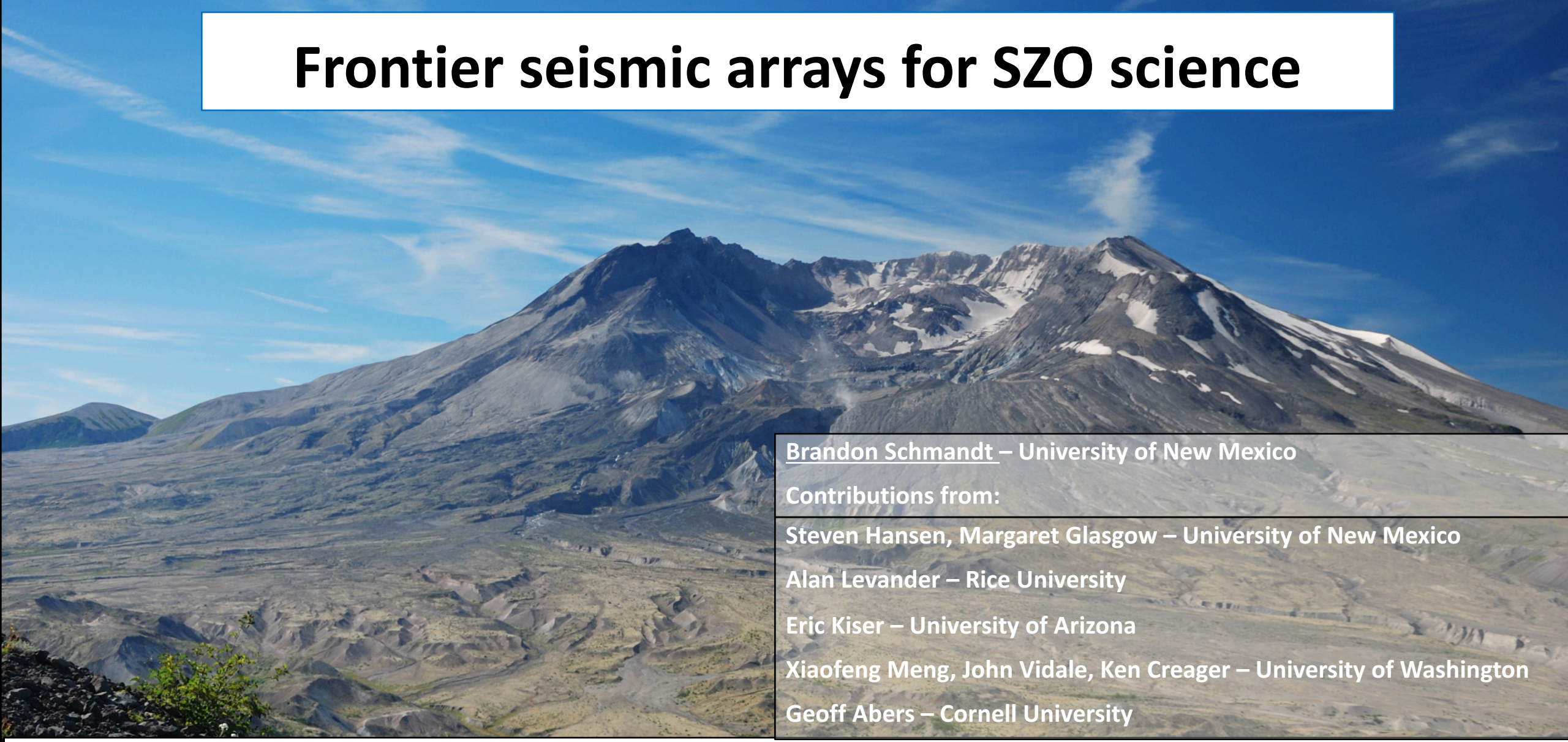
Frontier seismic arrays for SZO science



Brandon Schmandt – University of New Mexico

Contributions from:

Steven Hansen, Margaret Glasgow – University of New Mexico

Alan Levander – Rice University

Eric Kiser – University of Arizona

Xiaofeng Meng, John Vidale, Ken Creager – University of Washington

Geoff Abers – Cornell University

THE UNIVERSITY of NEW MEXICO

RICE

UNIVERSITY of WASHINGTON

CORNELL UNIVERSITY FOUNDED A.D. 1865

NODALSEISMIC
real cable free data acquisition

NSF

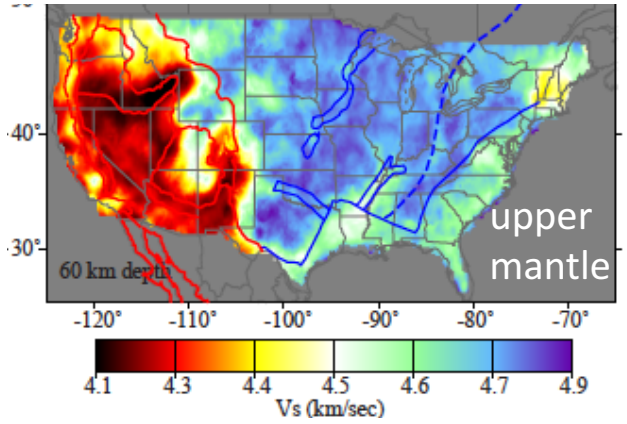
EarthScope's TA as an example

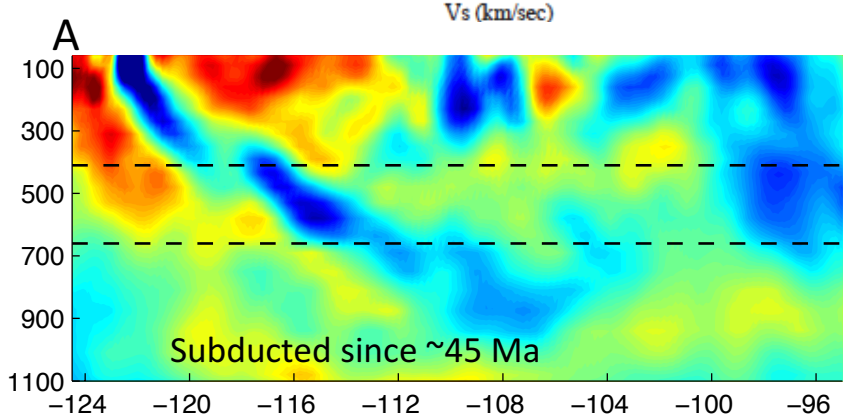
Key perspective to maintain for SZO seismic
-best data immediately open-access

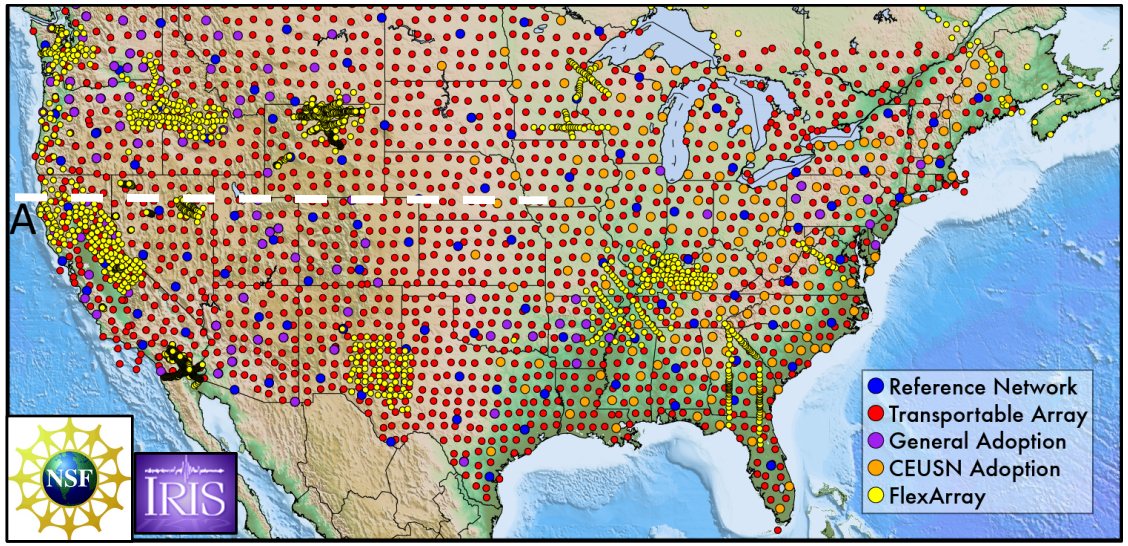
70 km TA grid is survey-mode science because prior sampling of continental interiors was sparse.

Similar survey mode SZO would be informative, but I expect less so than **zooming in and tailoring dense experiments and monitoring for specific processes and hypotheses**

→ **Our next world-class community-driven seismic arrays for SZO could be local-to-regional**

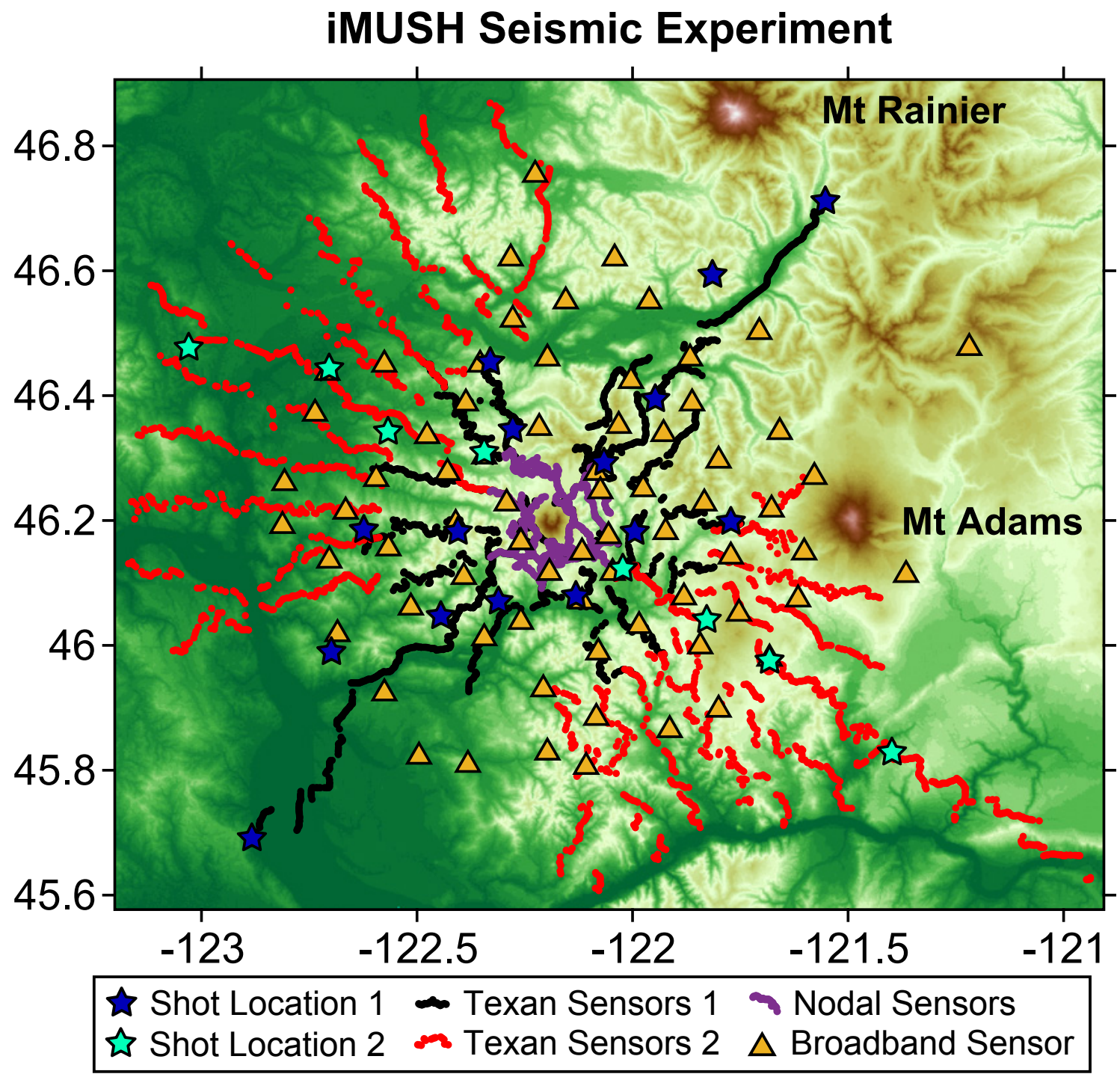






A half-way there example of zooming in on SZO science… in this case a volcano

(if you don’t care much about volcanoes, imagine the Osa Peninsula or your favorite megathrust)



Active

- 23 active source shots, 500-1000 kg
- ~2500 Texans deployed in each of two phases

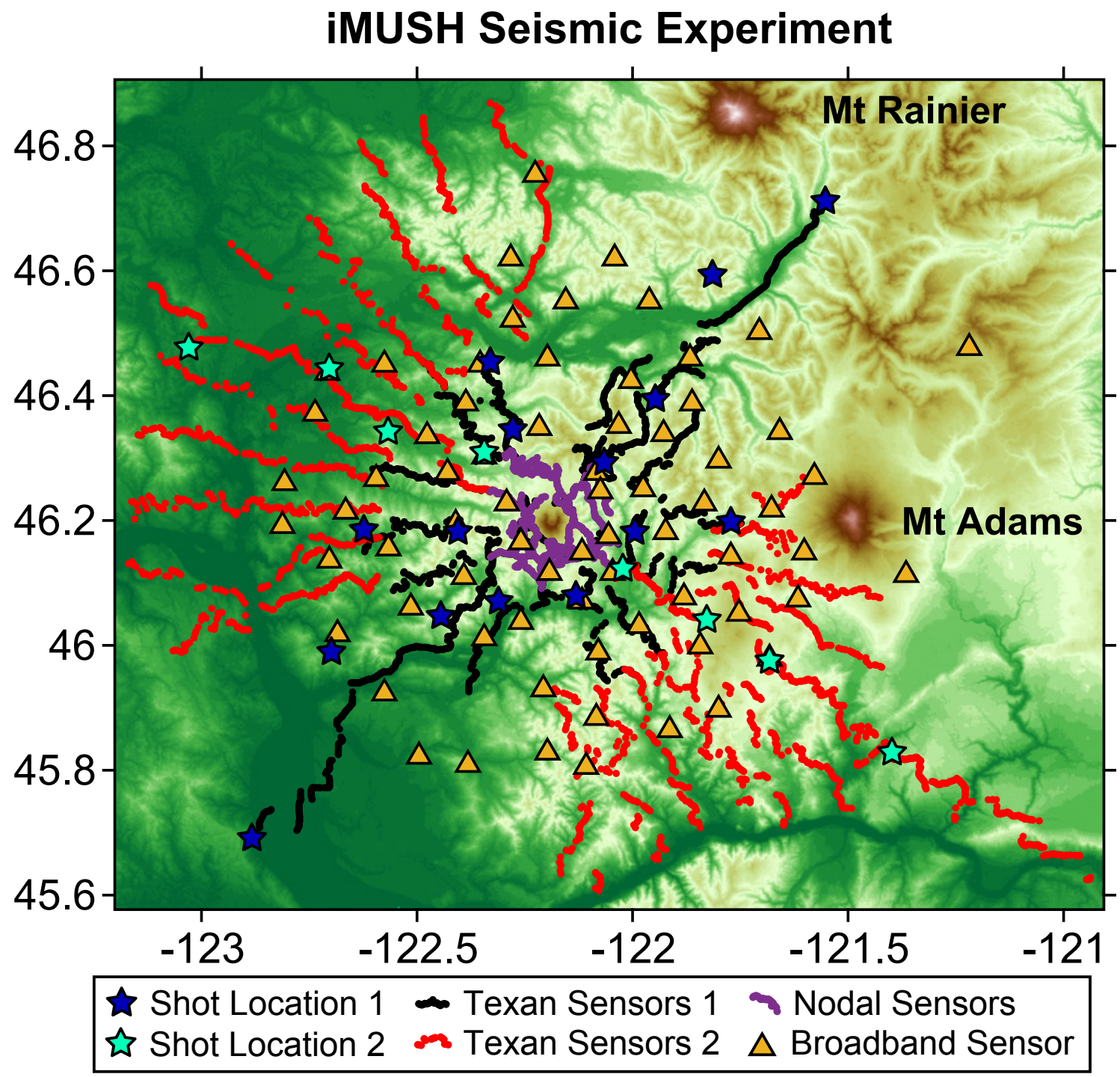
Passive

- 70 broadband seismometers
- ~2 years, ~10-15 km spacing

Hybrid (last-minute effort)

- 900 geophones (vertical)
- 2 weeks, 250 Hz sampling

Supported by: NSF GeoPRISMS, EarthScope, and Geophysics



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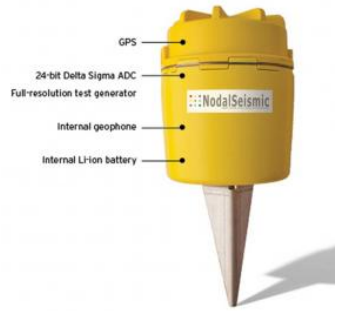
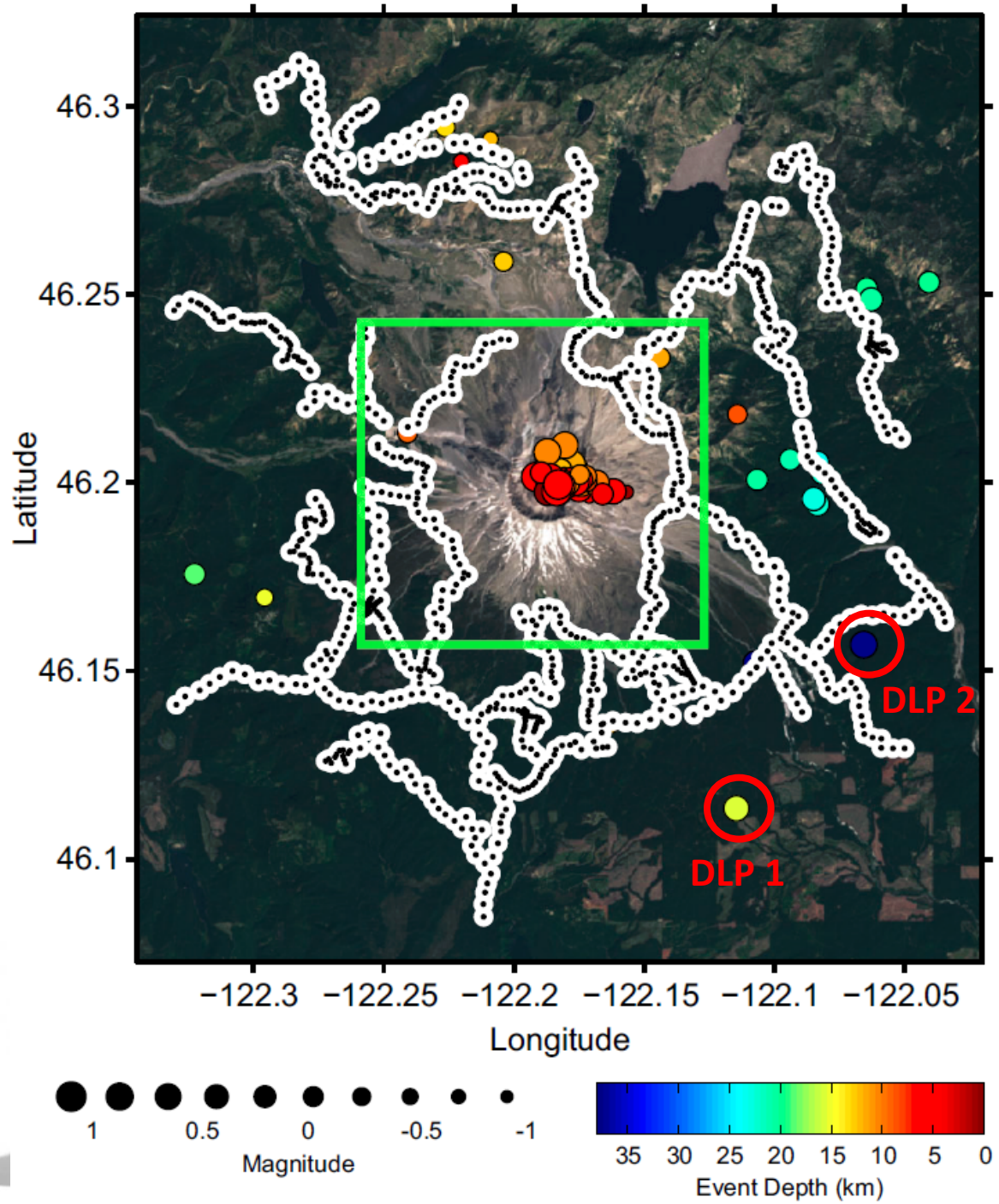
Lots of potential to do this better for SZO

NSF Rapid, EarthScope
EAR - 1445937

Node Deployment

- 920 first generation Fairfield Zland
- Continuous data for two weeks in Summer 2014
- Coincident with iMUSH active source experiment
- 45 shallow events cataloged by PNSN beneath the summit crater
- Deep long-period (DLP) events occurred on 7/23 and 7/29

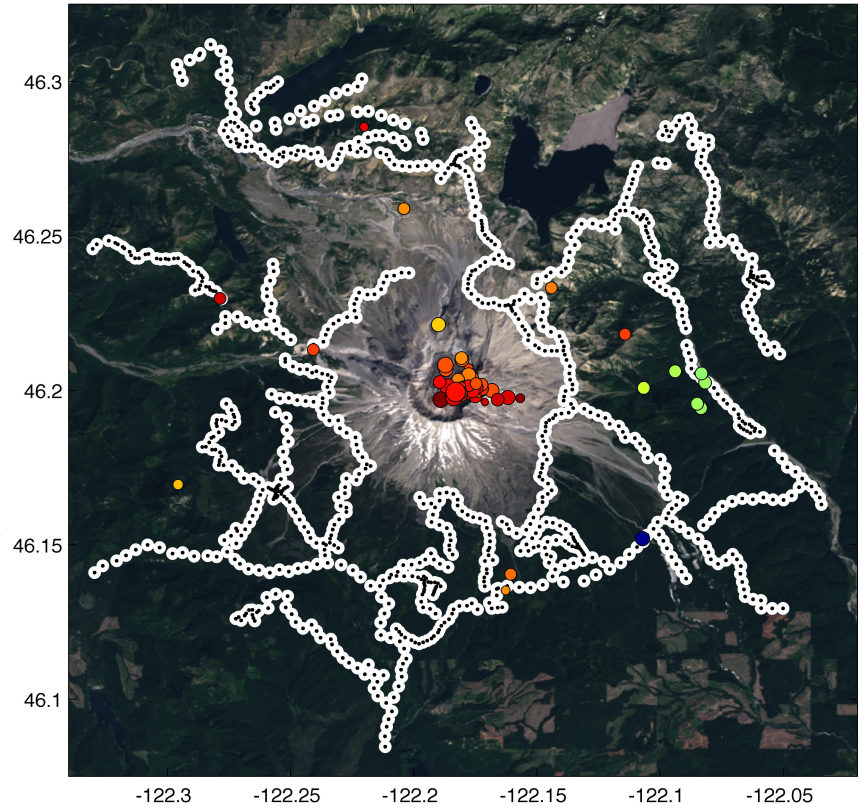




1,000 nodes (made it to 920)

13 Students UNM and Portland State
1 middle school teacher
2 field techs from NodalSeismic

Deployed in 4 days primarily by backpacking (up to 15 km from trailhead one-way)



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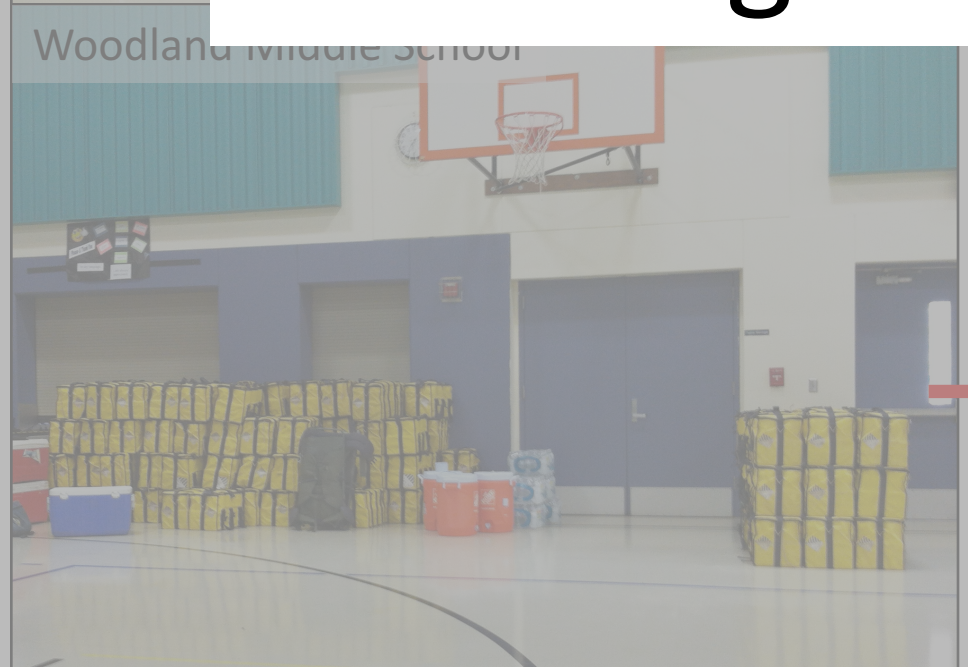
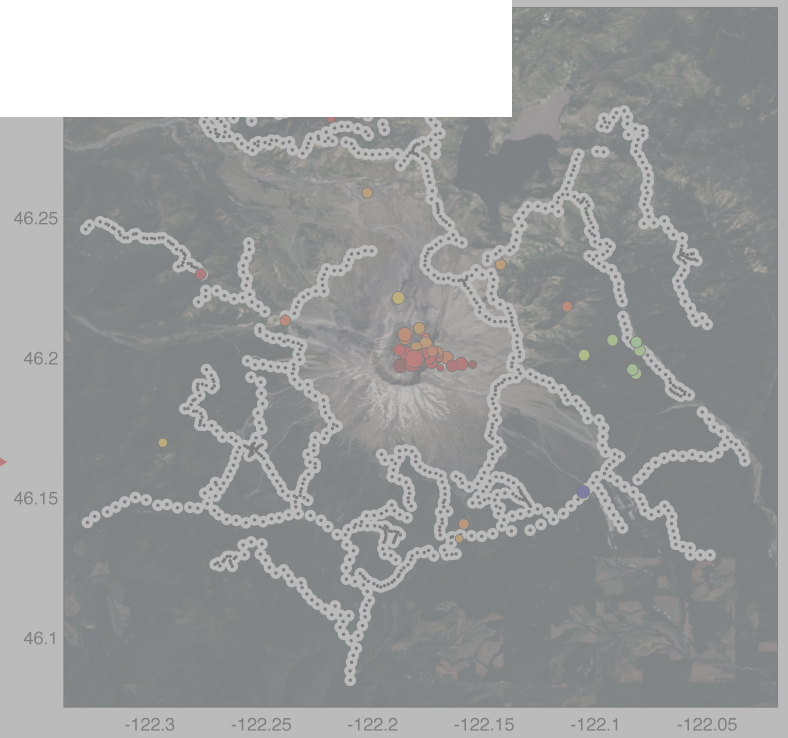
This is a small pilot project, SZO can go BIG

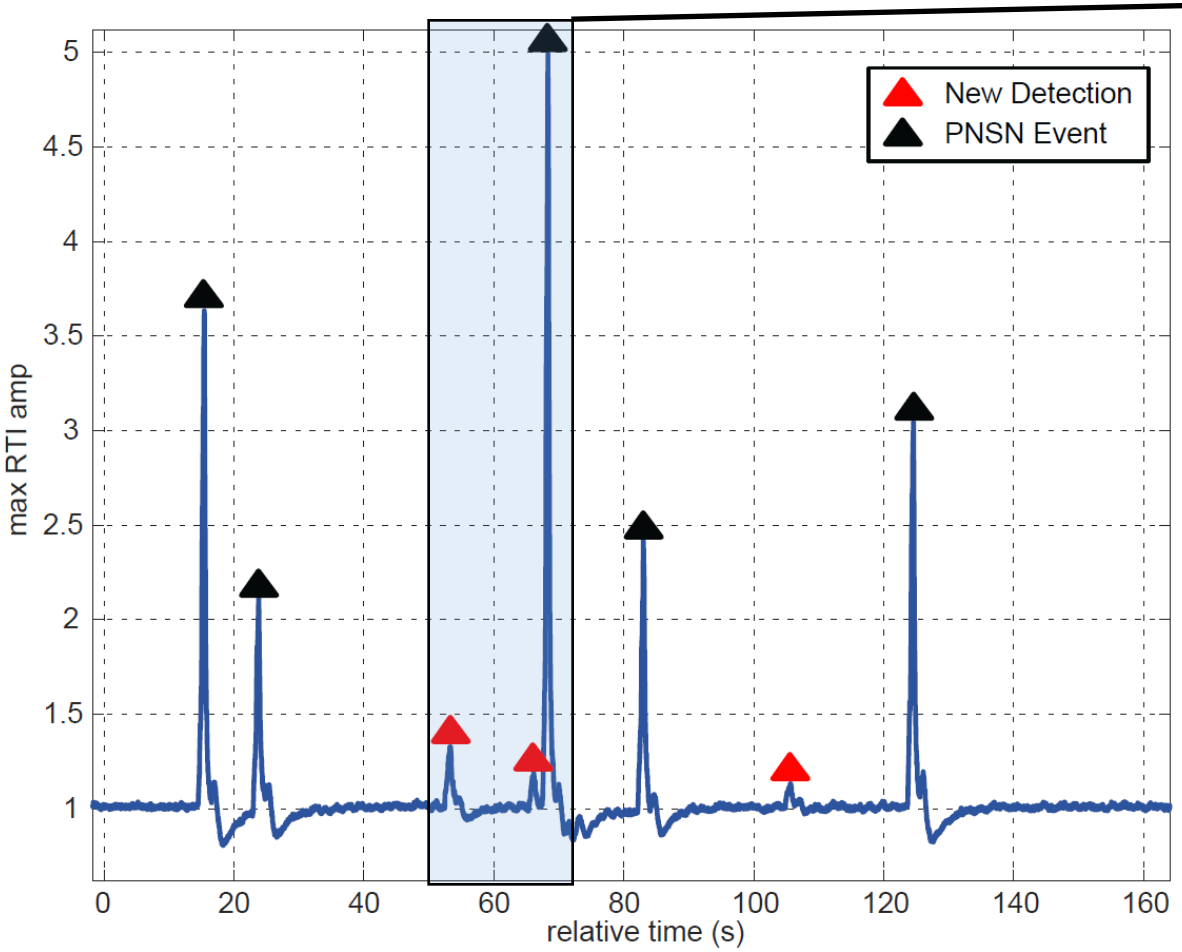


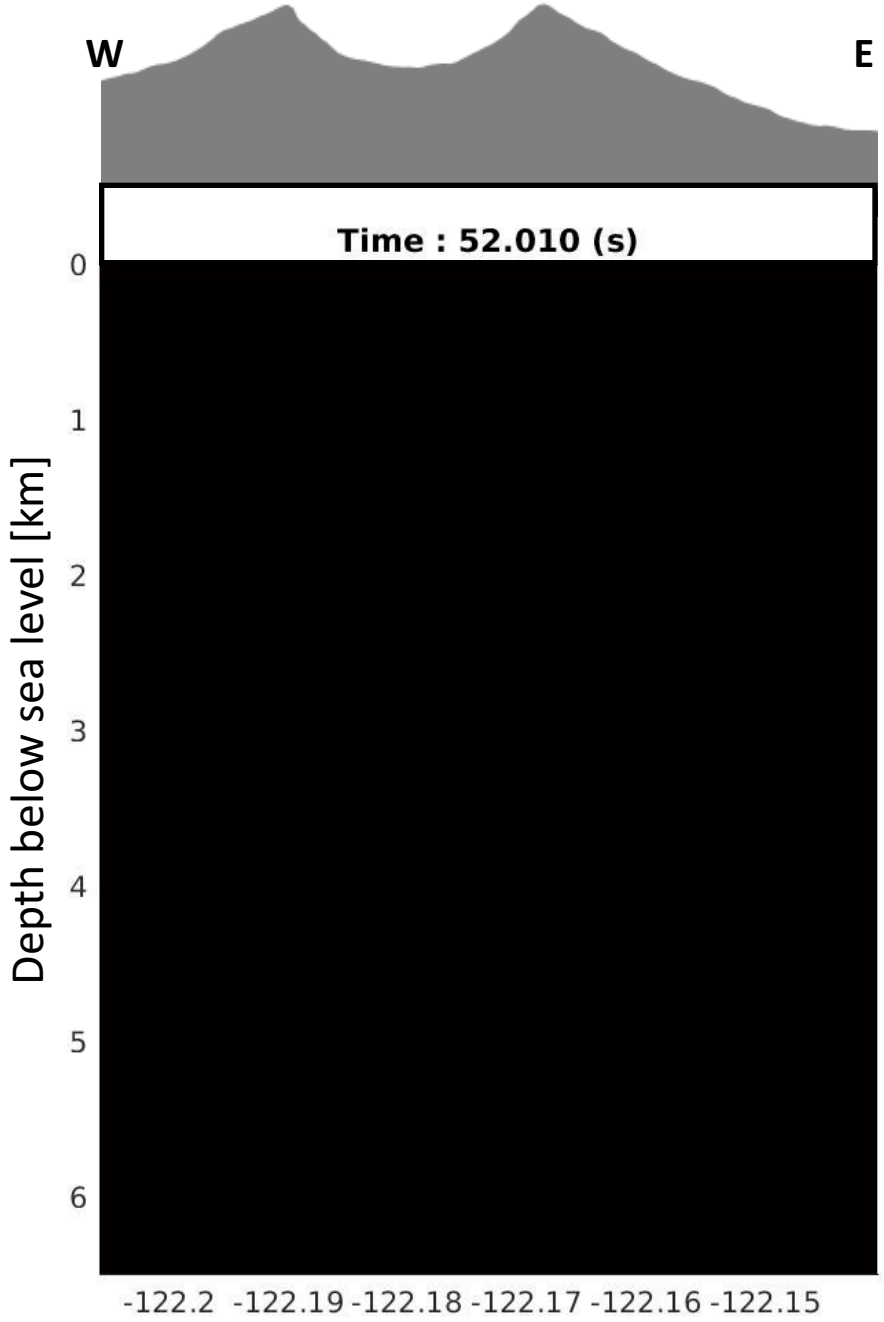


Microseismicity Detection and Location

(More on Steve Hansen's poster)

Reverse Time Imaging of microseismicity

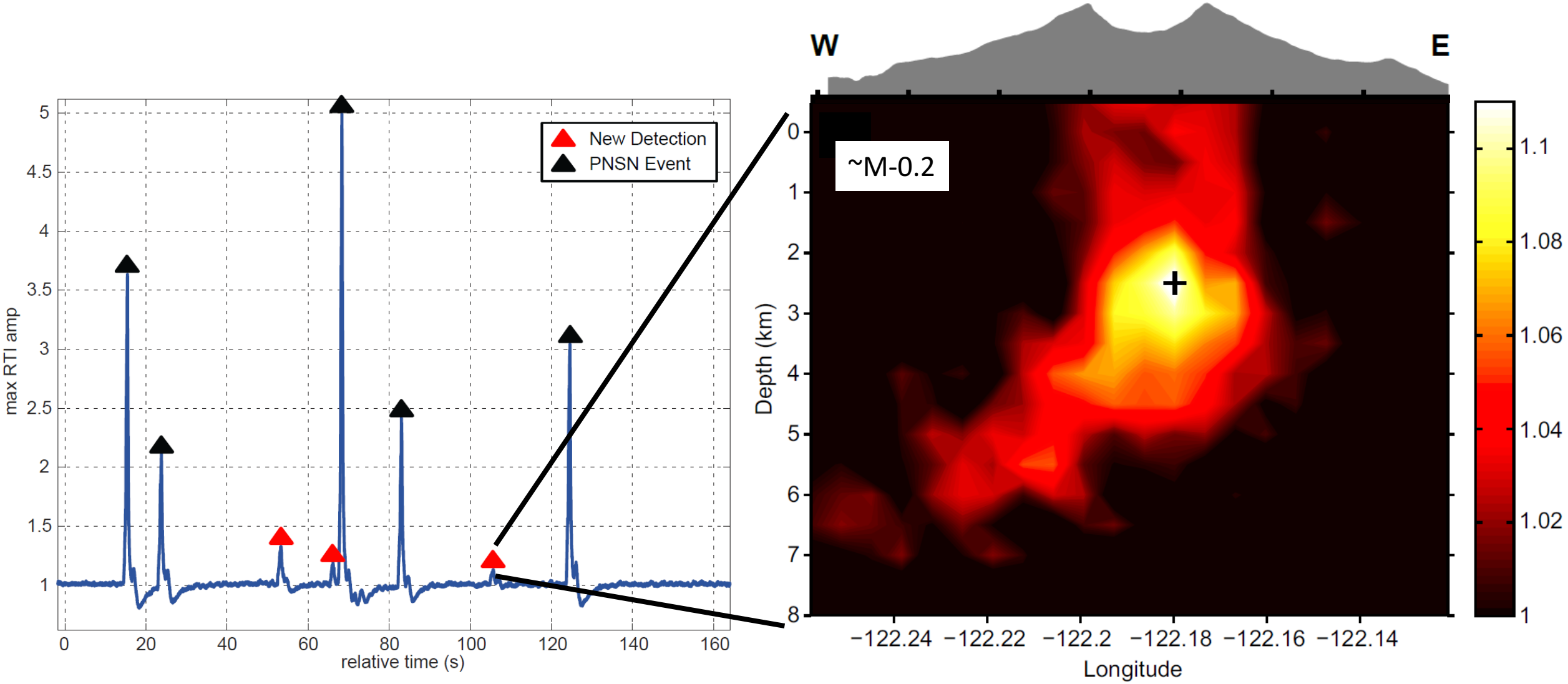




- 3-D kinematic back-projection using Waite and Moran [2009] P tomography
- Median value at each image point on 500 m grid
- 125 samples/s, ~120 million time samples

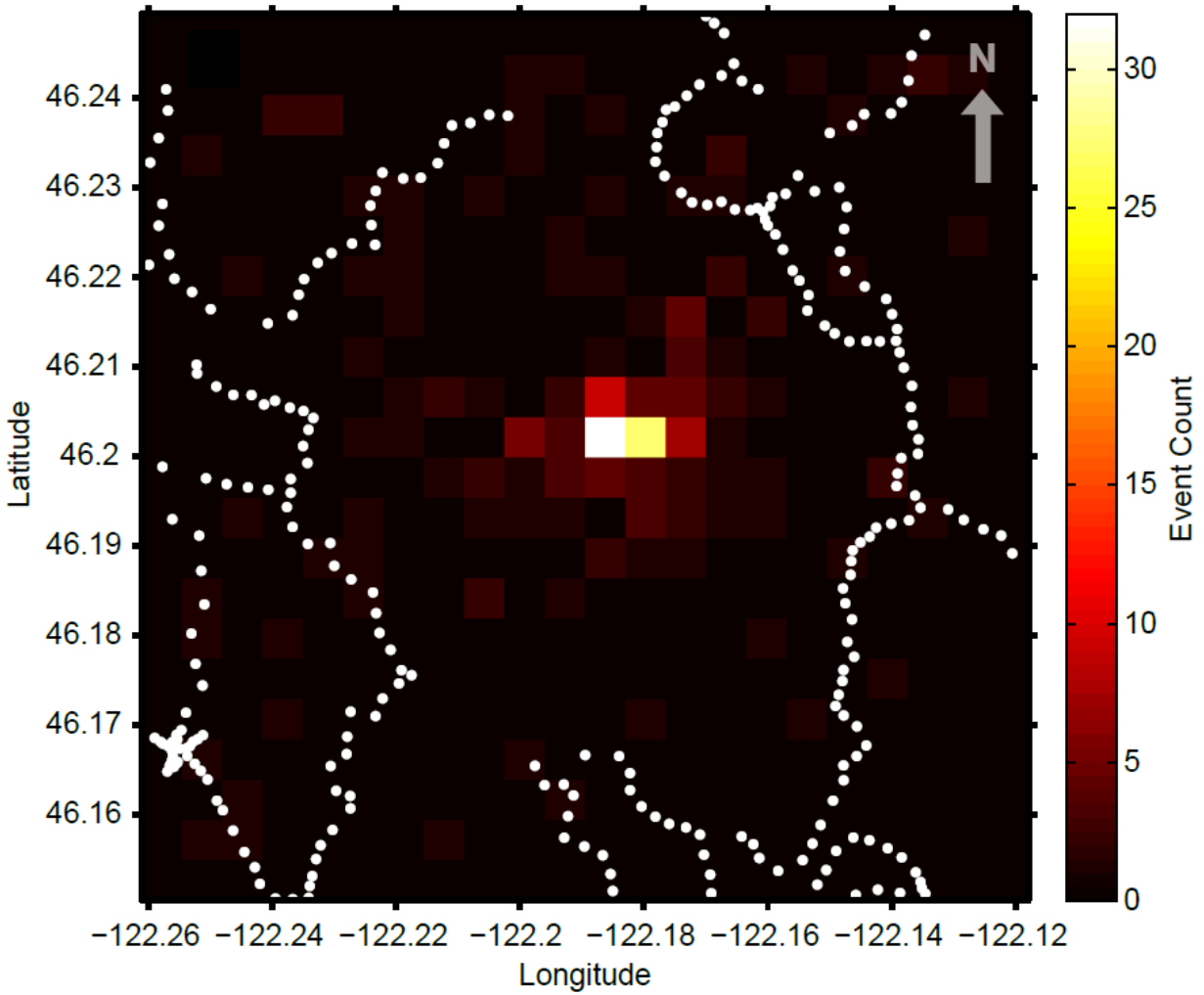
(Hansen and Schmandt, 2015)

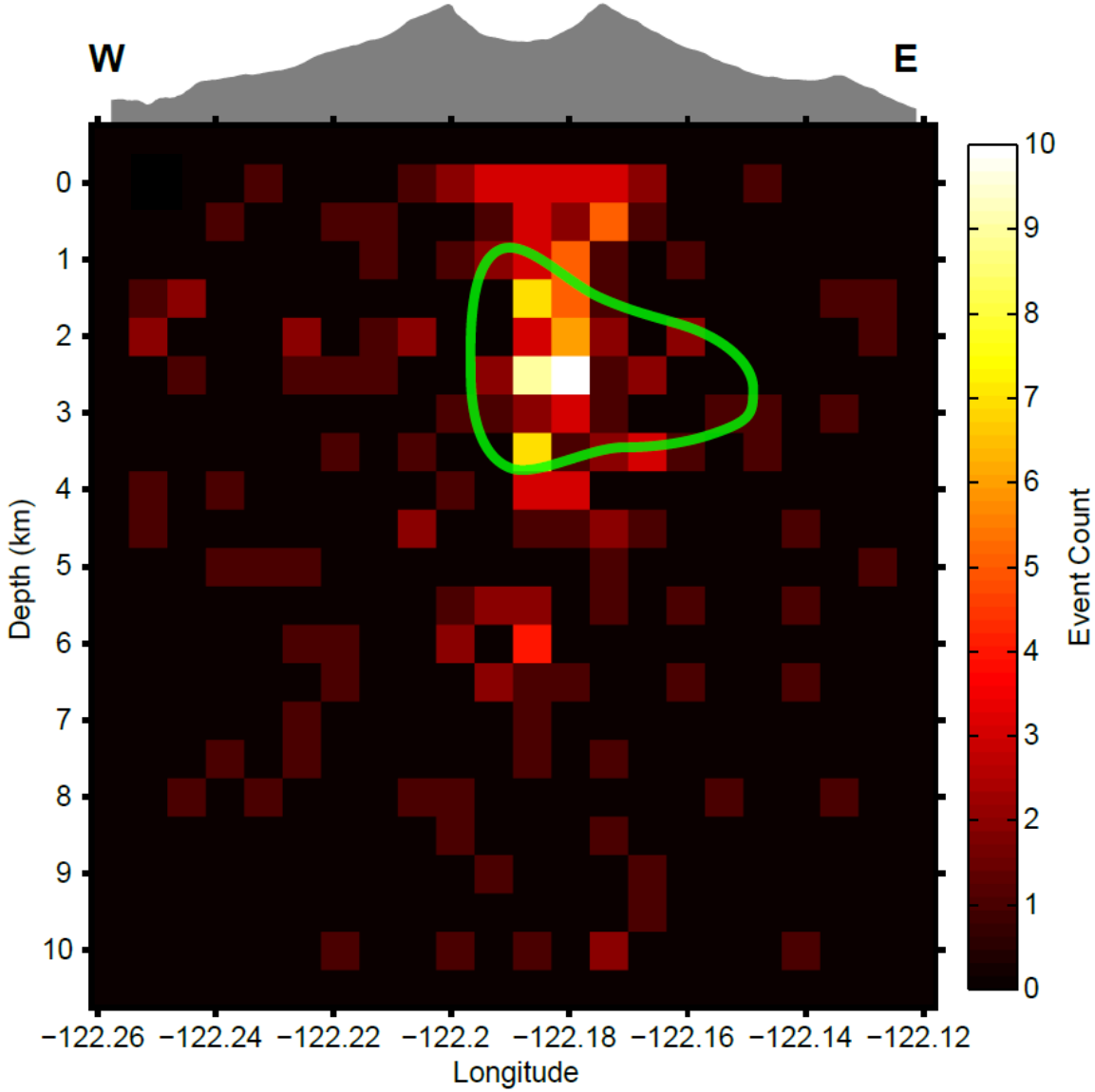
RTI Detection and Location



(Hansen and Schmandt, 2015)

Event Distribution





(Hansen and Schmandt, 2015)

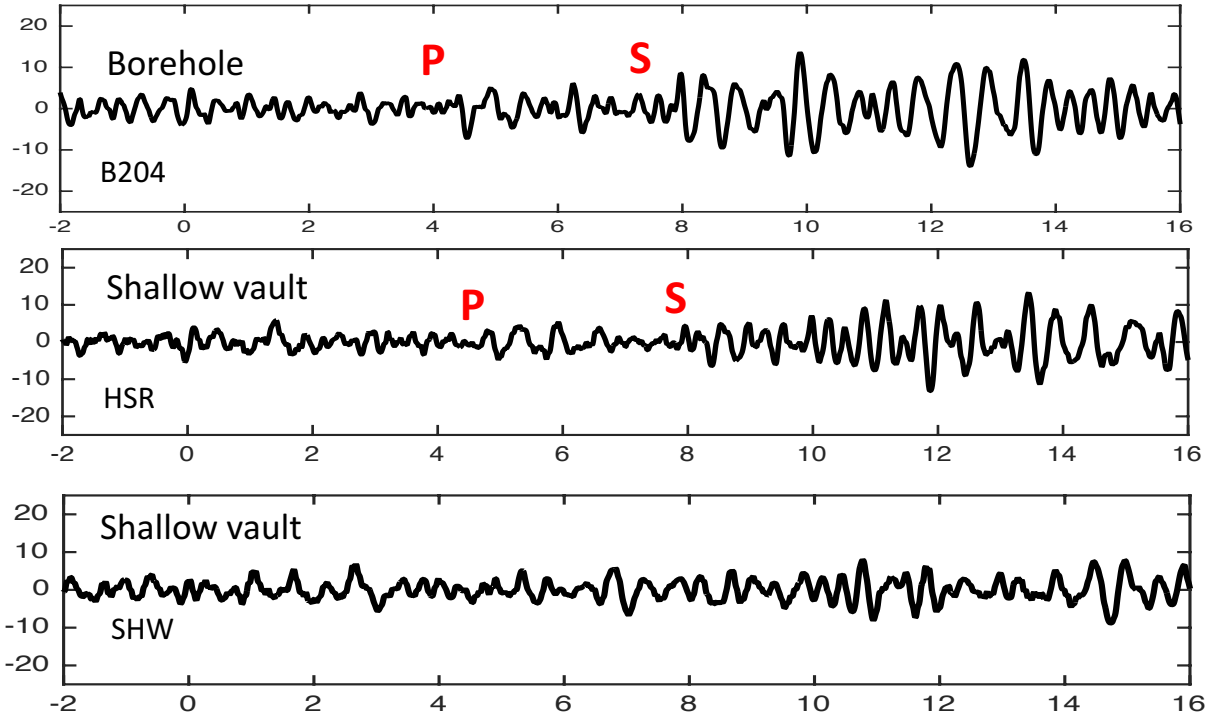
Hypothesized shallow magma chamber
[Waite and Moran, 2009]

Deep Long Period Earthquakes

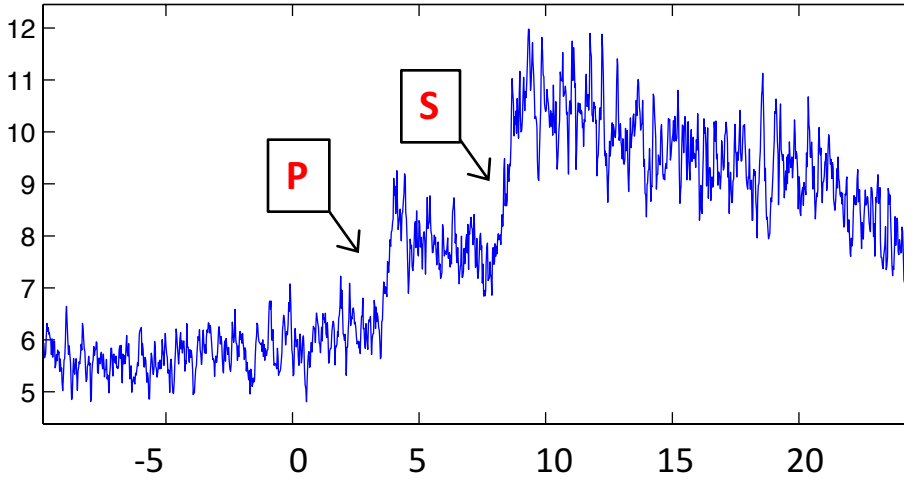
DLP Earthquake Observations

Node Array Observations

Regional Network waveforms for DLP on 7/29/2014

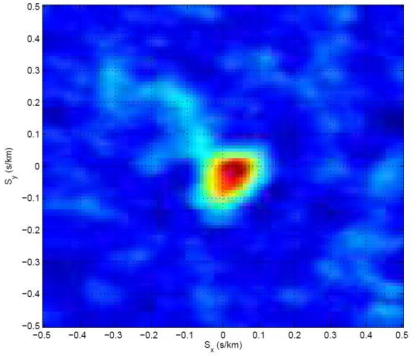


Median envelope for a cluster of 36 nodes



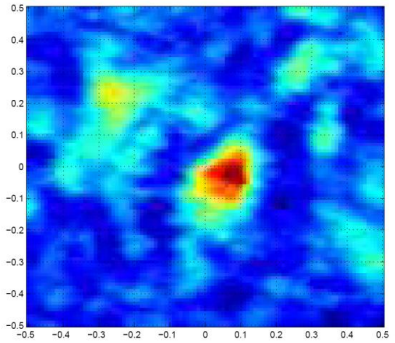
Beamforming with same sub-array

P wave arrival



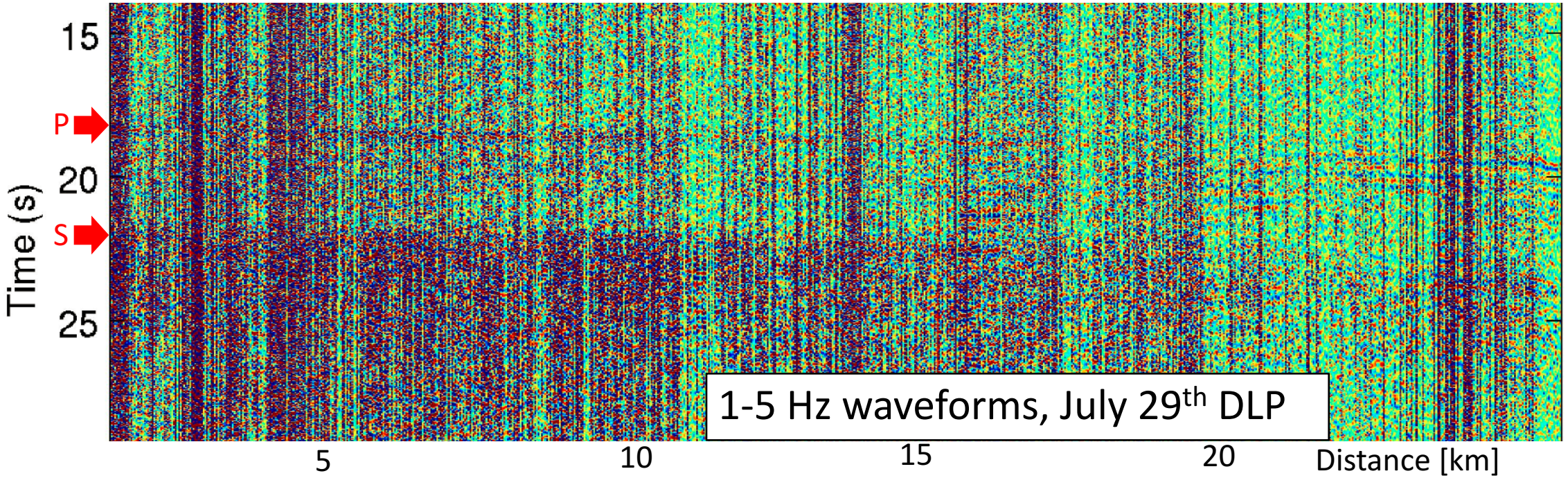
Peak at 22 km/s

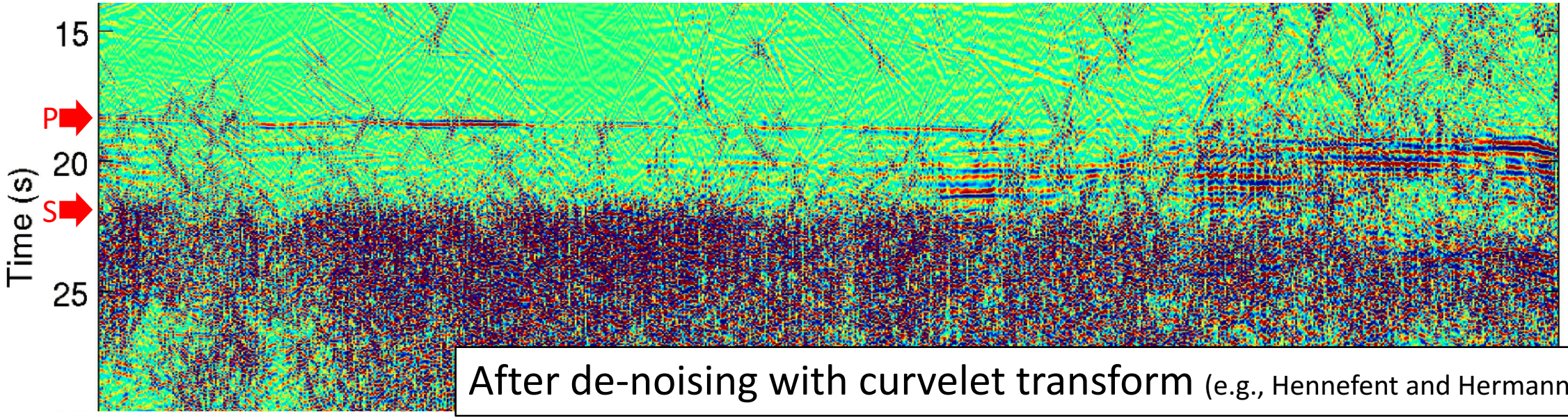
S wave arrival



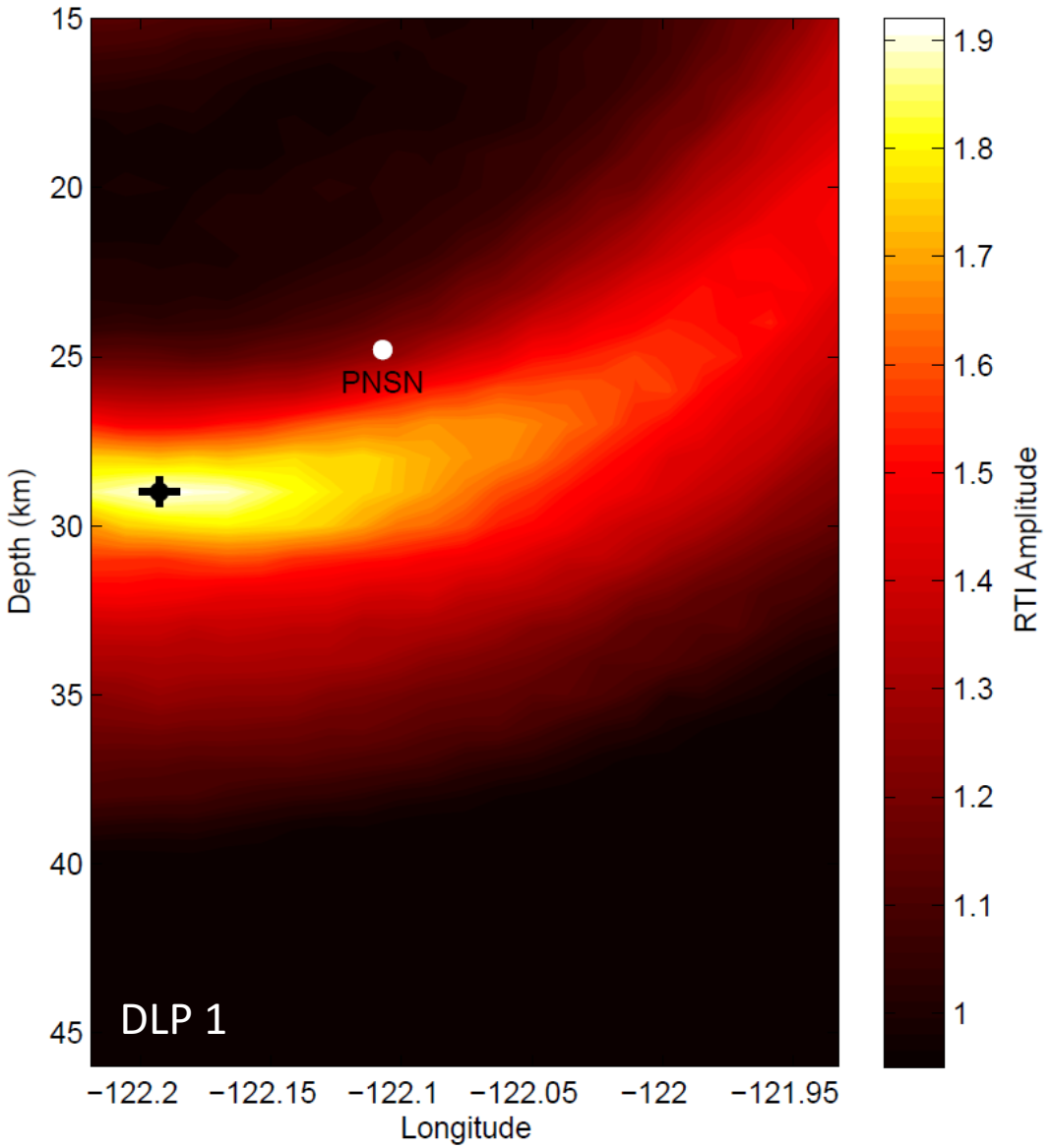
Peak at 12 km/s

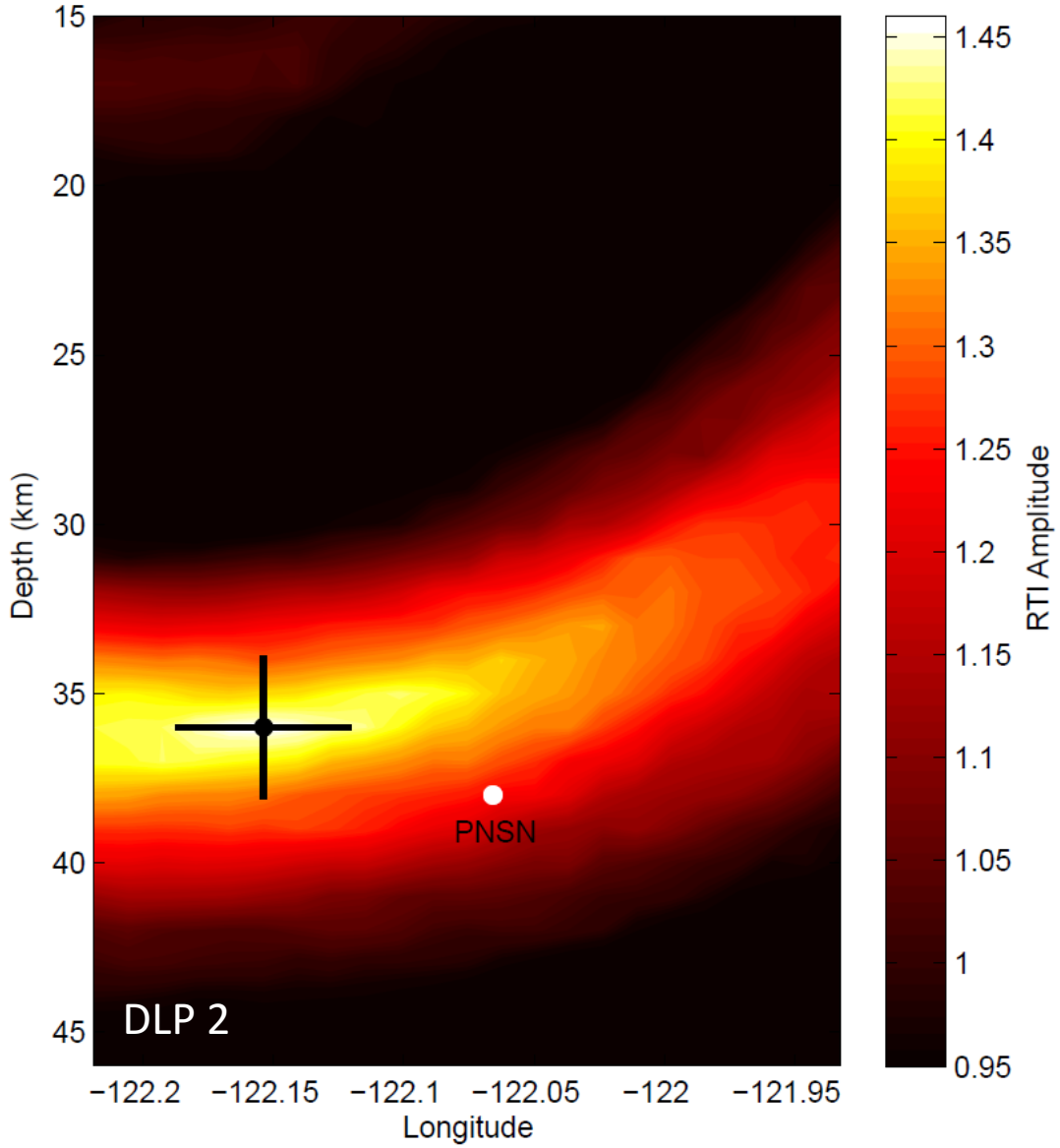
Potential for array processing of DLP sources





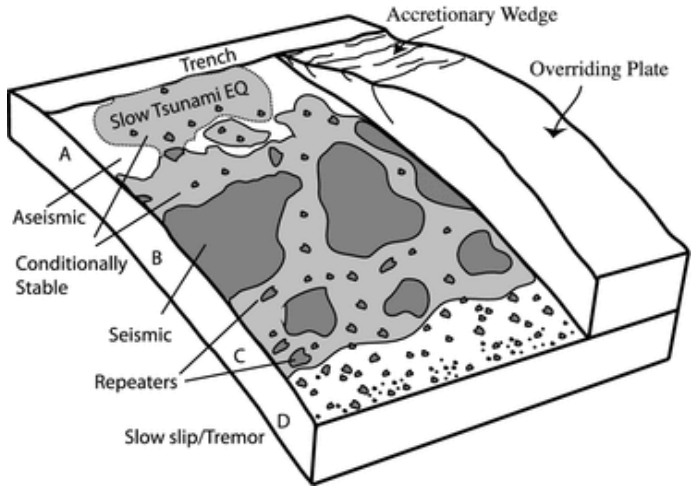
DLP Locations (simultaneous back-projection of P and S)





Mapping interface reflectivity, arc Moho

(imagine fore-arc setting and variations in megathrust reflectivity if you'd prefer)

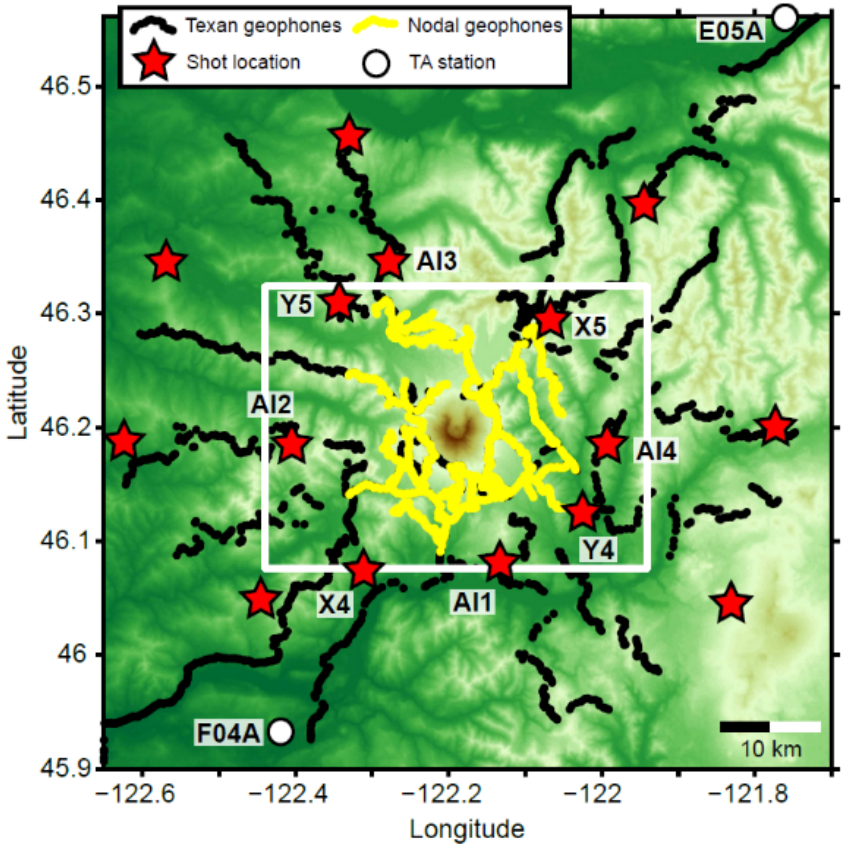


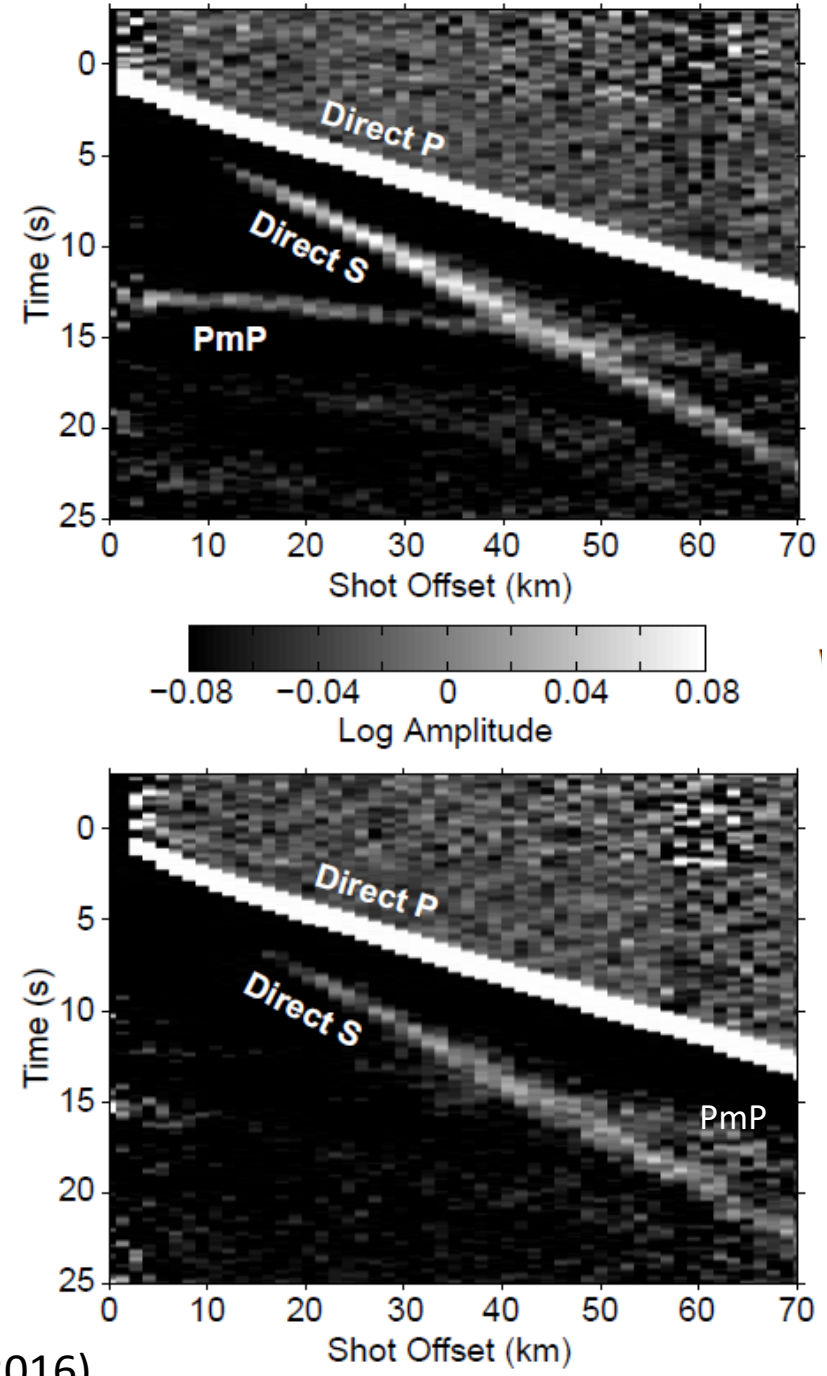
How visible is this in reflection data?

(Lay et al., 2012)

Active Source Offset Gathers

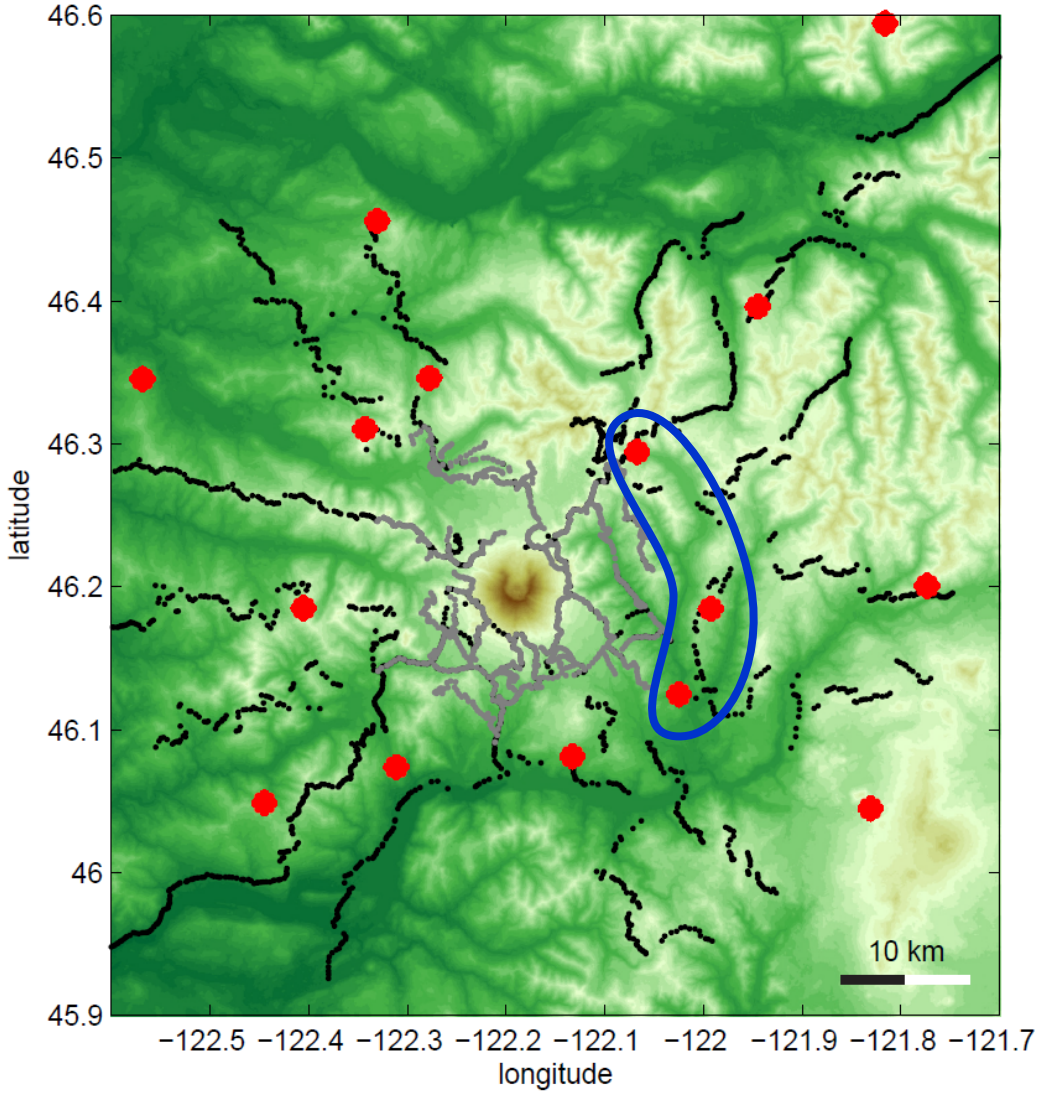
- 15-25 Hz bandpass
- STA/LTA
- Binned by distance
- Median trace

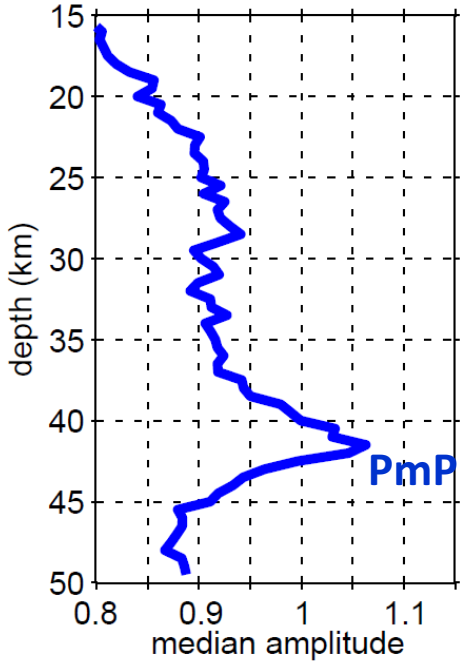


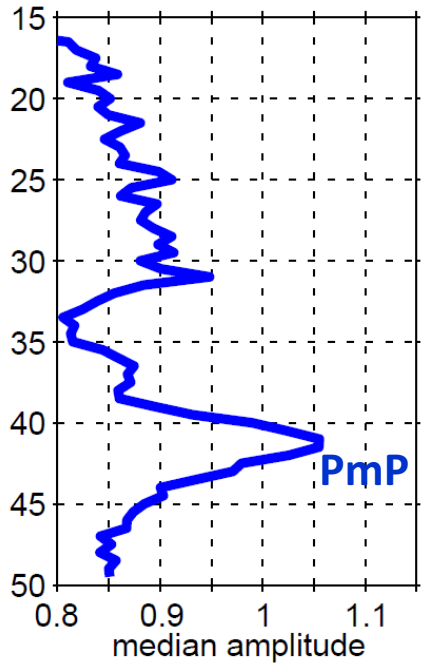


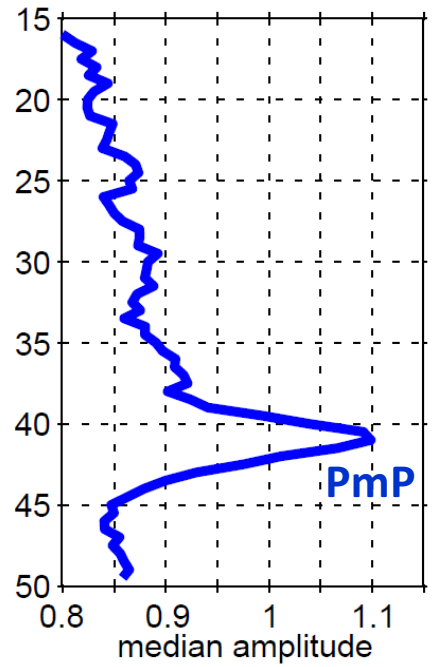
(Hansen et al., 2016)

NMO Shot Stacks



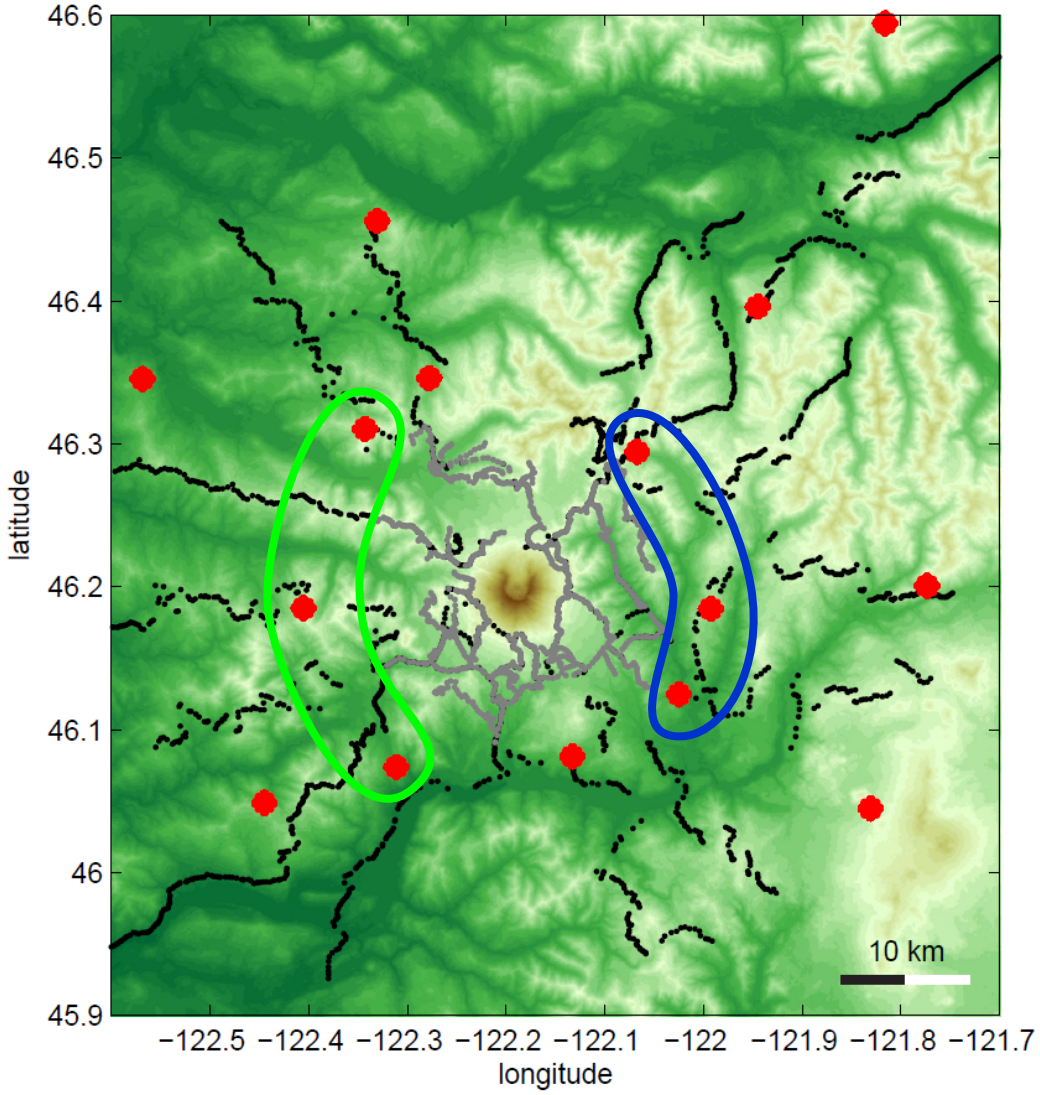




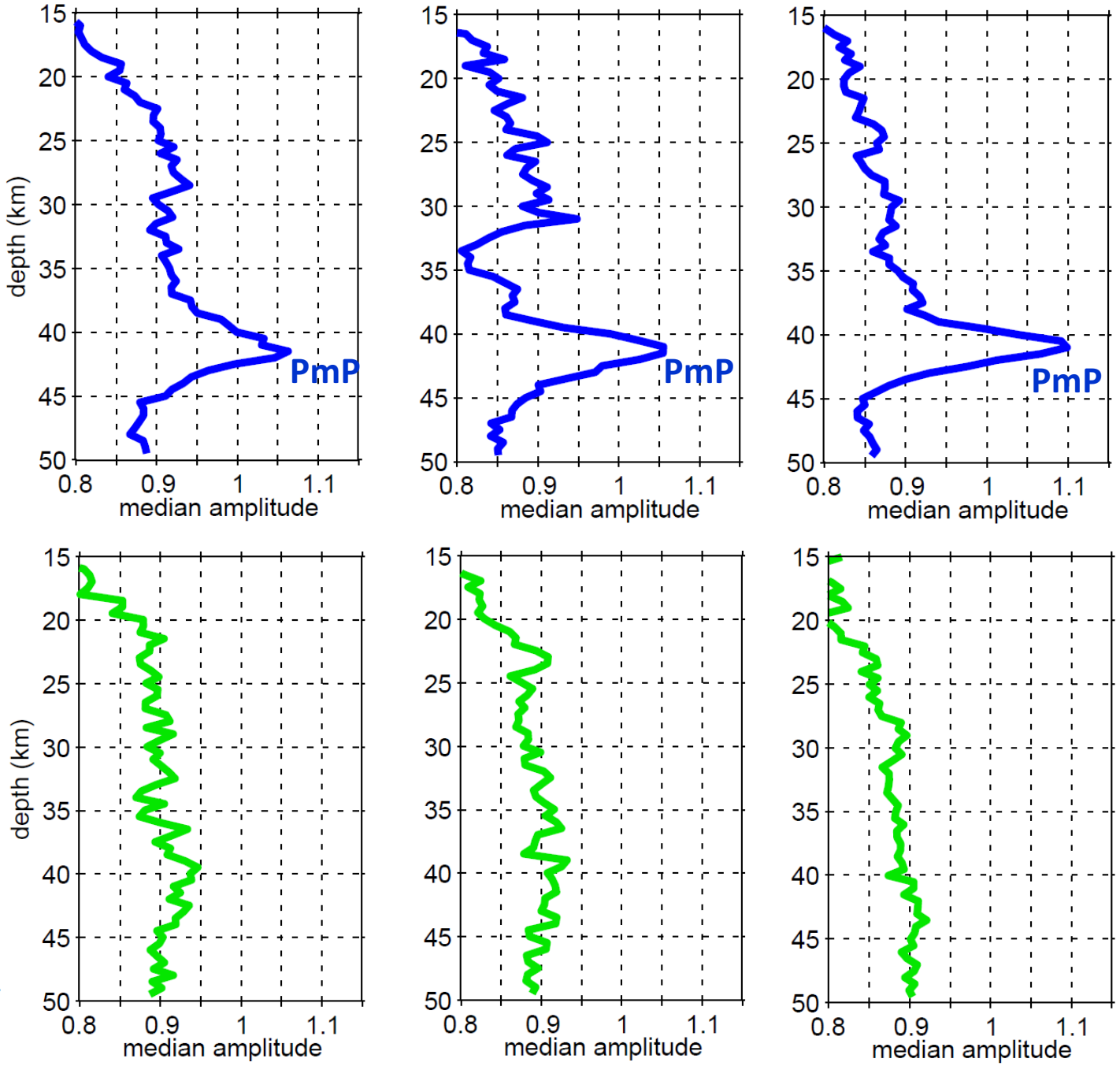


(Hansen et al., 2016)

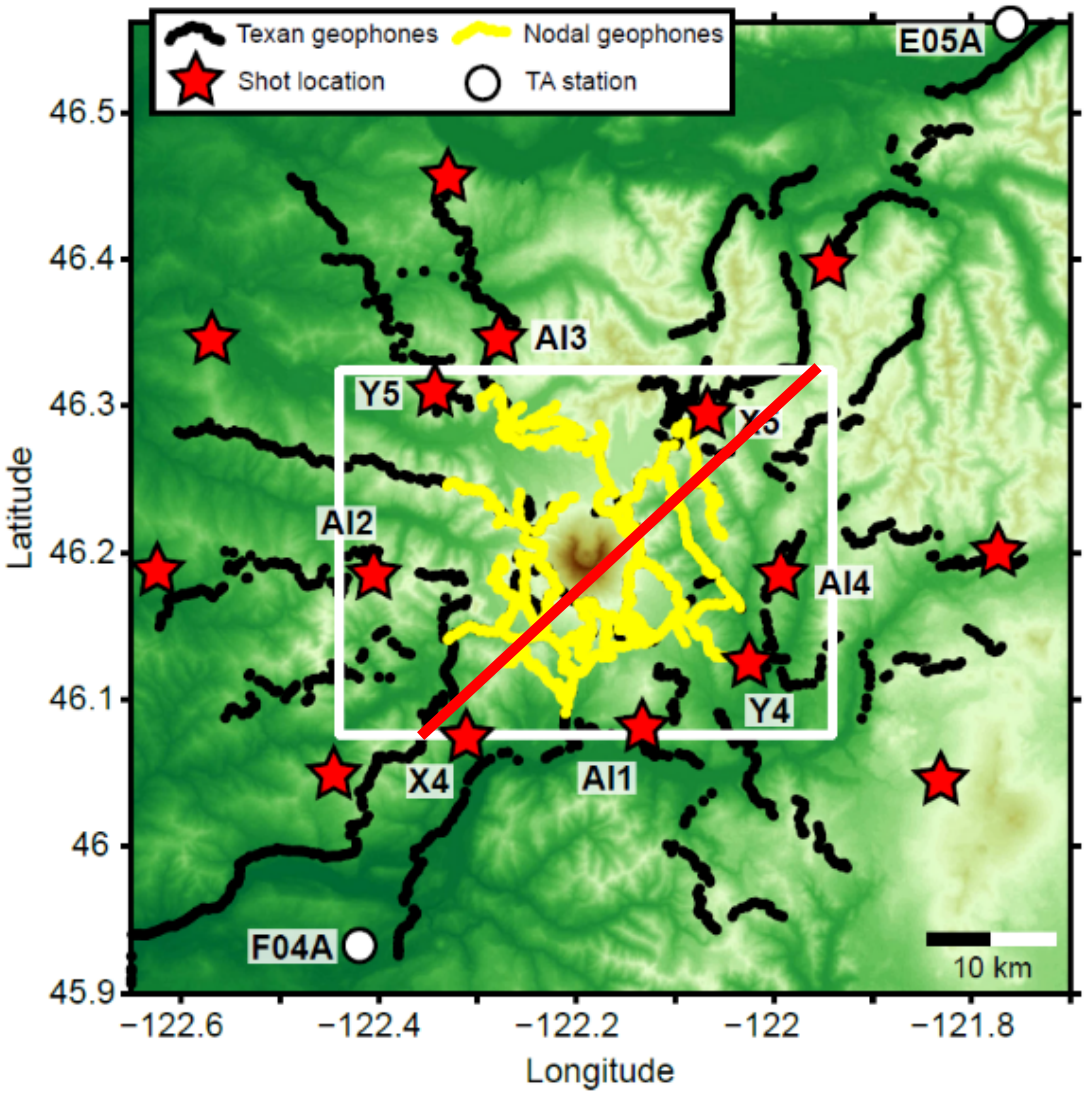
NMO Shot Stacks



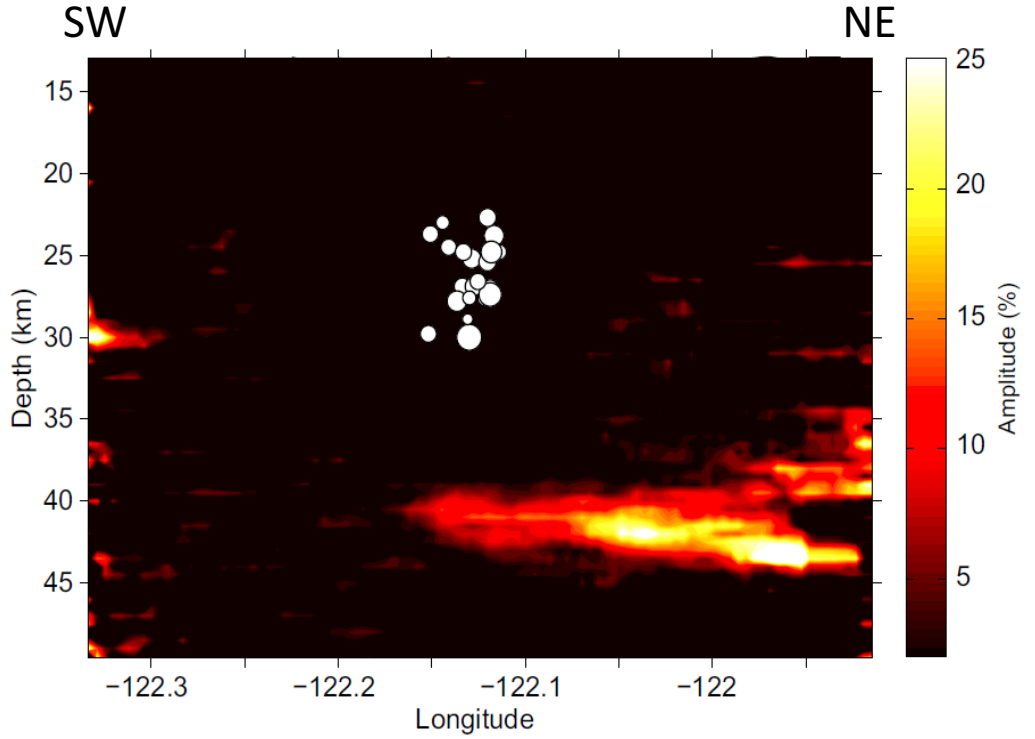
(Hansen et al., 2016)

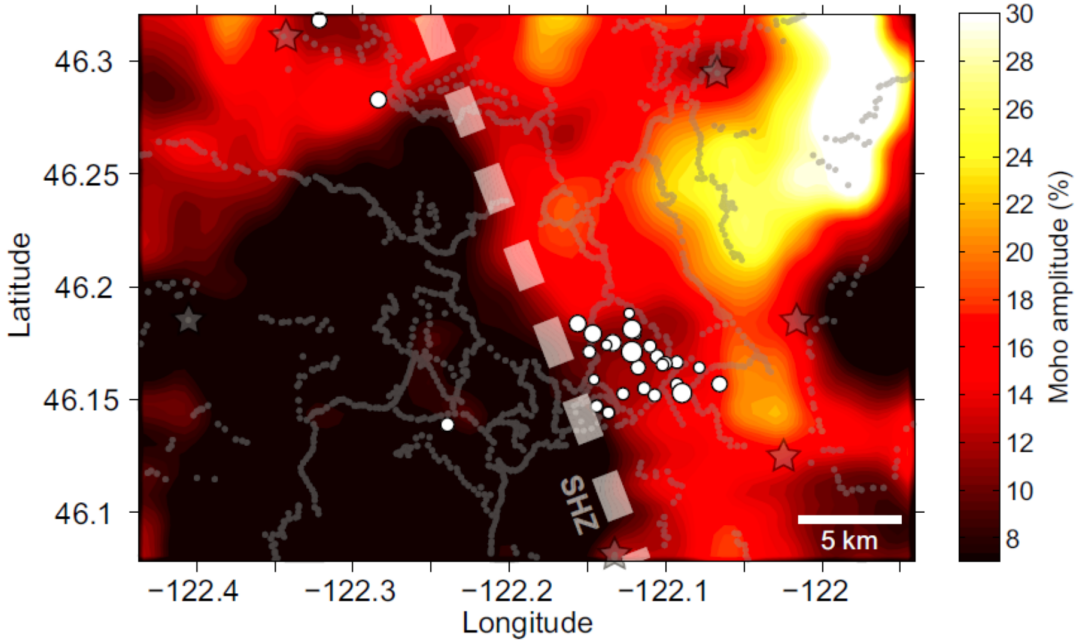


Mapping Moho Reflectivity

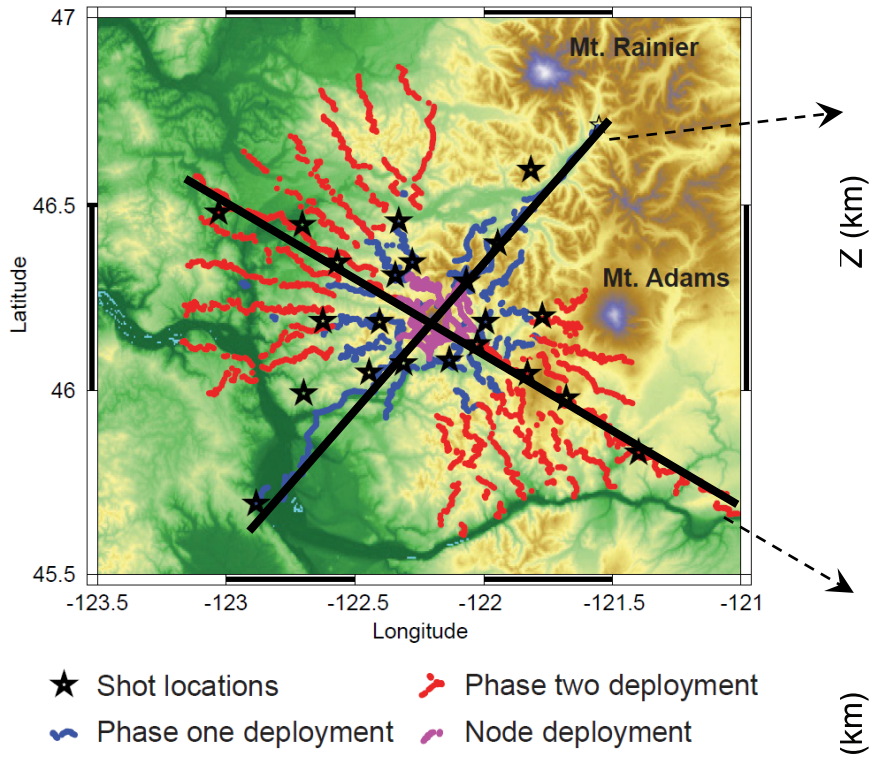


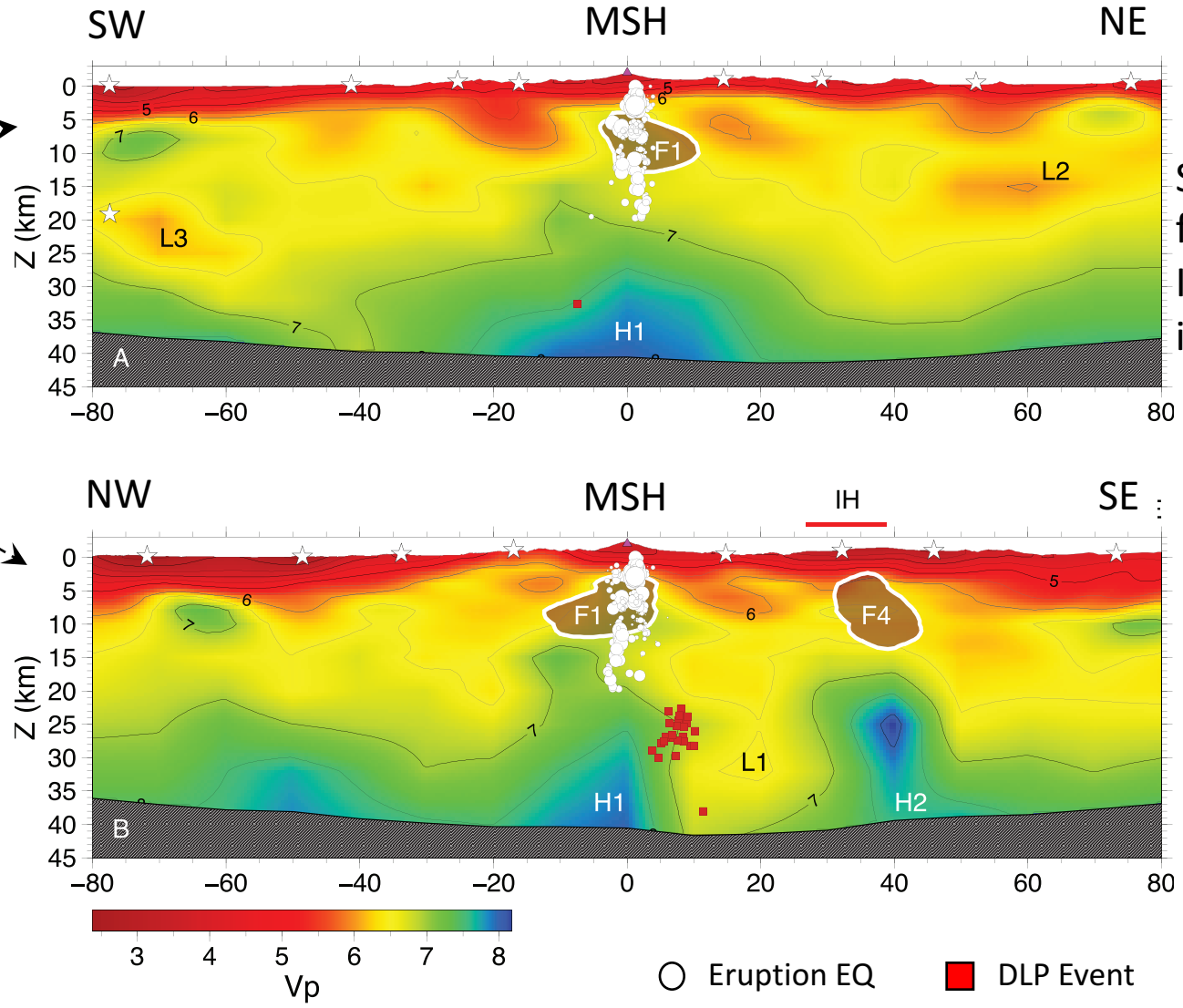
(Hansen et al., 2016)





Controlled source tomography using Texan & Node Arrays

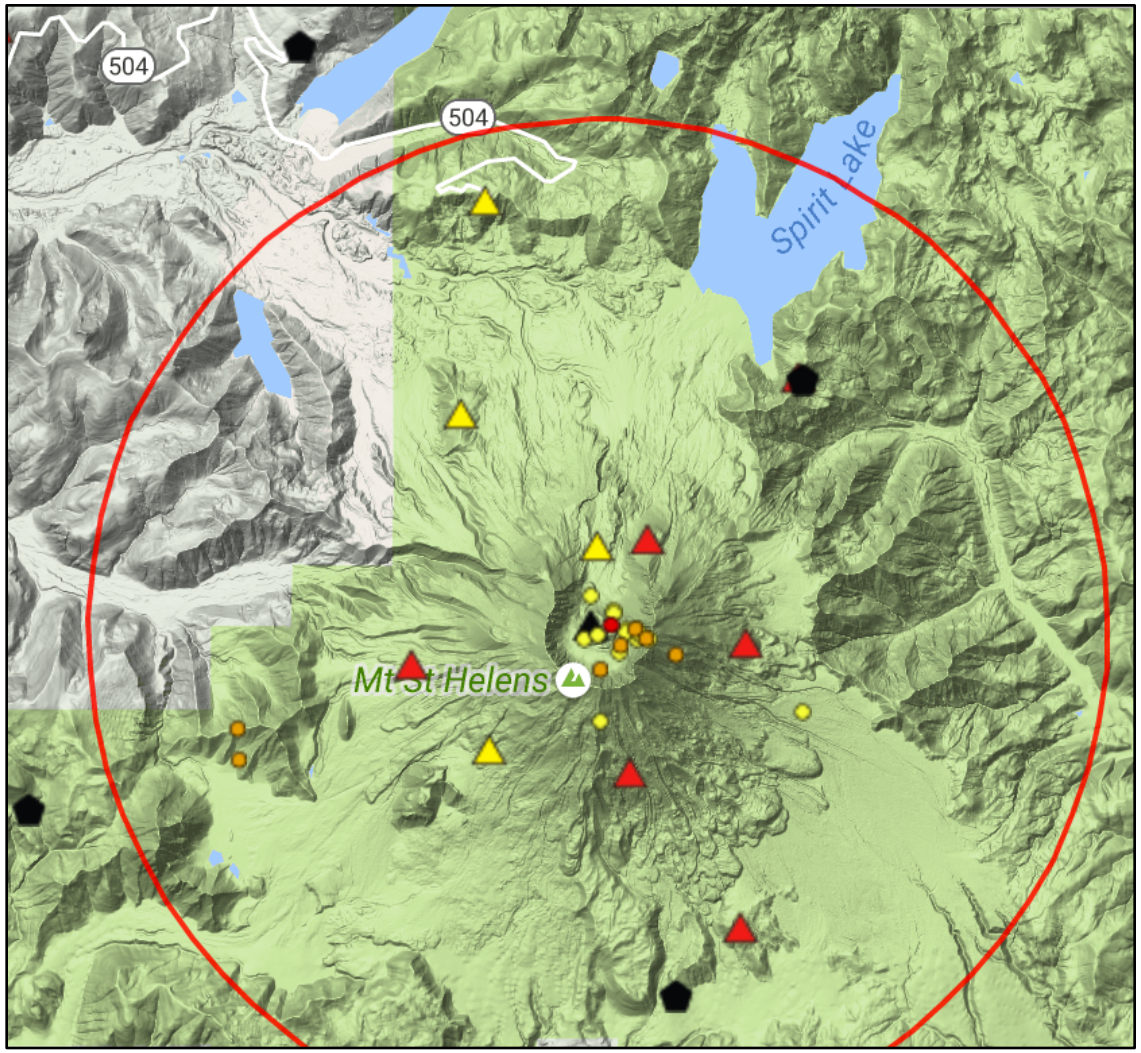




See Eric Kiser's poster for more, Including initial 3-D inversions

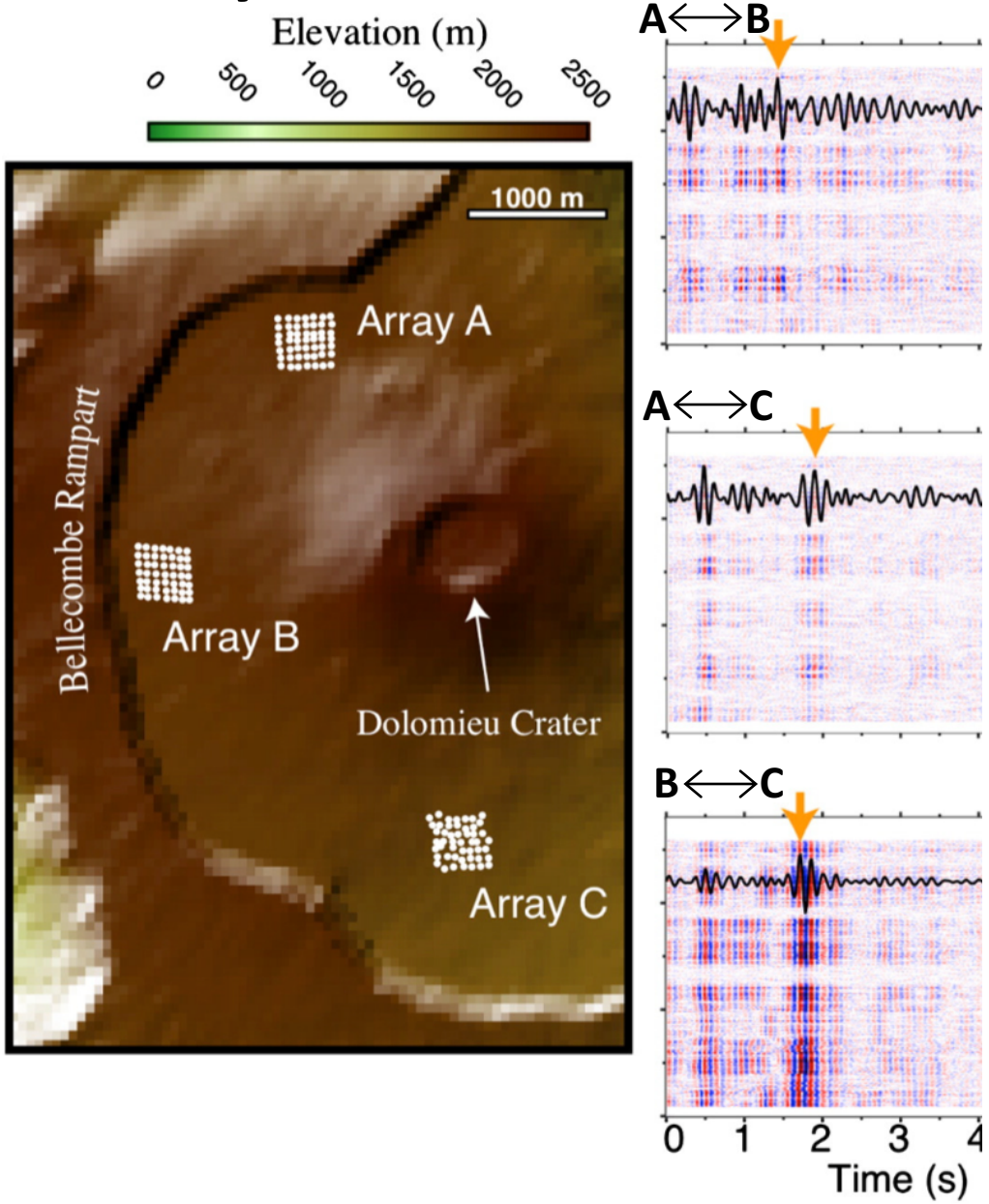
(Kiser et al., 2016)

Volcano observatories – after the multi-scale 3-D survey



Vertical geophone
3-C Broadband
3-C Borehole geophone

(www.pnsn.org)



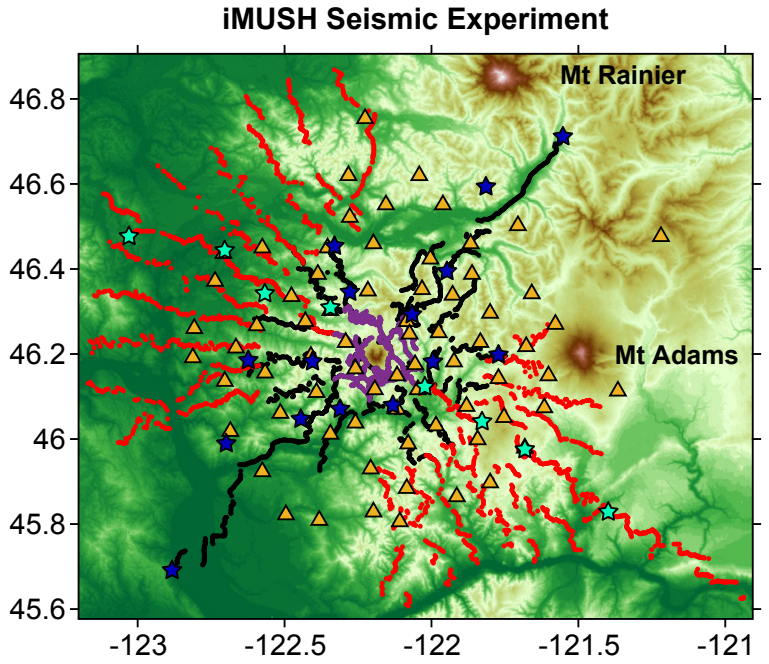
(Brenguier et al., 2015; Nakata et al., 2015)

Frontier seismic arrays for SZO science

- **See new, finer scales** (not accessible to individual PI's; great fuel for interdisciplinary science)

- **Focus sites & Staged approach**
  - 3-D structure and source experiments
  - Followed by monitoring tailored to local processes & hypotheses

- **Technical Needs**
  - *Nodes* - Longer duration and 3-C now available
  - Enough instruments to support mix of small/large projects in same field seasons
  - *Controlled sources!* For *3-D* and higher level products like *attenuation* and *anisotropy*
  - *Computational resources* and working group organization for 3D full waveform seismology up to ~5-10 Hz



In SZO this could be 10,000 3-C seismometers recording 100 shots,
And
Be followed for years with array of arrays style monitoring