

# Assessing WCEDS\* as an alternative pipeline processing system

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\* Waveform Correlation Event Detection System

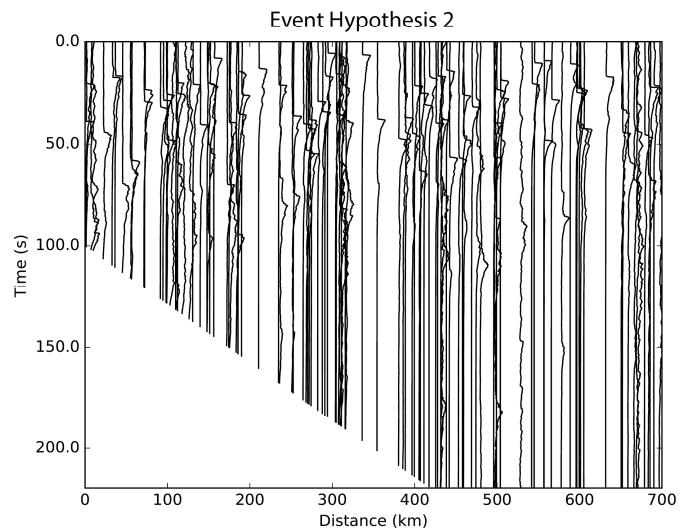
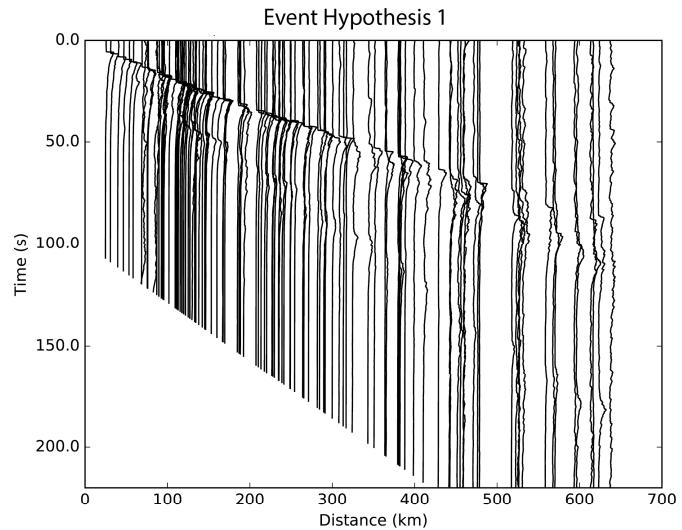
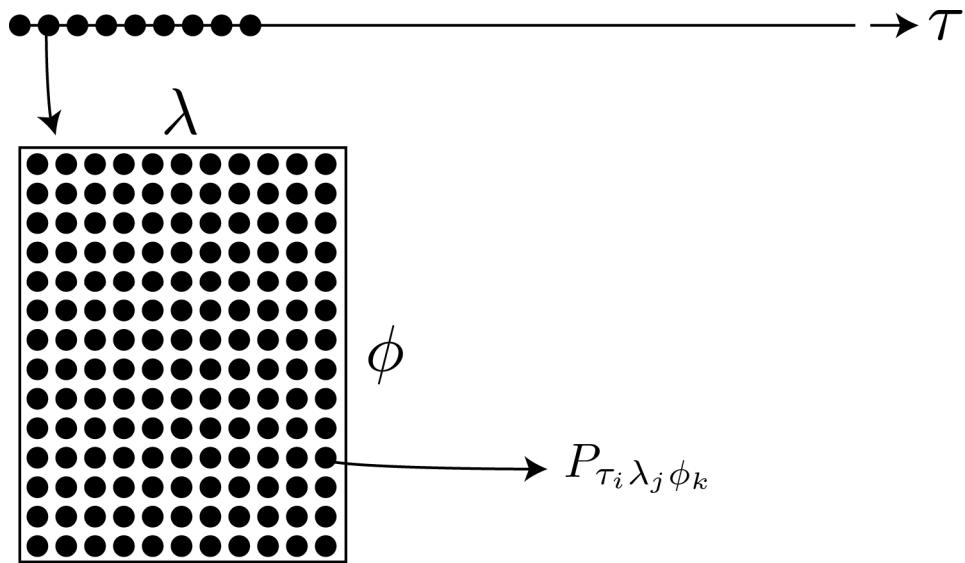
*Exceptional service in the national interest*



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# WCEDS Method

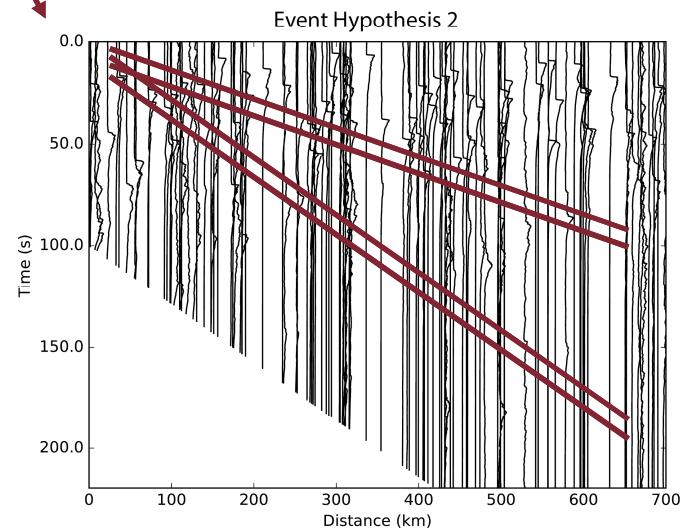
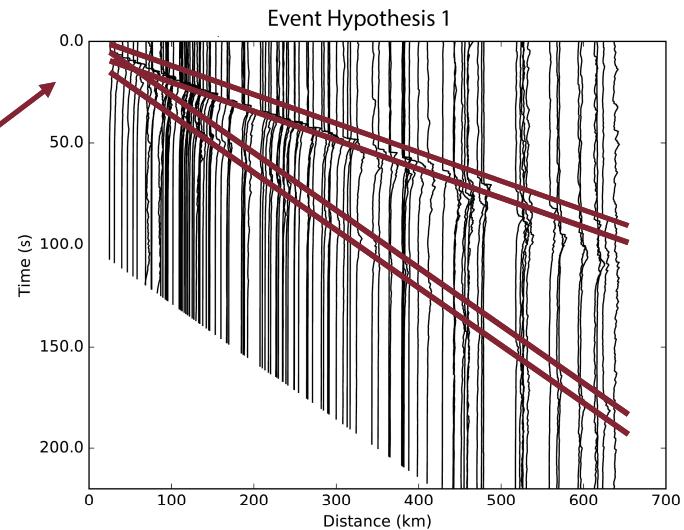
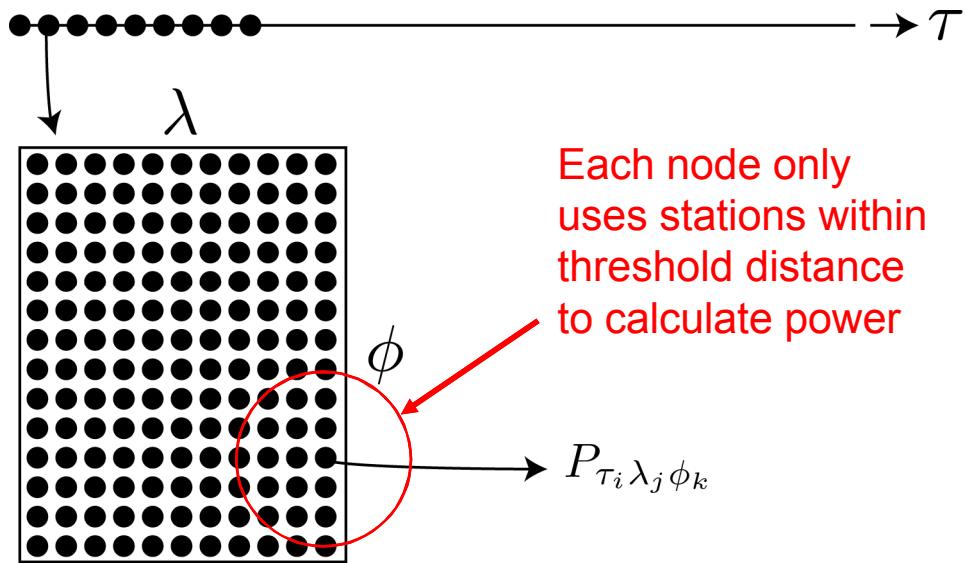
- WCEDS is a back-projection method: observed data are projected back to a set of discrete event hypotheses (e.g., lat, lon, time).
- The projection operator can be based on (a) the travel-time predictions for different seismic phases, or (b) an empirical stack based on a prior earthquake catalog.
- Detecting events is reduced to finding peaks in a multidimensional function.



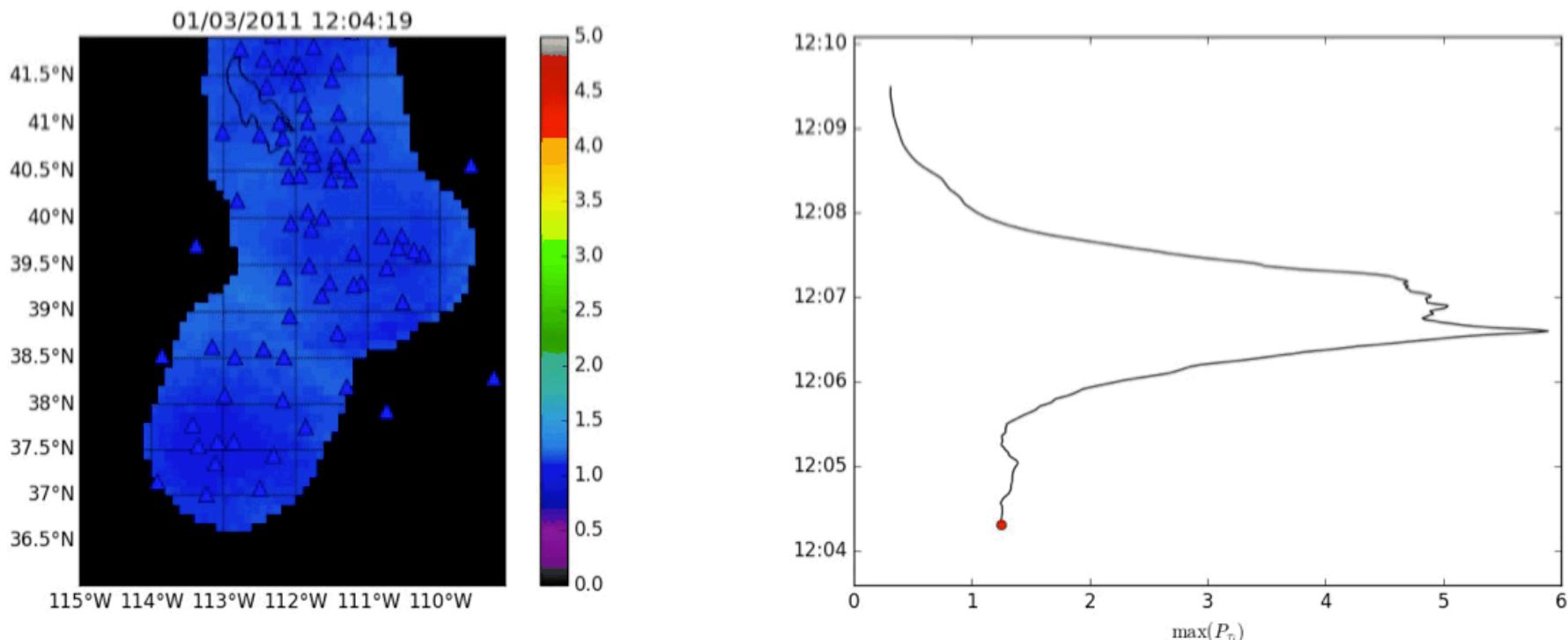
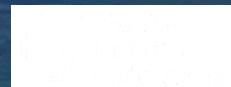
# WCEDS Method

- If based on travel-times, we can define (for a single phase):

$$P_{\tau_i \lambda_j \phi_k} = \frac{1}{N} \sum_{i=1}^N \left[ \sum_{m=-M}^M a(\tau + t_{i\lambda_j \phi_k} + m\delta t) \right]$$



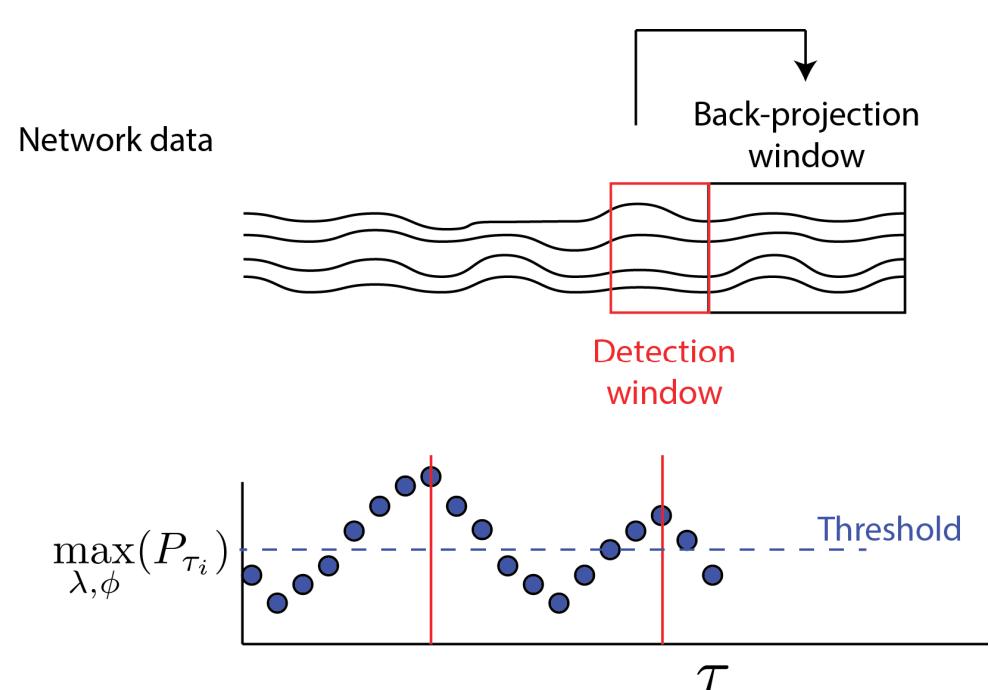
# WCEDS Method



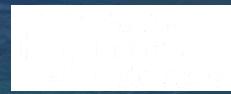
A movie showing  $P$  as a function of location and time, illustrating that events occur as transient peaks.

# WCEDS Method

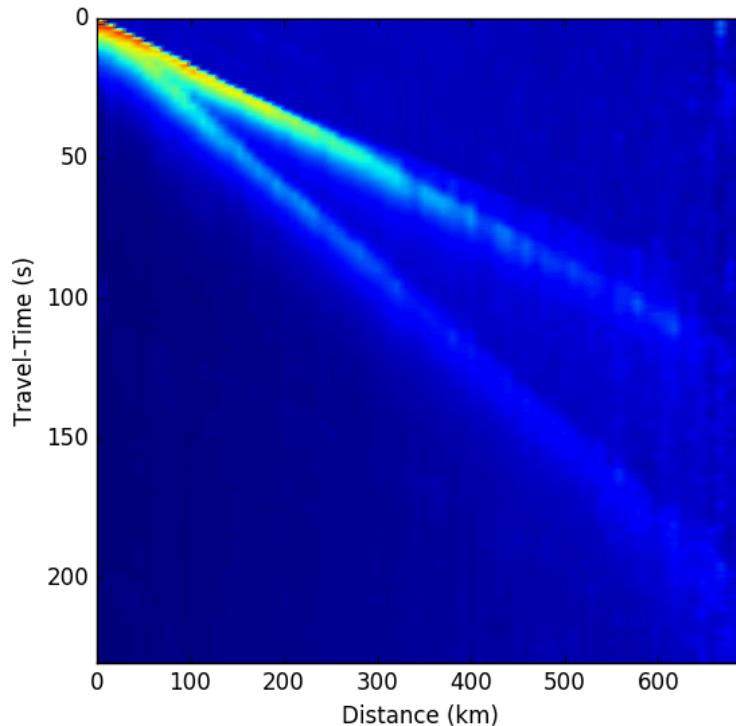
- Detection of peaks in multivariate function:
  - For a given origin time hypothesis, calculate  $\max(P_{\tau_i})$  over all spatial locations
  - Apply contextual peak finder to the time series of  $\max(P_{\tau_i})$  in a trailing time window
  - Remove phases from detected events and repeat as necessary
- Once a peak is found, save full event hypothesis  $(\tau, \phi, \lambda)$



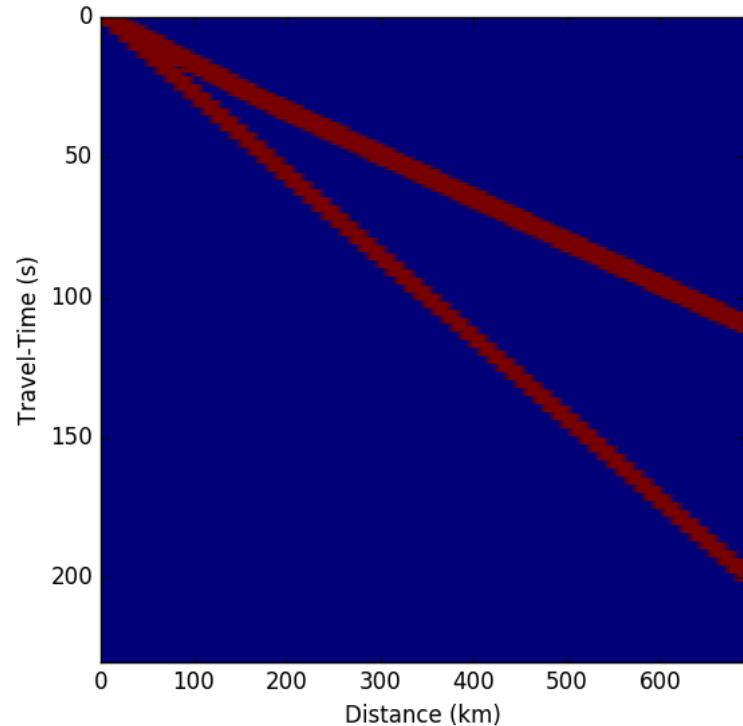
# Time-versus distance stacks



- If the travel-time prediction varies only with range (i.e., a 1D model), a simple dot product formulation is much more efficient (Young et al., 1996).
- The dot product formulation relies on a time-versus distance matrix of travel times and/or amplitudes.

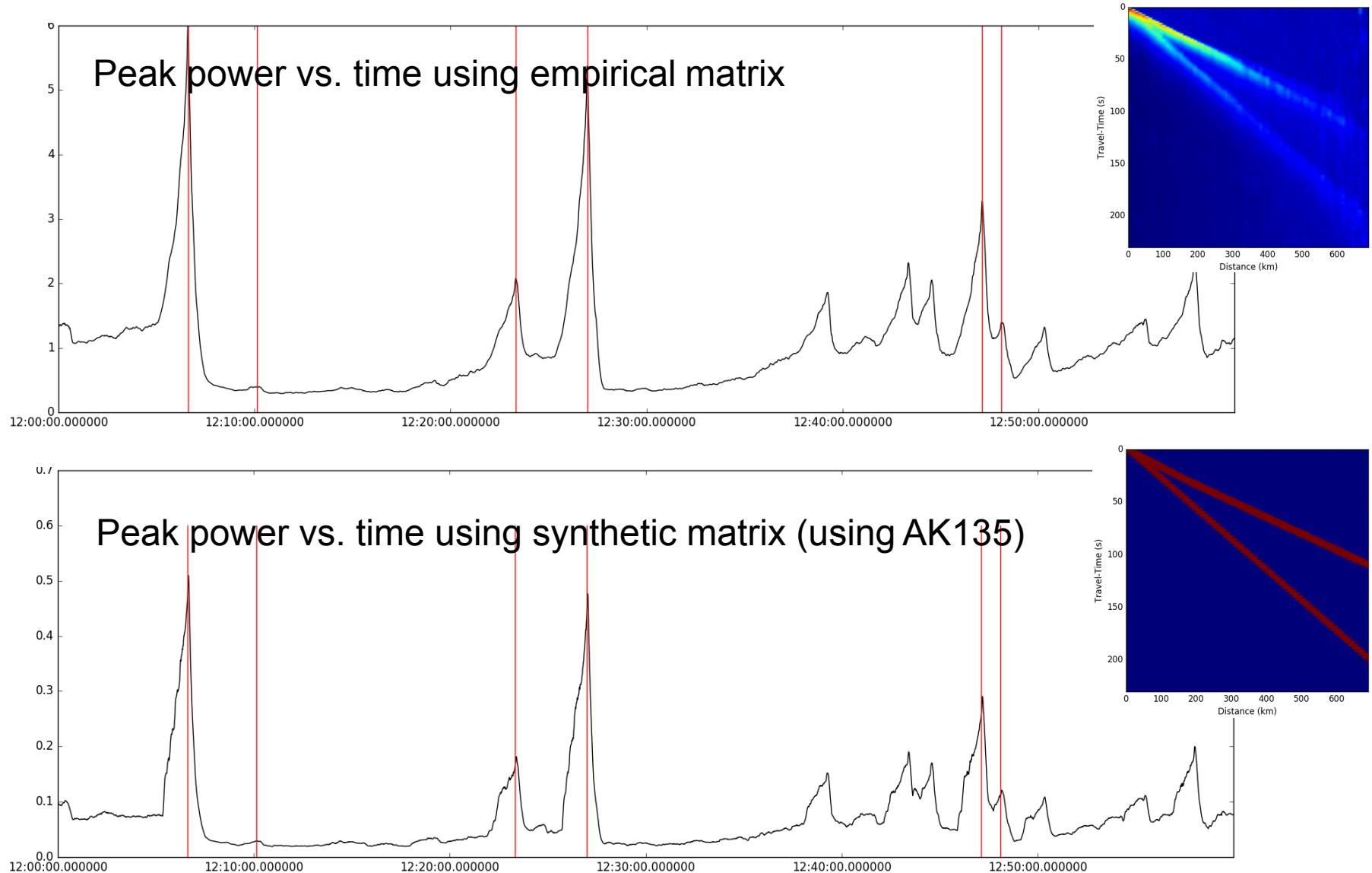
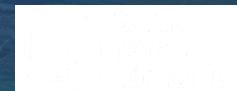


- Empirical time-versus-distance matrix, generated using an existing seismic catalog and stacking historical events.

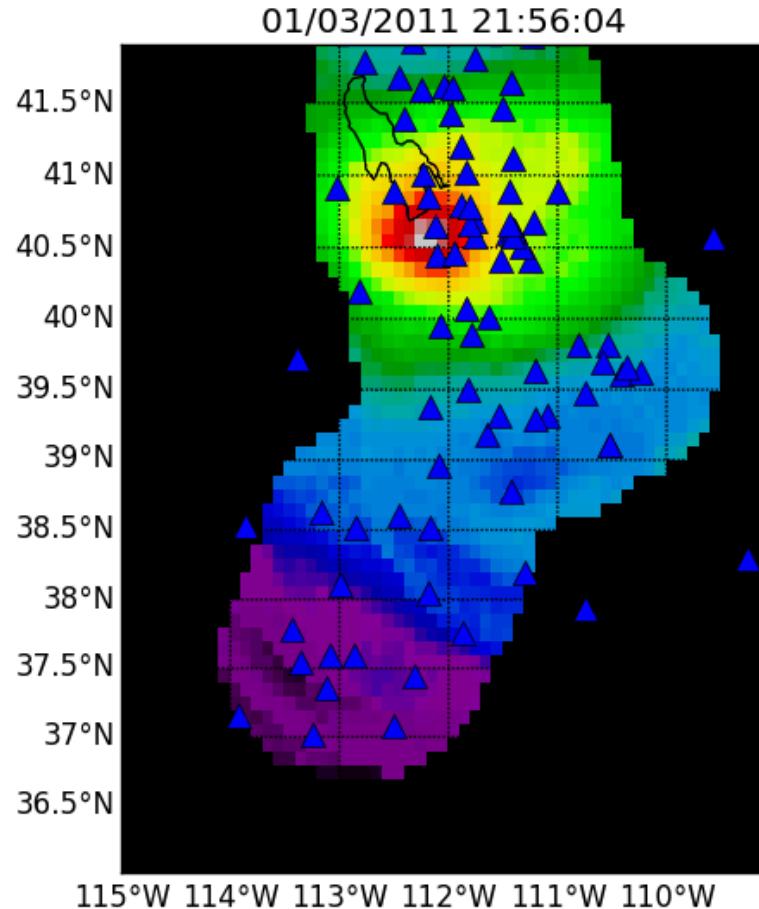


- Synthetic time-versus-distance matrix, comprising Pg and Lg.

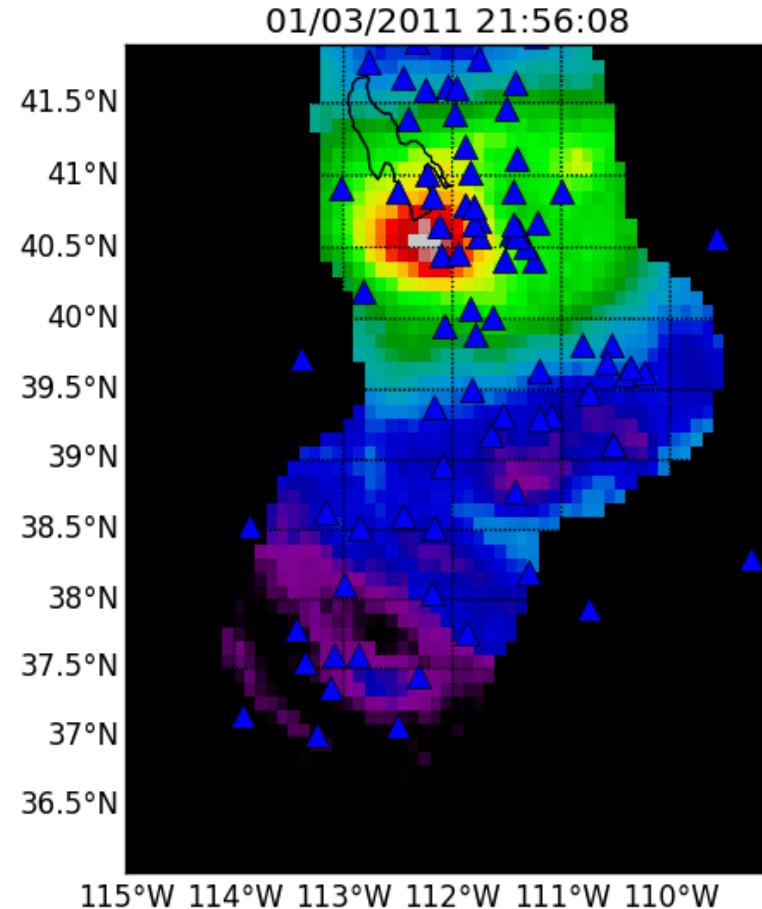
# Comparing empirical and synthetic results



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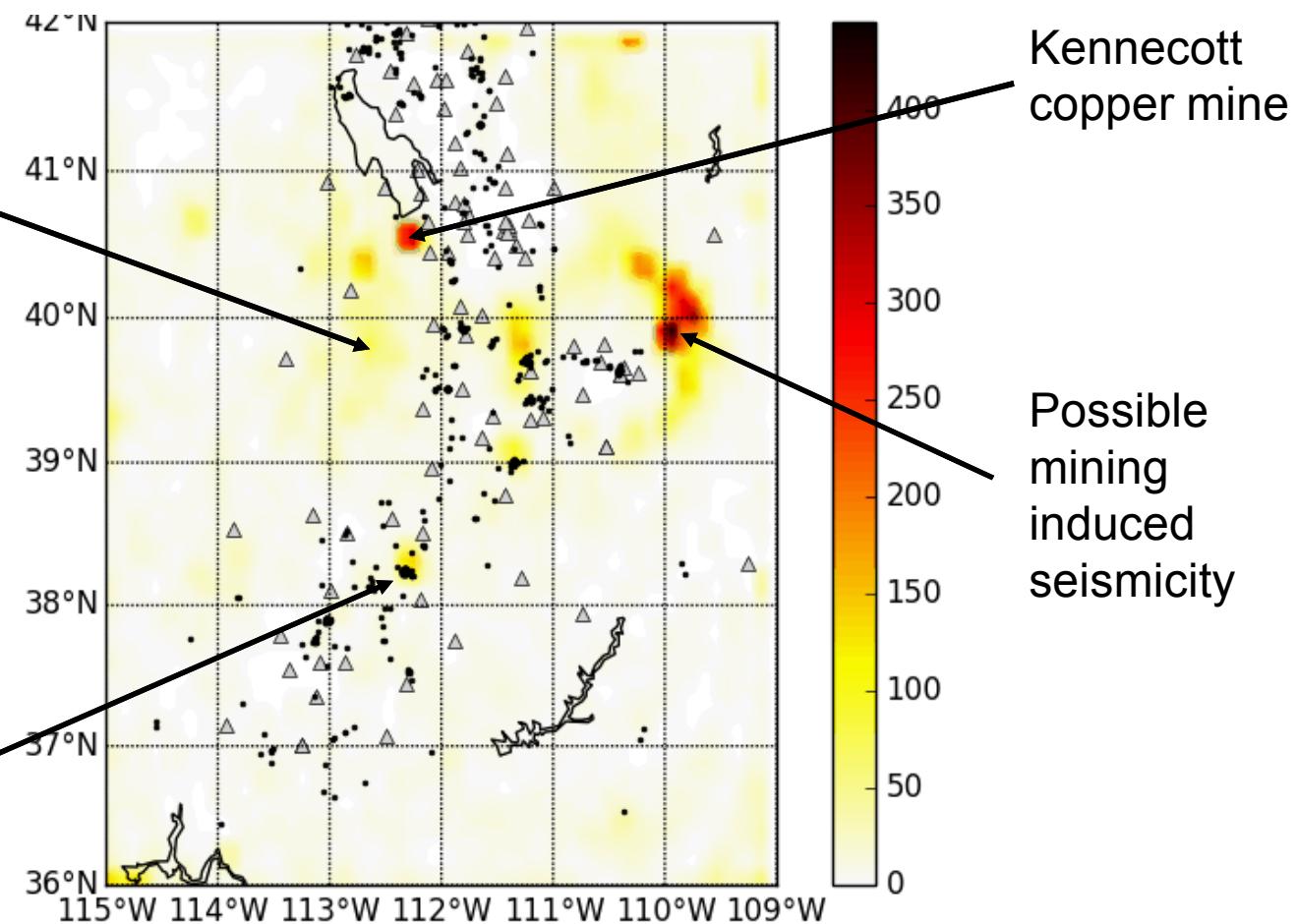
Kennecott mine blast, using empirical matrix



Kennecott mine blast, using synthetic matrix (AK135)

# WCEDS – 2011 catalog for Utah

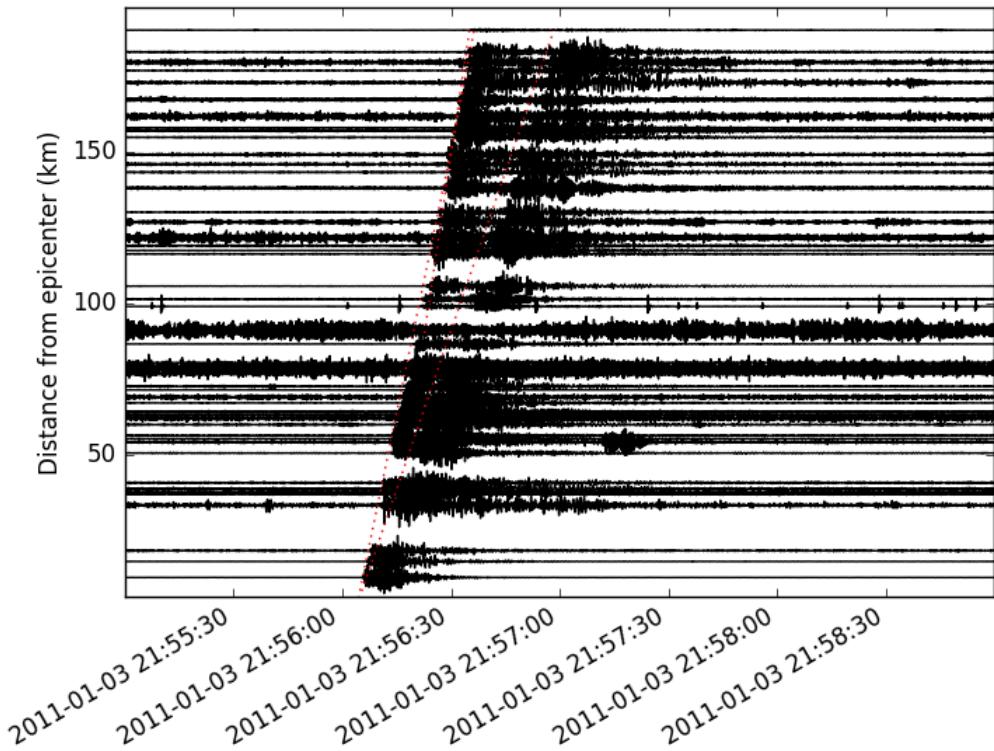
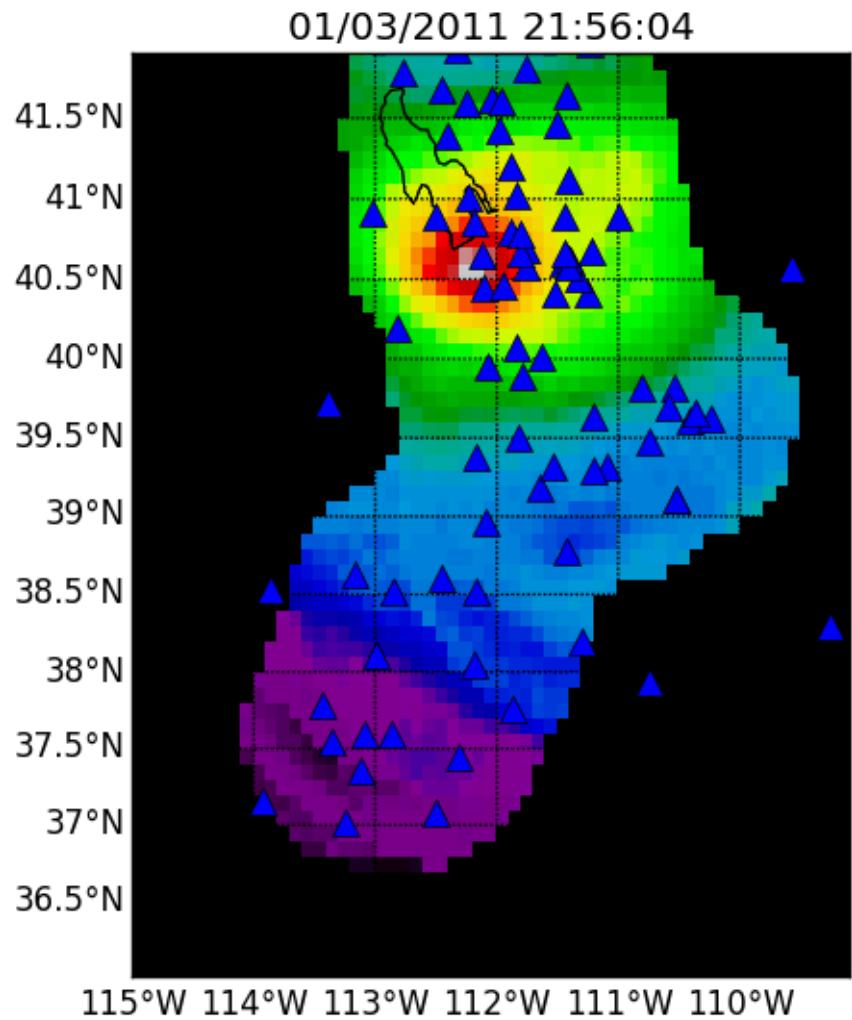
Military facilities?



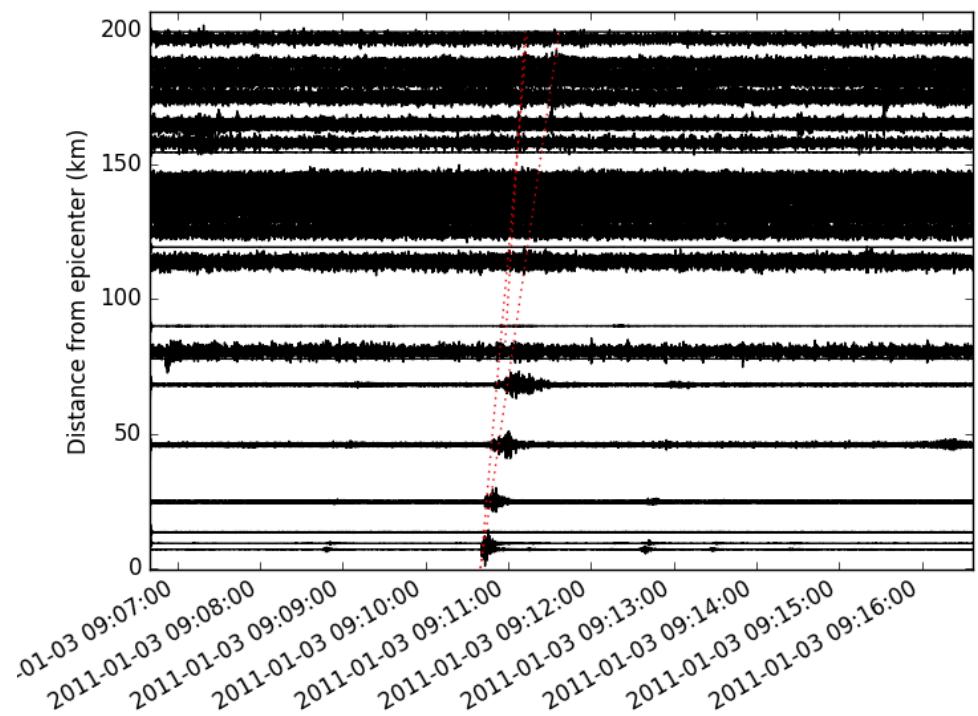
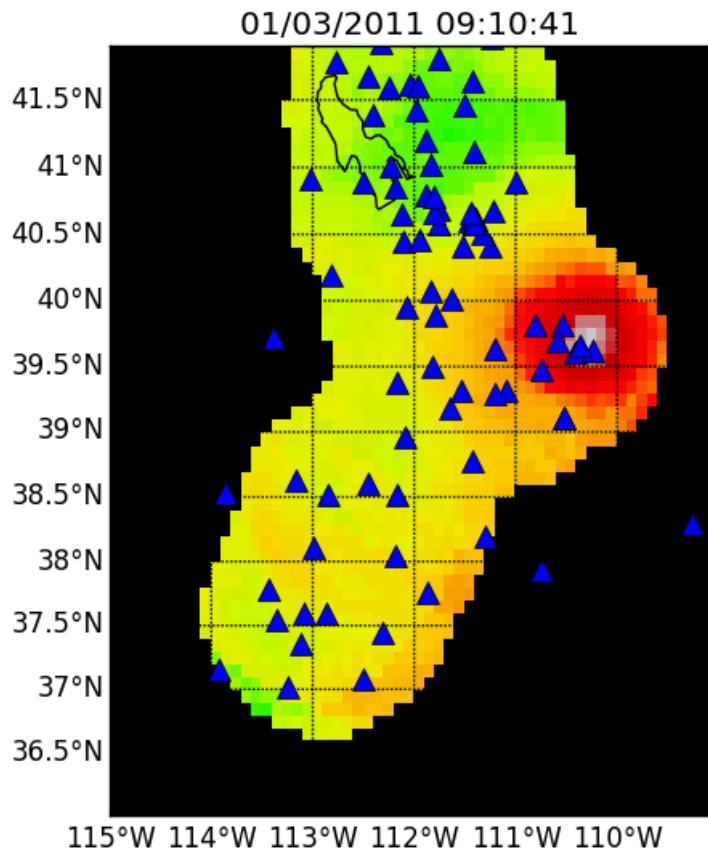
Circleville  
earthquake  
sequence

*Heat map showing number of events  
in  $0.1 \times 0.1$  degree cells*

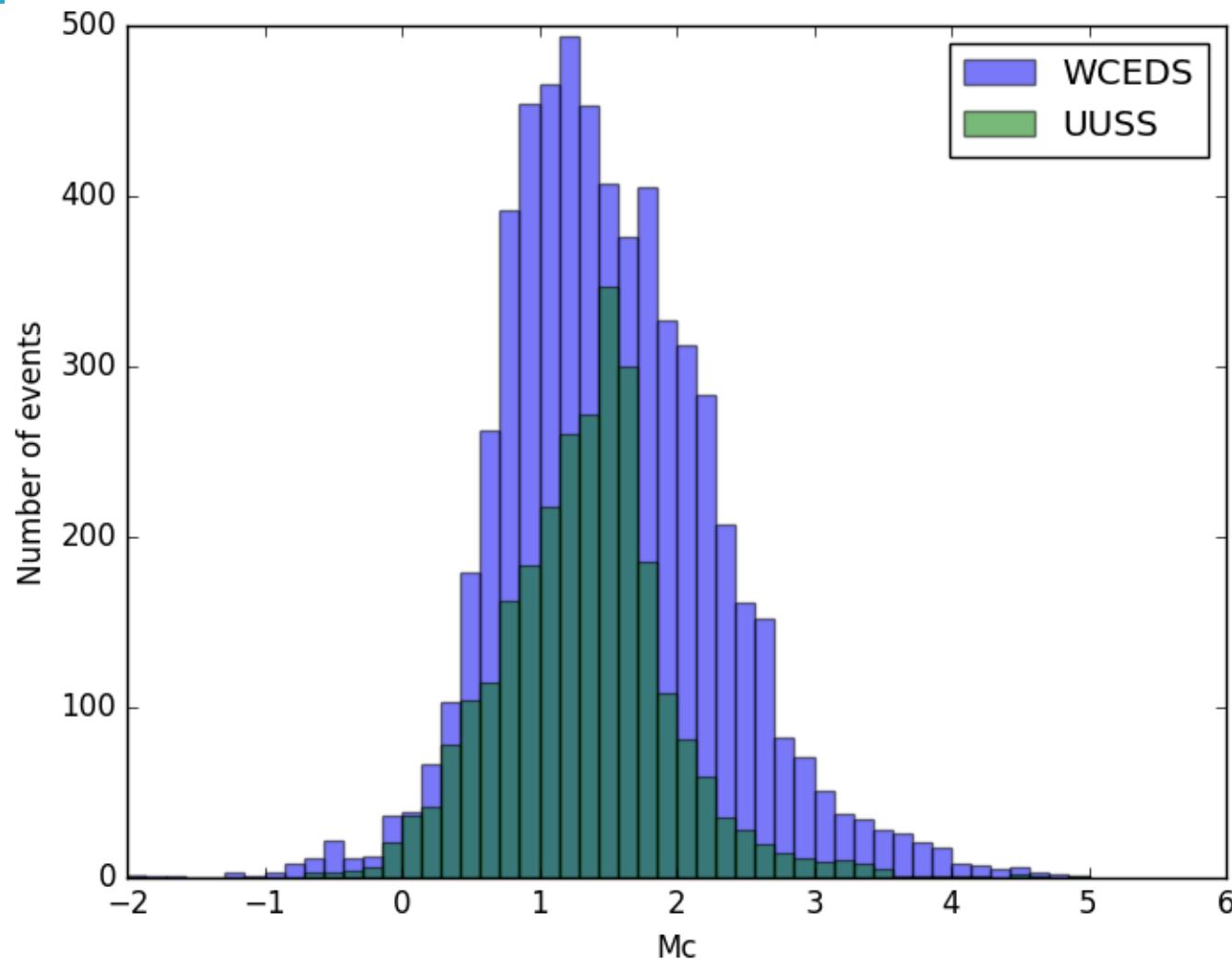
# Kennecott Mine Blast



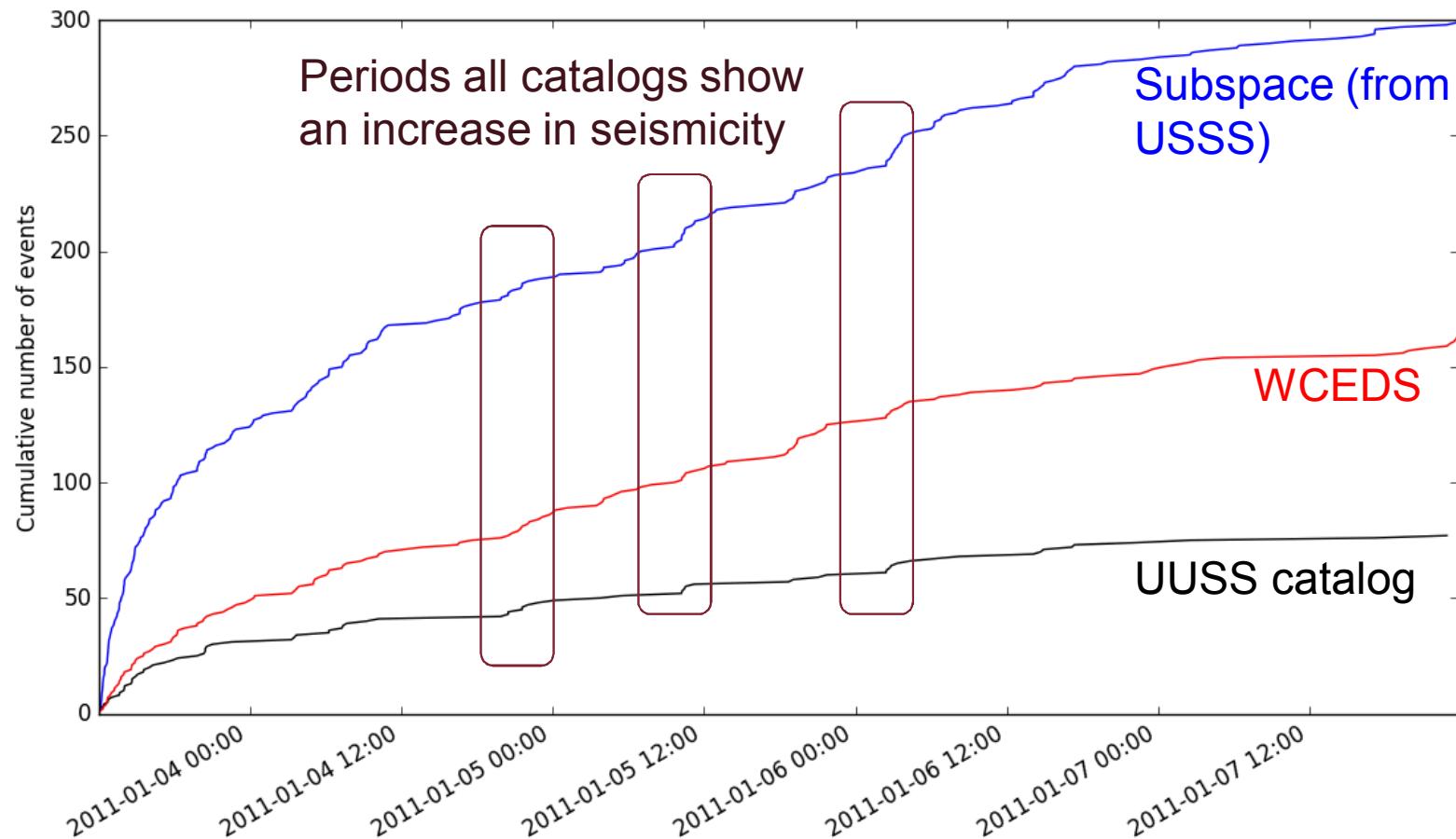
# Mining Induced Seismic event



# WCEDS – 2011 catalog for Utah



# WCEDS – The 2011 Circleville sequence



# Conclusions

- WCEDS is an alternative data processing workflow that is based on back-projection using a network of sensors.
- Our earlier work (Arrowsmith et al., BSSA, 106, 2037-2044) explored the method for continuous processing on one-day of Utah data.
- We have made several algorithm enhancements and compared synthetic and numerical approaches, applying WCEDS to 6 months of data to find events.
  - Initial results suggest WCEDS is finding many of the dominant sources of seismicity in Utah
- Future work will explore more comprehensive comparison of catalogs formed using WCEDS and standard pick-based methods.