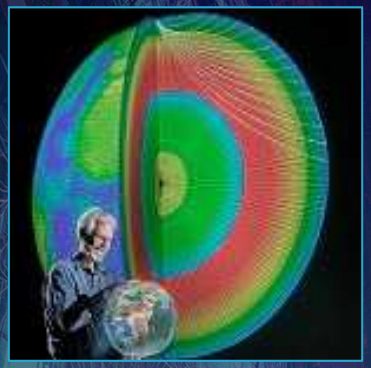
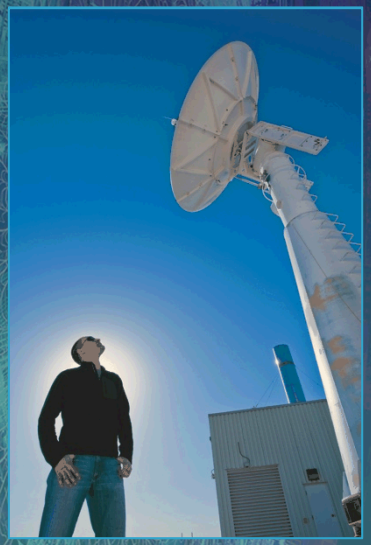
SAND2016-6887PE





Pickless seismic event detection using WCEDS

Stephen Arrowsmith, Chris Young, Sandy Ballard, Megan Slinkard, and Kristine Pankow

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Pick-based vs. Stack-based Methods

Sandia National Laboratories

- The standard paradigm for seismic data processing breaks the event detection problem down into two main processing levels:

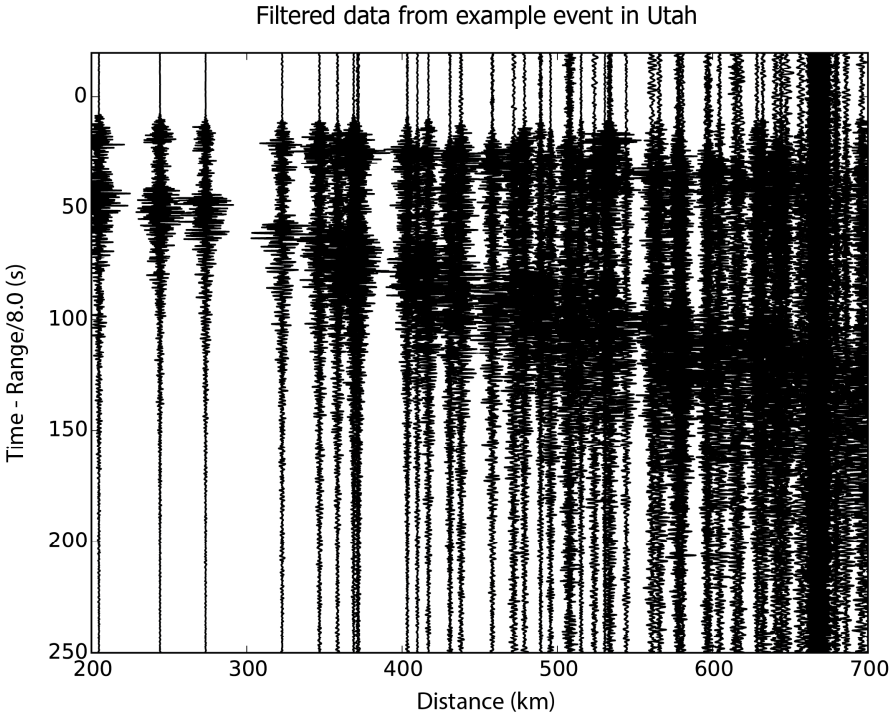
Processing Level	Processing Function	Prerequisites
Station-level	• Detect signals • Pick onset times • Identify phases	• Signal model
Network-level	• Associate phases across a network • Locate event	• Phase picks (from station-level) • Earth model • Propagation model

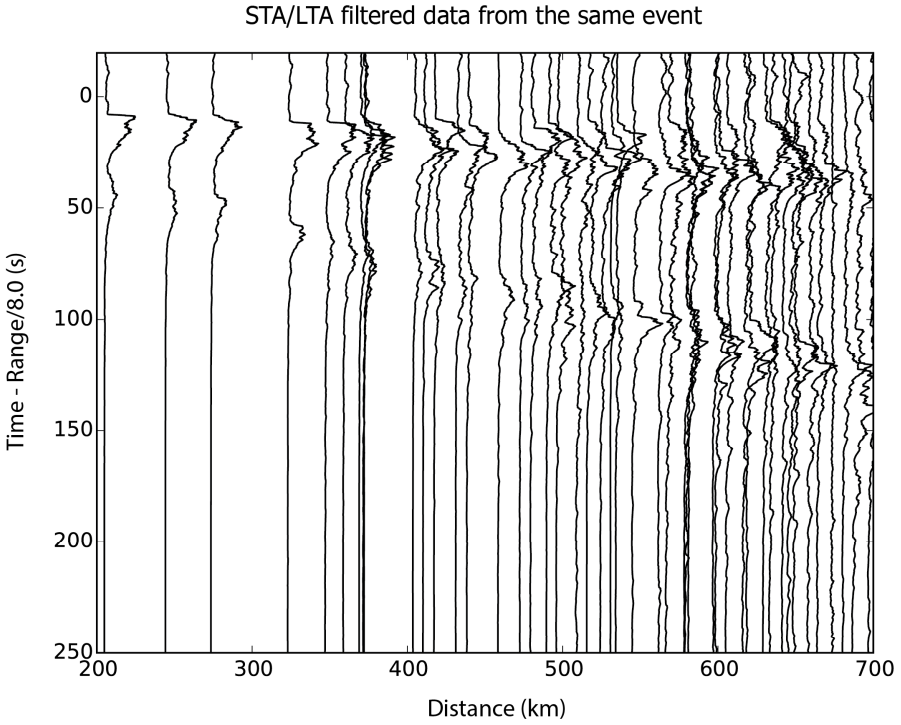
- A second class of methods exist, which we refer to as 'stack-based' methods:

Reverse-Time Migration, or WCEDS	Grid search over event hypotheses, focusing power in waveforms back towards each node.
WCEDS	Grid search over event hypotheses, correlating waveforms against an time-distance stack for each node.

WCEDS Method

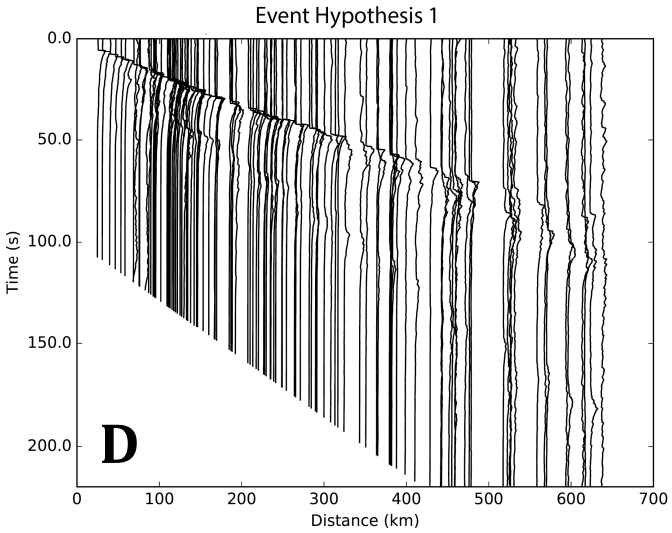
- WCEDS(E) exploits leading-order time-versus-distance properties of the seismic wavefield in a region of study – No assumptions of phases or travel times needed.

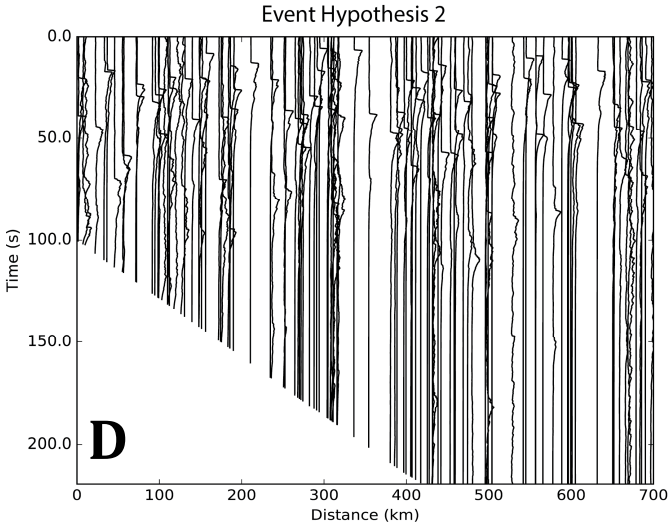


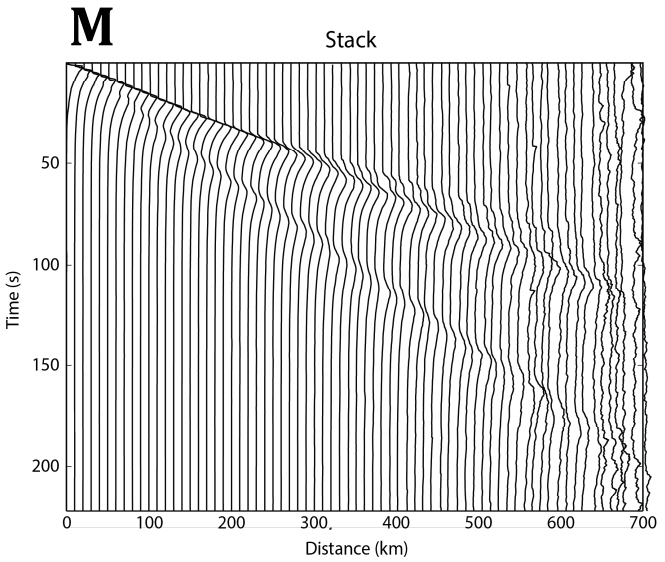


- Raw waveforms are very sensitive to source properties and specific source-receiver paths.
- STA/LTA filter removes high frequency effects – waveforms represent observed phases and travel time properties in a region.

WCEDS Method

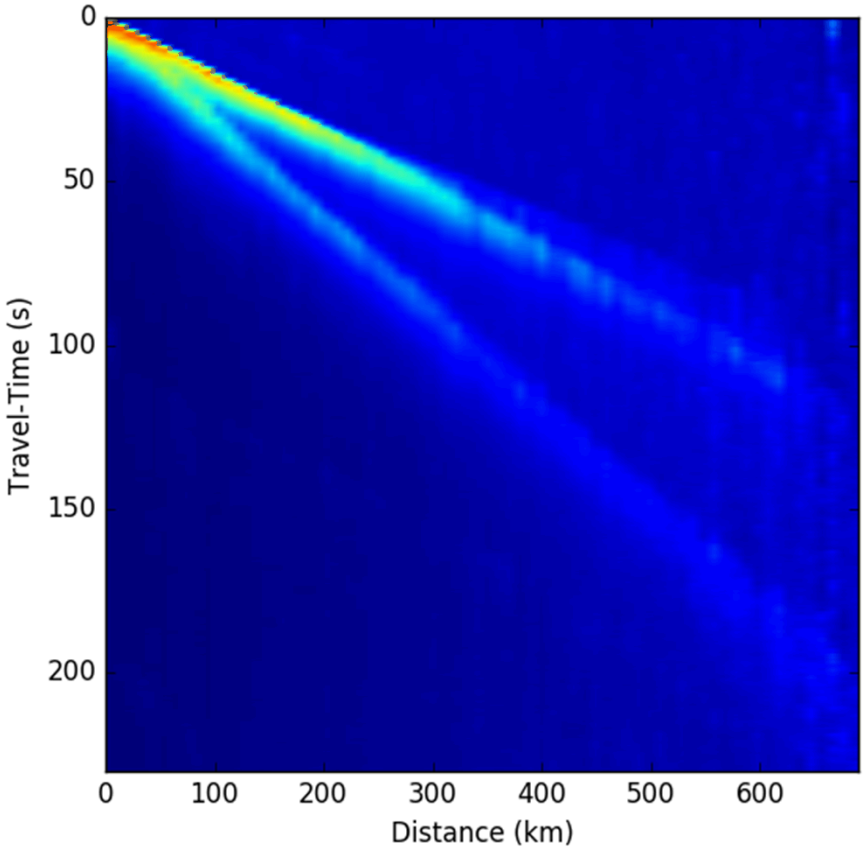




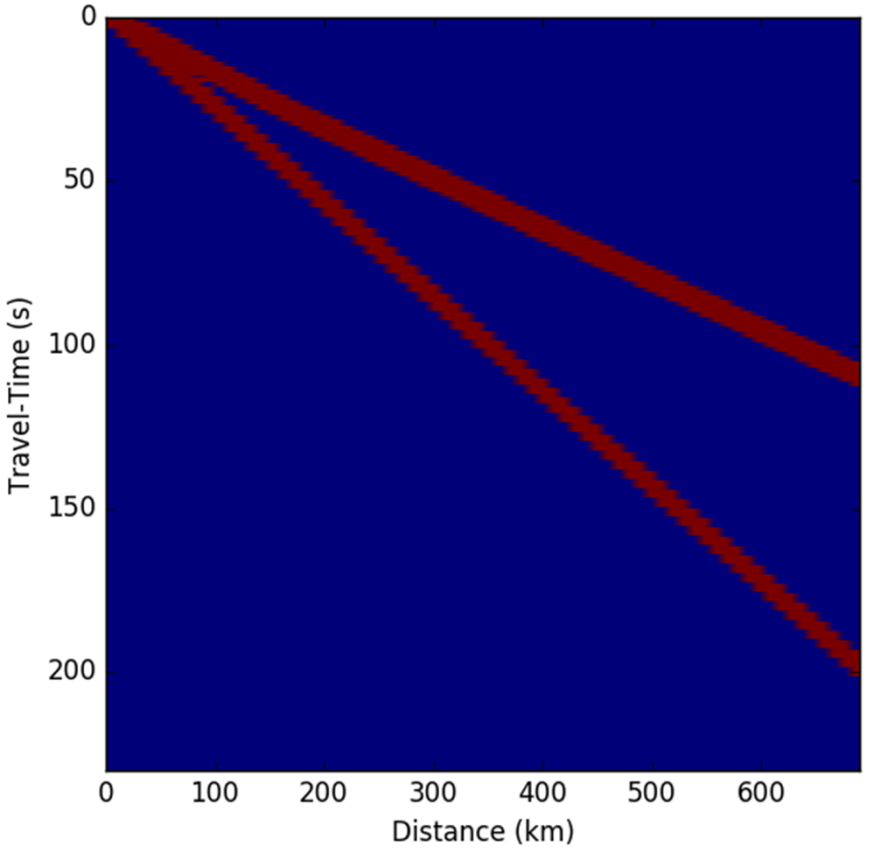


- Historical data, or synthetics, are used to generate a time-versus-distance STA/LTA stack
- Incoming data are 'correlated' against this stack

Time-versus distance stacks



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

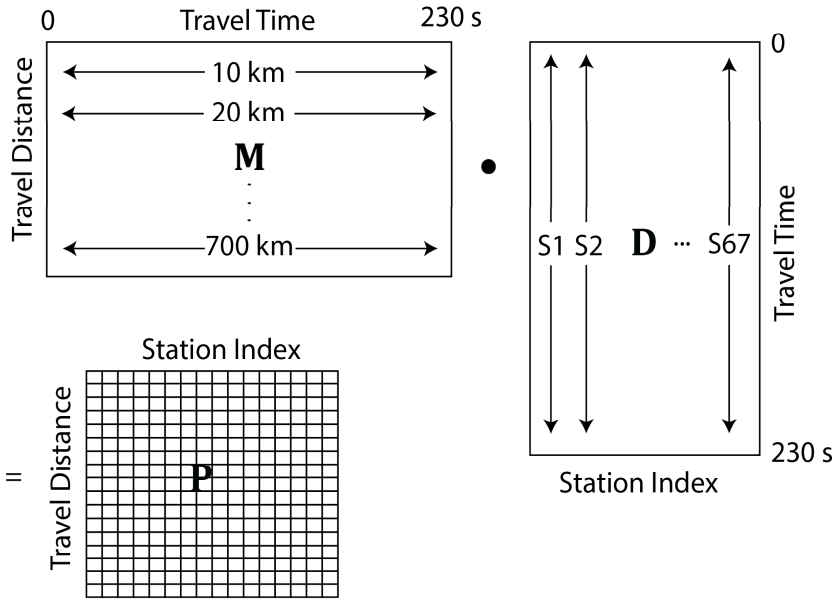


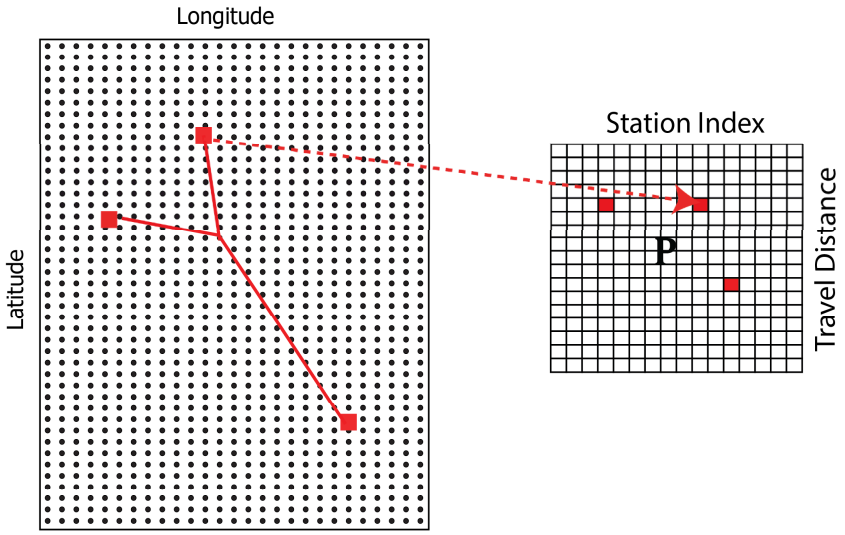
- Synthetic time-versus-distance stack, comprising Pg and Lg, with a regional velocity model and the Tau-P method used to estimate Pg, and a constant group velocity model of Lg = 3.5 km/s.

WCEDS Method

$$\mathbf{P}_w = \left(\mathbf{M} \cdot \mathbf{D}\right)^T$$

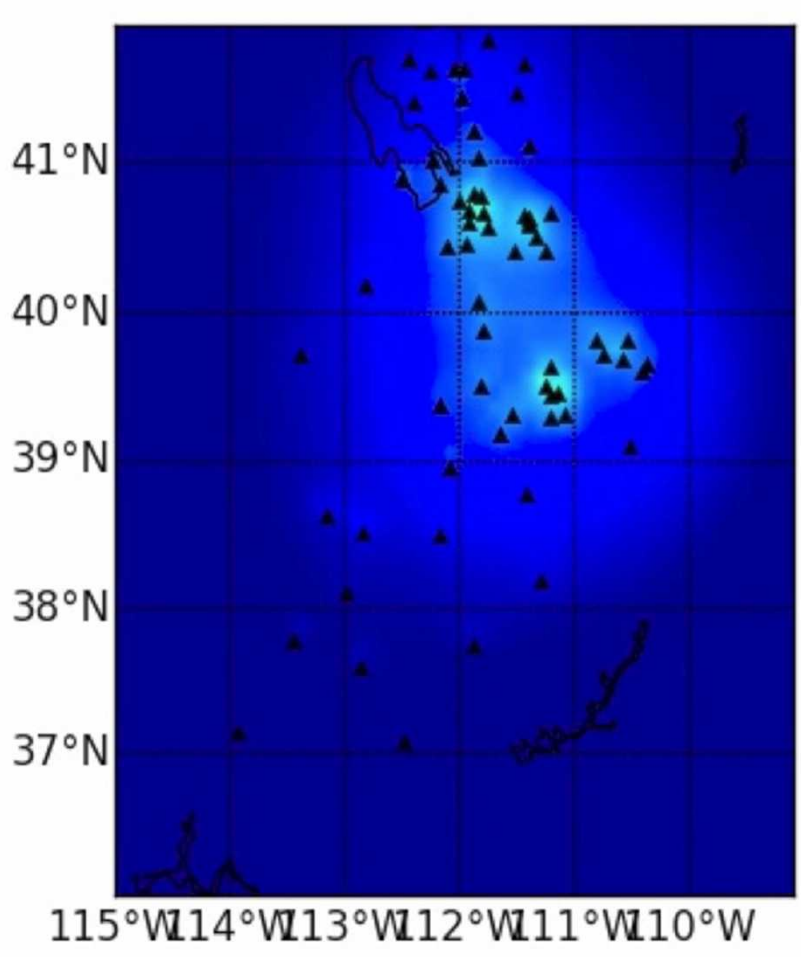
$$c = \frac{1}{N_S} \sum_{k=1}^{N_S} \left(\frac{p_{i_k j_k}}{N_T} \right)$$



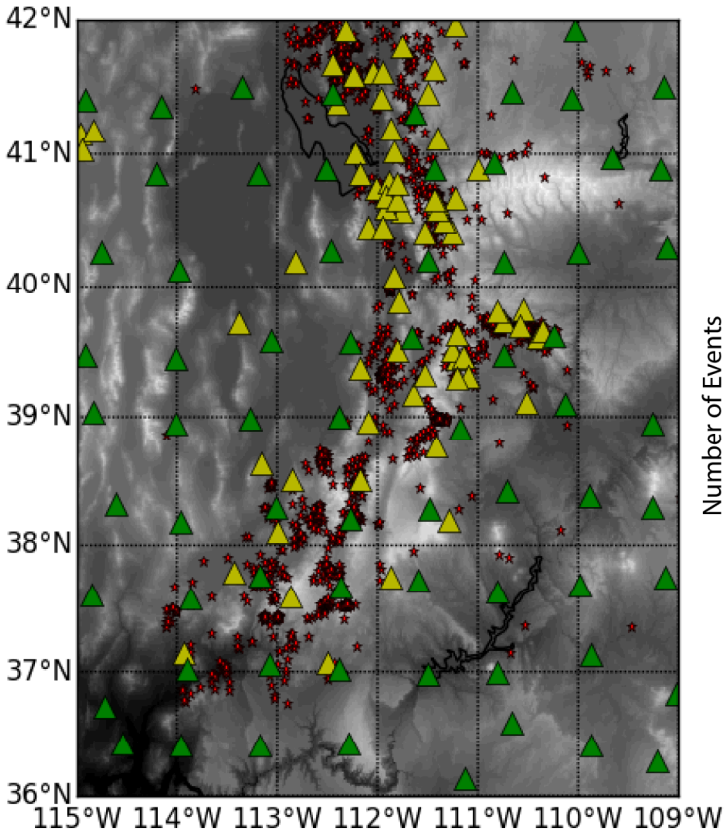


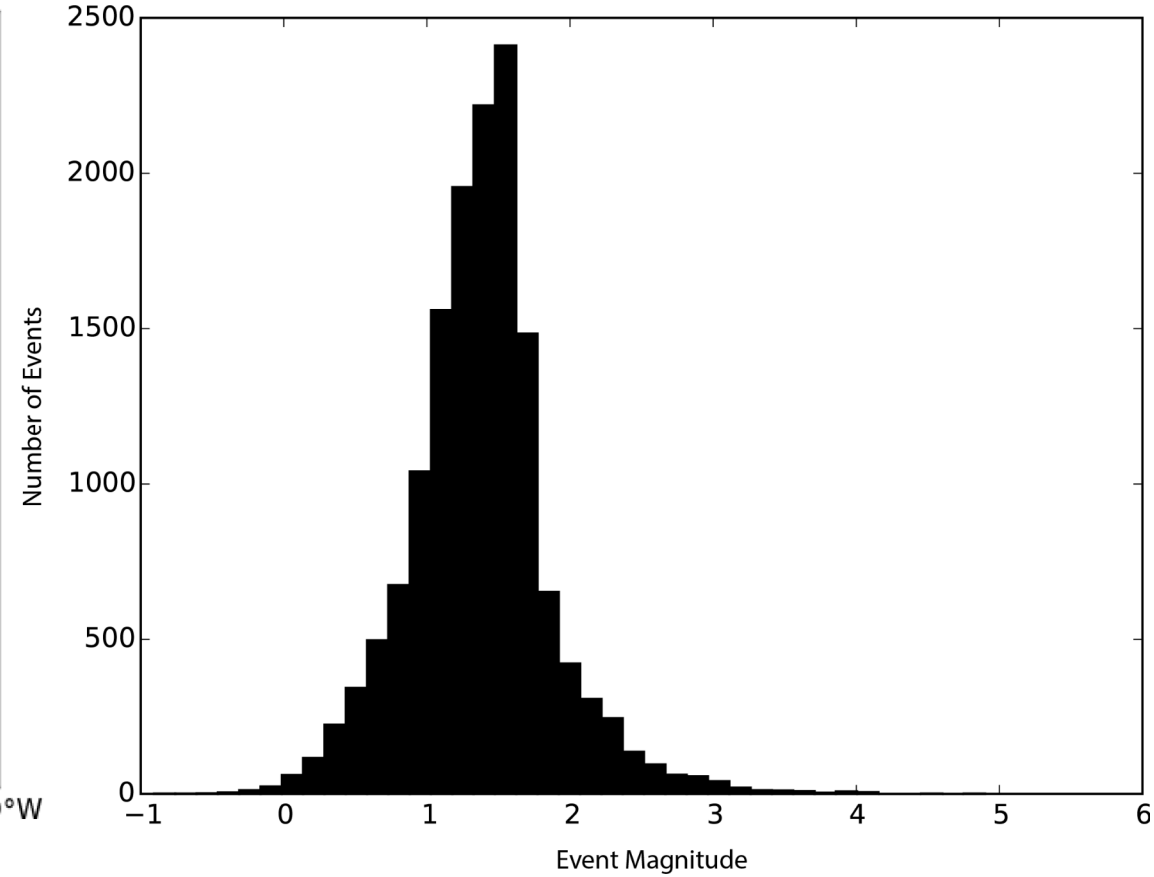
- Data are correlated over a set of nodes representing possible locations using an efficient dot product formulation

WCEDS Method



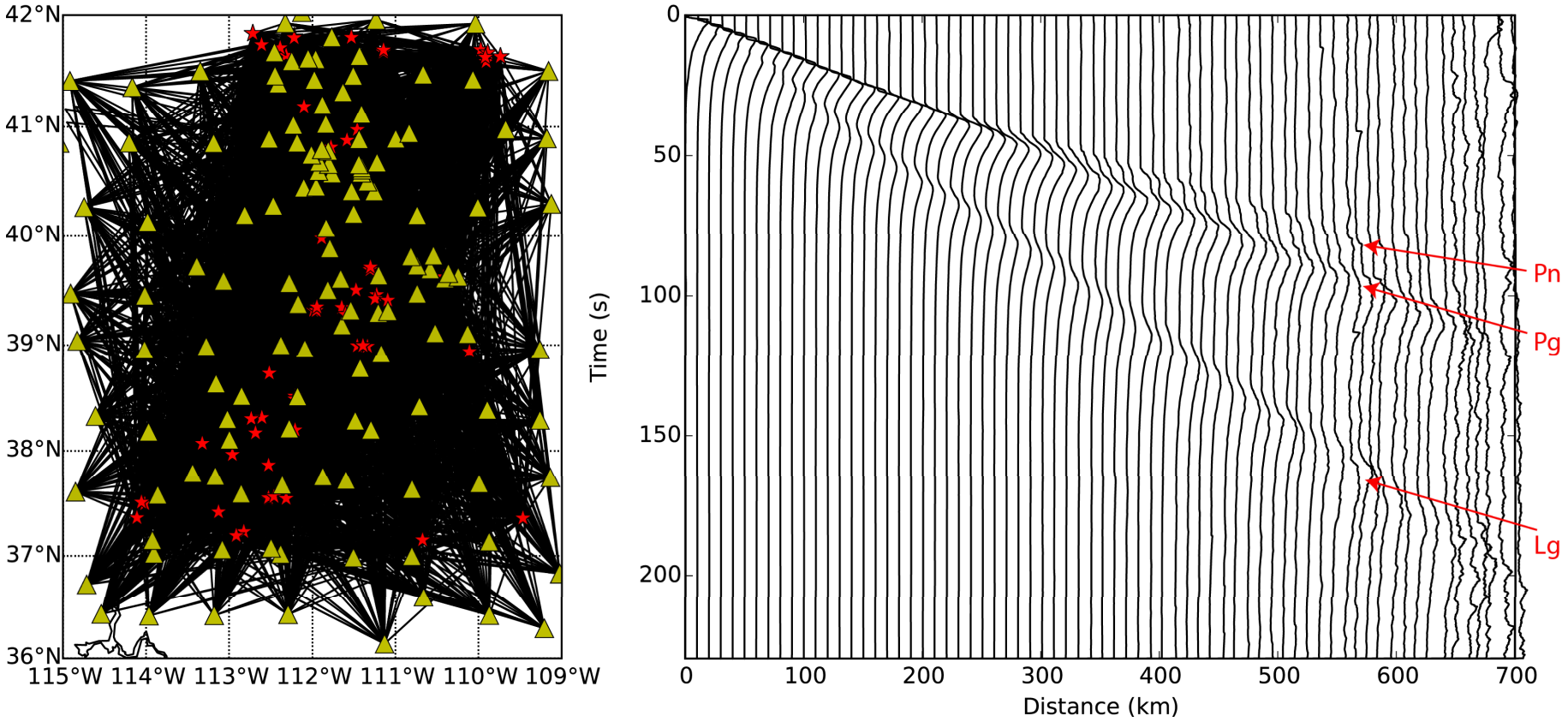
Dataset





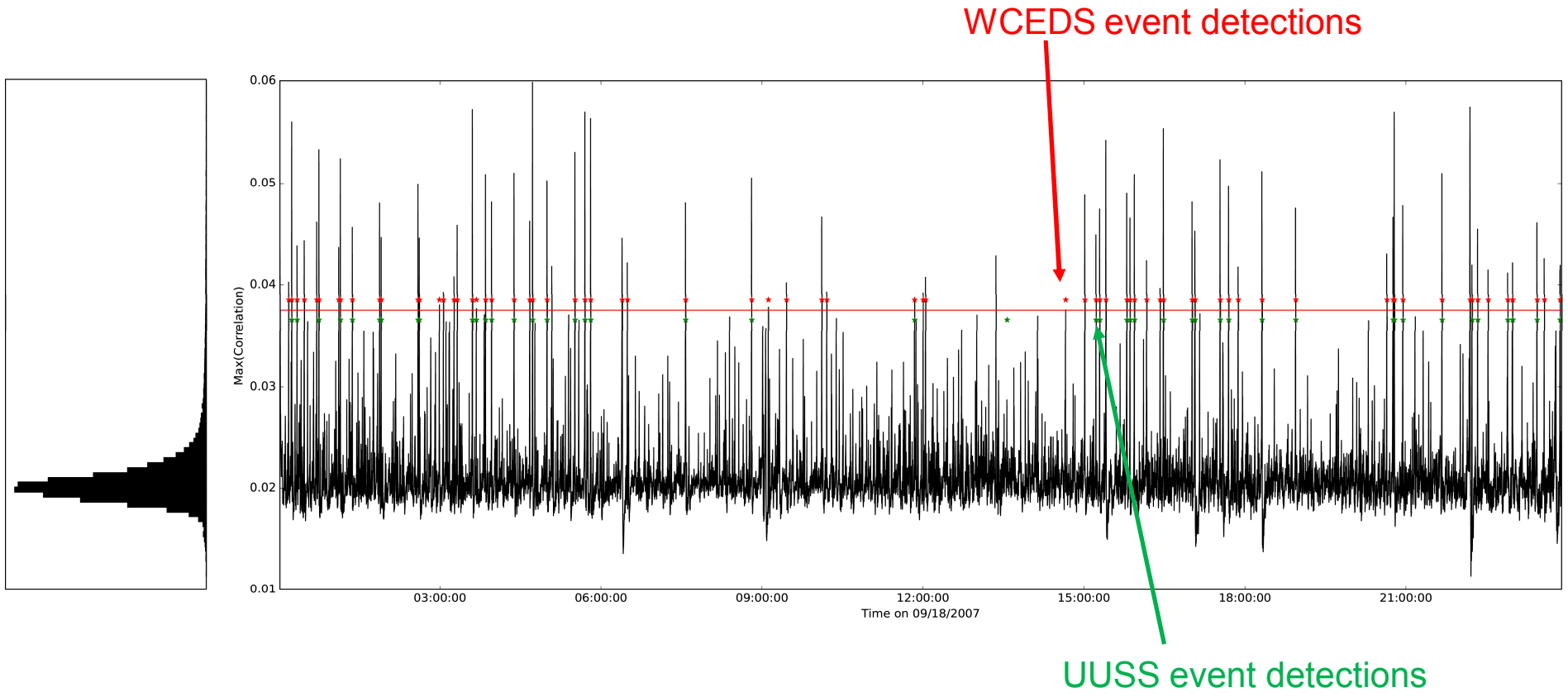
- Utah is chosen for testing WCEDS as it has a high density of stations, enabling experimentation with decimation, and a large number of low-magnitude events.

1D Time-vs-Distance Stack



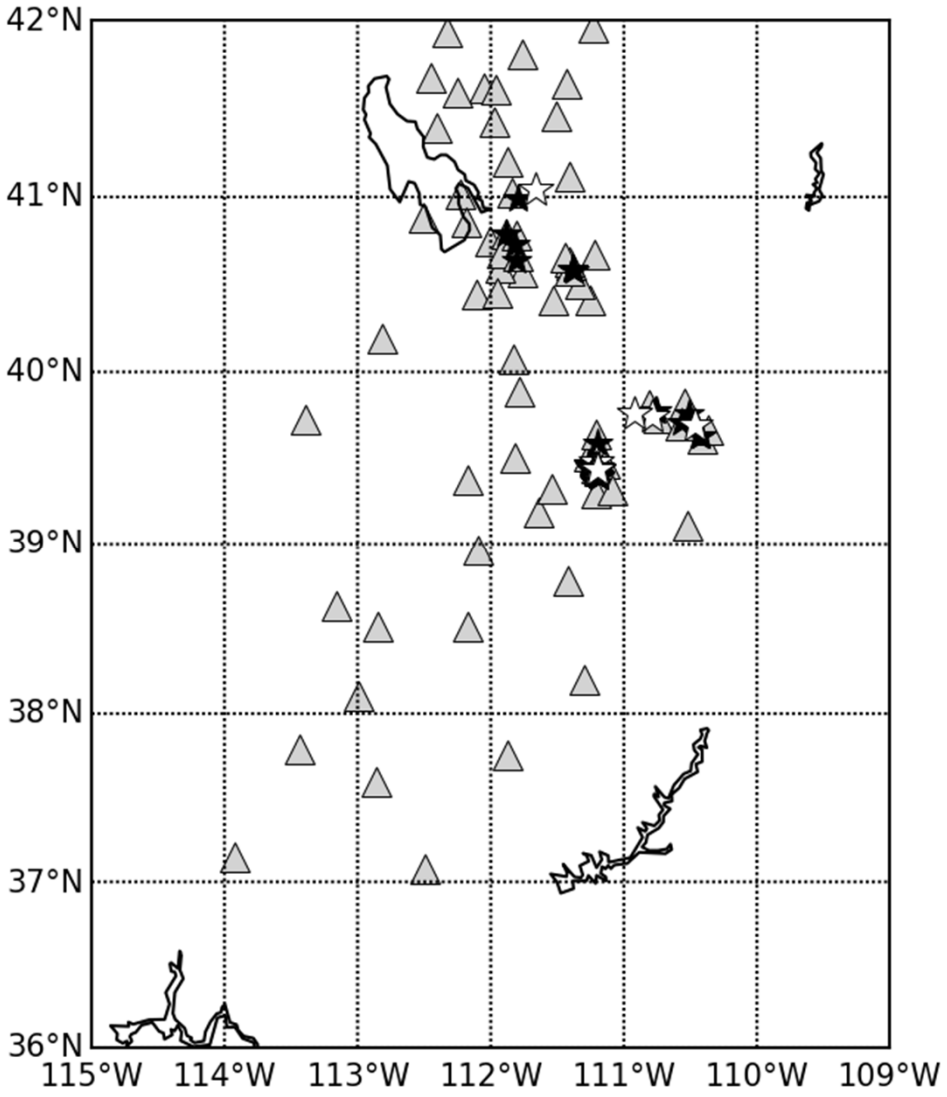
- A time-versus-distance stack is constructed using all 77 events larger than M=2.5 in a two year period → 8951 source-receiver paths

Results from 1-day of data with WCEDS



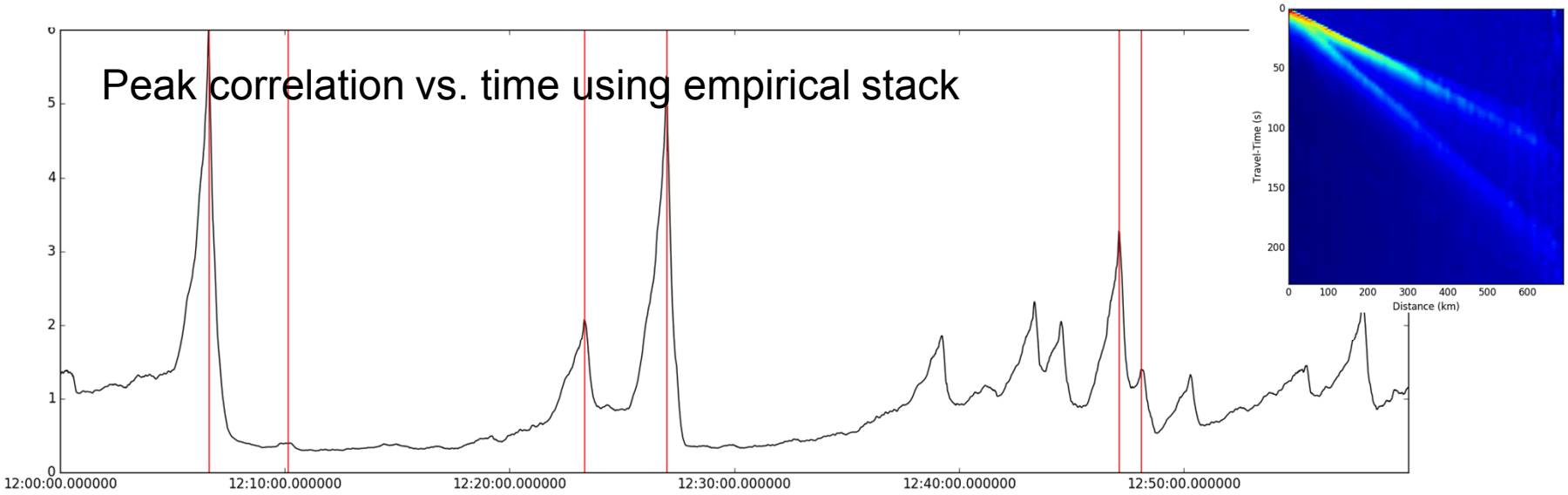
- In a 1-day period where UUSS report 47 events, WCEDS is tuned to detect 46 out of 47 events and detects an additional 26 analyst-confirmed events
- The new events are in a region of induced seismicity where UUSS use a high threshold

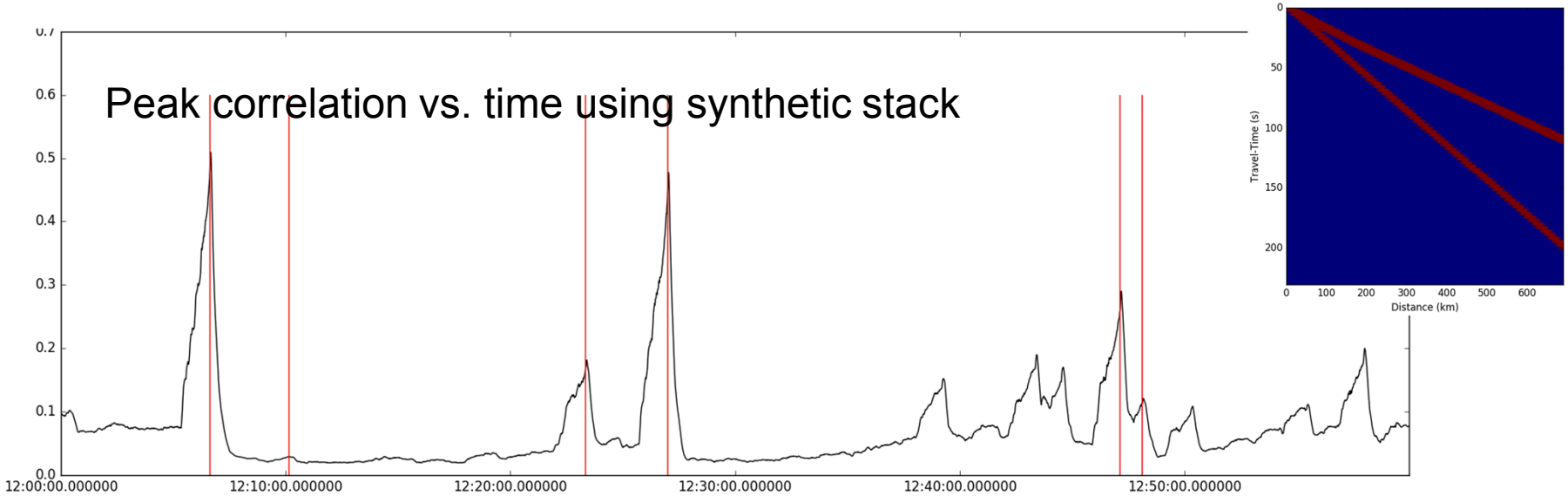
Event Locations



- Locations of events detected by WCEDS (black stars) and UUSS events (white stars)

Comparing empirical and synthetic results





Conclusions

- We have enhanced the WCEDS algorithm for event detection, finding that it is a viable alternative to the standard pick-based method implemented by UUSS for Utah.
- WCEDS(E) does not require an Earth model or a signal model, but assumes access to historical data and that a 1D time-versus-distance stack is adequate
- WCEDS(S) does not require historical data but does require an Earth model
- We are beginning to explore comparisons between WCEDS(E), WCEDS(S), and standard pick-based methods on an earthquake sequence in SW Utah.