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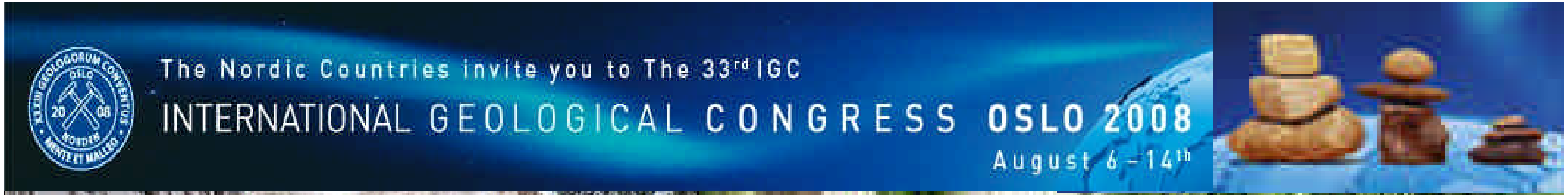
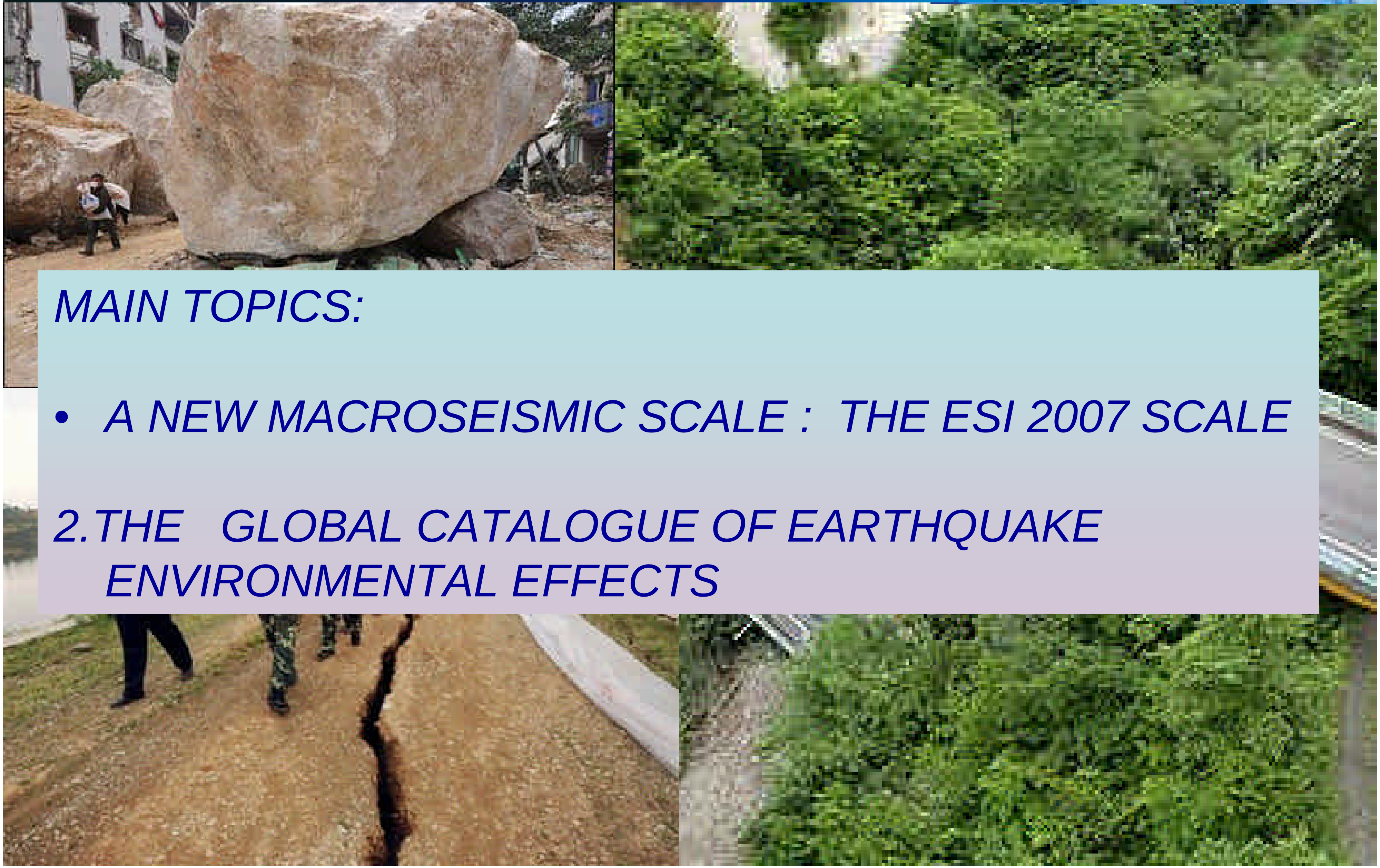
August 6 – 14th

Towards a catalogue of earthquake environmental effects

Michetti A.M., Comerci V., Esposito E., Guerrieri L., Porfido S.,
Serva L., Silva P.G. & Vittori E.



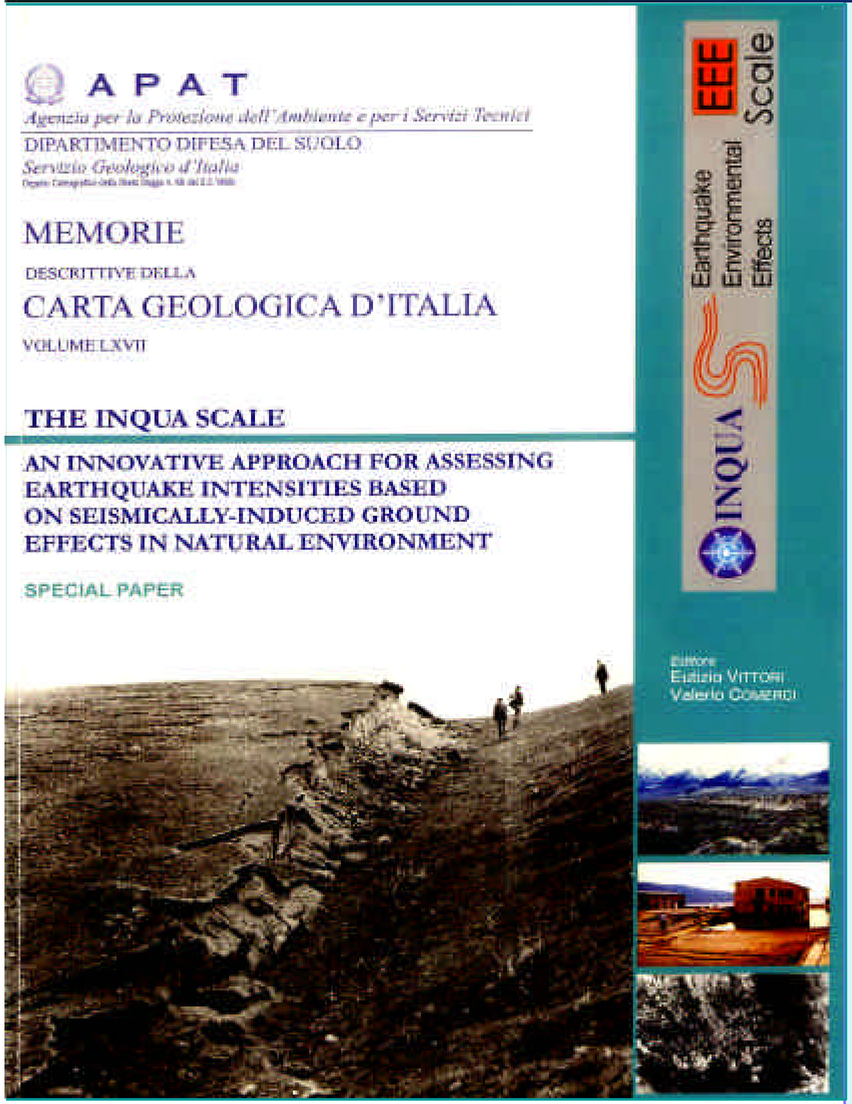


MAIN TOPICS:

- *A NEW MACROSEISMIC SCALE : THE ESI 2007 SCALE*

2.THE GLOBAL CATALOGUE OF EARTHQUAKE ENVIRONMENTAL EFFECTS

Brief history



(Michetti et al., 2004)

- Since the '90s, the idea of a new intensity scale based only on environmental effects was promoted within the scientific community and successively developed in the frame of INQUA (International Union for Quaternary Research, INQUA TERPRO (Commission on Terrestrial Processes).

- A Working Group including geologists, seismologists and engineers compiled a first version of the scale, that was presented at the 16th INQUA Congress in Reno (2003),and updated one year later at the 32nd International Geological Congress in Florence (Italy).

- The ESI 2007 scale results from the revision of the former version by a world-widespread team of scientists.

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What is ESI 2007? The Environmental Seismic Intensity scale (ESI 2007) is a new seismic intensity scale based only on the effects produced on natural environment.

It has been ratified by INQUA during the 17° Congress, Cairns (28 July – 3 August 2007).


International Union for Quaternary Research

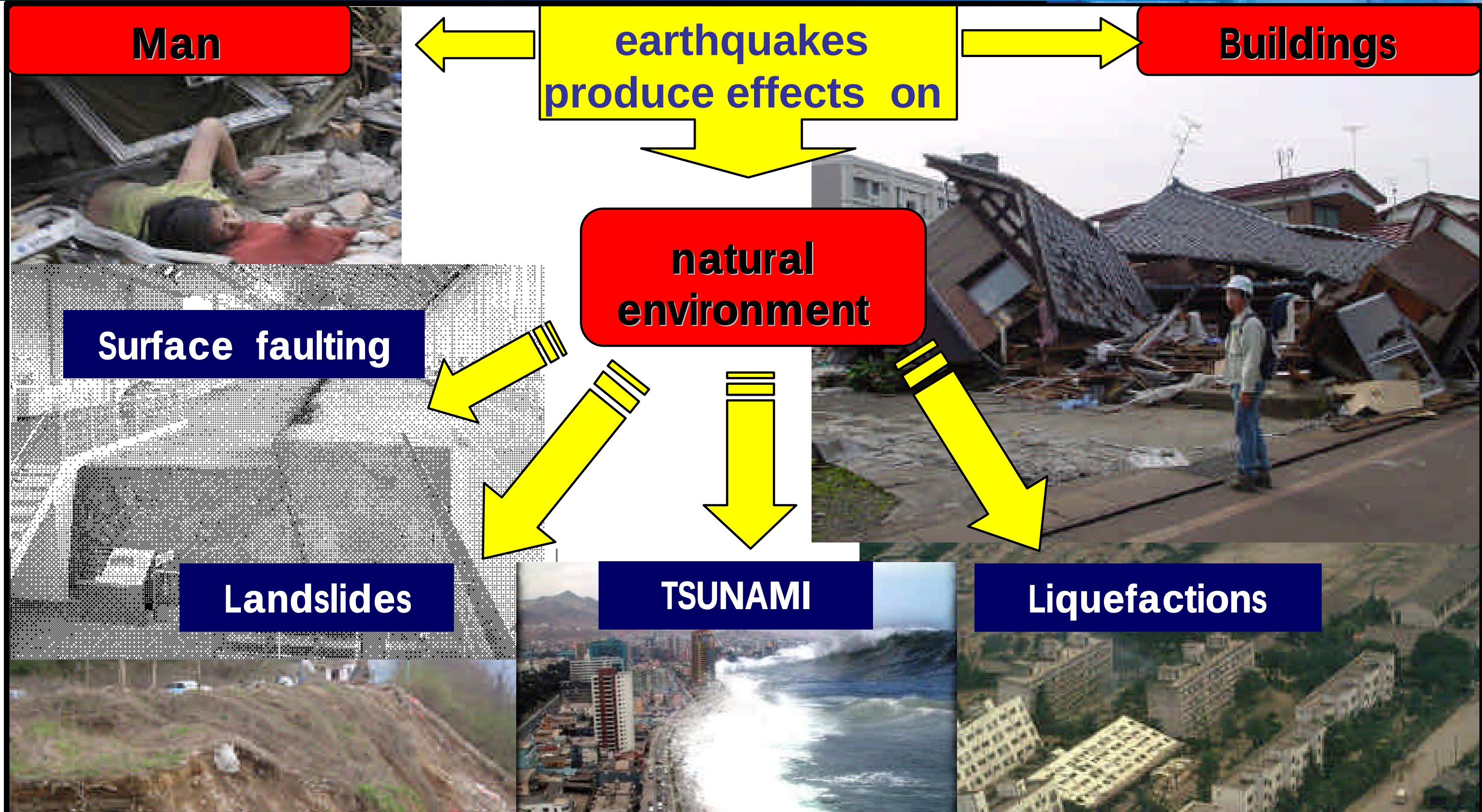
INTENSITY SCALE ESI 2007

La Scala di Intensità ESI 2007

Authors

A.M. Michetti, E. Esposito, L. Guerrieri, S. Porfido, L. Serva, R. Tatevossian, E. Vittori, F. Audemard, T. Azuma, J. Clague, V. Comerci, A. Gürpinar, J. McCalpin, B. Mohammadioun, N.A. Mörner, Y. Ota, E. Roghozin

http://www.apat.gov.it/site/enGB/Projects/INQUA_Scale/default.html/



According to the original definition of intensity in the traditional macroseismic scale, the assessment of intensity degrees is based on

- effects on humans
- effects on manmade structures
- effects on natural environment

} **EARTHQUAKE INTENSITY**

Background and rationale

- *In the early versions of the twelve degrees scales the effects of the earthquakes on the natural environment were documented. Their presence in the scale was mostly due to the many references to ground cracks, landslides, and landscape modifications.*
- Later, in the second half of the XX century, these effects have been increasingly disregarded in the literature and in the practice of macroseismic investigation, probably due to their inner complexity and variability, while increasing attention has been paid to the apparently easier to analyze effects on humans and manmade structures.

- Recent studies have offered new substantial evidence that coseismic environmental effects provide precious information on the earthquake size and its intensity field, complementing, de facto, the traditional damage-based macroseismic scales.

- As a matter of fact, with the outstanding growth of Paleoseismology as a new independent discipline, nowadays the effects on the environment can be described and quantified with a detail that is remarkable compared with that available at the time of the earlier scales. Therefore, today the definition of the intensity degrees can effectively take advantage of the diagnostic characteristics of the effects on natural environment.

Earthquake environmental effects are any phenomena generated in the natural environment by a seismic event. They can be categorized in two main types:

- ***Primary*** **surface faulting, surface uplift and subsidence**

- ***Secondary*** **hydrological change**
  anomalous sea wave , tsunami
  ground crack
  slope movement
  liquefaction/ground settlement

The ESI 2007 intensity scale is composed by:

- the Description of 12 Intensity degrees analogue to the structure used by the traditional macroseismic scales (i.e. Mercalli Cancani Sieberg - MCS; Mercalli Modificata – MM; Medvedev Sponeuer Karnik - MSK, European Macroseismic Scale - EMS).

The <u>guidelines</u>, which aim at better clarifying

1) the background of the scale and the scientific concepts that support the introduction of such a new macroseismic scale;

2) the procedure to use the scale alone or integrated with damage-based, traditional scales;

3) how the scale is organized;

4) the descriptions of diagnostic features required for intensity assessment.

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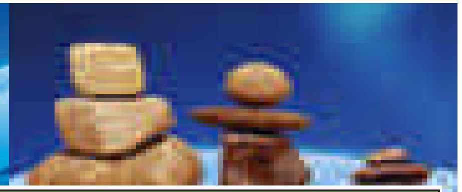


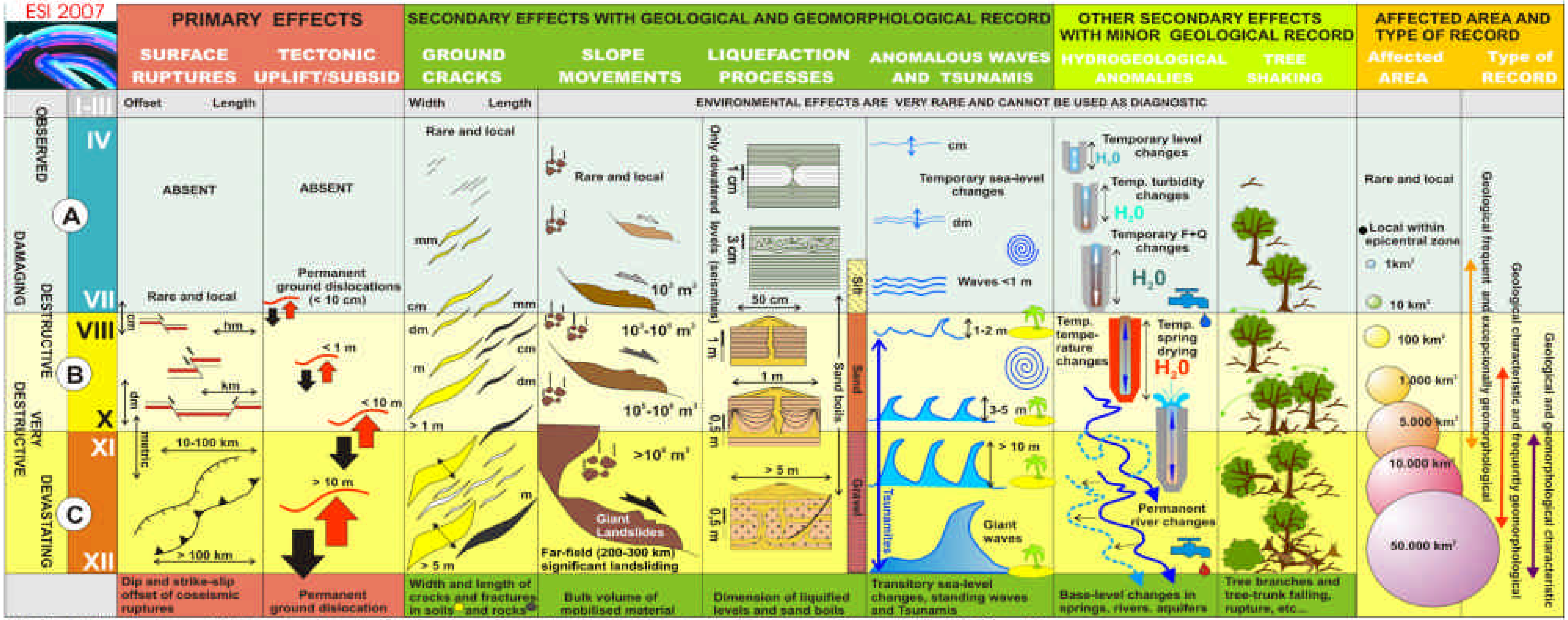
I) From I to III: There are no environmental effects that can be used as diagnostic.

II) From IV to IX: Environmental effects are easily observable starting from intensity IV, and often permanent and diagnostic especially starting from intensity VII. However, they are necessarily less suitable for intensity assessment than effects on humans and manmade structures. Their use is therefore recommended especially in sparsely populated areas.

III) From X to XII: Effects on humans and manmade structures saturate, while environmental effects become dominant; in fact, several types of environmental effects do not suffer saturation in this range. Thus, environmental effects are the most effective tool to evaluate the intensity.

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

by The Spanish Working Group (modified from Silva et al., 2008)



Michetti et al., 2007. Environmental Seismic Intensity scale - ESI 2007. Memorie Descrittive della Carta Geologica d'Italia, 74. Servizio Geologico d'Italia, APAT, Rome, Italy

Silva et al., 2008. Catalogue of the geological and environmental effects of earthquakes in Spain in the ESI-2007 Macroseismic scale. Cong. Geol. Esp. Gran Canaria, Spain

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ESI 2007 Form

This 2 pages - form has to be used for field surveys immediately after the earthquake and for the revision of environmental effects from historical sources. It is designed at the site level (one different form for each different site). Fields in *Italic* should be filled when required information is available.
A complete Guide to Compilation is available at the end of this Form.

Authors & Institution

1. ______
2. ______
3. ______
4. ______
5. ______

Earthquake

Earthquake Code ______ Earthquake Region ______

Year ______ Month ______ Day ______ Greenwich Time ______ Epicentral Intensity ______ Intensity type ______

Magnitude ______ Magnitude type ______ Focal Depth (km) ______ Depth accuracy ______

Latitude ______ Longitude ______ Earthquake References ______

Surface faulting (yes/ no) ______ *Map of rupture zone (available / not available)* ______

Maximum Displacement (m) ______ *Total Rupture Length (km)* ______ *Slip-sense* ______

Surface faulting References ______

Area of main secondary effects (km²) ______ *References for secondary effects* ______

ESI epicentral intensity assessment ______

Locality

Locality Code ______ EEE Survey Date ______ Surveyors ______

Locality ______ Town/District ______ Locality length (m) ______ Locality width (m) ______

Latitude ______ Longitude ______ Altitude (m) ______ Location accuracy ______

Distance from epicentre (km) ______ Local PGA (g) ______ Geomorphological setting ______

Local Macroseismic Intensity ______ Intensity type ______

EEE site

EEE Code ______ EEE type ______ Site length (m) ______ Site width (m) ______

Site position ______ Latitude ______ Longitude ______ Altitude (m) ______ Loc. accuracy ______

Description ______

Notes on the site ______

Bedrock lithology ______ Soft sediment lithology ______

Strength ______ Structure ______

EEE Site References ______

Effects on man-made structures

Type of man-made structures ______

Level of damage ______ Single/multiple ______

Surface faulting

Strike (°) ______ Dip (°) ______ Slip vector (°) ______ Type of movement ______

Vertical Offset (cm) ______ Horizontal Offset (cm) ______ Displaced features ______

Length of fault segment (km) ______ Scarp ______ Associated features ______

Hydrologic anomalies

Surface water effects ______ Ground water effects ______

Temperature Anomaly ☐ Temperature change (°C) ______ Discharge anomaly ☐ Discharge change (l/s) ______

Chemical anomaly Change chemical components ______ Gas emission ☐ Gas element ______

Duration of anomaly (days) ______ Time delay (hrs) ______ Velocity ______

Anomalous waves/tsunami

Max wave height (m) ______ Width (m) ______ Length of affected coast (km) ______ Time delay (min) ______

Description ______

Ground cracks

Origin ______ Strike (°) ______ Dip (°) ______ Areal density (Nr/m²) ______

Shape ______ Max opening (cm) ______ Length (m) ______

Slope movements

Type ______ Max dimension of blocks (m³) ______ Total volume (m³) ______

Linear density (Nr/m) ______ Areal density (Nr/m²) ______ Humidity ______

Time delay (hrs) ______ Width (m) ______ Slip amount (m) ______

Liquefactions

Type ______ Max diameter (m) ______ Linear density (Nr/m) ______

Areal density (Nr/m²) ______ Max lowering/uplift (m) ______ Shape ______

Humidity ______ Depth of water table (m) ______ Water ejection ☐ Sand ejection ☐

Velocity ______ Time delay/advance (hrs) ______

Other effects

Trees shaking ☐ Dust clouds ☐ Jumping stones ☐ Others ______

Description ______

Sketch

ESI local intensity assessment ______

Compilatore
Venezia Paola
Università degli studi di Napoli "Federico II"

Earthquake
Earthquake Code **IT19801123m** Earthquake Region **IRPINIA-BASILICATA**
Year **1980** Month **11** Day **23** Greenwich Time **18.34** Epicentral Intensity **X** Intensity type **MCS**
Magnitude **6.9** Magnitude type **Mw/Ms** Focal Depth (km) **18** Depth accuracy ____________
Latitude **40.85** Longitude **15.28** Earthquake References **Postpischl et al (1985), Esposito et al. (1986, 1998); Porfido et al. (2002); CFTI04 (2004), Serva et al. (2007)**
Surface faulting (yes/not): **Si** *Map of rupture zone (available/not available)* ________________
Maximum Displacement (cm) **100** *Total Rupture Length (km)* **40** *Slip-sense* **Normale**
Surface faulting References **Westway & Jackson (1984), Esposito et al. (1986), Pantosti & Valensise (1993), Blumetti et al. (2002)**
Area of max secondary effects (kms) ______________ *Reference for secondary effects* ____________

MCS - ESI epicentral intensity assessment X

Locality
Locality Code CALITRI EEE-Survey Date ______ Surveyors **Ortolani (1988); CNR-PFG (1983) Esposito et al. (1998)**
Locality **Calitri** Town/District **Avellino** Locality length (m) _______ Locality width (m) __________
Latitude **40,53** Longitude **15,25** Altitude (m) ______________ Location accuracy _____________
Distance from epicentre (km) **16** Local PGA (g) _______ Geomorphological setting _____________
Local Macroseismic Intensity VIII **Intensity type MCS**

EEE site
EEE Code _____________________________ EEE type________________________
Site length (m) ______________ Site width (m) ___________________ Site position_____________________
Latitude ___________ Longitude __________ Altitude (m)_____________ Loc. accuracy _________
Description ____
Notes on the site ____
Bedrock lithology____________________________ Soft sediment lithology _________________
Strength__________________________________Structure___________________________
EEE Site References ____

Effects on man-made structures

Type of man-made structures ____________________
Level of damage ____________________ Single/multiple ____________________

Surface faulting

Strike (°) ________ Dip (°) ________ Slip vector (°) ________ Type of movement ____________________
Vertical Offset (cm) ________ Horizontal Offset (cm) ________ Displaced features ____________________
Length of fault segment (km) ________ Scarp ________ Associated features: ____________________

Hydrologic anomalies

Surface water effects ____________________ Ground water effects ____________________
Temperature Anomaly Temperature change (°C) ____________________
Discharge anomaly Discharge change (l/s) ____________________
Chemical anomaly Change chemical components ____________________
Gas emission Gas element ____________________
Duration of anomaly (days) ________ Time delay (hrs) ________ Velocity ____________________

Anomalous waves/tsunami

Max wave height (m) _____ Width (m) _____ Length of affected coast (km) _____ Time delay (min) ________
Description ____________________

Ground cracks

Origin **scuotimento sismico** Strike (°) ________ Dip (°) ________ Areal density (Nr/m^2) **10/100.880**
Shape ________ Max opening (cm) ________ Length (m) **300-390-400-600-600-660-735-1375-1800**

Slope movements

Type **scivolamento di detrito-scorrimento rotazionale-colata di terra**
Max dimension of blocks (m^3) _____
Total volume (m^3) **$2x10^3$-$3x10^3$-$4x10^3$-$6x10^3$-$6x10^3$-$1x10^4$-$1,5x10^4$-$3x10^4$-$4x10^4$-$2x10^6$**
Linear density (Nr/m) ________ Areal density (Nr/m^2) **16/100.880** Humidity ________
Time delay (hrs) ________ Width (m) ________ Slip amount (m) ________

Liquefactions

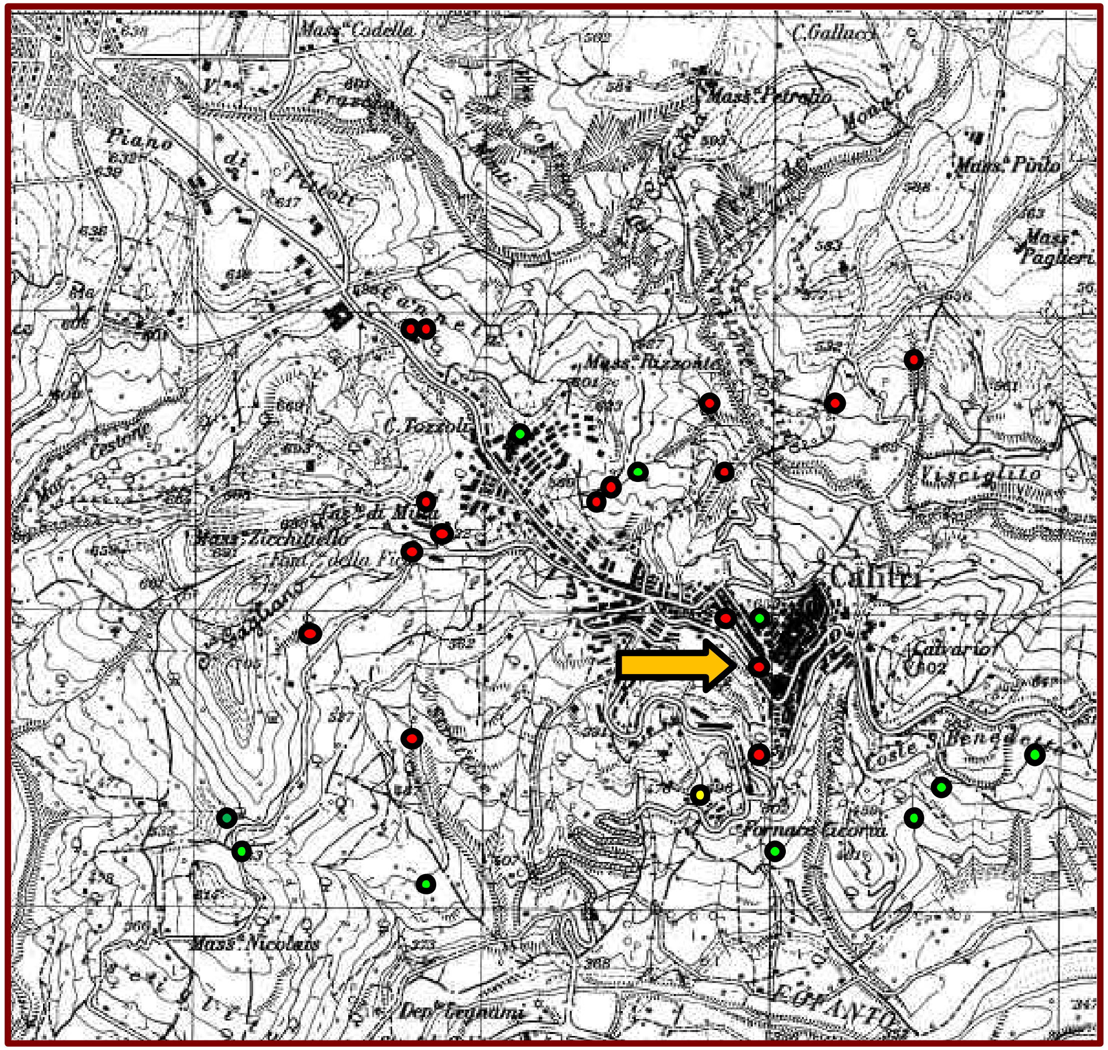
Type **liquefazione** Max diameter (m) ________ Linear density (Nr/m) ________
Areal density (Nr/m^2) **1/100.880** Max lowering/uplift (m) ________ Shape ________
Humidity ________ Depth of water table (m) ________ Water ejection **X** Sand ejection **X**
Velocity ____________________ Time delay/advance (hrs) ____________________

Other effects

Three shaking Dust clouds Jumping stones Other________________

Description________________________________

Sketch



landslides

Ground crack

liquefactions

Main landslide

(Via Matteotti, Campo sportivo, F. Ofanto)

Intensità locale ESI (ESI local intensity assessment) VIII

Coseismic reactivation of a landslide- Calitri (Avellino)

23, November 1980 Earthquake, M=6.9

Added value of ESI 2007

Its added value is particularly clear in case damages to buildings:

1) are lacking, such as in desert or sparsely populated areas;

2) suffer from saturation, i.e. the earthquake causes the total collapse of buildings (X intensity degree in Italy).
In these cases, effects on natural environment are the best tool, often the only one, to "measure" the earthquake intensity.

Intensity values based on environmental effects are more widely comparable than damages to buildings since they are not influenced by local socio-economic conditions.

AFP

- The use of the ESI scale, alone or integrated with the other traditional scale affords a better picture of the earthquake scenario, because only EEE allow comparison of earthquake intensity both in:

- TIME (EEE are comparable for a time window(recent, historic, palaeo seismic events) much larger than the period of instrumental records(last century)

- DIFFERENT GEOGRAPHIC AREAS: Environmental Effects do not depend on peculiar socio-economic conditions or different building practices.

Applications of ESI 2007

- Greece
- Italy
- Spain
- Israel
- Ecuador
- Central Asia
- Peru
- Japan
- Colombia
- Philippines
- Taiwan
- Indonesia

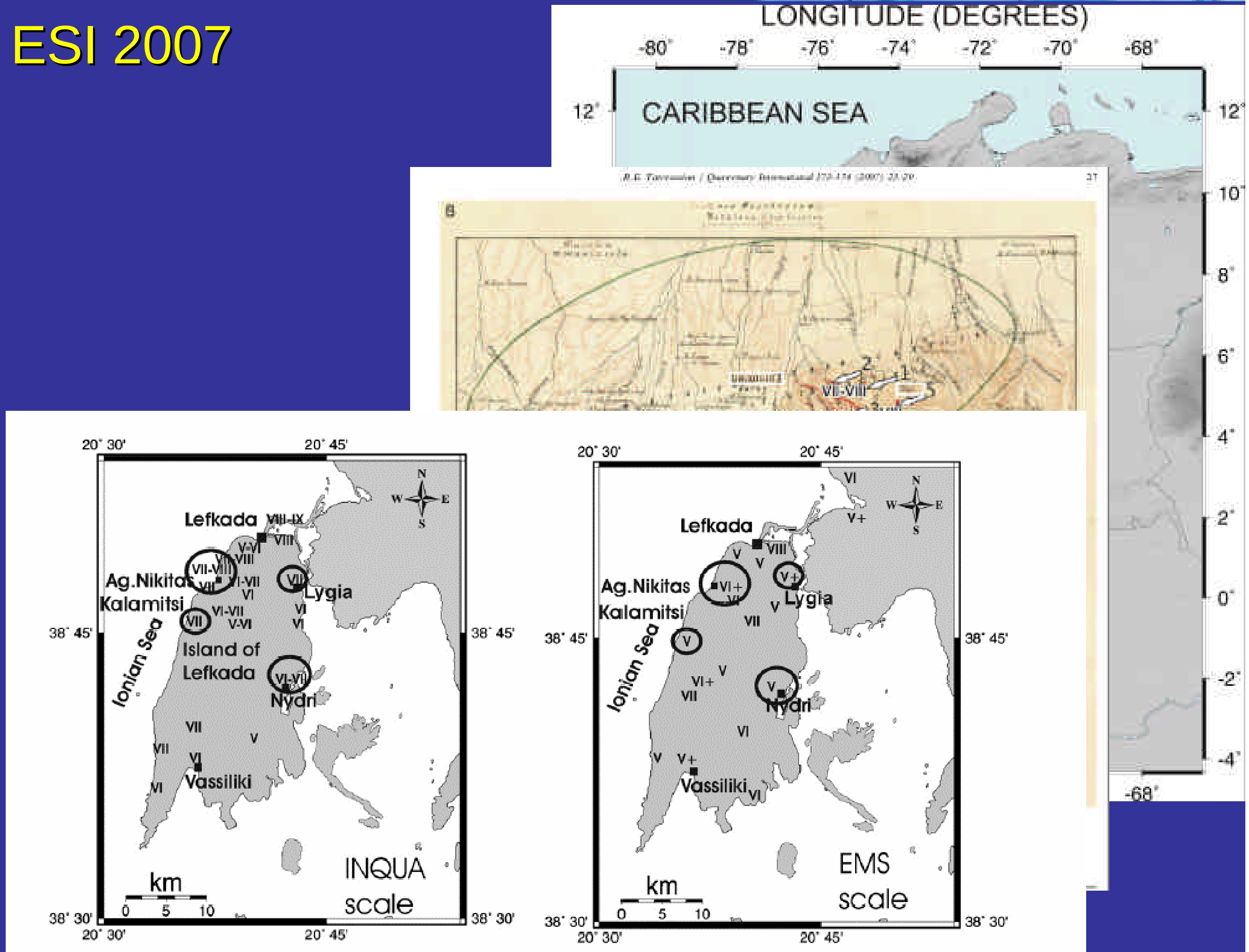


Fig. 6. Distribution of the evaluated intensities, concerning the 2003 earthquake, based on INQUA and EMS scale. The four sites, where significant differences among the evaluated intensities exist, are localized inside circles.

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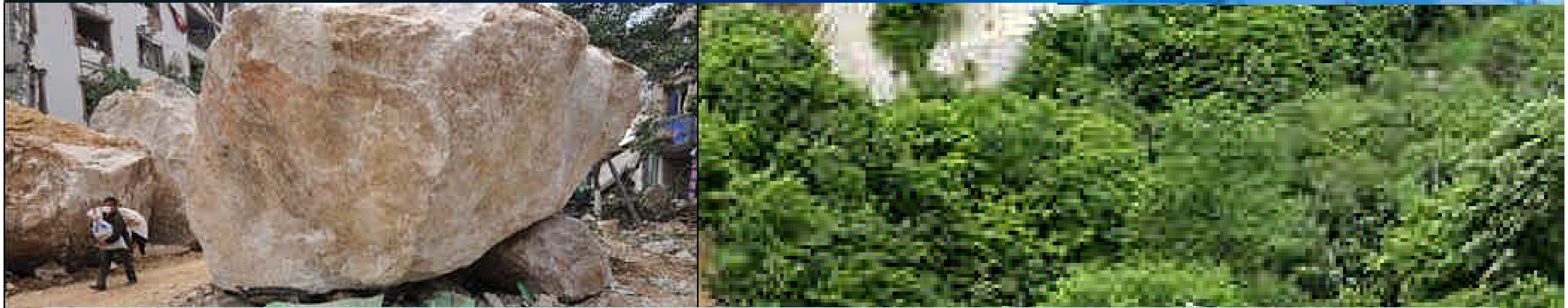
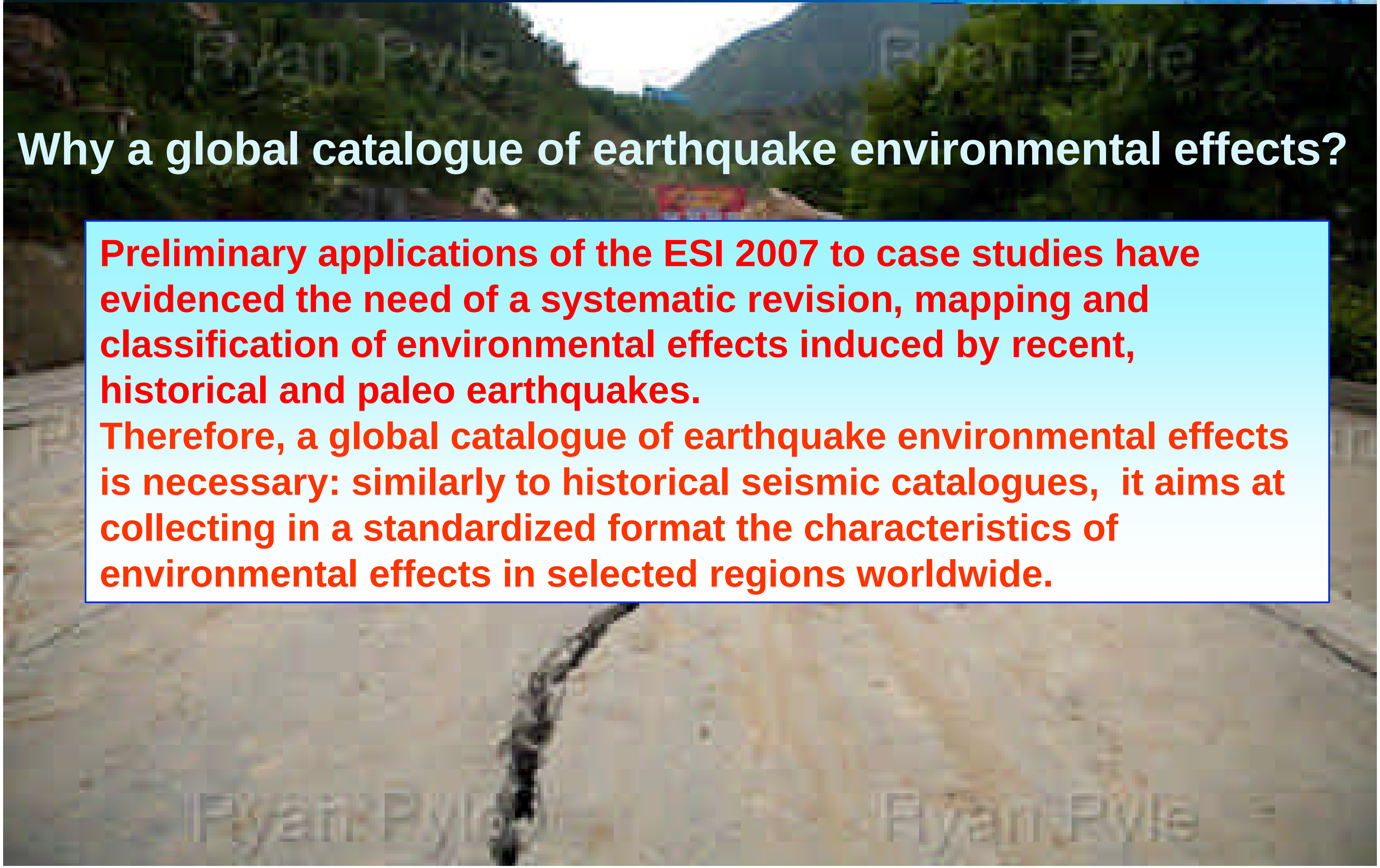


MAIN TOPICS:

- *A NEW MACROSEISMIC SCALE: THE ESI 2007 SCALE*

2. THE GLOBAL CATALOGUE OF EARTHQUAKE ENVIRONMENTAL EFFECTS



Why a global catalogue of earthquake environmental effects?

Preliminary applications of the ESI 2007 to case studies have evidenced the need of a systematic revision, mapping and classification of environmental effects induced by recent, historical and paleo earthquakes.
Therefore, a global catalogue of earthquake environmental effects is necessary: similarly to historical seismic catalogues, it aims at collecting in a standardized format the characteristics of environmental effects in selected regions worldwide.

A proposal of structure for the global catalogue of earthquake environmental effects

ID	Year	Month	Day	Hour	Min	Sec	Country	Epicentral Area	Epicentre Latitude	Epicentre Longitude

ID Number

Date of occurrence

Location of affected area and epicentre

SRL	MAX D	SLIP TYPE	TOTAL AREA	*ESI*	*N. eff*	I_0		*Earthquake*	M_{ESI}		Details
				Traditional	*Np…..*	I_0	*Type….*	I_0	*M*	*Type….*	

Surface faulting characteristics

Total area of secondary effects

Number of observations

Intensity and magnitude estimates according to ESI and traditional approaches.

Characteristics o
environmental effect
and local intensity
assessment

- In order to guarantee the maximum comparability among earthquakes, the structure of a global catalogue of EEE has to follow the above mentioned typical standard formats.

ID	Year	Month	Day	Hour	Min	Sec	Country	Epicentral Area	Epicentre Latitude	Epicentre Longitude

ID Number (ID) — Date of occurrence (Year, Month, Day, Hour, Min, Sec) — Location of affected area and epicentre (Country, Epicentral Area, Epicentre Latitude, Epicentre Longitude)

The second part of the string should be more specifically focused on the characteristics of environmental effects. Surface faulting parameters (surface rupture length, maximum displacement, prevalent slip type) and the total area of secondary effects are necessary data for the assessment of Io through the ESI scale.

SRL	MAX D	SLIP TYPE	TOTAL AREA	*ESI*	*N. eff*	I_0		*Earthquake* I_0	M_{ESI}		Details
				Traditional	*Np…..*	I_0	*Type….*		*M*	*Type….*	

Surface faulting characteristics (SRL, MAX D, SLIP TYPE)

Total area of secondary effects (TOTAL AREA)

Number of observations (N. eff / Np)

Intensity and magnitude estimates according to ESI and traditional approaches. (I_0, Earthquake I_0, M_{ESI})

Characteristics of environmental effects and local intensity assessments (Details)

AEQUA Catalogue of Earthquake Ground Effects in Spain: applications of the EEE INQUA Scale in the Iberian Peninsula (P.G. Silva et al., 2007)

The Spanish Catalogue of Earthquake Ground Effects is structured in four temporal sections which display an increasing quality of data source, from geological and archeological data, up to historical documents, contemporary reports and newspapers and finally to instrumental data.

At present, 32 seismic events have been compiled.

AEQUA Catalogue of Earthquake Ground Effects in Spain

The **catalogued historical earthquakes** is subdivided in different groups attending to the available information used for their classification:

- **Quality A):** *Events of Intensity ³ IX MSK documented by specific reports, epoch journals and newspapers, describing damage and environmental effects (>1800AD).*
- **Quality B):** *Events of Intensity VIII MSK documented by specific reports, epoch journals and newspapers, describing damage and environmental effects (>1800AD).*
- **Quality C):** *Events of Intensity ³ IX MSK historically and archeologically documented (1300-1800 AD).*
- **Quality D):** *Events of Intensity ³ IX MSK which Information only came from Archaeosieismic and or Paleoseismic research (< 1300 AD).*

- **Quality I):** *Events of Intensity VI-VII MSK instrumentally recorded and documented by specific reports published by public institutions (IGN, IAG, etc..) or in scientific journals.*

QUALITY A EVENTS: DOCUMENTED BY SPECIFIC REPORTS, EPOCH JOURNALS and NEWSPAPERS

Epicentral locality	Reported Intensity	(Mw) Estimated	Building Damage and Landscape and environmental change
Dalías-Berja (Almería) **1804 AD. 25/08**	IX MSK VIII-IX EMS	6.4	**MACROSEISMIC EPICENTRE:** Event reported in official Catalogues of the IGN Seismic Data-Base. **EIS 2007 INQUA FILES AVAILABLE:** SP18040825* **Geographical Coordinates**: 36º 46' N 2º 50' W **Datum:** WGS84

GENERAL DAMAGE: 407 deaths/ Collapse of churches and towers. > 200 houses destroyed.

Ref. Larramendi, M.J. (1829); Prado, C. del (1863)

EN VIRONMENTAL DAMAGE:

☒Surface rupture of probable coseismic origin of 200 m length decimetric width and a maximum depth of 9-10m.

❒Rockfalls and localized landslides 50-55 km away from the epicentre.

❒❒Change of chemical properties of springs.

❒Small sea-level retreat after the main shock.

Environmental damage area: *Maximum environmental damage over an area of 98.3 km².*

Local Intensity MSK: IX

Local Intensity EEE: IX

Research and data collection by J.J. Martínez Díaz (UCM), P.G. Silva (USAL)

Torrevieja (Alicante) **1829 AD. 21/03**	X MSK	6.6 – 6.9*	**MACROSEISMIC EPICENTRE:** Event reported in official Catalogues of the IGN Seismic Data-Base. **EIS 2007 INQUA FILES AVAILABLE:** SP18290321* **Geographical Coordinates**: 38º 05' N 0º 41' W **Datum:** WGS84

GENERAL DAMAGE: 389 deaths and 375 injuries / About 2,900 houses destroyed and around 2,000 ones damaged. 5 villages totally destroyed and other 13 ones needed a serious rebuilding. Four bridges over the Segura river where damaged. Seismic shacking was felt on a boat located about 32 km offshore from Torrevieja.

Ref. Larramendi, M.J. (1829); Prado, C. del (1863); Delgado et al. (1998), Alfaro et al., 2001, 2002

EN VIRONMENTAL DAMAGE:

☒Open fissures on the ground. Larger One in Cabo Cervera of decametric length and metric width

☒ ☒☒☒☒☒☒☒☒☒☒☒☒☒☒☒ Liquefaction and mud-volcanoes over an area of c.a. 7-17 km² with more than 7000 vents catalogued (site effect on flood plains and lagoons). Gas emissions with death of vegetation and animals. Almopradí, Daya Nueva, Daya Vieja, Catral, Los Dolores, San Fulgencio, San Miguel de Salinas, etc…

☒Overflow of an artesian well commonly at 12m depth during a month in Montesinos (9- km away).

☒Water fountains in shallow lagoons (10-12 km away) intermittently actives 3 years after the event. (11.5 km away).

☒☒☒ Change of flow rates in Springs (45-55 km away), wells and rivers.

☒Localized Rockfalls in Los Garres (Murcia) 35 km away.

❒Permanent uplift of about 10-7cm recorded in harbours and lagoons over a coastal length of ca. 13 km North of Torrevieja

❒Small sea-level retreat after the shock (Tsunami?).

Environmental damage area: *Maximum environmental damage over an area of 474km² over the Lower Segura Basin between Orihuela y San Fulgencio-Rojales.*

Local Intensity MSK: X

Local Intensity EEE: X

Research and data collection by P. Alfaro (UA), T.Bardají (UAH), P.G. Silva (USAL).

QUALITY B EVENTS: HISTORICALLY AND ARCHEOLOGICALLY DOCUMENTED

Epicentral locality	EMS Intensity	(Mw) Mag.	Building Damage and Landscape and environmental change
Tabernes (Valencia) **1396 AD. 18/12**	VIII-IX	6.5	**MACROSEISMIC EPICENTRE:** Event reported in official Catalogues of the IGN Seismic Data-Base. **Geographical Coordinates**: 39º 05' N 0º 13' W **Datum:** WGS84

GENERAL DAMAGE: Collapse of towers and bridges. Hundreds of houses destroyed.

Damage area *531 km²*

Ref. Galbis, 1932, 1940.

EN VIRONMENTAL DAMAGE: *PARTIALLY DOCUMENTED EVENT*

❒Open fissures in the ground at Tabernes

❒❒Liquefaction processes (site effect) at Tabernes and Alcira between 13 and 18 km away from the epicentre.

❒ Changes in flow rate and turbidity in springs (Alcira) 18 km away from the epicentre.

❒Localized rockfalls are also reported from the localities of Bacheta (1 km away), Vilalonga (20 km away) and Castel de Gallineta (24,5 km away).

Environmental damage area *over ca. 250 km²*

Local Intensity MSK: X.

Local Intensity EEE: IX-X

Research and data collection by: P.G. Silva

Queralps (Girona) **1428 AD. 02/02**	IX-X		**MACROSEISMIC EPICENTRE:** Event reported in official Catalogues of the IGN Seismic Data-Base. **Geographical Coordinates**: 42º 21' N 2º 10' W **Datum:** WGS84

GENERAL DAMAGE: 800 deaths. Churches and tower castles seriously damaged. Many houses damaged.

Damage area *980 km²*

Ref. Galbis, 1932, 1940.

EN VIRONMENTAL DAMAGE: *PARTIALLY DOCUMENTED EVENT*

❒Large fracture of 8 km length and decimetric opening.

❒Open fissures in the ground with associated emission of sulphuric gasses.

❒Scattered rockfalls.

Environmental damage area *over ca. 350 km²*

Local Intensity MSK: X.

Local Intensity EEE: IX-X

Research and data collection by: P.G. Silva

Atarfe (Granada) **1431 AD. 24/04**	VIII-IX	6.7	**MACROSEISMIC EPICENTRE:** Event reported in official Catalogues of the IGN Seismic Data-Base. **Geographical Coordinates**: 37º 08' N 3º 38' W **Datum:** WGS84

GENERAL DAMAGE: Damage in towers and mosques. Walls of the Arab Castle of Granada (Alhambra) partially collapsed, and the Alixares Palace SE of la Alhambra totally collapsed. Main damage at the villages of Ahendin and Otura about 5-7 km southwest from Granada. This earthquake was felt with intensity VI-VII EMS in Ciudad Real (200 km away) and of IV-V EMS in Madrid (400 km away).

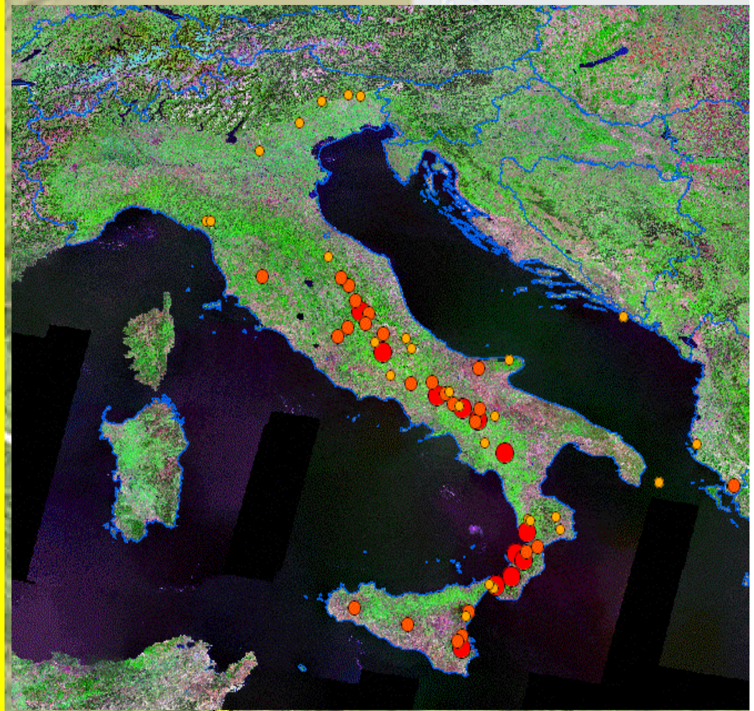
Damage area: *Damage mainly restricted to the eastern margin of the Granada Basin, around the City of Granada*

Ref. Galbis, 1932,1940, Espinar Moreno, 1994

EN VIRONMENTAL DAMAGE: *NO STUDIED EVENT.*

The ESI intensity scale is applied to a five events occurred in the Southern Apennines, one of the most seismic regions of Italy, to contribute to the world archive (EEE database) of coseismic geological effects under construction within the project.

The investigated earthquakes span in age from 1688 to 1980, with intensities between X and XI MCS (estimated magnitude 6.6-6.9). For each earthquake, the review of the original historical sources has permitted to construct an updated portrait of the type, distribution and size of the coseismic environmental effects.



Date	Region	I MCS	M	Victims
1688	Sannio	XI	6,7	10,000
1694	Irpinia-Basilicata	X-XI	6,9	6,000
1805	Molise	X	6,6	6,000
1930	Irpinia	X	6,7	1,425
1980	Irpinia-Basilicata	X	6,9	3,000

Methodology

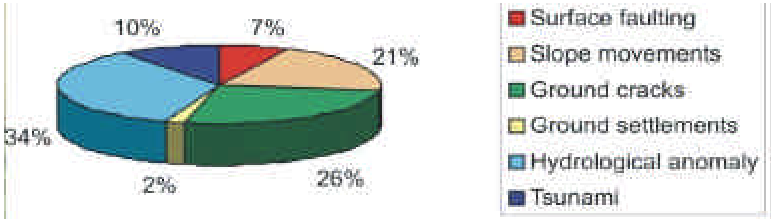
1. **Analysis of historic sources, including completeness and reliability of the document within the historical context and source classification.**

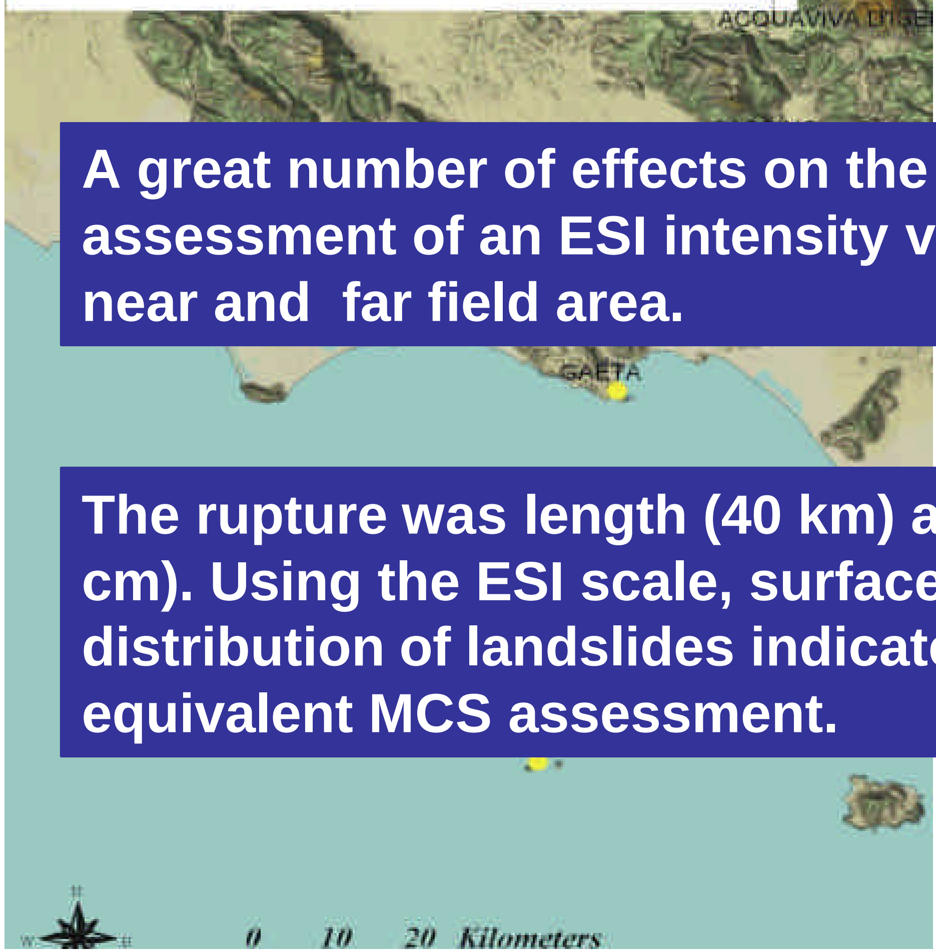
2. **Classification of the coseismic environmental effects**

3. **Intensity assessment by using ESI 2007 scale**

The Nordic Countries invite you to The 33rd IGC
INTERNATIONAL GEOLOGICAL CONGRESS OSLO 2008
August 6 – 14th

26 July 1805, Molise earthquake





Locality	Latitude	Longitude	Type of effect	Site distance	I_{MCS}	I_{EEE}
Acquaviva d'Isernia	41,87N	14,75E	SM	13	7	8
Agnone	41,8N	14,37E	HA	27	8	7
Alvignano	41,23N	14,33E	HA	31	7	7
Arienzo	41,02N	14,48E	HA	53	7	7
Bagnoli del Trigno	41,84N	14,47E	SM	18	7	7
Bojano	41,48N	14,47E	HA, GC	4	9	9
Caiazzo	41,18N	14,37E	HA	39	7	7
Campobasso	41,33N	14.4E	GC	13	9	>7
Cantalupo	41,31N	14,23E	GS	0	10	8
Capri	40,33N	14,55E	TS	110		5
Carovilli	41,42N	14,17E	SM	26	7	7
Cassino	41,48N	13,82E	HA	55	7	7
Castelfranco in Miscano	41,18N	15,5E	SM	54	7	7
Castelvenere	41,23N	14,53E	HA, GC	27	7	6
Cerreto sannita	41,28N	14,55E	HA, GC, SM	20	8	8
Madonna dell'Arco	40,85N	14,37E	HA	70	7	6
Melizzano	41,15N	14,5E	HA, GC	35	7	7
Montagano	41,38N	14,4E	GC	19	7	7
Morcone	41,35N	14,67E	SF	14	8	10
Napoli	40,51N	14,15E	HA, TS	77	7	8
Solopaca	41,18N	14,53E	HA, SM	35	8	8
Sorrento	40,37N	14,22E	TS	101	7	6
Telese	41,2N	14,52E	HA	34	7	7
Trivento	41,78N	14,55E	SM, GC	30	7	7
Ventotene	40,58N	13,52E	TS	122		5
Vesuvio	40,82N	14,42E	SM	60	7	6
Villamaina	40,97N	15,08E	HA	84	7	6

A great number of effects on the natural environment has allowed assessment of an ESI intensity value (from V to X) for 50 localities in the near and far field area.

The rupture was length (40 km) and the maximum displacement (150 cm). Using the ESI scale, surface faulting parameters and the total areal distribution of landslides indicate I_0 = X in agreement with the equivalent MCS assessment.

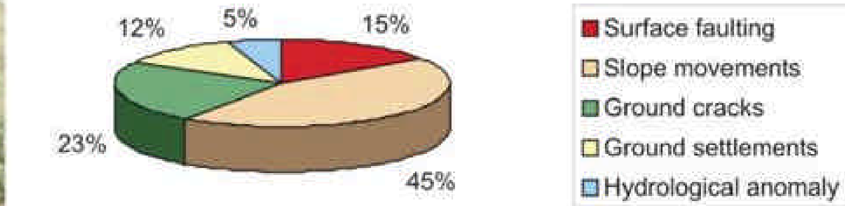
23 November 1980, Irpinia earthquake

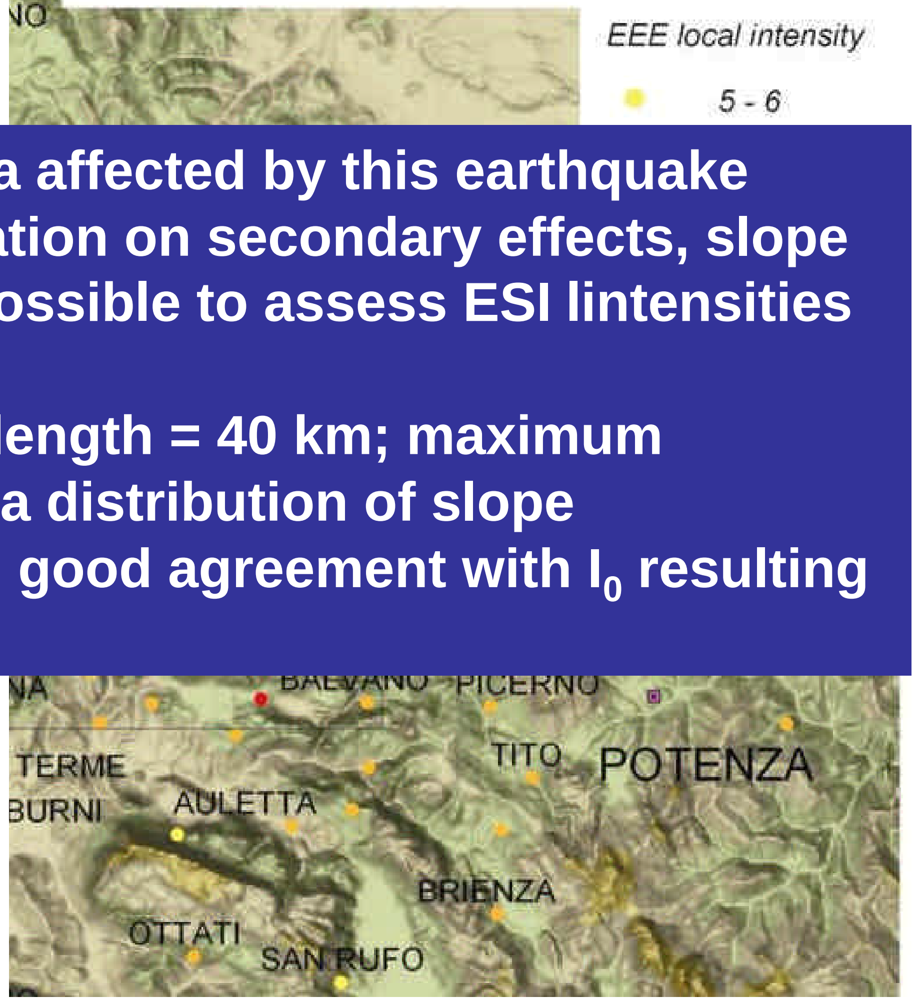
Locality	Latitude	Longitude	Type of effect	Site distance	I_{MCS}	I_{EEE}
Acerno	40,44N	15,03E	SM	27	8	7
Ailano	41,23N	14,12E	SM	118	5	5
Andretta	40,55N	15,19E	SM, GC	17	7	8
Atella	40,52N	15,39E	SM	25	7	7
Auletta	40,33N	15,25E	SM	33	8	7
Avigliano	40,39N	15,43E	SM	32	6	7
Balvano	40,39N	15,3E	SM	20	8	7
Bella	40,45N	15,32E	SM, SF	18	8	8
Brienza	40,28N	15,37E	GC	40	7	8
Brindisi di Montagna	40,36N	15,56E	SM	58	6	7
Buccino	40,37N	15,22E	SF	12	8	8
Caggiano	40,34N	15,29E	SM	28	7	8
Calabritto	40,47N	15,13E	SM, HA, SF, GC	13	9	8

Numerous geological surveys of the area affected by this earthquake have provided a large amount of information on secondary effects, slope movements and ground cracks .It was possible to assess ESI Iintensities to 66 localities (284 effects).

The amount of surface faulting (rupture length = 40 km; maximum displacement = 100 cm, and the total area distribution of slope movements (7400 km2) indicate I_0 = X, in good agreement with I_0 resulting from MSK scale.

Locality	Latitude	Longitude	Type of effect	Site distance	I_{MCS}	I_{EEE}
Scafati	40,44N	14,31E	GS	30	6	7
Senerchia	40,42N	15,12E	SM, GC, SF	17	9	9
San Giorgio la Molara	41,16N	14,55E	SM, GS	83	7	8
Sicignano degli Alburni	40,33N	15,18E	SM	26	6	6
San Gregorio Magno	40,66N	15,40E	SF	20	8	10
S. Mango	40,57N	14,58E	SM, GC	20	9	8
San Marzano sul Sarno	40,46N	14,35E	GS	59	5,5	6
S. Michele di Serino	40,52N	14,51E	GS	33	9	6
Solofra	40,49N	14,5E	SM, GC	43	8	8
S. Rufo	40,26N	15,27E	SM	40	7	8
Teora	40,51N	15,15E	GC	10	9	6
Tito	40,34N	15,4E	GC, SM	32	7	8
Torella dei Lombardi	40,56N	15,06E	SM	27	8	8
Vaglio Basilicata	40,39N	15,55E	SM	50	6	8
Valva	40,43N	15,16E	GC, SF, SM	10	8	7
Vietri di Potenza	40,35N	15,3E	GC, SF, SM	35	6	8
Villamaina	40,58N	15,05E	SM	25	8	8
Volturara Irpina	40,52N	14,54E	GS	28	8	7

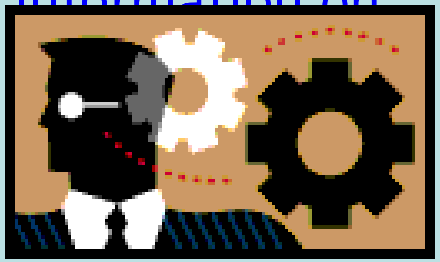




Open issues

•**What earthquakes are we going to collect?** Identification of a minimum threshold.

•The revision of the Wells and Coppersmith database provide information on several earthquakes but only concerning primary effects.



•**One worldwide catalogue or national catalogues?**

•Do we need to differentiate among
1) recent and future earthquakes, based on field surveys of environmental effects ;
2) revision of past earthquakes based on historical sources;
3) paleoearthquakes, based on paleoseismological features.

•**How to develop relationships between magnitude and ESI intensity degrees**


北淡町震災記念公園
Thank you