Assessment of the empirical matched field processing algorithm for autonomous tracking of aftershock sequences

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Autonomous algorithms can improve the processing of aftershock sequences, for example by reducing the analyst workload. We present a system for automatic detection and location of aftershocks in a specific region following a large earthquake. The system seeks to identify all signals generated by seismic events in the target region, while passing over signals generated by sources in all other regions. For a given station, we can generate a sensitive empirical matched field (EMF) detector for the target region using only an empirical template from the mainshock signal. These EMF detectors perform much better on seismic arrays than on 3-component stations. For each selected station in the network, a multivariate detector combines the EMF detector with an optimized continuous AR-AIC detector to generate a target-optimized detection list. For arrays, an additional continuous calibrated f-k process reliably screens out likely signals from other sources. A region-specific phase association algorithm takes the screened detection lists from each station and generates a preliminary aftershock bulletin. We have processed aftershock sequences from four major earthquakes: the Tohoku event in 2011 (Japan), the Illapel event in 2015 (Chile), the Papua New Guinea event in 2018 and the Gorkha event in 2015 (Nepal).

We evaluate the results in detail by comparing the automatically generated origins and corresponding phase arrival times with matching events and associated arrivals in the analyst reviewed (REB) and automatic (SEL3) bulletins issued by the CTBTO Preparatory Commission. Between 40% and 65% of all events in the REB are found to closely match the locations and origin times of the events found by our EMF-based procedure. The resulting discrepancies are assessed with respect to signal-to-noise ratio, number of defining stations, and epicentral distance. Furthermore, the REB events not detected by the EMF method are analyzed and a few phase misidentifications (i.e., P vs. pP) are assessed to better understand the limitations of the autonomous procedure. In general, we find that our EMF solutions are closer to the matching REB events than the corresponding SEL3 events. The analyst is helped both by the improved location estimates and a lower number of qualitatively incorrect event hypotheses. A key factor in the performance is the number of contributing seismic arrays. Aftershock sequences in the southern hemisphere performed the worst given the poorer array coverage.