EUB/AGS Geo-Note 2003-27

Orthorectified and Principal Component RADARSAT-1 Image Dataset for NTS 84H, Alberta

Alberta Energy and Utilities Board
Alberta Geological Survey

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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 84H 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 geological study and 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 84H 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 84H.

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.

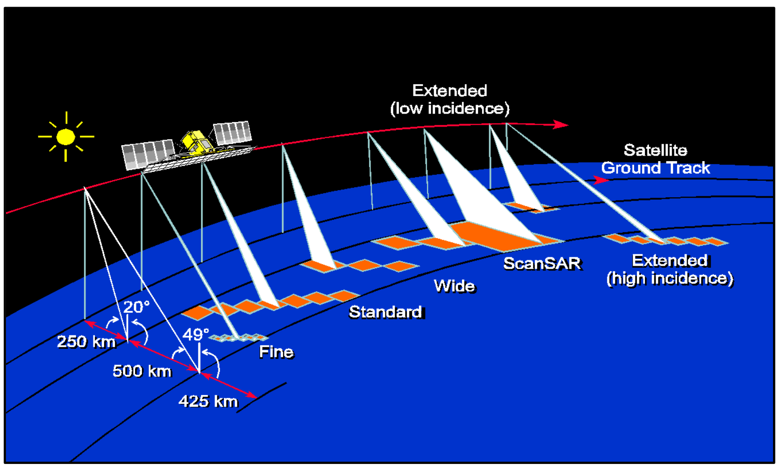

Figure 1. RADARSAT-1 beam modes (used with permision from RADARSAT International (RSI), 1997).

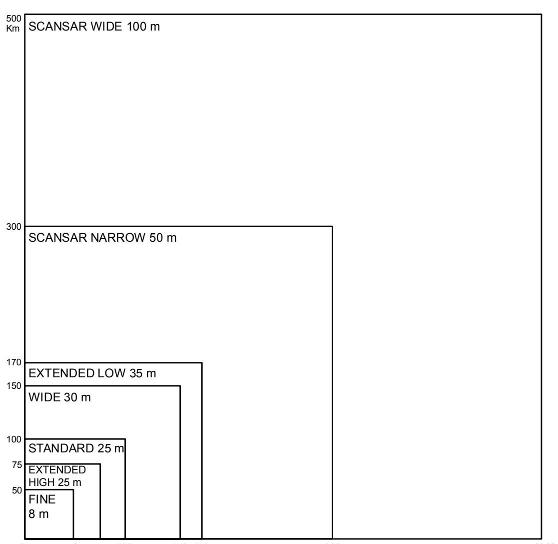

Figure 2. Coverage sizes and resolutions of RADARSAT-1 beam modes (modified after RADARSAT International (RSI), 1999).

The orthorectified and principal component RADARSAT-1 image datasets for NTS 84H 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.

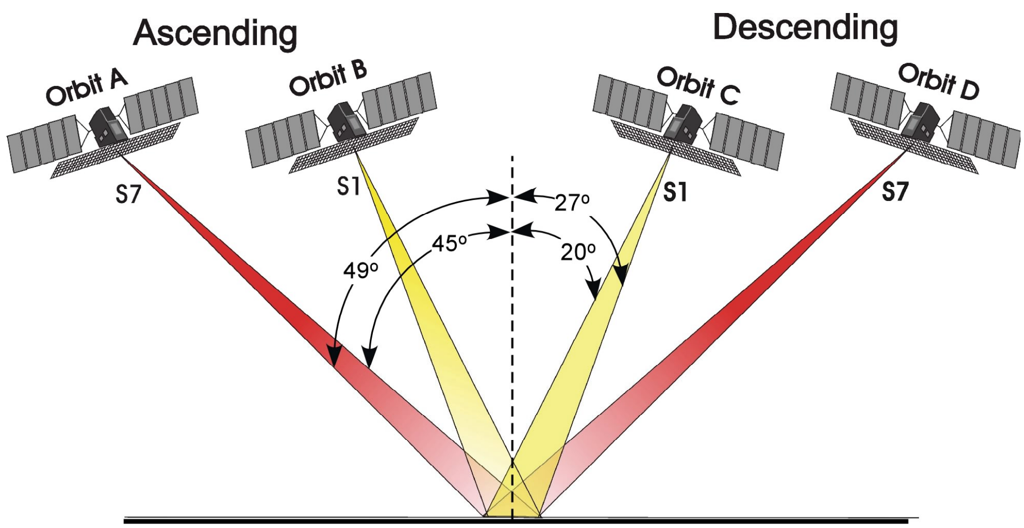

Figure 3. Multi-beam configuration of RADARSAT-1 S1 and S7 ascending/descending imagery (after Grunsky, 2002a).

3 Processes for Acquisition of the Orthorectified and Principal Component RADARSAT-1 Images for NTS 84H

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 84H 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 84H.

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 84H dataset. Table 1 lists the scenes that overlay the NTS 84H area. Figure 5 shows the spatial locations of the scenes overlaying NTS 84H. Many of these scenes were used for producing the NTS 84H orthorectified and principal component image datasets included on the CD.

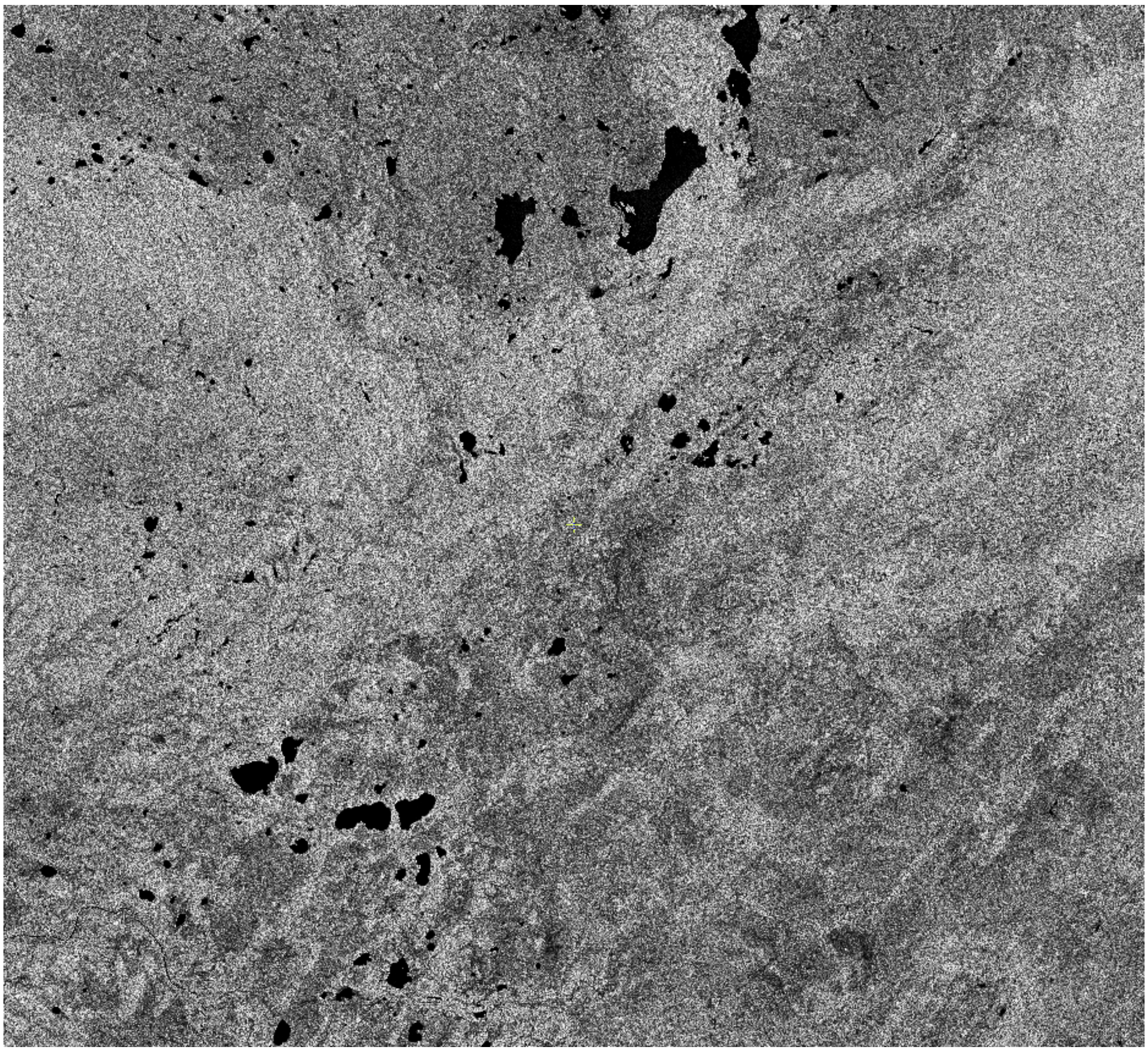

Figure 4. One of the original SGF scene images used for tiling the NTS 84H dataset: scene MO196606 of Standard Beam Mode 7 descending. RADARSAT data © Canadian Space Agency/Agence spatiale canadienne 1999, processed and distributed by RADARSAT International.

Table 1. List of the Path Images that Overlay NTS 84H

Scene ID	Beam	Path	UL_LAT	UL_LONG	UR_LAT	UR_LONG	LR_LAT	LR_LONG	LL_LAT	LL_LONG
M0197237	S1	ASC	58:08:50.79N	114:36:14.26W	58:23:46.38N	112:42:32.35W	57:28:55.98N	112:18:09.65W	57:14:14.79N	114:08:57.21W
M0197236	S1	ASC	57:19:38.31N	114:11:36.37W	57:34:20.76N	112:20:32.93W	56:39:27.40N	111:56:59.05W	56:24:58.42N	113:45:16.59W
M0196651	S1	ASC	58:09:47.25N	115:39:59.91W	58:24:42.85N	113:46:16.56W	57:29:52.89N	113:21:53.06W	57:15:11.70N	115:12:41.95W
M0196650	S1	ASC	57:20:33.57N	115:15:20.34W	57:35:16.02N	113:24:15.65W	56:40:22.71N	113:00:40.90W	56:25:53.75N	114:48:59.56W
M0196444	S1	ASC	58:10:01.08N	112:33:07.29W	58:25:02.60N	110:38:50.31W	57:30:12.52N	110:14:24.22W	57:15:25.58N	112:05:45.78W
M0196443	S1	ASC	57:20:52.70N	112:08:26.84W	57:35:40.98N	110:16:48.84W	56:40:47.95N	109:53:11.74W	56:26:13.29N	111:42:02.78W
M0195880	S1	ASC	58:05:04.41N	113:30:26.78W	58:19:57.03N	111:37:08.19W	57:25:06.93N	111:12:50.35W	57:10:28.61N	113:03:15.58W
M0195879	S1	ASC	57:15:43.80N	113:05:50.26W	57:30:23.35N	111:15:09.71W	56:35:30.32N	110:51:40.49W	56:21:04.13N	112:39:36.08W
M0199210	S1	DES	57:42:18.54N	112:49:27.65W	57:27:42.44N	110:58:44.67W	56:32:42.75N	111:25:18.59W	56:47:05.35N	113:13:14.49W
M0199209	S1	DES	58:31:20.87N	112:27:33.81W	58:16:31.84N	110:34:13.97W	57:21:56.18N	111:01:35.61W	57:36:30.85N	112:52:00.96W
M0196777	S1	DES	57:46:27.99N	114:56:10.04W	57:31:49.72N	113:05:08.33W	56:37:11.19N	113:31:37.77W	56:51:35.94N	115:19:52.58W
M0196776	S1	DES	58:35:49.10N	114:34:03.34W	58:20:57.67N	112:40:22.59W	57:26:22.72N	113:07:50.24W	57:40:59.68N	114:58:35.55W
M0196520	S1	DES	57:43:27.81N	113:54:59.26W	57:28:50.71N	112:04:09.47W	56:34:11.94N	112:30:35.38W	56:48:35.57N	114:18:38.84W
M0196519	S1	DES	58:32:51.03N	113:32:55.28W	58:18:00.76N	111:39:26.38W	57:23:25.30N	112:06:50.40W	57:38:01.15N	113:57:24.43W
M0199704	S7	ASC	58:16:45.87N	113:37:14.50W	58:25:08.25N	111:43:23.94W	57:30:31.08N	111:30:17.57W	57:22:08.29N	113:21:15.80W
M0199703	S7	ASC	57:27:29.14N	113:22:49.33W	57:35:51.89N	111:31:34.64W	56:41:14.12N	111:18:41.97W	56:32:50.63N	113:07:13.27W
M0199360	S7	ASC	58:15:47.55N	114:39:49.09W	58:24:10.22N	112:45:57.95W	57:29:11.27N	112:32:46.28W	57:20:48.18N	114:23:41.15W
M0199359	S7	ASC	57:26:27.91N	114:25:20.41W	57:34:50.96N	112:34:08.13W	56:40:13.21N	112:21:15.35W	56:31:49.42N	114:09:44.40W
M0198894	S7	ASC	57:29:18.25N	115:28:43.95W	57:37:40.84N	113:37:24.43W	56:43:03.07N	113:24:31.41W	56:34:39.76N	115:13:07.24W
M0198662	S7	ASC	58:13:21.73N	112:33:29.41W	58:21:43.96N	110:39:51.29W	57:27:06.78N	110:26:46.01W	57:18:44.11N	112:17:32.49W
M0198661	S7	ASC	57:23:57.35N	112:19:04.16W	57:32:19.99N	110:28:01.68W	56:37:42.19N	110:15:10.04W	56:29:18.79N	112:03:29.78W
C0014848	S7	ASC	58:18:42.08N	115:43:11.52W	58:27:04.29N	113:49:15.45W	57:32:27.14N	113:36:08.67W	57:24:04.52N	115:27:12.06W
M0200508	S7	DES	57:44:55.89N	114:40:43.56W	57:36:37.08N	112:49:21.30W	56:41:59.13N	113:04:57.27W	56:50:18.70N	114:53:35.05W
M0200507	S7	DES	58:34:17.32N	114:28:55.43W	58:25:58.86N	112:34:55.14W	57:31:21.84N	112:50:53.87W	57:39:40.74N	114:42:00.61W
M0197357	S7	DES	57:40:56.27N	115:46:41.28W	57:32:37.11N	113:55:31.34W	56:37:58.76N	114:11:06.12W	56:46:18.69N	115:59:32.27W
M0197356	S7	DES	58:30:18.39N	115:34:53.63W	58:21:59.61N	113:41:06.31W	57:27:22.58N	113:57:03.64W	57:35:41.82N	115:47:58.16W
M0197031	S7	DES	57:35:54.84N	112:39:10.86W	57:27:35.50N	110:48:16.26W	56:32:57.11N	111:03:49.04W	56:41:17.25N	112:52:00.72W
M0197030	S7	DES	58:25:12.01N	112:27:25.15W	58:16:53.06N	110:33:54.31W	57:22:15.99N	110:49:49.43W	57:30:35.43N	112:40:28.44W
M0196606	S7	DES	57:39:17.12N	113:41:38.96W	57:30:57.72N	111:50:33.37W	56:36:19.38N	112:06:07.72W	56:44:39.55N	113:54:29.79W
M0196605	S7	DES	58:28:36.93N	113:29:51.86W	58:20:17.91N	111:36:09.29W	57:25:40.89N	111:52:06.12W	57:34:00.37N	113:42:56.20W

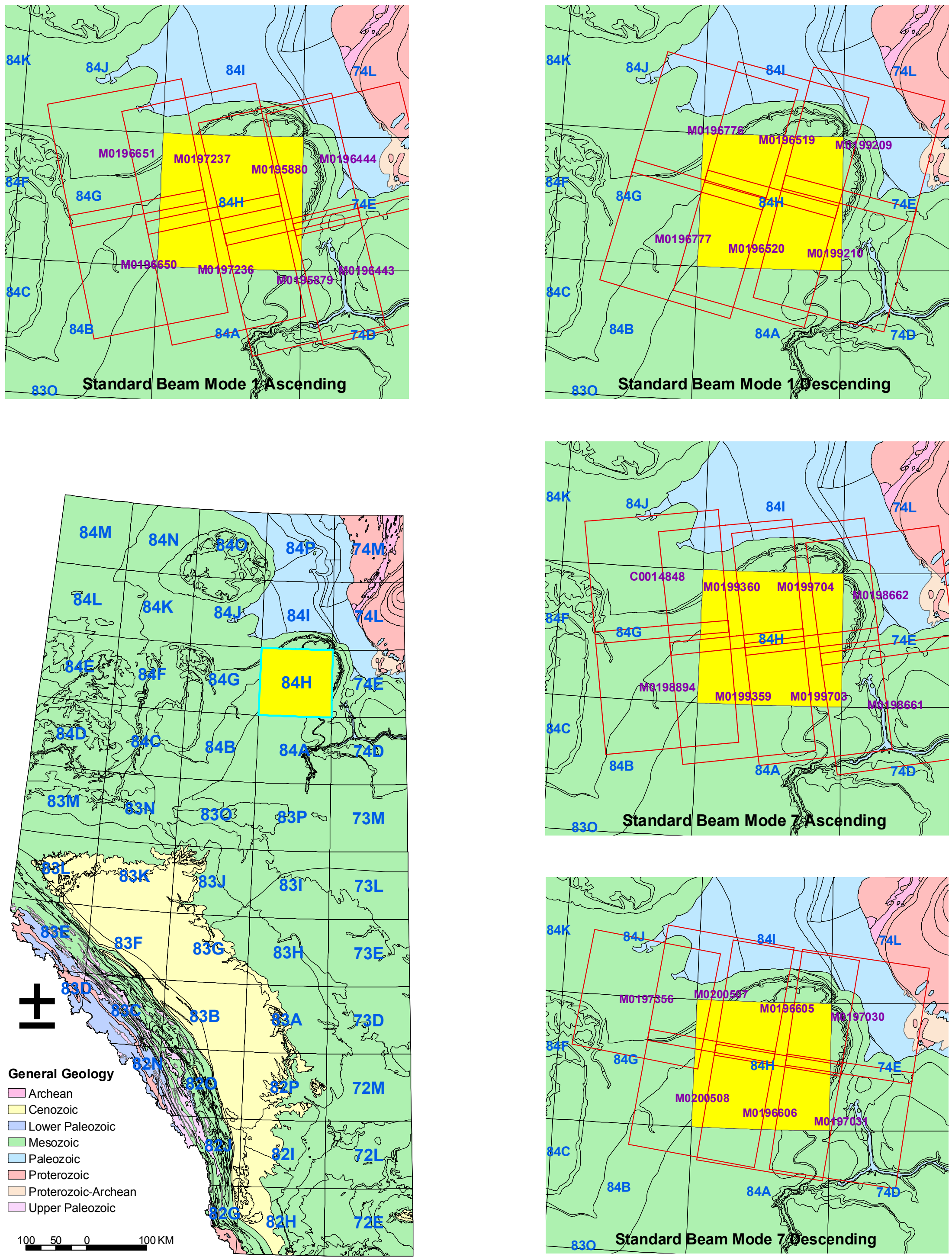

Figure 5. The scenes overlaying NTS 84H.

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 84H dataset.

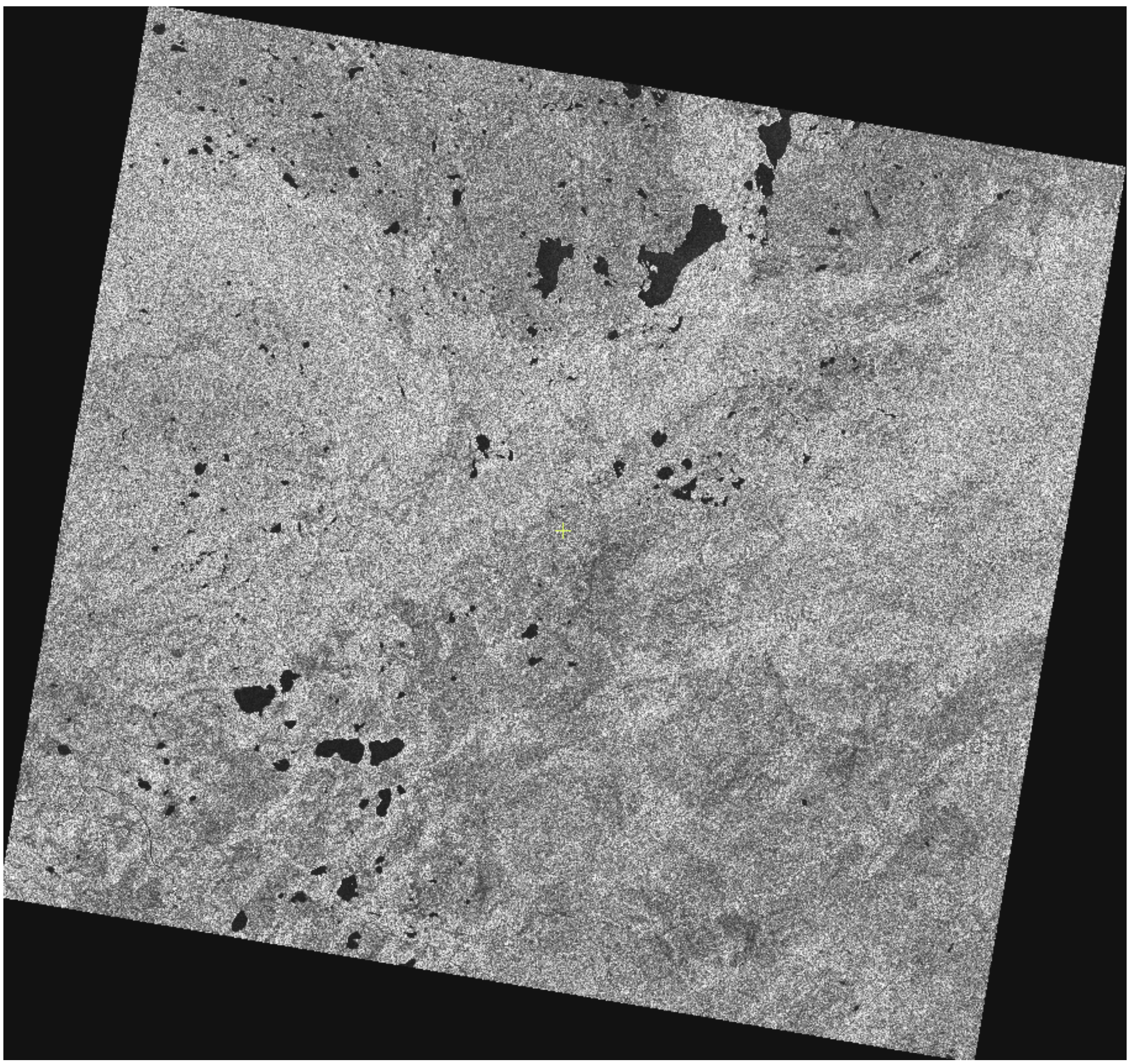

Figure 6. One of the orthorectified scene images used for tiling the NTS 84H dataset: scene MO196606 of Standard Beam Mode 7 descending.

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 84H image dataset.

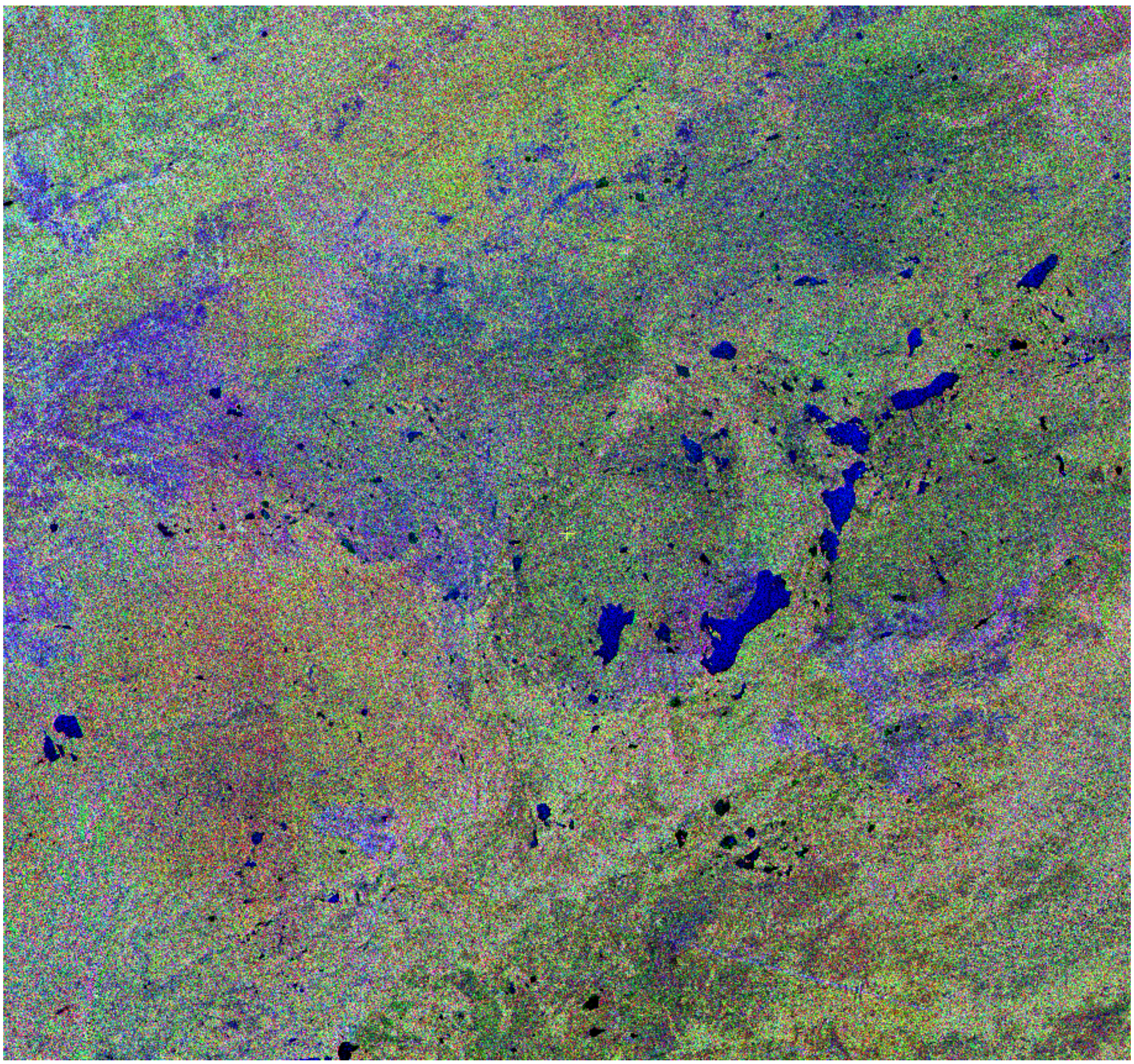

Figure 7. Pseudocolour composite of orthorectified NTS 84H image dataset of Standard Beam Mode S1/S7 ascending/descending beam positions (RGB=S7d, S7a, S1d).

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 84H.

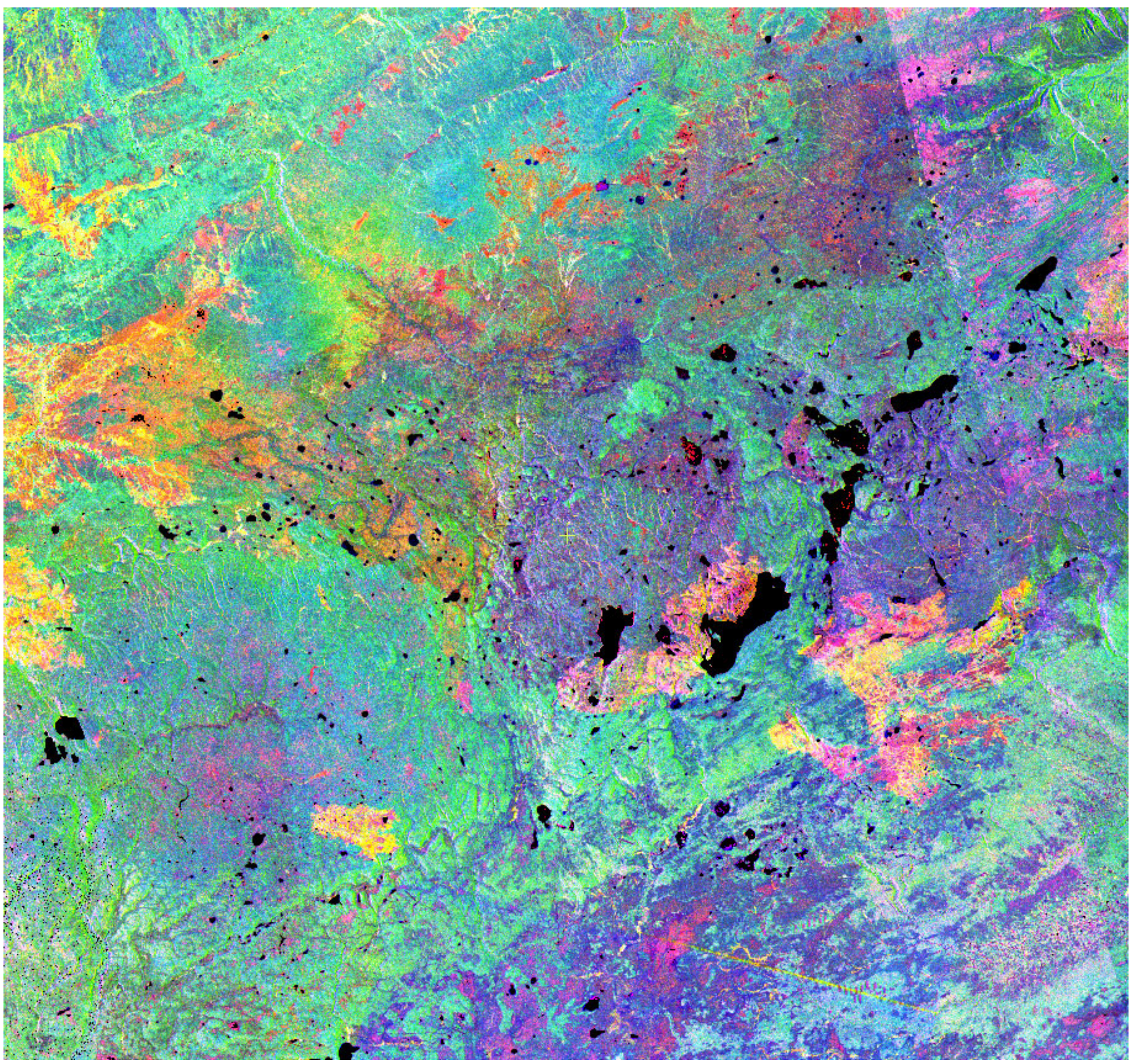

Figure 8. Pseudocolour composite of NTS 84H image dataset of principal component PC1, PC2, PC3 and PC4 (RGB=PC2, PC1, PC3).

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) S1descending, (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 84H 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 84H. 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 84H map area.

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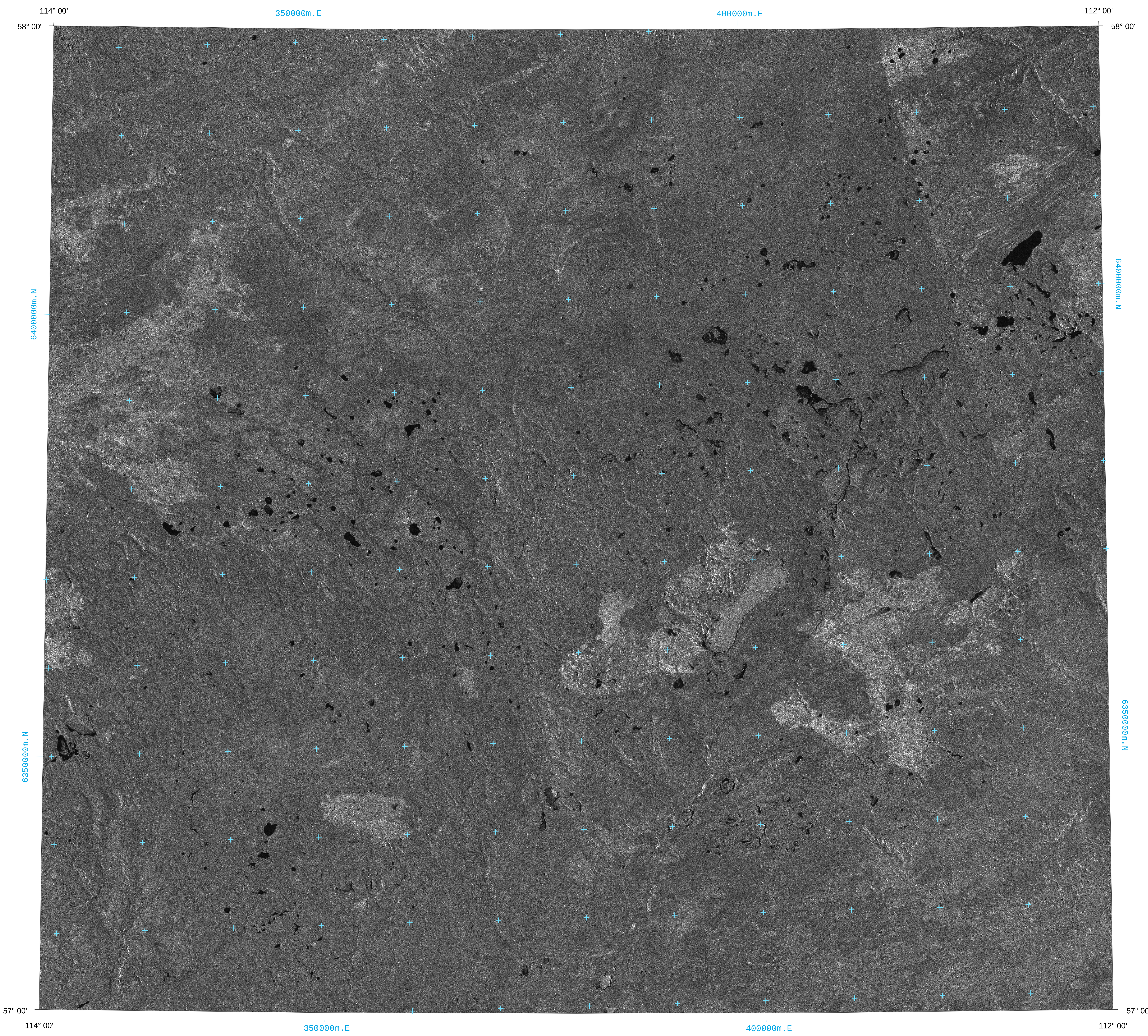

Introduction

The RADARSAT-1 satellite, launched by Canada in 1995, is an active, microwave-based sensor that sends its own microwave 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., ascending or east looking and descending or west looking), hence the opportunity exists for acquiring a number of separate radar 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.

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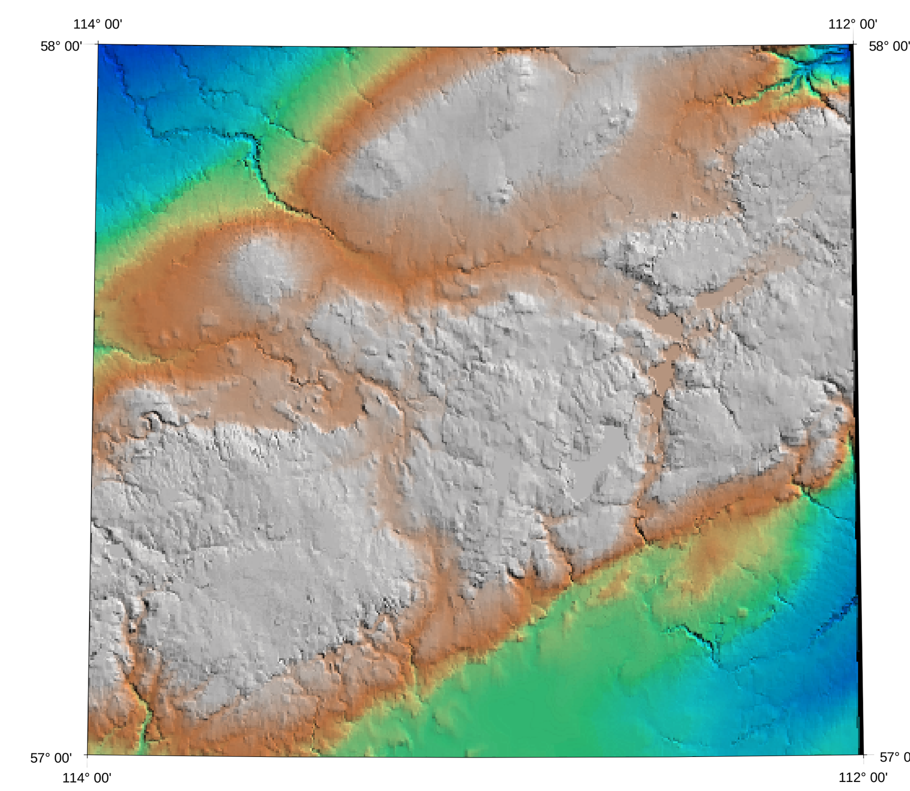
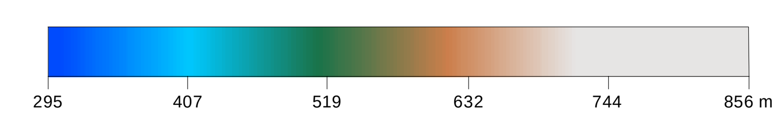
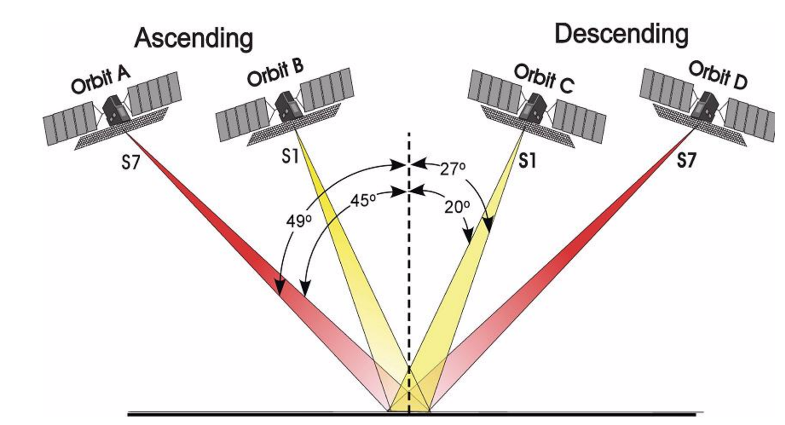
Elevation Map for NTS 84H



Elevation above Sea Level



Look Directions and Incident Angles of RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-27, Figure 9

RADARSAT-1 Standard Beam 1 Ascending Image for Namur Lake, Alberta (NTS 84H)

Compilation by S. Mei, 2003

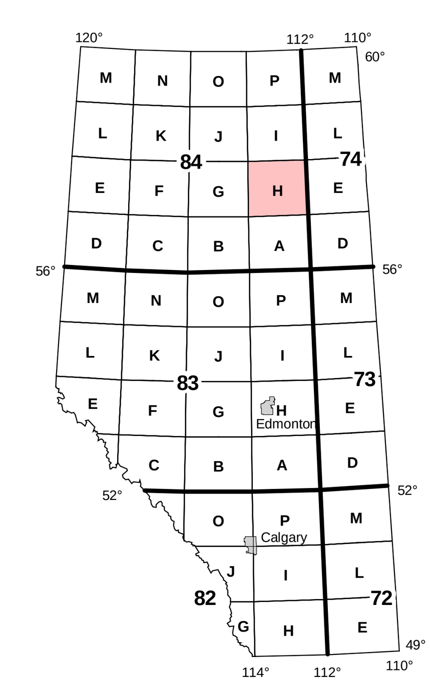
Scale 1:250 000

5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

Projection: Universal Transverse Mercator, Zone 12
Datum: North American Datum, 1983

EUB
Alberta Energy and Utilities Board
AGS
Alberta Geological Survey



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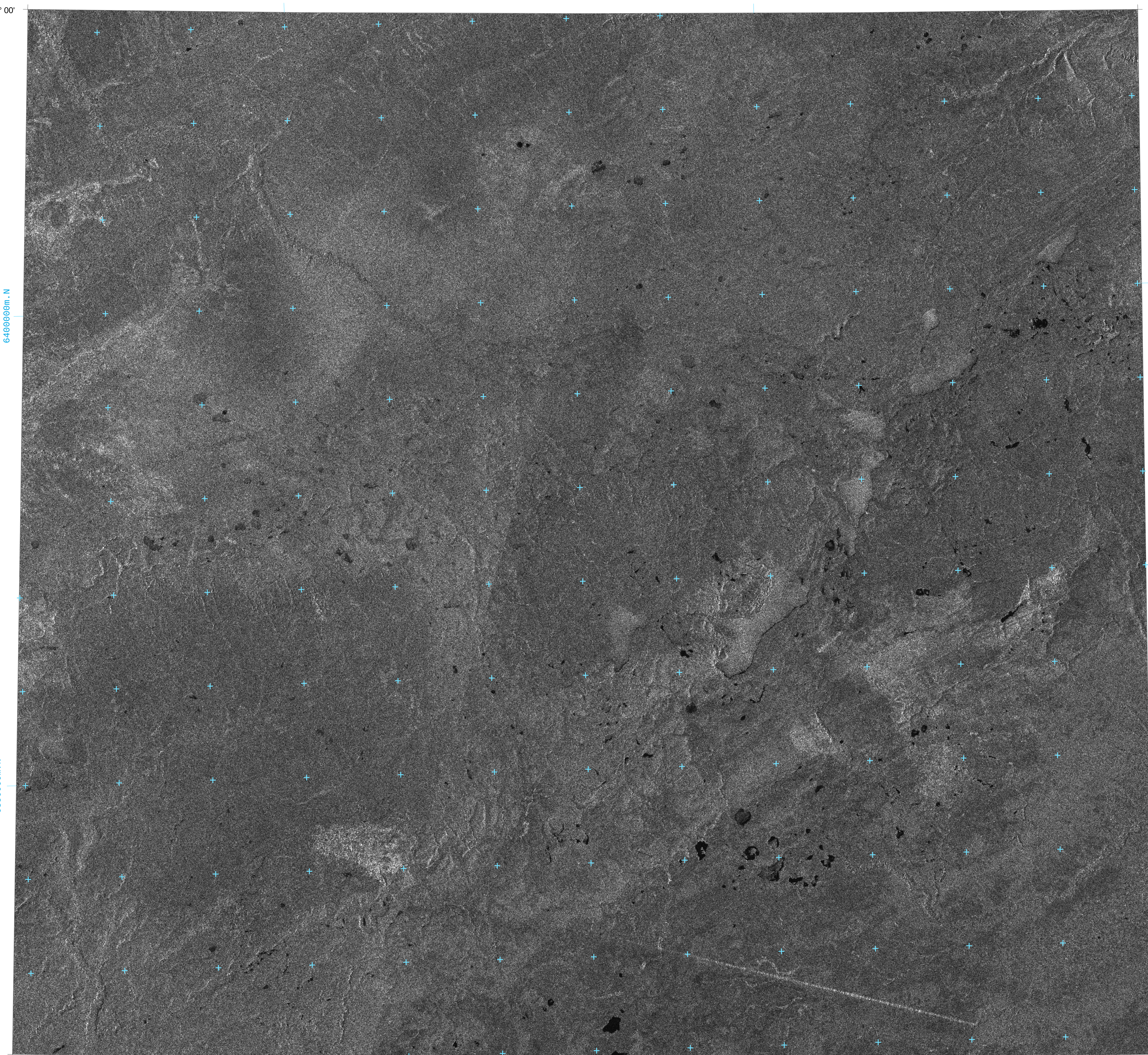
NTS 84H
RADARSAT-1



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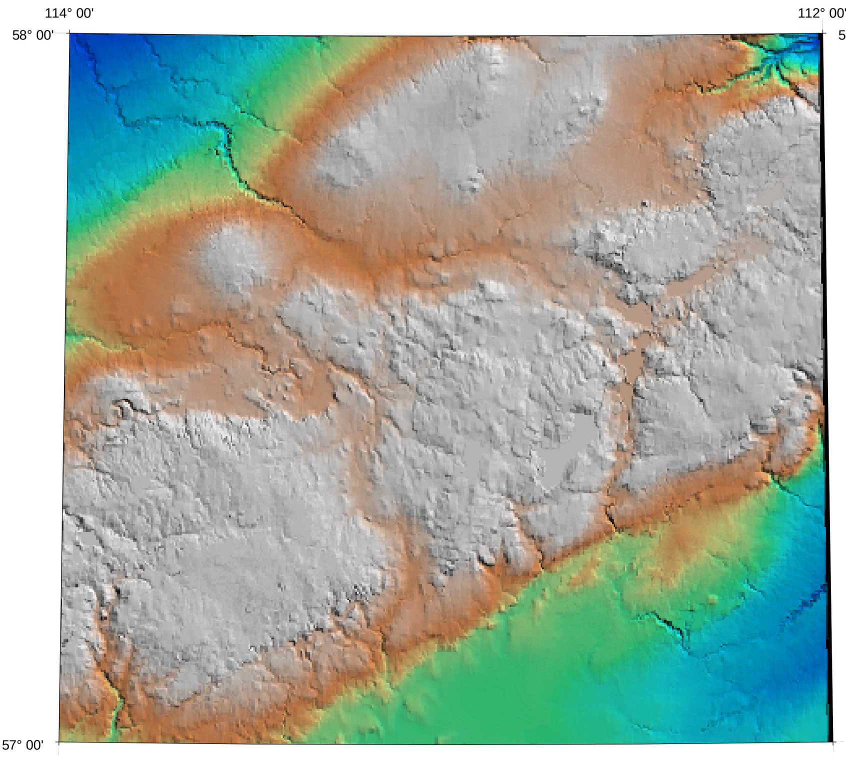
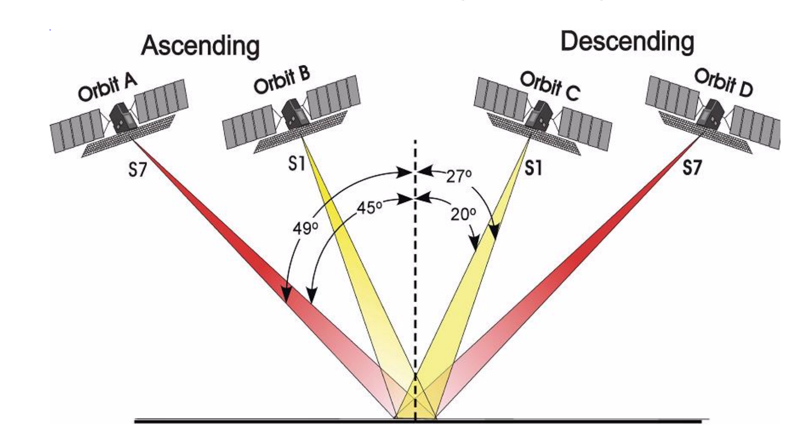
Elevation Map for NTS 84H



Elevation above Sea Level

Look Directions and Incident Angles of RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-27, Figure 10

RADARSAT-1 Standard Beam 1 Descending Image for Namur Lake, Alberta (NTS 84H)

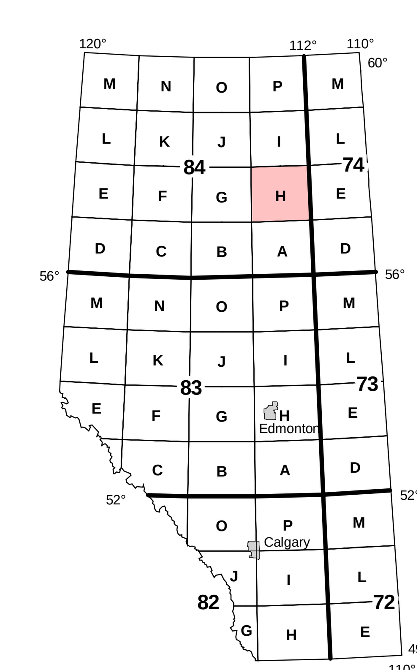
Compilation by S. Mei, 2003

Scale 1:250 000

5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

Projection: Universal Transverse Mercator, Zone 12
Datum: North American Datum, 1983



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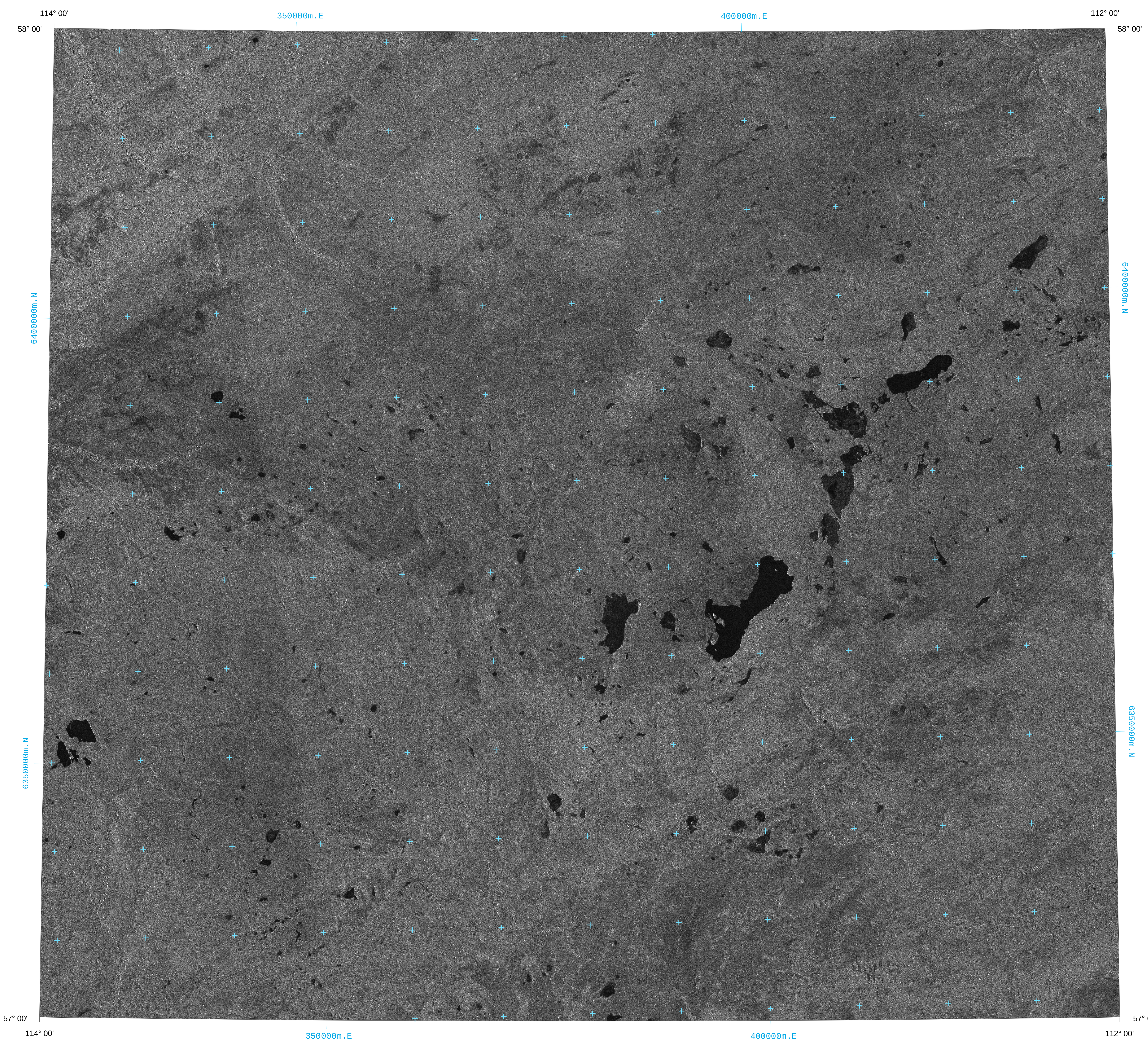
NTS 84H
RADARSAT-1



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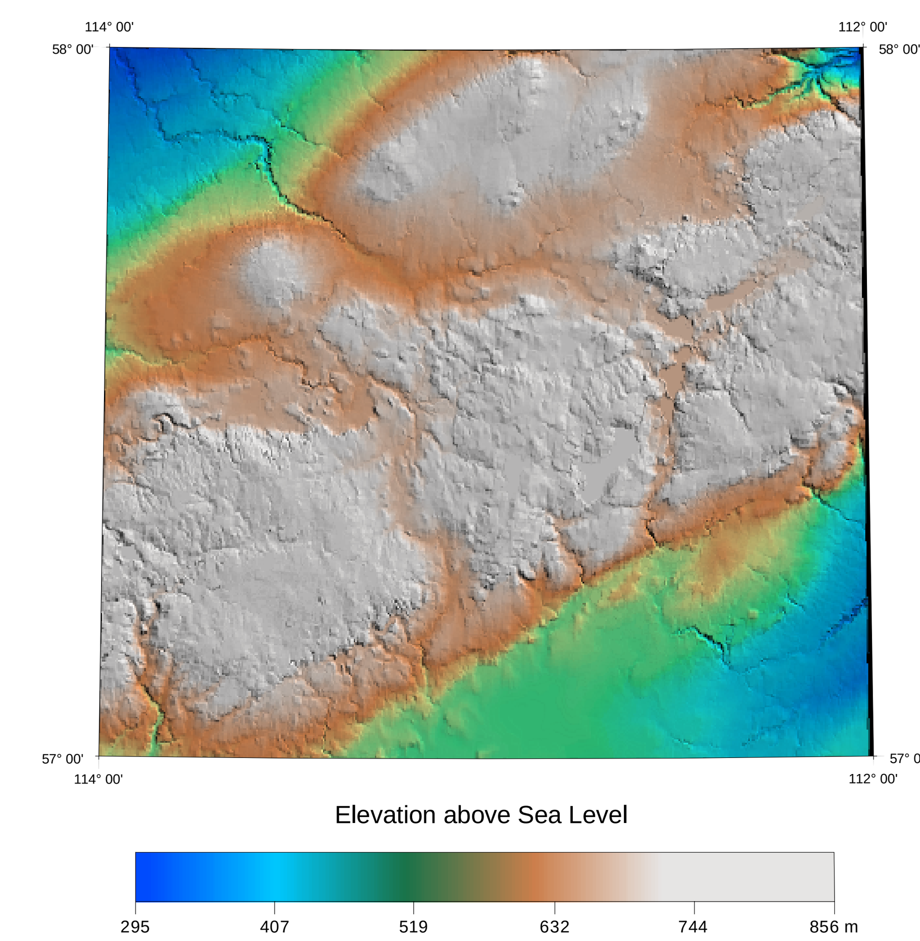
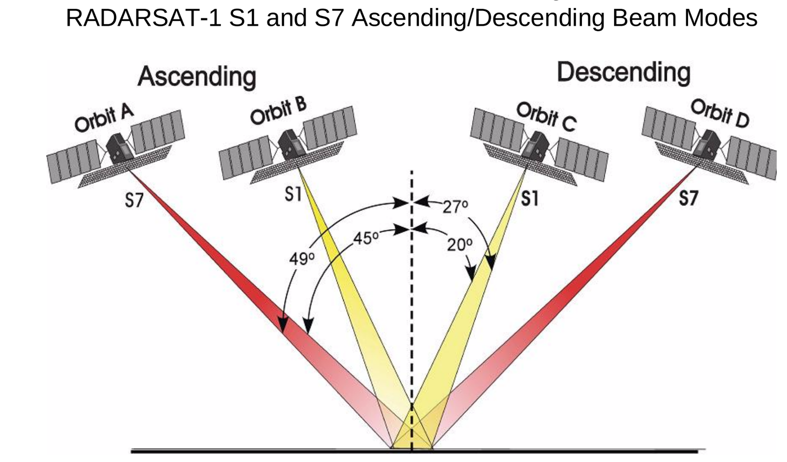


Look Directions and Incident Angles of
RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-27, Figure 11

RADARSAT-1 Standard Beam 7 Ascending Image for Namur Lake, Alberta (NTS 84H)

Compilation by S. Mei, 2003

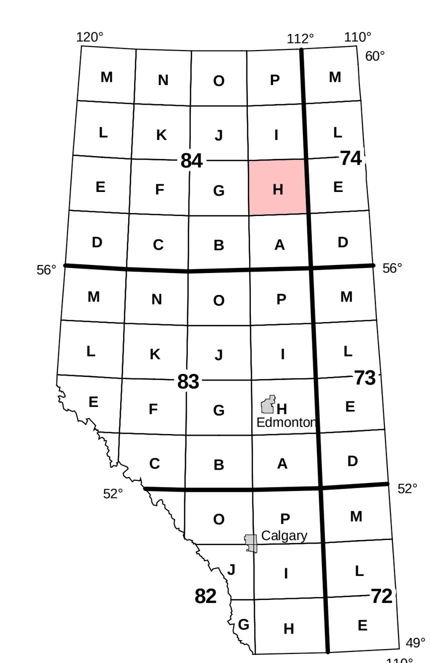
Scale 1:250 000

5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

Projection: Universal Transverse Mercator, Zone 12
Datum: North American Datum, 1983

EUB Alberta Energy and Utilities Board | AGS Alberta Geological Survey



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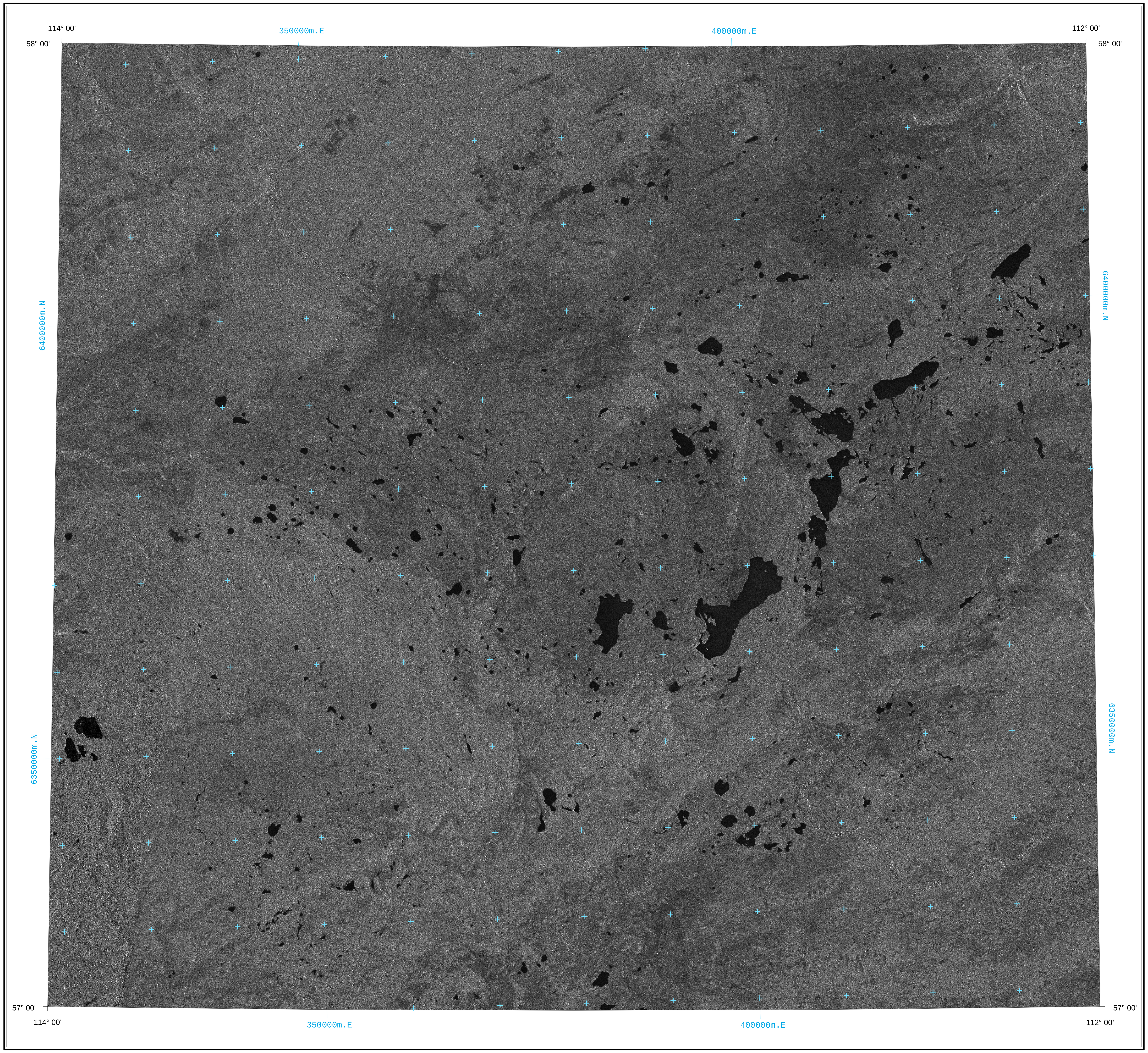
Disclaimer:

NTS 84H
RADARSAT-1



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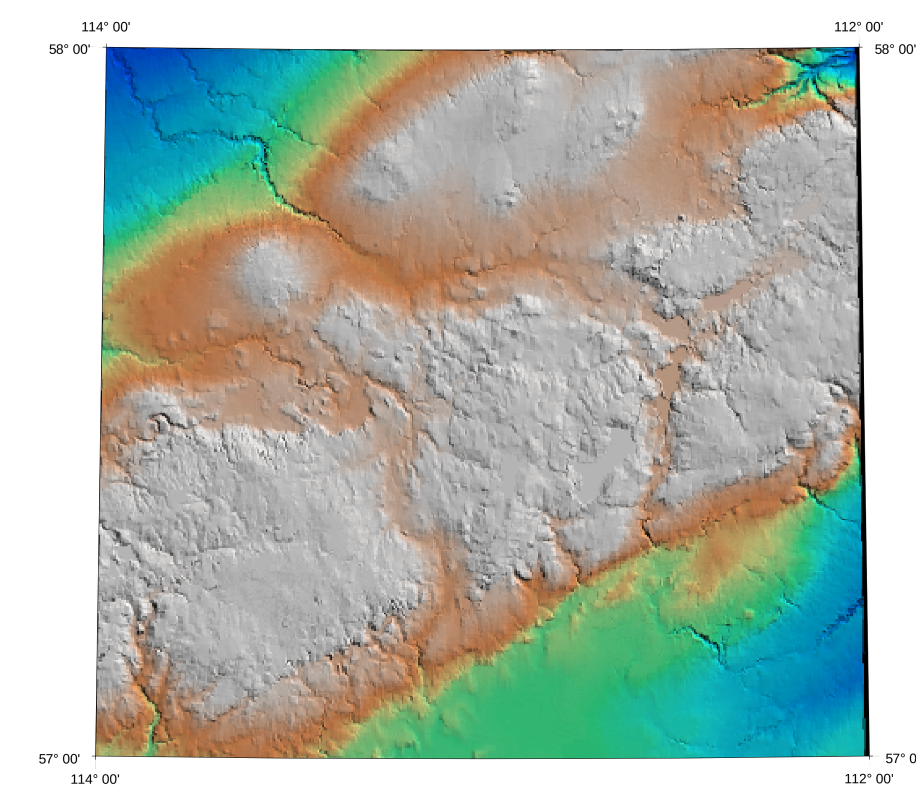

Elevation above Sea Level

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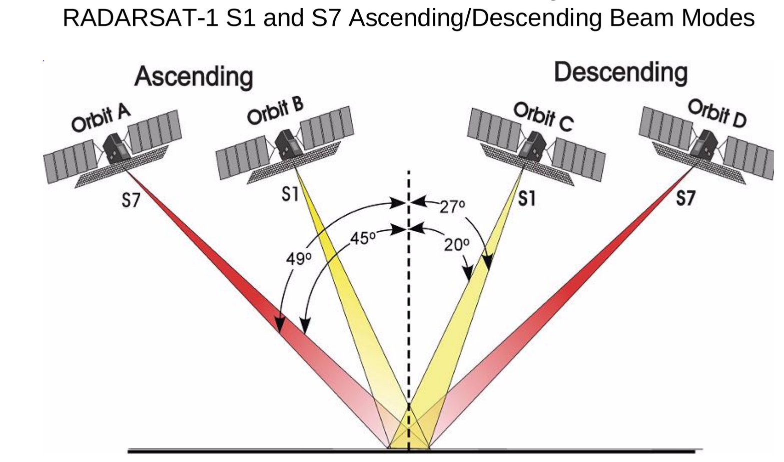

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Geo-Note 2003-27, Figure 12

RADARSAT-1 Standard Beam 7 Descending Image for Namur Lake, Alberta (NTS 84H)

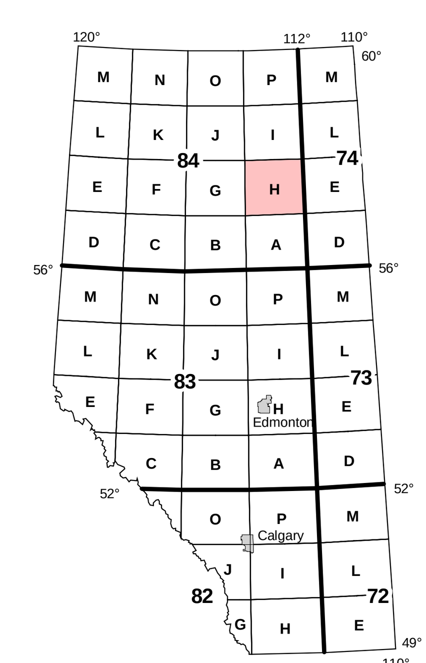
Compilation by S. Mei, 2003

Scale 1:250 000

5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

Projection: Universal Transverse Mercator, Zone 12
Datum: North American Datum, 1983



Acknowledgements:

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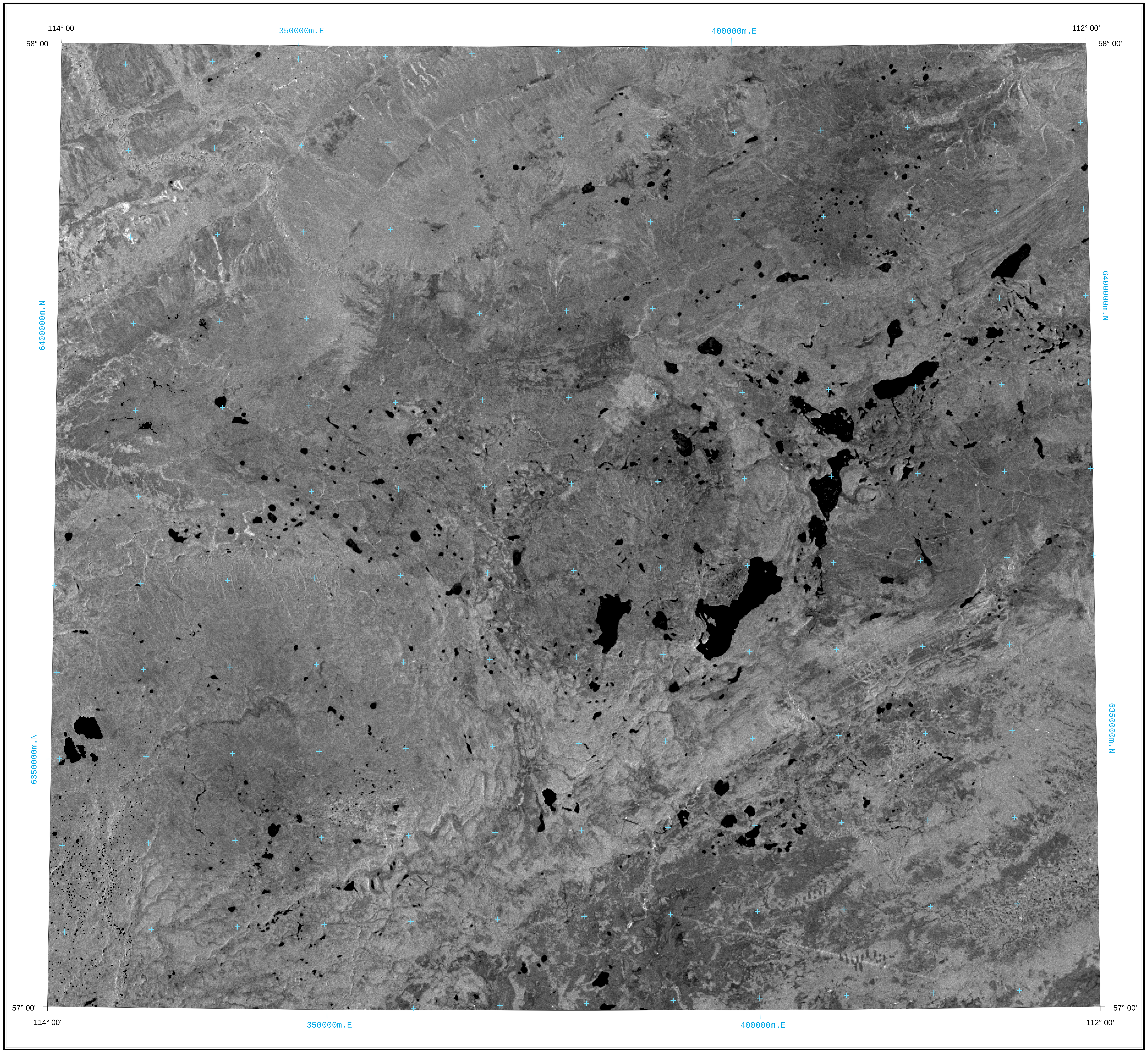
NTS 84H
RADARSAT-1



Introduction

The RADARSAT-1 satellite, launched by Canada in 1995, is an active, microwave-based sensor that sends its own microwave 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., ascending or east looking and descending or west looking), hence the opportunity exists for acquiring a number of separate radar 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 descending (70 scenes), Standard Beam 7 (S7) ascending (65 scenes) and S7 descending (68 scenes). The resolution of each of these datasets is about 25 m (that is, the resulting radar responses reflect or encompass a square cell that is areally about 25 m on each side). The strategy of acquiring S1 and S7 imagery was done to contrast the radar responses based on two incidence angles and two 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 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 evaluates correlation among the signals from the S1A, S1D, S7A and S7D image 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).

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, but there also exist farm lands, wetlands and some other settings with differing vegetation types. With respect to moisture, 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. With respect to surface roughness, this also is a complex response, but refers to 'roughness' at the centimetre scale, and results from a combination of both the roughness of the vegetation canopy and of the underlying ground surface terrain (i.e., 'averaged' across the about 25 m^2 field). As a result, surface roughness is related to the nature of the underlying geomorphology, the surficial geology and soil type, and the vegetation type, extent of vegetative coverage and canopy configuration. In turn, these factors also influence the amount of moisture in the soil, and the type of vegetation that is 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 of a few individual orthorectified RADARSAT-1 images, there can be in places a seemingly abrupt change in tone or texture; these normally occur across a linear or curvilinear boundary that reflects the join of the images. Therefore, because of these complicated interactions between the radar energy and the vegetation, moisture and surface roughness, 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).

Having said this, some general tips for interpreting the Figures 13 to 16 PCA 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.

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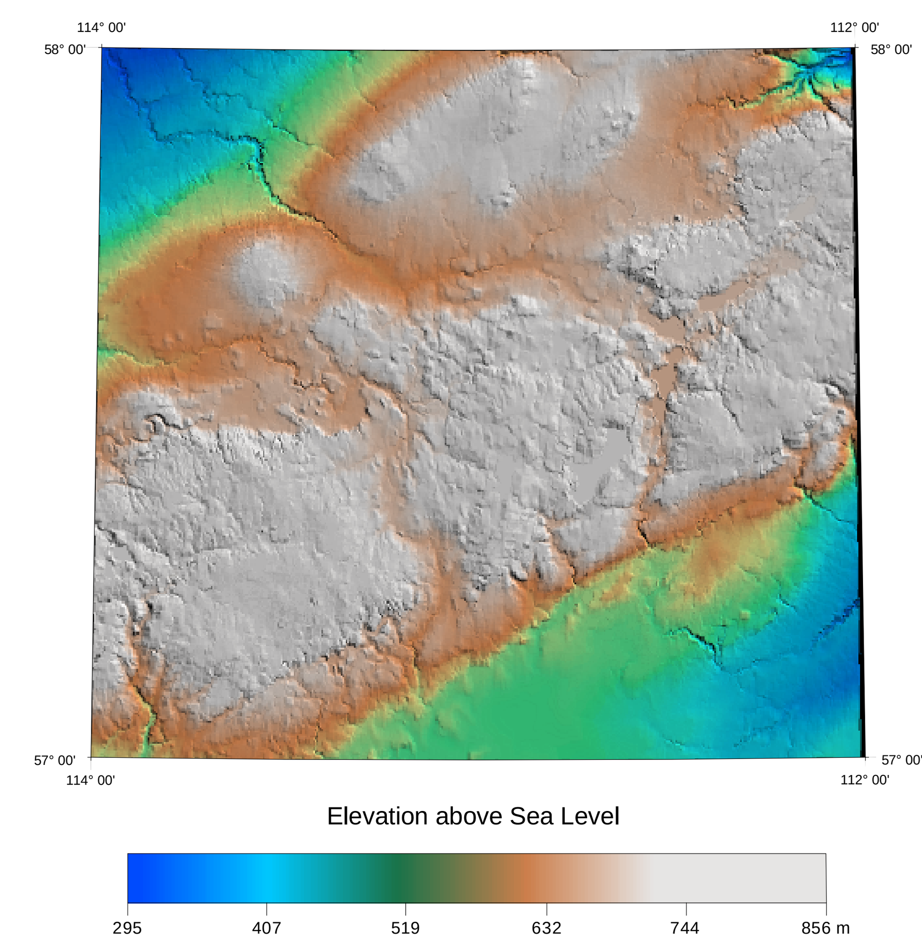
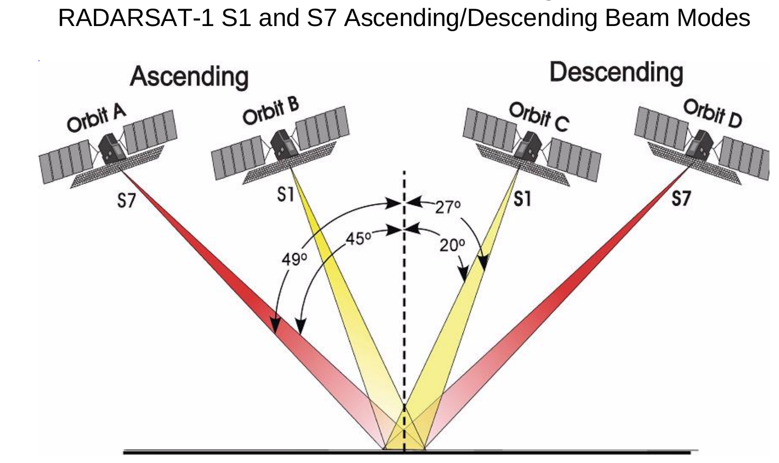
Elevation Map for NTS 84H



Look Directions and Incident Angles of
RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-27, Figure 13

RADARSAT-1 Principal Component 1 Image for Namur Lake, Alberta (NTS 84H)

Compilation by S. Mei, 2003

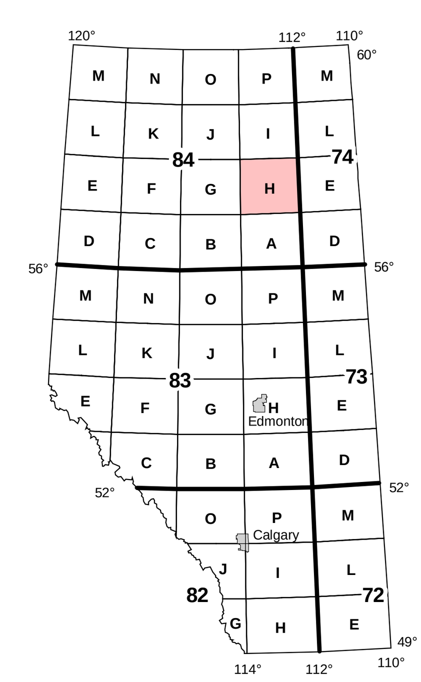
Scale 1:250 000

5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

Projection: Universal Transverse Mercator, Zone 12
Datum: North American Datum, 1983

EUB Alberta Energy and Utilities Board | AGS Alberta Geological Survey



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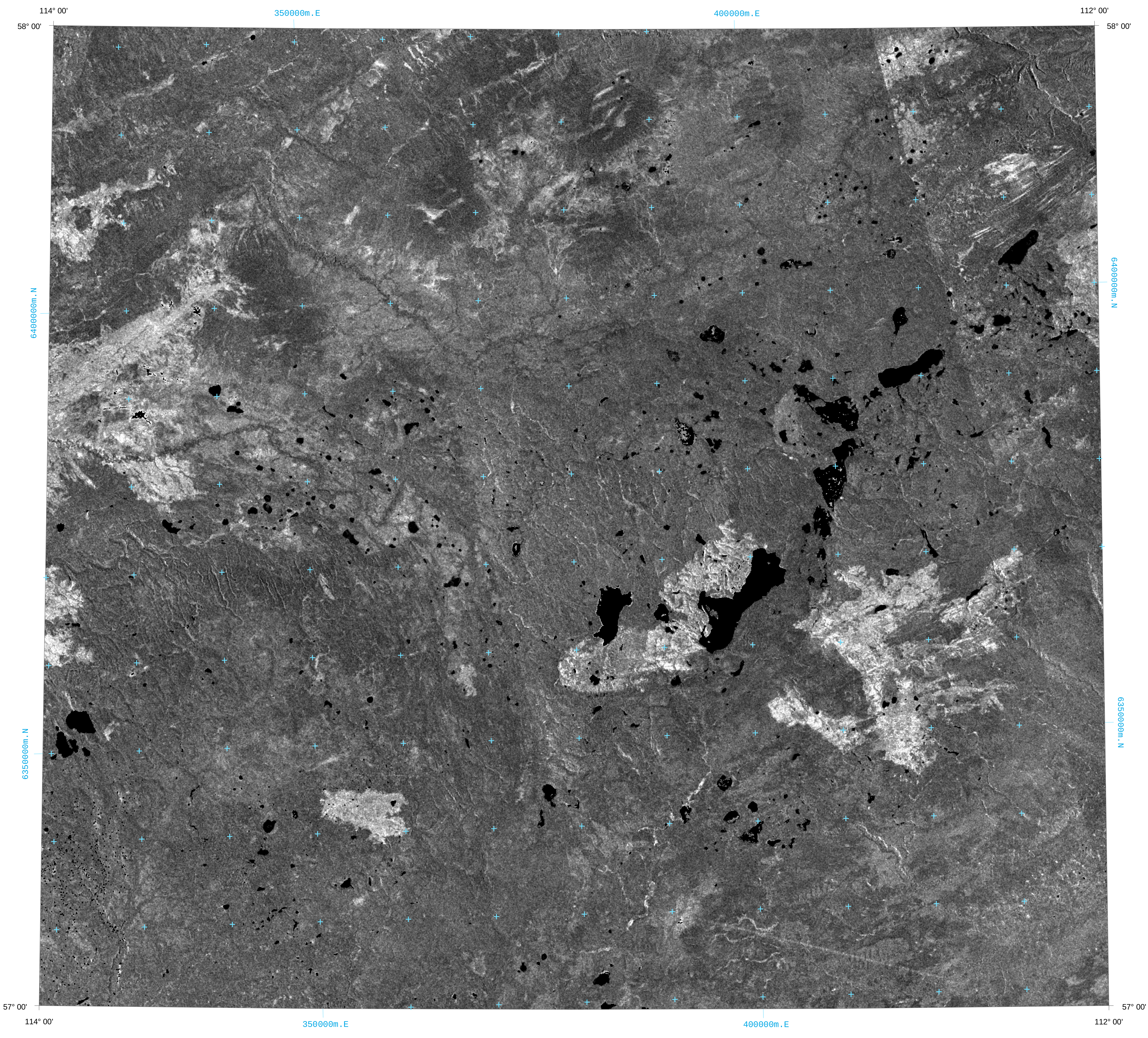
NTS 84H
RADARSAT-1



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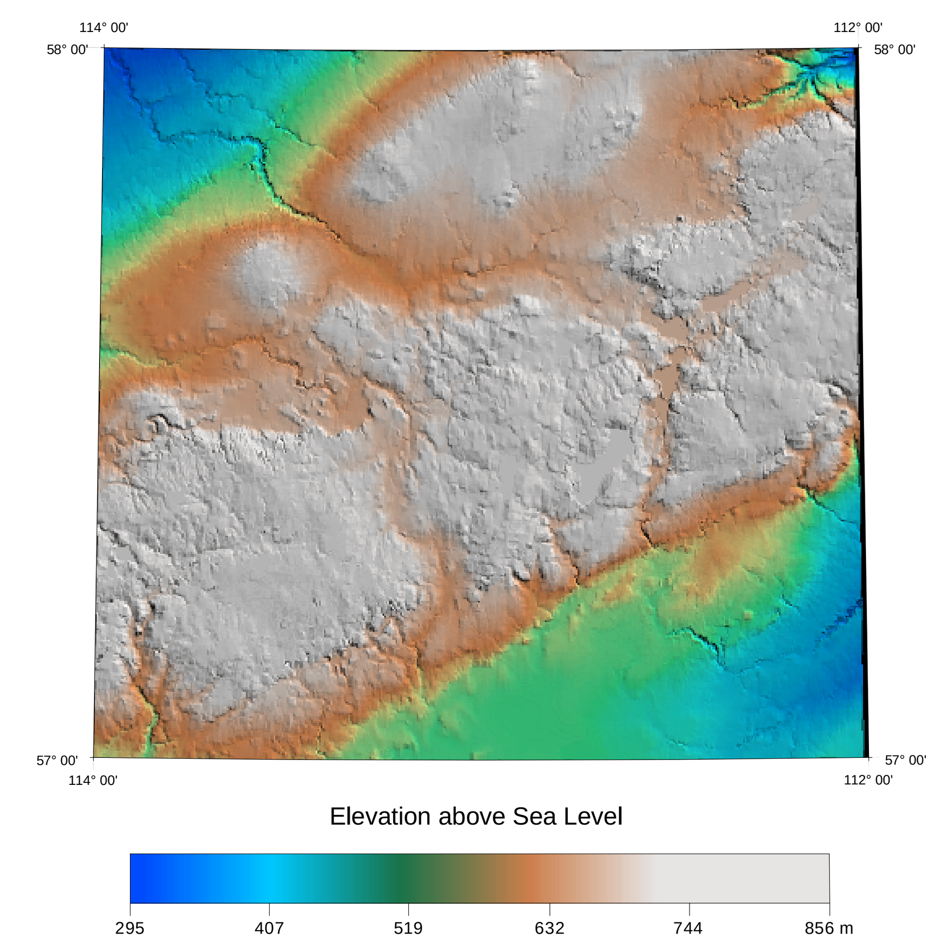
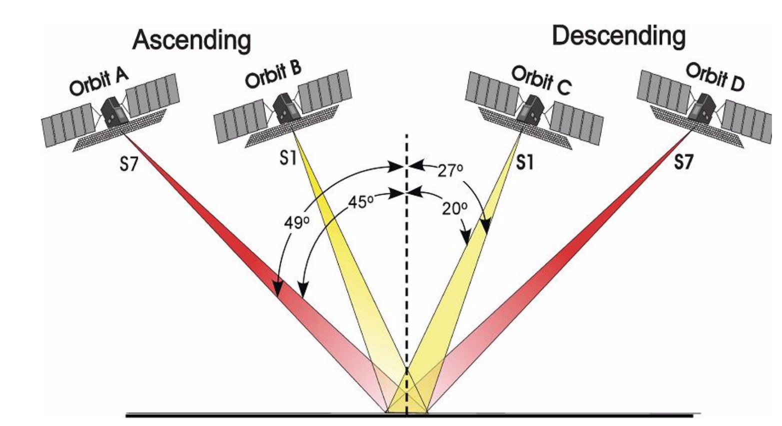
Elevation Map for NTS 84H



Look Directions and Incident Angles of
RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-27, Figure 14

RADARSAT-1 Principal Component 2 Image for Namur Lake, Alberta (NTS 84H)

Compilation by S. Mei, 2003

Scale 1:250 000

5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

Projection: Universal Transverse Mercator, Zone 12
Datum: North American Datum, 1983

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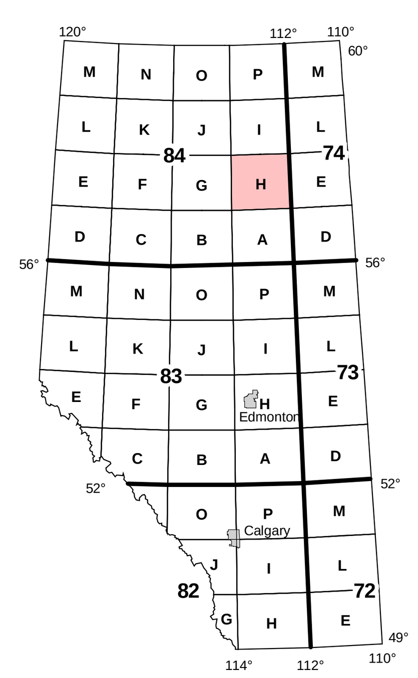

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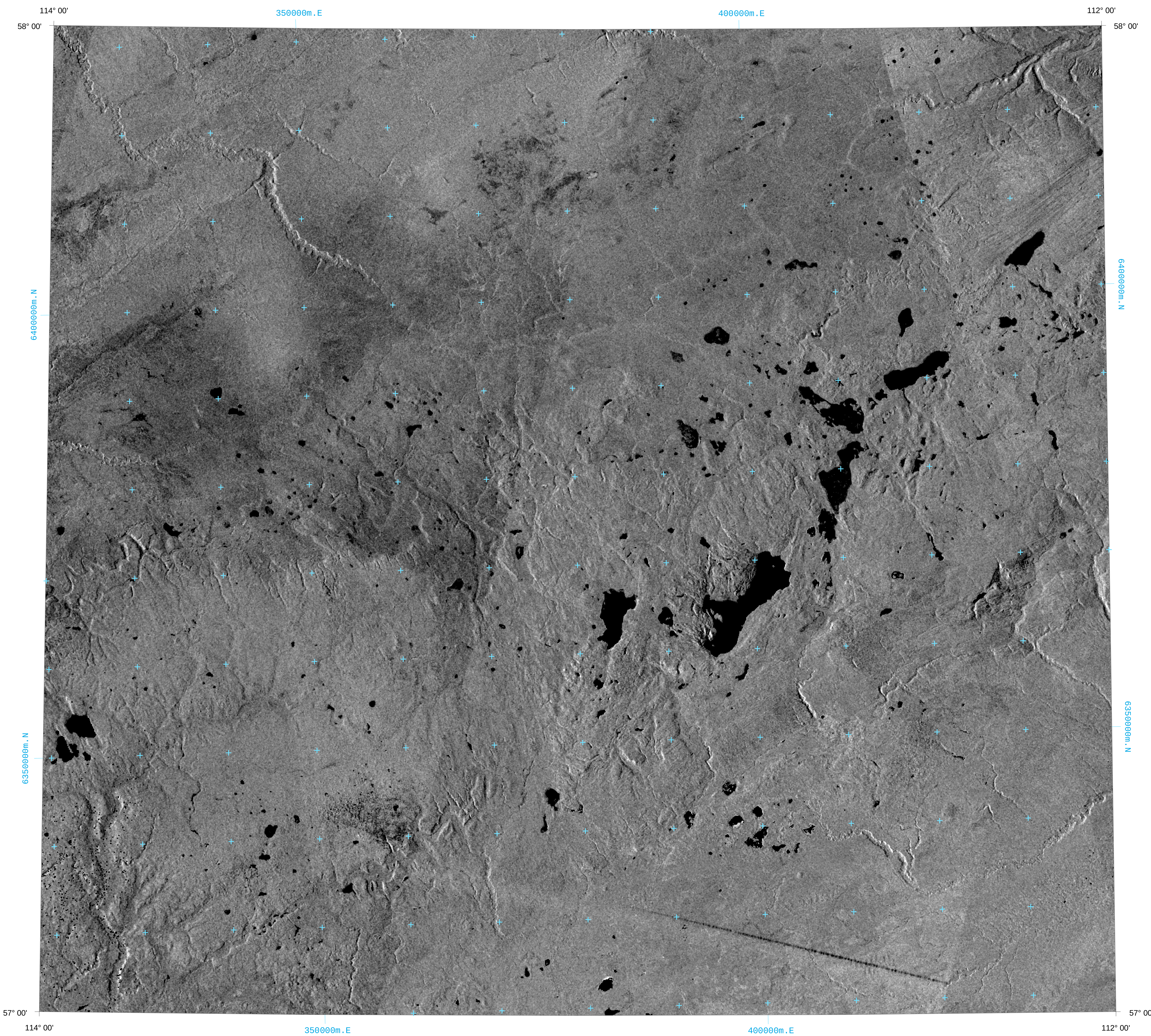
NTS 84H
RADARSAT-1



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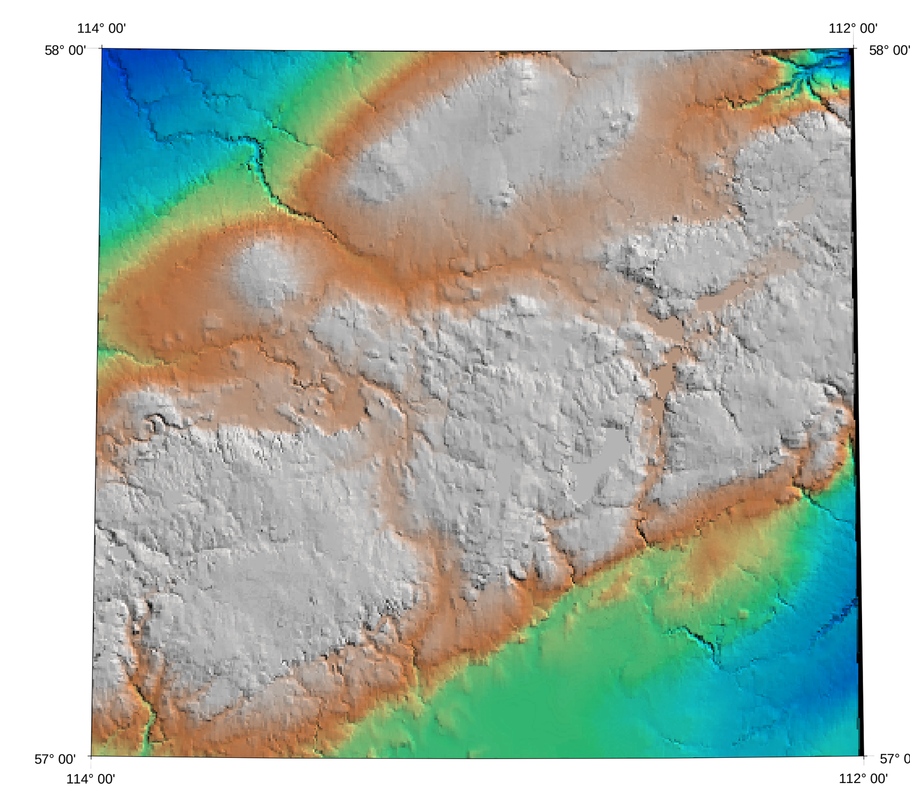
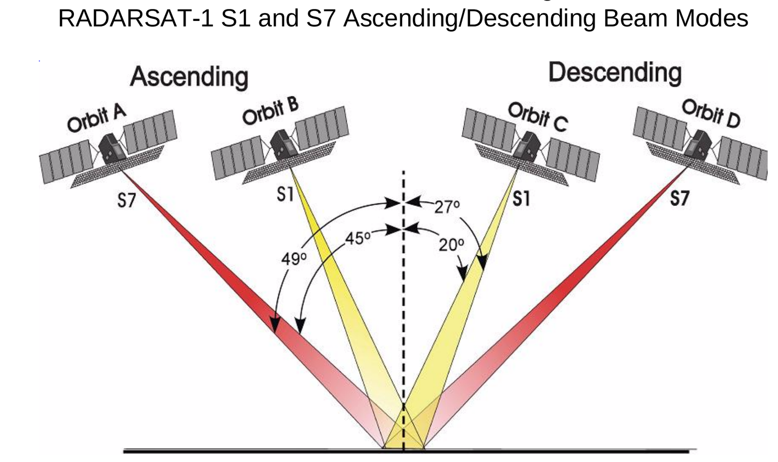
Elevation Map for NTS 84H



Elevation above Sea Level

295 407 519 632 744 856 m

Look Directions and Incident Angles of
RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-27, Figure 15

RADARSAT-1 Principal Component 3 Image for Namur Lake, Alberta (NTS 84H)

Compilation by S. Mei, 2003

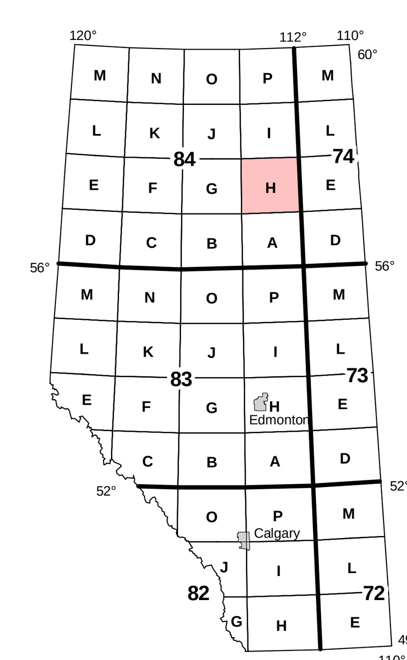
Scale 1:250 000

5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

Projection: Universal Transverse Mercator, Zone 12
Datum: North American Datum, 1983

Alberta Energy and Utilities Board | Alberta Geological Survey



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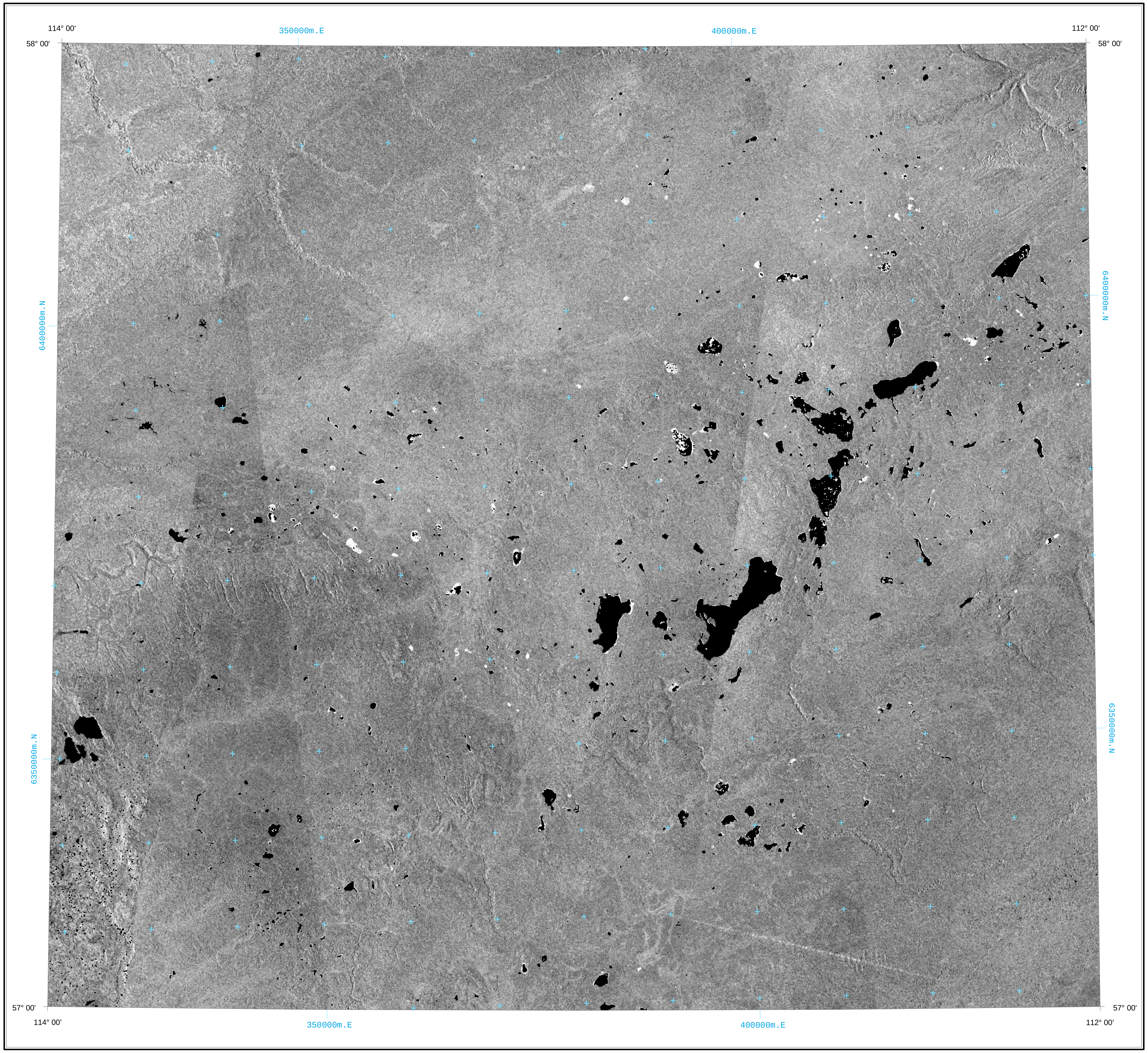
Disclaimer:

NTS 84H
RADARSAT-1



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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 descending (70 scenes), Standard Beam 7 (S7) ascending (65 scenes) and S7 descending (68 scenes). The resolution of each of these datasets is about 25 m (that is, the resulting radar responses reflect or encompass a square cell that is areally about 25 m on each side). The strategy of acquiring S1 and S7 imagery was done to contrast the radar responses based on two incidence angles and two 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 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 evaluates correlation among the signals from the S1A, S1D, S7A and S7D image 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).

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, but there also exist farm lands, wetlands and some other settings with differing vegetation types. With respect to moisture, 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. With respect to surface roughness, this also is a complex response, but refers to 'roughness' at the centimetre scale, and results from a combination of both the roughness of the vegetation canopy and of the underlying ground surface terrain (i.e., 'averaged' across the about 25 m^2 field). As a result, surface roughness is related to the nature of the underlying geomorphology, the surficial geology and soil type, and the vegetation type, extent of vegetative coverage and canopy configuration. In turn, these factors also influence the amount of moisture in the soil, and the type of vegetation that is 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 of a few individual orthorectified RADARSAT-1 images, there can be in places a seemingly abrupt change in tone or texture; these normally occur across a linear or curvilinear boundary that reflects the join of the images. Therefore, because of these complicated interactions between the radar energy and the vegetation, moisture and surface roughness, 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).

Having said this, some general tips for interpreting the Figures 13 to 16 PCA 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.

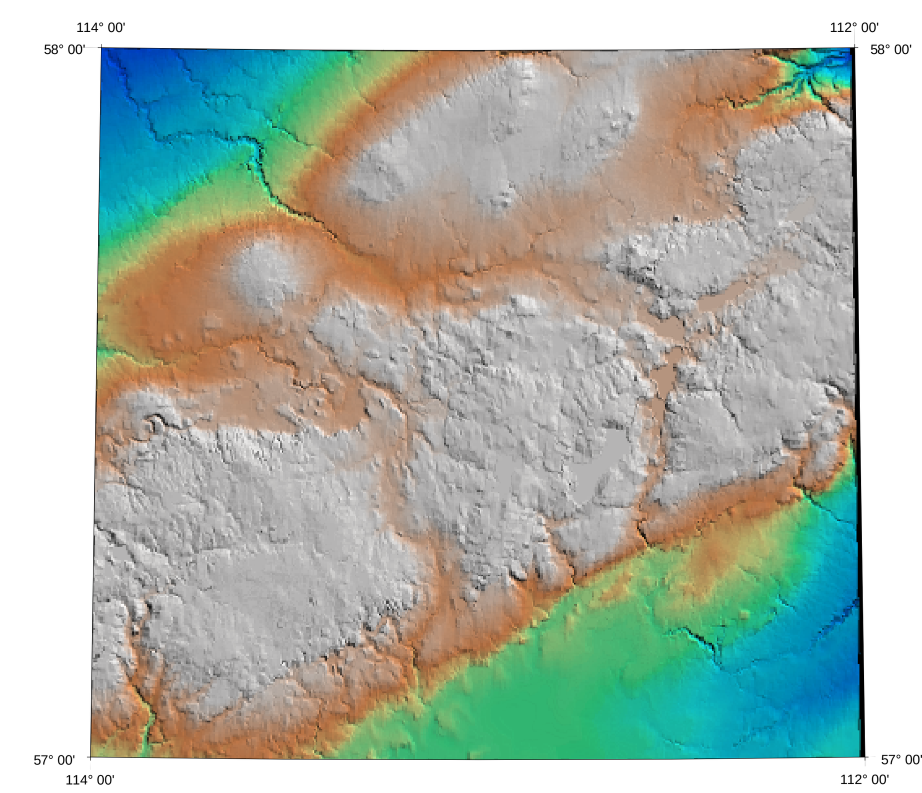
The First Principal Component (PC1) image (Figure 13) shows a range of brightness and texture that highlights features associated with differences in vegetation type and density. Areas of closed Aspen, closed Pine, open deciduous vegetation, grasslands and exposed soil appear to have a brighter tone with variable texture. Areas of open black spruce tend to show up as mid tone to dark grey. Shrubby and grassy wetlands also appear as dark areas. In general, darker tones tend to reflect areas of increased moisture (e.g., wetlands and areas of black spruce), whereas lighter tones reflect areas of drier conditions (e.g., better drainage with pine, aspen or exposed soil).

The Second Principal Component (PC2) image (Figure 14) provides information about the degree of land cover type and vegetation density. For example, well-forested lands show up as darker tones, whereas areas of burn and grassy or barren lands show up as lighter tones. 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.

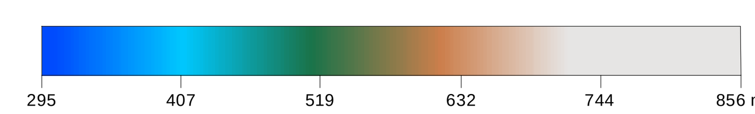
The Third Principal Component (PC3) image (Figure 15) highlights 'surface roughness'; hence it reflects topographic effects and surface texture of the ground or vegetation canopy. In fact, the discrimination of topographic features using the PC3 image is superior to any other optical commercial satellite imagery, with similar spatial resolution. As a result, areas of drumlins, sand dunes, eskers, embankments and other prominent topographic features typically are more clearly shown on PC3 images than on the other PCA images. Further, areas of outwash, dune fields, stream alluvium and ice contact deposits usually exhibit unique textural characteristics, which can act to assist in the preliminary mapping or differentiation of surficial materials.

The Fourth Principal Component (PC4) image (Figure 16) shows some added differences in vegetation surface and volume 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.

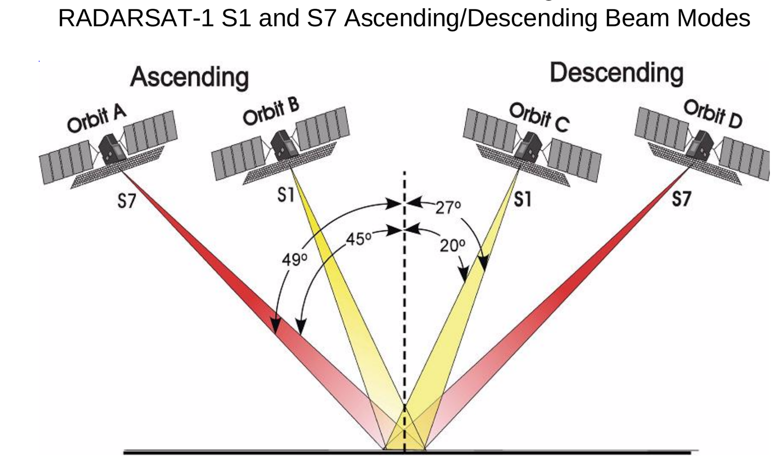
Elevation Map for NTS 84H



Elevation above Sea Level



Look Directions and Incident Angles of
RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Information Sales
Alberta Geological Survey
Telephone: (780) 422-3767
Web site: www.ags.gov.ab.ca

Geo-Note 2003-27, Figure 16

RADARSAT-1 Principal Component 4 Image for Namur Lake, Alberta (NTS 84H)

Compilation by S. Mei, 2003

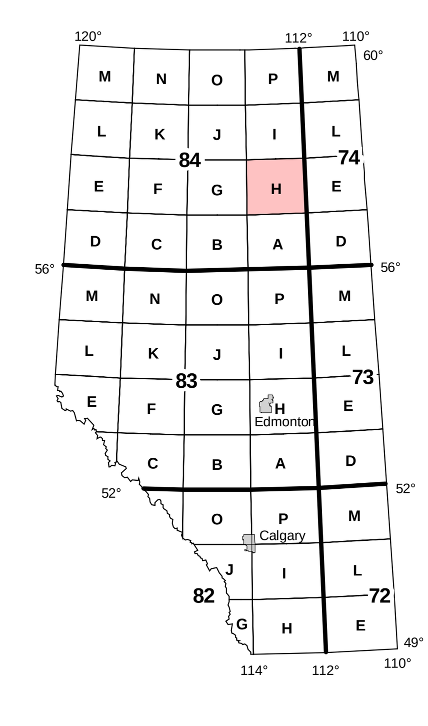
Scale 1:250 000

5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

Projection: Universal Transverse Mercator, Zone 12
Datum: North American Datum, 1983

EUB Alberta Energy and Utilities Board | AGS Alberta Geological Survey



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