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Developing GNSS-Aided Tsunami Early Detection System

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Massive destructions caused by recent earthquake tsunamis have prompted the urgent need for better tsunami detection methods that can provide early warnings to coastal communities in order to save lives. Seismic approaches to earthquake magnitude determination have been traditionally used for tsunami early warnings. Unfortunately, an unacceptable 75% false alarm rate has prevailed in the Pacific Ocean in according to the 2006 U.S. Government Accountability Office report. One of the main reasons for those unsuccessful warnings is that an earthquake's magnitude is not a good predictor of the resulting tsunami power.

Recently, we have advanced the fundamental understanding of the tsunami formation mechanism and discovered new technologies to detect tsunami energy scales, instead of earthquake magnitudes per se, directly from NASA's Global Navigation Satellite System (GNSS) network for early warnings [Song 2007; Song et al. 2008; Song et al. 2012; Xu and Song 2013; Song et al. 2017]. Here I will present forefront researches in the two areas: 1) New theories for better understanding of the tsunami formation mechanism, and 2) GNSS technologies for developing tsunami early warning systems.

A prototype system has been operated in JPL. Examples will be given to show its performance in both retrospective and real-time events. To be specific, for events with abundant GNSS data (e.g., the 2011 Mw 9.1 Tohoku earthquake), reliable co-seismic slip distribution is available within two minutes. In case of insufficient GNSS observations (e.g., the 2015 Mw 8.2 Illapel event), joint inversion based on GNSS and teleseismic P waves provides robust estimation of major asperity. For earthquakes without near-field GNSS data (e.g., the 2016 Mw 7.8 Solomon event), basic features of the earthquake are obtained and the predicted tsunamis agree with the observations reasonably well.