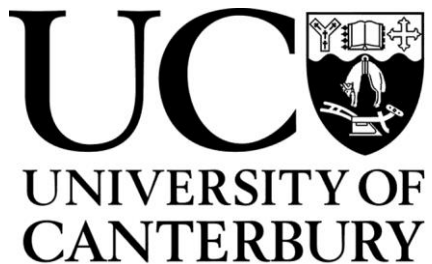# Future Steps for Validation of Site Response with Soil Heterogeneity and Wave Scattering

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28 November, 2019

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QuakeCoRE
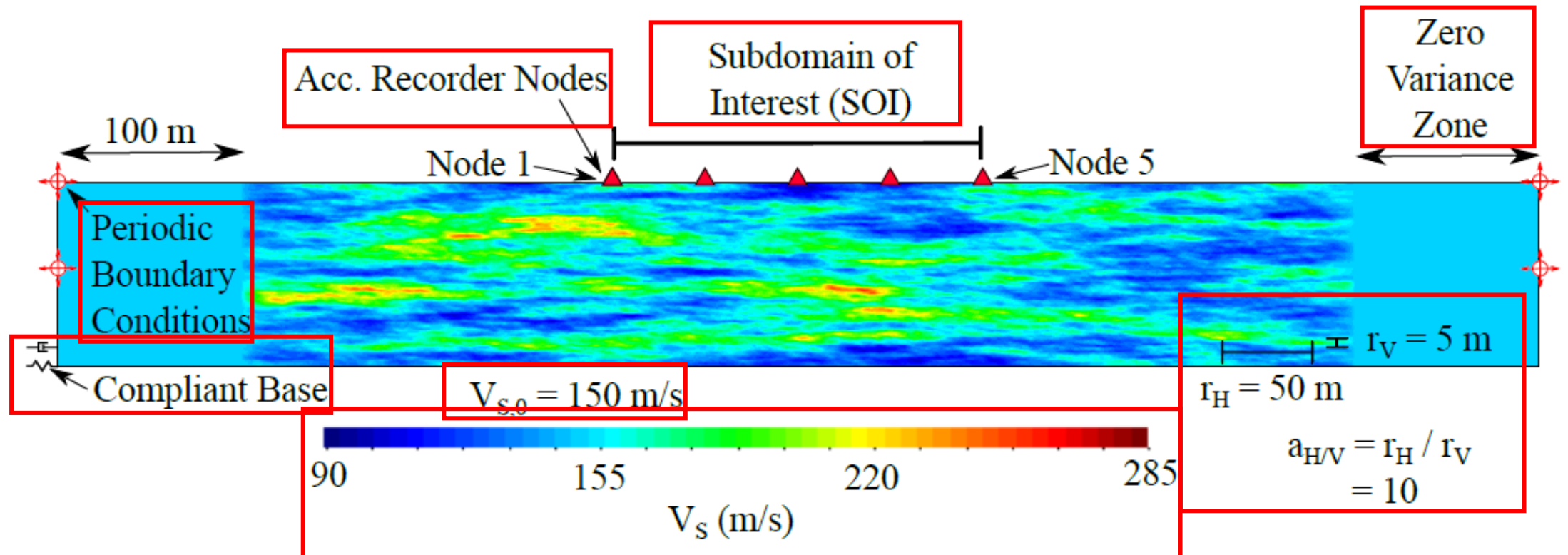NZ Centre for Earthquake Resilience

Outline

- Quick recap
  - Method
  - Work completed to date

- Present new results
  - Comparison with 1D equivalent viscous damping method

- Future steps for validation
  - Vertical array database

Site Response Methodology

- Site response in OpenSees (SP)
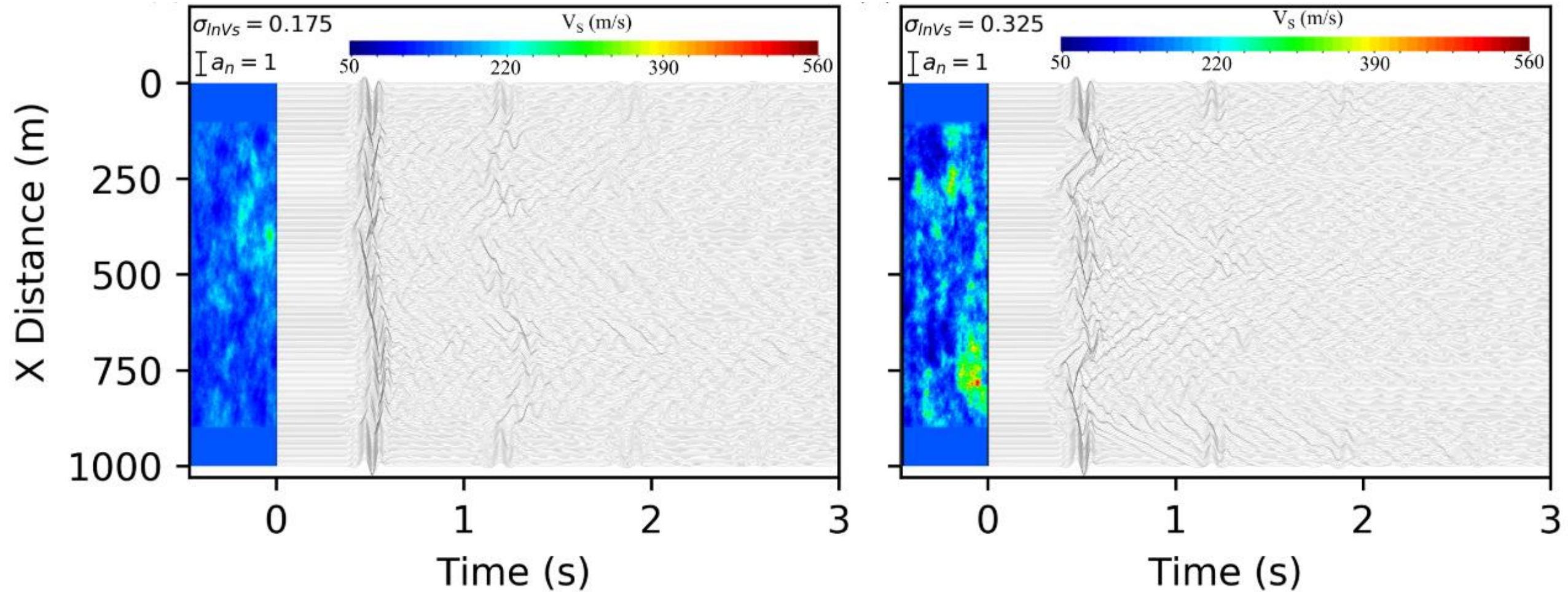 - HPC - Supercomputing
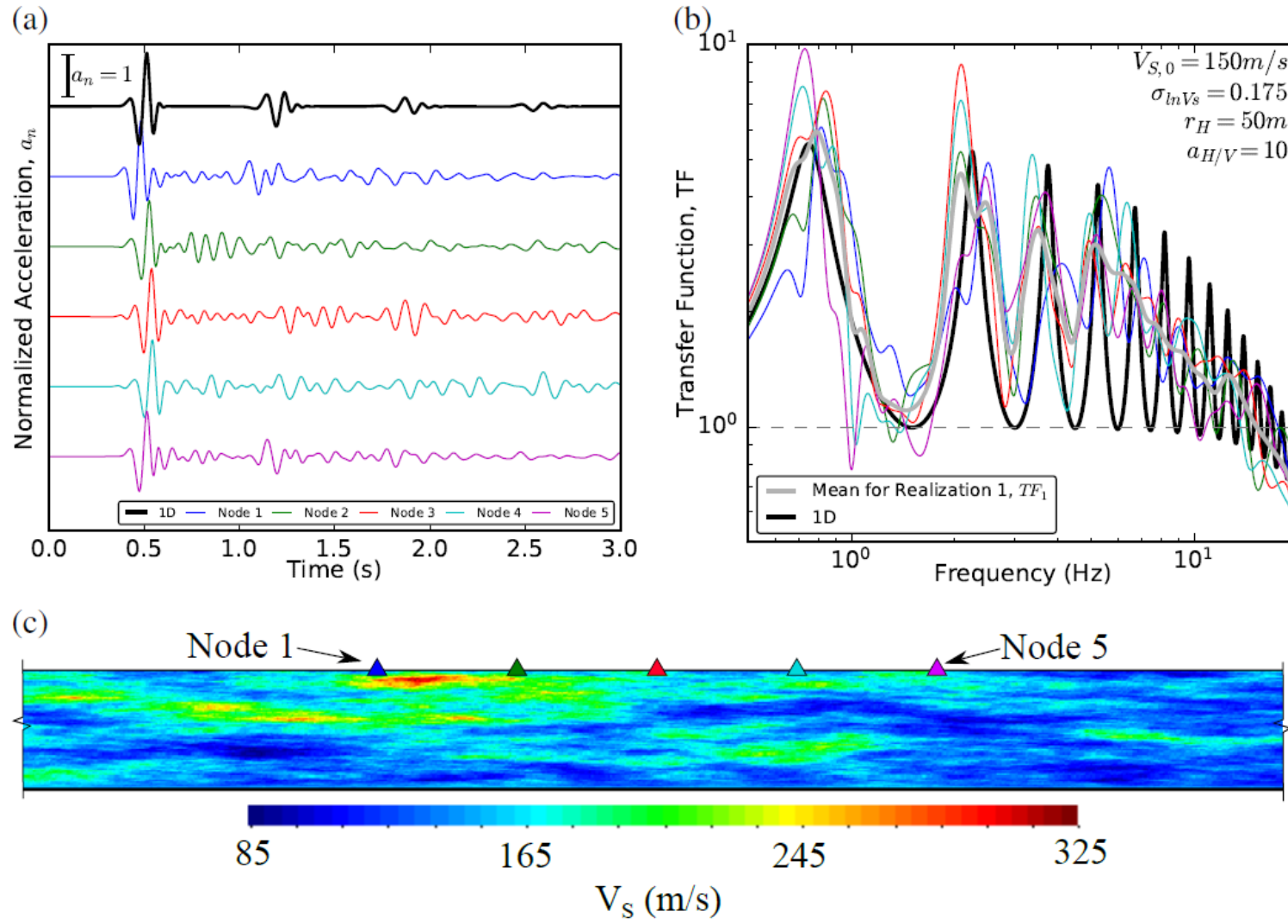
- Viscoelastic soil model

Parametric Study

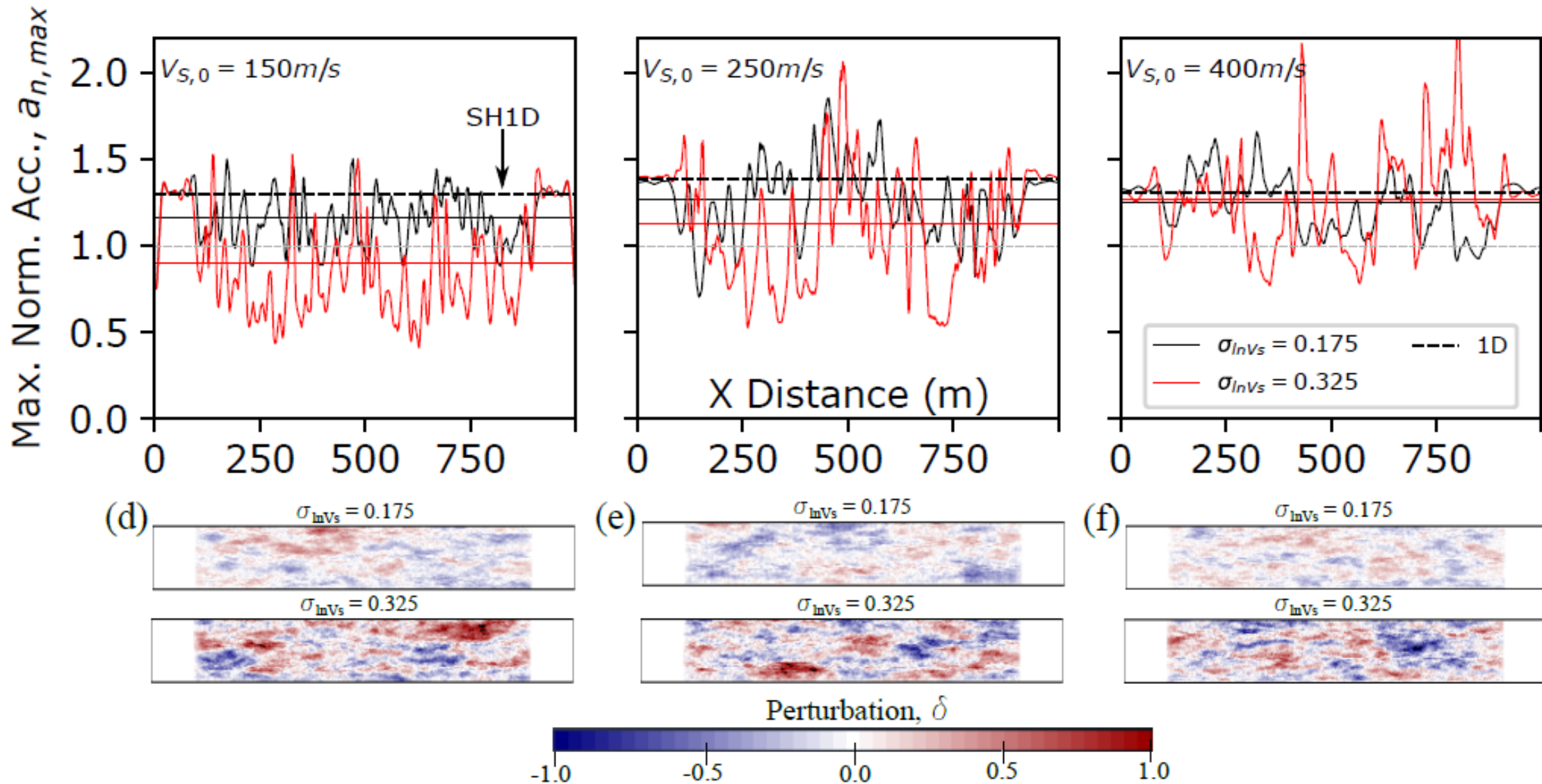| Parameter Name	Symbol	Values used in Sensitivity Analysis
Median Shear Wave Velocity	$V_{S,0}$	150, 250, 400 m/s
Standard Deviation of ln(V_S)	σ_{lnVs}	0.10, 0.175, 0.25, 0.325
Horizontal Correlation Length	r_H	5, 25, 50, 75, 100 m
Anisotropy Factor	$a_{H/V}$	1, 5, 10, 20

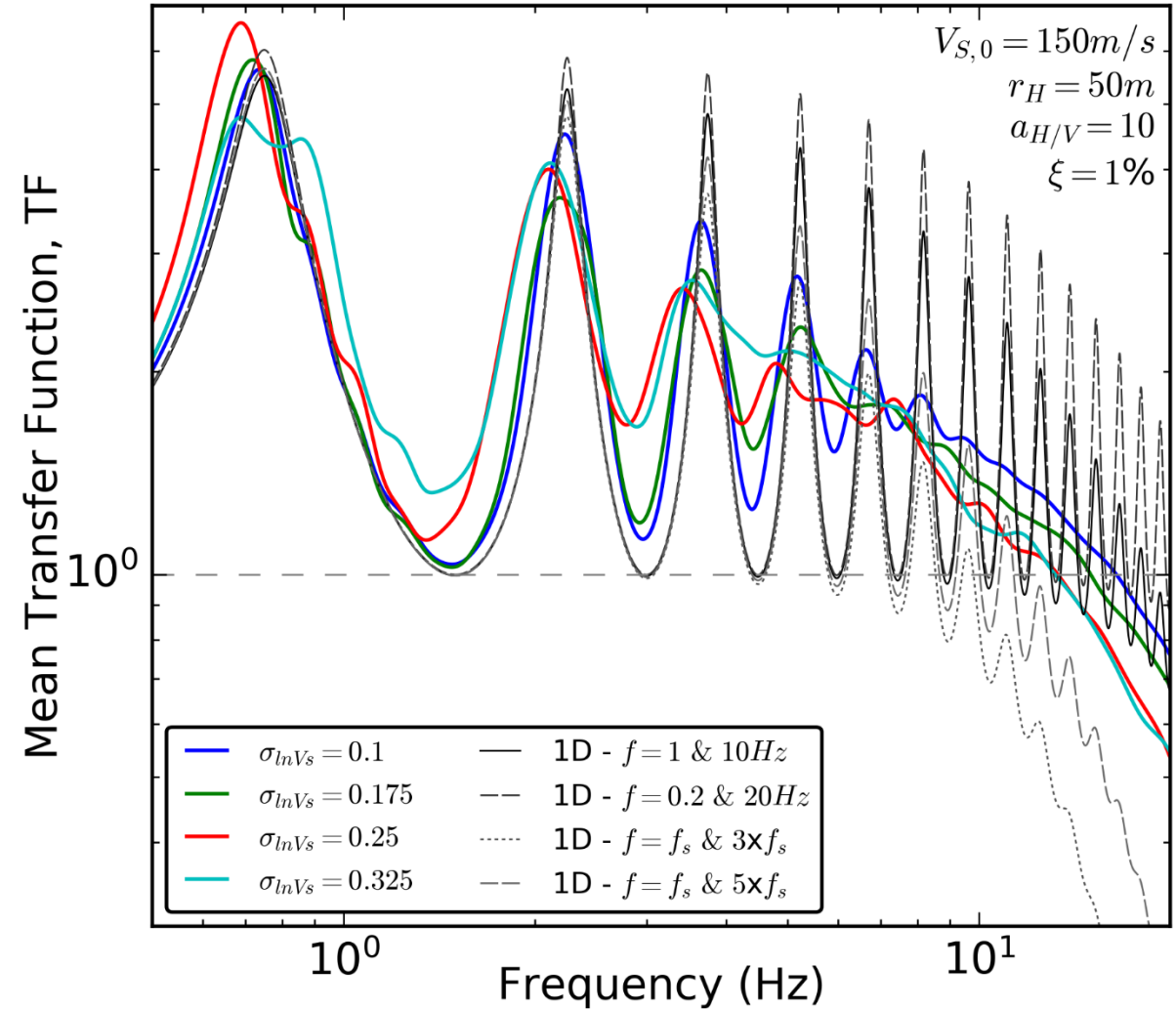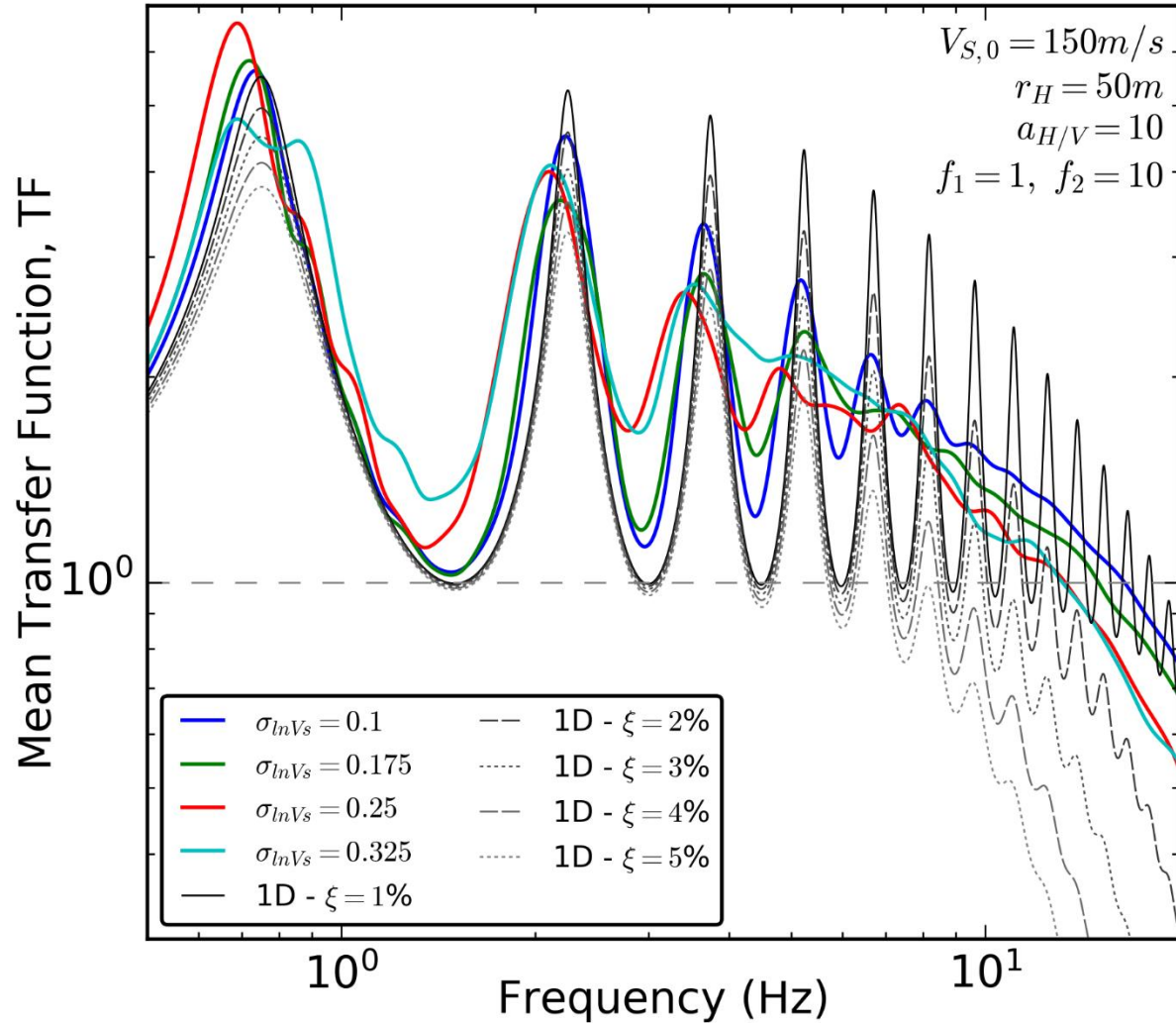x 10 realisations/permutation = 2,400 analyses

Wave Scattering in 2D models

Nodal Variability from Wave Scattering

(a)

(b) $V_{S,0} = 150 m/s$, $\sigma_{lnVs} = 0.175$, $r_H = 50m$, $a_{H/V} = 10$

Mean for Realization 1, TF_1
1D

(c) Node 1 → ... ← Node 5

V_S (m/s)

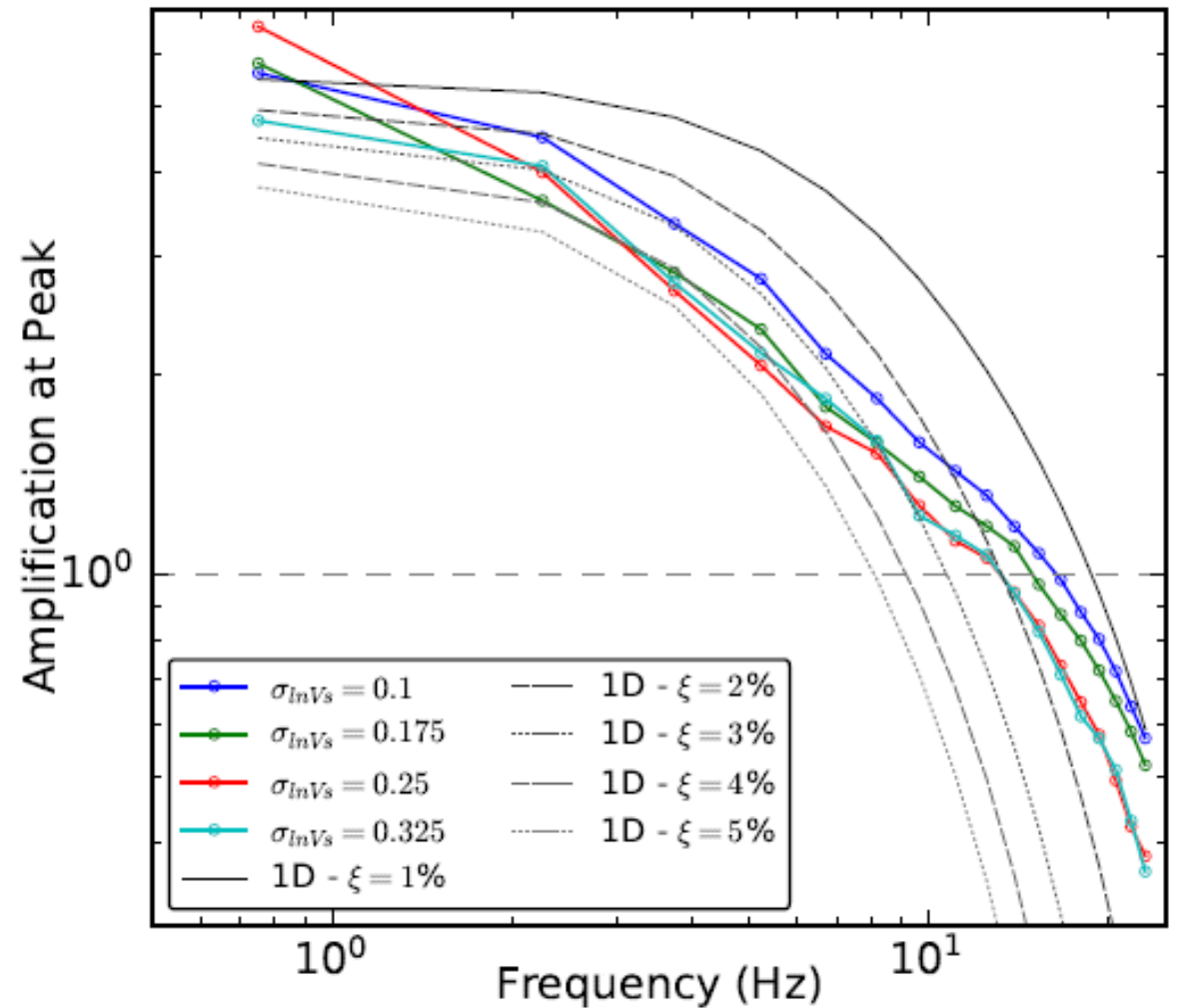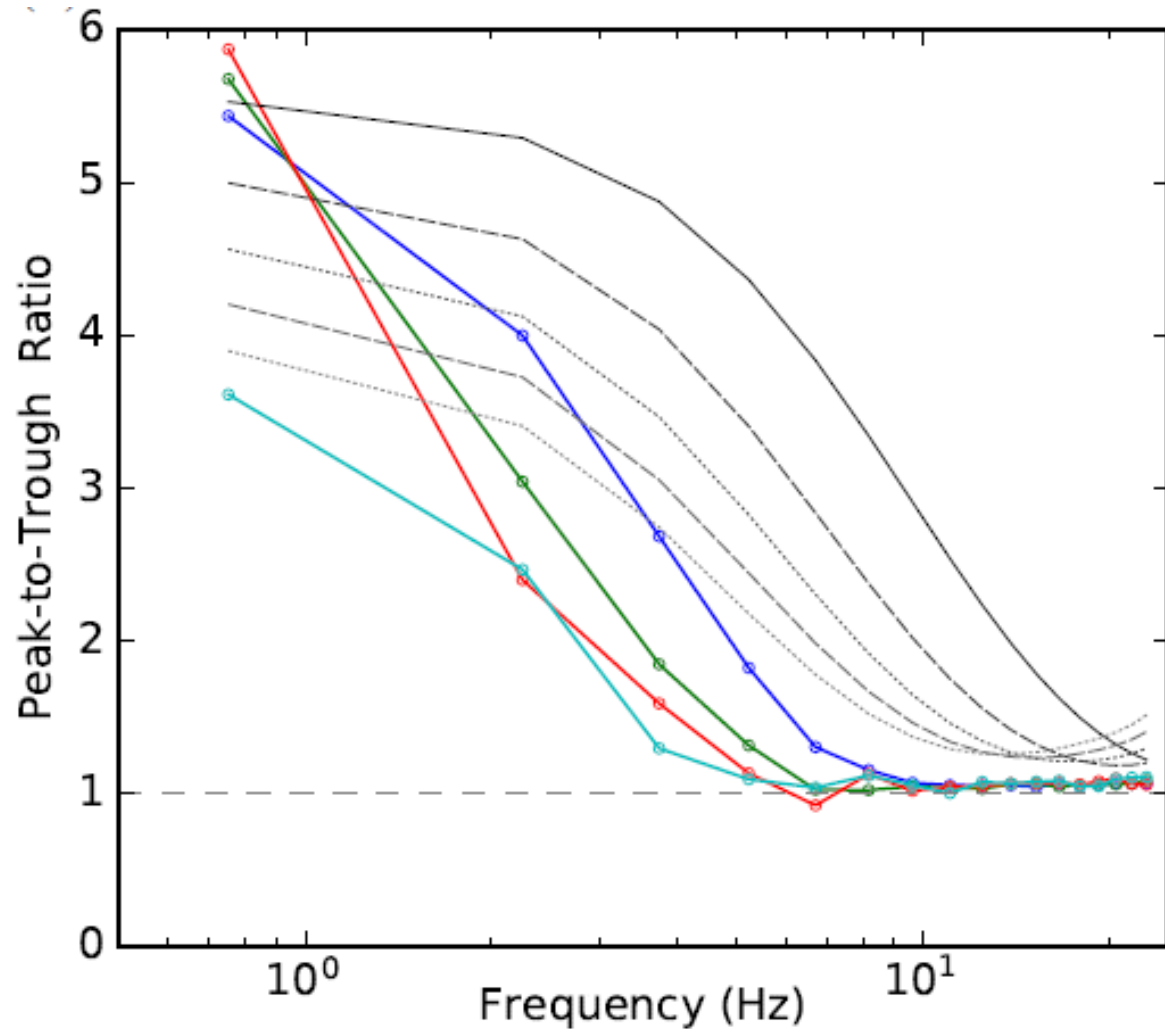# Variability in Peak Ground Accelerations

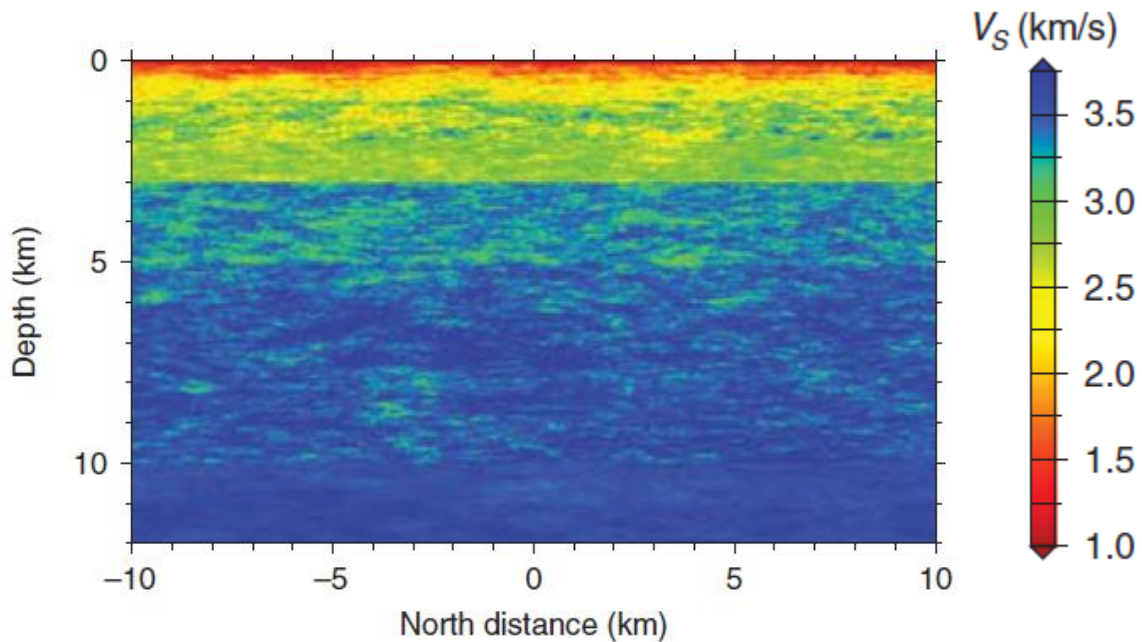# Comparison with Equivalent Viscous Damping

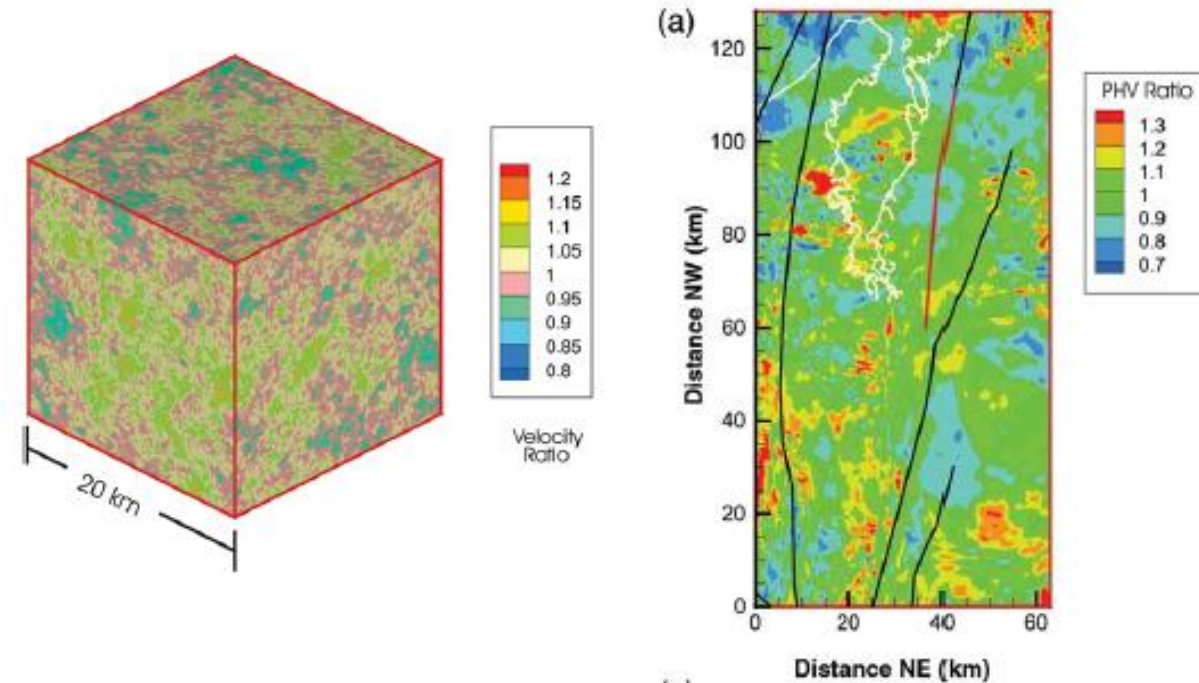# Can Viscous Damping Replicate Scattering Attenuation?

Modelling Soil Heterogeneity on a Larger Scale

- Work by other in context of GM Sim

Graves and Pitarka 2016

Hartzell et al. 2010

# Next Step: Validate with Vertical Arrays

|	KiK-Net (Thompson et al. 2012)	California (Afshari and Stewart 2019)
Num. Sites	104	21
Num. Records	3,714	287
Median V_{S30}	413 m/s	321 m/s
Geologic Setting	Mountainous	Flat River Basins
Within-Site Variability, σ_{ln}	Higher on Average	Lower on Average
Goodness of Fit (w/ 1D Theory)	Lower on Average	Higher on Average
V_S Data Quality	Lower Resolution and Quality	Higher Resolution and Quality

KiK-Net versus California

(from Afshari and Stewart 2019)
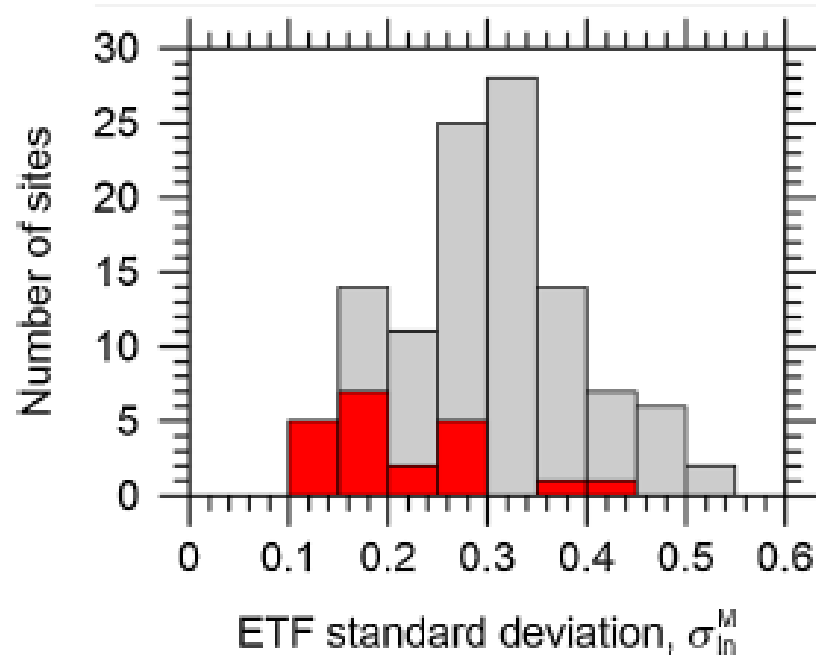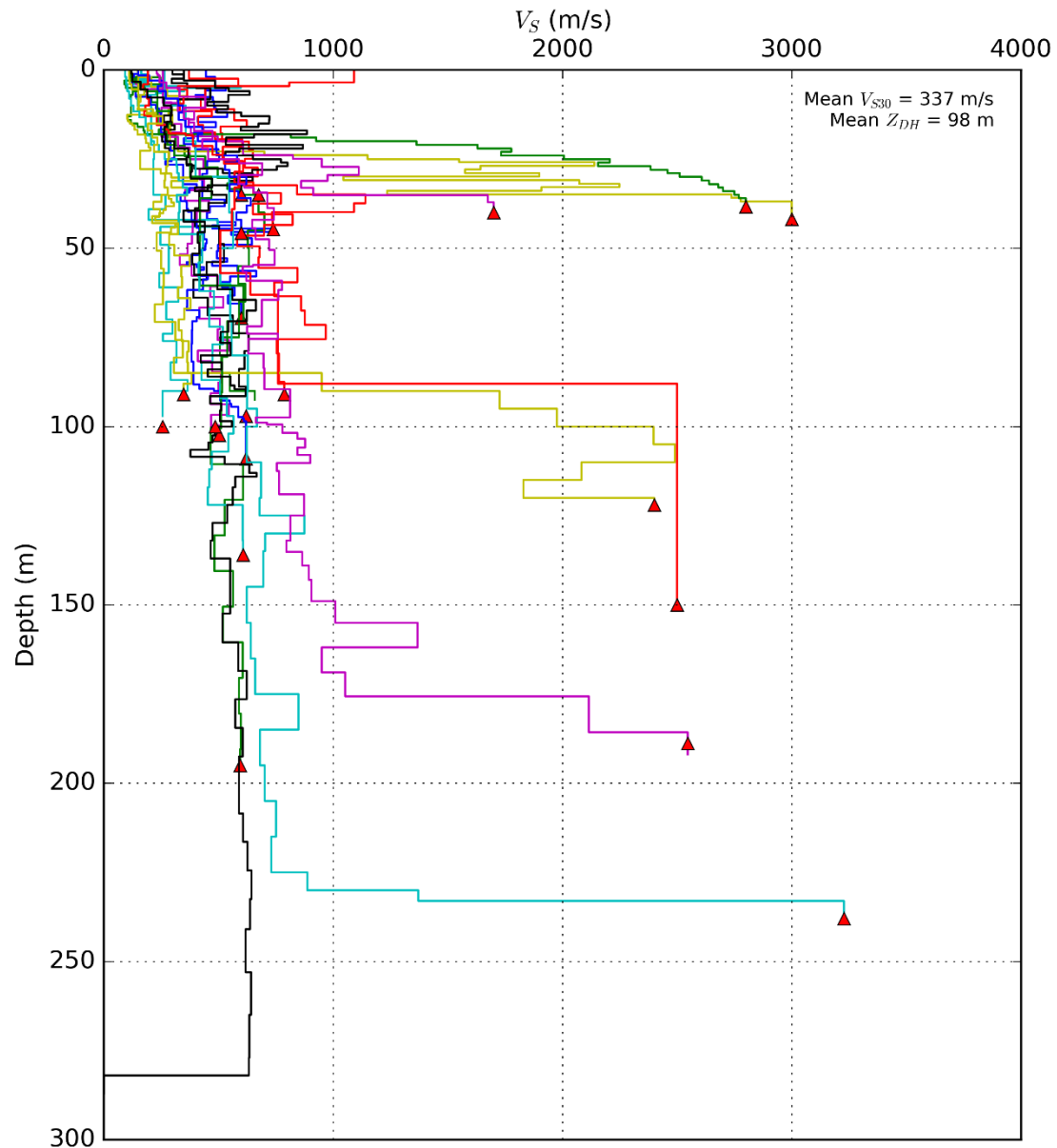

Afshari and Stewart 2019
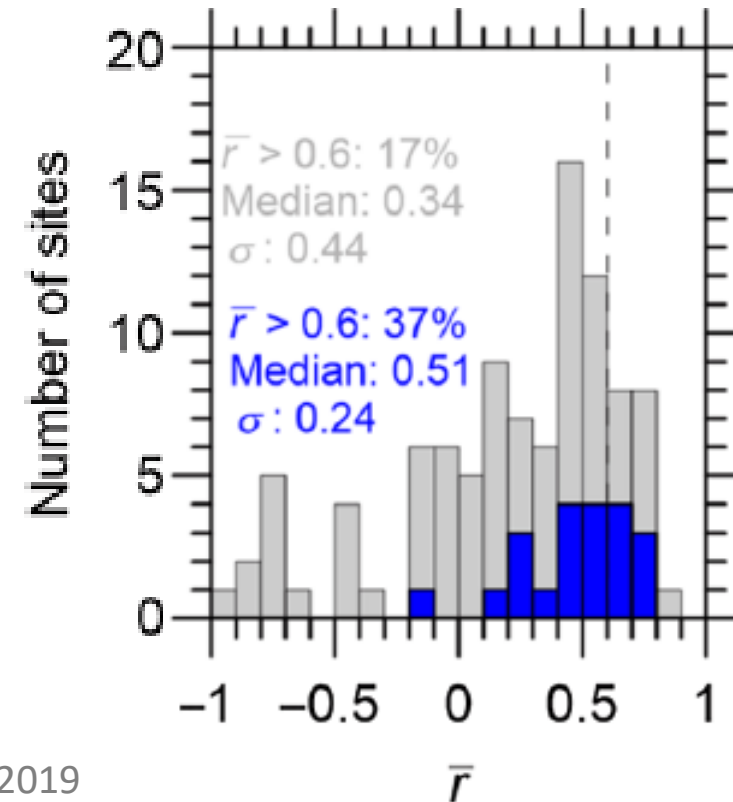
21 California Vertical Arrays

Mean V_{S30} = 337 m/s
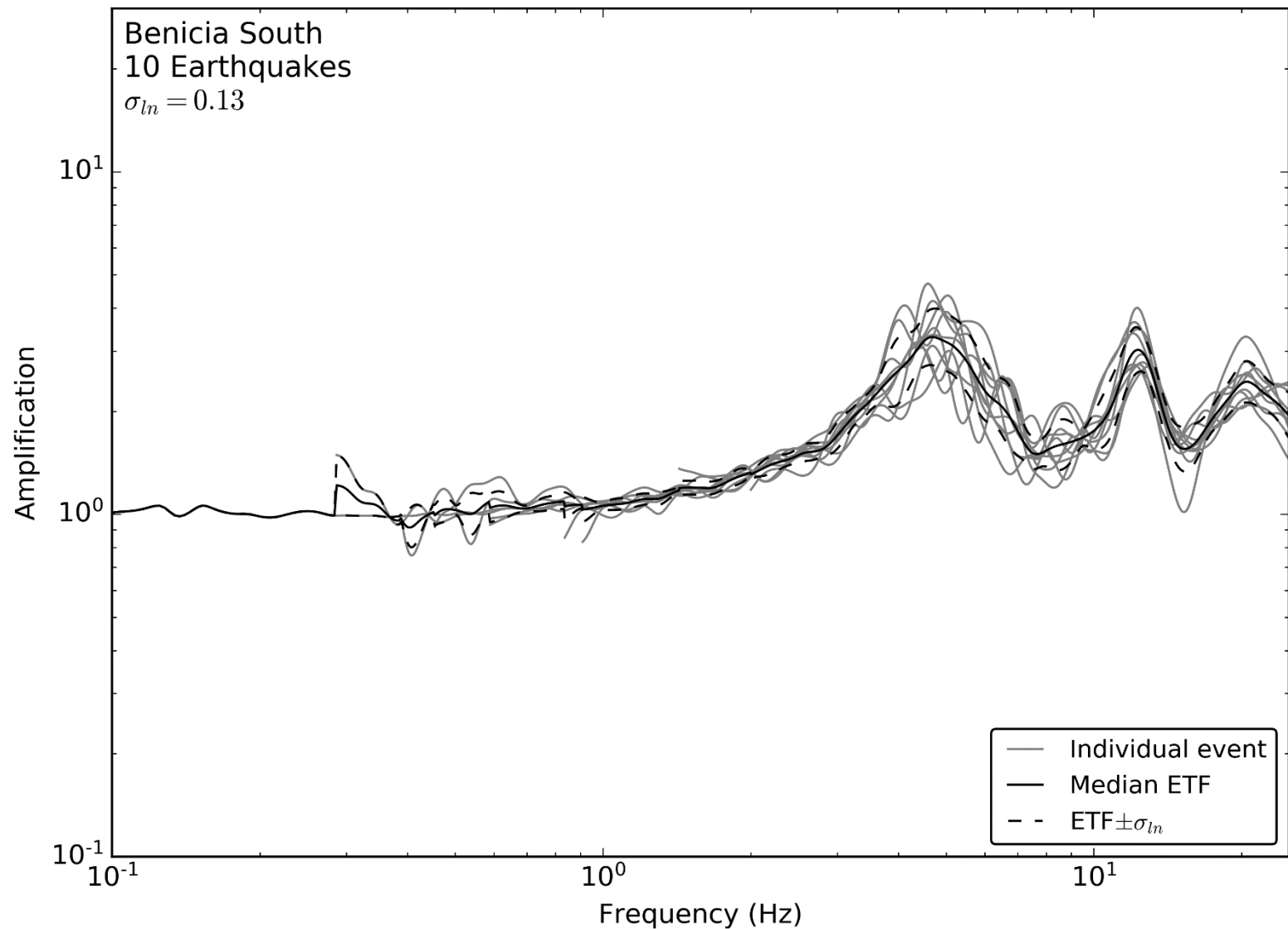Mean Z_{DH} = 98 m

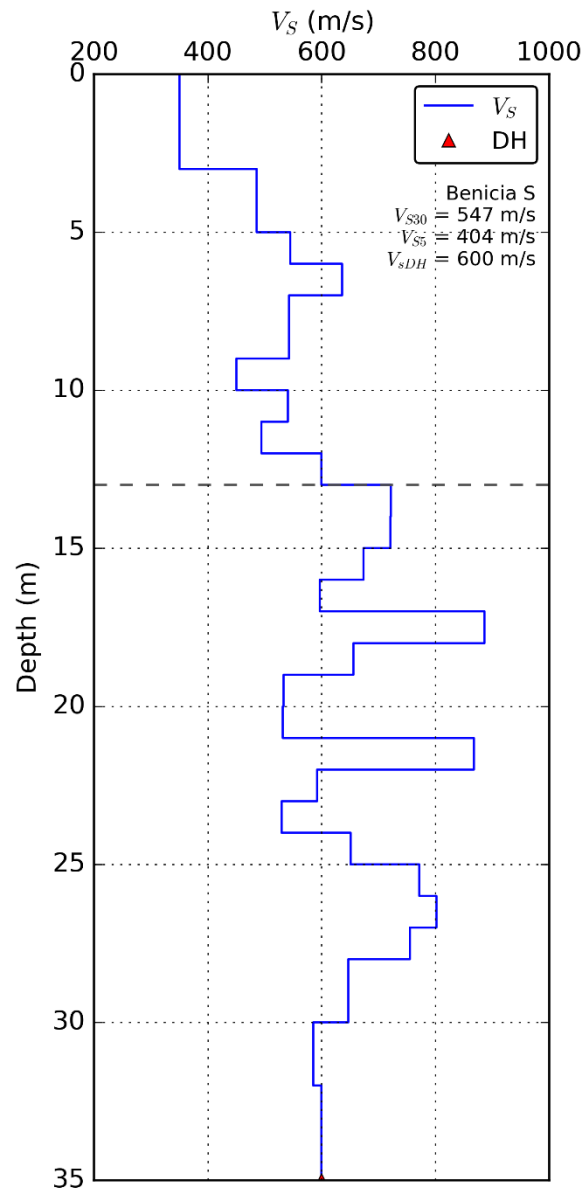## 5 Sites Identified as "Best" for 1D GRA

(Afshari and Stewart 2019)

- Low Within-Event Variability
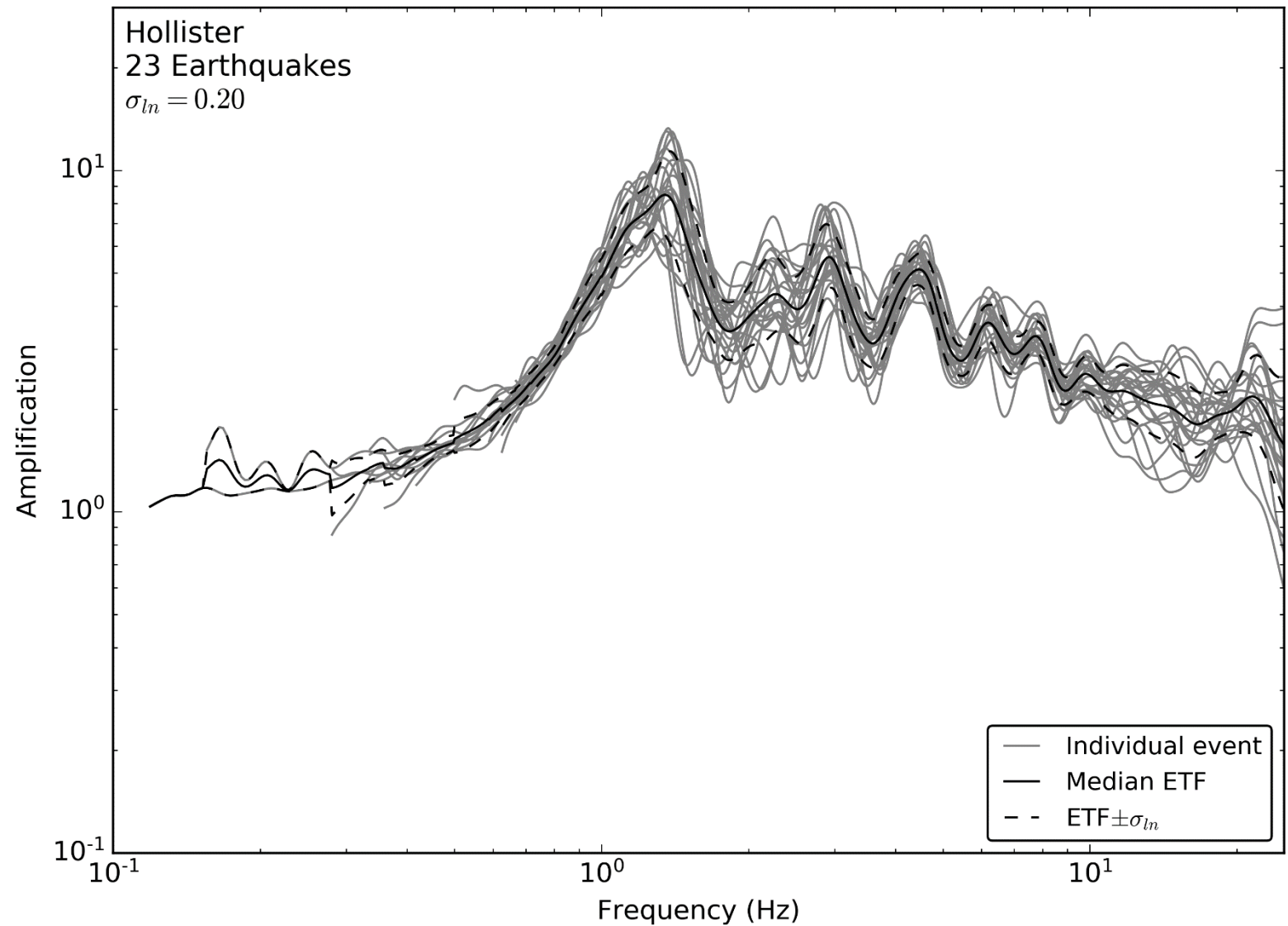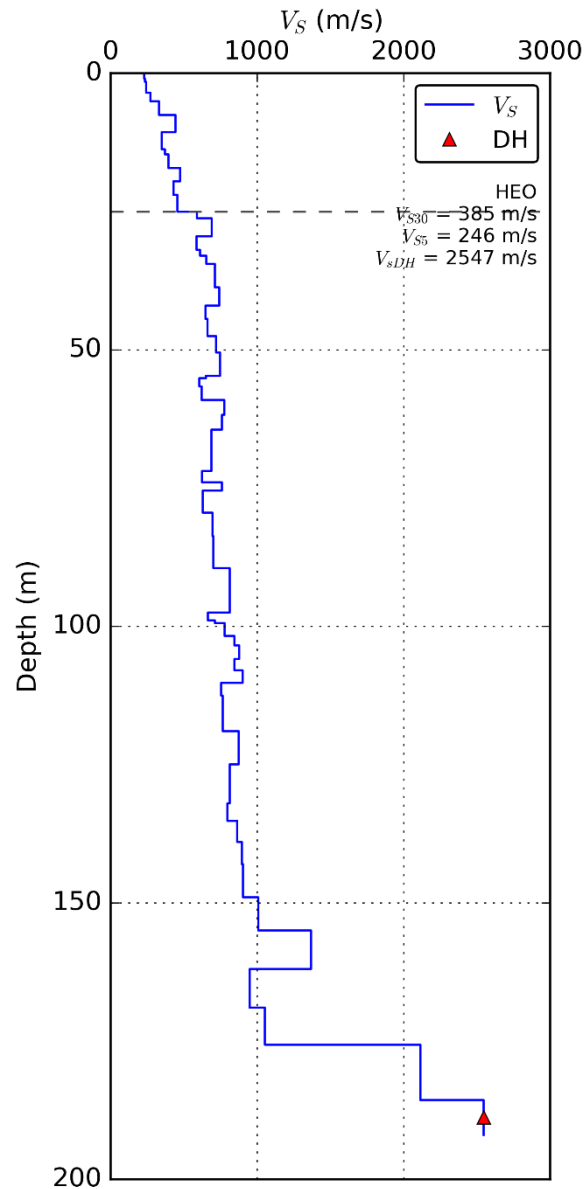- High Goodness of Fit

- Benicia-Martinez Bridge (South)
- Hollister Digital Array
- Eureka
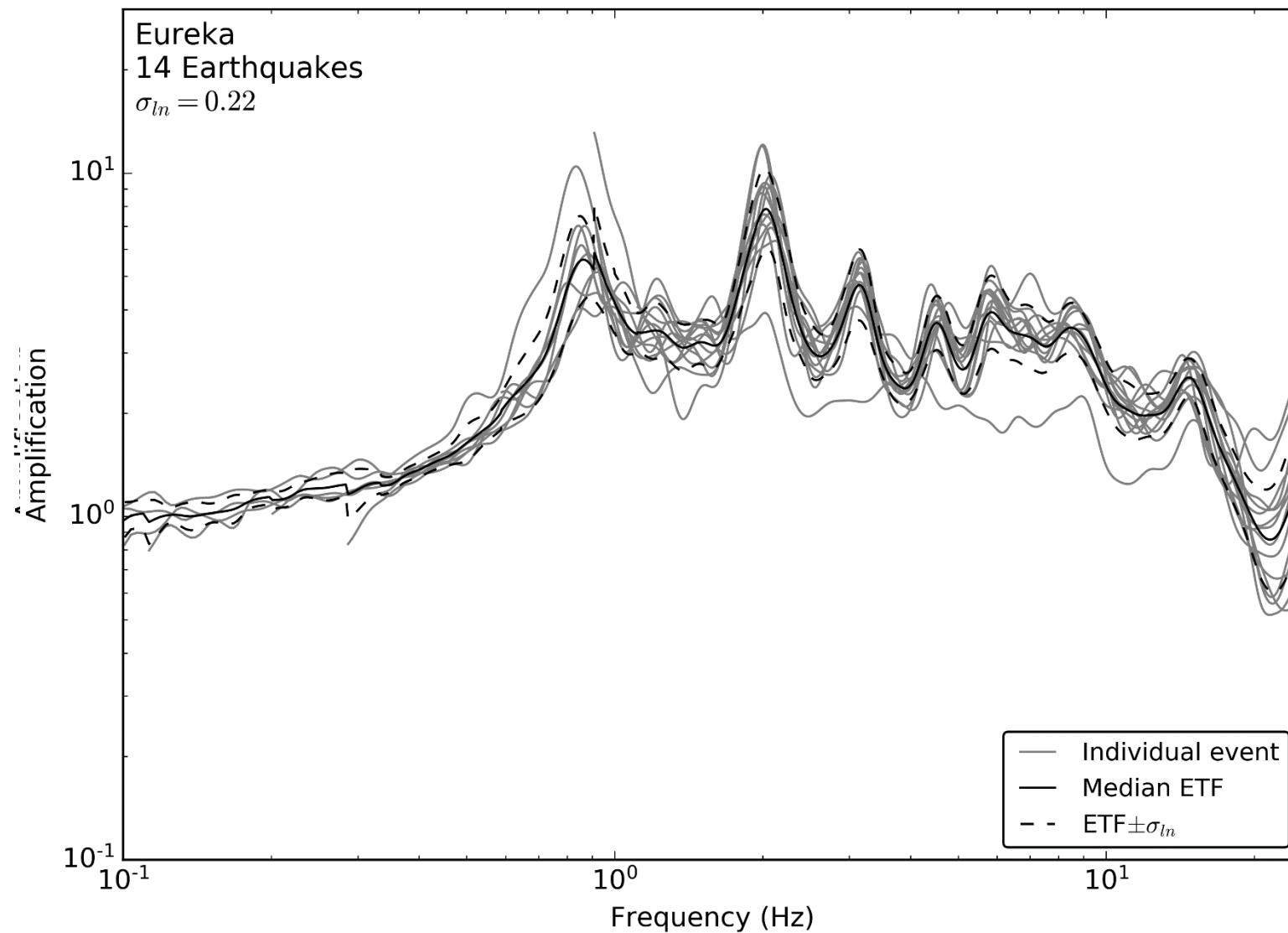- Treasure Island
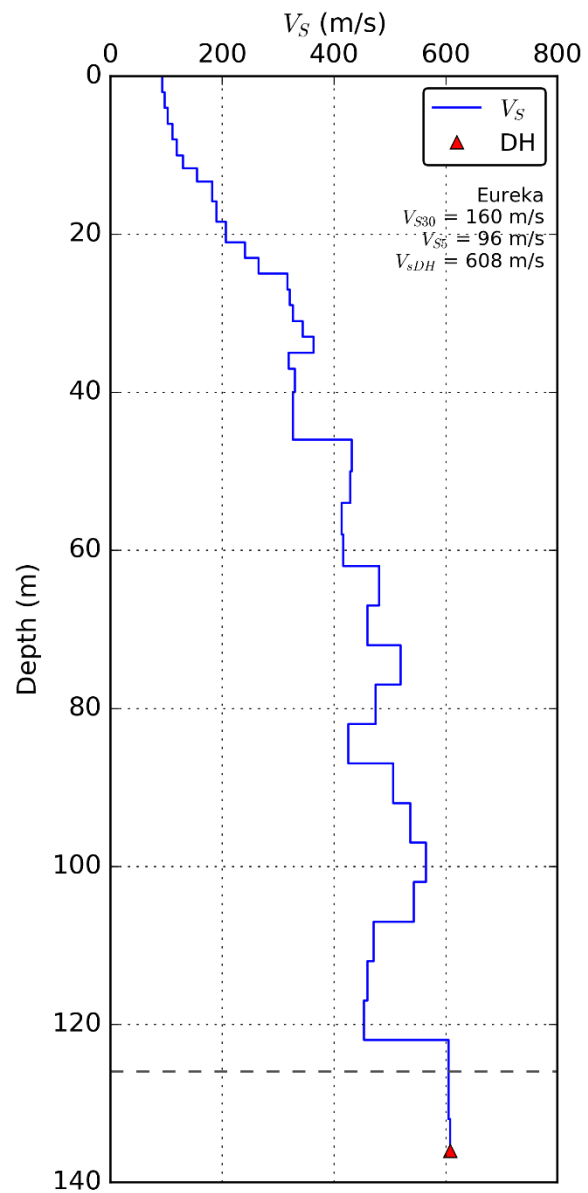- Wildlife Liquefaction Array

- 79 DH/Surface Pairs

Benicia-Martinez Bridge (South)
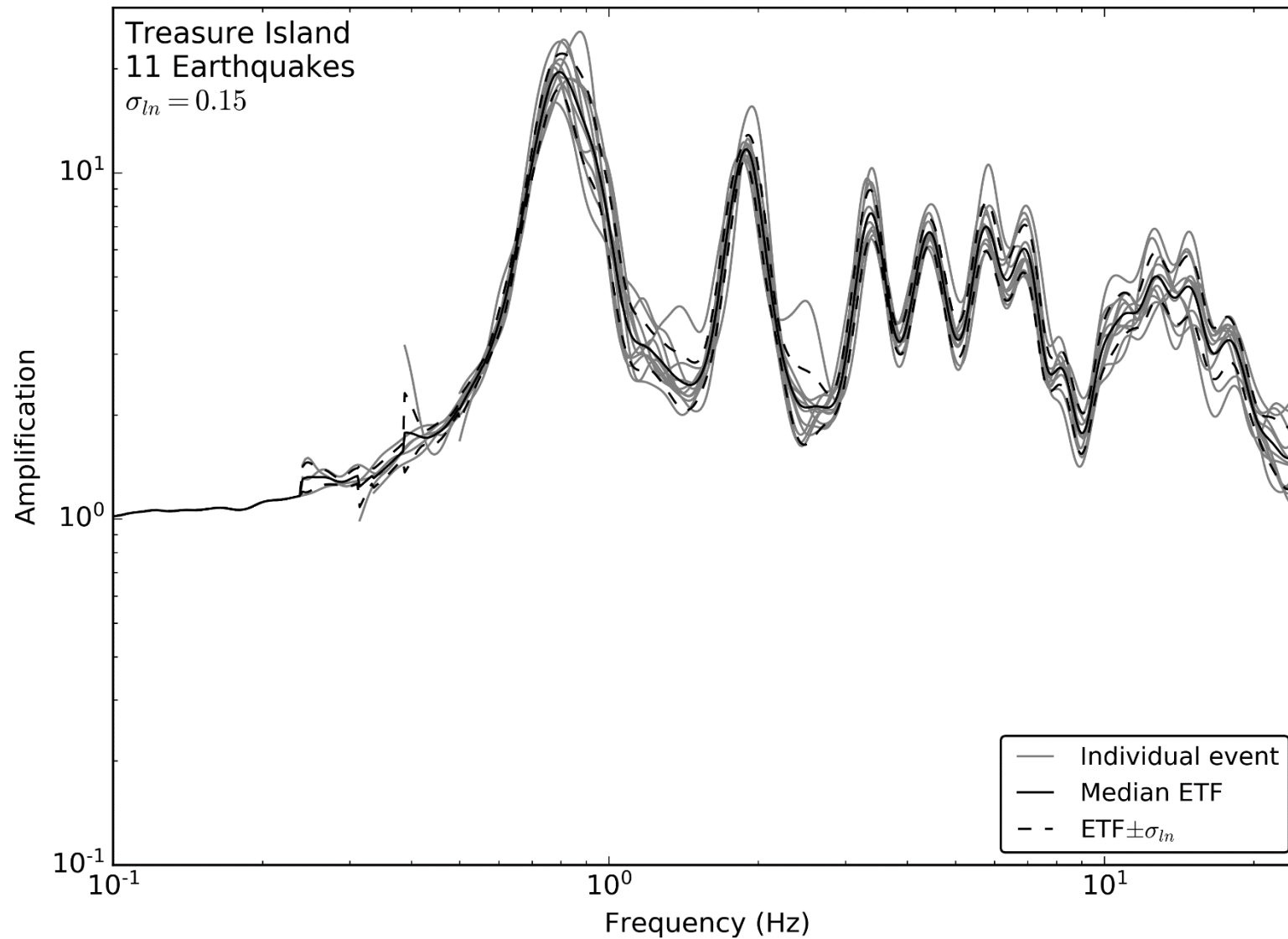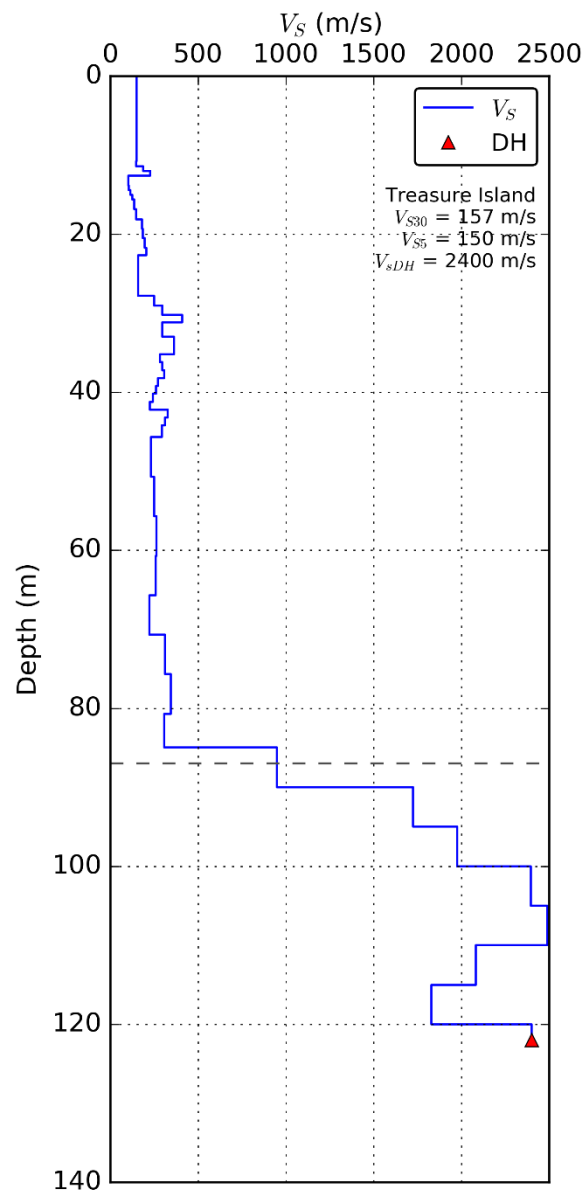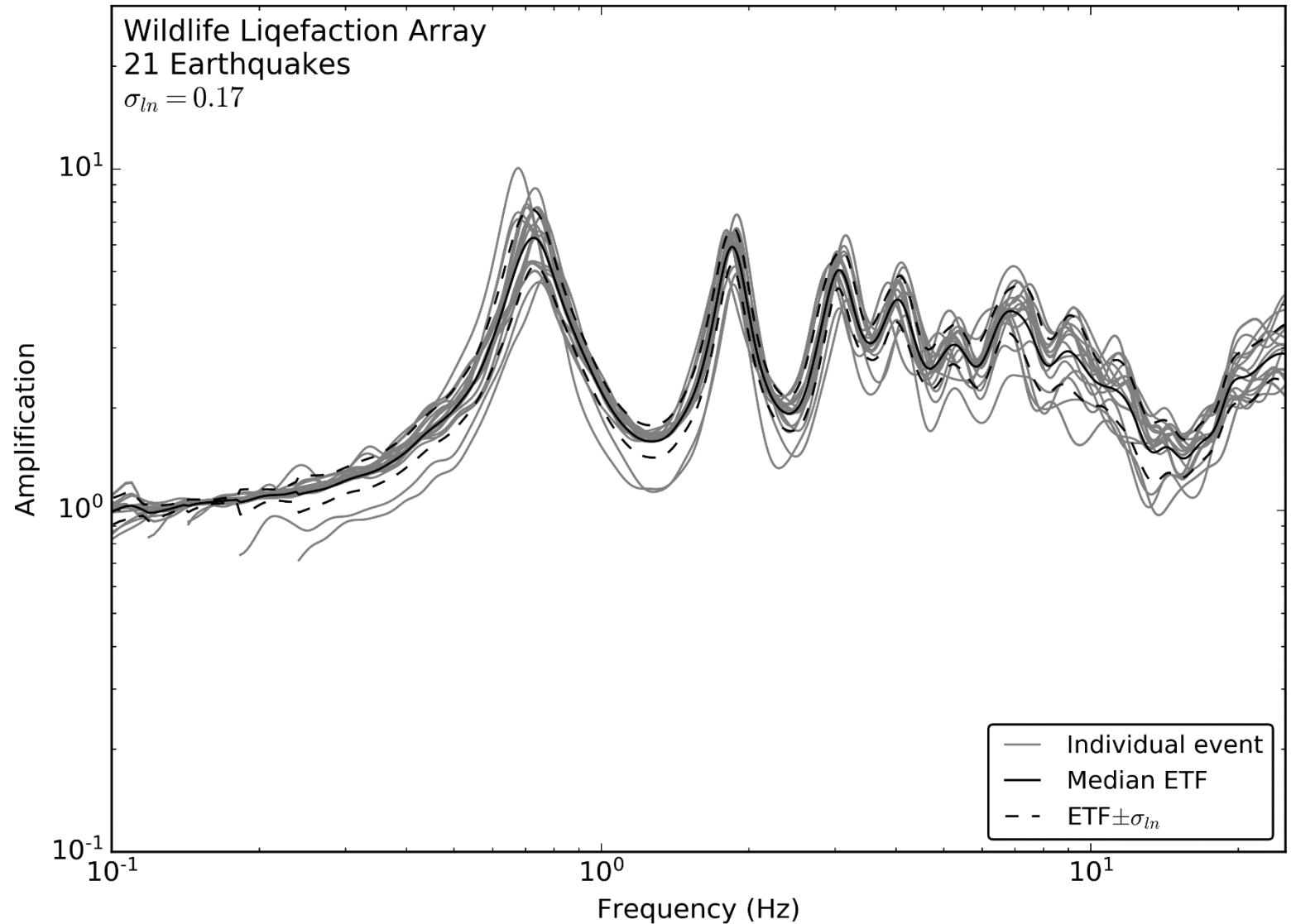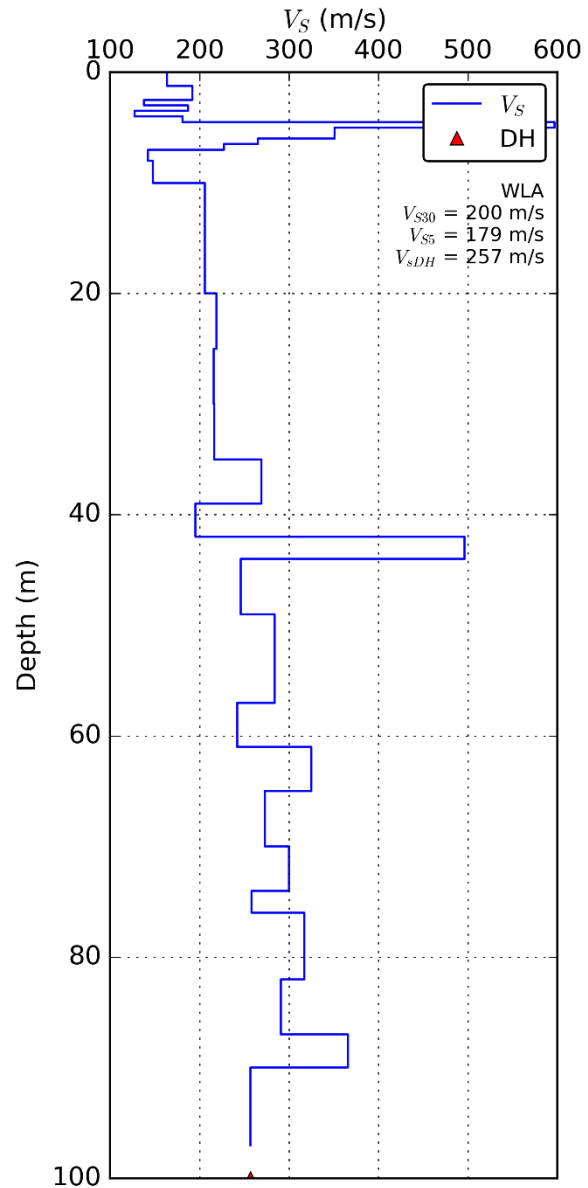
Hollister Digital Array (HEO)

Eureka

Treasure Island

Wildlife Liquefaction Array

Insights Gained from Vertical Arrays

- Does 2D/3D analysis with heterogeneity improve predictions?
- How does multi-layering influence effects of spatial variability?
- Why does it or does it not work at certain sites?
- How sensitive are results to random field model parameters?