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Spatial analysis for distributions of vegetation and soil thickness in a mountainous region using LIDAR data

IKEMI, Hiro[1*], Yasuhiro Mitani[1], Ibrahim Djamaluddin[1], Jia Ning[1]

[1]Graduate school of Engineering, Kyushu University

1. INTRODUCTION

In this research, we discuss a method to clarify a regional distribution of soil thickness which is an important factor of collapse in order to improve the accuracy of slope failure prediction. First, with a geographic information system (GIS), we have developed a method to extract information of vegetation such as tree heights and tree densities in mountainous regions using the 10m digital elevation model (10m-DEM) of the Geographical Survey Institute of Japan and airborne laser surveying data (xyz-points data; LIDAR data) collected by Fukuoka Prefecture in 2003. Next, a distribution of soil thickness has been simulated using the process-based model (Dietrich et al., 1995) in order to examine a relationship between the vegetation information and soil thickness.

The study region that is 20 km^2 is located at Umi in Fukuoka Prefecture of southwestern Japan. The geology consists of Mesozoic granitic rocks which are the Sawara granite and Itoshima granodiorite. In this region, more than a few hundred slope failures were caused by the torrential rain disaster in 2003. The subsequent geological survey has showed that the past debris flow events have been confirmed in some outcrops (Kyushu Branch of the Society of Engineering Geology, 2004). The mountainous region where disturbance to vegetation due to landslides often occurs like this region might show a correlation between vegetation and soil thickness (Kuroki et al, 2011).

2. METHODS

2.1 Extraction for information of vegetation using LIDAR data

The airborne laser survey can measure the height of ground surface and features with high precision by a pulsed laser light irradiated from the air. But the high precision DEM due to LIDAR cannot be expected owing to a lot of trees in the region. Thus, the basic geomorphic values have been calculated using the 10m-DEM, and the LIDAR data have been used for extraction of information about vegetation. At first, the LIDAR point data are modified in order to move each gradient vector of a 10m-grid into the horizontal plane, or to remove variations in height due to geomorphic relief. The next, simply assuming that variations in elevation after the modification depend on density and height of the vegetation on each grid, the vegetation coverage ratios (VCR) can be calculated as follows,

VCR = (average elevation - minimum elevation) / (maximum elevation - minimum elevation).

2.2 Simulation of soil thickness

Distribution of soil thickness has been calculated by the finite difference method using the process-based model. In this model, the movement of soil depends on geomorphic relief as defined by -Kdz (K: diffusion coefficient, dz: slope). The simulation of soil development has been carried out using the parameter of Dietrich et al. (1995) and the 10m-DEM as an initial elevation with 100 year time steps until 6000 years.

3. RESULTS AND DISCUSSIONS

The distribution of VCR has a tendency to increase in forest area. However, a linear correlation is not observed between the VCR and the normalized difference vegetation index (NDVI) derived from a LANDSAT image of 2001. It means that VCR and NDVI show different information of vegetation. The calculation of soil thickness shows relatively high values in the catchments which are identified as the runoff erosion threshold in the modeling of hillslope processes (Tucker & Brass, 1998). The variation of the soil thickness increases with the increase of the VCR, and reaches a maximum at around 0.7 in VCR. These results imply that the vegetation analysis using LIDAR data has a possibility to detect a soil distribution or slope failure inventories.

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Kuroki et al. (2011): Proc. of Japan Soc. Eng. Geol. Annual Meeting 2011, CD
Dietrich et al. (1995): Hydrological process, 383-400
Tucker & Bras (1998): Water resources research, 34(10), 2751-2764

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