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Energy of a tsunami in the framework of an irreversible deformation of the ocean bottom

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The classic approach to tsunami simulation by earthquake sources consists of computing the vertical static deformation of the ocean bottom due to the dislocation, using formalisms such as Mansinha and Smylie's [1971] or Okada's [1985], and of transposing that field directly to the ocean's surface as the initial condition of the numerical simulation.
We look into the limitations of this approach by developing a very simple general formula for the energy of a tsunami, expressed as the work performed against the hydrostatic pressure at the bottom of the ocean, in excess of the simple increase in potential energy of the displaced water, due to the irreversibility of the process.
We successfully test our results against the exact analytical solution obtained by Hammack [1972] for the amplitude of a tsunami generated by the exponentially-decaying uplift of a circular plug on the ocean bottom. We define a "tsunami efficiency" by scaling the resulting energy to its classical value derived, e.g., by Kajiura [1963]. As expected, we find that sources with shorter rise times are more efficient tsunami generators; however, an important new result is that the efficiency is asymptotically limited, for fast sources, to a value depending on the radius of the source, scaled to the depth of the water column; as this ratio increases, it becomes more difficult to flush the water out of the source area during the generation process, resulting in greater tsunami efficiency. Fortunately, this result should not affect significantly the generation of tusnamis by mega-earthquakes.