Enjeux de réseaux hyper-denses pour l'estimation du risque sismique

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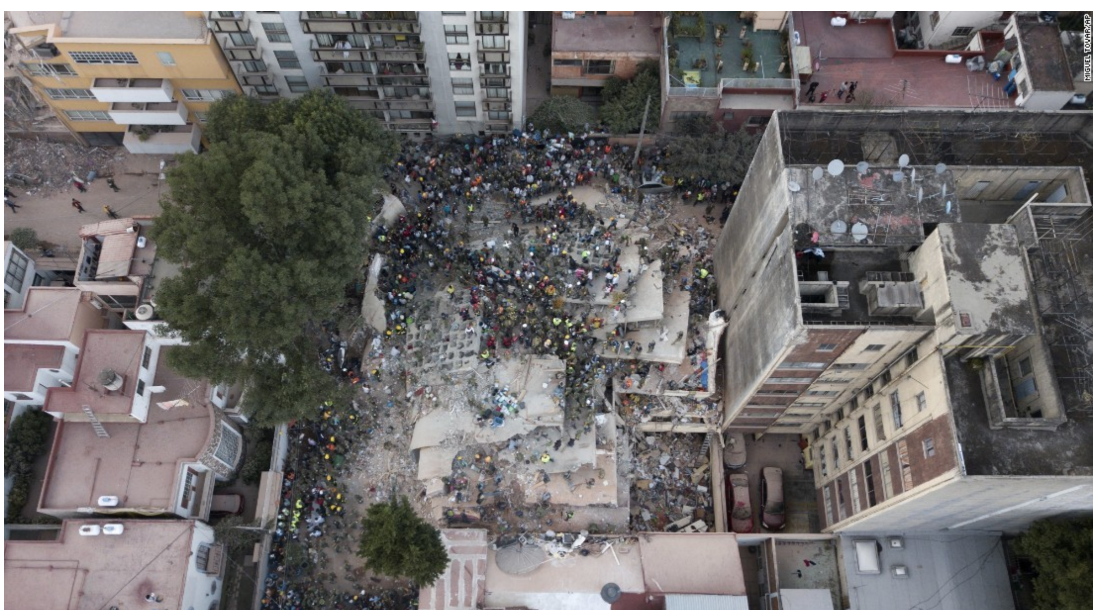
Earthquake damages

- Spatial variability of damages : < 100 m !
- Physical processes: source (near field), site effects (linear, non-linear), motion polarization/geometry, structural vulnerability.
- How to distangle those effects?

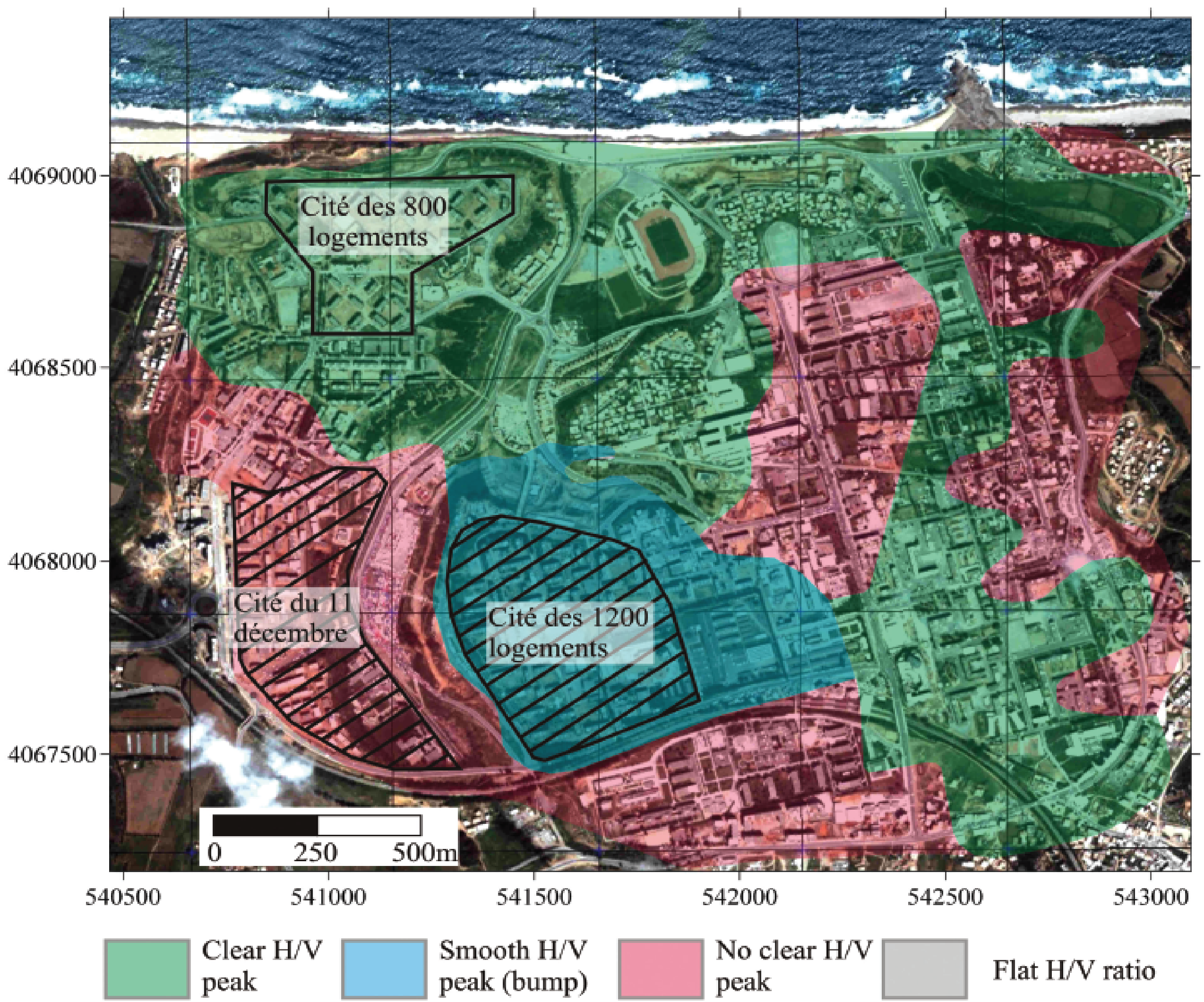
M6.8 Boumerdès, Algérie 2003

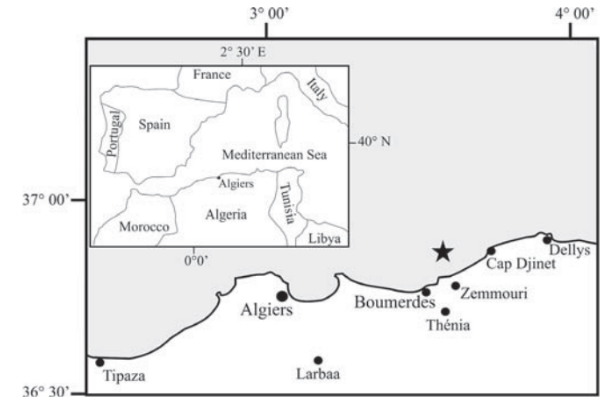


Mexico city, M7.1, Puebla eq 2017

M7.6 Izmit eq, Turquie 1999

M6.8 Boumerdès eq, Algérie 2003





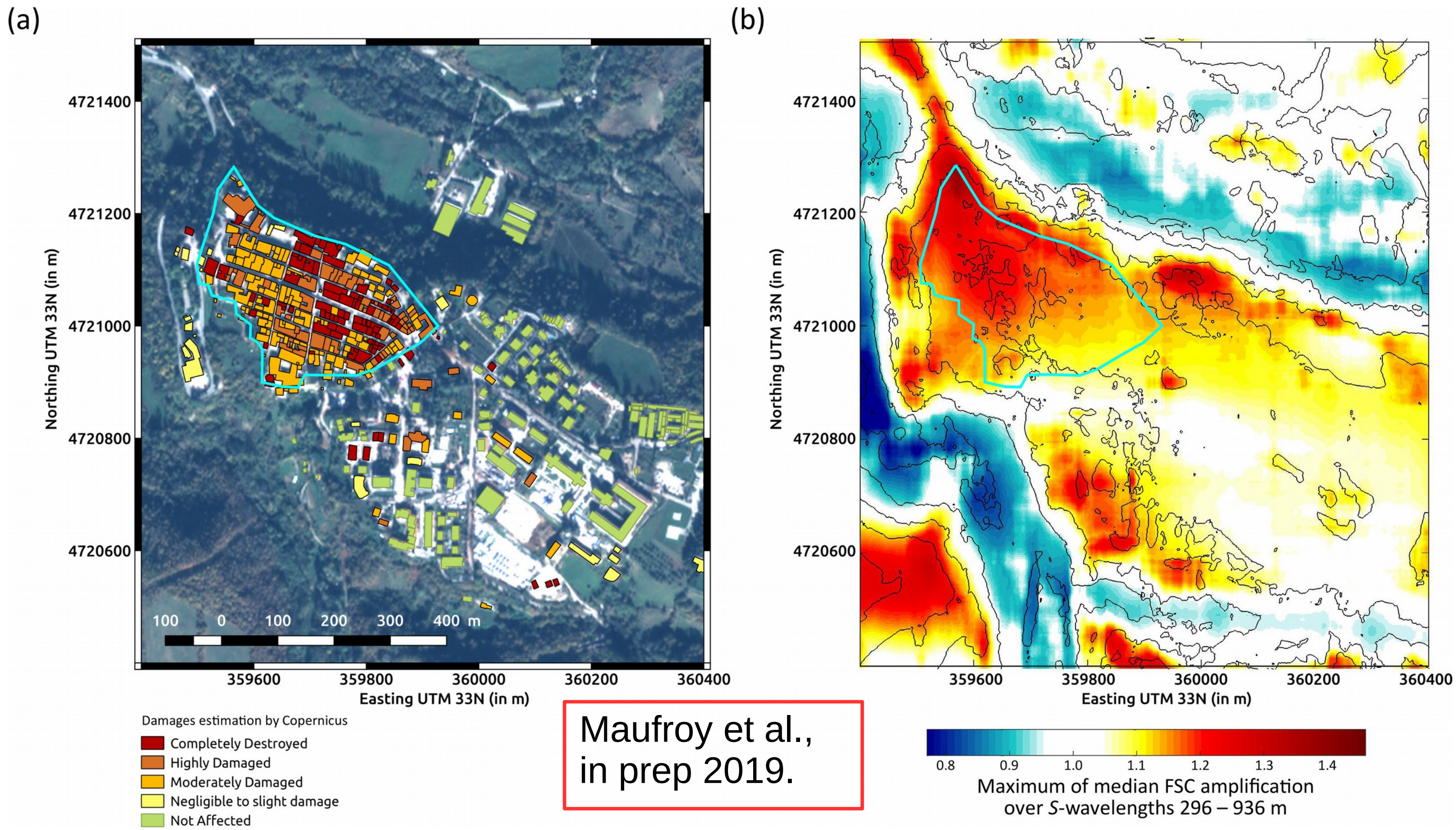
Depth = ~10 km
Dist to fault < 20 km

« Heavier Damages without Site Effects and Site Effects with Lighter Damages ...»

Hellel et al., 2010.

- No correlation between damages and 1D site effect proxy (H/V).
- Part of the damage variability caused by differences in vulnerability (structural defects).
- No EQ recordings available to go beyond.

M6.2 Amatrice eq, central Italy 2016



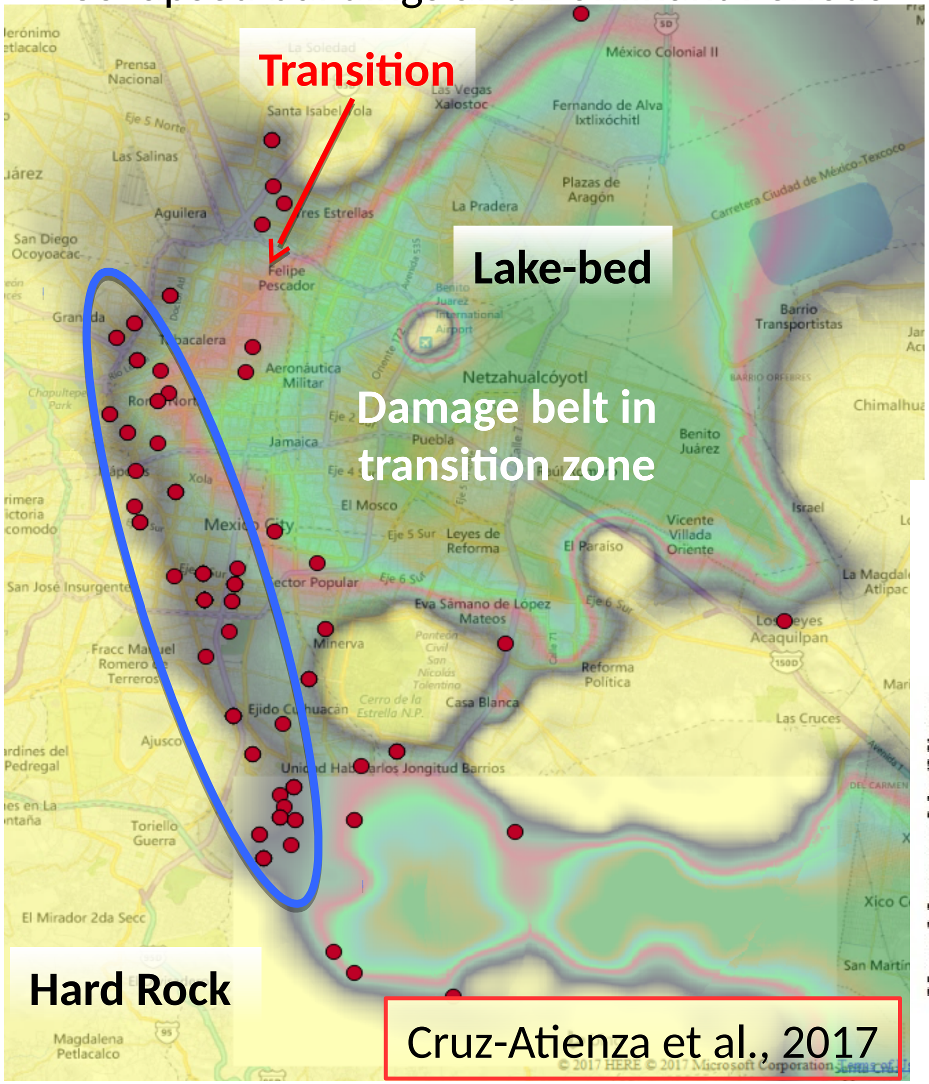
Maufroy et al., in prep 2019.

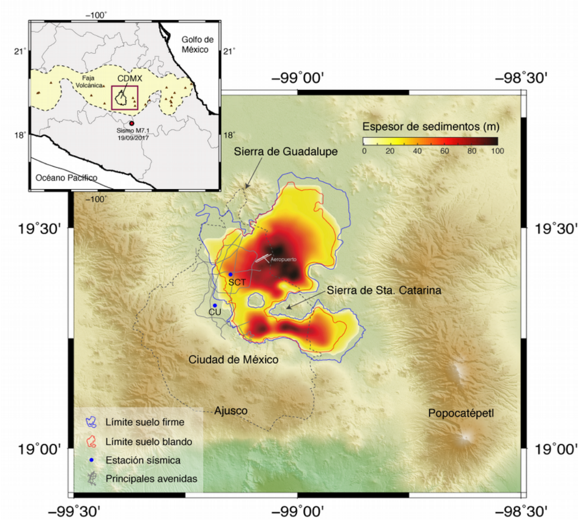
Damage distribution (**left**) correlates with that of topographical amplification proxy (**right**), but also corresponds to the most vulnerable building stock in the area.

No EQ recordings available to go beyond...

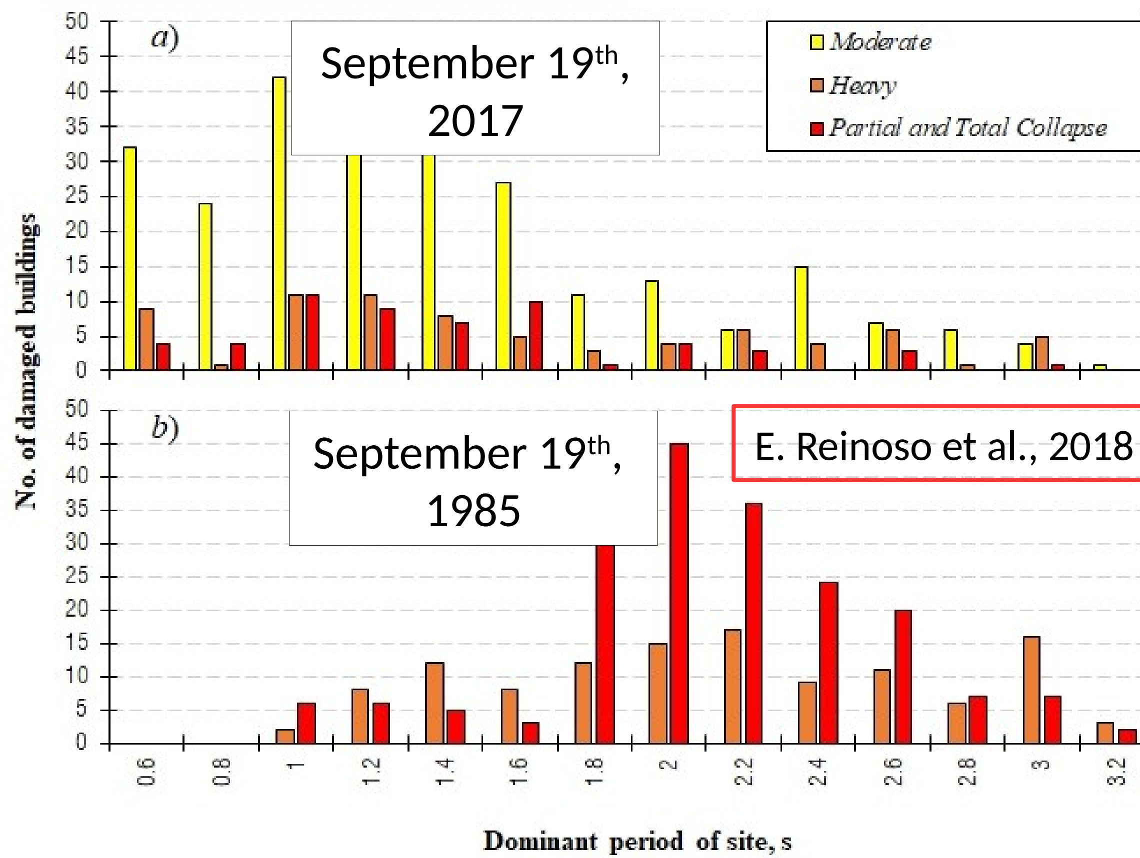
M7.1 Puebla eq, Mexico city, 2017

Collapsed buildings and Dominant Periods





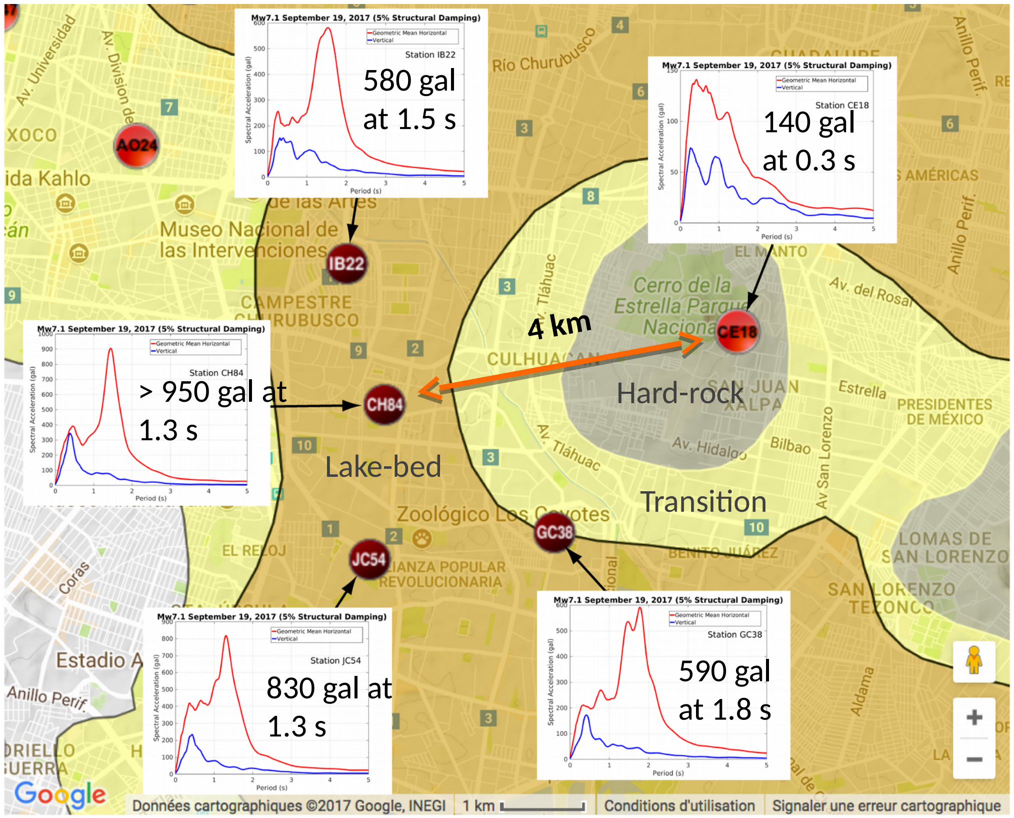
Intraslab event
Depth = 57 km
Dist = 114 km
SSE Mexico city



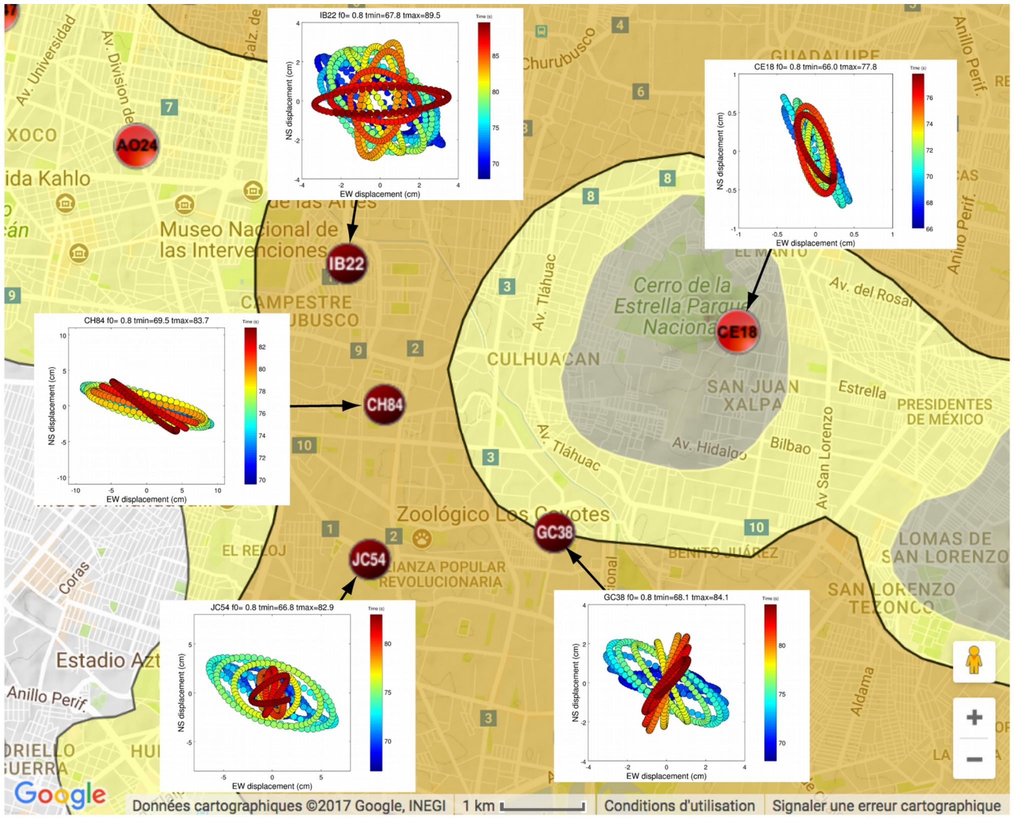
Damage zone close to basin edge coincides with areas with resonance periods between 1 s and 2 s.

M7.1 Puebla eq, Mexico city, 2017

Response Spectra (hard-rock vs. lake-bed)



Particle Motion Polarization at 1.3 s



74 strong motion records in the Valley of Mexico (RACM+RSVM)

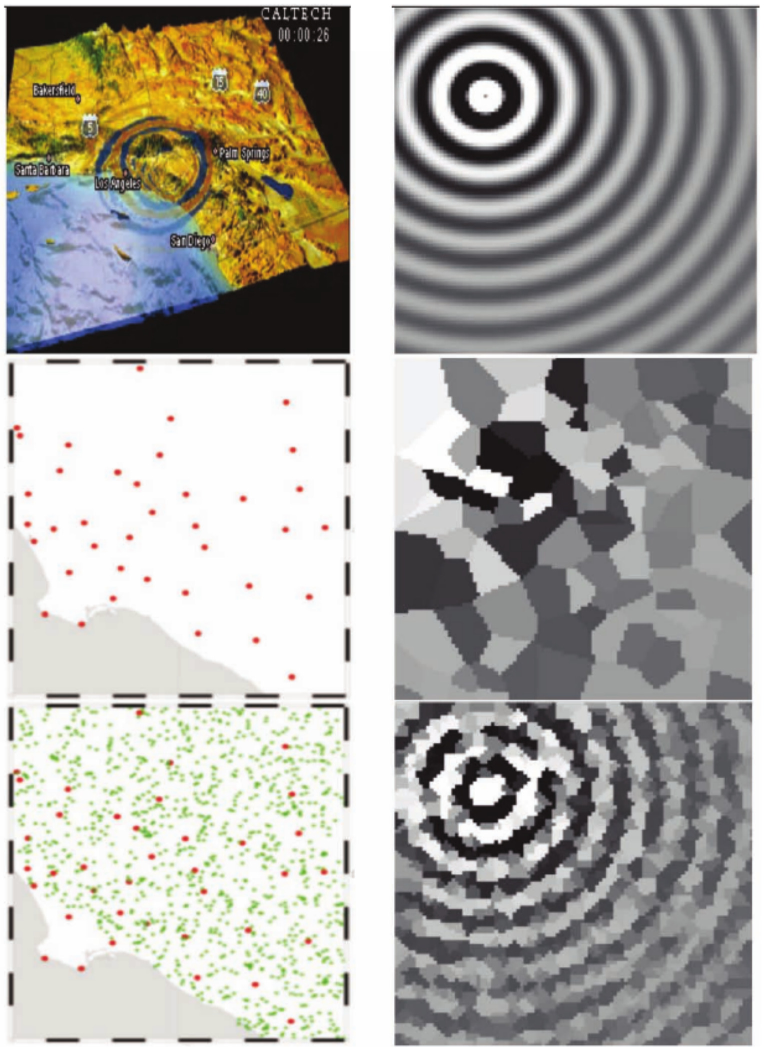
- Maximum SA (> 950 gal) at 1.3 s (> 15 times larger than at hard-rock)

- Strong phase polarization hardly compatible with 1D resonance.
- 3D basin structure induced surface waves suspected.
- Despite large **N** of measurements, difficult to go beyond.

One step beyond:

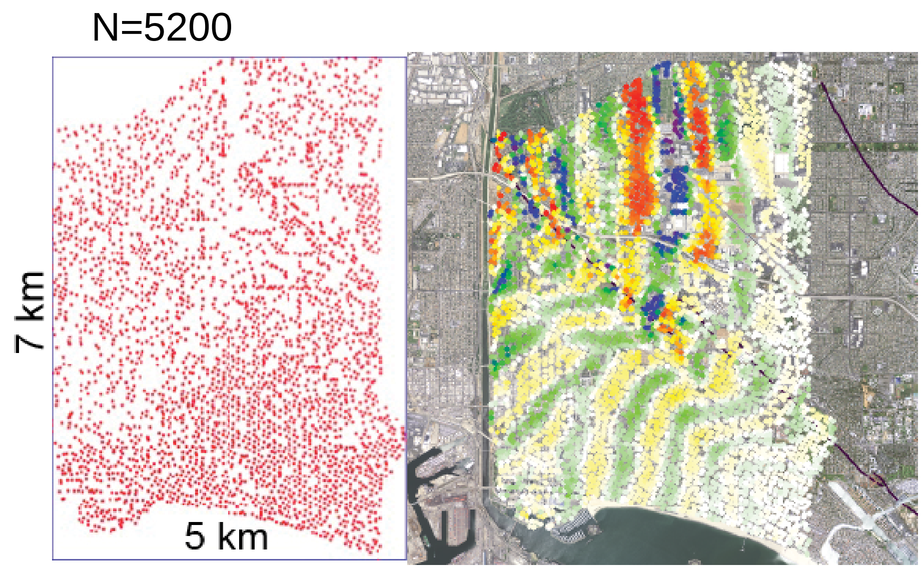
IRIS initiative 2014 –> ?

https://www.iris.edu/hq/initiatives/recording-the-full-seismic-wavefield



Clayton et al. 2011,
Community Seismic Network
Phidget 1043 + Raspberry-Pi 3b

2011 (100)
Project (1000)
+535 (2019)



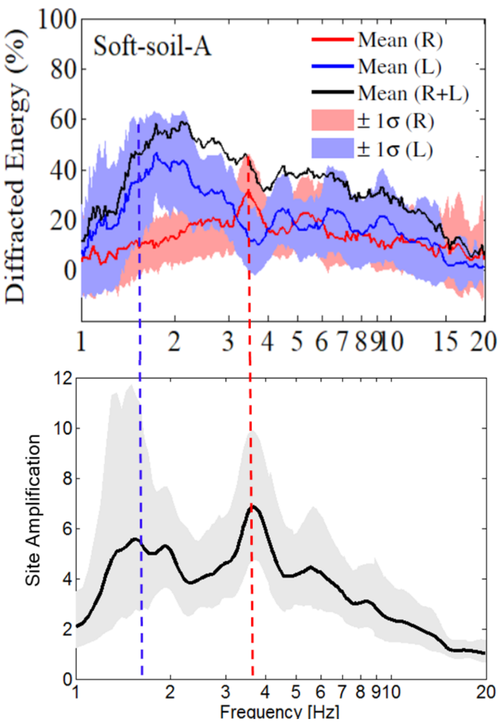
Long Beach array recording of a local (5km) M2.5 event, 2011

Low-cost sensors (MEMS) & long-term batteries. Fiber optic DAS.
=> Emergence of large N+T arrays

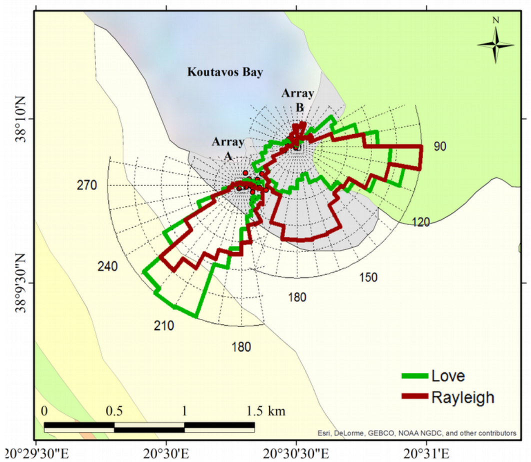
Studies so far: structural imaging-monitoring, seismicity detection-monitoring, S-wavefield from explosions (Large N source array, LLNL)
… but still **few seismic risk studies**.
Freq ~ [0.1 Hz – 20 Hz] **λ ~ [1m – 100m]**

Importance of seismic wavefield recordings for seismic risk applications

1 Characterize the **composition** of seismic wavefield (earthquakes, noise)



N = 20
Aperture = 160 m
Dmin = 5 m

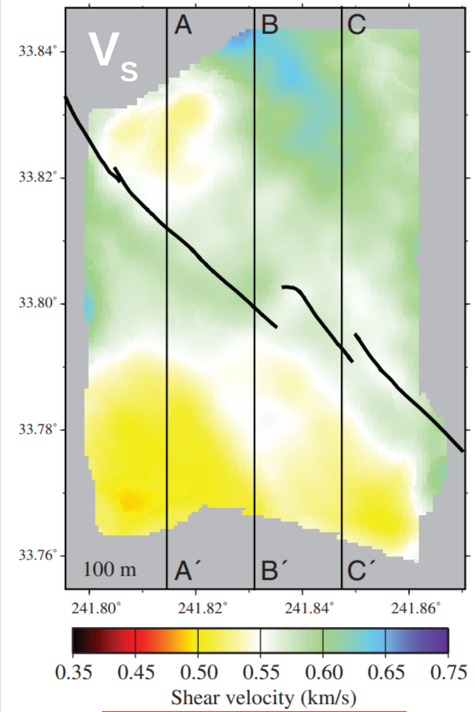


Imtiaz et al. 2019

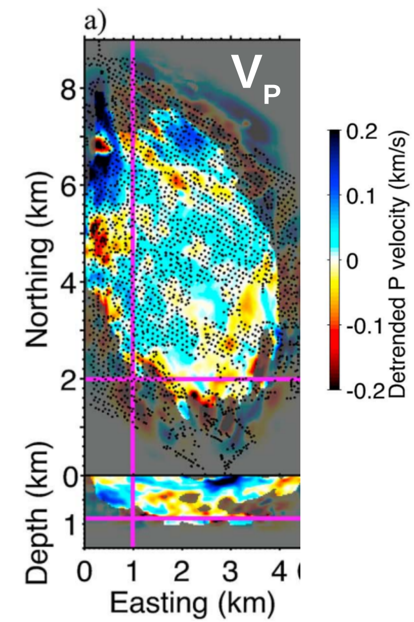
- Physical models of spatial variability
- Rotational motions excitation (torsion, rocking)
- Origin of strain levels for NL models
- Polarization models for NL studies
- Urban wavefields (site-city interactions)
- Amplification & attenuation from EQ & noise...

2 **Image** the propagation medium at small scales

Long Beach Array **noise** data



Lin et al., 2008

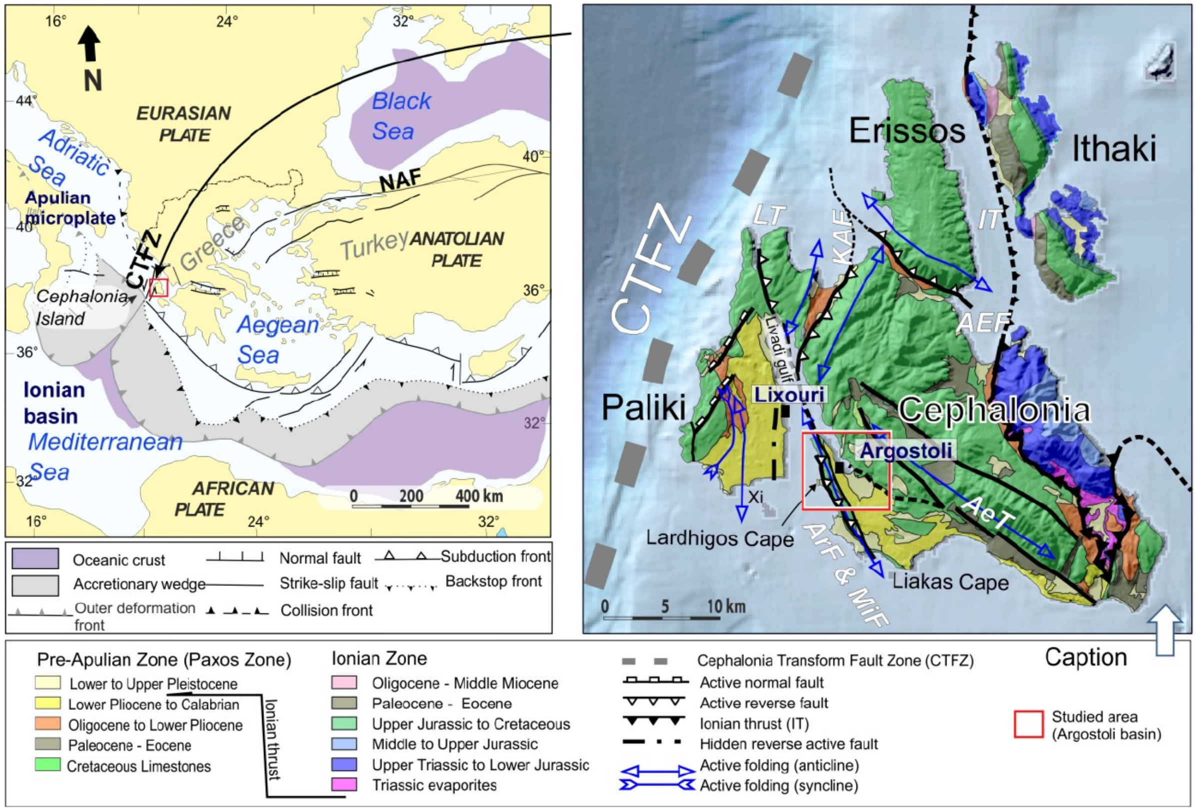


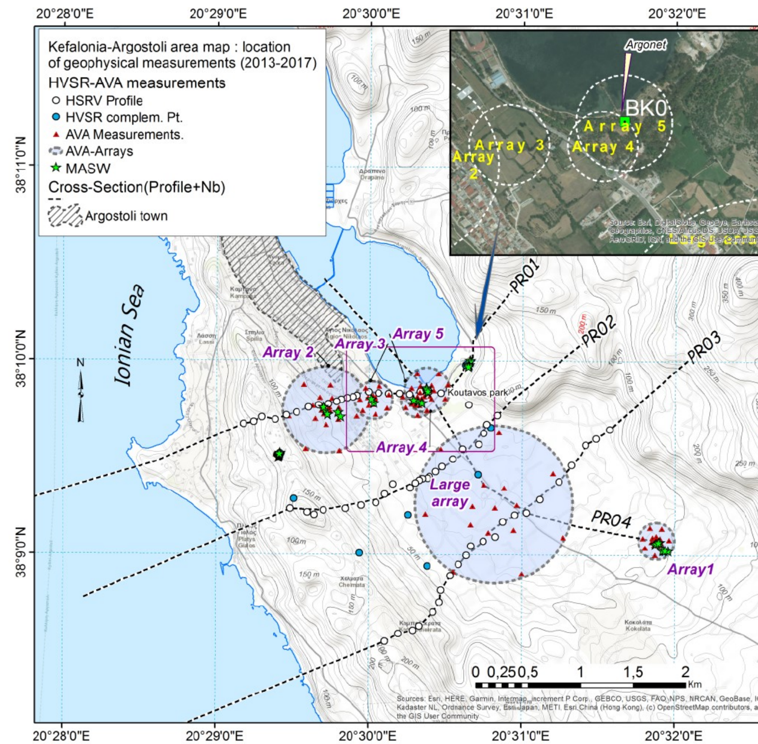
Nakata et al., 2015

+ Full waveform inversion from **EQ** data

Physics-based numerical predictions of Earthquake Ground Motion

A place to host a large N+T array: Argostoli

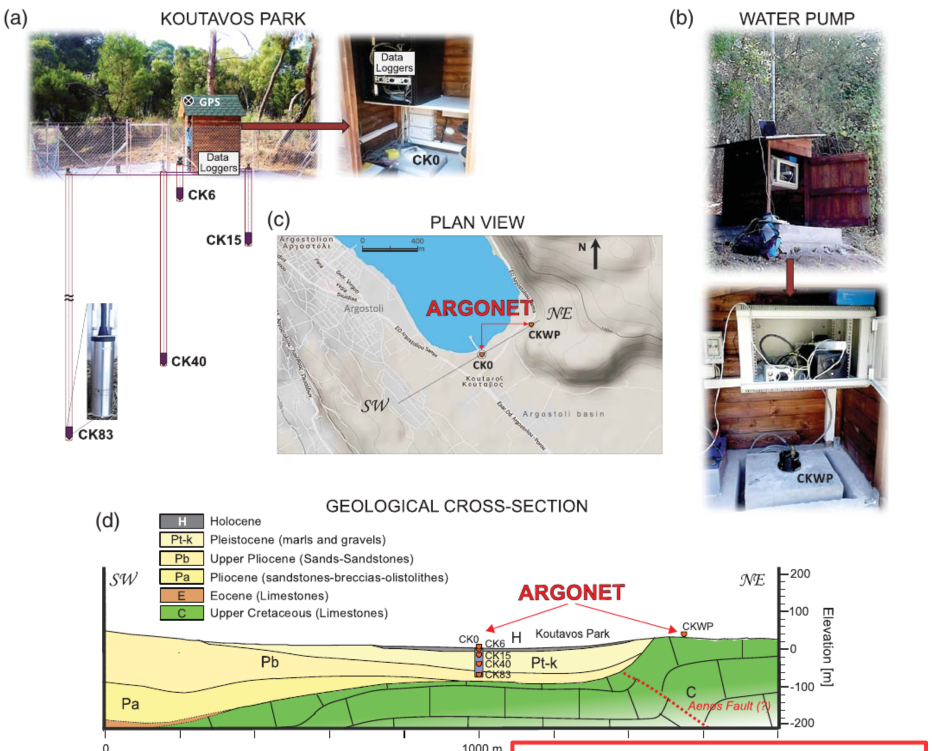




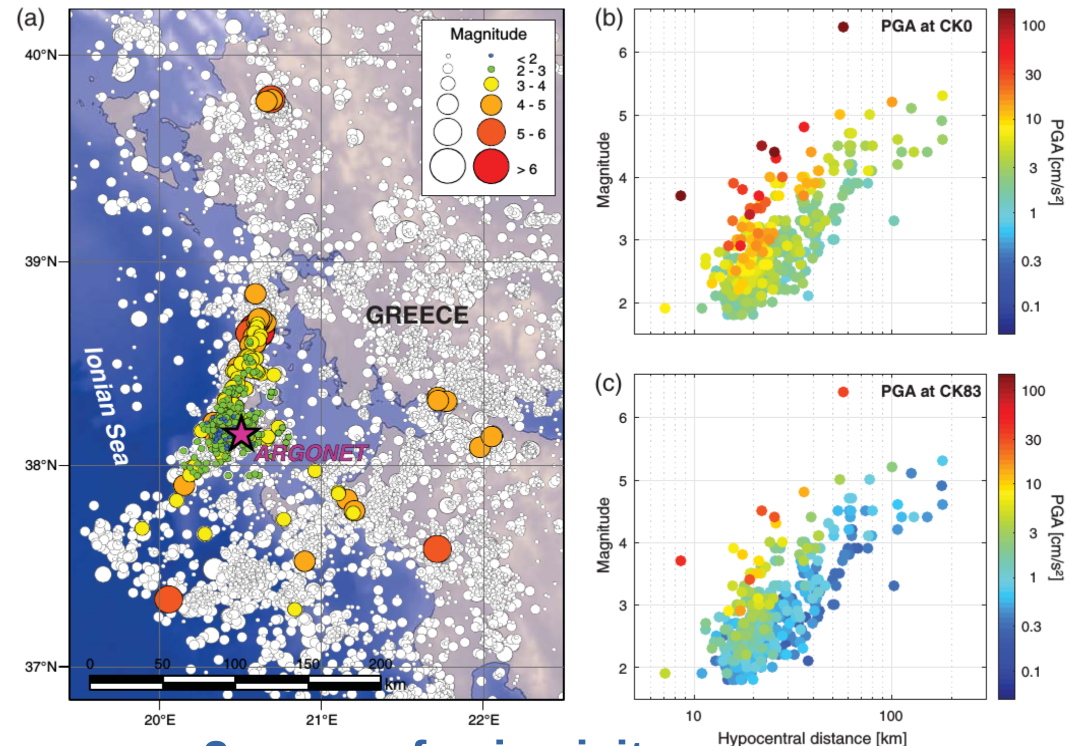
Cushing et al., 2019

- Cephalonia Island, 10 km close to the **Cephalonia Transform Fault Zone (CTFZ)**
- One of most seismically active place in Europe (M7.2 1953, last M6 in 2014)
- Structure already constrained from **previous studies** (EU-NERA, ANR-SINAPS@)
- Small (3 km wide), shallow (100 m) sedimentary basin.
- Easy access, not too urbanized site.

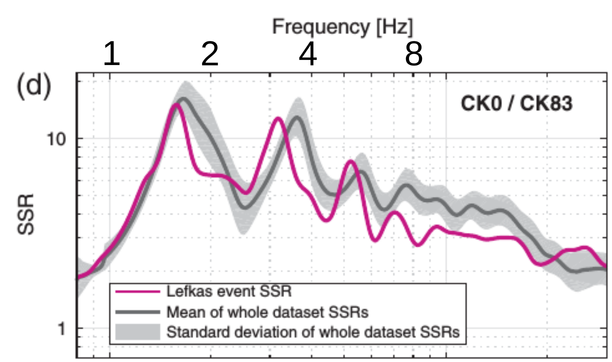
A place to host a large N+T array: Argostoli

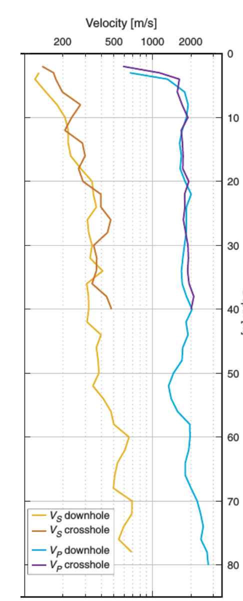


Theodoulidis et al., 2018



2 years of seismicity



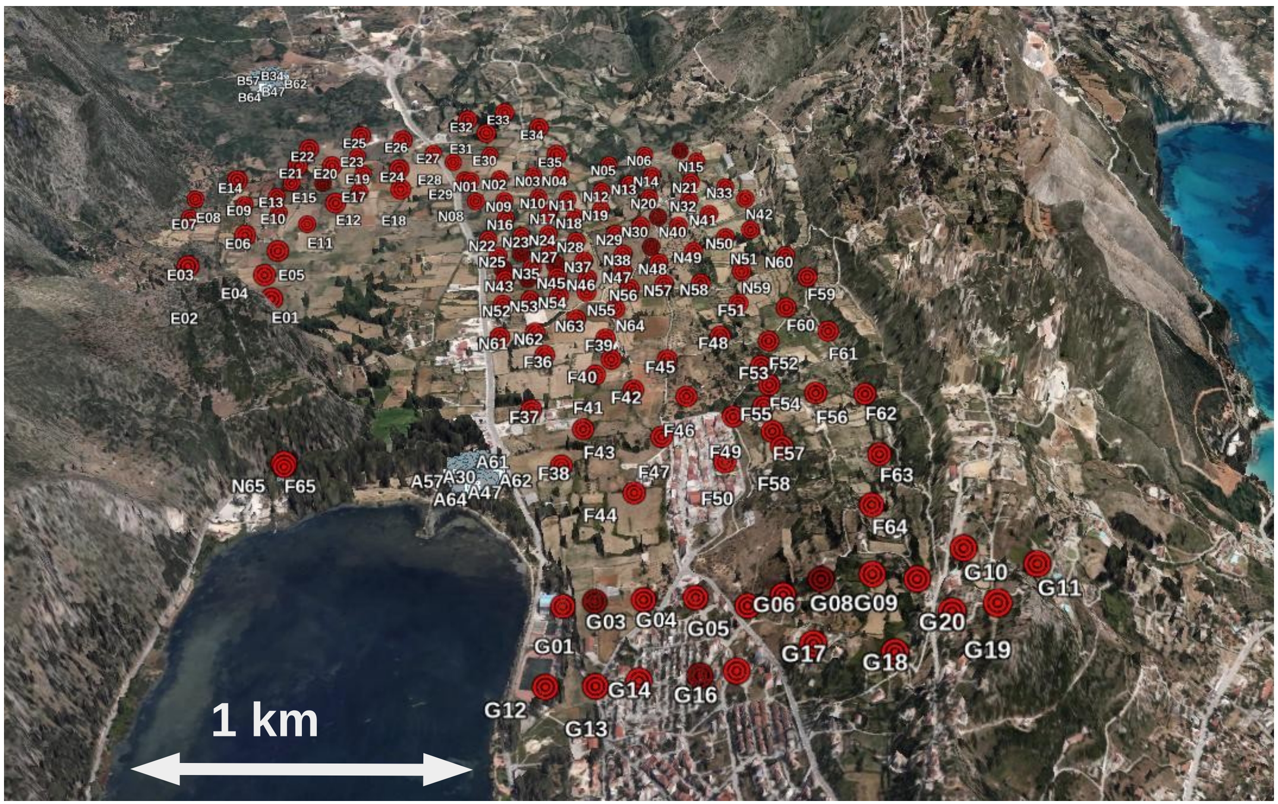


Site response

- **Argonet** instrumentation: Vertical array with 4 accelerometers (3 at depth).
- Test-site for **non-linear site response**.

Surface Vs~120m/s. f=4 Hz, **λ=30 m**.

Large N+T array in Argostoli: how large ?



2 km x 2 km Aperture
15 m interdistance
N>15000 !

=> only DAS could make it !

=> several subarrays N=100

1month node experiment ISTerre 2018
Aperture ~ 2-3 km
Dmin ~ 100 m

Project Status

Looking for fundings

Open to collaborations

Questions ?

Assos, Cephalonia