GFZ
Helmholtz-Zentrum
Potsdam

Helmholtz-Zentrum Potsdam
Deutsches
GeoForschungsZentrum

Site Classification Derived From Spectral Clustering of Empirical Site Amplification Functions

Sreeram Reddy Kotha

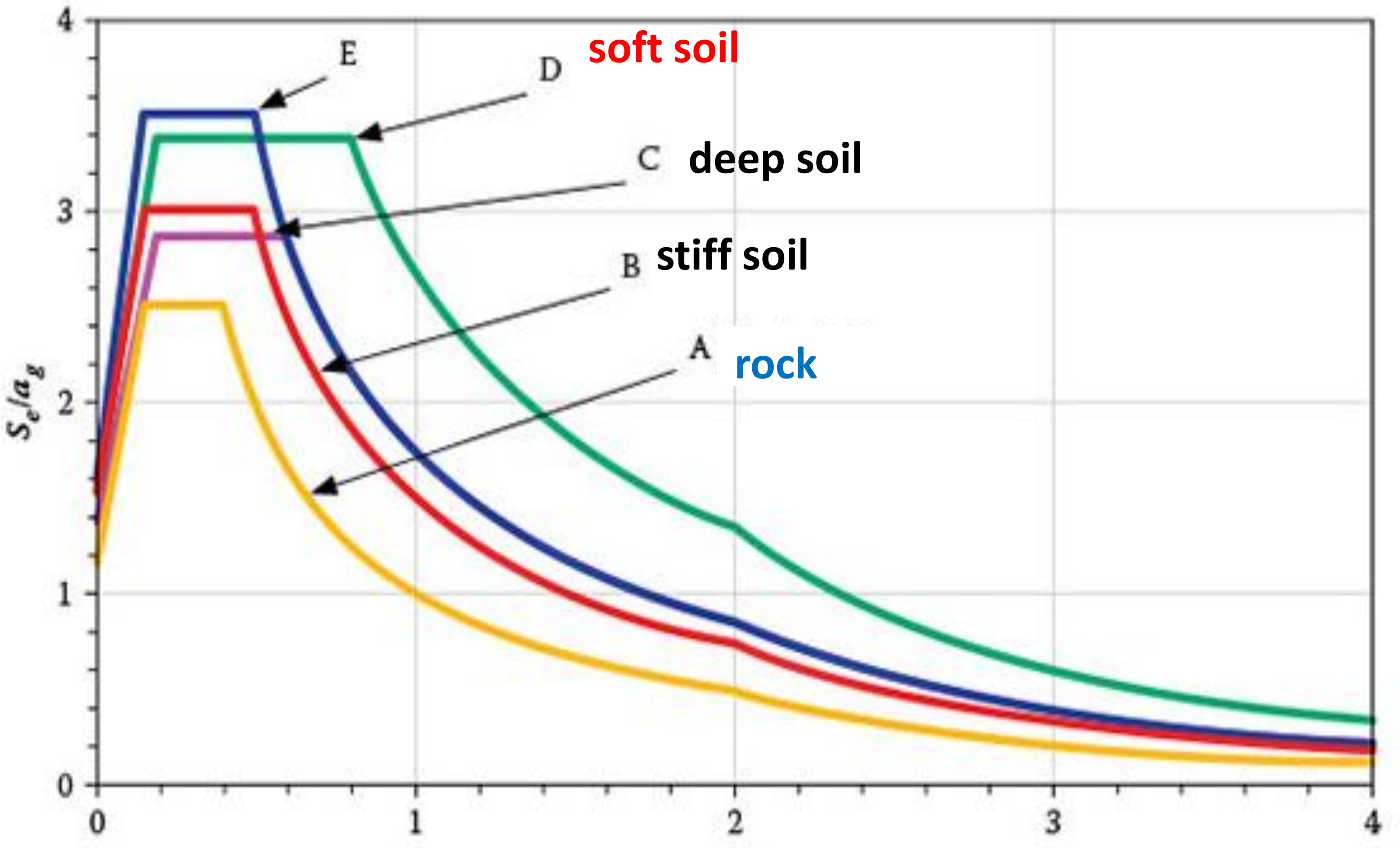
with Fabrice Cotton & Dino Bindi

Section 2.6: Seismic Hazard and Stress Field

GFZ Potsdam

Site Amplification

Site effects: "The effect of 'local site conditions' on 'ground motion'"



WORKU, *A. Soil-structure-interaction provisions: A potential tool to consider for economical seismic design of buildings?.* J. S. Afr. Inst. Civ. Eng. [online]. 2014, vol.56, n.1 , pp.54-62.

Outline

What are the issues?

1. Traditionally, site classes are defined a priori: V_{s30}, SPT, PI ranges etc.
2. Within each site class, the site-to-site variability of amplification is large

What is our plan?

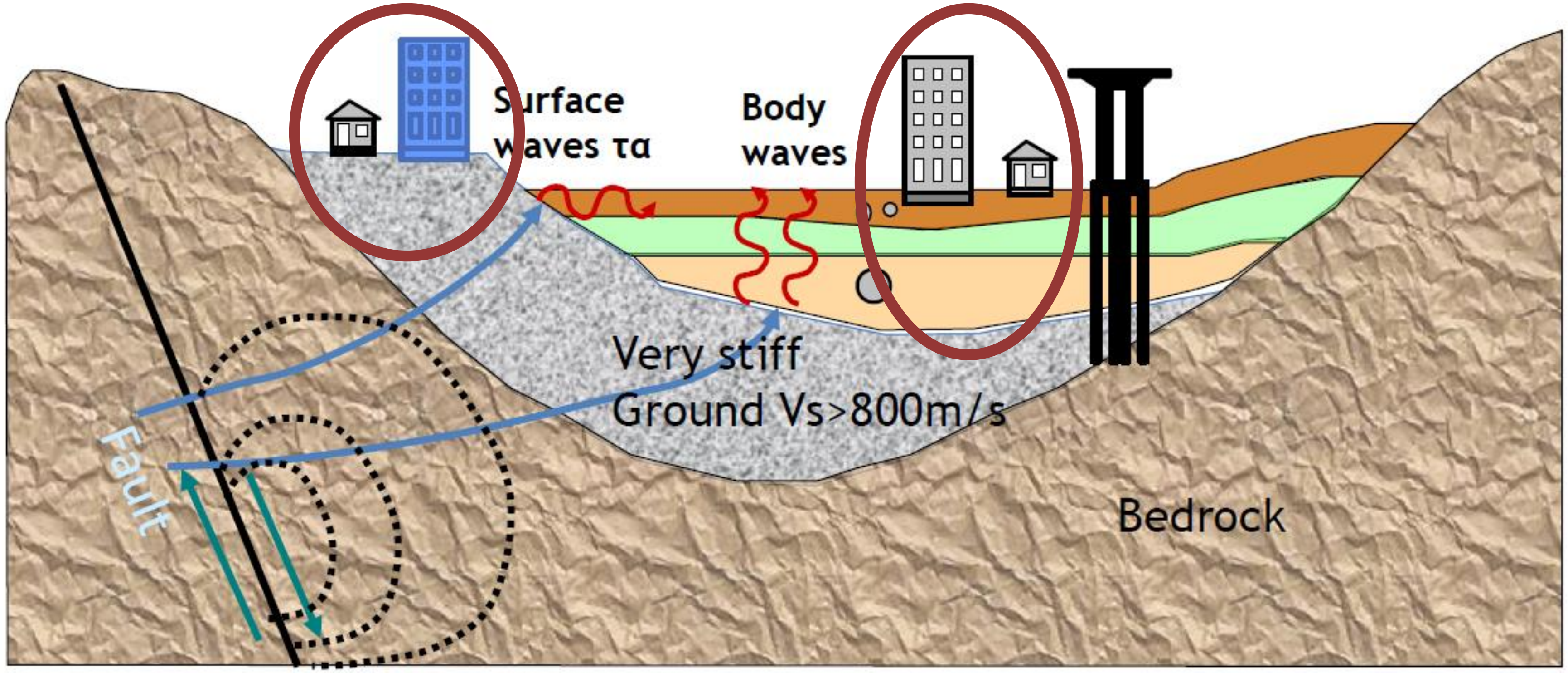
1. Use a rich strong motion dataset
2. Derive empirical site amplification functions for well-recorded sites
3. Use machine learning techniques to identify and cluster similar sites
4. Evaluate site response proxies that explain the new site classes

Empirical Site Amplification Functions : $\delta S2S_s(T)$

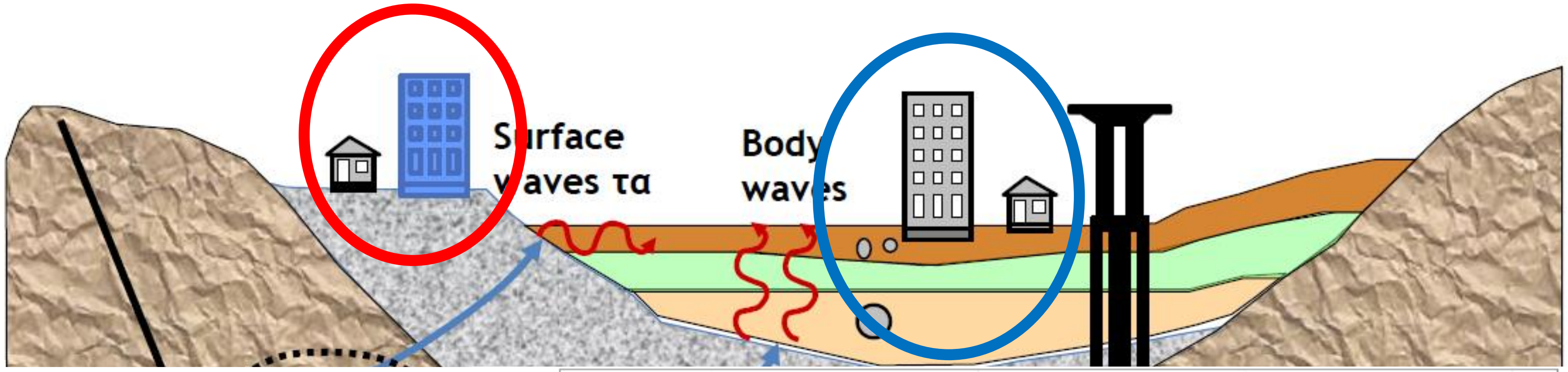
Ground Motion Prediction Equations (GMPE)

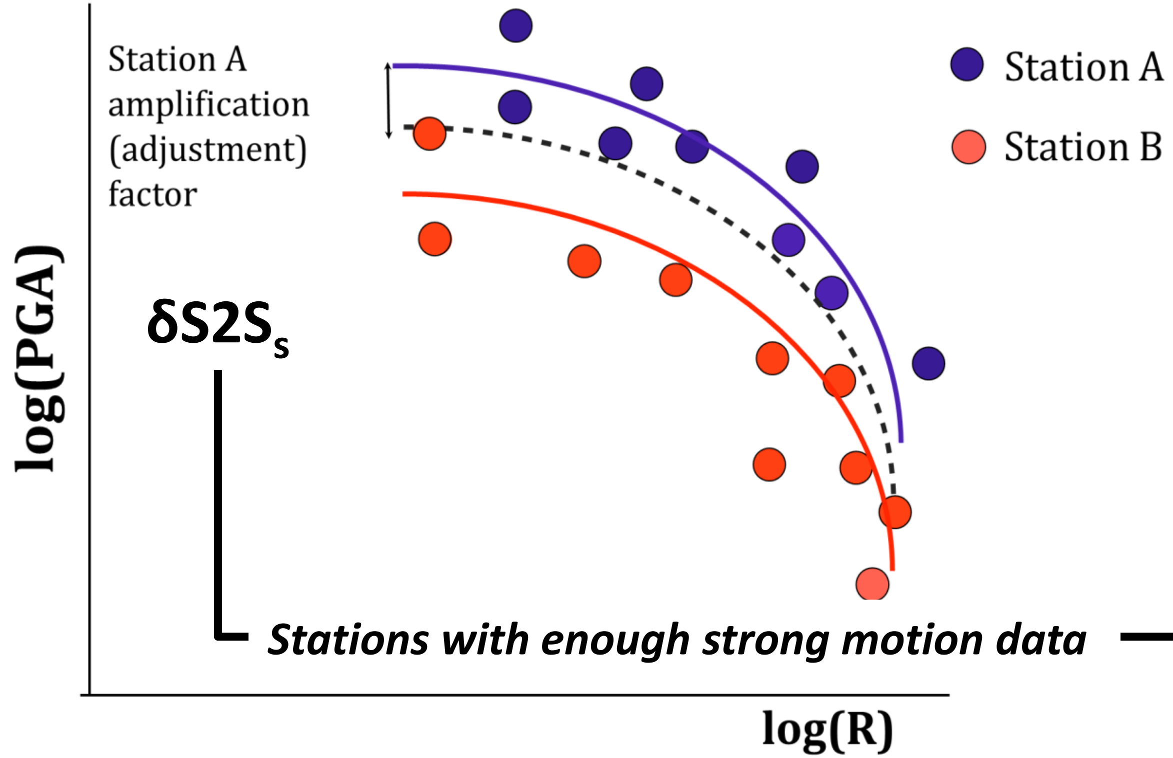
$$ln(GM_{e,s}) = F_M(M_e) + F_D(R_{e,s}, M_e) + F_S(\theta_s) + \delta B_e + \delta S2S_s + \delta WS_{e,s}$$

Observations *Predictor functions* *Random effects* *Residuals*



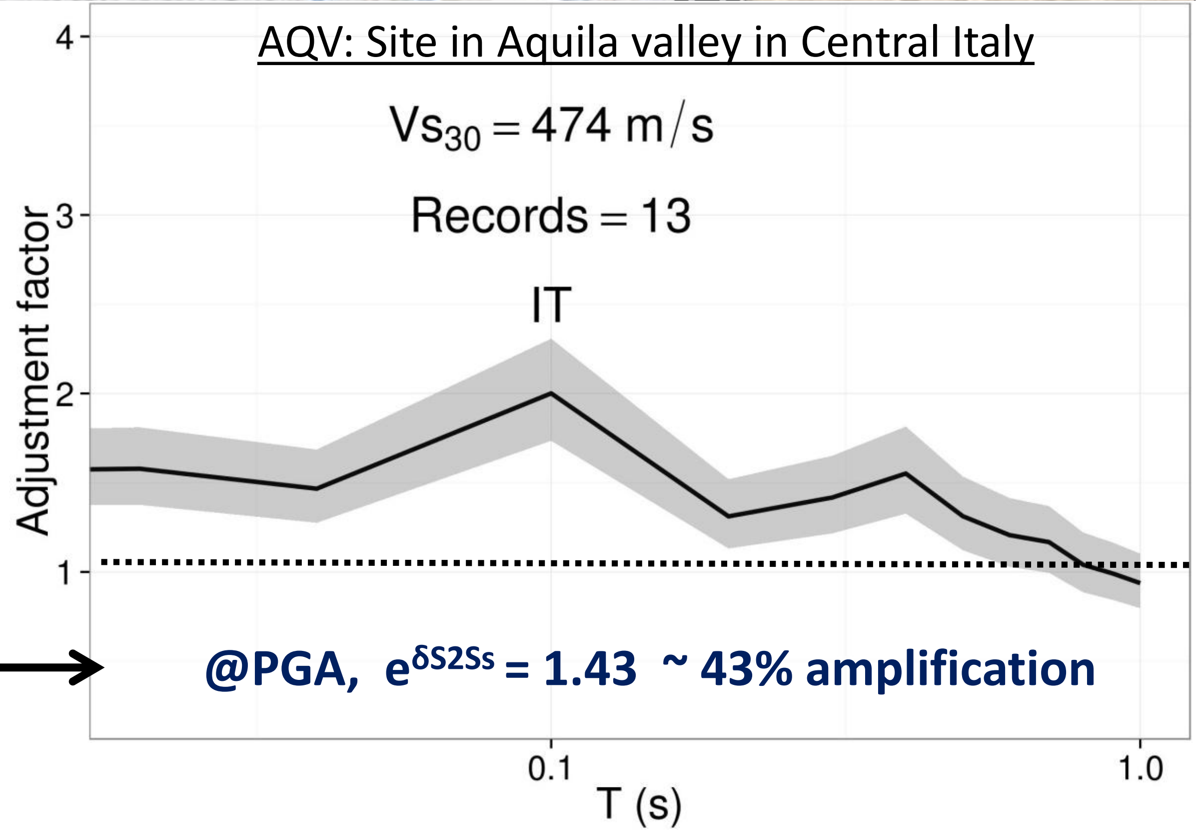
Empirical Site Amplification Functions : $\delta S2S_s(T)$





$\delta S2S_s$

Stations with enough strong motion data →



@PGA, $e^{\delta S2Ss} = 1.43$ ~ 43% amplification

Strong Motion Dataset: KiK-Net

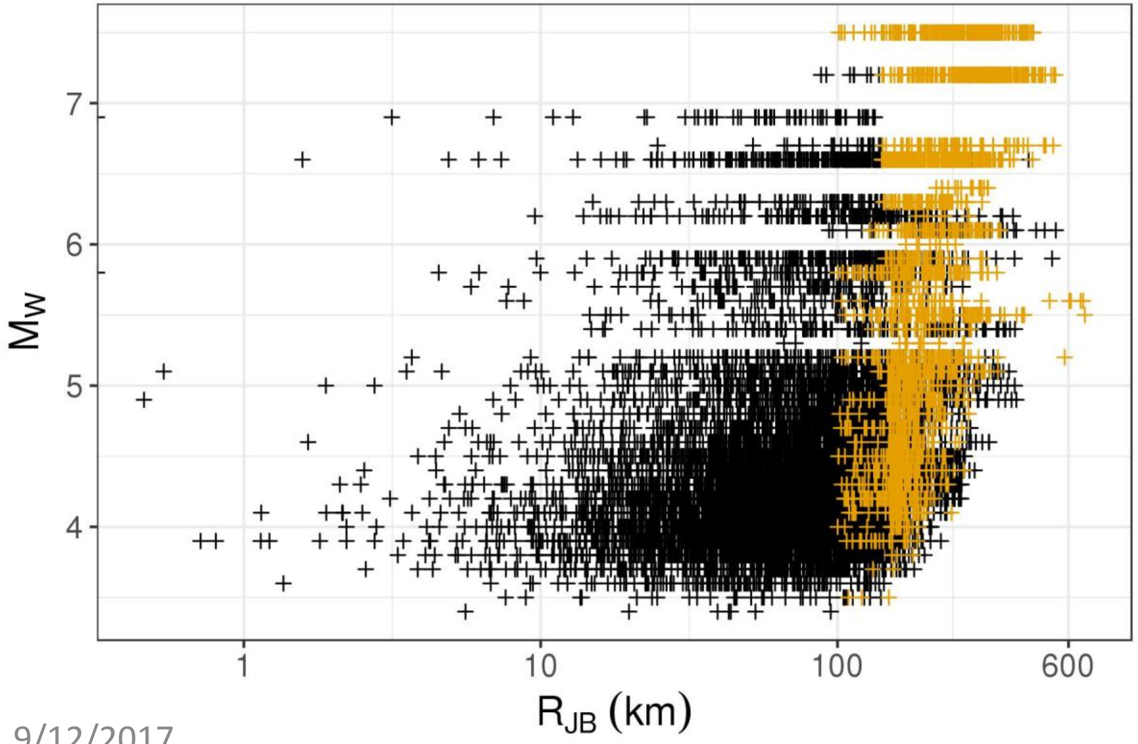
GMPE for GM of H - components of Response Spectra for Shallow Crustal events

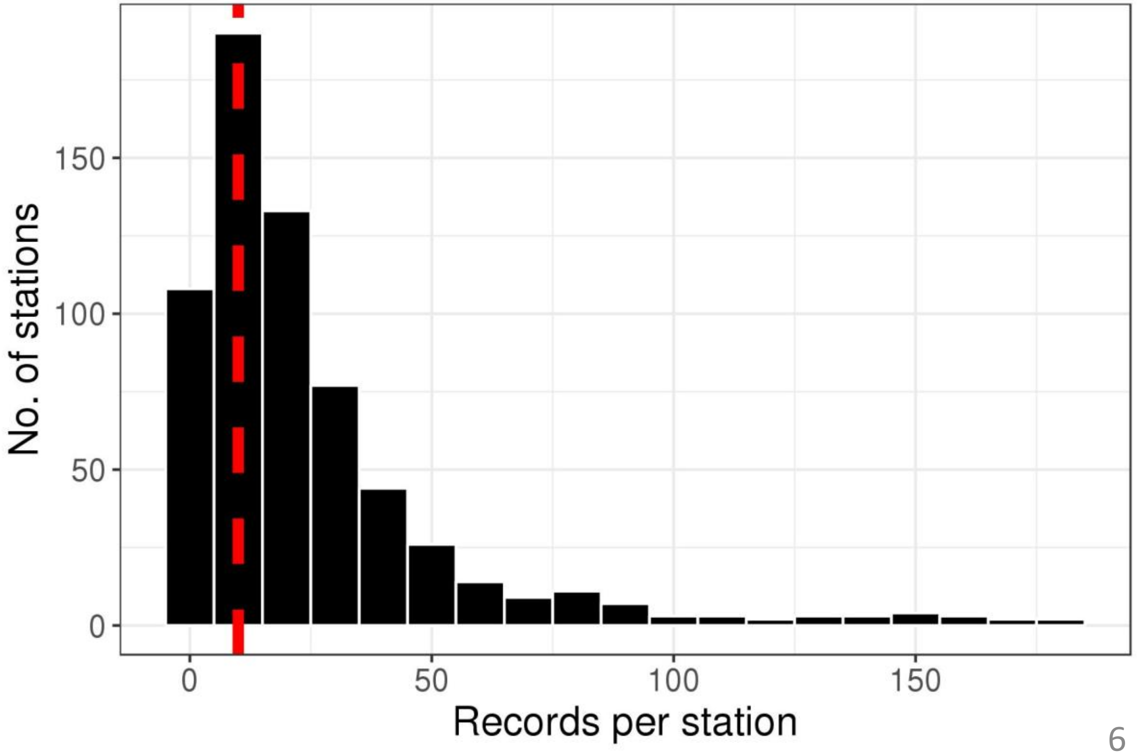
~16000 records : M3.4-M7.5, 0km < R_{JB} < 600km, T = 0.01s – 7s

~ 500 sites with more than 10 records

(Dawood, Rodriguez-Marek et al. 2016)

Data distribution



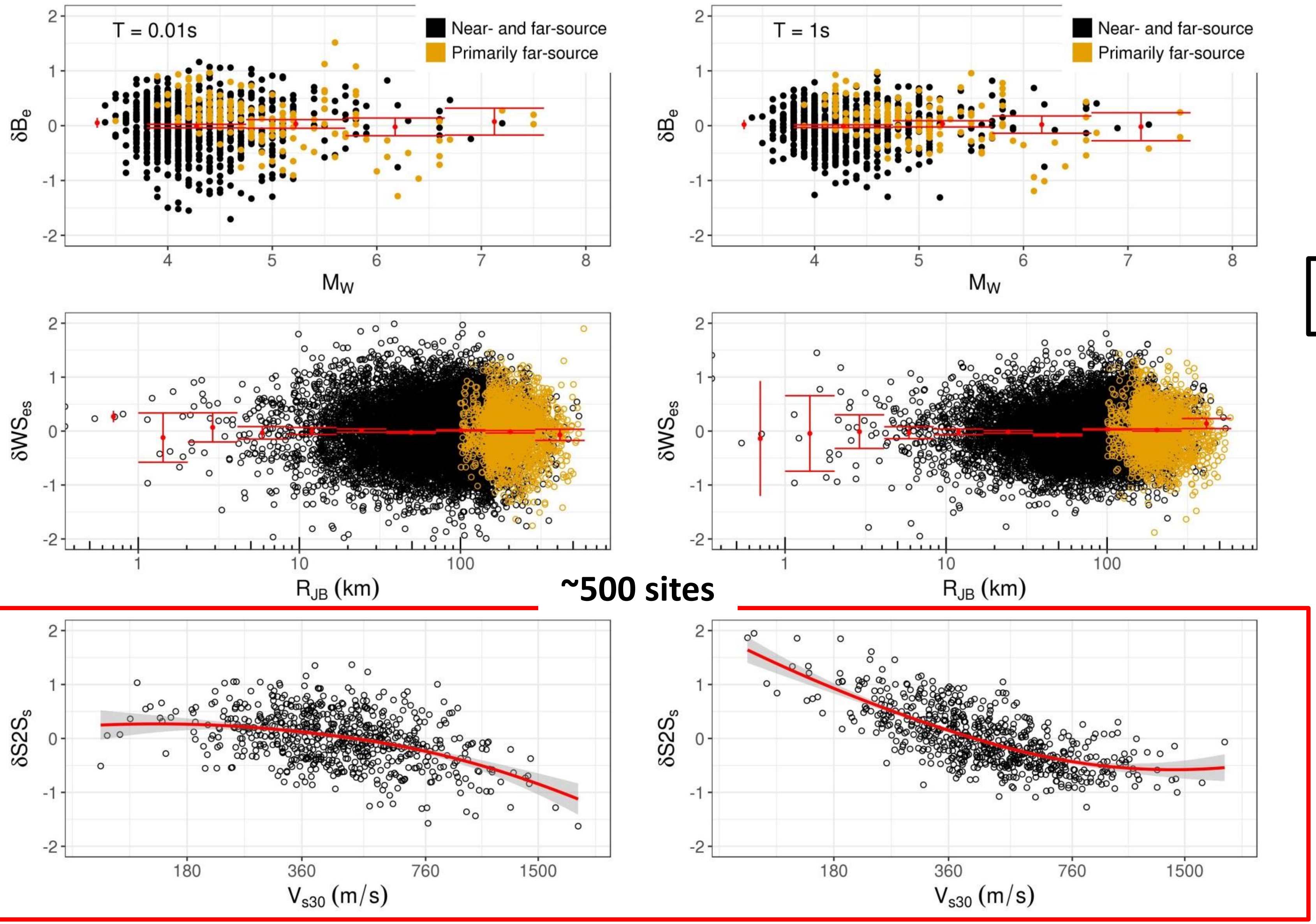


GMPE Random Effects and Residual Analysis

High frequency $\delta S2S_s$ shows a weak trend with V_{S30}

T = 0.01s

T = 1s

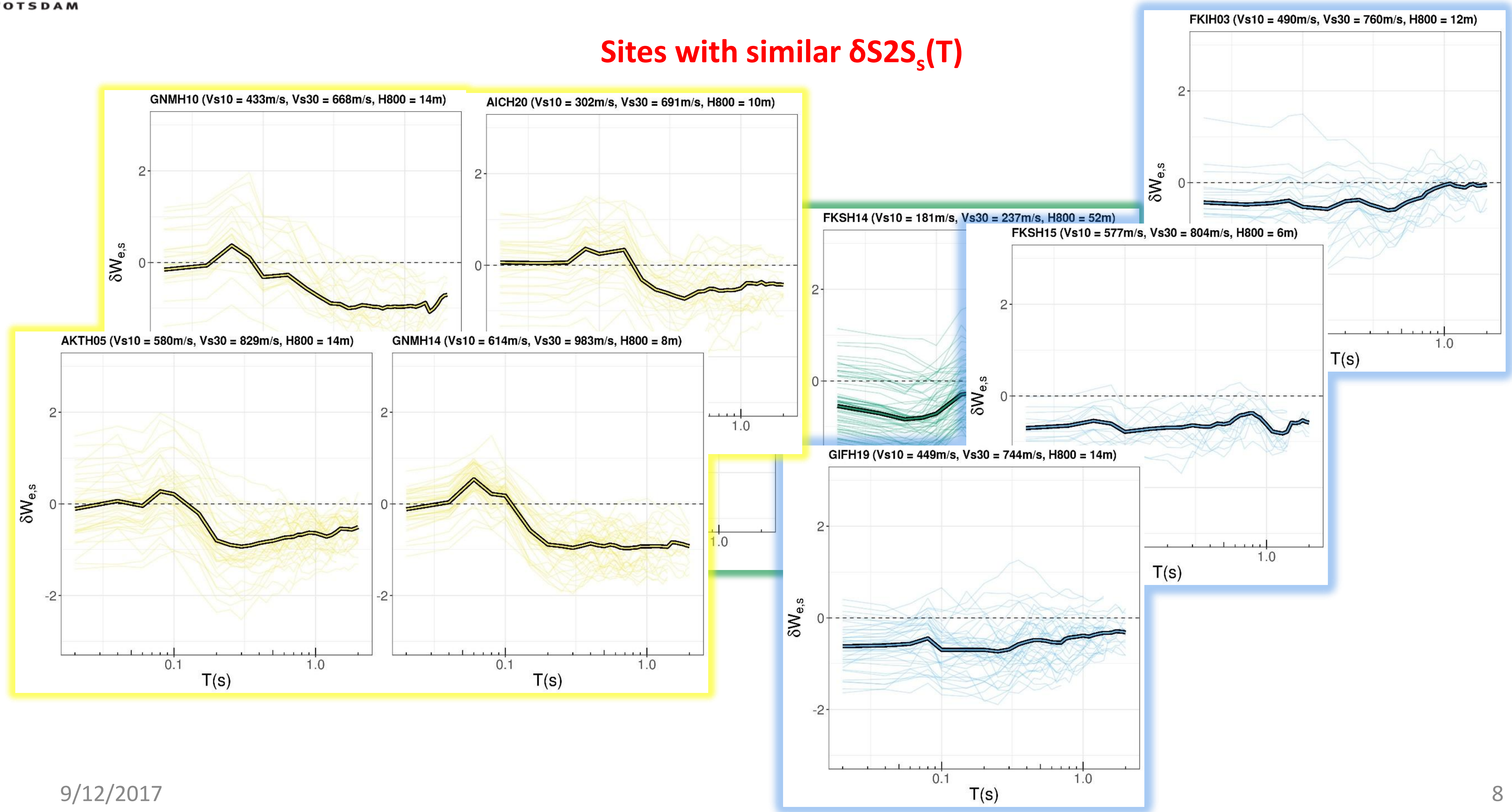


GFZ Helmholtz-Zentrum Potsdam

Helmholtz-Zentrum Potsdam Deutsches GeoForschungsZentrum

Spectral Clustering of $\delta S2S_s$ vectors

Sites with similar $\delta S2S_s(T)$

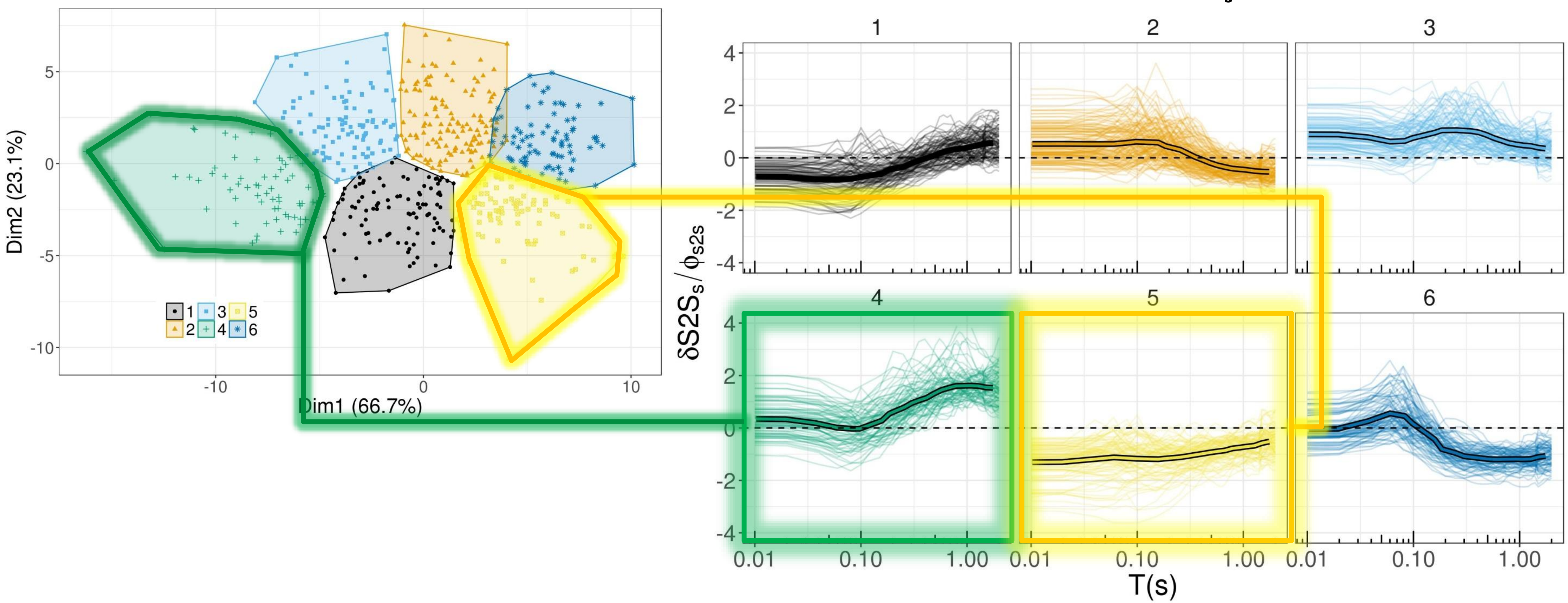


Cluster Amplification Functions

K-mean clustering of sites with similar response $\delta S2S_s(T)$

K-mean clusters

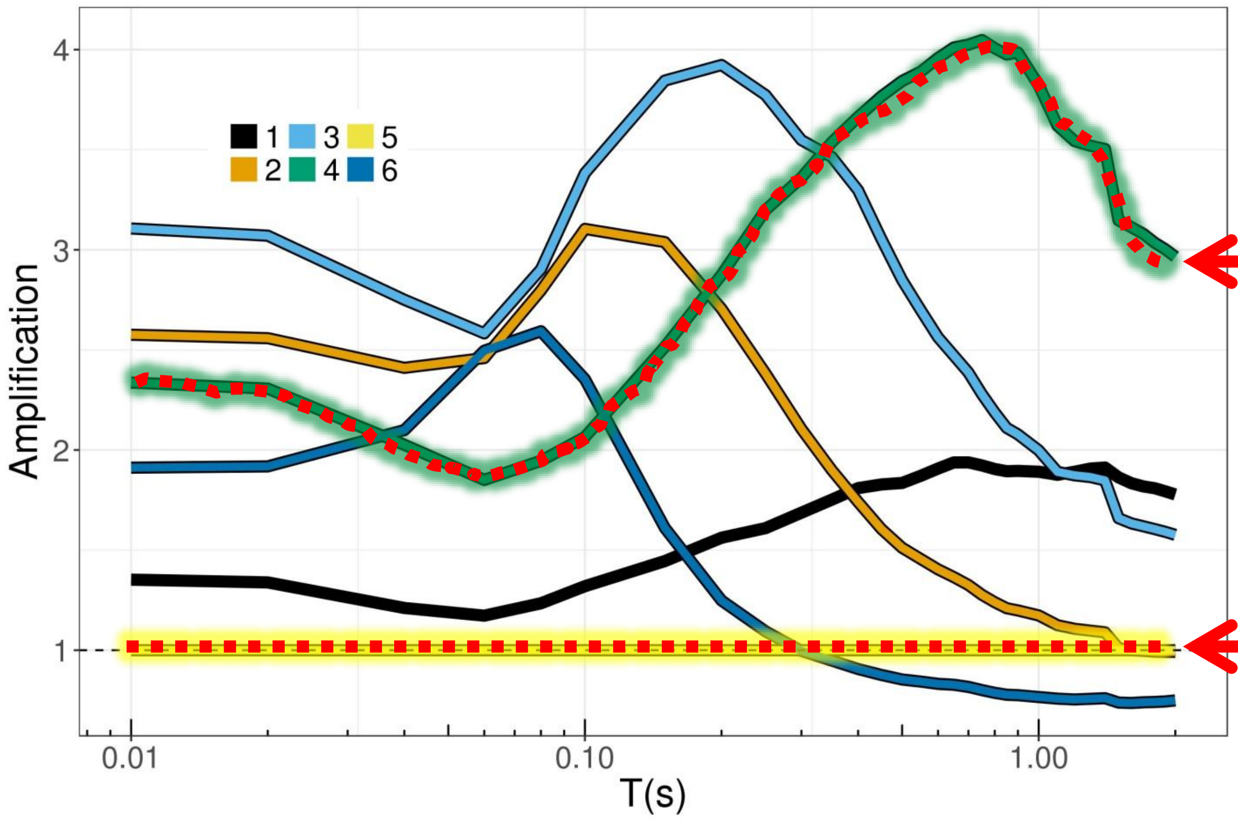
Clustered $\delta S2S_s(T)$



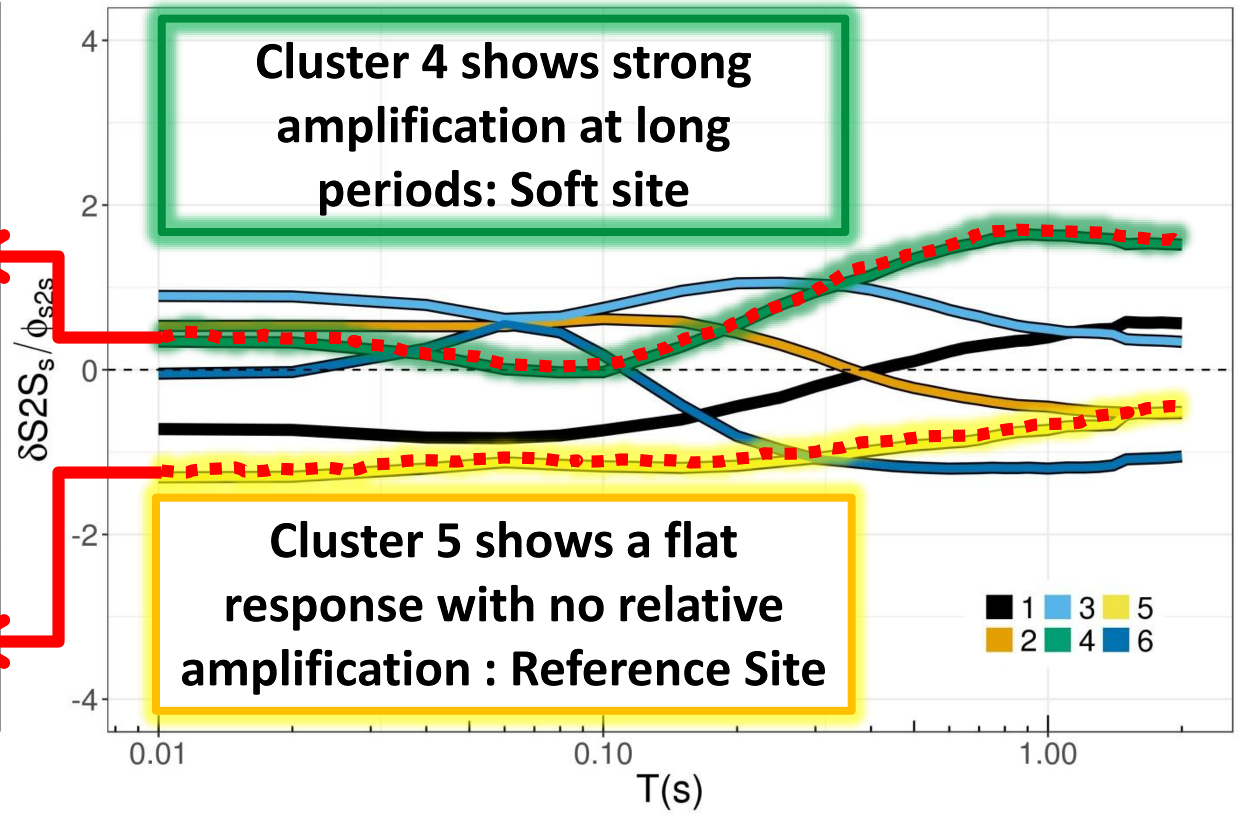
Empirical Site Amplification Functions

Scale w.r.t *reference site* $\delta S2S_s(T)$, and then $e^{\delta S2Ss(T)}$

Amplification functions



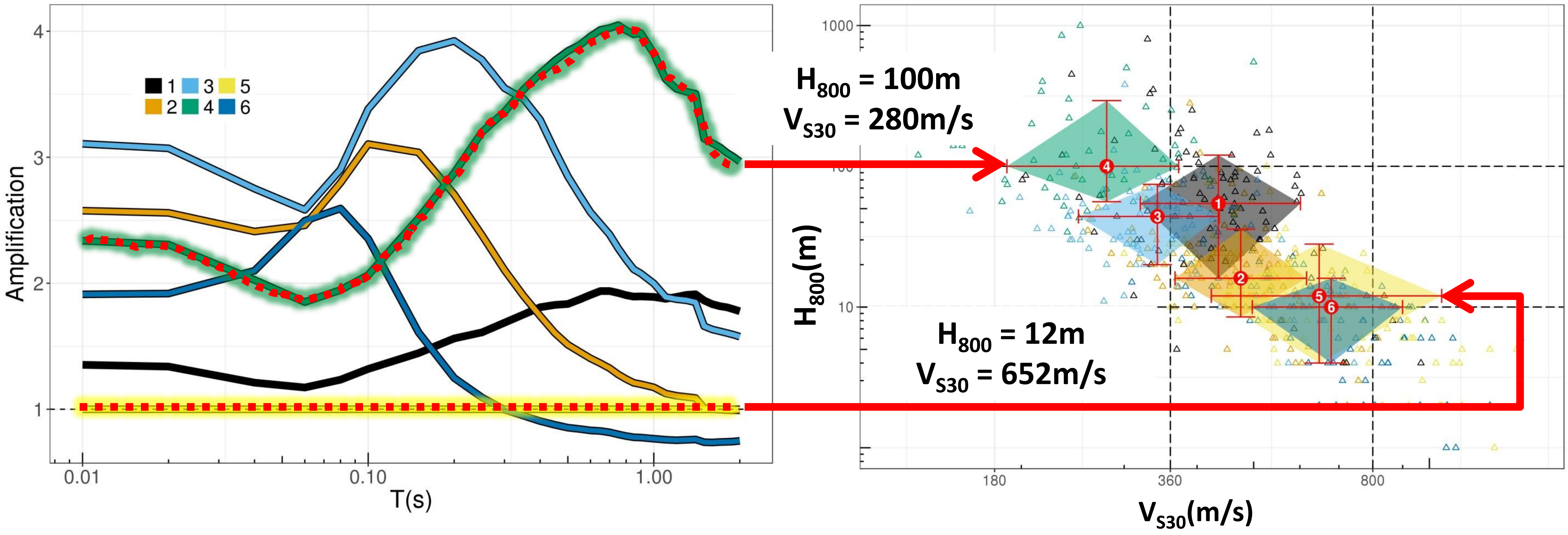
Means of clustered $\delta S2S_s(T)$



Site Conditions

Physical meaning of cluster specific $\delta S2S_s(T)$

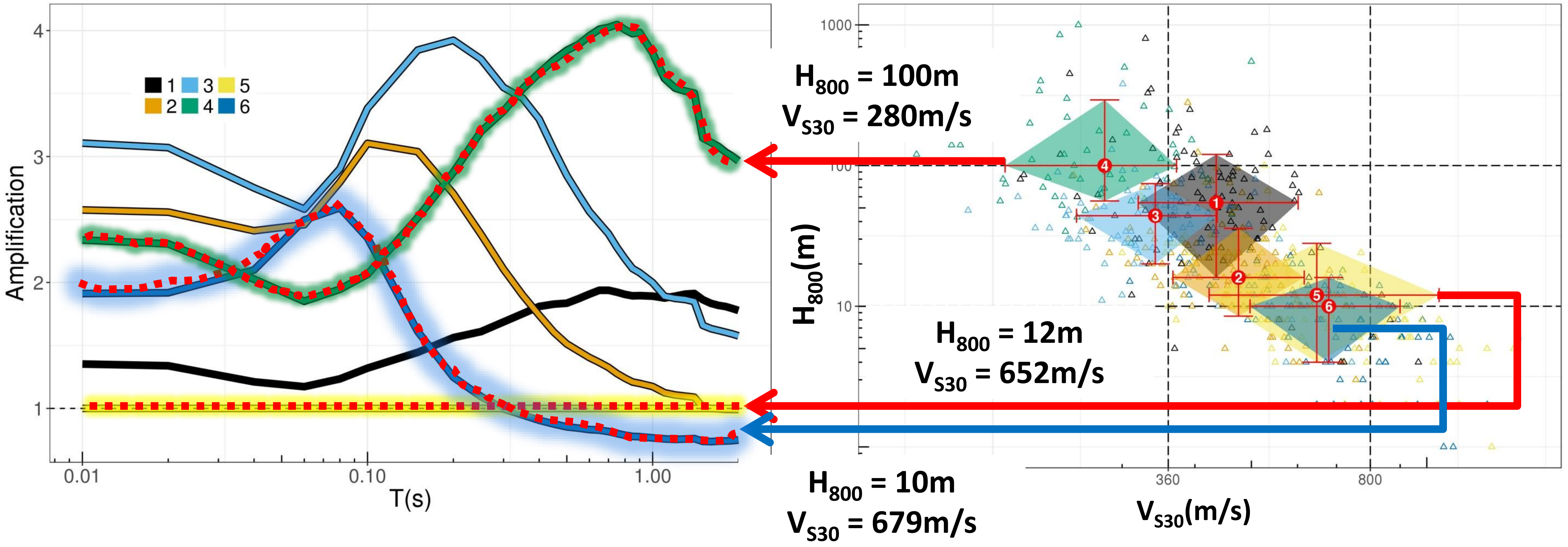
Amplification functions **Site conditions**



Site Conditions and Proxies

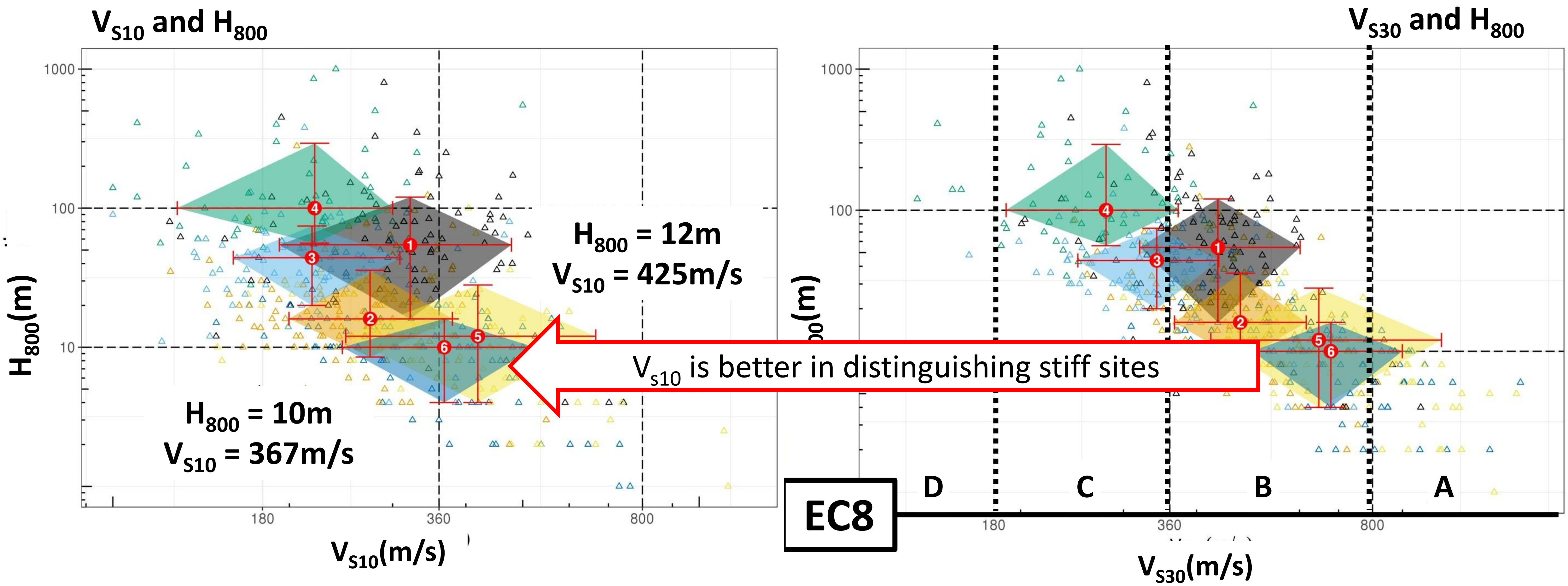
Reference 'rock' site conditions?

Amplification functions **Site conditions**



Site Response Proxies

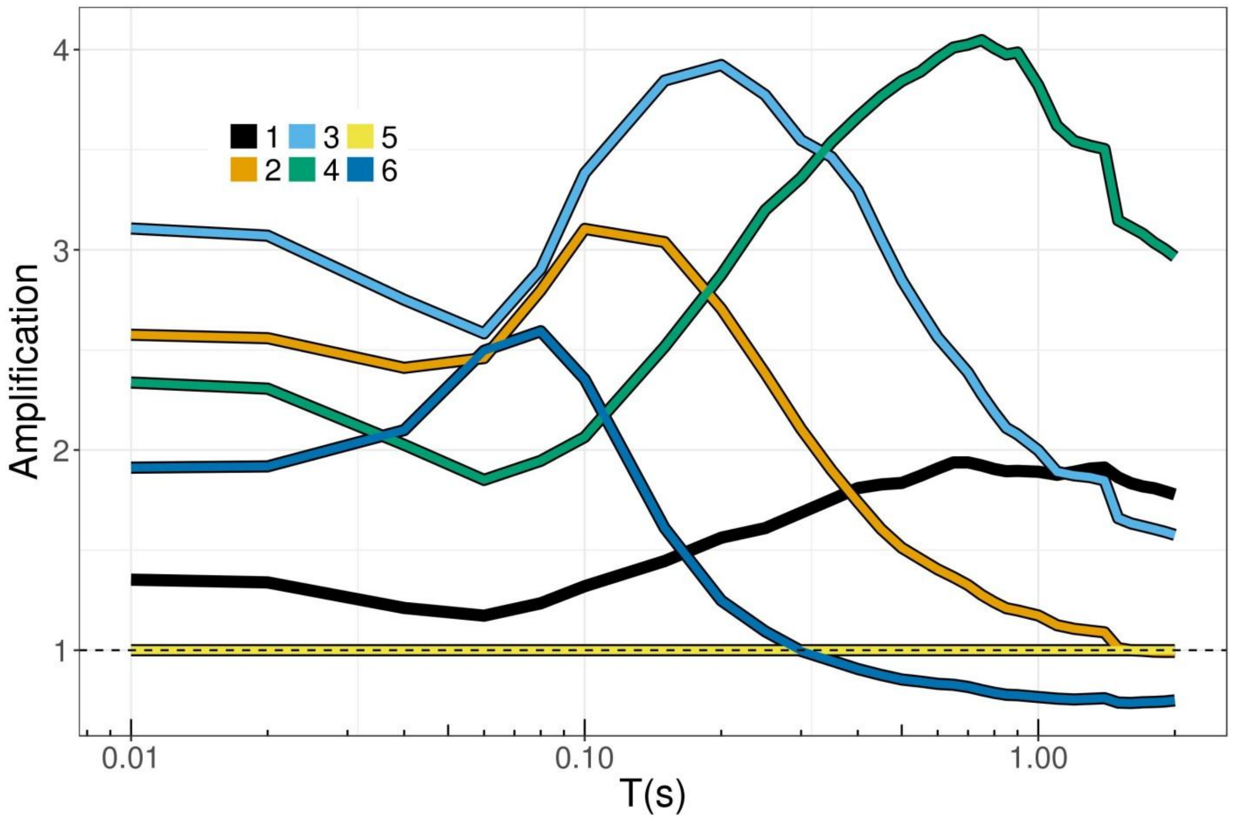
V_{S30} based classification may not be efficient



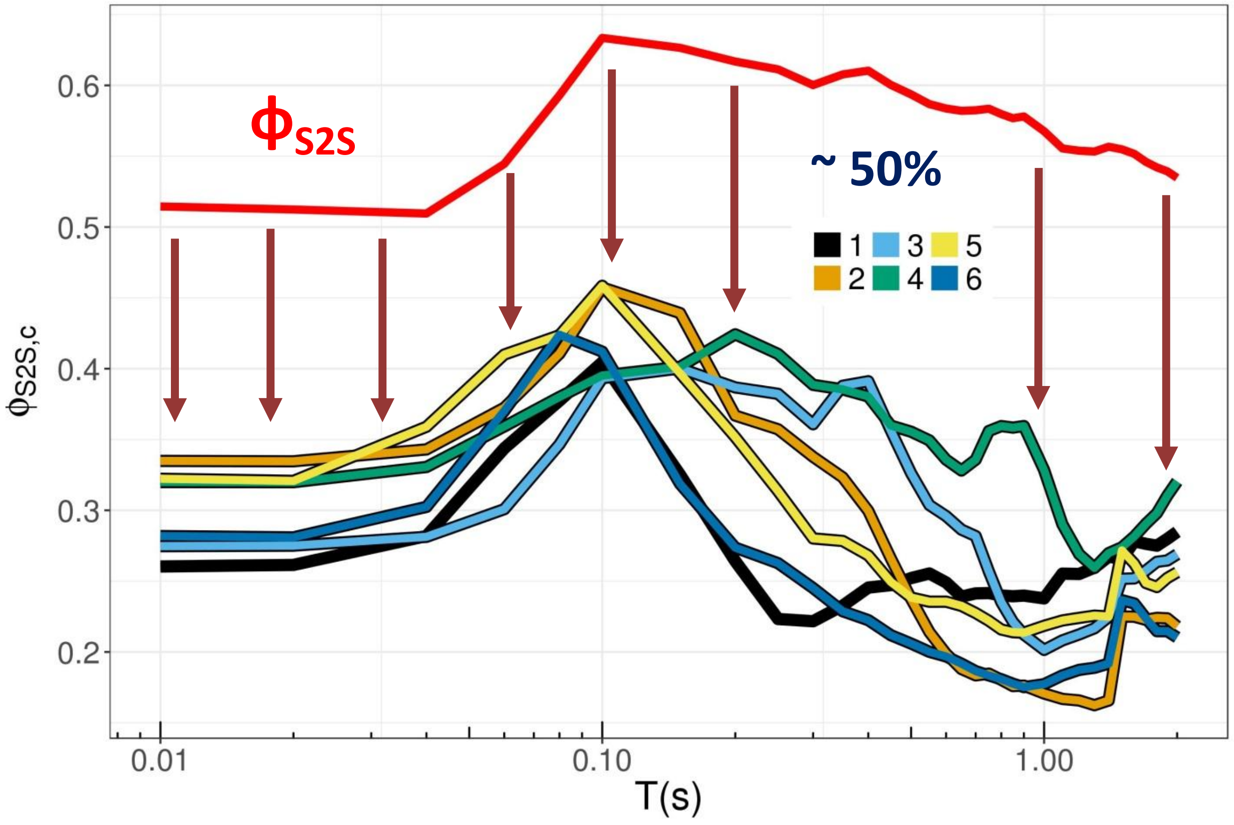
Site Amplification Functions: Mean and Variability

Within cluster site-to-site response variability ~ 50% smaller

Amplification functions



Site-to-site variability



Summary

What were the key issues?

1. Pre-defined sites classes based on V_{S30} may not be efficient
2. Large site-to-site variability within V_{S30} based classes

What we tried?

1. Site-specific random effects $\delta S2S_s(T)$ as empirical site AFs
2. Unsupervised machine learning techniques to cluster sites with similar response

What we found?

1. V_{S10} - H_{800} is an optimal proxy to classify 6 site clusters
2. ~ 50% smaller within-cluster site-to-site variability

What next?

1. The tools are open-source and easy to use… more sophistication is needed?
2. With a pan-European dataset, we may expect very different results!!!

…Thank you… review?