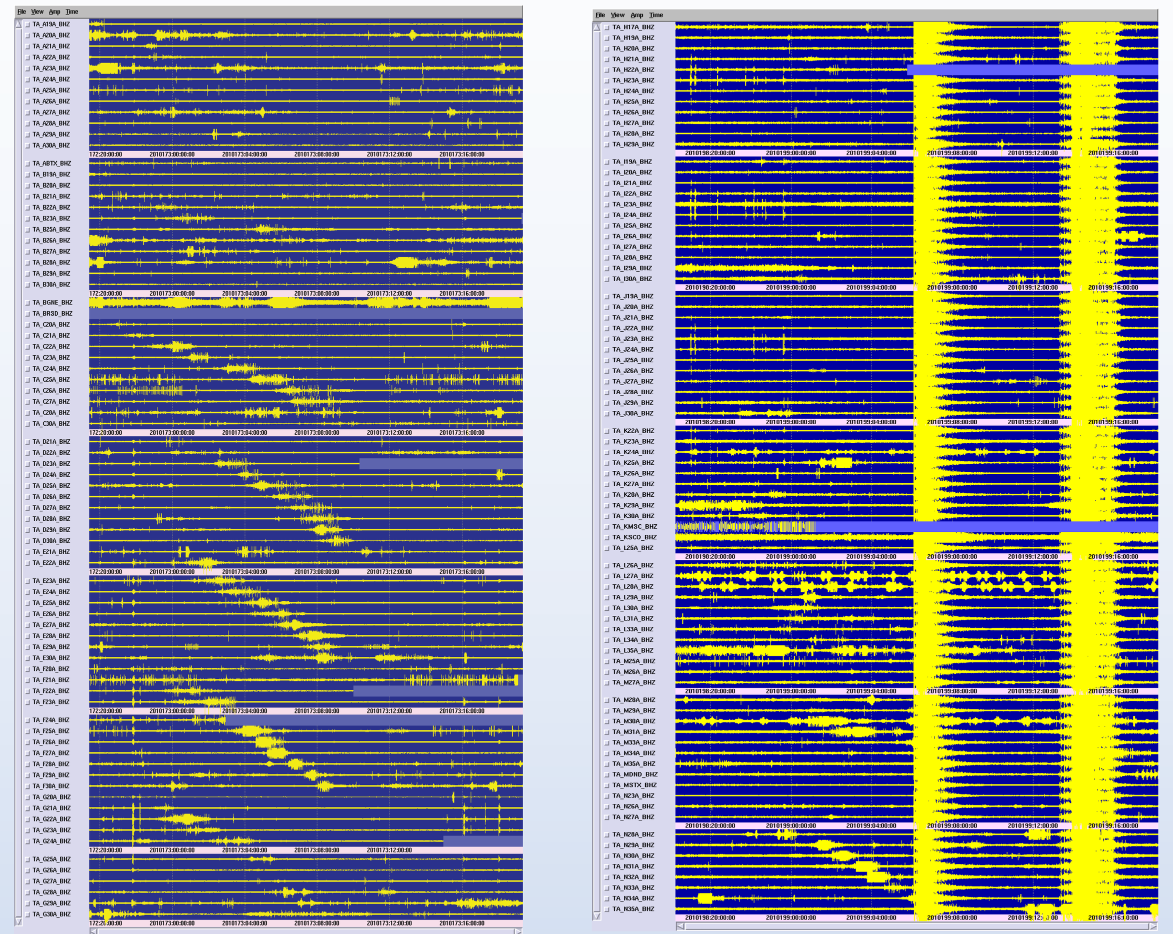
OBSERVATIONS OF WEATHER PHENOMENA BY NSF EARTHSCOPE USARRAY SEISMIC AND PRESSURE SENSORS

Frank L. Vernon, University of California, La Jolla, CA; and J. Eakins, J. E. Tytell, B. Busby, B. Woodward and M. A. H. Hedlin

Abstract

On June 22nd, 2010 two severe weather systems were tracked across portions of the Great Plains by the NSF EarthScope USArray Transportable seismic network; a dense array of over 400 seismic stations with a 75 km station spacing located in grid formation across the continental United States. While the seismic stations are equipped with a standard package of seismic instrumentation, many are also equipped with internal VTI SCP1000 MEMS barometric pressure gauges. Data from these sensors show clear correlation in time with thunderstorm cell passage and pressure changes and low-frequency seismic noise at the target USArray stations. The unique nature about all instrumentation onboard the USArray stations is that data is recorded continuously at 1 sps and transmitted in real-time. With the high quality of atmospheric pressure data return and a spatial distribution that is denser than the NEXRAD Doppler array, the USArray network provides a unique perspective on surface weather research and potential tool for now-casting severe weather events. This paper will present the observations from June 22nd 2010 and other storms to introduce potential research areas based on the various data acquired.

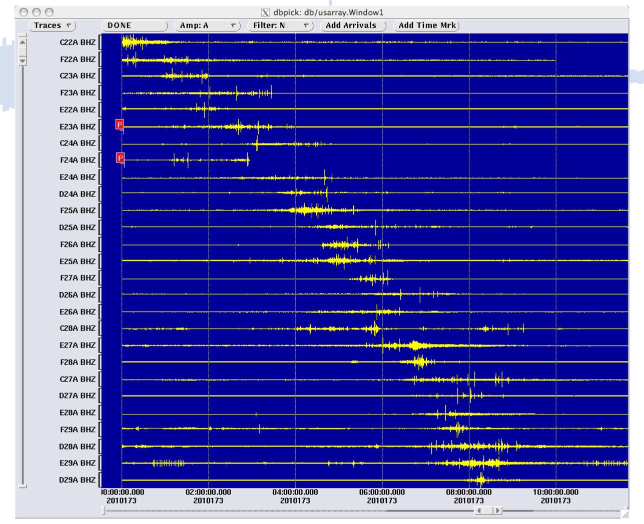
Observations in Seismic Data



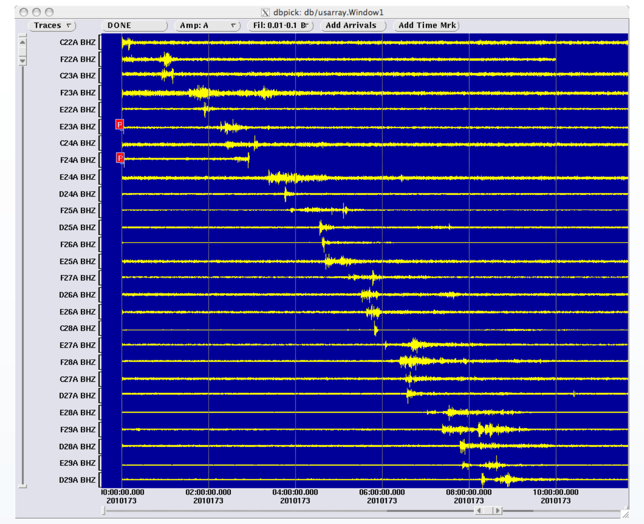
Slow moving signals

Earthquakes

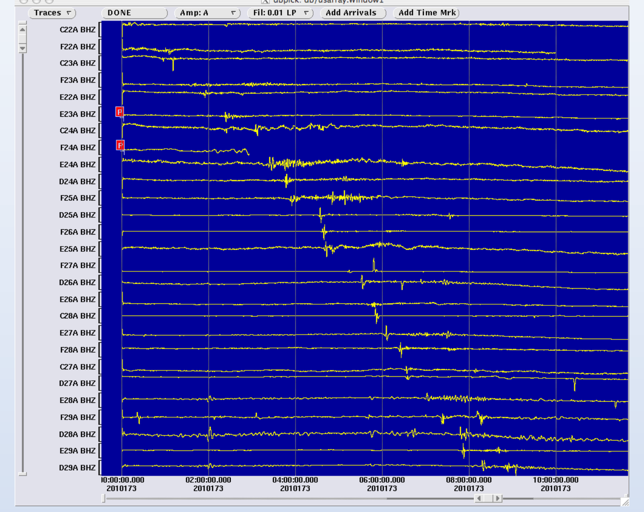
Seismic Signals across array



Raw seismic data across 27 TA stations. Records are 12 hours long.

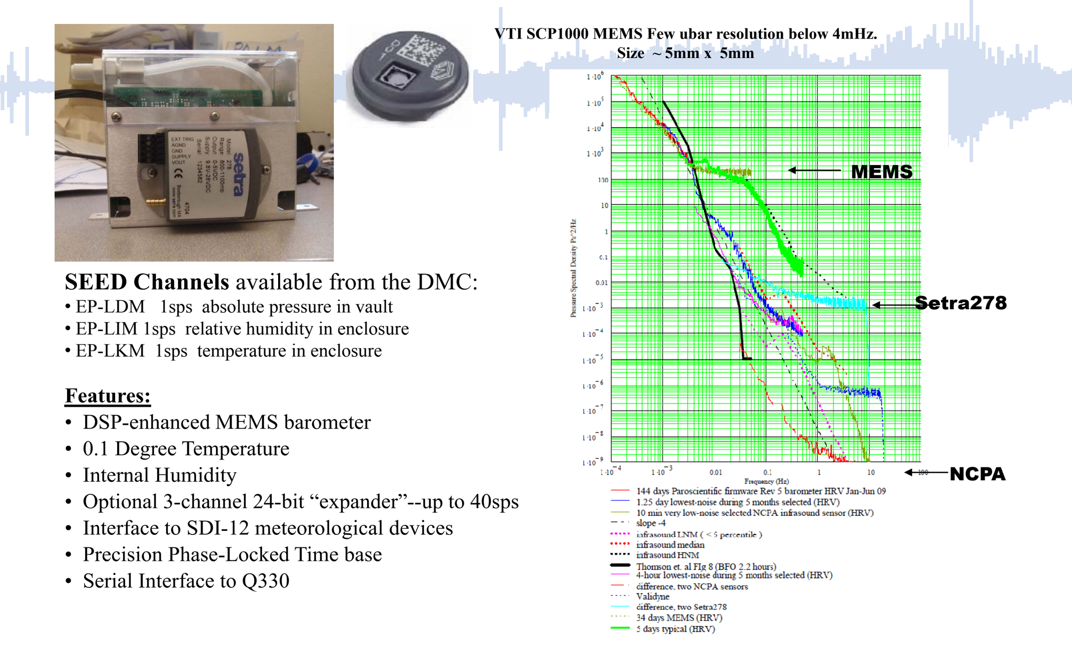


0.01 - 0.1 Hz bandpass filtered seismic data across 27 TA stations. Records are 12 hours long.

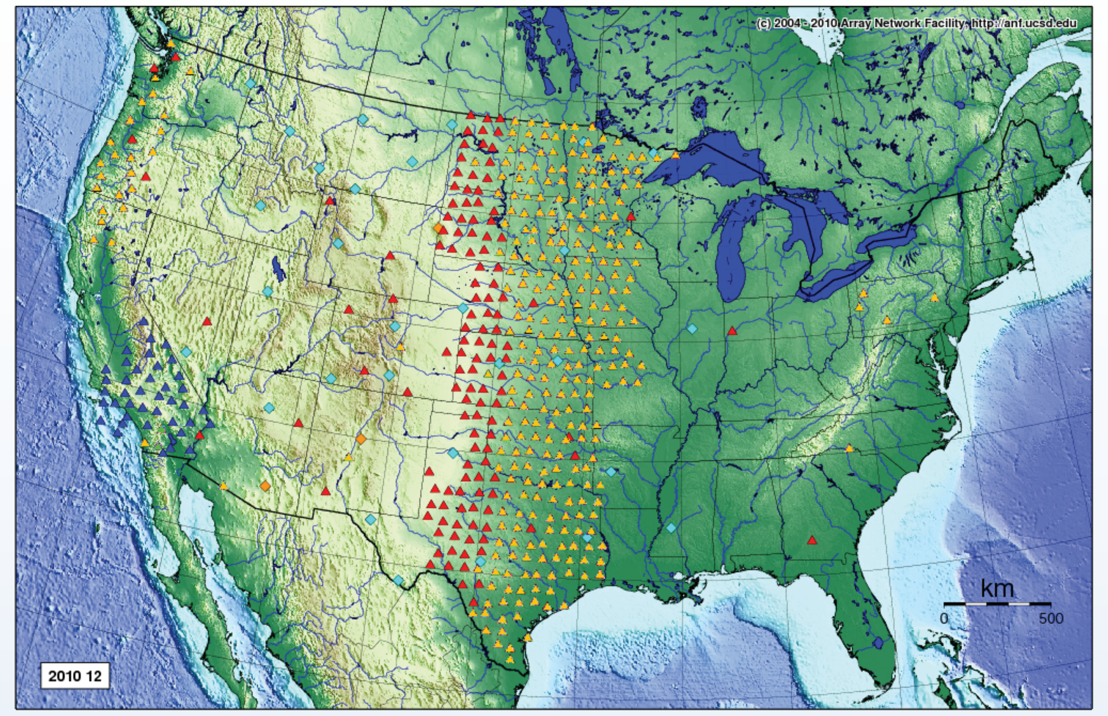


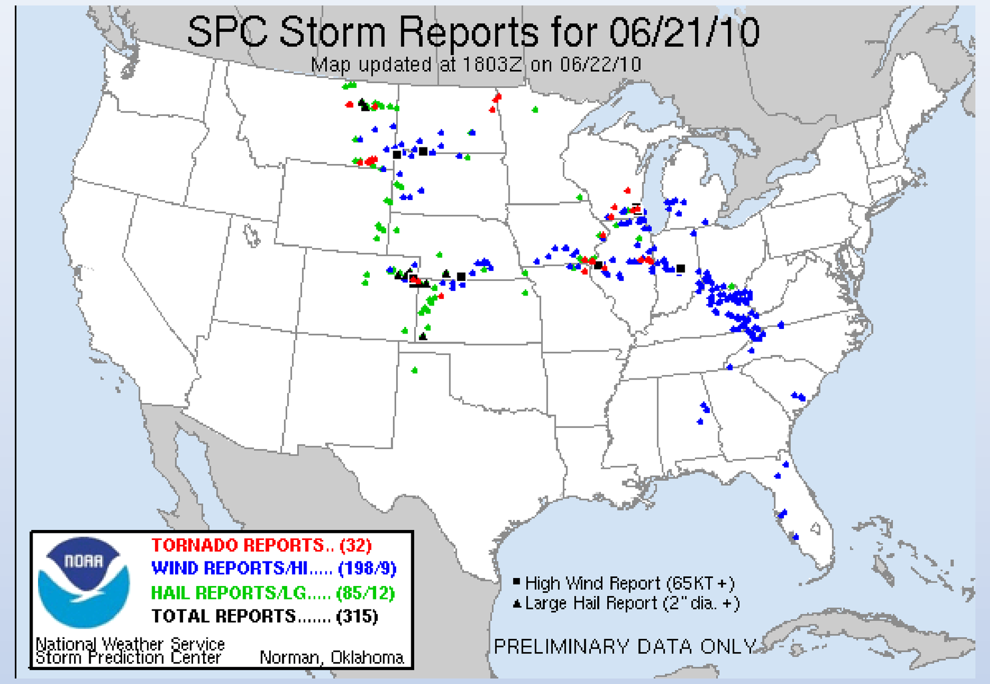
0.01 Hz low pass filtered seismic data across 27 TA stations. Records are 12 hours long.

Currently Installed Pressure Equipment

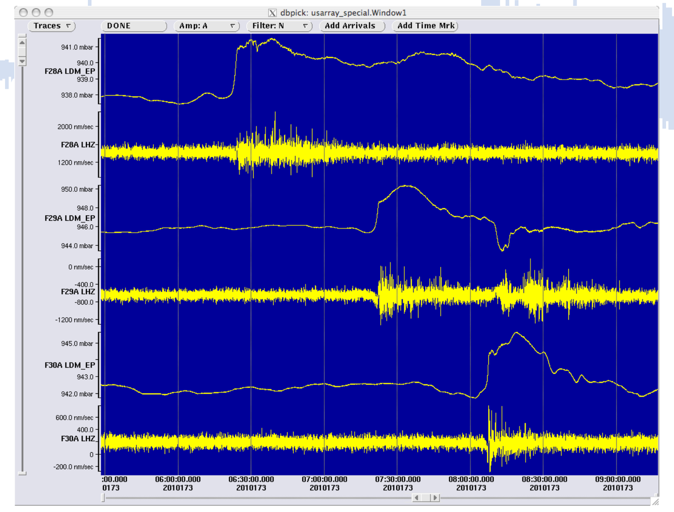


Current TA Deployment map

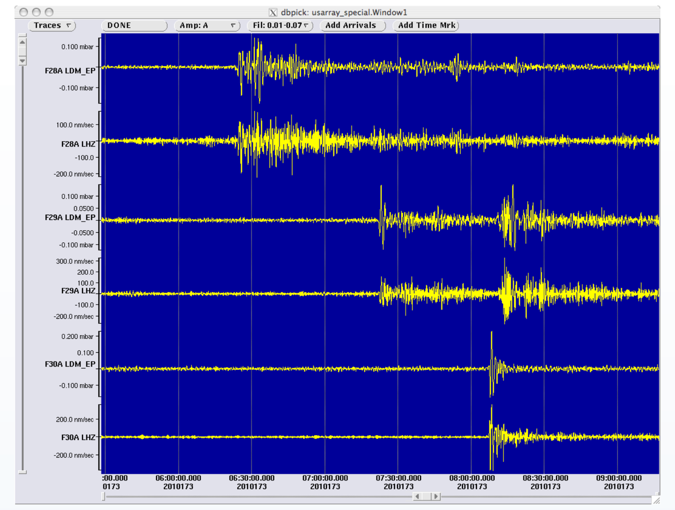




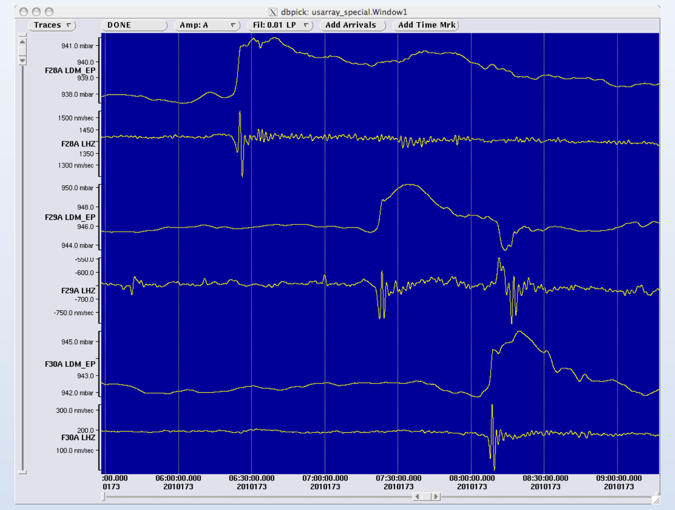
Seismic and Pressure at F28A, F29A, F30A



Raw seismic and pressure data at 3 TA stations. Records are 4 hours long.

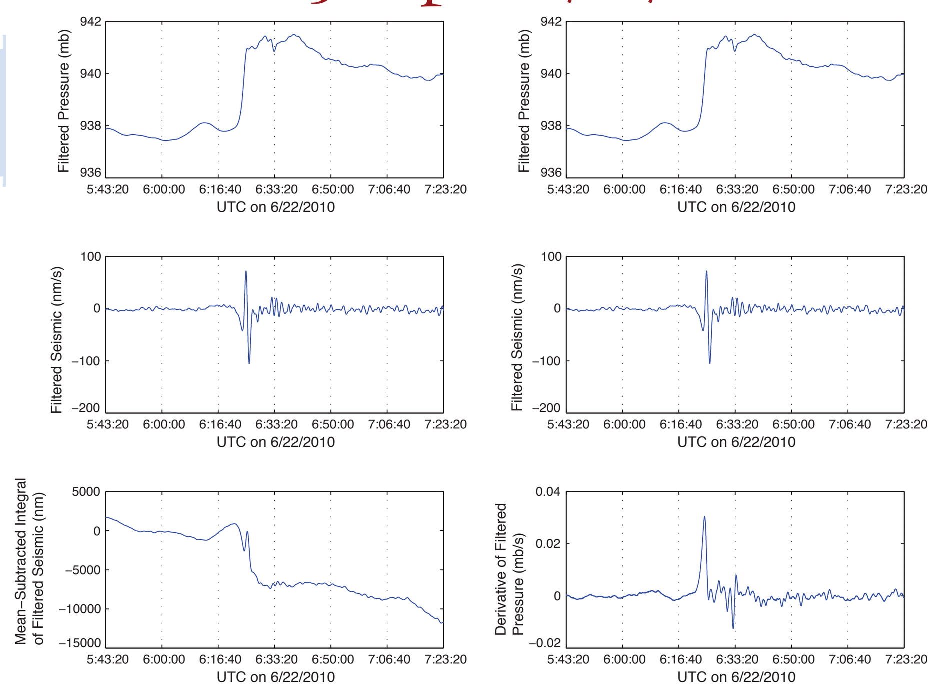


0.01 - 0.1 Hz bandpass filtered seismic and pressure data at 3 TA stations. Records are 4 hours long.



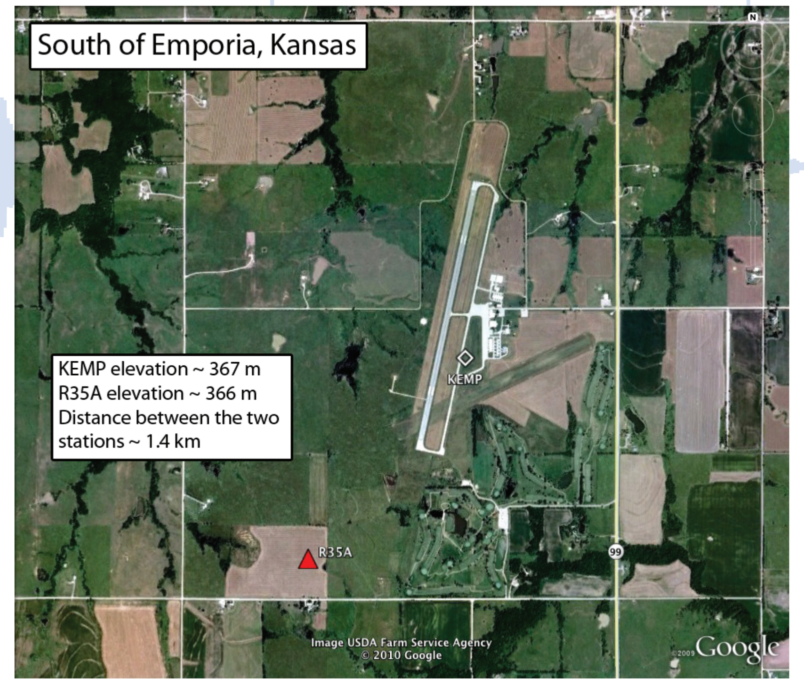
0.01 Hz low pass filtered seismic and pressure data at 3 TA stations. Records are 4 hours long.

F28A Analysis - Crustal Response to Pressure Jump on 6/22/2010



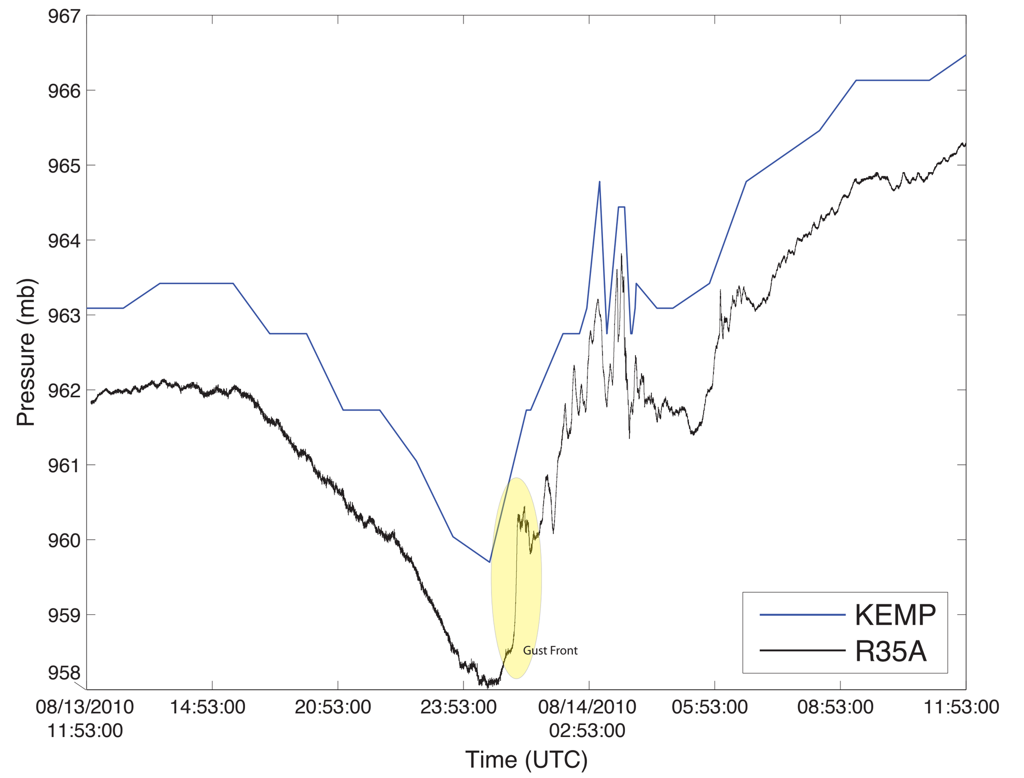
Left Column: Top panel depicts pressure jump at F28A with a 0.01 low pass filter applied. Below this is the seismic data with the same filter applied, and with the mean subtracted. Below that is the integration of the sesimic response in the second panel showing the total crustal response during this gust front passage. Right column: Same as left with the exception of the bottom panel, which depicts the derivative of the filtered pressure data.

Data Sampling Comparison



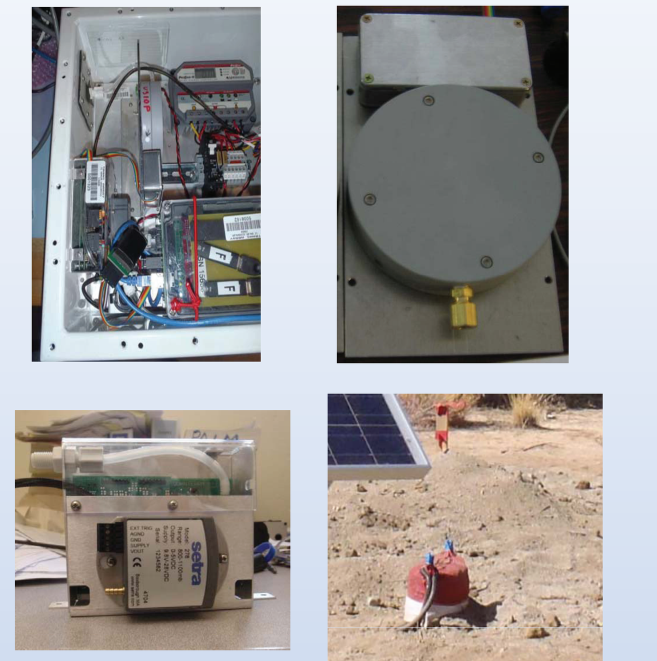
South of Emporia, Kansas, TA Station R35A and ASOS station KEMP lie in very close proximity (~ 1.4 km apart, and at the same elevation). This chart compares the data sampling resolution between these two stations for a gust front from a thunderstorm on 8/13/2010. What is presented here is the fundamental difference between the TA stations and the ASOS network: The TA stations record data at 1 sps in real-time, while the ASOS network typically only provides hourly records. Though there are usually several additional observations recorded by an ASOS station during a storm system, its minimal observational resolution can never be adequate enough to capture a gust front passing through in real-time.

ASOS Station KEMP vs. TA Station R35A

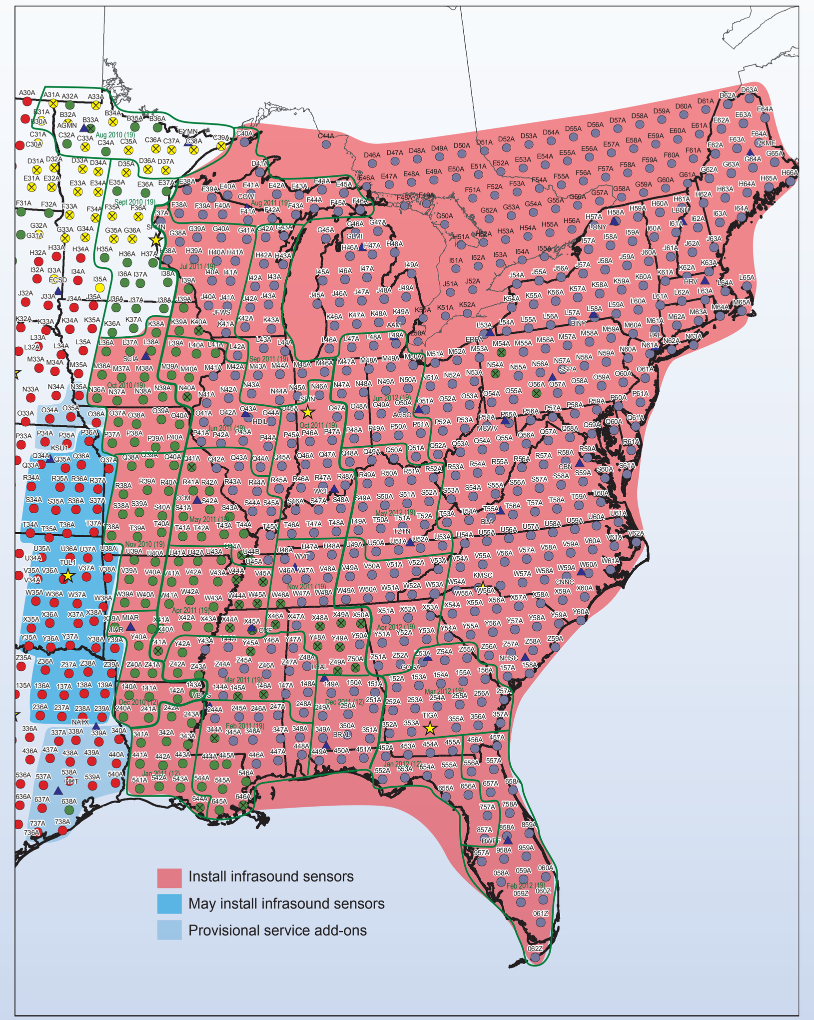


Pressure and Infrasound add-on to TA stations

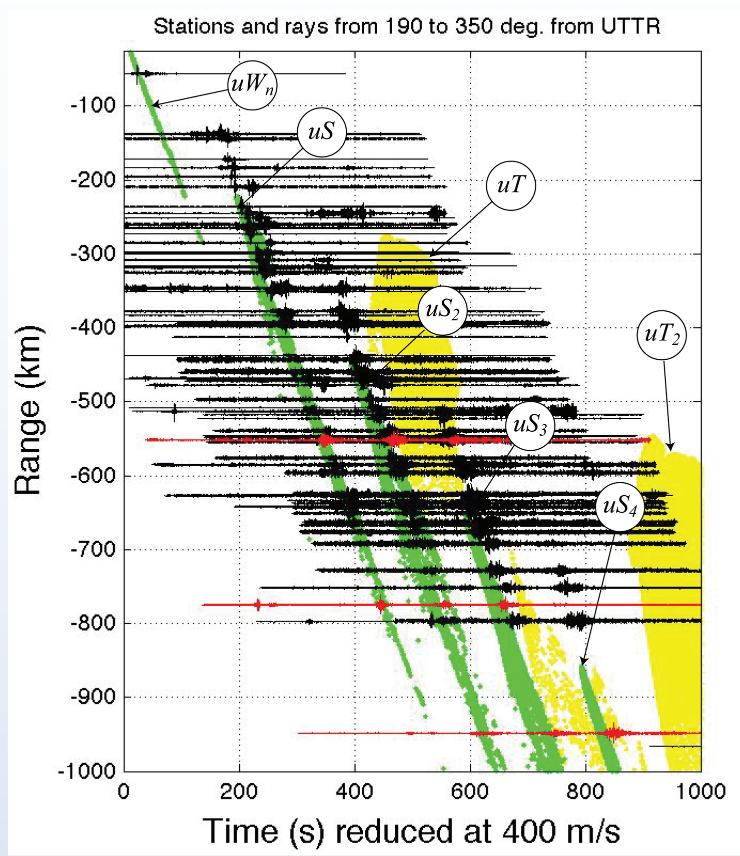
- UCSD's MRI-R² proposal funded
  - Primarily acquisition
  - 3ch A/D board level add on Absolute *barometer* and an infrasound sensor for every TA station.

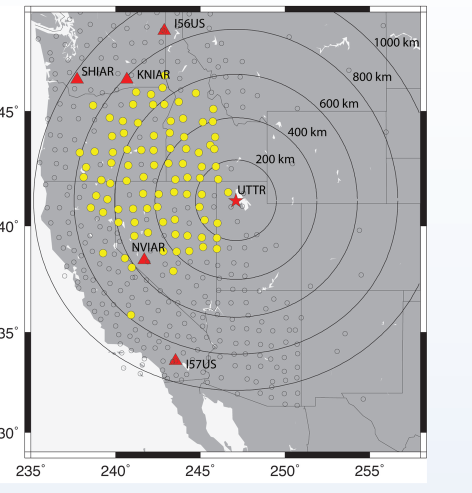


Planned infrasound sensor deployment



Infrasound Case Study - Large Blast at UTTR Facility on 6/11/2007





Map of the study area showing the configuration of USArray TA stations on day 162, 2007. At this time there were ~ 375 broadband seismic stations in the TA within 1000 km of UTTR. The subset of TA stations used in the plot to the left is highlighted in yellow.

Vertical component seismic recordings of the UTTR blast that occurred on day 162 (June 11) are plotted in black plotted with array recordings shown in red. All stations were located between azimuths of 190° and 350° from UTTR (and are highlighted in the map above). All traces have been bandpass filtered from 0.8 to 3.0 Hz. Four branches of infrasound signals are clearly evident in this figure.

The traces shown in this plot are replotted and shown with rays ducted in the thermosphere (shown in yellow) and below the thermosphere (green). The signal observed close to the source likely propagated in a low-level tropospheric duct. All branches have been identified using the nomenclature of Hedlin et al. (2010). The sub-thermospheric rays predict the onset times of the branches very well however do not predict signals observed close to the source.

References

Hedlin, M. A. H., D. Drob, K. Walker and C. de Groot-Hedlin, 2010. A study of acoustic propogation from a large bolide in the atmosphere with a dense seismic network. *J. Geophys. Res.,* 115, 1–17.
NOAA Weather and Climate Toolkit -> http://www.ncdc.noaa.gov/oa/wct/

NSF earthscope USArray the IRIS CONSORTIUM