Characterization of landslide deposits using SAR Images

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Abstract- This paper provides some preliminary results of the use of RADARSAT fine mode image for characterizing the debris size and distribution of a 30x $10^6 m^3$ rock avalanche. From the image we were able to classify coarse, medium and fine debris based on their SAR texture. Such simple textural classification will be useful to plan more detail field and aerial surveys on large landslides so as to understand landslide processes, post failure mechanism and mobility.

INTRODUCTION

Two distinct approaches can used to determine the characteristics of landslides from remotely sensed data. The first approach determines the number, distribution, type and character of landslides using high- resolution stereo and fused images. The second approach complements the first one, by measuring dimensions (length, width, thickness and local slope, motion, and debris distribution) along and across the landslides using stereo SAR, InSAR and topographic profiles (e.g. laser altimeter profiles). Where possible these dimensional data are compared to field information and previous studies.

However, the roughness of landslides has not been studied in detail from remote sensing. The lack of detailed topographic data for blocky landslides has also meant that the link between their roughness and radar backscatter (σ^0) has remained elusive. This paper looks at one aspect of the 2nd approach. We briefly discuss the use of SAR roughness images in characterizing landslide deposits with a focus of a southern Alberta rock avalanche.

A Rock Avalanches

Worldwide, thousands of landslides occur annually moving millions of tons of material. Based on estimates from the International Federation of Red Cross and Red Crescent Societies there were on average 1,550 landslide-related deaths per year. A rock avalanche is a large mass of predominantly dry rock debris derived from the collapse of a slope and moving at a high velocity and for a long distance, even on gentle gradients. The deposits often have large-scale surface structures such as ridges, folds, and grooves. They commonly occur with other natural disasters such as earthquakes [1], volcanic activity [2], and floods. The speed of a rock avalanche can be tens of meters per second, with travel distances in the order of kilometres. The volumes of material involved can exceed 1 x 10^6 m^3, covering areas of > 0.1 km^2. It is these characteristics that make this type of landslide extremely hazardous

The assessment of landslide hazards has traditionally been in the field of civil engineering. Slope stability analysis has been used to assess landslide hazards, and more recently remote sensing techniques are being used in stability assessment [3], [4],[5],[6].

Roughness is defined as the topographic expression of surfaces at horizontal scales of centimetres to a few hundred meters. Landslide surface structures and roughness provide information on flow emplacement parameters (such as emplacement rate, velocity, and rheology). Laser altimeters are used to calculate surface roughness. Digital image analyses of large-scale photographs were used to analyse grain size distribution of rock avalanche debris [7]. In-situ methods used to examine of the statistical roughness of geologic surfaces can improve the interpretation of remotely sensed data at all wavelengths.

Our study focused on the Frank Slide, a 30x $10^6 m^3$rockslide-avalanche of Paleozoic limestone occurred in April 1903 from the east face of Turtle mountain in the Crowsnest Pass region of southern Alberta, Canada (Figure 1). Seventy people were buried. Several investigations focused on characterizing grain size and distribution of this rock avalanche, in order to understand post failure mechanism and mobility. [7],[8].

B. *Methodology*

For this study, one RADARSAT Fine Mode, Beam 4, (43^o-45^o) ascending, acquired on 1-September-2001, was used. It was verified, that there had been no precipitation on the acquisition date as well as several days before in order to eliminate ground moisture induced effects on the radar backscatter. The data were processed to a 16-bit path oriented, single look product with 6.25 m pixel spacing (SGF). The image data were not filtered or rectified in order to avoid any disturbance of pixel neighborhood relationships introduced through the re-sampling procedures.

Several methods are available for evaluating SAR texture parameters and for subsequent classification; Well-established texture measures retrieved from co-occurrence matrices and the analysis of local histograms were used [9],[10]. A SAR textural map of the debris deposit showing debris size distribution was produced.

From field photographs of the accumulation zone, three areas of predominantly coarse, medium textured, and fine debris were selected for local histogram analysis. After linearly scaling the RADARSAT data to 8 bit, the pixel values for three windows of approximately 1400 pixels each, falling within the selected areas, were extracted from the SAR image. Histograms were generated for each sample, depicting gray value frequencies. Various statistical parameters are used to describe the local histograms' distribution (Figure. 2).

Figure 1: Field photograph of the Frank Slide, Alberta.

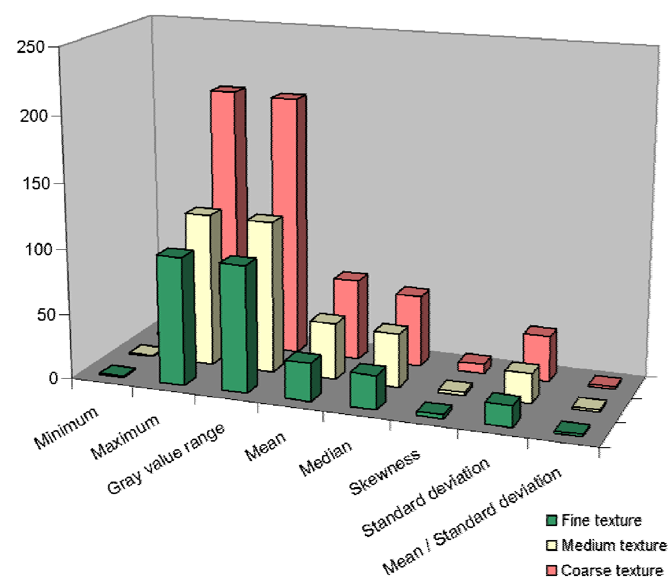

Figure 2: Statistical parameters showing the distribution of extracted histograms.

C. Results

Our results have shown that a SAR textural map of a large rock avalanche can a useful first step, in the understanding of post failure mechanism and mobility.

- There is a close relationship between the SAR textural measurements and the debris size distribution and ridge morphology.
- There is a random distribution of coarse debris throughout the deposit, except in areas where boulder ridges were identified. This would confirm that the dispersive forces during shearing and motion –induced vibration [8], would create such roughness distribution.
- Lateral ridges and distal rims characterized by coarse debris at the surface and a clean sharply defined edge of boulders were identified in the field [8] and on the SAR size distribution map.
- Close up field photos show vertical size sorting and a strong inverse grading described by [8]. Fig 2, shows the general abundance of coarse debris at the surface followed by the medium and fine. This again confirms the motion induced vibration mechanism.
- The fine materials in the splash zone at the side margins were not identified mainly because these areas are now covered by vegetation.

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