Crustal deformation and Fault Model for the 2015 Nepal (Gorkha) Earthquake obtained from ALOS-2 SAR Interferometry data

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A devastating earthquake with a moment magnitude (Mw) of 7.8 (USGS) struck central Nepal on April 25, 2015, with its hypocenter located in the Gorkha region. A Mw 7.3 aftershock occurred approximately 150 km east of the hypocenter of the main shock on 12 May 2015, which is the largest aftershock as of this writing. In this presentation, we report the detailed crustal deformation associated with these earthquakes obtained by InSAR analyses and the InSAR-inferred distributed slip model.

We employed a new Japanese L-band synthetic aperture radar satellite launched in 2014, called Advanced Land Observing Satellite-2 (ALOS-2), to measure the ground displacement. ALOS-2 possesses a ScanSAR mode which has an ability to observe over broad area with a swath width of 350 km in one action. The ScanSAR-based InSAR is indeed suitable for mapping the spatially comprehensive and detailed crustal deformation of the 2015 Gorkha earthquake.

We have successfully detected widely distributed ground displacements for the 2015 Gorkha earthquake by applying a ScanSAR-based interferometry analysis. A major displacement area extends with a length of about 160 km in the east-west direction. In the southern/northern part, the displacements moving toward/away from the satellite are observed in both orbits. The main crustal deformation area with ground displacement exceeding 1 m is located 20–30 km east from Kathmandu. A quasi-vertical displacement estimated by combining the ascending and the descending data indicates upheaval of about 1.4 m at maximum.

We inverted the InSAR data including both of the main shock and the largest aftershock to construct a slip distribution model. The fault geometry is assumed to be a plane fault. We set a rectangular fault with 220 km long and 150 km wide, corresponding to the plate interface between the Indian and the Eurasian plates. The fault is divided into square patches with a size of 10 x 10 km. The strike and the dip angles are set to be 290° and 10°, respectively. The major slip occurred with a maximum slip amount of approximately 6.3 m beneath the area 20-30 km northeast from Kathmandu, which is located in 80 km east-southeast of the hypocenter. No significant slip is identified further west from the hypocenter. The seismic rupture is thought to have propagated eastward unilaterally. The slips are nearly pure reverse fault motion, but on the deeper portion have a slight right-lateral component. The spatial extent is zonally distributed within a distance of 50 to 100 km from the surface along downdip direction. The downdip end of the slip is quite consistent with that of the interseismic coupling area geodetically inferred in previous studies. The total estimated moment magnitude including both the main shock and the Mw 7.3 event is 7.8 (seismic moment 7.0×10^{20} Nm). Inverting the InSAR data of pair Nos. 5 and 6 which are for the main shock only and the Mw 7.3 event only, respectively, the estimated moment magnitude is 7.8 (seismic moment 6.1×10^{20} Nm) and 7.3 (seismic moment 1.1×10^{20} Nm), respectively.

The slip distribution unnaturally bifurcates in the east, and we can identify a clear-cut slip deficit area with a radius of ~10 km just west side of the Mw 7.3 event. This area is presumably subjected to a strong shear stress which should promote a reverse fault slip. There is a possibility to produce a fault slip equivalent to Mw ~7.0 in the future although we do not know if the slip heterogeneity would be smoothed out by a seismic event or an aseismic event.

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