Validating the Method Estimating Fault Slip Angles by Using the Wallace-Bott Hypothesis and Regional 3D Stress Field

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The Wallace-Bott hypothesis, the direction of fault slip is parallel to the resolved stress vector on a preexisting fault, and regional 3D stress filed data by Terakawa and Matsu’ura (2010) are used to estimate fault slip angles for mapped submarine faults (e.g., MLIT, 2014). The strong ground motions and tsunamis were simulated by using the estimated fault slip angles. However, the method determining fault slip angles by using the Wallace-Bott hypothesis and regional 3D stress field has not been adequately validated. Here, we validate the methodology and applicability of estimating the fault slip angles using the two catalogs of focal mechanism solutions.

Terakawa and Matsu’ura (2010) estimated the regional 3D stress field by using the F-net focal mechanisms from January 1997 to January 2007, which were provided by the National Research Institute for Earth Science and Disaster Resilience and the method by Terakawa and Matsu’ura (2008). Here, we validated the above method for F-net mechanism solutions after February 2007 to December 2018 and Japan University Seismic Network Earthquake Catalog of First-Motion Focal Mechanisms (JUNEC FM[2]; Ishibe et al., 2014). We evaluated the misfit angles between the rake angles from focal mechanism solutions and those from estimated from the Wallace-Bott hypothesis and 3-D tectonic stress field by fixing the fault strike and dip angles. We also discussed the relationship between the residuals of fault slip angles and magnitudes of earthquakes, quality or variance reduction of focal mechanisms, or the number of nearby earthquakes used for the inversion.

The misfit angles are mostly small (<30 deg.) except for the source and surrounding regions of large earthquakes (e.g., 2011 off the Pacific coast of Tohoku earthquake) and swarm-like activities activated after the 2011 Tohoku-oki earthquake. The misfit angles correlate with both the number of earthquakes within a certain radius (e.g., 30 km), which were used for the stress inversion and quality of focal mechanism solutions used for the verification. These results imply the validity and effectiveness of estimating the fault slip angles for a specific fault with known fault geometry from the above method and data, while it requires close attention to apply the method for the regions with seismically inactive and/or nearby the recent large earthquakes where the stress field have been perturbed. We note that some swarm activities with large misfit angles show the transparent migration of hypocenters, which can be attributed to the contribution of fluid. Terakawa et al. (2013) suggested that the contribution of pore-fluid caused the unfavorable fault slip directions from the regional tectonic stress field.

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