Università degli Studi di Napoli Federico II

Scuola politecnica e delle scienze di Base

Dipartimento di Strutture per l'Ingegneria e l'Architettura (DiSt)

Consorzio Interuniversitario ReLuis

WORKSHOP: Approcci per la valutazione dei modelli di pericolosità sismica in Italia

Villa Orlandi, Anacapri, 7-8 settembre 2023

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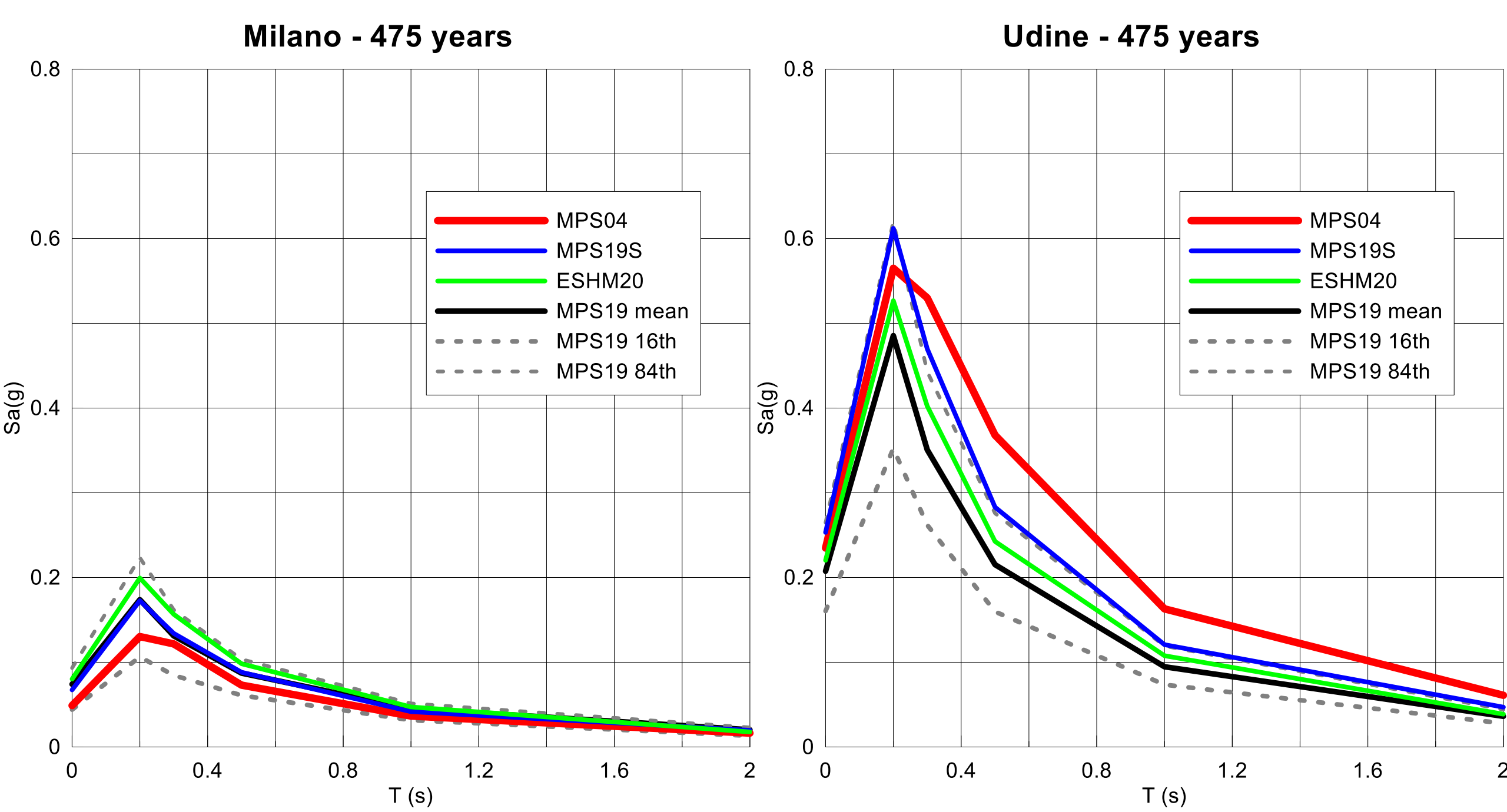
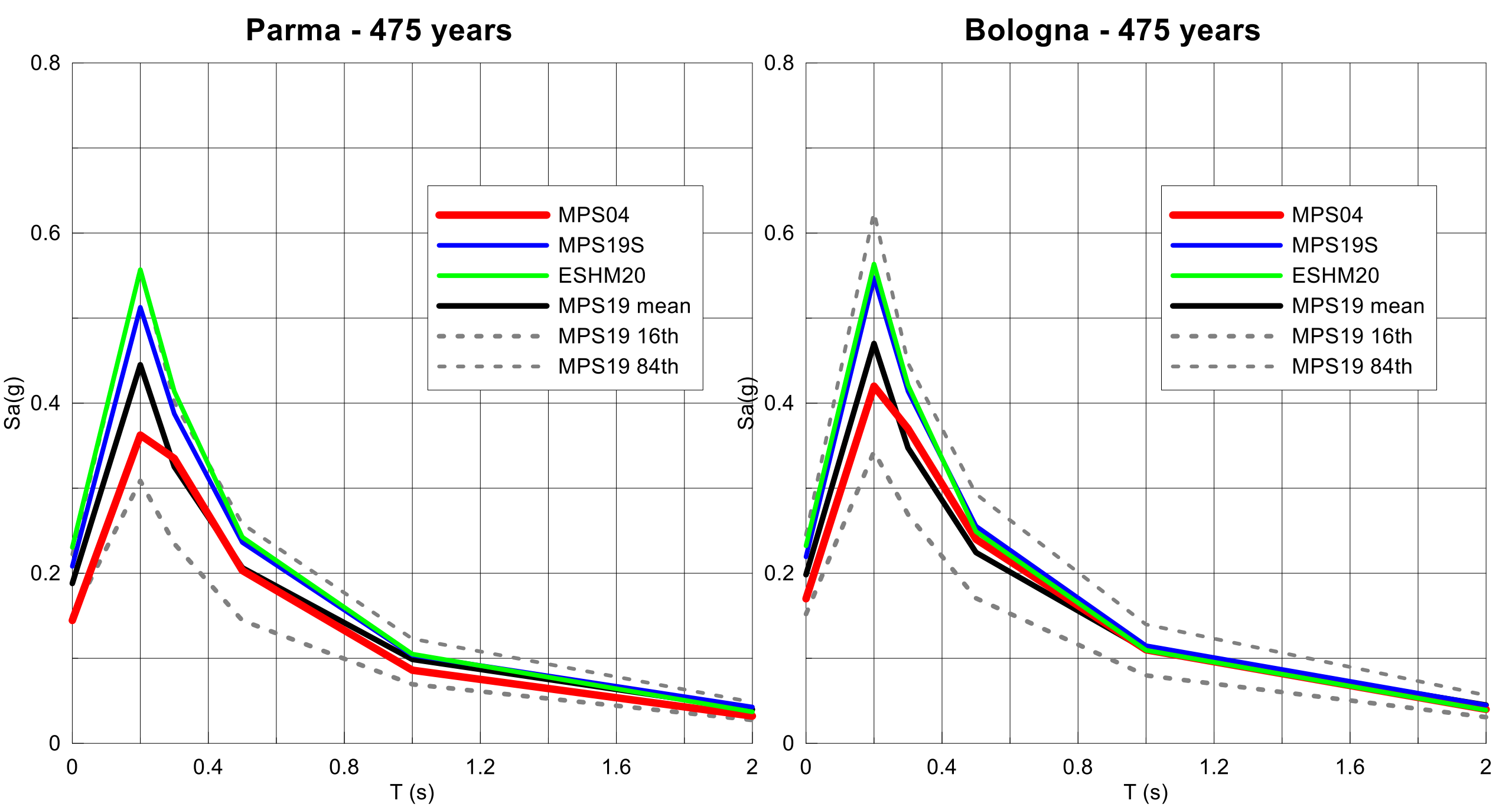
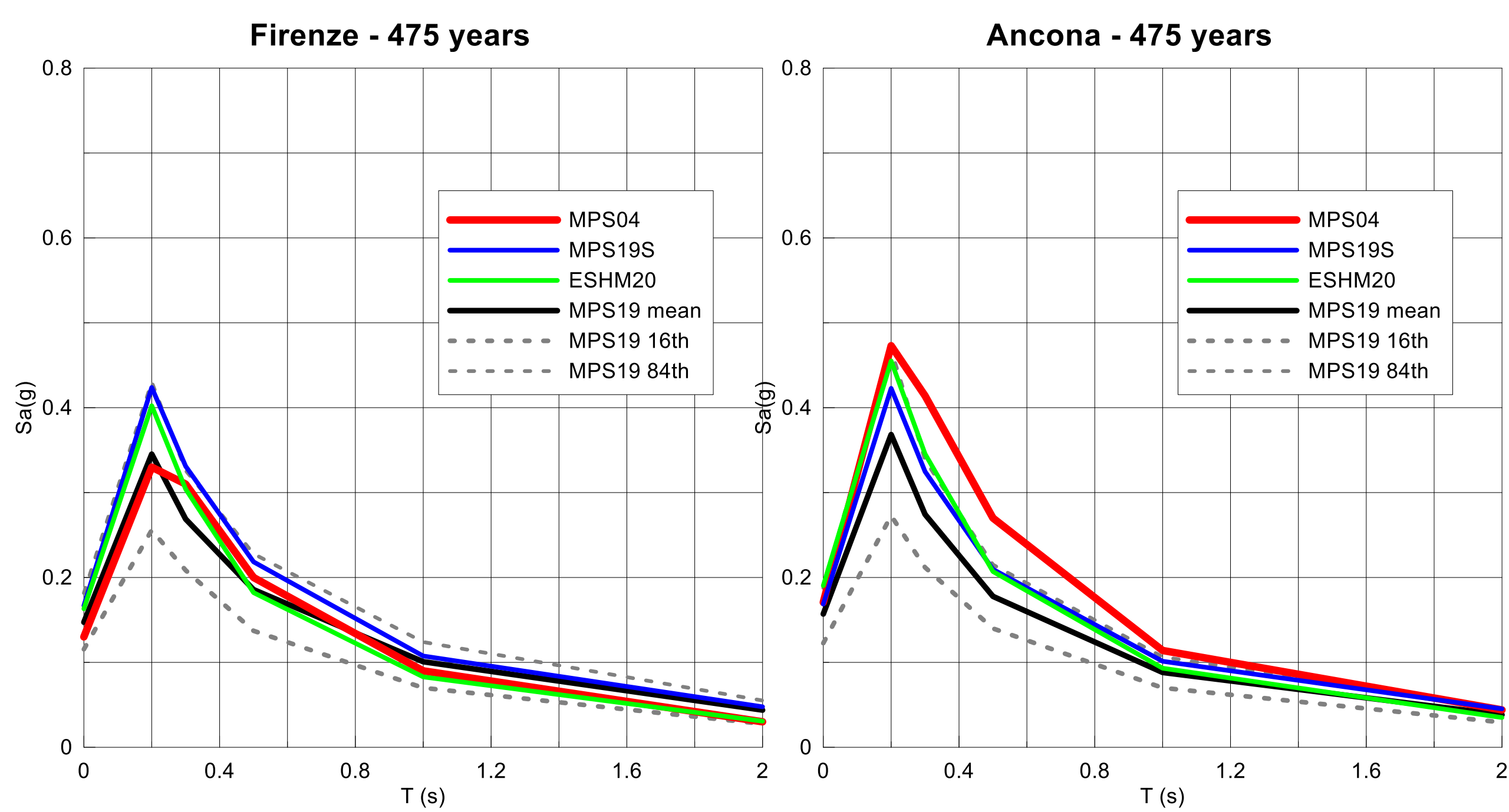
La fase di test di un modello di pericolosità sismica: come usare i dati storici macrosismici?

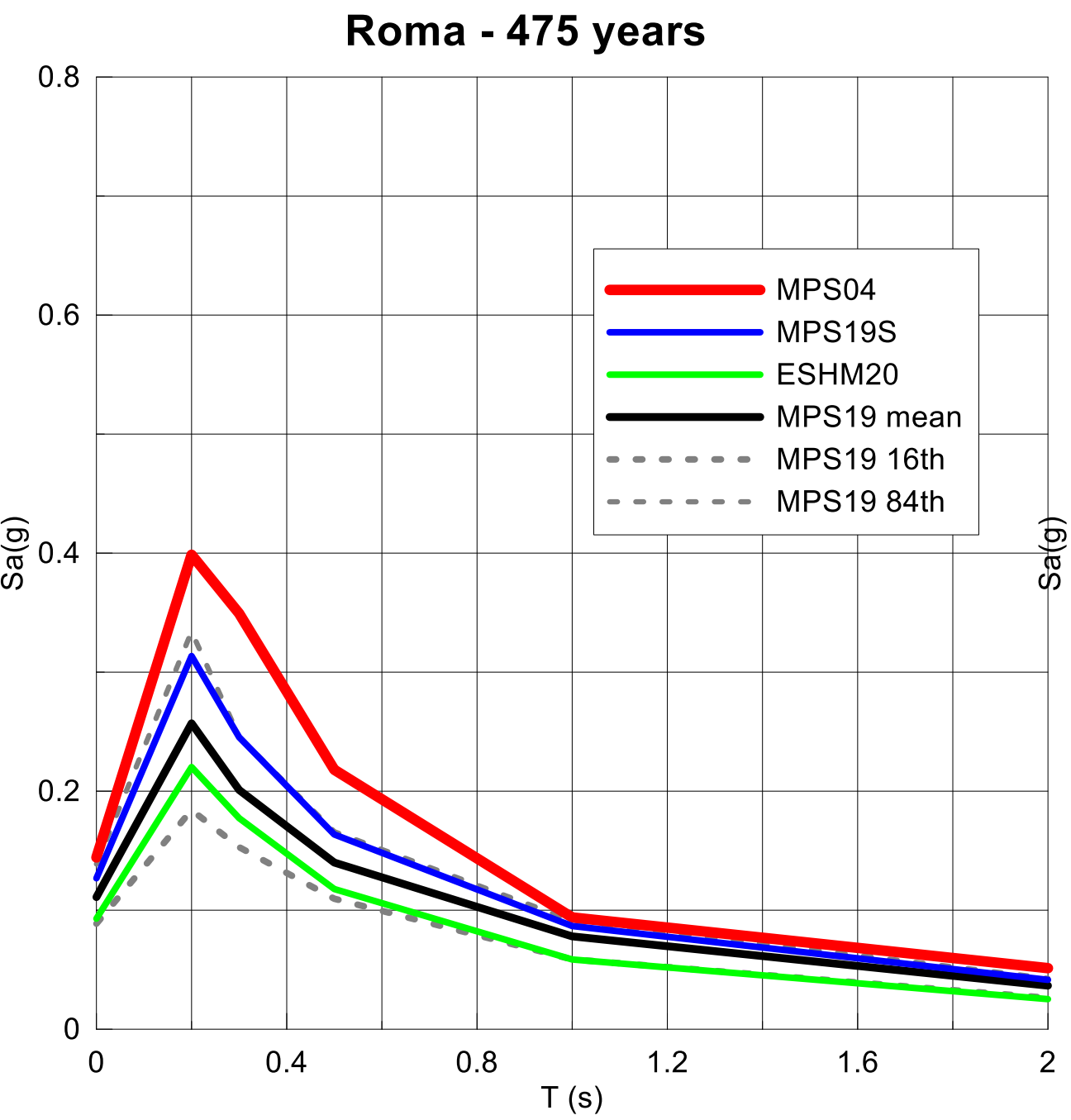
Contenuti

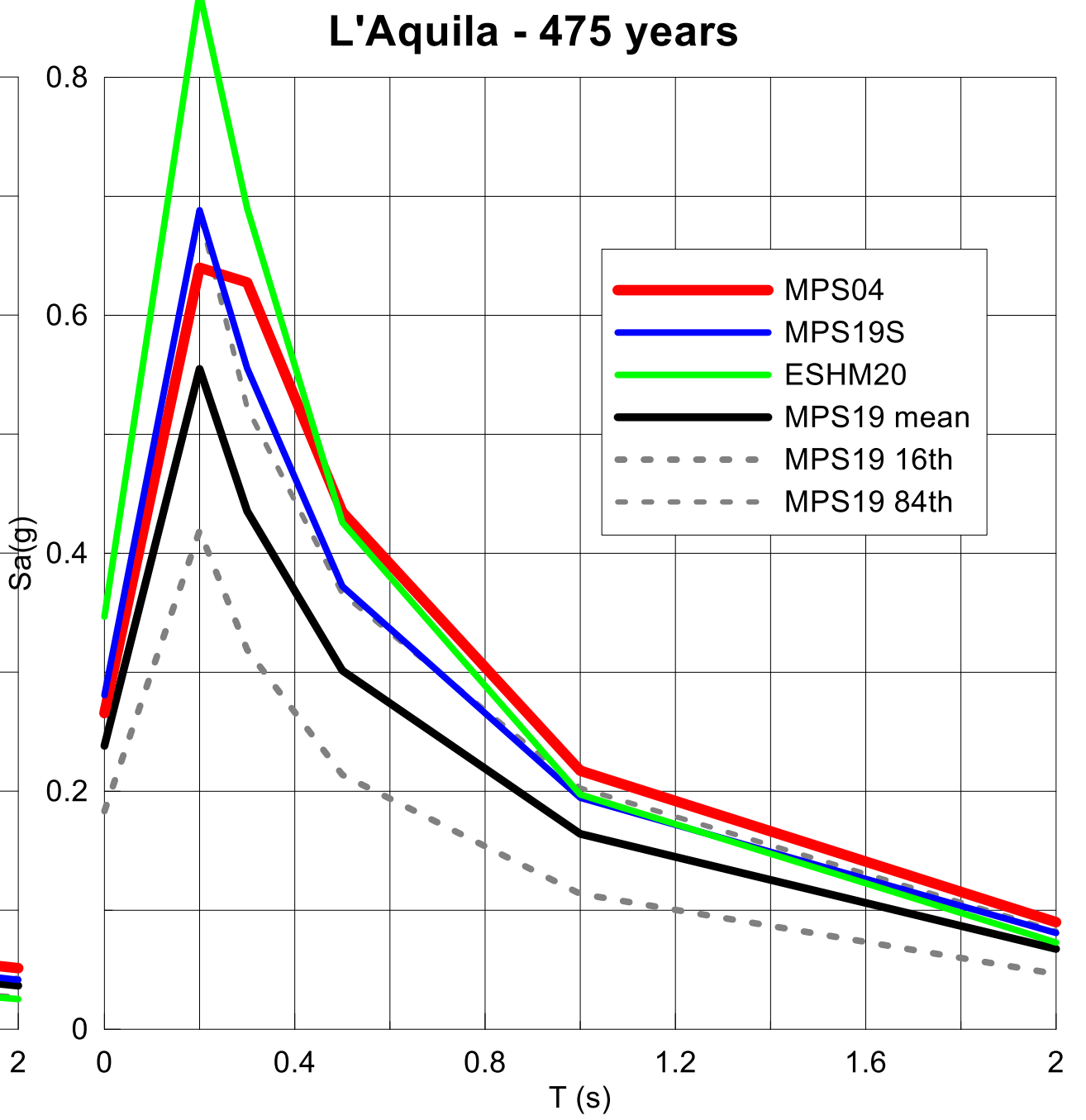
- ✓ MPS04 vs MPS19 vs MPS19s vs ESHM20: come decidere?
- ✓ come usare i dati storici macrosismici per una verifica di consistenza?
- ✓ i casi "patologici": cosa fare quando dato macrosismico e modello divergono? I casi di Napoli e Ischia
- ✓ il problema delle GMPE in campo vicino
- ✓ qualche considerazione conclusiva

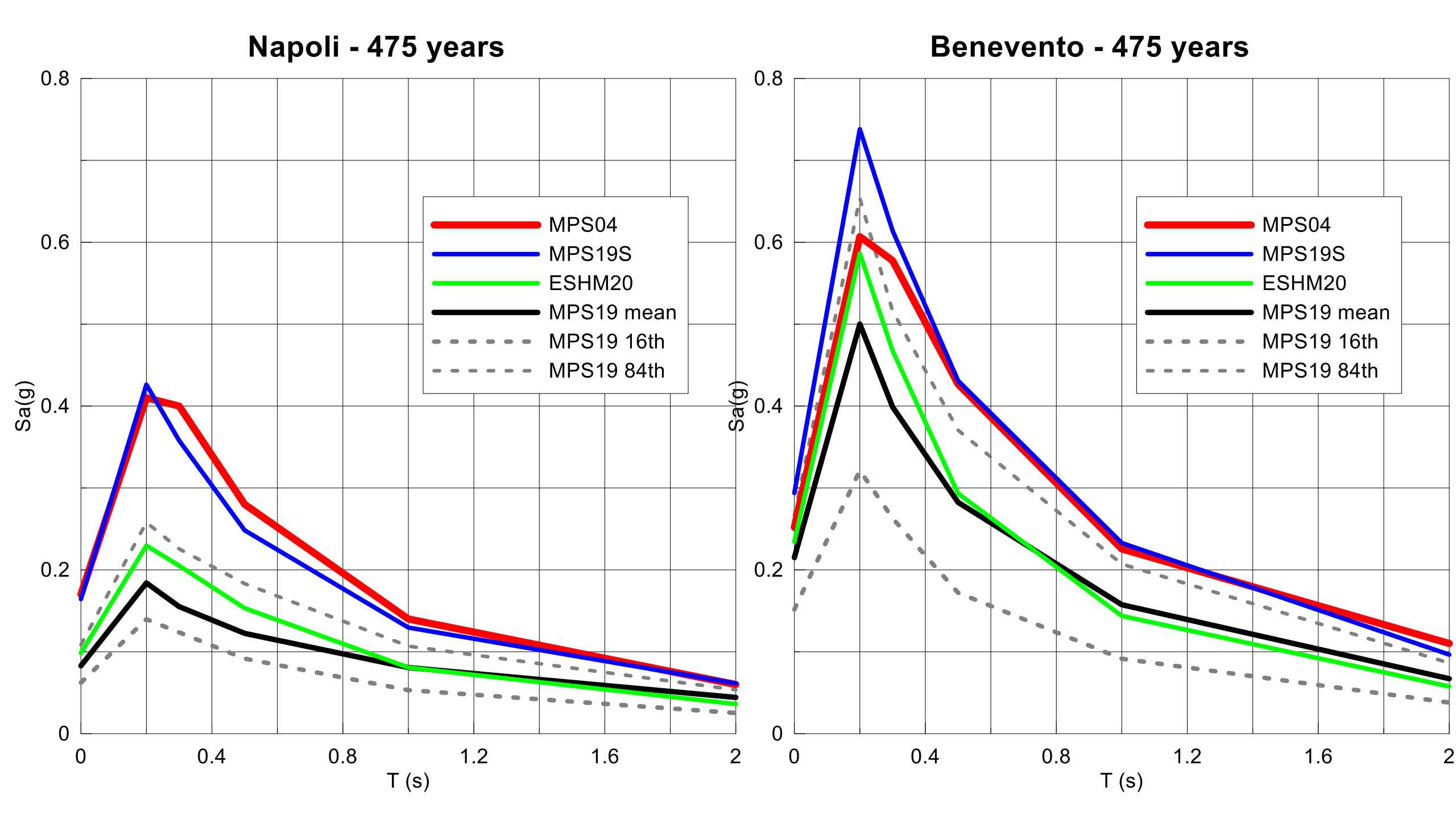

Milano - 475 years
Udine - 475 years
Sa(g)
T (s)
0
0.2
0.4
0.6
0.8
0
0.4
0.8
1.2
1.6
2
MPS04
MPS19S
ESHM20
MPS19 mean
MPS19 16th
MPS19 84th

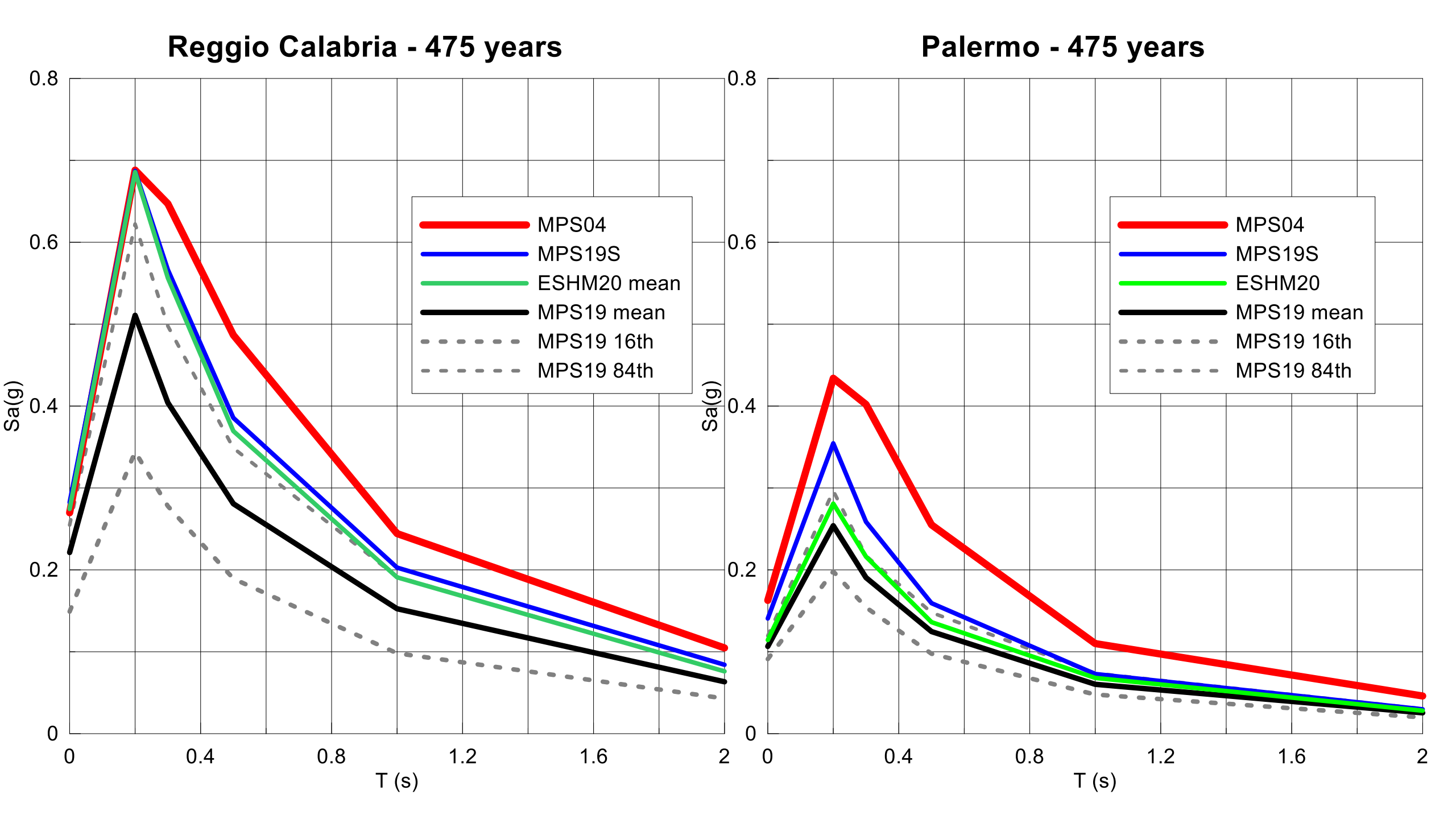

Parma - 475 years
Bologna - 475 years
MPS04
MPS19S
ESHM20
MPS19 mean
MPS19 16th
MPS19 84th
Sa(g)
T (s)
0
0.2
0.4
0.6
0.8
0
0.4
0.8
1.2
1.6
2

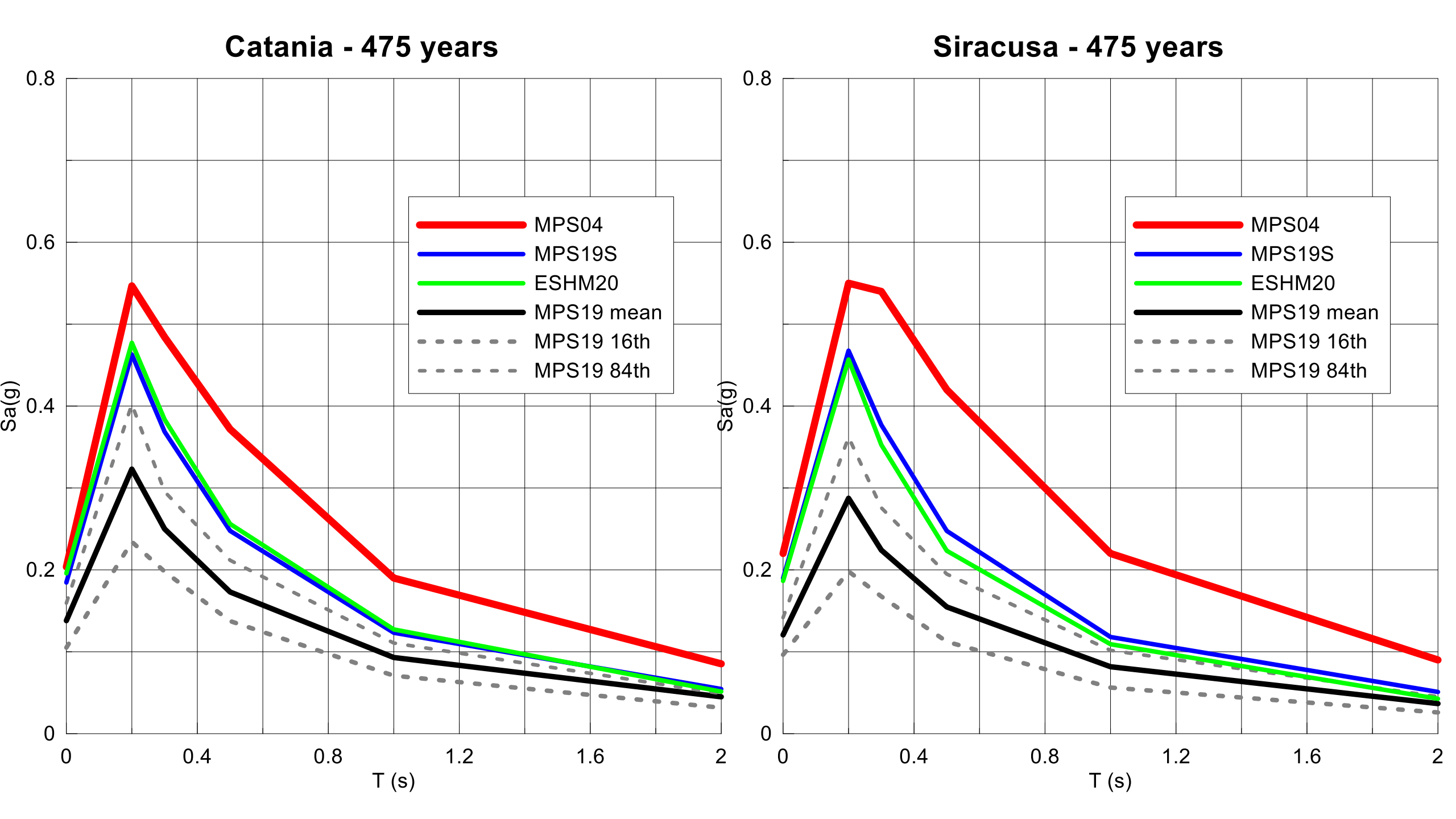

Firenze - 475 years
Ancona - 475 years
MPS04
MPS19S
ESHM20
MPS19 mean
MPS19 16th
MPS19 84th
Sa(g)
T (s)
0
0.2
0.4
0.6
0.8
0
0.4
0.8
1.2
1.6
2


Roma - 475 years
0.8
0.6
0.4
0.2
0
Sa(g)
0
0.4
0.8
1.2
1.6
2
T (s)
MPS04
MPS19S
ESHM20
MPS19 mean
MPS19 16th
MPS19 84th

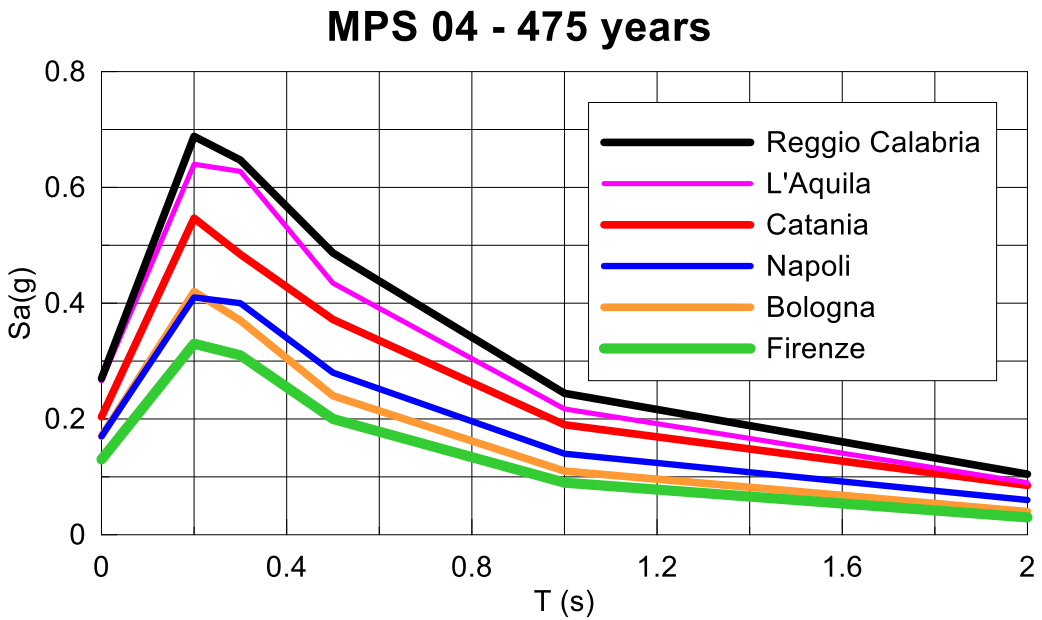

L'Aquila - 475 years
0.8
0.6
0.4
0.2
0
Sa(g)
0
0.4
0.8
1.2
1.6
2
T (s)
MPS04
MPS19S
ESHM20
MPS19 mean
MPS19 16th
MPS19 84th

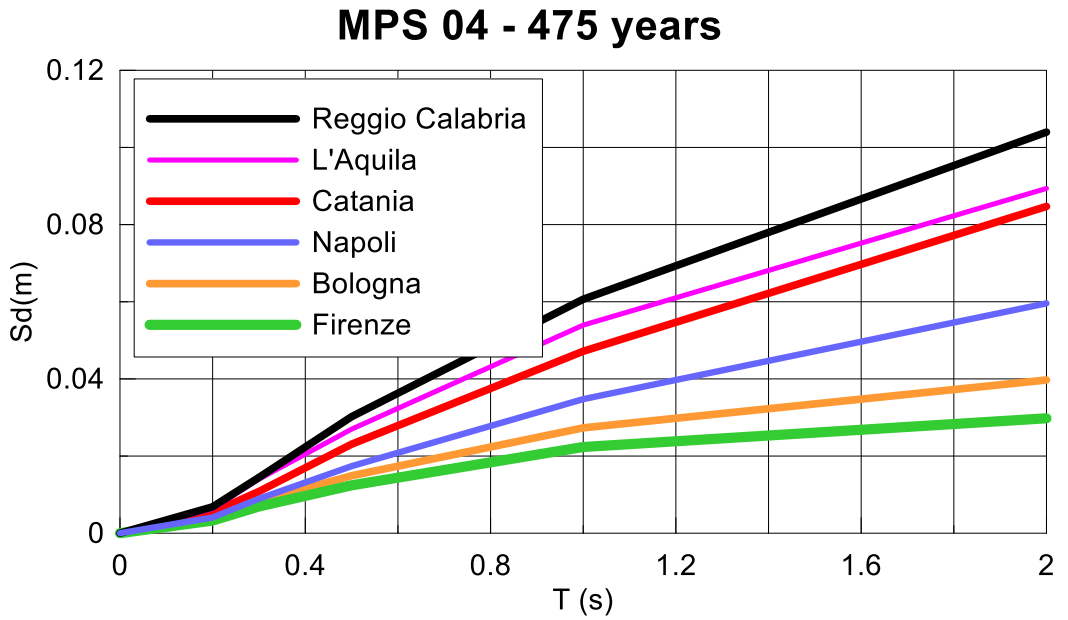

Napoli - 475 years
Benevento - 475 years
Sa(g)
T (s)
0
0.2
0.4
0.6
0.8
0
0.4
0.8
1.2
1.6
2
MPS04
MPS19S
ESHM20
MPS19 mean
MPS19 16th
MPS19 84th

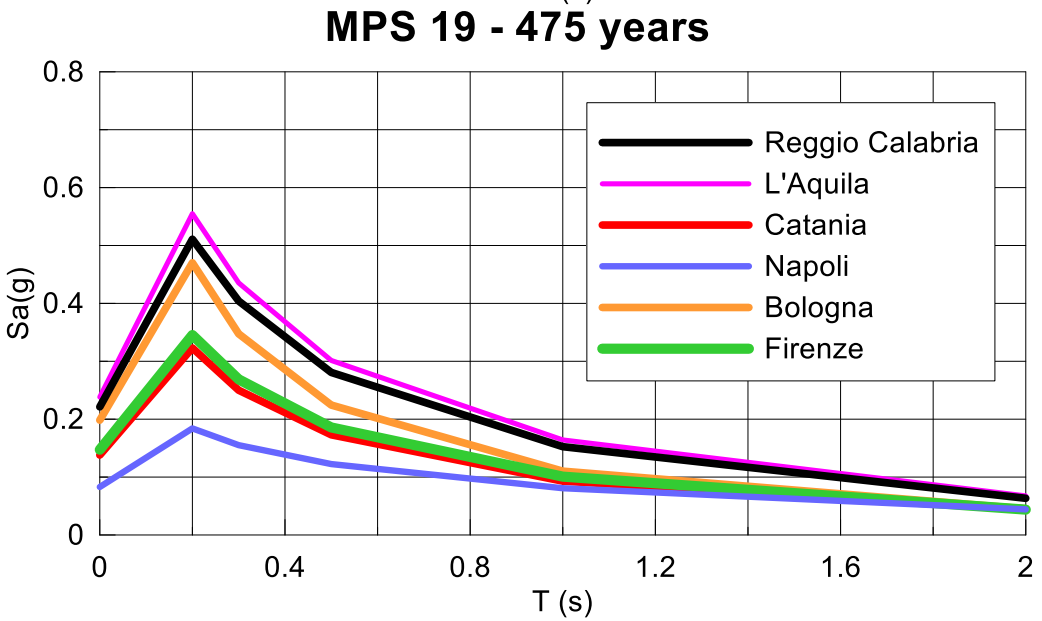

Reggio Calabria - 475 years
Palermo - 475 years
Sa(g)
T (s)
0
0.2
0.4
0.6
0.8
0.4
0.8
1.2
1.6
2
MPS04
MPS19S
ESHM20 mean
MPS19 mean
MPS19 16th
MPS19 84th
ESHM20

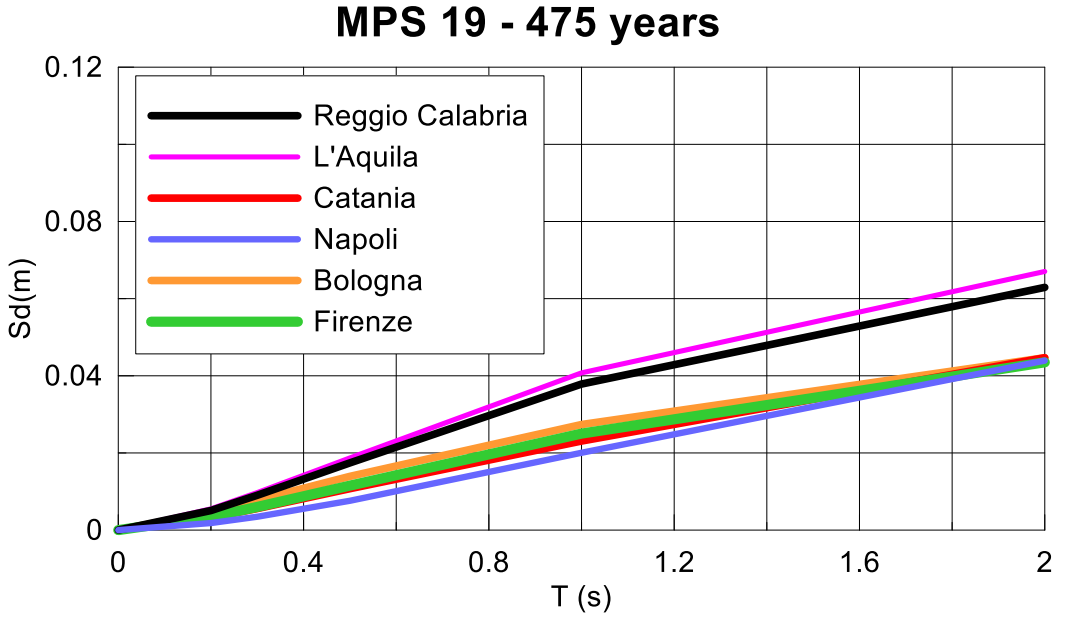

Catania - 475 years
Siracusa - 475 years
MPS04
MPS19S
ESHM20
MPS19 mean
MPS19 16th
MPS19 84th
Sa(g)
T (s)
0
0.2
0.4
0.6
0.8
0.4
0.8
1.2
1.6
2

MPS04 vs MPS19: periodo di ritorno 475 anni









Contenuti

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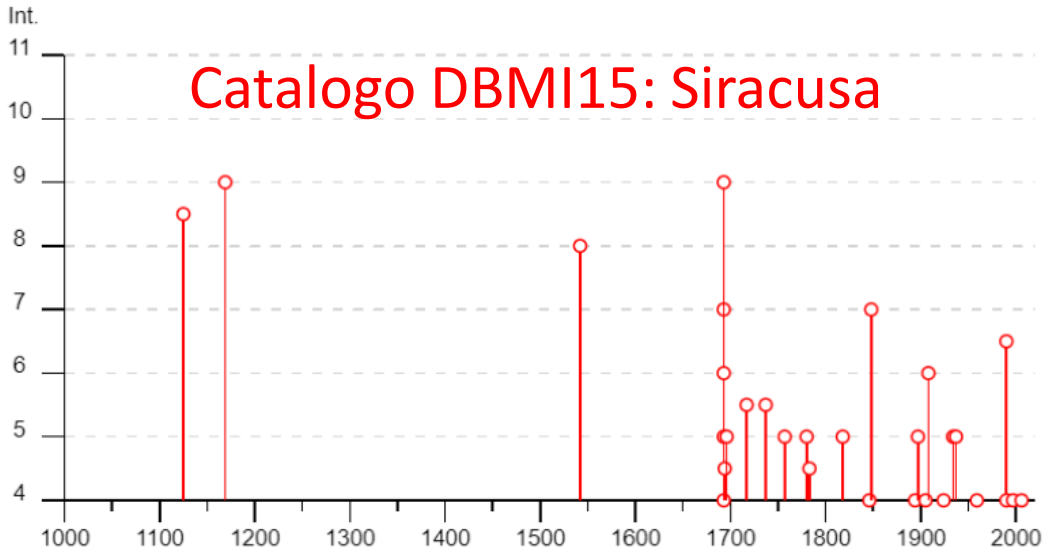
- ✓ qualche considerazione conclusiva

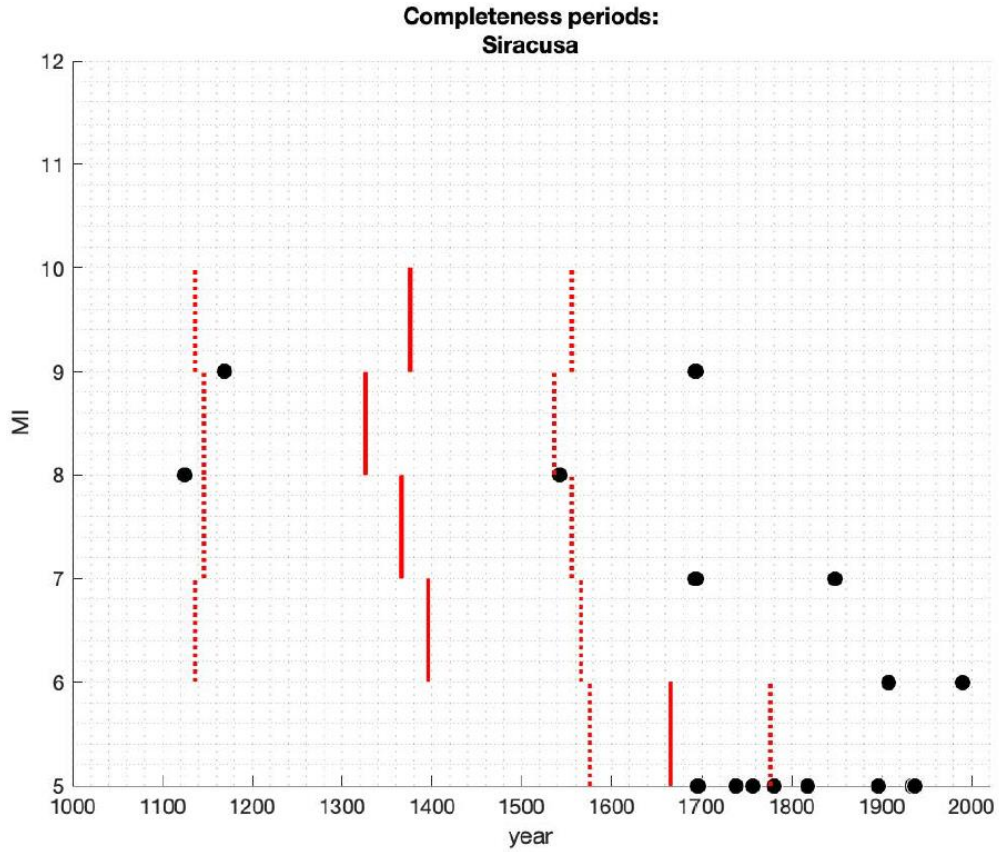
1) costruzione del catalogo dei risentimenti al sito

1.1 considerazioni di completezza



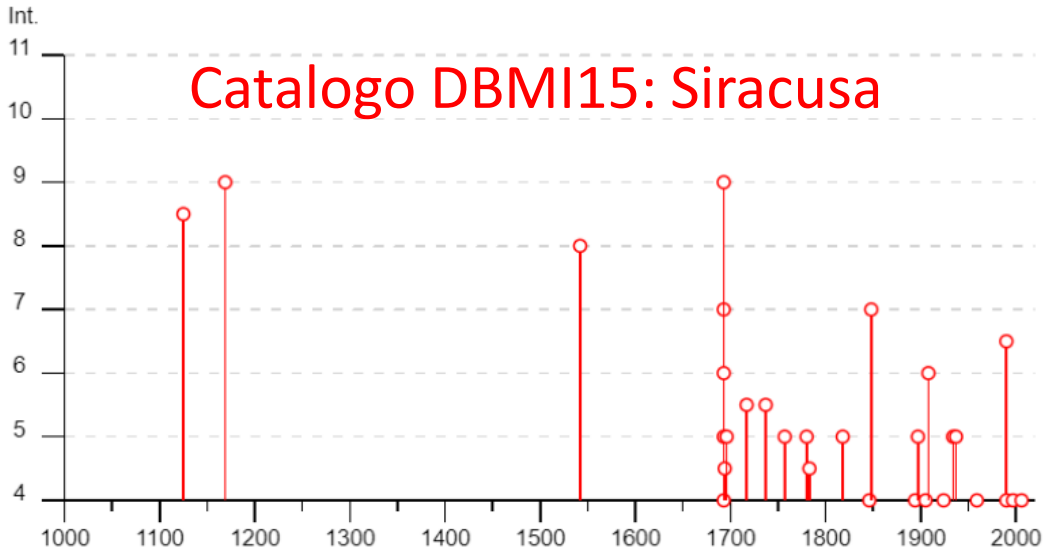
vengono eliminati i risentimenti la cui Is cade al di fuori degli intervalli di completezza stimati al sito

a) approccio statistico al sito (Albarello et al., 2001)



1) costruzione del catalogo dei risentimenti al sito

1.1 considerazioni di completezza

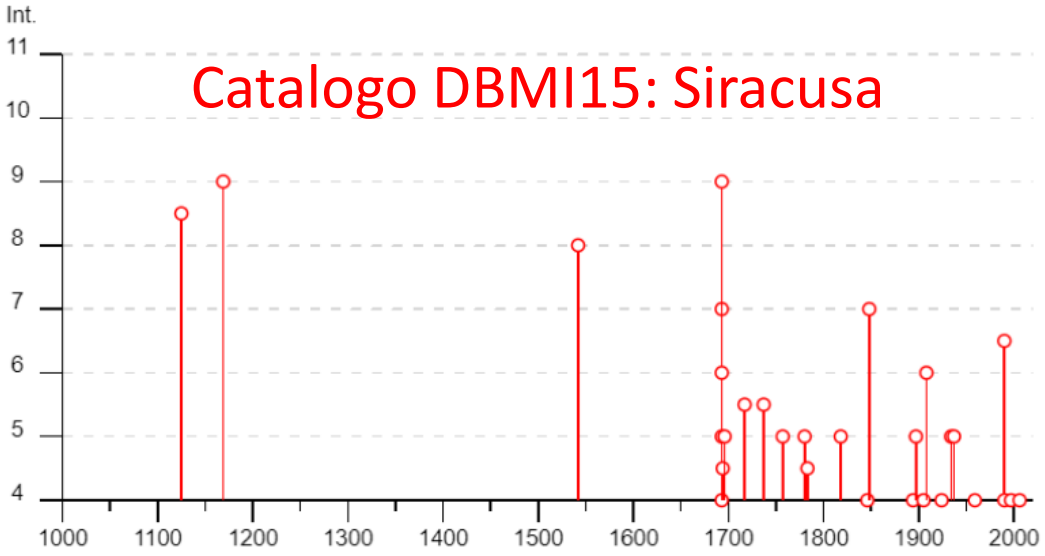


vengono eliminati i risentimenti prodotti da un terremoto la cui I0 cade al di fuori degli intervalli di completezza stimati per la macroarea

b) completezza sulla base di I0 per macroaree (da MPS19)

Io	Mw	Alpi	P.Padana	Centro	Sud	Isole	Mare
4-5	3.96	*1900*	*1950*	*1950*	*1950*	*1950*	*2002*
5	4.19	*1900*	*1836*	*1900*	*1895*	*1950*	*2002*
5-6	4.42	*1871*	*1836*	*1871*	*1895*	*1871*	*2002*
6	4.65	*1871*	*1836*	*1871*	*1895*	*1871*	*1984*
6-7	4.88	1871	1836	1871	1895	1871	*1984*
7	5.11	1700	1530	1650	1787	1700	*1984*
7-8	5.34	1700	1530	1650	1787	1700	*1984*
8	5.57	1530	1530	1650	1787	1700	*1963*
8-9	5.80	1530	1300	1530	1787	1530	*1963*
9	6.03	1300	1300	1530	1530	1530	*1963*
9-10	6.26	1300	1100	1300	1530	1300	*1963*
10	6.49	1300	1100	1300	1400	1300	*1963*
10-11	6.72	1300	1100	1300	1400	1300	*1963*
11	6.95	1300	1100	1300	1400	1300	*1963*
11-12	7.18	1300	1100	1300	1400	1300	*1963*

1) costruzione del catalogo dei risentimenti al sito



Catalogo DBMI15: Siracusa

estrazione catalogo sulla base di eliminazione repliche
+ completezza storica (da rapporto MPS19)

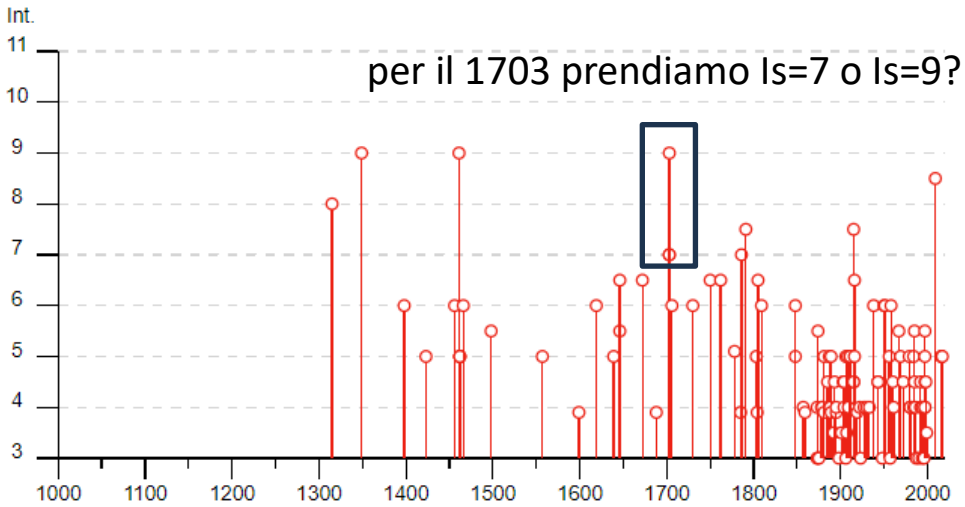
Anno	I0	Mw	Is	Completezza	Differenza	Ricorrenza
1542	10	6.7	8	1300	715	0.0013986
1693	11	7.3	9	1300	715	0.0013986
1780	7.5	5.5	5	1700	315	0.0031746
1818	9.5	6.3	5	1300	715	0.0013986
1848	7.5	5.5	7	1700	315	0.0031746
1894	9	6.1	4	1530	485	0.00206186
1897		5	5	1871	144	0.00694444
1908	11	7.1	6	1300	715	0.0013986
1924	5	4.7	4	1871	144	0.00694444
1934	5.5	4.8	5	1871	144	0.00694444
1937	5	4.5	5	1871	144	0.00694444
1959	6.5	5.1	4	1700	315	0.0031746
1990		5.6	6.5	1700	315	0.0031746
1997	4.5	4.5	4	1871	144	0.00694444
2006	4	4	4	1950	65	0.01538462

1) costruzione del catalogo dei risentimenti al sito

1.2 eliminazioni risentimenti in una sequenza

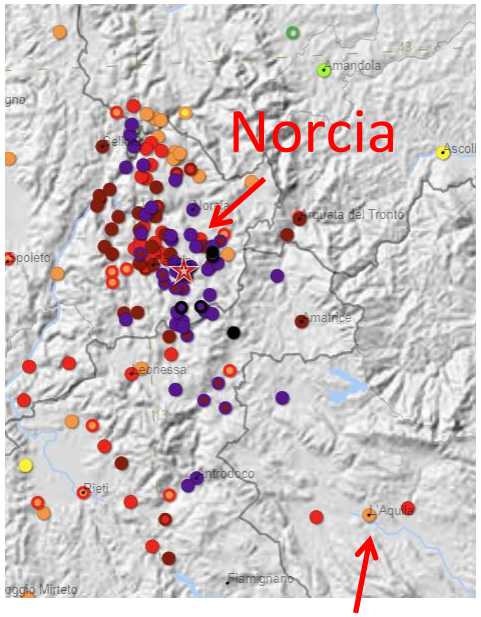
come definire il risentimento principale in una sequenza al sito?

Catalogo DBMI15: L'Aquila

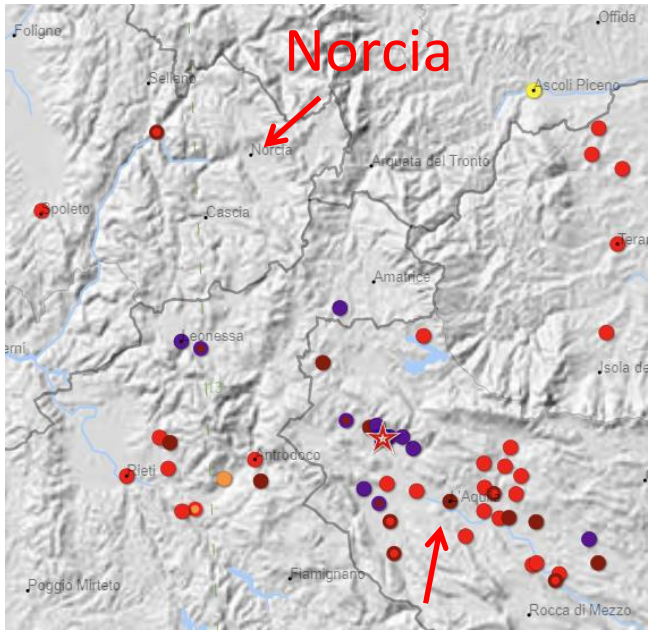


per il 1703 prendiamo Is=7 o Is=9?

14/01/1703 M6.9



02/02/1703 M6.7



una soluzione è considerare, all'interno della sequenza,
il terremoto per cui la stima di PGA al sito è massima

2) numero annuo di risentimenti al sito con Is ≥ i

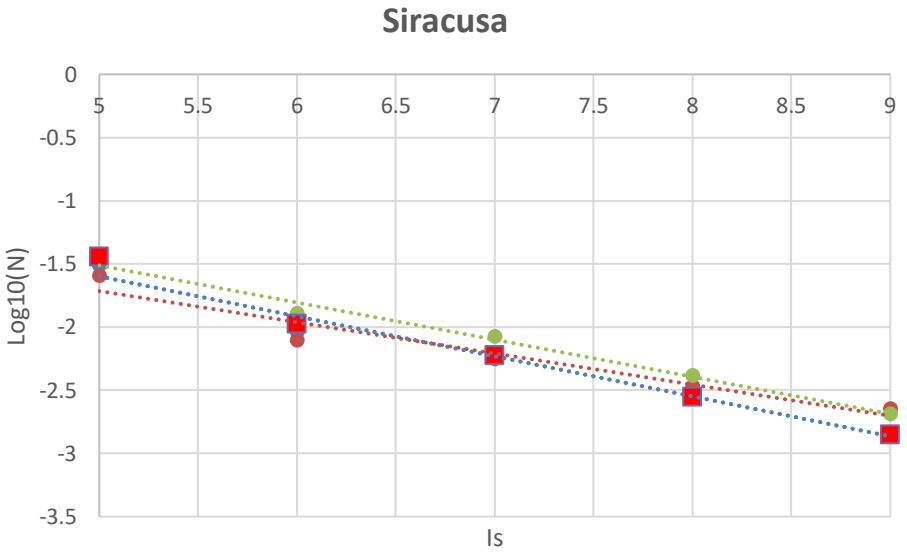
Il conteggio avviene calcolando il numero annuo N_i di risentimenti al sito di intensità Is ≥ i come segue:

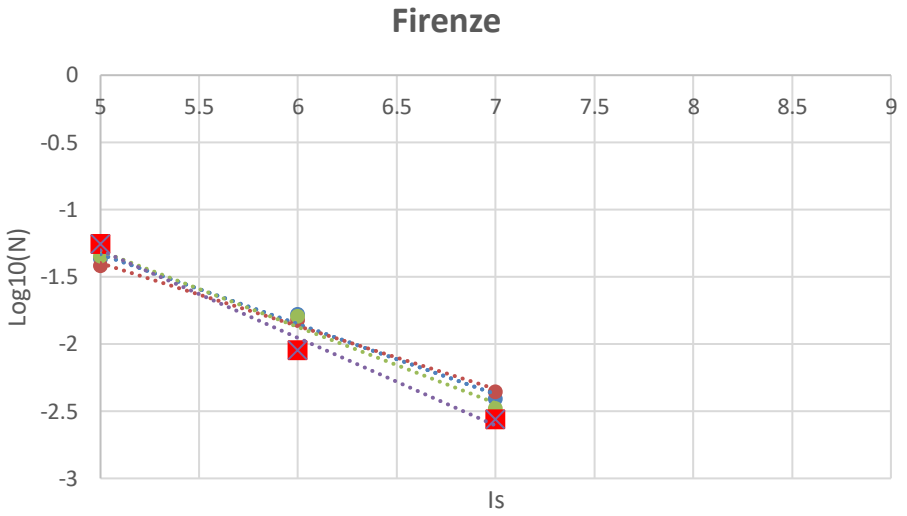
$$N_i = \frac{n_{i1}}{T_{c1}} + \frac{n_{i2}}{T_{c2}} + \ldots\ldots = \sum_{k=1}^{M} \frac{n_{ik}}{T_{ck}}$$

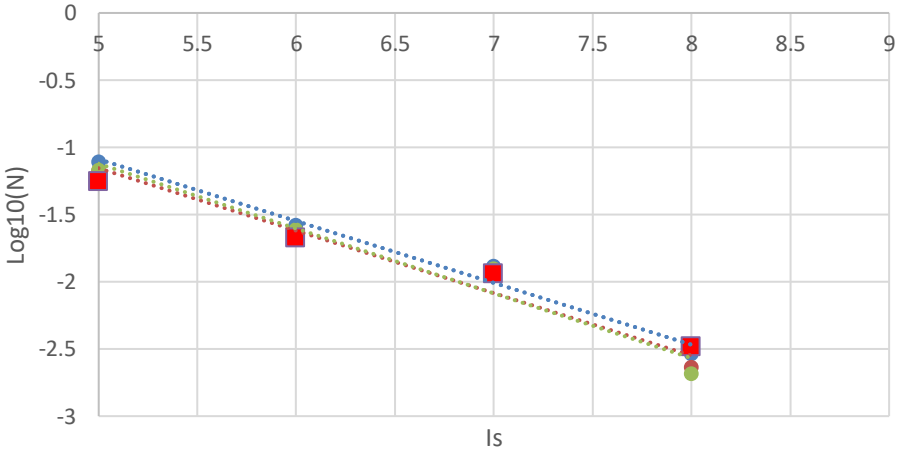
dove T_{ck} denota l'intervallo di completezza per l'intensità epicentrale I_{0k}, n_{ik} è il numero di risentimenti al sito ≥ i dovuti a un terremoto con intensità epicentrale I_{0k}, M è il numero di classi di intensità epicentrale.

2) numero annuo di risentimenti al sito con Is ≥ i

Confronto con stime basate sul numero di occorrenze al sito basate sui conteggi INGV, in termini di diverse ipotesi per il calcolo dell' intervallo di completezza (Tc) di Is al sito (a seconda dell'arrotondamento di Is e del 50° o 75° percentile di Tc)



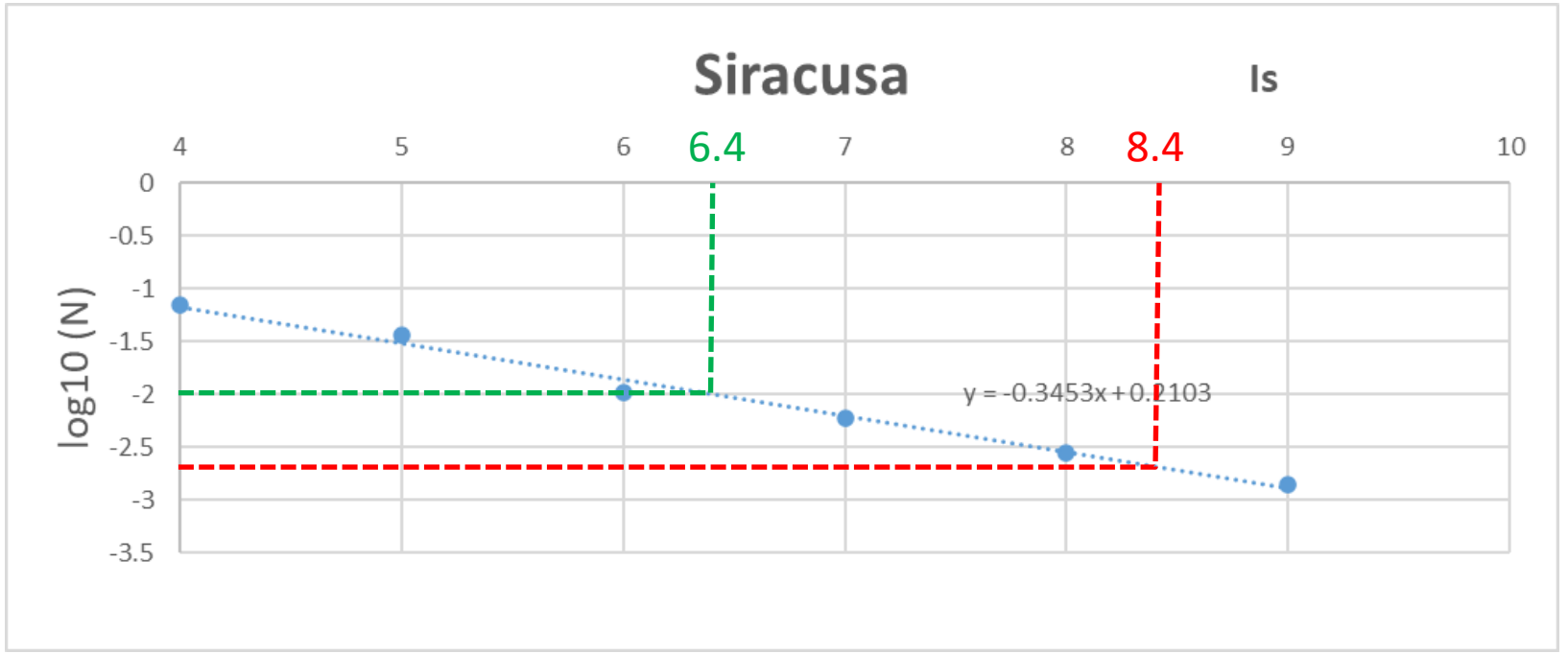




intervalli di completezza basati su I0

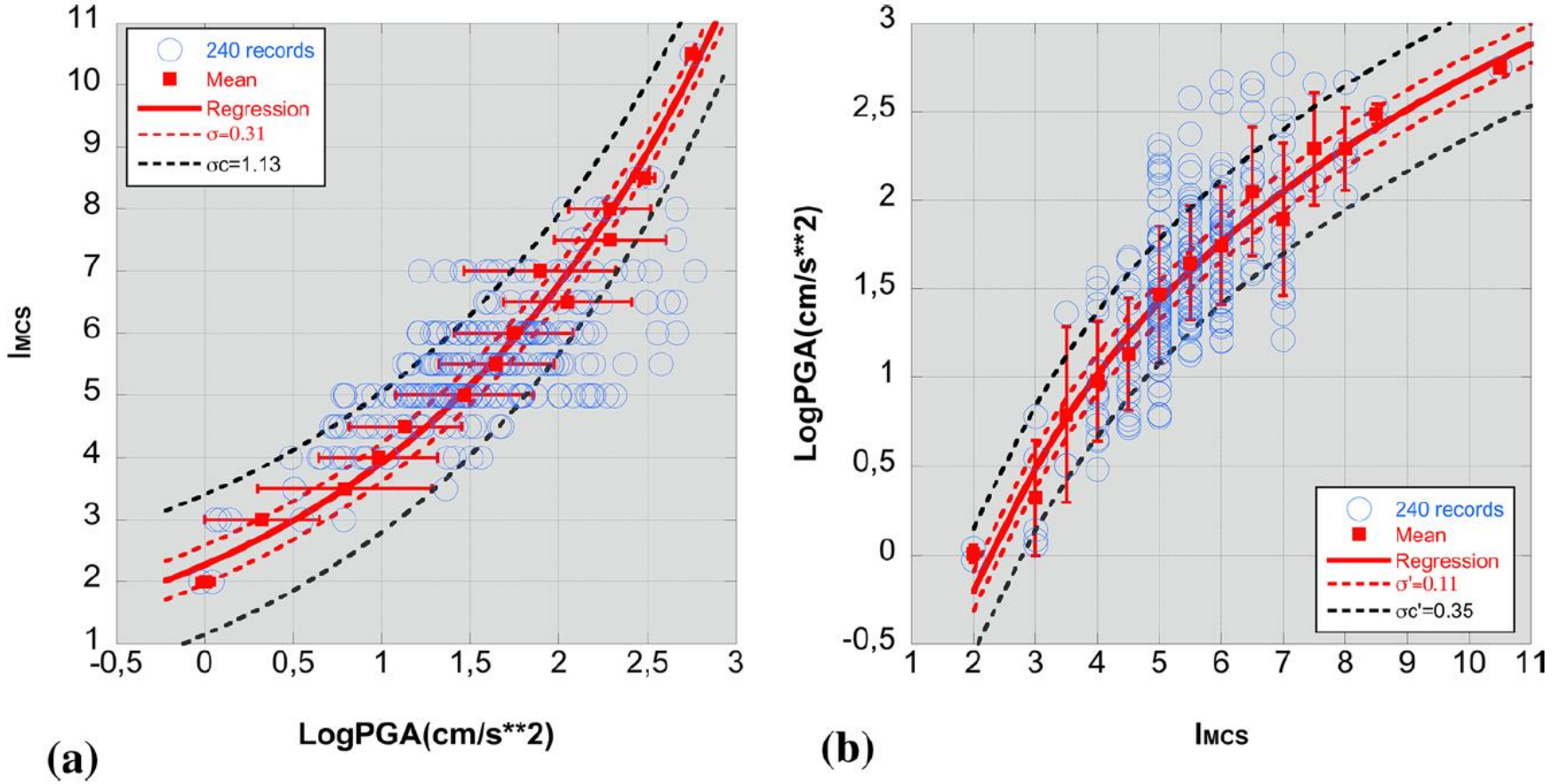
intervalli di completezza basati su Is

2) numero annuo di risentimenti al sito con Is ≥ i



3) conversione da Is a PGA

Gomez-Capera et al. 2020

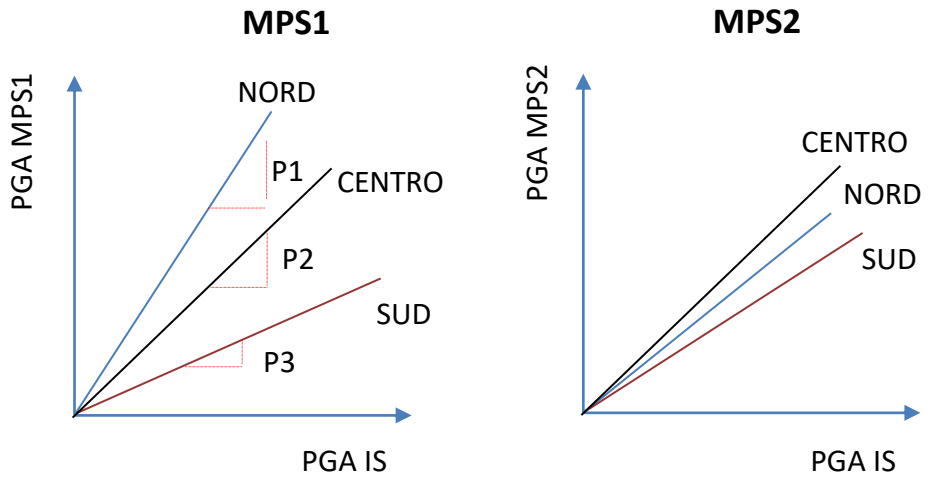


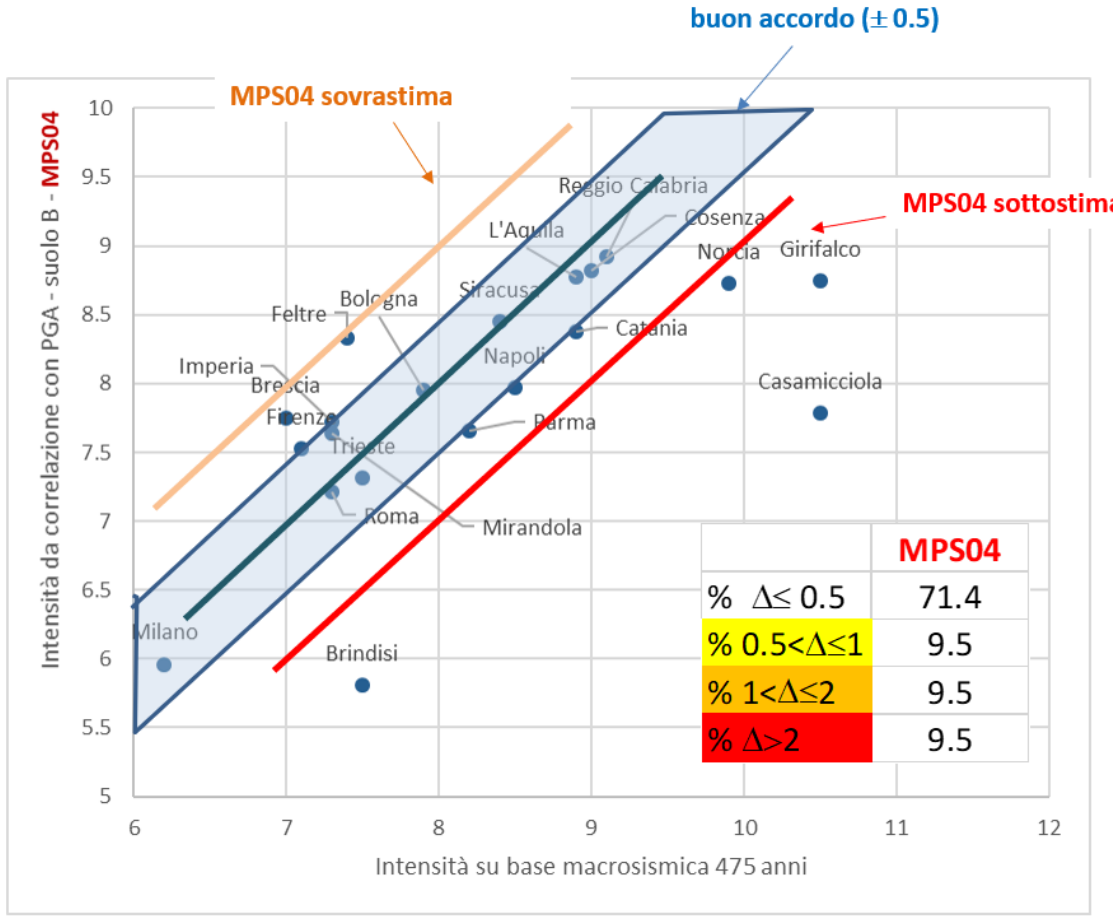
4) test di consistenza: quali obiettivi nel contesto italiano?

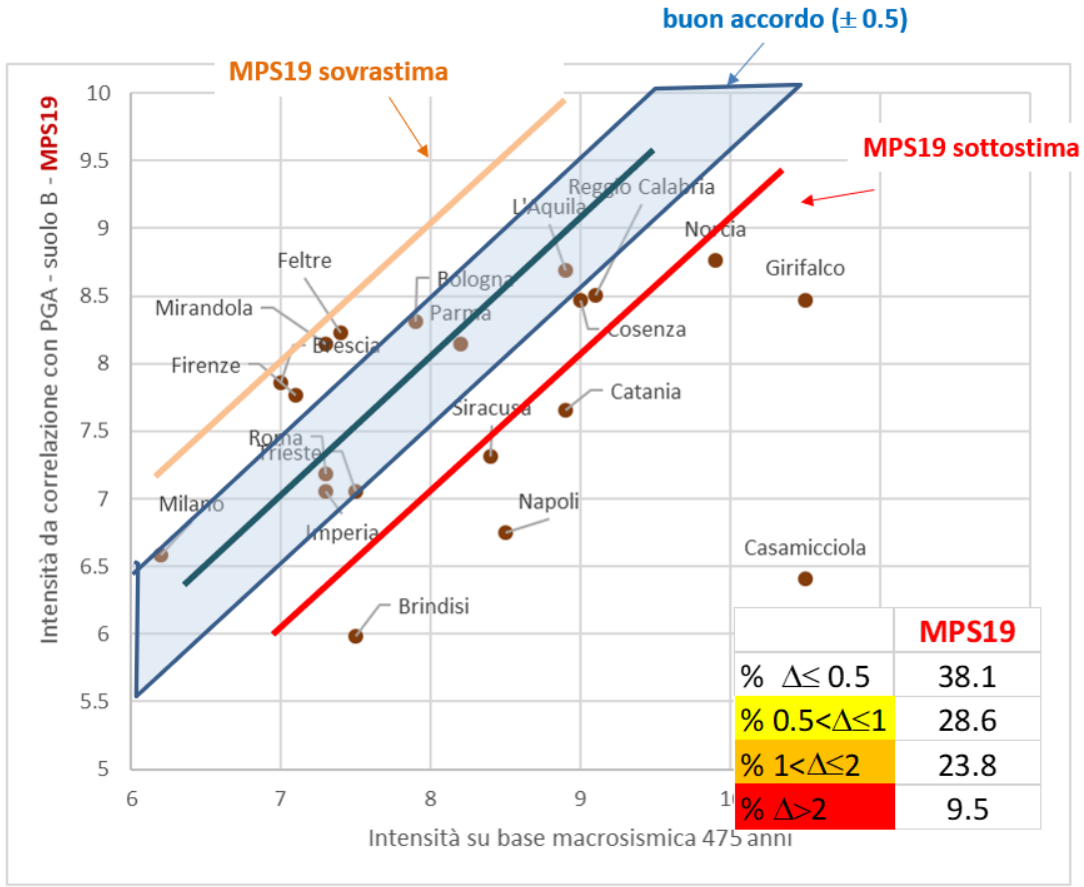
Non ci si attende una correlazione 1:1 tra i valori di Sa (e.g., PGA_{475}) stimati da approccio macrosismico e da MPS, però ci si attende:

- ✓ che le stime macrosismiche (PGA_{IS}) e quelle da MPS (PGA_{MPS}) concordino in termini di graduazione (ranking) della pericolosità tra le diverse località (correlazione approssimativamente lineare tra PGA_{IS} e PGA_{MPS})
- ✓ che non ci siano bias regionali, ovvero che la correlazione PGA_{IS} e PGA_{MPS} si mantenga grossomodo inalterata tra Nord, Centro e Sud Italia
- ✓ che si possa dare una spiegazione ben fondata nel caso di località che presentino un forte scarto dalle correlazioni tra PGA_{IS} e PGA_{MPS}

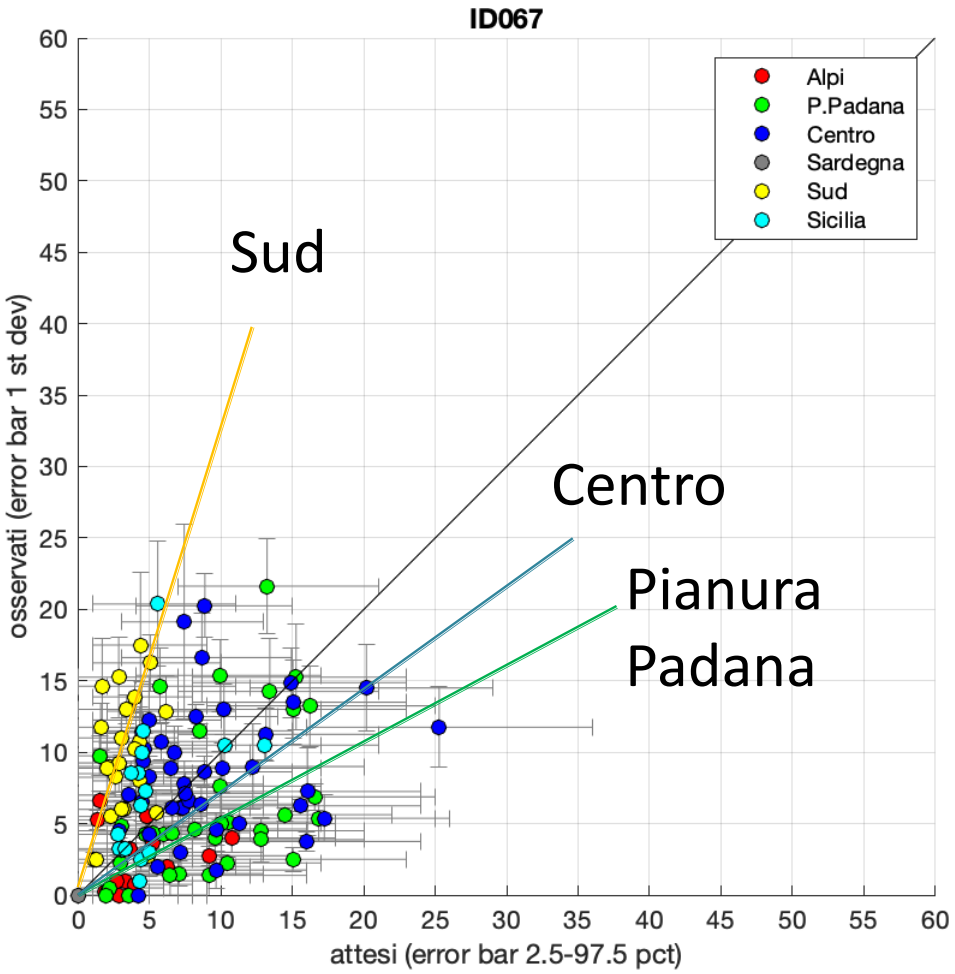
NB per i confronti si dovrebbero considerare le condizioni di sito prevalenti in ogni località: nel seguito, per semplicità, la PGA_{MPS} su suolo A è stata moltiplicata per 1.2, in modo indifferenziato



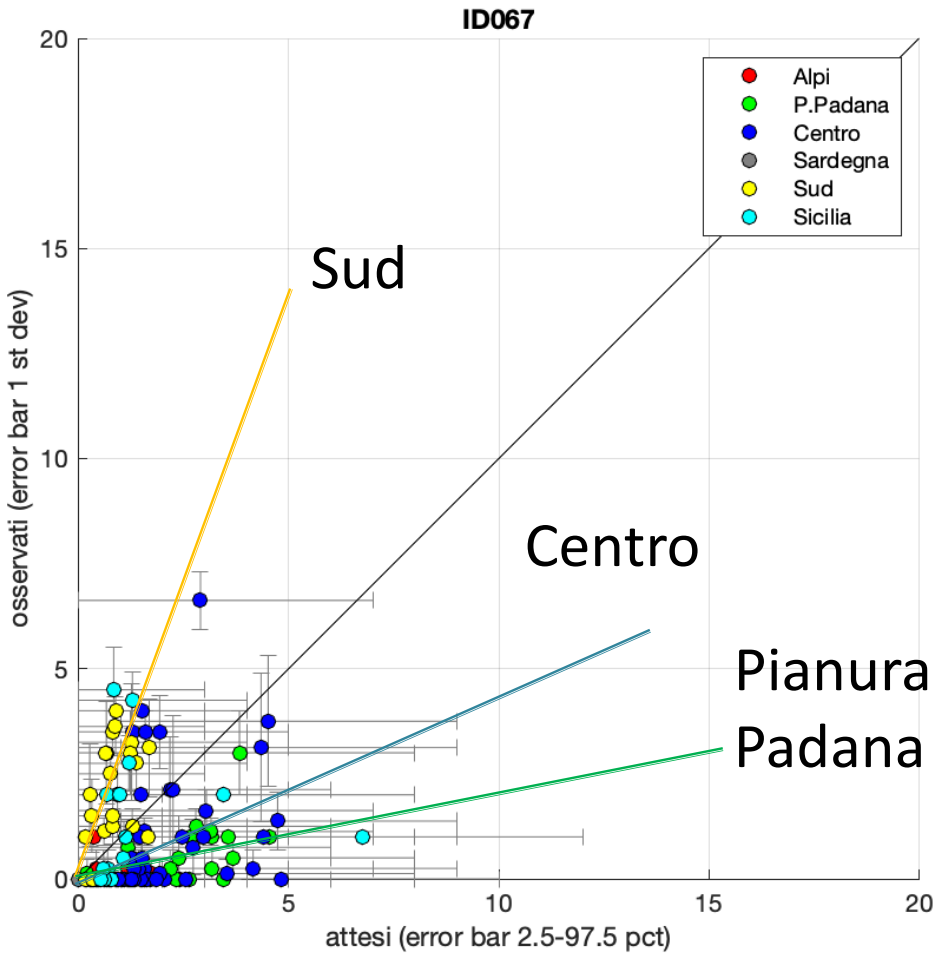

buon accordo (± 0.5)
MPS04 sovrastima
MPS04 sottostima
Intensità da correlazione con PGA - suolo B - MPS04
Intensità su base macrosismica 475 anni
Milano
Brindisi
Roma
Mirandola
Imperia
Brescia
Firenze
Trieste
Feltre
Bologna
Siracusa
Napoli
Parma
L'Aquila
Reggio Calabria
Cosenza
Catania
Noccia
Girifalco
Casamicciola
MPS04
% Δ≤ 0.5 71.4
% 0.5<Δ≤1 9.5
% 1<Δ≤2 9.5
% Δ>2 9.5


buon accordo (± 0.5)
MPS19 sovrastima
MPS19 sottostima
Intensità da correlazione con PGA - suolo B - MPS19
Intensità su base macrosismica 475 anni
Milano
Brindisi
Roma
Mirandola
Imperia
Brescia
Firenze
Trieste
Feltre
Bologna
Siracusa
Napoli
Parma
L'Aquila
Reggio Calabria
Cosenza
Catania
Noccia
Girifalco
Casamicciola
MPS19
% Δ≤ 0.5 38.1
% 0.5<Δ≤1 28.6
% 1<Δ≤2 23.8
% Δ>2 9.5

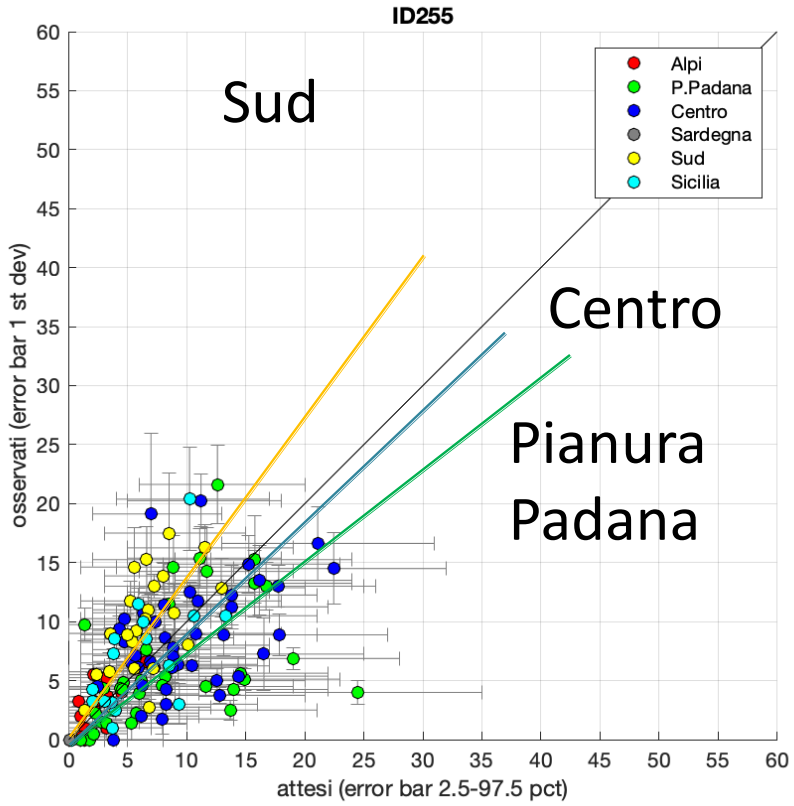
$I \geq 6$


ID067
Alpi
P.Padana
Centro
Sardegna
Sud
Sicilia
Sud
Centro
Pianura
Padana
osservati (error bar 1 st dev)
attesi (error bar 2.5-97.5 pct)
0
5
10
15
20
25
30
35
40
45
50
55
60

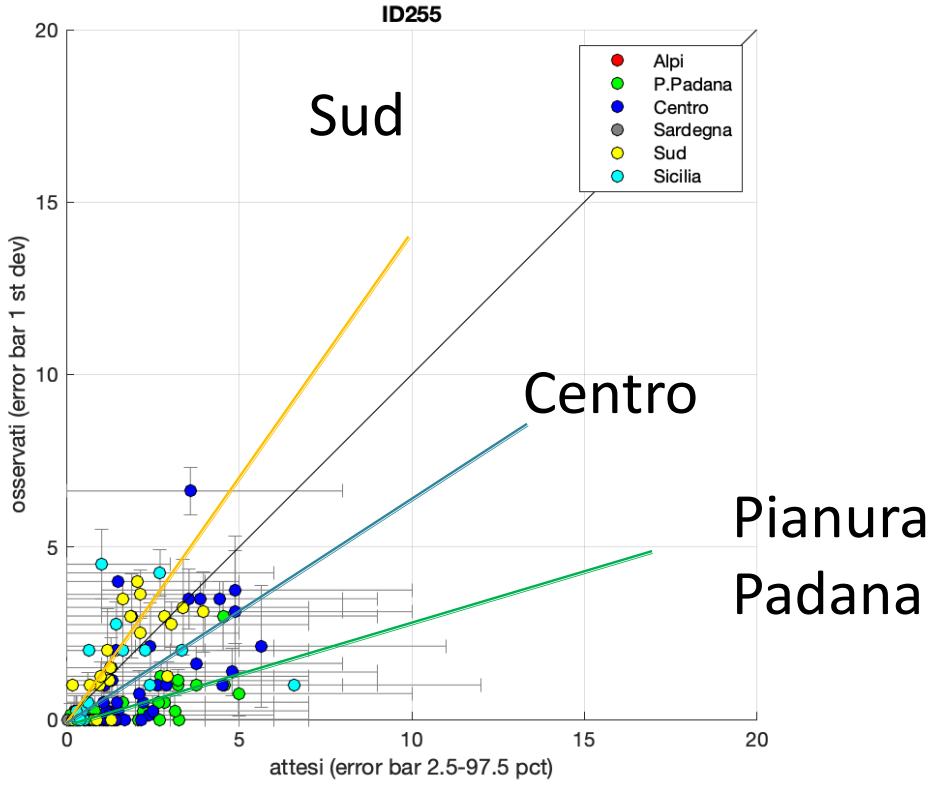
$I \geq 8$


ID067
Alpi
P.Padana
Centro
Sardegna
Sud
Sicilia
Sud
Centro
Pianura
Padana
osservati (error bar 1 st dev)
attesi (error bar 2.5-97.5 pct)
0
5
10
15
20

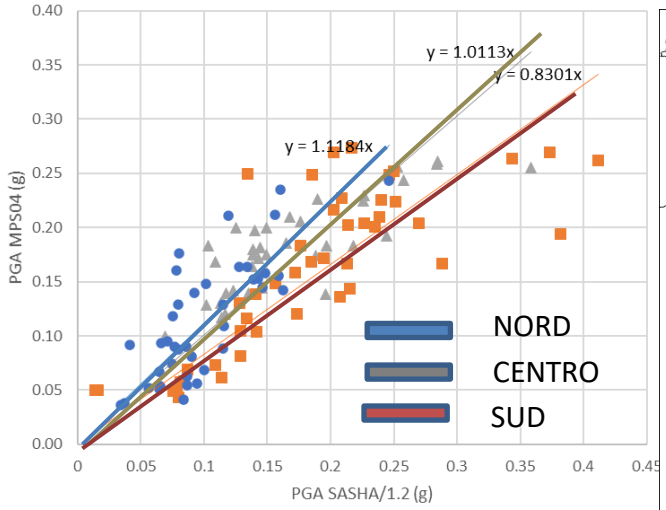
$I \geq 6$

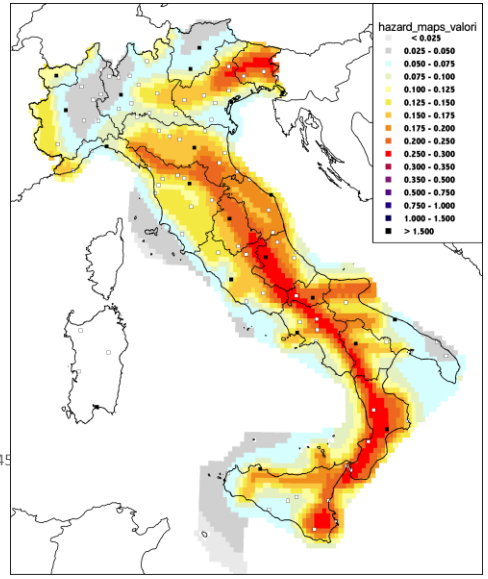

ID255
Sud
Centro
Pianura
Padana
Alpi
P.Padana
Centro
Sardegna
Sud
Sicilia
osservati (error bar 1 st dev)
attesi (error bar 2.5-97.5 pct)
0
5
10
15
20
25
30
35
40
45
50
55
60

$I \geq 8$

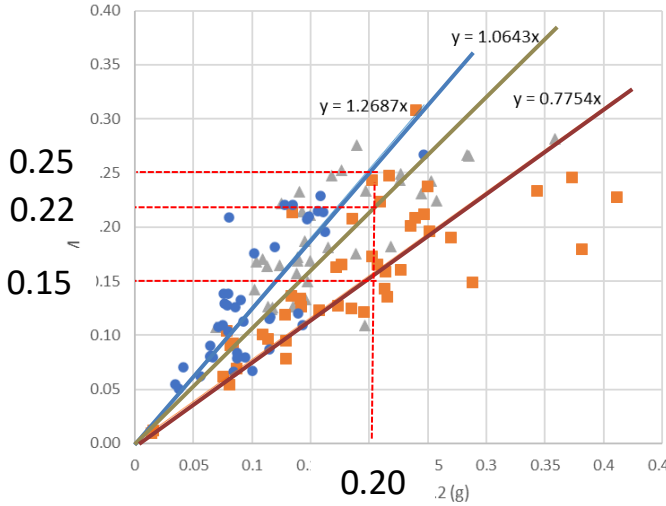

ID255
Sud
Centro
Pianura
Padana
Alpi
P.Padana
Centro
Sardegna
Sud
Sicilia
osservati (error bar 1 st dev)
attesi (error bar 2.5-97.5 pct)
0
5
10
15
20

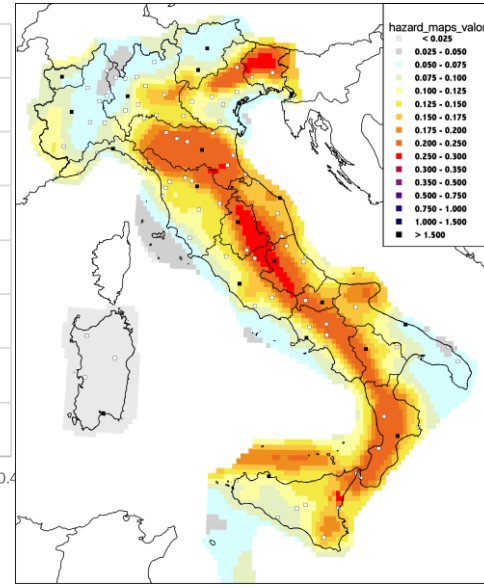
PGA MPS04
Score=1.12/0.83=1.35



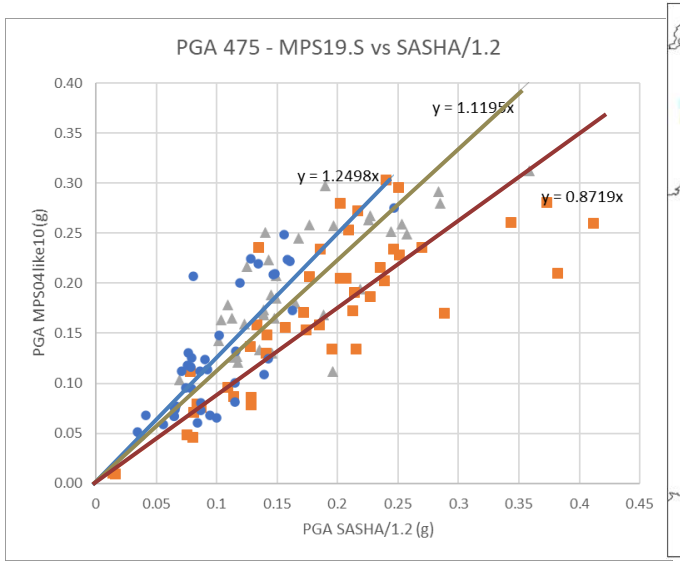


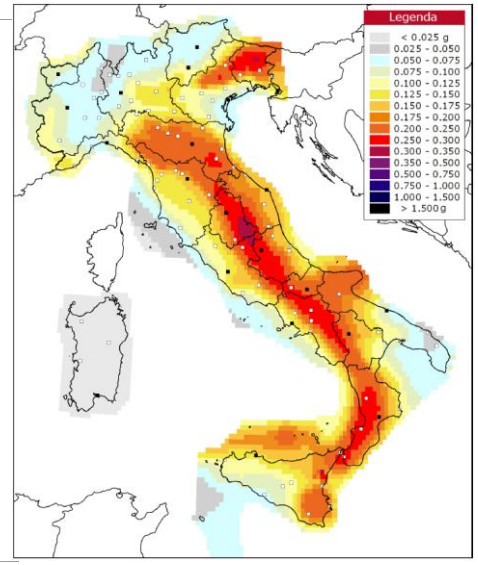
PGA MPS19bc
Score=1.27/0.77=1.64



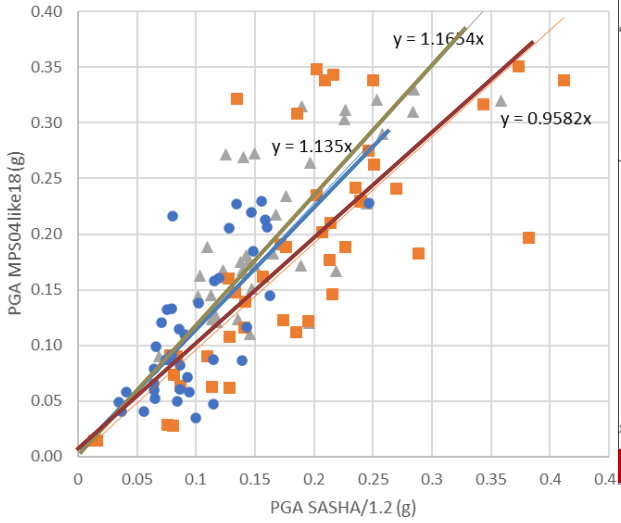


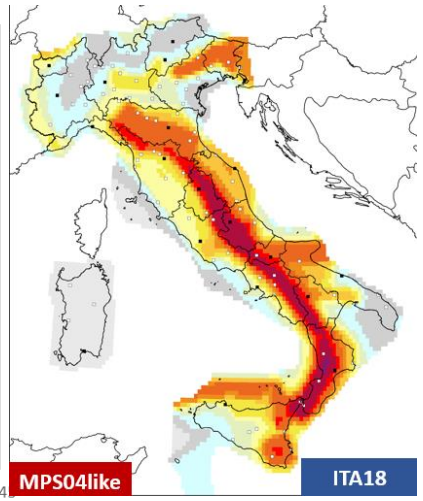
PGA MPS19.S
Score=1.34/0.87=1.43





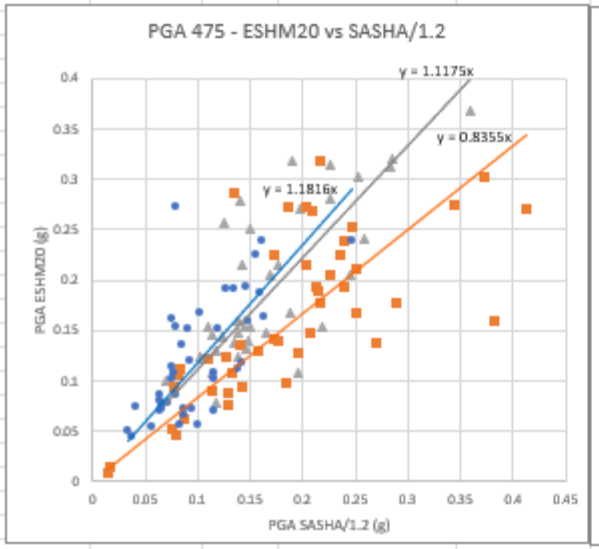
PGA MPS04like-ITA18
Score=1.13/0.96=1.22

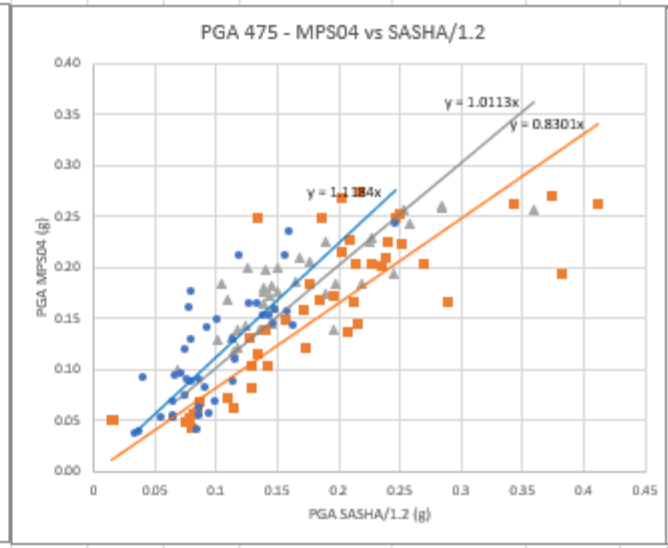


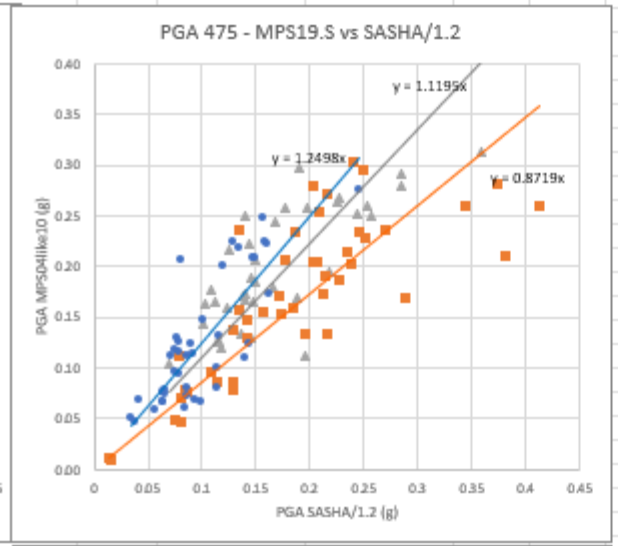


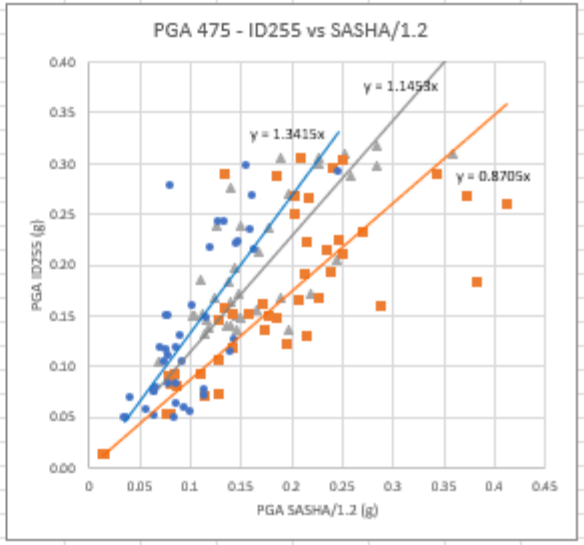
PGA

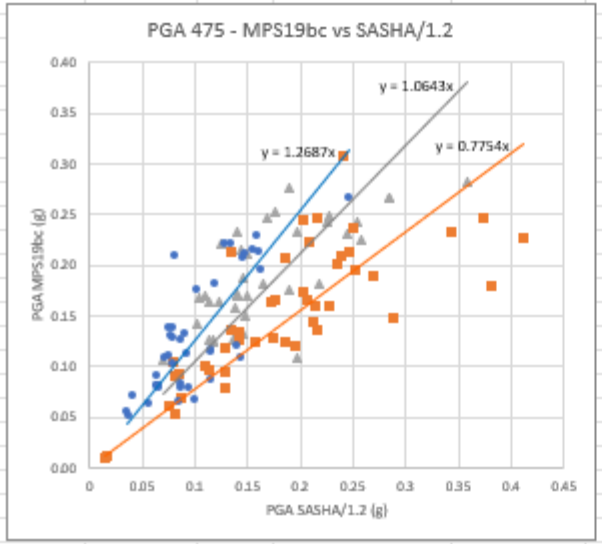
	ESHM20	MPS19bc	MPS04	MPS04like18	ID255	ID303	ID391	MPS19.S
Nord	1.18	1.27	1.12	1.13	1.34	1.33	1.11	1.25
Centro	1.12	1.06	1.01	1.17	1.15	1.17	1.02	1.12
Sud	0.84	0.78	0.83	0.96	0.87	0.84	0.86	0.87
Score	1.41	1.64	1.35	1.22	1.54	1.58	1.29	1.43
Average	1.04	1.04	0.99	1.09	1.12	1.11	1.00	1.08

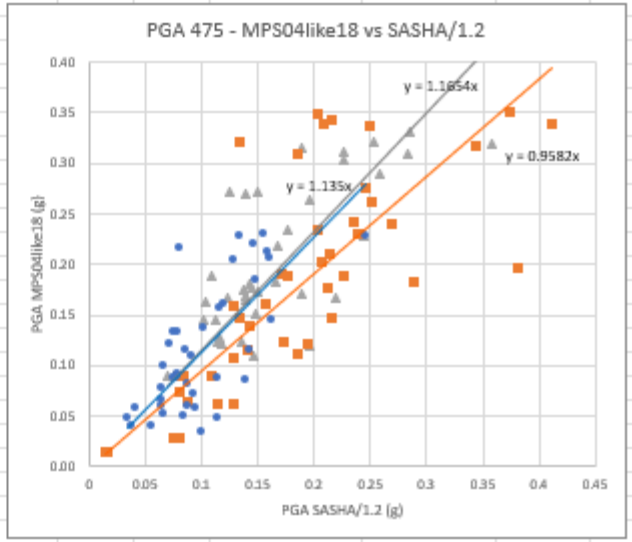


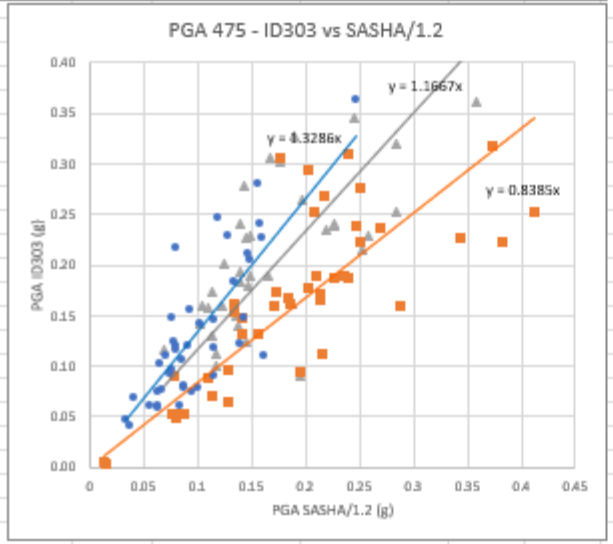


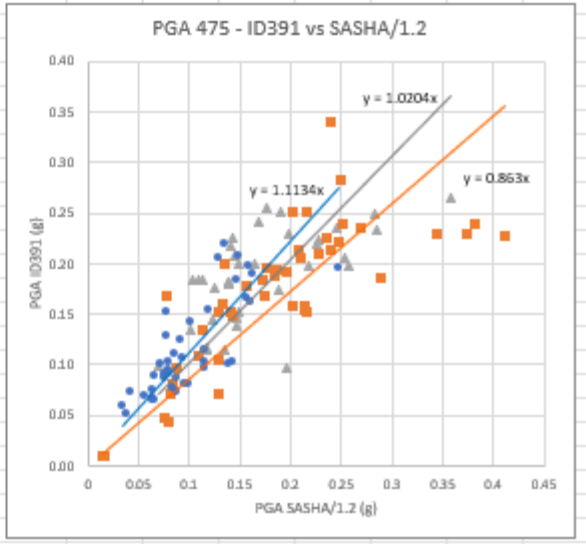






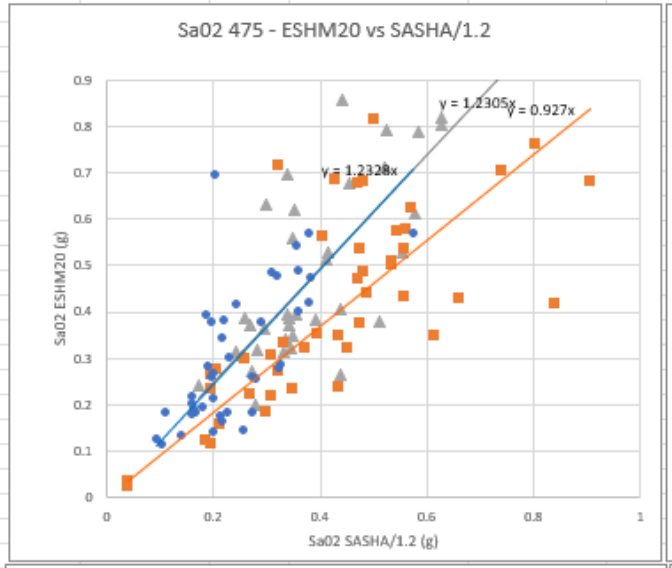


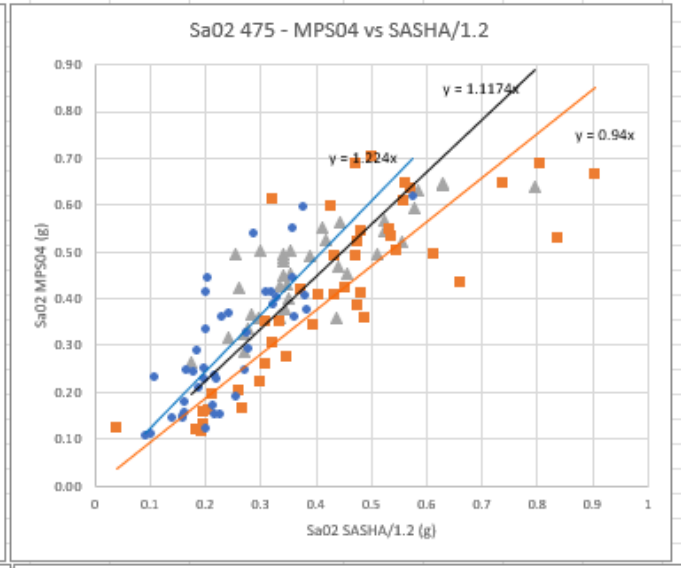


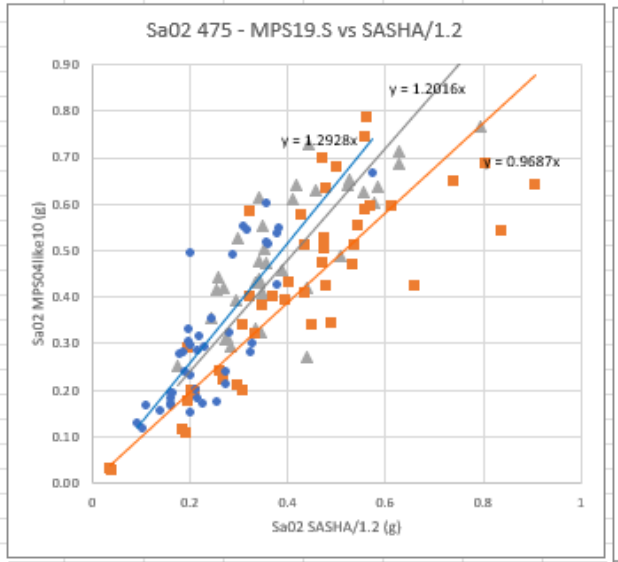


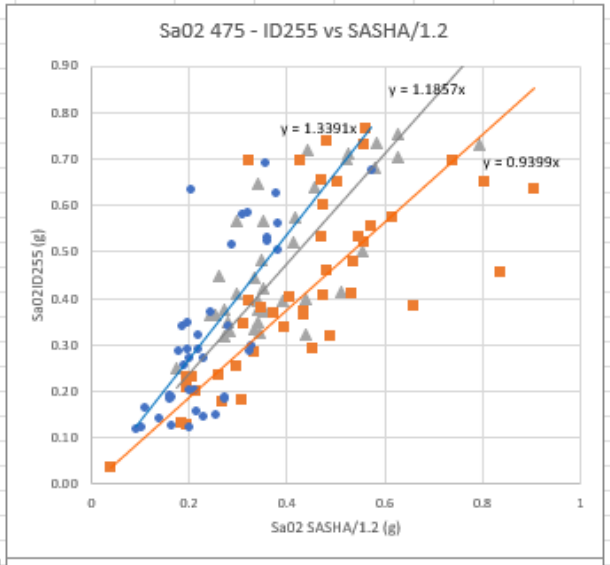
Sa 0.2s

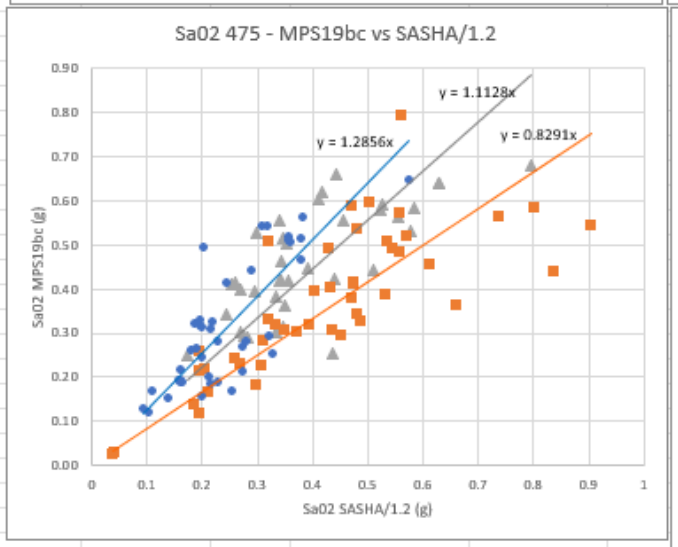
	ESHM20	MPS19bc	MPS04	MPS04like18	ID255	ID303	ID391	MPS19.S
Nord	1.232824289	1.28562305	1.224011	1.159210215	1.33912	1.34502	1.24861	1.29276906
Centro	1.23049006	1.112811288	1.117419	1.254468489	1.185728	1.211351	1.187835	1.201638975
Sud	0.926980989	0.829119359	0.940043	1.059579314	0.939921	0.893212	1.032222	0.96872055
Score	1.33	1.55	1.30	1.18	1.42	1.51	1.21	1.33
Average	1.130098446	1.075851232	1.093825	1.157752672	1.154923	1.149861	1.156222	1.154376195

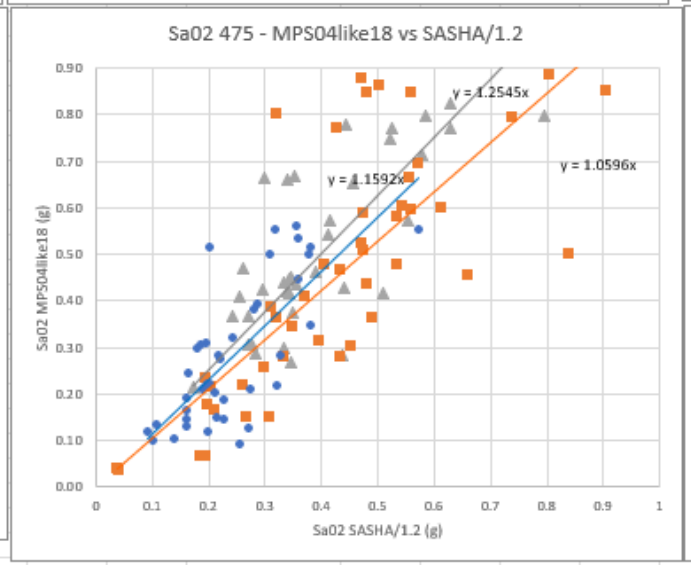


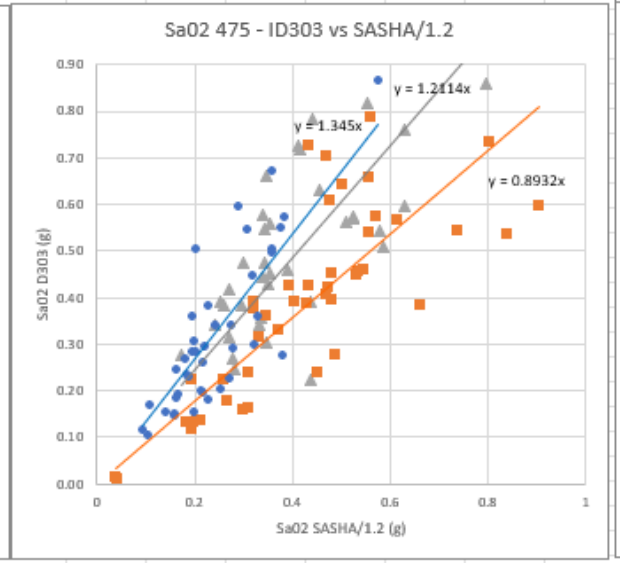


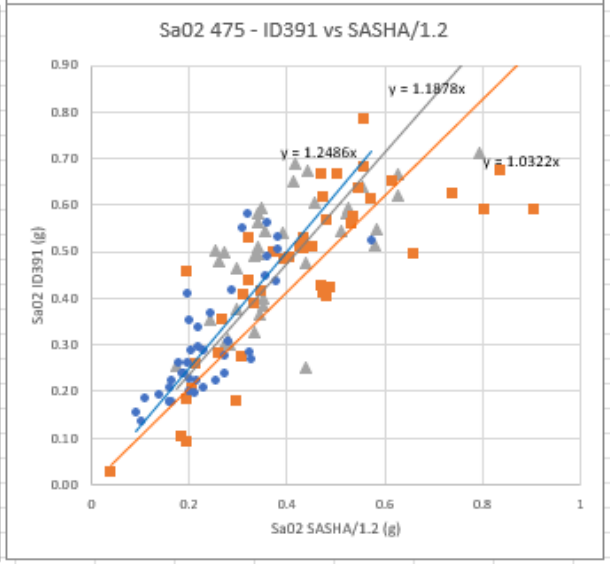






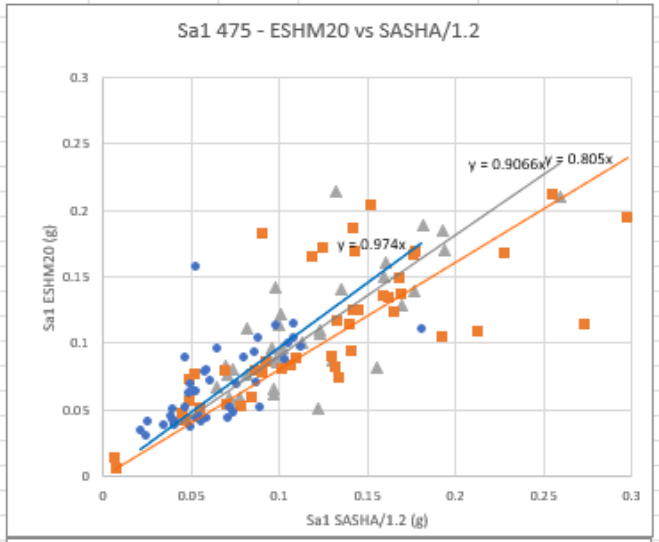


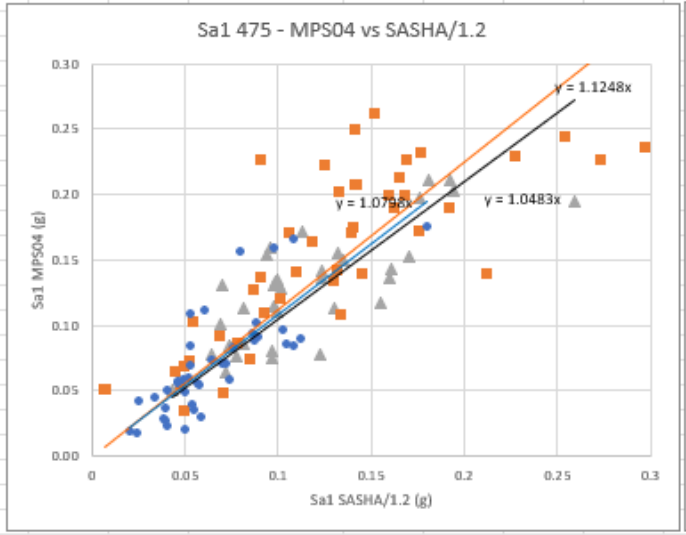


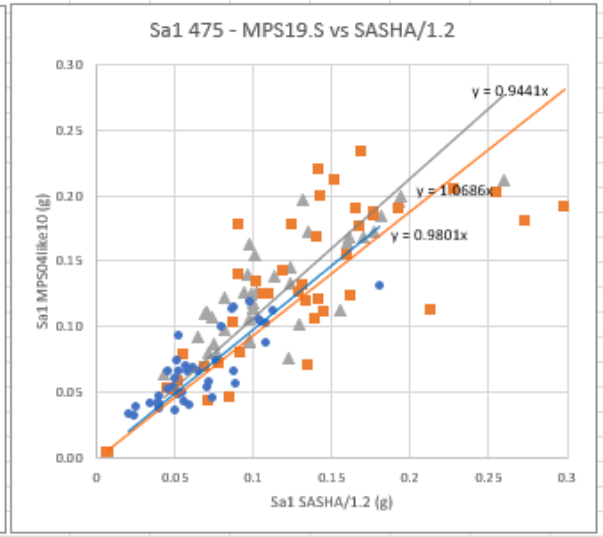


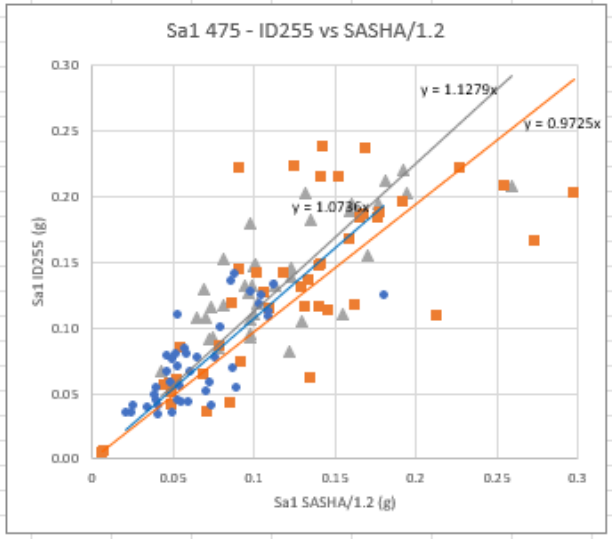
Sa 1s

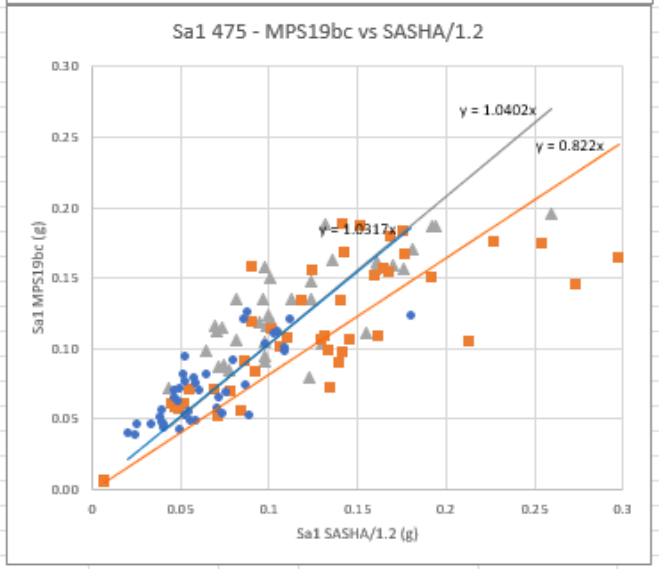
	ESHM20	MPS19bc	MPS04	MPS04like18	ID255	ID303	ID391	MPS19.S
Nord	0.973969837	1.031712475	1.079783	0.704368	1.073564	1.188155	0.798984	0.980079774
Centro	0.906614004	1.040213314	1.048279	0.888451787	1.127899	1.143959	1.008551	1.068561845
Sud	0.805005108	0.821983238	1.124825	0.908942491	0.97251	0.814103	1.04445	0.944068033
Score	1.21	1.27	1.07	1.29	1.16	1.46	1.31	1.13
Average	0.895196316	0.964636342	1.084296	0.833920759	1.057991	1.048739	0.950662	0.997569884

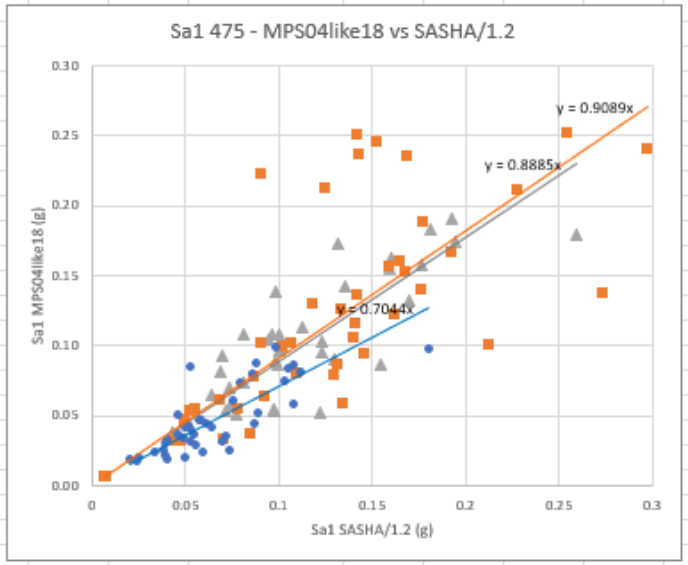


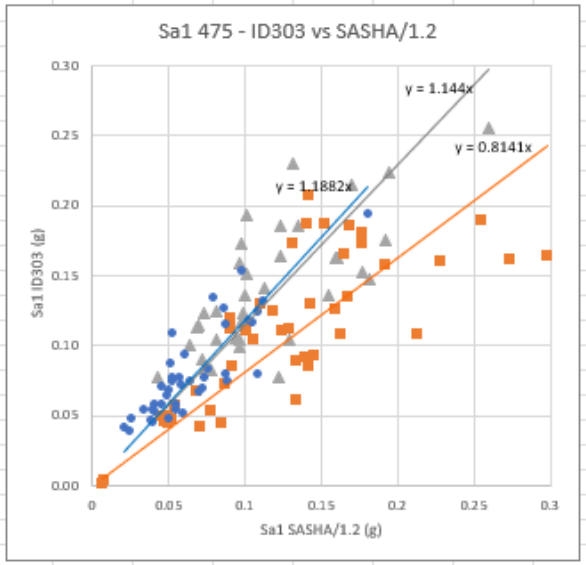


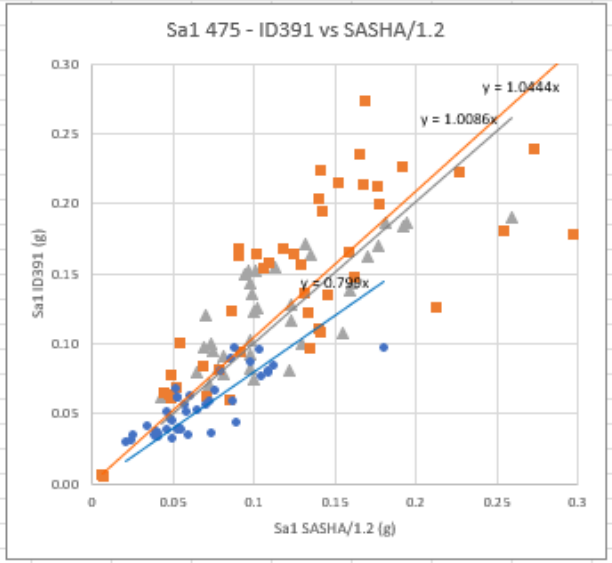








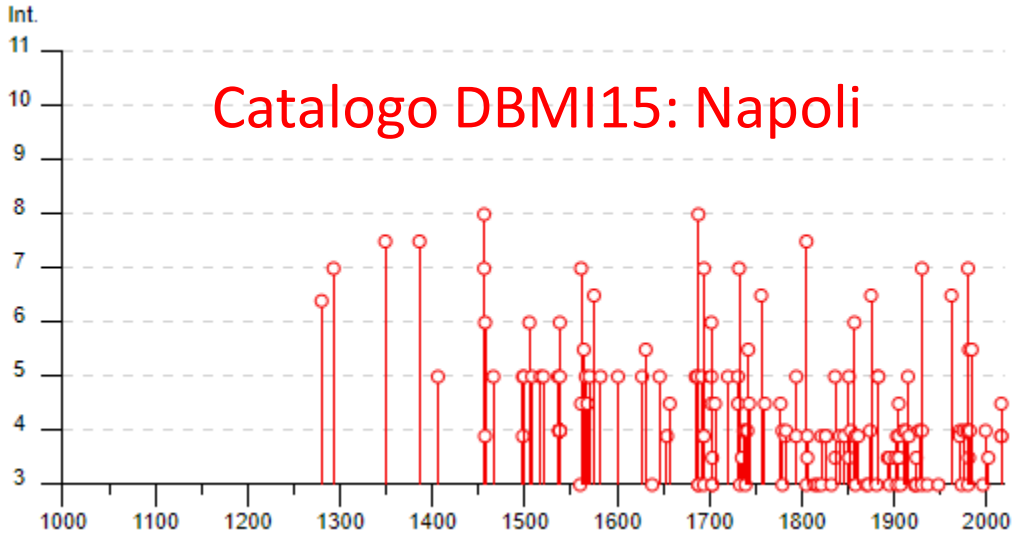


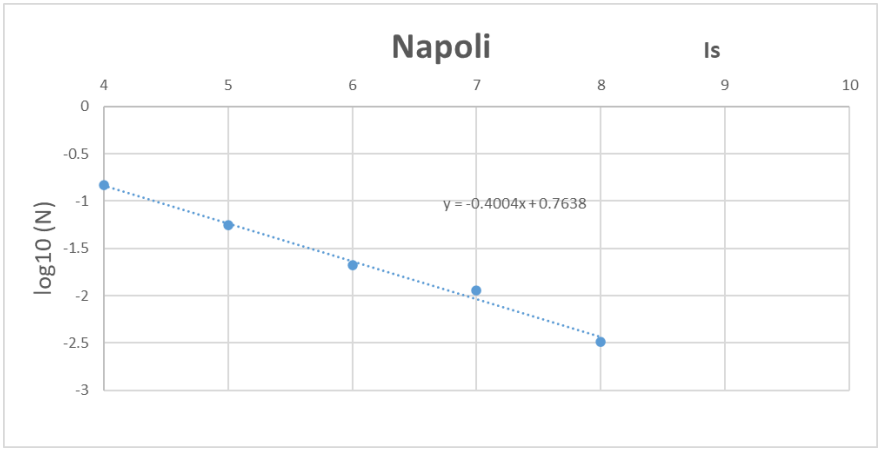


Contenuti

- ✓ MPS04 vs MPS19 vs MPS19s vs ESHM20: come decidere?
- ✓ come usare i dati storici macrosismici per una verifica di consistenza?
- ✓ i casi "patologici": cosa fare quando dato macrosismico e modello divergono? I casi di Napoli e Ischia
- ✓ il problema delle GMPE in campo vicino
- ✓ qualche considerazione conclusiva

casi patologici: Napoli

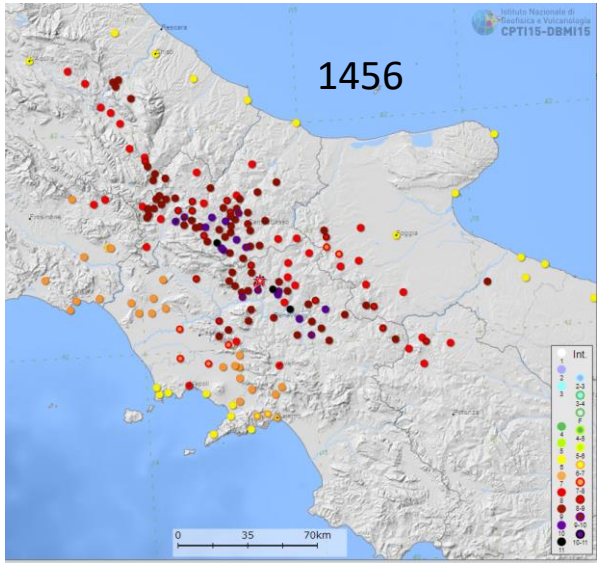


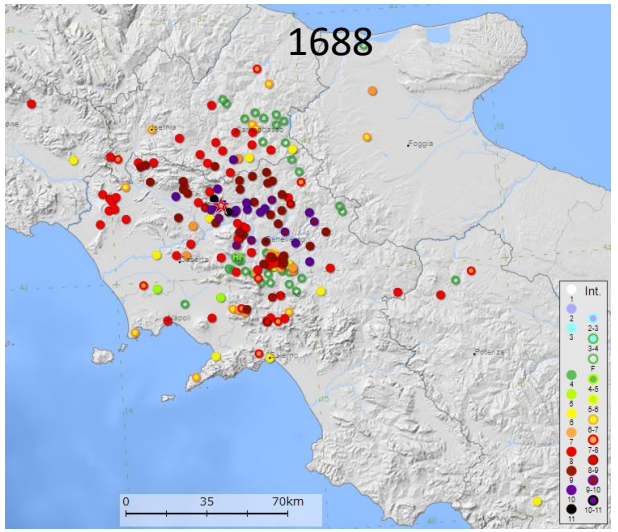


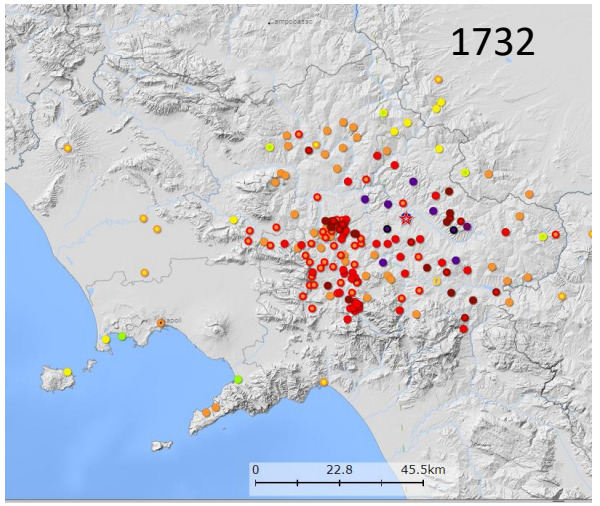
estrazione catalogo sulla base di eliminazione repliche + completezza storica (da rapporto MPS19)

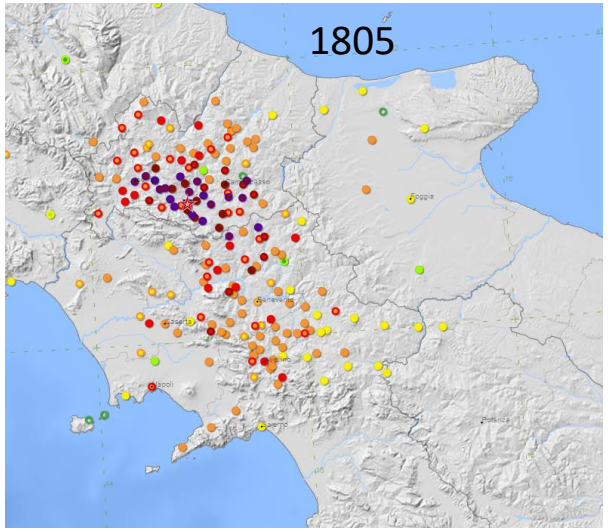
Anno	I0	Mw	Is	Completezza	Differenza	Ricorrenza	PGA GMPE (84%)
1456 12 05	11	7.19	8	1400	615	0.00162602	0.17
1561 08 19 15 50	10	6.72	4-5	1400	615	0.00162602	0.05
1627 07 30 10 50	10	6.66	5	1400	615	0.00162602	0.03
1646 05 31	10	6.72	5	1400	615	0.00162602	0.02
1688 06 05 15 30	11	7.06	8	1400	615	0.00162602	0.17
1694 09 08 11 40	10	6.73	7	1400	615	0.00162602	0.055
1702 03 14 05	10	6.56	6	1400	615	0.00162602	0.07
1706 11 03 13	10-11	6.84	4-5	1400	615	0.00162602	0.04
1731 03 20 03	9	6.33	5	1530	485	0.00206186	0.02
1732 11 29 07 40	10-11	6.75	7	1400	615	0.00162602	0.08
1743 02 20	9	6.68	4-5	1530	485	0.00206186	
1783 03 28 18 55	11	7.03	4	1400	615	0.00162602	
1794 06 12 22 30	7	5.26	5	1787	228	0.00438596	0.02
1805 07 26 21	10	6.68	7-8	1400	615	0.00162602	0.07
1836 11 20 07 30	8	5.86	5	1787	228	0.00438596	0.01
1851 08 14 13 20	10	6.52	5	1400	615	0.00162602	0.03
1853 04 09 12 45	8	5.6	4	1787	228	0.00438596	
1857 12 16 21 15	11	7.12	6	1400	615	0.00162602	0.07
1874 12 06 15 50	7-8	5.48	4	1787	228	0.00438596	0.01
1875 12 06	8	5.86	6-7	1787	228	0.00438596	
1882 06 06 05 40	7	5.2	5	1787	228	0.00438596	0.01
1883 07 28 20 25	9-10	4.26	5	1530	485	0.00206186	
1905 03 14 19 16	6-7	4.9	4-5	1895	120	0.00833333	0.02
1910 06 07 02 04	8	5.76	4	1787	228	0.00438596	0.02
1913 10 04 18 26	7-8	5.35	4	1787	228	0.00438596	0.01
1915 01 13 06 52 43.00	11	7.08	5	1400	615	0.00162602	0.06
1927 05 25 02 50	6	4.98	4	1895	120	0.00833333	
1930 04 27 01 46	7	4.98	4	1787	228	0.00438596	0.024
1930 07 23 00 08	10	6.67	7	1400	615	0.00162602	0.055
1962 08 21 18 19	9	6.15	6-7	1530	485	0.00206186	0.04
1971 05 06 03 45 05.00	6	4.83	4	1895	120	0.00833333	
1975 06 19 10 11	6	5.02	4	1895	120	0.00833333	
1979 09 19 21 35 37.00	8-9	5.83	4	1787	228	0.00438596	
1980 11 23 18 34 52.00	10	6.81	7	1400	615	0.00162602	0.07
1980 12 03 23 54 22.00	6	4.83	4	1895	120	0.00833333	
1981 02 14 17 27 45.00	7-8	4.88	5-6	1787	228	0.00438596	
1982 03 21 09 44 01.59	7-8	5.23	4	1787	228	0.00438596	
1984 05 07 17 50	8	5.86	5-6	1787	228	0.00438596	0.055
1999 10 09 05 41 05.47	5	3.24	4	1950	65	0.01538462	

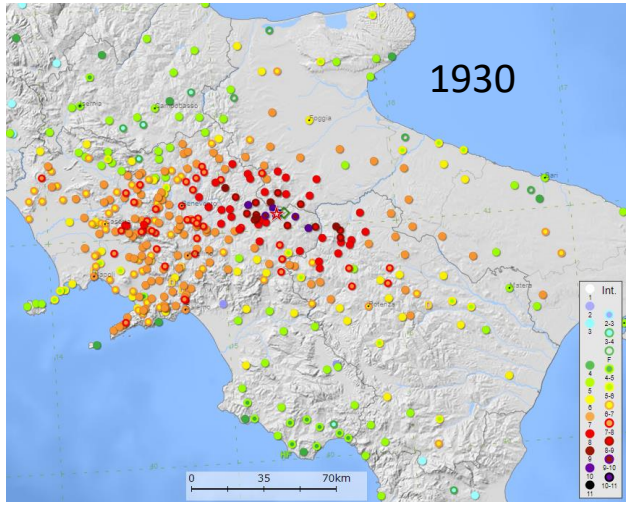
casi patologici: Napoli

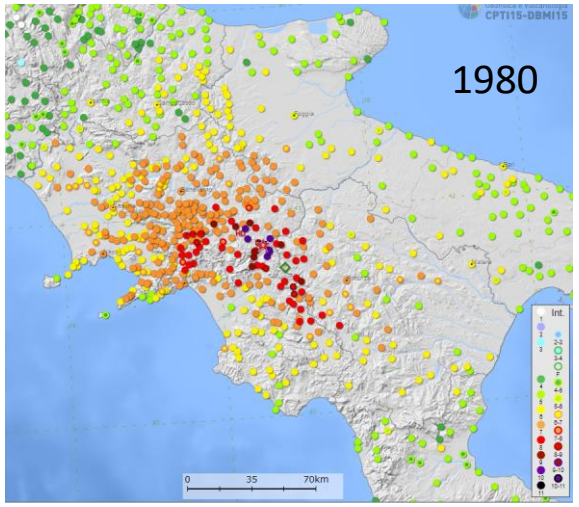






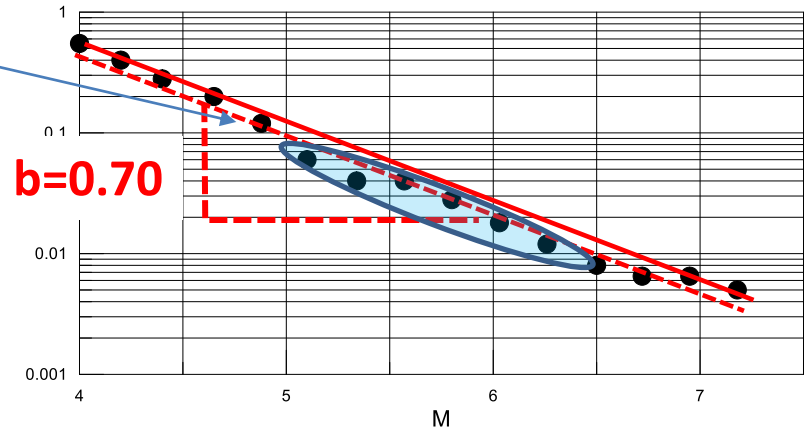




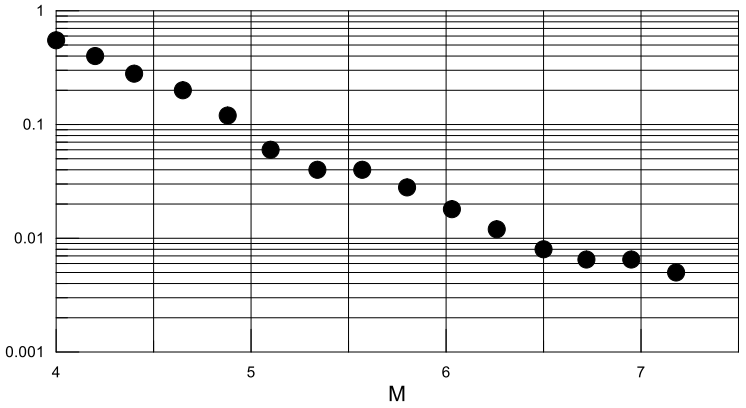


La diversa "visione" di MPS04 e MPS19

sovrastima dei tassi alle magnitudo intermedie

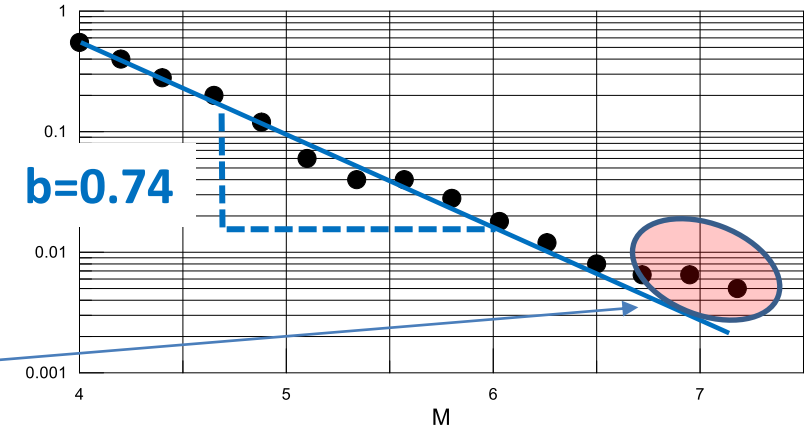


Tassi cumulati osservati nella ZS Calabria (MA4) secondo CPTI15



MPS04 = 0.6*tassi osservati+ 0.4*GR "bilanciata" (fit con LSQ e traslazione al tasso per M_{min})

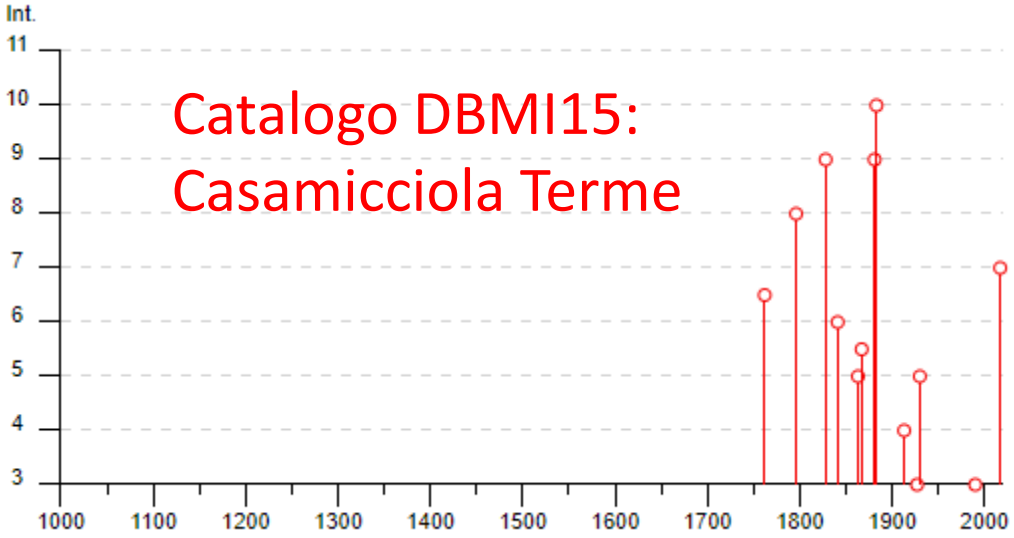
MPS19 (MA4) = fit con massima verosimiglianza. **In generale però i fit di MPS19 sono fatti su macro-aree**



sottostima dei tassi alle magnitudo elevate

31

casi patologici: Ischia

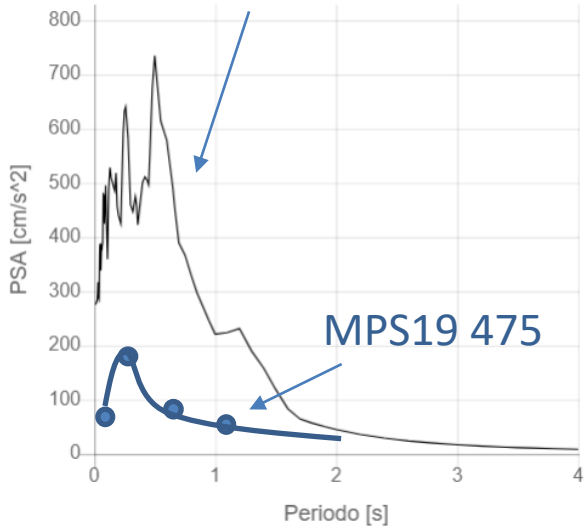


Catalogo DBMI15:
Casamicciola Terme

Anno	I0	Mw	Is	Completezza	Differenza	Ricorrenza
1796 03 18 16 30	8	3.88	8	1787	232	0.00431034
1828 02 02 09 15	8-9	4.01	9	1530	489	0.00204499
1881 03 04 12 15	9	4.14	9	1530	489	0.00204499
1883 07 28 20 25	9-10	4.26	10	1400	619	0.00161551
1913 10 04 18 26	7-8	5.35	4	1787	232	0.00431034
1930 07 23 00 08	10	6.67	5	1400	619	0.00161551
2017 08 21	7	4	7	1787	232	0.00431034

Sisma di Ischia (M_w3.9)
del 21 agosto 2017

registrazione di Casamicciola



Contenuti

- ✓ MPS04 vs MPS19 vs MPS19s vs ESHM20: come decidere?
- ✓ come usare i dati storici macrosismici per una verifica di consistenza?
- ✓ i casi "patologici": cosa fare quando dato macrosismico e modello divergono? I casi di Napoli e Ischia
- ✓ il problema delle GMPE in campo vicino
- ✓ qualche considerazione conclusiva

Il problema delle GMPE in campo vicino

Bulletin of Earthquake Engineering
https://doi.org/10.1007/s10518-021-01304-9

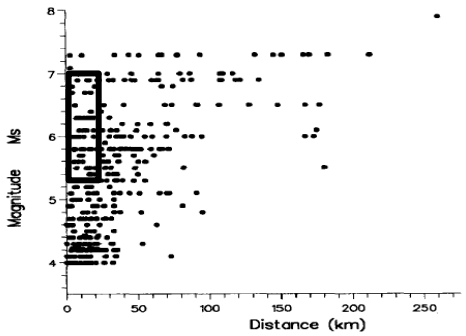
ORIGINAL ARTICLE

The older the better? The strange case of empirical ground motion models in the near-source of moderate-to-large magnitude earthquakes

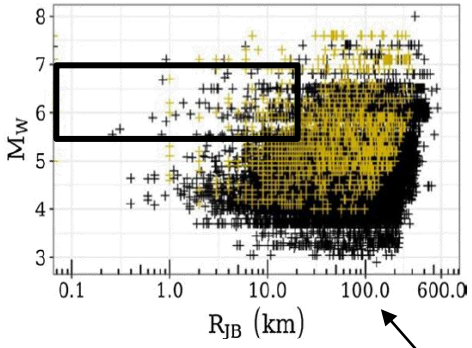
Roberto Paolucci[1] · Angela Chiecchio[1] · Manuela Vanini[1]

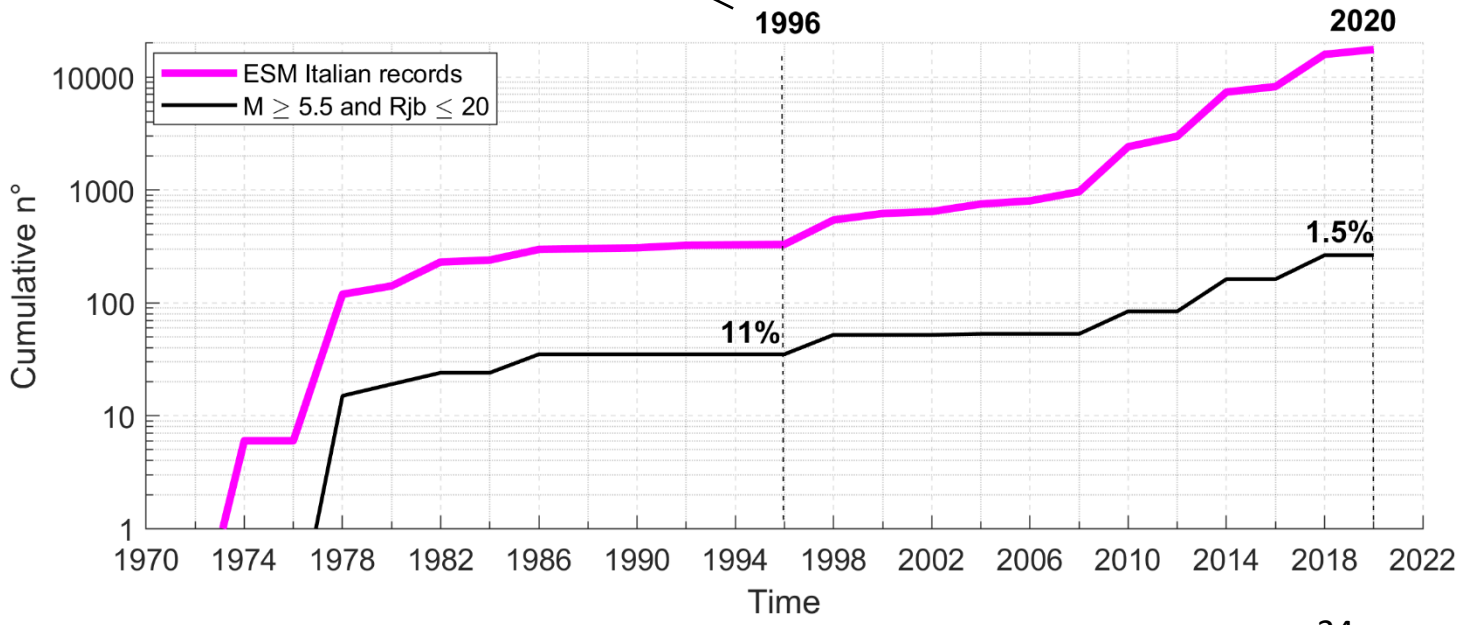
Received: 6 July 2021 / Accepted: 9 December 2021

Ambraseys et al. (1996)



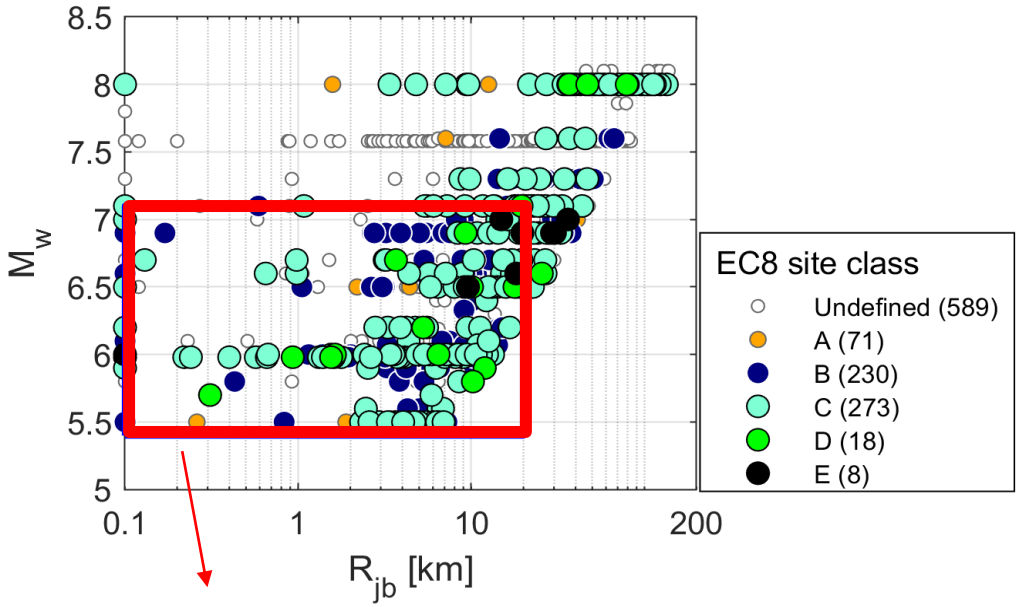
Kotha et al. (2020)





Il problema delle GMPE in campo vicino

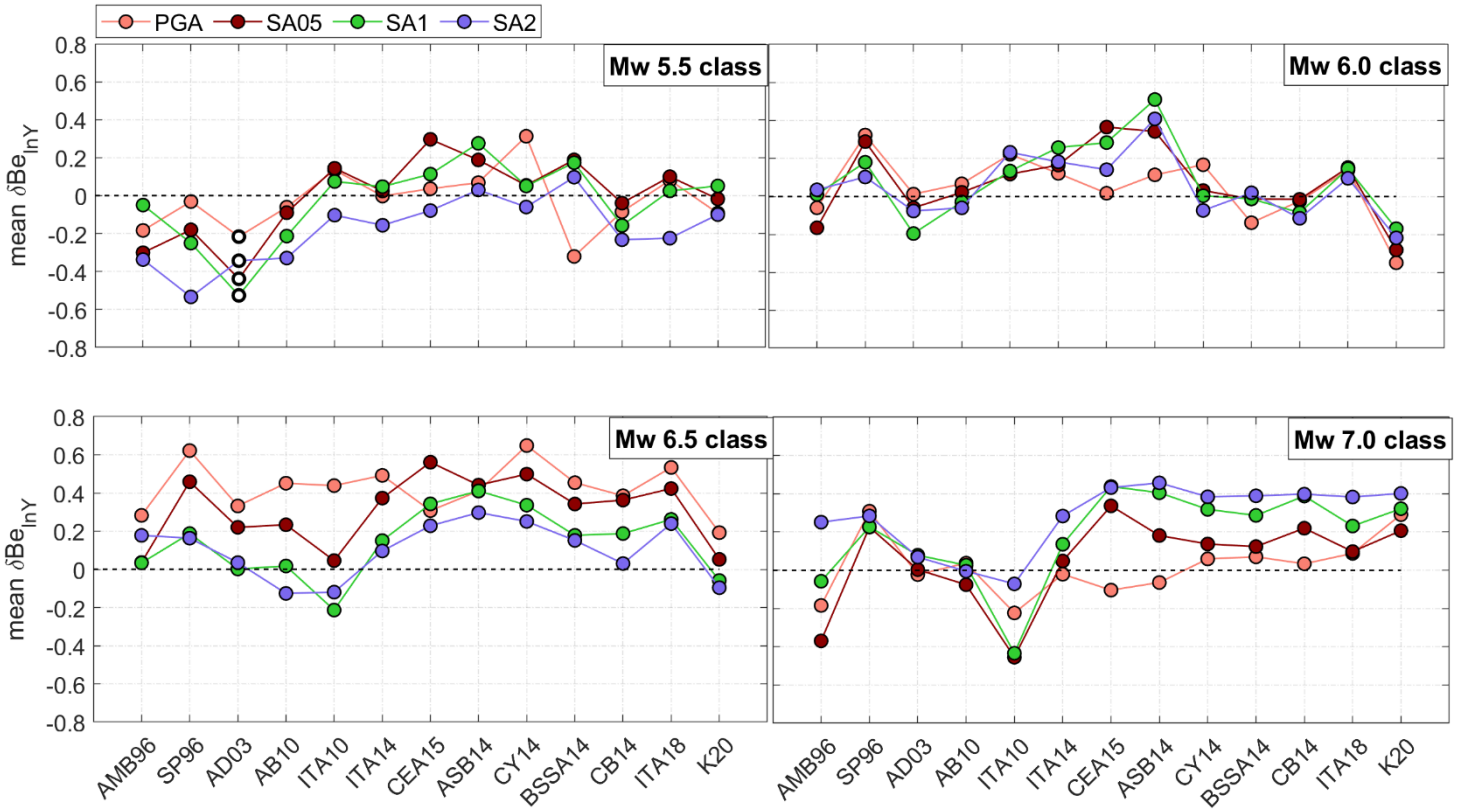
NESS2.0: Near-source strong motion dataset
(INGV, January 2021)



Data selected

- **Site class B**
- ***M_w* = 5.4 – 7.1**
- ***R_{jb}* ≤ 20km**

between-event residuals from different GMPEs



δBe > 0: GMM **under**estimate NESS
δBe < 0: GMM **over**estimate NESS

Contenuti

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Qualche considerazione conclusiva

- Quali **requisiti** devono essere soddisfatti da un MPS per poter essere applicato nel contesto normativo e di gestione del rischio in Italia?

  1) **continuità** rispetto al modello vigente: "*the inherent preference for the status quo of code-writing committees means that substantive changes in design ground motions over time tend to be avoided unless there is overwhelming justification*" (Stewart et al., Earthquake Spectra, 2020)

  2) **consistenza rispetto al dato storico macrosismico**, non solo a scala nazionale, ma anche a scala regionale e locale, da verificare con criteri condivisi e con attenzione ai casi "patologici" (e.g., Roma, Napoli, Palermo, …)

  3) **semplicità** della struttura del modello: questo deve essere riproducibile dai ricercatori interessati, e i suoi risultati devono essere spiegabili e comprensibili ai professionisti che li useranno