# Comparative analysis of manual and automatic extractions of hummock landforms in Mt. Gassan, northwestern Japan


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*Abstract*—We perform comparative analysis for quantitative extraction of hummock landforms in a debris avalanche deposits formed by volcanic sector collapse. Polygons of hummocks derived from manual reading of aerial photographs are more similar to those from object-oriented image analysis than from elevation scale change.

## I. INTRODUCTION

Hummocks are characteristic landforms formed on debris avalanche deposits (DADs) after catastrophic sector collapse of volcanoes [1,2], being a key morphology to estimate the characteristics of DADs. While identification of such hummocky landforms has often been performed manually using stereo-paired aerial photographs with support of field investigations [3-9], quantitative and quick extraction of hummock landforms from topography itself using digital elevation models (DEMs), which shall be useful particularly in remote areas, is a challenging theme. Here we perform comparative analysis of manual and automatic methods of the identification of hummock landforms.

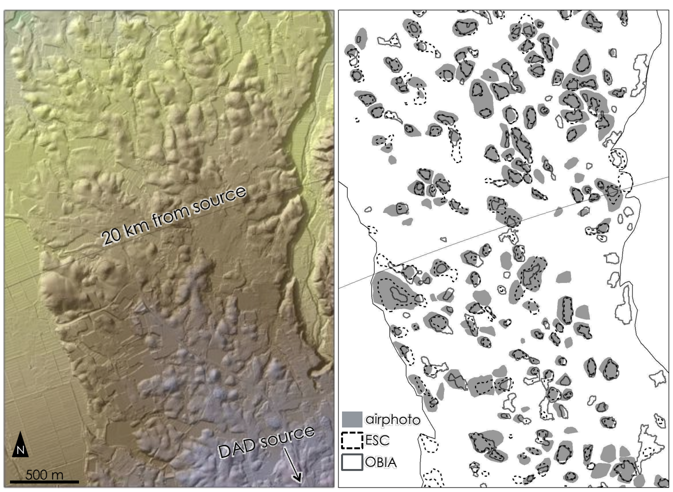


Figure 1. Hillshade image of the central part of the study site by 2-m resolution airborne laser scanning DEM, and hummock polygons extracted by the three different methods; light-gray-filled: manual airphoto reading, dashed black outline: ESC; solid dark-gray outline: OBIA

## II. STUDY AREA AND METHODS

We investigate the Sasagawa DAD (<400-300 ka, 50±30 x$10^8$ $m^3$) located at northern side of the Mt. Gassan volcano in northwestern Japan. DEM with a resolution of 2 m derived from airborne laser scanning is used for the automatic extraction methods.

As a reference, we use polygon data of hummocks manually extracted from stereo-paired aerial photographs taken in 1990s by means of stereopsis ("airphoto reading"). Two other automatic methods are proposed. One utilizes scale-dependent changes in elevation with increasing buffer lengths (10–150 m by a 10-m step) for each cell of DEM ("ESC"; elevation scale change). Local bulges with relatively higher elevations within the search scales can be identified by this method, which is similar to the algorithm to identify locally steep sections in rivers (knickzones) by slopes [10]. The other applies object-based image analysis ("OBIA") [11]. A multiresolution segmentation (MRS) was performed on a residual relief layer, computed as a difference between the original DEM and a smoothed surface. Classification of segments considered mean layer values, segment geometry, and context.

## III. RESULTS AND DISCUSSION

More than two hundred polygons are investigated in the study area. The area properties of the polygons derived from the different three methods indicate that the OBIA method is more

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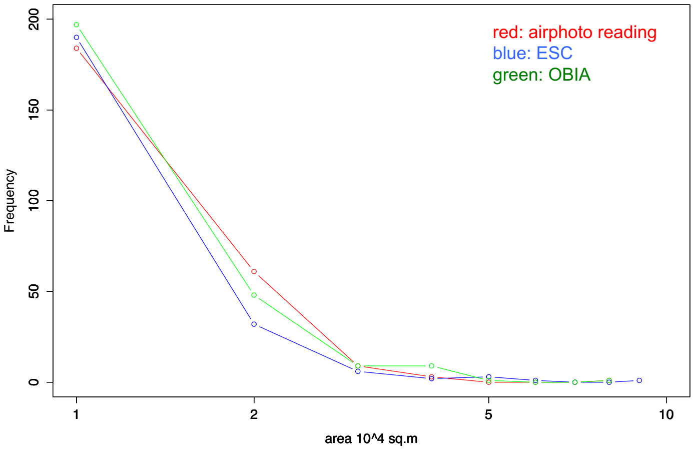


Figure 2. Histograms of polygon area of hummocks for the different extraction methods.

comparable to the airphoto reading in terms of polygon number and size (Table I, Fig. 2), while the ESC method often gives unexpected mounds particularly along the eastern edge of the DADs (Fig. 1). Although the actual extent of hummock edges would need to be validated in the field, the good agreement of airphoto reading and the OBIA methods method shows much potential of identifying numerous hummocks of DADs in remote areas.

## IV. Concluding Remarks

The comparative analysis of different approaches for hummock extraction in DADs was performed in this study as a case of a Japanese volcano. An object-oriented methodology was found suitable to extract hummocks in a way that closely replicates human interpretation. Based on this, such approaches will be further assessed in other regions including Japan and pan-Pacific areas. Examinations with different DEM resolutions and object scales are also important for worldwide comparisons.

TABLE I. Comparison of polygon sizes by the different methods

| | airphoto reading | ESC | OBIA |
|---|---|---|---|
| number of polygons | 258 | 235 | 265 |
| mean area ($m^2$) | 8331.65 | 6931.30 | 8432.70 |
| maximum area ($m^2$) | 71174.43 | 85501.58 | 73584.50 |
| minimum area ($m^2$) | 1074.20 | 5.48 | 1092.00 |

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