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The Seismic Sources of the 2009 Samoa Earthquake from Tsunami Simulation

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A big earthquake occurred in the Samoa-Tonga region on September 29, 2009, as the Pacific plate subducts westward beneath the Australia plate along the Tonga trench. The earthquake was recognized as a multiple-source event, but two distinct sets of rupture solutions have been presented: Deducing only from the seismic data, Lay et al. (2010) resolved this instance as an initiation of an intraplate normal faulting (Mw8.1) triggering the two underthrusting subevents (both in Mw7.8); whereas Beaven et al. (2010) presented that the normal fault (Mw7.9) was triggered by the slow thrusting of the interplate motion (Mw8.0), determined from various types of data including tsunami waves. Here, we explore whether and how much the simulations of tsunamis can help discriminating the seismic source solutions. The program COMCOT is used to model the tsunami waves and propagation. The simulated waveforms are compared with the actual observations from three ocean bottom pressure recorders of DART project (Deep-ocean Assessment Reporting of Tsunamis, developed by NOAA). We apply the two afore-mentioned rupture models to determine the respective initial conditions and the radial spreading of the tsunami waves. According to the tsunami waveform simulation, the tsunami waves are the sea-surface perturbation provoked by the large normal fault and the relatively minor thrusts, but in varied weightings of normal-to-thrust mechanism at different DART stations. Simulating with two rupture models for the normal fault provided by Lay et al., it favors the geometry of the normal fault of dipping to northeast, reverse to the commonly thought trench-ward image. This is consistent with the one determined by Beaven et al. Based on our experience, a detailed rupture description can draw a better approximation in tsunami simulation. However, the tsunami simulation cannot discriminate the variation of source mechanisms in the sense that the seismic source time functions processing within one or two minutes is far beyond the temporal resolution of the relatively long-period tsunami waves.

References:

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