S Projects and GMPEs

First-Year Evaluation of the INGV-DPC Seismological Projects

IEC observes that:

One of the main model components needed for a national seismic hazard map is: 1) the GMPEs, including treatment of site effects

Projects S2, S3, and S4 all involve the development and/or evaluation of attenuation relationships, and there seems to be little convergence (perhaps only in terms of a fragmentary discussion) on which are most appropriate for the different uses.

It therefore would be useful to have a process by which these issues were discussed broadly and openly, and perhaps the *ad hoc* group mentioned above could facilitate and coordinate this process.

QUESTIONS

- Do the S-Projects use different GMPEs because they are applied with different scopes?
- Does it make sense to seek the most appropiate GMPEs for Italian territory?
- Does it make sense to use regional GMPEs?
- How should we treat the site effects in the GMPEs?

Summary - 1

S-Projects adopt:

- Global GMPEs (Boore and Atkinson, 2008; Cauzzi and Faccioli; 2008) S2-S3
- European GMPEs (Akkar and Bommer; 2007a and 2007b) S2-S3
- Italian GMPEs (Bindi et al; 2009; Di Alessandro et al; 2009; Sabetta and Pugliese, 1996) S2-S4
- Regional attenuation model obtained by the parametrization of observed Fourier spectra (Malagnini et al.; 2000) S3

Summary - 2

The various GMPEs predict the following variables:

- Peak ground motions (PGA-PGV) and Spectral ordinates (PSV, PSA, SA, DRS (up to 2s and 20s) at different periods

Ground motion components:

- Maximum H;
- geometrical mean H;
- GMRotI50 (Orientation Independent Ground Motion);
- Vertical Component

Summary - 3

Model Parameters:

Distance: Repi, Rhypo, RJB — Magnitude: Mw, Ml

Glob.	GMPE	Rjb	[0 – 200] km	[5.0 - 7.6]
Italian	GMPEs	R	[0 – 200] km	[4.0 - 6.9]
Reg.	GMPE	Rhypo	[20 – 200] km	[1.2 - 6.0]

Site term:

vs30, dummy variables (0, 1, 2), Predominat Period

Functional form

Geometrical spreading M-dependent

Style of faulting

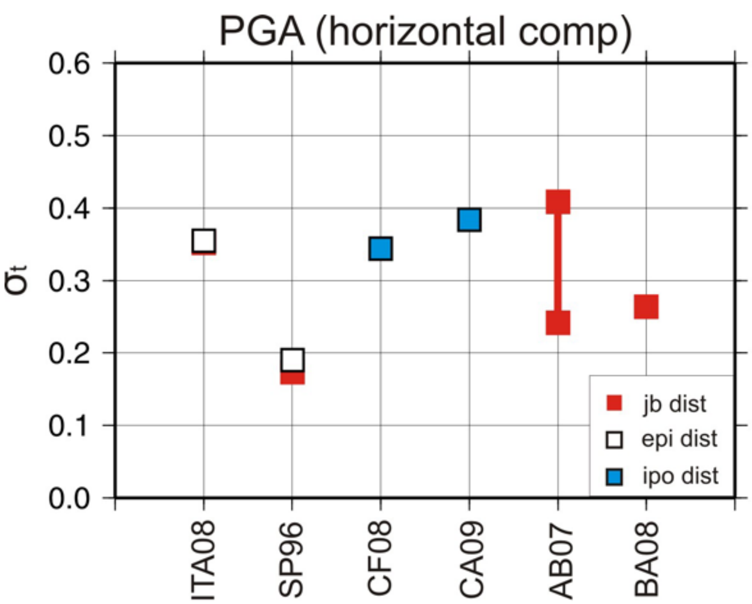
Anelastic attenuation (Di Alessandro et al.; 2009)

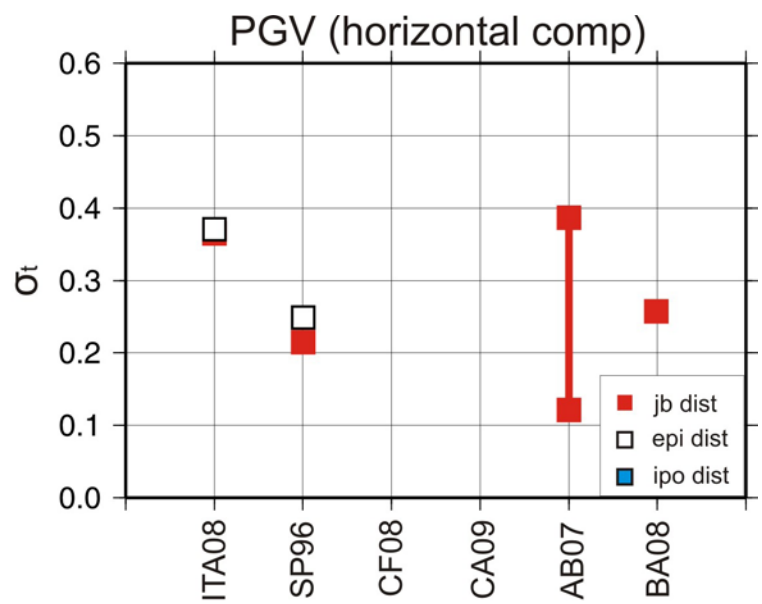
Summary - 4

Total Standard deviation:

Inter-event, intra-event Standard deviations

Standard deviation dependent on Magnitude





S2

Several ground motion prediction models have been adopted in the Project, suitable of being implemented in CRISIS++ as built-in options (in terms of external DLLs), in addition to those already contemplated in the previous versions of the code.

Horizontal ground motions

- Sabetta and Pugliese (1986 and 1996), for historical reasons
- Boore and Atkinson (2008), as NGA representative
- Akkar and Bommer (2007), dealing with Eurasian data and overdamped spectra
- Cauzzi and Faccioli (2008), worldwide databank, overdamped spectra and fully digital
- Atkinson and Boore (2003), for subduction zone earthquakes

Vertical ground motions

- Bozorgnia and Campbell (2004)
- Cauzzi and Faccioli (2008)
- Sabetta and Pugliese (1996)

S2

Dataset	Origin of Data set	Number of earthquakes	Number of stations	Number of Recordings	Magnitude* Range	Distance* Range, km	Instrument type	Correction procedure	Depth range, km
1. Sabetta and Pugliese (1996)	*Italian*	*17*		*95*	*4.6 – 6.8 Ms, Ml*	*≤ 200 Rjb or Repi*	*Analog*	*From 0.2 to 0.4 Hz for the high-pass filtering and from 25 to 35 Hz for the low-pass filtering*	*≤ 16*
2. Boore and Atkinson (2008)	*Global*	*Max 58*		*Max 1574, period-dependent*	*5 - 8 Mw*	*≤ 200 Rjb*	*Analog + digital*	*See NGA flatfile*	*≤ 31*
3. Akkar and Bommer (2007)	*Eurasia*	*Max 131*		*Max 532, period dependent*	*5 – 7.6 Mw*	*≤ 100 Rjb*	*Analog + digital*	*See Akkar and Bommer (2007)*	
4. Cauzzi and Faccioli (2008), updated for the 14WCEE	*Global*	*60, updated to 77 for the 14WCEE*		*1164 updated to 1634 for the 14WCEE*	*5 - 7.2 Mw, enlarged for the 14WCEE (4.5 – 7.6)*	*≤ 150 Rhypo or Rcd*	*Digital, exception of 9 records of the Irpinia eq.*	*Pre-evet BC + hp acausal filter 0.05 Hz, see Paolucci et al. (2008)*	*≤ 22*

S3

Several ground motion prediction models have been adopted in the Project, both European and regional scale

Horizontal ground motions

- Akkar and Bommer (2007a; 2007b), dealing with Eurasian data and overdamped spectra
- Malagnini et al. (2000), Apennines
- Scognamiglio et al. (2002), NE-Italy
- Morasca et al. (2006), NW-Italy

Vertical ground motions

S3

Origin of Data set	Number of Earthquake	Number of stations	Number of Recordings	Magnitude* Range	Distance* Range	Depth range
PGV-Europe/Middle East ***Akkar&Bommer (BSSA,2007)***	133		532	5.0≤Mw≤7.6	<100 km	Shallow ?
PGA-Europe/Middle East ***Akkar&Bommer (EESD,2007)***	131		532	5.0≤Mw≤7.6	<100 km	Shallow ?
NE-Italy ***(Scognamiglio et al., 2002)***	1753		17238 digital and some analog accelerations seismograms	1.0≤Mw≤5.6	Hypocentral 20-200 km	1-20
Apennines Malagnini et al. ***(BSSA, 2000)***	446		>6000 seismograms digital	2.0≤Mw≤6.0	Hypocentral 30-80 km	?
NW-Italy ***Morasca et al. (JOSE, 2006)***	957		> 7500 seismograms digital	1.2≤Mw≤4.8	Hypocentral < 200 km	

S4

Two ground motion prediction equations have been developed in the Project, suitable to identifying peculiar earthquake and stations and to testing different site scheme classification

Horizontal ground motions

- ITA08, Bindi et al.; (2009), only Italian data
- Di Alessandro et al.; (2009), only Italian data

Vertical ground motions

- ITA08, Bindi et al.; (2009), only Italian data
- Di Alessandro et al.; (2009), only Italian data

S4

ITA08

Origin of Data set	Number of Earthquake	Number of stations	Number of Recordings	Magnitude* Range	Distance* Range	Depth range
Italian	107	206	561 (each has three component)	4-6.9	up to 100 km	up to 29 km

Di Alessandro et al., 2009

Origin of Data set	Number of Earthquake	Number of stations	Number of Recordings	Magnitude* Range	Distance* Range	Depth range
Italian	120	214	602 (each has 3 components)	4.0– 6.8	0-200 km	0 – 32

What could we do in ITALY?

- Developing new GMPEs
- Evaluating the applicability of existing GMPEs at Italian Territory
- Deal with the problem of regional vs global GMPEs

An Overview of the NGA Project

Maurice Power,[a] M.EERI, Brian Chiou,[b] Norman Abrahamson,[c] M.EERI,
Yousef Bozorgnia,[d] M.EERI, Thomas Shantz,[b]
and Clifford Roblee,[b] M.EERI

Scope

The objective of the project is to develop new ground motion prediction relations through a comprehensive and highly interactive research program.

Requirements

- Ground-motion parameters of peak ground acceleration (PGA), peak ground velocity, (PGV), and 5% damped elastic pseudo-response spectral accelerations in the period range of 0 to 10 seconds;
- Average horizontal component of ground motion, as well as ground motion in the fault-strike-normal (FN) and fault-strike-parallel (FP) directions;
- Shallow crustal earthquakes (strike-slip, reverse, and normal earthquakes) in the western United States;
- Moment magnitude range of 5 to 8.5 (strike-slip earthquakes) and 5 to 8 (reverse and normal earthquakes);
- Distance range of 0 to 200 km; and
- Commonly used site classification schemes, including the NEHRP classification scheme.

NGA PROJECT - GMPEs

5 sets of ground-motion models were developed for shallow crustal earthquakesin the western United States and similar active tectonic regions.

The models were developed for wider ranges of magnitudes, distances, site conditions,

The NGA models were in terms of the average horizontal component of ground motion.

Each NGA developer team developed its model independently but with frequent interaction with the other developers

NGA PROJECT – Predictive parameters

The predictive parameters variously incorporated in the developers' models included

Earthquake magnitude, Style of faulting, Depth to top of fault rupture, Source-tosite distance, Site location on hanging wall or foot wall of dipping faults, Nearsurface soil stiffness, and Sedimentary basin depth/depth to rock.

One of the most significant decisions made by all developers was to use the average shear-wave velocity in the upper 30 meters of sediments, VS30.

The use of VS30 with nonlinearity is considered to result in a much-improved characterization of site amplification effects as compared to characterizations in the pre-existing relations

NGA PROJECT - DATASET

One of the major accomplishments of the NGA project was the expansion and updating of the PEER database of ground-motion recordings, which provided the database used by the developers.

Especially important was the systematic effort made to compile and extend the supporting information (metadata) about the causative earthquakes, travel paths, and site conditions at recording stations, including the estimation of VS30 values using correlations at every station not having measured values.

The development of the NGA models would not have been possible without the PEER-NGA database.

GMPEs in ITALY

The primary goal should be to determine whether existing GMPEs are applicable for different use in Italy territory.

Residual analysis could be performed, examing the average residuals, binned by distance and magnitude, from observed and predicted graound motion values.

Observed strong motion data-set should be defined

Allen, T.I., and Wald, D.J., 2009, Evaluation of ground-motion modeling techniques for use in Global ShakeMap—A critique of instrumental ground-motion prediction equations, peak ground motion to macroseismic intensity conversions, and macroseismic intensity predictions in different tectonic settings: U.S. Geological Survey Open-File Report 2009–1047, 114 p.

Regional vs Global

Bull Earthquake Eng
DOI 10.1007/s10518-009-9122-9

ORIGINAL RESEARCH PAPER

Current empirical ground-motion prediction equations for Europe and their application to Eurocode 8

Julian J. Bommer · Peter J. Stafford · Sinan Akkar

Douglas (2007) discusses reasons for the appearance of regional differences in ground motions, highlighting that this can arise due to differences between the regions that may not be included in the ground-motion prediction equations, such as the focal depth distribution (at least for smaller earthquakes). In other cases, there may be differences that are not resolved in the relatively crude parameterisation of the equations, such as site classes, where shear-wave velocity profiles in one region can be systematically different from those in another even though the sites fall within the same broad class.

Bulletin of the Seismological Society of America, Vol. 97, No. 6, pp. 2152–2170, December 2007, doi: 10.1785/0120070081

The Influence of Magnitude Range on Empirical Ground-Motion Prediction

by Julian J. Bommer*, Peter J. Stafford, John E. Alarcón, and Sinan Akkar

The conclusion of the study is that empirical derivation of ground-motion prediction equations should be based on datasets extending at least one unit below the lower limit of magnitude considered in seismic hazard calculations.

The inclusionof small-magnitude recordings results in a significant increase in the aleatory variability of the equations, although it is yet to be established whether this is due to greater uncertainty in the associated metadata or whether ground-motion variability is genuinelydependent on earthquake magnitude.