Normal-faulting earthquakes in the northern area of Ibaraki Prefecture in 2011 and 2016 - Duplicate events detected by InSAR observations -

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Introduction

Following the 2011 Tohoku earthquake, many inland crustal earthquakes has occurred with a source mechanism of normal fault motion in the Fukushima hamadori and northern Ibaraki areas. 30 seismic events larger than or equal to Mj5.0 (4 events >= Mj6.0) has occurred in this area, but there has been no events more than or equal to Mj5.0 since January, 2014 (for Mj6.0 since May, 2011). Under such a seismological background, an inland earthquake with Mj6.3 occurred in the northern area of Ibaraki Prefecture at 21:38 on Dec. 28, 2016. On the next day, an L-band synthetic aperture radar (SAR) satellite, known as the Advanced Land Observing Satellite 2 (ALOS-2), makes observations with an emergency operation for the purpose of detecting crustal deformation using SAR interferometry (InSAR), and the crustal deformation has been detected. The most interesting point is that the location, spatial distribution, and magnitude of the obtained deformation is almost same as those observed for the inland earthquake that occurred with Mj6.1 on March 19, 2011. In this presentation, I will show the crustal deformation and the fault model for the 2016 event, and discuss the similarity to the 2011 event.

Crustal deformation and fault model

I applied InSAR analysis to ALOS-2 data to obtain the crustal deformation. The most concentrated crustal deformation is located about 10 km west of the city of Kitaibaraki, with a maximum slant range lengthening of about 30 cm. The deformation elongated along the north-south orientation. A displacement discontinuity with a length of about 2 km is recognized in the northeast of the source region, probably suggesting that a rather shallow slip occurred. On the basis of the interferogram data, we constructed a fault model under an assumption of a rectangular fault with a uniform slip in elastic half-space. I assumed two fault planes to account for the widely-distributed deformation and the local deformation with the displacement discontinuity. The two-segment model is able to reconcile the observations well. The fault model shows (1) west-dipping fault planes with dip angles of 50–60 deg, (2) NNW-SSE (NW-SE) strike direction, (3) nearly pure normal fault motions, and (4) a shallow local slip. The widely-distributed deformation can be explained by a fault that has a fault length of 8 km with NNW-SSE strike at about 2km depth (upper edge of fault). The estimated moment magnitude (Mw) is 5.83. On the other hand, a shallow fault slip that produces the displacement discontinuity on the ground is inferred at the northeast of the main fault. The Mw is estimated to be 5.13. The total Mw is 5.85. The aftershocks occurred around the inferred fault, while there are little aftershocks in the proximity of the fault.

Comparison with the 2011 evetnt

It should be noted that the observed crustal deformation is similar to that for the 2011 event. The crustal deformation for the 2011 event, which is obtained from the InSAR analysis using ALOS data, distributes in almost the same area (Kobayashi et al., 2011). Also for this event, a clear displacement discontinuity was observed, and it is surprising that both the position and the length of the discontinuity are the same between the two events. It strongly suggests that a shallow slip occurred at almost the same location. As is the case in the 2016 event, the aftershocks occurred around the inferred fault, while there are little aftershocks in the proximity of the fault.

Acknowledgements: ALOS-2 data were provided from the Earthquake Working Group under a cooperative research contract with JAXA (Japan Aerospace Exploration Agency). The ownership of ALOS-2 data belongs to JAXA.

Keywords: InSAR, crustal deformation, normal fault earthquakes, Northern Ibaraki

