

First results from temporary deployment of small seismic network following the Mw=6.4 Petrinja earthquake

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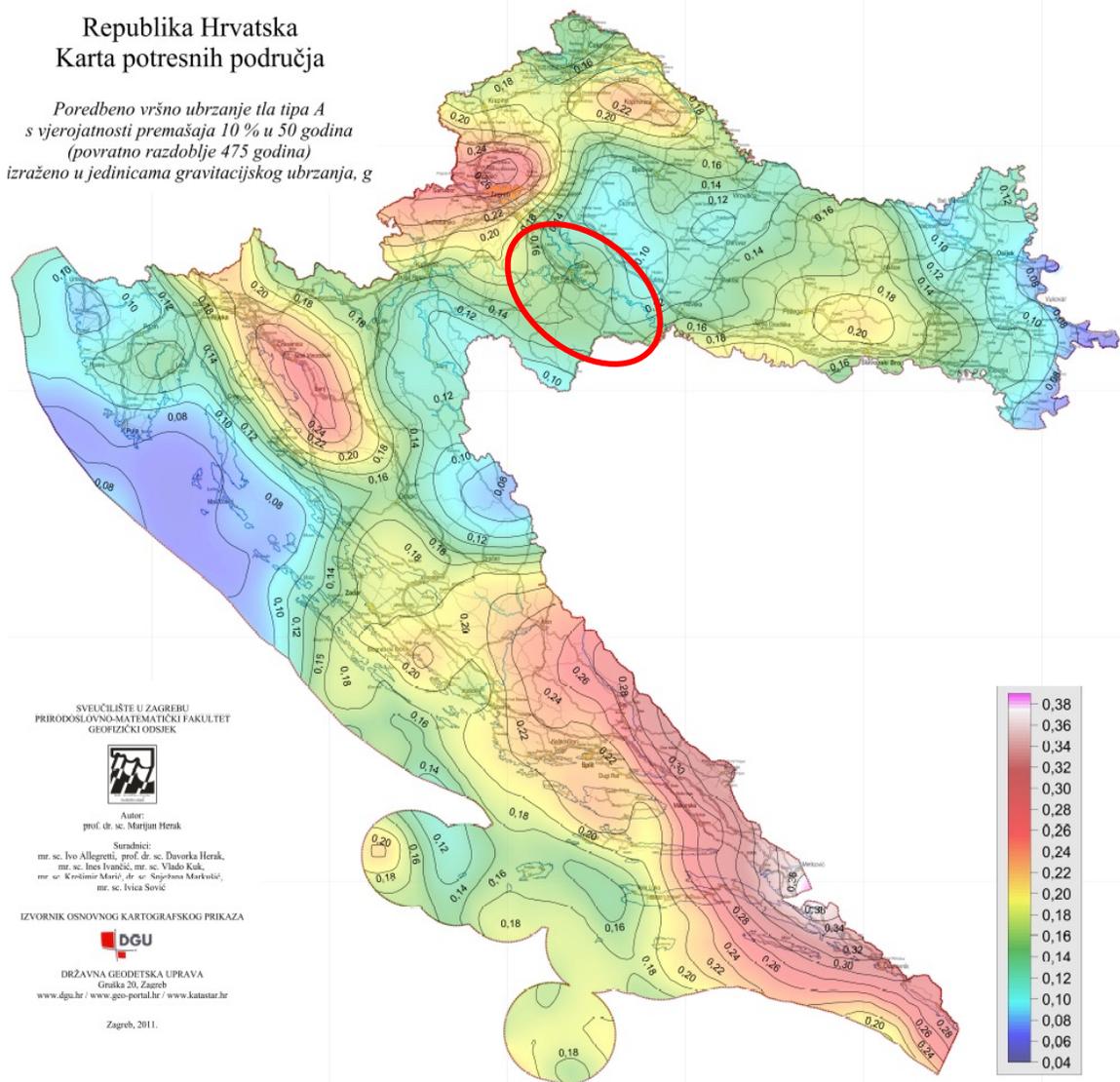
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Seismicity and earthquake hazard in Croatia

Republika Hrvatska
Karta potresnih područja

Poredbeno vršno ubrzanje tla tipa A
s vjerojatnosti premašaja 10 % u 50 godina
(povratno razdoblje 475 godina)
izraženo u jedinicama gravitacijskog ubrzanja, g



SVEUČILIŠTE U ZAGREBU
PRIRODOSLOVNO-MATEMATIČKI FAKULTET
GEOFIZIČKI ODSJEK



Autor:
prof. dr. sc. Mirjan Herak

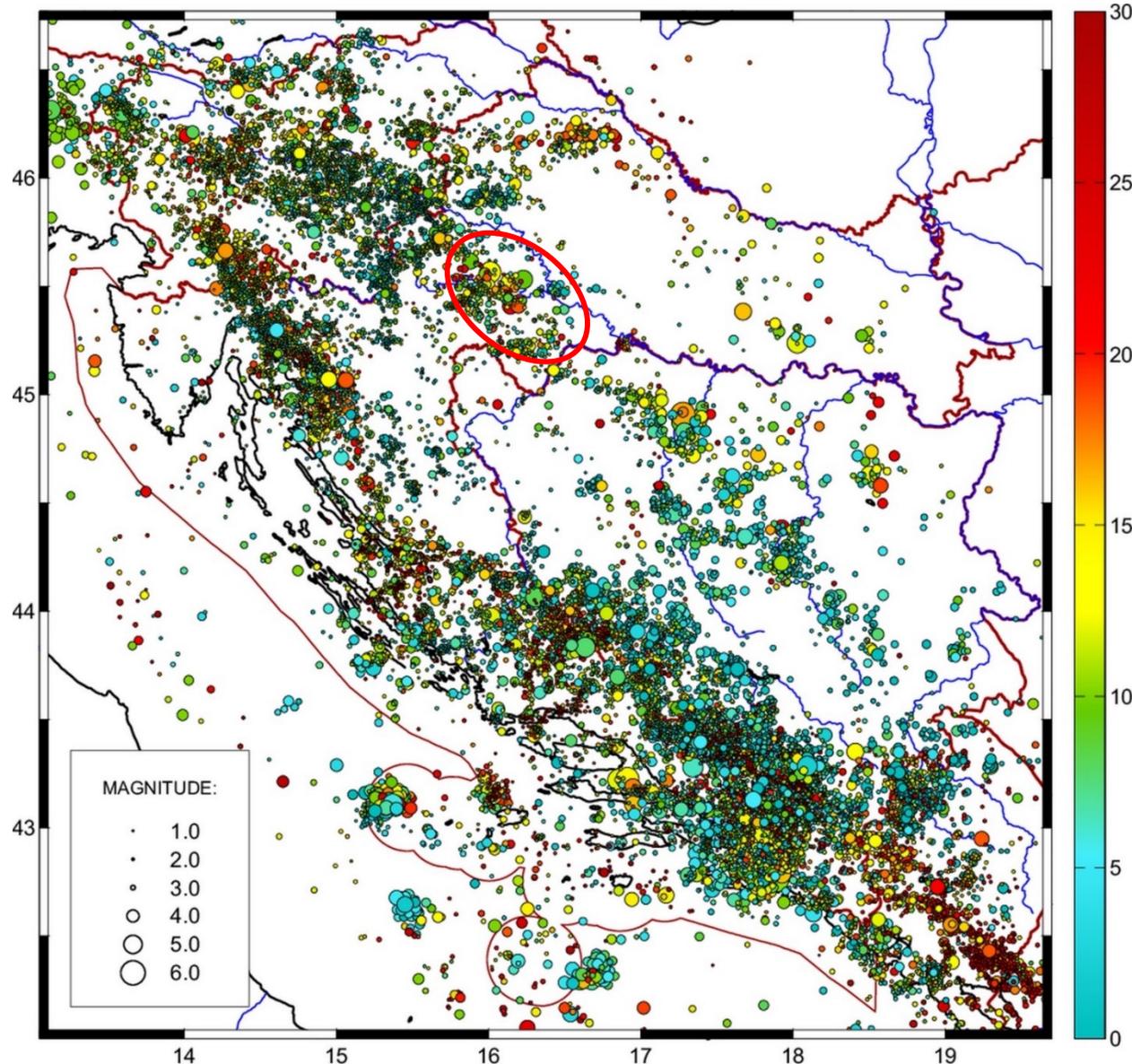
Suradnici:
mr. sc. Ivo Allegretti, prof. dr. sc. Davorka Herak,
mr. sc. Ines Ivančić, mr. sc. Vlado Kuk,
mr. sc. Kresimir Marušić, dr. sc. Katarina Marković,
mr. sc. Ivica Šović

IZVORNIK OSNOVNOG KARTOGRAFSKOG PRIKAZA



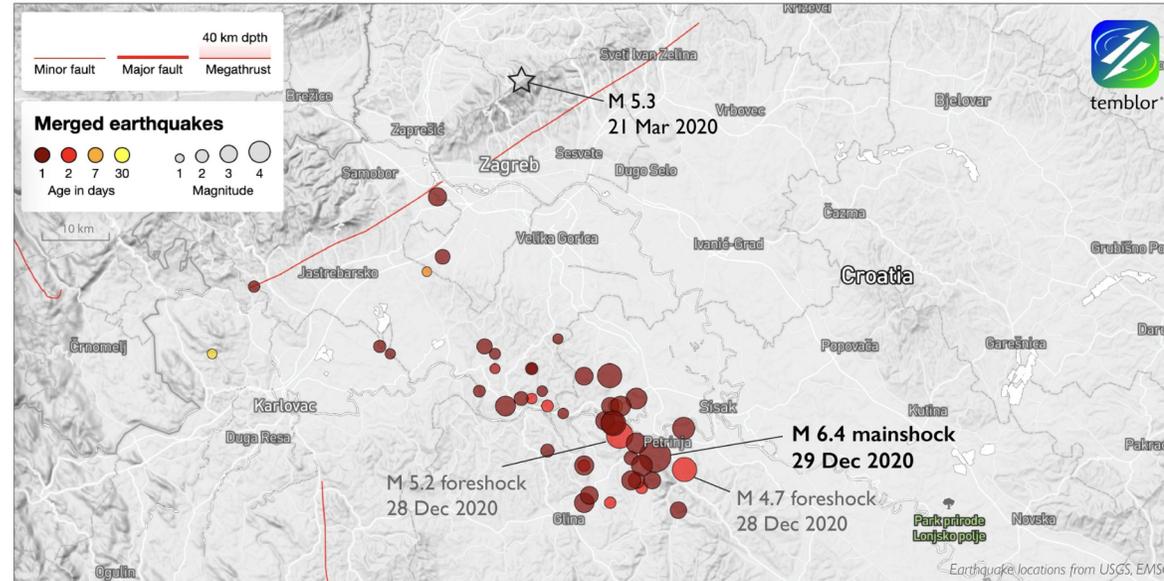
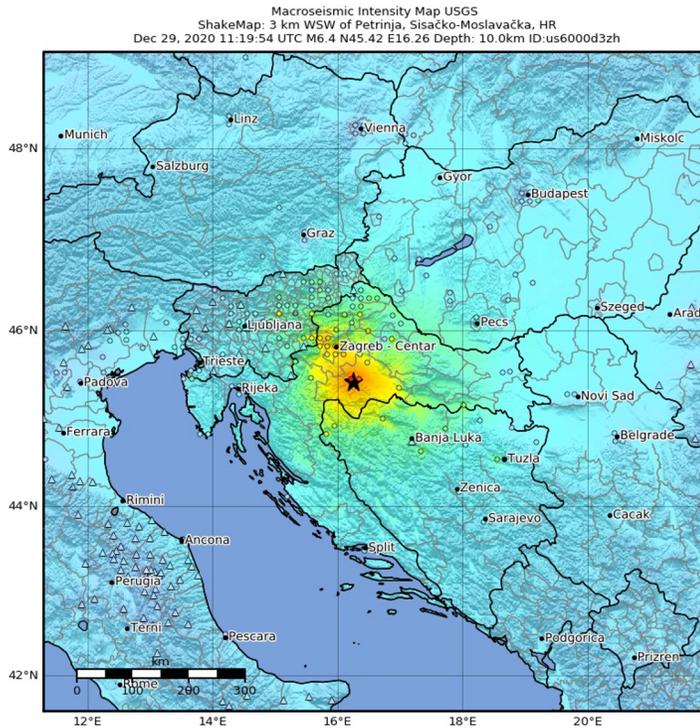
DRŽAVNA GEODETSKA UPRAVA
Grafičar 20, Zagreb
www.dgu.hr / www.geo-portal.hr / www.katstar.hr

Zagreb, 2011.



Petrinja Earthquake – first reports

On 29 December 2020 at 11:19:54 (UTC) Mw 6.4 event stroke the city of Petrinja, about 50 km southeast of the Croatian capital Zagreb, where two other major events (Mw 5.5 and 4.9) also occurred in March of the same year.



From Bijelić, N., Brzev, S., Lazarević, D., 2020, Croatian earthquake causes significant damage, *Tembler*, <http://doi.org/10.32858/temblor.148>

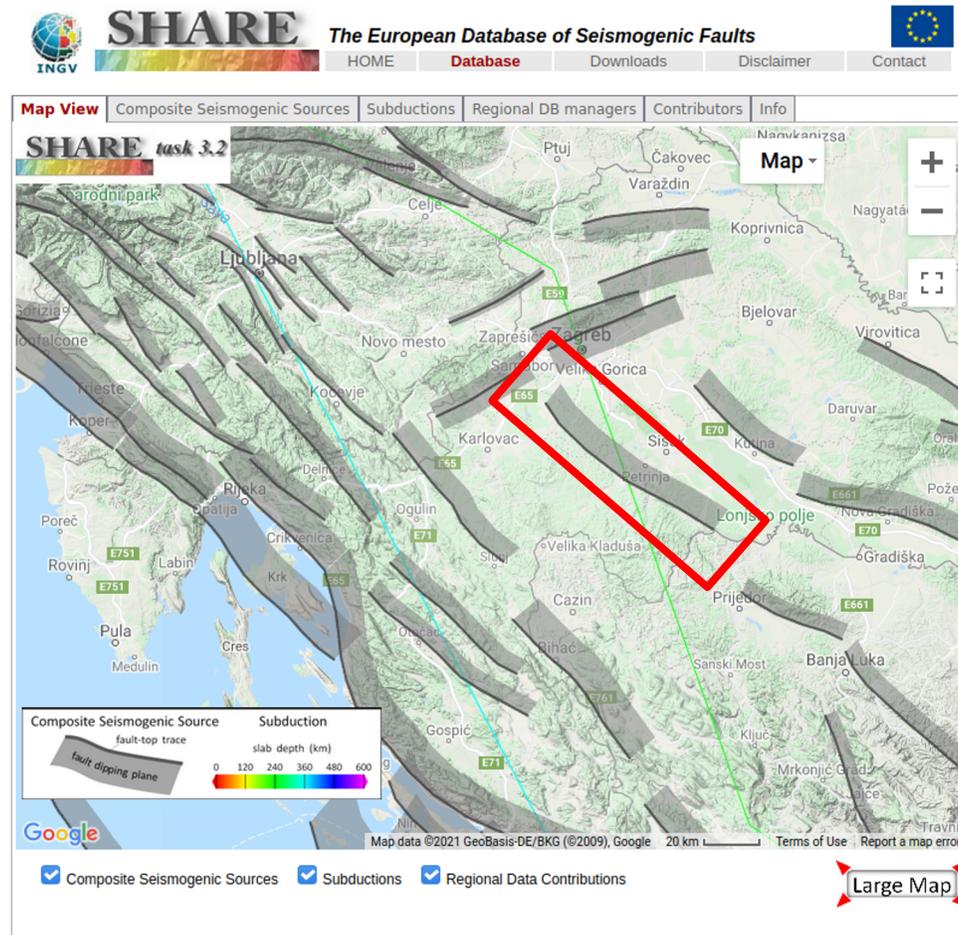
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.0464	0.297	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.0215	0.135	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII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

Scale based on Worden et al. (2012) Version 4: Processed 2020-12-30T11:21:46Z
 △ Seismic Instrument ○ Reported Intensity ★ Epicenter

The day before the main event, two fore-shocks (Mw5.2 and 4.7, respectively at 6:28 and 7:49), were recorded in the area, causing no damage.

Seismotectonics and first reports of the event

The Petrinja sequence is connected to a rather complex transpressional regime related to the development of the External Dinarides, with reverse faults to the north and strike-slip faults in the middle of the country.



The Mw6.4 mainshock occurred on a right-lateral strike-slip fault oriented roughly NW-SE named Pokupsko/Petrinja Fault (technically a composite fault).

The rupture is shallow, and probably extends for a length of 15-25km and depth of around 10km.

The rupture apparently did not reach the surface.

Earthquake Impact

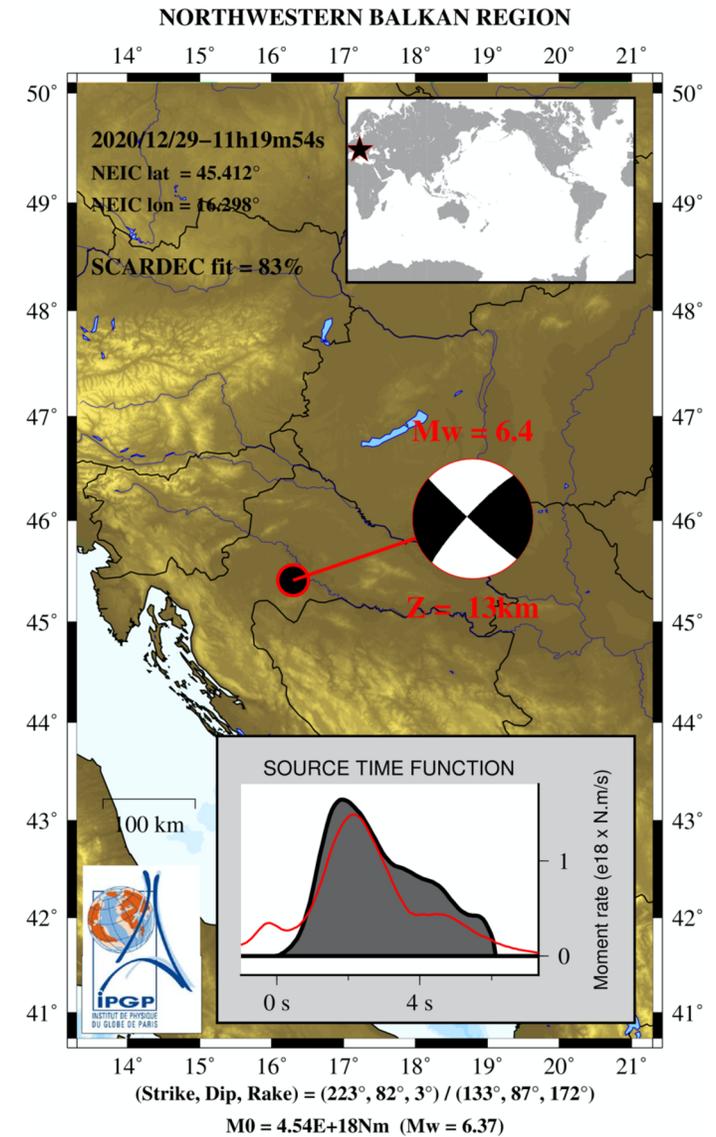
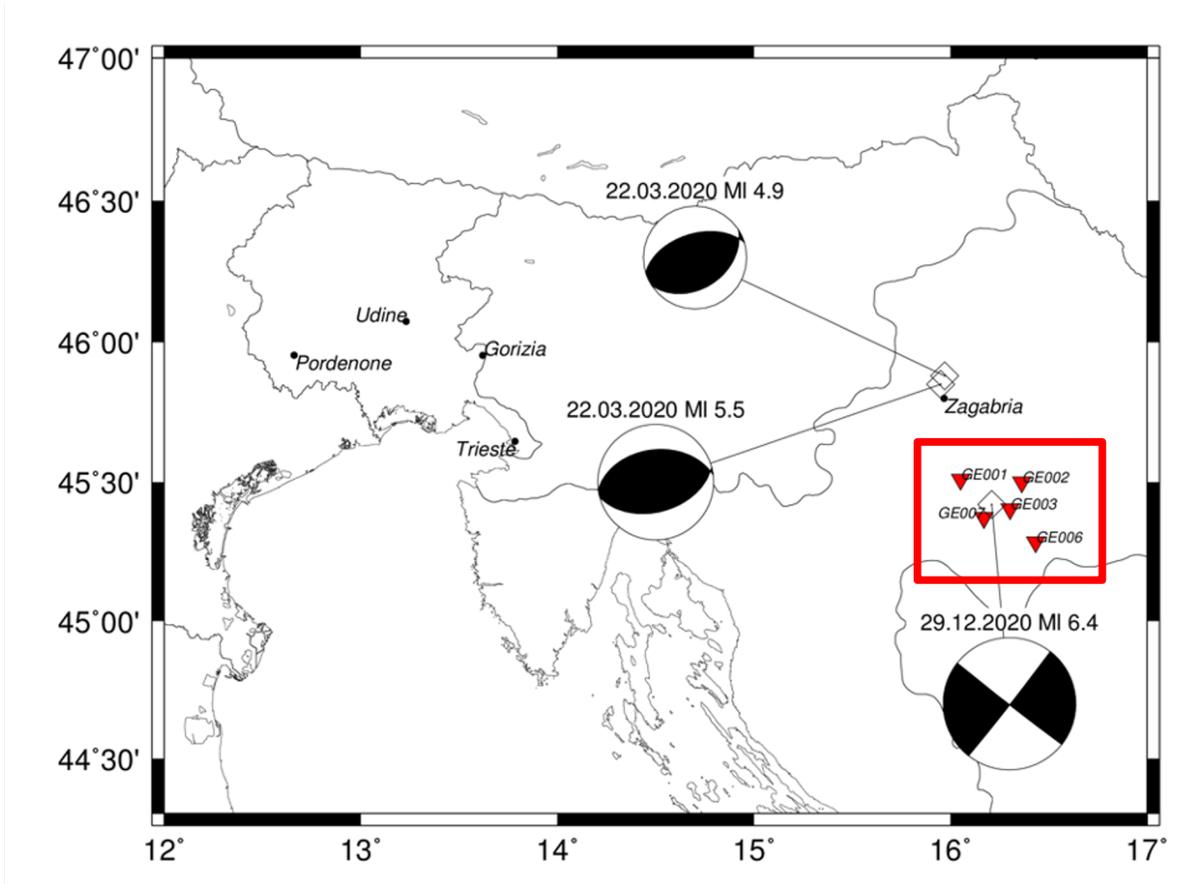
The Petrinja earthquake is one of the largest earthquake to hit Croatia since instrumental recording began. It caused 7 victims and about 20 injuries (far less than the 1976 Friuli earthquake, of comparable magnitude MI 6.5, but causing more then 900 victims).

Damage was nonetheless widespread, up to 100km away, due to the high vulnerability of the area, primarily consisting of unreinforced masonry structures.



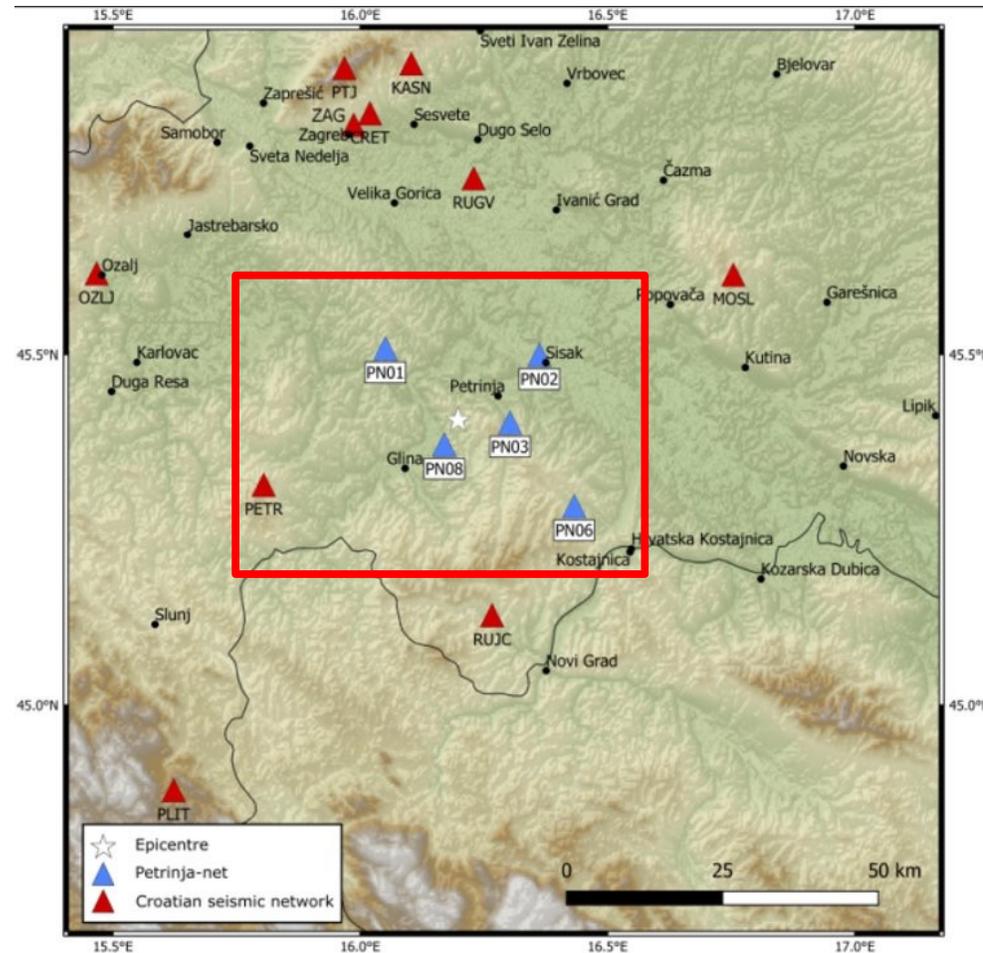
Moment Tensor Solution

The moment tensor solutions of the mainshock indicate NW-SE strike-slip faulting in agreement with the regional tectonics.



The small seismic network (rapid?) deployment

Following the 6.4 event, the Geophysical Department of the University of Zagreb has organized a post-event support survey in collaboration with the Seismological Research Centre of OGS.



Five low-cost seismic stations has been installed in locations surrounding the epicentral area.

Additional BB seismic station has been deployed at Petrova Gora (PETR) location east of the epicentral area.

Goal was to characterize the evolution of the earthquake sequence and to obtain strong motion recordings in near field.

Stations were installed on 4th and 5th of January in the midst of covid epidemics restrictions.

Seismic Stations

Each station consisted of a Lunitek Sentinel GEO instrument, equipped with a short period triaxial velocimeter and a MEMS accelerometer.

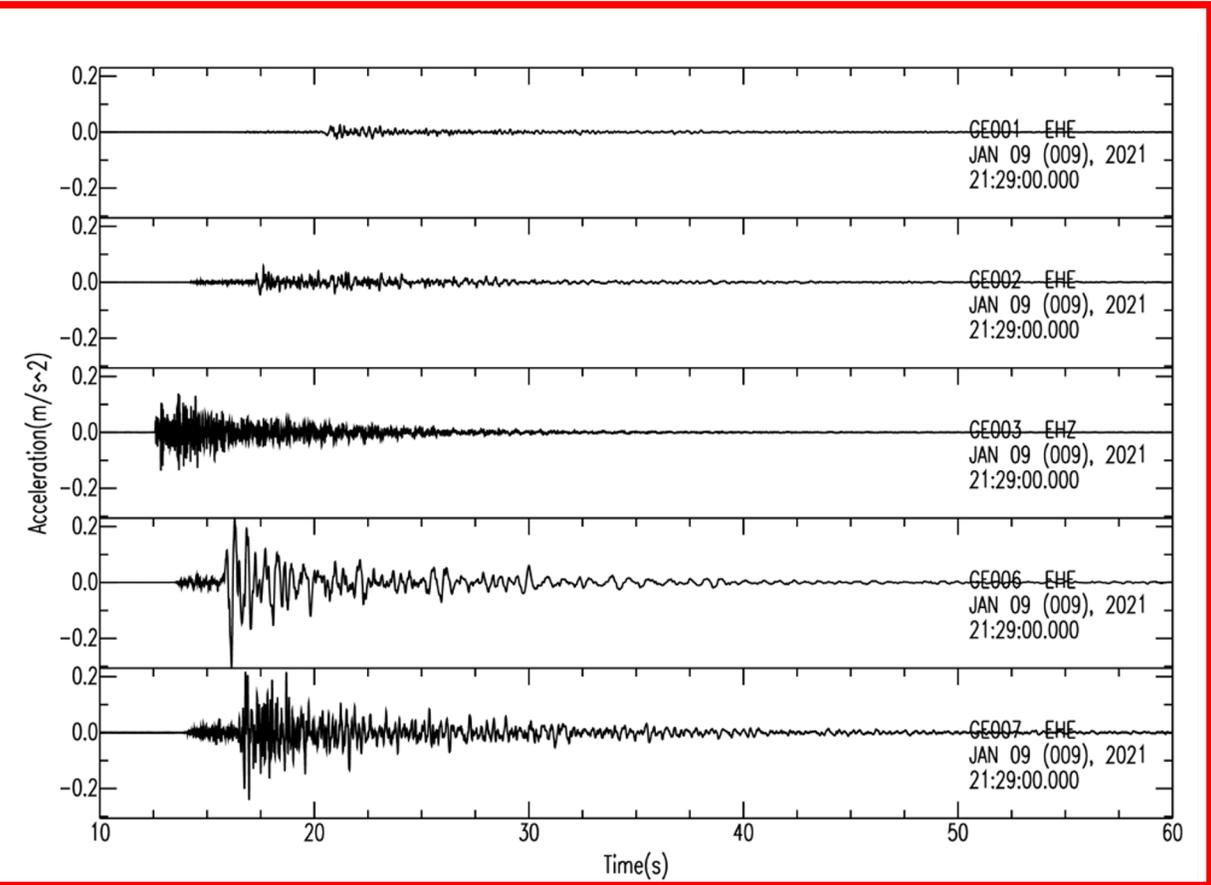
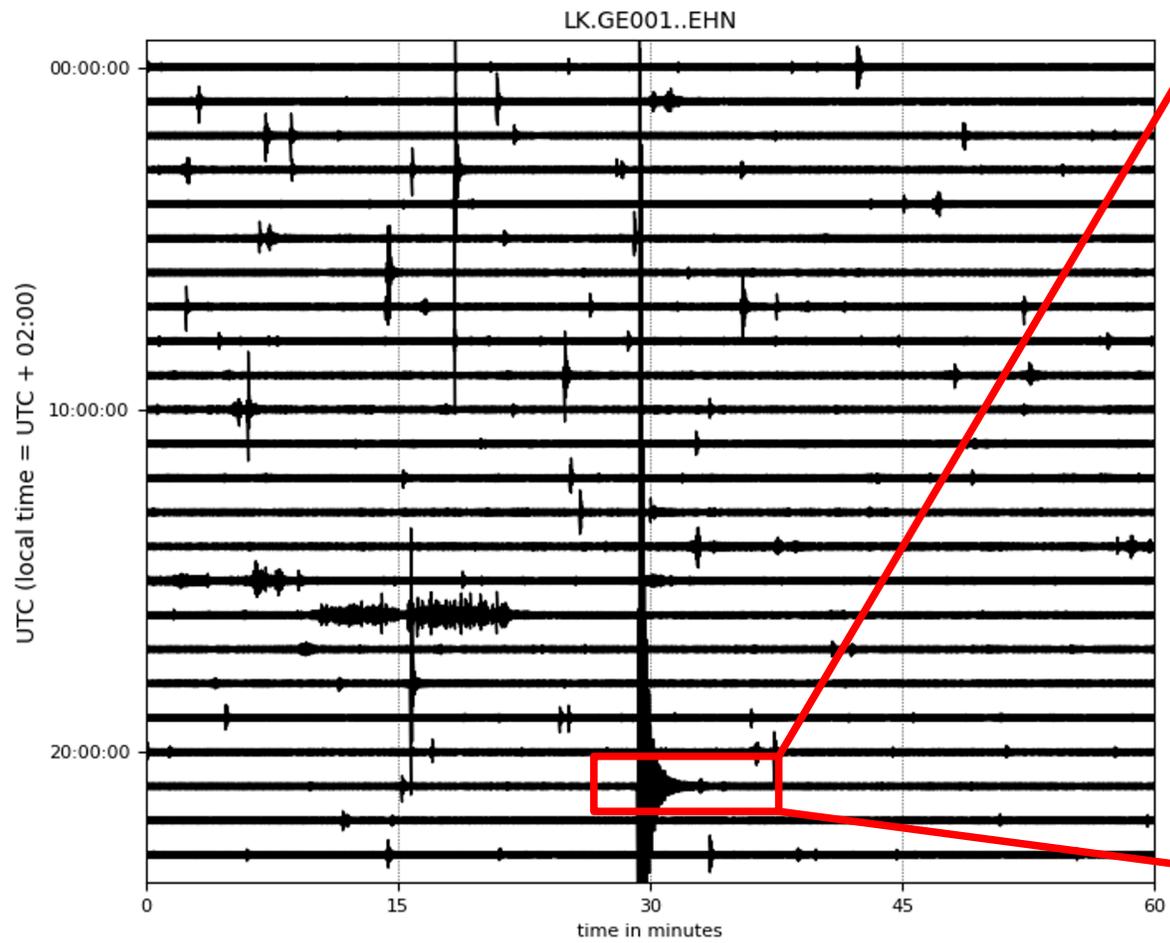
Station characteristics:

- Integrated velocimetric sensor (4.5Hz Geophones, passive)
- Integrated MEMS accelerometer
- Adc resolution 24 bit; Dynamic range > 136dB @100 sps
- Sampling rates 1, 20, 25, 50, 100, 200, 250, 500, 1000 sps
- Built-in GNSS receiver, Synchronous sampling
- Lan, Wi-fi connectivity
- Miniseed local storage (3 weeks) / Internal Seedlink server
- Built-in battery

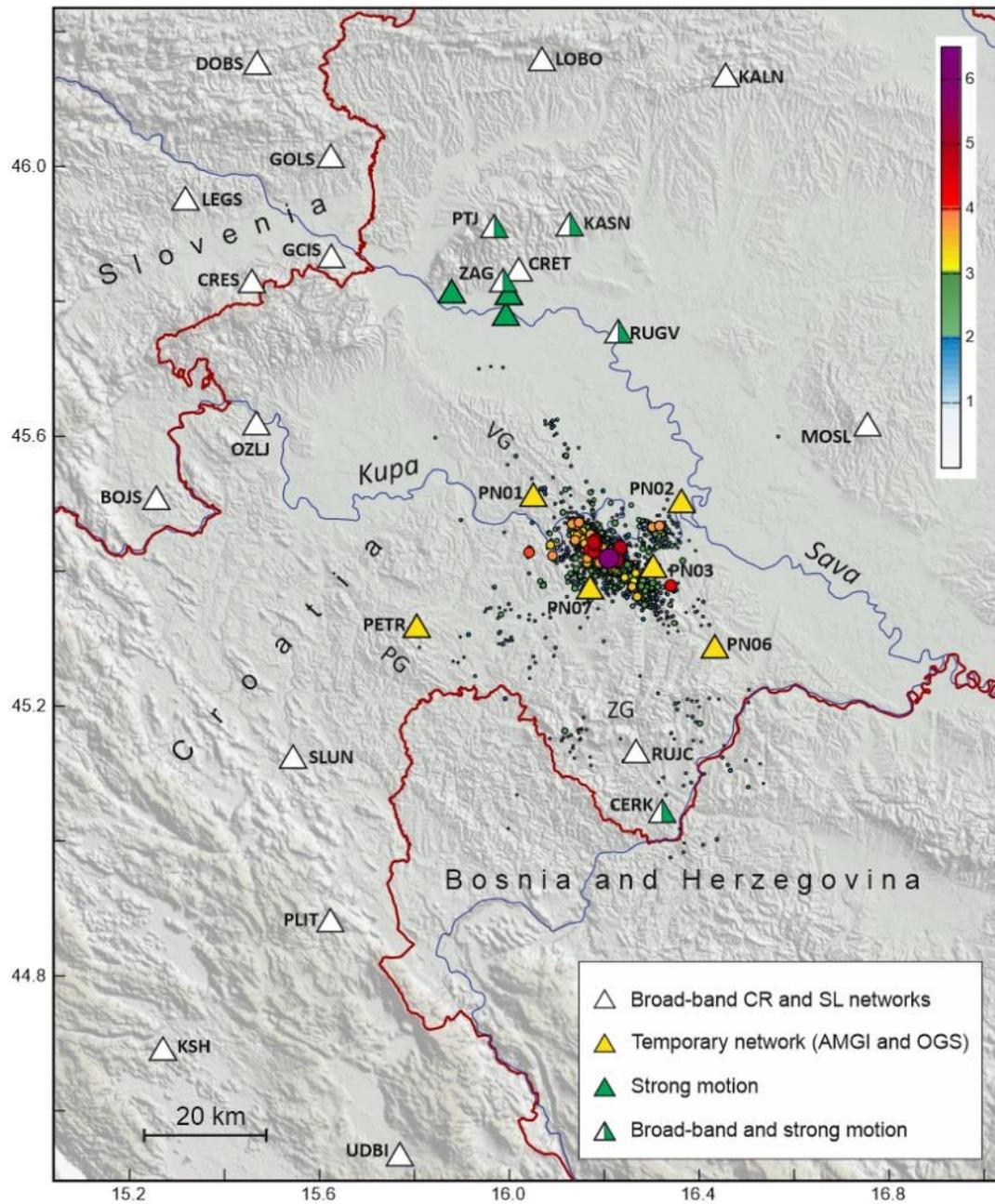


Example of recording

The five stations are presently recording continuously since the 5th of January.

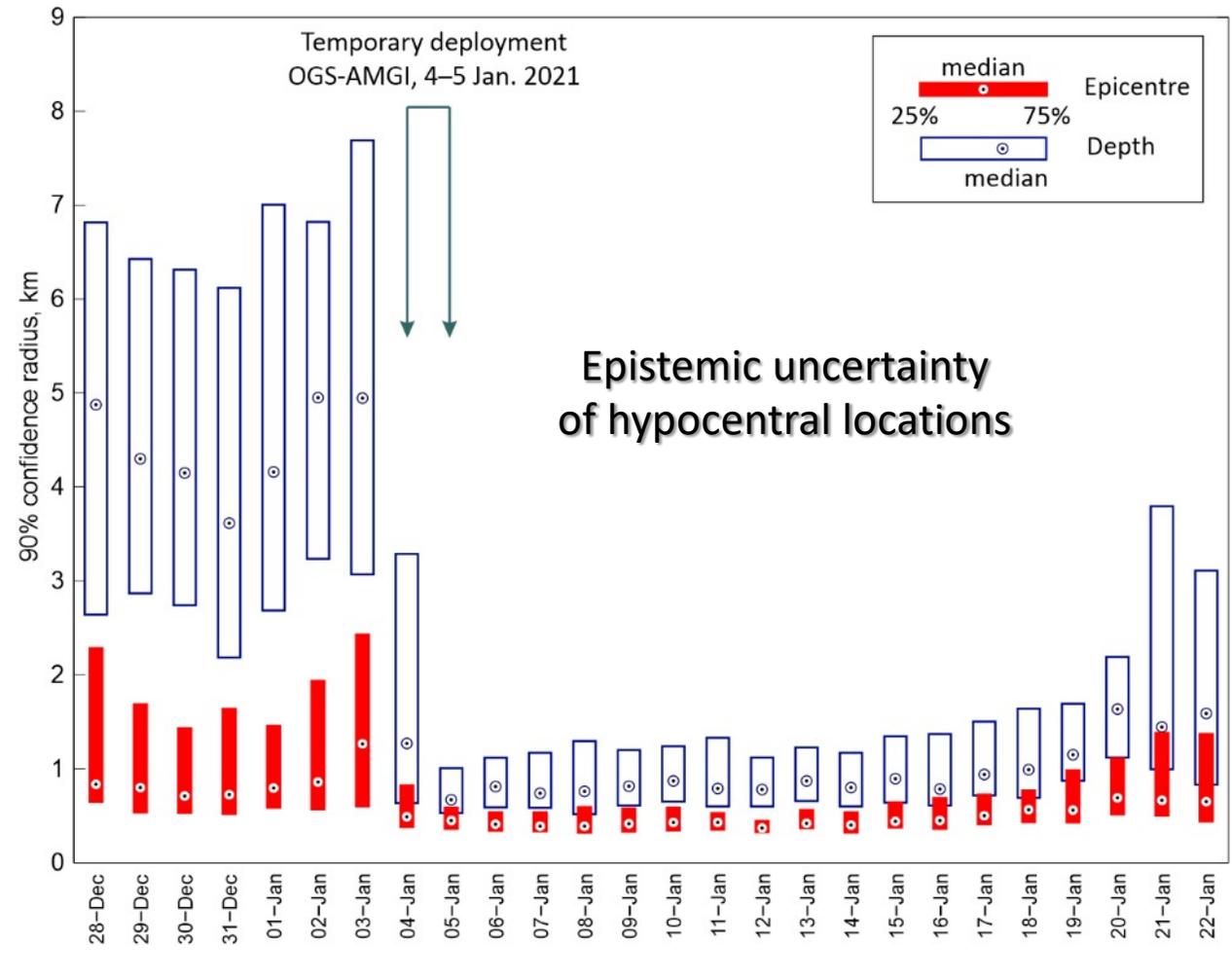


Event ML 4.7 recorded at the five stations



Temporary network (4 January 2021 – 21 April 2021):

National Institute of Oceanography and Applied Geophysics – OGS and Andrija Mohorovičić Geophysical Institute (AMGI, Zagreb)

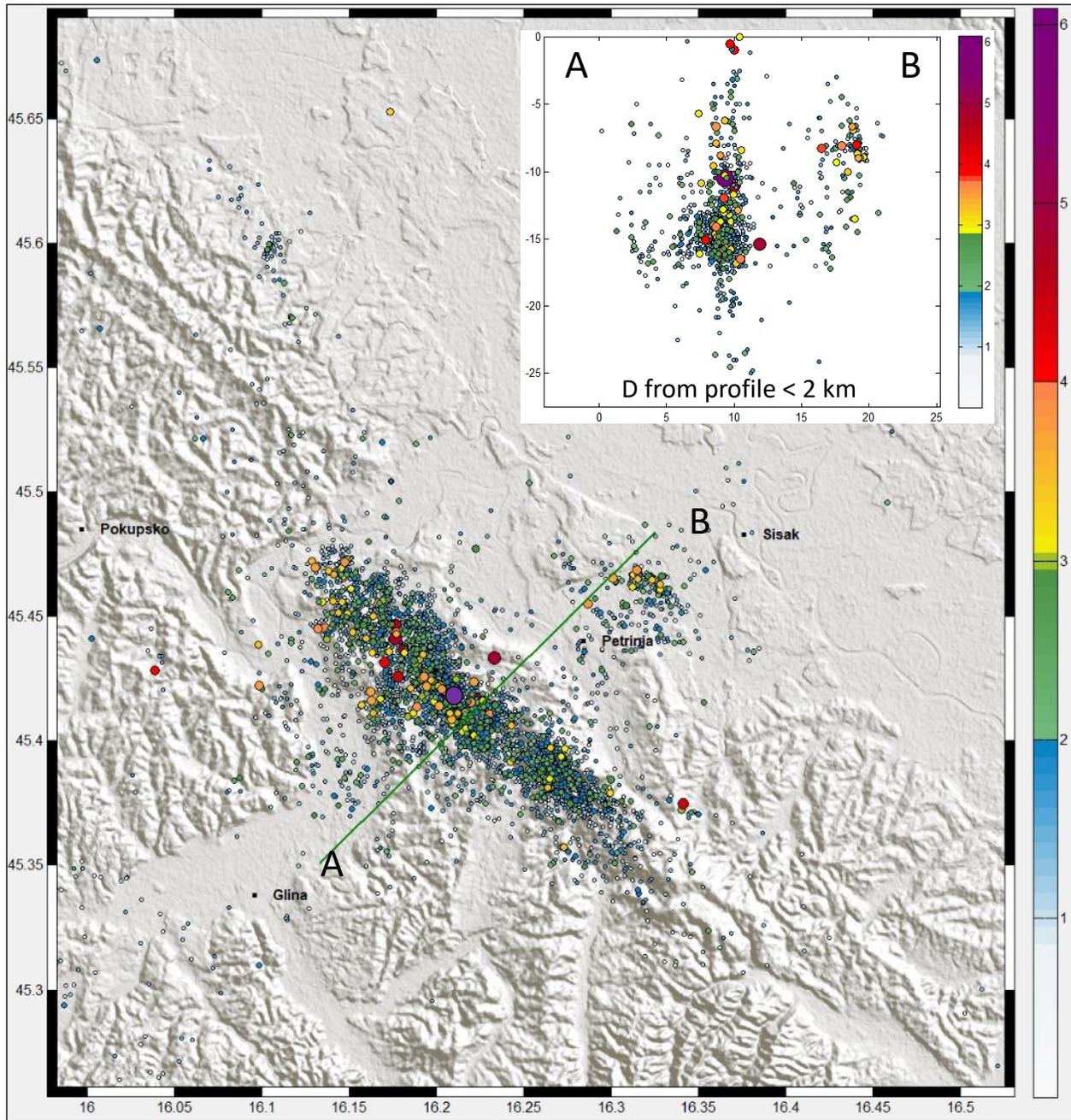


28 December 2020–22 February 2021

Number of located events: 4301

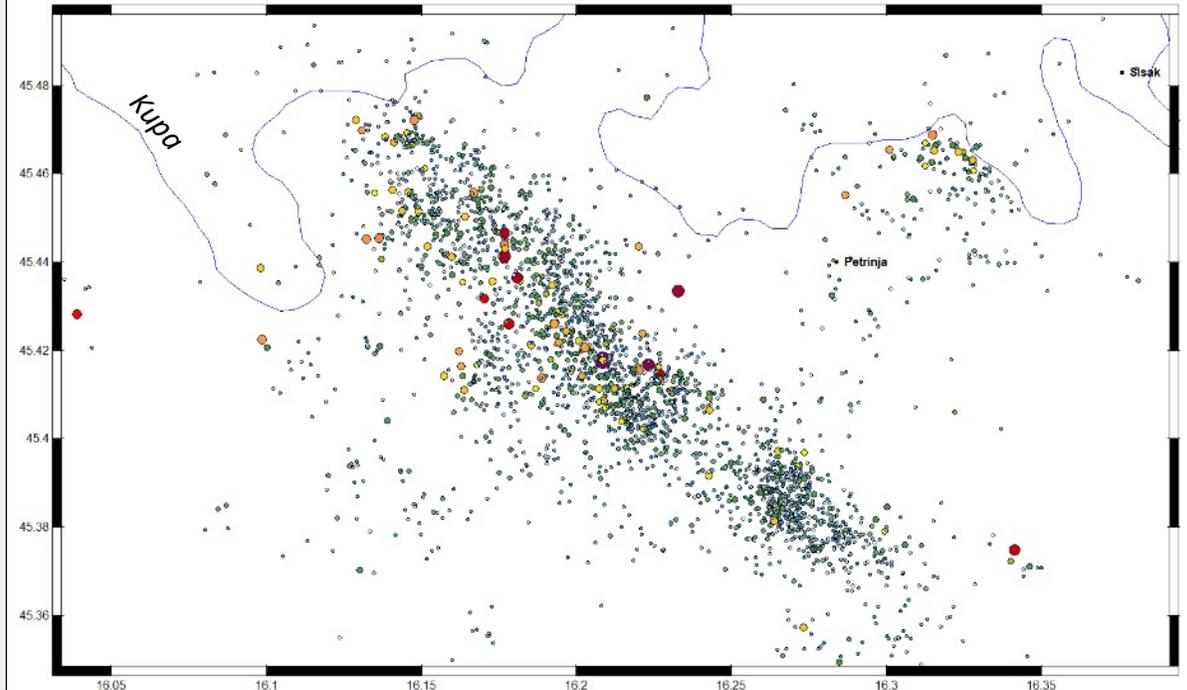
Completeness: $M \geq 1.5$

81759 hand-picked phases!



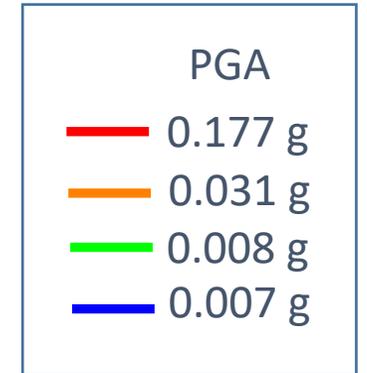
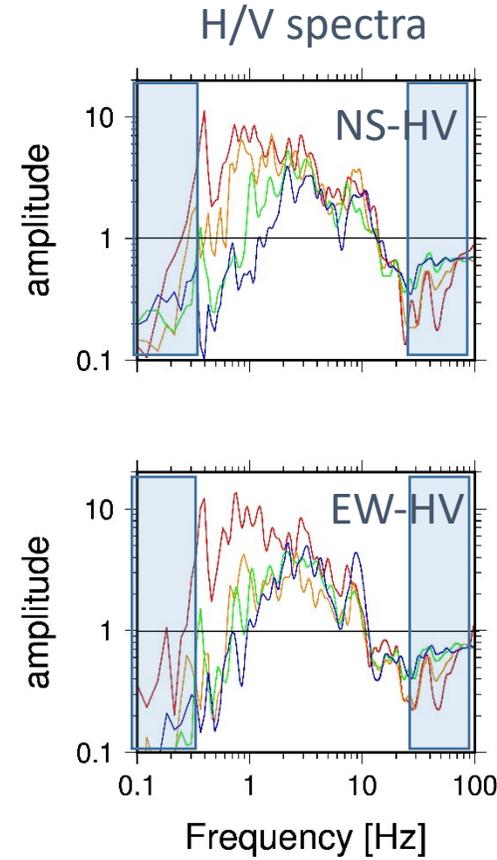
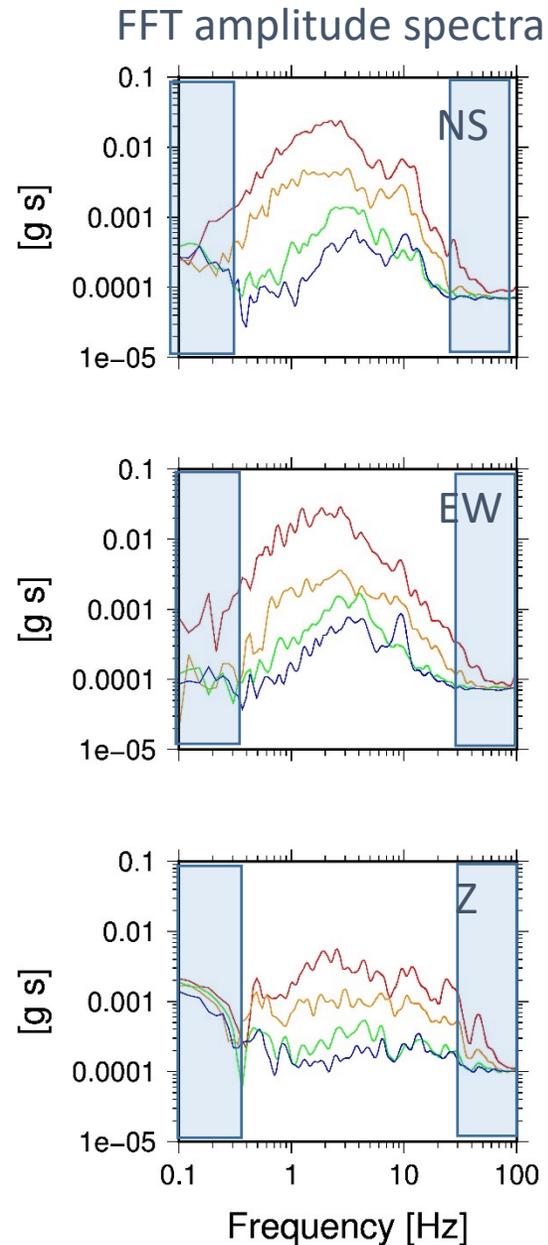
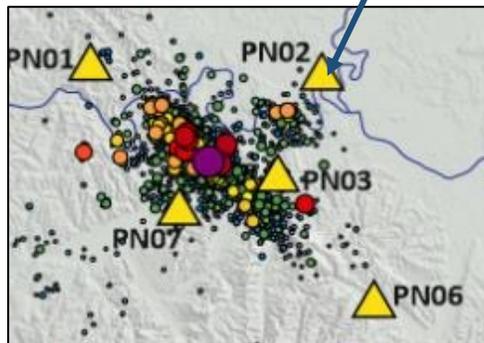
1958 best located events:

$N_{\text{phases}} \geq 12$; Focus confidence radius < 2 km; Azimuthal gap < 125°



Station PN2

PN2, Sisak, aluvial deposits



Main spectral features do not depend on the level of shaking!

After the earthquake...

The People

- The community is slowly healing the wounds and rebuilding
- Lot of help from all around the world was sent to the earthquake hit region

The Science

- European seismological and geological communities have shown similar open hands in helping the Croatian colleagues
- Currently a lot of research is being conducted on the topic of Petrinja earthquake and lot of new results are coming
- Without collaboration between Department of Geophysics and OGS lot of invaluable measurements would have been missed
- New investment in Croatian seismological infrastructure – let's hope it materializes