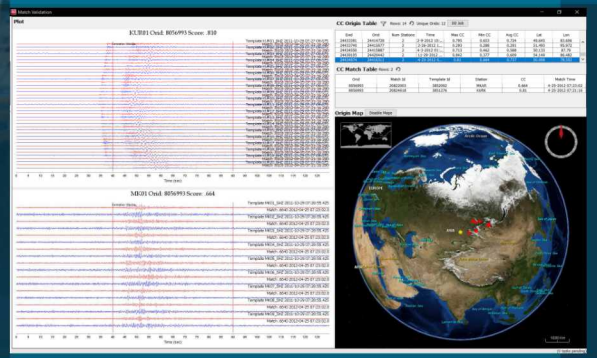
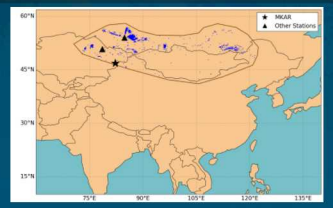
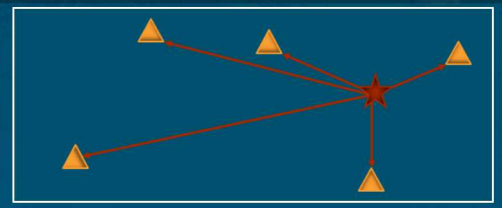
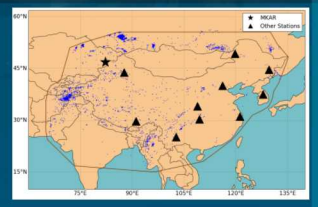
SAND2019-1602PE

Waveform Correlation:
Two broad area studies in Asia in collaboration with Columbia University









PRESENTED BY

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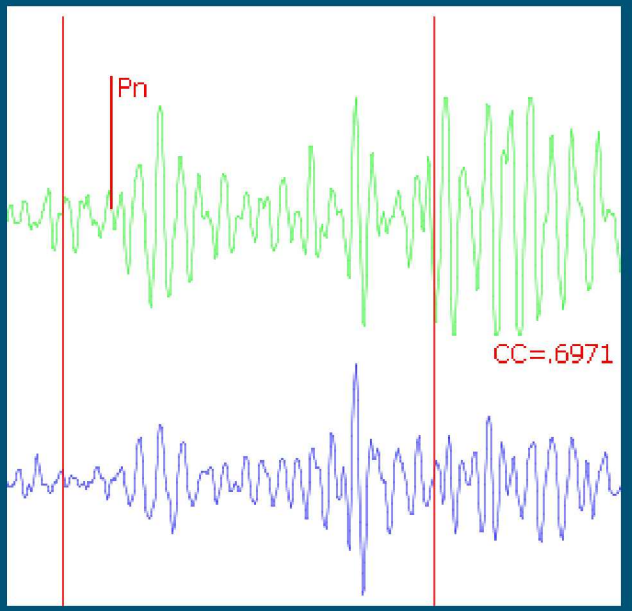
Introduction to Asia Studies

Waveform correlation premise: Use empirical waveform templates to detect repeating seismicity

- Research has demonstrated excellent results for aftershocks and mining activity over small geographic areas
- Investigate application in broad area studies
- Collaboration with Paul Richards and David Schaff of Lamont-Doherty Earth Observatory, Columbia University

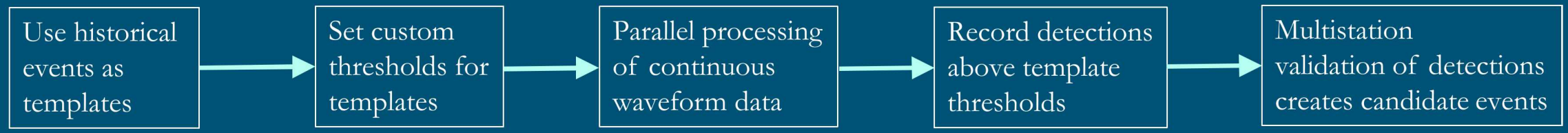


Goal: Produce newly-detected real and well-located events.

- Sandia brings high performance computing for parallel processing of waveforms and non-proliferation and nuclear treaty monitoring.
- Columbia brings expertise with precision relocation using double-difference algorithm.

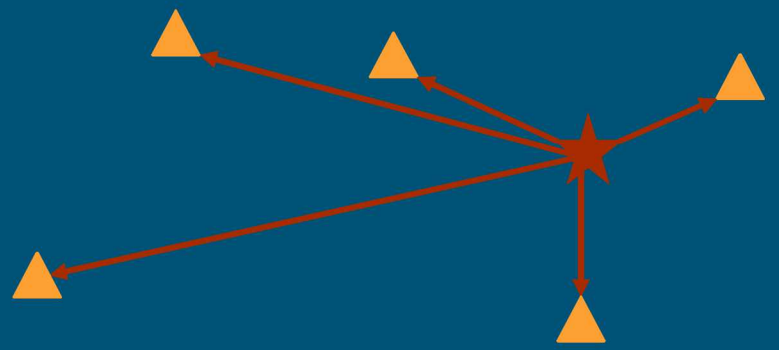
Waveform Correlation Approach

Our basic approach to waveform correlation:



Study design

- Geographical size of study area (e.g., local, global)
- Topology of network (e.g., choice of stations)
- Duration of template archive
- and so on… many choices



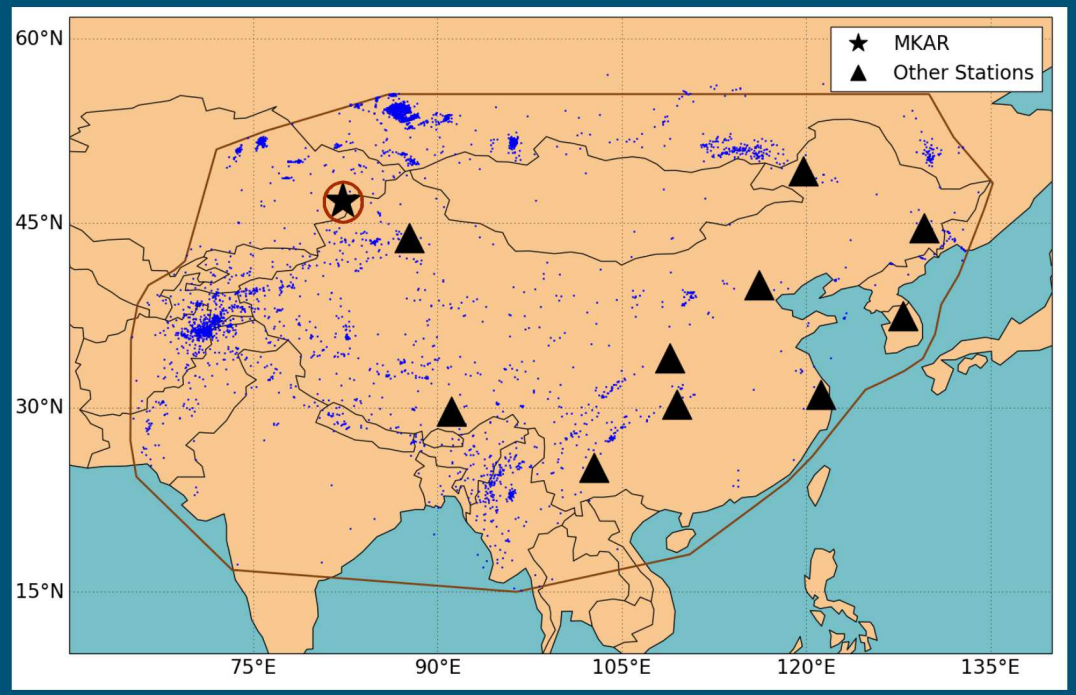
There are two main controls beyond the basic study decisions

- Template cross-correlation thresholds
- Selection of template waveforms

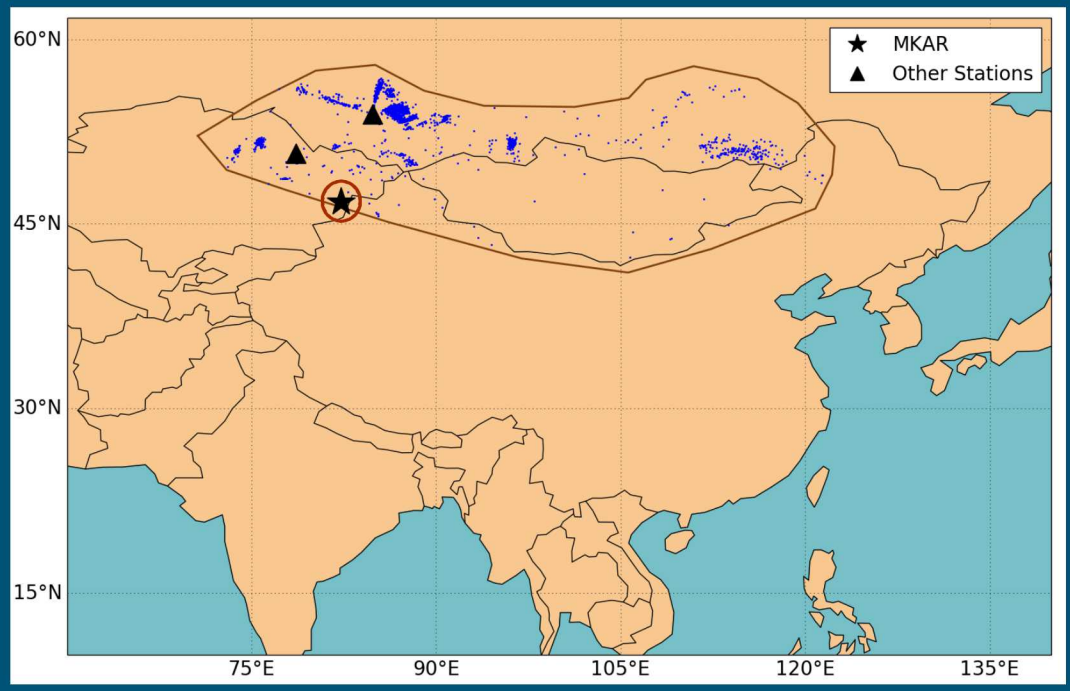
Makanchi Array (MKAR) in two Asia studies

Stations and 2012 LEB Events

Eastern Asia centered on China



Mongolia and surrounding area



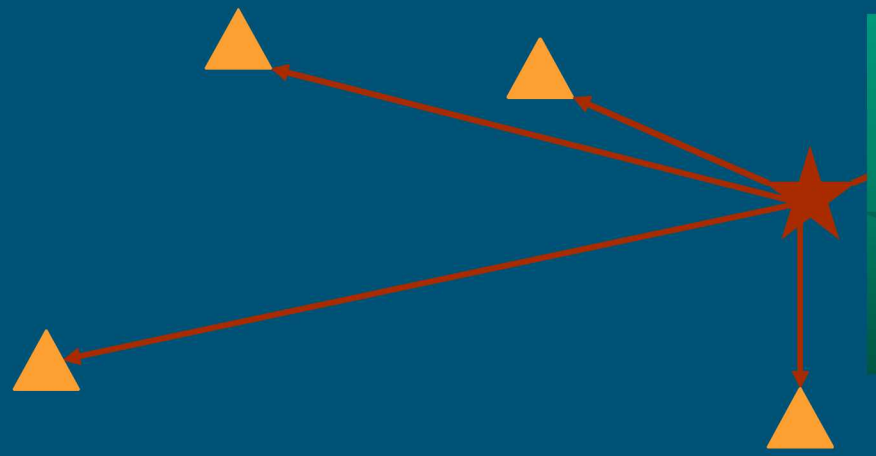
Many single station detections in this study were not validated by multiple stations.

We are experimenting with a network-based approach to template winnowing for this study.

Network-Based Template Winnowing

Network-based template selection approach for a sparse network:

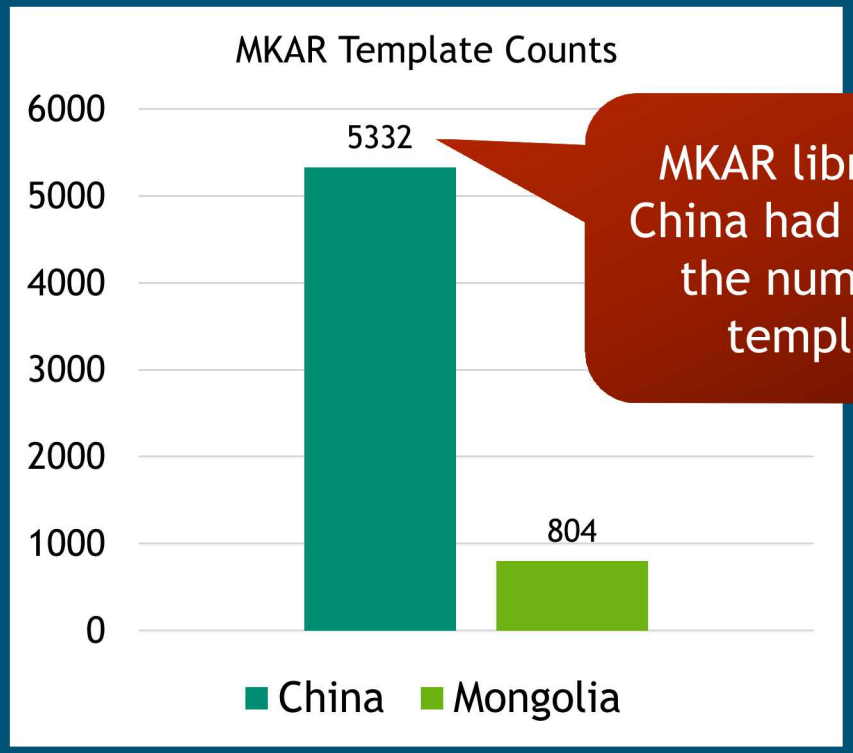
Choose templates from events that were detected by multiple stations in the network, not simply from arrivals seen at a single station

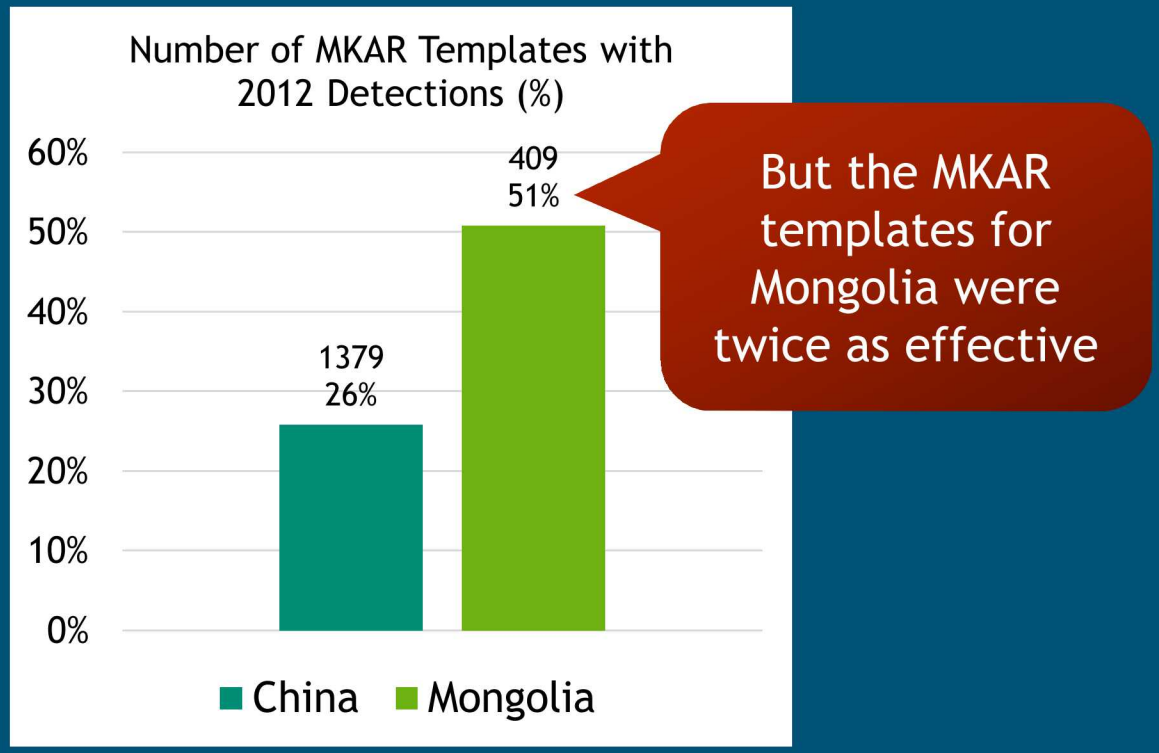


Example: Arrivals are seen by multiple stations in the network for this event. Make candidate waveform templates from these arrivals.

For a sparse network, this may limit templates to waveforms from larger events recorded at large distances, but waveform correlation can lower a detection threshold by one magnitude unit.

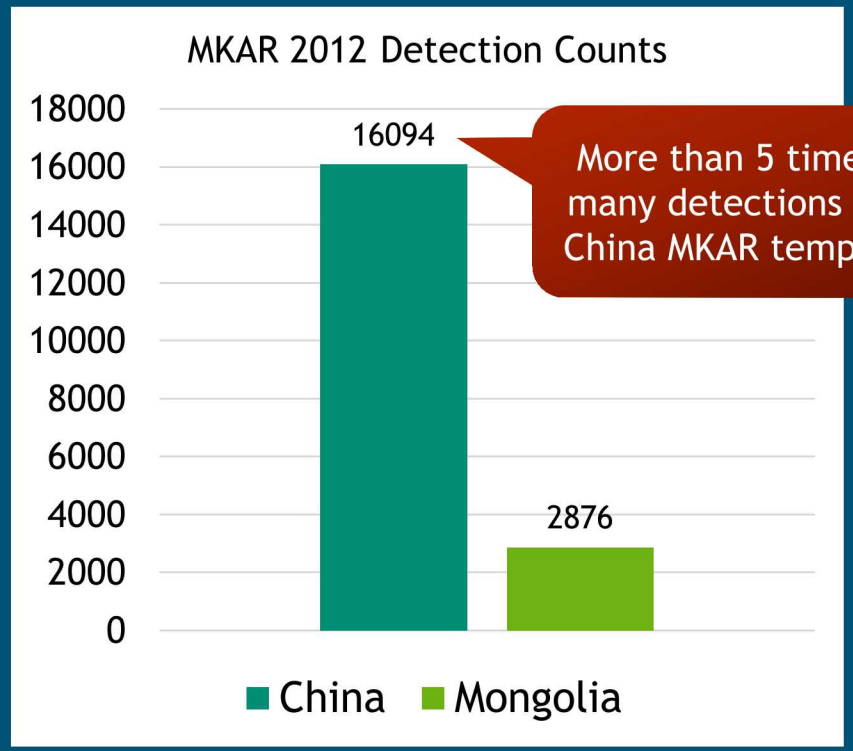
MKAR template library comparison for the two Asia studies





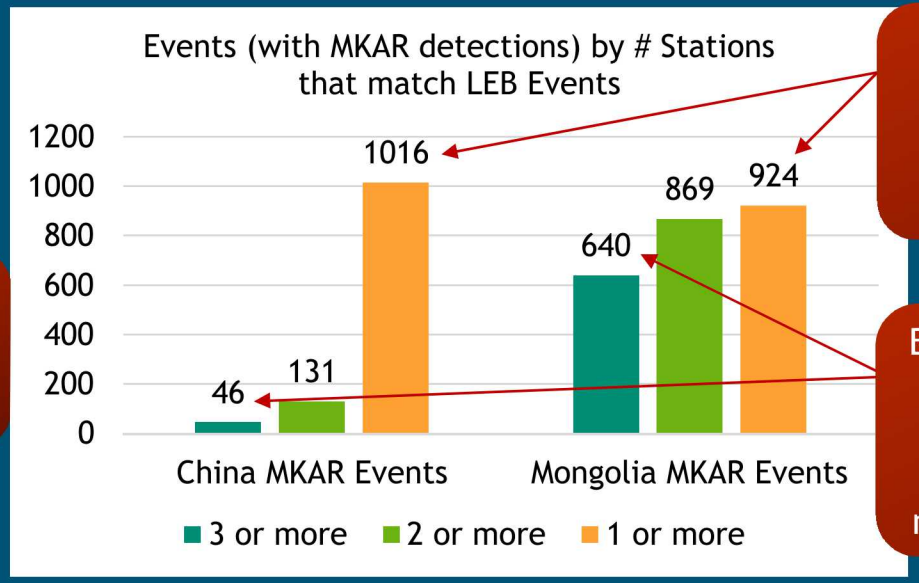
Template quality is crucial.

MKAR Detection Comparison with LEB for the two Asia studies



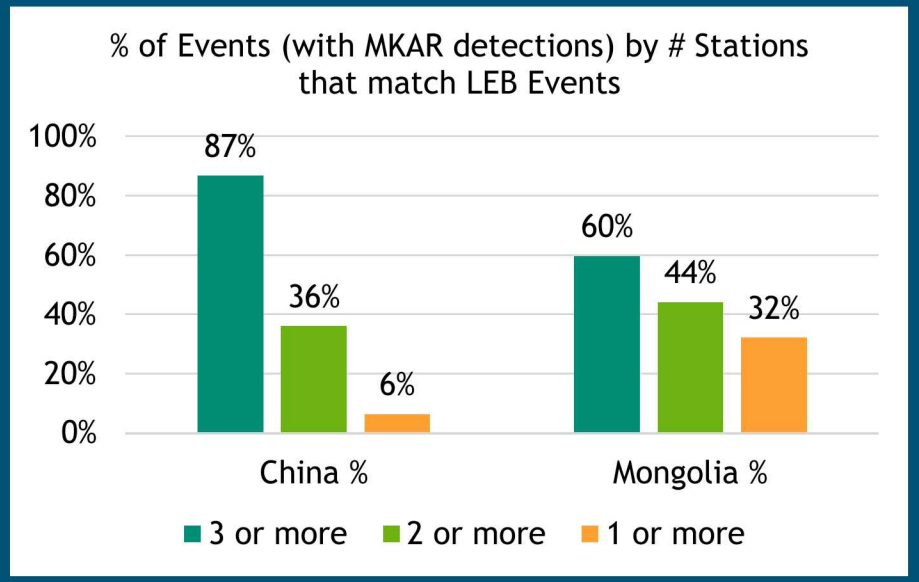
More than 5 times as many detections from China MKAR templates

More detections does not guarantee correct or useful event formation.

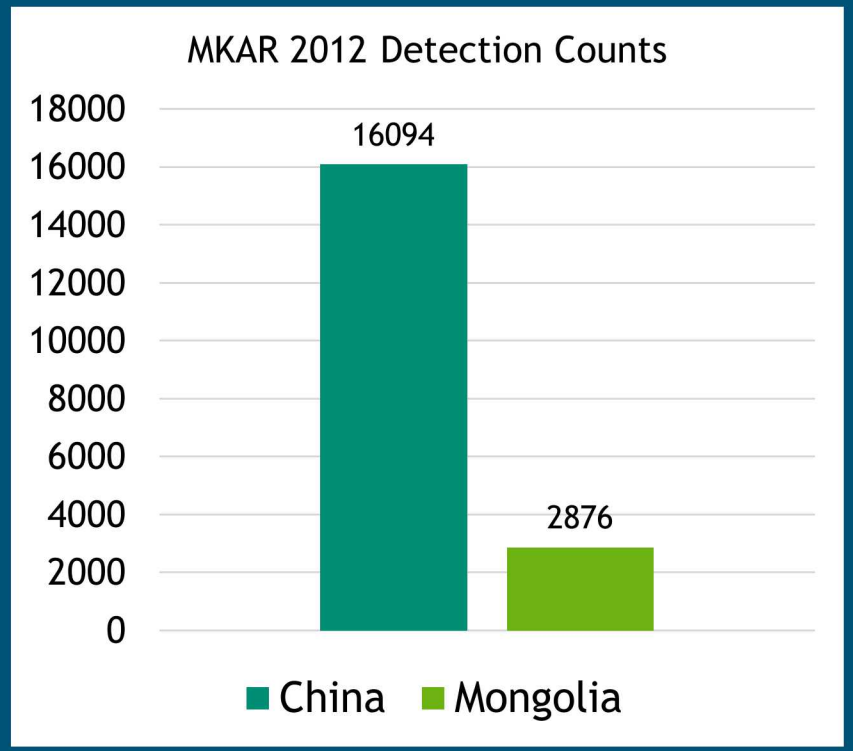


Correlation events with MKAR detections matched LEB events in both studies; MKAR performed well alone.

But there were almost 14 times more 3 station events with Mongolia MKAR templates; network performed well.



MKAR Detection Comparison with LEB for the two Asia studies



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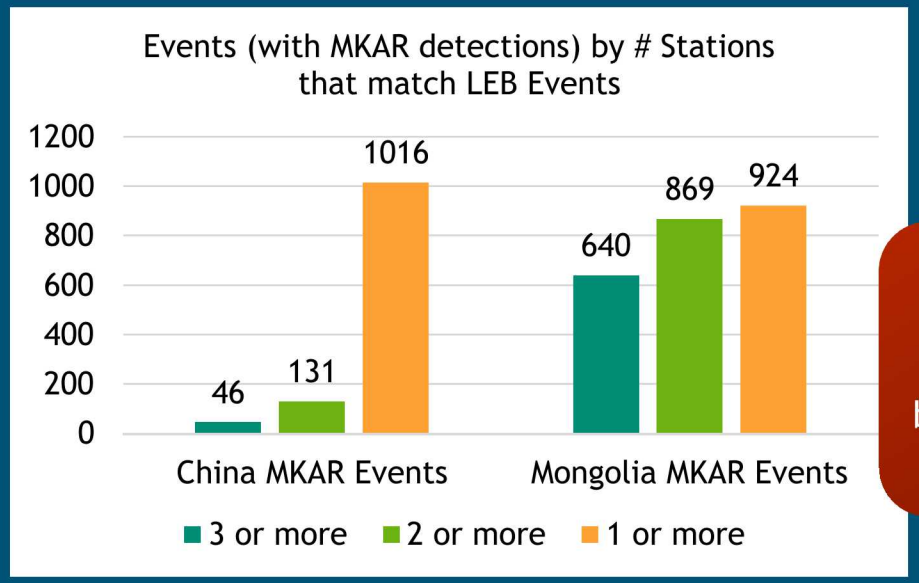
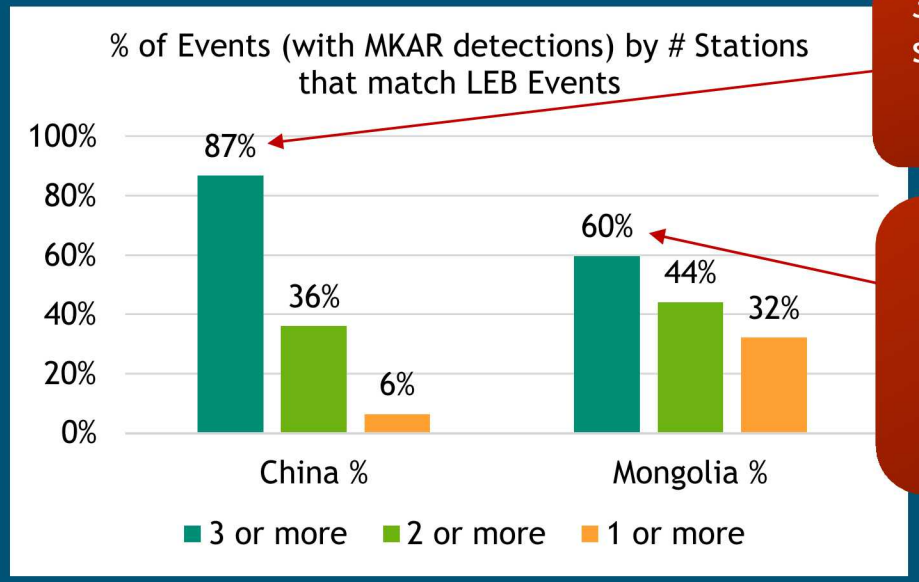


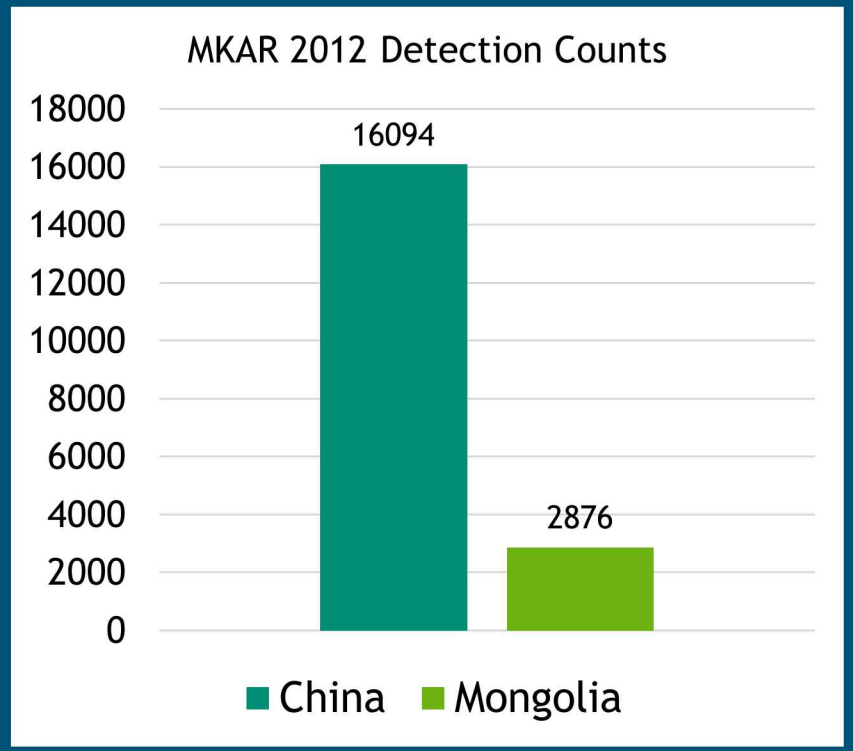
We want a balance of matches to catalog events for validation, but also new events from waveform correlation.



3 station events in China study matched LEB well, but few additional 3 station events created.

60% of 3 station events in Mongolia matched LEB, so 40% are new events that we have confidence in.

MKAR Detection Comparison with LEB for the two Asia studies



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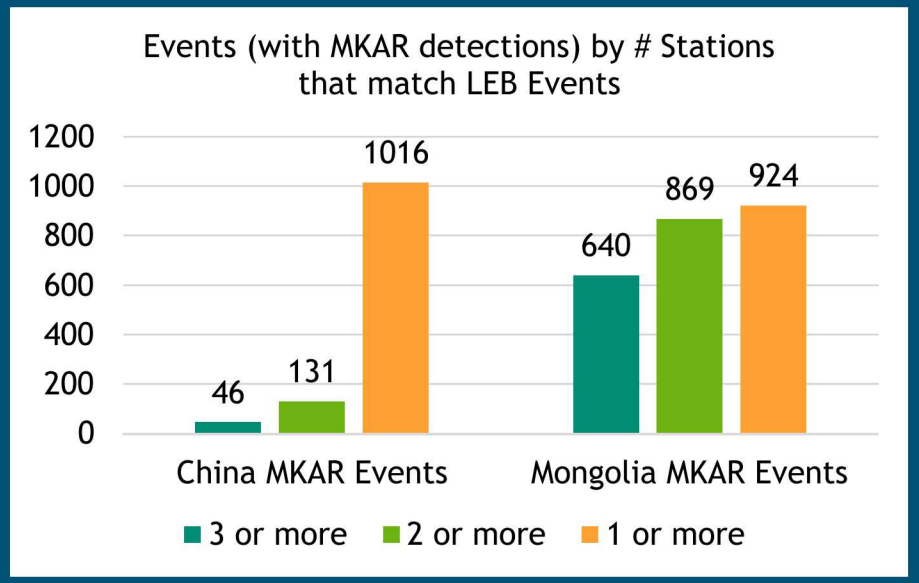

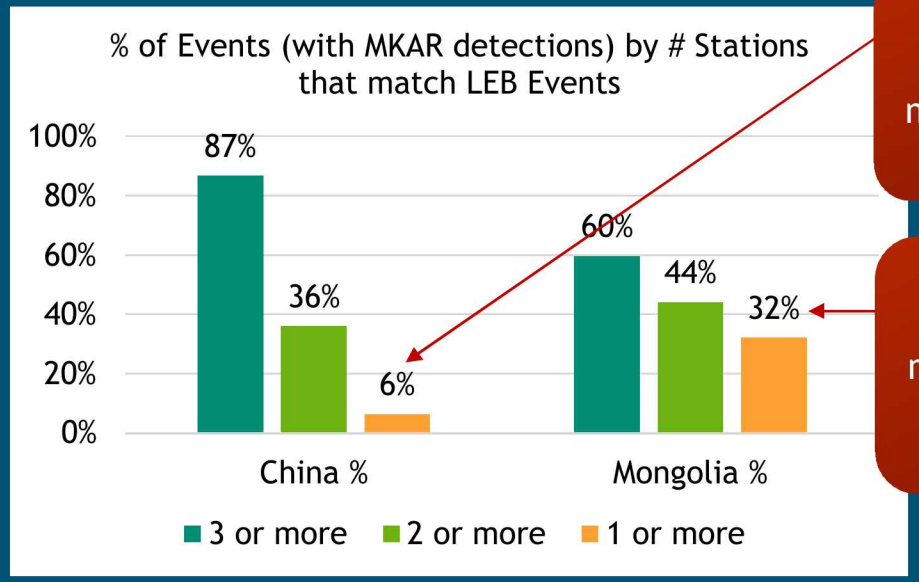

Only 6% of MKAR single station events in China matched LEB events – are these good detections?

With >30% matches to LEB events, we have more confidence in MKAR single station events in Mongolia.

Summary

The Eastern Asia study is complete.

- Substantial processing time.
  - 12 stations (3 arrays, 9 3-C) for 1 year required > 600 hours correlation time on computing cluster
- Many single station detections were not validated by other stations.

The Mongolia study is on-going.

- Fewer templates reduced processing time
  - 4 arrays for 5 years required less than 200 hours correlation time

A network-based winnowing of candidate arrivals will:

- Retain high-quality template waveforms for network-detected historical events
- Reduce the number of template waveforms and corresponding processing time
- Produce detections that associate to multi-station events

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