1976 Seismic Sequence

MessaggeroVeneto

Catastrofico terremoto in Friuli

ALLE 21 UNA SCOSSA SISMICA DELL'OTTAVO GRADO DELLA SCALA MERCALLI HA DEVASTATO MAIANO, BUIA, GEMONA, OSOPPO, MAGNANO, ARTEGNA, COLLOREDO, TARCENTO, FORGARIA, VITO D'ASIO E MOLTI ALTRI PAESI DELLA PEDEMONTANA - GENEROSA OPERA DI SOCCORSO PER ESTRARRE LE VITTIME DALLE MACERIE - A UDINE E IN TUTTI I CENTRI DELLA REGIONE UNA NOTTE DI PAURA E DI VEGLIA ALL'APERTO - L'ALBA CI MOSTRA I SEGNI DELL'IMMANE DISASTRO

Origin time: 20:00:13 UTC
epicenter 46° 17’ N - 13° 17’ E
Depth: 5 - 12 km

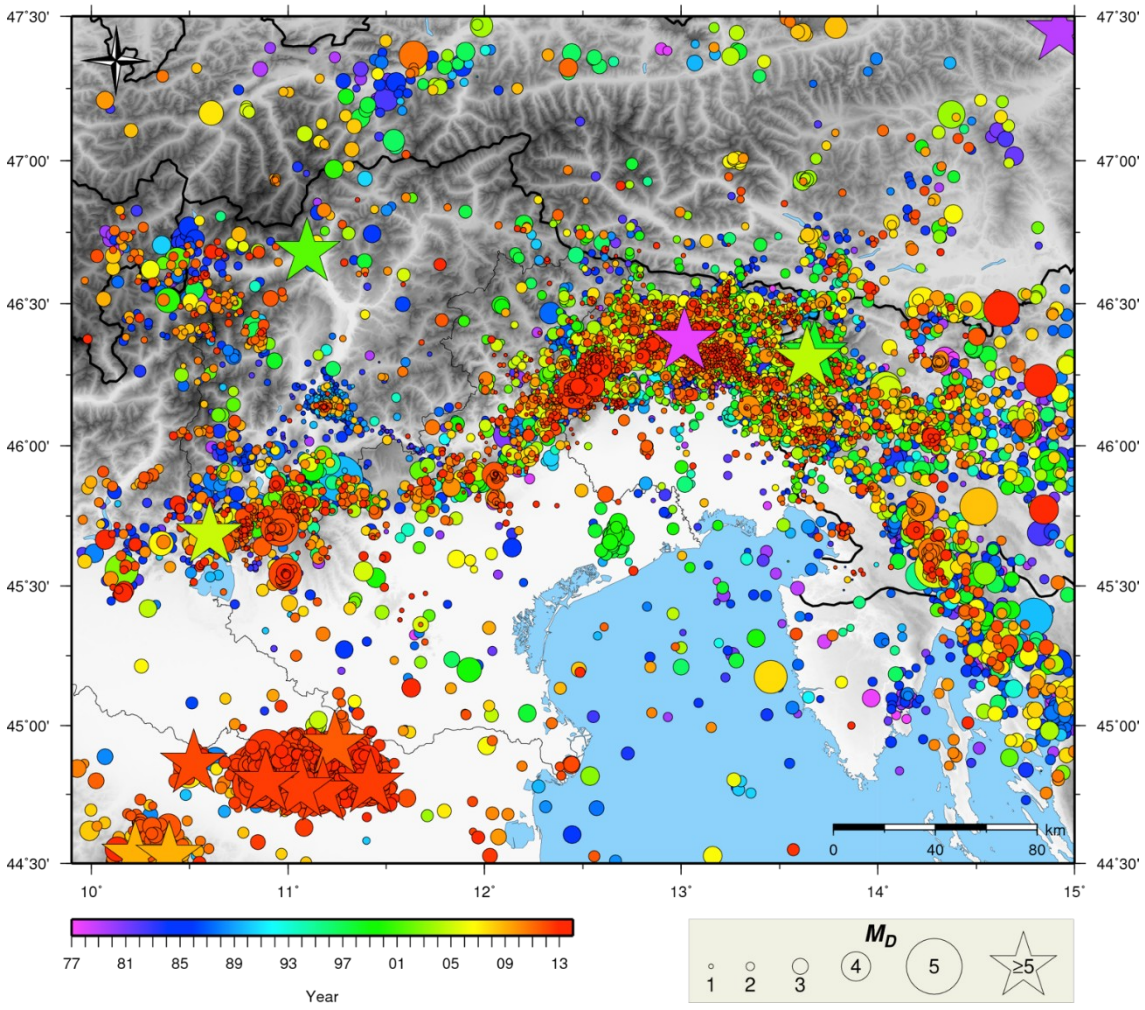
Magnitude: 6.0 mb 6.5 Ms 6.4 ML
Epicentral intensity: X MKS

Max PGA recorded: 0,36 g

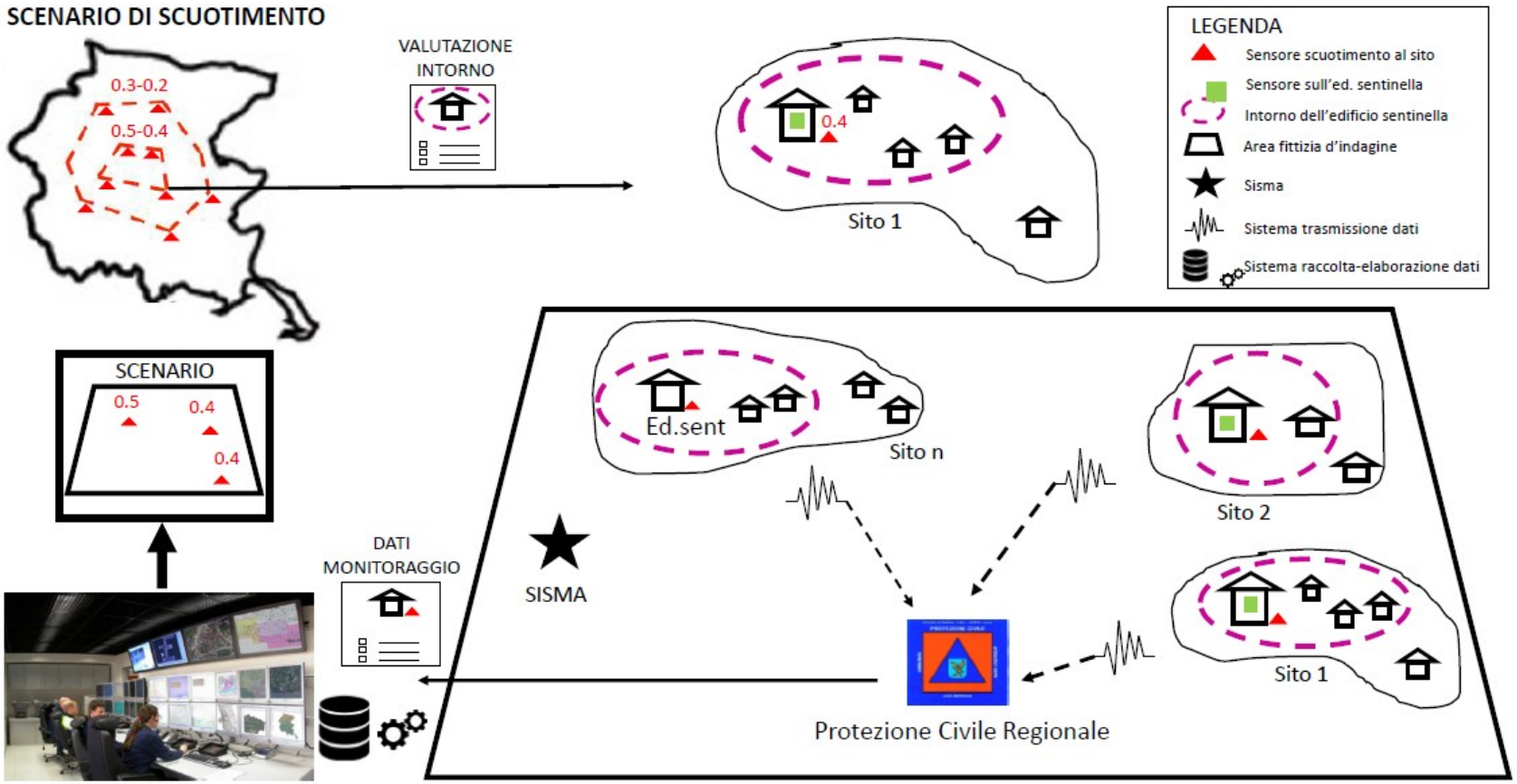
Felt at distance of : 579 km
Impact Area : 5.700 km^2
Death toll: 989

People needing shelters: 110.000
Damage: 4.500.000 milions (lire in 1976)

Earthquakes recorded since 1977 (>33.000 events)



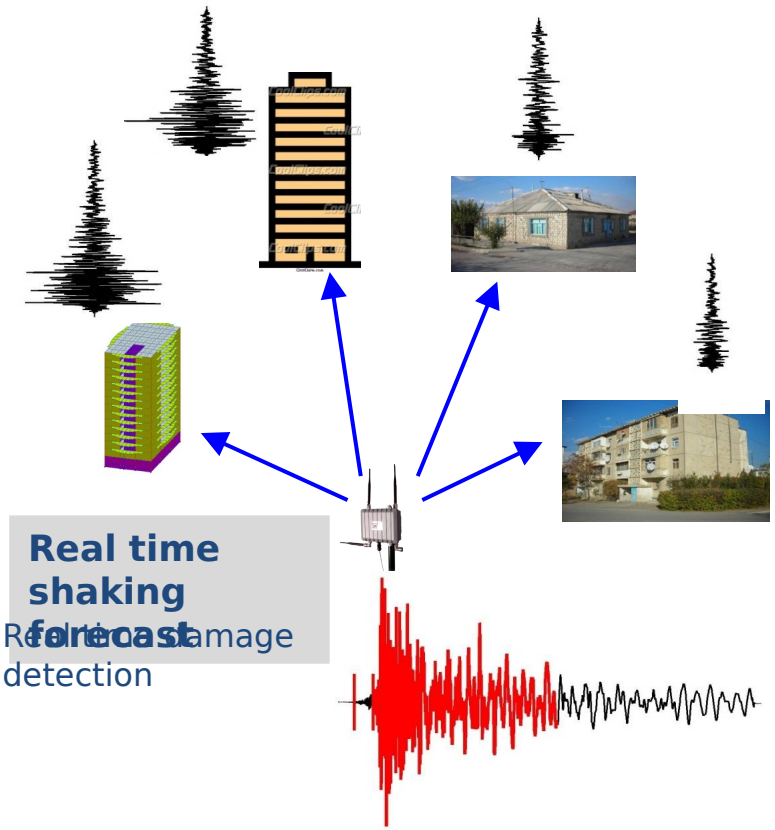
Rapid Damage forecasting in buffer areas



from Grimaz et al.,2017

Method 1

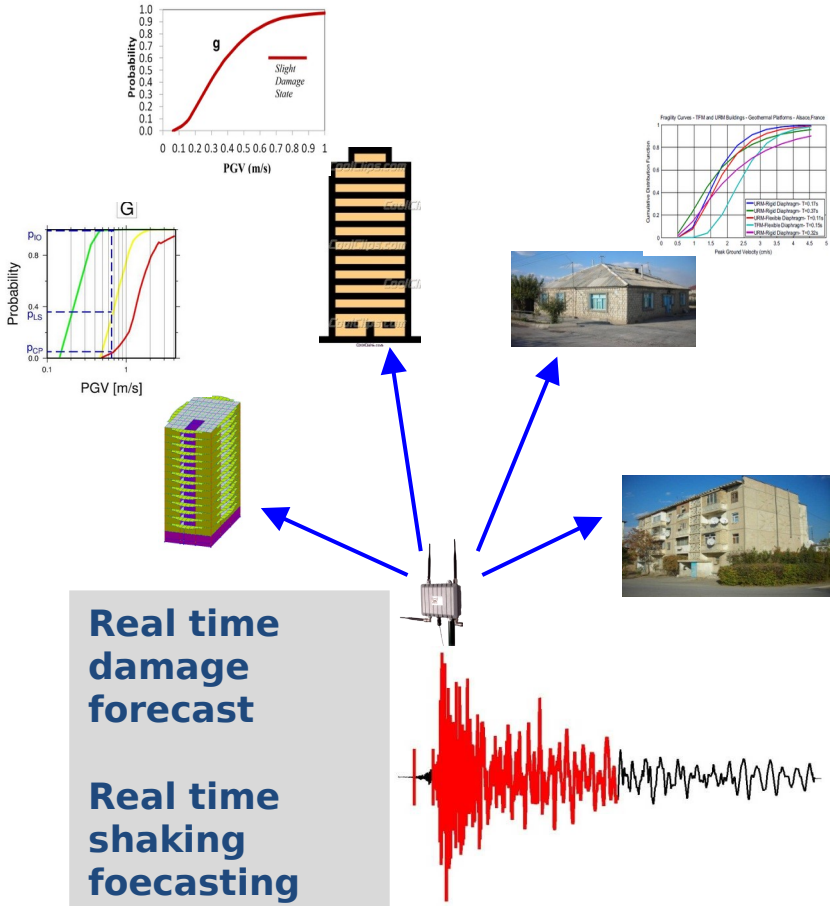
Real time estimation of shaking for different buildings.
Input: base of one of the sentinel building 1) recording at the base of one of the sentinel building (OGS-Uni Trieste)
2) Frequency of oescillation for building type (Uni Udine)



Real time shaking forecast
Real time damage detection

from
Parolai et al.,2015, SRL

Method 2



Real time damage forecast

Real time shaking foecasting

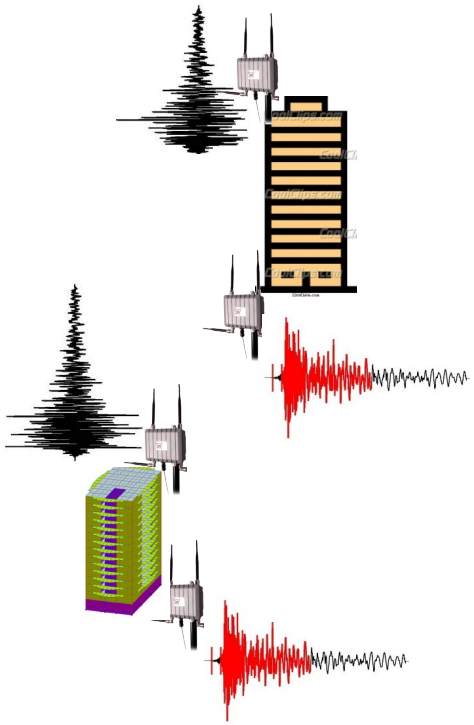
from
Parolai et al.,2015, SRL
Megalooikonomou et al. 2018.

Estimation of the probability of exceedance of acertain limit state for different buildings within an area

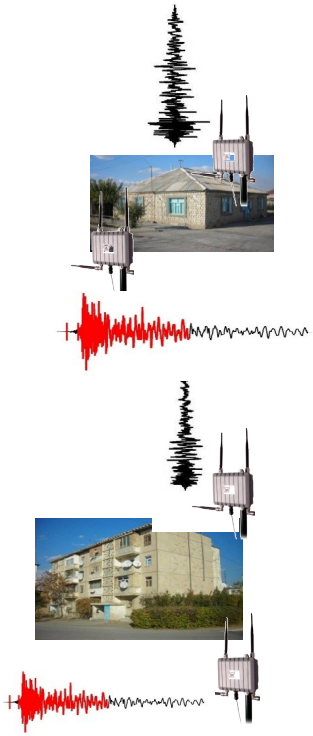
Input: 1) recording at the base of one of the sentinel building (OGS-Uni Trieste)
2)Fragility curves for building type (Uni Udine)

Method 3

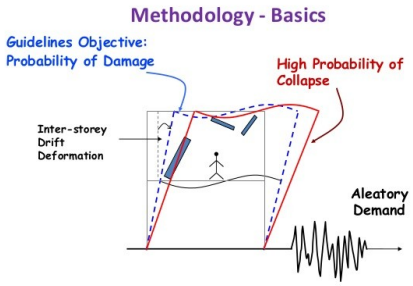
First level estimate of possible damage in buildings with sensors at the base and at the top.
Input: 1) recording at the base of one of the sentinel building (OGS-Uni Trieste)
2) Real time measurement of interstorey-drift and/or resonance frequency variation (OGS-Uni Udine)



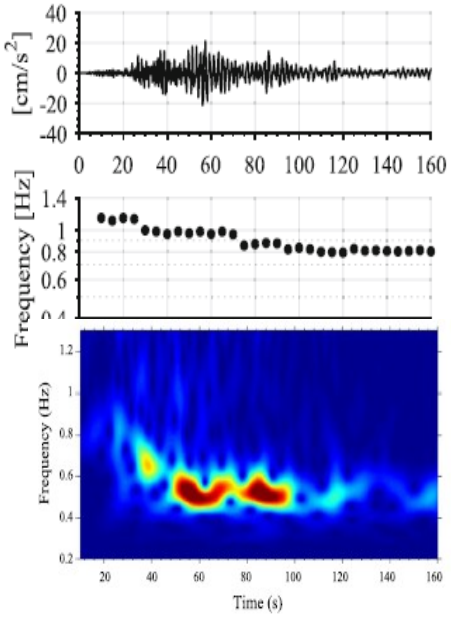
Real time impact forecast



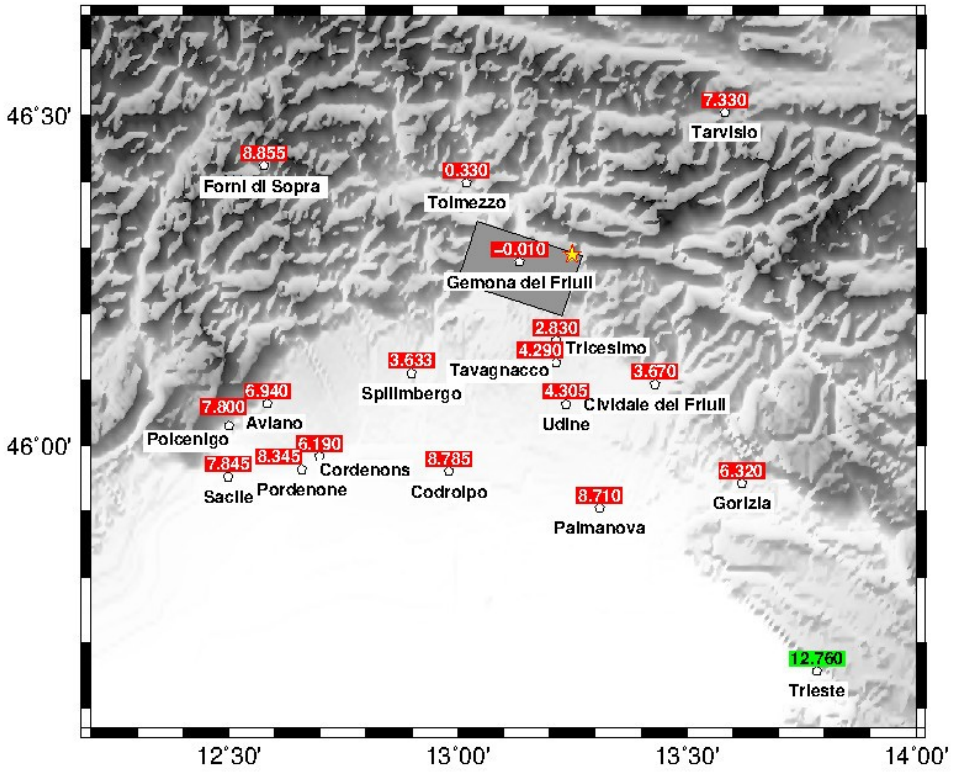
from
Parolai et al.,2015, SRL

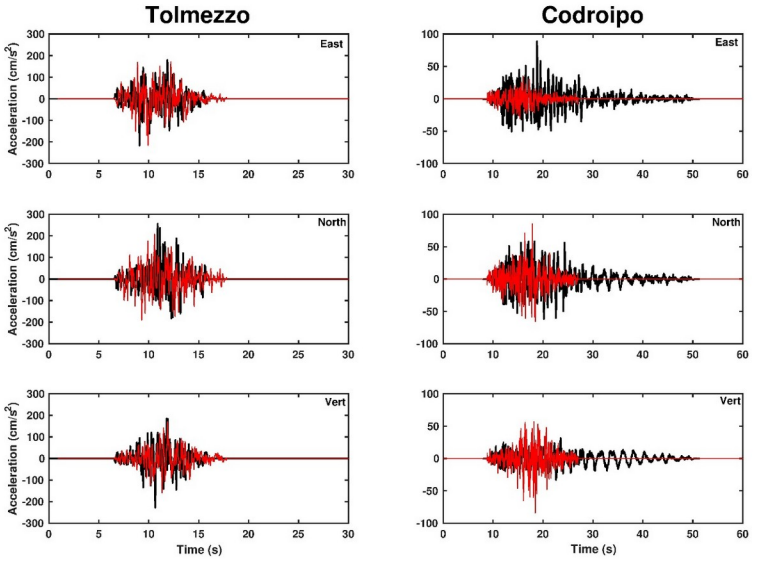


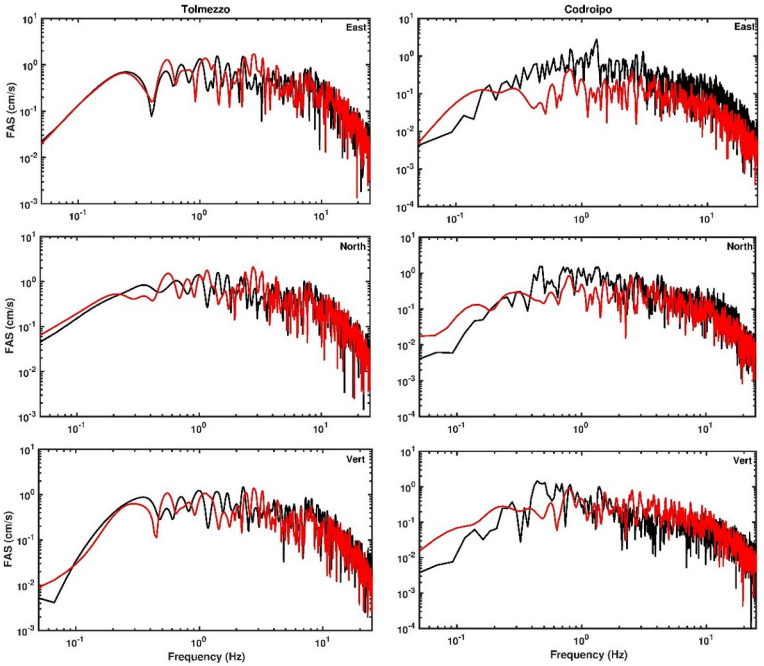
from Pianese et al, 2018



Feasibility for DOSEEW in case of repetition of the 1976 Event

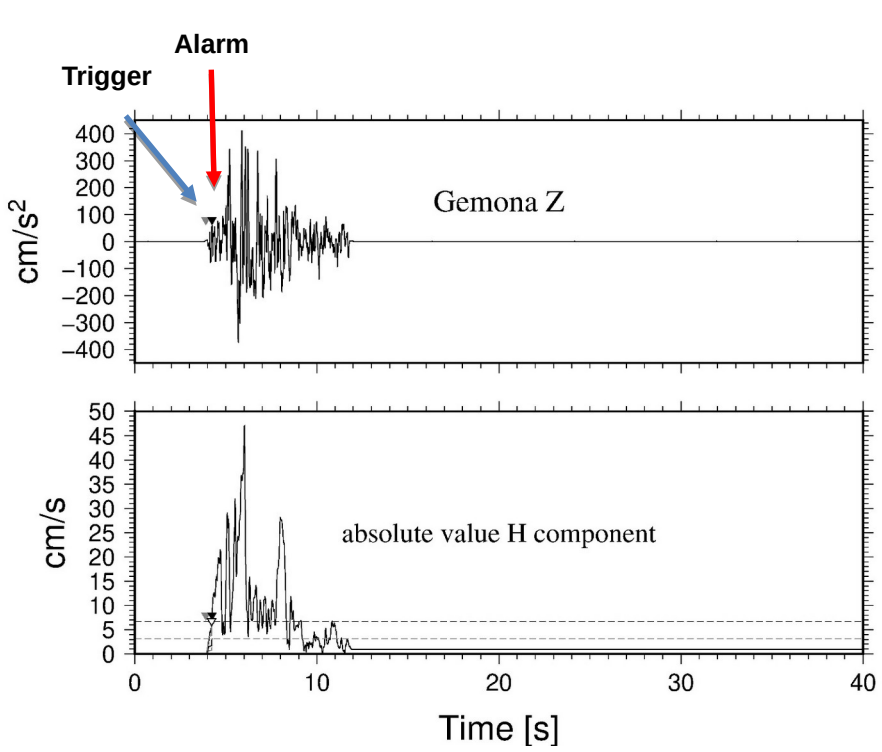


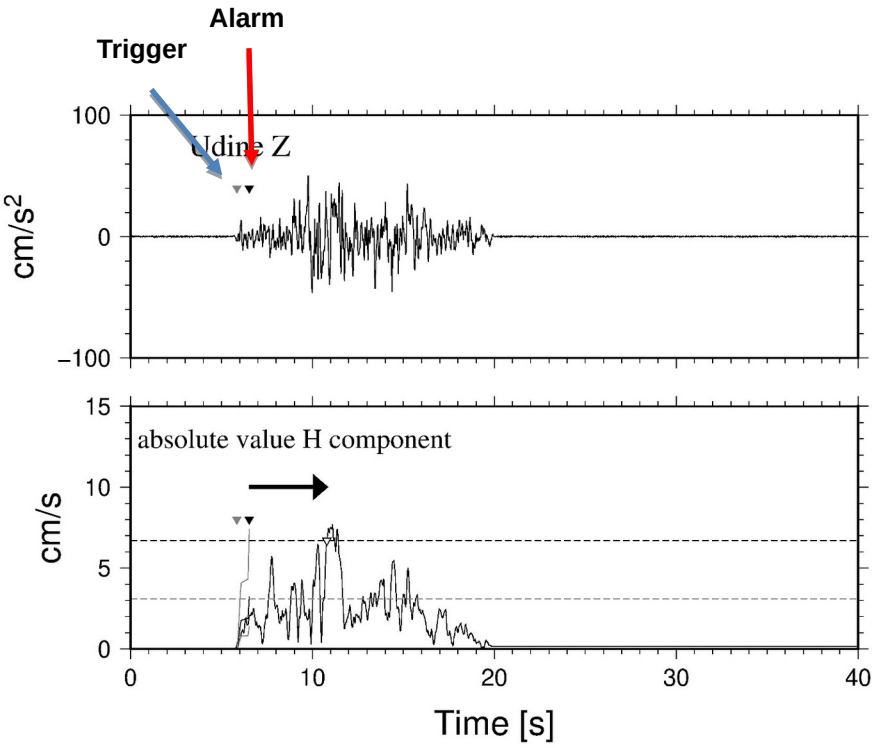




from
Parolai et al.,2020

DOSEEW applied to the synthetic data

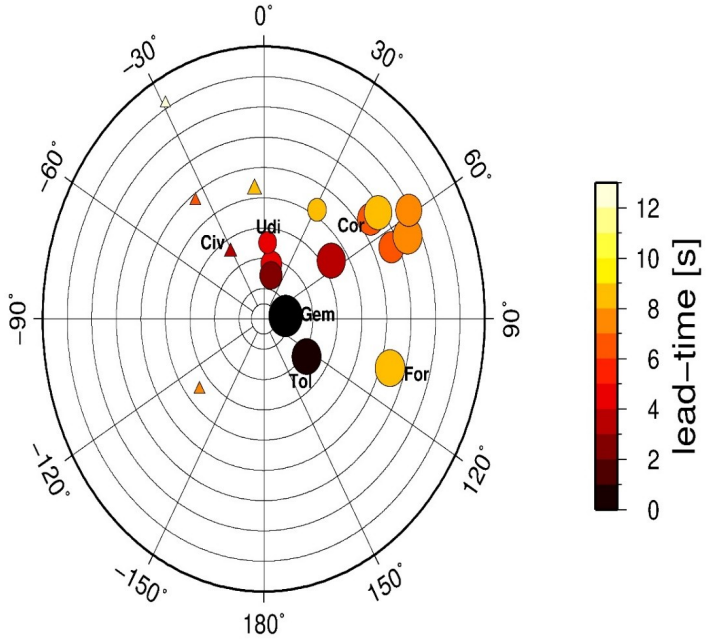


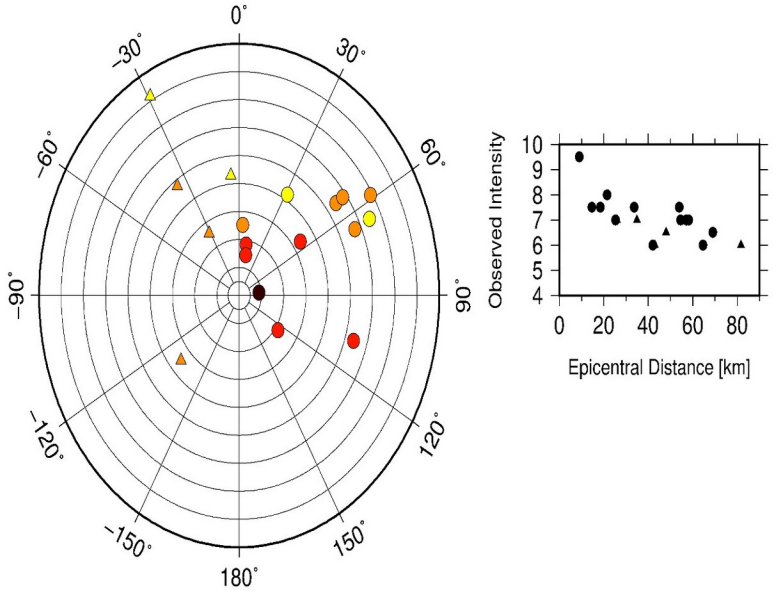


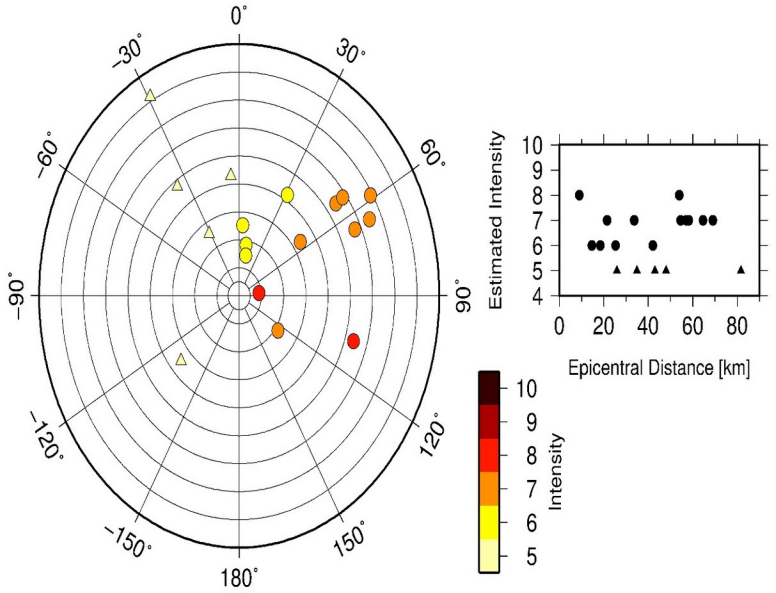
from
Parolai et al.,2020

DOSEEW applied to the synthetic data

Strong dependency of lead-time on slip distribution

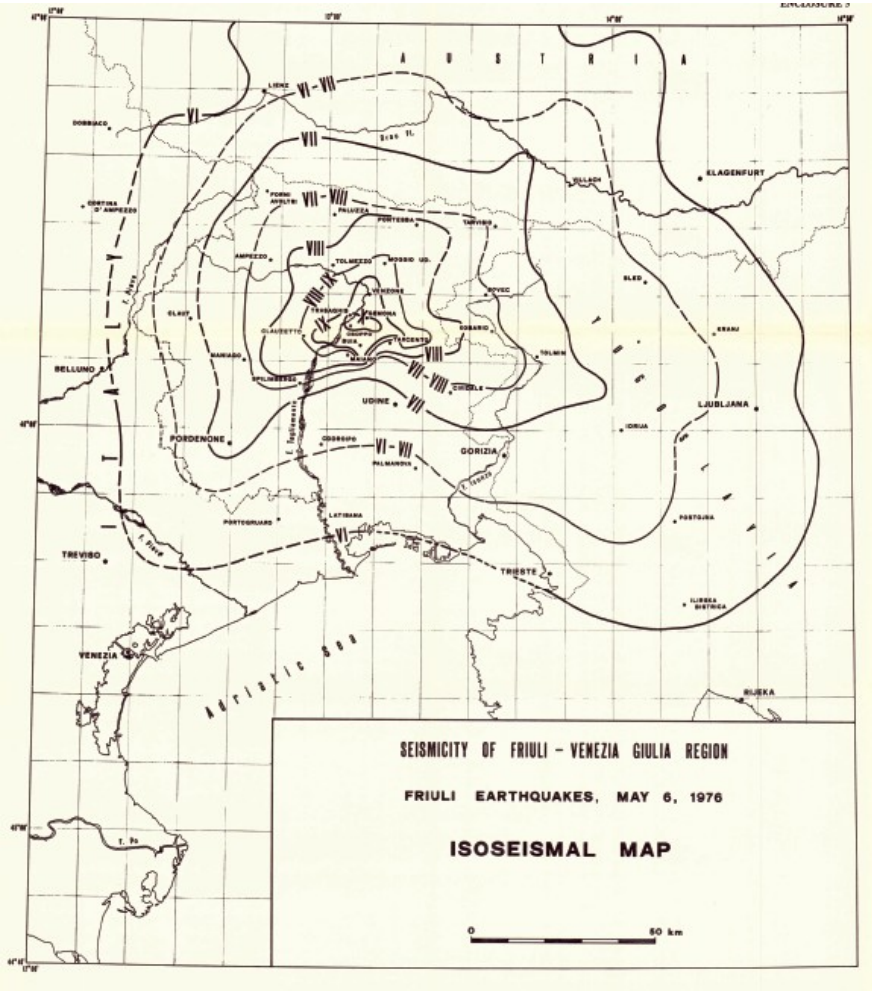






from
Parolai et al.,2020

Possible reduction of 10% of injured persons



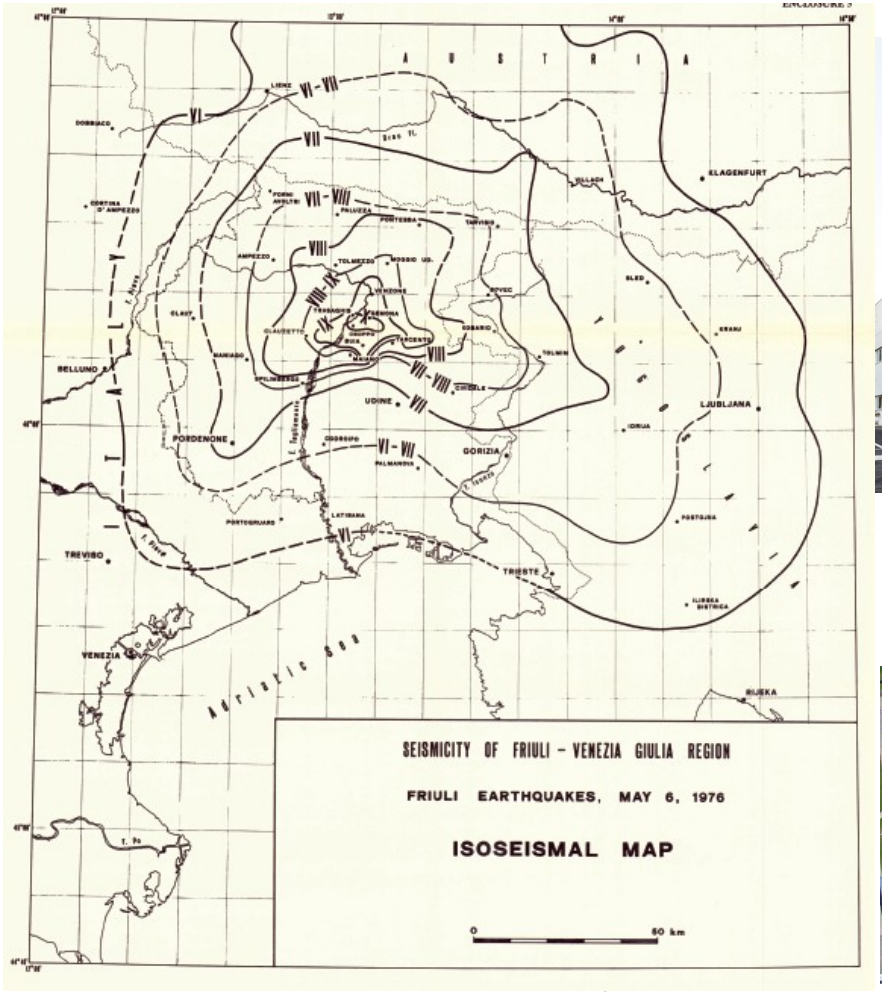
from
Parolai et al.,2020

Table 1 - Summary of the localities and lead times vs injured person during the 1976 Friuli earthquake.

Locality	Lead time (s)	1976 Intensity	1976 Injured
Cividale	3.67	VII	18
Cordenons	6.19	VII	5
Tarvisio	7.33	VII	5
Pordenone	8.34	VII	27
Udine	4.30	VII	53
Forni di Sopra	8.85	VII-VIII	4
Sacile	7.84	VI-VII	6
Tavagnacco	4.29	VII-VIII	24
Spilimbergo	3.63	VII-VIII	10
Tricesimo	2.83	VII-VIII	10

Possible several seconds to stop the plant of TAL

No action was possible for this scenario for the Magnetic Marelli being in the blind zone



from
Parolai et al.,2020

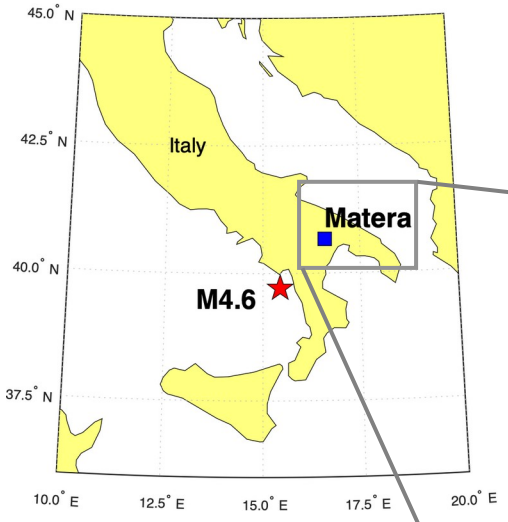
Magneti Marelli Automotive Lighting, Tolmezzo (UD)

- production of electronic
- components for LED lights
- 5.000 m^2
- > 1100 employees

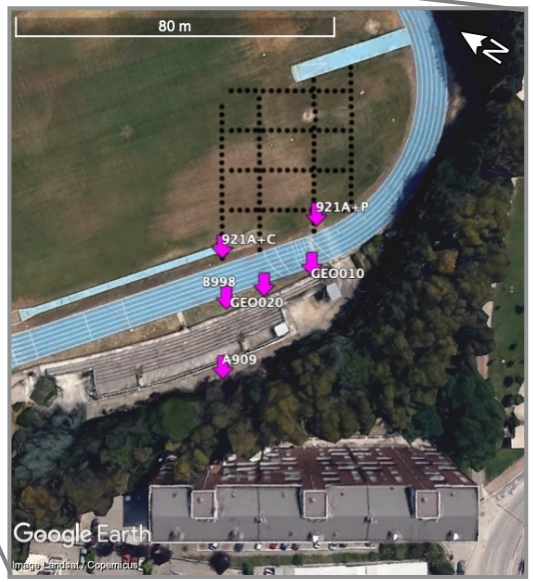
TAL – Transalpine Pipeline

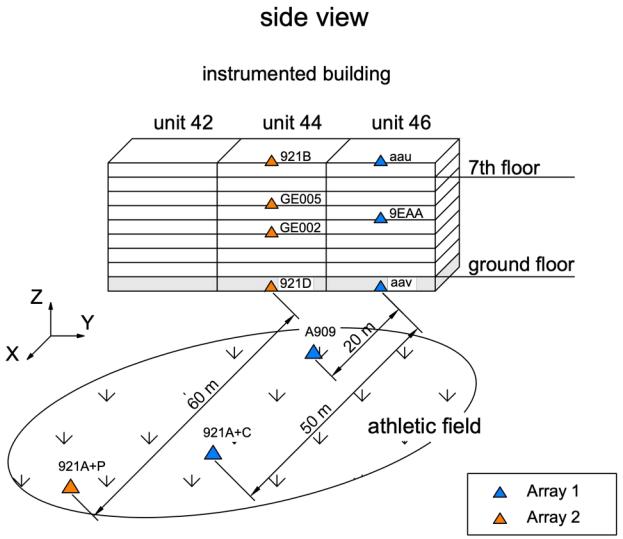
- Italy, Austria and Germany
- 40% of the energy needs of Germany and the Czech Republic, and 90% of Austria
- 753 km
- 7500 m^3/h
- 750 employees involved
- 1.2 x 10^9 €

Seismic interferometry: soil-structure interaction



Matera experiment





Data recorded on 23-24-25/10/2019

- Seismic noise
- Earthquake: M4.6 event on 25/10/2019

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Seismic interferometry: soil-structure interaction

1. Resonant frequency of the structure

Information on the frequency band of interest

2. Deconvolution

Combined analysis of the recordings from the building and surroundings

3. Phase identification, wavefield reconstruction

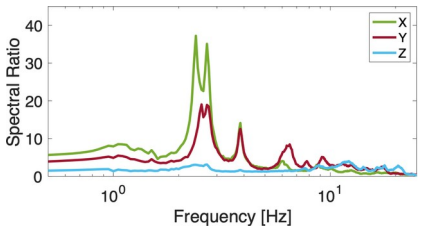
Identification of the phases transmitted from the structure

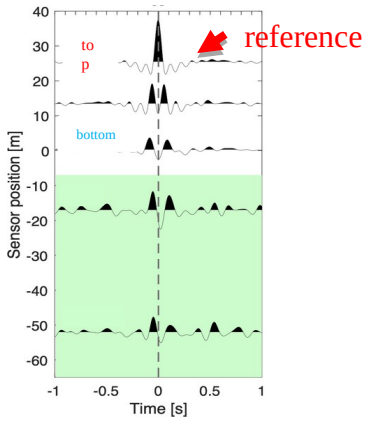
4. Polarization analysis

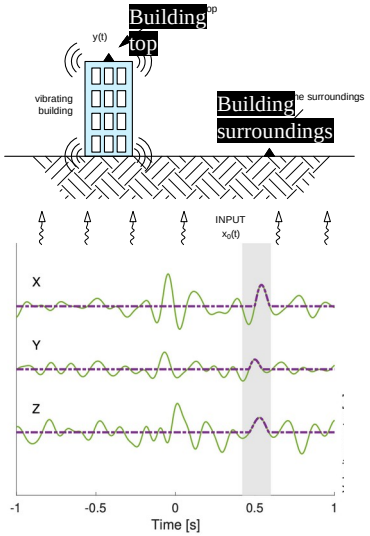
Identification of different waves and their respective contribution

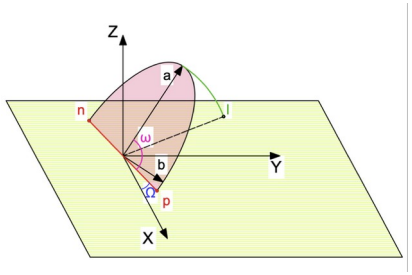
$$S(f)=\frac{u_1(x_1,z_1,f)\,u_2^*(x_2,z_2,f)}{¿u_2(x_2,z_2,f)¿^2+\varepsilon}$$

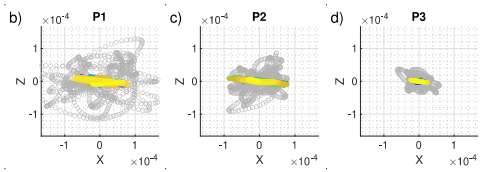
$$SR_{tb}=\frac{\text{top spectra}}{\text{bottom spectra}}$$











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Step 3. Phase identification

Analytical model

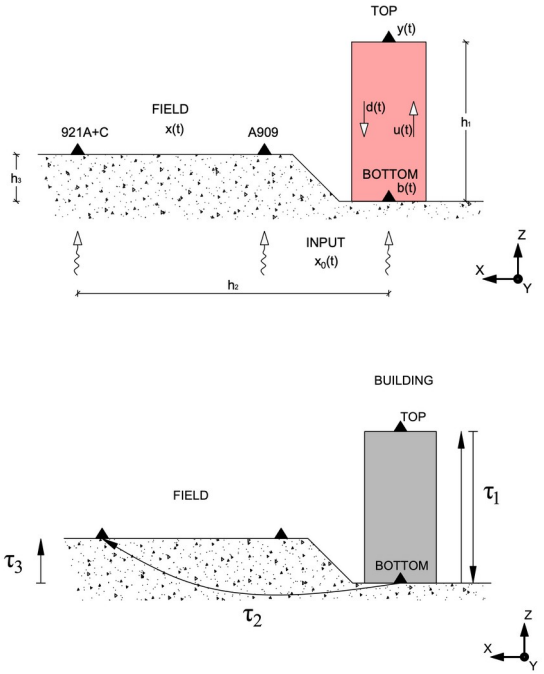
- Based on **simplified geometry**
- **Transfer function** between the building and

$$\frac{X(f)}{Y(f)} = P_1 + P_2 + P_3$$

$$P_1 = \frac{1}{1+r} e^{-i2\pi f(-\tau_1+\tau_3)},$$

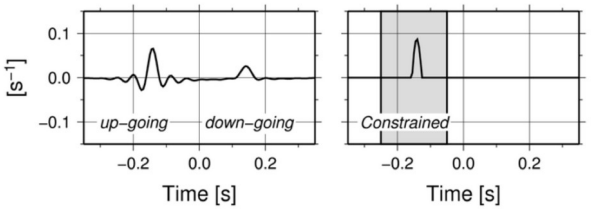
$$P_2 = \frac{r}{1+r} e^{-i2\pi f(\tau_1+\tau_3)},$$

$$P_3 = \frac{(1-r)}{2} e^{-i2\pi f(\tau_1+\tau_2+\tau_3)}.$$



Constrained deconvolution

- Based on the method proposed by Bindi et al. (2010)
- **Phase corresponding to the radiated wavefield**



From Bindi et al. (2010)

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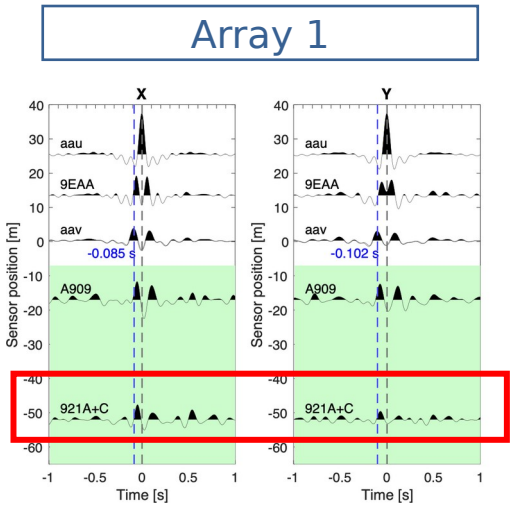
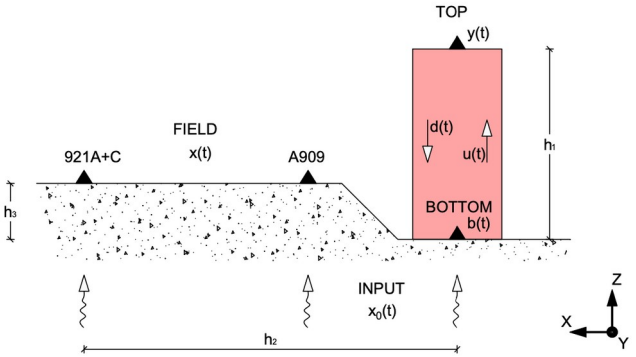
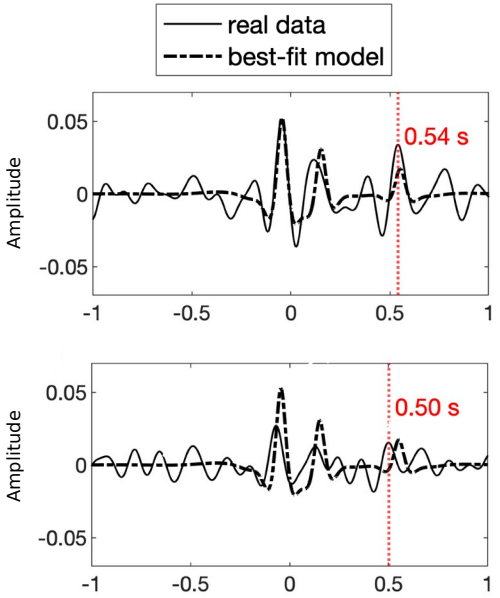
Matera experiment – results
Phase identification







Assumptions for the model:

- Input -> vertically propagating plane wave
- Simplified geometry
- The transfer function between the field sensors and the reference sensor at the top of the building

- Frequency band 2-10 Hz
- Searched parameters – time delays of the wave propagation in the building and the soil

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Seismic interferometry: soil-structure interaction

- The proposed approach allows the **wave-field related to the energy radiated from a vibrating structure** to its surroundings on the surface to be separate and to identify **the wave types.**

- In the Matera experiment, the most significant impact of the vibrating building on the ground motion is **near the resonant frequencies of the building and it is due to quasi Rayleigh or quasi Love waves**

- The knowledge of the dominant wavelength of the radiated wavefield, combined with the polarization analysis => information **about locations of positive and negative wavefield interference** for a given earthquake motion