ESTIMATION OF PGA ATTENUATION LAWS FOR SPAIN AND MEDITERRANEAN REGION. COMPARISON WITH OTHER GROUND MOTION MODELS

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ABSTRACT

A multiple regression analysis has been conducted using the accelerometric data recorded in Spain, in order to obtain PGA attenuation laws as a function of the magnitude, distance and soil conditions. As these data correspond to moderate and small earthquakes, the deduced models are first applicable only in a narrow range of magnitudes (2-5). Other more extensive models have also been deduced, relying on data from the Mediterranean region, using the method aforementioned. The second aim of this study is to compare the local model of Spain with that of the Mediterranean region and others developed for more extensive areas such as Italy (Sabetta and Pugliese, 1996; Tento et al., 1992), Europe (Ambrasys et al., 1996), East part of the USA (Atkinson and Boore, 1995; Toro et al., 1996), and others which are more global (Dhale et al., 1990; Spudich et al., 1999). The aim of this comparison is to identify those models that fit better in our estimated local one and therefore are more suitable for sites in the Iberian Peninsula.
Using the results from this comparison, we have proven that the local and the Mediterranean models show similar trends with to those from European data, while important differences are observed related to the American models. Suitable laws can thus be established for estimating ground motion in sites located in the Iberian Peninsula. These will allow a reliable empirical prediction for different magnitudes, distances and soil conditions.

ESTIMATION OF GROUN MOTION MODELS

The attenuation models of PGA for the Mediterranean region and Spain have been deducted by regression analysis of strong motion data, fiting them to the expresion:

$$\mathrm{Ln\ PGA} = C_1 + C_2 . M + C_3 (R+R_0) + C_4 \mathrm{Ln} (R+R_0) + C_5 . S + \varepsilon$$

where
- M: moment magn. M_0, surface magn. M_s or body waves magn. Lg, m_{bLg}
- R: epicentral distance, R_{ep}, hypocentral dist, R_{hyp} or Joiner and Boore dist R_{JB}
- S: soil factor
- R_0: non attenuation ratio
- ε: error

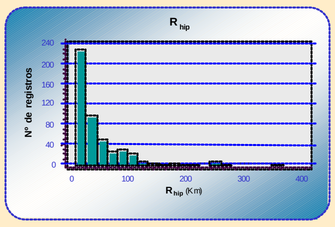
For both regions different models have been inferred for vertical component PGA_v or maximun horizontal componet PGA, with the different definitions of distance and magnitude. With each combination of variables, a model is obtained for each class of soil. The following classes have been taken:

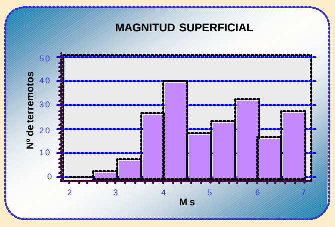
Soil classification

- S1. Hard rock
- S2. Sedimentary rock and conglomerate
- S3. Glacier sediments
- S4. Alluvium

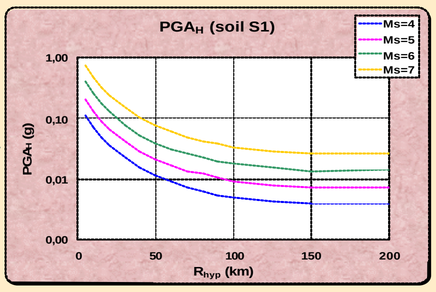
MODELS FOR THE MEDITERRANEAN REGION

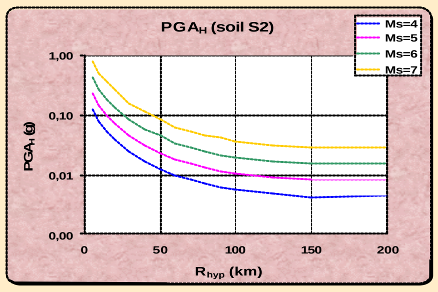
Distribution of records versus: Hypocentral Distance, R_{hyp} and Magnitud Ms

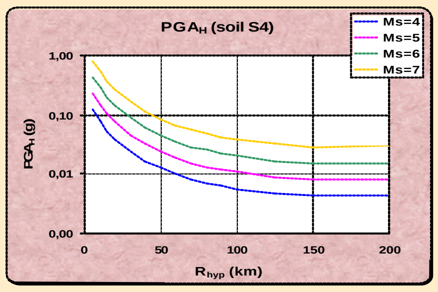




Examples of the estimated models







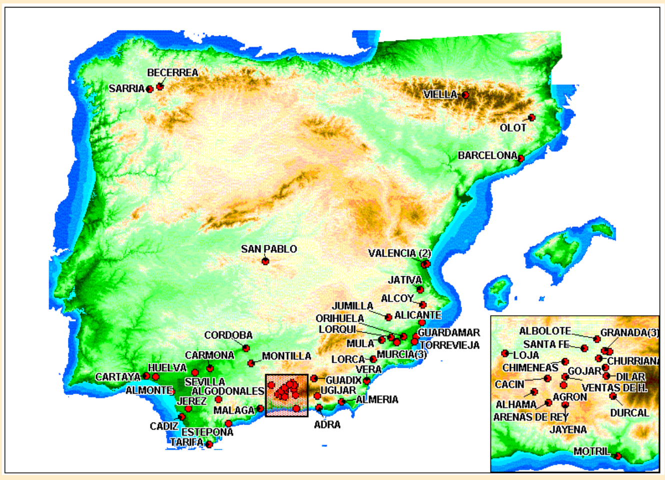
$$PGA_H = f(R_{hip}, M_S, S, R_0 = 20)$$

[PGA_H Maximun of the horizontal components]

Soil	Attenuation Laws
S1	$Ln(PGA_H) = 11.045 + 0.633\, M_S + 0.015\, (R_{hip}+20) - 2.878\, Ln(R_{hip}+20)$
S2	$Ln(PGA_H) = 11.139 + 0.633\, M_S + 0.015\, (R_{hip}+20) - 2.878\, Ln(R_{hip}+20)$
S3	*Data S3 in same clase than S4*
S4	$Ln(PGA_H) = 11.143 + 0.633\, M_S + 0.015\, (R_{hip}+20) - 2.878\, Ln(R_{hip}+20)$

MODELS FOR SPAIN

Recording stations of the strong motion data emploided in the analysis



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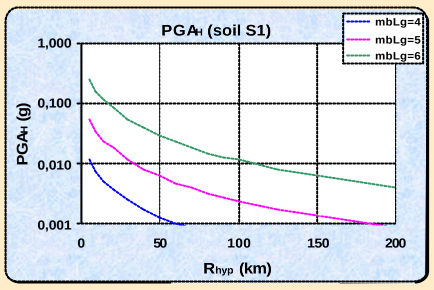
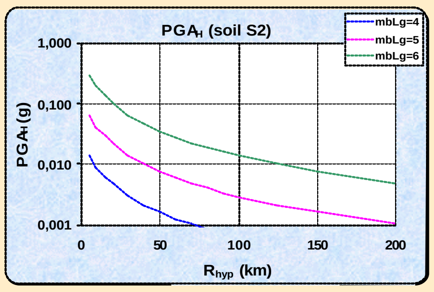
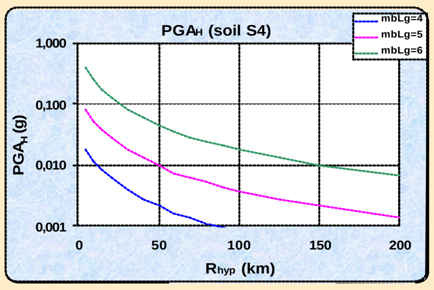




Examples of the estimated models



$$PGA_H = f(R_{hip}, m_{bLg}, S, R_0 = 10)$$

Soil	Attenuation Laws
S1	$Ln(PGA_H) = 0.461 + 1.538\, m_{bLg} - 1.553\, Ln(R_{hip}+10)$
S2	$Ln(PGA_H) = 0.672 + 1.538\, m_{bLg} - 1.553\, Ln(R_{hip}+10)$
S3	*There is not data S3*
S4	$Ln(PGA_H) = 0.911 + 1.538\, m_{bLg} - 1.553\, Ln(R_{hip}+10)$

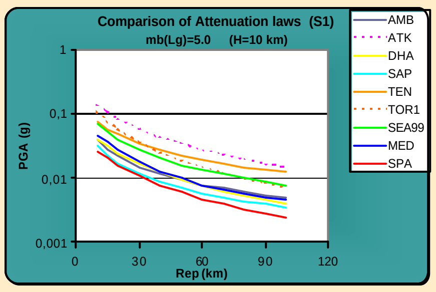
COMPARISON WITH OTHER GROUND MOTION MODELS

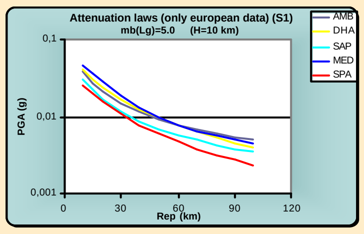
Summary of ground motion models: main characteristics and suitable ranges

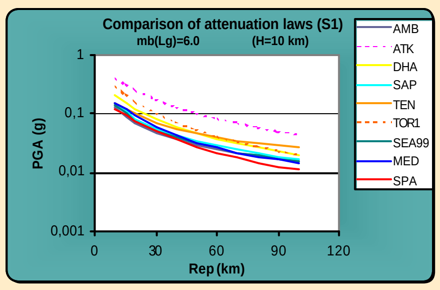
Model	Source zone	Magnitude Type	Magnitude Range	Distance Type	Distance Range	Soil Clasiffication	Predicted parameter
Ambraseys et al. (1996)	Europe and Middle East (422 acc.)	Ms	4.0 - 7.5	R	< 200 km	rock stiff soil soft soil softest soilsblando	SA (g) 0.5 - 10 Hz
Sabetta & Pugliese (1996)	Italy (95 records)	M_L (<5.5) Ms(>=5.5)	4.6 - 6.8	R_{ep} R_{JB}	1-100 km	rock surface alluvium depth alluvium	PGA (g) IA (cm2/s3) t Van Mark & Lai (s) PSV (cm/s) (0,25-25 Hz)
Benito (1993)	Friuli (Italy) (62 records.)	M_L	4.2 - 6.5	R_{hyp}	2 - 194 km	rock surface alluvium depth alluvium	SA (gal) 0.1 - 25 Hz
Tento et al. (1992)	Italy (137 ac.)	M_L	4.0 - 6.6	R	3.2 - 170 km	No clasification average conditions	PGA (gal) PSV (cm/s) (0,36 - 25 Hz)
Dahle et al. (1990)	North America, Europe, Chineese y Australia (87 ac.)	Ms	3 - 7	R_{hyp}	10 -1000 km	No clasificación average conditions	PGA (m/s^2) PSV(m/s) FA (m/s) (0.25-10 Hz)
Toro et al. (1996)	Central and East North América	M m_{Lg}	5 - 8	R_{hyp} $R_{JB}=R_{ep}$	1 - 500 km	rock	PGA (g) SA (g) (1-35 Hz)
Atkinson & Boore (1995)	East North América	M	4 - 7.0	R_{hyp}	10 - 500 km	rock	PGA (g) PGV (cm/s) SA (g) (0.5 - 20 Hz)
Youngs et al. (1996)	Subduction zone: interface and intraslab	M	5 - 8.1	R_{JB} R_{hyp}	10 - 500 km	rock surface alluviuml depth alluvium	PGA (g) SA(g)
SEA-99 (1999)	Extensional Regime	M	5 - 7.7	R_{JB}	0 - 100 km	rock surface alluvium depth alluvium	PGA (g) SA(g)
Mediterráneo (1999)	Cuenca del Mediterráneam Basin	Ms	2.5 - 7.0	R_{hyp}	0 - 250 km	roca aluvión superficial aluvión profundo	PGA (cm/s^2)
España (1999)	Spaish sites	mb_{Lg}	2.5 - 6.0	R_{hyp}	0 - 300 km	roca aluvión superficial aluvión profundo	PGA (cm/s^2)

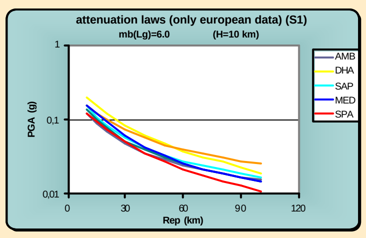
Models analyzed

AMB	Ambraseys et al (1996)
ATK	Atkinson and Boore (1996)
DHA	Dhale et al (1990)
SAP	Sabetta and Pugliese (1996)
TEN	Tento et al (1992)
TOR	Toro et al (1996)
SEA	SEA-1999
Med	Mediterranean (1999)
Spa	Spain (1999)









CONCLUSIONS

Strong motion models for Spain supplies values of PGA smaller than the other models for the same magnitude and distance.

The difference between the attenuation of Spain and Mediterraneam region is higher for the smaller magnitudes (M=4).

The attenuation laws for Spain and Mediterranean region estimated in this work come closer to the others with European data.

Strong motion models for America supplies higher values of PGA that the European models, in similar conditions of magnitude and distance.