Title: From Top to Bottom- Seismicity, Motion Patterns & Stress Distribution in the Alpine Crust

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Goals: We use the recorded Alpine seismicity to quantify the deformation and stress distribution in the Alps.
At a regional scale, our main aim is to provide a consistent, improved catalog of seismic moment tensors (MT) by applying a novel MT inversion technique, which will allow us to subsequently derive the 3-D crustal stress field of the Alps. Next to the 1D moment tensor inversion we plan to implement a first 3D inversion setup and test it in selected regions (e.g., AF-D).
At a local scale, we intend to detect microseismicity with focus on identified target zones and decipher the roles of tectonic, gravitational and externally triggered processes.

Preliminary results: In the first year of our project, we developed a new tool dedicated to automated station quality control of dense seismic networks and arrays (*AutoStatsQ toolbox)*. The toolbox was applied successfully for controlling gain errors, misorientations of the seismic sensors and to provide frequency ranges that can be used in the moment tensor inversions in the next step of the project (Petersen et al., 2019). AASN and Swath-D stations with gain errors, mostly due to metadata errors, and misoriented horizontal components were identified, corrections suggested and network operators informed.
We then tested the moment tensor inversion tools that have been developed by our working group (e.g. Cesca et al., 2010) using the AASN and SWATH-D datasets. We have computed moment tensor solutions for all events between 2016 and end of 2019 in the AlpArray region for M > 3.0 (See Fig. 1). For M > 3.5 events, the results are always stable, for M between 3.0 and 3.5 it strongly depends on station density, noise levels, site effects and velocity models. We tested and compared different methods and implemented a new envelope fitting method.
In our ongoing work, we develop a network based waveform similarity clustering tool, and we plan to compare different approaches aiming for smaller events (M_W 2.5- 3.0). We identified seismic clusters of interest within the SWATH-D region and target regions within the larger AlpArray.

Furthermore, we have implemented and refined a waveform-based event detection algorithm, which now features data-driven selection of stations and a new parameter analysis to identify false alarms. To increase efficiency and allow reasonable applicability to the large SWATH-D data volume , it is GPU based. We have now applied the method successfully to the continuous seismic data recorded by both the on-line and off-line stations in the Swath-D region between 2017 and 2019. This allowed us to improve the event detectability and thereby increase the number of detected earthquakes in the Swath-D region as compared to the available local event catalogs by the Swiss, Italian and Austrian agencies by a factor of about 10 (see Fig. 2).
We are currently refining the P & S arrival time picks for the detected events by a combination of preliminary picks and cross-correlation based differential travel times. These will be used in the next step to calculate precise hypocenter locations and provide an event catalog for the recorded data in the SWATH-D region.

Publications:

Hofman, R., Kummerow, J., Cesca, S., Wassermann, J., Plenefisch, Th., 2018. Detecting Microseismicity in the Eastern Alps using the Swath-D Network, *Geophysical Research Abstracts*, 20, EGU2018-7693.

Hofman, R., Kummerow, J., Cesca, S., Wassermann, J., Plenefisch, Th., 2019. Spatial and Temporal Patterns in Microseismicity in the Eastern Alps, *Geophysical Research Abstracts*, 21, EGU2019-11122.

Petersen, G., Cesca, S., Kriegerowski, M, AlpArray Working Group, 2019. Automated Quality Control for Large Seismic Networks: Implementation and Application to the AlpArray Seismic Network. *Seismological Research Letters* ; 90 (3): 1177–1190, doi: https://doi.org/10.1785/0220180342.

Petersen, G., Cesca, S., Kriegerowski, M., Heimann, S., Alp Array Working Group (2019): Towards automatized moment-tensor inversion for small magnitude events in the Alps: Automatized quality control and preliminary focal mechanisms. - Mitteilungen / Deutsche Geophysikalische Gesellschaft, 2, 27-29.

in preparation:

Hofman, R., Kummerow, J., Alp Array Working Group (2020): Microseimsic event detection workflow with application to the SWATH-D network in the Eastern Alps.

Petersen, G., Cesca, S., Heimann, S., Niemz, P., Dahm, T. (2020): Lessons learned from regional CMT inversion of small to moderate earthquakes using the dense AlpArray seismic network.

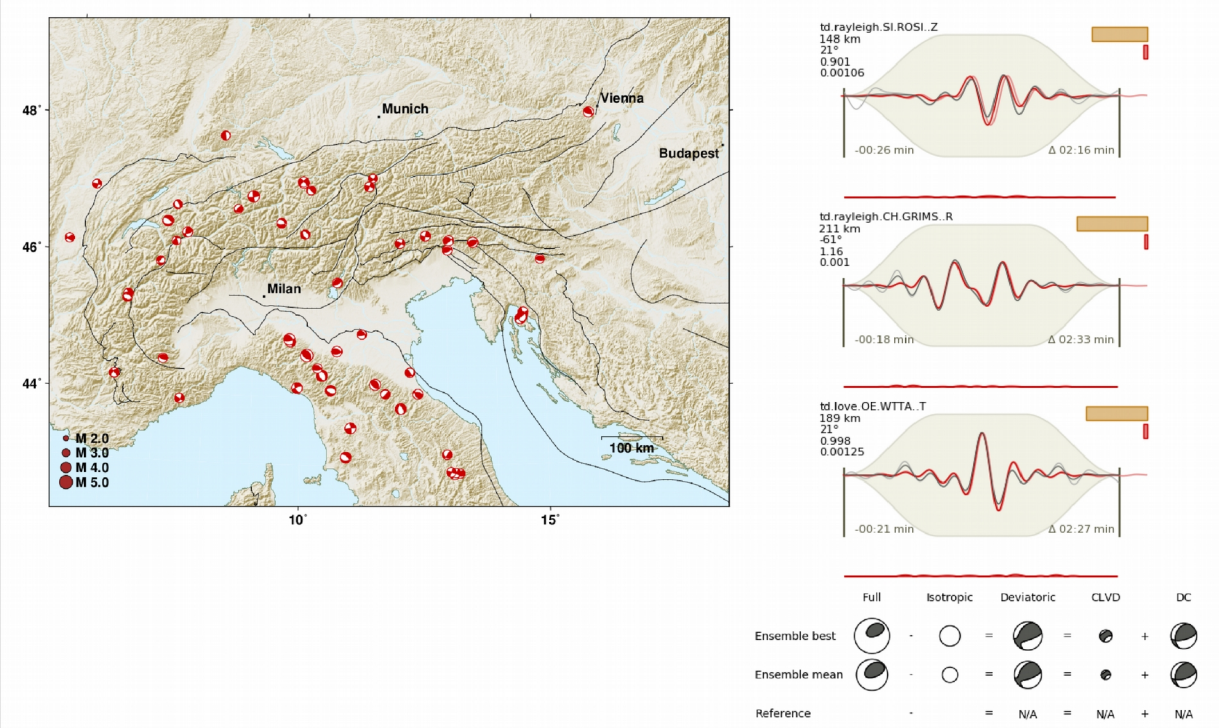

Fig. 1: Overview of preliminary moment tensor inversions for the Alpine region in 2017-2019, using the ALPARRAY data.

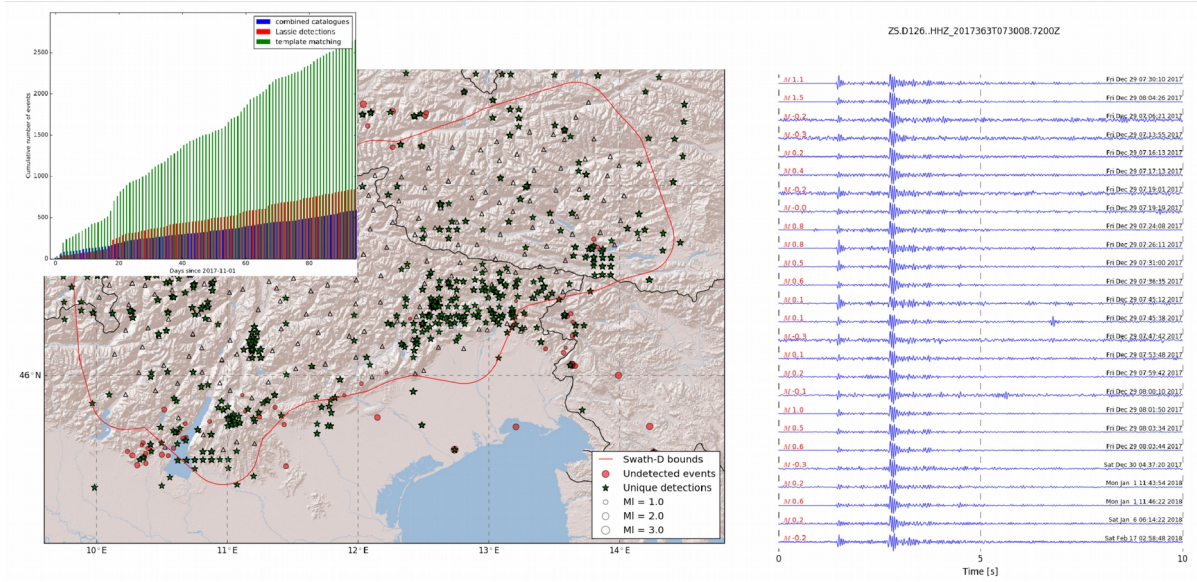

Fig.2: Preliminary detection of local earthquakes in the SWATH-D region. Application of a new template-matching work flow results in an increased number of event detections (top left); the right subfigure shows an example of a template family, consisting of events with very similar waveforms.