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Analysis of crustal deformation due to the 2010 El Mayor-Cucapah Earthquake in Mexico using SAR data

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El Mayor-Cucapah earthquake (Mw 7.2) occurred on April 4th, 2010, in Baja California, a region of high seismicity in association with the complex Pacific and North American plate boundary. Its hypocenter is located near a pull-apart basin and the tectonics in this area is very complex owing to distributed normal and conjugate strike-slip faults. In this study, we are going to reveal relationship between the generation process of co- and postseismic fault motions by detecting detailed co- and postseismic deformations by using ALOS/PALSAR and ENVISAT/ASAR data.

We detected range change of about 150cm in the vicinity of the source fault in the ascending co-seismic interferograms. However, we recognized disturbances of fringes in the vicinity of the northwestern part of the source fault and phase discontinuity at a separate fault off the main rupture. In the descending images, we can recognize many concentric fringes along the traces of northwestern part of the source fault, which suggest that local fault motion occurred in connection with the main rupture. In addition, the phase discontinuity is observed in the same area of the ascending interferograms. Therefore subsidiary faults off the main source fault may have generated local deformation during the main shock. We assumed a sufficiently large rectangular plane fault and estimated slip distributions on it. Right lateral strike slips with slight normal component were estimated, and its maximum slip of about 3.5m was obtained in the northwestern vicinity of the hypocenter and at a depth of 3-4km. The optimal dip angle was 68 degrees. While this model can explain the main feature of co-seismic deformation, the residuals in the vicinity of the northwestern part of the source fault are slightly larger than southeastern part. This suggests that it is difficult to explain these local deformations by estimated fault model.

During the postseismic period, about six months after the main shock, we recognized some signals in the northwestern part of the source fault in both ALOS and ENVISAT descending interferograms. Some profiles show range increases (movement to west or subsidence) up to 5cm. These displacements are observed on the west side of the source fault except at the northwestern edge. In addition, we recognized range increase of about 2.5cm in the vicinity of the other faults about 10km southwest of the source fault. This suggests that other faults, which did not slip during co-seismic period, could have moved during the postseismic period. We estimated postseismic slip distributions on the estimated co-seismic fault model. Reverse dip-slip components were dominant in the northwestern part. However this reverse dip-slip is inconsistent with slip during the mainshock in this region, and this model could not explain observed data well. Therefore observed postseismic deformations could have been generated by other factors.

Here, we assumed models with five faults dipping to southwest to explain the postseismic deformations. After trial and errors, we could find a model that can explain the observed phase variations and is consistent with co-seismic fault model which includes slightly normal component. This suggests that subsidiary faults in the vicinity of the source fault moved after the main shock as a result of complex changes of the stress in the crust.

Keywords: SAR, interferometry, El Mayor-Cucapah earthquake, coseismic deformation, postseismic deformation, afterslip