

Results and Lessons Learned from USArray

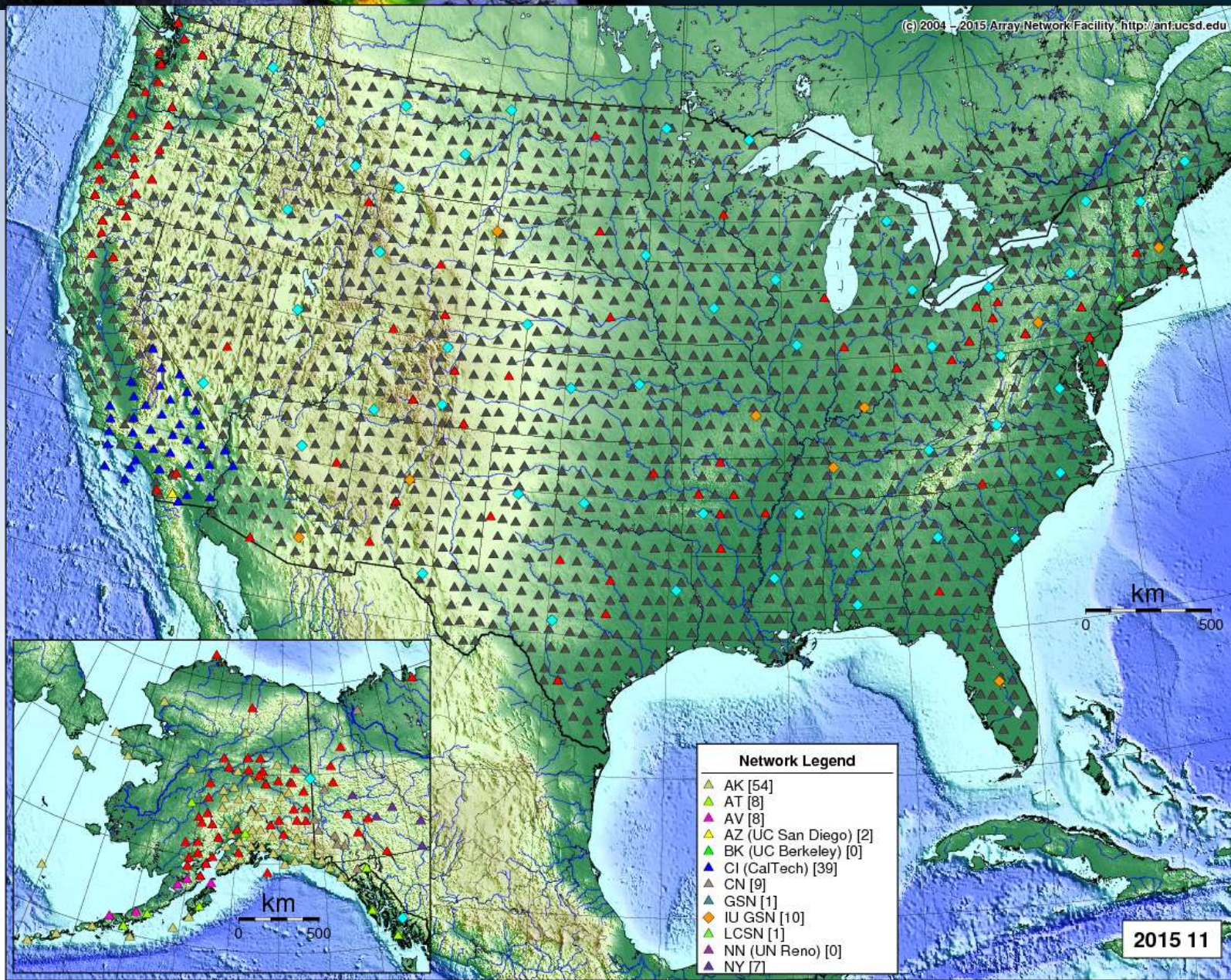


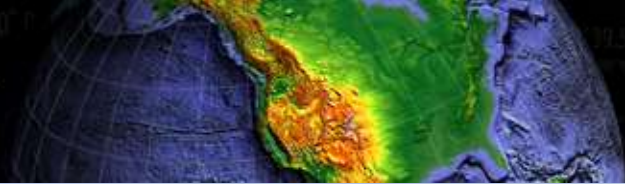
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University of California, San Diego*

AUG Rome, Italy

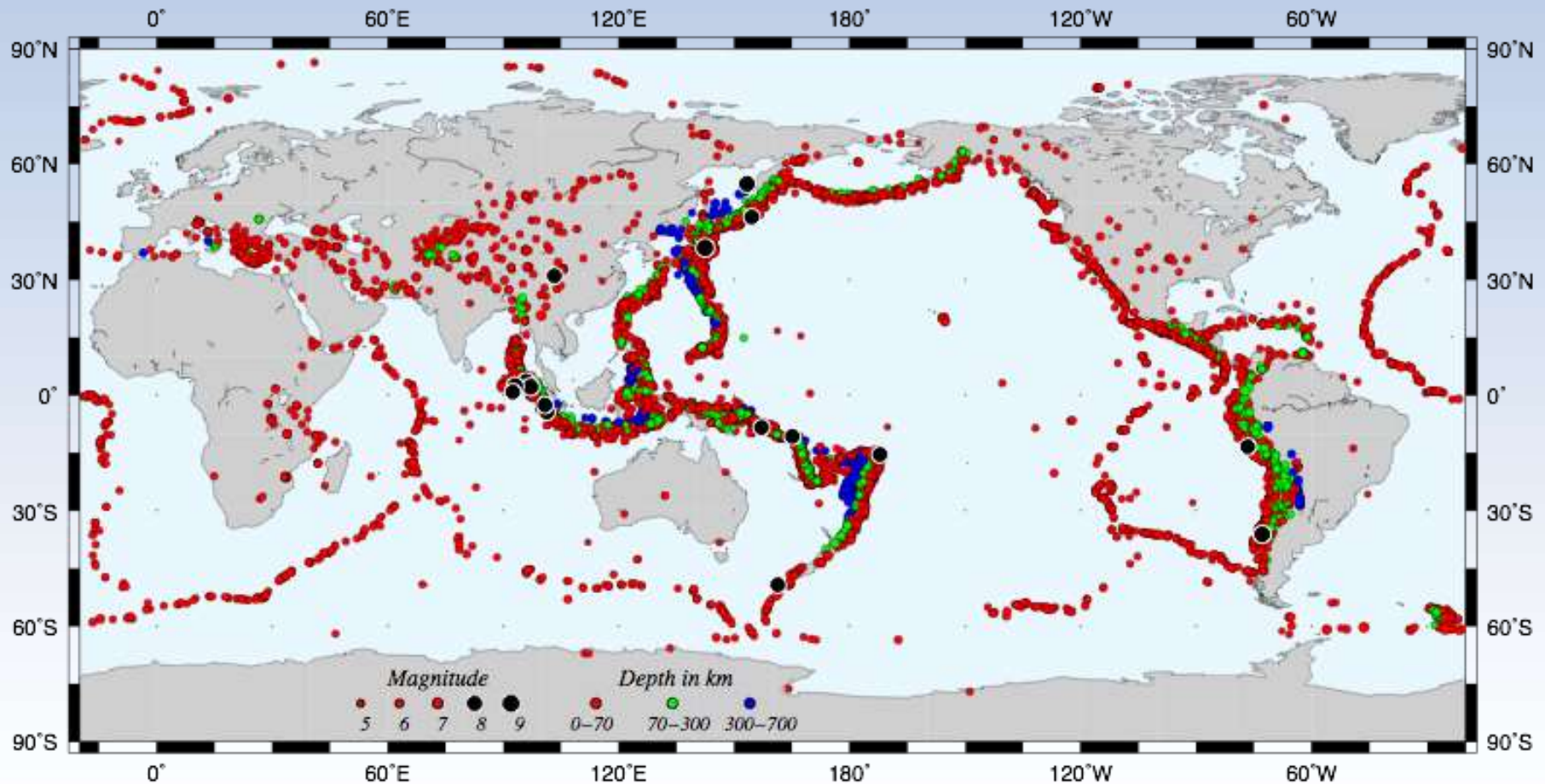
19 May 2016





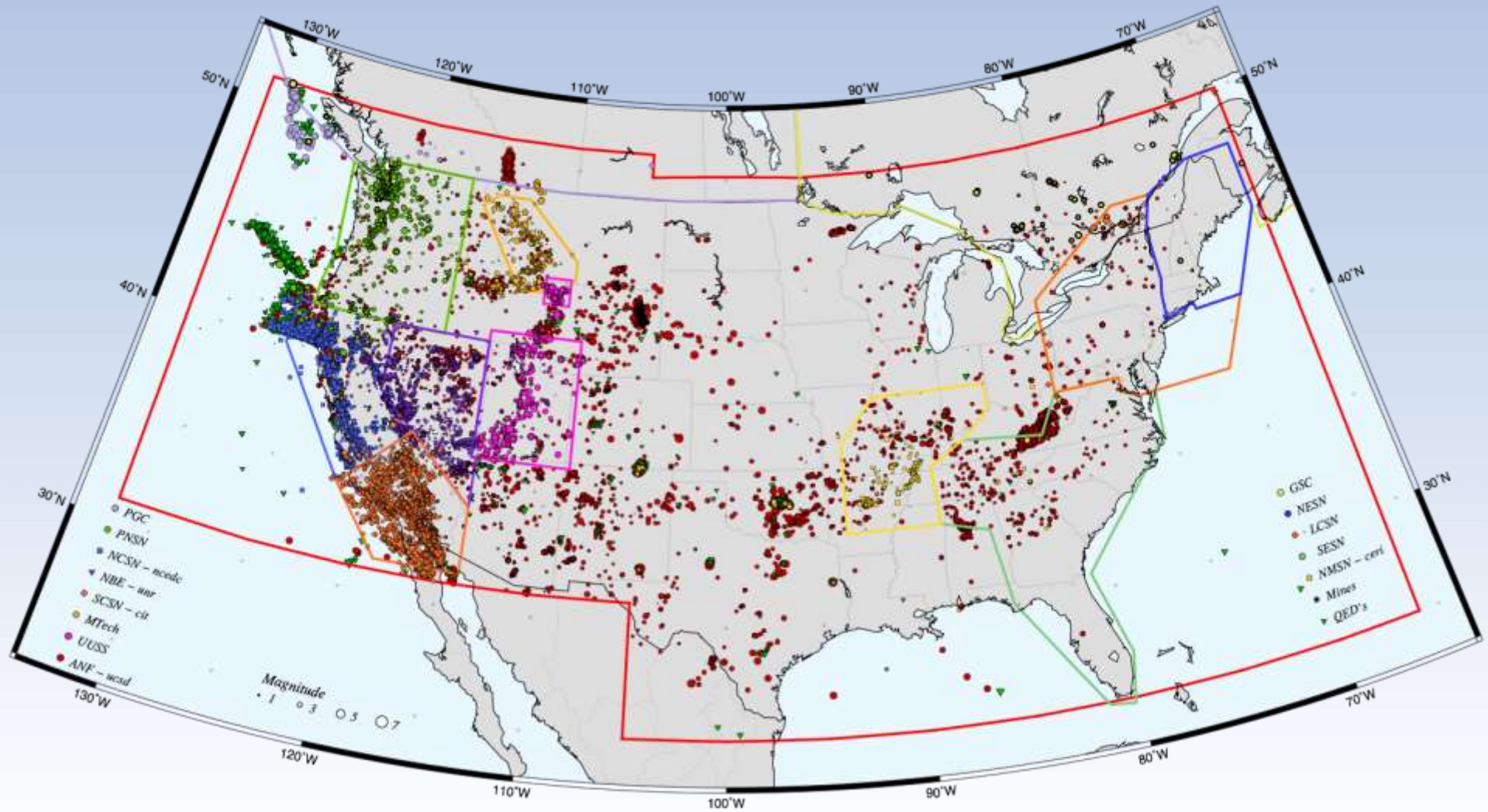
Global Seismicity

12,221 events with $M \geq 5.0$ recorded by USArray from April 2004 to November 2013



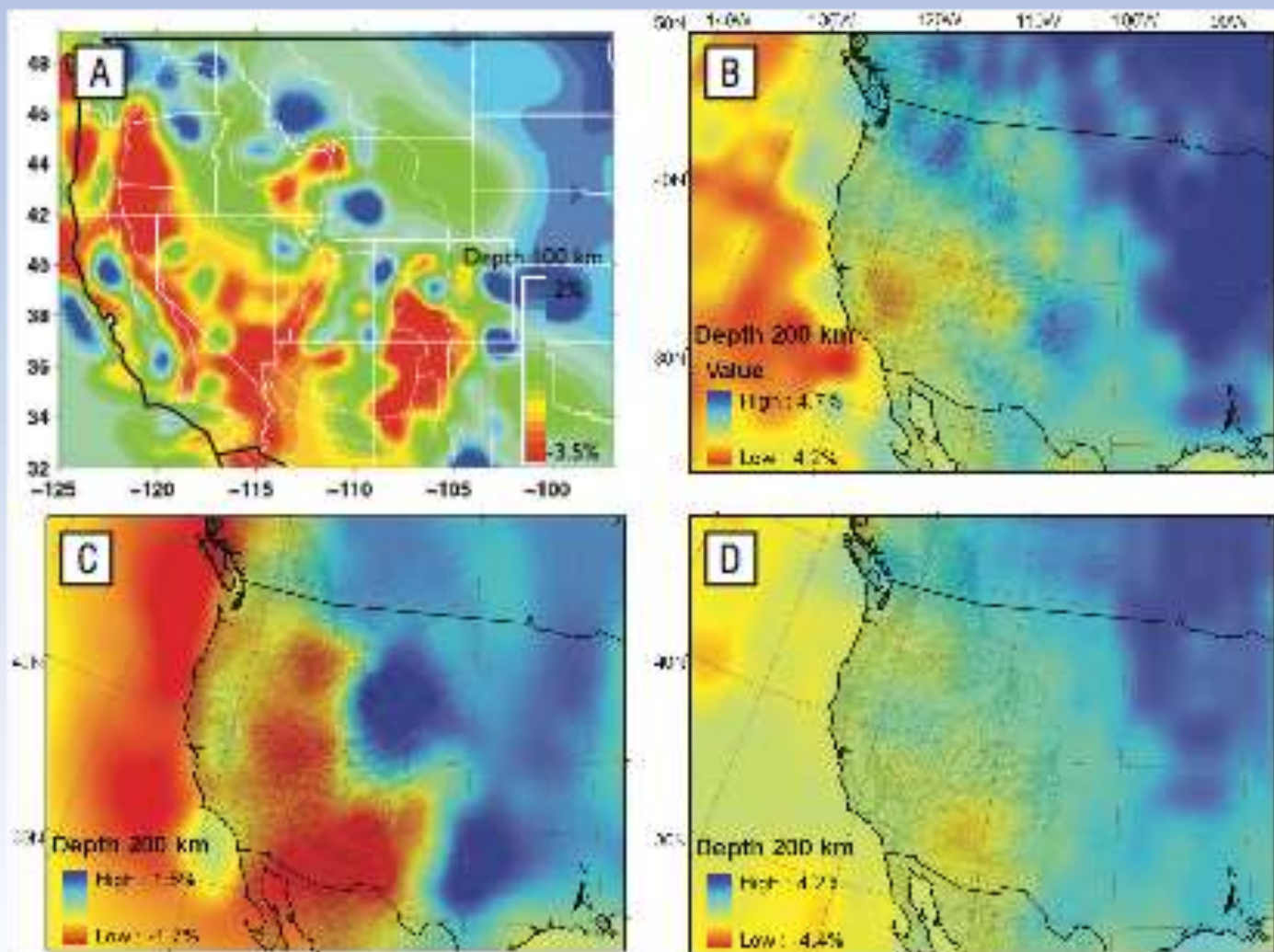


US Seismicity

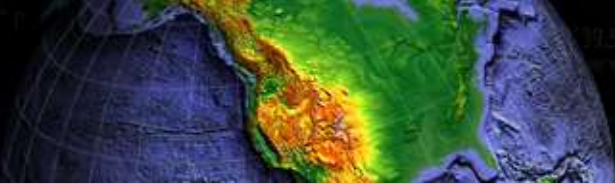




Tomography Before TA



▲ **Figure 1.** (A) Model made by piecing together local tomography studies from Humphreys and Dueker (1994) and inverting with global data set (after Dueker *et al.* 2001). (B) Global S-wave model from surface wave diffraction (Ritzwoller *et al.* 2002). (C) Global P-wave model using finite frequency kernels (Montelli *et al.* 2004). (D) Global S-wave travel-time model (Grand 2002).



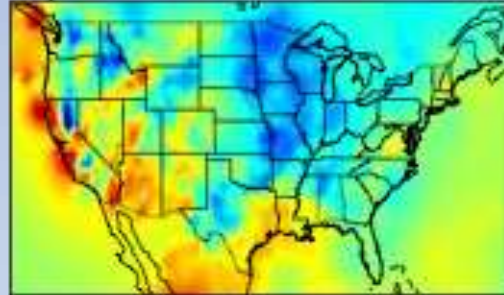
Tomography

Burdick et al. 2016

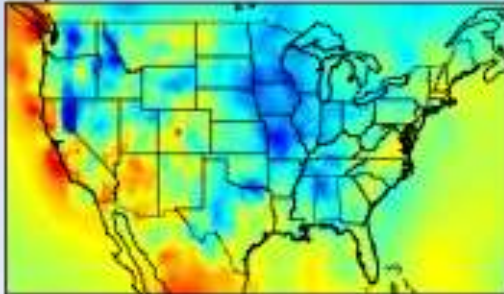
Depth 100 km $\pm 1.7\%$



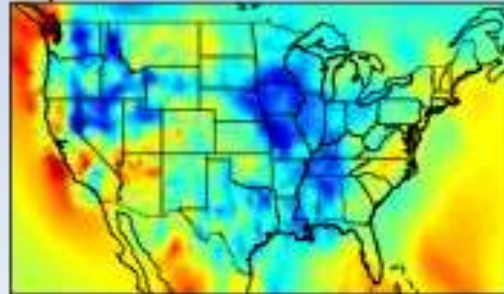
Depth 200 km $\pm 1.5\%$



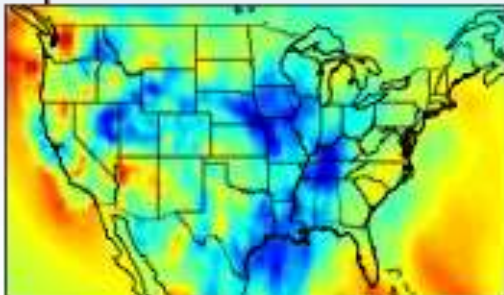
Depth 300 km $\pm 1.3\%$



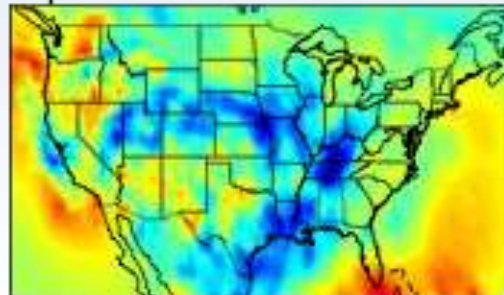
Depth 400 km $\pm 1.0\%$



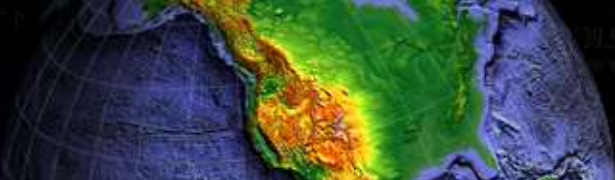
Depth 500 km $\pm 1.0\%$



Depth 600 km $\pm 1.0\%$

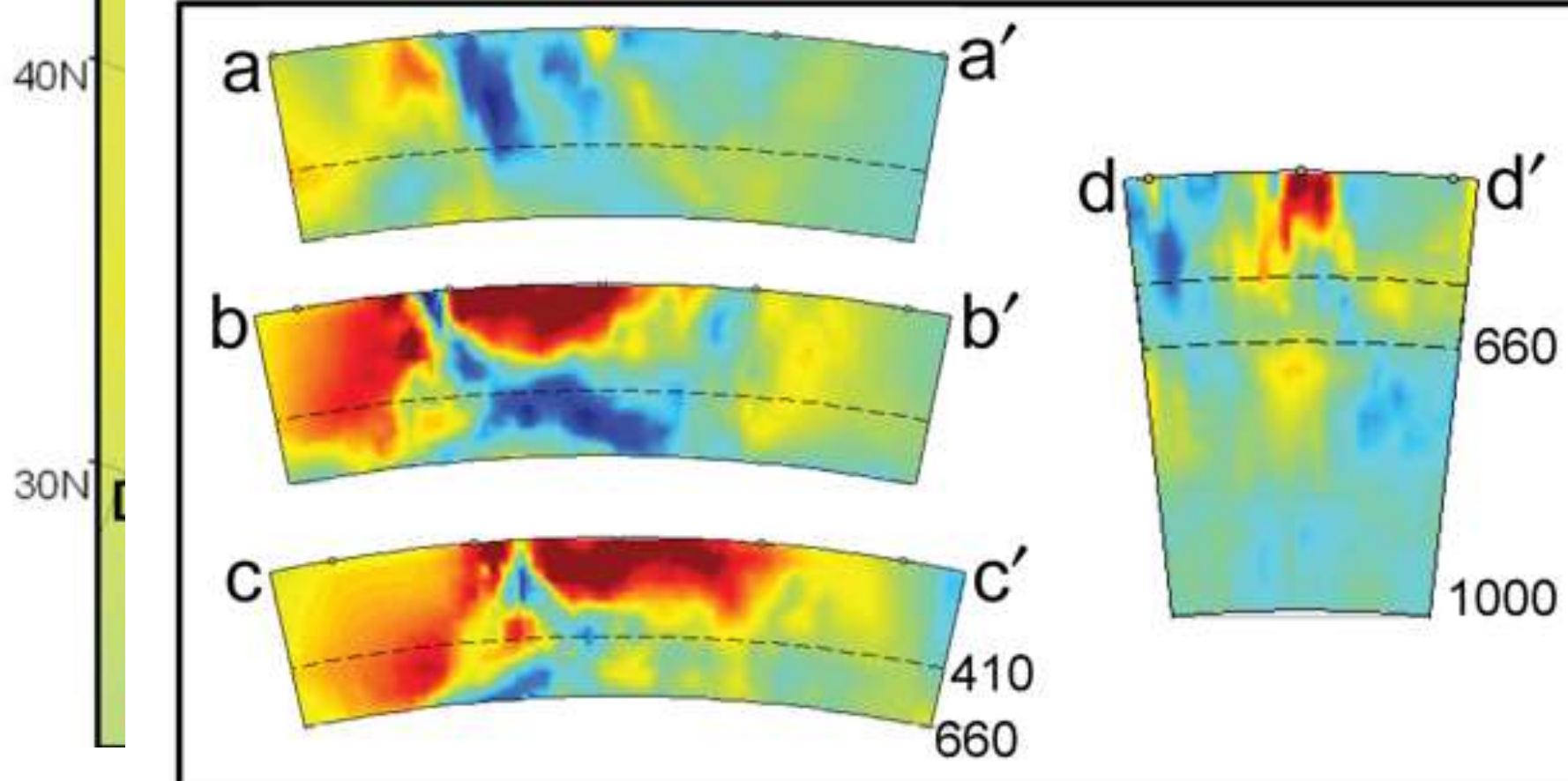
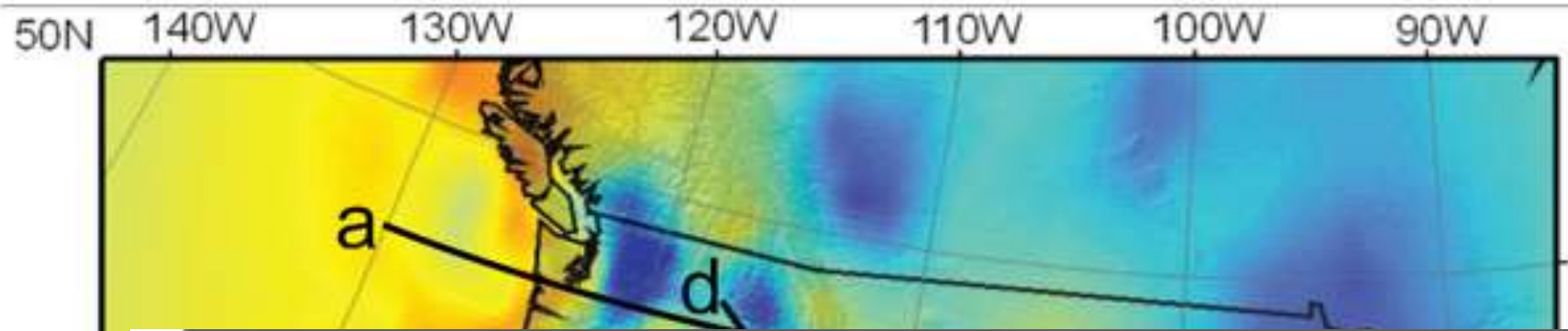


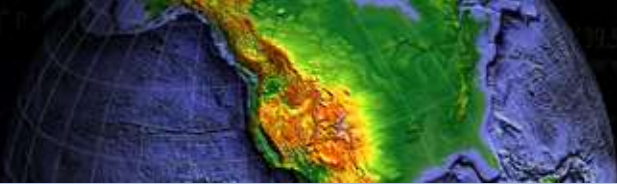
slow  fast



Tomography

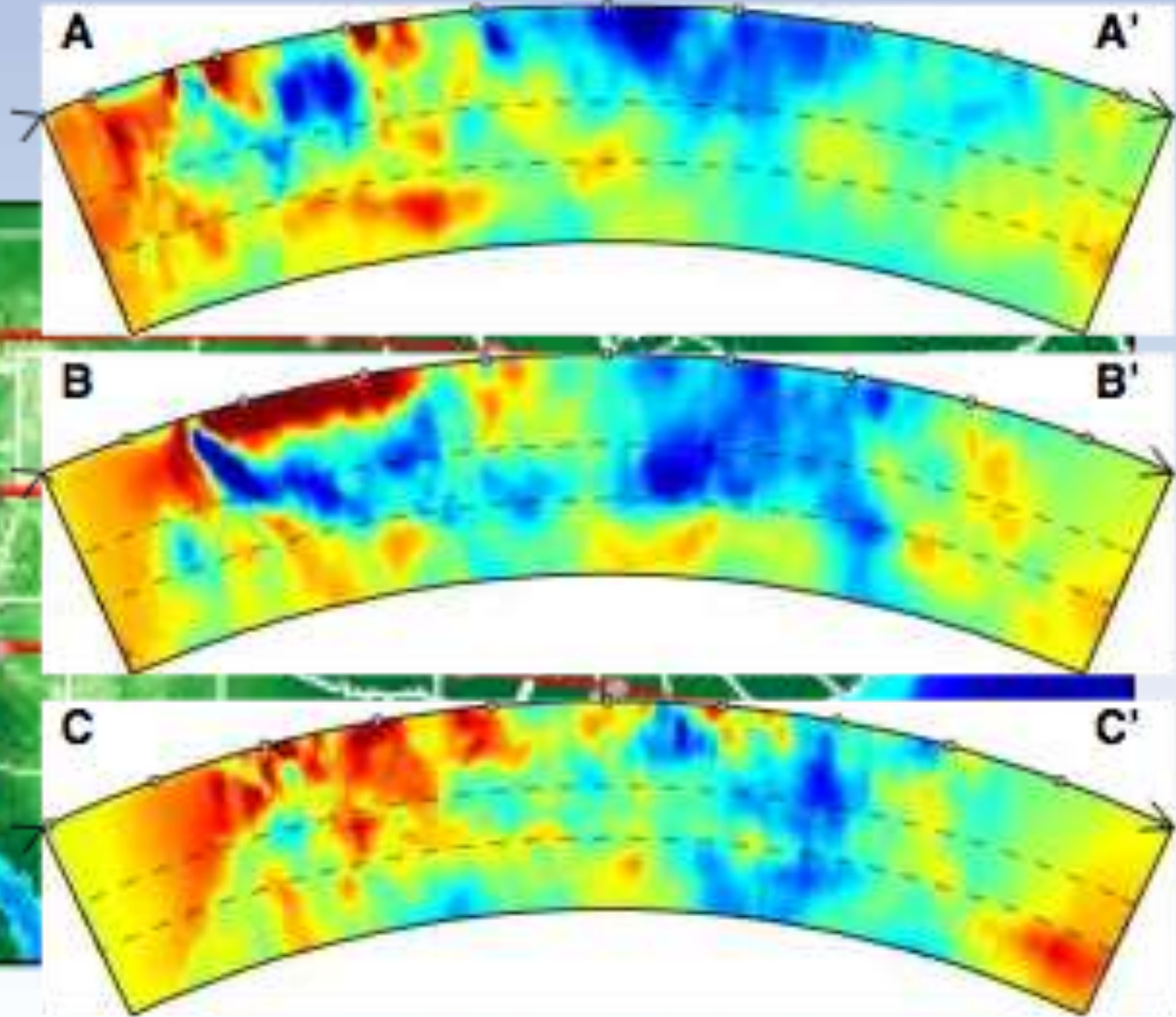
Burdick et al. 2008





Tomography

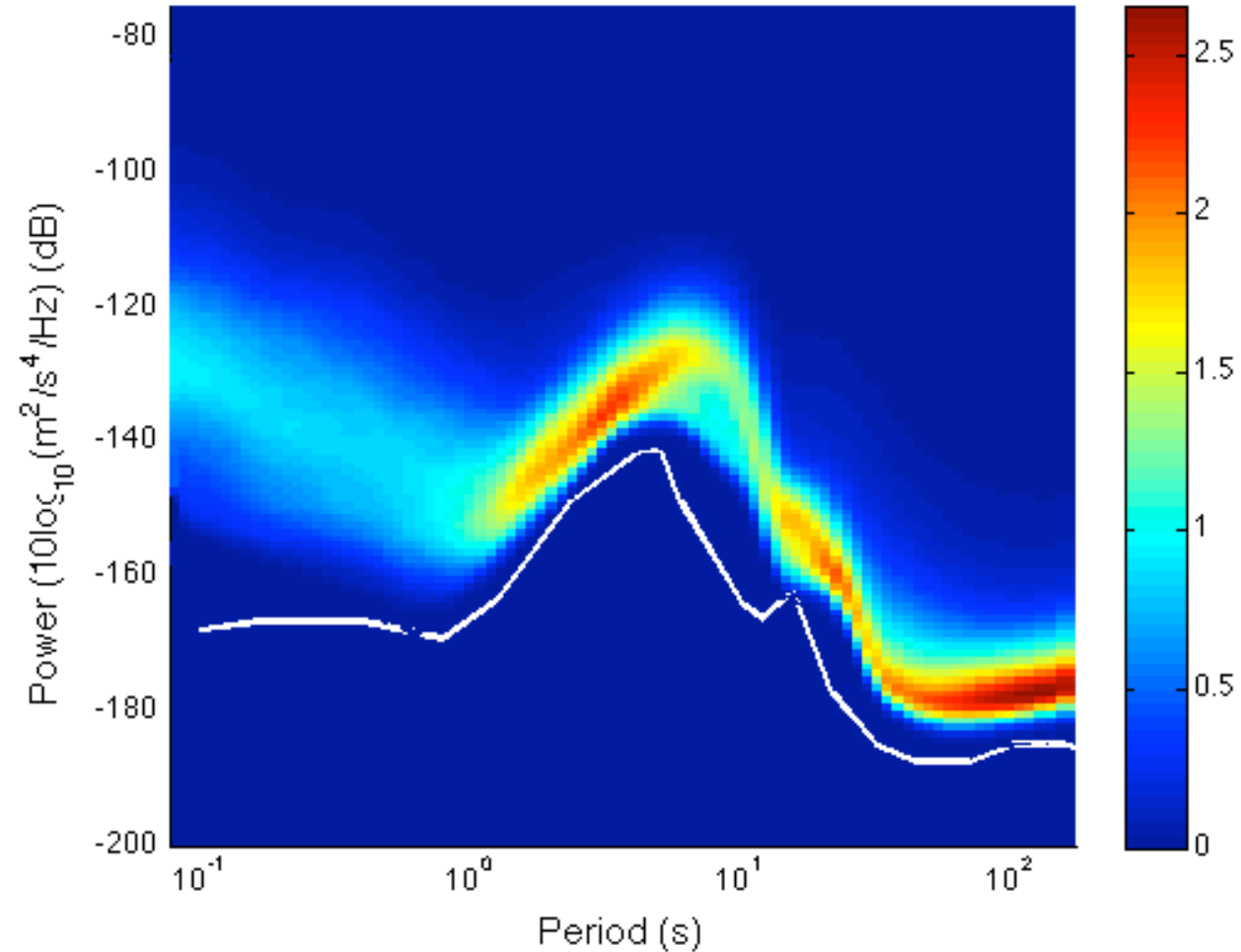
Burdick et al. 2016



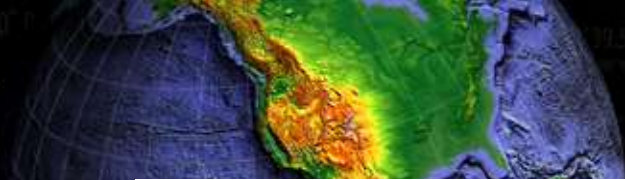


TA Performance

Cumulative PSD TA 2004-2010 BHZ (26,915,558 spectra) $\times 10^8$

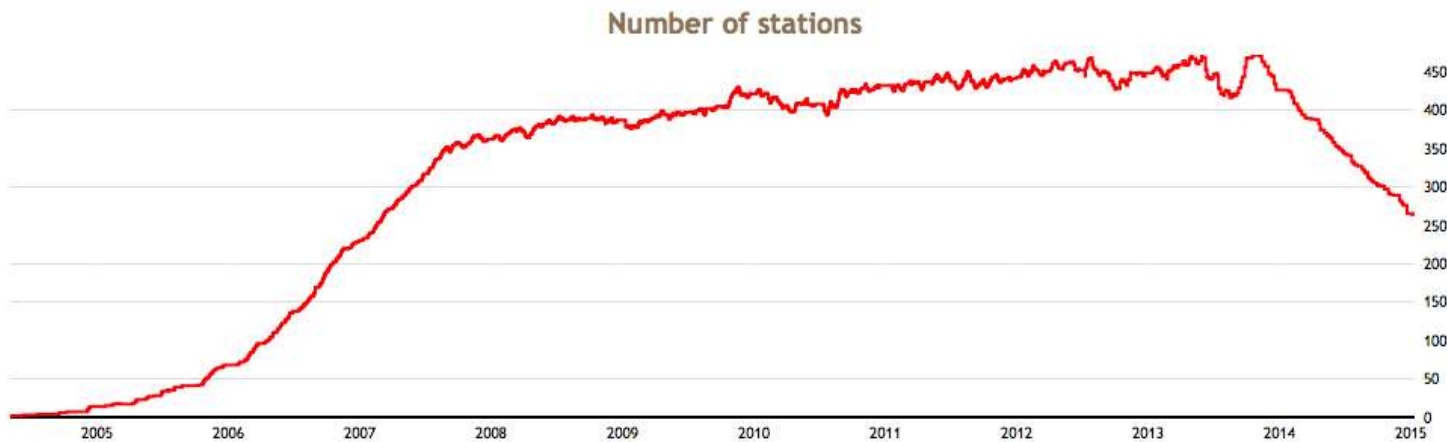
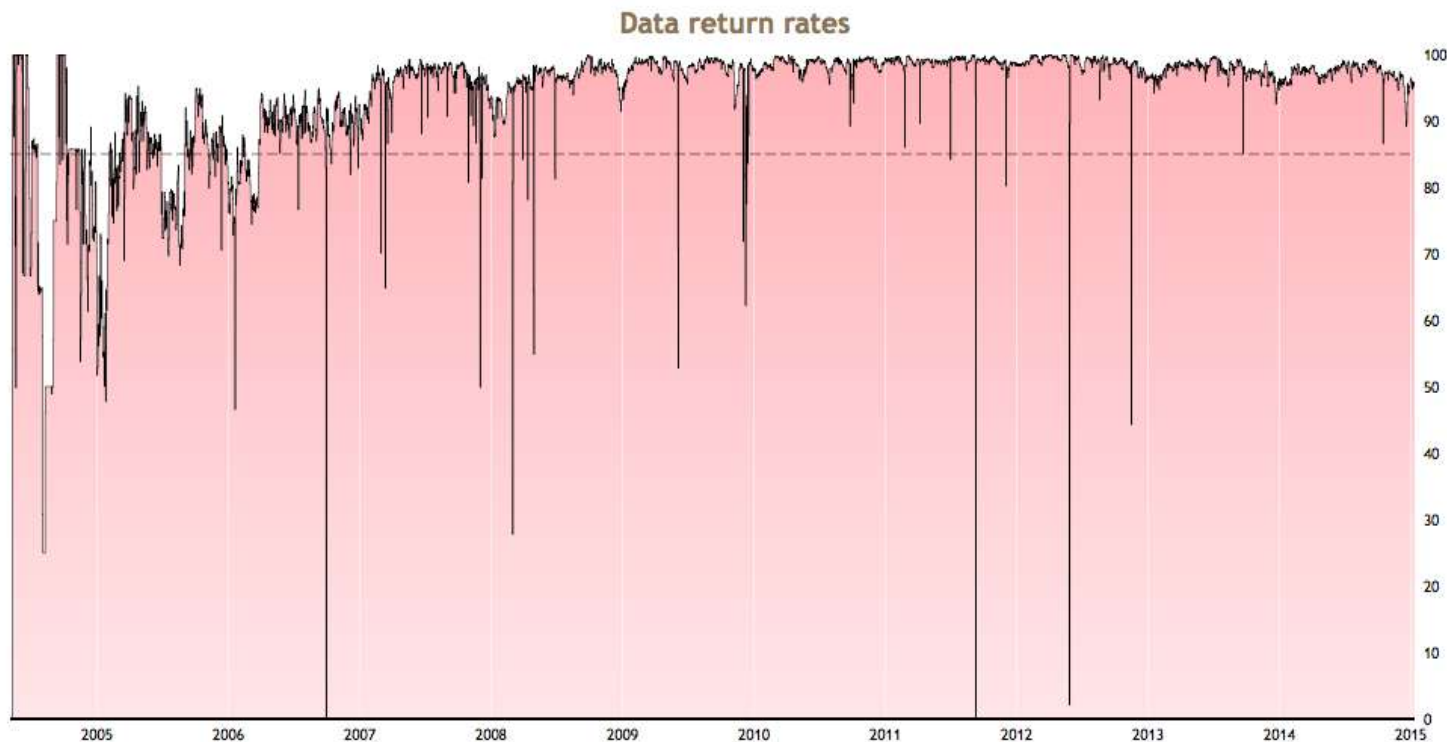


Station noise highly uniform and quite low for temporary installations



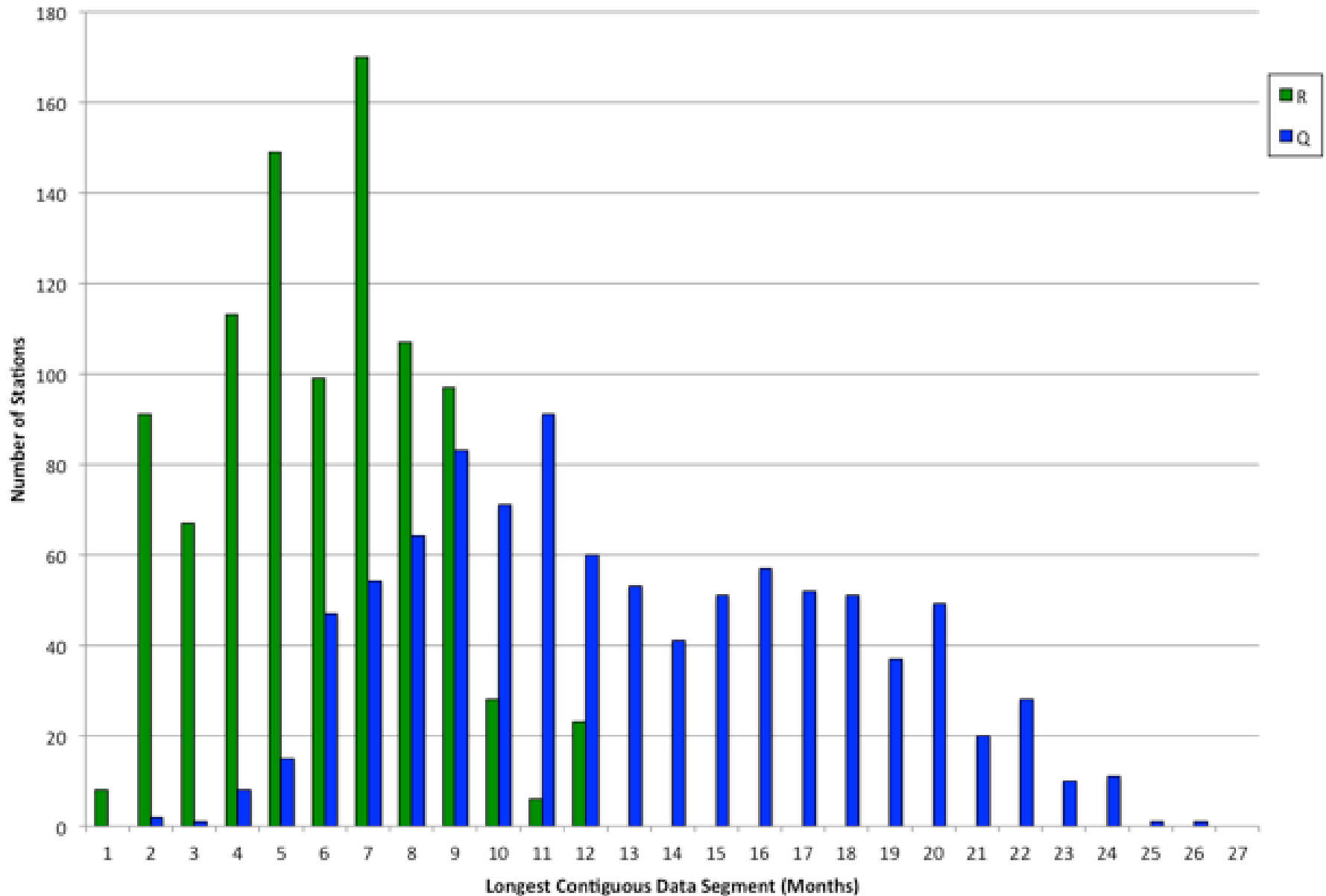
TA RT Performance

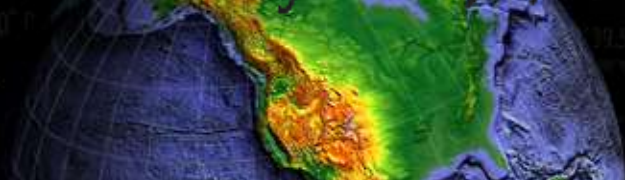
Realtime
Network
availability
typically
exceeds
98%





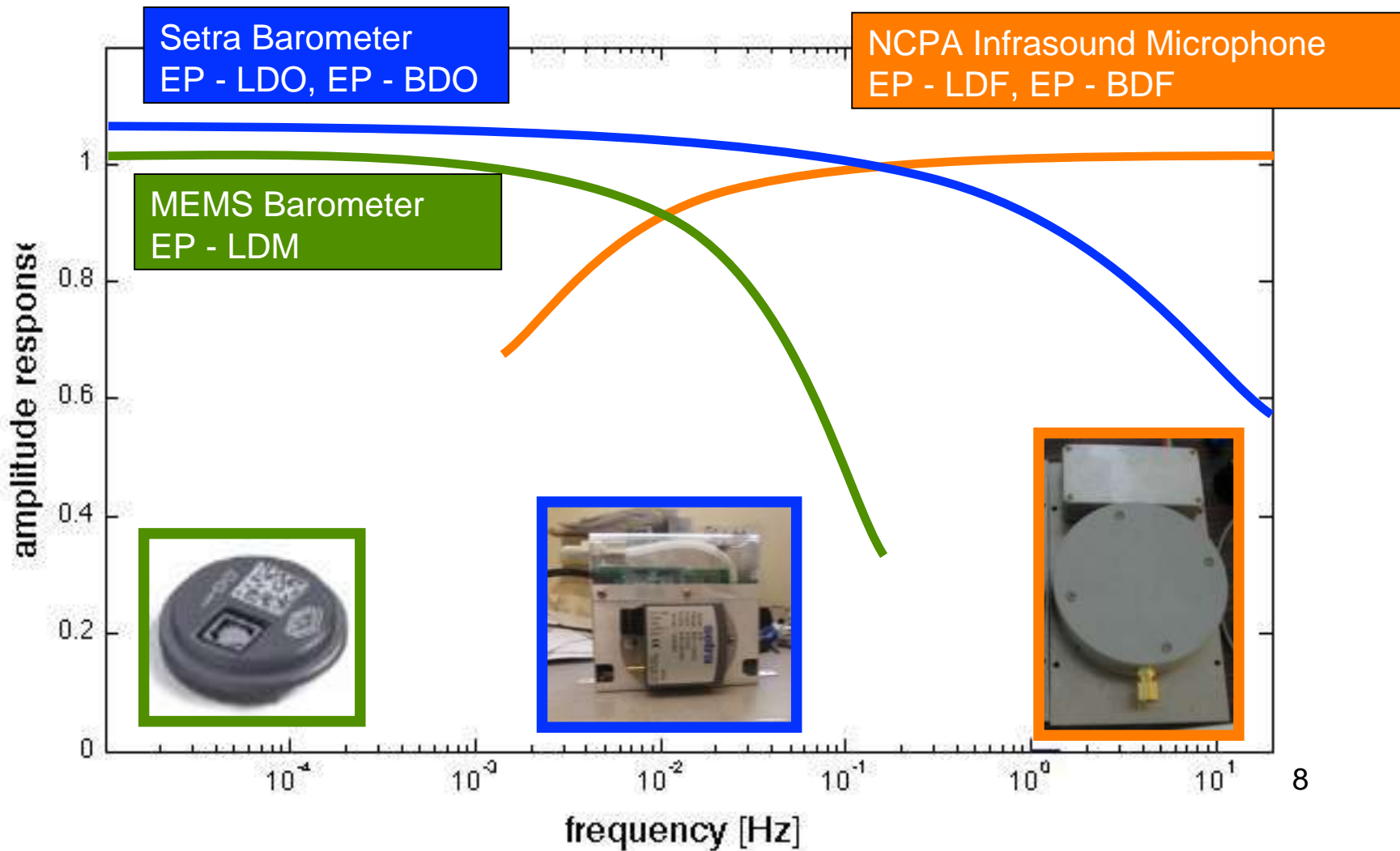
Contiguous Time Series





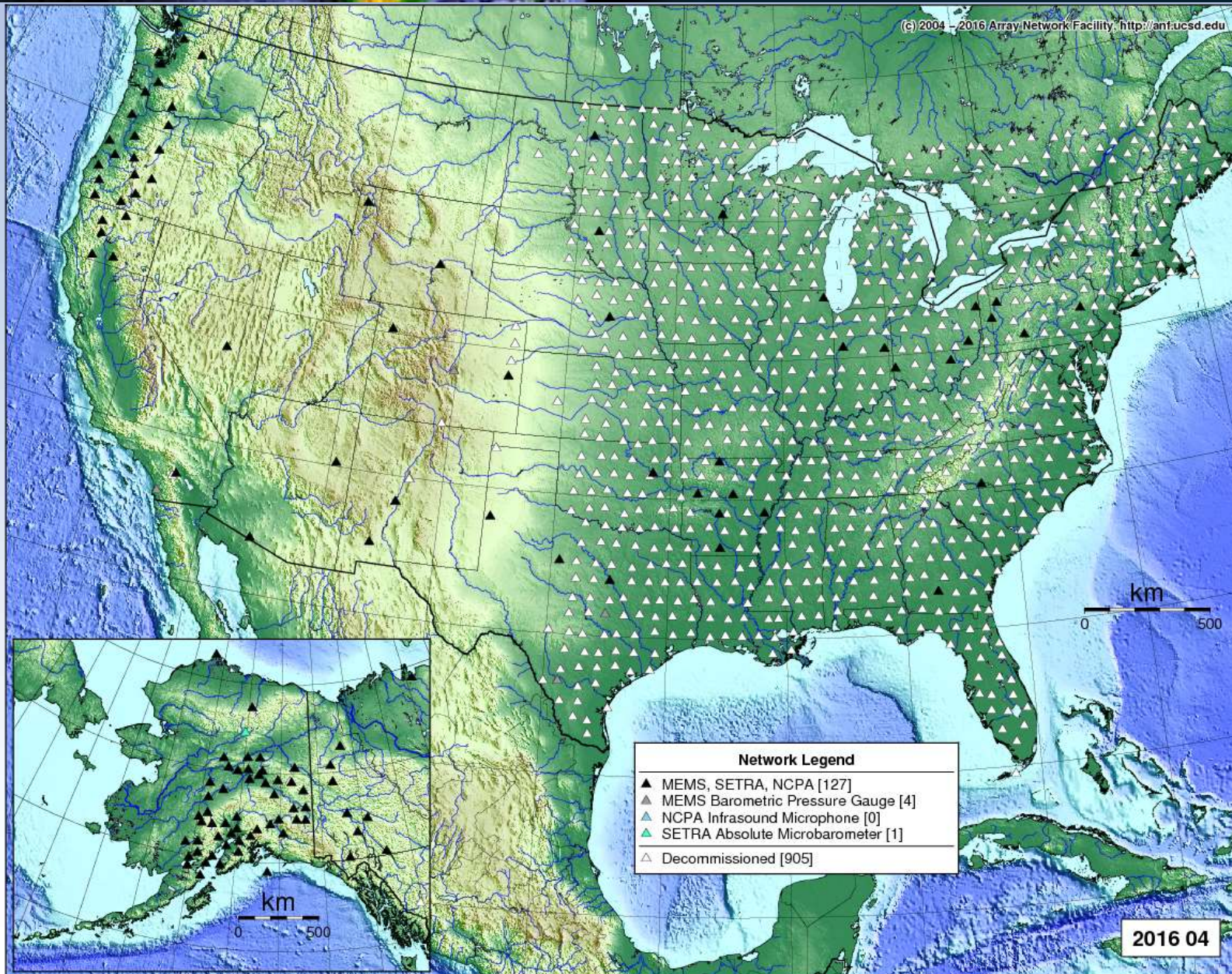
Pressure Sensor Response

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



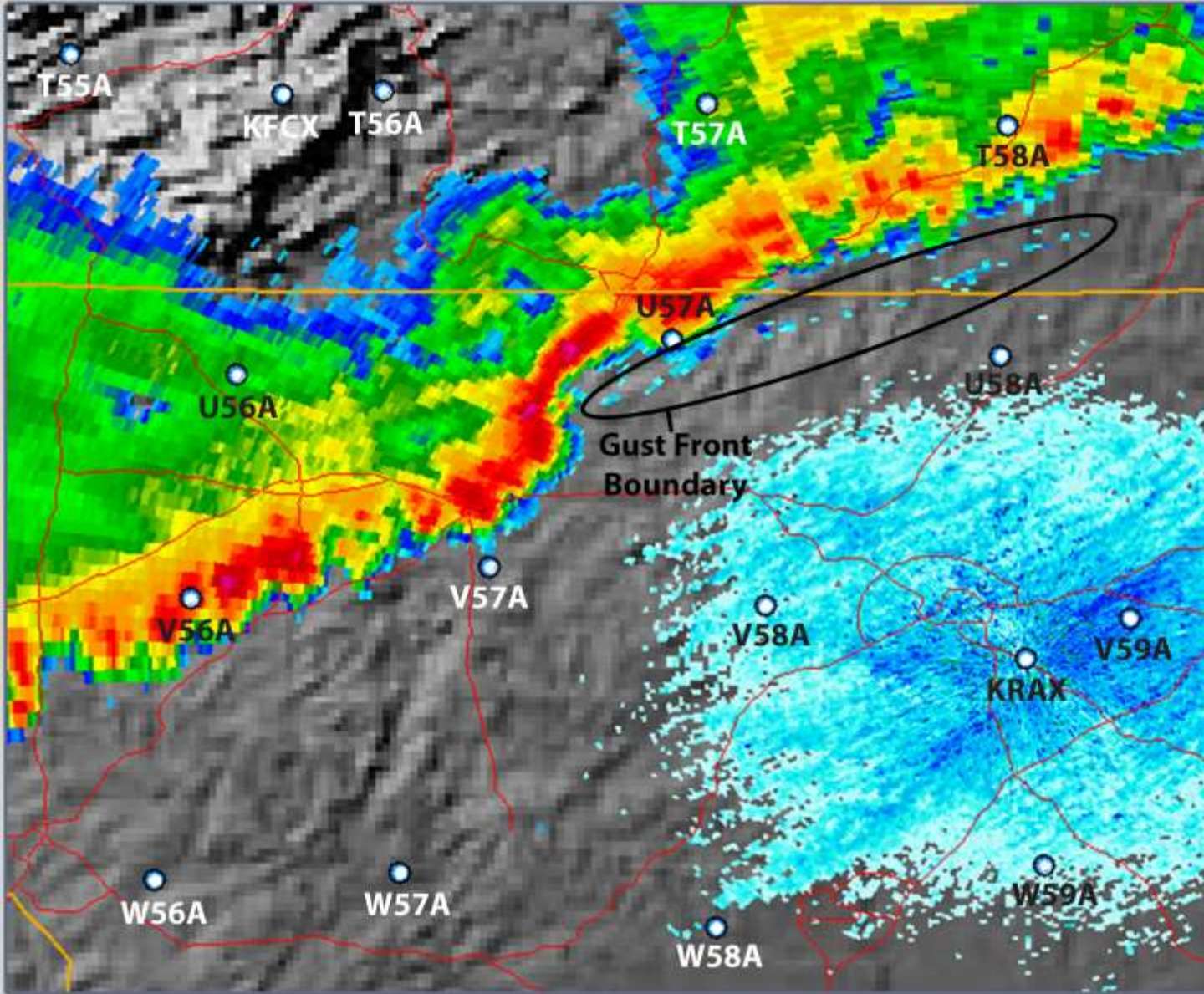


TA InfraMet





Squall Line Following 6/13/2013 Derecho



NEXRAD LEVEL-III
BASE REFLECTIVITY
KRAX - RALEIGH/DUR, NC
06/13/2013 20:32:33 GMT
LAT: 35/39/53 N
LON: 78/29/23 W
ELEV: 461 FT
MODE/VCP: A / 212

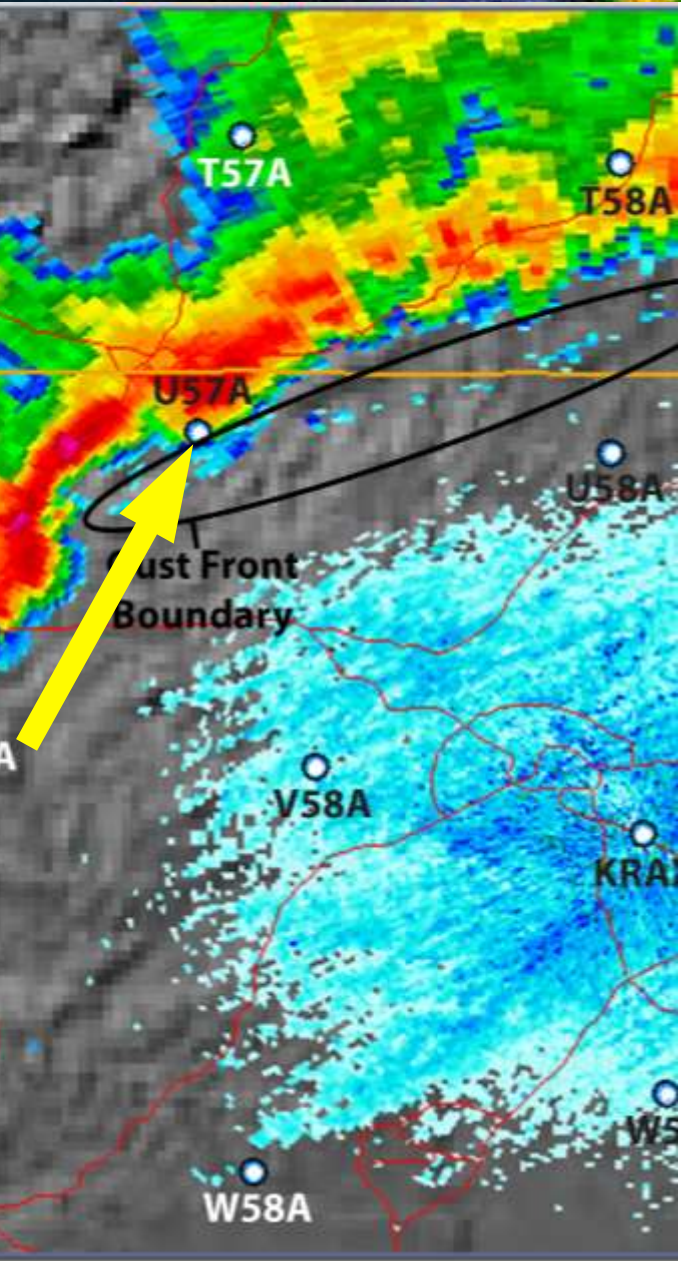
ELEV ANGLE: 0.50 °
MAX: 63 DBZ
RANGE: 248 NM

Legend: dBZ

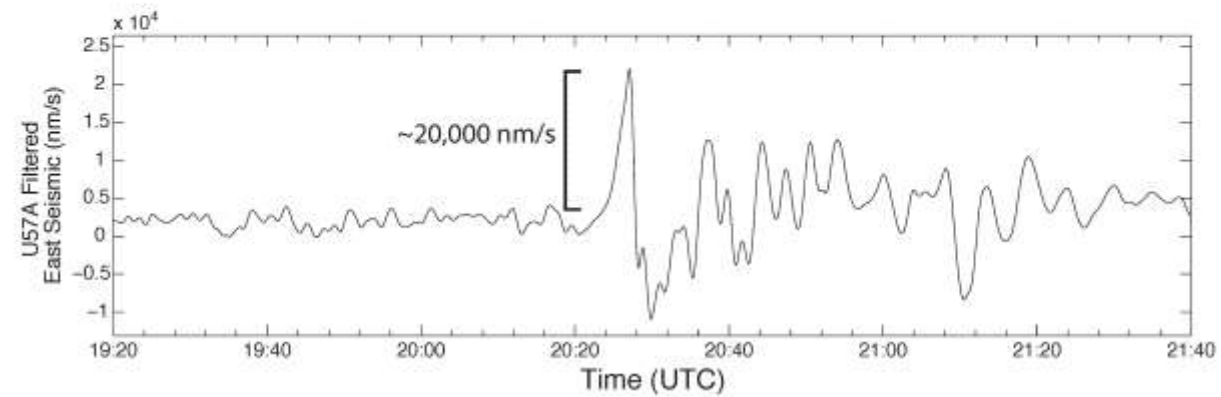
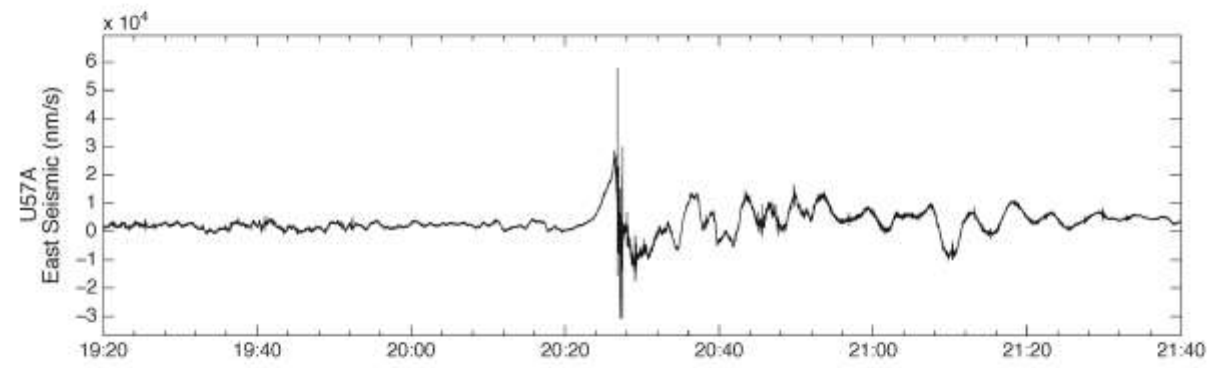
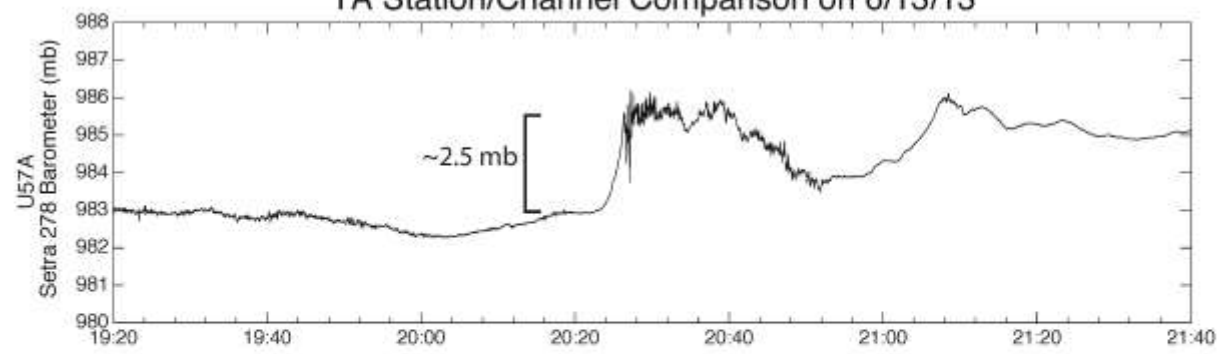
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
RF



6/13/2013 Derecho U57A



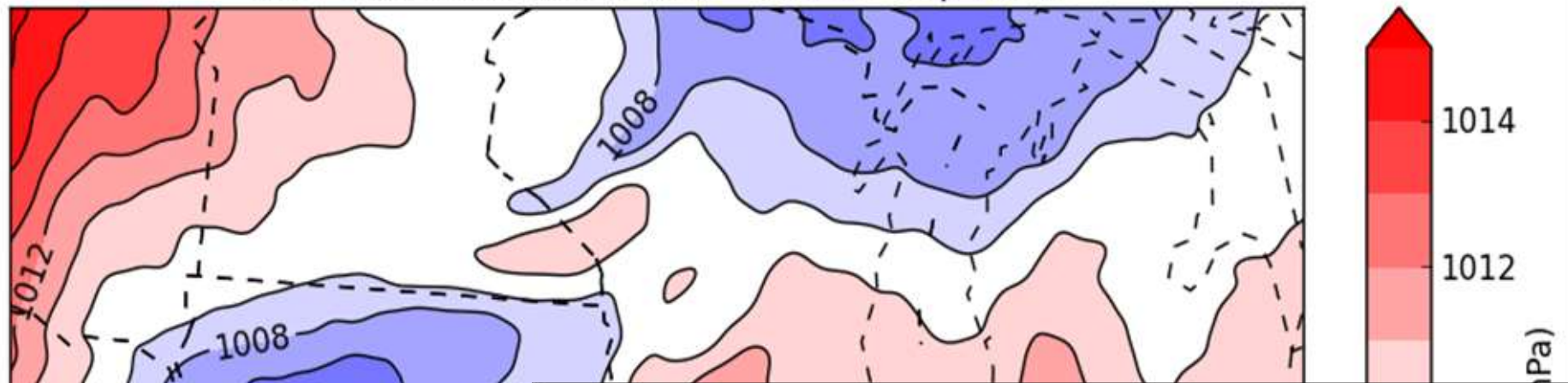
TA Station/Channel Comparison on 6/13/13



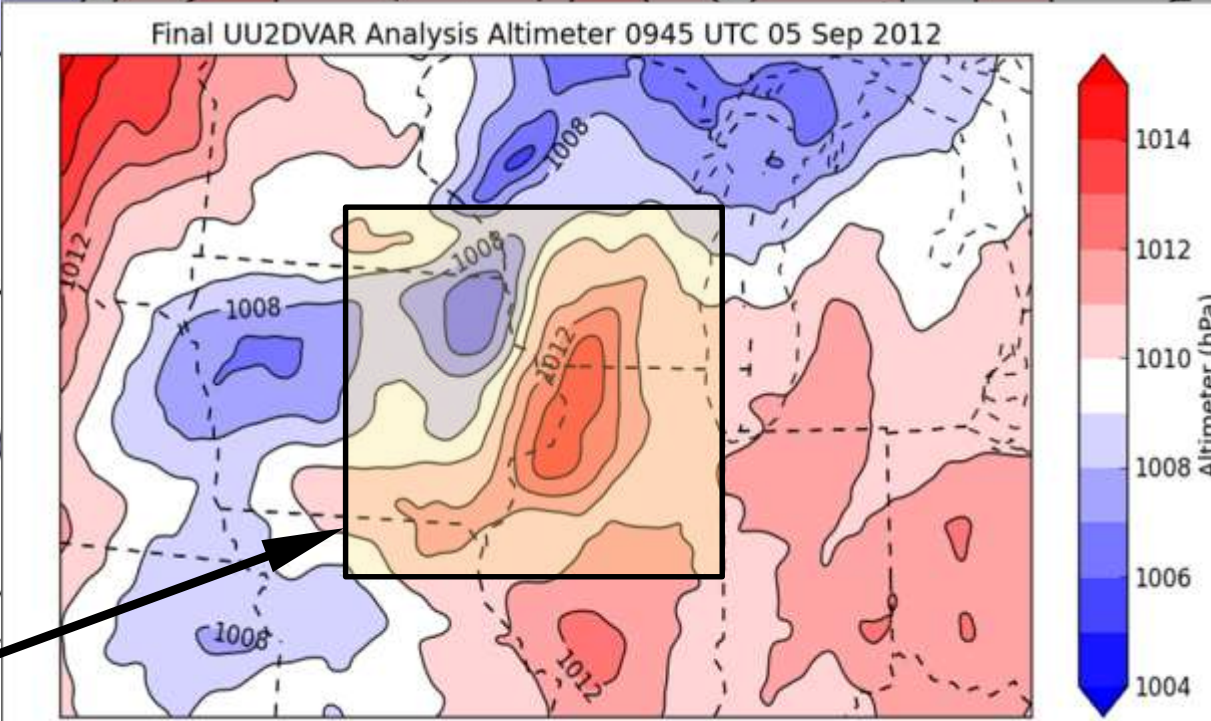


Propagating Mesoscale Convective System - Jacques (2015)

First Guess Altimeter 0945 UTC 05 Sep 2012



Final UU2DVAR Analysis Altimeter 0945 UTC 05 Sep 2012



Mesohigh/wake-low couplet

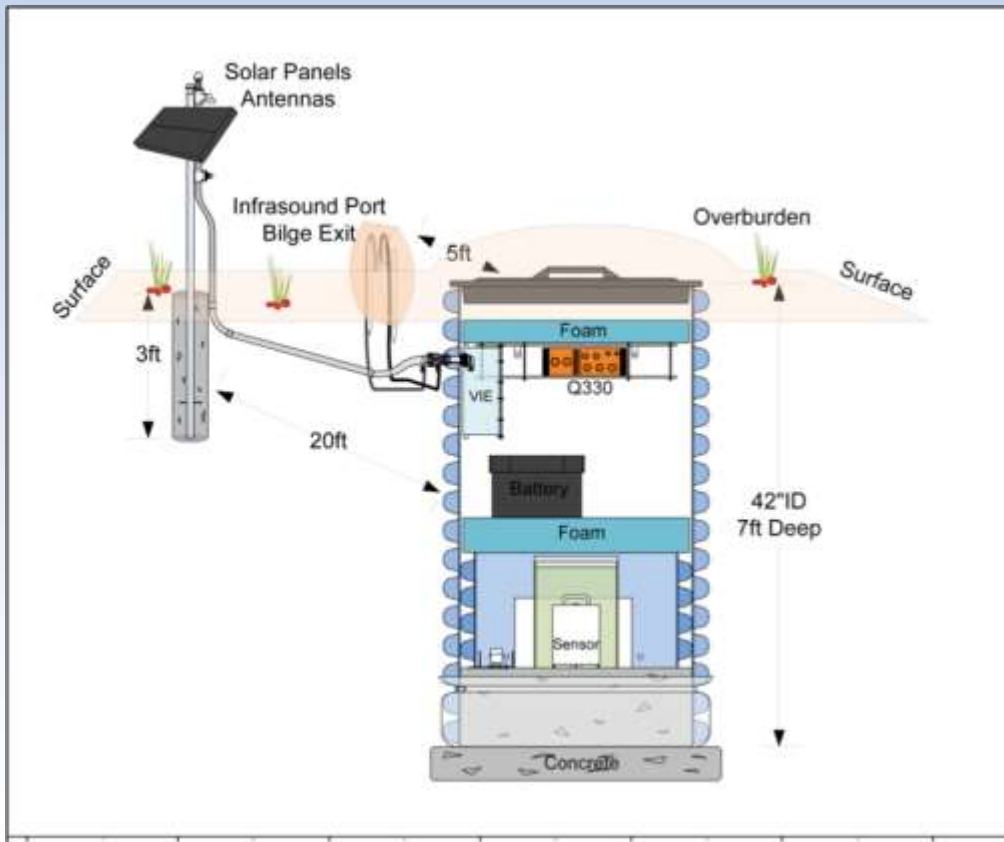
- Meteorological sensors can enhance understanding of seismic data
- Meteorological sensors can create opportunities for collaboration between different scientific communities
 - real time monitoring
 - hazards
 - civil defense
- Seismic networks provide sites, permitting, real time telemetry

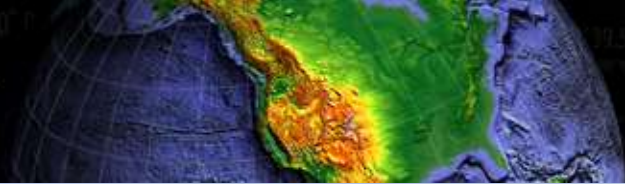


TA Basic Description

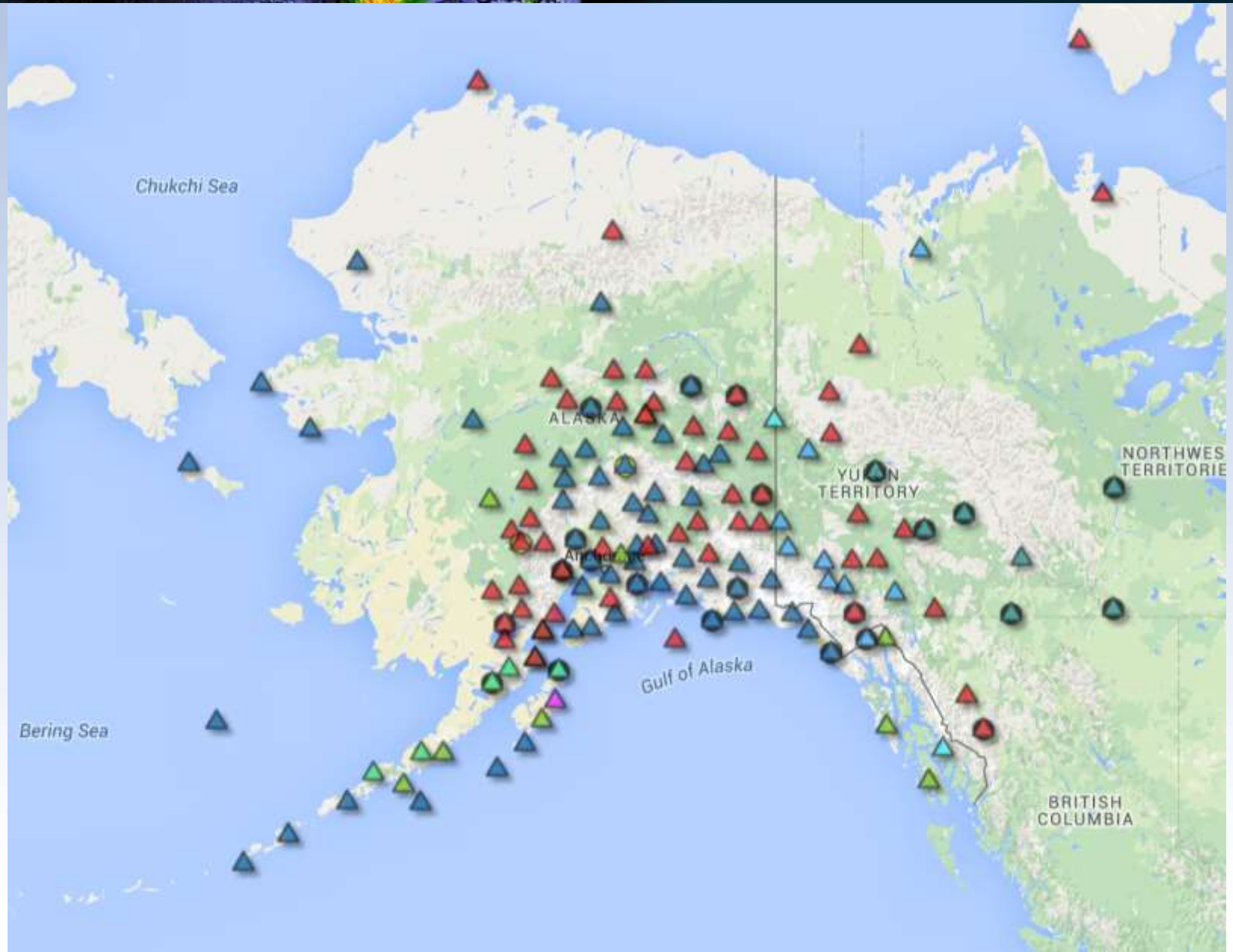
- Sensor: 3 component Broadband seismometer & auxiliary sensors
- Datalogger & local data storage
- Power & data telemetry

TA Station 345A, MS



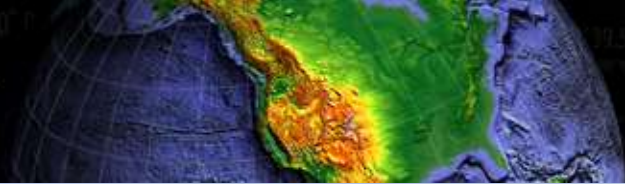


Alaska TA May 18, 2016



Status of TA Sites May 2016





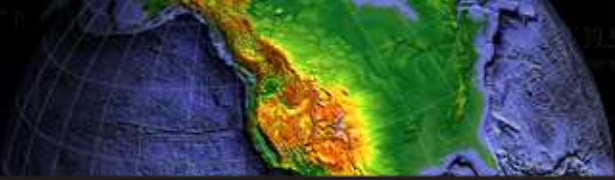
Basic Description of Buried Sensor Design for AK

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

N25K Seismic Station



Stations to be in place for 3 to 5 years



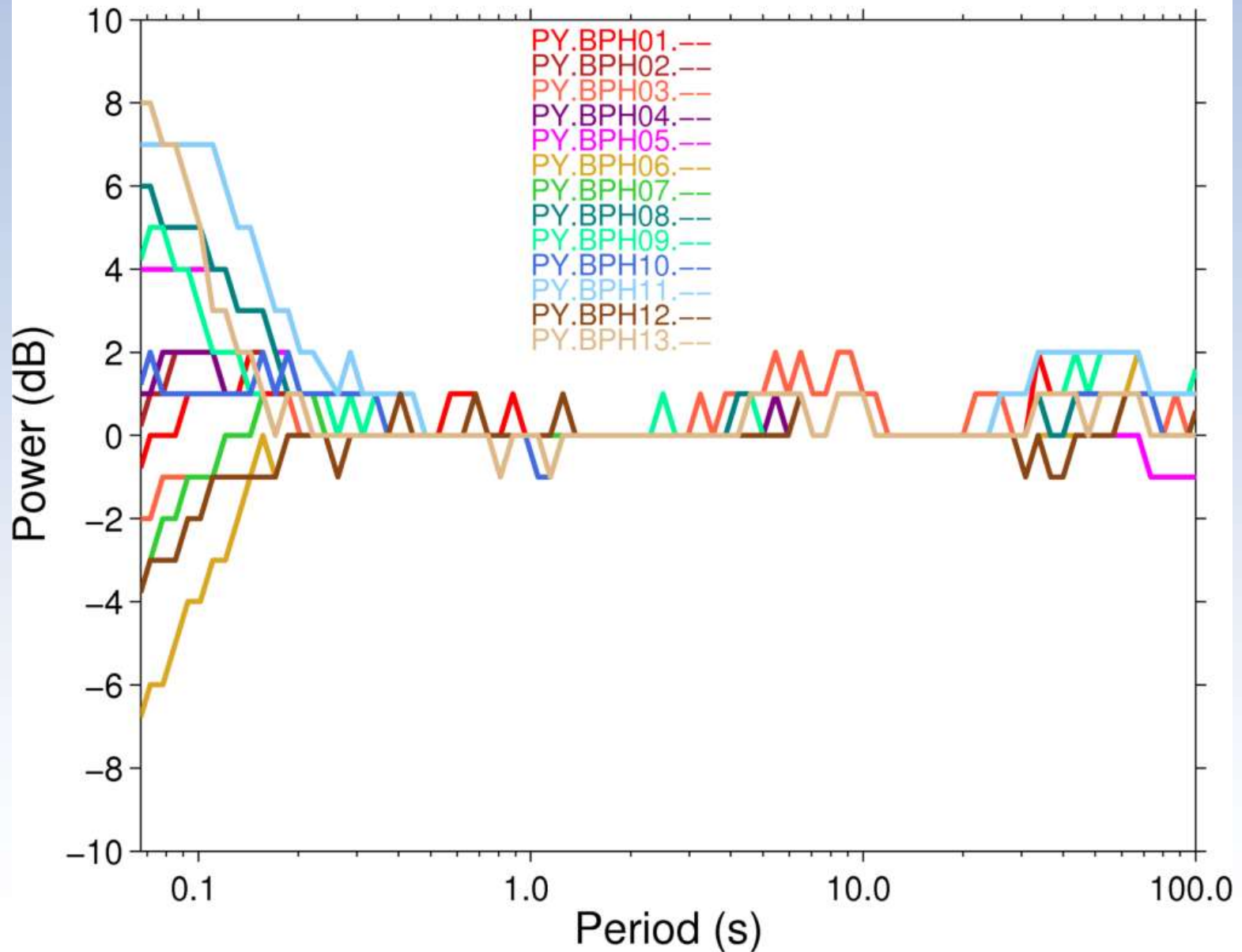
PFO PY Posthole Test





PY-TPFO Comparison

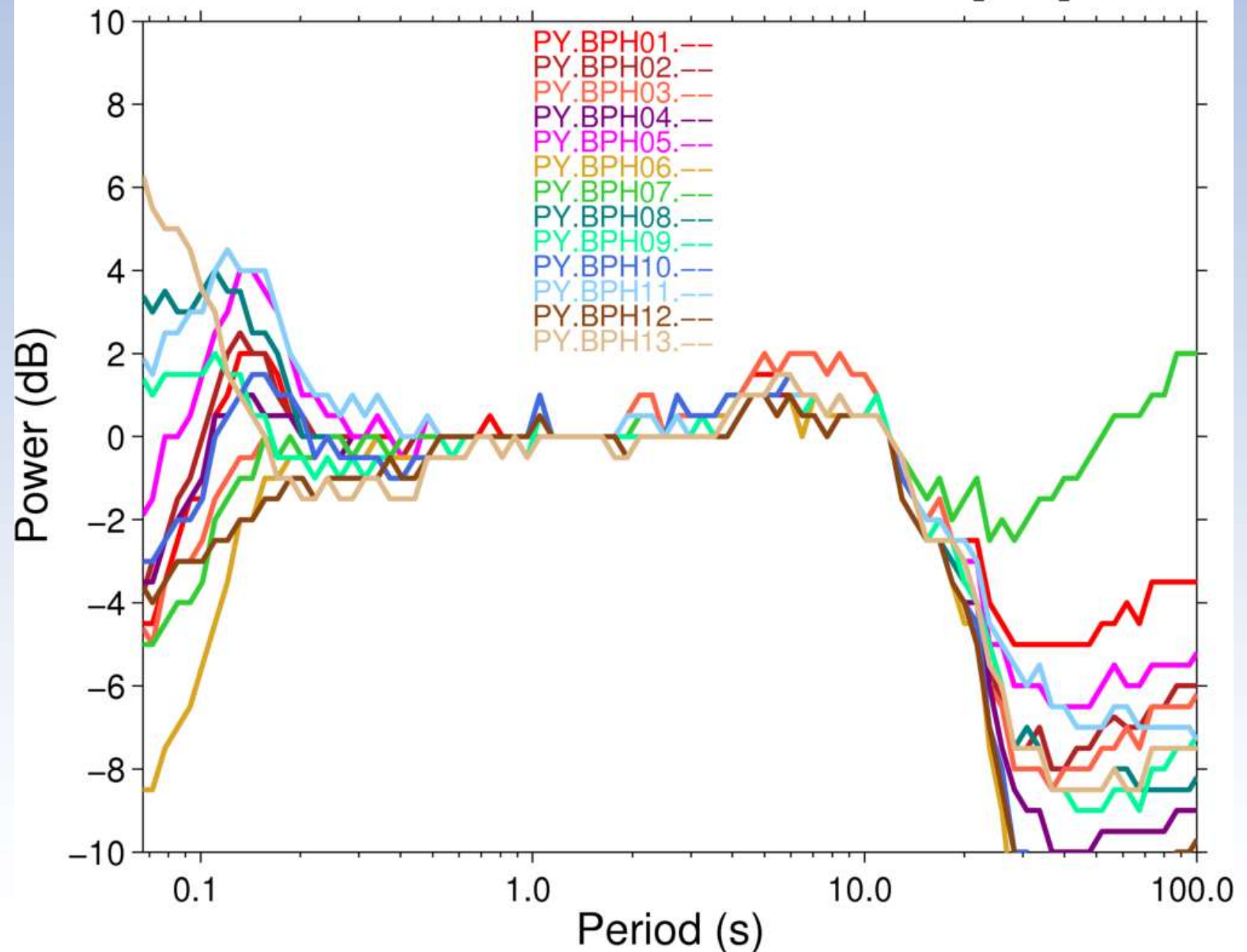
Station PDF Residual Medians BHZ





PY-TPFO Comparison

Station PDF Residual Medians BH[E/N]





Sensors

- Broadband seismic coverage, 1 and 40 sps
- Two surface barometric pressure channels at 1 sps
 - MEMS
 - Setra 278
- Hyperion Infrasound microphone, 1 sps
- Vaisala WXT520 Weather Stations, 1 sps
 - 25 sites
 - 265 additional sites possible if funding found

- Integrated system
 - Sensors
 - Dataloggers
 - Data acquisition hardware and software
 - Resiliency
 - Buffering at stations
 - Onsite storage
 - Failover systems
 - Web presentation
 - Field support
 - Outreach
- Leverage commercial developments
 - telemetry
 - IP networking
 - computer hardware and operating systems
- Software
 - Sustainability and operational costs
 - commercially supported (open source or closed source)
 - open source (who is responsible for support ?)



- High Quality Data
 - High data return > 99.5%
 - Sensor orientation ~ 2° for 1 sigma
 - Sensor calibration ~ 2% for 1 sigma
 - Accurate timing across all sensors ~ 1 microsecond
 - Low noise
 - Continuous time series. majority of stations > 9 months
 - High density spatial observations spatially unaliased in lower frequency bands
 - Multidisciplinary observations
- Science Returns
 - Improved seismicity observations
 - Improved body wave and surface wave tomography
 - Ambient noise tomography
 - Back propagation for large event rupture inversion
 - Atmospheric research
- Science Opportunities
 - Crustal compliance from atmospheric pressure and seismic data - multi taper transfer functions
 - Develop or improve frequency domain approach to ambient noise analysis
 - Multidisciplinary analysis