Automatic monitoring of crustal seismic activity in Galati region of southeastern Romania using full waveform-based approach

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Map showing seismic activity in Galati region, with permanent and temporary stations marked. The maps are labeled for the years 2013 and 2017-present. The imaging function with color bar and time axis is also included.
2013 Galati seismic swarm and seismic network in the area

Galati area of SE Romania - low & complex crustal seismicity; poorly monitored

2013 seismic swarm - exceptional seismic activation of the region
Swarm characteristics: ~ 3 month long; > 800 events; Ml 0.1-4.0 (>15 events, Ml > 3.0)
Impact: felt by local population; proximity of oil exploitation wells - mass-media attention
Installation of local seismic monitoring network (including borehole stations) - Nov. 2017
Methodology and workflow outline

1. Extracting and locating seismic events from continuous data flow

- Signal processing
- Cross-Correlation (TDE functions)
- Mapping according to TDOA (pairwise SLF)

2. Building event database

- Event classification
  - Similarity analysis (multiplets and repeaters)
- Event relocation
  - P & S relocation
  - Double difference relocation

Data and target area

Target area:
- Region activated during 2013 seismic swarm

Data:
- Continuous 3-C seismic recordings; closest 5 station; local 1-D velocity model
- Time-period 2017-2019 including small region re-activation

Main goal:
- Continuous data flow rapid and fully automated analysis
- Detection/location and characterisation of local low-magnitude events
- Potential of identifying seismic activation
- Pseudo real-time setup (one-day delay data processing)
• Current stage and results; comparison with ROMPLUS catalog

Preliminary catalog of automatically located events for Galati region

Analysed time-period: November 2017 - December 2019 - workflow & parameter setup

- BackTrackBB-based continuous data processing: ~400 events
- > 350 true detection
- Allows detecting smaller-magnitude event
- More details about activity evolution in time

• ROMPLUS revised catalog: ~ 120 events
• Mostly larger events with good SNR
• Current stage and results; comparison with ROMPLUS catalog

Event characterisation - identifying similar events with cross-correlation analysis

Location of identified families

Selected family waveforms: 2.0 -15.0 Hz filtered

- 5-station, 3-component CC analysis for identifying families of similar events (CC>0.8)
- ~ 8 families: 2-20 events per family
- Sequential activation of families during period of more intense activity
- Small swarm-like activity in Jan 2018 - March 2018
- Pattern similar to 2013 swarm
- Automatic catalog - more details about intense activity period
**Challenges**

- Mislocated and misidentified regional events - due to small-scale of network -> careful event-selection scheme (spectral analysis?)
- Increased number of false detections if number of functioning stations is decreased (only 5-stations) -> additional false-event removal procedure (SNR-based)

**Example of mislocated regional event**

**Ongoing and future developments**

- Current-stage - off line data processing :P-wave detection/location and event similarity
- Ongoing development - P&S-wave based event relocation, removal of regional events
- Future development - pseudo real-time setup of analysis workflow: analysing with one-day delay continuous daily data (achievable on a local multi-core PC)
- Investigating source properties of local events - improvement of parameter setup and evaluation of seismic (re-)activation identification