Project funded by the EUROPEAN UNION

SciNet NatHaz Prevention

Black Sea CROSS BORDER COOPERATION

A Scientific Network
for Earthquake, Landslide & Flood Hazard Prevention

SciNetNatHazPrev - PROJECT WORKSHOP

Seismic Hazard Assessment Methodologies :

Partner's Presentation

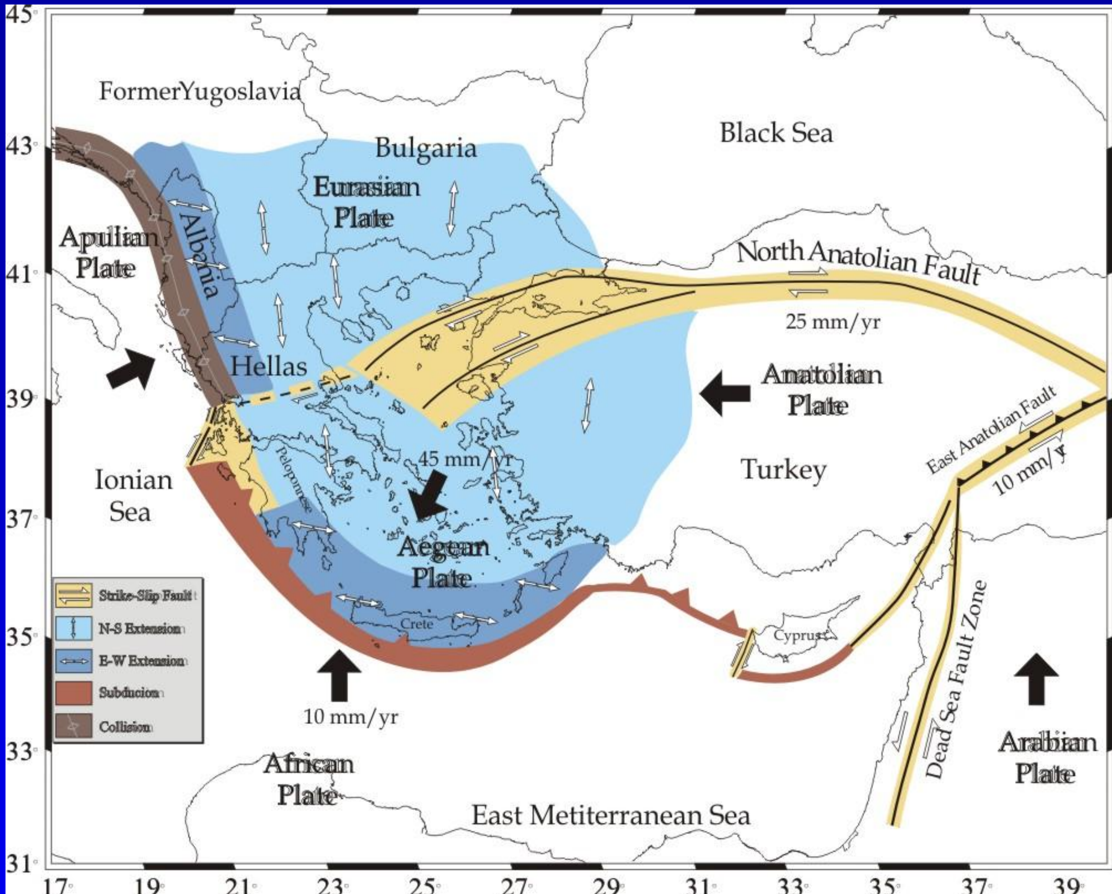
Greek P2: *Selected Seismic Hazard Assessment Methodologies at Regional and Local Case Studies*

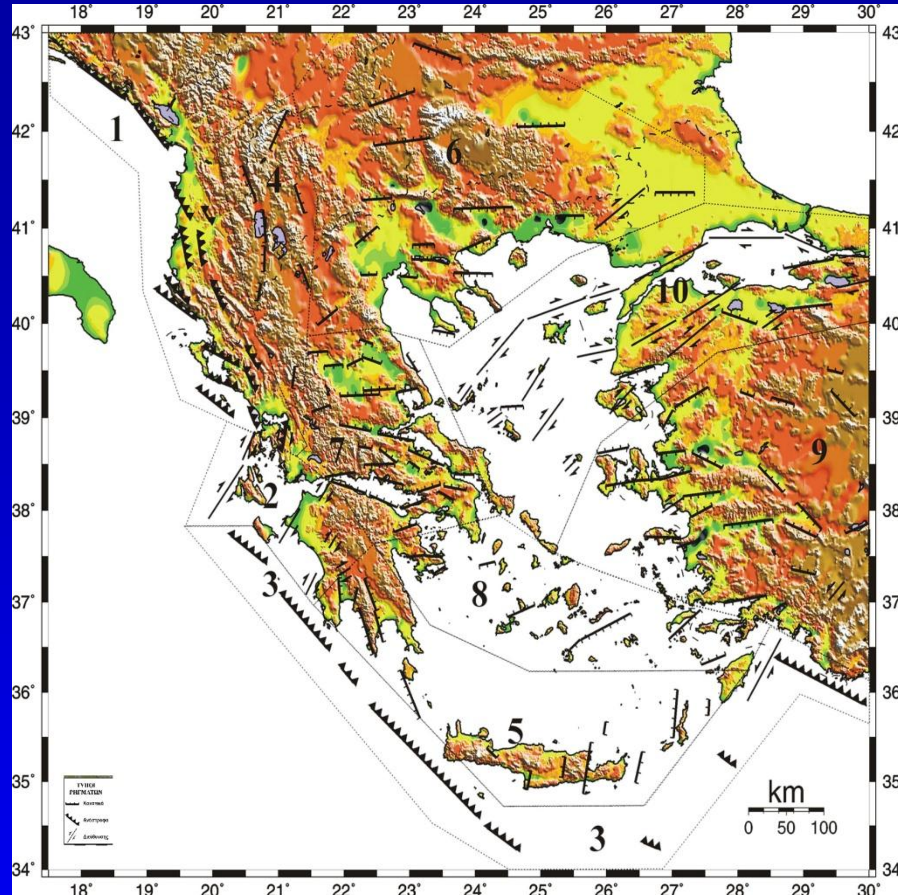
Basil N. Margaris
Dr. Geophysicist-Seismologist

Seismic Hazard Assessment

- *Seismic Sources*
- *Ground motion parameters*
- *Deterministic Seismic Hazard Analysis*
- *Probabilistic Seismic Hazard Analysis*
- *Results of Seismic Hazard Analysis*

Seismic Source in Greece



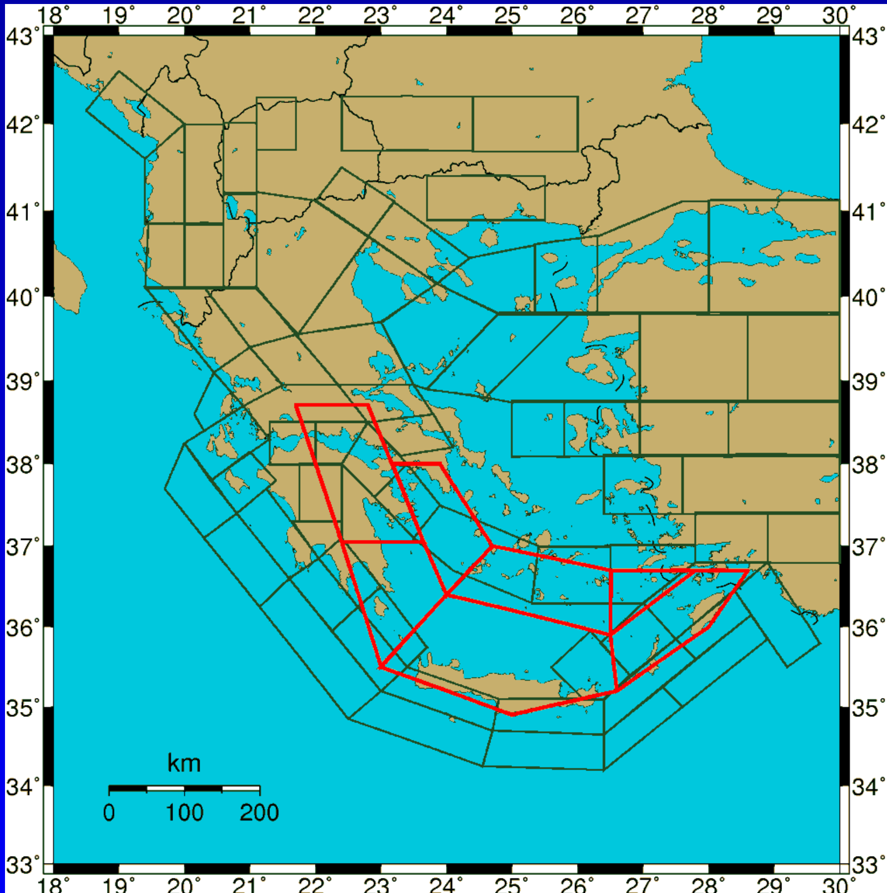


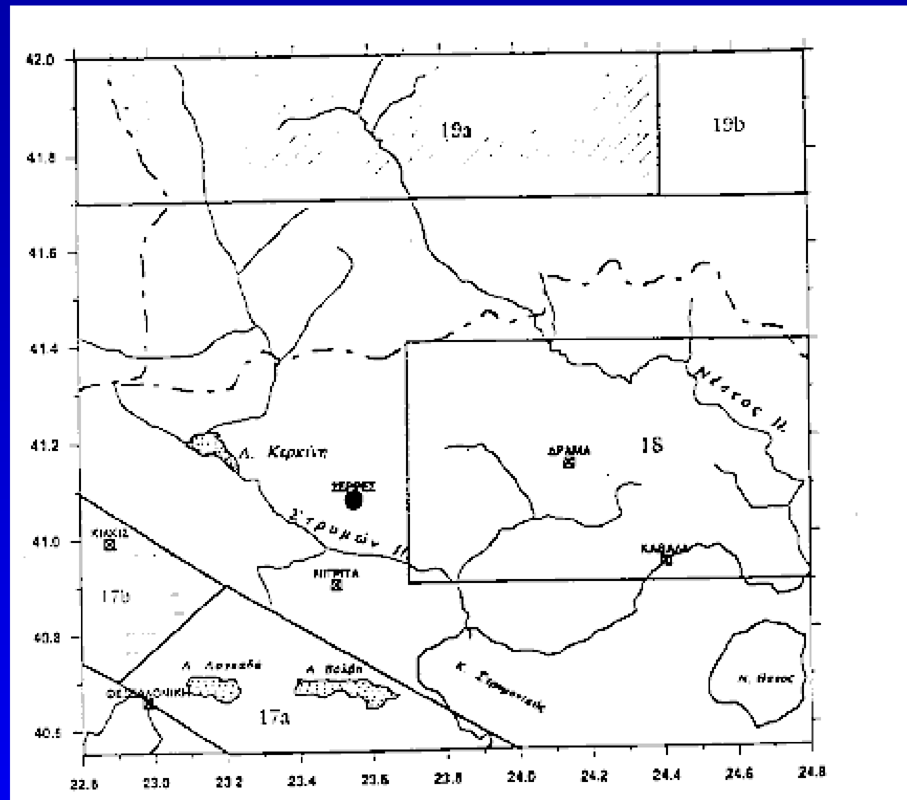
The main lithospheric movements determinning the active tectonic of the area (Papazachos etal., 1998)

The main faults of shallow strong (M≥6.0) earthquakes in the Agegean areas (Papazachos et al., 2001).

Seismic Source in Greece

(Papazachos etal. 1993)



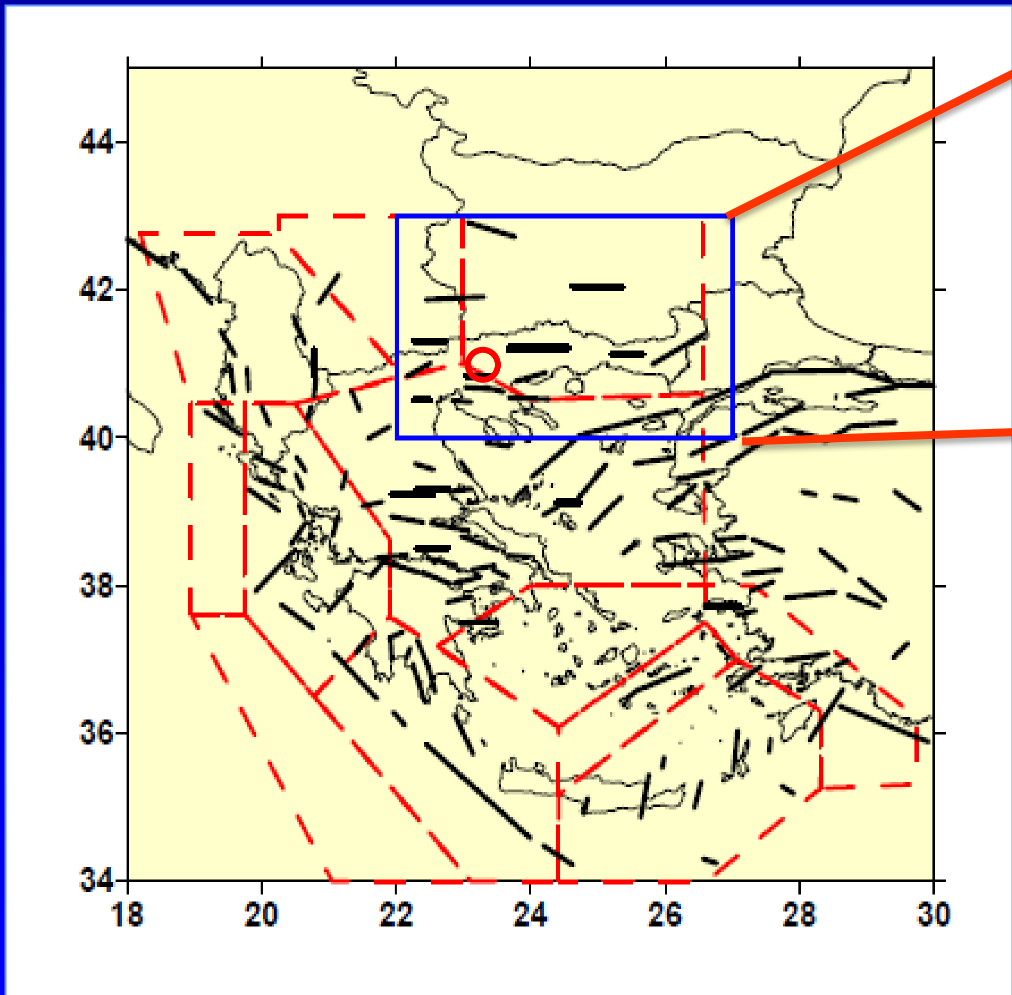


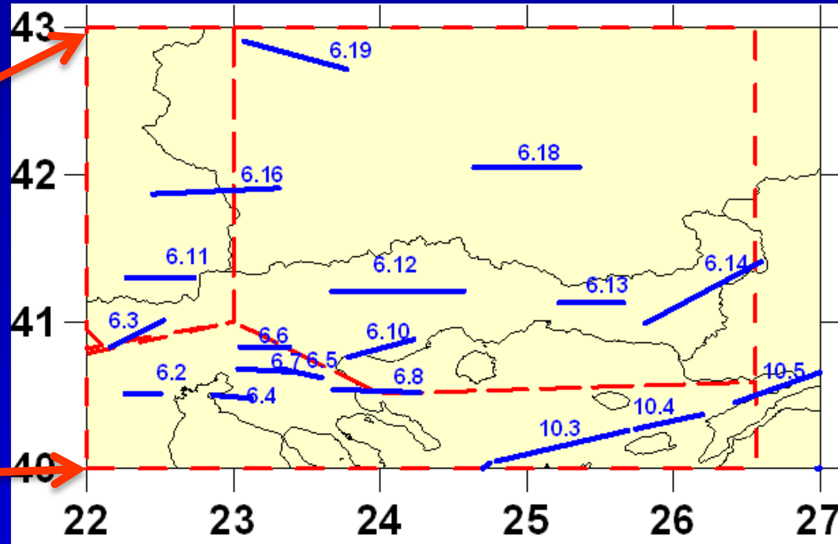
Σχ. 5. Χάρτης σεισμικών πηγών στην ευρύτερη περιοχή των Σερρών.

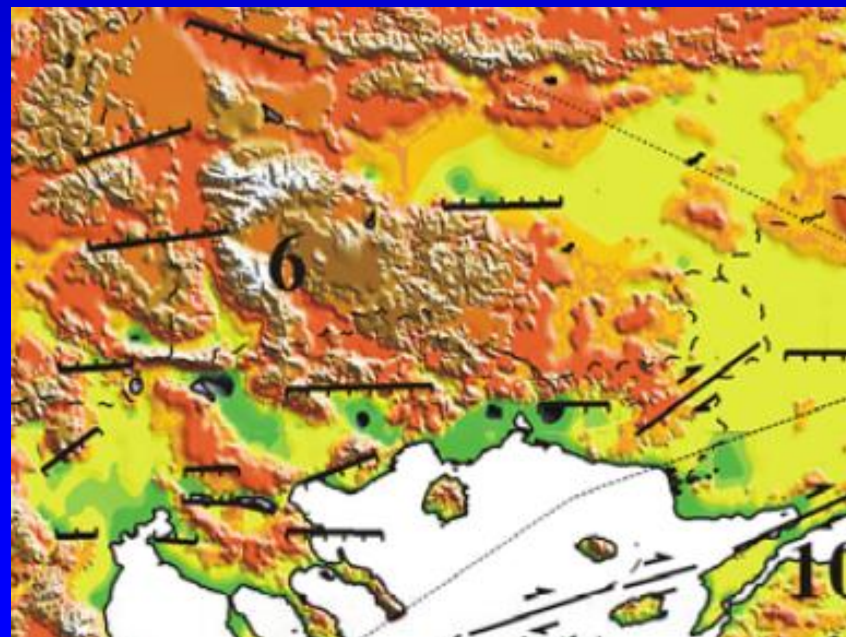
Seismic sources models of shallow (black) and intermediated depth (red) earthquakes (Papazachos and Papaioannou, 1993 revised).

Seismic Source in Greece

(Papazachos etal. 2006)



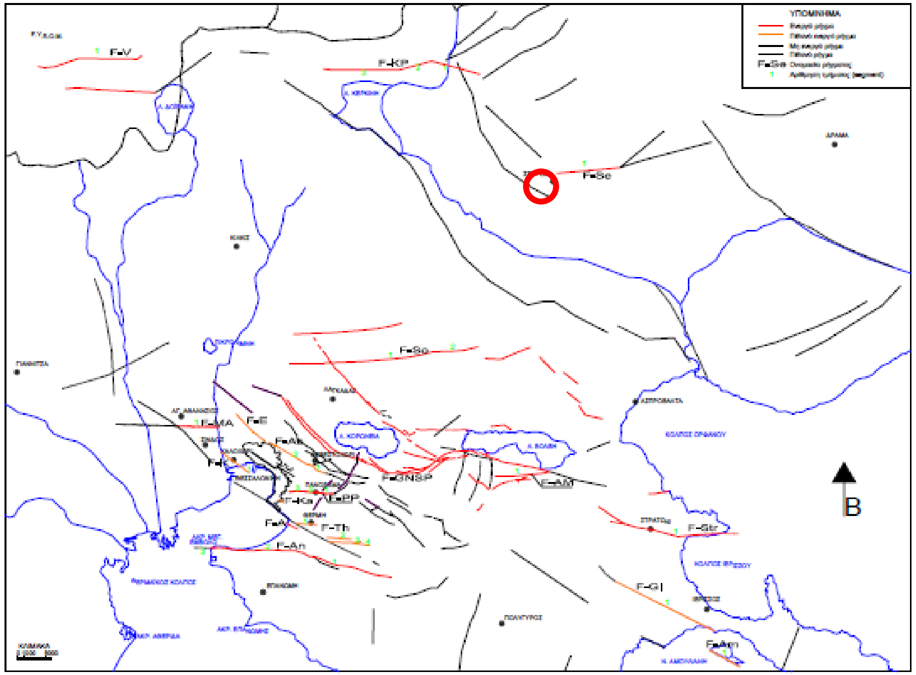




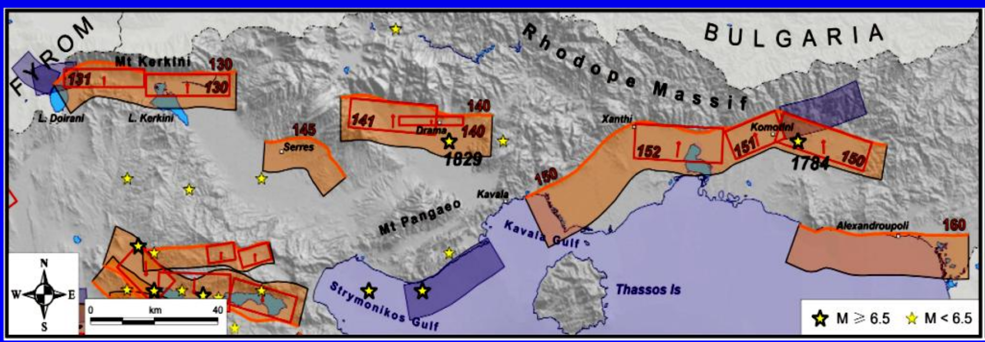
Seismic Faults (Papazachos etal., 2001)
Seismic Sources (Papazachos and Papaioannou, 2000)

Active Faults in Area Studied

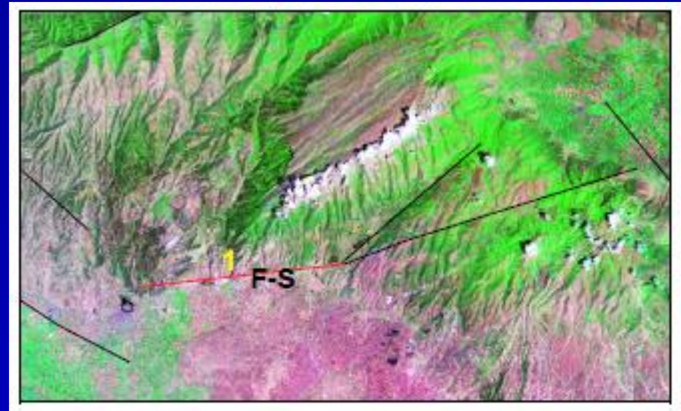
(Pavlidis et al., 2005)



Χάρτης 1: Ενεργά ρήγματα της ευρύτερης περιοχής της Θεσσαλονίκης (F-Str Στρατωνίου, F-Gl Γοματίου–Ιερισσού, F-KP Κερκίνης–Πετριτσίου, F-Th Θέρμης, F-An Ανθεμούντα, F-PP Πυλαίας–Πανοράματος, F-As Ασβεστοχωρίου, F-E Ευκαρπίας, F-A Αεροδρομίου, F-MA Ν. Μεσημβρίας–Αγχίαλου, F-K Καλοχωρίου, F-So Σοχού, F-AM Ν. Απολλωνίας–Ν. Μαδύτου, F-Se Σερρών, F-Am Αμουλιανής, F-V Βαλάντοβο, F-GNSP Γερακαρούς–Νικομιδηνού–Στίβου-Περιστερώνα F-Ka Καλαμαριάς).



(Caputo et al., 2012).



GMPE's: Ground Motion Prediction Equations in Greece (Skarlatoudis etal., 2003; BSSA)

$$\ln Y = c_1 + c_2 M + c_3 \ln(R + R_0) + c_4 S \pm \sigma$$

Y	c_1	c_2	c_3	c_4	R_0	σ
PGA	2.465	1.037	-1.350	0.138	6	0.659

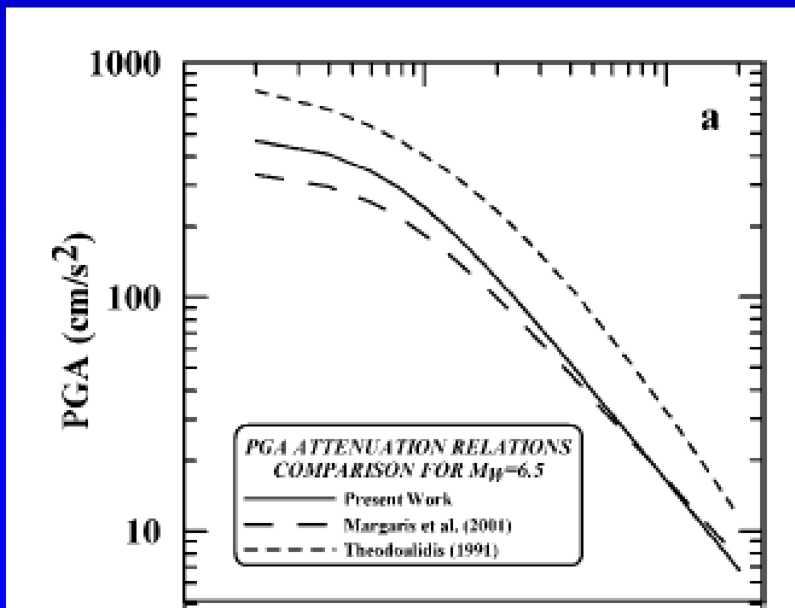
$$\ln Y = c_1 + c_2 M + c_3 \ln(R^2 + h^2)^{\frac{1}{2}} + c_4 S \pm \sigma$$

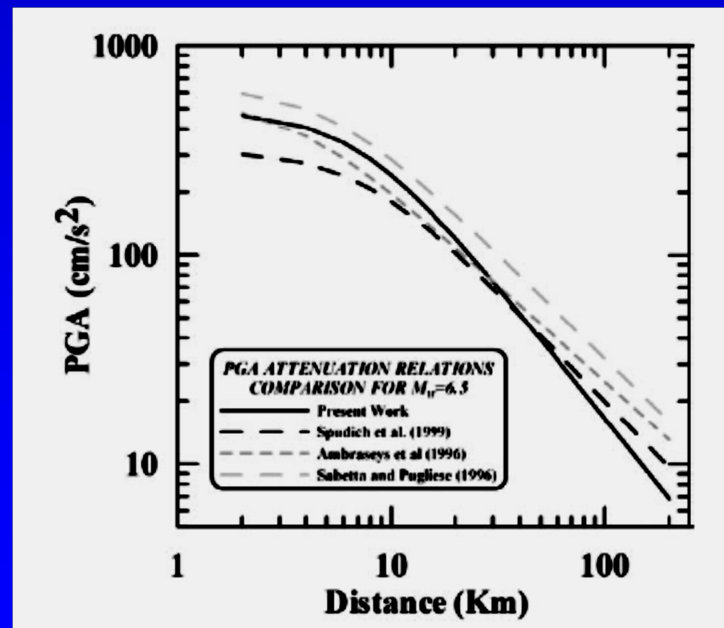
Y	c_1	c_2	c_3	c_4	*h*	σ
PGA	1.982	1.037	-1.270	0.138	7	0.659

Εμπειρικές σχέσεις εξασθένησης σεισμών ενδιαμέσου βάθους (Θεοδουλίδης, 1991):

$$\ln Y = c_1 + c_2 M + c_3 \ln(R + R_0) + c_4 S \pm \sigma$$

Y	c_1	c_2	c_3	c_4	R_0	σ
PGA	3.47	0.75	-0.85	-0.27	-	0.66





Seismic Hazard Assessment

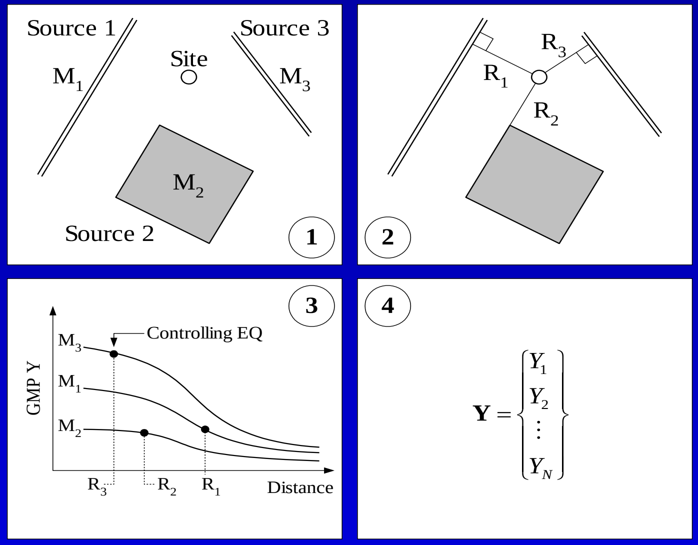
Seismic Hazard Analysis: Estimation of ground-shaking hazards at a particular site

Two basic approaches

Deterministic (DSHA):

Assumes a single "scenario"

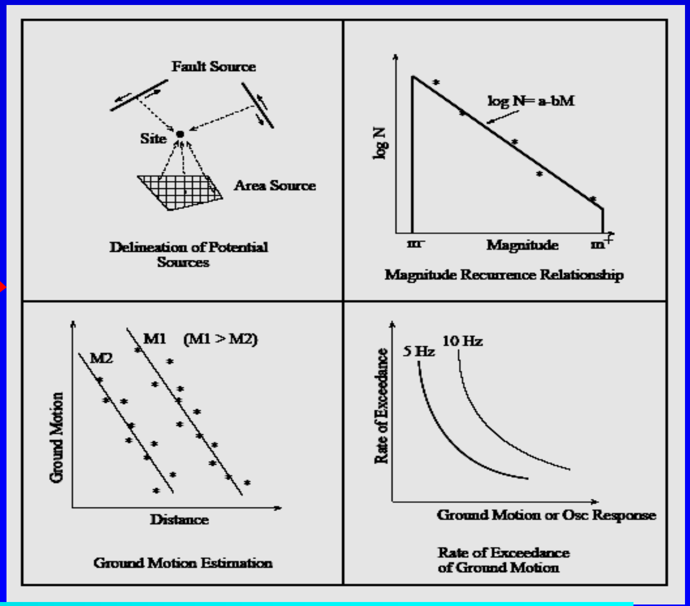
- Select a single magnitude, *M*
- Select a single distance, *R*
- Assume effects due to *M, R*



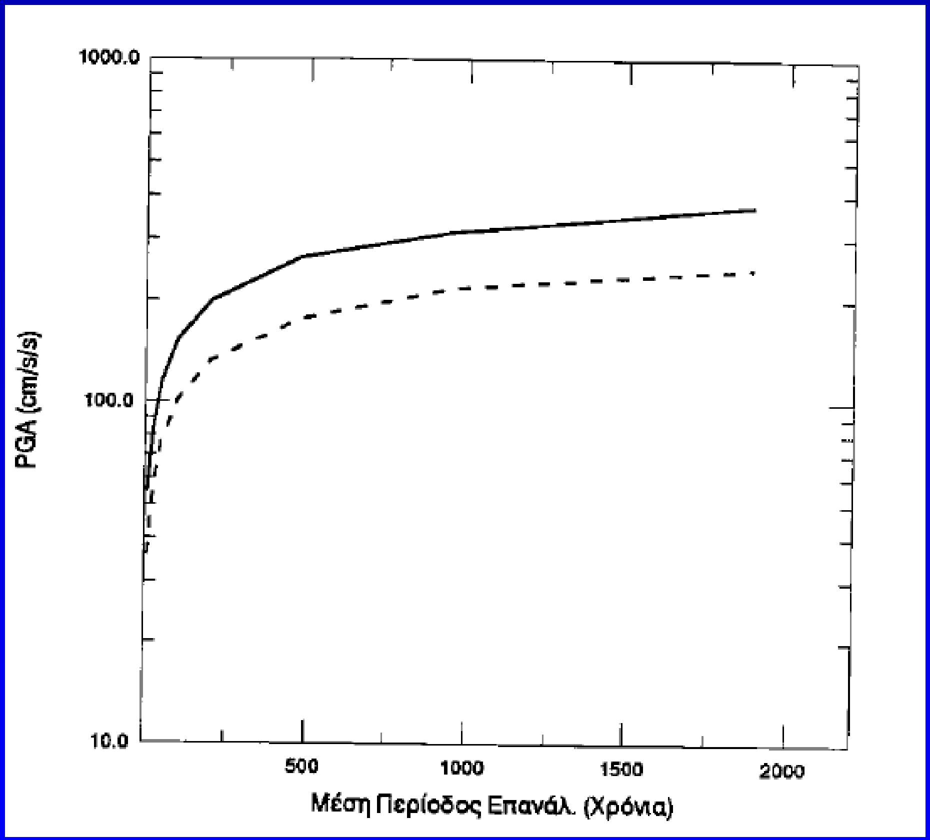
Probabilistic (PSHA):

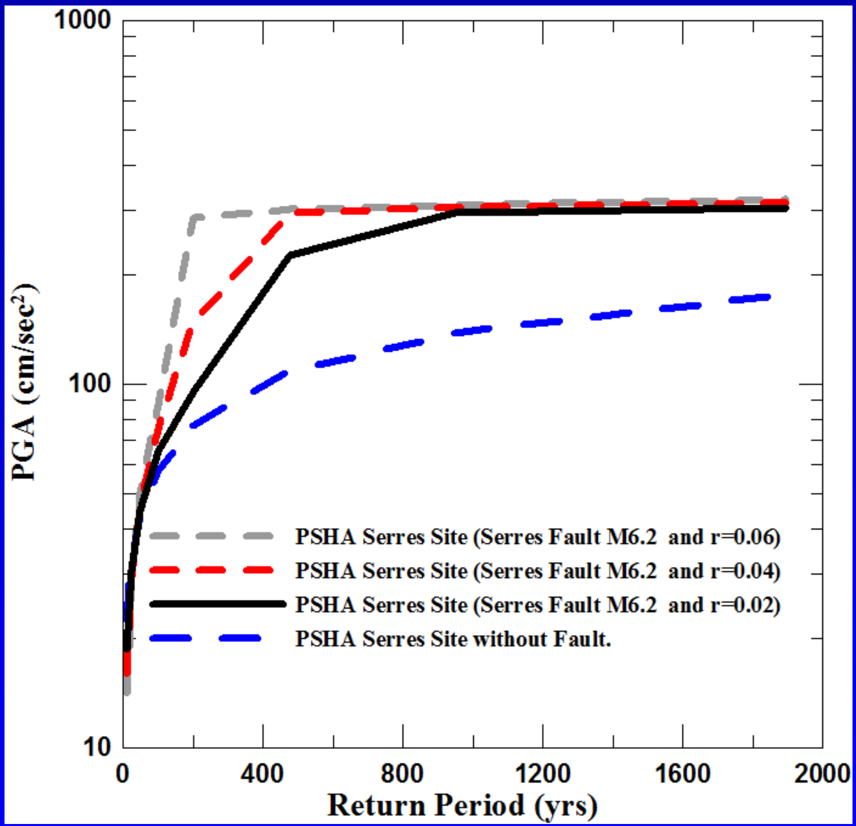
Assumes many scenarios

- Consider all magnitudes
- Consider all distances
- Consider all effects



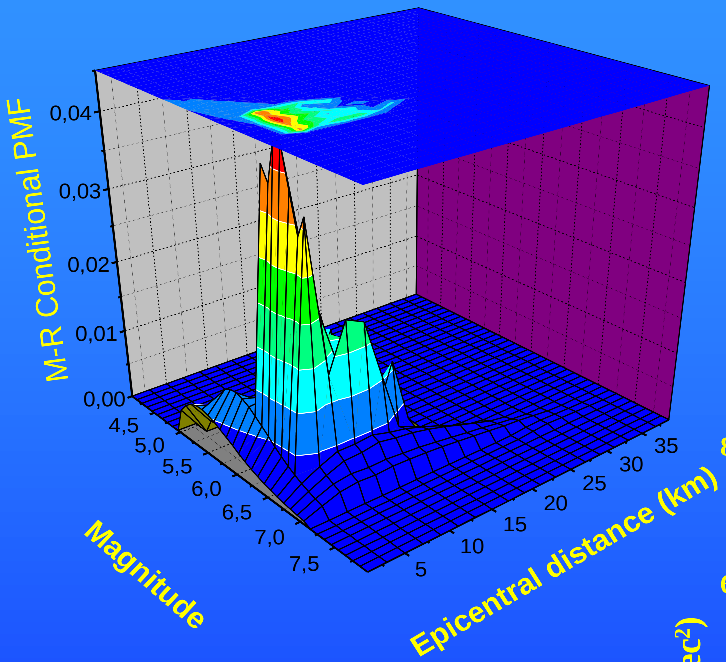
PSHA for Serres Site Greece (Papazachos etal., 1996)



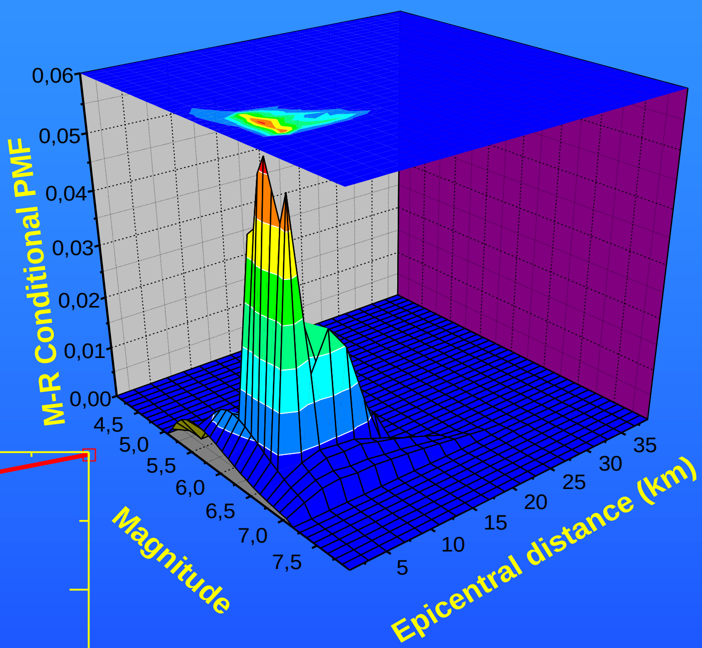


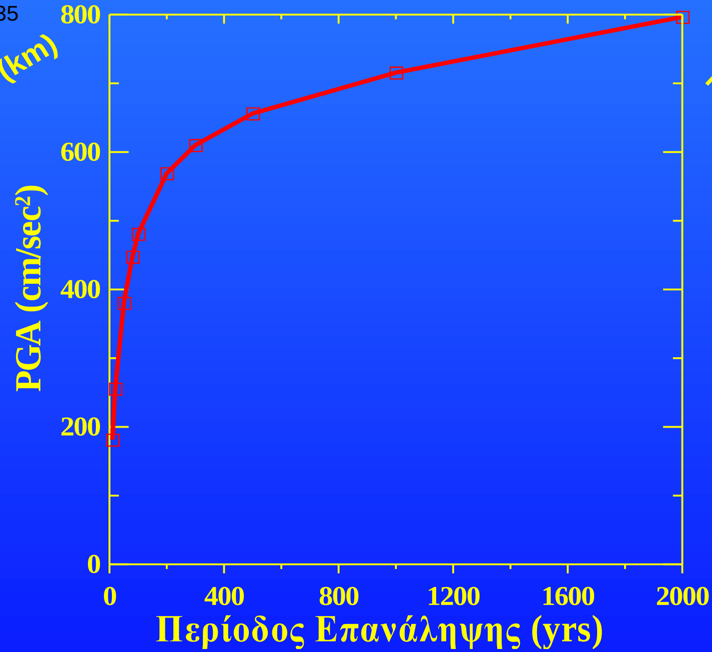
PSHA & Dis-Aggregation (Margaris & Koutrakis 2004)

Πόλη Λευκάδας, PGA=333 cm/sec^2(~52 yrs RP)
M-R max at 6.35-5.0



Πόλη Λευκάδας PGA=410 cm/sec^2(~87 yrs RP)
M-R max at 6.35-5.0



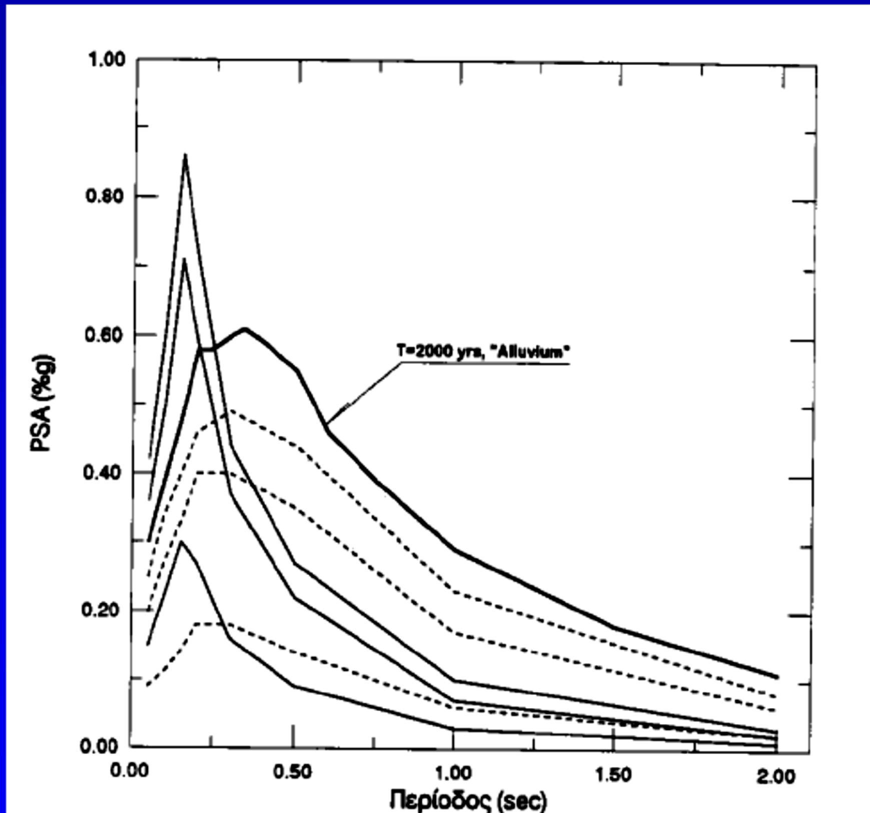


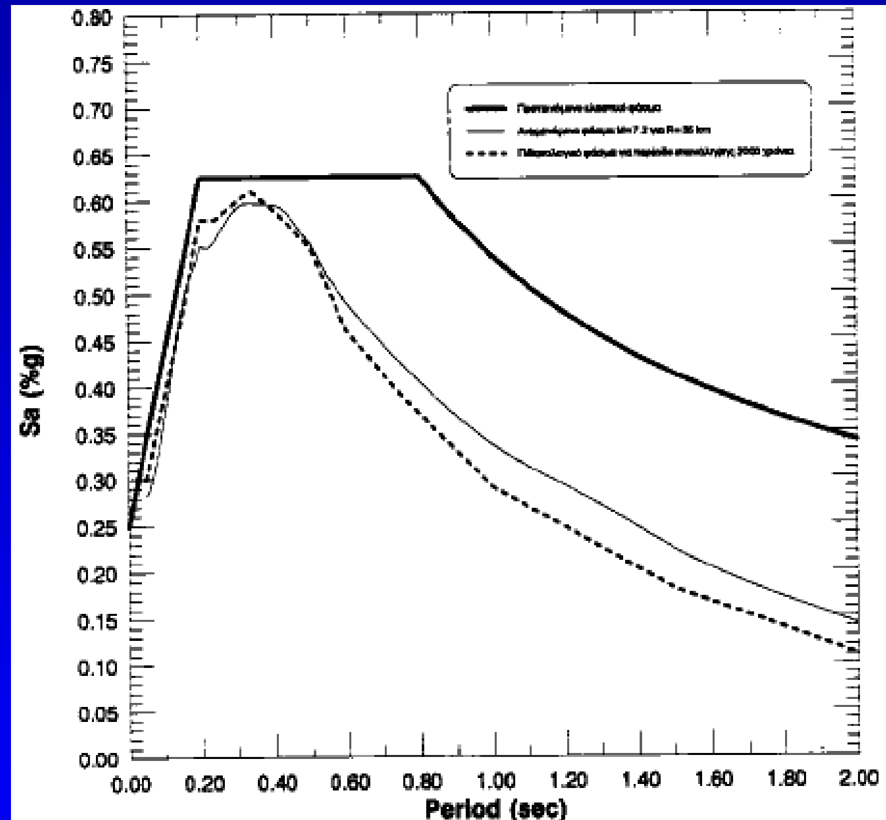
PSHA and Disaggregation Analysis in Serres Site (Margaris, 2013)

PGA / TR(yrs)	10	25	50	100	200	475	950	1890
PGA (cm/s^2) r=0.02 M6.2	18.58	30.61	44.66	65.17	95.08	225.38	296.20	305.51
PGA r0.02 M6.2 +1σ	41.07	63.63	87.65	124.48	187.83	485.07	551.14	552.81
PGA (cm/s^2) r=0.04 M6.2	15.96	29.53	47.03	74.92	146.86	296.03	305.43	315.06
PGA (cm/s^2) r=0.06 M6.2	14.06	29.12	50.51	87.61	286.12	301.44	311.02	320.84
PGA (cm/s^2) r=0.07 M6.7	13.68	29.46	52.62	93.99	218.52	376.48	480.18	523.72
PGA r0.07 M6.7 +1σ	41.38	68.63	103.01	201.39	453.94	745.01	909.76	1109.56
PGA (cm/s^2) without SF	22.47	32.73	43.51	57.84	76.89	107.90	138.43	176.16
PGA (cm/s^2) Papazachos etal. (1996)	45.30	70.3	95.3	127.5	165.6	220.4	265.7	310.00

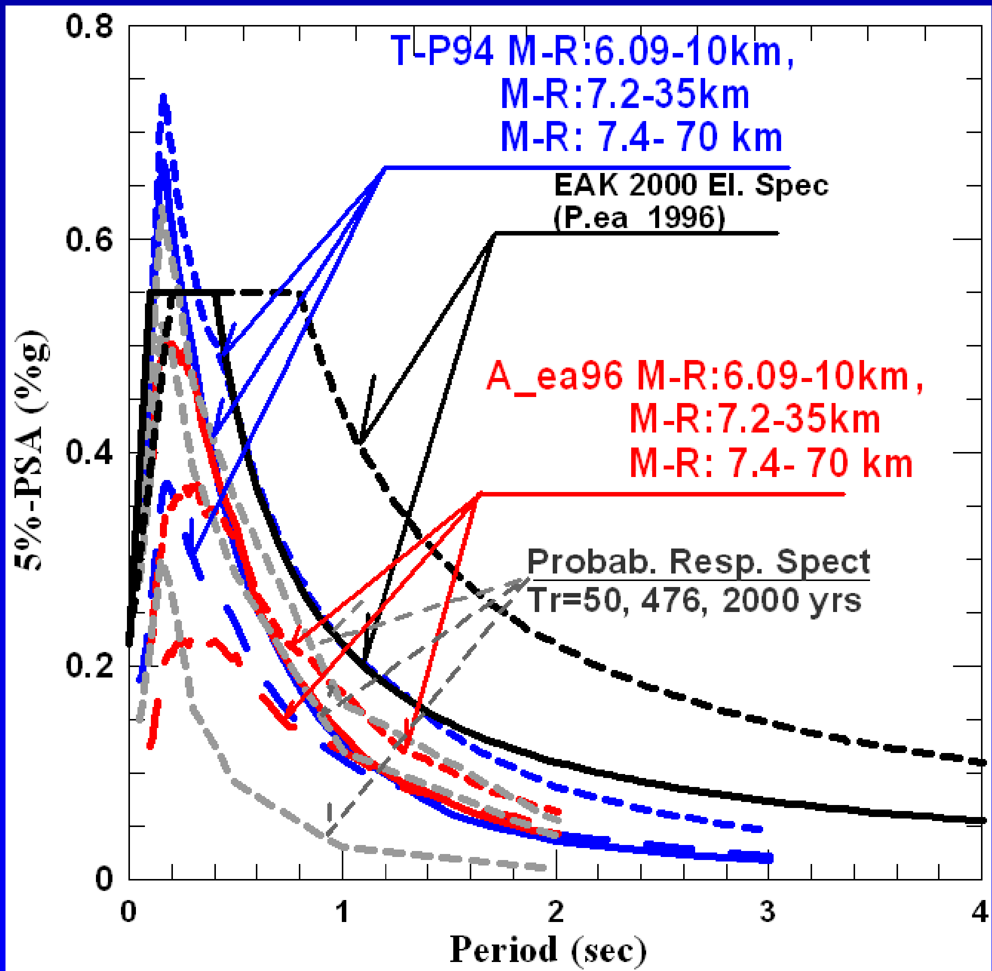
Tr(yrs) :	100	200	475	950	1890
Hazard (pdf) disaggregated in M, D and EPS M6.2					
PGA_INPUT(cm/s^2)	65.17	95.08	225.38	296.2	305.51
M*	6.05	6.05	6.05	6.05	6.15
D*(km)	15.00	15.00	15.00	15.00	3.00
Eps*	-0.0625	-0.0625	0.312	0.687	-0.0625
Hazard (pdf) disaggregated in M, D and EPS M6.7					
PGA_INPUT(cm/s^2)	93.99	218.52	376.48	480.18	523.72
M*	6.15	6.15	6.15	6.55	6.55
D*(km)	15.00	15.00	15.00	5.00	5.00
Eps*	-0.0625	0.0625	0.812	-0.0625	-0.0625

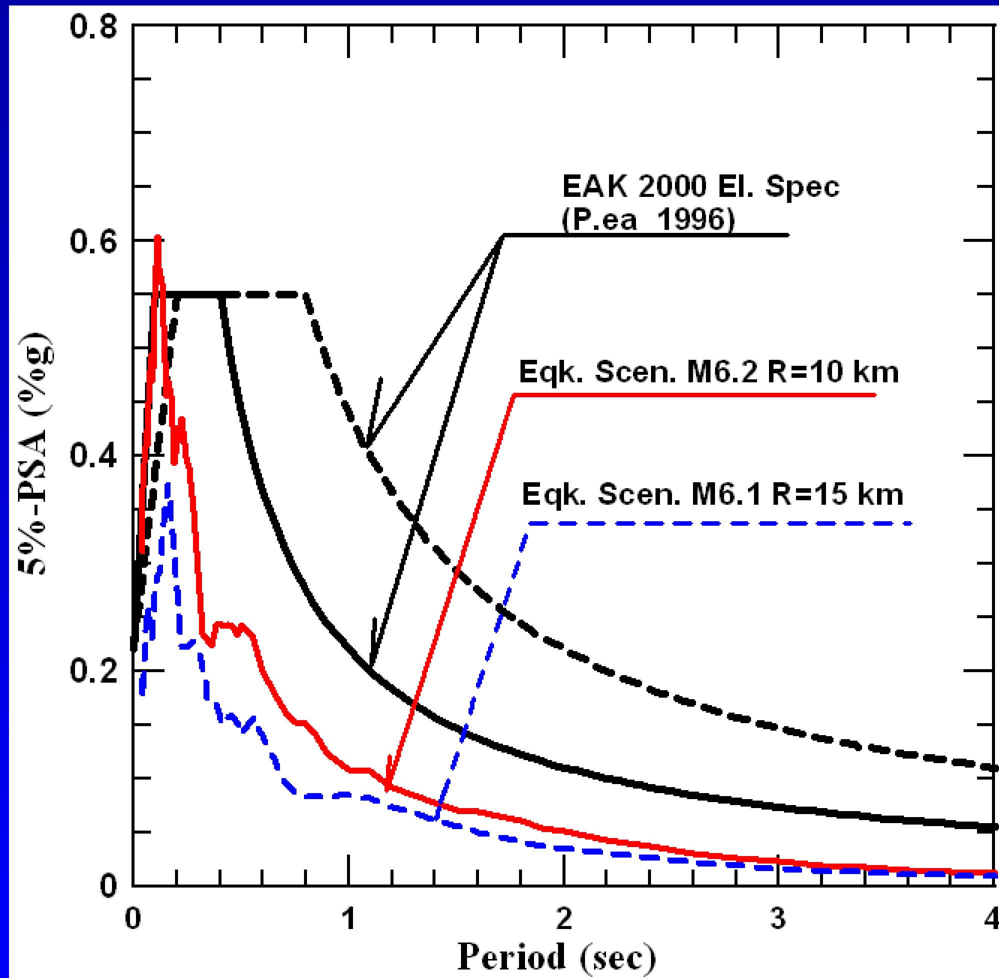
PSHA in Serres Site Greece & Design Response Spectra (Papazachos etal., 1996)





Response Spectral Comparison vs Design Spectra
(Papazachos etal., 1997: Margaris, 2013)



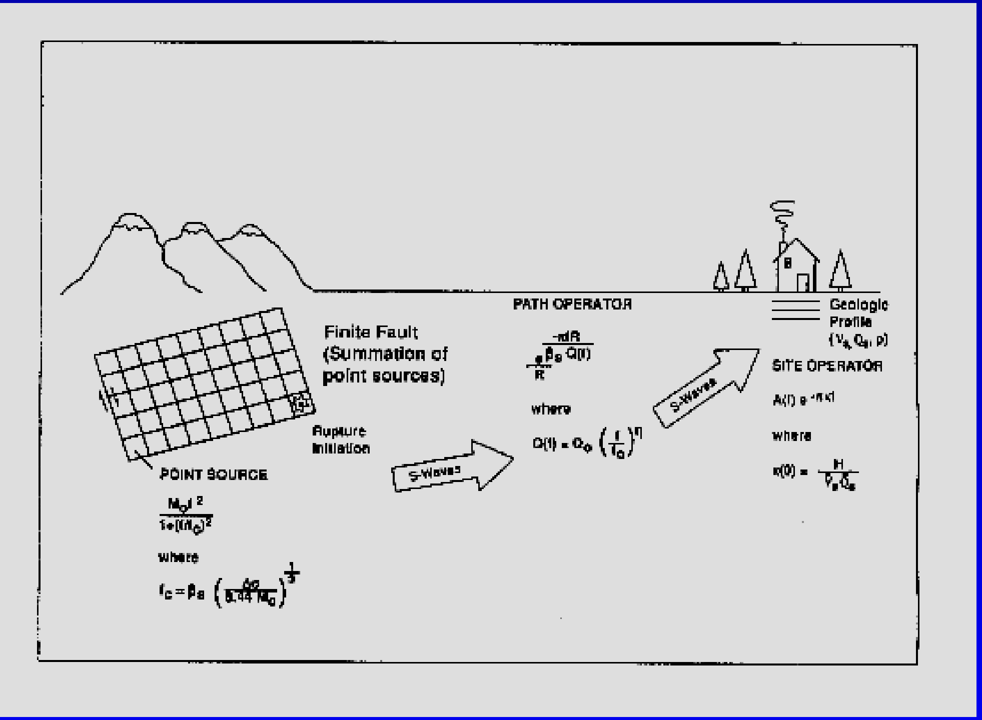


Strong Motion Stochastic Siumulation (PSM-FSM)

Methodology

1. Point Source Model (PSM)

(Hanks, 1979; McGuire & Hanks, 1981; Boore, 1983;Joyner,1984; Boore,1997; Margaris & Boore, 1998; Margaris 2002, Atkinson and Boore 2000, 2006, Boore etal., 2009, among others).



Description

Ground Motion Spectrum: $R(f) = C\ S(f)\ A(f)\ D(f)\ I(f)$

1. $C = (R_{\theta\varphi}\ F\ V) / (4\pi\rho_0\ \beta_0^3\ R)$ Scaling Factor

2. $S(f) = M_0 / [1 + (f/f_0)^2]$ Source Spectrum Factor

3. $A(f) = (\rho_0\beta_0 / \rho_r\beta_r)$ Amplification factor

4. $D(f) = [(-\pi\ f\ R)/(Q(f)\ \beta_0)]\ P(f)$ Diminuition factor

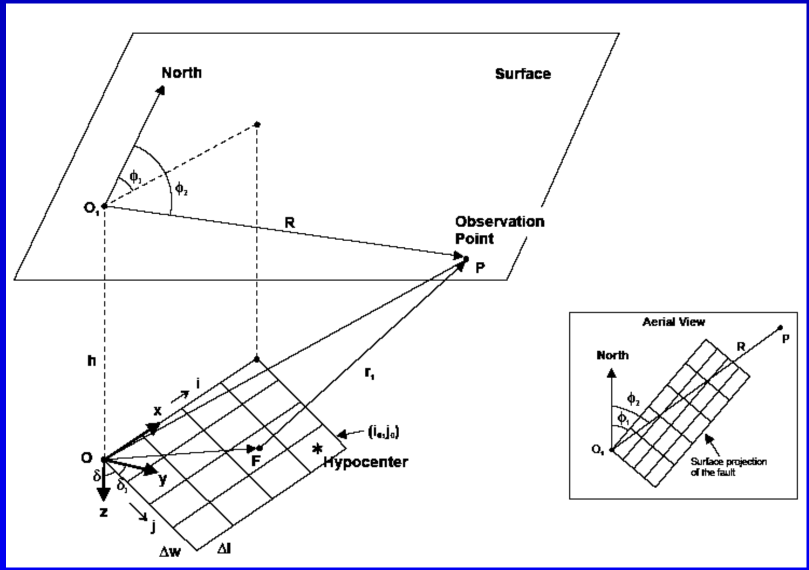
   $P(f) = \exp(-\pi\kappa_0 f)$ (Anderson and Hough, 1984)

5. $I(f) = (2\ \pi\ f)^n$ n=1,2 Παράγοντας Απόκρισης Οργάνου

Strong Motion Stochastic Siumulation (FSM: continued)

2. <u>Finite fault Model (FSM)</u>

(Beresnev and Atkinson, 1997; 1998a; 1998b; 1999; Atkinson and Silva, 1997; 2000, Margaris 2001; Boore 2009).



Description

$f_0 = (y\ z\ /\ \pi)\ \beta_0\ /\ \Delta l$ Corner Frequency

$m_0 = \Delta\sigma\ \Delta l^3$ Seismic Momment

$\log \Delta l = -2.0 + 0.4\ M$ Relation Fault length vs M

Basic Equations

$$f_0 = 4.9\ 10^6\ \beta_0\ (\Delta\sigma/M_0)^{1/3}$$

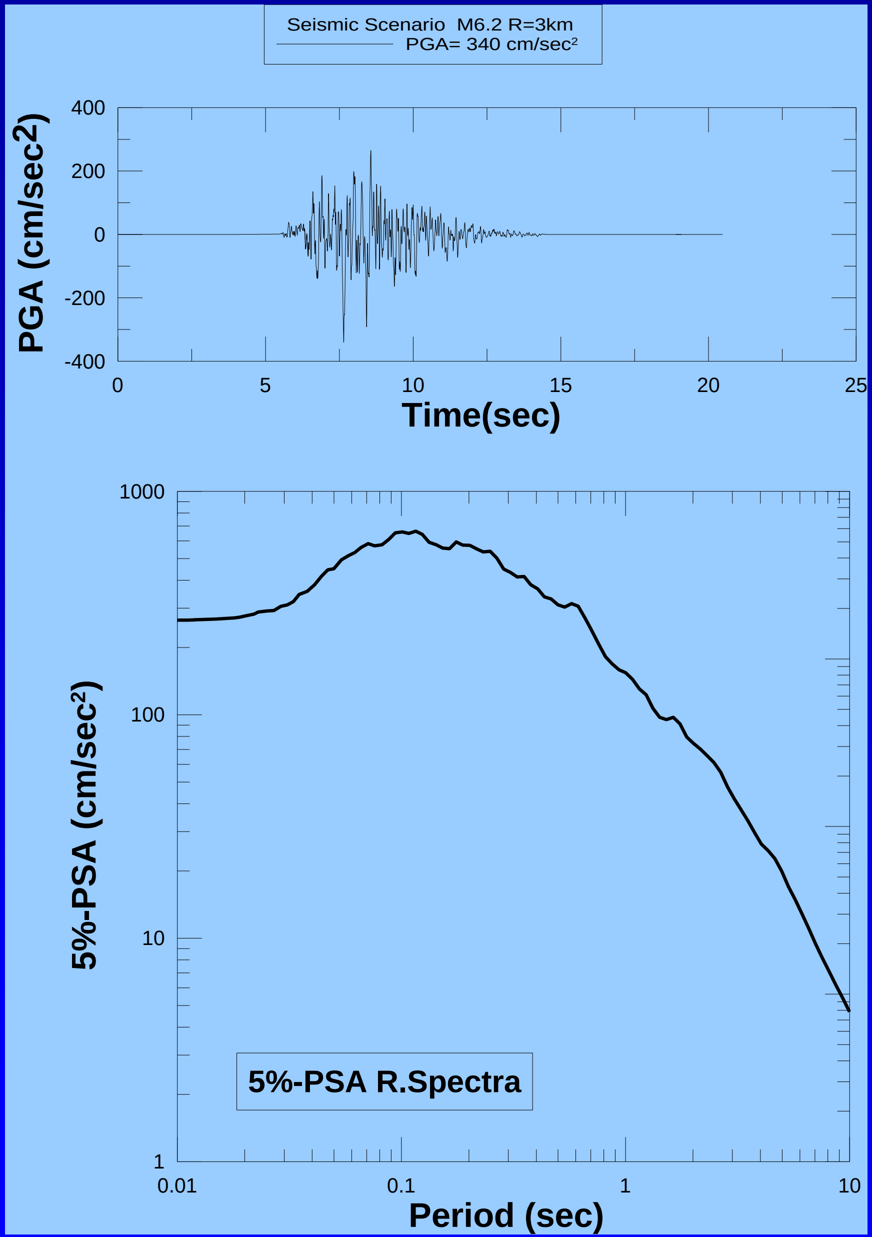
Corner Frequency (Brune, 1970)

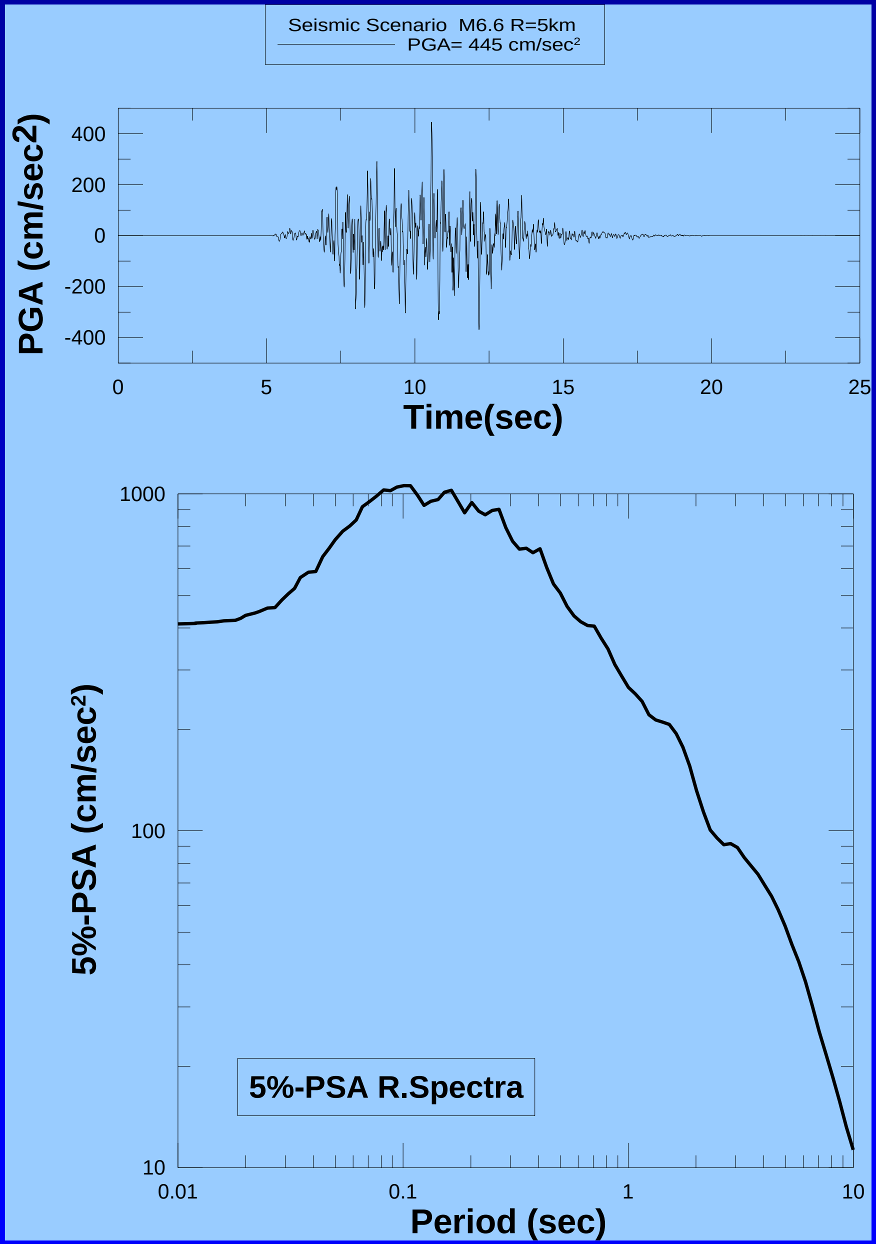
(Margaris & Hatzidimitriou 2002)

$$T_w = T_s + T_d\ (R)$$

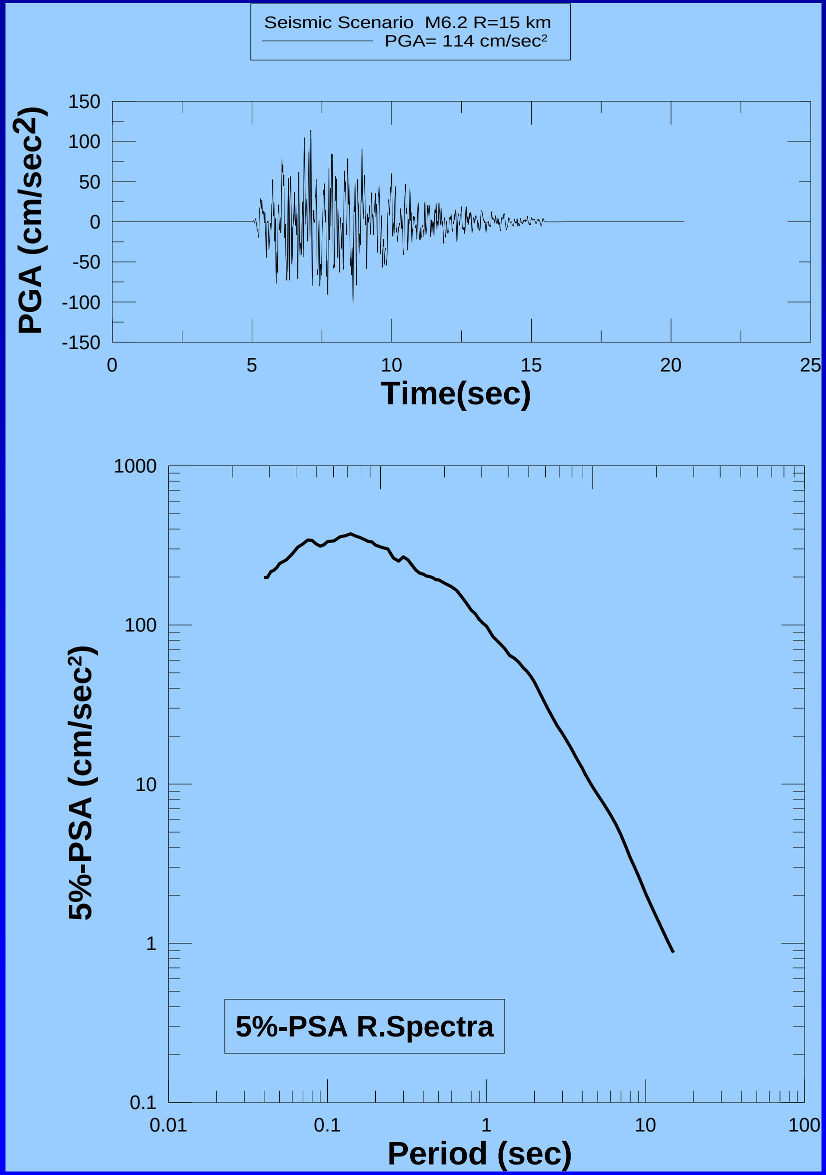
Duration (Hanks & McGuire, 1981; Herrmann, 1985; Atkinson, 1993)

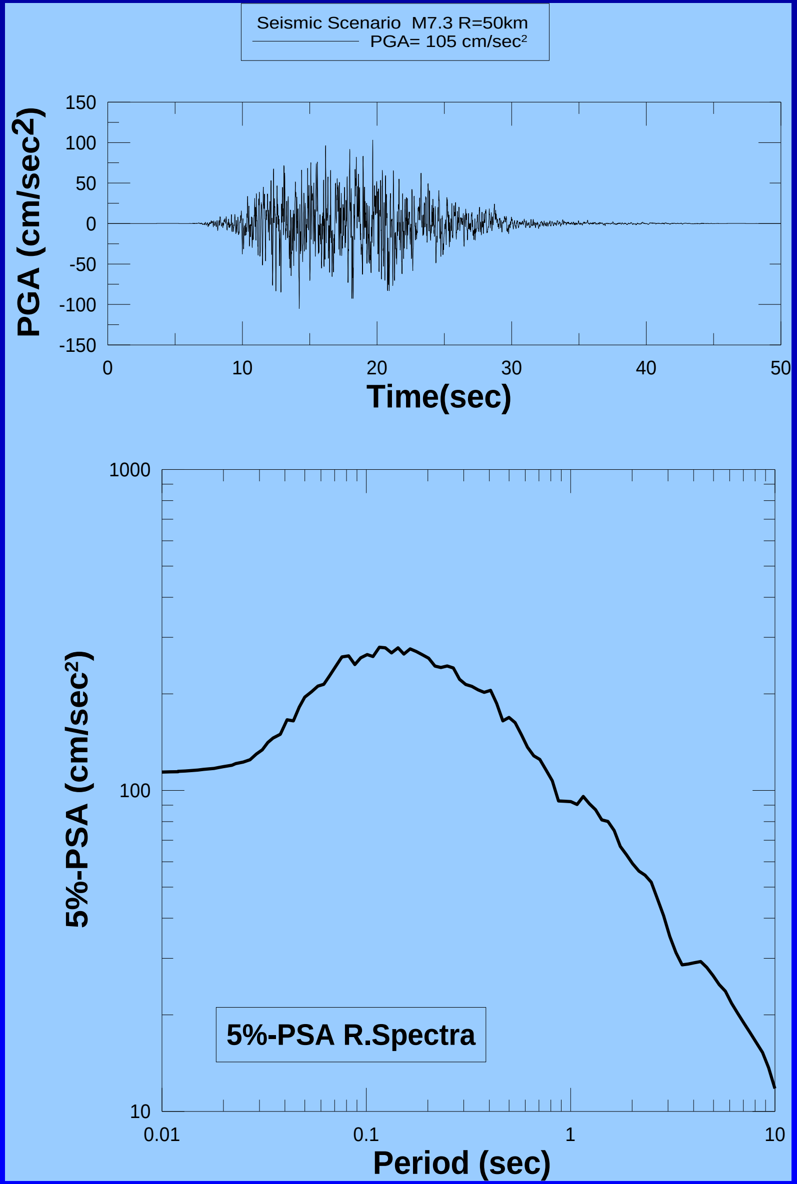
Strong Motion Stochastic Siumulation (FSM: continued)





Strong Motion Stochastic Siumulation (FSM: continued)





Thank you for your attention