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東北地方太平洋沖地震にともなう津波による地形変化のレーザ測量調査
Laser scanning surveys to analyze morphological impacts of the 2011 Tohoku-Oki Tsunami, northeastern Japan

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A massive earthquake of Mw = 9.0 occurred on Friday 11 March, 2011, off the Pacific coast of northeastern Honshu, Japan. The earthquake triggered destructive tsunami waves that struck the Pacific side of Japan, traveling up to 9 km inland. The damage caused by the tsunami waves was much greater than that by ground motion due to the large earthquake. We investigated the impact of the huge tsunami on landforms in the coastal area. The tsunami waves destroyed numerous buildings and other artificial objects, and they entrained mud and sand from the seabed. However, erosion and deposition on flat lowlands and relatively wide valley bottoms were unexpectedly limited. In contrast, side-slopes of valleys along a ria-type coast locally underwent erosion, including the removal of vegetation, soil, and regolith, and even bedrock may also have been modified due to strong wave action. To understand the characteristics of landforms affected by such erosion, we conducted field surveys in some coastal valleys and collected high-resolution 3D topographic data using a terrestrial laser scanner (TLS). The targets of scanning include both relatively broad valley-side slopes and specific landslides caused by the tsunami waves. They include the valley of Aneyoshi, where the maximum tsunami run-up height was measured (38.9 m). The results indicate some differences between the surveyed slopes and more usual slopes. For example, nearly vertical segments often occur at lower slopes, although they are almost free from erosion by normal coastal waves and rivers. The inclination of side slopes of river meander bends also differs from that resulting from normal fluvial erosion due probably to erosion by tsunami waves. In addition, the locations of some landslides correspond well to the measured heights of tsunami inundation, pointing to erosion induced by the tsunami on March 11. Historical and sedimentological records indicate that the study area experienced multiple large tsunamis in the late Holocene. Erosion by the repeated tsunamis seems to be responsible for the observed unique slope shapes. In other words, topographic characteristics of slopes may be used to identify areas with high risk of large tsunamis.
Keywords: tsunami, erosion, bedrock, terrestrial laser scanning, valley-side slope