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The 3D Surface Displacements of the 2008 Wenchuan (Mw7.9) Earthquake Estimated from ALOS and Envisat SAR Data

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The Mw7.9 Wenchuan earthquake (12 May 2008) ruptured the middle segment of the Longmenshan (LMS) thrust belt, located at the eastern margin of the Tibetan Plateau. The location and size of this earthquake shocked many geoscientists even though some prior observations suggested that the faults in this area were active. In the past 4 years, many aspects of the Wenchuan earthquake have been studied using InSAR data, such as the coseismic-slip distribution, the earthquake fault geometry and earthquake triggering. However, the published ALOS InSAR data include strong ionospheric distortions, which were dealt with in various ways, resulting in significantly different coseismic deformation fields of the earthquake as well as dissimilar estimations of the fault geometry and slip distribution.

Out of the 6 parallel ascending ALOS tracks we used (and other authors have used) to map the coseismic deformation, we find that data from 3 tracks are severely distorted by ionospheric effects. Unfortunately, these are also the tracks where the most important fault slip patterns are located, such as the largest surface fault rupture and a transition from pure reverse faulting to a combination of reverse and right-lateral strike slip. Here we use additional interferogram pairs that only include the ionospheric effects, but no coseismic deformation, to remove the ionospheric signals and produce “ionospheric free” coseismic interferograms. We validated our InSAR results against GPS measurements, which show that our corrected InSAR data are in a very good agreement with the GPS observations, confirming a successful removal of the ionospheric signals.

Standard InSAR observations provide limited information along the Wenchuan earthquake rupture because of near-fault phase decorrlation. To overcome this problem, we use azimuth and range pixel offset-tracking to retrieve the full 3D rupture-zone displacements using both the ascending ALOS and descending Envisat data. These observations show well the fault-trace location and help in constructing the earthquake fault geometry. From our fault-trace location, we find that this event also ruptured the Qingchuan Fault with about 60 km, which maybe change the total length of the coseismic surface zone associated with the Wenchuan earthquake. From the 3D surface deformation, we find that right-lateral motion was not only concentrated along the northeastern part of the Beichuan fault, as previously reported, but also along its southwestern portion (Yingxiu county). We also find that the earthquake ruptured only 45 km of the Pengguan fault, or much less than the 72 km or 90 km that have been reported by field studies. Finally, we find that the largest vertical offset was in Beichuan County, about 6 m, which is a somewhat smaller than field estimates.

In our fault modeling we use information from the pixel-offset measurements to constrain the location and geometry of the different fault segments. We then combine the corrected ALOS InSAR and azimuth offset data with GPS observations and descending Envisat (both image mode and ScanSAR) data and estimate spatial details of the fault slip that occurred during the Wenchuan earthquake.

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