

Task 4

Identification of anomalous sites and records

Task responsables:

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1st semester evaluation by the International Evaluation Committee

Rome, INGV, Via Nizza, 128

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Main Objectives

To qualify the acceleration record, for a more rationale use in the engineering applications, e.g., by identifying those records than can, or cannot, be used in a specific geological context.

To calibrate on the ITACA dataset up-to-date ground motion prediction equations and to select and identify on this dataset the records falling outside the dispersion bands

To study, both by in-field monitoring and by numerical modelling, the seismic response at selected sites where an anomalous site response was observed or is expected based on the available information.

To clarify the effect on earthquake ground motion of complex geological structures commonly found in Italy, such as fault-related deep alluvial basins and steep topographies.

Main activities

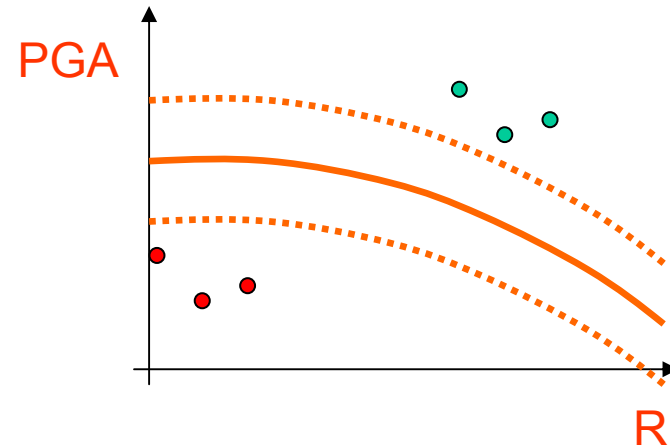
- 4.1 Identification of anomalous sites and records
- 4.2 (a) In-field monitoring at several selected station sites
(b) Numerical modelling
- 4.3 Classification of reported anomalies and synthesis of results

Task 4 – Deliverables

<p>D8 Responsibles RU2-INGV-RM1 RU3-POLI-MI Deadline:12m</p>	<p>Identification of ITACA sites and records presenting anomalies in the seismic response (Technical report)</p> <p><i>Product of immediate interest to DPC</i></p>	<p>This report will include the research activities to identify the anomalous stations of the ITACA database and to select the sites where detailed analysis will be performed both through monitoring and numerical modelling.</p>
<p>D9 Responsibles RU2-INGV-RM1 RU3-POLI-MI Deadline 24m</p>	<p>Experimental and numerical results for all stations selected to study the effects of anomalous site conditions (Technical report).</p> <p><i>Research product, for future applications of interest to DPC</i></p>	<p>This report will summarize the research activity within Task 4, and will include:</p> <ol style="list-style-type: none">1) results of experimental and numerical investigations at the selected sites;2) investigations of soil-structure interaction effects at recording stations;3) classification of the anomalous sites and records in the database and quantification of possible correction factors.

Task 4 – Identification of anomalous sites and records

(a) Analysis of records



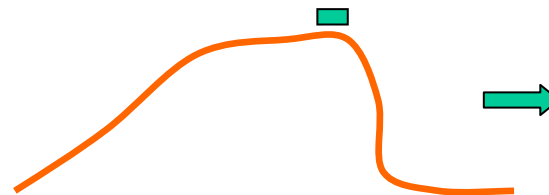
● records from the same site but different earthquake

➔ anomalous earthquake

● records from different earthquakes but same site

➔ anomalous site

(b) Morphology study

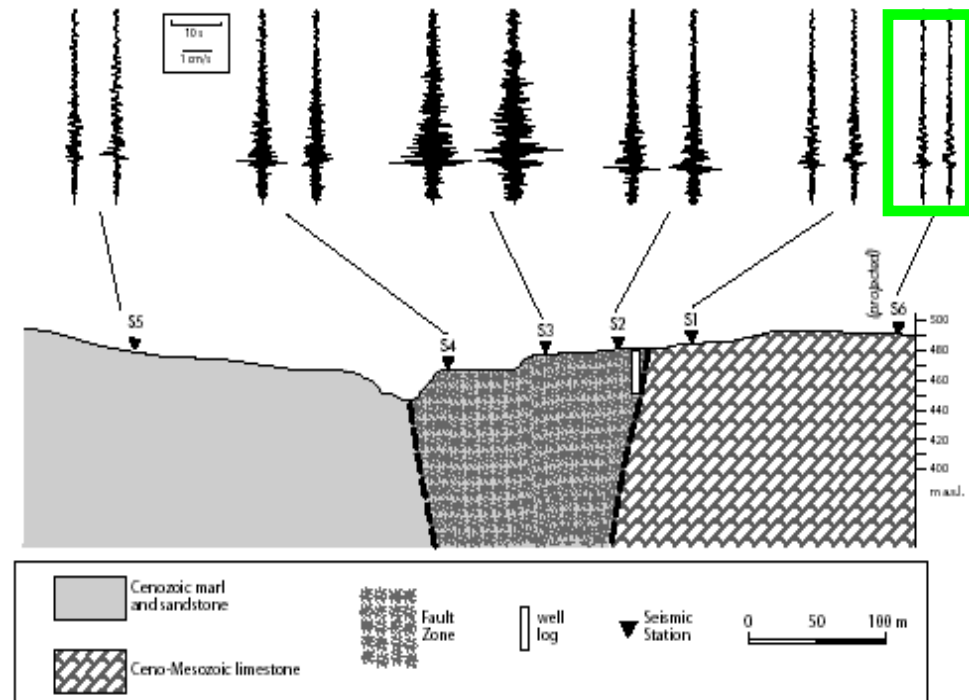
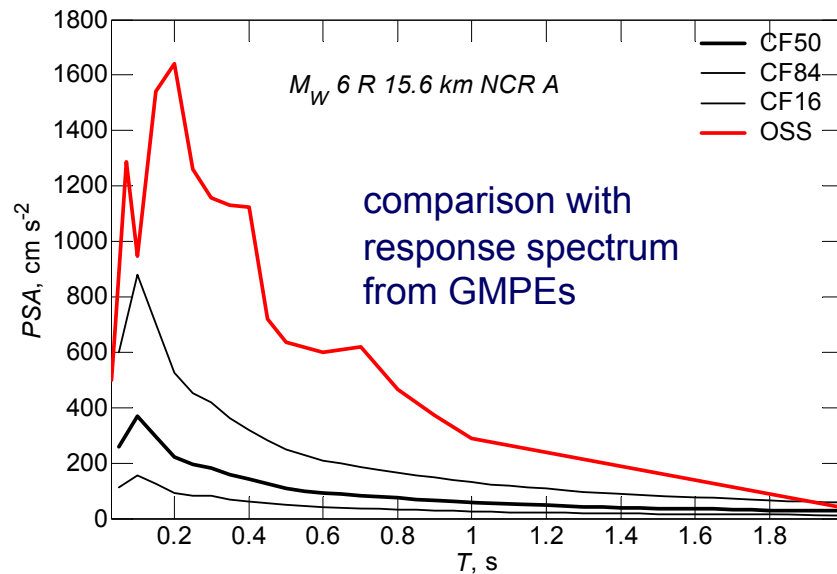
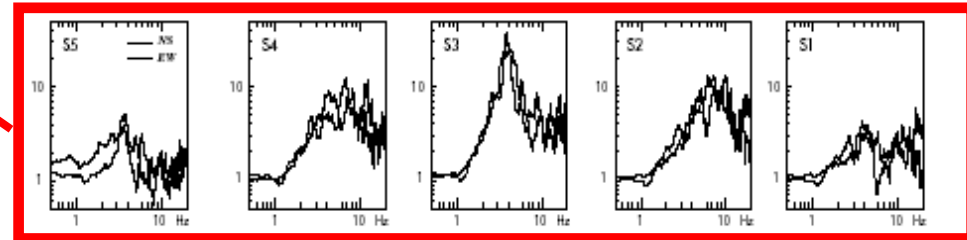


do the records of this site belong to the anomalous records identified in (a) ?

Anomalous sites and records: Nocera Umbra, Umbria-Marche 1997

After Rovelli et al. , BSSA, 2002

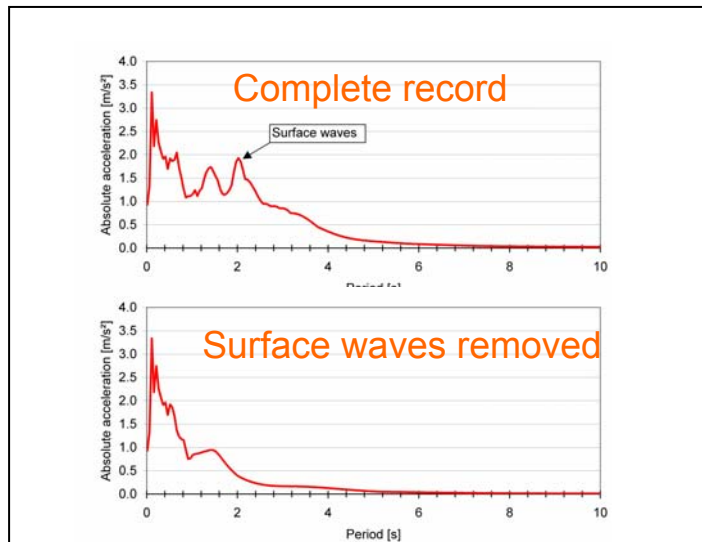
spectral ratios with respect to S6



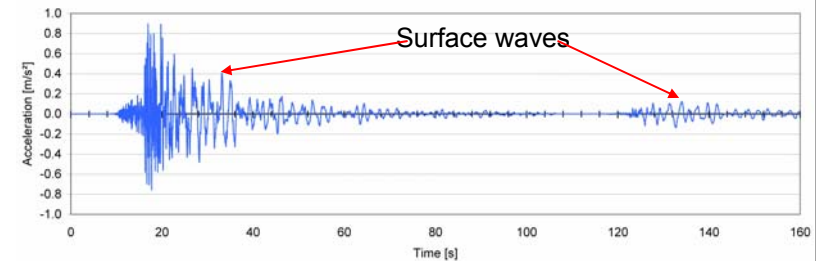
Anomalous sites and records: Gubbio, Umbria-Marche 1997



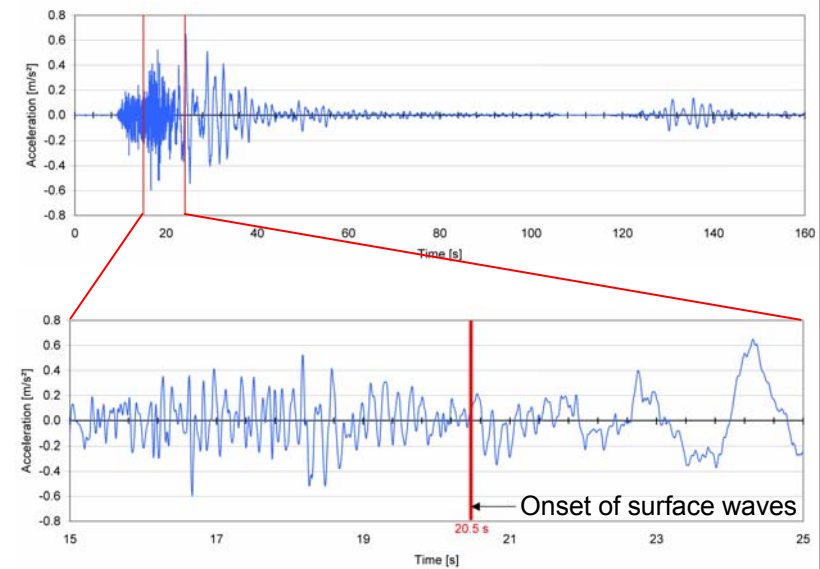
Response spectrum



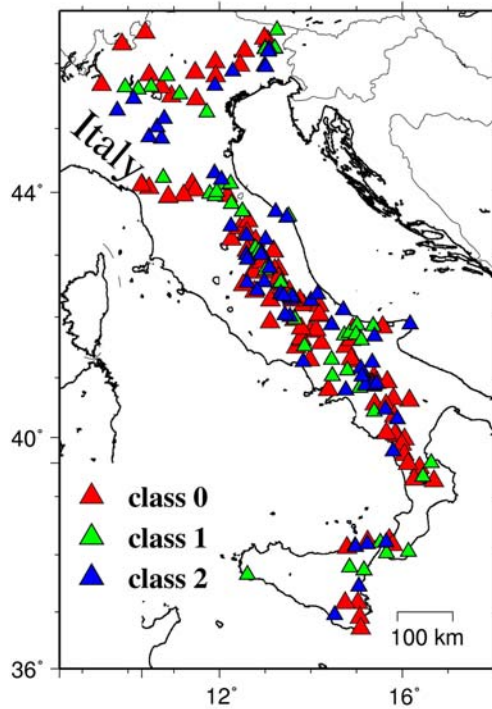
① Complete record of the horizontal component



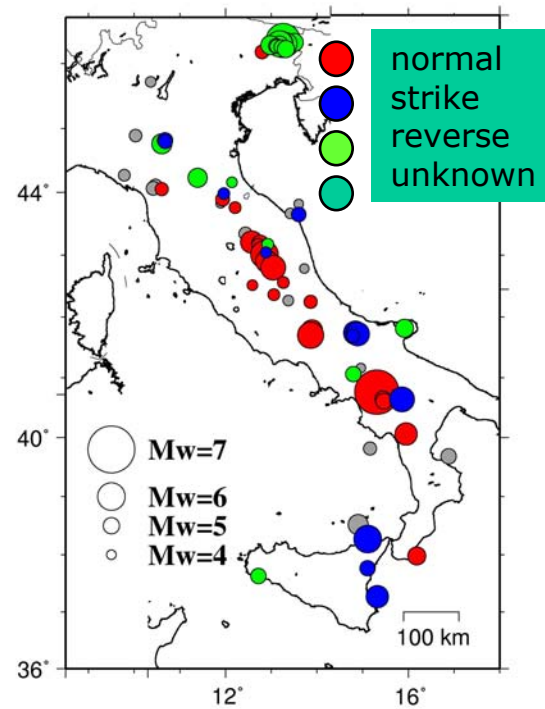
② On the vertical component, identification of the onset of surface waves



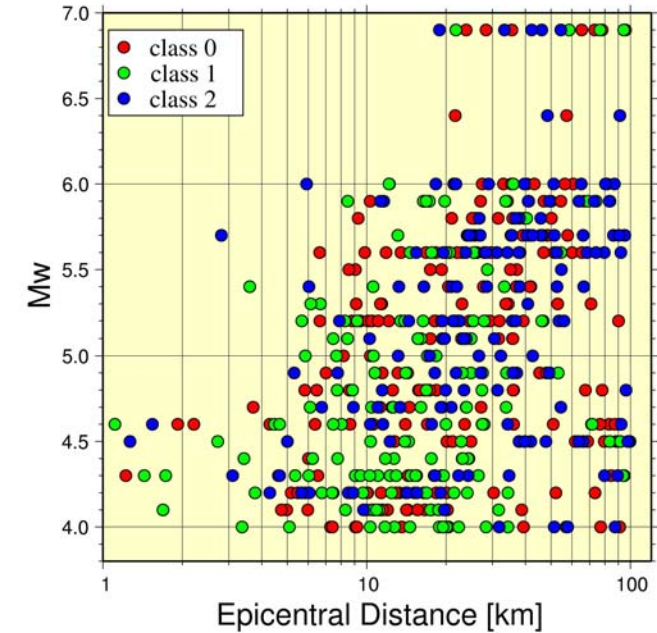
Calibration of a new GMPE based on ITACA records (Bindi et al., 2008)



206 stations



107 events ($4 \leq M_w \leq 6.9$)



561 records ($0 \leq R_{jb} \leq 100 \text{ km}$)

class 0 : rock
 class 1 : shallow alluvium ($\leq 20 \text{ m}$)
 class 2 : deep alluvium ($> 20 \text{ m}$)

Sabetta and Pugliese (1996)
 site classes

Calibration of a new GMPE based on ITACA records (Bindi et al., 2008)

$$\log_{10} Y = a + b_1(M_W - M_{ref}) + b_2(M_W - M_{ref})^2 + (c_1 + c_2(M_W - M_{ref})) \log_{10} \sqrt{(R_{JB}^2 + h^2)} + e_i S_i$$

$$\log_{10} Y = \log_{10} Y^{Pre} + \varepsilon$$

the error ε is partitioned as follows:

$$\varepsilon_{ij} = \tau_i + \gamma_j + \mu_{ij}$$

ε_{ij} = error for event i recorded at station j

Record-to-record: normal distribution, mean= 0, std= σ_{rec}

Inter-station : normal distribution, mean= 0, std= σ_{sta}

Inter-event : normal distribution, mean= 0 std= σ_{eve}

$$\sigma_{TOT} = \sqrt{\sigma_{rec}^2 + \sigma_{eve}^2 + \sigma_{sta}^2}$$

Standard deviation of predictive model

Procedure to extract anomalous records

✓ Calculation of residuals normalized by the spectral acceleration $SA(T, \xi=5\%)$ as a function of period:

$$R_i^N(T) = \frac{\text{Log}SA_{obs,i}(T) - \text{Log}SA_{gmpe,i}(T)}{\sigma_{gmpe}(T)}$$

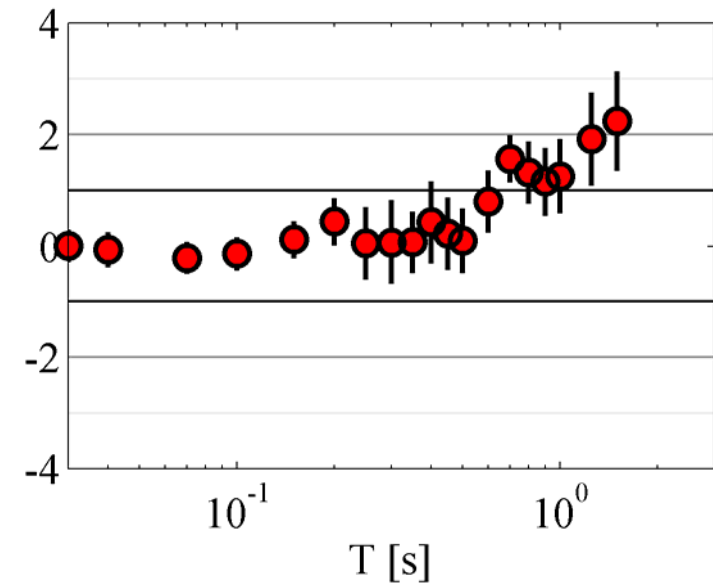
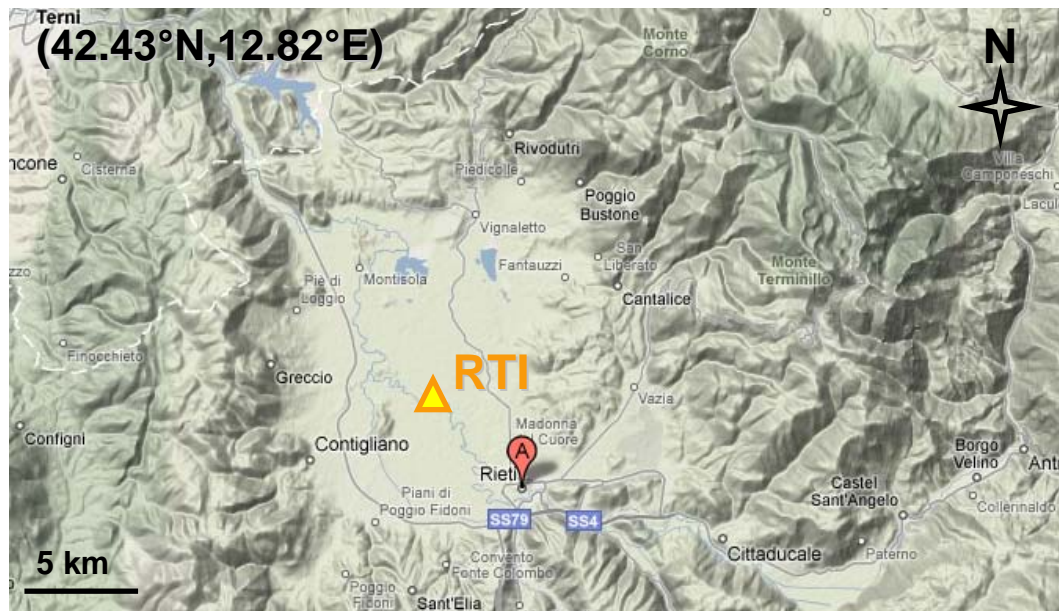
- a) Ambraseys et al. (2005)
- b) Cauzzi & Faccioli (2008)
- c) Boore & Atkinson (2008)
- d) Bindi et al. (2008)

✓ Residuals are calculated with respect to the GMPE corresponding to the station site class $S=0,1,2$

✓ Correction of residuals for inter-event variability ε_j :

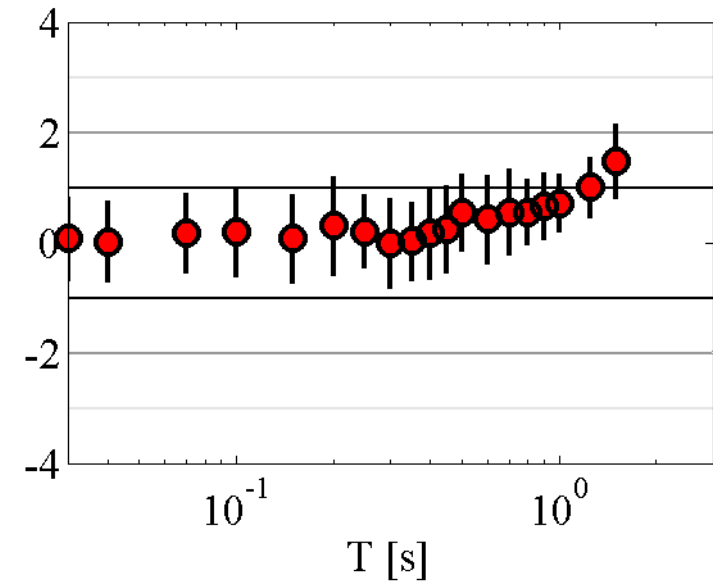
Task 4 – Identification of anomalous sites and records

Rieti - Nreg = 6 - site class 2 (deep alluvial basin)



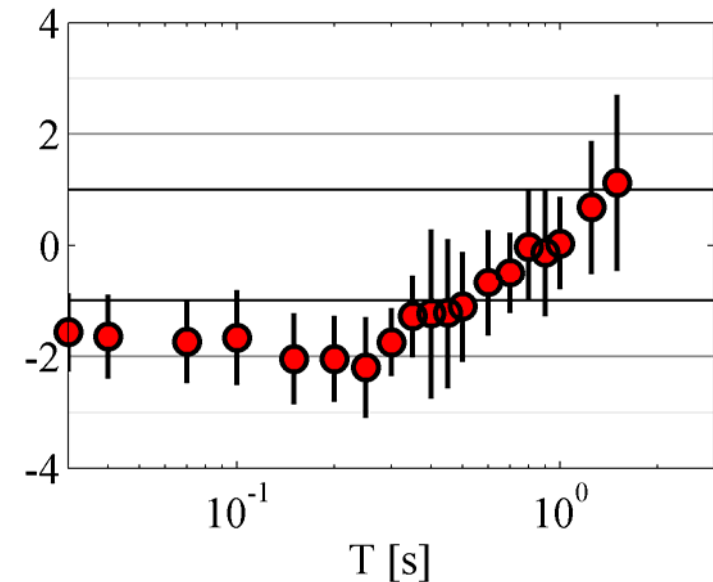
Task 4 – Identification of anomalous sites and records

Gubbio piana - $N_{reg} = 8$ - site class 2 (deep alluvial basin)



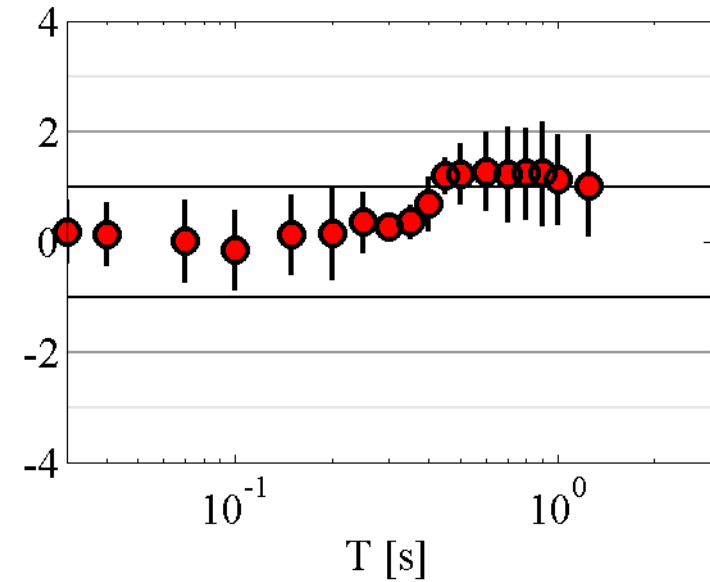
Task 4 – Identification of anomalous sites and records

Aquila V.Aterno Park. - Nreg = 3 - site class 2 (deep alluvial basin)



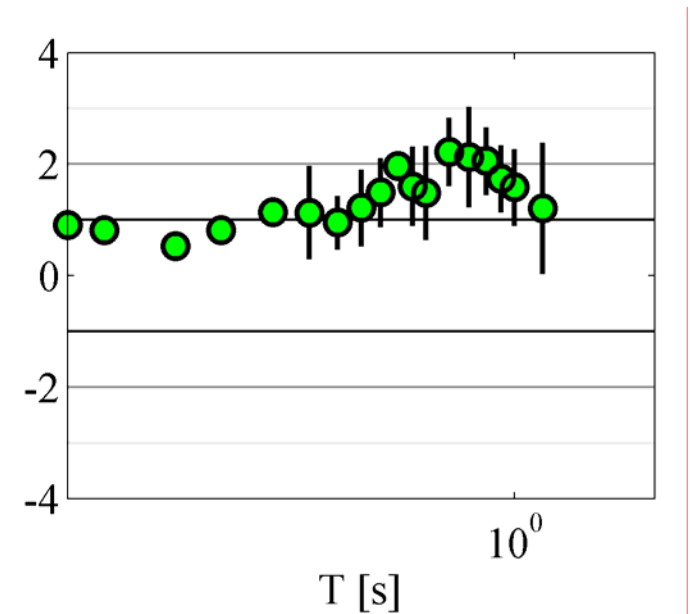
Task 4 – Identification of anomalous sites and records

Novellara - Nreg = 3 - site class 2 (deep alluvial basin)



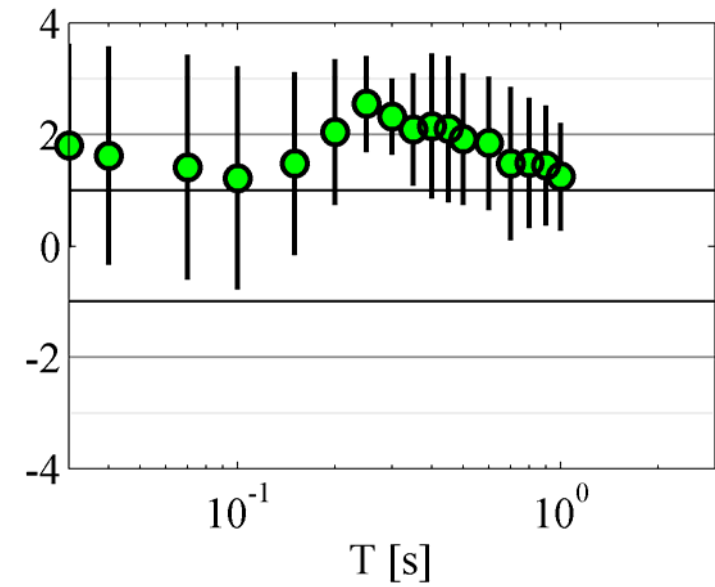
Task 4 – Identification of anomalous sites and records

Lesina - Nreg = 2 - site class 1 (shallow alluvial basin)



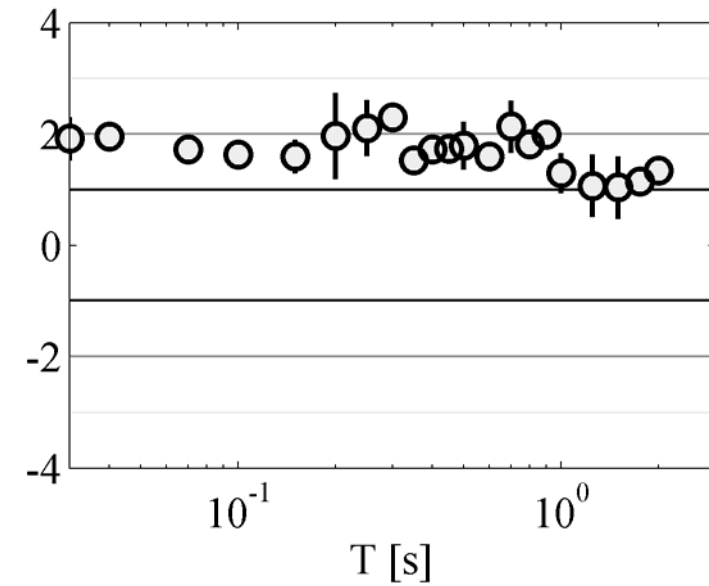
Task 4 – Identification of anomalous sites and records

Peglio - Nreg = 3 - site class 1 (shallow alluvial basin)



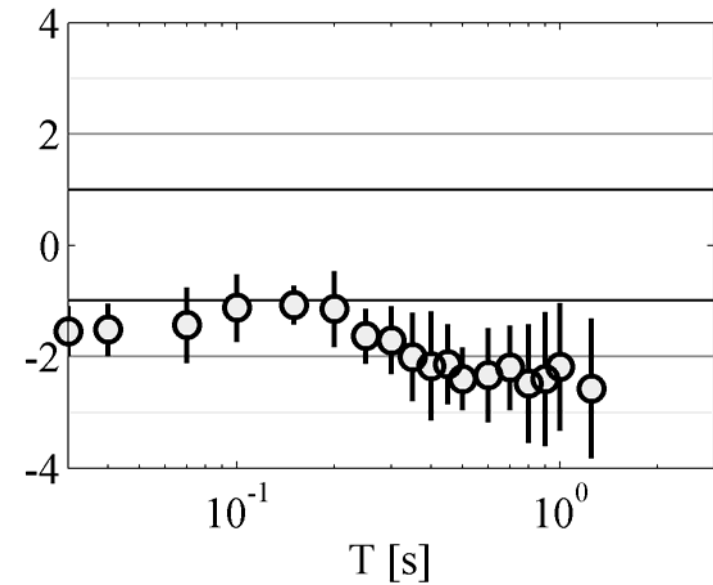
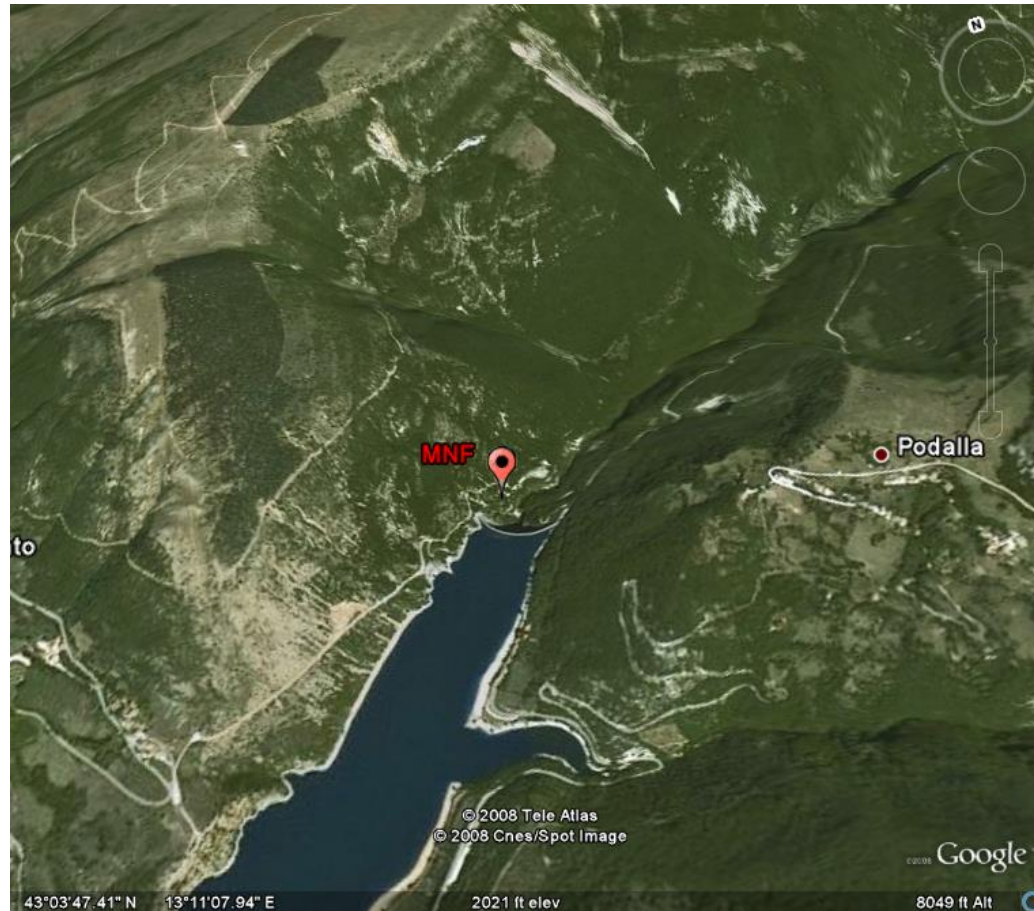
Task 4 – Identification of anomalous sites and records

Naso - Nreg = 2 - site class 0 (rock)



Task 4 – Identification of anomalous sites and records

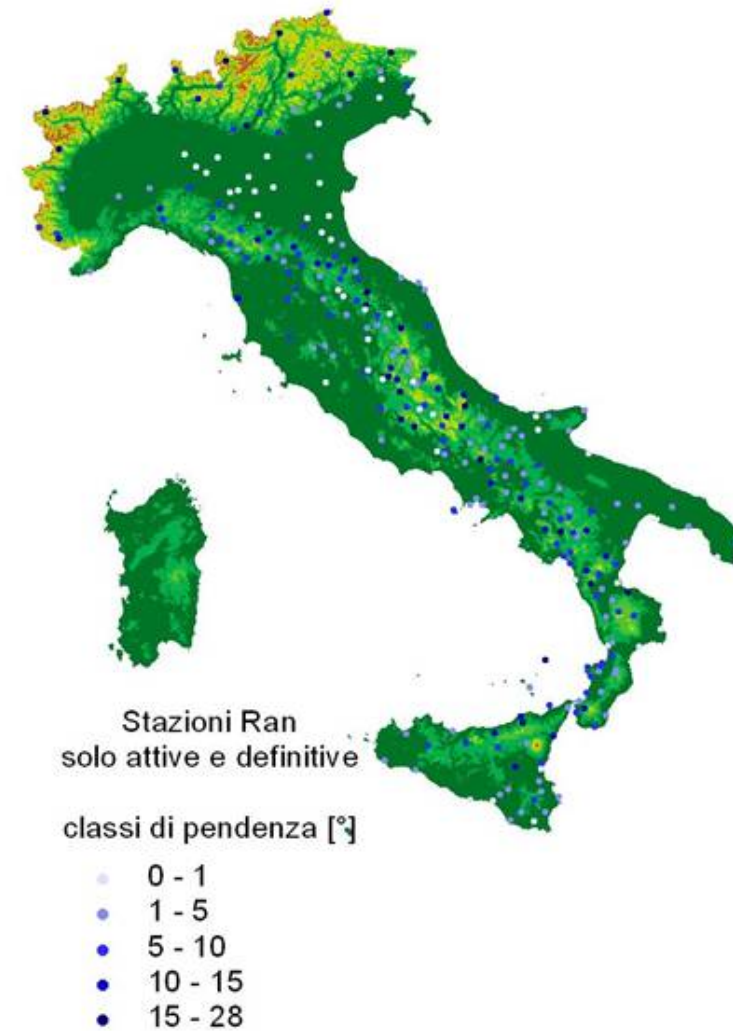
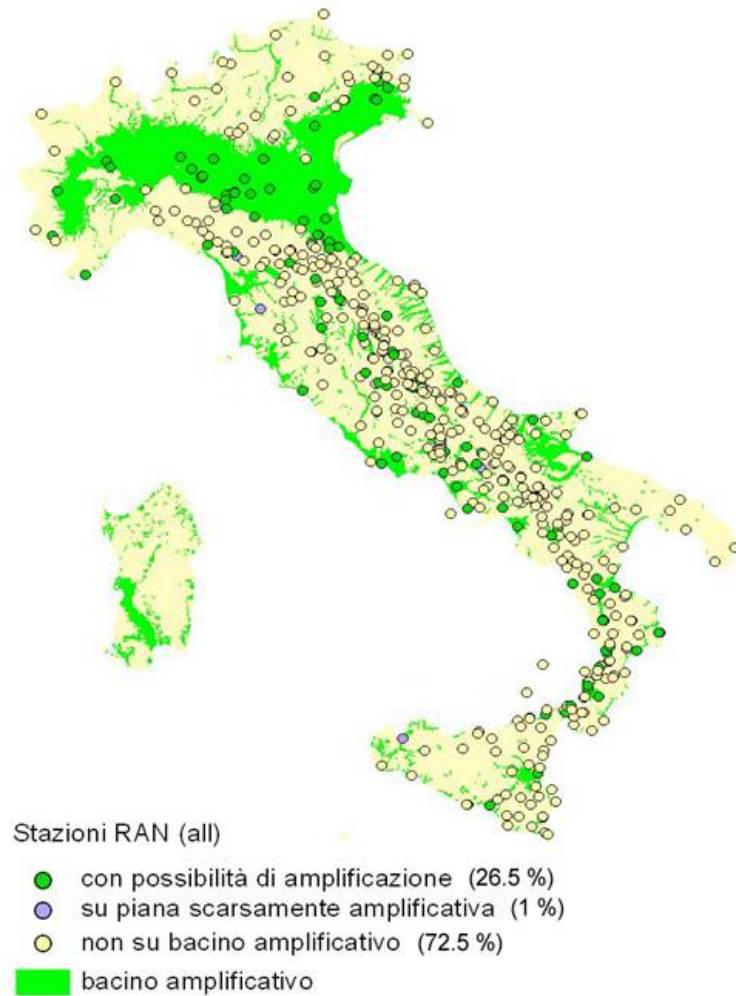
Monte Fiegni (Fiastra) - Nreg = 5 - site class 0 (rock)



Task 4 – Identification of anomalous sites and records

GIS-based identification of potentially amplifying basins and topographies

Basin map from Project S5 DPC-INGV 2005-07



Task 4 – Identification of anomalous sites and records

Possible soil-structure interaction effects

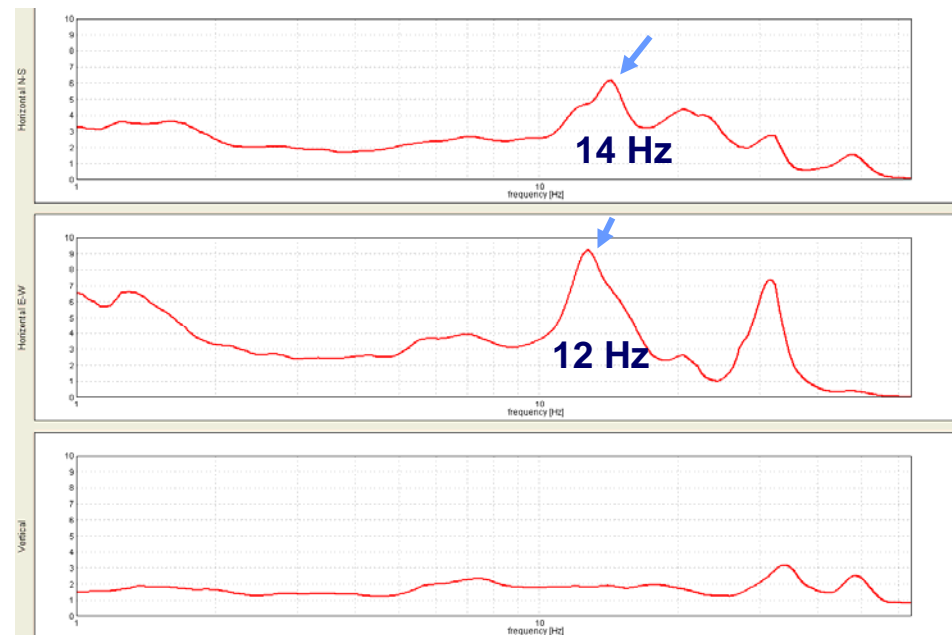
→ evaluation of literature and available data to assess the influence of ENEL boxes on the acceleration response

→ catalog of RAN stations that may be affected by (i) interaction with the hosting structures; (ii) interaction by surrounding structures; (iii) foundation problems and proximity to underground cavities;

→ detailed study of few cases among the previous types of interaction;



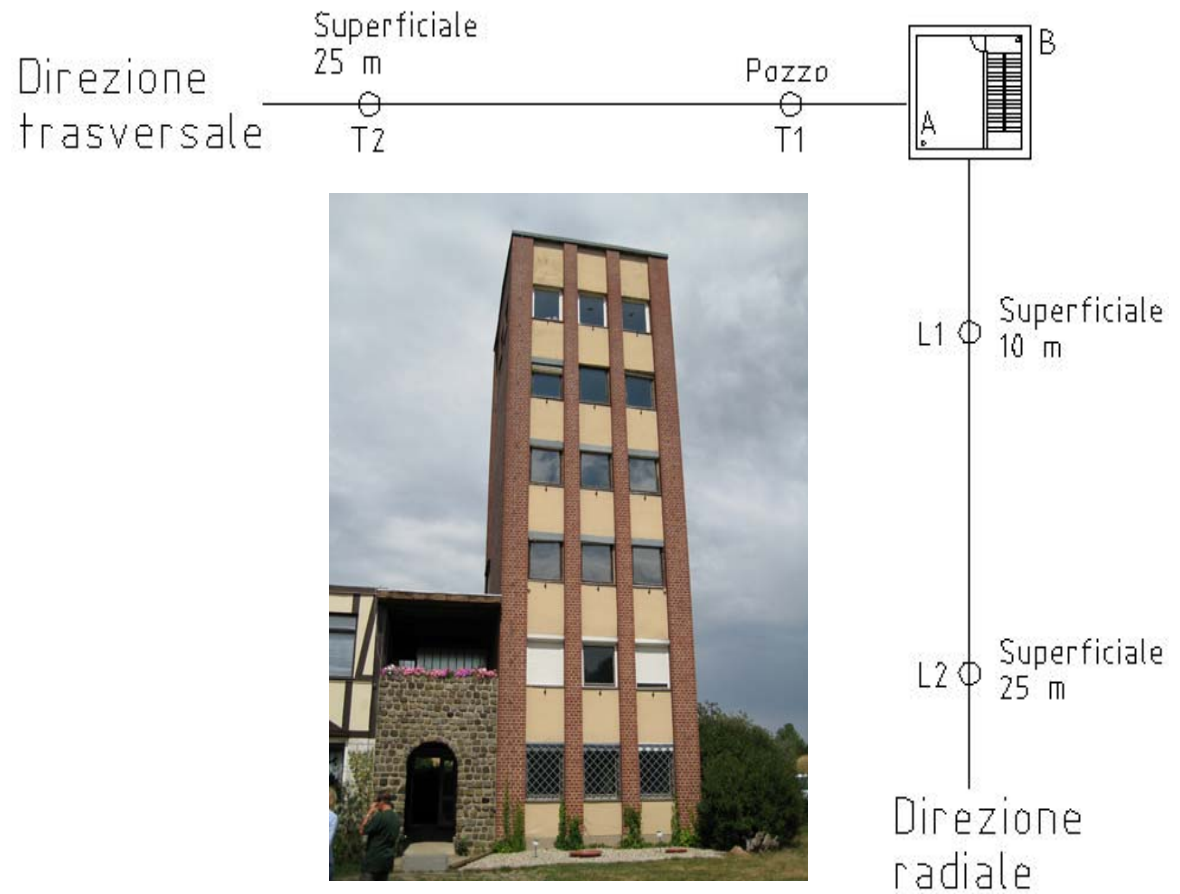
soil-to-base spectral ratio



Task 4 – Identification of anomalous sites and records

Possible soil-structure interaction effects

Vibrations due to an adjacent building

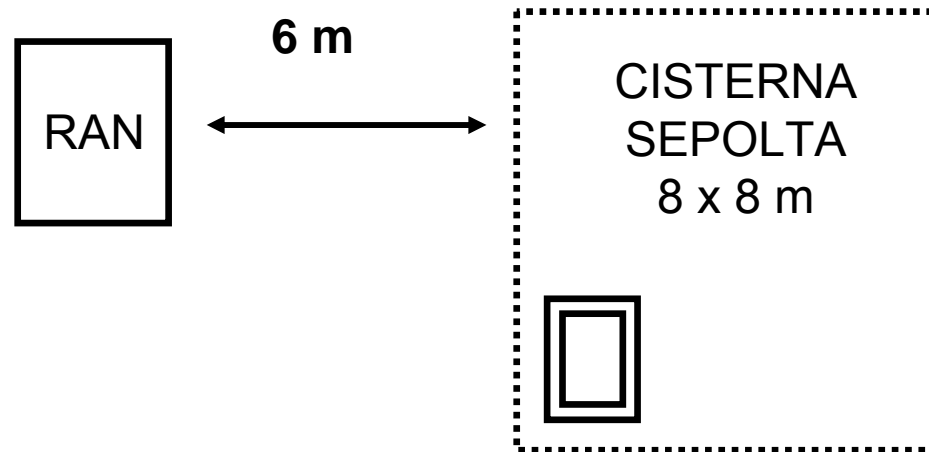


Task 4 – Identification of anomalous sites and records

Possible soil-structure interaction effects



Interaction with buried cavities: the Genova station



Main activities

4.1 Identification of anomalous sites and records

4.2 (a) In-field monitoring at several selected station sites

(b) Numerical modelling

4.3 Classification of reported anomalies and synthesis of results

Task 4 - In-field monitoring at several selected sites

Fucino plain

(INGV-RM, from Nov 2008 to Nov 2009)

- Pros:
- 4 RAN stations in the area
 - devastating M7 earthquake on Jan 13 1915 (33000 victims)
 - closed-shape basin with very soft soils
 - good knowledge of the site (tectonic, geology, Telespazio site)
 - municipalities located at basin edges
- Cons:
- relatively rare seismicity

Norcia

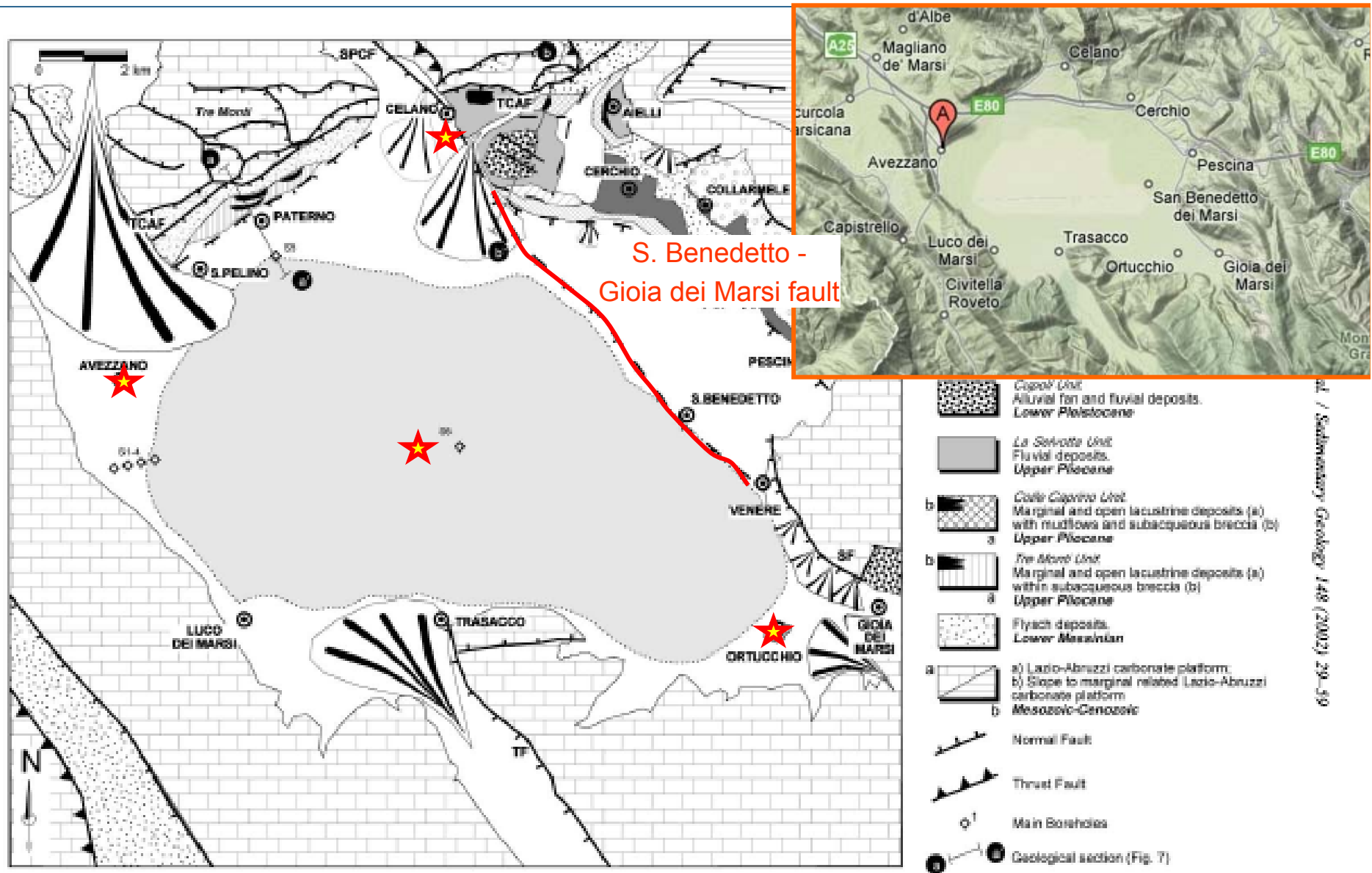
(GFZ+INGV-MI, from Jan 2009 to Apr 2009)

- Pros:
- 2 RAN + 2 ENEA stations in the area
 - irregular closed-shape basin
 - records from the Umbria-Marche earthquake sequence
 - good knowledge of the site (microzonation study)
 - frequent seismic activity

Topography site

(INGV-MI: to take a final decision between three candidate sites)

Task 4 – Seismic monitoring at Fucino plain



L / Sedimentary Geology 148 (2002) 29–39

Task 4 – Seismic monitoring at Fucino plain

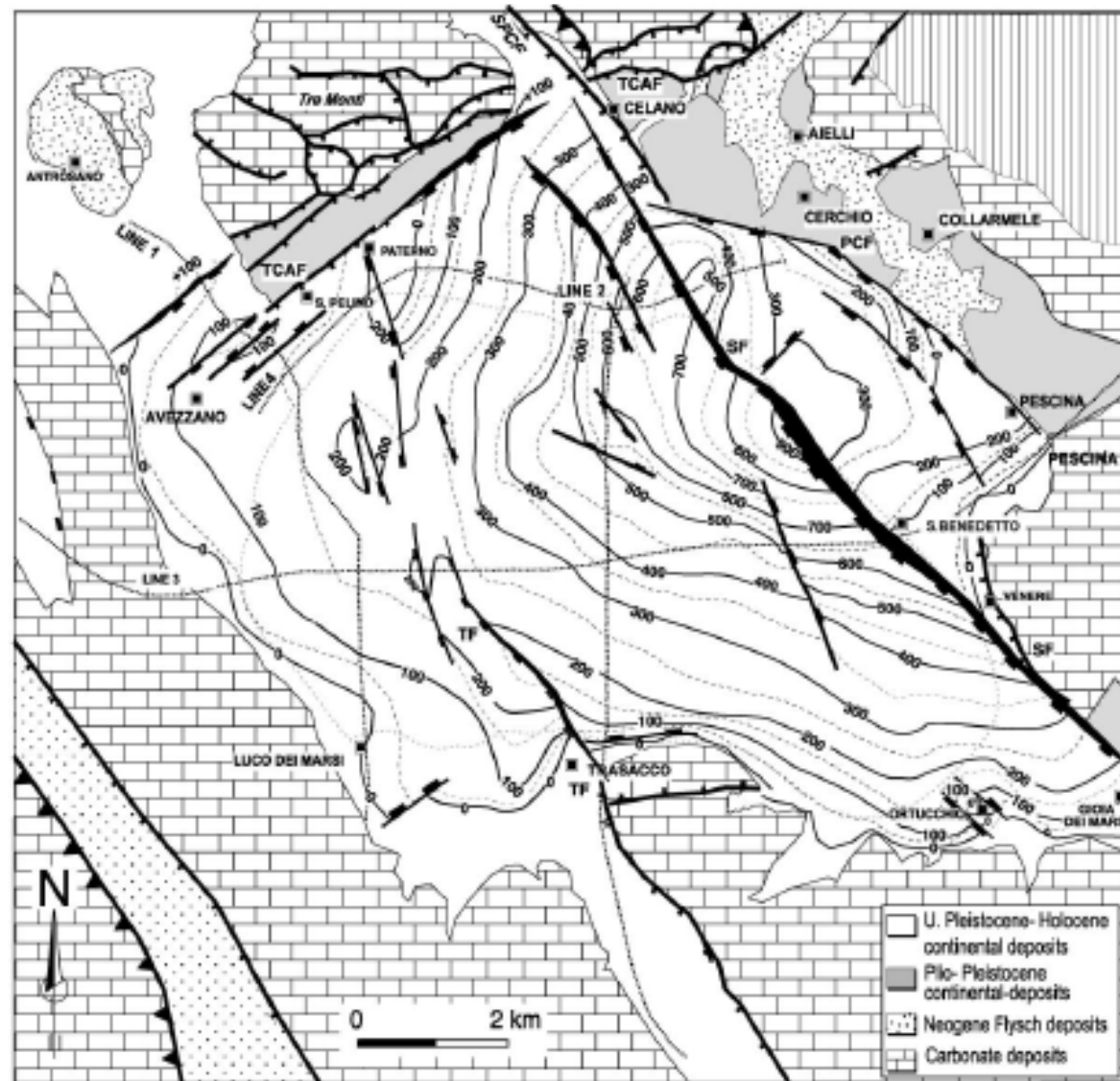
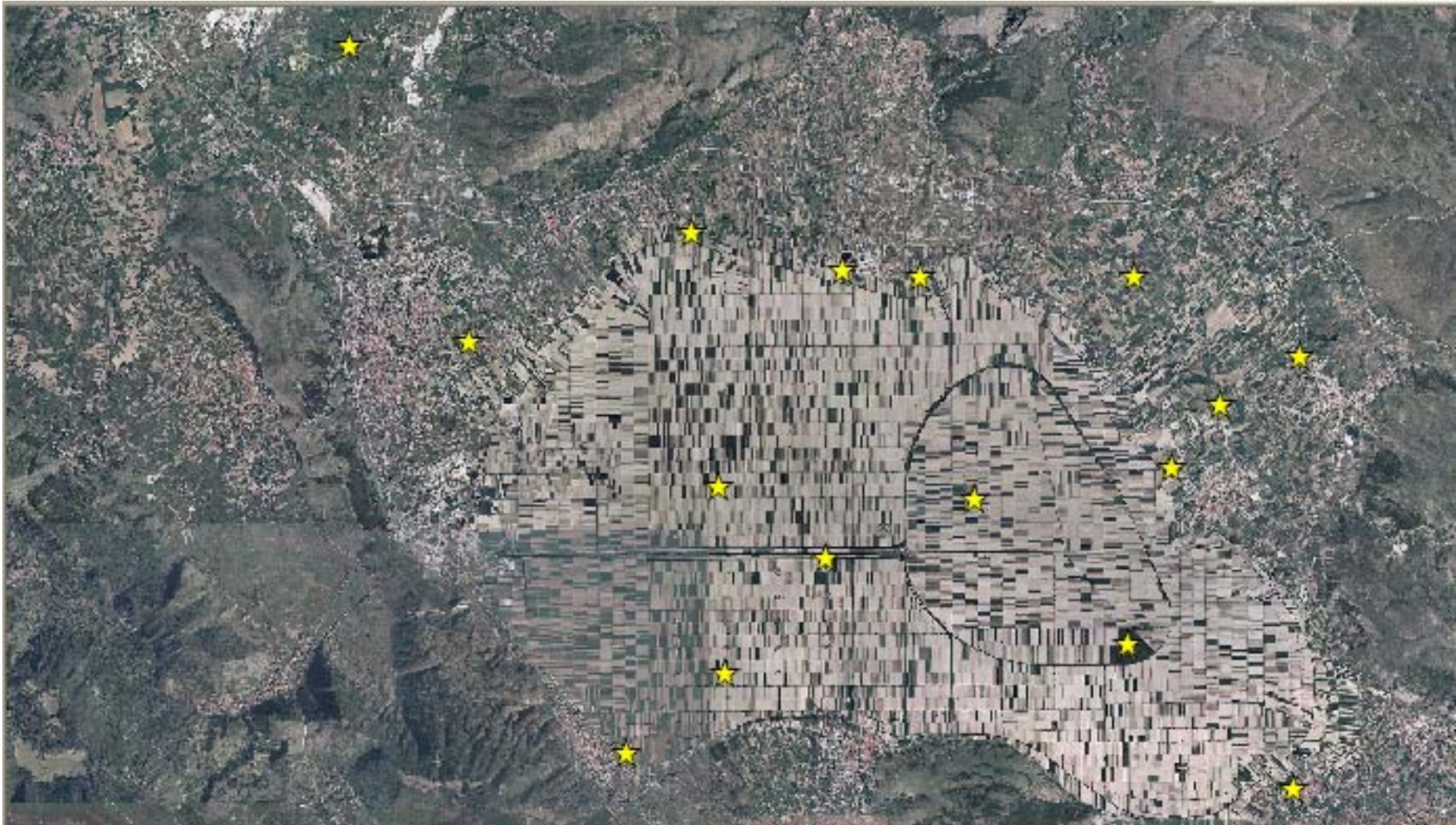


Fig. 15. Isochron contour map (interval 50 ms and 100 ms) of the alluvial and lacustrine deposits (Sequence 3 and 4).

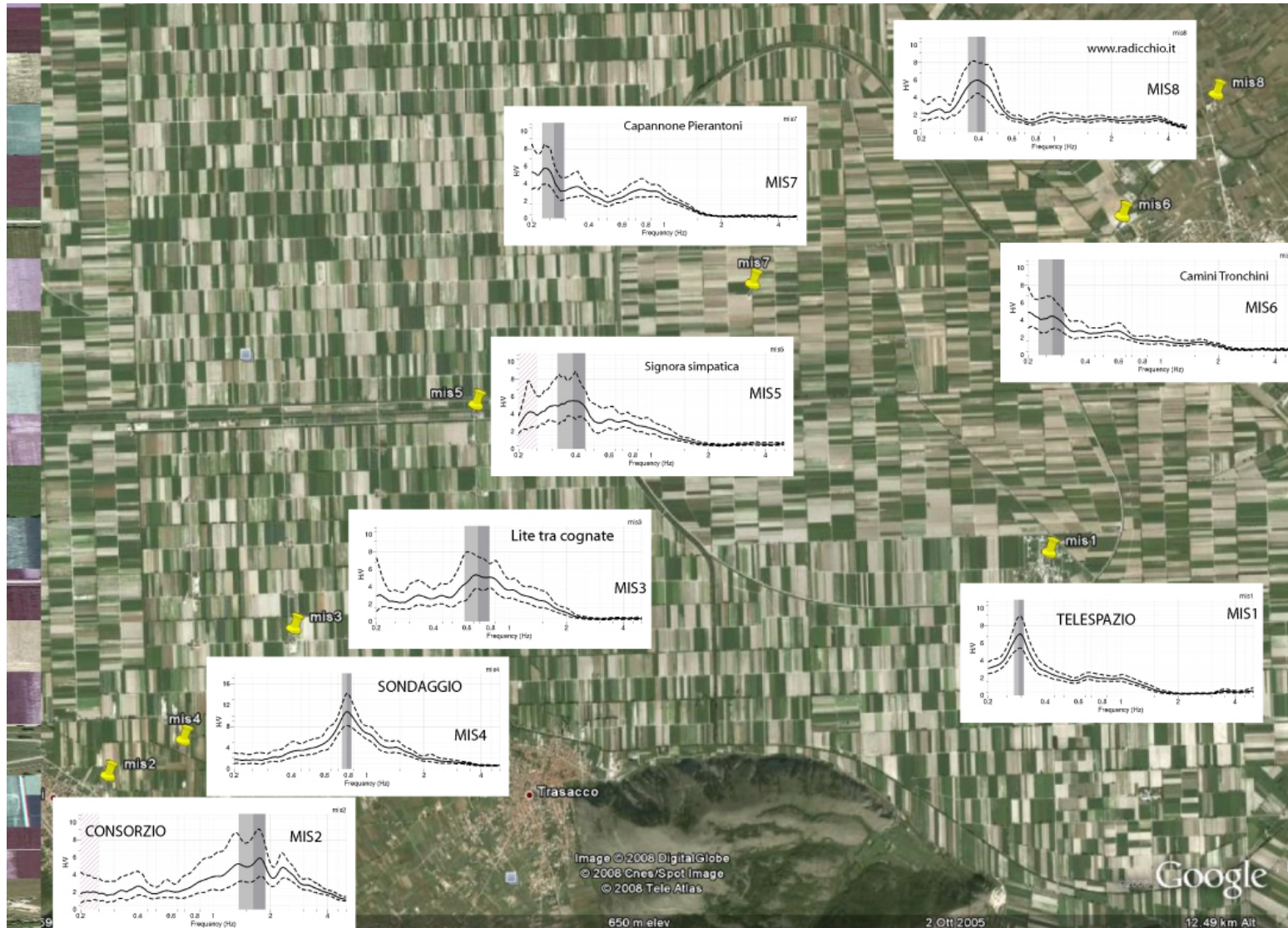
Task 4 – Seismic monitoring at Fucino plain

Installation sites of the temporary network (INGV-RM - duration: 1 yr)

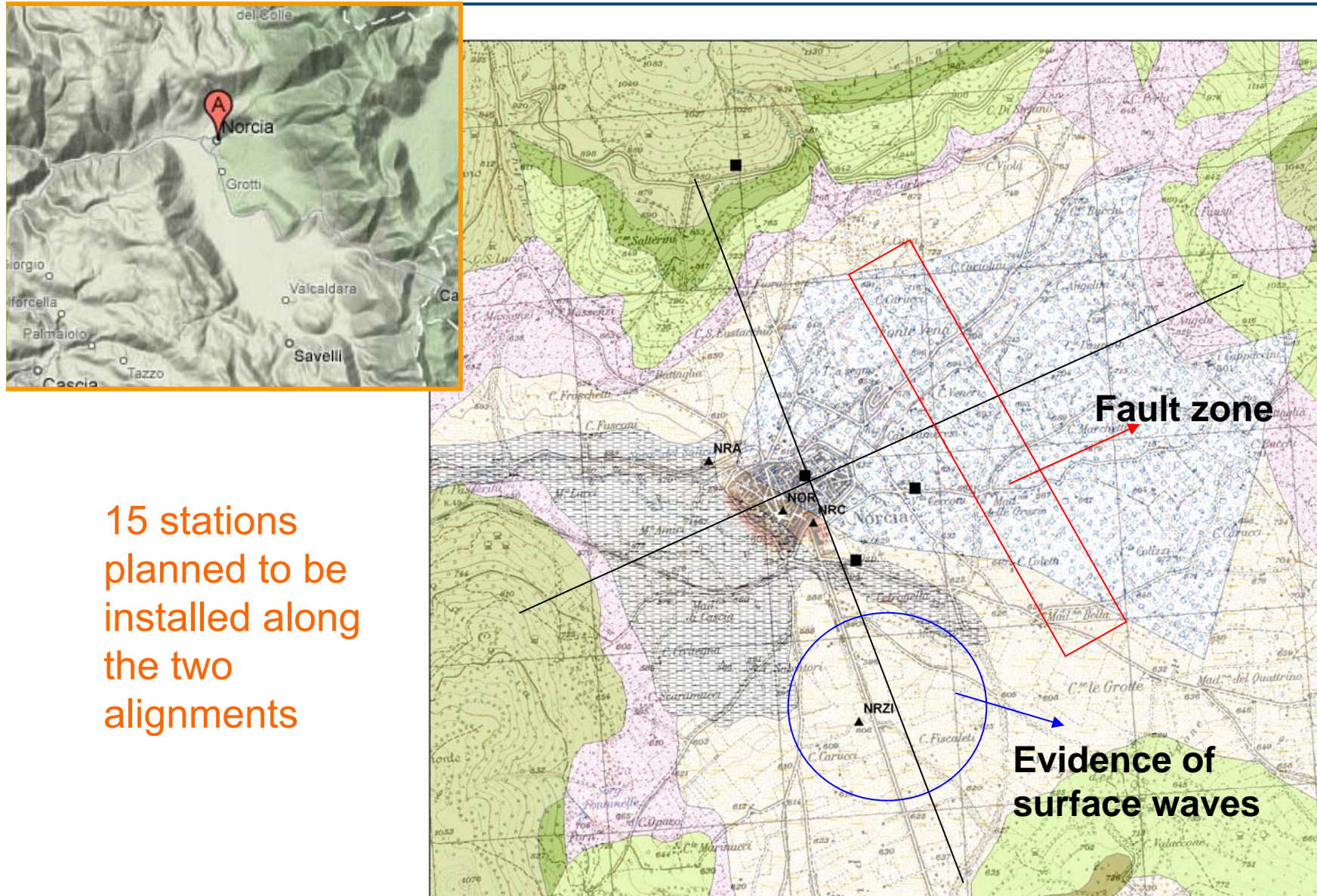


Task 4 – Seismic monitoring at Fucino plain

preliminary results from H/V microtremors analyses



Task 4 – Seismic monitoring at Norcia



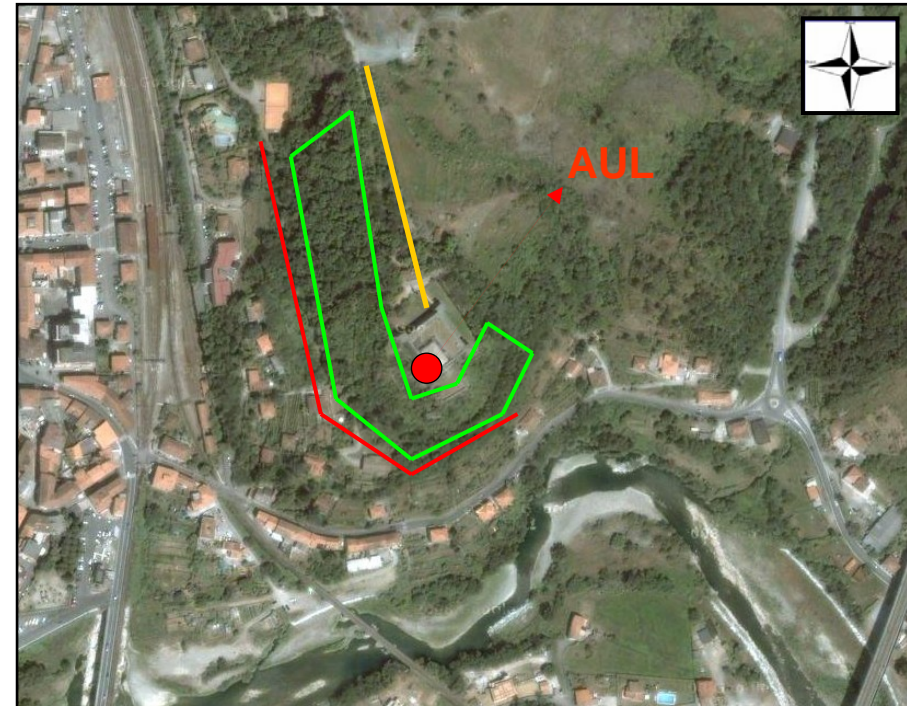
15 stations
planned to be
installed along
the two
alignments

Fault zone

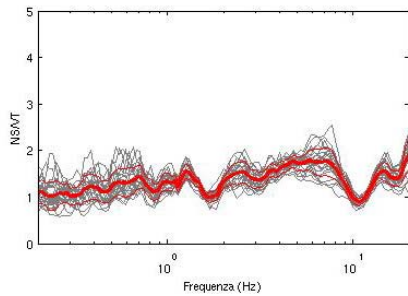
**Evidence of
surface waves**

Task 4 – Seismic monitoring at a topographic site: candidates

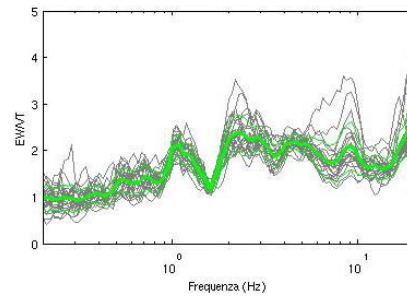
Aulla (Toscana)



● H/V measurements at AUL station

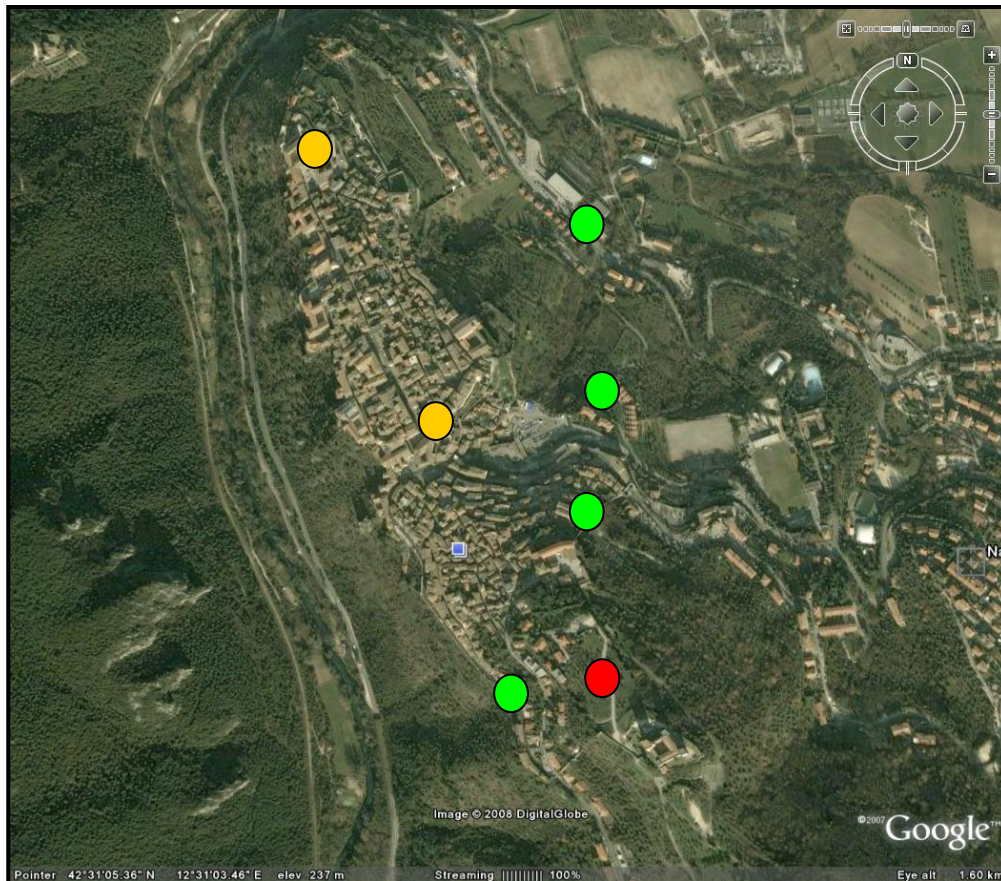


NS/V



EW/V

Task 4 – Seismic monitoring at a topographic site: candidates



- NRN accelerometer station
- proposed installations along the crest
- proposed installations along the slope

Narni (Umbria)

Task 4 – Seismic monitoring at a topographic site: candidates

Montecassino (Lazio)



Main activities

4.1 Identification of anomalous sites and records

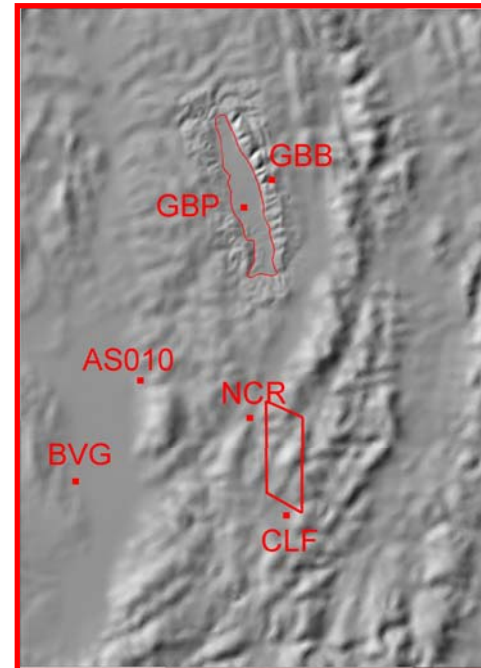
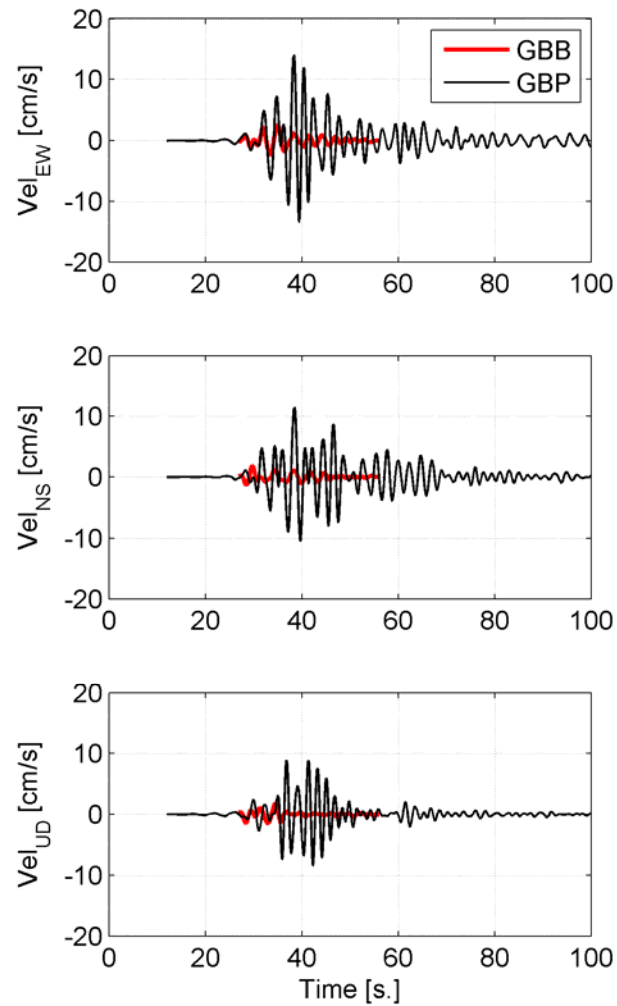
4.2 (a) In-field monitoring at several selected station sites

(b) Numerical modelling

4.3 Classification of reported anomalies and synthesis of results

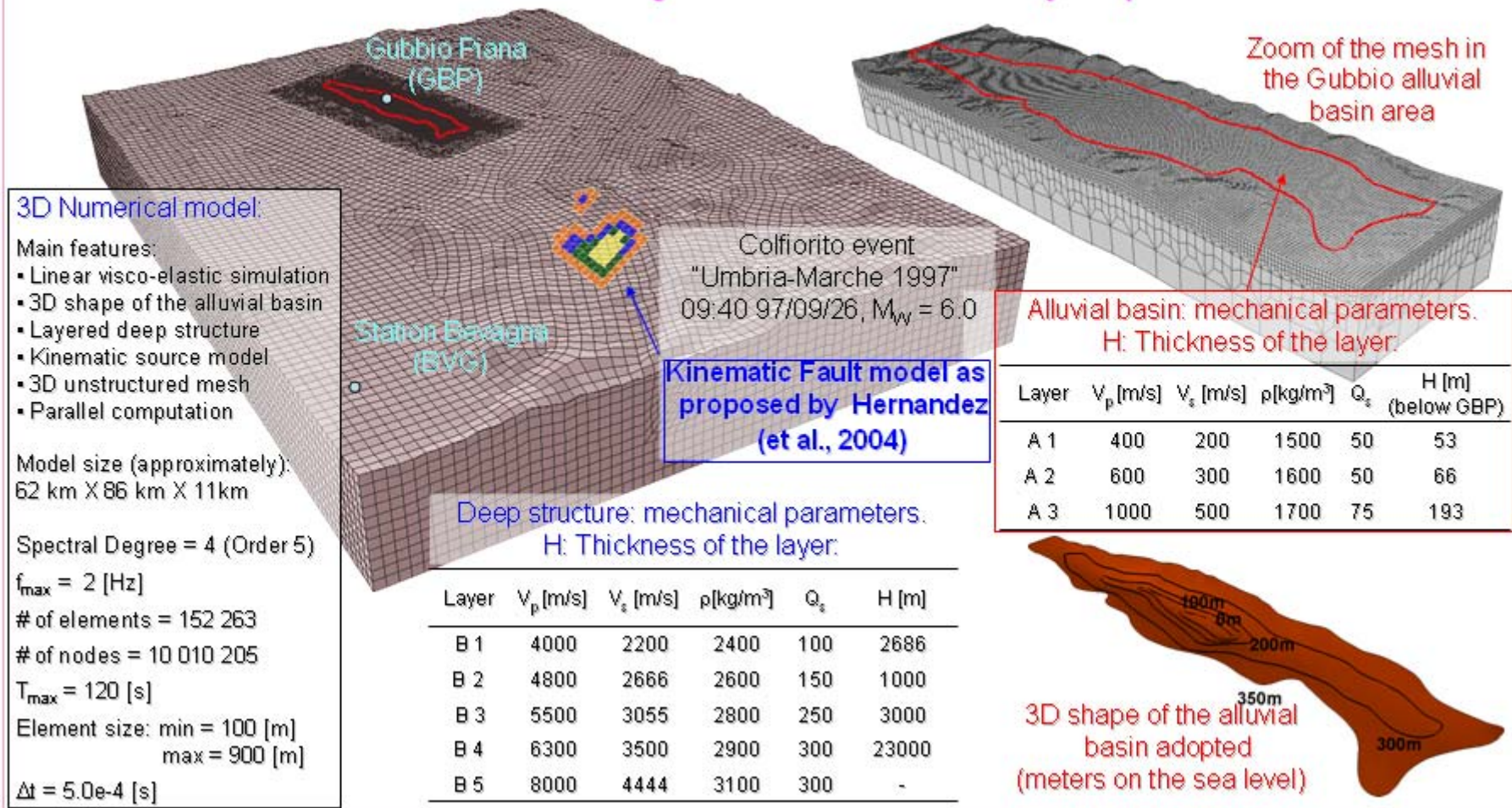
Task4 – Numerical modelling – Gubbio basin

Records of 26/9/1997 9.40 – Umbria Marche



Task4 – Numerical modelling – Gubbio basin

The 3D numerical model: mesh designed with **CUBIT** and analyses provided with **GeoELSE**



- 1 - Digital Elevation Model 2 - Geotechnical soil description 3 - Fault model
(bedrock and alluvial dep.)

Geo-ELSE (GEO-ELastodynamics by Spectral Elements)



Developers

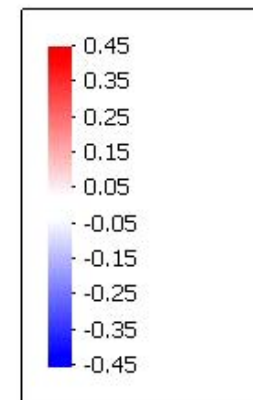
- Politecnico di Milano, DIS (Department of Structural Engineering)
- CRS4 (Centro Ricerche e Sviluppo Studi Superiori Sardegna)

Web site: <http://geoelse.stru.polimi.it>

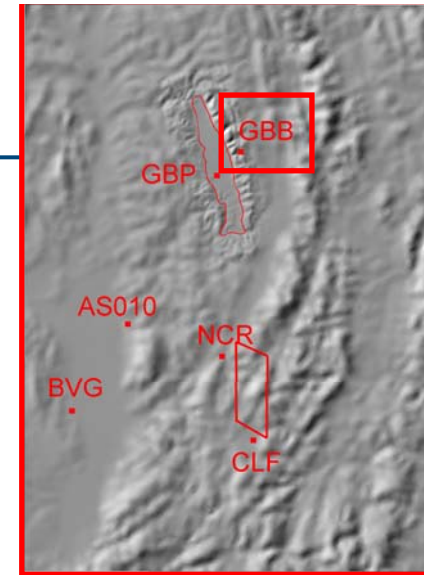
Task4 – Numerical modelling – Gubbio basin



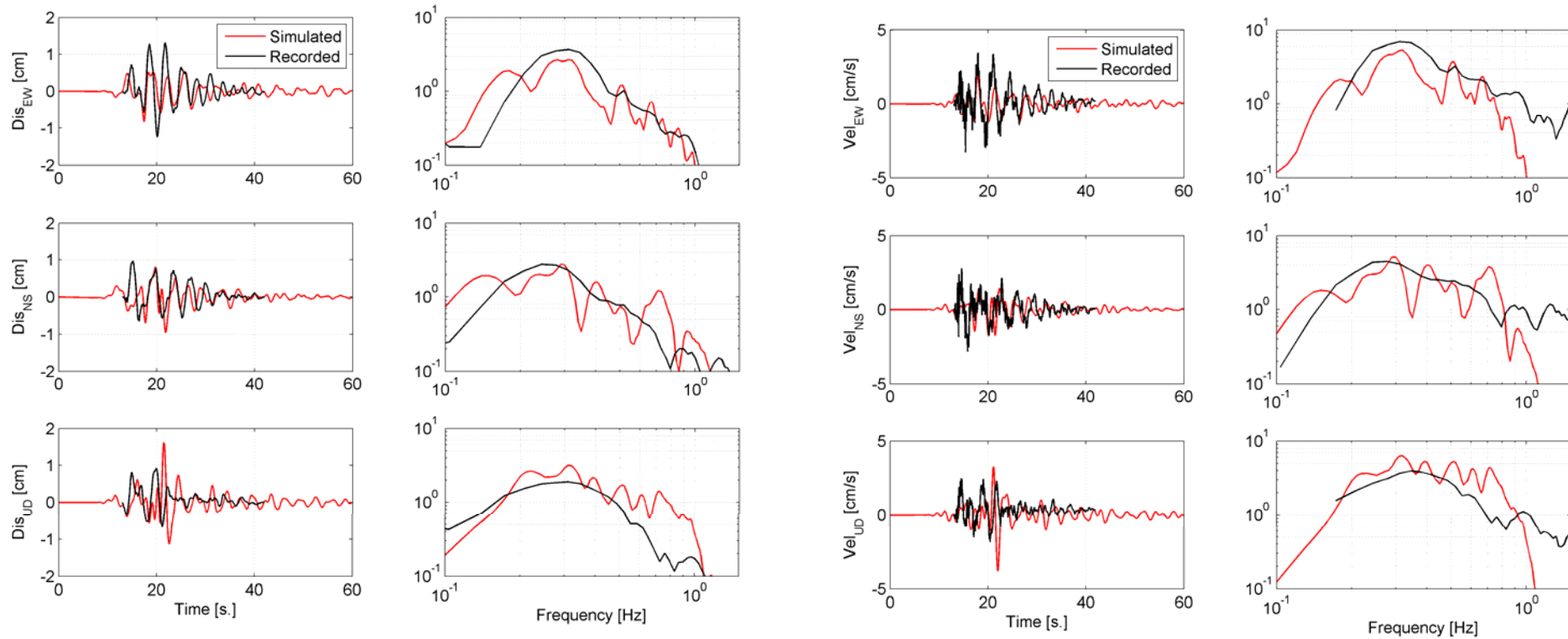
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Contour Fill of veloc, X-veloc.



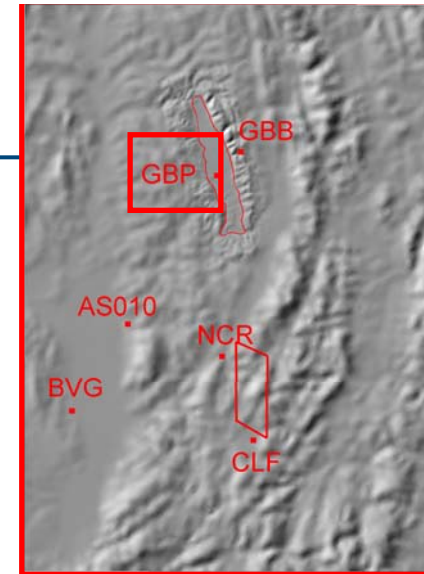
Task4 – Numerical modelling – Gubbio basin



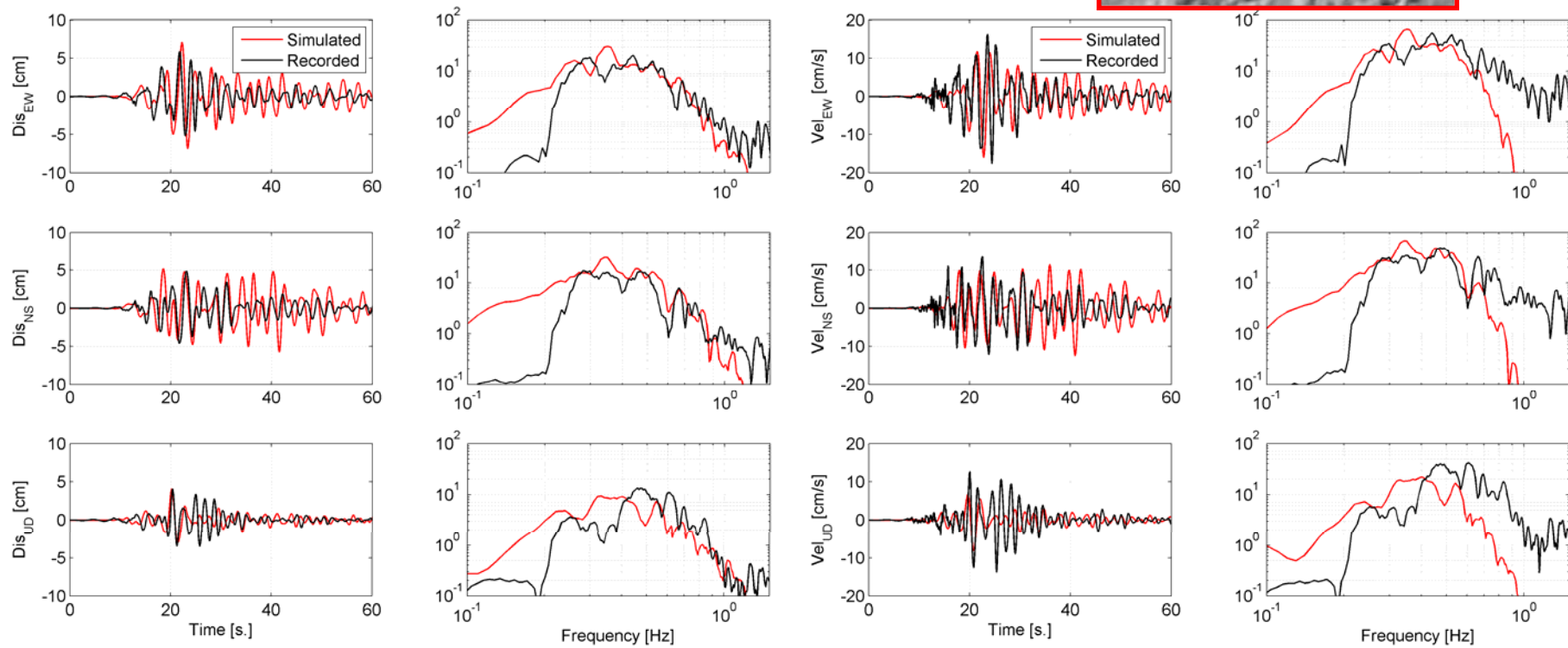
Station GBB – Outcropping Bedrock



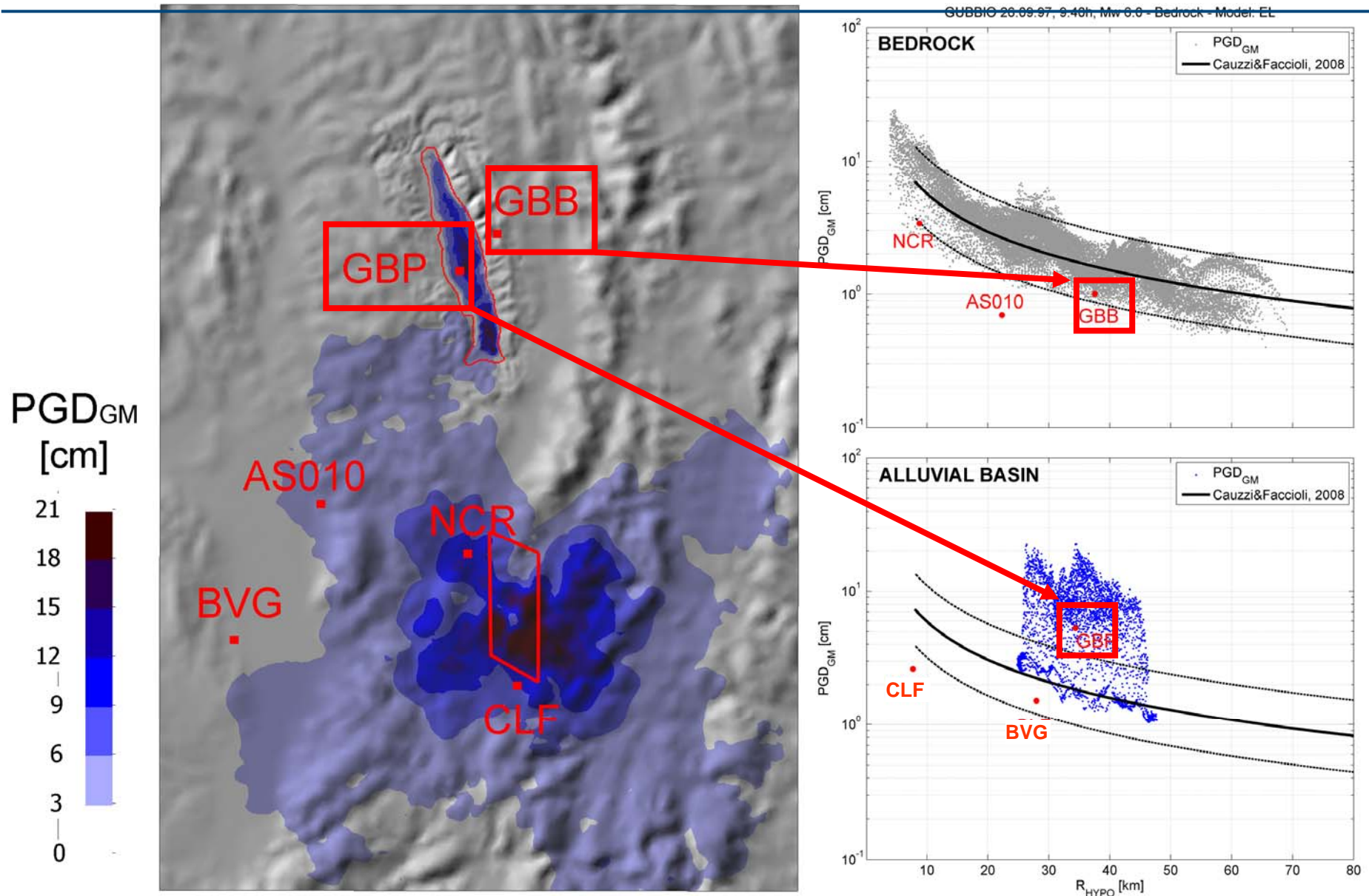
Task4 – Numerical modelling – Gubbio basin



Station GBP – Alluvial basin



Task4 – Numerical modelling – Gubbio basin



Main activities

4.1 Identification of anomalous sites and records

4.2 (a) In-field monitoring at several selected station sites
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Task4 – Synthesis of results

Closed-shape alluvial basins

Avezzano



Gubbio



Norcia



Sulmona (→S2)



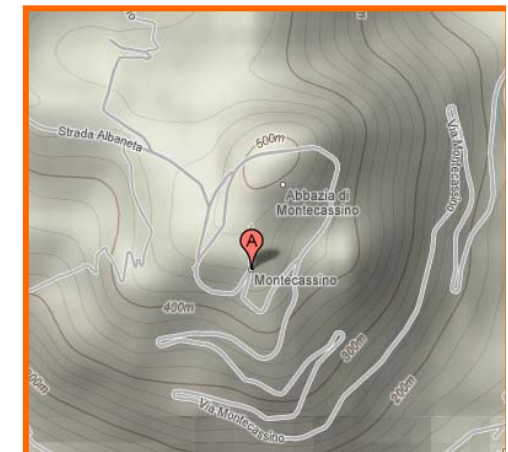
- Catalog of ITACA stations with possible complex alluvial basin or topography effects

- Identify period ranges (and expected amplification factors?) affected by such effects

- Records suitable for 1D site response analyses?

Topographies

Montecassino (?)



Task4 – Work progress

Planned

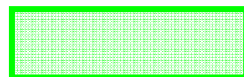
Identification of anomalous sites and records	1st	2nd	3rd	4th
Bibliographic search	X			
Identification of anomalous sites based on geomorphological evidence	X			
Identification of anomalous sites based on statistical analysis of existing records	X	X		
Seismic monitoring of selected sites		X	X	X
Numerical modelling of seismic response at selected sites		X	X	X
Synthesis of results and implementation in the database				X



almost completed



started on schedule



ahead of schedule

Problems

This task is going on schedule. No major problems found