Detailed fault ruptures for the 2023 Turkey earthquake revealed by SAR-based crustal deformation analysis

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Introduction

On February 6, 2023 at 01:17 UTC, a Mw7.7 earthquake occurred in Turkey. About 9 hours later, a Mw7.6 earthquake occurred in the north of the main shock. In this presentation, we will report the details of the crustal deformation of both earthquakes obtained by SAR interferometry (InSAR) using emergency observation data from the ALOS-2 satellite, and the fault model inferred from the crustal deformation data.

Data and method

Here we used ALOS-2 satellite data. In this analysis, crustal deformation over a wide area was comprehensively investigated by InSAR using ScanSAR mode that can observe a 350 km wide area at a time. In addition to a standard InSAR method, a MAI method was also applied to detect displacement of north-south component. Finally, 3D displacements were estimated using these data.
We further estimated slip distribution on fault planes. As described below, we found displacement discontinuities across which the orientation of ground motion is opposite. Based on the discontinuities, we set fault planes consisting of small patches, and estimated the slip by a least squares method. We incorporated a spatial smoothing processing using a Laplacian operator. The hyperparameters controlling the smoothing were determined by ABIC.

SAR-derived crustal deformation and fault model

We successfully detected large crustal deformation for both the events. The crustal deformations associated with the Mw7.7 and Mw7.6 events were distributed around the southern and northern strands of the western part of the East Anatolian Fault (EAF), respectively. Displacement discontinuities can be observed with a length of approximately 300 km along the southern branch fault zone. The discontinuity extends from the epicentral area to the east with about N60˚E in strike, while on the western side it changes its strike near Türkoğlu and extends southwestward, terminating near Antakya. The locations of the displacement discontinuities suggest that the Erkenek, Pazarcı k, and Amanos fault segments which are comprised of the EAF were ruptured. Horizontal displacement is predominant in all of these segments, consistent with left lateral fault motion. Displacements of up to approximately 4 m were observed. A significant displacement boundary that branches southward from the Erkenek segment to the Narlı segment was recognized near the epicenter of the Mw7.7 event.
On the other hand, along the northern strand, a displacement discontinuity was observed over a distance of about 100 km from east to west. Horizontal component is dominant and consistent with a left lateral motion. Displacements of up to approximately 5 m were observed. The displacement discontinuities are located just along the Çardak segment. At the eastern end, the strike changes to the northeast. The displacement discontinuity overlaps a portion of the western end of the Sürgü segment which is in the eastern extension of the Çardak segment, but does not continue on the Sürgü segment thereafter, extending in a northeast direction. At the western end of the Çardak segment, the strike changes to the southwest, but there is no clear discontinuity up to the Savrun segment that is the western extension of the Çardak segment. It is further noted that a displacement discontinuity of a few centimeters with a

length of about 70 km is also observed in the Karataş segment, which is distant from the above two fault zones.
The obtained slip distribution indicates almost pure left lateral displacement on all fault planes. Slips on the fault planes are generally concentrated at depths shallower than 5 km. Slip of about 10 m is estimated for the southern strand, while slip of more than 10 m is estimated for the northern strand. In this presentation, we will report the latest model based on more elaborated analysis.

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Keywords: SAR, ALOS-2, Crustal Deformation, Fault Model

