Coherence and Spectra Analysis of the USARRAY TA PY Posthole Test Array

Frank Vernon
University of California, San Diego

David Thomson
Queens University

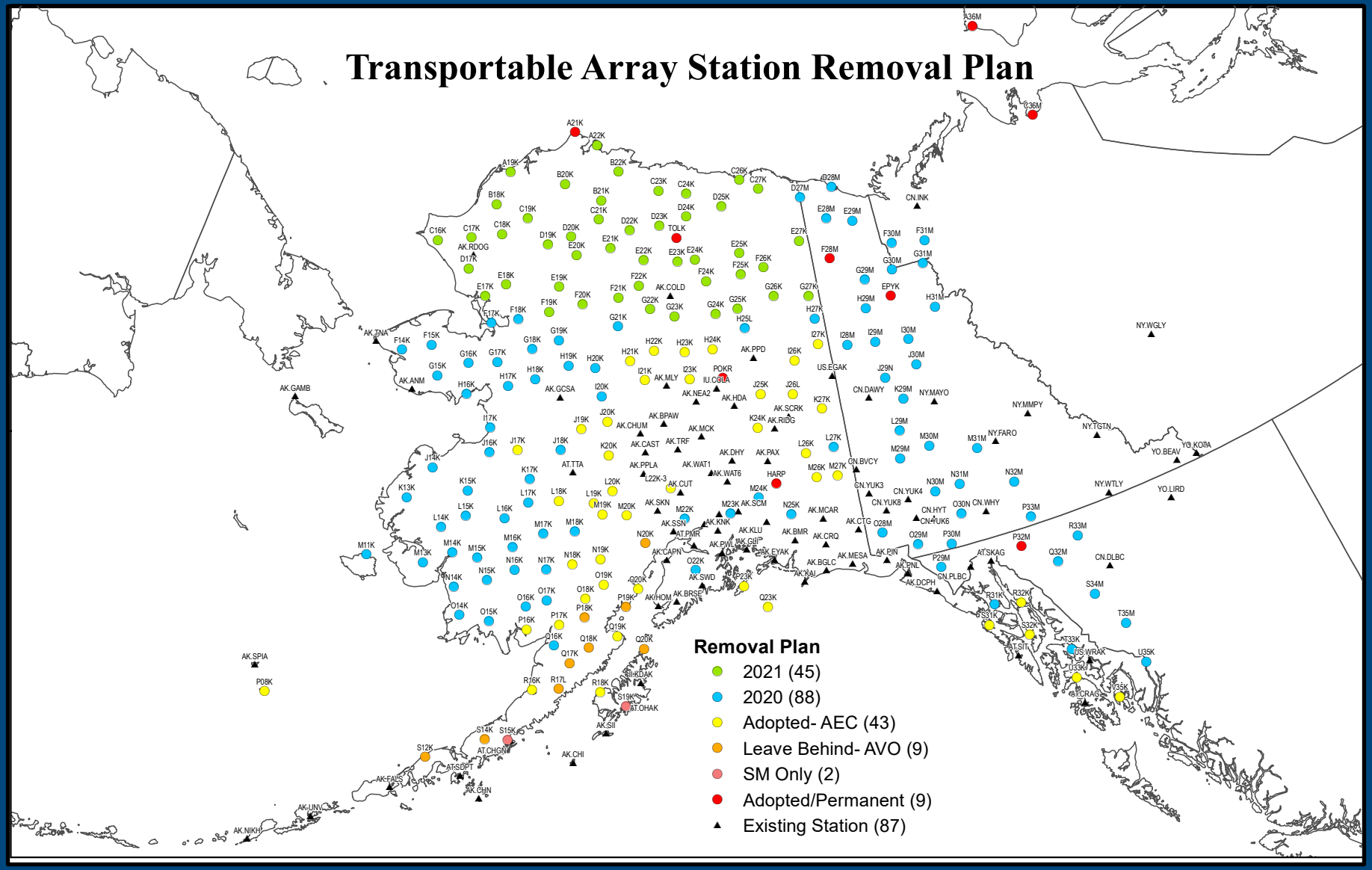
Lei Qin
China University of Geosciences

BIRS Multitaper Workshop
25 June 2022

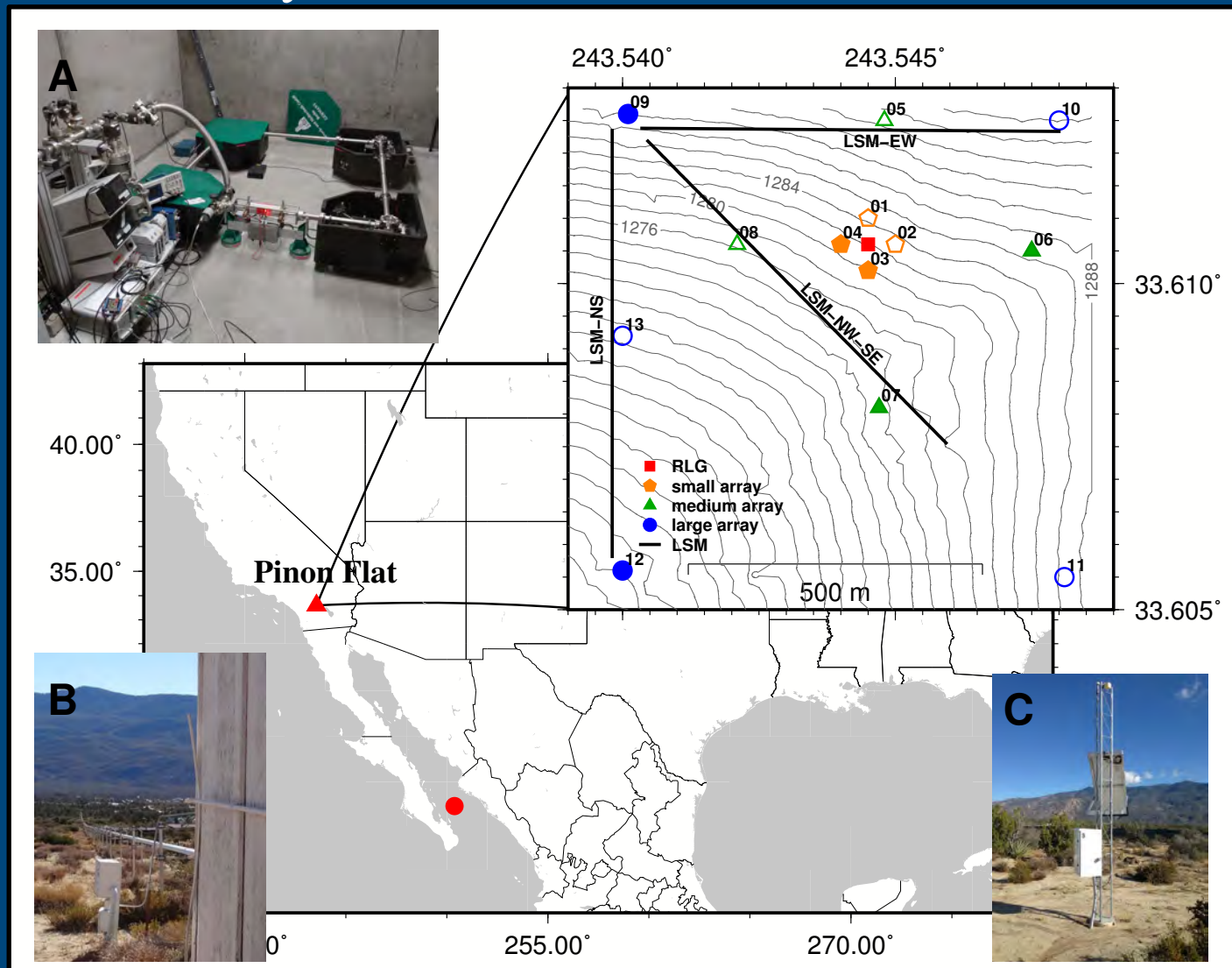
Outline

- USArray Alaska Deployment Motivation
- PFO Testbed
- Spectra and Coherences
- Event data
- Impact of Atmosphere and Oceans
- Conclusions

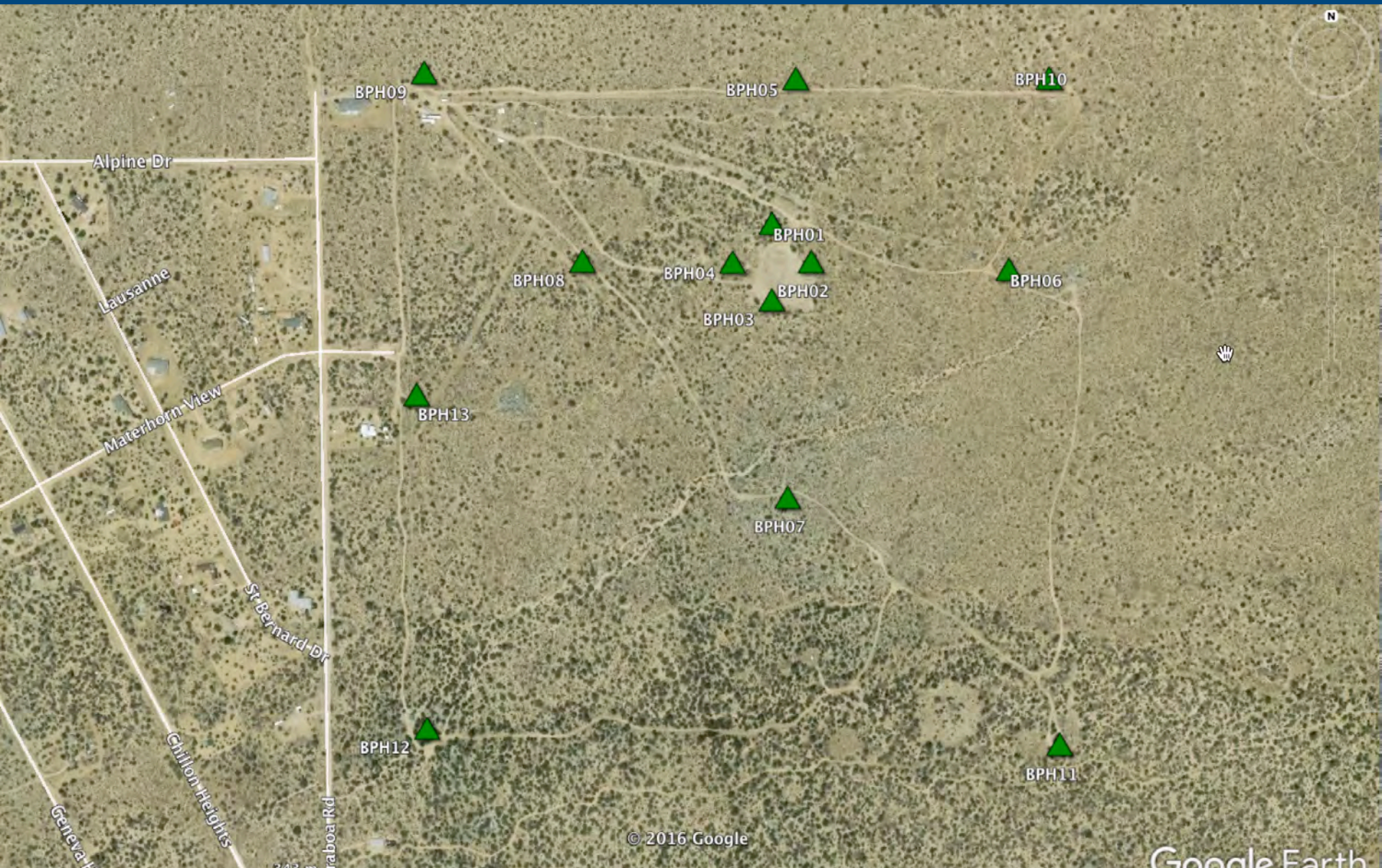
USArray TA Alaska Deployment



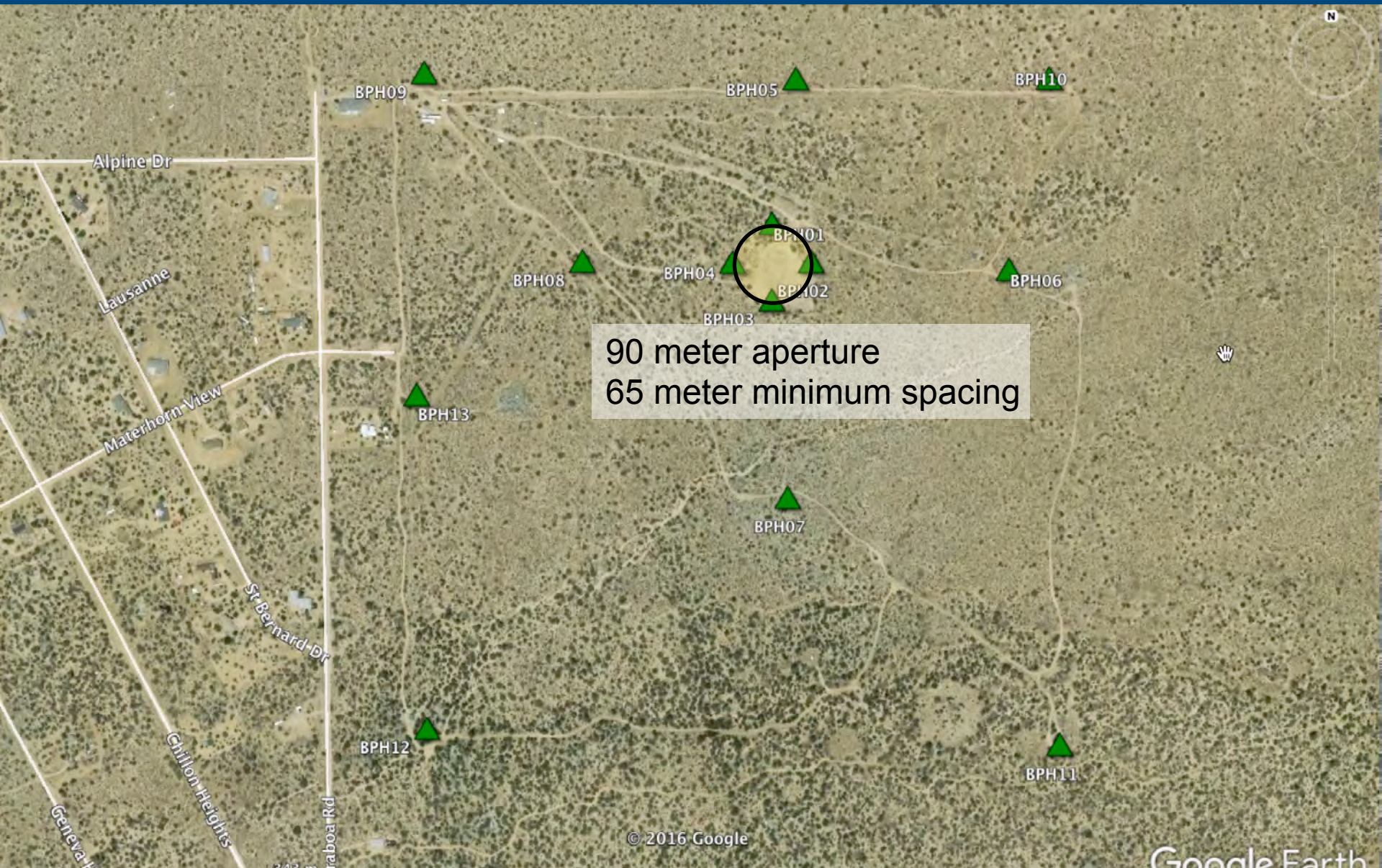
PY Array - Piñon Flat Observatory



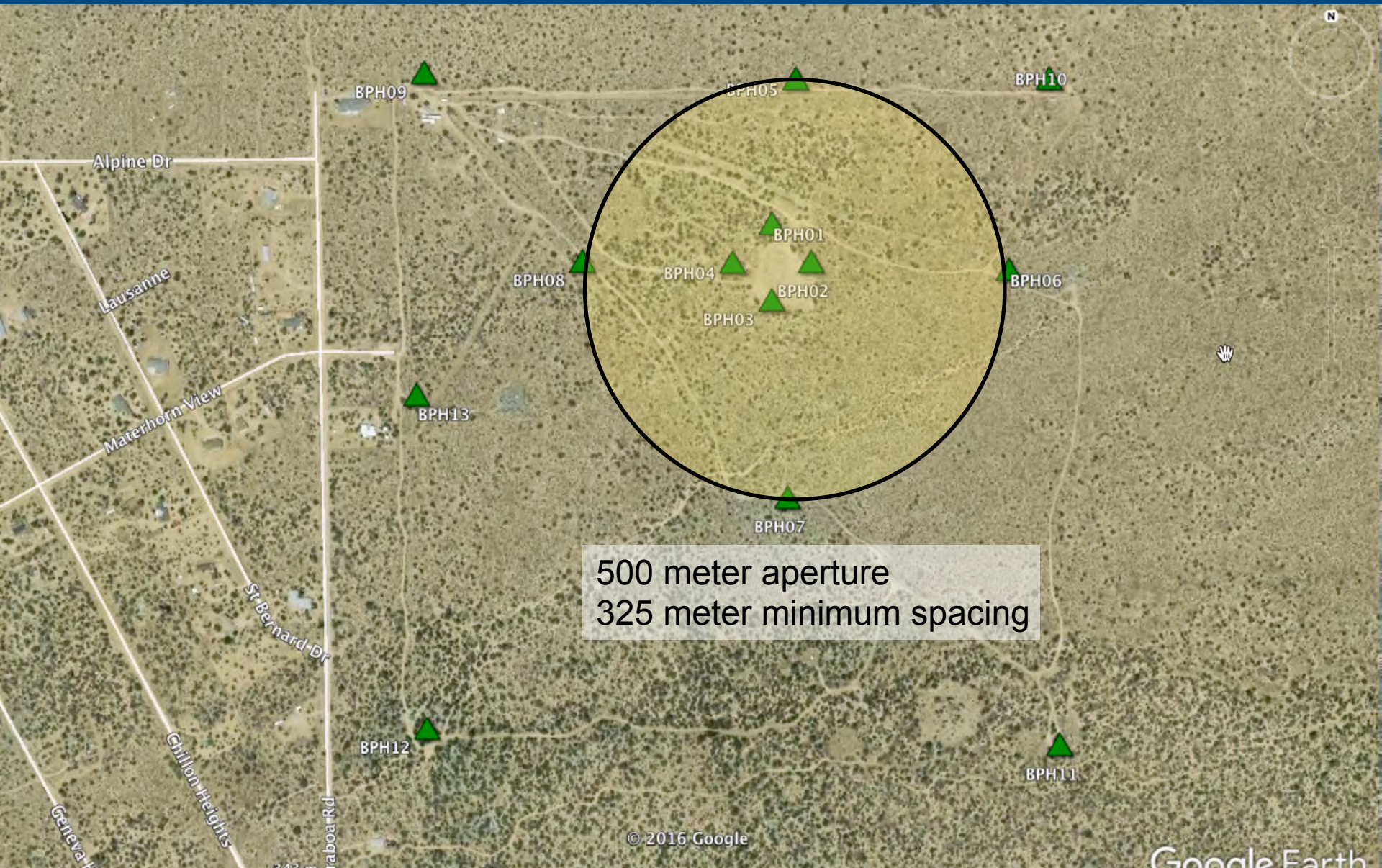
Piñon Flat PY Array



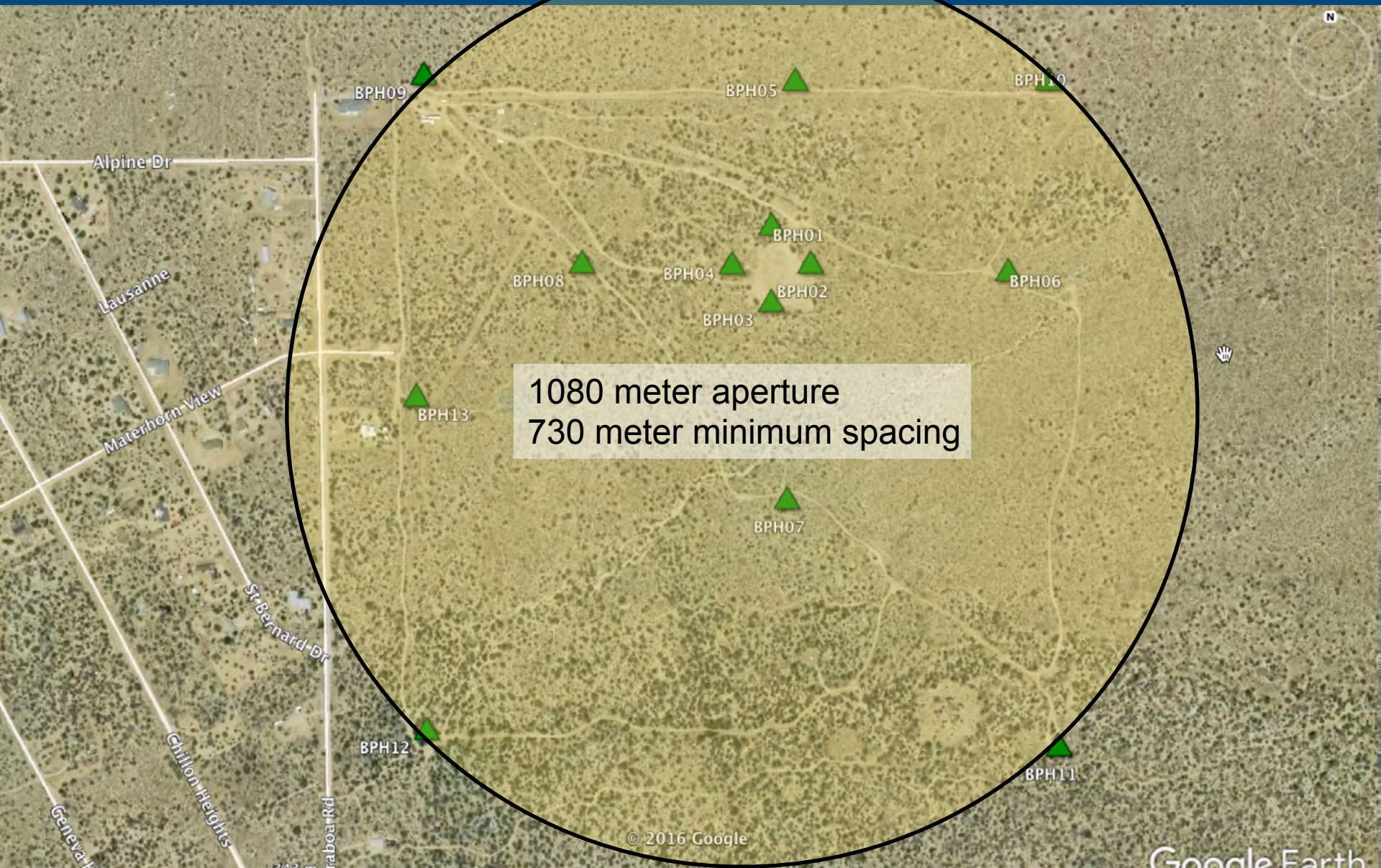
Piñon Flat PY Array



Piñon Flat PY Array

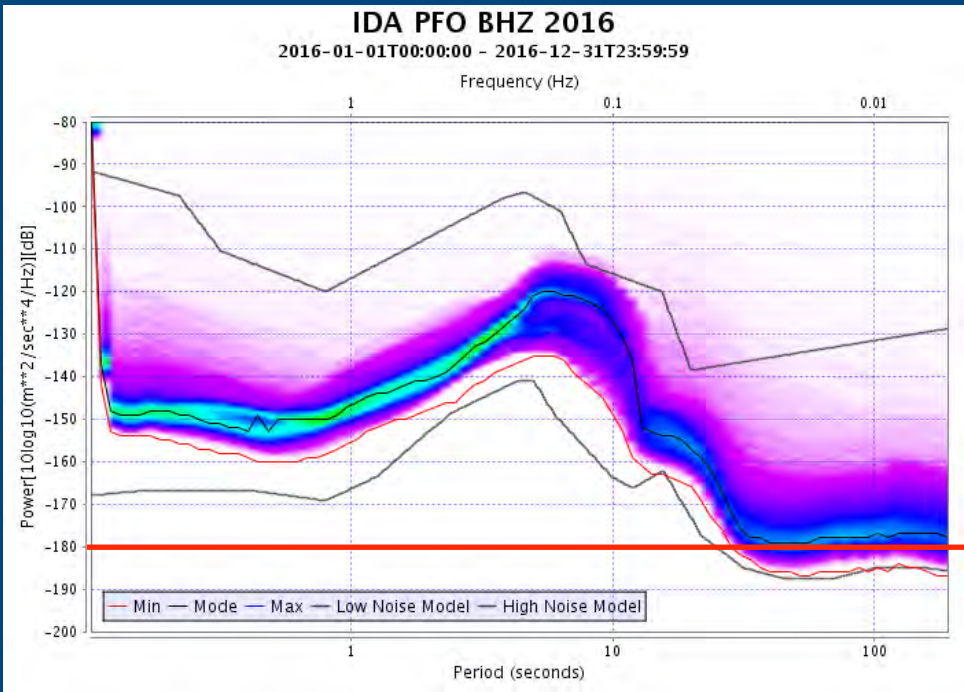


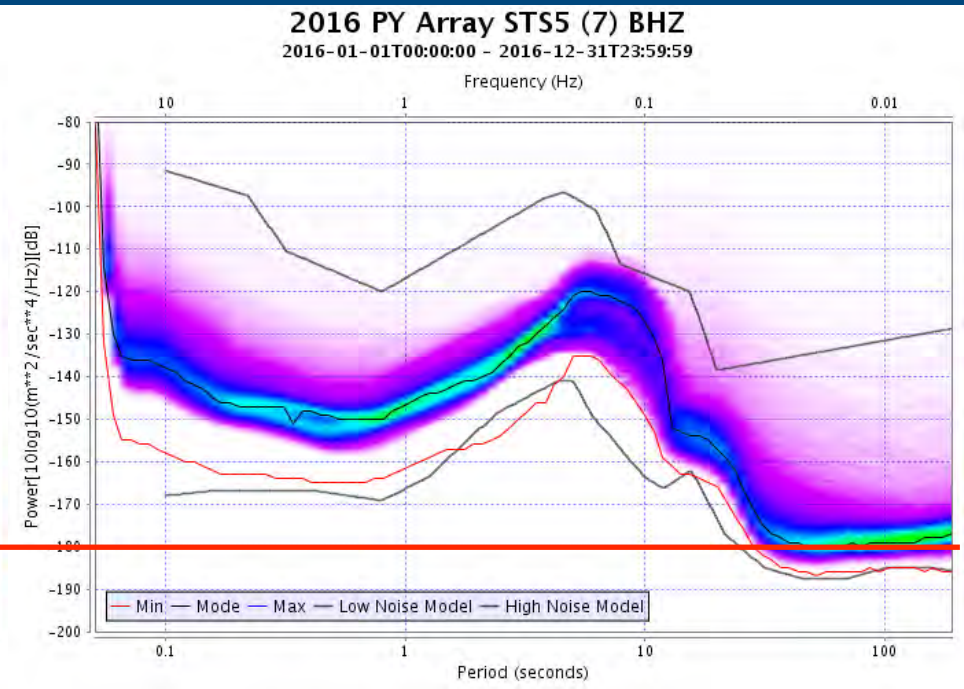
Piñon Flat PY Array



GSN-PY BHZ Sensor Comparison

- 1 Jan - Dec 31 2016

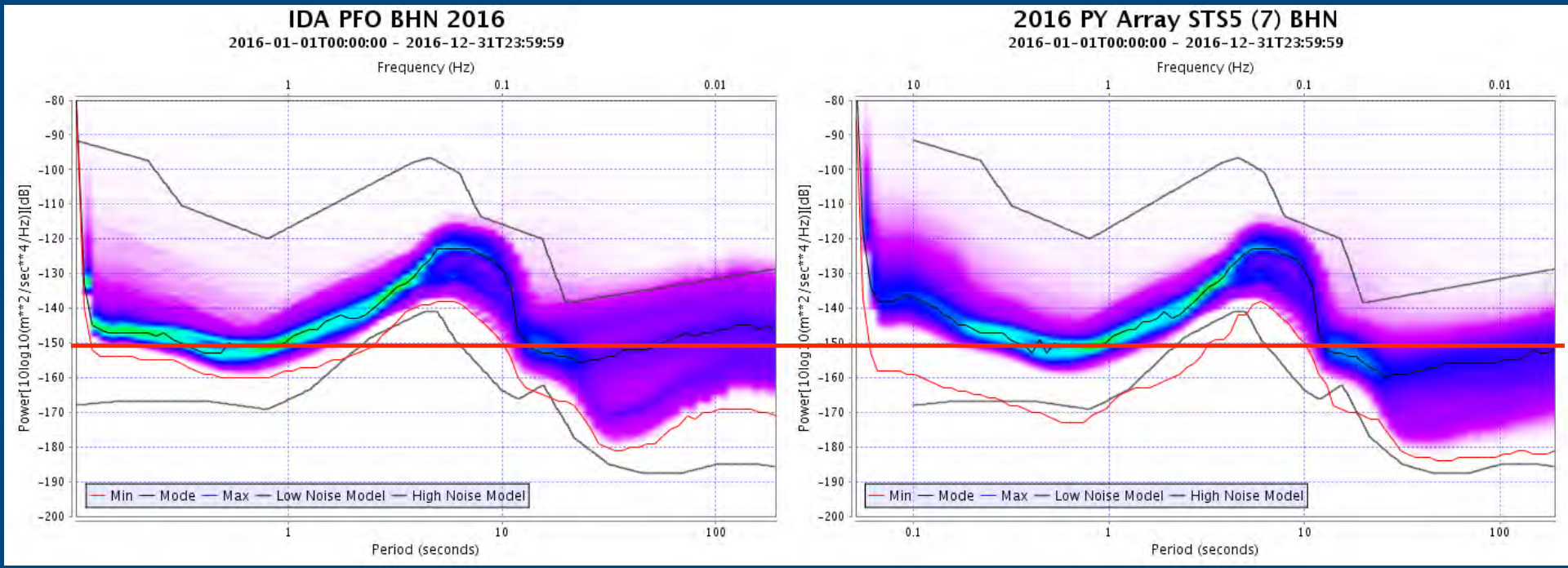




Similar performance between STS-5 Posthole and STS-1

GSN-PY BHN Sensor Comparison

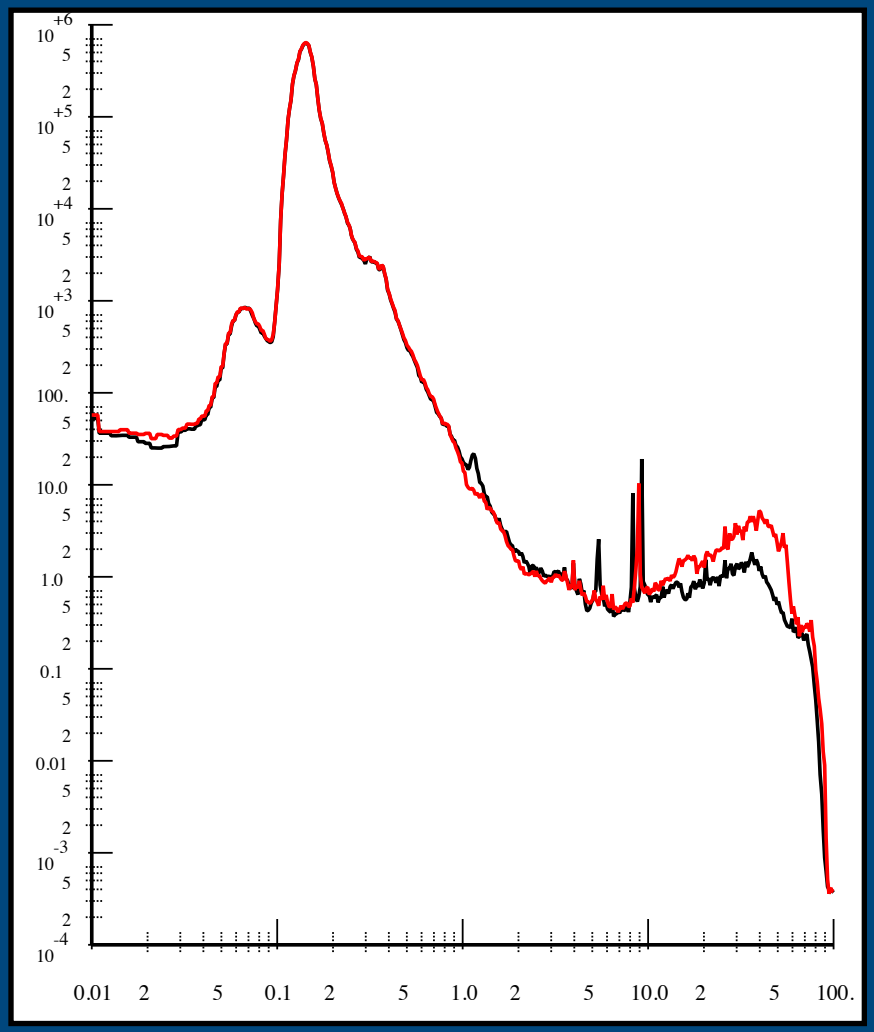
- 1 Jan - Dec 31 2016



Improved performance of STS-5 Posthole over STS-1

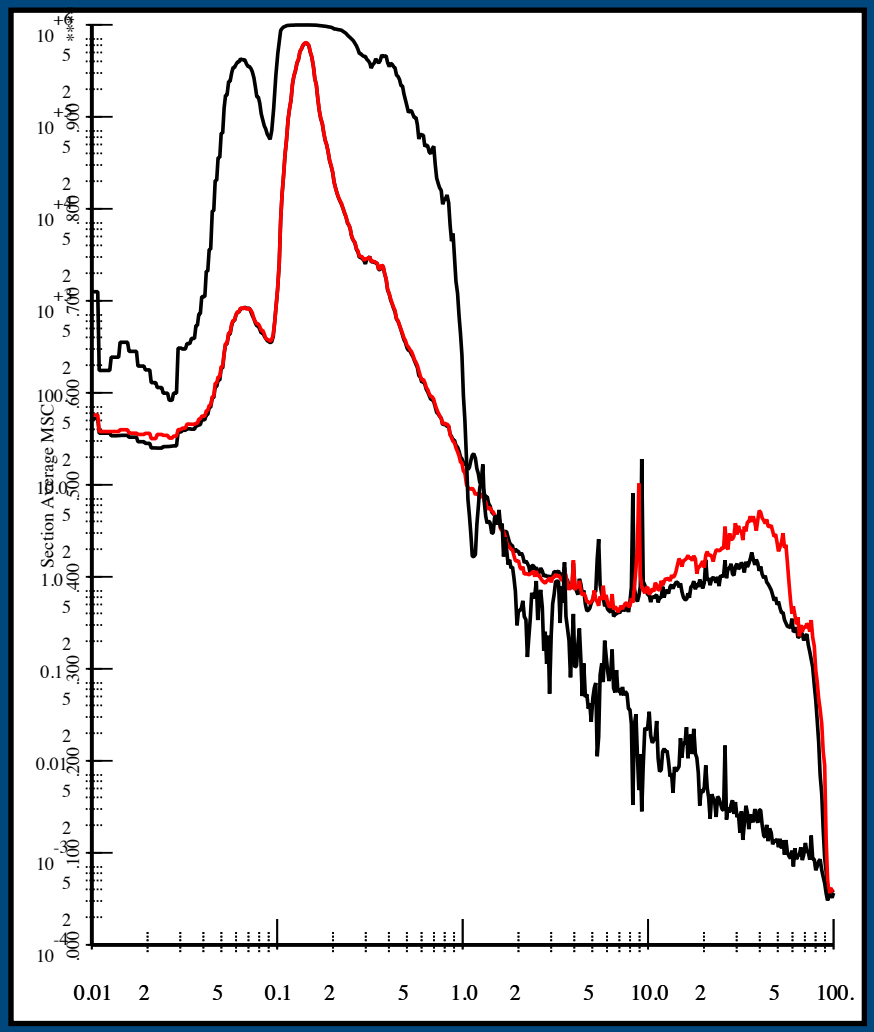
STS5 HHZ
BPH01-BPH02 65 Meter Separation

- multi taper spectra
  - 200 sps
  - 600 sec windows
  - 600 sec offset
  - 140 windows
  - 10 tapers
  - 6 NW (time bandwidth product)



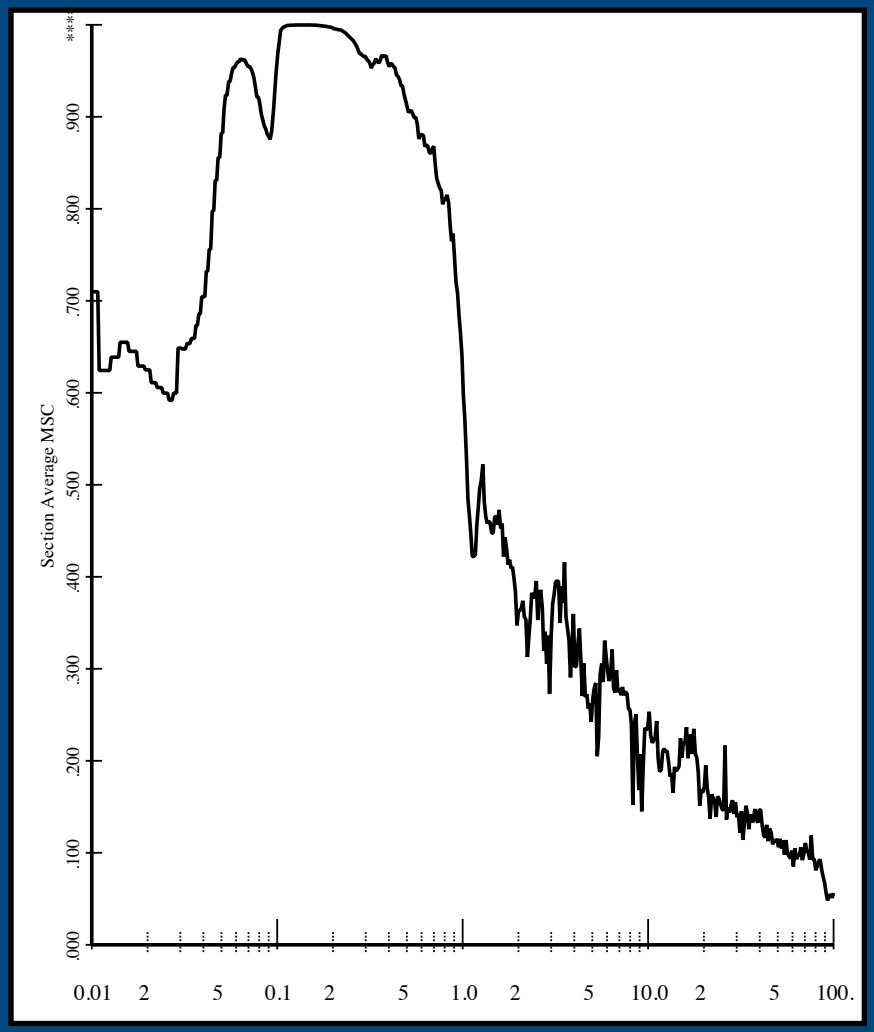
STS5 HHZ
BPH01-BPH02 65 Meter Separation

- multi taper spectra
  - 200 sps
  - 600 sec windows
  - 600 sec offset
  - 140 windows
  - 10 tapers
  - 6 NW (time bandwidth product)
- multi taper coherence



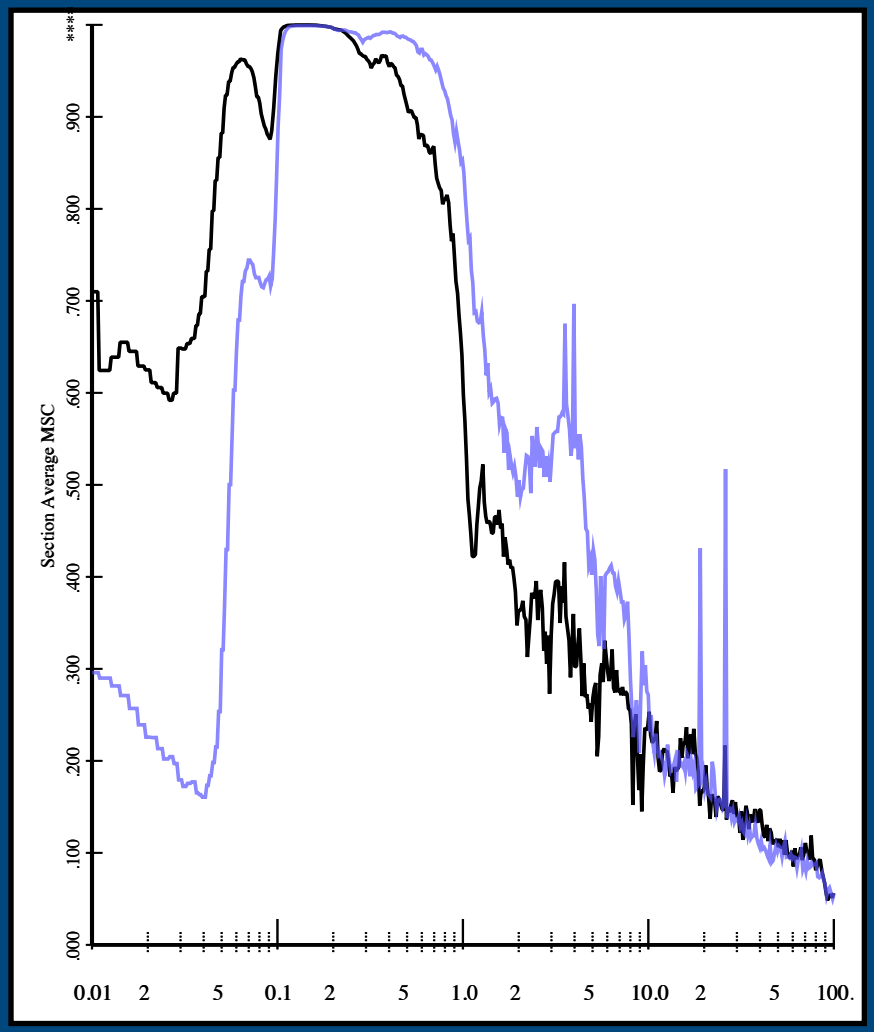
STS5 Coherence
BPH01-BPH02 65 Meter Separation

- HHZ MSC



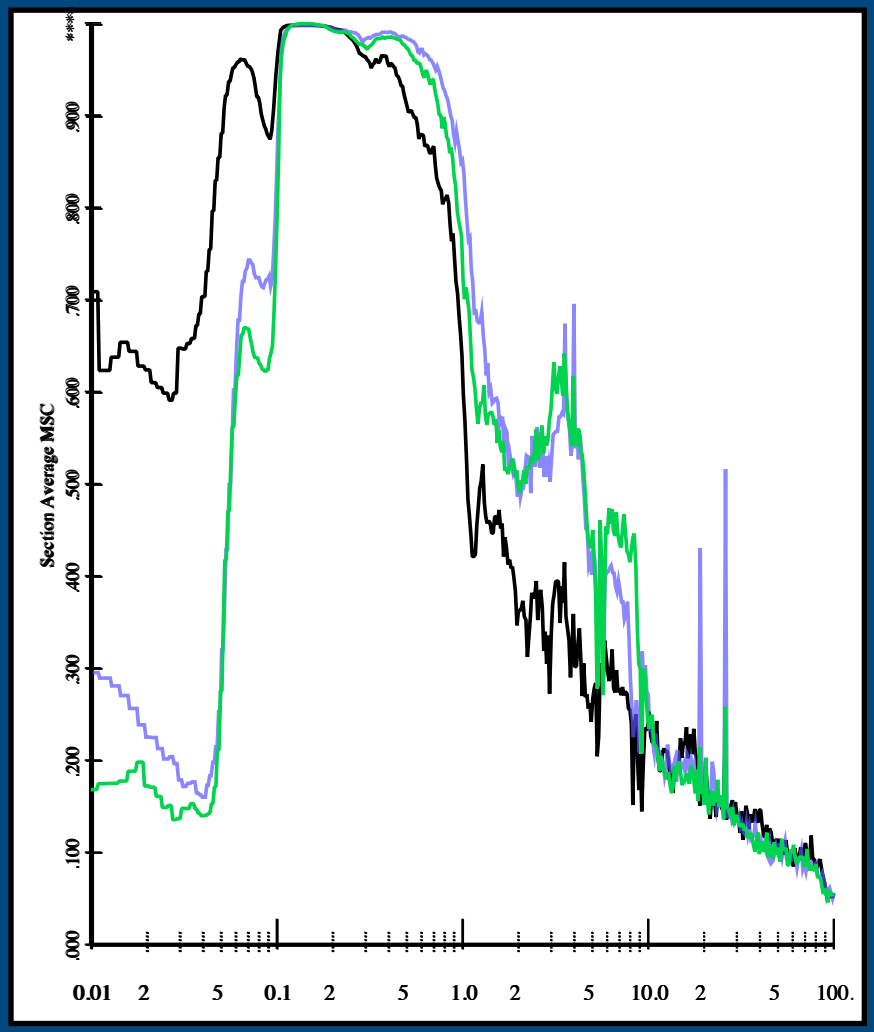
STS5 Coherence
BPH01-BPH02 65 Meter Separation

- HHZ MSC
- HHN MSC
  - << HHZ
    0.01 Hz to 0.1 Hz
  - > HHZ
    1 Hz to 10 Hz



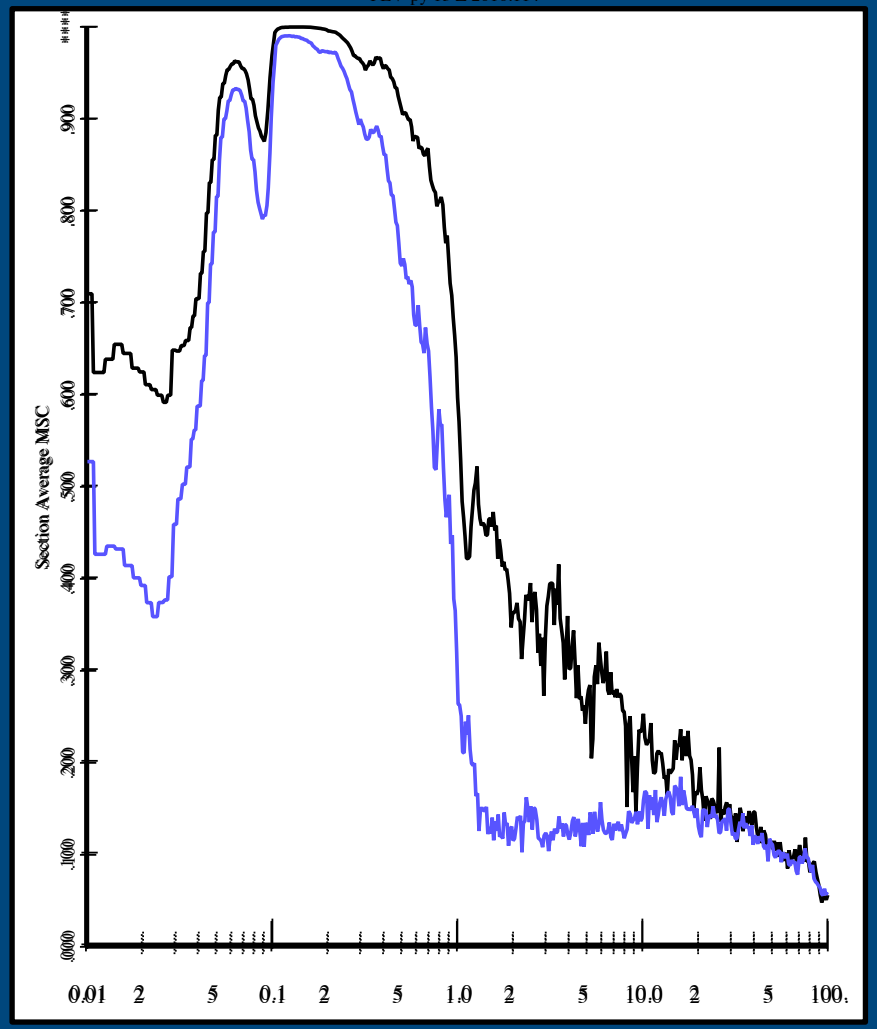
STS5 Coherence
BPH01-BPH02 65 Meter Separation

- HHZ MSC
- HHN MSC
  - << HHZ
    0.01 Hz to 0.1 Hz
  - > HHZ
    1 Hz to 10 Hz
- HHE MSC
  - Similar to HHN

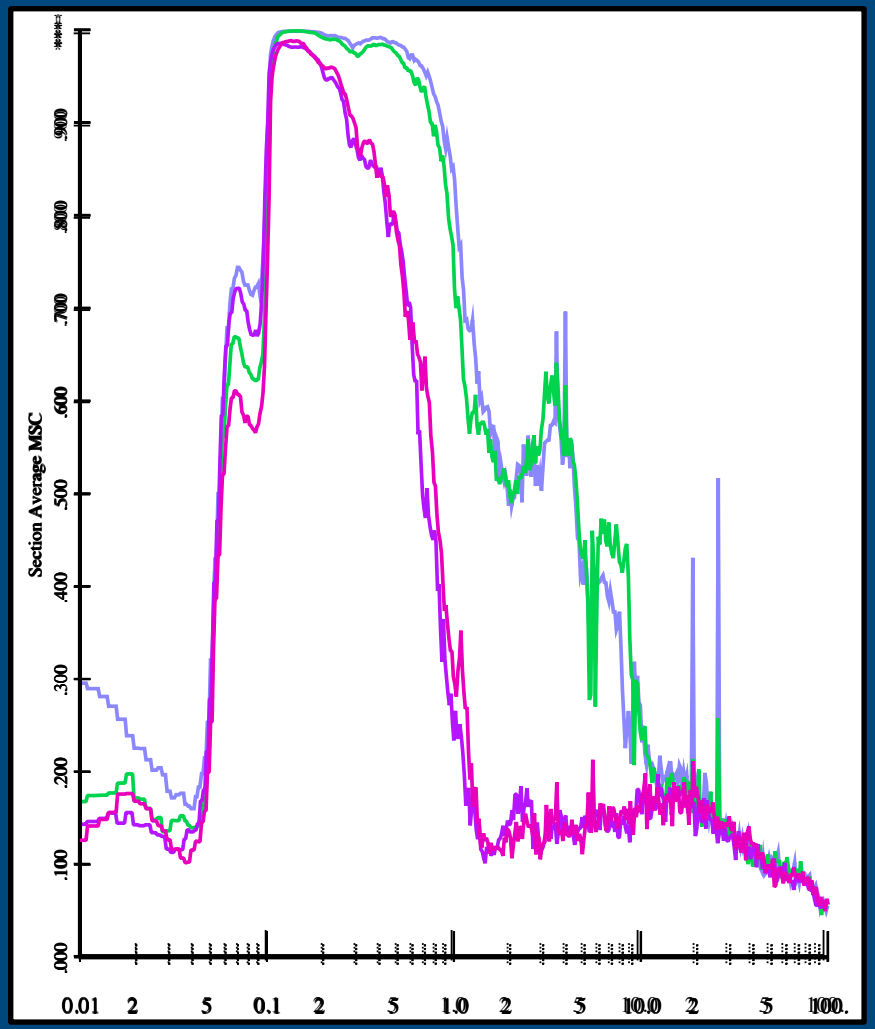


STS5 Coherence - 65 meters vs 870 meters

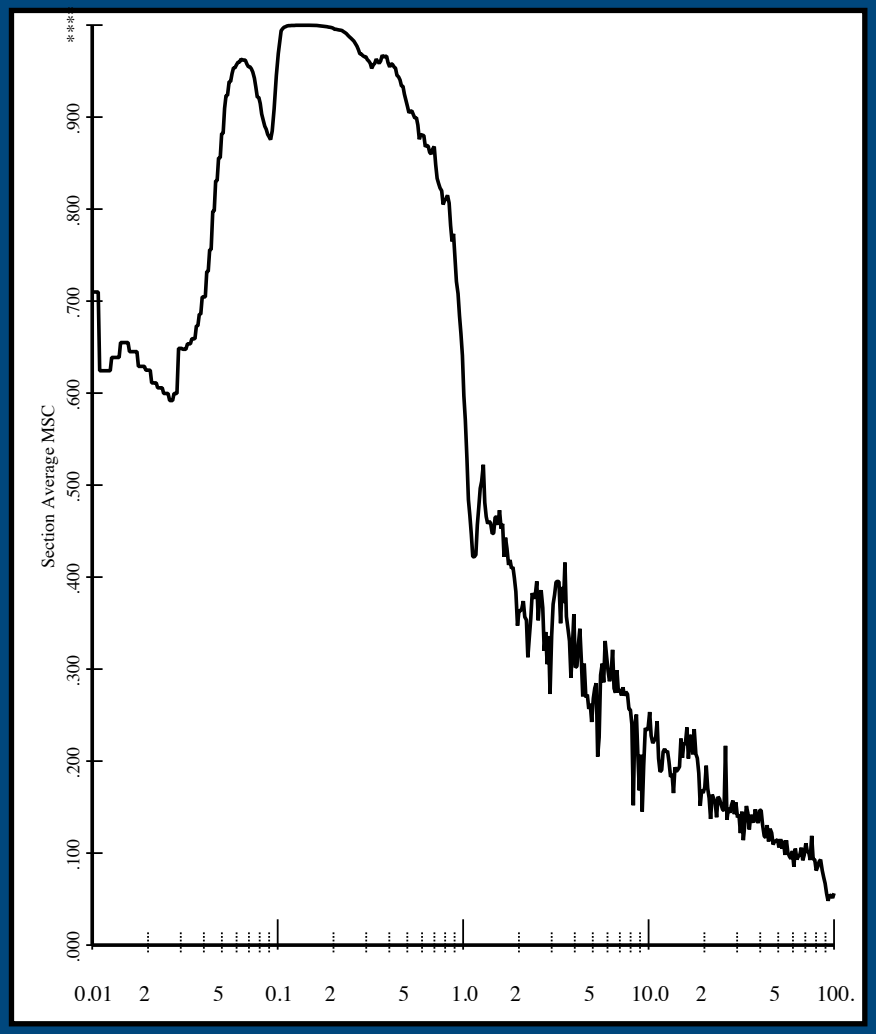
BHZ

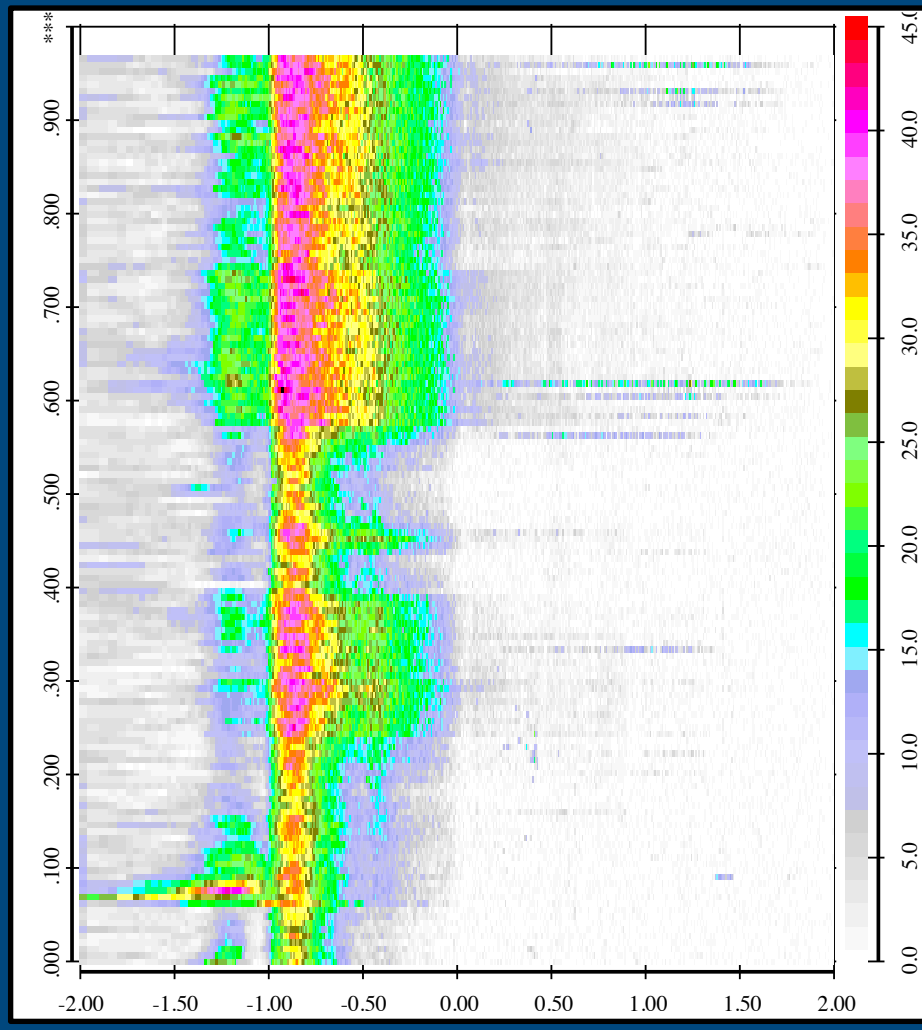


BHN BHE



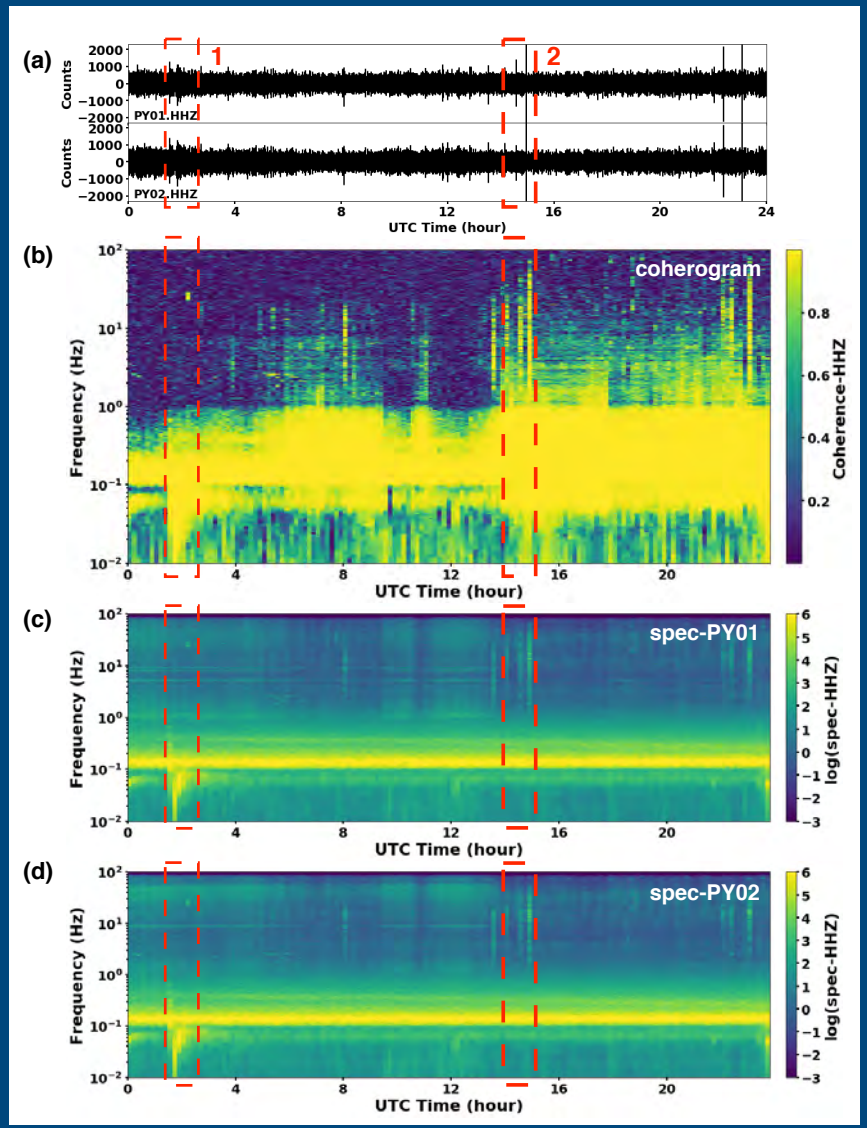
STS5 HHZ
BPH01-BPH02 "Coherogram"



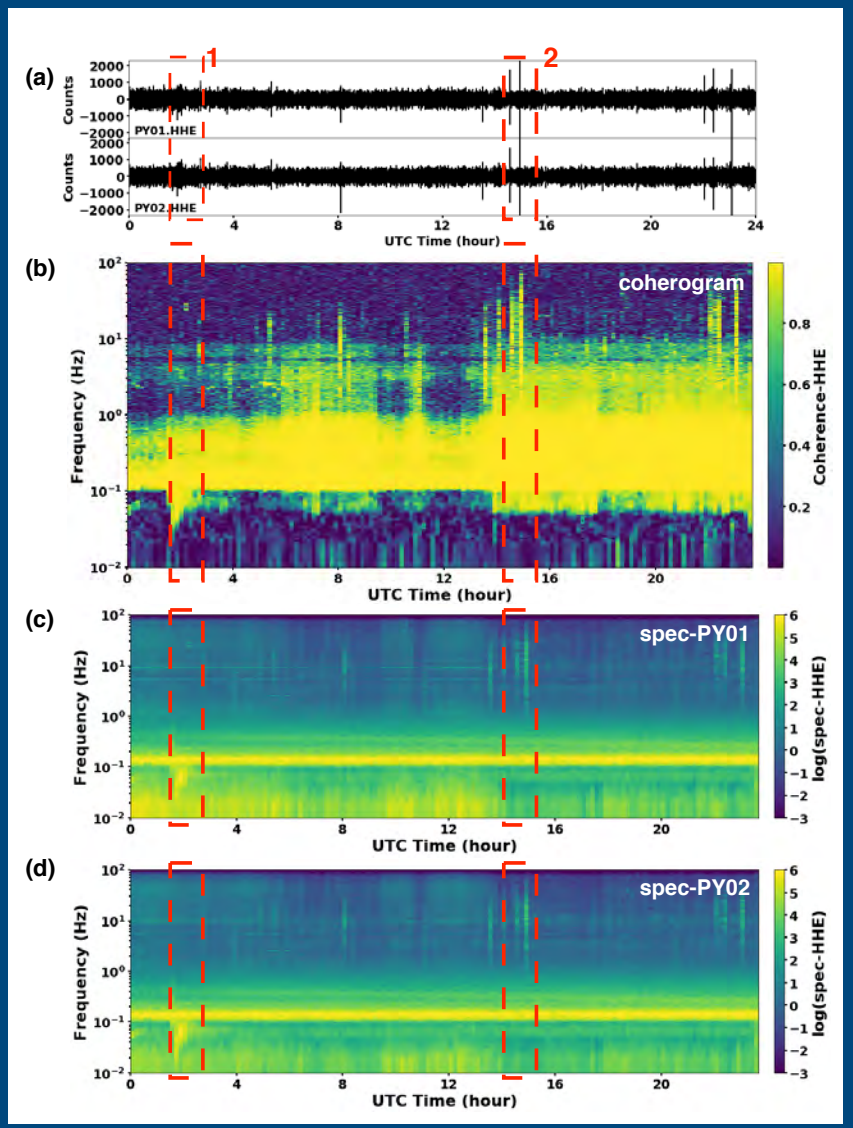


2016 114 Cohero and Spectragrams

HHZ



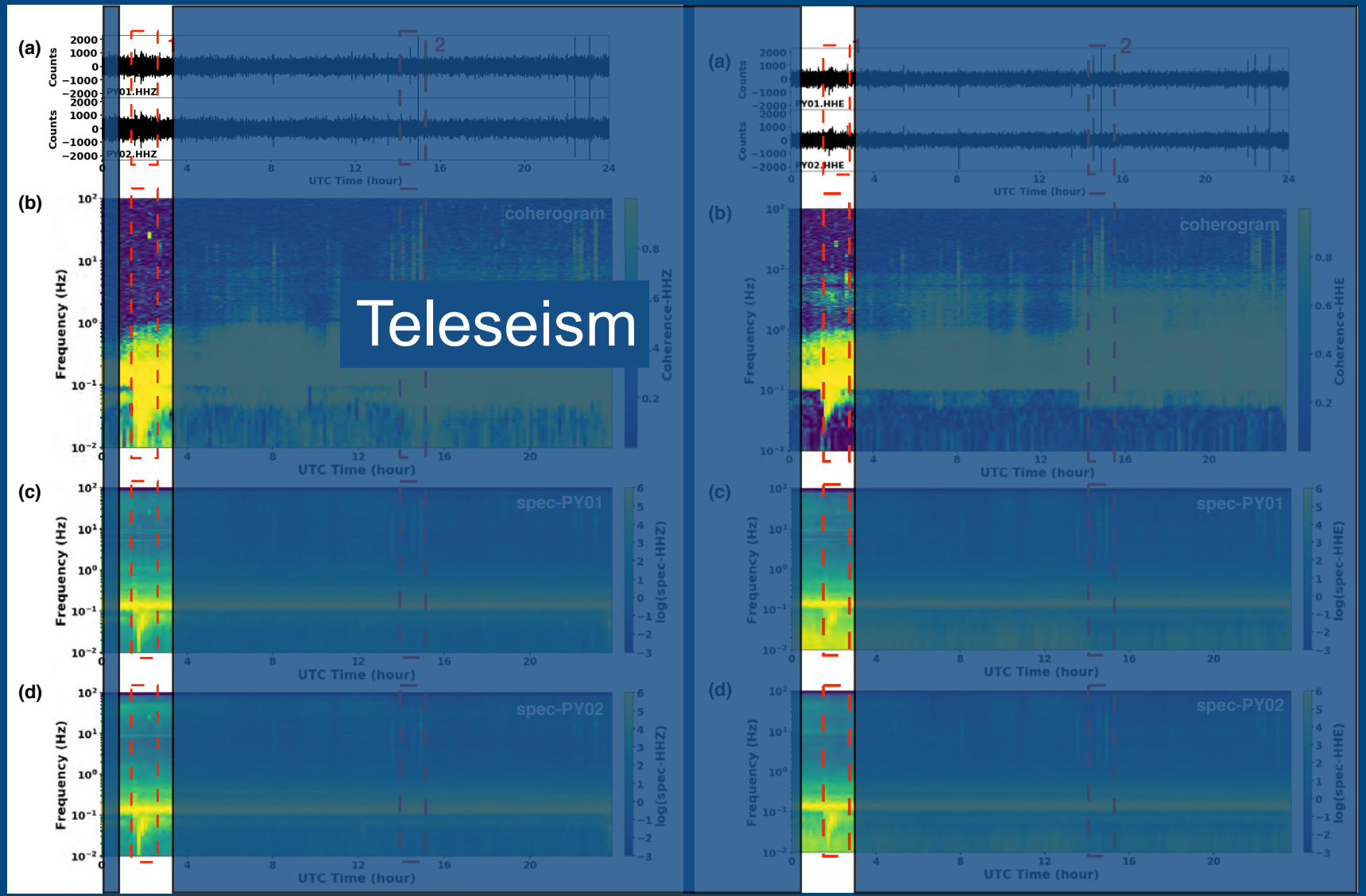
HHE



2016 114 Cohero and Spectragrams

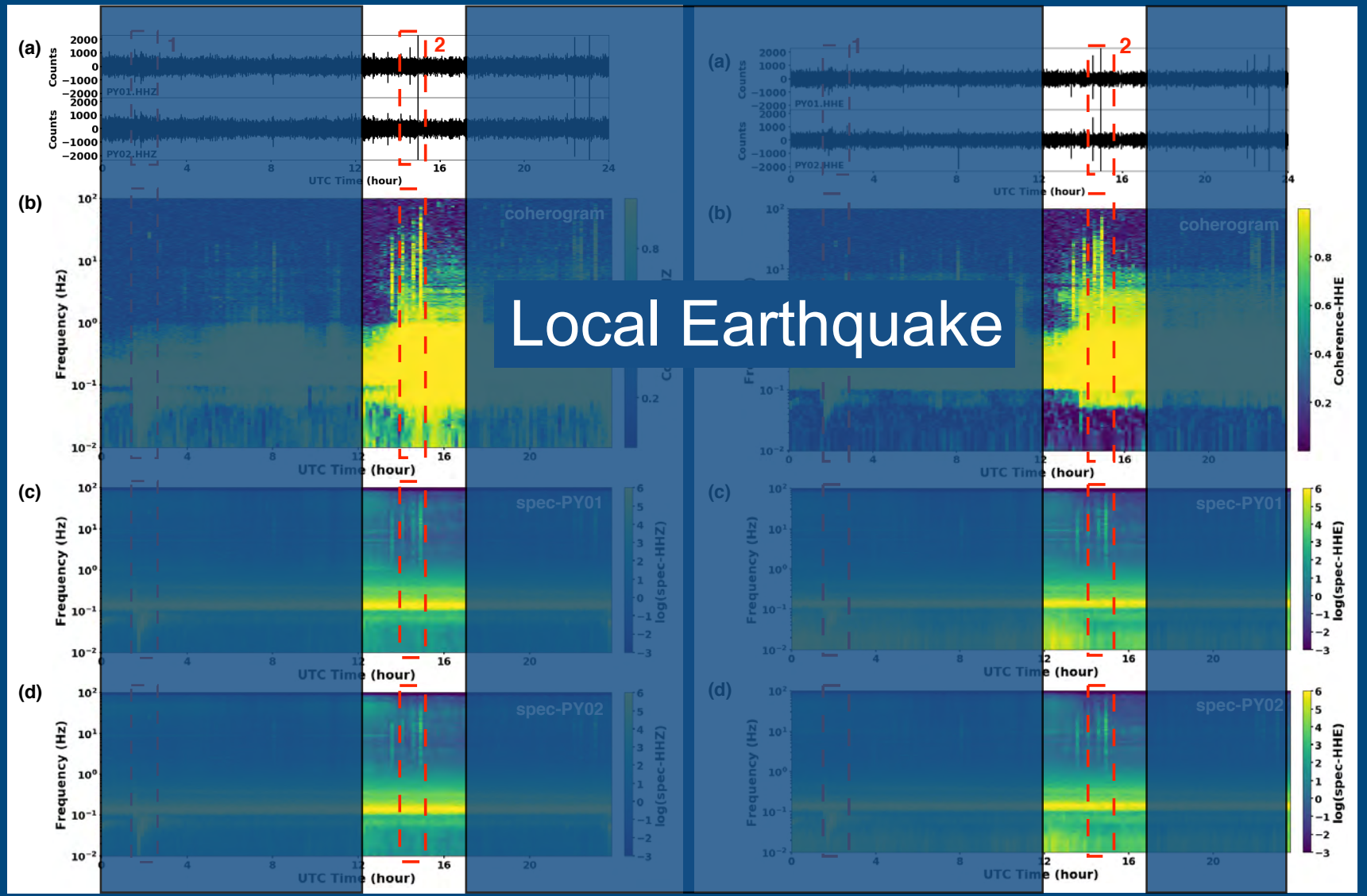
HHZ

HHE

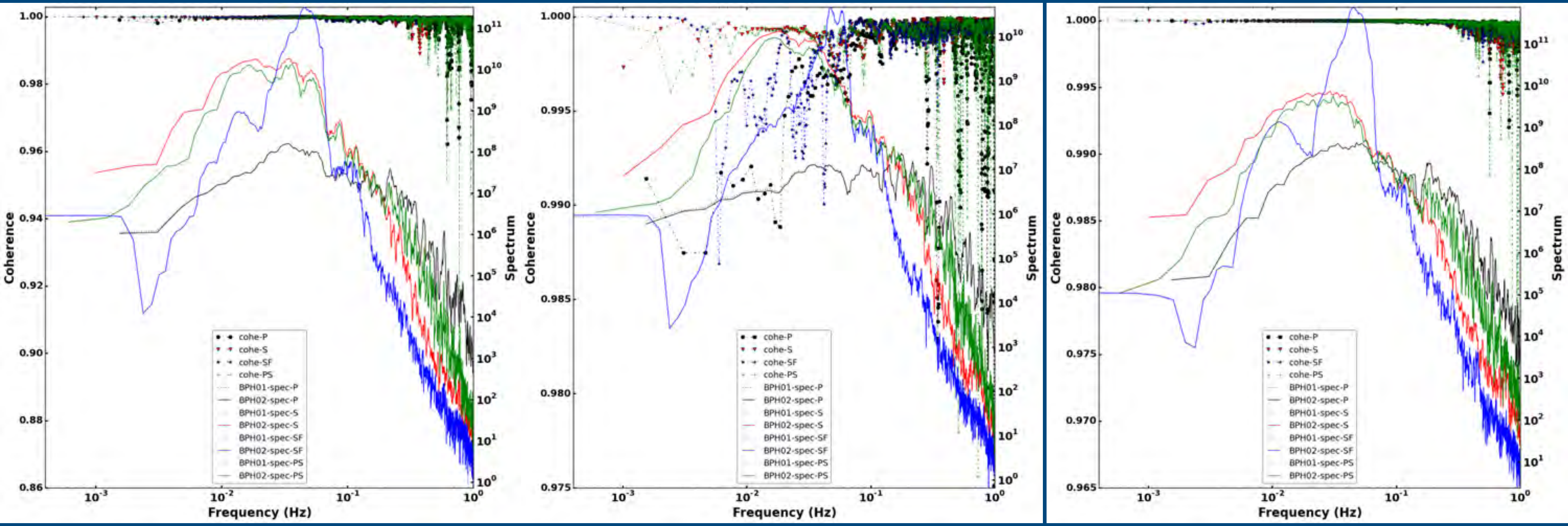


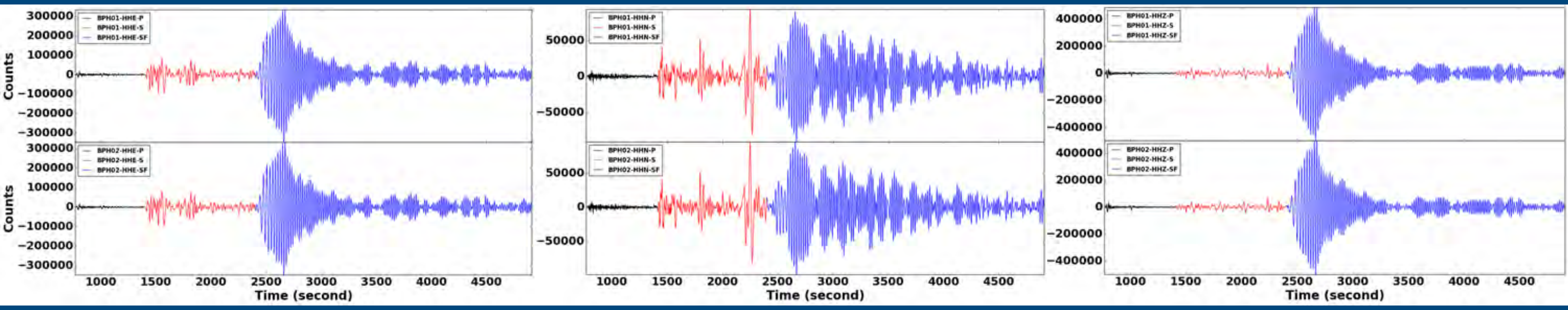
2016 114 Cohero and Spectragrams

HHZ HHE

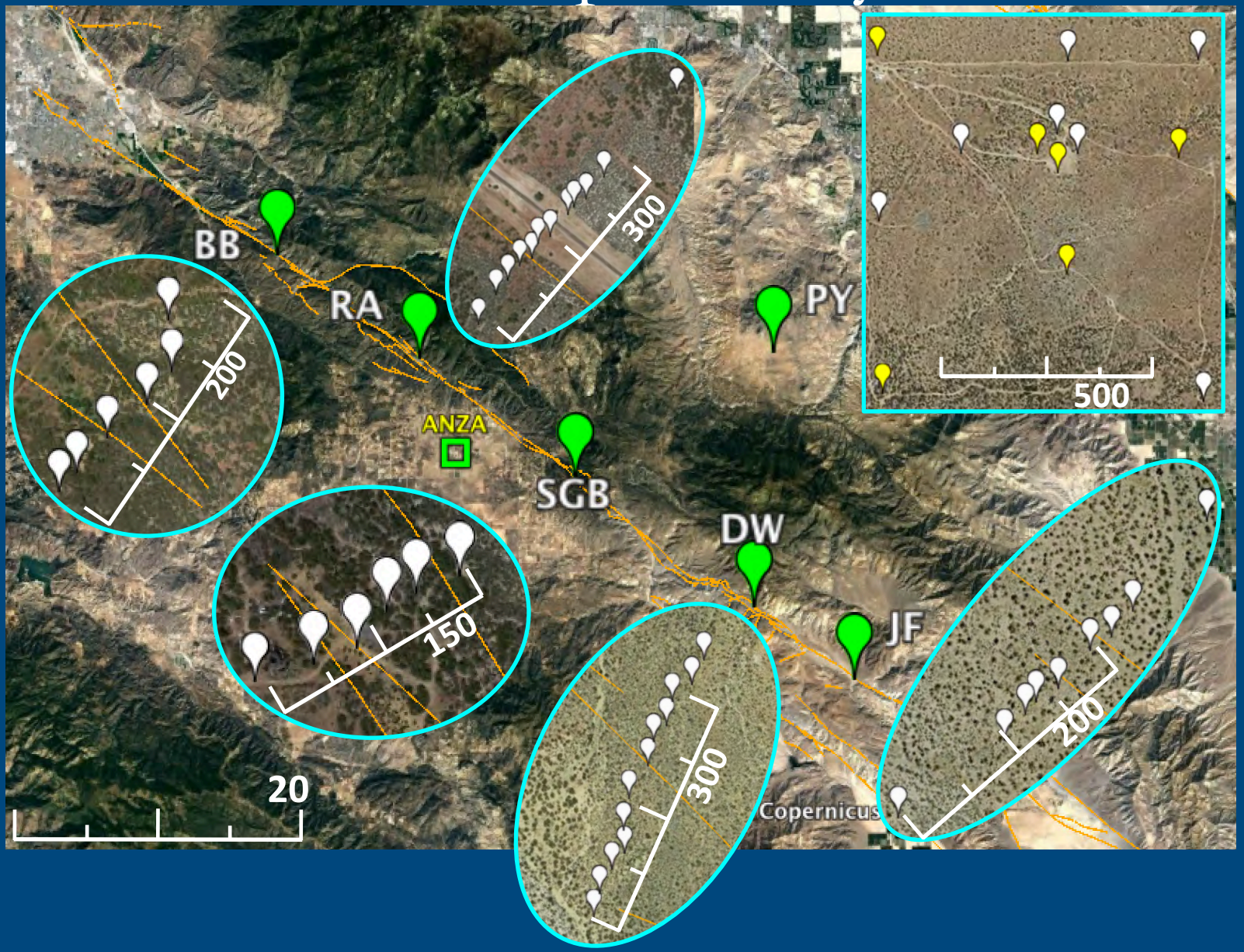


Three Teleseisms

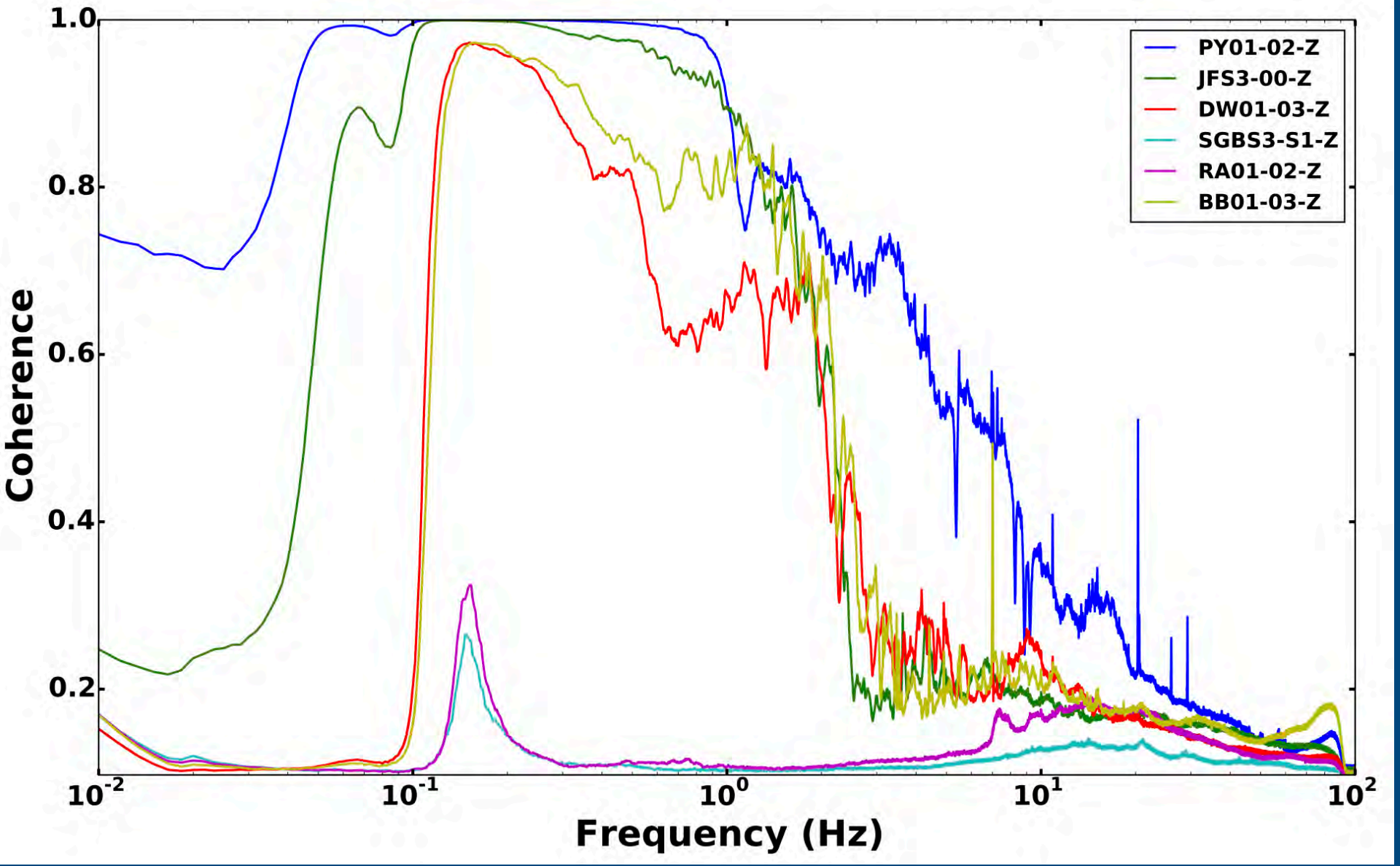




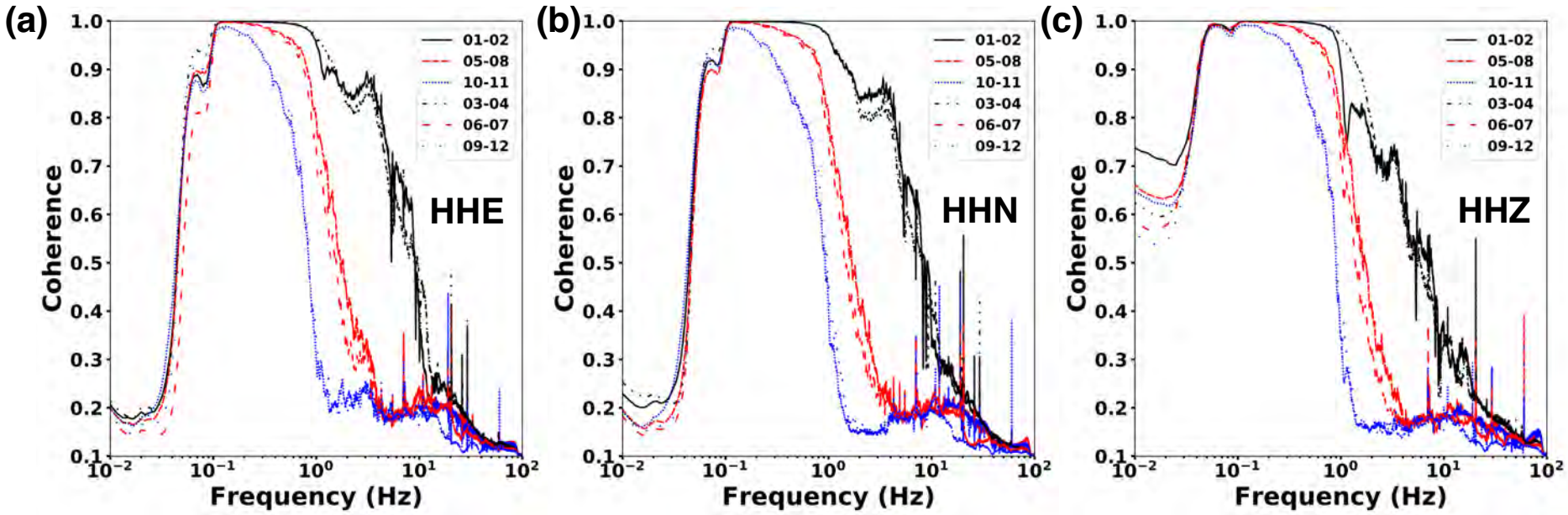
Multiple Arrays



Multiple Arrays



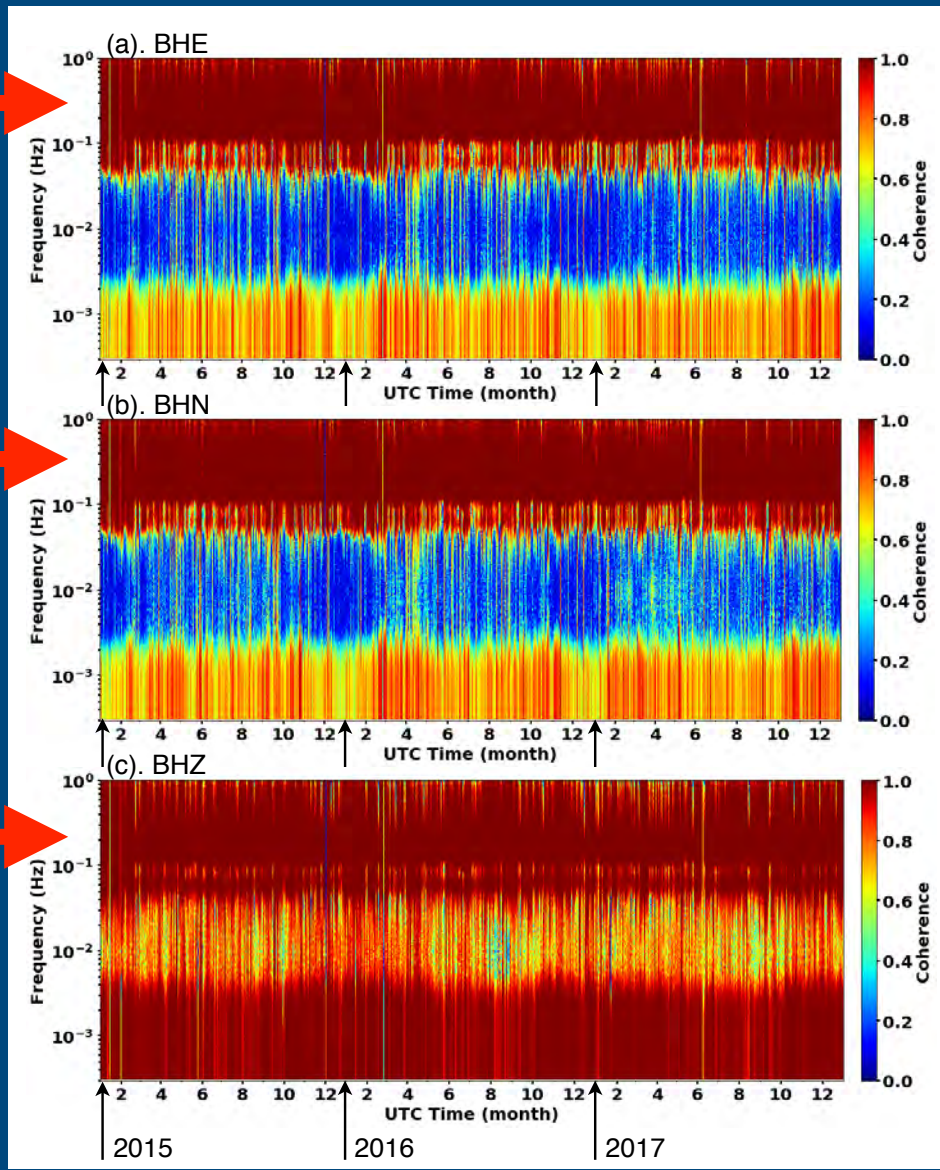
Three Year Median Coherence



65 Meters, 325 Meters, 730 Meters

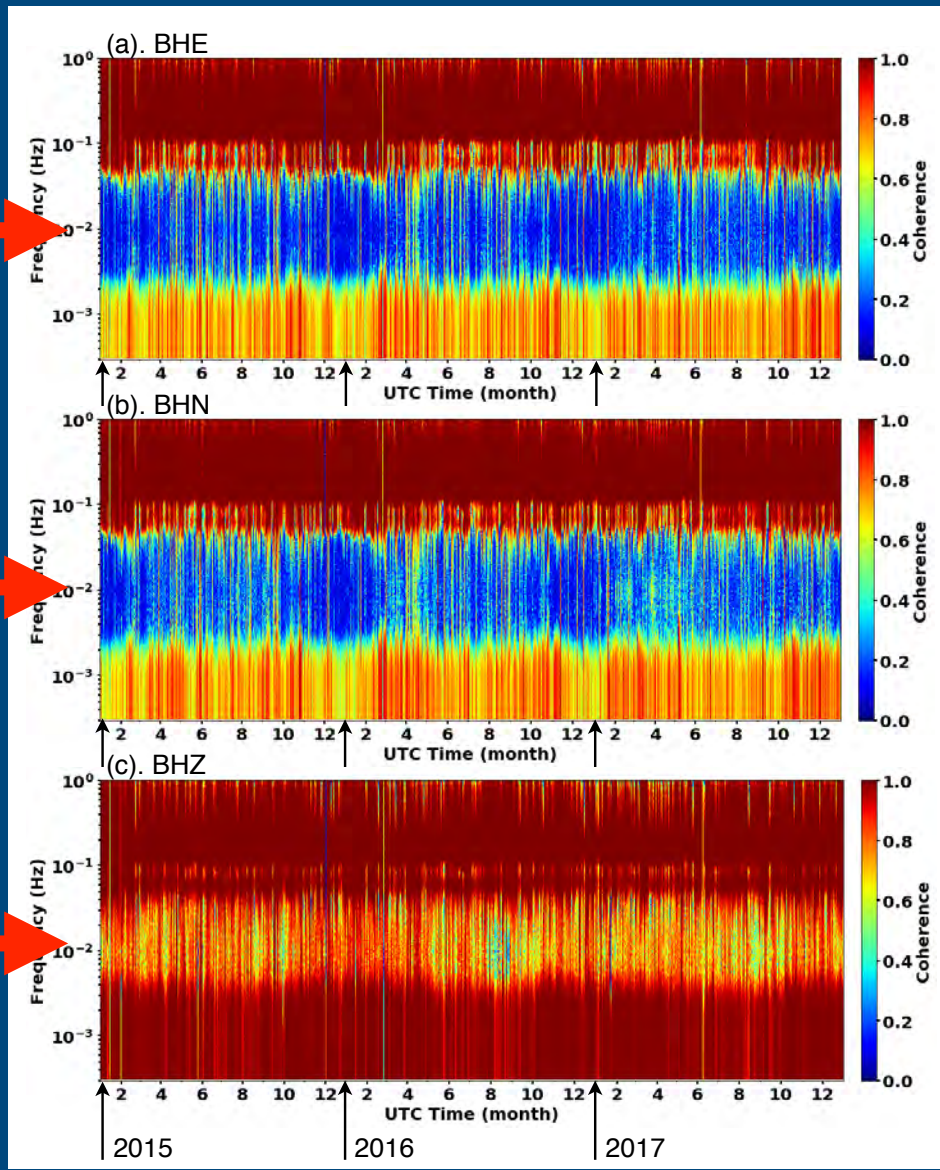
3 Year Coherograms - BH[ZNE] 65m spacing

- Microseisms very coherent



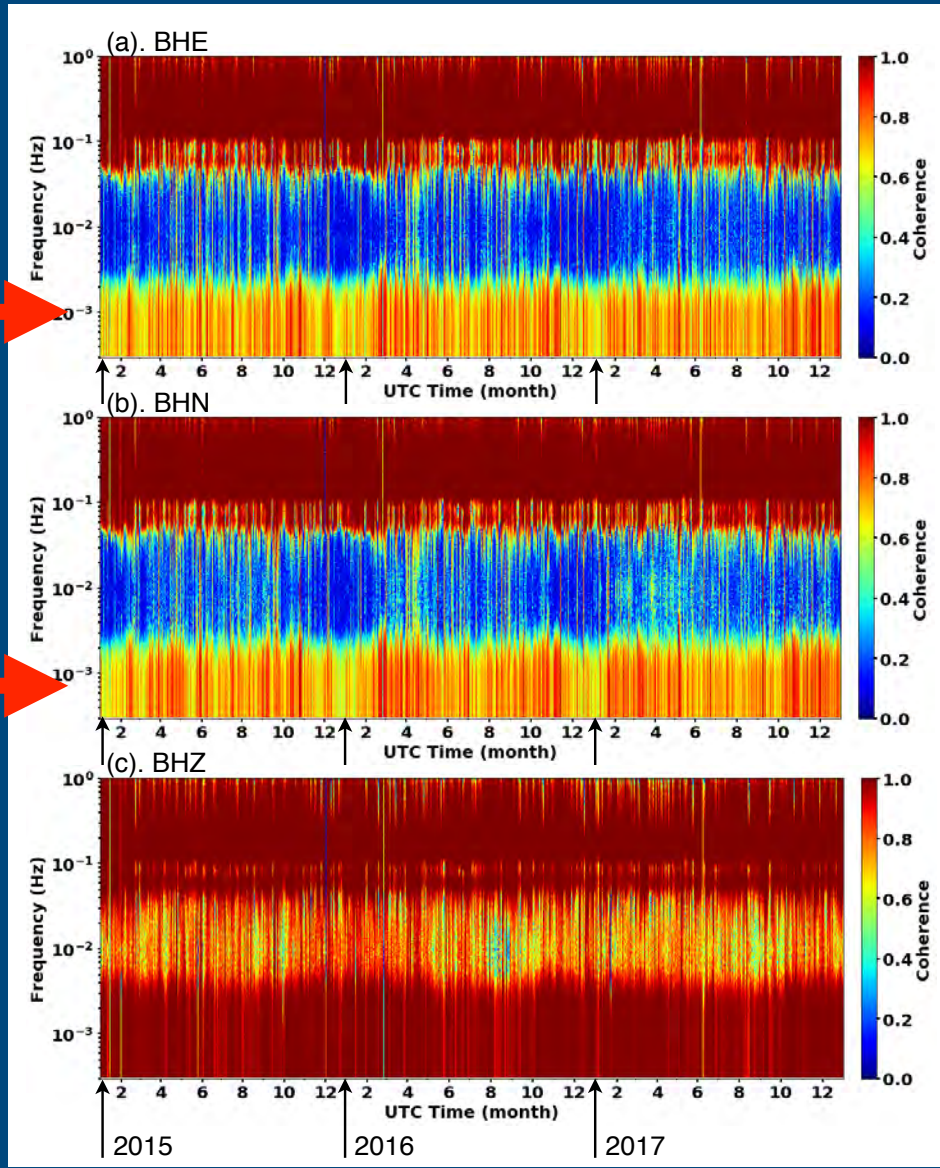
3 Year Coherograms - BH[ZNE] 65m spacing

- Microseisms very coherent
- 40 sec - 300 sec are incoherent



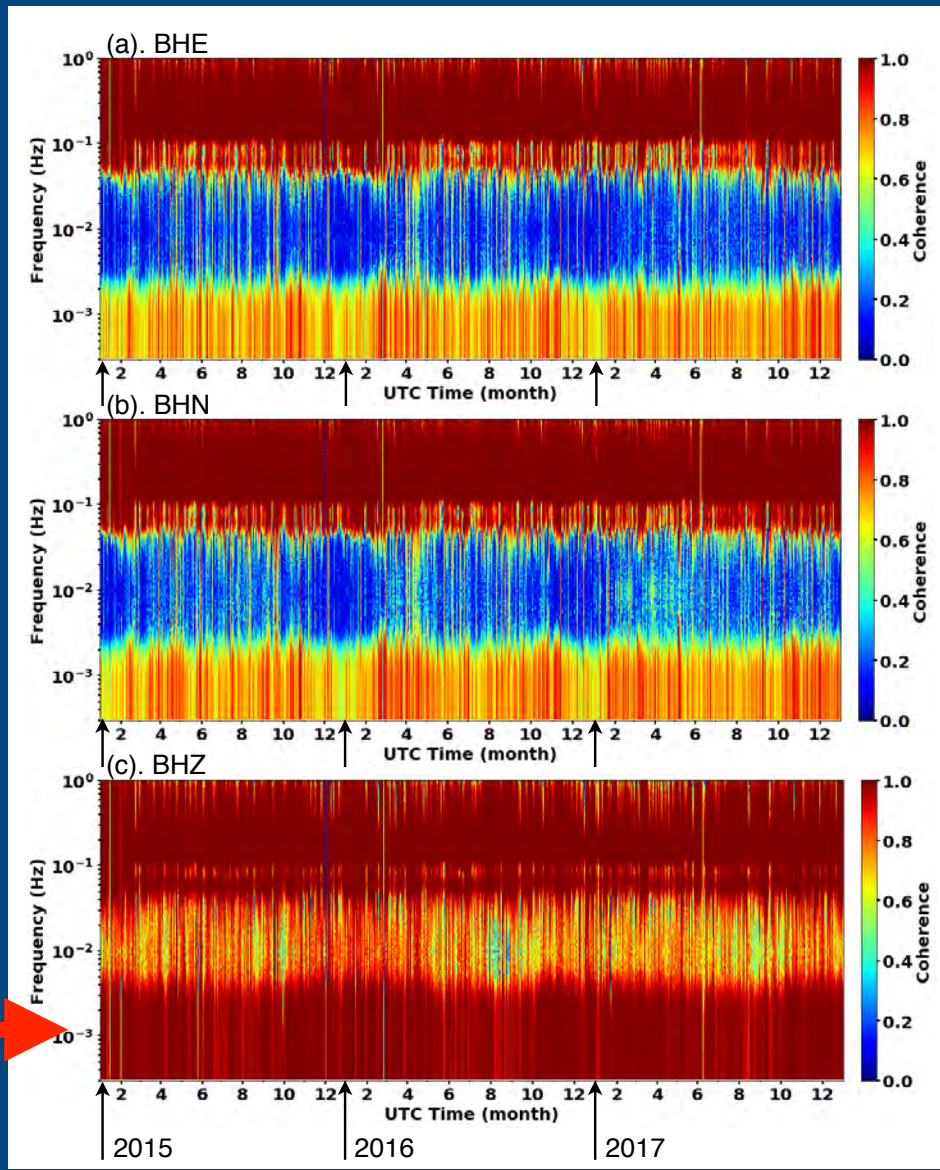
3 Year Coherograms - BH[ZNE] 65m spacing

- Microseisms very coherent
- 40 sec - 300 sec are incoherent
- >300 seconds on horizontals are partially coherent

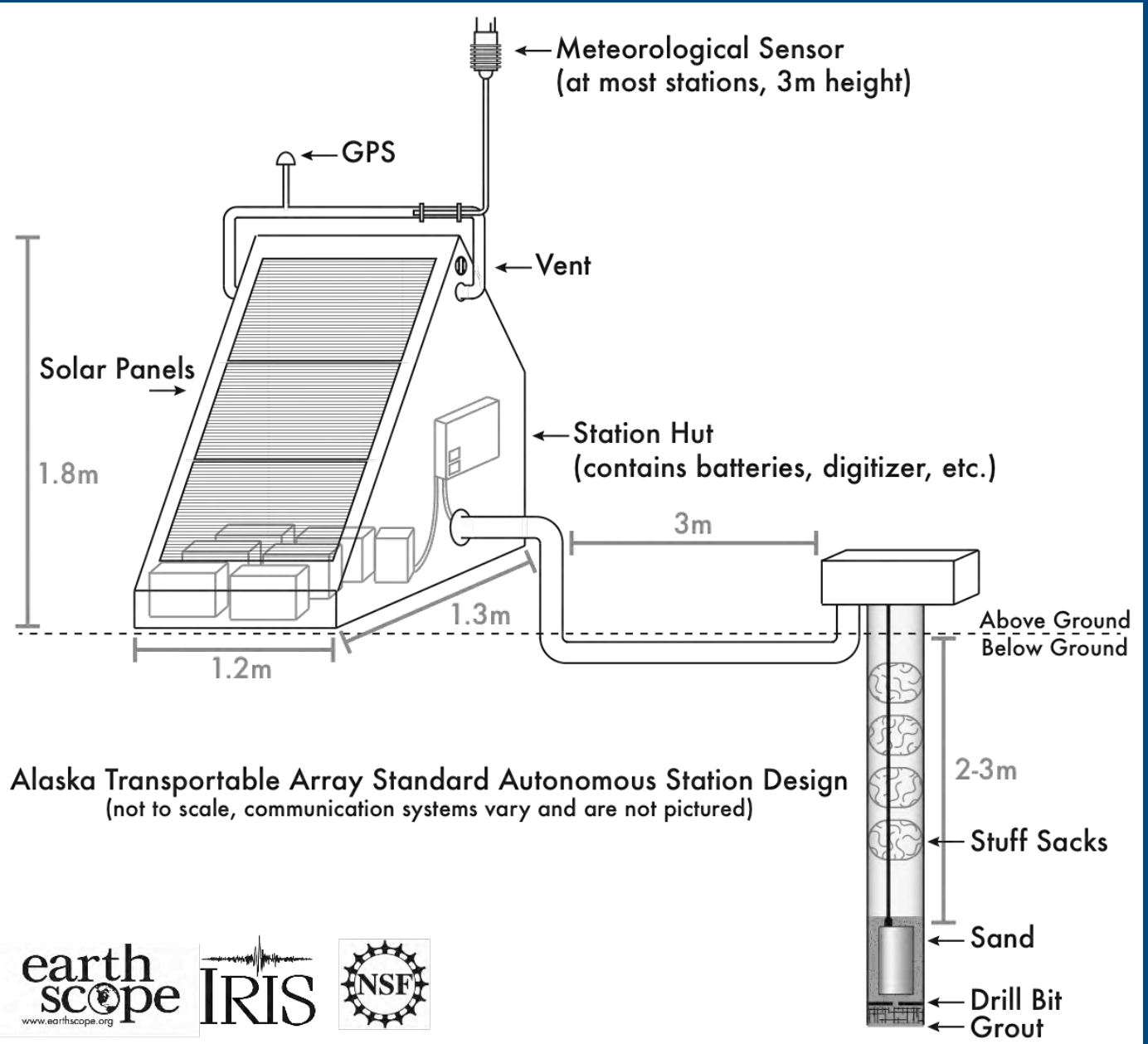


3 Year Coherograms - BH[ZNE] 65m spacing

- Microseisms very coherent
- 40 sec - 300 sec are incoherent
- >300 seconds on horizontals are partially coherent
- >300 seconds on verticals are coherent



Station Schematic view



Alaska Transportable Array Standard Autonomous Station Design
(not to scale, communication systems vary and are not pictured)

Equipment & Instruments
Basics:
Power, shelter and data comms

Added:
Barometric Pressure
Infrasound

In Alaska:
Strong Motion Instruments

Meteorological Packages

Soil Temperature profilers

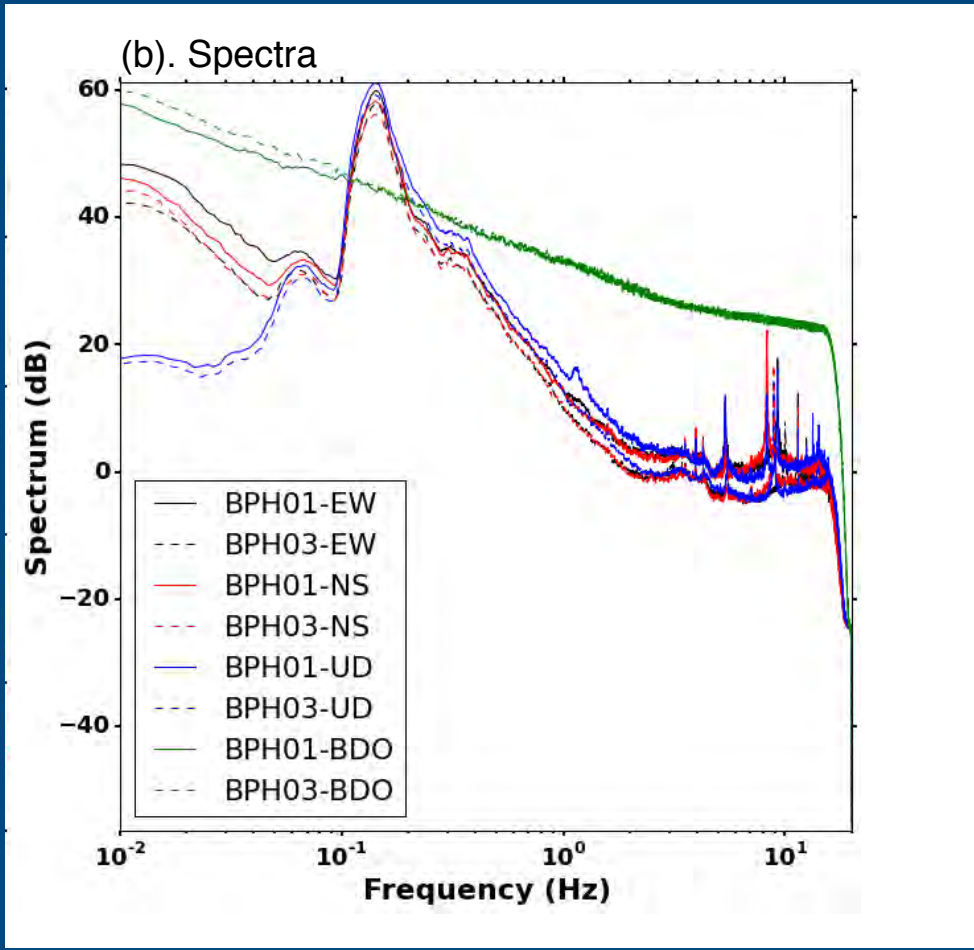
Emplacement procedure
Grout hardens (30 minutes)

4 inches sand in hole bottom,
level and tamp sand,
Lower sensor with rope,
Orient sensor with rod,
Add sand up to top of sensor
Insert compression sacks
Level / Center sensor remotely.

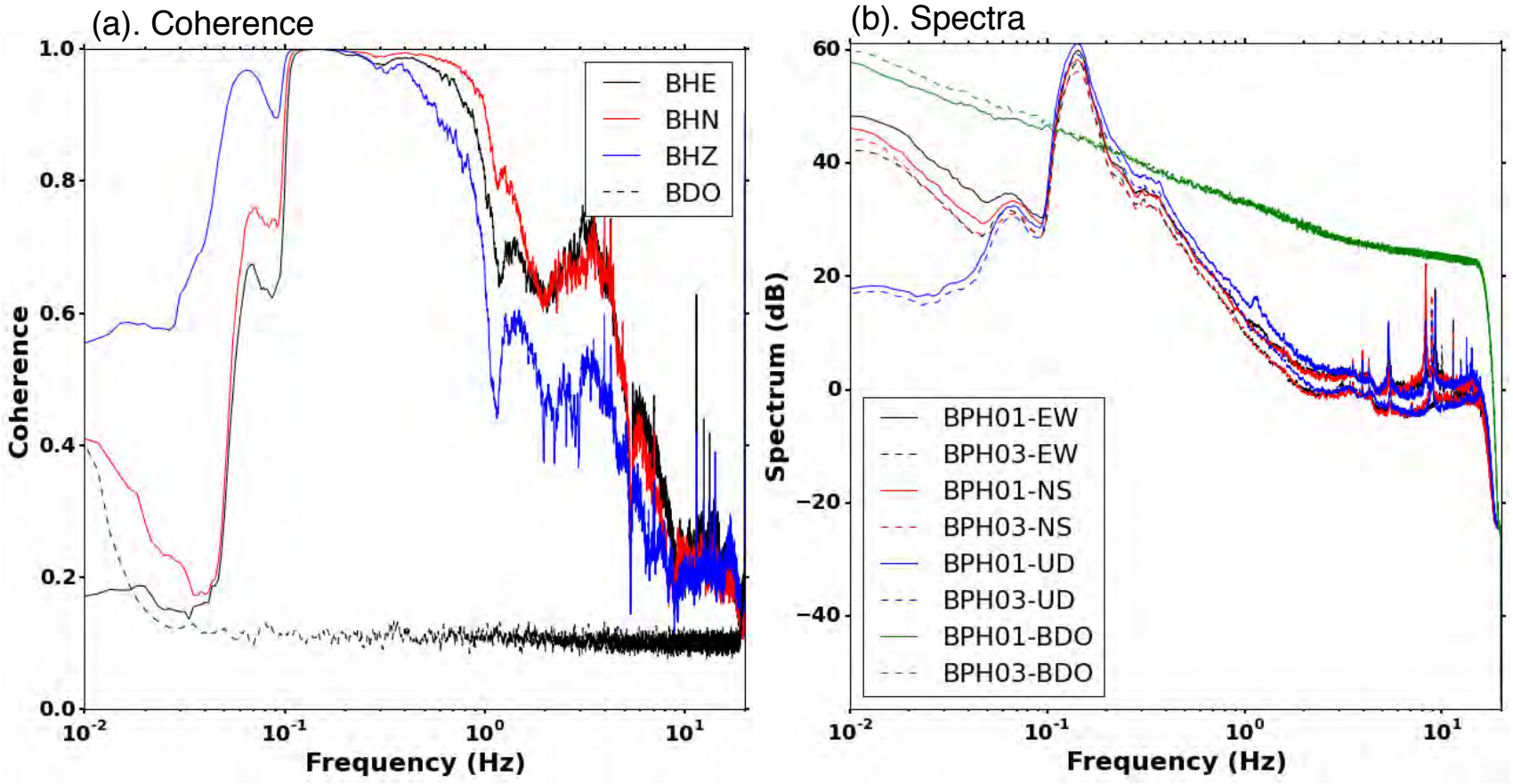
å

Crossing Disciplines

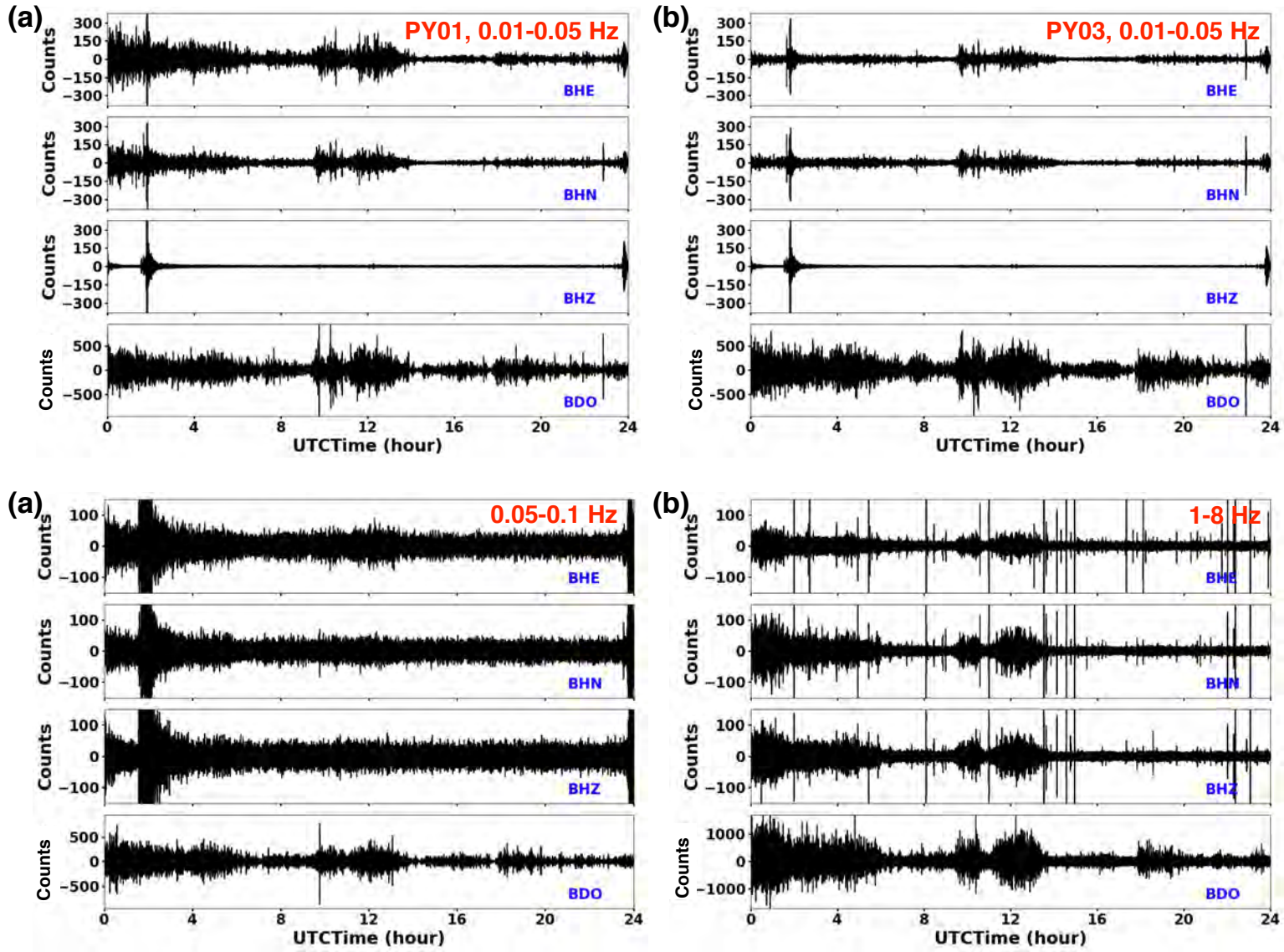
- Atmospheric pressure sensors added to TA in 2010 to understand effects of pressure on broadband seismometers.
- Thunder storms, storm fronts, derechos and tornados have significant impacts on broadband seismic data



Crossing Disciplines

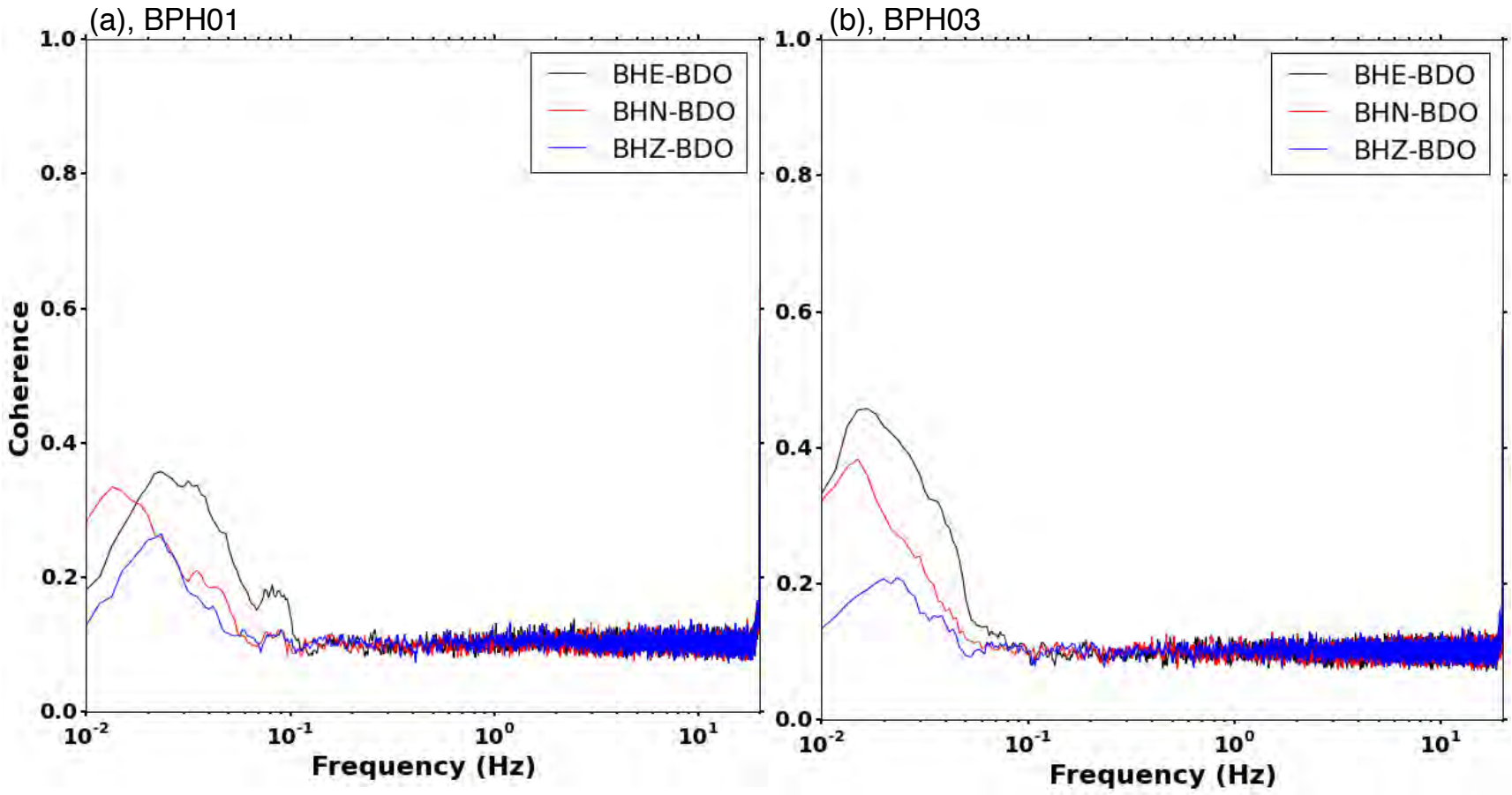


Broadband Seismic and Pressure

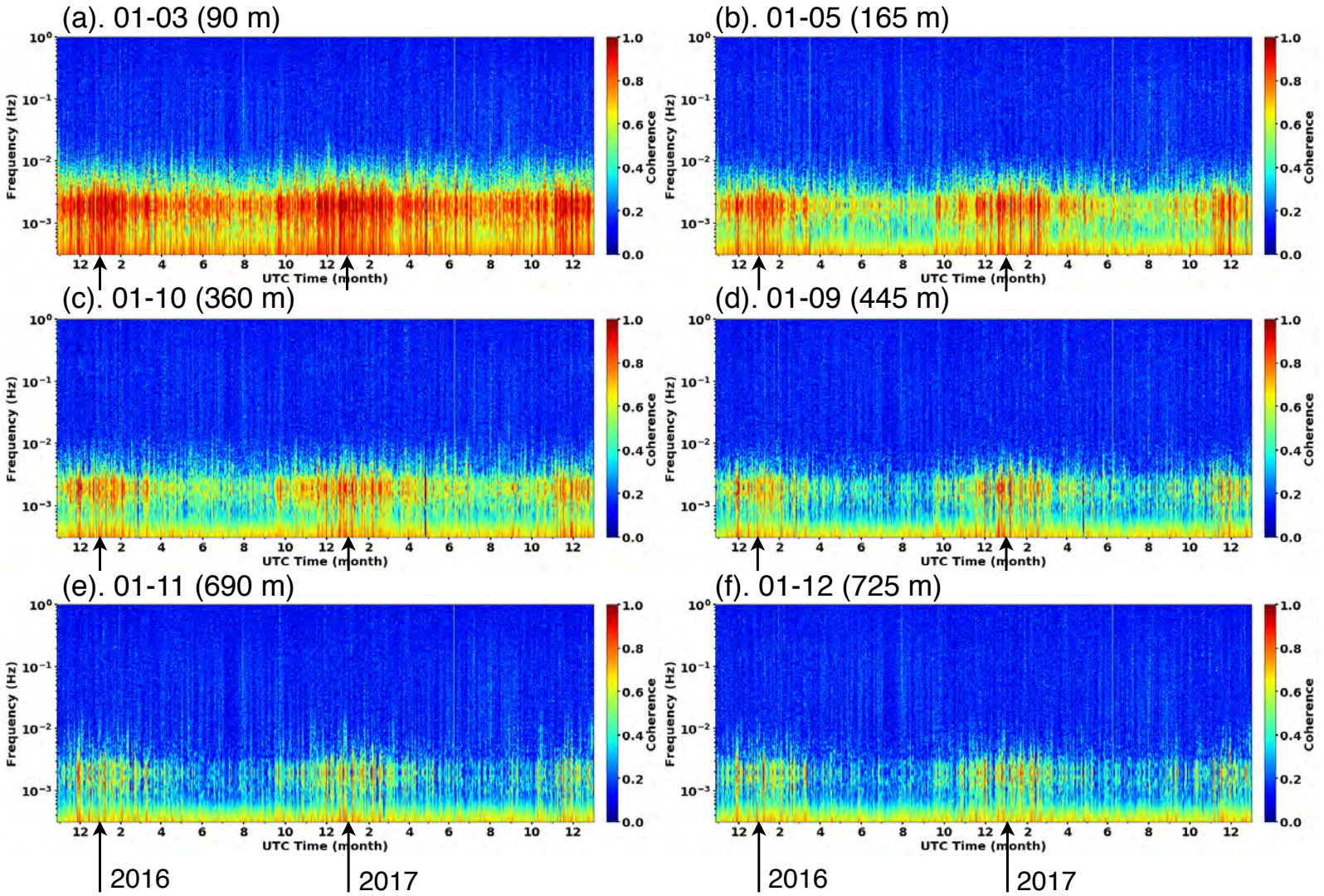


Coherence between Atmospheric Pressure and Seismic Noise

- Results from BPH01 and BPH03

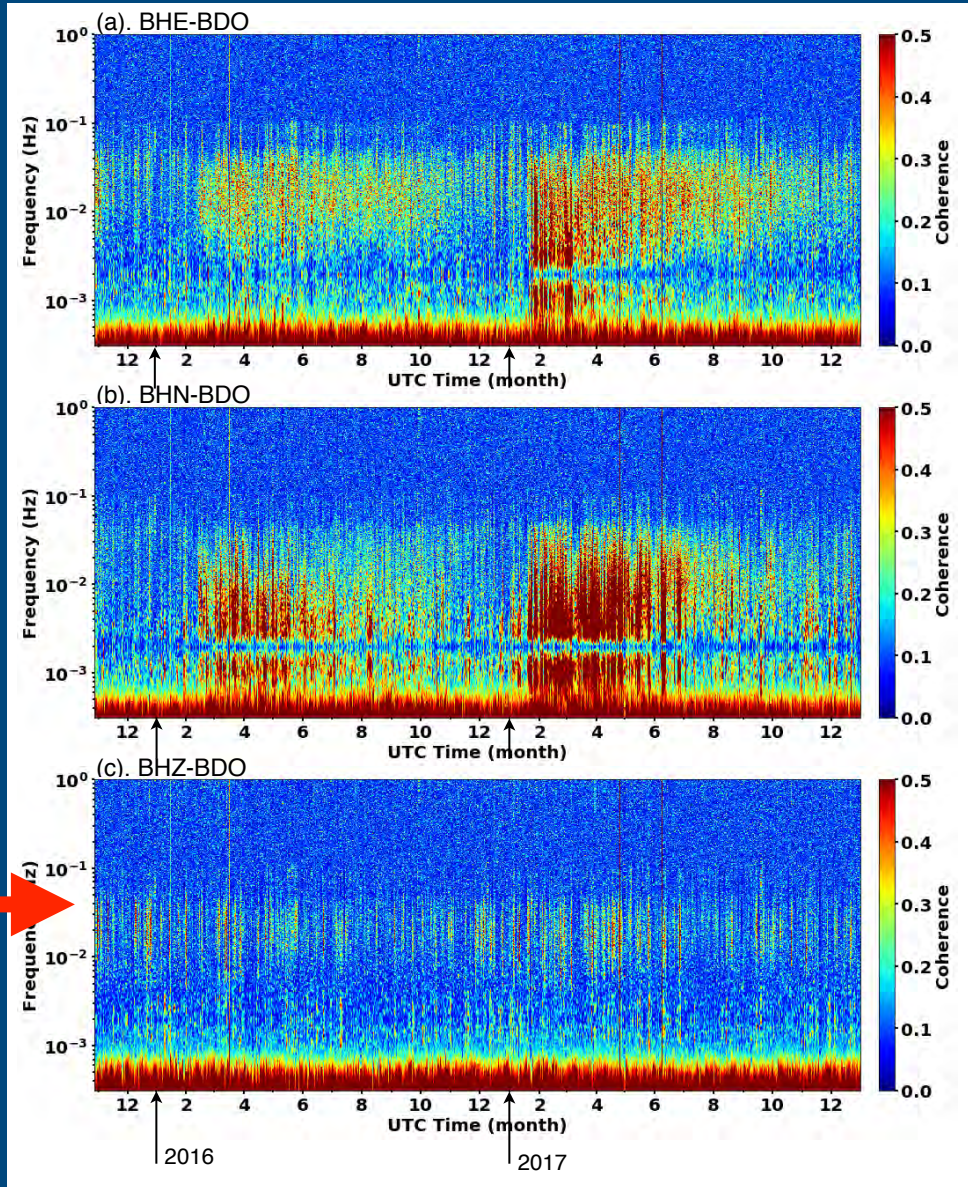


2 Year BDO Coherences between 6 station pairs



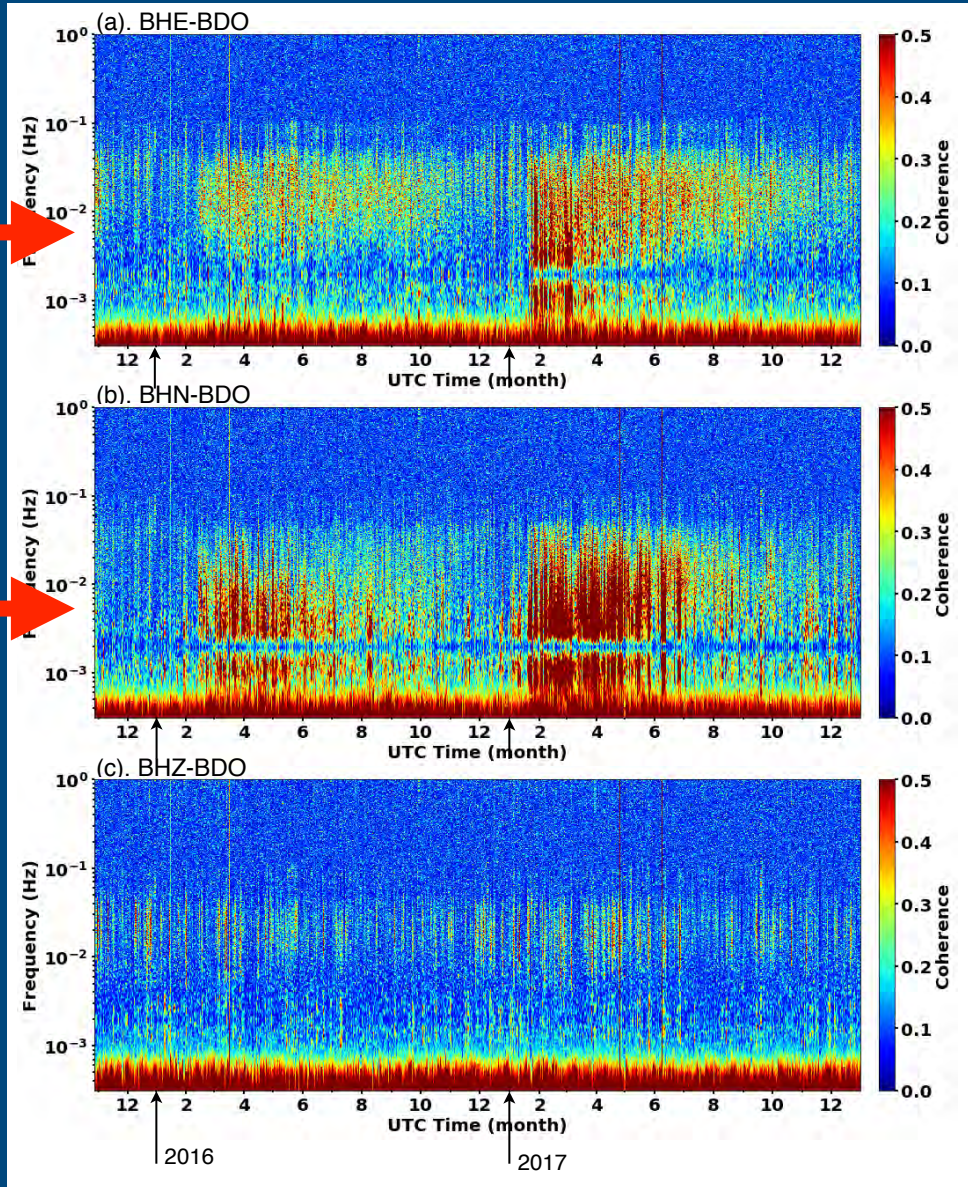
2 Year Coherence between BHZ/BHN/BHE and BDO

- Low BDO-BHZ coherence from 1 sec to over 1000 seconds

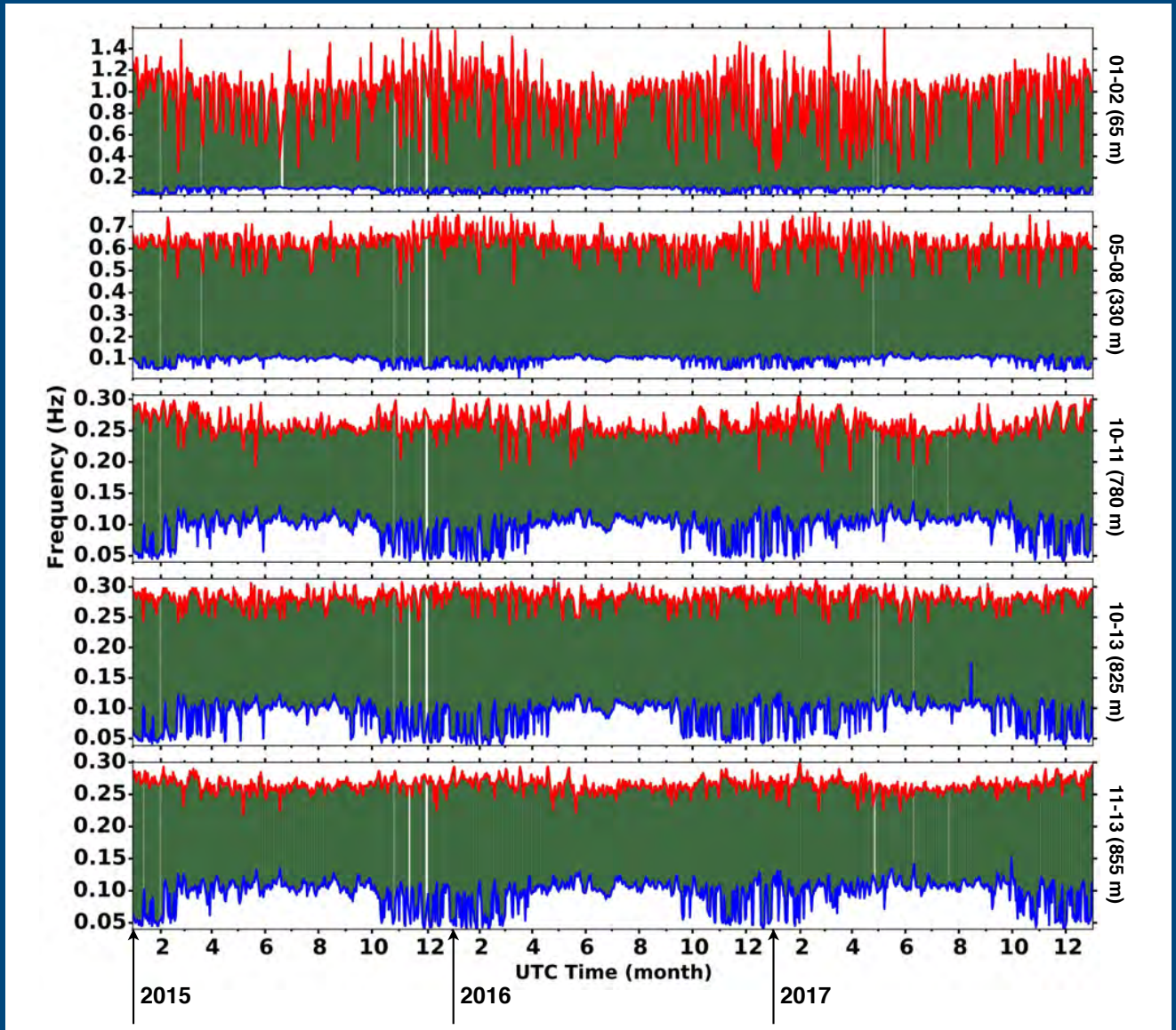


2 Year Coherence between BHZ/BHN/BHE and BDO

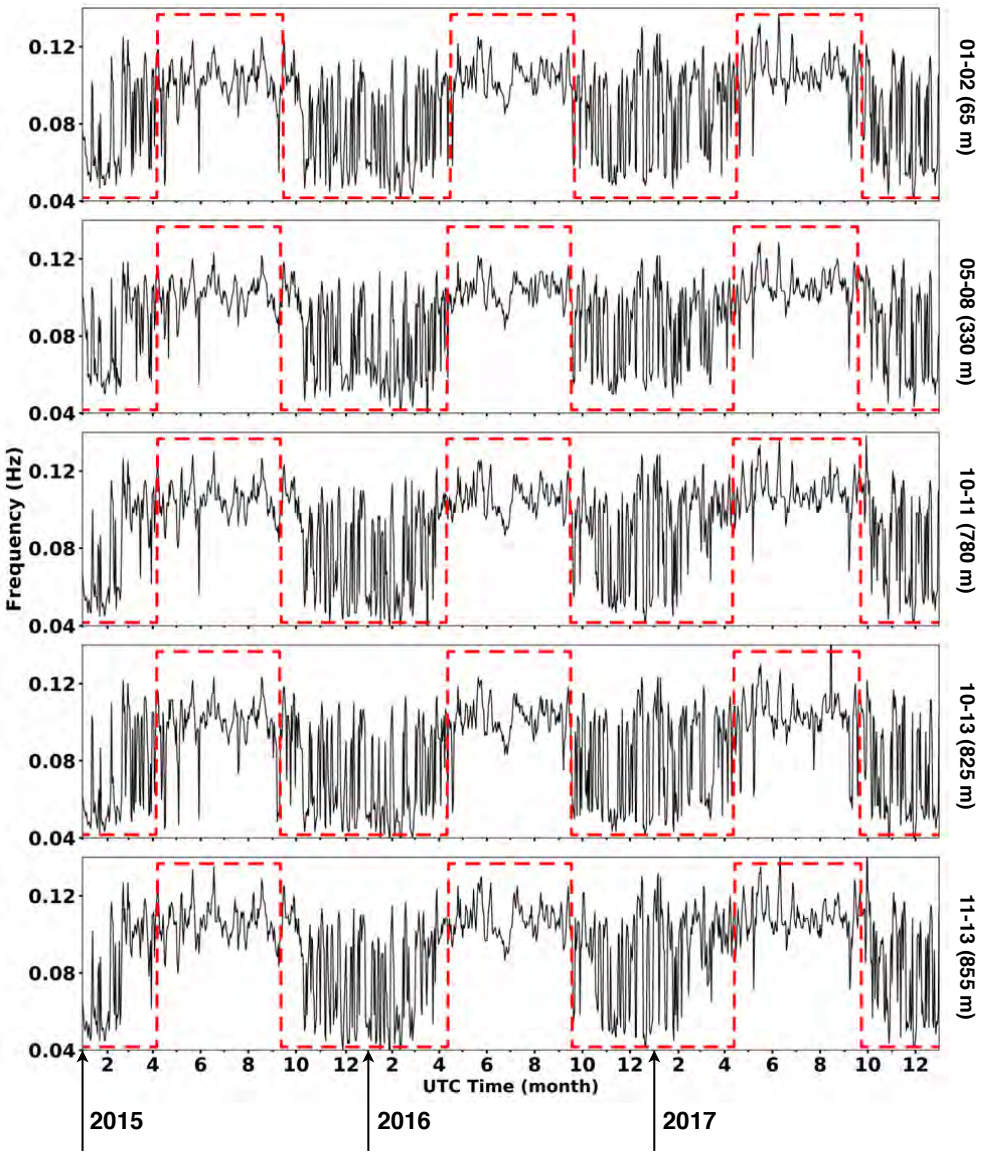
- Low BDO-BHZ coherence from 1 sec to over 1000 seconds
- Variable BDO-BHN/E coherence from 30 sec to over 1000 seconds as a function of time and frequency



95% Coherence Between STS5 BHE Pairs



Low Frequency Coherence 95% Bound

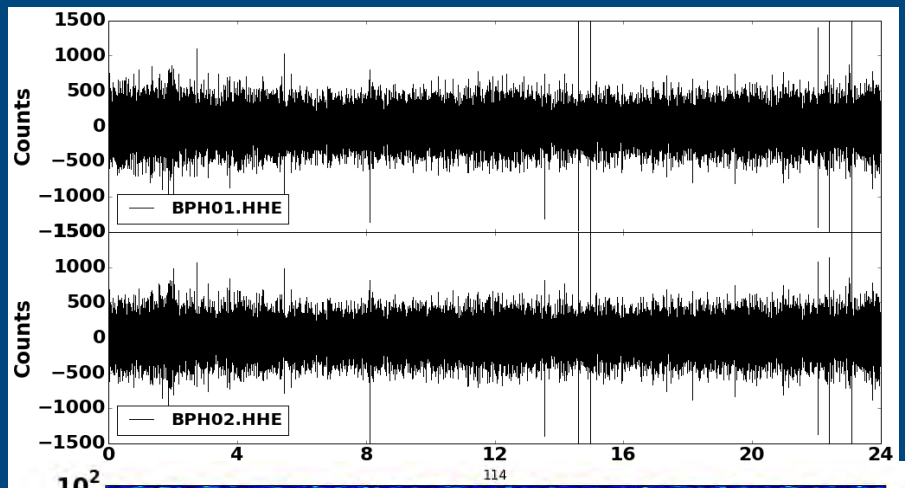


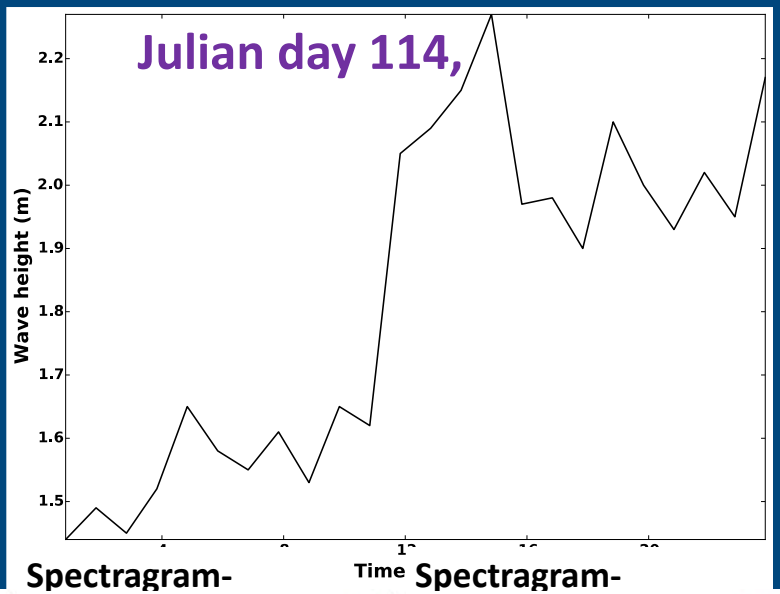
National Data Buoy Center

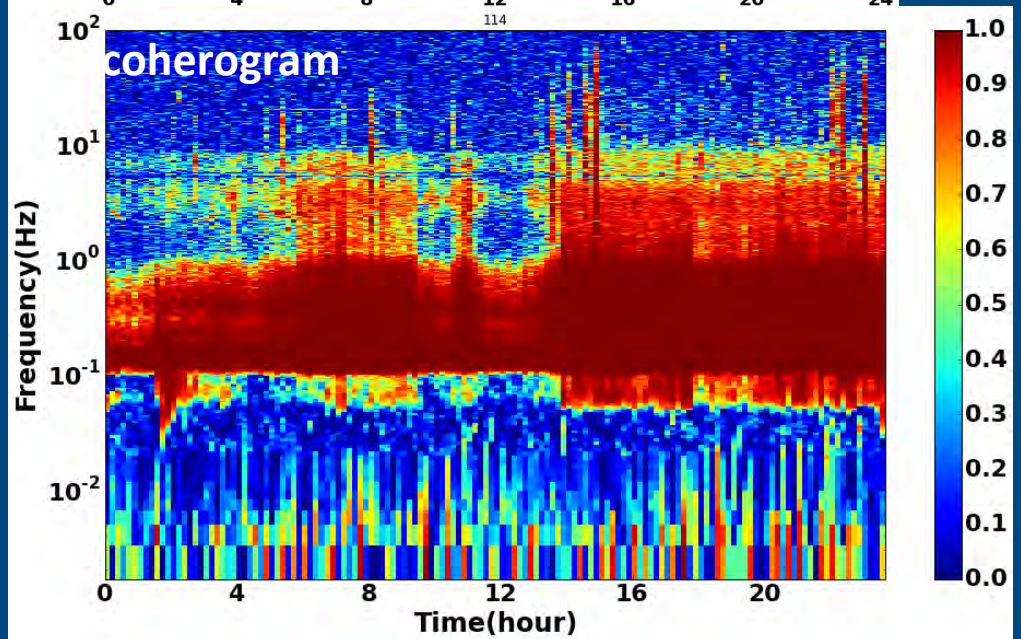
Temperature, wind, ocean wave height….

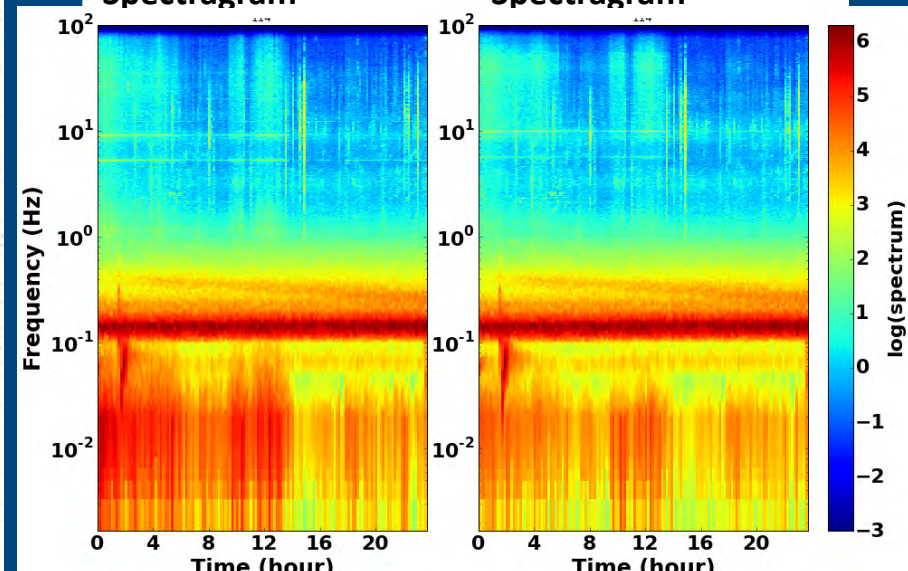
Significant wave height = average of the highest one-third of all of the wave heights during the 20-minute sampling period

BPH01-02 2016 114

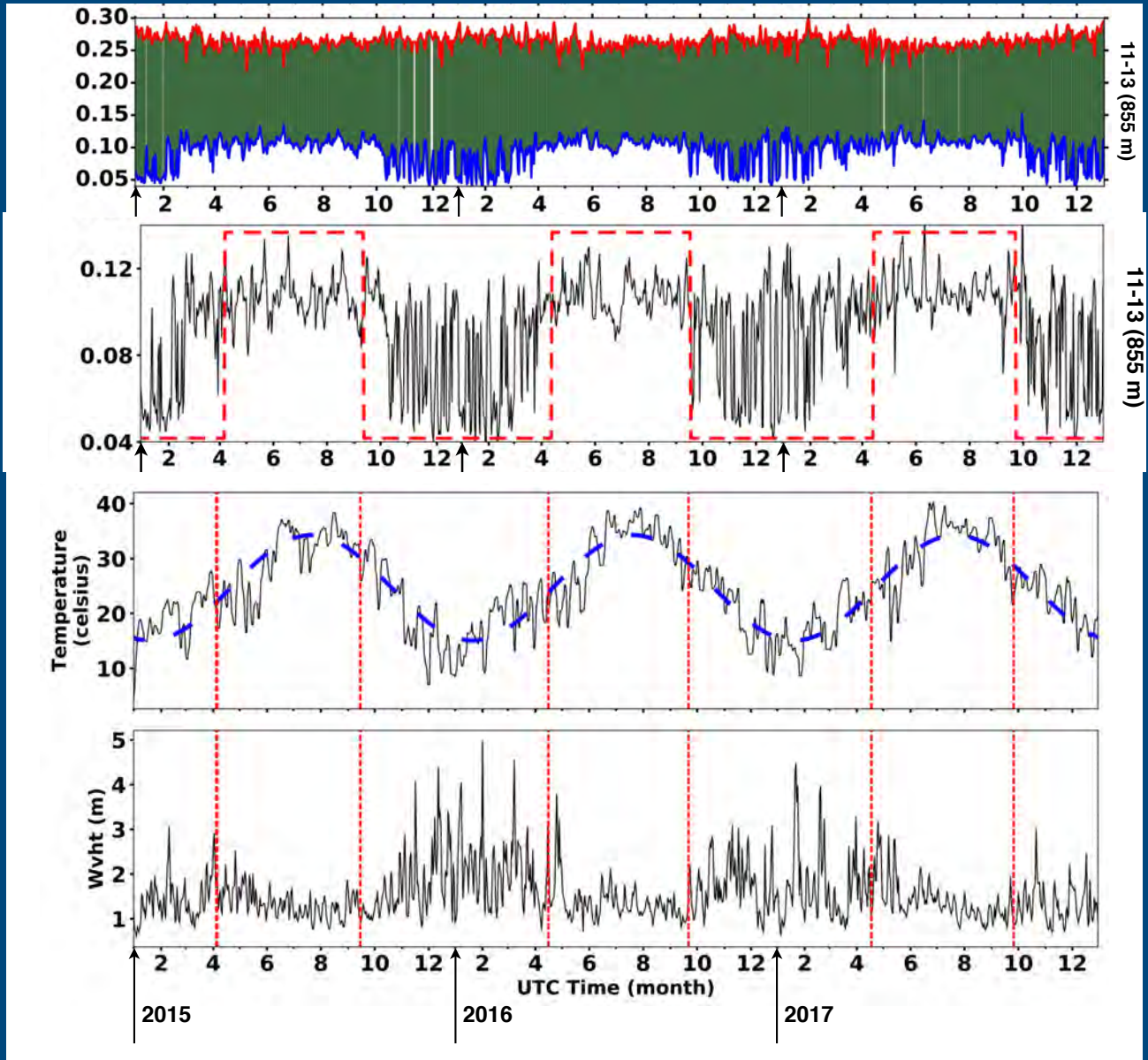








Seasonal Temperature and Ocean Swell



Summary

- USArray Posthole Deployment provides consistent high quality data
- All array elements with the same orientation are have highly coherent ground noise in the microseism band
- Earthquake signals exhibit higher coherence across a wider bandwidth
- Outside the microseism band the coherence of ground noise drops significantly as a function of distance.
- The low frequency incoherence between seismic sensors is caused by local atmospheric turbulence.
- There is a seasonal dependence on oceanic waves