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Rapid and robust characterization of the earthquake source for tsunami early-warning

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Effective tsunami early-warning after an earthquake is difficult when the distances and tsunami travel-times between earthquake/tsunami source regions and coast lines at risk are small, especially since the density of seismic and other monitoring stations is very low in most regions of risk. For tsunami warning worldwide, seismic monitoring and analysis currently provide the majority of information available within the first tens of minutes after an earthquake. This information is used for direct tsunami hazard assessment, and as basic input to real-time, tsunami hazard modeling. It is thus crucial that key earthquake parameters are determined as rapidly and reliably as possible, in a probabilistic, time-evolving manner, along with full uncertainties.

Early-est (EArthquake Rapid Location sYstem with EStimation of Tsunamigenesis) is the module for rapid earthquake detection, location and analysis at the INGV tsunami alert center (CAT, “Centro di Allerta Tsunami”), part of the Italian, candidate Tsunami Watch Provider. Here we present the information produced by Early-est within the first 10 min after an earthquake to characterize the location, depth, magnitude, mechanism and tsunami potential of an earthquake. We discuss key algorithms in Early-est that produce fully automatic, robust results and their uncertainties in the shortest possible time using sparse observations. For example, a broadband picker and a robust, probabilistic, global-search detector/associator/locator component of Early-est can detect and locate a seismic event with as few as 4 to 5 P onset observations. We also discuss how these algorithms may be further evolved to provide even earlier and more robust results.

Finally, we illustrate how the real-time, evolutionary and probabilistic earthquake information produced by Early-est, along with prior and non-seismic information and later seismic information (e.g., full-waveform moment-tensors), may be used within time-evolving, decision and modeling systems for tsunami early warning.