ITALIAN STRONG MOTION DATABASE

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Task 4 : **Identification of anomalous sites and records**

Task 5 : **Site classification**

WHY USE EMPIRICAL GROUND MOTION PREDICTION EQUATIONS (EGMPEs) IN THE PROJECT ?

Records in the ITACA dataset (http://itaca.mi.ingv.it) my be affected by distinctive feautures in their seismic response

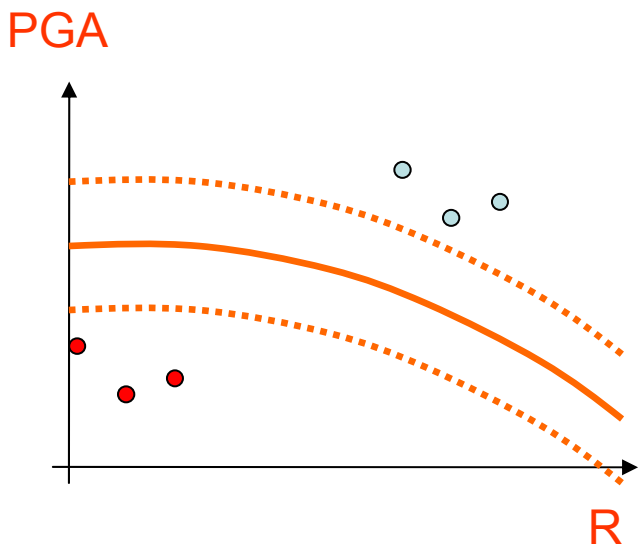
Reliable estimations of EGMPEs are needed in order

- to select on this dataset the records falling outside the dispersion bands
- to test different site classification schemes (task 5)

Analysis of records

- records from the same earthquake but different sites

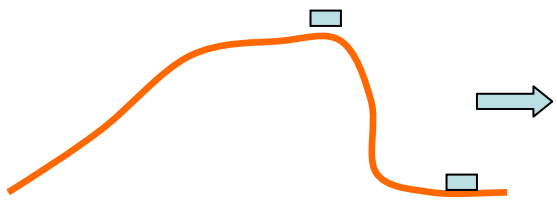
→ anomalous earthquake (forward/backward directivity, high/low stress drop, anomaluos shallow/deep earthquake focus)



- records from different earthquakes but same site

→ anomalous site (not accurate site classification, complex geological/morphological configuration, soil-structure interactions)

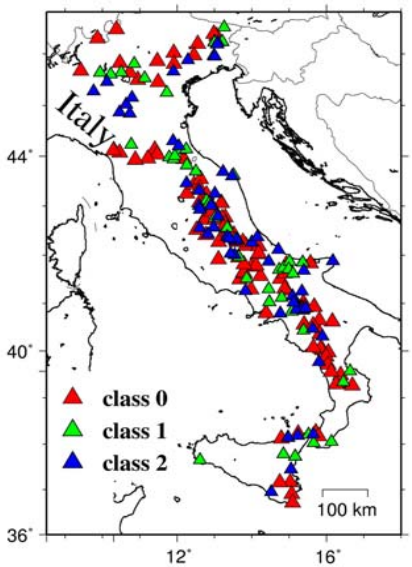
Morphology effects (isolated hill or deep sedimentary basin) ?



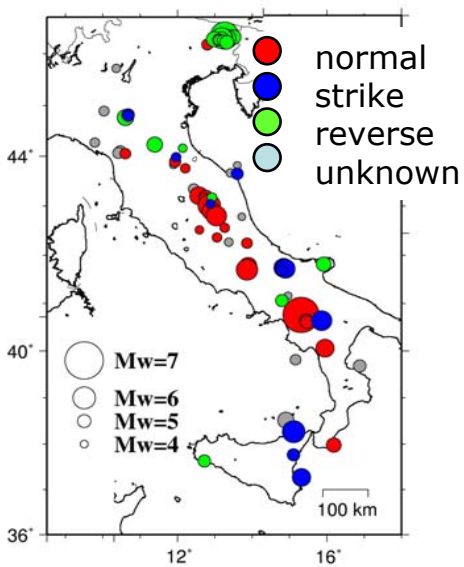
Sites with anomalous records ?

Development of EGMPEs (ITA08, Bindi et al., 2009, BEE in press)

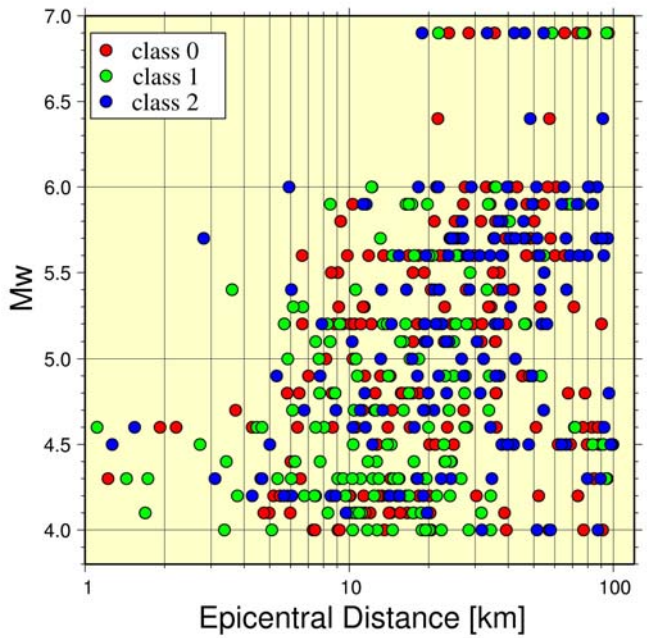
data from RAN (DPC) and RAIS
(INGV MI/PV, http://rais.mi.ingv.it)



206 stations



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



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

Sabetta and Pugliese (1996) site classes
class 0 : rock (104 stations)
class 1 : shallow alluvium (≤20m) (47 stations)
class 2 : deep alluvium (>20m) (55 stations)

Revision of the event parameters

Hypocentres: Before **1981**: *ING-INGV Catalogue* or *CPTI.04;* **1981-2003**: *CSI 1.1*
2003-2004: *CSI 2.0* (courtesy of R. Di Stefano)

Magnitude (Ms, Mb, Ml, Mw) from *ISC*, *NEIC, or ING-INGV Bulletins, CSI Regional Centroid Moment Tensor (RCMT), or EMMA catalogues*

Focal mechanism: *CMT* 1976-2004, RCMT (Pondrelli et al. 2006) or 1972-1976 Mediterranean focal mechanisms, *EMMA* (Vannucci and Gasperini, 2004)

Fault geometry: *DISS3.0.2* (Database of Individual Seismogenic Sources, *www.ingv.it/DISS*

Data Processing

1. the data have been pre-processed in order to remove the so called non-standard errors (multiple events in the same records and/or spikes)

2. a first-order baseline operator is applied to the entire record, in order to have a zero-mean of the signal, then, a simple baseline correction is applied by removing the linear trend, computed with a least square method

3. the convolution with the instrument response has been made for analogue data only

4. resampling at 200 sps

5. data were band-pass filtered using an acausal fourth order Butterworth filter.For all waveforms the corner frequencies were selected by visual inspection of the Fourier spectrum of individual records

6. zero's were added applying a cosine taper (generally 5%) at both sides of the record.

- Functional form (e.g. Akkar & Bommer, 2007):

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

Explanatory variables: Mw, Rjb, S_i , F_j

Response variables: PGA, PGV, SA (5%, 0.03≤T≤ 2sec) both maximum H and vertical

- Random effect model (e.g. Brillinger & Preisler, 1985):

$$\log_{10} Y_{ij} = \Gamma(M_i, R_{ij}, S_j, F_i; \mathbf{x}) + \eta_i + \varepsilon_{ij}$$

Inter-event (η_i)

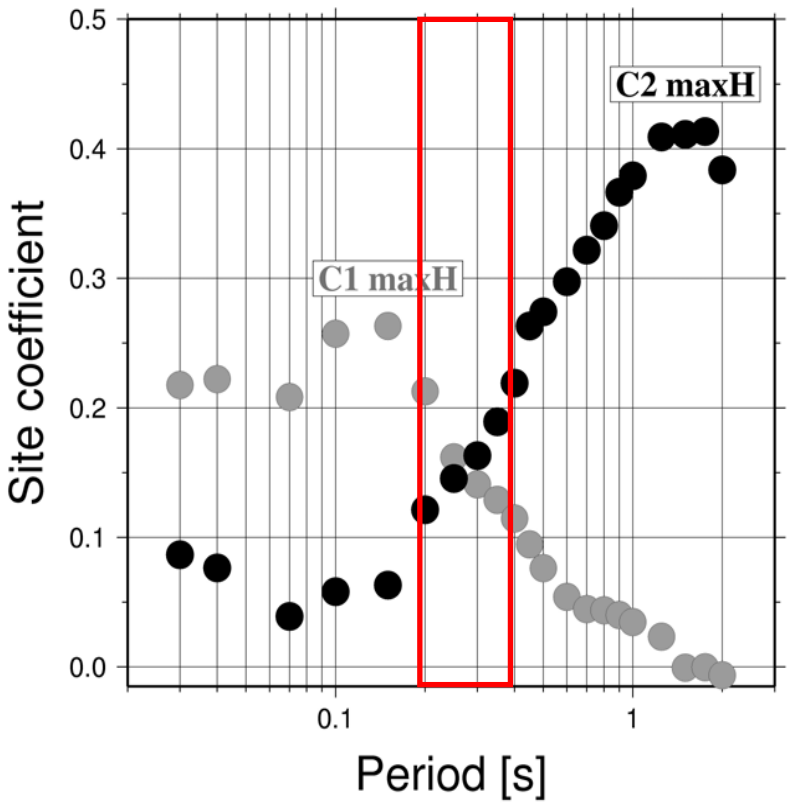
$$\log_{10} Y_{ij} = \Gamma(M_i, R_{ij}, S_j, F_i; \mathbf{x}) + \varphi_j + \varepsilon'_{ij}$$

Inter-station (φ_j)

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

Site classification

Site coefficients for classes C1 (shallow alluvium)
and C2 (deep alluvium) for SA (Hmax) as function of period (s)

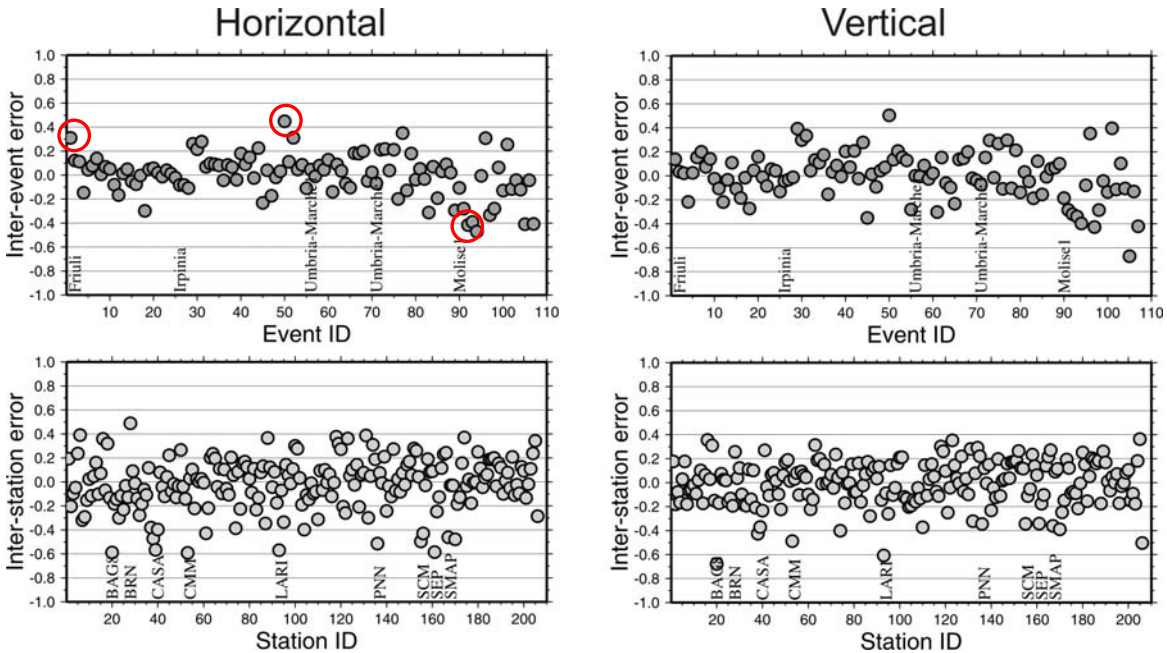


CL I (D09) (T<0.2s) = C1 ITA08 (shallow basin)

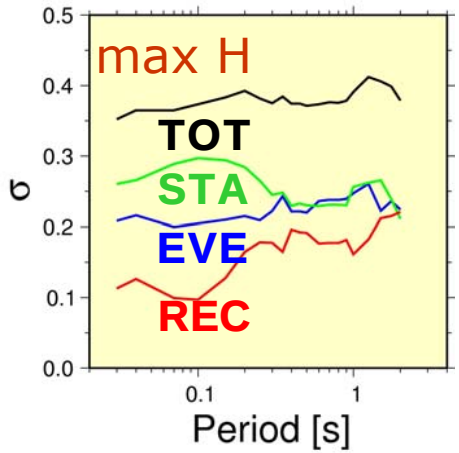
CL II (D09) (0.2<T<0.4) = transition zone ITA08

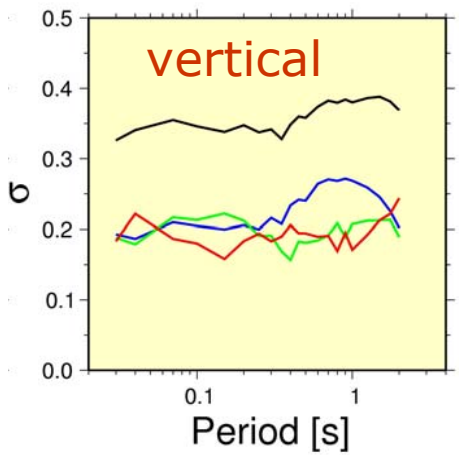
CL III/IV (D09) (T>0.4) = C2 ITA08 (deep basin)

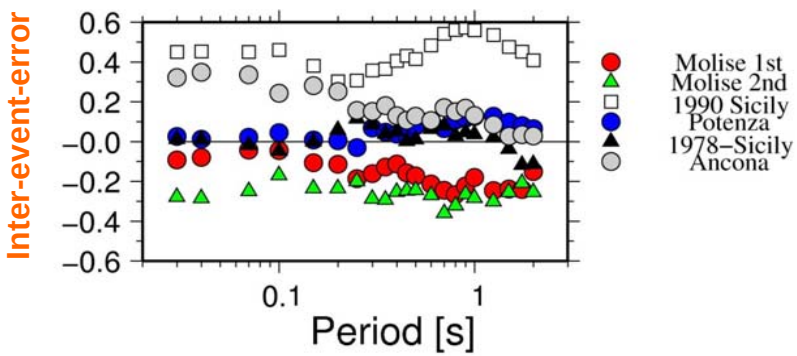
CL V (D09) (flat H/V) = C0 ITA08 (rock)



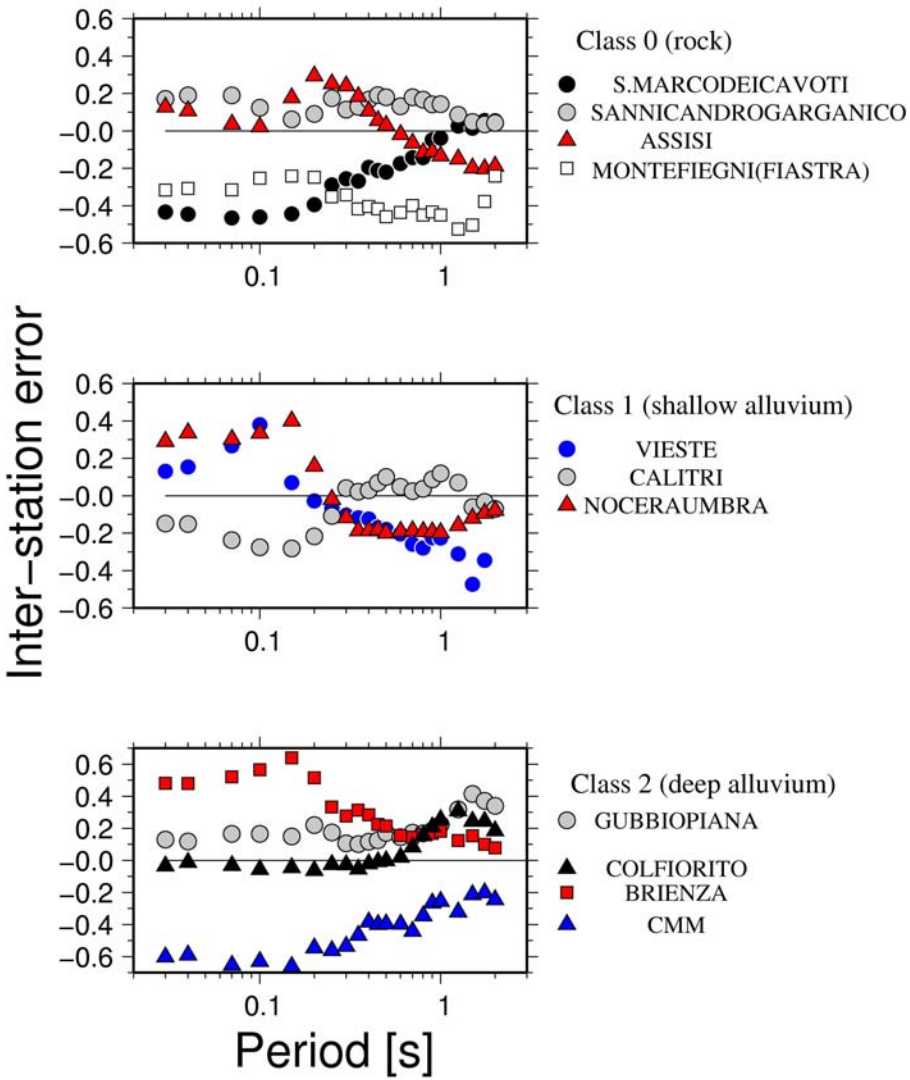
standard deviation







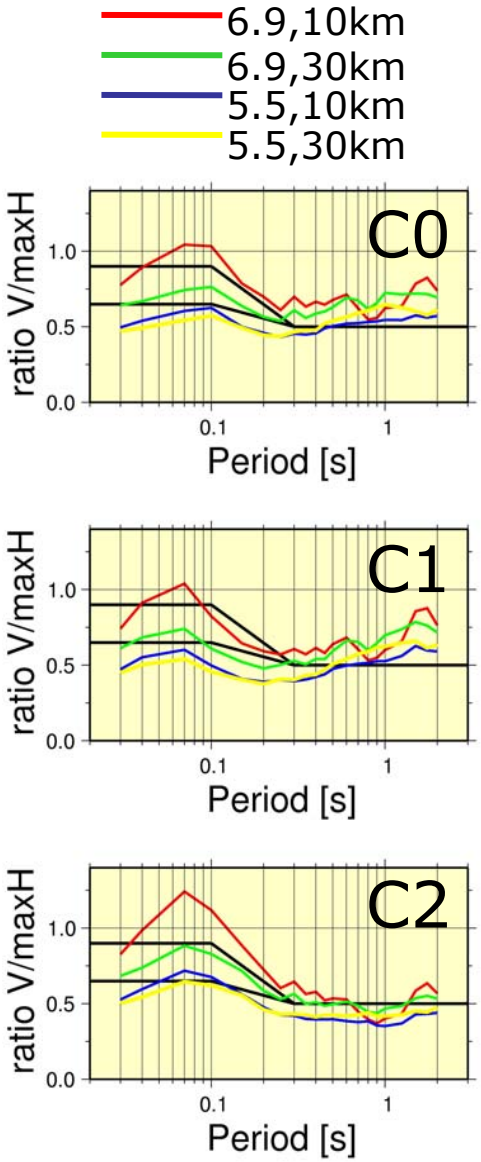
Inter stations variability



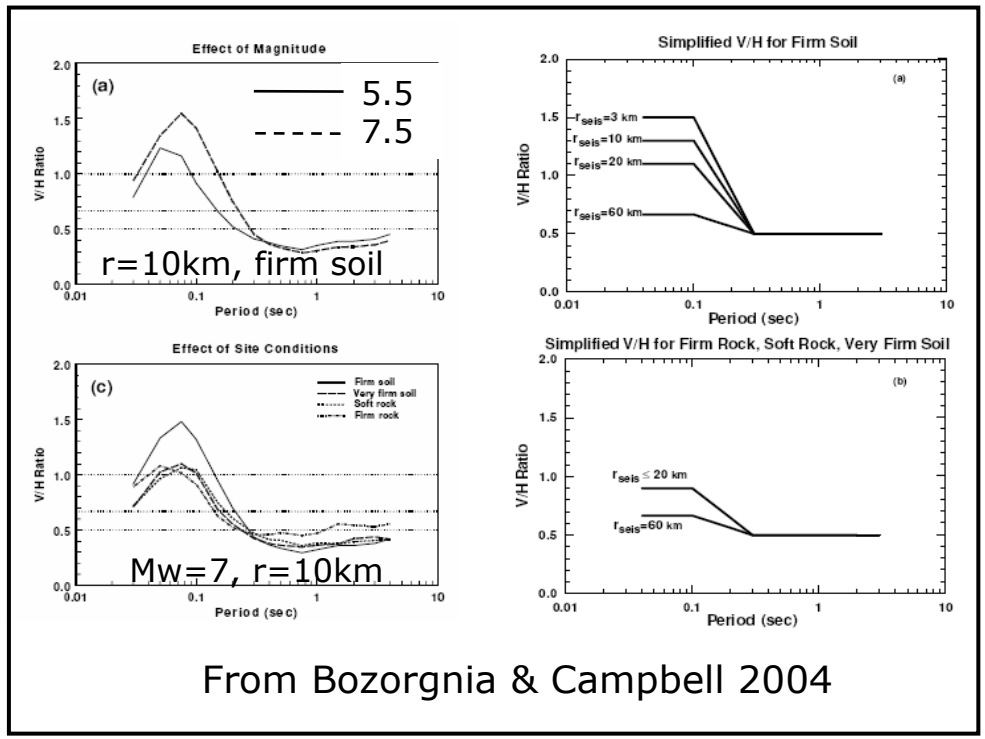
Assisi: was installed close to S. Francis Cathedral: soil-site interaction (?)
SMC and **SNN** recorded the 2002 Molise eq.

The amplification for **Nocera** is well documented (Rovelli et al., 2002; Cultrera et al., 2003)

Gubbio Piana: deep basin (>500m) with 2D/3D amplification effects (Pacor et al. 2007; Bindi et al. 2008)
Colfiorito: basin 80m thick, amplification around 1Hz is well documented *(Di Giulio et al., 2003; Rovelli et al., 2001)*
Brienza:30m of sediments with average velocity of 500 m/s



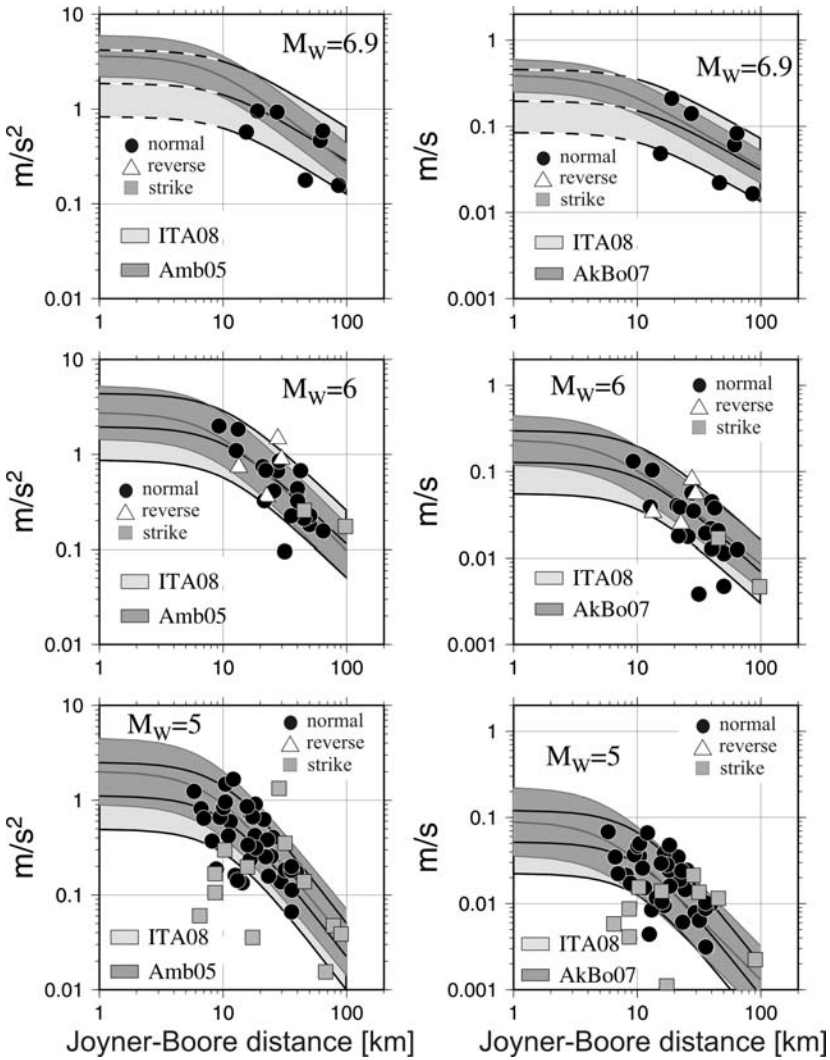
V/Hmax ratio

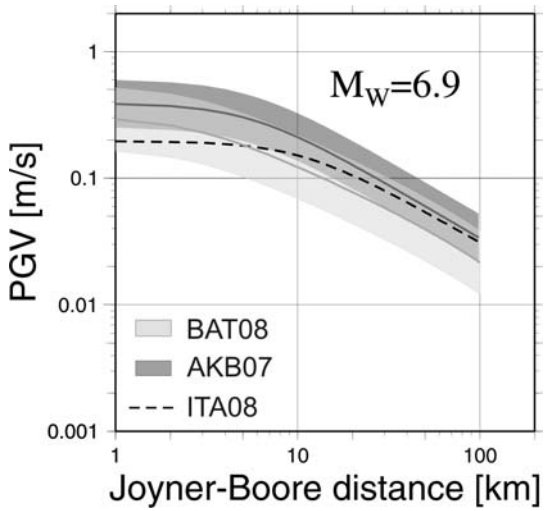


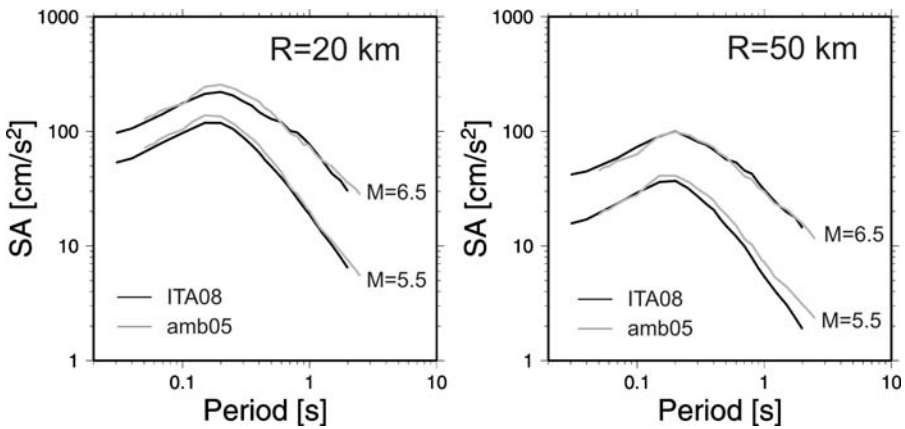
From Bozorgnia & Campbell 2004

- V/H exceeds 1 at T<0.1s for C2
- V/H ~0.5 at long periods

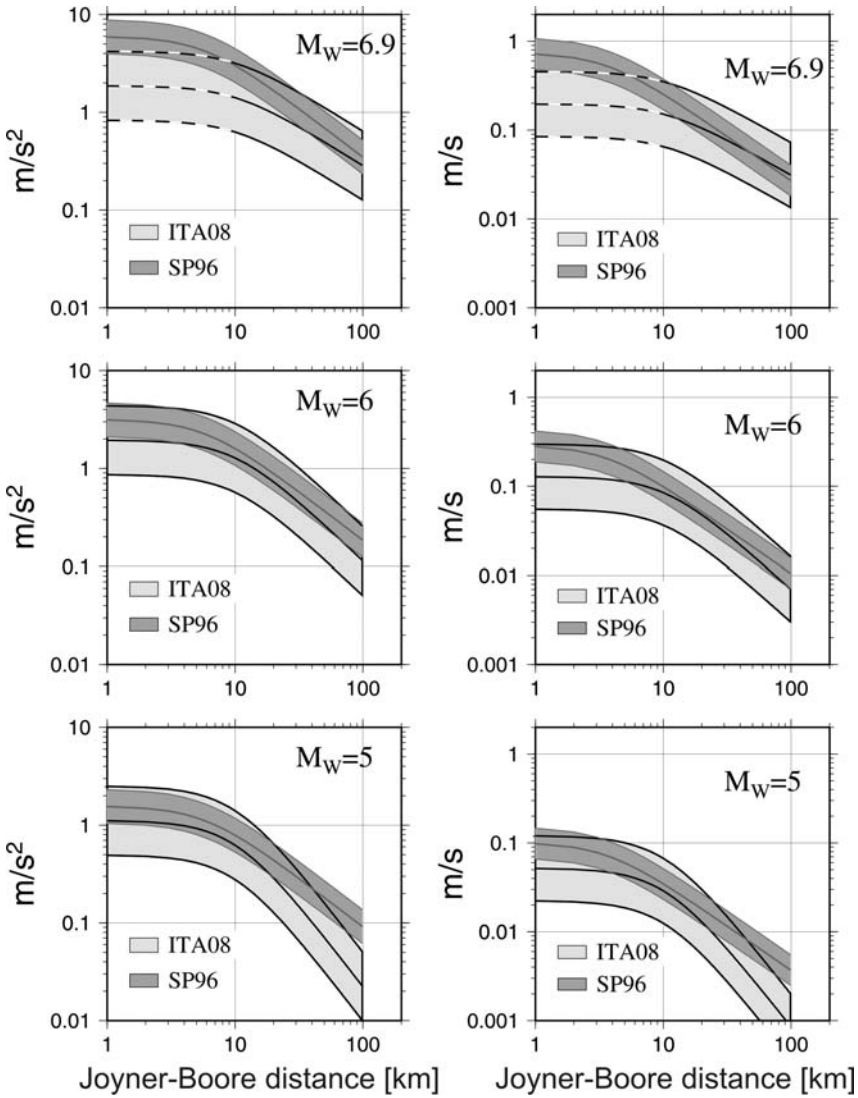
Comparison with European and global-scale models



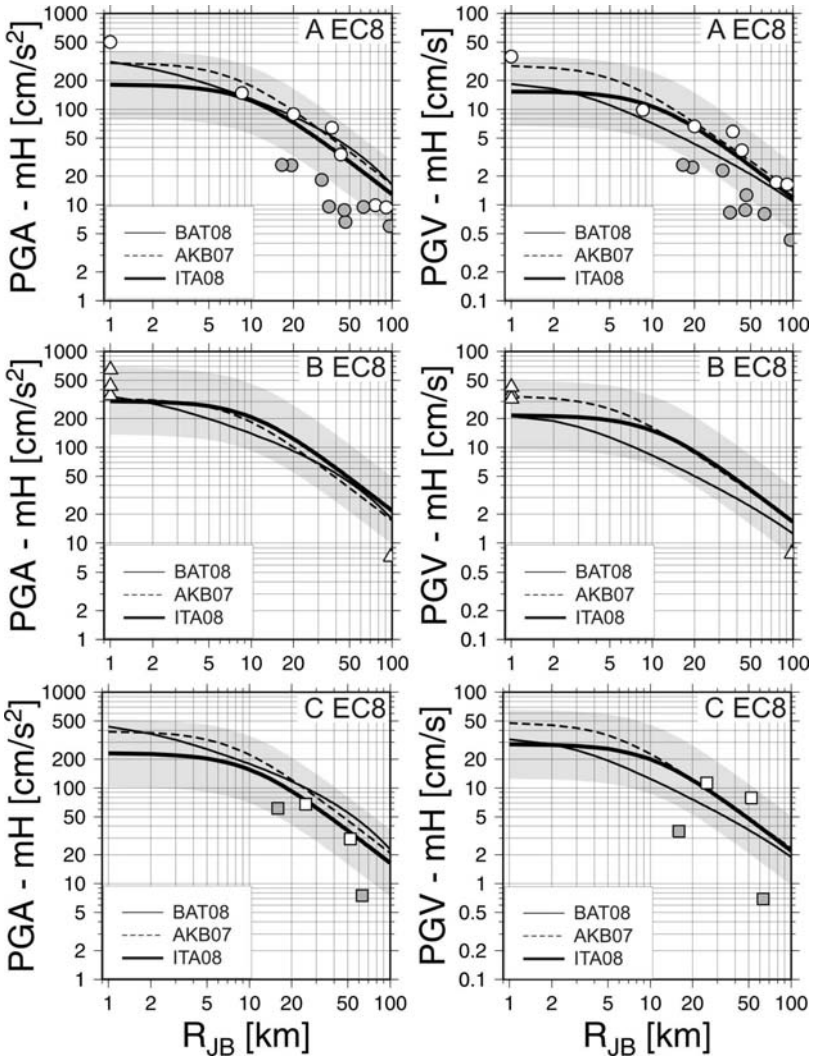


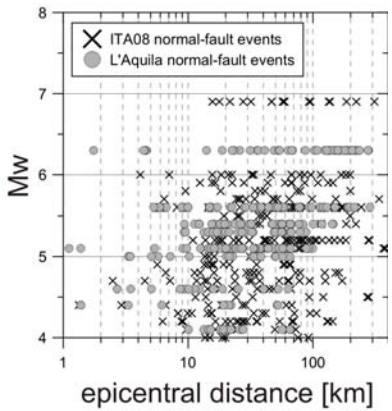


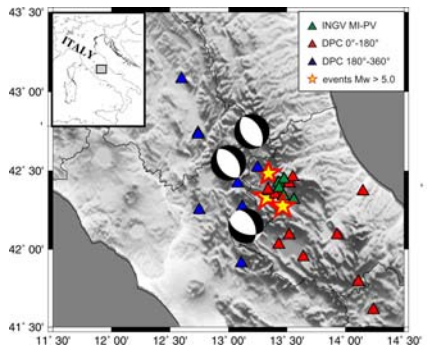
Comparison with Italian models



Validation : 6 April 2009, Mw 6.3 L'Aquila earthquake





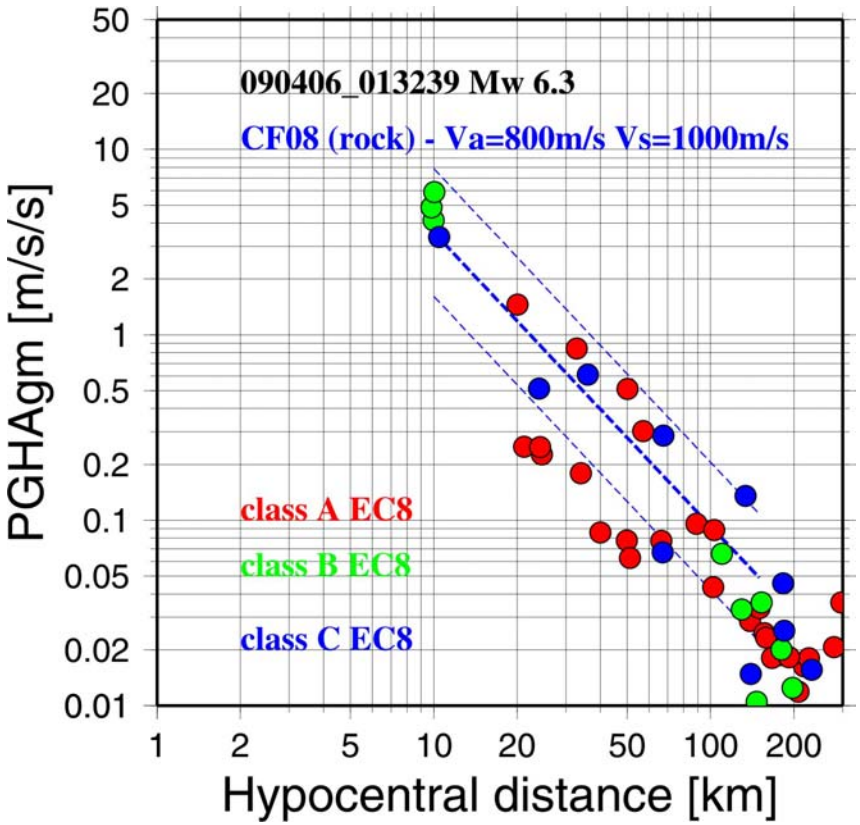


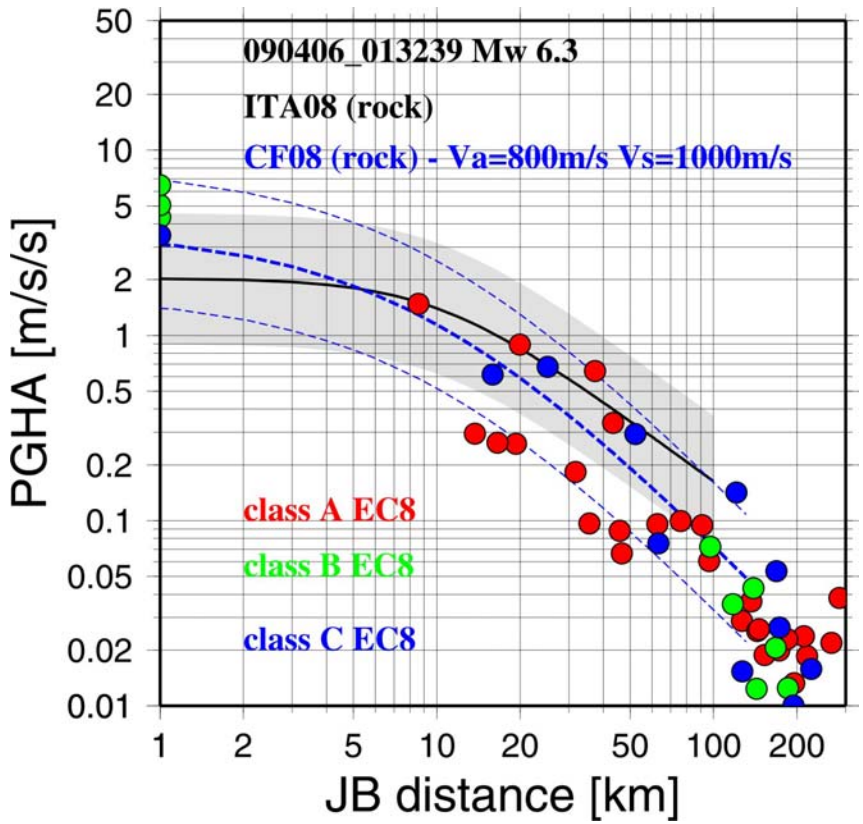
L'Aquila sequence

13 earthquakes with Mw >= 4.0

about 200 strong-motion records (both V and Hmax) with epicentral distance < 100 km)

Validation : 6 April 2009, Mw 6.3 L'Aquila earthquake





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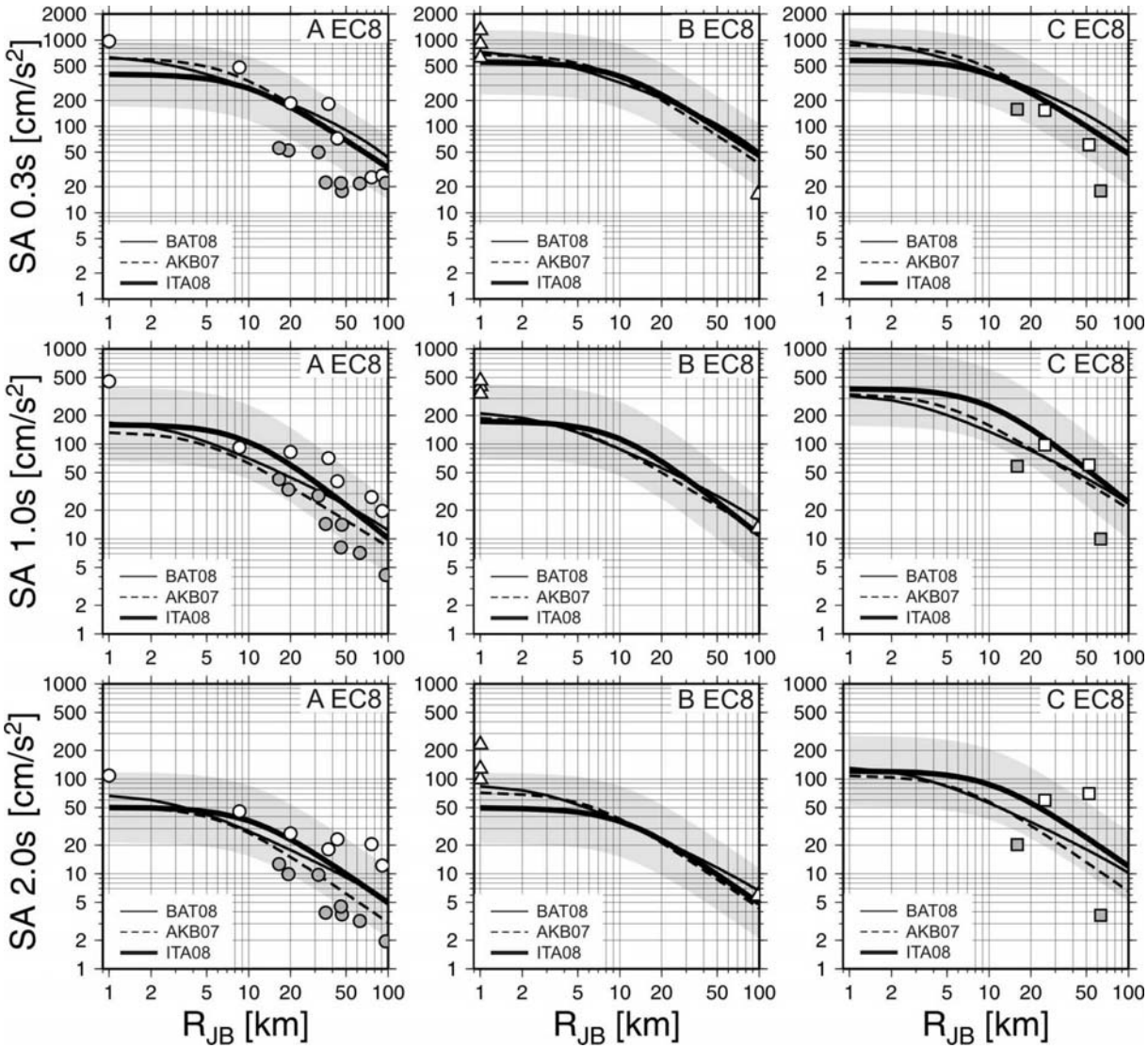
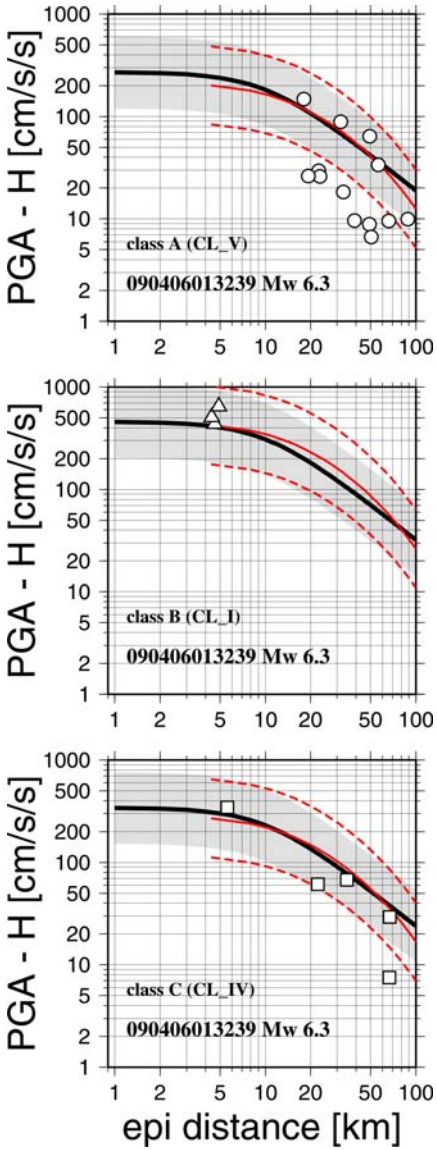
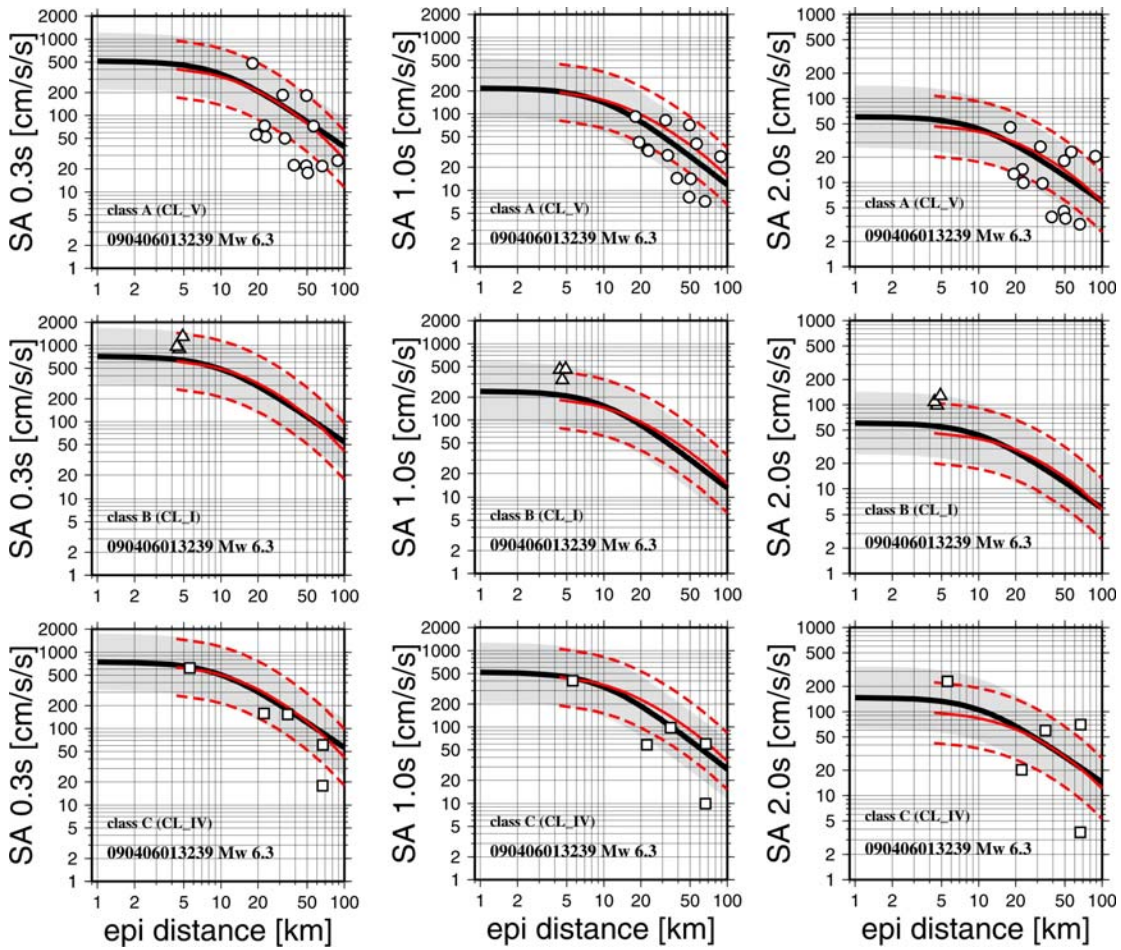


Comparison to EGMPEs developed by Di Alessandro et al., 2009





Determination of anomalous sites

Calculation of residuals considering spectral acceleration $SA(T,\xi=5\%)$:

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

a) Ambraseys et al. (2005)

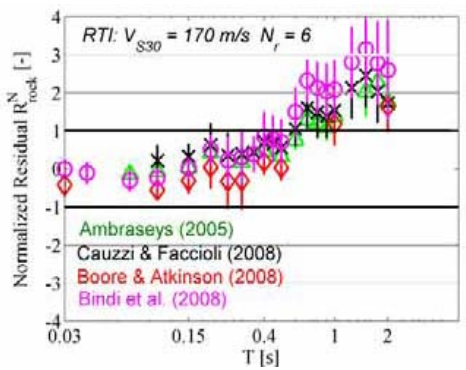
b) Cauzzi & Faccioli (2008)

c) Boore & Atkinson (2008)

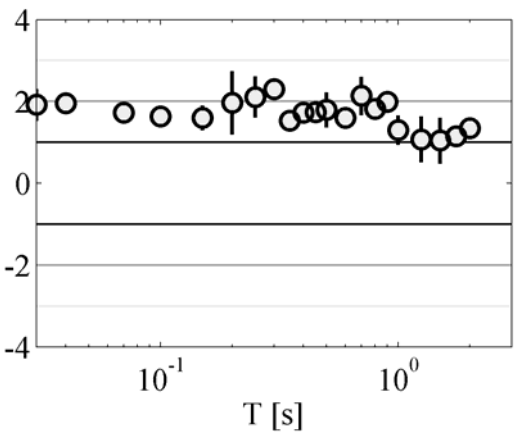
d) **Bindi et al. (2008)**

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

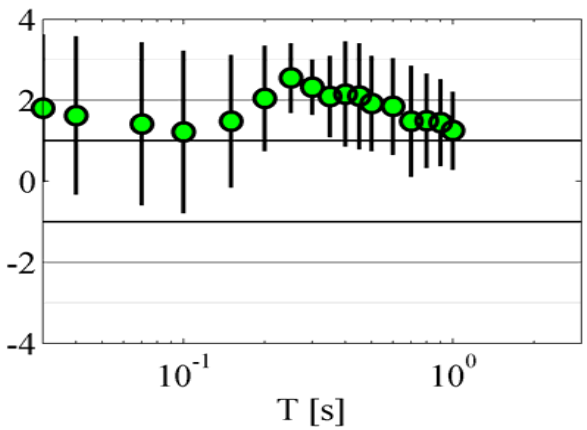
Correction of residuals for inter-event variability



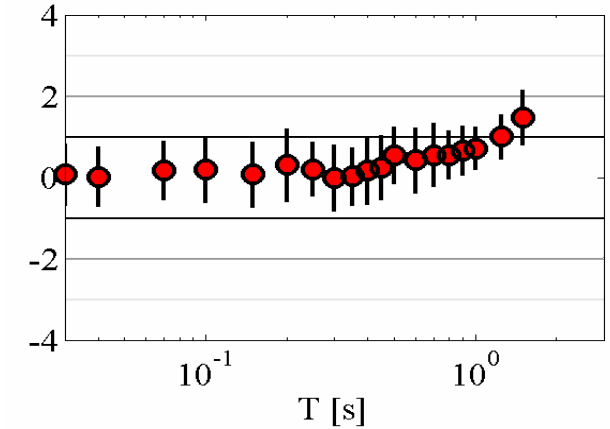
Naso - C0 (rock)



Peglio – C1 (shallow basin)



Gubbio P. – C2 (deep basin)



Future development of EGMPEs (ITA08)

1. improvment of the dataset by adding both Mw 5.4 and 4.9 Parma earthquakes and the L'Aquila sequence (13 events with Mw > 4.0)

2. distances up to 300 km and Mw down to 3.5 will be considered

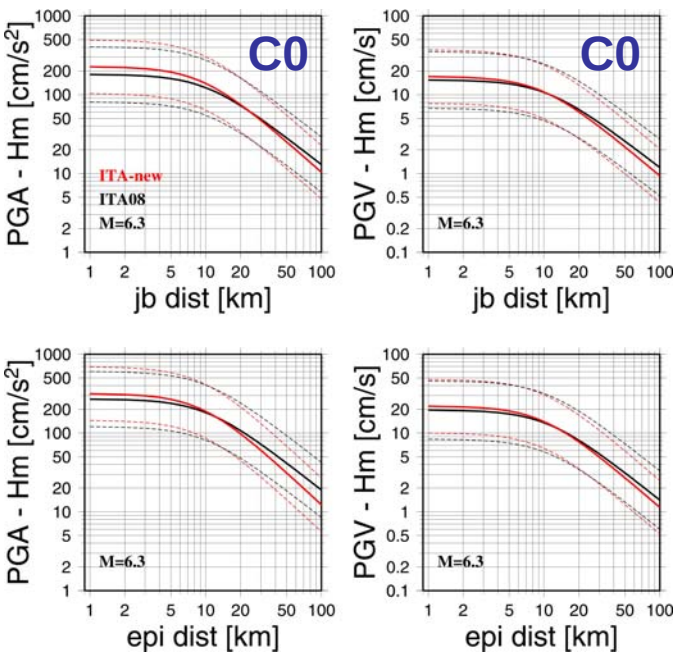
3. the anelastic attenaution term will be introduced in the model

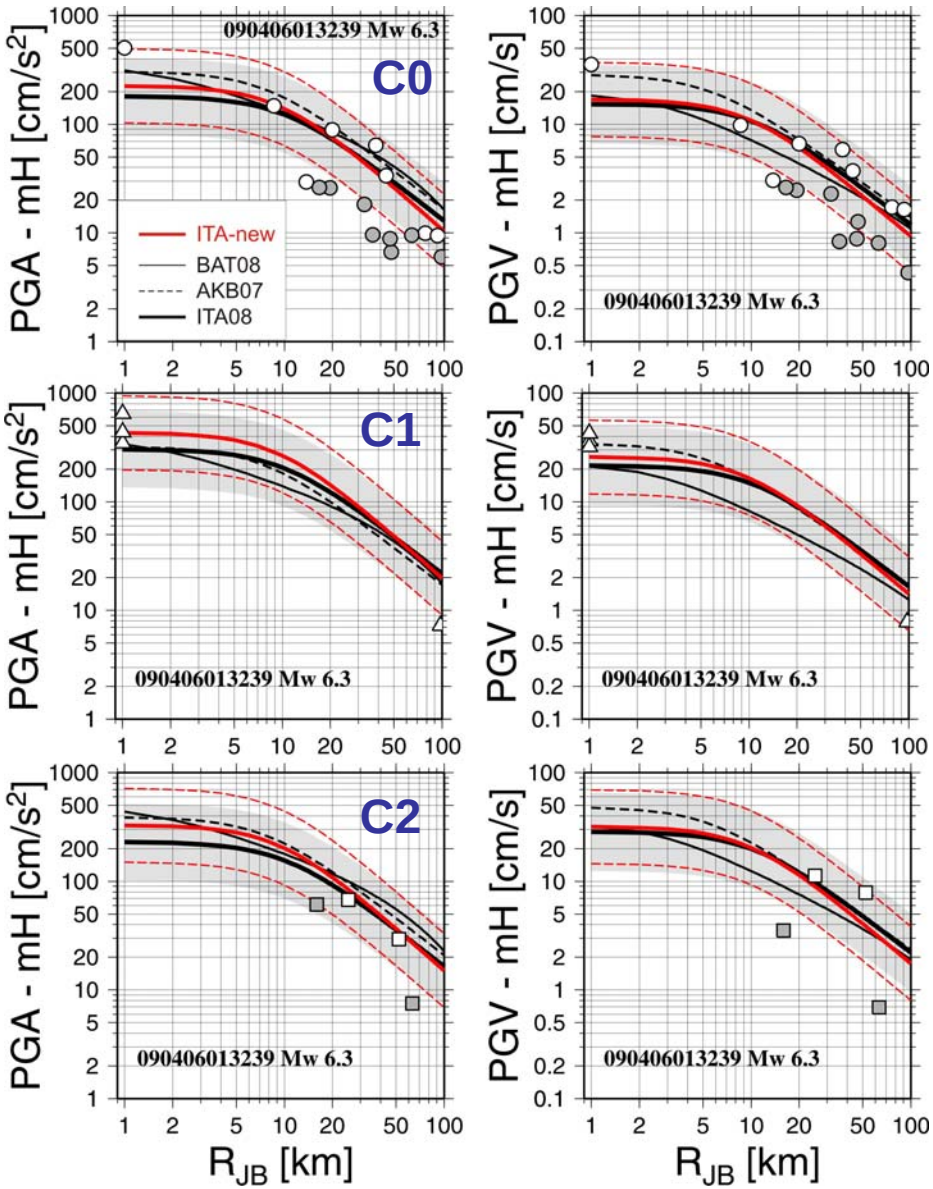
4. update soil classification on the basis of the results obtained during the S4-project

Preliminary results (PGA and PGV for Hmax)

1. same functional model as in ITA08
2. Distance (epi and Rjb) up to 100 km
3. from 561 to 802 strong-motion records (for both V and Hmax)

ITA08 Vs. ITA-new



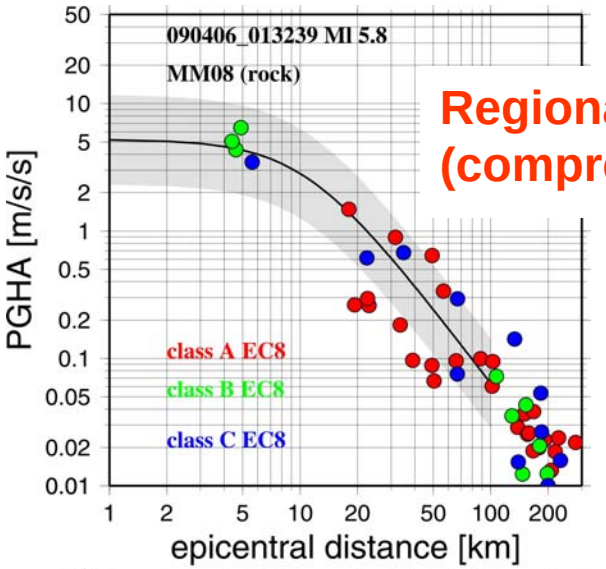


Open questions

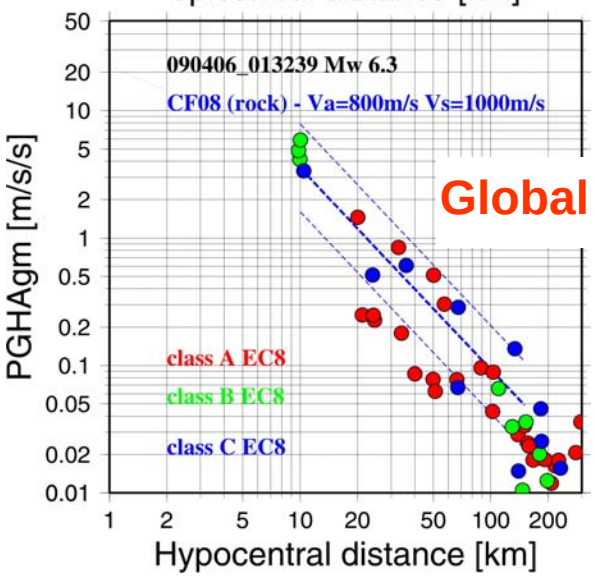
i) is it necessary that all S-Projects use the same GMPEs?

ii) is it possible to move toward homogeneous models ?

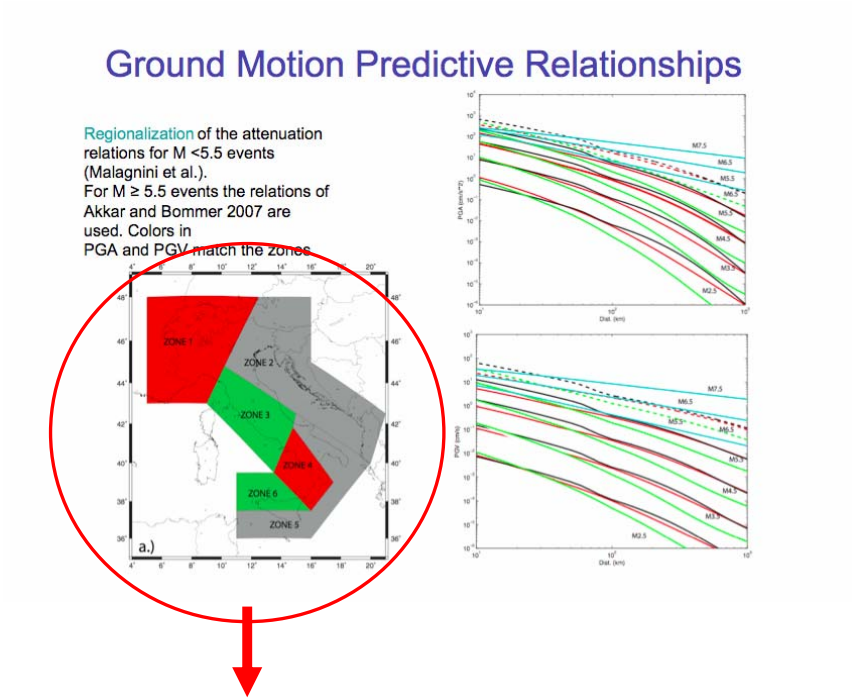
iii) what could be the contribution of the S-projects?



Regional dataset
(compressive tectonic regime!)



Global dataset



Are regional GMPEs useful ?