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Optimal, real-time earthquake location for early warning

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Destructive S and surface waves from a large earthquake can take several tens of seconds to travel from the earthquake source region to distant populated areas and sensitive infrastructure. If there is a seismological monitoring network in the source region, modern seismological analysis methods and communications systems allow characterization of the event and the issuing of alarm messages within seconds, leaving tens of seconds for mitigating actions to be taken. This procedure is known as early warning.

For example, for an earthquake in the Irpinia region of Southern Italy there is a delay of about 25-30 sec before the first energetic S wave trains arrive at Naples at about 80-100 km distance. With an early warning system, alarm messages could be sent to critical sites in Naples 20 or more seconds before strong shaking commences.

The characterization of an earthquake includes, most importantly, estimates of its location and size. Here we are concerned with obtaining the most constraint possible on the location of the event hypocenter as time passes after event detection.

We developed an evolutionary, real-time location technique, based on the equal differential time (EDT) formulation and on a probabilistic approach for hypocenter estimation. The algorithm, at each time step, relies on the information coming from triggered arrivals and not yet triggered station. With just one recorded arrival, hypocentral position can be constrained by the Voronoi cell associated to the first triggering station. As time passes and more triggers become available, the evolutionary location converges to a standard EDT location.

We performed synthetic location tests using the actual geometry of the ISNet (Irpinia Seismic Network) in order to evaluate the accuracy of the algorithm and its robustness

in the presence of outliers.