INSTALLATION TECHNIQUES AND NETWORK PERFORMANCE

Impact of sensor installation techniques on seismic network performance

M. Laporte, G. Bainbridge, D. Baturan, P. Devanney
Ottawa, Canada

SUMMARY

The magnitude of completeness (Mc) of a seismic network is determined by a number of factors including station density, self-noise and passband of the sensor used, ambient noise environment and sensor installation method and depth. Sensor installation techniques related to depth are of particular importance due to their impact on network deployment costs. We present example simulations of array performance illustrating Mc for local and regional arrays using different installation depths. Models of typical noise in different depth ranges were derived by averaging background seismic PSDs from various Nanometrics projects throughout North America; they are representative of areas with limited overburden thickness (< 15 m) as commonly found in post-glacial environments around the world. Noise performance improves with depth, and this effect is frequency dependent, so the benefit of depth depends on the band of interest of seismic events as a function of distance and magnitude.

DEPTH NOISE SUPPRESSON

- Case study of multiple North American broadband data sets with concurrent deployments at surface and at depth
- Results grouped into 3 depth categories
  - 0.5m: direct burial
  - 3m to 10m: cased hole, screwpile
  - 15m to 30m: borehole
- Focus on high frequencies used for event detection
- Noise Suppression Frequency Band
  - 3 – 10m depth: > 10 Hz
  - 15 – 30m depth: > 1.5 Hz

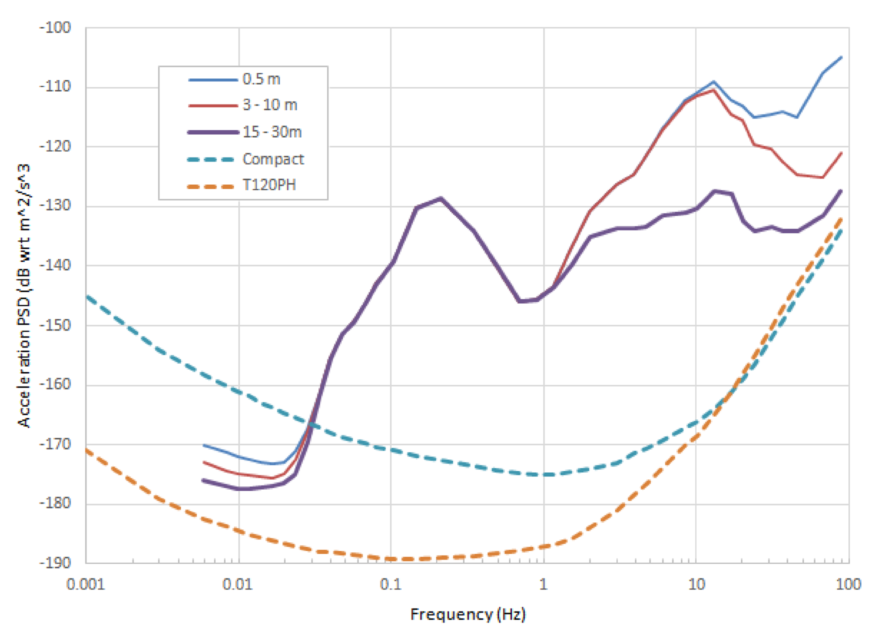

Figure 1: Noise Performance vs Depth, Acceleration PSD (presented in Velocity in detection threshold plots)

RESULTS

- A local array detecting small, nearby events can benefit from emplacement of sensors in rock at a depth of 15-30 m, with Mc reduced by 0.6 compared to shallow, direct-buried stations in our case study. However the same benefit can instead be gained by a closer spacing of shallow stations, with an additional improvement in location accuracy with a denser array.
- A regional array also can benefit from installation at depth, although the benefit is smaller in terms of Mc (reduced by 0.45) and minimal for distant events compared to direct burial (M2.4 vs. M2.5 detectable at 98 km). Therefore an array of shallow, direct buried instruments with an appropriate station spacing may provide the most efficient solution for regional networks.
- Shallow boreholes (3-10 m) in sediment perform similarly to direct burial in a regional array, but in a local array they have some advantage in terms of single-station detection threshold (M-0.7 vs. M-0.2 detectable at 3 km distance).

REFERENCES

Brune, J. (1970). Tectonic Stress and the Spectra of Seismic Shear Waves from Earthquakes. *J. Geophys. Res., Vol. 75, No. 26*, 4997-5009.

Stabile, T. A., Iannaccone, G., Zollo, A., Lomax, A., Ferulano, M. F., Vetri, M. L. (2013). A comprehensive approach for evaluating network performance in surface and borehole seismic monitoring. *Geophys. J. Int.*, *192*, 793–806.

Zivčić, M., and Ravnik, J. (2002). Detectability and earthquake location accuracy modeling of seismic networks, IS 7.4. In P. Bormann (Ed.), *New Manual of Seismological Observatory Practice* (Vol. 1). Potsdam: GeoForschungsZentrum.

Greig, W. and N. Ackerley, (2014). Microseismic network performance estimation: Comparing predictions to an earthquake catalogue, *Poster Paper, SSA*

LOCAL ISM NETWORK

- Region of Interest: 10km Radius Circle
- Station Count: 5
- Median Inter-station spacing: ~16.8km
- Hypocentral distance range: 3 – 14.5 km
- Passband of Interest for Event Detection : 10 – 100 Hz

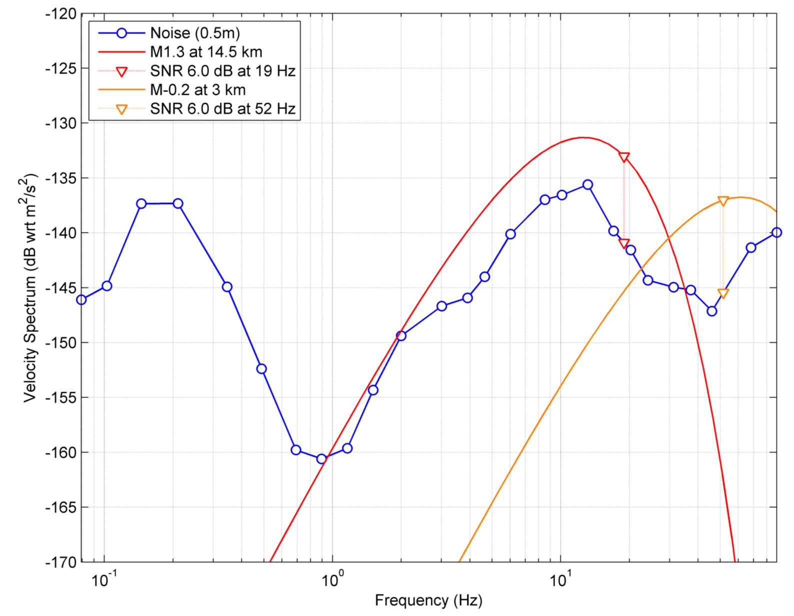

Figure 2a: Single station detection thresholds for distant and nearby events (0.5m depth)

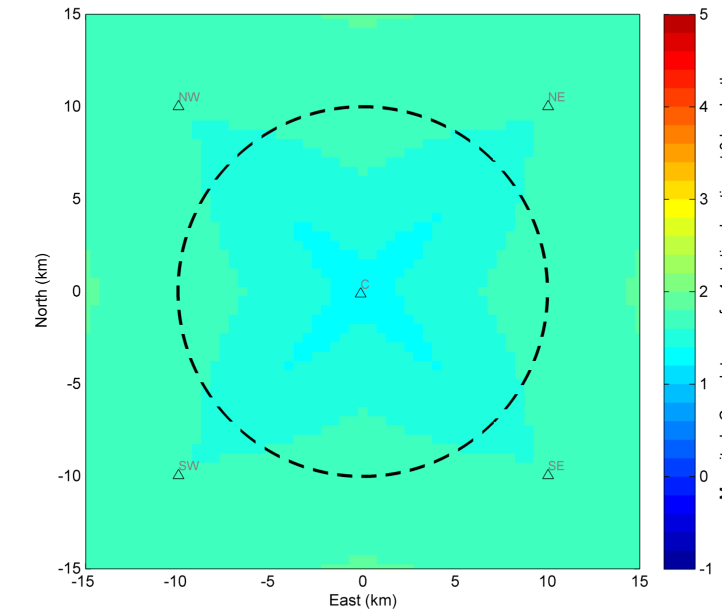

Figure 2b: Network Mc plot (0.5m depth), Average Mc = M1.530

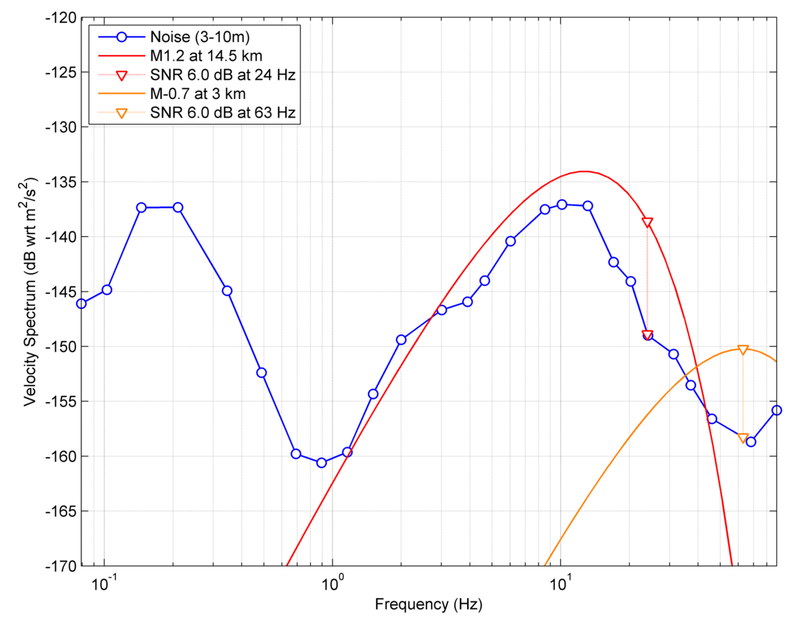

Figure 3a: Single station detection thresholds for distant and nearby events (3-10m depth)

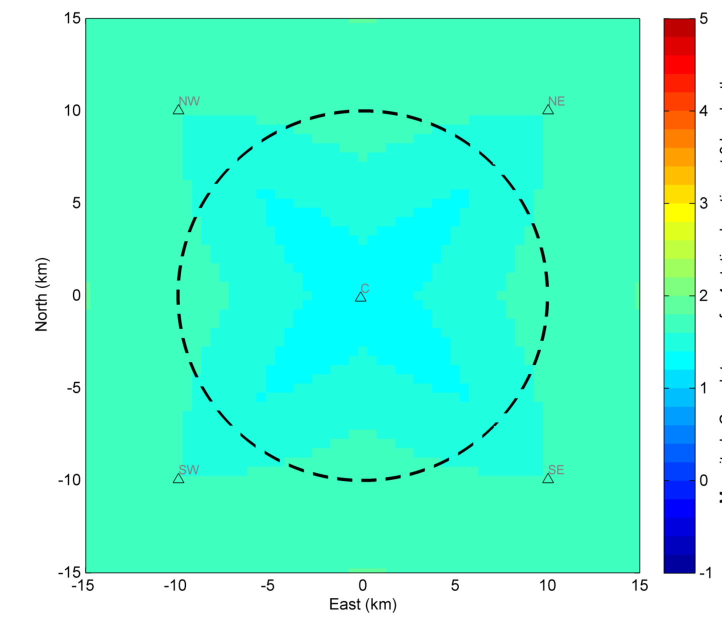

Figure 3b: Network Mc plot (3-10m depth), Average Mc = M1.482

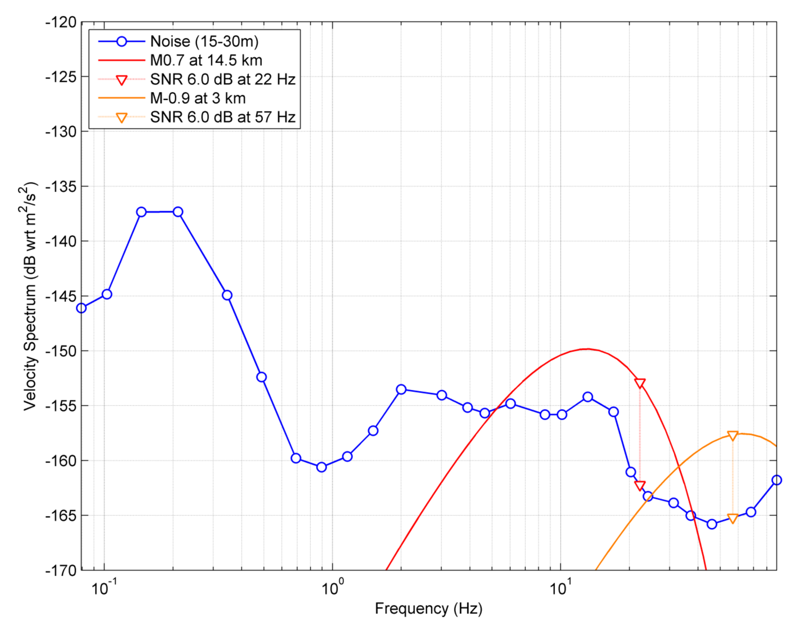

Figure 4a: Single station detection thresholds for distant and nearby events (15-30m depth)

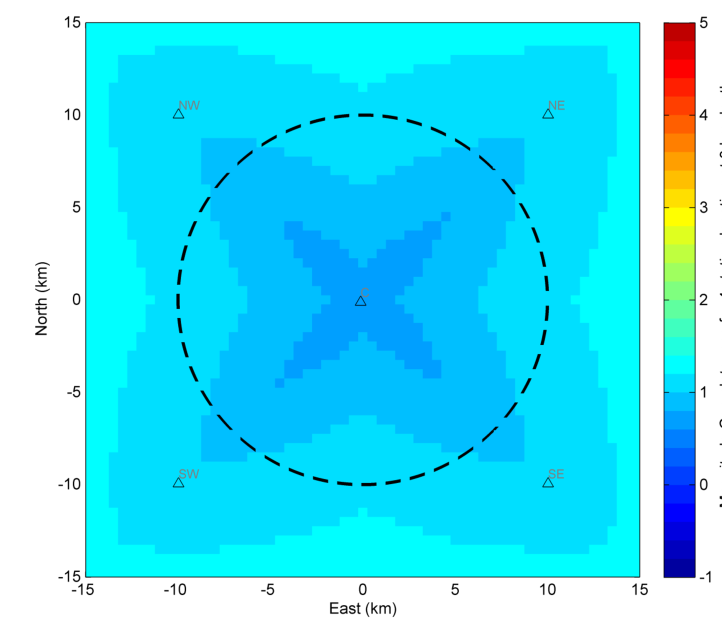

Figure 4b: Network Mc plot (15-30m depth), Average Mc = M0.932

REGIONAL ISM NETWORK

- Region of Interest: 125x150km Rectangle
- Station Count: 30
- Inter-station spacing: 25km
- Hypocentral distance range: 15.5 – 98.5 km
- Passband of Interest for Event Detection: 0.5 – 25 Hz

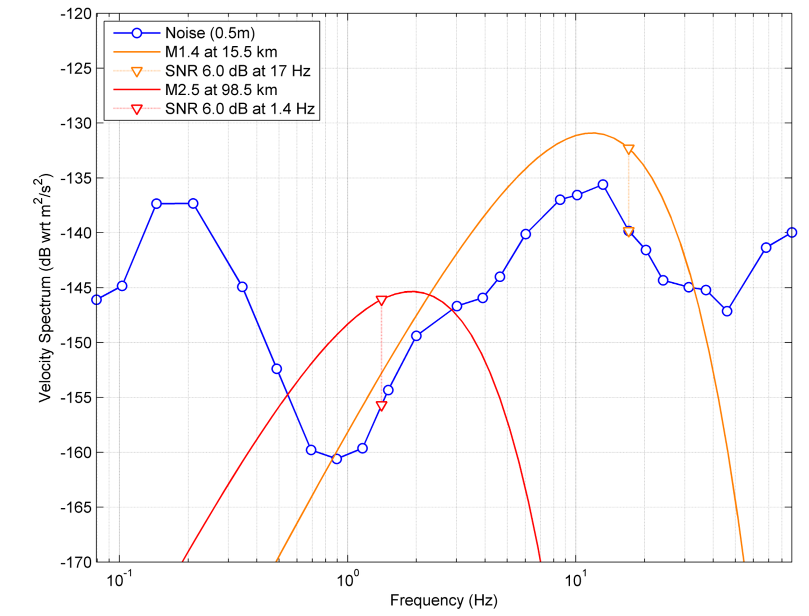

Figure 5a: Single station detection thresholds for distant and nearby events (0.5m depth)

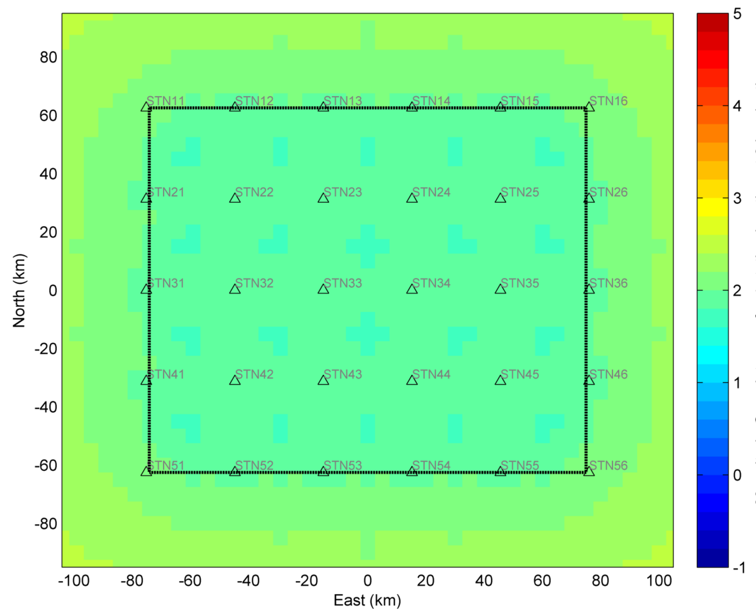

Figure 5b: Network Mc plot (0.5m depth), Average Mc = M1.902

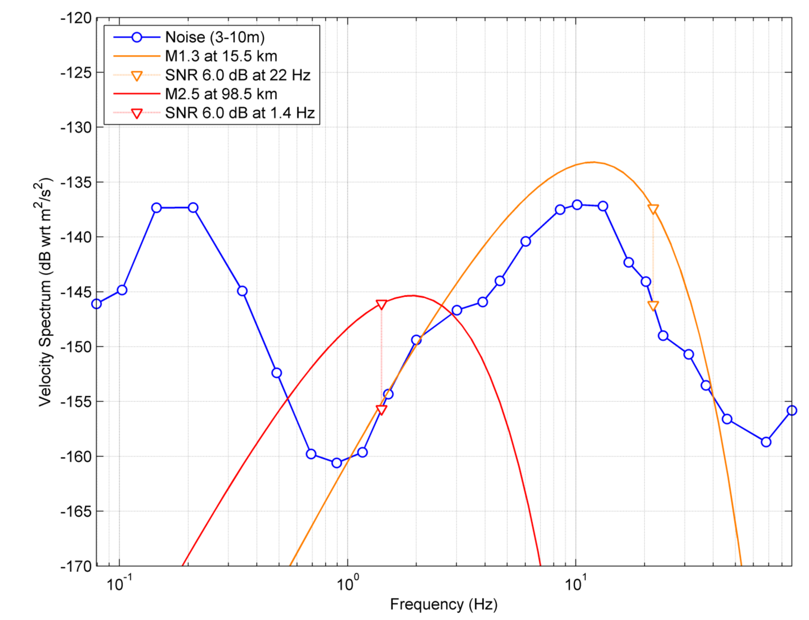

Figure 6a: Single station detection thresholds for distant and nearby events (3-10m depth)

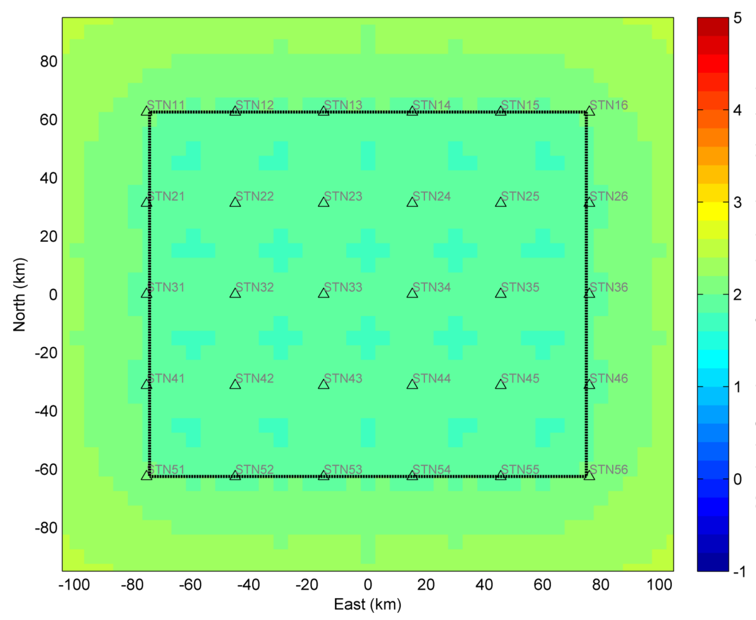

Figure 6b: Network Mc plot (3-10m depth), Average Mc = M1.897

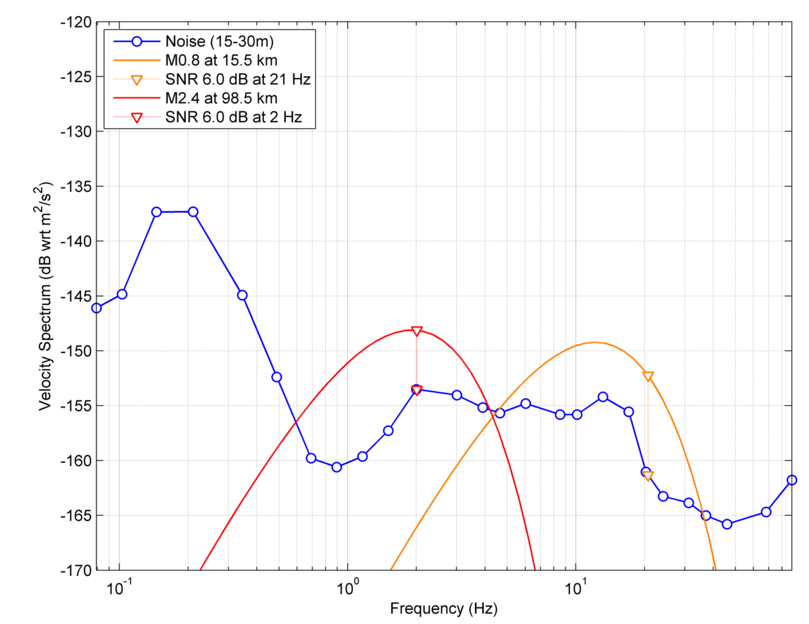

Figure 7a: Single station detection thresholds for distant and nearby events (15-30m depth)

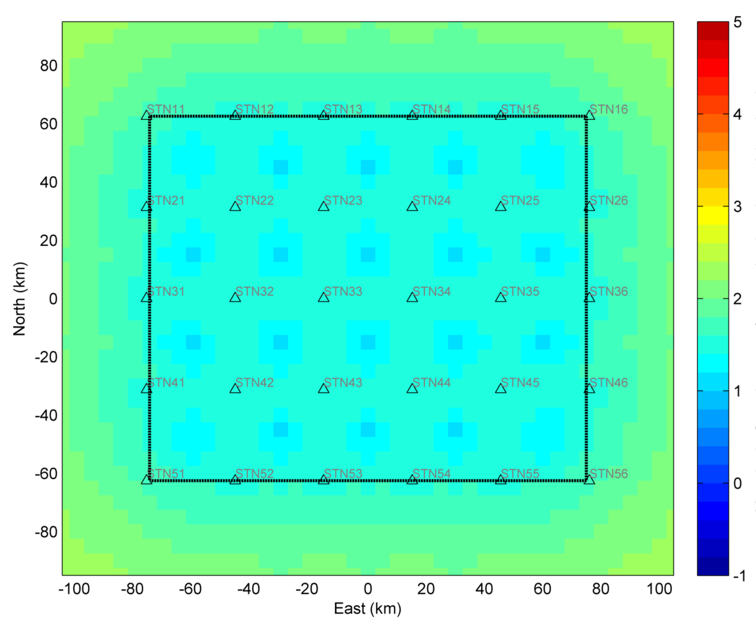

Figure 7b: Network Mc plot (15-30m depth), Average Mc = M1.453