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Machine-learning-based operational tsunami warning from light-speed elasto-gravity signals

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Earthquake early warning (EEW) systems implemented worldwide use early seismic records of P waves to rapidly detect, locate, and estimate the magnitude (M_w) of potentially damaging earthquakes. These systems are well known to saturate for large magnitude events, which results in dramatic underestimation of the subsequent tsunamis. Alternative approaches based on different signals have been proposed to rapidly estimate the magnitude of large events, but these approaches are much slower (taking 10 to 20 minutes for first warning). Prompt elasto-gravity signals (PEGS) are light-speed gravitational perturbations induced by large earthquakes that can be recorded by broadband seismometers. They have tremendous potential for early warning but their extremely small amplitudes (on the order of 1 nm/s^2) have challenged their possible operational use. We designed a deep learning approach to rapidly estimate the magnitude of large earthquakes based on PEGS. We applied this approach to the seismic networks operating in Japan, Chile, Alaska and Peru. We will present the performances obtained in these different contexts. In Alaska, the approach has proven capable to reliably estimate the magnitude of $M_w \geq 7.6$ earthquakes (without saturation) in less than 2 minutes, outperforming state-of-the-art tsunami early warning algorithms. Motivated by these performances, we initiated a first implementation of an operational tsunami warning system based on PEGS in Peru. We will present the simulated real-time performance of this system.