EUCENTRE
European Centre for Training and Research in Earthquake Engineering

IUSS Sapere Aude

SEVENTH FRAMEWORK PROGRAMME

UNISDR
مكتب الأمم المتحدة للحد من مخاطر الكوارث

Seismic Risk Mitigation in Palestine
SASPARM Project

MICROZONATION FOR THE REFERENCE SEISMIC INPUT IN TUSCANY REGION (CENTRAL ITALY)

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Acknowledgments

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Outline

- Seismic risk and hazard
- Seismic input definition (spectra and accelerograms)
- Italian building code (NTC 2008 – 2015 ?)
- Selection of real accelerograms
- Projects for the Tuscany Region
- Procedure to define the reference seismic input in Tuscany
- Software: SCALCONA 2.0
- Concluding remarks

Seismic risk and hazard

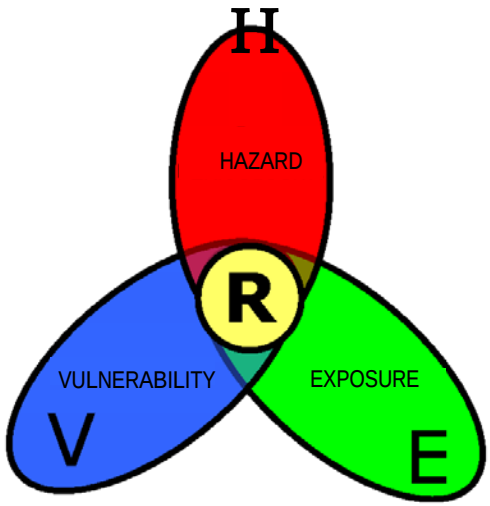
SEISMIC RISK

Seismic risk means, in a very broad sense, the expected losses (deaths and direct, but also indirect damages) as a result of earthquakes. In a probabilistic sense, it defines the probability that a given level of losses caused by earthquakes is exceeded within a given amount of time at a site, a group of sites or within an area. Note that, as a result of this definition, the risk is cumulative, thus it takes into account overall losses induced by different earthquakes, possibly on an annual basis.

danni
senso
erdite
sito,
one il
te da

terremoti diversi, eventualmente riportate su base annua. (Faccioli, 2003)

Seismic risk => *convolution* of seismic hazard with vulnerability and exposure of the structure and the construction s[illegible]o earthquake effects.

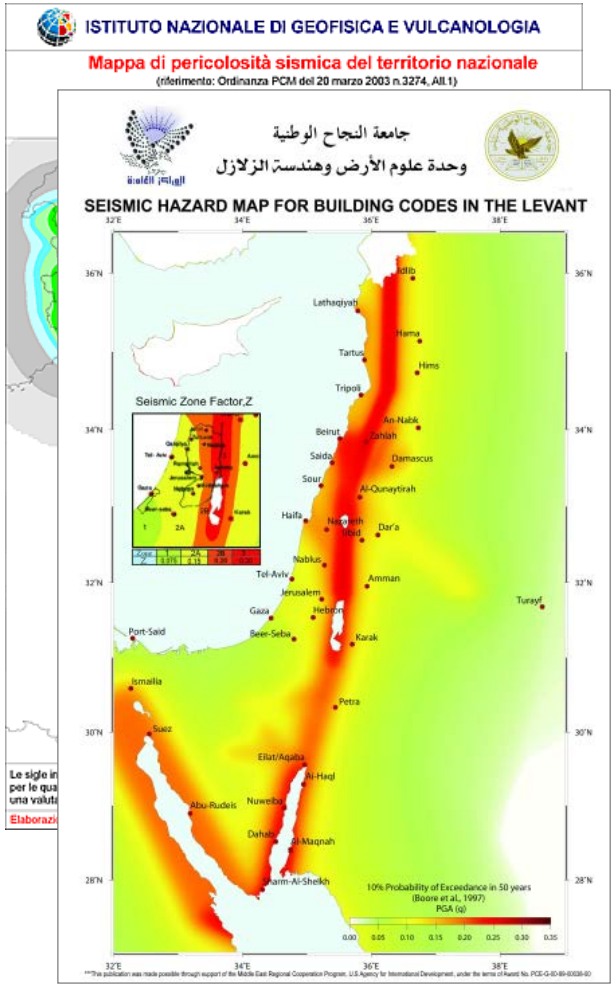


mathematical operation to compose by "*superposition*" concurrent entities, such as seismic hazard, vulnerability and exposure that interact each other.

SEISMIC RISK

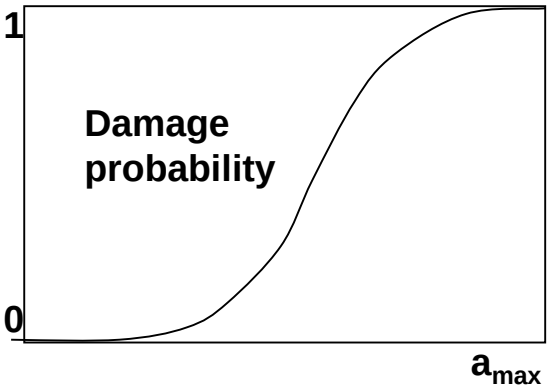
HAZARD

Propensity of a site to be subject to direct or indirect seismic action (that depends on seismicity / geology)



VULNERABILITY

Intrinsic propensity of a structure to suffer damage due to a seismic event of a given intensity.



EXPOSURE

Quantitative measure of the economic and social (in terms of involved people) value of structure or construction.

SEISMIC RISK MITIGATION

It is not possible to reduce seismic hazard, but it is possible to mitigate seismic risk by reducing earthquake impacts through actions with the aim to reduce vulnerability and exposure:

- Proper design and construction to reduce the structures vulnerability
- Land-use planning (susceptibility to liquefaction, landslides, etc.)
- Setting up an effective civil protection system: awareness and dissemination of information, systems for emergency management
- To implement mitigation actions, you should first define what the seismically dangerous areas are within the investigated region: seismic hazard assessment is essential to design and for land-use planning, and to optimize spending policies.

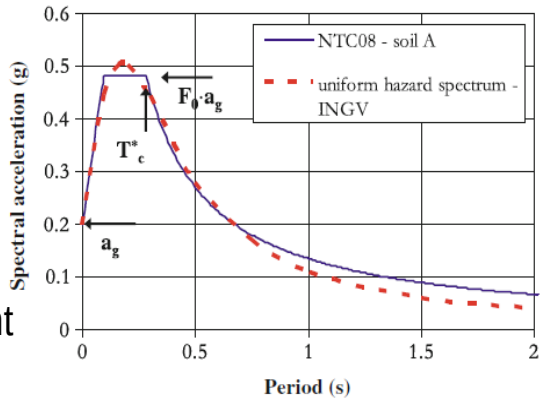
Seismic hazard assessment for a region requires specific studies, such as historical, geological, geophysical. Some notions of geodynamics, seismology and probability are required to illustrate the basic concepts of seismic hazard.

Seismic input definition

FLOW-CHART FOR THE COMPUTATION OF THE SEISMIC ACTION

Seismic macrozonation

T_R = return period $\Rightarrow$ ref. seismic hazard
a_g = max. ground acceleration at rock
F_0 = max. amplif. factor
T_C^* = control period that marks the start of constant velocity branch



Seismic microzonation

stratigraphic amplification (S_S, C_C)
topographic amplification (S_T)

SEISMIC ACTION

response spectra

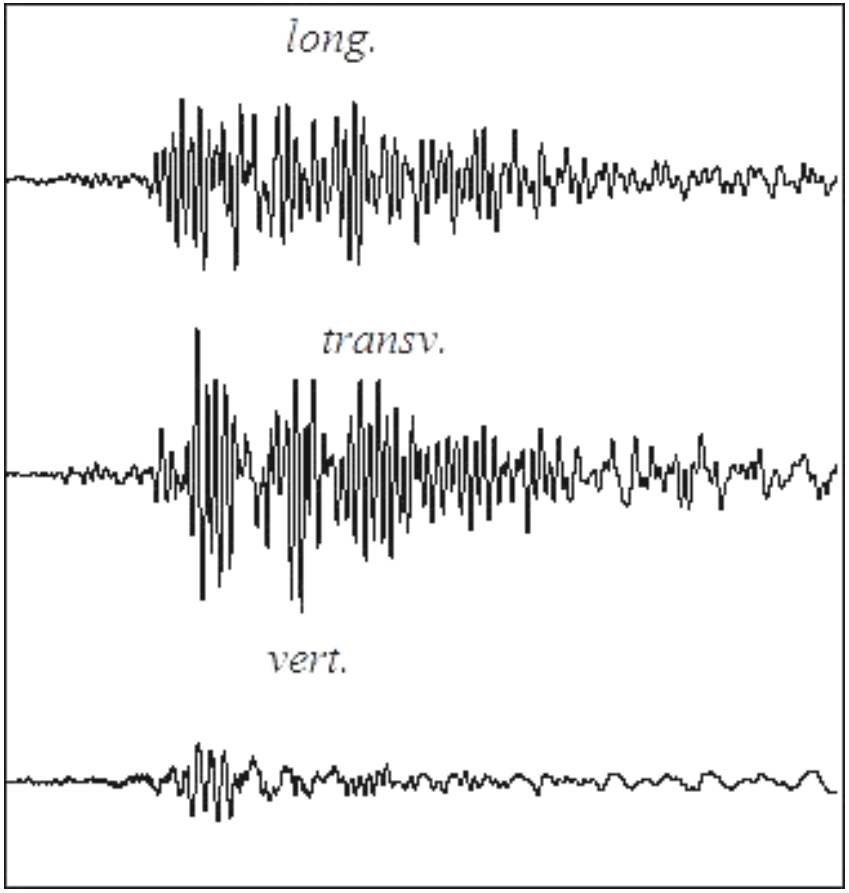
horizontal/vertical
elastic/inelastic
acceler./displ.

accelerograms

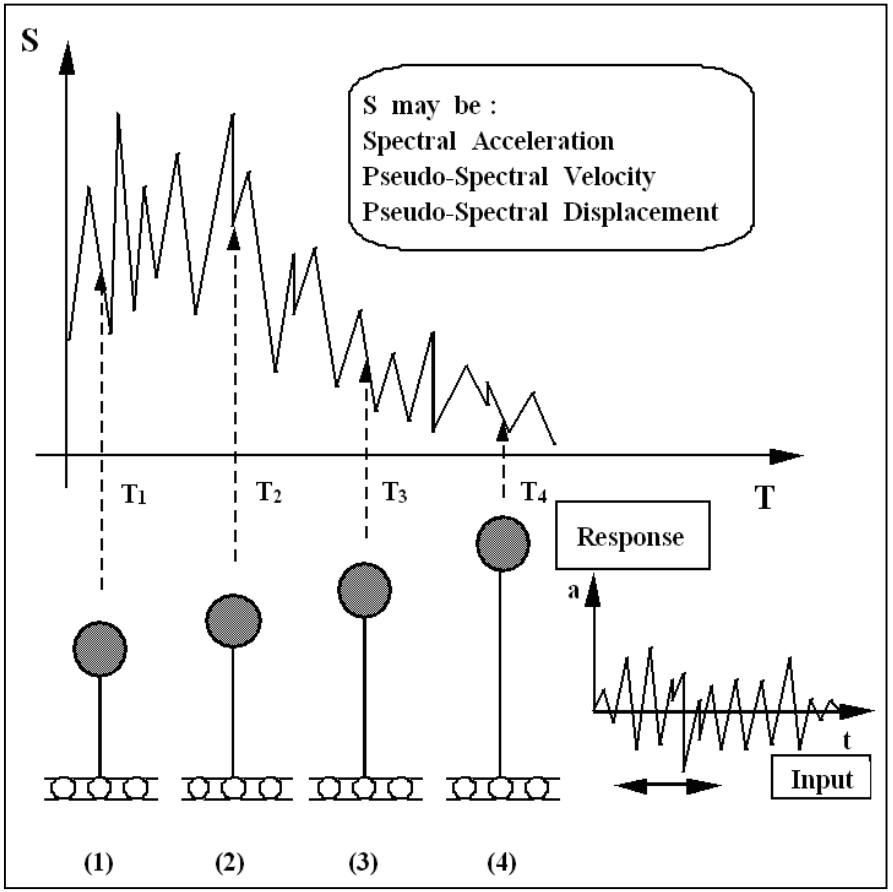
real
artificial
synthetic

(from *Italian building code NTC 14-01-2008*)

Representation of seismic action



time histories (accelerograms)



elastic response spectrum

Italian building code

ITALIAN BUILDING CODE

Seismic hazard => primary element of knowledge to define the seismic action

3.2 AZIONE SISMICA

Le azioni sismiche di progetto, in base alle quali valutare il rispetto dei diversi stati limite considerati, si definiscono a partire dalla "pericolosità sismica di base" del sito di costruzione. Essa costituisce l'elemento di conoscenza primario per la determinazione delle azioni sismiche.

La pericolosità sismica è definita in termini di accelerazione orizzontale massima attesa a_g in condizioni di campo libero su sito di riferimento rigido con superficie topografica orizzontale (di categoria **A** quale definita al § 3.2.2), nonché di ordinate dello spettro di risposta elastico in accelerazione ad essa corrispondente $S_e(T)$, con riferimento a prefissate probabilità di eccedenza P_{V_R}, come definite nel § 3.2.1, nel periodo di riferimento V_R, come definito nel § 2.4. In alternativa è ammesso l'uso di accelerogrammi, purché correttamente commisurati alla *pericolosità sismica* del sito.

Seismic hazard is defined, for given return periods, in terms of:

- maximum ground horizontal acceleration
- elastic acceleration response spectrum
- accelerograms

ITALIAN BUILDING CODE

Use of accelerograms

The Italian building code (NTC 14/01/2008 § 3.2.3.6) states:

- Ultimate and serviceability limit states may be verified using artificial or synthetic or natural accelerograms.

- Each accelerogram describes a component (horizontal or vertical) of the seismic action; the set of three components (two horizontal, orthogonal to each other, and one vertical) represents a group of accelerograms.

- The duration of artificial accelerograms should be established on the basis of the magnitude and other physical parameters that influence the choice of a_g and S_S. In the absence of specific studies, the duration of the pseudo-stationary part should be at least equal to 10 s.

ITALIAN BUILDING CODE

Use of accelerograms

The Italian building code (NTC 14/01/2008 § 3.2.3.6) states:

- The use of synthetic accelerograms generated by the simulation of the source and propagation mechanism is permitted if the assumptions concerning the seismogenetic features of the source and the propagation medium are properly justified.

- The use of recorded accelerograms is permissible if they are representative of the seismicity of the site and properly justified on the basis of the seismogenetic features of the source, of the recording site conditions, of the magnitude, of the distance from the source and of the horizontal peak ground acceleration expected at the site.

- The recorded accelerograms should be selected and scaled to approximate the response spectra within the range of periods of interest for the problem under investigation.

(UNDER REVISION PRESCRIPTIONS -> NTC 2015)

(MORE RESTRICTIVE!)

ITALIAN BUILDING CODE

TYPE OF ACCELEROGRAMS

The REAL accelerograms are preferable to the ARTIFICIAL ones as they represent more realistically the ground shaking for:

- energy and frequency content (number of cycles)
- duration in relation to the seismogenic parameters of the scenario
- correlation among vertical and horizontal components
- correspondence between phases and not only for the amplitudes (spectrograms)
- correspondence with the (seismotectonic) scenarios of interest at the site

The Italian building code (NTC 14/01/2008 § 3.2.3.6) states:

3.2.3.6 Impiego di accelerogrammi

L'uso di accelerogrammi artificiali non è ammesso nelle analisi dinamiche di opere e sistemi geotecnici.

The use of *artificial accelerograms* is **not** permitted in the dynamic analyses of geotechnical structures and systems.

ITALIAN BUILDING CODE

Circolare 2 Febbraio 2009 , n. 617 delle NTC 2008

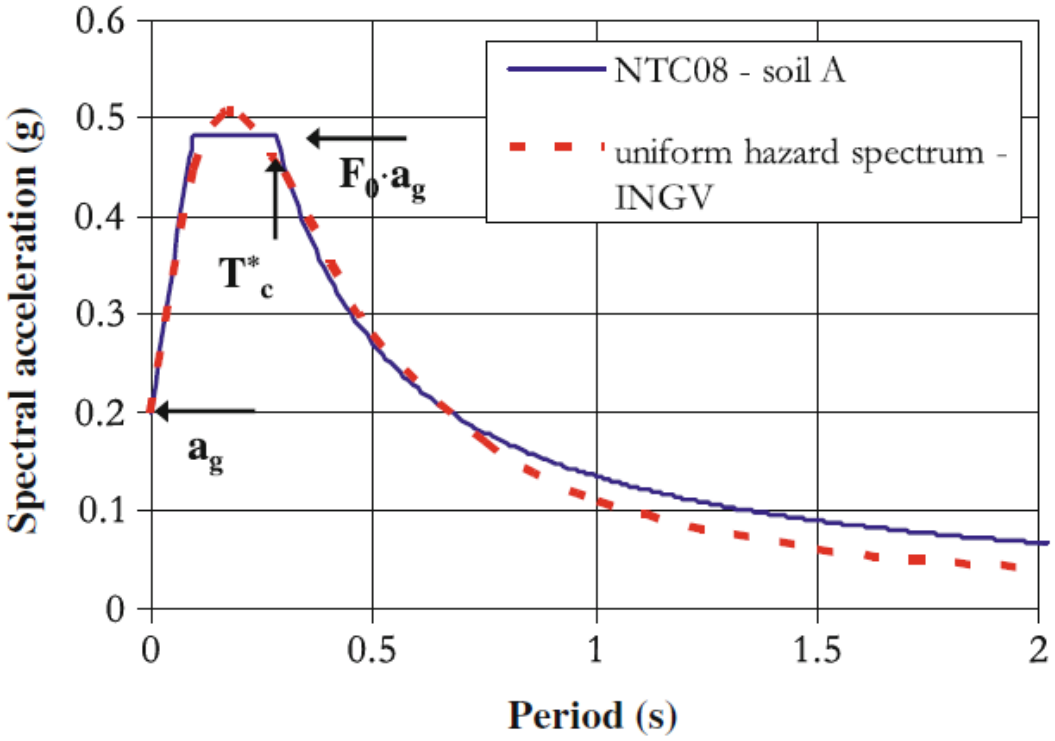
C3.2.3.6 Impiego di accelerogrammi

NTC08 § 3.2.3.6 states that the **artificial accelerograms** should respect the constraints of average compatibility with the elastic spectrum of reference, while for the **simulated and natural** ones the choice should be based on the features of the source, propagation and/or the dominant event.

However, detailed information on the source mechanism, on the magnitude and distance which determines the spectrum at the site in the range of periods of interest for the structure under investigation, are not always available. It is possible, alternatively, to use the spectral average compatibility conditions defined for artificial signals also for the natural ones, respecting the geological conditions of the site and choosing accelerograms whose spectrum is, as far as possible, similar to the reference one.

The accelerograms can be linearly scaled in amplitude limiting the scaling factor in case of signals from events of small magnitude.

Norme Tecniche per le Costruzioni, D.M. 14.1.2008



- a_g : the peak horizontal ground acceleration
- F_0 : the maximum value of the amplification factor of the horizontal acceleration response spectrum
- T_C^* : period indicating the beginning of the constant velocity branch of the horizontal acceleration response spectrum

ITALIAN BUILDING CODE

Norme Tecniche per le Costruzioni, D.M. 14.1.2008

Allegato B – NTC08

9 return periods (T_R= 30, 50, 72, 101, 140, 201, 475, 975, 2475 years)

			T_R=30			T_R=50			T_R=72			T_R=101		
ID	LON	LAT	a_g	F_o	T_C^*	a_g	F_o	T_C^*	a_g	F_o	T_C^*	a_g	F_o	T_C^*
13111	6,5448	45,134	0,263	2,50	0,18	0,340	2,51	0,21	0,394	2,55	0,22	0,469	2,49	0,24
13333	6,5506	45,085	0,264	2,49	0,18	0,341	2,51	0,21	0,395	2,55	0,22	0,469	2,49	0,24
13555	6,5564	45,035	0,264	2,50	0,18	0,340	2,51	0,20	0,393	2,55	0,22	0,466	2,50	0,24
13777	6,5621	44,985	0,263	2,50	0,18	0,338	2,52	0,20	0,391	2,55	0,22	0,462	2,51	0,24
12890	6,6096	45,188	0,284	2,46	0,19	0,364	2,51	0,21	0,431	2,50	0,22	0,509	2,48	0,24
13112	6,6153	45,139	0,286	2,46	0,19	0,366	2,51	0,21	0,433	2,50	0,22	0,511	2,48	0,24
13334	6,621	45,089	0,288	2,46	0,19	0,367	2,51	0,21	0,434	2,50	0,22	0,511	2,49	0,24
13556	6,6268	45,039	0,288	2,46	0,19	0,367	2,51	0,21	0,433	2,51	0,22	0,510	2,49	0,24
13778	6,6325	44,989	0,288	2,46	0,19	0,366	2,52	0,21	0,430	2,51	0,22	0,507	2,50	0,24
14000	6,6383	44,939	0,286	2,47	0,19	0,363	2,52	0,21	0,426	2,52	0,22	0,502	2,50	0,24
14222	6,6439	44,889	0,284	2,47	0,19	0,360	2,53	0,21	0,421	2,53	0,22	0,497	2,50	0,24

10751 nodes

on

mainland

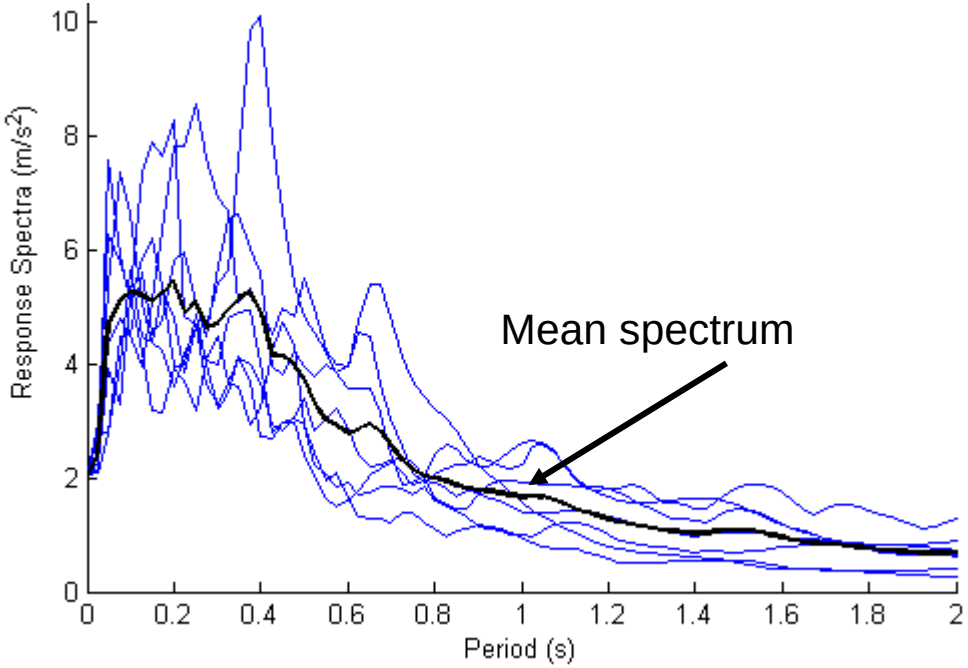
	T_R=30			T_R=50			T_R=72			T_R=101			T_R=140			T_R=201			T_R=475			T_R=975			T_R=2475		
Isole	a_g	F_o	T_C^*	a_g	F_o	T_C^*	a_g	F_o	T_C^*	a_g	F_o	T_C^*	a_g	F_o	T_C^*	a_g	F_o	T_C^*	a_g	F_o	T_C^*	a_g	F_o	T_C^*	a_g	F_o	T_C^*
Arcipelago Toscano, Isole Egadi, Pantelleria, Sardegna, Lampedusa, Linosa, Ponza, Palmarola, Zannone	0,186	2,61	0,273	0,235	2,67	0,296	0,274	2,70	0,303	0,314	2,73	0,307	0,351	2,78	0,313	0,393	2,82	0,322	0,500	2,88	0,340	0,603	2,98	0,372	0,747	3,09	0,401
Ventotene, Santo Stefano	0,239	2,61	0,245	0,303	2,61	0,272	0,347	2,61	0,298	0,389	2,66	0,326	0,430	2,69	0,366	0,481	2,71	0,401	0,600	2,92	0,476	0,707	3,07	0,517	0,852	3,27	0,564
Ustica, Tremiti	0,429	2,50	0,400	0,554	2,50	0,400	0,661	2,50	0,400	0,776	2,50	0,400	0,901	2,50	0,400	1,056	2,50	0,400	1,500	2,50	0,400	1,967	2,50	0,400	2,725	2,50	0,400
Alicudi, Filicudi,	0,350	2,70	0,400	0,558	2,70	0,400	0,807	2,70	0,400	1,020	2,70	0,400	1,214	2,70	0,400	1,460	2,70	0,400	2,471	2,70	0,400	3,212	2,70	0,400	4,077	2,70	0,400
Panarea, Stromboli, Lipari, Vulcano, Salina	0,618	2,45	0,287	0,817	2,48	0,290	0,983	2,51	0,294	1,166	2,52	0,290	1,354	2,56	0,290	1,580	2,56	0,292	2,200	2,58	0,306	2,823	2,65	0,316	3,746	2,76	0,324

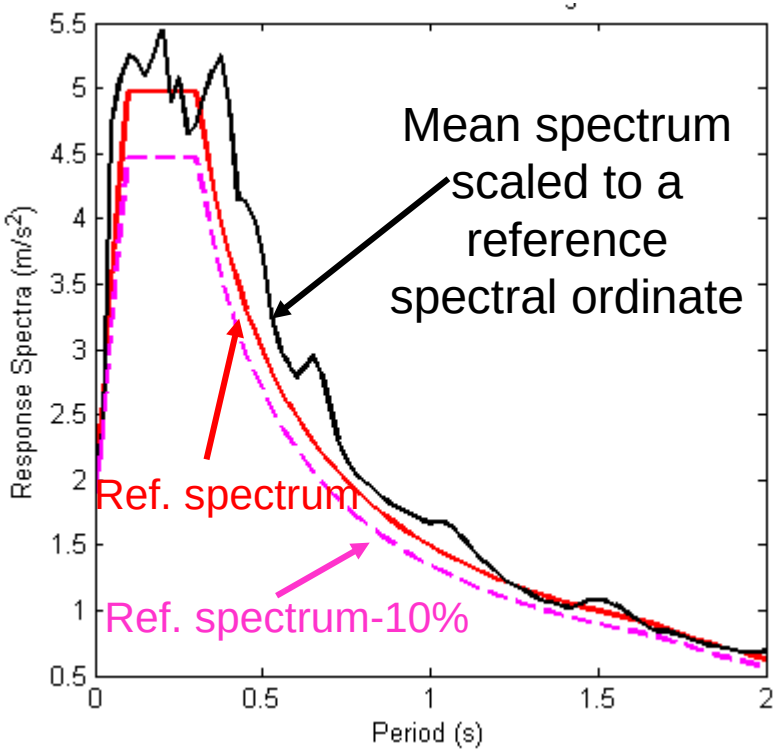
islands

ITALIAN BUILDING CODE

Spectrum-compatibility criterium (NTC 2008)

The main condition to be satisfied is that the average elastic spectrum (of the chosen set) does not underestimate the 5% damping elastic code spectrum, with a 10% lower bound tolerance, in the larger range of periods between [0.15s,2s] and [0.15s,$2T_1$] for safety verifications at *ultimate limit state* (T_1 *is the fundamental* period of the structure in the direction where the accelerograms will be applied) or in the larger period ranges between [0.15s,2s] and [0.15s,$1.5T_1$], for structural safety verifications at *serviceability limit state. For seismically isolated structures, the code provides a narrower* range of spectrum matching around the fundamental period, [0.15s,$1.2T_{is}$], where T_{is} is the equivalent period of the isolated structure.





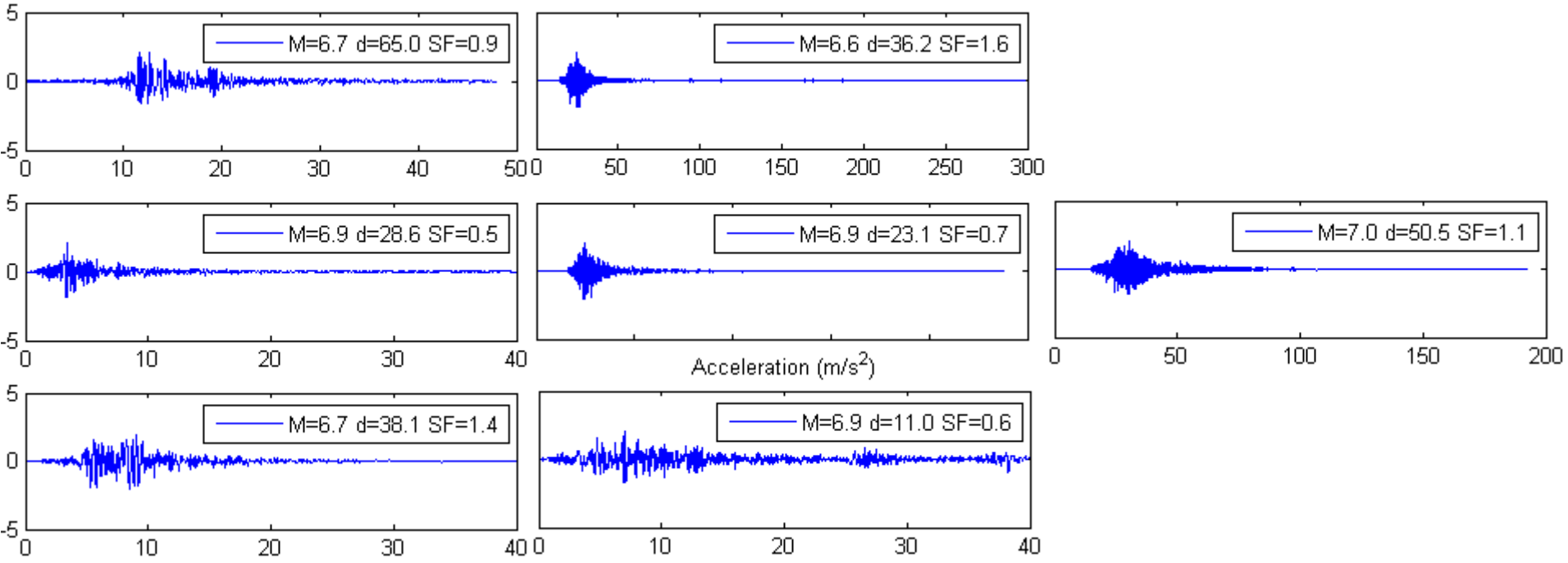
ITALIAN BUILDING CODE

Spectrum-compatibility criterium (NTC 2008)

A minimum of 3 records should be selected and, if less than 7 records are used, the maximum structural response (in absolute terms) must be used as the basis for design and assessment. Alternatively, if 7 or more time-histories are employed, then the average structural response can be considered.

7.3.5 RISPOSTA ALLE
ALLA VARIABILI

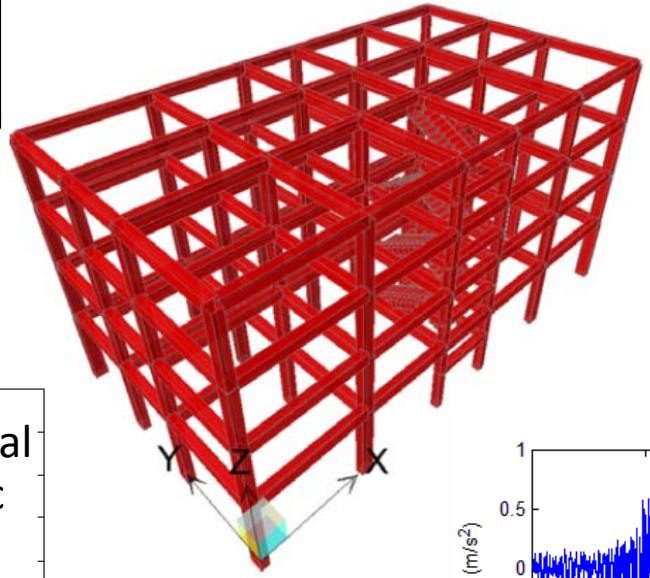
Se la risposta viene valutata
non lineare, le due compon
sono applicate simultaneame
sono rappresentati dai valori medi degli effetti più sfavorevoli ottenuti dalle analisi, se si utilizzano almeno 7 diversi gruppi di accelerogrammi, dai valori più sfavorevoli degli effetti, in caso contrario. In nessun caso si possono adottare meno di tre gruppi di accelerogrammi.



Selection of real accelerograms

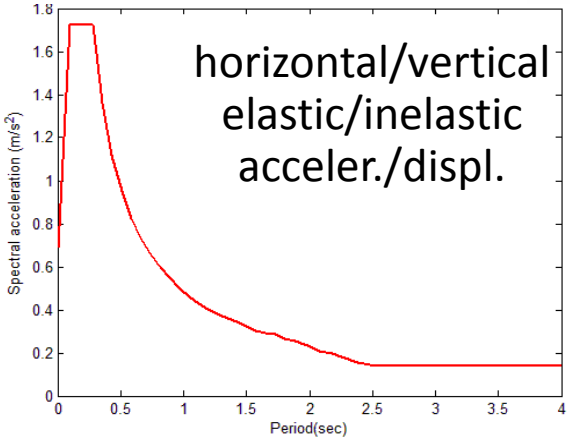
Seismic input for analyses of structures

STATIC AND DYNAMIC LINEAR ANALYSIS



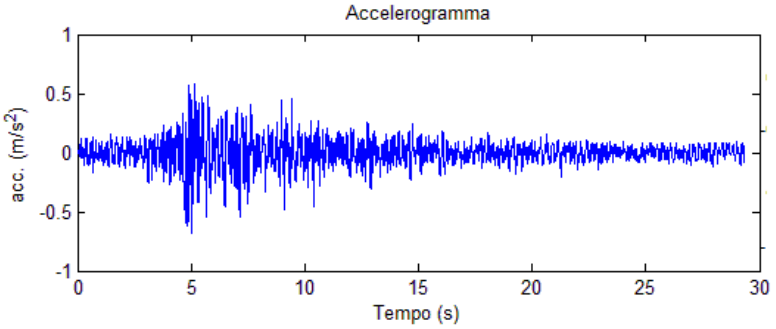
DYNAMIC NON-LINEAR ANALYSIS

RESPONSE SPECTRA



horizontal/vertical
elastic/inelastic
acceler./displ.

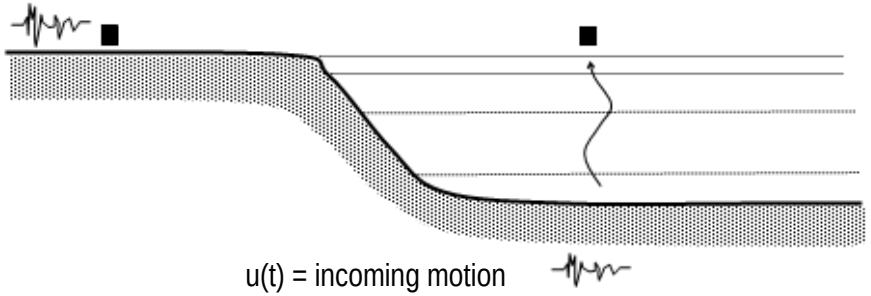
ACCELEROGRAMS



artificial, synthetic, real

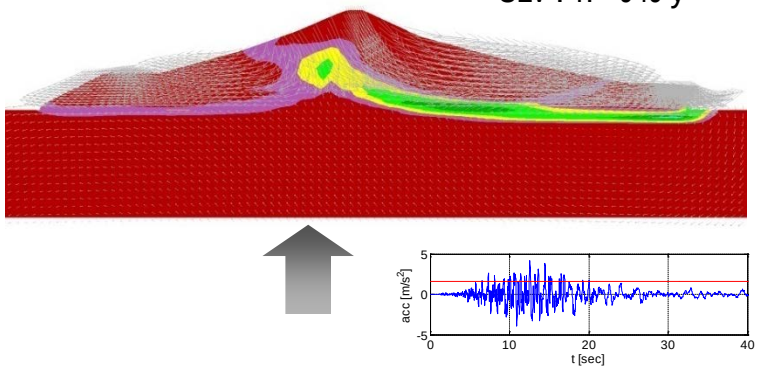
Seismic input for analyses of geotechnical systems

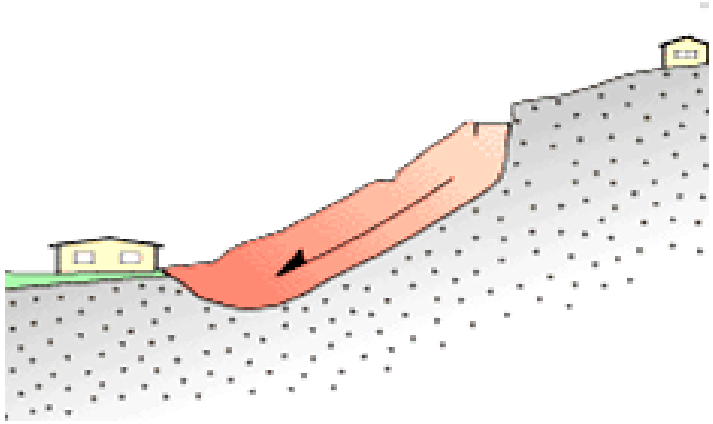
r(t) = 2u(t) = motion on outcopping rock s(t) = motion on soft deposit to be defined



u(t) = incoming motion

SLV : Tr =949 y





u(t) = incoming motion

Accelerograms to be used for:

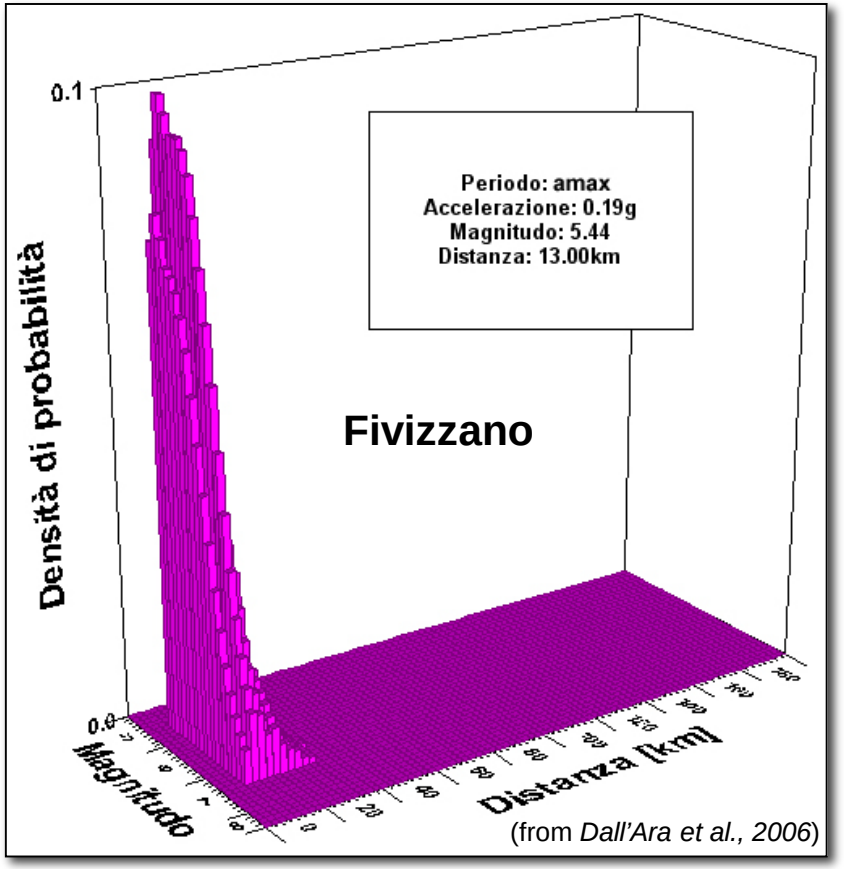
1. ground response analysis
2. co-seismic slope stability
3. embankment dam stability
4. liquefaction susceptibility
5. retaining structures analysis

SELECTION OF NATURAL ACCELEROGRAMS

- **EXAMPLE: Selection of natural accelerograms at the Fivizzano site**

- **PGA_{475} = 0.191g**

- **M = 5.5, d = 13 km**



(from *Dall'Ara et al., 2006*)

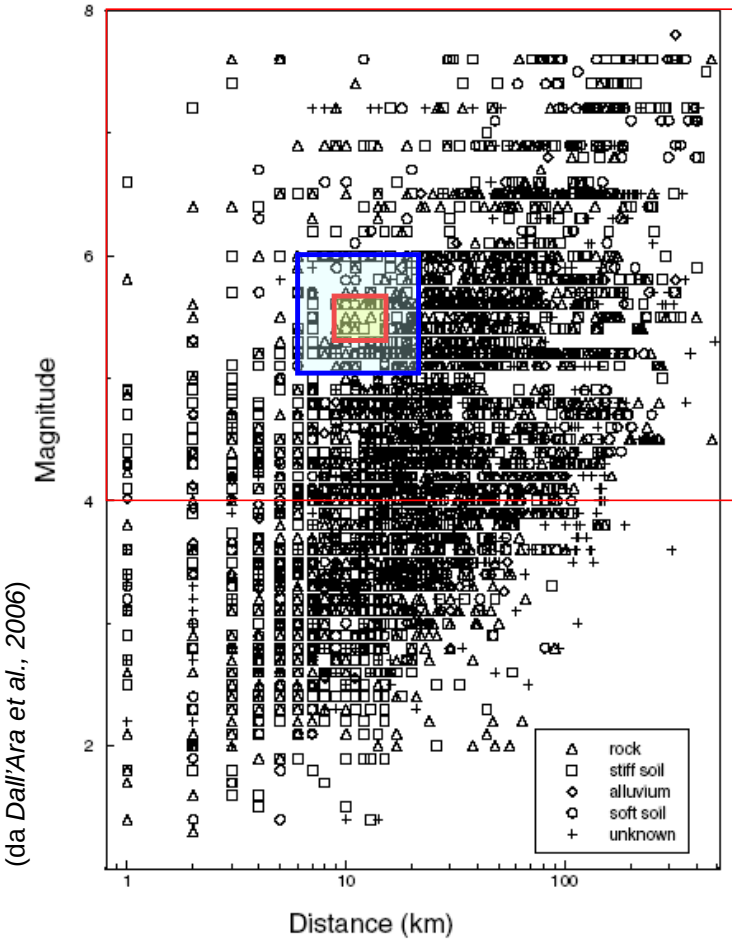
Selection criteria:

- Stations on outcropping rock
- Magnitude $\Delta = \pm 0.2 \Rightarrow$ M = 5.3 – 5.7
- Distance $\Delta = \pm 4$ km $\Rightarrow$ d = 9-17 km

- Magnitude $\Delta = \pm 0.5 \Rightarrow$ M = 5.0 – 6.0
- Distance $\Delta = \pm 7$ km $\Rightarrow$ d = 6-20 km

SELECTION OF NATURAL ACCELEROGRAMS

AVAILABLE DATA **f (M,R) | rock**



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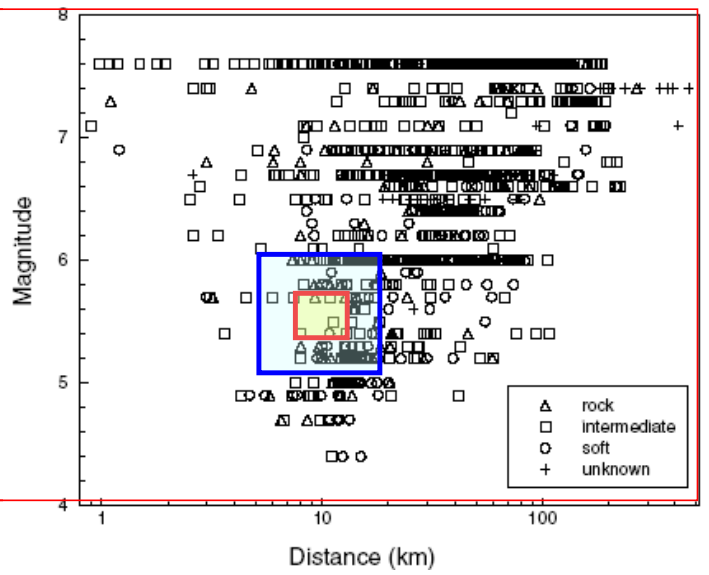


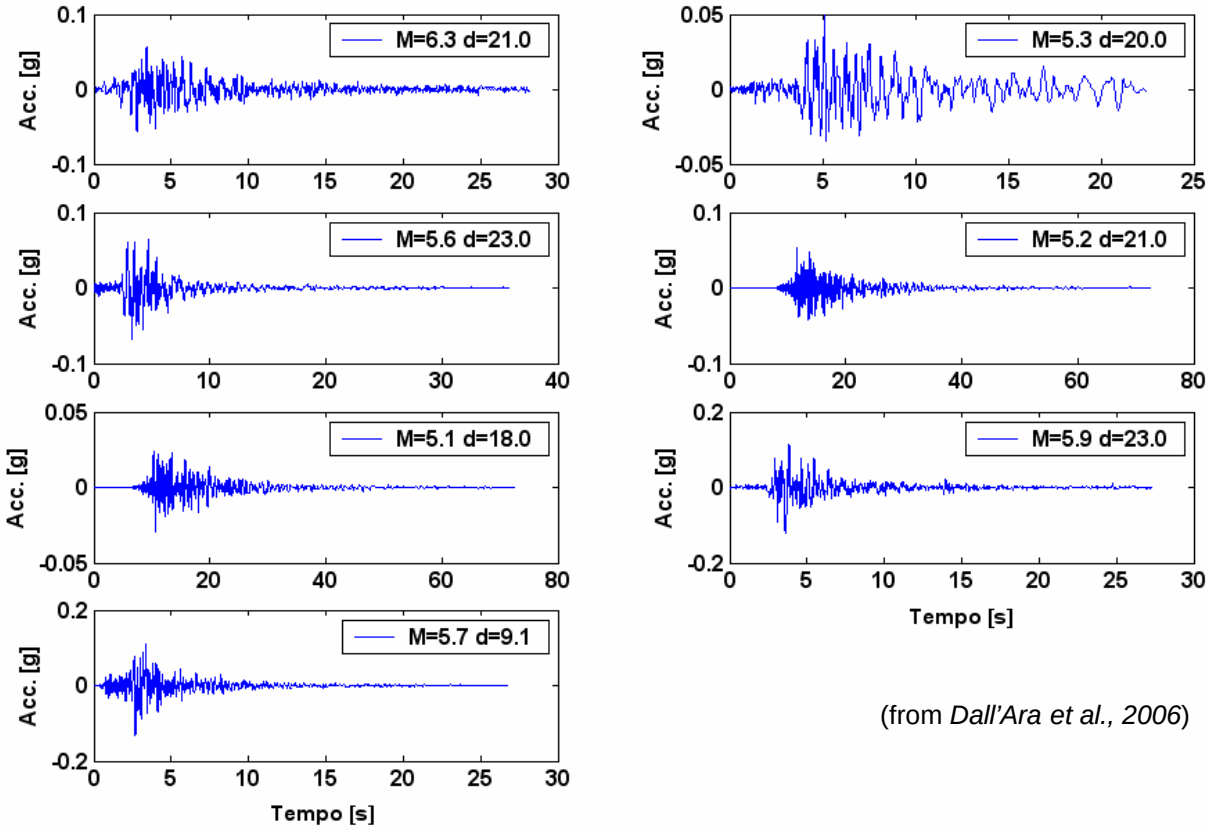
PEER

- (M, R) pairs on “rigid” sites
- compatible seismotectonic setting

European Strong Motion Database

SELECTION OF NATURAL ACCELEROGRAMS

- Selection of real accelerograms, spectrum-compatible with a target response spectrum (T_R = 475 years) at the site of Fivizzano (Lucca)



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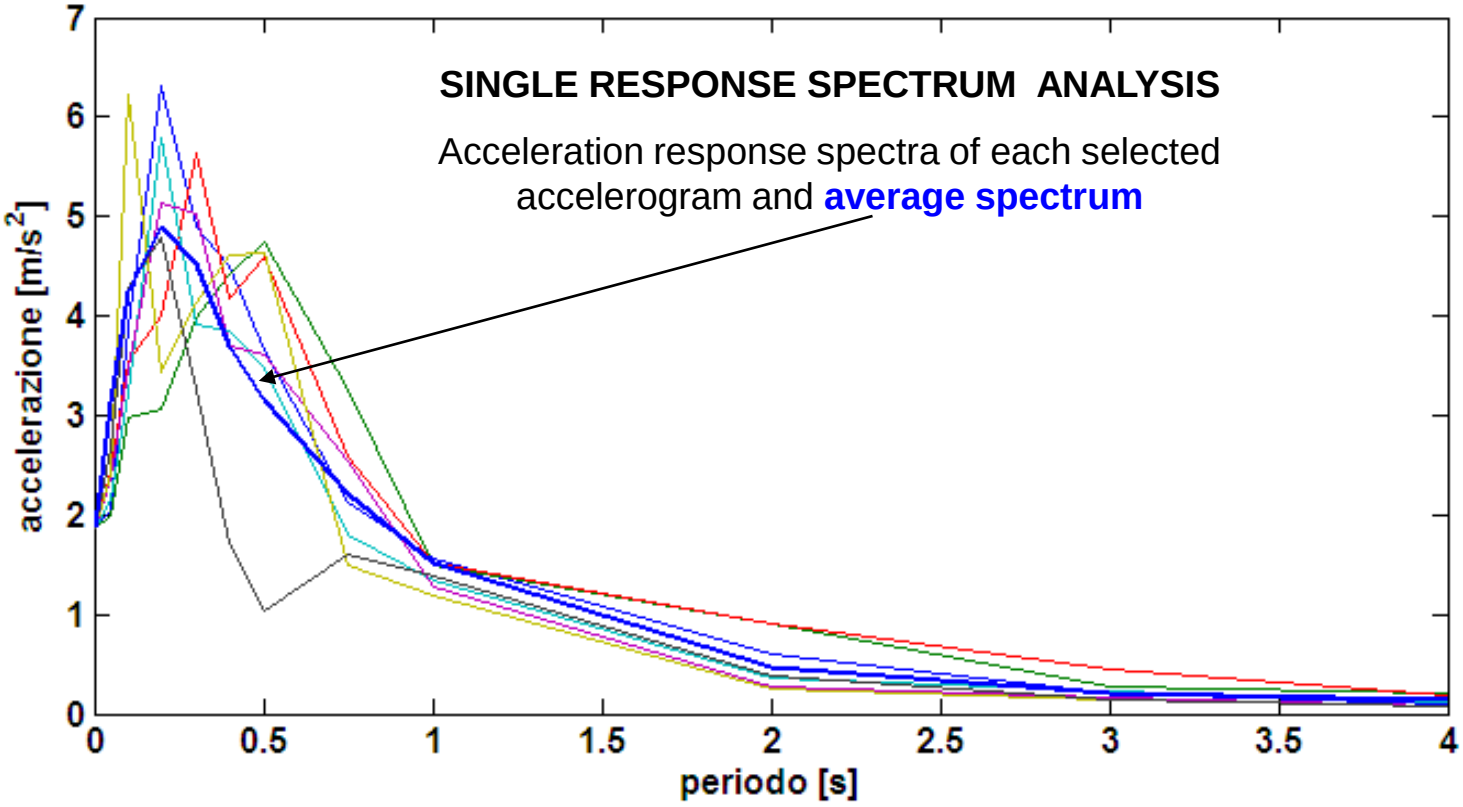
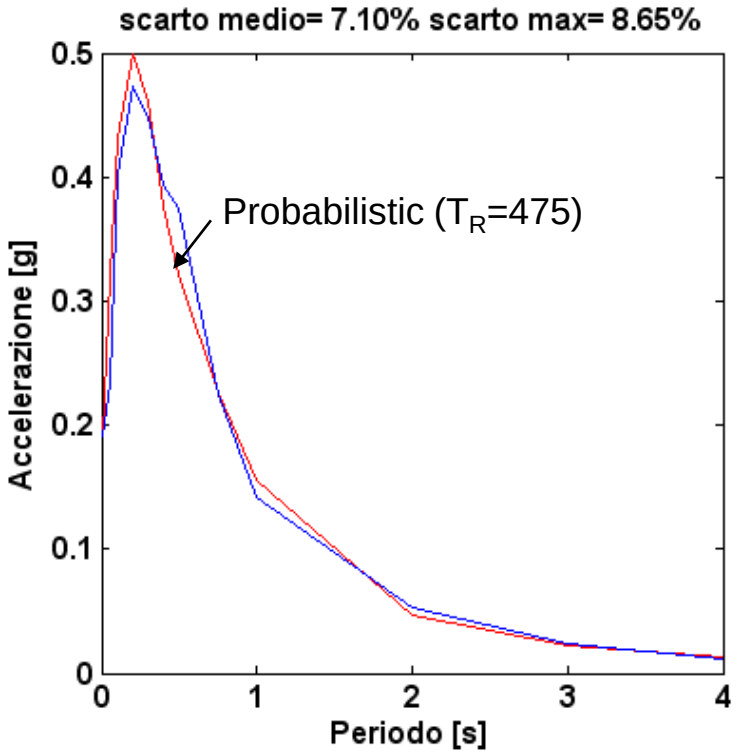
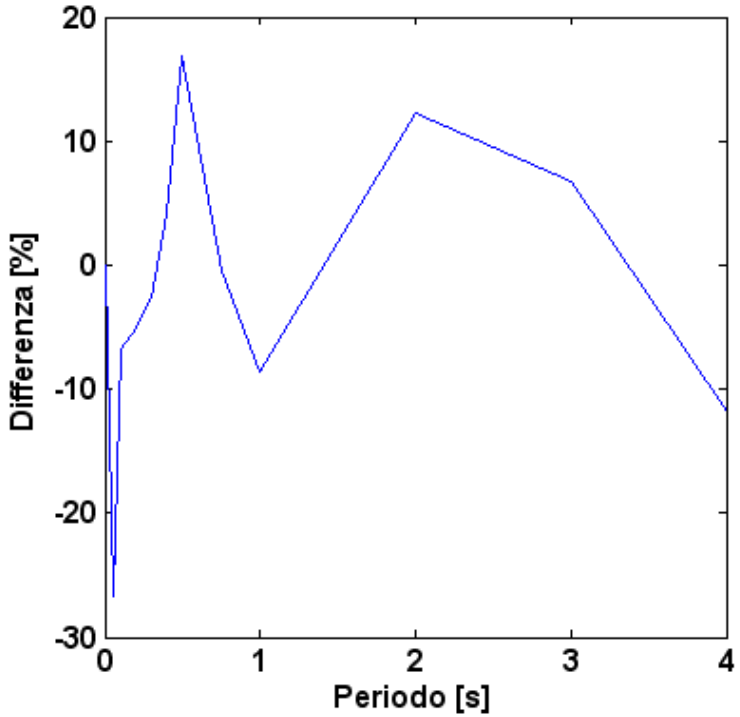


SELECTION OF NATURAL ACCELEROGRAMS

- Selection of real accelerograms, spectrum-compatible with a target response spectrum (T_R = 475 years) at the site of Fivizzano (Lucca)

(from *Dall'Ara et al., 2006*)





- average percentage difference (between the mean spectrum of the 7 accelerograms and the reference spectrum) of 7.10%
- maximum negative difference of 8.65%,

Projects for the Tuscany Region

	EUCENTRE (2011)	UNIPV (2012)
Area	Garfagnana, Lunigiana, Mugello, Val di Sieve, Montagna Fiorentina	Tuscany Region
Return periods (years)	30, 50, 72, 101, 140, 201, 475, 975, 2475	50, 75, 101, 475, 712, 949
Methodology	▪ mesozonation ▪ reference spectrum ▪ accelerograms selection ▪ scaling	▪ mesozonation ▪ reference spectrum ▪ accelerograms selection ▪ scaling
Software	SCALCONA	SCALCONA 2.0

Publications (Tuscany Region)

- Zuccolo, E., Corigliano, M., Taverna, L., Lai, C.G., *Meso-Zonazione di un Territorio per la Definizione di Accelerogrammi Reali Spettro-Compatibili*. Atti del 14° Convegno Nazionale in Ingegneria Sismica, ANIDIS 2011, Bari, 18-22 Settembre, 2011.

- Zuccolo E., Corigliano M., Lai C.G. (2014). *Selection of spectrum- and seismo-compatible accelerograms for the Tuscany region in Central Italy*. Soil Dynamics and Earthquake Engineering, vol. 66, p. 305-313.

Publications (SEISM-HOME)

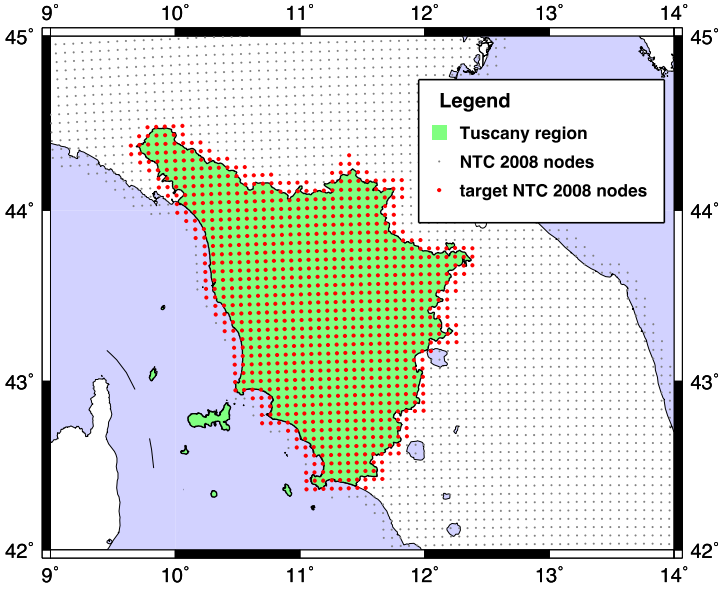
- Rota, M., Zuccolo, E., Taverna, L., Corigliano, M., Lai, C.G., Penna, A. *Mesozonation of Italian Territory for Definition of Compatible Accelerograms*. Bulletin of Earthquake Engineering. Agosto 2012. DOI 10.1007/s10518-012-9369-4.
- Taverna, L., Zuccolo, E., Corigliano, M., Rota, M., Lai, C.G., Penna, A., *Accelerogrammi Reali Spettro-Compatibili per l'Intero Territorio Italiano*. Sottoposto a revisione alla rivista Progettazione Sismica. Novembre 2011.
- Taverna, L., Zuccolo, E., Corigliano, M., Rota, M., Lai, C.G., Penna, A., *SEISM-HOME: Selection of Input Strong-Motion for Homogeneous Megazones*. Atti 30° Congresso Nazionale GNGTS (Gruppo Nazionale di Geofisica della Terra Solida). Trieste, 14-17 Novembre, 2011.
- Zuccolo, E., Rota, M., Lai, C.G., Taverna, L., Corigliano, M., Penna, A. *Definition of Spectrum-Compatible Natural Records for the Italian Territory*. Proceedings, 15th World Conference on Earthquake Engineering. Lisbon, Portugal, September, 24-28, 2012. Paper Reference No. 1989

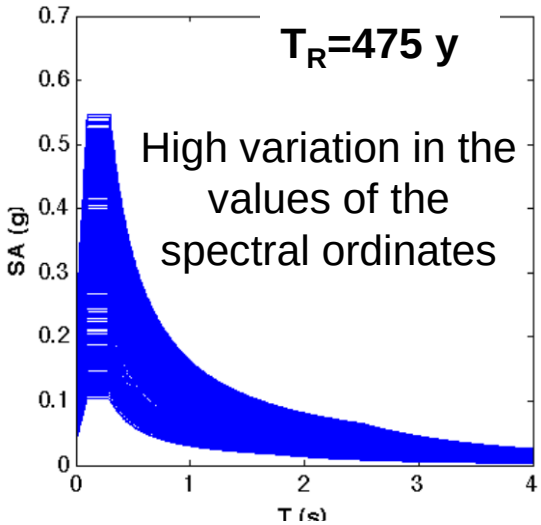
Procedure to define the reference seismic input in Tuscany

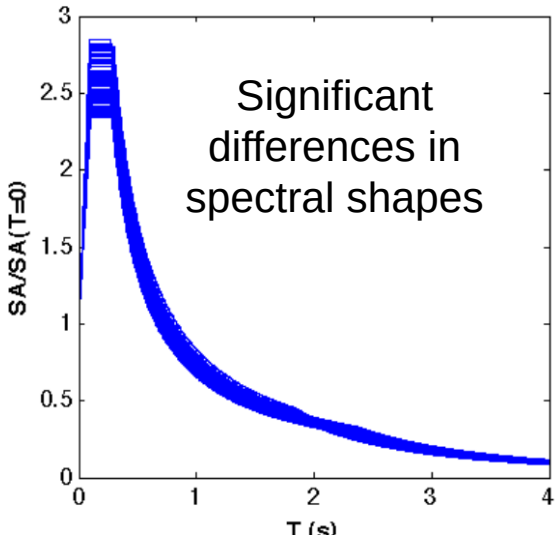
Procedure

Acceleration response spectra (horizontal component) prescribed by the Italian building code NTC08 for outcropping rock site with flat topografic surface (soil category ‘A’)

- **Mainland: spectra for 923 nodes of the reference grid (located inside the Tuscany region plus those located within a distance of 0.1 degrees from the outermost ones)**







need to identify a minimum number of significant spectral shapes, which represent the totality of the spectra

Procedure

Acceleration response spectra (horizontal component) prescribed by the Italian building code NTC08 for outcropping rock site with flat topografic surface (soil category ‘A’)

- **Mainland: spectra for 923 nodes of the reference grid (located inside the Tuscany region plus those located within a distance of 0.1 degrees from the outermost ones)**

PROCEDURE:

Step 1: mesozonation of the territory

Step 2: definition of the reference spectrum

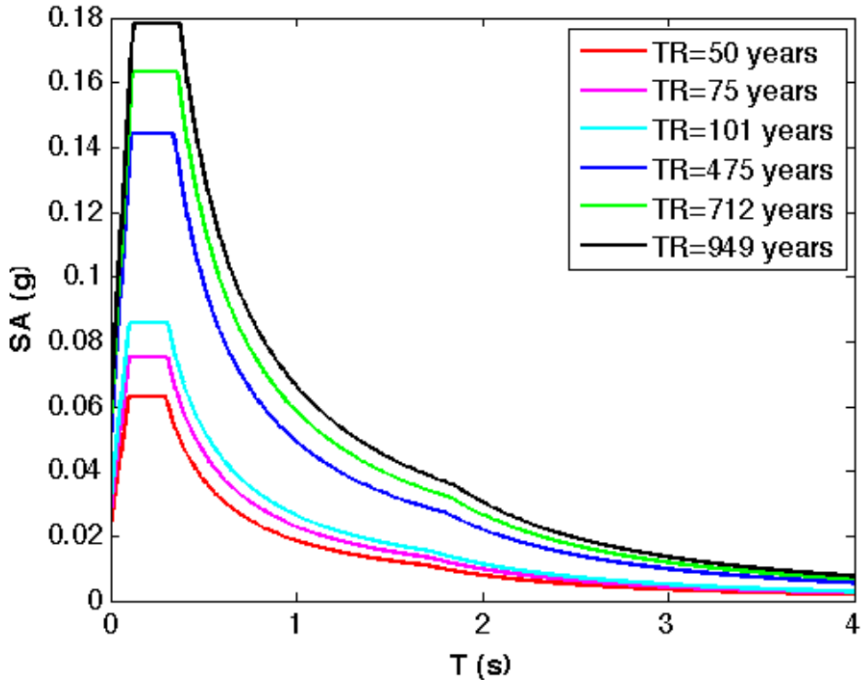
Step 3: selection of real accelerograms compatilble to the reference spectrum

Step 4: linear scaling of the selected accelerograms (SCALCONA 2.0)

Procedure

Acceleration response spectra (horizontal component) prescribed by the Italian building code NTC08 for outcropping rock site with flat topografic surface (soil category ‘A’)

- **Isole: one spectrum for each return period**



PROCEDURE:

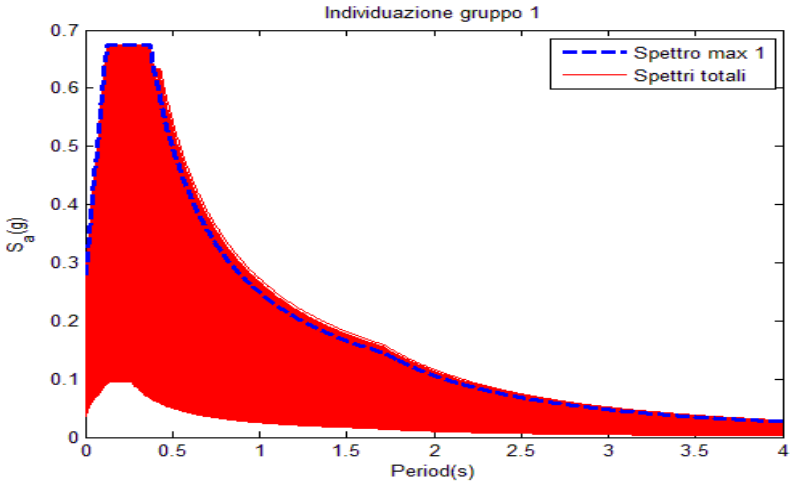
Step 3: selection of real accelerograms compatilble to each spectrum

Step 1: mesozonation of the territory

Identification of groups of spectra with similar characteristics and shape.

Iterative procedure

- Identification of the spectrum with $a_g * F_0$ max



- Application of 3 criteria:

1) average spectrum deviation, δ
(Iervolino et al., 2008)

$$\delta_j < 0.2$$

2) T_C^* (NTC08)

$$\left| T^*_{c,\max} - T^*_{c,i} \right| \leq 0.05$$

3) F_0 (NTC08)

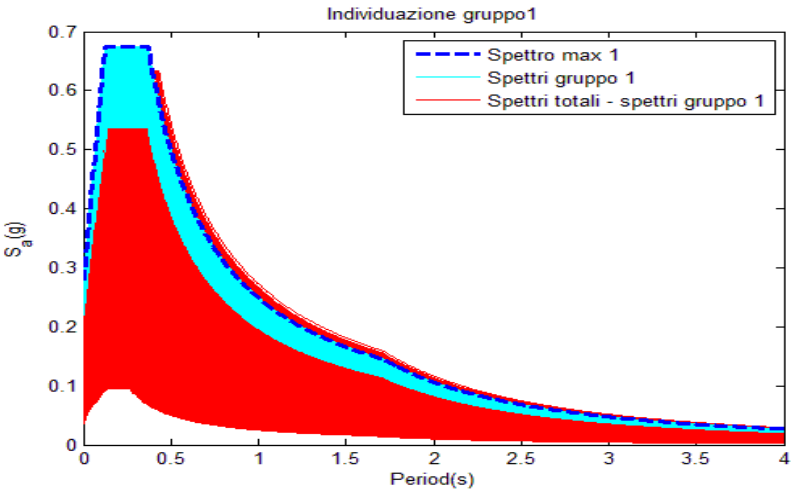
$$(a_{g,i} \cdot F_{0,i}) > a_{g,\max} \cdot (F_{0,\max} - 0.5)$$

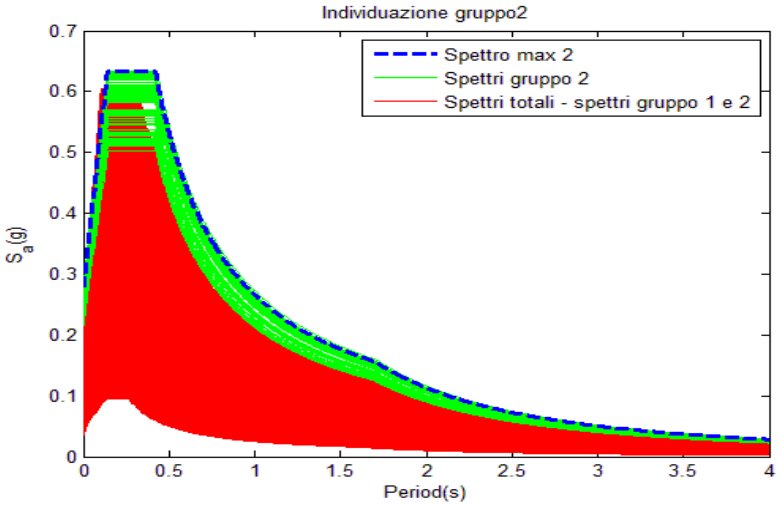
Step 1: mesozonation of the territory

Identification of groups of spectra with similar characteristics and shape.

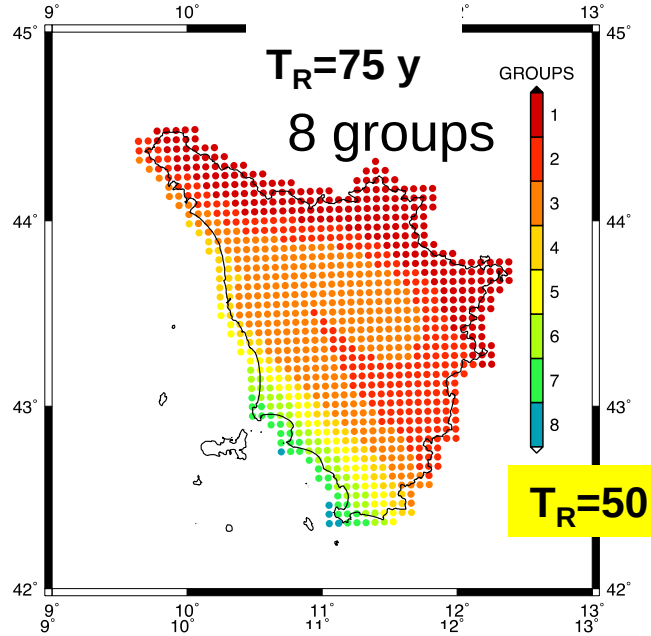
Iterative procedure

- Identification of the spectrum with a_g*F_0 max
- Application of 3 criteria
- Group 1 = spectra which satisfy the 3 criteria (n spectra)
- Removing spectra of group 1
- Group 2 = procedure repetition for the remaining spectra (923-n)

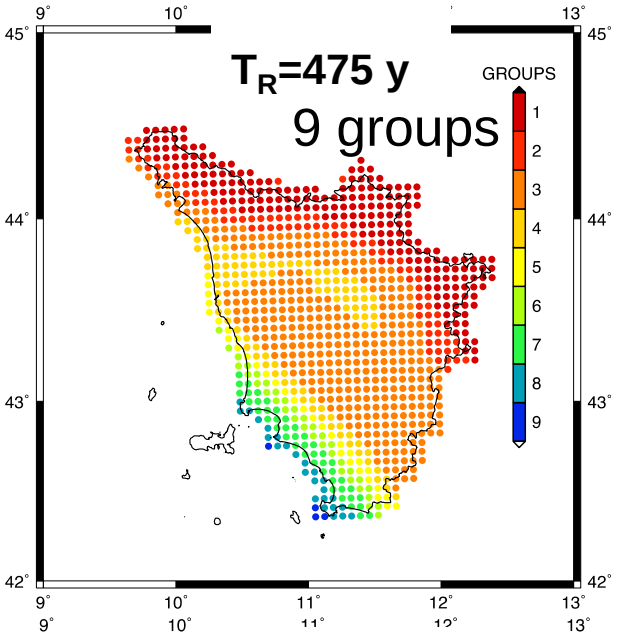


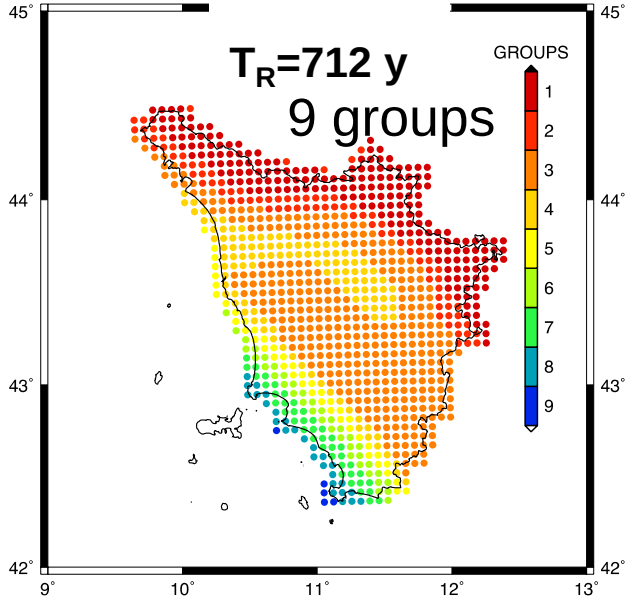


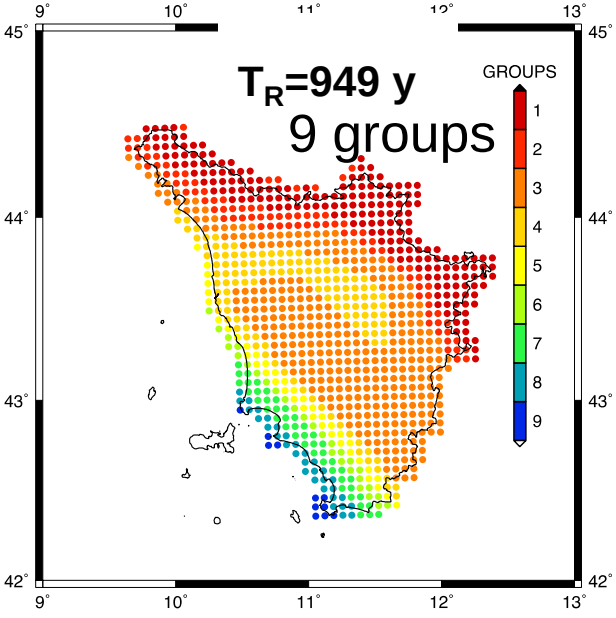
Step 1: mesozonation of the territory



T_R=50 y and 101 y



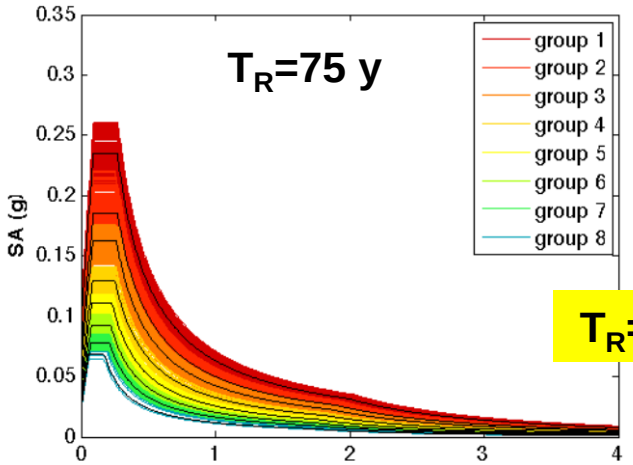




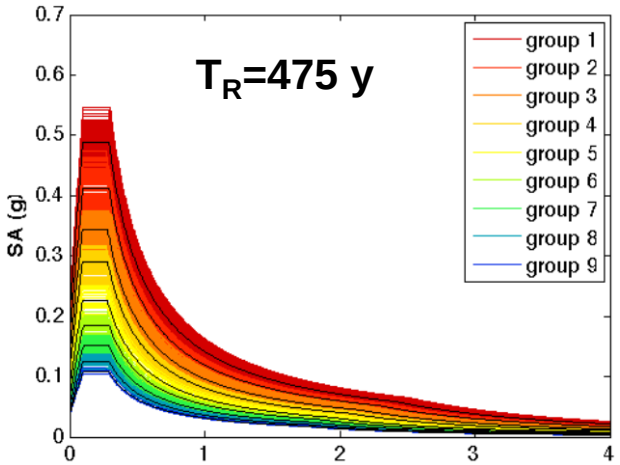
Step 2: definition of the reference spectrum

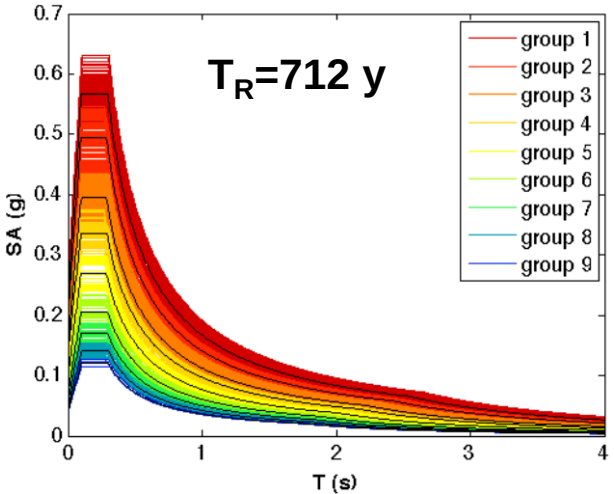
- Computation of the mean spectrum of the group
- The spectrum with min. δ with respect to the mean spectrum

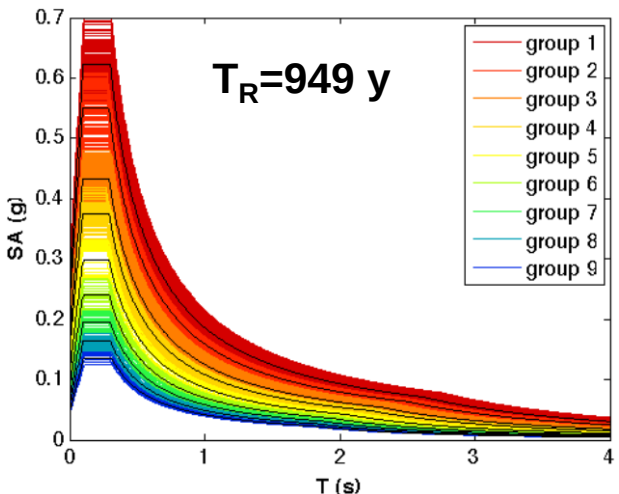
=> the reference spectrum of the group.



T_R=50 y and 101 y

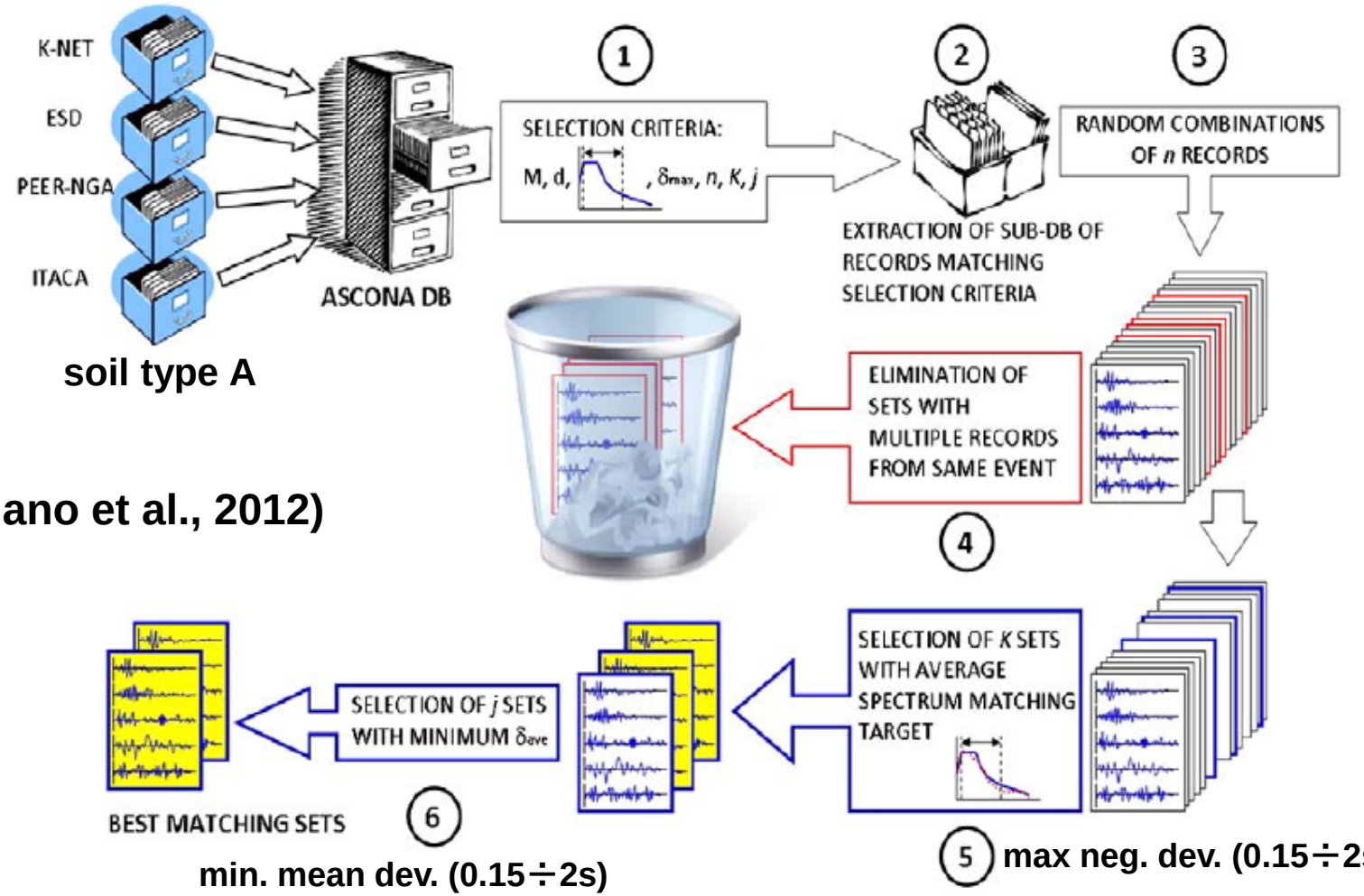






Step 3: selection of real spectrum-compatilble accelerograms

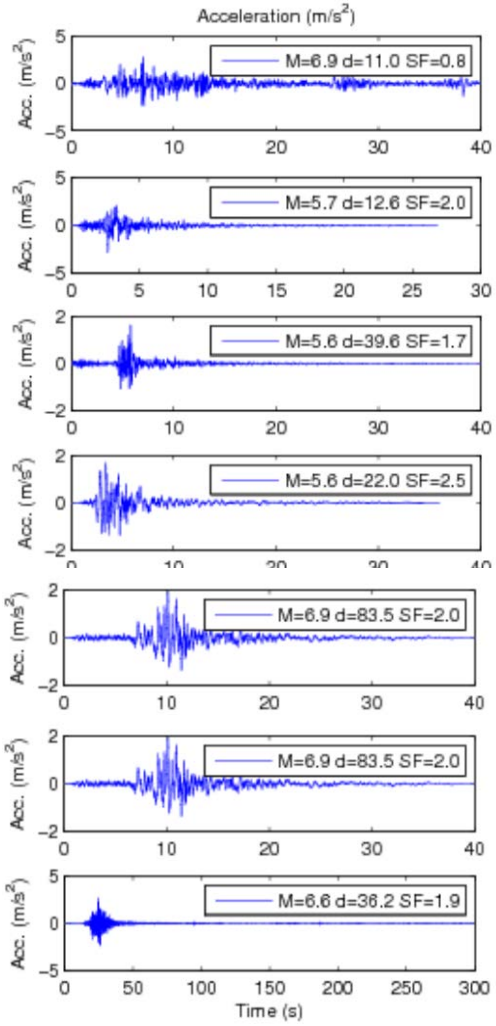
ASCONA -Automated Selection of COmpatible Natural Accelerograms



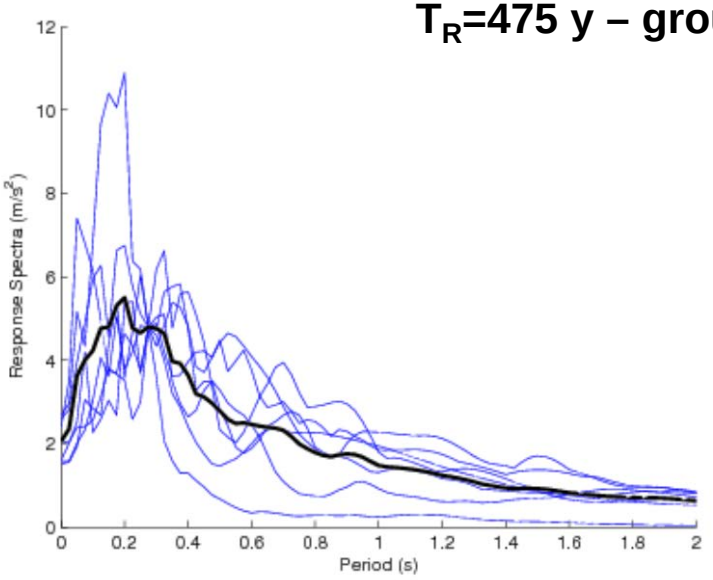
(Corigliano et al., 2012)

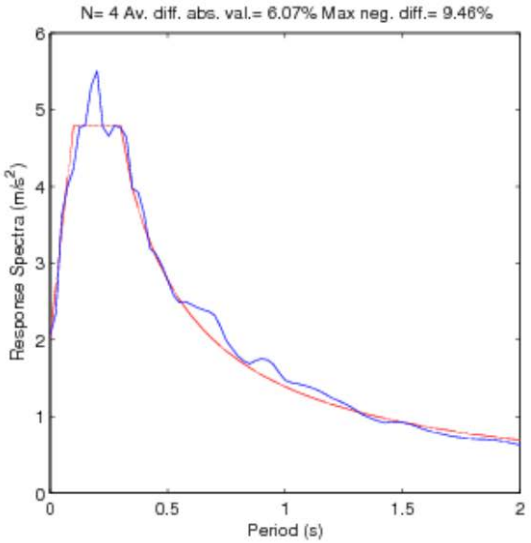
Total number of selections: 6 (islands) + 35 (mainland) = 41

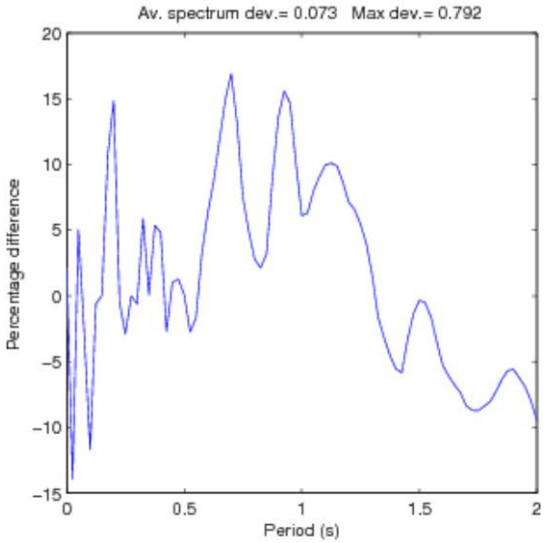
Step 3: selection of real spectrum-compatilble accelerograms



T_R=475 y – group 1

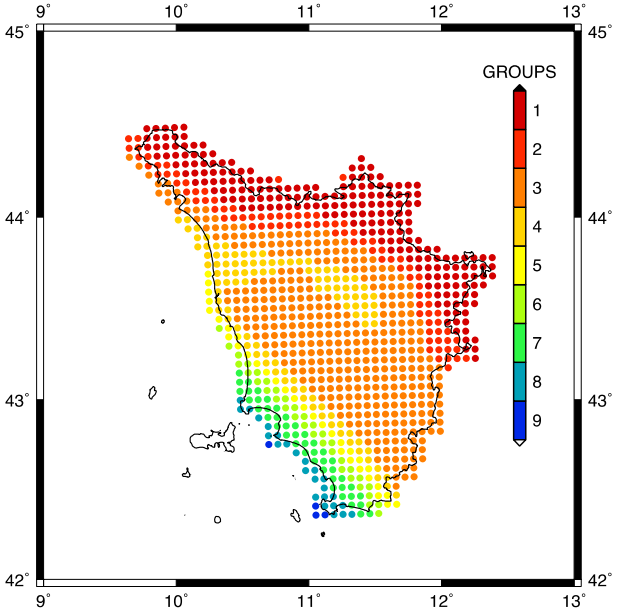




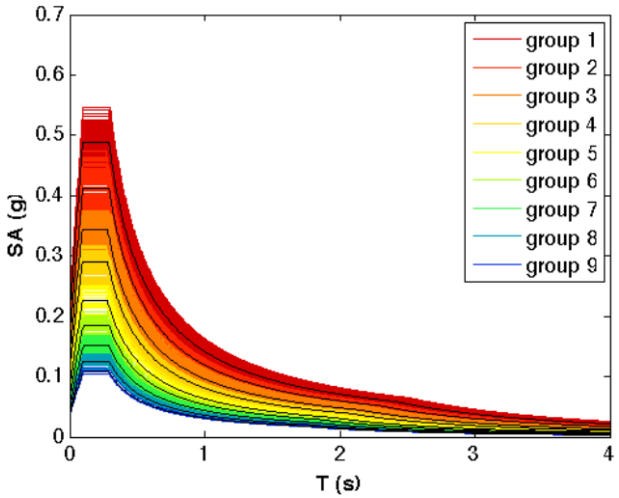


Step 4: linear scaling of the selected accelerograms

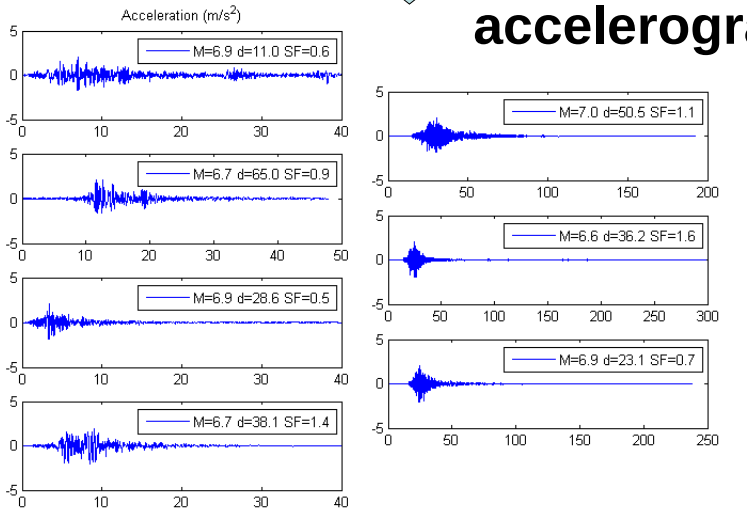
Mesozonation



Reference spectrum



Seletion of accelerograms



Set of 7 accelerograms compatible to response spectra different from the reference spectrum and the response spectra for 50 and 101 years return periods?

Linear scaling of accelerograms

Step 4: linear scaling of the selected accelerograms

SF=SF1*SF2

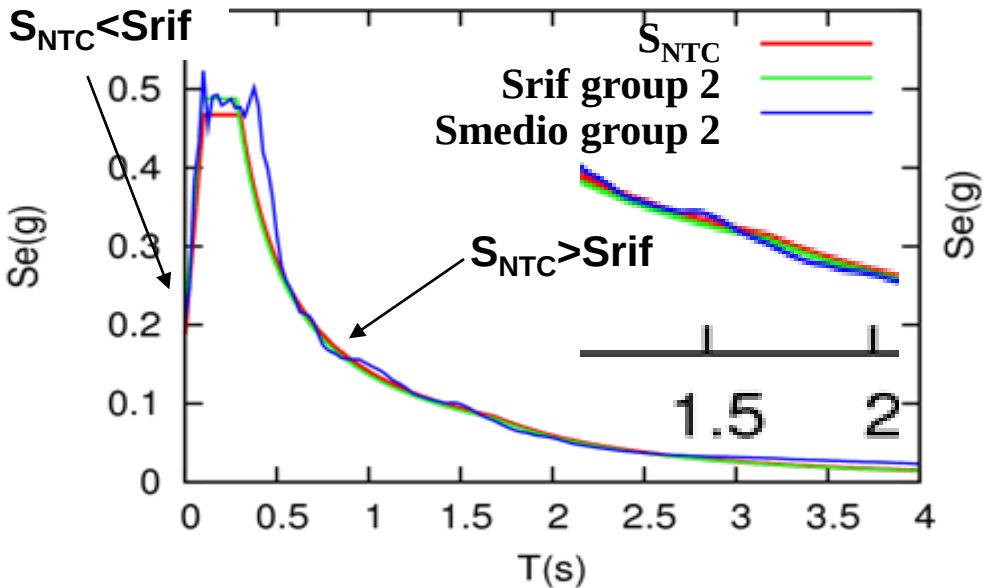
$$SF1 = \frac{S_{NTC}(T = T_{rif})}{S_{medio_gruppo}(T = T_{rif})}$$

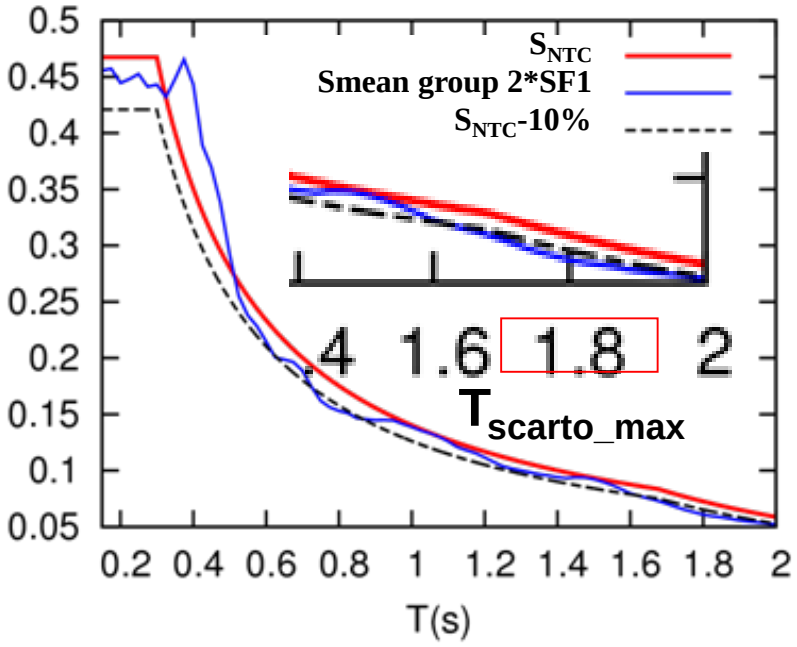
T_{rif} =0 for T_R=75 y

T_{rif}=T_C* for T_R=475, 712 and 949 y

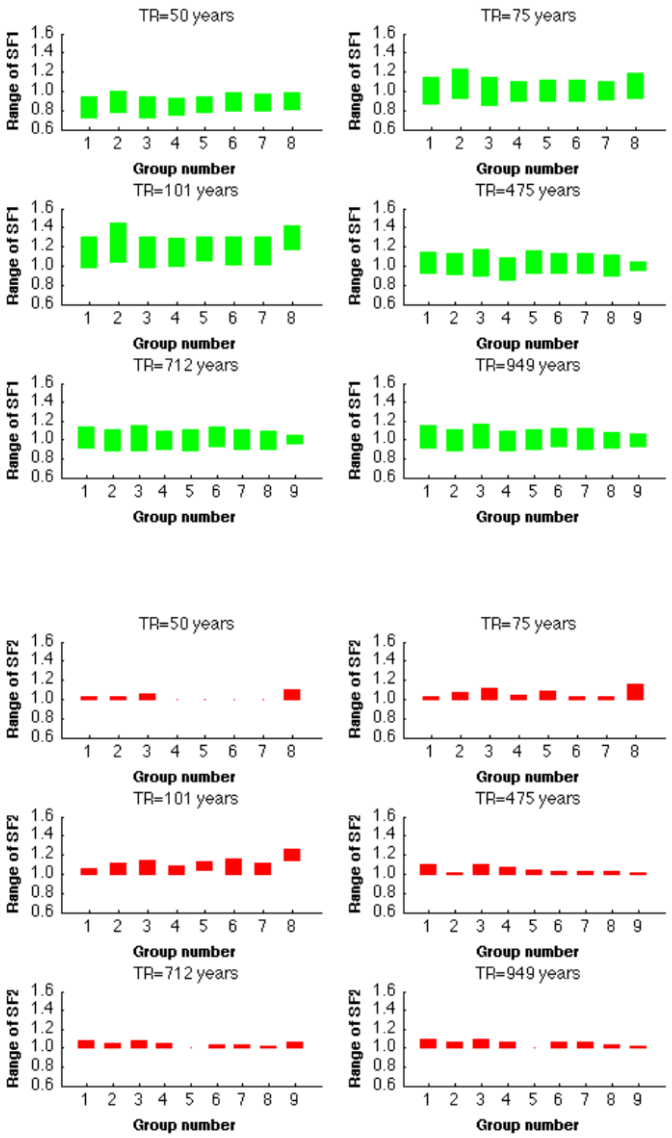
If the spectrum-compatibility is verified using SF1 then SF2=1

$$SF2 = \frac{S_{NTC}(T_{scarto_max}) - 0.09999 * S_{NTC}(T_{scarto_max})}{S_{medio_gruppo_scalato_SF1}(T_{scarto_max})}$$



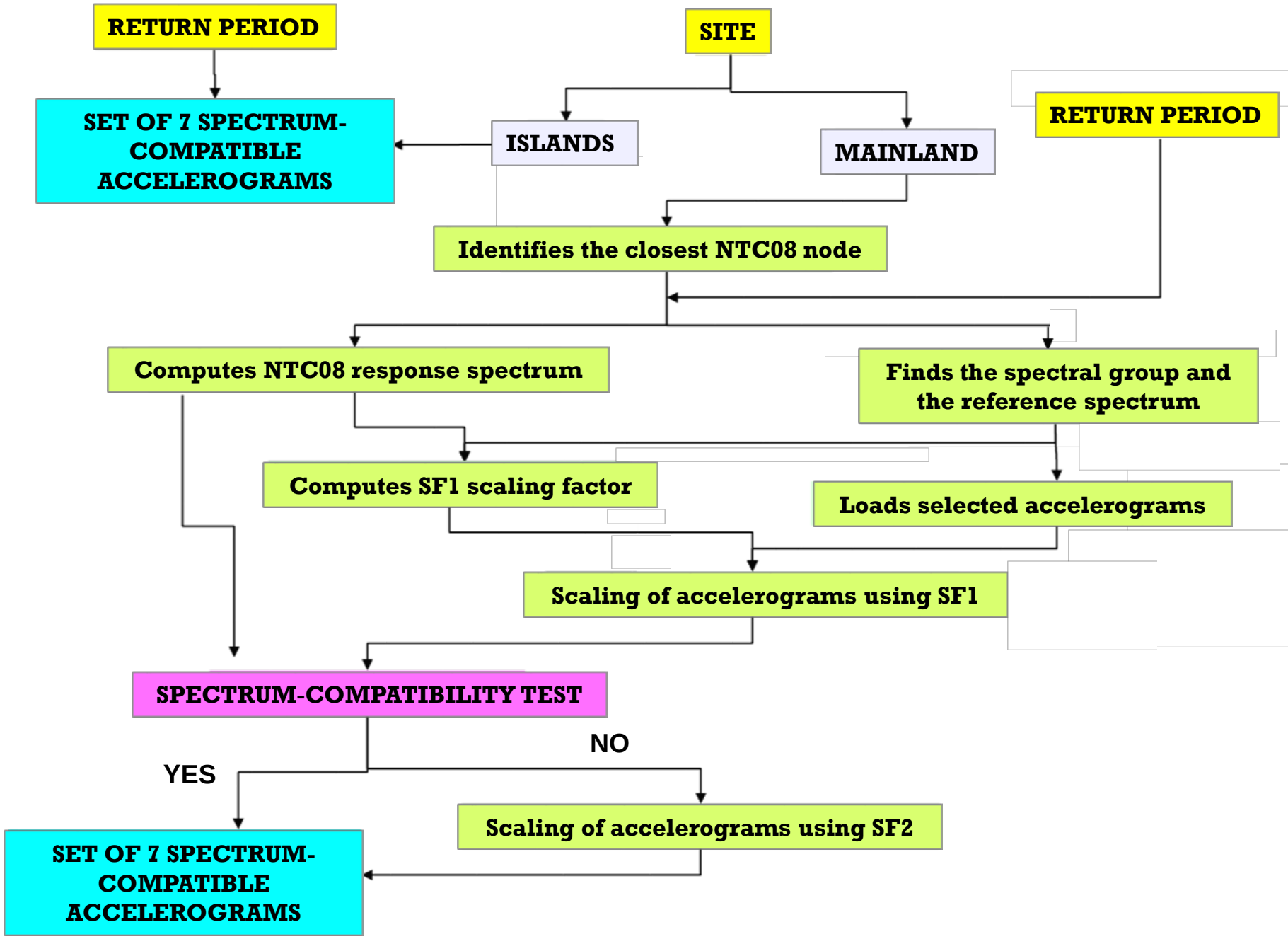


Step 4: linear scaling of the selected accelerograms

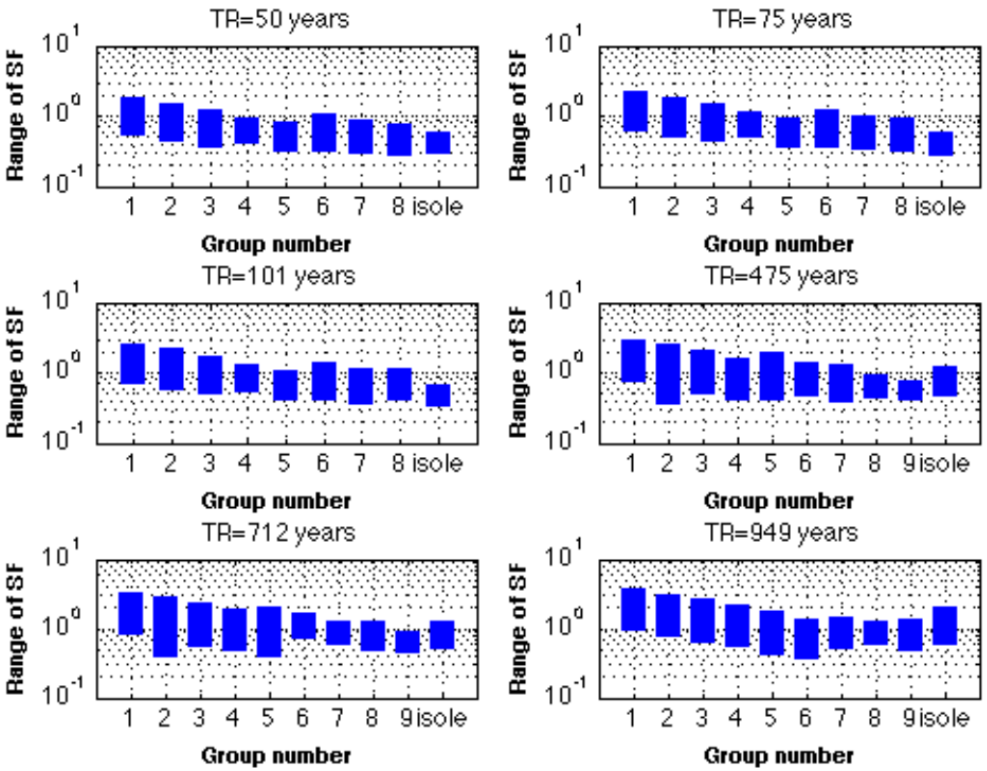


T_R	SF1		SF2	
	Min	Max	Min	Max
50 years	0.728	0.994	1.	1.097
75 years	0.857	1.226	1.	1.152
101 years	0.982	1.445	1.	1.257
475 years	0.858	1.174	1.	1.099
712 years	0.891	1.148	1.	1.083
949 years	0.887	1.164	1.	1.097

Flow-chart of SCALCONA 2.0



Scaling factors with respect to the original accelerograms

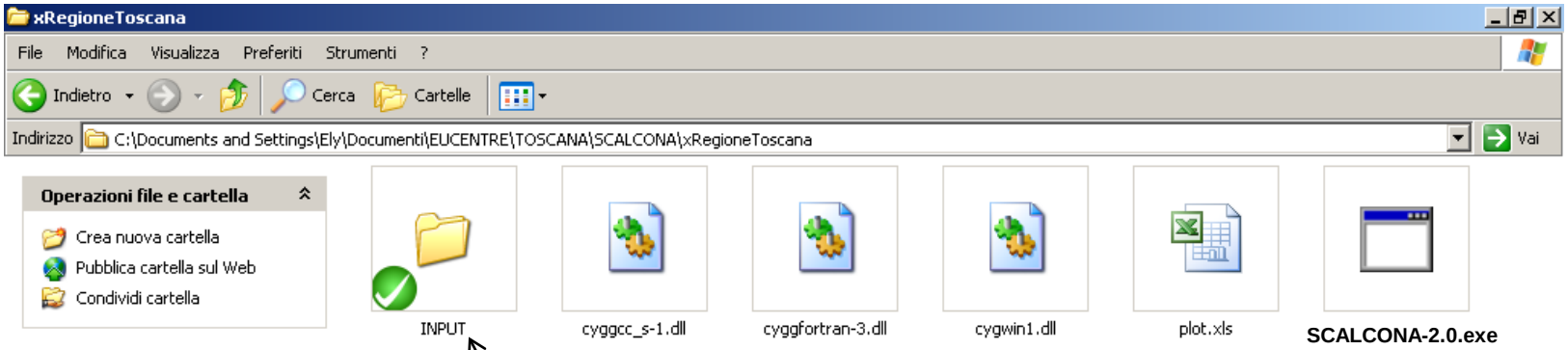


RT (years)	SF			% of cases with SF between 2/3 and 1.5
	Min	Max	Mean	
50	0.28	1.87	0.83	59
75	0.29	2.27	0.99	69
101	0.35	2.59	1.12	63
475	0.36	2.91	1.33	48
712	0.40	3.33	1.53	35
949	0.37	3.74	1.71	30

Software: SCALCONA 2.0

SCALCONA 2.0

SCALing of COmpatible Natural Accelerograms version 2.0



379 files:

- Allegato B of Italian building code NTC08
- 2 files with coordinates and names of municipalities on islands/mainland
- 2 files containing coordinates of polygons that represent islands/mainland
- 1 file containing periods used for scaling in ASCONA
- 4 files containing groups
- 41 files containing response spectra
- 287 files containing accelerograms
- 41 files containing information on accelerograms

SCALCONA 2.0 - INPUT

***Input*: site and return period under investigation**

```
SCALCONA-2.0 (SCALing of COmpatible Natural Accelerograms)

Per interrompere premere CTRL+C in qualsiasi momento

Inserire il periodo di ritorno (TR=50,75,101,475,712,949):
3000
Il periodo di ritorno non e' corretto o non e' ammesso


Inserire il periodo di ritorno (TR=50,75,101,475,712,949):
475
Inserire le coordinate (lon lat) o il comune:
```

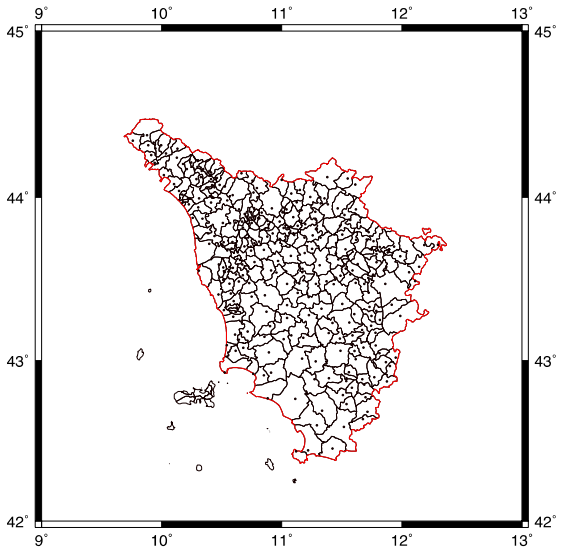
SCALCONA 2.0 - INPUT

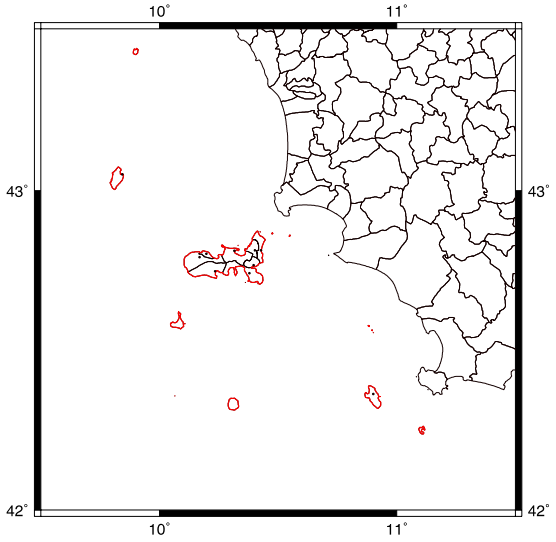
Input: site **and return period under investigation**

```
Inserire le coordinate (lon lat) o il comune:

10.00 44.0

Le coordinate non sono corrette o non sono ammesse

Inserire le coordinate (lon lat) o il comune:

11.254167 43.771389 oppure Firenze
```

SCALCONA 2.0 - INPUT

Municipality	Latitude	Longitude	Municipality	Latitude	Longitude
1.1707962	Monteverdi Marittimo				





SCALCONA 2.0 - OUTPUT

***Output*: set of 7 accelerograms compatible to the elastic response spectrum prescribed by the Italian building code (NTC08)**

```
Sono stati creati i seguenti files:
sr_TR00475_Firenze.txt
acc_TR00475_Firenze_1.txt
acc_TR00475_Firenze_2.txt
acc_TR00475_Firenze_3.txt
acc_TR00475_Firenze_4.txt
acc_TR00475_Firenze_5.txt
acc_TR00475_Firenze_6.txt
acc_TR00475_Firenze_7.txt
readme_TR00475_Firenze.txt

Il programma e' terminato correttamente
```

Response spectra

Spectrum-compatible accelerograms

Main seismological characteristics of the selected accelerograms

SCALCONA 2.0 - OUTPUT

SCALCONA — vim — 115×25

vim

```
%Scaled acceleration response spectrum
%Period  Spectral acceleration (NB: the first column of RS is the average, the last column is the NTC08 spectrum)
%(sec)       (m/s2)
0.000      1.4940      2.4349      1.8232      1.0247      1.3767      1.0916      1.6349      1.0722      1.2767
0.025      1.7152      2.7174      2.0137      1.0611      1.3911      1.3650      2.3814      1.0767      1.7236
0.050      2.6877      4.2490      3.5131      1.3131      1.6204      1.7172      5.0334      1.3677      2.1705
0.075      3.0723      5.7750      2.9505      2.0762      1.6407      2.8547      4.6259      1.5835      2.6173
0.100      3.6539      9.4657      4.6424      1.9350      1.7381      1.5418      4.1904      2.0633      3.0642
0.125      3.8151      8.2818      6.5758      1.8233      2.1318      1.7595      3.3707      2.7624      3.0642
0.150      3.5629      5.2071      7.0737      2.9813      2.5935      2.0669      2.5525      2.4648      3.0642
0.175      3.5574      4.1430      6.8439      3.6524      2.4897      1.8239      2.5095      3.4386      3.0642
0.200      3.5009      2.8864      7.4067      2.4338      2.3944      3.6501      3.1572      2.5774      3.0642
0.225      3.1168      3.0426      4.3316      3.1874      1.7587      3.6774      2.9608      2.8595      3.0642
0.250      3.0753      2.8386      4.2064      4.0978      2.0384      2.5026      2.5575      3.2859      3.0642
0.275      3.2604      3.2604      3.2604      3.2604      3.2604      3.2604      3.2604      3.2604      3.0642
0.300      3.2869      3.4511      2.9510      3.4219      4.1986      2.4600      3.2012      3.3246      3.0642
0.325      3.2231      3.1917      3.2915      3.4693      4.5048      1.4049      3.8366      2.8630      2.8285
0.350      2.8034      2.8779      3.6628      2.3701      3.2477      1.0809      3.9225      2.4618      2.6264
0.375      2.7650      2.6292      3.5830      2.0152      3.8084      0.8802      3.9633      2.4756      2.4513
0.400      2.6147      2.5931      3.2727      1.7964      3.8328      0.8770      3.2274      2.7037      2.2981
0.425      2.3392      2.5500      2.6109      1.9067      3.4616      0.7579      2.2315      2.8559      2.1629
0.450      2.3003      2.4357      2.5234      2.2294      3.0117      0.6546      2.3768      2.8700      2.0428
0.475      2.1969      2.2589      2.7641      2.3841      2.3046      0.5255      2.3730      2.7682      1.9353
0.500      2.0425      2.0409      3.0488      2.2346      1.5847      0.4578      1.9199      3.0106      1.8385
"sr_TR00475_Firenze.txt" 164L, 18527C                                                          1,1           Top
```

SCALCONA — vim — 11

vim

```
%Scaled time histories
%Scaling Factor 0.9
%Time Acceleration
%(sec)  (m/s2)
  0.0000 -0.000329
  0.0100  0.000420
  0.0200  0.000766
  0.0300  0.000033
  0.0400  0.000770
  0.0500  0.000263
  0.0600  0.000450
  0.0700  0.000550
  0.0800  0.000263
  0.0900  0.000600
  0.1000  0.000321
  0.1100  0.000452
  0.1200  0.000476
  0.1300  0.000321
  0.1400  0.000526
  0.1500  0.000343
  0.1600  0.000434
  0.1700  0.000440
  0.1800  0.000332
"acc_TR00475_Firenze_1.txt" 2314L, 43967C
```

SCALCONA — vim — 116×24

vim

```
% Magnitude(Mw) Epic.Distance(km) Scaling_Factor Source File_Name
5.60  12.00 0.95 % ESD 000766xa.cor
6.87  11.00 0.55 % ESD 000182xa.cor
6.20  32.00 1.35 % ESD 000234ya.cor
6.93  83.53 1.33 % NGA 0804y.txt
5.61  39.60 1.14 % NGA 1649y.txt
6.60  36.18 1.32 % KNET1 SAG0010503201053.NS
5.60  22.00 1.73 % ITACA 19971014_152309ITDPC_CSC__WEC.DAT
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
"readme_TR00475_Firenze.txt" 8L, 675C                                          1,1           All
```

Concluding remarks

Main results:

1. Semi-automated procedure to define the seismic input in terms of natural (recorded on outcropping rock) spectrum-compatible time histories (ASCONA)

2. Final result: software which permits to obtain automatically the seismic input at the Tuscany region for 50, 75, 101, 475, 712 and 949 years return periods.

Thank you for your attention!