Spatial and temporal variation of stress state in east Japan during the 2011 Tohoku-oki earthquake: Insights from S-wave splitting analysis from ambient noise records

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The 2011 Tohoku-oki earthquake induced significant deformation of east Japan. However, the temporal and spatial variations of the regional stress field are poorly known. Here we apply S-wave splitting analysis for continuous ambient noise records to reveal temporal and spatial variations of the stress field during the 2011 Tohoku earthquake. Before the Tohoku earthquake, we observed small temporal variations in fast S-wave oscillation directions (FSODs), indicating high time-stability of our approach. At the Tohoku earthquake, we observed clear change in FSODs. We identified small rotations of FSODs and their gradual return to pre-earthquake values. We suggest that these changes represent temporary rotations of the maximum horizontal stress directions caused by the earthquake. We further identified 90° changes in FSODs in the volcanic region, suggestive of changes in pore pressure conditions due to magmatic activities. We also observed 90° changes in FSODs in the eastern coast of the study area. We interpret the cause of these 90° changes as changes in pore pressure conditions because increase of maximum shear strain or seismicity was observed in this region. From temporal and spatial variations of estimated FSODs, we classified east Japan into three regions with similar stress change associated with the Tohoku earthquake. Since our approach using ambient noise has high temporal resolution, we can identify temporal changes in FSODs and monitor their recover process. As a result, we can possibly distinguish changes in FSODs associated with rotations of maximum horizontal stress directions with those associated with pore pressure conditions. Therefore, our approach may be a new monitoring tool of stress state to identify unstable regions and predict aftershock and volcanic activity.

Keywords: temporal changes, ambient noise, S-wave splitting, Tohoku-oki earthquake, stress state

