IRIS Wavefields Community Experiment Using Nodal Arrays

Justin Sweet, Kent Anderson, Bob Woodward, Andy Frassetto

www.iris.edu/wavefields

Instrumentation

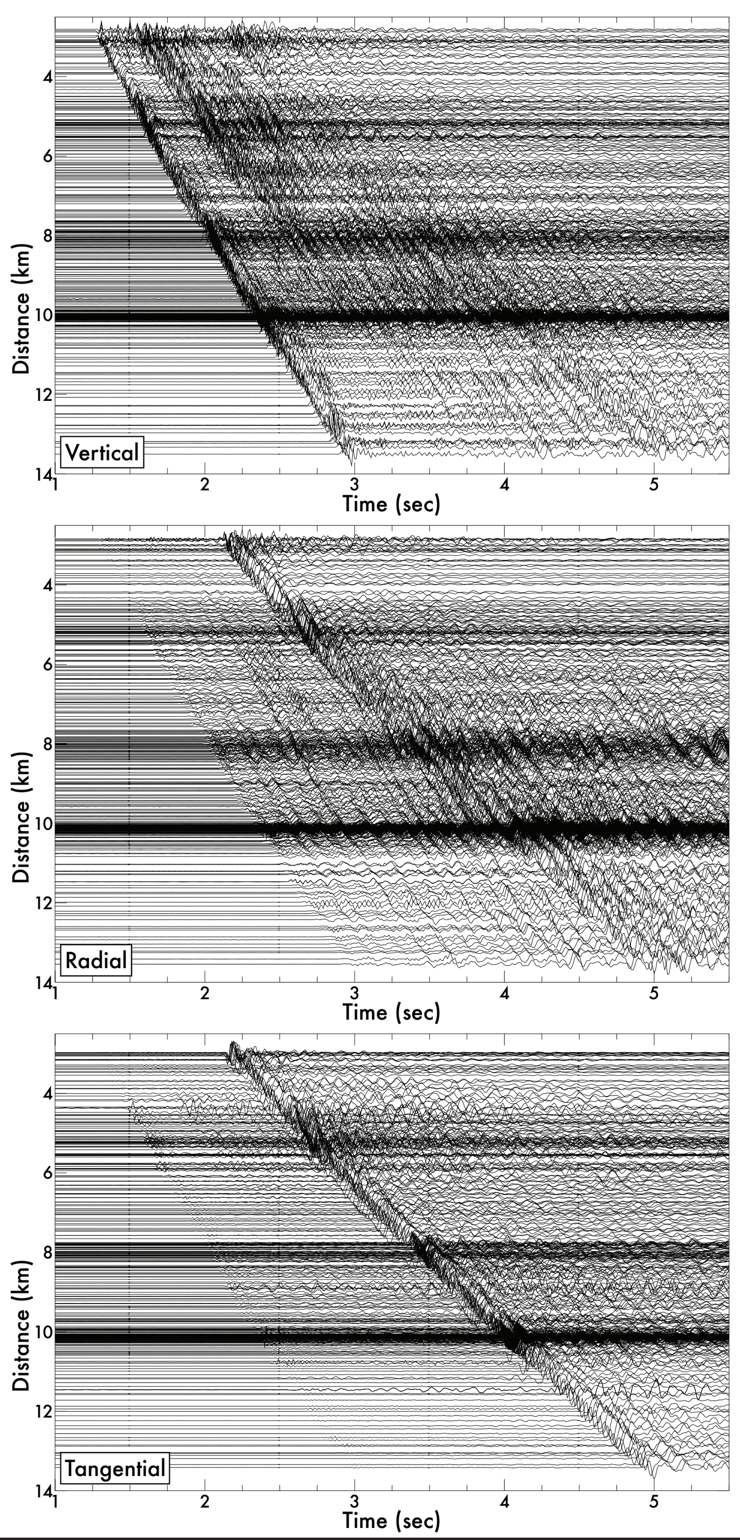
In June of 2016, IRIS led a community experiment to demonstrate the feasibility and usefulness of recording the full seismic wavefield. The experiment made use of **363 FairfieldNodal ZLAND 3C, 3-component 5Hz nodal systems** recorded at 250 samples/sec to deploy 3 seismic lines and a 7-layer nested gradiometer for 30 days. In addition to nodes, **18 Guralp CMG-3T 3-component BB sensors** recorded on a Reftek RT-130 DAS at 100 samples/sec were deployed in a "Golay" array design, along with **9 Hyperion Microbarometers** recorded on a Reftek RT-130 DAS at 100 samples/second co-located with 9 of the broadband stations. The broadband and infrasound stations were deployed for 5 months.

Waveforms

Local Earthquake

M2.7 - a few kilometers from the array

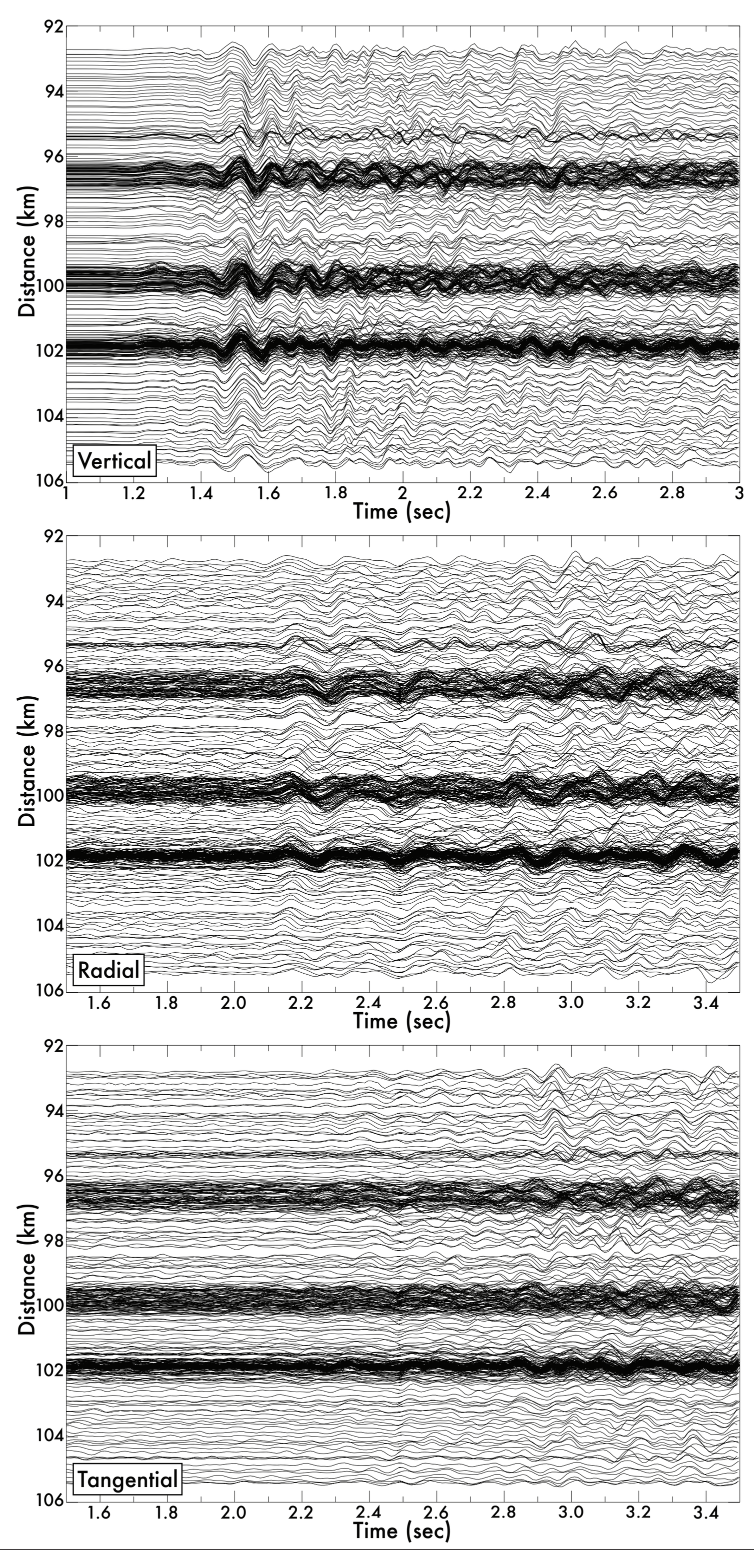
Record sections for a M2.7 earthquake that occurred within a few kilometers of the array showing the moveout of the seismic energy accross the entire array. This plot includes all 363 nodes and the 18 broadband stations. The data have been rotated to show the radial and tangential signal components.



Local Earthquake

M4.4 - ~100km from the array

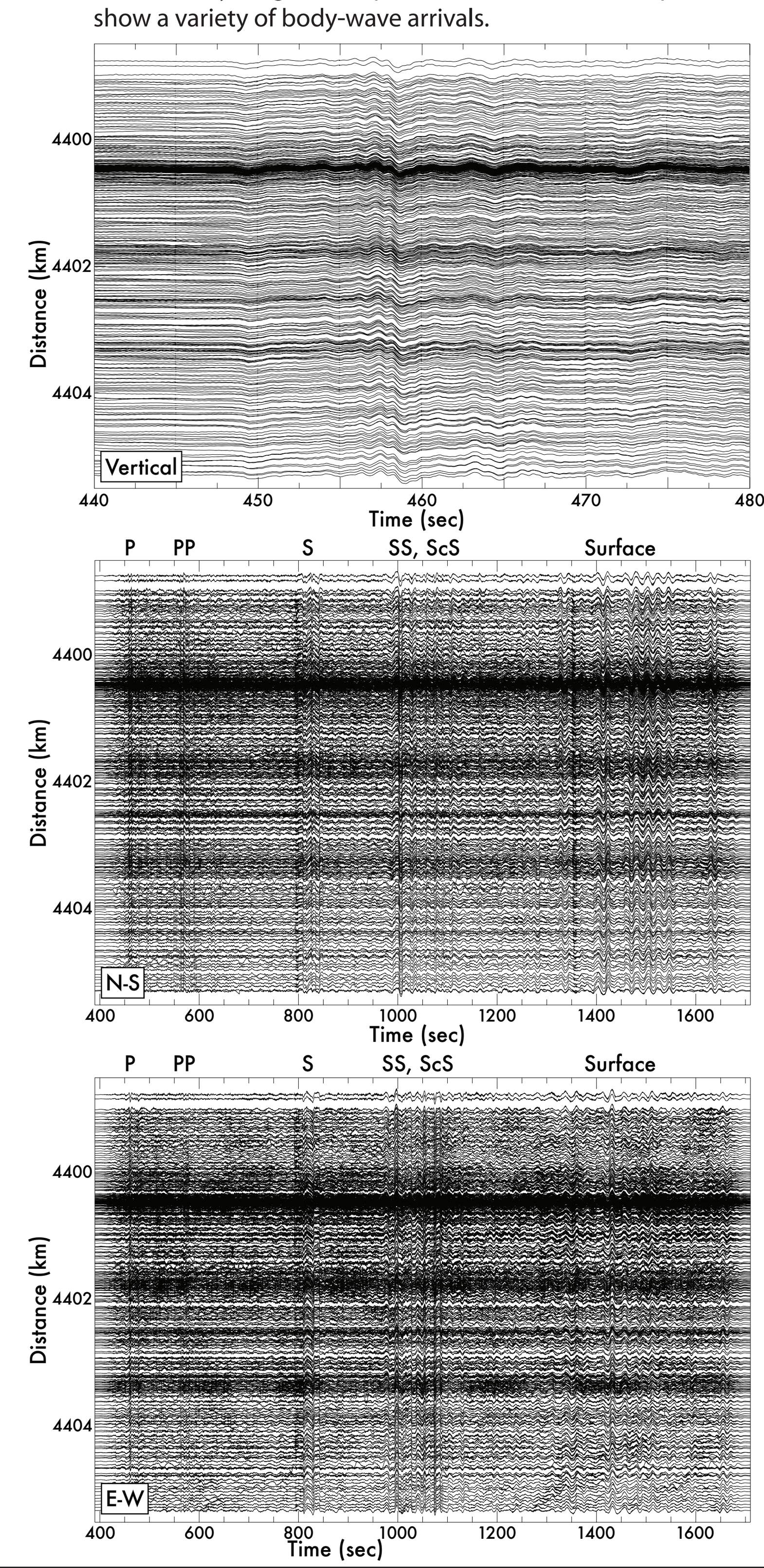
Rotated and reduced travel-time record sections for the largest local earthquake during the deployment, the M4.4 Fairview earthquake occurring on 7/9/16. The vertical component record section is reduced by 6.3 km/s to emphasize the coherence of the P-wave arrival at ~100 km distance. The horizontal component record sections are reduced by 3.7 km/s to similarly illustrate S-wave coherency.



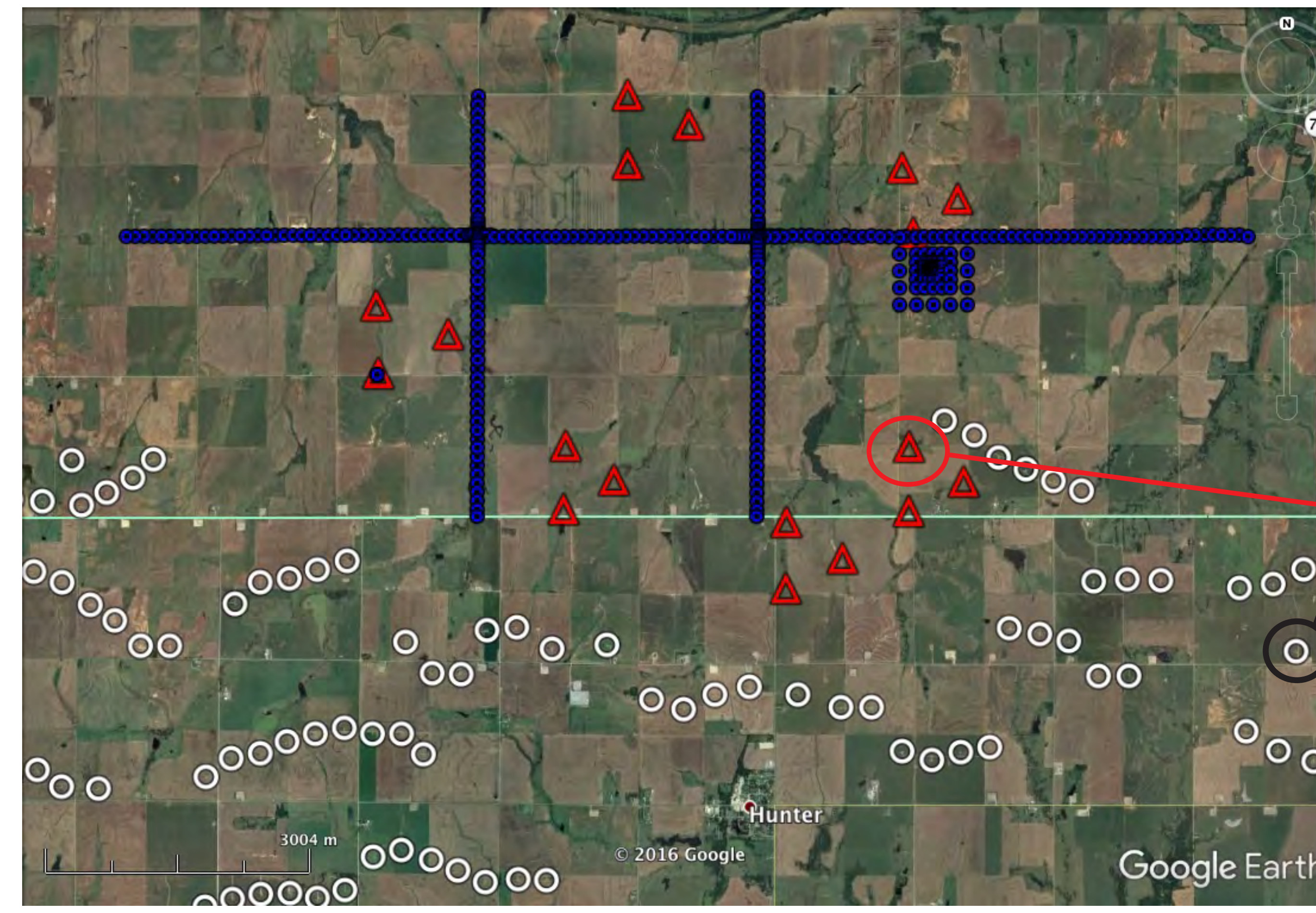
Distant Earthquake

M6.3 - Ecuador 7/11/16 ~4,700 km from the array

Record sections for a M6.3 earthquake in Ecuador which occurred on 7/11/16 demonstrate the ability of the Nodes to register teleseismic arrivals at high quality. Here we have corrected for instrument response and filtered between between 0.05-2 Hz (below the 5 Hz corner of the Nodal instruments) to highlight the consistency of three-component teleseismic arrivals across the array. We focus 40 seconds around the P-wave arrival on the vertical component, and a considerably longer timespan on the horizontal components to show a variety of body-wave arrivals.



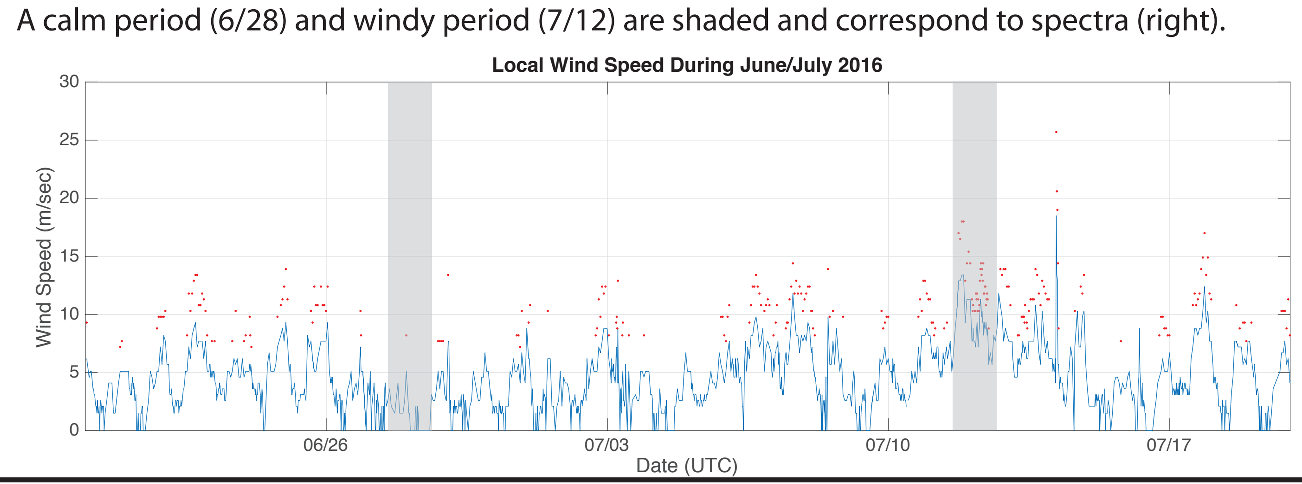
Wind Turbine Signals



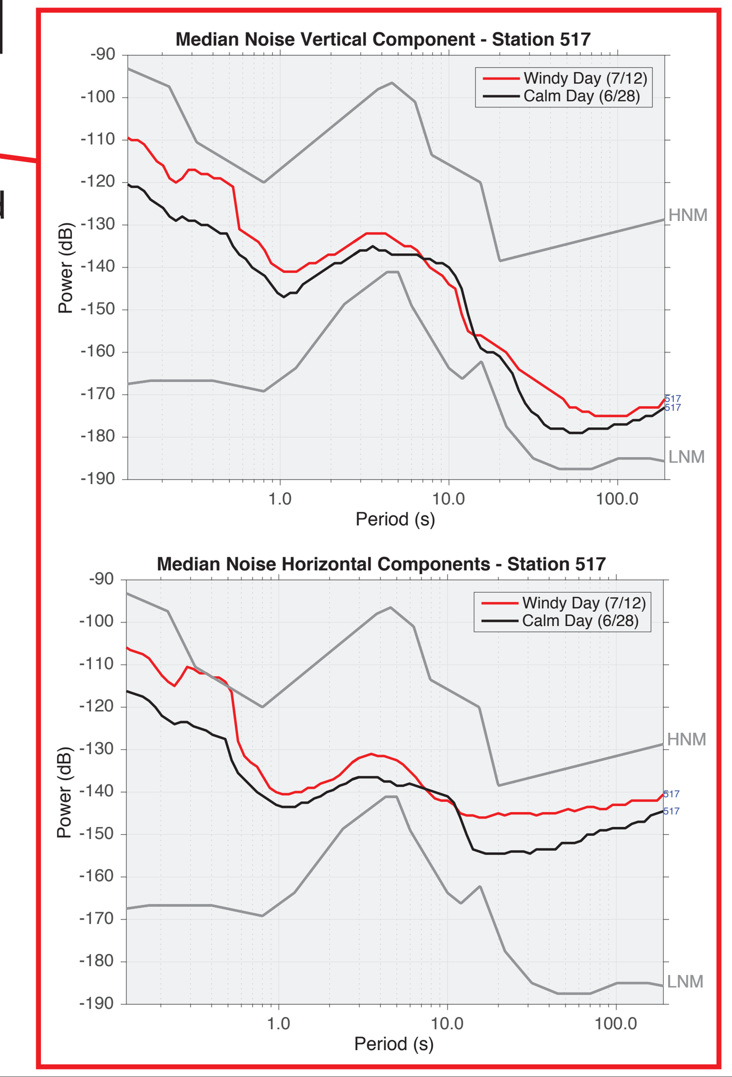
Location of deployment in north-central Oklahoma

Map of deployment (above) with nodes (blue), broadband stations (red) and wind turbines (white). Below is a plot of local wind speeds and gusts as measured at a nearby airport during the deployment. A calm period (6/28) and windy period (7/12) are shaded and correspond to spectra (right).

Our array was deployed within a few miles of a large wind farm.



We analysed noise spectra for one station on a windy day (red, right) and calm day (black, right). We observe a large peak in both vertical and horizontal spectra between 6-8 Hz that is likely a result of noise from the turbines.

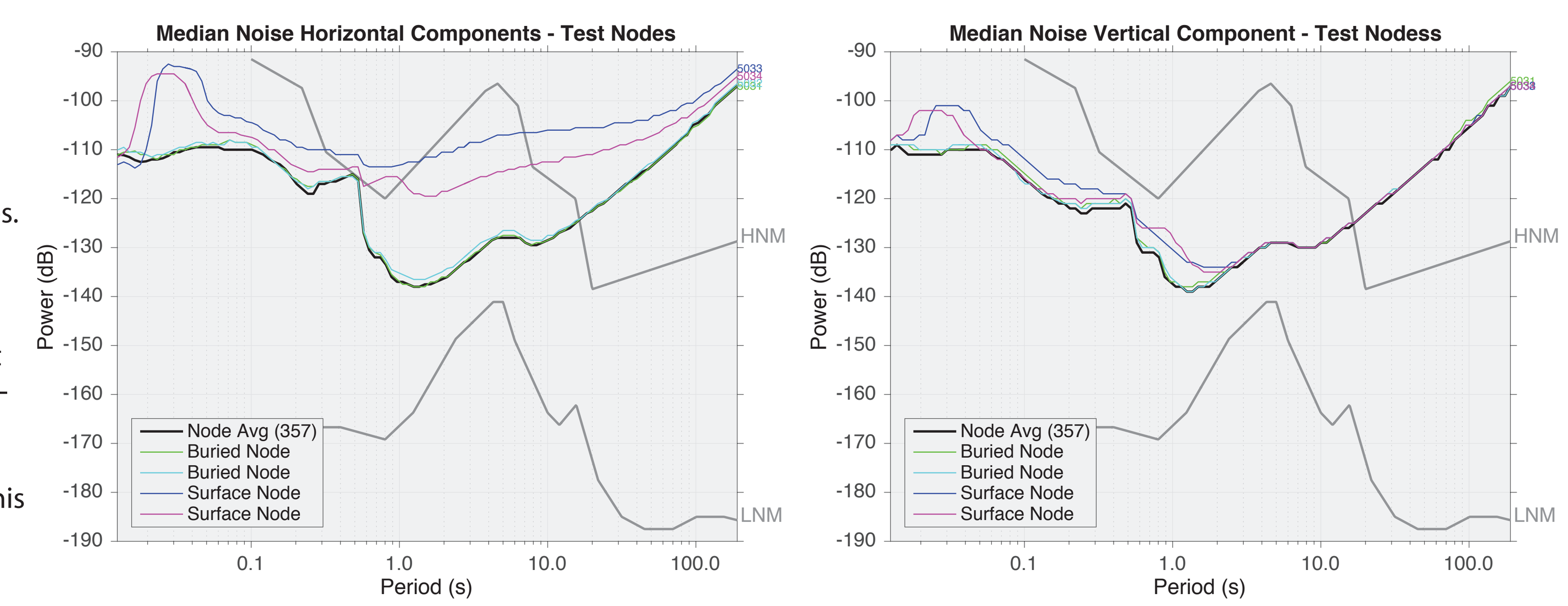


Buried vs Surface Nodes

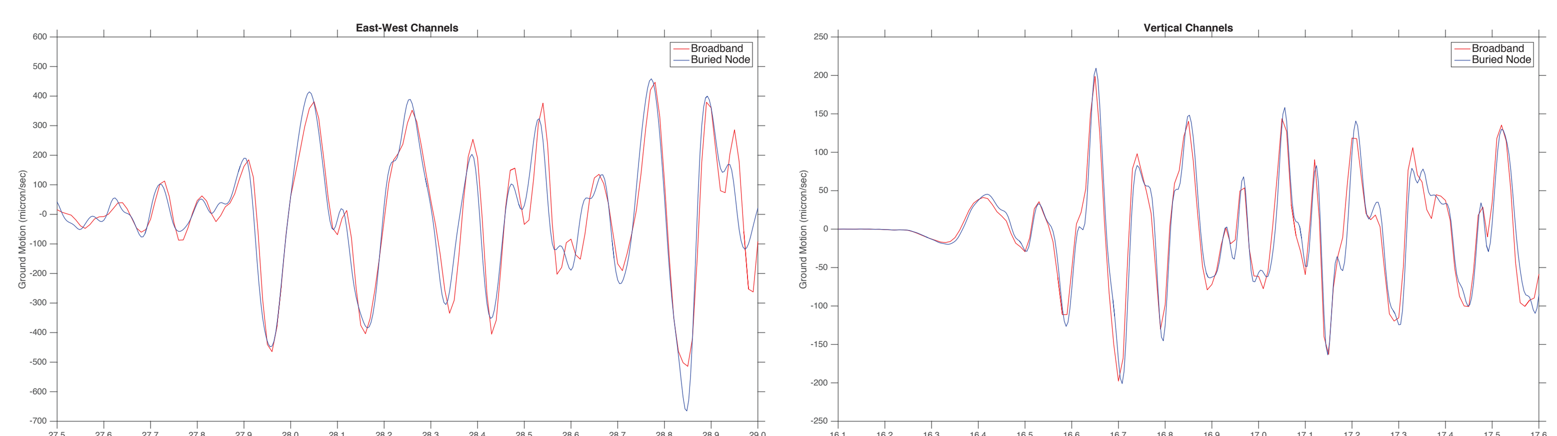
Test nodes: In an attempt to determine the difference between buried and surface nodes, we set up 2 pairs of test nodes ~20 feet apart near a broadband station (red circles below). Nodes were in slightly different soil types which show substantial signal differences.

Horizontal and vertical spectra (right) show how the 4 test nodes compared. The 2 surface nodes exhibit significantly higher noise levels across the board, with a prominent peak seen between about 50-100 Hz. This peak is unlikely to be related to noise from wind turbines since nearby buried nodes do not have a similar peak.

With the exception of 2 test nodes, all the 3-C nodes deployed for this project were buried so that the top of the node was just below the surface. This was done to ensure better coupling and lower noise.

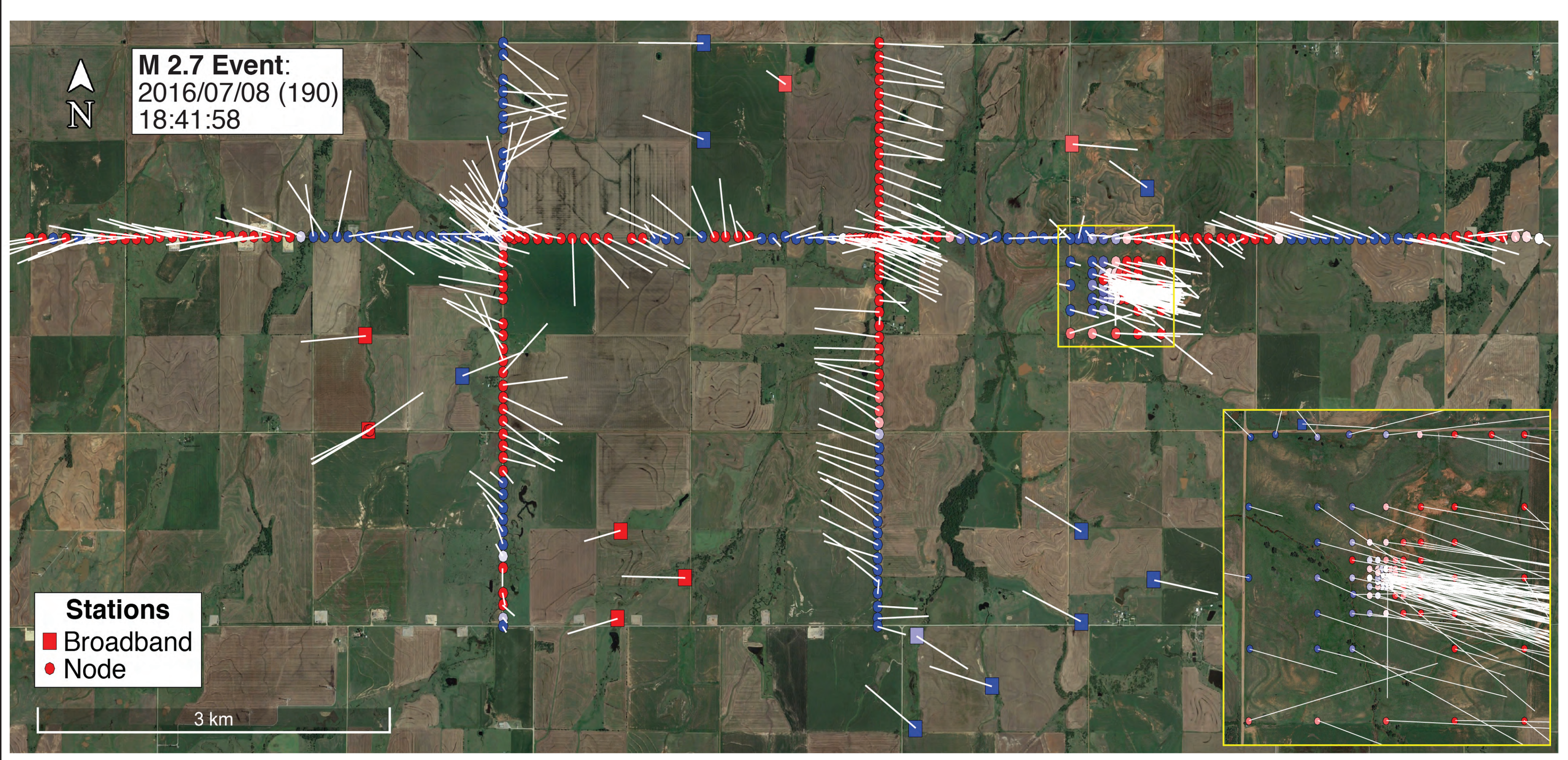


The above spectra show a comparison (horizontal, left; vertical, right) between 2 buried and 2 surface nodes and an average spectra for all 357 nodes deployed during the experiment. The nodes deployed are 3-component and have a corner frequency of 5 Hz.



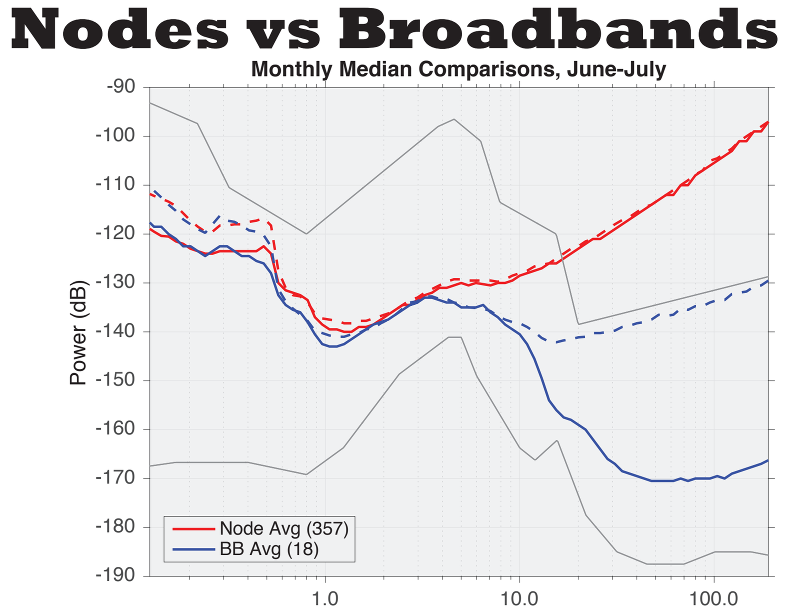
Here we show a comparison between our co-located broadband station (pictured, left) and one of the buried nodes at the same site. These data are from a nearby M4.4 event on 7/9/16 and have been bandpass filtered between 5 and 40 Hz.

Ground Motion Visualizations



IRIS has produced several ground motion visualizations of the array and we'll show a few of these off using a tablet at the poster presentation. The image above is the array during a nearby M2.7 event (blue=up, red=down, and bars indication horizontal displacement.

Nodes vs Broadbands



30-day spectra average for 357 nodes (red) and 18 broadbands (blue). Solid lines represent vertical channels, dashed are average of horizontals.

The Partners

Oklahoma Geological Survey, New Mexico Tech, The University of Memphis, Miami University, Cornell University, The University of Oklahoma, UTEP, IRIS, SMU, The University of Utah

Acknowledgements

This work was funded by the National Science Foundation through the IRIS SAGE award. IRIS procured a small set of evaluation nodes for this experiment that remain in our pool, but the bulk of the 363 nodes were leased from FairfieldNodal, the University of Utah and the University of Texas, El Paso. Broadband station installations were led by personnel from the IRIS PASSCAL Instrument Center - New Mexico Tech. The Okalahoma Geological Survey provided excellent field support during the installation and demobilization of the equipment. Road access was approved and granted by the Garfield County Commission and Broadband and Gradiometer permits were granted by 7 different and welcoming landowners from the area. Most important is the hard work of the 30+ graduate students from 20 different institutions who braved the Oklahoma heat to help install these arrays.