Orthorectified and Principal Component RADARSAT-1 Image Dataset for NTS 83M, Alberta
Orthorectified and Principal Component RADARSAT-1 Image Dataset for NTS 83M, Alberta

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Alberta Geological Survey

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Abstract

This report details the acquisition, characteristics and processing of the orthorectified and principal component RADARSAT-1 images for NTS map area 83M by the Alberta Geological Survey (AGS). The acquisition of the original RADARSAT-1 scene imagery was made through a Provincial Partnership Memorandum of Understanding. Original RADARSAT-1 path images (SGF) have been purchased by Alberta Sustainable Resource Development (SRD) from RADARSAT International (RSI) and then made available to AGS, based on an agreement that AGS would pay for orthorectification of the original RADARSAT-1 imagery in exchange for obtaining the value-added imagery for public distribution.

This resulted in acquisition of coverage for all of northern Alberta (north of 55 degrees north latitude) for Standard Beam Modes S1 and S7 in both ascending and descending look directions. This imagery is available at a nominal resolution of 12.5 m. Two hundred and fifty scenes have been orthorectified and, in total, cover northern Alberta (north of 55 degrees north latitude) in the four beam positions. They were tiled to 25 1:250 000 scale NTS map areas. The image file for each NTS map area contains four layers to accommodate four images from the four beam positions. These four layers were then used for principal component analysis to produce an image file for each NTS map area containing four layers holding PC1, PC2, PC3 and PC4 images. The orthorectified and principal component RADARSAT-1 dataset for NTS map area 83M is one of the 25 NTS-tiled products to be delivered to the public by AGS. It will permit users to further process and interpret the RADARSAT-1 data to obtain geoscience, environmental, forestry or other information.
1 Introduction

The Government of Alberta participated in a RADARSAT-1 pre-launch agreement that permitted the acquisition of radar imagery at a significantly reduced price. The acquisition of the RADARSAT-1 imagery was made through a Provincial Partnership Memorandum of Understanding that offered participating provinces a price of $609 CDN per scene. This agreement tested the application of RADARSAT-1 satellite imagery for agricultural, mapping and natural resources management. Alberta Sustainable Resource Development (SRD) and the Alberta Geological Survey (AGS) participated in this agreement, and they agreed to a satellite image acquisition plan in 1999. The funding of the original RADARSAT-1 path images (SGF) was covered and managed by SRD, and it was agreed AGS would pay for orthorectification of the original RADARSAT-1 imagery in exchange for its use. AGS agreed to provide a complete set of orthorectified imagery to SRD in return. The RADARSAT-1 imagery was obtained from September to December 1999. A total of 274 scenes of RADARSAT-1 standard beam modes S1 and S7 were captured for both ascending and descending passes, covering all of northern Alberta (north of 55 degrees north latitude). This number was mistakenly reported as 280 scenes in previous reports (Grunsky, 2002a, 2002b, 2002c), due to 6 duplicate records of scenes that were found afterwards. Two hundred and fifty of the 274 scenes were orthorectified and then tiled to 25 NTS map areas (Grunsky, 2002a). The other 24 scenes were not orthorectified because they are peripheral complementary images. The image file for each NTS map area contains four layers to accommodate four images from the four beam positions. These four layers were then used for principal component analysis (PCA) to produce an image file for each NTS map area, which contains four layers with PC1, PC2, PC3 and PC4 images. Each of the four principal components of the 25 tiled NTS areas was then assembled to produce the northern Alberta mosaic of principal component images (Grunsky, 2002b). All of these value-added images are made available to the public by AGS. A detailed documentation of the acquisition and availability of these images is provided by Grunsky (2002a).

The RADARSAT-1 satellite is an active, microwave-based sensor that sends its own microwave signals down to the Earth and processes the signals it receives back. It differs from optical sensors, such as LANDSAT TM and SPOT, which are referred to as passive systems. Since the optical sensors collect data at frequencies of visible and infrared, they rely on sunlight reflected off the Earth and, as a result, are unable to collect data in darkness or poor atmospheric conditions, such as cloud cover, fog, dust, hail or smoke. RADARSAT-1’s longer microwave wavelength is better suited for atmospheric penetration and can collect data regardless of the Earth’s atmospheric conditions. The radar backscatter qualities are directly related to ground topography, dielectric properties and surface roughness of the terrain being imaged. As a result, RADARSAT-1 images are complementary to optical satellite images. In addition, radar can acquire multiple images to provide stereoscopic viewing.

The imagery obtained by AGS has great potential in geological studies when combined with other satellite images and existing geological data. September to December 1999, when the imagery was obtained, was a dry autumn and, thus, provided ideal conditions of no deciduous foliage and no snow. The four combinations of varying incidence angles and look directions provided four additional dimensions for highlighting differences in geomorphology, surficial and structural features and drainage. For example, Grunsky (2002c) applied the principal component images for land cover and terrain mapping, and Paganelli et al. (2003) used them for structural mapping in a portion of the northern Buffalo Head Hills area. This report describes the acquisition, characteristics and processing of the orthorectified and principal component RADARSAT-1 image dataset for NTS 83M.

2 RADARSAT-1 Standard Beam Mode Images

RADARSAT-1 was launched on November 4, 1995, as a result of a joint venture between the Canadian government, private industry and NASA (RADARSAT International (RSI), 1999). As Canada’s first
Earth observation satellite, and the world’s first operationally-oriented radar sensor, it provides complete global coverage with the satellite’s orbit repeated every 24 days. The Arctic is imaged daily, whereas equatorial areas achieve complete coverage approximately every five days. It differs from research-oriented radar sensors, such as ERS and JERS-1, as it is the first radar sensor totally dedicated to operational applications, and it offers a variety of beam modes to meet requirements for the particular application at hand. It uses a single frequency C-Band (5.3 Ghz frequency or 5.6 cm wavelength) and has the ability to send and receive this microwave energy at a number of spatial resolutions and different incidence angles over a 500-kilometre range. RADARSAT-1’s side-looking geometry greatly enhances subtle topographic features that aid in the interpretation of lineaments (RADARSAT International (RSI), 1997). RADARSAT-1 offers 35 beam positions with a viewing angle range of 10 to 60 degrees (Figure 1). The spatial resolution can vary from 8 m to 100 m (Figure 2). As a result, the RADARSAT-1 satellite is programmable so various beam modes and resolutions can be changed according to requirements.

Figure 1. RADARSAT-1 beam modes (used with permission from RADARSAT International (RSI), 1997).

Figure 2. Coverage sizes and resolutions of RADARSAT-1 beam modes (modified after RADARSAT International (RSI), 1999).
The orthorectified and principal component RADARSAT-1 image datasets for NTS 83M contain images from two beam modes and four beam positions: Standard Beam Mode 1 ascending, Standard Beam Mode 1 descending, Standard Beam Mode 7 ascending and Standard Beam Mode 7 descending (Figure 3). It also includes four principal component images (PC1, PC2, PC3 and PC4) derived from them.

3 Processes for Acquisition of the Orthorectified and Principal Component RADARSAT-1 Images for NTS 83M

The RADARSAT-1 image orthorectification, mosaic and principal component analysis were carried out by Resource GIS and Imaging Ltd. (RGI) using processing methods and software developed by RGI and proprietary to RGI. Their software and processes run within the ER Mapper processing environment.

The processes for producing the orthorectified and principal component RADARSAT-1 Image dataset for NTS 83M are:

- acquisition of the original RADARSAT-1 Standard Beam Mode path images
- orthorectification of the path images
- mosaicking of the orthorectified scene images to NTS map areas; and
- principal component analysis of the tiled NTS map area images.

Following are detailed descriptions of the original input data and steps to produce the orthorectified and principal component RADARSAT-1 images for NTS 83M.

3.1 Original RADARSAT-1 Standard Beam Mode Images

The original RADARSAT-1 image data are the path images (SGF) and have been converted to ground range and are multi-look processed. Each Standard Beam image is a composite of four looks. This composite increases the signal-to-noise ratio at the expense of the spatial resolution. The imagery is provided at a nominal resolution of 12.5 m (close to the single look spatial resolution), although the true spatial resolution of the averaged four-look image is closer to 25 m. The image is calibrated, but remains
oriented in the direction of the orbit path. The image is sampled in unsigned, 16-bit integer format and written in Committee of Earth Observation Satellites (CEOS) standard format. The projection is in UTM zone 11 or 12 with an ellipsoid of WGS84. Figure 4 shows an example of the original path images used for tiling the NTS 83M dataset. Table 1 lists the scenes that overlay the NTS 83M area. Figure 5 shows the spatial locations of the scenes overlaying NTS 83M. Many of these scenes were used for producing the NTS 83M orthorectified and principal component image datasets included on the CD.

Figure 4. One of the original SGF scene images used for tiling the NTS 83M dataset: scene MO196563 of Standard Beam Mode 1 descending. RADARSAT data © Canadian Space Agency/Agence spatiale canadienne 1999, processed and distributed by RADARSAT International.
Table 1. List of the Path Images that Overlay NTS 83M

<table>
<thead>
<tr>
<th>Scene ID</th>
<th>Beam</th>
<th>Path</th>
<th>UL_LAT</th>
<th>UL_LONG</th>
<th>UR_LAT</th>
<th>UR_LONG</th>
<th>LR_LAT</th>
<th>LR_LONG</th>
<th>LL_LAT</th>
<th>LL_LONG</th>
</tr>
</thead>
</table>
Figure 5. The scenes overlaying NTS 83M.
3.2 Orthorectification Process

The original RADARSAT-1 path images are orthorectified by RGI contracted by AGS. The individual orthorectified RADARSAT-1 images have no filtering nor any radiometric processing applied to them. Radiometrically they are identical to the original images. Orthorectification is performed using digital elevation data provided by the Resource Data Division (RDD) of the Alberta Department of Sustainable Development. The digital elevation data used has a 100 m resolution. Ground control points (GCPs) are collected from 1:20 000 Alberta Access Vectors and an Alberta mosaic of orthorectified Indian remote sensing satellite (IRS) images, which are also provided by RDD. An average GCP root mean-square error of 20 m is obtained. The image file is in ER Mapper format and projected to UTM zone 11 or 12 with a datum of NAD83. The data remain in unsigned, 16-bit integer format, and the pixel size remains at 12.5 m. Figure 6 is an example of the orthorectified images used for tiling the NTS 83M dataset.

Figure 6. One of the orthorectified scene images used for tiling the NTS 83M dataset: scene MO196563 of Standard Beam Mode 1 descending.
3.3 Mosaic (Tiling) Process

The orthorectified images are tiled to 25 NTS map areas of Standard Beam Mode S1/S7 ascending/descending. For the S1 mosaics, the near-nadir sides of the images have been favoured in the mosaic process. For the S7 mosaics, the off-nadir sides of the images have been favoured. This maximizes the incidence angle difference between the S1 and S7 mosaics. Radiometric differences between adjacent images are minimized using two-dimensional, piecewise linear gain and offset adjustment functions, which are interactively adjusted to achieve an optimum balance. The balanced mosaics are then clipped to 1:250 000 NTS tiles. The NTS tile image file is in ER Mapper format and projected to UTM zone 11 or 12 with a datum of NAD83. The data are converted into unsigned, 8-bit integer format, and the pixel size remains at 12.5 m. Figure 7 is a pseudocolour composite of the orthorectified and tiled NTS 83M image dataset.

Figure 7. Pseudocolour composite of orthorectified NTS 83M image dataset of Standard Beam Mode S1/S7 ascending/descending beam positions (RGB=S7d, S7a, S1d).
3.4 Principal Component Analysis

NTS images of four beam positions (S1 ascending/descending and S7 ascending/descending) for the same NTS map area are used as input channels for principal component analysis (PCA). This results in 25 PCA image datasets; each contains four layers for the PC1, PC2, PC3 and PC4 images for the same NTS map area. During the PCA, the S7 ascending image is used to mask the lakes so as to remove the lakes from the calculation of the covariance eigenvectors. The S1 ascending image is multiplied by 1.35, and the S1 descending image is multiplied by 1.60 so as to match the means of the S1 and S7 ascending/descending images. The covariance eigenvectors are determined using a 10 000 columns by 20 000 rows window of the four beam mode images. The window is located between UTM zone 12 NAD 83 coordinates 339313 E to 464319 E and 6414500 N to 6164502 N. An ER Mapper std_dev_1.6 filter is applied to each of the four beam position images. After PCA, a value of 11 000 was added to PC3 values and 5 000 to PC4 values to bring all of the image values into the positive range. The resultant image dataset is in ER Mapper format and projected to UTM zone 11 or 12 with a datum of NAD83. The dataset was converted into unsigned, 8-bit integer format, and the pixel size remains at 12.5 m. Figure 8 is a pseudocolour composite of the principal component dataset for NTS 83M.

![Figure 8. Pseudocolour composite of NTS 83M image dataset of principal component PC1, PC2, PC3 and PC4 (RGB=PC2, PC1, PC3).](image-url)
3.5 Additional Resampled Images and Maps

For a wider scope of users, including non-GIS or inexperienced professionals to use the data, single-band images in GeoTIFF format were created from each band of the orthorectified and PCA image datasets mentioned above. This results in 8 images for each NTS map area. They are: (1) S1 ascending, (2) S1 descending, (3) S7 ascending, (4) S7 descending, (5) PC1, (6) PC2, (7) PC3 and (8) PC4 images. The GeoTIFF images are in the same projection as the orthorectified and PCA image datasets, but have been re-sampled into 27 m pixel size in order to reduce file size. They can be used with other GIS data to generate maps of specific interests to the user.

In addition, simple maps for these images were created. This results in 8 maps for each NTS map area. These maps are included on the two accompanying CDs as Figures 9 to 16. They can be printed or plotted, depending on the users’ software and output capability, and each map includes some general tips for interpretation.

4 Conclusion

The image datasets for NTS 83M contain two sets of data: orthorectified RADARSAT-1 image dataset with images of four beam mode positions: S1/S7 beam modes and ascending/descending paths; and principal component image dataset containing images of PC1, PC2, PC3 and PC4, which are derived from the orthorectified image dataset. The imagery is obtained through orthorectification and mosaicking of the RADARSAT-1 path images covering NTS 83M. Additional single-band images in GeoTIFF format were also created. The various image datasets included herein can be used for a wide range of applications, including forestry, land cover classification, soil moisture mapping, hydrology, geomorphology and geology for the NTS 83M map area.

5 References


Introduction

The Alberta Geological Survey acquired RADARSAT-1 images over northern Alberta as part of their regional mapping strategy. These datasets are well suited for mapping geological structure, geomorphology, and the moisture content of vegetation or sediment surface materials to a very shallow depth. The strategy of acquiring S1 and S7 imagery was done to contrast the radar responses based on two incidence angles. The acquired scenes include imagery acquired between September and December 1999, providing ideal conditions of no to little deciduous foliage or snow.

As noted above, radar backscatter is affected by vegetation type, moisture content in both the vegetation and surface soils, surface roughness, and the moisture content in both the vegetation and surface soils. With respect to surface roughness, this is a complex response, but typically associated with the soil. As well, Principal Component Analysis of the RADARSAT-1 imagery adds more complexity to the interpretation process. Finally, because each tiled 1:250,000 scale map area image is a composite of a few individual images, the interpretation of the eight 'simple maps' of RADARSAT-1 imagery (Figures 9 to 16) or Principal Component Analysis imagery (Figures 13 to 16) is more challenging.

1. Standing water, when not disturbed by a strong wind, reflects almost all the incident microwave radiation away from the sensor, resulting in a black or dark tone. In contrast, a strong wind would cause patches of lighter tone on the normally darker water.
2. The same terrain may appear different in tone when imaged at different incident angles and in different look directions, reflecting different backscatter characteristics.
3. Slopes facing toward the sensor are usually lighter than slopes facing away from the sensor.
4. Moist soils are usually brighter than dry soils.
5. Forest canopies generally show up with a more coarse texture than grasslands, which reflects their greater variability in surface roughness response. Wetlands with areas of grass or moss interspersed with trees (e.g., black spruce) can also show up as a mottled or 'salt-and-pepper' texture.
6. Canopies with high water content or wetness appear in a lighter tone.
7. Conifer versus deciduous trees without leaves show different texture and tones under certain combination of beam mode and polarization.
8. In general, Standard Beam 1 images are more sensitive to soil and vegetation moisture than Standard Beam 7 images. As a result, Standard Beam 1 images tend to show more variation of tones.
9. The same terrain may appear different in tone when imaged at different incident angles and in different look directions, reflecting different backscatter characteristics.

Acknowledgments

The Alberta Geological Survey acknowledges the contributions of the J. G. Young Foundation and the N.L. Blundon and S. Mei Fund, which provided financial support for this project. The RADARSAT-1 imagery was provided by the Canadian Space Agency (CSA) as part of the RADARSAT-1 Commercial User Program. The project was managed by the RGI of the University of Calgary and was carried out by S. Mei and N.L. Blundon. The digital cartography was made by N.L. Blundon and S. Mei. The Principal Component images were processed by RGI of the University of Calgary. The Alberta Geological Survey and its employees and contractors make no warranty, guarantee or representation, express or implied, as to the correctness, accuracy, completeness, or reliability of this publication. When using this publication, the user accepts all risks associated with it, and the Alberta Geological Survey has no legal liability regarding the correctness, accuracy, completeness, or reliability of this publication.

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RADARSAT-1 signals down to the Earth and processes the signals that it receives back. It differs from optical sensors, such as LANDSAT, SPOT and IRS, which collect data at visible and infrared frequencies and rely on reflected sunlight from the Earth. In addition, RADARSAT-1 images are well suited for mapping geological structure, geomorphology and the moisture content of vegetation or sediment surface materials to a very shallow depth.

As part of their regional mapping strategy, the Alberta Geological Survey acquired RADARSAT-1 images over northern Alberta (north of 55 degrees north latitude) with the following four beam positions: Standard Beam 1 (S1) ascending (71 scenes), S1 each side (71 scenes), Standard Beam 7 (S7) descending (4 scenes) and S7 each side (4 scenes). The strategy of acquiring S1 and S7 imagery was done to contrast the radar responses based on two incidence angles for the same terrain being imaged. As a result, RADARSAT-1 images are well suited for mapping geological structure, geomorphology and the moisture content of vegetation or sediment surface materials to a very shallow depth.

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Digital cartography is made by N.L. Blundon and S. Mei. The RADARSAT-1 principal component images are processed by RGI Resources GIS and Imaging (now renamed as PhotoSat). Additional image processing is made by S. Mei. Reg Olson and Rick Richardson are thanked for beneficial and constructive review.
**Introduction**

The Alberta Geological Survey acquired RADARSAT-1 images over northern Alberta to implement a regional mapping strategy. RADARSAT-1 images are well suited for mapping geological structure, geomorphology, and the moisture content of vegetation or sediment surface materials to a very shallow depth. The quality of the radar backscatter signal is directly related to ground topography, dielectric properties, and surface roughness of the terrain being imaged. As a result, RADARSAT-1 images are processed using Principal Component Analysis (PCA) to evaluate correlation among signals from the S1A, S1D, S7A, and S7D images and generate resultant principal component images for each NTS map area. The first four principal components for each NTS map area are then used to produce four simple images.

As part of their regional mapping strategy, the Alberta Geological Survey acquired RADARSAT-1 images over northern Alberta. These images were orthorectified and then tiled into 25,000 m x 25,000 m scenes. The acquisition of scene images was conducted for two ascending and two descending beam modes (i.e., differing incidence angles, scene coverage, and resolutions) and look directions (i.e., 118° and 120°)

The acquired scene images were processed using PCA, which is a statistical method that evaluates correlation among signals from the S1A, S1D, S7A, and S7D images and generates resultant principal component images for each NTS map area. The first four principal components for each NTS map area were then used to produce four simple images.

Some general tips for interpreting the Figures 9 to 12 images are provided below, but these are generalizations and intended only as a starting point for further interpretation. These images typically show standing water, standing snow, and the surface roughness response. As well, wetlands with areas of grass or moss interspersed with trees (e.g., black spruce) can also show up as a mottled or 'salt-and-pepper' texture.

The same terrain may appear different in tone when imaged at different incident angles and in different look directions, hence the same area may have a differing response depending on the simple map or figure evaluated.

**Key Points**

1. Standing water, when not disturbed by a strong wind, reflects almost all the incident microwave radiation away from the sensor.
2. Standing snow reflects most of the microwave radiation away from the sensor.
3. Slopes facing toward the sensor are usually lighter than slopes facing away from the sensor.
4. Moist soils are usually brighter than dry soils.
5. Conifer versus deciduous trees without leaves show different texture and tones under certain combination of beam mode and incidence angle.
6. With respect to vegetation, much of northern Alberta is covered by boreal forest, but there also exist farm lands, wetlands, and some other settings with differing vegetation types.
7. With respect to moisture, some general tips for interpreting the Figures 9 to 12 images are provided below, but these are generalizations and intended only as a starting point for further interpretation.

**Figures 9 to 12**

The Figures 9 to 12 images typically show standing water, standing snow, and the surface roughness response. As well, wetlands with areas of grass or moss interspersed with trees (e.g., black spruce) can also show up as a mottled or 'salt-and-pepper' texture.

The same terrain may appear different in tone when imaged at different incident angles and in different look directions, hence the same area may have a differing response depending on the simple map or figure evaluated.
The RADARSAT-1 satellite, launched by Canada in 1995, is an active, microwave-based sensor that sends its own microwave signal. The quality of the radar backscatter signal is directly related to ground topography, dielectric properties, and surface roughness of the terrain being imaged. As a result, RADARSAT-1 images are well suited for mapping geological structure, geomorphology, and the moisture content of vegetation or sediment surface materials to a very shallow depth.

As part of their regional mapping strategy, the Alberta Geological Survey acquired RADARSAT-1 images over northern Alberta descending (70 scenes), Standard Beam 7 (S7) ascending (65 scenes) and S7 descending (68 scenes). The resolution of each of the images is 1:250,000 scale NTS map areas that cover all of northern Alberta north of latitude 55°N. This results in four RADARSAT-1 images (S7A and S7D) for each NTS map area were processed using Principal Component Analysis (PCA). PCA is a statistical method that evaluates correlation among the signal data, and generates resultant principal component images.

As noted above, radar backscatter is affected by vegetation type, moisture, and surface roughness. It is also dependent on the incidence angle and look direction of the radar beam. With respect to vegetation, much of northern Alberta is covered by boreal forest. The response differs markedly for lakes versus land, but the radar moisture signal on land is complex because it reflects varying vegetation, soil, and canopy configuration. In turn, these factors also influence the amount of moisture in the soil, and the type of vegetation that is present.

Orthorectified RADARSAT-1 images, there can be in places a seemingly abrupt change in tone or texture; these normally result from the change in incidence angle. The same terrain may appear different in tone when imaged at different incident angles and in different look directions. The same terrain may appear different in tone when imaged at different incident angles and in different look directions, as well as from the same look direction but different incident angles. The response of the radar sensor to these angles and look directions is discussed in the methodology section.

Some general tips for interpreting the Figures 9 to 12 images are provided below, but these are generalizations and intended only for assisting less experienced users to browse the image or evaluate variations on the printed map.

1. Standing water, when not disturbed by a strong wind, reflects almost all the incident microwave radiation away from the sensor, resulting in a black or dark tone. In contrast, a strong wind would cause patches of lighter tone on the normally dark surface.
2. Standing water under vegetation, such as some wetlands, particularly those covered by grass, moss, and relatively few trees, tends to result in a light tone.
3. Slopes facing toward the sensor are usually lighter than slopes facing away from the sensor.
4. Moist soils are usually brighter than dry soils.
5. The same terrain may appear different in tone when imaged at different incident angles and in different look directions.
6. The same terrain may appear different in tone when imaged at different incident angles and in different look directions, as well as from the same look direction but different incident angles.
7. Standing water under vegetation, such as some wetlands, particularly those covered by grass, moss, and relatively few trees, tends to result in a light tone.
8. The same terrain may appear different in tone when imaged at different incident angles and in different look directions.
9. Moist soils are usually brighter than dry soils.
10. The same terrain may appear different in tone when imaged at different incident angles and in different look directions, as well as from the same look direction but different incident angles.

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Acknowledgements:

The RADARSAT-1 data was provided by Natural Resources Canada. The RADARSAT-1 images were processed by PhotoSat. Additional image processing is made by S. Mei. Reg Olson and Rick Richardson are thanked for beneficial and constructive review.
The RADARSAT-1 satellite, launched by Canada in 1995, is an active, microwave-based sensor that sends its own microwave signals. It employs variable beam modes (i.e., differing incidence angles, scene coverage, and resolutions) and look directions, offering the opportunity to acquire separate radar images or datasets from the same area.

The quality of the radar backscatter signal is directly related to ground topography, dielectric properties, and surface roughness. The response differs markedly for lakes versus land, but the radar moisture signal on land is complex because it reflects varying moisture content in both the vegetation and surface soils. Surface roughness also affects the response, making the underlying ground surface terrain (i.e., 'averaged' across the 25 m areal extent) a factor in the radar's interpretation.

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RADARSAT-1

120° 00' 350000m.E 400000m.E

signals down to the Earth and processes the signals that it receives back. It differs from optical sensors, such as LANDSAT, SPOT and IRS, which collect data at visible and infrared frequencies and rely on reflected sunlight from the Earth. In addition, RADARSAT-1 employs variable beam modes (i.e., differing incidence angles, scene coverage and resolutions) and look directions (i.e., east looking and descending or west looking), hence the opportunity exists for acquiring a number of separate radar images for each NTS map area (Figures 9 to 12). As well, the four Radarsat image datasets (i.e., S1A, S1D, S7A and S7D) for each NTS map area were processed using Principal Component Analysis (PCA). PCA is a statistical method that reduces the dimensionality of the data, and generates resultant principal component images for each NTS map area. The first four principal components for each NTS map area were then used to produce four simple PCA maps (Figures 13 to 16).

Incidence angle and look direction of the radar beam. With respect to vegetation, much of northern Alberta is covered by boreal forest or snow. The acquired scene images were individually from the four beam positions for each NTS map area (Figures 9 to 12). As well, the four Radarsat image datasets (i.e., S1A, S1D, S7A and S7D) for each NTS map area were processed using Principal Component Analysis (PCA). PCA is a statistical method that reduces the dimensionality of the data, and generates resultant principal component images for each NTS map area. The first four principal components for each NTS map area were then used to produce four simple PCA maps (Figures 13 to 16). Having said this, some general tips for interpreting the Figures 13 to 16 PCA images are provided below, but these are not intended to be exhaustive.

The Third Principal Component (PC3) image (Figure 15) highlights 'surface roughness'; hence it reflects topographic effects and surface texture of the ground or vegetation canopy. In fact, the discrimination of topographic features using the PC3 image is superior to any other optical commercial satellite images. Further, open black spruce forest is characterized by darker tones; closed pine forest is displayed in mid-range tones, and areas of dunes and exposed soil show up as the lightest tones. Finally, areas dominated by grass or little vegetation or of burned forest, show up as light- to medium-grey tones. The moisture content of vegetation or sediment surface materials to a very shallow depth.

This document is a product of the Alberta Regional Geoscience Initiative (ARGI) and funded by the Western Economic Diversification Canada (WD) Interregional Agreements Program. The data, if used, must reference the Alberta Regional Geoscience Initiative (ARGI) and be processed using NGA (Natural Resources Canada) software. The Alberta Geological Survey and its employees and contractors make no warranty, guarantee or representation, express or implied, as to the accuracy, sufficiency, reliability or completeness of the information contained herein or its fitness for any particular purpose. The Alberta Geological Survey and its employees and contractors make no warranty, guarantee or representation, express or implied, as to the accuracy, sufficiency, reliability or completeness of the information contained herein or its fitness for any particular purpose.

Digital cartography is made by N.L. Blundon and S. Mei. The RADARSAT-1 principal component images are processed by RGI. The interpretation of the maps and figures was made by the authors. The interpretation of the maps and figures was made by the authors.
Introduction

The RADARSAT-1 satellite, launched by Canada in 1995, is an active, microwave-based sensor that sends its own microwave signals, which then can either be evaluated individually or combined statistically in various ways to produce additional information. The quality of the radar backscatter signal is directly related to ground topography, dielectric properties and surface roughness of the terrain being imaged. As a result, RADARSAT-1 images are well suited for mapping geological structure, geomorphology and the moisture content of vegetation or sediment surface materials to a very shallow depth.

As part of their regional mapping strategy, the Alberta Geological Survey acquired RADARSAT-1 images over northern Alberta (north of 55 degrees north latitude) with the following four beam positions: Standard Beam 1 (S1) ascending (71 scenes), S1 looking north, S1 looking south, and S1 descending. The acquired scenes imaged the surface geomorphology and surficial geology and soil type and the vegetation type, extent of vegetative coverage and nature of the underlying geomorphology, the surficial geology and soil type, and the vegetation type, extent of vegetative coverage typically associated with the soil. As well, Principal Component Analysis of the RADARSAT-1 imagery acts to add more complexity to the interpretation process. Finally, because each tiled 1:250,000 scale map area image is a composite, usually based on several separate radar images, it is difficult to provide unique interpretation methods for the eight 'simple maps' of RADARSAT-1 imagery (Figures 9 to 16) or PCA imagery (Figures 13 to 16).
NTS 83M
RADARSAT-1

120° 00’
118° 00’
120° 00’

Introduction

RADARSAT-1 is an advanced, polar-orbiting sensor providing SAR data at 120° east looking and descending or 118° east looking, hence the opportunity exists for acquiring a number of separate radar signals down to the Earth and processes the signals that it receives back. It differs from optical sensors, such as LANDSAT, SPOT and IRS, which collect data at visible and infrared frequencies and rely on reflected sunlight from the Earth. In addition, RADARSAT-1 employs variable beam modes (i.e., differing incidence angles, scene coverage and resolutions) and look directions. The images were obtained in a dry autumn (September to December 1999) and, thus, provided ideal conditions of no to little deciduous foliage or snow. The acquired scene images were individually orthorectified and then tiled into 25,1:250,000 scale NTS map areas that cover all of northern Alberta north of latitude 55°N. This results in four RADARSAT-1 images for each NTS map area were processed using Principal Component Analysis (PCA). PCA is a statistical method that generates resultant principal component images for the eight ‘simple maps’ of RADARSAT-1 imagery (Figures 9 to 16) or PCA imagery (Figures 13 to 16).

As noted above, radar backscatter is affected by vegetation type, moisture and surface roughness. It is also dependent on the moisture content in both the vegetation and surface soils. With respect to surface roughness, this also is a complex response, but the underlying ground surface terrain (i.e., ‘averaged’ across the about 25 m

The Third Principal Component (PC3) image (Figure 15) highlights ‘surface roughness’; hence it reflects topographic effects and the scattering response that are not noted from the other three PCA images. Interestingly, open black spruce forest usually appears to display a lighter tone on PC4 images. Such differences on PC4 may reflect a combination of vegetation density and morphology.

Acknowledgments

The Alberta Geological Survey and its employees and contractors make no warranty, guarantee or representation, express or implied, as to the correctness, accuracy, completeness, or reliability of this publication. When using information from this publication in other publications or presentations, due acknowledgement should be given to the Alberta Energy Resources GIS and Imaging (now renamed as PhotoSat). Additional image processing is made by S. Mei. Reg Olson and Rick Richardson are thanked for beneficial and constructive review.

Edmonton

Calgary

Elevation above Sea Level

Scale 1:250,000
Datum: North American Datum, 1983