SEISMIC NETWORK PERFORMANCE ESTIMATION

Comparing predictions to observation from an earthquake catalogue

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SUMMARY

We compare predictions of network performance to observations made from an earthquake catalogue. We estimate event spectra using Brune modeling and station noise to predict the magnitude of completeness for a network. We compare the predicted magnitude of completeness to an earthquake catalogue for the network. We use the maximum curvature method to assess the magnitude of completeness observed in the catalogue. We find that predicted and observed magnitude of completeness agree reasonably well, with the observed result being consistently lower than the predicted.

NETWORK BASICS

- Network of ISIS L-28 geophones, Trillium 120 seismometers and CMG seismometers
- Monitors New Madrid Seismic Zone
- Catalogue of 2370 events since 2002
- Median site noise is computed via an SQLX analysis on 4 weeks of data from 4 different seasons
- Network details are available at http://www.memphis.edu/ceri/seismic/

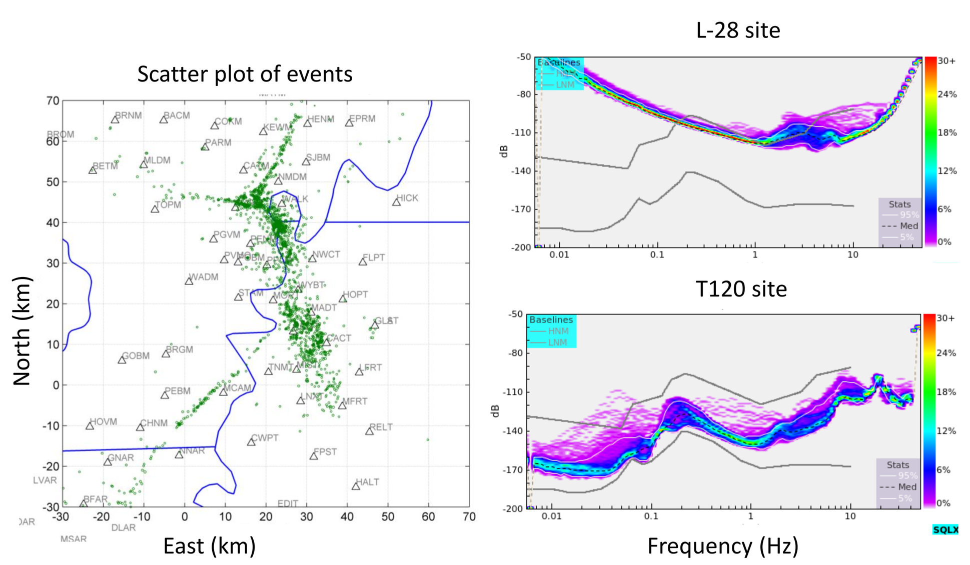


Figure 1: Left – Earthquake catalogue and station distribution for the seismic network. Right – SQLX analysis for an L-28 geophone (top) and a Trillium 120 (bottom) broadband seismometer.

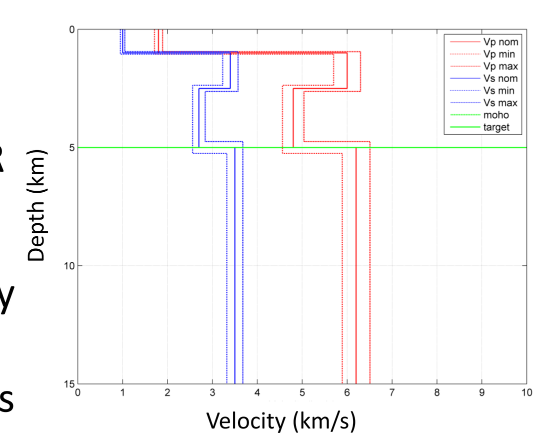
PREDICTING NETWORK PERFORMANCE

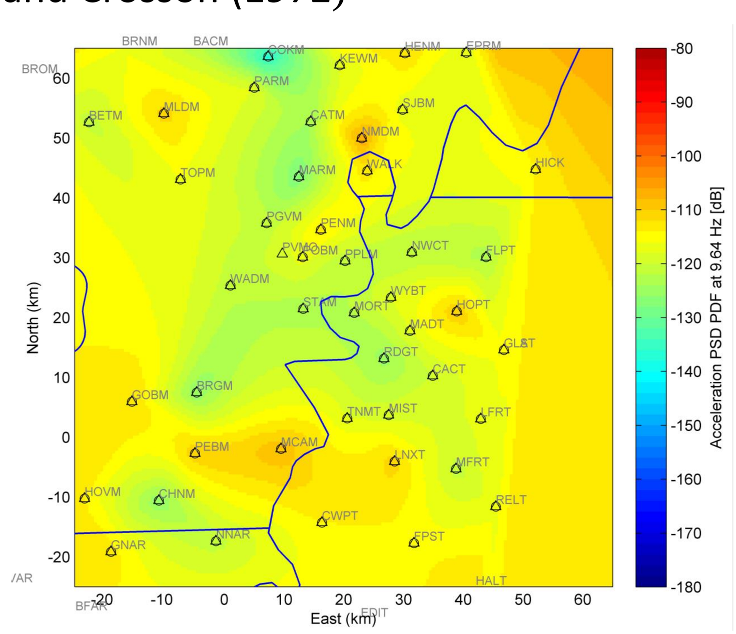
Computing predicted magnitude of completeness

- Simulate event spectra based on Brune modeling
- Determine minimum magnitude event exceeding threshold SNR

Computing predicted location accuracy

- Determine a 1-D velocity model with depth and velocity uncertainties (we use the model of Chiu et al, 1992)
- Compute covariance matrix (error ellipse) according to Peters and Crosson (1972)





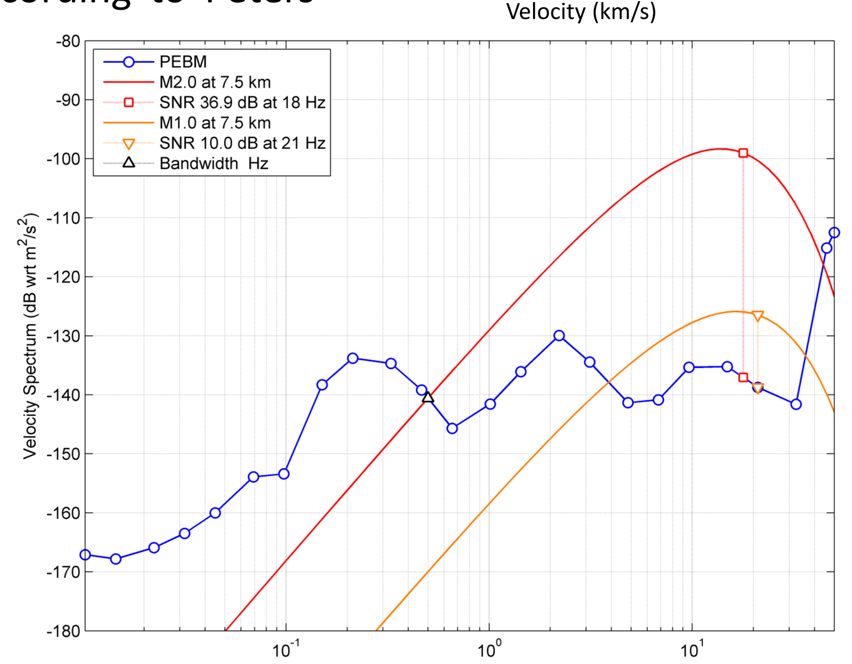


Figure 2: Top right – Velocity model for the New Madrid Seismic Zone. Right – Depiction of the Brune modeling of seismic events. Shown are a magnitude 2.0 and a magnitude 1.0 compared to the observed site noise for an station 7.5 km away from the simulated event. Left – Noise map for the region plotted at 10 Hz.

PREDICTED NETWORK PERFORMANCE

- Predicted location accuracy of 330 metres or better for most of catalogue
- Predicted magnitude of completeness between 1.0 and 1.5 for most of catalogue

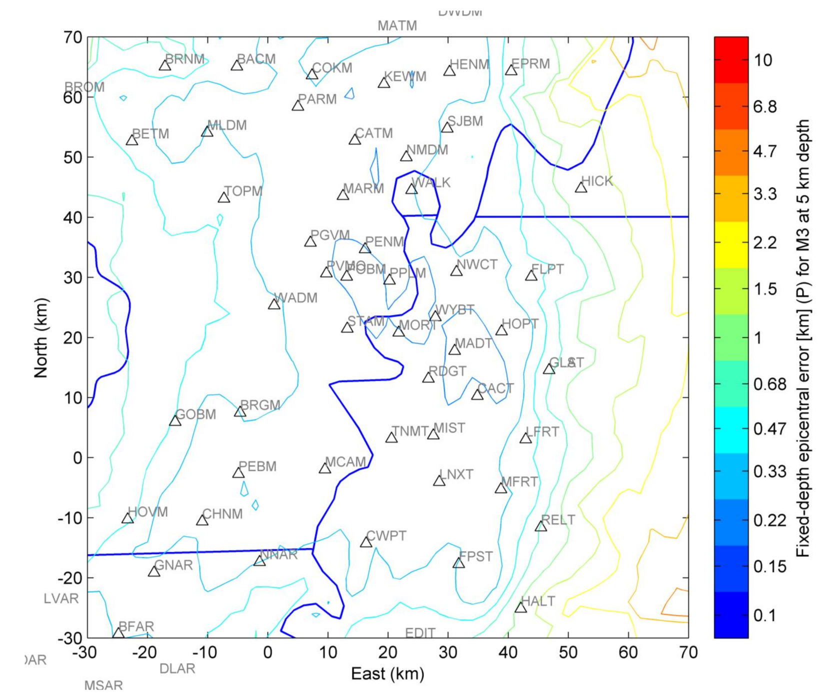


Figure 3: Predicted location accuracy for the seismic network. Location accuracy is lower in regions of improved azimuthal coverage and increased station density.

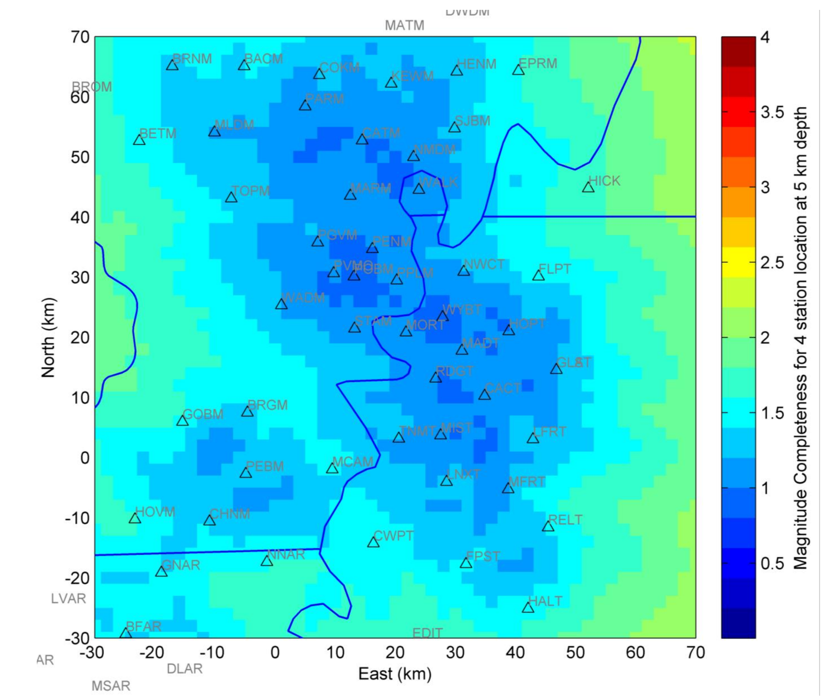


Figure 4: Predicted magnitude of completeness for the network. Magnitude of completeness is lowest in regions of lower site noise and increased station density.

PERFORMANCE ASSESSMENT FROM CATALOGUE

- Separate events into grid squares and magnitude bins
- Generate 200 synthetic catalogues using bootstrap sampling
- Compute maximum curvature of the frequency magnitude distribution and average over the 200 Bootstrap samples
- Mandate a minimum number of events in each grid square to increase reliability of estimate
- Re-compute predicted magnitude of completeness on the same grid for comparison

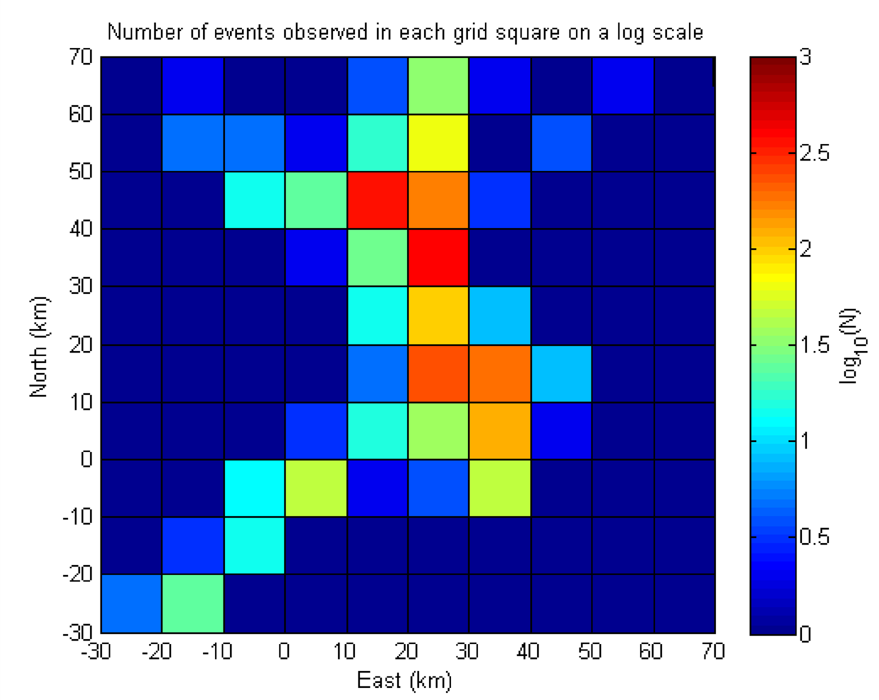


Figure 5: Number of events in each grid square. We require 50 events in every grid square in order to compute magnitude of completeness

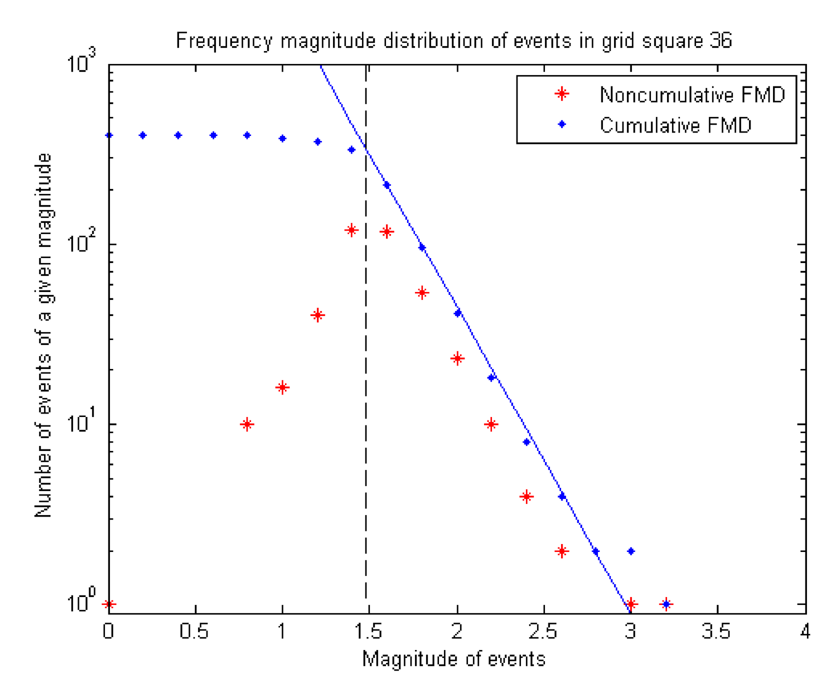


Figure 6: Sample frequency magnitude distribution for the catalogue. The average magnitude of completeness from the bootstrap sampling is 1.483.

COMPARISON OF OBSERVED AND PREDICTED RESULTS

- Predicted magnitude of completeness consistently lower than observed result by 0.3

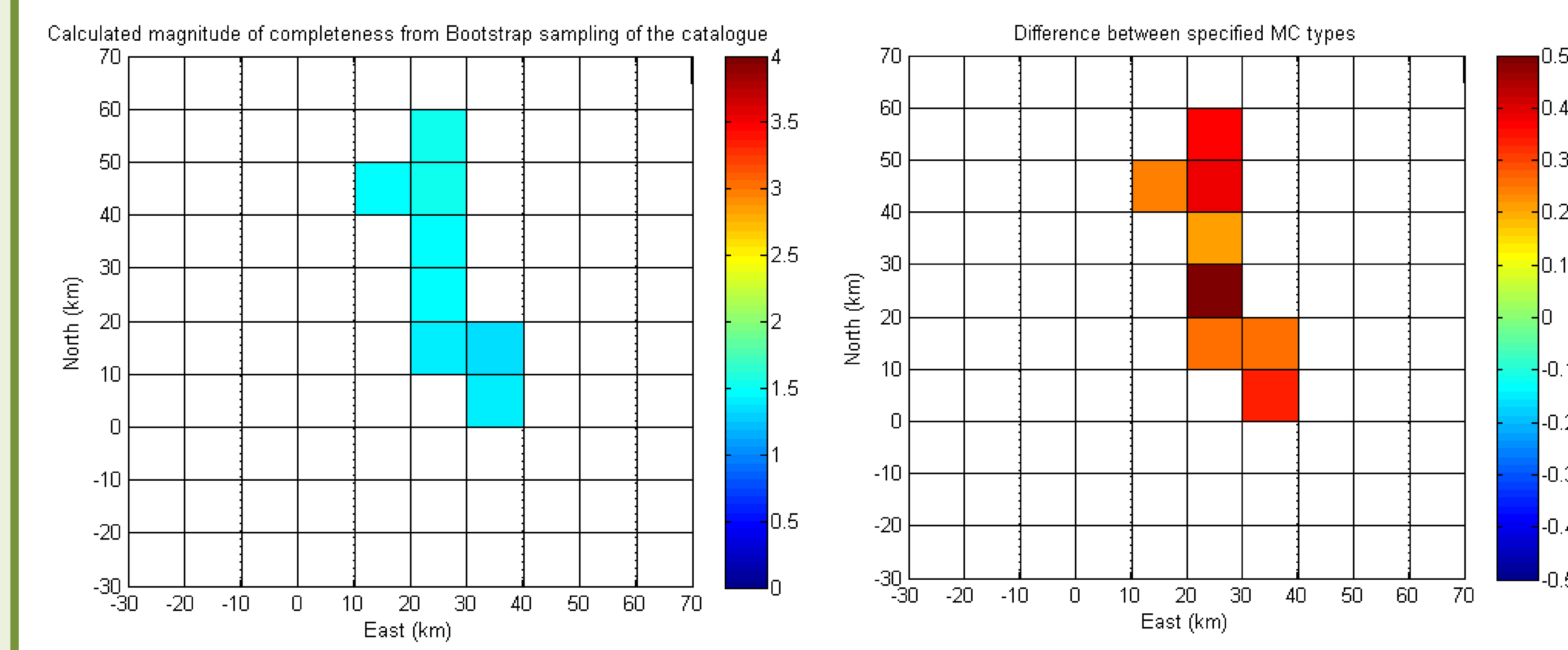


Figure 7: Left – Observed magnitude of completeness computed from the average of the Bootstrap samples. Right – Difference between observed and predicted magnitude of completeness (observed minus predicted).

DISCUSSION

- Predicted and observed magnitude of completeness have reasonable agreement, the average difference is 0.3 magnitude units
- Some leading candidates for sources of discrepancy in the results:
  - Distortion of the frequency magnitude distribution associated with discretization of catalogues
  - Tuning of signal to noise ratio: how much signal is actually necessary to detect an event?
  - Bias in the maximum curvature method
- Future work should focus on a number of areas:
  - Fitting frequency magnitude distribution for a shape parameter describing the range in which some events are detected and others are not
  - Obtaining estimates of magnitude of completeness for sparser catalogues
  - Tuning the parameters used to estimate predicted magnitude of completeness (e.g. SNR) to reflect the trigger algorithms used for detection
  - Verification of the predicted location accuracy using data from earthquake catalogues
- Network performance would improve significantly with the use of broadband seismometers instead of geophones

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