Terrain interpretation from SAR Techniques

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***Abstract*—Our results have shown that selective processing of RADARSAT-1 images have assisted in regional terrain mapping of large areas the northern boreal forest region in Canada. Terrain roughness information derived from RADARSAT-1 when fused with high resolution DEM data provided image maps that are useful for landform interpretation.**

Keywords-Terrain Mapping, RADARSAT, Boreal Forest

INTRODUCTION

The use of radar images for terrain mapping has been reported by, [1,2,3,4]. However, the correlation between SAR backscatter and terrain units varies considerably based on local relief, vegetation and surficial materials. This paper describes interpretation methods using RADARSAT thematic image maps for geological terrain mapping in generally low relief areas dominated by coniferous vegetation of the northern boreal forest regions of Canada.

The Ontario Geological Survey and the Canada Centre for Remote Sensing have developed methods for engineering geology terrain analysis using RADARSAT, TM images and high-resolution Digital Elevation Models (DEMs) within the boreal forest region of the Canadian Shield [2,5]. Traditional air photo methods for terrain interpretation and field mapping are expensive because of the limited access and the vast area involved. Four main components of the terrain are considered: material, landform, relief and regional drainage conditions. Landform (roughness) and relief are derived automatically from an analysis of a detailed hydrologically conditioned DEM. Regional drainage and soil moisture/texture conditions are estimated from SAR imagery. The classification and enhancement of the RADARSAT S2 and S7 images have assisted in delineating well-drained coarse grain materials associated with mainly jack pine vegetation.

The study area, located within the northern boreal forest region of Ontario is dominated by spruce and pine species. This low Canadian Shield terrain is characterized by irregular Precambrian igneous and metamorphic outcrops. Direct glacial sedimentation was deposited primarily under the glacier (till) or along the ice margin. Subglacial landforms include till plains and fluted till plains, drumlins and eskers. Ice-marginal landforms include large end moraines, which contain deltas and subaqueous fans, and washboard moraines. The distribution of fine-grained sediments is controlled by low lake-bottom topography. Abandoned shoreline features, beaches, bars and spits are well developed along the larger moraines and other isolated hills of ice-contact sediments. Many small wetlands occur in low areas among bedrock-dominated terrain. Larger areas of wetlands occur within the broad plains underlain by glaciolacustrine fine-grained sediments [5].

METHODOLOGY

The RADARSAT images were selected based on local topographic conditions as described by [1]. Since the relief is relatively low (60 m), and dominated by outcrops, RADARSAT S2 mode (24-31° incidence angle) was chosen to enhance the edges of the outcrops, and map moisture conditions related to the texture of glacial deposits. The 25 m spatial resolution RADARSAT S2 data were orthorectified using GCPs based not only on the drainage vectors to establish planimetric locations, but also on elevation data derived from the DEM. This facilitates the fusion of RADARSAT, TM and DEM. A linear contrast stretch was used for all of the images. Individual images were produced in map format at a scale of 1:100,000, with lat/long coordinates and a UTM grid. The DEMs and derivatives, such as hill-shaded DEM, slope and elevation in conjunction with RADARSAT, and high -resolution satellite imagery, were used to produce image-based terrain maps.

Other RADARSAT derived image products include a classification of 4 classes used to estimate regional drainage conditions, as shown in Fig. 1a. These classes were compared with the results of photo interpretation (Fig. 1b). They correspond closely to regional moisture/vegetation and material distribution. The classes are open water (red), wetlands, (organic terrains) mainly bogs and fens (black spruce and sedges - blue), till (mixed spruce - green), and sand and gravel (mainly jack pine - yellow). A mask based on the derived aspect and slope layers was used to limit the effects of topography on SAR backscatter, because the high backscatter values on steep slopes do not necessarily reflect the moisture conditions.

Fig. 2 shows a series of derived image maps which contributed to the interpretation of surficial deposits (Fig. 2d). The RADARSAT/TM fusion (Fig. 2b) is more useful than the stretched image (Fig. 2a), and facilitates the delineation of the Lac Seul Moraine which extends diagonally through the centre of the figures (Fig. 2b). A large ice-marginal delta, part of the Lac Seul Moraine, is located in the southeast corner of the image. Areas of recent forest cuts were also mapped. Detailed classification of vegetation based on treetop texture corresponds to major tree species of the northern boreal forest (Fig. 2e). The classification was too detailed to be correlated to surficial materials, except for sand and gravel deposits. Principal component enhancement of RADARSAT S2 and S7 modes [4] provided a slightly better visual interpretation than the SAR/TM fusion of major terrain features and minimized the effect of the forest cuts on terrain interpretation.

Results

RADARSAT images have provided regional material, moisture conditions and vegetation cover information which facilitated the interpretation and delineation of terrain units. Terrain mapping at a scale of 1:100,000, requires a simple four-class technique rather than a more detailed classification. This level of classification allows a regional understanding of the relationship between forest types and surficial deposits. For example, gravel and sand is commonly found in dry, positive relief, rough areas, with jack pine forest cover. Clay is commonly found under wet, low relief plains beneath black spruce dominated forests. Such relationships are only possible in the northern boreal forest regions where the topography is relatively low, and the vegetation distribution is relatively uniform. Other SAR fusion and principal component enhancement techniques assisted in landform delineation. The ultra fine (3 m) pseudo stereo mode and the left/right looking capabilities of RADARSAT-2 will further improve high-resolution terrain mapping in northern Canada.

References

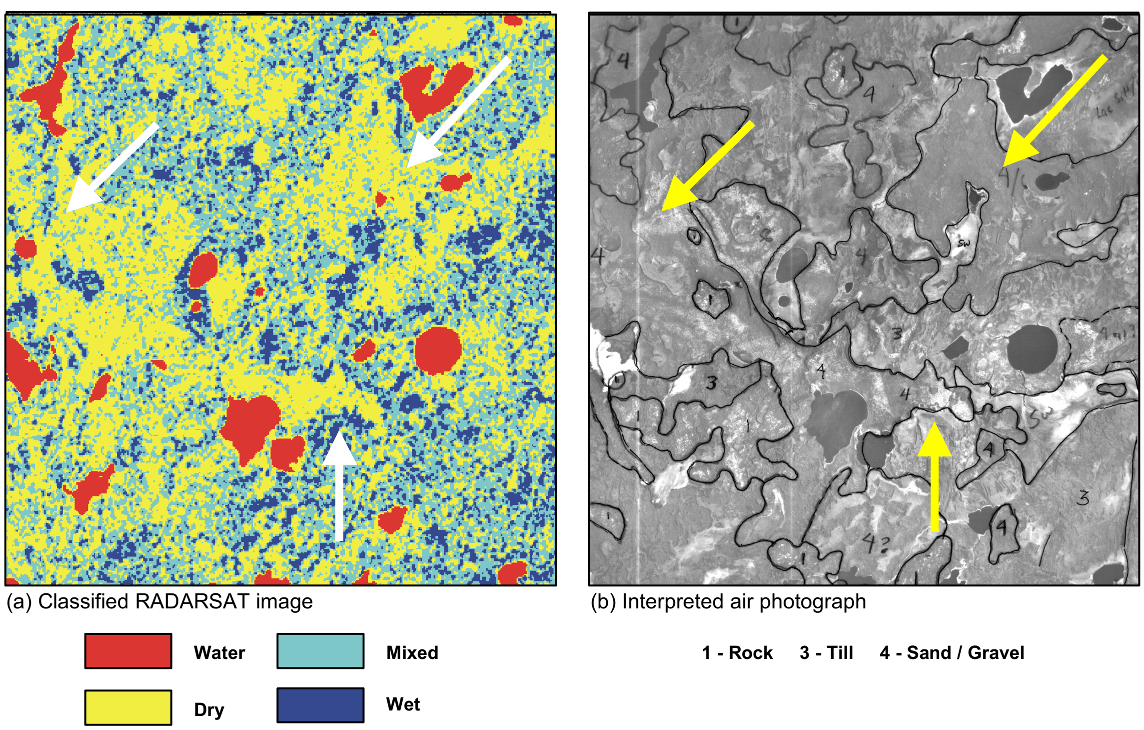
[1] V. Singhroy and R. Saint-Jean, "Effects of Relief on the Selection of RADARSAT-1 Incidence Angle for Geological Applications," *Can. Jour. Rem. Sens.*, vol. 29, 3, pp. 211-218, 1999.

[2] V. Singhroy and P. Barnett, "Satellite Based Standardized Terrain Maps: A case study," in *Spatial Methods for Solution of Environmental and Hydrologic Problems—Science, Policy and Standardization*, V. Singhroy, D. Hansen, R. Pierce, and A. Johnson, Eds. ASTM International, West Conshohocken, PA, 2003, pp. 148-159.

[3] F. Kenny, P. Barnett, and V. Singhroy, "Application of airborne multispectral and radar images for Quaternary geology mapping," *Can. Jour. Rem. Sens.*, vol. 20, 3, pp. 286-292, 1994.

[4] E. Grunsky, "The application of principal components analysis to multi-beam RADARSAT-1 satellite imagery: A tool for land cover and terrain mapping". *Can. Jour. Rem. Sens.*, vol. 28, 6, pp. 758-769, 2002.

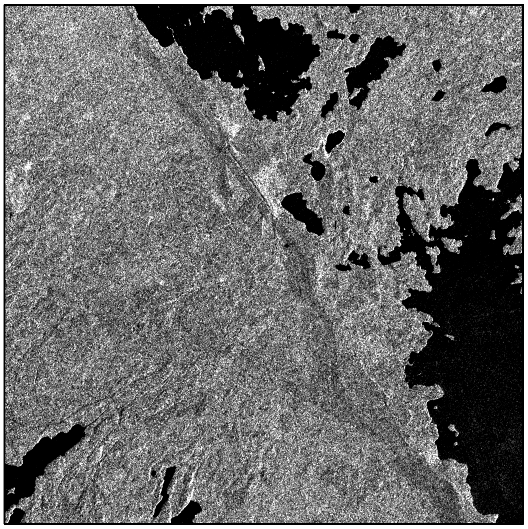
[5] P. Barnett, V. Singhroy, J. Shirota, and S. Leney, "Methods for remote engineering geology terrain analysis in boreal forest regions of Canada," *Environmental and Engineering Geosciences Journal*, in press.



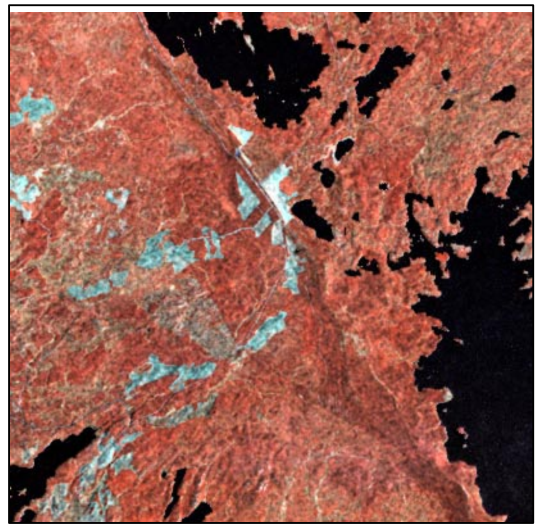
(a) Classified RADARSAT image

(b) Interpreted air photograph

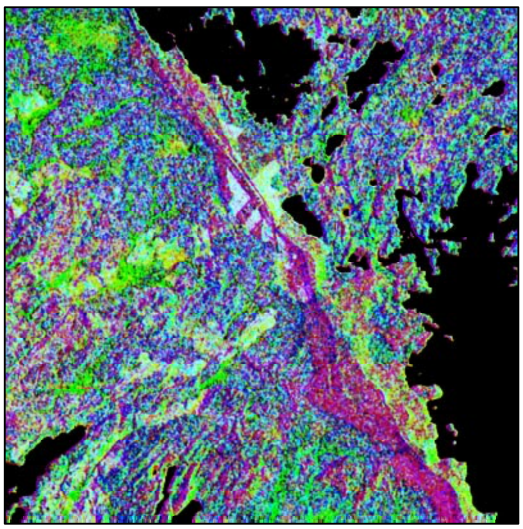
Figure 1. RADARSAT-1 - Regional moisture, material, and vegetation determination



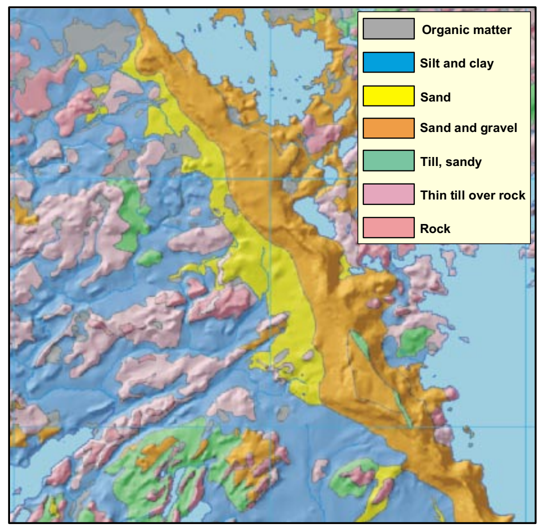
(a) RADARSAT Standard Mode, Beam 2 Image



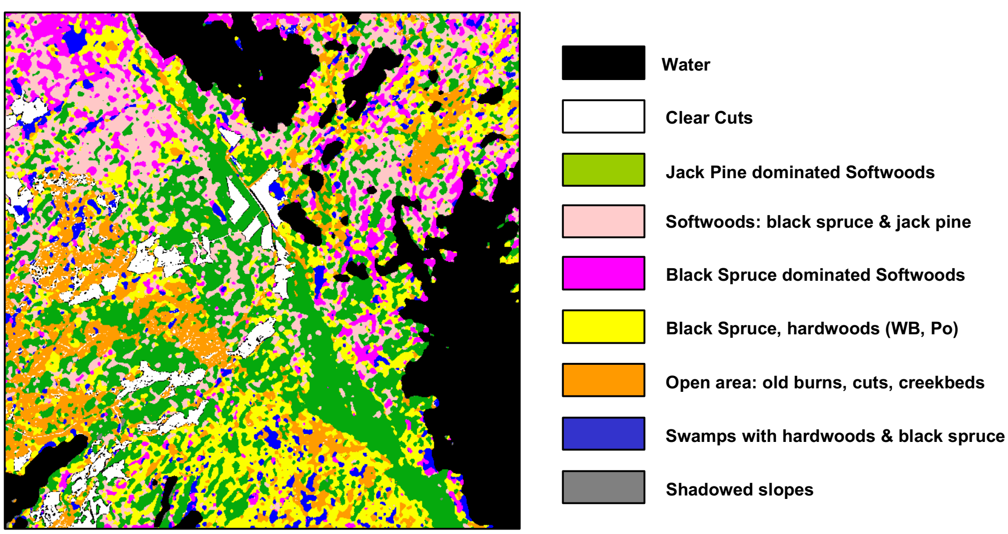
(b) Landsat ETM+ merged with RADARSAT



(c) Principal component color composite from RADARSAT S2 & S7, asc. & desc.



(d) Derived surficial materials over shaded relief



(e) Unsupervised landcover classification

Figure 2. RADARSAT-1 - Derivative imagery and interpretation