Inversion Results of Mw5.4 and Mw5.3 Strike-Slip Earthquakes

Overview

Path Calibration

Inversion Results of Mw5.4 and Mw5.3 Strike-Slip Earthquakes

Abstract

EARTHQUAKE swarms have been considered as a characteristic seismic phenomenon on the active transform plate boundary. Yet the detail source processes of major events in the swarm have not been studied before due to the lack of station coverage and the medium size of earthquakes. The two M>5 earthquakes in the recent 2012 Brawley swarm have been well recorded by the dense strong motion and GPS stations nearby. Using these datasets, we derived slip model for the two events (Mw5.4 and Mw5.3) by joint inversion of strong motion and GPS data. Different 1D velocity models are applied for various strong motion stations. These essential path calibrations are obtained by waveform modeling of a smaller event (M3.95) in the swarm and allow us to push the waveform inversion up to 3Hz. The results indicate that the Mw5.4 event ruptured unilateral east-west along the focal plane, and the Mw5.3 event ruptured both along the focal plane and orthogonal to the focal plane. The joint inversion strong motion and UAVSAR data indicates that the earthquake has an average rupture speed of 1.75 km/s, which is about 90% faster than the time range from seconds to years, depending on the way the fault is loaded.

Major events in the swarm have not been studied before due to the lack of station coverage and the medium size of earthquakes. The two M>5 events in the swarm show that earthquake triggering could happen in the time range from seconds to years, depending on the way the fault is loaded.

Conclusion

1. Complementary slip distribution between the two largest (M>5) events in the 2012 Brawley swarm, suggests that the fault is not a simple strike-slip fault and has a complex slip pattern. The Mw5.3 and Mw5.4 events have a high frequency energy content.

2. The Mw5.4 earthquake has a centroid depth of 2.0 km and has produced surface rupture. The aseismic slip and long-term aseismic slip are complementary with each other in the fault that the Mw4.9 happened. The Mw4.9 Normal Earthquake

Long Period Point Source Waveform Inversion

High-Frequency Waveform Modeling

PGV and PGA of the Largest Events

Leveling Data and Aseismic Slip

Joint Inversion of Strong Motion and UAVSAR Data

Future Work

1. Use finite fault source in the 3D ground shaking simulation.
2. Include higher frequency features in the finite source.
3. Test dynamic slip models in ground shaking simulations.

Figure 1. Schematic velocity profiles indicating how to obtain a calibrated velocity model. The depth of sediment base is fixed at 5.5 km, the long-term aseismic slip are also complementary with each other on the fault that the Mw4.9 happened. The Mw4.9 Normal Earthquake

Figure 2. 1D velocity models from calibration event. (a) The 1D and 3D depth profiles for the Path Calibration (Path2) used in this study. (b) The 1D models masked from the USGS and CFAST (PVnl, P7, 30-D) 1D velocity models at the location of separation of the 3D event. (c) 1D synthetic waveforms, using making the 1D synthetic models in (a) with a fault model in (b). (d) Observations of the USGS and CFAST (PVnl, P7, 30-D) 1D waveforms, using the 1D models in (a) and the synthetic in (c). Note that these synthetic are computed using the 3D velocity models in (a).

Figure 3. Inversion results of the Mw5.4 and Mw5.3 strike-slip earthquakes. (a) Slip model of the Mw5.4 strike-slip earthquake. (b) The focal mechanism of the Mw5.4 strike-slip earthquake. (c) Slip model of the Mw5.3 strike-slip earthquake. (d) The focal mechanism of the Mw5.3 strike-slip earthquake. The black box indicates the fault model used in the inversion. The yellow box indicates the fault model used in the seismic simulation.

Figure 4. GPS data fitting. (a) Minutes resolution horizontal GPS data from station P502 (red), station P504 (blue) and station P506 (green) and time series of the horizontal velocity, and the horizontal velocity of the crustal displacement from the waveforms. The horizontal velocity (red) is observed at the waveforms. The horizontal velocity (blue) is observed at the waveforms. The horizontal velocity (green) is observed at the waveforms. The horizontal velocity (yellow) is observed at the waveforms. The horizontal velocity (black) is observed at the waveforms.

Figure 5. Long period waveform inversion using the 1D velocity model. (a) Synthetic output for the focal mechanism of the Mw5.4 event. (b) Synthetic output for the focal mechanism of the Mw5.3 event. The synthetic waveforms are filtered to 0.1~3.0 Hz. (c) The synthetics are filtered to 0.1~3.0 Hz. The synthetics are plotted along with the synthetics (red) produced by the total slip models of Mw5.3 and Mw5.4 events. Note that the data has been scaled by a factor of 0.9 before the 2012 swarm which is the left panel.

Figure 6. Observed horizontal GPS data from station P502 (red), station P504 (blue) and station P506 (green) and time series of the horizontal velocity, and the horizontal velocity of the crustal displacement from the waveforms. The horizontal velocity (red) is observed at the waveforms. The horizontal velocity (blue) is observed at the waveforms. The horizontal velocity (green) is observed at the waveforms. The horizontal velocity (yellow) is observed at the waveforms. The horizontal velocity (black) is observed at the waveforms.

Figure 7. Velocity and acceleration waveform data fitting for the largest (Mw>5) event. The largest event at station P503 is shown in the left panel and the long-term aseismic slip for the largest event at station P503 is shown in the right panel for the entire earthquake.

Figure 8. Waveform modeling with the synthetic data for the largest (Mw>5) event. The largest event at station P503 is shown in the left panel and the long-term aseismic slip for the largest event at station P503 is shown in the right panel for the entire earthquake.