USArray and CEUSN

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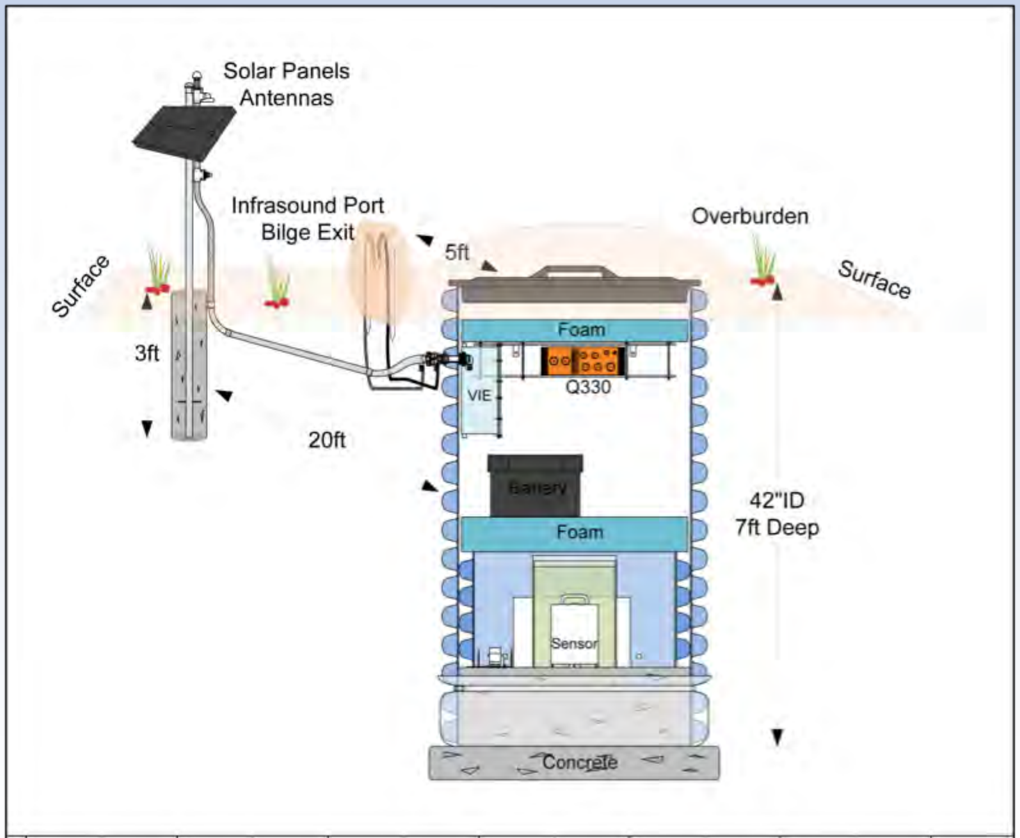
14 January 2015

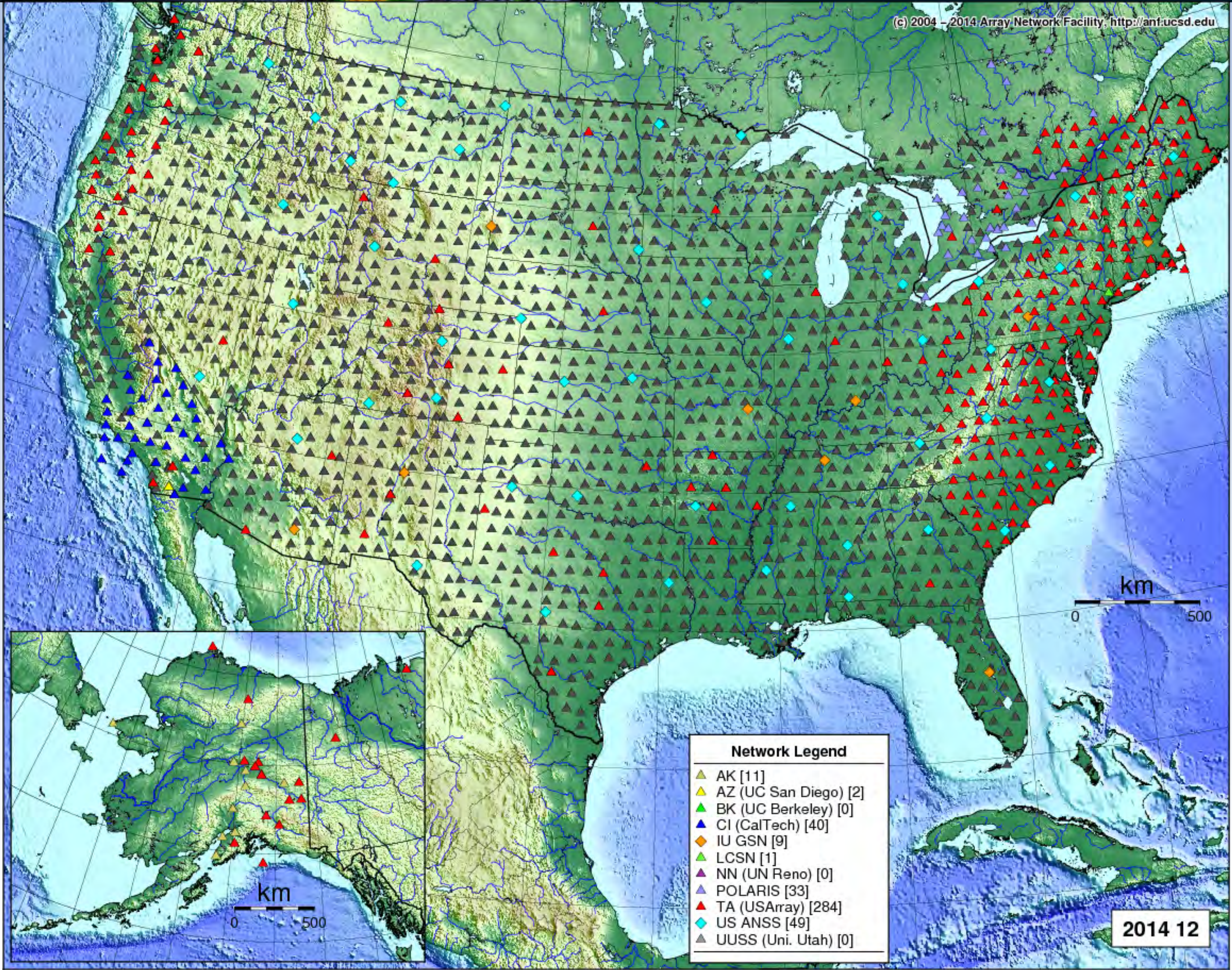
TA Basic Description

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

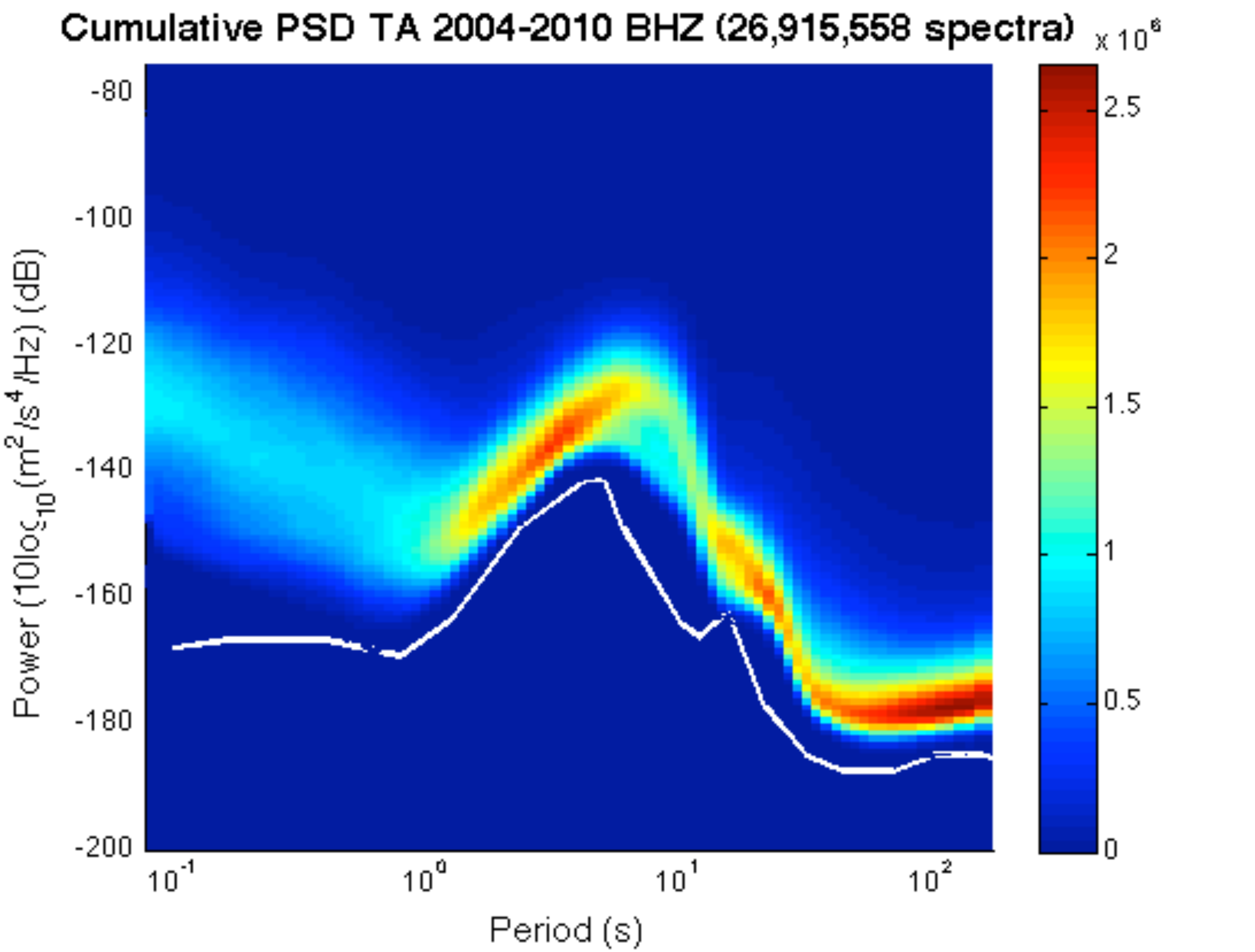


TA Station 345A, MS

USArray TA 2004-2014



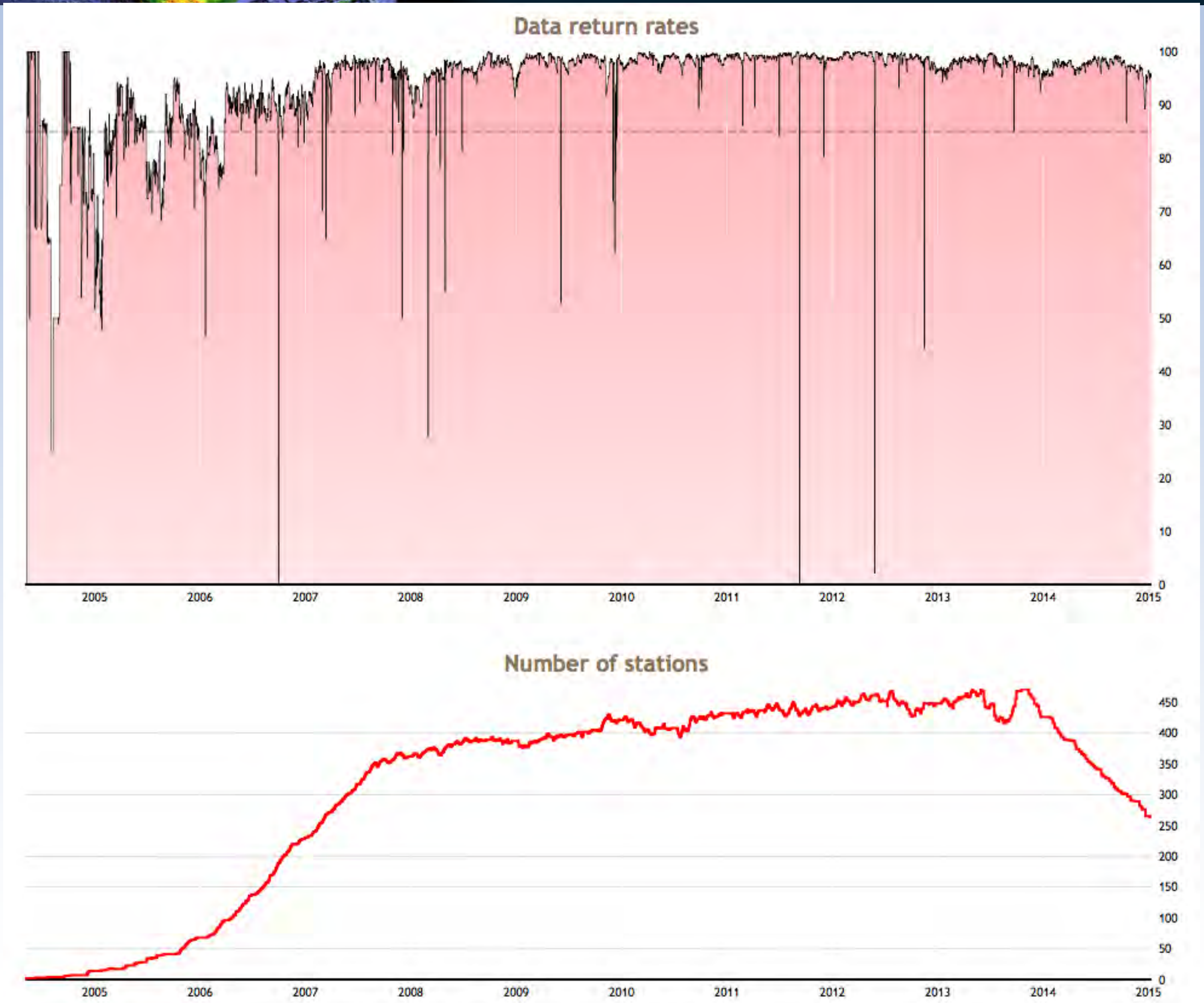
TA Performance



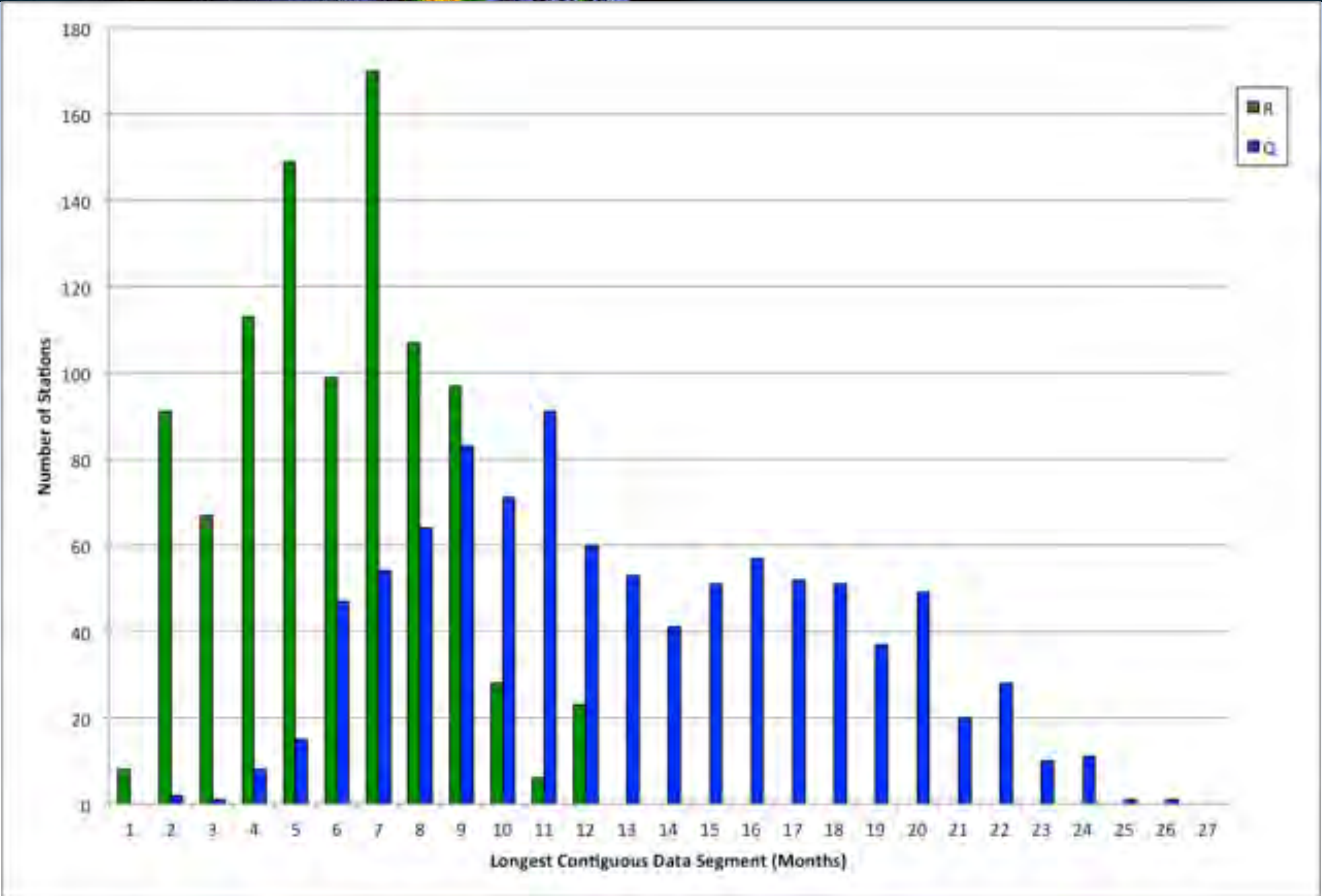
Station noise highly uniform and quite low for temporary installations

TA Performance

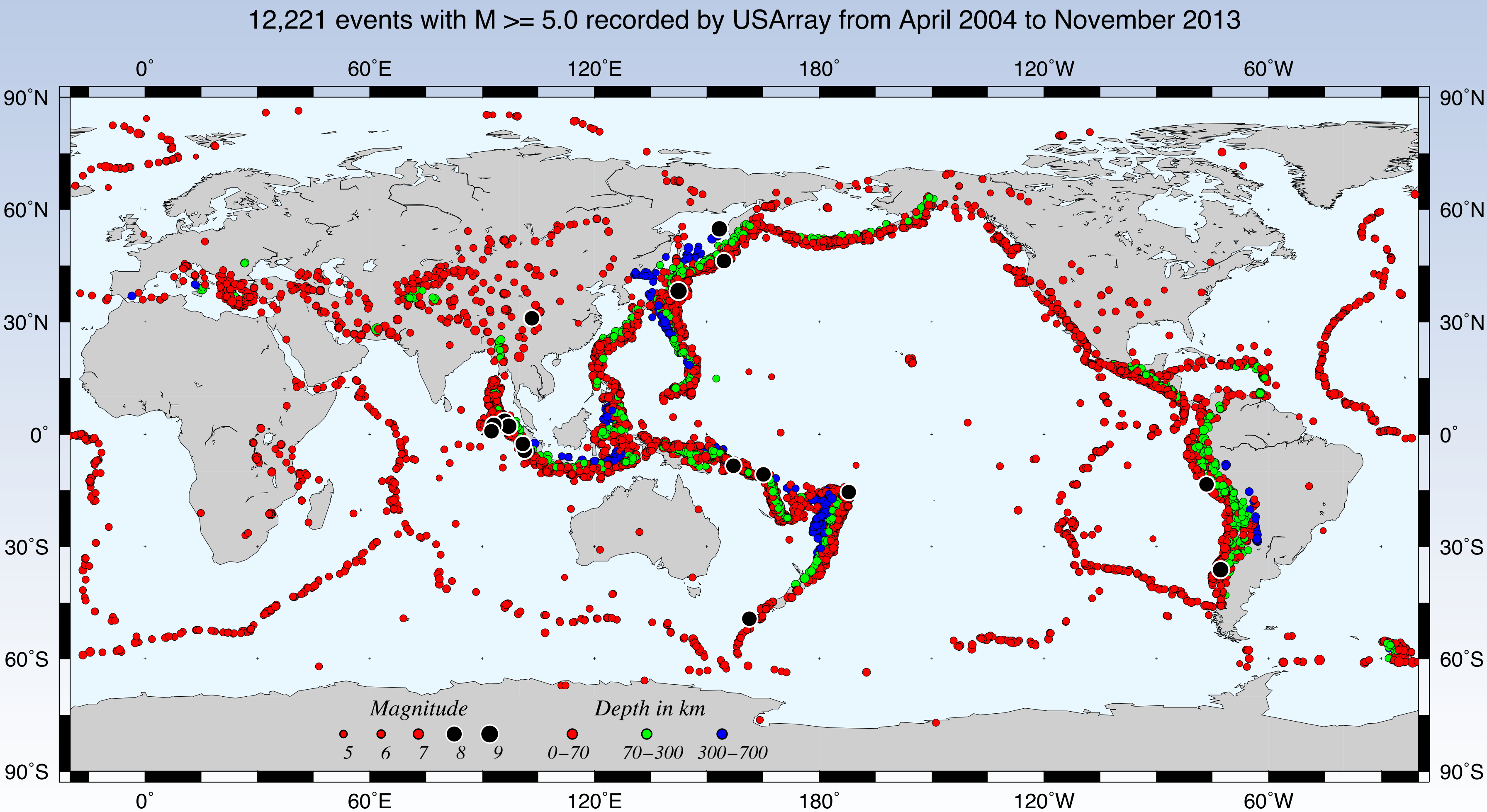
Network availability typically exceeds 98%



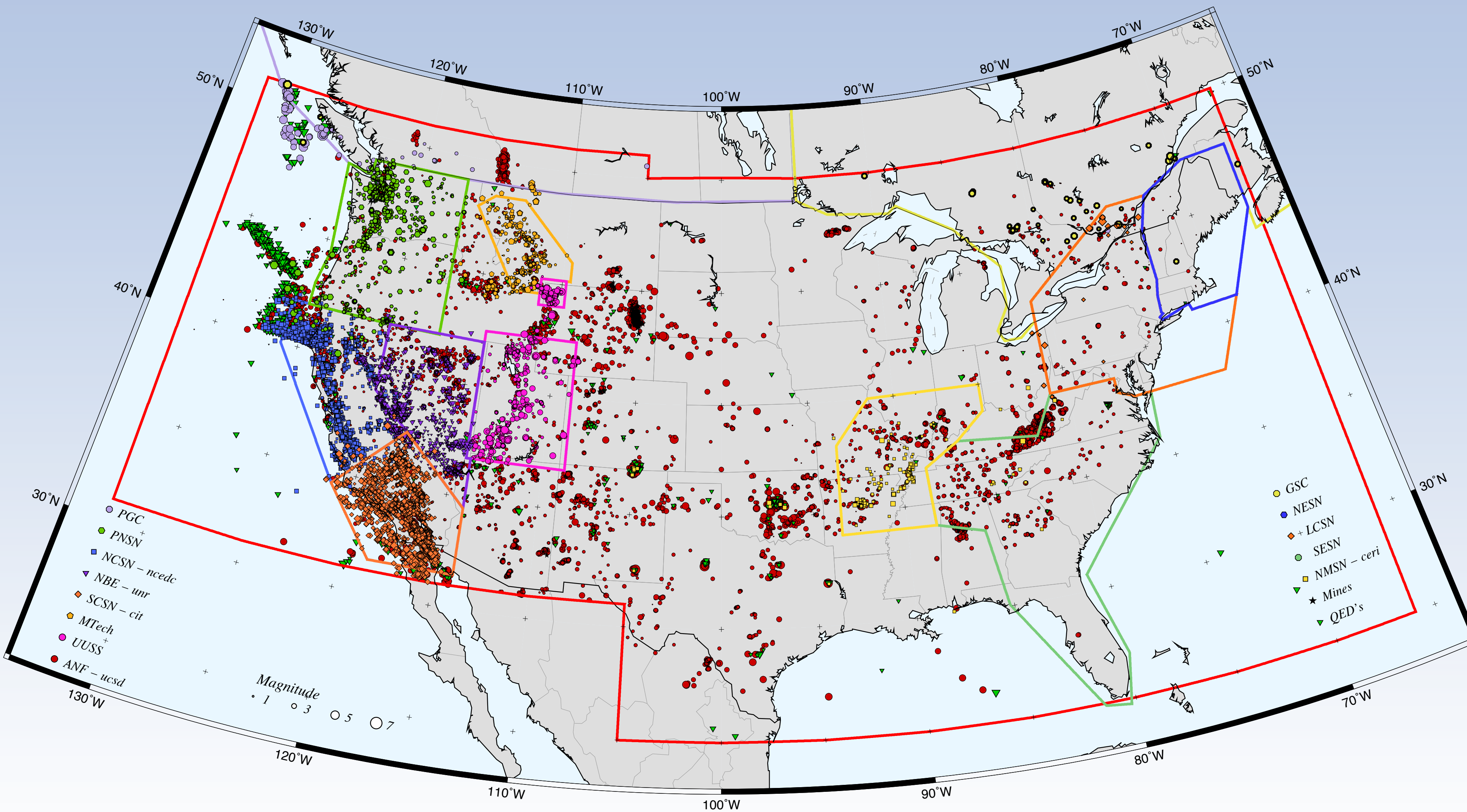
Contiguous Time Series



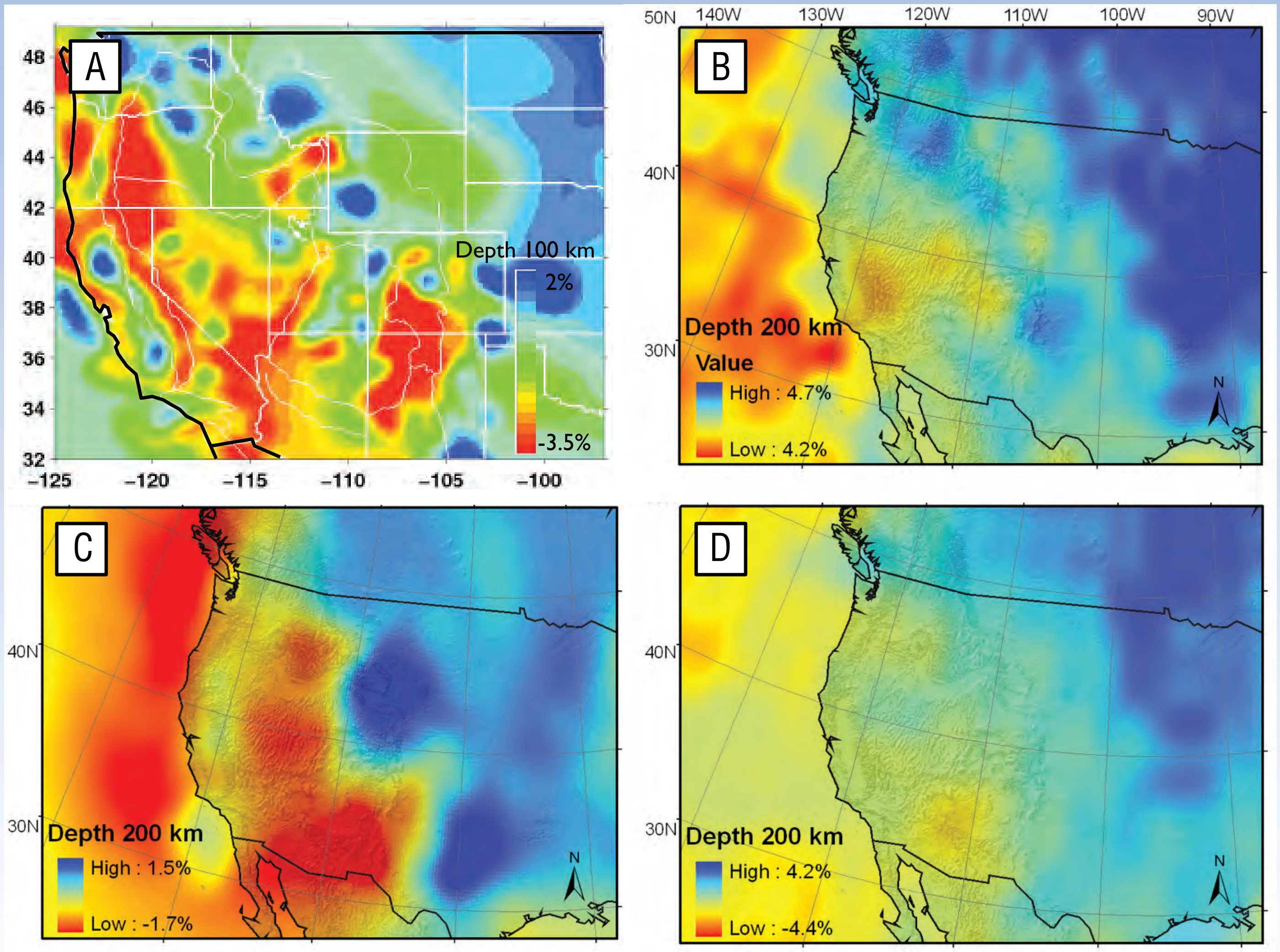
Global Seismicity



US Seismicity

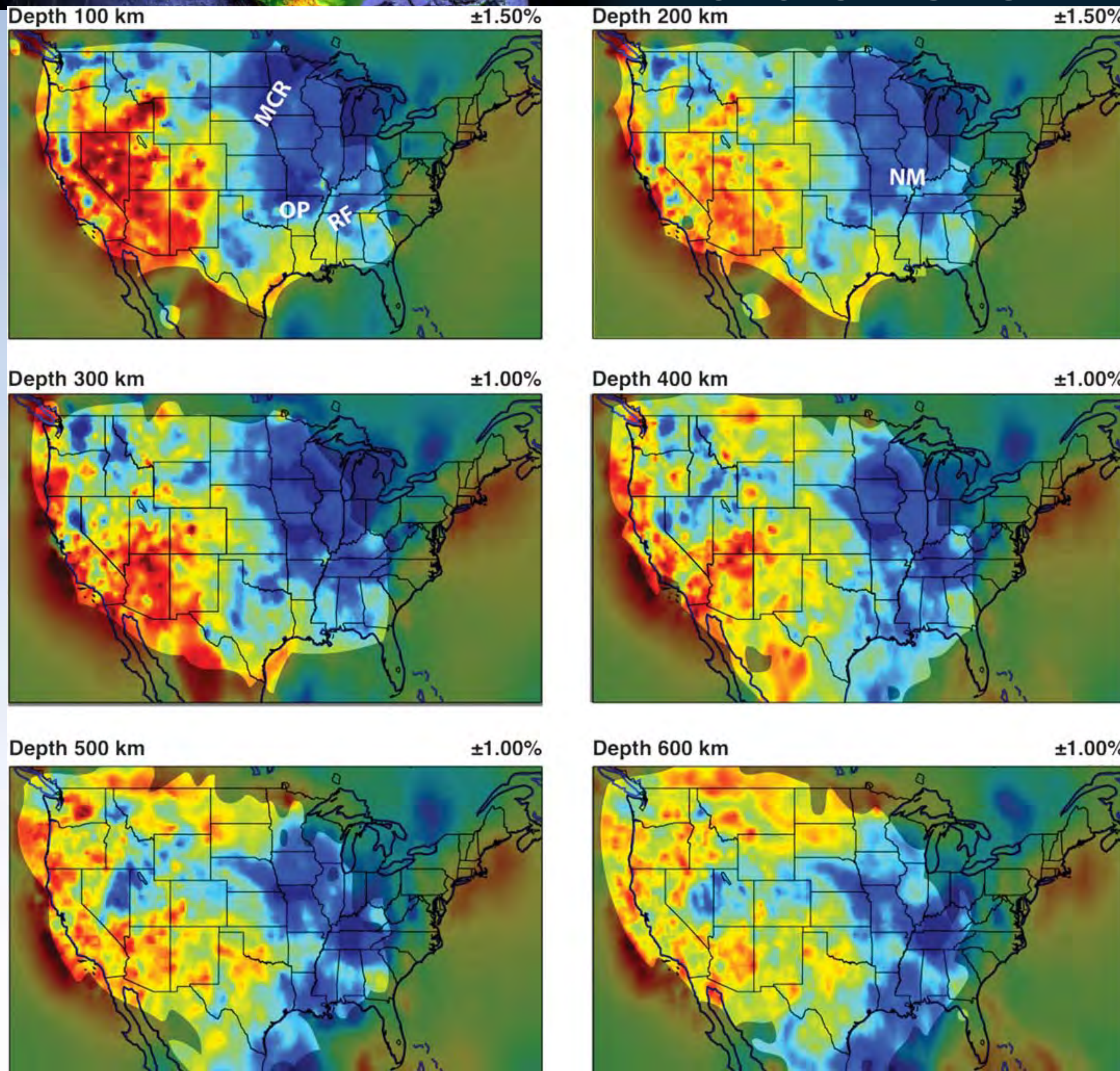


Tomography Before TA

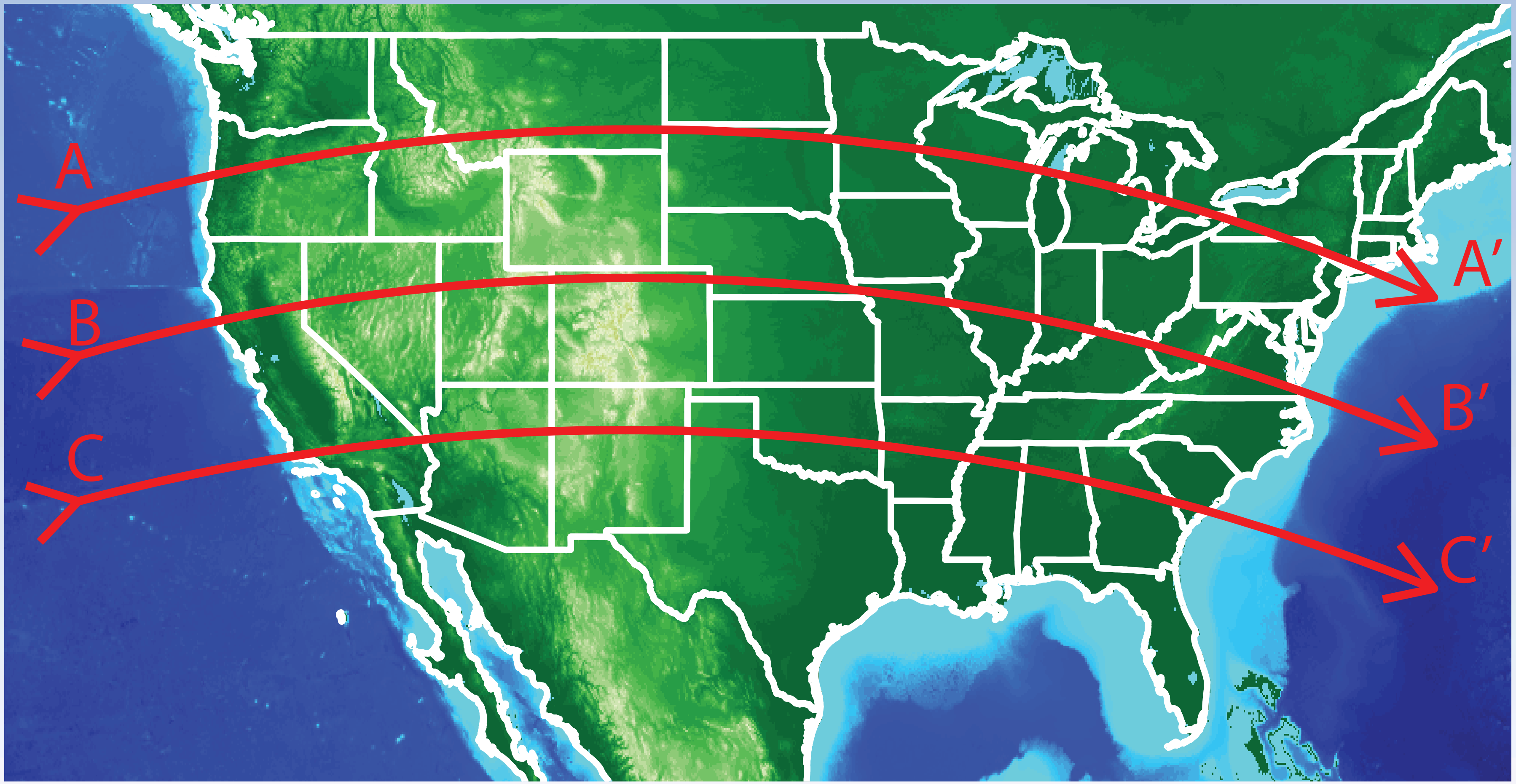


▲ **Figure 1.** (A) Model made by piecing together local tomography studies from Humphreys and Dueker (1994) and inverting with global data set (after Dueker *et al.* 2001). (B) Global *S*-wave model from surface wave diffraction (Ritzwoller *et al.* 2002). (C) Global *P*-wave model using finite frequency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

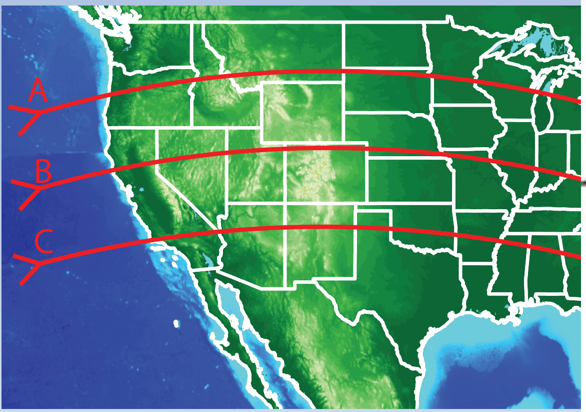
Tomography
Burdick et al. 2014

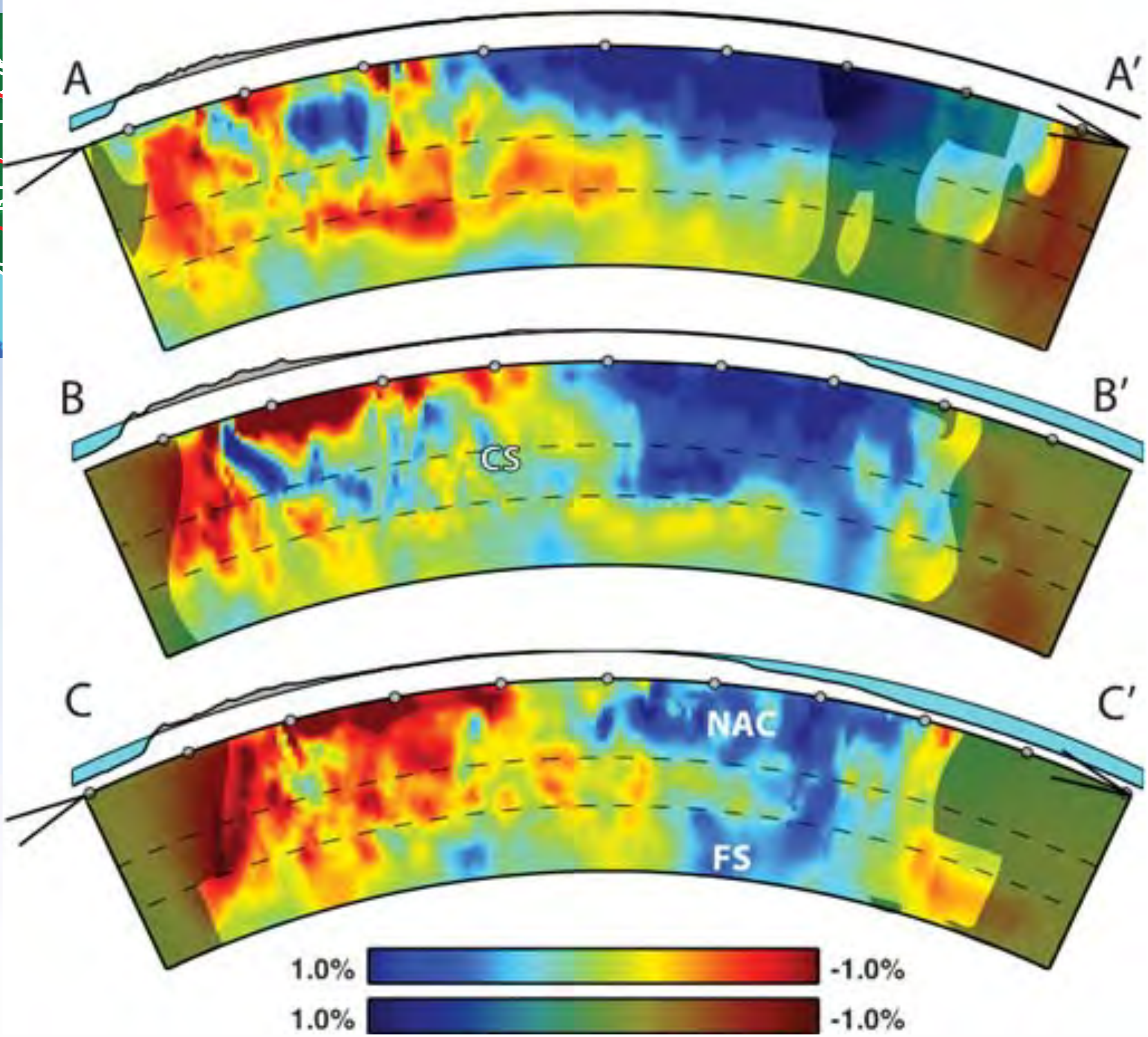


Tomography
Burdick et al. 2014

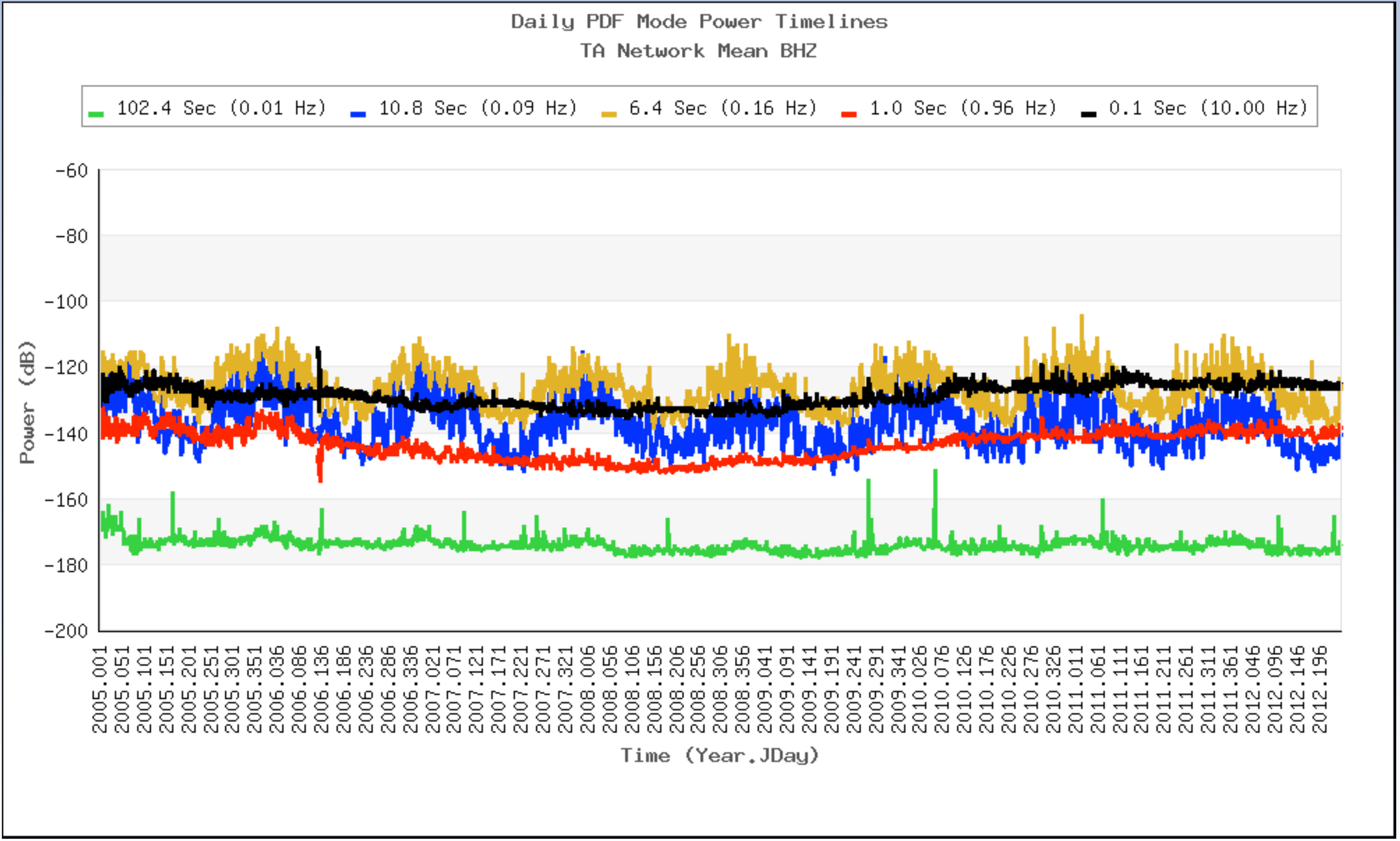


Tomography
Burdick et al. 2014

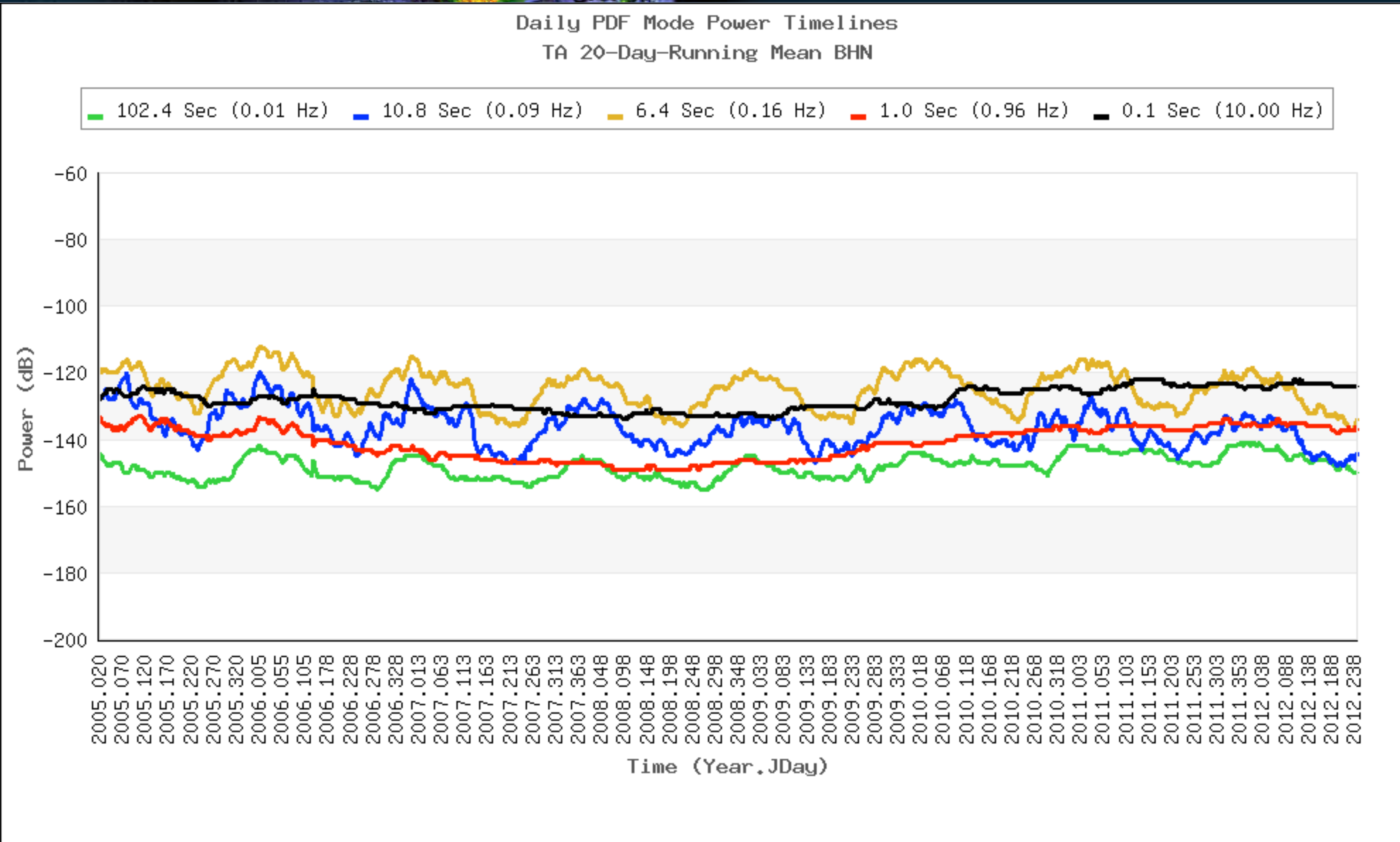




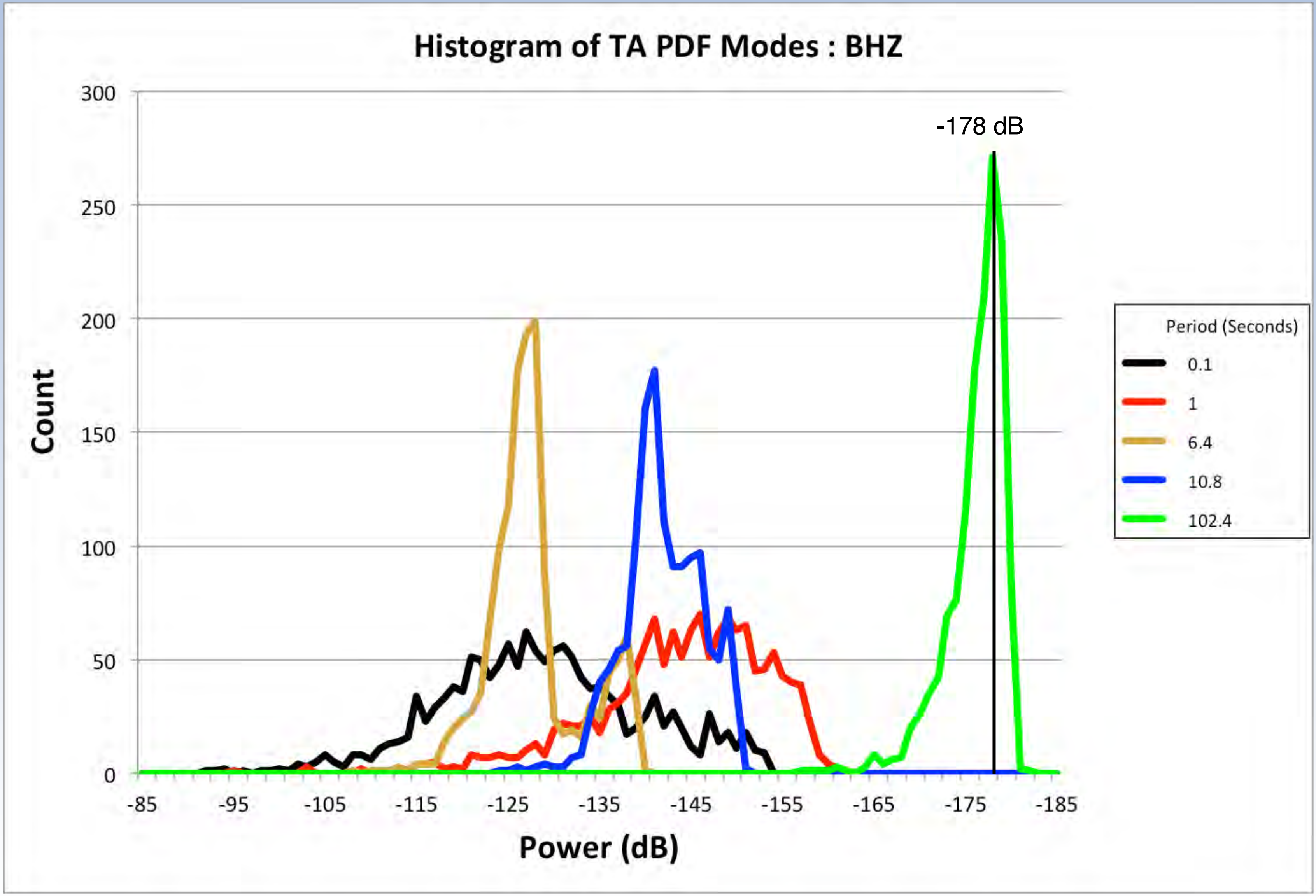
Daily PDF Modes



Daily PDF Modes

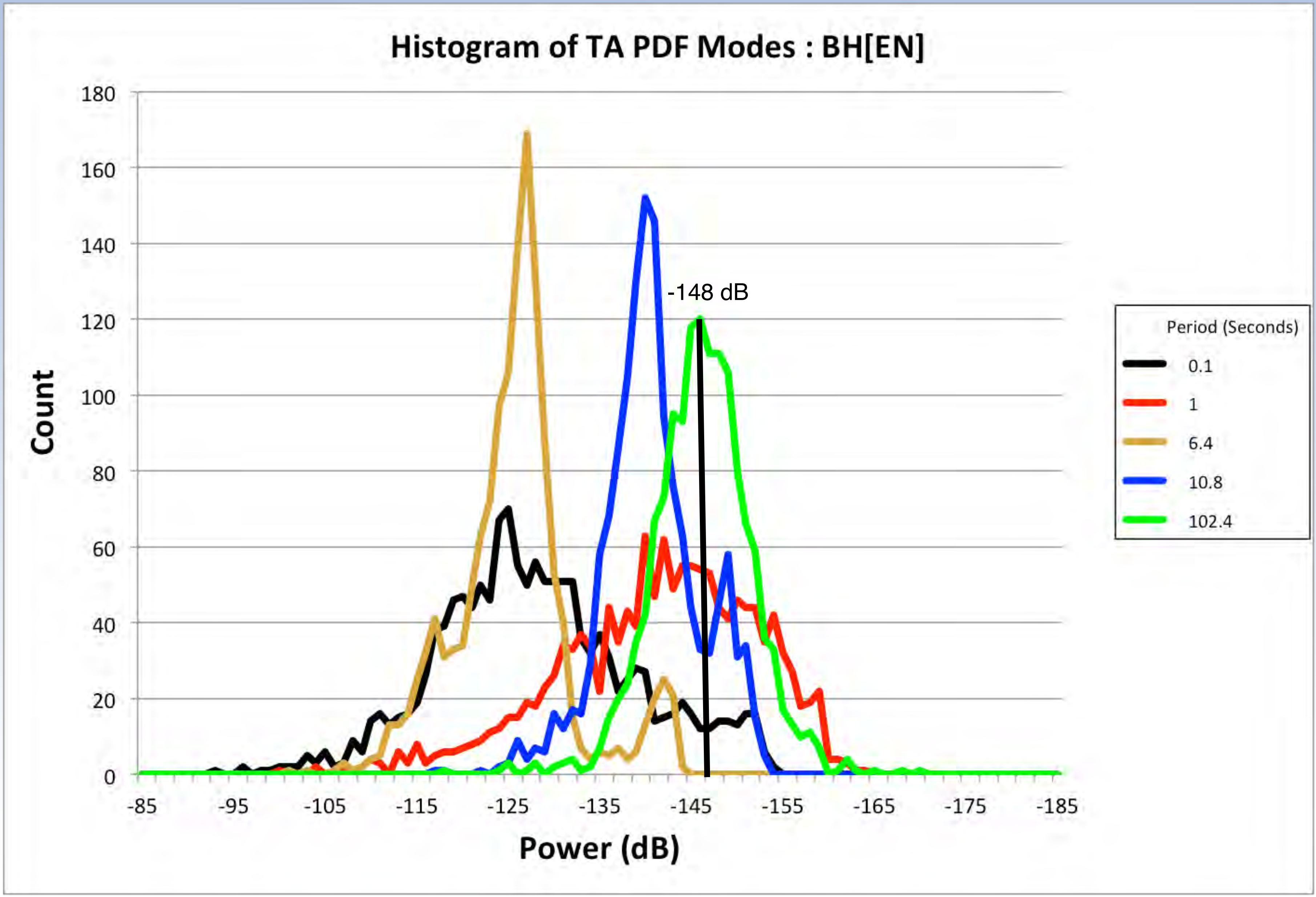


Histograms



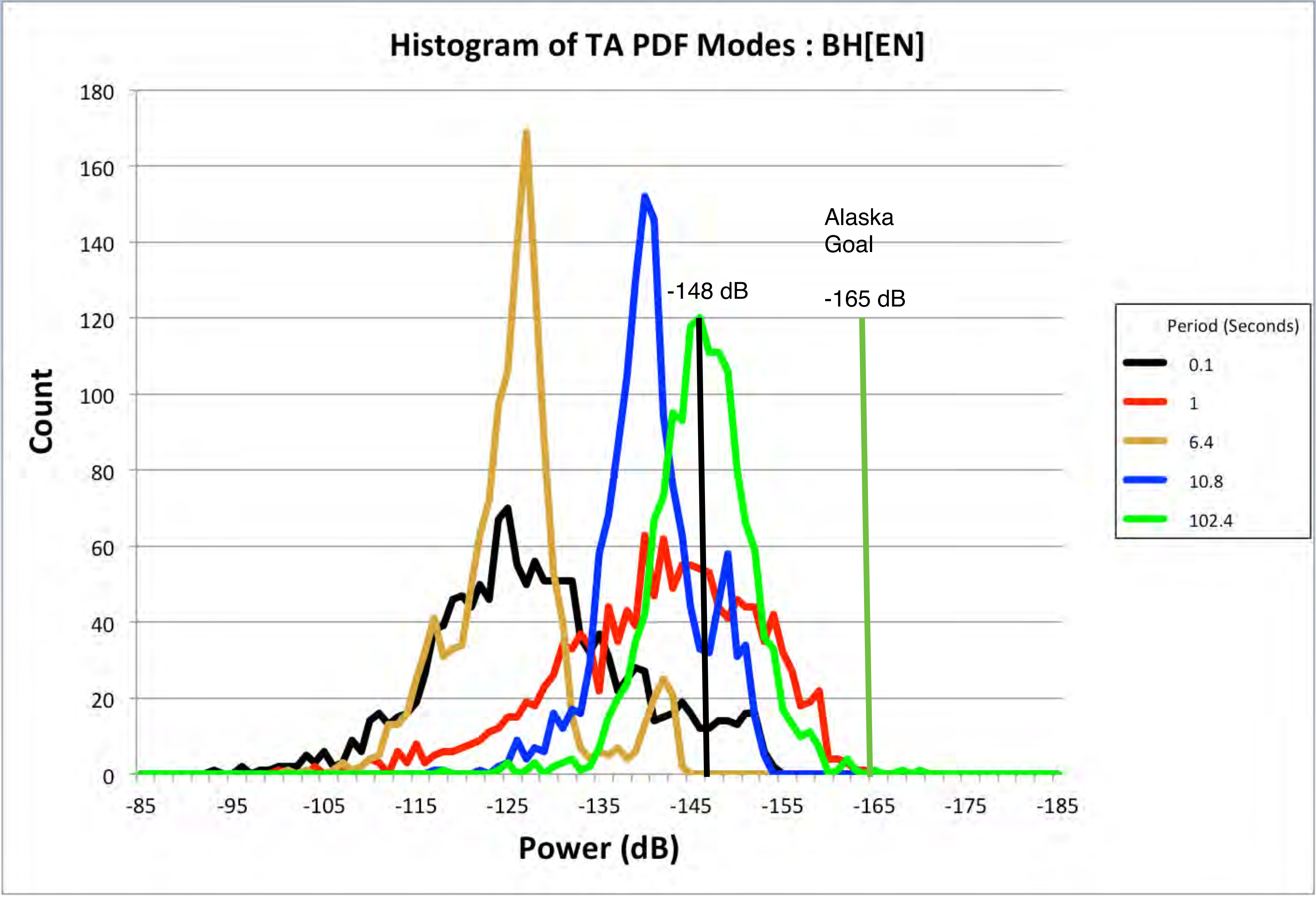
Histogram of TA PDF Modes : BHZ
-178 dB
Count
300
250
200
150
100
50
0
-85
-95
-105
-115
-125
-135
-145
-155
-165
-175
-185
Power (dB)
Period (Seconds)
0.1
1
6.4
10.8
102.4

Histograms

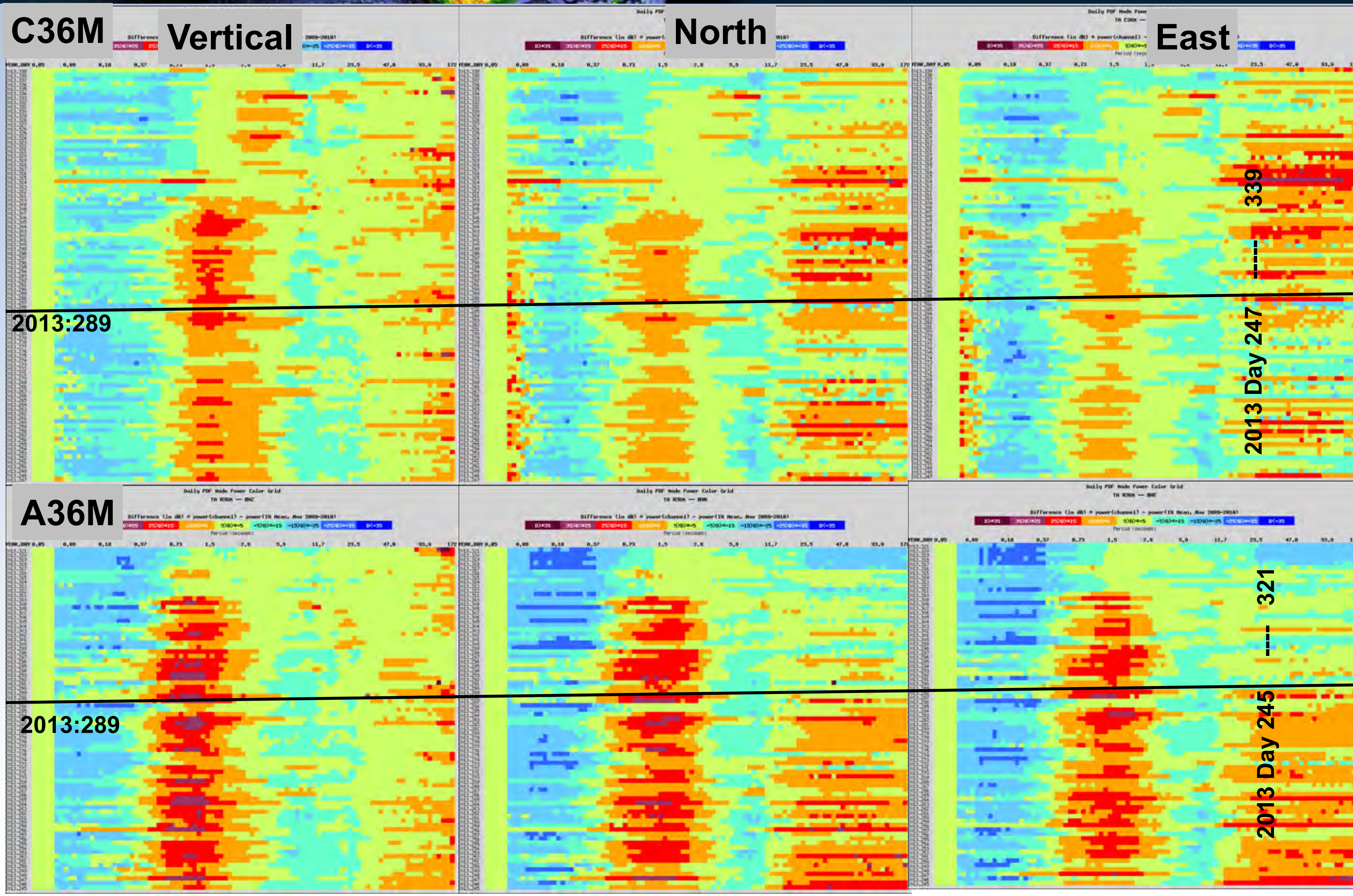


Histogram of TA PDF Modes : BH[EN]
Count
Power (dB)
-148 dB
180
160
140
120
100
80
60
40
20
0
-85
-95
-105
-115
-125
-135
-145
-155
-165
-175
-185
Period (Seconds)
0.1
1
6.4
10.8
102.4

Histograms


Histogram of TA PDF Modes : BH[EN]
Count
Power (dB)
180
160
140
120
100
80
60
40
20
0
-85
-95
-105
-115
-125
-135
-145
-155
-165
-175
-185
-148 dB
Alaska
Goal
-165 dB
Period (Seconds)
0.1
1
6.4
10.8
102.4

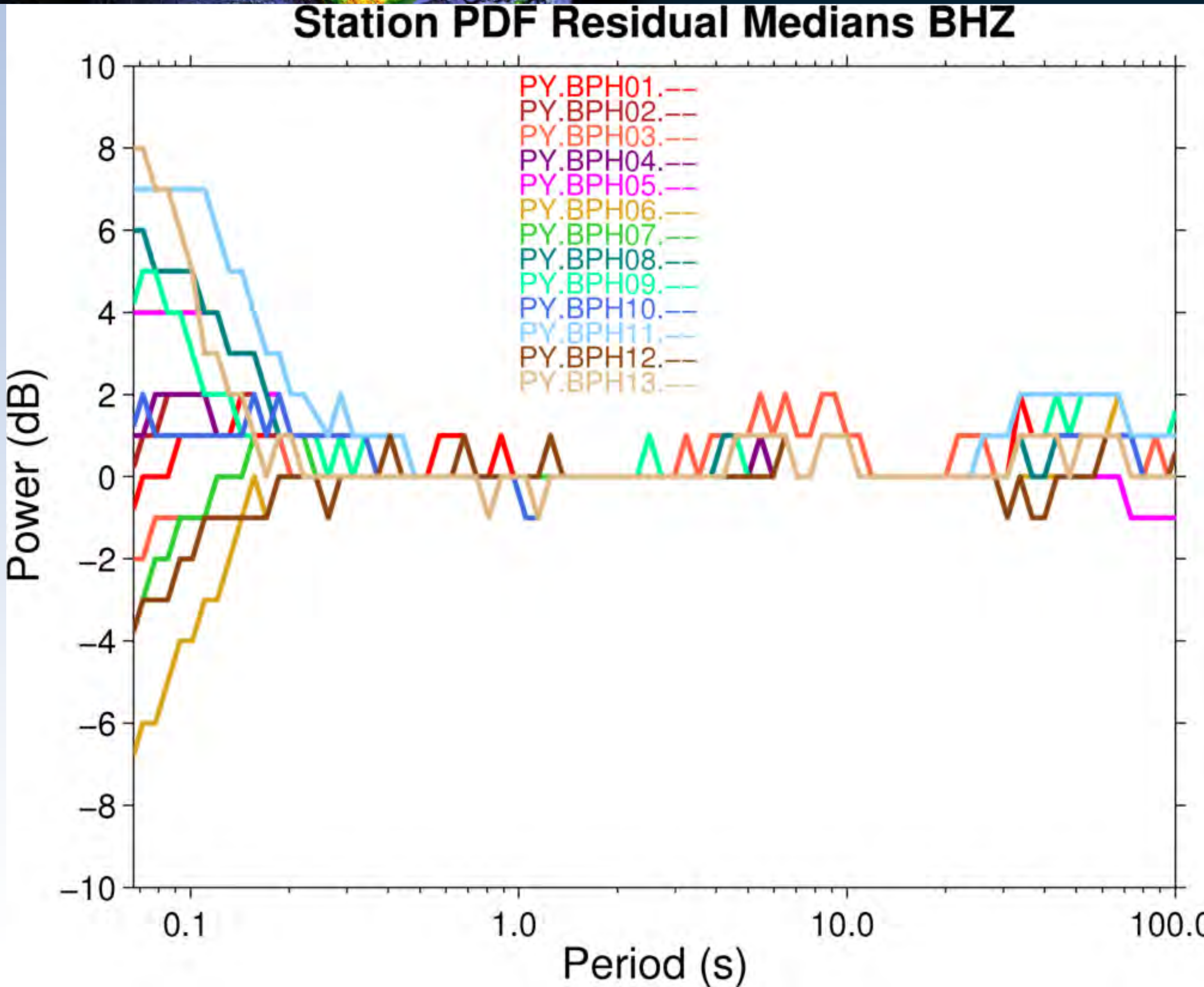
Paulatuk C36M
Sachs Harbor A36M



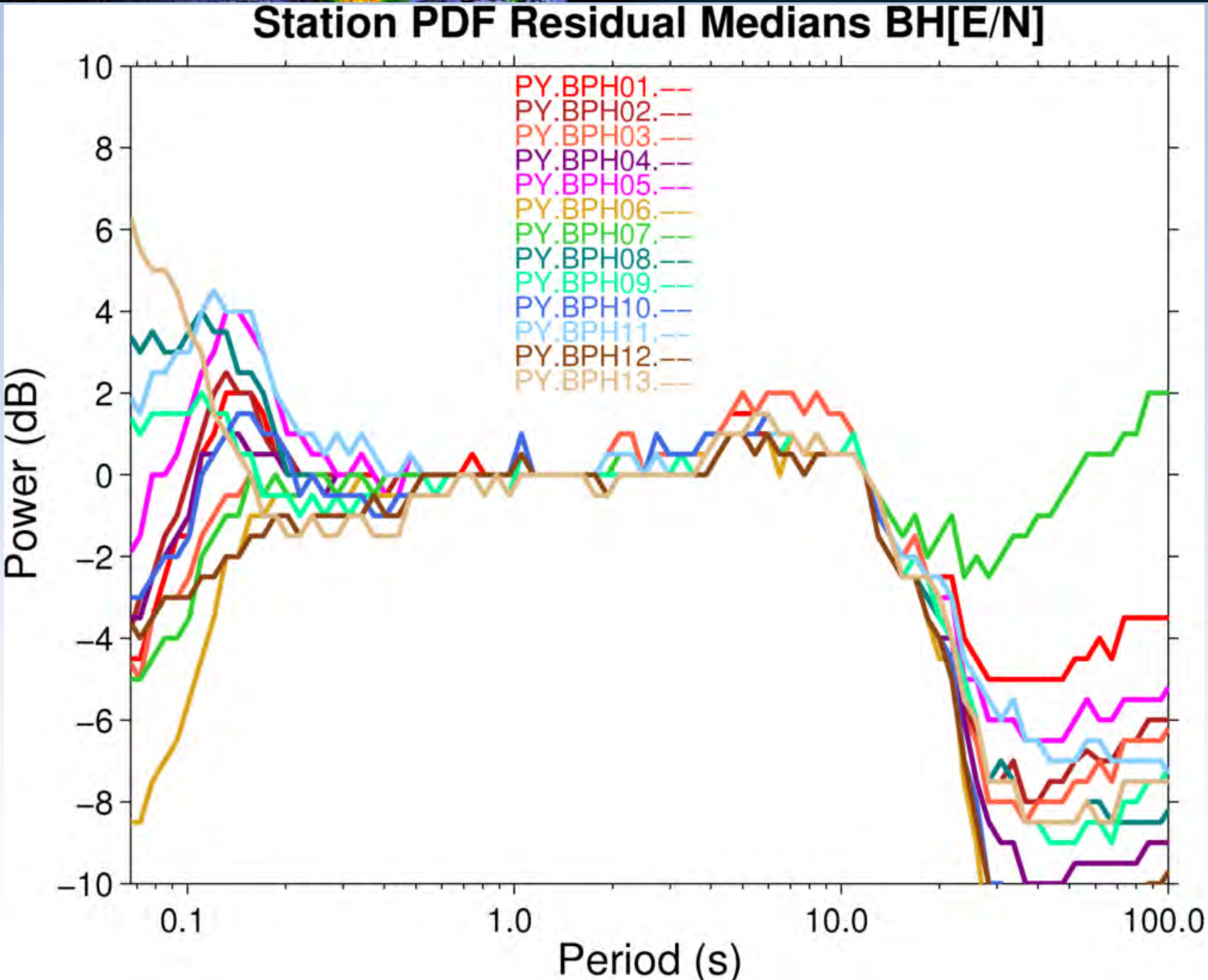
A dramatic seasonal improvement of noise performance at freeze up, of interest to sea-ice modelers.

PFO PY Posthole Test

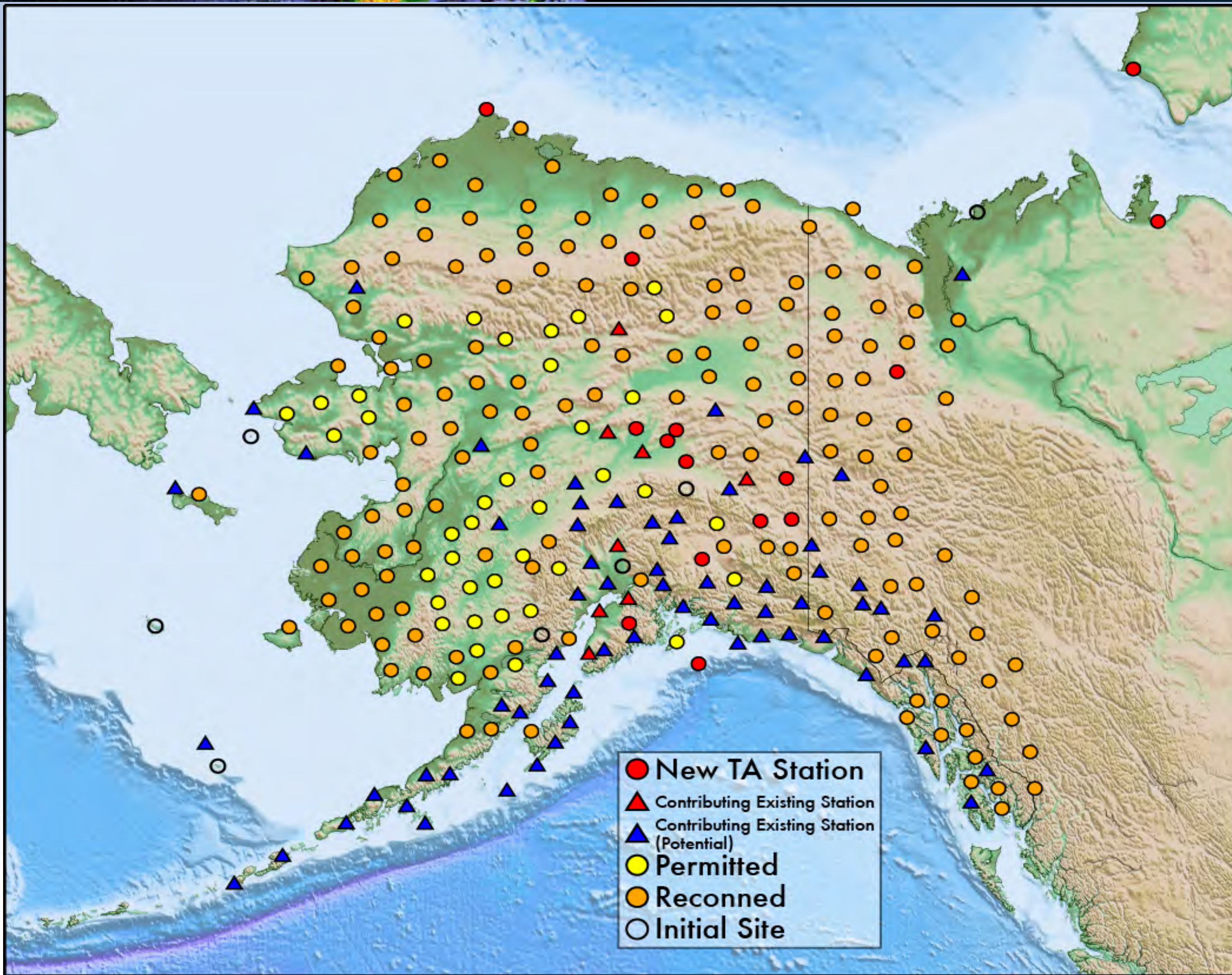
PY-TPFO Comparison



PY-TPFO Comparison

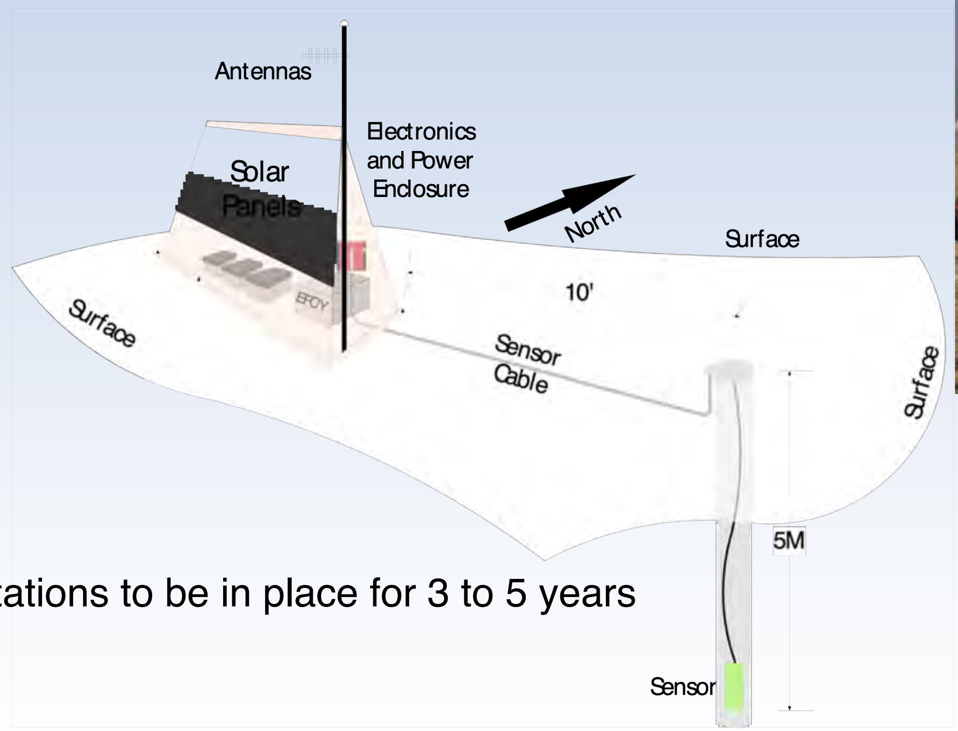


Status of TA Sites October 2014



Basic Description of Buried Sensor Design for AK

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



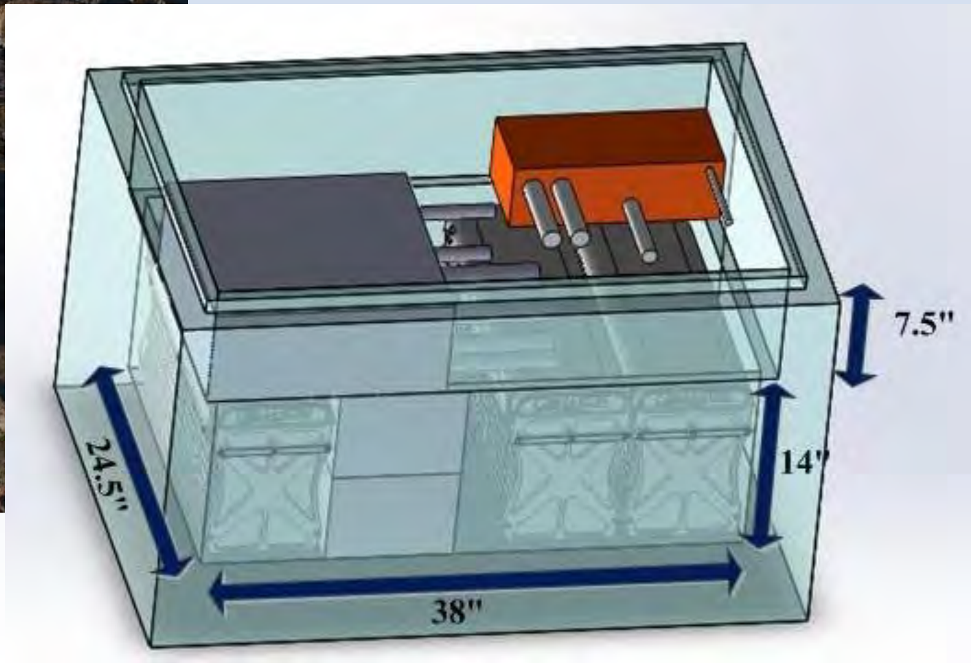
Stations to be in place for 3 to 5 years

N25K Seismic Station

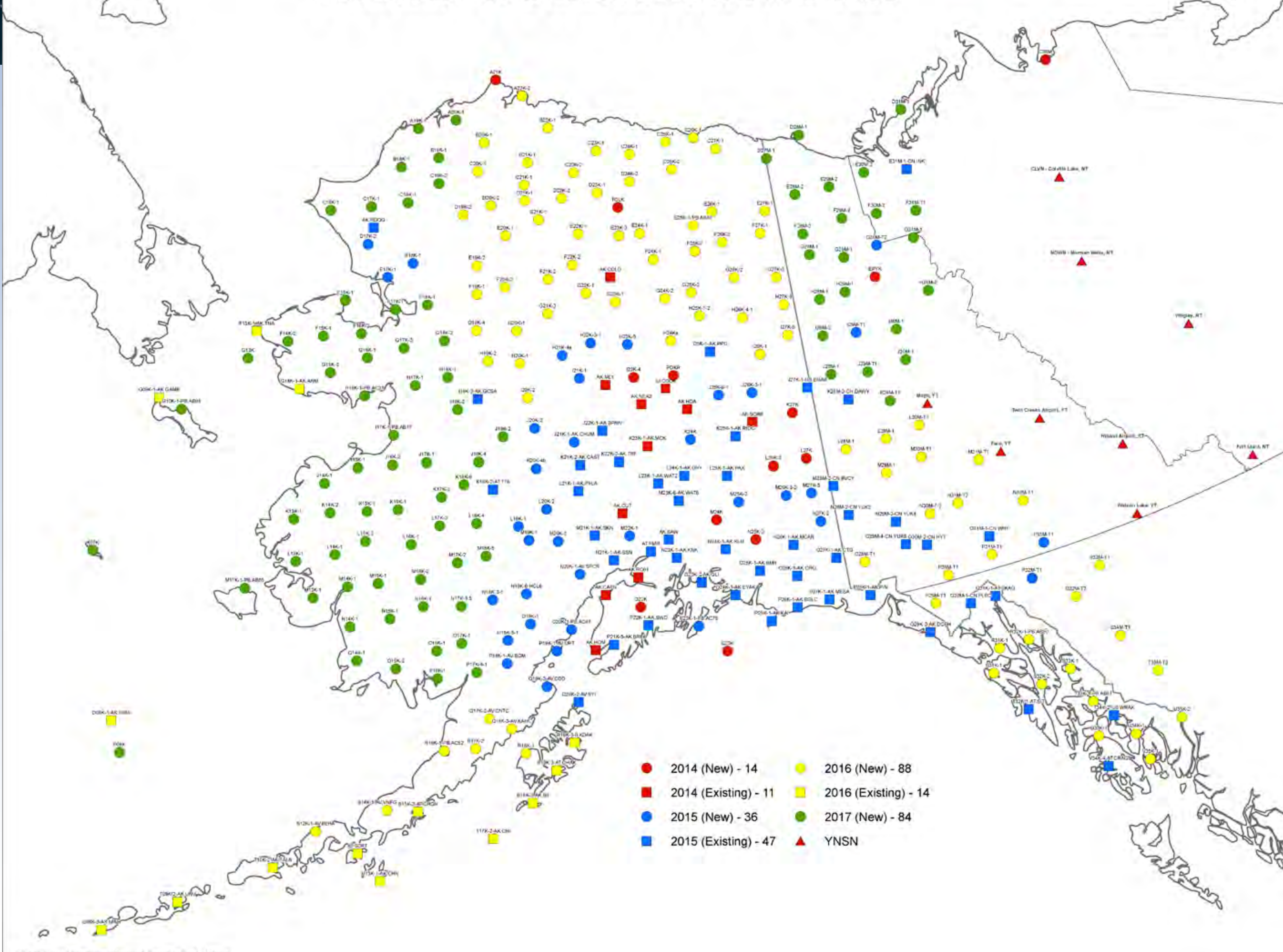
Alternative Enclosure

Contents:
(4) 100AH AGM Lead-Acid
(6) 180AH LiFePO4
Datalogger
Charge controller
local data storage
Comms terminal

410kg
30 x 44 x 28 inches



Alaska TA Installation Plan



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

Communications

Objective:

Deliver 40 Mbytes/day, with latencies under 4-6 hours. Need not be a continuous connection, but that is preferred when power and cost allow it. Must be under 2 Watts average daily power.

12 Gb/day compared with about 23 Gb/day today.

Can send data as file transfers or streaming packets or a combination to obtain highest compression.

Options:

Freewave and Cell where available, village wifi

HughesNet VSAT

InMarSat M2M BGAN Hughes 9502 terminal

Iridium DoD RUDICs XEOS XI-100B

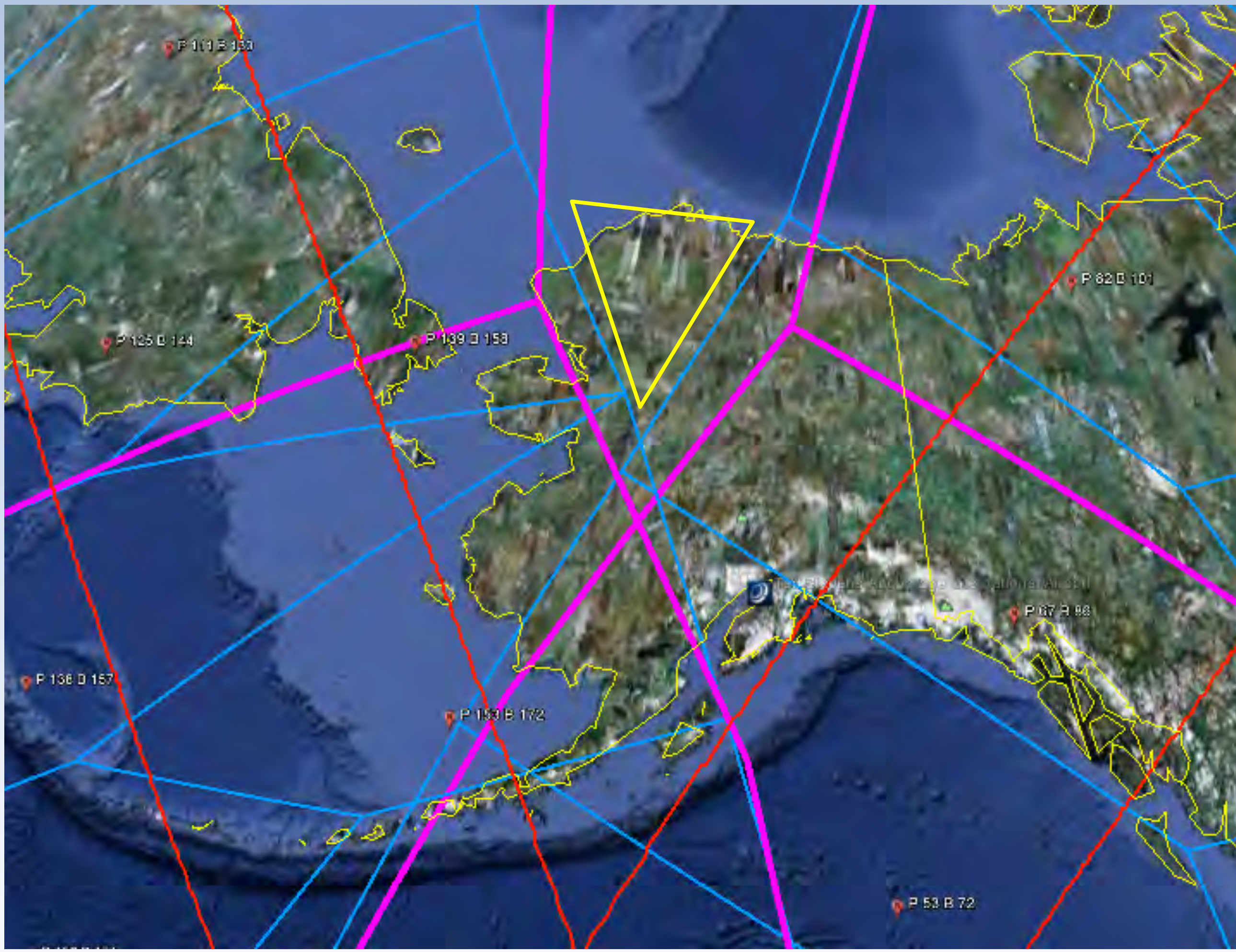
OmniSpace

~ $1780K annually

Hughes 9502 Inmarsat BGAN M2M Terminal

11-15W full transmit at 400kbps
1W standby, SMS wakeup
0.1W sleep
$1000

BGAN I4 EIRP Elevation



12 x 12 x 2 inch flat plate
20 degree requirement

Tested reception at all Reconned sites in north.

Limitation is cost- $1k/mo
350kbps bandwidth
2Gbyte/mo throughput

RED Lines = 10 Degree elevation = minimum recommended for BGAN
PINK Lines = Regional Beams of APAC and AMER satellites = Should Work
BLUE Lines = Narrow Beams = Hard to reach
This map depicts Inmarsat's expectations of coverage, but does not represent a guarantee of service. The availability of service at the edge of coverage areas fluctuates depending on various conditions.

HughesNet VSAT

- Works at high latitudes (north of Toolik)
- High power – 30 W
- Bandwidth can support two stations, usually one.
- Low Cost - $90/mo

- Reliability in winter,

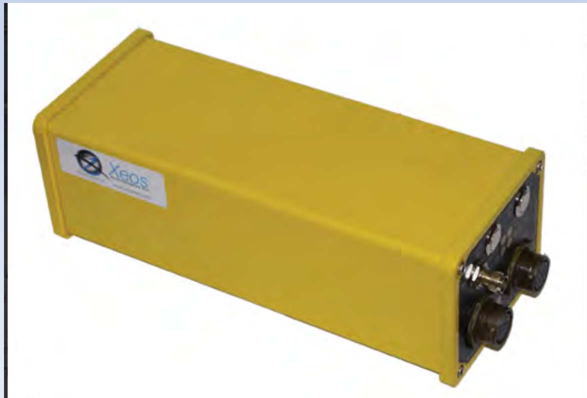
and to maintain pointing.

TA.K27K, Chicken PBO VSAT & Hut

Iridium Rudics

- XI-100B modem, 5 Watts
- Max rate 2400 bps, 24Mbyte/day
- Lots of link cycles
- Cost $290/mo

- Omnidirectional antenna
- Rudics tunnel protocol



XI-100

XI-100

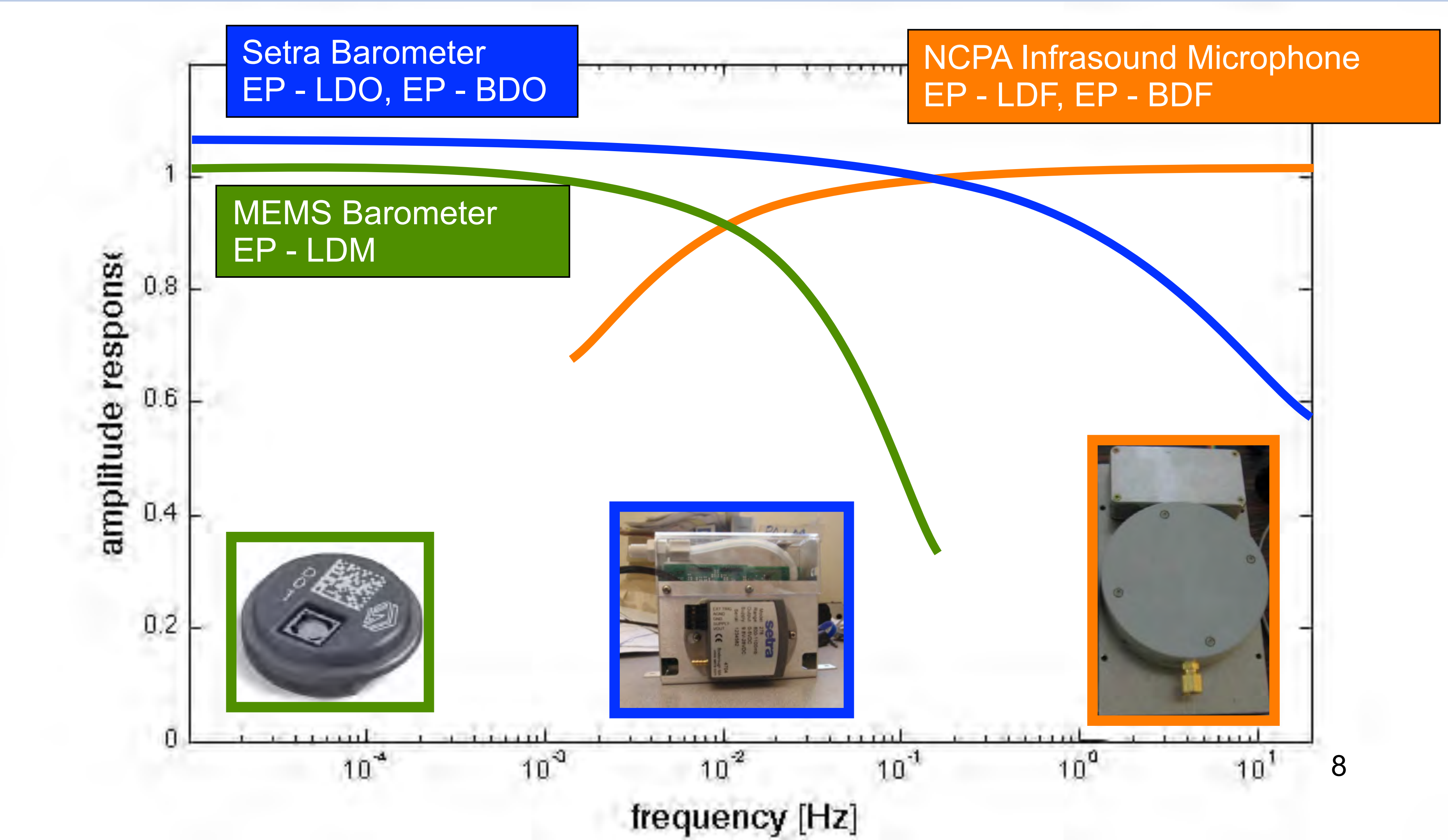
OmniSpace

- Custom Terminal -- S band
- Boeing GEO satellite in MEO
- Max rate of 128kbps
- (3) 30 min links per day
- Single downlink Brewster WA
- Cost $400/mo for 1.2Gbyte

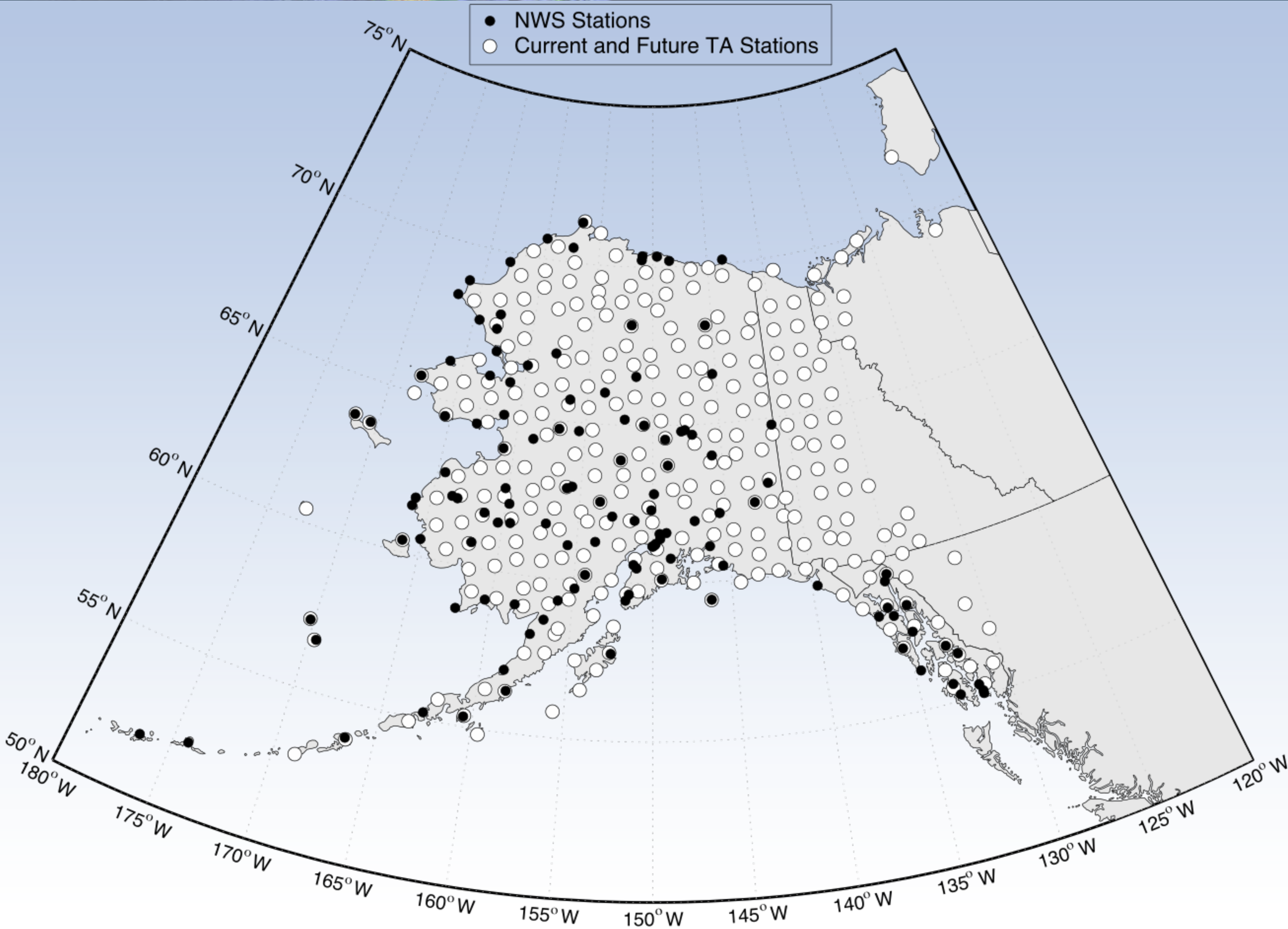
- Omnidirectional antenna
- VPN tunnel

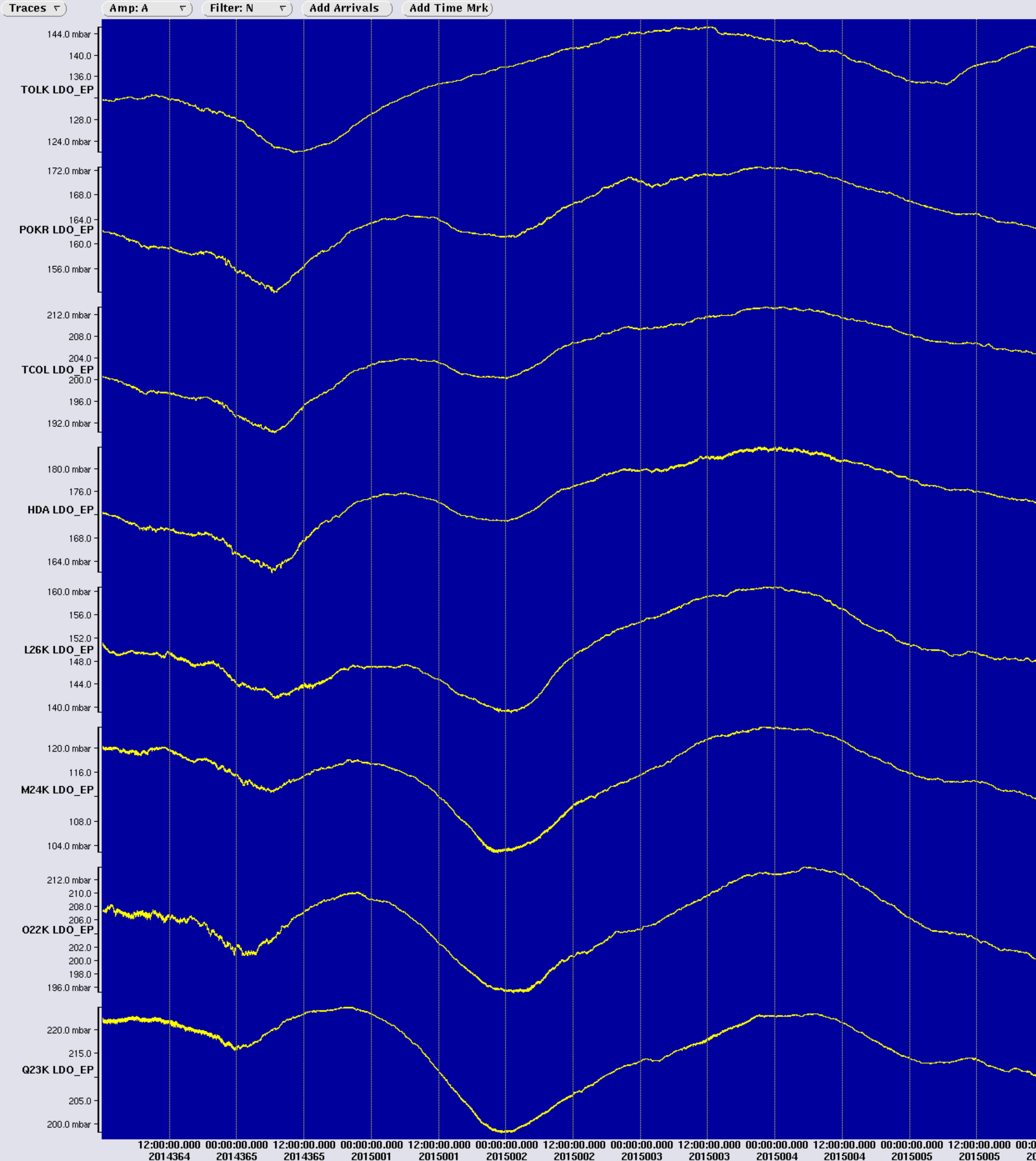
Pressure Sensor Response

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



TA and NWS coverage





AK Met data

- **One week of data (12/30/2014 to 1/05/2015)**
- **Setra 278 Barometer**
- **1 sps**

Summary

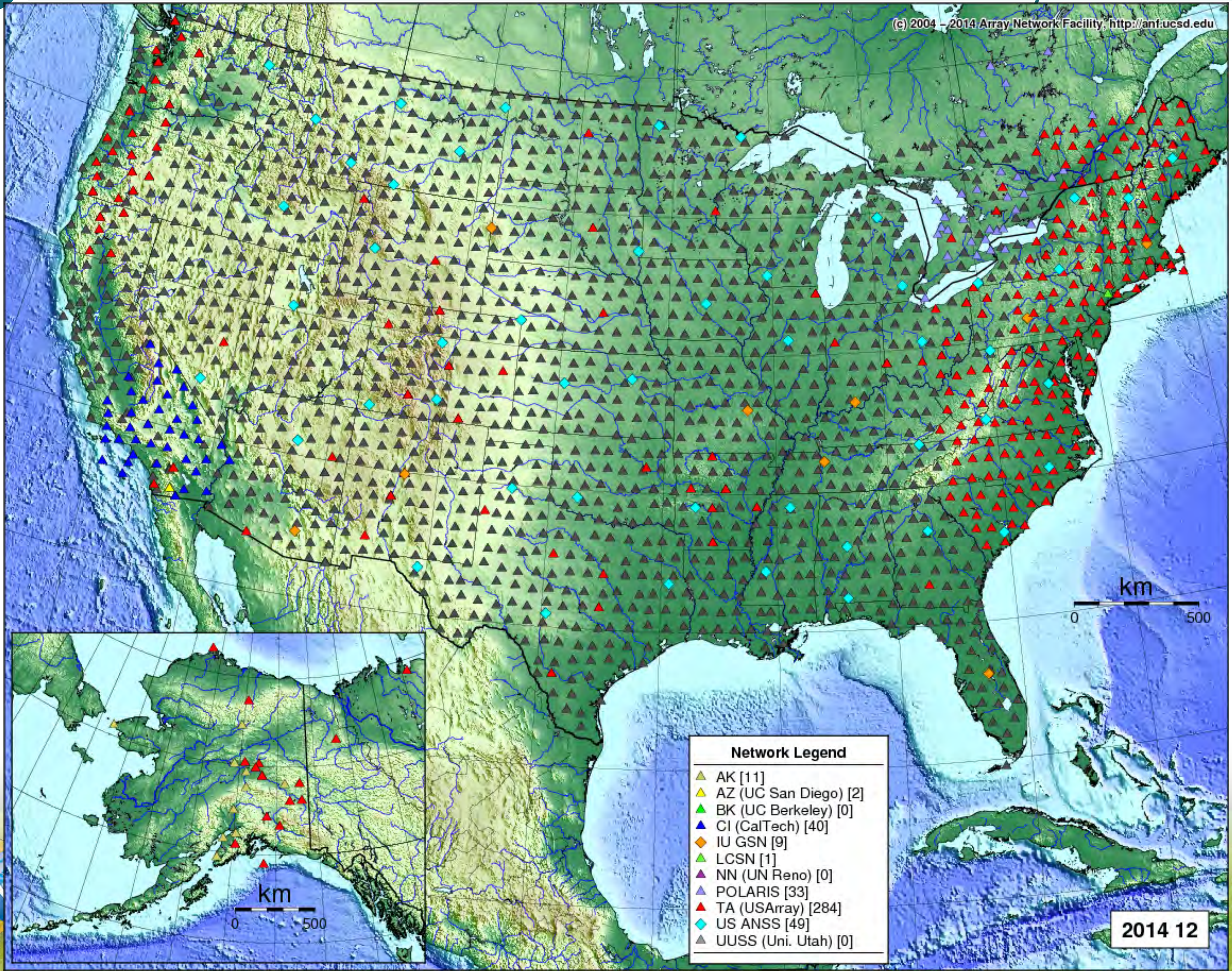
- High Quality Data
  - High data return > 99.5%
  - Sensor orientation ~ 2° for 1 sigma
  - Sensor calibration ~ 2% for 1 sigma
  - Accurate timing across all sensors ~ 1 microsecond
  - Low noise
  - Continuous time series. majority of stations > 9 months
  - High density spatial observations spatially 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
  - ……

CENTRAL & EASTERN
U.S. NETWORK

USArray Transportable Array Evolving into the Central and Eastern United States Network (CEUSN)

CENTRAL & EASTERN U.S. NETWORK

USArray TA



TA Legacy of Permanent Stations

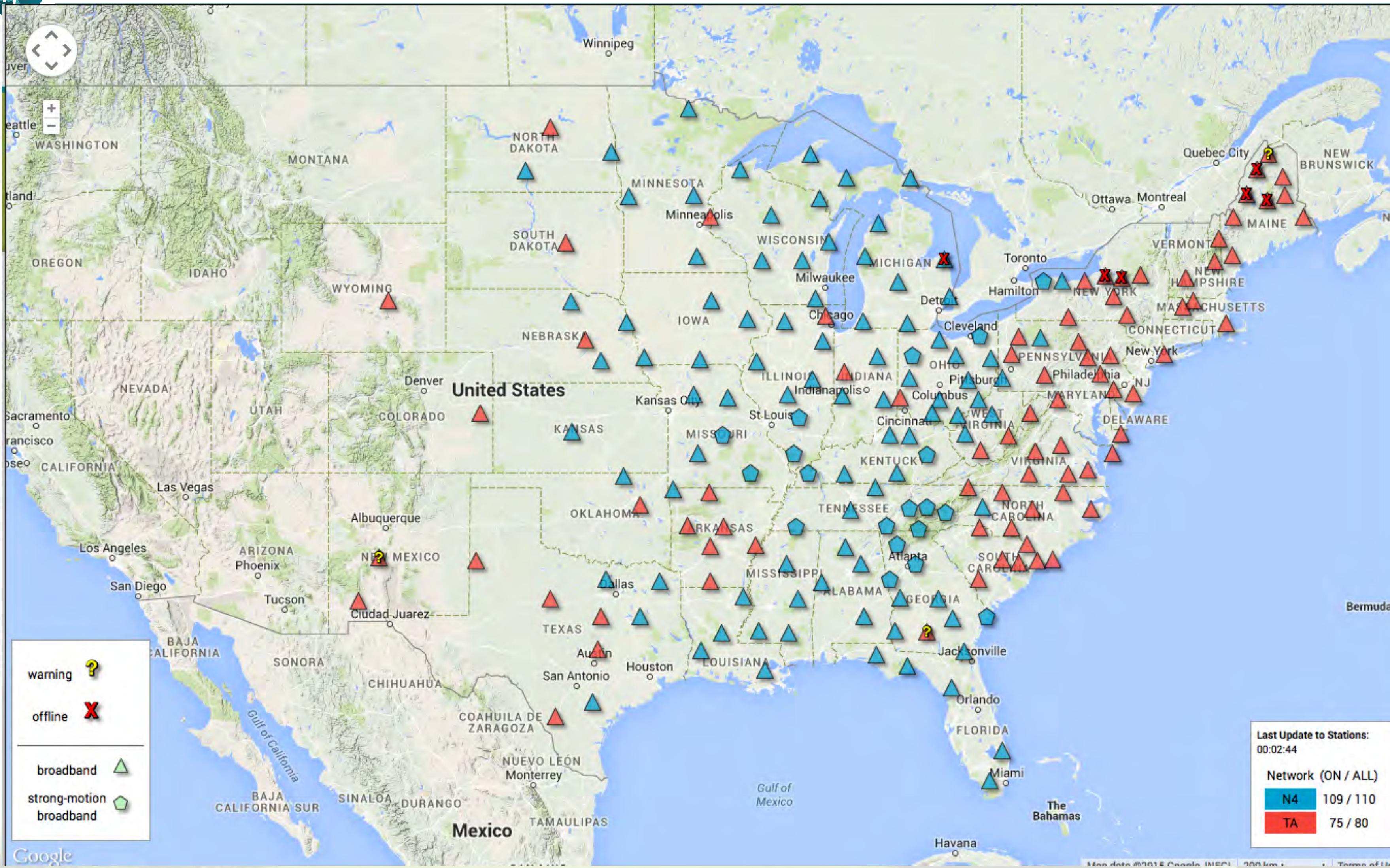
Brief History

- TA Site Selection Working Group set about selecting and prioritizing target stations
  - Chaired by Harley Benz, USGS
  - Included representation of USGS, US NRC, DOE, regional network operators, state geologists, academic seismologists
- TASSWG report prioritized 200 stations
  - Proximity to seismic hazard (and where additional coverage was required)
  - Proximity to critical infrastructure (e.g., nuclear power plants)
  - General areal coverage
- Target station configuration
  - Broadband continuous telemetry at 100, 40, 1 sps
  - Triggered recording at 200 sps
  - Some sites with 3 comp strong motion at 100 sps continuous telemetry
  - Sites retain atmospheric sensors

Current Status

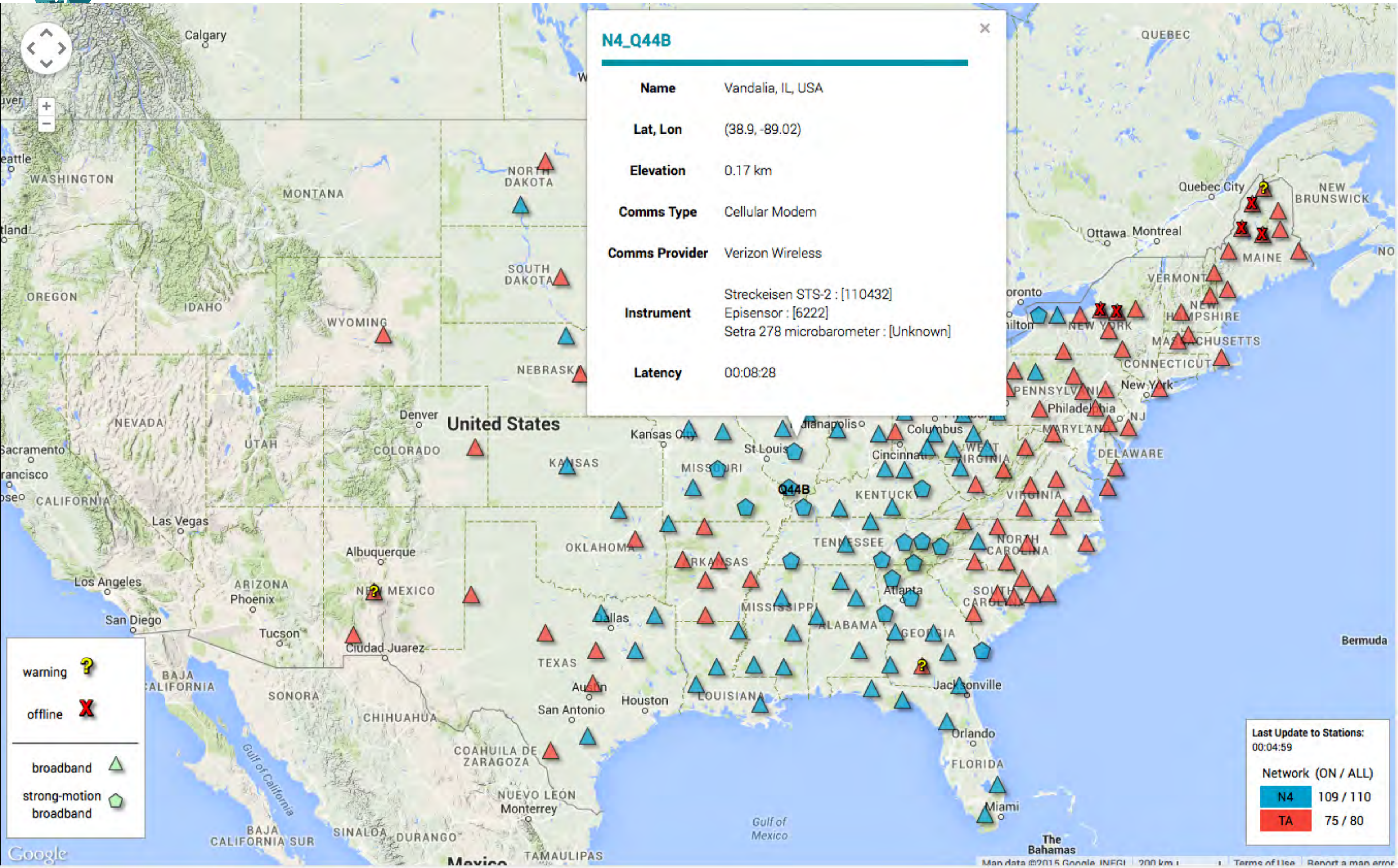
- All CEUSN stations are in the ground
  - Some in CEUSN configuration; Network code N4
  - Some still as part of TA
- Westernmost stations that had been removed are being re-constructed and re-installed
- Stations west of footprint that were not removed are being reconfigured
- All other CEUSN stations operating as part of active TA footprint. These will be reconfigured at the point they would otherwise be removed
- USGS intent to work towards obtaining budget increase necessary to operate and maintain the CEUSN

Current N4-TA



NSF
the IRIS CONSORTIUM
earthscope
USGS science for a changing world

CENTRAL & EASTERN U.S. NETWORK



IRIS CONSORTIUM
earthscope
USGS science for a changing world

CENTRAL & EASTERN U.S. NETWORK State of Health

CENTRAL & EASTERN U.S. NETWORK

about contact

HOME DEPLOYMENT STATUS EARTHQUAKES DATA

Real-time Station Status

Original View | Masses View

Sort on station names THEN bring up any problems on: RunTime, Latency, Clock Quality, Buffer Full, 24h Link Cycles

Last update to information on table: 00:01:09

Station	Reserve battery	24h R Bytes	24h W Bytes	Comms Effic	Clock Drift	GPS Latency	Current	Latency	I/O Rate	Temp	Voltage	24h gaps	GPS quality	GPS status	Clock Quality	24h IP Cycles	24h Link Cycles	24hPOC	24h Reboots	Buffer Full	RunTime	Thruput
N4_T47A	1	72.3 Mb	1.1 Mb	-	0	00:00:00	7.4 mA	00:04:56	0.0 Kb/s	17 C	12.8 V	00:00:00	elck 3d ilck	-	100%	0	12	0	0	0%	-00:04:09	0.0
N4_I40B	1	68.1 Mb	1.1 Mb	100%	0	00:00:00	7.6 mA	00:00:03	6.7 Kb/s	11 C	13.1 V	00:00:00	elck 3d	-	99%	0	1	0	0	0%	22:45:18	1.0
N4_352A	1	96.1 Mb	1.4 Mb	100%	0	00:00:00	6.1 mA	00:00:03	7.3 Kb/s	26 C	12.0 V	00:00:00	elck 3d ilck	-	100%	0	36	18	0	0%	15:58:06	1.0
N4_D41A	1	71.0 Mb	1.1 Mb	100%	1	00:00:00	11.8 mA	00:00:03	6.5 Kb/s	6 C	12.6 V	00:00:00	elck 3d	-	100%	0	7	0	0	0%	00:58:15	1.0
N4_L40A	1	80.9 Mb	1.2 Mb	100%	0	00:00:00	5.7 mA	00:00:03	7.2 Kb/s	14 C	12.8 V	00:00:00	elck 3d	-	100%	0	42	12	0	0%	05:46:16	1.0
N4_N38B	1	79.6 Mb	1.3 Mb	100%	-2	00:00:00	6.0 mA	00:00:03	7.4 Kb/s	14 C	12.8 V	00:00:00	elck 3d	-	100%	0	147	26	0	0%	13:49:48	1.0
N4_S51A	1	86.9 Mb	1.2 Mb	-	-2	00:00:00	7.8 mA	00:02:44	1.5 Kb/s	19 C	12.9 V	00:00:00	elck 3d	-	100%	0	19	1	0	0%	00:01:12	0.0
N4_T35B	1	75.2 Mb	1.1 Mb	100%	0	00:00:00	6.0 mA	00:00:03	7.1 Kb/s	19 C	13.8 V	00:00:00	elck 3d	-	100%	0	8	2	0	0%	05:36:17	1.0
N4_V51A	1	87.5 Mb	1.2 Mb	100%	1	00:00:00	6.4 mA	00:00:05	8.1 Kb/s	19 C	13.3 V	00:00:00	elck 3d	-	100%	0	26	151	0	0%	00:33:36	1.0
N4_Z35B	1	80.2 Mb	1.2 Mb	100%	0	00:00:00	5.6 mA	00:00:03	6.9 Kb/s	23 C	13.3 V	00:00:00	elck 3d	-	100%	0	12	7	0	0%	03:03:05	1.0
N4_Z51A	1	76.8 Mb	1.3 Mb	99%	0	00:00:00	5.4 mA	00:00:10	7.4 Kb/s	20 C	13.8 V	00:00:00	elck 3d	-	100%	0	89	5	0	0%	08:23:21	1.0
N4_060A	1	83.2 Mb	1.2 Mb	100%	0	00:00:00	5.3 mA	00:00:03	7.9 Kb/s	31 C	13.3 V	00:00:00	elck 3d	-	100%	0	1	2	0	0%	19:25:10	1.0
N4_061Z	1	73.5 Mb	1.1 Mb	100%	0	00:00:00	5.4 mA	00:00:03	7.1 Kb/s	34 C	13.3 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	19:20:28	1.0
N4_143B	1	72.2 Mb	1.1 Mb	100%	0	00:00:00	5.3 mA	00:00:03	6.7 Kb/s	21 C	13.5 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	21:38:03	1.0
N4_146B	1	75.8 Mb	1.1 Mb	99%	0	00:00:00	5.6 mA	00:00:03	7.0 Kb/s	23 C	12.8 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	06:05:34	1.0
N4_152A	1	77.3 Mb	1.1 Mb	100%	0	00:00:00	5.2 mA	00:00:03	7.2 Kb/s	21 C	13.5 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	03:10:50	1.0
N4_154A	1	74.3 Mb	1.1 Mb	100%	0	00:00:00	5.7 mA	00:00:03	6.9 Kb/s	24 C	12.6 V	00:00:00	elck 3d	-	100%	0	2	0	0	0%	00:27:02	1.0
N4_237B	1	76.3 Mb	1.1 Mb	100%	0	00:00:00	7.1 mA	00:00:03	6.8 Kb/s	23 C	13.5 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	15:34:25	1.0
N4_250A	1	75.8 Mb	1.2 Mb	99%	0	00:00:00	5.6 mA	00:00:03	7.1 Kb/s	23 C	13.9 V	00:00:00	elck 3d	-	100%	0	3	0	0	0%	05:58:45	1.0
N4_255A	1	69.1 Mb	1.1 Mb	100%	0	00:00:00	5.9 mA	00:00:03	6.4 Kb/s	23 C	12.4 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	18:42:57	1.0
N4_257A	1	109.3 Mb	1.6 Mb	100%	0	00:00:00	6.8 mA	00:00:03	10.2 Kb/s	27 C	13.2 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	08:58:11	1.0
N4_342B	1	76.1 Mb	1.1 Mb	100%	0	00:00:00	5.2 mA	00:00:03	7.3 Kb/s	24 C	13.3 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	13:55:37	1.0
N4_344B	1	73.8 Mb	1.1 Mb	100%	0	00:00:00	5.5 mA	00:00:03	7.0 Kb/s	22 C	13.3 V	00:00:00	elck 3d ilck	-	100%	0	1	0	0	0%	18:13:34	1.0
N4_346B	1	72.9 Mb	1.1 Mb	100%	0	00:00:00	5.4 mA	00:00:03	6.6 Kb/s	24 C	13.7 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	06:22:38	1.0
N4_441B	1	74.9 Mb	1.2 Mb	100%	0	00:00:00	5.4 mA	00:00:03	7.1 Kb/s	26 C	13.5 V	00:00:00	elck 3d	-	100%	0	3	1	0	0%	09:33:36	1.0
N4_451A	1	85.0 Mb	1.2 Mb	100%	0	00:00:00	6.6 mA	00:00:03	7.8 Kb/s	23 C	12.4 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	02:21:44	1.0
N4_456A	1	86.0 Mb	1.2 Mb	100%	1	00:00:00	6.0 mA	00:00:03	8.2 Kb/s	26 C	12.6 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	11:04:00	1.0
N4_545B	1	103.3 Mb	1.4 Mb	100%	0	00:00:00	7.1 mA	00:00:03	10.5 Kb/s	25 C	13.3 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	18:55:28	1.0
N4_553A	1	76.2 Mb	1.2 Mb	100%	0	00:00:00	6.4 mA	00:00:03	7.3 Kb/s	25 C	11.8 V	00:00:00	elck 3d	-	100%	0	3	2	0	0%	04:57:35	1.0
N4_656A	1	81.9 Mb	1.2 Mb	100%	0	00:00:00	5.6 mA	00:00:07	8.3 Kb/s	27 C	13.3 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	12:32:00	1.0
N4_735B	1	78.2 Mb	1.1 Mb	100%	0	00:00:00	5.6 mA	00:00:03	7.0 Kb/s	30 C	13.3 V	00:00:00	elck 3d	-	100%	0	1	0	0	0%	06:40:30	1.0

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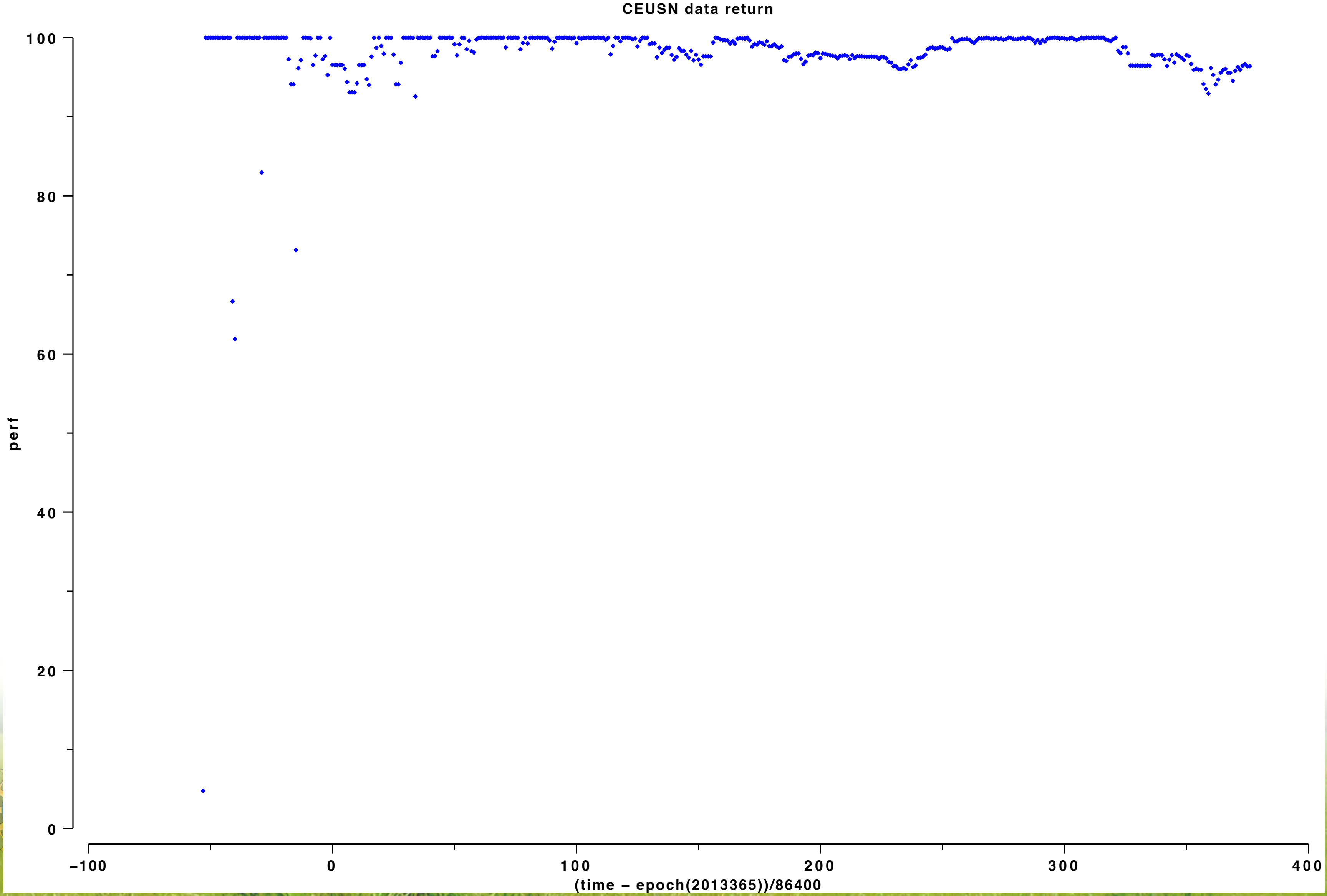
2014 N4 Data Return



Open Data

- Data policy
  - All data openly available in real time
- DMC Data Access
  - N4 network code
  - _CEUSN virtual network code
  - BUD system for streaming real time data
  - Web Services and other archive interfaces