Activities for ET site studies

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Our site search throughout Europe







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What makes a good site?

• Low seismic PSD:

 $\sqrt{P_{xx}(f)} = 5 \times 10^{-10} / f^2 \quad [m/\sqrt{Hz}], \quad 1 < f < 10 \text{ Hz}$

- This corresponds to an RMS displacement of 0.1 nm @ 2 Hz.
- Soil dispersion and seismic correlations



⇒ Since we would like to using subtraction techniques for NN suppression it will be of great importance to also characterize the soil coherence.



18 measurement sites in 11 countries

Suomi	Mr. Carl	Location	Depth [m]	Elev. [m]	Seis. RMS [nm]	Basic geological
WA MT OND MN Sverige Sweden Finland	50000				$(f_c = 2 \text{ Hz})$	description
OR ID WY SD WI MI NY	J 14 .	Spain	900	1600	0.070	Hard rock
NV UT CO KS MO WW		- LSC, Canfranc				
CA OK AR TN NC DE N Bothnia	Acmon ACT	Italy	185	205	0.077	Hard rock
TX GA Uppsala Helsinki	Akita 秋田 Monoka	- Sardinia				
Guit of FL Stockholm O	Nigeta	Hungary	400	400	0.082	Hard rock
México Mexico Baltic Sea Japa		- Gyöngyösoroszi	70	400	0.12	
	ku 最好 花椒	France	1750	1000	0.10	Hard rock
North Sea	O Nagoya 東京 名古屋 O	- Frejus	1000	9 F 0	0.11	TT 1 1
Glasgow o Cedinburgh Danmark O Malmo 中心 Cmmark	Shizuoka Tsu mitti	Japan	1000	358	0.11	Hard rock
Belfast Manchester Hamburg Szczecin		- Kamloka Finland	0	195	0.11	Surface real
Ireland Liverpool		Sumisinon	0	165	0.11	Surface rock
Birmingham London O And Inds H ver Pols Reporting	and the second sec	- Sumanen Italy	1400	970	0.13	Hard rock
Belgique Germany Kraków	Kuis) Kharkov (Xapkis)	- Gran Sasso	1400	510	0.10	Hard TOCK
Celtic Sea Brest	Україна Опергорети	Germany	95	850	0.20	Granite
Rennes OV Munchen Wien Slove 4ko Strasbourg Osterreich Moldov	Ukraine O ODor	- Black forest				
Nantes France Vaduz Austria Magyarország	(Sanopixoka)	USA	1250	350	0.21	Hard rock
Bay of Limoges O Lyo Milano Venezia Beograd Româna Biscay Torino O P Hrvatska (Georpau) Romania	Odessa Odeca)	- Homestake mine	610	990	0.39	
Bordeaux Tole e Montpellier ONice Italia Croatia Cрбија OBucures	Black See	Romania	190	195	0.25^{\dagger}	Salt
Vigo Valladolid Zaradoza Marseille (Capajeeo), Or България Prishtine, Rulgaria	Black Sea	- Slănic-Prahova				
Porto Madrid Barcelona Roma Bari Tirane Thessaloniki O	stanbul Samsun	Germany	35	455	0.70	Hard rock
Portugal España o O Sea ExAóc Bursa	kisehir Torking	- Moxa				
Spain Valencia Pa Lisboa Sevilla Murcia Pa	Konya Turkey	Netherlands	10	135	1.07	Surface rock
Carla Catania (A6ryog)	o o Gazi	- Heimansgroeve	220	20 7	2.10	
		Belgium	230	-205	2.10	Clay
		- Mol	0	140	2 70	C - l'an and a march
		USA LICO Hanford	0	142	3.79	Sedimentary rock
		- LIGO, Hallioru	0	64	4.03	Sodimontary rock
		- GEO600 Sarstedt	0	04	4.05	Sedimentary TOCK
		USA	0	-7	4.34	Sedimentary soil
		- LIGO Livingston	0	•	1.01	Seamentary son
		Italy	60	-30	9.24^{\dagger}	Salt
		- Sicily				
		Italy	0	52	26.8	Sedimentary soil



- Virgo, Pisa

Site comparison







VEBSN data @ Heimansgroeve







Correlation measurements (week 26, 2012)







Correlation and coherence



- X_n = Fourier transformed displacement of sensor *n*
 - = Complex conjugate
- $\langle \cdot \rangle$ = Ensemble average



Extracting velocity information from the data

We can try to fit the correlation using velocity as the only free parameter:

 $Re[K_{12}(\omega)] = J_0[\omega \Delta z / c_r(\omega)]$

The resulting measured velocity profile gives an exponential fit

 $c_R(f) = 150 + 1000e^{-f/1.5}$



G. H. F. Gardner, L. W. Gardner, and A. R. Gregory. Formation velocity and density—the diagnostic basics for stratigraphic traps. Geophysics, 39(6):770–780, 1974.



Extracting soil density information





Work done on sensing arrays



0 0 50 Mirror displacement [nm] 100

150







-150

-100

-50

-200

Signal Amplitude [V]

O

-2



200

-Ramp / 5 Difference

Summary

- We concluded the preliminary site selection program
- We aim to start long-term site characterizations, where we map soil characteristics like coherence.
- For this, we are developing various seismic sensors aimed for Newtonian noise subtraction schemes.
- By the end of this year we aim to have our first sensor grid up and running.

