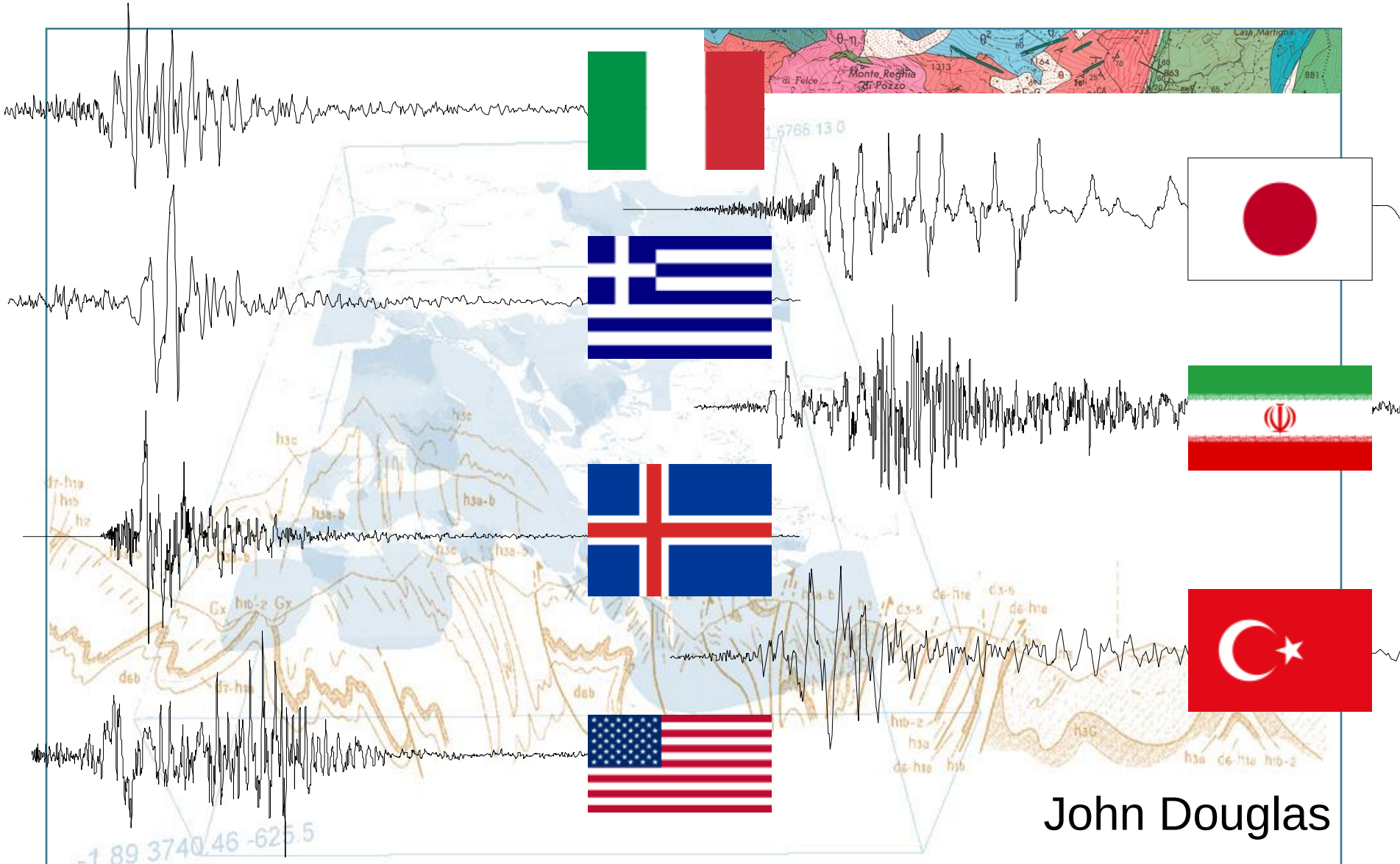


Does strong-motion data have a nationality?

Investigating regional dependency of earthquake ground motions

John Douglas

Géosciences pour une Terre durable
brgm

19th March 2014, Nicholas Ambraseys Memorial Symposium, London

Ground-motion prediction equations (example)

$$\log_{10}(PGA) = a_1 + a_2 M_w + (a_3 + a_4 M_w)\log_{10}\sqrt{(r_{jb}^2 + a_5^2)} + a_6 S_S + a_7 S_A + a_8 F_N + a_9 F_T + a_{10} F_O$$

Where:

PGA: peak ground acceleration

a_1 ... a_{10}: regression coefficients

M_w: moment magnitude

r_{jb}: Joyner-Boore distance in km

S_S and S_A site conditions: S_S = 1 for soft soil sites and 0 otherwise

S_A = 1 for

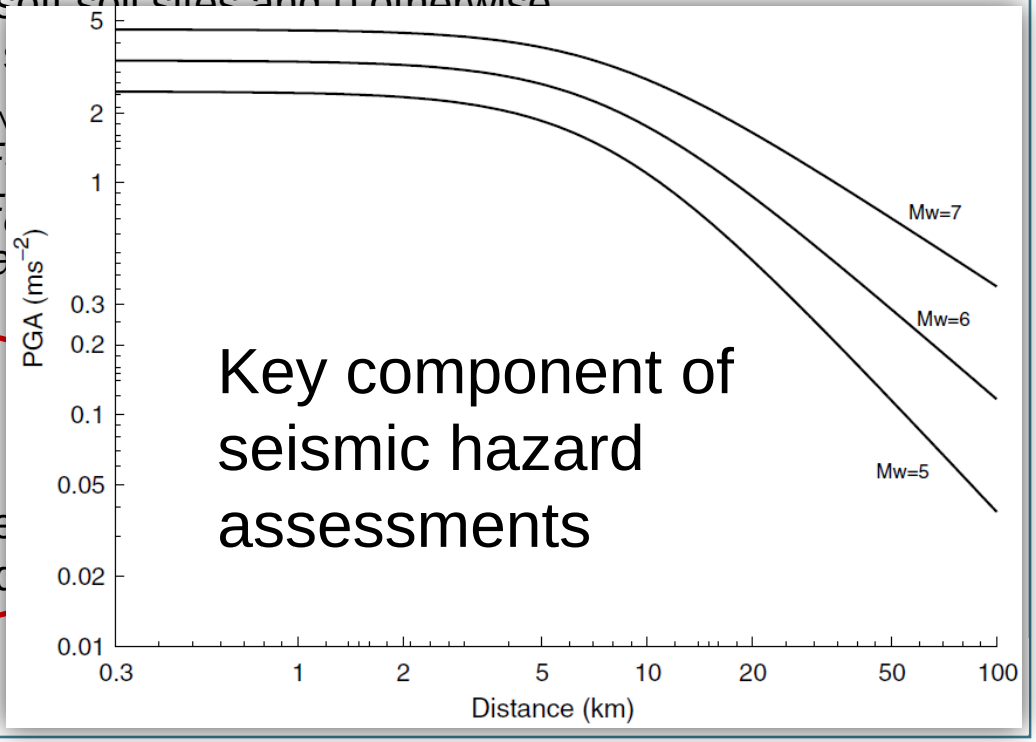
F_N, F_T and F_O faulting parameters: F_N

F

F

a

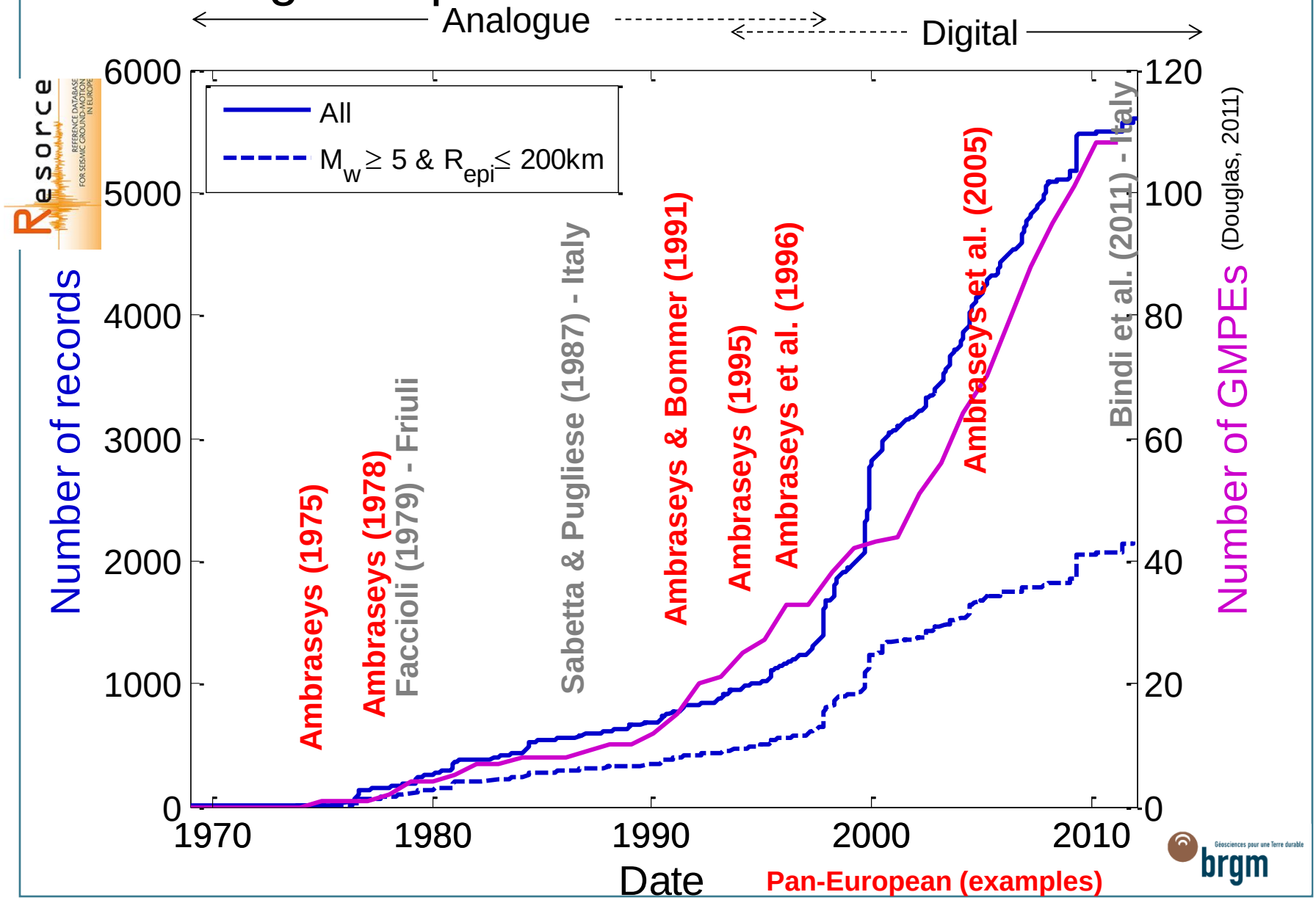
a_1 = 2.632 a_6 = 0.124 (soft soil)
a_2 = -0.109 a_7 = 0.070 (stiff soil)
a_3 = -2.990 a_8 = -0.033 (normal)
a_4 = 0.289 a_9 = 0.090 (thrust/reve
a_5 = 8.1 a_{10} = -0.039 (odd/oblic



Key component of seismic hazard assessments

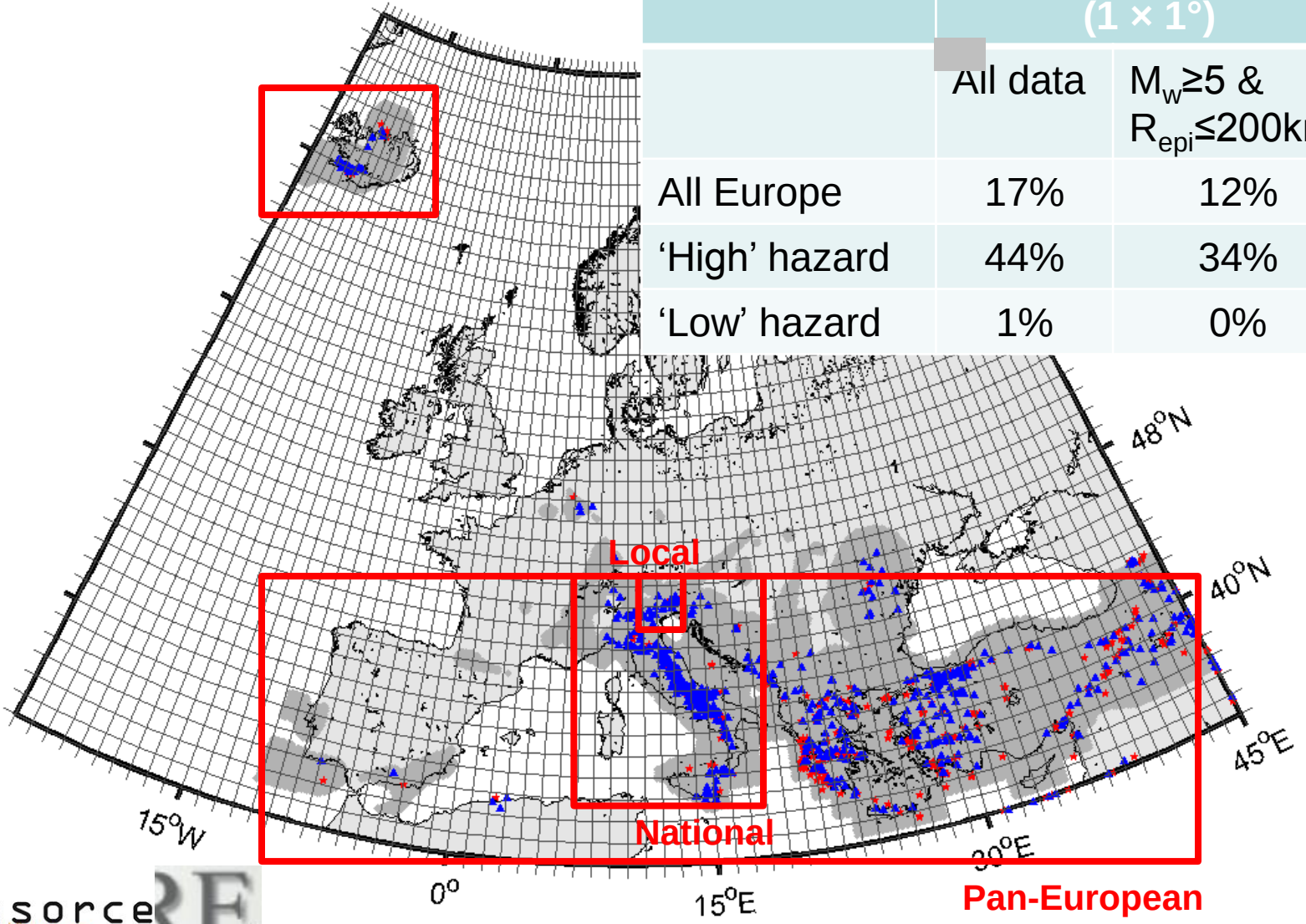
Ambraseys et al. (2005)

Increasing European data and GMPEs



Born of necessity

Zone	Station coverage (1 × 1°)	
	All data	$M_w \geq 5$ & $R_{epi} \leq 200$km
All Europe	17%	12%
'High' hazard	44%	34%
'Low' hazard	1%	0%



At present, there is **no doubt that these relations are different for different seismic regions**, and “region and site-specific” models should be developed on the basis of available strong ground motion records.

From Sokolov (2000)

We have found for peak accelerations remarkable agreement between Europe and western North America and we are as yet **unconvinced by apparent regional differences** such as are found in Central America and Japan.

From Ambraseys et al. (1997)

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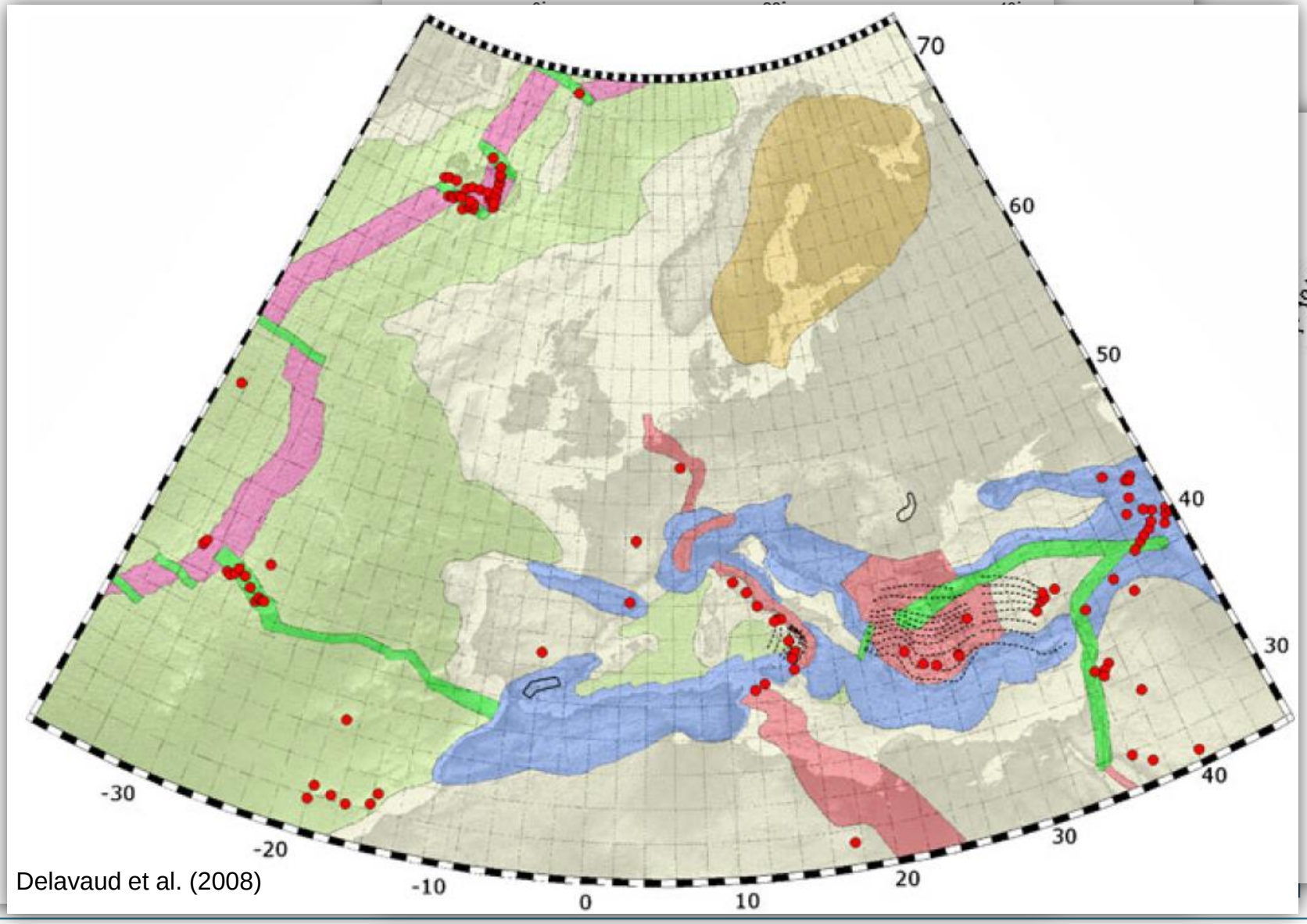
Seismotectonic arguments



Delavaud et al. (2008)

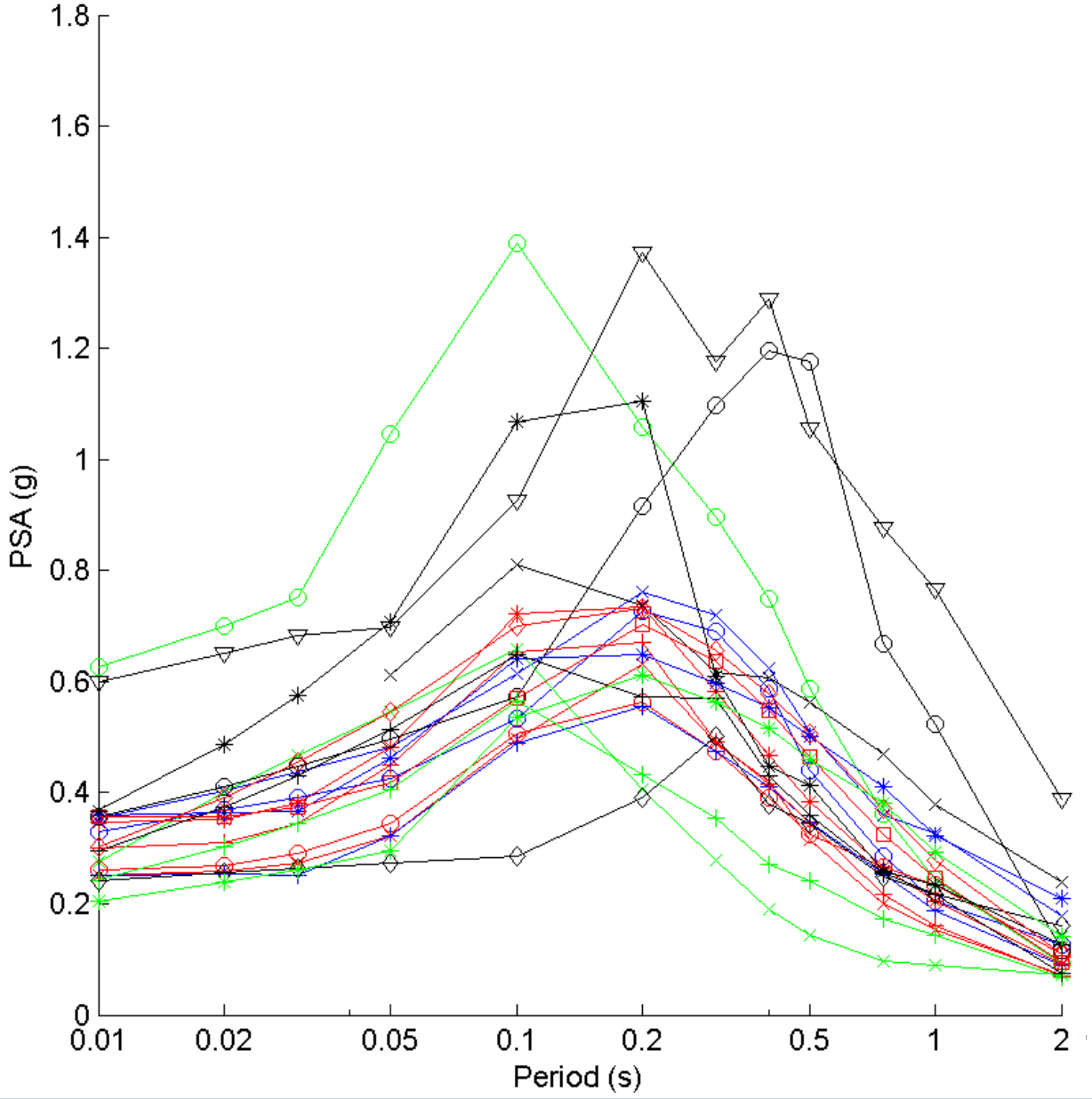
Comparing GMPEs

Japan

California

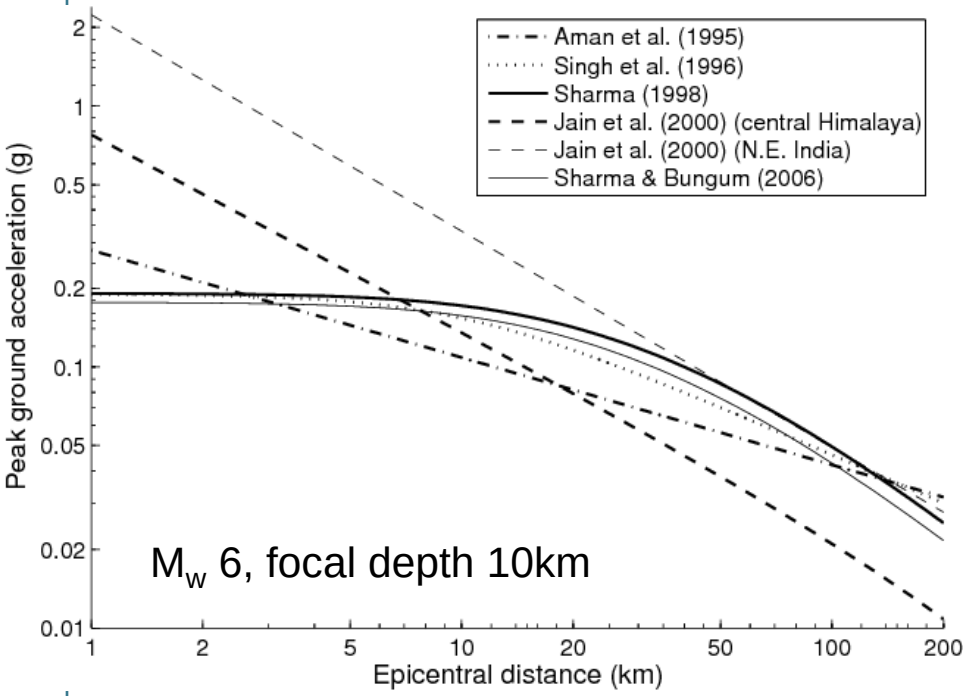
Europe/Middle East

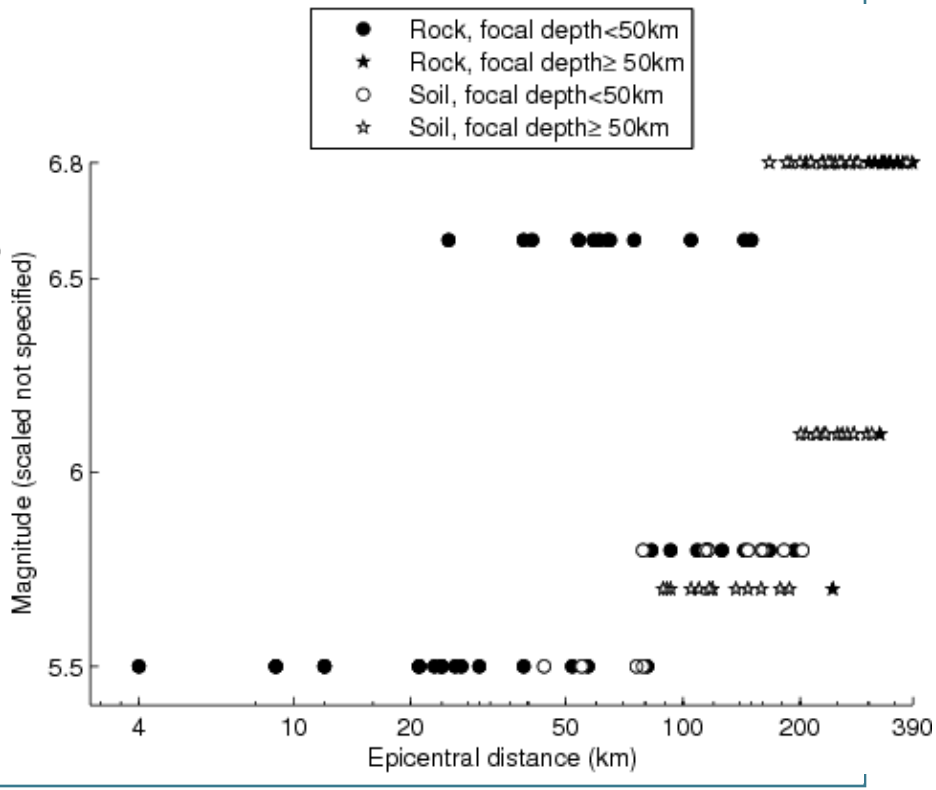
Local (Turkey, Italy, Greece, Iran & NZ)



M_w 7
r_{rup}=5km
r_{jb}=5km
r_{epi}=16.3km
r_{hypo}=22.1km
strike-slip

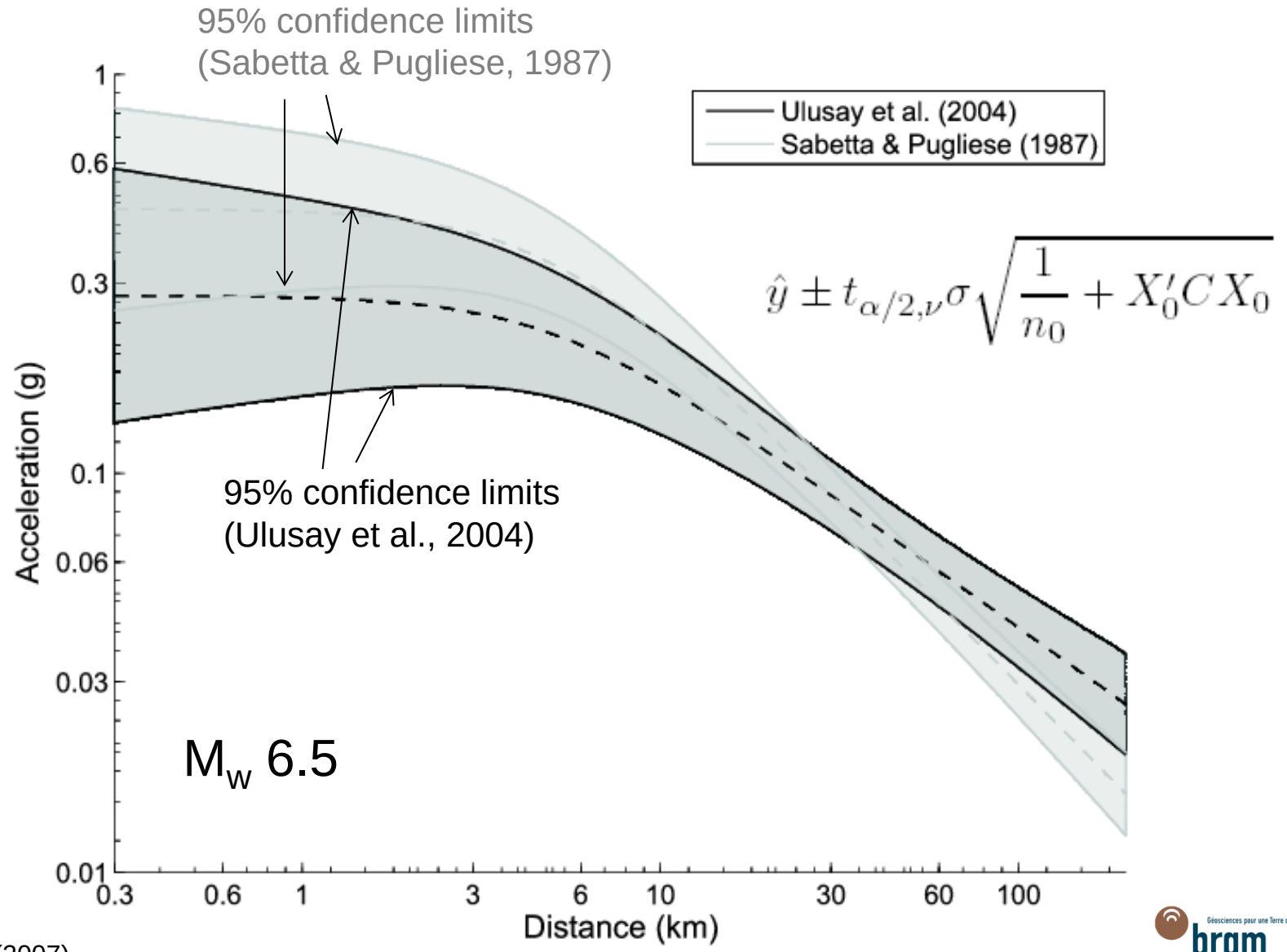
The problem with local models (intra-regional dependence)





Douglas (2007)

Turkey (Ulusay et al., 2004) v Italy (Sabetta & Pugliese, 1987)



Douglas (2007)

Comparing standard deviations of GMPEs

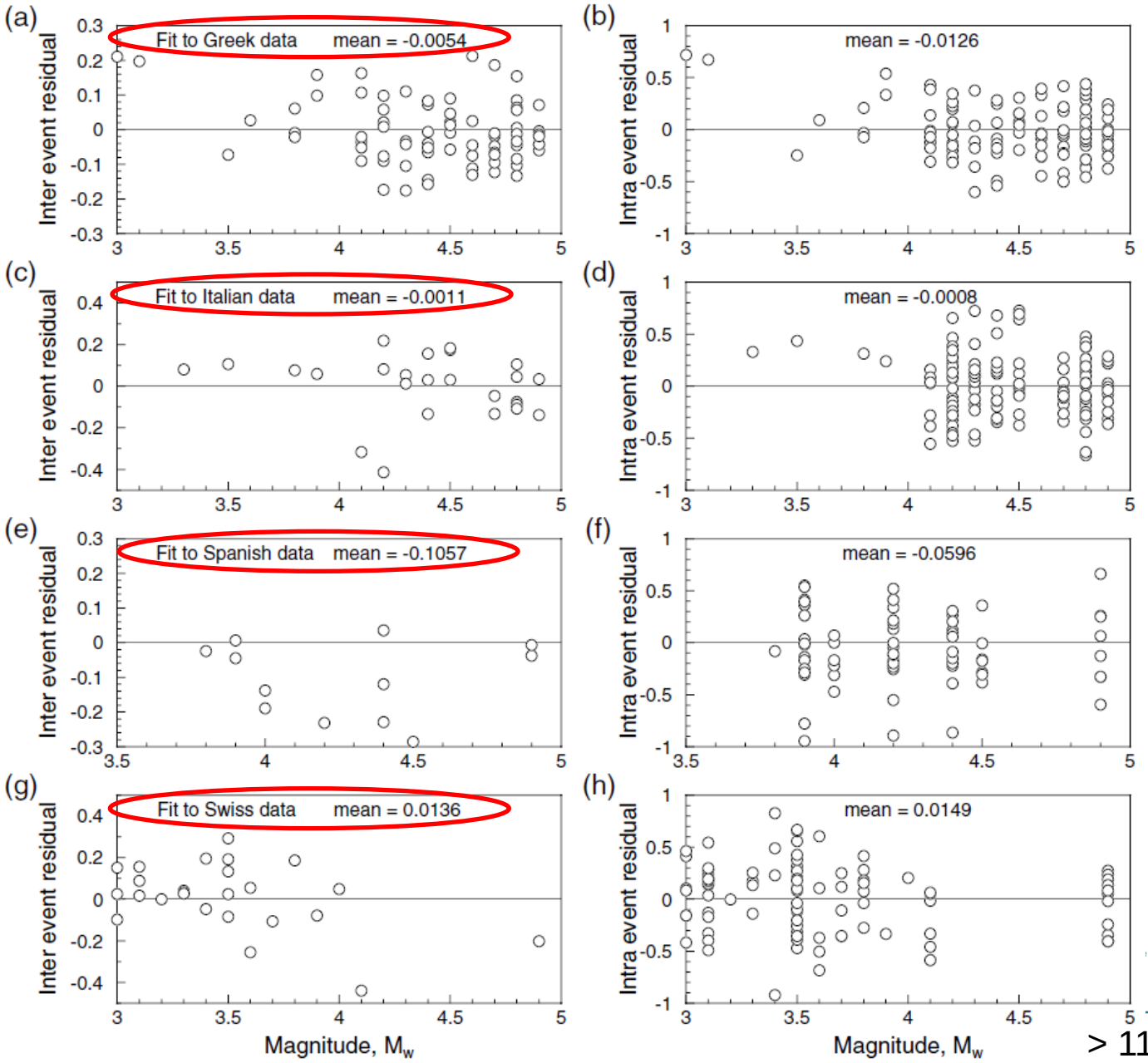
Small regions

Broad regions

Reference	Region			M range	d range (km)	σ
Bindi et al. (2006)	Umbria-Marche	239	45	$4.0 \leq M_L \leq 5.9$	$1 \leq d_e \leq 100$	0.27
Bragato and Slejko (2005)	Eastern Alps	1402	240	$2.5 \leq M_L \leq 6.3$	$0 \leq d_f \leq 130$	0.36
Costa et al. (2006)	Friuli	900	123	$3.0 \leq M_L \leq 6.5$	$1 \leq d_e \leq 100$	0.34
Frisenda et al. (2005)	NW Italy	6899	1152	$0.0 \leq M_L \leq 5.1$	$0 \leq d_h \leq 300$	0.32
Kalkan and Gülkan (2004)	Mainly NW Turkey	112	57	$4.0 \leq M_w \leq 7.4$	$1 \leq d_f \leq 250$	0.27
Luzi et al. (2006)	Molise	886	N/A	$2.6 \leq M_L \leq 5.7$	$5 \leq d_h \leq 55$	0.35
Marin et al. (2004)	France	63	14	$2.6 \leq M_L \leq 5.6$	$5 \leq d_h \leq 700$	0.55
Özbey et al. (2004)	NW Turkey	195	17	$5.0 \leq M_w \leq 7.4$	$5 \leq d_f \leq 300$	0.26
Sabetta and Pugliese (1987)	Italy	95	17	$4.6 \leq M_s, M_L \leq 6.8$	$1 \leq d_f \leq 179$	0.17
Zonno and Montaldo (2002)	Umbria-Marche			$4.5 \leq M_L \leq 5.9$	$2 \leq d_e \leq 100$	0.28
Abrahamson and Silva (1997)	Mainly California	655	58	$4.4 \leq M_w \leq 7.4$	$0 \leq d_r \leq 220$	0.19–0.31
Ambraseys et al. (1996)	Europe & Middle East	422	157	$4.0 \leq M_s \leq 7.9$	$0 \leq d_f \leq 260$	0.25
Ambraseys et al. (2005)	Europe & Middle East	595	135	$5.0 \leq M_w \leq 7.6$	$0 \leq d_f \leq 99$	0.19–0.36
Berge-Thierry et al. (2003)	Europe & Middle East	802	403	$4.0 \leq M_s \leq 7.9$	$4 \leq d_h \leq 330$	0.29
Boore et al. (1997)	Mainly California	271	20	$5.1 \leq M_w \leq 7.7$	$0 \leq d_f \leq 118$	0.23
Campbell and Bozorgnia (2003)	Mainly California	443	36	$4.7 \leq M_w \leq 7.7$	$2 \leq d_s \leq 60$	0.17-0.25
Joyner and Boore (1981)	Mainly California	182	23	$5.0 \leq M_w \leq 7.7$	$0 \leq d_f \leq 370$	0.26
Lussou et al. (2001)	Japan	3011	102	$3.7 \leq M_{\mathrm{JMA}} \leq 6.3$	$4 \leq d_h \leq 600$	0.32
Sadigh et al. (1997)	Mainly California	960	119	$3.8 \leq M_w \leq 7.4$	$0 \leq d_r \leq 305$	0.17–0.30
Spudich et al. (1999)	Worldwide extensional regimes	142	39	$5.1 \leq M_w \leq 7.2$	$0 \leq d_f \leq 99$	0.20

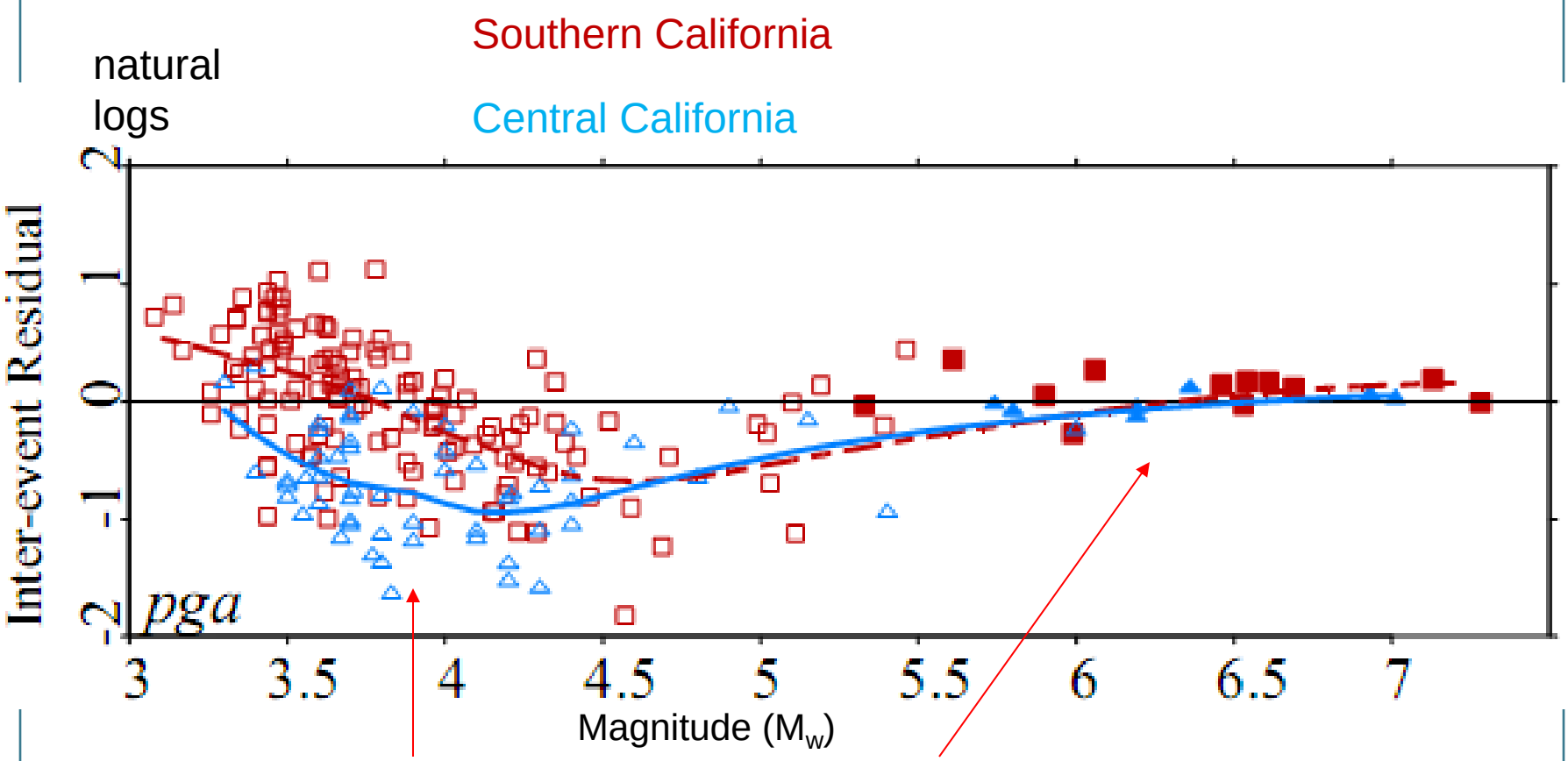
Douglas (2007)

Residuals with respect to model for broad region



Bommer et al. (2007)

True for weak motions → for strong motions too?

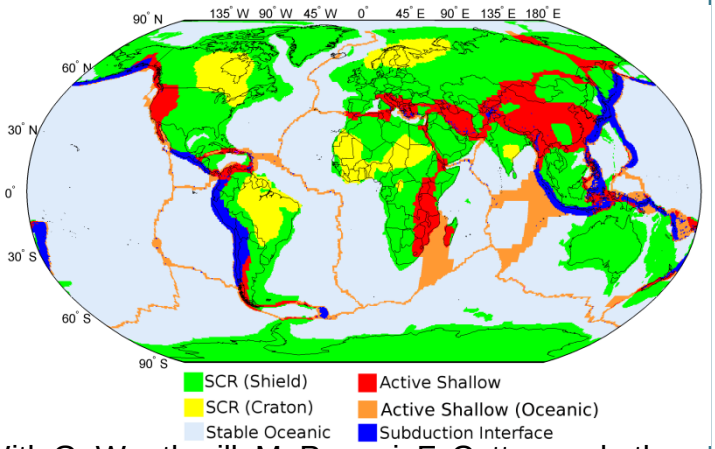


Chiou et al. (2010)

Some ways forward

> GEM Working Group on Tectonic Regionalization:

- Seek to develop global map of tectonic regimes
- Objectively combine evidence from various global resources:
  - Global plate boundary map
  - Global strain rate map
  - Global Q map
  - …



With G. Weatherill, M. Pagani, F. Cotton and others

> Better GMPEs

- Remove pseudo-regional dependency
- Models with regional (e.g. Q) terms (e.g. NGA West 2)

> Rapidly developing networks:

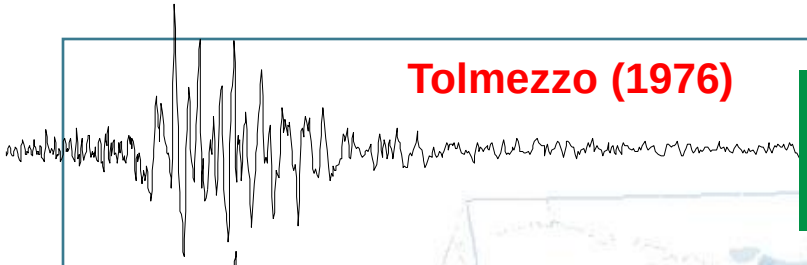
- Broadband networks
- Accelerometric networks
- Citizen observatories, e.g.:
  - Quake-Catcher (cheap MEMS accelerometers)
  - Did you feel it (macroseismic intensity)?

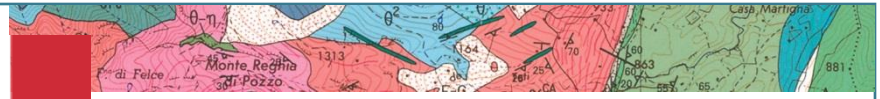
The verdict

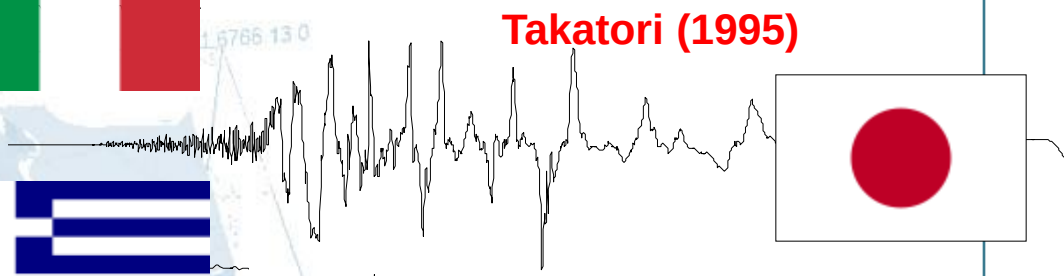
Not proven (the Scottish Verdict):

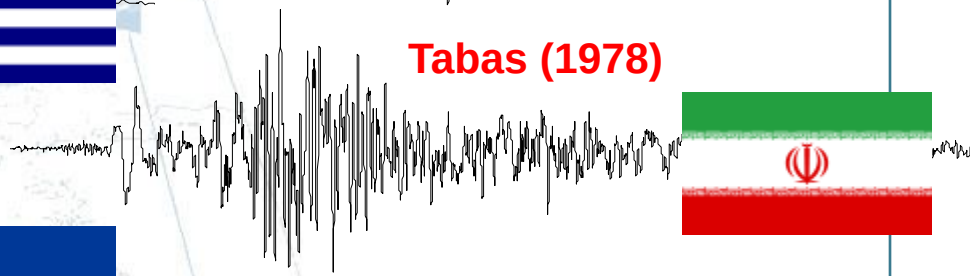
‘… the "not proven" verdict is an acquittal used when the judge or jury **does not have enough evidence to convict** but is **not sufficiently convinced of the accused person's innocence** to bring in a "not guilty" verdict.’ (Wikipedia)

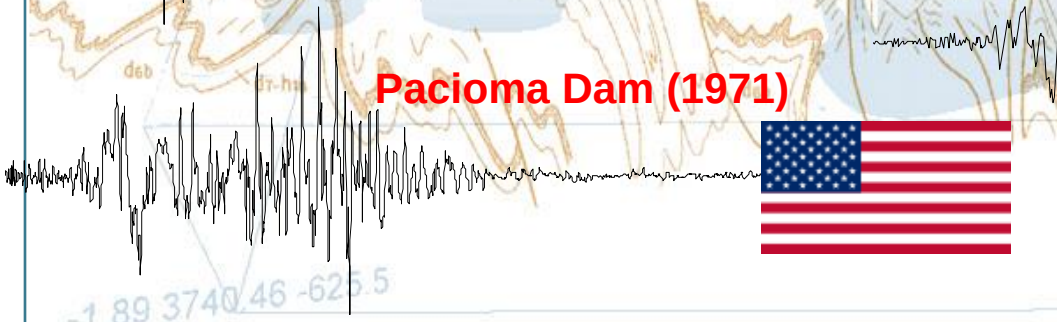
‘Doubt is an uncomfortable condition,
but certainty is a ridiculous one.’
‘Le doute n'est pas un état bien agréable,
mais l'assurance est un état ridicule.’
– Voltaire











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