



Euro-Mediterranean  
Seismological Centre



Centre Sismologique  
Euro-Méditerranéen

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**SCOR**  
FONDATION POUR LA SCIENCE



# How Citizen Seismology Contributes to Risk Reduction: The LastQuake System

Rémy Bossu on behalf of EMSC and collaborators

Paris, Oct. 2023



# Why Citizen Seismology & How does LastQuake Work?

# And then a Revolution!



Roma, April 2005

Election of Pope Benedict XVI



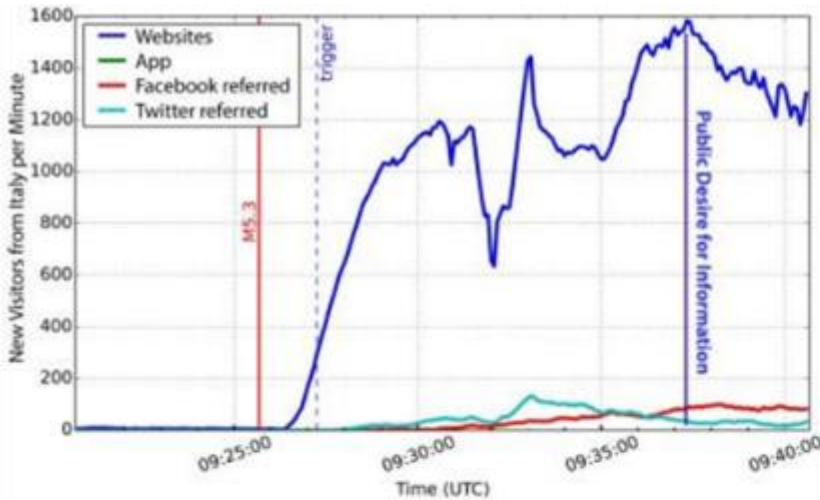
Roma, March 2013

Election of Pope Francis

# SF 1906: Iconic Picture!

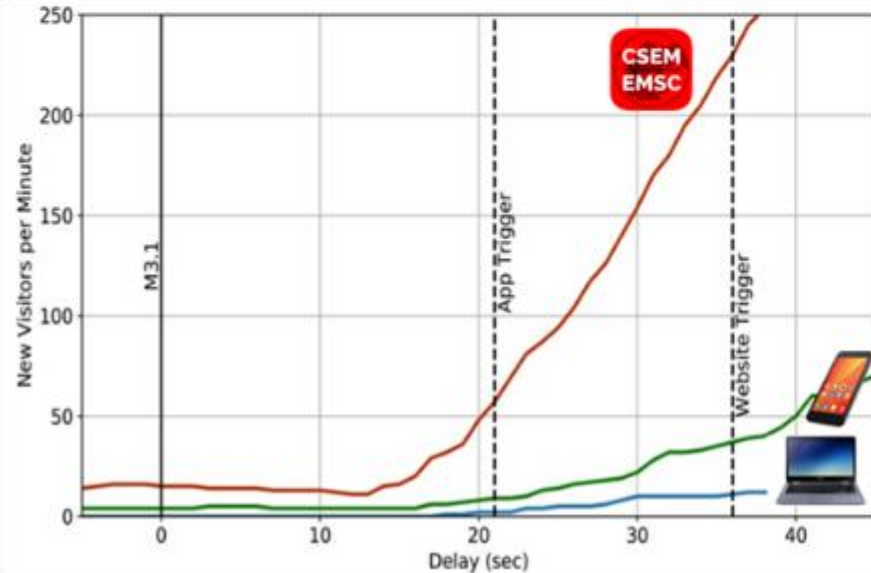


# Crowdsourced Detections (15-90s)



## EMSC Website Traffic Monitoring:

- Since 2006
- Works at global scale
- IP location at city level

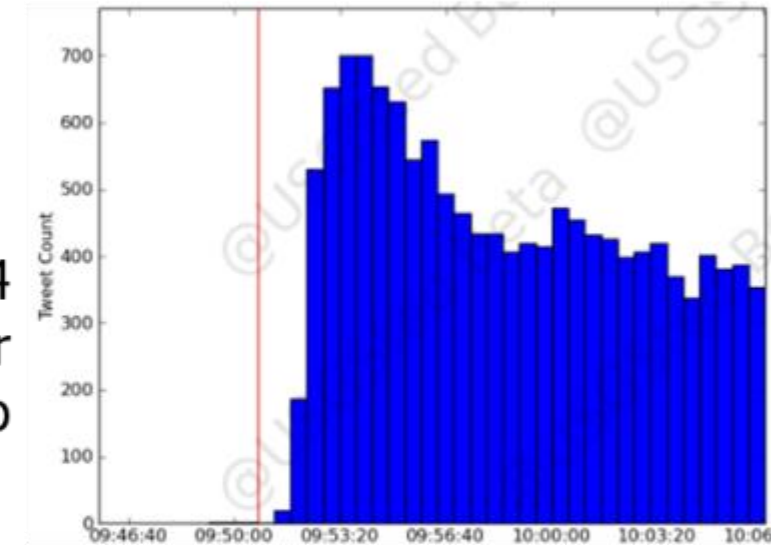


## LastQuake App EQ Detection:

- Since 2016
- Where LastQuake app is popular
- Accurate locations

## Twitter EQ Detection (USGS):

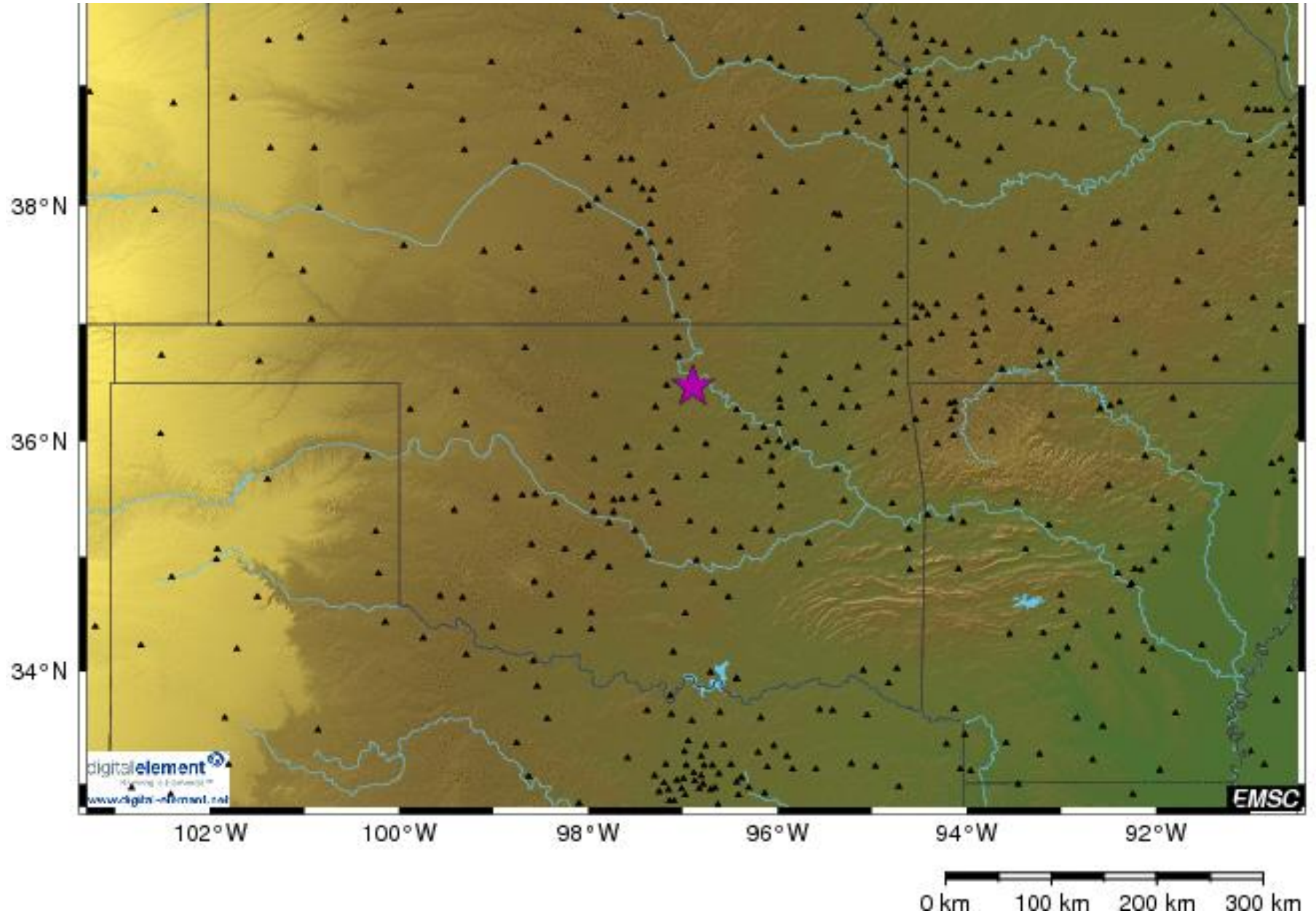
- Since 2014
- Where Twitter is popular
- Poor geographical Info



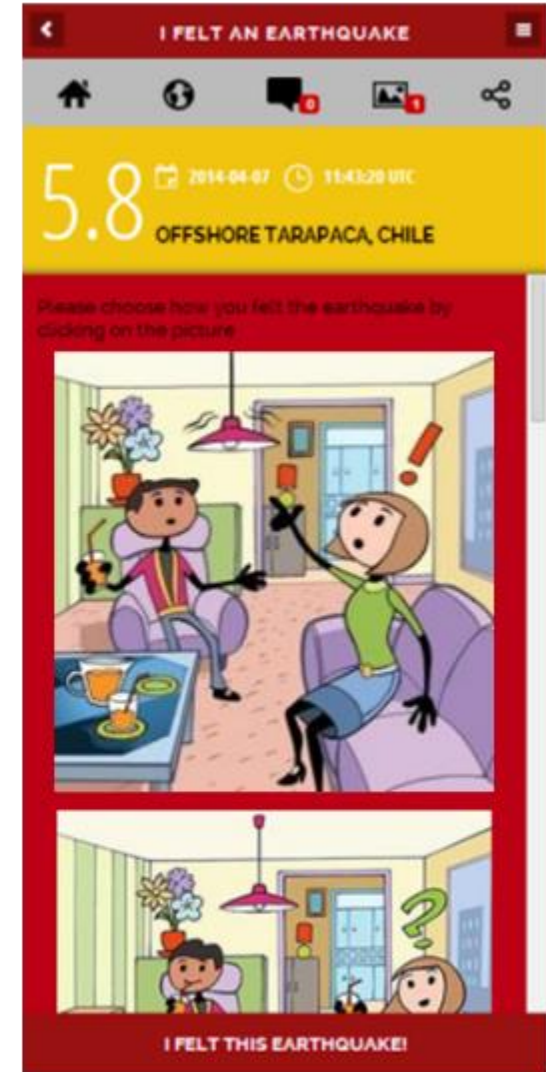
# Internet as Digital Nervous System of our Planet!

OK M5.6 2016

Virginia EQ located  
in 2min with 30 km  
accuracy

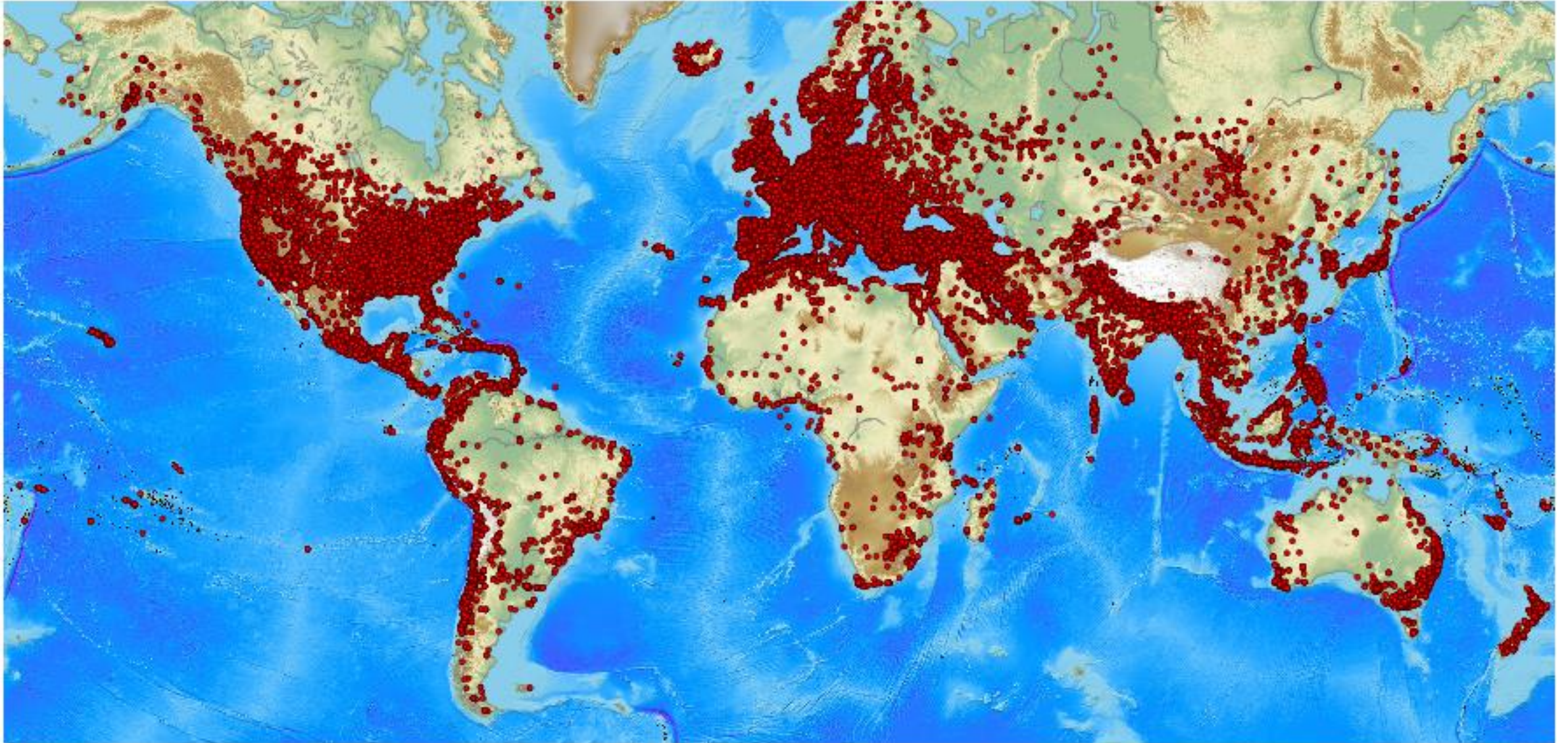


# Earthquakes that Matter for the Public!



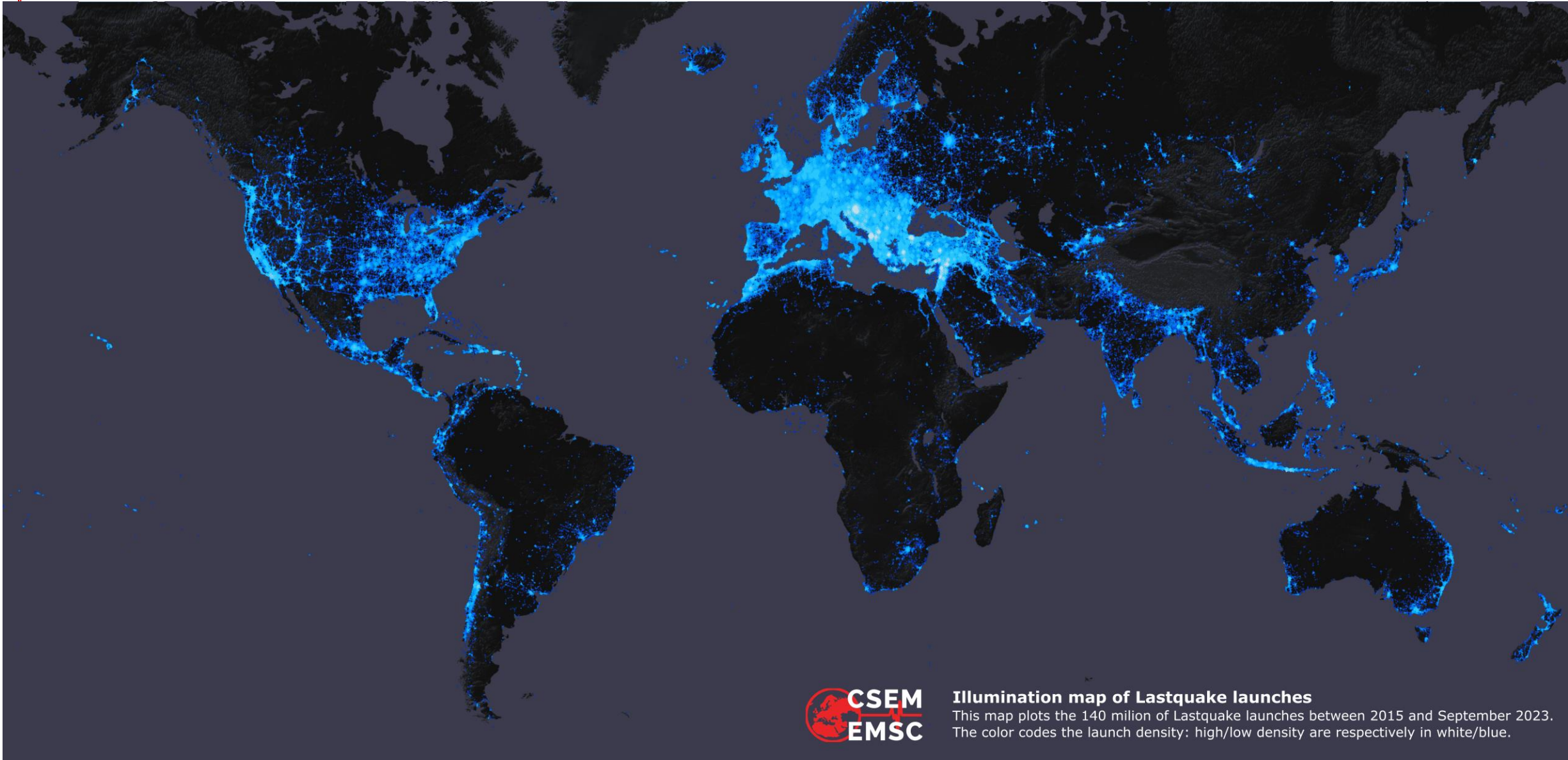
- Questionnaires replaced by cartoons
- Collect geolocated pics & videos
- Comments shared on Facebook, Twitter
- Available in 40+ languages

1M+ Users

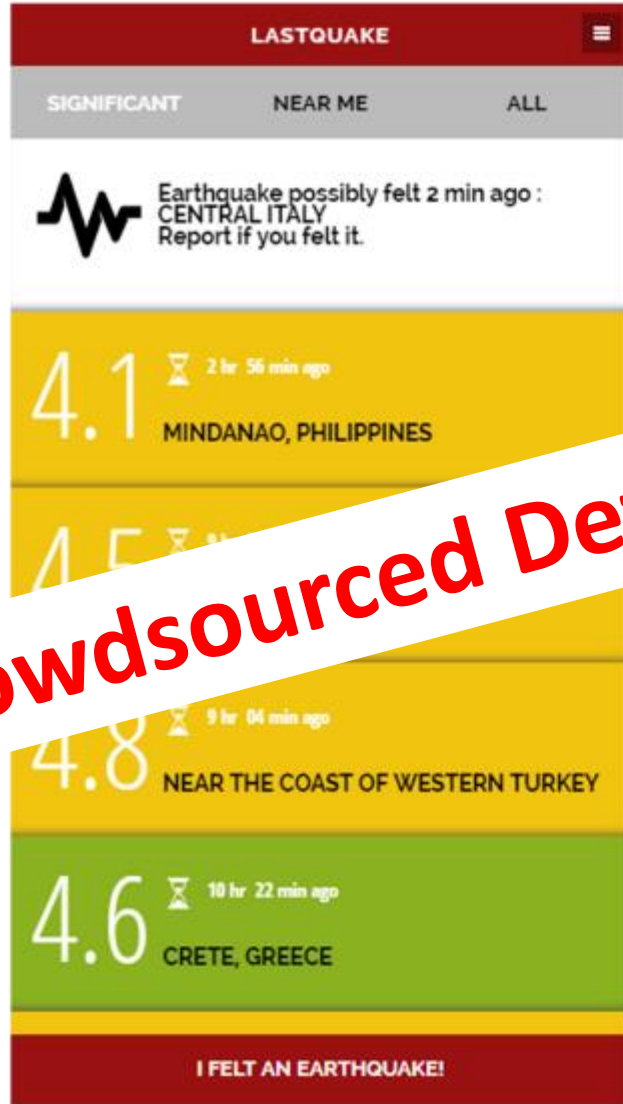




# Cumulative LastQuake App Activity!



# Crowdsourced Detections for Eyewitnesses' Engagement



APP



WEBSITES

**Crowdsourced Detections are NOT notified!**



# Findability and Visibility: Jan. 2022 Sunda strait M6.6

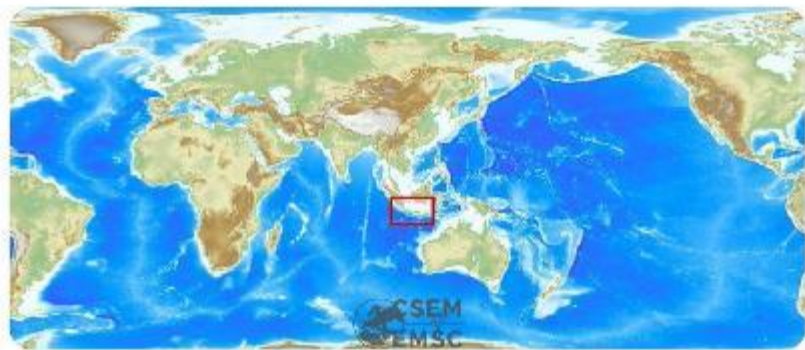


EMSC

@LastQuake

#Earthquake (#gempa) possibly felt 2 min ago in #Daerah Khusus Ibukota Jakarta #Indonesia. Felt it? See [emsc-csem.org](https://emsc-csem.org)

Traduire le Tweet



10:07 · 14 janv. 22 · EMSC Felt earthquakes

||| Voir l'activité du Tweet

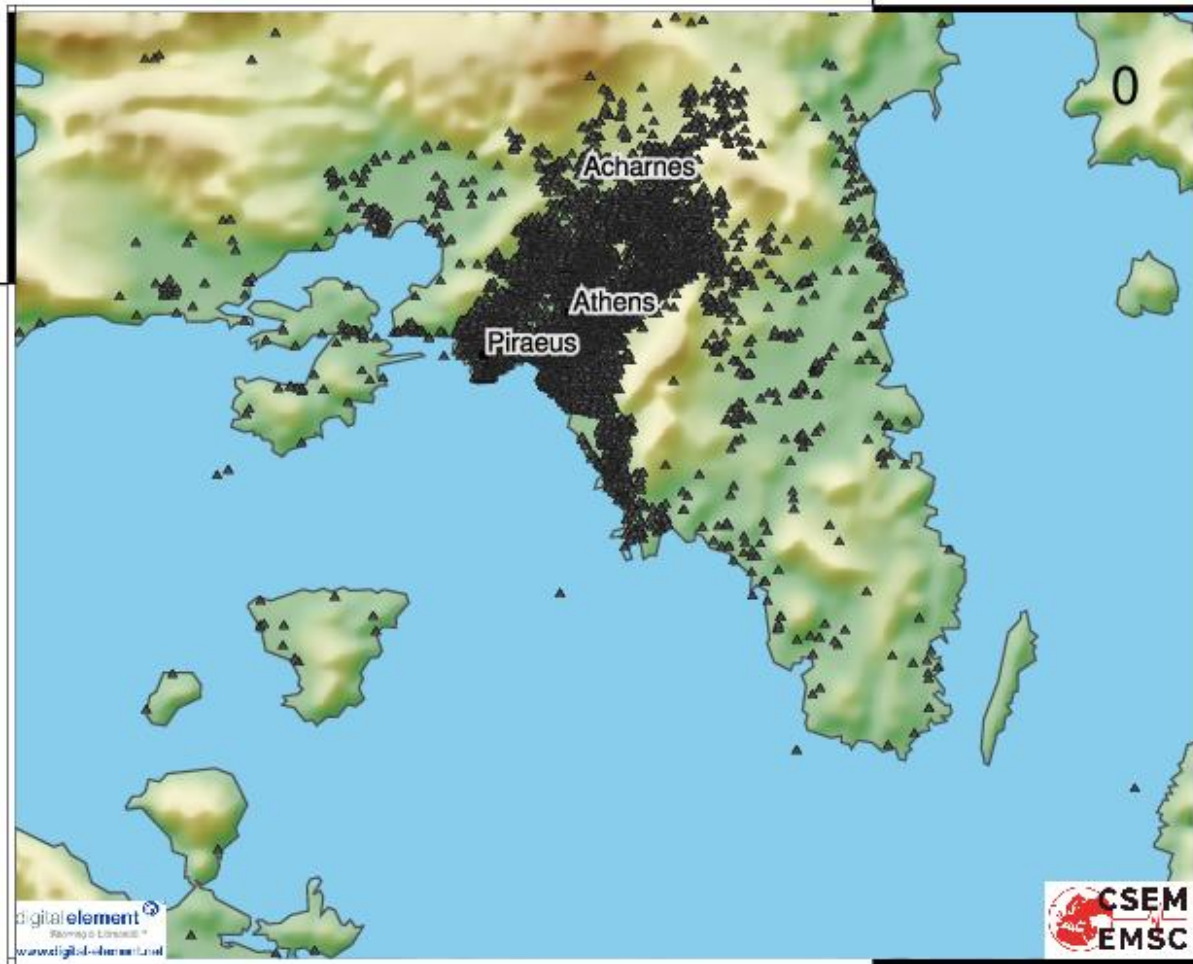
7 173 Retweets 2 522 Tweets cités

20K J'aime

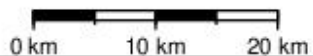
- « #Earthquake » in local language
- Tweet geo-located at detection location
- 2M views (15k followers from Indonesia)
- 77% of the 4,873 Indonesian website visitors within 30 min from this Tweet!
- 2/3 of the 438 felt reports collected from websites



# M2.9 Athens, Greece, Oct. 25<sup>th</sup> 2021 12:52 UTC



24°E



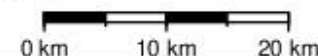
## Visitors within 0:00 minutes of earthquake occurrence

- LastQuake Apps Launched (new in last 30 minutes)
- LastQuake Apps Launched after app notification
- ▲ Installed Geolocated LastQuake Apps (last known locations)
- P wave
- S wave
- ★ Epicenter

Updated on 2021/11/18 10:15:22 UTC



24°E



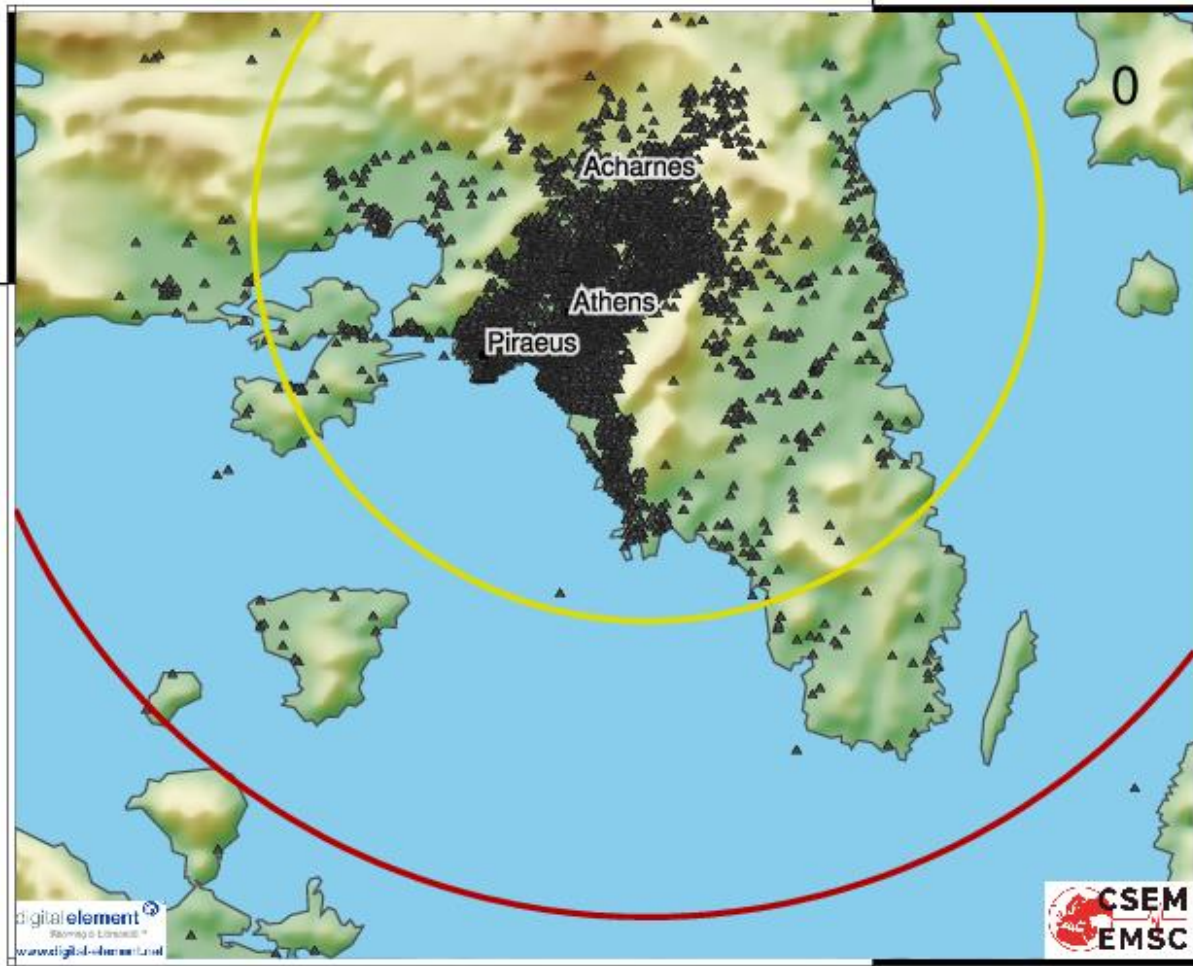
## Visitors within 0:00 minutes of earthquake occurrence

Reported as:

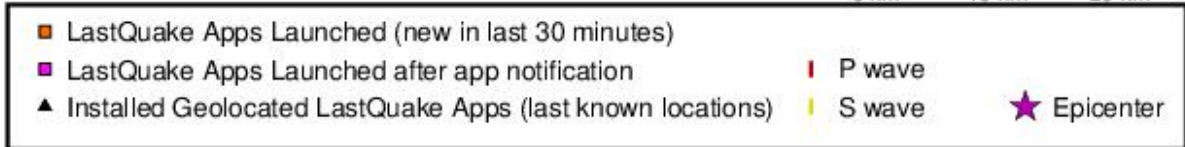
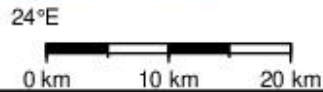
- Not felt
- Felt
- Largely felt
- Damaging
- P wave
- S wave
- ★ Epicenter

Updated on 2021/11/18 10:26:59 UTC

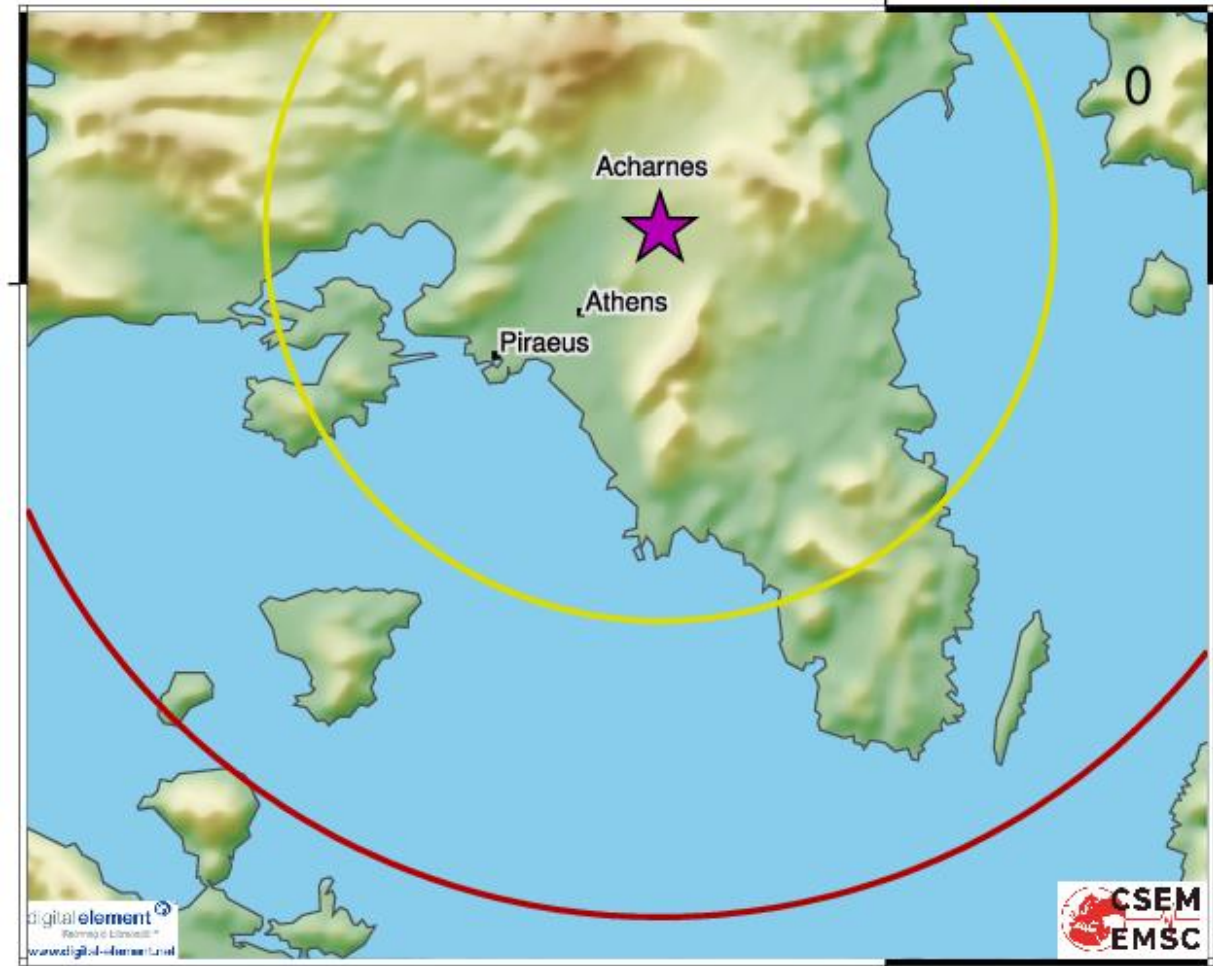
# M2.9 Athens, Greece T0 + 010s



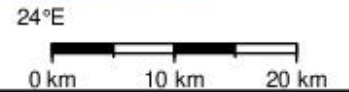
Visitors within 0:10 minutes of earthquake occurrence



Updated on 2021/11/18 10:15:22 UTC

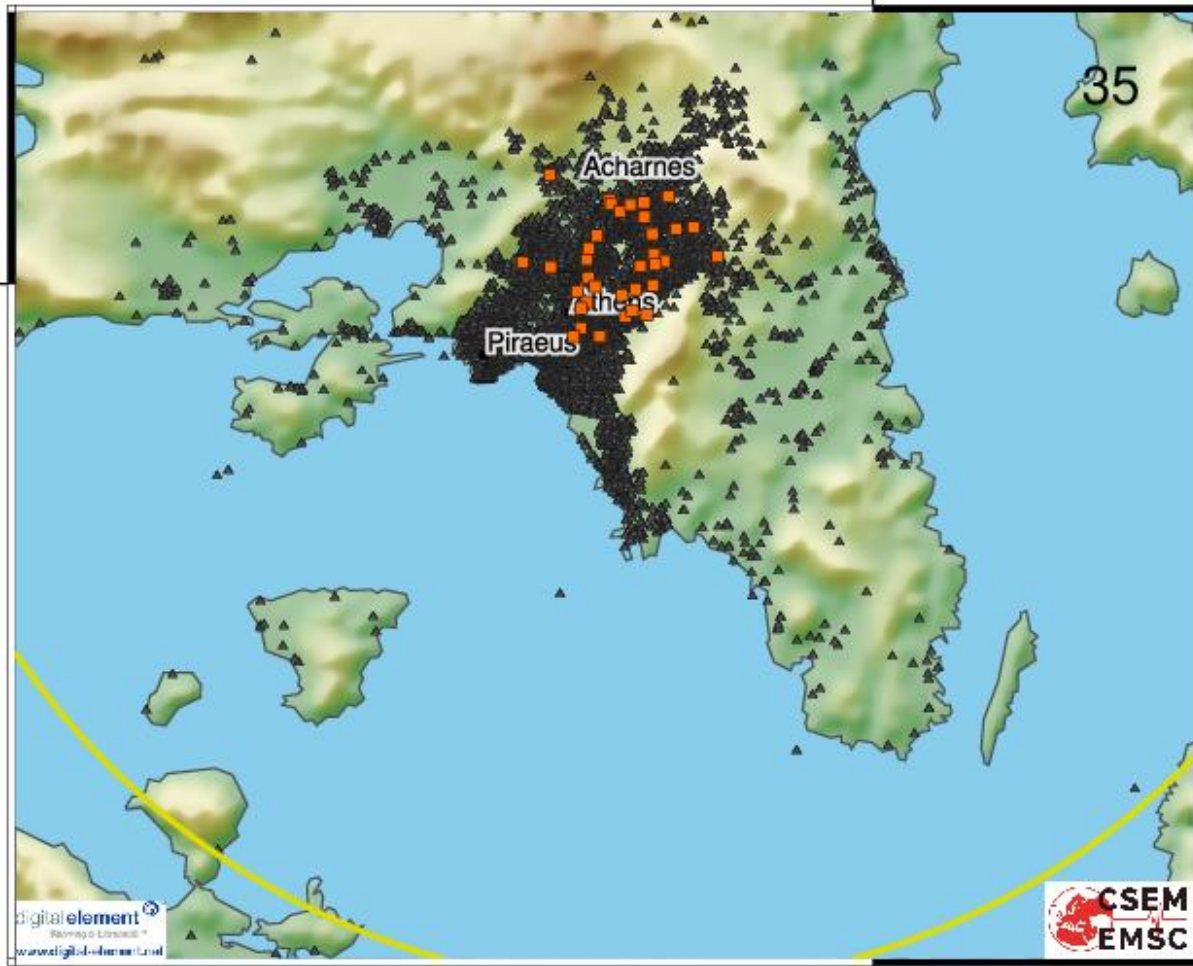


Visitors within 0:10 minutes of earthquake occurrence



Updated on 2021/11/18 10:26:59 UTC

# M2.9 Athens, Greece T0 + 018s



Visitors within 0:18 minutes of earthquake occurrence

- LastQuake Apps Launched (new in last 30 minutes)
- LastQuake Apps Launched after app notification
- ▲ Installed Geolocated LastQuake Apps (last known locations)
- P wave
- S wave
- ★ Epicenter

Updated on 2021/11/18 10:15:22 UTC

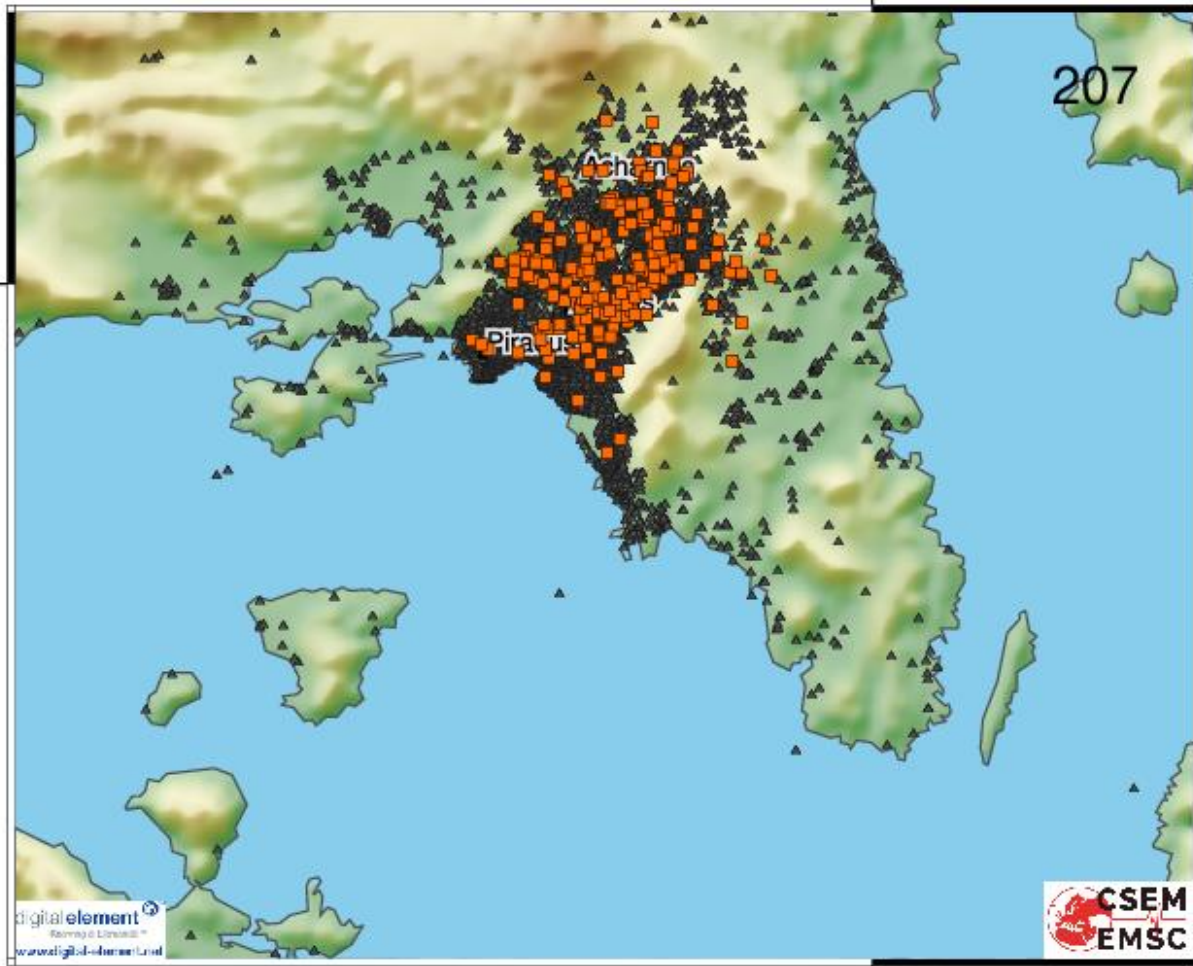


Visitors within 0:18 minutes of earthquake occurrence

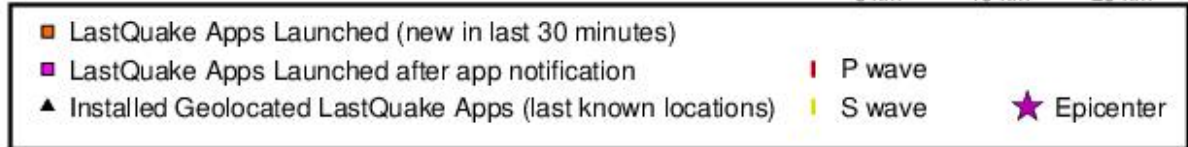
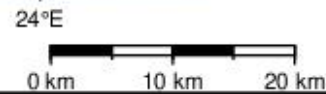
- Reported as:
- Not felt
  - Felt
  - Largely felt
  - Damaging
  - P wave
  - S wave
  - ★ Epicenter

Updated on 2021/11/18 10:26:59 UTC

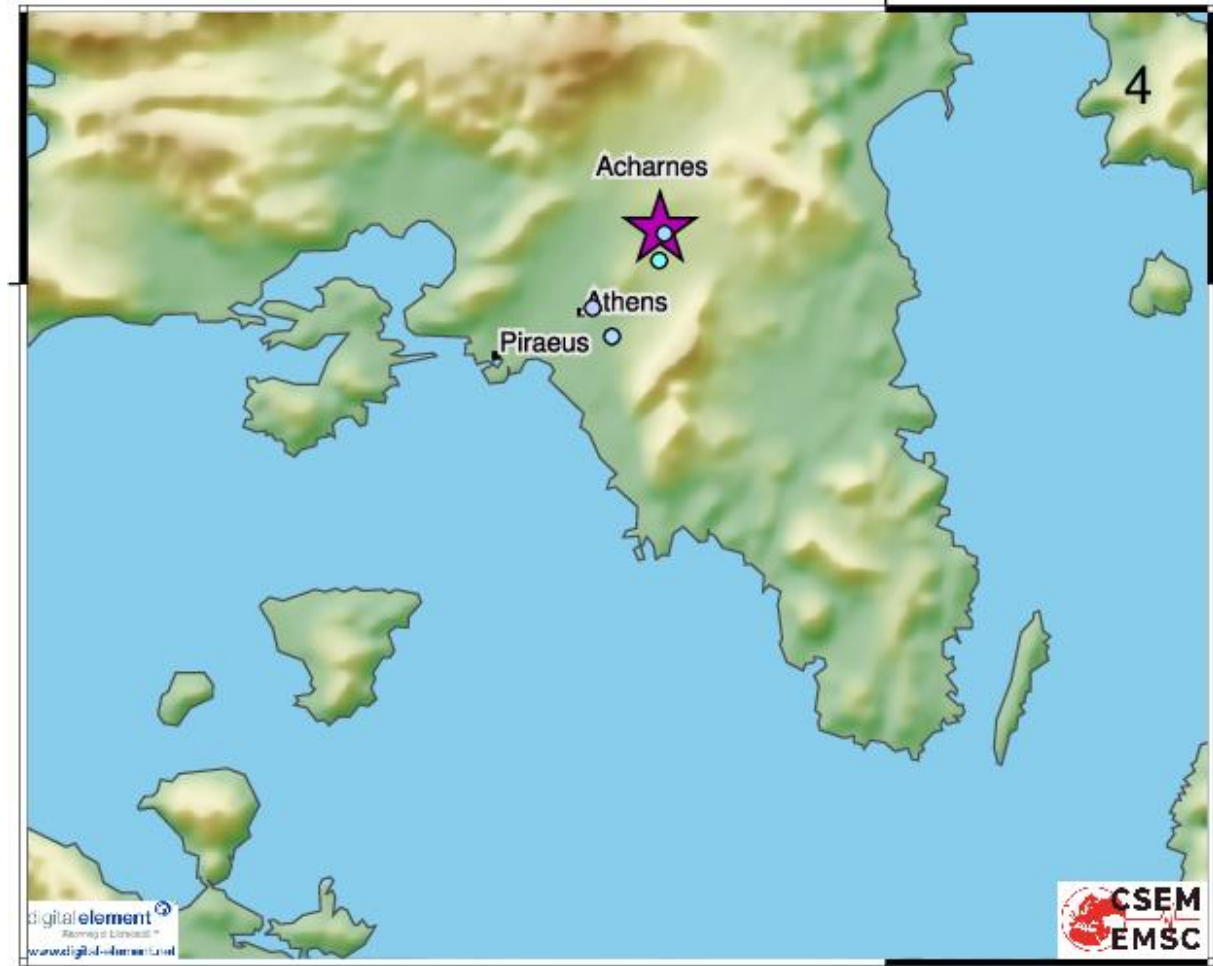
# M2.9 Athens, Greece T0 + 030s



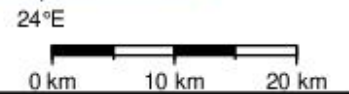
Visitors within 0:30 minutes of earthquake occurrence



Updated on 2021/11/18 10:15:22 UTC

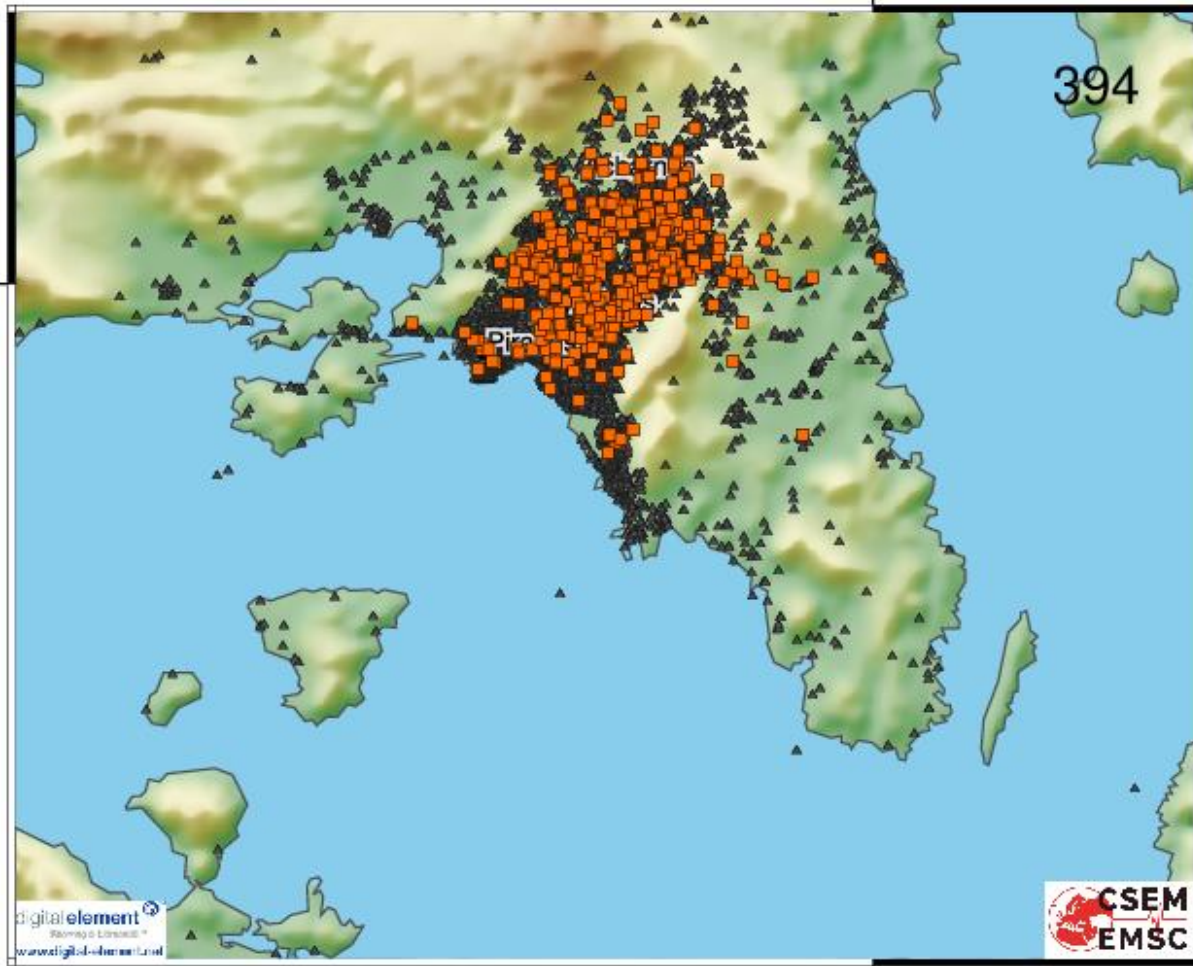


Visitors within 0:30 minutes of earthquake occurrence



Updated on 2021/11/18 10:26:59 UTC

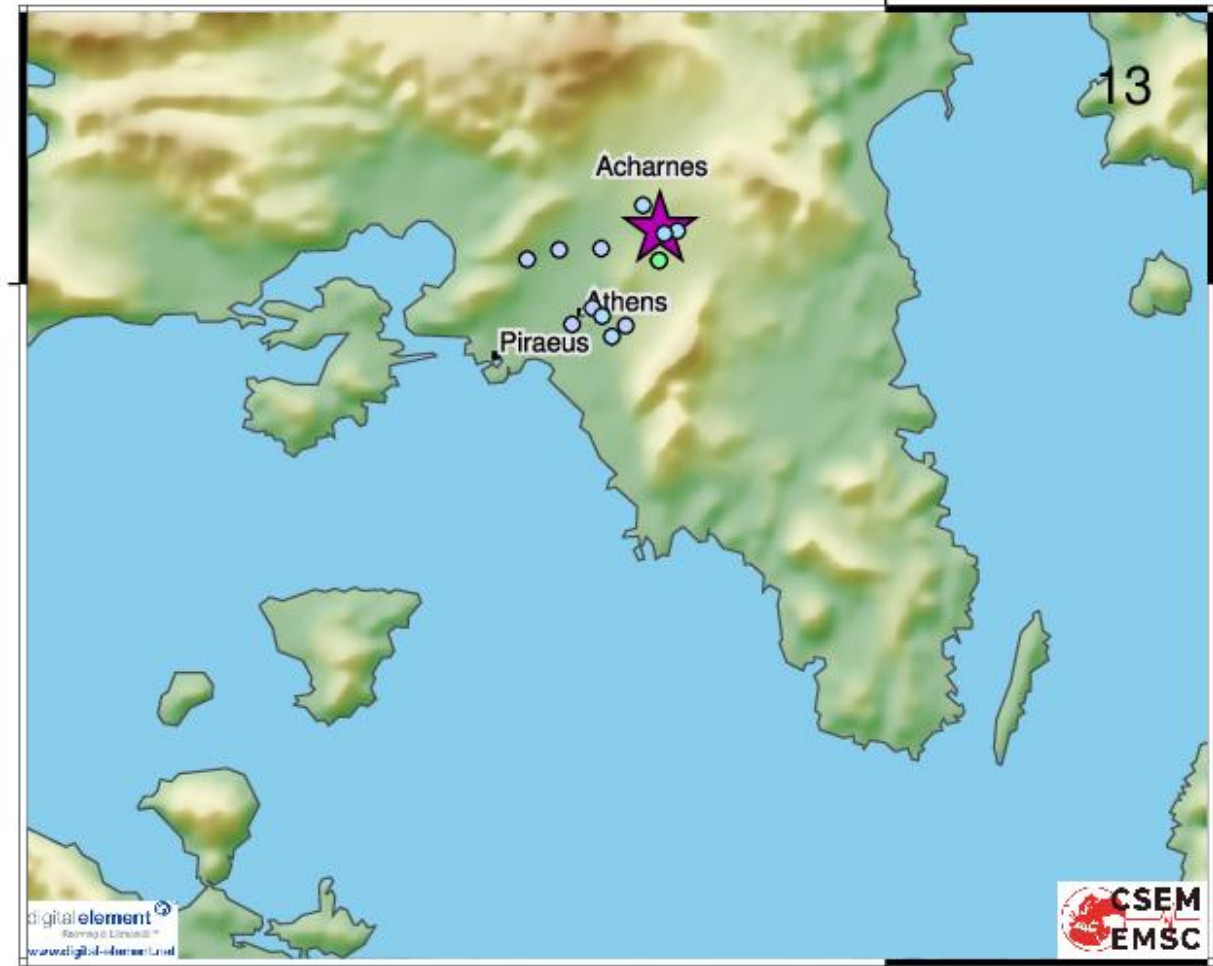
# M2.9 Athens, Greece T0 + 040s



Visitors within 0:40 minutes of earthquake occurrence

- LastQuake Apps Launched (new in last 30 minutes)
- LastQuake Apps Launched after app notification
- ▲ Installed Geolocated LastQuake Apps (last known locations)
- P wave
- S wave
- ★ Epicenter

Updated on 2021/11/18 10:15:22 UTC



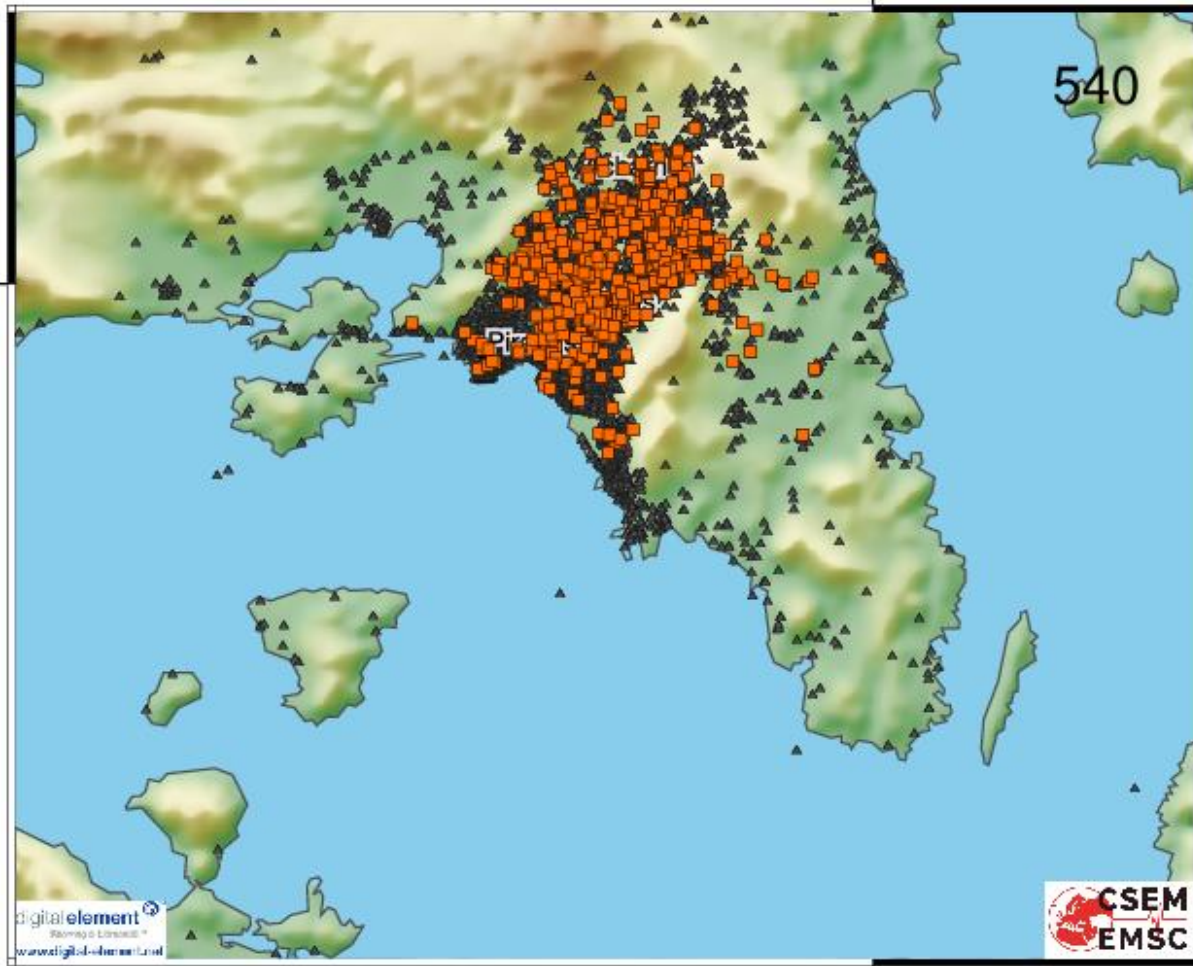
Visitors within 0:40 minutes of earthquake occurrence

- Reported as:
- Not felt
  - Felt
  - Largely felt
  - Damaging
  - P wave
  - S wave
  - ★ Epicenter

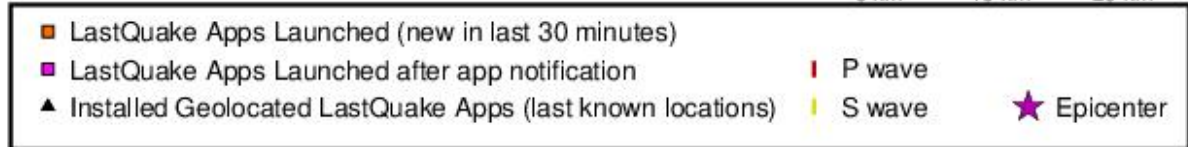
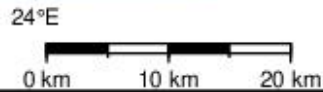
Updated on 2021/11/18 10:26:59 UTC



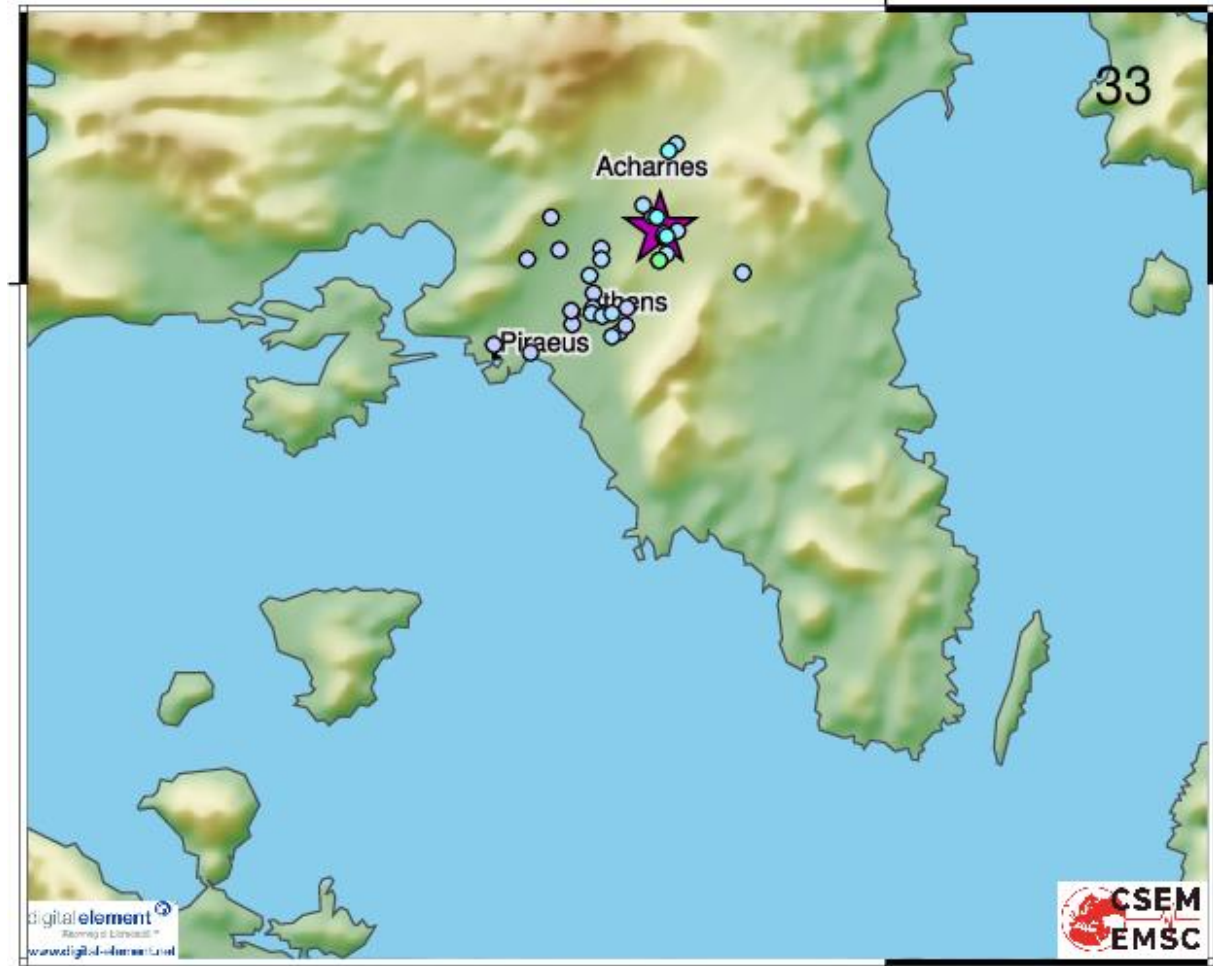
# M2.9 Athens, Greece T0 + 050s



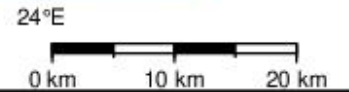
Visitors within 0:50 minutes of earthquake occurrence



Updated on 2021/11/18 10:15:22 UTC

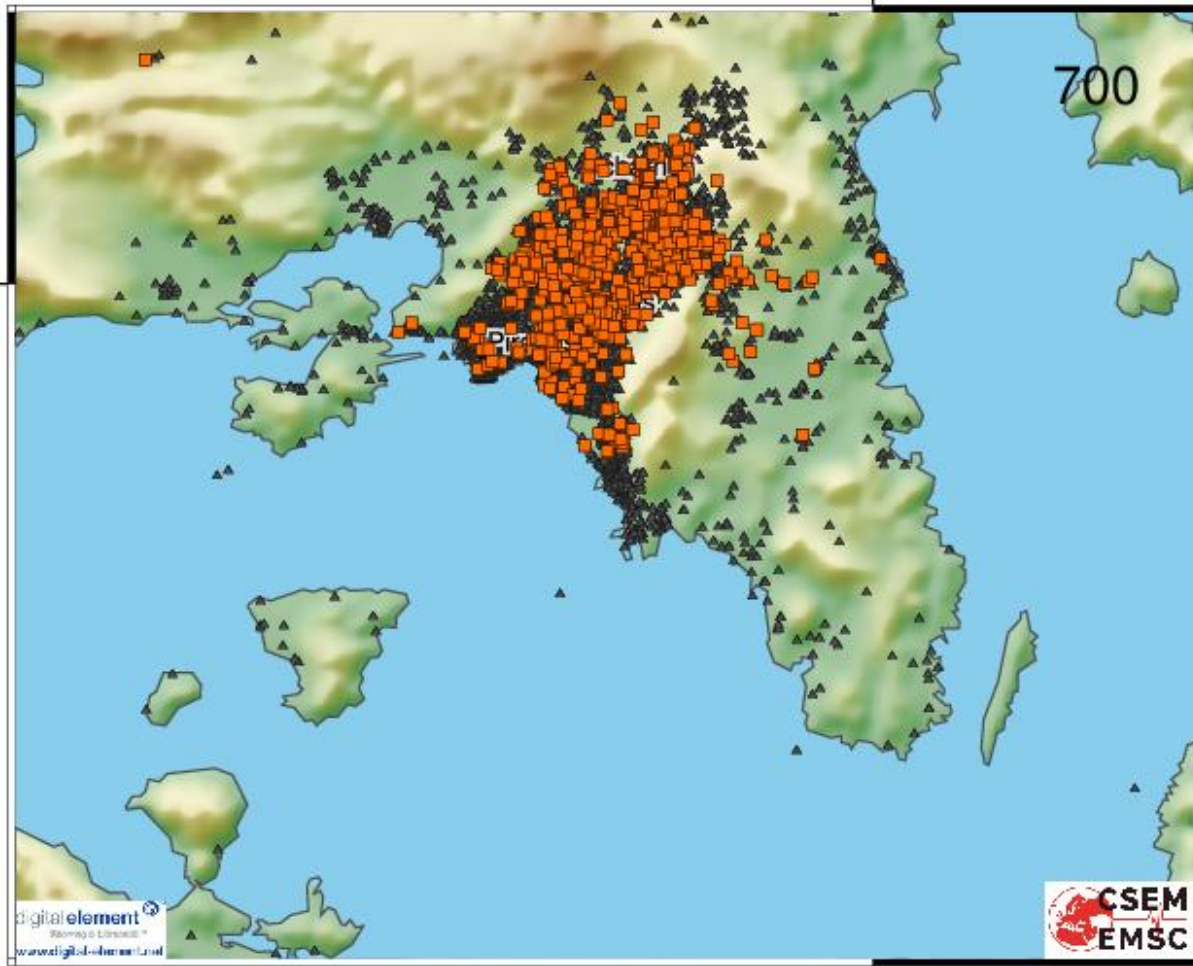


Visitors within 0:50 minutes of earthquake occurrence



Updated on 2021/11/18 10:26:59 UTC

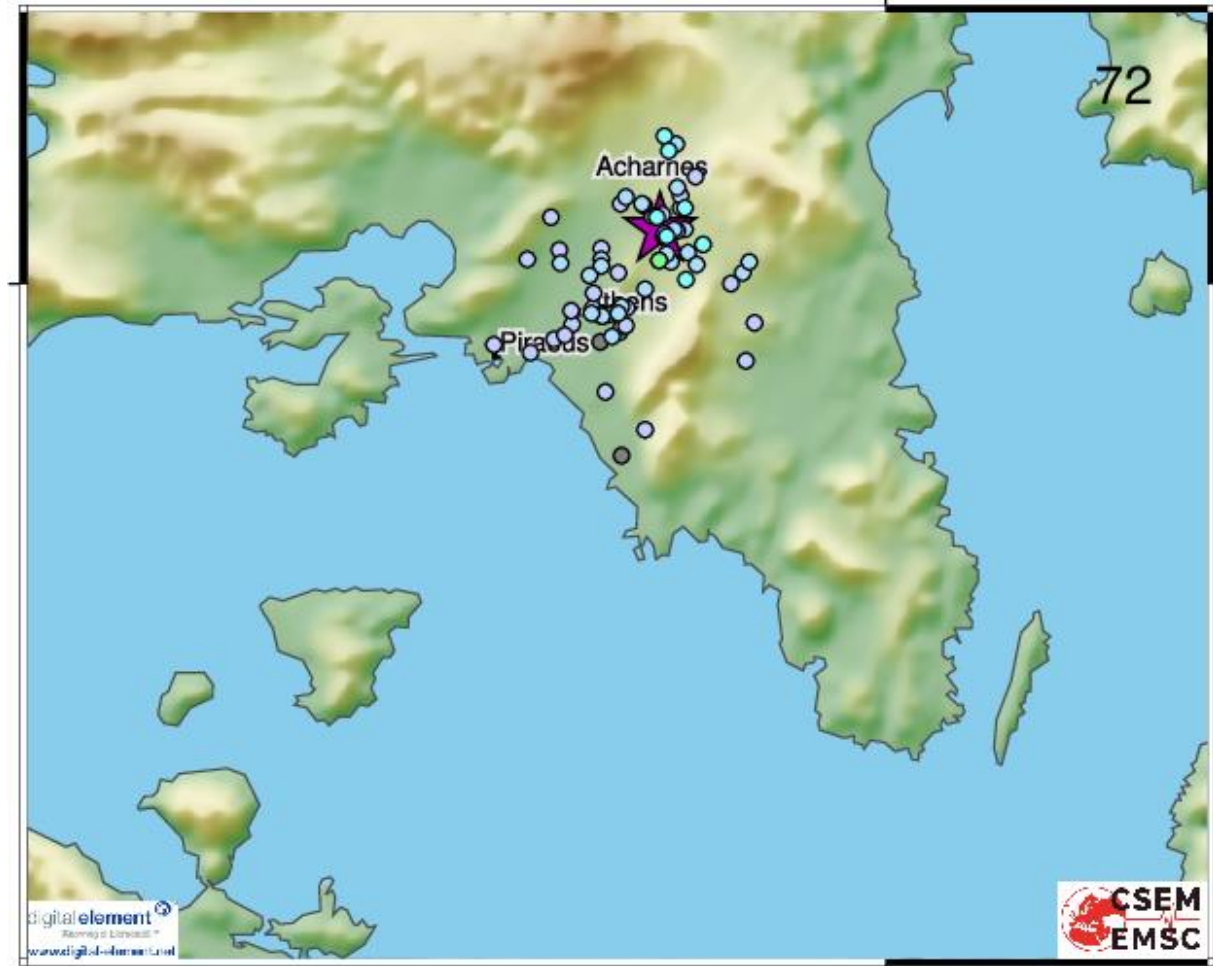
# M2.9 Athens, Greece T0 + 060s



Visitors within 1:00 minutes of earthquake occurrence

- LastQuake Apps Launched (new in last 30 minutes)
- LastQuake Apps Launched after app notification
- ▲ Installed Geolocated LastQuake Apps (last known locations)
- P wave
- S wave
- ★ Epicenter

Updated on 2021/11/18 10:15:22 UTC

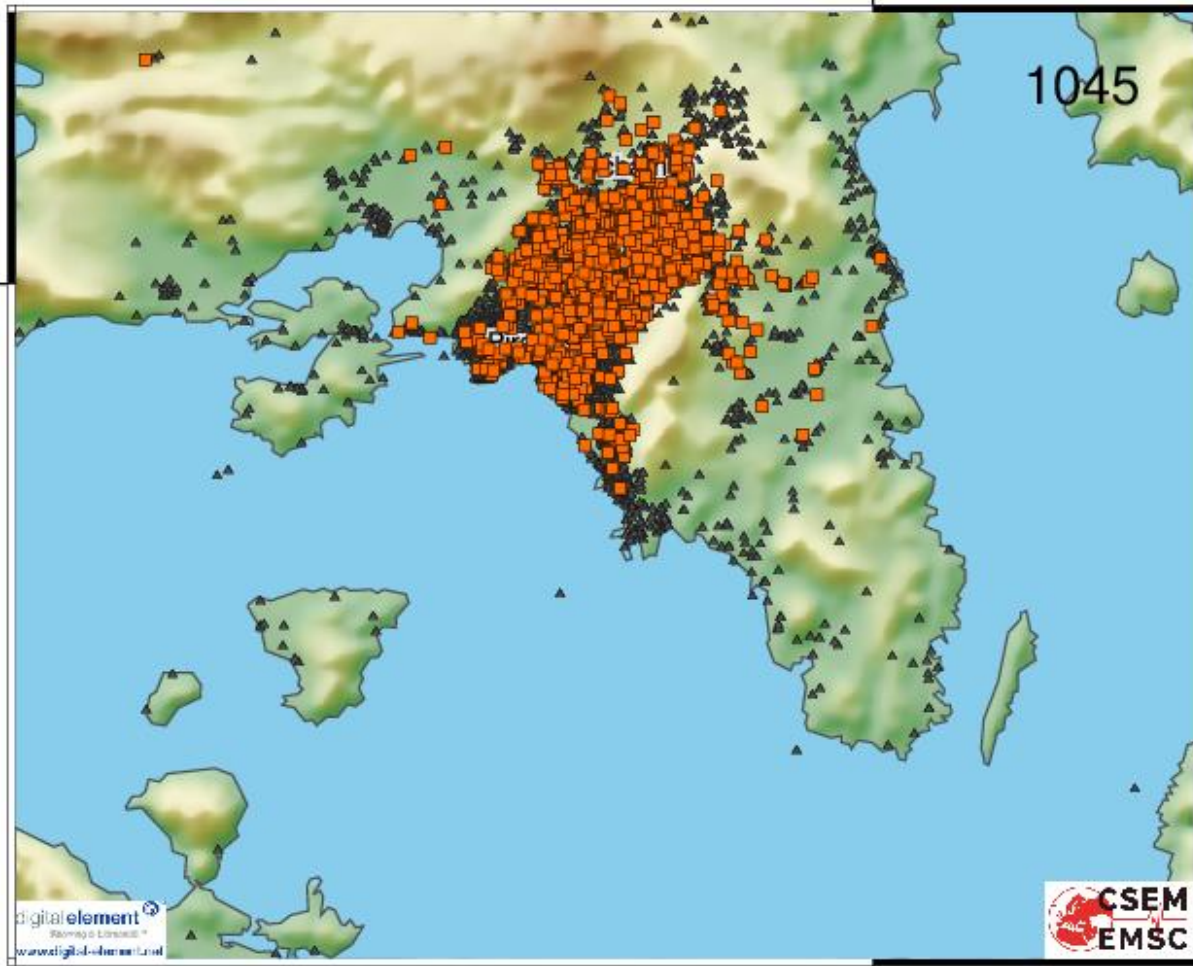


Visitors within 1:00 minutes of earthquake occurrence

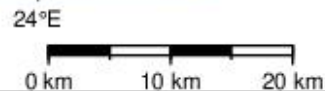
- Reported as:
- Not felt
  - Felt
  - Largely felt
  - Damaging
  - P wave
  - S wave
  - ★ Epicenter

Updated on 2021/11/18 10:26:59 UTC

# M2.9 Athens, Greece T0 + 090s

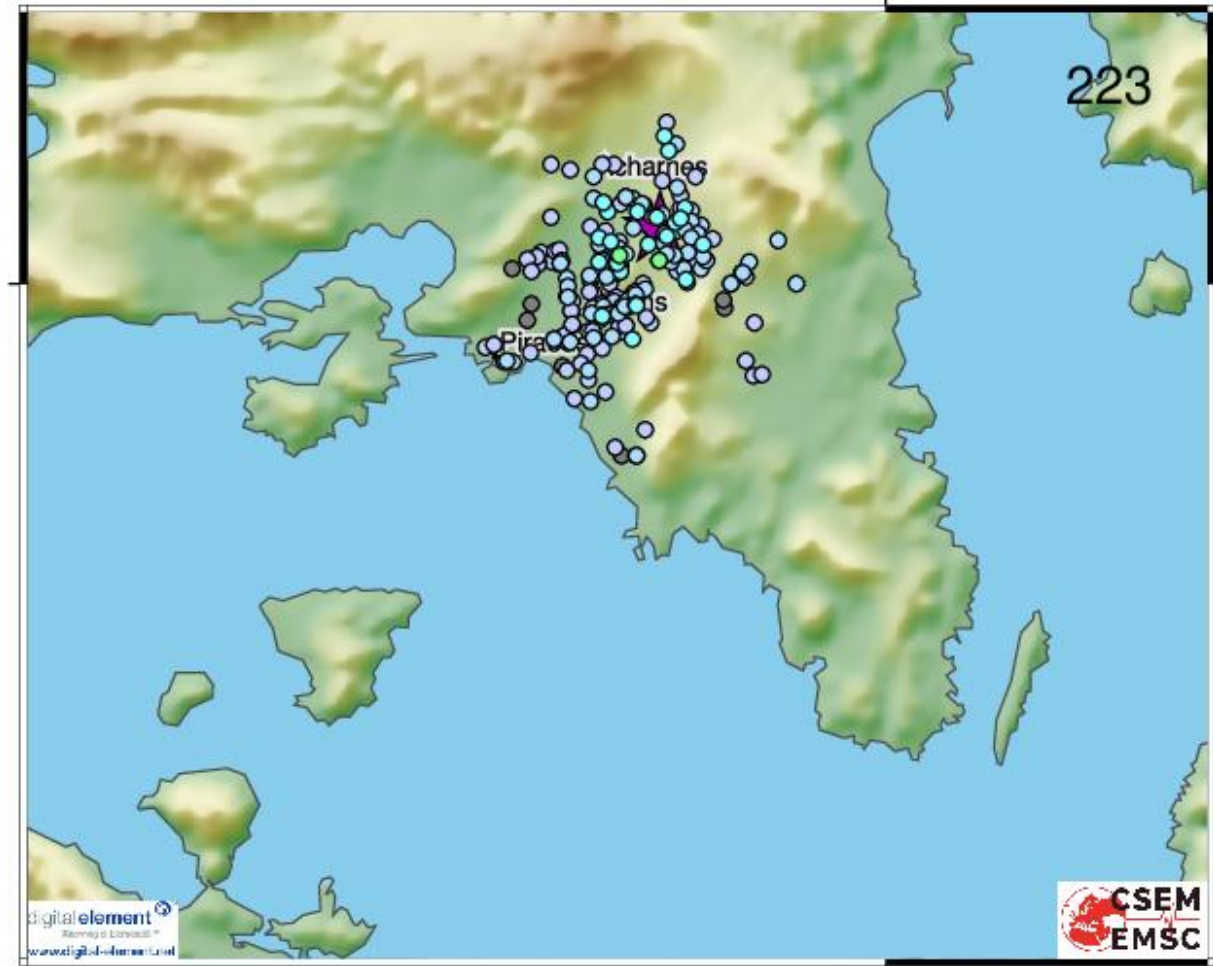


Visitors within 1:30 minutes of earthquake occurrence

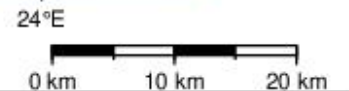


- LastQuake Apps Launched (new in last 30 minutes)
- LastQuake Apps Launched after app notification
- ▲ Installed Geolocated LastQuake Apps (last known locations)
- P wave
- S wave
- ★ Epicenter

Updated on 2021/11/18 10:15:22 UTC



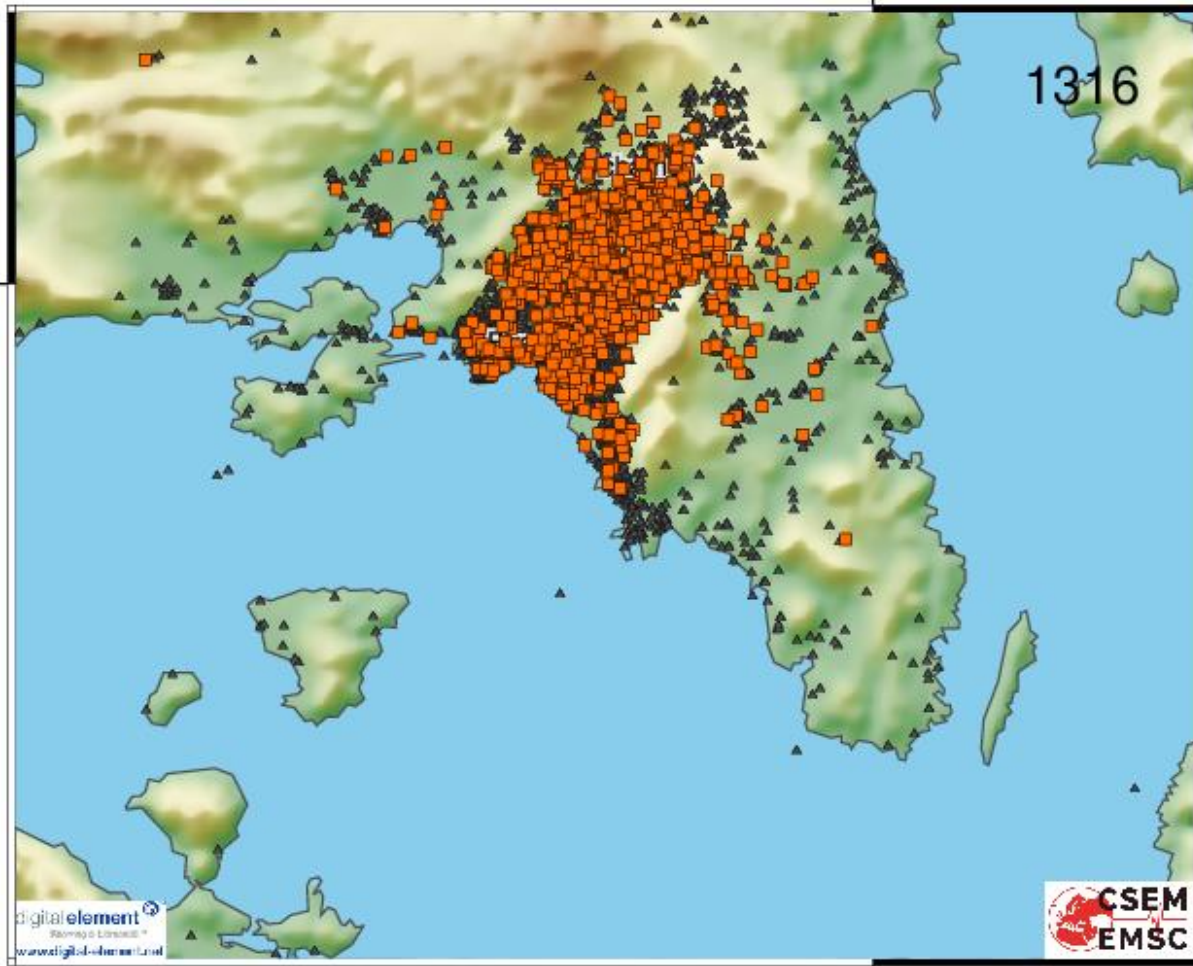
Visitors within 1:30 minutes of earthquake occurrence



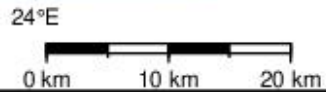
- Reported as:
- Not felt
  - Felt
  - Largely felt
  - Damaging
  - P wave
  - S wave
  - ★ Epicenter

Updated on 2021/11/18 10:26:59 UTC

# M2.9 Athens, Greece T0 + 120s

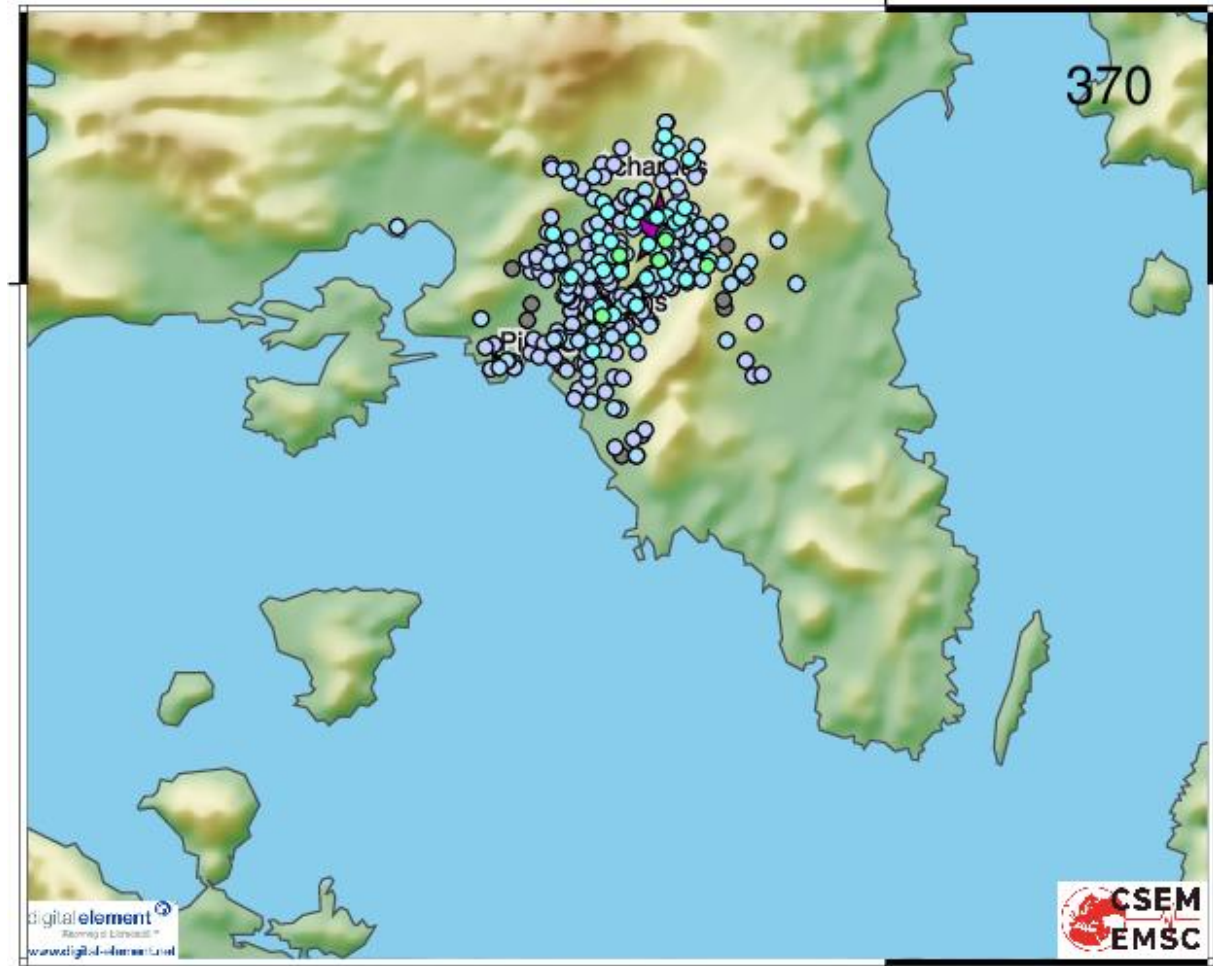


Visitors within 2:00 minutes of earthquake occurrence

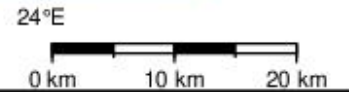


- LastQuake Apps Launched (new in last 30 minutes)
- LastQuake Apps Launched after app notification
- ▲ Installed Geolocated LastQuake Apps (last known locations)
- P wave
- S wave
- ★ Epicenter

Updated on 2021/11/18 10:15:22 UTC



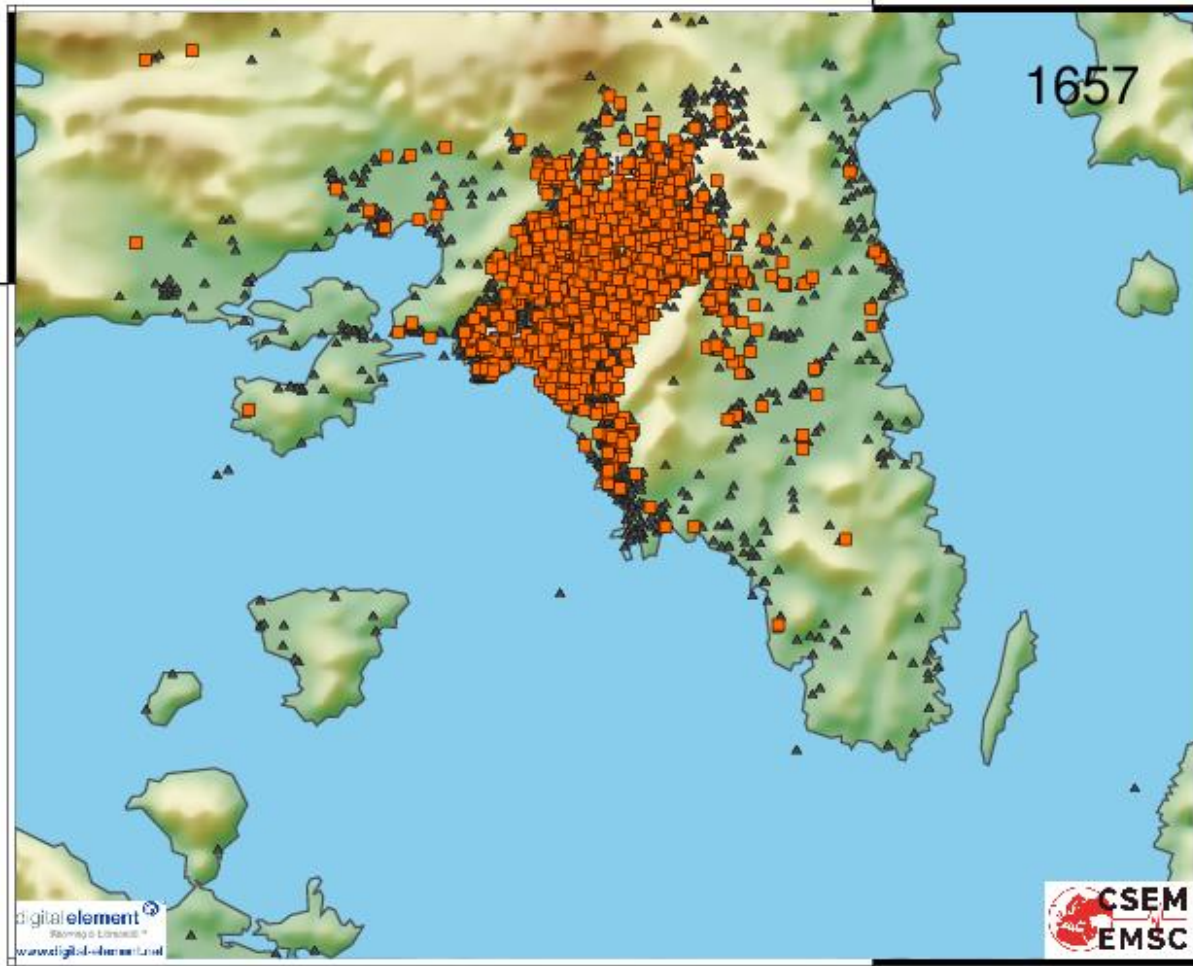
Visitors within 2:00 minutes of earthquake occurrence



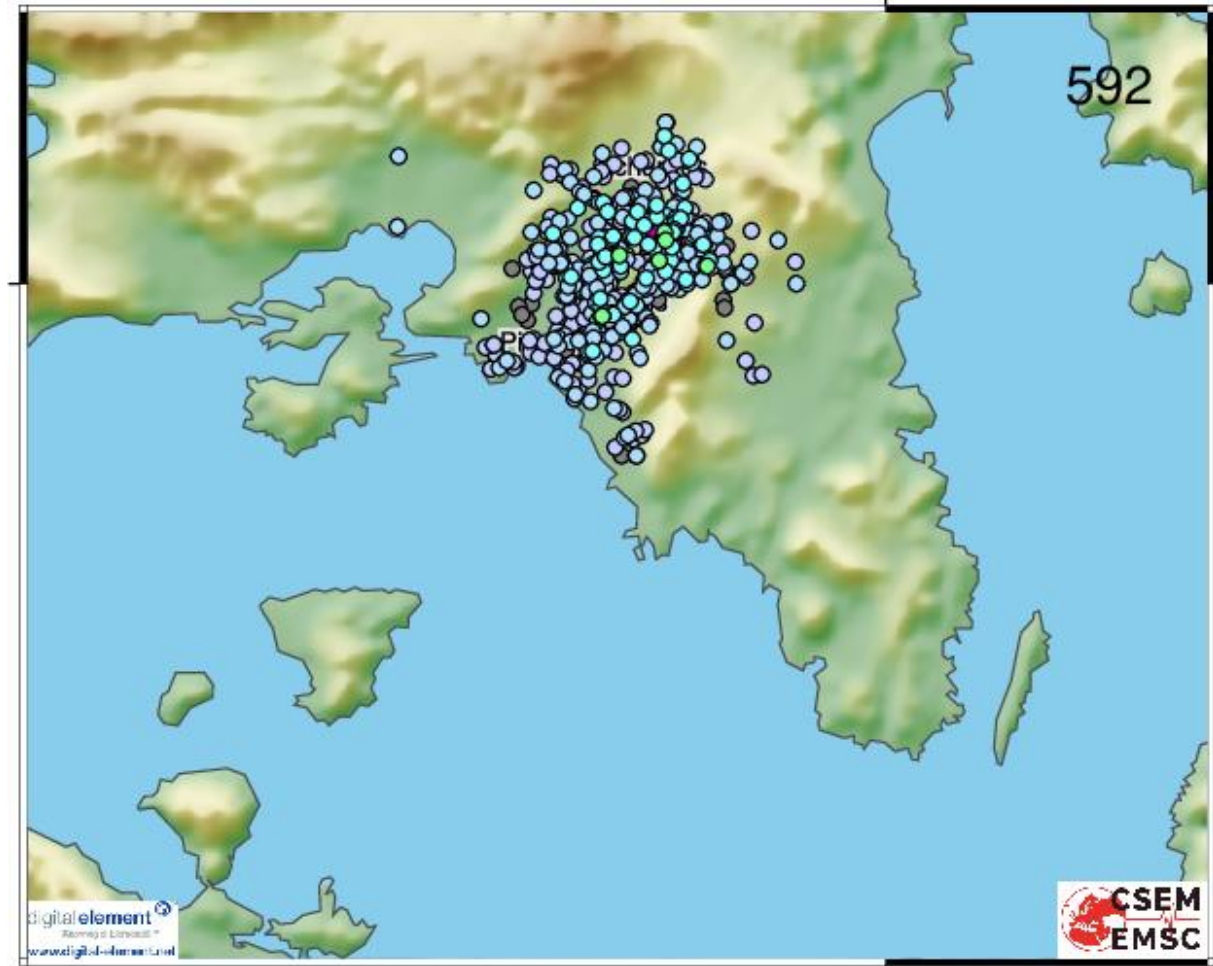
- Reported as:
- Not felt
  - Felt
  - Largely felt
  - Damaging
  - P wave
  - S wave
  - ★ Epicenter

Updated on 2021/11/18 10:26:59 UTC

# M2.9 Athens, Greece T0 + 180s



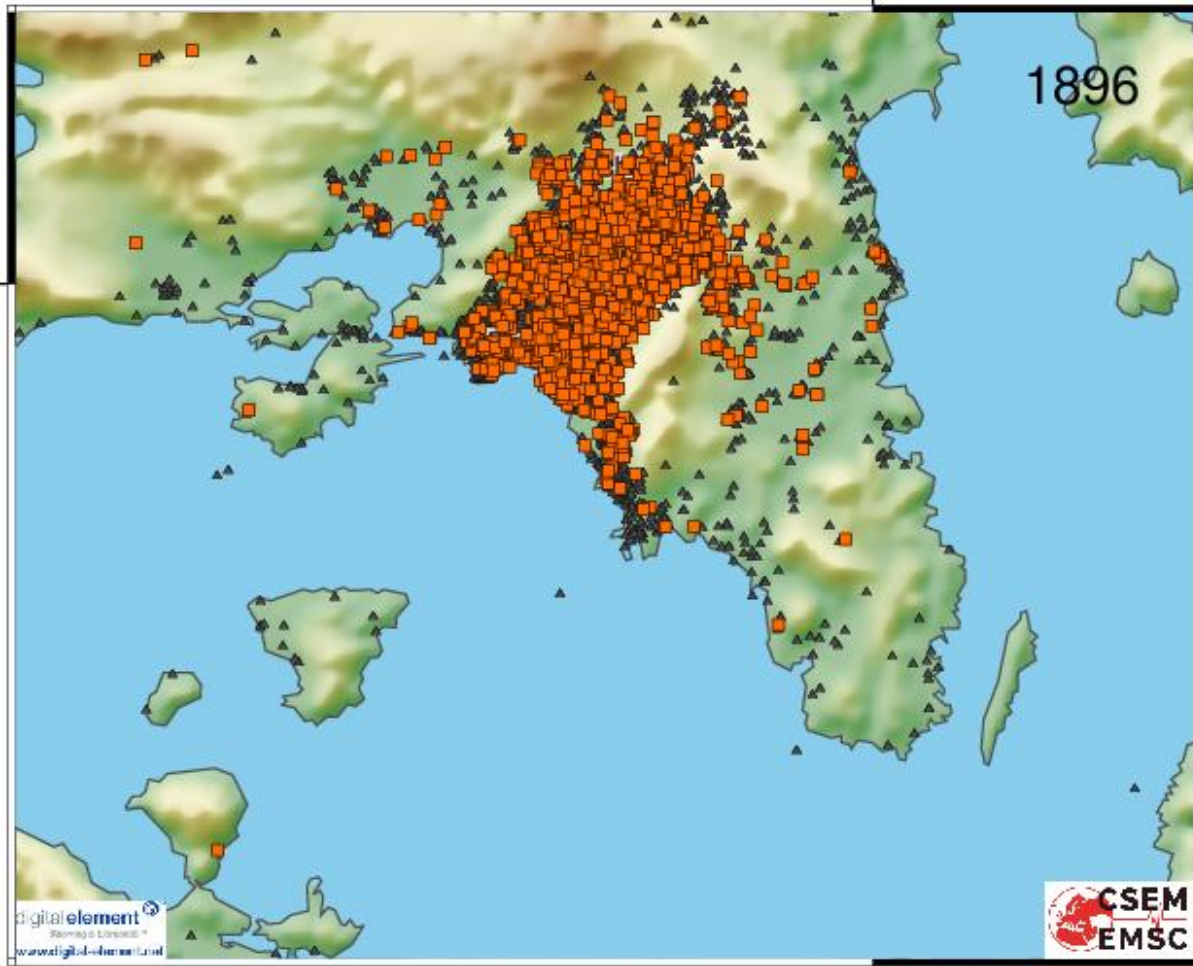
Updated on 2021/11/18 10:15:22 UTC



B

Updated on 2021/11/18 10:26:59 UTC

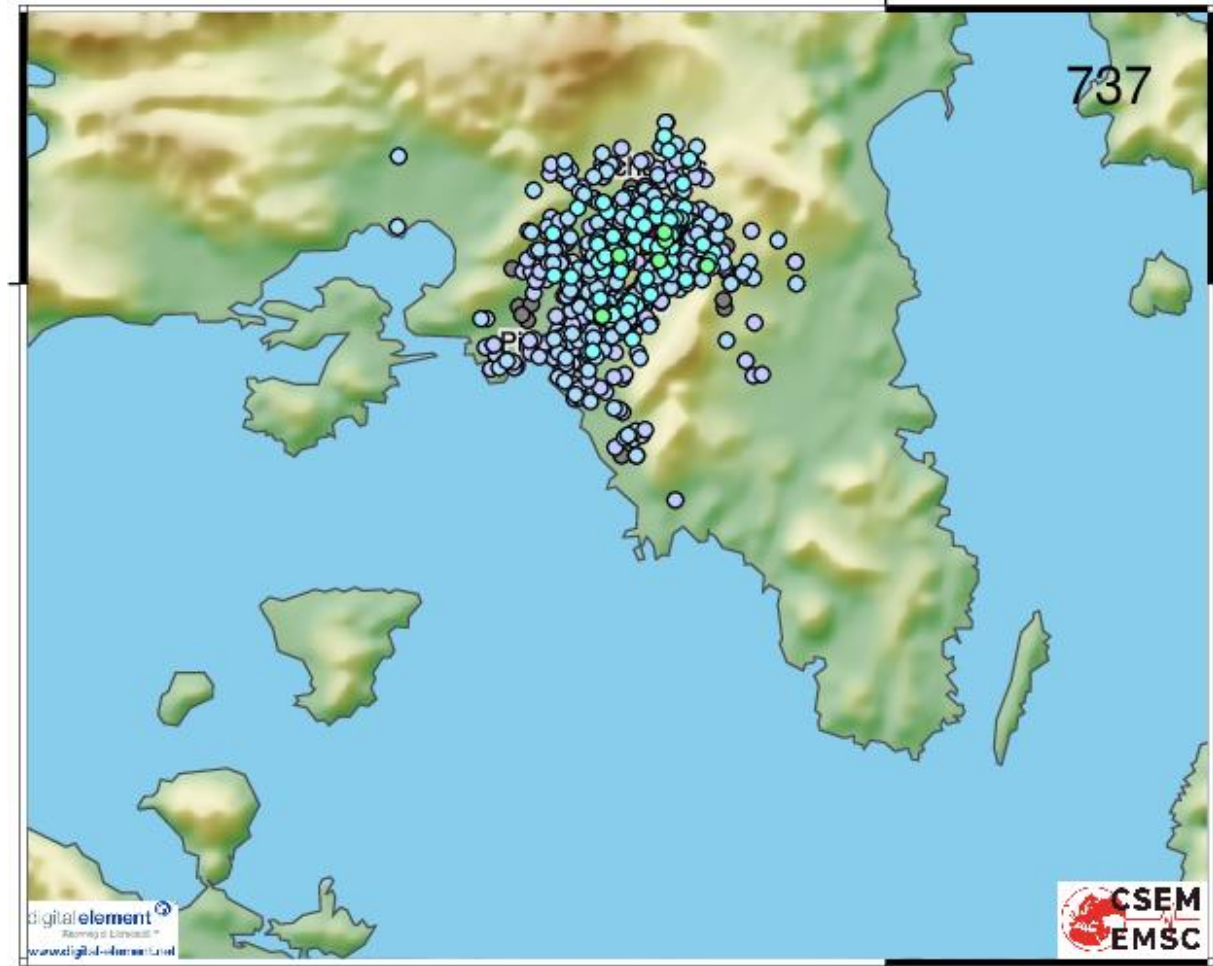
# M2.9 Athens, Greece T0 + 240s



Visitors within 4:00 minutes of earthquake occurrence

- LastQuake Apps Launched (new in last 30 minutes)
- LastQuake Apps Launched after app notification
- ▲ Installed Geolocated LastQuake Apps (last known locations)
- P wave
- S wave
- ★ Epicenter

Updated on 2021/11/18 10:15:22 UTC

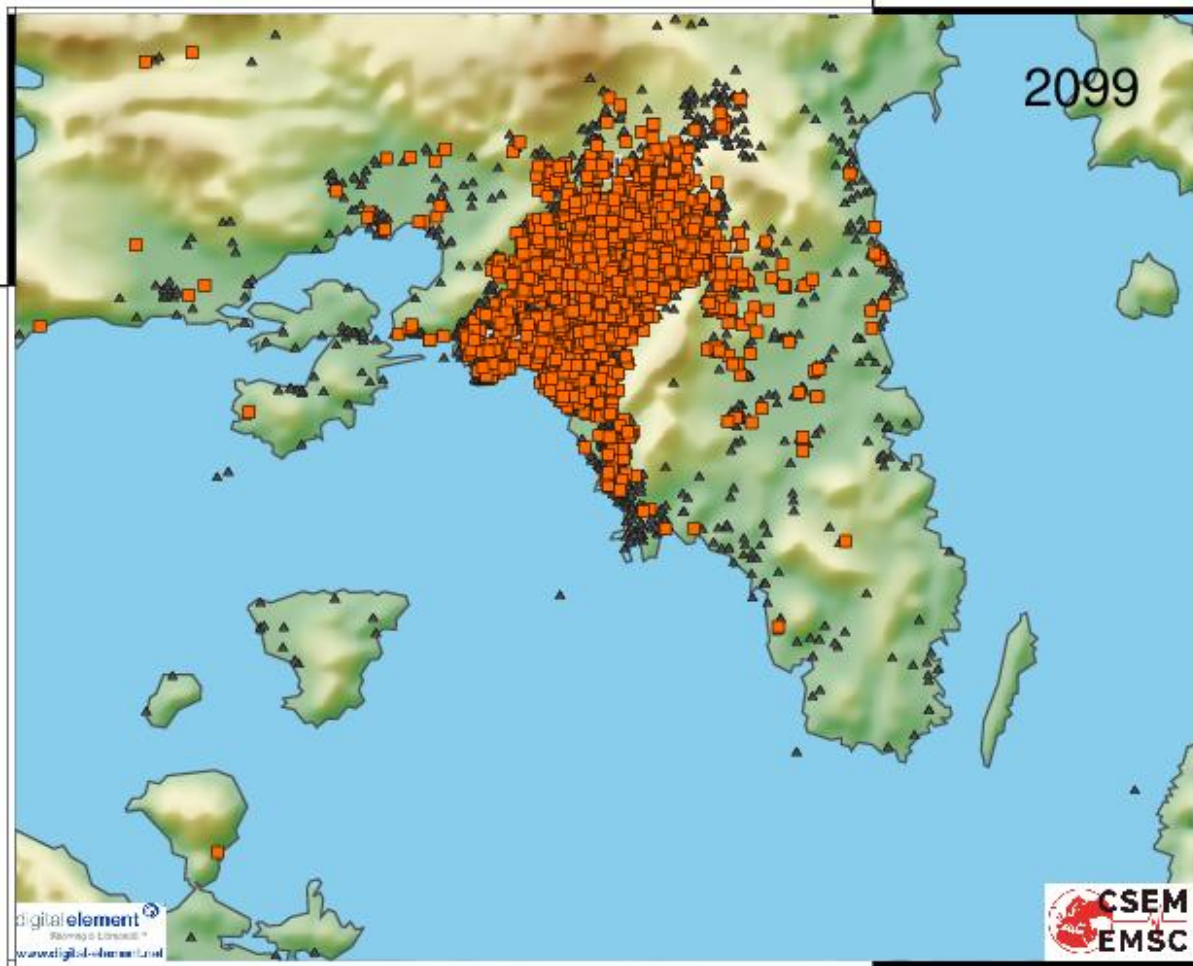


Visitors within 4:00 minutes of earthquake occurrence

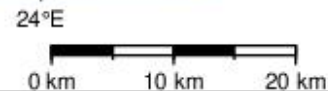
- Reported as:
- Not felt
  - Felt
  - Largely felt
  - Damaging
  - P wave
  - S wave
  - ★ Epicenter

Updated on 2021/11/18 10:26:59 UTC

# M2.9 Athens, Greece T0 + 300s

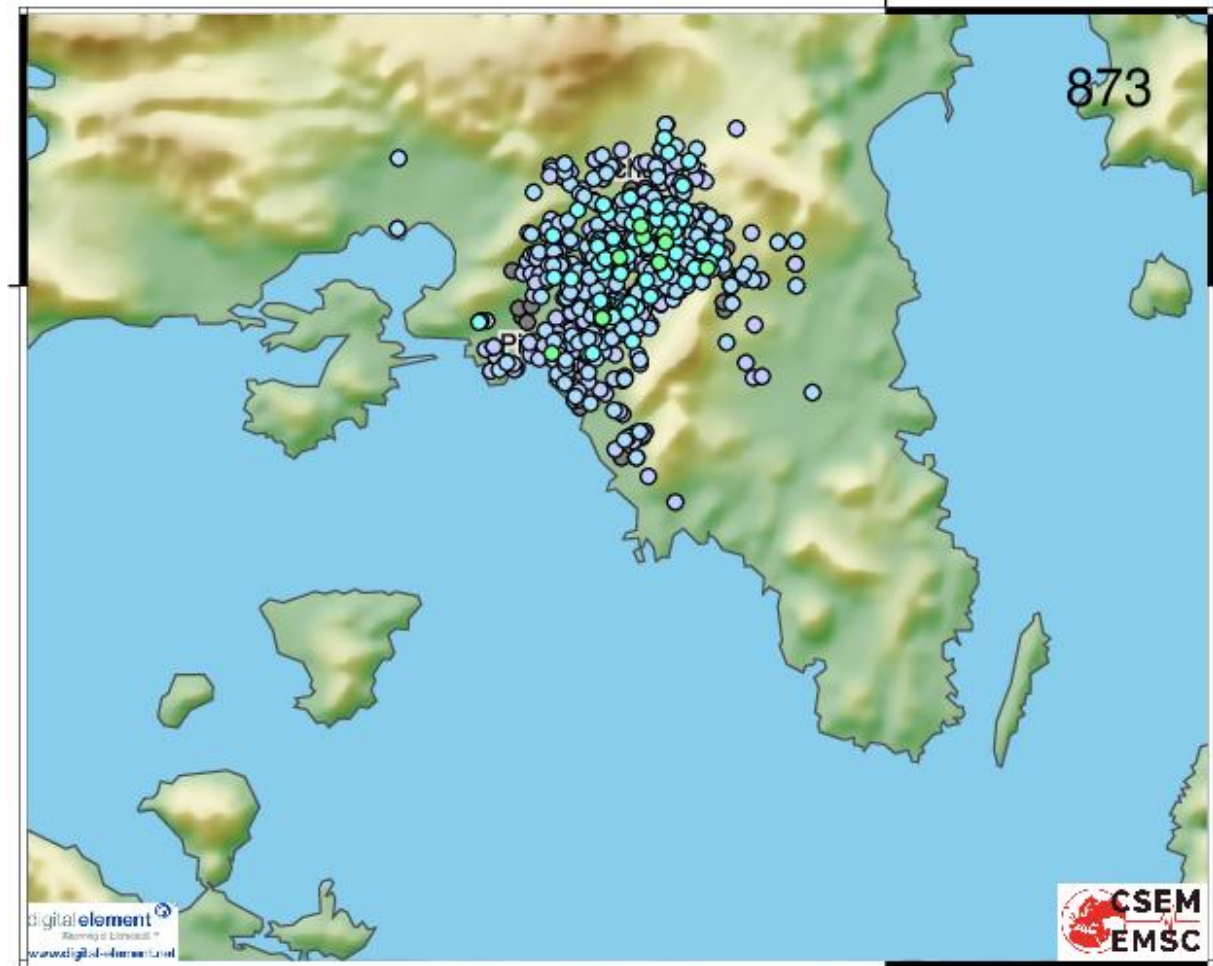


Visitors within 5:00 minutes of earthquake occurrence

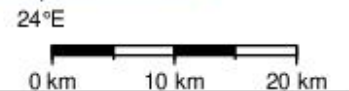


- LastQuake Apps Launched (new in last 30 minutes)
- LastQuake Apps Launched after app notification
- ▲ Installed Geolocated LastQuake Apps (last known locations)
- P wave
- S wave
- ★ Epicenter

Updated on 2021/11/18 10:15:22 UTC



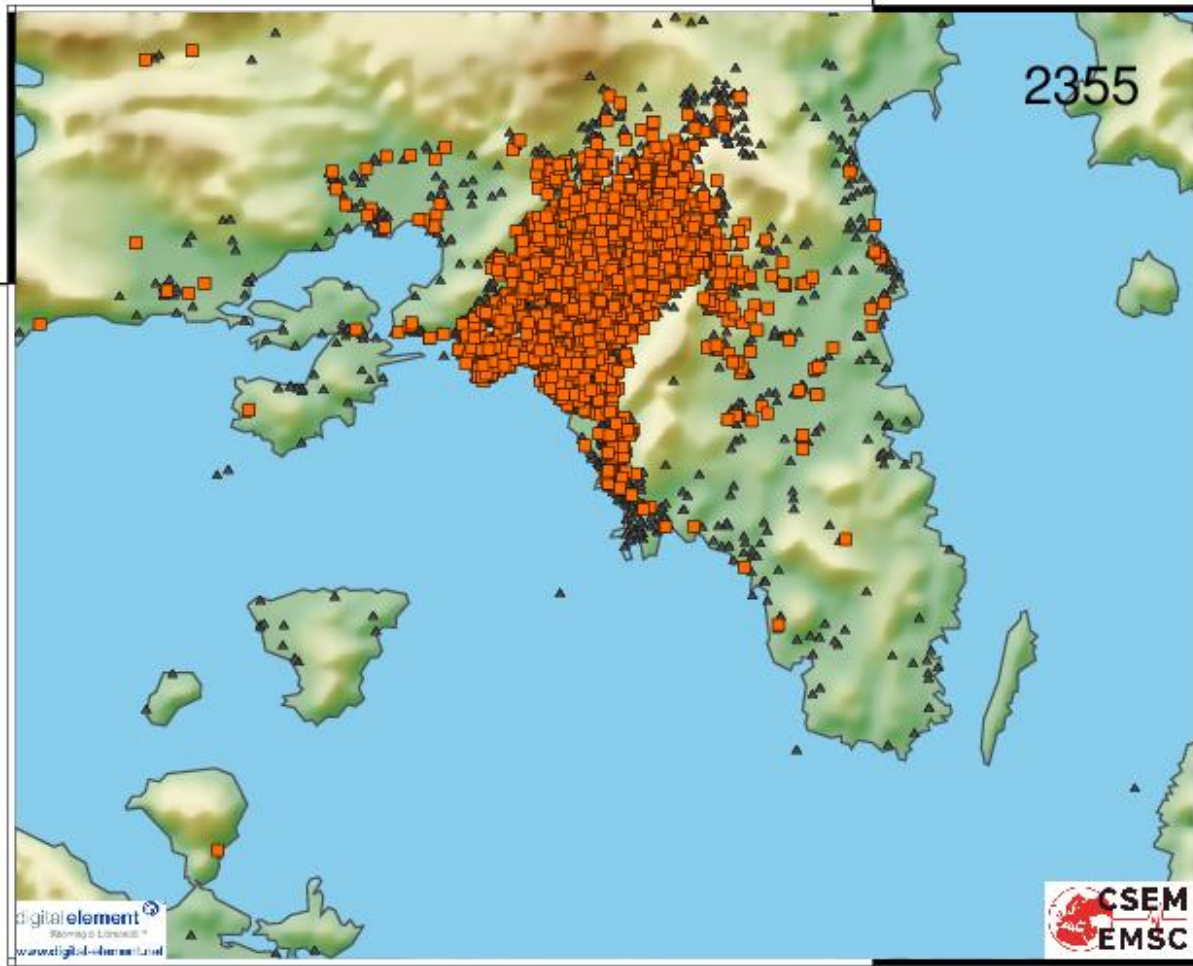
Visitors within 5:00 minutes of earthquake occurrence



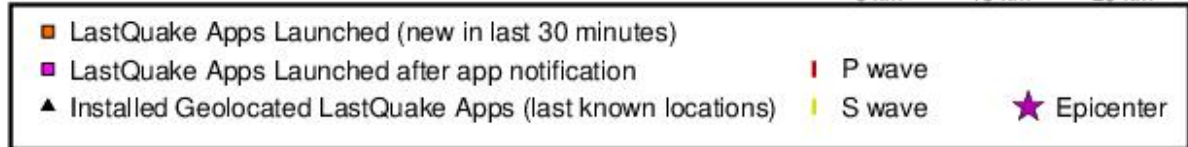
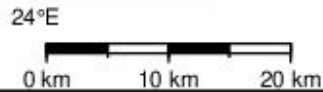
- Reported as:
- Not felt
  - Felt
  - Largely felt
  - Damaging
  - P wave
  - S wave
  - ★ Epicenter

Updated on 2021/11/18 10:26:59 UTC

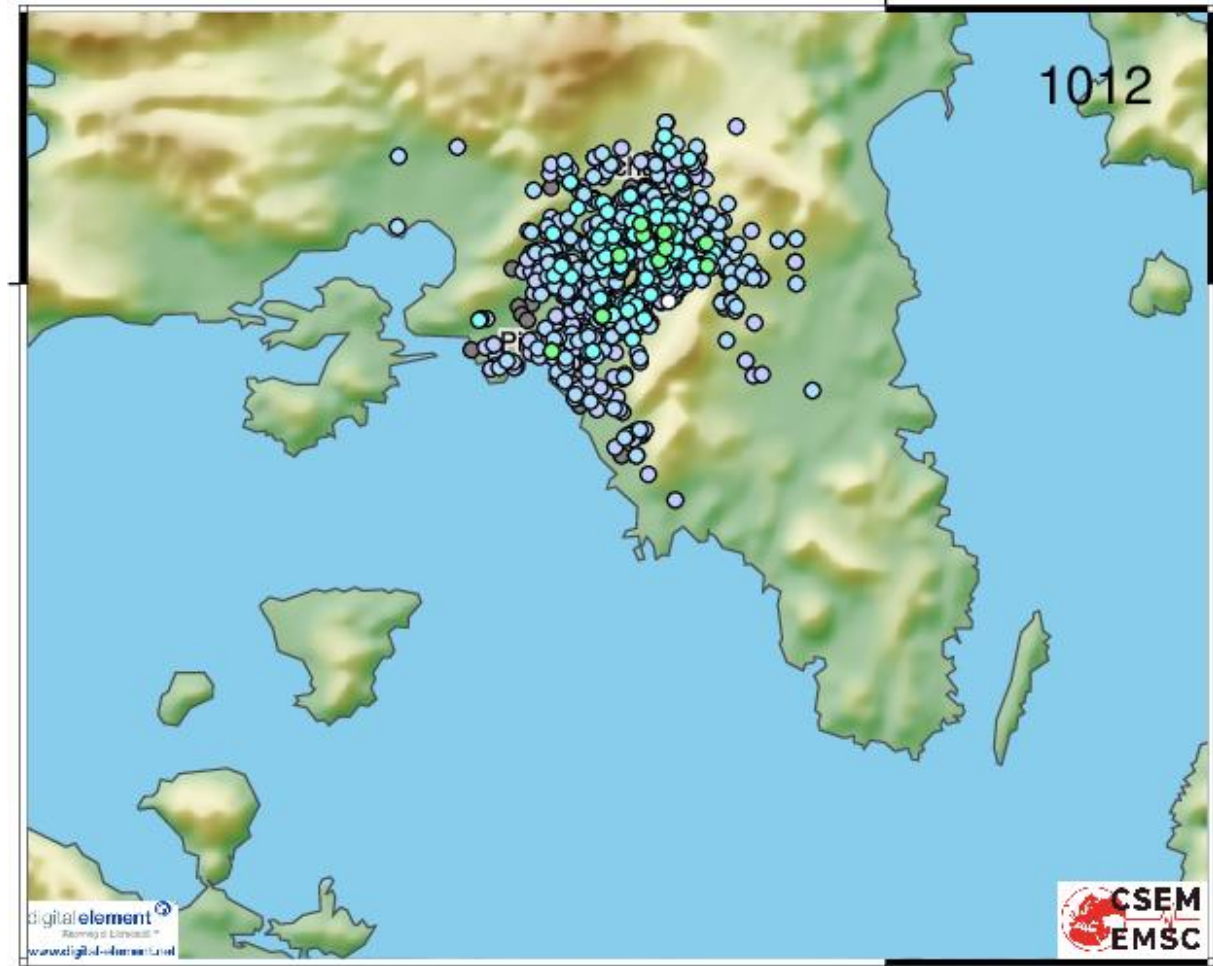
# M2.9 Athens, Greece T0 + 400s



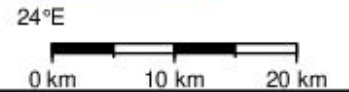
Visitors within 6:40 minutes of earthquake occurrence



Updated on 2021/11/18 10:15:22 UTC



Visitors within 6:40 minutes of earthquake occurrence

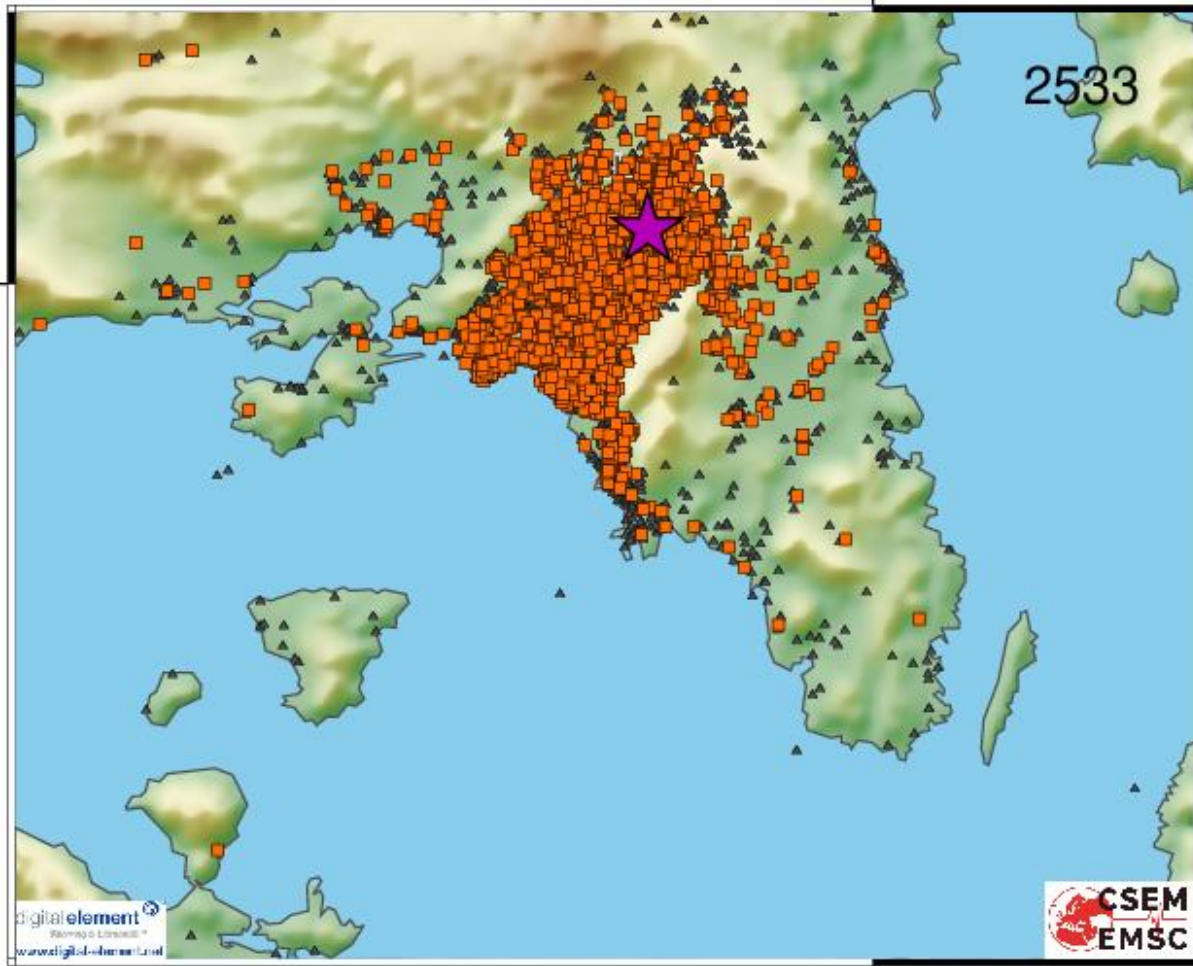


Updated on 2021/11/18 10:26:59 UTC

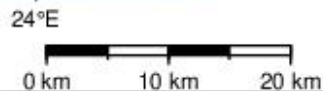
B



# M2.9 Athens, Greece T0 + 533s

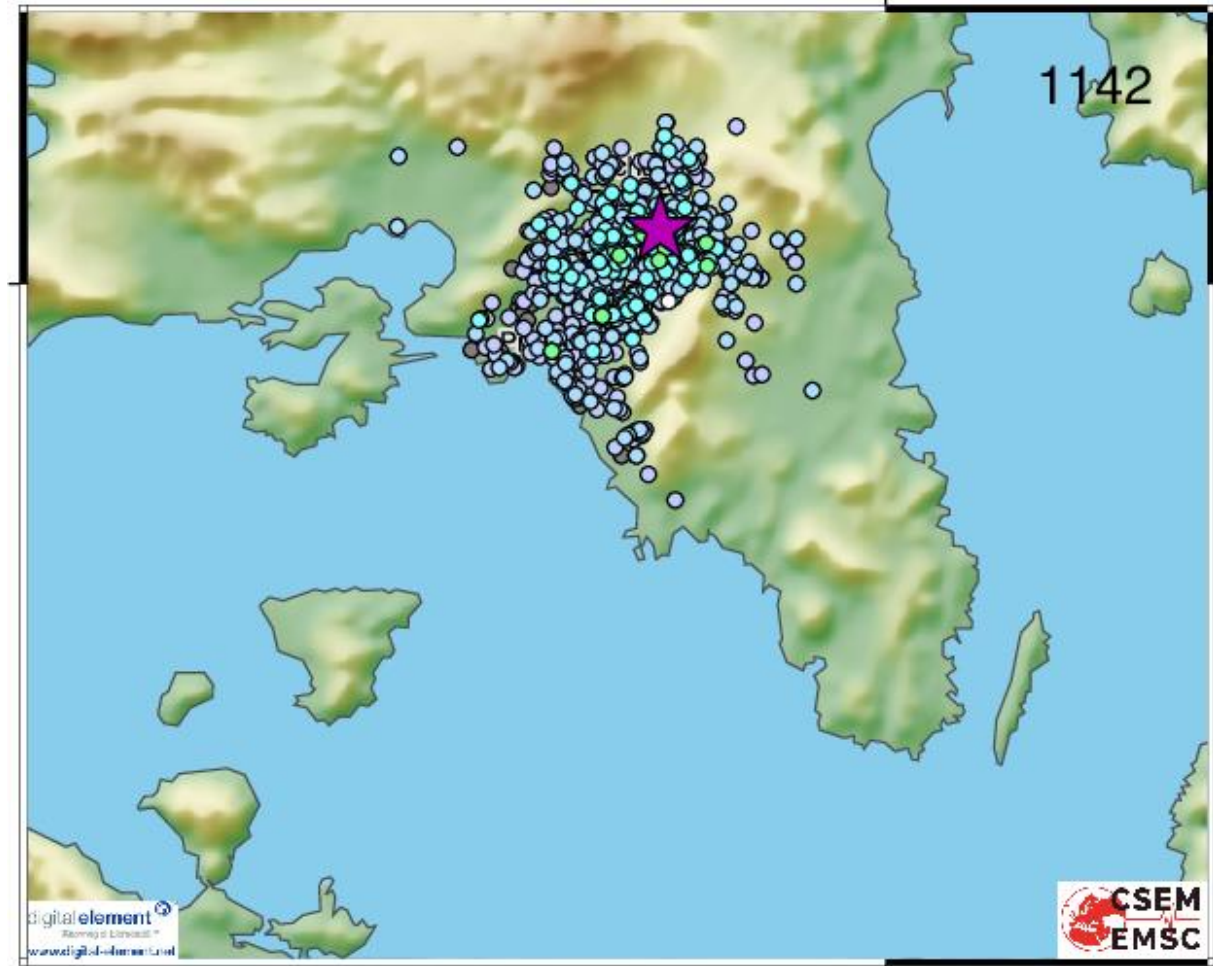


Visitors within 8:53 minutes of earthquake occurrence

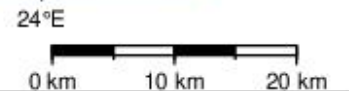


- LastQuake Apps Launched (new in last 30 minutes)
- LastQuake Apps Launched after app notification
- ▲ Installed Geolocated LastQuake Apps (last known locations)
- P wave
- S wave
- ★ Epicenter

Updated on 2021/11/18 10:15:22 UTC



Visitors within 8:53 minutes of earthquake occurrence



- Reported as:
- Not felt
  - Felt
  - Largely felt
  - Damaging
  - P wave
  - S wave
  - ★ Epicenter

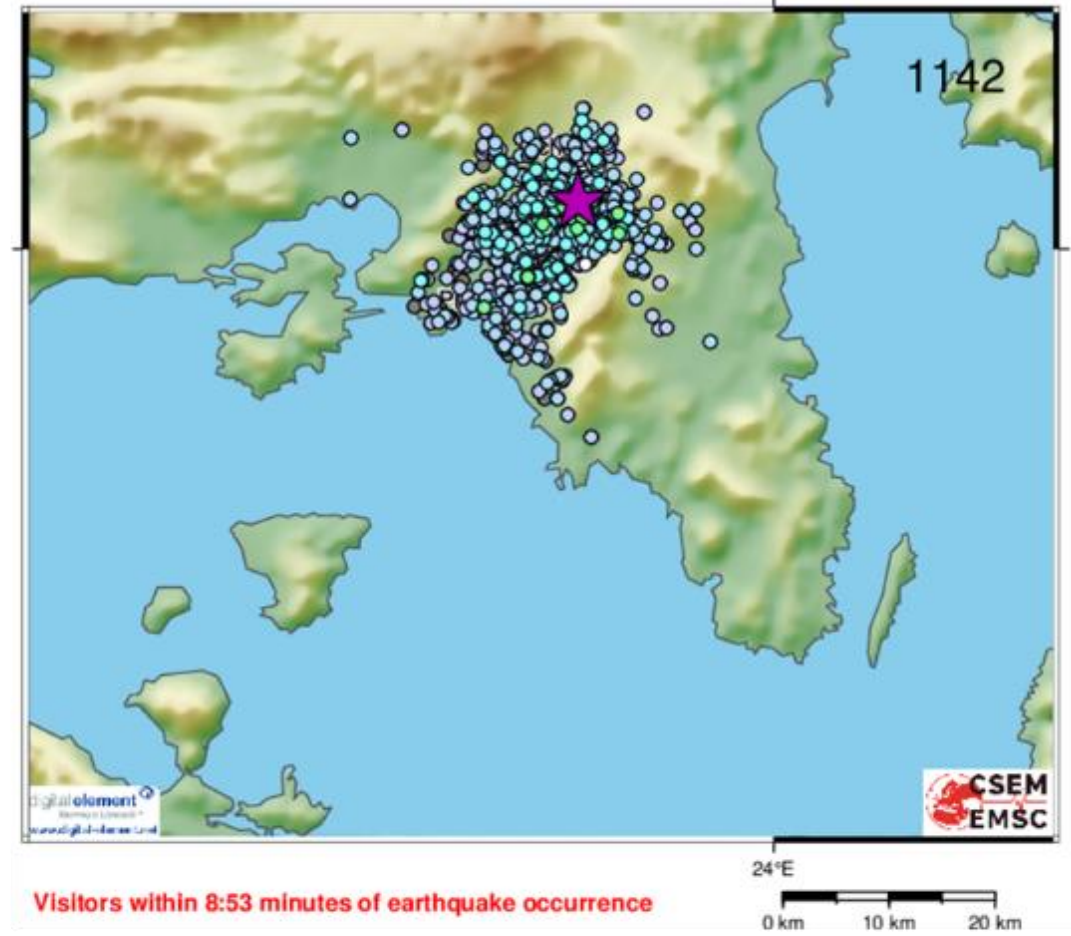
Updated on 2021/11/18 10:26:59 UTC

# M2.9 Athens. Felt Reports: 80% BEFORE Notification!

**2021: 37% of felt reports BEFORE preliminary loc (<5 min)**



**1 460**

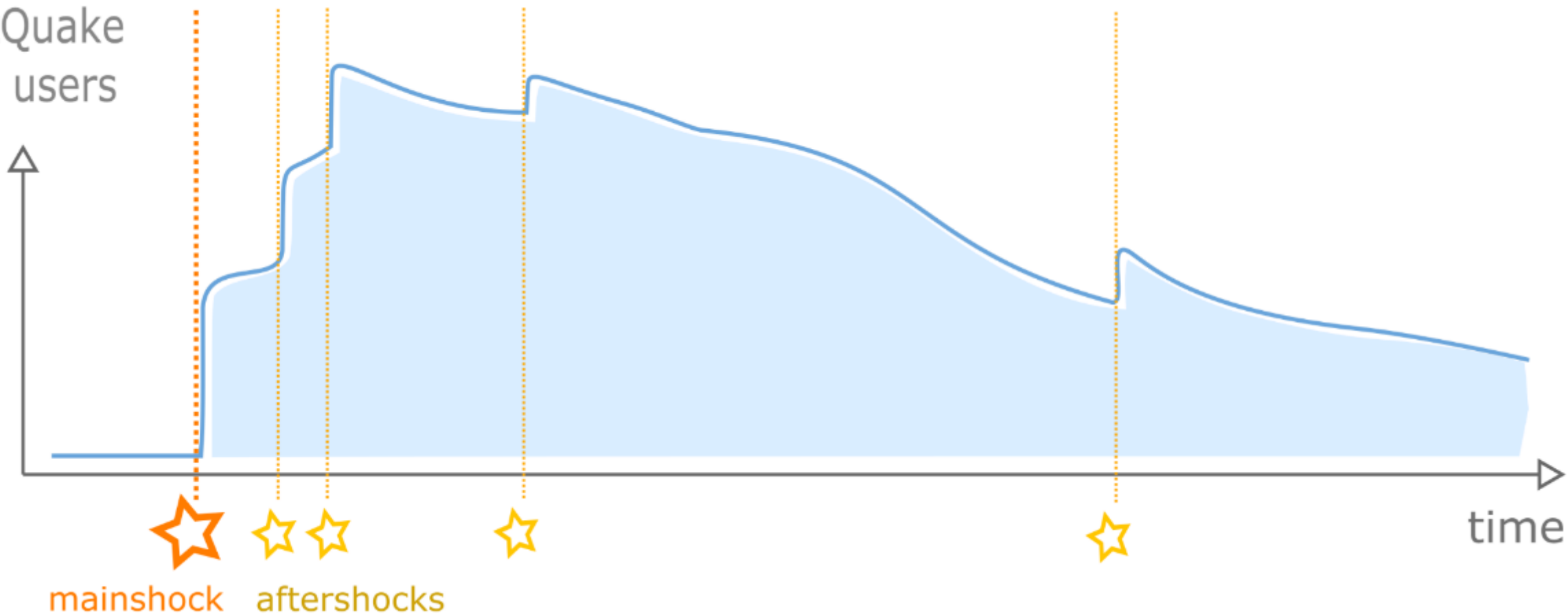


**1 142**



# An App is NOT enough!

LastQuake  
app users



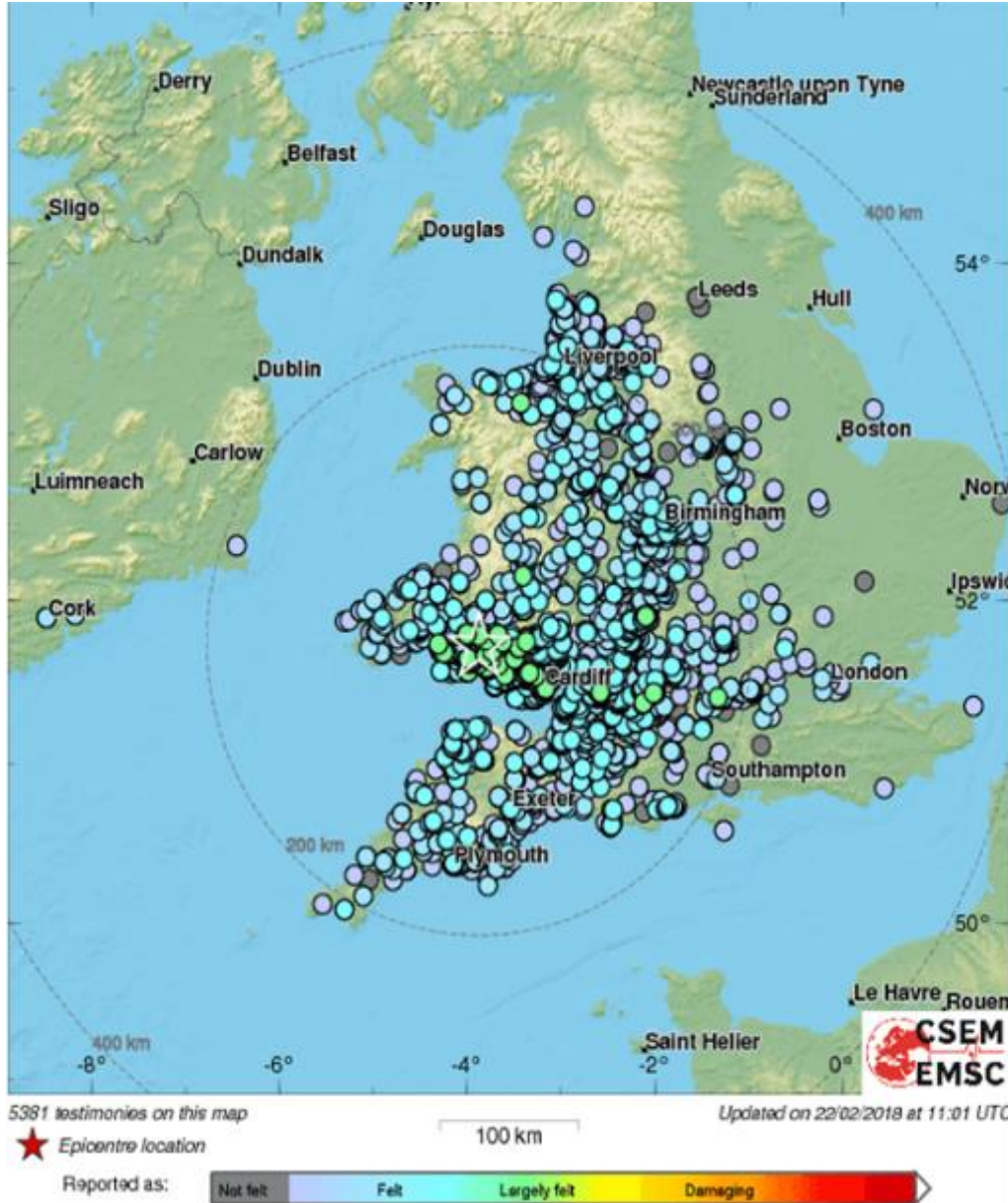
mainshock

aftershocks

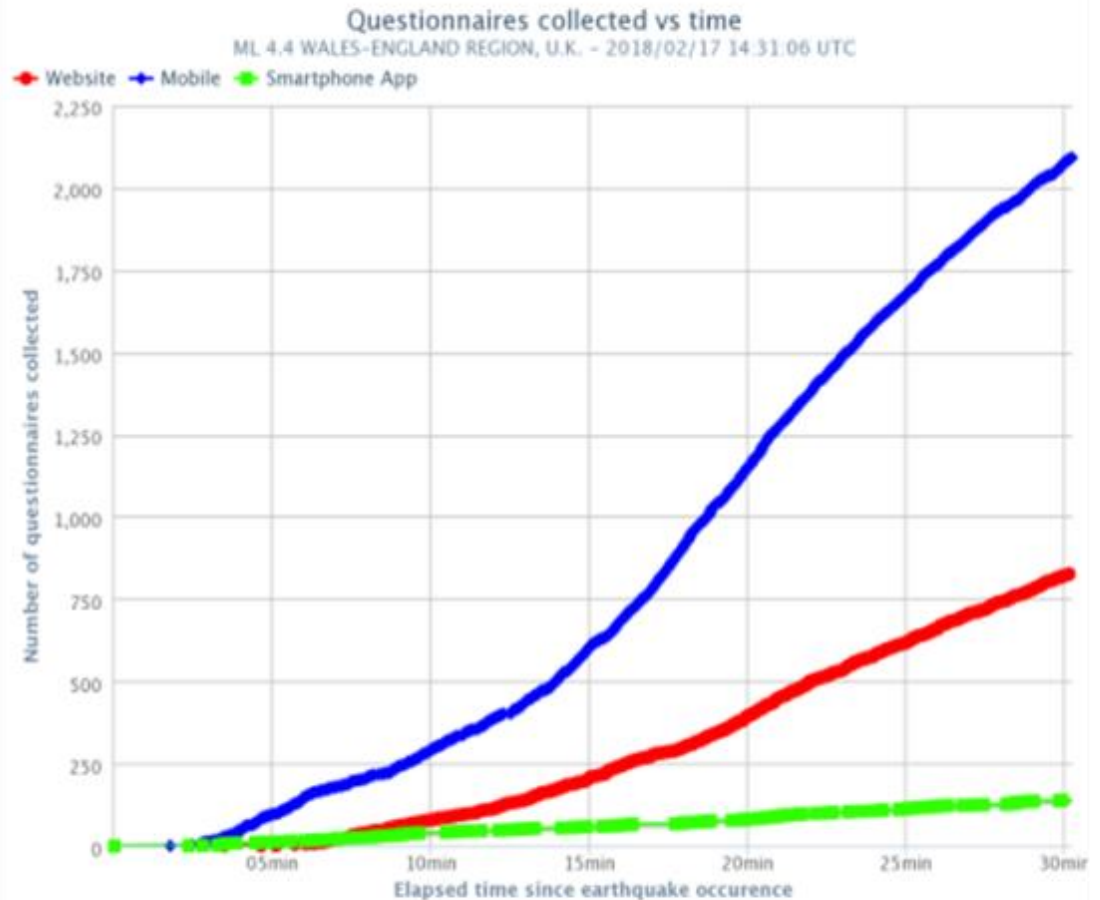
time



# Wales-England Region Feb. 17 2018



**3 000 felt reports in 30 min**  
**>90% collected through websites!**

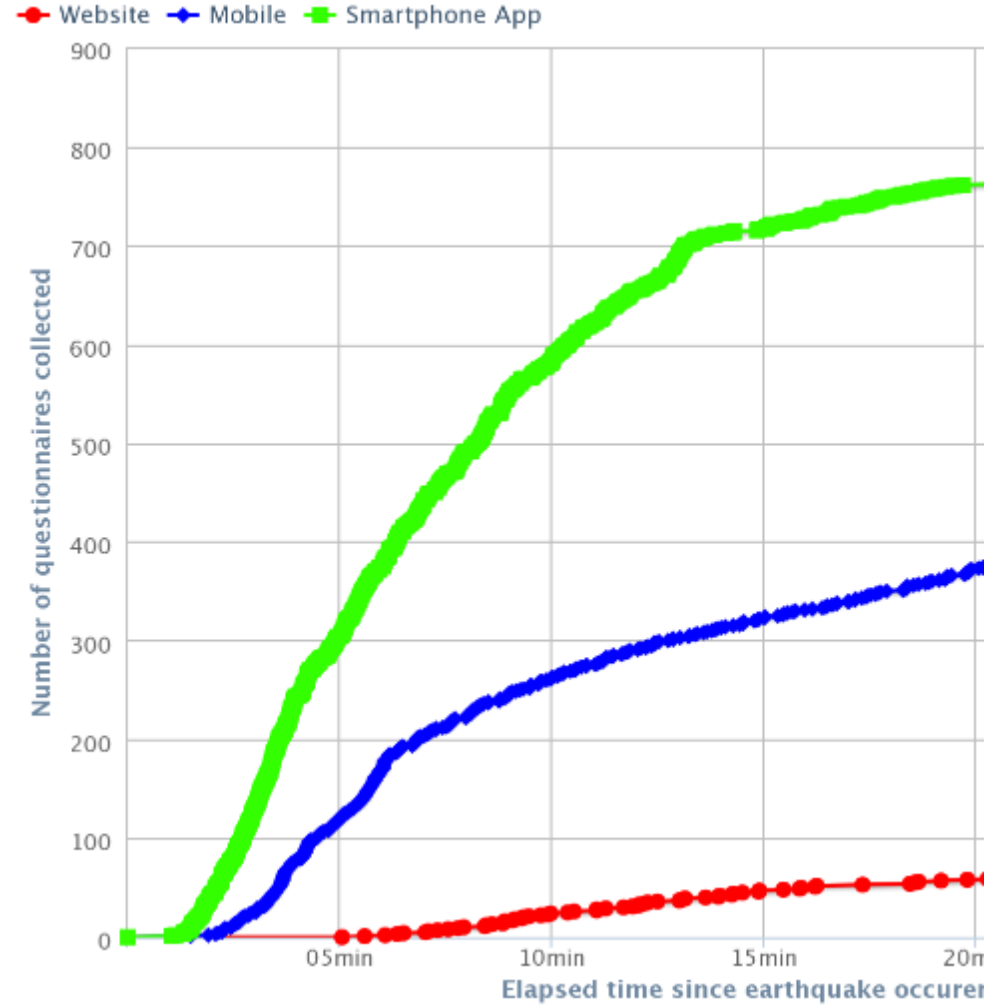


# M5.6 Albania, Sept. 21, 2019 14:04

2 286 Felt reports



400 reports in 5 min (300 by the app)

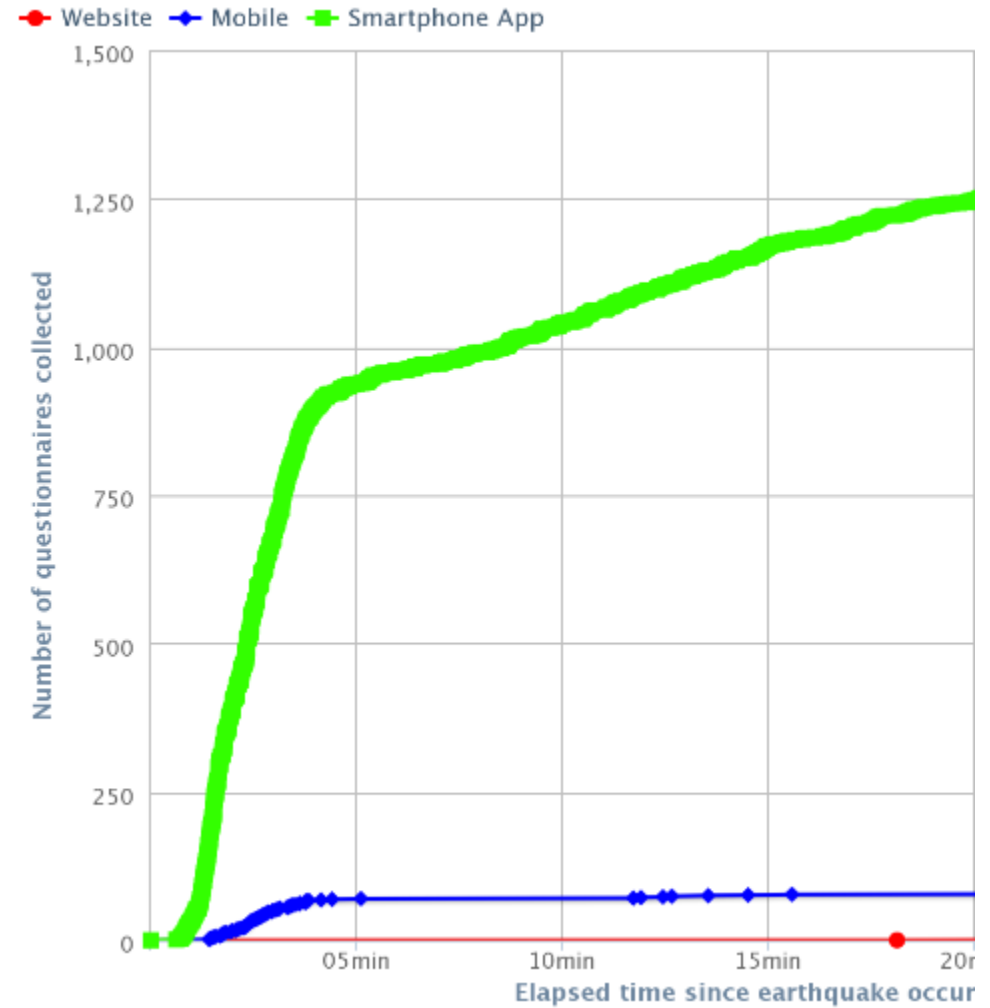


# M4.4 Albania, 30 hours Later

2 260 Felt reports



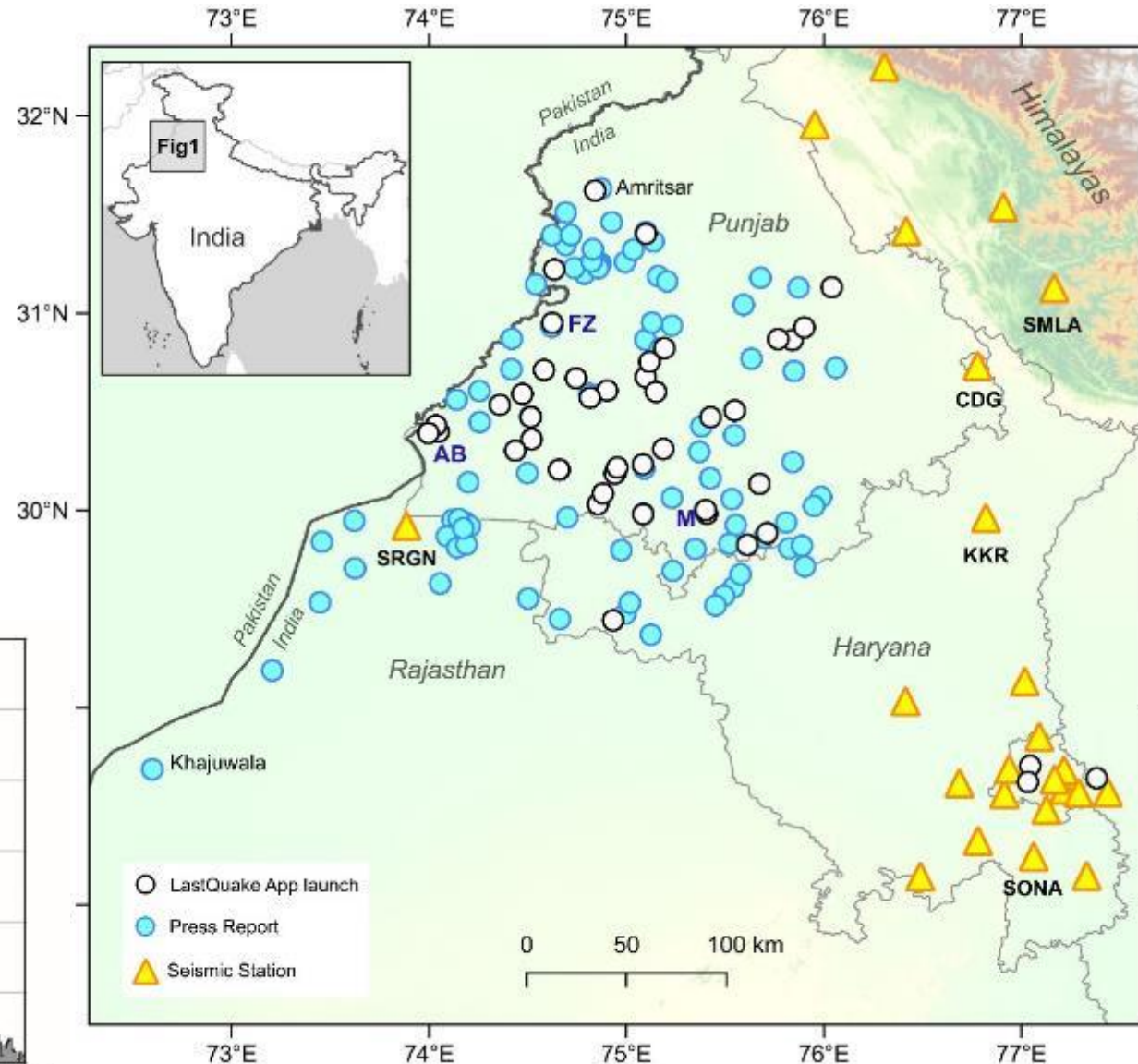
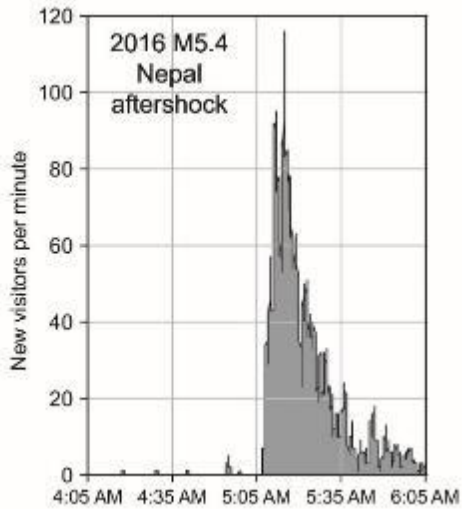
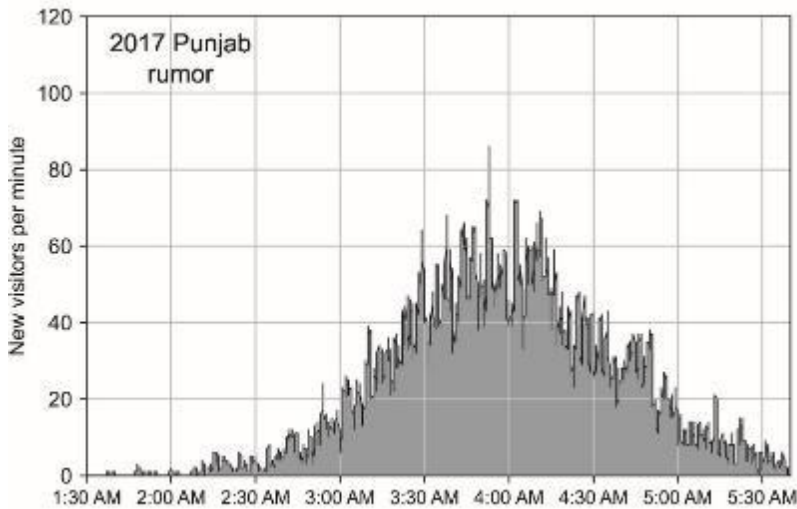
1 000 reports in 5 min (900 by the app)



# Not Only Earthquakes!

Decreasing Frequency

Sonic booms  
 Media coverage  
 Explosion (e.g., Beyrouth)  
 Meteor (Croatia)  
 Prediction...





# LastQuake: Risk and Crisis Communication



# Smartphones: Right Info at the Right Time at the Right Person!

## Safety Tips: Timely Geo-targeted Information Safety checks: Inform your loved ones

TIMELINESS



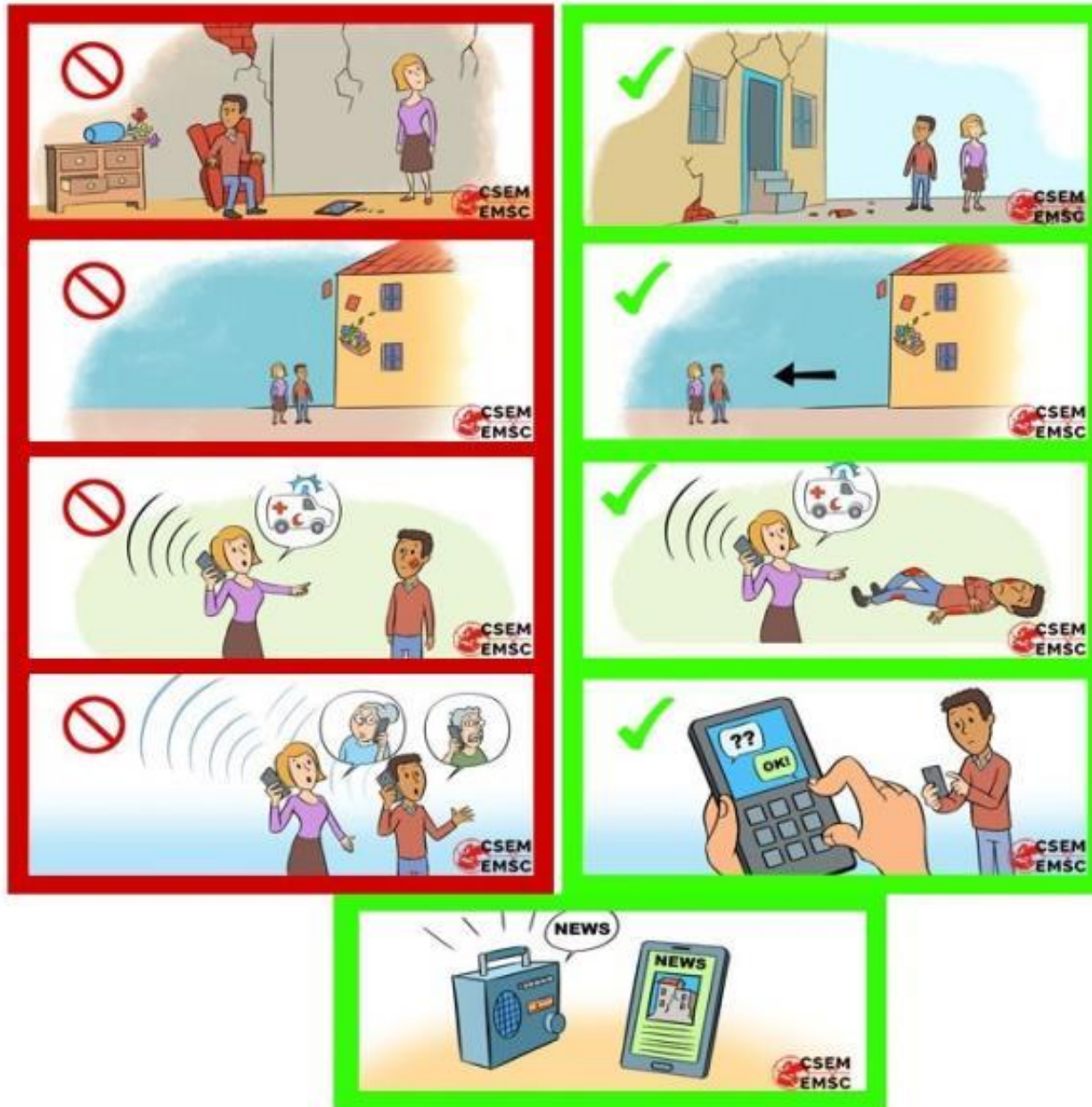
**Bobby Laurie**  
@BobbyLaurie



PEOPLE: Listen to your flight attendants! ALMOST EVERYONE in this photo from @SouthwestAir #SWA1380 today is wearing their mask WRONG. Put down the phone, stop with the selfies.. and LISTEN. \*\*Cover your NOSE & MOUTH. #crewlife #psa #listen #travel #news #wn1380



# « What Should I do After an Earthquake? » Do's & Don'ts



# Tsunami: Warnings and Safety Tips





# @LastQuake Twitter bot: 300+K followers

DESTRUCTIVE

Mag>7.5 NOT FELT

LARGE, WITH AUDIENCE

LARGE, NO AUDIENCE

SMALL, WITH AUDIENCE

SMALL, NO AUDIENCE

## Information on the system

e.g., earthquake crowdsourced detection, shaking felt by eyewitnesses, LastQuakers forum.

## Educational tweets

e.g., difference between earthquake magnitude and intensity, earthquake energy, intensity and damages.

## Seismological insights

e.g., number of aftershocks, moment tensor solutions, recent seismicity, recent deadliest earthquakes.

## Audience information

eyewitnesses' comments, pictures and videos.

## Misinformation fight

e.g., awareness on fake news and claims about earthquake prediction.

- 6 types of earthquakes
- 6 types of information
- 53 different tweets
- To be extended (national resources)

# Not Only a Bot: Answering Questions in Real Time

Echoing that. I'm really surprised there has been no authoritative real time info on earthquakes in English for tourists in Indonesia. @LastQuake has been it - keep up the good work!

Traduire le Tweet

16:46 - 7 août 2018

Your doing a great job by the way @LastQuake very nice for me to have updates as im away from home and can keep an eye on things and call home to Bali once i know there has been another aftershock, hope it calms down soon for the people in Lombok



Traduire le Tweet

17:38 - 9 août 2018

The lack of info after the 6.9 by the hotel staff. I had to dig for info by myself and found someone referring to your profile on tweeter. I then followed your advice by downloading your app. Thank you for the amazing work. I somehow feel more secure knowing whats happening.

Traduire le Tweet

17:53 - 9 août 2018

I know it's crazy making to repeat it over & over, but I promise you are helping SOOOO much. I don't know what I'd do w/o you guys right now! We log onto Twitter in a panic and scroll to latest entry...no time to review previous entries when unsure what to do next. SO THANK YOU!

Traduire le Tweet

18:18 - 6 août 2018



## Misinformation: 2018 Mayotte: An Earthquake Sequence in a Poorly Instrumented Region

- **Many felt earthquakes that cannot be located**
- **Rumours, fake news and conspiracy theories**

***Explain Why Information Is Missing!***

# Disinformation: Not New!



The 1887 quake in Menton?

No! 1873 EQ, Belluno, Venetia, Italy

*(courtesy A. Laurenti)*



# Earthquake Prediction: 2019 Albania, People Leaving Tirana!



 **EMSC**  @LastQuake · 22 sept.

To our friends in #Albania, you are likely to have heard or to hear in the coming days people claiming to have predicted yesterday's earthquake or future ones. Do not listen to them: Earthquake prediction DOES NOT exist as today. Stay safe



# Debunking, Pre-bunking Misinformation



EMSC   
@LastQuake

"Earthquakes do their best to be as unpredictable as possible" - Watch this video from @geosociety where seismologist Ross Stein explains why #earthquakes cannot be predicted at present 🙅

[Traduire le Tweet](#)



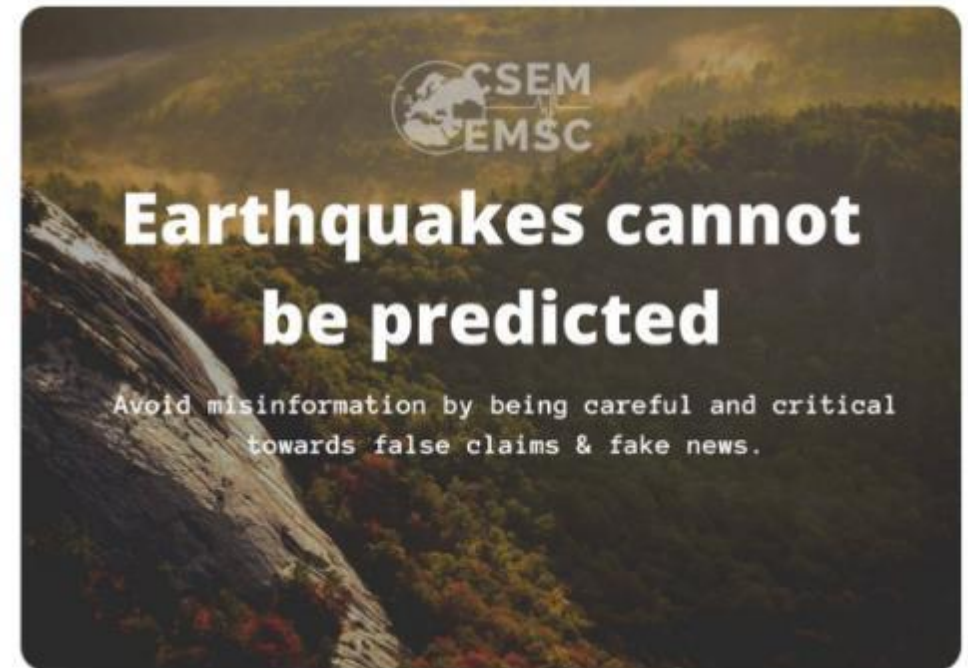
youtube.com  
Quakecaster - Ross Stein, GSA Lecture  
Earthquakes explained by GSA's 2017-2018 GSA James B. Thompson, Jr. Distinguished International Lecturer Ross ...



EMSC   
@LastQuake

? Do you have an #earthquake prediction? The Collaboratory for the Study of #Earthquake Predictability([scec.org/research/proje...](https://scec.org/research/proje...)) accepts predictions & evaluates them. Careful though: saying you did predict after the #earthquake happens means nothing 😊

[Traduire le Tweet](#)



# The Role of Seismologists!



**Michael T**  
@theevomo

Suivre

[@LastQuake](#) I live in California but seeing you answer tweets from people in Indonesia is awesome especially since they probably are feeling fear during this crazy period. I don't think any other organization would do this.

Traduire le Tweet

18:11 - 19 août 2018

8 J'aime



3



8



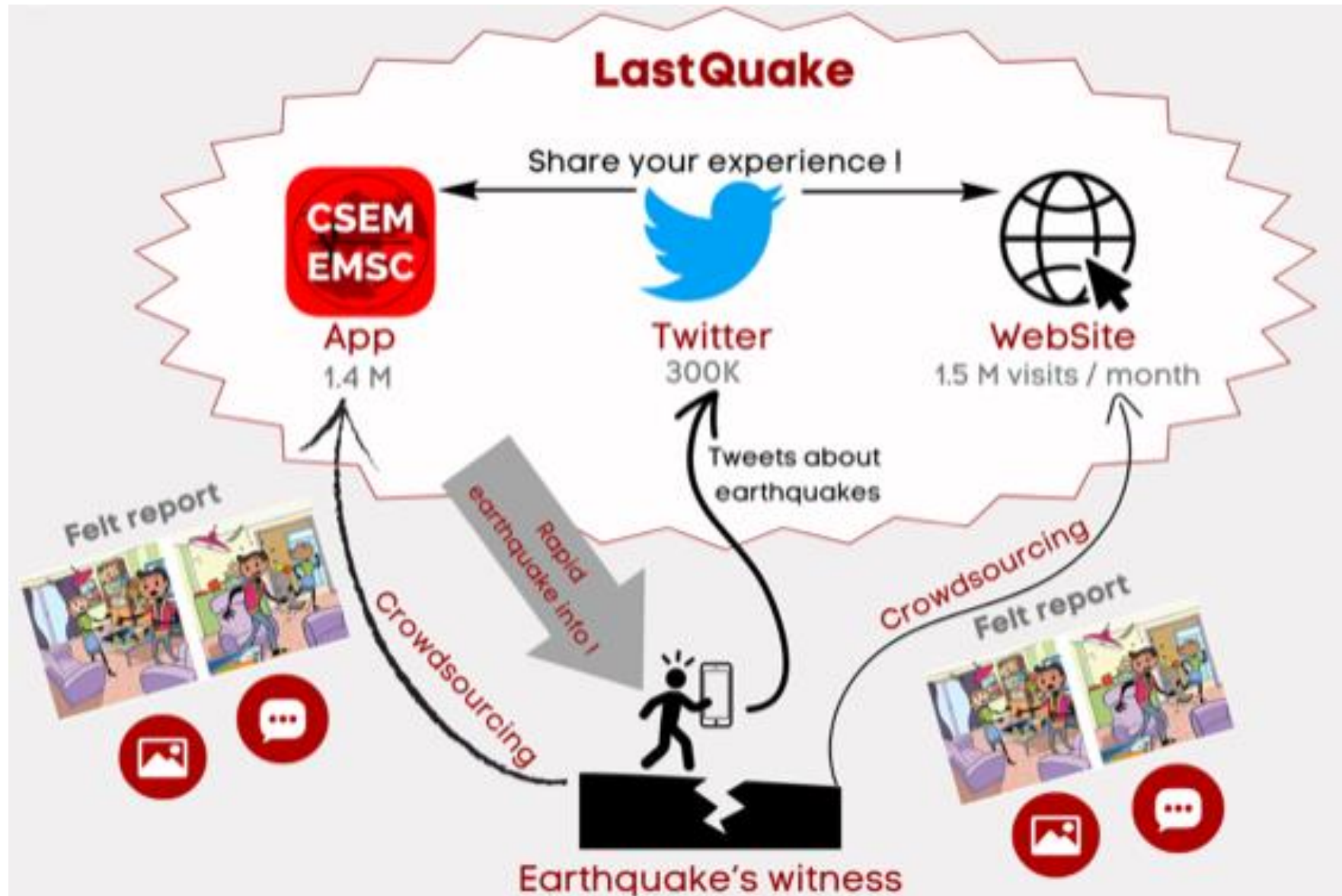
# Main Media also Covering Misinformation (12/09/2023)



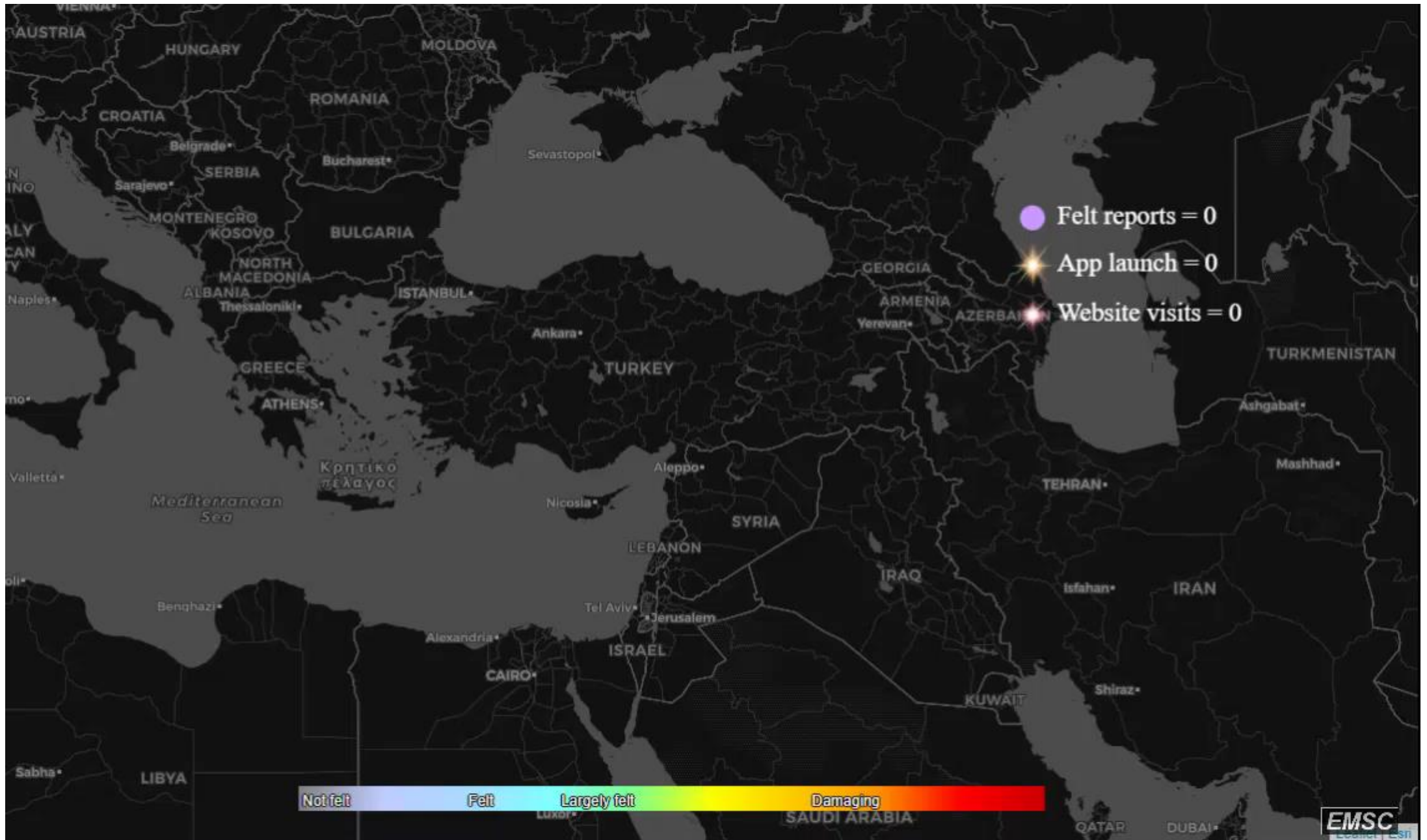


# CrowdSourced Data for Rapid Impact Assessment

# LastQuake: A Multi-component Information and Crowdsourcing System

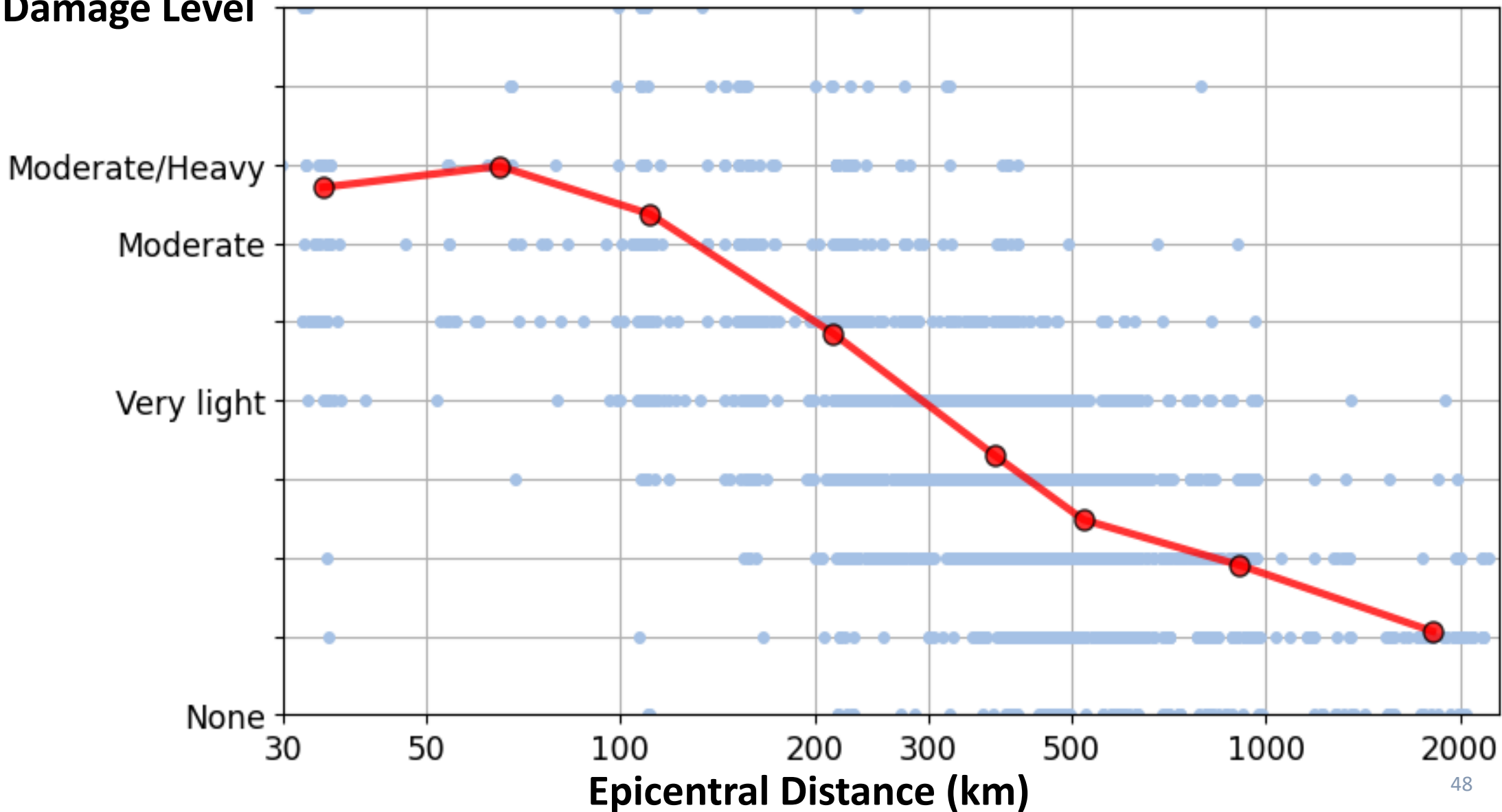


# The Use of LastQuake in the Aftermath of the M7.8 2023 Turkish Earthquake



# At least 3 M subjected to Moderate/Heavy Damage

## Damage Level





# Ingestion in ShakeMaps, M6.4 Petrinja, Croatia

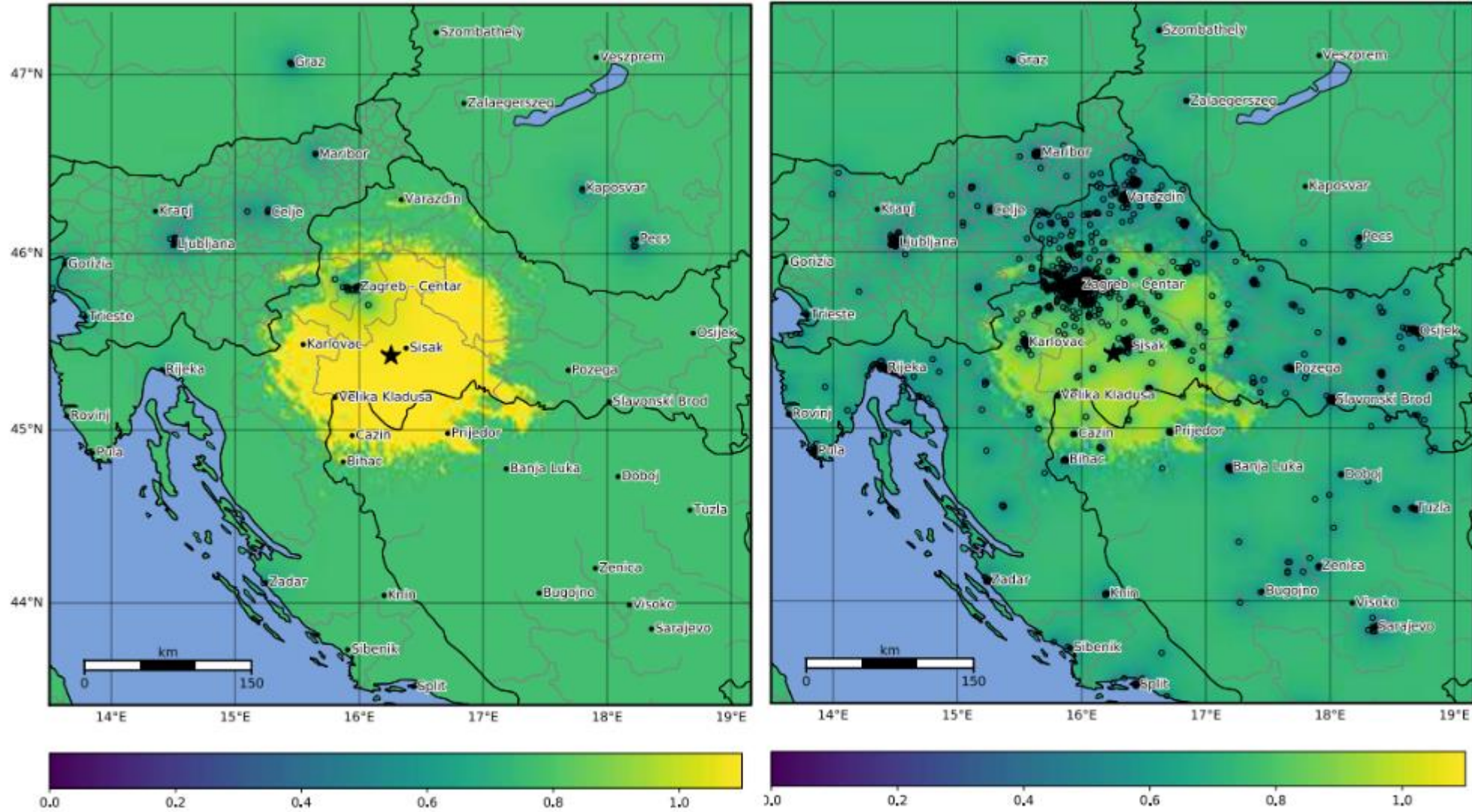
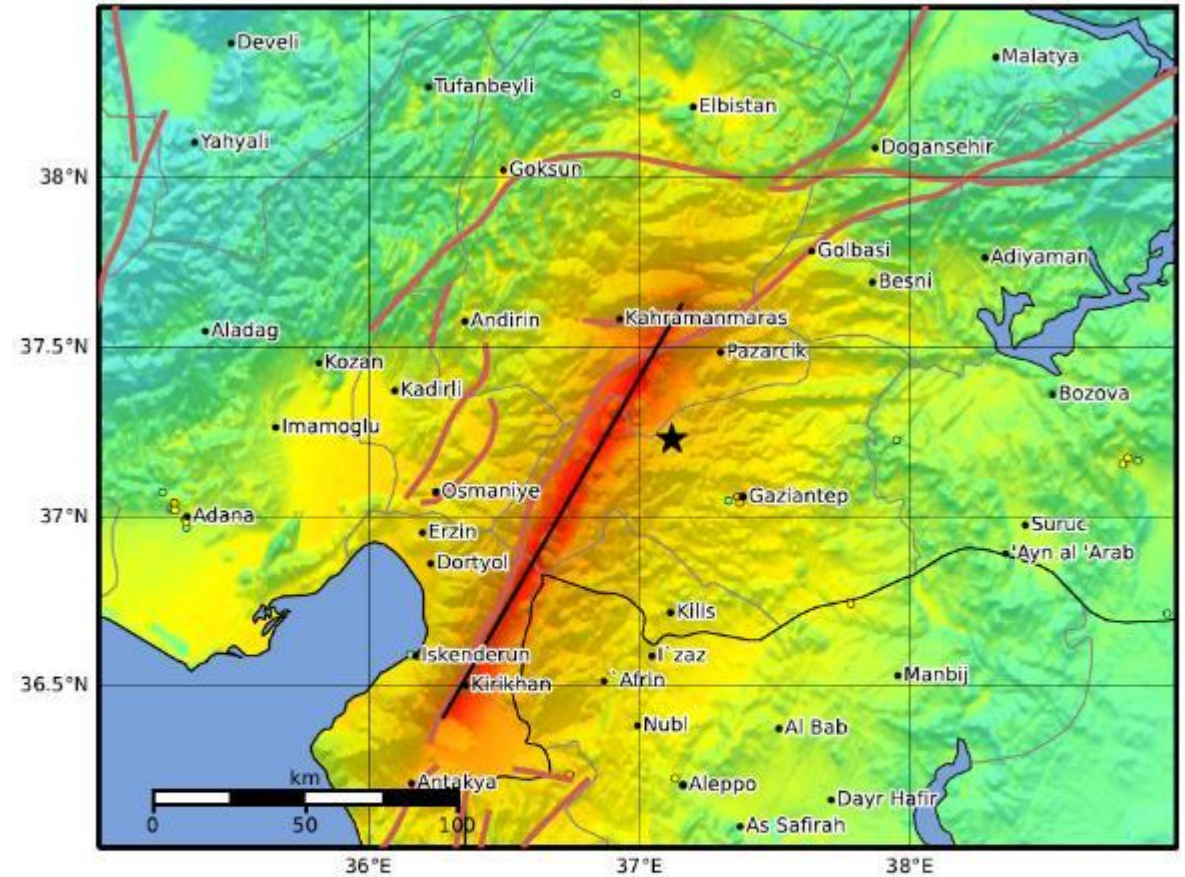
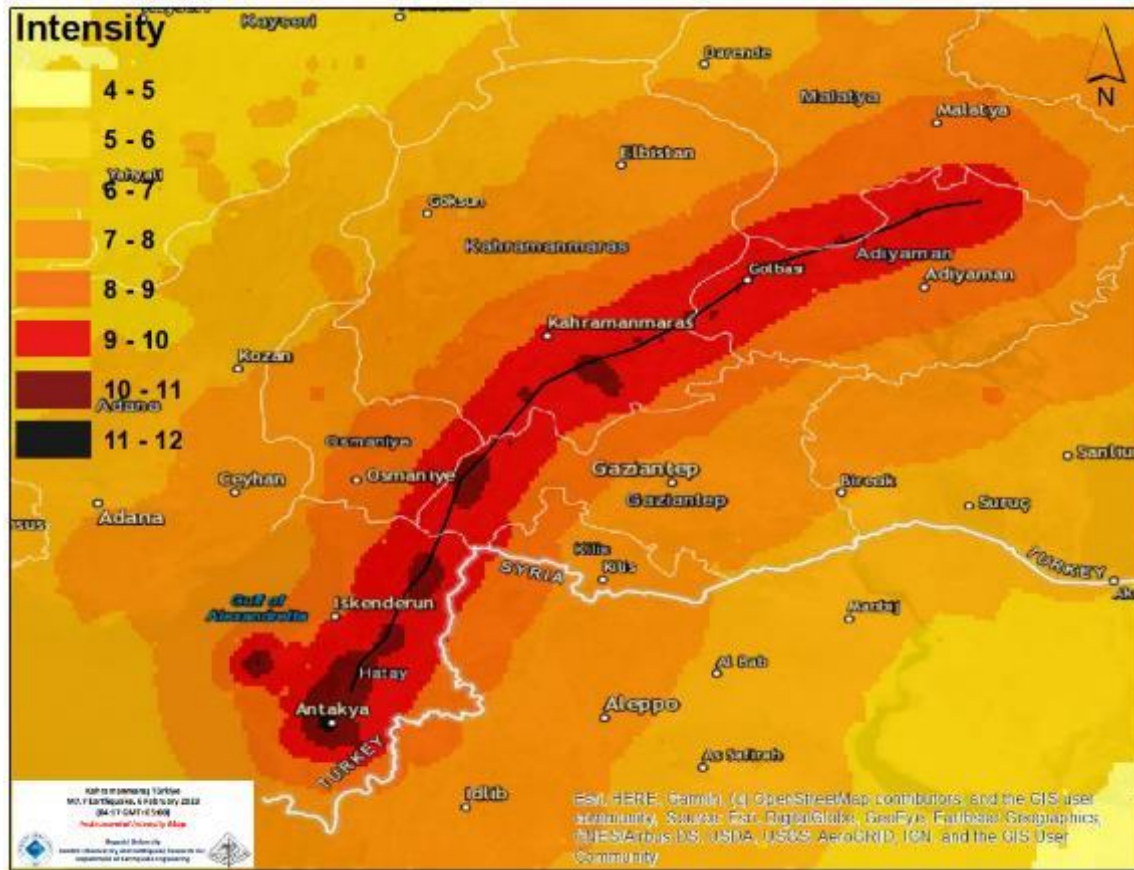


Fig. 7. ShakeMap uncertainty maps for the DYFI (left) and EMSC (right) datasets. Brighter colors indicate higher uncertainty.



## Field Survey



SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.0464	0.297	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.0215	0.135	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Worden et al. (2012)  
 Version 1: Processed 2023-03-16T13:45:33Z  
 Δ Seismic Instrument ○ Reported Intensity ★ Epicenter □ Rupture



# Images with Severe Damage



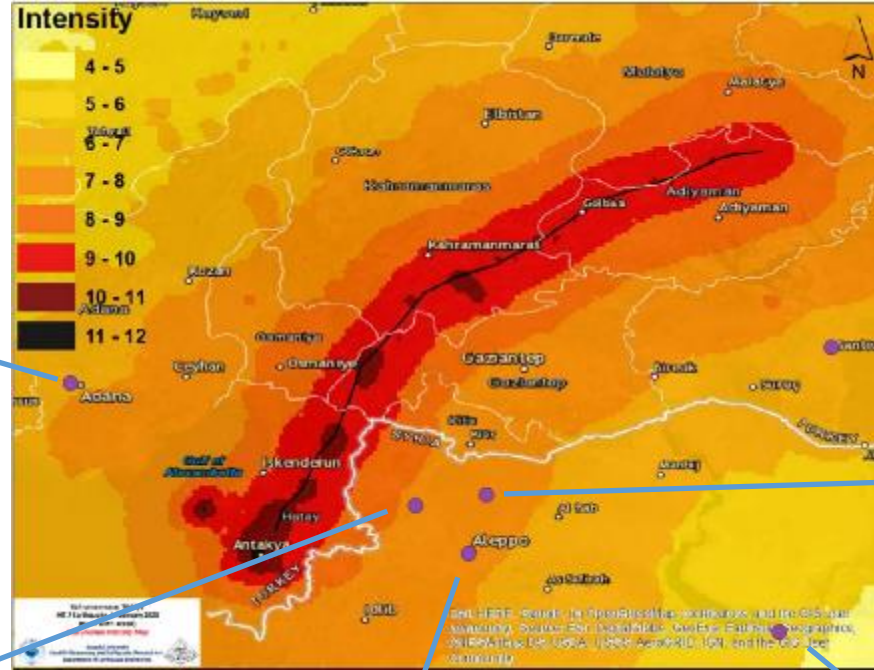
3hr 30min



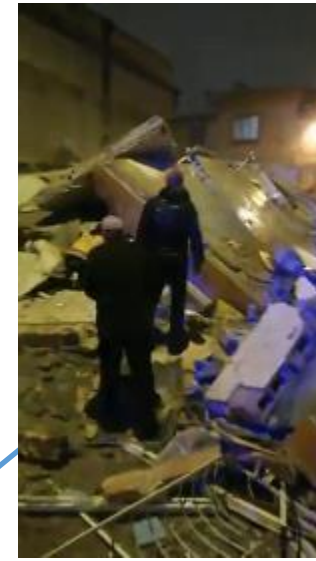
29min 200 km



3hr  
175 km



3hr 45min



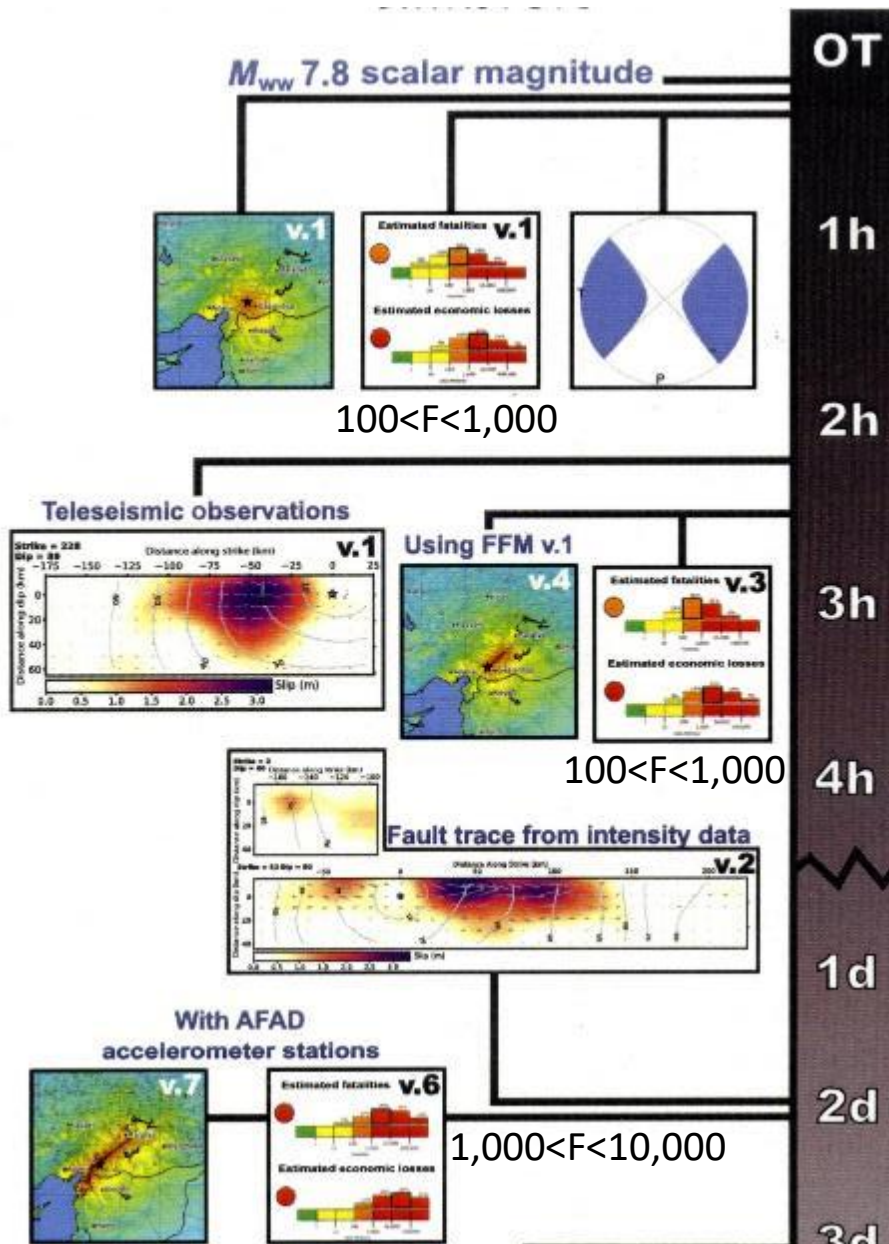
2hr 53 min



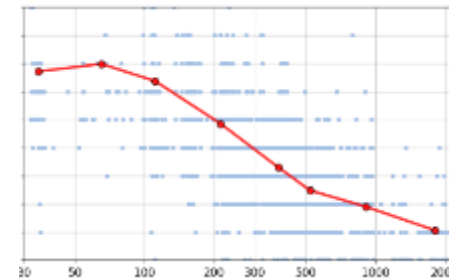
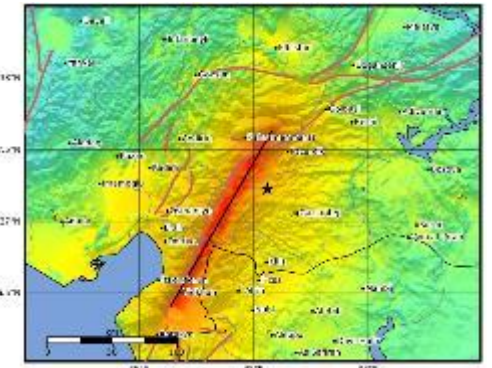
3hr  
200 km



# Added Value for Impact Assessment: the M7.8 earthquake



- 10 min: Prob.: 0,68+/-014



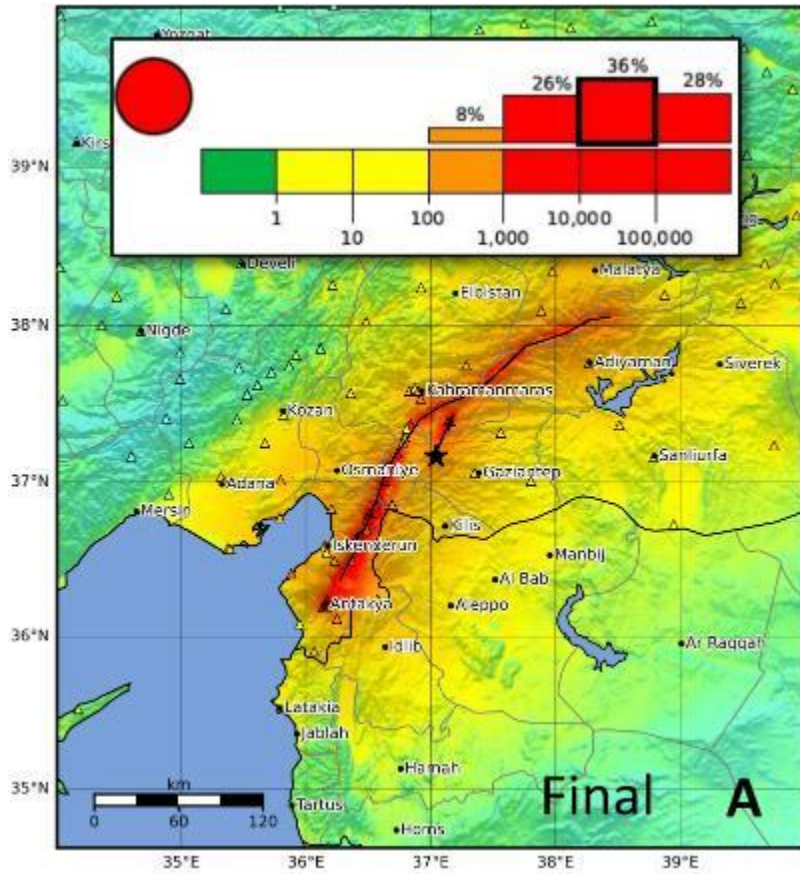
- $F \gg 3,000$

- Intensity locally  $\gg$  moderate-heavy

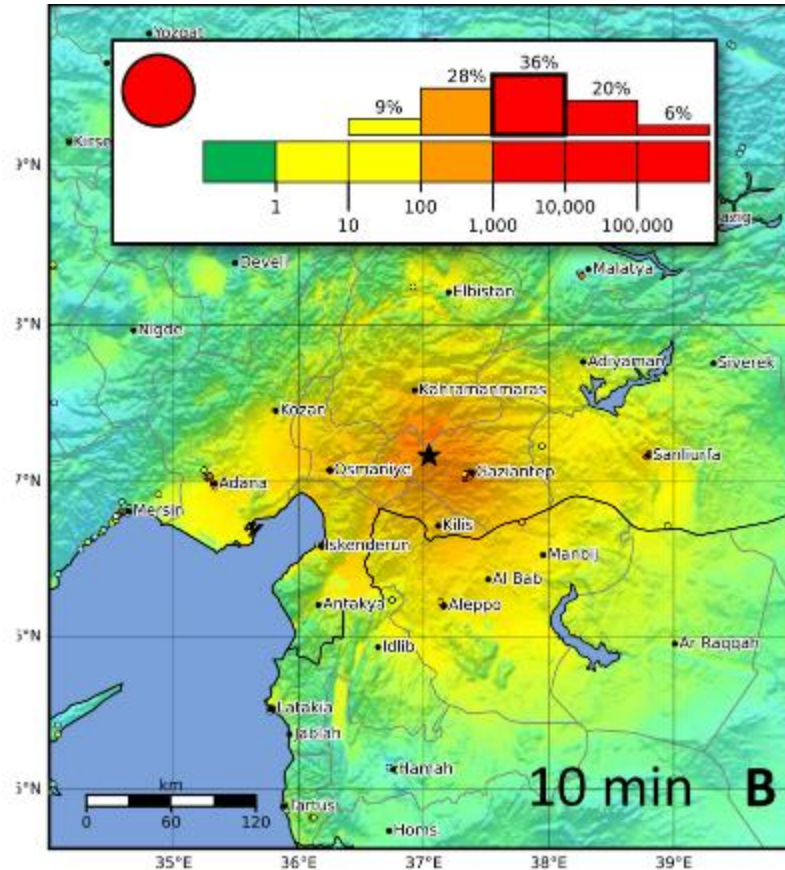
- 12 hr: Landslide



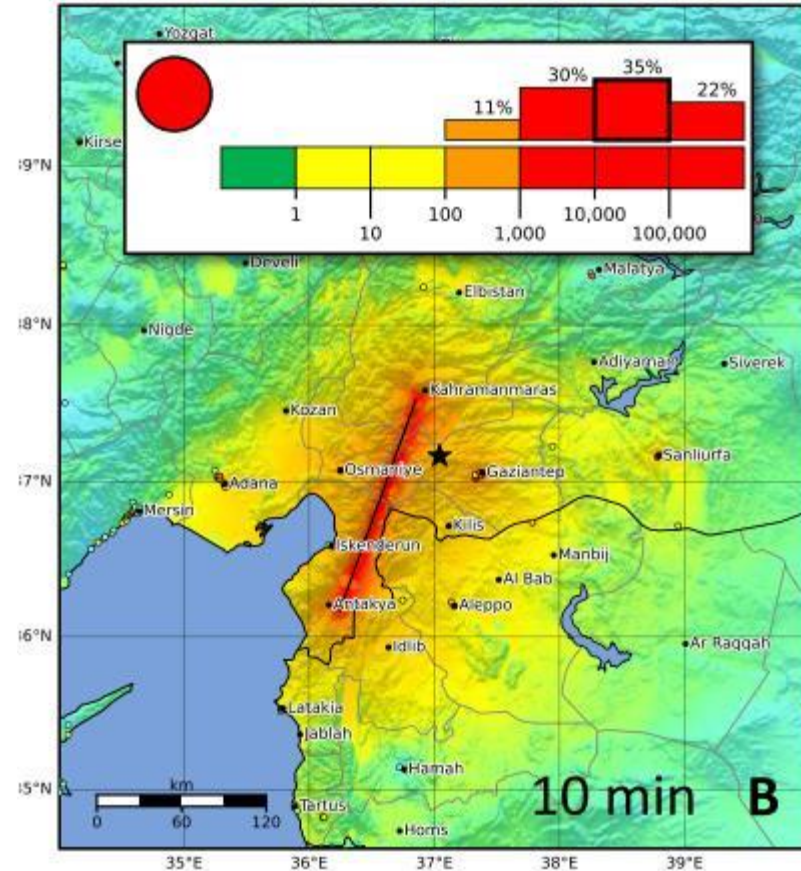
# Fatality estimates: Felt Reports and Finite Fault Model



T0 + 6 days



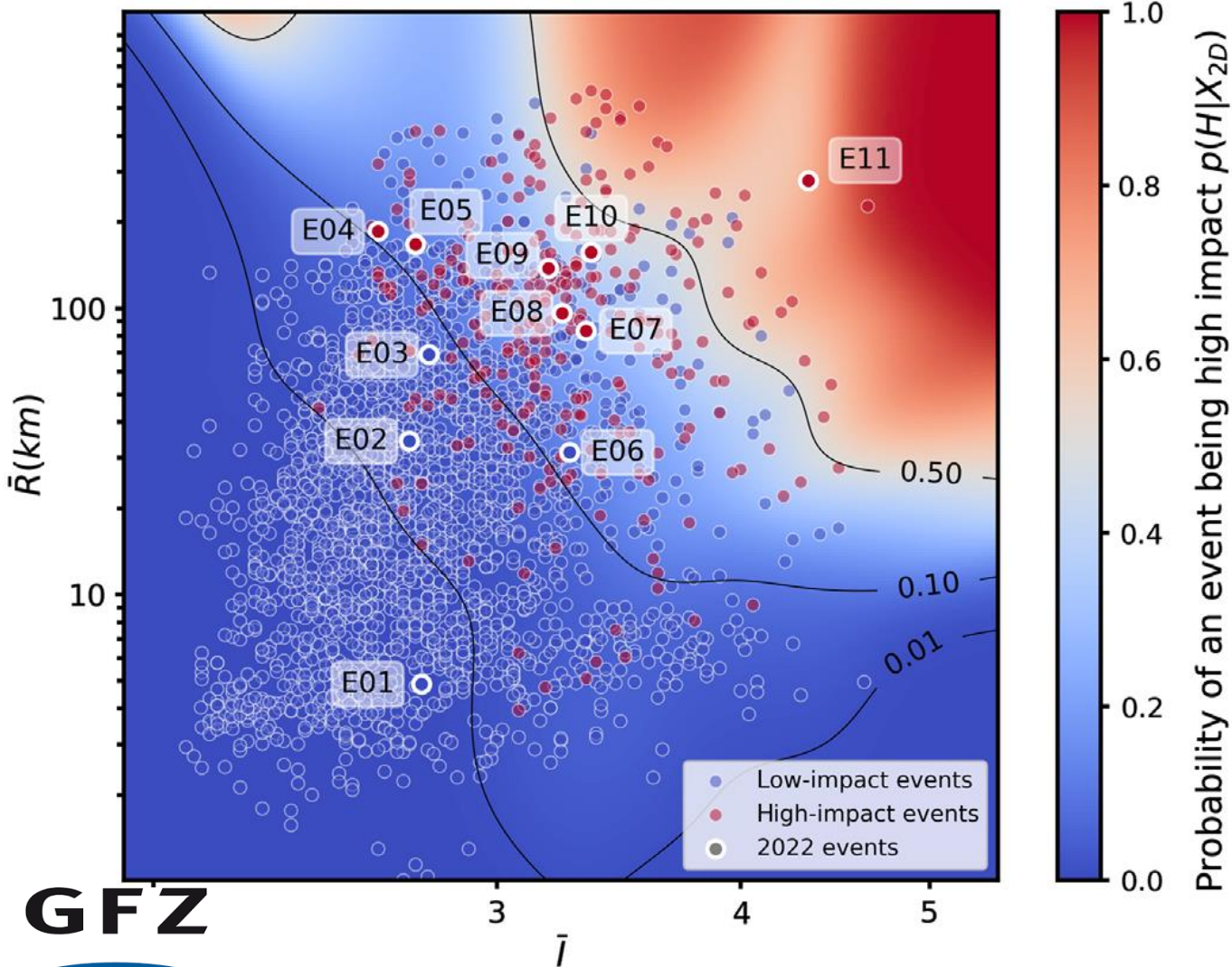
Felt Reports only



Felt Reports + Finite Fault

# Felt Reports to Distinguish High-Impact from Low-Impact Earthquakes

First 10 min of Felt Reports only



Afghanistan M5.9 June 2022

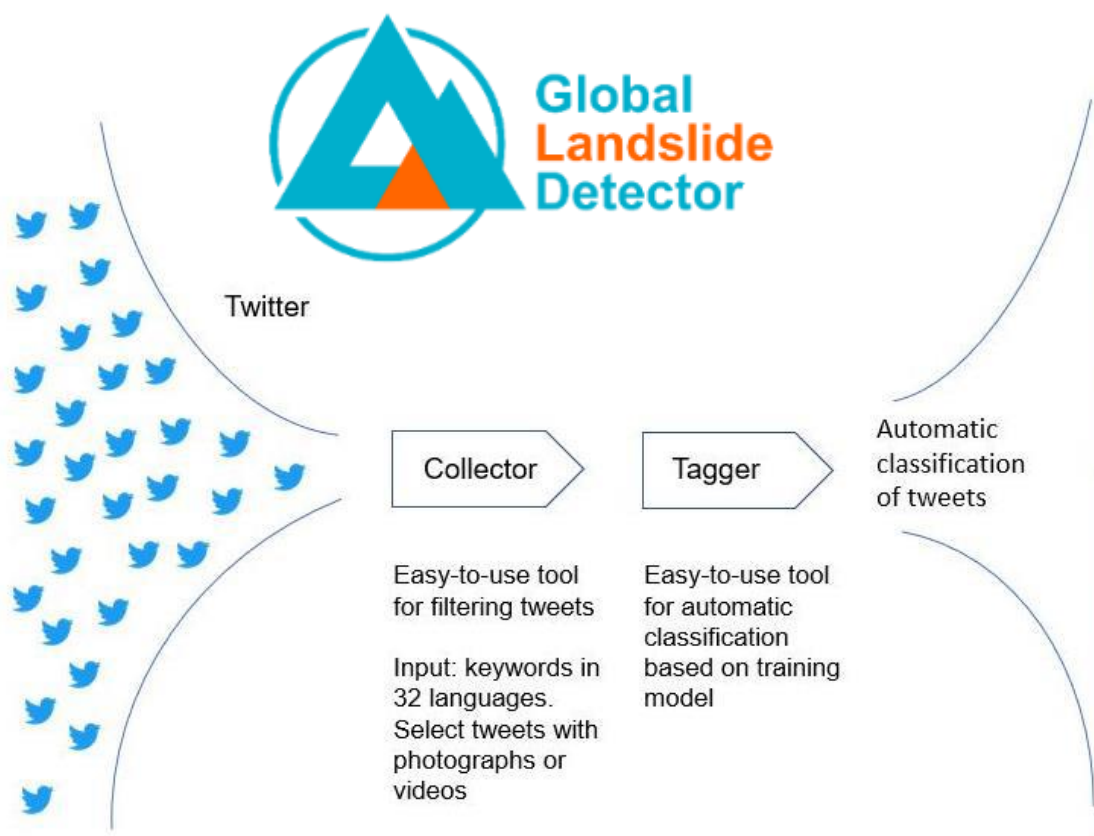
1 150 dead: E10

Japan M7.3 March 2022, 4 dead

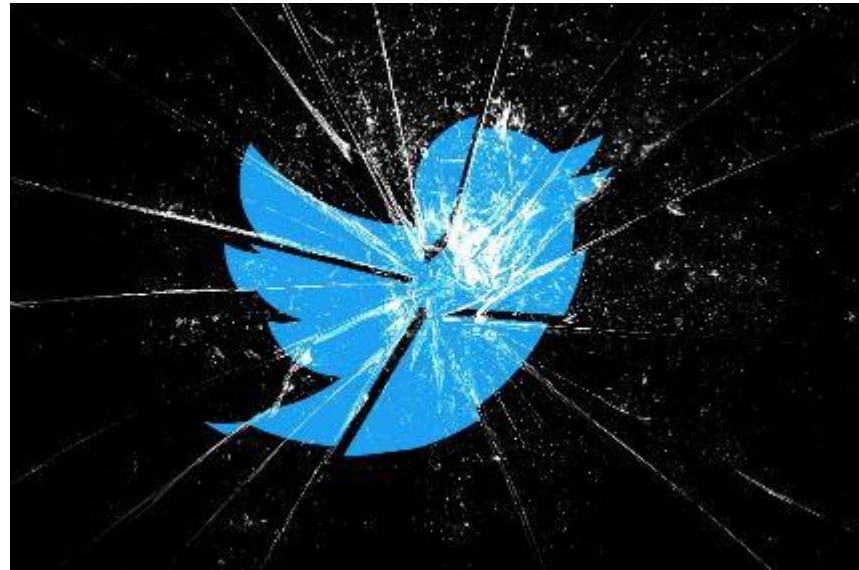
E11



# Goodbye Twitter (?), Hello Telegram and WhatsApp!



T0+12h



## Messaging Apps



QCRI  
معهد قطر لبحوث الحوسبة  
Qatar Computing Research Institute  
جامعة حمد بن خليفة  
HAMAD BIN KHALIFA UNIVERSITY



British Geological Survey



## Eyewitnesses hold the Key for Rapid Earthquake Impact Assessment

- Eyewitnesses hold the data and the tools exist to collect it (social media, websites, messaging apps...)
- Understand & satisfy their evolving needs and habits in return for this data
- No single tool can do it all: crowdsourcing, social media harvesting, AI, statistics...
- Beyond impact: engage with eyewitnesses to improve awareness and preparedness
- LastQuake data included in ARISTOTLE's impact assessments to the ERCC (ECPU)





Thank you for your attention!

- EMSC Team:

- J.M. Cheny, L. Fallou, S. Issartel, M. Landès, J. Roch, F. Roussel, R. Steed, G. Ucciani

- External Collaborators:

- M. Böse & F. Massin (ETHZ), F. Cotton & L. Lilienkamp (GFZ), C. Pennington (BGS), V. Quitoriano & D Wald (USGS), M. Imran, F. Ofli & U. Qazi (QCRI)

- EMSC thanks its members, data contributors and users as well as its sponsor (and welcomes new ones!):



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