Geophysical Research Abstracts
Vol. 14, EGU2012-4273, 2012
EGU General Assembly 2012

Co- and postseismic slip distribution for the 2011 March 9 earthquake based on the geodetic data: Role on the initiation of the 2011 Tohoku earthquake

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A large foreshock with M7.3 occurred on March 9, 2011 at the subducting Pacific plate interface followed by the M9.0 Tohoku earthquake 51 hours later. We propose a slip distribution of the foreshock deduced from dense inland GPS sites and Ocean Bottom Pressure gauge (OBP) sites. The multiple OBP gauges were installed before the M7.3 foreshock in and around the focal area. We succeed to collect the OBP gauge data in 9 sites, which included two cabled OBPs in off Kamaishi (TM1, TM2). The inland GPS horizontal coseismic displacements are estimated based on baseline analyses to show the broad area of displacement field up to ∼30mm directing to the focal area. In contrast, there is no coherent signal in the vertical components. The several OBP sites, for example, P2 and P6 sites located the westward from the epicenter of the foreshock clearly detected the coseismic displacement. The estimated coseismic displacement reached more than 100mm in P6 sites. Intriguingly, GJT3 sites, which the most nearly OBP sites from the epicenter, did not show the significant displacement. Based on the inland GPS sites and OBPs data, we estimated a coseismic slip distribution in the subducting plate interface. The estimated slip distribution can explain [U+3000] observations including the vertical displacement obtained at the OBP sites. The amount of moment release is equivalent to Mw 7.2.

The spatio-temporal aftershock distribution of the foreshock shows a southward migration from our estimated fault model. We suggest that aseismic slip occurred after the M7.3 earthquake. The onshore GPS data also supports the occurrence of the afterslip in the southwestward area of the coseismic fault. We estimated the sub-daily coordinates every three hours at the several coastal GPS sites to reveal the time evolutional sequences suggesting the postseismic deformation, especially in the horizontal components. We also examine volumetric strain data at Kinka-san Island, which is situated at the closest distance from the hypocenter. The time series also clearly show the postseismic signal after the M7.3 earthquake. The both of strain meter and GPS time series did not show any acceleration expected as a nucleation process of the M9.0 event; rather, both time series show deceleration of the postseismic deformation before the M9.0 event, even for only two days after the M7.3 earthquake. The OBPs data also indicated the postseismic deformation after the foreshock until the M9 mainshock. Based on the GPS and OBPs data, we estimated the afterslip distribution. The estimated slip distribution is located the southeastern part of the foreshock coseismic distribution. We suggest that aftershocks of the March 9 event may have been caused by stress concentrations along the edge of the afterslip. One of these aftershocks may trigger the huge M 9.0 Tohoku earthquake, although more investigations are required to confirm this scenario.