Challenge for a better measurement of high frequency seismic motion

(and link with heterogeneity studies)

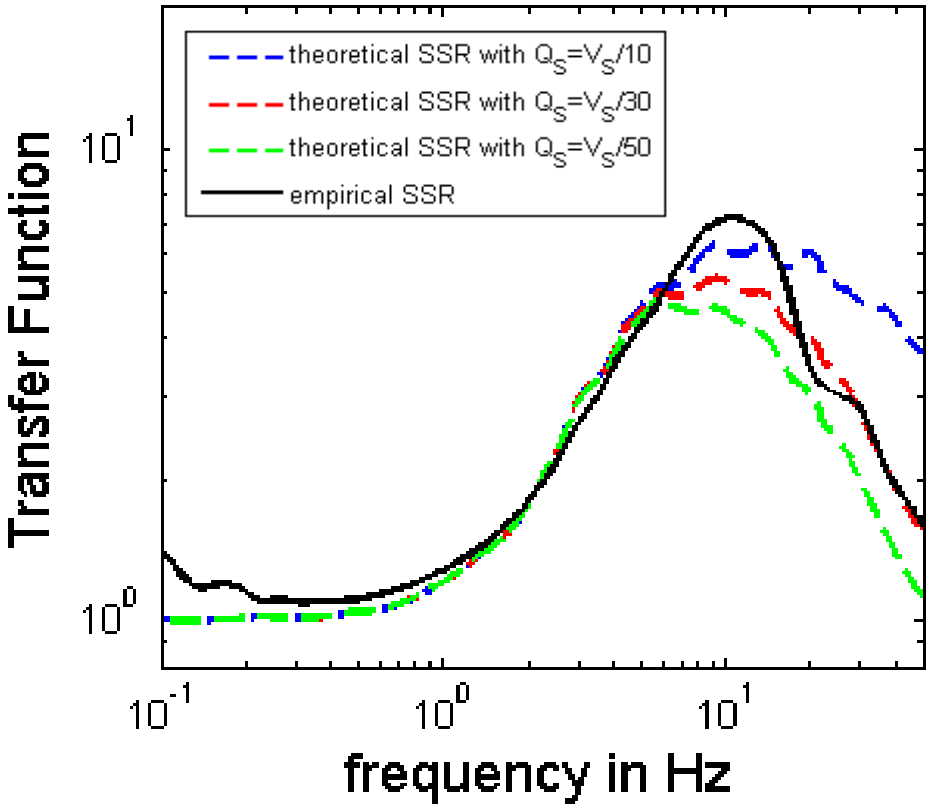
Fabrice HOLLENDER

(with contributions from Hussein SHIBLE, Zafeiria ROUMELIOTI, Emeline MAUFROY, Paola TRAVERSA, Armand MARISCAL, any many others)

Outline

- Importance of the measurement of high frequency for the heterogeneity studies
- Influence of sensor coupling on HF content
- Influence of sensor installation depth on HF content
- Influence of seasonal variations on HF content
- Some evidences of these effects on selected RAP stations
- Does the classical measurement of the “kappa” parameter still make any sense?

Why HF measurements are important to study heterogeneities ?



from Shilbe et al. 2018

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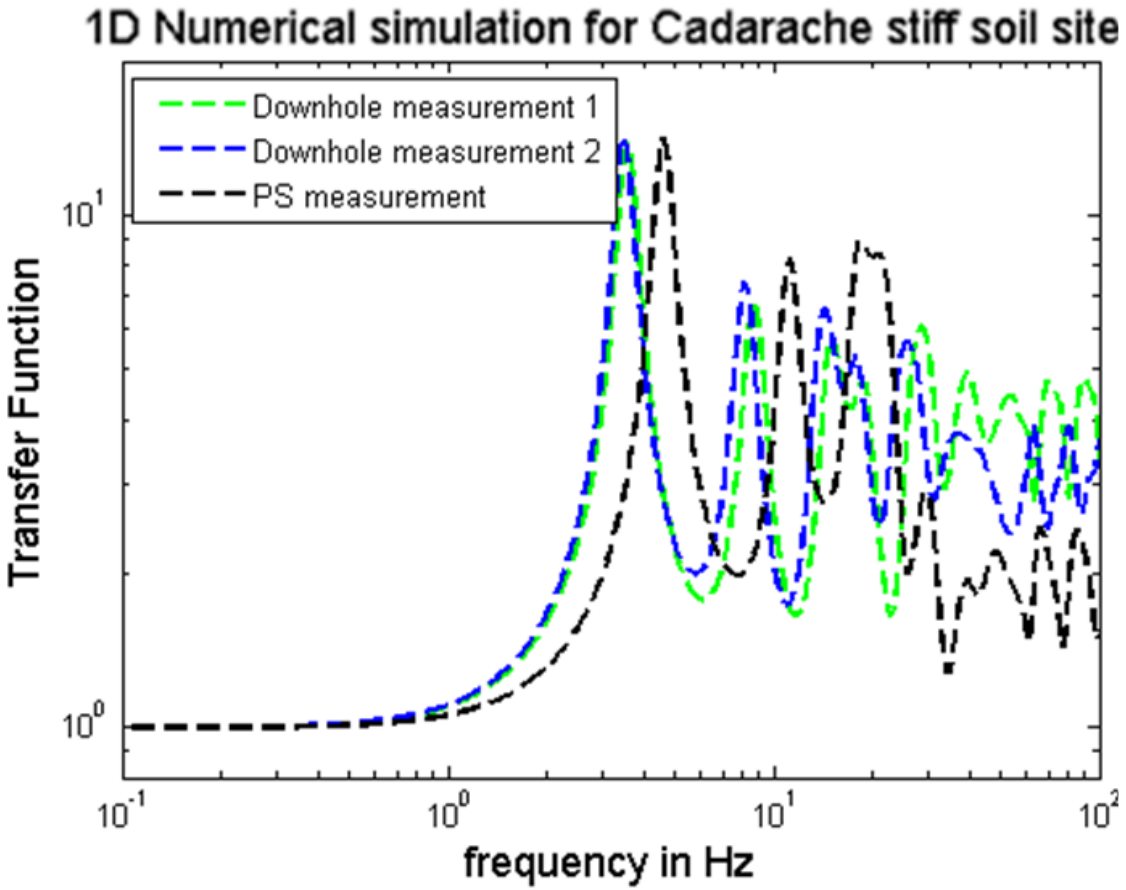

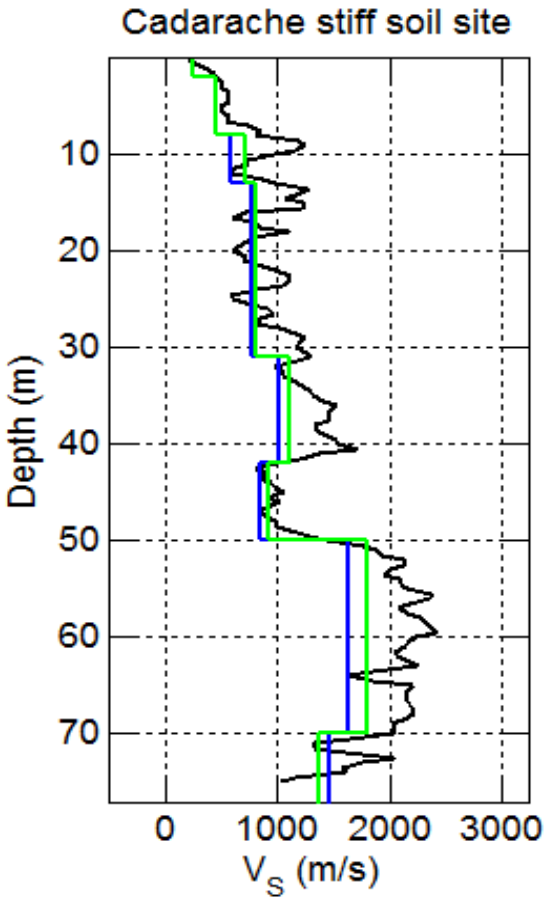

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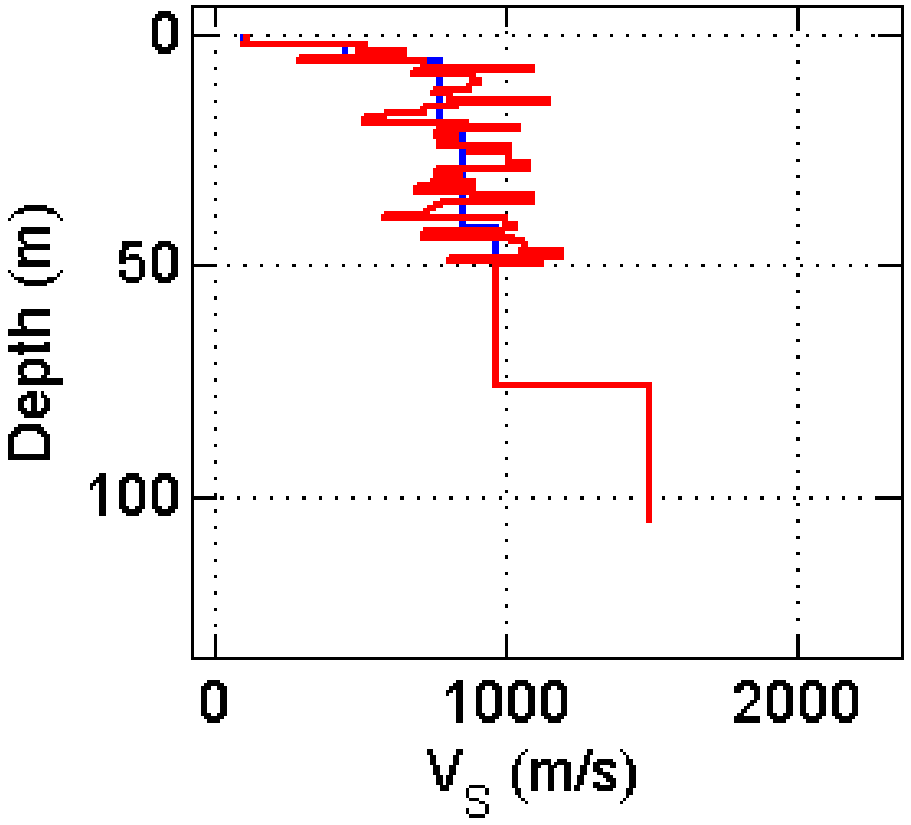

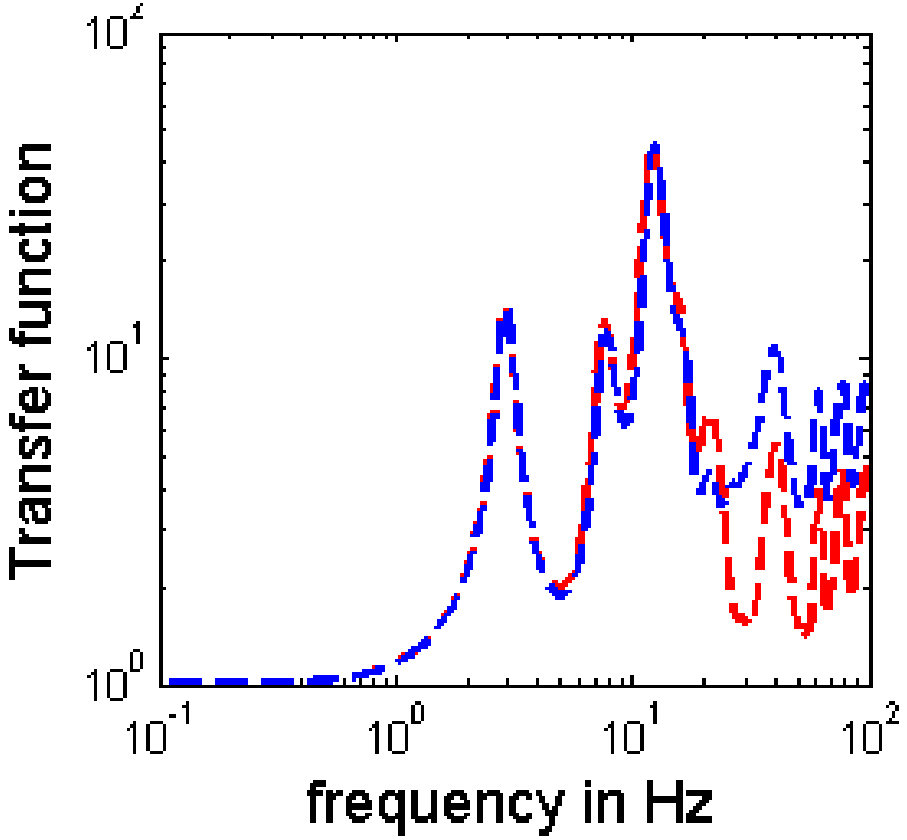

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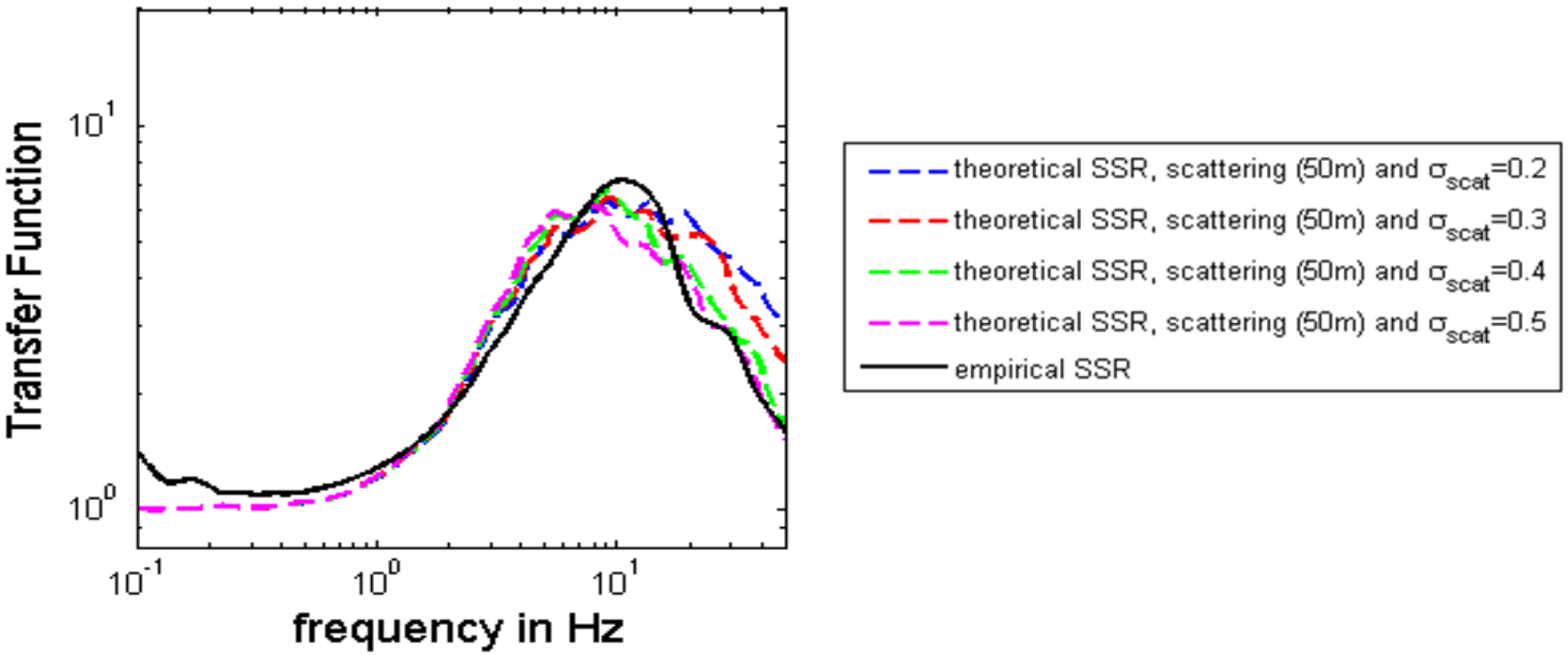
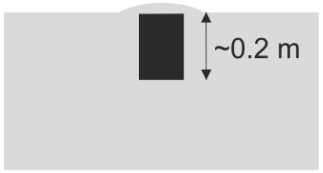


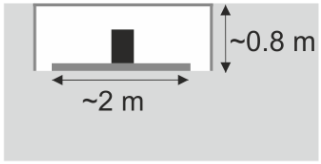
from Shilbe et al. 2018

Sketches of the different station installation configurations

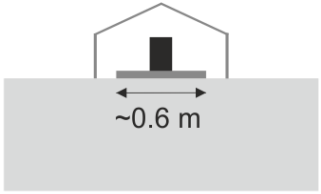
a. Direct burrial



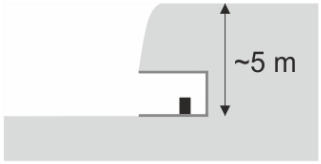
b. Manhole



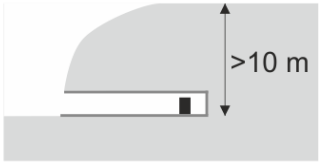
c. Shelter



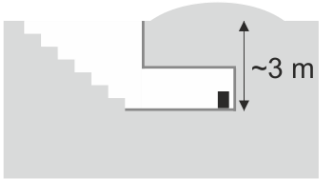
d. Cave



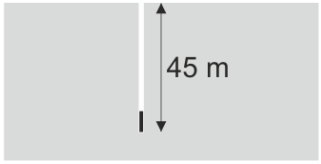
e. Tunnel



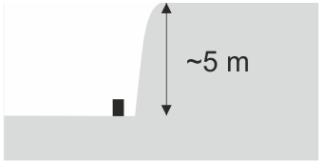
f. Vault



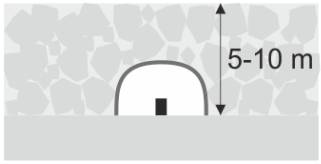
g. Borehole



h. Foot of a cliff



i. Gallery covered by blocks



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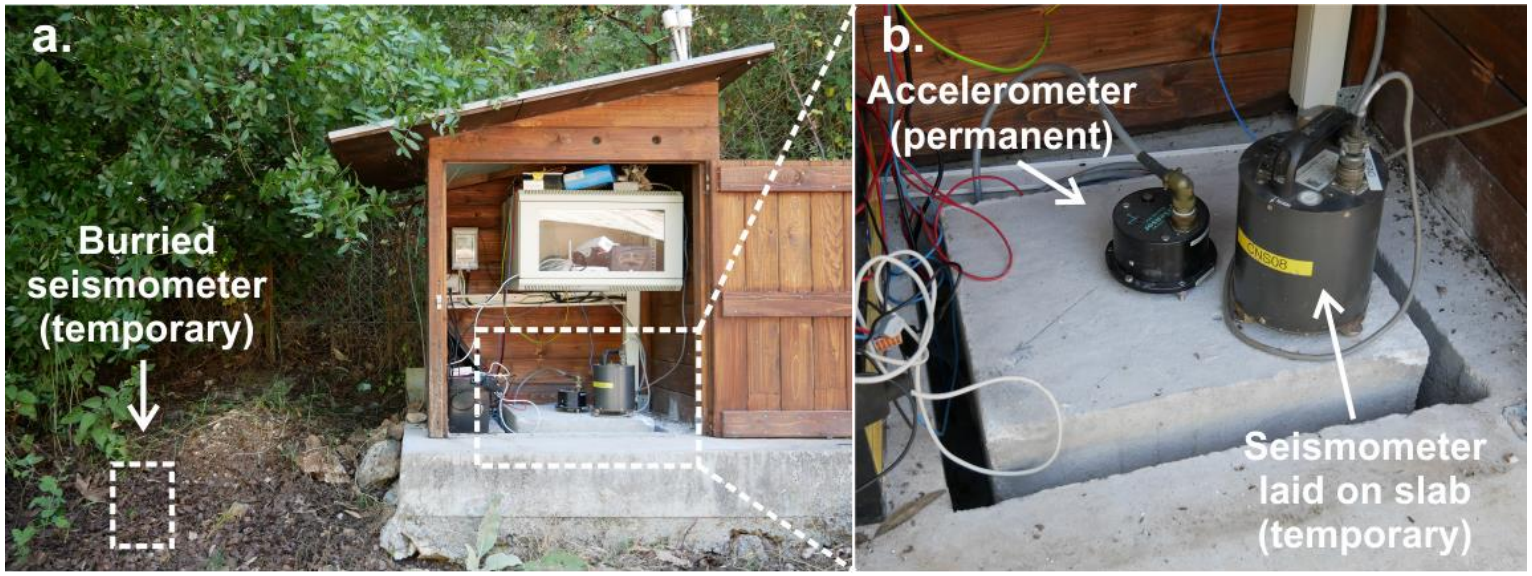
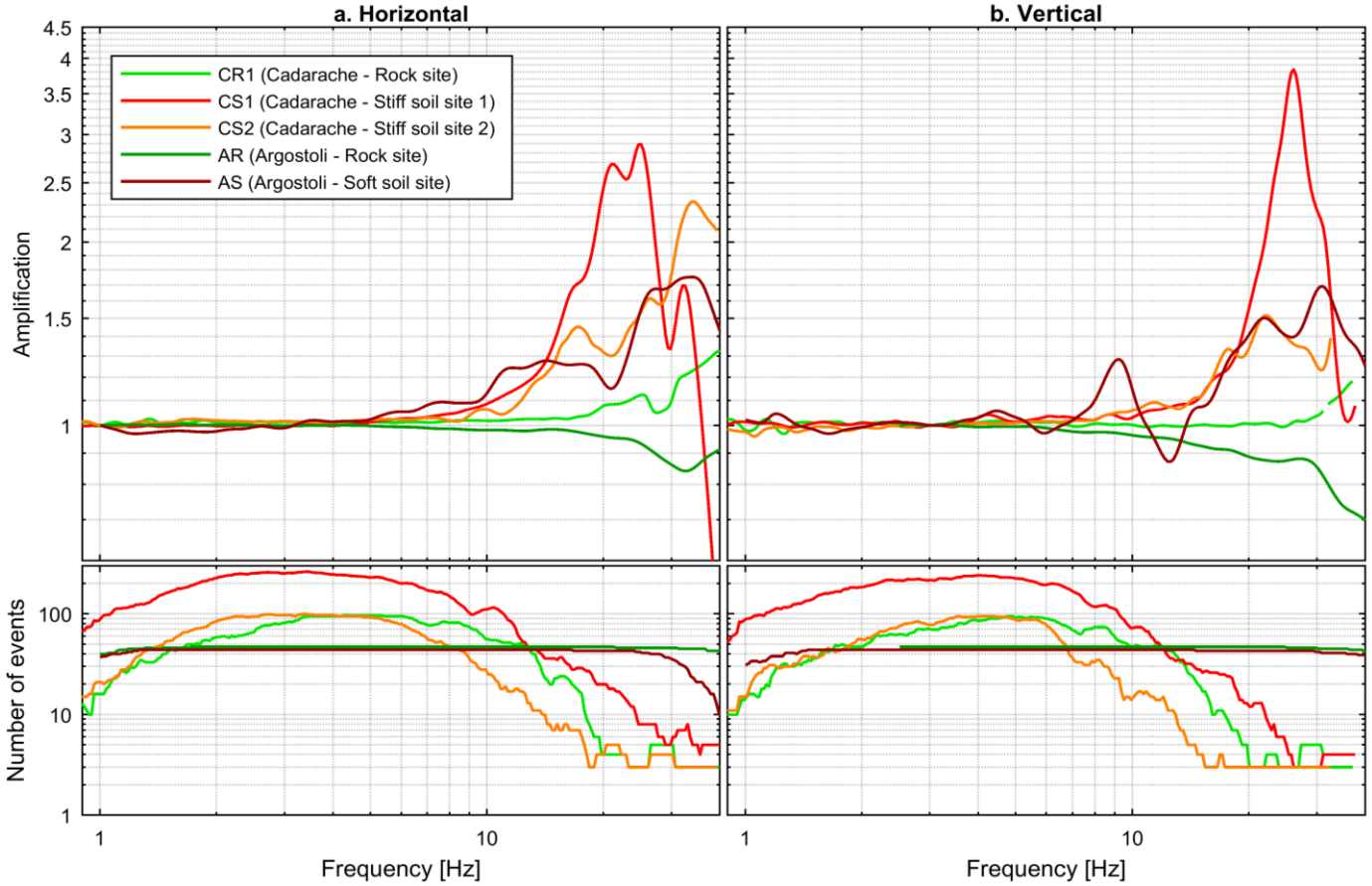
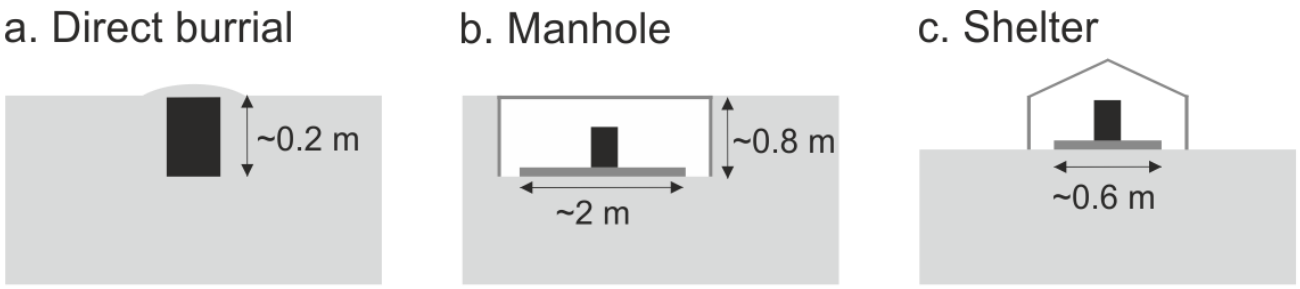


Slab soil-structure interaction effects

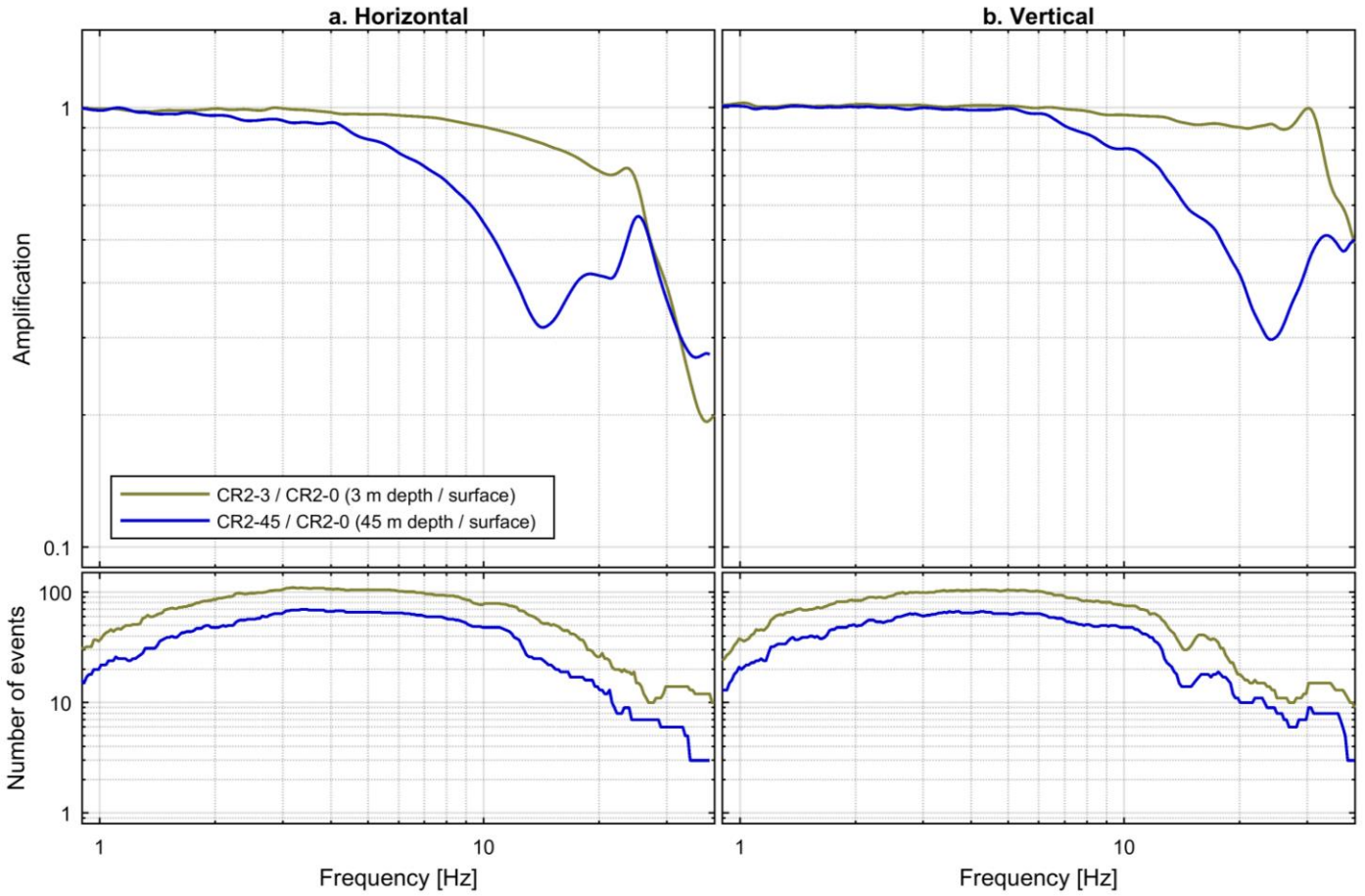


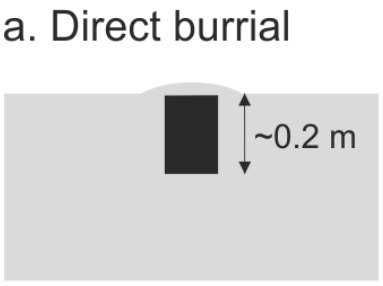
Soil sites: significant "soil-slab" interaction

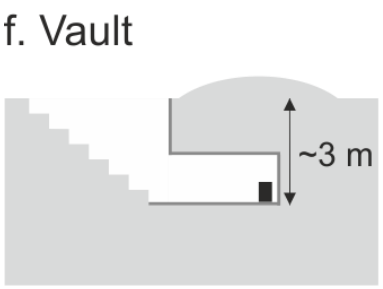
Rock sites: small or no "soil-slab" interaction, (same order of magnitude than spatial variability?)

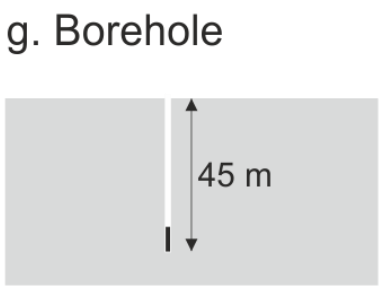


Depth effects









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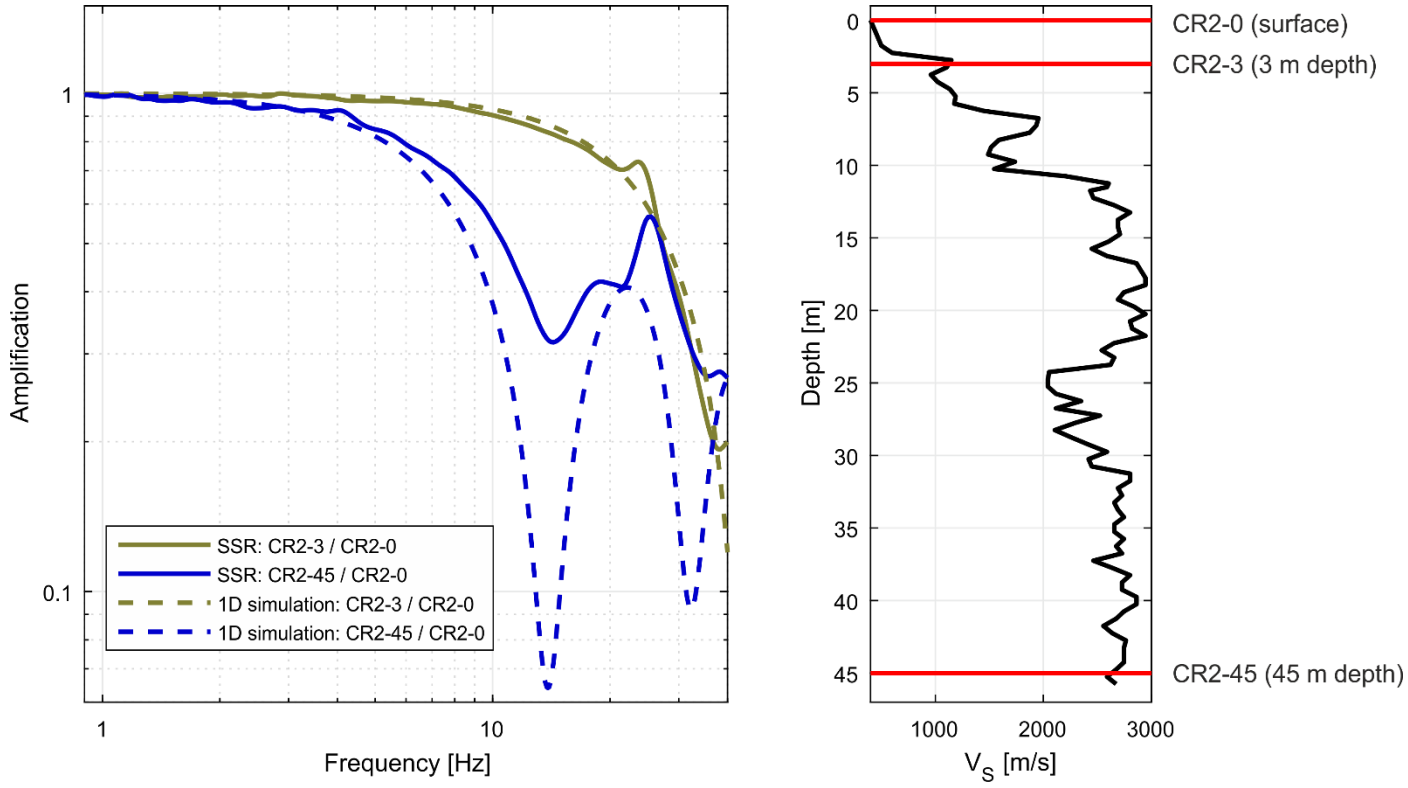

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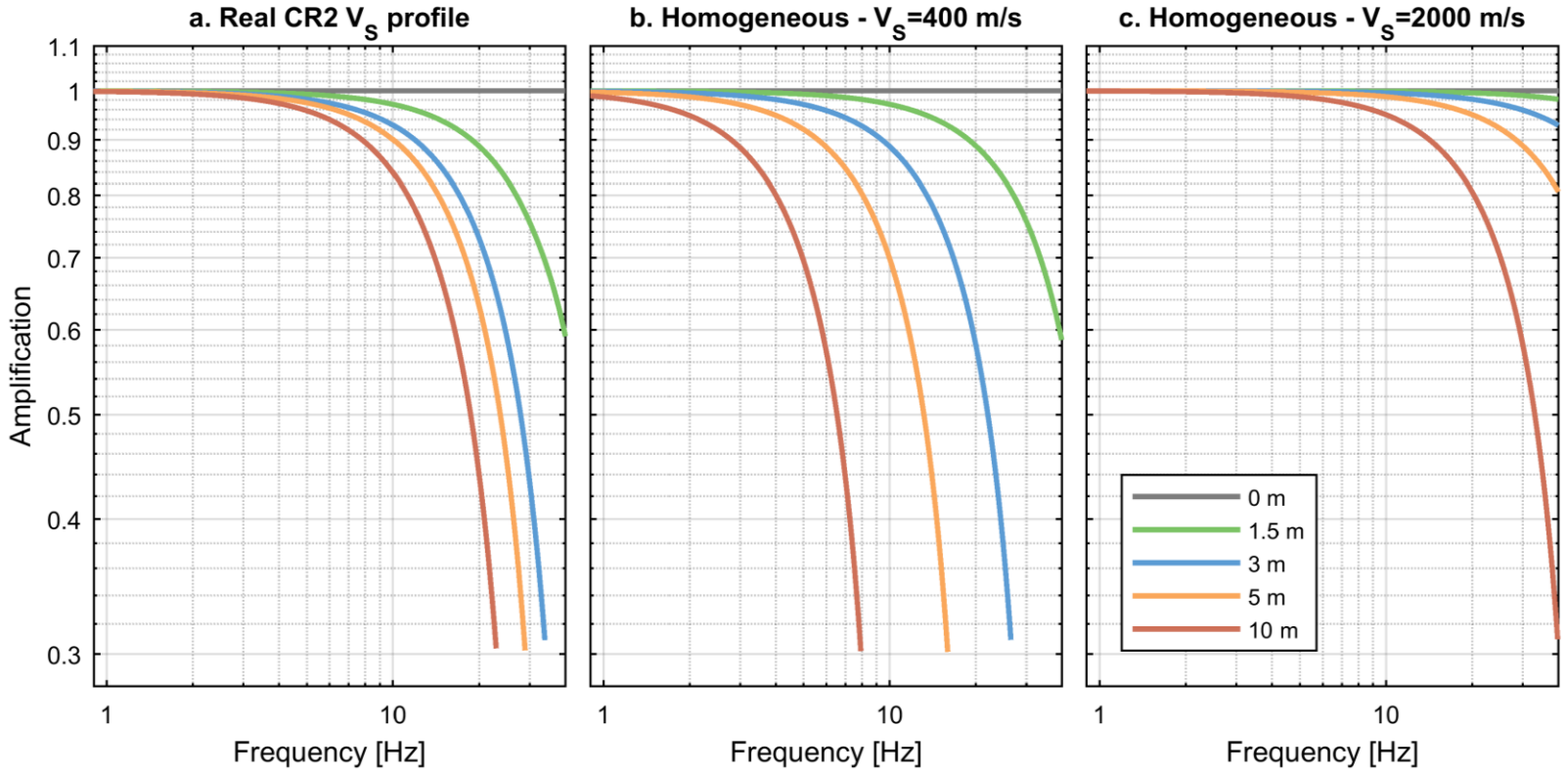
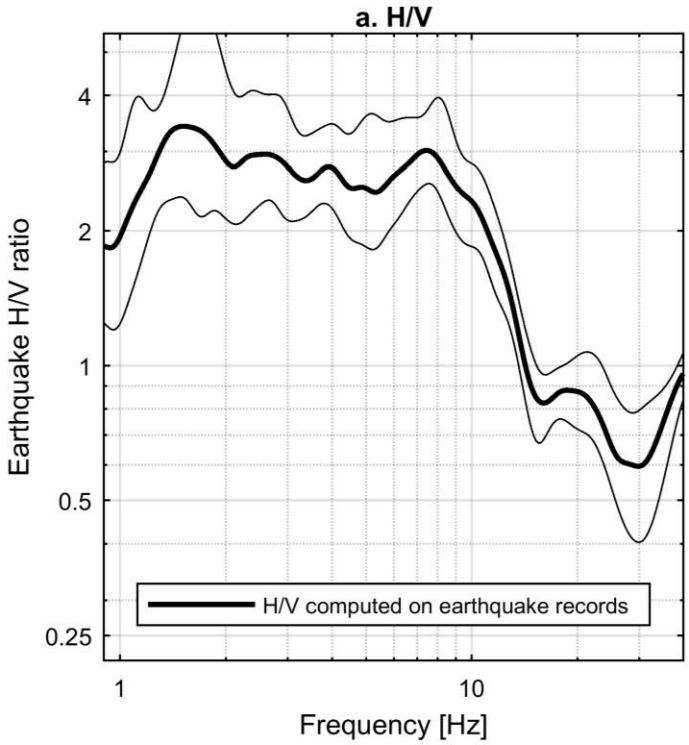
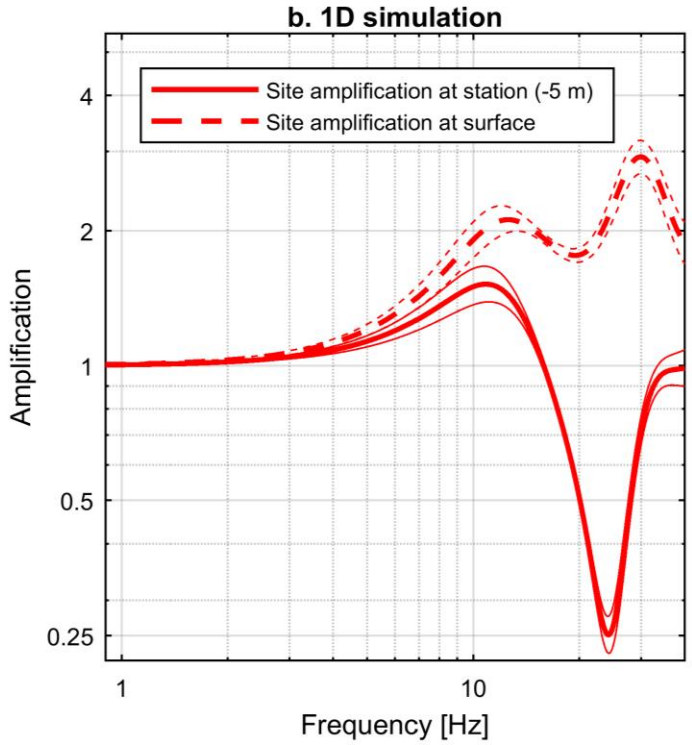


Depth effects: GRN RAP station





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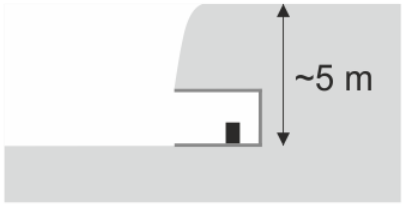
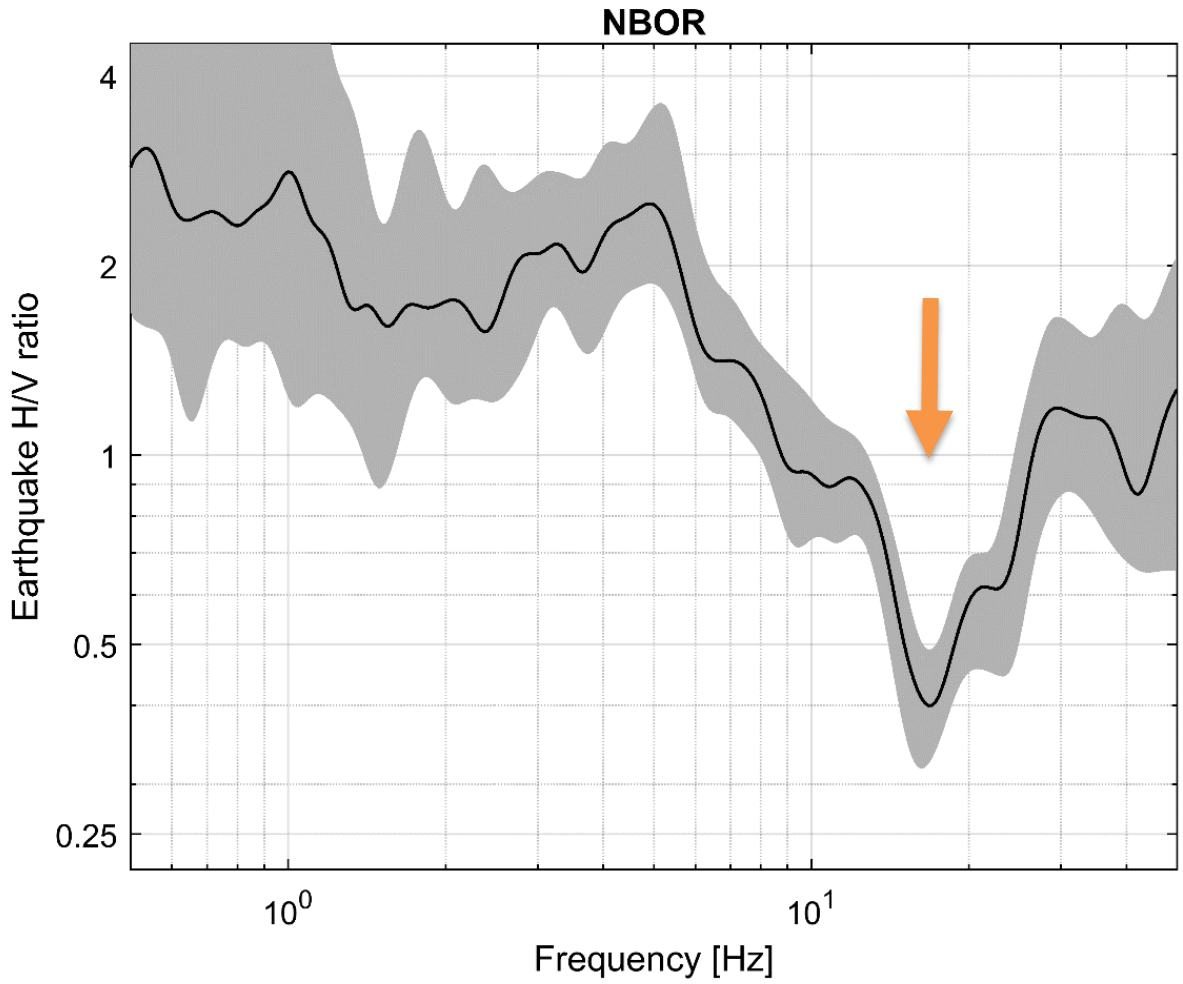


Depth effects: NBOR RAP station



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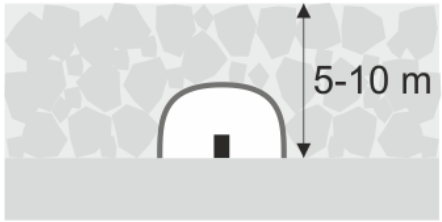

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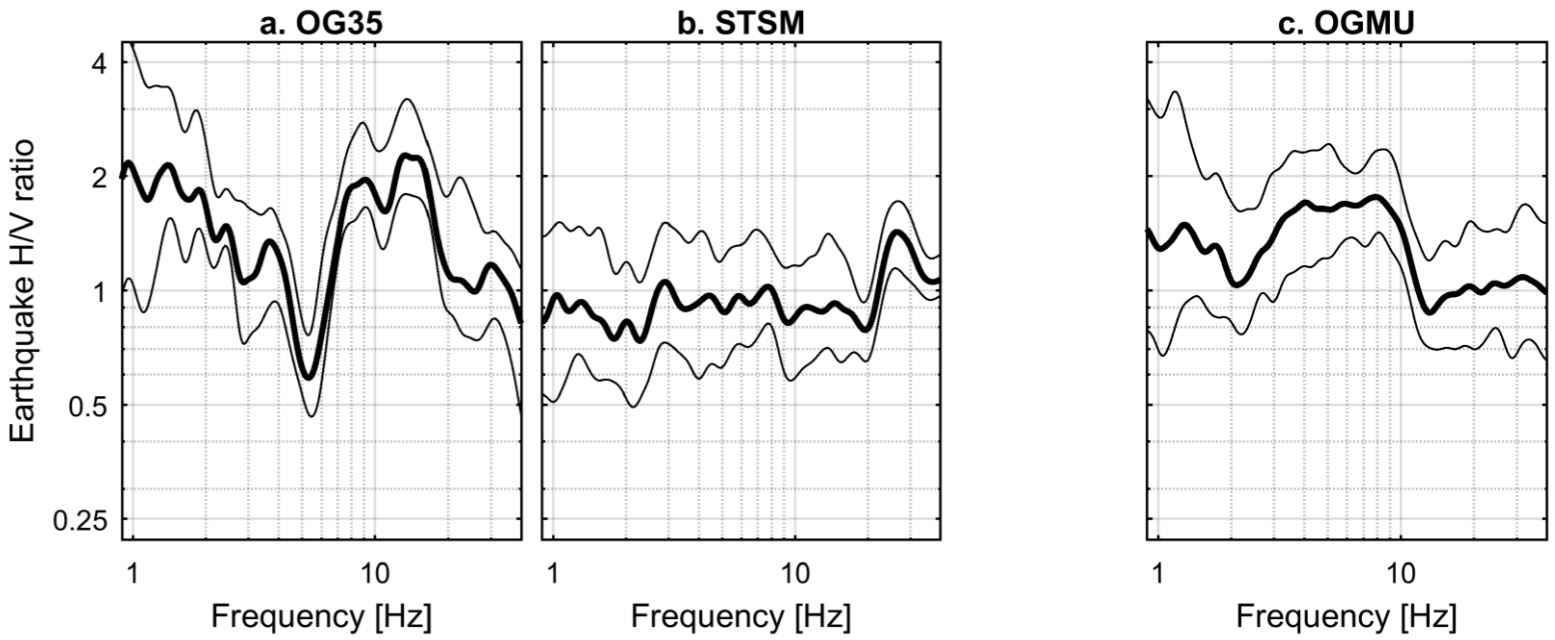

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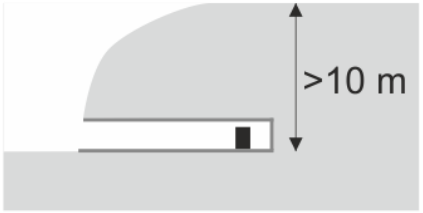

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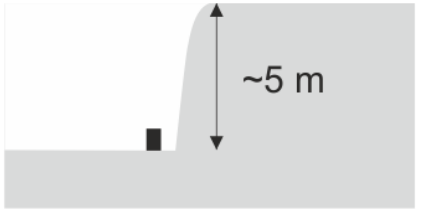
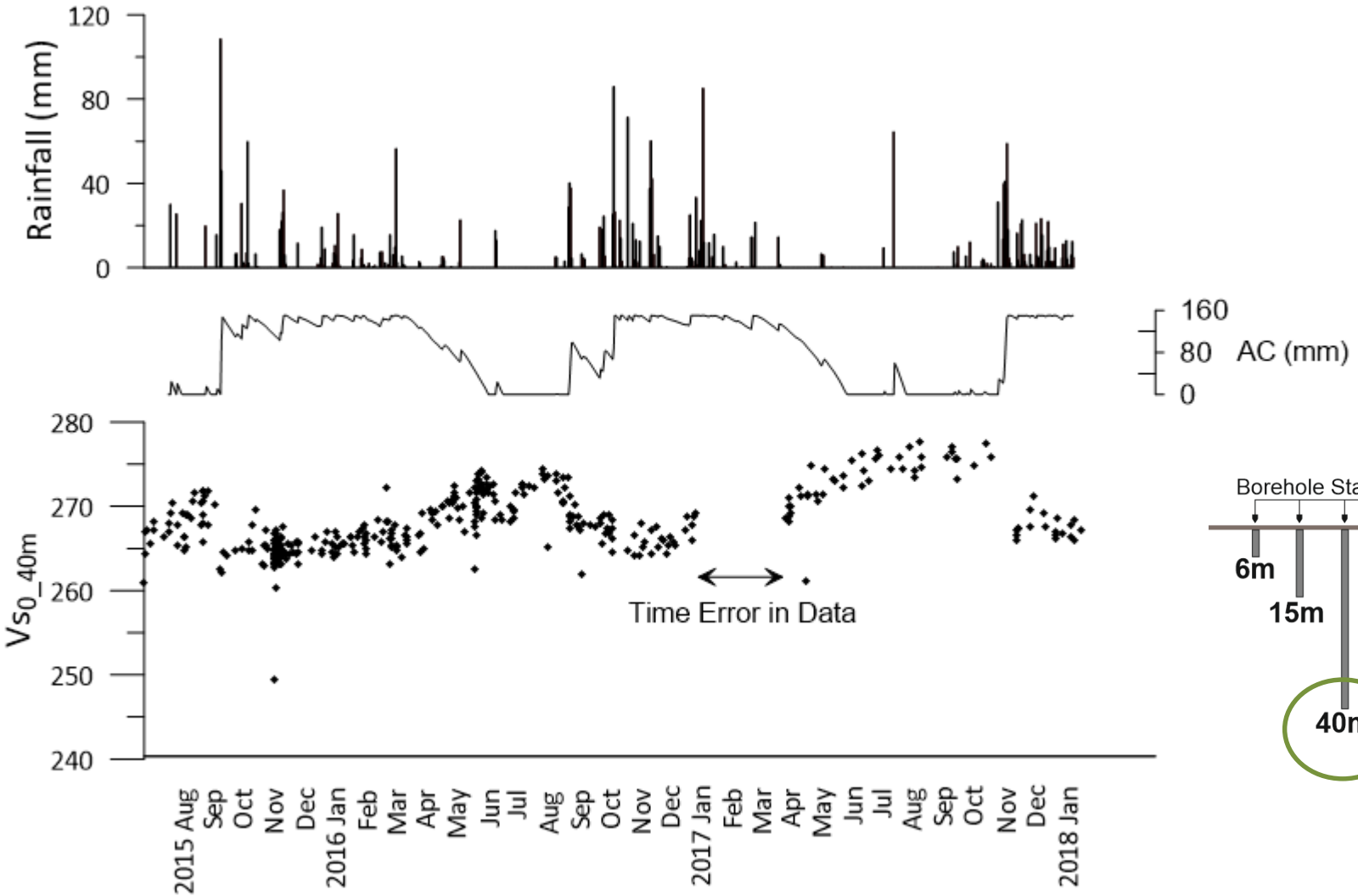


Seasonal variations



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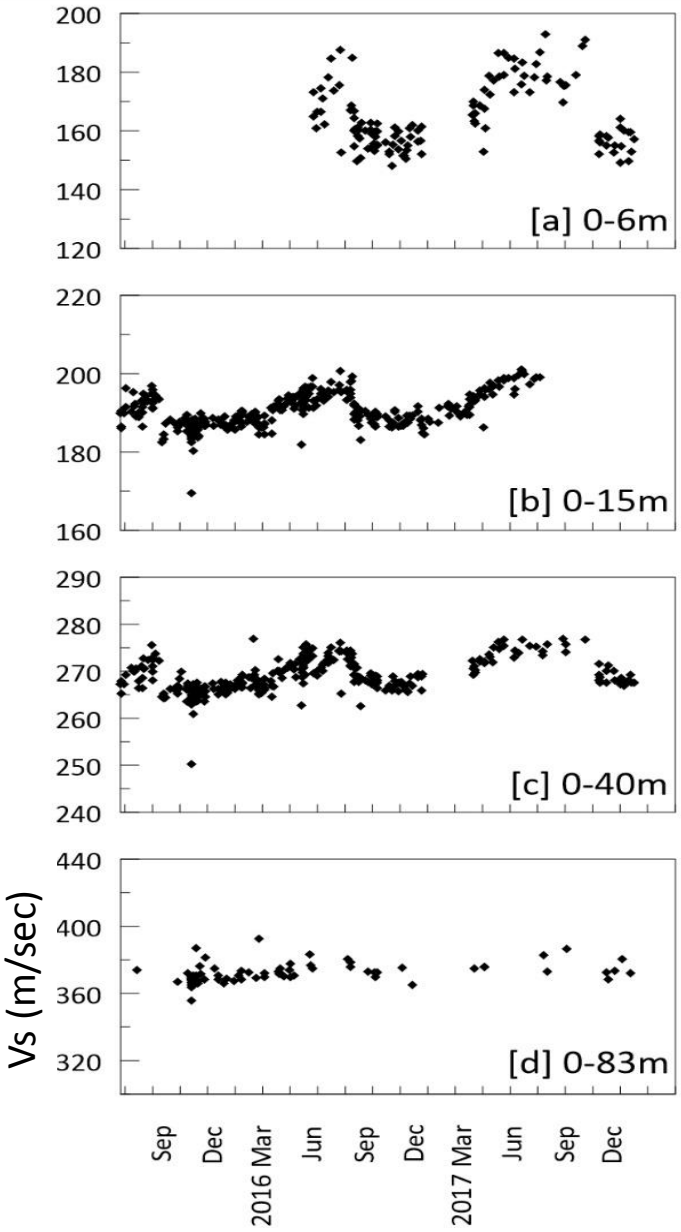
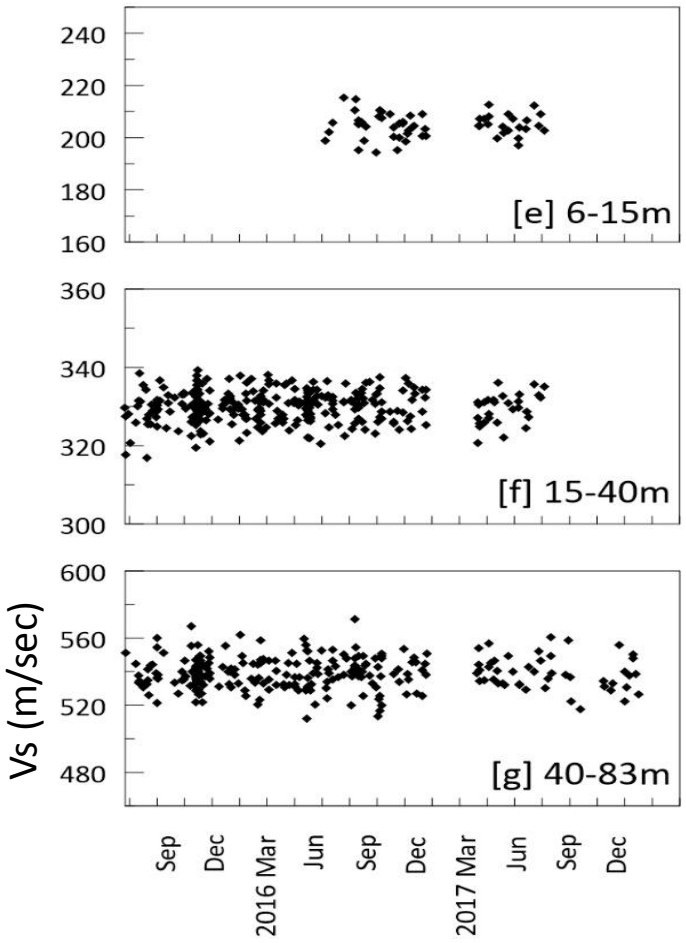
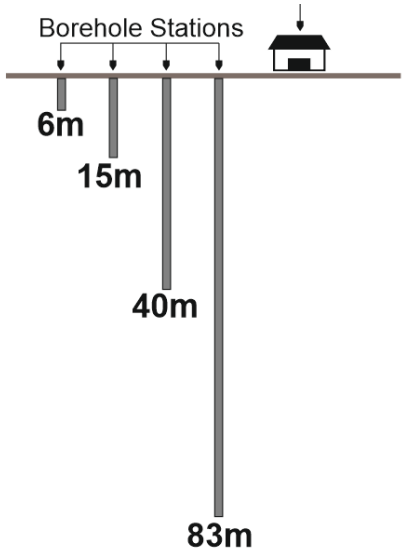


Vs variation seems to be restricted within the very top few meters





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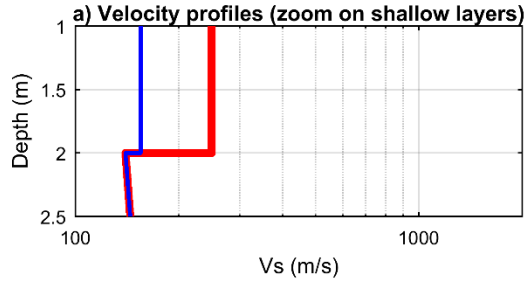
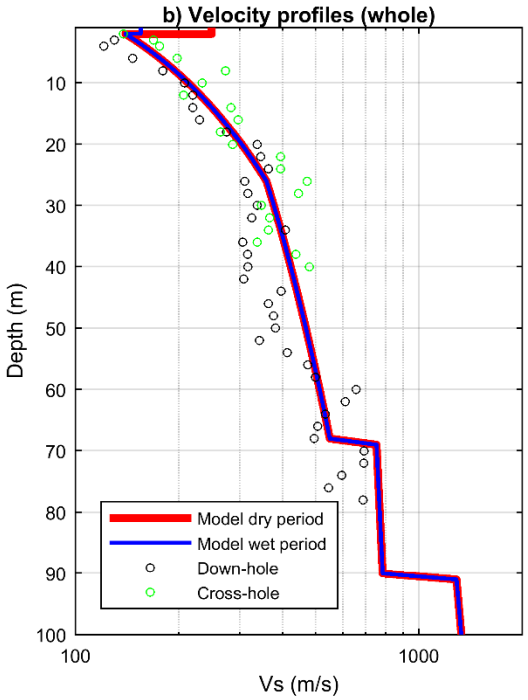
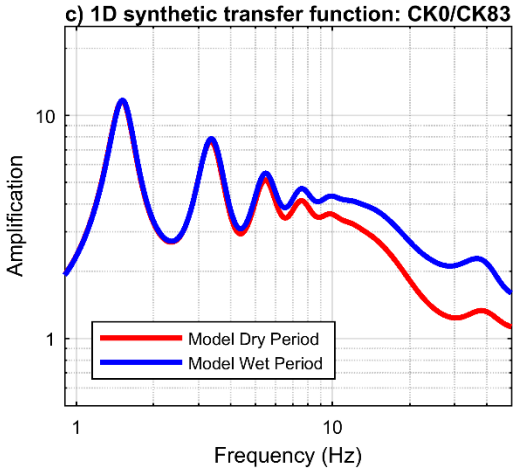
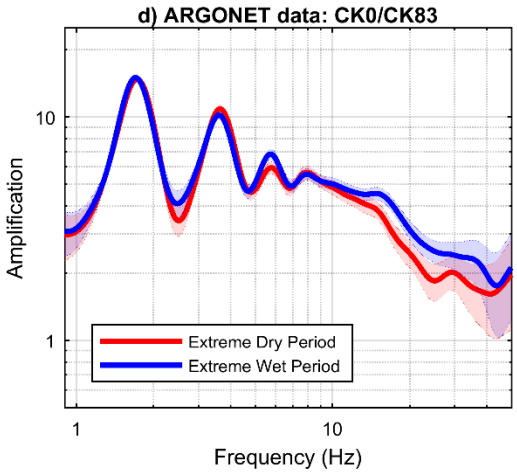
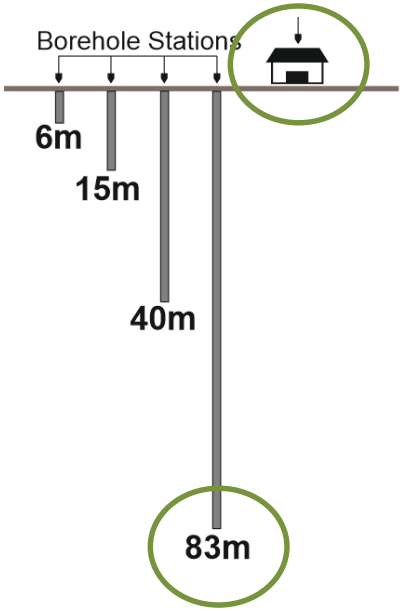


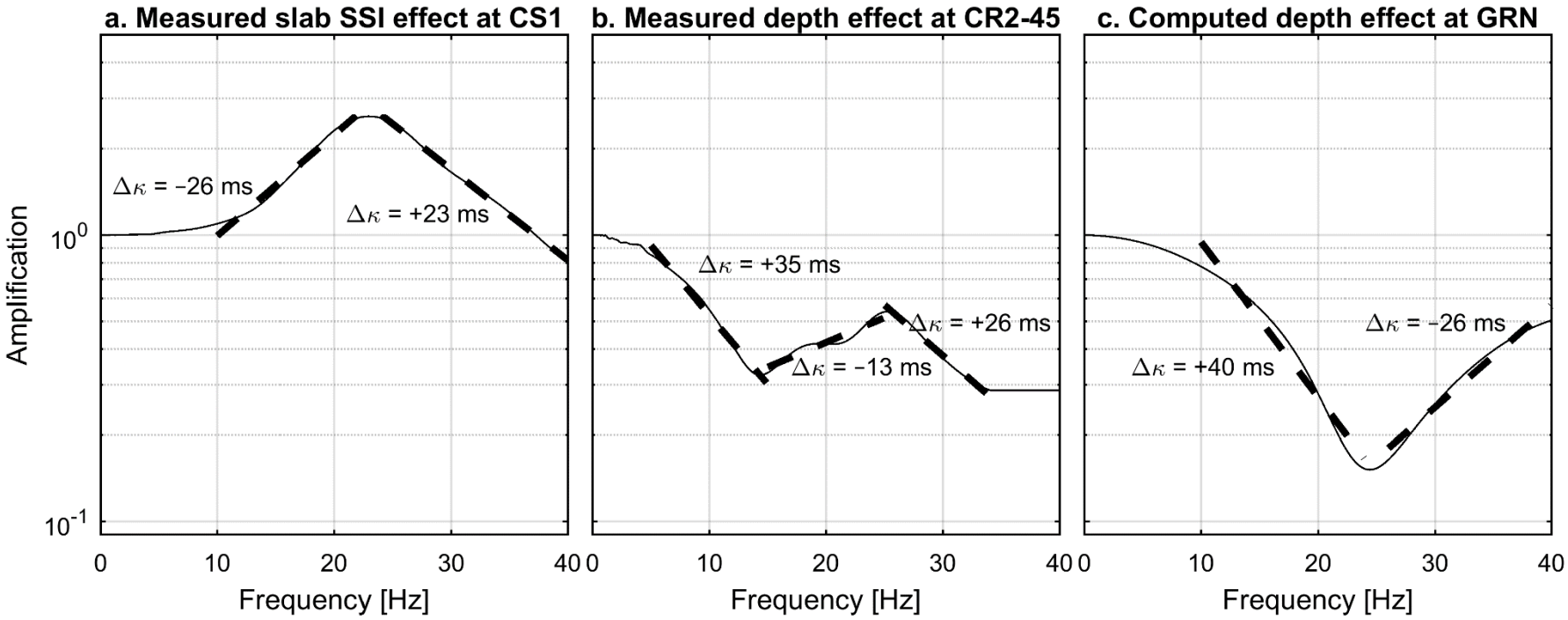




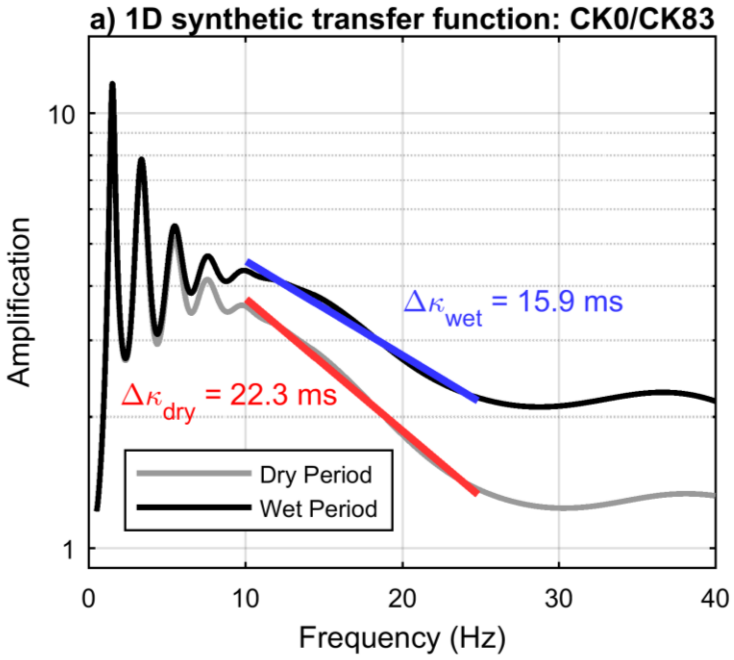


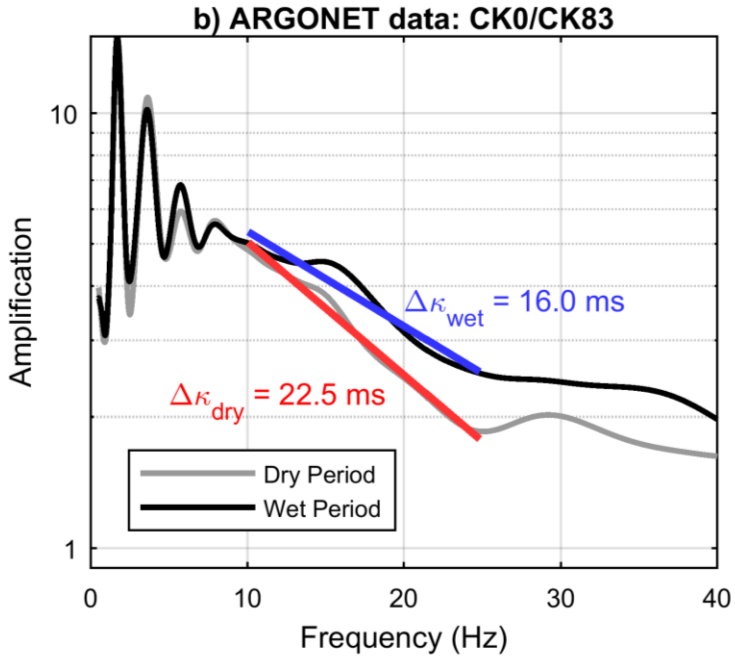


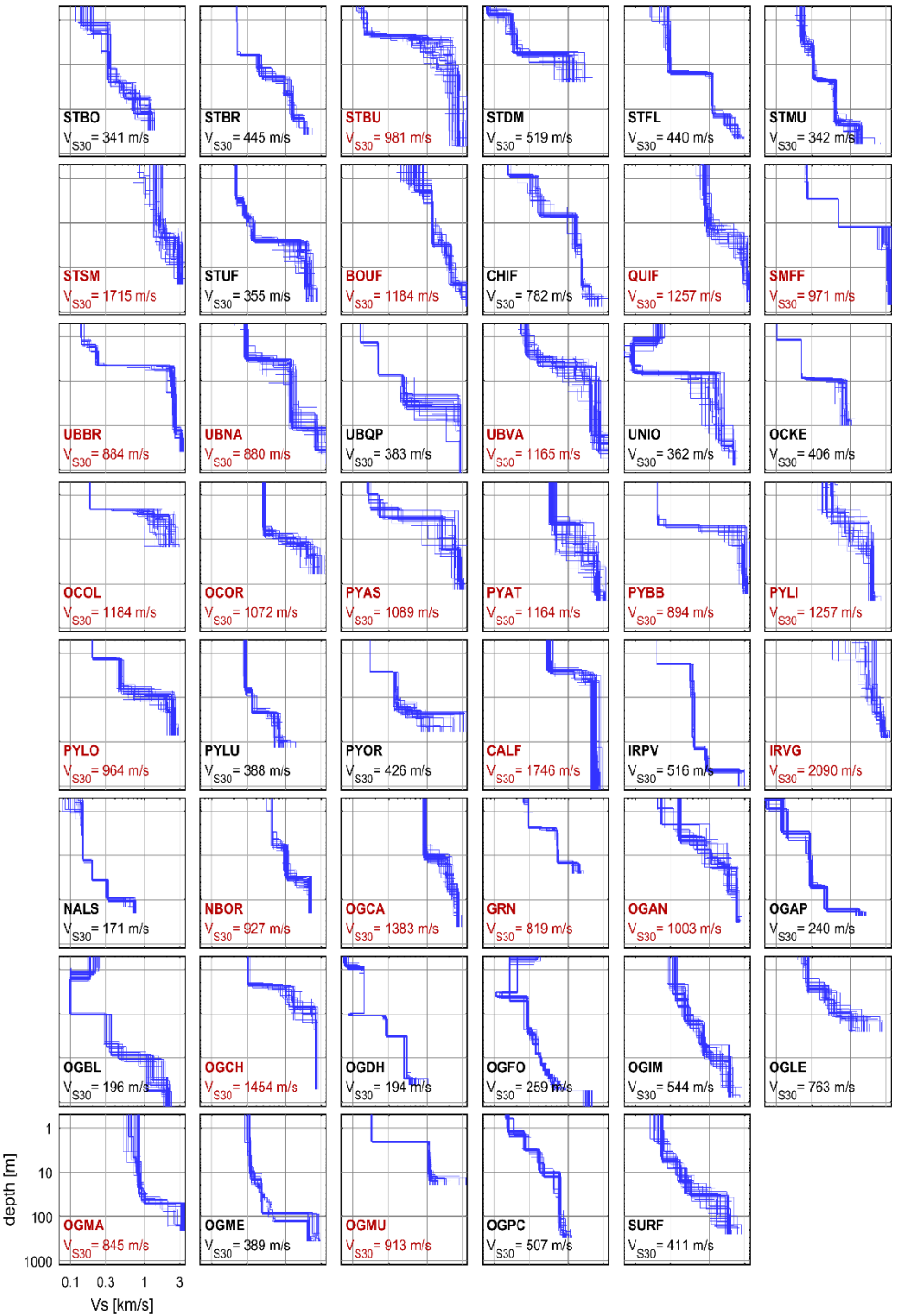
Effects on ‘kappa’ (slab and depth effects)

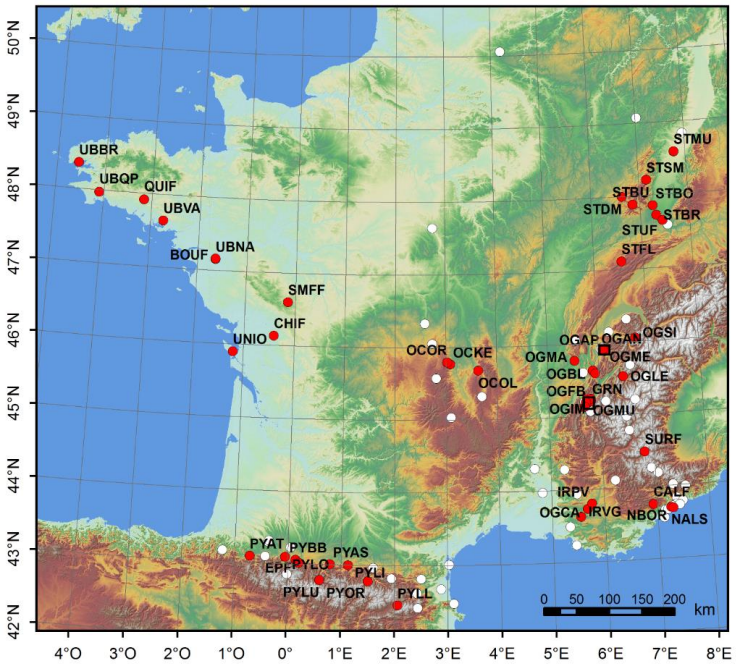


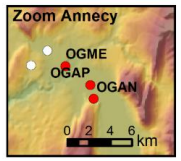
Effects on ‘kappa’ (seasonal variation)

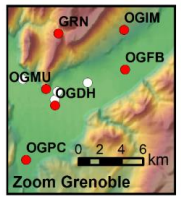








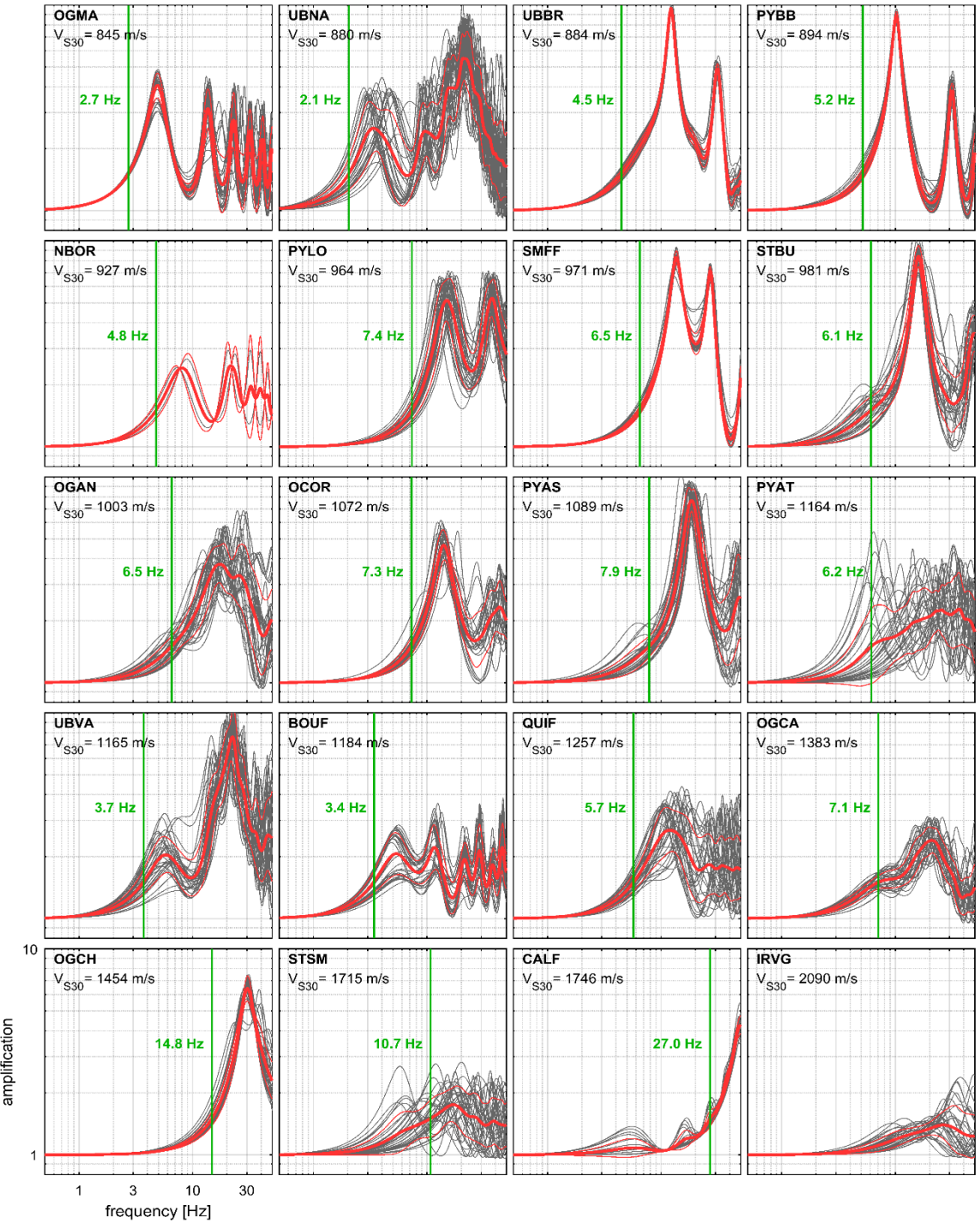




● Stations caractérisées
○ Autres stations

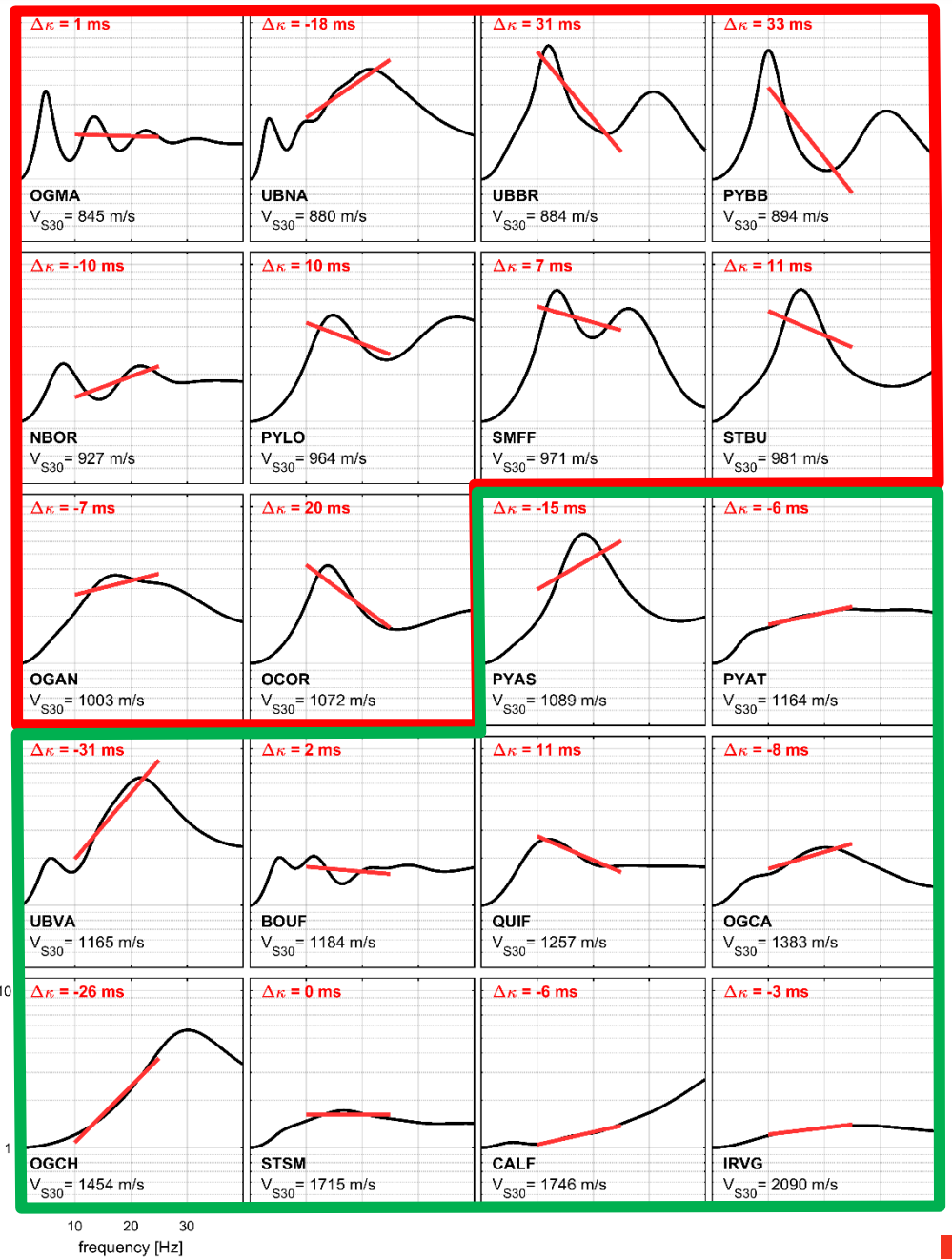
Homogeneous site does not exist!

RAP station V_S profiles



1D transfer functions for 20 RAP A-class stations

Effects on ‘kappa’: soil response of rock and hard-rock site



‘standard’ rock
mean Δκ = + 8 ms
mean V_{S30} = 940 m/s

16 ms

‘hard’ rock :
mean Δκ = - 8 ms
mean V_{S30} = 1420 m/s

Conclusions

- High frequency in ground motion recordings: crucial for heterogeneity studies
- Slab SSI and depth effects can have a strong impact on HF content of recordings from strong motion (and other) databases
- Seasonal variations can add variability in site response HF measurements
- Measuring kappa without any perturbing effects (SSI, depth, amplification due to shallow weathered layers) could only be done on very, very, very few stations
- The observed statistical difference between ‘standard-rock kappa’ and ‘hard-rock kappa’ is likely due to local amplification (and not due to attenuation differences)