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Prompt detection of fault rupture with a gravity-based earthquake early warning system

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During a seismic event, the rupture and the propagation of seismic waves redistribute masses within the Earth. This mass redistribution generates a dynamic long-range perturbation of the Earth's gravity, which can theoretically be recorded before the arrival of the direct seismic waves. In addition to the gravity perturbation, a seismometer also records a gravity-induced ground acceleration: we refer to the overall signal as elastogravity perturbation. Elastogravity perturbations are observed with broadband seismometers and accurately modeled before the arrival of the direct seismic waves following the Tohoku-oki event (magnitude 9.1, march 2011, Japan). We show that such observations provide an early estimate of a magnitude greater than 9, in the three minutes following the origin time. We further propose to use a next generation of instruments to increase the range of magnitude where gravity perturbations can be observed. We show that high-precision gravity-strainmeters with sensitivity of $10^{-15}/\sqrt{\mathrm{Hz}}$ at 0.1 Hz and above can detect prompt gravity perturbations induced by earthquakes. As immediate application, we discuss the possibility to improve current earthquake early warning systems (EEWS). Our results suggest that a gravity-based warning system could reduce the size of the blind zone of the EEWS and increase warning times.