Observations of Atmospheric Phenomena from USArray Observing System

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IGPP
UCSD

Antelope User Group
Allegro Papagayo, Costa Rica
4-6 November 2013

Array Network Facility

The Array Network Facility (ANF) at UC San Diego

- **Specializes in real-time data acquisition, quality control, dissemination of seismic and met data**

Two main projects:

- **USArray Transportable Array Network (anf.ucsd.edu)**
- **Anza Network – UCSD operated seismic network in SoCal**

Acknowledgements

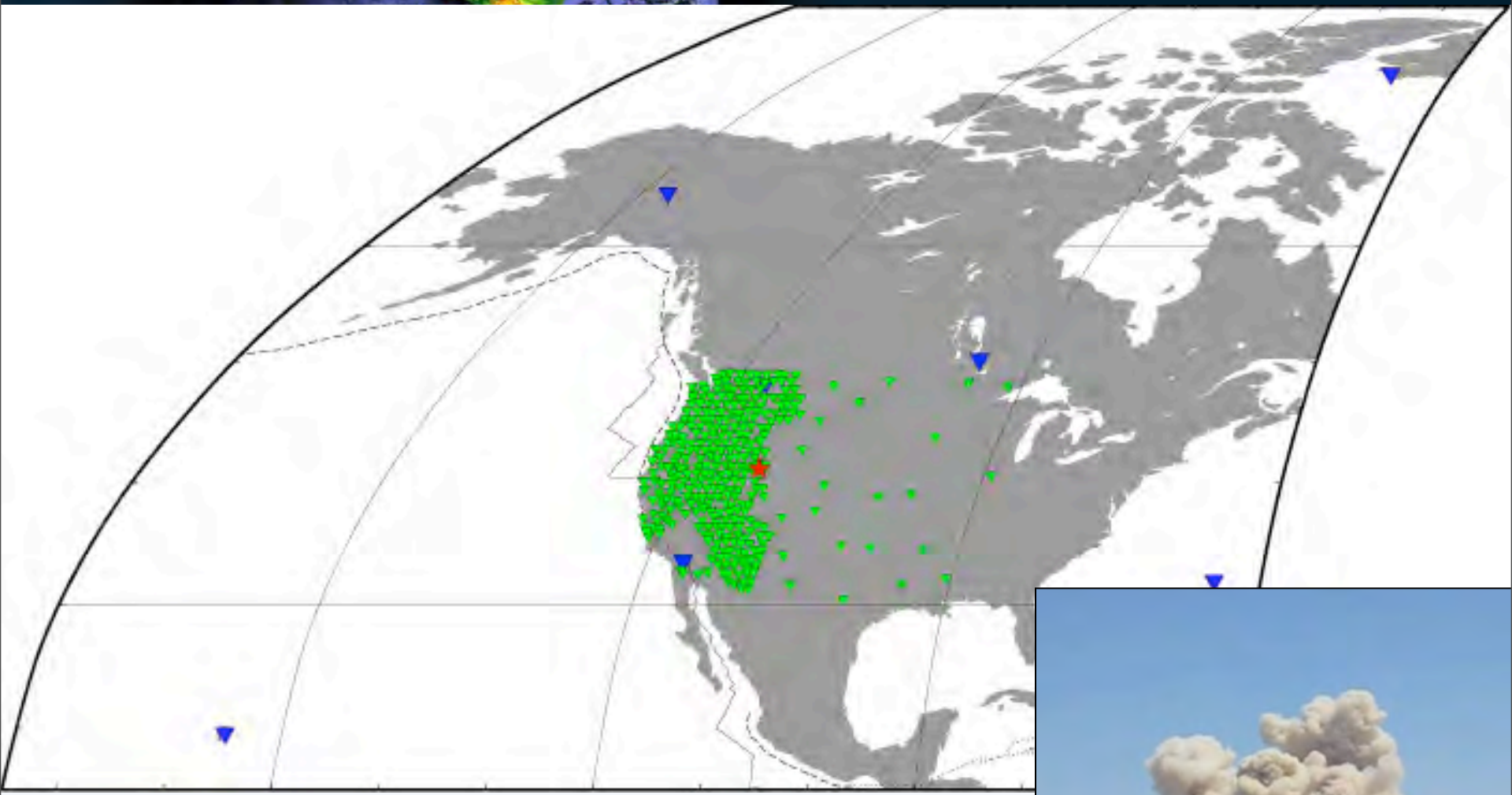
EarthScope is funded by the National Science Foundation.

EarthScope is being constructed, operated, and maintained as a collaborative effort with UNAVCO, IRIS, and Stanford University, with contributions from the US Geological Survey, NASA and several other national and international organizations.

Seismic Noise

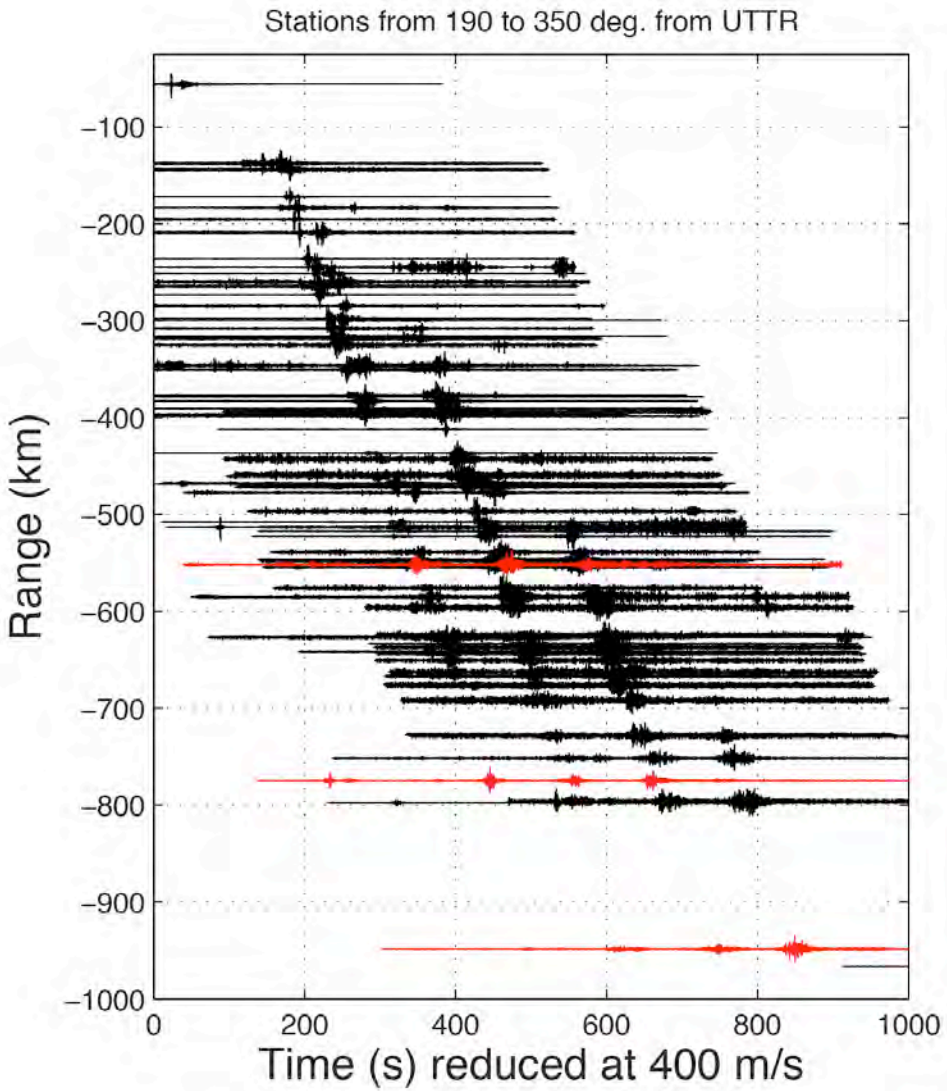
- **Multiple sources of seismic noise:**
  - **Anthropogenic**
    - **Planes**
    - **Trains**
    - **Automobiles**
  - **Natural**
    - **Wildlife**
    - **Rainfall**
    - **Hail**
    - **Wind**
    - **Thunder**
    - **Storms**
    - **Bolides (meteorites)**

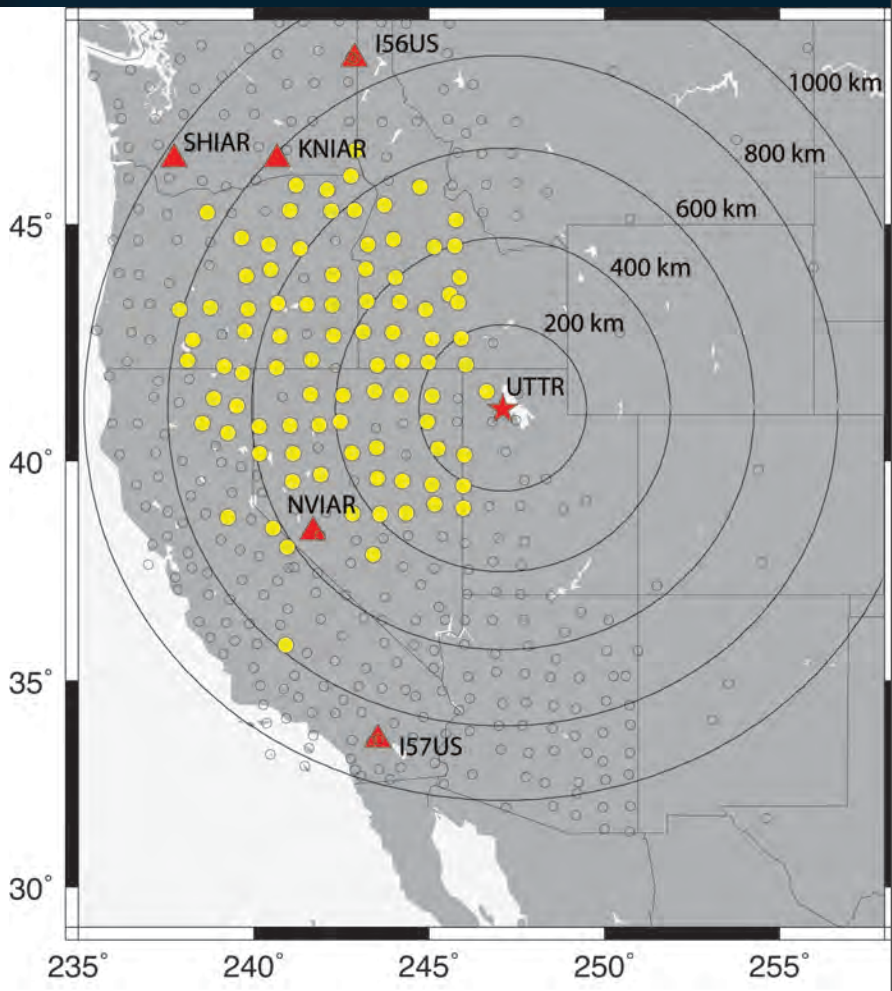
IMS Infrasound arrays and USArray TA in June, 2007



11 rocket motor detonations from May to September

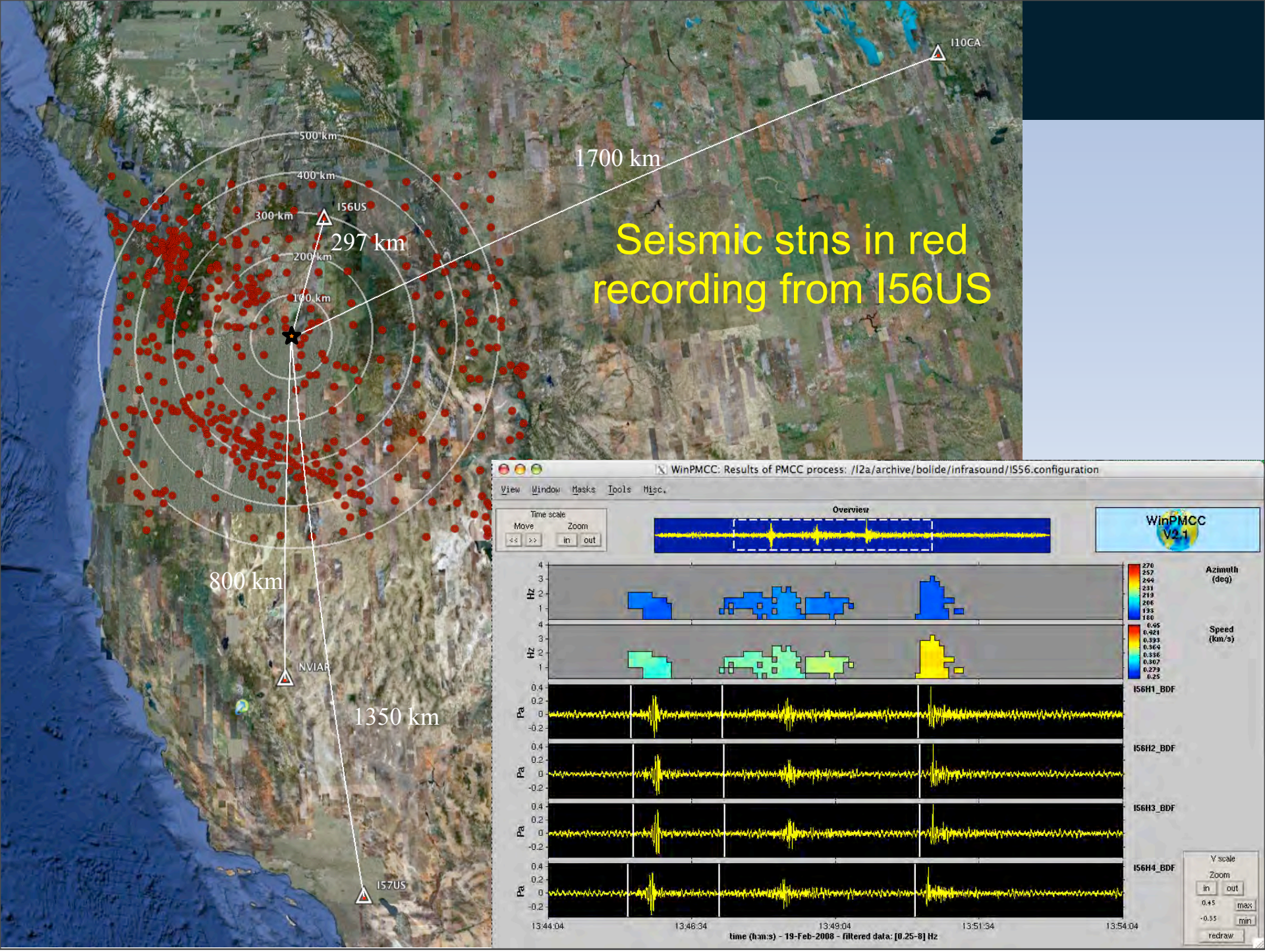
IMS Infrasound arrays and USArray TA in June, 2007





Oregon Bolide 2008-02-19

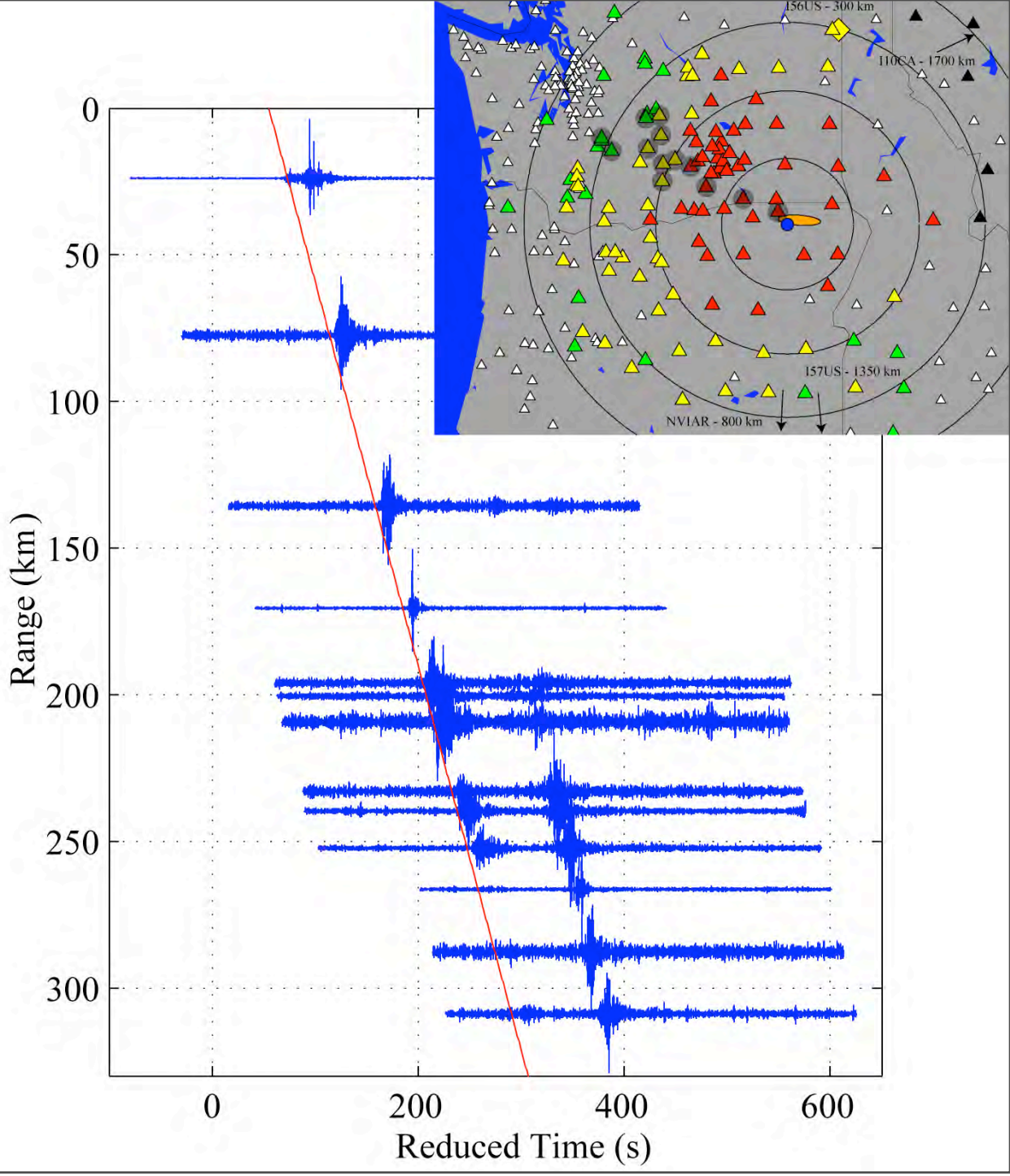
- A bolide burst above NE Oregon at 05:30 AM local time on Feb 19, 2008
- The event was recorded by 4 infrasound arrays and several hundred seismic stations in the USArray and regional networks
- The seismic stations reveal how infrasound signals vary with range and azimuth
- Celerity (horizontal distance traveled/travel time) vs range plots may shed light on propagation paths and provide useful information about atmospheric structure


I10CA
1700 km
500 km
400 km
300 km
I56US
297 km
200 km
100 km
Seismic stns in red
recording from I56US
800 km
NVIAR
1350 km
I57US
WinPMCC: Results of PMCC process: /I2a/archive/bolide/infrasound/IS56.configuration
View
Window
Masks
Tools
Misc.
Time scale
Move
Zoom
Overview
WinPMCC
V2.1
Azimuth
(deg)
Speed
(km/s)
I56H1_BDF
I56H2_BDF
I56H3_BDF
I56H4_BDF
Hz
Pa
Y scale
Zoom
in
out
max
min
redraw
13:44:04
13:46:34
13:49:04
13:51:34
13:54:04
time (h:m:s) - 19-Feb-2008 - filtered data: [0.25-8] Hz

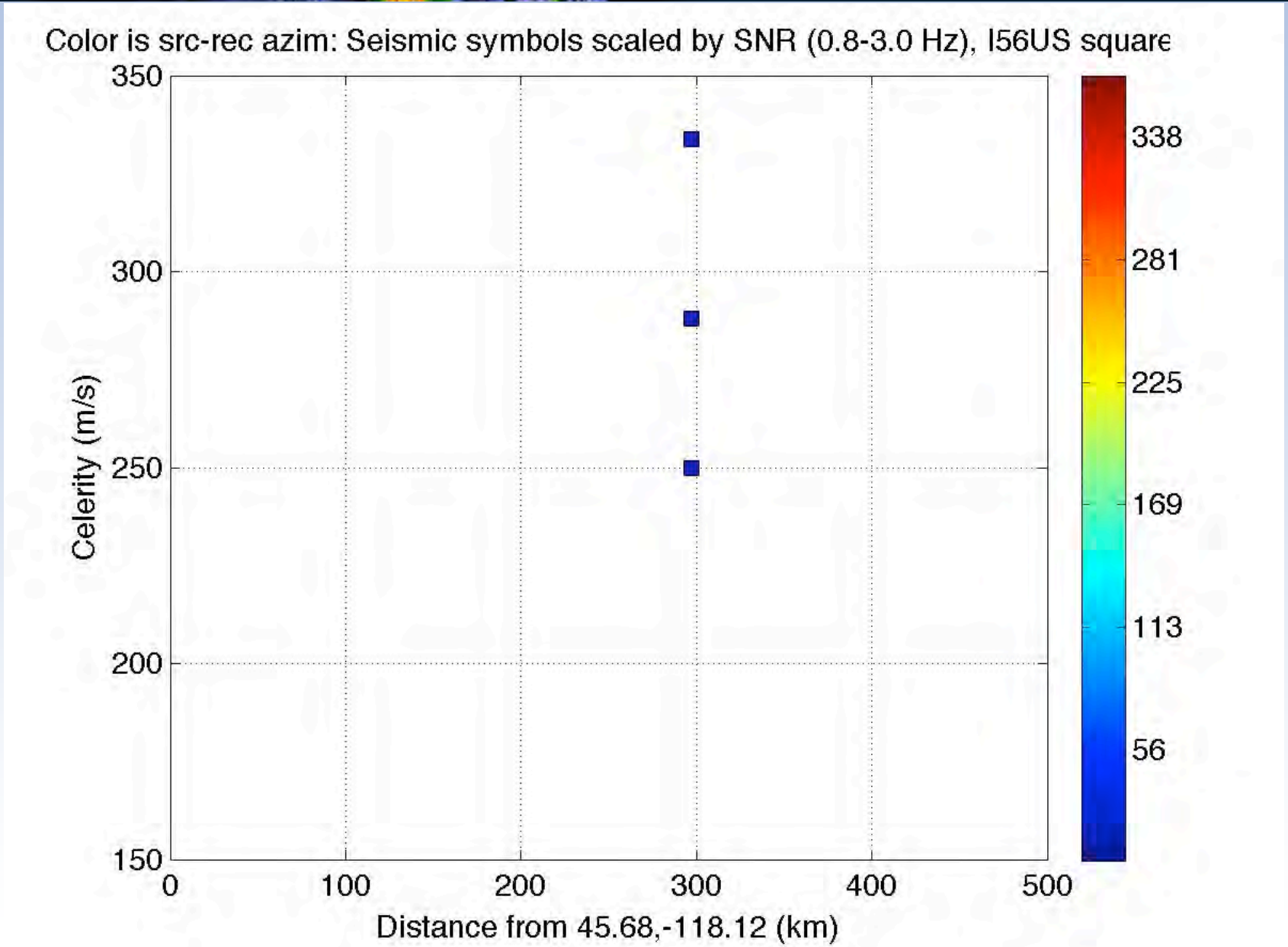
Sample record section to west of event

Z components

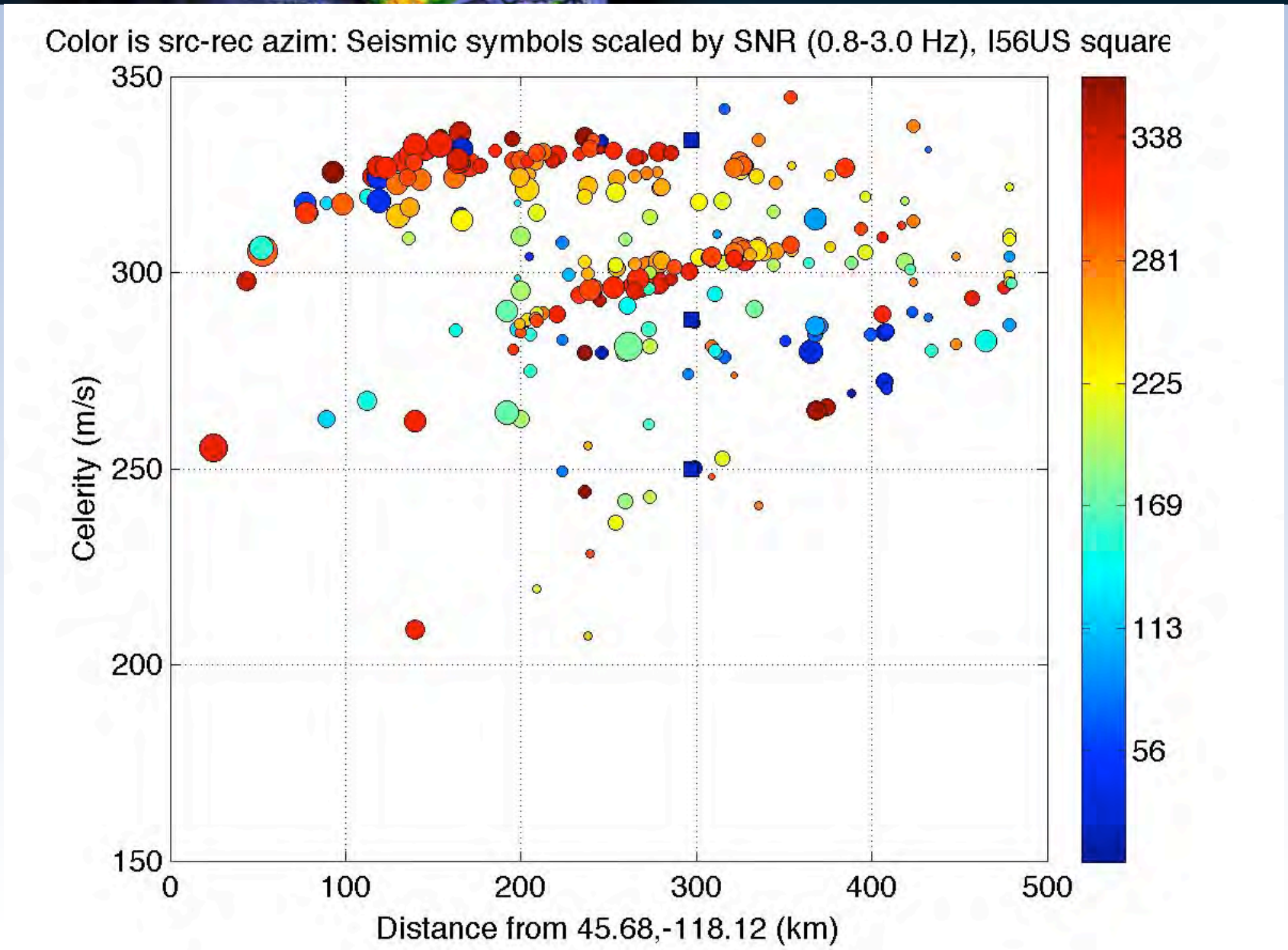
Bp 0.8-3.0 Hz



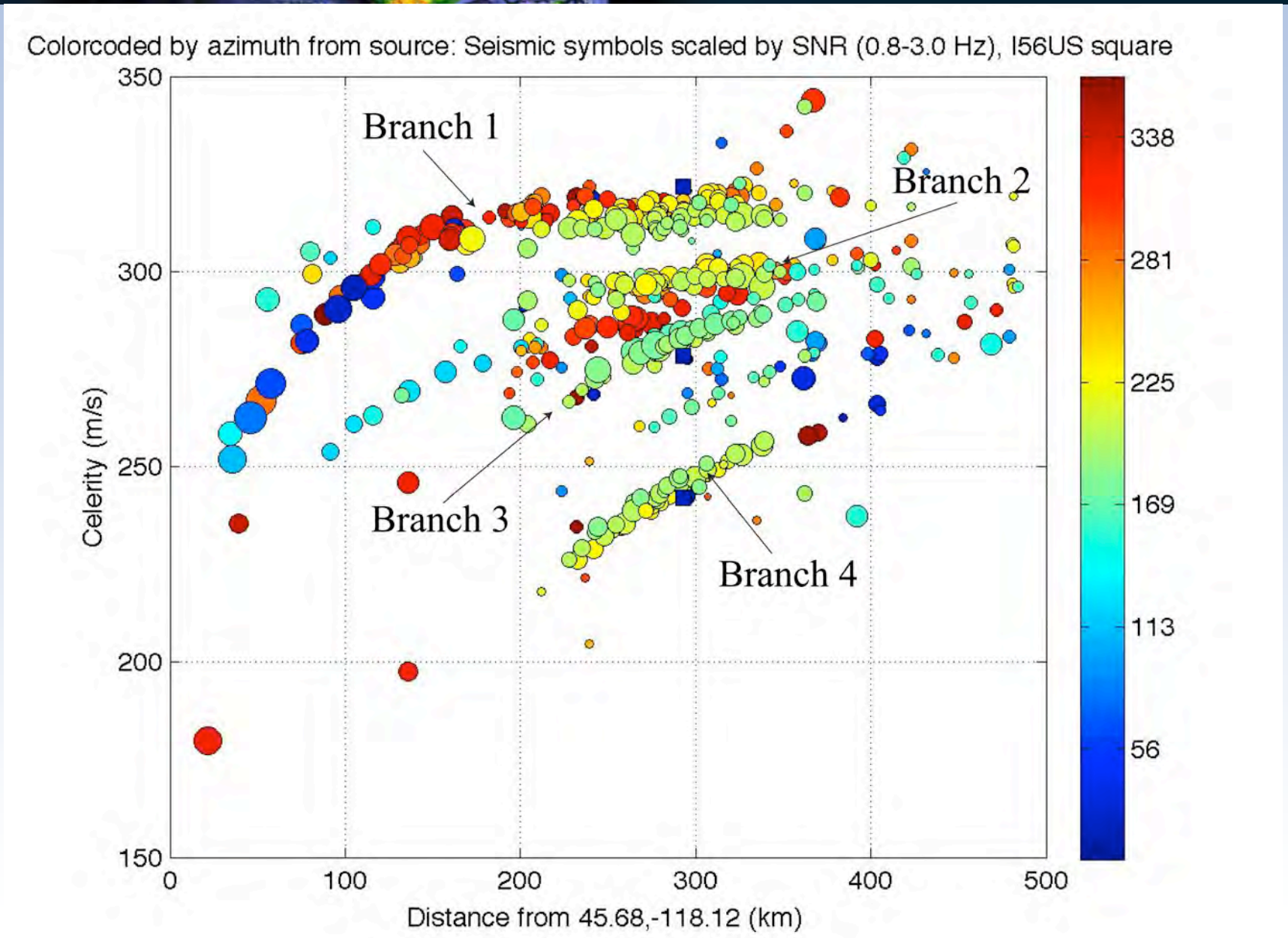
Array Celerity



TA + Array Celerity

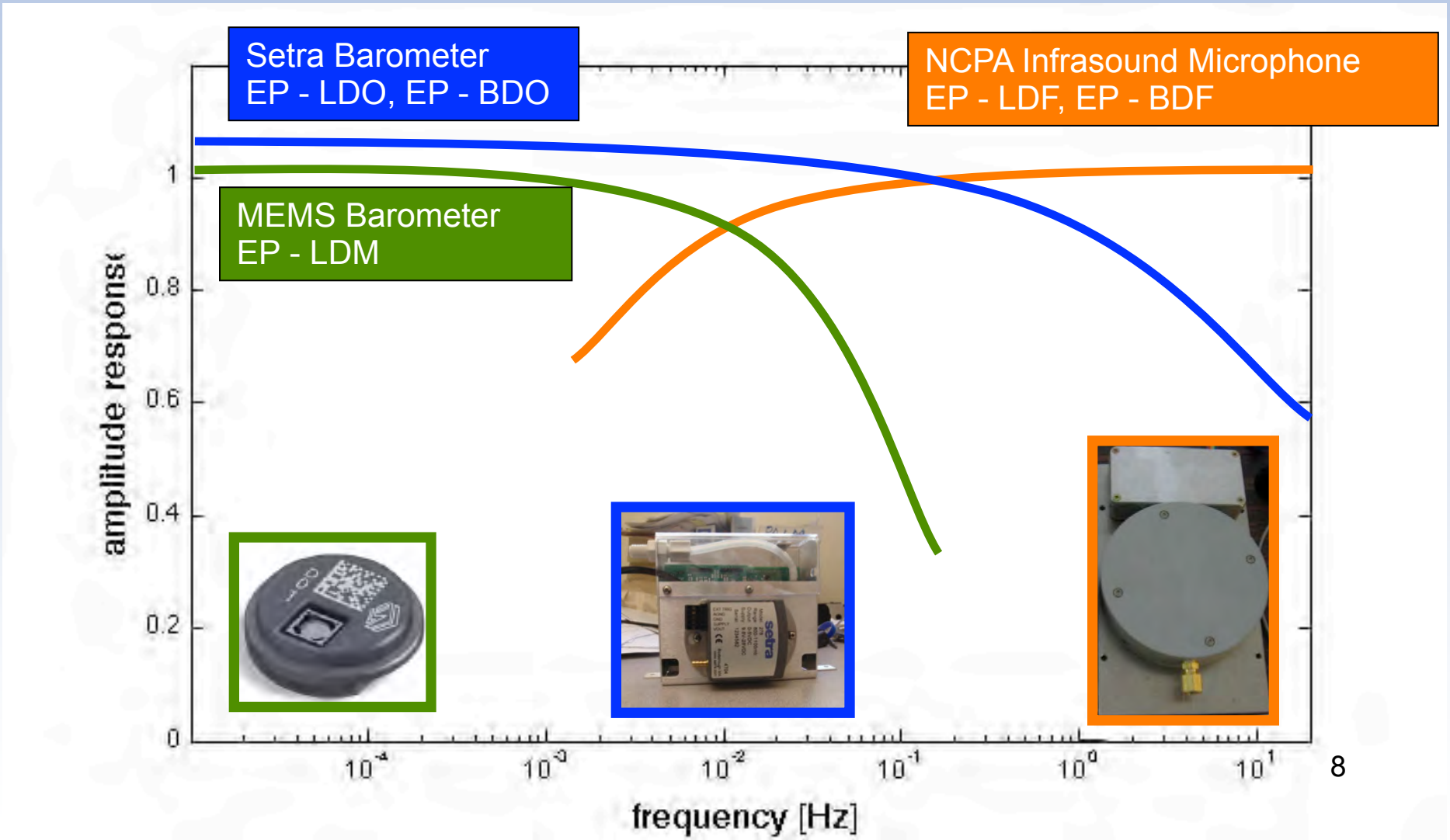


Acoustic branches Hedlin et al 2010



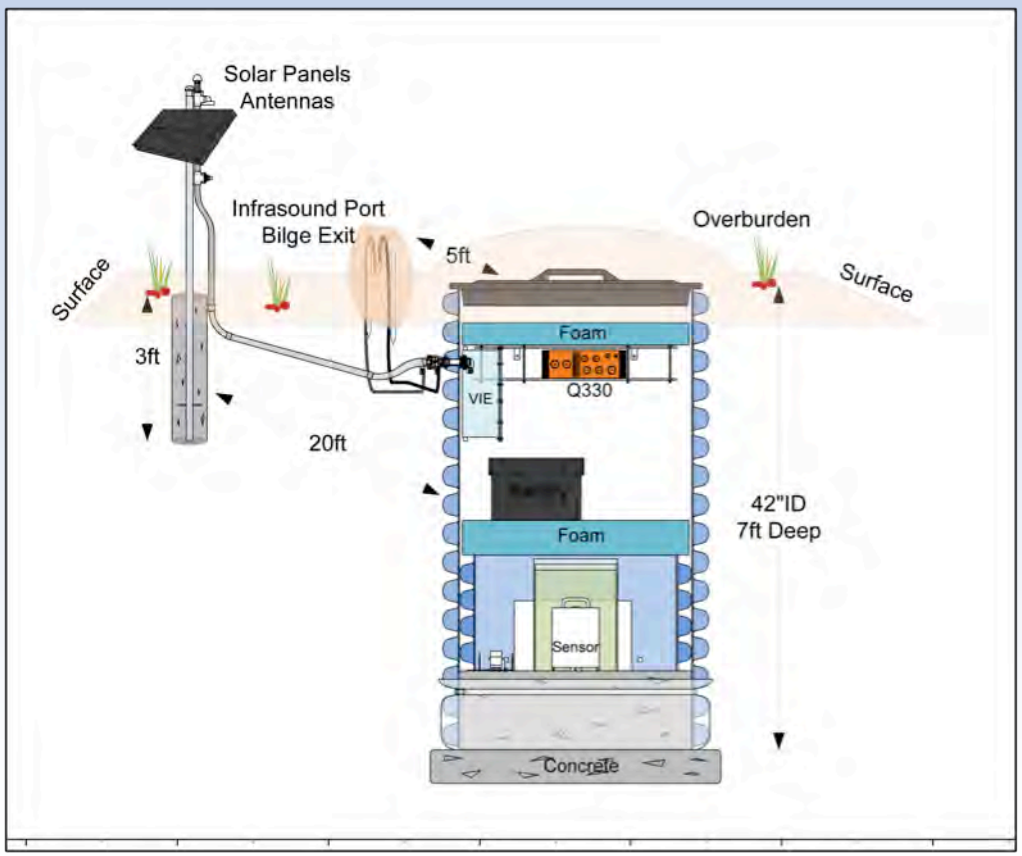
Pressure Sensor Response

- Overlapping pass-bands provides continuous coverage from DC to 20 Hz



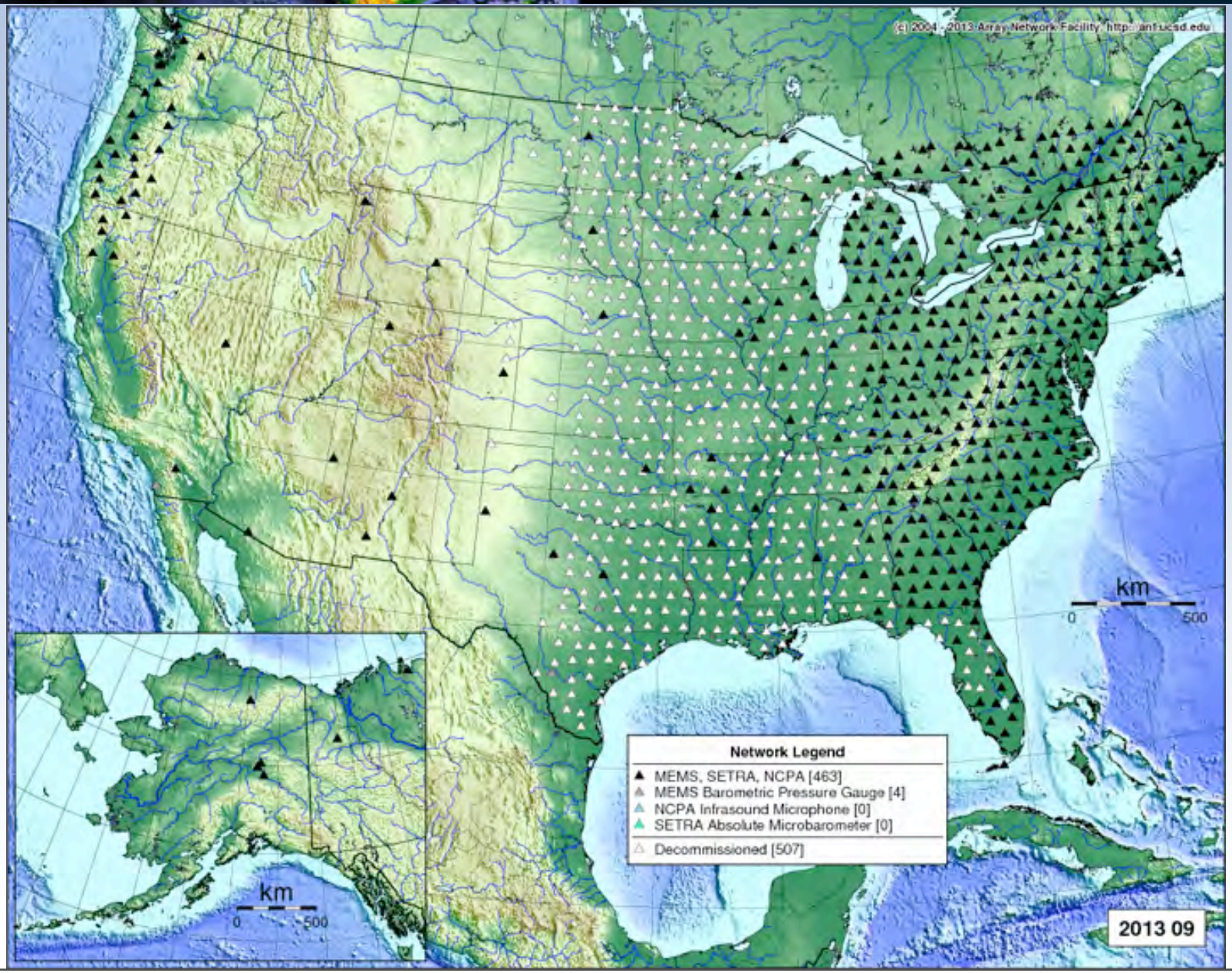
Basic Description

- Sensor: 3 component Broadband seismometer & auxiliary sensors
- Datalogger & local data storage
- Power & data telemetry



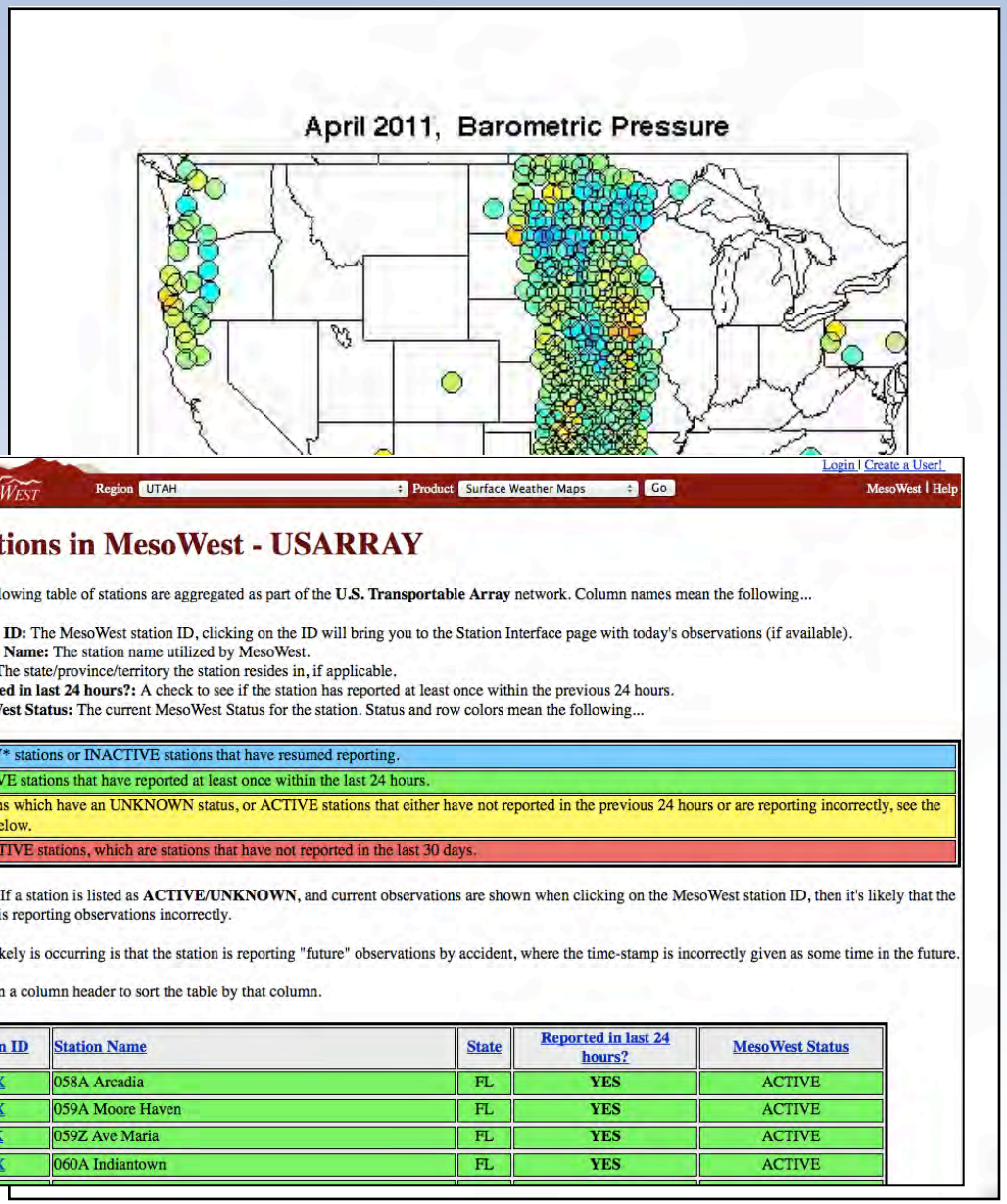
TA Station 345A, MS

Implementation of Atmospheric Pressure Sensors



Pressure Observations

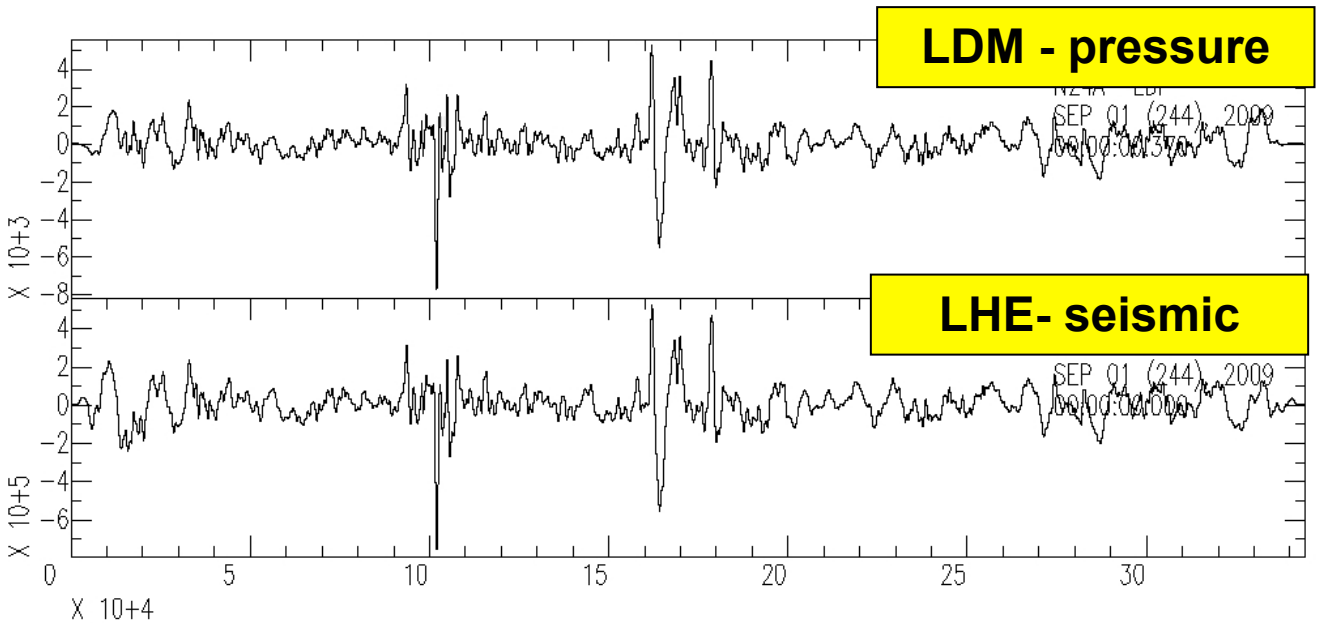
- Pressure and infrasound at every TA station
- Sampled at 40 samples per second
- Pressure fluctuations from DC to 20 Hz
- Multiple applications
  - Noise induced on vertical and horizontal seismic channels
  - Meso-scale atmosphere variation
  - Acoustic energy propagating in the atmosphere
  - Acoustic – seismic coupling



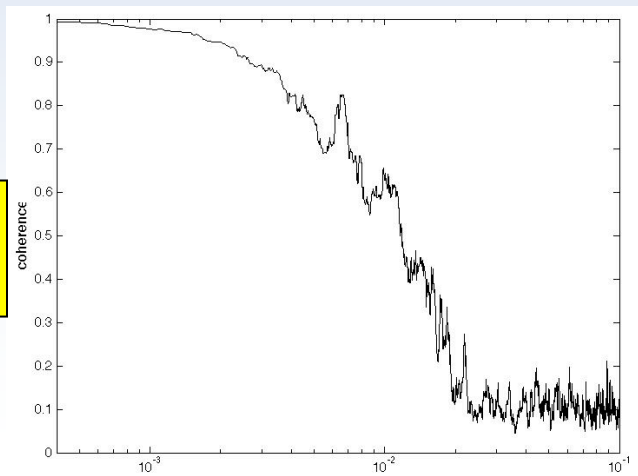
MesoWest is accessing data via web services

Basic Observation

- Pressure observations show strong correlation to seismic data

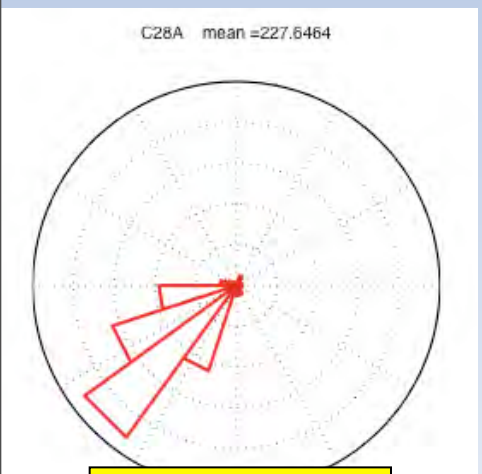


Pressure – Seismic Coherence

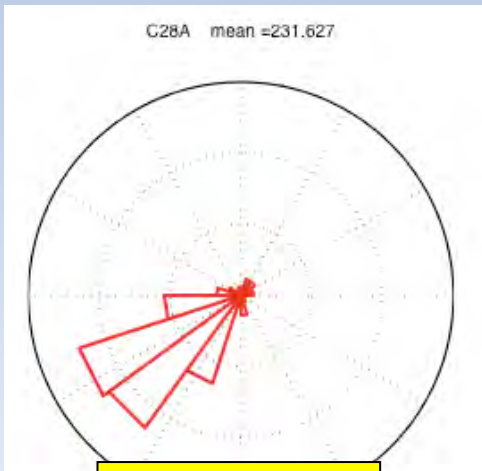


Coherent Behavior at Neighboring Stations

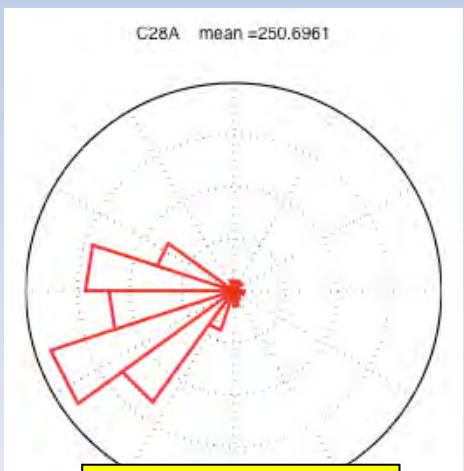
- Preferred orientation stable, but changes with time
- Neighboring stations C28A-D28A (70 km) behave similarly



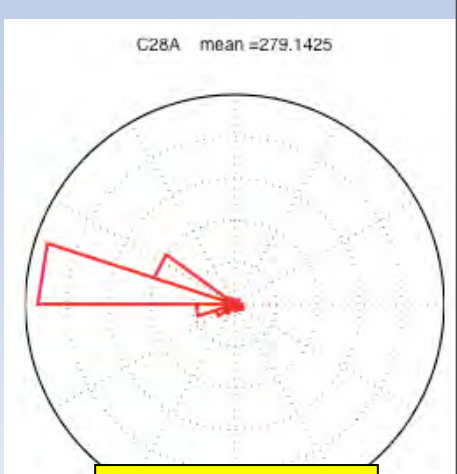
Aug 2010



Sept 2010



Oct 2010



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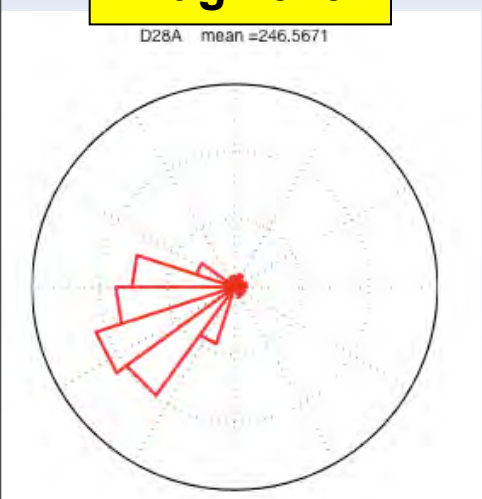
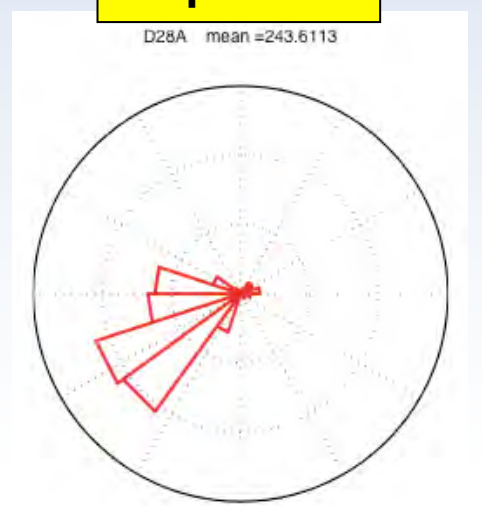
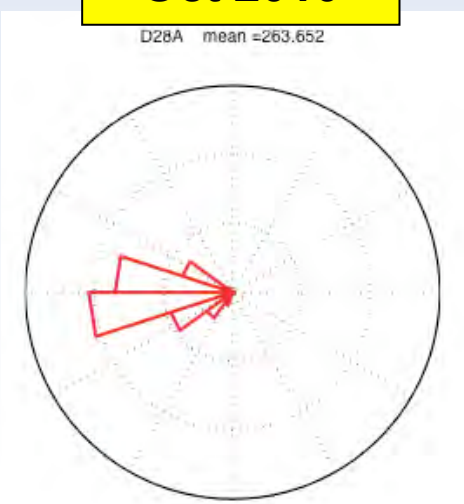
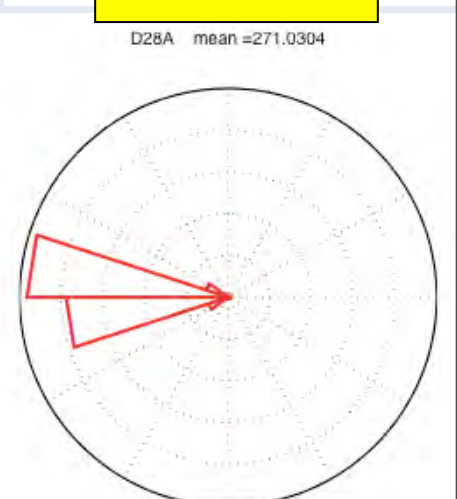
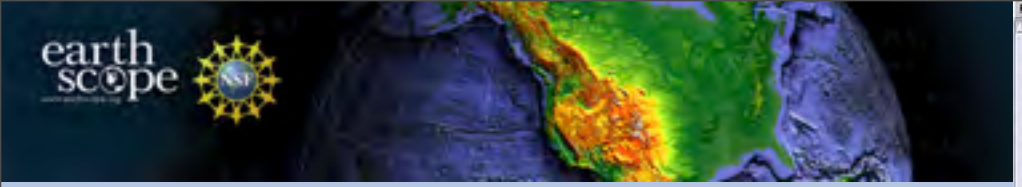


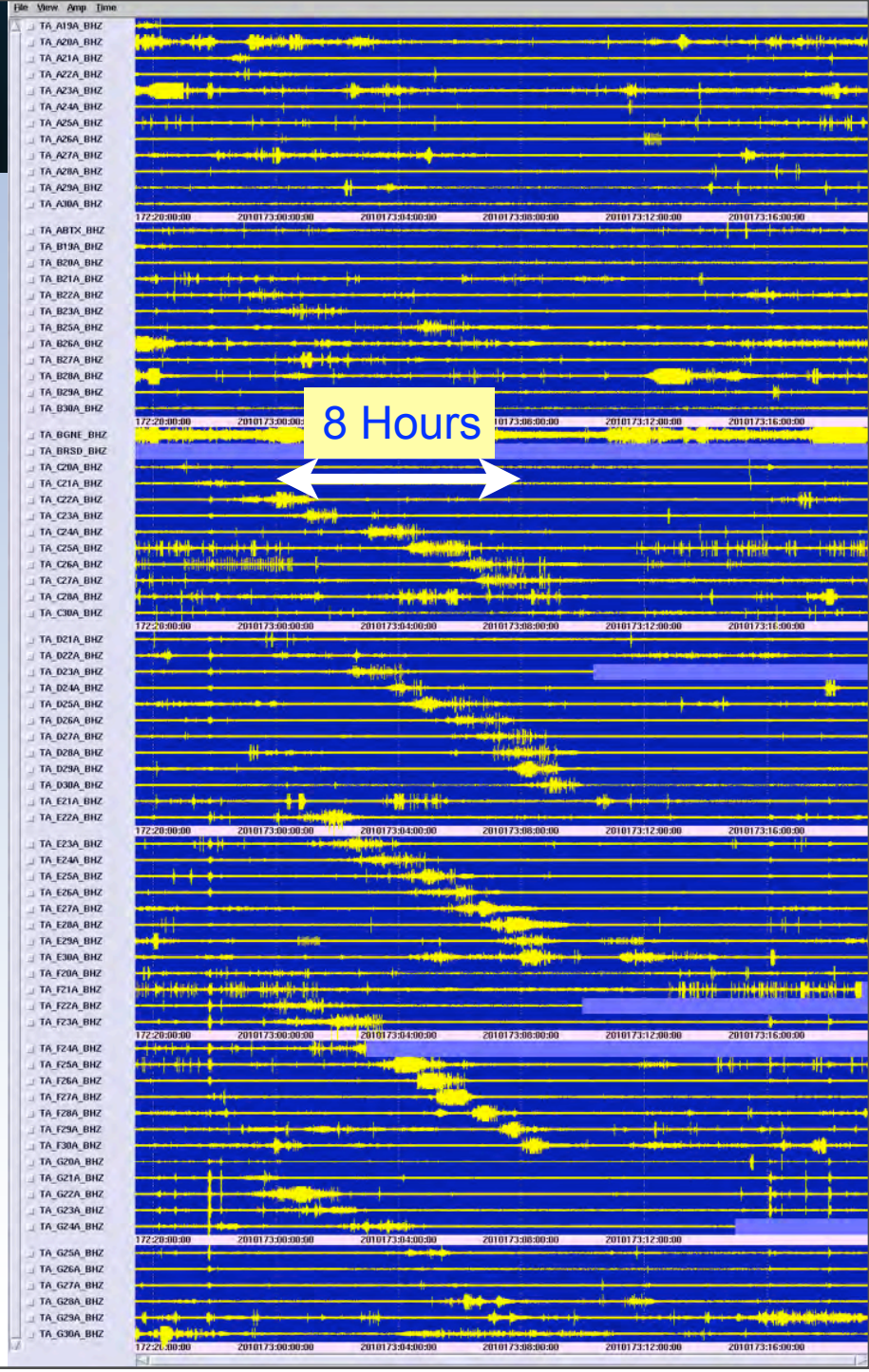


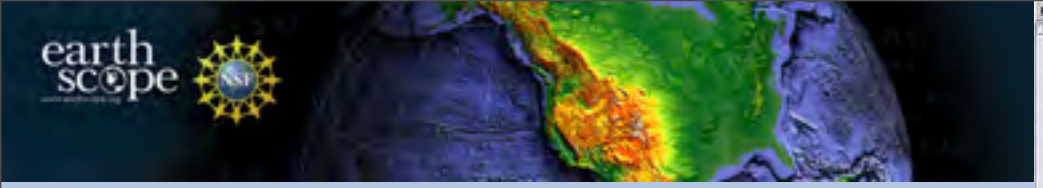




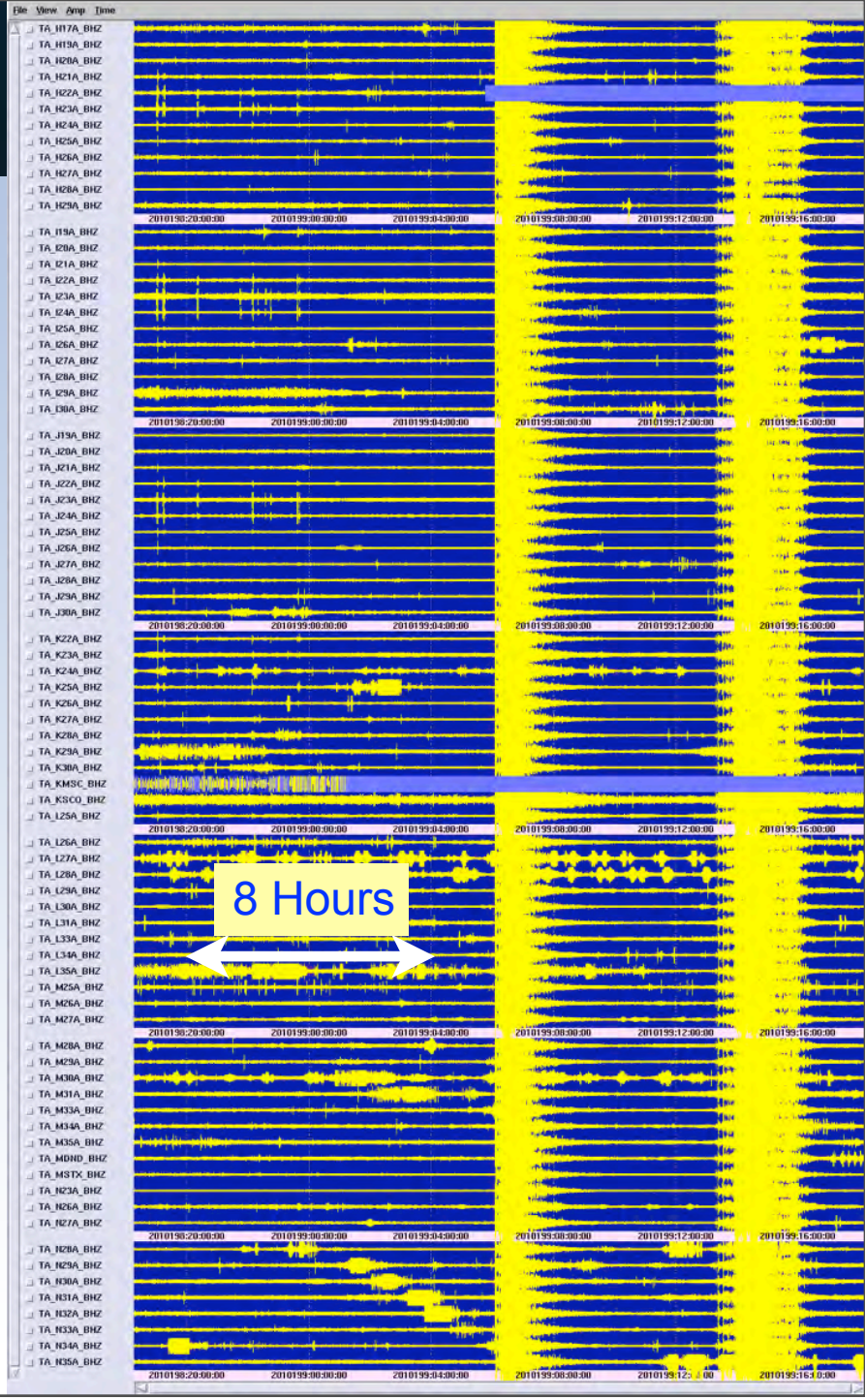


- Strange signals
- Correlated across stations
- Slow move out
- Too slow for seismic
- Too slow for infrasound





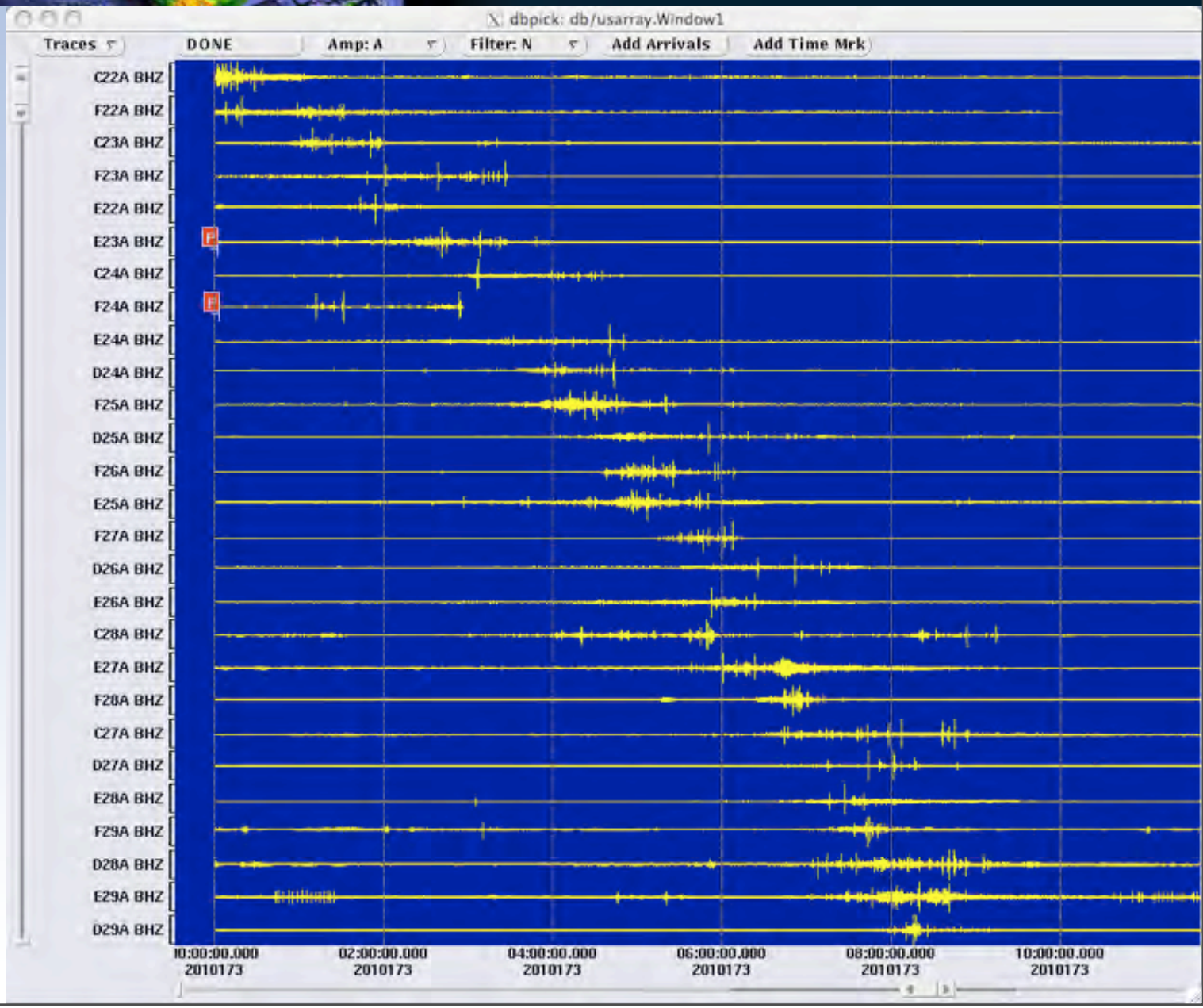
- 6.7 Aleutian Islands
- 6.9 New Britain
- 7.3 New Britain
- Slow move out
  - Too slow for seismic
  - Too slow for infrasound



Interesting Signals

40 sps

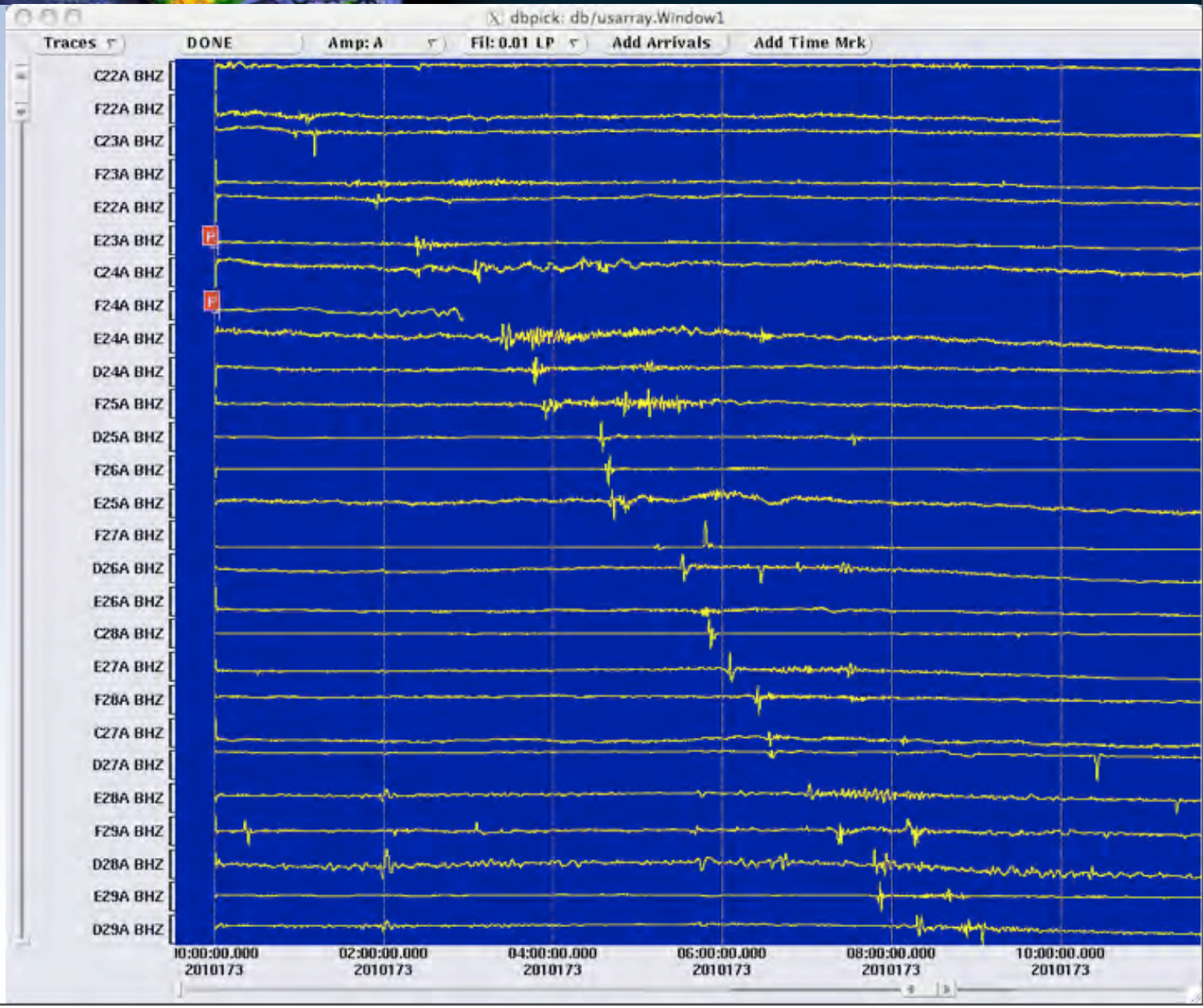
Unfiltered



Interesting Signals

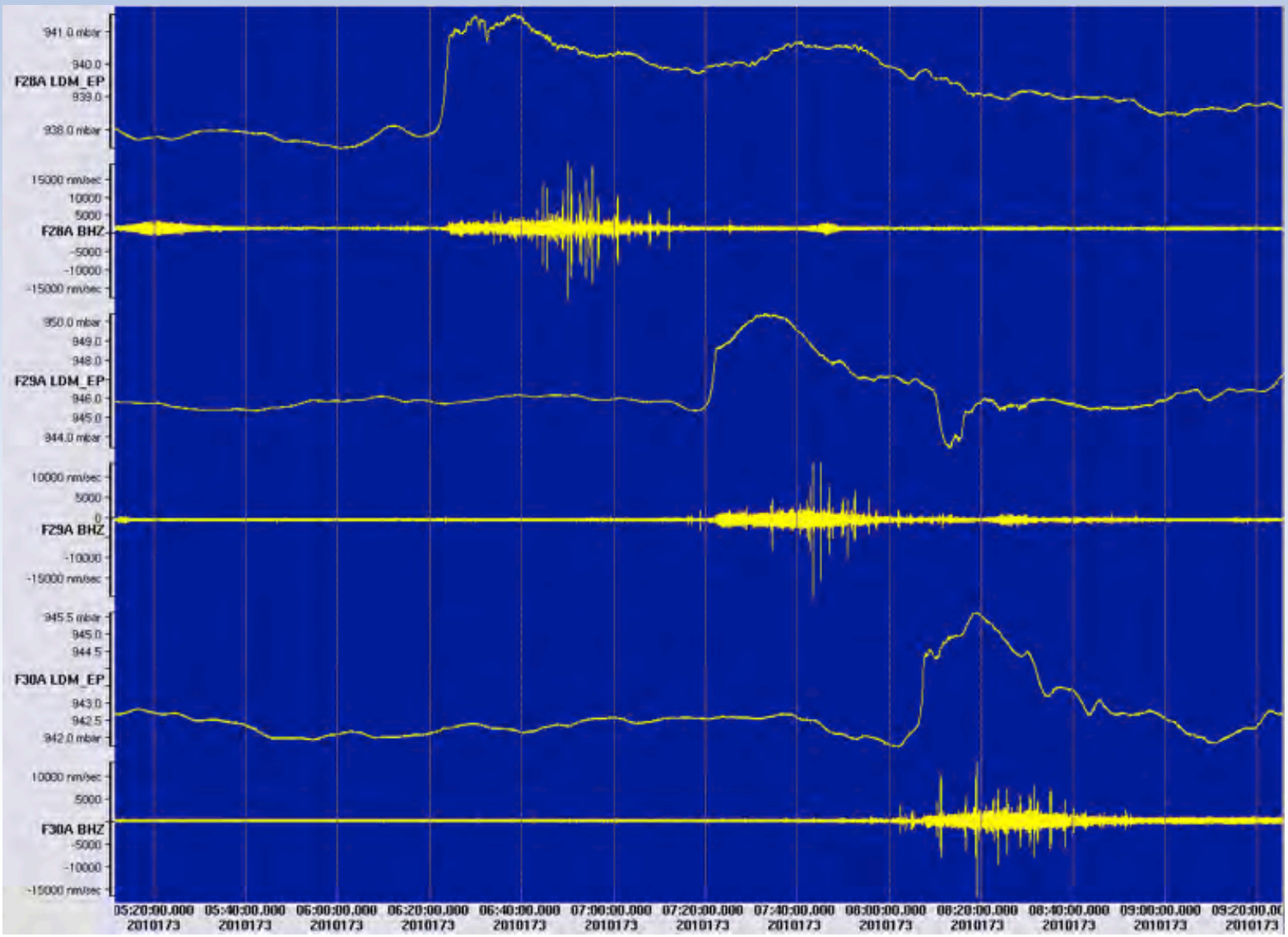
40 sps

DC - 0.01 Lowpass Filter



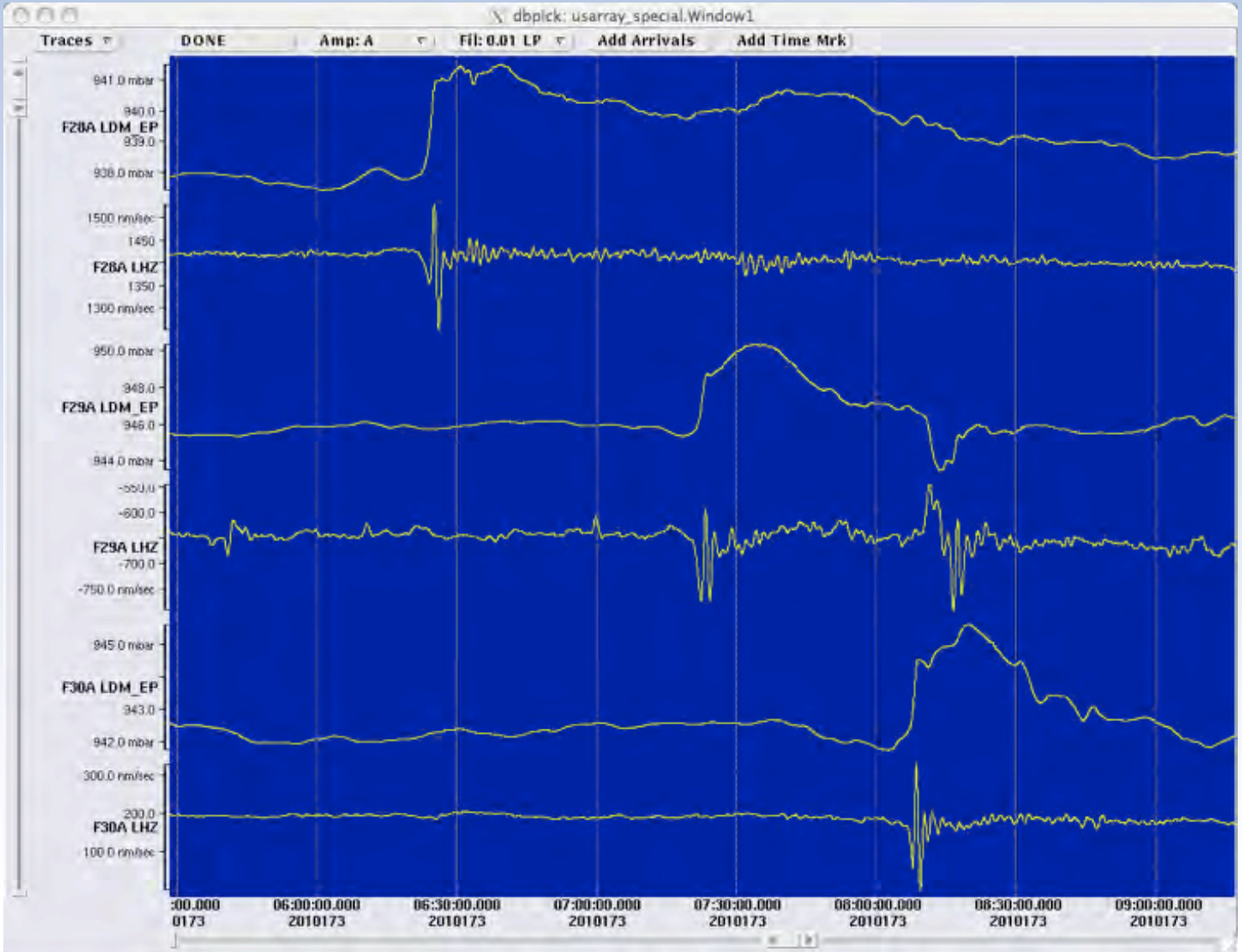
Interesting Signals

Broadband Seismic (40 sps) compared to Atmospheric Pressure (1 sps)

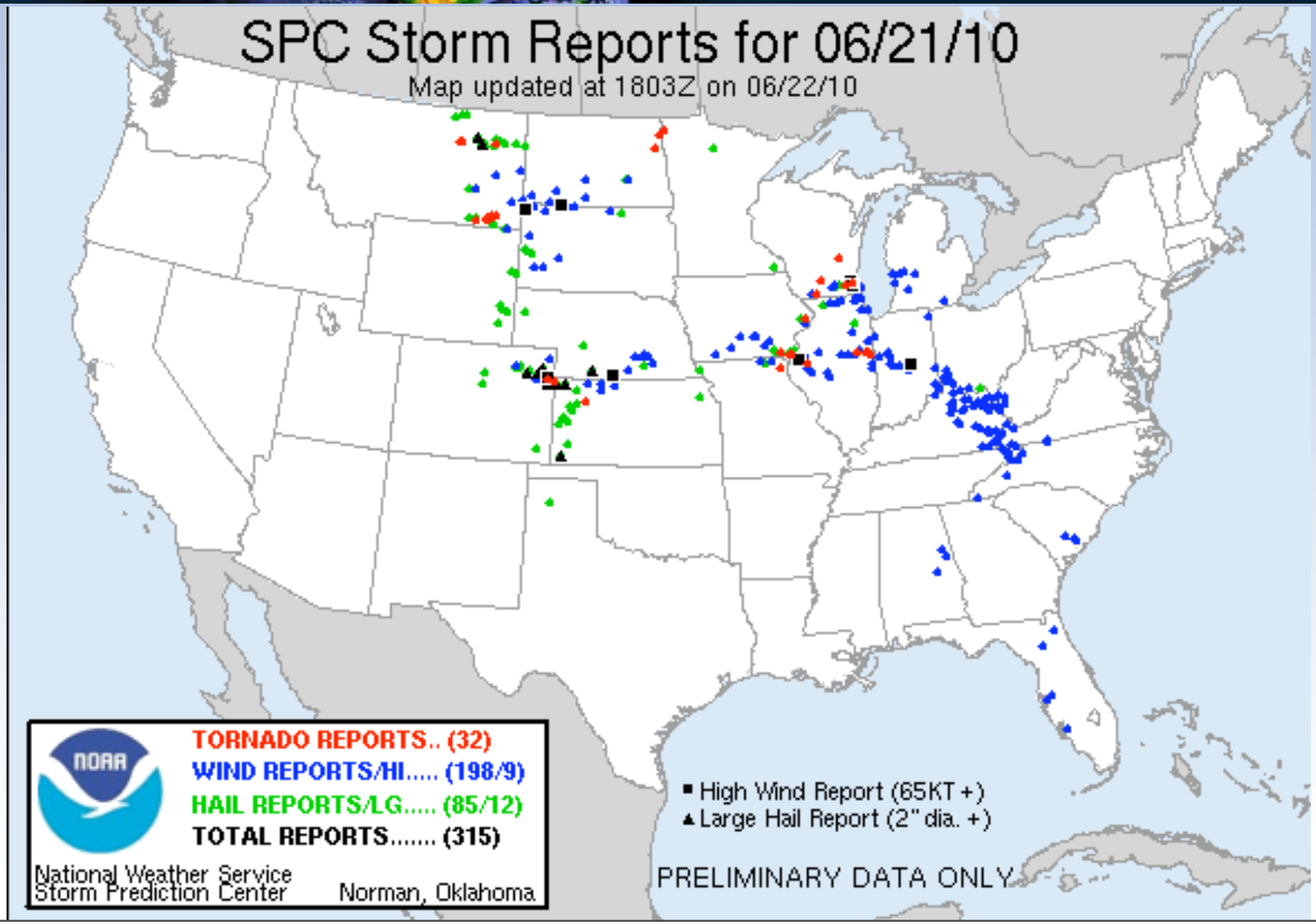


Interesting Signals

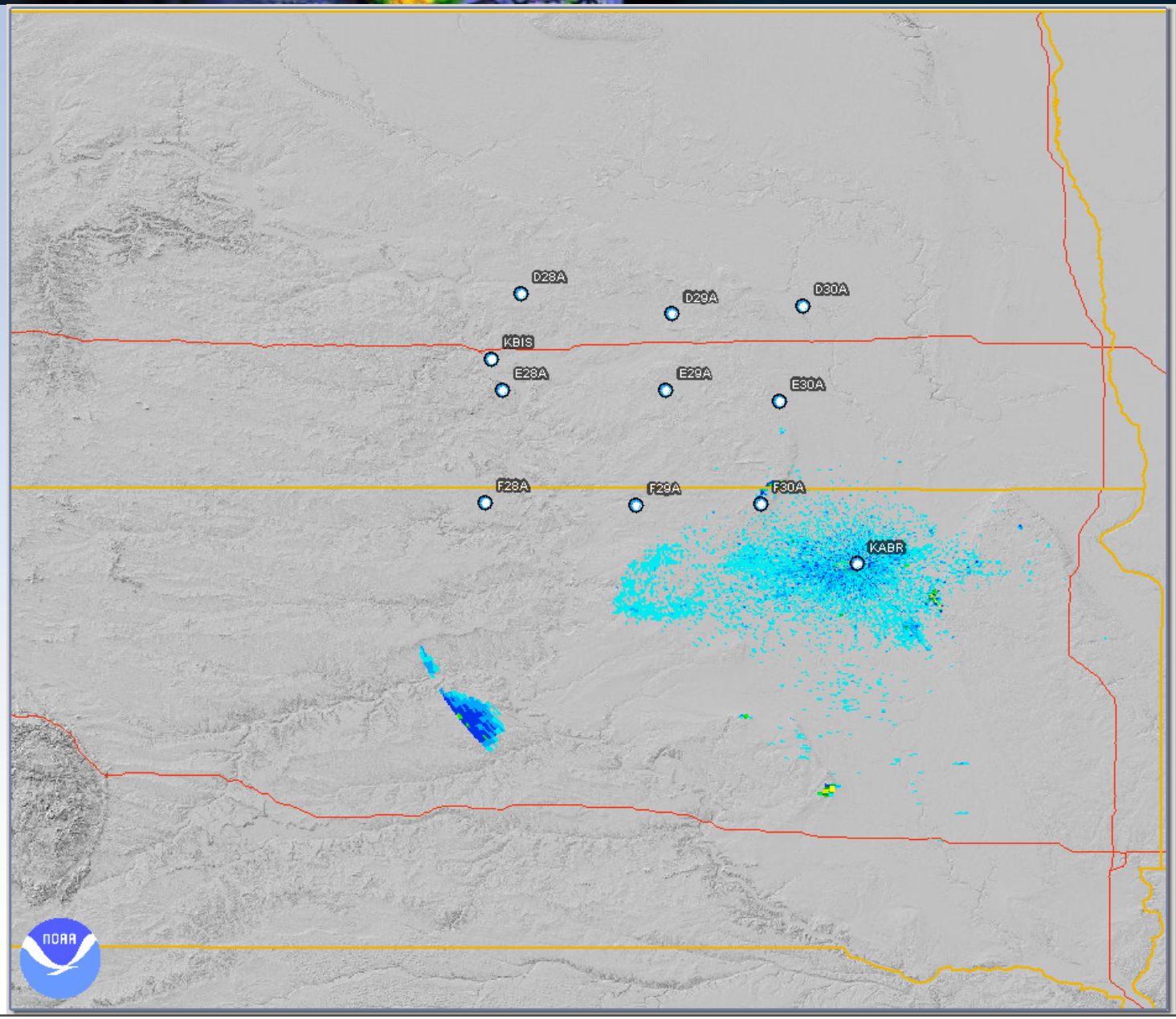
Low Frequency Seismic (< 0.01 Hz) compared to Atmospheric Pressure (1 sps)
Ground deforming to pressure increase



Storm Reports



Interesting Signals



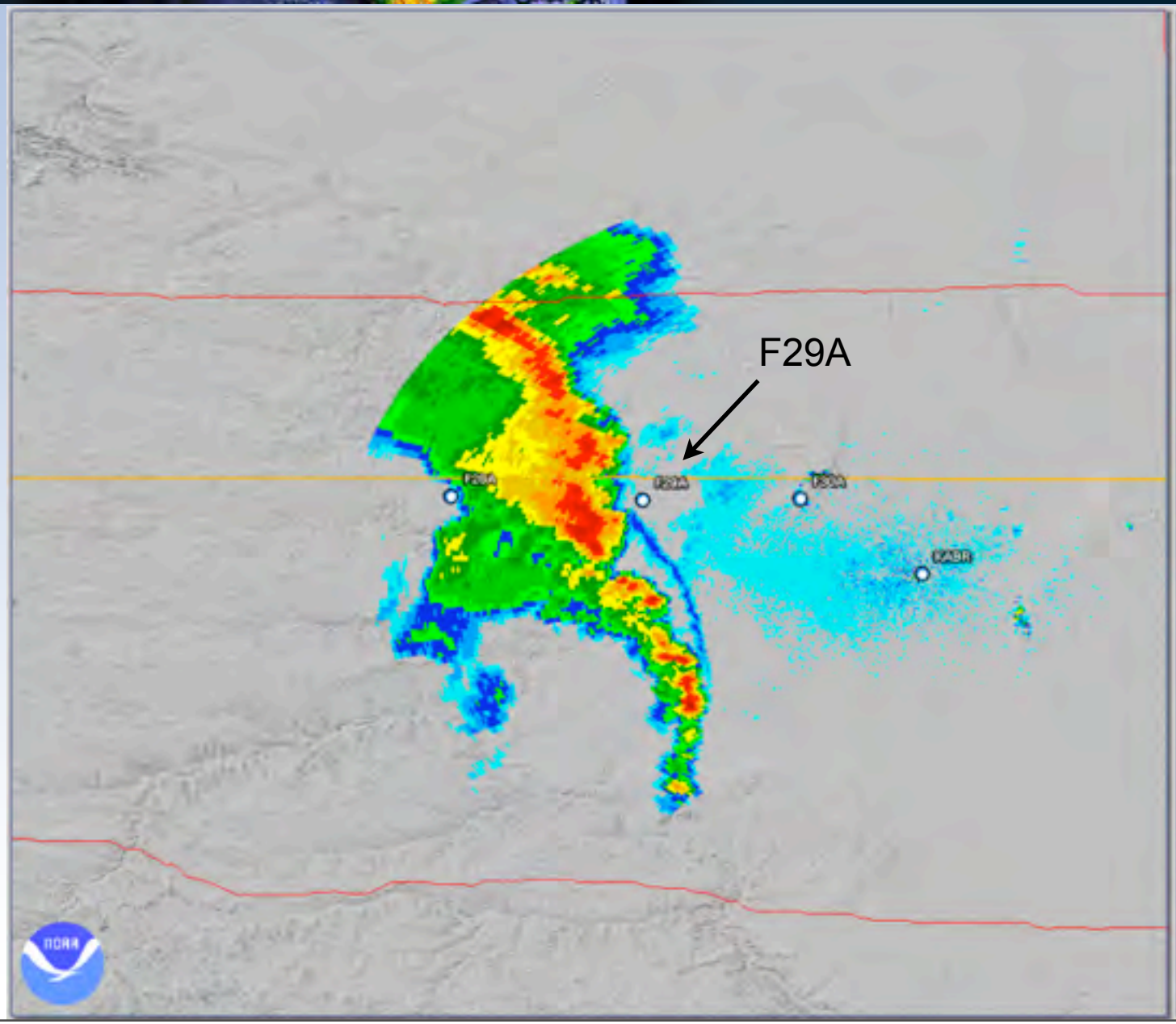
NEXRAD LEVEL-III
BASE REFLECTIVITY
KABR - ABERDEEN, SD
06/22/2010 04:58:35 GMT
LAT: 45/27/21 N
LON: 98/24/46 W
ELEV: 1383 FT
MODE/VCP: A / 212

ELEV ANGLE: 0.50 °
MAX: 46 dBZ

Legend: dBZ (Category)

75 (15)
70 (14)
65 (13)
60 (12)
55 (11)
50 (10)
45 (9)
40 (8)
35 (7)
30 (6)
25 (5)
20 (4)
15 (3)
10 (2)
5 (1)

Radar Image 1 - F29A



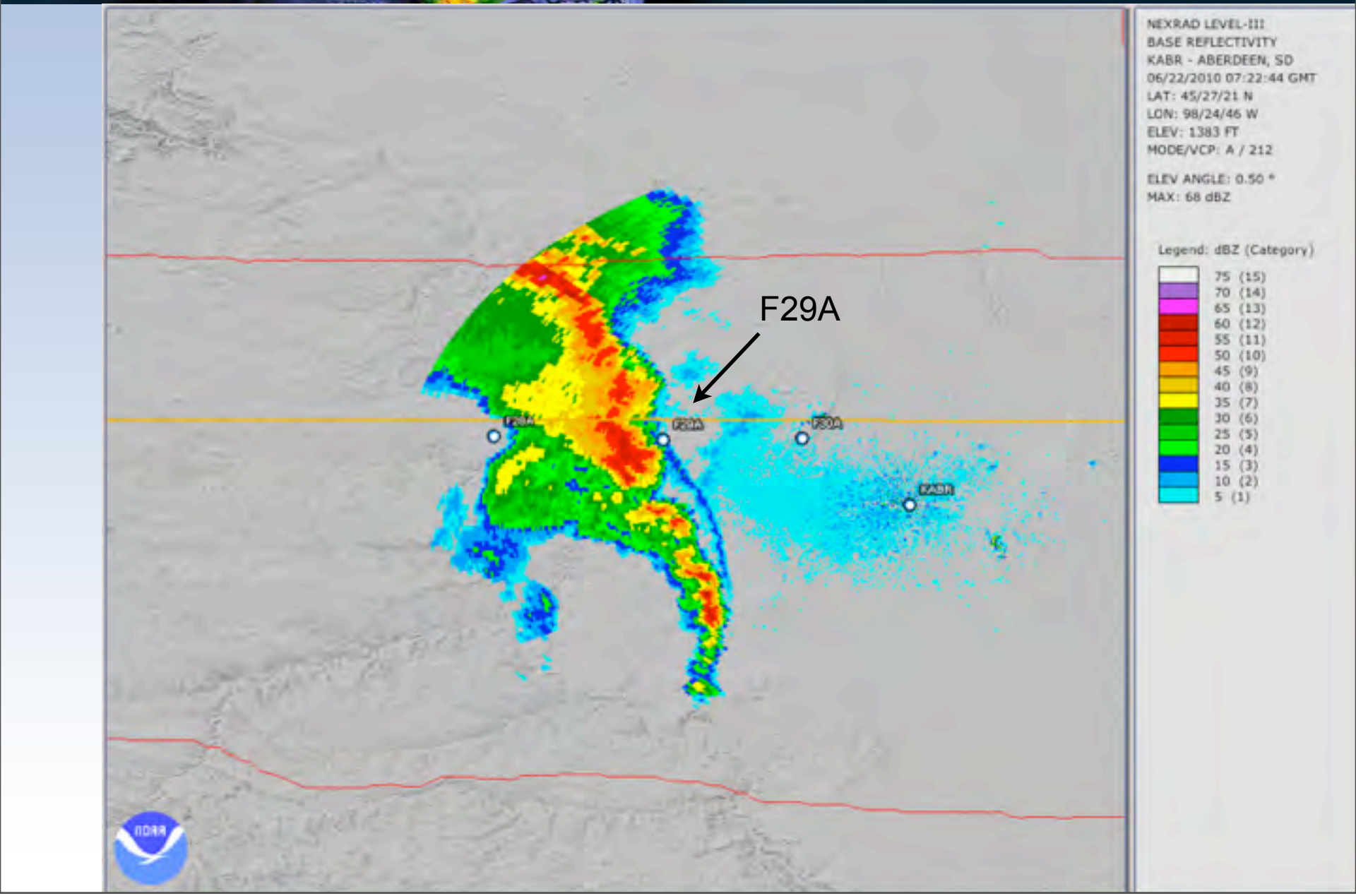
NEXRAD LEVEL-III
BASE REFLECTIVITY
KABR - ABERDEEN, SD
06/22/2010 07:18:15 GMT
LAT: 45/27/21 N
LON: 98/24/46 W
ELEV: 1383 FT
MODE/VCP: A / 212

ELEV ANGLE: 0.50 °
MAX: 63 dBZ

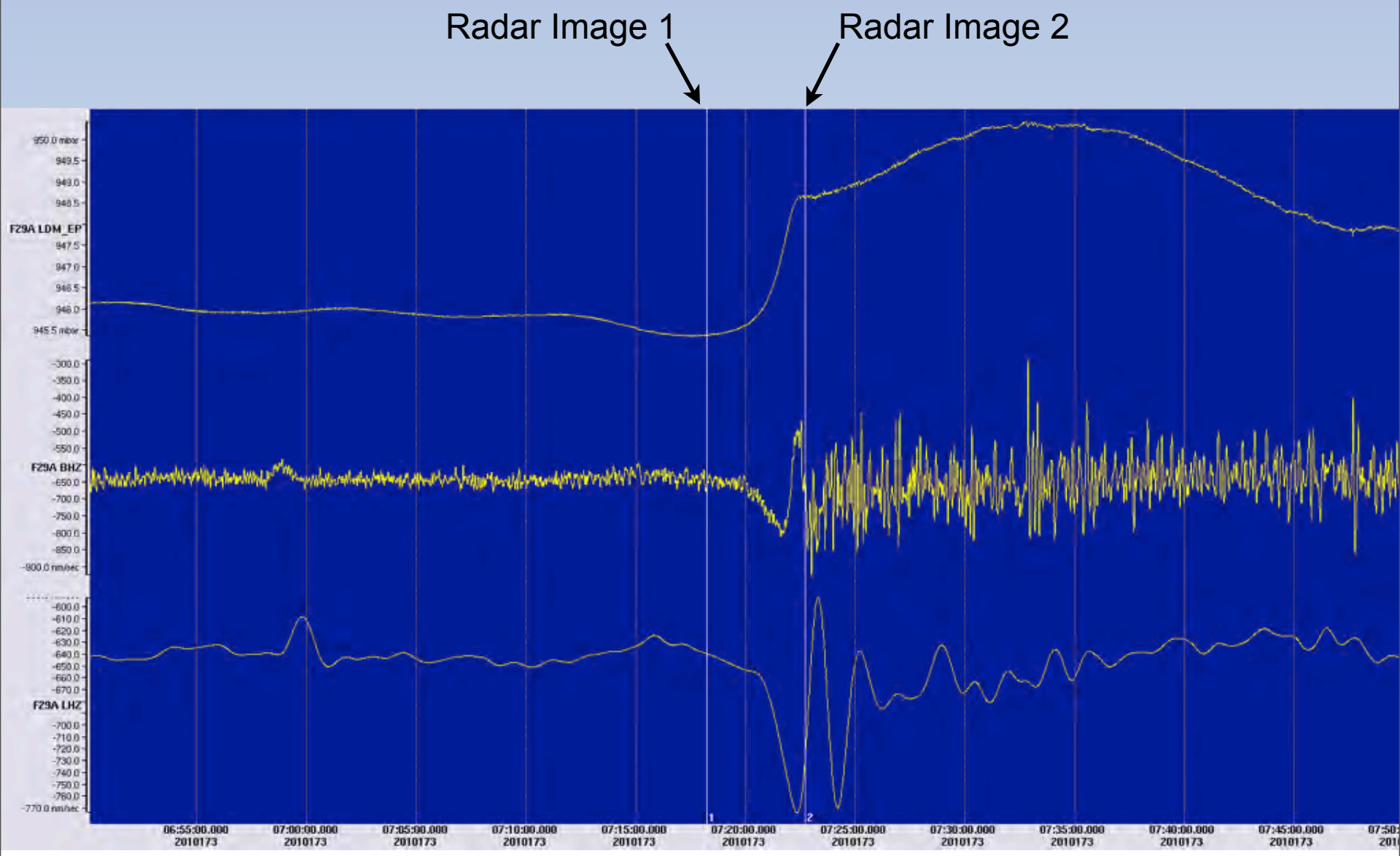
Legend: dBZ (Category)

75	(15)
70	(14)
65	(13)
60	(12)
55	(11)
50	(10)
45	(9)
40	(8)
35	(7)
30	(6)
25	(5)
20	(4)
15	(3)
10	(2)
5	(1)

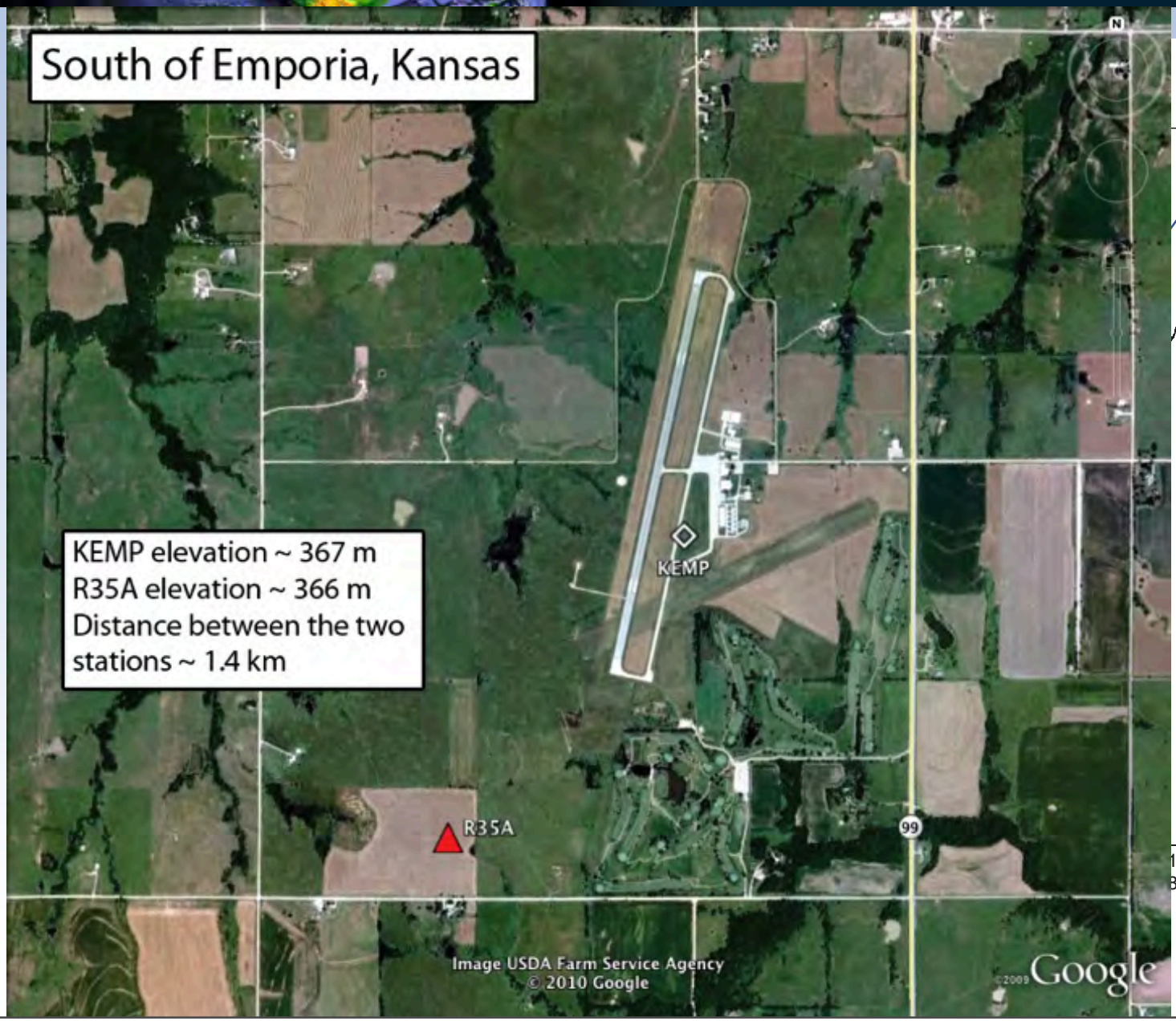
Radar Image 2 - F29A

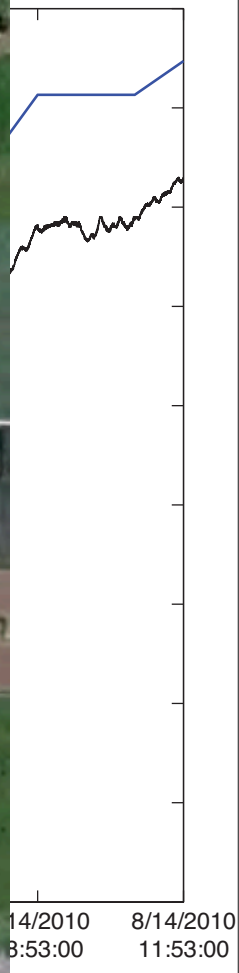


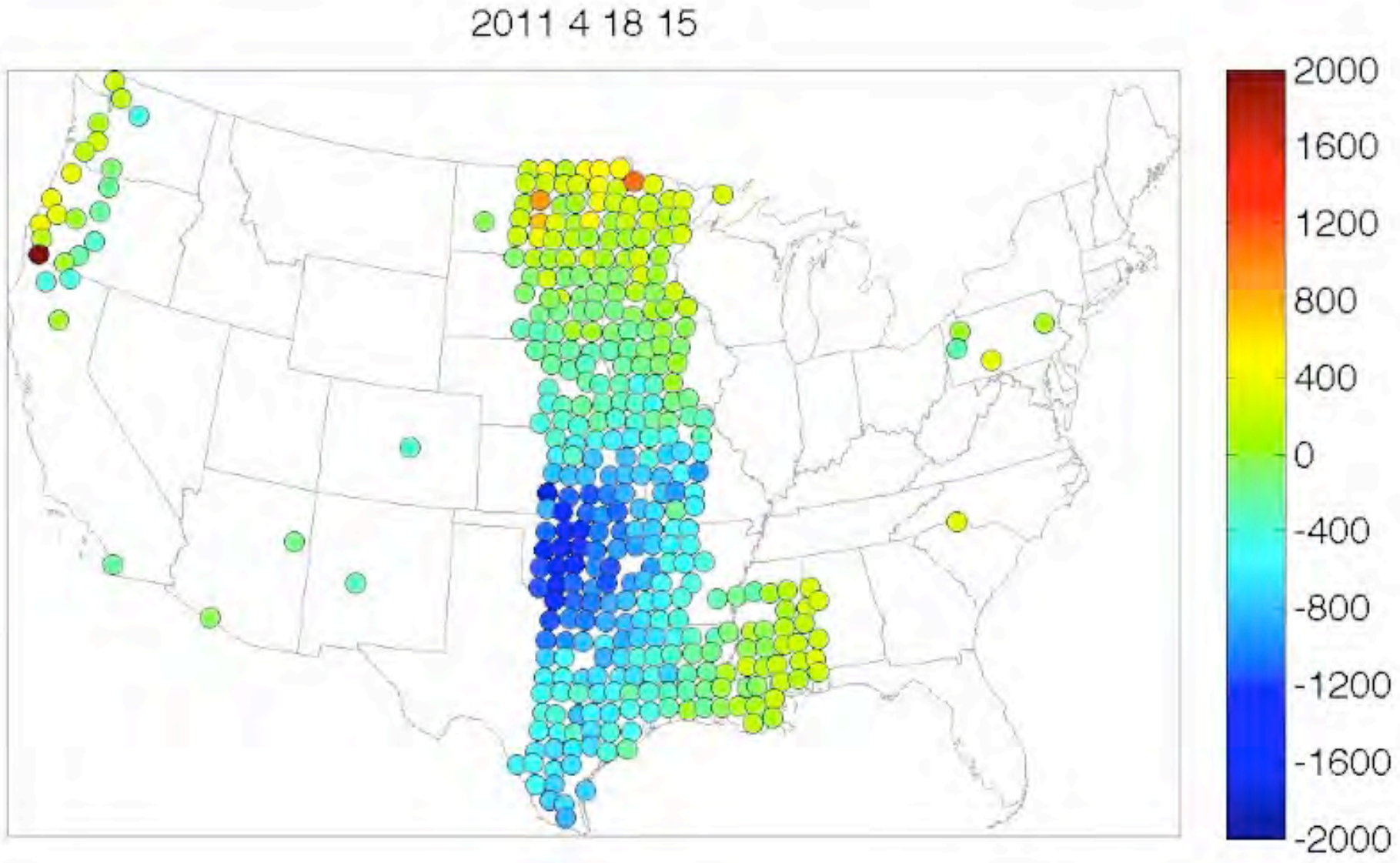
F29A Pressure and Seismic



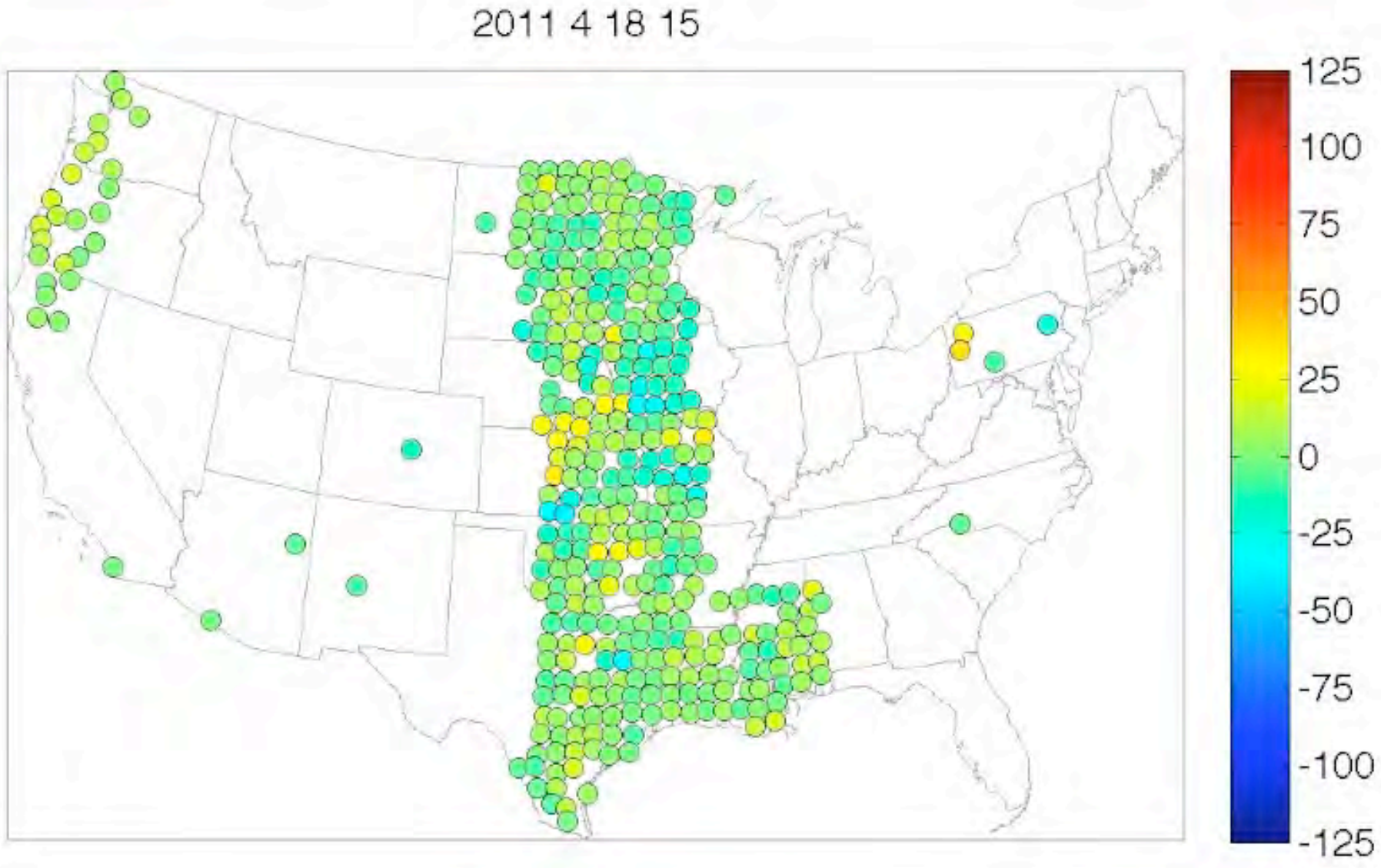
NWS Comparason





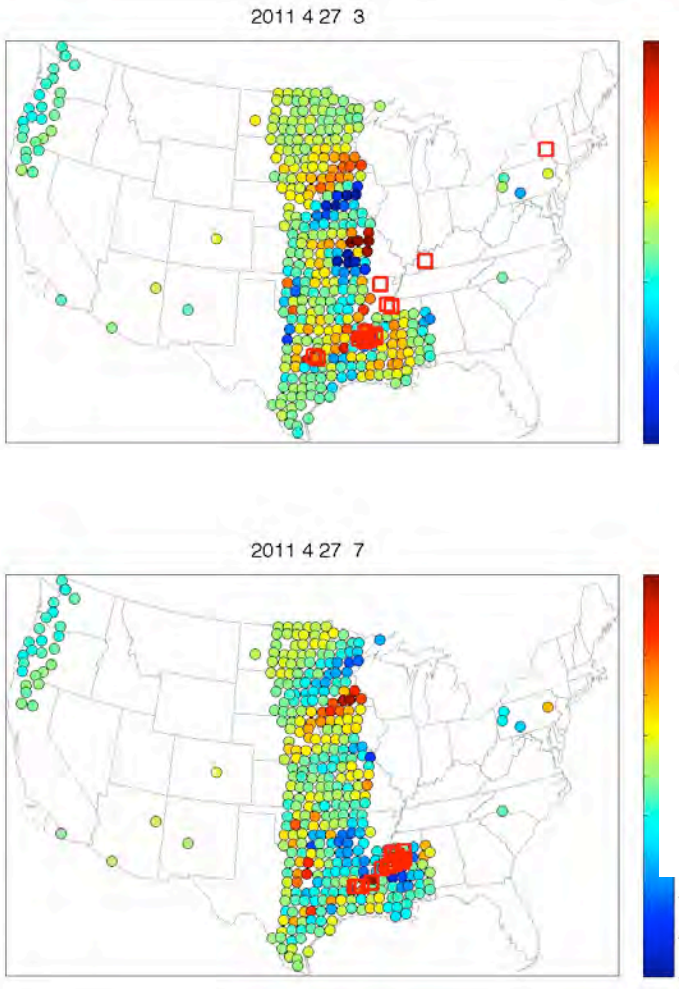


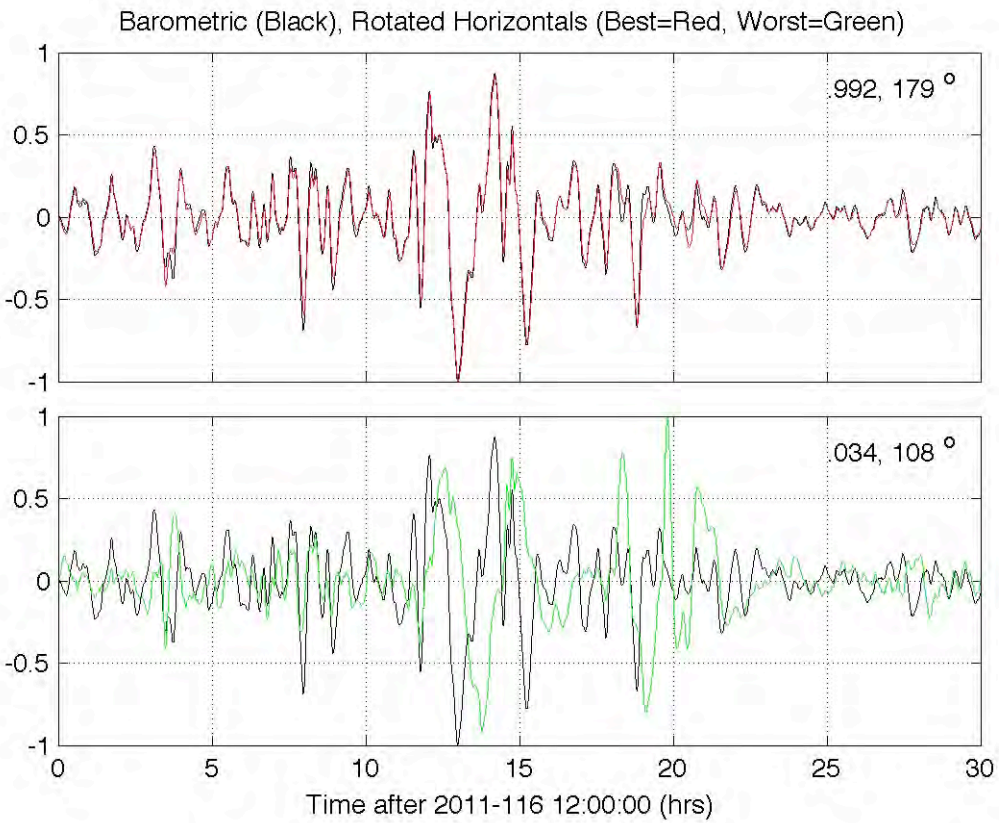
Barometric Pressure Variations
Unfiltered Data



Atmospheric Gravity Wave Band
Periods - 2 to 6 Hours

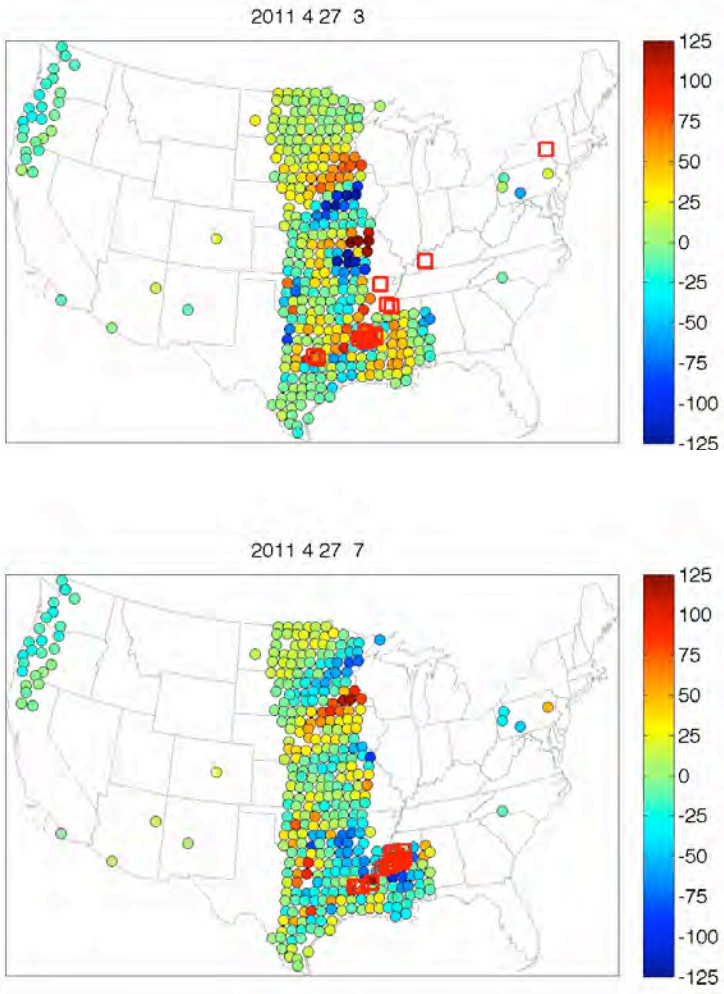
North propagating 2-6 hr GW

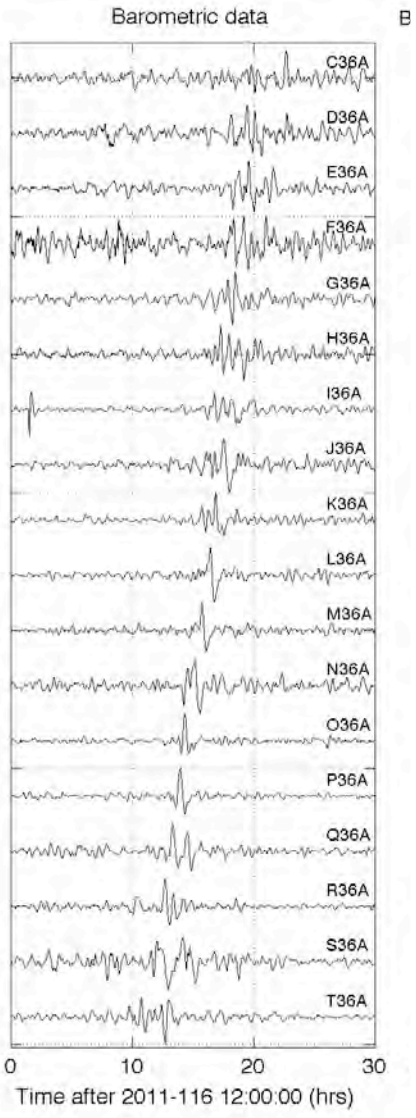




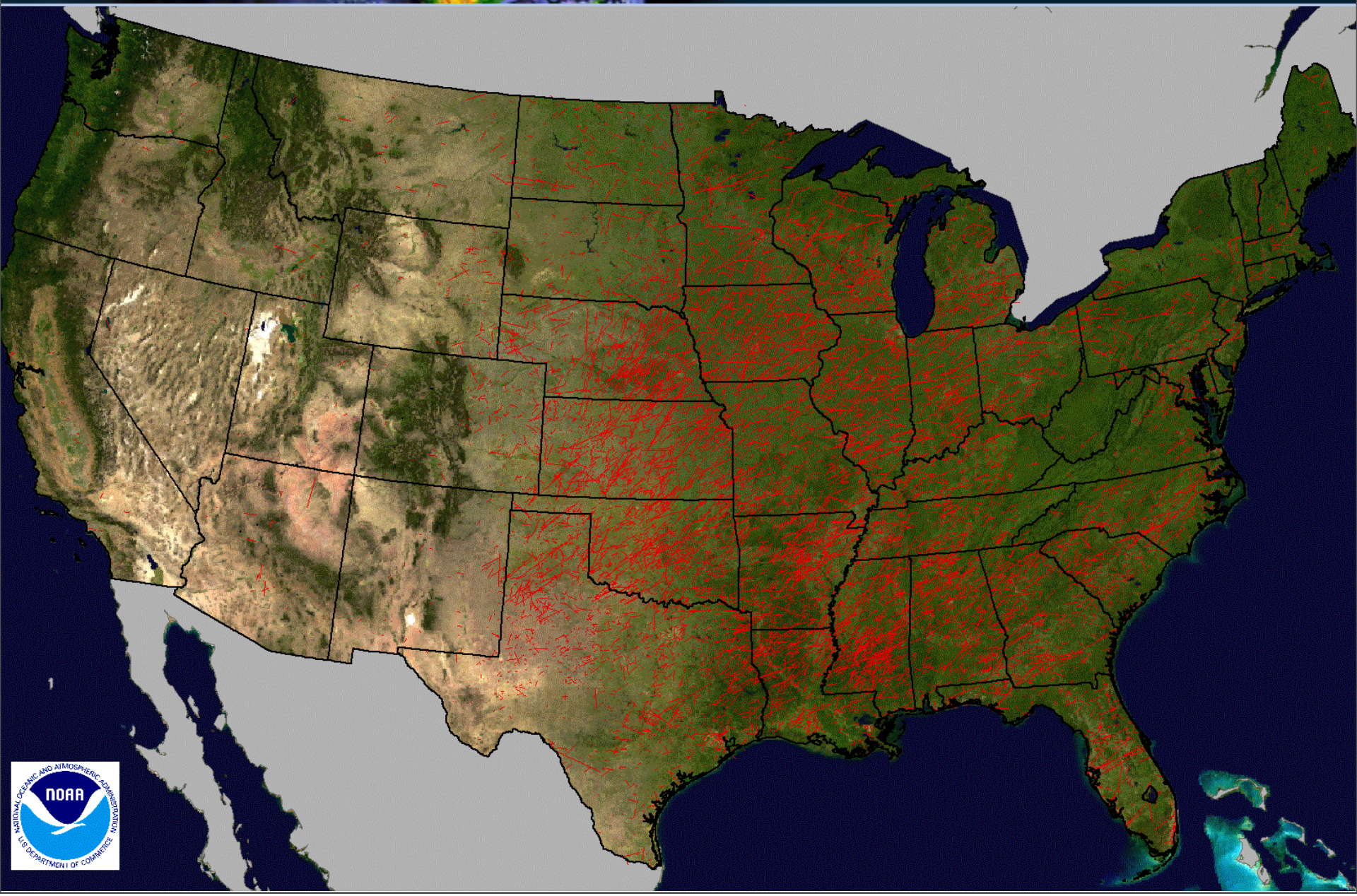
S36A: 1,800 to 8,000 s

North propagating 2-6 hr GW



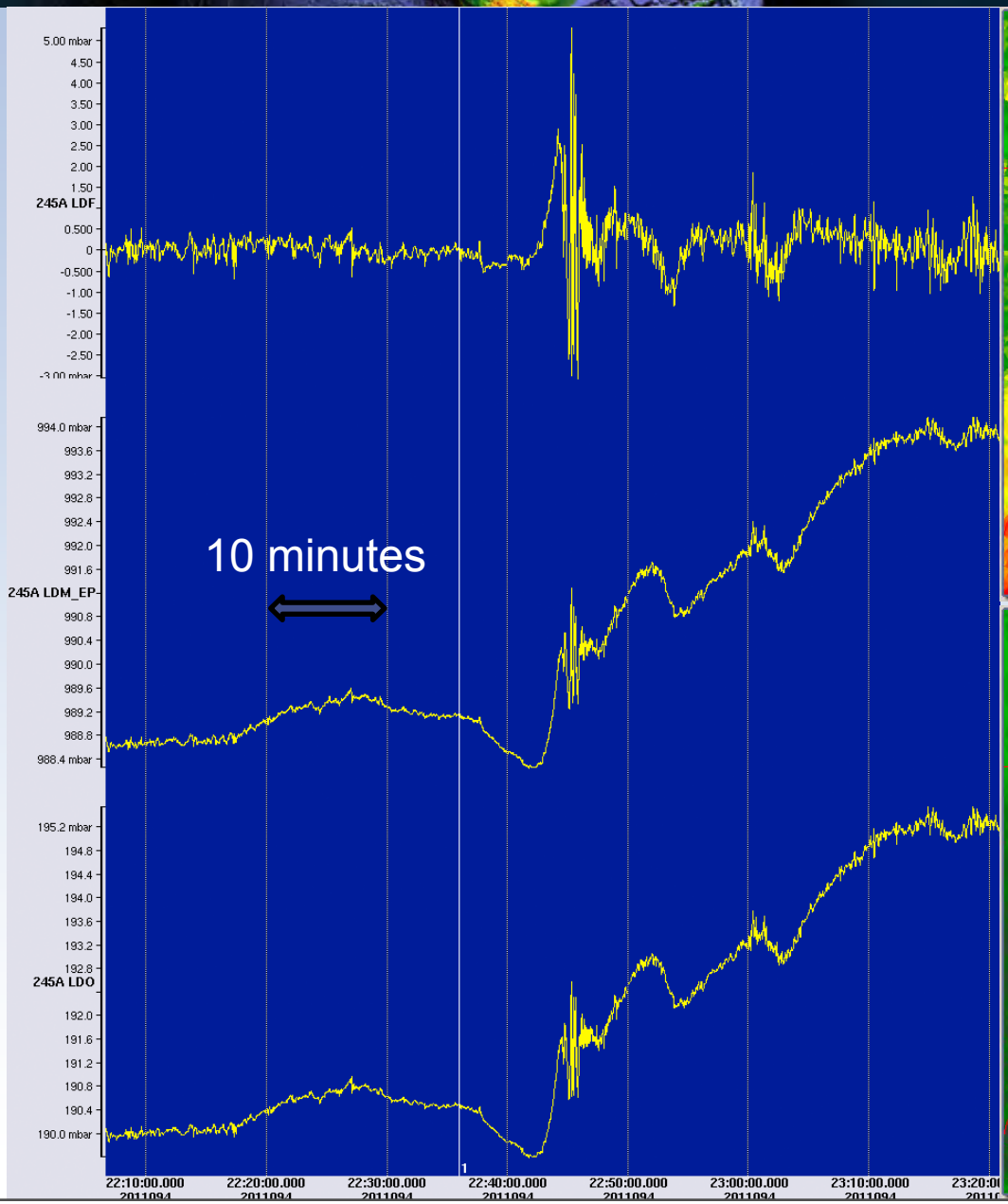


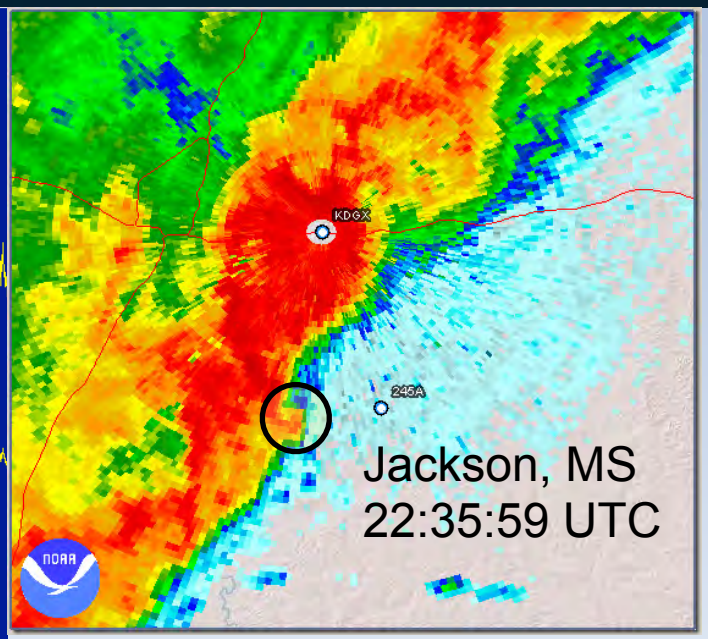
Tornado Prevalence

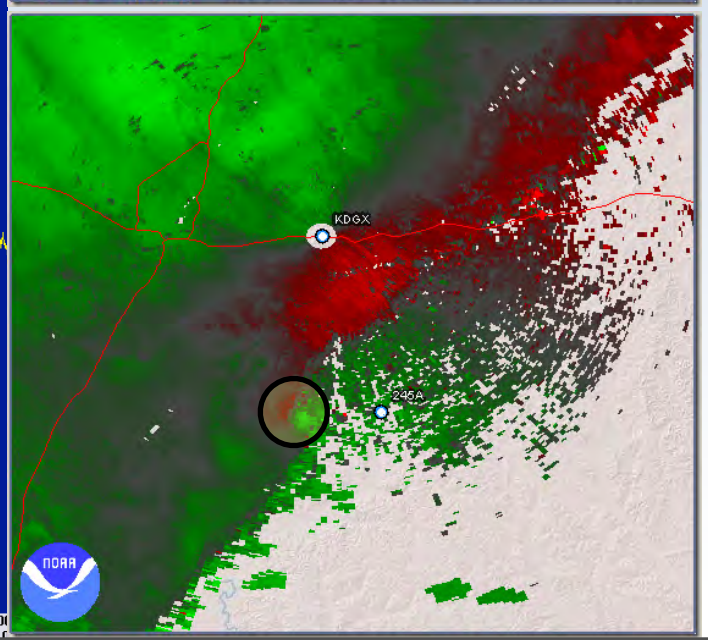


Jackson Tornado on 4/15/2011 – 245A

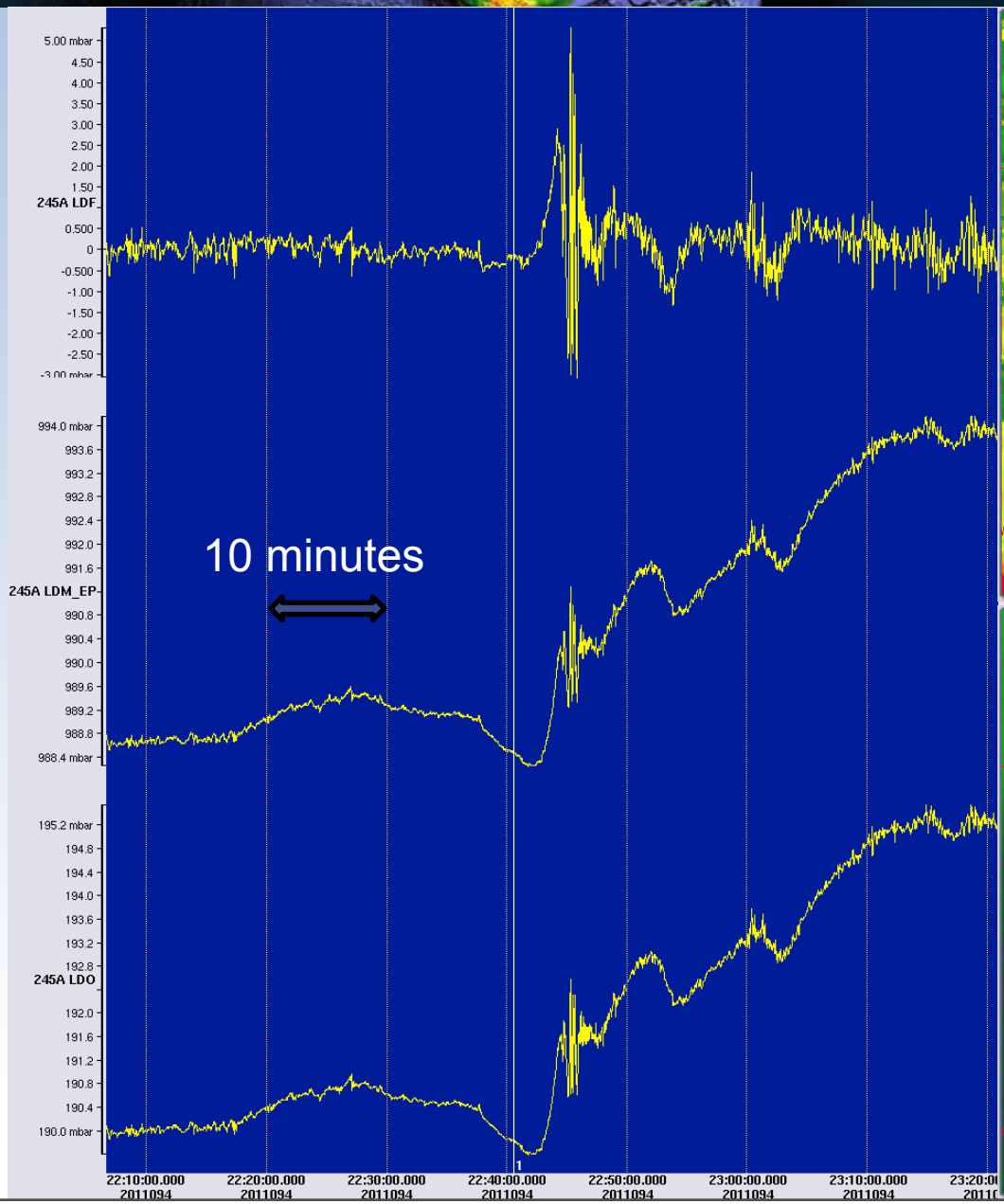
Jackson Tornado on 4/15/2011 – 245A

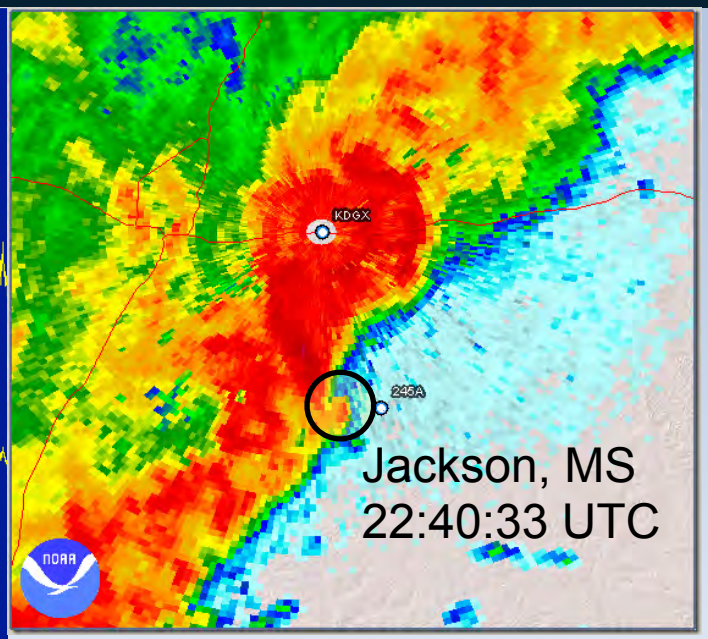


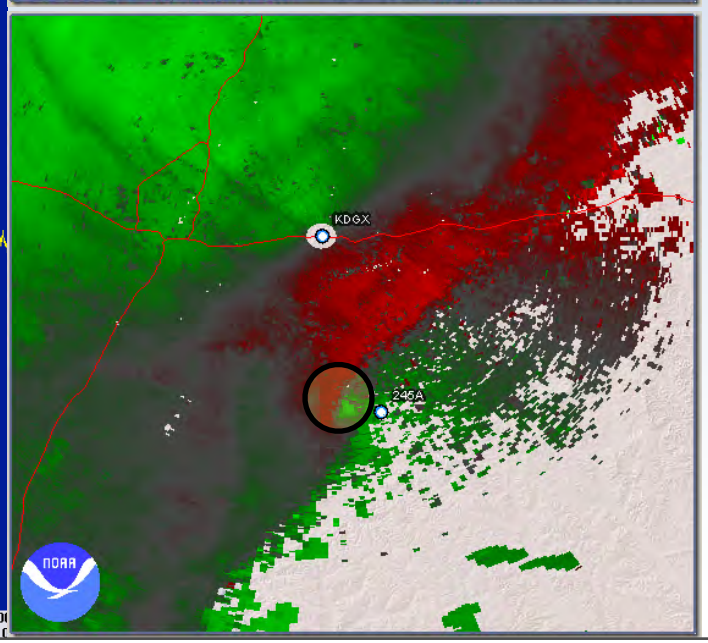




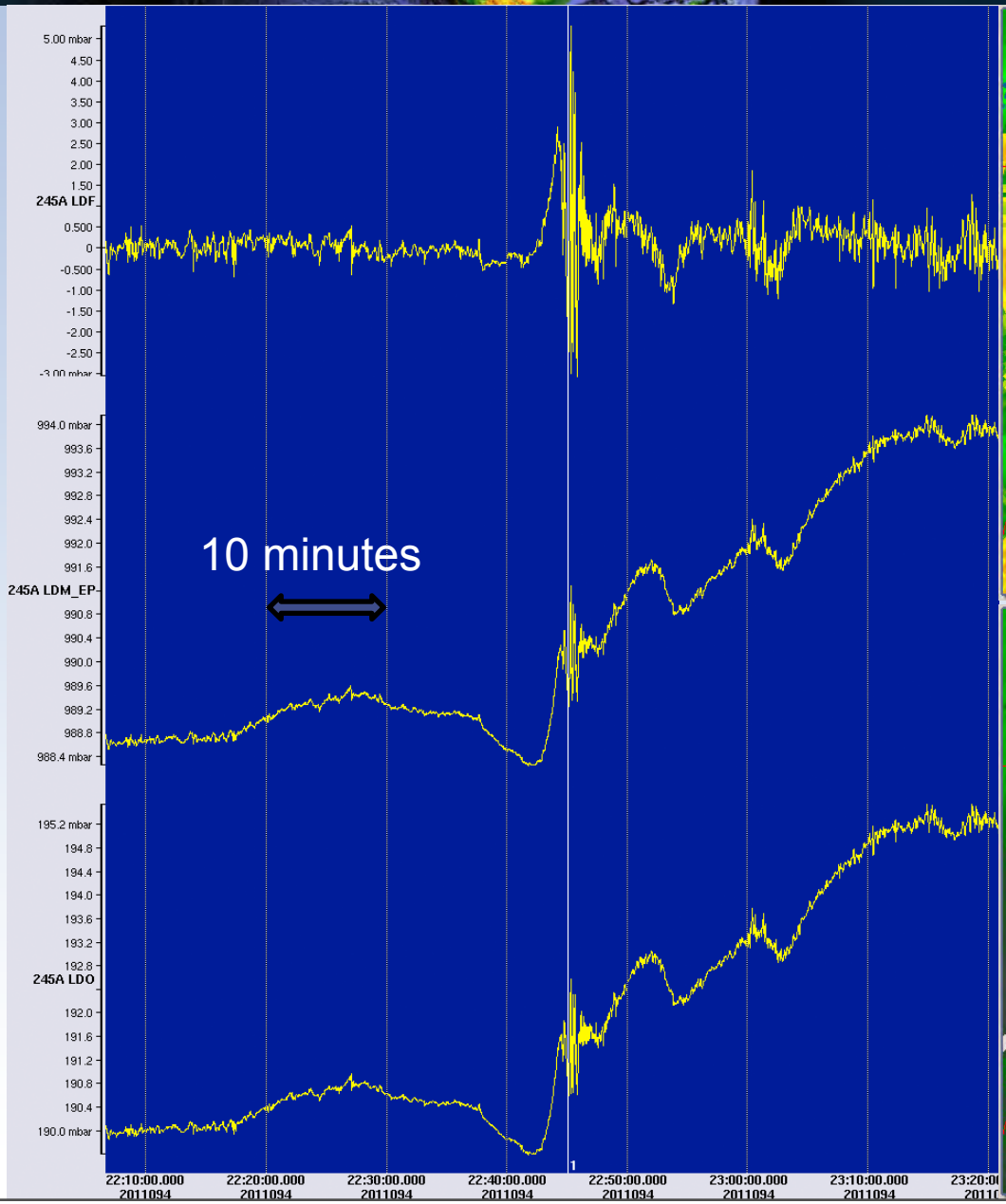
Jackson Tornado on 4/15/2011 – 245A

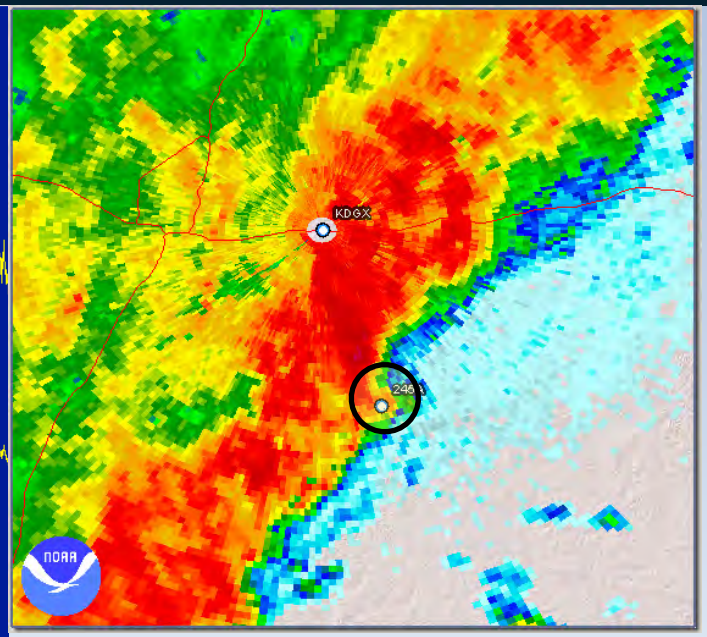


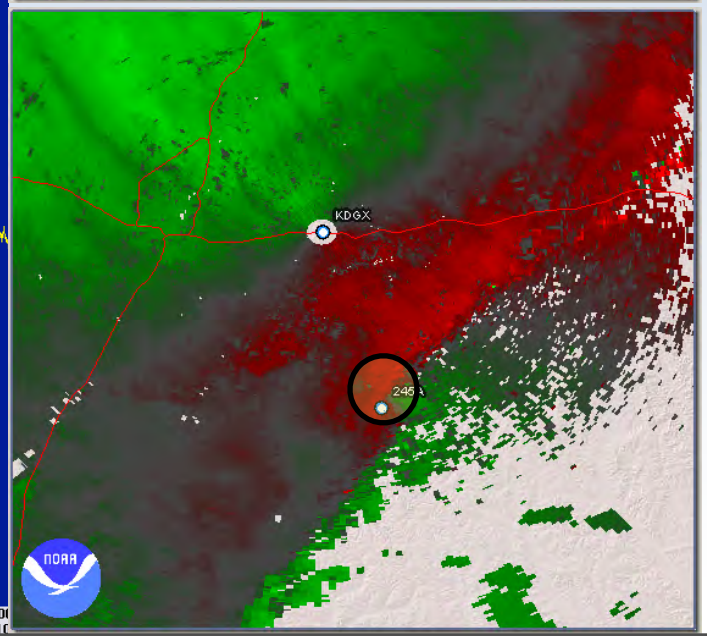




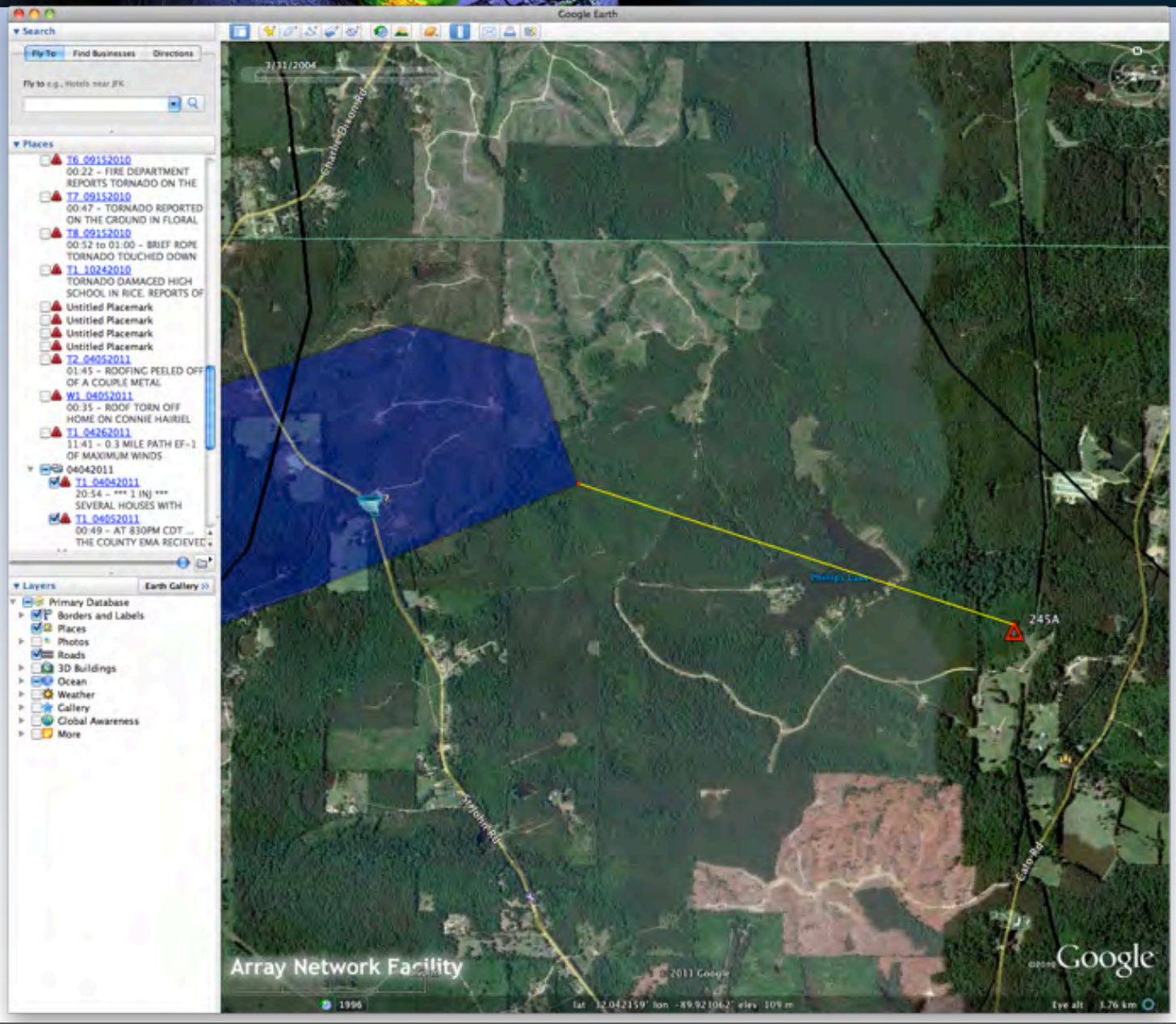
Jackson Tornado on 4/15/2011 – 245A



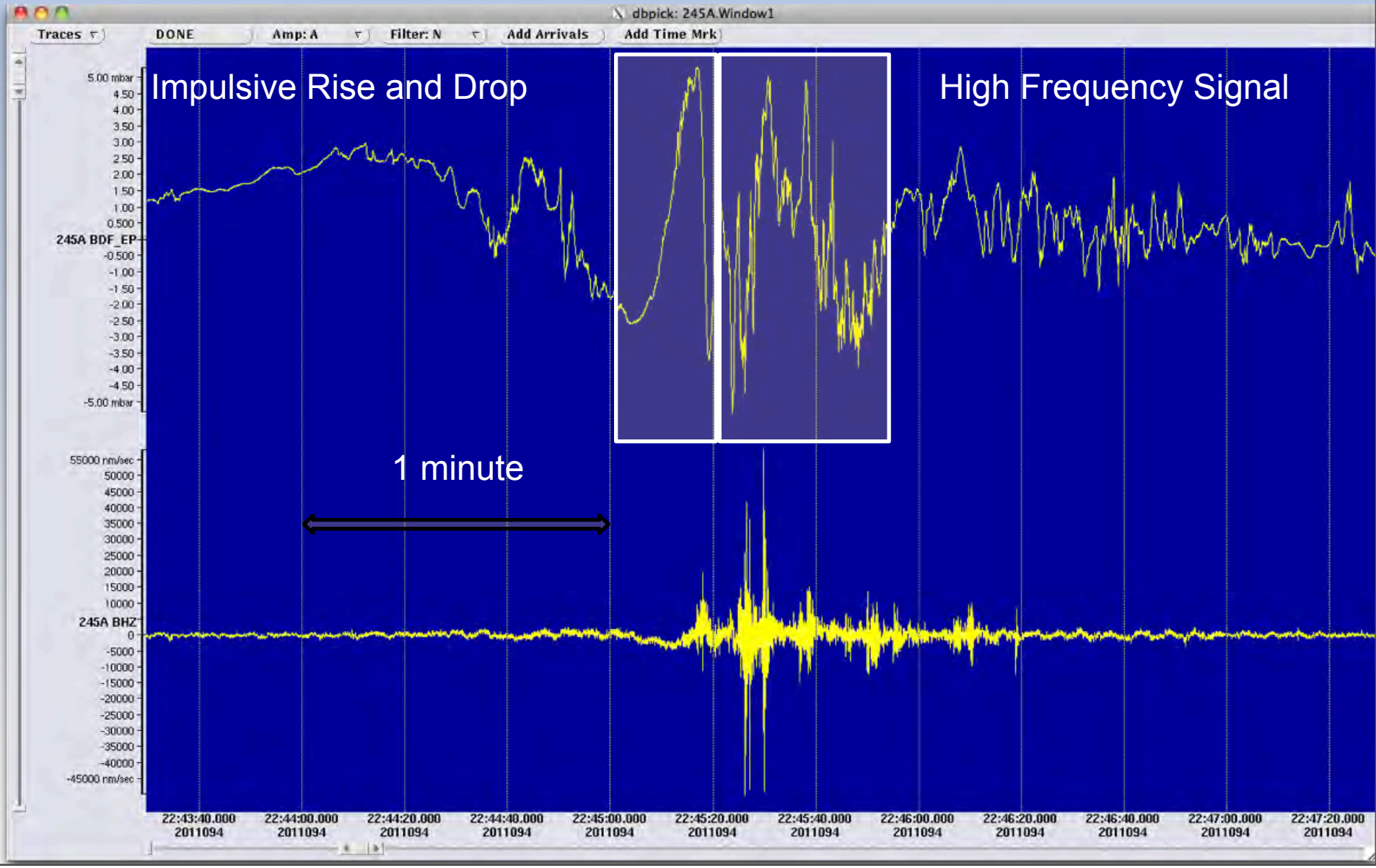




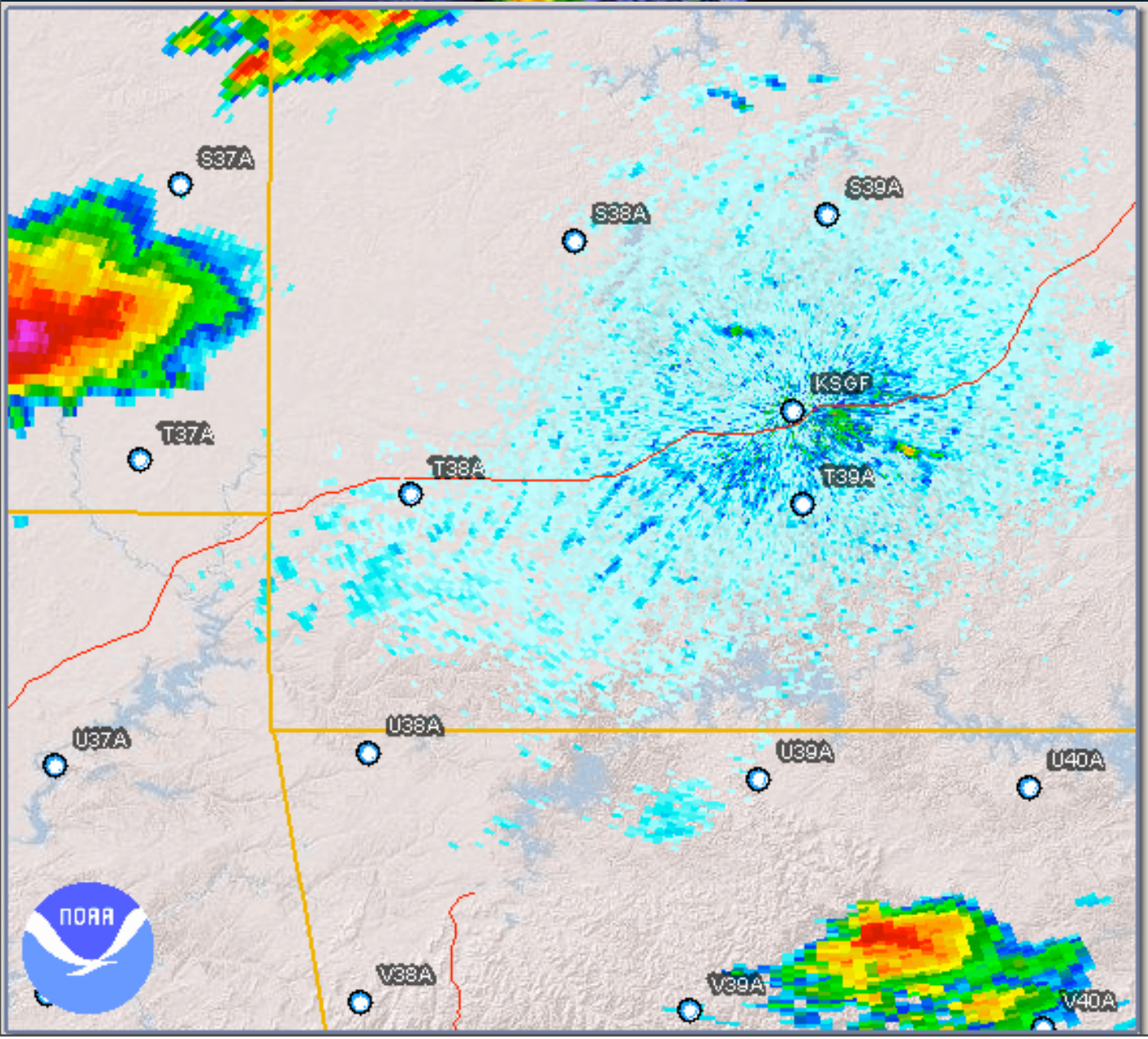
Jackson Tornado on 4/15/2011 – 245A



Jackson Tornado on 4/15/2011 – 245A



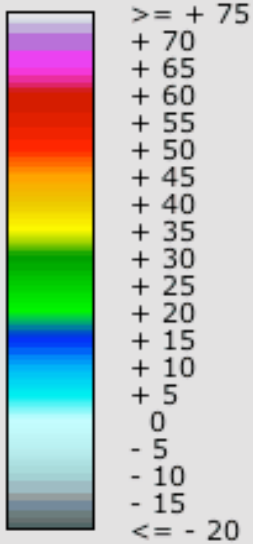
Joplin Tornado 5/22/2011 – T38A



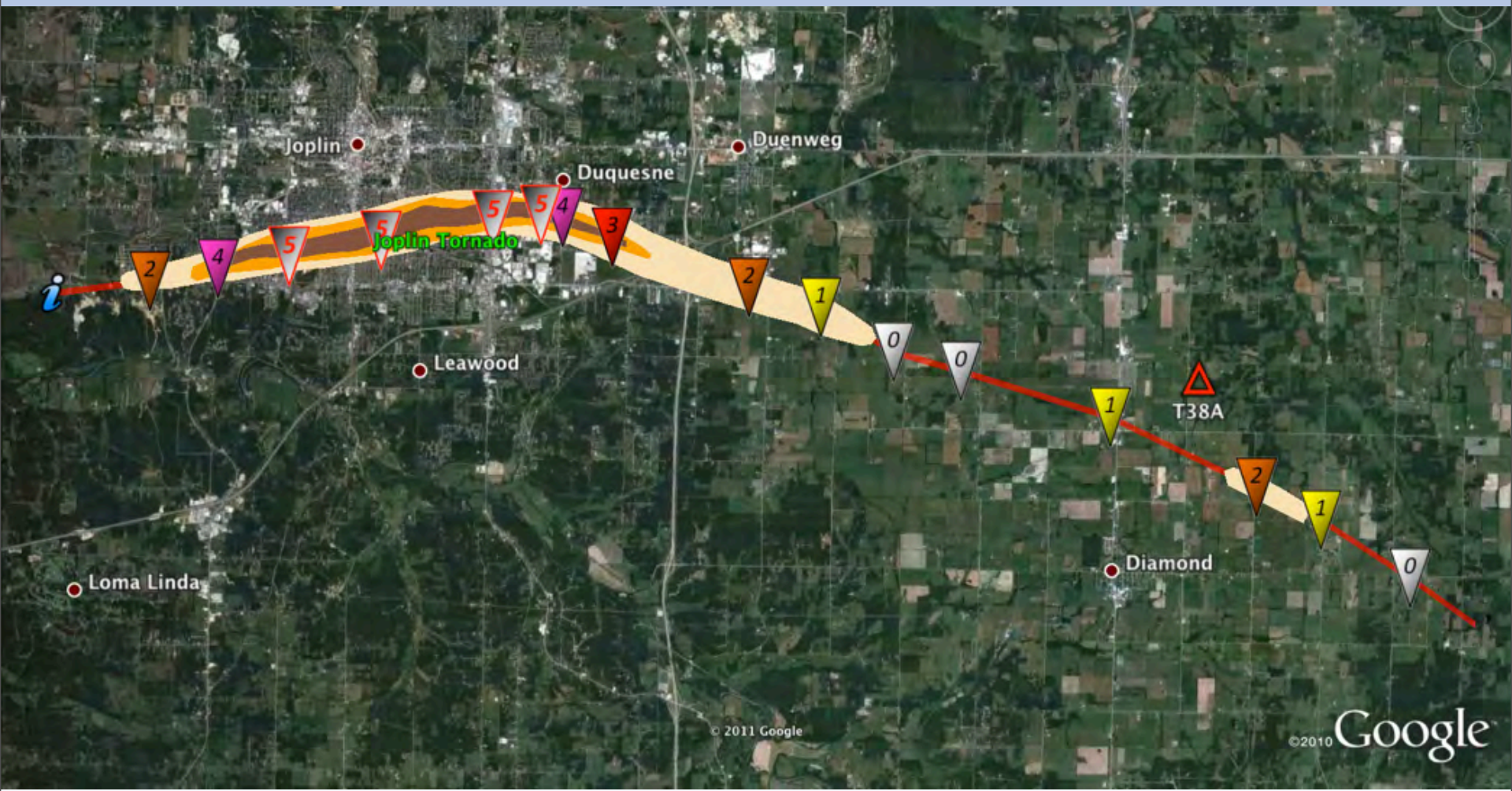
NEXRAD LEVEL-III
BASE REFLECTIVITY
KSGF - SPRINGFIELD, MO
05/22/2011 21:02:17 GMT
LAT: 37/14/05 N
LON: 93/24/00 W
ELEV: 1375 FT
MODE/VCP: A / 211

ELEV ANGLE: 0.50 °
MAX: 66 DBZ
RANGE: 248 NM

Legend: dBZ

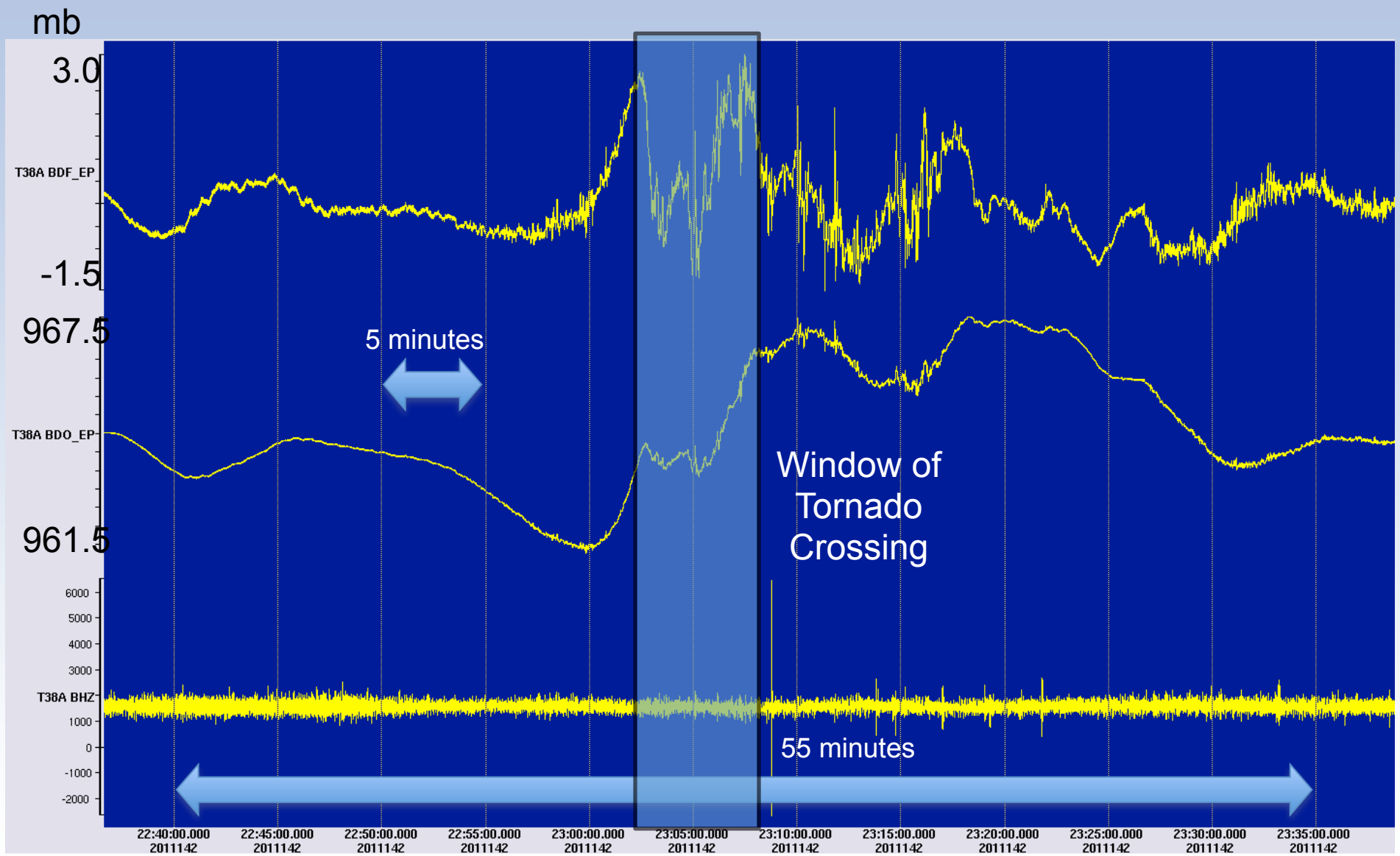


Joplin Tornado 5/22/2011 – T38A



Joplin Tornado 5/22/2011 – T38A

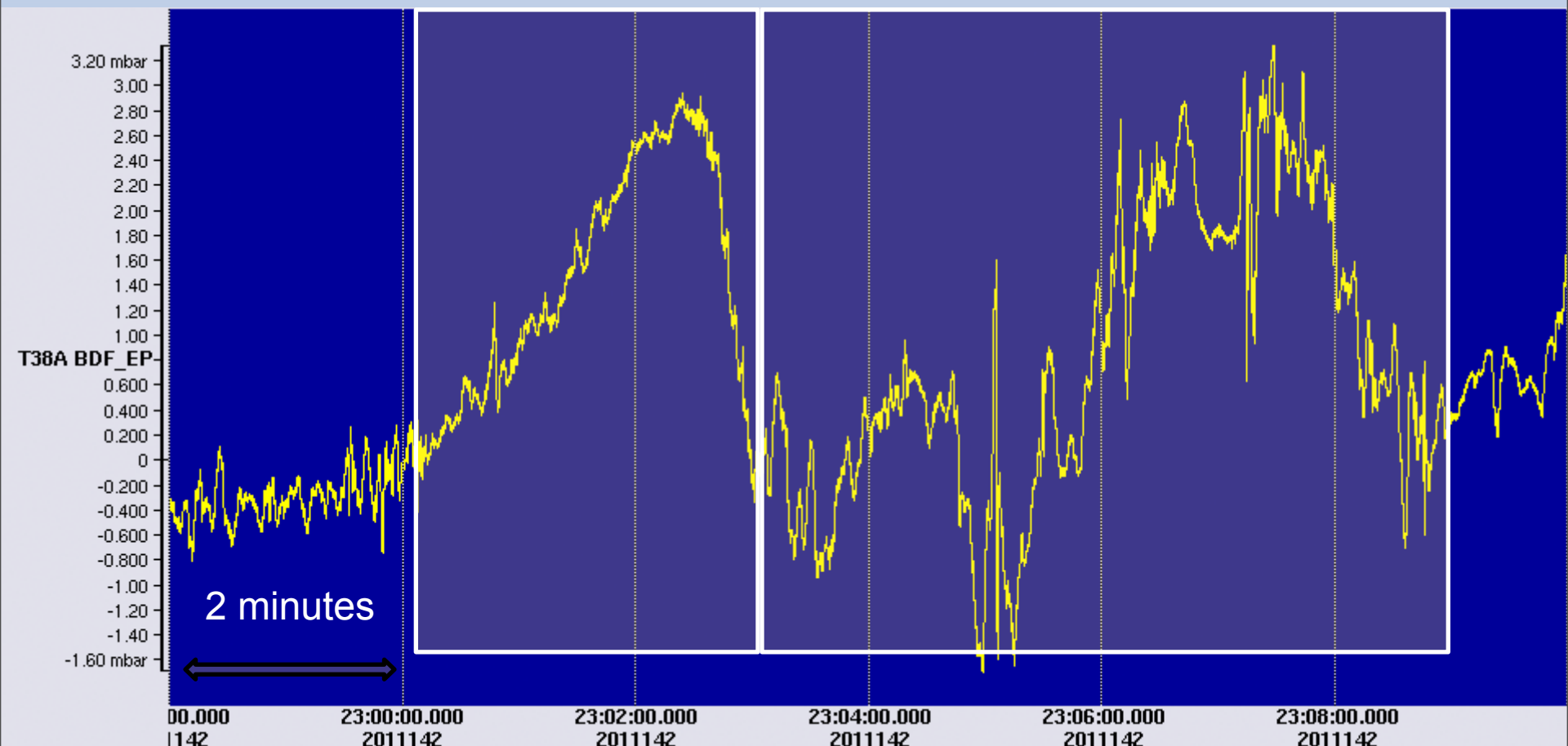
Joplin Tornado 5/22/2011 – T38A



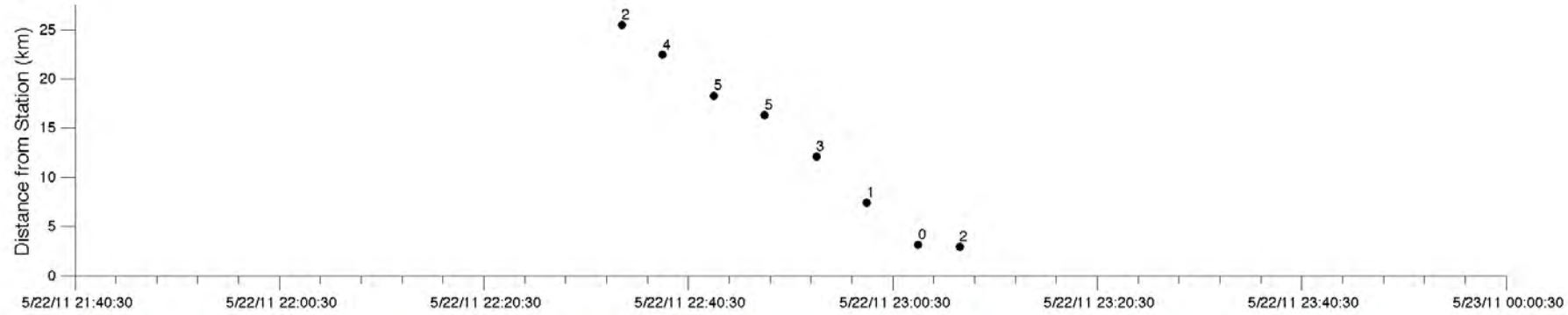
Joplin Tornado 5/22/2011 – T38A

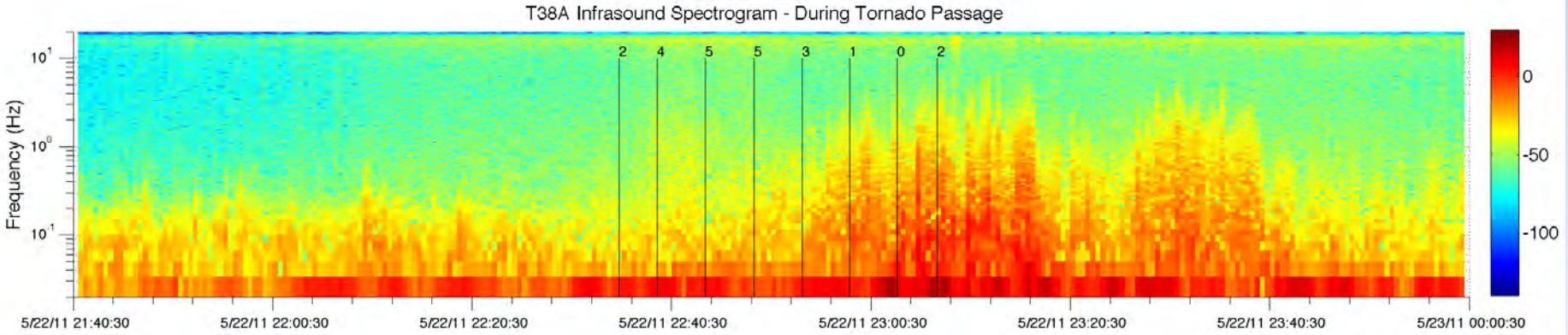
Impulsive Rise and Drop

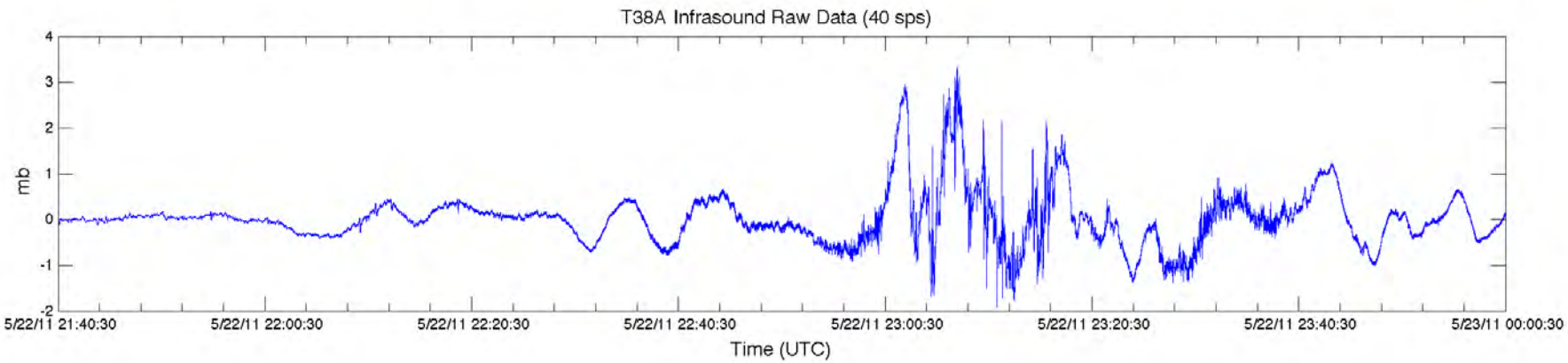
High Frequency Signal



Joplin Tornado 5/22/2011 – T38A

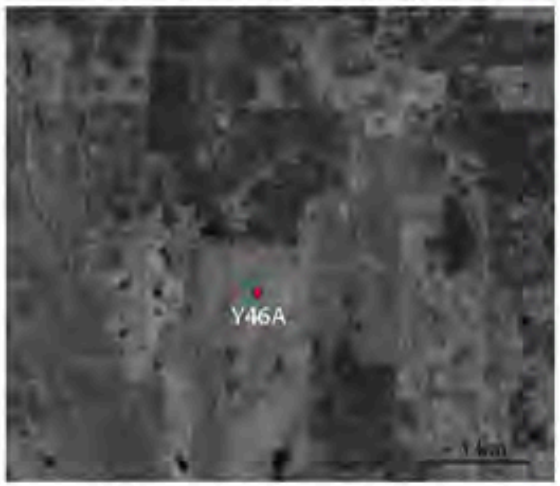




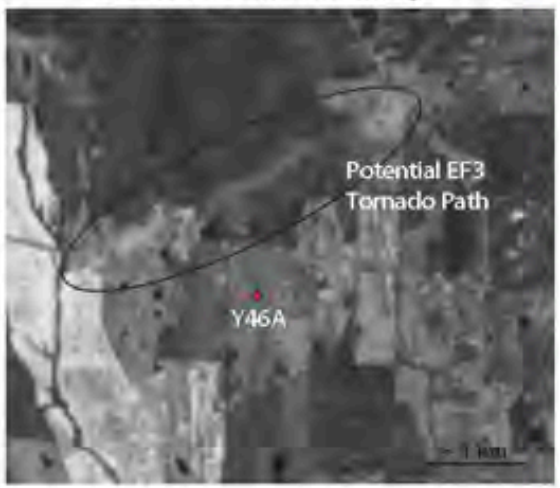


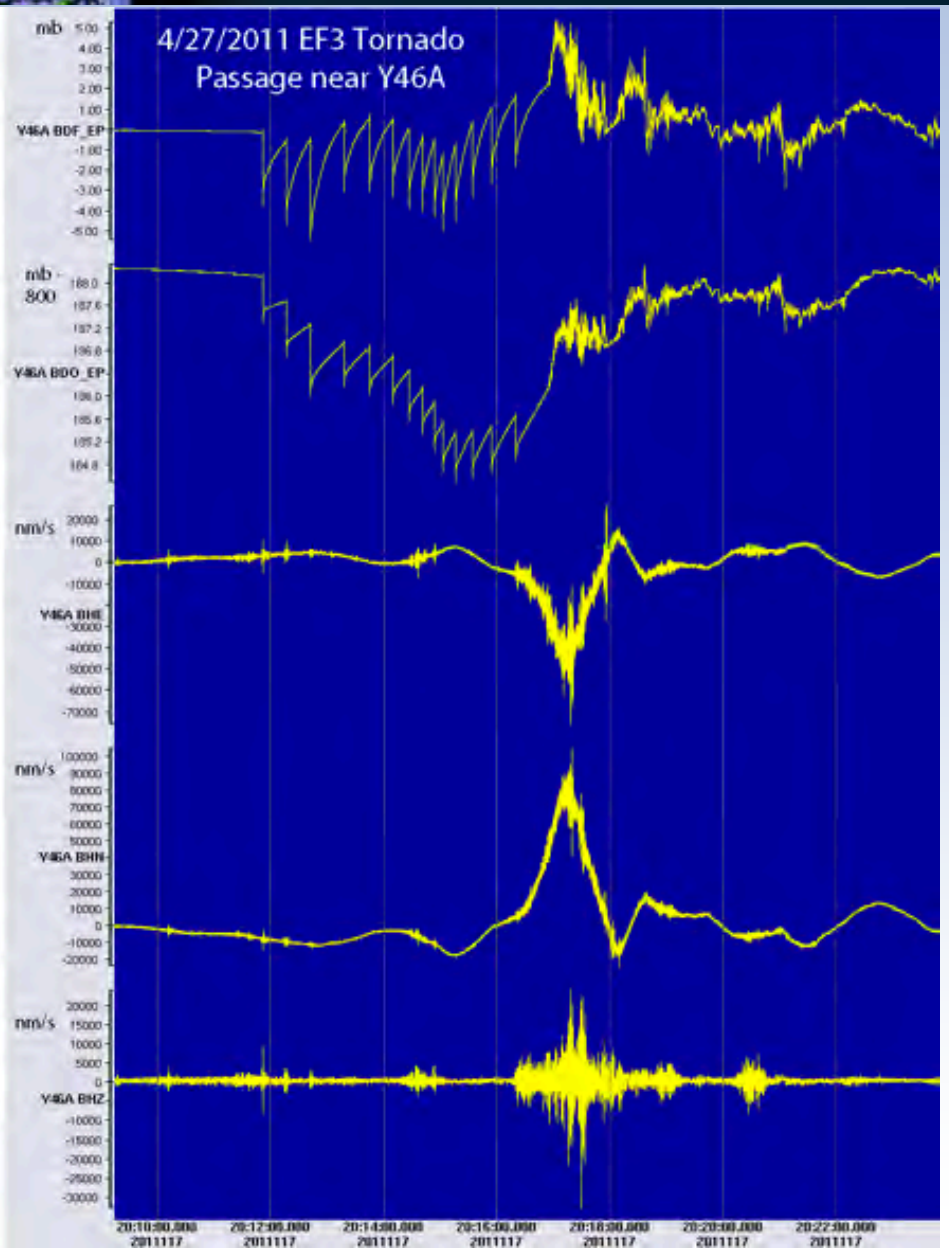
Oklahoma Tornado on 4/27/2011 – Y46A

3/16/2011 LandSat Image



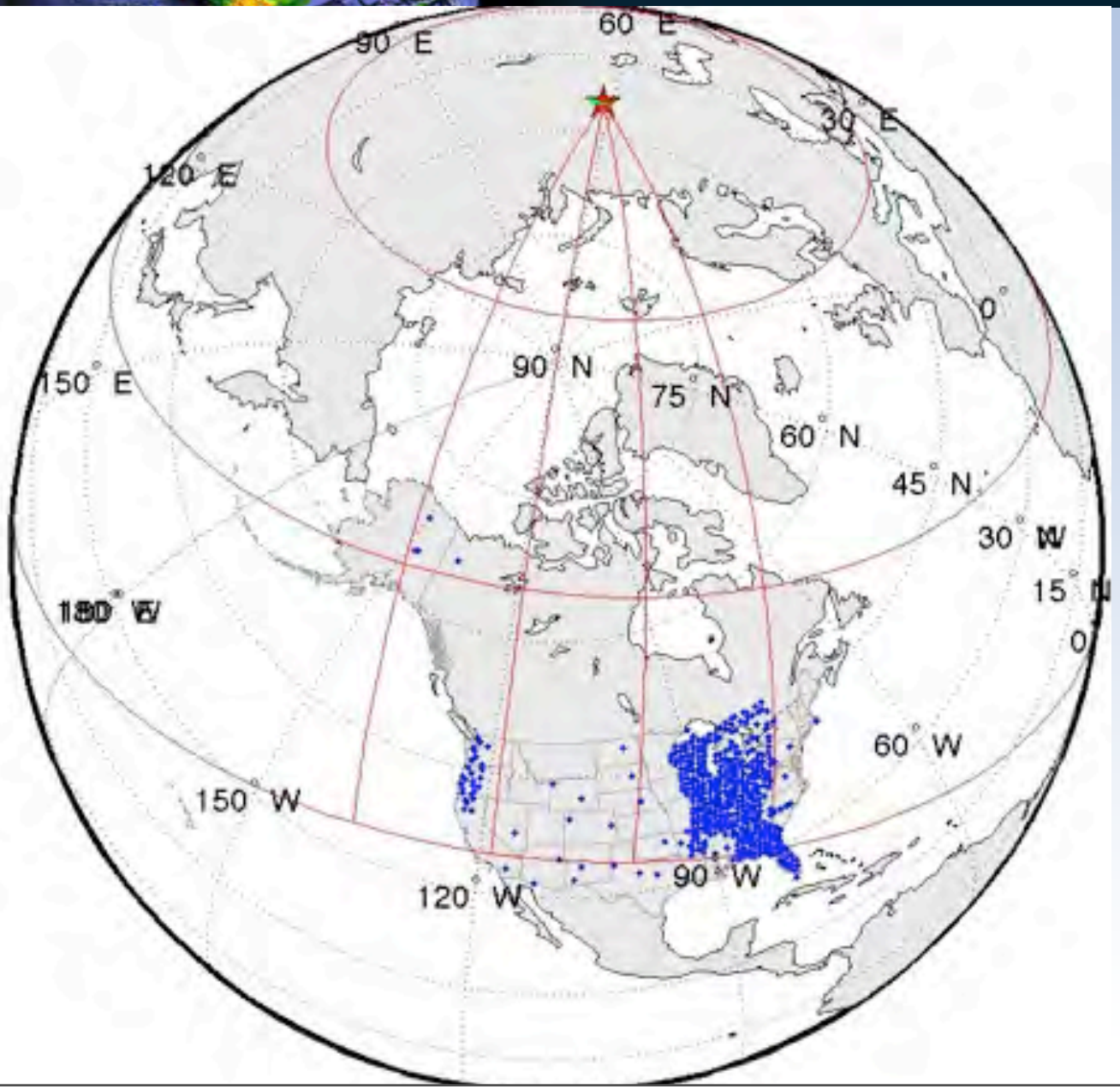
5/19/2011 LandSat Image



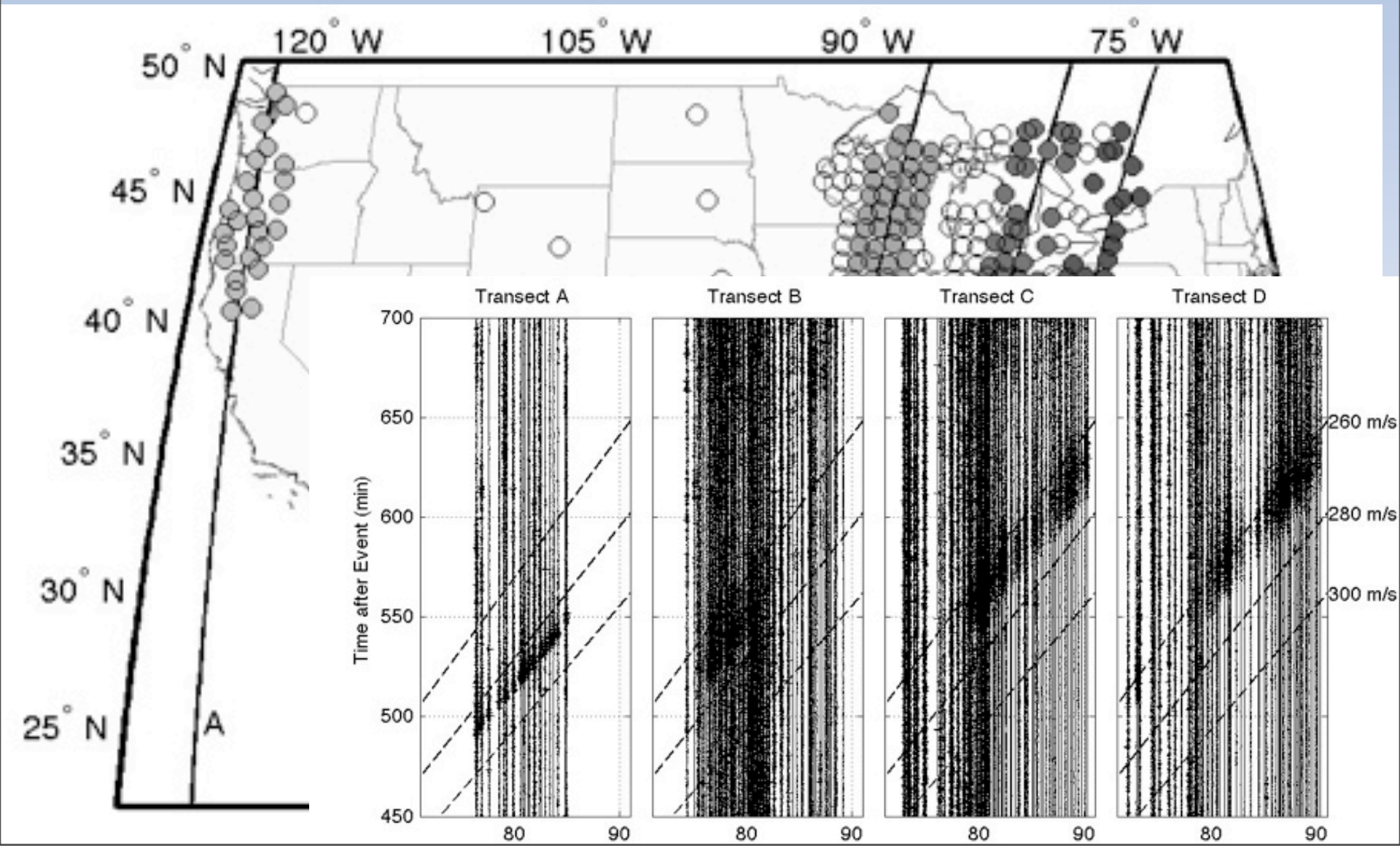


Russian meteor 2013-02-15

Russian meteor 2013-02-15



Russian meteor 2013-02-15



Russian meteor 2013-02-15

Conclusions

- Meteorological sensors can enhance understanding of seismic data
- Meteorological sensors can create opportunities for collaboration between different scientific communities
  - real time monitoring
  - hazards
  - civil defense
- Seismic networks provide sites, permitting, real time telemetry