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Elasto-gravity signals heralding the arrival of seismic waves

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After an earthquake, the earliest deformation signals are not expected to be carried by the fastest (P) elastic waves but by the speed-of-light changes of the gravitational field. The observations of these weak signals, and their full understanding, would provide a new data type with a strong potential for a rapid estimate of the earthquake magnitude. We show here that gravity perturbations are particularly well observed with broadband seismometers at distances between 1000 and 2000 kilometers from the source of the 2011, moment magnitude 9.1, Tohoku earthquake. We can accurately model them by a new formalism, taking into account that a ground-attached seismometer is sensitive to two effects: (1) the gravity changes at the seismometer location, mostly caused by the transient dilations/compressions of the medium by the earthquake "classical" elastic waves; and (2) the motions themselves induced by the gravity changes everywhere in the Earth. The latter effect can be understood as an elastic relaxation of the Earth in order to react to the gravity changes. These prompt elasto-gravity signals open the window for minute time-scale magnitude determination for great earthquakes.