WHAT MECHANISMS ARE RESPONSIBLE FOR TSUNAMI OF THE GREAT TOHOKU EARTHQUAKE OF 2011 : ELASTIC DEFORMATION OR LANDSLIDES ?

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The consequences of the tsunami waves spilling over the sea-walls at Sanriku and the hillside of Fukushima in the aftermath of the great Tohoku earthquake has brought the world anxiously to its knees. The sea-walls built in the 1970s were designed originally to withstand tsunami waves of about 10 meters. Yet the first waves leaped over them with ease. We wish to address these issues in terms of two different models for wave excitation. The first is based on elastic dislocation theory and comes from geophysicists, because it was motivated by analytical tractability of the problem and availability of seismic data, namely, the deformation of the seafloor by the elastic stresses produced by the time-dependent elasto-dynamical strain fields associated with the earthquake rupture. The second is due to the landslides caused by the overlying sediments from localized geological sources along the Japanese coastal margins. With modern instrumentation from submersible observation and initial GPS results, which showed downward displacement along the coast near Fukushima, it is feasible to reconstruct possible scenarios for the landslide model in the vicinity of this site. We employ state-of-the-art code GEOCLAW which can capture the run-up dynamics with a Riemann solver for hyperbolic equations to connect the sea and the beach and to zoom-in the Fukushima coastline with adaptive mesh refinement (AMR) with a local spatial resolution of around 50 meters Some poignant issues we wish to address are : (1) the relative efficacy of the wave-height generation at Fukushima by these two mechanisms shown in Figure 1 (2) what is the degree of nonlinearity in the height of tsunami waves on the beach as a function of the earthquake magnitude. (3) Whether we can test the null hypothesis of a mechanism due solely to the elastic dislocation model. Important to this endeavor is the availability and acquisition of LIDAR data of the seafloor topography with at least 50 to 100 meters spatial resolution near the coast and GPS data along the Japanese coast.

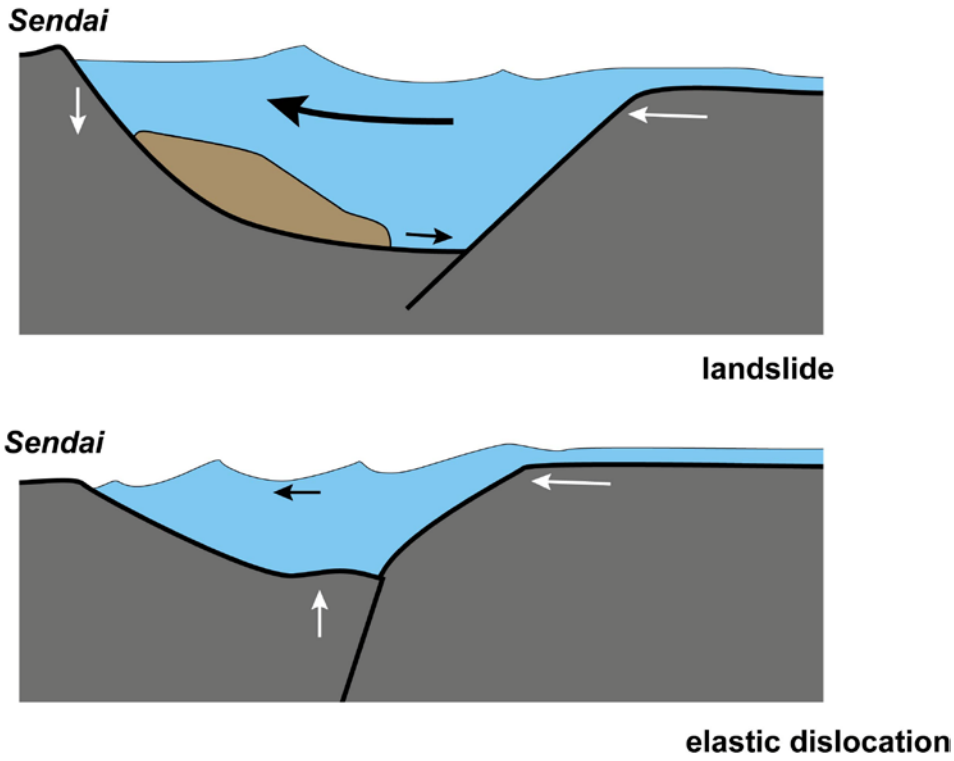
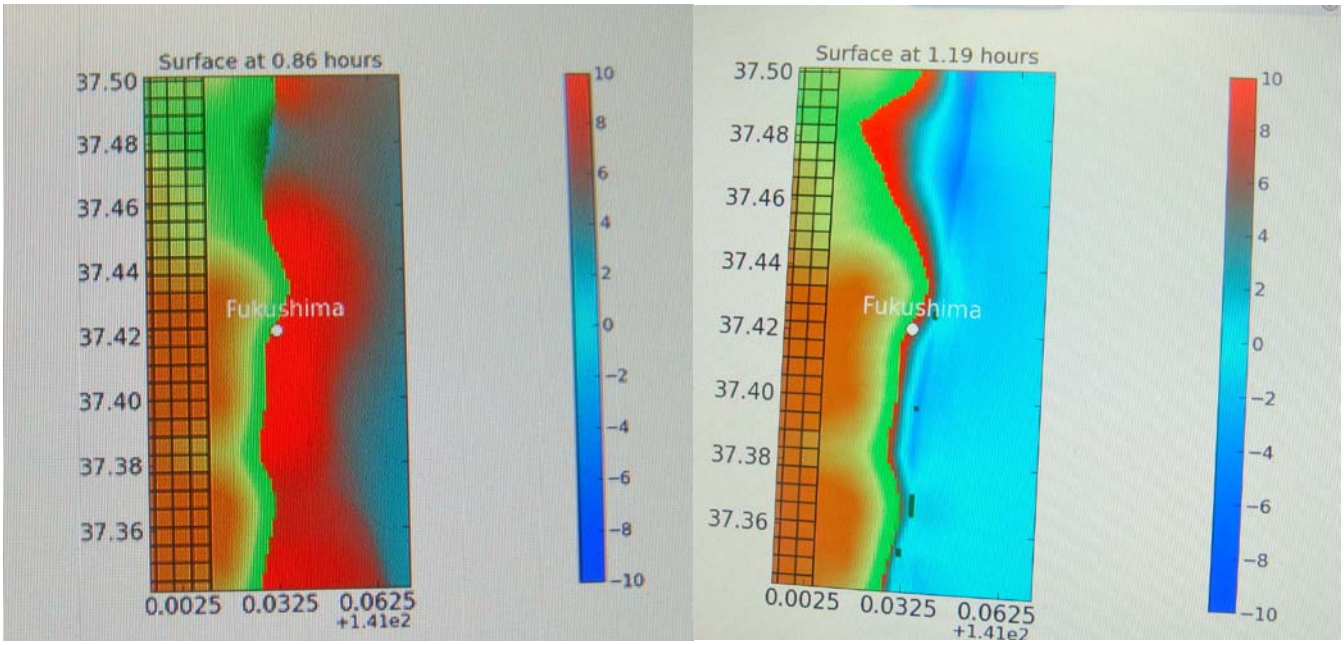


Figure 1 Schematic diagram portraying the two different mechanisms for excitation of tsunami waves associated with Tohoku earthquake



The two snapshots of the modeled sea-surface at Fukushima are taken at times of 0.86 and 1.19 hr after the initial earthquake jolt on March 11, 2011.

Figure 2 Snapshots of numerical simulations of waves hitting the coastline near the Fukushima coastline by the nuclear plant