ESC2016-156, 2016
35th General Assembly of the European Seismological Commission

Smartphone-Network for Earthquake and Tsunami Early Warning in Chile

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Chile has been struck by a number of very large (>M7.5) earthquakes and tsunamis in the past. There is clear need for building systems to provide rapid situational awareness, as well as earthquake and tsunami early warning. Since scientific instrumentation is expensive, we are exploring the use of dense networks of seismic and geodetic low-cost sensors. The U.S. Geological Survey (USGS) Earthquake Science Center has recently started to deploy a prototype network of dedicated smartphone units in Northern Chile, covering a ∼1,500 km long coastal section between the Arica Gap and Santiago (Brooks et al., 2016). Installation and data analysis is facilitated in close collaboration with partners at the University of Chile, Chilean National Seismological Center, University of Houston, GISMatters Inc., and the Swiss Federal Institute of Technology (ETH) Zurich. Each sensor box contains a smartphone with integrated MEMS accelerometer, and an external consumer-quality GPS chip and antenna. The total cost of each box is on the order of a few hundred dollars, nearly two orders of magnitude lower than scientific-grade installations. Our goal is to build and deploy over 200 smartphone-based monitoring stations this year; a first subset of 9 sensor units has been installed in November 2015.
For large earthquakes (>M7.5) we will jointly invert seismic and geodetic data from the smartphone units for distributed slip models and unsaturated magnitude estimates using the FinDer-BEFORES algorithm (Minson et al., 2015). This algorithm utilizes the probabilistic estimates of fault strike and length by the seismic FinDer algorithm (Böse et al., 2012, 2015) as prior in the Bayesian geodetic BEFORES algorithm (Minson et al., 2014). For smaller events, we will determine near-field acceleration-based line source models using FinDer only. There are a number of features that make FinDer well-suited for application in noisy low-cost sensor networks. First, FinDer does not require phase picks and pick associators, which can get easily confused in times of high seismicity or noise. Second, FinDer uses amplitude thresholds rather than absolute ground-motion levels to estimate source parameters. Thus clipping of wave amplitudes in large earthquakes or at close epicentral distances, as is expected in low-cost sensors due to their limited dynamic range, should not affect FinDer results. Third, smartphone accelerometers are strong-motion sensors and as such well-suited to record high-frequency motions, but will likely fail to reproduce long-period signals. FinDer is not affected by this limitation, since the algorithm uses high-frequency motions only. Retrospective batch processing all of the data collected so far from the first subset of sensors shows that our proposed analysis method successfully detects, locates, and estimates the magnitude for both M>5 earthquakes that have occurred since the sensors were deployed while producing zero false alarms. We expect that the system's performance will improve further once the full sensor network is installed.