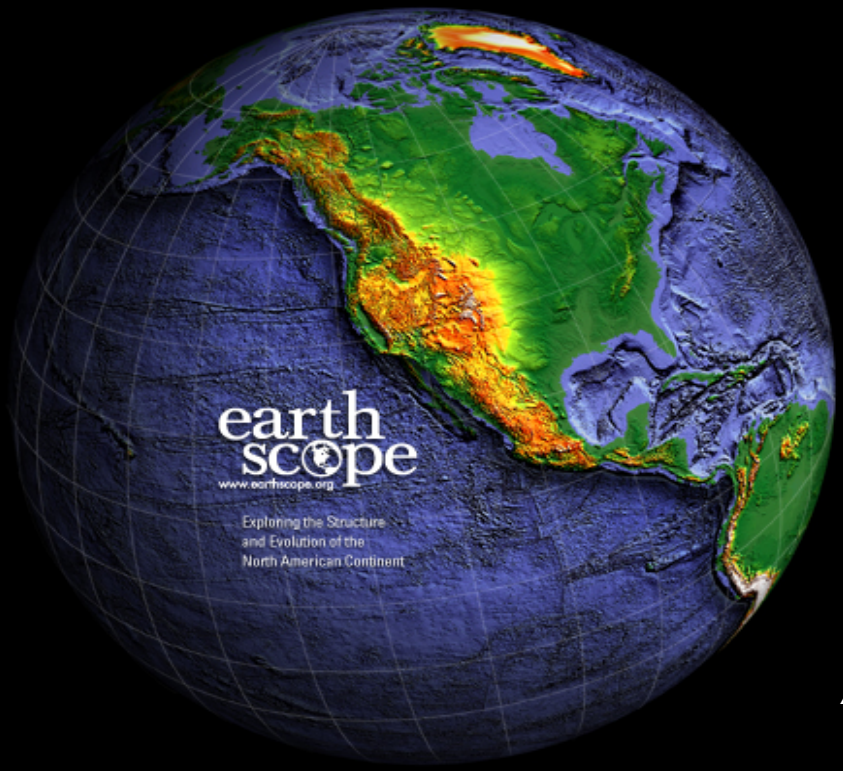
EarthScope's Transportable Array:



Robert Busby, TA Manager

Kasey Aderhold, Project Associate

Max Enders, Deployment Coordinator

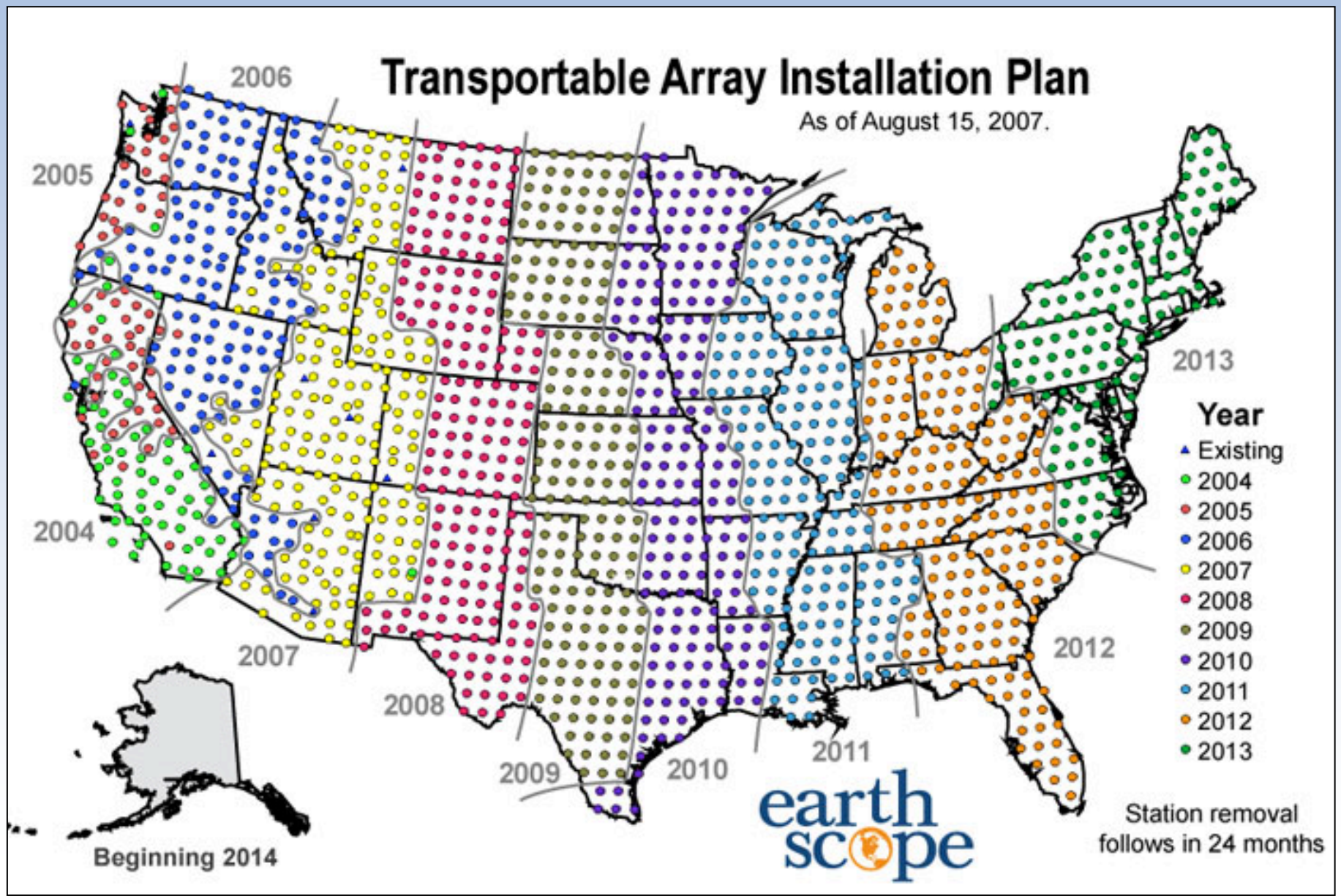
Transportable Array Opening Gala Oct 18, 2017
Anchorage, AK

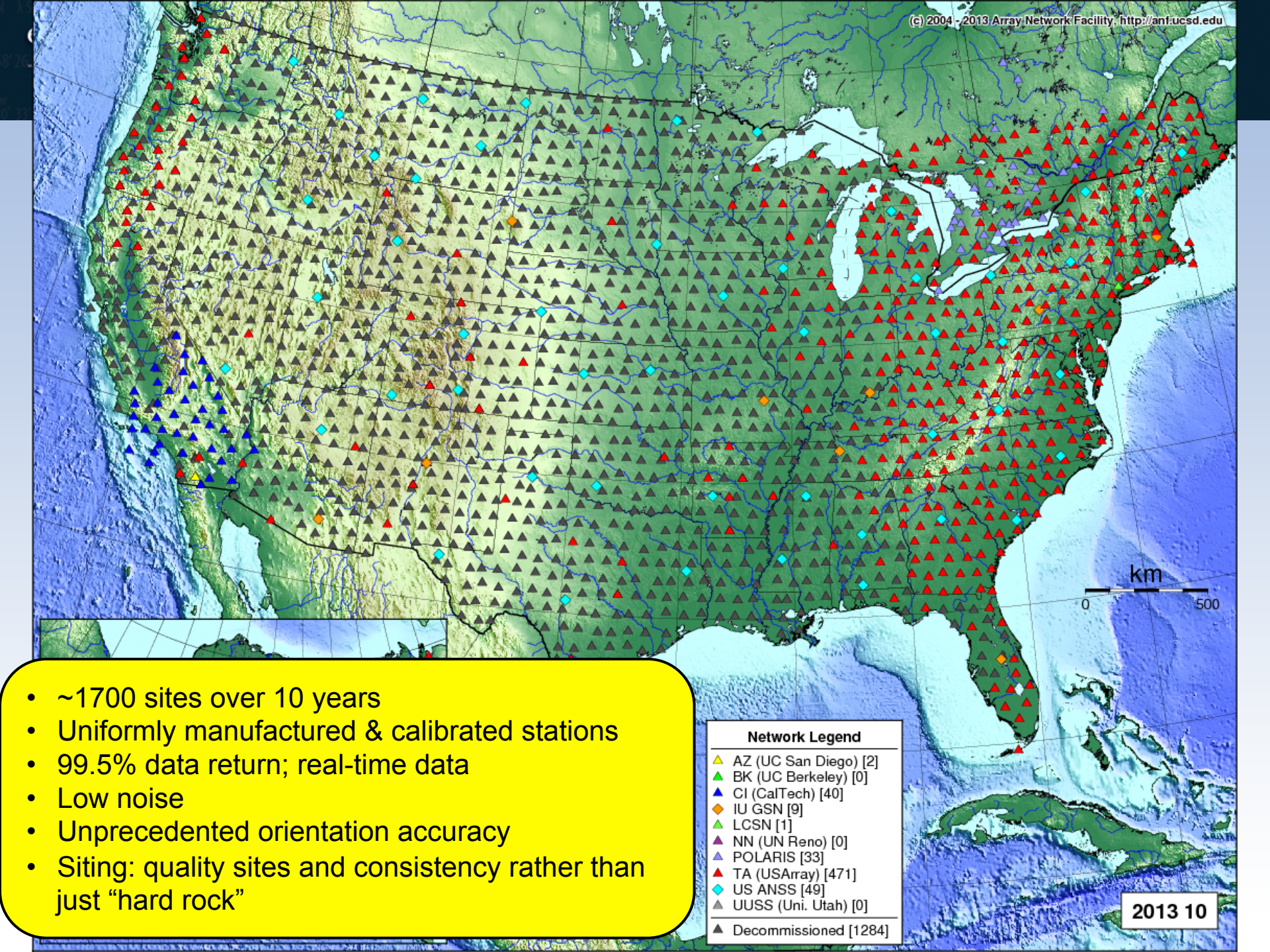
Outline

- Overview of TA project and what it does.
- Brief look at Building the TA in Alaska
- Status and Plan for TA in Alaska / Yukon
  - Array is now completely installed
  - Will operate for two years
  - Stations begin to be removed summer 2019, completed in summer 2020. Some stations are likely to remain.
- Novel research topics in the region

From NSF: Transformative research involves ideas, discoveries, or tools that radically change our understanding of an important existing scientific or engineering concept or educational practice . . .

The TA: 15 Year Plan





- ~1700 sites over 10 years
- Uniformly manufactured & calibrated stations
- 99.5% data return; real-time data
- Low noise
- Unprecedented orientation accuracy
- Siting: quality sites and consistency rather than just “hard rock”

Data Products

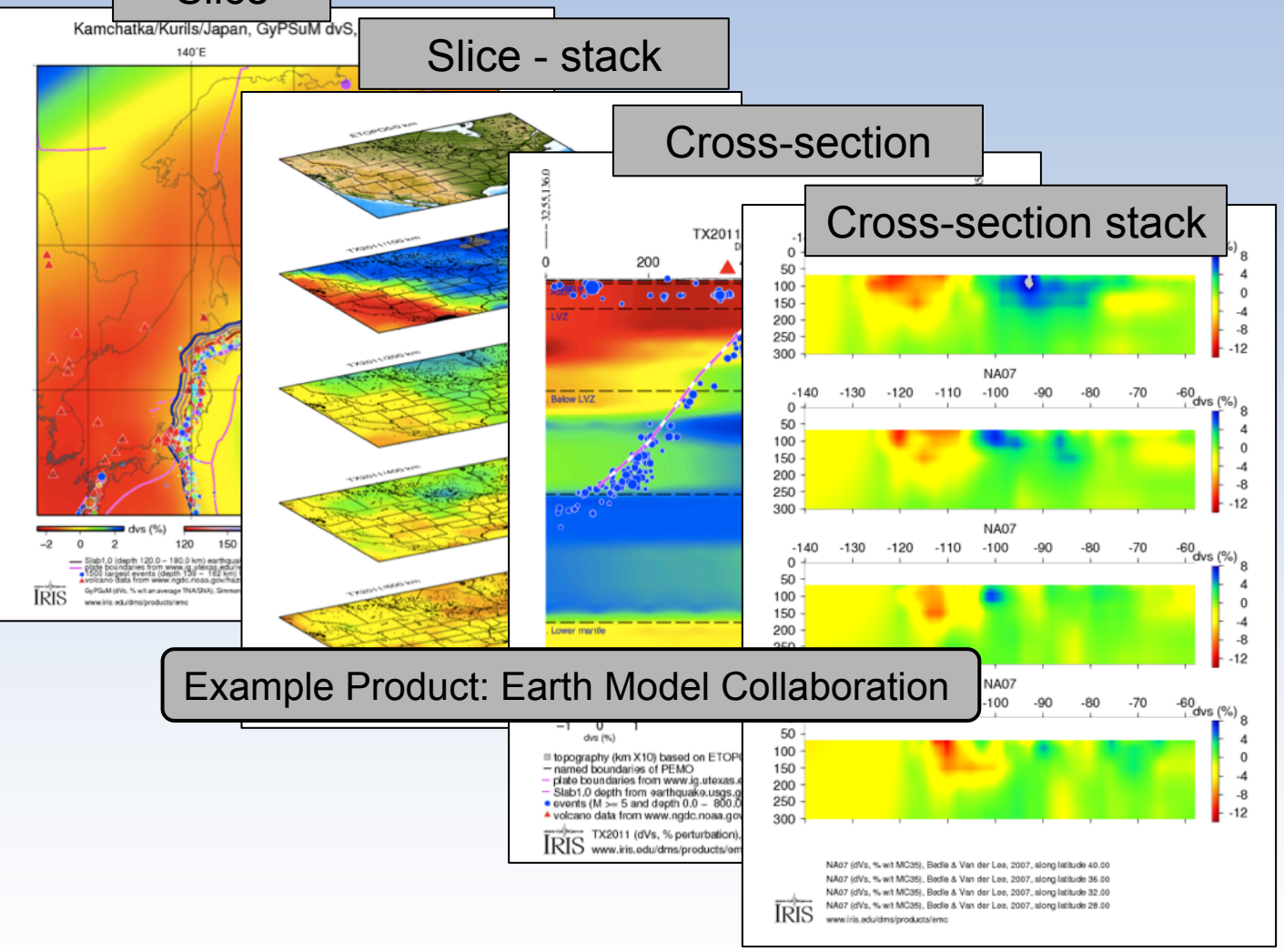
Imaging Earth structure from 8km depth to more than 800km

Slice

Slice - stack

Cross-section

Cross-section stack



Example Product: Earth Model Collaboration

backprojections

gmv

event plots

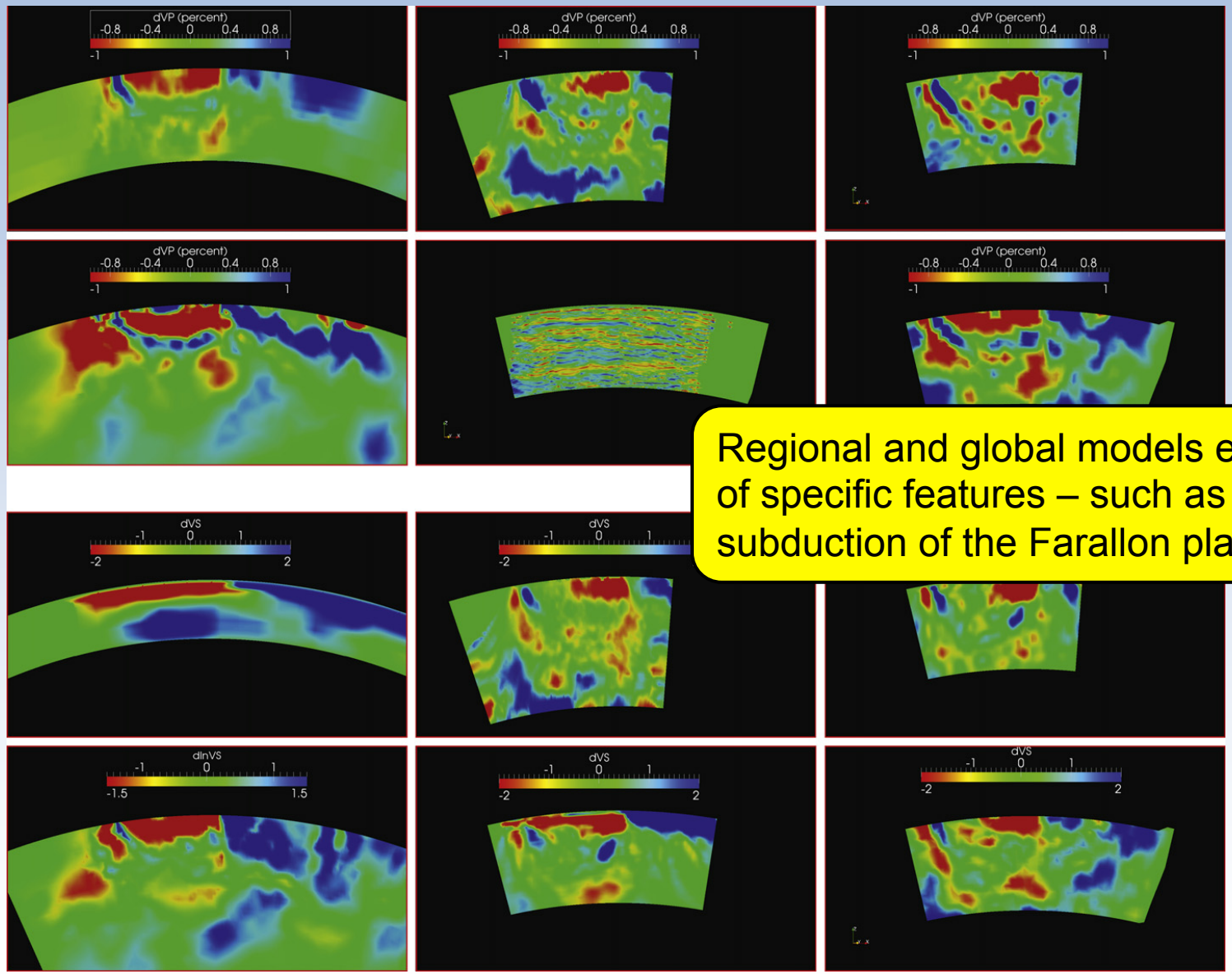
Infrasound

Western US Ambient Noise X-Correlation

Other products

A rich set of higher order data products

Body Wave Tomography



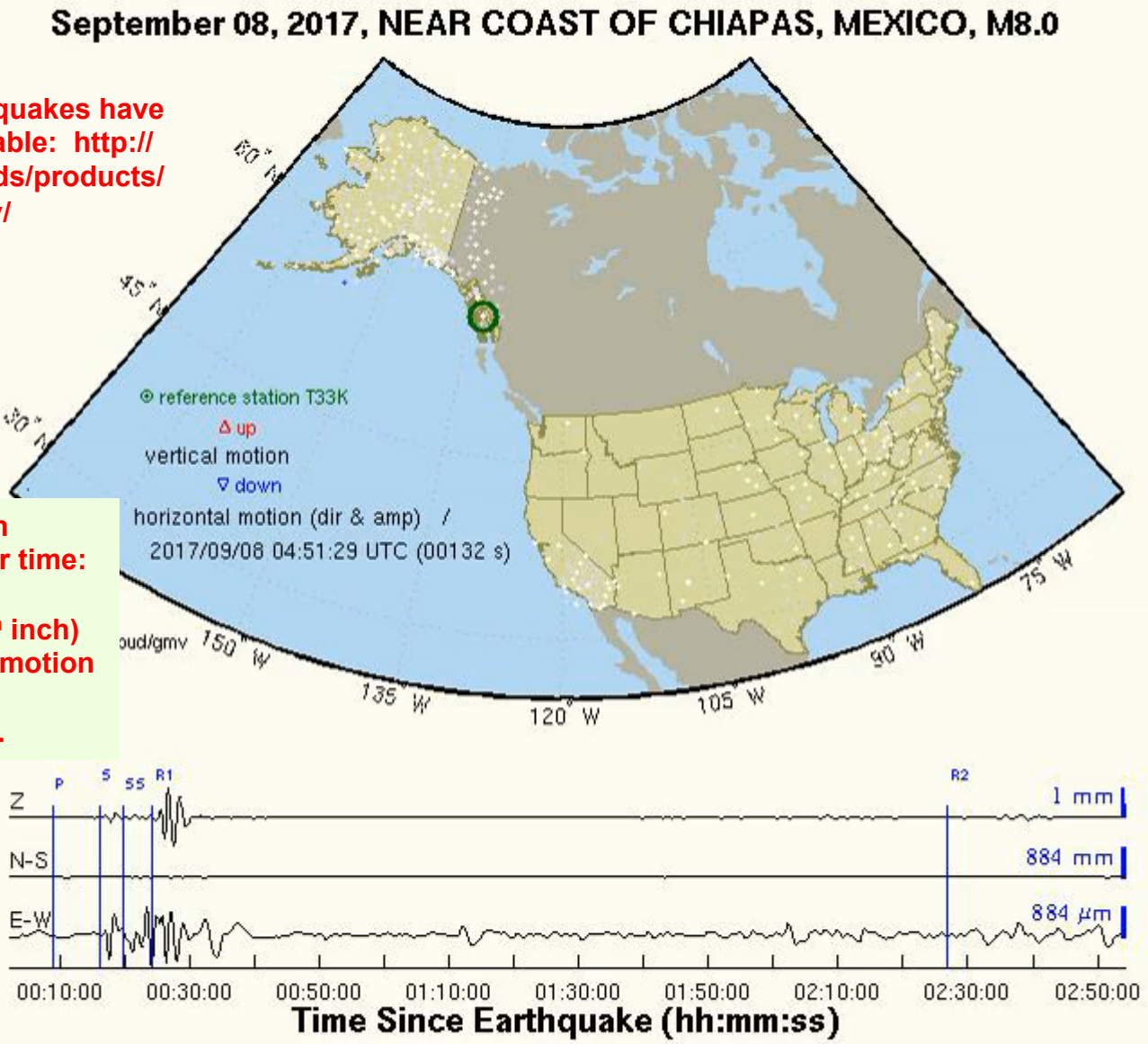
P wave models

Regional and global models enable studies of specific features – such as the subduction of the Farallon plate

S wave models

Pavlis, et. al., *Tectonophysics*, 2012

Ground Motion Video (GMV)



Many earthquakes have views available: http://ds.iris.edu/ds/products/usarraygmv/

Displays ground motion at each station from an earthquake over time:
RED goes up,
BLUE goes down, (about 1/16th inch)
STICK FLAGS show horizontal motion

This video is 3 hours of motion.

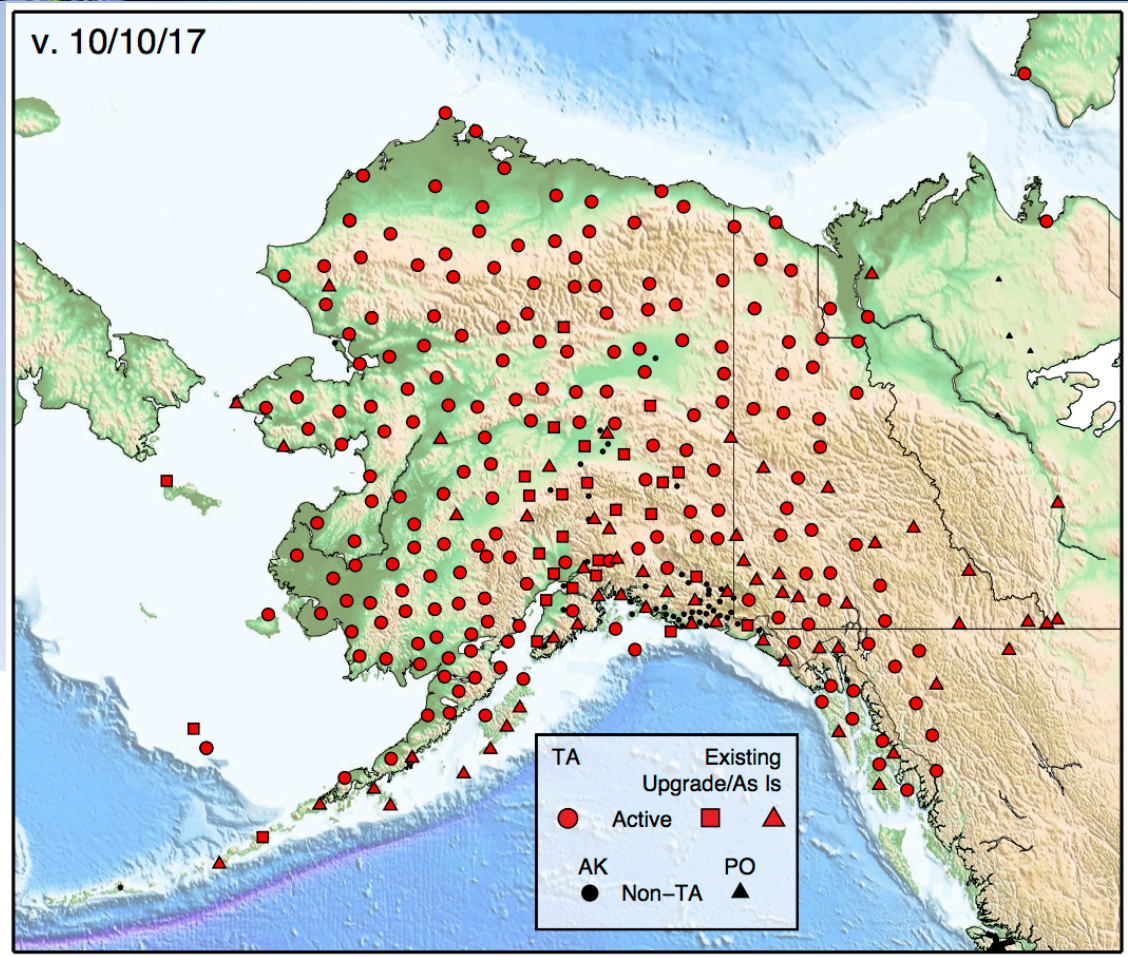
Science Impact

- A very small sample of recent results
- Illustrates some of the ways USArray has enabled the research

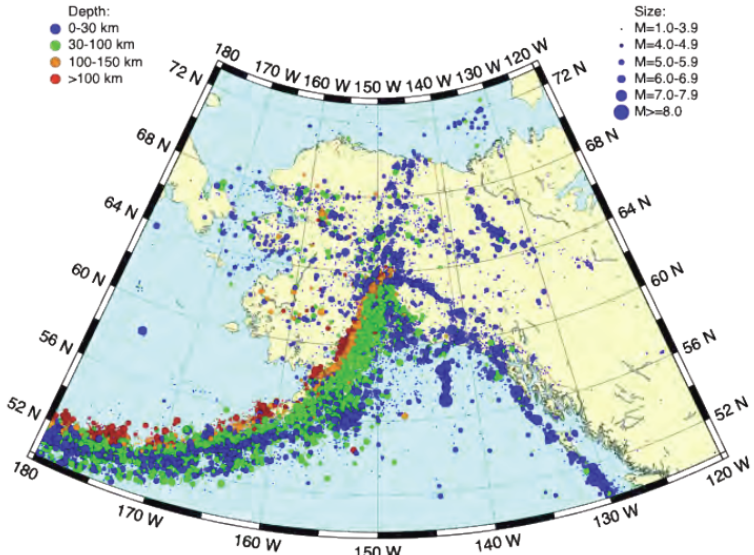
Science Oct 5, 2017

TA in Alaska / Yukon

- ~280 sites [2017]
- 85 km spacing
- Broadband Seismometers
  Infrasound, pressure
  meteorlogical, Soil Temp
- <4hr Communications
- Fully deployed 2017



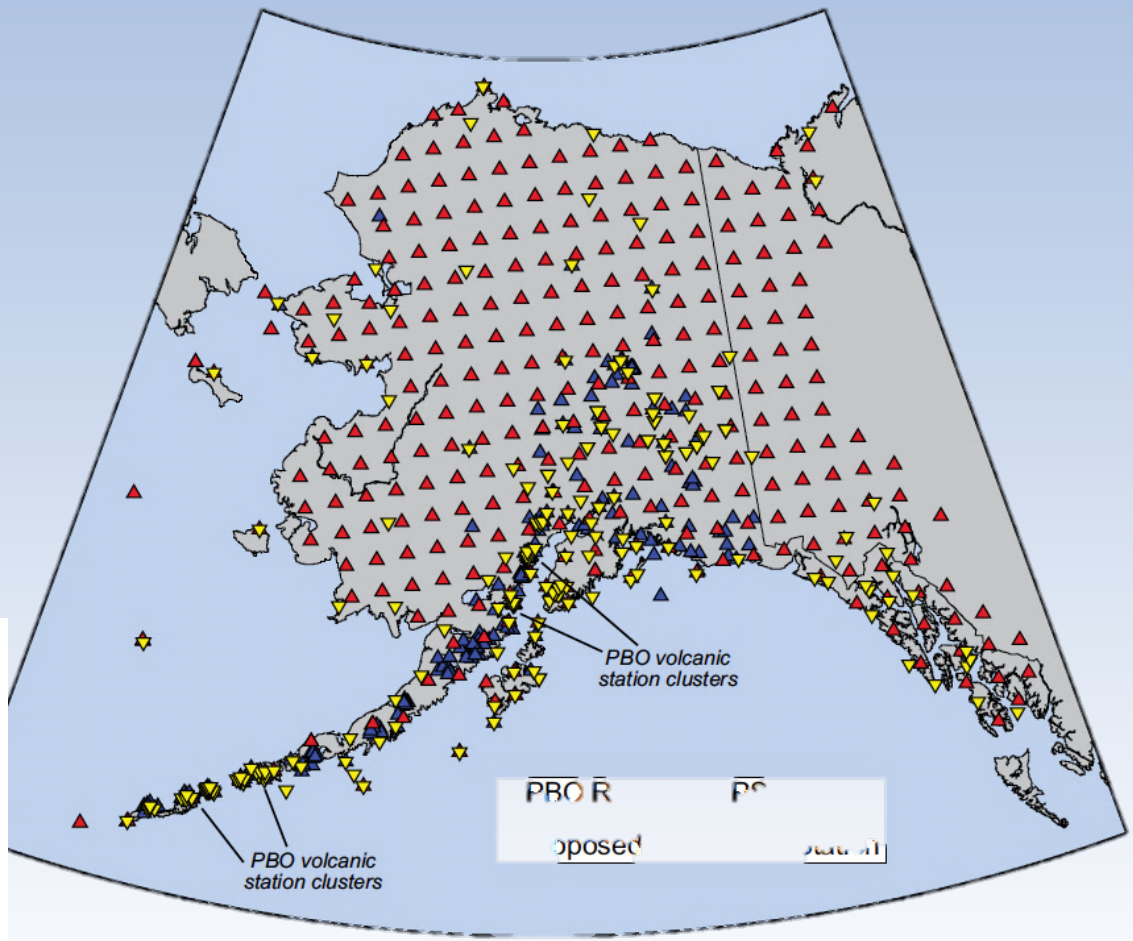
Seismicity in Alaska & Yukon



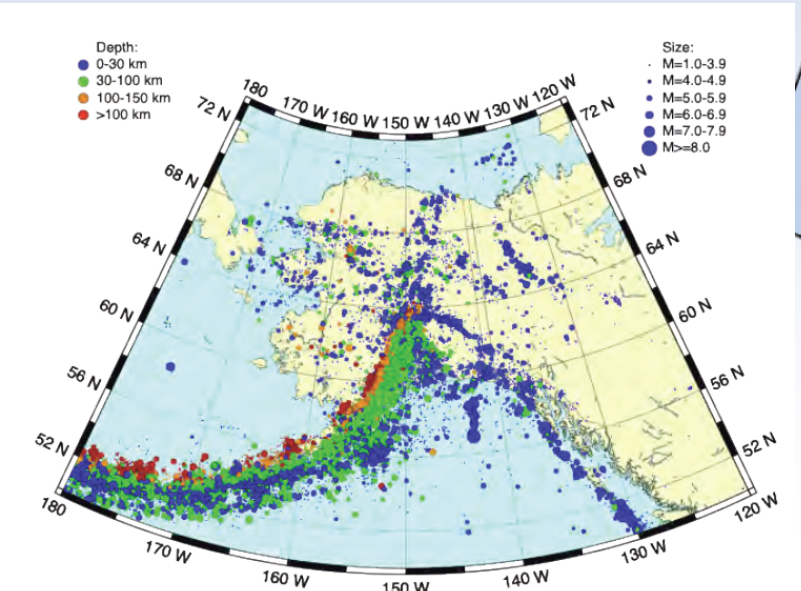
www.usarray.org/alaska

TA in Alaska / Yukon

- ~290 sites [2013]
- 85 km spacing
- Broadband Seismometers
  - Infrasound, pressure
    - Some met packages
- Communications
- fully deployed 2017

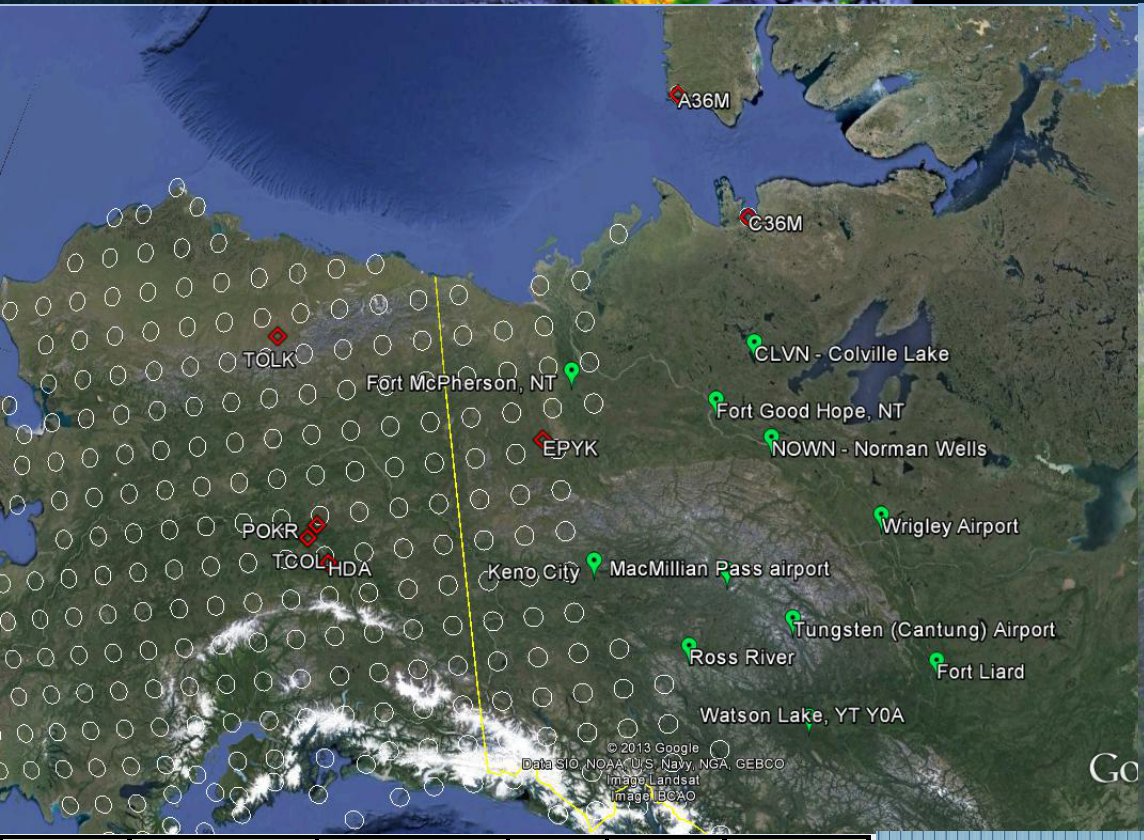


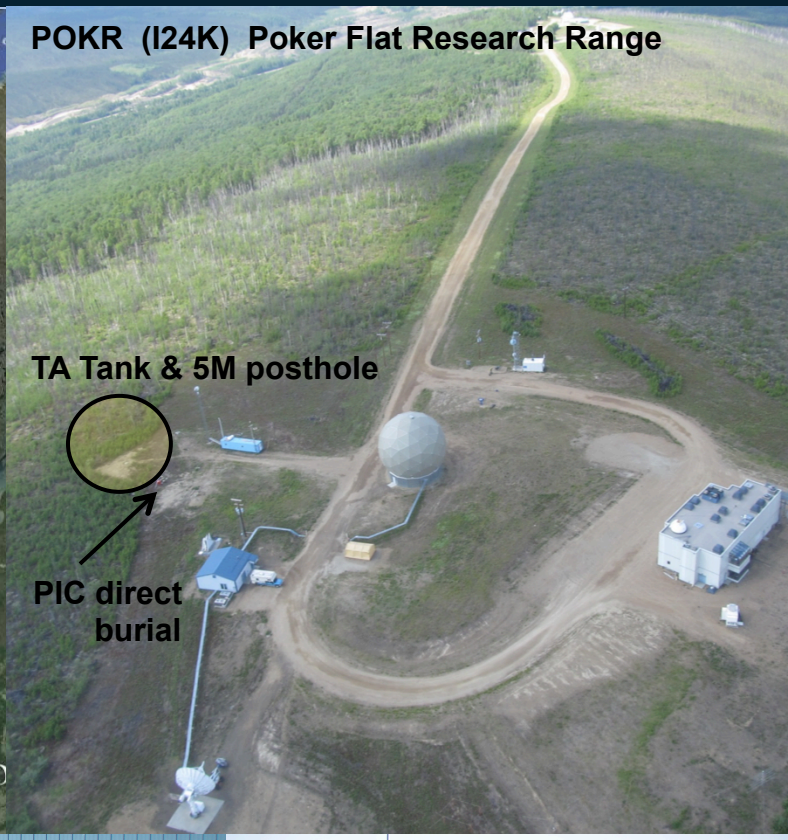
Seismicity in Alaska & Yukon



www.usarray.org/alaska

Testing and Evaluation 2012 - 2014





Station	Location	Hole Type	Sensor	Depth (m)	Started
TCOL (--)	CIGO, Fairbanks, AK (adjacent to COLA)	Augered 8" PVC casing	STS-4B	10	10/9/2012
TCOL (01)	CIGO, Fairbanks, AK (adjacent to COLA)	Augered 8" PVC casing	STS-4B	5	10/9/2012
HDA	Harding Lake AK (replaced AK.HDA)	Augered 8" PVC Casing	T120PH	5	10/4/2012
POKR (--)	Poker Flat Research Range, AK	TA Tank into rock	T240	2	10/12/2012
POKR (01)	Poker Flat Research Range, AK	Augered 8" PVC casing	T120PH	5	10/12/2012
EPYK	Eagle Plains YT	Cored in rock	T120PH	1.4	10/15/2012

Consultation and Preapplication Dialog

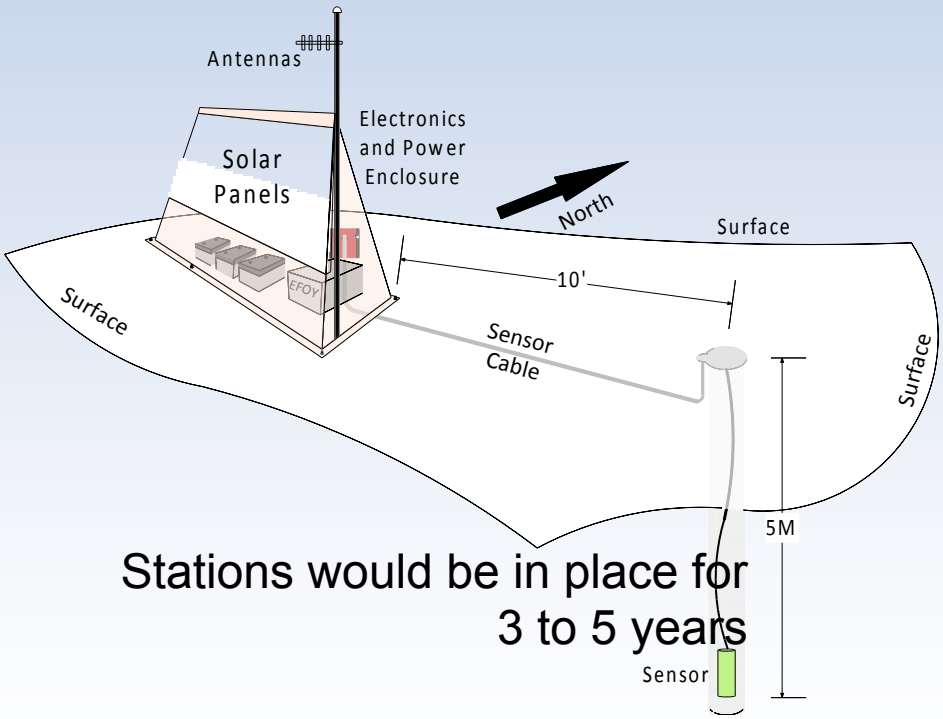
In **2011-2014**, as project proponents we visited numerous agencies and stakeholders. Informational meetings, gathering requirements for application materials and understanding the timeline and process for obtaining permits.

We began by visiting **6 Native Corporation** Offices with maps and handouts, had a booth for two years at **AFN** and in Canada visited 10 villages to reach out to **15 First Nations**. Participated in Subsistance Advisory panels in Barrow and Anchorage.

BLM Anchorage, Fairbanks and NPRA District Offices
National Park Service
US Fish & Wildlife
US Forest Service
State of Alaska DNR and DOT
Yukon Lands
Parks Canada

Basic Description of Buried Sensor Design for AK

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



Stations would be in place for 3 to 5 years

Footprint ~10 feet X 20 feet

N25K Seismic Station

Sensor Emplacement

Most sites are installed via helicopter with custom portable drill.

Drill a 6 inch diameter hole 3 m into soil or rock. A steel casing follows bit and is grouted into place. In soil, an auger bit and PVC casing can reach depths of 5m.

3-4 person team constructs site and installs equipment

Drill on sling, and onsite below

Hammer Drilling, AK.SCRK

Hammer drill, N25K

Mike Lundgren auger in Palmer AK

Deployment Operations

Work from a hub and jump sequentially between sites until ending at next hub

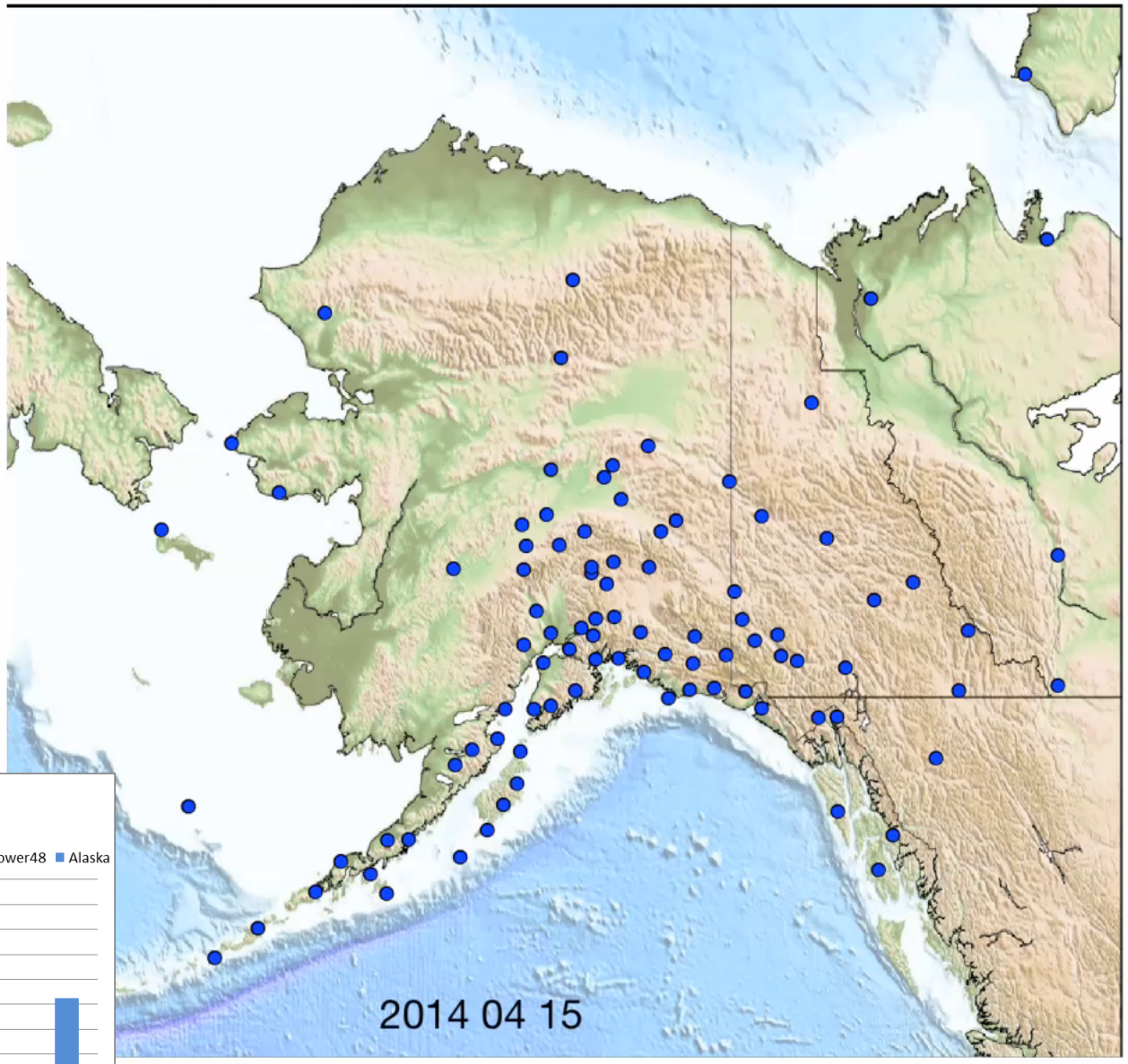
Usually a two helicopter operation-lift Helicopter (A-Star-B3) and a support Helicopter (R66 or Long Ranger)

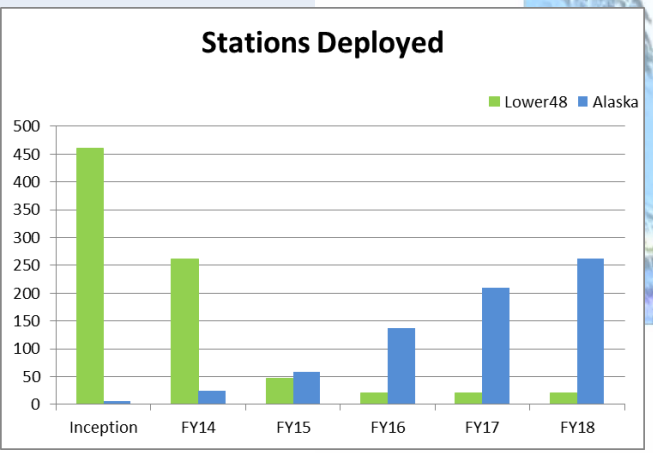
A Daily evaluation of weather, fuel, fire to advance the plan.

Forest Fires, Old Crow Yukon 2017

Hub location with drill, Helo, Fuel, huts

Deployment of Alaska Transportable Array





Collaborations

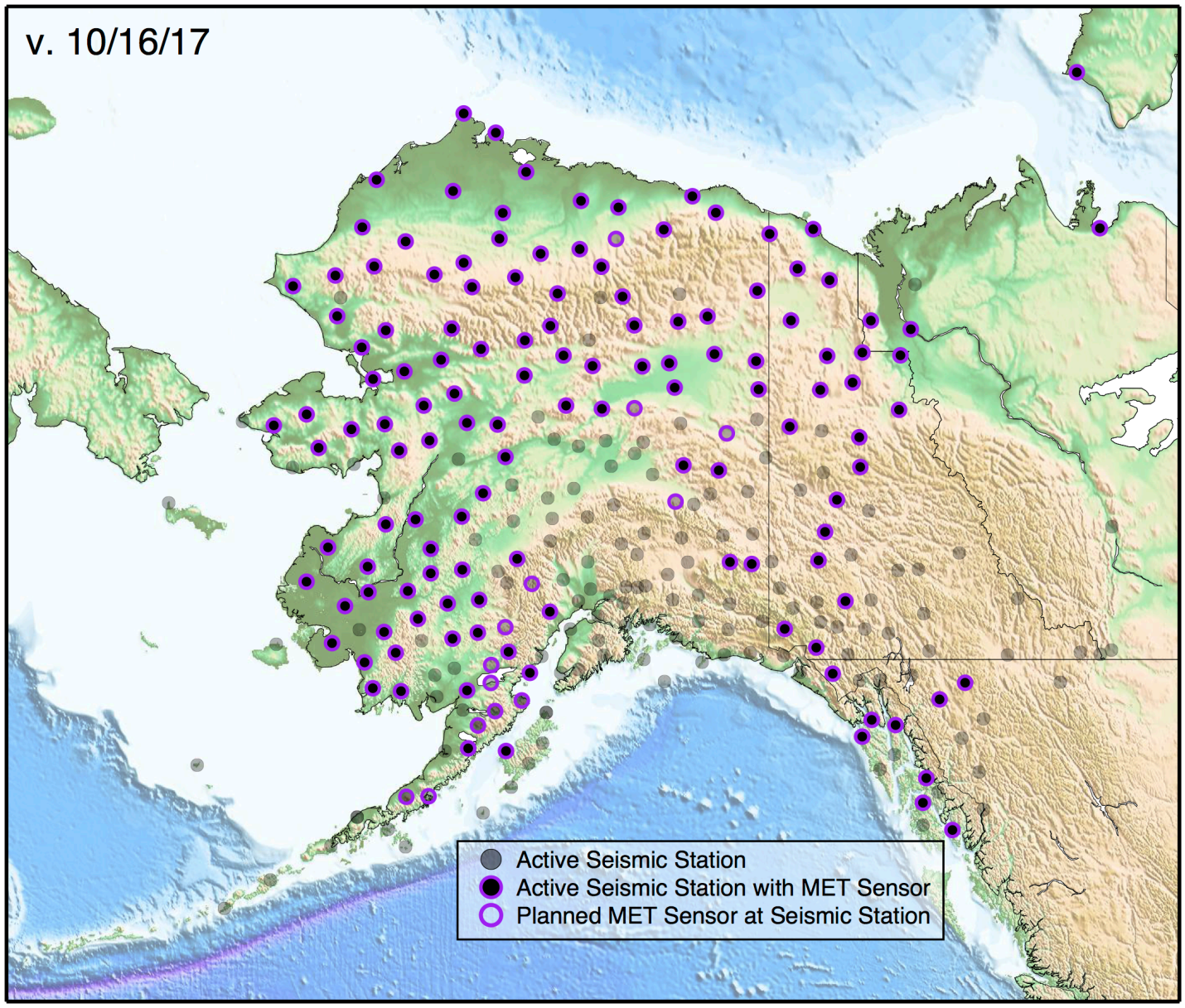
Seismology Partners:

- UAF Alaska Earthquake Center (AEC)
- USGS Alaska Volcano Observatory
- NOAA Tsunami Warning Center
- EarthScope Plate Boundary Observatory (PBO)

Other Science Partners:

- NASA Arctic Boreal Verification Experiment (ABoVE)
  - Soil Temperature and Meteorological Instruments
- National Weather Service Alaska Region
- Yukon Wildlands Fire Division

Met sensors in AK



30 TA supplied, NSF
35 UCSD, NSF
27 NOAA NWS so fa
40 NASA ABoVE
2 Yukon
==========
134 sensors

132 installed
13 planned
==========
145 stations

New Research Areas

- Seismicity: Earthquakes in ANWR and Noatak and other regions

- Tremor observations:
  - Gomberg & Prejean JGR 16Dec2013
  - Canada-PGC

- Environmental monitoring
  - Sea ice thickness from Seismic background spectra
  - Meteorological Sensors added to array
  - Soil Temperature Profiles added to array

Triggered motion from distant Earthquakes

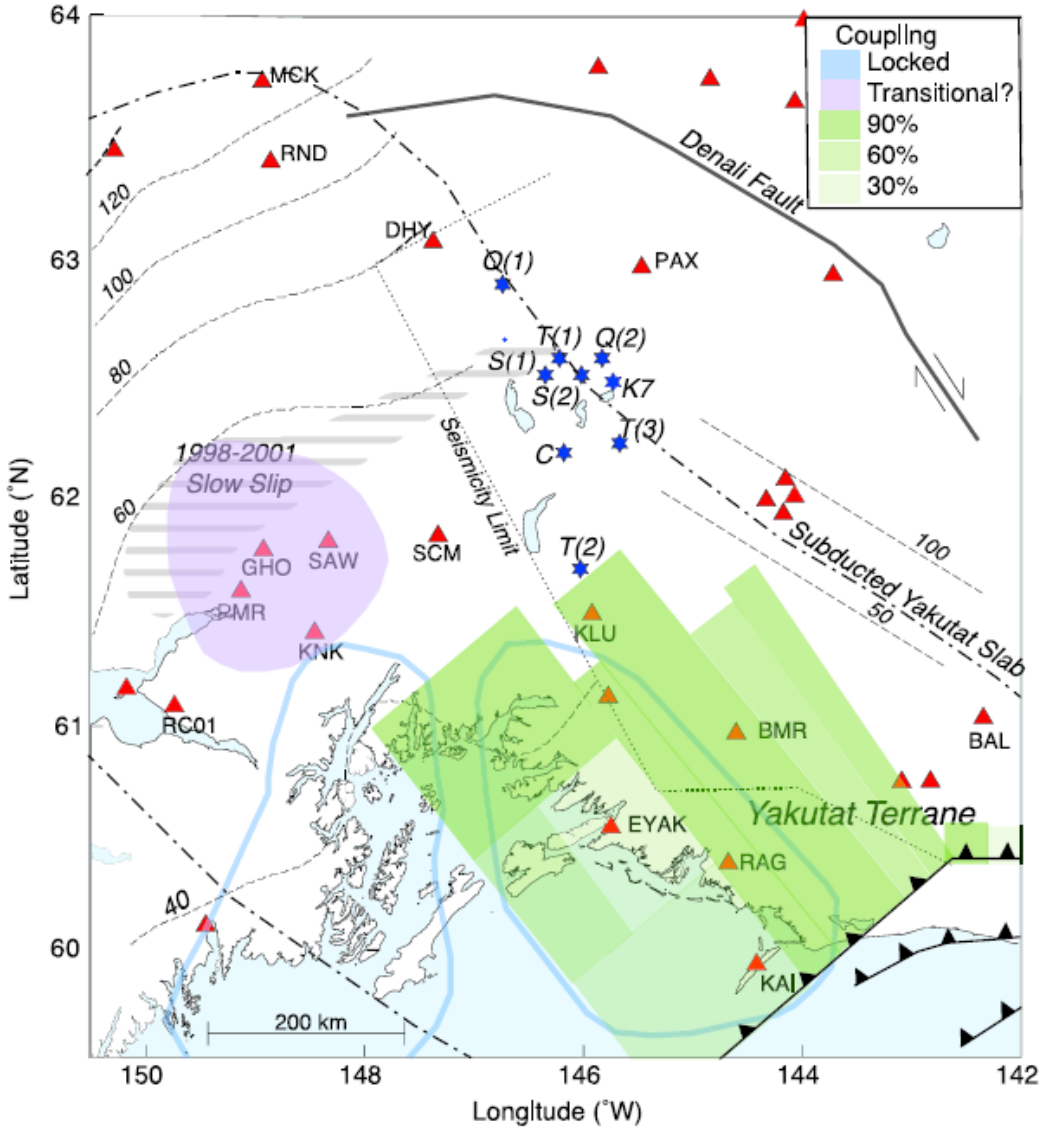


Figure 5. Map of epicenters of mainland tremor sources.

Blue Stars indicate locations of Tremor events triggered by large teleseismic earthquakes. No corresponding slip is observed.

JGR Dec 2013, Gomberg & Prejean
DOI 10.1002/2013JB010273, 2013

Triggered motion from distant Earthquakes

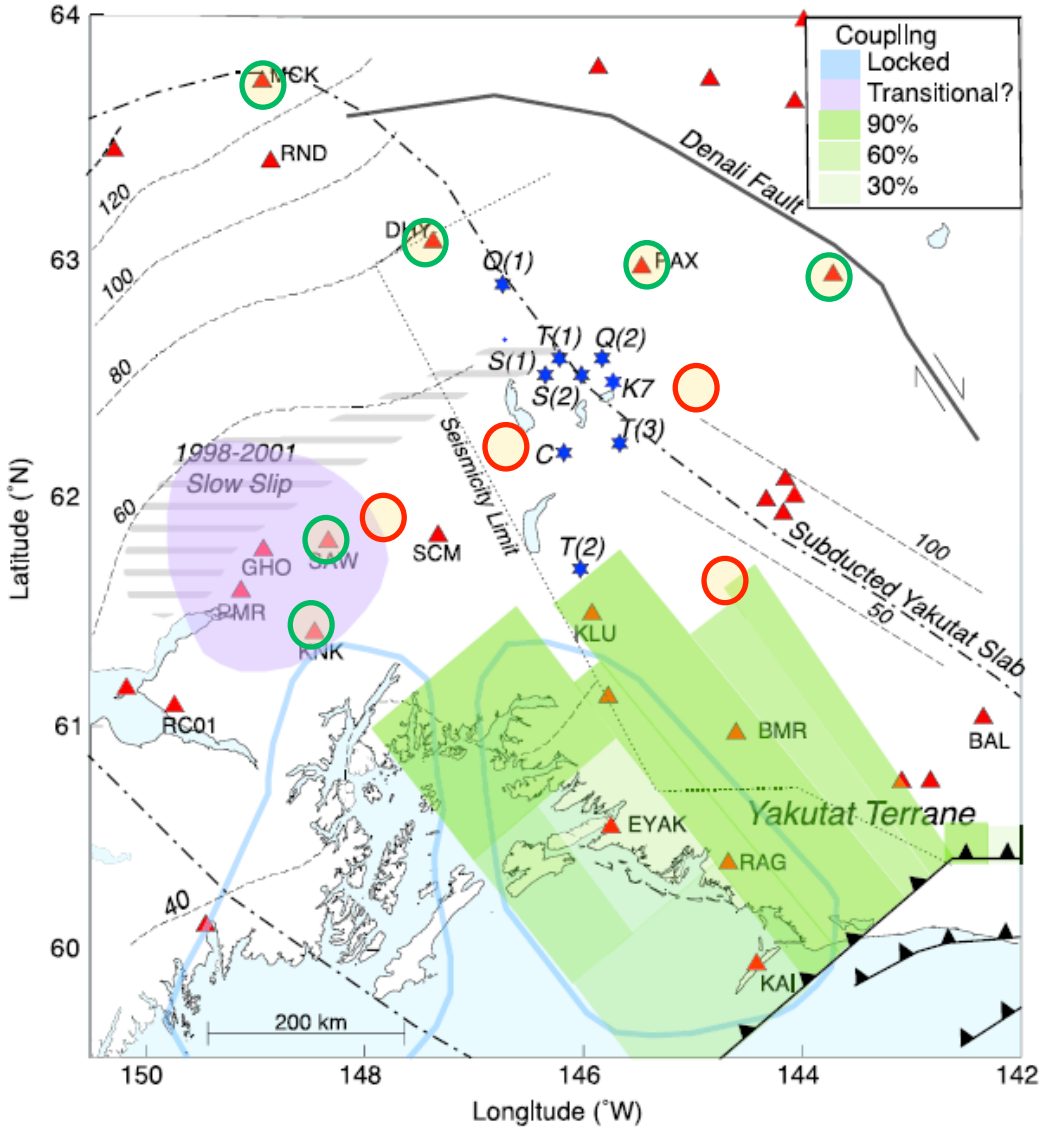


Figure 5. Map of epicenters of mainland tremor sources.

Blue Stars indicate locations of Tremor events triggered by large teleseismic earthquakes. No corresponding slip is observed.

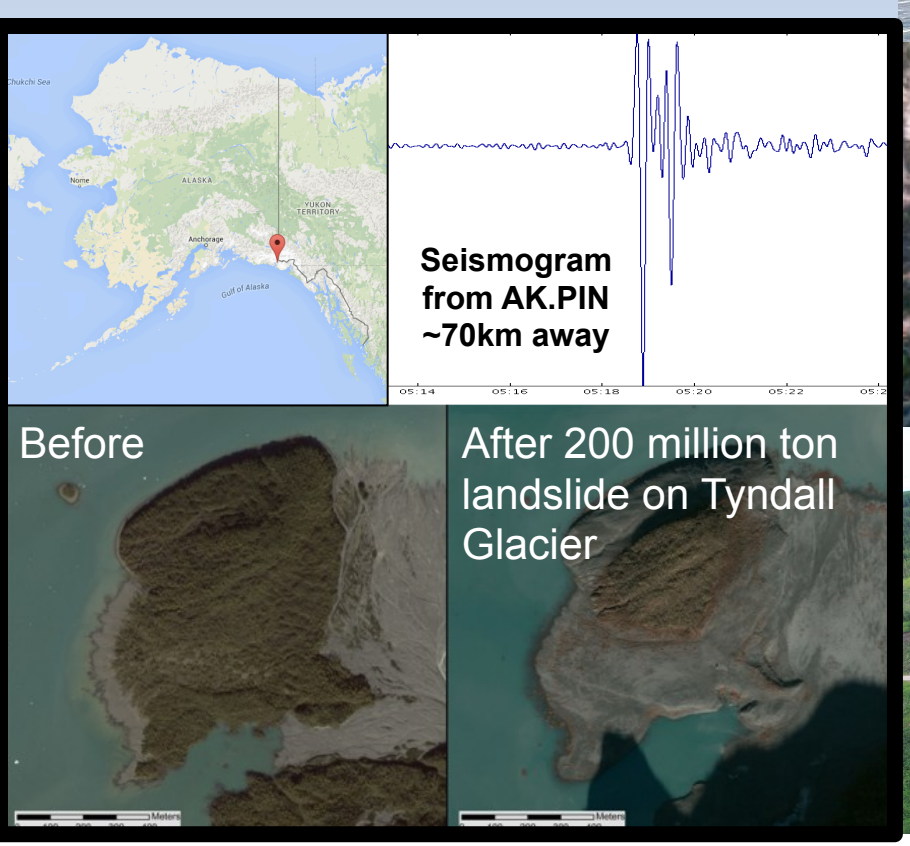
New TA Station

Upgraded Station

JGR Dec 2013, Gomberg & Prejean
DOI 10.1002/2013JB010273, 2013

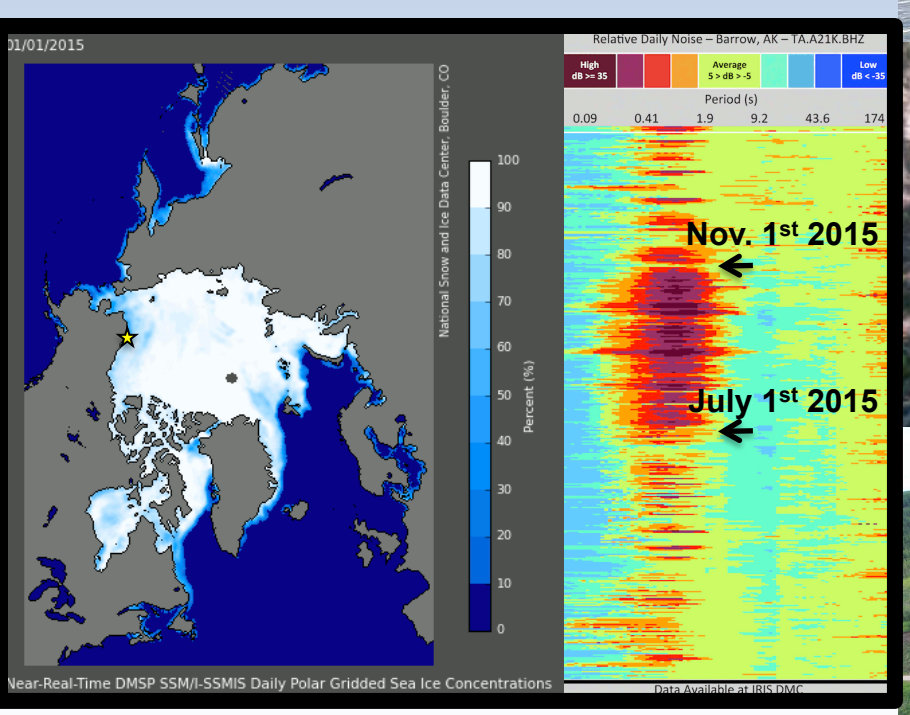
Network of ~280 seismometers and other sensors recording a variety of signals

Example: 2015 Tyndall landslide



Network of ~280 seismometers and other sensors recording a variety of signals

Example: 2015 Sea Ice extent



Observatory Summary

The Transportable Array has been transformative

- The TA has been successfully deployed in a challenging frontier region.
- The TA has established a foundation for research in seismology and hazard monitoring.
- Multiple Sensors engage interdisciplinary science

Transformative research involves . . . tools that radically change our understanding . . .

For More Information

On the Web

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

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