Source process of recent M6-class inland earthquakes in Japan

*柴田 律也[1]、麻生 尚文[1]、中島 淳一[1]、井出 哲[2]
*Ritsuya Shibata[1], Naofumi Aso[1], Junichi Nakajima[1], Satoshi Ide[2]

1. 東京工業大学理学院地球惑星科学系、2. 東京大学大学院理学系研究科地球惑星科学専攻
1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2. Department of Earth and Planetary Science, University of Tokyo

In recent years, inland earthquakes frequently occur in Japan including the 2016 Kumamoto earthquake (Mw7.0). Among them, M6-class events are the best targets to study the mechanics of two-dimensional rupture propagation, since smaller events are more difficult to study finite slip distribution while rupture area of larger events tend to be restricted in depth. For this purpose, we investigate the source process of the 2016 Central Tottori earthquake (Mw6.2) and the 2018 Hokkaido Eastern Iburi earthquake (Mw6.6), which are characterized by strike-slip and reverse-fault types, respectively, by applying slip inversion to strong-motion seismograms.

We use KiK-net stations deployed and maintained by NIED (National Research Institute for Earth Science and Disaster Resilience) within 50 km from the epicenter for both earthquakes. Fault geometry is assumed to be same as Kubo et al. (2017) for the 2016 Central Tottori earthquake, while we assume the fault geometry of the 2018 Hokkaido Eastern Iburi earthquake from the aftershock distribution. Fault discretization, source duration, source time discretization, and band-pass filters are optimized manually for each event.

Regarding 2016 Central Tottori earthquake, there has been discrepancies between previous studies. While Kubo et al. (2017) reported the slip of 0.3–0.6 m widely distributed over 5×8 km^2, Ross et al. (2018) estimated concentrated slip of >4 m in 3×3 km^2. Recently, Meneses-Gutierrez et al. (2019) obtained the slip of 1–2 m over 5×5 km^2 by analyzing GNSS (Global Navigation Satellite System) data. Our results mainly agree with Kubo et al. (2017), but larger slip is distributed more heterogeneously in our model because we do not apply smoothing. The concentration of slip near the hypocenter as reported by Ross et al. (2018) is also confirmed especially when we use finer model resolution. Therefore, the discrepancy reported in the previous studies may be due to the resolvability of slip with strong directivity in ordinary finite fault inversion, which usually requires sparse discretization and/or a smoothing constraint.

As a result of slip distribution of the 2018 Hokkaido Eastern Iburi earthquake, we obtained the slip in between right-lateral strike-slip type and reverse-fault types at the beginning, which is consistent with the mechanism determined by JMA (Japan Meteorological Agency) using first-motion polarities, while total slip is predominated by the reverse-fault component, which is consistent with the CMT (centroid moment tensor) solution determined by NIED using surface wave amplitudes. The final slip is separated in the shallow part and the deep part, similar to the distribution of aftershocks.

In both earthquakes, the rupture tends to expand in the direction parallel to the slip regardless of the rake direction. The prevailing mode II rupture over mode III rupture is consistent with the expectation from rupture mechanics (e.g., Day, 1982; Madariaga et al., 1998).

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