Acquisition of micro-landforms in the forest using small UAV-LiDAR: An example from surface rupture of the 2008 Iwate-Miyagi Nairiku, Japan, earthquake

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For active fault research, photogrammetry (e.g., Photoscan) with UAV (Unmanned Aerial Vehicle) has been introduced to map surface ruptures for the recent earthquakes. However, this method has mainly two drawbacks: it is necessary to set reference points (GCP: Ground Control Point), and it cannot be applied to ground in the dense forest. A small LiDAR equipment attached to the UAV laser is expected to overcome these issues. Although this approach is considered to be effective for detailed mapping of earthquake surface ruptures, none of the papers has been published such an application in the forest. Here we investigate the effectiveness of UAV laser surveying under the forest comparing to the topographical data acquired by terrestrial laser survey (Maruyama et al., 2008; Yoshimi et al., 2010) for the surface rupture that appeared at the 2008 Iwate Miyagi Nairiku earthquake.

Our study field is along the ~0.7-km-long surface rupture located in the north-east of the Aratozawa Dam. The heights of the free faces was several tens of cm to 2 m. We conducted the UAV flights at an altitude of 50-70 m on November 15, 2018. The area is densely covered with cedar plantations and broad-leaved trees, and thus surface rupture is almost invisible from aerial photographs. For the UAV aviation laser surveying, DJI Matrice 600 Pro owned by Waseda University was used. Six GNSS receivers mounted on the UAV allows us to precisely calculate the UAV location only with the errors of the attitude (0.1 °) and the position (1 cm). Based on the precise position information of the UAV, we attached the LiDAR equipment Velodyne's VLP-32C to the UAV to acquire detailed topographical data in the forest. We filtered the point cloud data using Landforms of ISP's software, and then extracted only the ground surface removing the points reflected from vegetation. The swath of ~0.16 km^2 along the surface rupture, measured in about 15 minutes of flight, enable us to provide about 69-million-point cloud data. Among them, the ground point data of ~200,000 points were only screened (~0.3%). Even though it is much fewer than the 8 million points obtained by terrestrial laser surveying of Mariuyama et al. (2008), the points are more homogeneously distributed and data loss is small. Since the terrestrial laser irradiates the beam to the horizontal direction from the installed machine, the data could not be acquired from a blind spot behind trees. In terms of data precision, we confirmed the DEM model from UAV LiDAR is comparable with the terrestrial LiDAR DEM with centimeter-order accuracy. An absolute advantage of the UAV LiDAR is overwhelmingly short operation that allows us to perform not only urgent post-earthquake survey but also repeating measurements to follow degradation process of fault scarps.

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