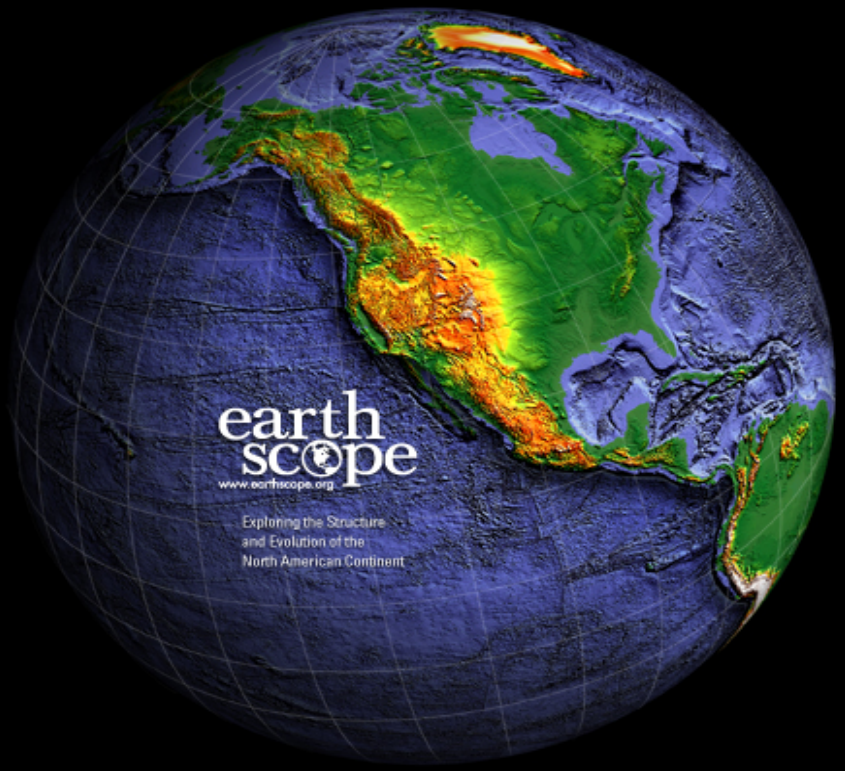
What is USArray?
…and IRIS for that matter…

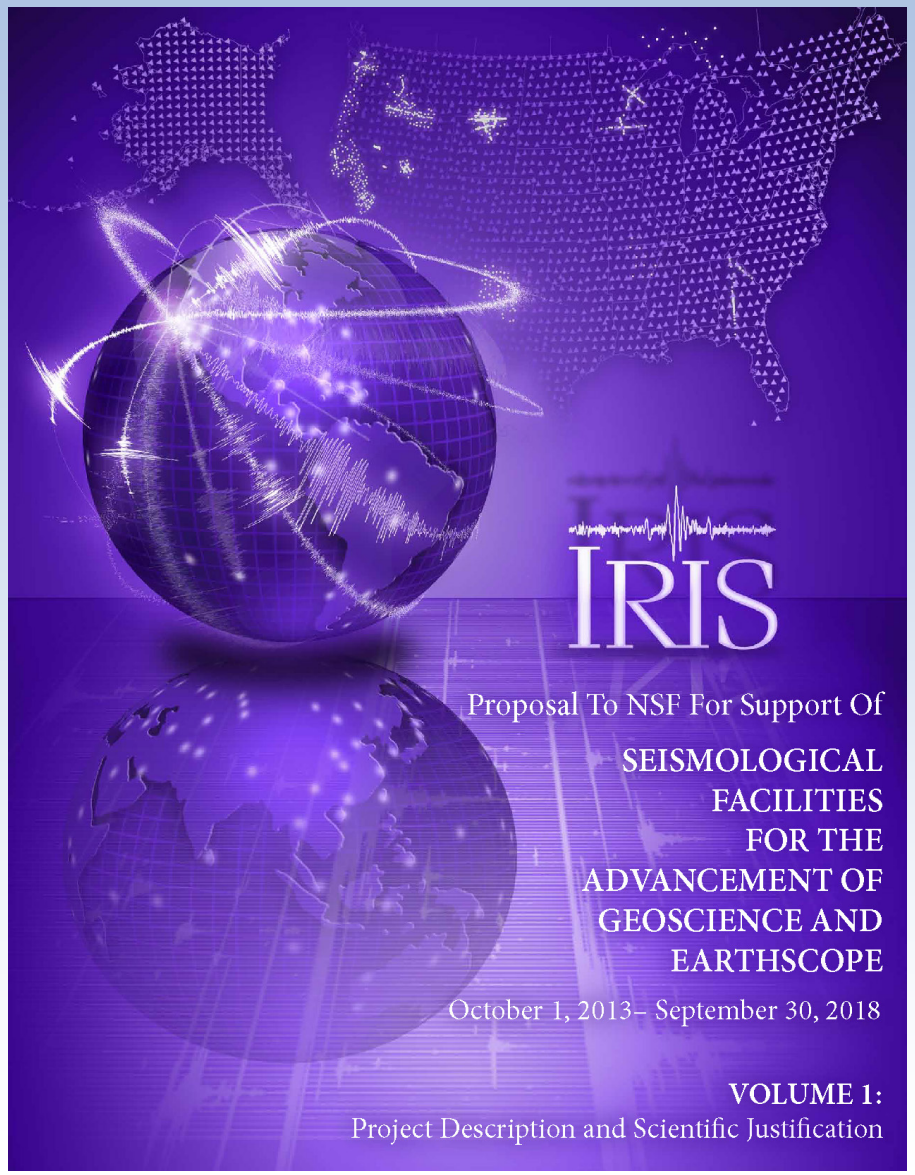


Andy Frassetto
Senior Project Associate, IRIS
Given by: Justin Sweet

USArray Data Processing
and Analysis Short Course

August 1-5, 2016
Northwestern University
Evanston, IL

Incorporated Research Institutions for Seismology



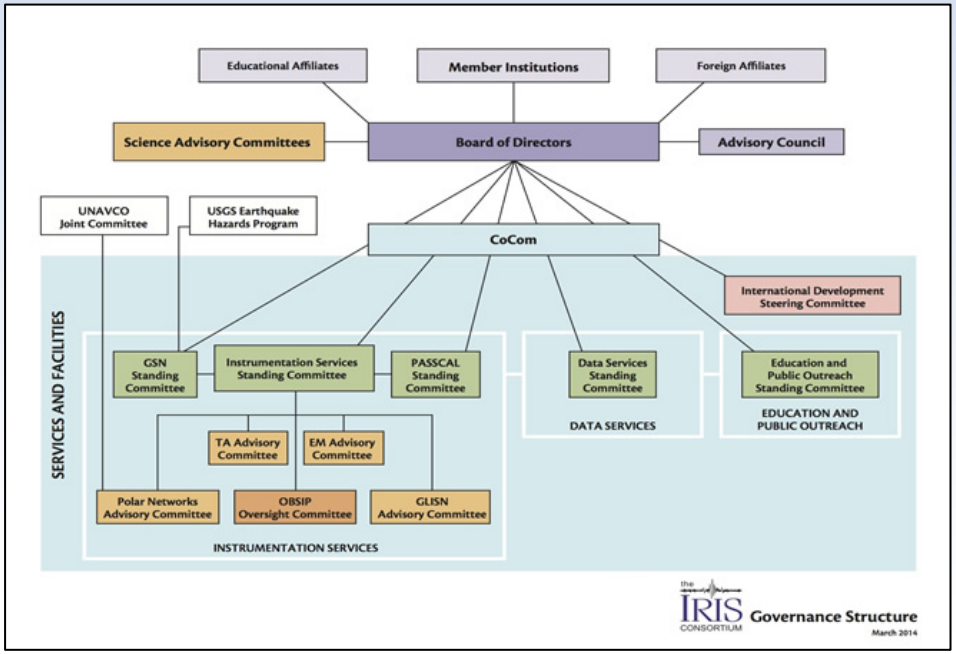
Founded in 1984, IRIS is…

a **CONSORTIUM** of 123 institutions (plus affiliates) focusing on academic research seismology, democratizing scientific progress.

a **FACILITY** that operates and manages seismological observatories, instrument depots, and data centers.

Incorporated Research Institutions for Seismology

GROWING beyond its "core" programs by managing new facilities, e.g. USArray, Ocean Bottom Seismographic Instrument Pool, Greenland Ice Sheet Monitoring Network.

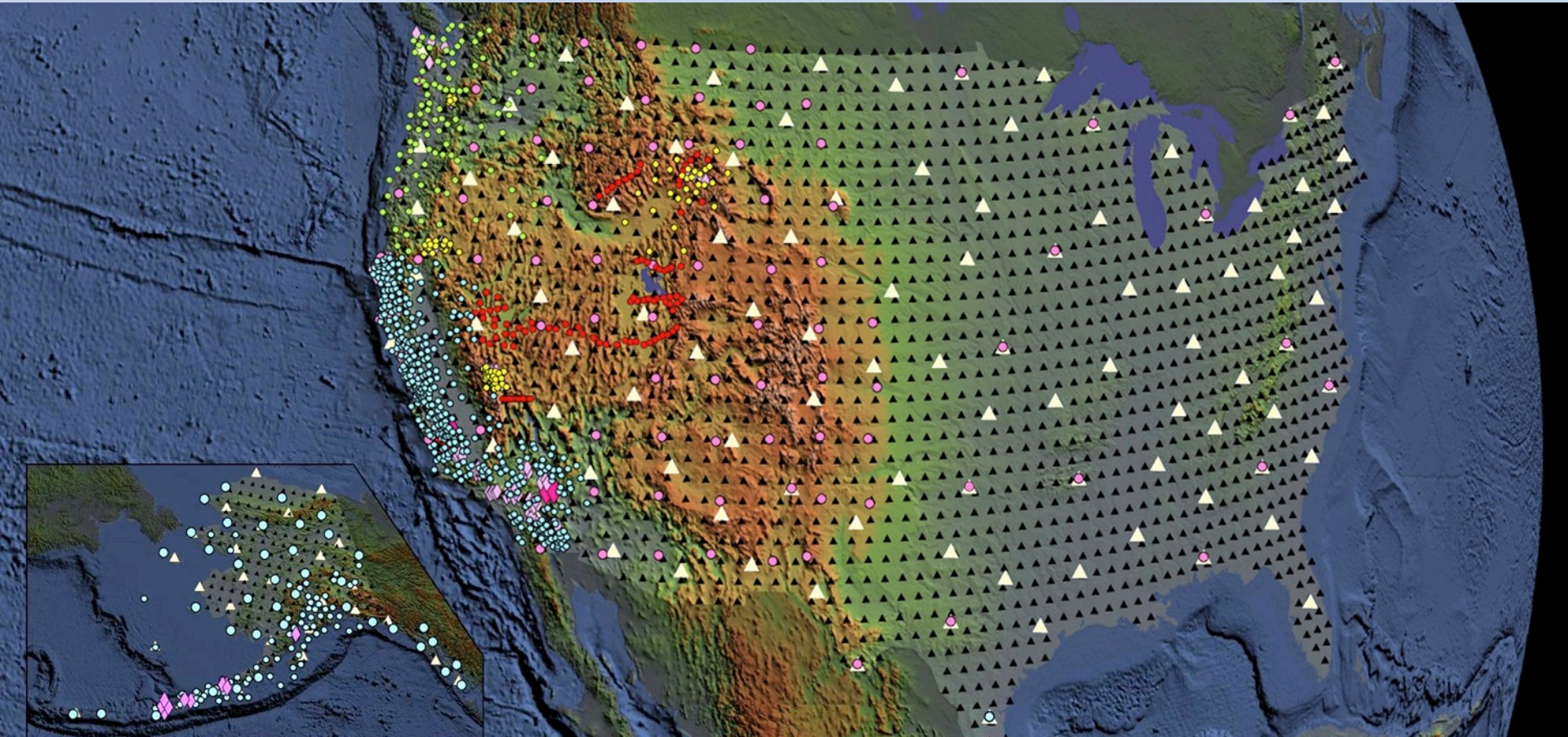


GOVERNED closely by the community it serves.

EarthScope Program

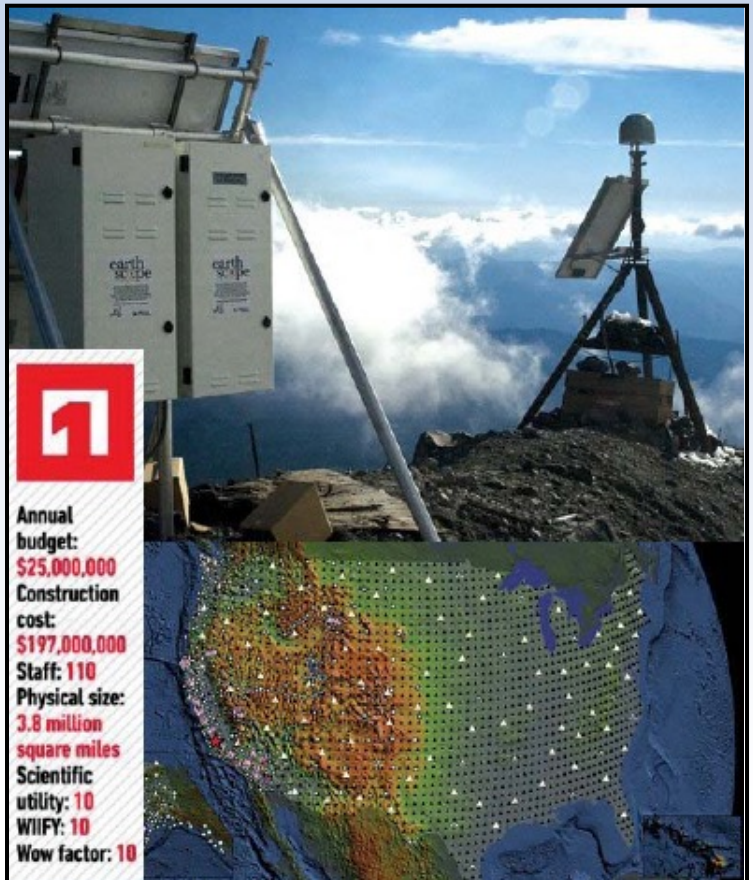
Study the three dimensional structure and evolution of the North American Continent

- 3.2 km borehole into San Andreas Fault
- 1100 permanent GPS stations
- 74 borehole strainmeters
- 6 laser strainmeters
- 78 borehole seismometers
- 100 Permanent seismic stations
- 400 transportable seismic stations occupying 2000 sites
- 20 magnetotelluric campaign systems
- 7 magnetotelluric backbone stations
- 100 campaign GPS stations
- 2146 campaign seismic stations



Popular Science Ranks EarthScope as the #1 Most Epic Science Project

#1 EarthScope

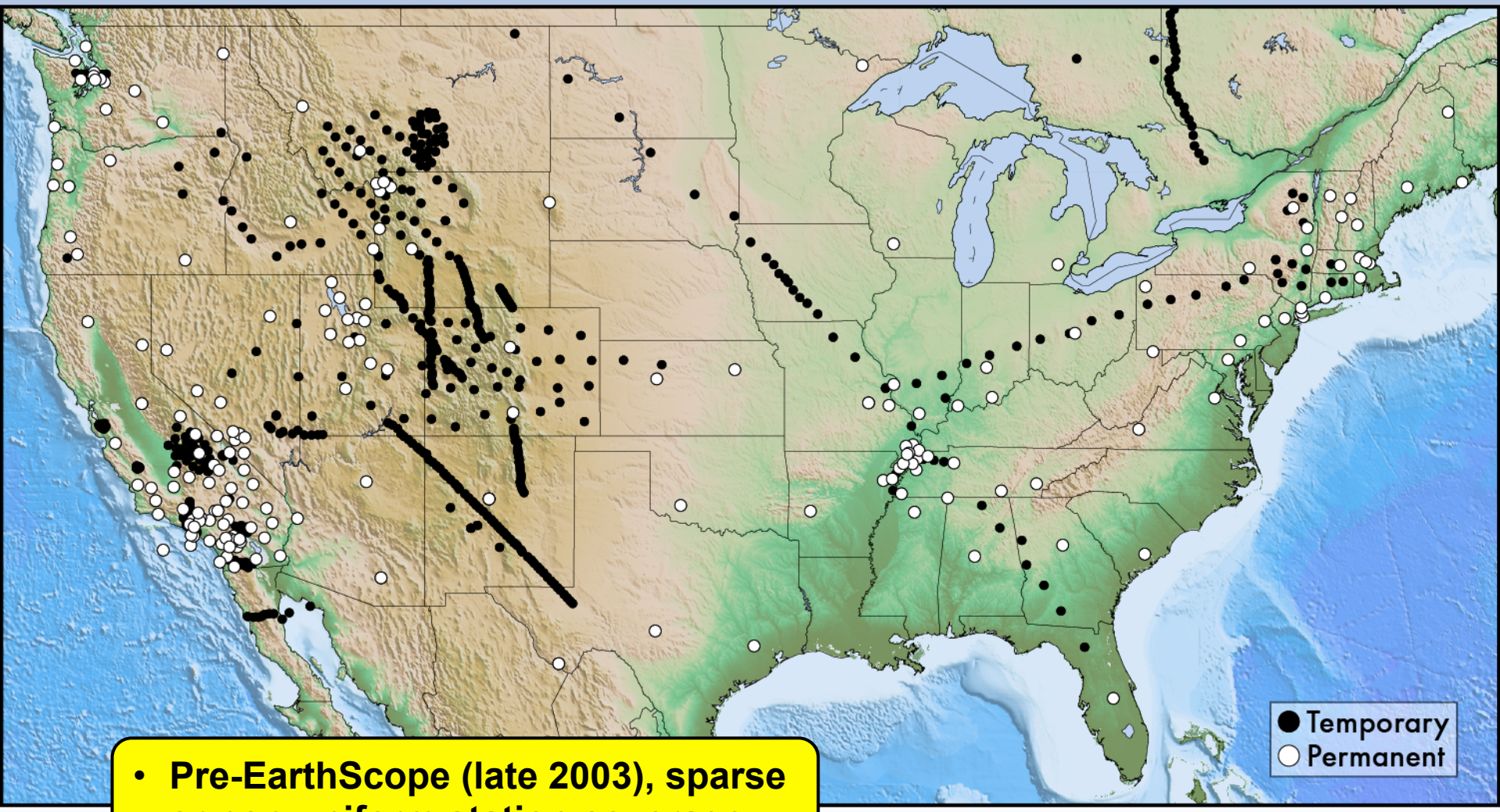


- 2 – Large Hadron Collider
- 3 – Spallation Neutron Source
- 4 – International Space Station
- 5 – Advanced Light Source
- 6 – Juno (Jupiter Orbiter)
- 7 – National Ignition Facility
- 8 – The Very Large Array
- 9 – Neptune Undersea Obs.
- 10 – Heavy Ion Collider

Some of the "metrics" used:

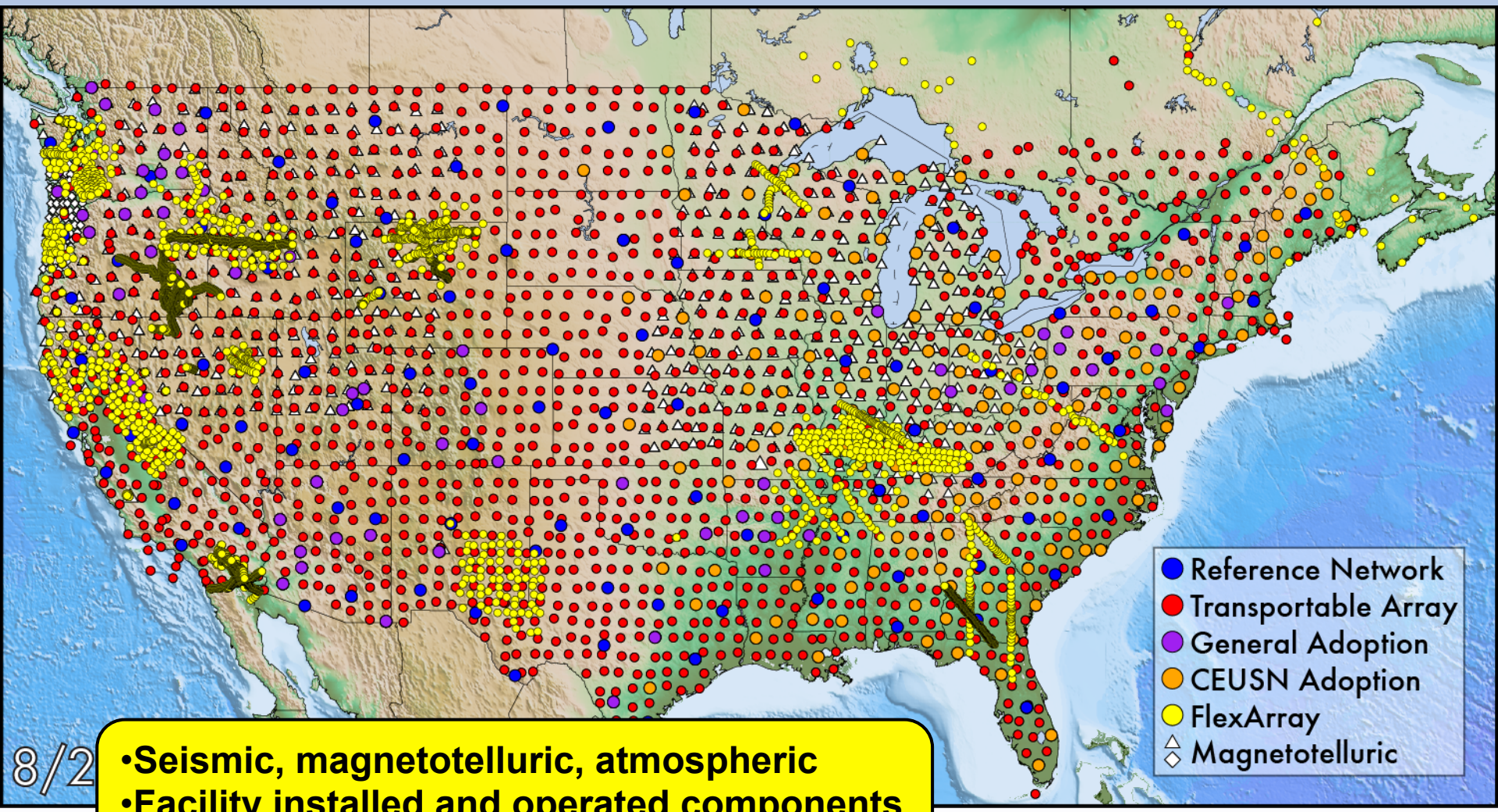
- **Scientific utility**
- **What's in it for you**
- **Wow factor**

Pre-USArray



- **Pre-EarthScope (late 2003), sparse or non-uniform station coverage**

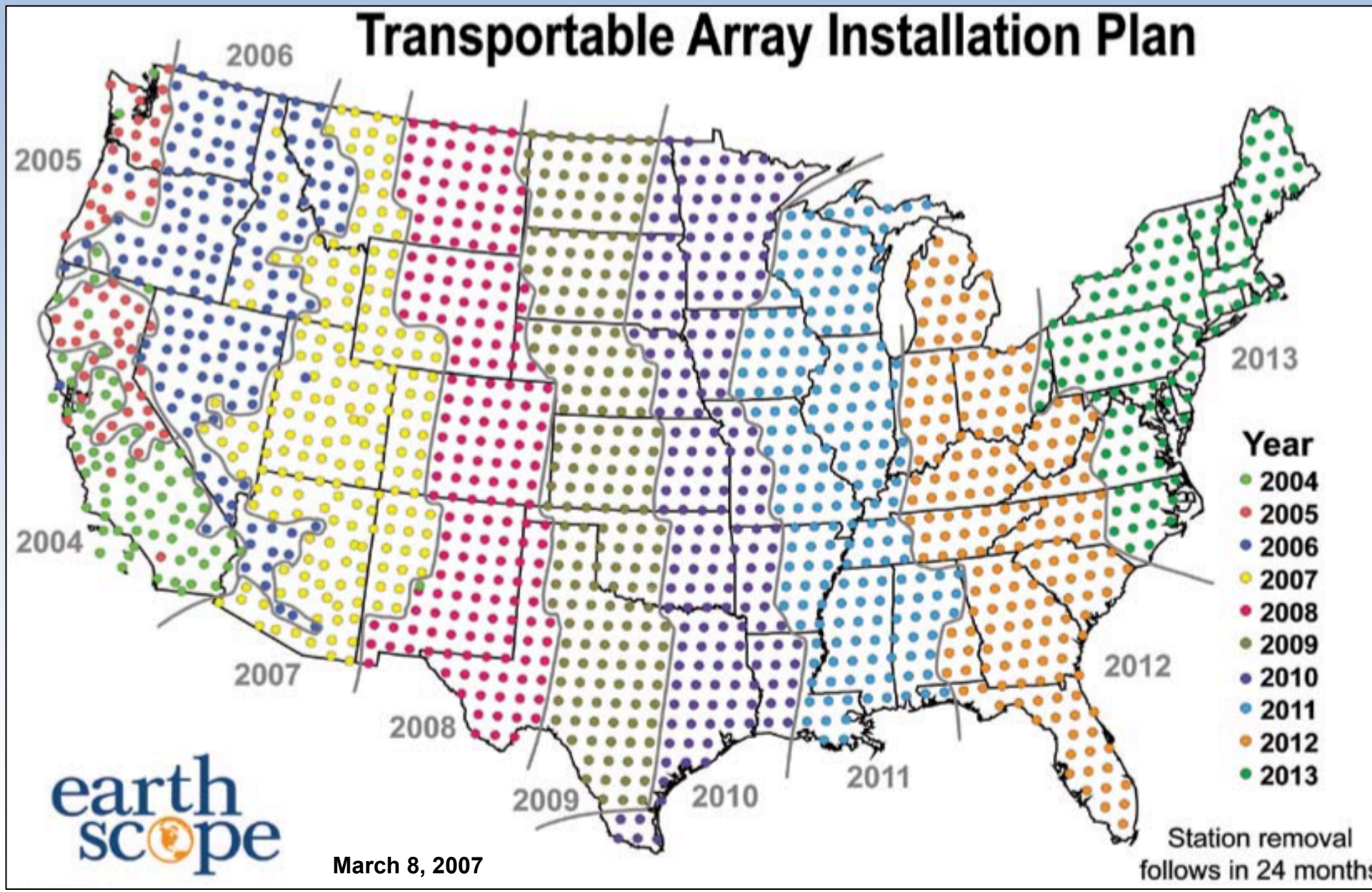
USArray through 2014



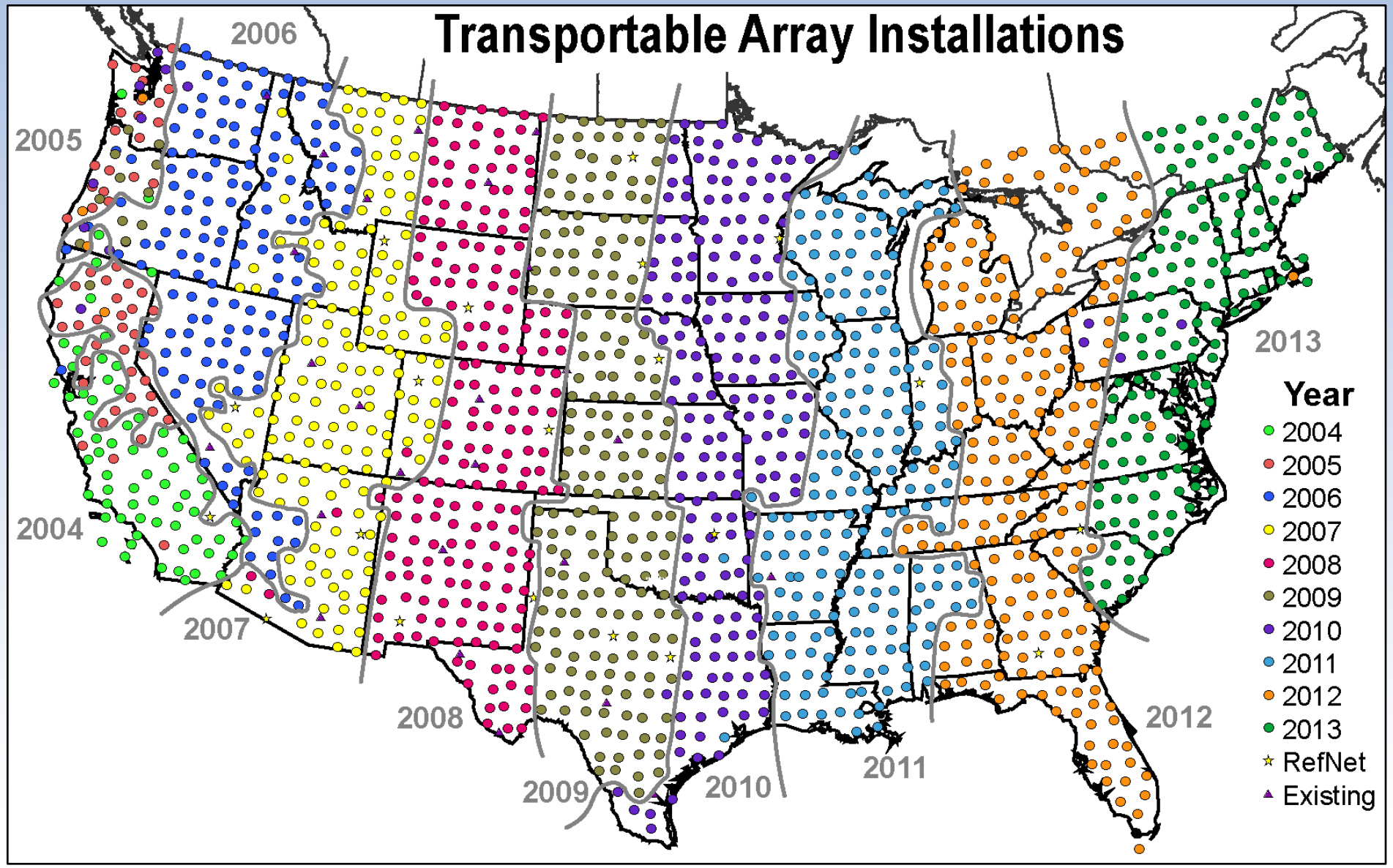
8/2

- Seismic, magnetotelluric, atmospheric
- Facility installed and operated components
- PI installed and operated components

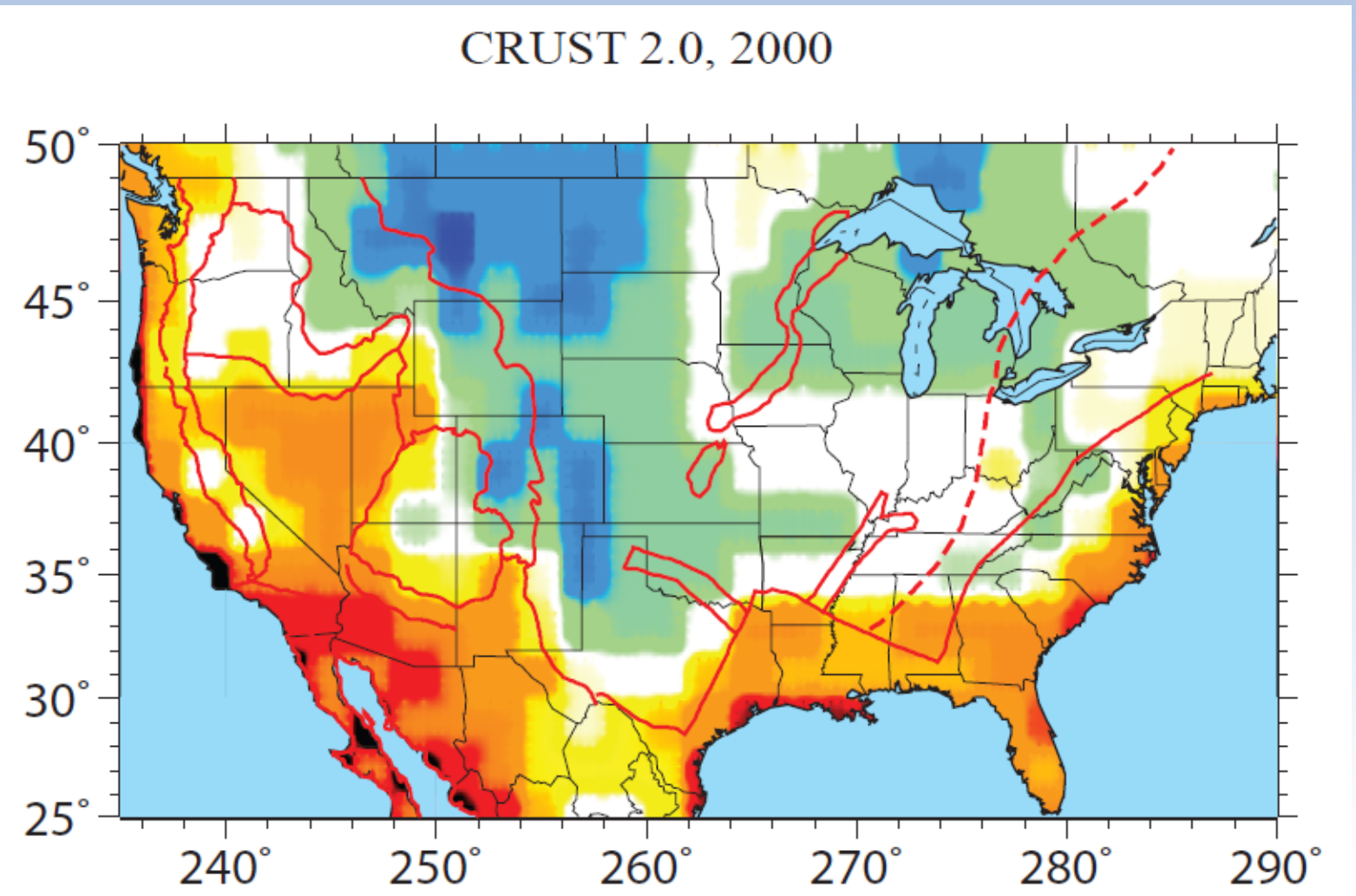
A Ten Year Plan



Ten Year "As Built"

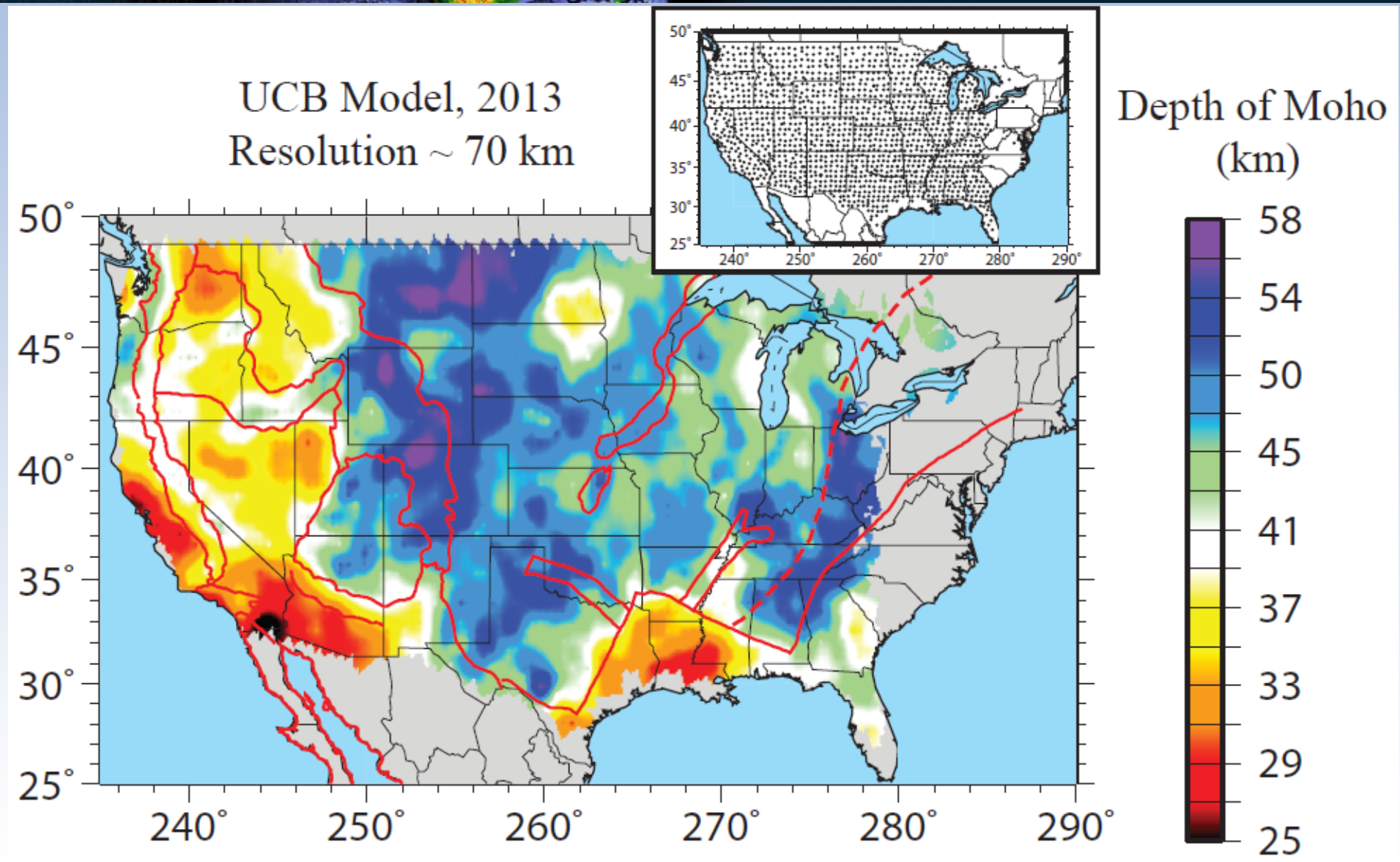


Resolution Before



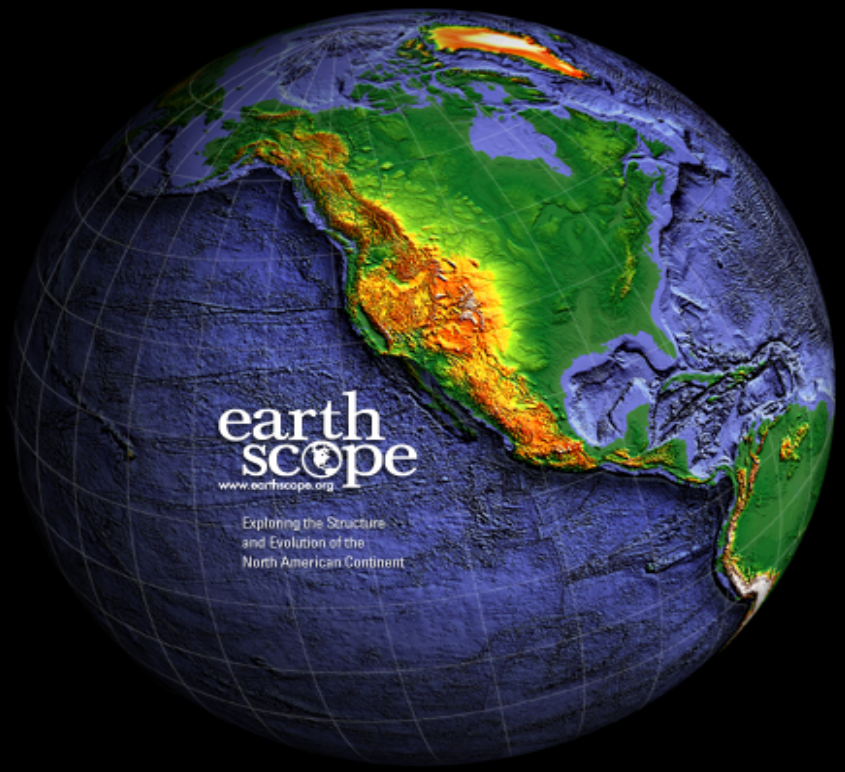
Bassin et al., 2000 AGU Fall Meeting

Resolution After

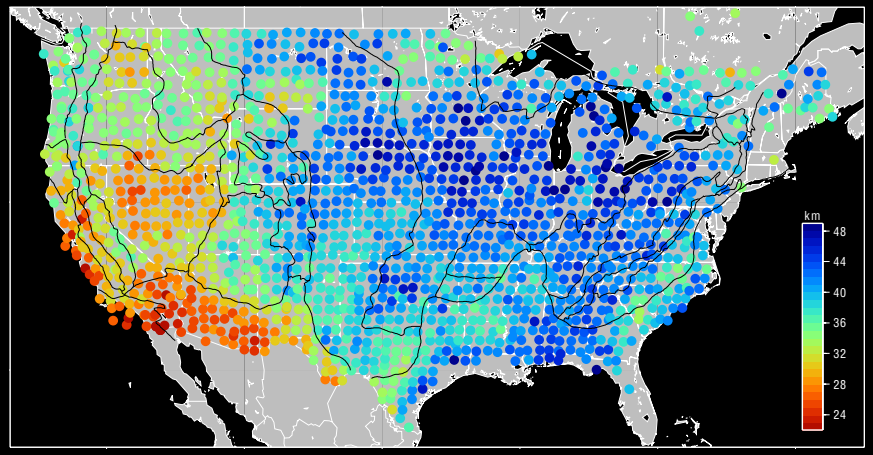


Shen and Ritzwoller, CU-Boulder, 2013 AGU Fall Meeting

Science Highlights



Crustal thickness measurements, Buehler and Shearer

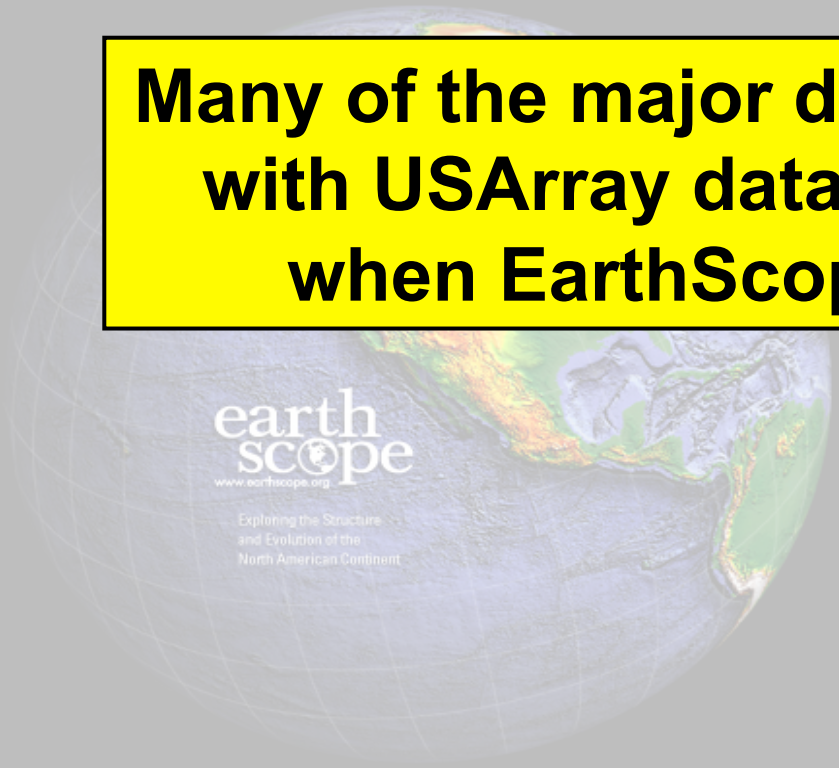


Tip of the iceberg…
at least 293 peer-reviewed USArray papers just during 2009-2013

Science Highlights

Crustal thickness measurements, Buehler and Shearer

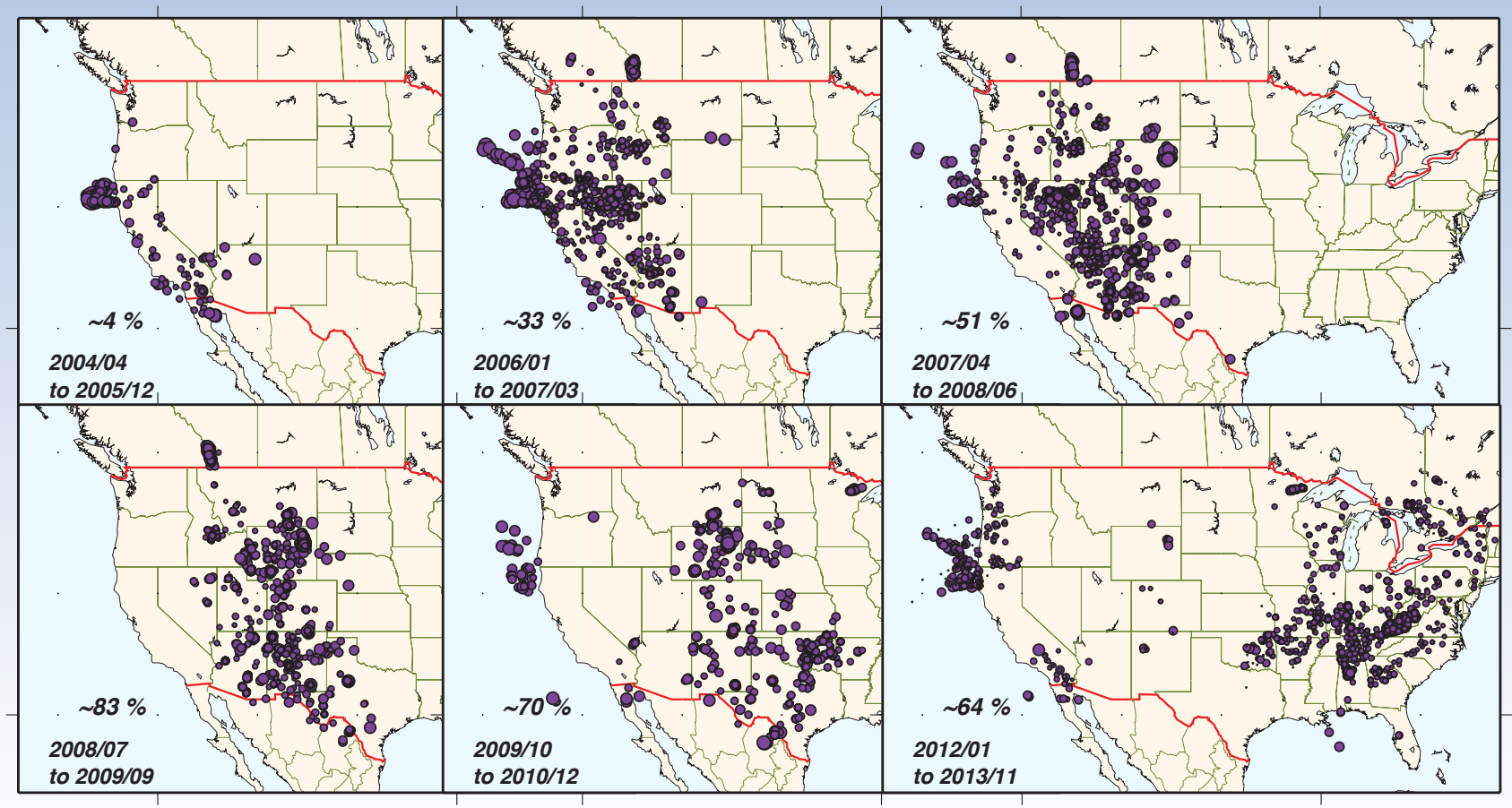
Many of the major discoveries associated with USArray data were unanticipated when EarthScope was proposed.



Tip of the iceberg…
at least 293 peer-reviewed USArray papers just during 2009-2013

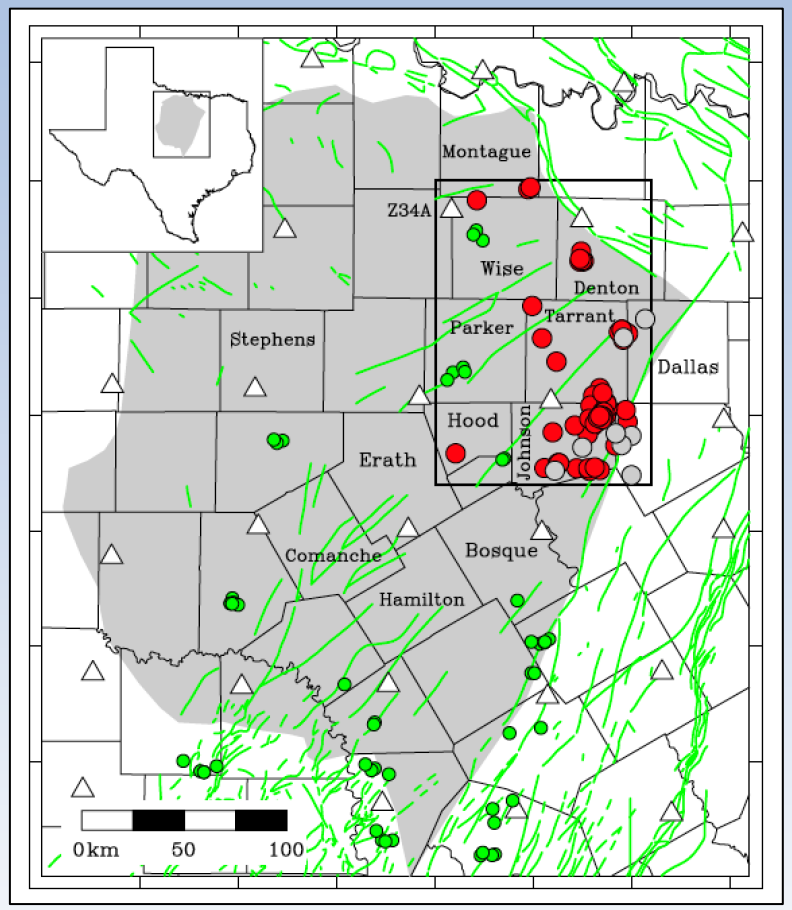
Improved Event Detection

A large percentage of events only reported by ANF with TA data
Astiz et al., *SRL*, 2014



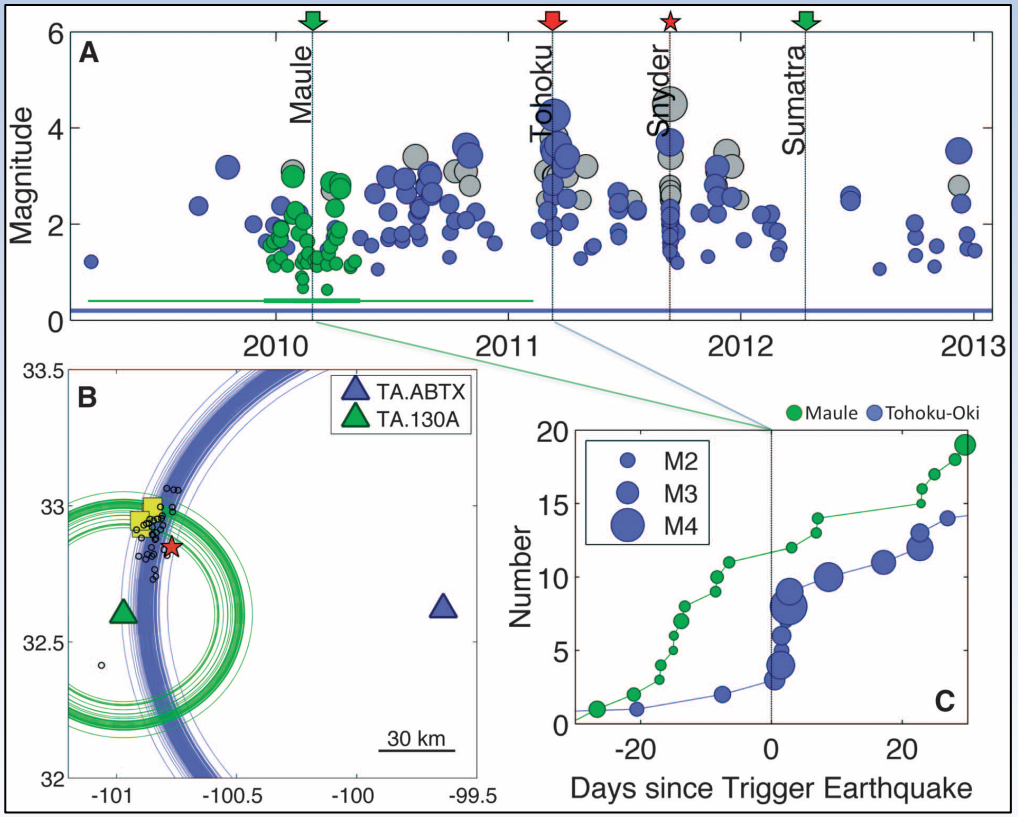
Looking eastward, the Array Network Facility made a high percentage of unique event detections.

Characterizing Seismicity



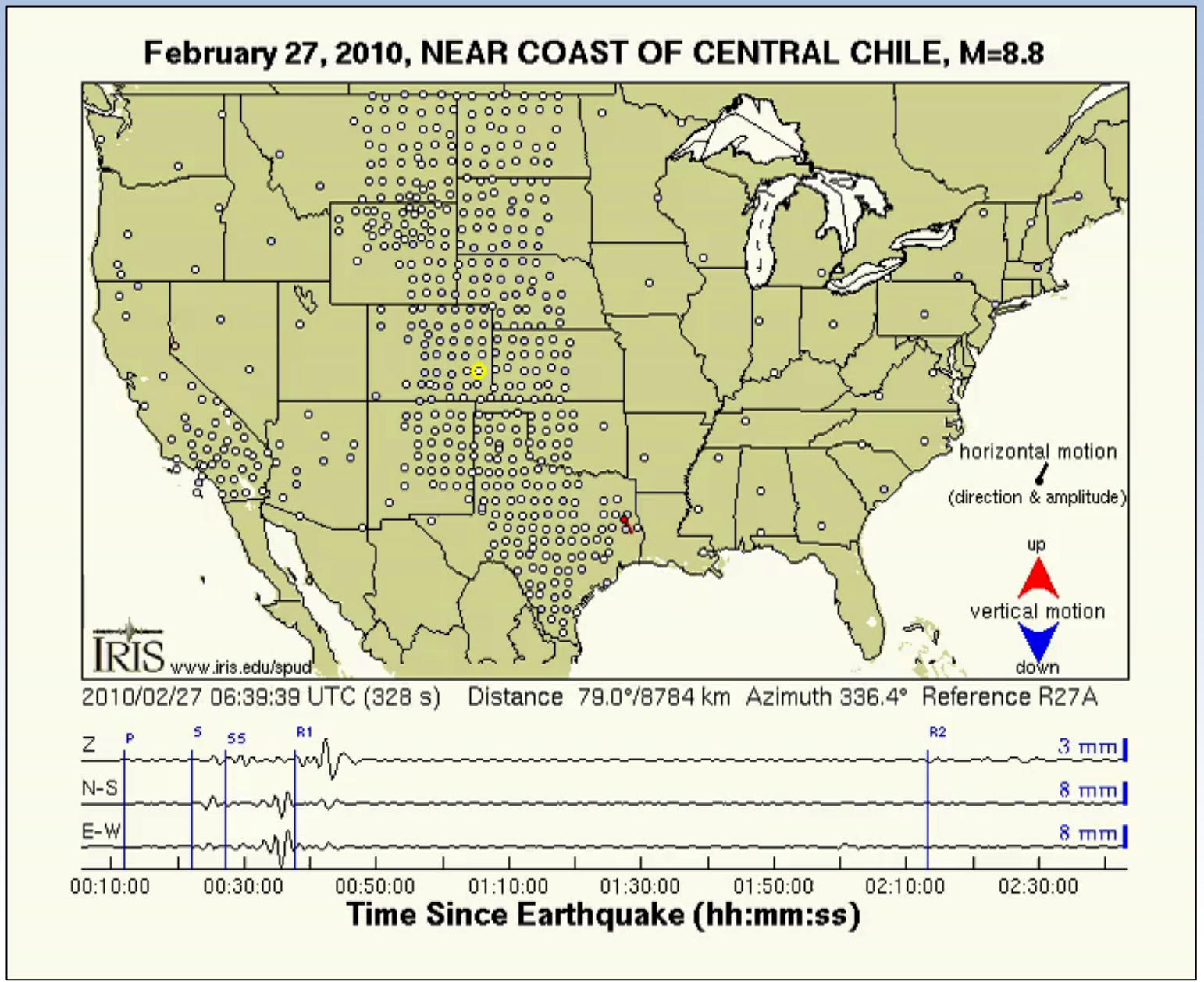
Injection triggered earthquakes, Barnett Shale
Frolich, *PNAS,* 2012

Remote earthquake triggering at injection sites
Van der Elst et al., *Science*, 2013

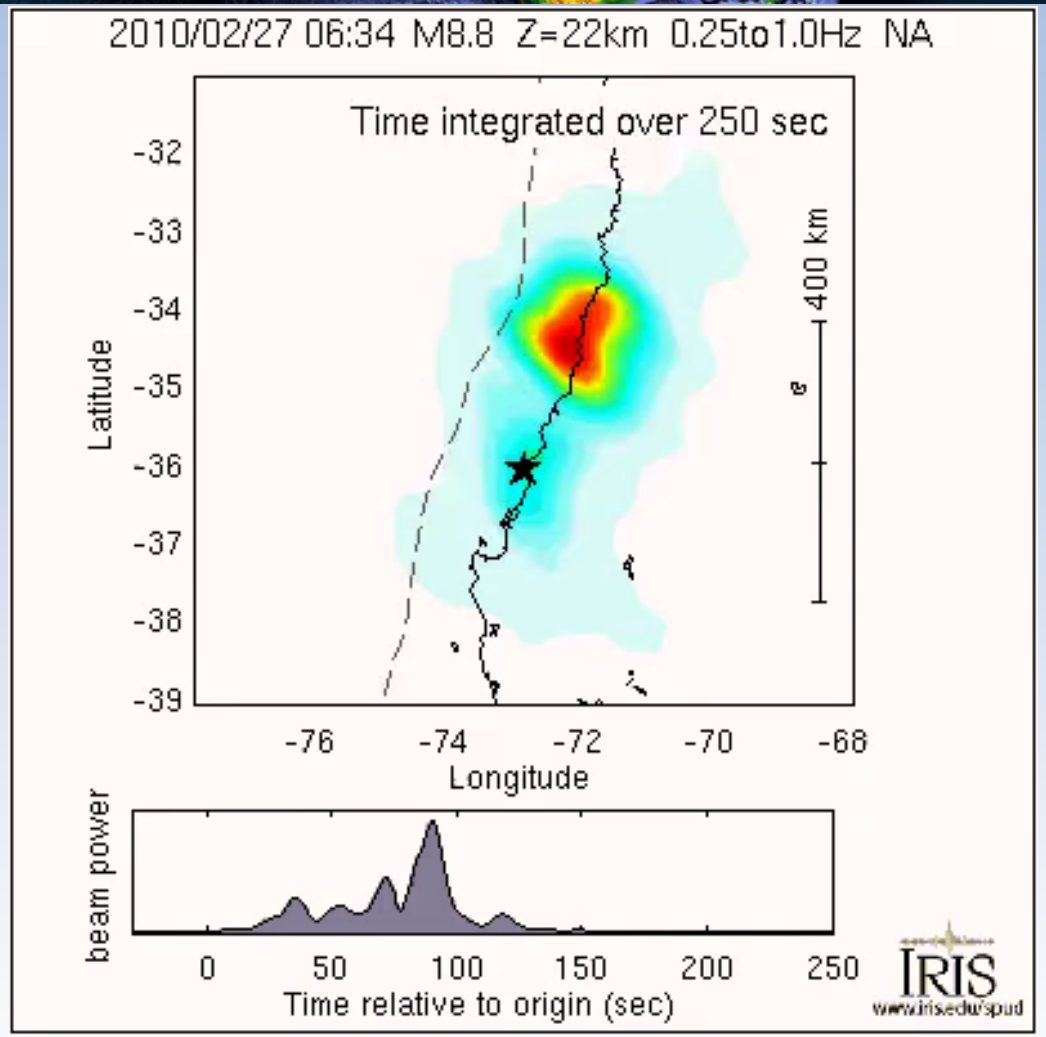


TA deployment provided the opportunity to study uptick in seismicity in central and eastern U.S.

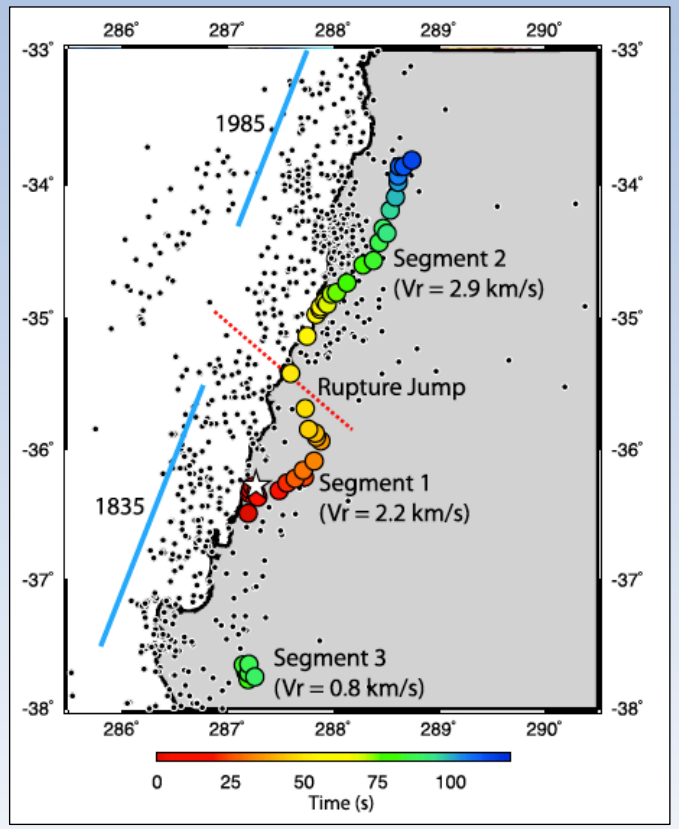
Understanding Great Earthquakes



Understanding Great Earthquakes

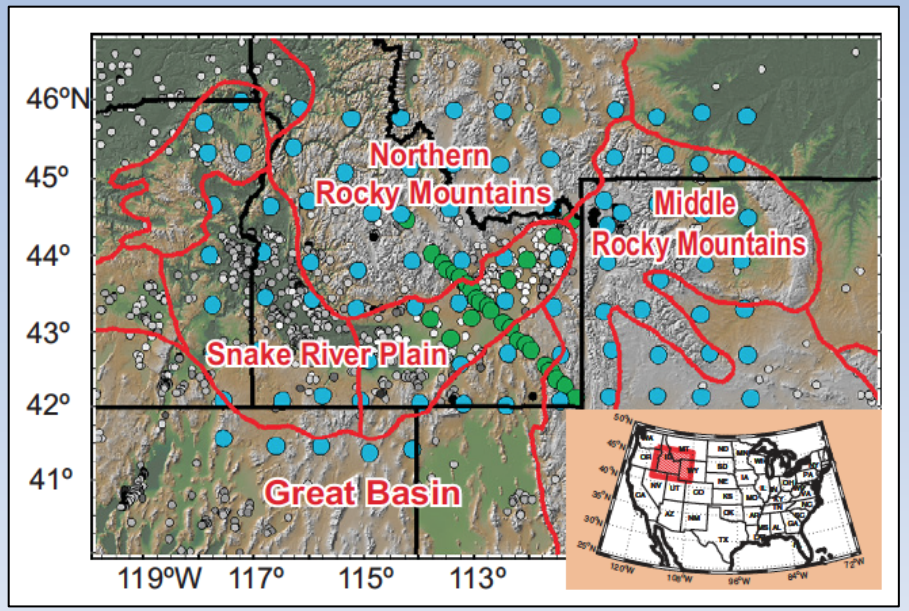


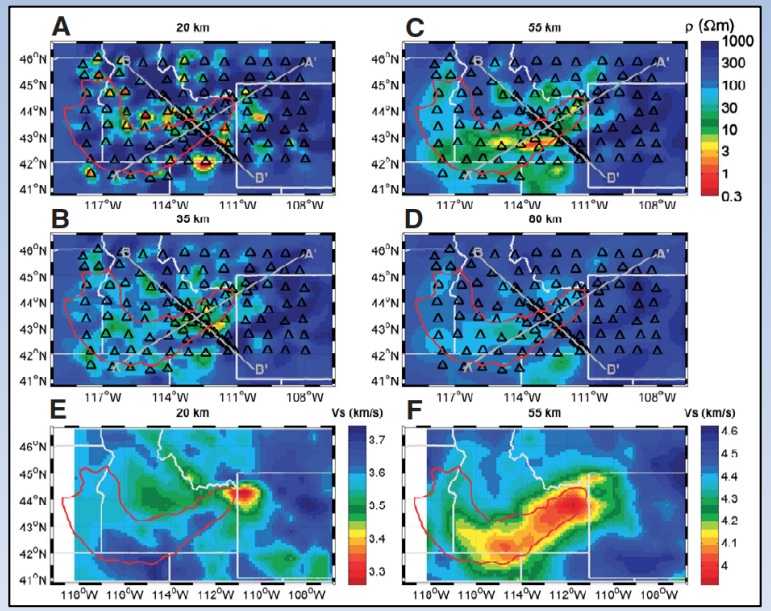
Automated IRIS back projection provides a reference



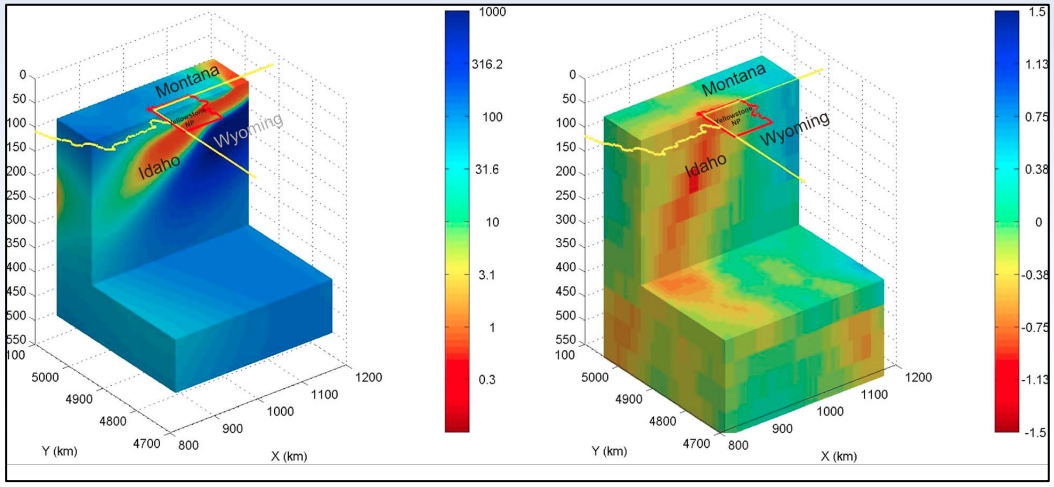
Backprojection analysis of Maule
Kiser and Ishii, *GRL*, 2011

Imaging Melts and Fluids





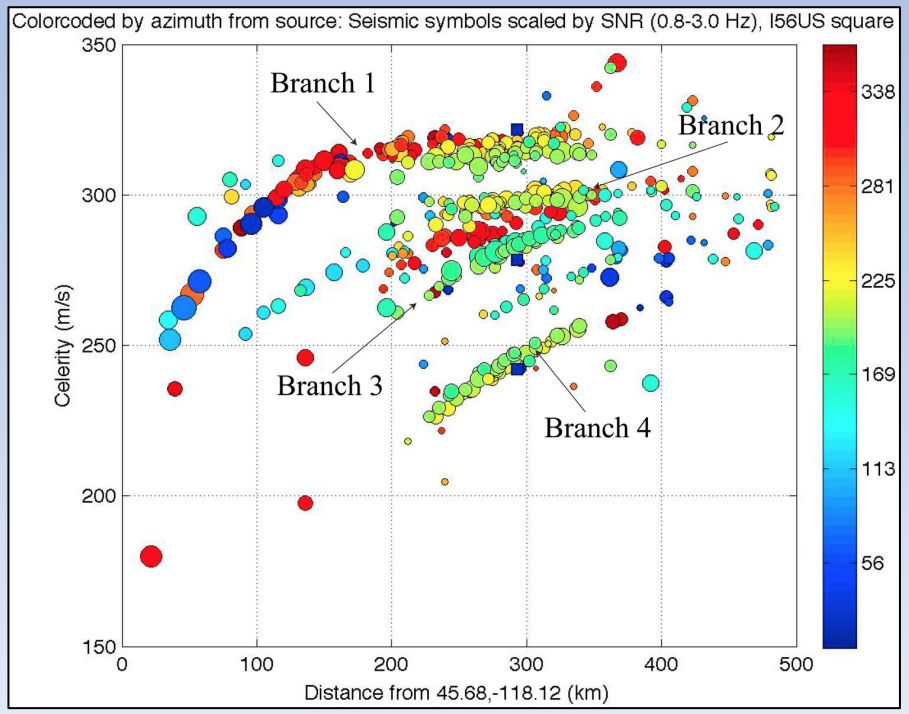
Geoelectric images of the crust and mantle along Snake River Plain and Yellowstone
Kelbert et al., *Geology*, 2012



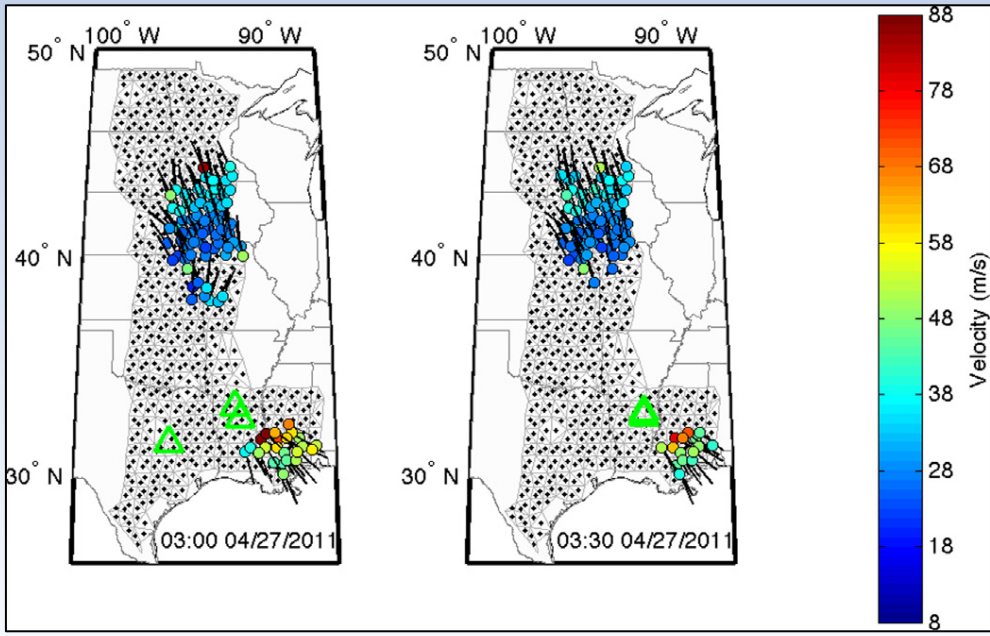
MT can identify melts and resolve ambiguities in seismic results, such as temperature vs. composition.

Mantle MT 3D model compared to seismic tomography for Yellowstone
Zhdanov et al., *GRL*, 2011

Atmospheric Studies

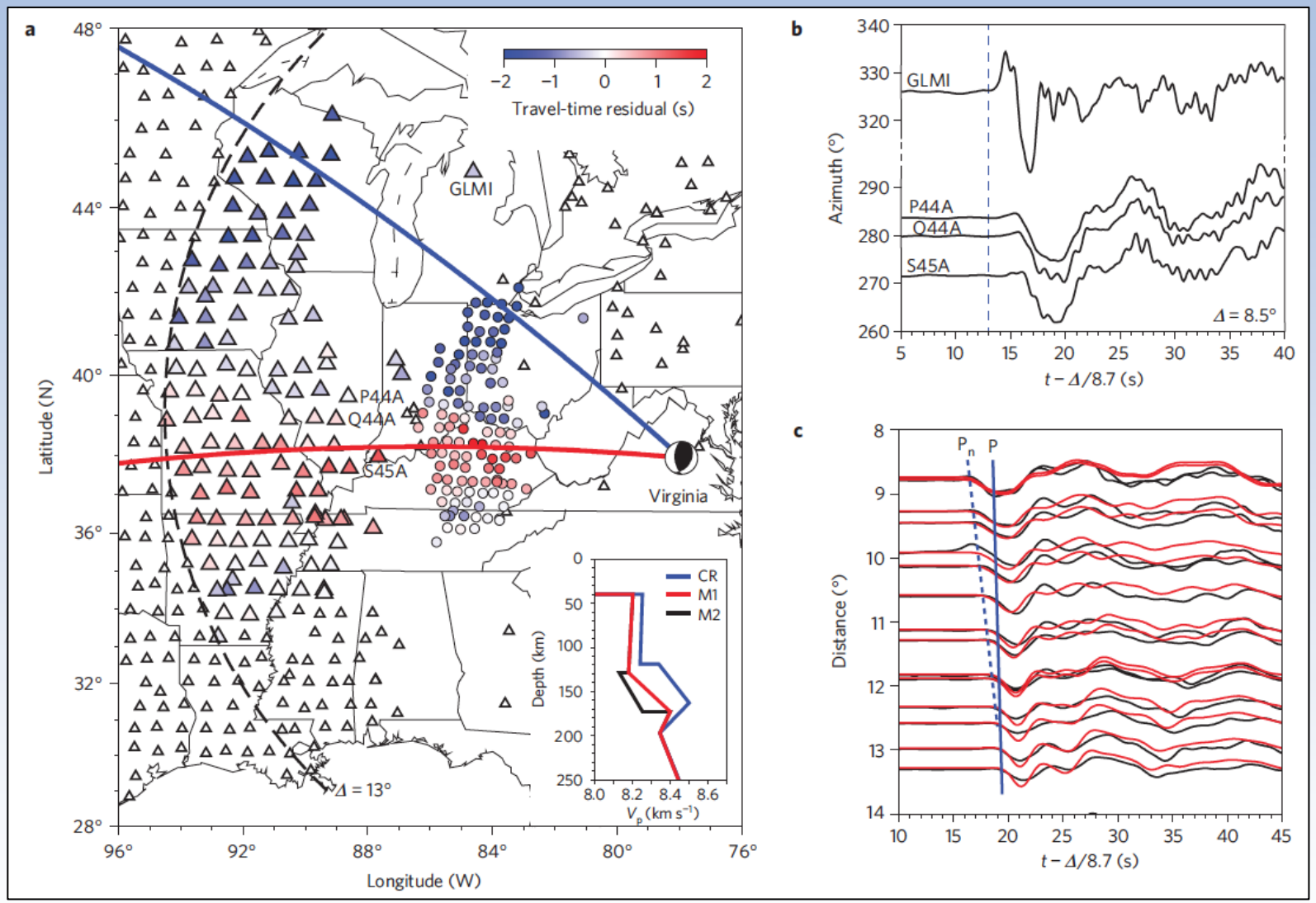


Exploiting acoustic to seismic signals, with distance and azimuth coverage, to illuminate traveltime branches
Hedlin et al., *JGR*, 2010



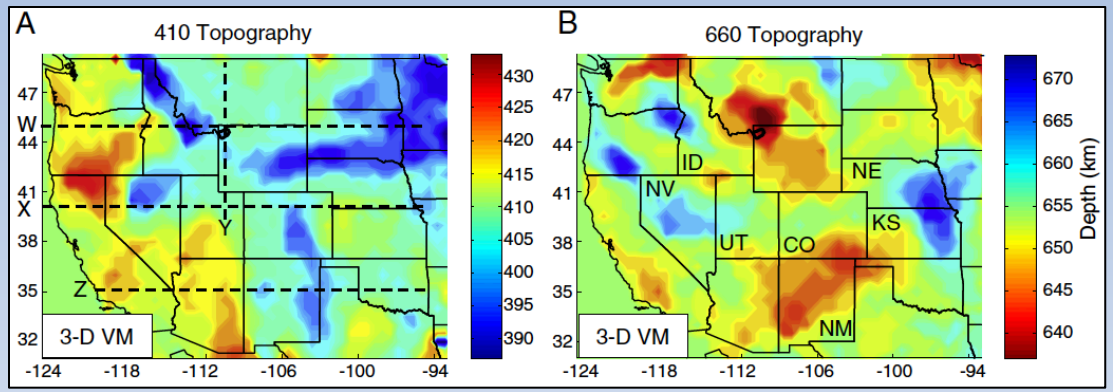
Gravity waves propagating across the TA
de Groot-Hedlin et al., *EPSL*, 2013

Using Regional Events

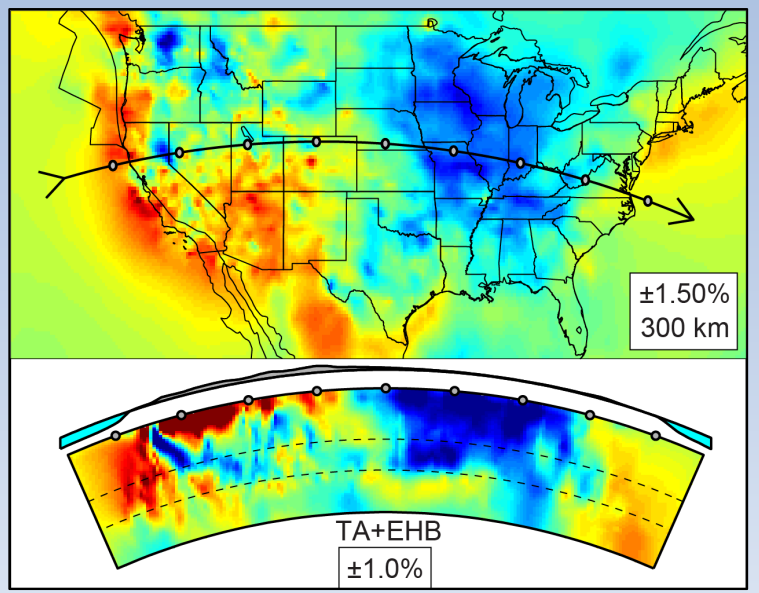


Mineral earthquake energy used to discern ancient hotspot track in Central U.S.
Chu et al., *Nature Geoscience*, 2013

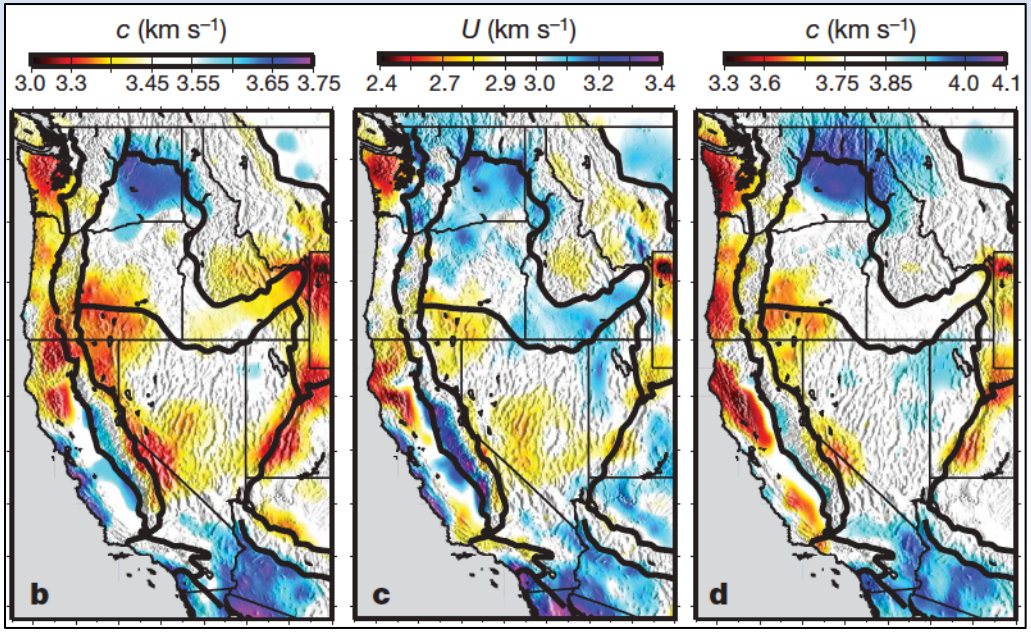
An Imaging Revolution



Mantle discontinuity depth beneath the Western U.S.
Schmandt et al., *EPSL*, 2012



P-wave tomography model
Burdick et al., *SRL*, 2013



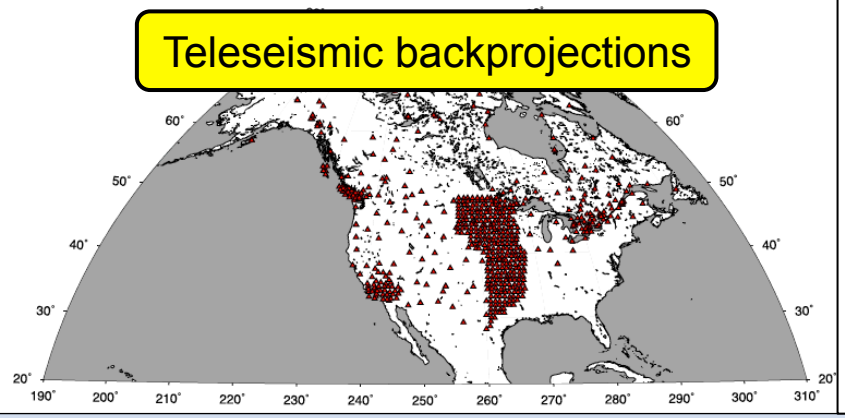
Many new models of North American crust and upper mantle structure from tomography and receiver functions

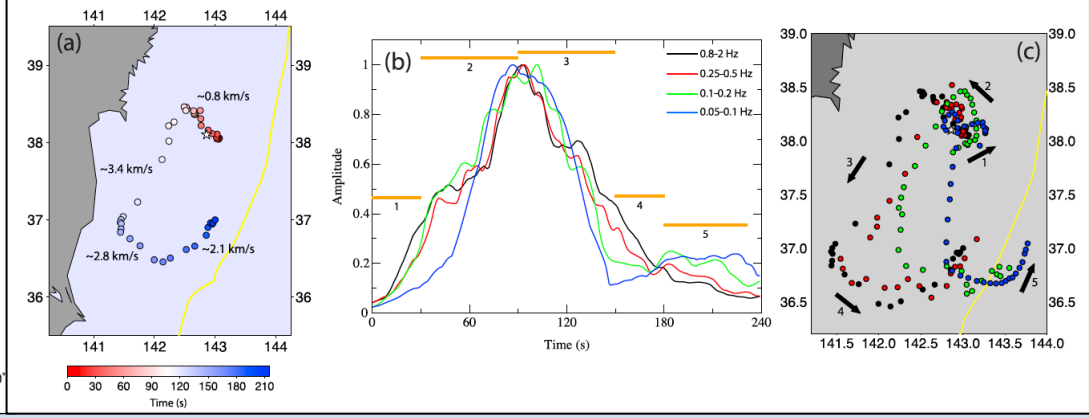
Ambient noise tomography discerns crustal deformation fabric
Moschetti et al., *Nature*, 2010

Impacts on Seismology

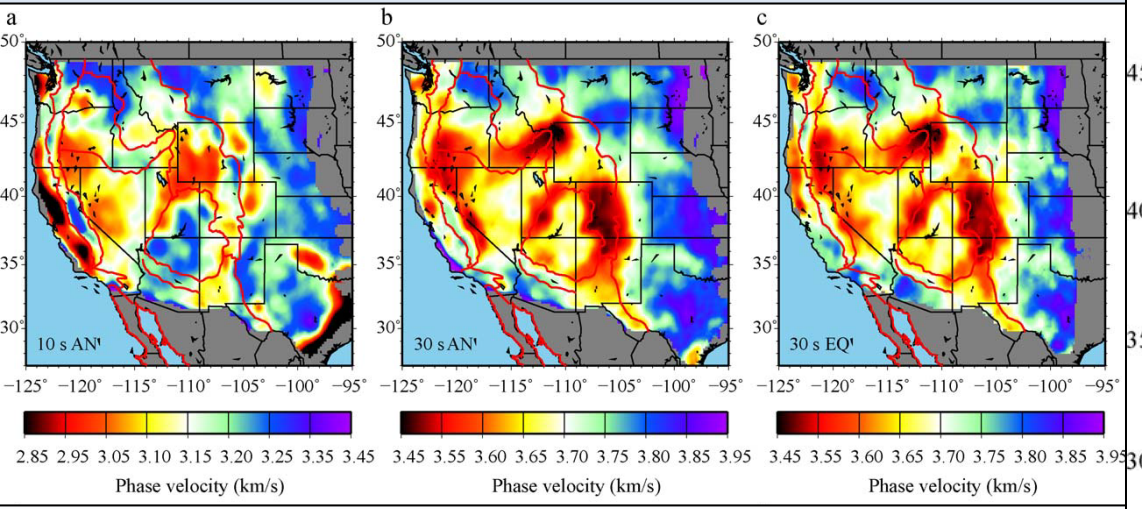
Pioneering new methodologies

Teleseismic backprojections

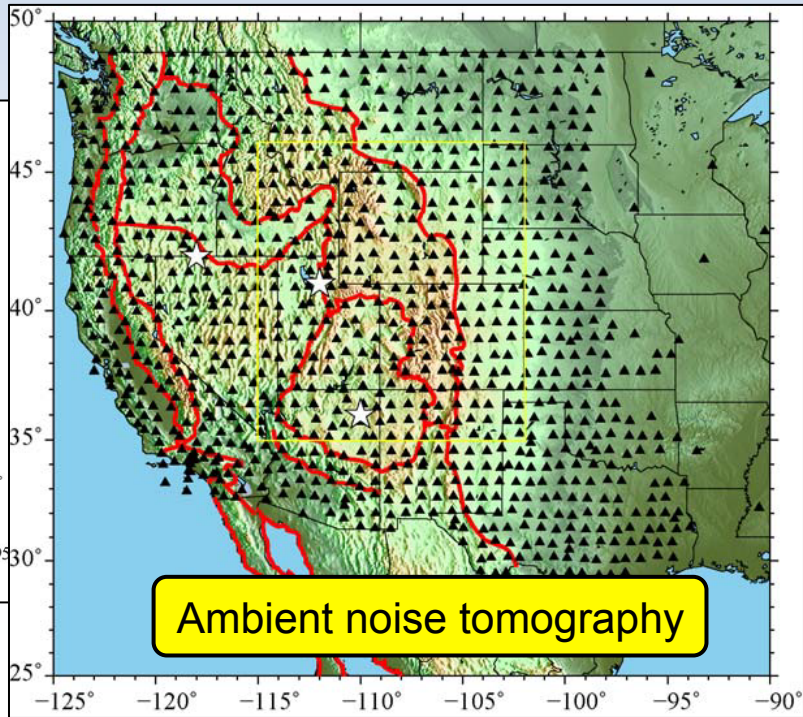




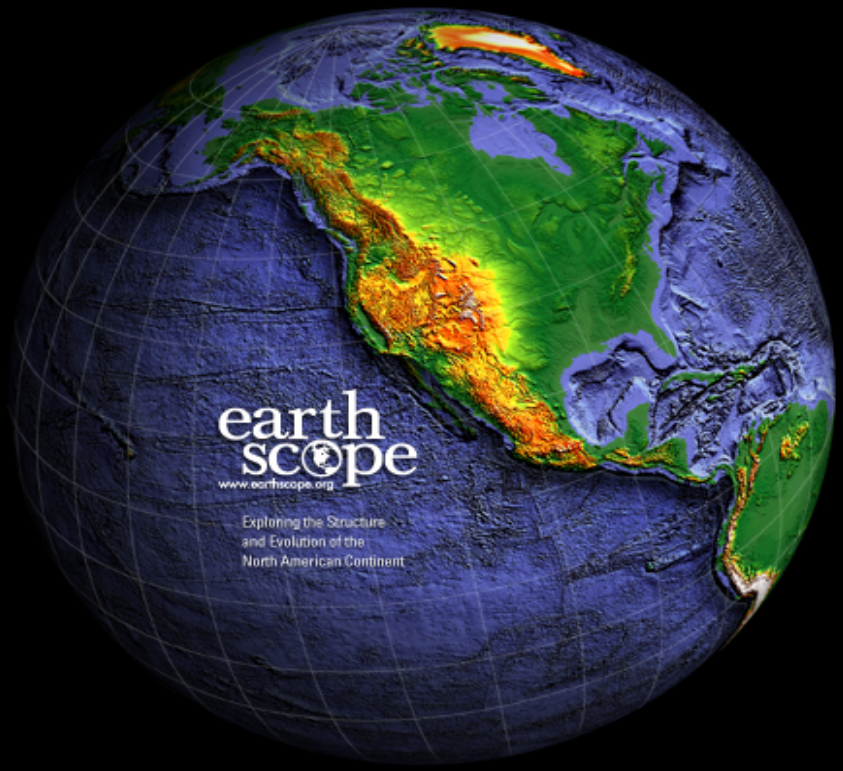
Backprojection of Tohoku-Oki earthquake
Kiser and Ishii, *GRL*, 2012



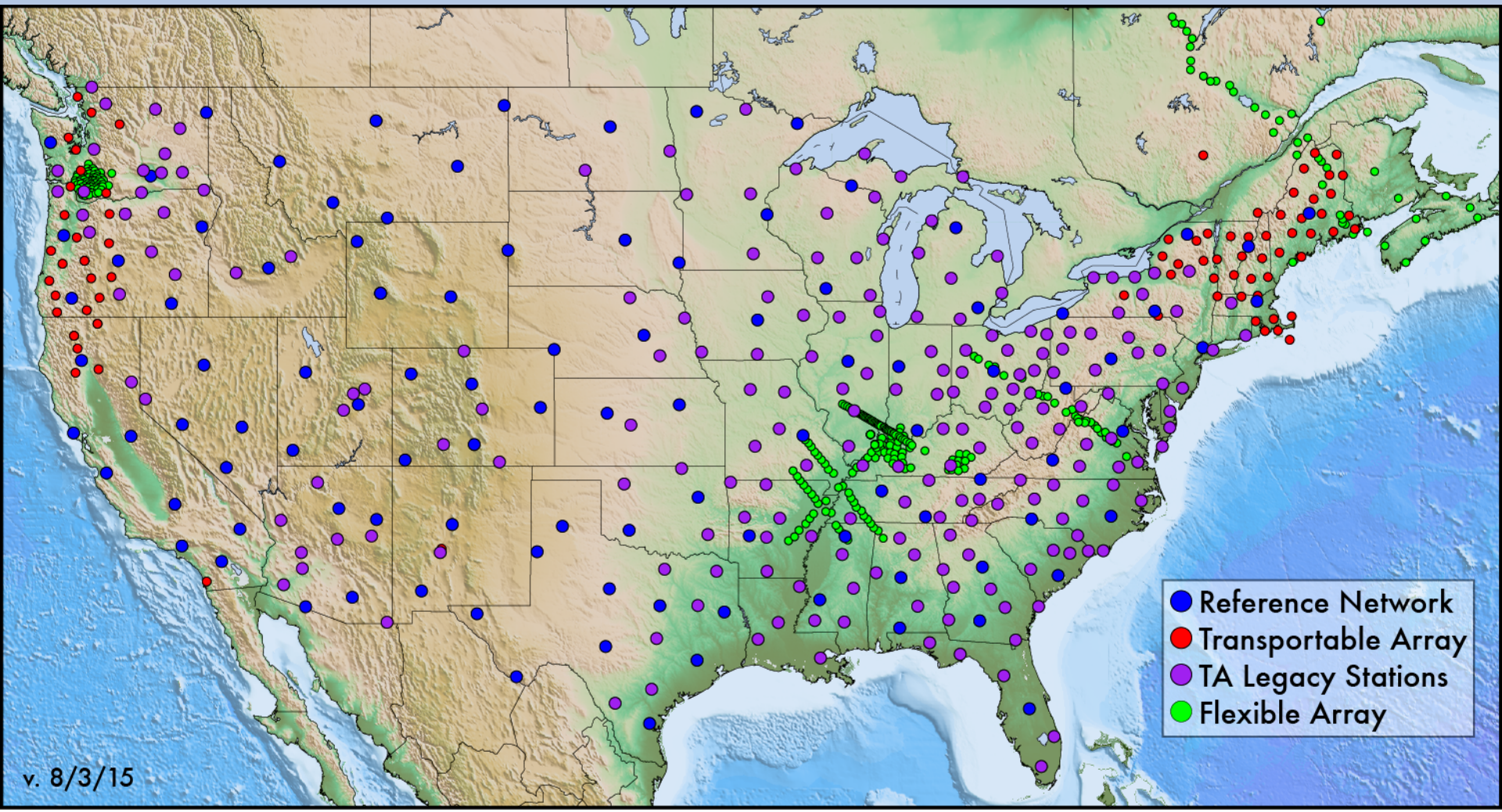
Ambient noise tomographic imaging
Ritzwoller et al., *CR*, 2011



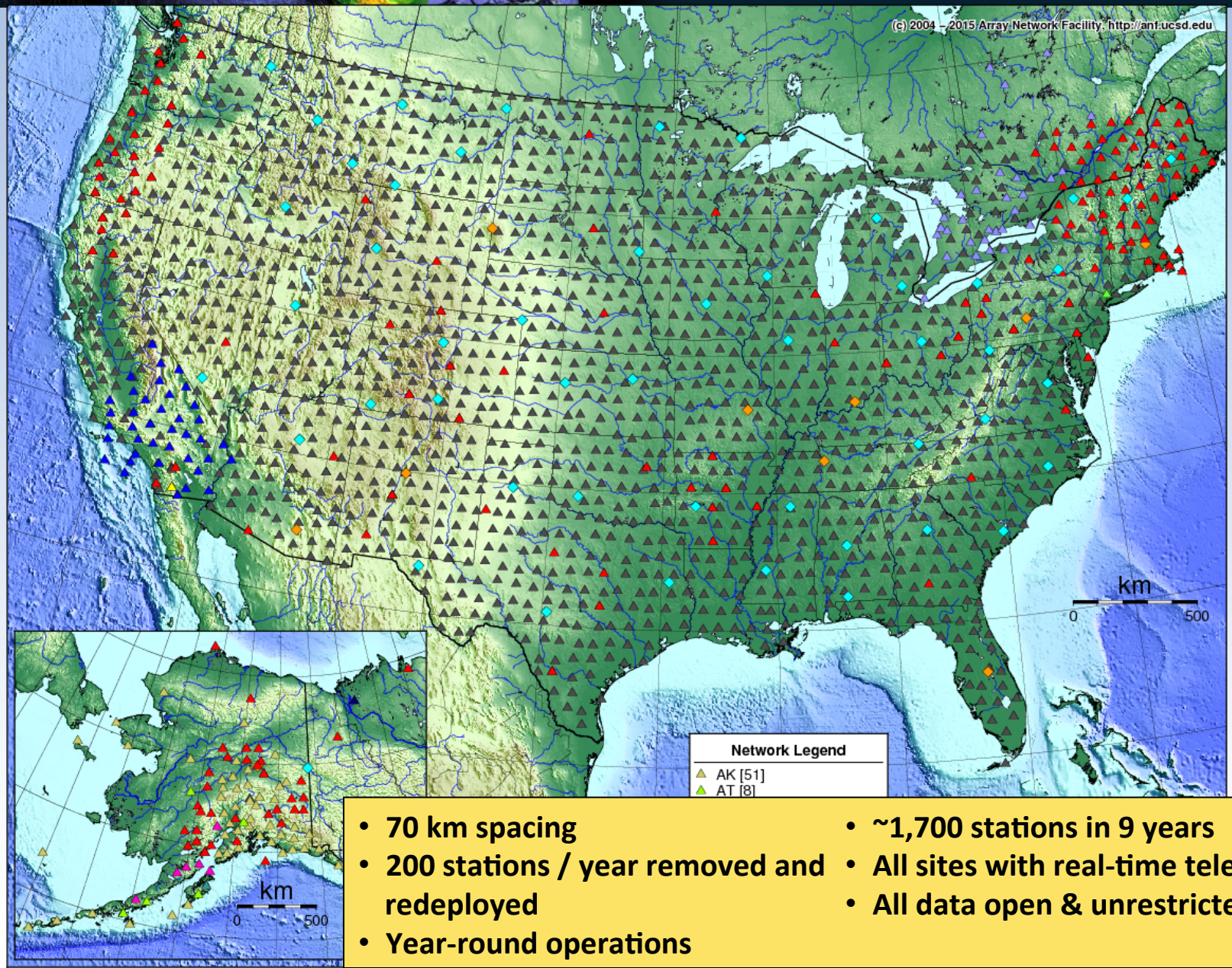
Continent Scale Seismology: Reference Network & Transportable Array



TA and RefNet

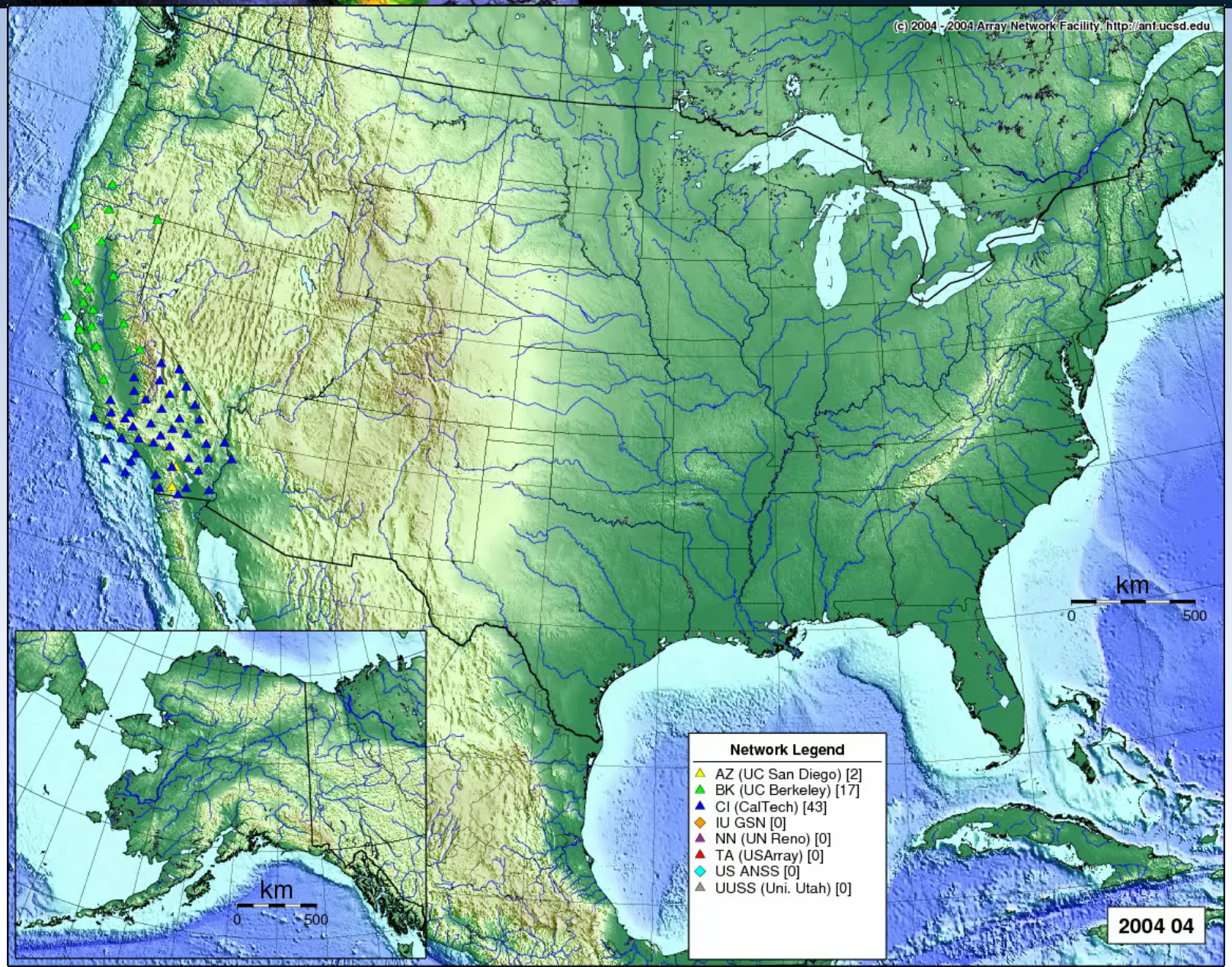


Transportable Array

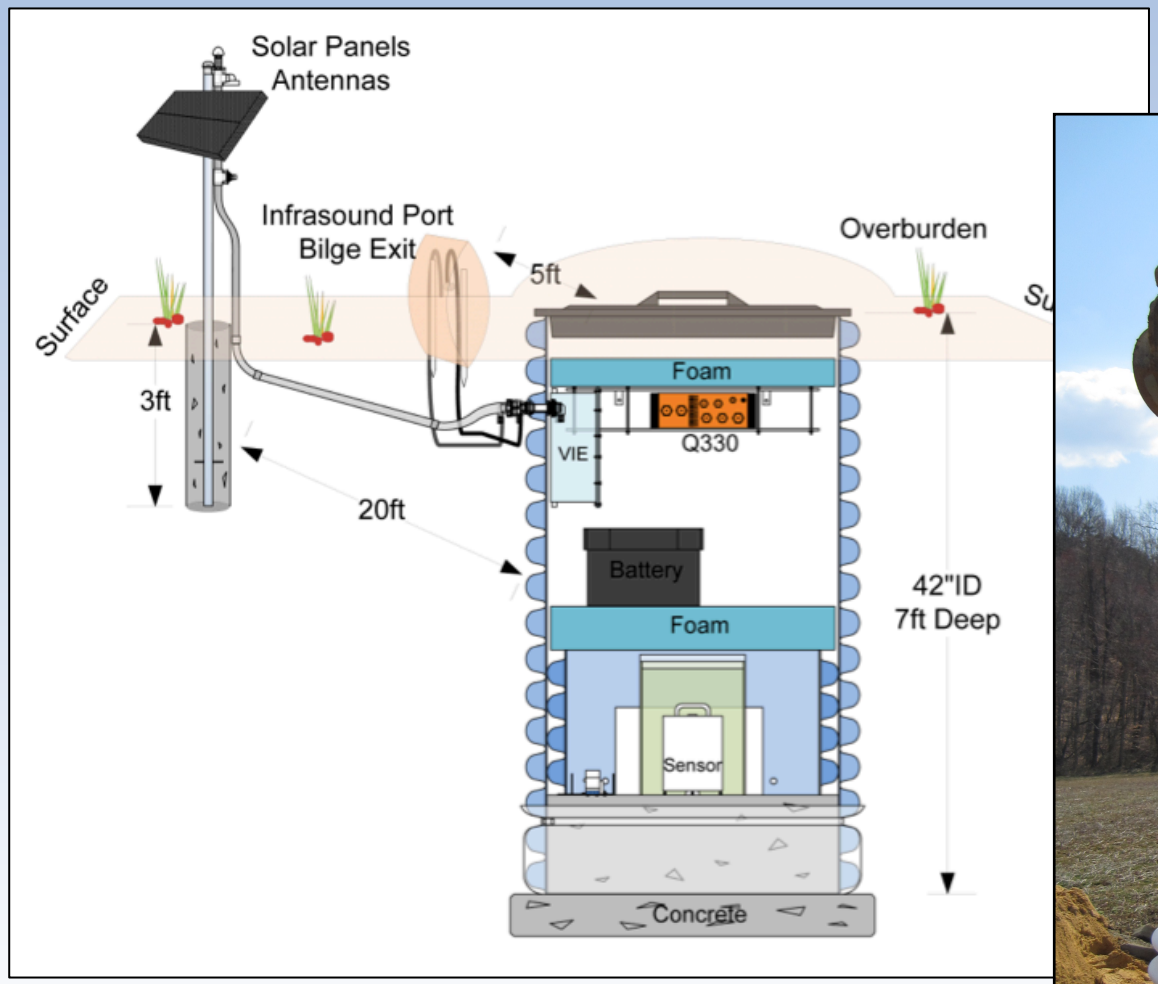


- 70 km spacing
- 200 stations / year removed and redeployed
- Year-round operations
- ~1,700 stations in 9 years
- All sites with real-time telemetry
- All data open & unrestricted

TA Rolling Deployment

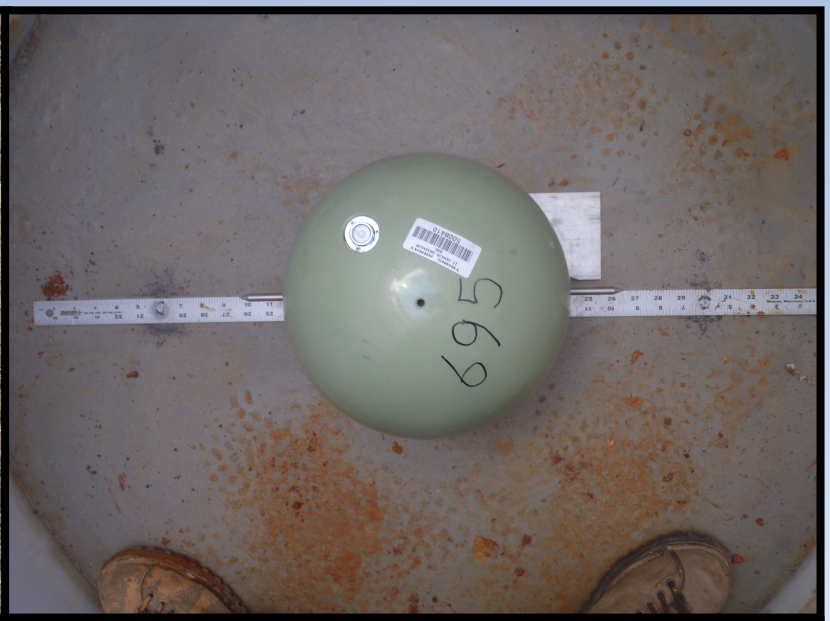


Traditional TA Station



A high precision manufacturing operation!

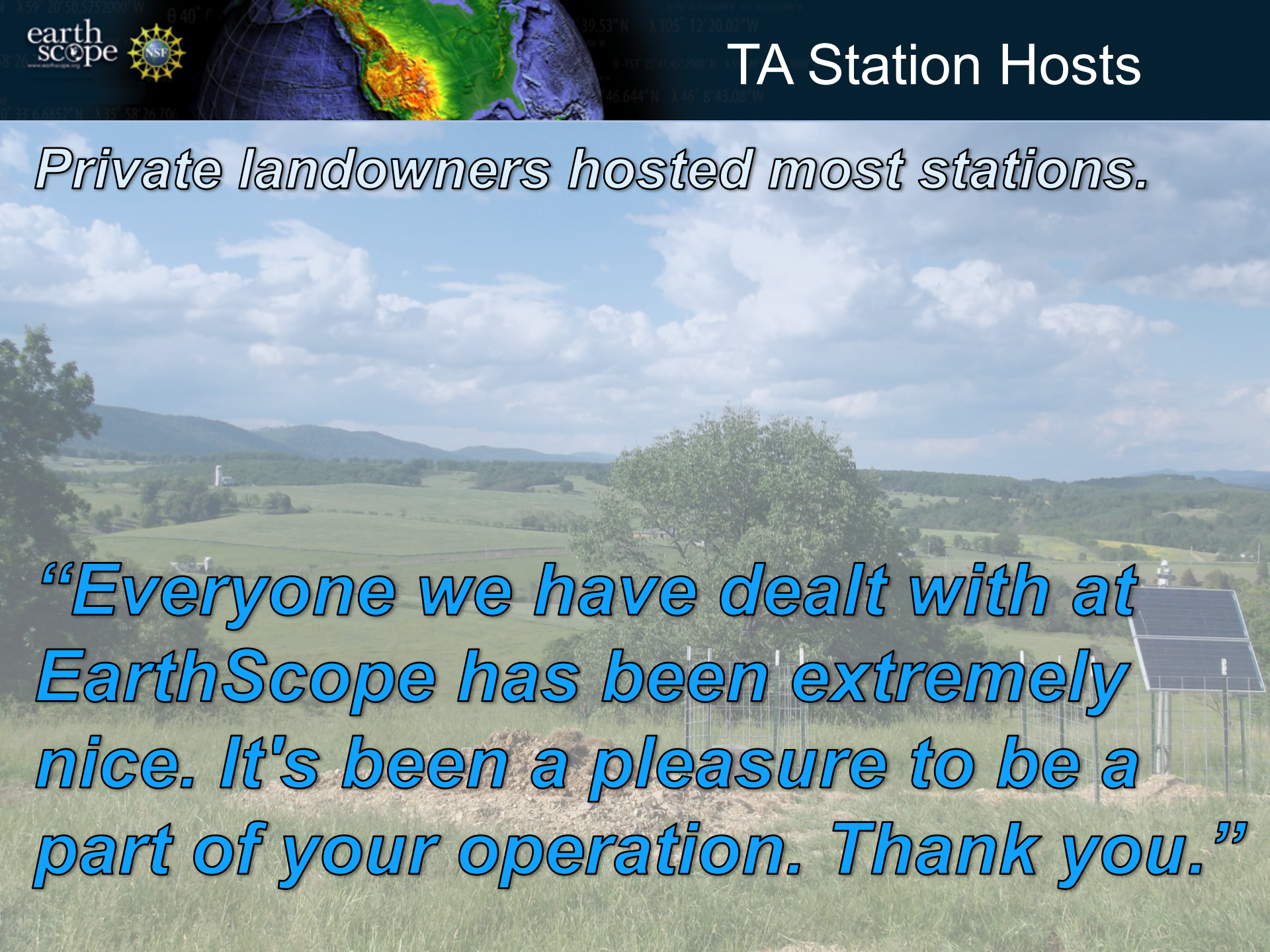
Traditional TA Station




earth scope
earth scope
DEWALT
HUSKY

TA Station Hosts

Private landowners hosted most stations.



"Everyone we have dealt with at EarthScope has been extremely nice. It's been a pleasure to be a part of your operation. Thank you."

In Their Words

"Great Job! You have very professional employees. Everyone we dealt with was outstanding! You are welcome on my land anytime!"

"My granddaughter took picture when it was installed. She made a presentation to class, teachers wanted to see it, too."

"Happy with the project, very impressed with how nice everyone has been."

"Thanks for letting us host the earth monitoring station. We enjoy the OnSite newsletter."

"Everyone we have dealt with at EarthScope has been extremely nice. It's been a pleasure to be a part of your operation. Thank you."

Science Impacts with Regular People

"We hope the station provided helpful information to you and your fascinating project. We were pleased to have been a small part of it."

"Thanks. I had a 4th grade tour of the site last summer; they liked it."

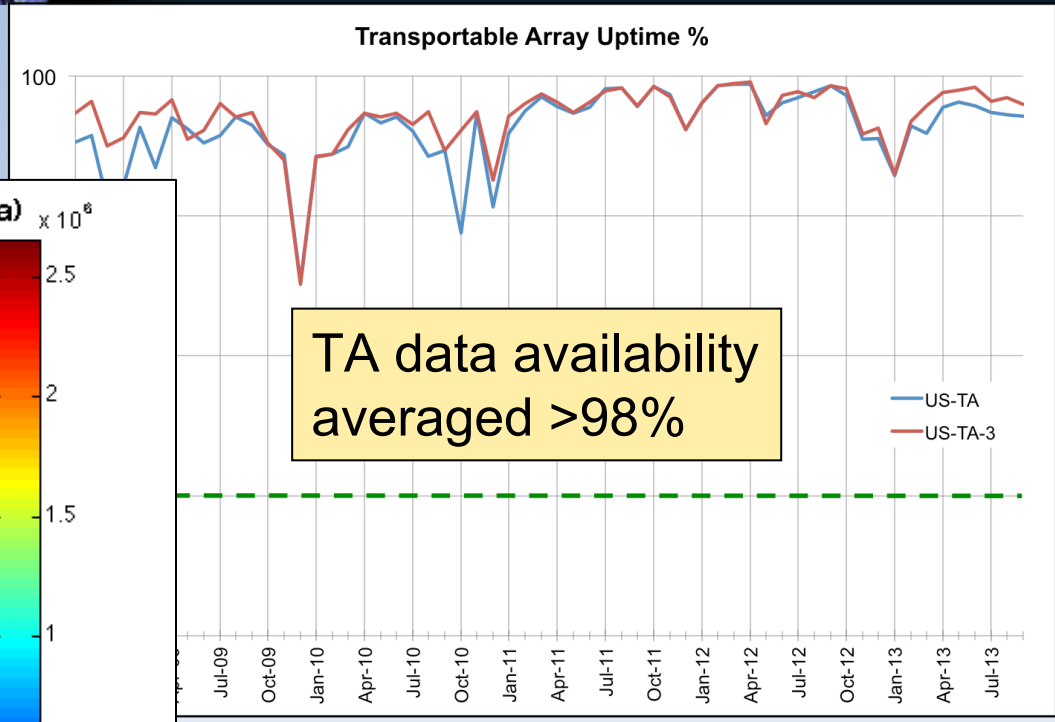
"It's been a good experience with EarthScope."

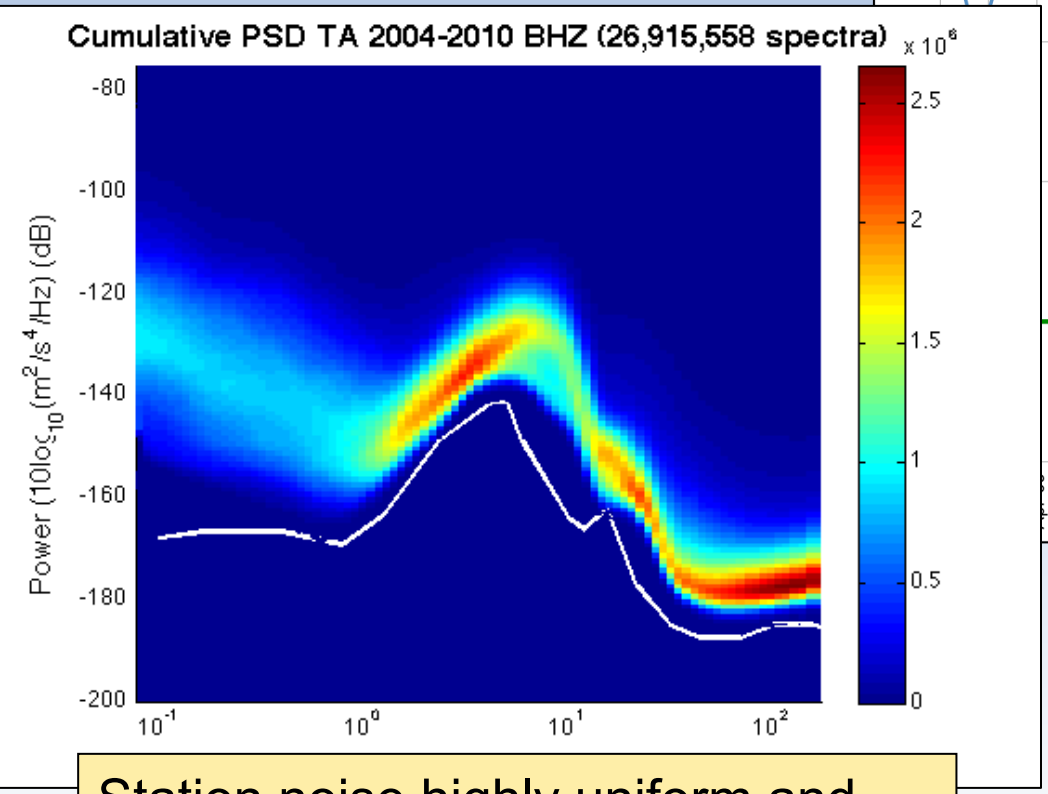
"Glad to be a part of the project. I hope the data collected will benefit us in the future."

"We appreciated having the earthquake station on our property. It did generate a lot of interest among the neighbors. If this is ever needed again, you are welcome back."

So far, 468 vaults left at landowners' behest!

Performance & Quality



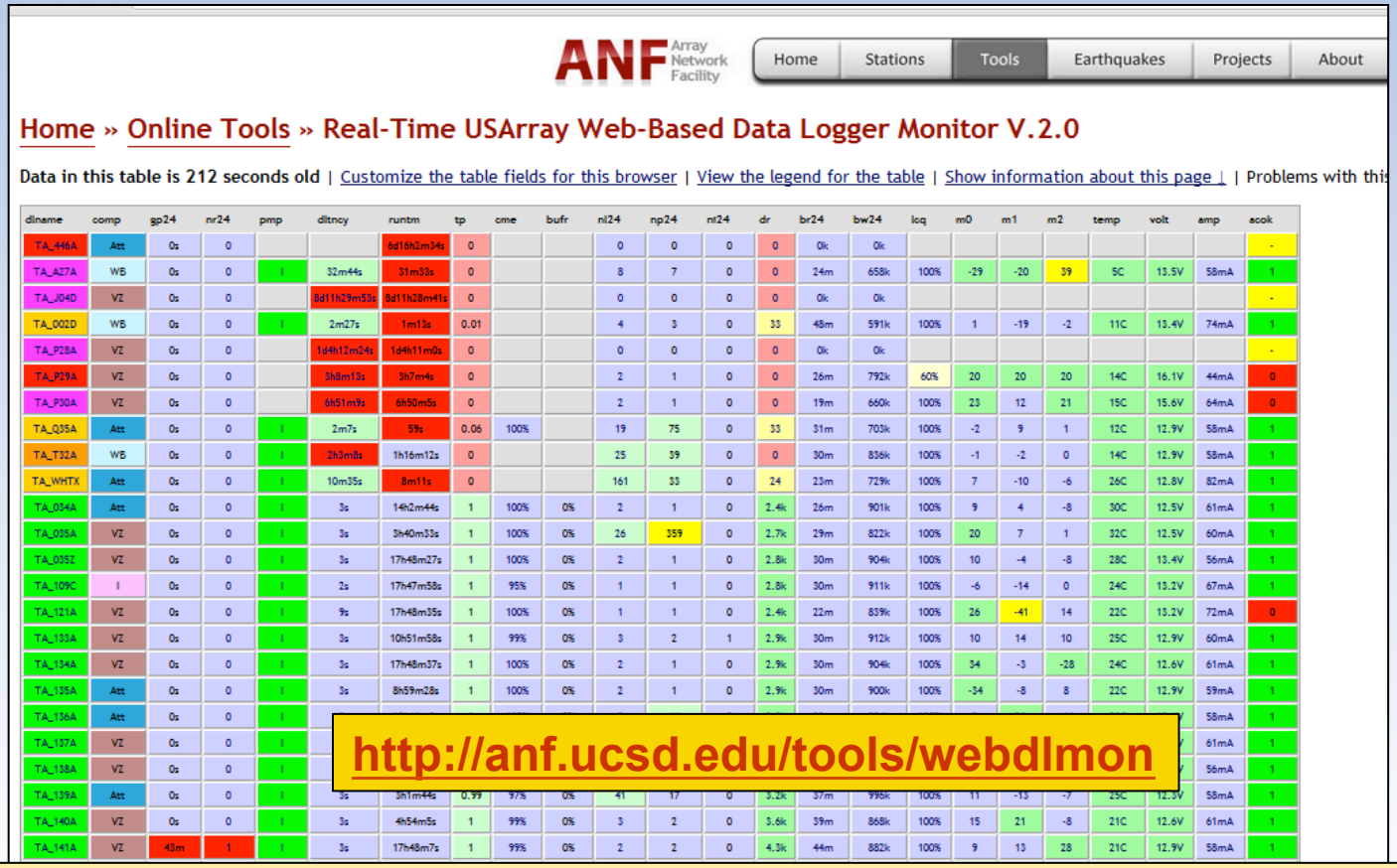


Station noise highly uniform and quite low for temporary installations

For the first 958 completed stations: The median contiguous time series is 11.7 months long!

The quality and consistency of the data have been key to the science!

Value of standardized network operations

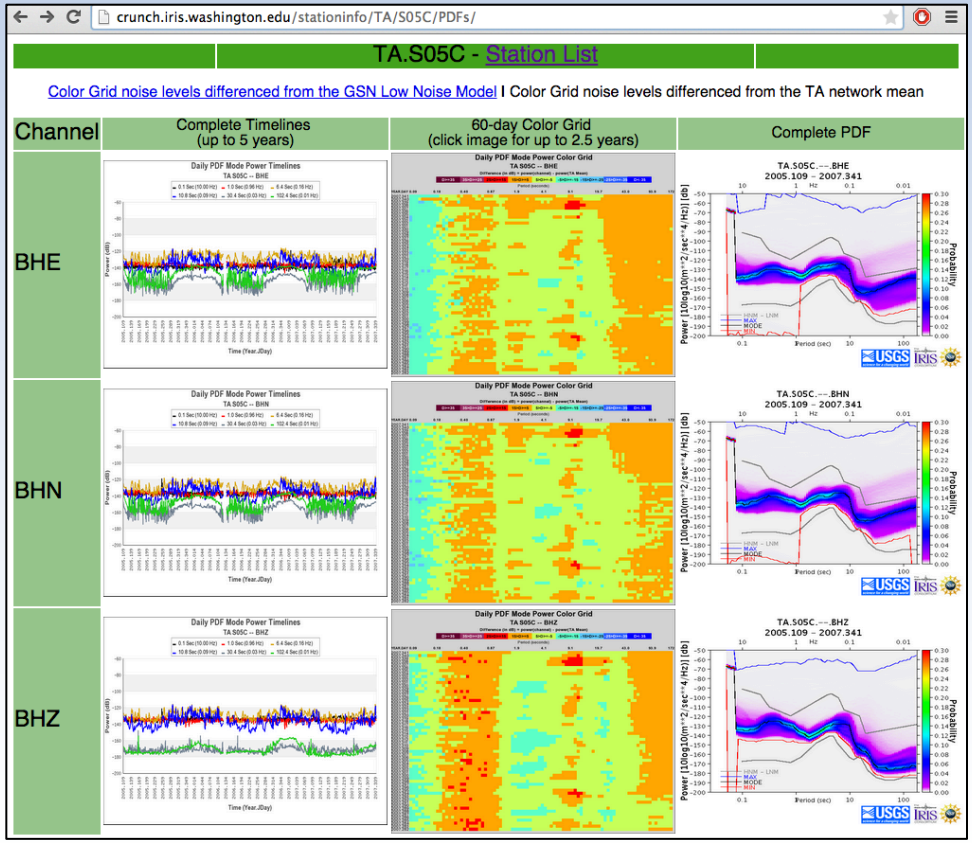


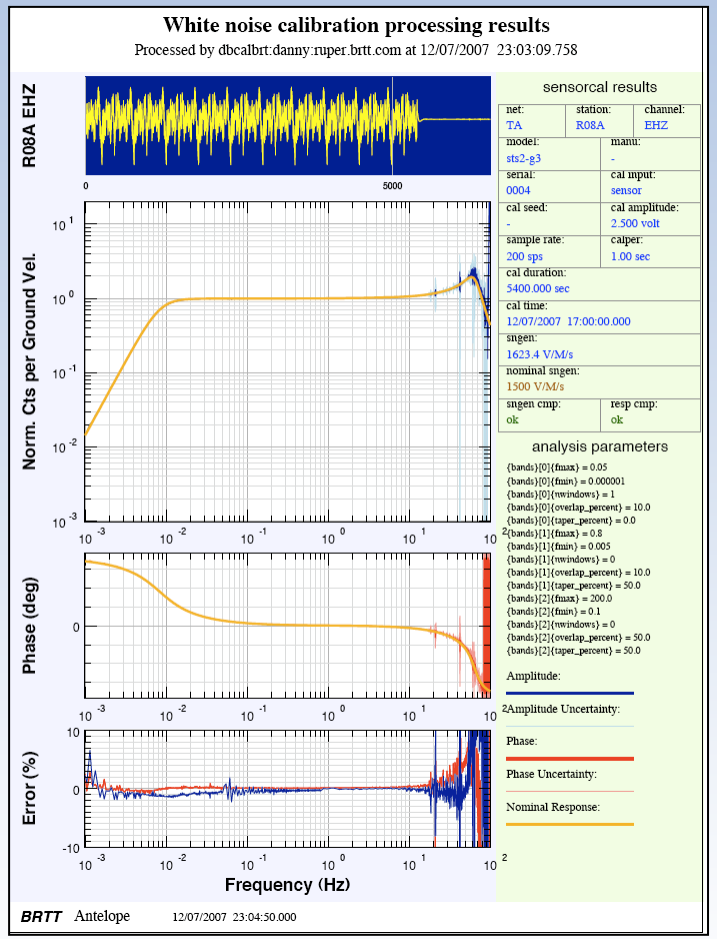
- **Monitoring system renders data into actionable format**
- **Information feeds weekly management prioritization for all service activities**

Impacts on Seismology

Value of automated quality control

- Automated process for command, capture, and analysis of calibration signals



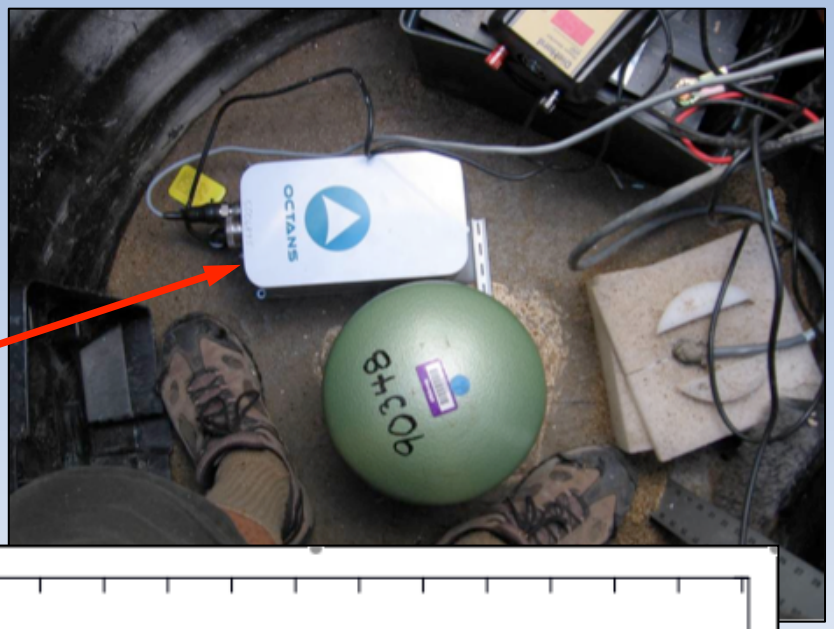


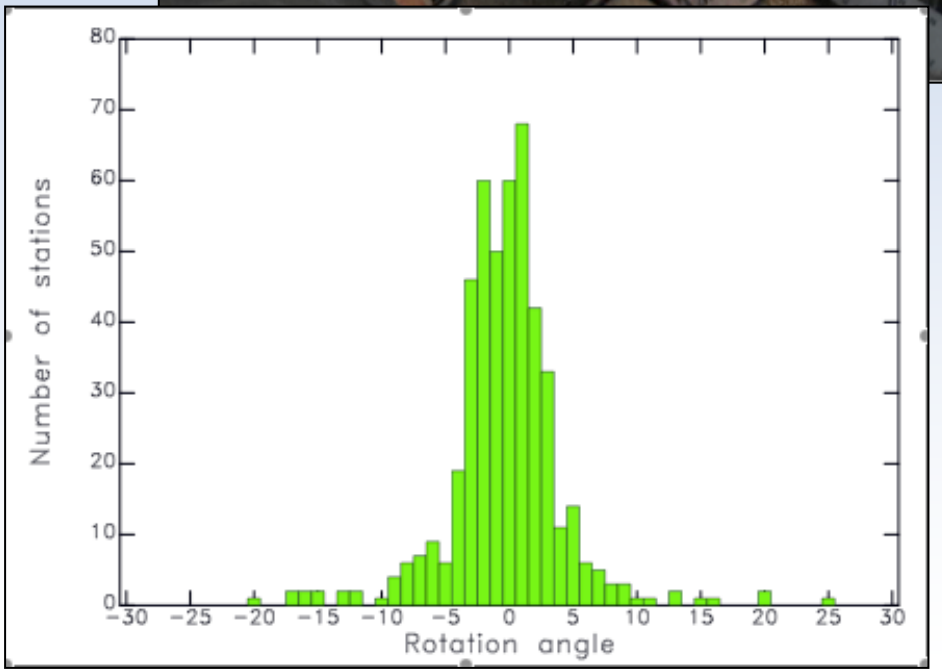
- Real-time noise analysis identifies station performance issues

Impacts on Seismology

Improved sensor orientation practices

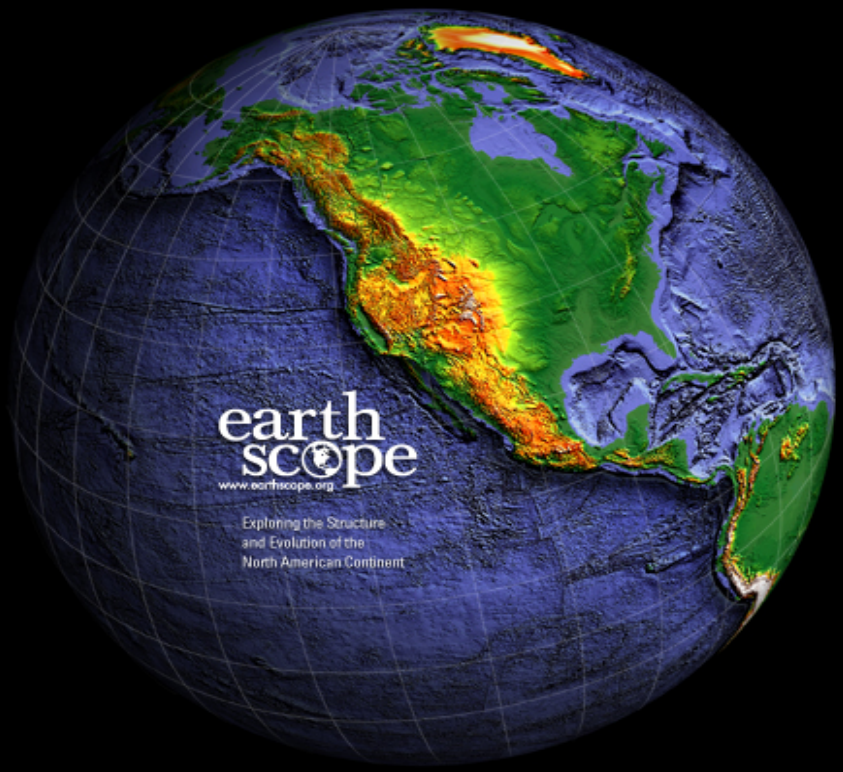
- Direct measurement of orientation of all stations on install/removal
  - Uses fiber-optic gyroscope
  - Measures orientation to < 0.2°
  - Validates empirical estimates
- As of 2011, 95.6% of the TA stations have polarization anomalies within +-3°.
- In 2008, this number was 79.9%.





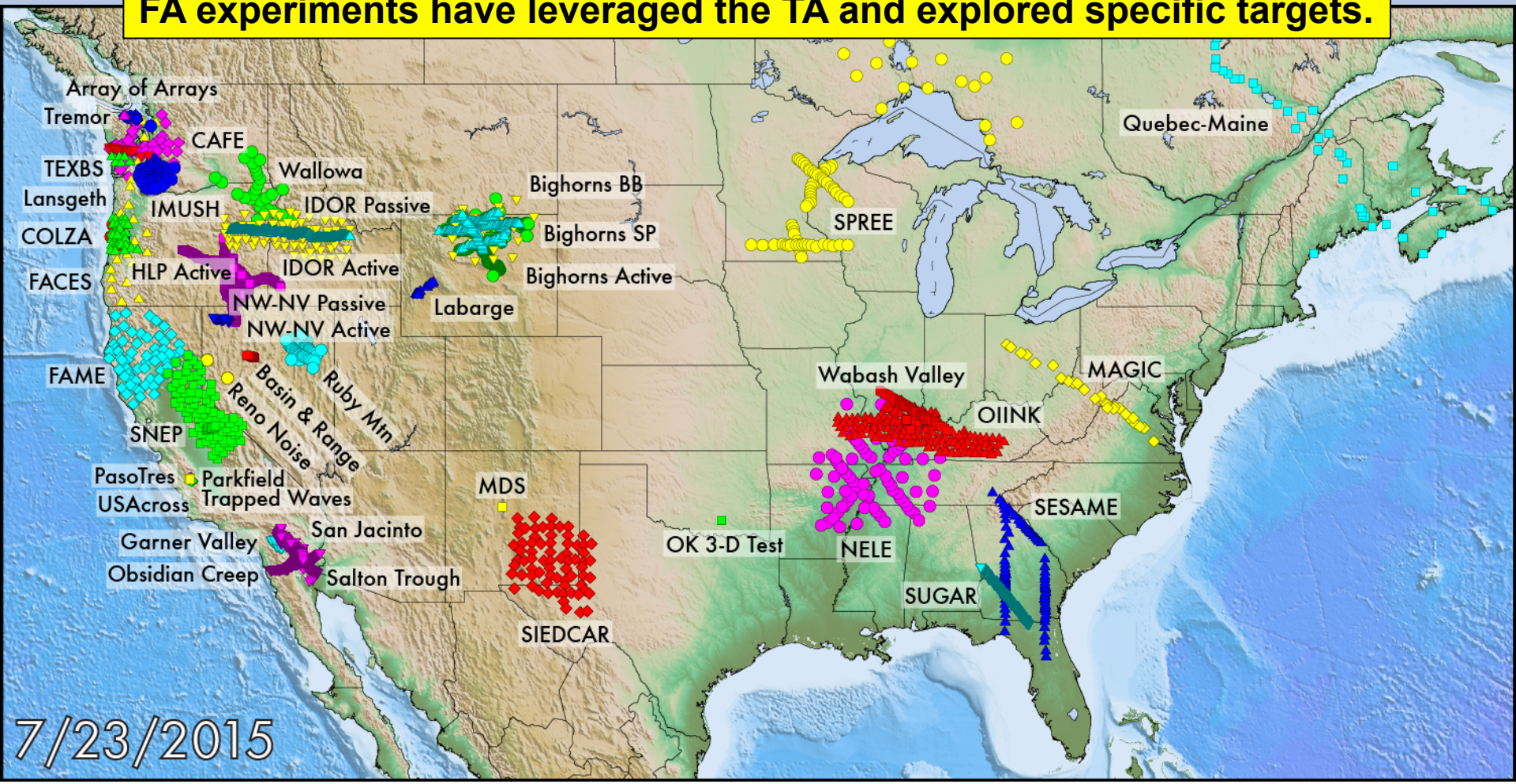
TA station orientation, relative to north, from empirical analysis
Ekström and Busby, SRL, 2008

Flexible Array



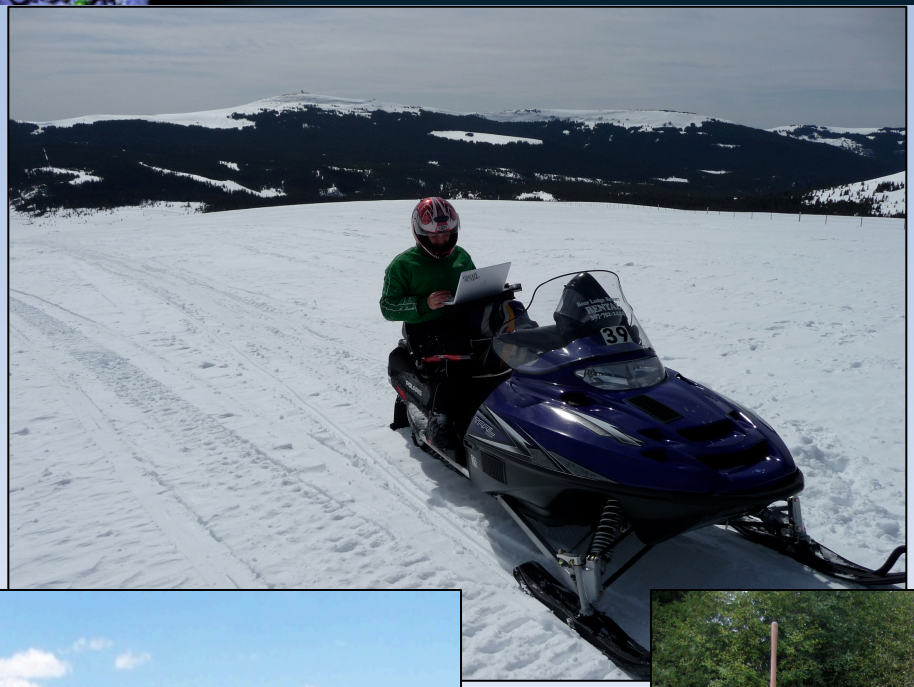
Flexible Array

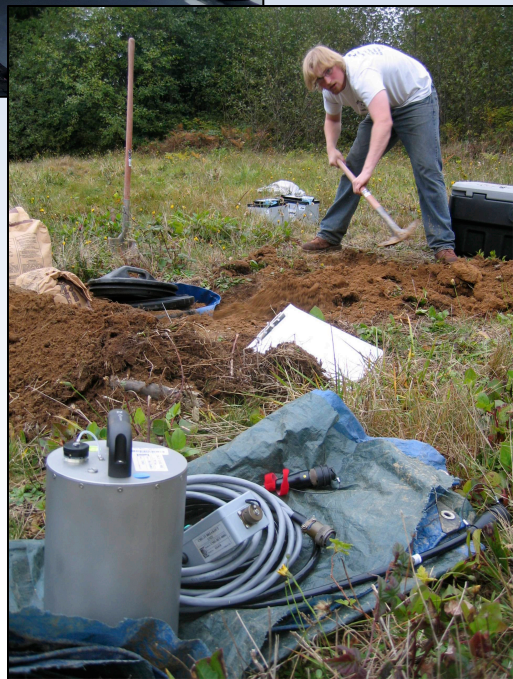
FA experiments have leveraged the TA and explored specific targets.



- 326 broadband, 120 short period, 1700 Texan (active source) systems
- 21 passive and 3 active source experiments supported during award period

Flexible Array





FA Equipment

Data Acquisition Systems

Reftek R125 "Texan"

1700

Reftek R130

407 (+ 40 Q330)

Sensors

GS11 Hi F

L-40 Hi F

Episensor Short-period

CMG- 40T-1HZ Short-period

CMG- 3T- Broadband

1700

400

20

135

370

Station with radio communications solar power system

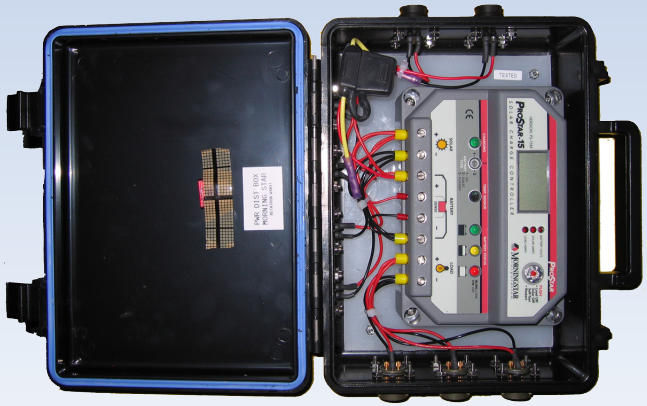
Field testing of broadband systems

Standard Station Equipment

Sensor vault systems

Charge and power control systems

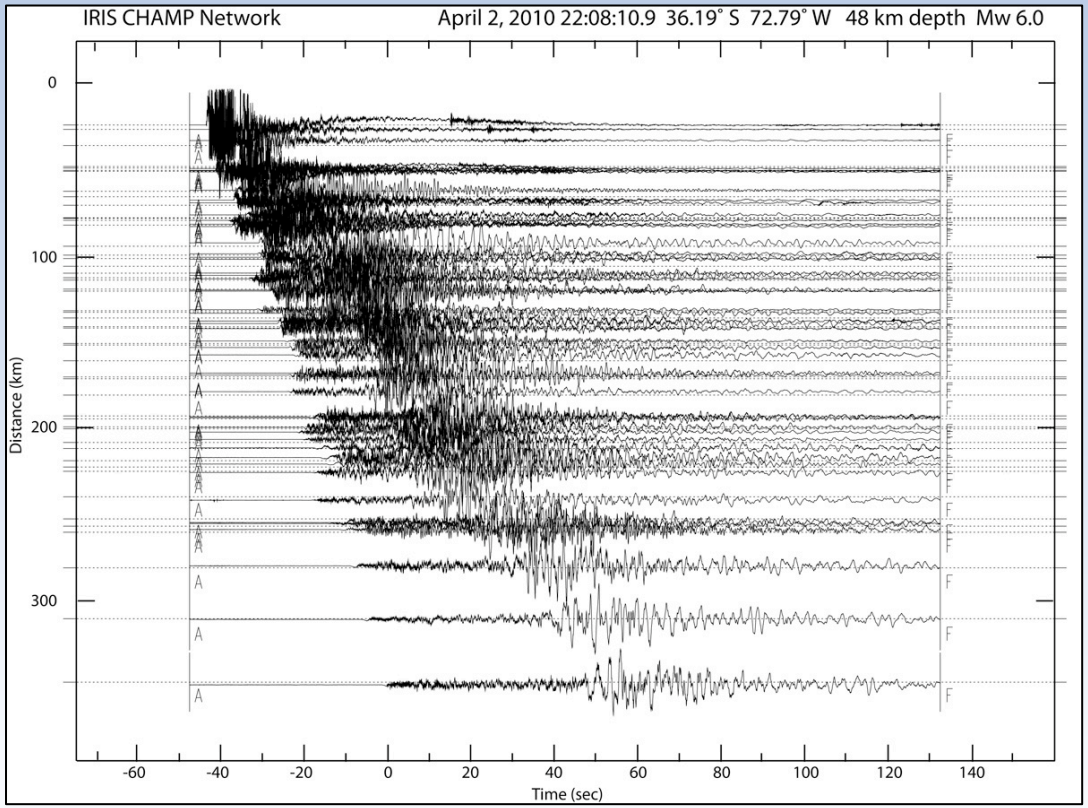
Equipment enclosures



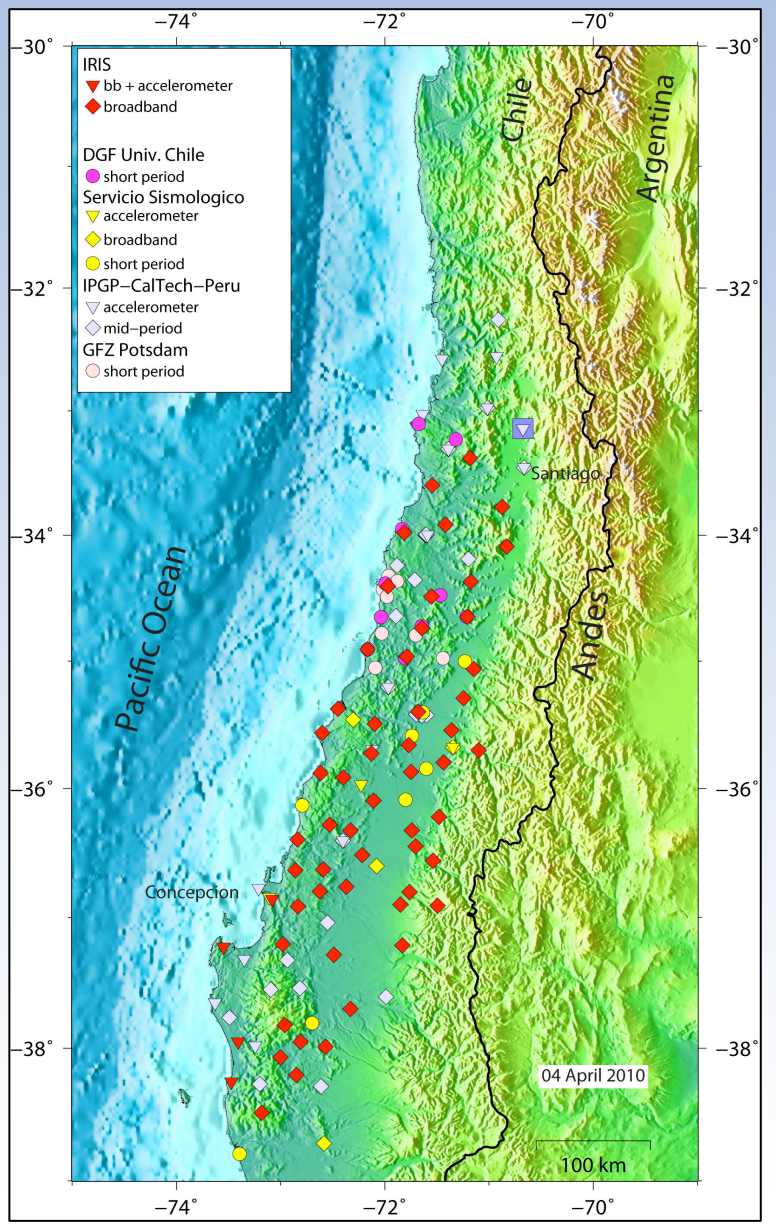
~410 stations worth of standardized equipment available

Chile RAMP

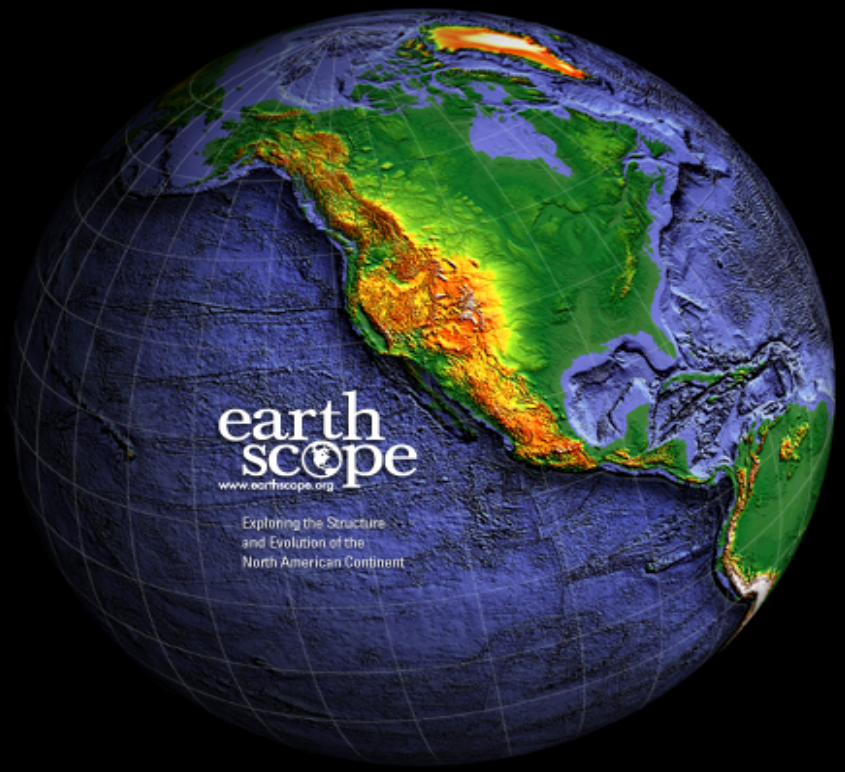
- FA broadbands in Chile



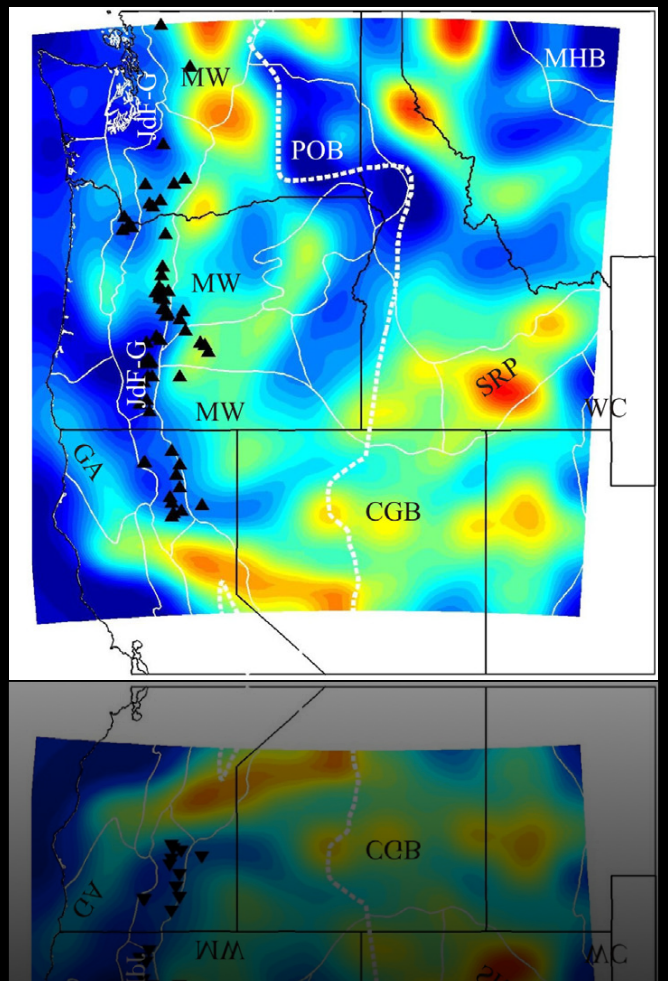
50 BHZ records of M6 aftershock on 4/2/10



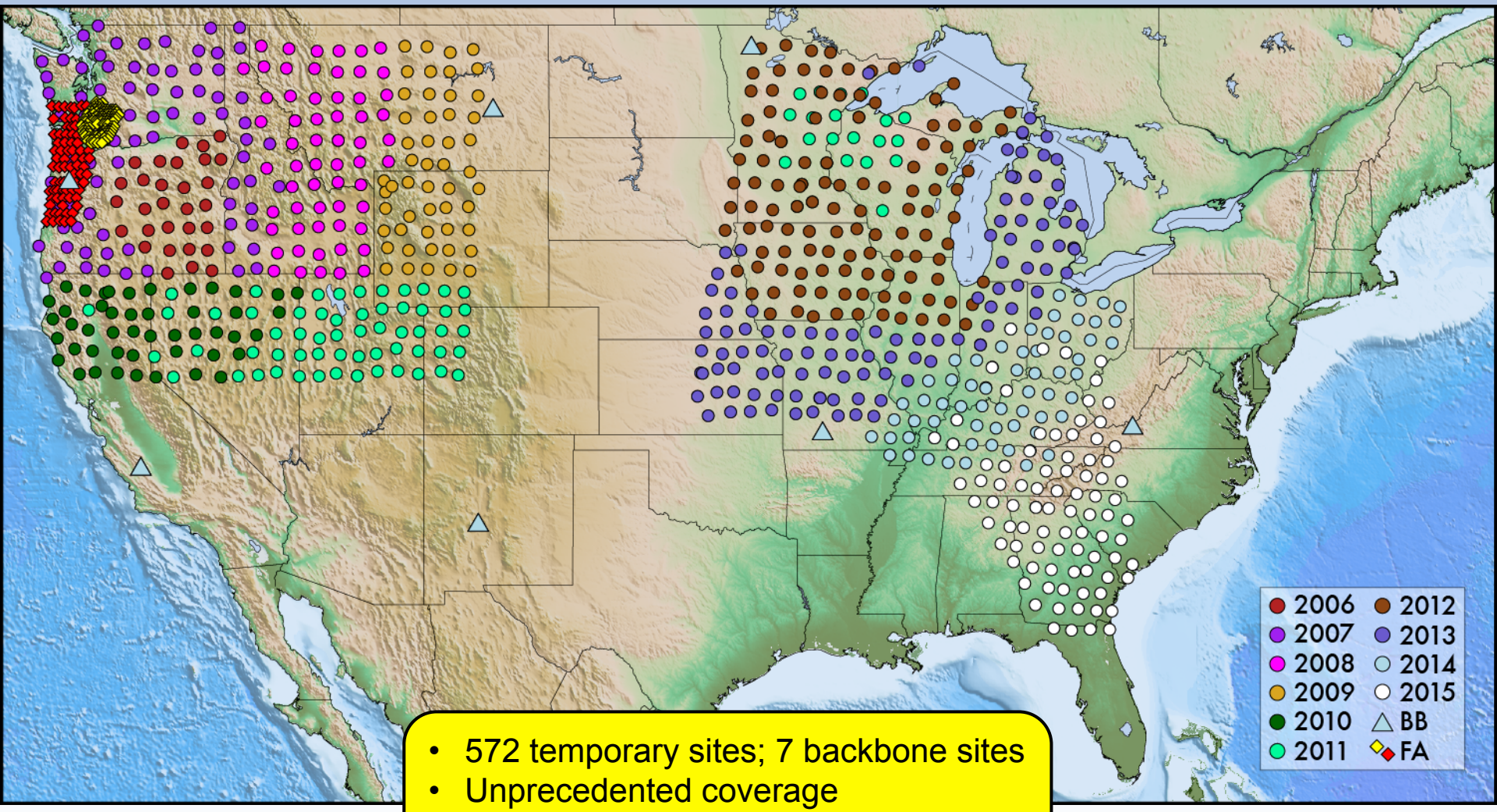
Magnetotellurics



Mantle resistivity beneath the Pacific Northwest
Bedrosian and Feucht



Magnetotelluric Stations



- 572 temporary sites; 7 backbone sites
- Unprecedented coverage
- Move from profiles to 3D
- Uniform, open community data sets

Magnetotelluric Stations

- MT-TA station in 2-3 weeks per site
- Program collecting a first of-its-kind dataset, a powerful new complementary observation

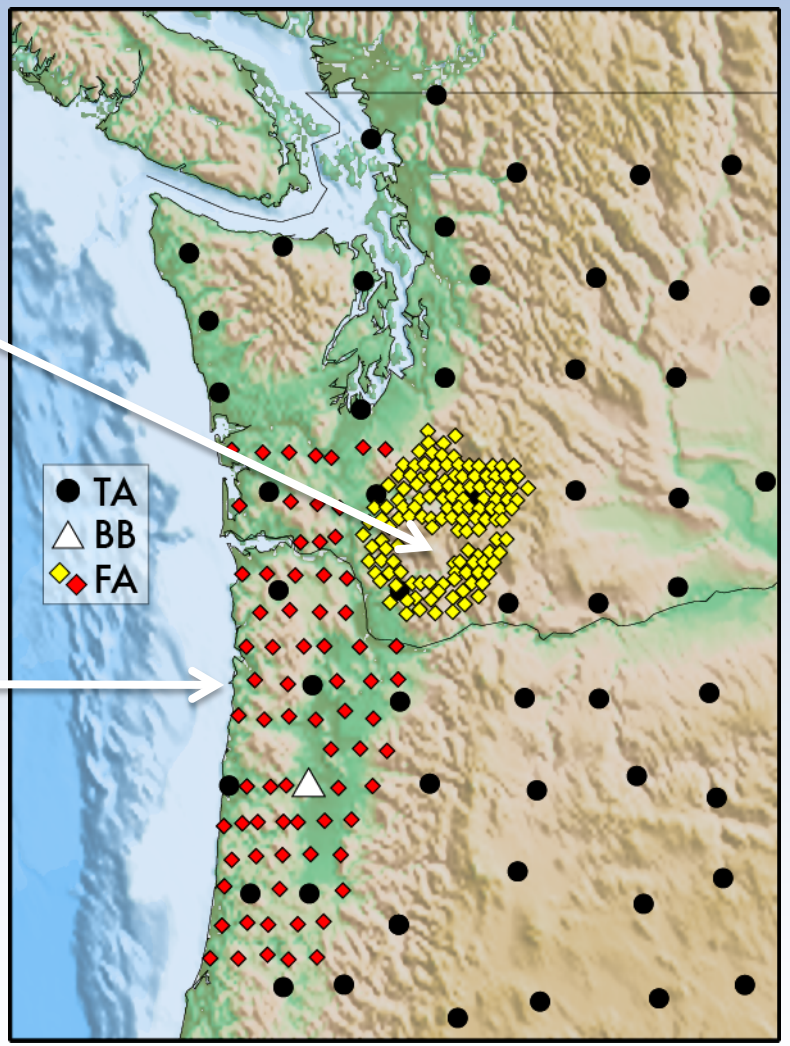
MT – Flexible Arrays

EarthScope/GeoPRISMS iMUSH

Purpose: Image Magma Under St. Helens

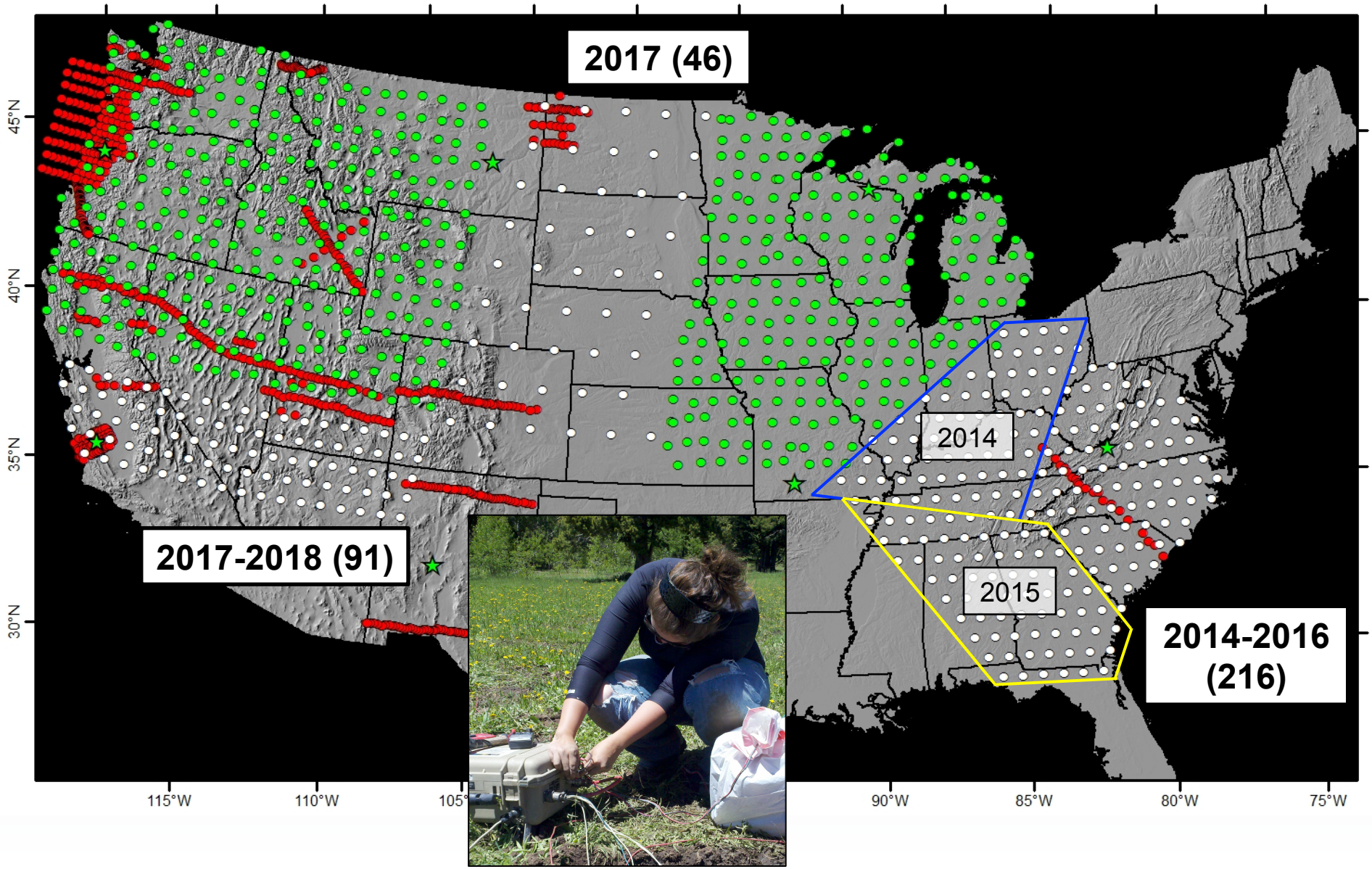
EarthScope *MOCHA*
"*Magnetotelluric Observations of Cascadia using a Huge Array*"
onshore-offshore MT project

Purpose: Characterize role of fluids in Episodic Tremor and Slip/Margin Segmentation/Megathrust Earthquakes

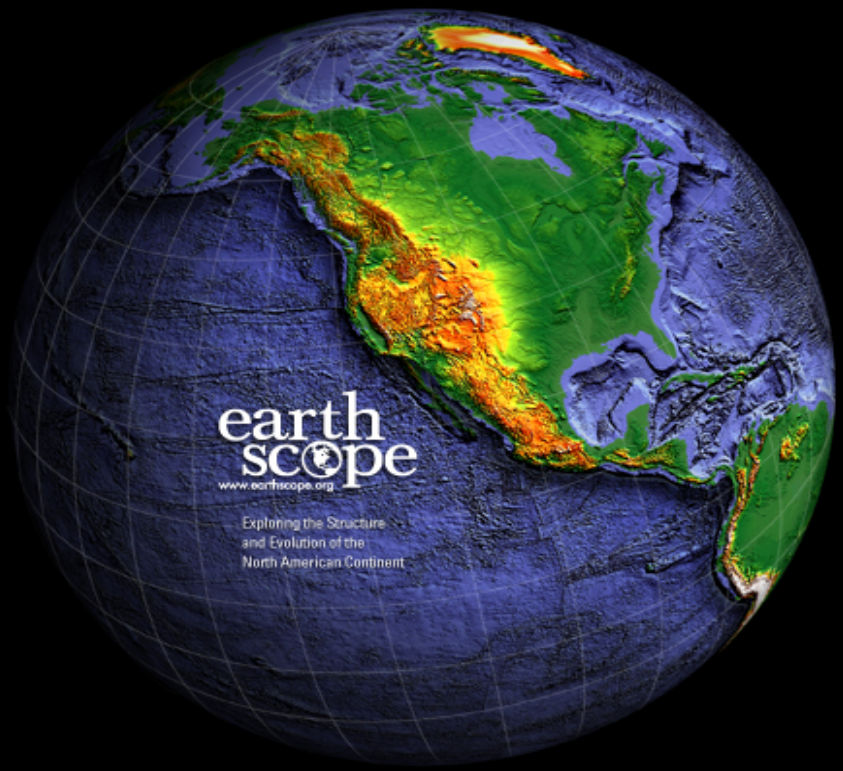


- EarthScope MT PI support didn't exist in 2009!
- Now a significant activity

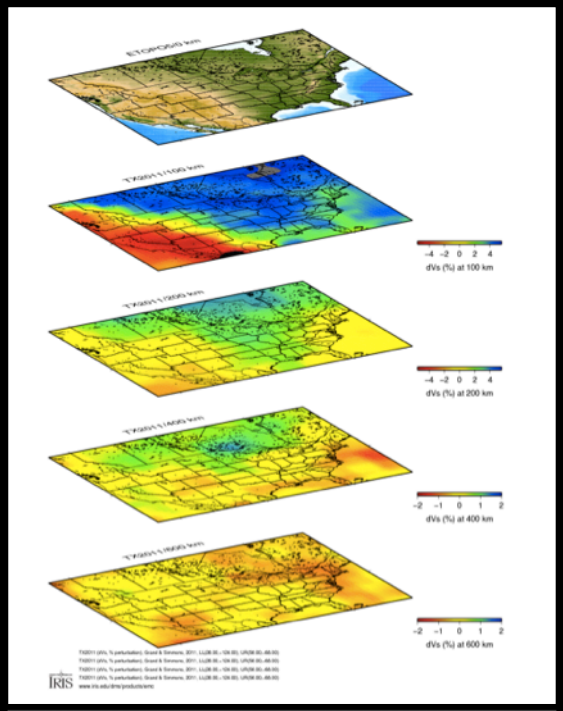
Looking Ahead

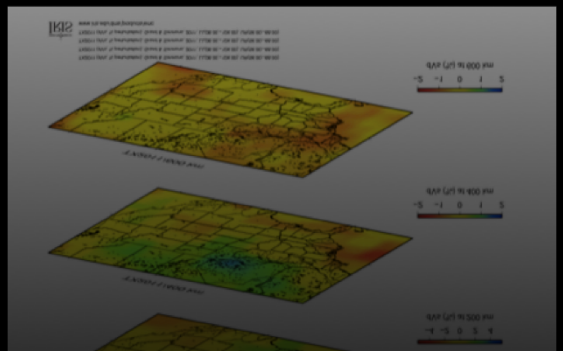


Data Management

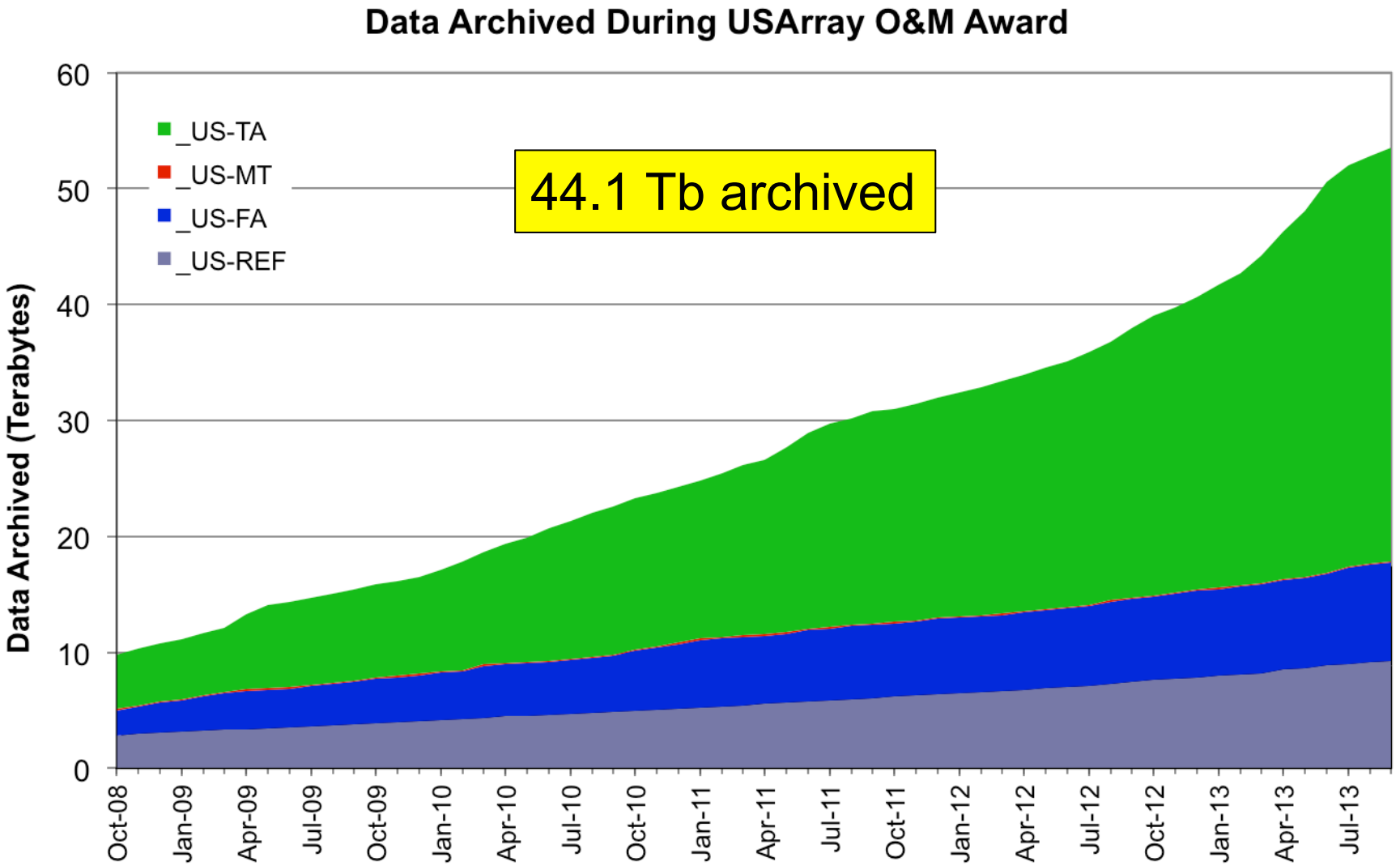


Earth Model Collaboration

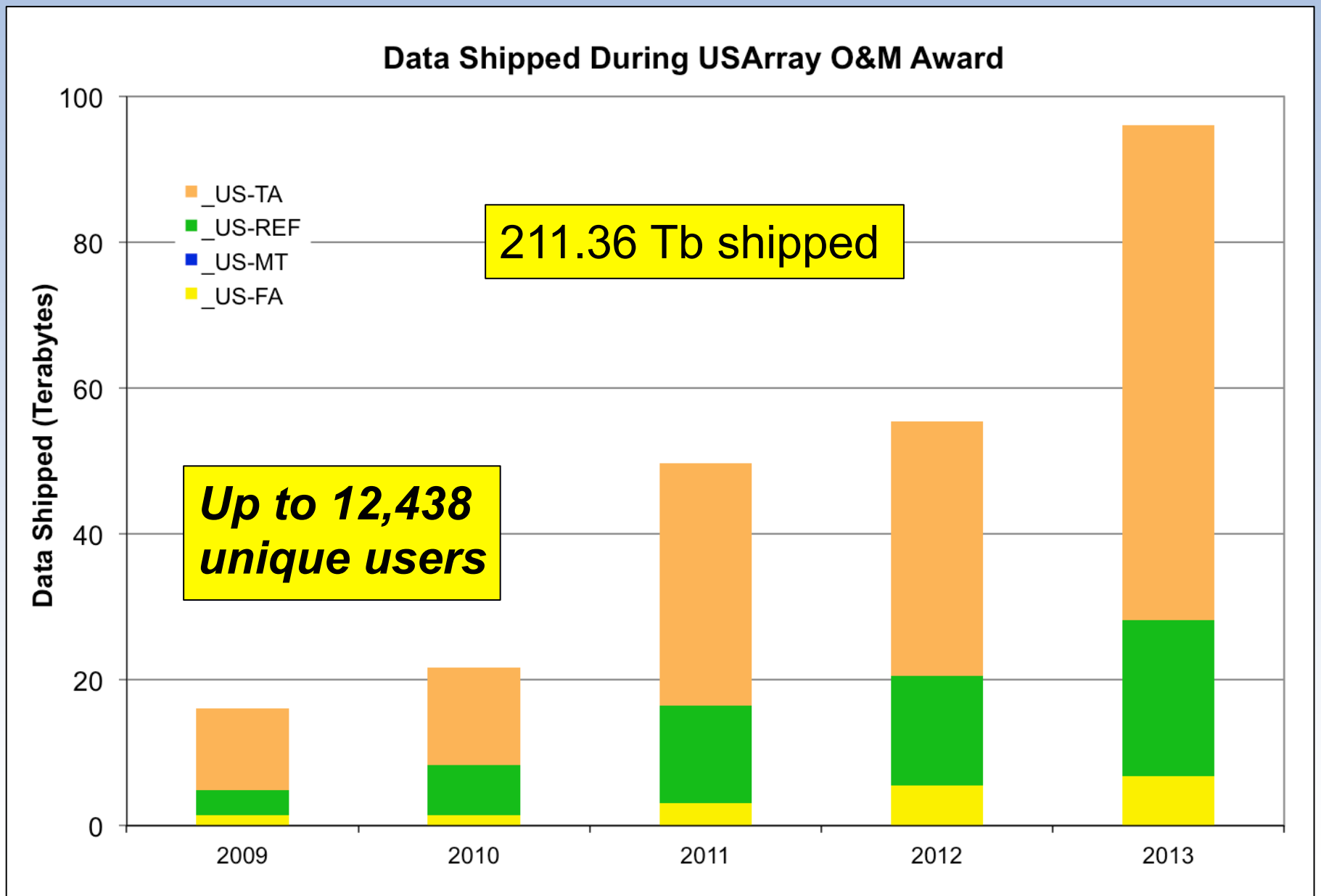




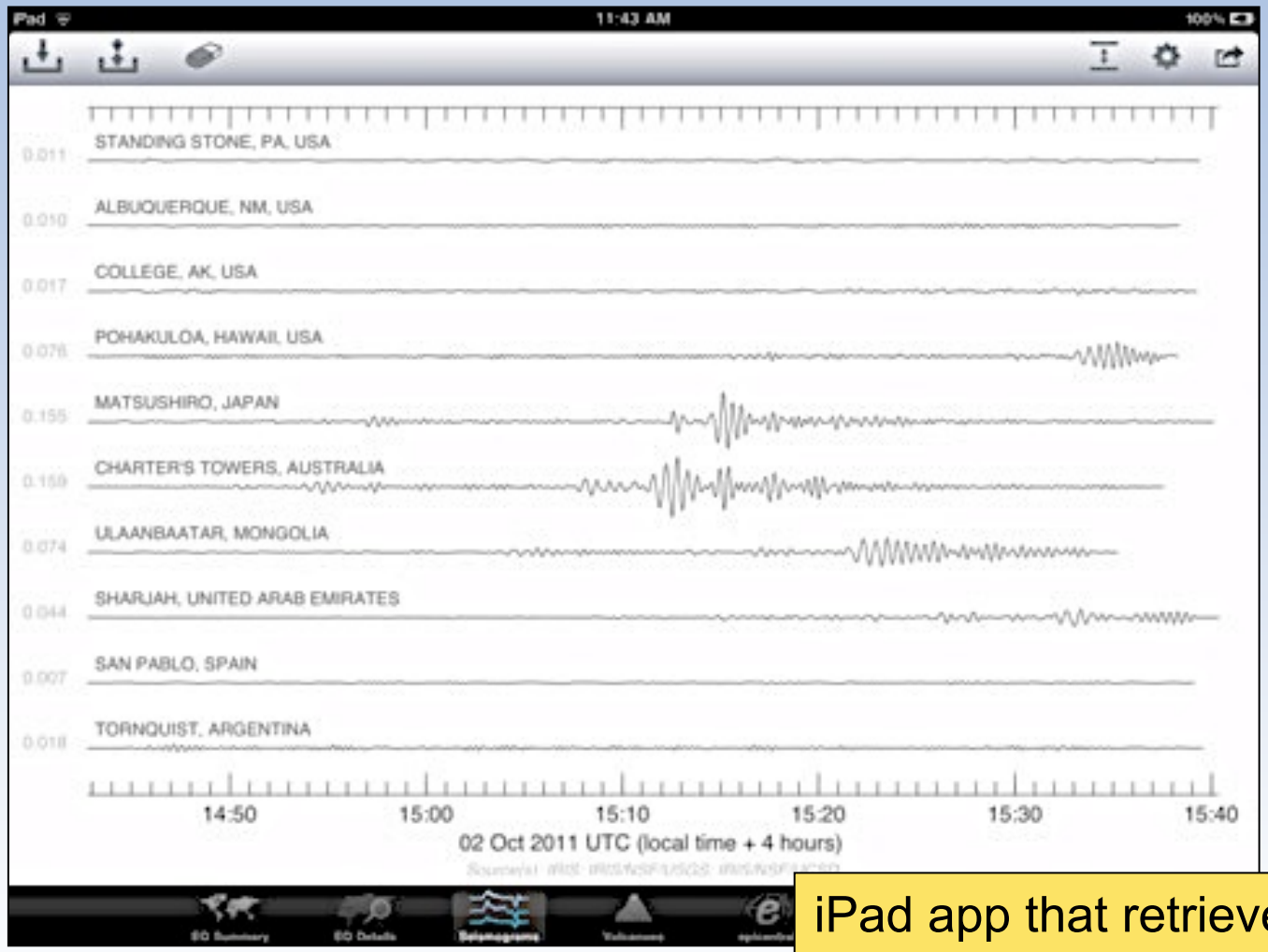
Data Archived



Data Shipped



Open Data

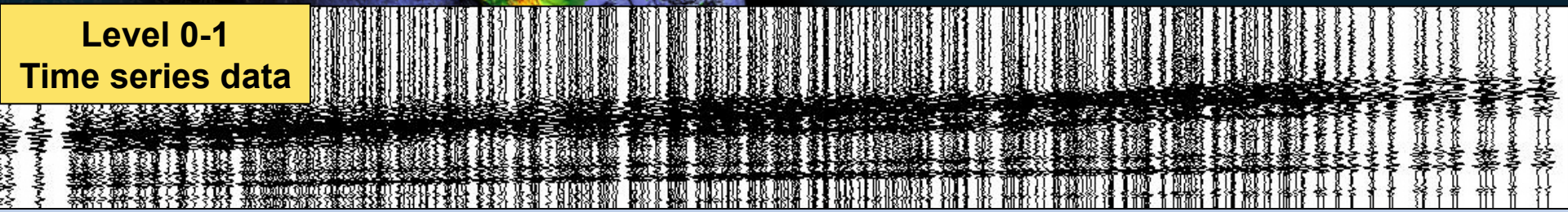


iPad app that retrieves real time seismic data via webservices

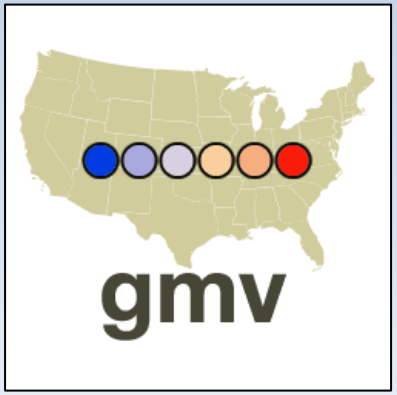
EpiCentral+ App created by Chuck Ammon, Penn State

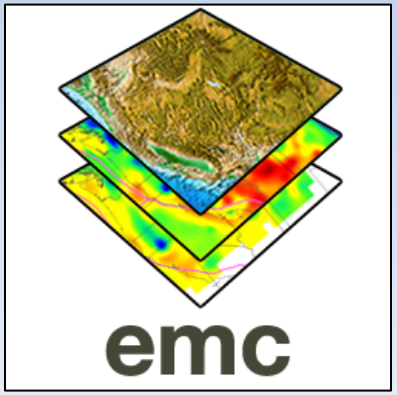
Data Products

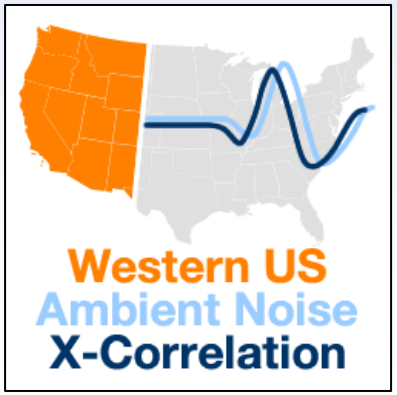
Level 0-1
Time series data

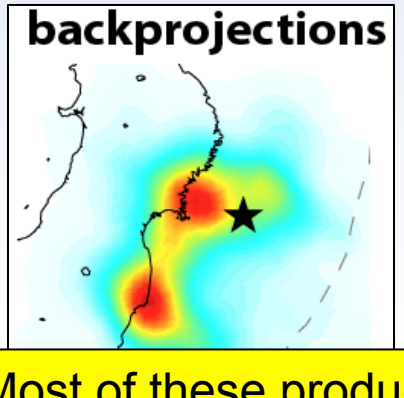


Level 2-3 Products



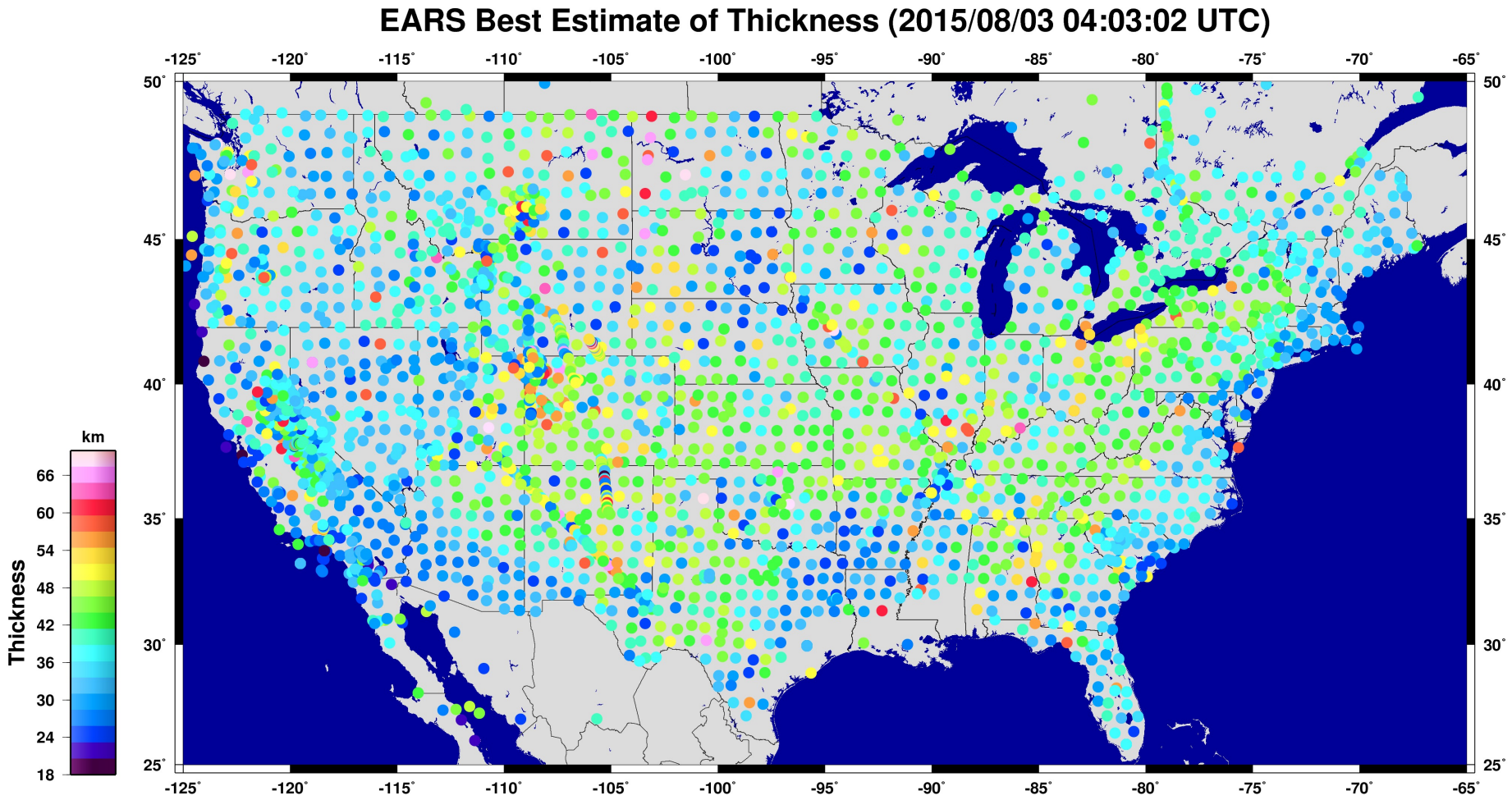






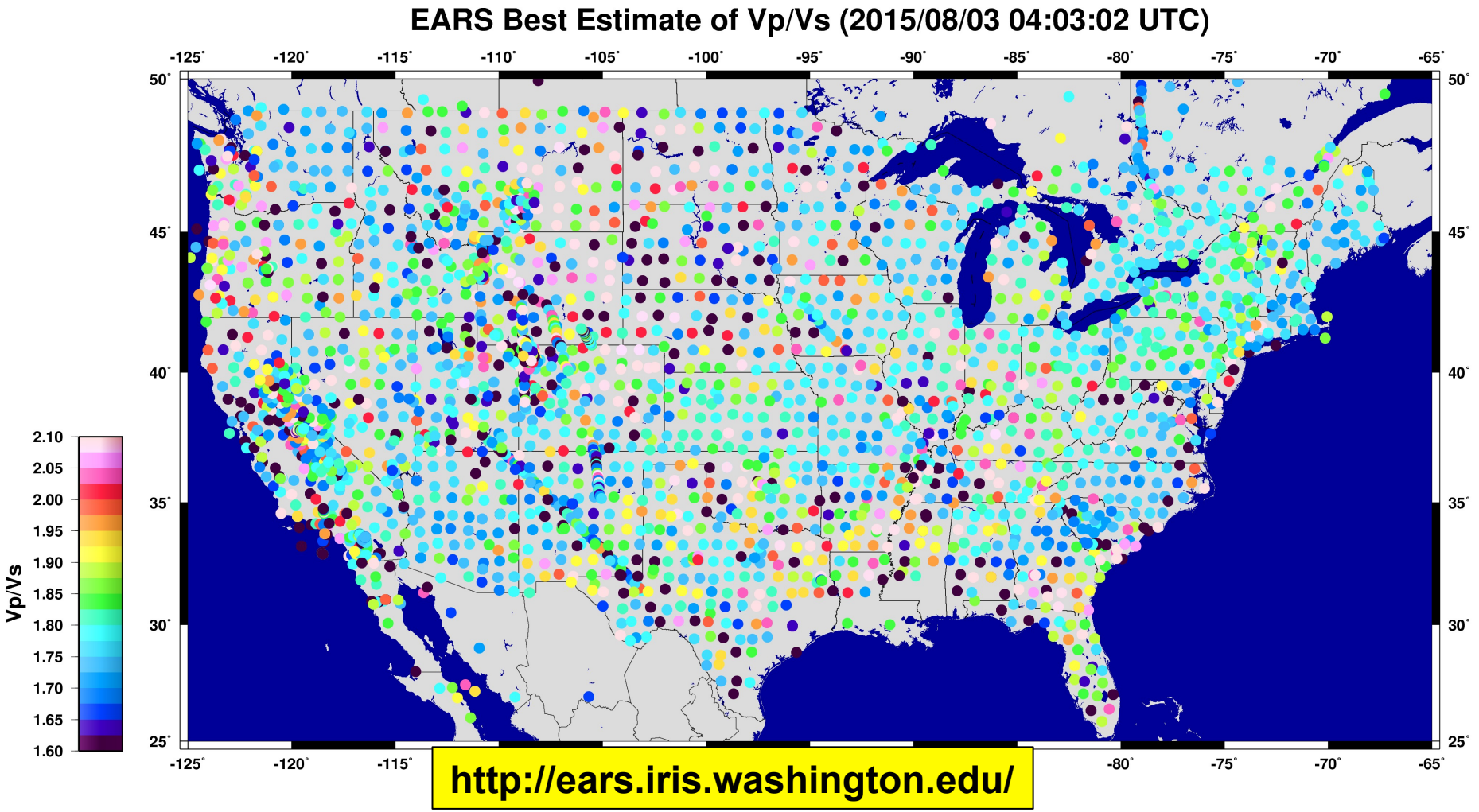
Most of these products did not exist in 2009

EARS


EARS Best Estimate of Thickness (2015/08/03 04:03:02 UTC)
-125˚ -120˚ -115˚ -110˚ -105˚ -100˚ -95˚ -90˚ -85˚ -80˚ -75˚ -70˚ -65˚
50˚ 45˚ 40˚ 35˚ 30˚ 25˚
Thickness
km
66 60 54 48 42 36 30 24 18

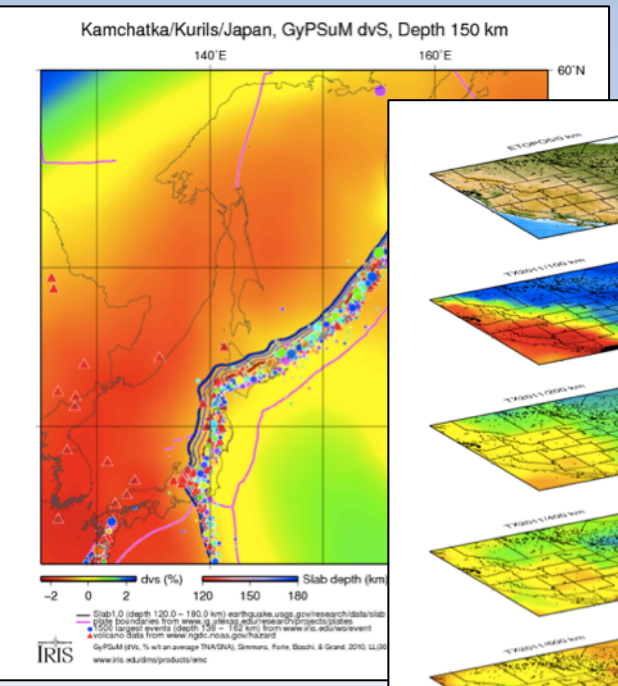
EARS

- EARS transitioned to DMC and in routine operation

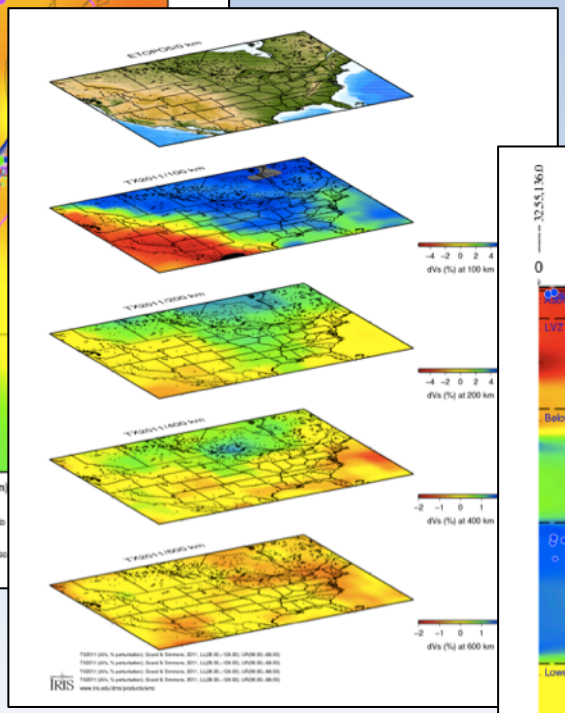


Earth Model Collaboration

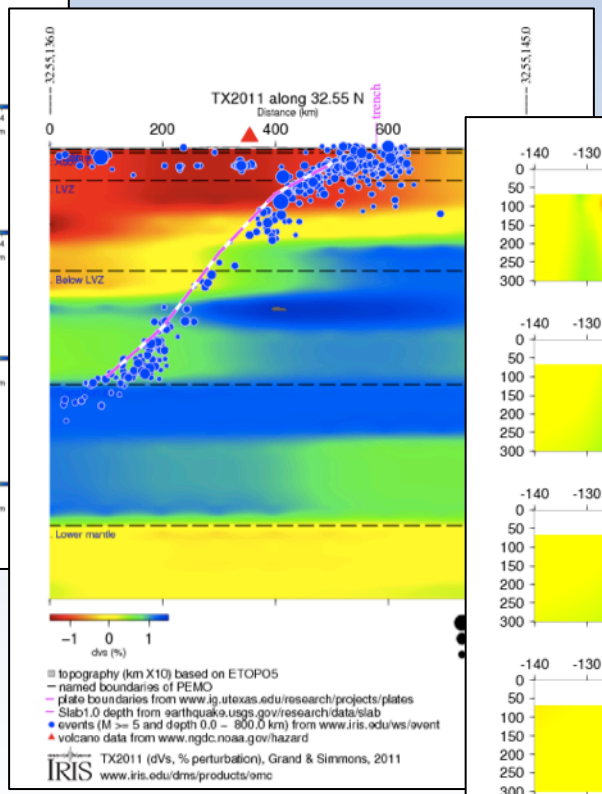
Slice



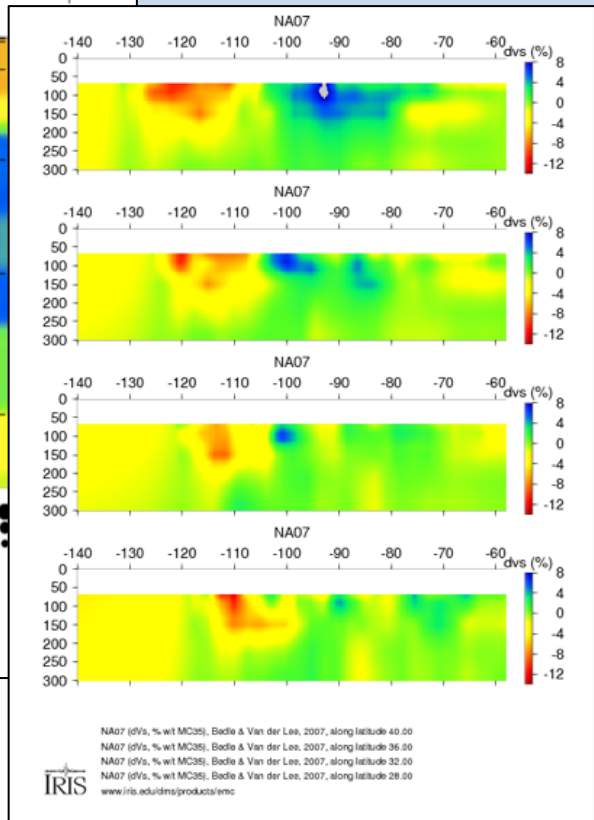
Slice - stack



Cross-section



Cross-section stack



- User contributed models
- Reference datasets
- Web interface and model export

The ability to compare models was identified as critical cyberinfrastructure

Community Models

Query Results: 37 items found

Page: 1 of 1 — 100

Type	Model Name	
1D Reference	AK135-F	ak135-F spherical average model
3D Tomography	GyPSuM	A global 3-D model of mantle shear wave (S) and compressional (P) spe
3D Tomography Earth Model	S362ANI+M	This model is an update to S362ANI and S362WMANI representing an a
3D Tomography Earth Model	US-SL-2014	P and S teleseismic body-wave tomography of the mantle beneath the U
1D Reference	STW105	A 1D Reference Earth Model
1D Reference	TNA/SNA	Average of the TNA and SNA models
1D Reference	PREM500	Modified PREM (Preliminary Reference Earth Model)
1D Reference	PREM	Preliminary Reference Earth Model (PREM)
1D Reference	PEM	Parametric Earth Models (PEM)
1D Reference	MC35	A 1D modified PEM-C S velocity model
1D Reference	IASP91	iasp91 velocity model
3D Tomography	LLNL-G3Dv3	A global P wave tomography model based on regional and teleseismic tr
3D Q Model	QRLW8	A global upper mantle shear attenuation model
3D Tomography Earth Model	Taiwan.TTT.KWS.2012	3D P-wave velocity model of Taiwan from travel-time tomography
3D Tomography Earth Model	CASCADE.ANT.GAO-SHEN.2014	3D shear-wave velocity model of the Cascades from full-wave ambient n
3D full-waveform Earth Model	SEMum	A high-resolution global shear velocity model of upper mantle
3D Tomography	wUS-SH-2010	P and S teleseismic body-wave tomography of the western United State
3D Tomography	S2.9EA	A global model with higher resolution in the upper mantle beneath Eura
3D Tomography	S362WMANI	A global model of shear-wave velocities
3D Tomography	S362ANI	A global model of shear-wave velocities
3-D Regional Electrical Conductivity Model	SRPY-MT	Regional 3-D electrical conductivity model of Snake River Plain / Yellows
3D Tomography	TX2011	A global mantle shear-wave tomography model
3D Tomography	TX2000	A global mantle shear-wave tomography
3D Tomography	SAW642AN	Global radially anisotropic mantle S velocity
3D Tomography	SAW642ANb	Global radially anisotropic mantle S velocity
3D Tomography	SAW24B16	A global shear velocity structure of the mantle
3D Tomography	PNW10-S	3D S-wave tomography Earth model for the Cascadia Subduction Zone
3D Tomography	NWUS11-S	3D S-wave tomography model for NW United States
3D Tomography	NWUS11-P	3D P-wave tomography model for NW United States
3D Tomography	NA07	N. American upper mantle surface wave tomography
3D Tomography	NA04	N. American upper mantle surface wave tomography
3D Tomography	HMSL-S06	A global shear velocity model of the mantle
3D Tomography	HMSL-P06	A global compressional velocity model of the mantle
3D Tomography	DNA13	P- and S-velocity models for the western US integrating body- and surfa
3D Tomography	DNA10-S	3D S-wave tomography Earth model
3D Tomography	DNA09	3D P- & S-velocity tomography Earth model
3D full-waveform Earth Model	SAWum-NA2	A high-resolution North American shear velocity model of upper mantle

ds.iris.edu/spud/earthmodel/9785430

Products ▾ Help ▾

DNA10-S - 3D S-wave tomography

Model Summary

Name:	DNA10-S
Title:	3D S-wave tomography Earth model
Type:	3D Tomography
Sub Type:	S velocity perturbation (%)
Year	2010
Author(s):	Mathias Obrebski Department of Earth and Planetary Science University of California, Berkeley California, USA Richard M. Allen Department of Earth and Planetary Science University of California, Berkeley California, USA Fred Pollitz US Geological Survey Reston, VA USA Shu!Huei Hung Department of Geosciences National Taiwan University Taipei, Taiwan
Reference(s):	Obrebski, M., R.M. Allen, F. Pollitz, and S.-H. Hung. 2011. "Lithosphere-asthenosphere interaction beneath the western United States from the joint inversion of body-wave traveltimes and surface-wave phase velocities." Geophys. J. Int. 185:1003-1021.
Depth Coverage:	0.0 - 1000.0 km
Areal Coverage:	Latitude: 30.0 to 50.0 Longitude: -126.0 to -98.0
Model Description	The DNA10-S model integrates teleseismic body-wave traveltime and surface-wave phase velocity measurements into a single inversion to constrain the S-wave velocity structure beneath the western US (from the Pacific coast to ~100 deg W, from Mexico to Canada).
Data Set Description	[Obrebski et al. (2011)] The station distribution that used in this study covers all the major magmato-tectonic features of the active western United States plus the westernmost part of the stable cratonic United States. This includes more than 1200 stations from the USArray transportable array, regional seismic networks, and temporary seismic deployments. Data were recorded from 2006 January to 2010 January. Relative traveltimes of teleseismic body waves (S and SKS) obtained from about 162 earthquakes, and surface wave phase velocity measurements from 167 eartqhuakes were used to constrain the model.
Web Page	seismo.berkeley.edu/~rallen/research/dna/dna10
EMC Page	ds.iris.edu/ds/products/emc-dna10-s

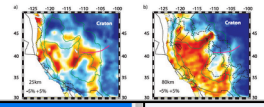
Model Data

Description	Size	Model
The netCDF binary for the above model.	2.2 MB	Download

Model URLs

URL	Description
http://seismo.berkeley.edu/~rallen/research/dna/dna10/download/DNA10.tar.gz	original model files from the model download page

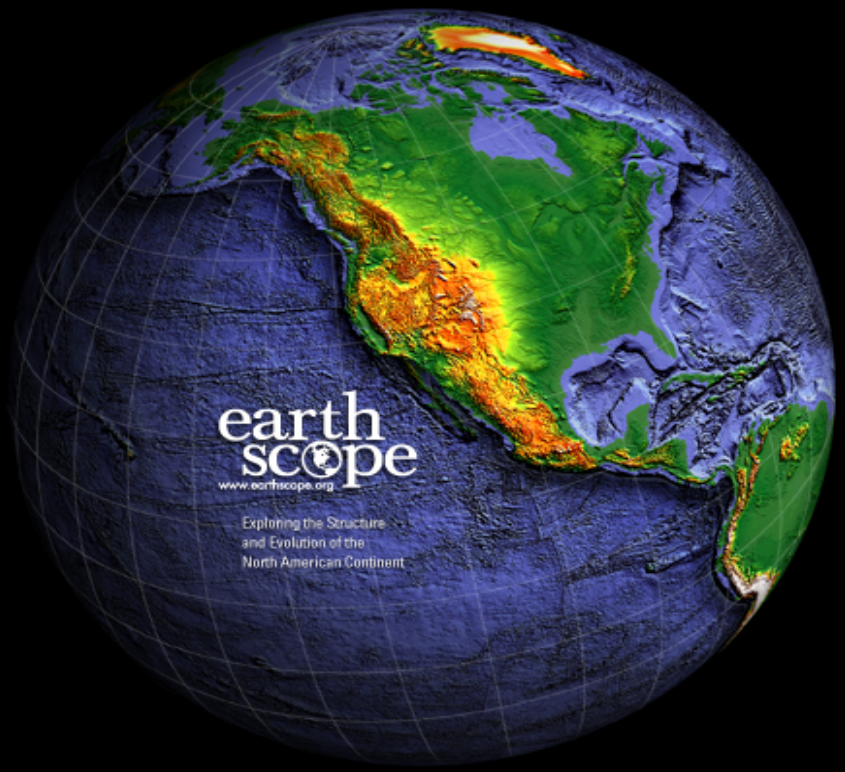
Figure below, Obrebski et al. (2011) , shows model DNA10-S S velocity perturbation at 8 depths.



emc

At least 12 new models available in Earth Model Collaboration have been generated with USArray data.

Outreach



"X-RAY EARTH", aired May 15, 2011

Science Impact

Prominently featured in major scientific news publications


NEWS | IN FOCUS

Scientists tested rugged new equipment for the Transportable Array near Toolik Lake, Alaska, in 2011.

GEOSCIENCE

US seismic array eyes its final frontier

Moveable sensor grid will begin monitoring Alaska next summer.

BY ALEXANDRA WITZE

On Maine's rugged coast, just north of the tourist town of Boothbay, an underground seismometer is listening for earthquakes. Engineers activated it on 26 September, completing the US$90-million Transportable Array …

… rises in the hot spot deep beneath Yellowstone National Park in Wyoming.

"As the array has moved, the whole picture of what's under North America has gotten much sharper," says Andy Frassetto, a seismologist at the Incorporated Research Institutions for Seismology (IRIS) in Washington DC, which operates the stations.

Now, the Transportable Array's operators are looking to the far north, in what may be its toughest challenge yet. Having almost finished the job in the lower 48 states, the seismometers will start to be relocated next spring to Alaska …

… across North America on all aspects of geoscience. EarthScope's second component comes in the form of Global Positioning System instruments that detect tiny changes in ground movement, such as those that occur along geological faults. The initiative's third component was a 3.2-kilometre-deep hole drilled into California's San Andreas fault, although the effort was marred when instruments lowered down the hole stopped working after just days (see *Nature* **459**, 20–21; 2009).

But the first two parts of EarthScope are yielding plenty of insights. "We've learned a …

… deeper into Earth, and with greater regularity, than with other, smaller arrays.

Among other things, the EarthScope seismic data have allowed researchers to construct images of the deep Earth, rather like a geological computerized-tomography scan (Y. Yang

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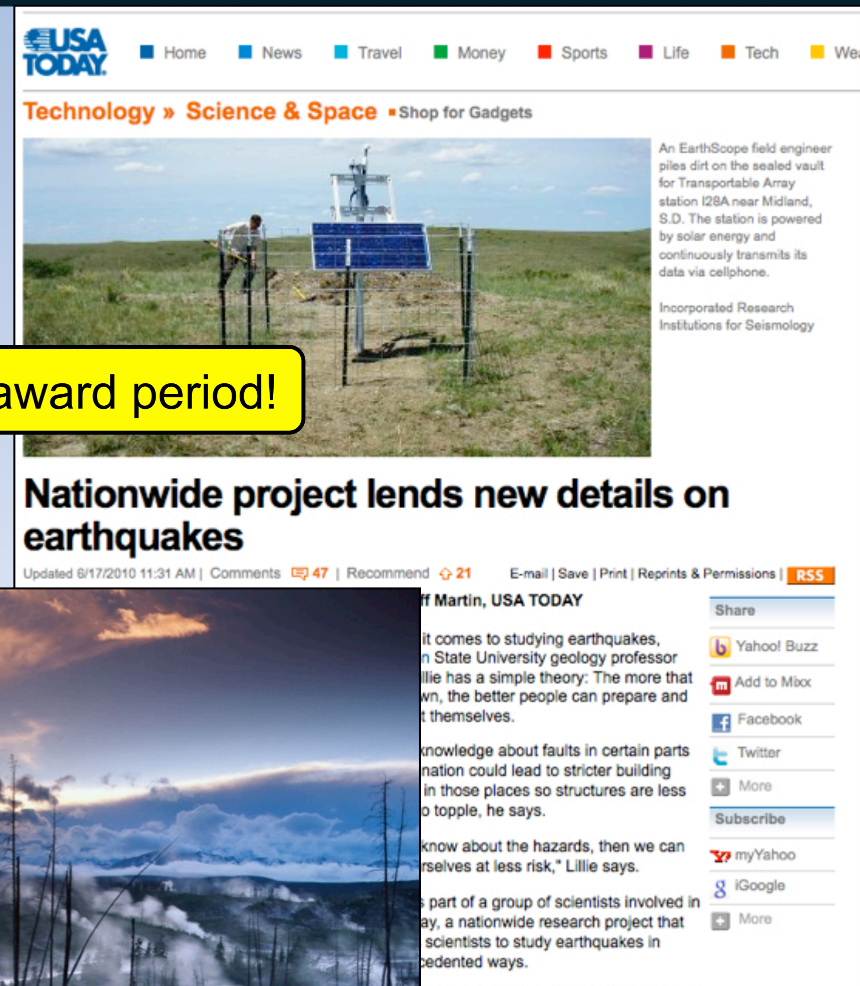
NEWSFOCUS

GEOPHYSICS

Scoping Out Unseen Forces Shaping North America

As it sweeps across America, the USArray network of seismometers is revealing an impressive but often befuddling subsurface menagerie of slabs, drips, and plumes

Public Impact



Major publicity during award period!

International Coverage

Gruppe5 Film – Cologne, Germany
L49A near Milan, Michigan

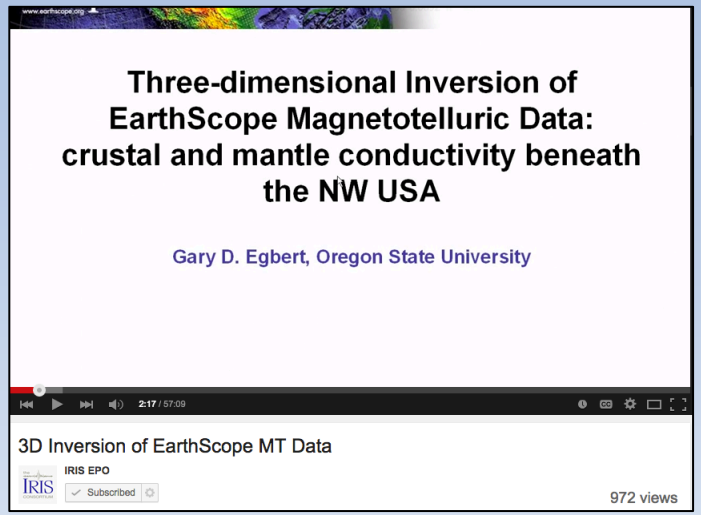


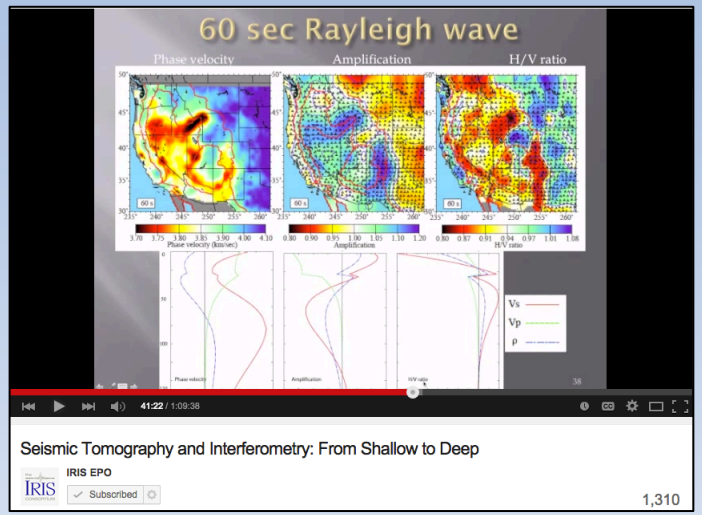




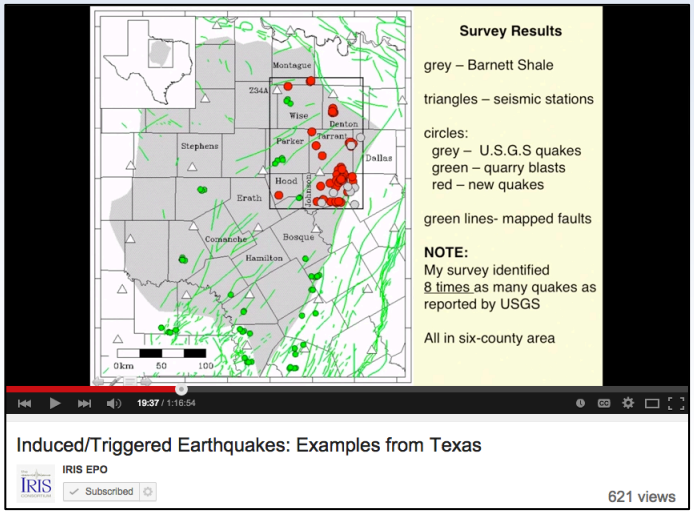
- This coverage finds us.
- Often better coverage than in US

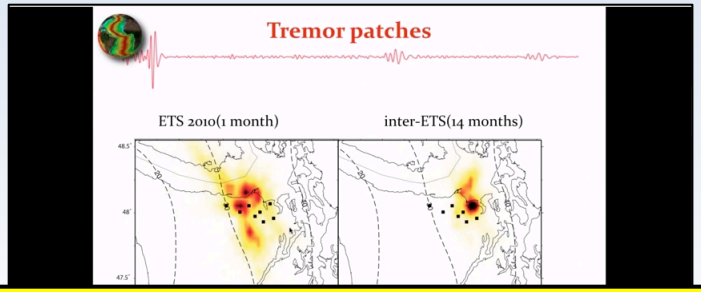
Research Webinars





- Routinely >100 attend live, hundreds of subsequent views
- 13 webinars directly linked to USArray data





- Research seminars broadcast live and archived for future viewing
- Broadly subscribed by national and international earth science communities

USArray Goes Viral

Discover
SCIENCE FOR THE CURIOUS

THE MAGAZINE | BLOGS | HEALTH & MEDICINE | MIND & BRAIN | TECHNOLOGY

BLOGS D-brief | The Crux | Body Horrors | But Not Simpler | Citizen Scienc
Out There | Science Sushi | Seriously, Science? | Field Notes

Bad Astronomy

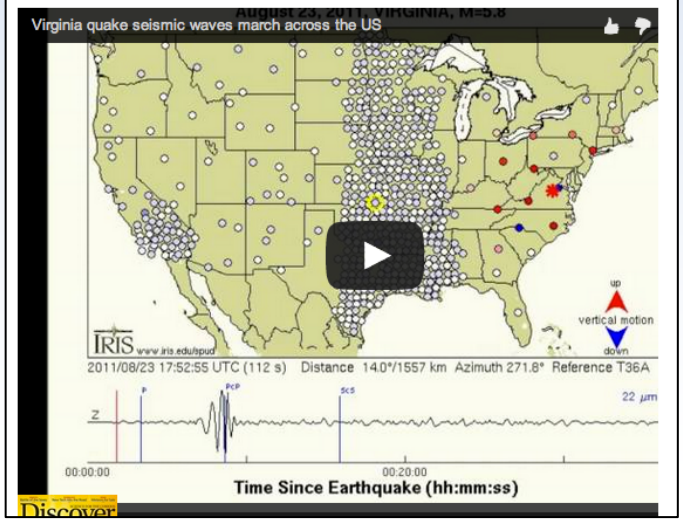
« Another jaw-dropping time lapse video: Tempest WISE finds coolest brown dwarfs ever seen! »

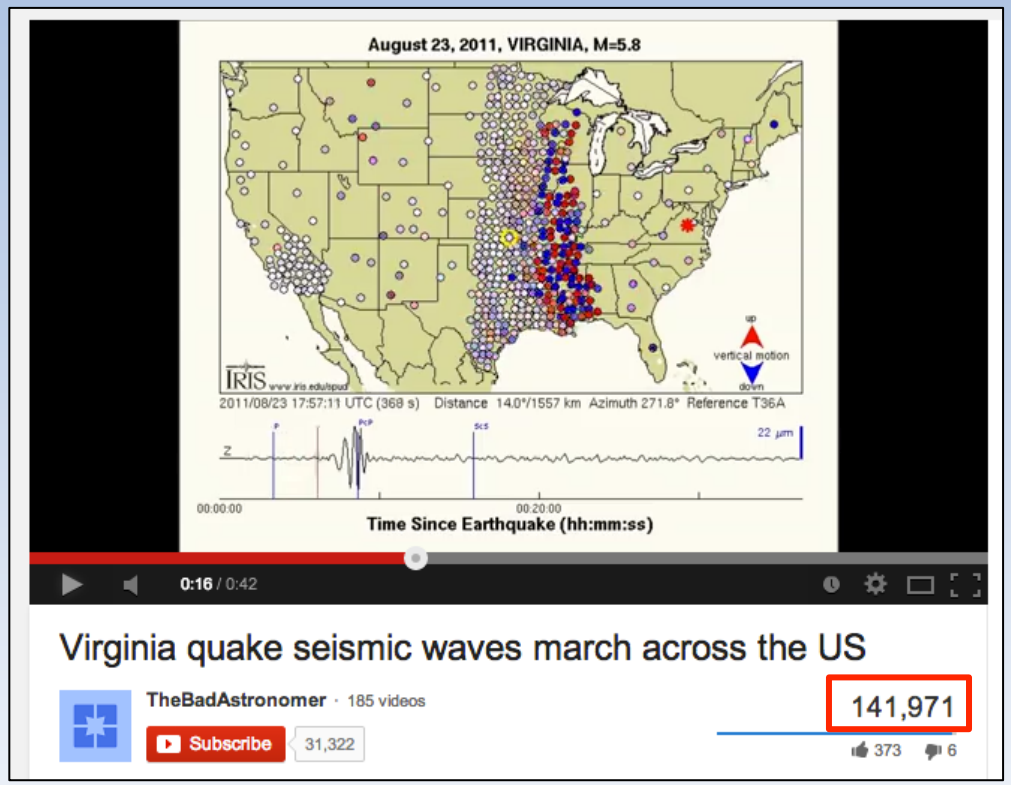
Virginia earthquake waves ripple across the US!

By Phil Plait | August 23, 2011 5:10 pm

19

This is very cool: seismometers deployed across the United States detected the seismic waves from the magnitude 5.9 earthquake that hit Virginia on August 23, 2011. In this animation showing the data you can actually *see* the wave rippling across the country!





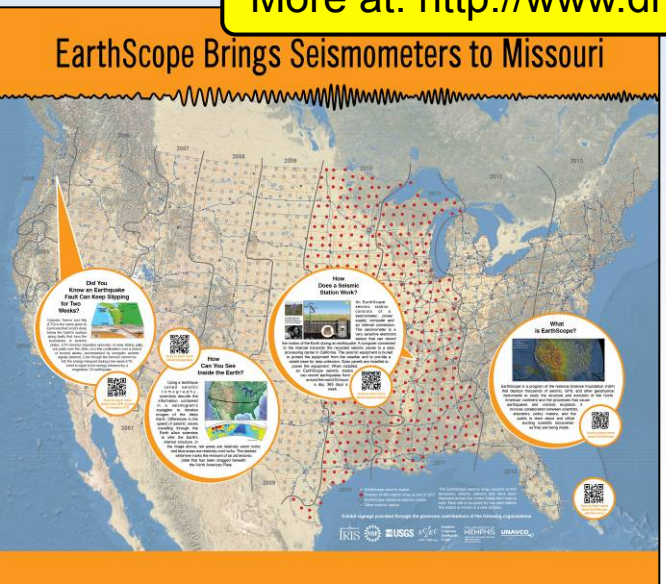
- For Virginia earthquake and other major events, IRIS content prominently used in blogs/social media

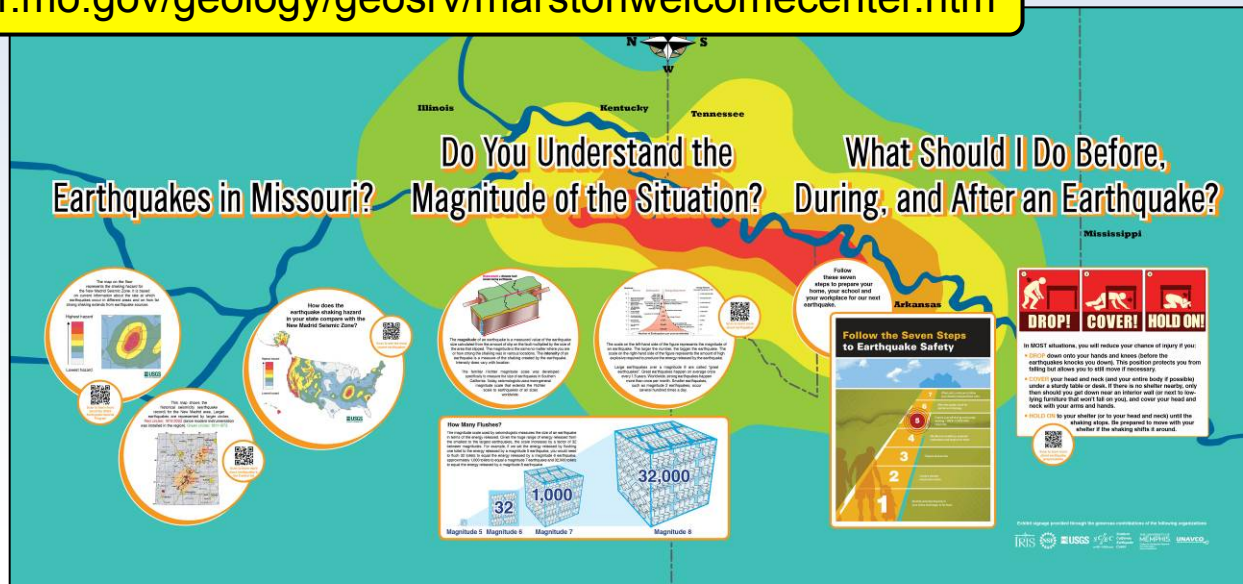
Displays for the Public

Marston Welcome Center

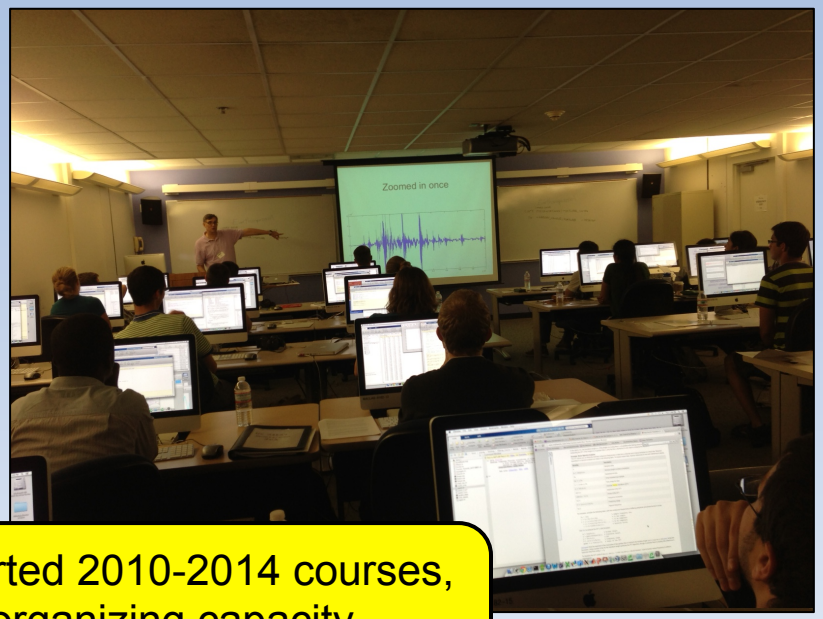
- IRIS developed content for EarthScope-themed exhibit
- Active Earth Display connected to the internet with associated signage
- Located near New Madrid, MO Southbound I-55, mile 42.4

More at: http://www.dnr.mo.gov/geology/geosrv/marstonwelcomecenter.htm





Short Courses



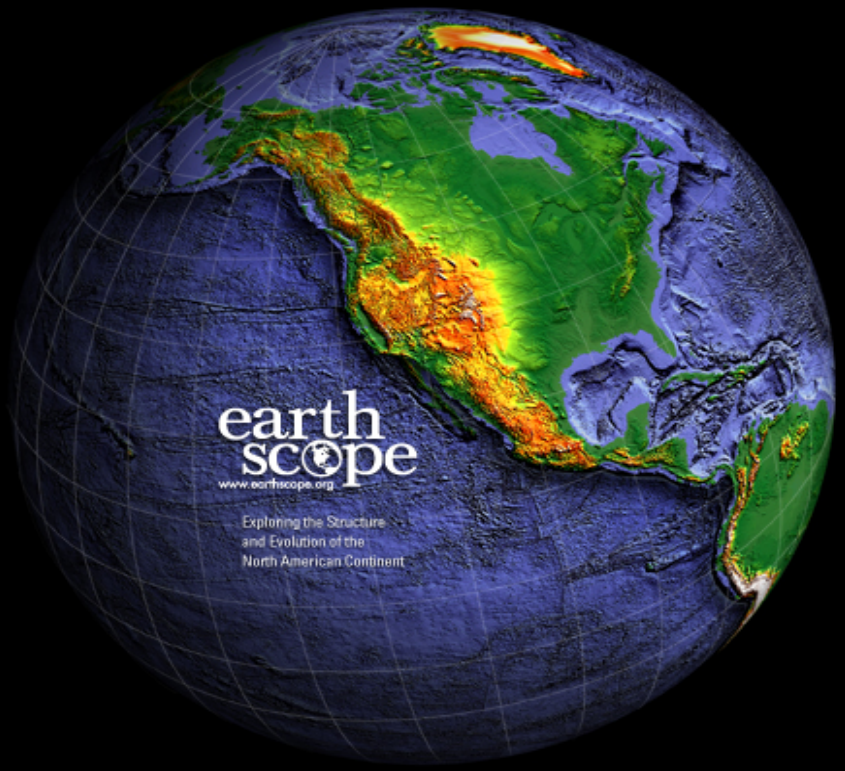
- **New scope**: Award supported 2010-2014 courses, IRIS brings expertise and organizing capacity
- 2009-2011, 2013-2014, 121 students in 6 courses

Impacts on Seismology

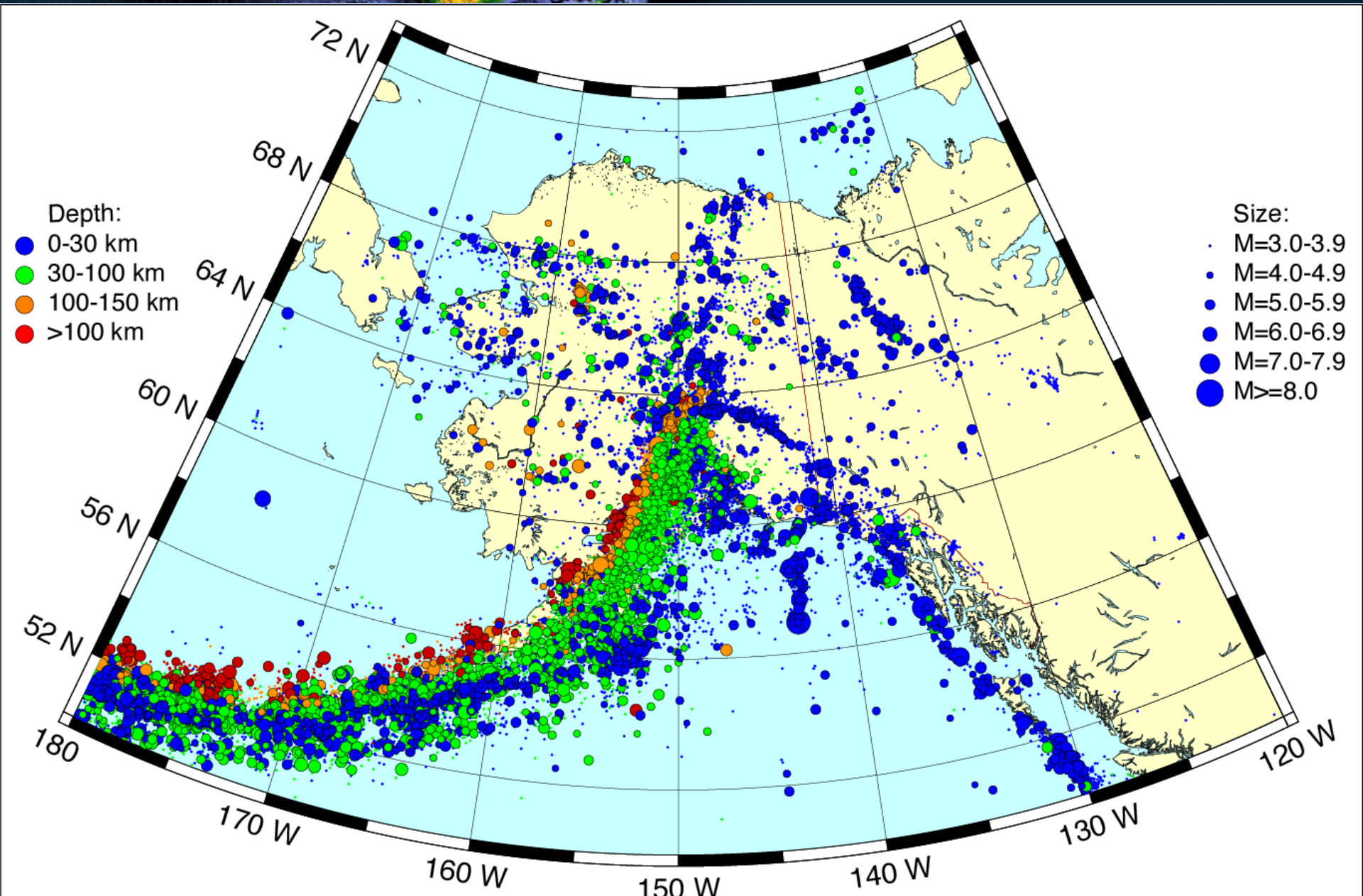
Jump starting professional partnerships and research foundations

2014 USArray Data Processing Short Course

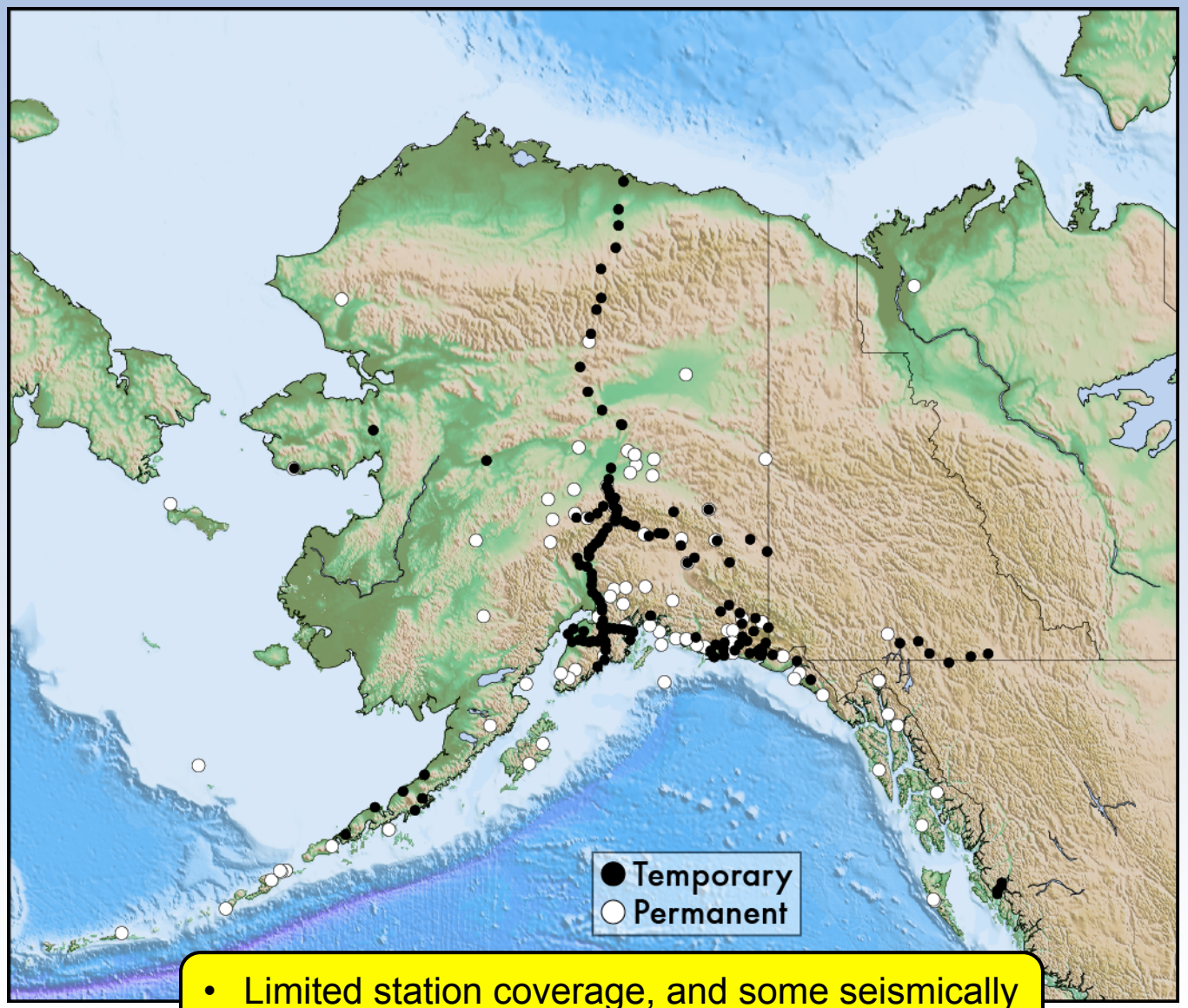
USArray's Legacy and Looking Ahead



TA in Alaska

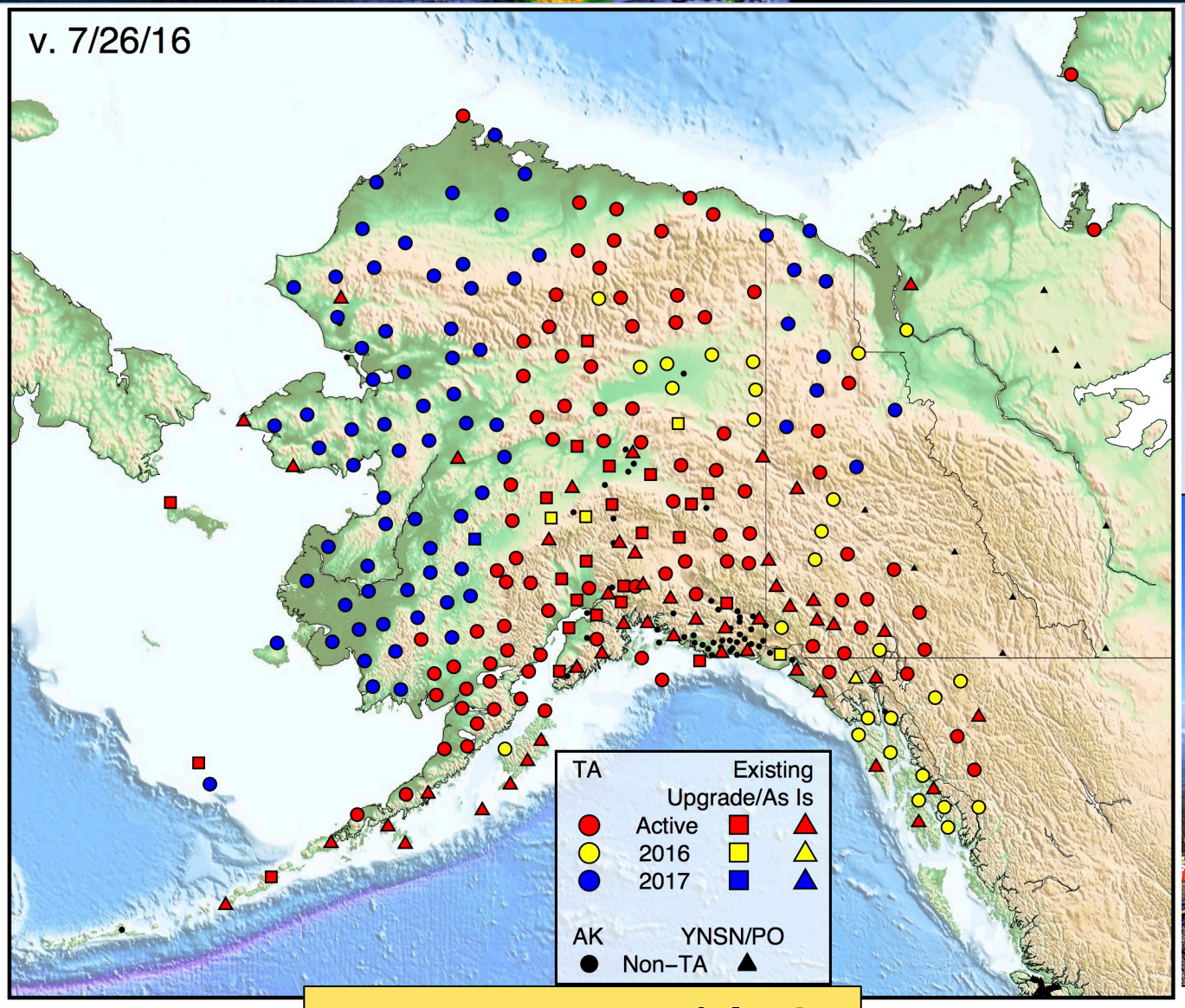

Depth:
0-30 km
30-100 km
100-150 km
>100 km
Size:
M=3.0-3.9
M=4.0-4.9
M=5.0-5.9
M=6.0-6.9
M=7.0-7.9
M>=8.0
72 N
68 N
64 N
60 N
56 N
52 N
180
170 W
160 W
150 W
140 W
130 W
120 W

Before USArray



- Limited station coverage, and some seismically active areas sparsely instrumented

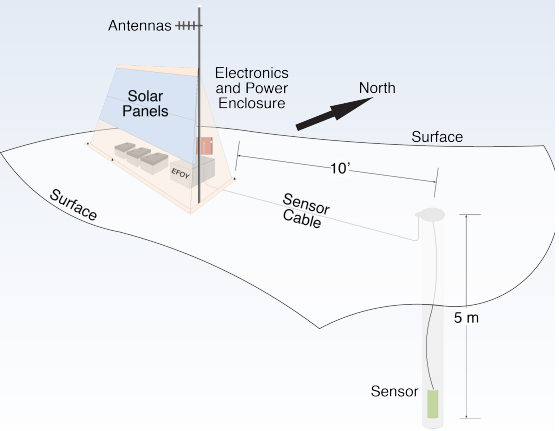
TA in Alaska – So Far

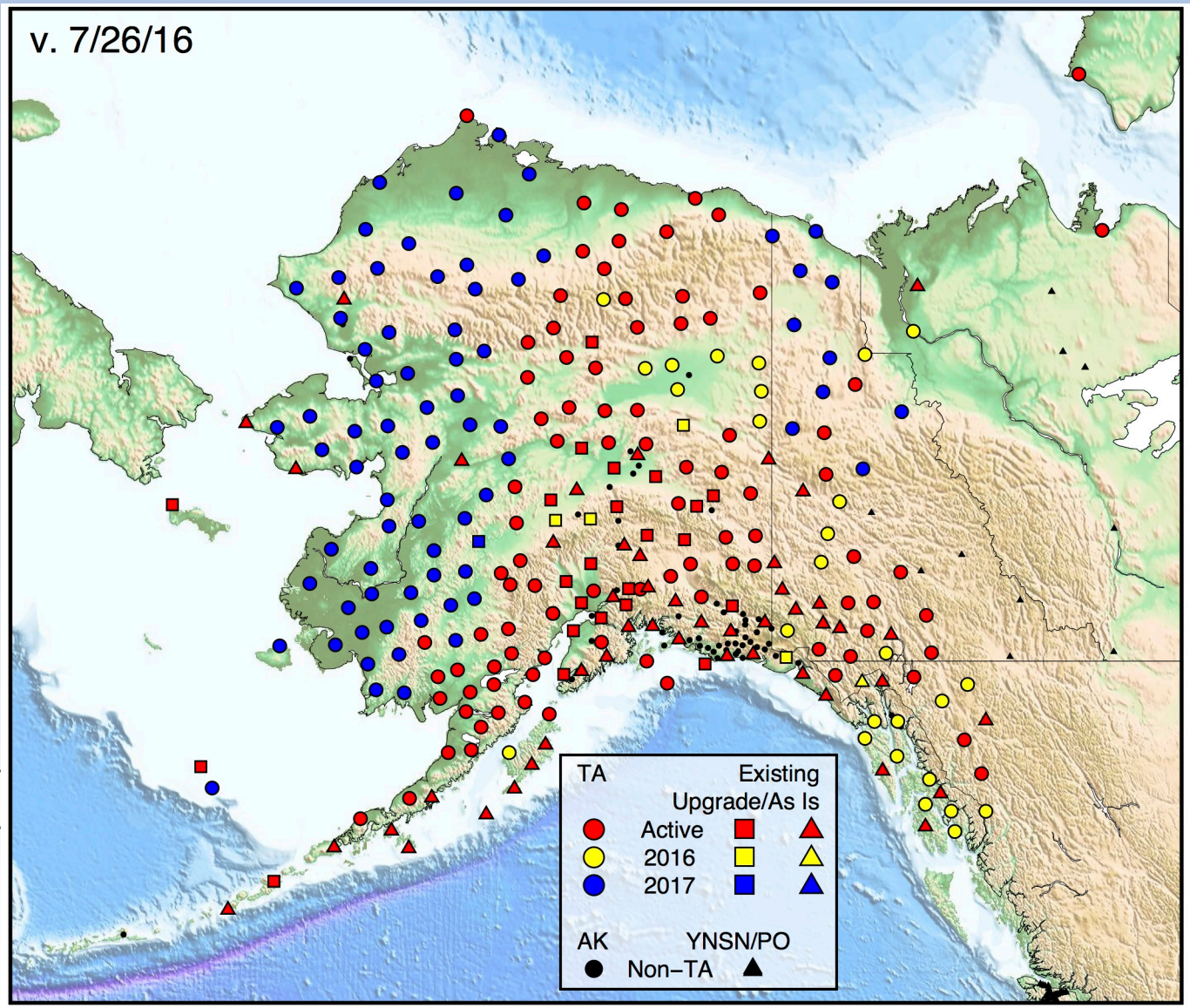


- 2014: 9 new TA, 11 AK upgraded, 26 total
- 2015: 36 new TA, 47 integrations/ upgrades
- 2016: 70 new TA

www.usarray.org/alaska

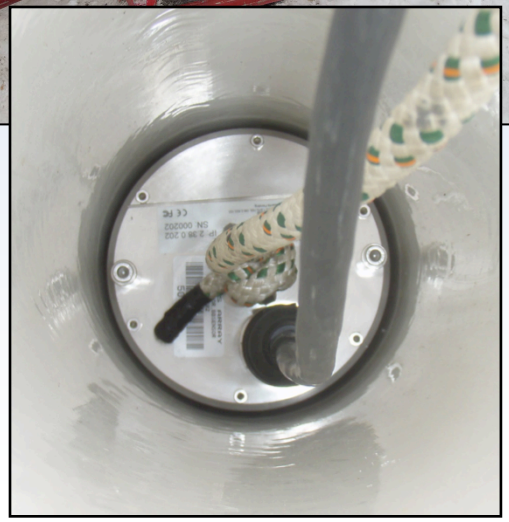
TA in Alaska - Plans





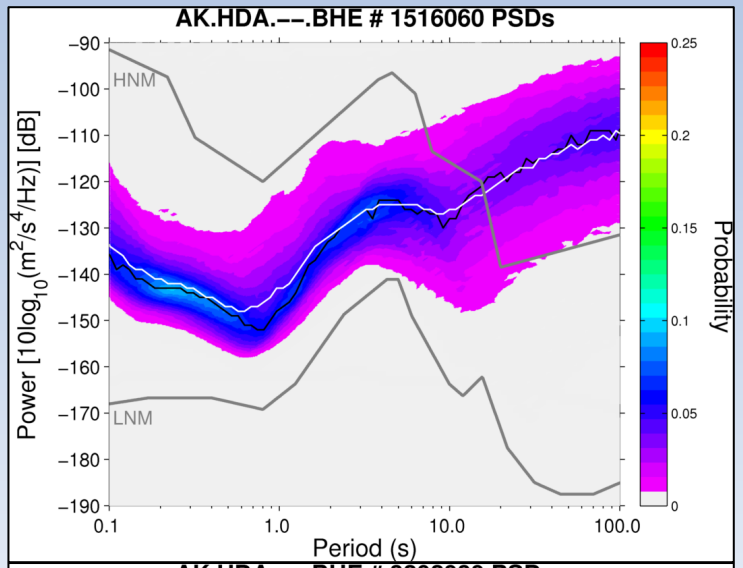
TA in Alaska / Yukon

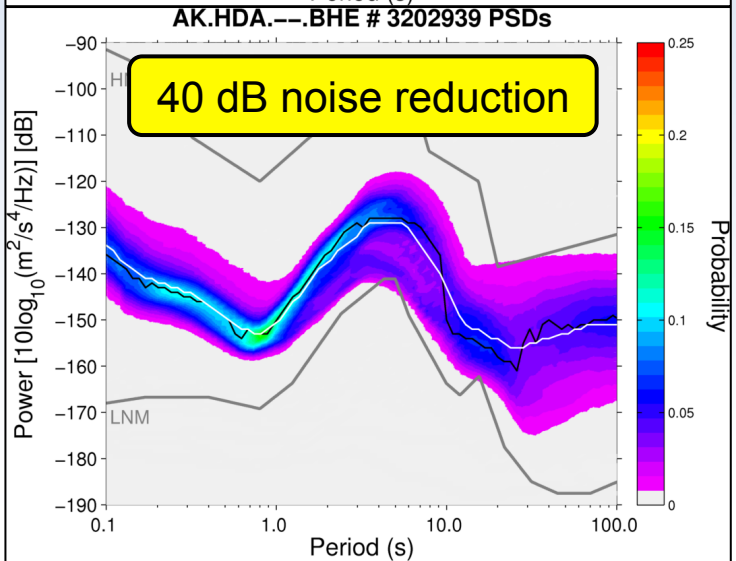
Motivation: High quality data; all equipment designed for transport in fixed wing aircraft or helicopter.



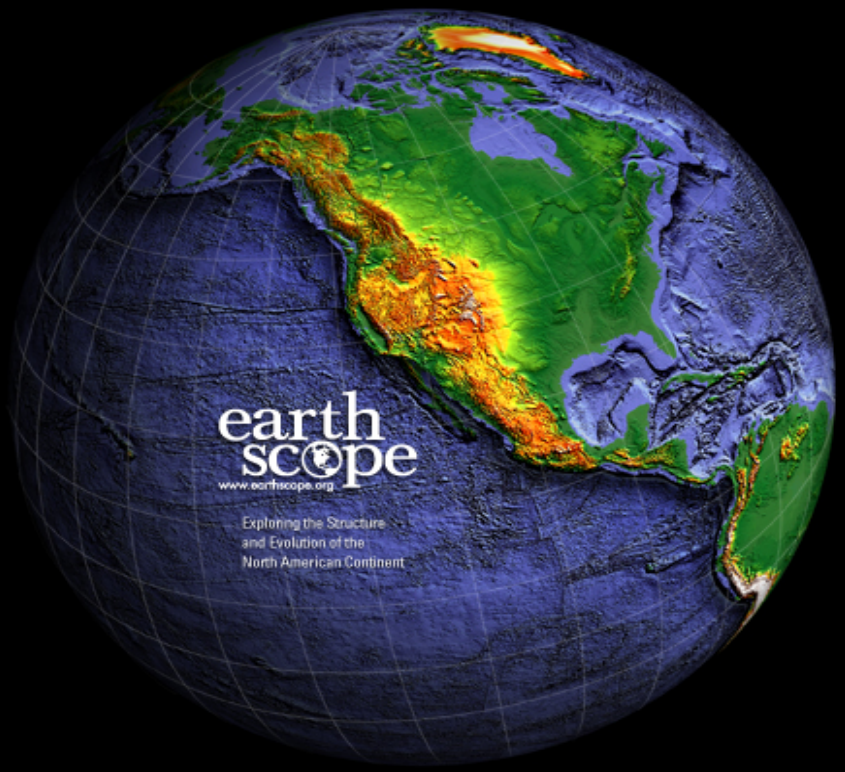
- ~261 new & upgraded sites by 2017, spaced 85 km
- Broadband seismometers w/atmospheric sensors
- New/advanced power and communications
- Complex logistics

New styles of seismometer emplacement

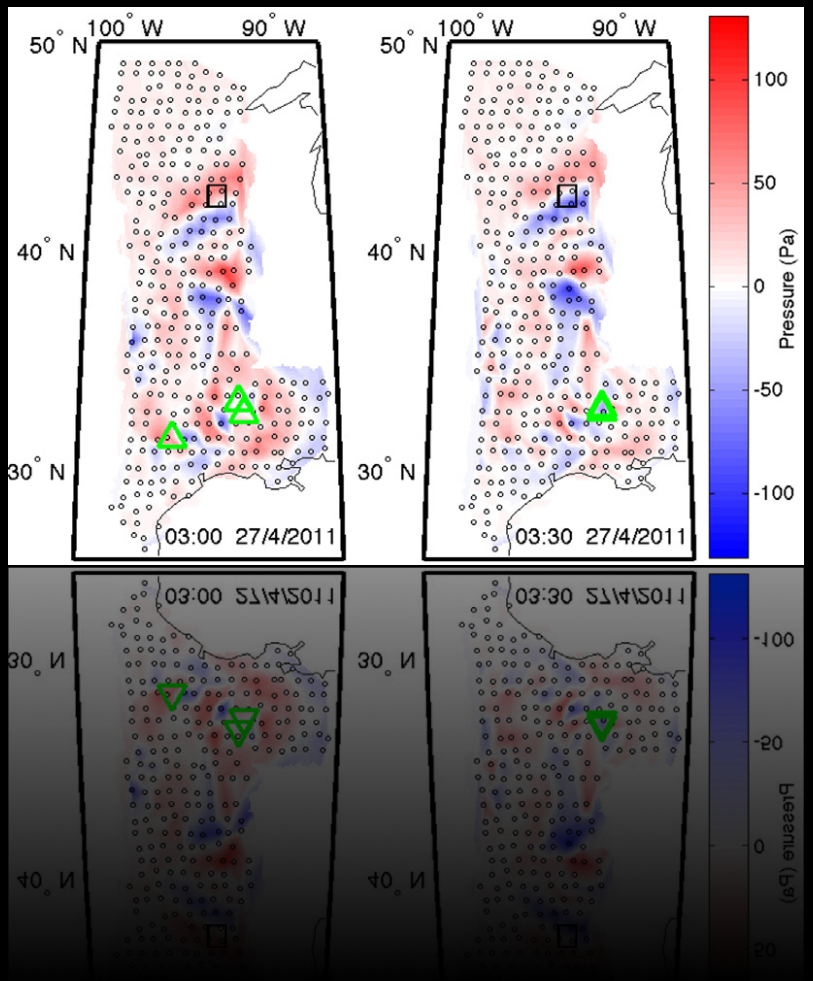




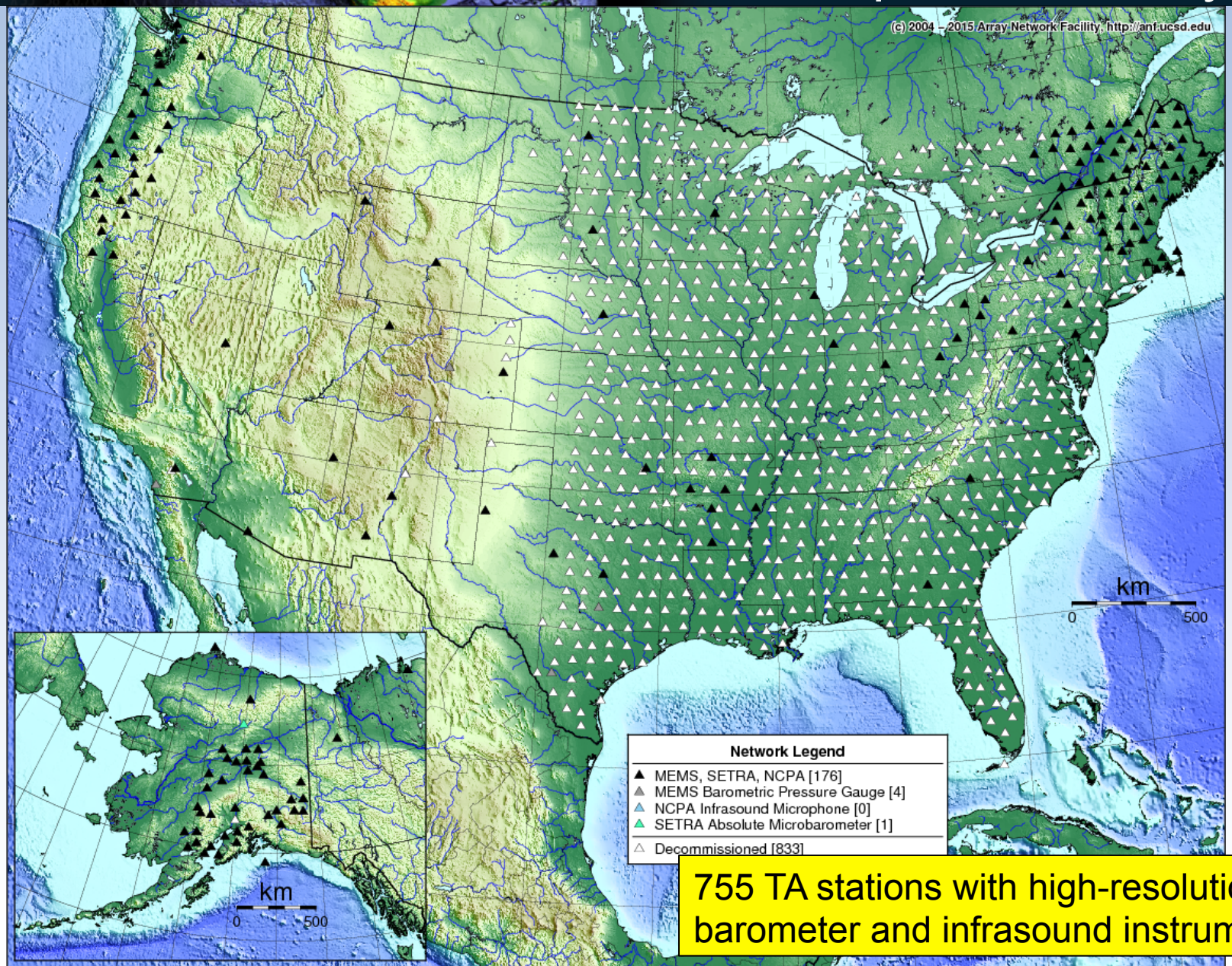
USArray's Enhanced Scope and Legacy



Atmospheric Gravity Waves on the TA
Catherine deGroot-Hedlin et al.



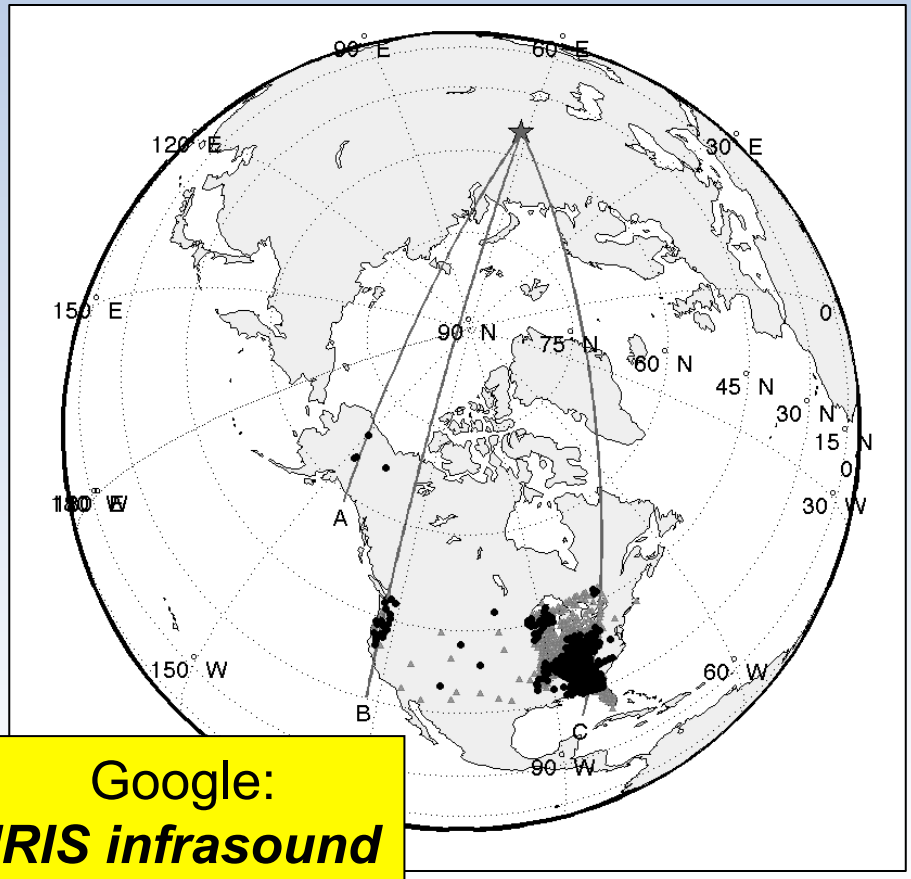
Atmospheric Acoustic Transportable Array

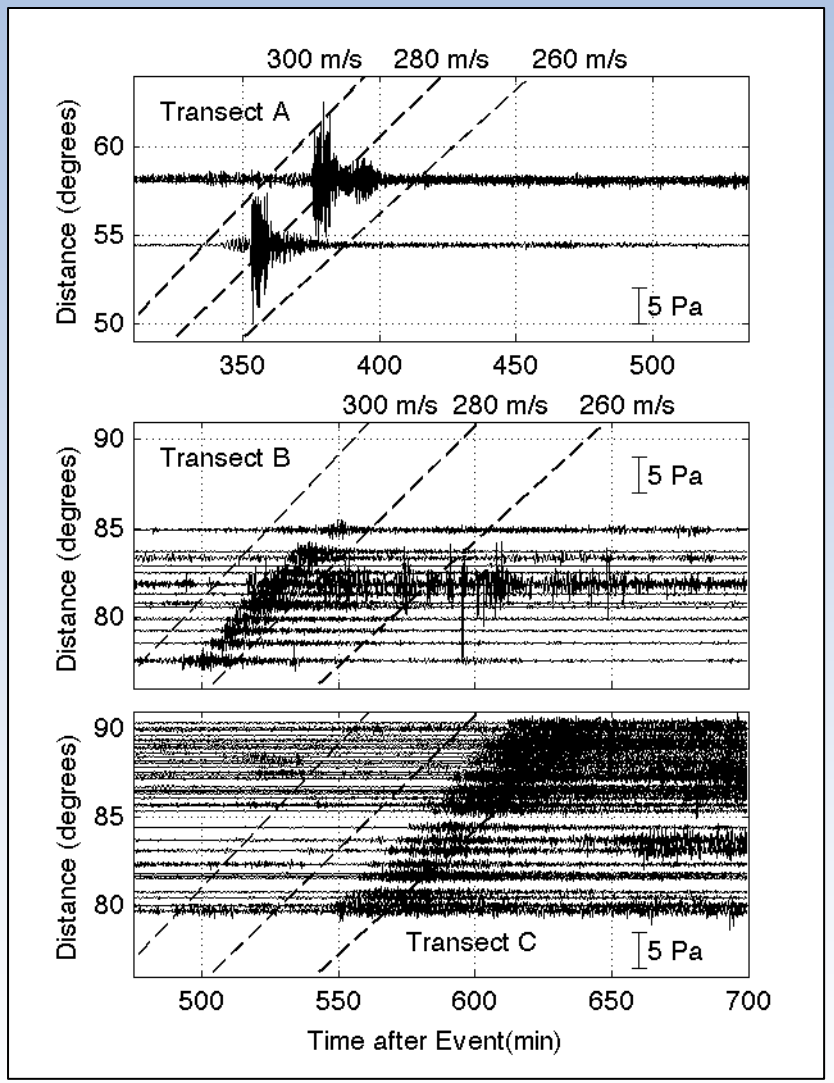


755 TA stations with high-resolution barometer and infrasound instruments

Acoustic Transportable Array

Infrasound detection of the Chelyabinsk Meteor on the TA



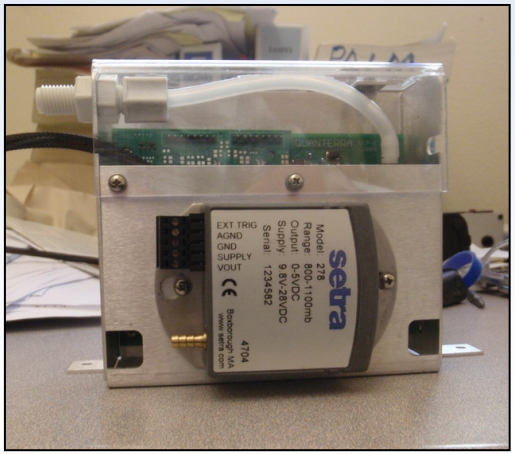


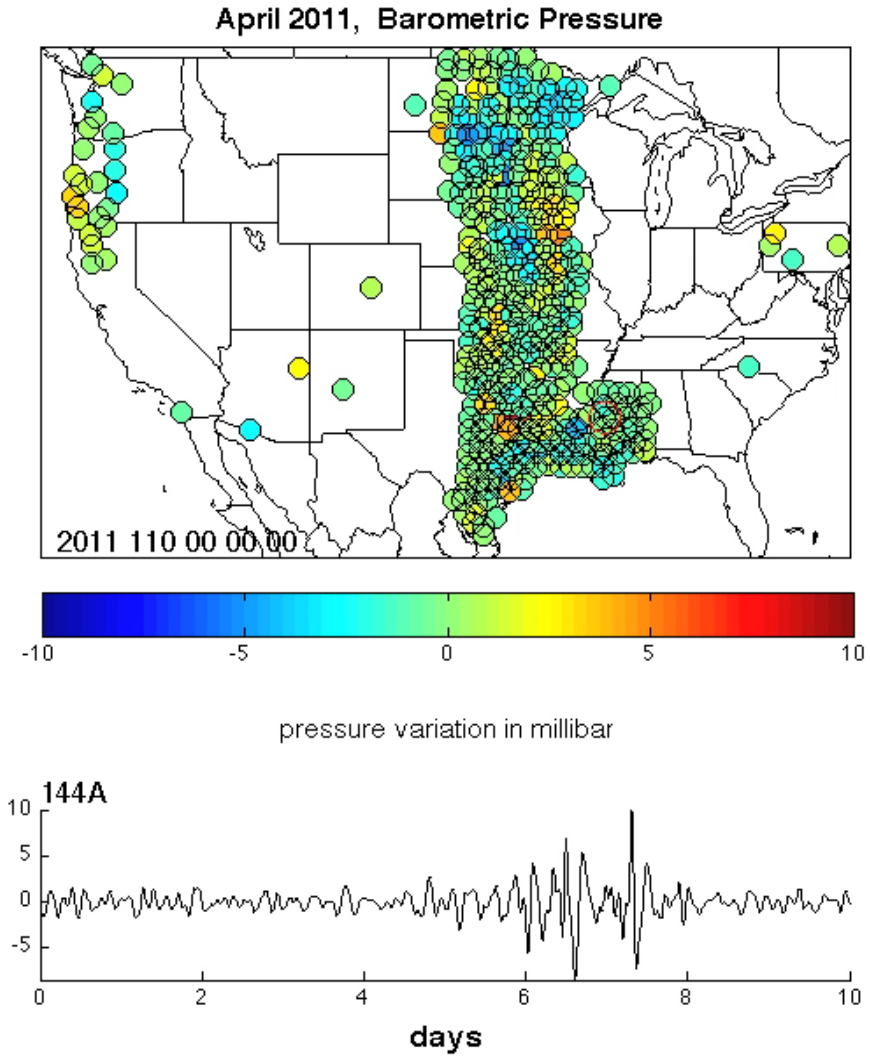
Google:
IRIS infrasound
For events and detections

de Groot-Hedlin & Hedlin, EPSL, 2014

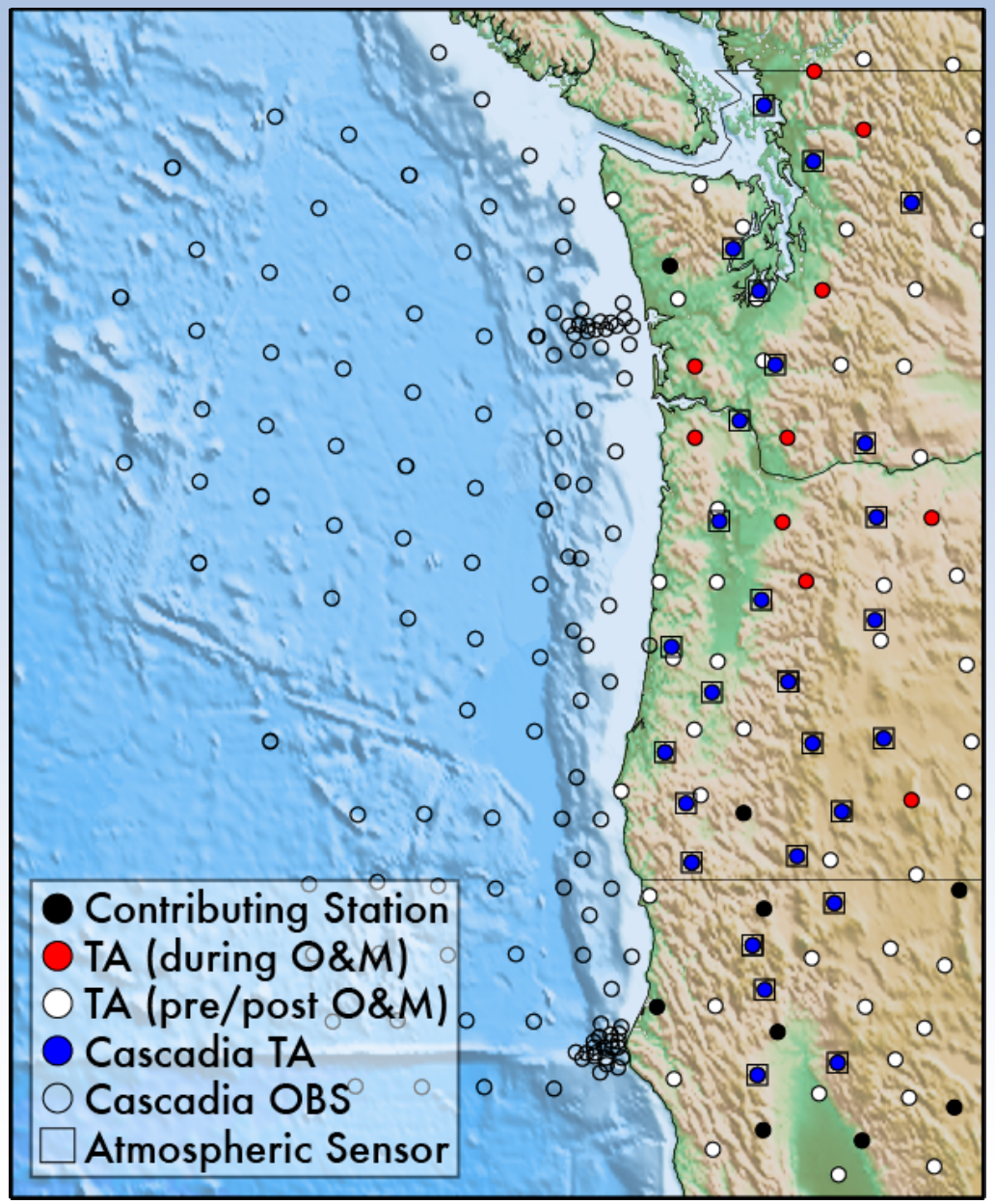
Acoustic Transportable Array

- Barometric pressure and infrasound at every TA station
- Multiple applications
  - Noise induced on vertical and horizontal seismic channels
  - Meso-scale atmosphere variation
  - Acoustic energy propagating in the atmosphere
  - Acoustic – seismic coupling





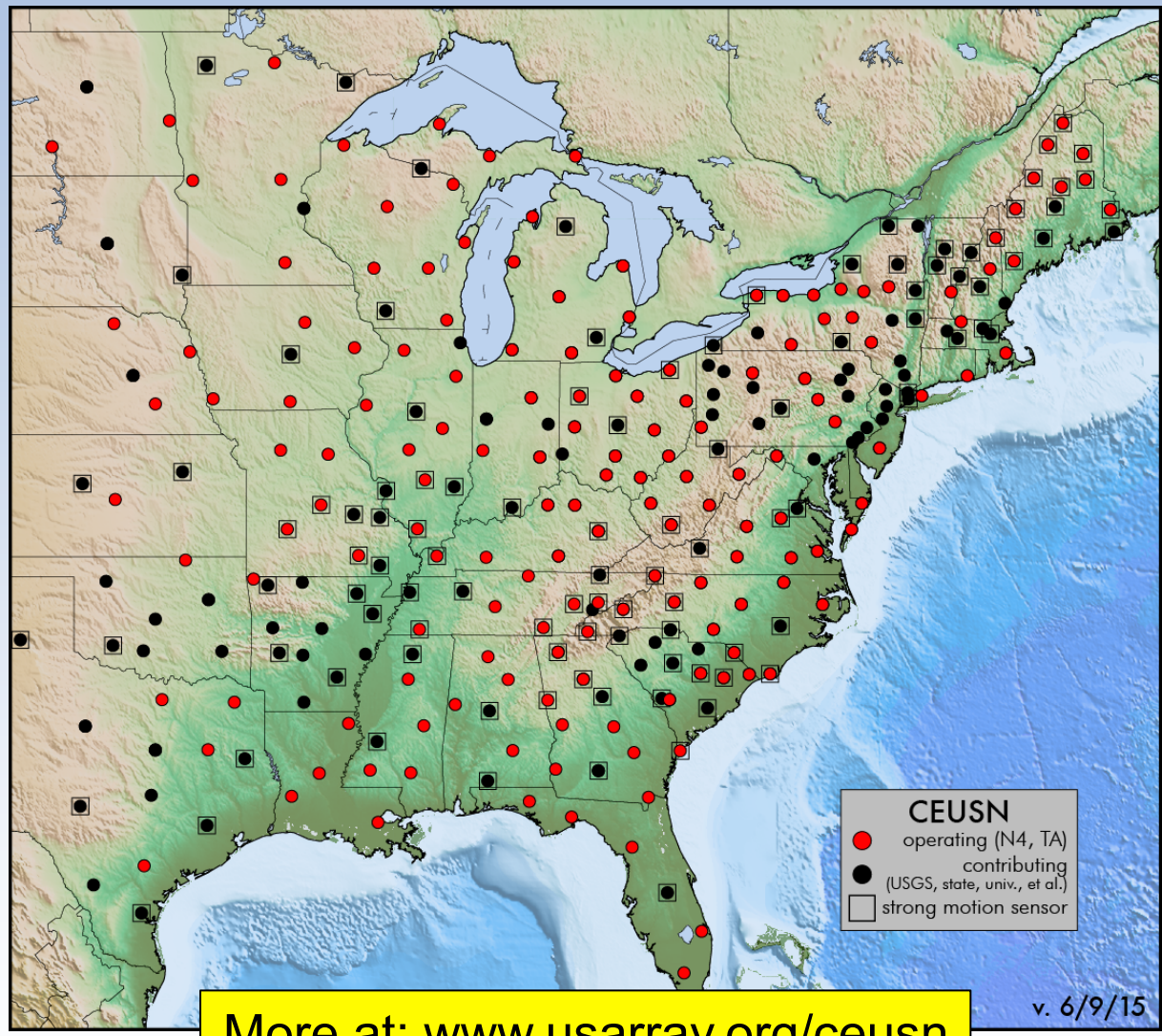
TA Cascadia



- 27 TA stations (w/atmospheric sensors and strong motion instruments) reinstalled in 2009-2010 to anchor the Cascadia Initiative offshore experiment
- 15 Oregon stations to be adopted by the state

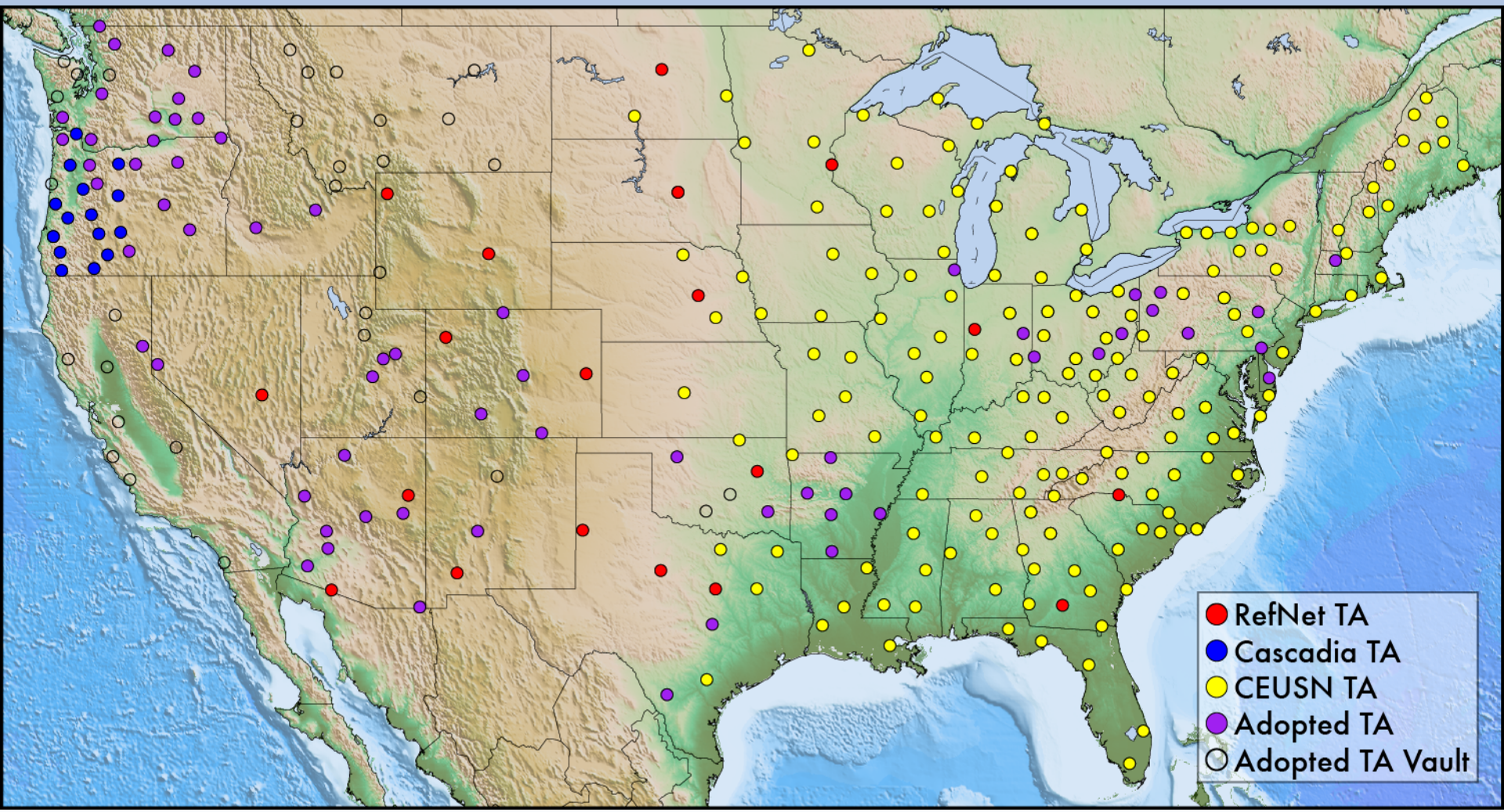
Central and Eastern US Network

- Five year plan to operate 159 (**37 reinstalled**) TA stations for:
  - Research
  - Hazards assessment
  - Critical facilities
- Multi-agency collaboration
  - NSF, USGS
  - NRC, DOE
- “Good government”
  - Uniquely addressing multiple missions / needs
- Enhanced instrumentation/data
  - 100 s.p.s. broadband
  - 34 new strong motion instruments



More at: www.usarray.org/ceusn

USArray Legacy Stations



Between TA and Cascadia-TA adoptions and CEUSN, potentially 235 new “permanent” stations in N.A. since 2008

USArray's Unique Aspects

- **Bold** approach to seismology research facilities (size, scope, quality)
- **Diverse** offerings (telemetry, auxiliary instruments, etc.)
- **Biggest** open dataset for seismology…ever
- **Substantial community input** into evolution of the facility
- **Coordinated** and **collaborative** with other EarthScope programs

People Make it Happen

USArray Transportable Array Team Photo on Completion of the TA in the Lower-48 States
October 1, 2013

Want More Info?

On the Web

- EarthScope
  www.earthscope.org
- USArray
  www.usarray.org
- National Science Foundation
  www.nsf.gov

woodward@iris.edu

EarthScope is funded by the National Science Foundation.

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