Analysis of stream-net structure on bare lands based on digital photogrammetry and GIS

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High-resolution digital elevation models were constructed for bare lands in Usu Volcano and the Southern Japanese Alps using digital aerial photogrammetry. Stream nets were delineated on the assumption that a threshold contributing area determines the position of channel heads. Stream nets were also digitized on the ortho-rectified photographs. The obtained data allowed the calculation of morphometric parameters such as slope angle, stream order, drainage density, the bifurcation ratio and the stream length ratio. The relations among these parameters were analyzed using GIS. The results provided new insights into the relation between drainage density and the slope and that between the bifurcation ratio and the stream length ratio.

In Japan, accelerated erosion due to rapid channelization has often been observed on bare lands caused by hazards such as volcanic eruptions and large landslides. Analyses of drainage structure and the relationship between the drainage structure and the other geomorphological properties are important to understand channelization and erosion processes in bare lands. Previous studies on this subject often relied on detailed field measurements of topography, but their spatial coverage of data has been limited. High-resolution quantitative data for wide areas are necessary for the detailed analyses of stream nets on bare lands. The recent development of digital photogrammetry has allowed the construction of such data in the form of DEMs (Digital Elevation Models).

This study deals with two bare lands in Japan. One is located near the top of Usu Volcano, Hokkaido, where eruptions in the late 1970's produced ash-covered bare surfaces. Many small channels and gullies have been developing on the surfaces. The other is a large landslide called Aka-Kuzure in the Southern Japanese Alps of central Japan. A landslide scar has undergone intensive channelization to create a badland.

Using 1:8000-scale stereo aerial photographs and a DPW (Digital Photogrammetric Workstation), DEMs with a 1-meter grid interval were constructed for an area of 0.47 square kilometers in Usu Volcano, and for an area of 0.7 square kilometers in Aka-Kuzure. Digital input images were scanned from the contact positive films of the air photos at a 20 um resolution. The errors of triangulation height adjustments to the ground control points were smaller than 1.0m for the Usu area. The ortho-photo images of the two areas were also created.

The obtained DEMs allowed the automatic derivation of channel networks by assuming a threshold contributing area or the location of channel heads. Channel networks in the Usu area were also digitized from ortho-photo images. We applied some different values of the threshold contributing area, and compared constructed stream nets with the digitized nets to determine an appropriate threshold value.

Based on the obtained channel networks, basic properties of the drainage structure such as stream orders, drainage density, the bifurcation ratio and the stream length ratio were derived. Height and slope angle data for sub-watersheds were also obtained from DEMs. Then the relationships among the morphometric properties were investigated. All these analyses were performed with GIS (Geographical Information Systems).

The results have provided some new insights into the stream-net structure on the bare lands. Previous studies pointed to positive correlations between slope angle and drainage density in terrains where overland flow is a dominant erosion process; whereas, negative correlations hold true in terrains dominated by mass wasting. Although the bare land in the Usu area is dominated by overland flow, a negative correlation between drainage density and the slope angle is observed for Usu as well as Aka-kuzure. The graphs of drainage density versus the slope angle for sub-watersheds can be classified into two types: convex and concave. The convex type tends to occur in more severely eroded sub-watersheds, suggesting that the concavity of the graphs corresponds to the stage of channelization. Although previous research has indicated that the bifurcation ratio and the stream length ratio vary according to terrain steepness and the two parameters are negatively correlated, the data for Usu and Aka-kuzure indicate positive correlation between the two parameters.