1st INQUA-IGCP-567 International Workshop on Earthquake Archaeology and Palaeoseismology,
Baelo Claudia, Spain (2009)

Cataloguing earthquake environmental effects in Italy : Analyses of some strong earthquakes

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OUTLINE

- Some questions about the catalogue.
- Analysis of some strong earthquakes
- Summary of ground effects
- Implications

- Some important questions:

- *Why is so important the EEE Catalogue ?*

  It is important to have a complete data set in order to compare recent , historical and paleoearthquakes at global and local scale.

- *Who can use it ?*

  Scientific Community, Administrators, politicians, private insurance
- *How can you use the catalogue?*

  From scientific ,political and administrative point of view

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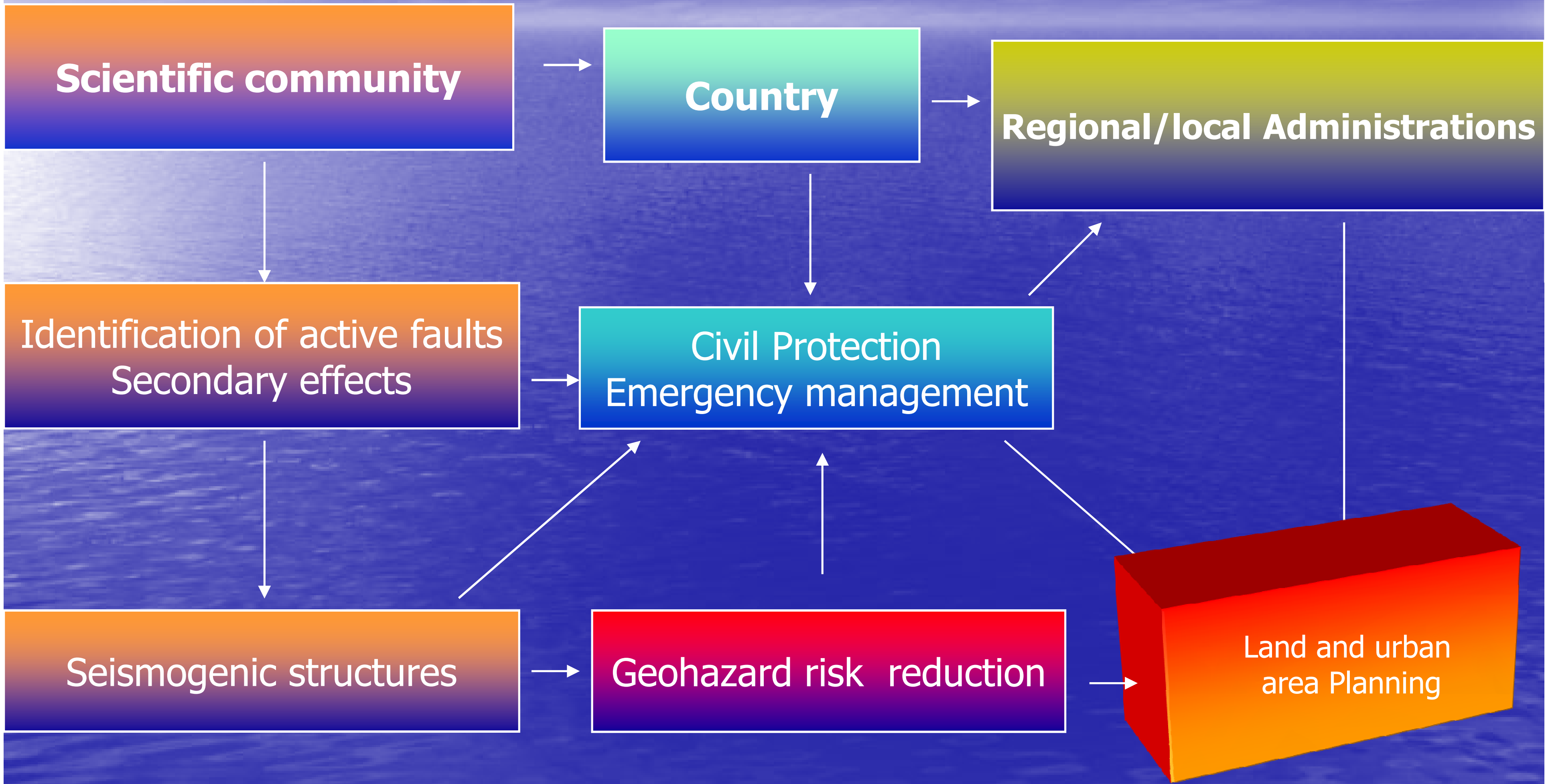

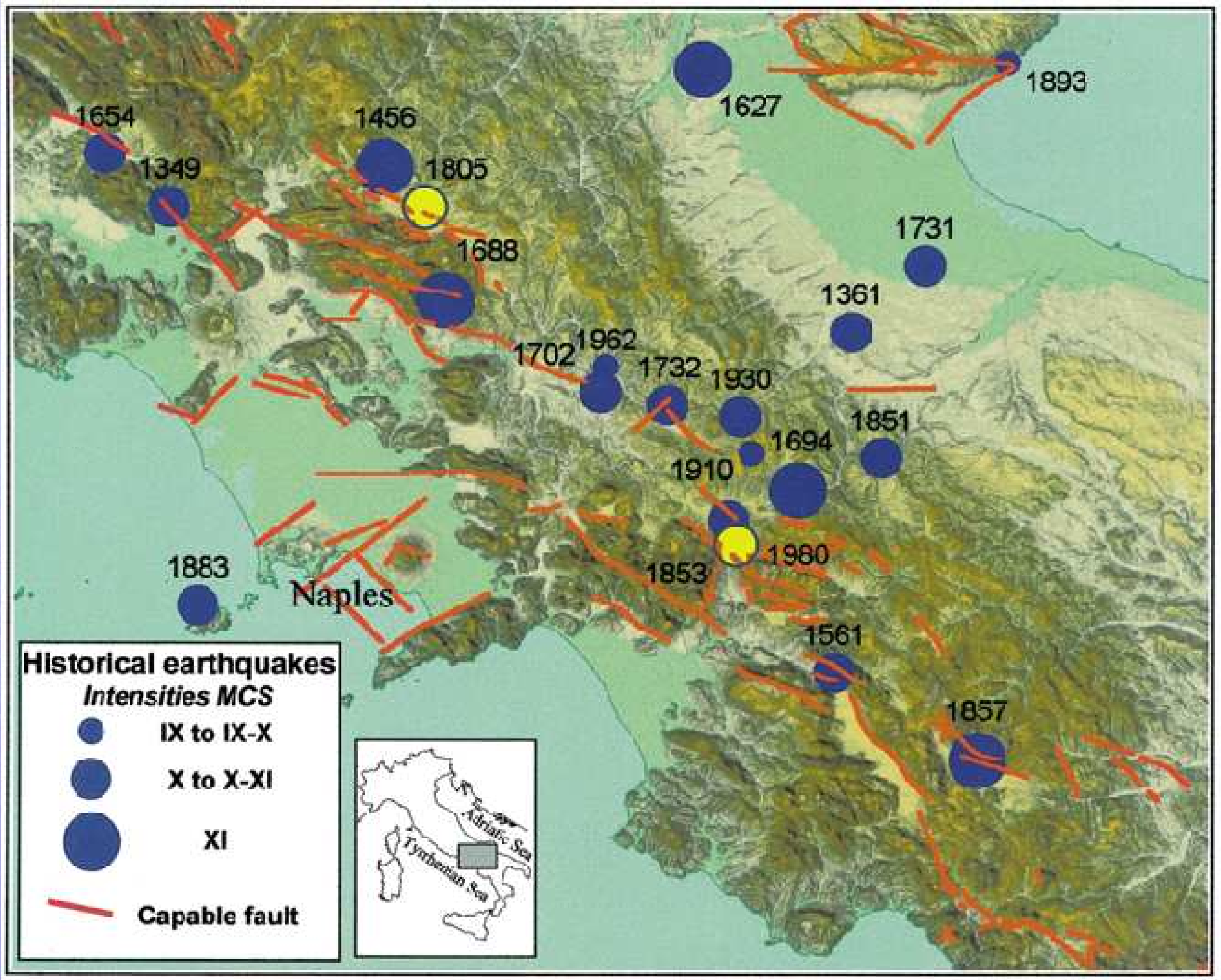

Historical earthquakes of Intensity ≥ IX MCS (from CPTI) and capable faults (ITHACA database), in the Southern Apennines, superimposed on a digital elevation model of the Southern Apennines (Porfido et al., 2002)

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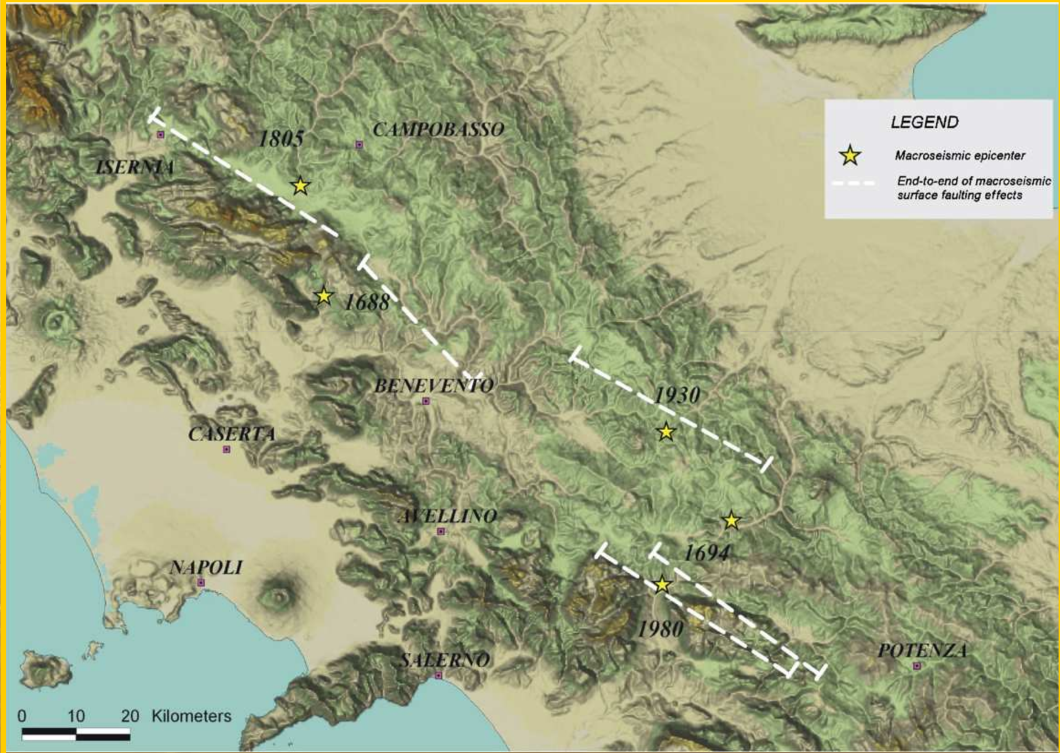
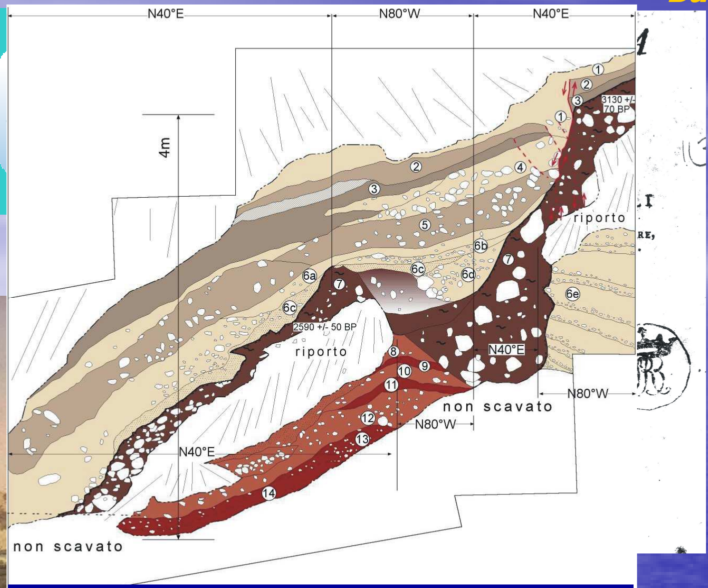


Date Y.M.D.	Region	Epicenter Latitude	 Longitude	I_0 MCS	Magnitude
1688.06.05	Sannio	41.28	14.57	XI	6.7 (Mm)
1694.09.05	Irpinia-Basilicata	40.88	15.35	X-XI	6.9 (Mm)
1805.07.26	Molise	41.50	14.47	X	6.6 (Mm)
1930.07.23	Irpinia	41.05	15.37	X	6.7 (Ms)
1980.11.23	Irpinia-Basilicata	40.85	15.28	X	6.9 (Ms)

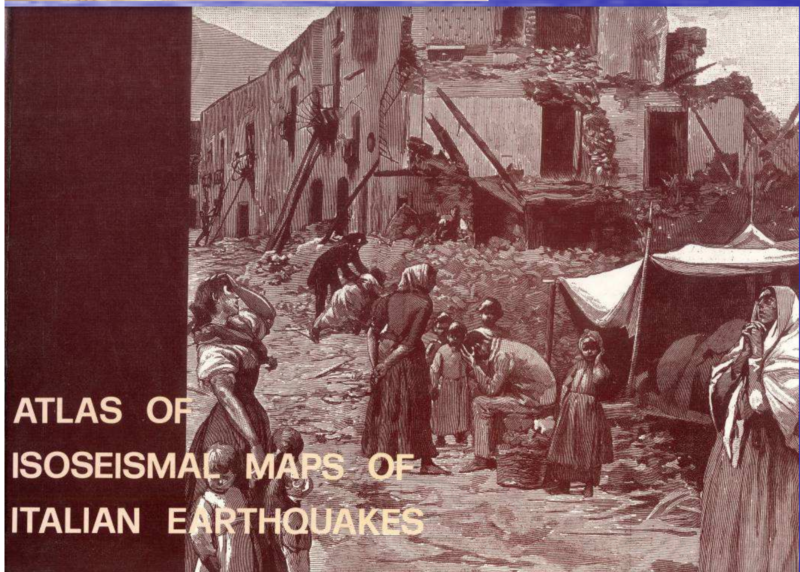
Epicenters (yellow stars) and end-to-end length of rupture zones (white lines) regarding 1688, 1694, 1805, 1930 and 1980 historical earthquakes in Southern Apennines

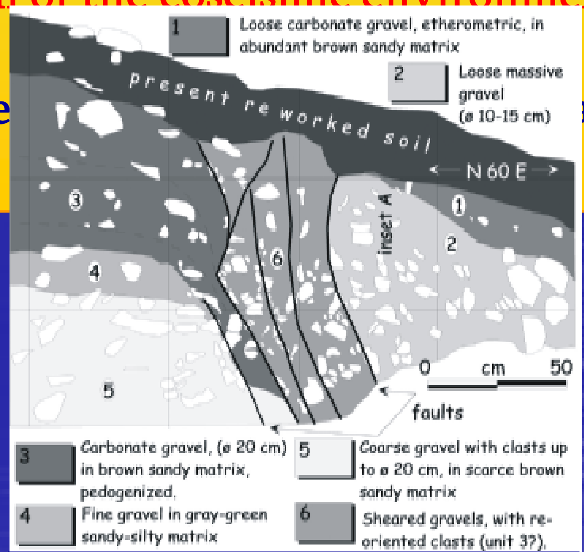


Blumetti et al. (2000)

Methodology

1. Analyses of historic sources, including completeness and reliability of the document within the historical context and source classification.
2. Scientific papers, technical reports, air photo interpretation, field checking and paleoseismological analyses in trenches, Eye-witness accounts,
3. Classification of the coseismic environmental effects
4. Intensity asse... ale



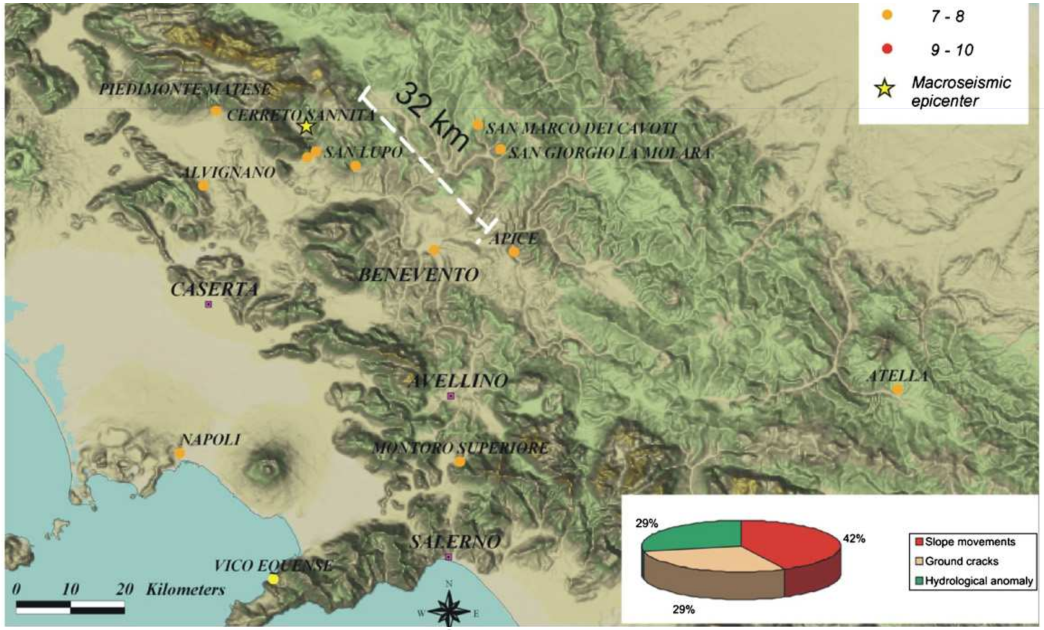


5 June 1688, Sannio earthquake						
Locality	Longitude	Latitude	Type of effect	Site distance	I_{MCS}	I_{EEE}
Alvignano	14,34E	41,24N	HA	19	9	**8**
Apice	14,90E	41,11N	HA	39	10	**7**
Atella	15,65E	40,88N	GC	105	8	**7**
Benevento	12,05E	44,15N	HA, SM	29	10	**7**
Cerreto sannita	14,55E	41,28N	HA, SM, GC	0	9	**8**
Montoro superiore	14,90E	41,11N	SM	59	8-9	**7**
Napoli	14,27E	40,86N	HA	57	7-8	**7**
Piedimonte d'Alife	14,37E	41,35N	HA, GC	15	9	**8**

Macroseismic surface fault ing parameters: Rupture Length: **32 km**; *Max. displacement:* **Unknown**

Total distribution of slope movements **≃ 1,700 km²** (except Pomarico)

INQUA EEE intensity scale **I_0 = X**



I=XI MCS

21 effects

14 ESI Int.

1688, Sannio earthquake

5 September 1694, Irpinia-Basilicata earthquake

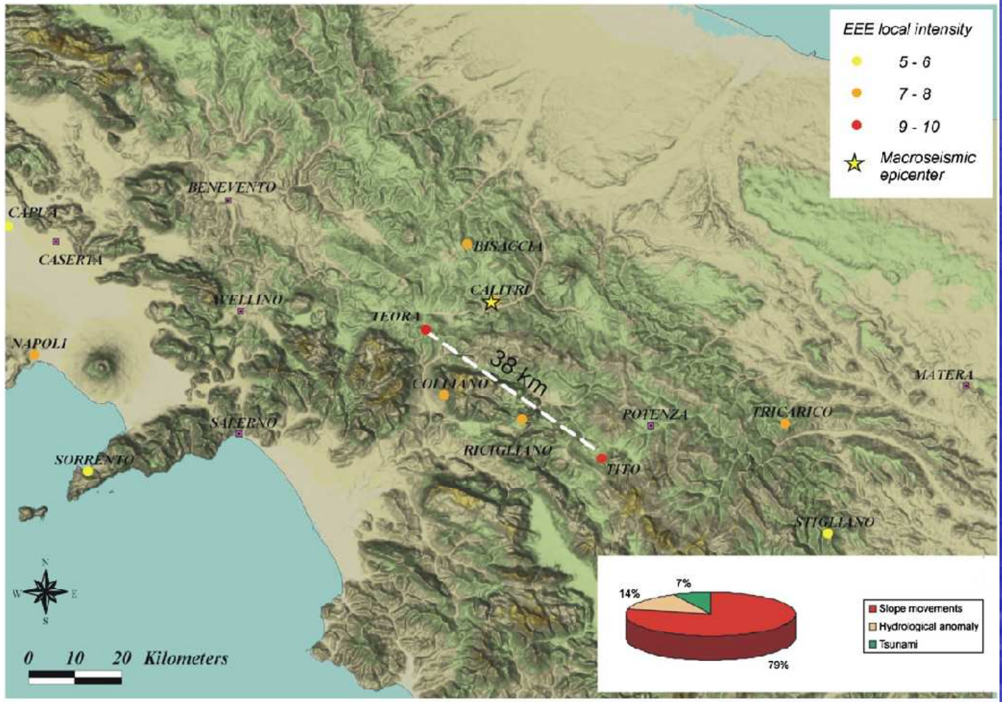
Locality	Latitude	Longitude	Type of effect	Site distance	I_{MCS}	I_{EEE}
Bisaccia	41,01N	15,37E	SM	13	9/10	8
Brindisi	40.62N	17.94E	TS	216	5	4
						8
						5
						8
						7
						8
						5
						6
						10
						9
						8

Macroseismic surface faulting parameters: Rupture Length: **38 km**; *Maximum displacement:* ***Unknown***

Total distribution of slope movements ~ **6,300 km²**

INQUA EEE intensity scale **I_0 = X**

I=X-XI MCS
16 effects
12 ESI Int.



1694, Irpinia-Basilicata earthquake

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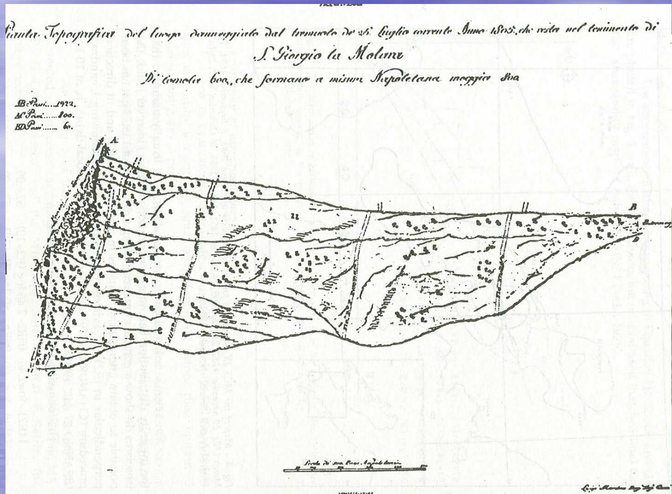
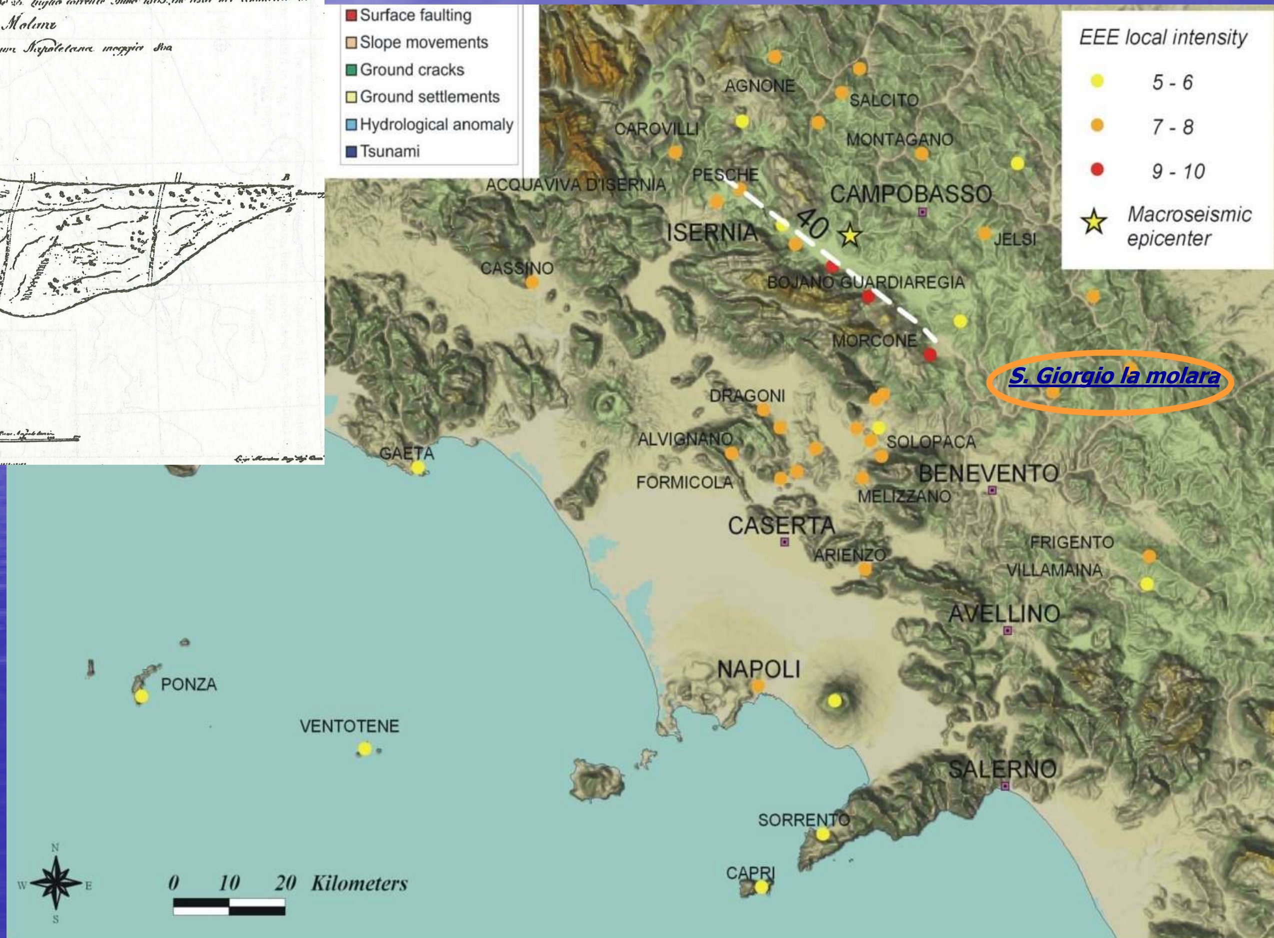




1805, Molise earthquake

I=XI MCS

80 effects

50 ESI Int.

Macroseismic surface faulting parameters: Rupture Length: ***40 km***; Maximum displacement: ***150 cm***.

Total areal distribution of slope movements ≃ **5,300 km^2**

INQUA EEE intensity scale **I_0 = X**

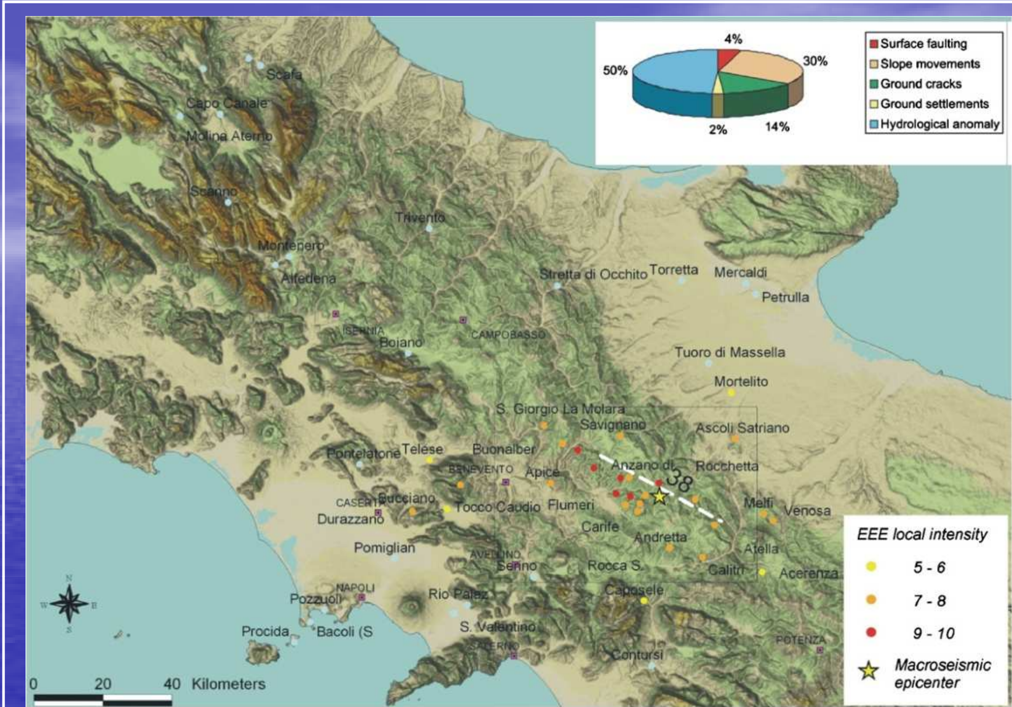
Old *Aquilonia, Landslide*

1930, Irpinia earthquake

I=X MCS

73 effects

61 ESI Int.



Macroseismic surface faulting parameters: Rupture Length*:* **38 km**; Max displacement: **40 cm**

Total areal distribution of slope movements $\simeq$ **3.900 km^2**

INQUA EEE intensity scale **I_0 = X**

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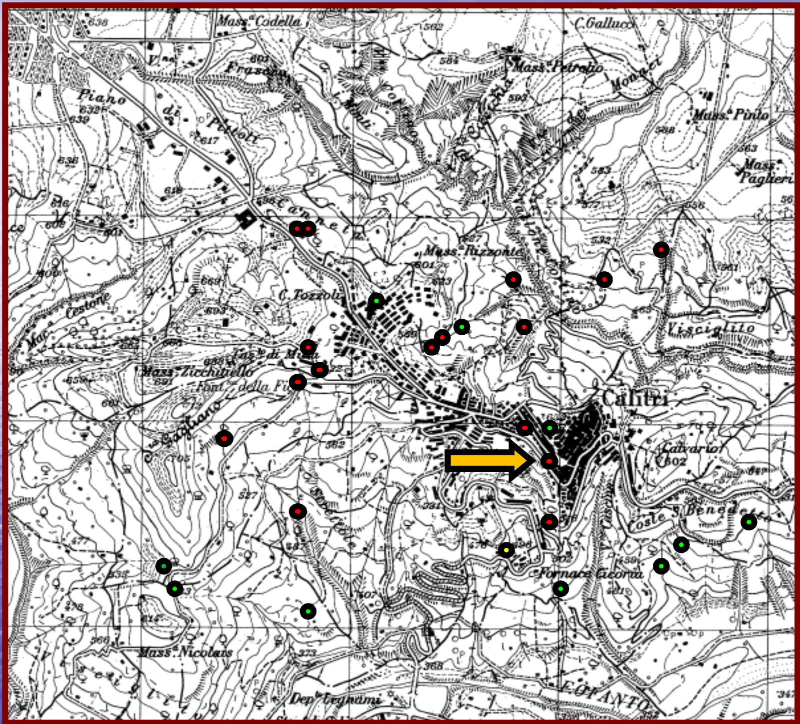
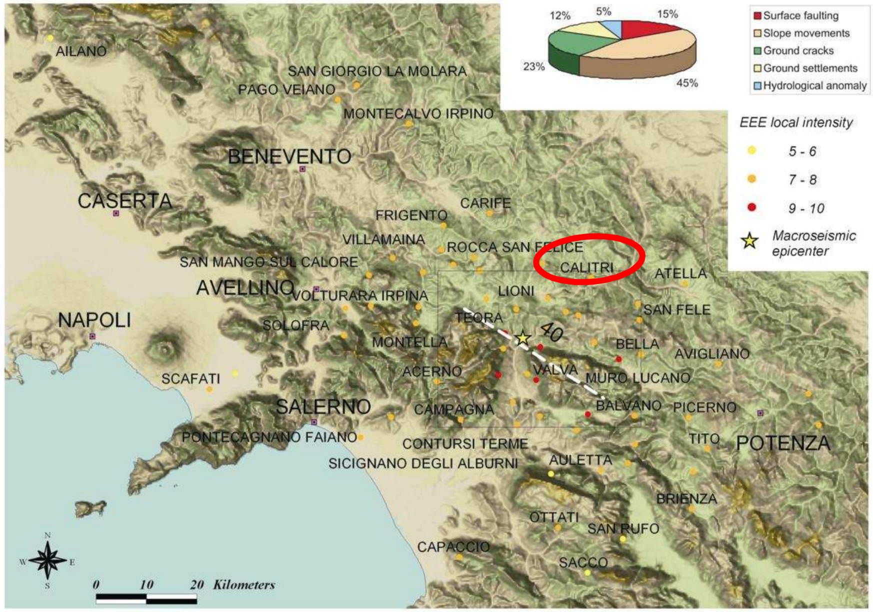
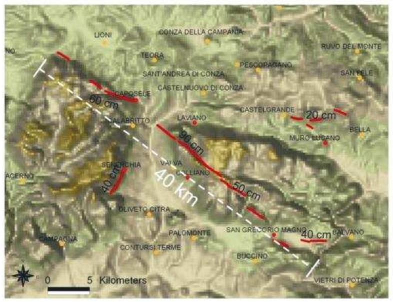
CALITRI - ESI Loc Int=8



landslides Ground crack liquefaction

Main landslide



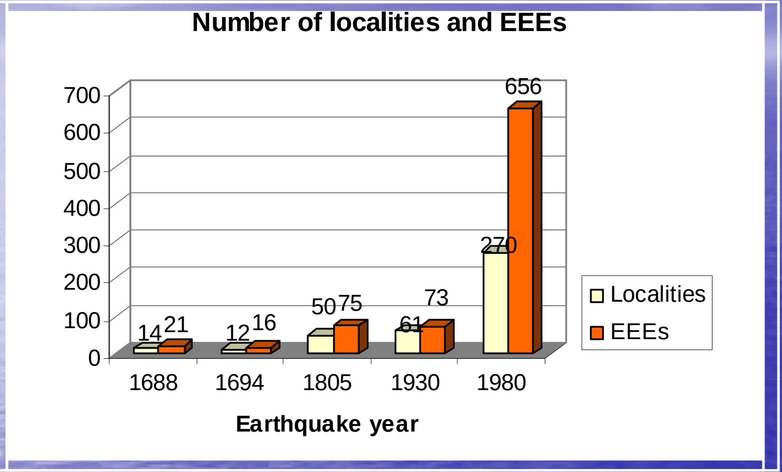


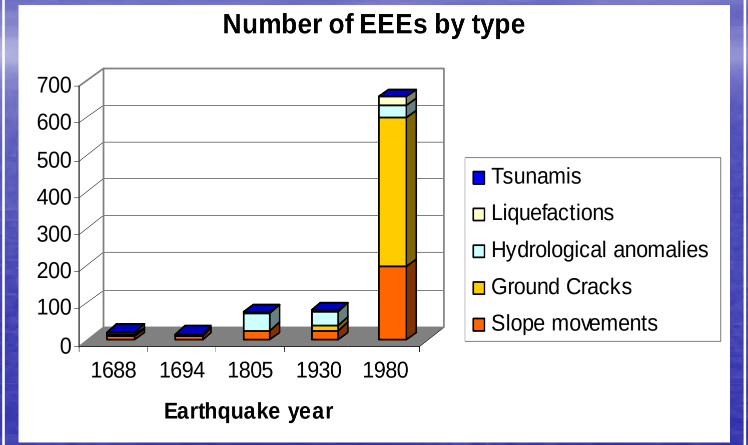
Macroseismic surface faulting parameters: Rupture Length: ***40-45 km****; Maximum displacement:* ***100 cm***

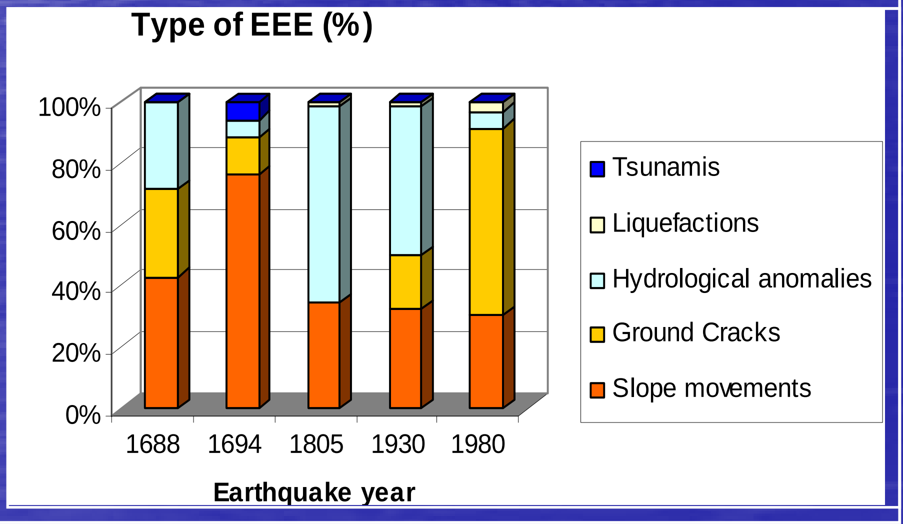
Total areal distribution of slope movements	$\simeq$ **7,400 km^2**
INQUA EEE intensity scale	**I_0 = X**

1980, Irpinia-Basilicata earthquake

Date	Epicentral area	Victims	ESI epicentral Int.	Surface faulting
1688.06.05	Sannio	10,000	10	SRL: 32 km Max D = 90 cm
1694.09.08	Irpinia-Basilicata	6,000	10	SRL: 38 km
1805.07.26	Molise	6,000	10	SRL: 40 km Max D = 150 cm
1930.07.23	Irpinia	1,404	10	SRL:38 km; Max D: 40 cm
1980.11.23	Irpinia-Basilicata	3,000	10	SRL: 40 km Max D = 100 cm


Number of localities and EEEs
700
600
500
400
300
200
100
0
14
21
12
16
50
75
61
73
270
656
1688
1694
1805
1930
1980
Earthquake year
Localities
EEEs


Number of EEEs by type
700
600
500
400
300
200
100
0
1688
1694
1805
1930
1980
Earthquake year
Tsunamis
Liquefactions
Hydrological anomalies
Ground Cracks
Slope movements


Type of EEE (%)
100%
80%
60%
40%
20%
0%
1688
1694
1805
1930
1980
Earthquake year
Tsunamis
Liquefactions
Hydrological anomalies
Ground Cracks
Slope movements

mitigation of environmental effects

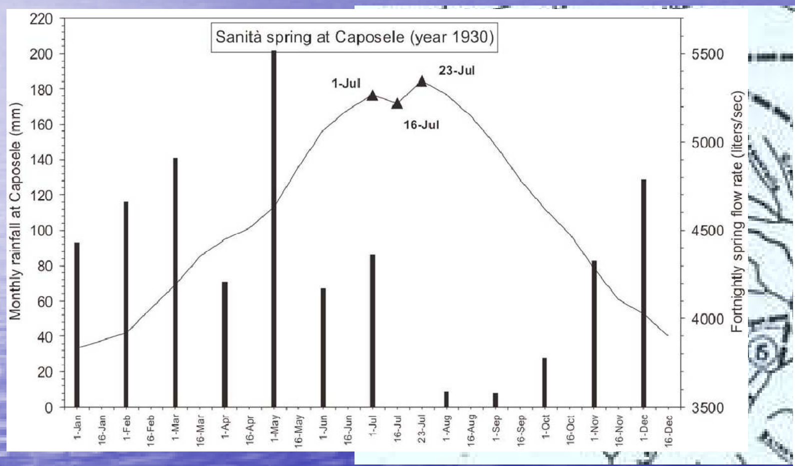
implications

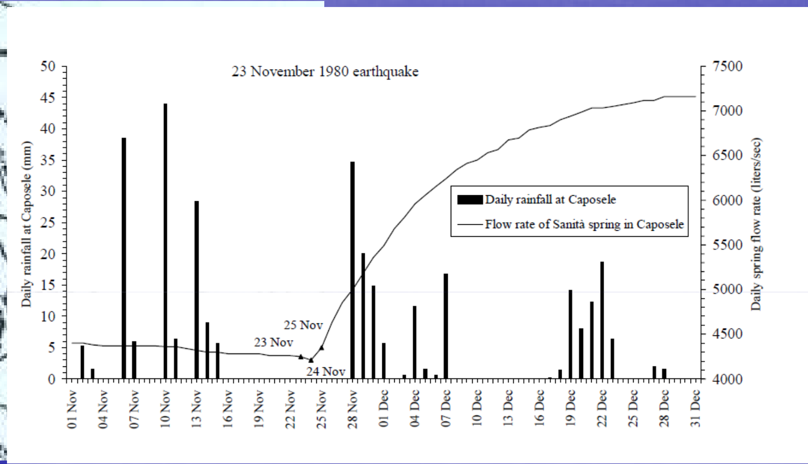
ground rupture hazard?

earthquake scenario?

1930, Irpinia earthquake

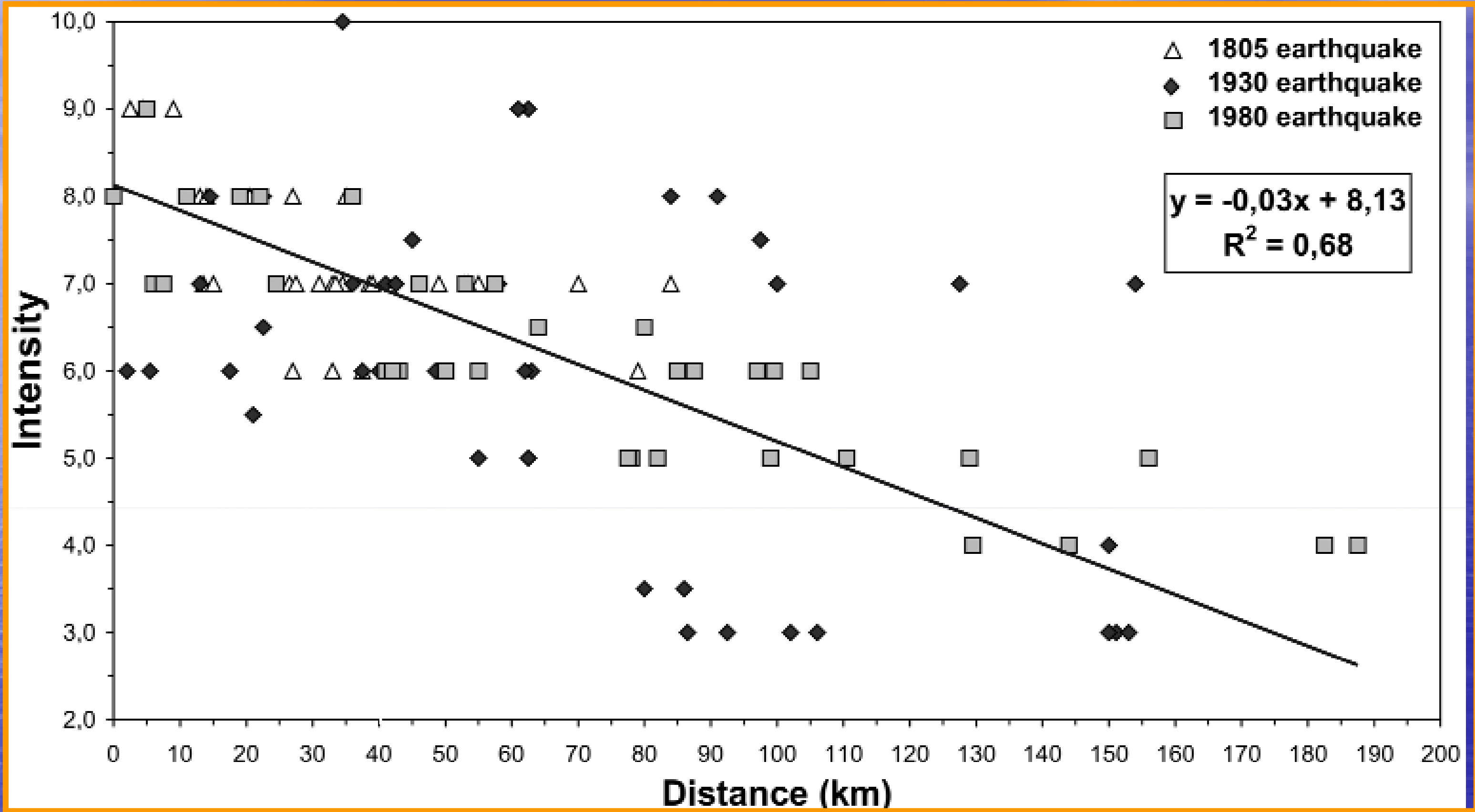
1980, Irpinia-Basilicata earthquake



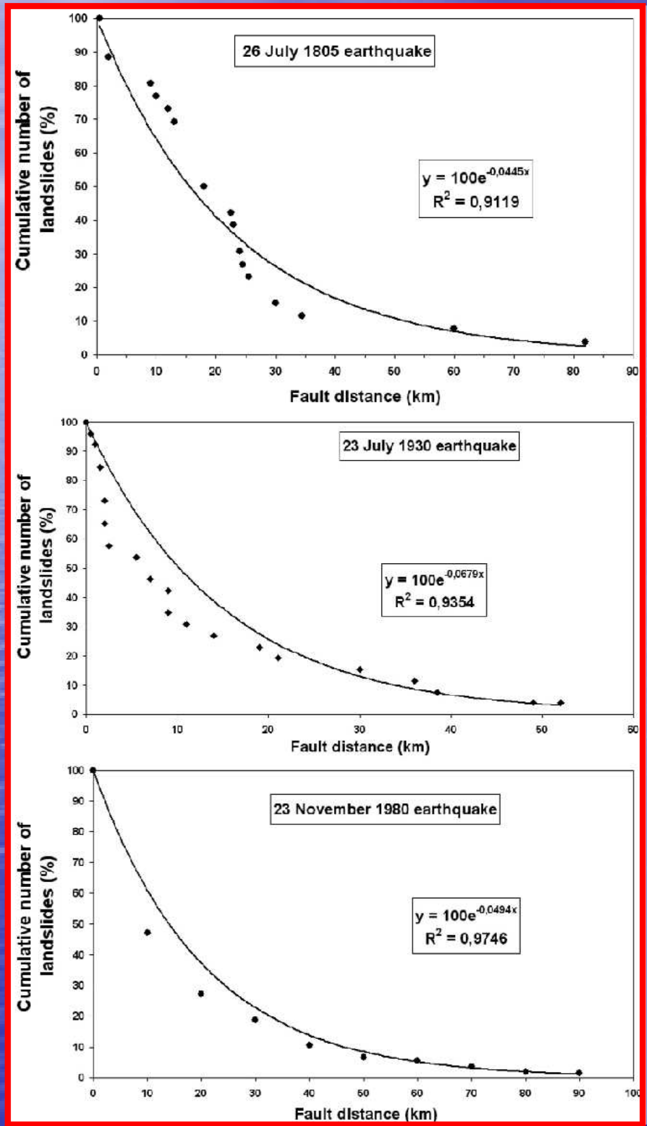


Caposele spring at 22.5 km from the fault. A discharge increase of 150 liters/sec (about 3%) was measured a few hours after the seismic event, compared to the measurement on 16 July 1930, a week before the earthquake

Caposele spring at 5 km from the fault. Flow of the Caposele spring increased of 3000 l/s (about twice). A general increase in discharge was observed for a period of 6 to 12 months after the earthquake



The distribution of hydrologic variations displays an almost linear decay away from the causative faults, with 90% of the effects within **40 km** for the **1805** event and **130 km** for the **1980** event. Most of the anomalies produced by the 1930 earthquake were **30 to 120** km from the fault (ESPOSITO *et alii*, 2001,2009; PORFIDO*et alii*, 2002,2007)



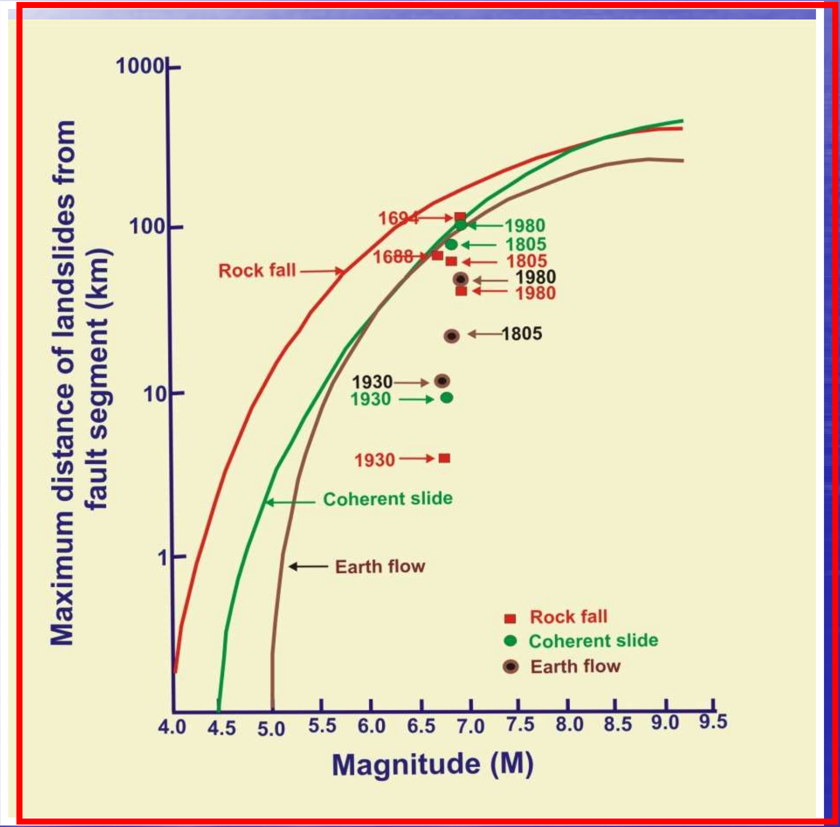
Cumulative number of landslides vs. minimum distance from earthquake fault.

•(A) **1805 earthquake**: 11.5% of landslides occurred at a distance >30 km.

•(B) **1930 earthquake:15.3**% of landslides occurred at a distance > 30 km.

•(C) **1980 earthquake**: 17.5% landslides occurred at a distance > 30 km.

The landslides distribution vs fault distance shows that most of them (81,4%) occurred within a distance of 30 km, the 13% decreases very rapidly with distance between 30 and 60 km. Isolated phenomena (5%) were observed up to distances of nearly 100 km.



Plot of the maximum distances from the fault of the three main types of landslide induced by the 1805, 1930 and 1980 earthquakes.
All the values are in good agreement with the upper-bound envelope curves proposed by Keefer (1984).

Land-Urban Planning

Can we really rebuild an area without considering the ground effects?

Active faults distribution

Paganica fault-L'Aquila 2009

Secondary effects area

Landslides distribution

Hydrological changes

Liquefaction phen.

Fractures along Sinizzo Lake, 2009

Kashiwazaki,2007

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CHART OF THE INQUA ENVIRONMENTAL SEISMIC INTENSITY SCALE 2007 - ESI 07

Silva et Alii,2008