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Earthquake Early Warning application in Central Greece

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Greece is the most seismically active country in Europe, with an estimated 50% of Europe's and 2% of the world's annual seismic energy being released on major active faults that cross the Greek territory (Bath, 1983). Several strong earthquakes during the last decades have caused serious damage and loss of human lives. With operational short-term earthquake forecasting still being an elusive prospect, Earthquake Early Warning (EEW) is currently one of the most important developing technologies in applied seismology. These systems are focused on acquiring information from the faster seismic phases, including arrival time, peak-to-peak displacement amplitude and, optionally, pulse duration to estimate location and magnitude based on probabilistic and other approaches before the slower but destructive seismic waves arrive. Depending on the density of the seismological network and the latency of waveform data transmission, an operational EEW system can generate and transmit alerts for impending seismic strong motion at target sites of significant importance and inform the authorities, companies or even the public to take specific risk/damage mitigation measures within the short time window between the warning signal and the arrival of the strong shear or surface waves.

In the framework of the Hellenic Plate Observing System (HELPOS) research project, the National and Kapodistrian University of Athens has been working on the application of EEW focused in Central Greece. The monitored region includes major active fault systems, such as the Cephalonia-Lefkada Transform Fault Zone (CLTFZ; Stiros *et al.*, 1994; Papadimitriou *et al.*, 2006; Karakostas *et al.*, 2015) and the thrust faults near Zakynthos island (Papadimitriou *et al.*, 2012) in the west, the Andravida fault (Ganas *et al.*, 2009; Papadopoulos *et al.*, 2010) in NW Peloponnese, the Corinth Rift (Bernard *et al.*, 1997; Kapetanidis *et al.*, 2015; Kaviris *et al.*, 2017, 2018), the pull-apart fault system in Lake Trichonis (Kassaras *et al.*, 2014) and, towards the east, the fault systems surrounding the capital, Athens (Papadimitriou *et al.*, 2002), and the fault systems in Atalanti (Pantosti *et al.*, 2001) and Evia rift (Ganas *et al.*, 2016).

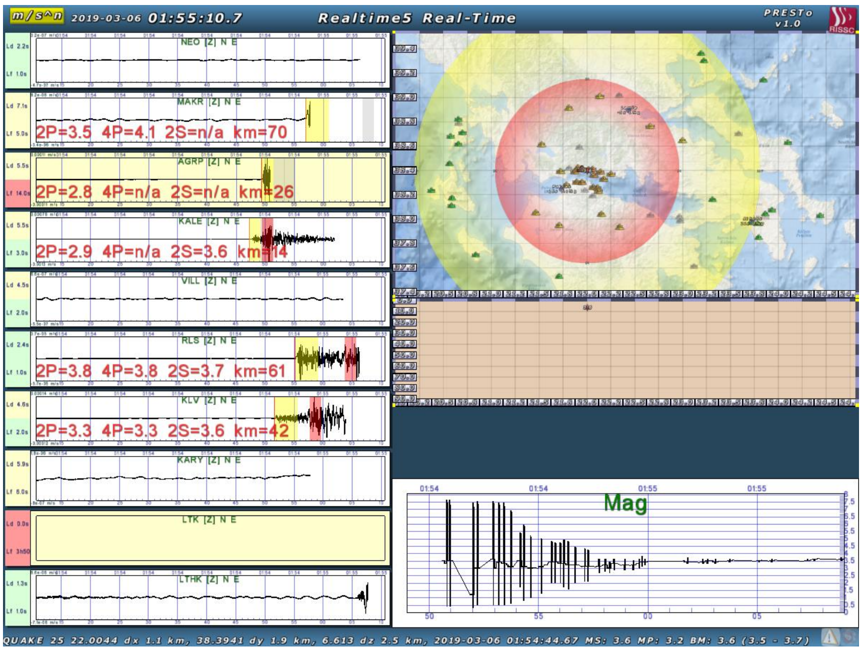

Figure 1. Example of a real-time alert from PRESTo EEW for an event that occurred in the WGoC. The first solution was available only 6 sec after the origin time, allowing for a 4 sec window before the S-waves arrival at the city of Patras, at an epicentral distance of 30 km.

In this work we present preliminary results of a pilot application using the PRESTo EEW software (Satriano *et al.*, 2011). We incorporate data from seismological stations of the Hellenic Unified Seismological Network (HUSN), along with stations of the local Corinth Rift Laboratory Network (CRLN; Lyon-Caen *et al.*, 2004) installed in the Western Gulf of Corinth (WGoC). The target sites are major cities of central Greece, including Athens, Patras, Aigion, Corinth and Agrinion. However, we chose to use a much broader area, to avoid strong earthquakes that occur outside the true region of interest being mislocated inside the latter and producing false alerts.

The playback feature of the EEW software was used to fine-tune the automatic location algorithm of PRESTo and to calibrate the equations used to calculate the magnitude, by employing a large dataset of significant earthquakes recorded during the past years in the study area. We estimated the absolute capacity of the currently available network to detect and locate earthquakes promptly. To this purpose, we also take into account the latency of data transmission, given that waveforms have to be transferred to the central server running the EEW software before being processed. The EEW system works best in areas where the seismological network is dense enough for first arrivals to be picked in at least 4 stations within a reasonable travel-time. During the real-time application we recorded examples of earthquakes in which the EEW system produced its first alert promptly and with adequate precision allowing for a 4 sec time-window before the shear waves arrive at a major target city at a minimum 30 km epicentral distance (e.g. Fig. 1).

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