Fault Model of the Niigataken Chuetsu-oki earthquake in 2007 estimated from geodetic data and precise aftershock distribution

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The Niigataken Chuetsu-oki earthquake in 2007 (hereafter Chuetsu-oki earthquake) with JMA magnitude 6.8 occurred west off Kashiwazaki city in the Sea of Japan on July 16, 2007. The precise analysis of aftershock distribution with the ocean bottom seismometers(OBSs) after the earthquake (Shinohara et al., 2008) clarifies the alignment of the most aftershocks dipping to southeast, which suggests that the major fault plane of the main-shock dips to southeast. In this study, we assume the simple geometry of the fault planes of the Chuetsu-oki earthquake from aftershock distribution determined with the OBSs. And then we estimate the slip distribution on the faults from the geodetic data.

The geodetic data used in this study are the horizontal and vertical displacements at the continuous GPS (GEONET) stations, the line-of-sight displacement from SAR interferomtry with the Daichi (ALOS) satellite, and the vertical displacement by leveling. We used the SAR data acquired from the ascending orbit on June 14 and Sepmteber 14, 2007 and from the descending orbit on January 16 and July 19, 2007. The coseismic deformation shows the contrast of uplift and subsidence in the coastal area. The uplift amounting to 25 cm was observed near the epicenter of the main-shock which locates in the northeastern part of the aftershock area. The subsidence of 5-10 cm was observed near the southwestern part of the aftershock area.

We assumed a fault plane of the main-shock dipping to southeast from the aftershock distribution. The strike and dip of the assumed fault are both 40 degs. We divided the fault plane into 2 by 2 km^2 patches and estimated amounts of dip-slip and strike-slip on each patch. There are clusters of aftershocks dipping to northwest only in the northeastern part of the aftershock area. We, therefore, tested a case with an additional fault plane dipping to northwest. This additional fault assumed only in the northeastern part of the aftershock area. Its strike and dip are 220 and 50 degs, respectively. In order to calculate the synthetic displacement, we used not only Okada(1985)'s method assuming a homogeneous half-space medium but also Wang et al.(2003)'s method assuming a layered half-space medium. The elastic property for the layered medium is characterized by thick sedimental layers. It approximates the velocity structure used in the hypocenter determination. All tested models regardless the medium and the additional fault can explain the observed deformation reasonably. However the RMS with the layered medium is smaller than that with the homogeneous medium. The model with an additional northwest-dipping fault gives smaller RMS than that of only southeast-dipping fault. However, the difference of the RMS is not significant considering the number of parameters. The estimated slip distributions are much different among the tested models. The slip distribution for the model with a homogeneous medium is very rough and seems unreasonable. The estimated moment magnitude is 6.9, which is considerably larger than other studies. The slip distribution with a layered medium is smoother than that with a homogeneous medium. Normal slip, right-lateral strike slip, and reverse slip are estimated in the northwestern part, the shallow part, and the other part on the fault, which looks still unreasonable. The model of both dipping faults with the layered medium gives a smooth and simple slip distribution. The seismic moment for the southeast-dipping and northwest-dipping faults is $1.1*10^{19}$Nm and $0.3*10^{19}$Nm, respectively. The total moment magnitude is 6.7. Considering the misfit and the estimated slip distribution, we suggest that the major fault of the Chuetsu-oki earthquake dips to southeast and that the minor fault dipping to northwest ruptured in the northeastern part of the source area simultaneously. We also suggest that the layered medium is essentially important to calculate the coseismic deformation of the Chuetsu-oki earthquake.