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Evaluation and optimization of seismic networks for earthquake early warning - The case of Istanbul (Turkey)

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In recent years, large efforts have been devoted to developing earthquake early warning systems for earthquake-prone regions around the world. In general, one can distinguish between so-called regional systems, which are based on the seismic signals recorded by local or regional networks, and on-site respectively 'single station' approaches, which use the information carried by the P-wave at a single station to issue warnings for a given close-by user site. In the regional approach, an essential question is how to optimally configure the seismic networks in order to obtain the best possible warning behavior. This includes (a) the largest possible warning times, (b) correct alert levels following a given definition and (c) the lowest possible rate of false and missed alarms.

Using the Istanbul area as a test case, we develop a methodology to optimize the location of seismic stations with respect to the requirements mentioned above. Currently, the Istanbul Earthquake Rapid Response and Early Warning System (IERREWS) comprises ten real-time strong motion sensors distributed around the shoreline of the Sea of Marmara. With our methodology, we mimic the early warning process of the current system. Different sensor configurations are evaluated in terms of their early warning capabilities, using a catalogue of synthetic earthquake records generated from the finite-fault stochastic modeling technique. The catalogue comprises 180 earthquakes with magnitudes ranging between 4.5 and 7.5. The region around the Sea of Marmara is covered by a regular grid of possible station locations and a genetic algorithm is used to find sets of optimum station locations. By including possible locations within the Sea of Marmara in our computations, the added value to the early warning behavior by using one or several ocean bottom stations can be evaluated with this optimization scheme.

We show that, while the current station locations of the existing Istanbul EEW system are well chosen, its performance can be enhanced by modifying the parameters governing the declaration of warnings. Furthermore, unless using ocean bottom seismometers or modifying the current EEW algorithm, additional stations might not lead to any significant performance increase.