Moment Tensor Code

Moment Tensor and Focal Mechanism Code

UCSD - Workgroup

- Gert-Jan van der Hazel (ORFEUS-KNMI)
- Juan Reyes
- Rob Newman
- Frank Vernon

UCSD

Rewrite of Doug Dreger's Time-Domain Moment Tensor Inverse Code using Antelope's Python Interface:

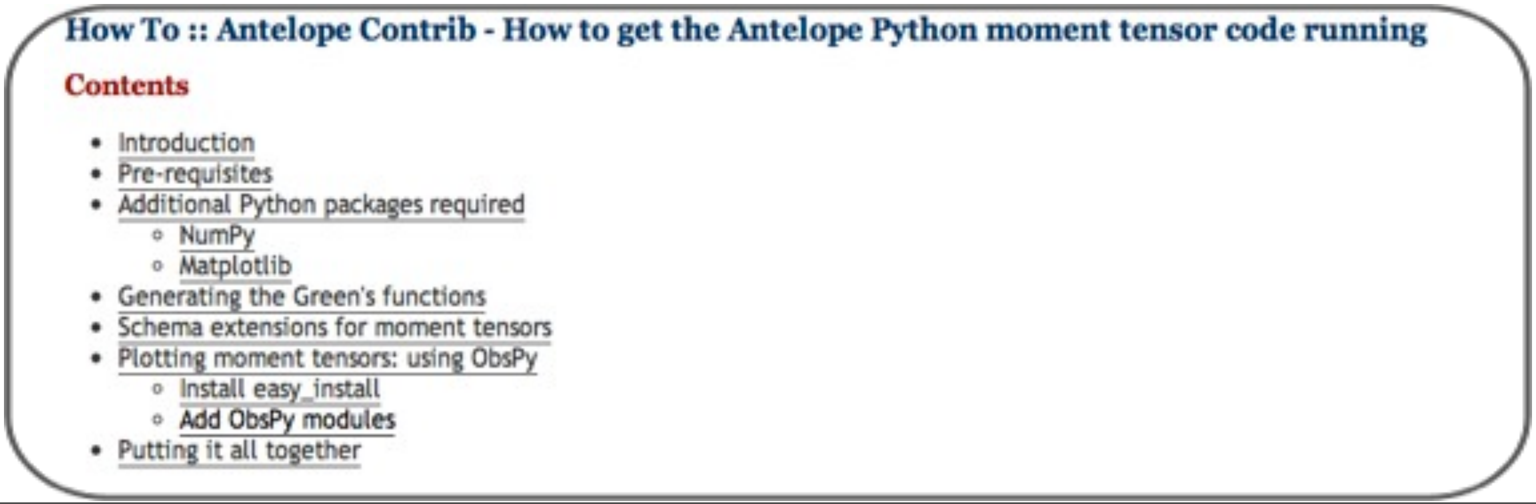
- All components are rewritten in Python
  - frequency-wavenumber integration
  - MT inversion
- Remove intermediate data formats
- Remove wrapper scripts
- New Datascope schemas for MT results
- Consolidate configuration in .pf file

UCSD - Additional Python packages required

- Numpy
- Matplotlib
- ObsPy - Open source Python toolbox for seismology

Rob Newman

http://eqinfo.ucsd.edu/~rnewman/howtos/antelope_contrib/moment_tensor/#addmods



How To :: Antelope Contrib - How to get the Antelope Python moment tensor code running

Contents

UCSD - So far...

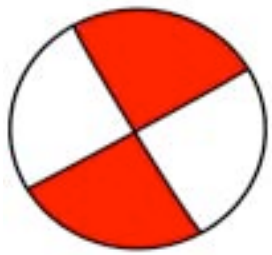
- Get origins and stations from Datascope tables.
- Filtering and rotation from E-N-Z into R-T-Z.
- Building of Data Matrix.
- Get pre-calculated Green's functions from Datascope schema based on distance and azimuth.
- Construct Green's Matrix
- Calculate MT using both datasets.
- Invert the MT and from the eigen values/vectors calculate the MT solution
- Update Datascope with results.

UCSD - Datascope Extensions...

Relation moment_tensor_greensfuncs
    Fields (vmodel delta depth azimuth dip dir dfile lddate)
    Primary (vmodel delta depth dfile)
    Description ("Table of precomputed Greens functions")
    Detail {
        Precomputed Greens functions for moment tensor creation
    };

UCSD - Datascope Extensions...

Relation moment_tensor_images
    Fields (sta orid dir dfile lddate)
    Primary (sta orid dir dfile)
    Description ("Moment tensor beachball images")
    Detail {
        Final product images of per station and event
        moment tensor beachballs
    };



UCSD - ObsPy

Beachballs

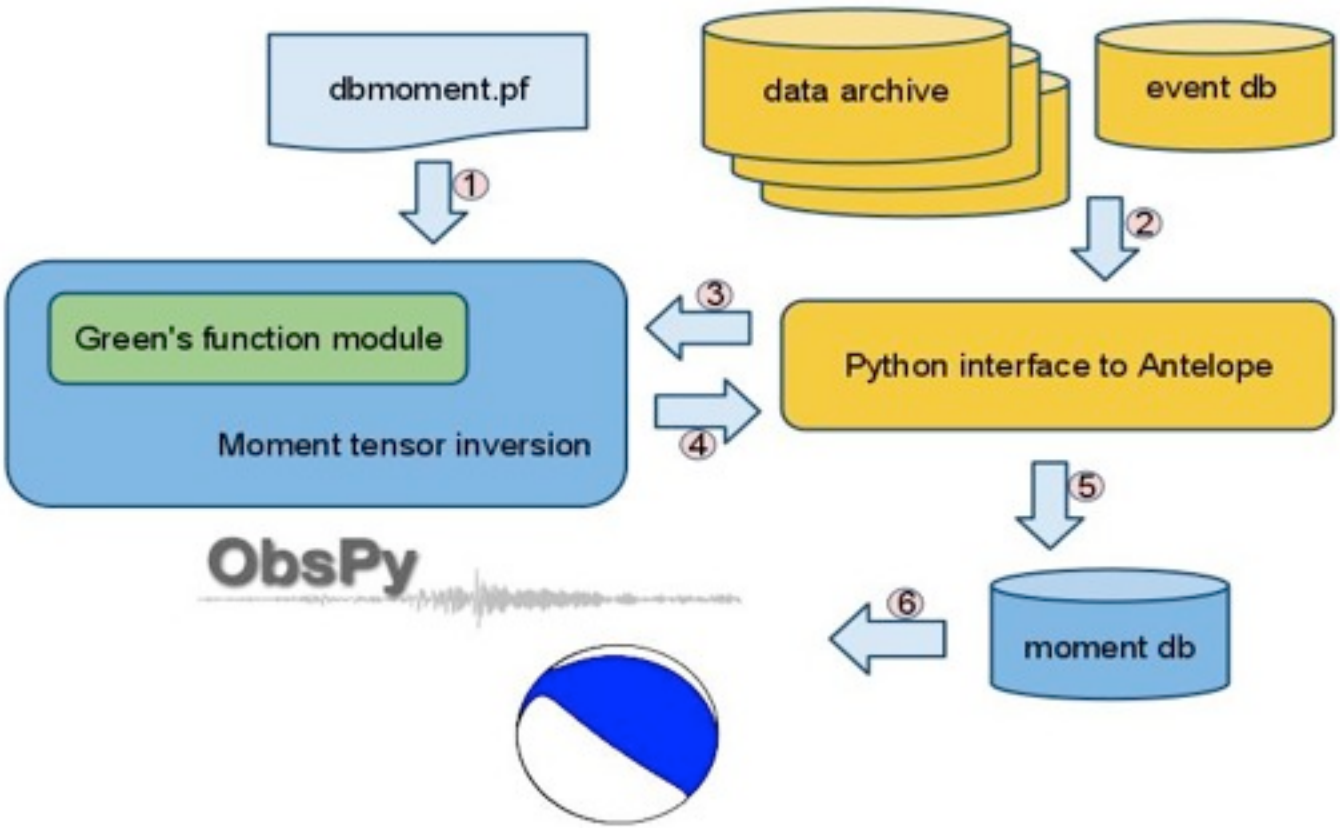
The focal mechanism can be given by 3 (strike, dip, and rake) components.

```
>>> from obspy.imaging.beachball import Beachball
>>> np1 = [150, 87, 1]
>>> Beachball(np1)
<matplotlib.figure.Figure object at 0x...>
```

The focal mechanism can also be specified using the 6 independent components of the moment tensor (Mxx, Myy, Mzz, Mxy, Mxz, Myz).

```
>>> from obspy.imaging.beachball import Beachball
>>> mt = [-2.39, 1.04, 1.35, 0.57, -2.94, -0.94]
>>> Beachball(mt)
<matplotlib.figure.Figure object at 0x...>
```

Overview


dbmoment.pf
data archive
event db
1
2
3
4
5
6
Green's function module
Moment tensor inversion
Python interface to Antelope
moment db
ObsPy

UCSD - Missing...

- Frequency-Wavenumber integration program is not stable and requires some debugging .
- Expand code to decimate higher sample rate data.
- Continued comparason of solutions against Dreger's solutions.

EGU 2011

Moment Tensor code for the Antelope Environmental Monitoring System

Poster in Halls X/Y at board number XY672.
The Display Time will be Monday, 04 Apr 2011, 08:00-19:30

The Waveform Server

Juan Reyes, Rob Newman, Frank Vernon
Scripps Institution of Oceanography
University of California San Diego

AUG, Bucharest, Romania

21 March 2011

Waveform Server

- interactive web-based interface
- multi-station and multi-channel seismic waveforms
- stored in CSS 3.0
- client-side interface simple JSON-based AJAX queries
- incorporate a variety of User Interface (UI) improvements
- standardized calendars for defining time ranges
- applying on-the-fly data calibration and unit representation
- time-zone correction.

Waveform Server

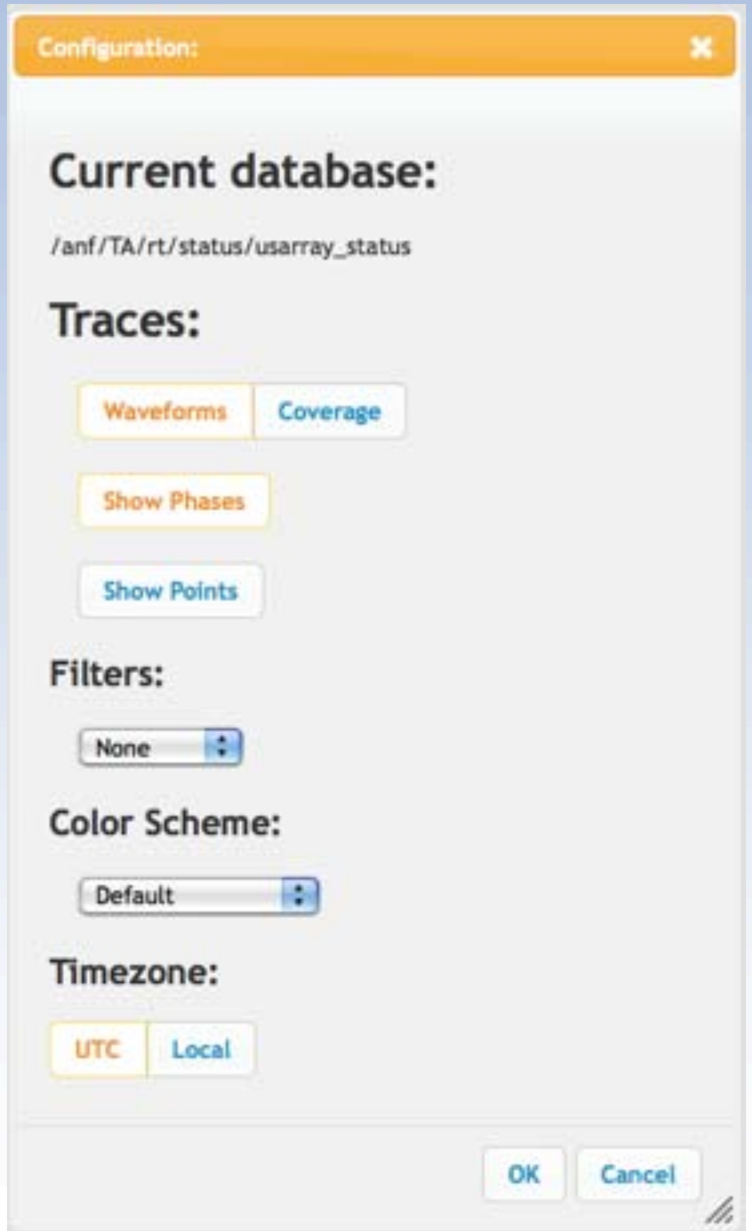
- based on expanded specifications and current user feedback
  - server-side infrastructure and client-side interface have been extensively rewritten
  - Python server-side code has been fundamentally modified to retrieve data using Python Deferred Objects
  - multi-threaded architecture
  - access data stored in cluster-based databases
  - Interactive web-based access to high sample rate (+200Hz) waveform data
  - span multiple years, common lifespan of broadband seismic networks

Waveform Server

- JSON - JavaScript Object Notation
  - lightweight text-based open standard
  - faster parsing and processing.
- Dbcentral
  - Divide datasets into multiple independent databases
  - by day, week, month or year.
- jQuery
  - cross-browser JavaScript library
  - abstraction into low-level client-side scripting

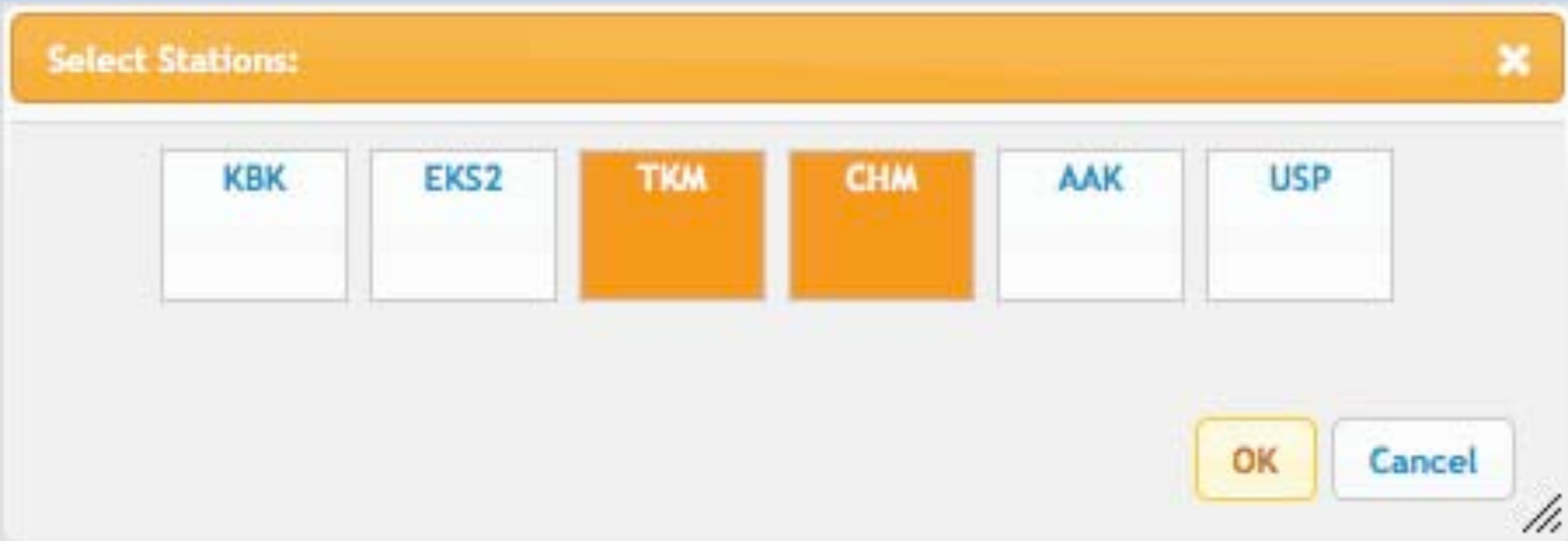
Waveform Server

- advanced interactive plugins
  - Control window



Waveform Server

- advanced interactive plugins
  - Station and channel selection windows

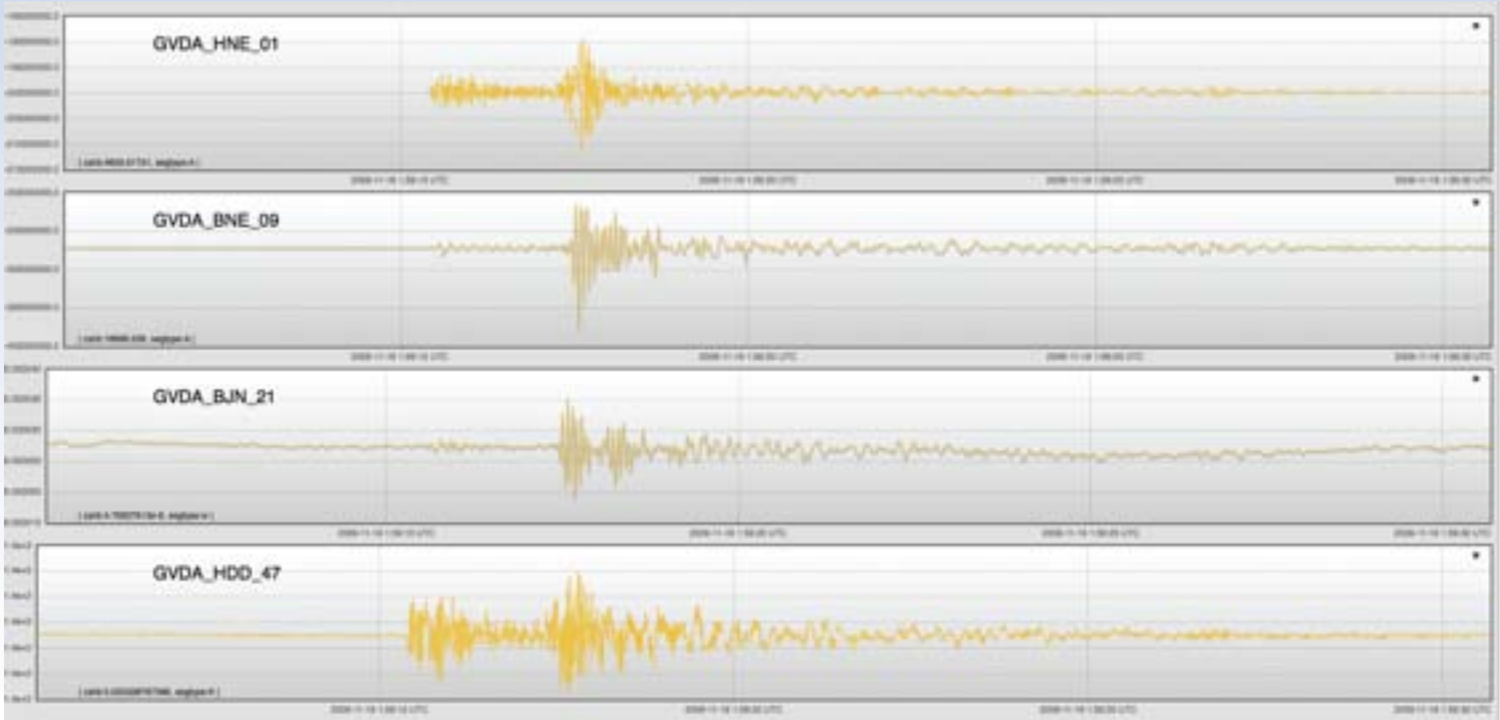


Waveform Server

- advanced interactive plugins
- Calendar

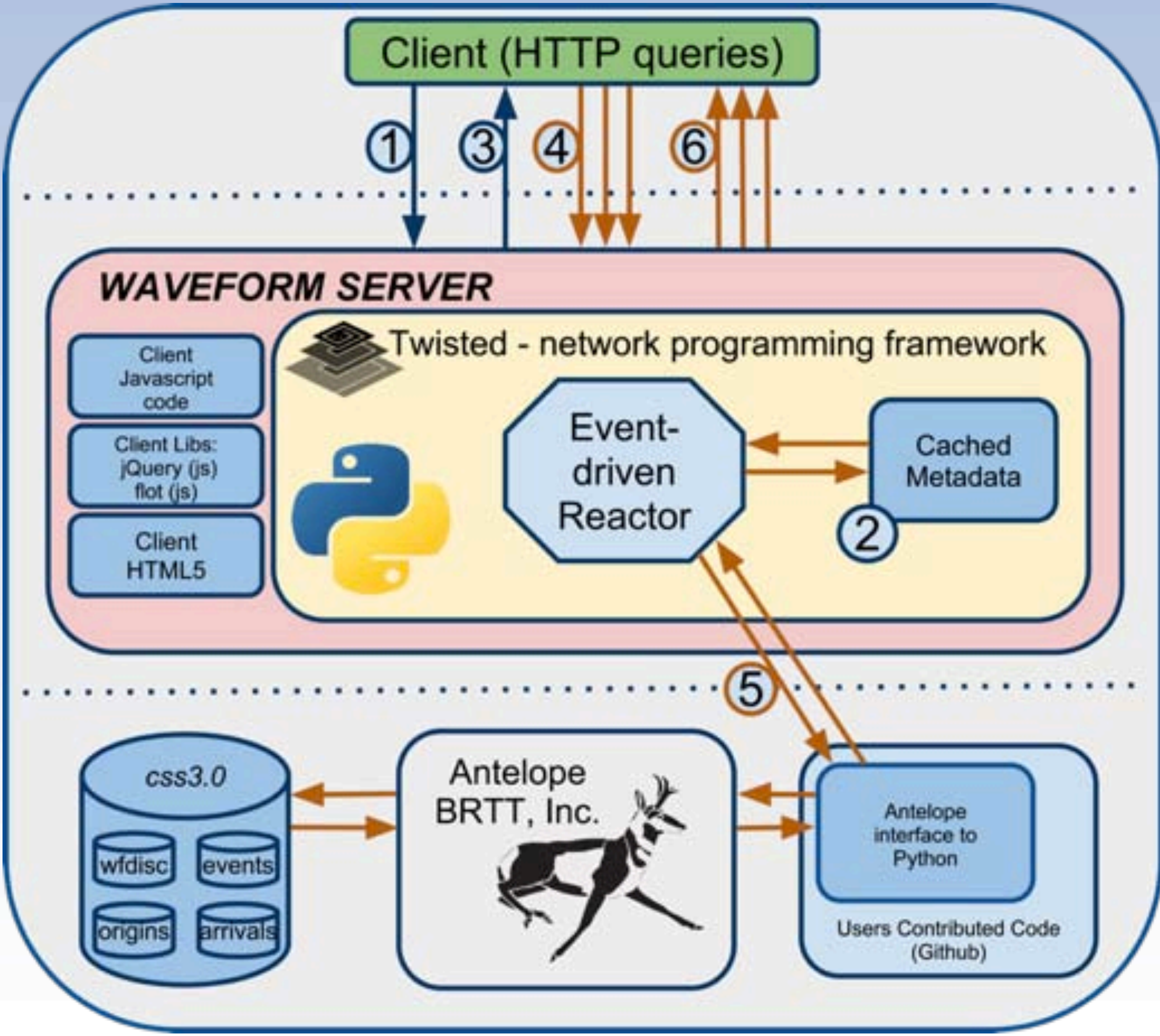
Waveform Server

- Efficient rendering of high and low density traces.
  - Channels BNE and BJN are 40 Hz
  - Channels HNE and HDD are 200 Hz



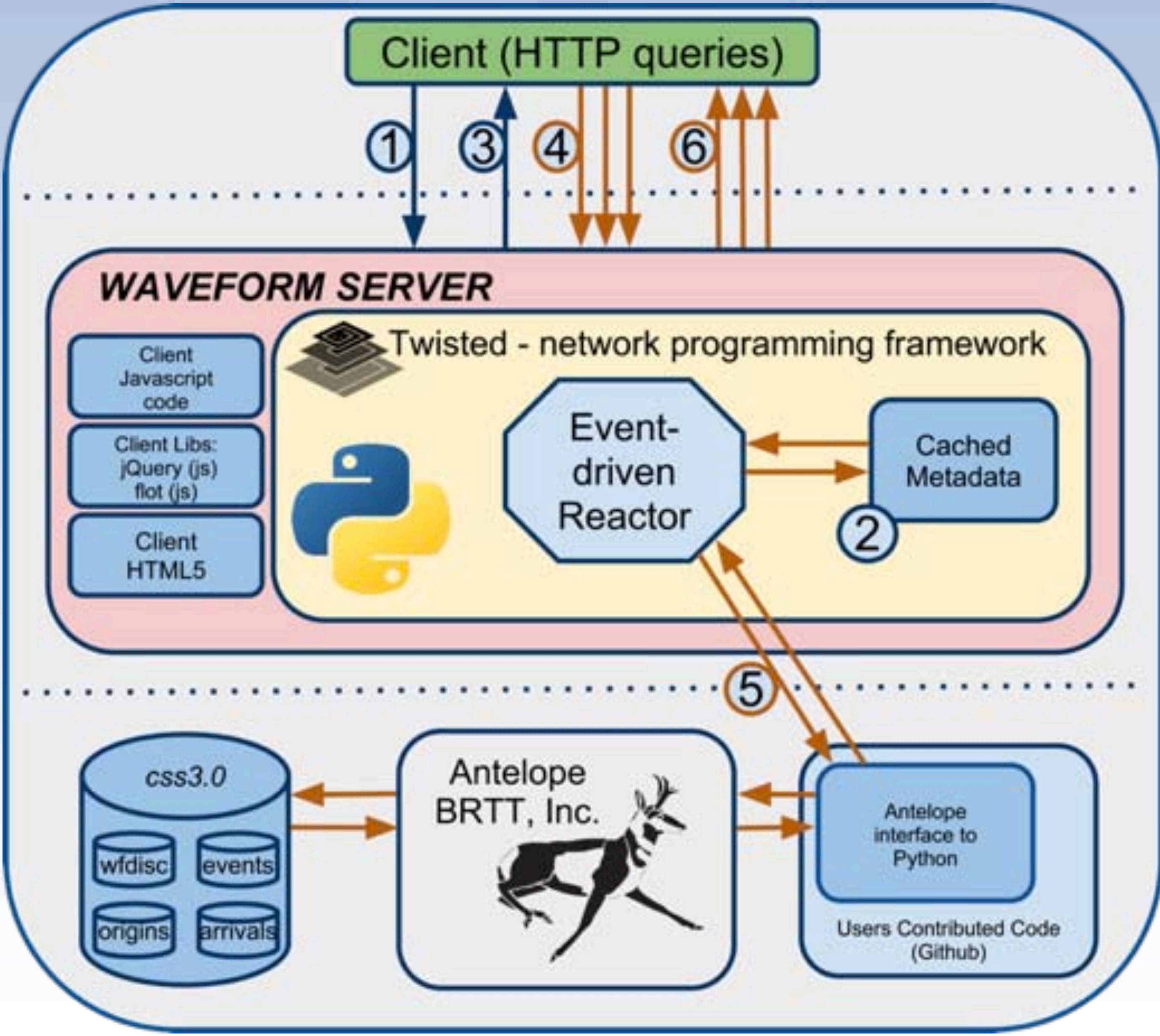
Waveform Server

1) Client (i.e. web browser) initiates process by querying the server with a user provided URI



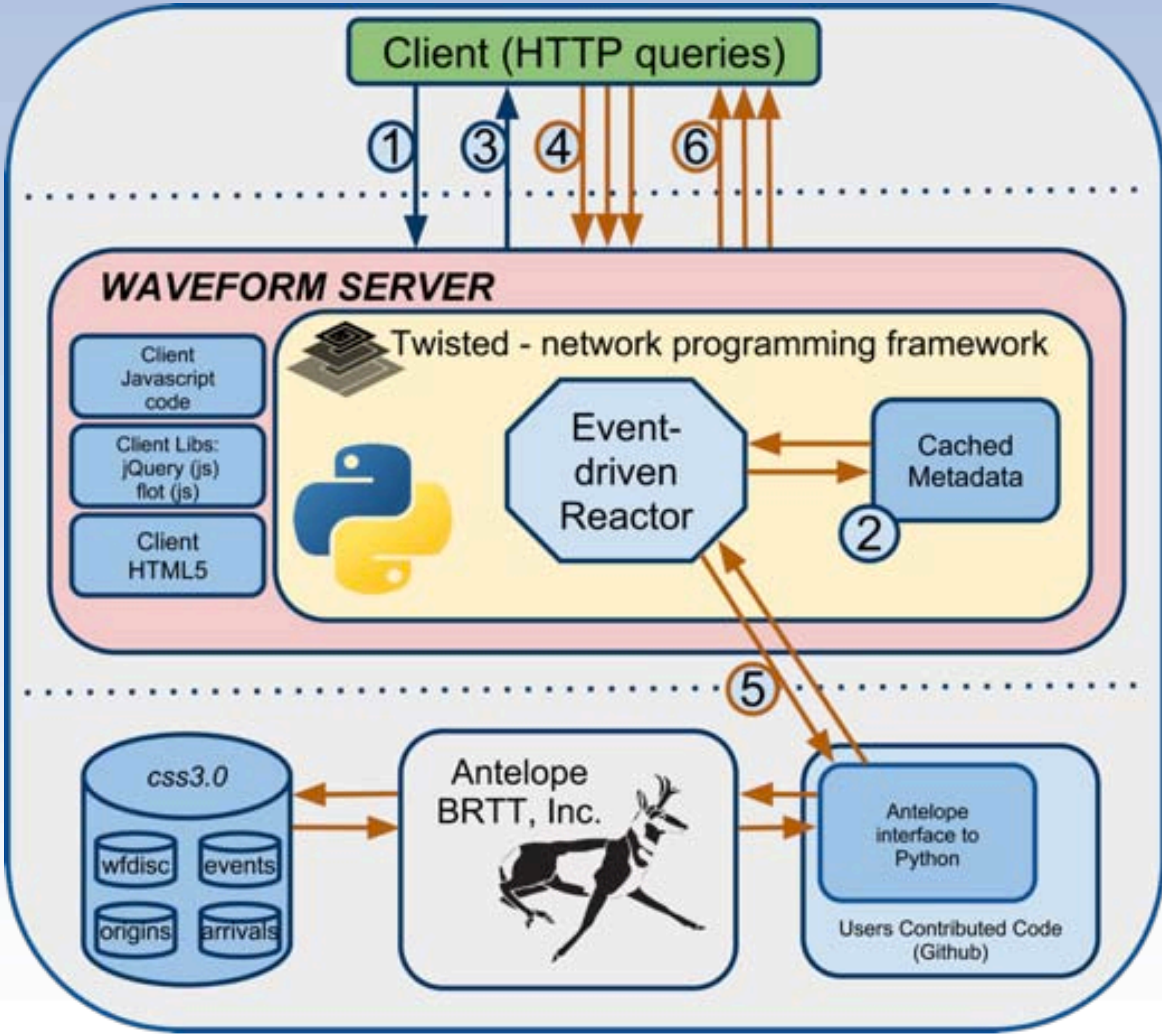
Waveform Server

2) Reactor interprets URI using cached metadata and produces meta-query object that contains references to the requested data.



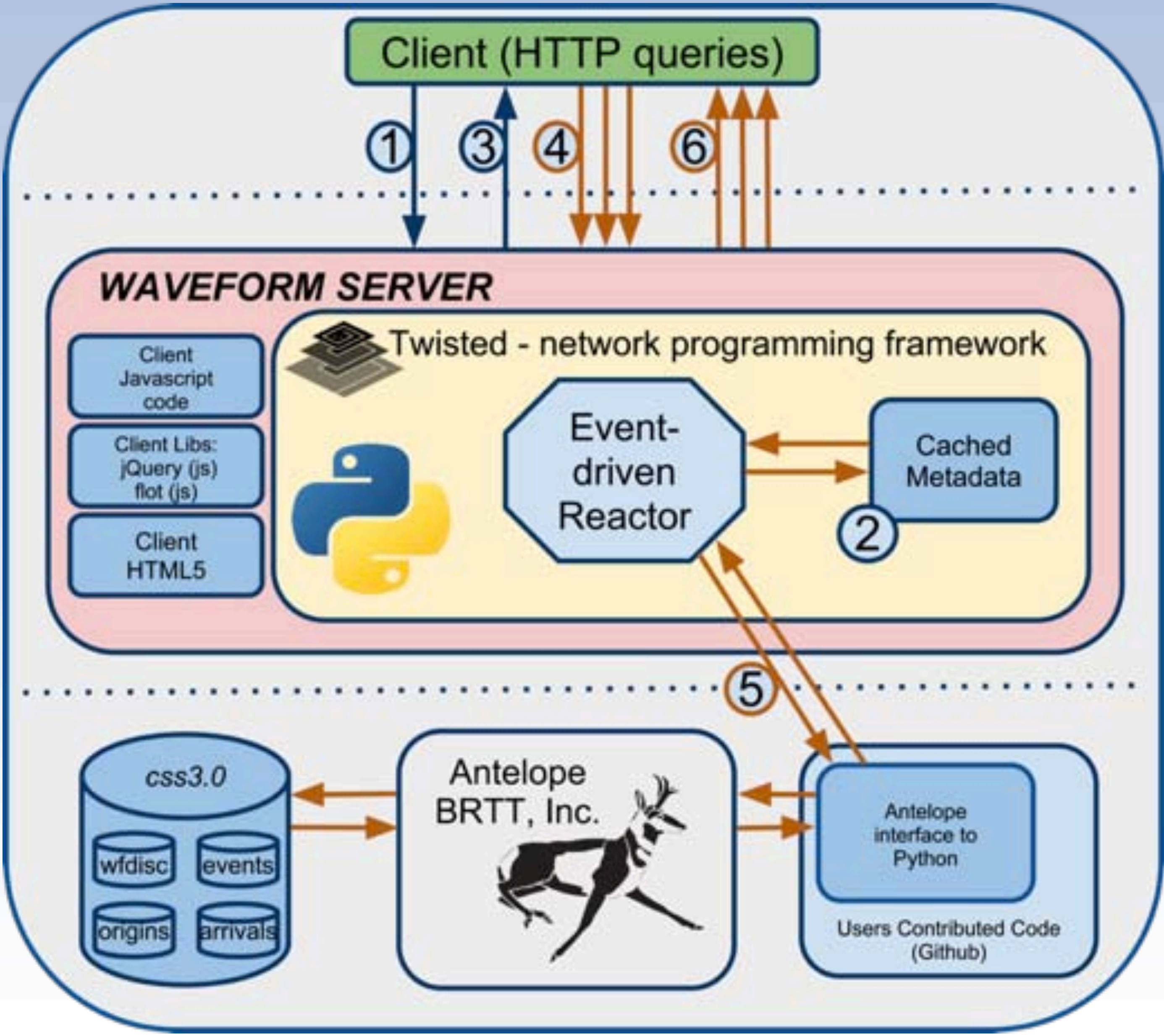
Waveform Server

3) Meta-query object gets injected in the HTML application that will return to the browser



Waveform Server

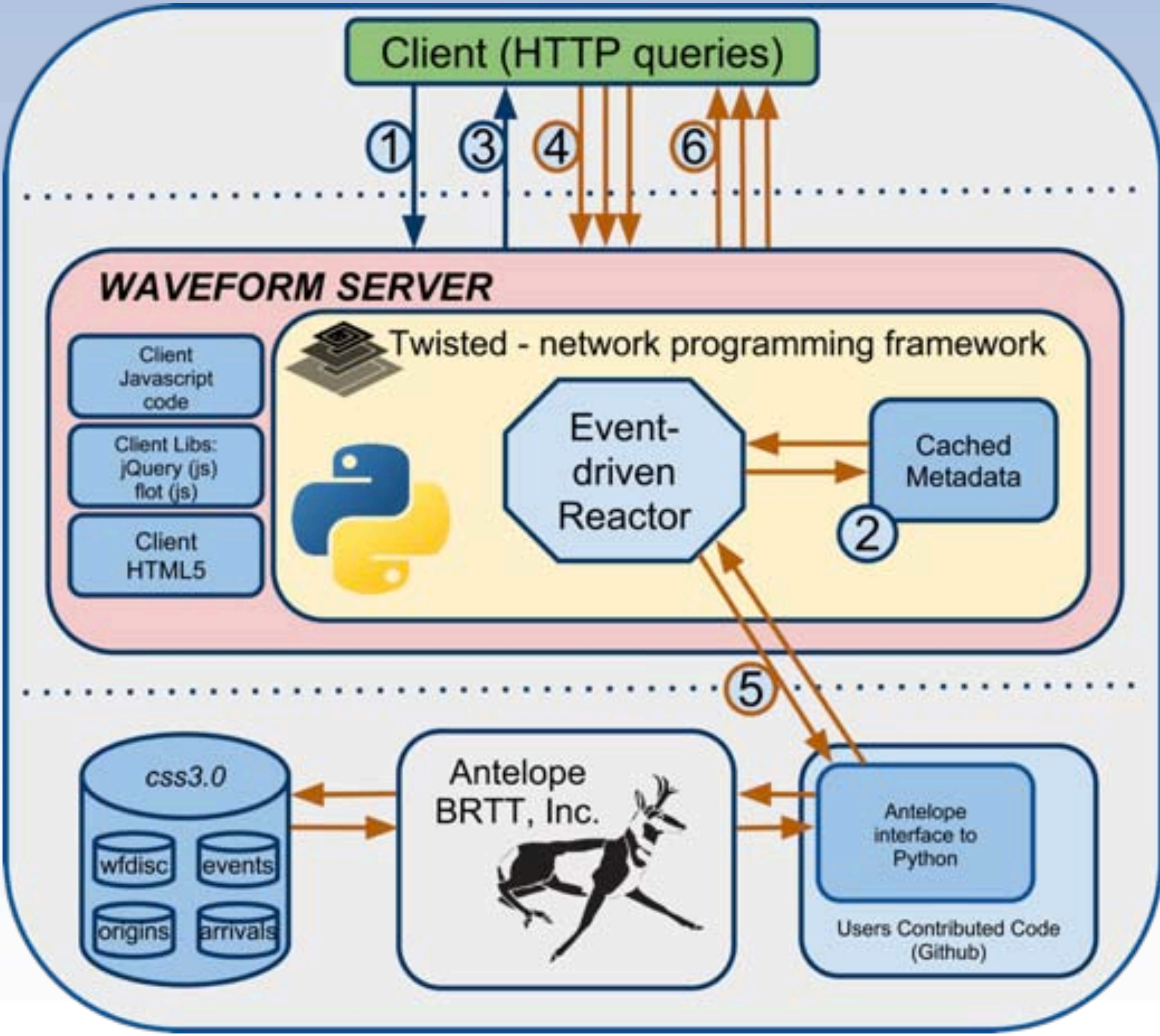
4) JavaScript code prepares the application (HTML5) initiates independent asynchronous queries to the server to populate the canvas elements with the waveforms.



Waveform Server

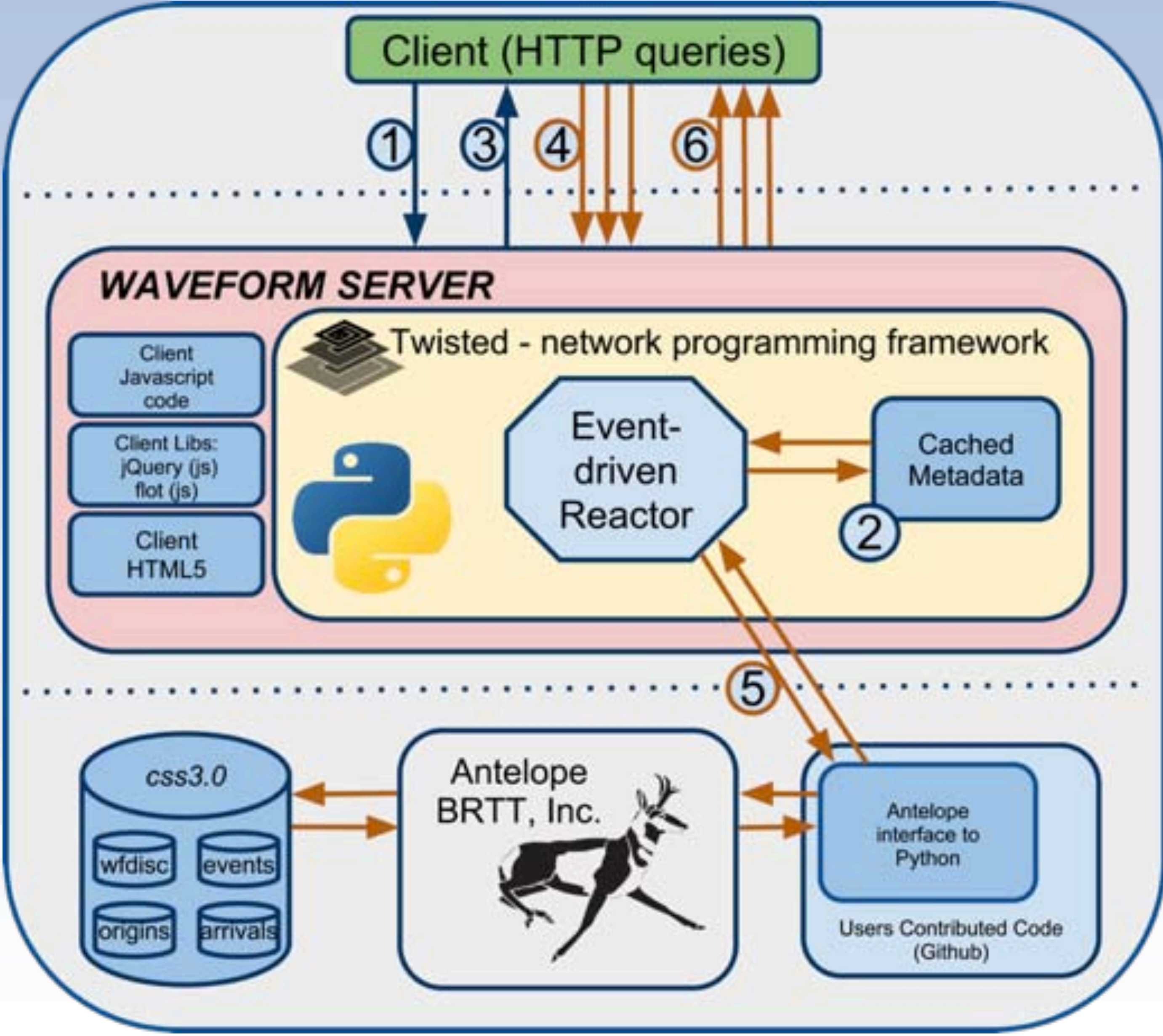
5) The Reactor produces Deferred Objects.

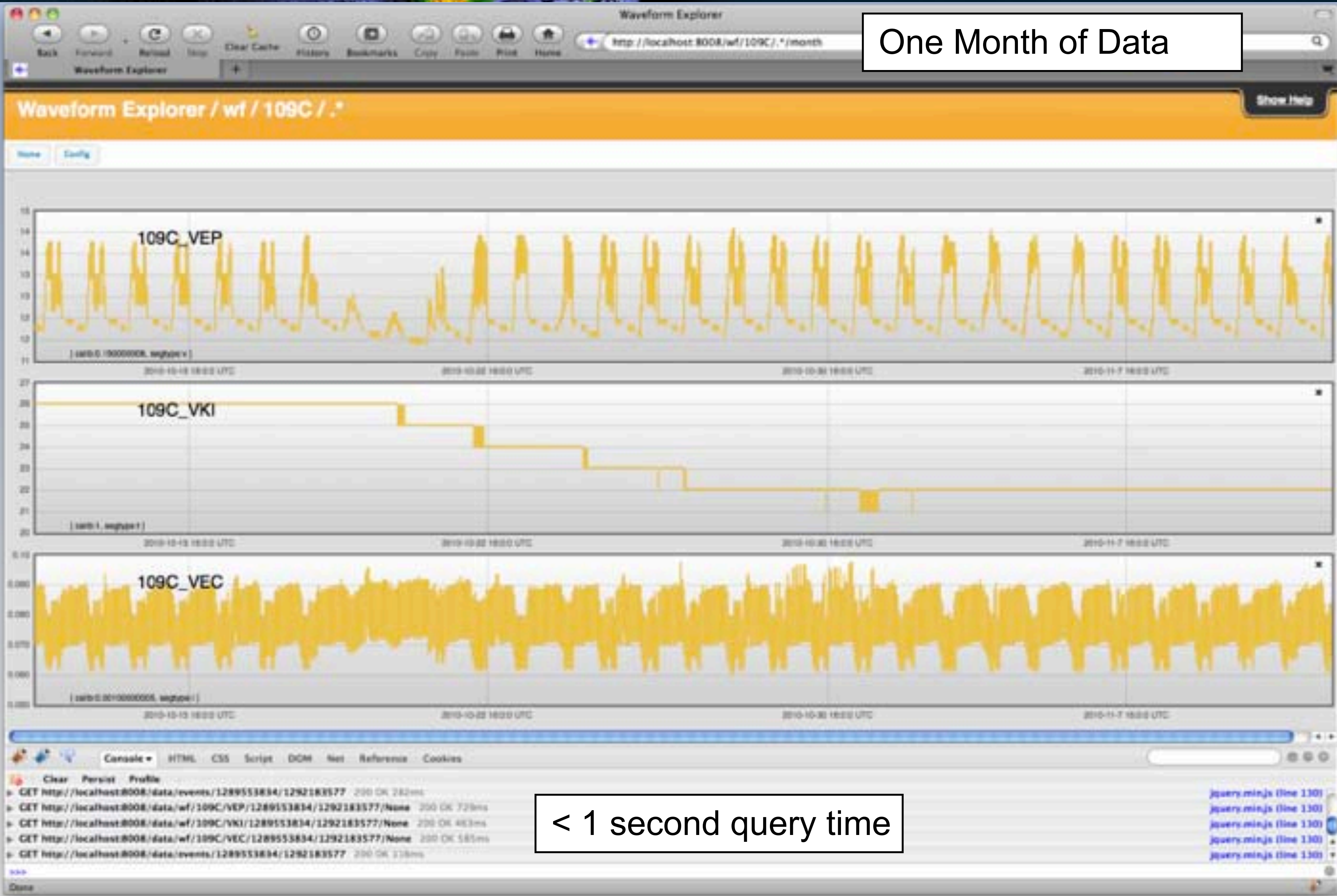
Each Deferred Object gets its own thread and the data retrieval process continues out of the Reactor.



Waveform Server

6) Each Deferred Object will return independent JSON objects in parallel to the client.





One Month of Data

< 1 second query time

- Future development
  - Real time live interface to streaming waveforms from a Object Ring Buffer (ORB).
  - Automate the installation of server-side library dependancies.
  - Promote the development of new clients that can use the server as a gateway to the databases.
- Download
  - online Git repository hosted by Github.
  - http://github.com/antelopeusersgroup/antelope_contrib

NSF EarthScope USArray Transportable Array

Frank Vernon
Scripps Institution of Oceanography
University of California San Diego

AUG, Bucharest, Romania

22 March 2011

USArray TA

Data Center Requirements

- Dynamic Metadata
  - On average install and remove one station for every work day
- High Data Quality
  - Accurate timing (~1μSec)
  - Calibrations
  - Orientation
  - Data completeness
- Minimize data latency
- Automatic event processing
  - Detectors
  - Associators
  - Magnitude Calculators
- Automatic event association to external catalogs
- Analyst review
- Data Archive

Q330 Interface Requirements

- Communication Types
  - Cell - 413 (ATT, Alltel, Edge, Unicel, Union, Verizon)
  - VSAT - 19 (Wild Blue, SpaceNet, Hughes)
  - Internet - 2
  - ~~DSL~~
  - ~~WiFi~~
  - ~~Cable~~
- Stations with IPs generated by DHCP
  - Point of Contact (POC)
- Intermittent Communications
  - Communication Duty Cycling
  - No data loss

Data Exchange Requirements

- Data Imports
  - AZ BK CI IU NN US UU
  - Antelope
  - Earthworm
  - Seedlink
- Data Exports
  - IRIS DMC
    - Archive and distribution
    - Seedlink
  - Regional Networks
    - BK CI NN UU PN

TA Deployment History

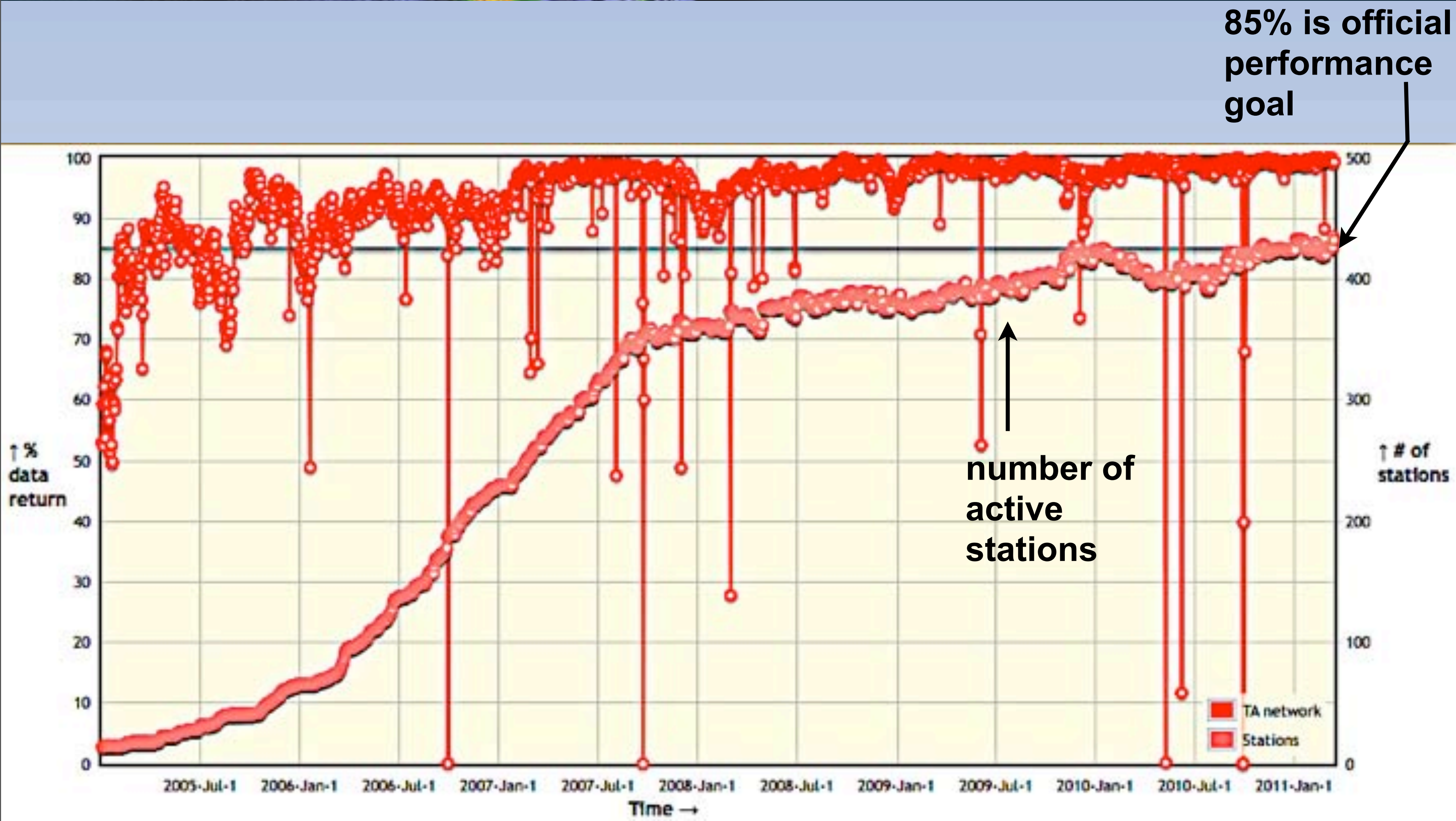
USArray Data Flow

- 8.4 Tbytes of compressed data April 2004 - March 2011
- As of March 2011
  - 4 Gbytes/day compressed data
  - 2 Mbit/sec data export
  - 424 seismic stations
  - 2736 seismic channels
  - 512 barometer and infrasound channels
  - ~14000 soh channels

TA Metadata issues

- Q330 configurations
  - Q330 + Met
  - Q330 + Met + Setra
  - Q330 + Met + NCPA
  - Q330 + Met + Setra + NCPA
  - Q330 + Met + Serial
  - Q330 + Met + Setra + NCPA + Strong Motion
- Metadata updates - Monday and Fridays
- Address Installation, Removal, Service reports with 1 week
- Online reports on daily basis (weekends also)
  - Data certification with one week

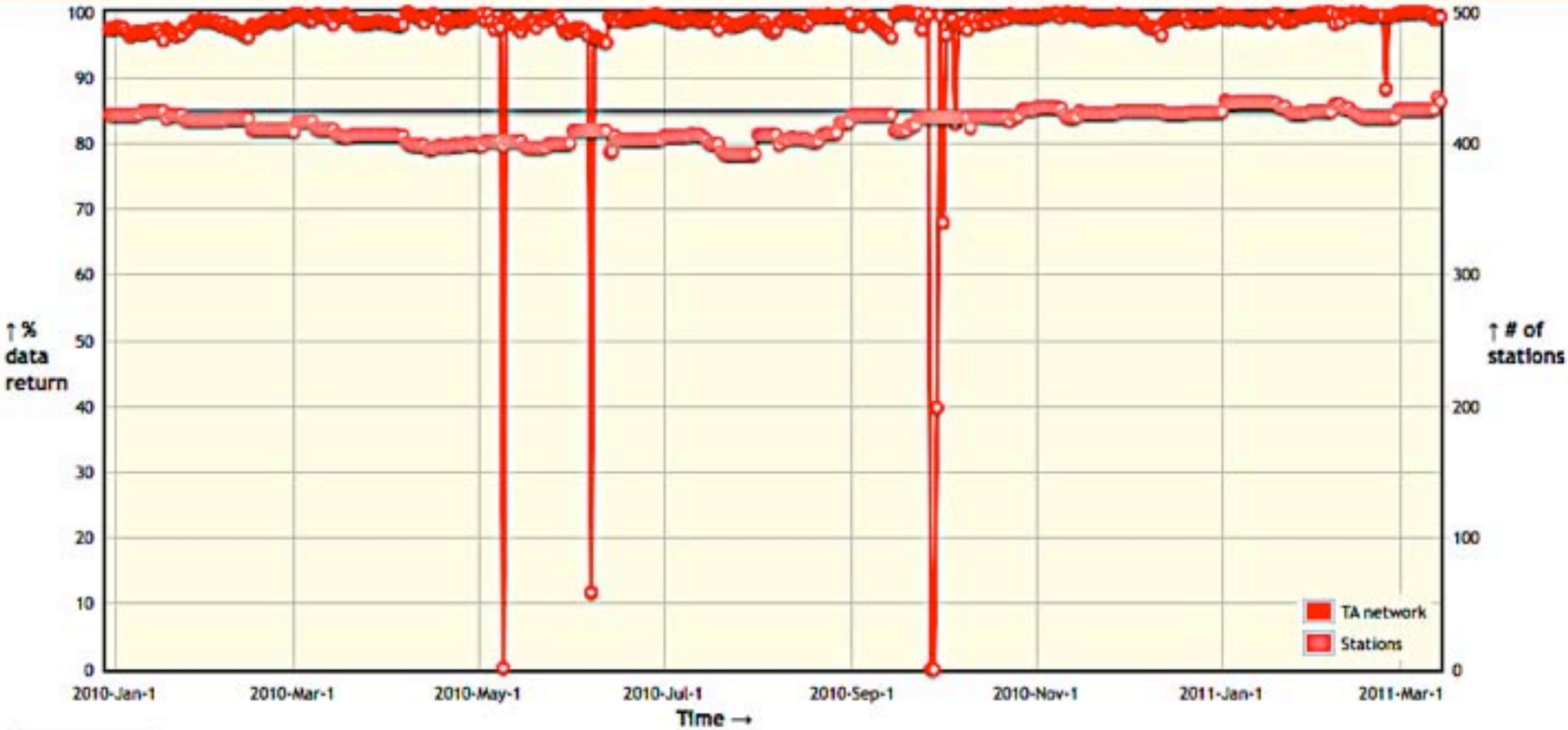
TA Total RT Data Return



TA 2010-11 RT Data Return

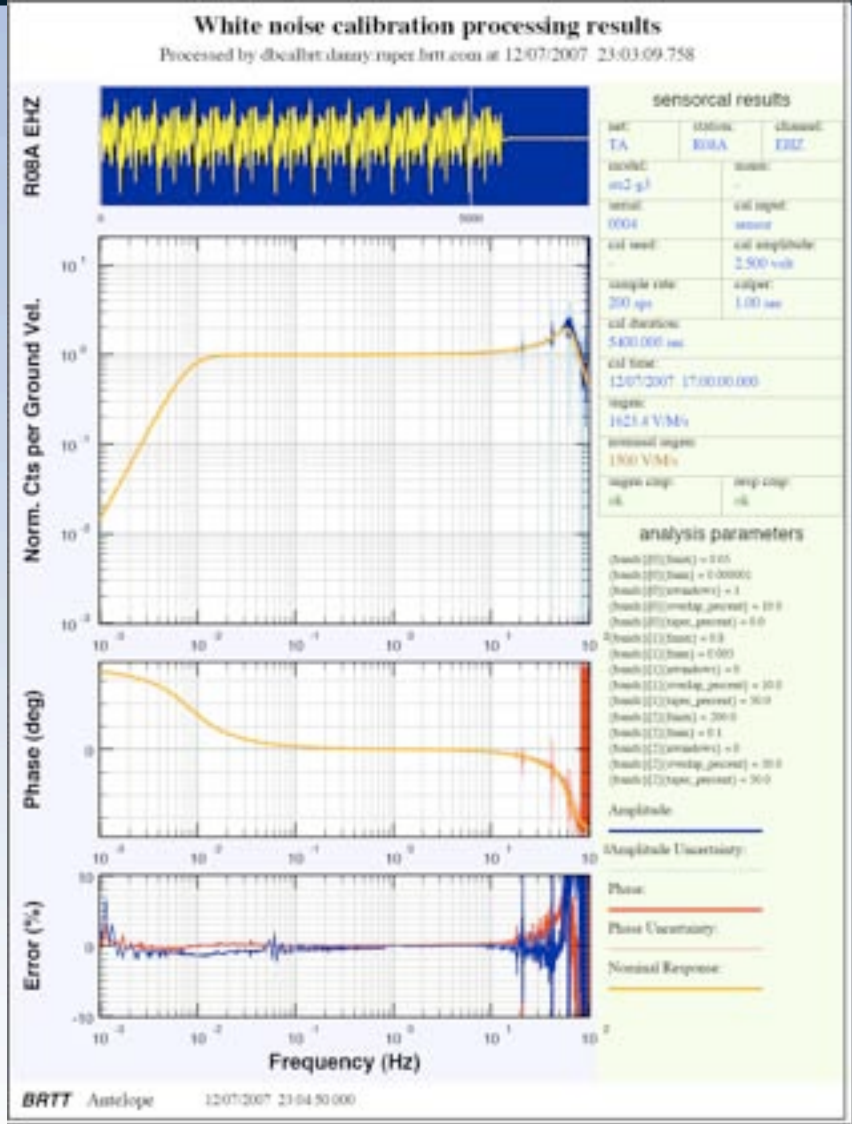
6 days 100.00% Data Return

Mean Data Return - 97.37%
Median Data Return - 98.90%

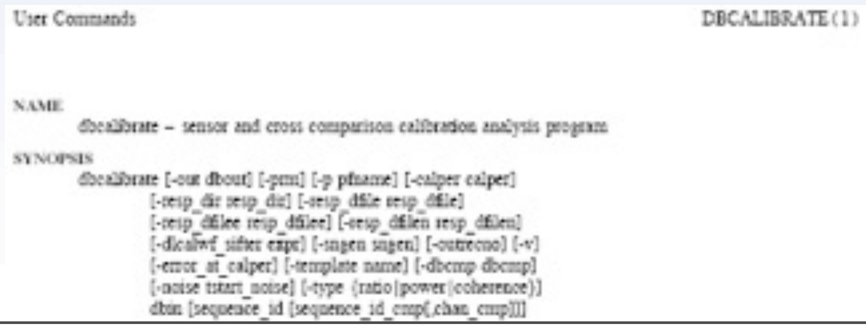


Calibration

- Automated process to command, capture and analyze cal signals applied in situ using Antelope.
- Interpret calibration analyses to verify amplitude and phase response, stationarity of sensor
- Applied to all stations at beginning and end of deployment.
- Archived as Data Product



Results from BRTT Antelope software


User Commands DBCALIBRATE(1)

NAME
dbcalibrate – sensor and cross comparison calibration analysis program

SYNOPSIS
dbcalibrate [-out dbout] [-pmi] [-p pfname] [-calper calper]
[-resp_dir resp_dir] [-resp_dfile resp_dfile]
[-resp_dfilee resp_dfilee] [-resp_dfilen resp_dfilen]
[-dicalwf_sifter expr] [-ingen singen] [-outrecno] [-v]
[-error_at_calper] [-template name] [-dbcmp dbcmp]
[-noise tstart_noise] [-type {ratio|power|coherence}]
dbin [sequence_id [sequence_id_cmp[,chan_cmp]]]

SOH archive explorer

ANF Array Network Facility

Home | Stations | Tools | Earthquakes | Projects | About | Admin | Search

Transportable Array State-Of-Health Archive Explorer

View state-of-health plots from different time periods for specific channels. If there is a missing channel combination that you think would be useful, please email rlnewman@ucsd.edu.

Notes:

- A station has to be operational for at least one month before archived plots are created and stored for it.
- Wild Blue stations do not allow comms SOH information to be gathered.

2010 −

January: **lo** [AG HN OW X9] **mass** [AG HN OW X9] **vault** [AG HN OW X9]
February: **lo** [AG HN OW X9] **mass** [AG HN OW X9] **vault** [AG HN OW X9]
March: **lo** [AG HN OW X9] **mass** [AG HN OW X9] **vault** [AG HN OW X9]
April: **lo** [AG HN OW X9] **mass** [AG HN OW X9] **vault** [AG HN OW X9]
May: **lo** [AG HN OW X9] **mass** [AG HN OW X9] **vault** [AG HN OW X9]
June: **lo** [AG HN OW X9] **mass** [AG HN OW X9] **vault** [AG HN OW X9]
July: **comms** [AG HN OW X9] **lo** [AG HN OW X9] **mass** [AG HN OW X9] **vault** [AG HN OW X9]
August: **comms** [AG HN OW X9] **lo** [AG HN OW X9] **mass** [AG HN OW X9] **vault** [AG HN OW X9]

2009 +

Last updated: 2010-09-02 (245) 21:41:25 UTC

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EarthScope is funded by the National Science Foundation. The EarthScope Array Network Facility supports USArray with the Incorporated Research Institutions for Seismology.

SOH archive explorer

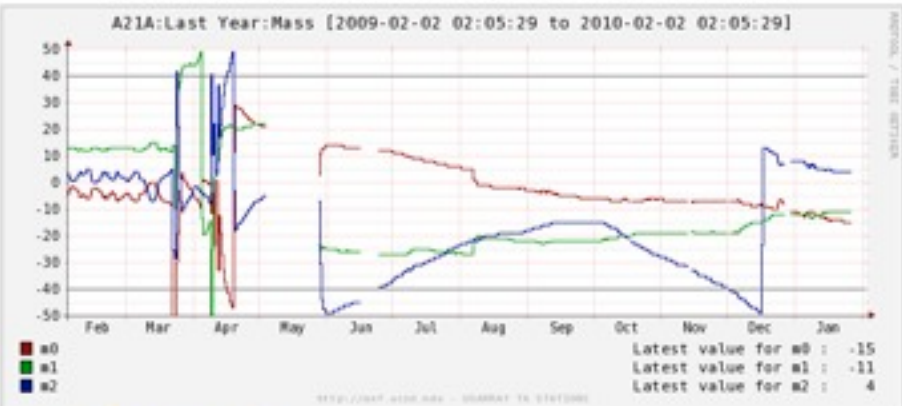
TA_A20A

Sensor model: Guralp

TA_A20A

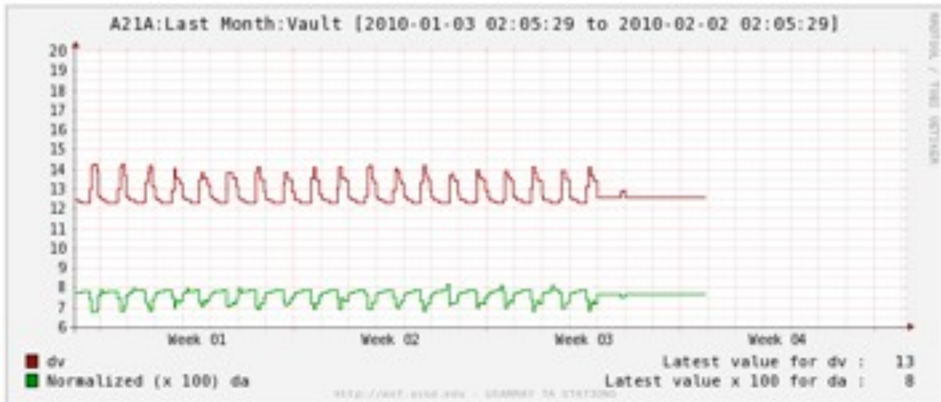
Datalogger model: Quanterra Q330 Baler model:

TA_A21A



Sensor model: Streckeisen STS-2

TA_A21A



Datalogger model: Quanterra Q330 Baler model:

Environmental options

Included:

Pressure
Humidity
Temperature

VTI SCP1000 MEMS

Few ubar resolution below 4mHz. Size ~ 5mm x 5mm

Analog Options: Precision Barometer or Infrasound -- 40 sps and 1 sps

Setra 278
Precision
Analog

Digital Option: SDI-12

VAISALA

P.O. Box 26, FI-00421 Helsinki, FINLAND
Tel: +358 9 894 91
Fax: +358 9 8949 2485
Email: industrialsales@vaisala.com
www.vaisala.com/WXT520

Vaisala Weather Transmitter WXT520
Access to Real Time Weather Data

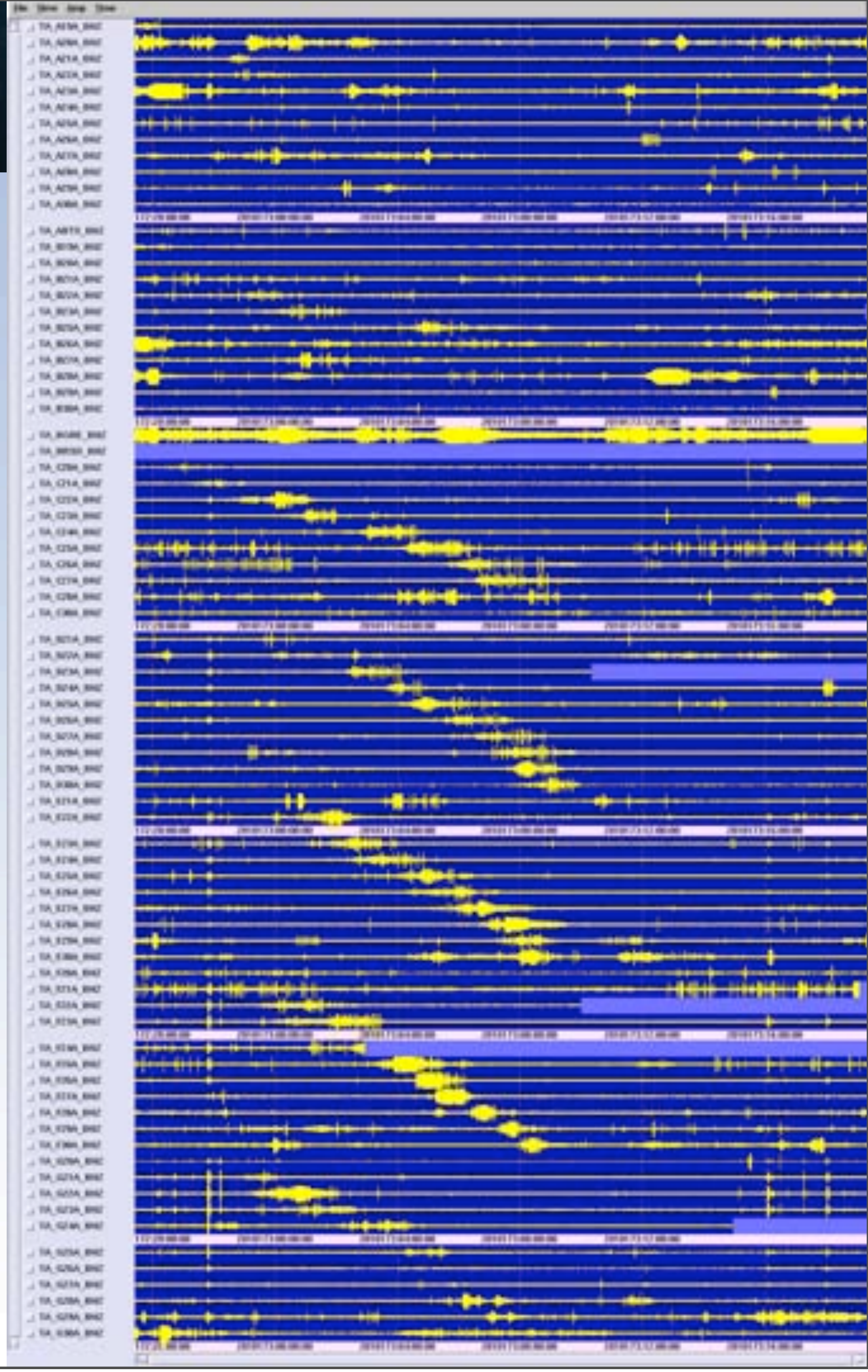
Features/Benefits

- Measures 6 most essential weather parameters
- Accurate and stable
- Low power consumption - works also with solar panels
- Compact, light-weight
- Easy to install
- No moving parts
- Vaisala Configuration Tool for pc
- USB connection
- IP66 housing with mounting kit
- Applications: weather stations, dense networks, harbors, marinas

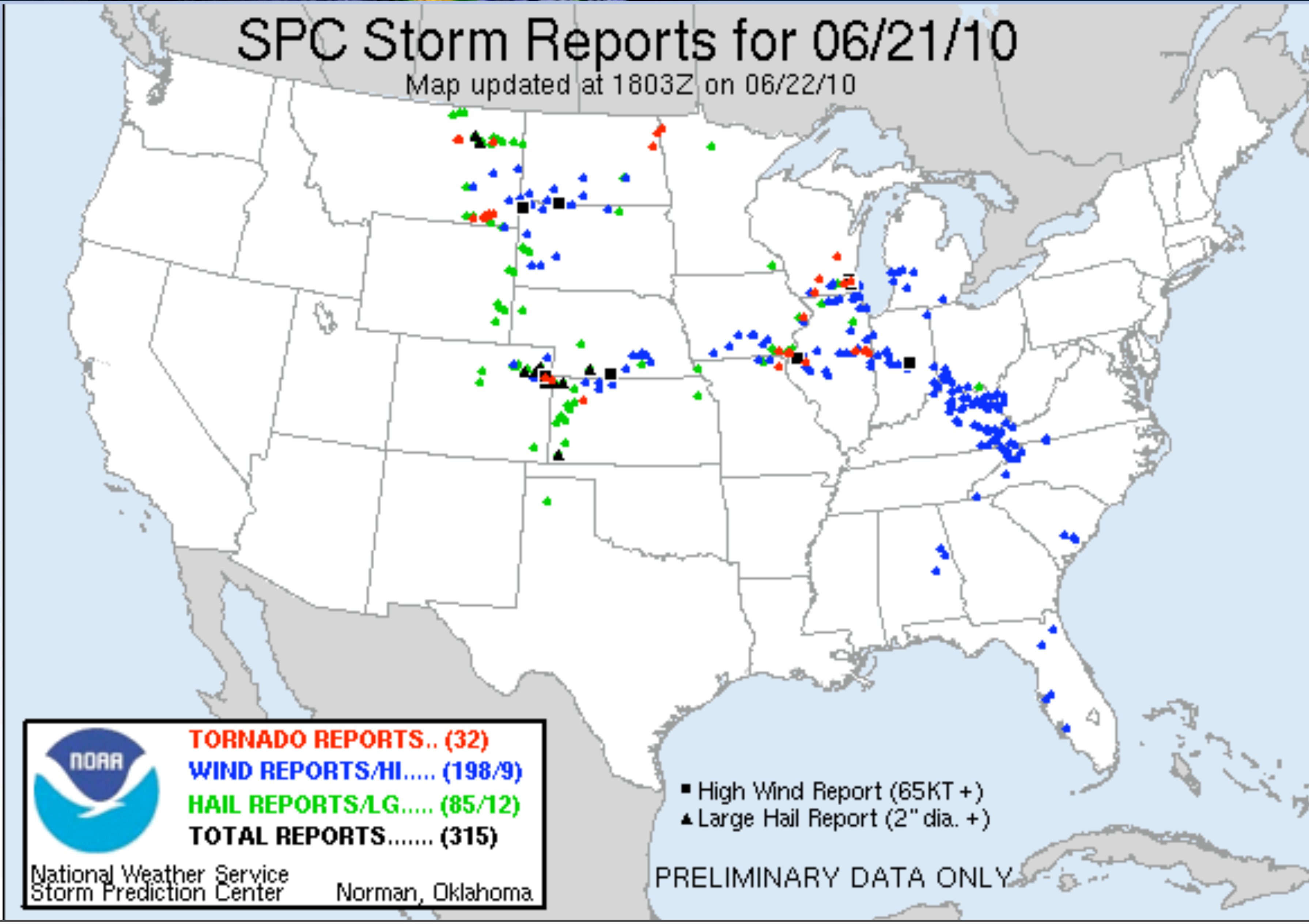
The Vaisala Weather Transmitter WXT520

Infrasound Choices:
NCPA 50500

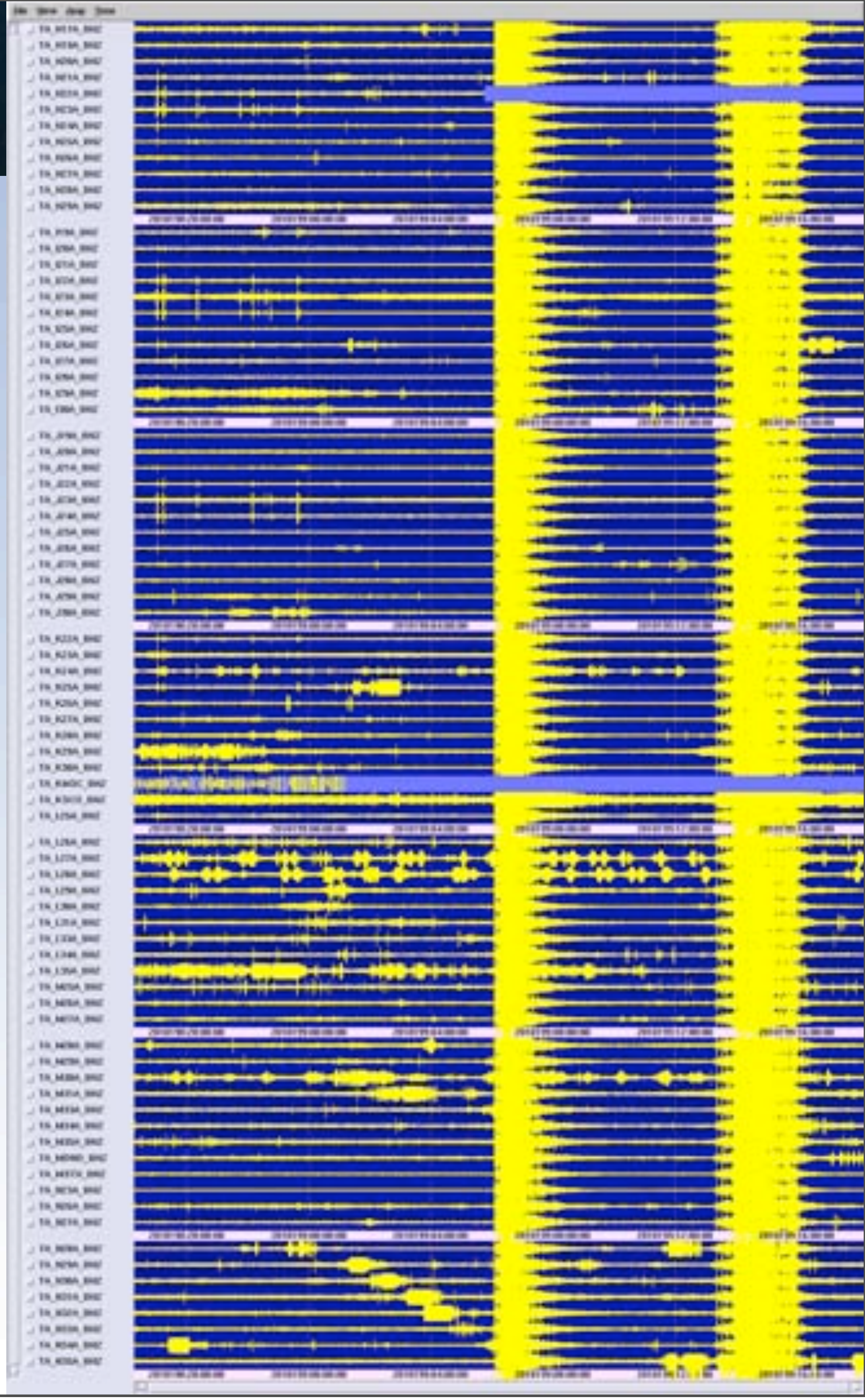
- **Strange signals**
- **Correlated across stations**
- **Slow move out**
- **Too slow for seismic**
- **Too slow for infrasound**



Storm Reports



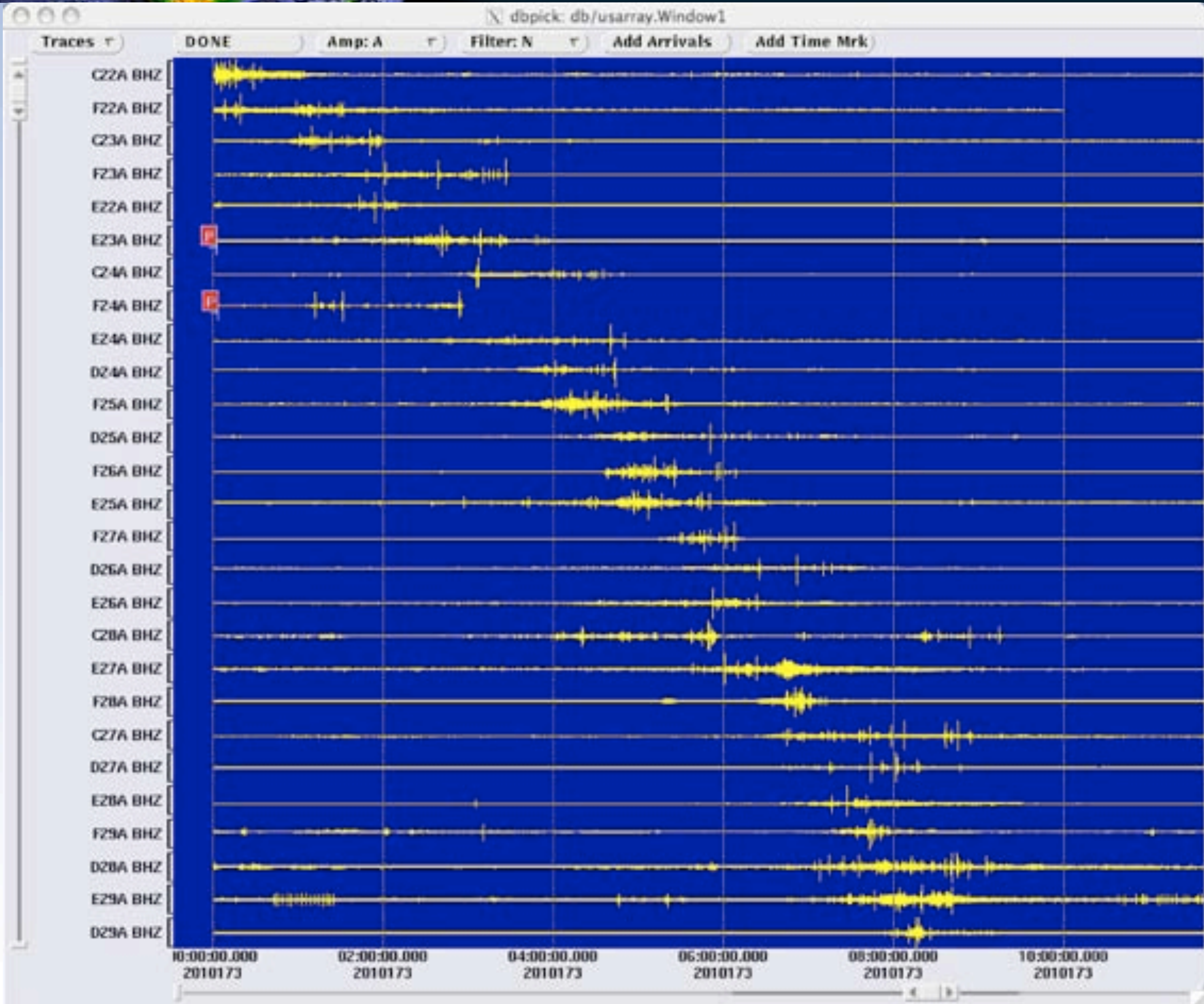
- 6.7 Aleutian Islands
- 6.9 New Britain
- 7.3 New Britain
- Slow move out
    - Too slow for seismic



Interesting Signals

40 sps

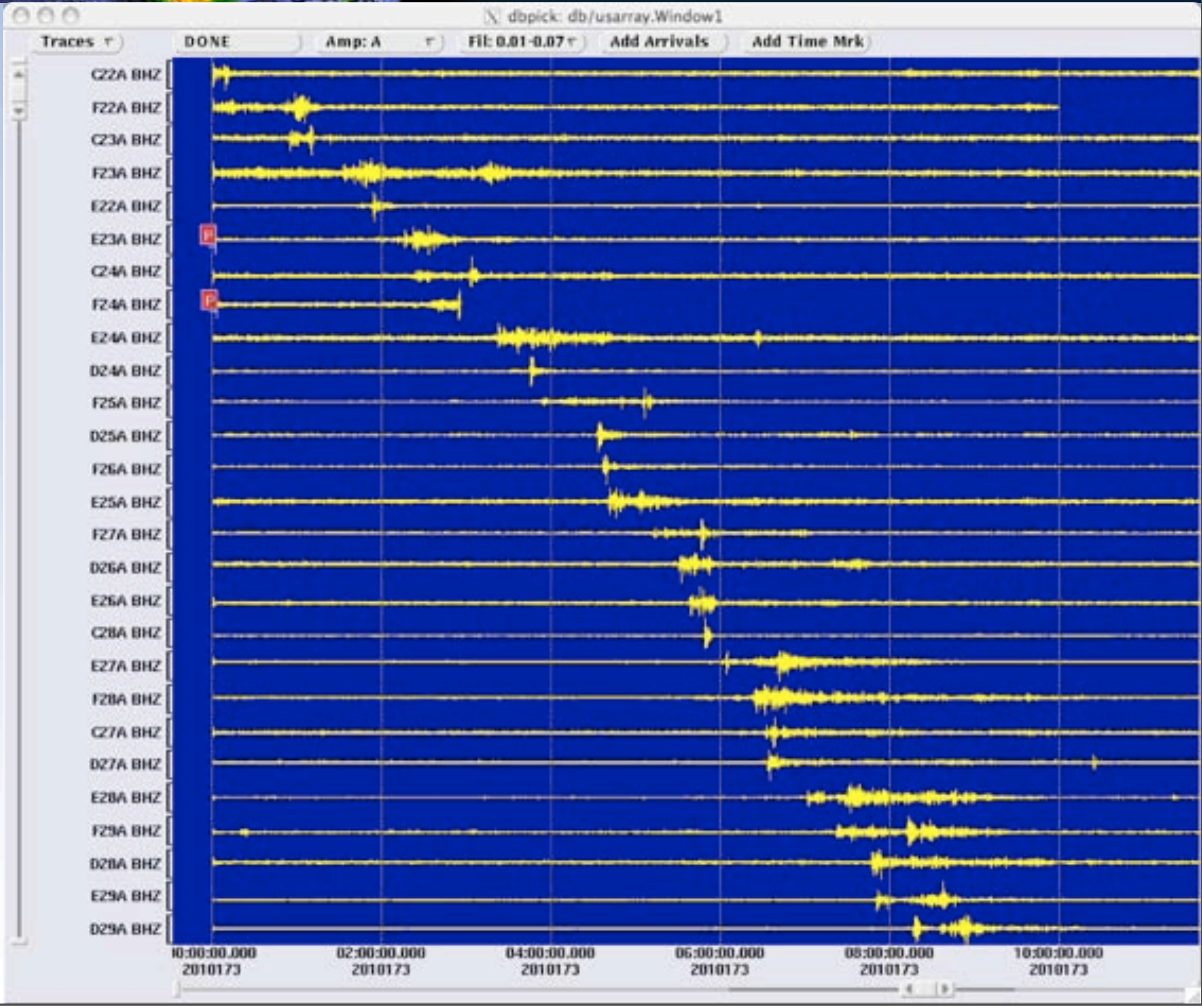
Unfiltered



Interesting Signals

40 sps

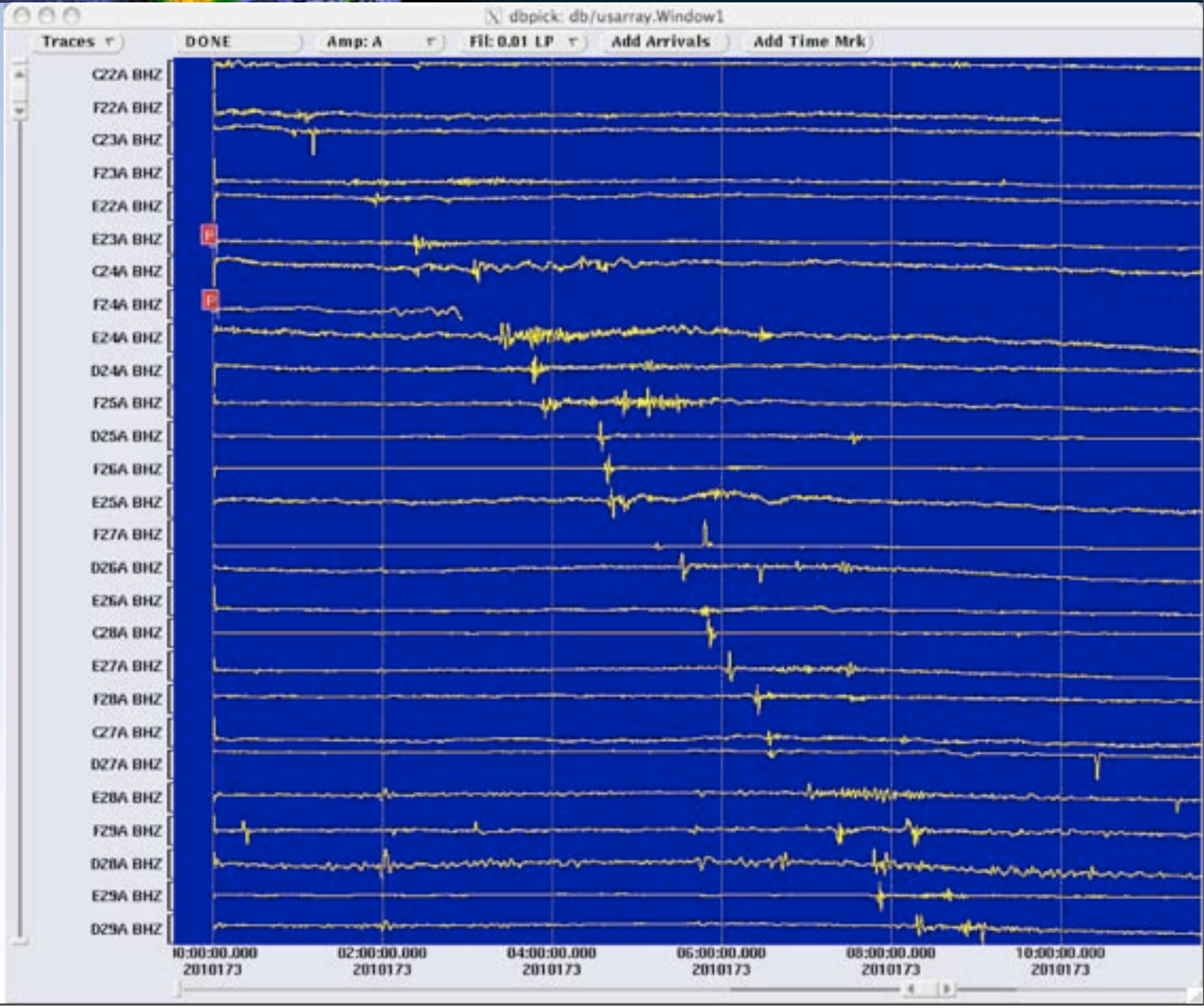
0.01 - 0.07 Bandpass Filter



Interesting Signals

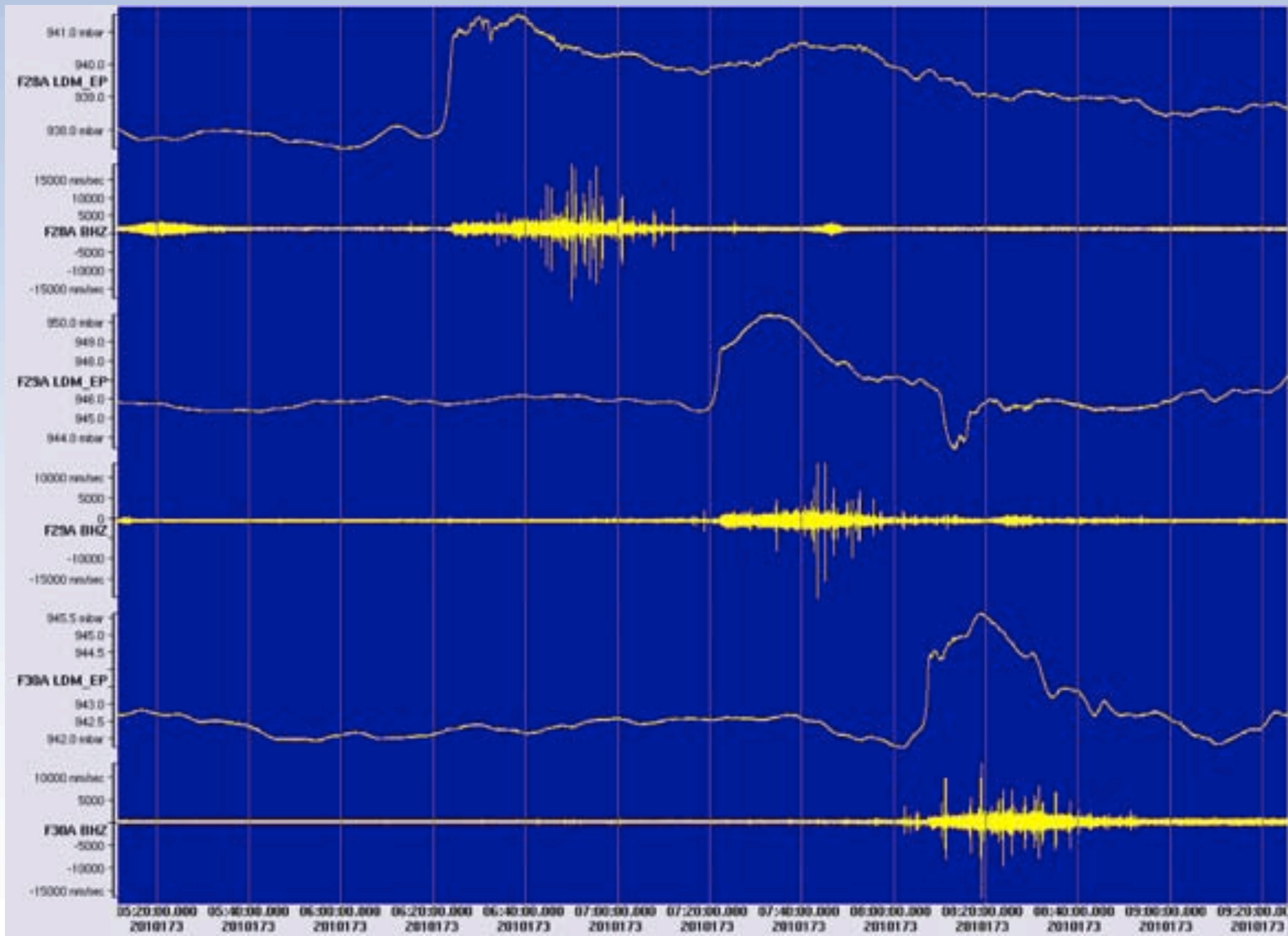
40 sps

DC - 0.01 Lowpass Filter



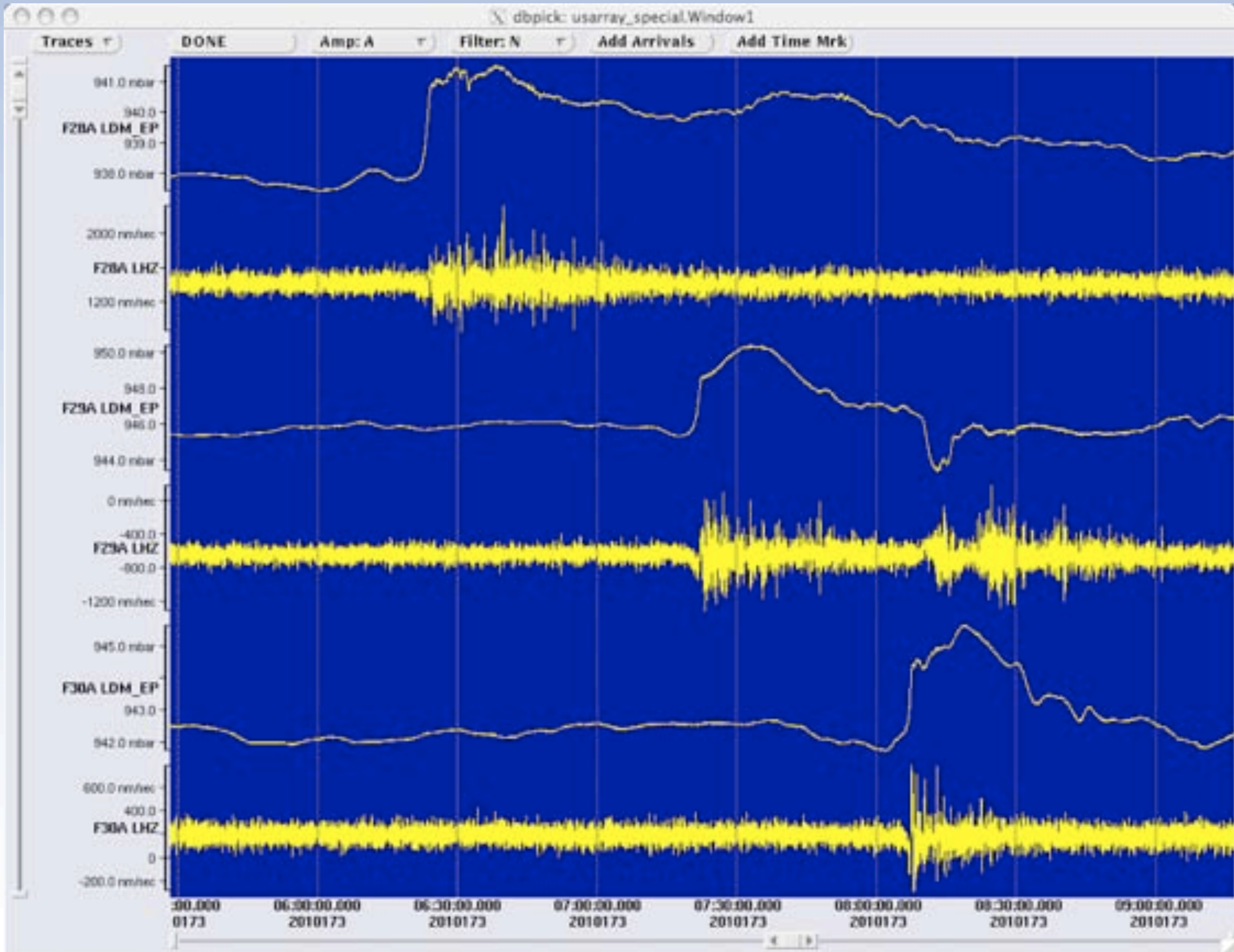
Interesting Signals

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



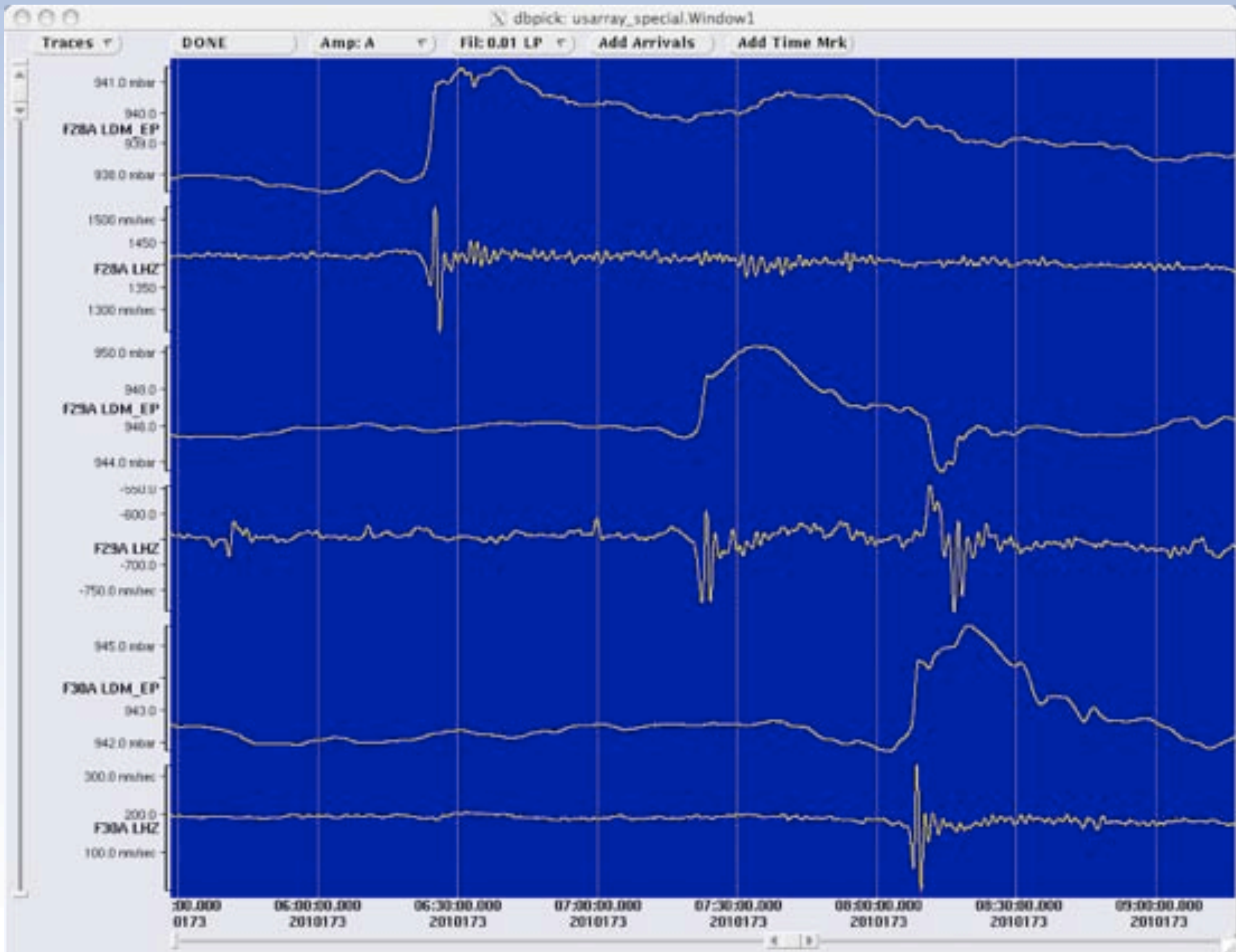
Interesting Signals

Low Frequency Seismic (1 sps) compared to Atmospheric Pressure (1 sps)

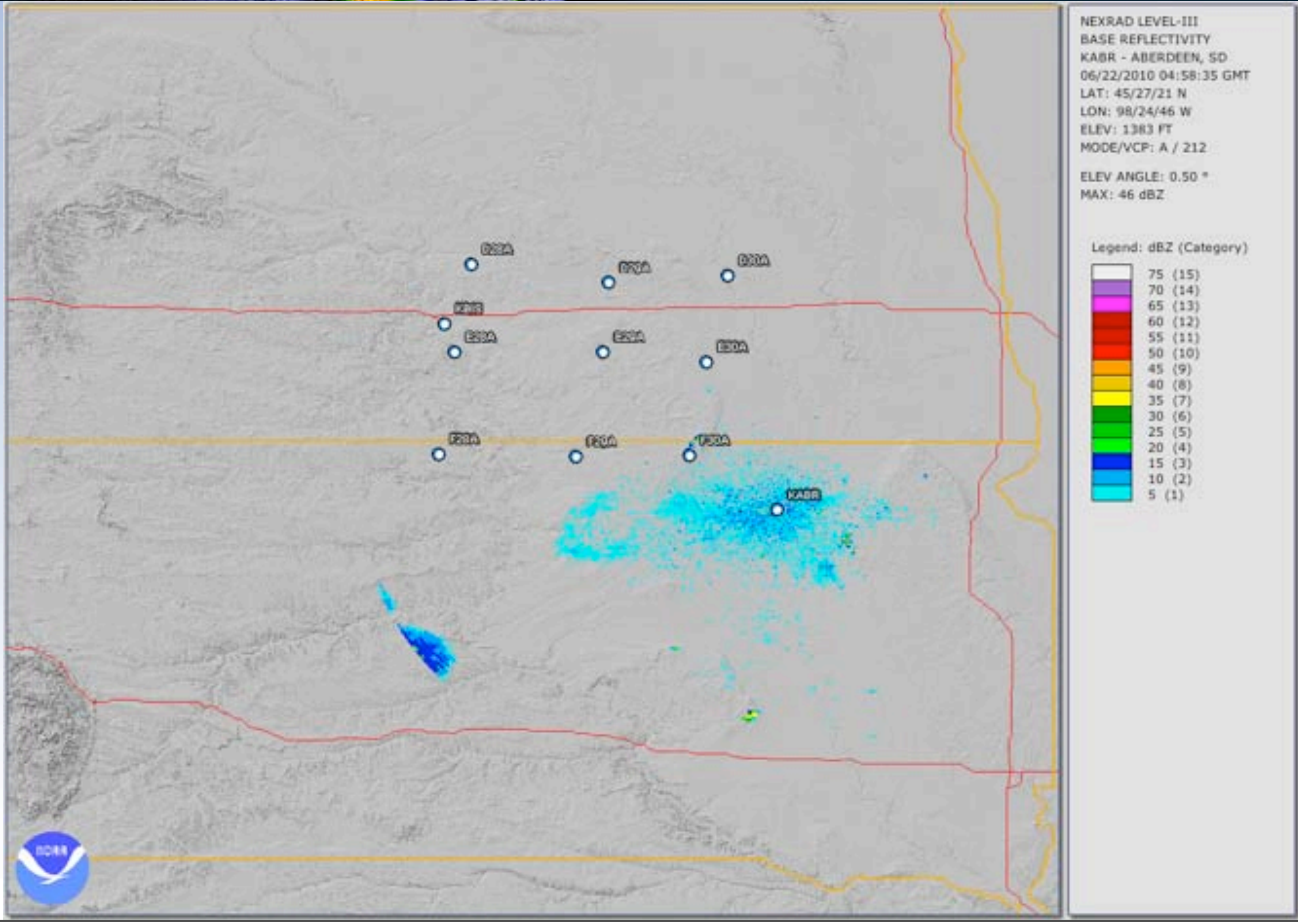


Interesting Signals

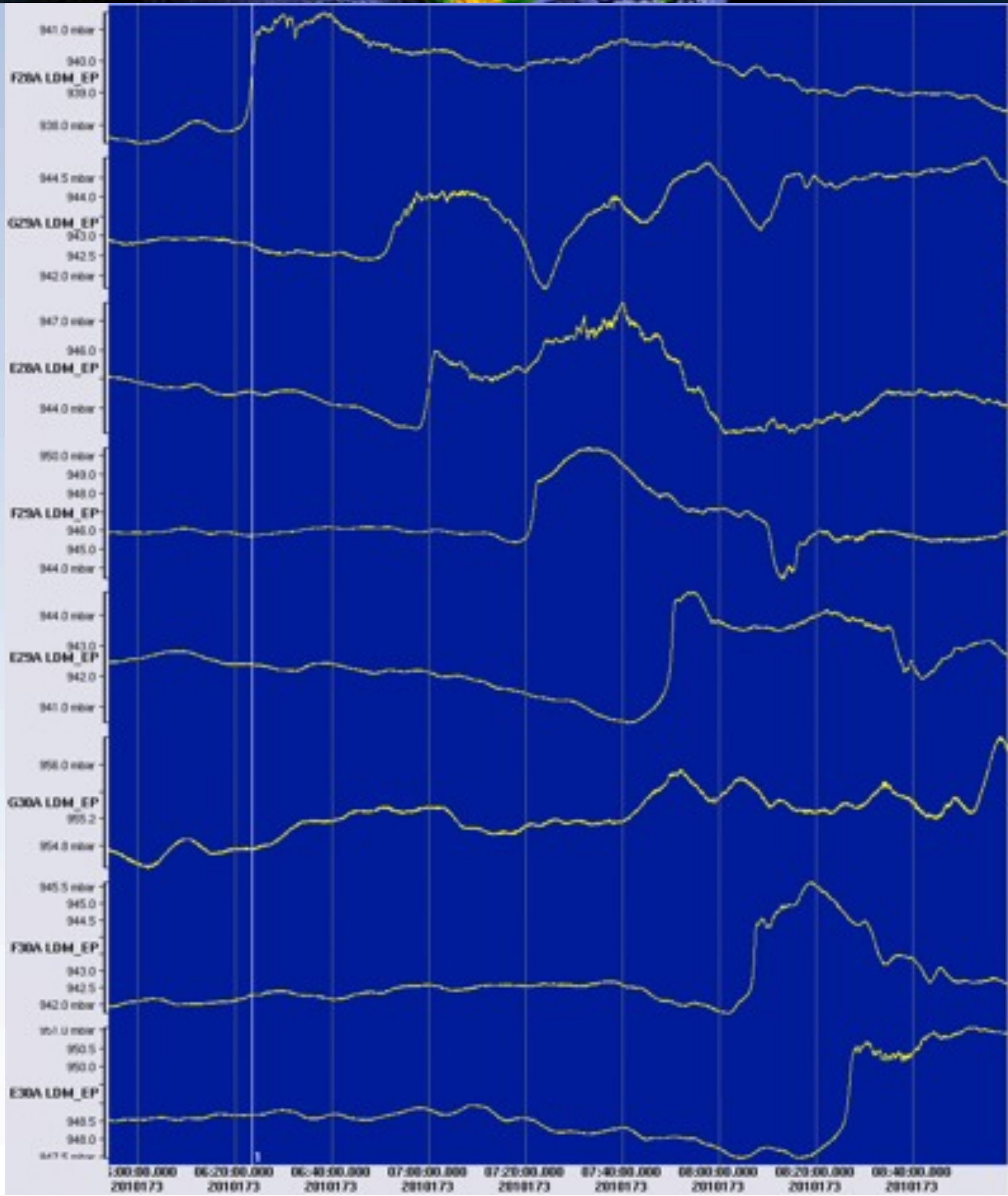
Low Frequency Seismic (< 0.01 Hz) compared to Atmospheric Pressure (1 sps)
Ground deforming to pressure increase

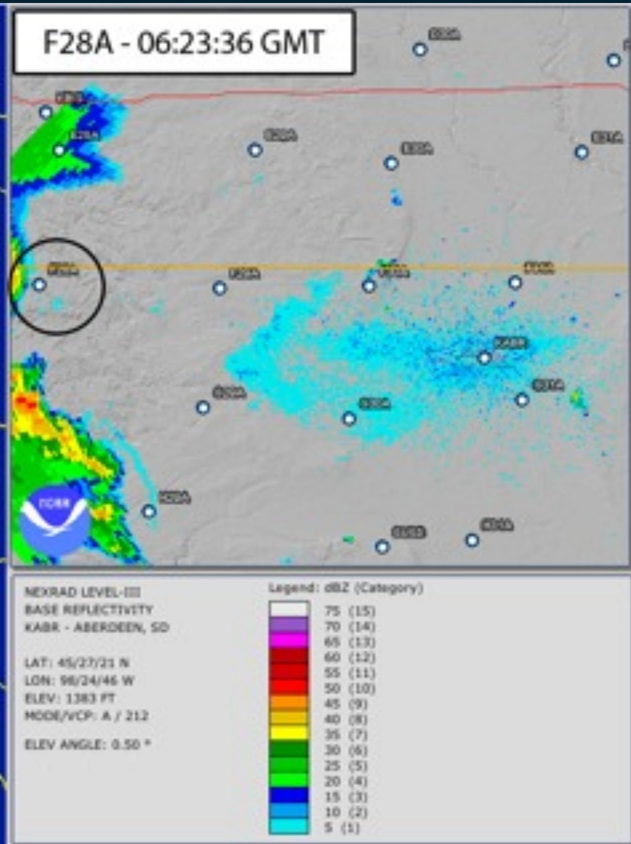


Interesting Signals

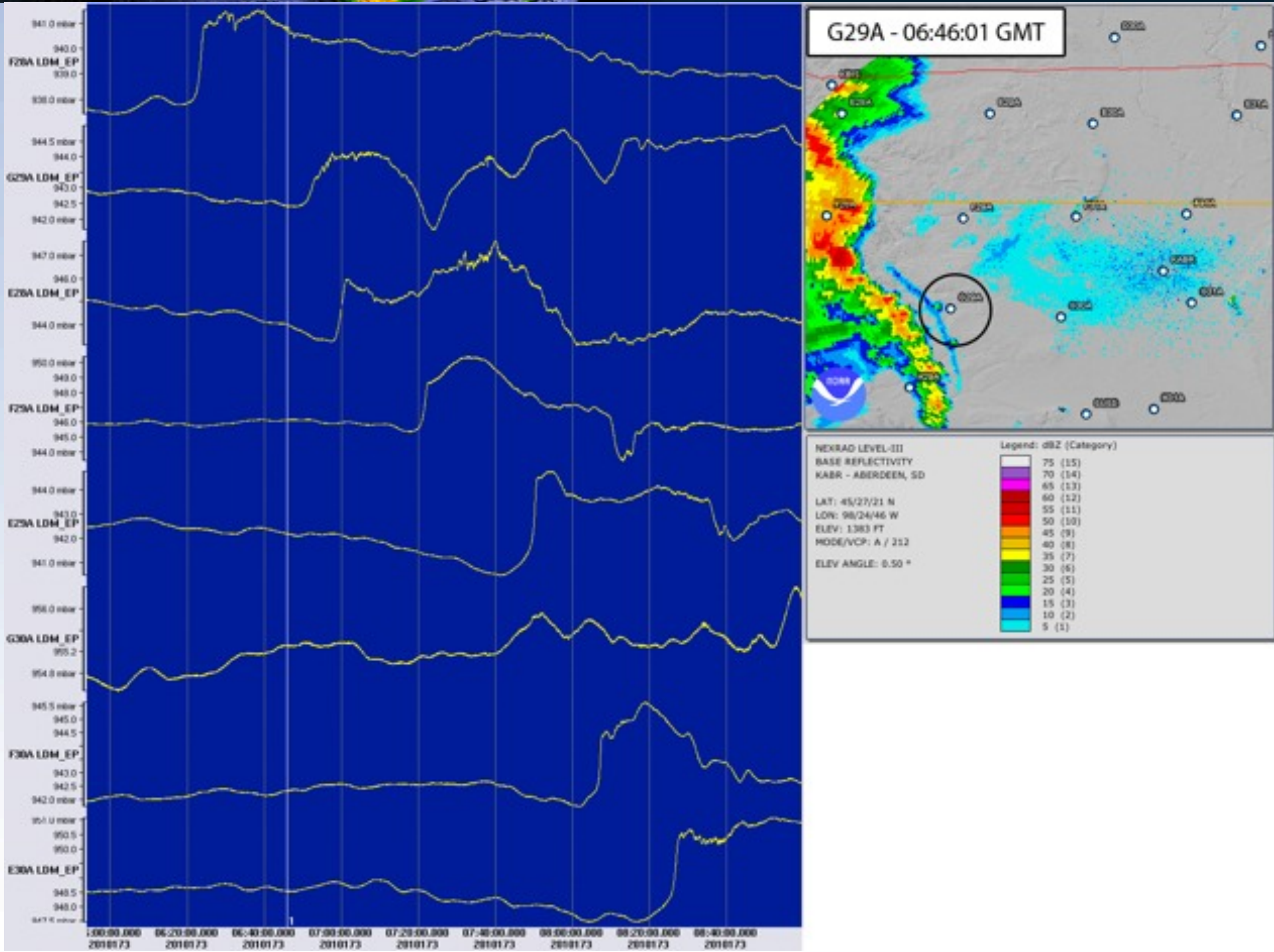


Case Study - 6/22/2010

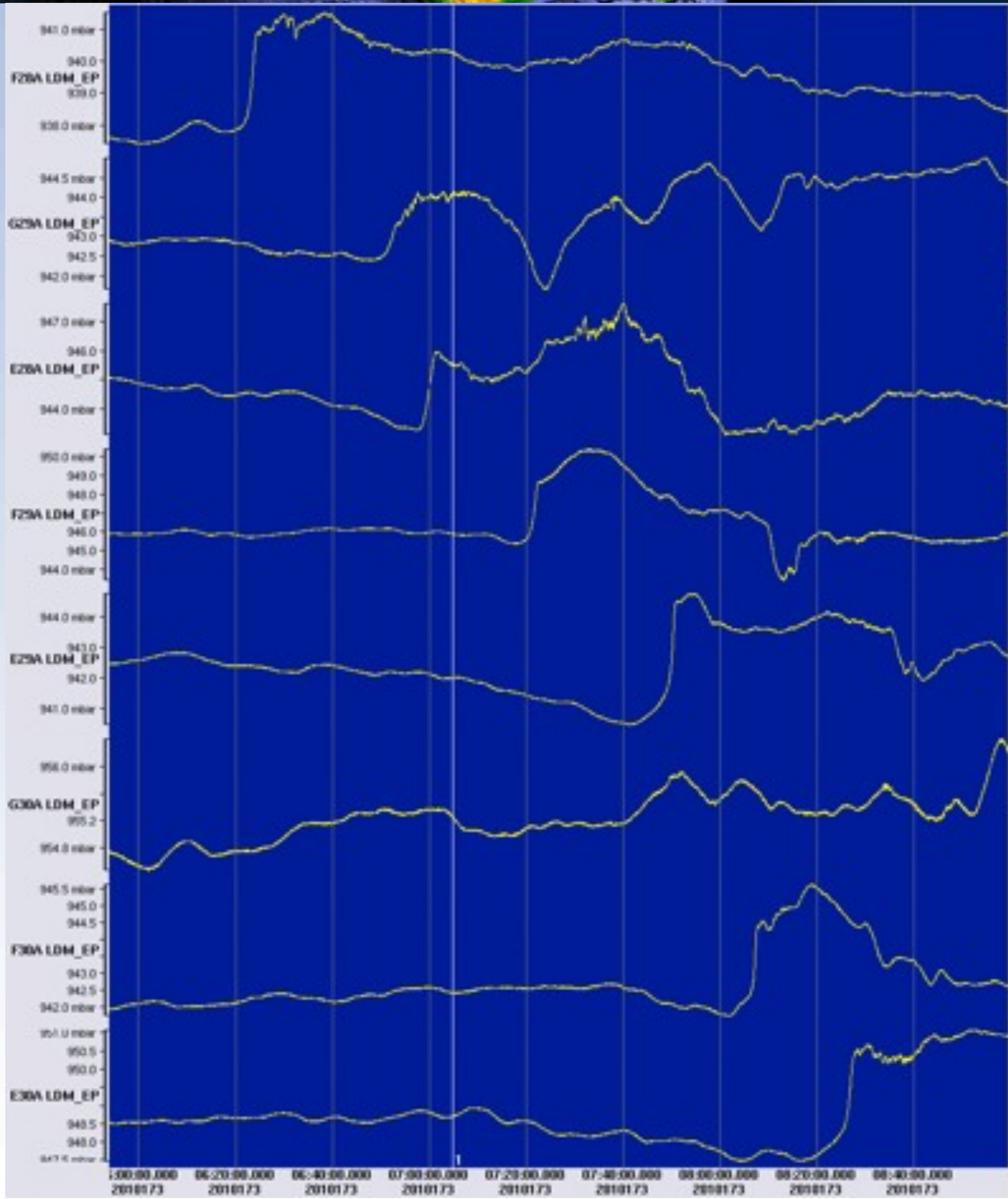


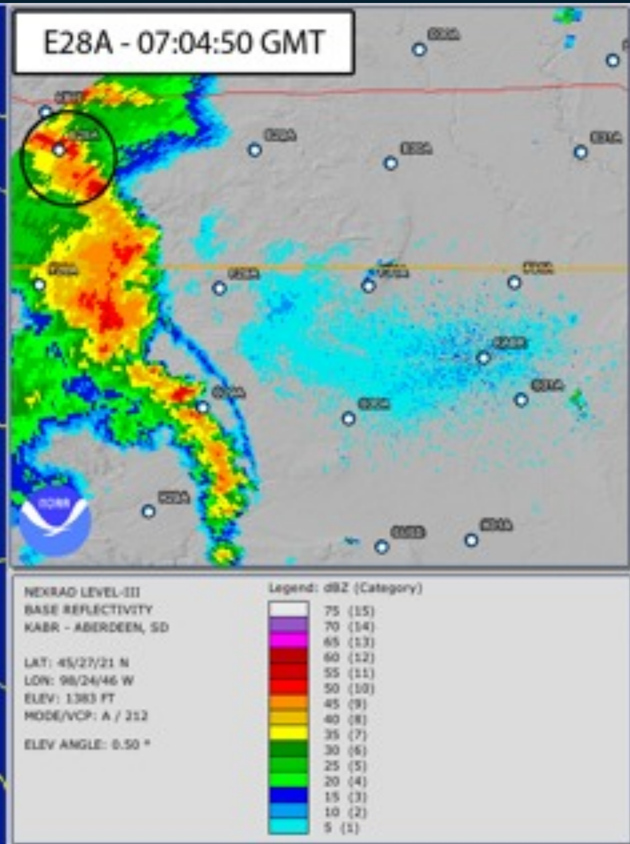


Case Study - 6/22/2010



Case Study - 6/22/2010





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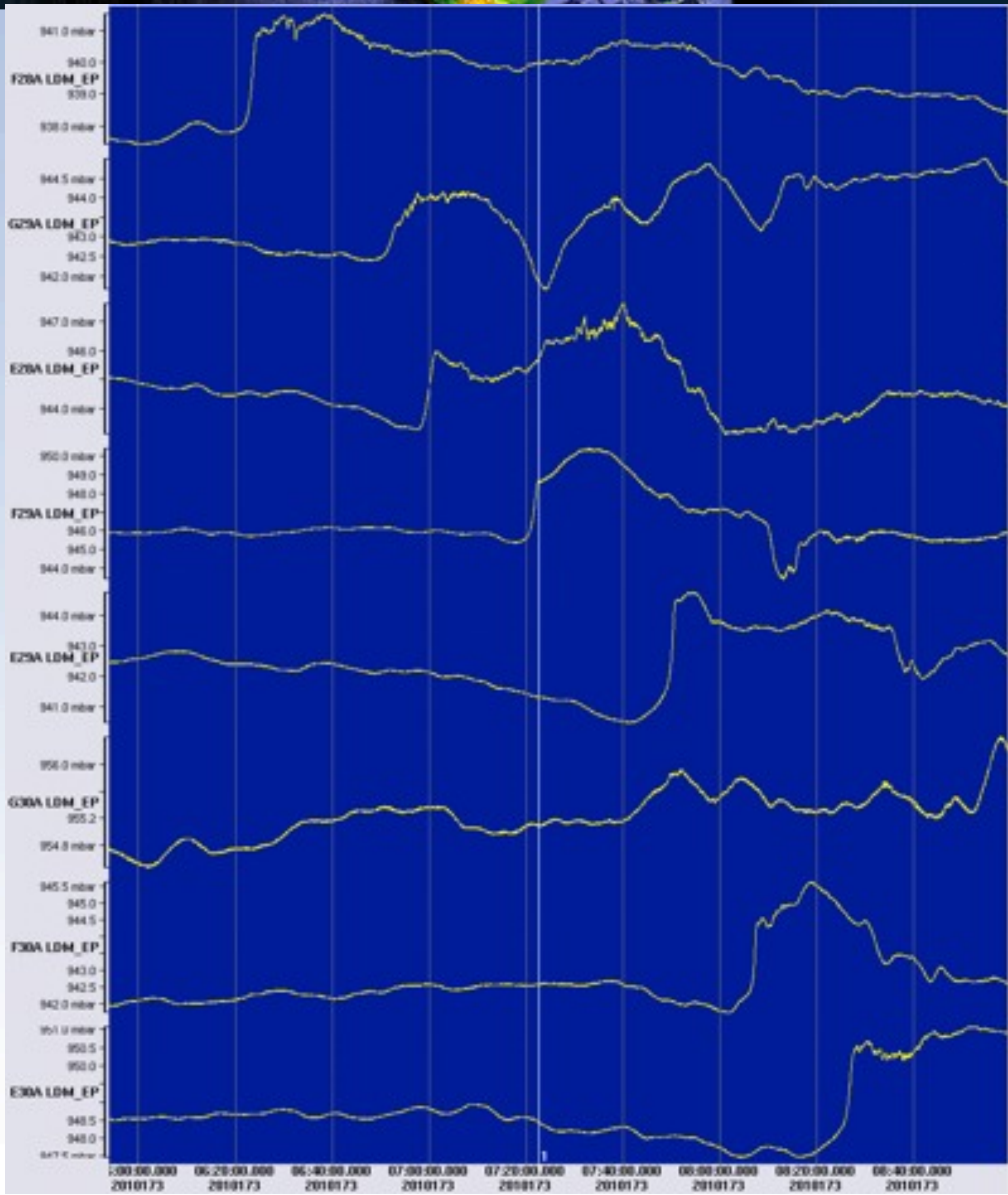
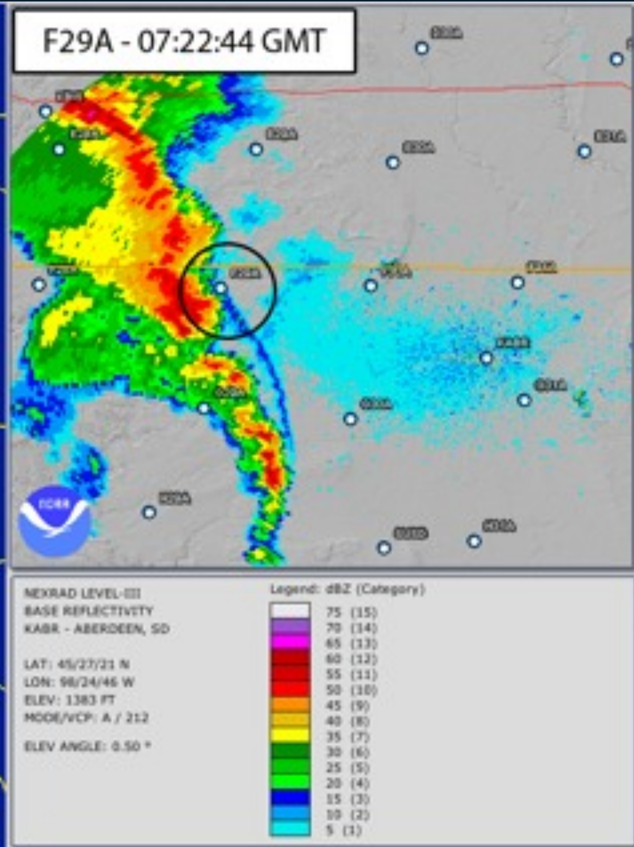
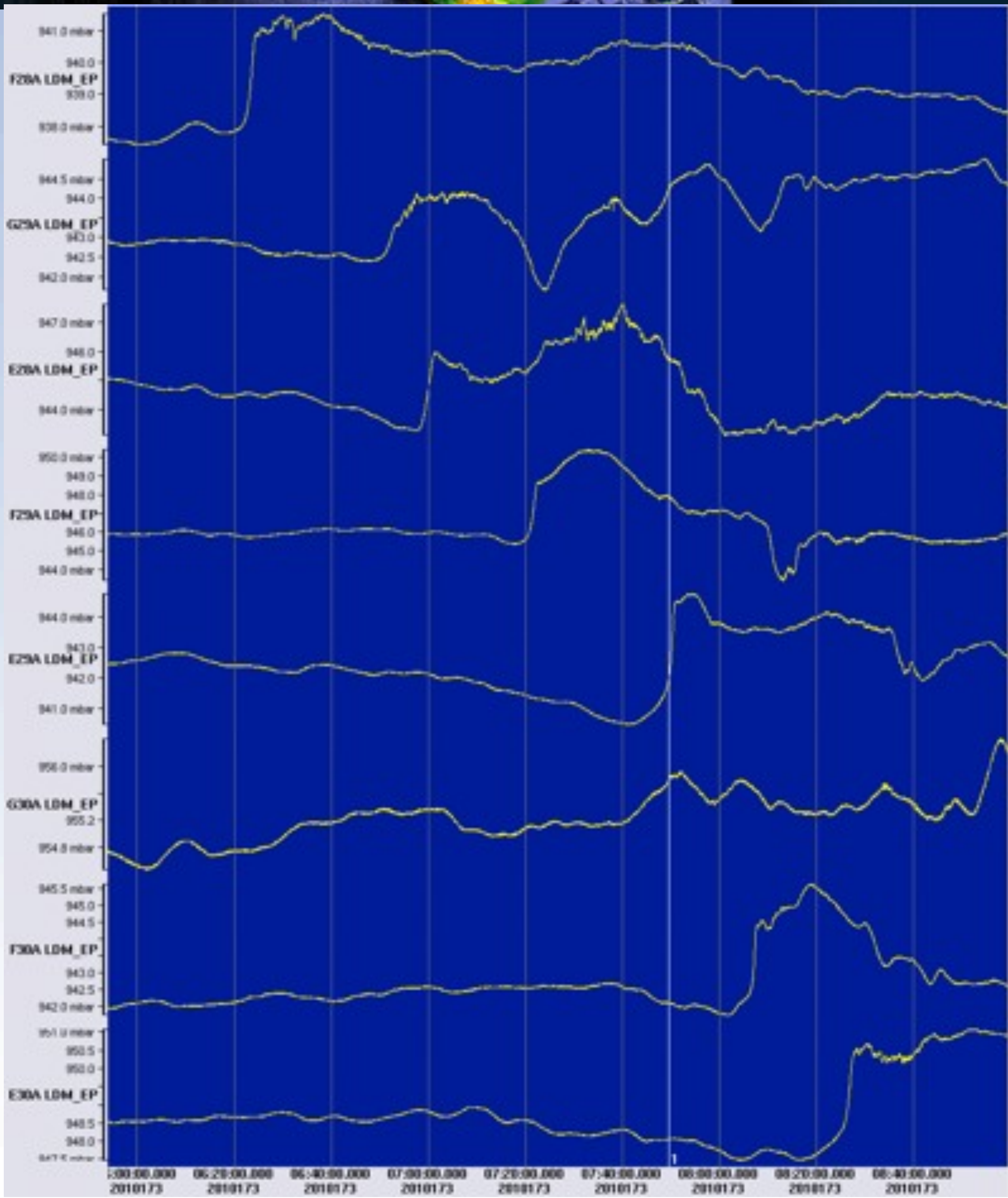
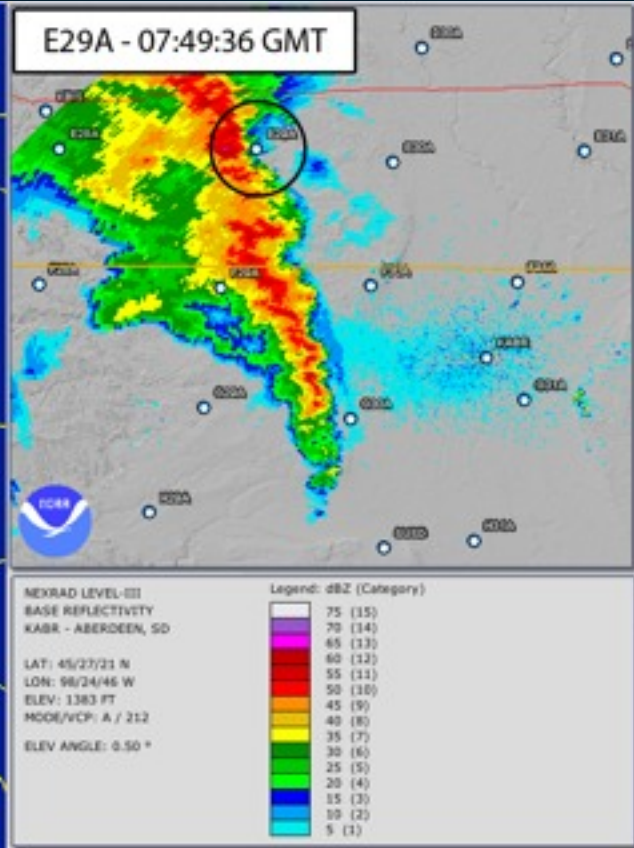


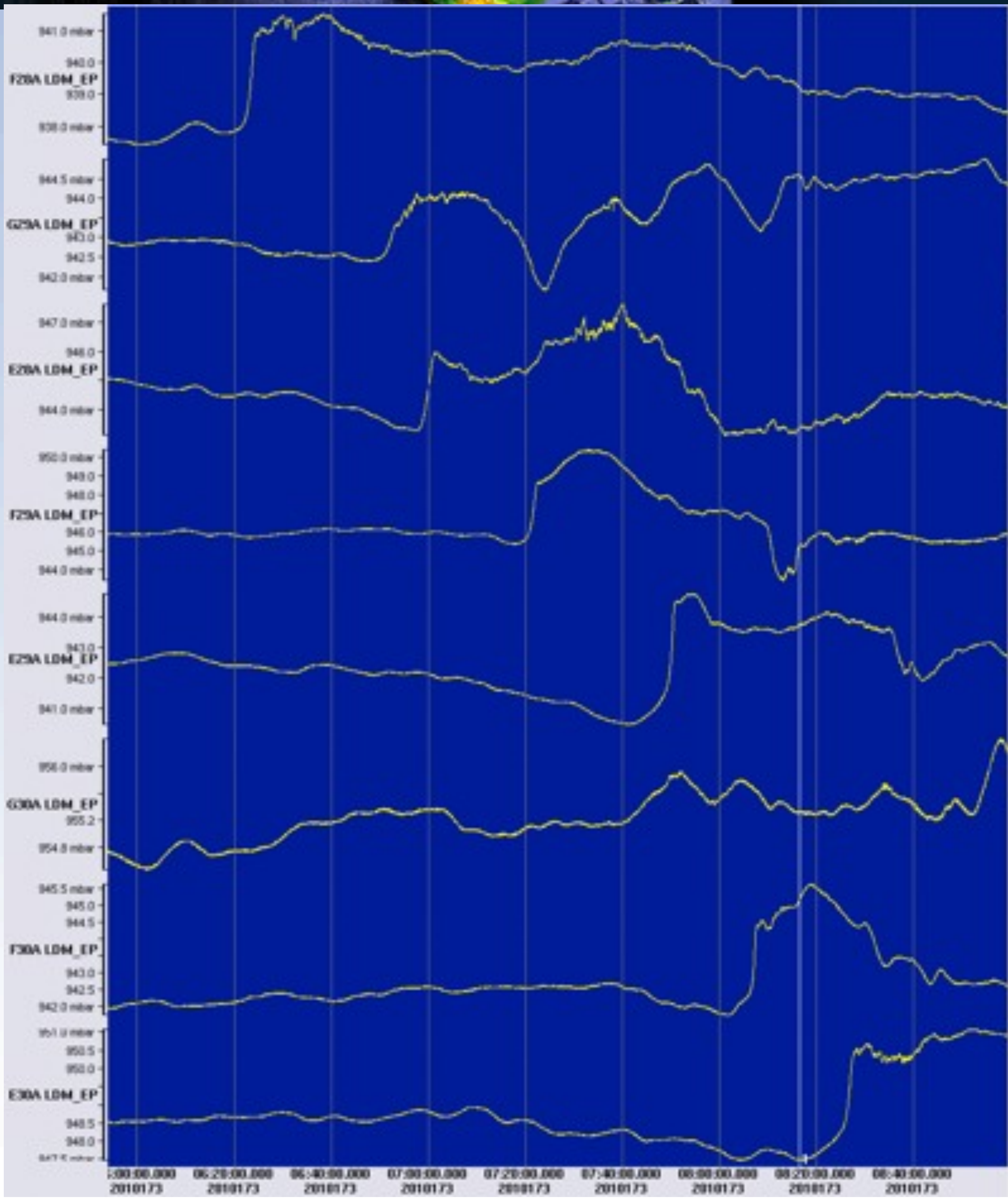


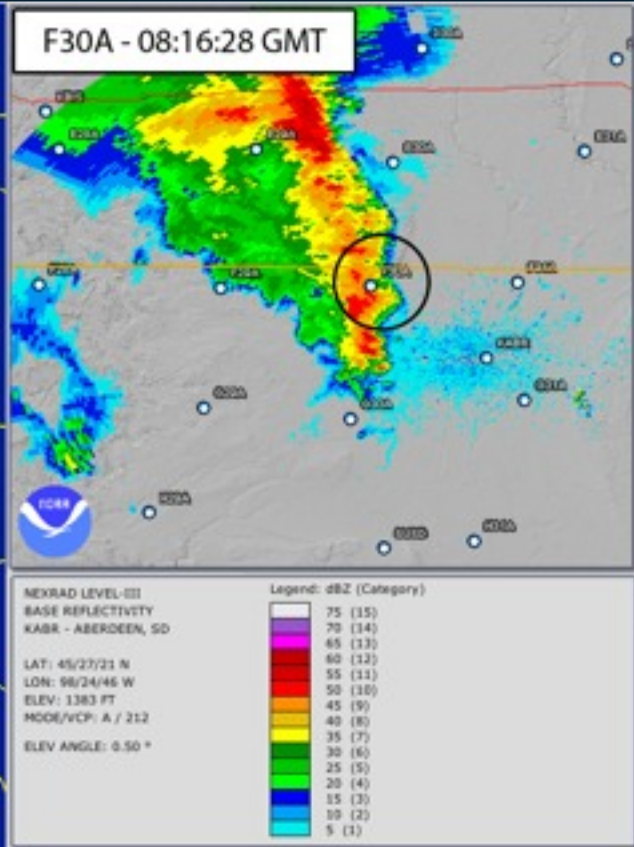
Case Study - 6/22/2010





Case Study - 6/22/2010





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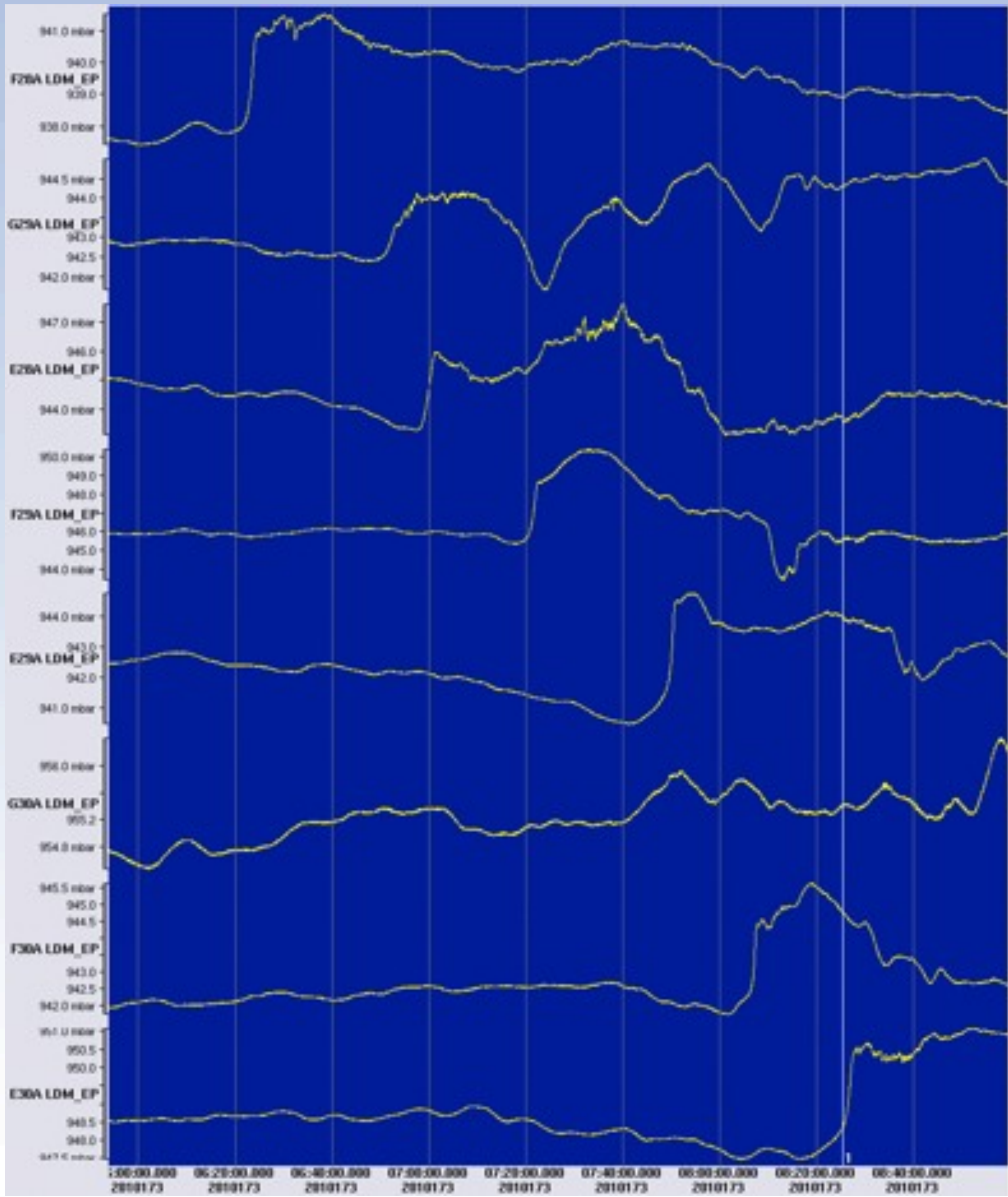
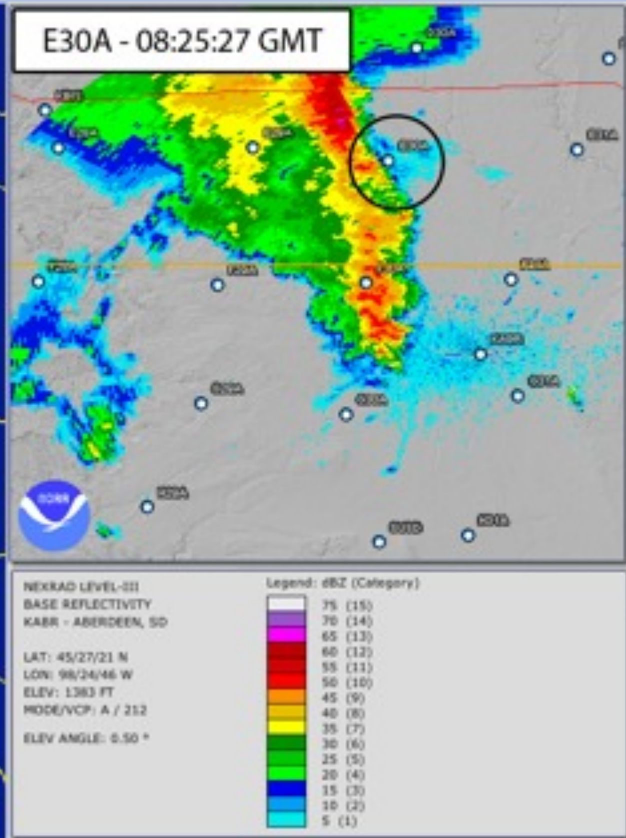
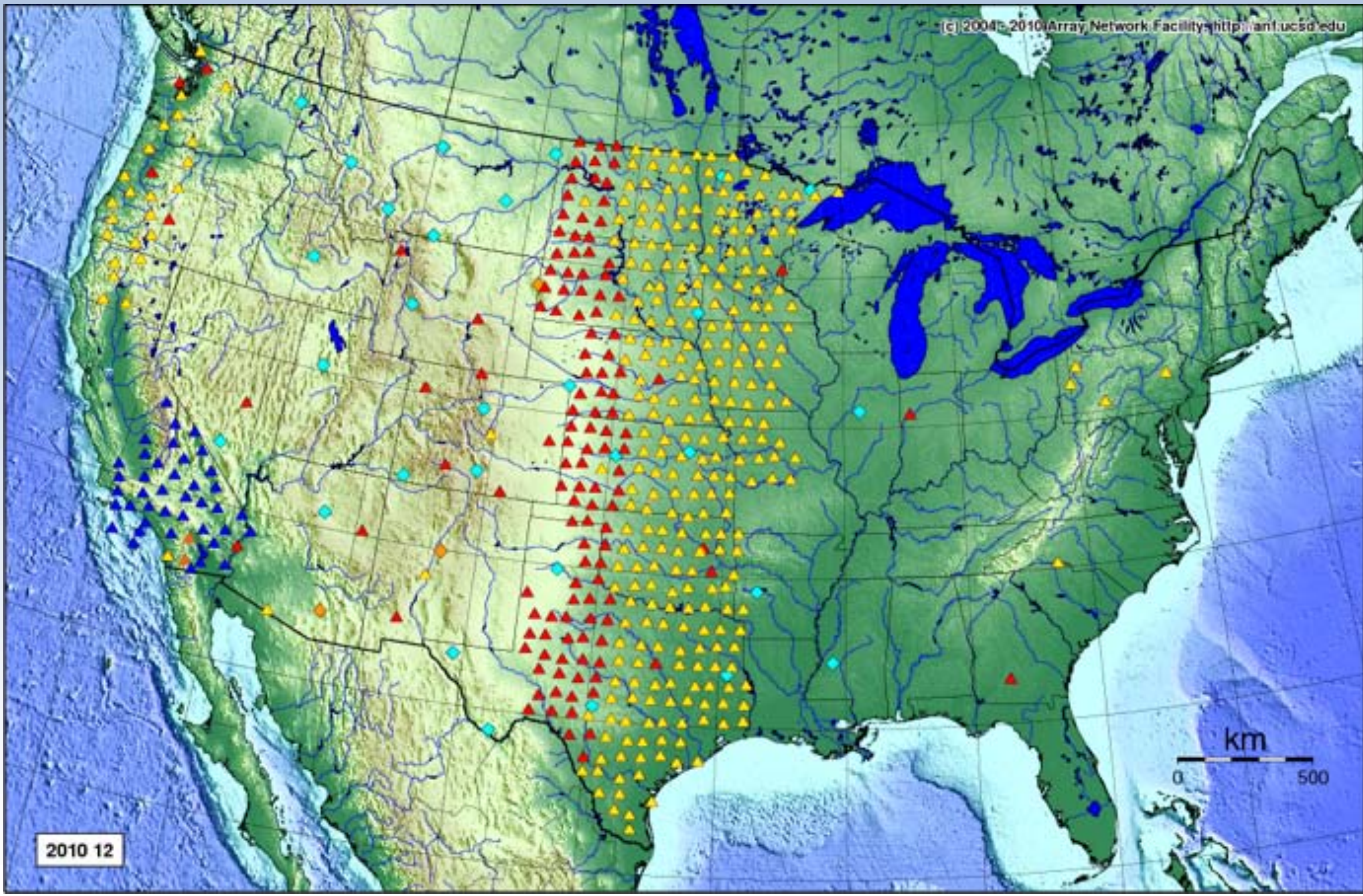
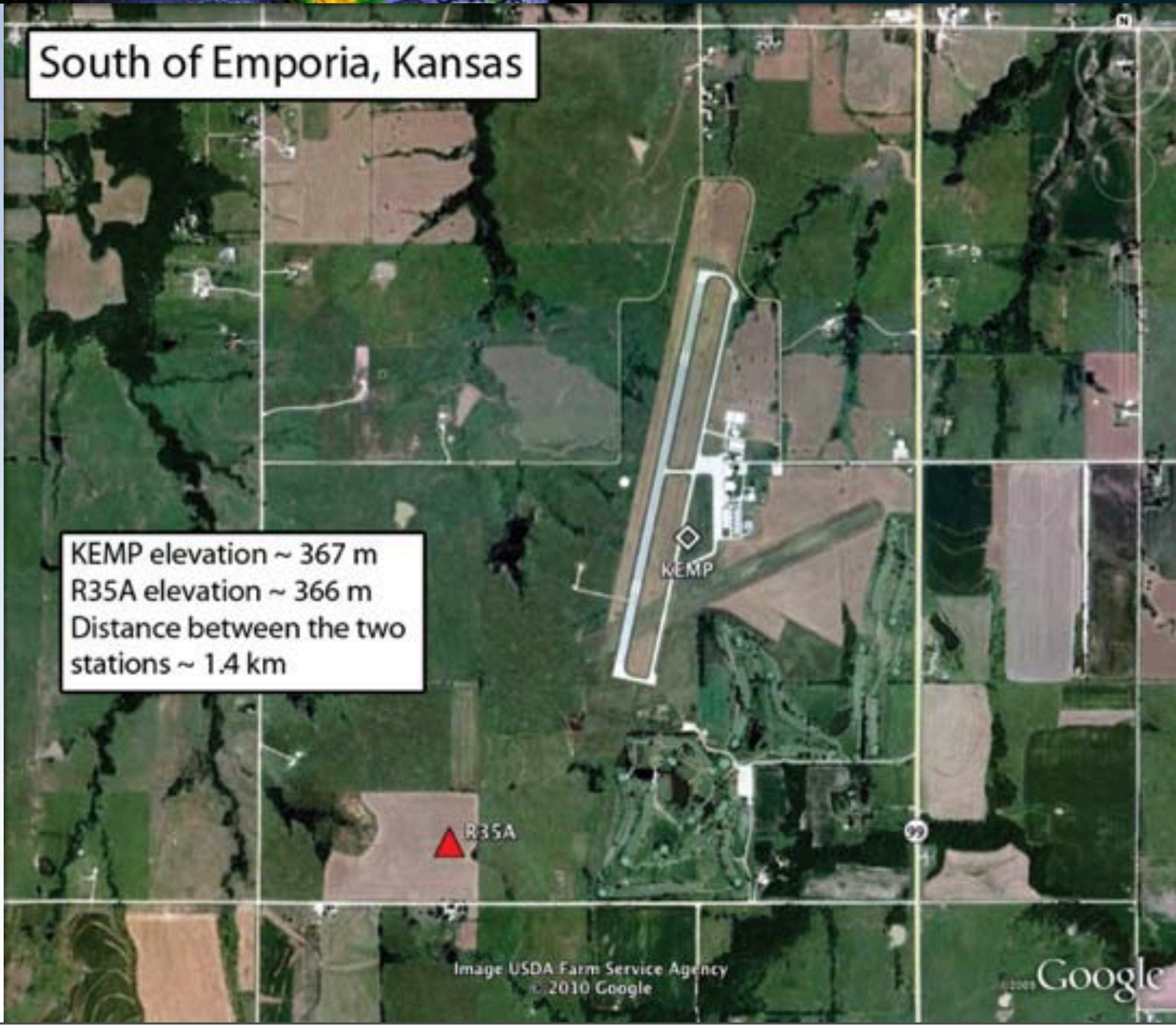


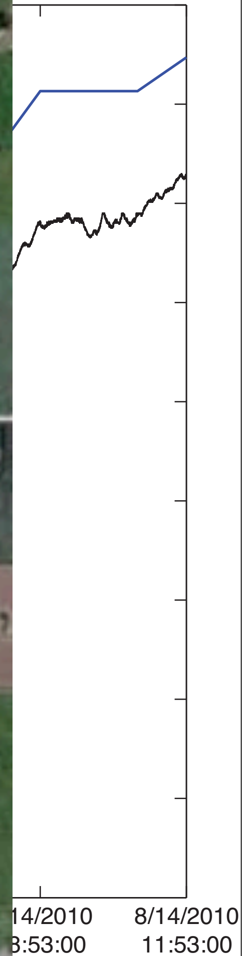


Current MEMS Barometer Deployment

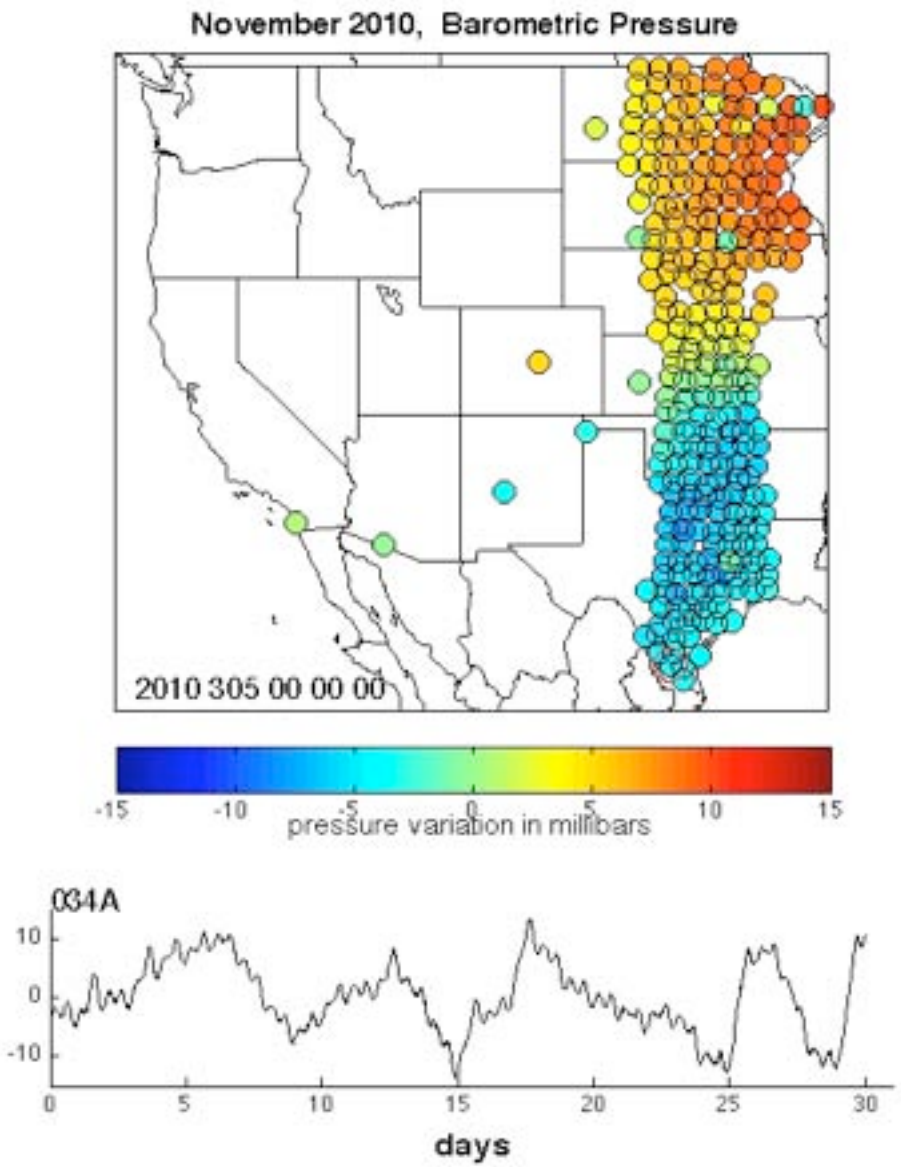


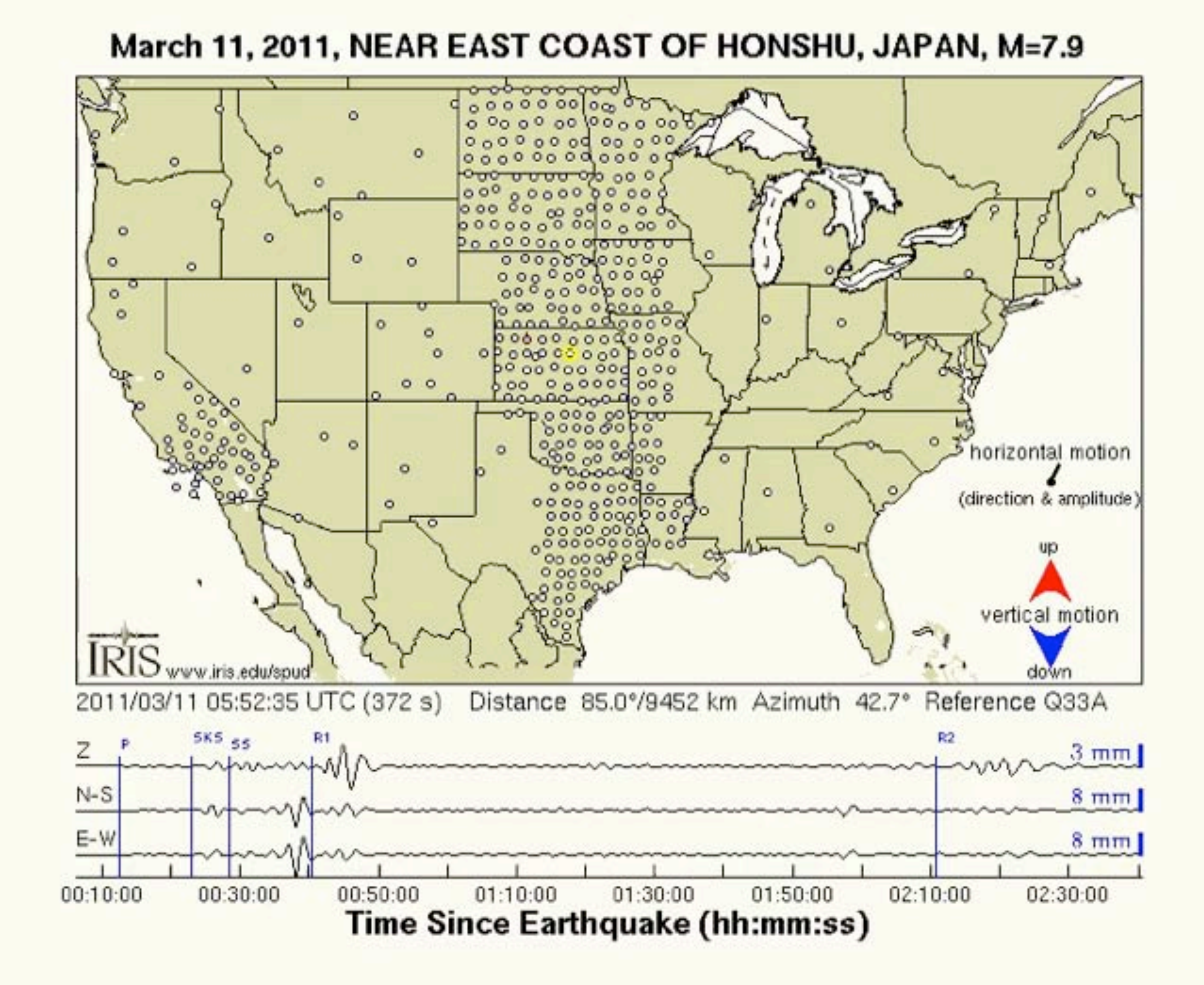
NWS Comparason





November 2010 Barometric Pressure

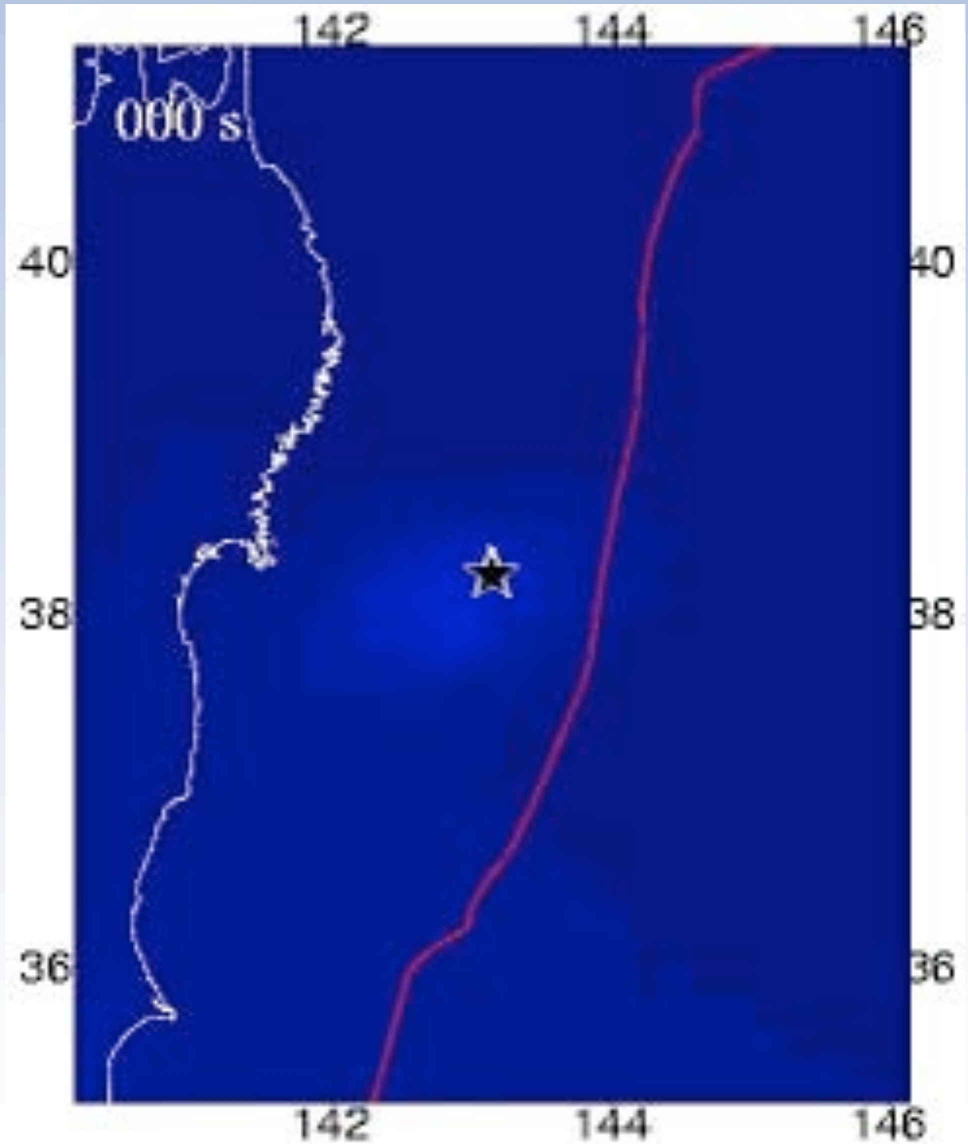




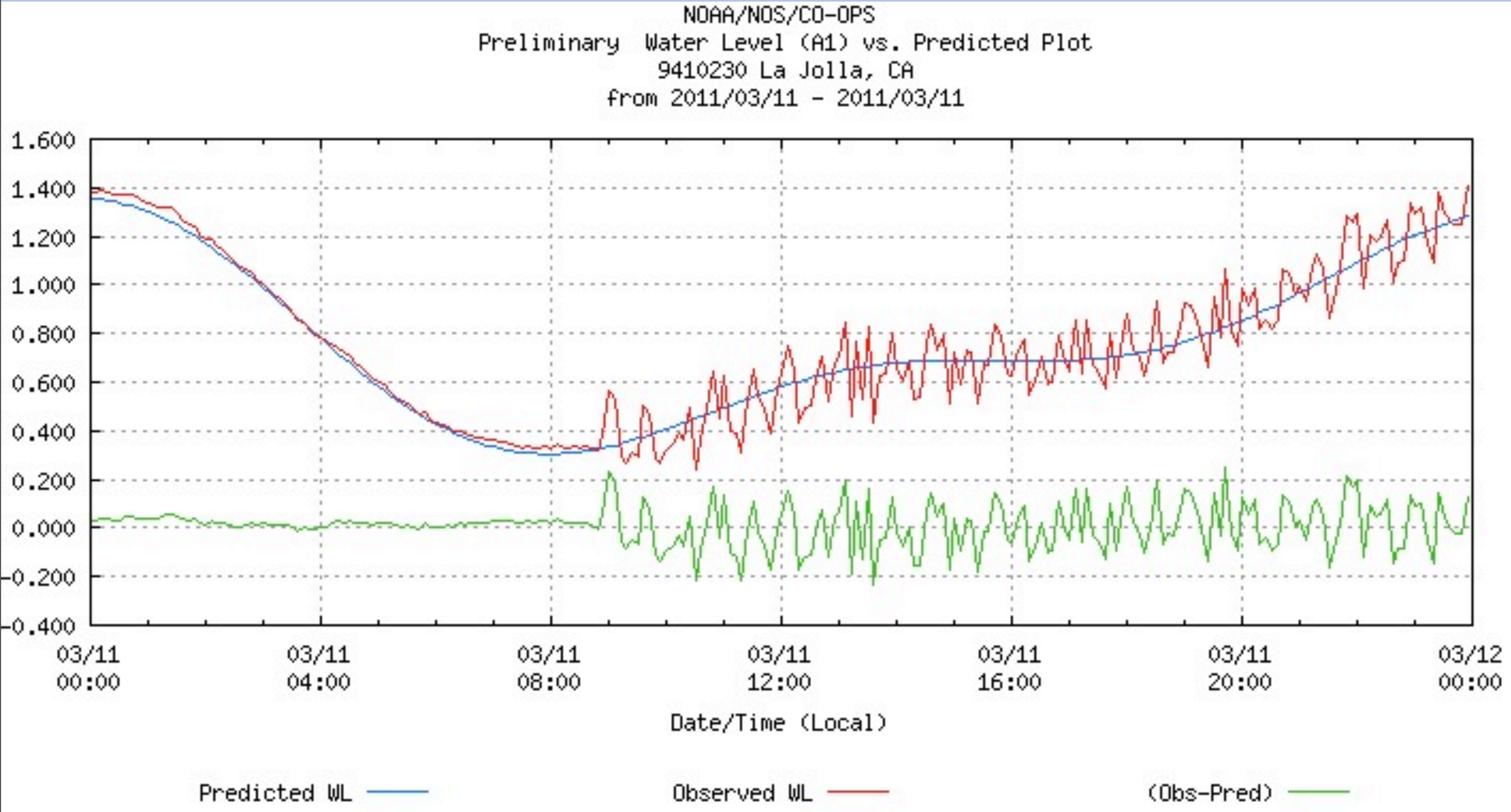
March 11, 2011, NEAR EAST COAST OF HONSHU, JAPAN, M=7.9
horizontal motion
(direction & amplitude)
up
vertical motion
down
IRIS www.iris.edu/spud
2011/03/11 05:52:35 UTC (372 s) Distance 85.0°/9452 km Azimuth 42.7° Reference Q33A
Z
N-S
E-W
P
SKS
SS
R1
R2
3 mm
8 mm
8 mm
00:10:00
00:30:00
00:50:00
01:10:00
01:30:00
01:50:00
02:10:00
02:30:00
Time Since Earthquake (hh:mm:ss)

TA Array Processing

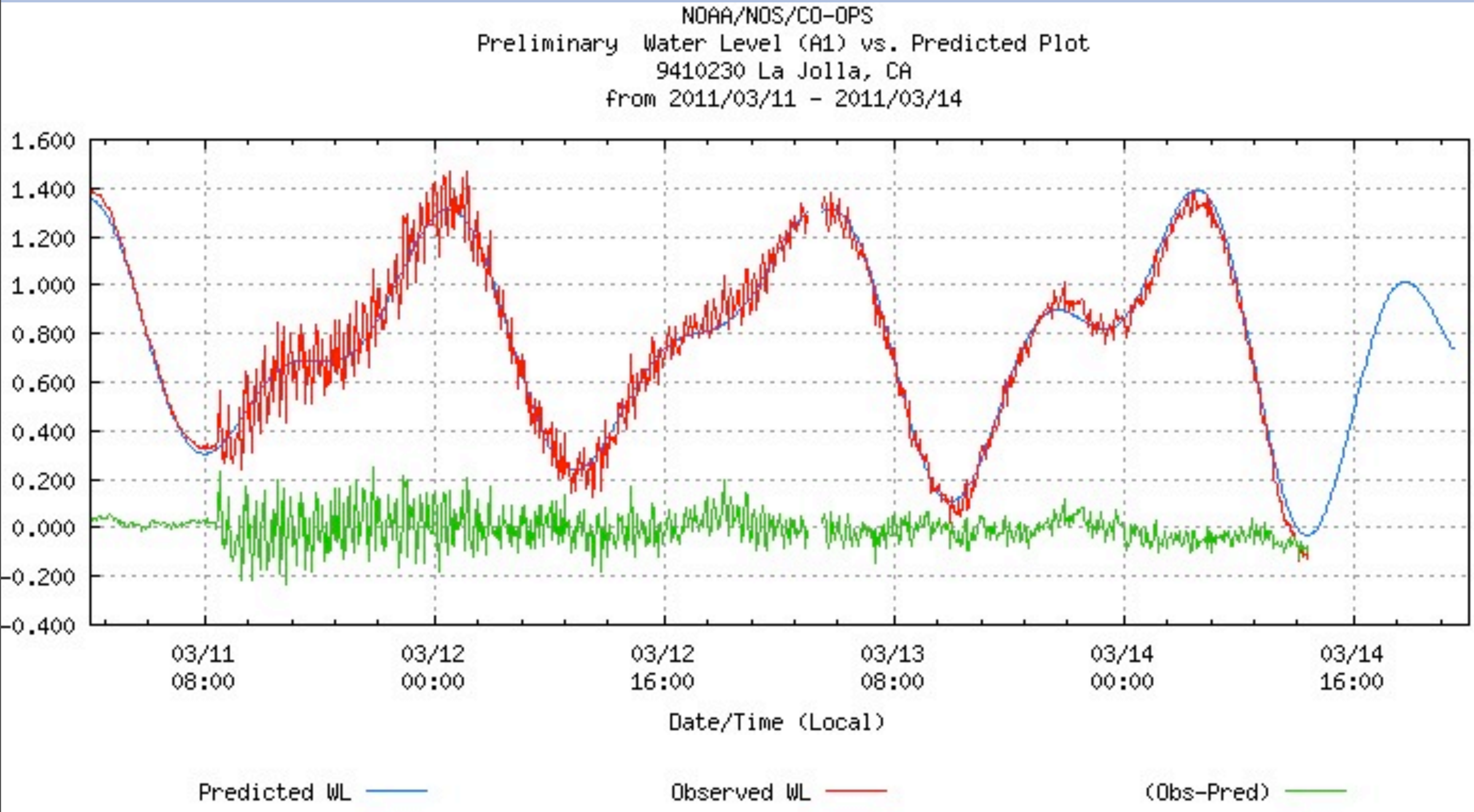
- http://seismology.harvard.edu/research_japan.html



Tsunami


NOAA/NOS/CO-OPS
Preliminary Water Level (A1) vs. Predicted Plot
9410230 La Jolla, CA
from 2011/03/11 - 2011/03/11
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
03/11 00:00
03/11 04:00
03/11 08:00
03/11 12:00
03/11 16:00
03/11 20:00
03/12 00:00
Date/Time (Local)
Predicted WL
Observed WL
(Obs-Pred)

Tsunami



NOAA/NOS/CO-OPS
Preliminary Water Level (A1) vs. Predicted Plot
9410230 La Jolla, CA
from 2011/03/11 - 2011/03/14
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
03/11 08:00
03/12 00:00
03/12 16:00
03/13 08:00
03/14 00:00
03/14 16:00
Date/Time (Local)
Predicted WL
Observed WL
(Obs-Pred)

21 Feb 2008 M 6.0 Wells Earthquake

Surface waves radiating inward from M 6.0 Wells Earthquake