海陸測地観測データにもとづく2011年東北地方太平洋沖地震直後の余効すべりの時空間的特徴

Spatial and temporal characteristic of the early afterslip following the 2011 Tohoku-Oki earthquake deduced from onshore and offshore geodetic data

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The Tohoku-Oki earthquake (M_w 9.0) struck northeast Japan on March 11, 2011. A dense onshore geodetic network in tandem with seafloor geodetic observations captured large coseismic and postseismic deformation. An understanding of the spatial and temporal evolution of the early afterslip, beginning immediately after such a massive interplate earthquake, is essential to understanding the frictional properties of the plate boundary. On this basis, we investigated the spatial and temporal evolution of the early afterslip following the 2011 Tohoku-Oki earthquake using on- and offshore geodetic data. To identify the distribution of early afterslip, we utilized geodetic observations from onshore Global Navigation Satellite System (GNSS) and Ocean Bottom Pressure gauge (OBP) sites to quantify postseismic deformation. We adopted the kinematic GNSS analysis to obtain a higher temporal resolution. We applied the common-mode error analysis and principal component analysis to improve the signal-to-noise ratio of the kinematic GNSS time series. To estimate early afterslip distribution, we utilized L1-norm regularization, which is characterized by regularization without smoothing. The main area of the estimated early afterslip was located off the shores of Iwate, Miyagi, Fukushima, and Ibaraki at a depth of 30–60 km. The slip was narrow along the dip direction with an along-strike variation. Several fault patches were estimated to occur offshore. These were estimated to explain the subsidence at the OBP sites. We examined the spatial relationship between the early afterslip with the down-dip limit of the interplate earthquakes and the distribution of the aftershocks. The estimated early afterslip distribution was consistent with the down-dip limit of the interplate earthquakes off Miyagi and Iwate. Several cross-sections along the strike direction clearly showed the different characteristics and locations of the afterslip and aftershock activities. For example, off Miyagi and Iwate, the location of afterslip tended to be in the up-dip portion of the larger afterslip area. In contrast, off Fukushima, the distribution of aftershocks was in the down-dip of the larger afterslip area. This discrepancy is attributed to along arc-variation with different structural characteristics. Based on the temporal evolution of afterslip, we emphasized the relationship between early afterslip evolution and the number of aftershocks. Aftershock–afterslip temporal evolution is consistent in almost every region, although the regions off Iwate and Miyagi showed a lack of aftershocks 30 hours after the mainshock, in contrast with the estimated early afterslip.