Stress field in the source area of the 2004 mid-Niigata prefecture earthquake

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Stress tensors in the source region of the mid-Niigata prefecture earthquake were inverted directly from the first motion data without assuming that focal mechanisms were known, applying the first motion stress inversion method (termed MOTSI code) as described by Abers and Gephart [2001]. The technique produces estimates of four stress parameters. It also works well for ascertaining the more complete uncertainties associated with the stress tensor parameters by incorporating the uncertainties associated with determining focal mechanisms.

It is likely that events with poorly constrained focal mechanisms, either from insufficient first motion observations or incorrect picks, are generally not useful in constraining the stress parameters [Abers and Gephart, 2001]. We therefore selected 382 events from 2668 aftershocks with more than 20 first-motion polarities, which give well constrained focal mechanisms. In order to investigate the spatial pattern of the stress field in the source region, we divided it into eight areas based on aftershock cluster distributions associated with large events. The velocity structure in the source region estimated by the tomography has significant lateral variations. We therefore used a three-dimensional velocity structure [Kato et al., 2005] to calculate the takeoff angle and the azimuth of each event, which were then used with first motion data to invert the stress tensor parameters.

It is found that the azimuth of the maximum principal stress ranges from W20N to W30N in the central regions (Mainshock area) with a small plunge angle, while the minimum principal stress extends in an almost vertical direction. The orientation of the maximum principal stress is consistent with the regional compressional strain rate axis inferred from GPS data [Sagiya et al., 2000]. Conversely, in the southwest region, the azimuth for the maximum principal stress is from W0N to W10N with a small plunge angle. The difference in the maximum principal stress between the southwest and central regions is significant at the confidence limit of 95% based on the marginal probability density functions for the principal stress axis trend. Note also that the epicenters of the aftershocks located in the southwest area are aligned along N15E, and rotate by approximately 20 counter-clockwise as compared with those in the central one.