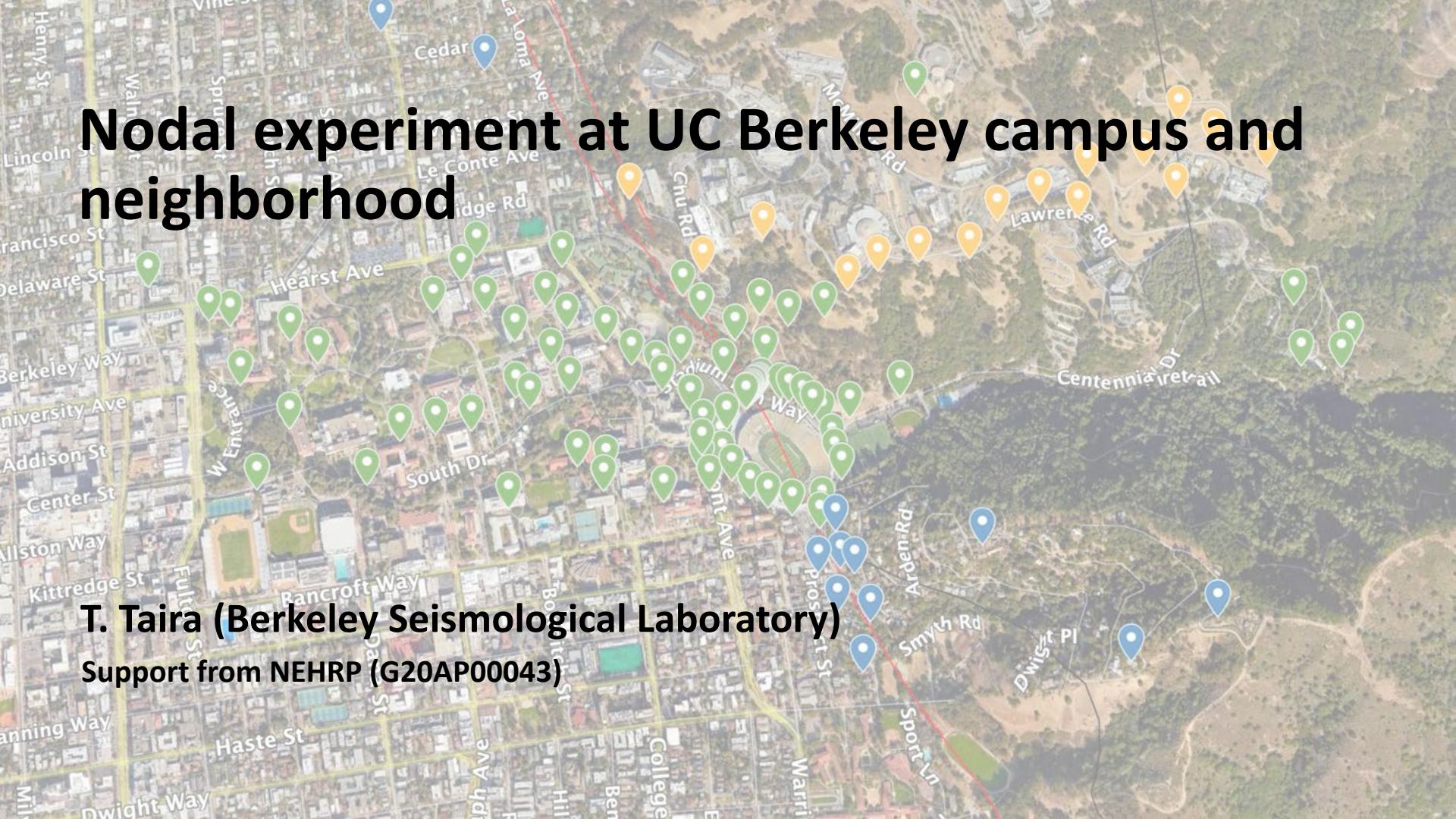


# Nodal experiment at UC Berkeley campus and neighborhood

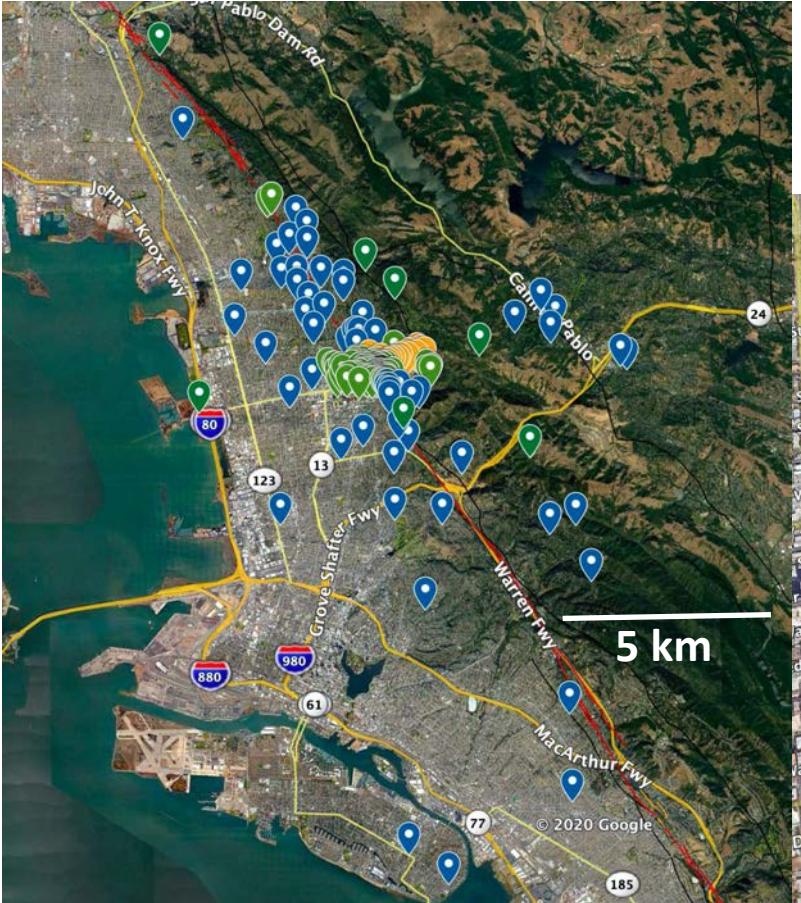
T. Taira (Berkeley Seismological Laboratory)

Support from NEHRP (G20AP00043)



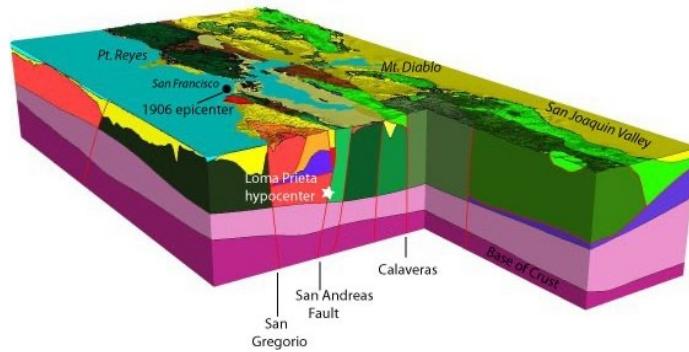
# Nodal Seismic Experiment

- Over 170 nodal sensors (three-component  
Fairfield Z-land 5 Hz)
- Duration: late Nov 2020 through early Jan 2021



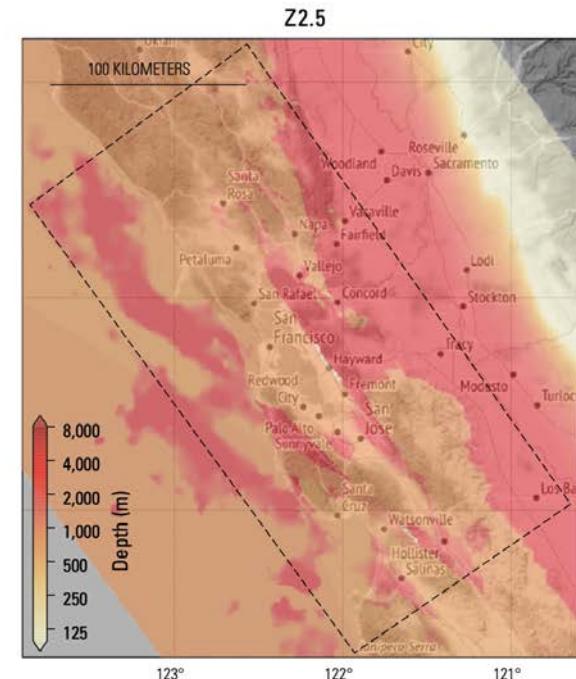
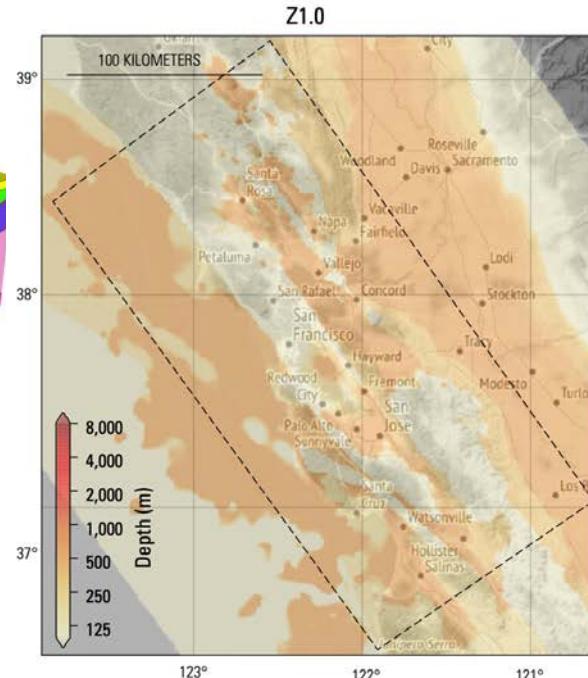
# USGS 3D San Francisco Bay Area Velocity Model

- Velocity contrast across the Hayward Fault (10-20%) is not consistent with observed data (Rodgers et al., 2008, BSSA)



USGS Bay Area Model 8.3.0  
Geologic/seismic model

- <https://www.usgs.gov/>



- Aagaard et al. (2020, USGS Open-File Report)

# Nodal Sensor



- Dimension: about ~15cm in diameter and 30cm in length
- Short-period geophone (5 Hz)
- Offline recording (No telemetry)
- Battery lasting ~35 days

# Deployment of Nodal Sensor



- Sensors were buried under ground to maximize ground coupling



# Deployment of Nodal Sensor

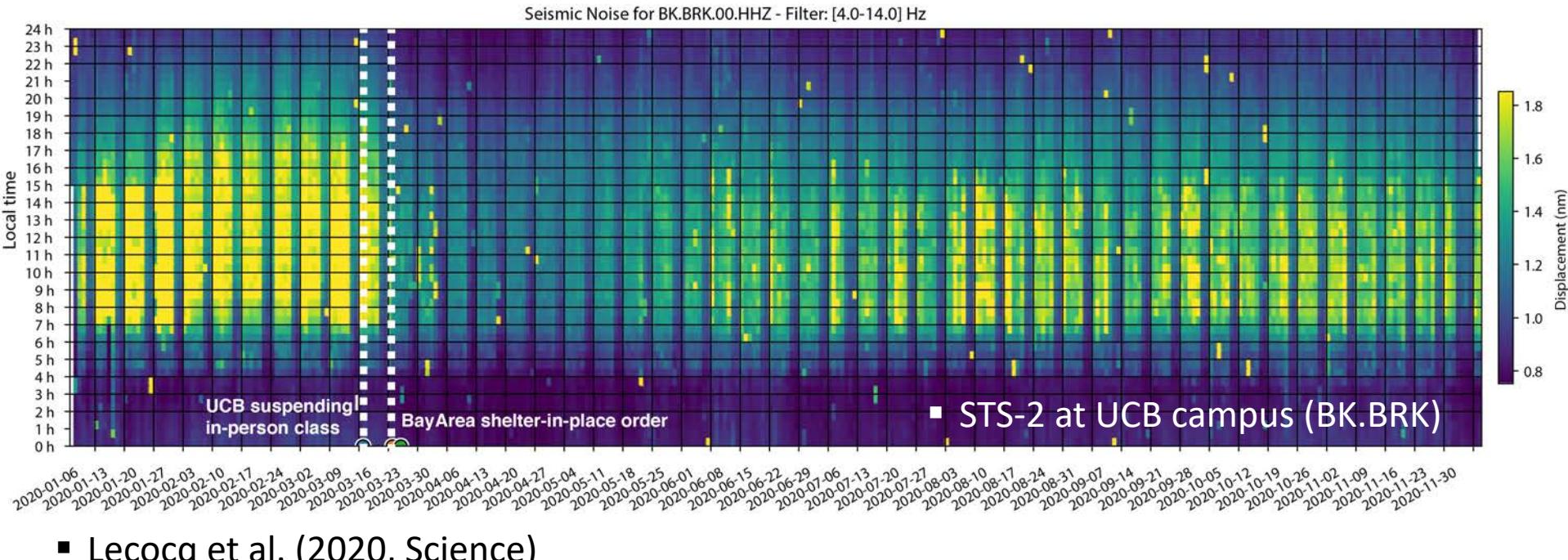
- UC Berkeley campus (86)
  - UC Botanical Garden (4), Lawrence Hall of Science (1), Blake Garden (2)
- LBL campus (12)
- East Bay Regional Park (7)
  - Tilden (3), Eastshore State (1), Wildcat Canyon (1), Claremont Canyon Regional Preserve (1), Sibley Volcanic Regional Preserve (1)
- Residential backyard (68)
  
- Field supports: Sierra Boyd, Fabia Terra, Avinash Nayak, Doug Dreger, Amir Allam

# Project Goals

- Ambient noise surface wave tomography (2D profile)
  - High-resolution imaging of fault structure
- Earthquake detections
  - Template match analysis
- Provide new seismic data set to the community

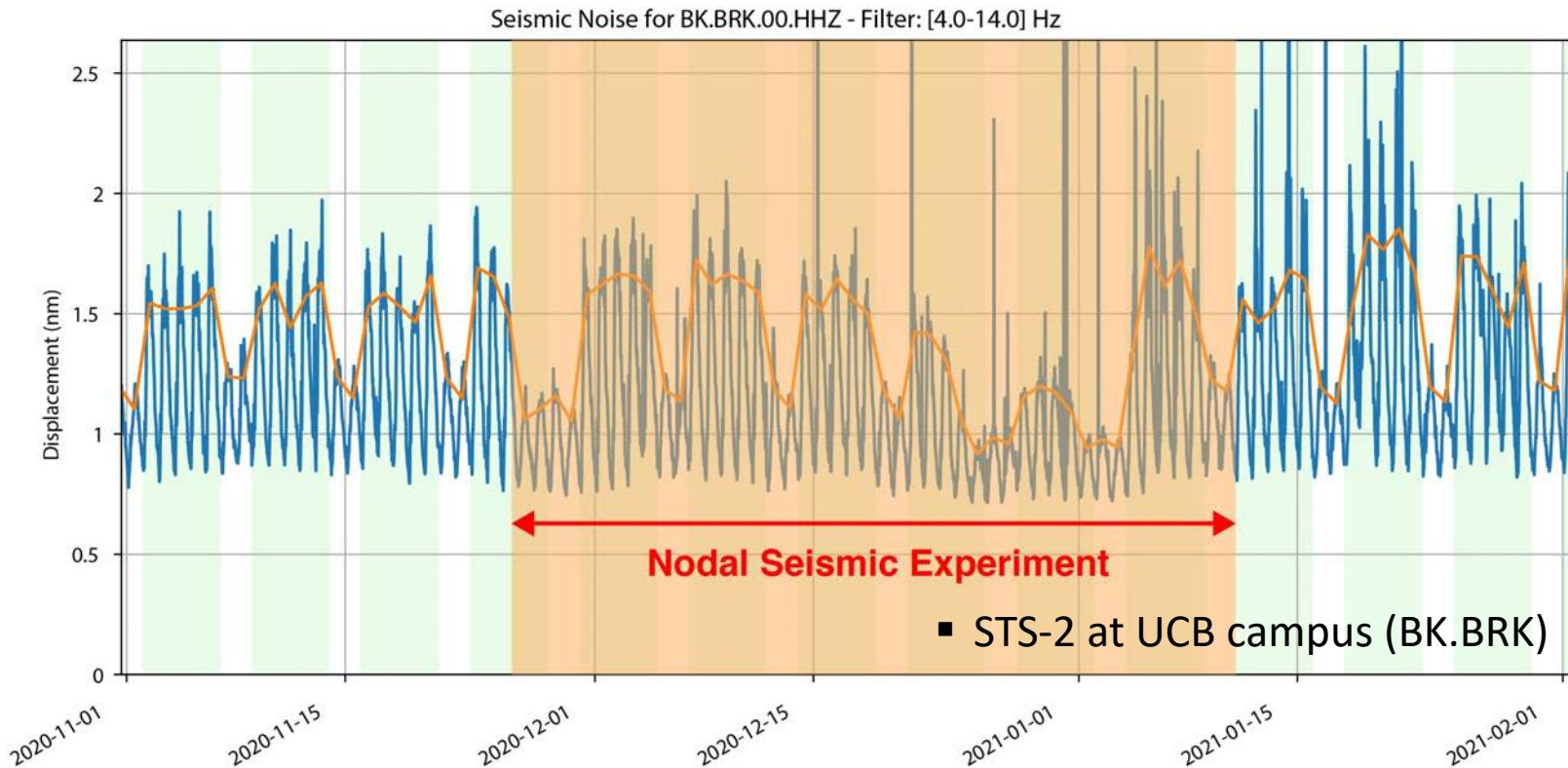
# COVID-19 Shelter-in-Place Order

- March 10, 2020: UCB suspended in-person class
- March 17, 2020: CA governor issued Bay Area shelter-in-place order



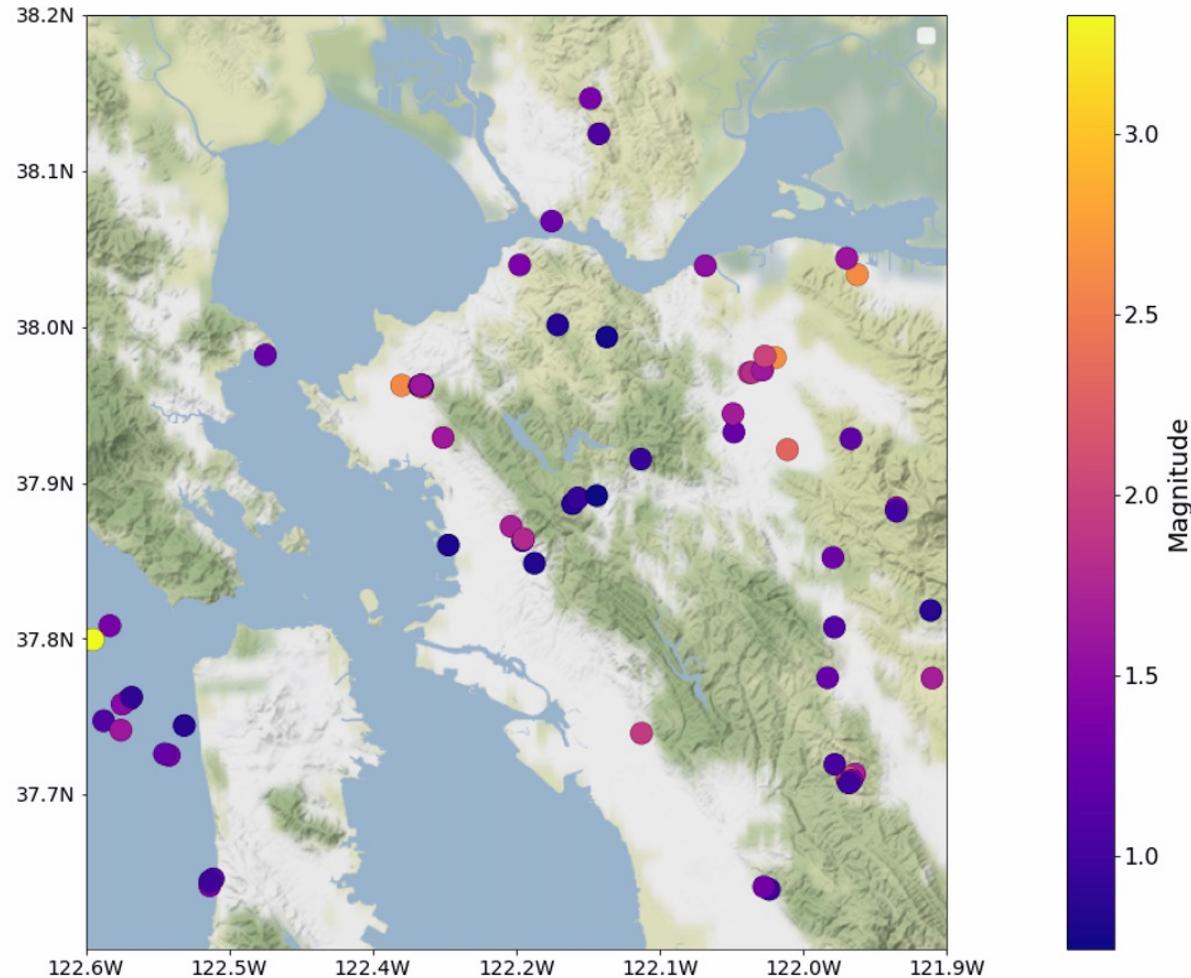
# COVID-19 Shelter-in-Place Order

- Nodal experiment was performed when cultural noise seems to be lowest
- Possibly capture EQ (and non-EQ) signals more easily



# Local EQs

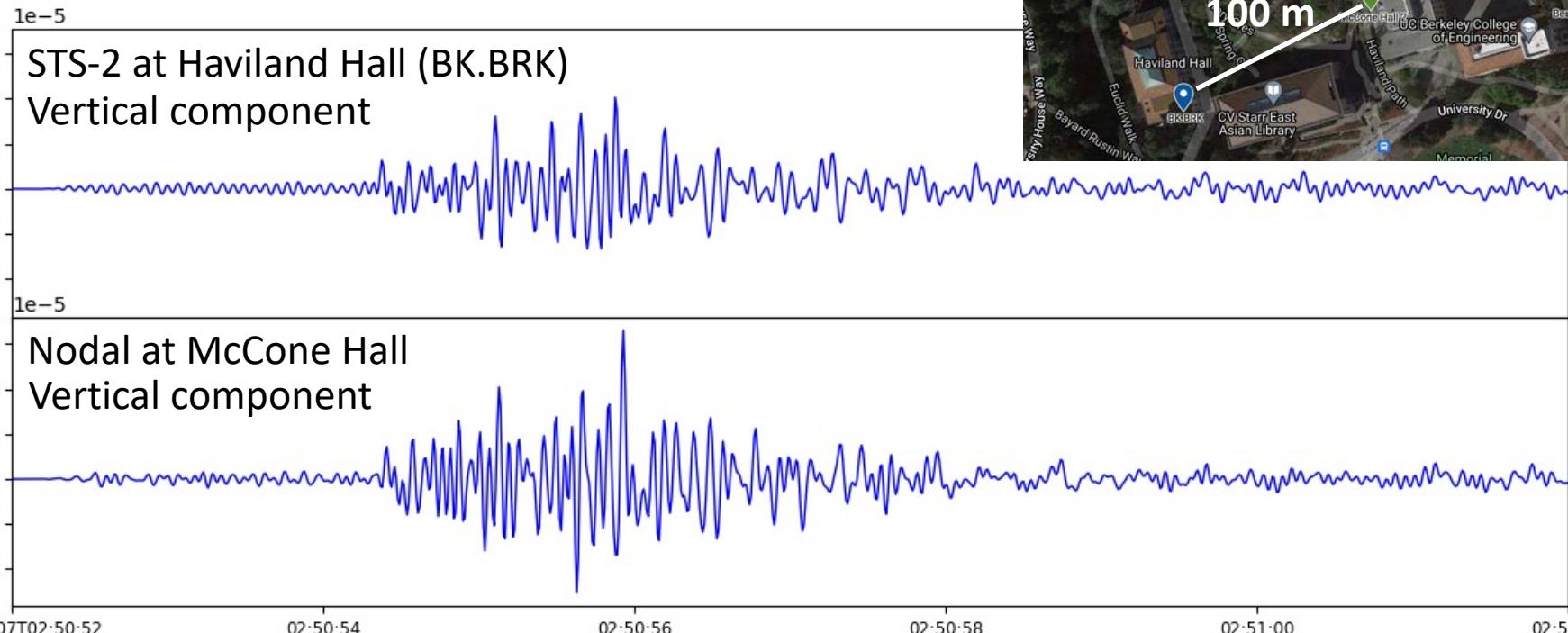
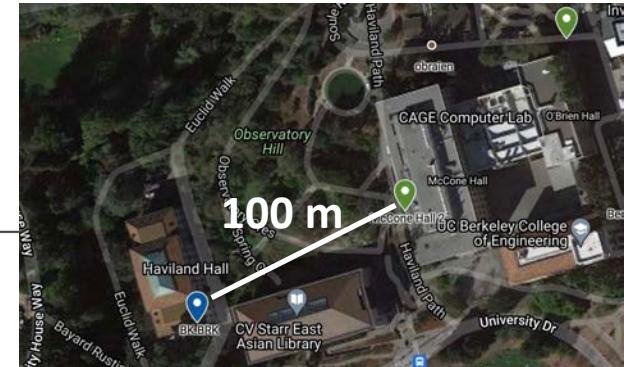
- ~70 local EQs during the experiment
- Can be used for travel-time tomography?



# Nodal and STS-2 Waveform Comparison

- Local Berkeley EQ (M1.8)
- A 1-20 Hz bandpass filter applied

2020-12-07T02:50:52 - 2020-12-07T02:51:02

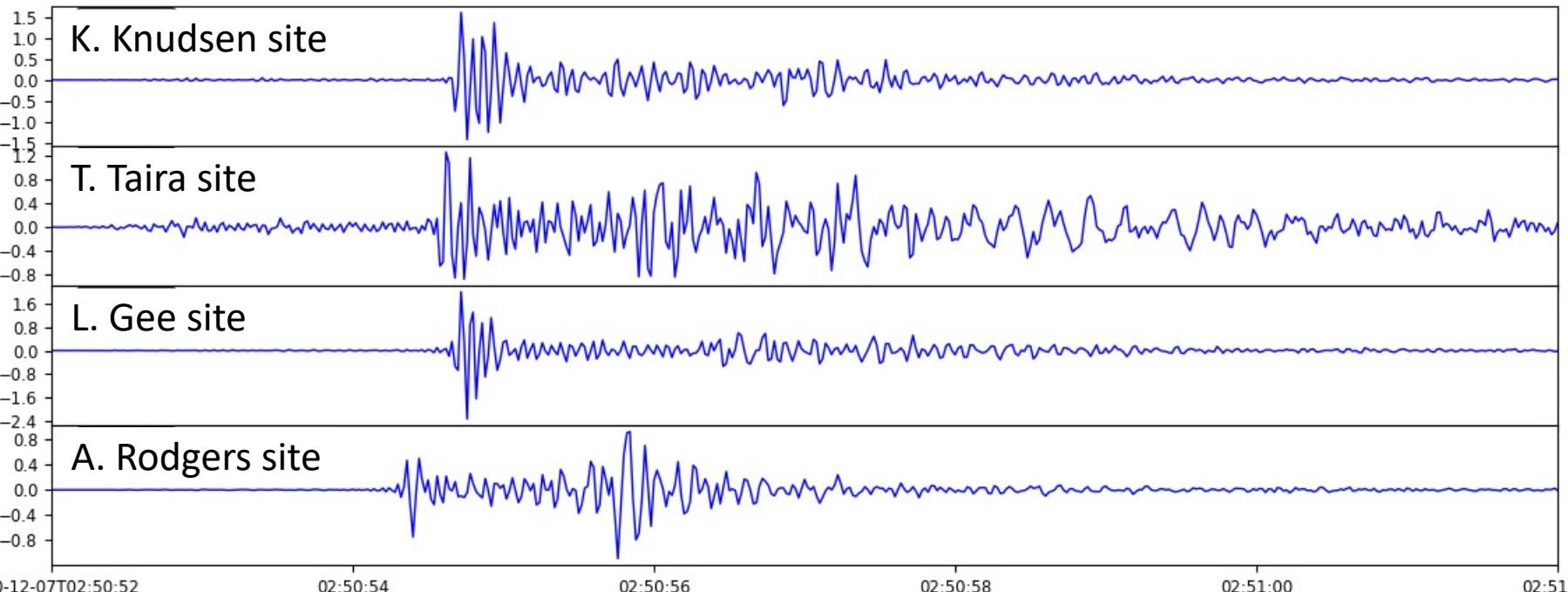


# Nodal Data at Residential Backyard

- Local Berkeley EQ (M1.8) & A 1-20 Hz bandpass filter applied
- 3D ground motion simulation with SW4?

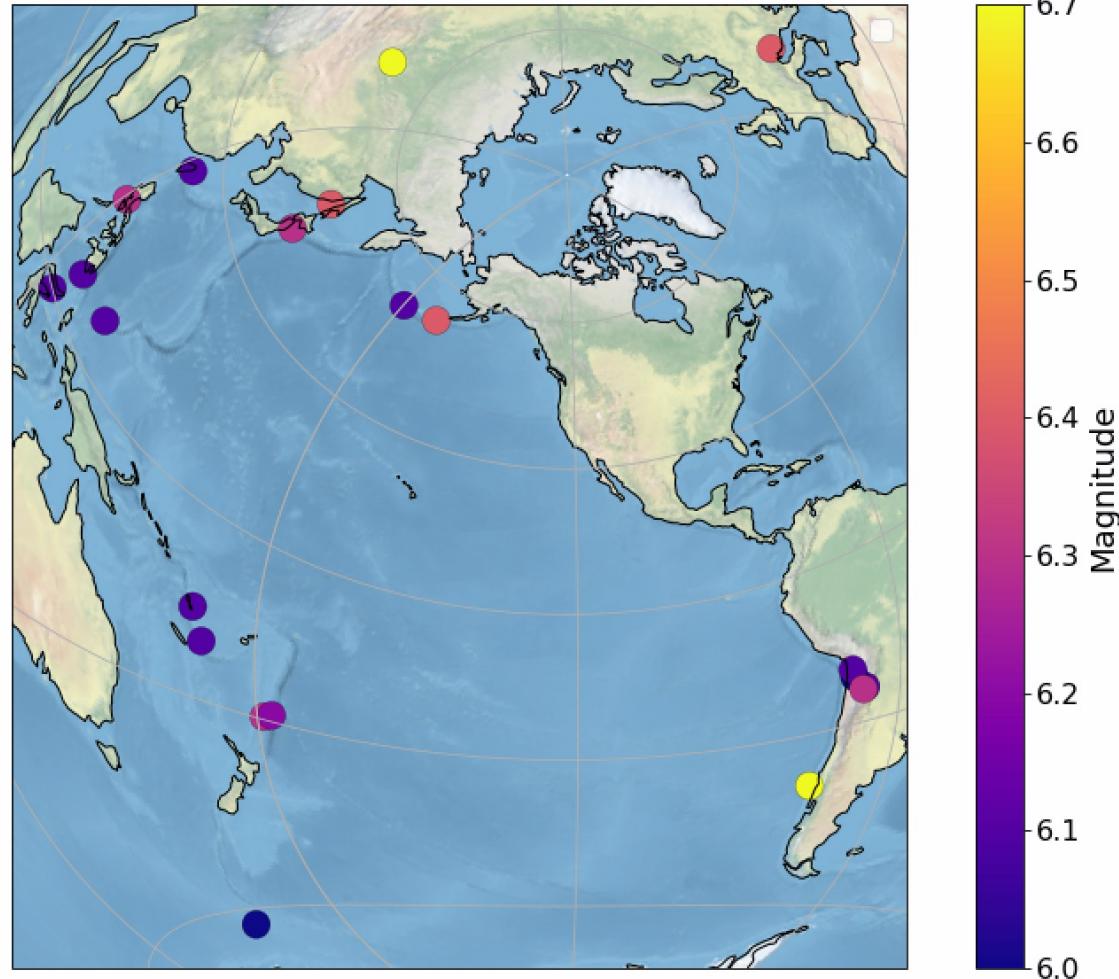
2020-12-07T02:50:52 - 2020-12-07T02:51:02

Vertical component



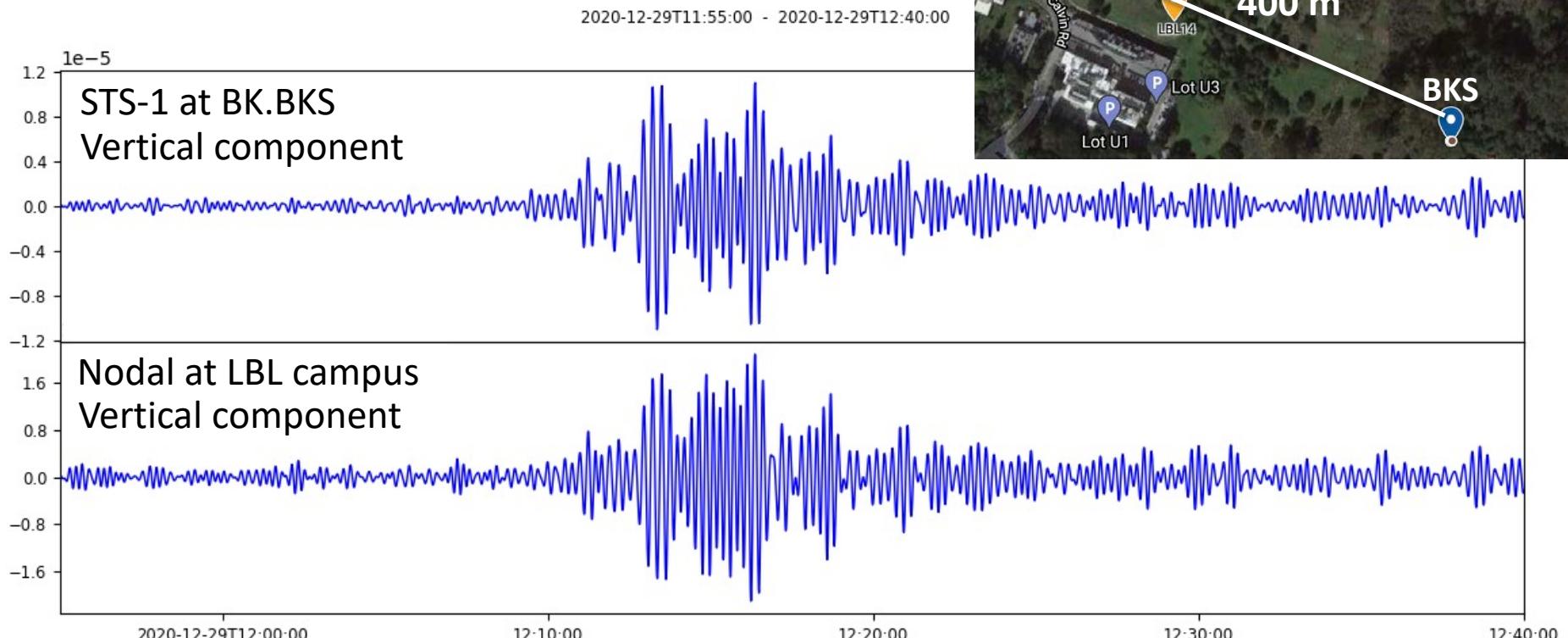
# Teleseismic EQs

- ~20 teleseismic EQs ( $M \geq 6.0$ ) during the experiment
- Receiver function?

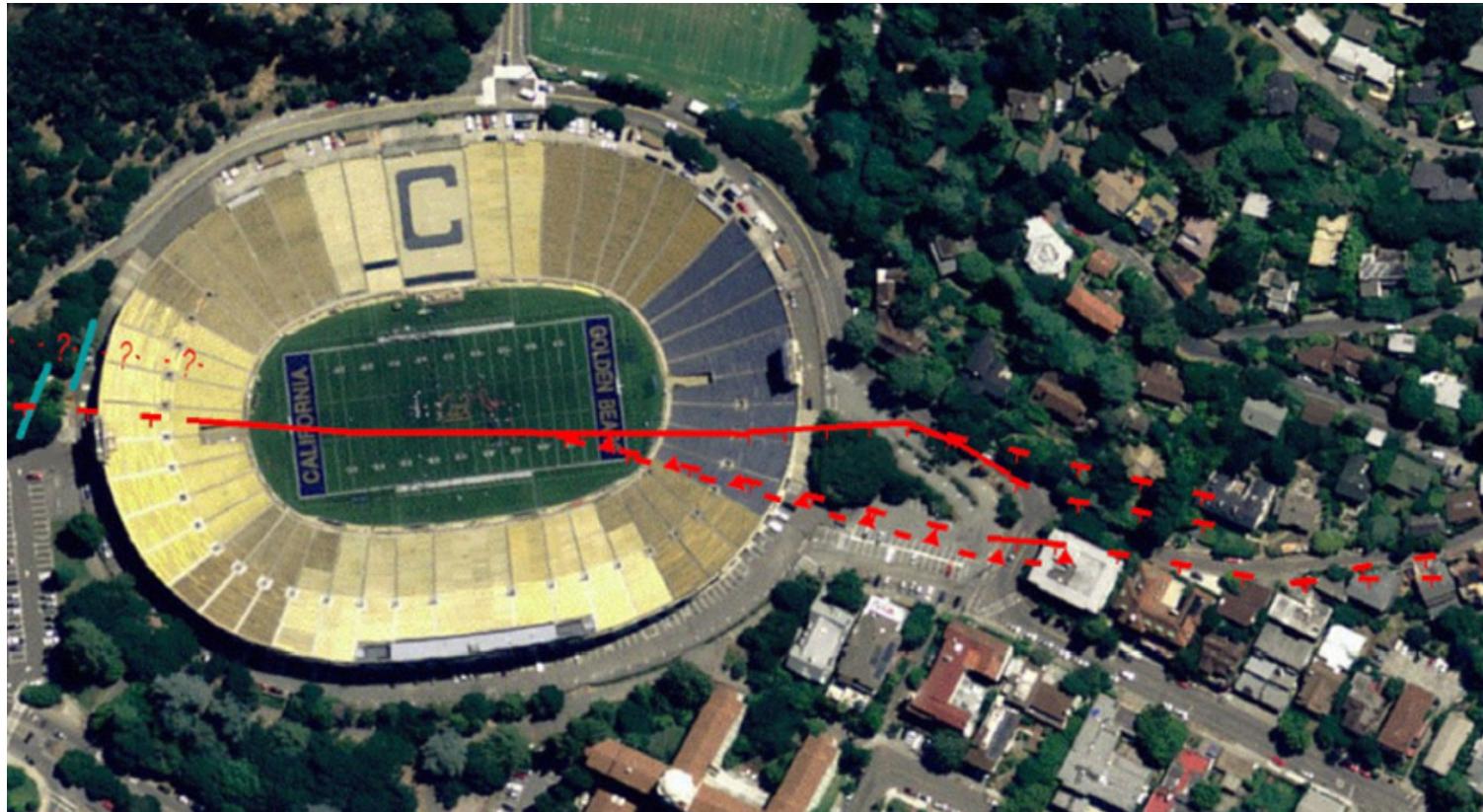


# Nodal and STS-1 Waveform Comparison

- Croatia EQ (M6.4)
- A 0.05-0.1 Hz bandpass filter applied

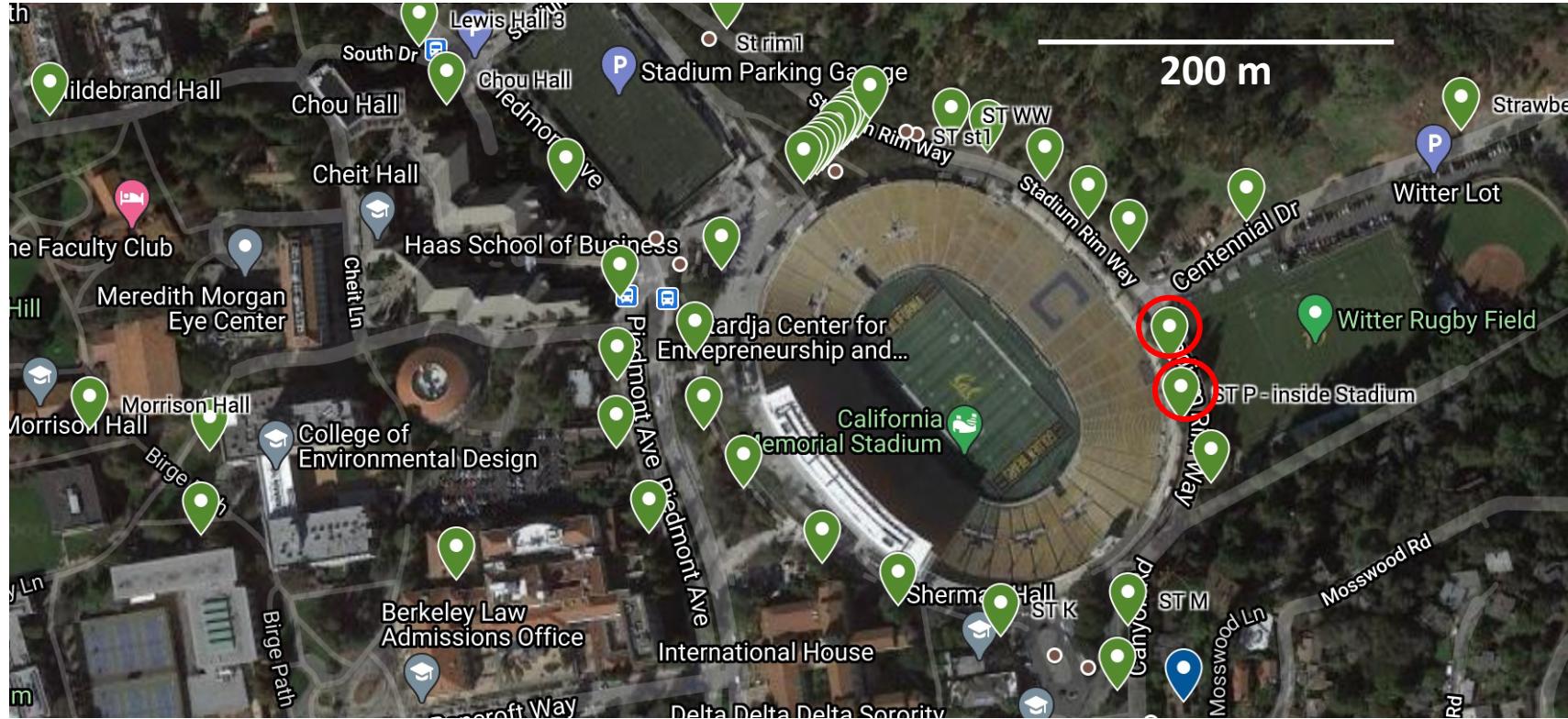


# Hayward Fault runs through Cal Stadium



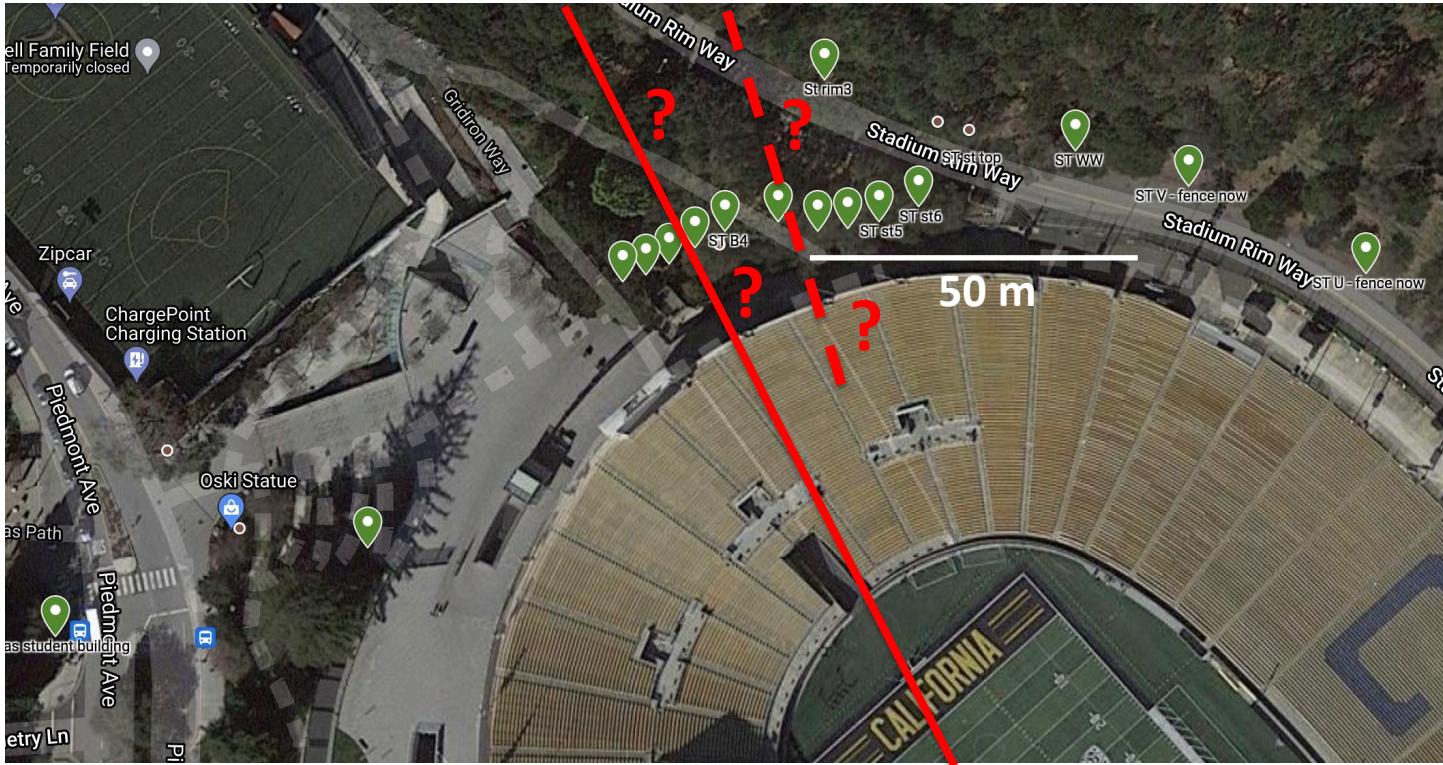
# Nodal sites near Cal Stadium

- Two sites (ST P & ST Q) inside the stadium



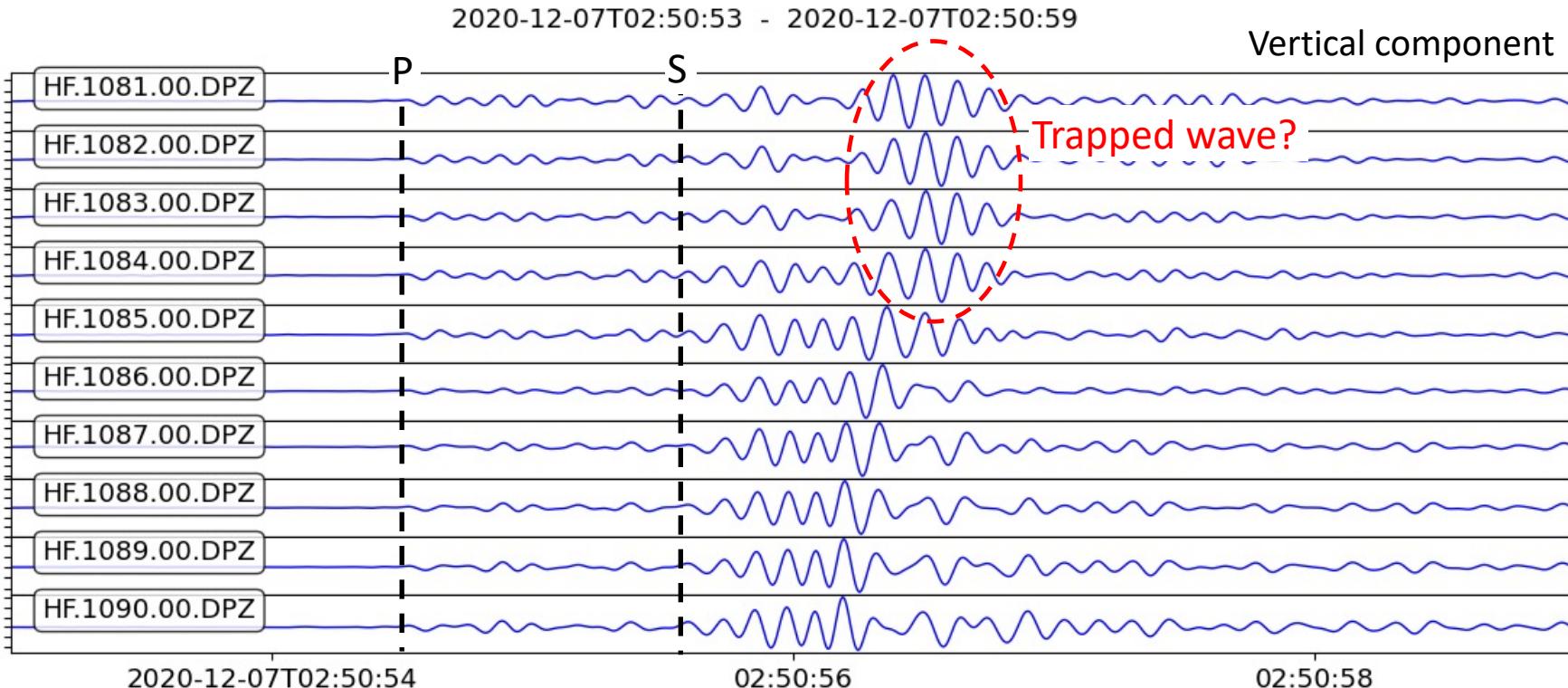
# HF (Short) Linear Array

- 10 sites with ~5 m spacing.
- Aim to observe fault-zone trapped waves to evaluate a fault width



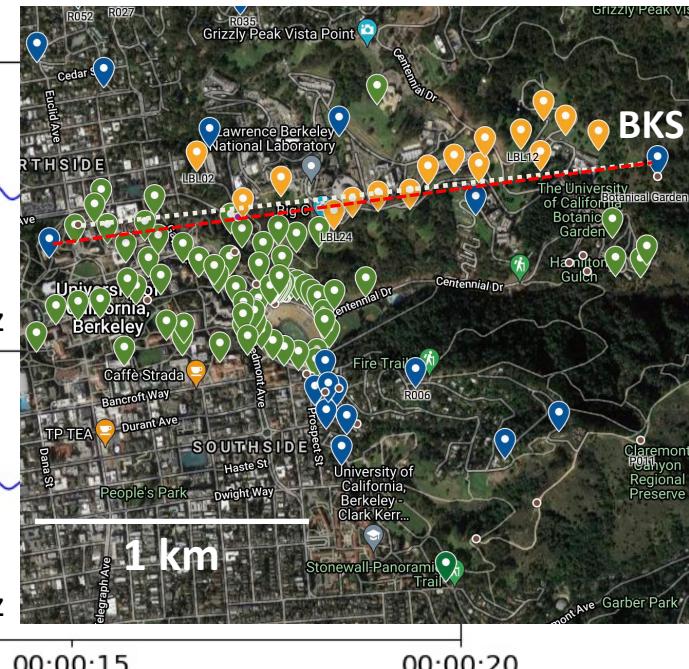
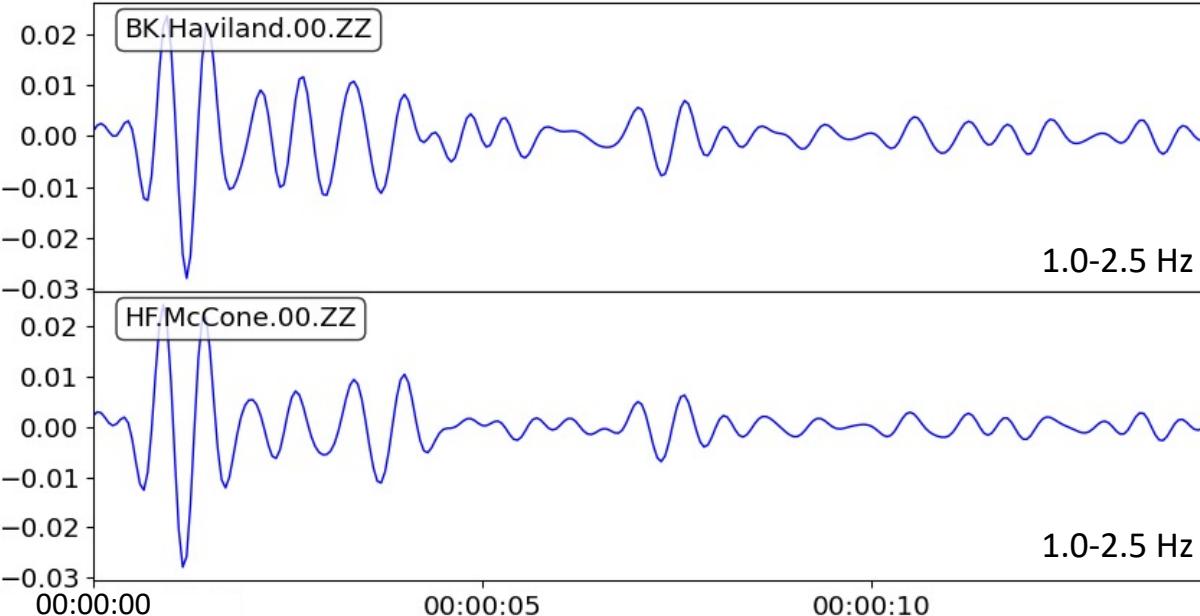
# HF (Short) Linear Array

- Local Berkeley EQ data (M1.8)
- A 1-10 Hz bandpass filter applied



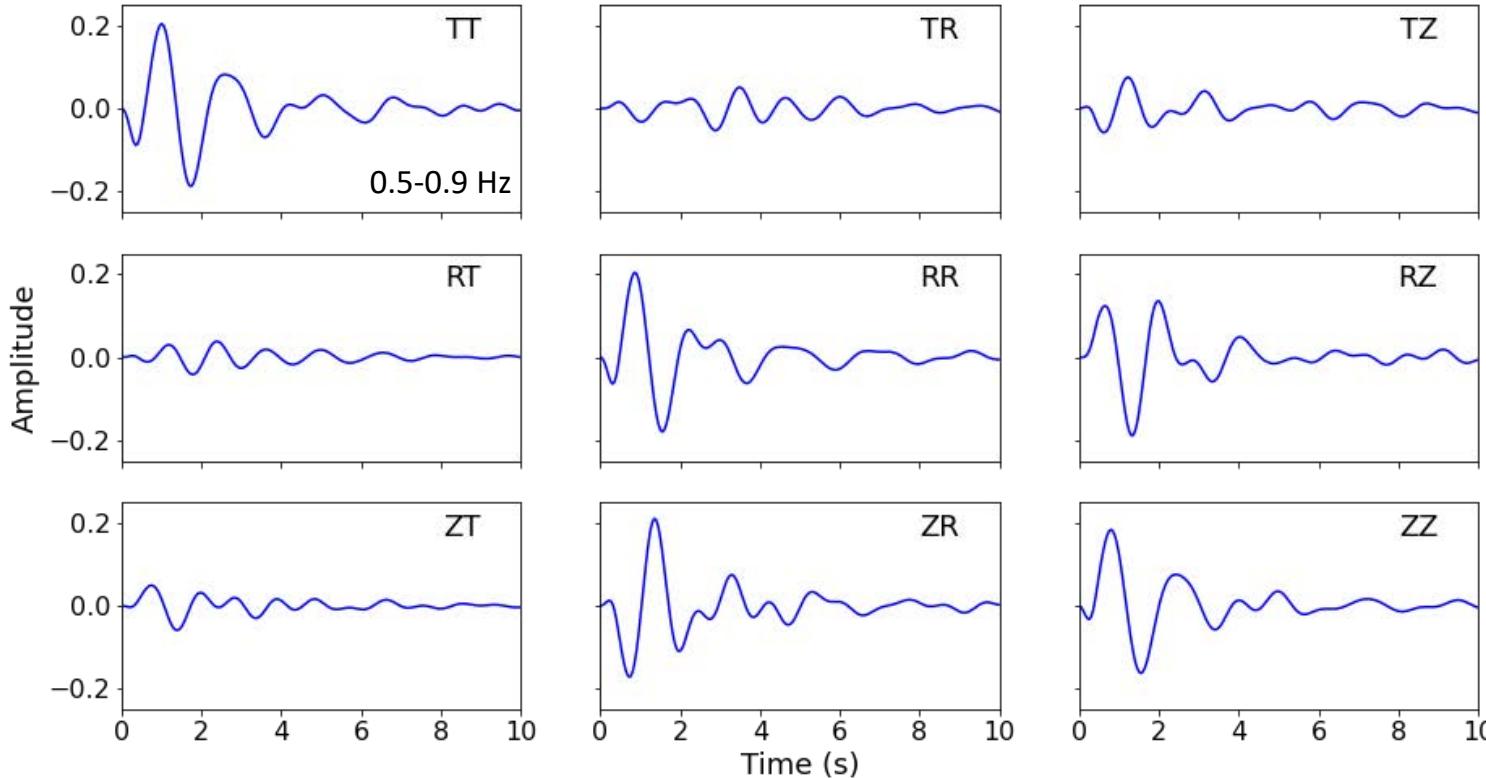
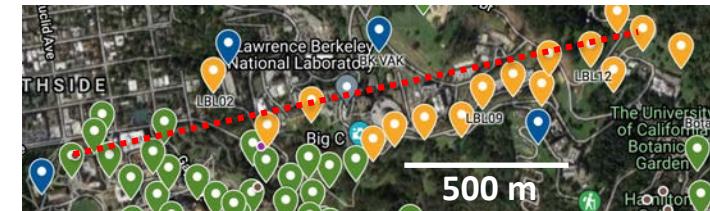
# Ambient Noise Cross-Correlation

- Extracting Rayleigh and Love waves by cross-correlating continuous seismic data (~30 days) between every pair of two stations
- Measuring surface wave group and phase-velocity dispersion curves
- Performing surface wave tomography



# Ambient Noise Cross-Correlation

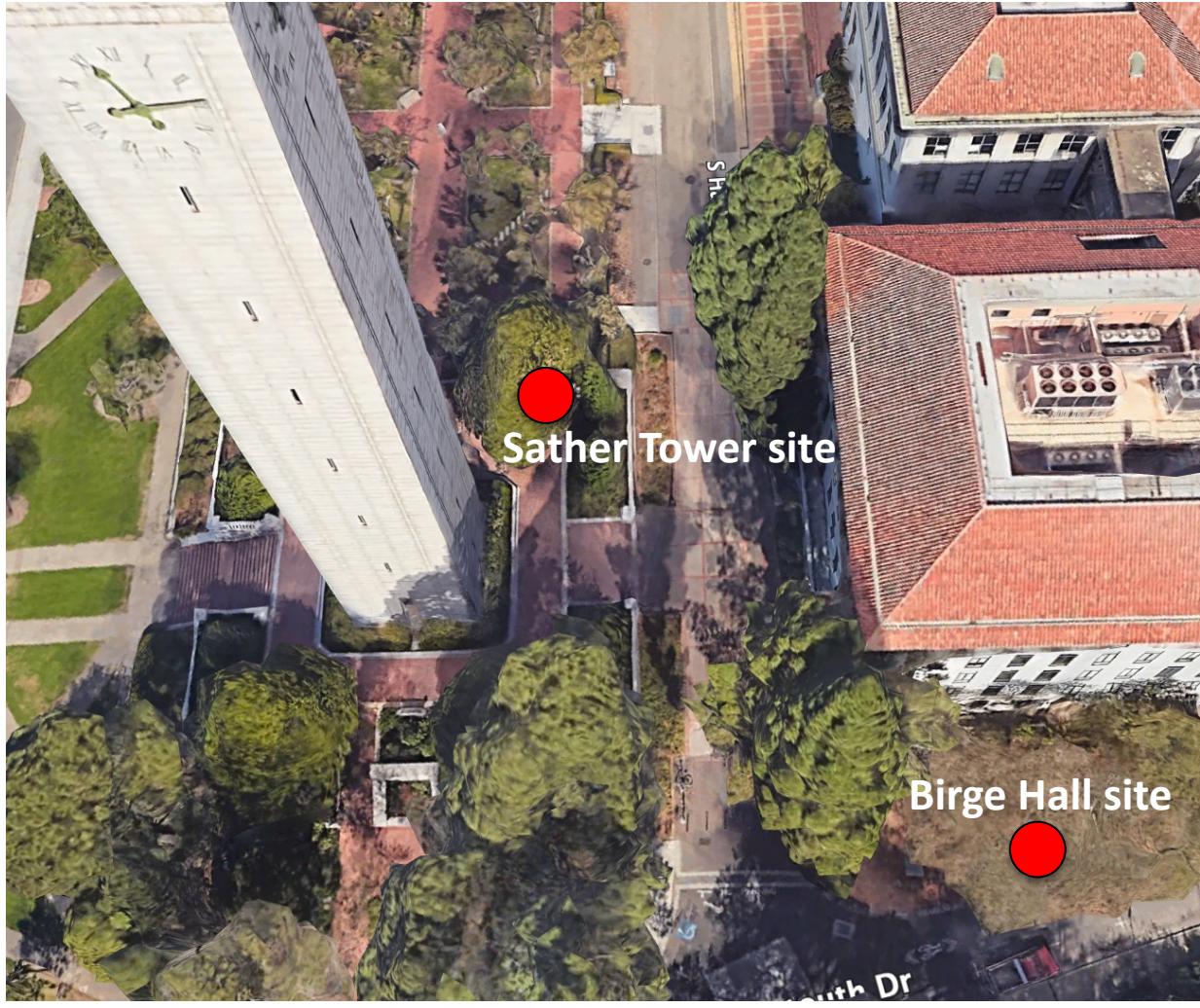
- Both Rayleigh and Love waves are extracted
- Evaluating H/V ratio



# Summary

- Successfully deployed ~170 sensors at UC Berkeley campus and neighborhood
  - All sensors returned
- Local and teleseismic EQs were recorded
- Ambient noise cross-correlation retrieved surface waves
- All data will be opened to everyone (by late this year)
  - Improve the USGS SFBA velocity model

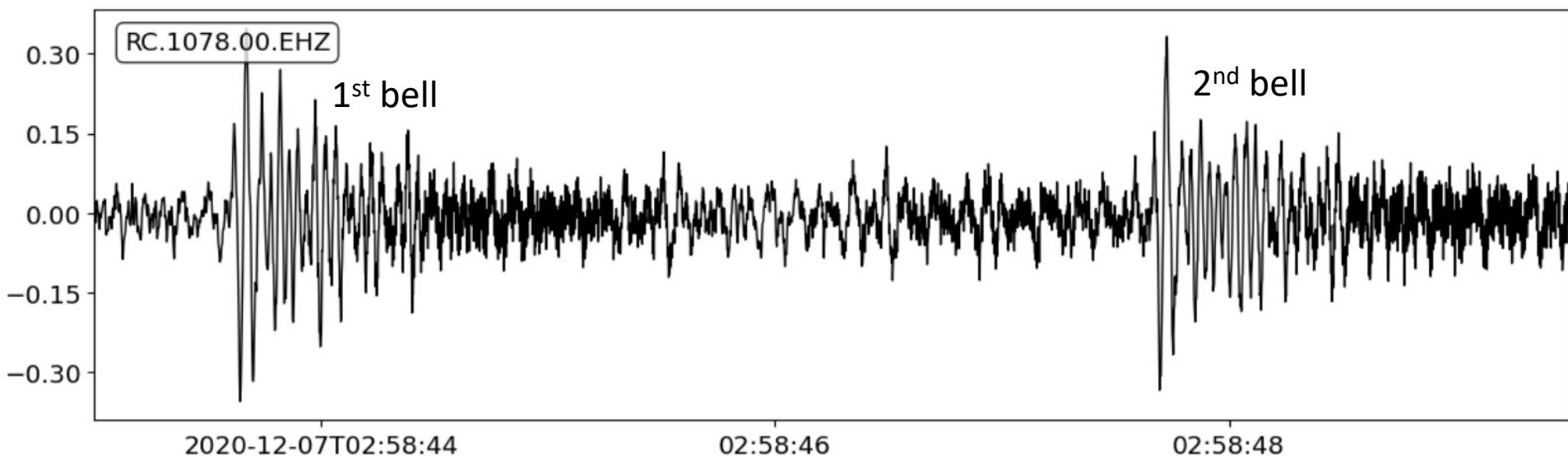
# Sather Tower



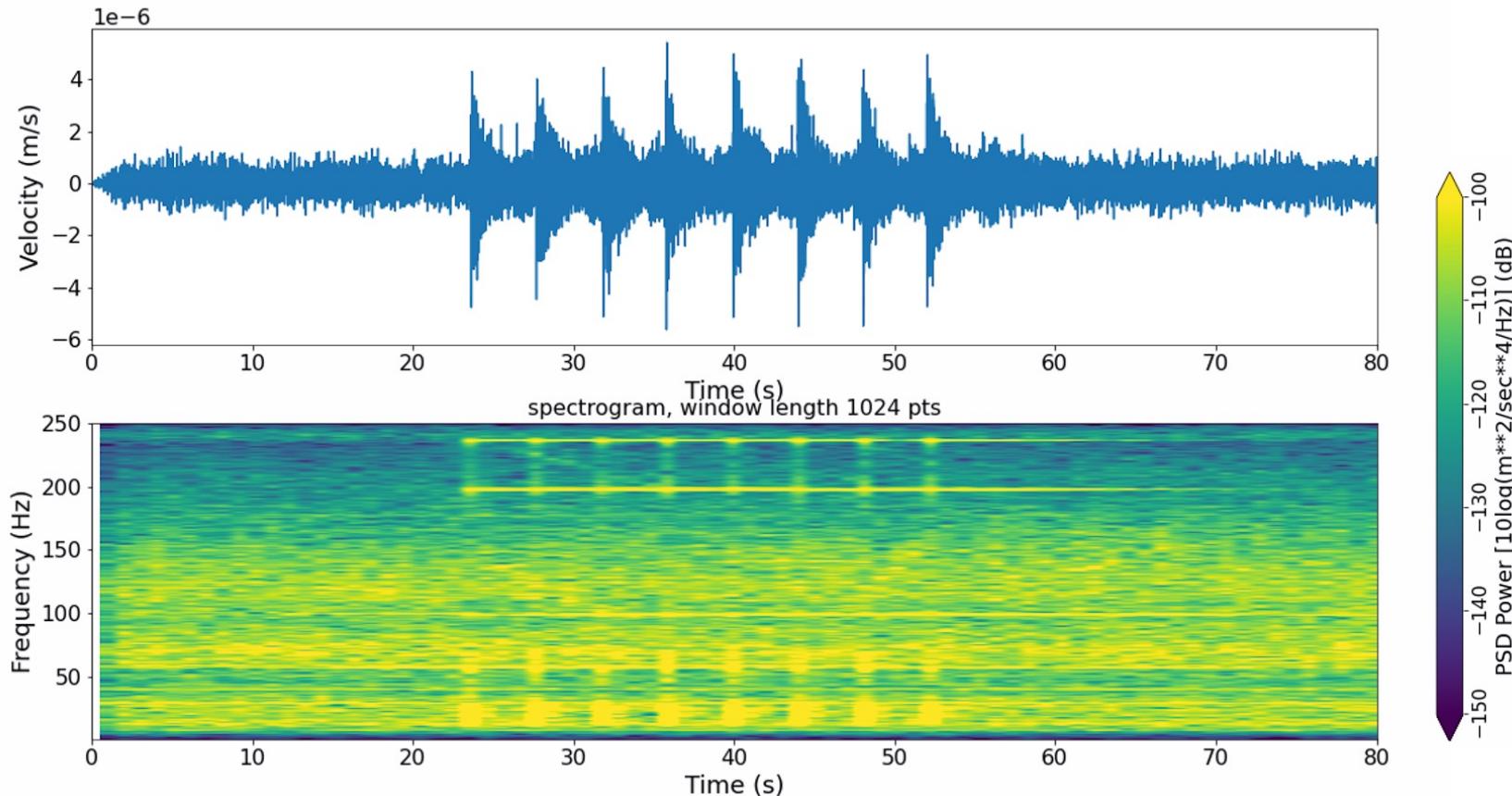
# Sather Tower “Bells” as Repeatable Sources?

- How similar each “bell” vibration? Correlation?
- How far we can see signals? Stacking?

2020-12-07T02:58:43.003648 - 2020-12-07T02:58:49.503648

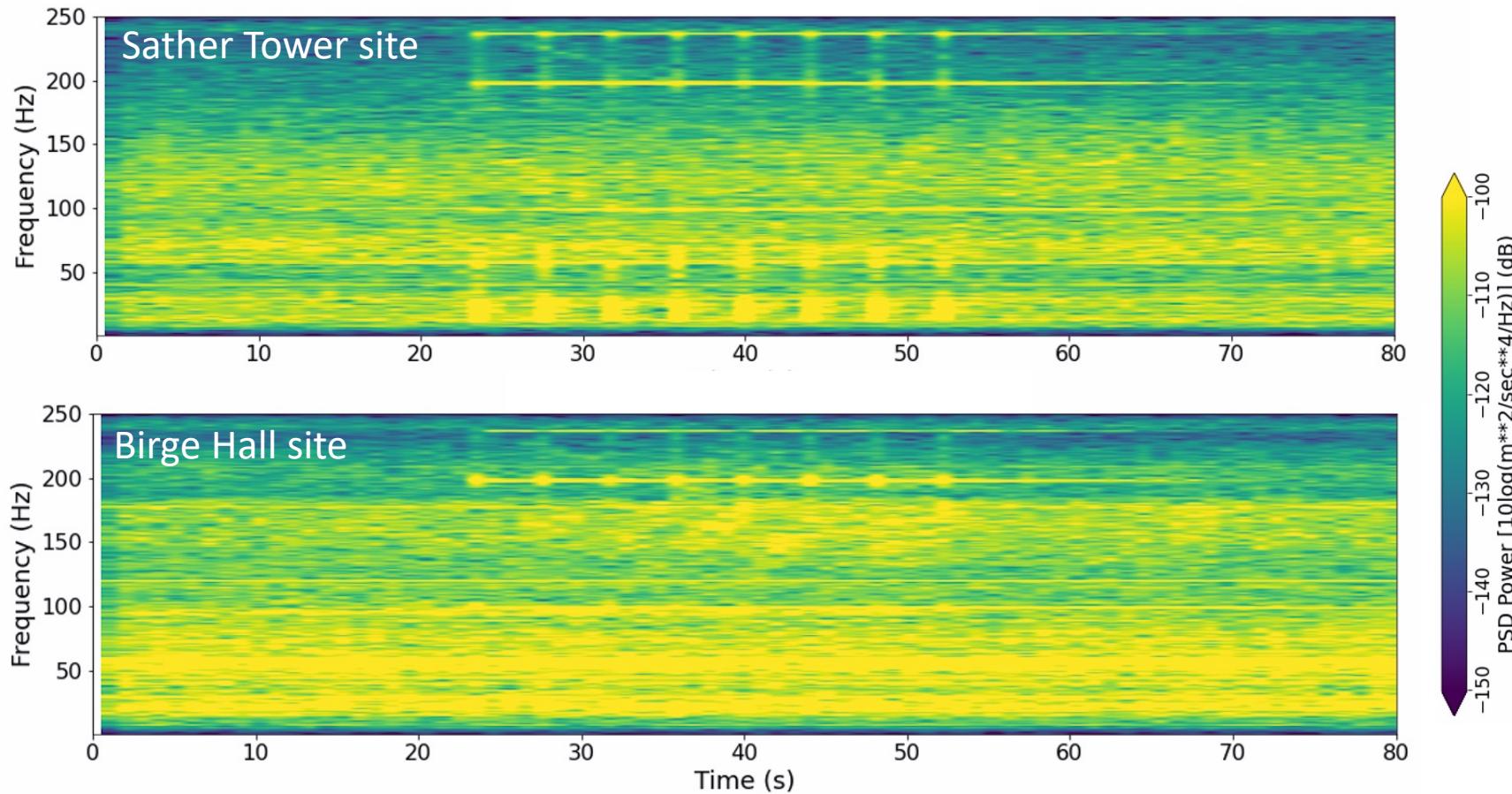


# Ground Vibrations by Sather Tower Bell



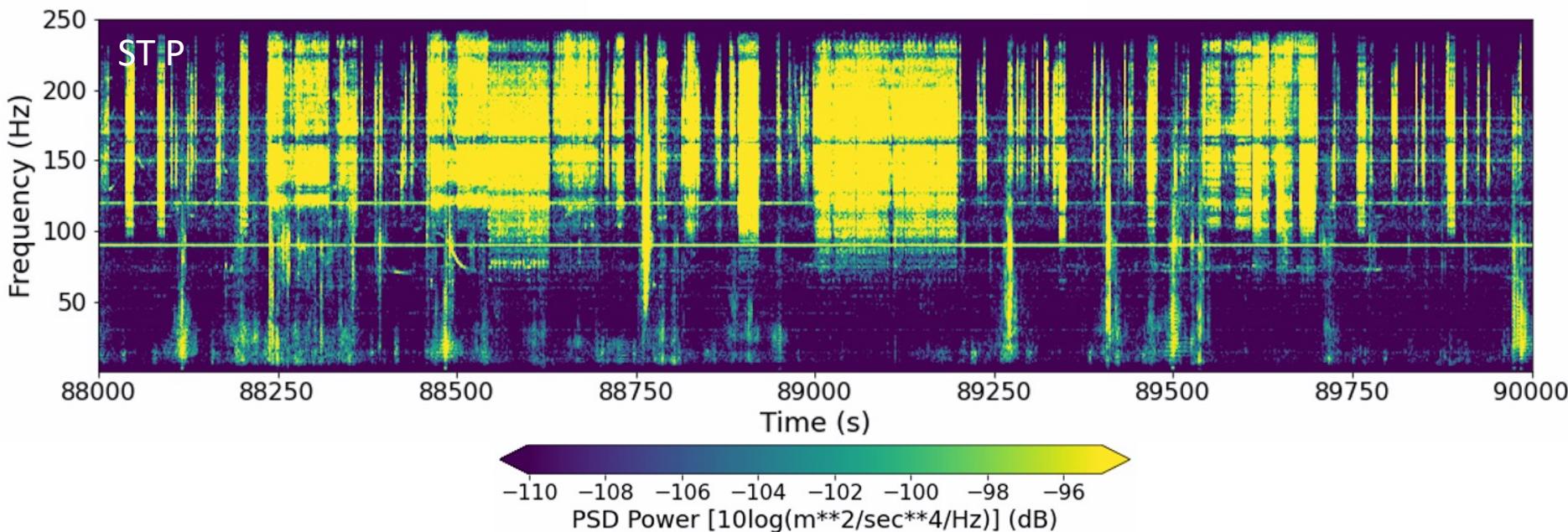
- Previous work: Díaz et al. (2020, J. Seismo.) – European church bells

# Sather Tower & Birge Hall (~45m)



# Cal vs U. Oregon (Dec 5, 2020, local time)

- Cal beats U. Oregon for first win!
  - No audiences -> "noise" directly related to players?
  - High-frequency noise (>100 Hz)



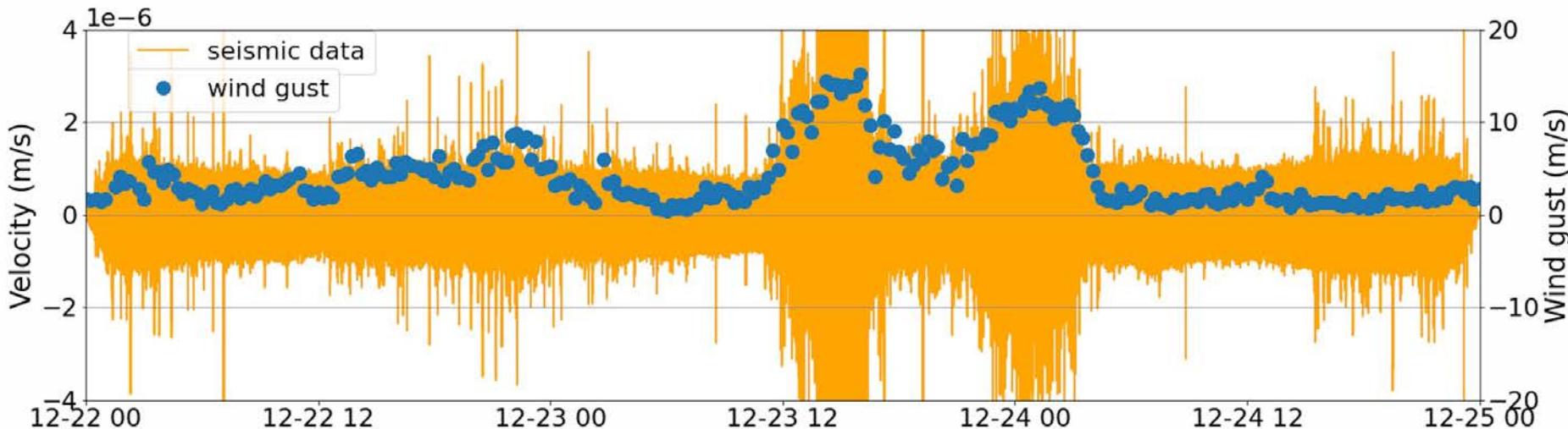
# Berkeley Hills

- Large numbers of high wind events at Berkeley hills
- Installed one sensor at a slope of Berkeley hills (Lawrence Hall of Science)



# Wind (storm) Induced Noise?

- Two bursts of wind on Dec 23 & 24



- Previous work: Johnson et al. (2019, JGR) – Nodal experiment in S. California

# Wind (storm) Induced Noise?

- High-frequency signals (>50 Hz)

