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Tsunami-induced deformations on land: theory and possible applications for on-shore tsunami recording

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As demonstrated in occasion of the two December, 30 2002 tsunamis that occurred at Stromboli volcano (southern Italy), broad-band seismometers that are installed on-shore in sites located within a short distance from the coastline can detect a signal that can be associated with the tsunami impact against the coast. It is therefore of interest to investigate the deformation on land induced by the tsunami from a theoretical point of view, and to explore the possibility of exploiting this effect to record the tsunami passage by means of onshore stations, in addition to the usual coastal tide-gauges. The ground deformations produced by the tsunami can be seen as the combination of sources of two types: normal forces are associated with the time-dependent hydrostatic pressure field on the sea floor that is caused by the transit of the tsunami waves, and shear forces are probably to be related to the motion of the water particles parallel to the sea floor and to the sea bottom friction. Boussinesq and Cerruti found analytical solution respectively for the normal and the shear single-point force acting on the free surface of a perfectly elastic half-space. Here the horizontal and vertical ground displacements induced by tsunami waves are computed by means of the extension of the Boussinesq's and the Cerruti's solutions to a source of rectangular shape. We consider a 2D tsunami, attacking a coast with normal incidence. The evolution of the approaching tsunami is computed by means of both analytical and numerical methods. Analytically we examine tsunamis induced by near-shore earthquakes and attacking a constant-slope beach, while the numerical approach is used to consider tsunamis generated far from the coast and/or propagating over more realistic bathymetries. Both methods allow one to compute the sea elevation and the horizontal velocity of the water at any position and at any time. Then we use these quantities to calculate the normal load and the traction exerted by the sea on the sea floor, and eventually to

calculate the deformations caused on given coastal points, in terms of Earth’s surface displacements and tilts.