

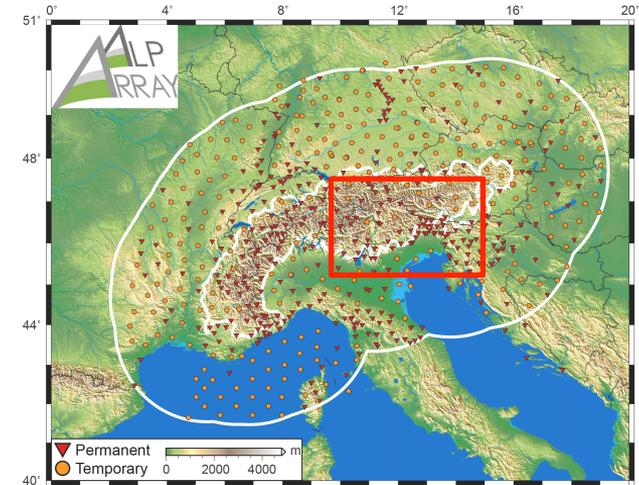
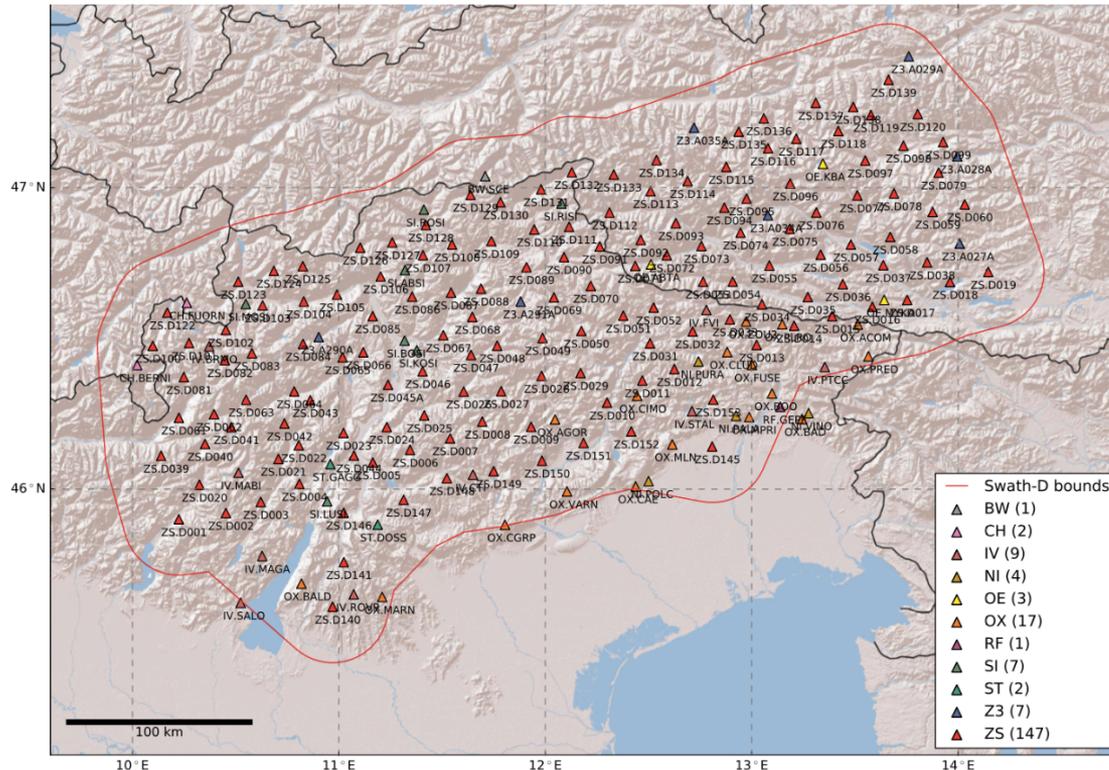


Local Seismicity in the Eastern Alps From GPU-Based Template Matching

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Data and Study Area (Swath-D Network)



- 147 Swath-D stations (ZS)
- 7 AlpArray Backbone stations (Z3)
- 46 additional public stations (ODC, LMU, ETH, INGV, GFZ)
- 2 years of continuous data

Template Matching

Templates

a selection of known events
(~8000)

Cross Correlation

$$f(t) \star g(t) = f(-t) * g(t)$$

Similarity between two signals

$8k$ events \times 5 stations \times 3 components = $120k$ templates

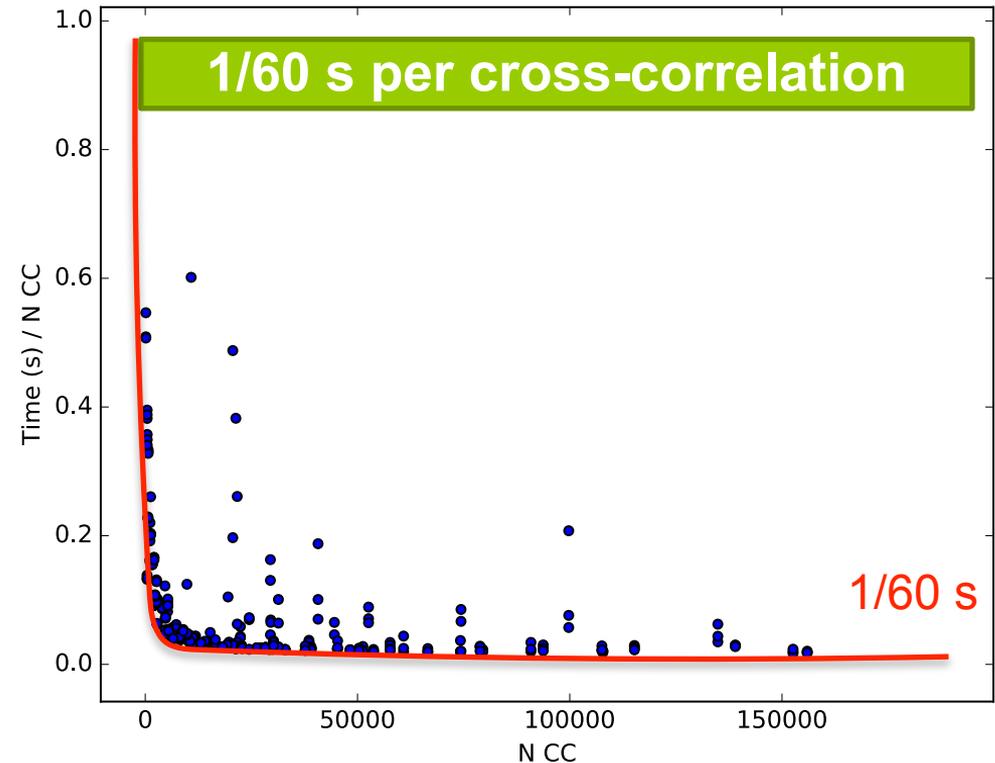
$120k$ templates \times 2 years of data = $90M$ cross-correlations*

This requires an efficient implementation

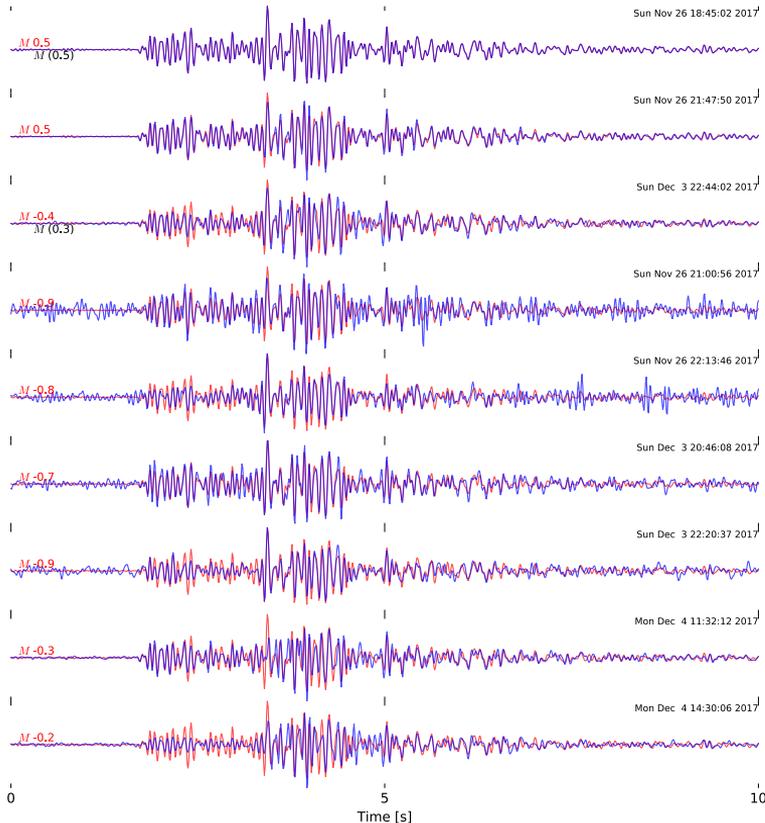
* where one cross-correlation: single template waveform with 1 day of continuous data

Template Matching

- GPU-based implementation
- [CuPy](#) allows for an easy integration of CUDA in Python
- Implementation allows processing of 60 cross-correlations per second
- This includes reading waveform data, preprocessing and writing detected signals
- Processing time increases with excessive number of detections

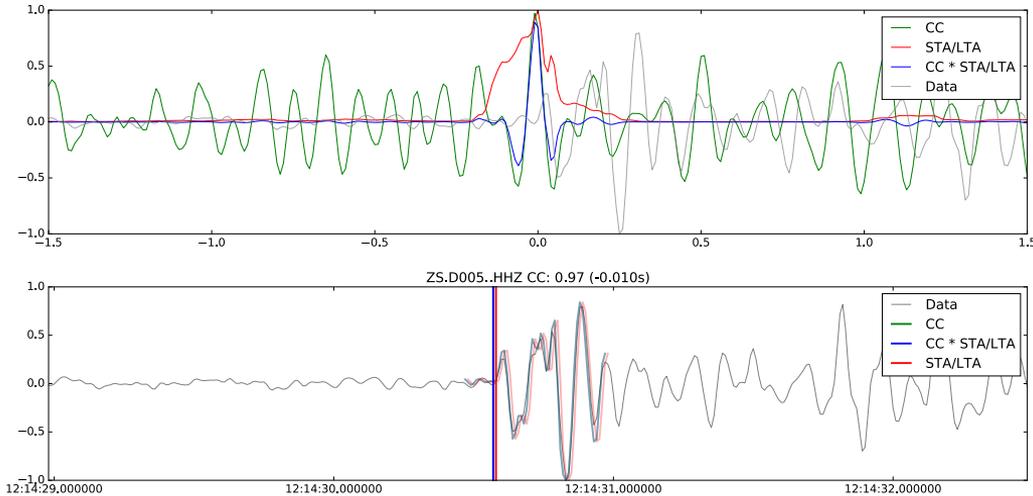


Picks & Locations



- Template matching yields detections of signals similar to a template signal
- This information can be used to create clusters of co-located events
- A characteristic signal can be handpicked for each cluster
- These picks can be extrapolated to the other events in the same cluster, allowing for a relative shift of the individual phases

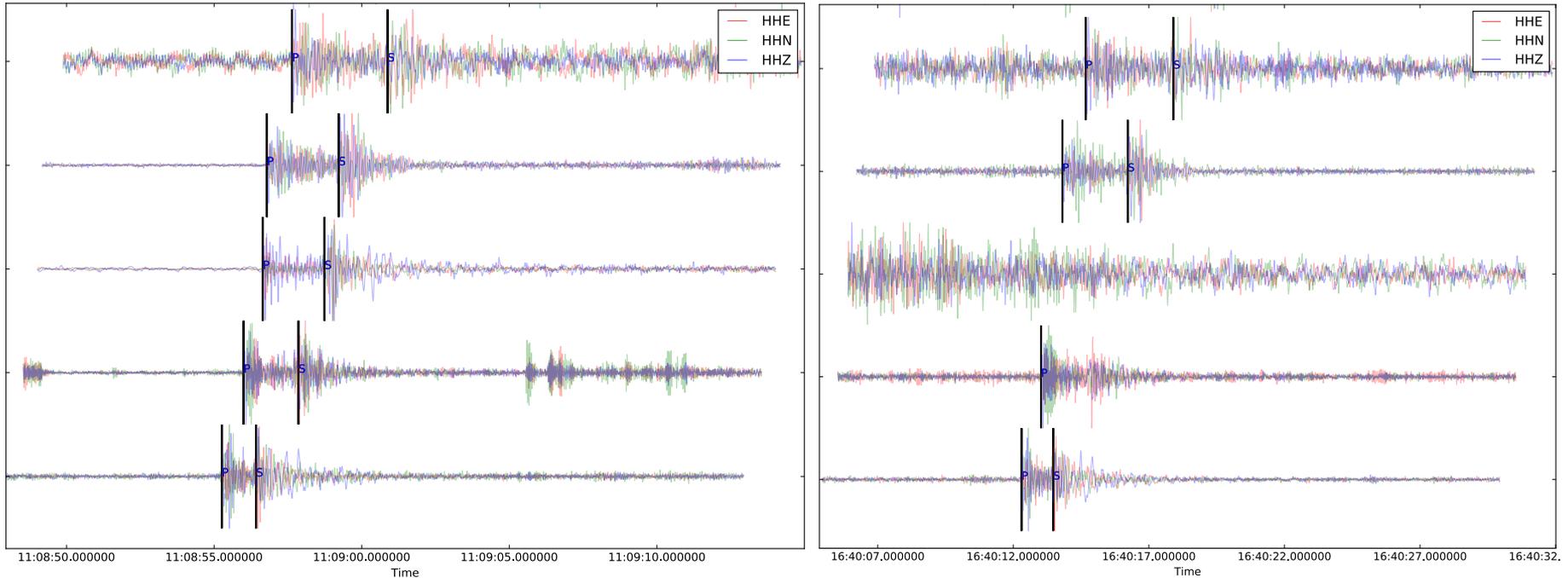
Picks & Locations



Example of the extrapolation of a handpicked phase to a detected event. The upper panel shows the cross-correlation and STA/LTA functions, the lower panel shows the waveform data of the detected signal and the handpicked phase.

- A combination of the cross-correlation function and a STA/LTA filter are used to shift the picks within a small time window
- The STA/LTA tends to find the approximate onset of the phase
- The cross-correlation function allows for an accurate alignment

Picks & Locations

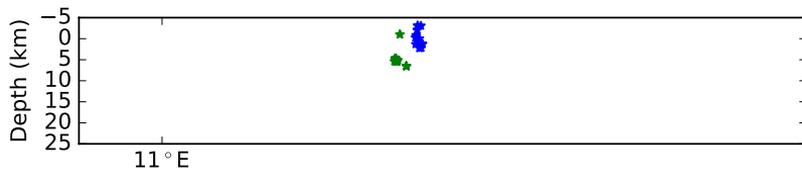
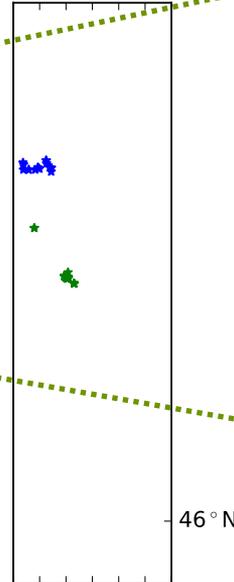
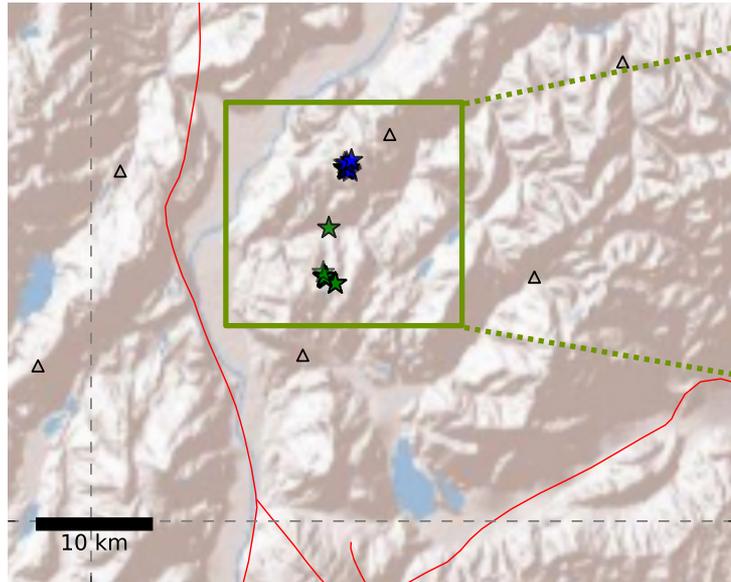


Example of a handpicked master event (left), and extrapolated picks to a detected event (right). Picks are accepted only if the similarity and SNR are high enough.



Picks & Locations

Google Maps



Example localisation of two event clusters containing quarry blasts. The locations can be visually verified. Depths still need to be improved, these depend mainly on the velocity model used.