EGU General Assembly 2022
SM1.1: EGU22-9062

TE-DISSA

Investigating Vrancea intermediate-depth seismic activity in Romania using automatic waveform processing methods

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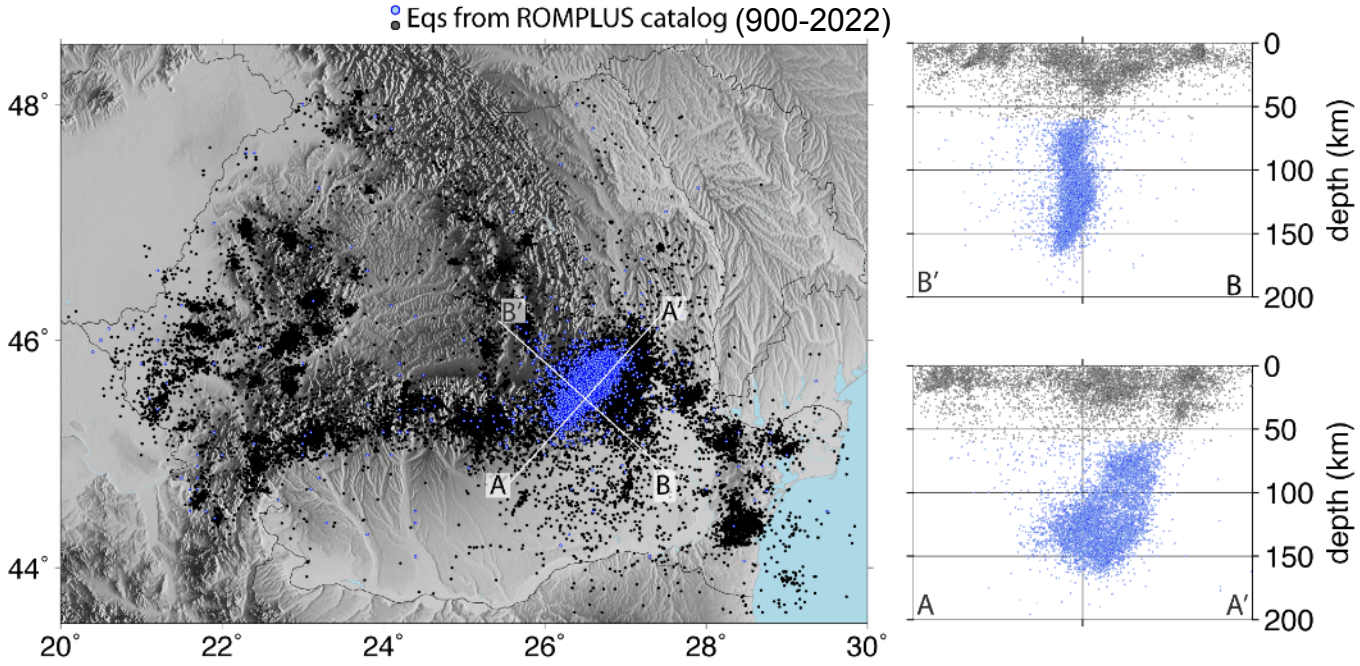
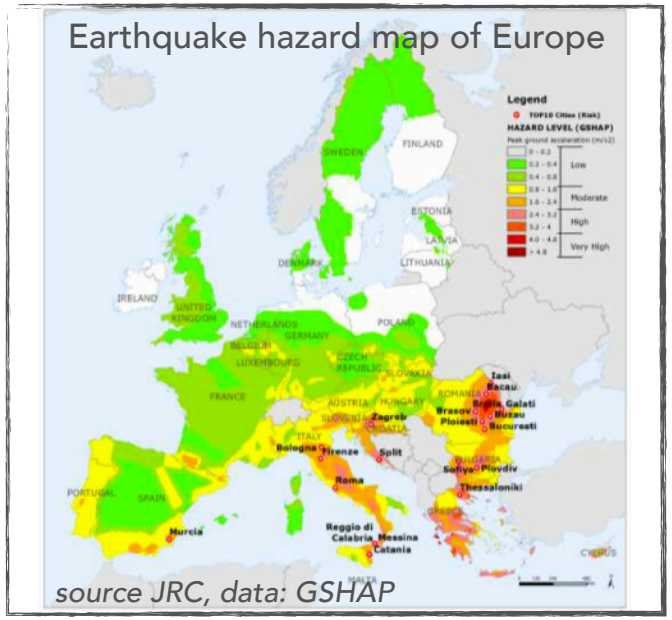
INFP

International Seismological Centre

1. Introduction: Seismic activity in Romania

Vrancea seismic zone: main source of seismic hazard in Romania

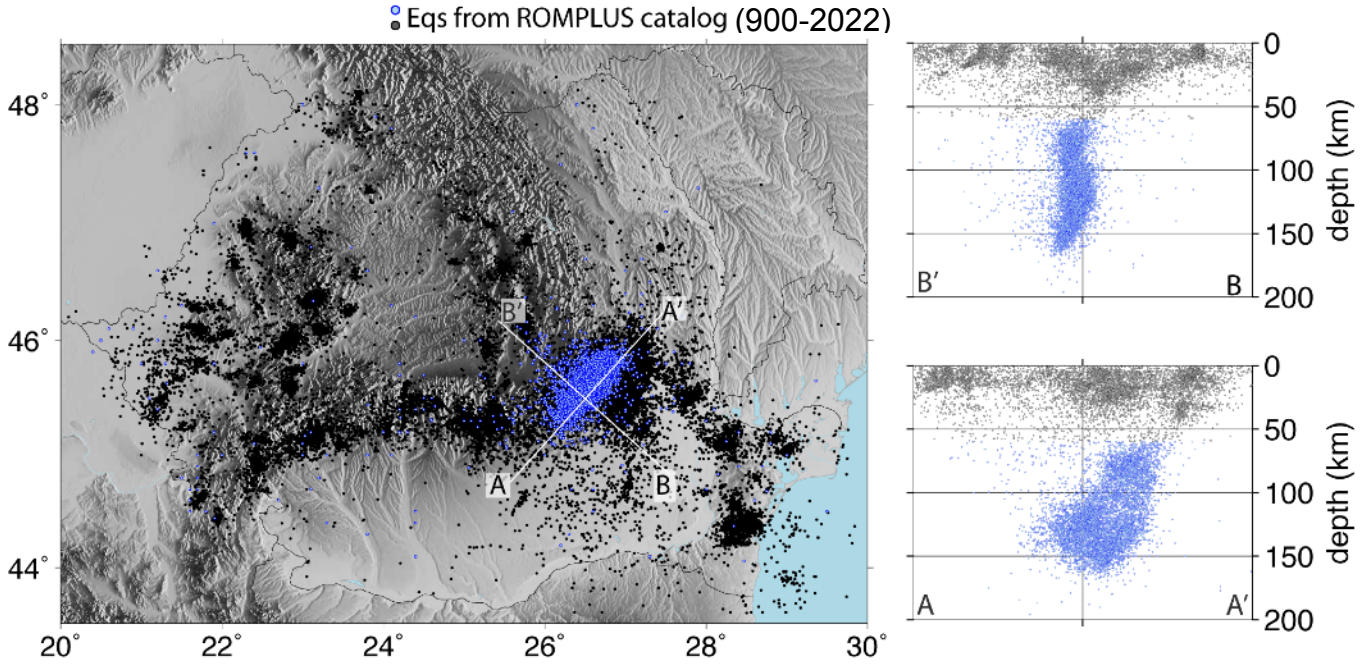


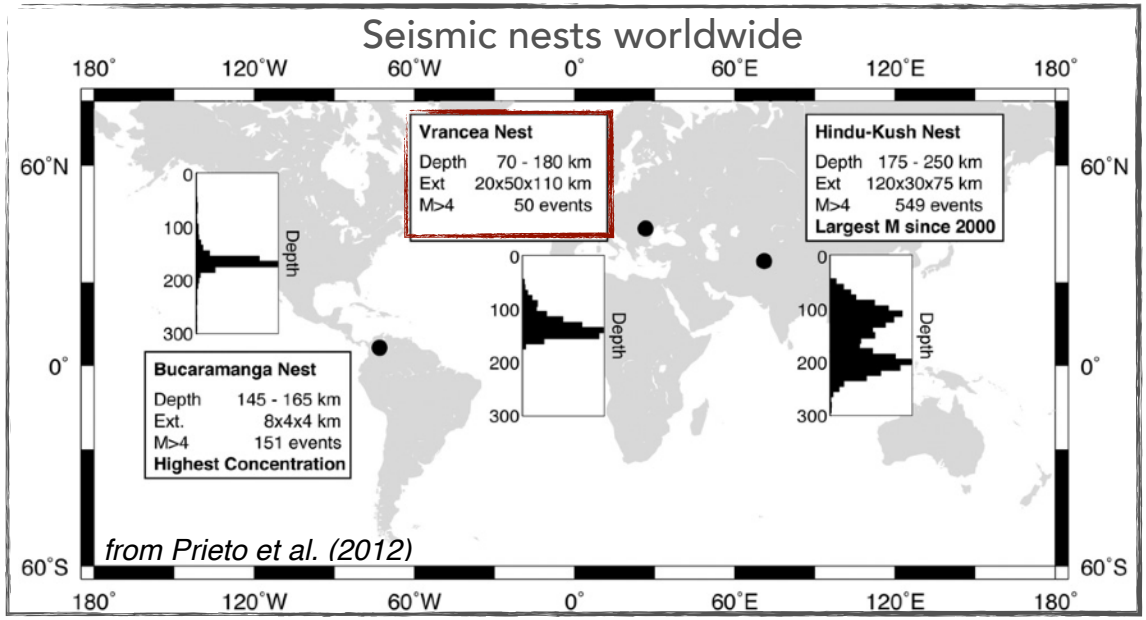


- Accounts for 90% of seismic energy released in Romania
- Important source of seismic hazard in Europe
- Recent large, damaging earthquakes - 1940 (Mw 7.7) and 1977 (Mw 7.4)
- Intermediate-depth seismicity constrained to compact volume
- Characteristics of *seismic nest*

1. Introduction: Seismic activity in Romania

Vrancea seismic zone and earthquake nests world wide

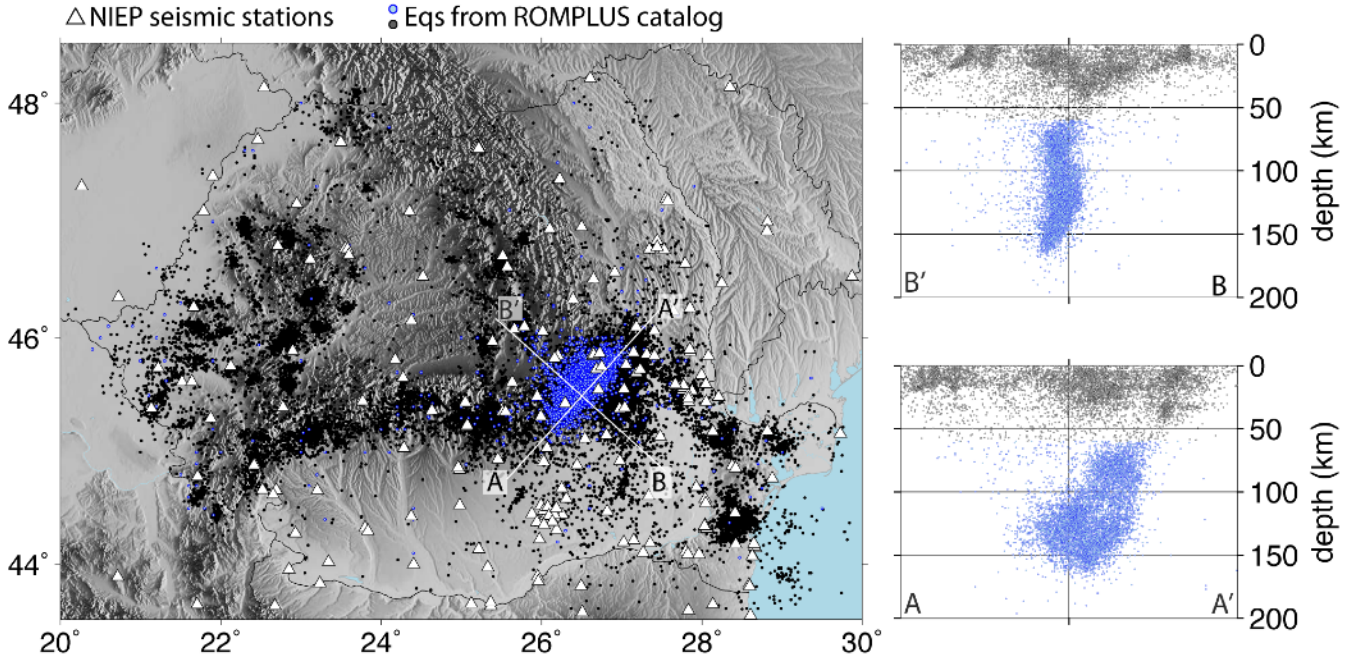




- One of 3 well-known seismic nests worldwide
- Seismic activity rates - high and persistent
- Not well understood seismic environment
- Detailed analysis is important for understanding physical mechanisms behind intermediate-depth earthquakes

1. Introduction: Romanian Seismic Network (RSN)

Modern Digital Seismic network of Romania



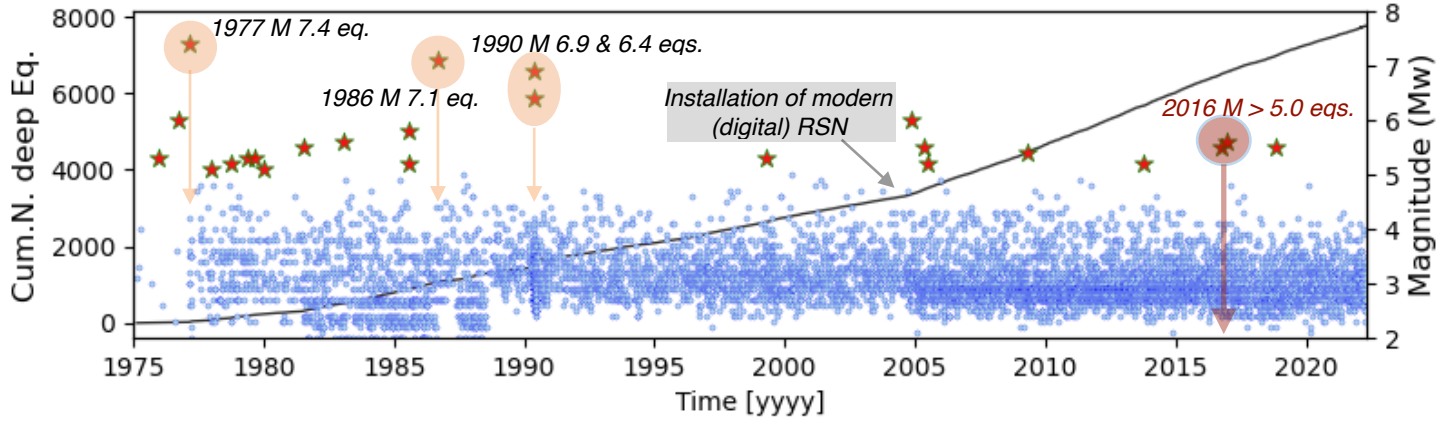
- Good case study for intermediate-depth seismic nests
- Allows developing and testing new methods for earthquake detection an characterisation
- Can provide tools for constrains on physics of earthquake rupture and initiation

~140 stations (3-component)

Operational since 2000-2004

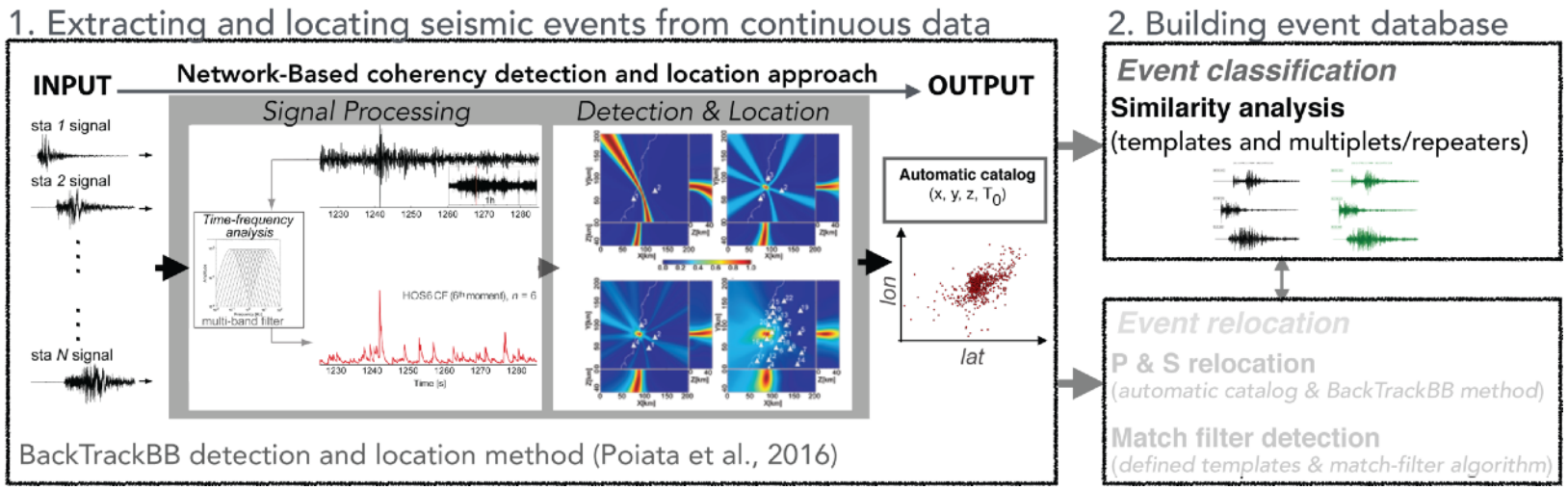
Continuous waveforms stored at NIEP data centre

Significant volume of high-quality seismic data



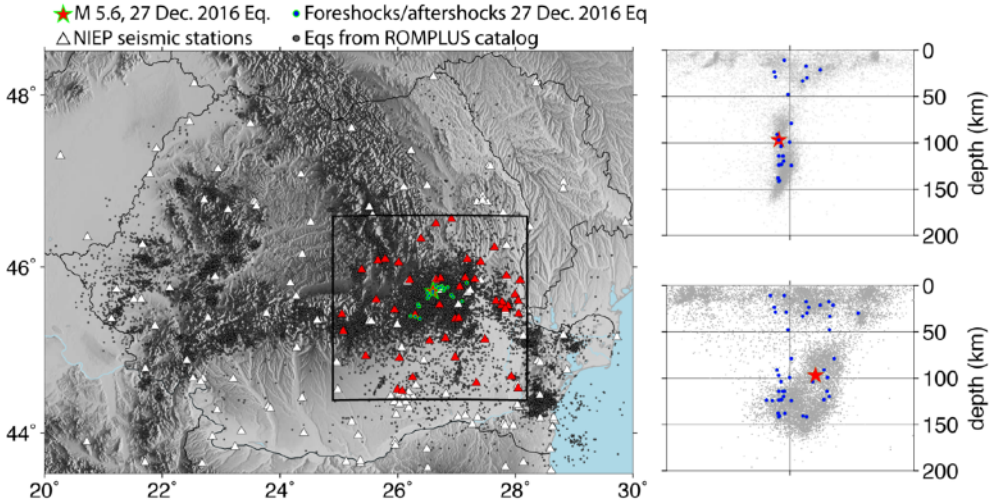
2. Methodology and targeted data

Automatic full waveform analysis: coherent detection and location + template-based search



- Combination of modern full-waveform approaches
- Improved detection and location through coherence-based method - BackTrackBB
- Event characterisation through waveform similarity analysis

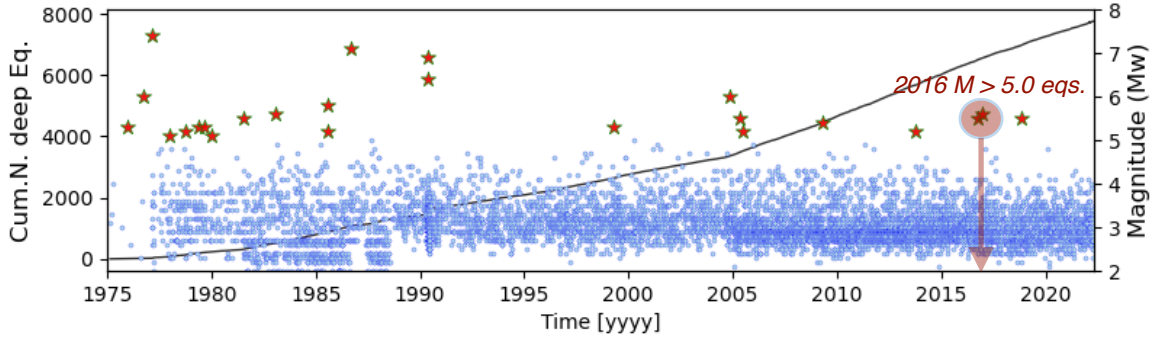
Data: 2016 M >5.0 earthquakes



Main goal: improve understanding of Vrancea seismic activity through extensive seismic data analysis

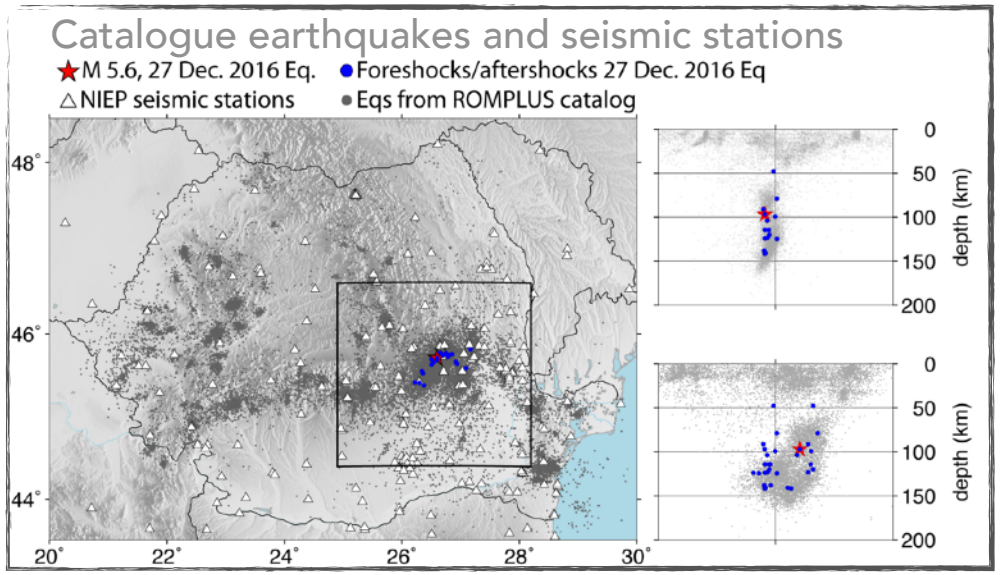
Targeted time period: recent (2016), Mw 5.5 and 5.6 earthquakes

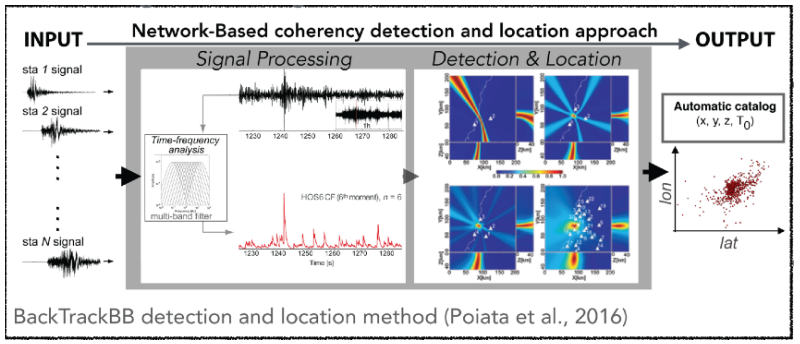
Seismic data: 3-C (continuous) recordings from RSN seismic stations



3.1 Detection and location of earthquakes from Vrancea zone

Automatic detection and location with network-based coherence method



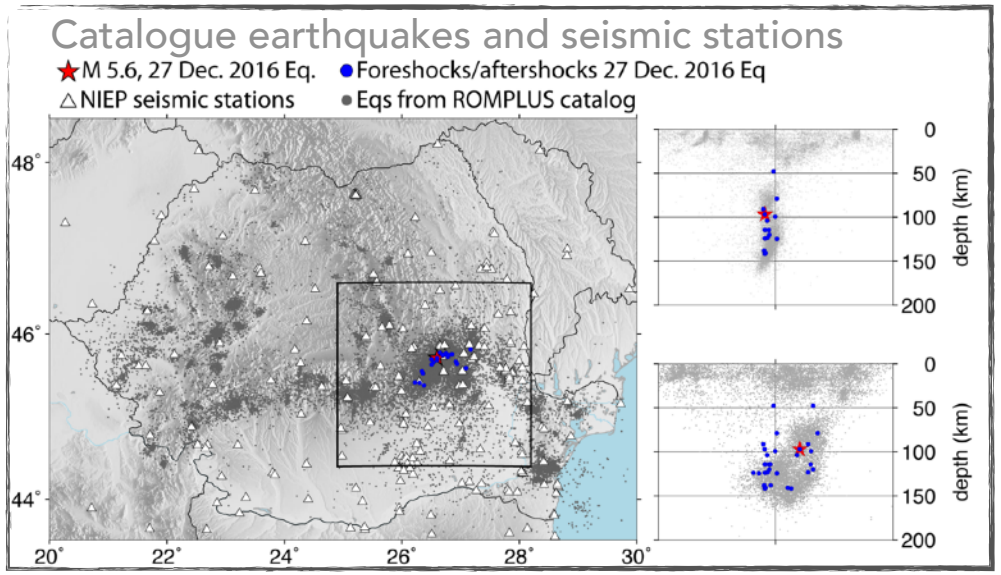


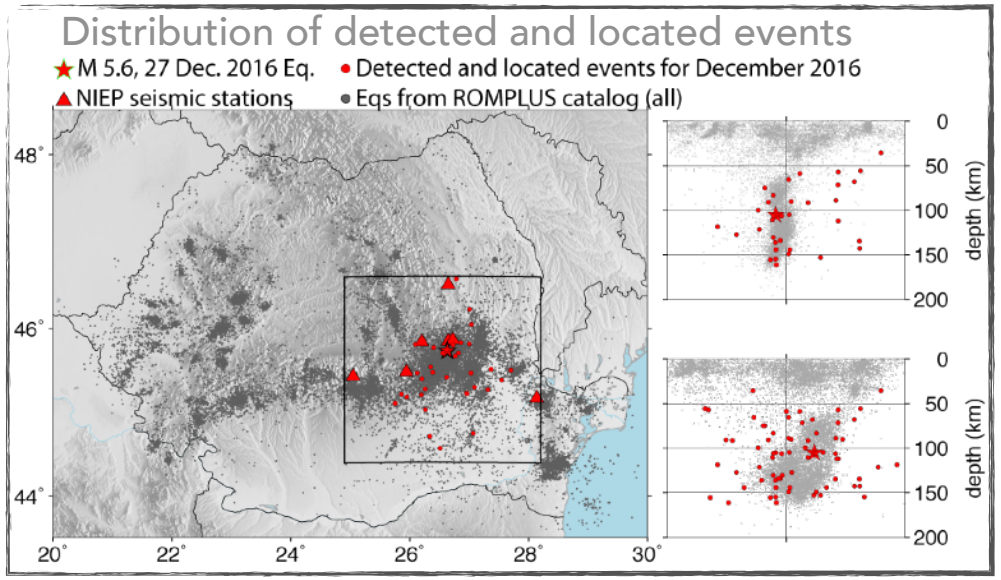
BackTrackBB detection and location method (Poiata et al., 2016)

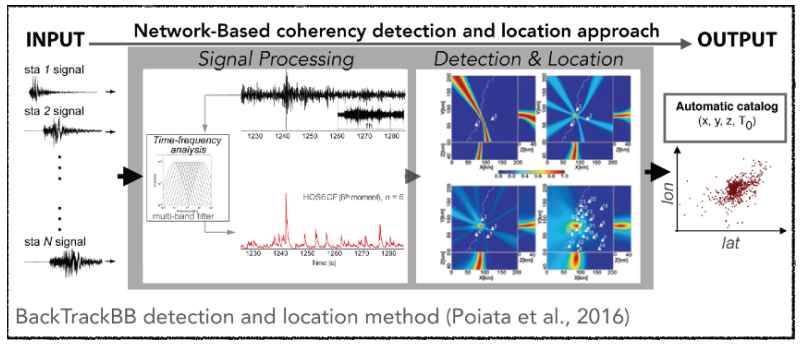
- Method - BackTrackBB (Poiata et al. 2016)
- 7 pre-selected stations & vertical component
- 1-D velocity model & P-wave assumption
- 340km x 240km x 190km source volume grid
- December 2016-January 2017 time period

3.1 Detection and location of earthquakes from Vrancea zone

Automatic detection and location with network-based coherence method







BackTrackBB detection and location method (Poiata et al., 2016)

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- 340km x 240km x 190km source volume grid
- December 2016-January 2017 time period

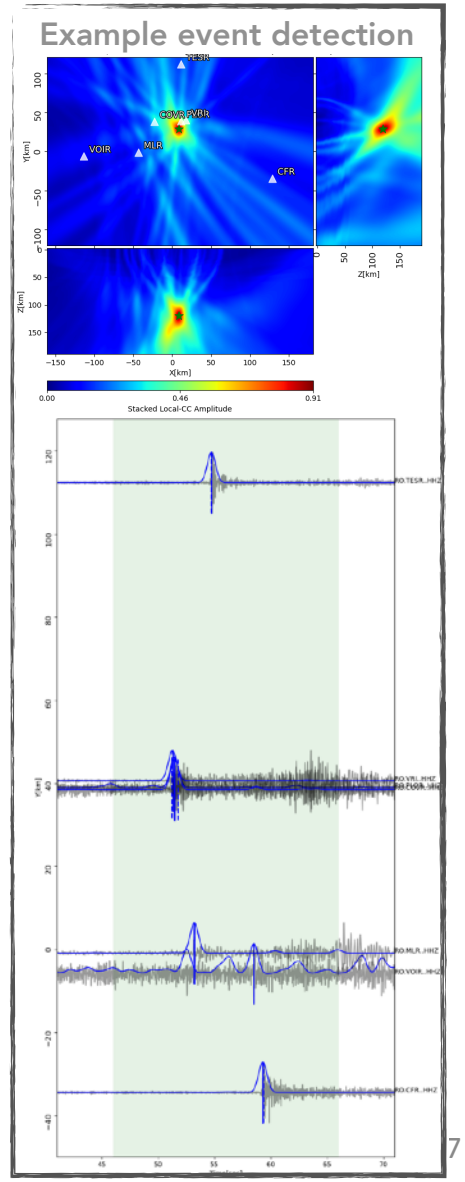
Results:

36 detected vs. 20 earthquakes in catalogue

December 27, 2016 (M 5.6) Eq. - well reproduced

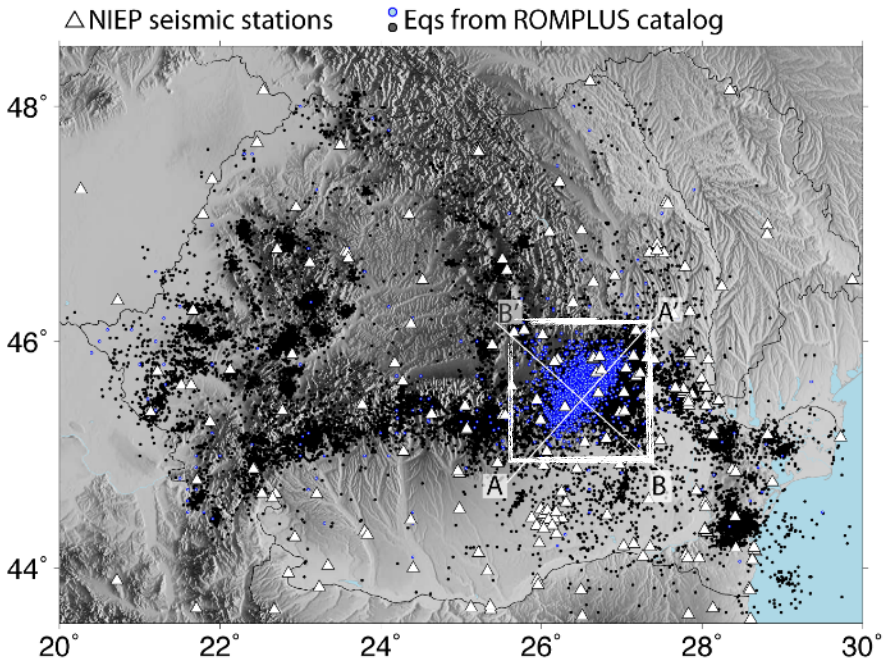
Challenging application - high station SNR variability

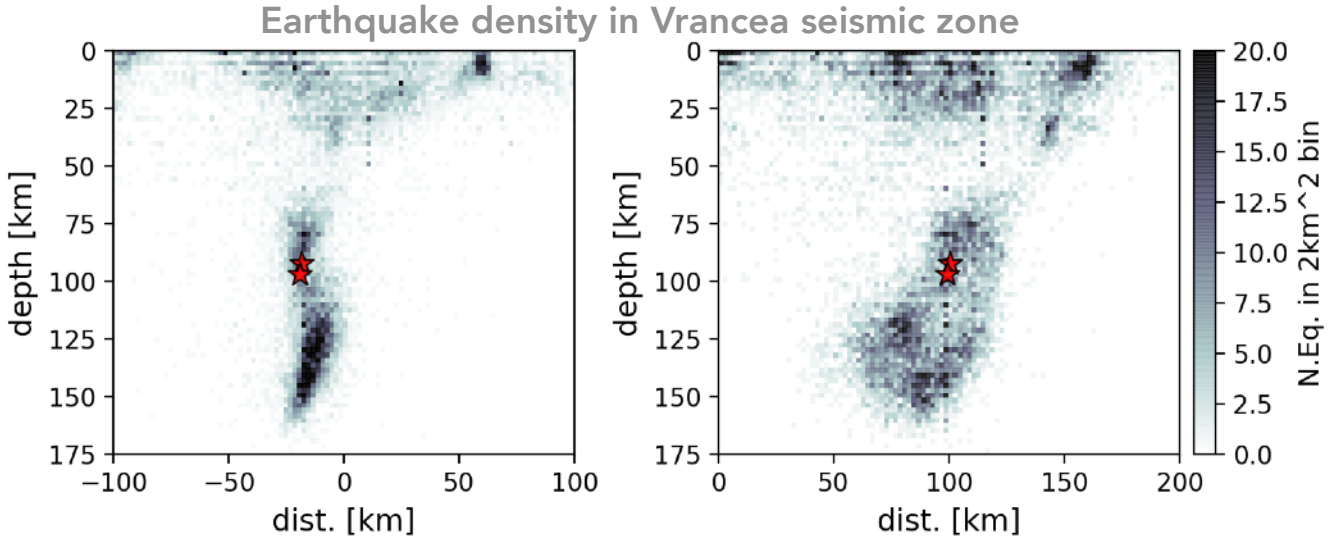
Further improvements and considerations required for small earthquakes detection



3.2 Search for similar earthquakes in Vrancea seismic zone

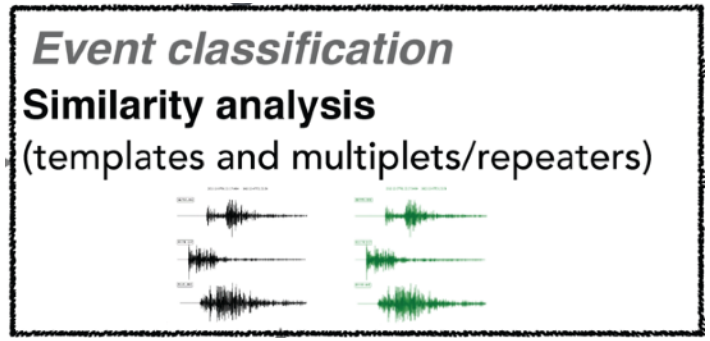
Problem setup and data





Identifying similar earthquakes (multiplets) using waveform cross-correlation:

- September 2016 - February 2017 (6 month) time-period
- 3 component records (all available common stations)
- Earthquake family: group of events with CCmax>0.7 for 6 component
- frequency: 2.0 - 10.0 Hz; P and S recording parts



Extending observations from other nests (Bucaramanga, Prieto et al. 2010) and subduction zones (Wiens and Snider, 2001) to Vrancea case

Potential first observation of repeating earthquakes in Vrancea

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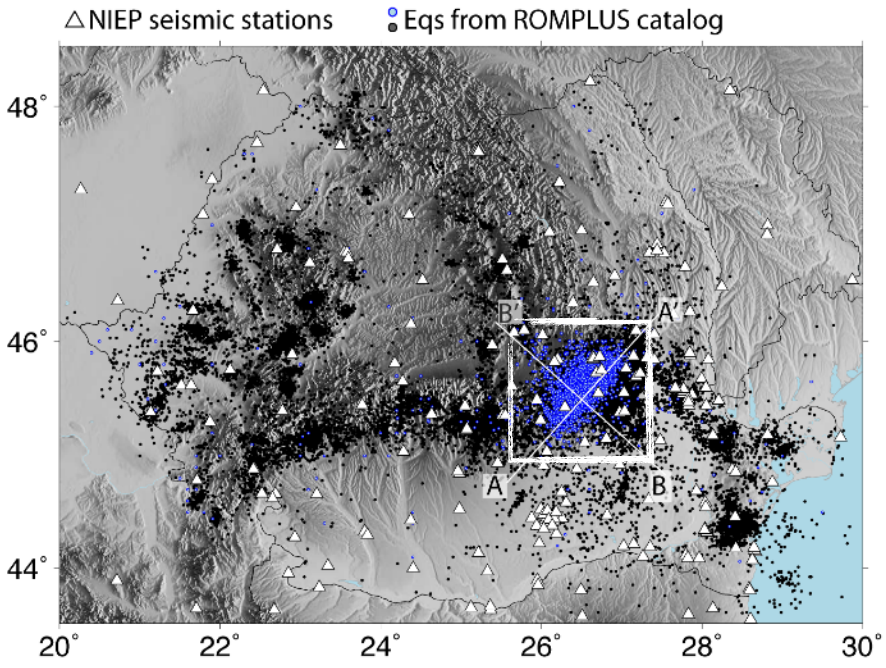
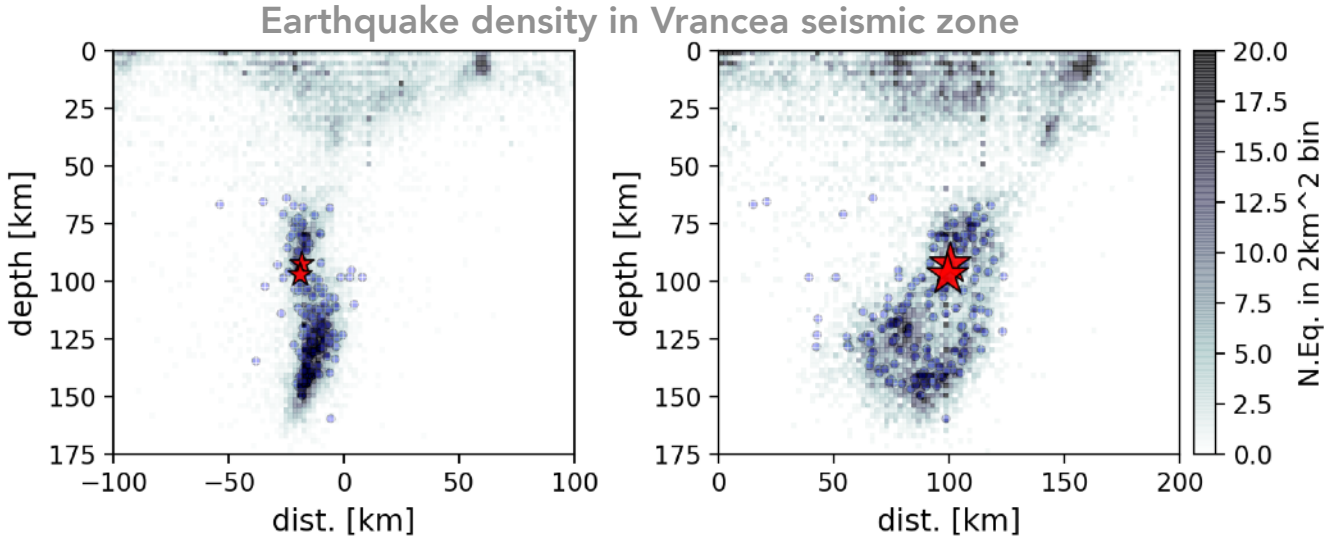
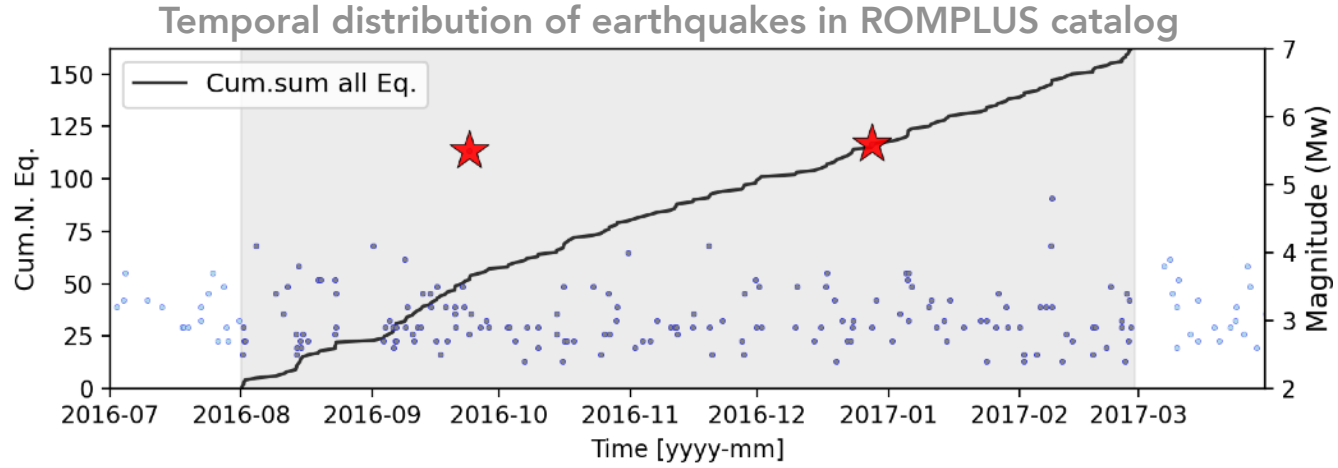
Problem setup and data







Identifying similar event using waveform cross-correlation:

September 2016 - February 2017 (6 month) time-period

Including both 2016 M > 5.0 earthquakes

Events from ROMPLUS catalog

Earthquake family: group of events with CCmax>0.7 for 6 component

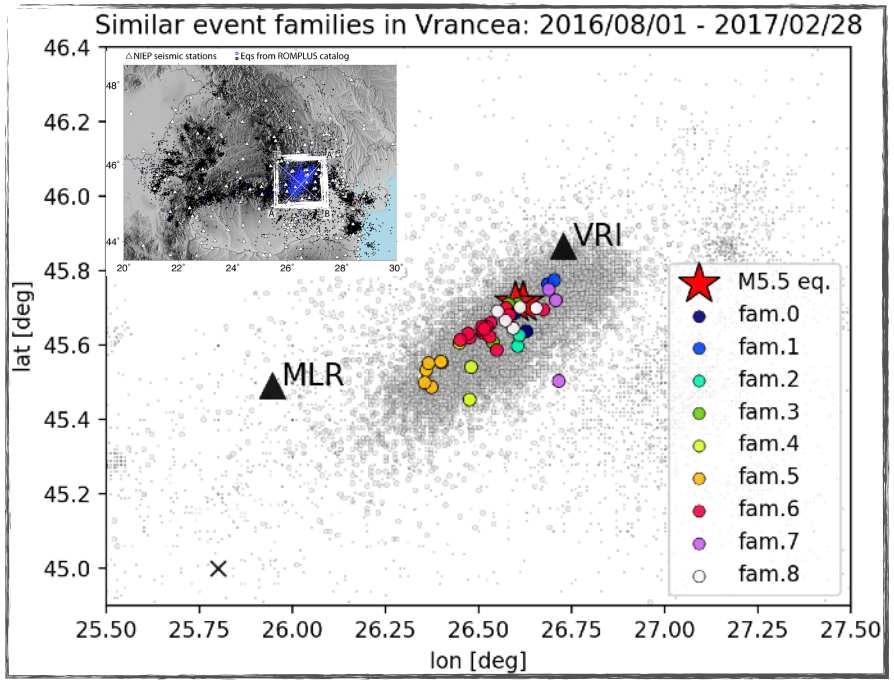
3.2 Search for similar earthquakes in Vrancea seismic zone

Results: similar earthquake families in Vrancea seismic zone

8 families of events classified as similar or multiplets

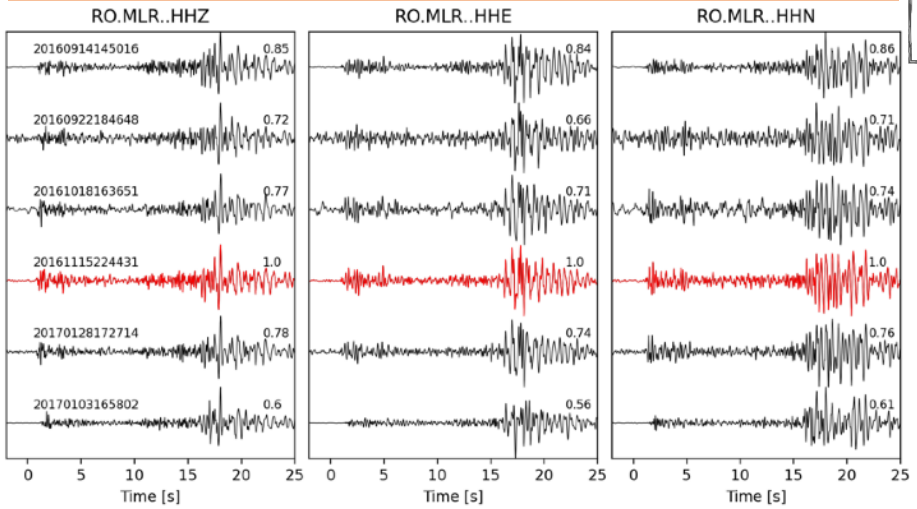
Number of earthquakes per family: 2 - 14

Total of 40 earthquakes from 162 in catalog

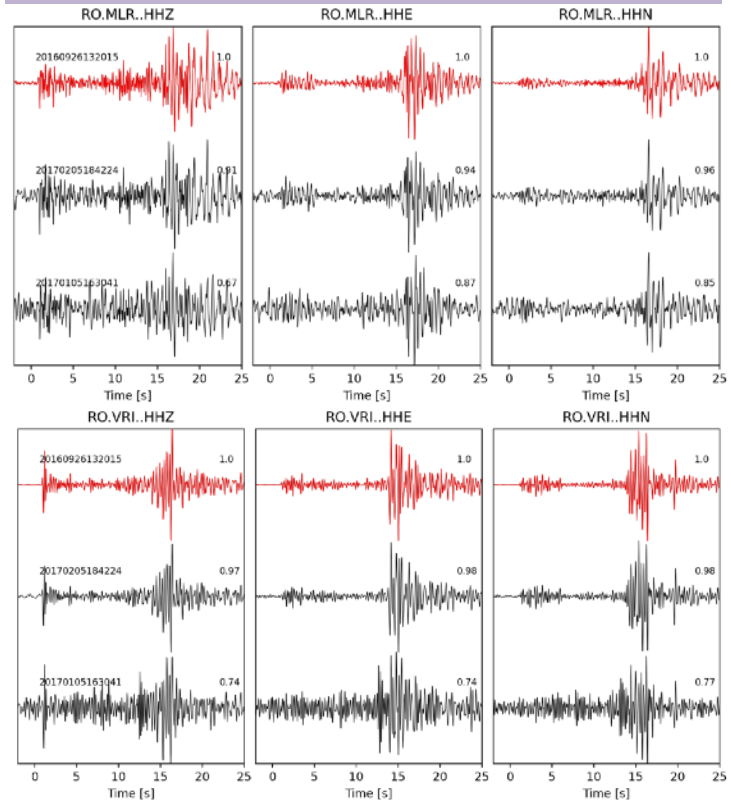


Most of the families located in regions of high earthquake density

Station-record examples for family 5

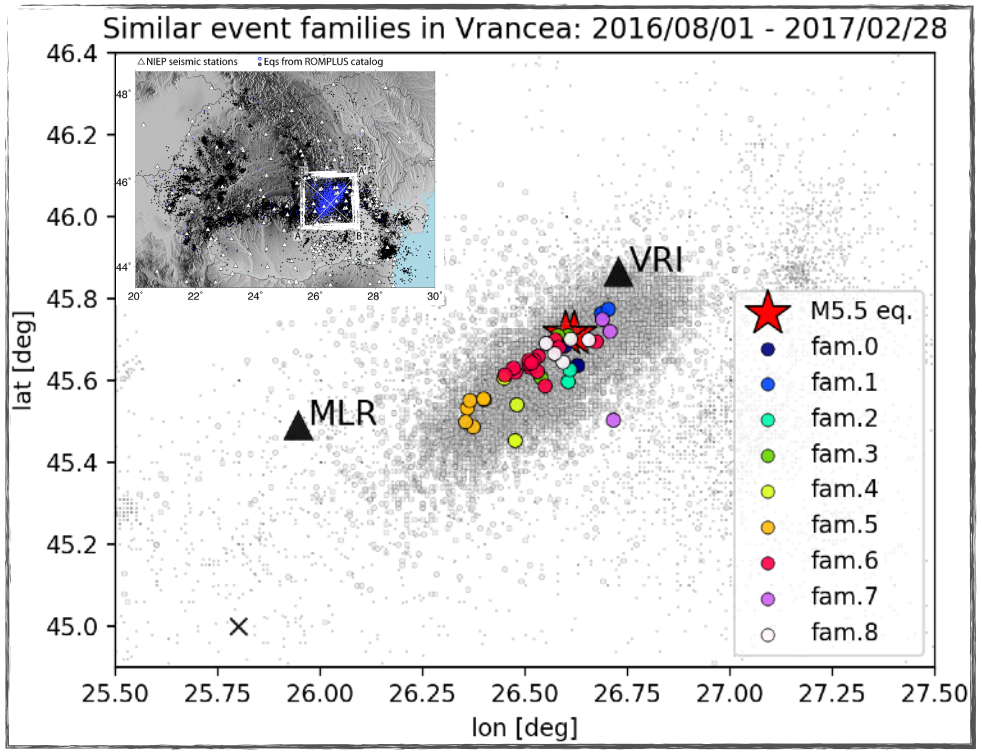


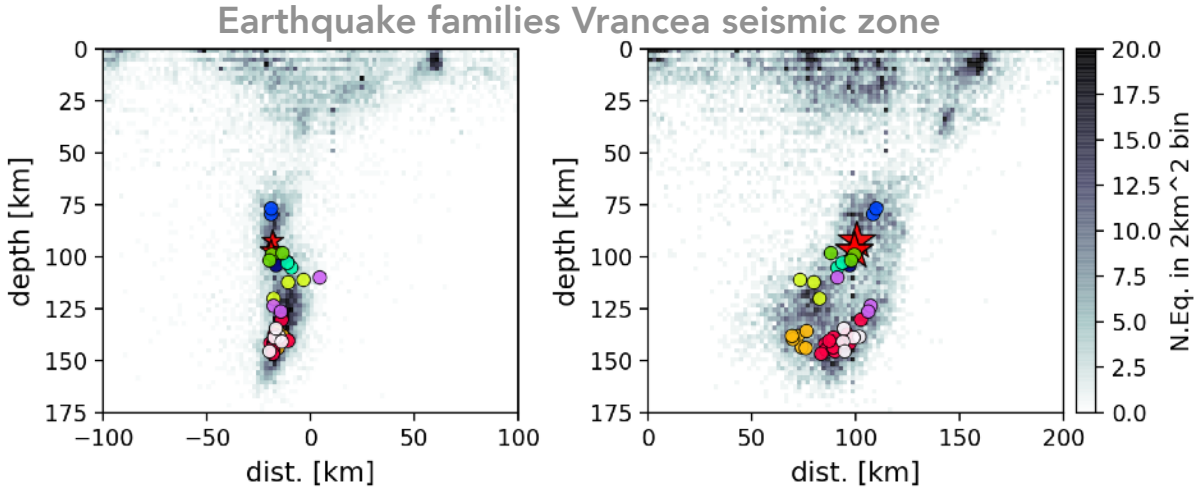
Station-record examples for family 7

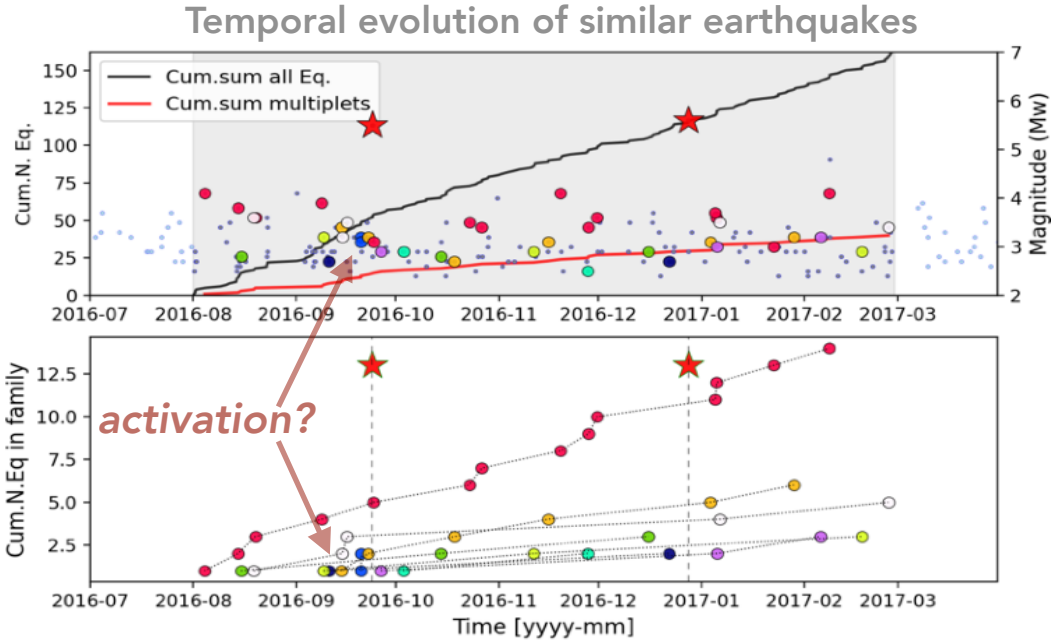


3.2 Search for similar earthquakes in Vrancea seismic zone

Results: similar earthquake families in Vrancea seismic zone







Most of the families located in regions of high earthquake density

Some families are active through all time period

There can be observed an increase in activity before September 2016 (M 5.5) earthquake

Some families seem to be activate 7 days before

4 Summary

Vrancea intermediate-depth earthquakes - peculiar and not well understood case of ***seismic nests***

Romanian seismic network provides a good station coverage and significant volume of high-quality continuous data

Applied automatic full-waveform methods provide new information about the seismic activity in Vrancea seismic zone and highlights methodological challenges

Automatic detection and location using continuous data is challenging and currently cannot significantly increase earthquake detectability in the area requiring improvements and adjustments

Earthquake similarity analysis provides ***first evidence of similar events in Vrancea*** seismic zone; most occurring in the high earthquake density regions at depth > 75 km

We observe a potential multiplet activation from ~7 day before September, 2016 (M 5.5) event

Future work:

Improvement of the automatic detection and location scheme

Extending the analysed time-period

Performing template-based detection from continuous data