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Infrasound Overview

Stephen Arrowsmith, Rod Whitaker

July 17, 2014

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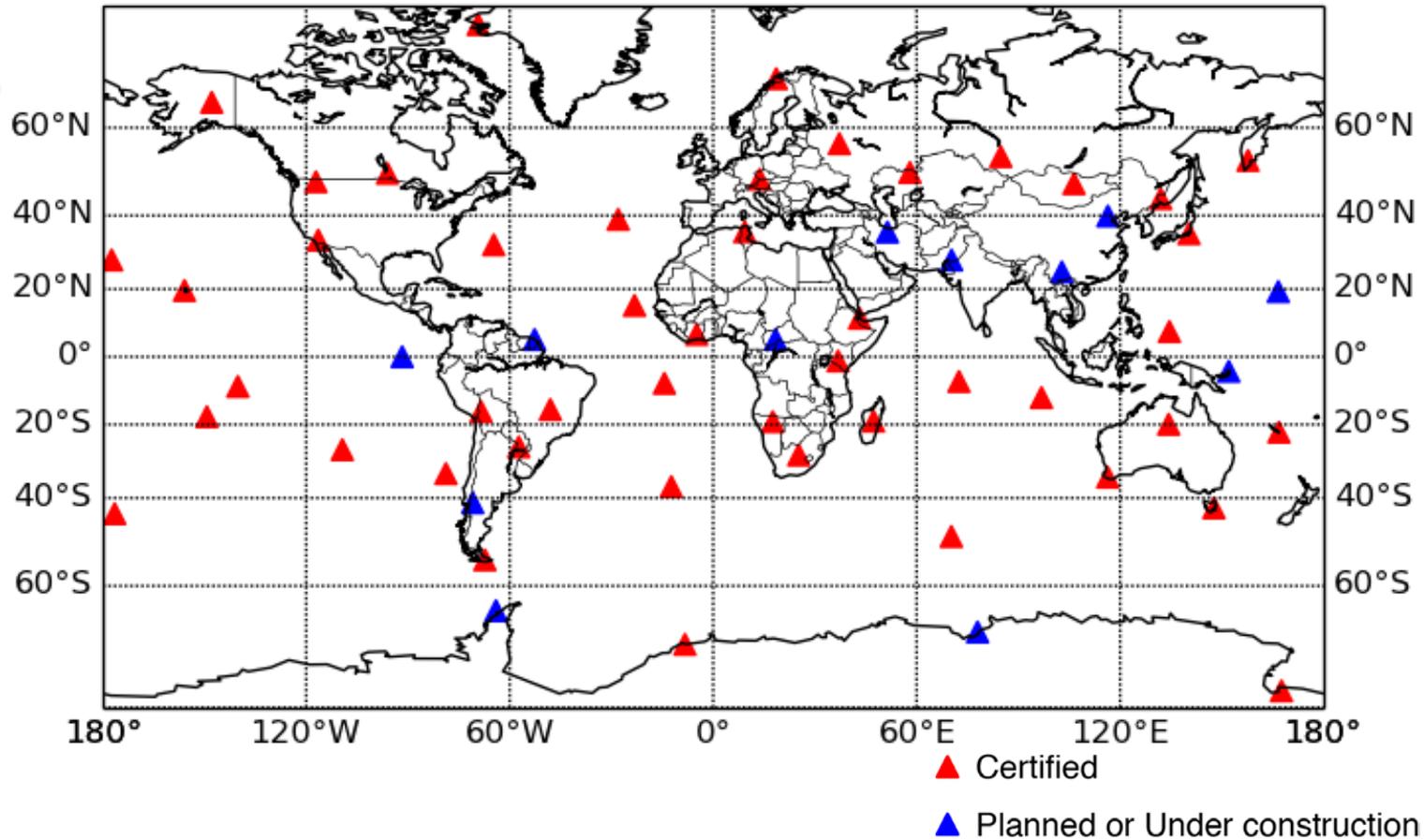


Overview

- Existing capability with ground-based sensors
- Modeling solid earth/atmosphere coupling

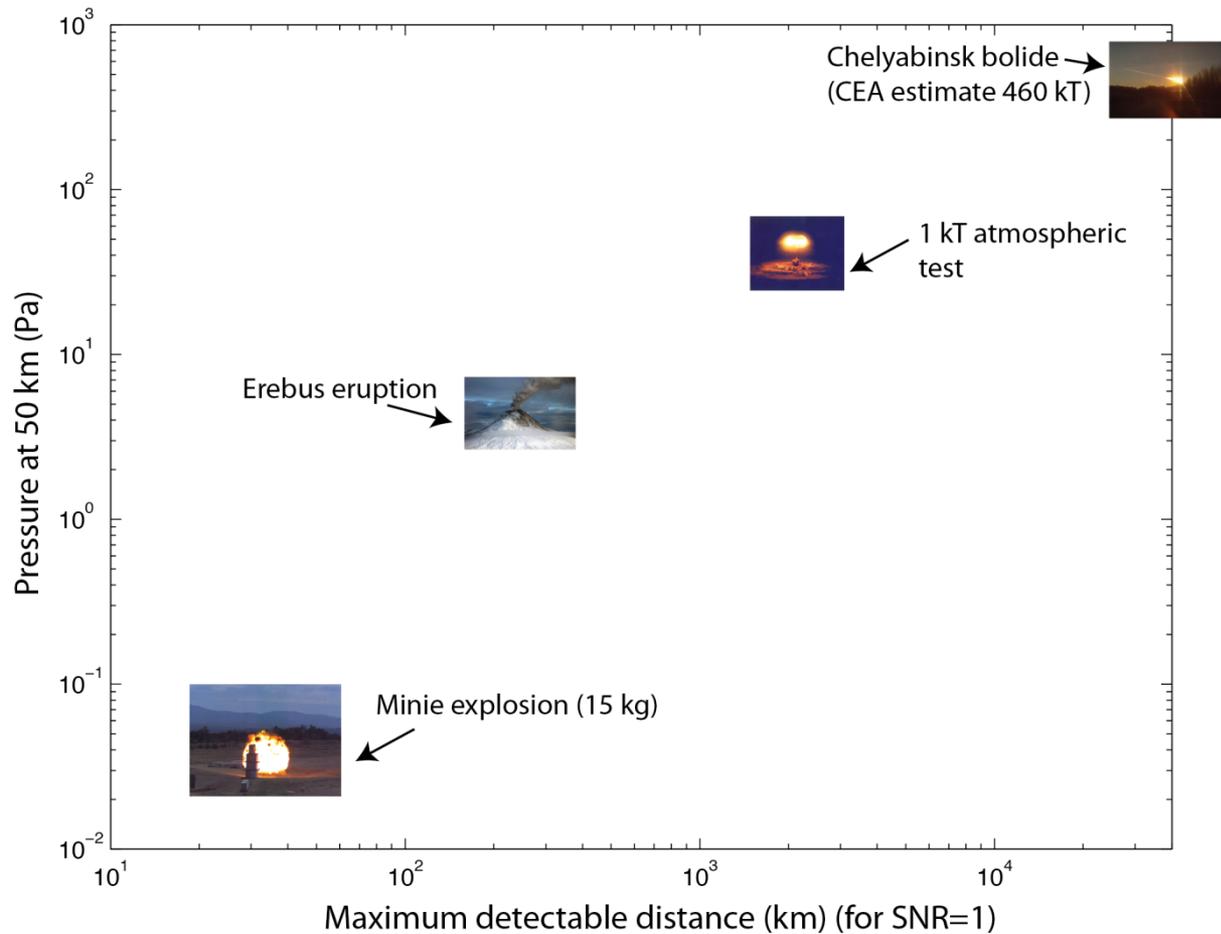
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Infrasound: Global IMS Network



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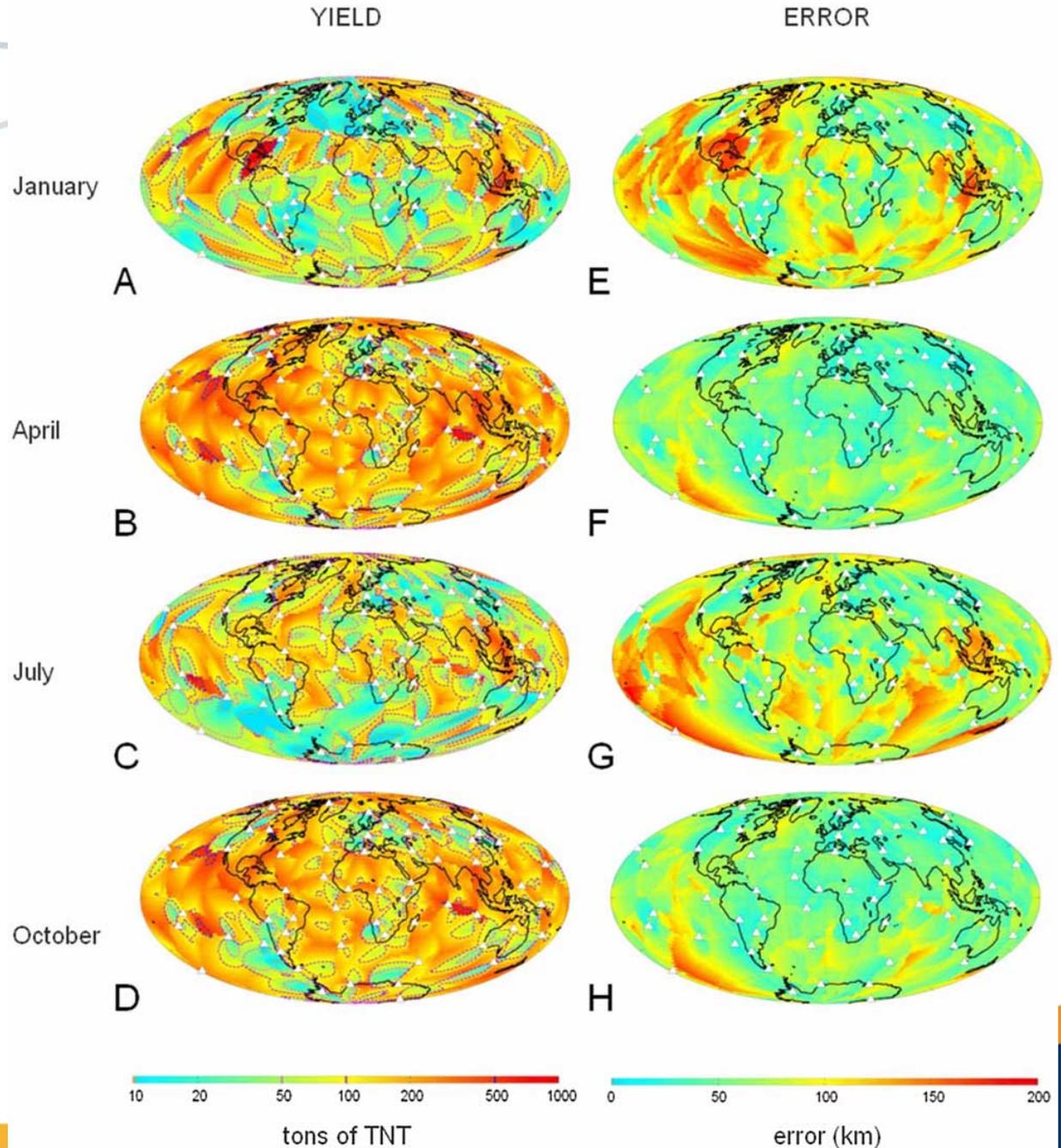
Infrasound: Source Scales



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Network performance: IMS Network

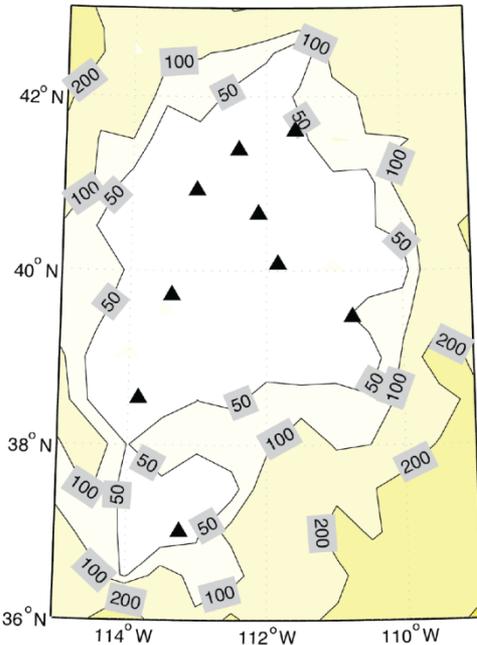
- Estimates of detection and location capability for above-ground tests using the IMS infrasound network.
- Yield precision is best during winter and summer, location precision is best at the equinox periods



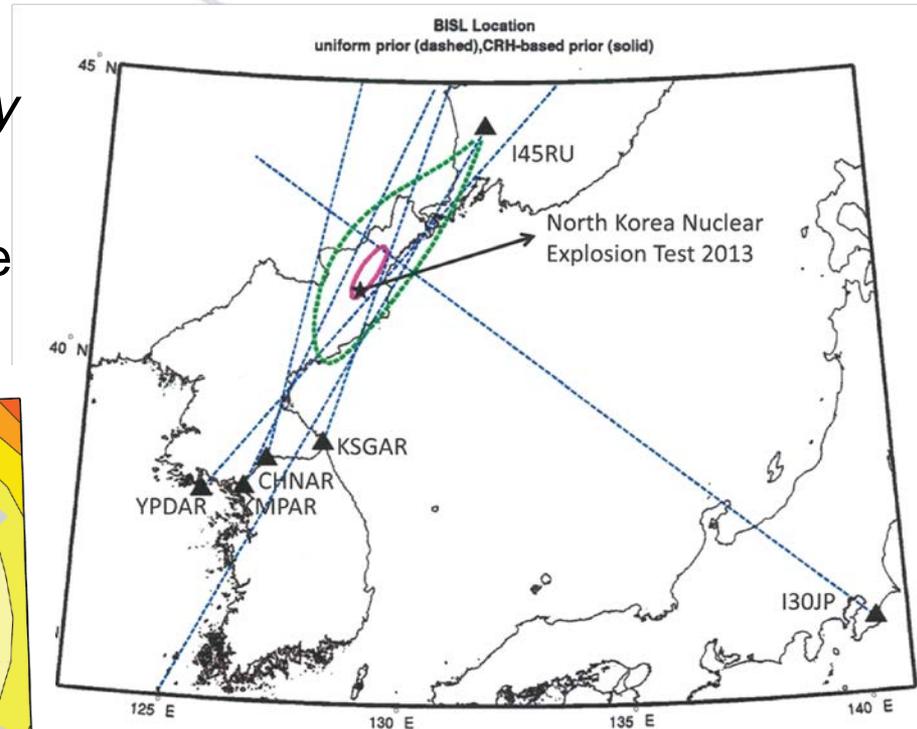
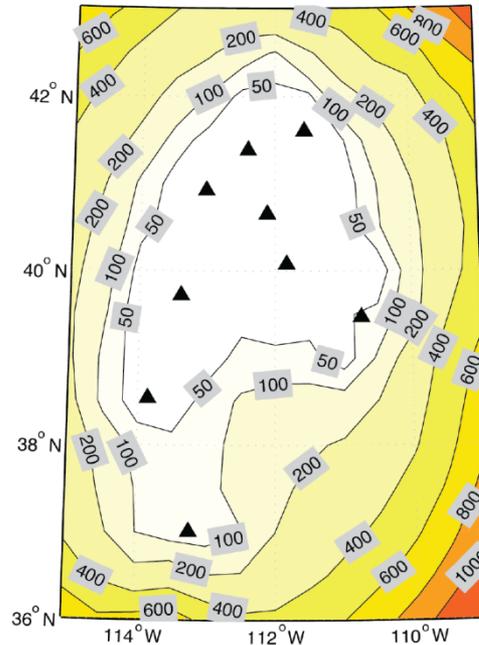
Network performance: Regional Location

- Can be quantified by both *accuracy* and *precision*.
- For any real or notional network we can simulate these parameters.

Backazimuths and Arrival Times



Backazimuths Only



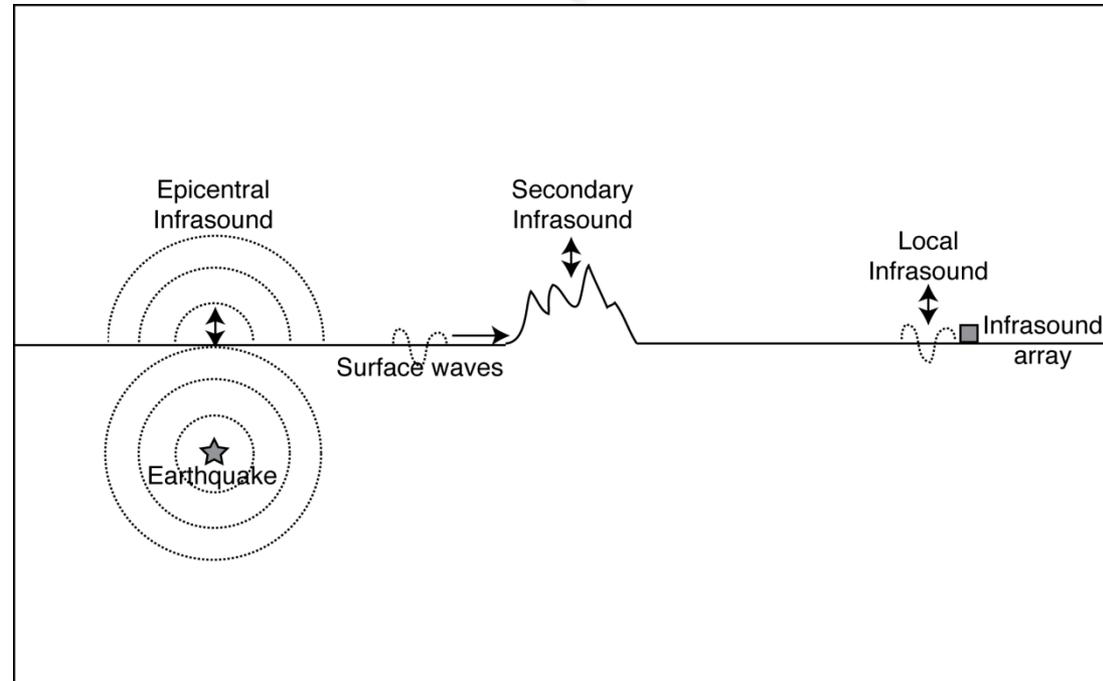
Locations for the 2013 DPRK test

Location precision for Utah network with (a) azimuth and time, (b) time information.

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Coupling Processes

- Epicentral infrasound
 - ‘Baffled piston’ model. Observations have not been supported by modeling.
- Secondary infrasound
 - Passage of surface waves through areas of extreme topography (mountains, cliffs). Good agreement with modeling in recent studies.
- Local infrasound
 - Associated with the generation of infrasound from vertical motion at the receiver.

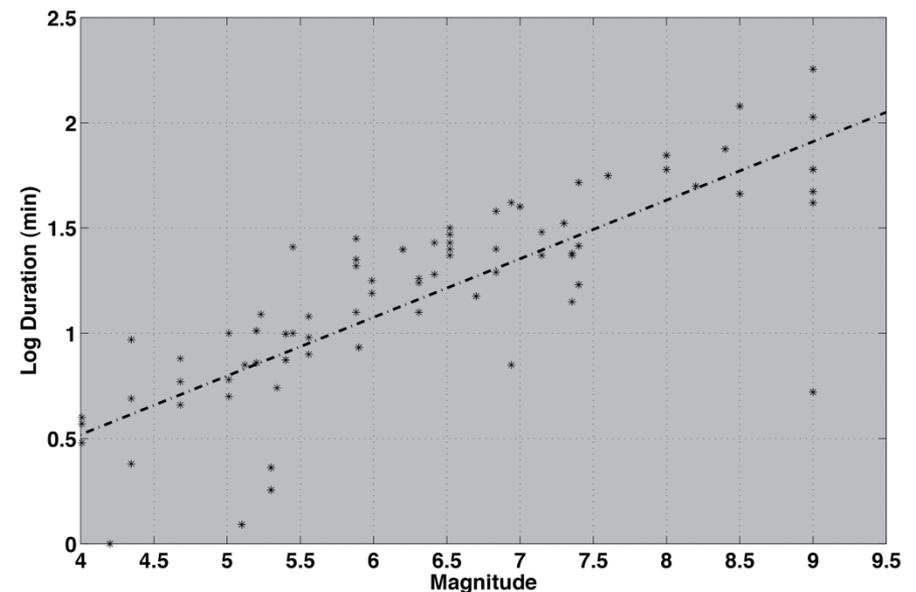
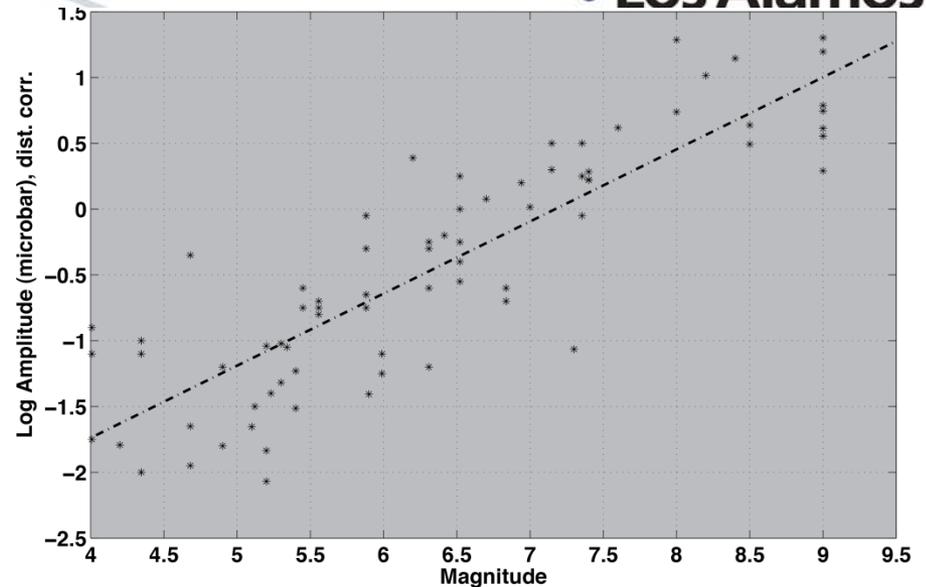


A schematic diagram illustrating different mechanisms of infrasound generation from earthquakes.

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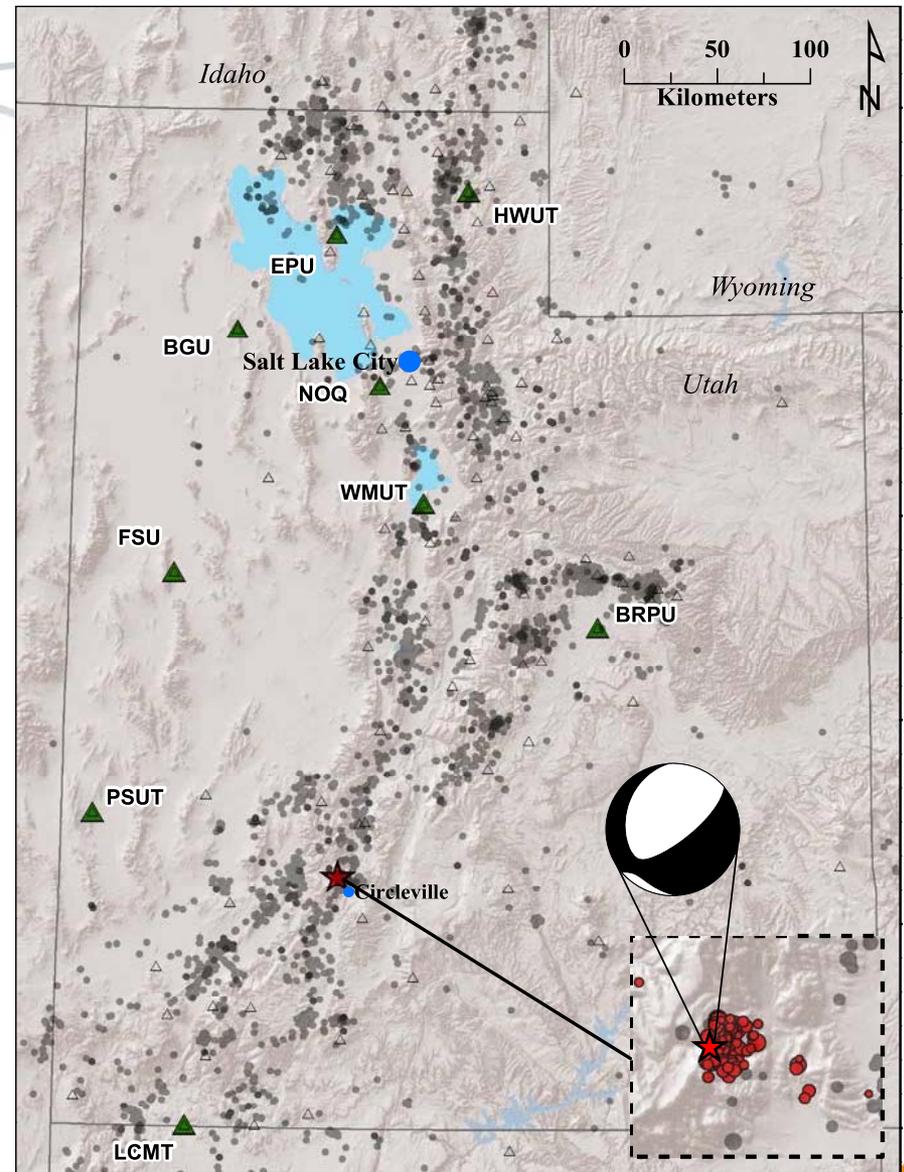
Earthquake Infrasound

- The earthquake infrasound observational record is limited to MB 4 and above
- Thus, infrasound shows promise as a potential discriminant at low magnitudes (e.g., for separating EQ's and mine blasts)
- We can explore the physics behind this using modeling...



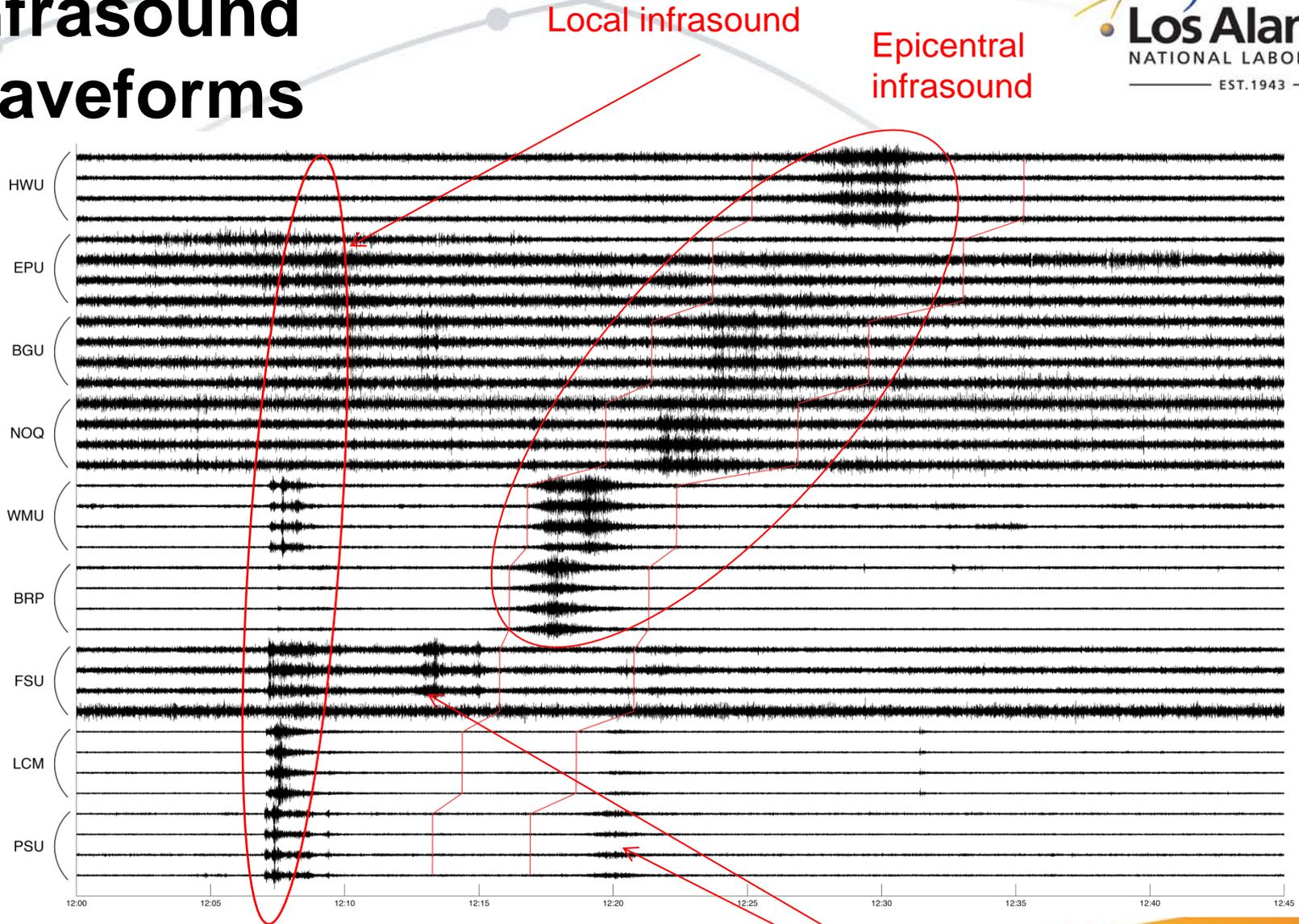
The Utah infrasound network & Circleville, UT

- Nine infrasound arrays, co-located with 3C seismometers, spanning the Utah intermountain seismic belt
- Each array has 4 elements (Chaparral 2, 2.5, and IML models)
- Circleville was a normal faulting Mw 4.7 earthquake in southern Utah
- Depth was constrained at 8 km from moment tensor inversions



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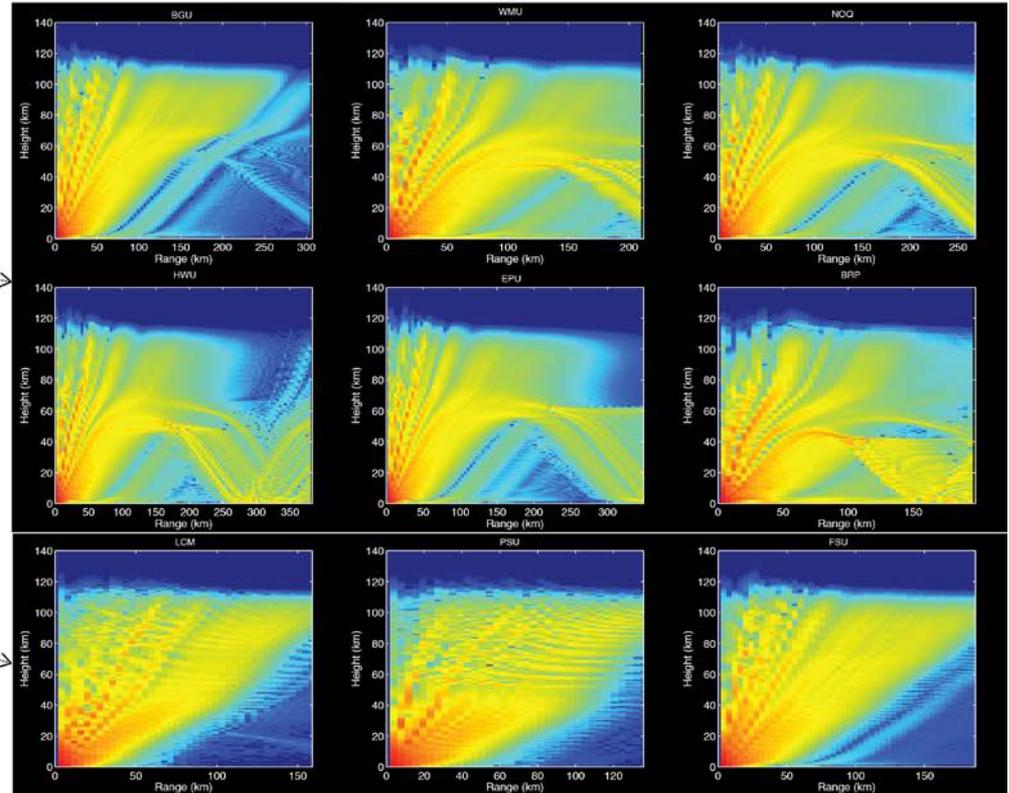
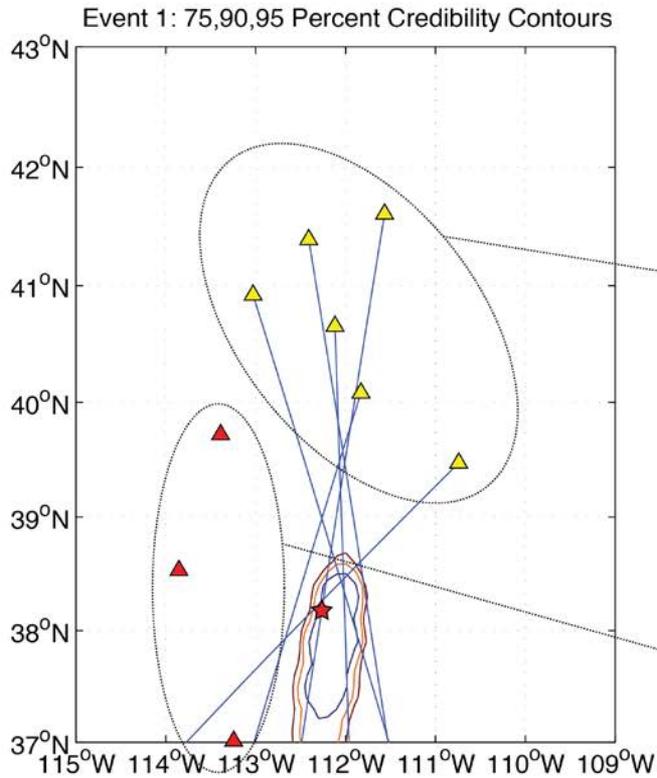
Infrasound waveforms



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Secondary infrasound

Detection, location suggests epicentral source



Red triangles & bottom panel: No detections
Yellow triangles & top 2 panels: Detections

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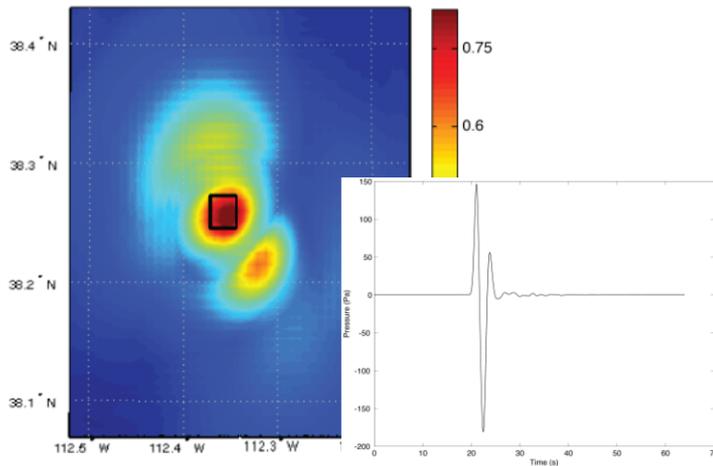
Modeling the seismic source (movie)



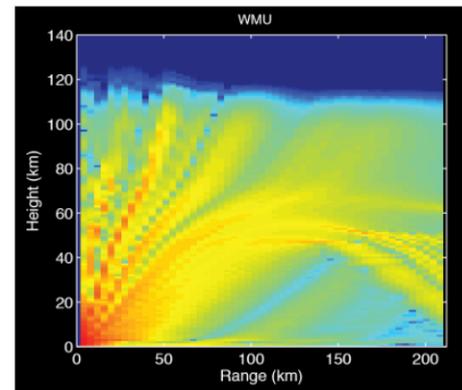
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Modeling the acoustic source

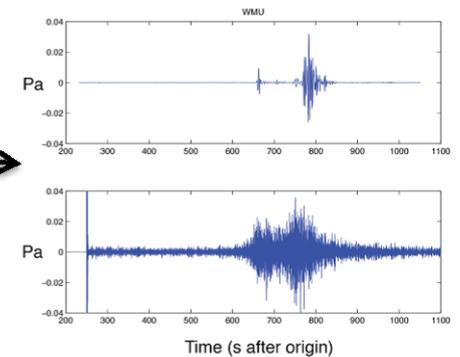
Seismoacoustic source modeling



Propagation in atmosphere



Predictions & observations



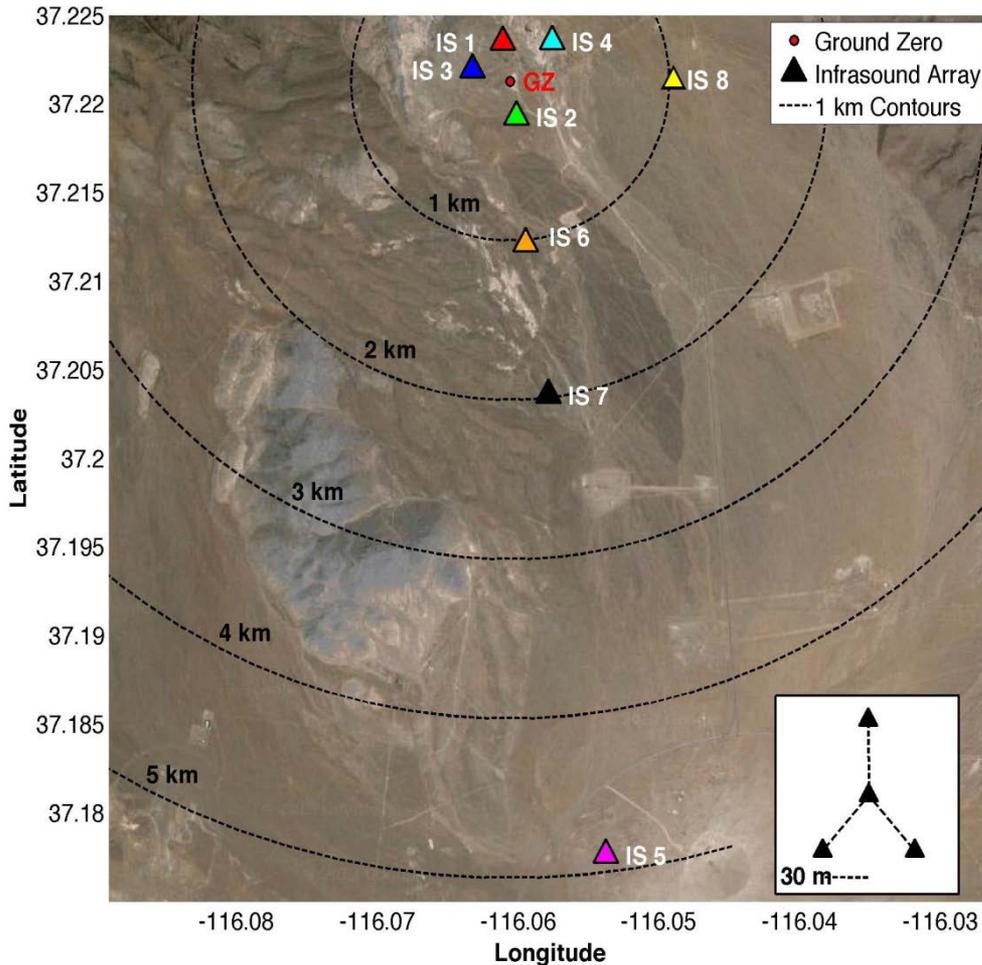
$$p(x, y, z, t) = \rho_0 \int_S \frac{\dot{u}(x', y'; t - \frac{R}{c_0})}{2\pi R} dS,$$

The Rayleigh Integral is an approximation to the Kirchoff-Helmholtz integral in the far field.

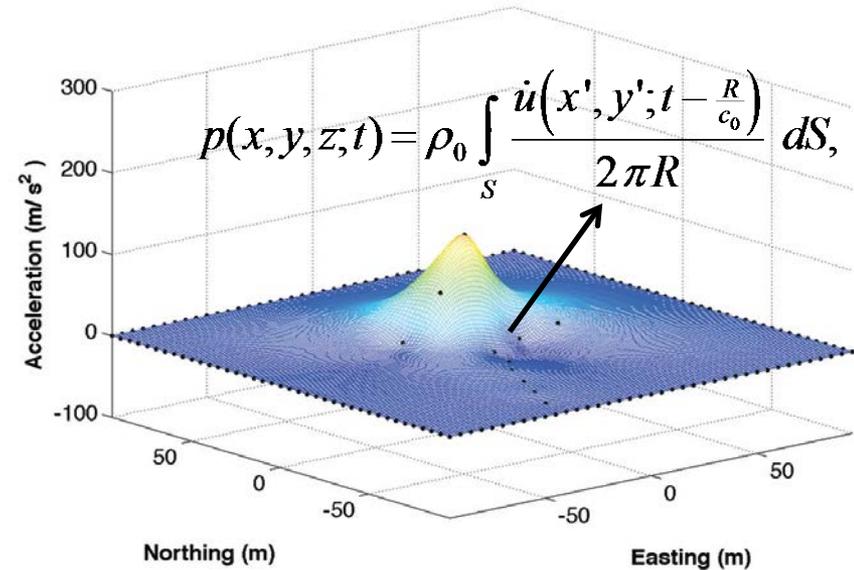
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Modeling small buried explosions

Infrasound Station Locations for SPE



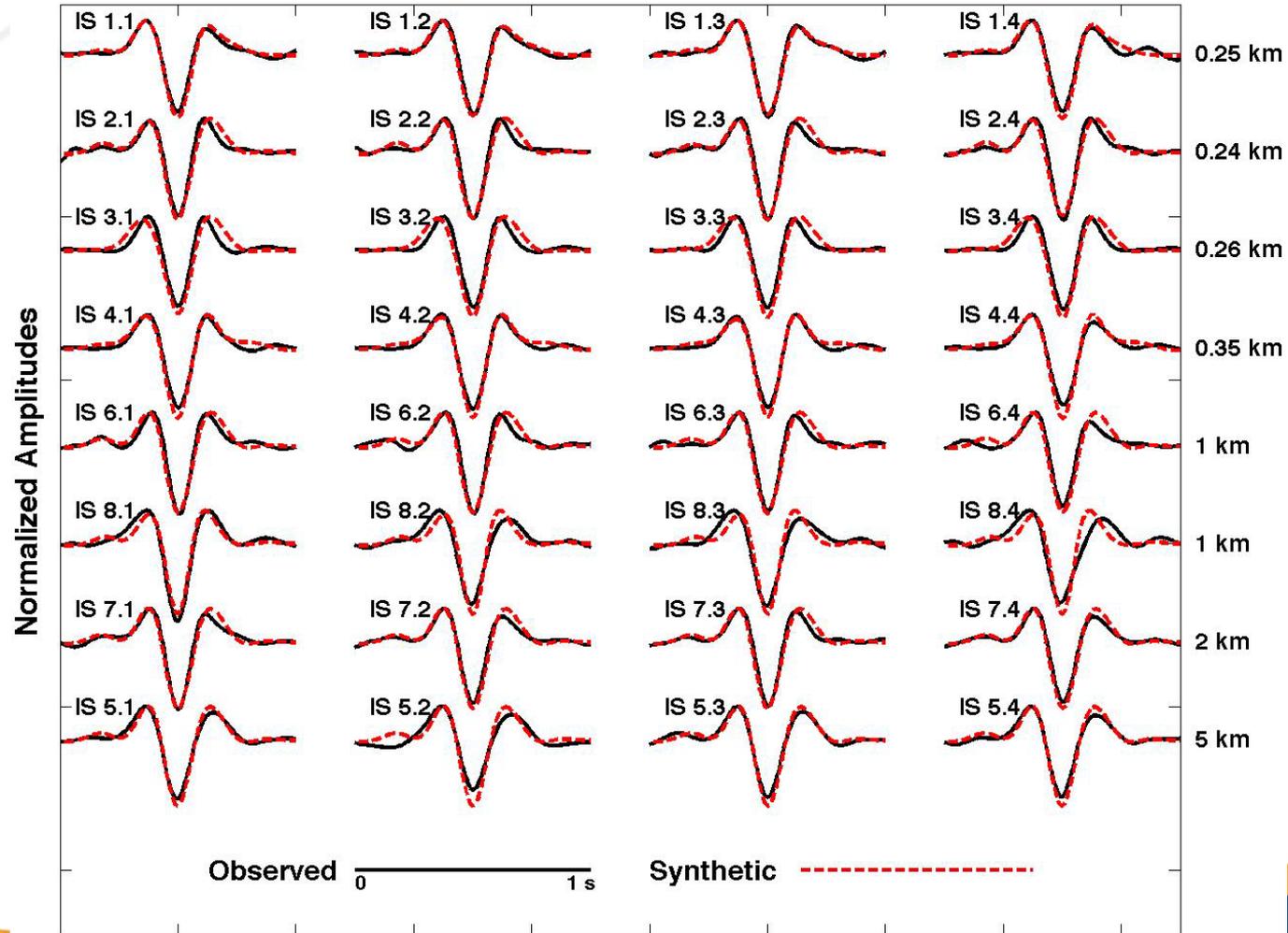
Interpolated/Extrapolated Acceleration Surface at Time: 0.025 s



- The Source Physics Experiment has provided an excellent opportunity to test coupling models in the near-field.
- R&D on modeling larger shots, shots in different media, and extending the modeling to higher frequencies is needed

Modeling small buried explosions

SPE 3 Observed vs. Synthetic Waveforms - Filtered [1-5 Hz]



Summary

- We can quantify the current capability of infrasound detection, location thresholds for above-ground tests.
- Recent research could in principle be extended to produce similar maps for below-ground tests.
- These simulations should be considered when evaluating GPS-TEC techniques.
- The modeling techniques developed for underground events (EQ, EX) can be coupled with plasma codes to simulate GPS-TEC.

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