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Joint inversion of teleseismic and strong motion data for the rupture process of the 2008 Wenchuan, China, earthquake

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The 2008 Wenchuan, China, earthquake, that is the largest and deadliest earthquake of the world for 2008, occurred on May 12, 2008 (local time). We first obtained teleseismic data observed at stations of FDSN from IRIS DMC, and carried out preliminary point sources analyses of them using the algorithm of Kikuchi and Kanamori (1991). The results of these analyses and aftershock distribution by USGS indicate low-angle dip slips in the southern half and high-angle strike slips in the northern half. Some surface fault investigations (e.g., Hao et al., 2009) suggest two parallel fault traces in the southern half, but only the one closer to the Sichuan basin should be related to the source fault of the earthquake, because the other cannot be of low angle. Accordingly, we defined a fault system consisting of two single-trace segments. The strike and dip angles for the southern and northern segments are respectively given to be (228, 35) and (232, 65) based on the results of the point source analyses.
We next used strong motion data observed by the Institute of Engineering Mechanics of the China Earthquake Administration, and then carried out a joint finite source inversion of them and the teleseismic data mentioned above. We adopted the Green's functions of Kohketsu (1985) and Kikuchi and Kanamori (1991). We also used the inverse algorithm of Yoshida et al. (1996) with the revisions of Hikima and Koketsu (2005), and the location of the hypocenter determined by USGS (103.33E, 30.99N, depth 12 km) as a rupture initiation point. The resultant slip distribution indicates the first asperity with the largest reverse-faulting slip of about 7 m and the second asperity with a strike slip of about 3 m to be located in the southern and northern segments, respectively. The total seismic moment is 1.0 x 10**21 Nm, which corresponds to a moment magnitude (Mw) of 7.9. Significant slips appear in a 250 km long region (10,000 km**2) of the source fault, and these length and area are close to averages for an Mw 7.9 low-angle reverse-faulting earthquake. The strong motion records closest to the source fault mainly consist of the ground motions from the southern asperity and the slips around the hypocenter. They overlap each other because of the rupture velocity (Vr) nearly equal to the S-wave velocity (Vs). Heavily damaged towns such as Yingxiu and Beichuan and the zones of seismic intensity XI determined by IEM were located just above the southern asperity or at the end of the southern segment. The Vr nearly equal to Vs resulted in strong directivity effects and these caused the damaging ground motion at the end of the southern segment.