Using Waveform Correlation to Process Aftershock Sequences: Improving Monitoring Efficiency

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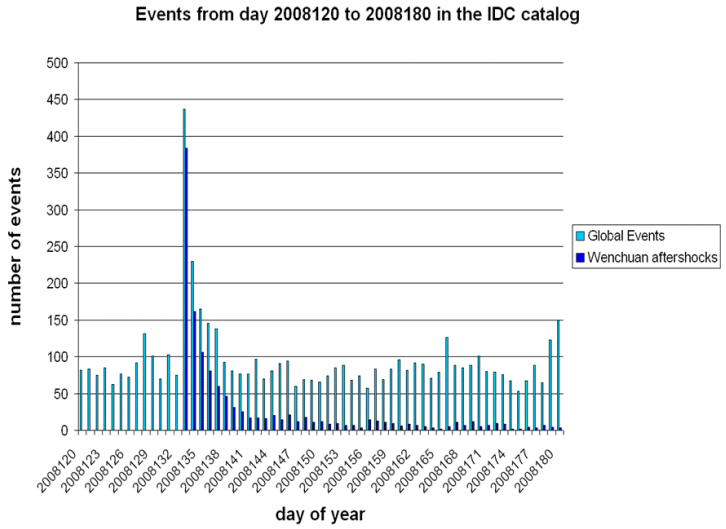
National Nuclear Security Administration

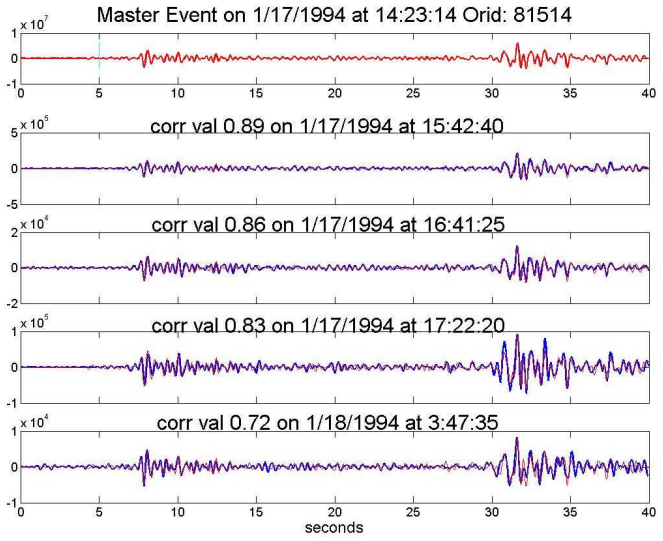
Ground-based Nuclear Explosion Monitoring R&D

Waveform correlation research seeks to use the high degree of waveform similarity expected in earthquake and mining swarms to make the monitoring system more efficient.

- Monitoring data from the global seismic network for possible nuclear explosions implies detecting and screening **several hundred events per day**



- Waveform similarity implies waveforms are from the *same source and location (λ/2)* to a high degree of certainty. **"If it looks the same, it is the same"**



Four events in the next week correlated well with the first event.

All were later localized to 34.3 lat, -118.4 lon

- Earthquake swarms and mining activities often contain many events in the **same location**
- Using waveform correlation to **separate** out and track earthquake and mining events allows the analyst to focus on possible nuclear explosions

WC Objectives and the WC Detector

Ground-based Nuclear Explosion Monitoring R&D

Objectives

Develop and implement correlation-based methods to aid and improve analyst sorting routines:

- **Faster** Processing
- Reduction of **detection threshold**
- More **accurate** phase picks (leads to more accurate localization)
- Better use of **analyst resources**

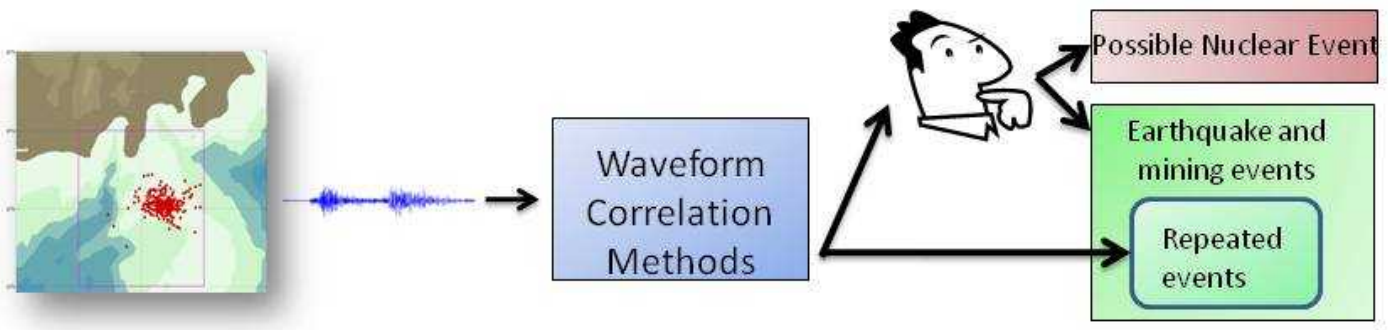
WC Detector Results

Implemented a Waveform Correlation Detector

- Prototype simulates being inserted before the analyst in the monitoring pipeline; identifies recognized events.

Evaluated effectiveness on diverse datasets

- **Reduced analyst load up to 24% - 92%** (false match rate of 1/yr)
- **Found hundreds of new events** not in the catalog (lowering detection threshold).



Results for typical sequences

Event	Station	Station distance	# of catalog events seen at station	% catalog events belonging to a family (Reduction in workload)	# of new events identified
Northridge (M_w 6.7)	PAS	27km	412	**92%**	**942**
Wenchuan (M_w 7.9)	CD2	39km	262 (data dropouts)	**39%** (data dropout issues)	**300**
Pakistan (M_w 7.6)	NIL	99km	440	**78%**	**740**
Northridge (M_w 6.7)	MHD	348km	352	**59%**	**208**
Wenchuan (M_w 7.9)	XAN	621km	752	**29%**	**218**
Pakistan (M_w 7.6)	AAK	907km	360	**24%**	**10**

Future work

- Journal article very close to being submitted for publication
- Optimizing selection of thresholds, window size, filter bands, station selection, and search region. Goal is for the system to automatically recognize that a swarm has started, and determine the best parameters for processing.
- Improve JAVA version of code
- Integrate results from multiple stations
- Develop prototype operational system (integrate WC into traditional processing flow)