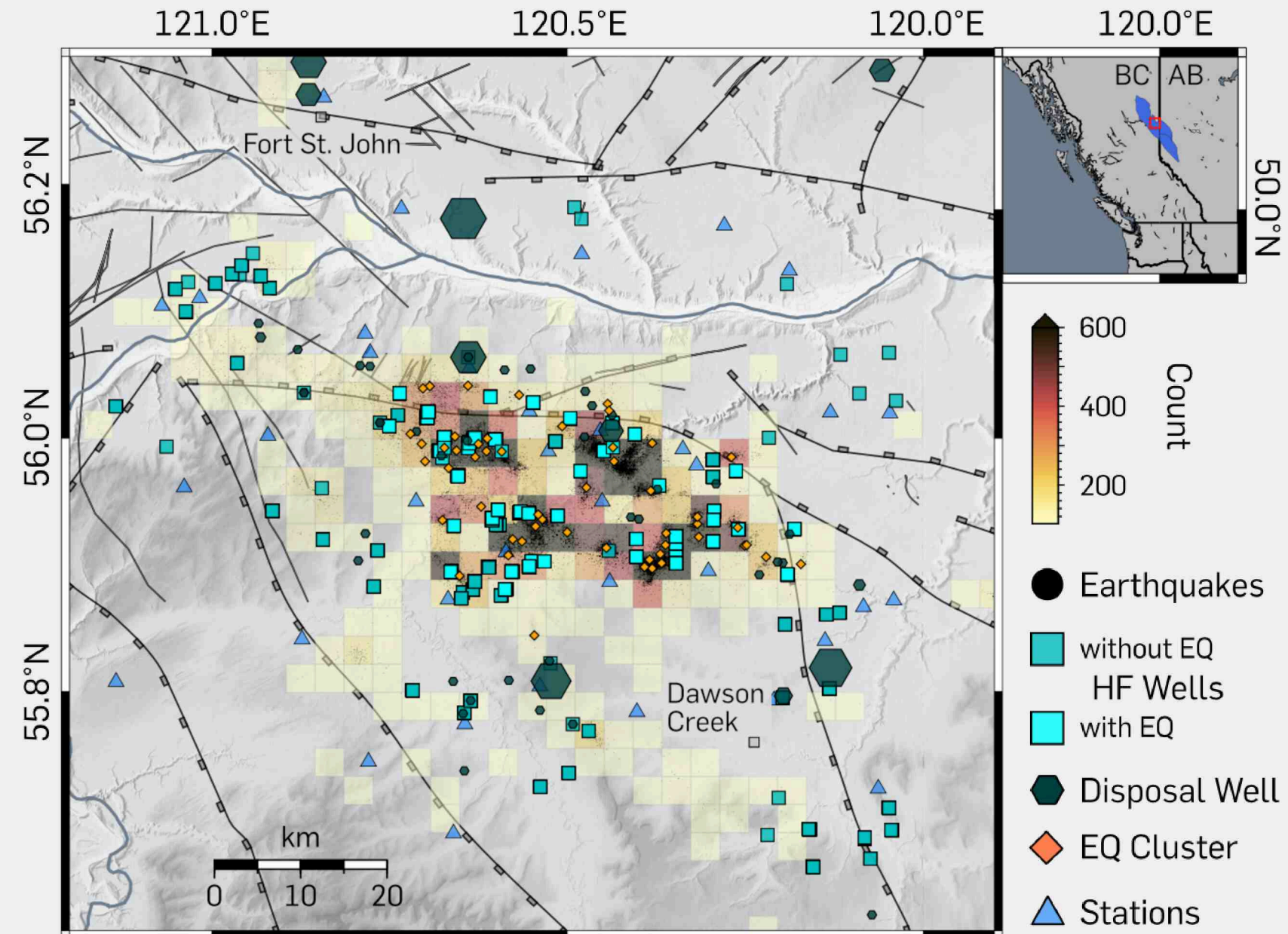
Multi-station Matched Filter

- All STA/LTA detections as templates (Roth et al., 2020)
- 2017-07-12 to 2020-12-31
 - Maximum horizontal error 5km
 - 33,296 additional events

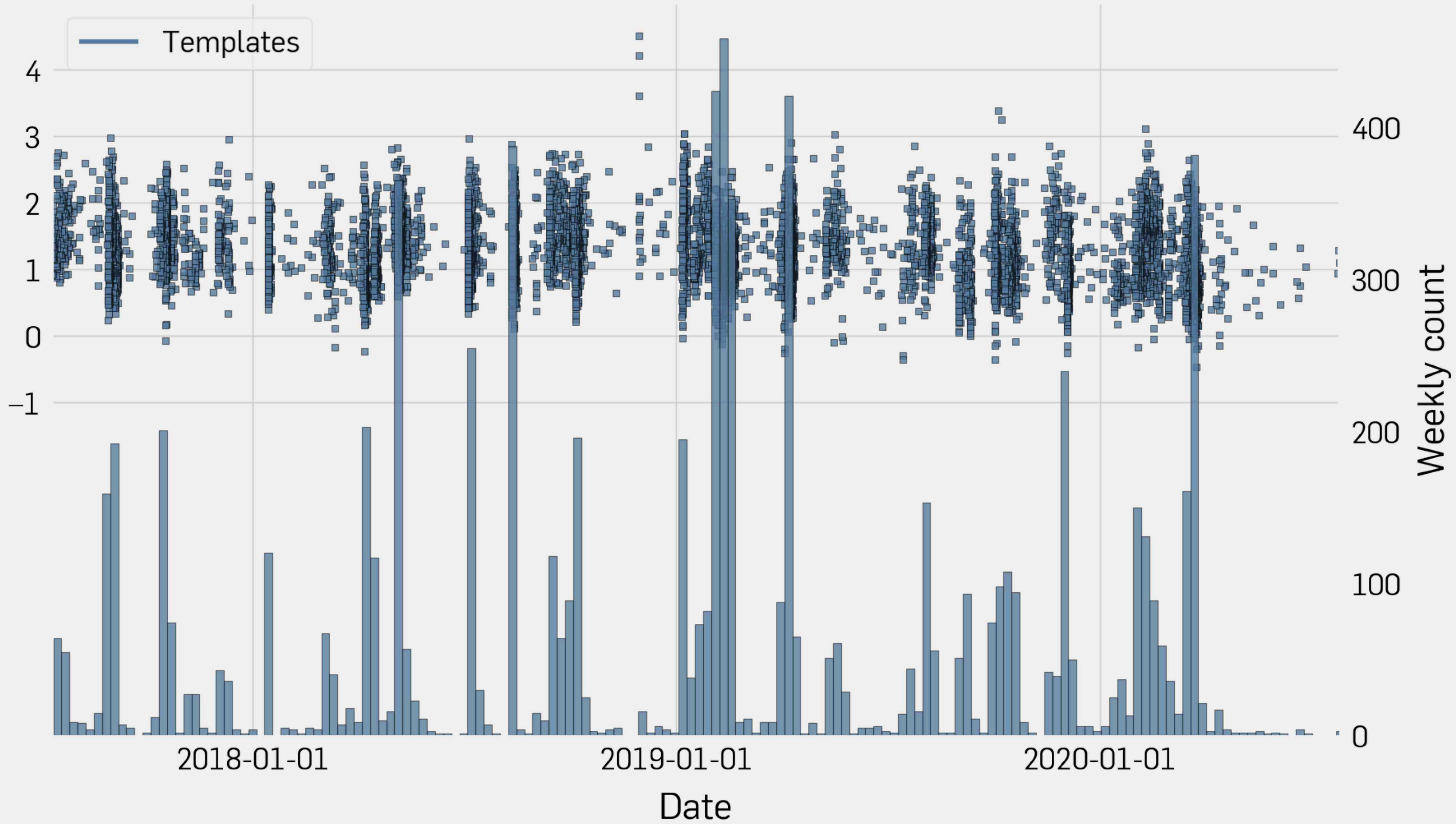


Multi-station Matched Filter

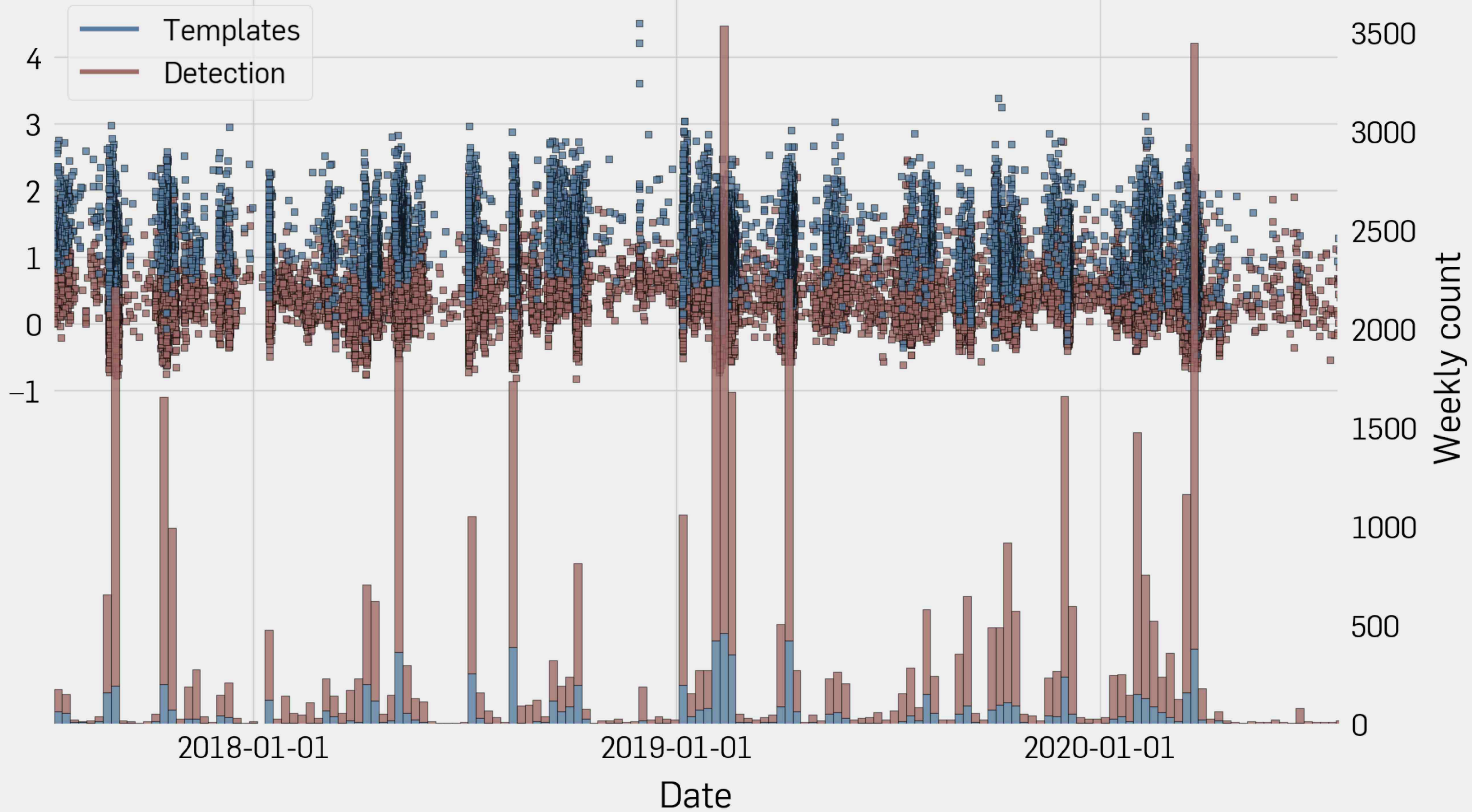
- All STA/LTA detections as templates (Roth et al., 2020)
- 2017-07-12 to 2020-12-31
 - Maximum horizontal error 5km
 - 33,296 additional events

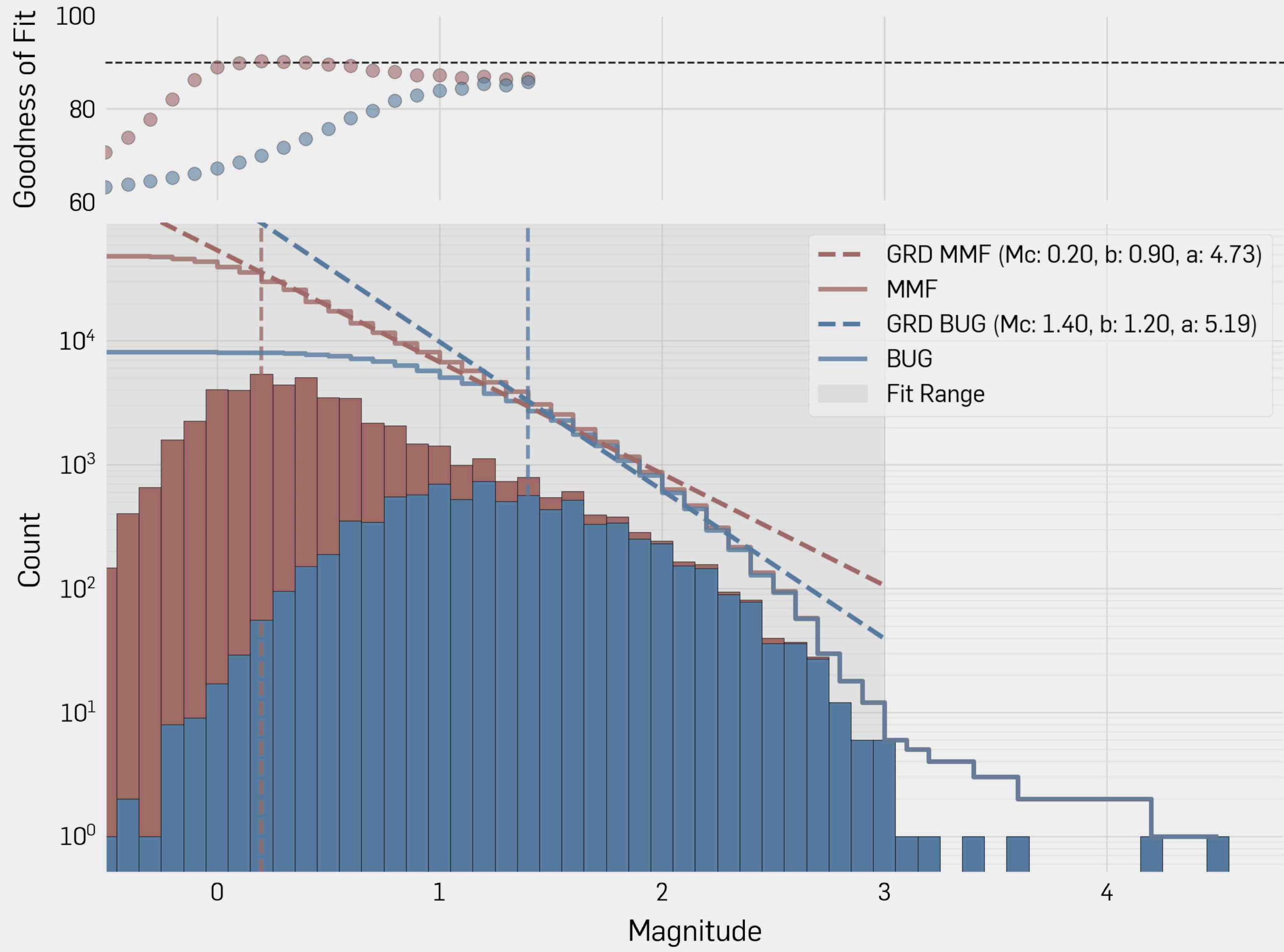


Local Magnitude



Local Magnitude

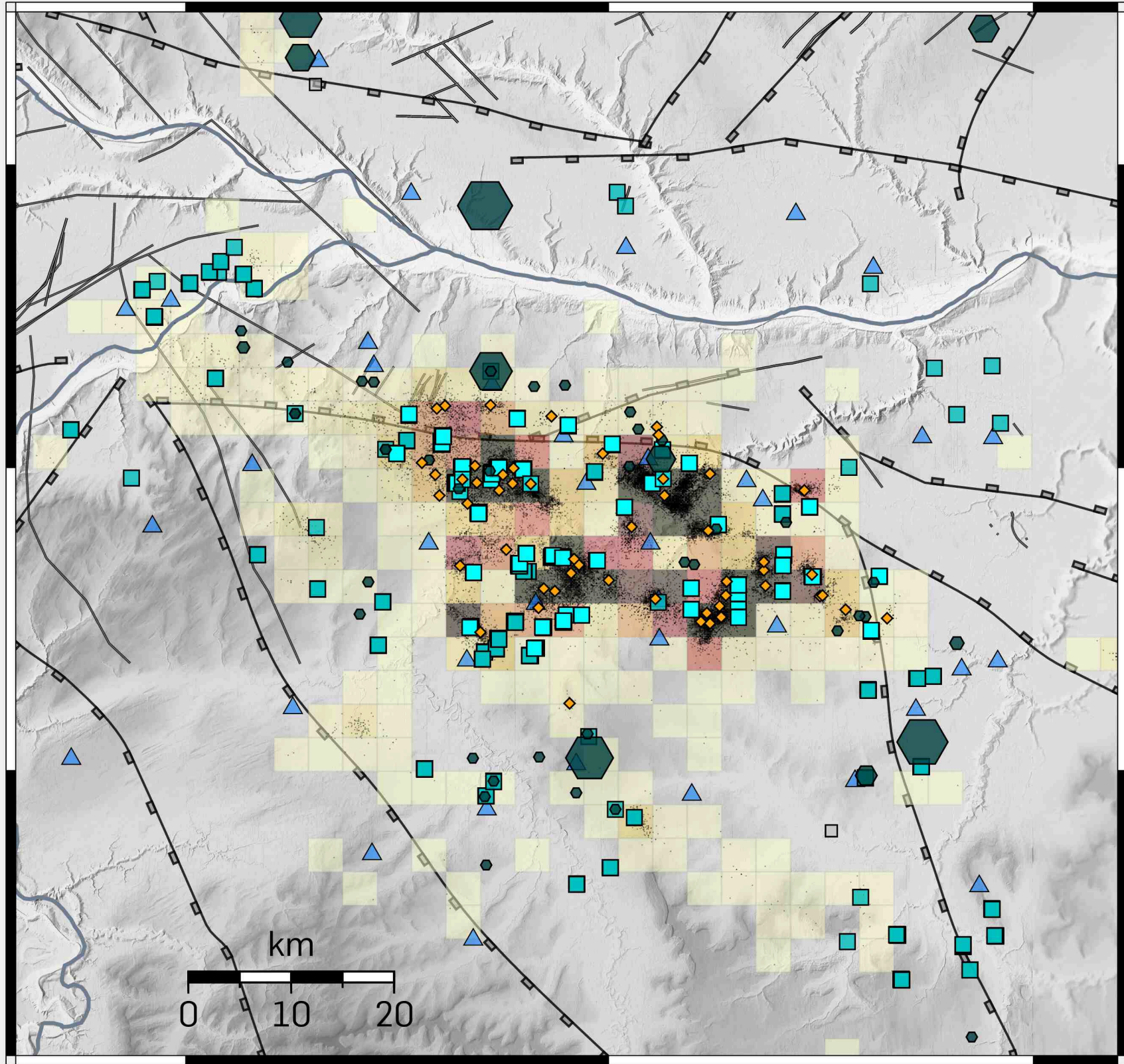




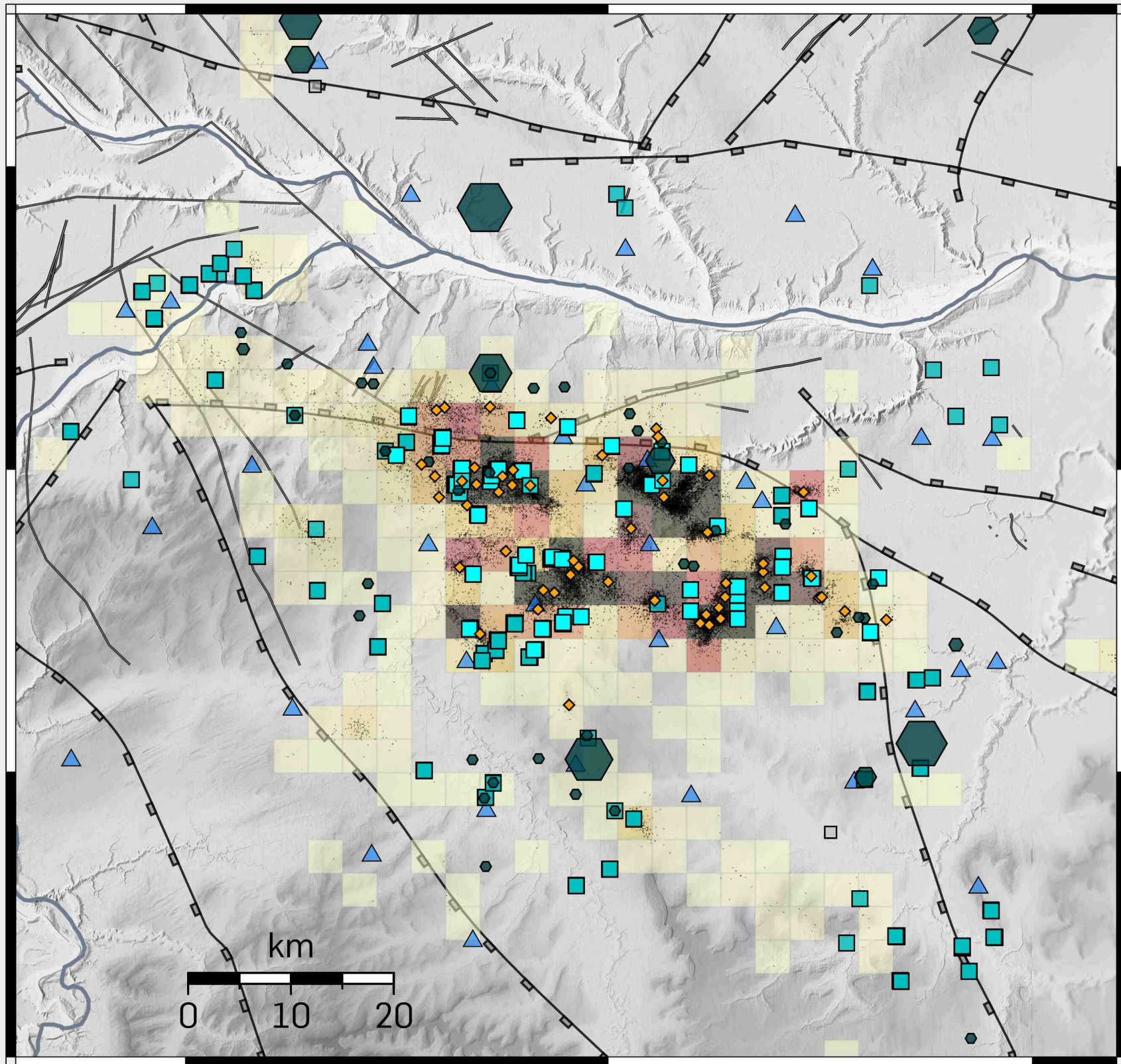
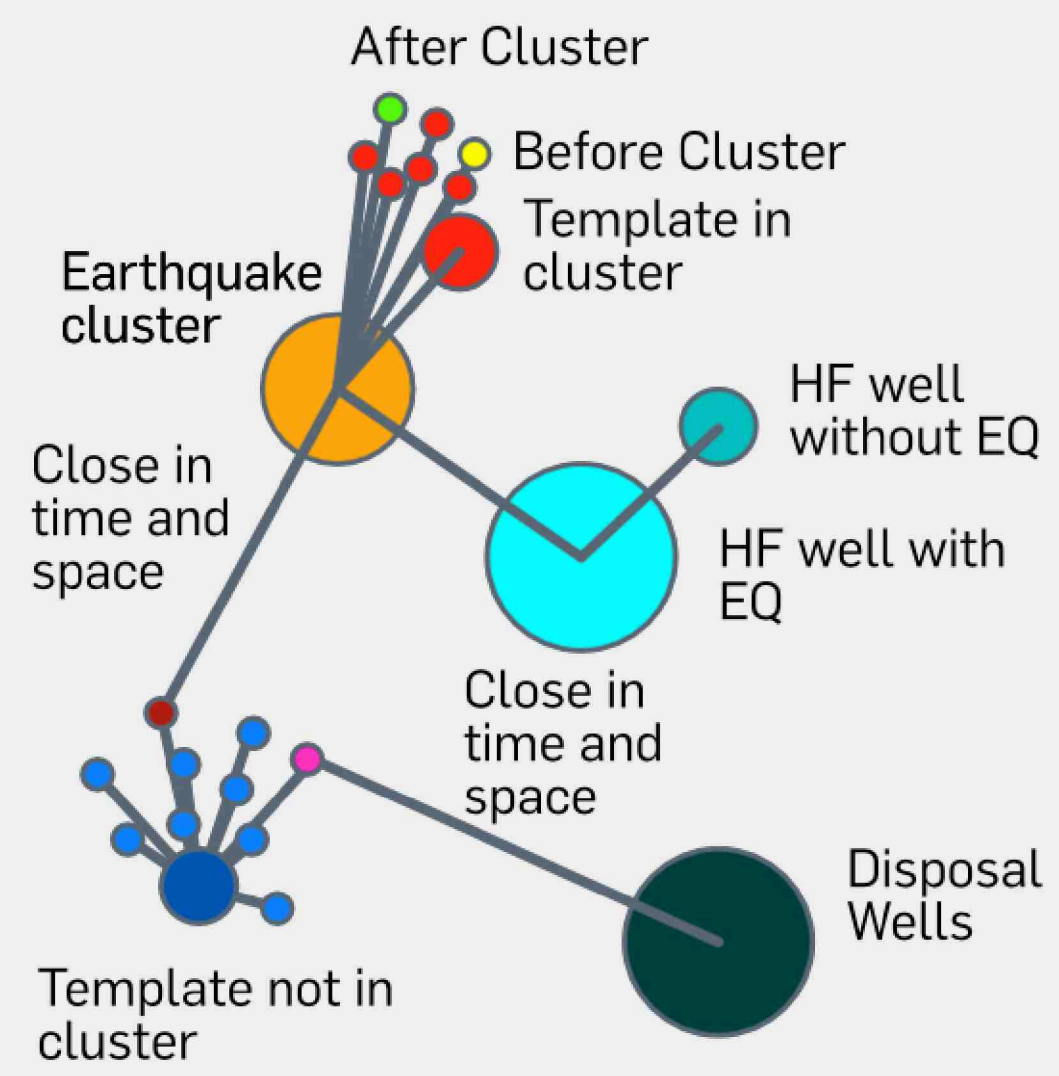
Correlate features

- Wells
- Earthquake clusters
- Earthquakes

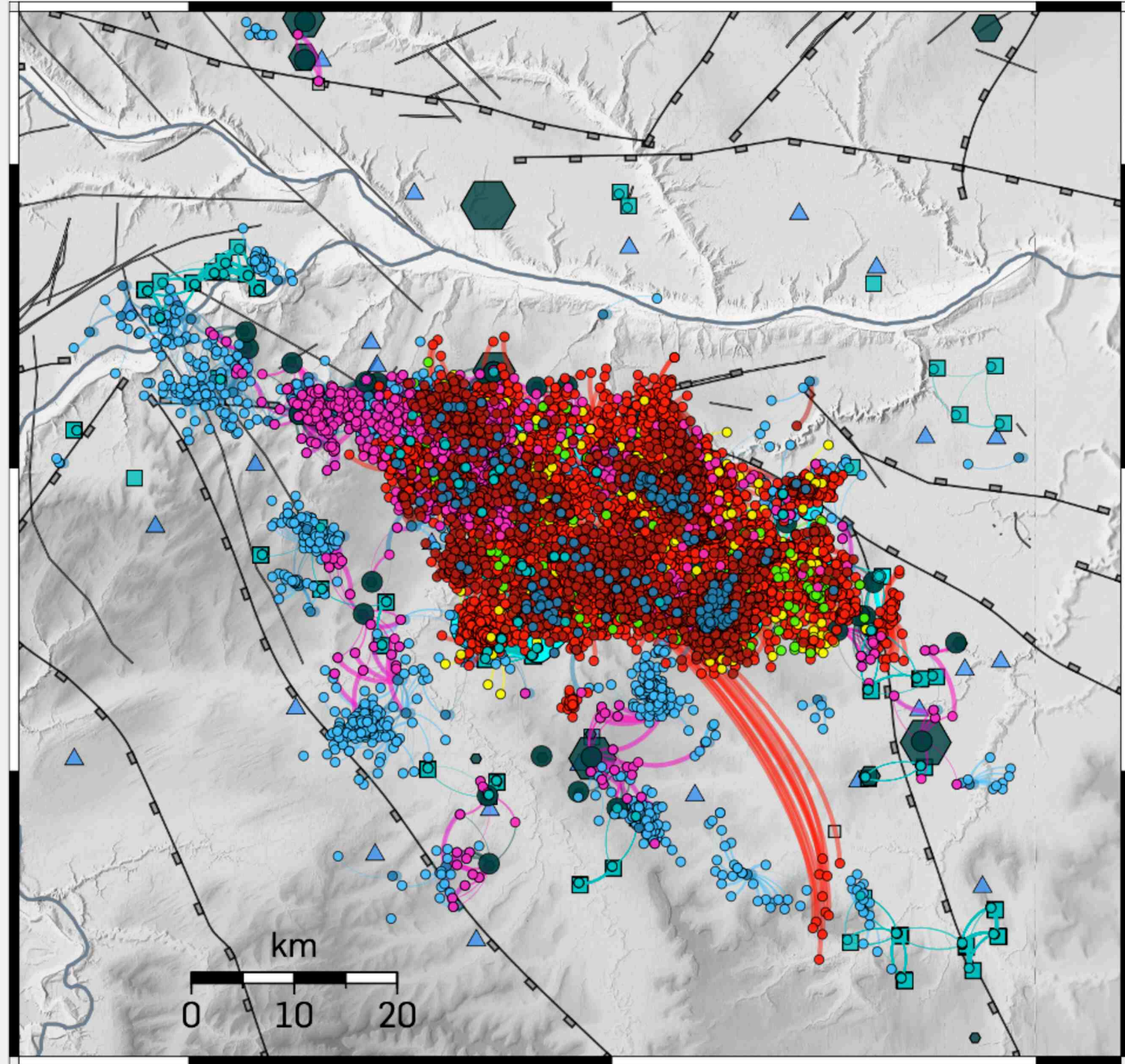
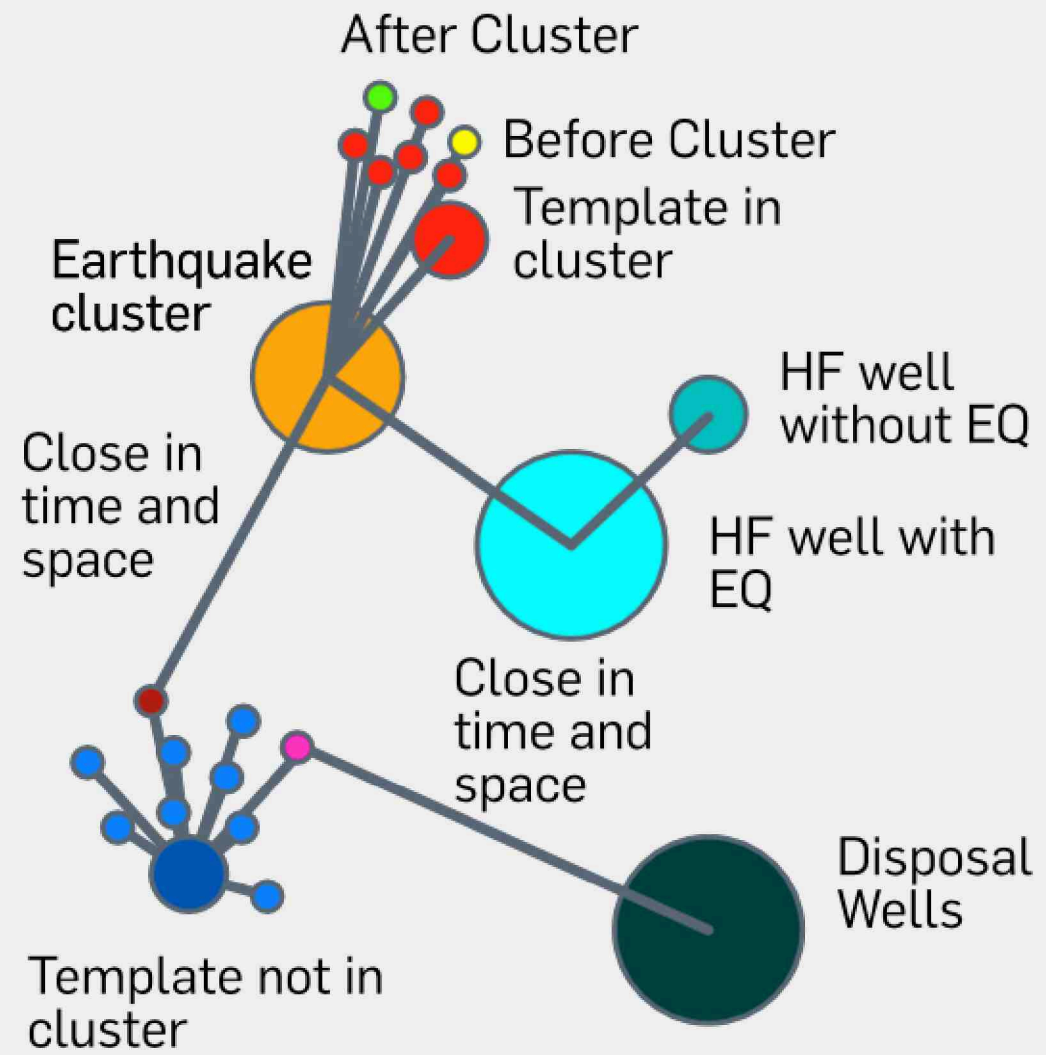
Network plot



Network plot

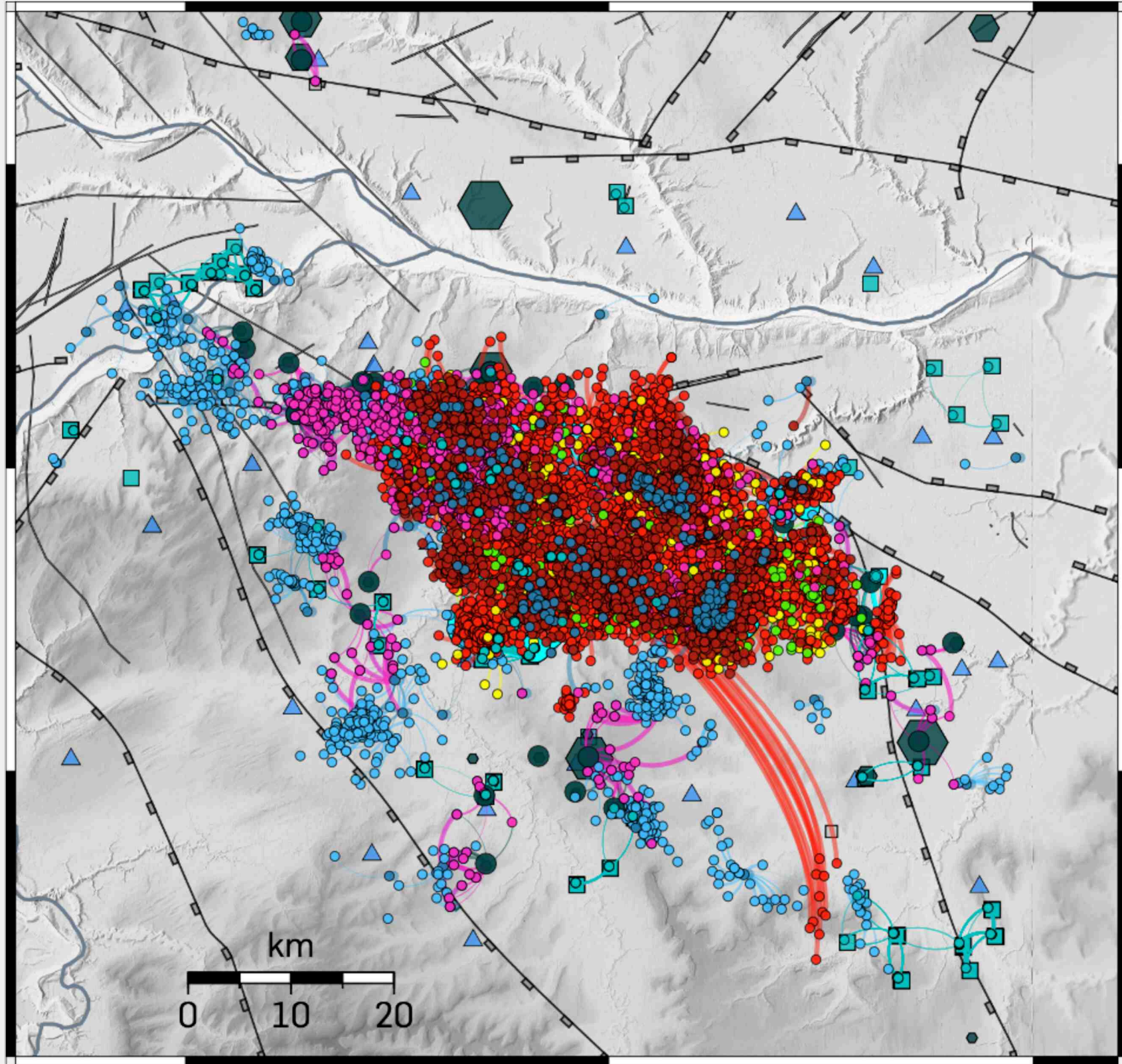


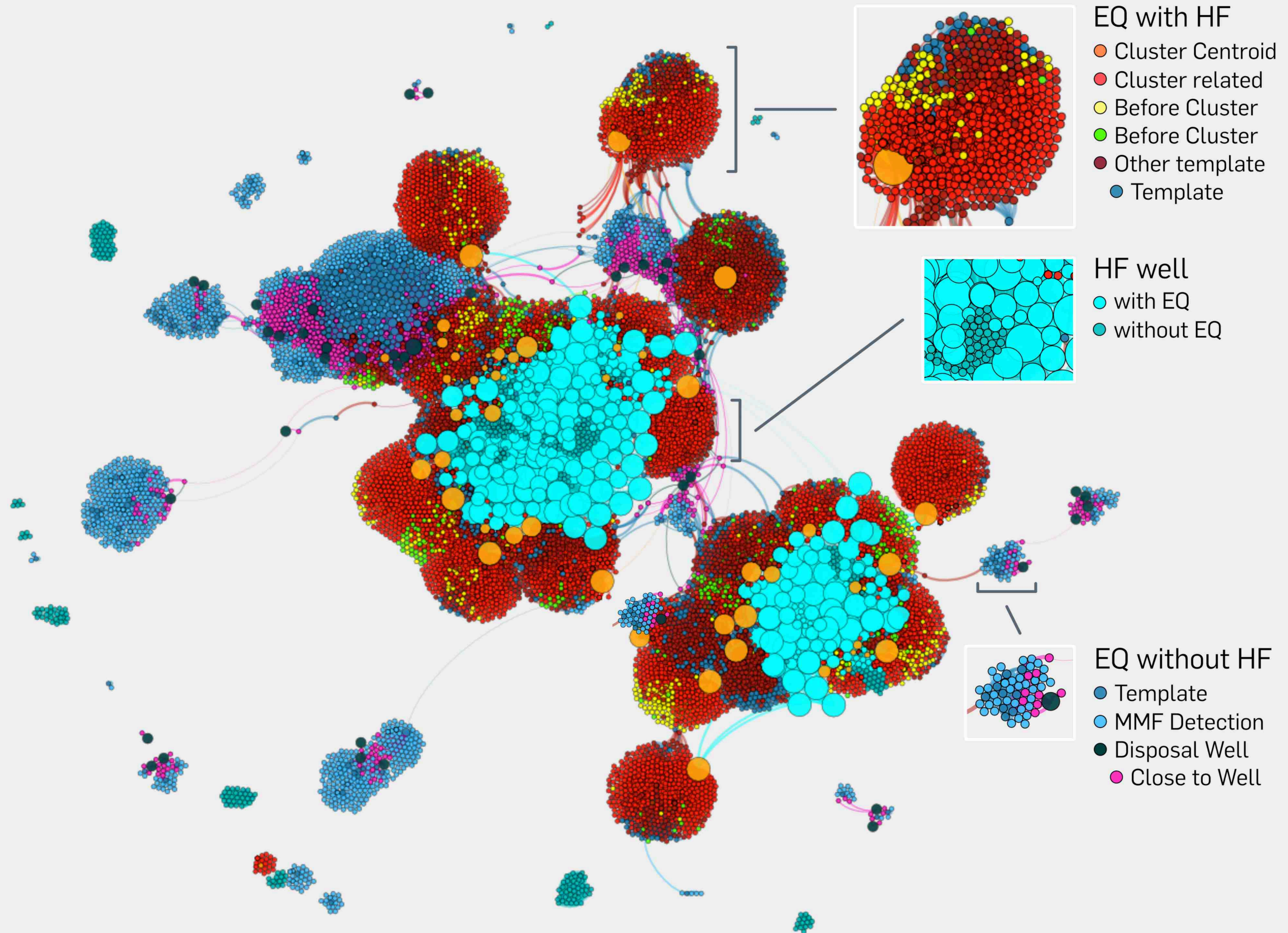
Network plot



Network plot

- Use ForceAtlas2 for graph layout (Jacomi et al., 2014)





References

Chamberlain, C. J., C. J. Hopp, C. M. Boese, E. Warren-Smith, D. Chambers, S. X. Chu, K. Michailos, and J. Townend. 2017. EQcorrscan: Repeating and Near-Repeating Earthquake Detection and Analysis in Python. *Seismological Research Letters*. doi:10.1785/0220170151.

Jacomy M, Venturini T, Heymann S, Bastian M (2014) ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software. *PLoS ONE* 9(6): e98679. <https://doi.org/10.1371/journal.pone.0098679>

Roth, M. P., A. Verdecchia, R. M. Harrington, and Y. Liu. 2020. High-Resolution Imaging of Hydraulic-Fracturing-Induced Earthquake Clusters in the Dawson-Septimus Area, Northeast British Columbia, Canada. *Seismological Research Letters*. doi:10.1785/0220200086.