Intensity and coseismic surface rupture parameters

Comerci V.*, Esposito E., Guerrieri L.*, Mohammadioun B.***, Mohammadioun J.***, Porfido S.**, Serva L.*, Vittori E.***

* APAT – Geological Survey of Italy, Roma, Italy
** CNR-IAMC, Napoli, Italy
*** Robinswood Consulting, France

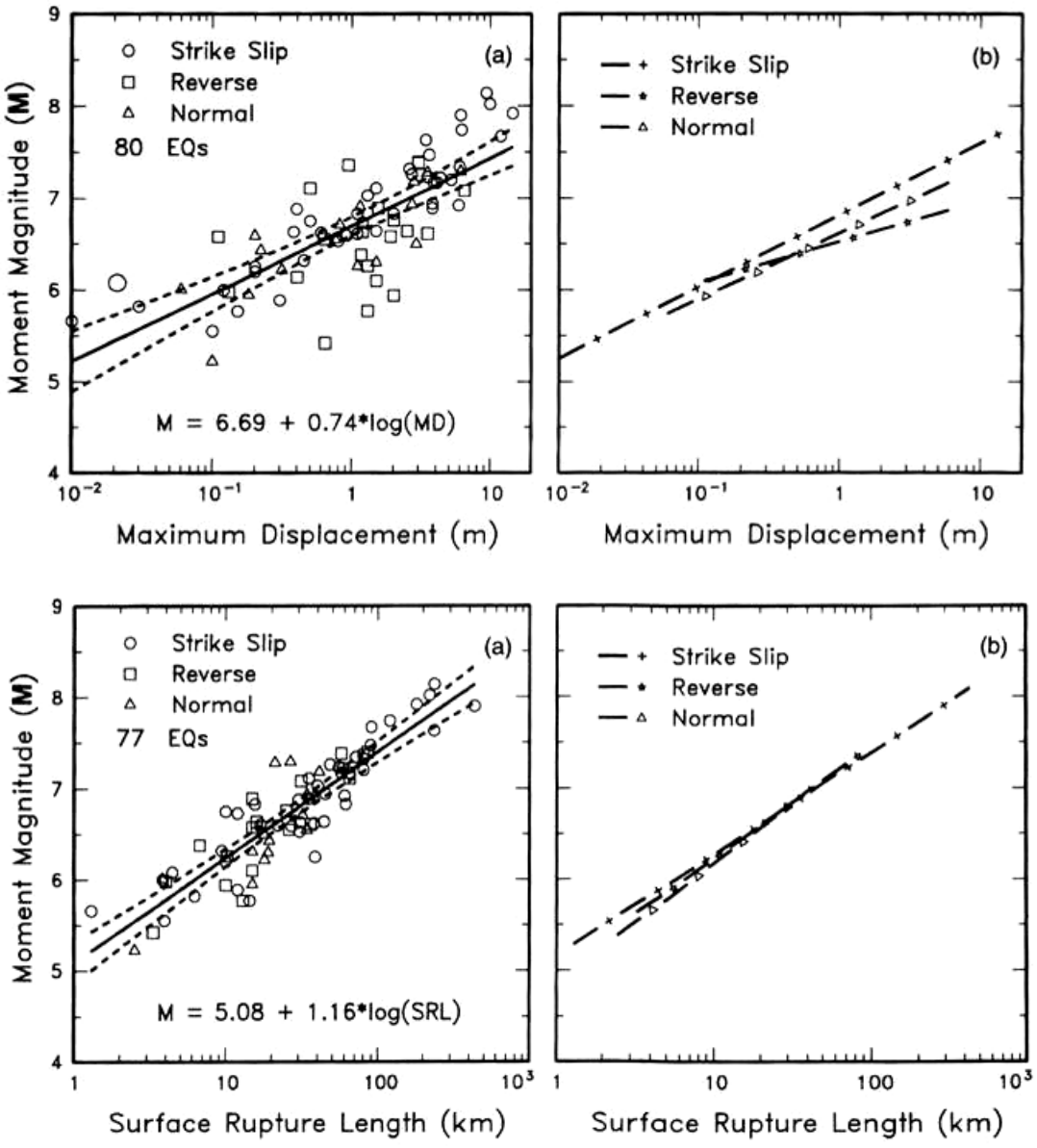
valerio.comerci@apat.it
APAT, Roma, Italy

Examples of recent compilations of earthquake surface rupture parameters

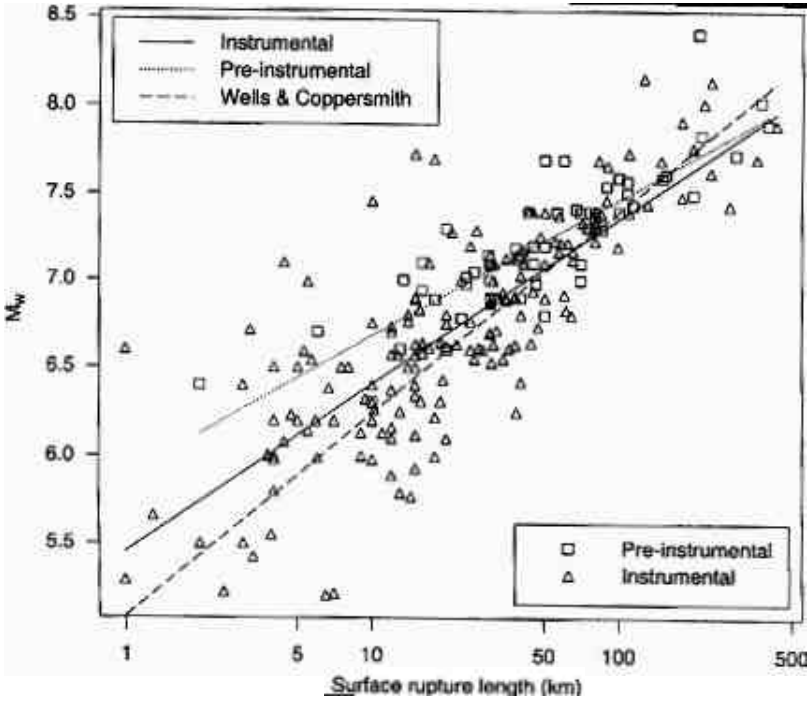
Pioneers: Bonilla et alii, 1984; Slemmons and DePolo, 1986

authors	Year	Number of eq
Wells and Coppersmith, BSSA	**1994**	**244**
Yeats, Sieh and Allen, The Geology of earthquakes, Oxford University Press	**1996**	**320**
Ambraseys and Jackson, Geophys. J. Int. (Eastern Mediterranean region)	**1998**	**150**
Strom, PhD thesis, unpublished (many former USSR and central Asia events)	**1998**	**302**
Stirling, Rhoades and Berryman, BSSA	**2002**	**389**
Pavlides and Caputo, Tectonophysics (Egean region)	**2004**	**60**

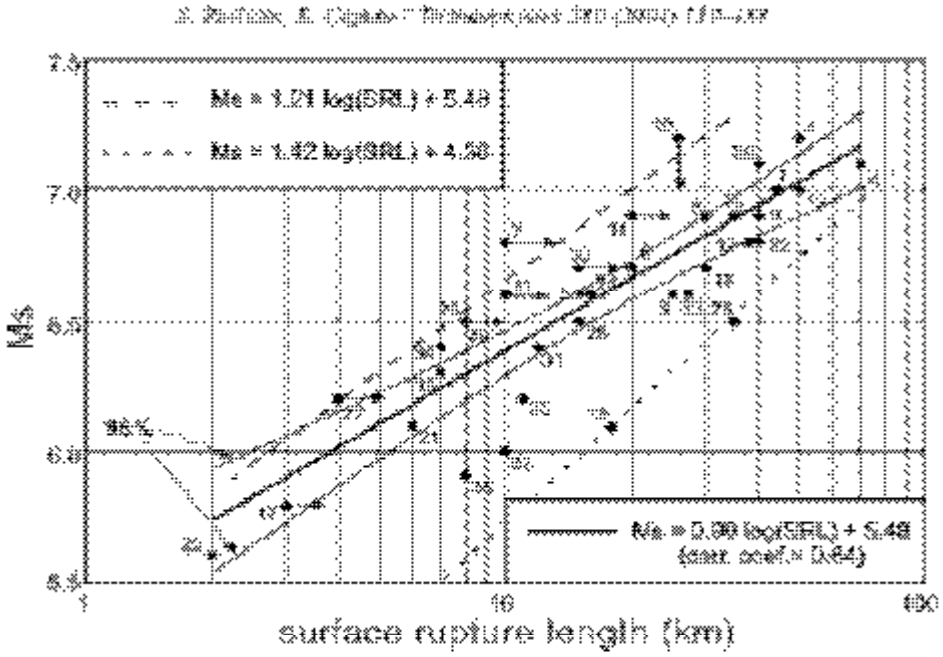
Wells and Coppersmith, BSSA, 1994

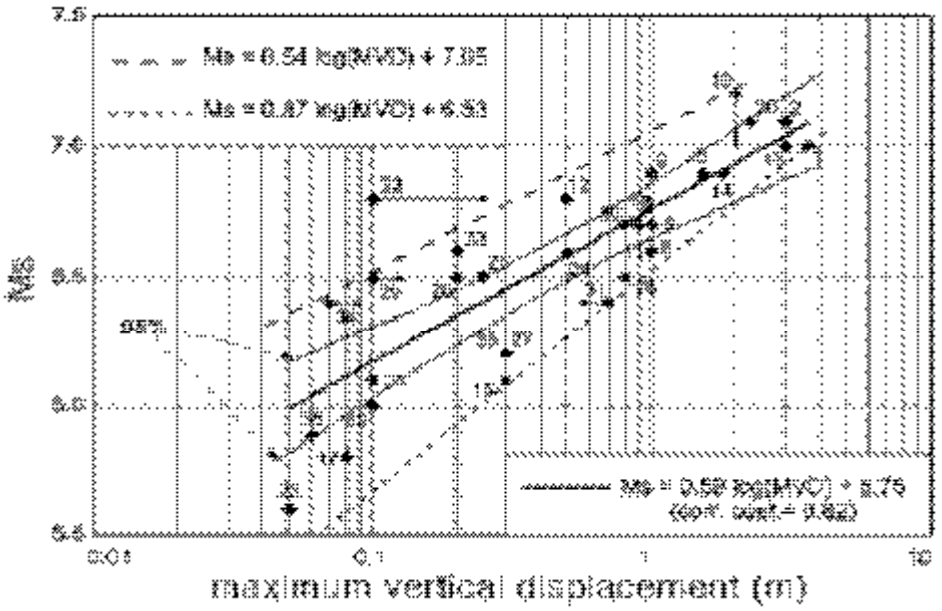


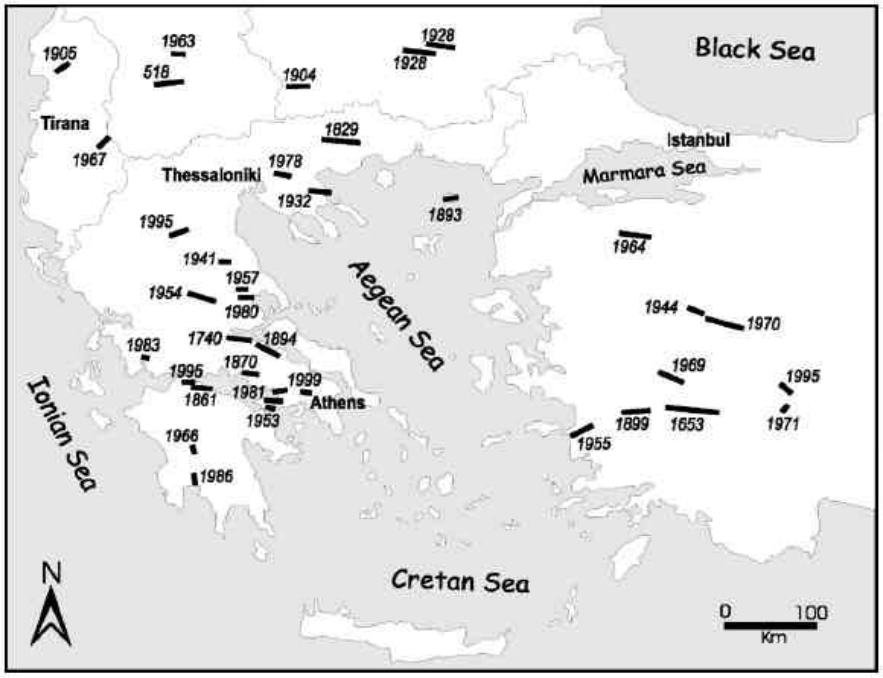
Stirling et alii, BSSA, 2002



Examples of regression analyses of rupture parameters vs. Magnitude


Ms
surface rupture length (km)


Ms
maximum vertical displacement (m)


Black Sea
Tirana
Thessaloniki
Istanbul
Marmara Sea
Aegean Sea
Ionian Sea
Athens
Cretan Sea
N
0
100
Km

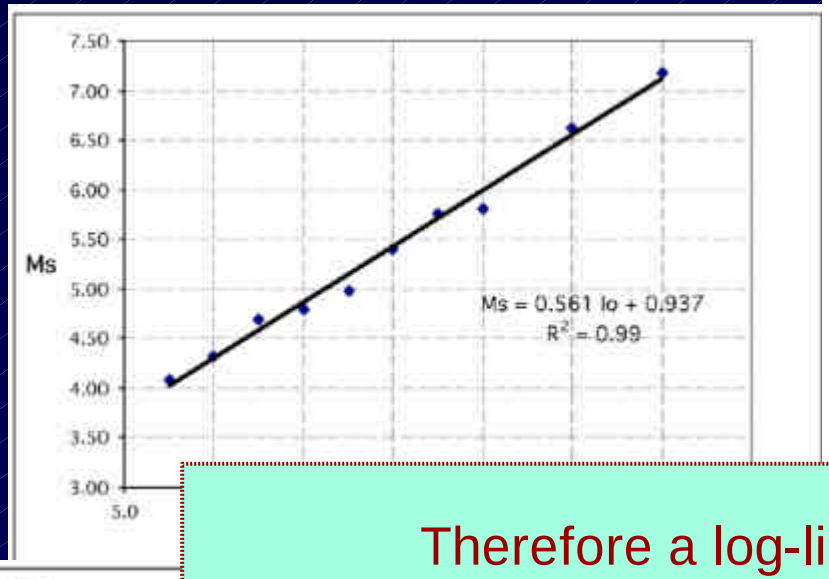


Tabella 4
Valori medi di Ms per classi di Io (*r.m.s. medio* 0.46)

Io	Ms media	*r.m.s.*	*N dati*	*Ms calc*
V-VI				
VI				
VI-VII				
VII				
VII-VIII				
VIII				
VIII-IX				
IX				
IX-X				
X				
X-XI				
XI				

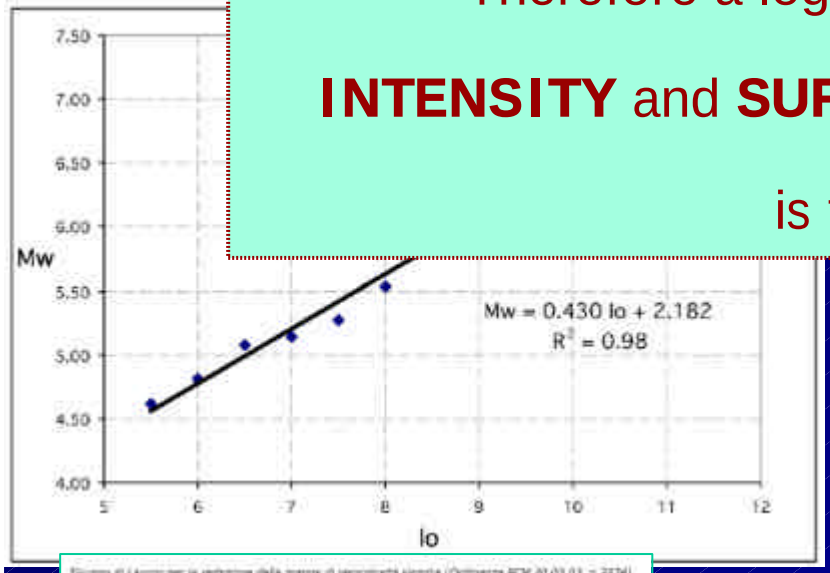
Tabella 3
Valori medi di Mw per classi di Io (*r.m.s. medio* 0.34)

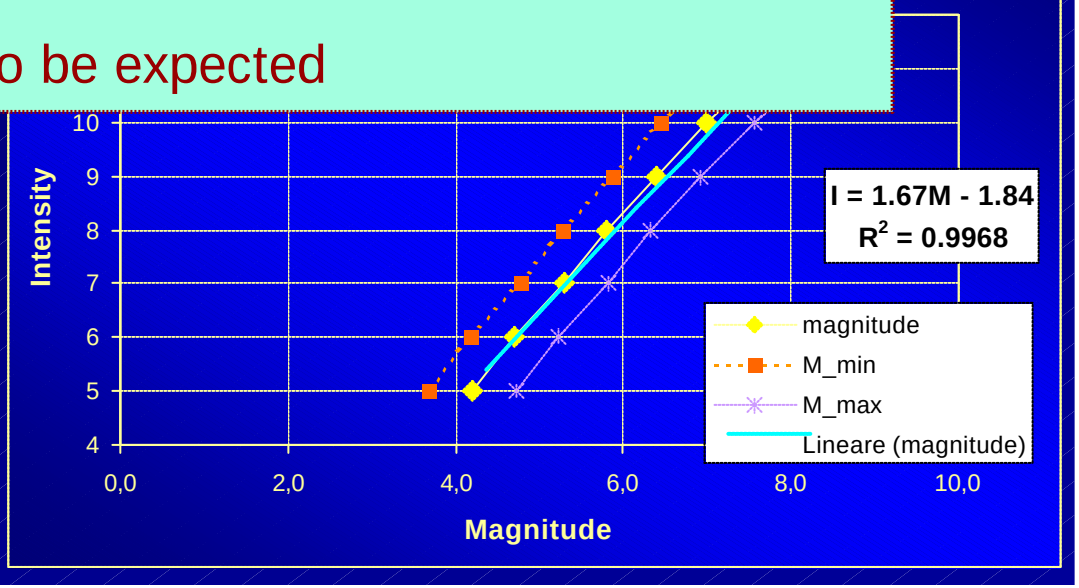
Io	Mw media	*r.m.s.*	*N dati*	*Mw calc*
V-VI	4.62	0.40	32	4.55
VI	4.81	0.37	182	4.76
VI-VII	5.07	0.34	18	4.98
VII	5.14	0.35	52	5.19
VII-VIII	5.27	0.38	20	5.41
VIII	5.54	0.43	24	5.62
VIII-IX	5.86	0.16	3	5.84
IX	5.90	0.39	7	6.05
IX-X	n.d.	n.d.	n.d.	6.27

Therefore a log-linear relationship between

INTENSITY and **SURFACE RUPTURE PARAMETERS**

is to be expected





Catalogo dei terremoti CPTI2 – App.1 al Rapporto Conclusivo

a cura di P. Gasperini (marzo 2004)
con contributi di R. Camassi, C. Meletti e M. Stucchi
e con la collaborazione di A. Azzaro, F. Bernardini, C. Chiarabba, E. Ercolani, I. Leschiutta, C. Meletti, G. Selvaggi e della società SGA

SURface Faulting and INtensity dataset

SURFIN

AIM To link fault parameters and epicentral intensity (Io)

Parameters

Date and epicentral area name

Latitude and Longitude

Kinematics

Focal depth

Magnitude (Ms)

Intensity (MM)

Surface Rupture Length (SRL)

Maximum Displacement (MD)

Data Sources

- Original documents
- Scientific papers and reports
- Other databases

Conversions

Different intensities scaled to MM.

For pre-instrumental events Magnitude scaled from Intensity with several methods, sometimes from rupture parameters

MAIN DIFFICULTY **To obtain reliable input data (I_0,SRL,MD)**

SURface Faulting and INtensity dataset

SURFIN

AIM To link fa

Parameters

Date and epice

Latitude and Longitude

Kinematics

Focal depth

Magnitude (Ms)

Intensity (MM)

Surface Rupture Length (SR

Maximum Displacement (MD

MAIN DIFFICULTY

Output

ESI 2007 values

papers and reports

bases

sities scaled to MM.

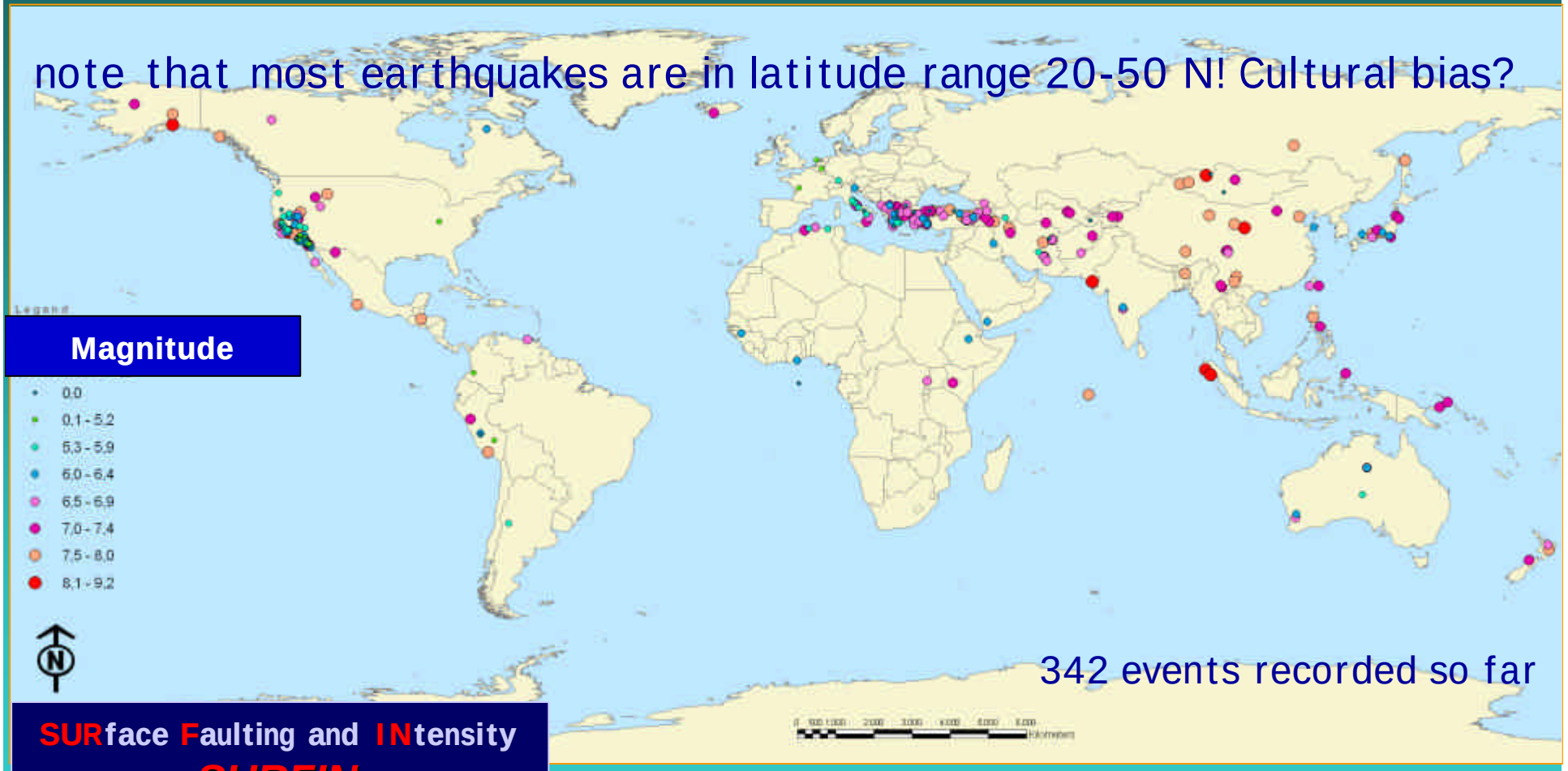
mental events Magnitude

ensity with several methods,

m rupture parameters

nput data (I_0,SRL,MD)

Distribution of earthquakes with known Intensity and surface rupture parameters

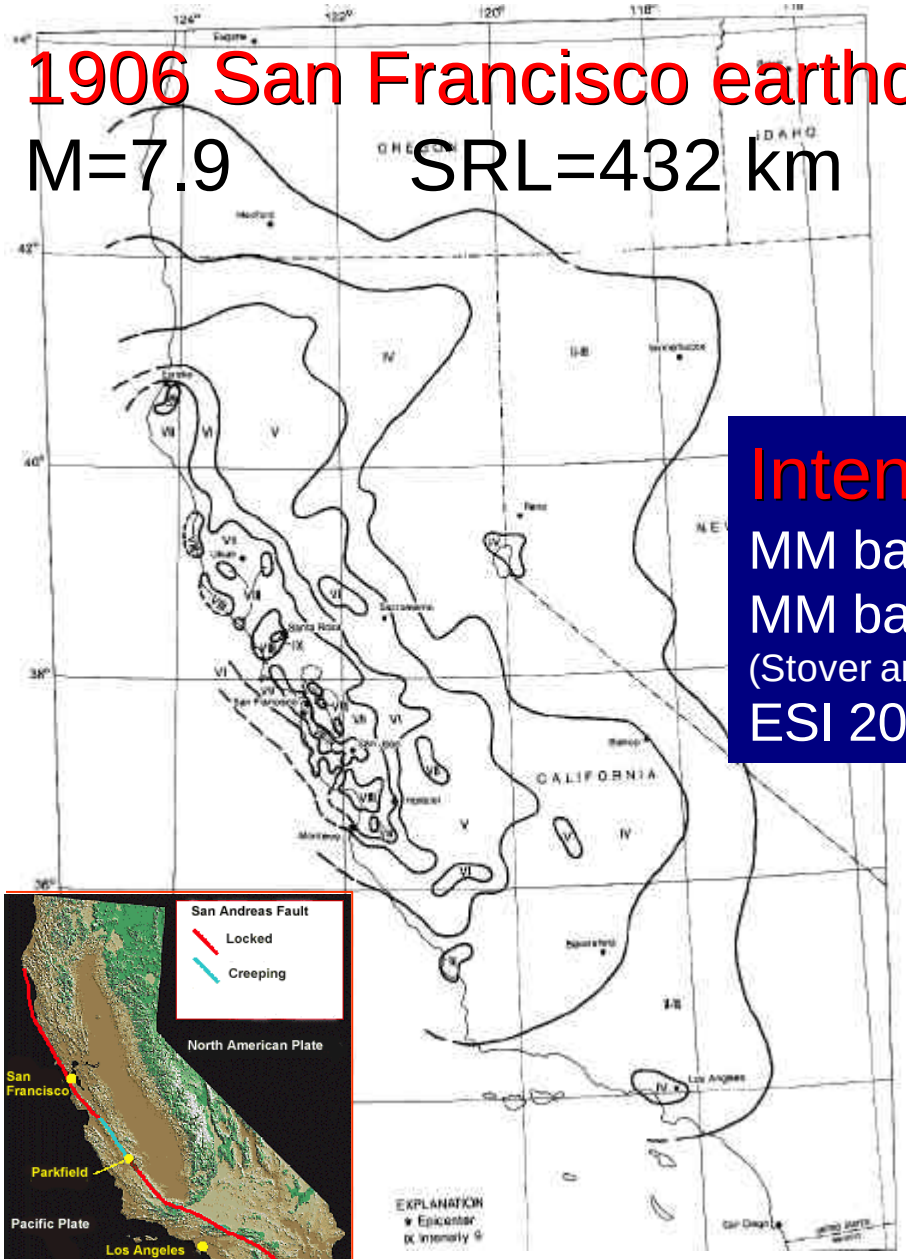


SURface Faulting and INtensity

SURFIN

1906 San Francisco earthquake

M=7.9 SRL=432 km MD=6.4



Intensity

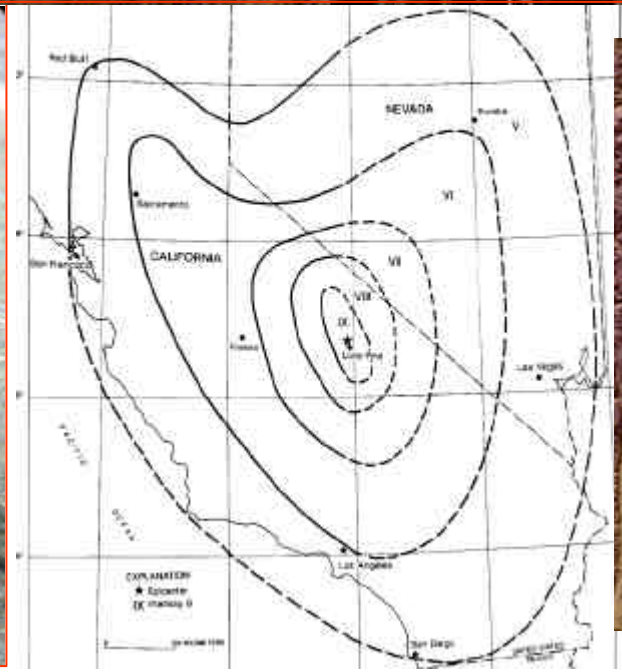
MM based on damage	IX
MM based on geologic effects	XI
(Stover and Coffman, 1993)	
ESI 2007	XII

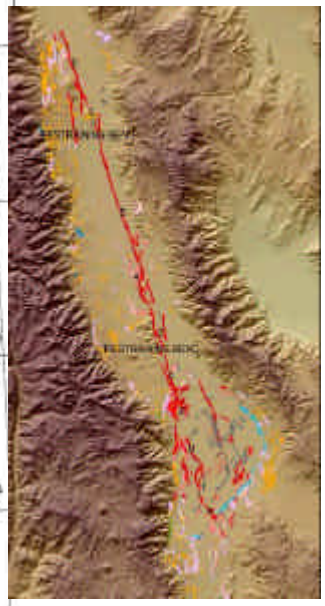
26.03.1872 Owens Valley (California, USA)

M=7.6 SRL>110 km MD=10m

Intensity

MM (based on damage)	IX
ESI 2007	XI





7.12.1988 Spitak (Armenia)

M=6.8

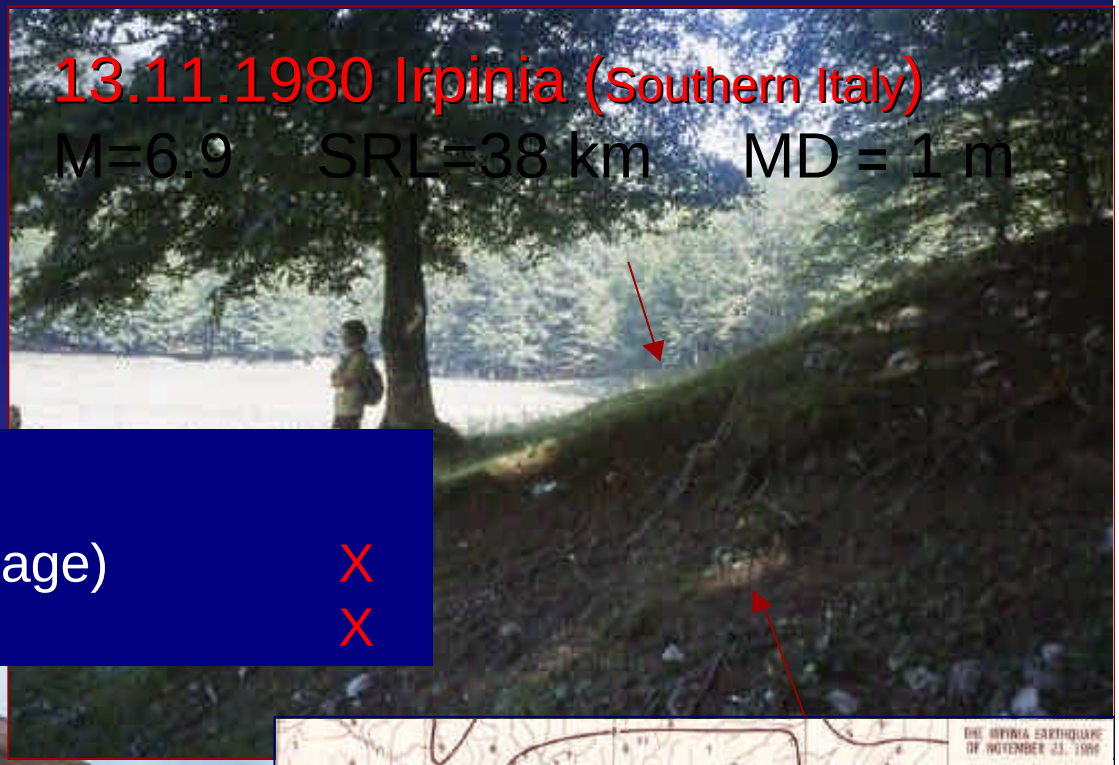
SRL=25 km

MD=2 m

Intensity

MSK (based on damage)	X
ESI 2007	X


16.07. 1990 Luzon (Philippines)
M=7.7 SRL=120 km MD=6.2 m
Intensity
based on damage very difficult (sparsely populated area)
ESI 2007 XI
Courtesy of Takashi Nakata

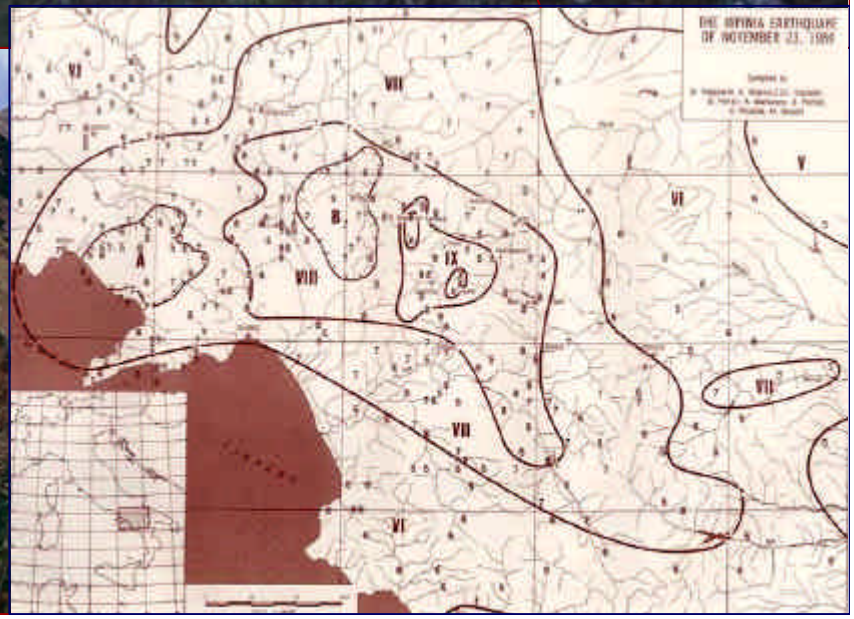


13.11.1980 Irpinia (Southern Italy)

M=6.9 SRL=38 km MD = 1 m

Intensity

MCS (based on damage)	X
ESI 2007	X

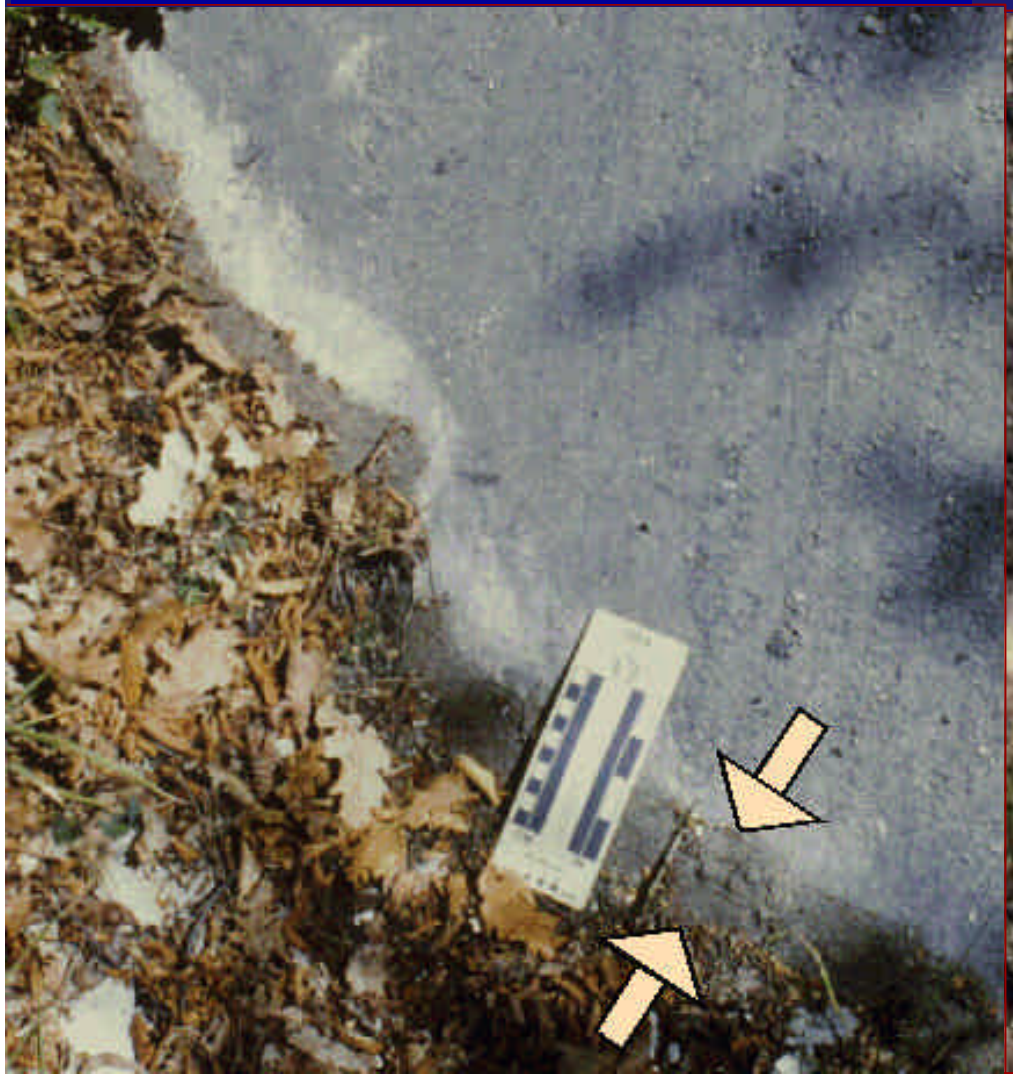


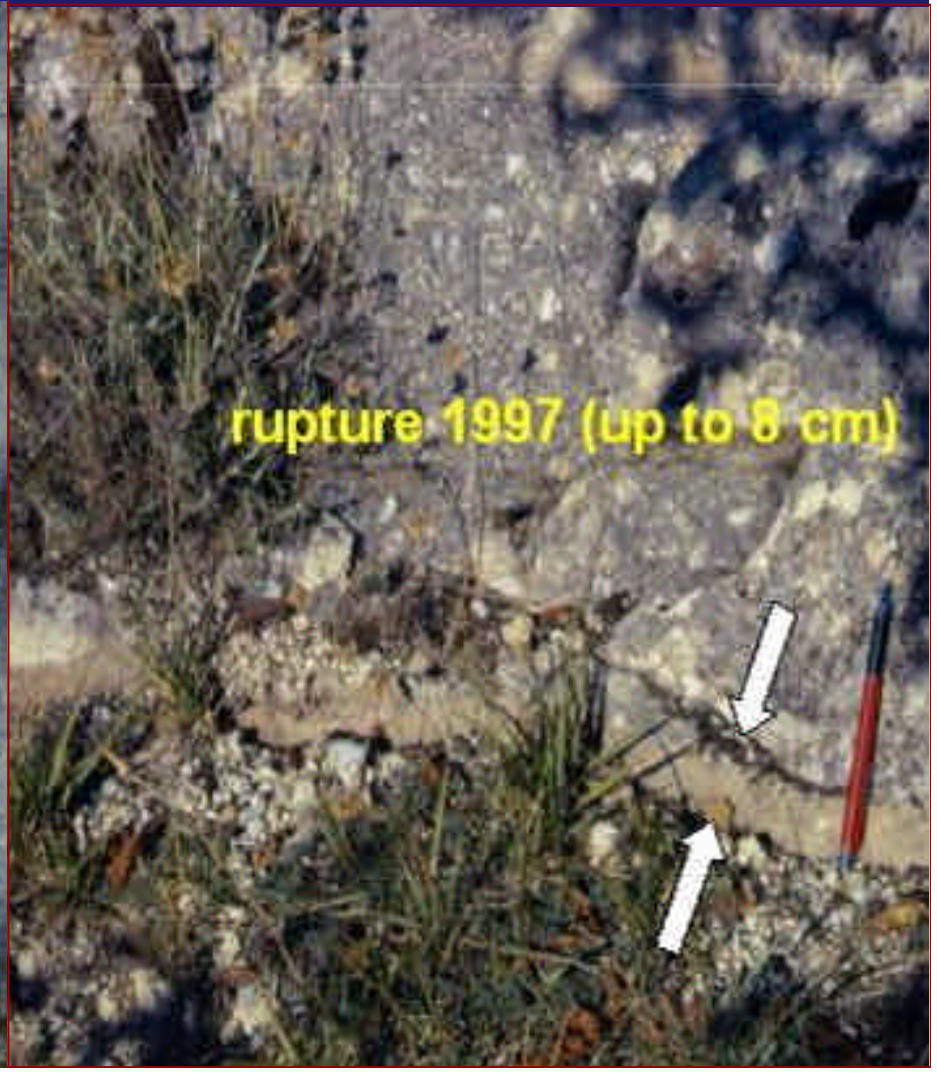
26.09.1997 Umbria-Marche (Central Italy)

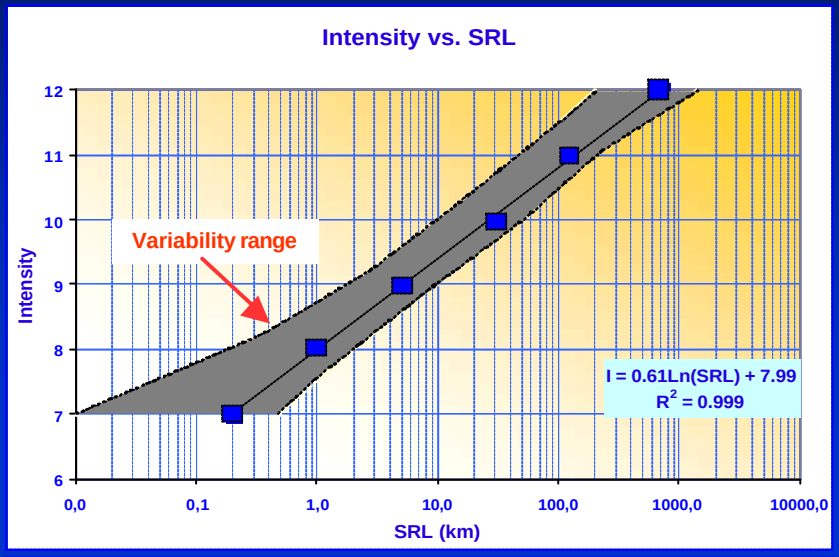
M=6.0 SRL=12 km MD = 8 cm

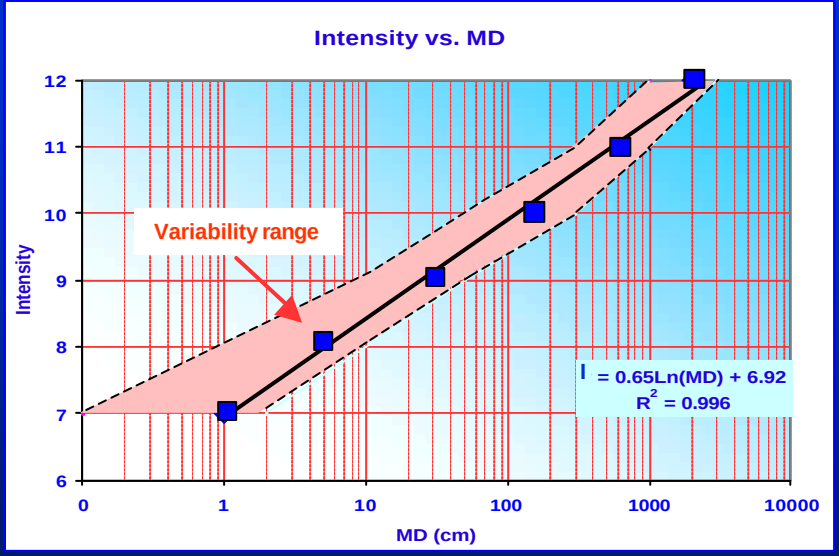
Intensity

MCS (based on damage)	IX
ESI 2007	IX

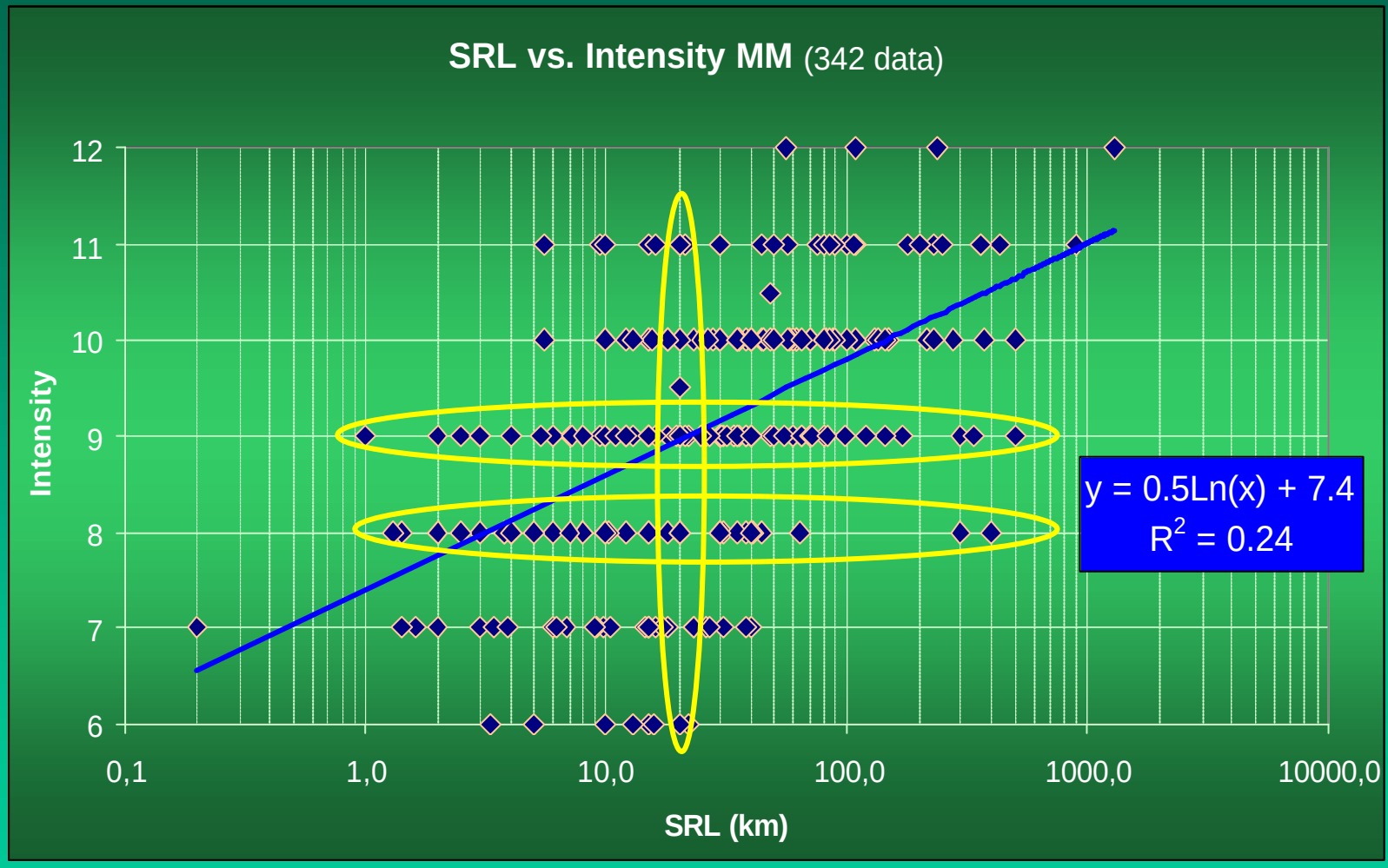


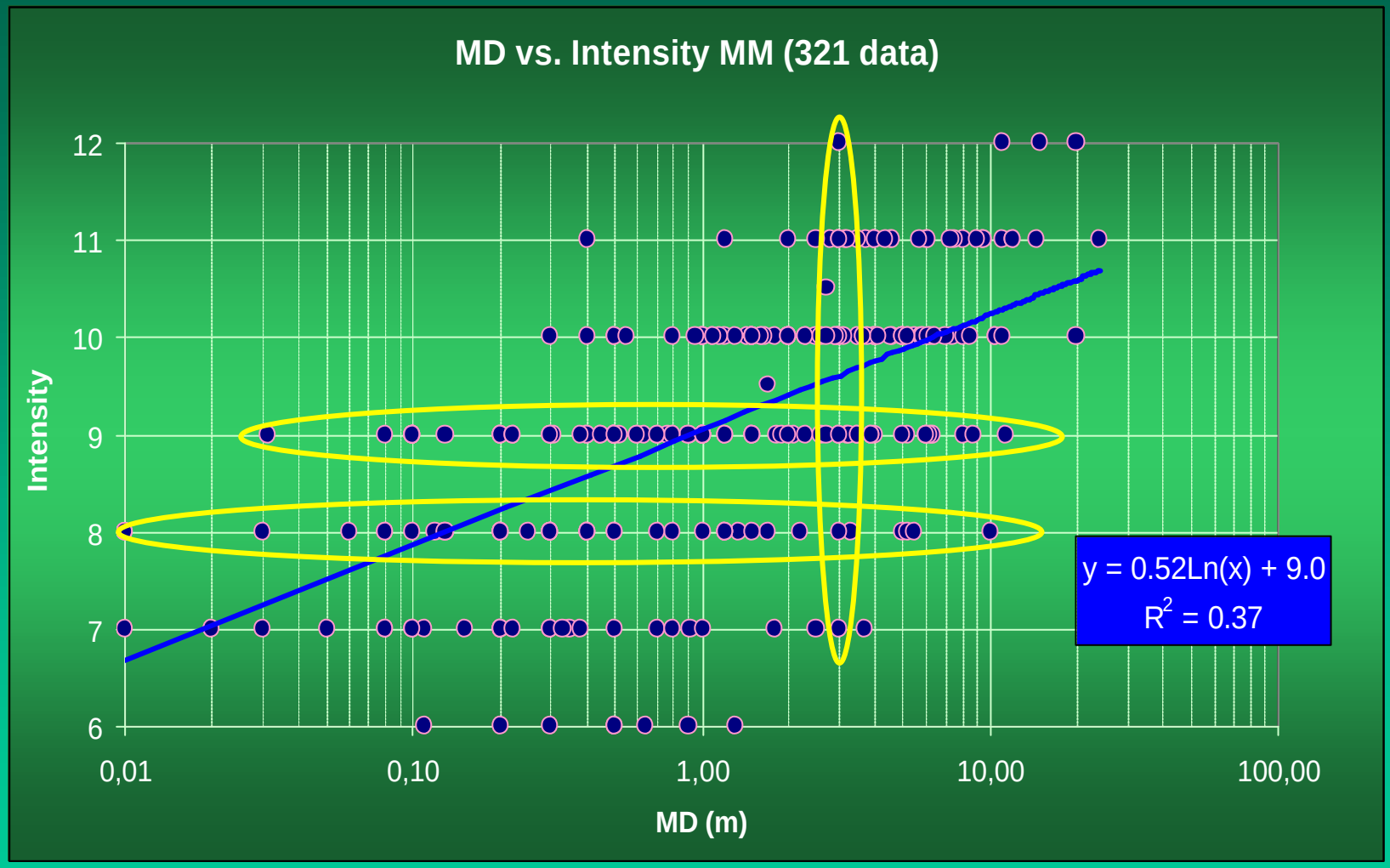


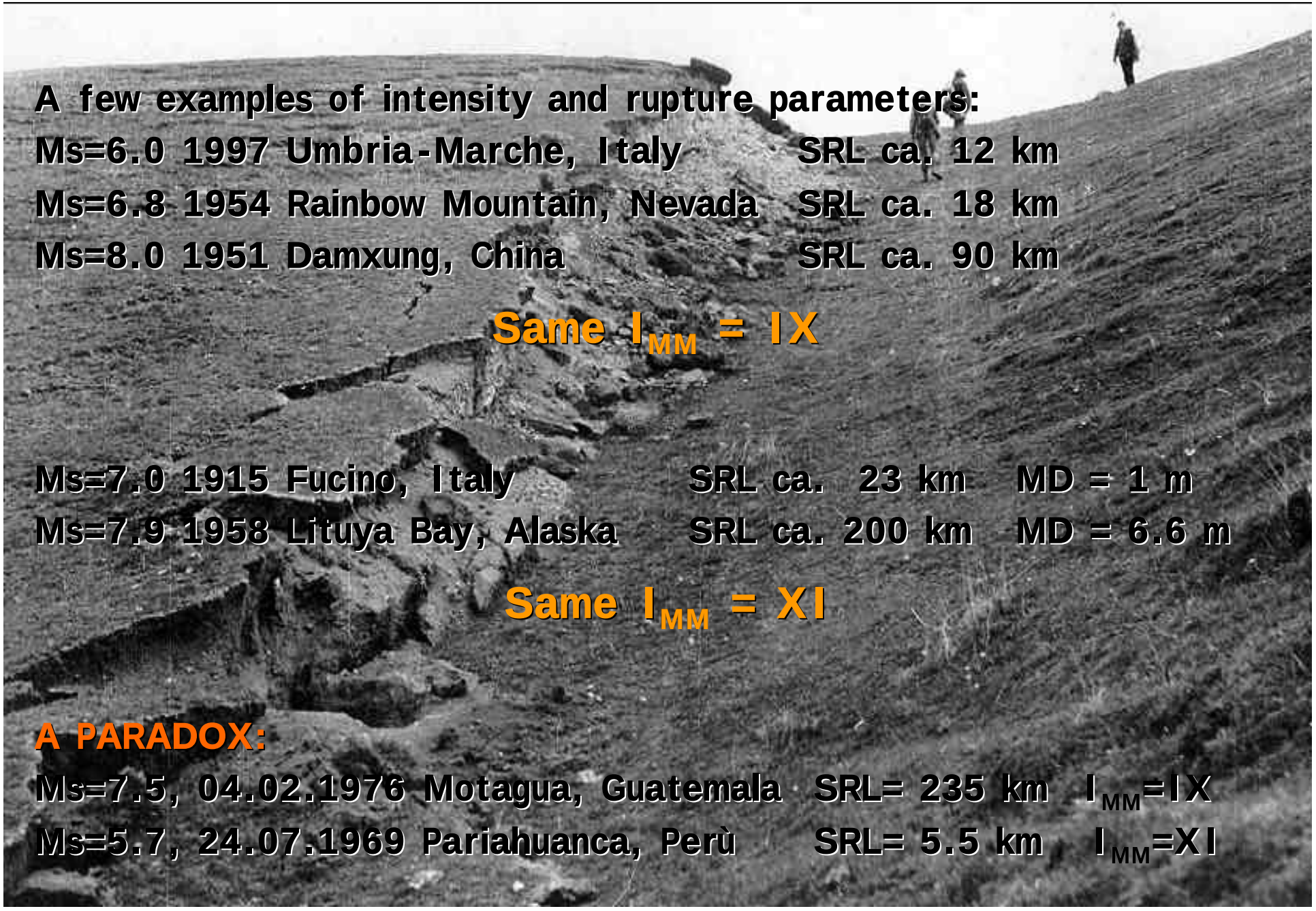




ESI 2007	SRL range	MD range	SRL plot (km)	MD plot (cm)
VII	generally absent or negligible, might be hundreds of meters for very shallow events	generally absent or negligible, centimetric for very shallow events	0,2	1
VIII	generally absent might be up to several hundred meters	up to a few cm, typically less or even absent	1	5
IX	up to a few km	in the order of several cm	5	30
X	few tens of km	from tens of cm up to a few meters	30	150
XI	from several tens up to more than 100 km	several meters	120	600
XII	> few hundreds of km	up to 24 m (largest known displacement)	700	2000


SRL vs. Intensity MM (342 data)
Intensity
12
11
10
9
8
7
6
0,1
1,0
10,0
100,0
1000,0
10000,0
SRL (km)
y = 0.5Ln(x) + 7.4
R2 = 0.24


MD vs. Intensity MM (321 data)
Intensity
12
11
10
9
8
7
6
0,01
0,10
1,00
10,00
100,00
MD (m)
y = 0.52Ln(x) + 9.0
R2 = 0.37



A few examples of intensity and rupture parameters:

Ms=6.0 1997 Umbria-Marche, Italy **SRL ca. 12 km**

Ms=6.8 1954 Rainbow Mountain, Nevada **SRL ca. 18 km**

Ms=8.0 1951 Damxung, China **SRL ca. 90 km**

Same I_{MM} = IX

Ms=7.0 1915 Fucino, Italy **SRL ca. 23 km** **MD = 1 m**

Ms=7.9 1958 Lituya Bay, Alaska **SRL ca. 200 km** **MD = 6.6 m**

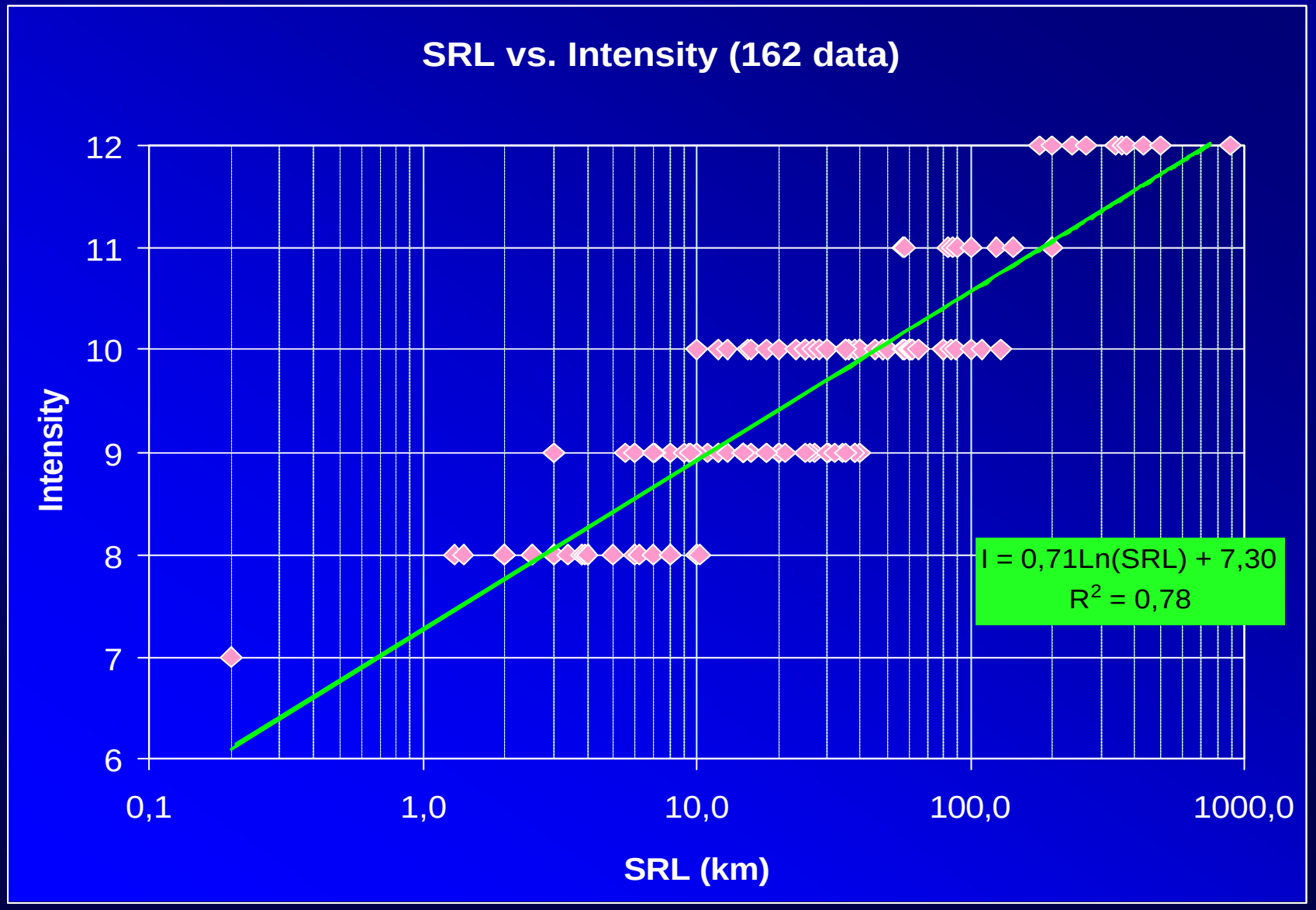
Same I_{MM} = XI

A PARADOX:

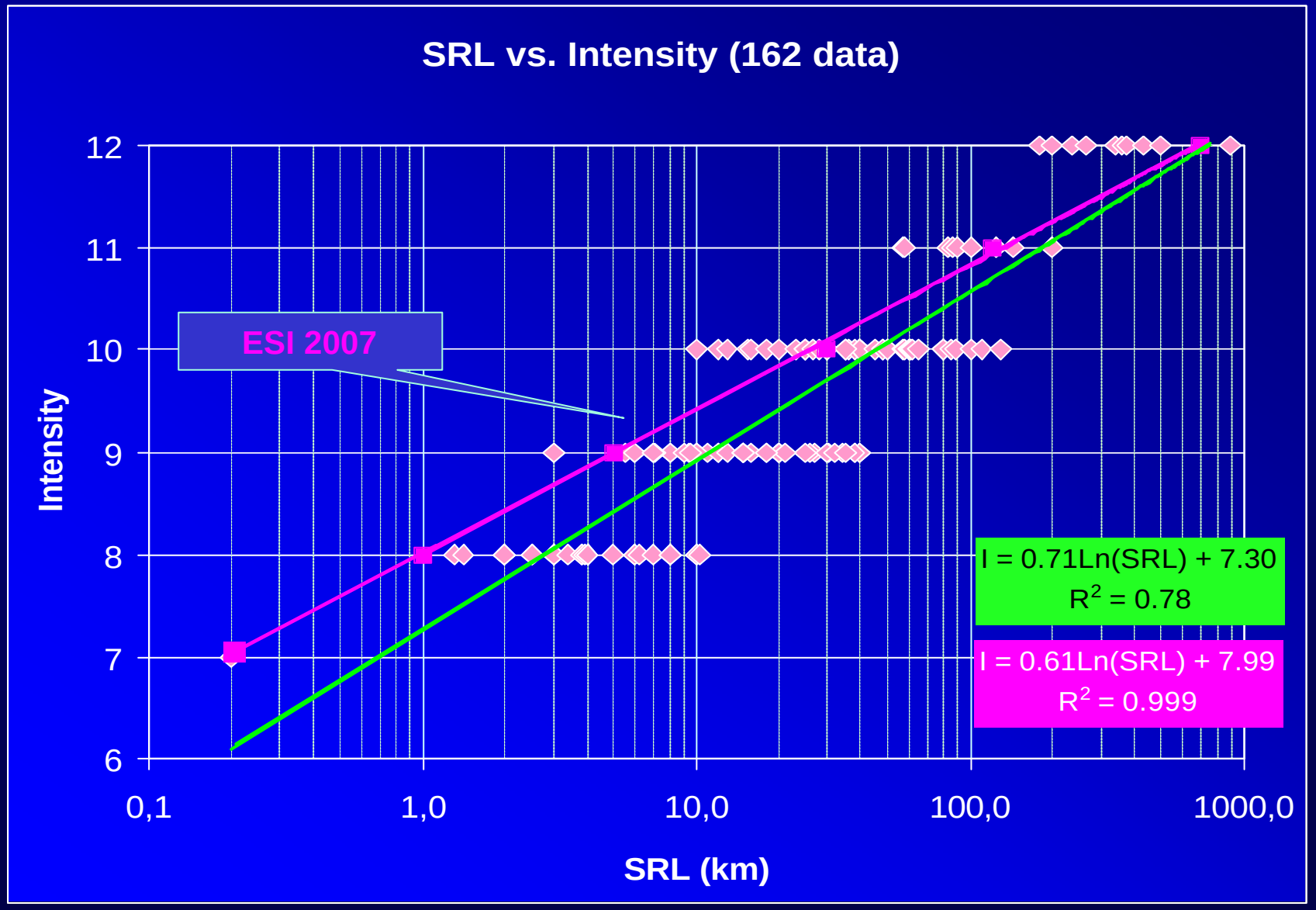
Ms=7.5, 04.02.1976 Motagua, Guatemala **SRL= 235 km** **I_{MM}=IX**

Ms=5.7, 24.07.1969 Pariahuanca, Perù **SRL= 5.5 km** **I_{MM}=XI**

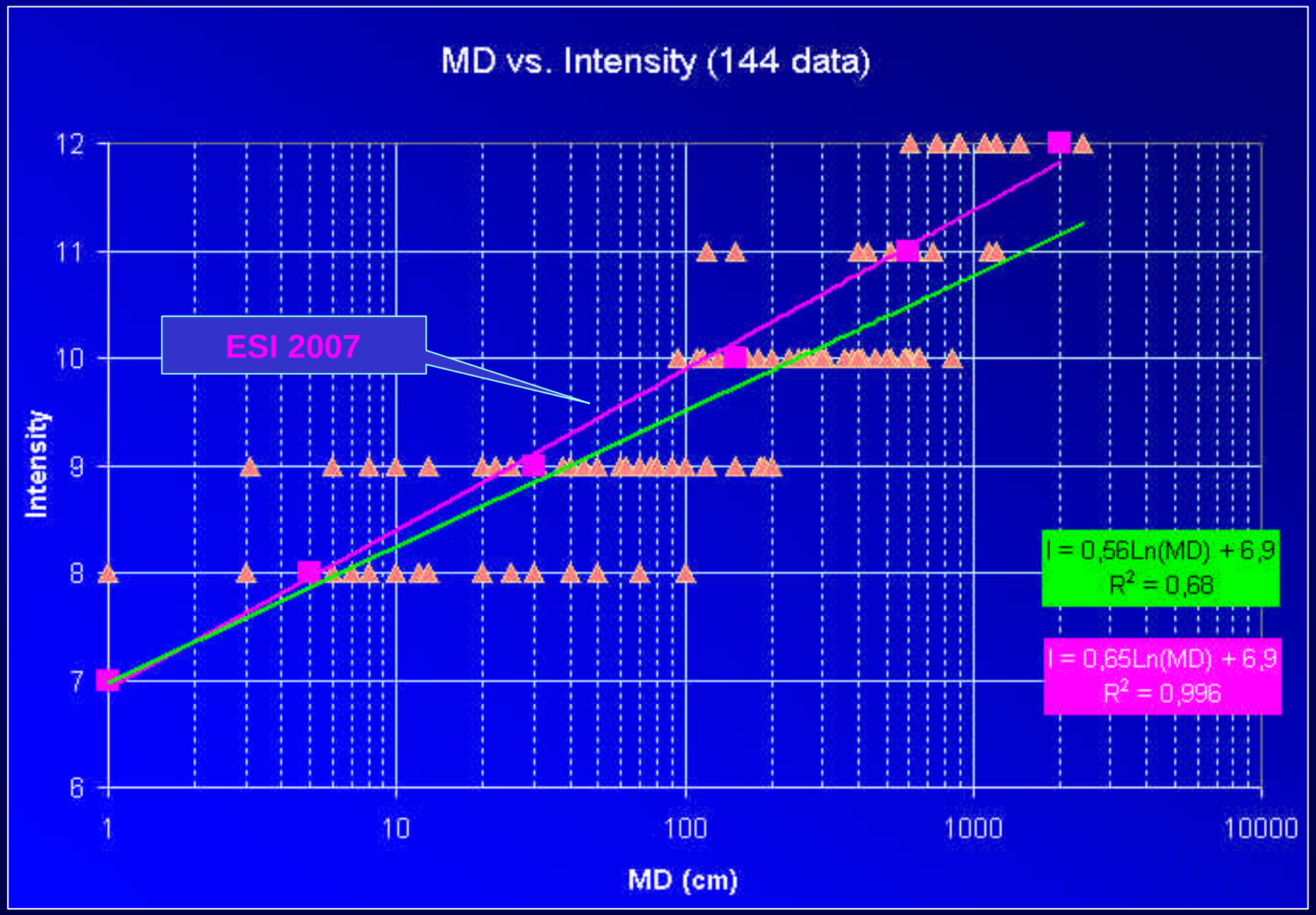
Only events since year 1900 – events in remote areas partially filtered out



Only events since year 1900 – events in remote areas partially filtered out



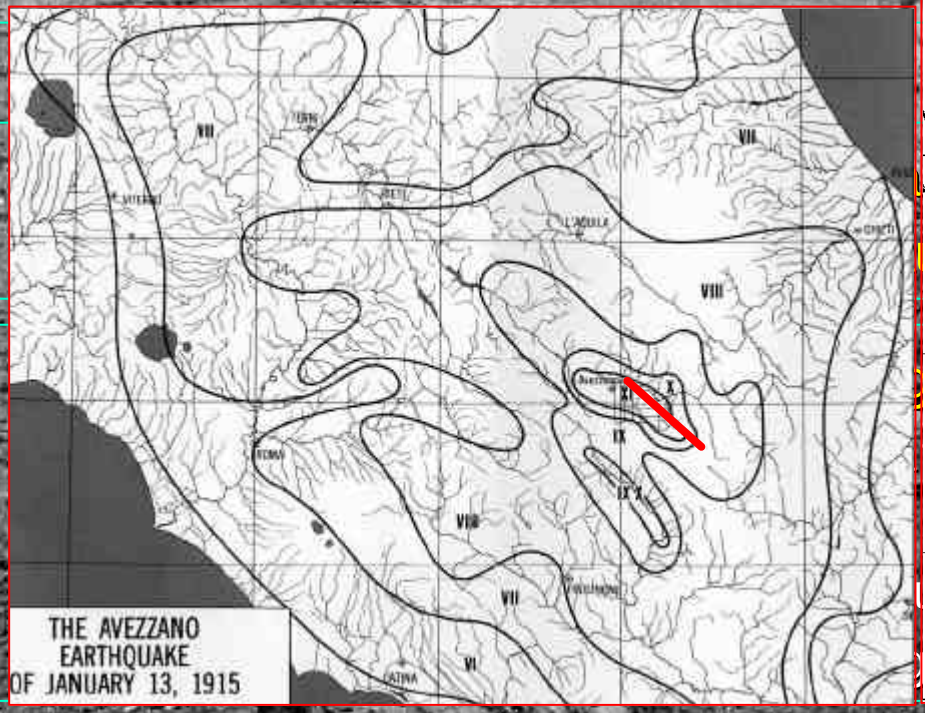
Only events since year 1900 – events in remote areas partially filtered out

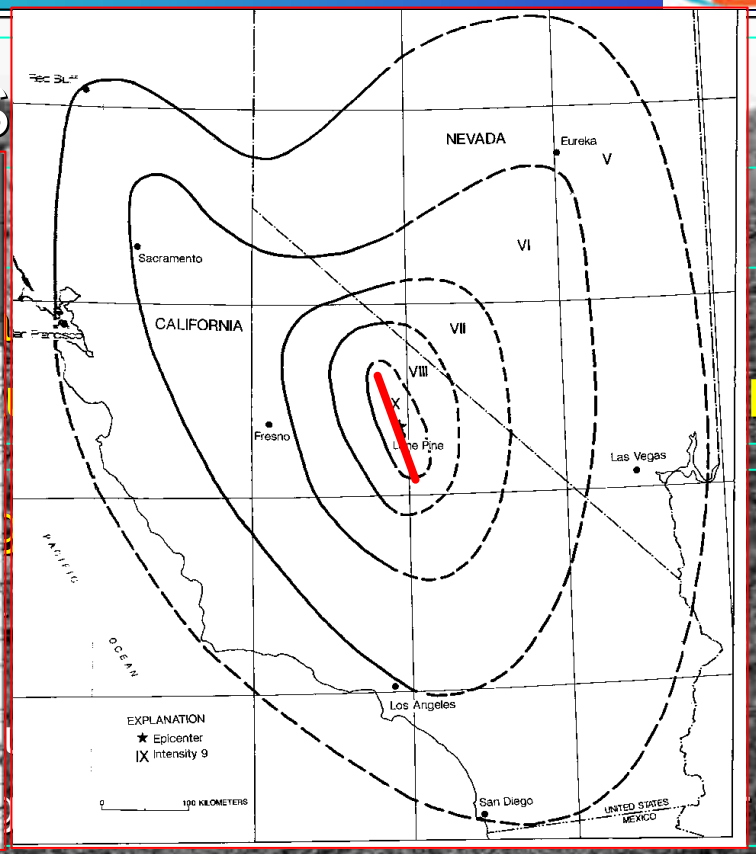


CONCLUS

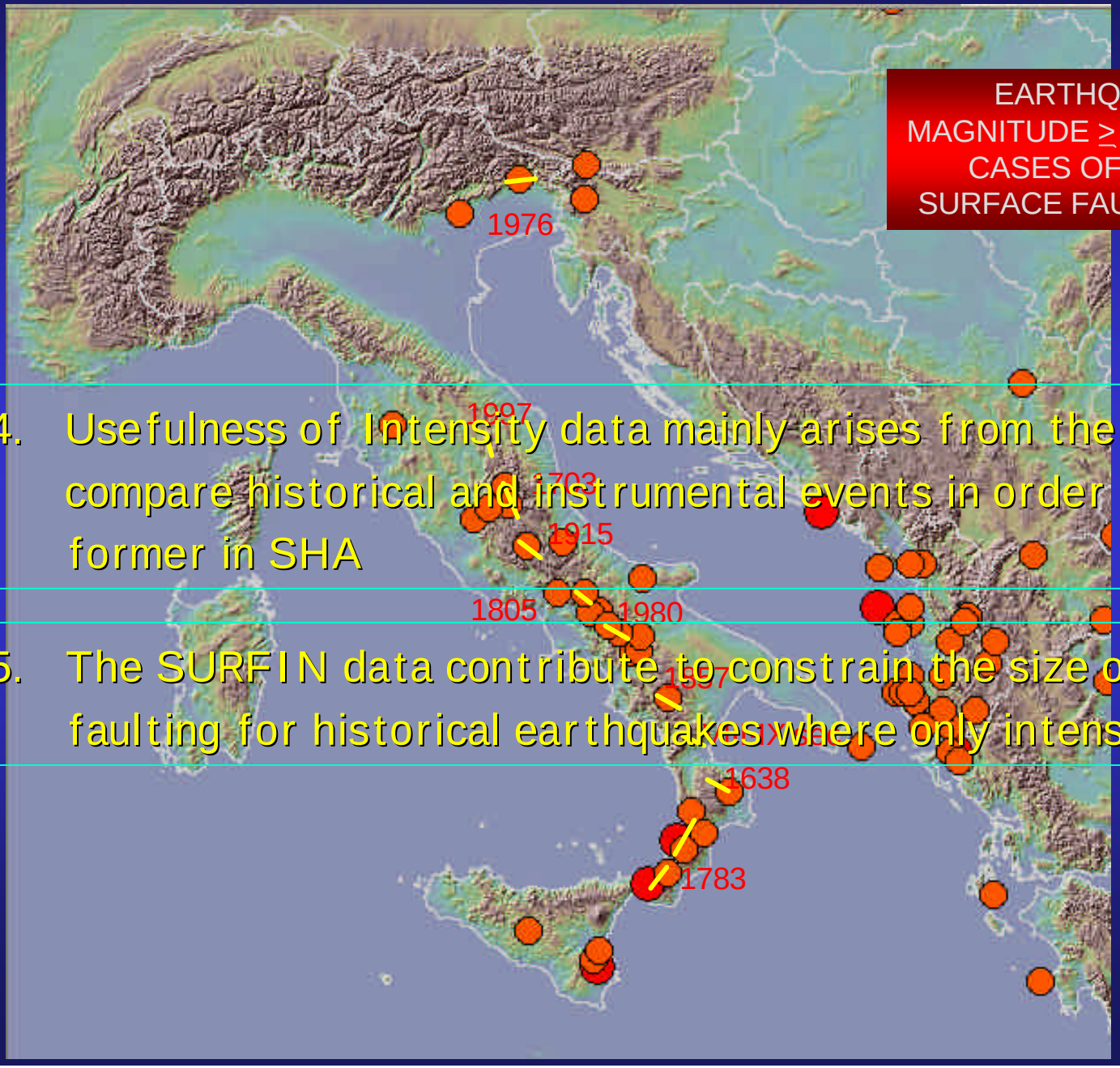
1.

2.





3. Therefore, INTENSITY is to be taken as a valuable measure of size of earthquakes, provided that only "truly" epicentral intensities are concerned.



4. Usefulness of Intensity data mainly arises from the need to compare historical and instrumental events in order to include the former in SHA

5. The SURFIN data contribute to constrain the size of surface faulting for historical earthquakes where only intensity is known

FUTURE WORK

1. Improvement of database with the contribution of regional WG through:
   a. Accurate analysis of new earthquakes
   b. Re-analysis of intensity estimates and environmental effects of past events
   c. Plot by focal depth and kinematics

2. Building of improved regression curves

3. Adjustment of range definitions of primary effects in ESI scale if revised SURFIN data prove it appropriate

THANK YOU!