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An automatic procedure for high-resolution earthquake locations: a case study from the TABOO near fault observatory (Northern Apennines, Italy)

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The characterization of the geometry, kinematics and rheology of fault zones by seismological data depends on our capability of accurately locate the largest number of low-magnitude seismic events.
To this aim, we have been working for the past three years to develop an advanced modular earthquake location procedure able to automatically retrieve high-resolution earthquakes catalogues directly from continuous waveforms data.
We use seismograms recorded at about 60 seismic stations located both at surface and at depth. The network covers an area of about 80x60 km with a mean inter-station distance of 6 km. These stations are part of a Near fault Observatory (TABOO; http://taboo.rm.ingv.it/), consisting of multi-sensor stations (seismic, geodetic, geochemical and electromagnetic). This permanent scientific infrastructure managed by the INGV is devoted to studying the earthquakes preparatory phase and the fast/slow (i.e. seismic/aseismic) deformation process active along the Alto Tiberina fault (ATF) located in the northern Apennines (Italy). The ATF is potentially one of the rare worldwide examples of active low-angle (< 15°) normal fault accommodating crustal extension and characterized by a regular occurrence of micro-earthquakes.

The modular procedure combines: i) a sensitive detection algorithm optimized to declare low-magnitude events; ii) an accurate picking procedure that provides consistently weighted P- and S-wave arrival times, P-wave first motion polarities and the maximum waveform amplitude for local magnitude calculation; iii) both linearized iterative and non-linear global-search earthquake location algorithms to compute accurate absolute locations of single-events in a 3D geological model (see Latorre et al. same session); iv) cross-correlation and double-difference location methods to compute high-resolution relative event locations.
This procedure is now running off-line with a delay of 1 week to the real-time. We are now implementing this procedure to obtain high-resolution double-difference earthquake locations in real-time (DDRT).
We show locations of ∼30k low-magnitude earthquakes recorded during the past 4 years (2010-2013) of network operation, reaching a completeness magnitude of the catalogue of 0.2. The spatiotemporal seismicity distribution has an almost constant and high rate of r = 24.30e−04 eqks/day*km2, interrupted by low to moderate magnitude seismic sequences such as the 2010 Pietralunga sequence (M L 3.8) and the still ongoing 2013 Gubbio sequence (M L 4.0 on 22nd December 2013).
Low-magnitude seismicity images the fine scale geometry of the ATF: an E-dipping plane at low angle (15°) from 4 km down to ∼15 km of depth. While in the ATF hanging-wall we observe the activation of high-angle minor synthetic and antithetic normal faults (4–5 km long) confined at depth by the detachment. Both seismic sequences activated up to now only these high-angle fault segments.