



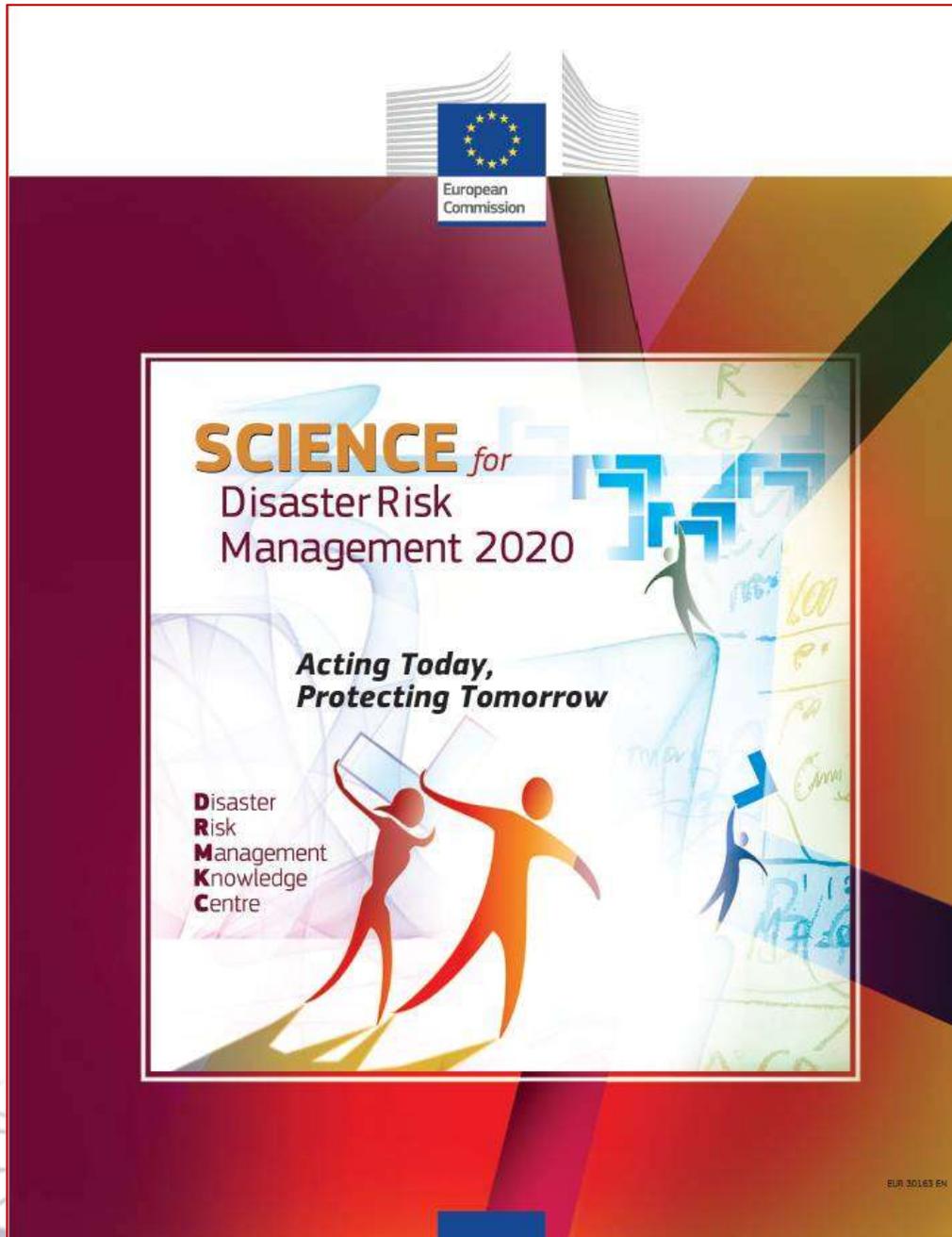
# Earthquakes in Central Italy in 2016-2017

Daniela Di Bucci, Mauro Dolce



PROTEZIONE CIVILE  
Presidenza del Consiglio dei Ministri  
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# Foreword



# Eqs in Central Italy 2016-2017

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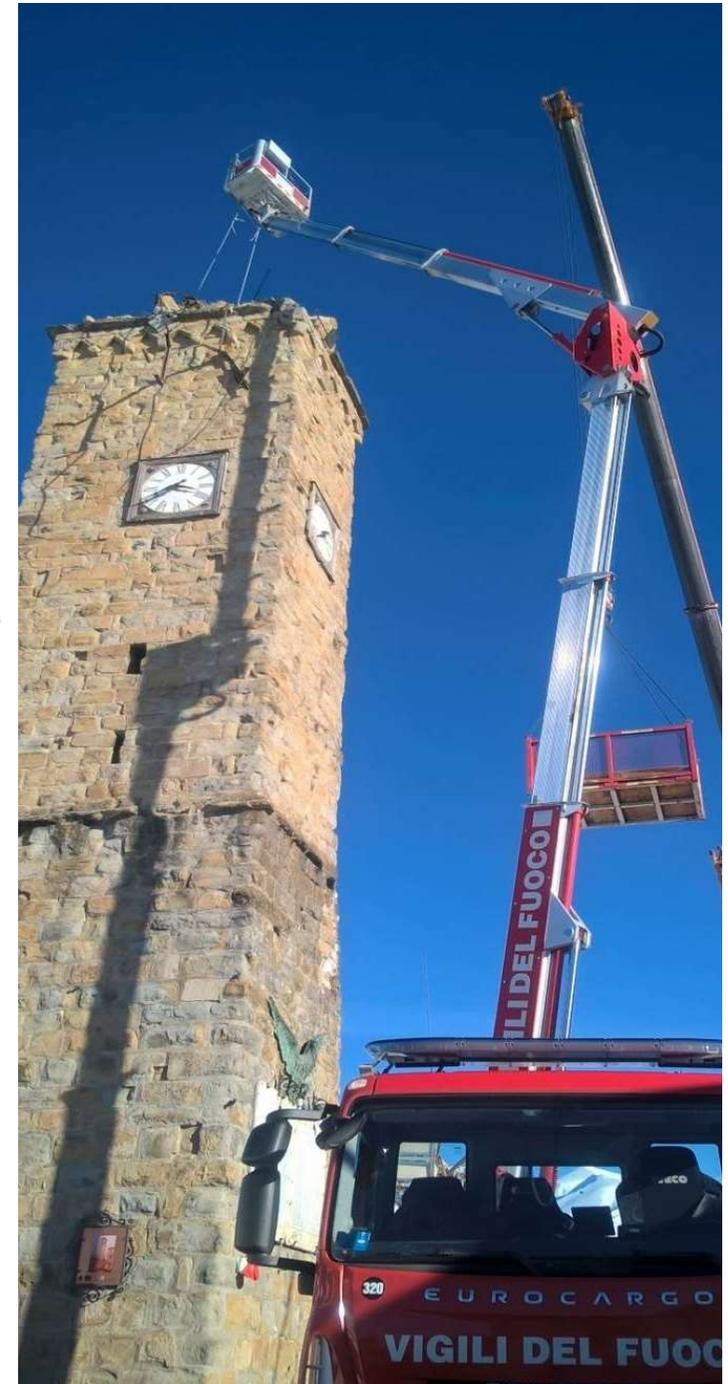
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## ABSTRACT

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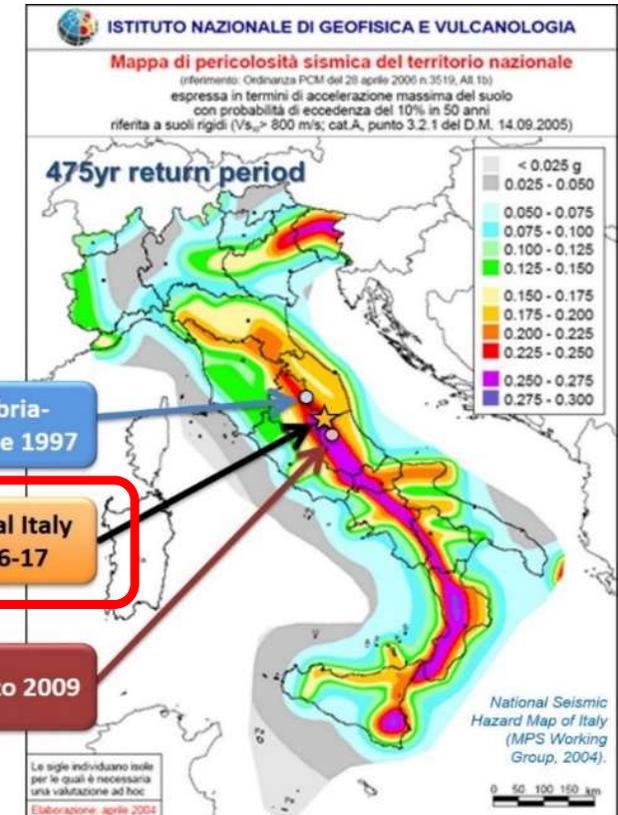
## REFERENCES



# Eqs in Central Italy 2016-2017

Starting on 24 August 2016, a severe and very long seismic sequence hit central Italy. Two out of the nine major shocks had moment magnitude ( $M_w$ )  $\geq 6.0$ .

*2016–17 Central Apennines seismic sequence:  $M_w \geq 5.5$  earthquake*



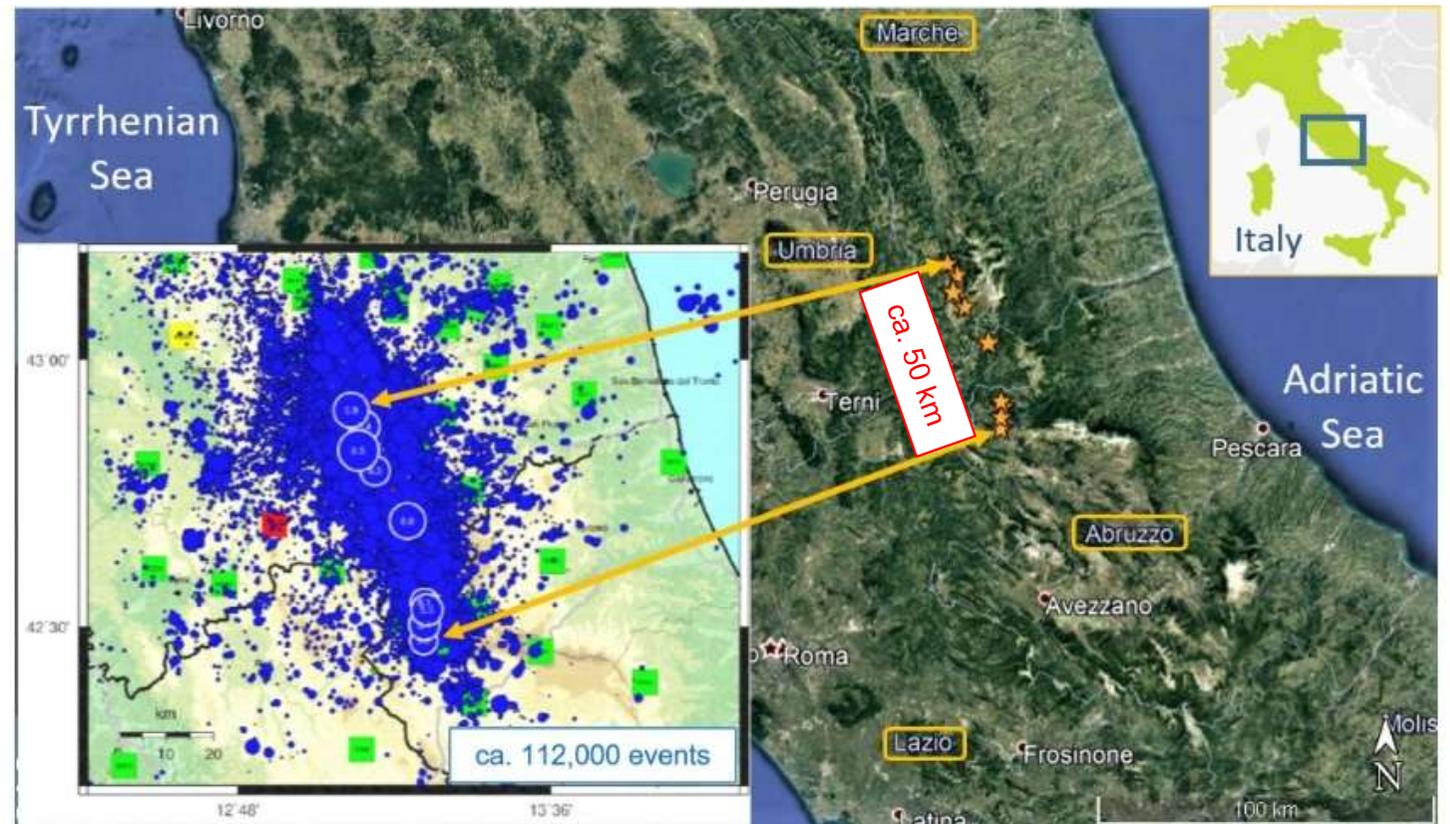
Date	$M_w$	Zone	Lat	Long	PGA max ( $\text{cm/s}^2$ )	Fatalities	Injured
<b>2016-08-24</b>	<b>6.0</b>	1 km W Accumoli (Rieti)	42.70	13.23	916	299	392
<b>2016-10-26</b>	5.9	3 km NW Castelsantangelo sul Nera (Macerata)	42.91	13.13	684	0	0
<b>2016-10-30</b>	<b>6.5</b>	5 km NE Norcia (Perugia)	42.83	13.11	650	0	38
<b>2017-01-18</b>	5.5	2 km NW Capitignano (L'Aquila)	42.53	13.28	584	0	0

# Eqs in Central Italy 2016-2017

The affected area, along the Apennines, has a NNW–SSE direction.

The maximum observed intensity on the Mercalli–Cancani–Sieberg scale was **XI** (catastrophic).

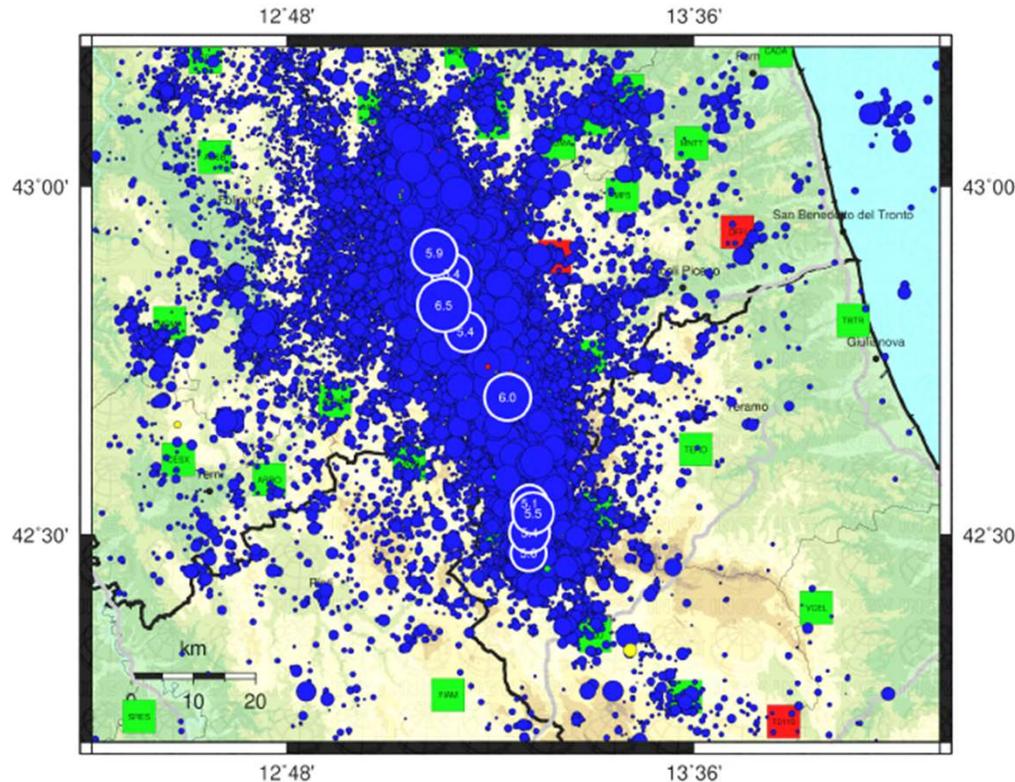
A total of **299** people lost their lives.



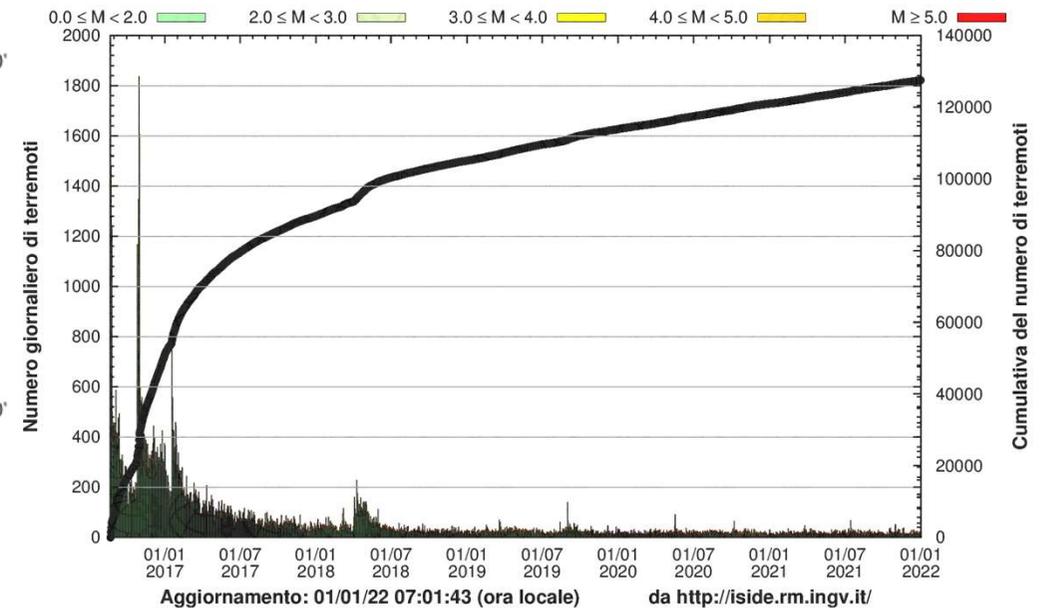
Central Italy 2016–2017 seismic sequence in the regional context. The four regions involved are marked in yellow. Bottom left insert: seismic sequence updated at 1 October 2019 (from Istituto Nazionale di Geofisica e Vulcanologia: <http://terremoti.ingv.it/>)

# The seismic sequence to date

Mappa Epicentrale della Sequenza Sismica  
per il periodo 23-08-2016 : 01-01-2022



After more than 5 years, the seismic sequence is still ongoing, although with few minor eqs.



Aggiornata al 2022-01-01,06:01:05 UTC, numero di eventi **127525**

	Oggi	Ieri	2gg fa	Precedenti
MI < 3.0	6	24	22	126200
3.0 ≤ MI < 4.0	0	0	0	1197
4.0 ≤ MI < 5.0	0	0	0	66
MI ≥ 5.0	0	0	0	9



Central Italy 2016–2017 seismic sequence, 1<sup>st</sup> January 2022 update (from Istituto Nazionale di Geofisica e Vulcanologia: <http://terremoti.ingv.it/>).

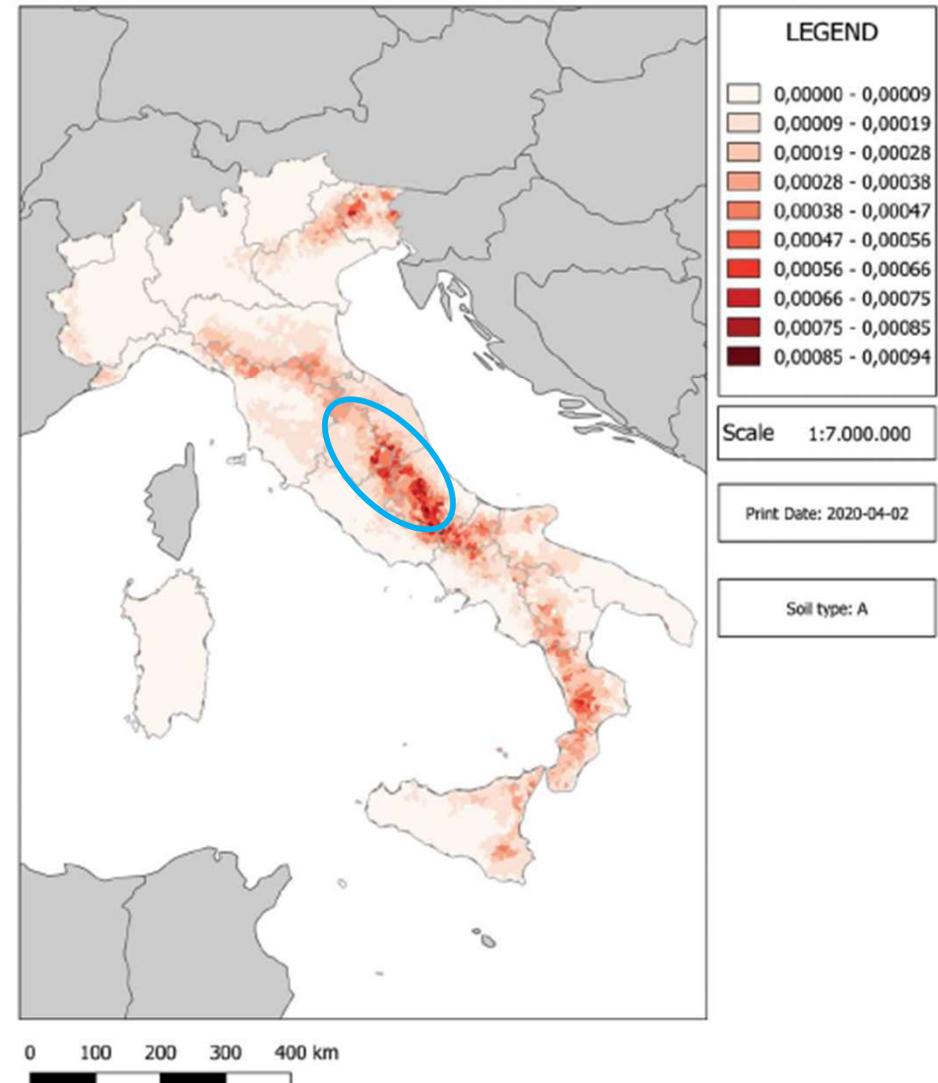
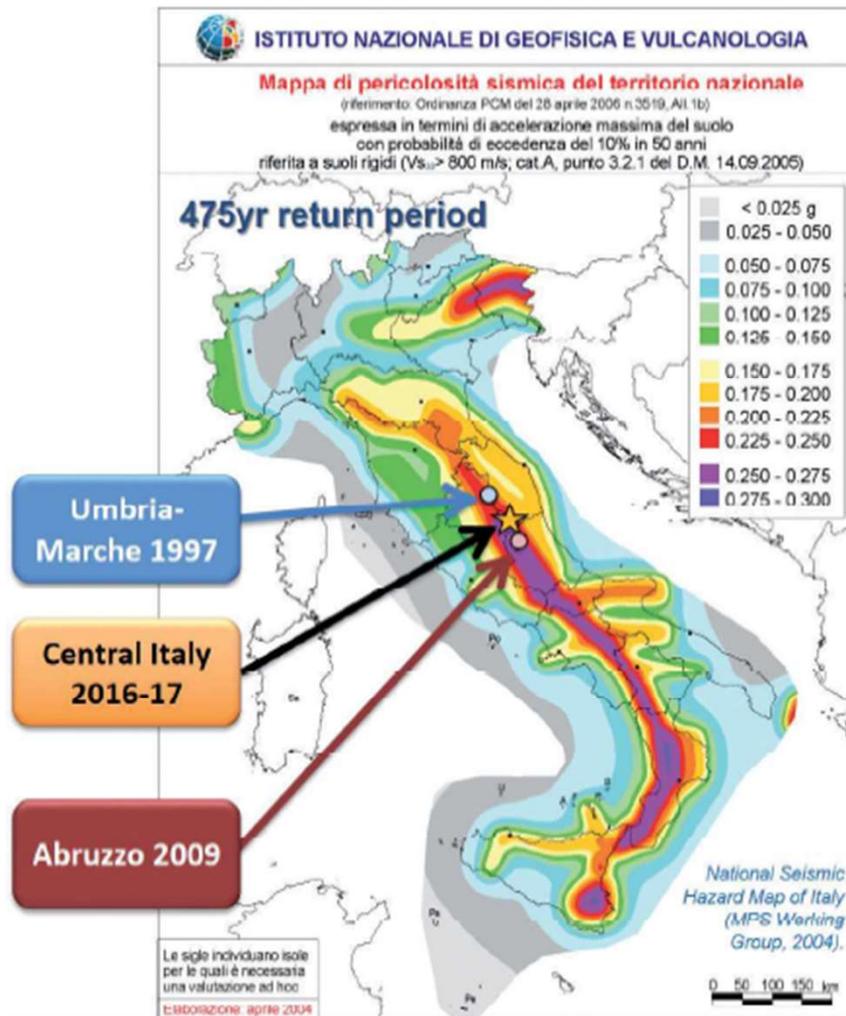
## Characteristics of the epicentral area

- Affected area located in Central Italy, **at the boundaries between 4 Regions**: Abruzzo, Lazio, Marche and Umbria.
- **7 Provinces involved**: Ascoli Piceno, Fermo, L'Aquila, Macerata, Perugia, Rieti, Teramo.
- Territory prevalingly **mountainous**, with more than 70% exceeding 900 m elevation.
- Population average **density of 15 people/km<sup>2</sup>** (vs. 200 people/km<sup>2</sup> national average; ISTAT, 2016), distributed over small municipalities formed by a large number of localities (2600 people in the Amatrice municipality, distributed over 47 localities).
- Average income per person less than **€ 10,000/yr** (vs. national equivalent € 12,790/yr).

## Characteristics of the affected territory

- **65% of population working** where they live (national average 54%) → local labor market, mainly based on agricultural economy.
- **High percentage of farms** (especially breeding farms): more than 7 farms per 100 inhabitants (national average 2.7).
- **Tourism** → important economic activity related to the nature of the area: great **environmental interest** and low urbanization.
- Availability of **accommodation** (> 300 beds per 1000 inhabitants, national average 80); large number of B&B and holiday farms.
- Many **tourists are house-owners** living in the surrounding cities and spending their holidays in their houses, which are a relevant part of the damaged building stock.

# Seismic hazard and risk



Left) Central Italy 2016-2017 seismic sequence projected on the National Seismic Hazard Map of Italy along with the nearby Umbria–Marche 1997 and Abruzzo 2009 seismic sequences. Source: Stucchi et al., 2004.

Right) Map of the average expected numbers of dwellings affected by Damage Level 5 (partial or total collapse) in 1 year in proportion to the total number of dwellings in the municipalities. Source: DPC, 2018a.

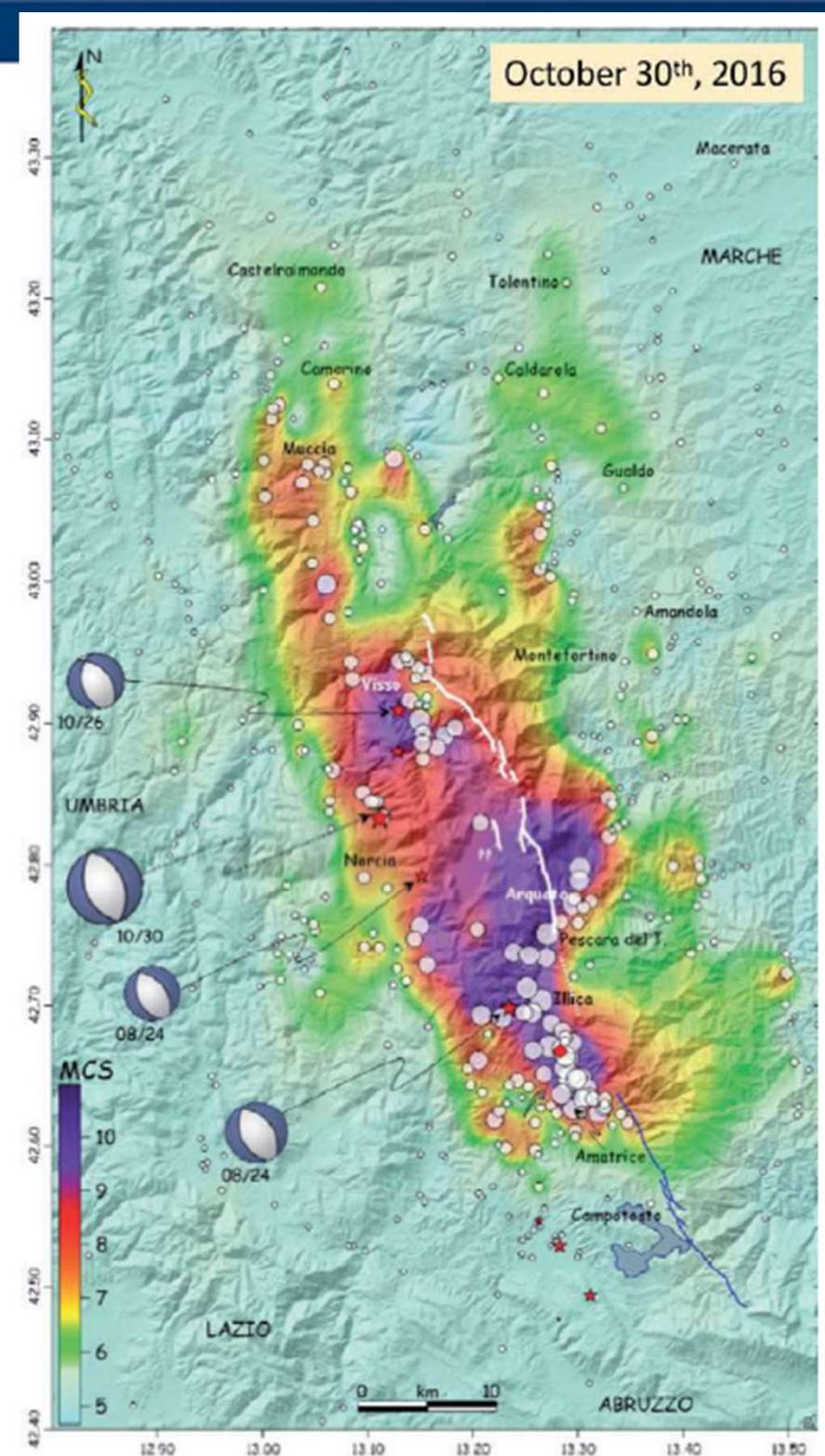
# Overall impact of the seismic sequence

After the first main shock, macroseismic MCS intensities up to **X** or **XI** (ruinous or catastrophic) were observed. After 30 October 2016, the damaged area enlarged considerably.

The maximum observed (cumulative) intensity was **XI** (Tertulliani and Azzaro, 2016a,b, 2017; Galli et al., 2016; 2017).

The area with I MCS  $\geq$  **VII** (very strong) was about 70 km long and 30 km wide.

Macroseismic survey of the 2016–2017 Central Italy seismic sequence in the MCS Intensity scale after the October 30th, 2016, strongest main shock (Galli et al., 2017).



# Eqs in Central Italy 2016-2017



**Devastating damage** happened to buildings, cultural heritage, roads and other lifelines, resulting in huge losses.

The **emergency response** was coordinated by the Italian National Civil Protection Department.

The severity and duration of the sequence and its dramatic impact on population, territories and assets make this disaster a **perfect case study to address the goal of knowing better and losing less.**



## Impact on the main assets

The damage to the various assets was devastating (cumulative effect of several main shocks): residential buildings, schools, hospitals, cultural heritage, livestock farms, roads and other lifelines were strongly affected → huge direct economic losses (about 21 billion €) and considerable indirect social and economic impacts.

Public and strategic buildings and structures	Safe	Slightly unsafe	Very unsafe	Total	Safe	Slightly unsafe	Very unsafe	Safe	Slightly unsafe	Very unsafe
					% of total			% of category		
Hospital and socio-health buildings	241	102	75	418	6	3	2	58	24	18
City hall buildings	240	167	89	496	6	4	2	48	34	18
Civil collective activity buildings	366	252	149	767	9	6	4	48	33	19
Military collective activity buildings	212	83	51	346	5	2	1	61	24	15
Religious collective activity buildings	92	109	129	330	2	3	3	28	33	39
Technological service buildings	80	25	45	150	2	1	1	53	17	30
Transportation structures	12	9	5	26	0	0	0	46	35	19
Other public sector buildings	768	382	355	1505	19	9	9	51	25	24
<b>Grand total</b>	2.011	1.129	898	<b>4.038</b>	<b>50</b>	<b>28</b>	<b>22</b>			

Summary of the results of the damage and usability inspections on public and strategic buildings and structures (data from ICPD)

# Impact on the main assets

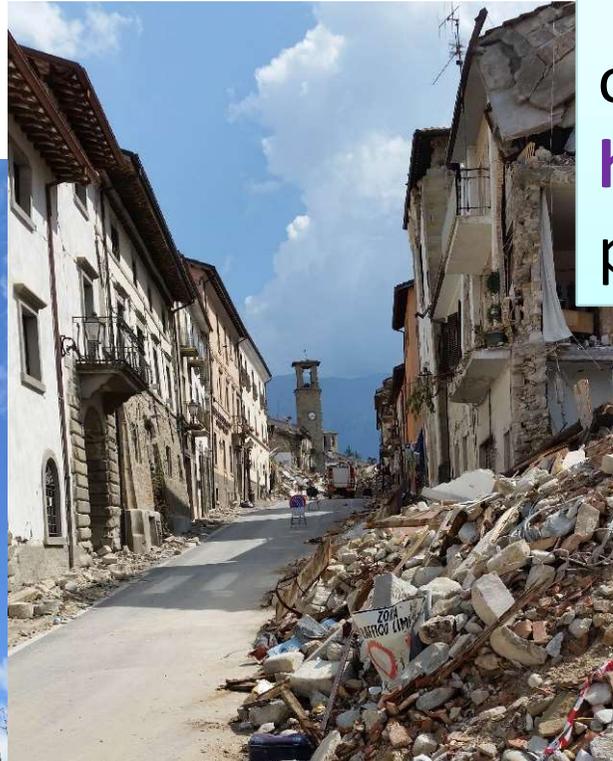
c. **220,000** damage and usability inspections carried out after the main shocks

~ **50 %** of the 4038 **public and strategic buildings**, excluding schools, judged **unsafe**. The hospital system suffered serious consequences (14 hospital complexes and 32 buildings unsafe)



# Impact on the main assets

~ 5200 damage inspections carried out on immovable **cultural heritage assets**; 1670 underwent post-earthquake stabilisation



## Impact on the main assets

Special attention is devoted to **schools**, whose activity in Italy starts at mid-September.

The Head of the National Department of Civil Protection met in the DICOMAC the Minister of Education, Universities and Research.

**2678** inspections of **school buildings**; 66 % of the buildings judged safe, the remaining 34 % (27 % slightly, 7 % very) unsafe



The temporary new school at Amatrice ready on September <sup>16</sup>12, 2016



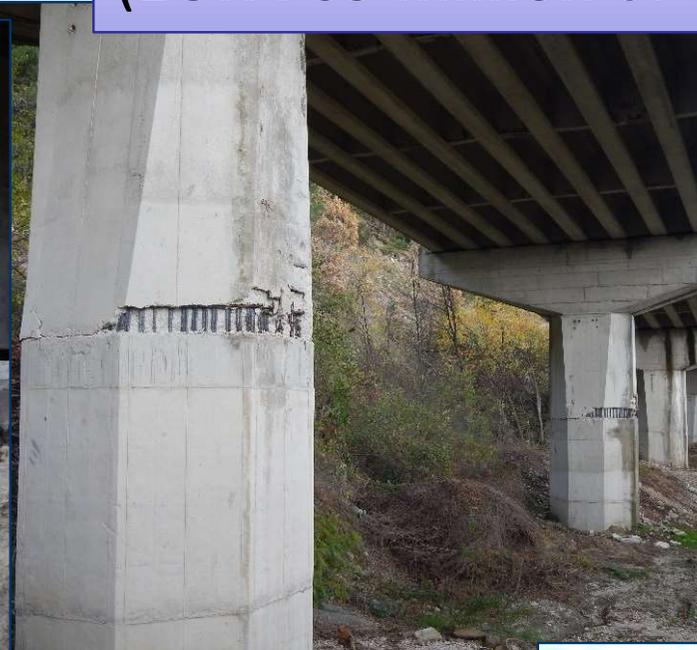
## Impact on the main assets



The road access is important for the emergency management

# Impact on the main assets

The rehabilitating interventions on the **roads** were all entrusted to the national road company ANAS (EUR 769 million of total investment)



## Summarizing ...



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## IMPACT ON THE MAIN ASSETS

**Highlight**

*Residential buildings, schools, hospitals, cultural heritage, livestock farms, roads and other lifelines were severely affected, with direct economic losses in the order of EUR 21 billion and considerable indirect social and economic impacts.*

# Lessons learned and Gaps

**Lessons learned** have been presented concerning the main assets, with particular focuses on emergencies and recovery, prevention and mitigation, management and governance.



**Gaps to be filled** have been analysed following three steps:

understanding risk,  
planning risk reduction and  
implementing risk reduction.

# Examples of lessons learned

The **continuity of school activity** is crucial to **avoid depopulation** and support a rapid recovery to normal life conditions



## Examples of lessons learned

The need to **provide heritage assets with adequate seismic protection** has to be emphasised



The reconstruction process must take into account the need for **reinterpretation of the landscapes**, as **not everything** can be rebuilt where it was and how it was



# Examples of lessons learned

The **damage and safety assessment** of buildings has an important role in **both the emergency management and reconstruction** phases



Introducing **compulsory seismic risk insurance** would allow the (Italian) state to save progressively money paid for damage and then invest more in prevention



# Examples of lessons learned

## ECO SISMA BONUS



In earthquake-prone areas, **energy upgrading** should be **combined with seismic retrofitting** in an integrated approach



EU policy should consider **incentivising** seismic, as well as energy, **retrofits** in earthquake-prone regions



# Examples of gaps to be filled in

The discovery of the **different dimensions of the vulnerability** of communities adds knowledge necessary to promote resilience



A comprehensive plan is needed to **seismically upgrade** the huge number of inadequate **schools** within a reasonable time horizon



15SNO

School

Norcia

R.C.

15 Km



# Examples of gaps to be filled in

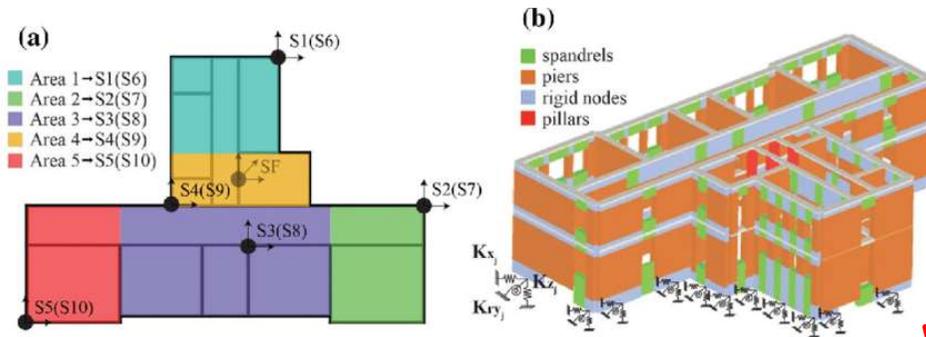
Only responsible regional and municipal planning offers a response to the increasingly complex realities faced by communities



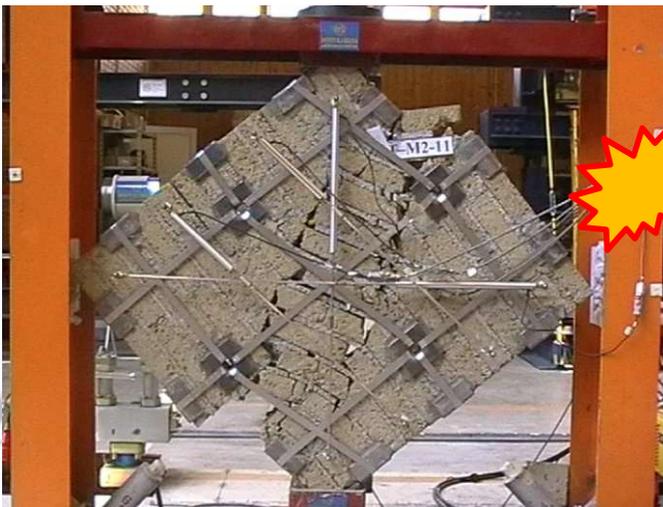
National and local governments: seek **new and creative ways** to build awareness, by **involving communities** in disaster planning and preparedness activities



# Examples of gaps to be filled in



**Structural response monitoring**  
has shown its usefulness for  
understanding risk



Promoting scientific tests to  
**validate new retrofitting materials**  
and techniques, as well as  
dissemination to professionals

# Examples of gaps to be filled in

## AFPS Field Investigation Conclusions and Perspectives



**Post-seismic surveys:**  
fundamental to learn lessons  
from the field and train young  
specialists



**Highlight**

## LESSONS LEARNED

*Time turns out to be a critical factor in post-earthquake recovery scenarios, because of multiple socioeconomic and other external factors.*



## FILLING THE GAPS

**Highlight**

*National and local governments should seek new and creative ways to build awareness, by involving communities in disaster planning and preparedness activities, and in the decision-making process.*



## FINAL REMARKS

*The reconstruction process, while reducing risk, should preserve the specific characteristics and landscape of the territory, and promote innovation in production systems to avoid further depopulation.*

**Highlight**

Thank you for your attention!

