A Swiss-army-knife approach to nearly automatic microearthquake analysis for natural and induced sequences.

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Many Swiss earthquake sequences have been studied using relative location techniques, which often allowed to constrain the active fault planes and shed light on the tectonic processes that drove the seismicity. Yet, in the majority of cases, the number of located earthquakes was too small to infer the details of the space-time evolution of the sequences, or their statistical properties. Therefore, it has mostly been impossible to resolve seismicity patterns of individual sequences in a sufficiently high precision needed to improve the understanding of the mechanisms behind them.

Here we present a nearly automatic workflow that combines well-established seismological analysis techniques and allows to significantly improve the completeness of detected and located earthquakes of a sequence.

We start from the manually timed routine catalog of the Swiss Seismological Service (SED), which contains the larger events of a sequence. From these well-analyzed earthquakes, we dynamically assemble a template set and perform a matched filter analysis on the station with: the best SNR for the sequence; and a recording history of at least 10-15 years, our typical analysis period. This usually allows us to detect events several orders of magnitude below the SED catalog detection threshold. The waveform similarity of the events is then further exploited to derive accurate and consistent magnitudes. The enhanced catalog is then analyzed statistically to derive high-resolution time-lines of the a- and b-value and consequently the occurrence probability of larger events.

Many of the detected events are strong enough to be located using double-differences. No further manual interaction is needed; we simply time-shift the arrival-time pattern of the detecting template to the associated detection. Waveform similarity assures a good approximation of the expected arrival-times, which we use to calculate event-pair arrival-time differences by cross-correlation. After a SNR and cycle-skipping quality check these are directly fed into hypoDD. Using this procedure we usually improve the number of well-relocated events by a factor 2-5.

We demonstrate the successful application of the workflow at the example of natural sequences in Switzerland and present first results of the advanced analysis the was possible with the enhanced catalogs.

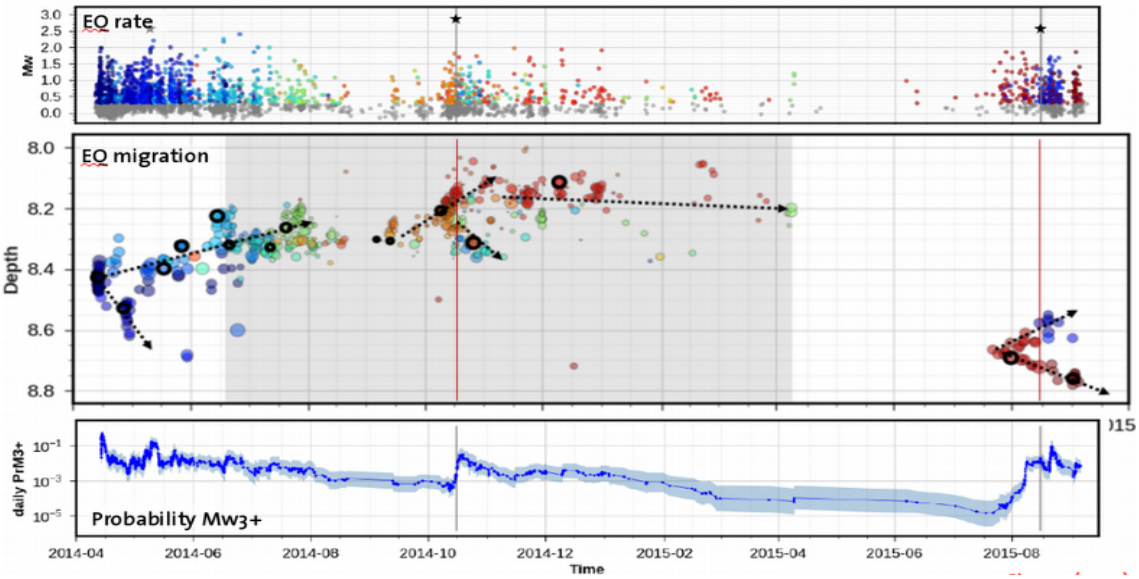

Figure 1. Temporal evolution of the Diemtigen/BE sequence 2014/15: Top: earthquake rate, middle: migration of earthquakes with depth (absolute depth uncertainty of seismic cloud app. 1km), bottom: probability for a Mw ≥ 3 event. Colors indicate the associated template. ML3.2 event in Oct. 2014 and ML2.7 event in Aug. 2015 are indicated by vertical lines.

REFERENCES

Simon, V., (2017) High precision analysis of natural earthquake sequences in Switzerland. Master Thesis, IDEA League, Joint Master Program in Applied Geophysics, ETH Zurich, 11. Aug. 2017, pp. 92.