EUB/AGS Geo-Note 2003-30

Orthorectified and Principal Component RADARSAT-1 Image Dataset for NTS 84K, 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 84K 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 84K 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 84K.

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.

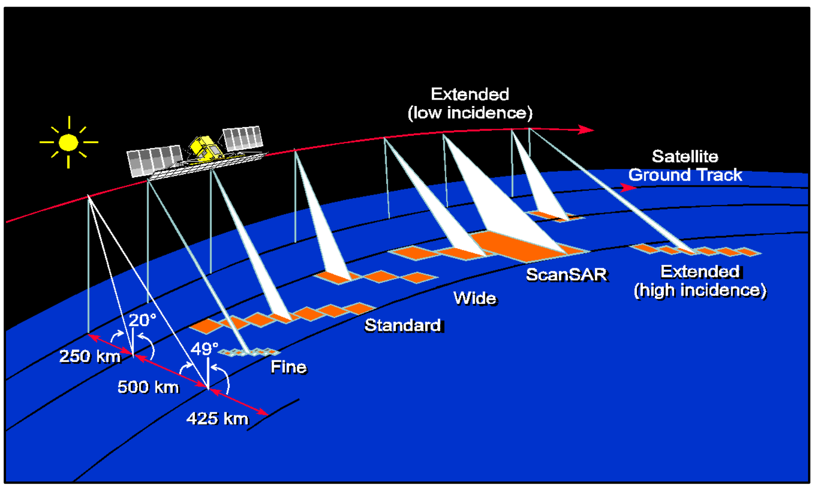

Figure 1. RADARSAT-1 beam modes (used with permision from RADARSAT International (RSI), 1997).

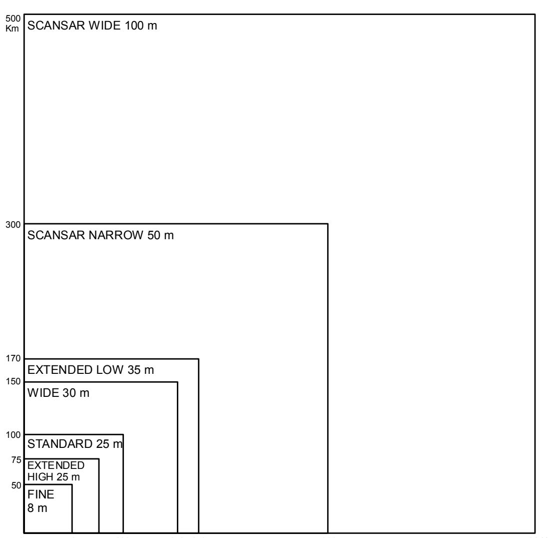

Figure 2. Coverage sizes and resolutions of RADARSAT-1 beam modes (modified after RADARSAT International (RSI), 1999).

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

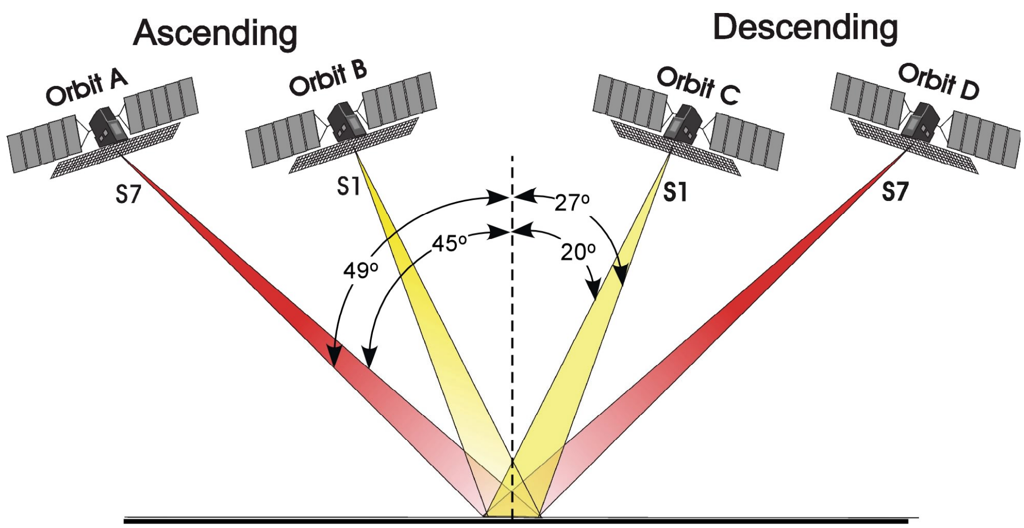

Figure 3. Multi-beam configuration of RADARSAT-1 S1 and S7 ascending/descending imagery (after Grunsky, 2002a).

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

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 84K 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 84K.

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

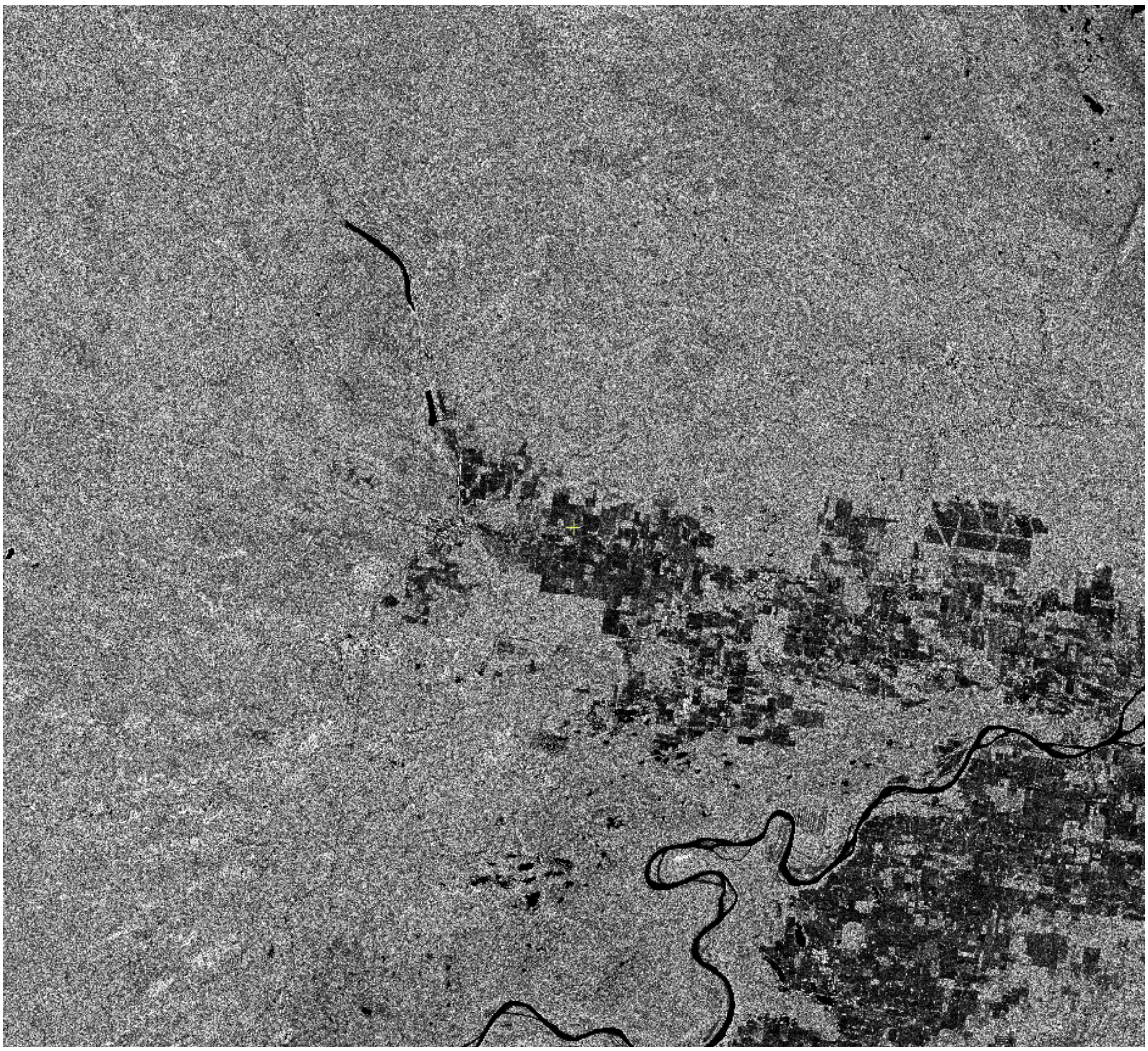

Figure 4. One of the original SGF scene images used for tiling the NTS 84K dataset: scene MO197333 of Standard Beam Mode 7 ascending. RADARSAT data © Canadian Space Agency/Agence spatiale canadienne 1999, processed and distributed by RADARSAT International.

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

Scene ID	Beam	Path	UL_LAT	UL_LONG	UR_LAT	UR_LONG	LR_LAT	LR_LONG	LL_LAT	LL_LONG
M0198316	S1	ASC	59:00:57.25N	119:15:24.08W	59:16:07.15N	117:18:49.54W	58:21:19.65N	116:53:30.62W	58:06:25.23N	118:47:01.32W
M0198315	S1	ASC	58:11:44.11N	118:49:44.68W	58:26:39.88N	116:55:57.53W	57:31:49.62N	116:31:31.87W	57:17:08.31N	118:22:24.26W
M0196472	S1	ASC	59:49:03.55N	118:37:51.45W	60:04:29.27N	116:38:18.85W	59:09:45.13N	116:12:03.28W	58:54:36.00N	118:08:22.35W
M0196471	S1	ASC	58:59:55.23N	118:11:11.99W	59:15:05.89N	116:14:34.79W	58:20:18.39N	115:49:16.63W	58:05:23.21N	117:42:49.98W
M0196470	S1	ASC	58:10:47.28N	117:45:35.61W	58:25:43.83N	115:51:45.47W	57:30:53.57N	115:27:20.41W	57:16:11.49N	117:18:15.78W
M0196327	S1	ASC	58:15:41.28N	119:54:38.73W	58:30:38.22N	118:00:36.97W	57:35:48.16N	117:36:07.37W	57:21:05.76N	119:27:13.61W
M0195964	S1	ASC	59:50:05.42N	117:36:07.60W	60:05:31.28N	115:36:31.41W	59:10:47.16N	115:10:14.86W	58:55:37.90N	117:06:37.34W
M0195963	S1	ASC	59:00:53.64N	117:09:25.51W	59:16:04.33N	115:12:45.88W	58:21:16.85N	114:47:26.87W	58:06:21.66N	116:41:02.51W
M0195962	S1	ASC	58:11:46.63N	116:43:48.96W	58:26:43.29N	114:49:55.74W	57:31:53.05N	114:25:29.91W	57:17:10.87N	116:16:28.20W
M0196922	S1	DES	58:35:08.43N	119:49:25.09W	58:20:17.24N	117:55:47.78W	57:25:41.99N	118:23:14.95W	57:40:18.71N	120:13:56.94W
M0196921	S1	DES	59:24:32.25N	119:26:28.73W	59:09:26.19N	117:30:03.54W	58:14:55.46N	117:58:33.61W	58:29:45.30N	119:51:54.33W
M0196736	S1	DES	58:37:37.64N	116:39:36.24W	58:22:46.14N	114:45:52.67W	57:28:11.03N	115:13:22.64W	57:42:48.03N	117:04:10.52W
M0196735	S1	DES	59:26:53.69N	116:16:39.71W	59:11:48.12N	114:20:09.06W	58:17:16.82N	114:48:42.02W	58:32:06.86N	116:42:07.83W
M0196560	S1	DES	58:33:38.97N	118:46:28.11W	58:18:48.40N	116:52:56.92W	57:24:12.63N	117:20:22.32W	57:38:48.76N	119:10:58.48W
M0196559	S1	DES	59:22:59.48N	118:23:33.96W	59:07:54.91N	116:27:16.13W	58:13:23.70N	116:55:43.81W	58:28:12.82N	118:48:57.56W
M0196088	S1	DES	58:39:47.36N	117:41:28.30W	58:24:55.08N	115:47:35.74W	57:30:20.13N	116:15:08.31W	57:44:57.85N	118:06:04.72W
M0196087	S1	DES	59:29:04.81N	117:18:29.93W	59:13:58.33N	115:21:49.02W	58:19:27.58N	115:50:24.61W	58:34:18.48N	117:44:00.21W
M0199944	S7	ASC	59:12:34.89N	117:00:40.35W	59:20:54.67N	115:03:51.74W	58:26:18.77N	114:50:31.70W	58:17:58.91N	116:44:17.28W
M0199943	S7	ASC	58:23:05.80N	116:47:53.58W	58:31:28.07N	114:53:42.51W	57:35:05.11N	114:40:09.18W	57:26:42.44N	116:31:21.28W
M0198985	S7	ASC	59:02:33.84N	119:02:57.43W	59:10:54.05N	117:06:41.44W	58:16:18.15N	116:53:24.03W	58:07:57.78N	118:46:38.98W
M0198984	S7	ASC	58:13:03.62N	118:50:19.83W	58:21:26.45N	116:56:39.70W	57:26:48.71N	116:43:33.70W	57:18:25.45N	118:34:22.12W
M0197334	S7	ASC	59:44:08.36N	118:15:31.88W	59:52:28.07N	116:16:53.17W	58:57:52.32N	116:03:23.07W	58:49:32.75N	117:58:52.13W
M0197333	S7	ASC	58:54:47.82N	118:00:28.39W	59:03:07.41N	116:04:41.60W	58:08:30.41N	115:51:27.08W	58:00:10.59N	117:44:14.41W
M0197332	S7	ASC	58:05:13.55N	117:47:53.40W	58:13:35.81N	115:54:41.24W	57:18:58.60N	115:41:38.33W	57:10:35.84N	117:32:00.35W
M0200867	S7	DES	58:36:55.72N	119:42:17.40W	58:28:37.43N	117:48:09.26W	57:33:59.82N	118:04:09.27W	57:42:18.54N	119:55:23.34W
M0200866	S7	DES	59:26:14.05N	119:30:16.43W	59:17:55.73N	117:33:20.24W	58:23:20.10N	117:49:44.72W	58:31:38.50N	119:43:37.06W
M0200095	S7	DES	58:35:09.73N	117:37:22.50W	58:26:51.30N	115:43:20.15W	57:32:14.29N	115:59:19.34W	57:40:33.15N	117:50:29.99W
M0200094	S7	DES	59:24:34.44N	117:25:19.92W	59:16:16.05N	115:28:30.26W	58:21:40.02N	115:44:54.19W	58:29:58.49N	117:38:40.34W
M0199671	S7	DES	58:36:41.26N	118:40:15.34W	58:28:22.70N	116:46:07.29W	57:33:45.72N	117:02:07.37W	57:42:04.71N	118:53:21.41W
M0199670	S7	DES	59:26:01.72N	118:28:12.90W	59:17:43.18N	116:31:17.49W	58:23:07.58N	116:47:42.24W	58:31:26.19N	118:41:33.85W
M0199030	S7	DES	58:38:34.08N	116:33:00.78W	58:30:15.63N	114:38:46.57W	57:35:38.67N	114:54:47.40W	57:43:57.52N	116:46:07.24W
M0199029	S7	DES	59:27:53.09N	116:20:58.20W	59:19:34.65N	114:23:56.36W	58:24:59.06N	114:40:21.92W	58:33:17.56N	116:34:19.57W

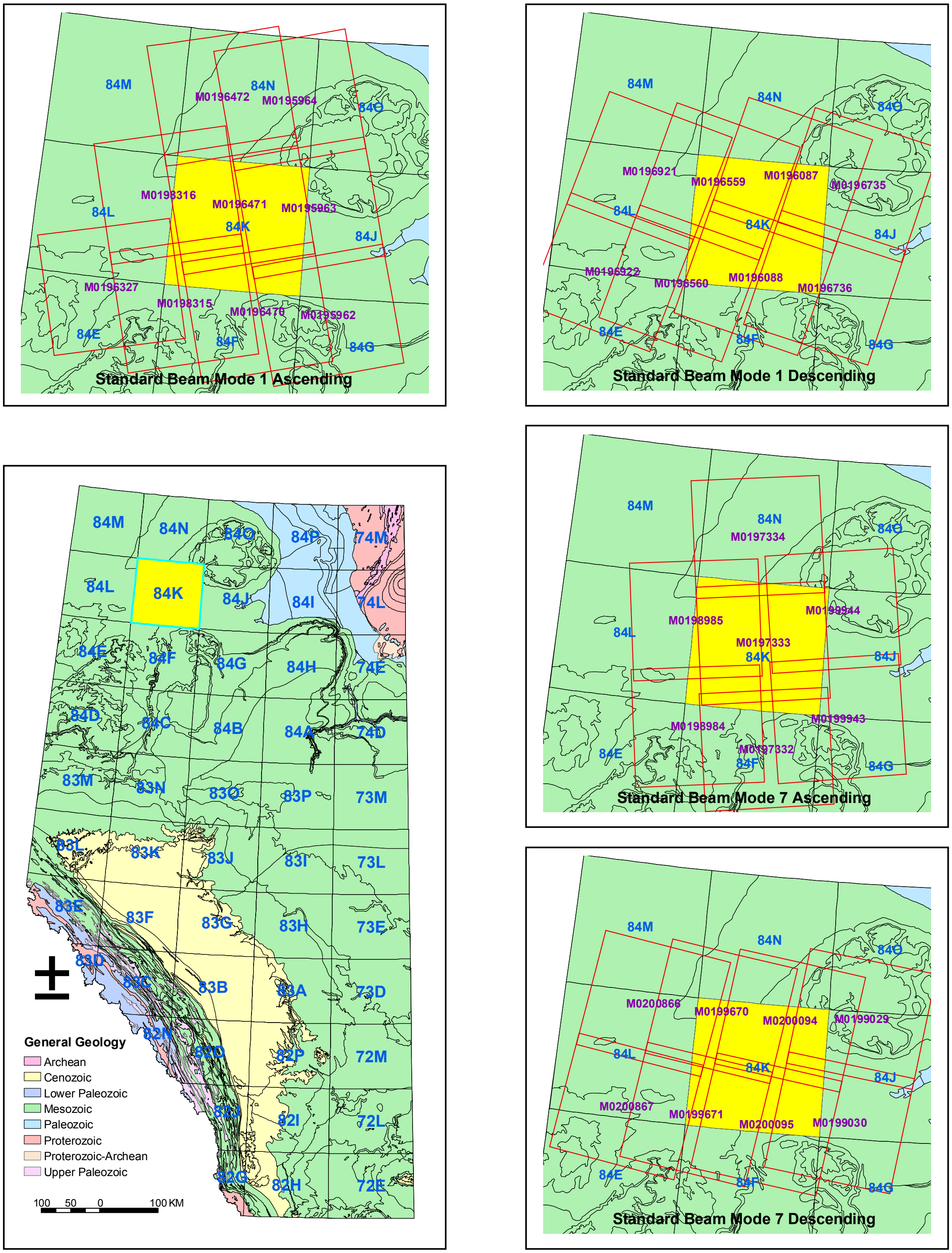

Figure 5. The scenes overlaying NTS 84K.

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 84K dataset.

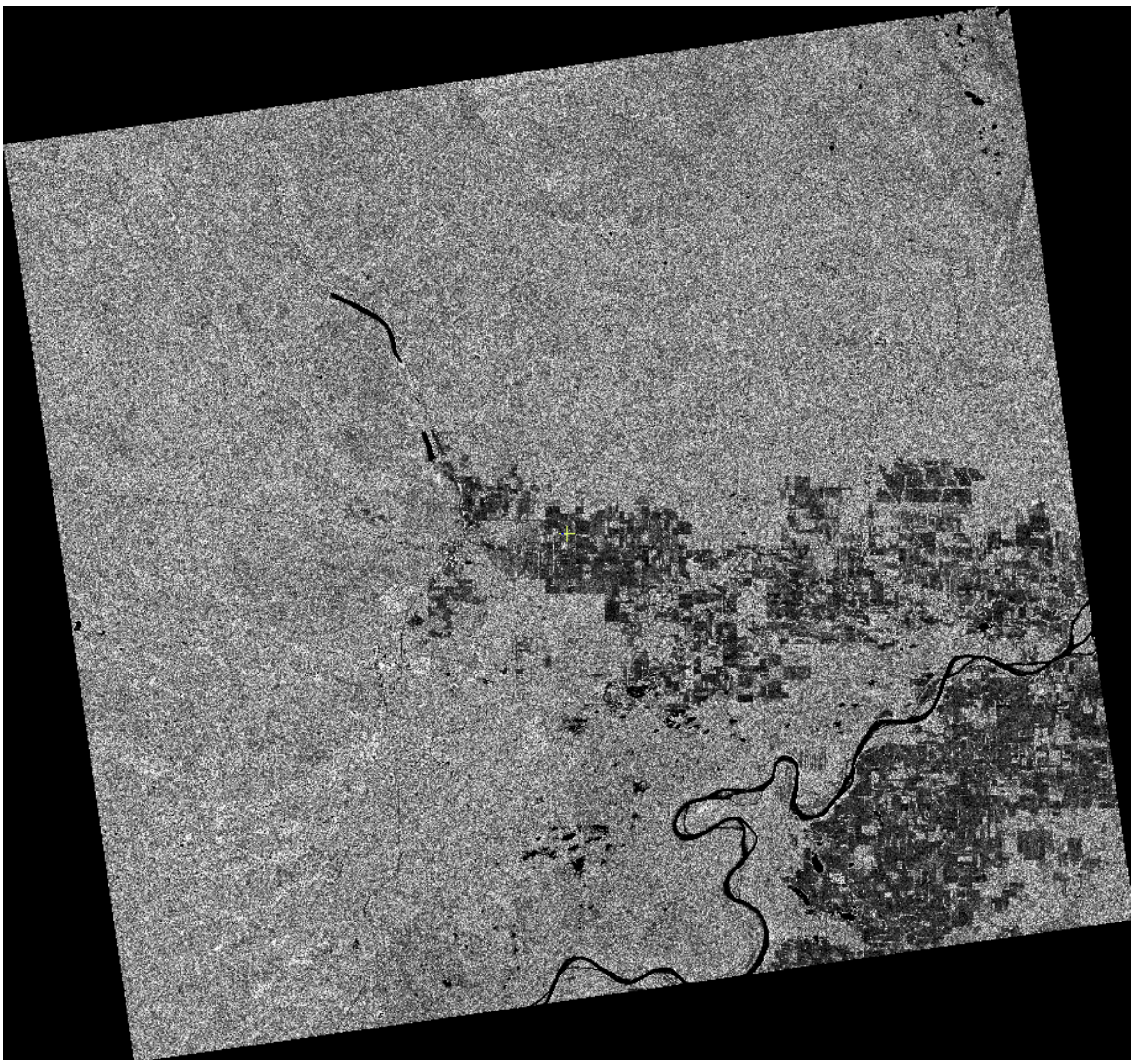

Figure 6. One of the orthorectified scene images used for tiling the NTS 84K dataset: scene MO197333 of Standard Beam Mode 7 ascending.

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 84K image dataset.

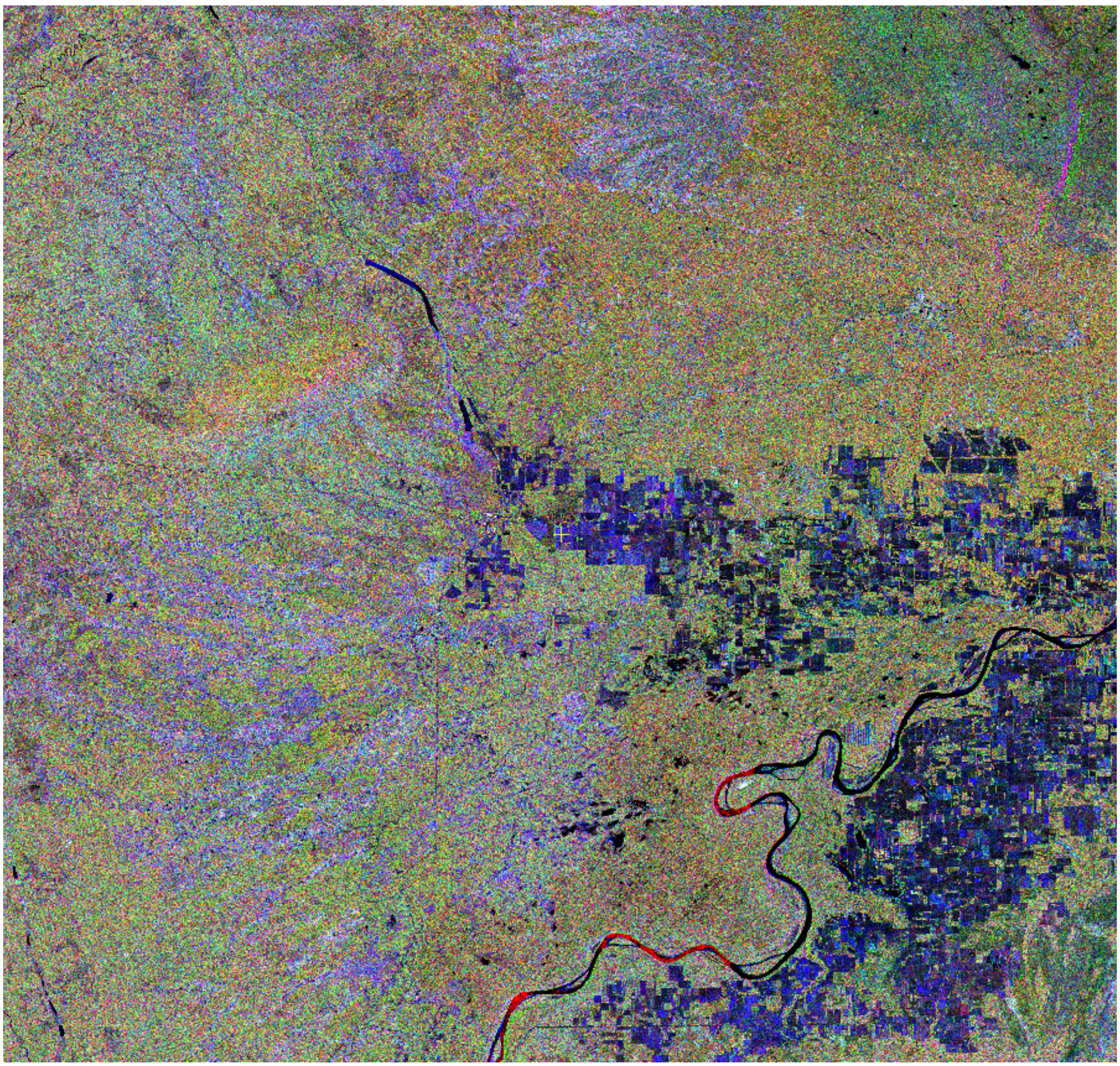

Figure 7. Pseudocolour composite of orthorectified NTS 84K image dataset of Standard Beam Mode S1/S7 ascending/descending beam positions (RGB=S7d, S7a, S1d).

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 84K.

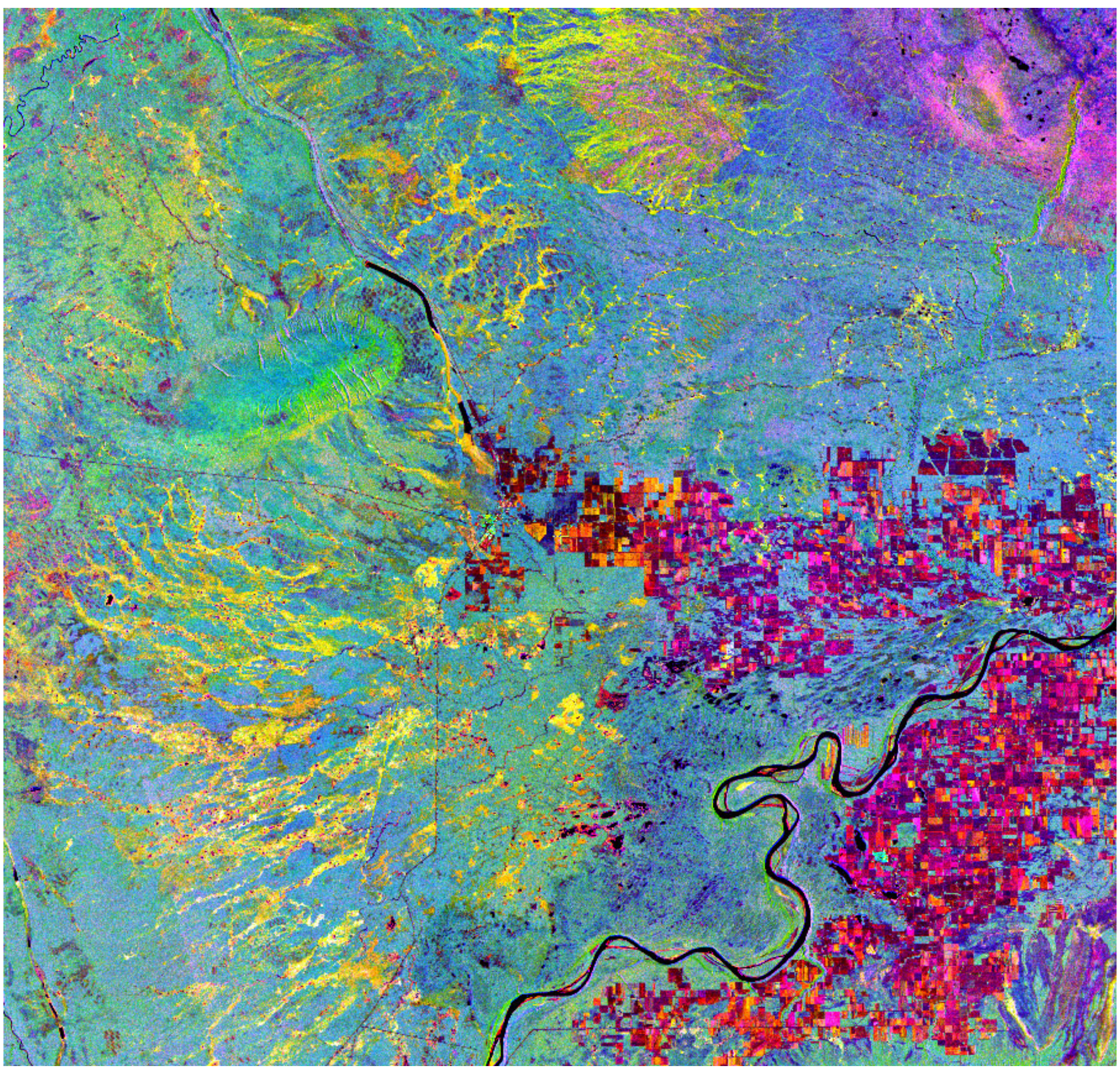

Figure 8. Pseudocolour composite of NTS 84K image dataset of principal component PC1, PC2, PC3 and PC4 (RGB=PC2, PC1, PC3).

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 84K 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 84K. 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 84K map area.

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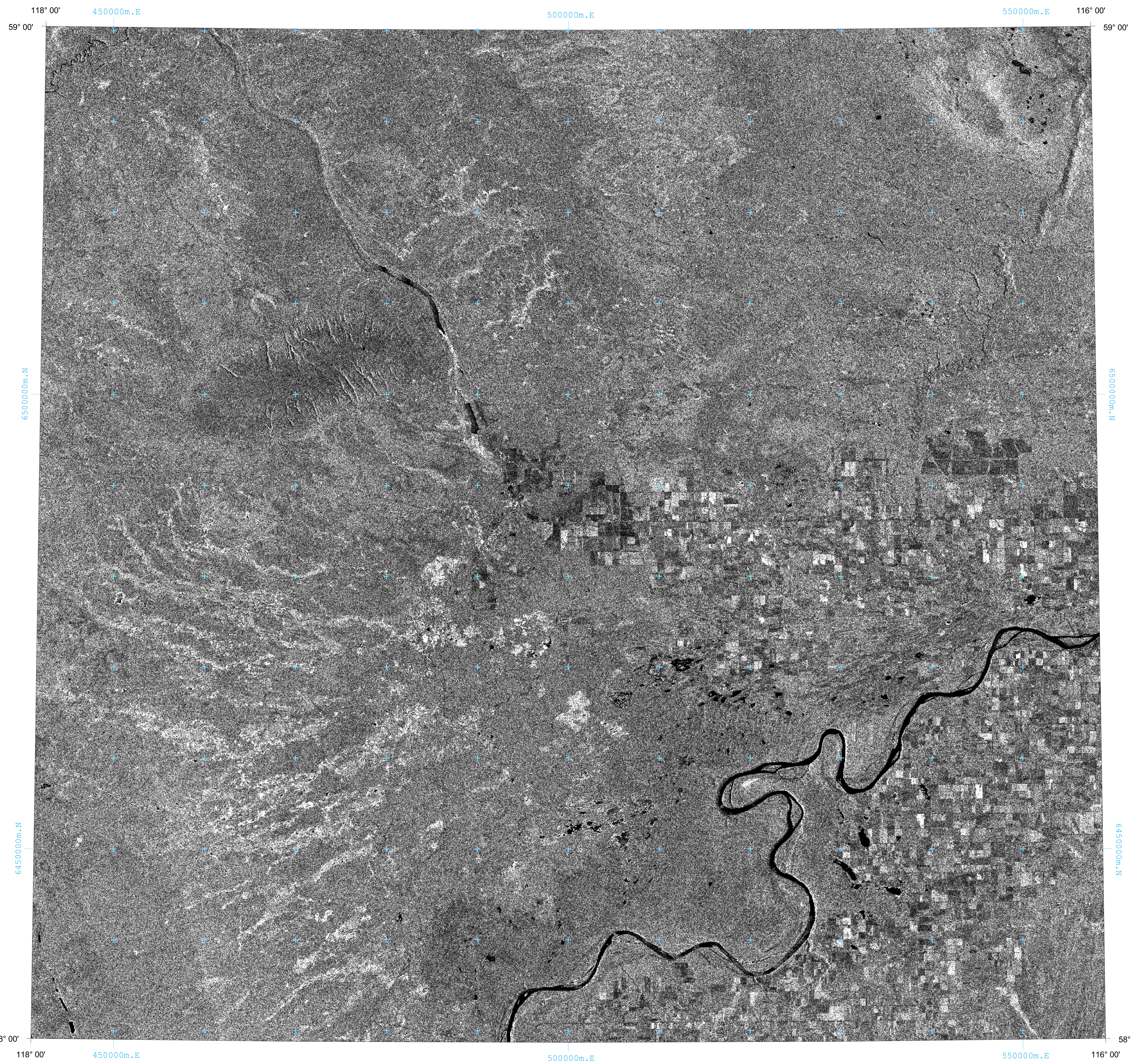
NTS 84K
RADARSAT-1



Introduction

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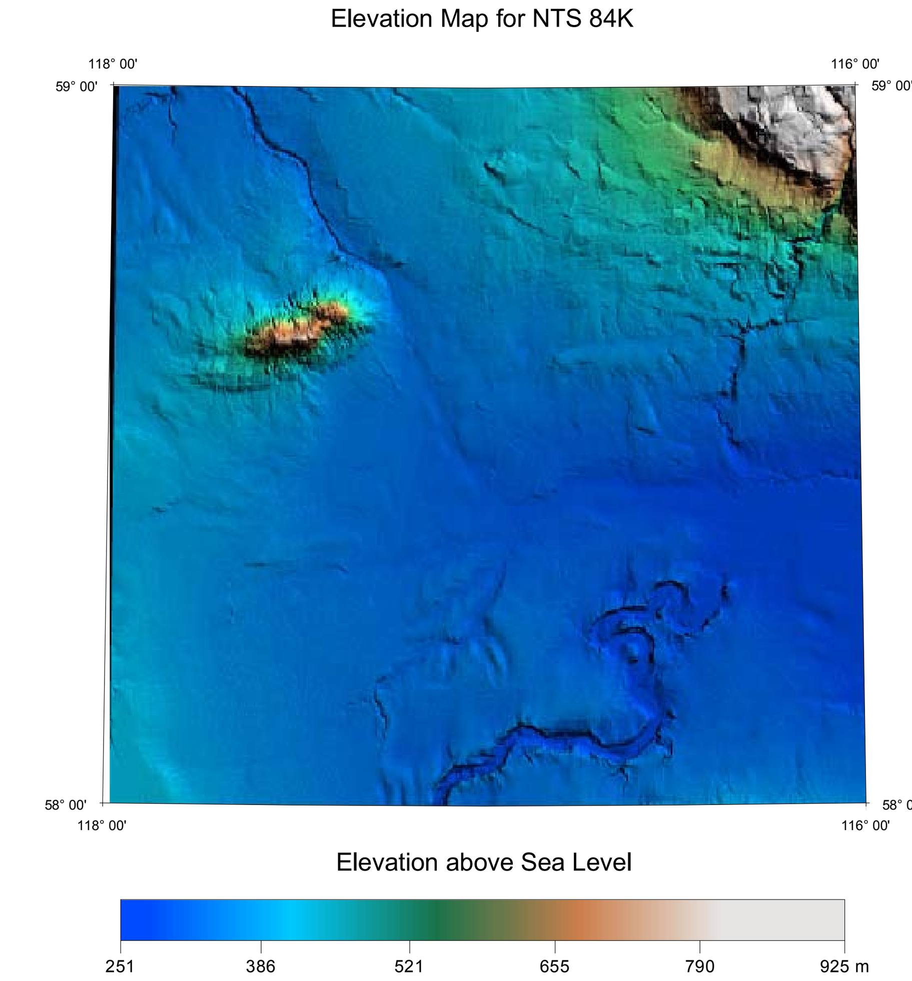
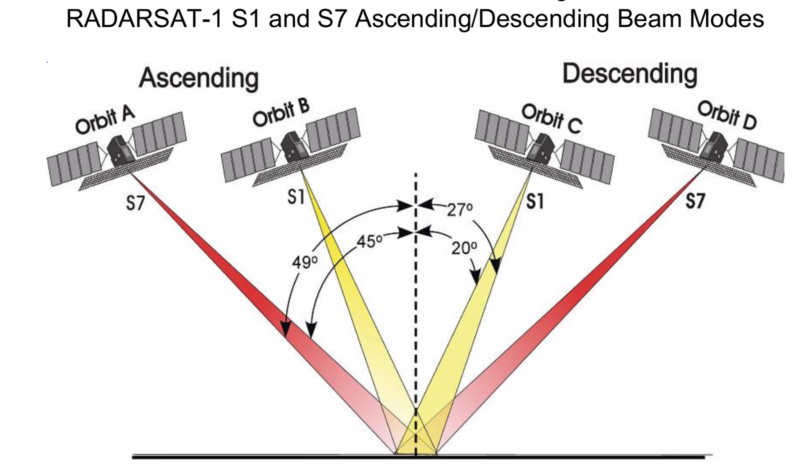
Elevation Map for NTS 84K



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



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Geo-Note 2003-30, Figure 9

RADARSAT-1 Standard Beam 1 Ascending Image for Mount Watt, Alberta (NTS 84K)

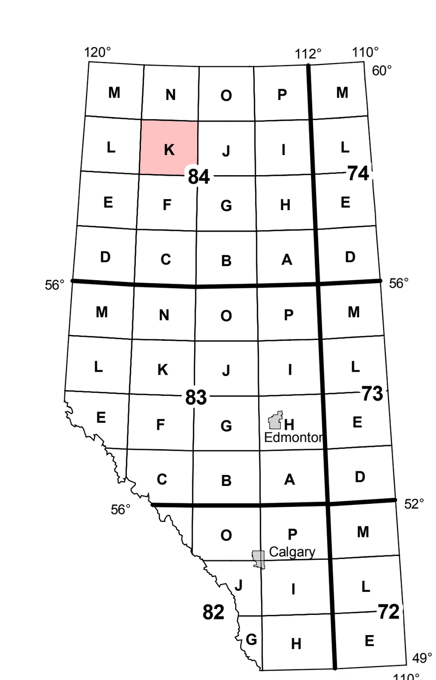
Compilation by S. Mei, 2003

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 11
Datum: North American Datum, 1983



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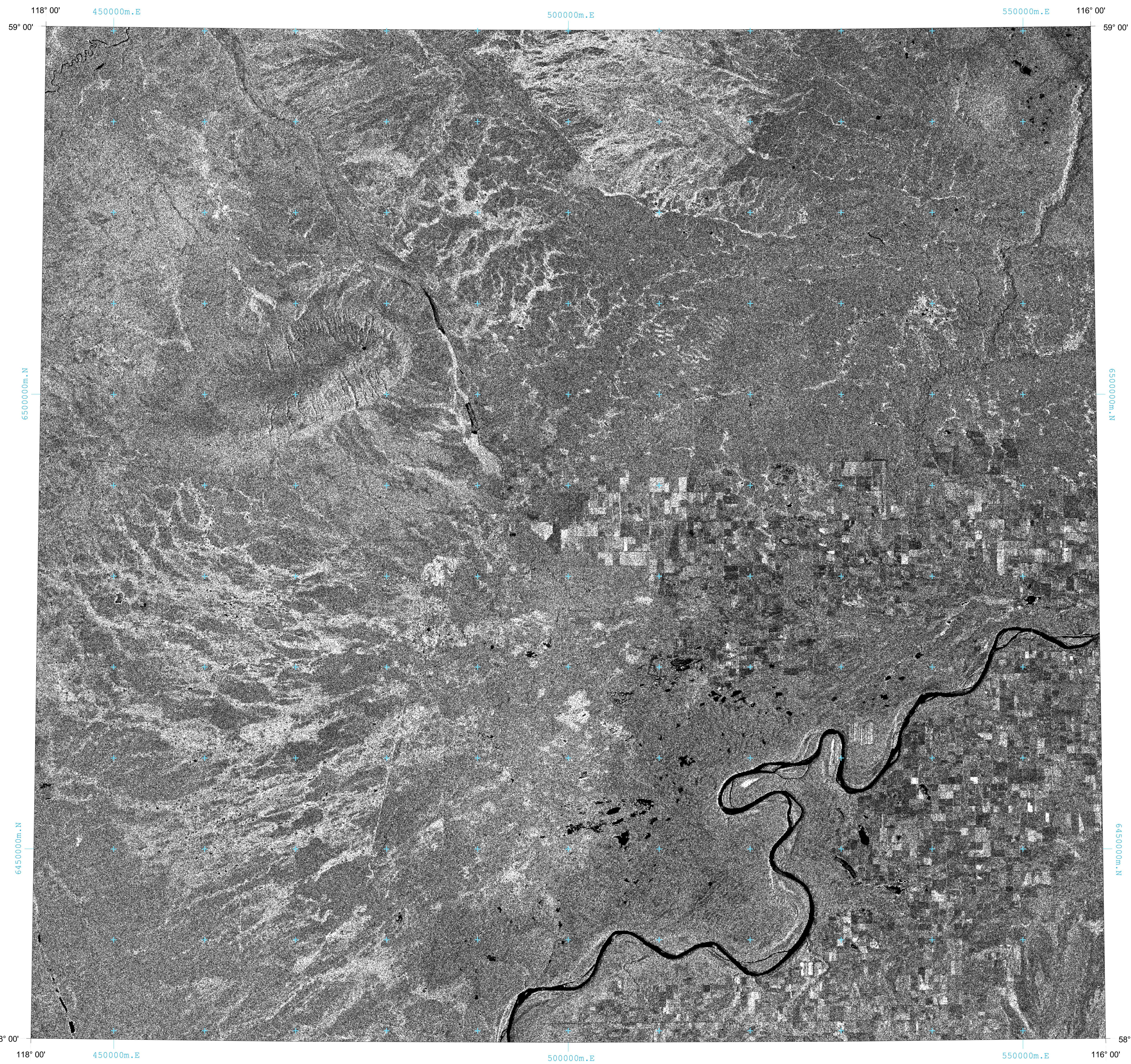
NTS 84K
RADARSAT-1



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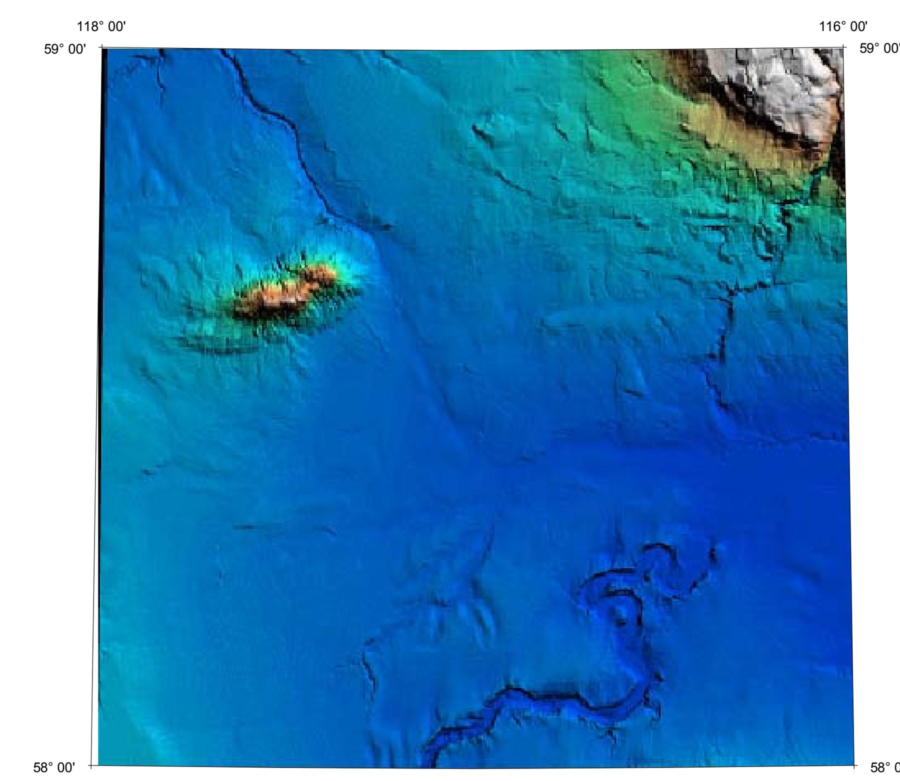
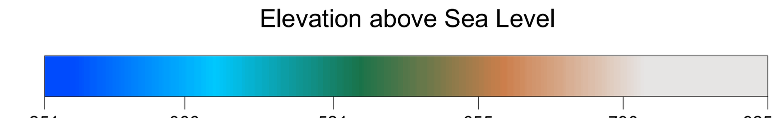
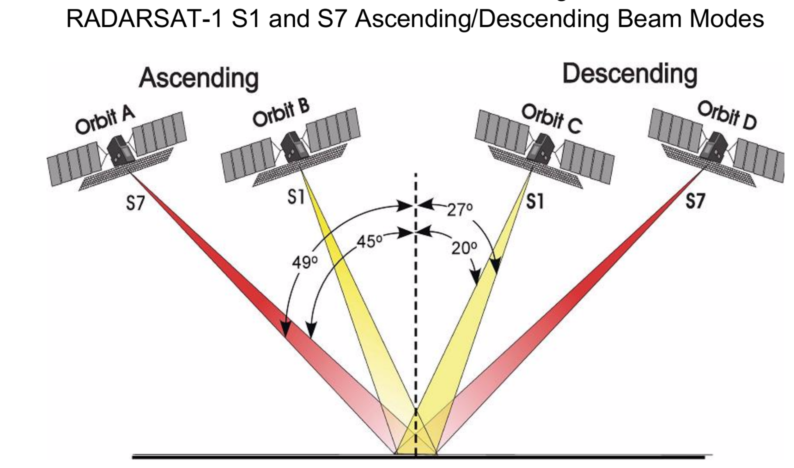
Elevation Map for NTS 84K



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 2003-30, Figure 10

RADARSAT-1 Standard Beam 1 Descending Image for Mount Watt, Alberta (NTS 84K)

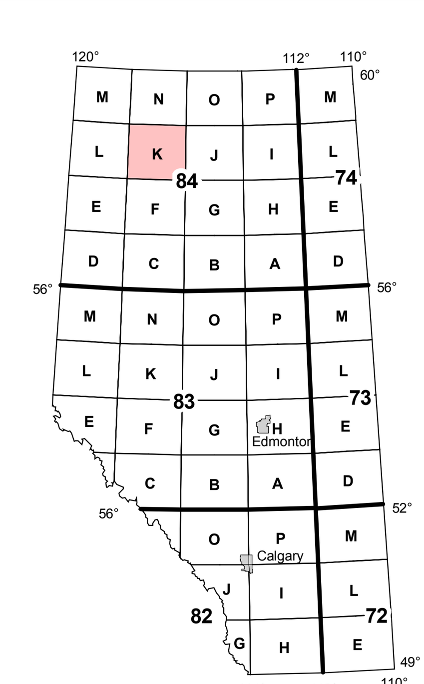
Compilation by S. Mei, 2003

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 11
Datum: North American Datum, 1983



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AGS Alberta Geological Survey

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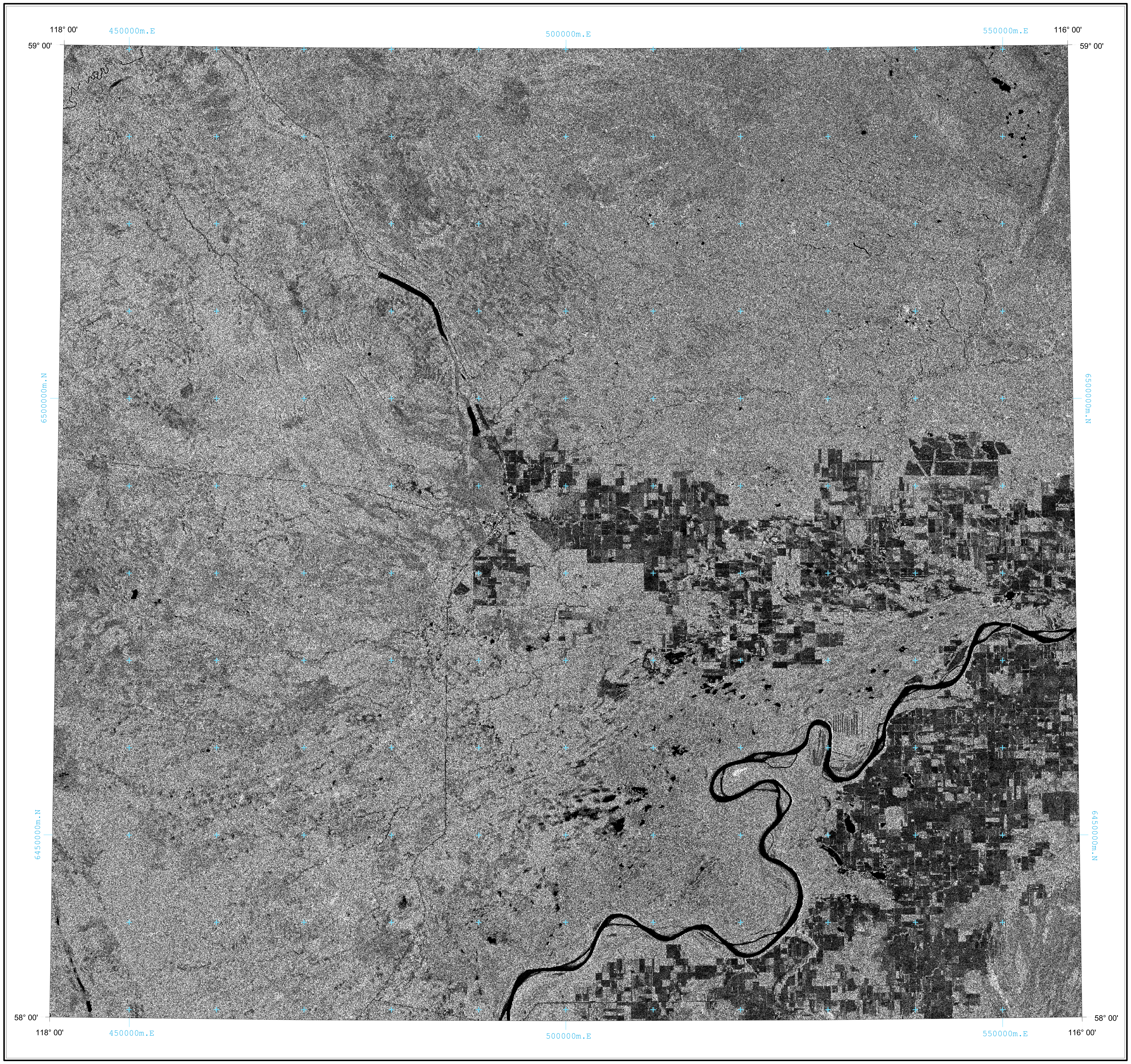
Disclaimer:

NTS 84K
RADARSAT-1



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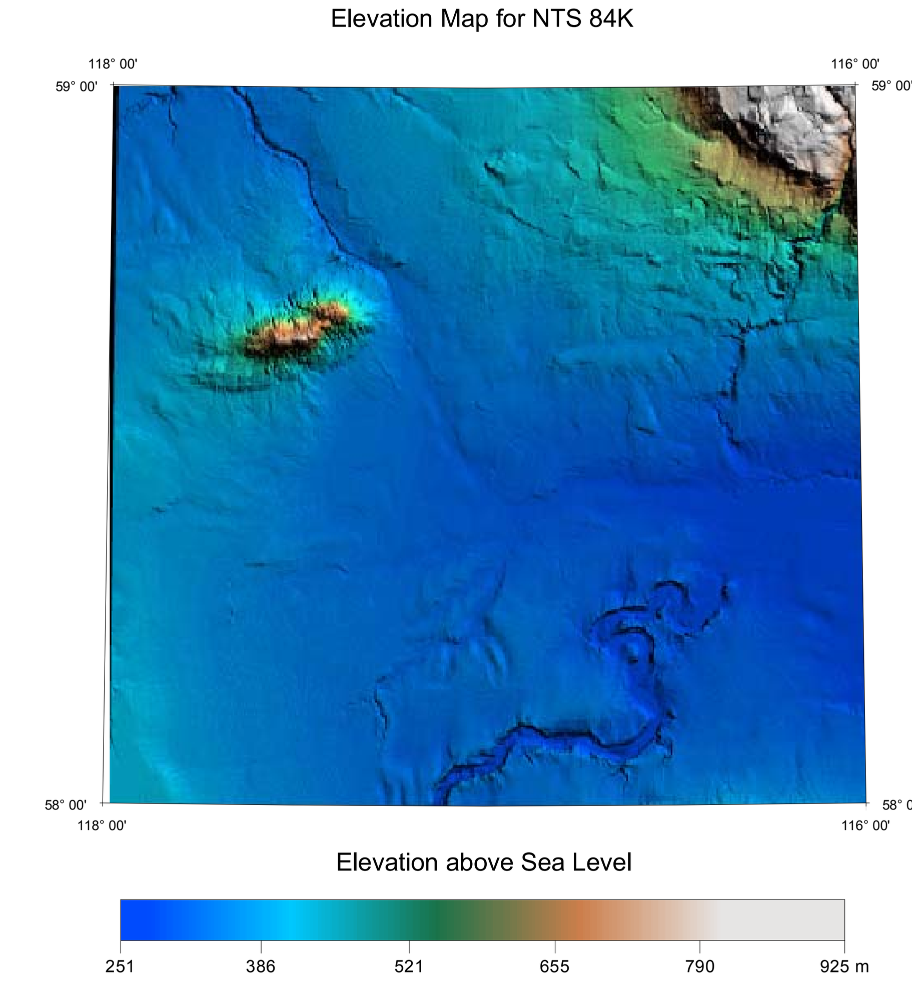
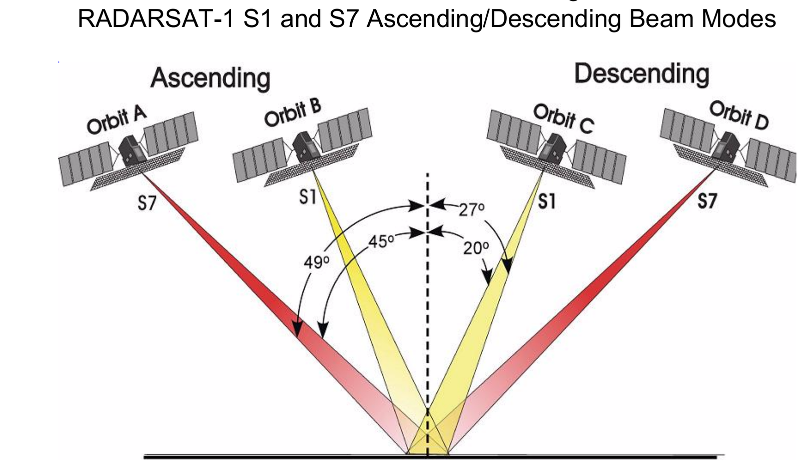


Look Directions and Incident Angles of
RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-30, Figure 11

RADARSAT-1 Standard Beam 7 Ascending Image for Mount Watt, Alberta (NTS 84K)

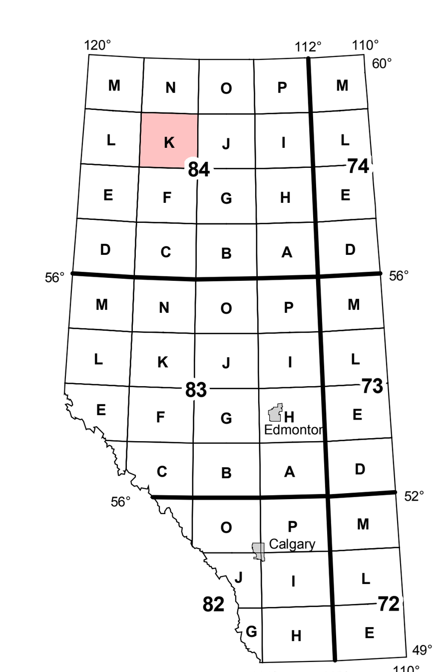
Compilation by S. Mei, 2003

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 11
Datum: North American Datum, 1983



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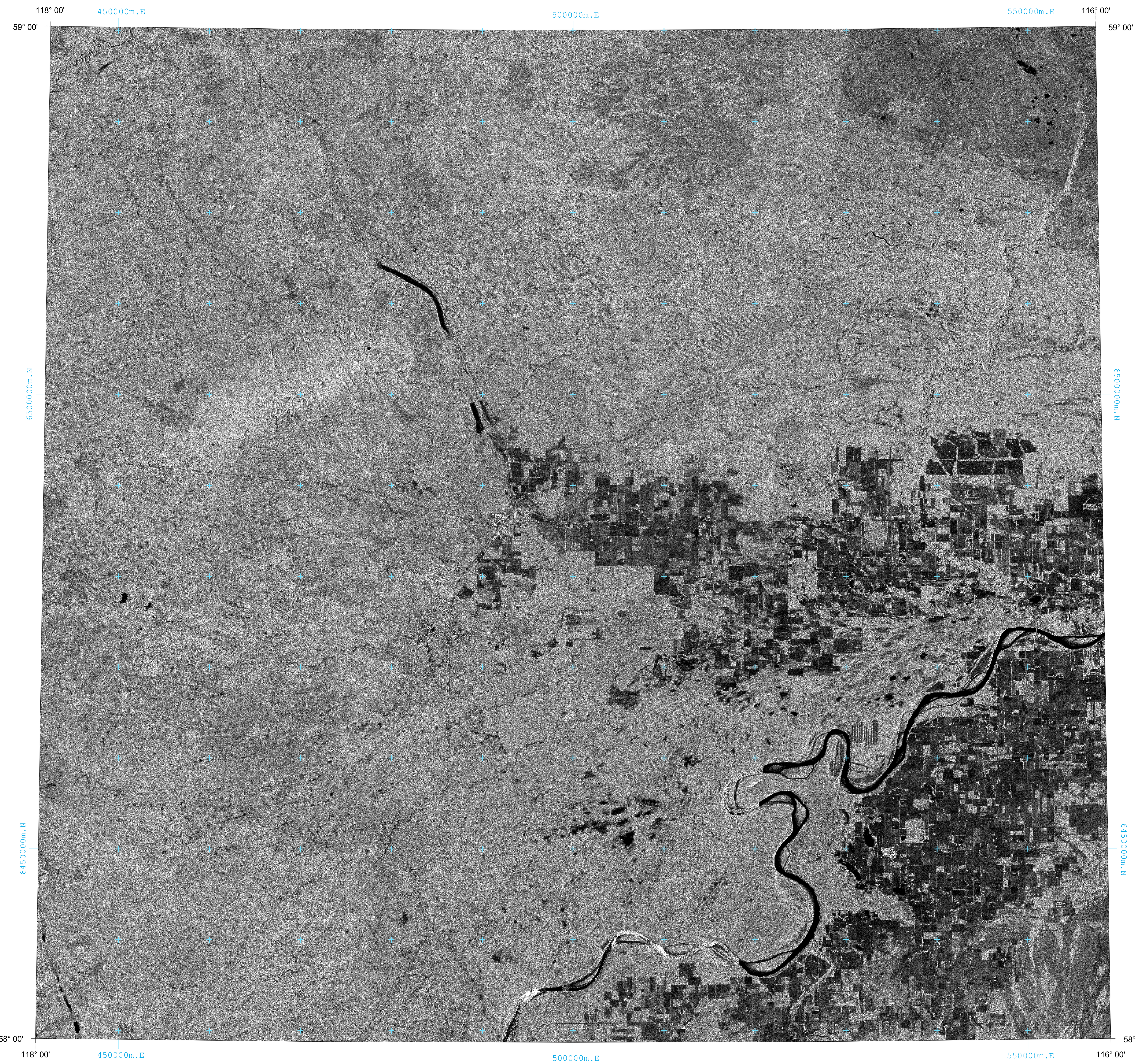
Disclaimer:

NTS 84K
RADARSAT-1



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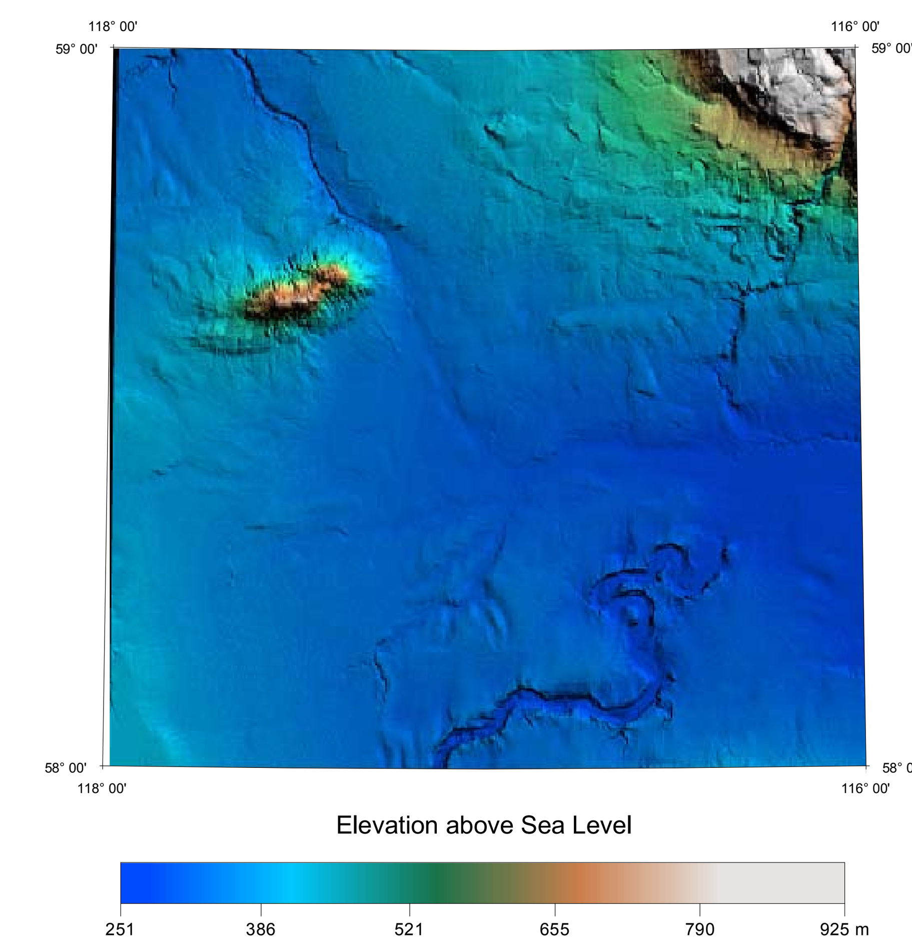
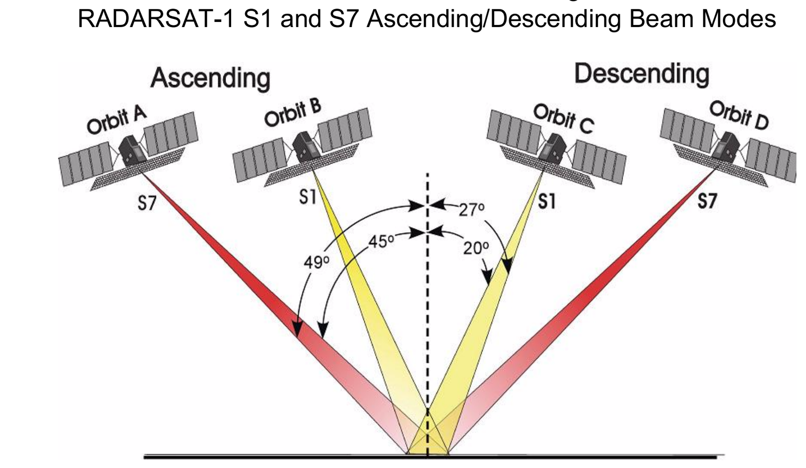


Look Directions and Incident Angles of RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-30, Figure 12

RADARSAT-1 Standard Beam 7 Descending Image for Mount Watt, Alberta (NTS 84K)

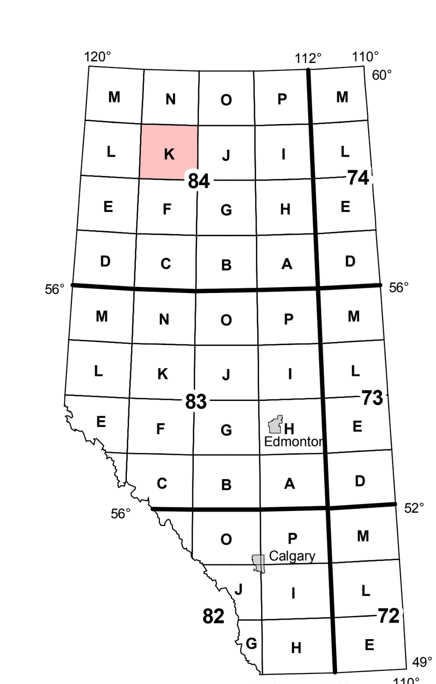
Compilation by S. Mei, 2003

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 11
Datum: North American Datum, 1983



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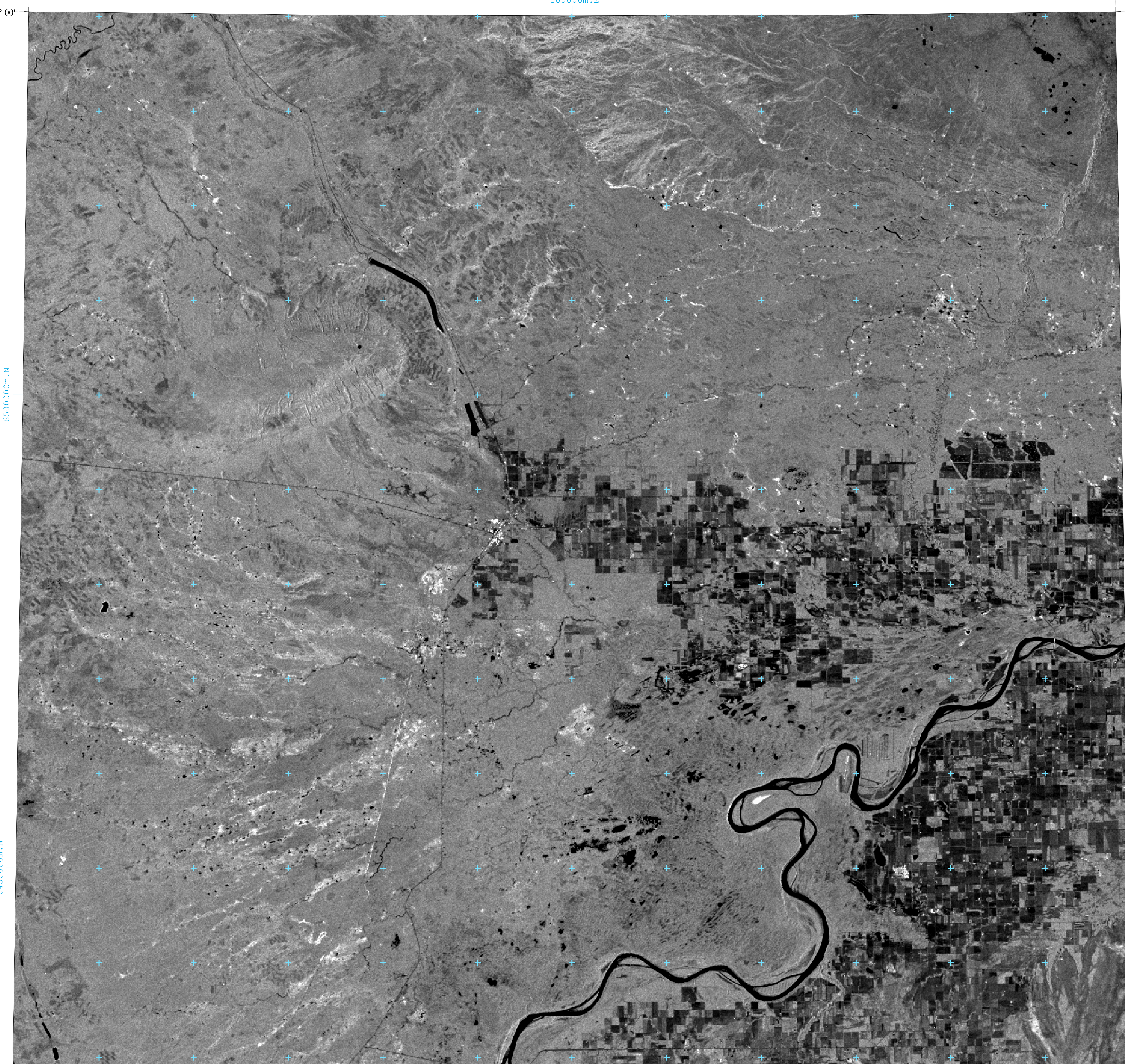
Alberta Energy and Utilities Board
Alberta Geological Survey

NTS 84K
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).

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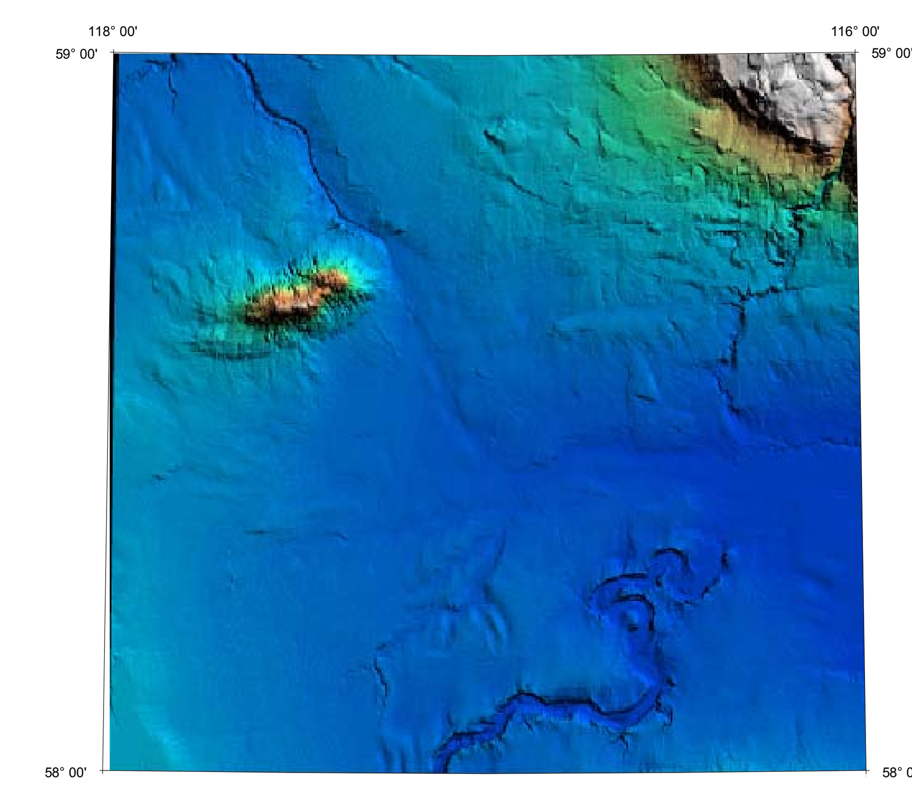
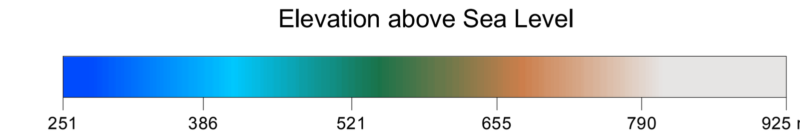
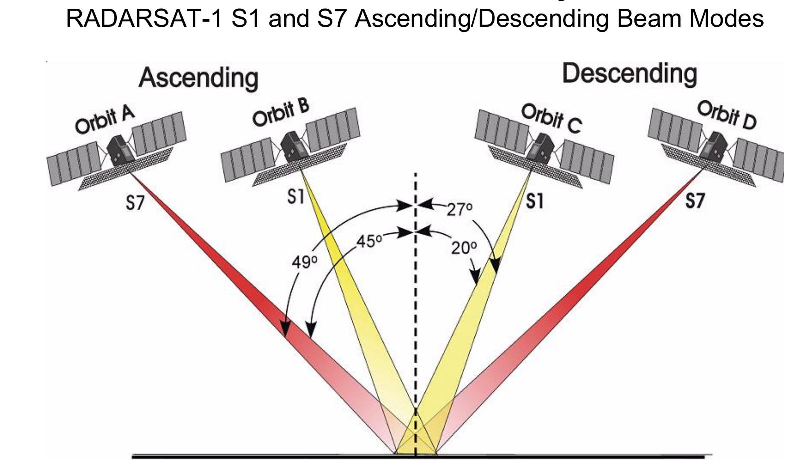
Elevation Map for NTS 84K



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 2003-30, Figure 13

RADARSAT-1 Principal Componet 1 Image for Mount Watt, Alberta (NTS 84K)

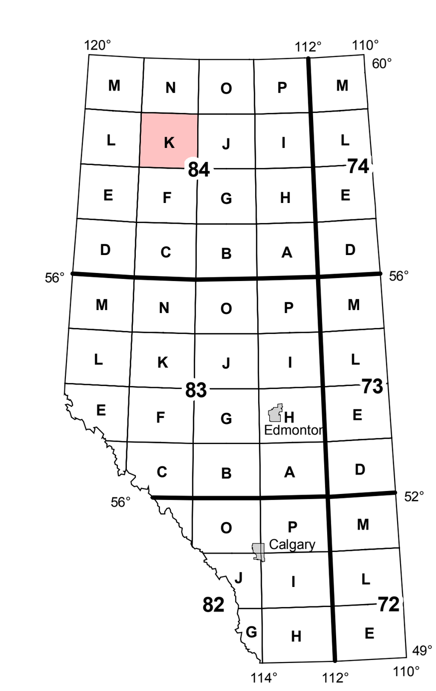
Compilation by S. Mei, 2003

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 11
Datum: North American Datum, 1983



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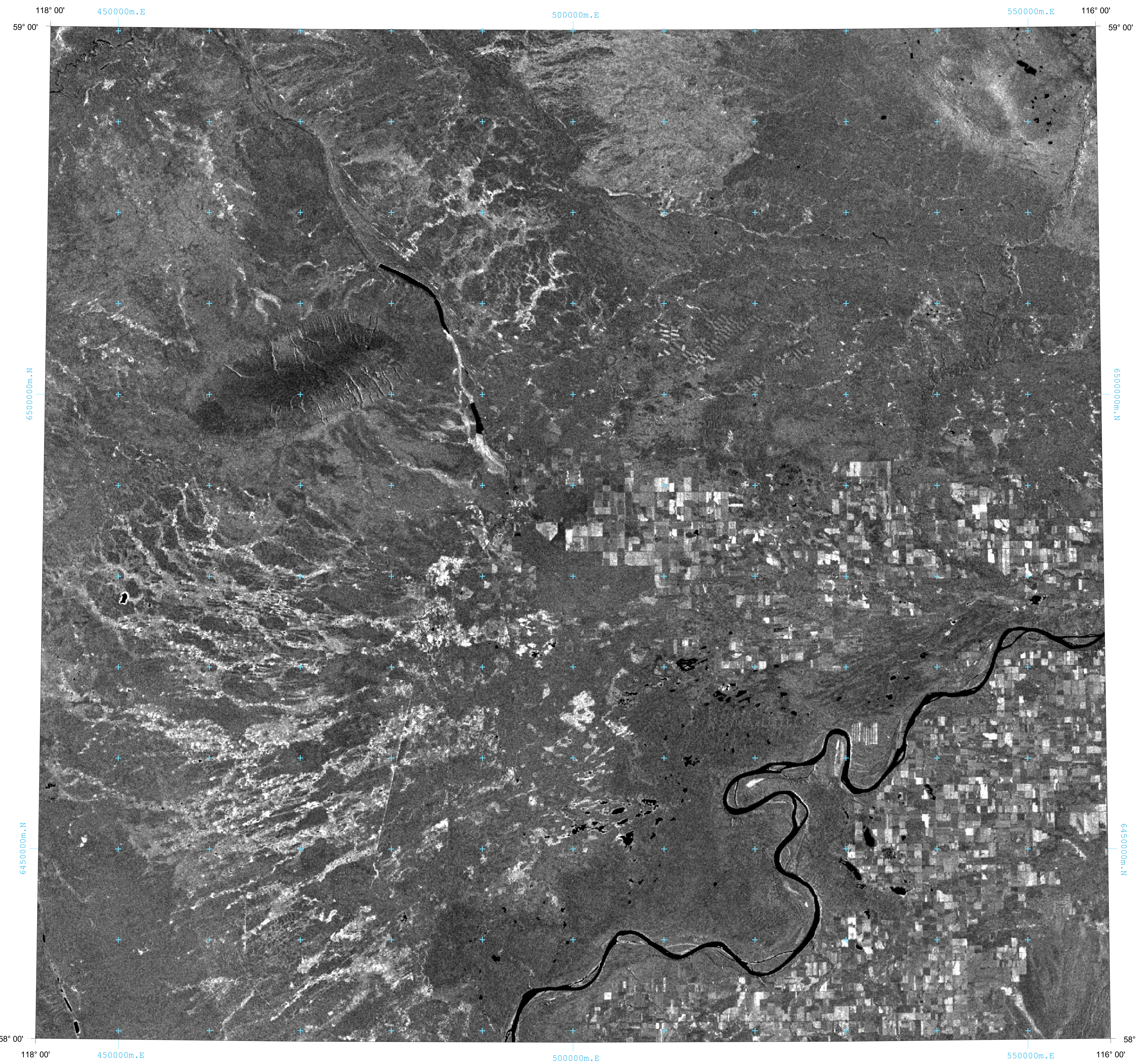
NTS 84K
RADARSAT-1



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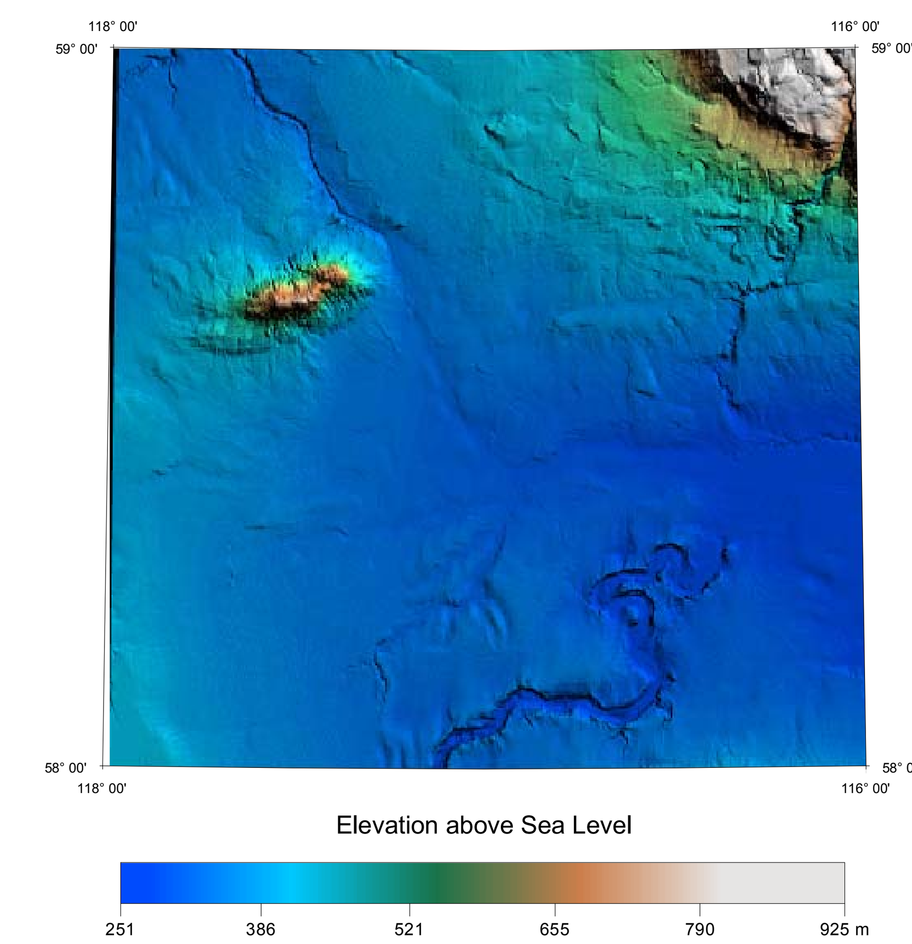
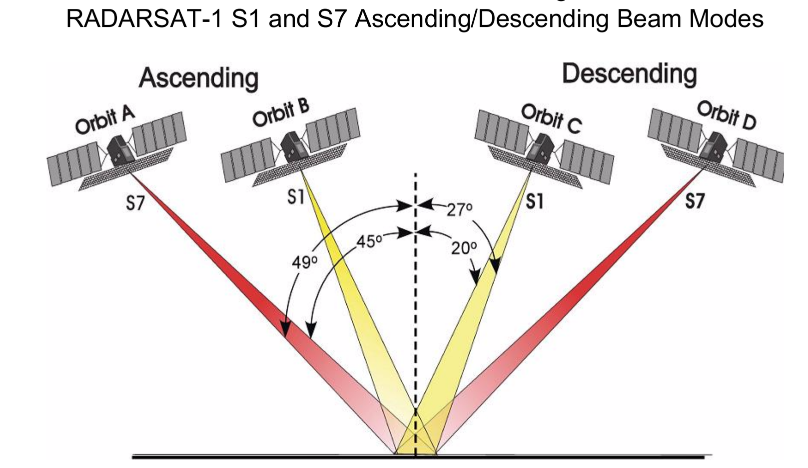
Elevation Map for NTS 84K



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



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Geo-Note 2003-30, Figure 14

RADARSAT-1 Principal Componet 2 Image for Mount Watt, Alberta (NTS 84K)

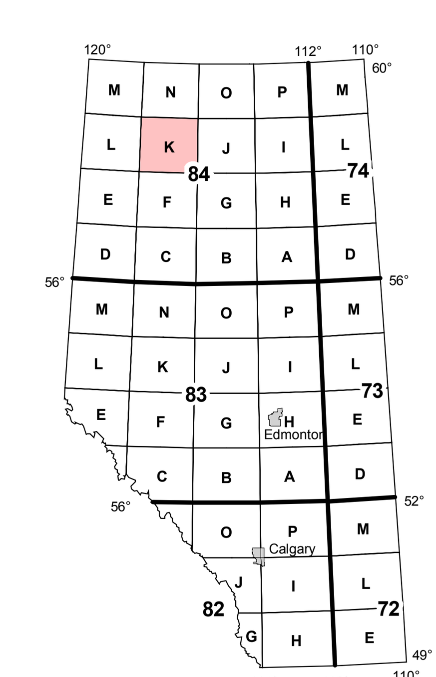
Compilation by S. Mei, 2003

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 11
Datum: North American Datum, 1983



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Alberta Geological Survey

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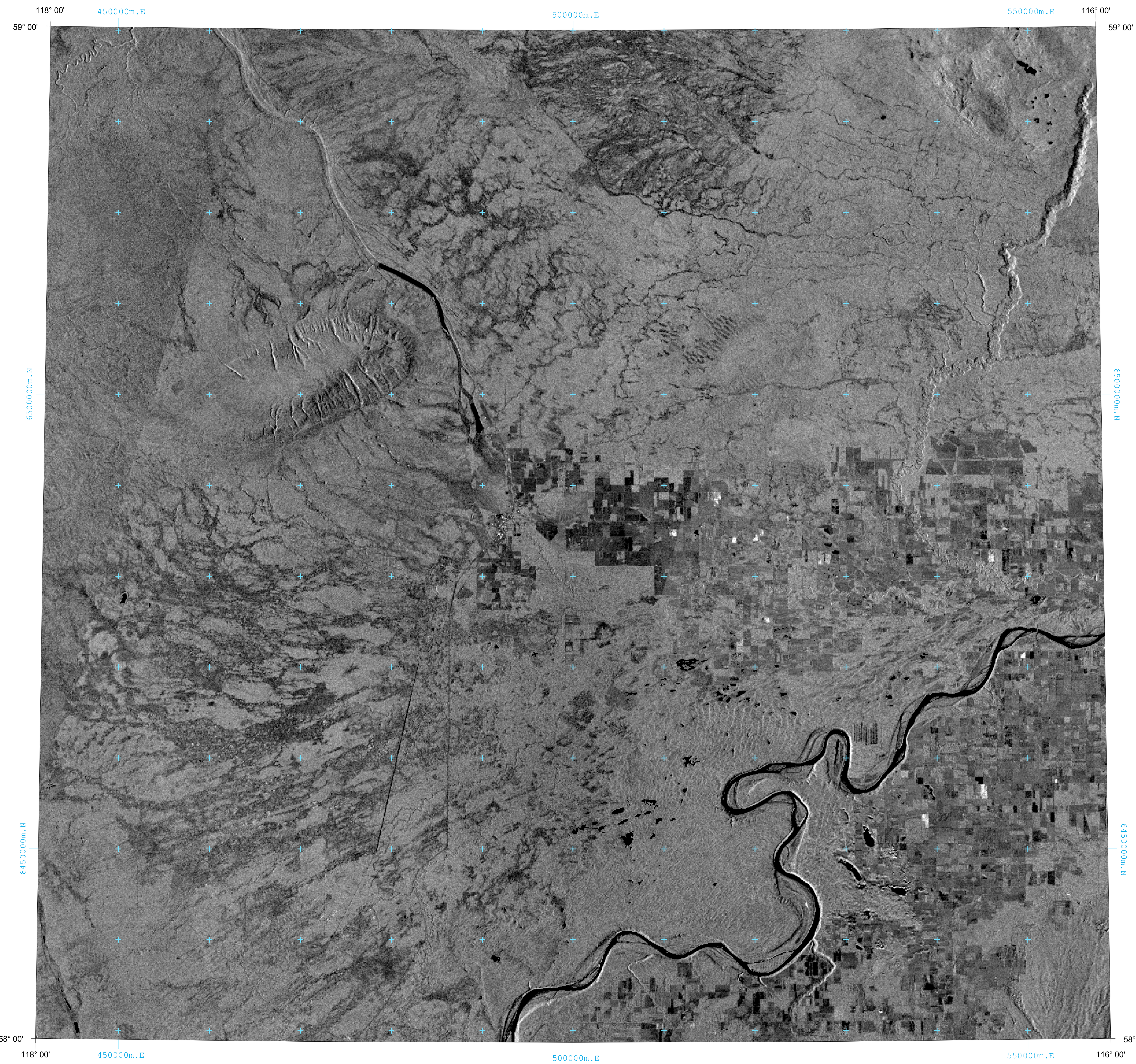
NTS 84K
RADARSAT-1



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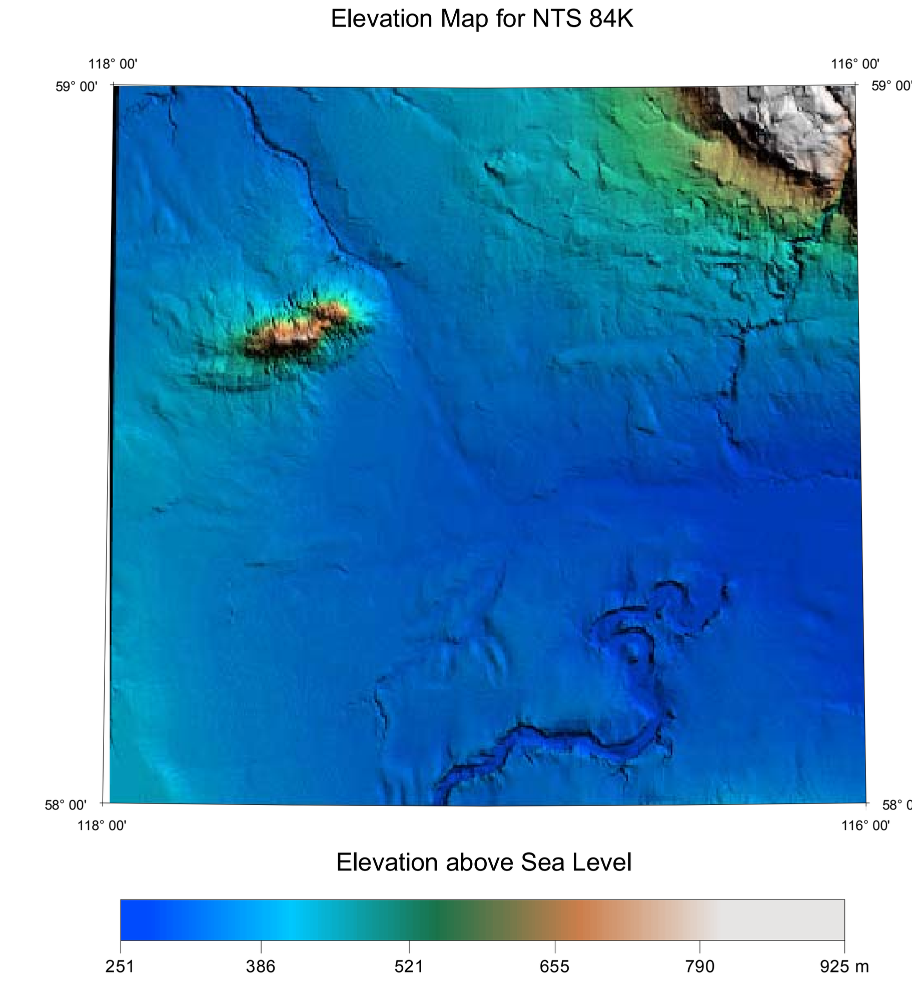
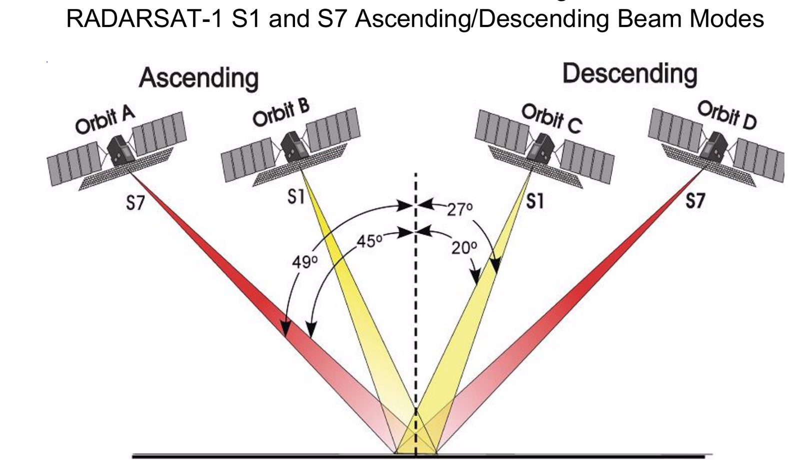
Elevation Map for NTS 84K



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



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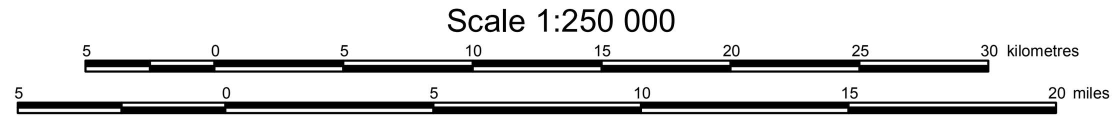
Geo-Note 2003-30, Figure 15

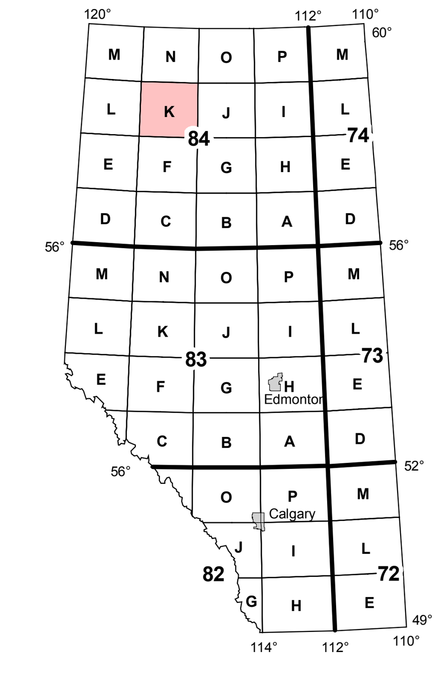
RADARSAT-1 Principal Componet 3 Image for Mount Watt, Alberta (NTS 84K)

Compilation by S. Mei, 2003

Scale 1:250 000



Projection: Universal Transverse Mercator, Zone 11
Datum: North American Datum, 1983



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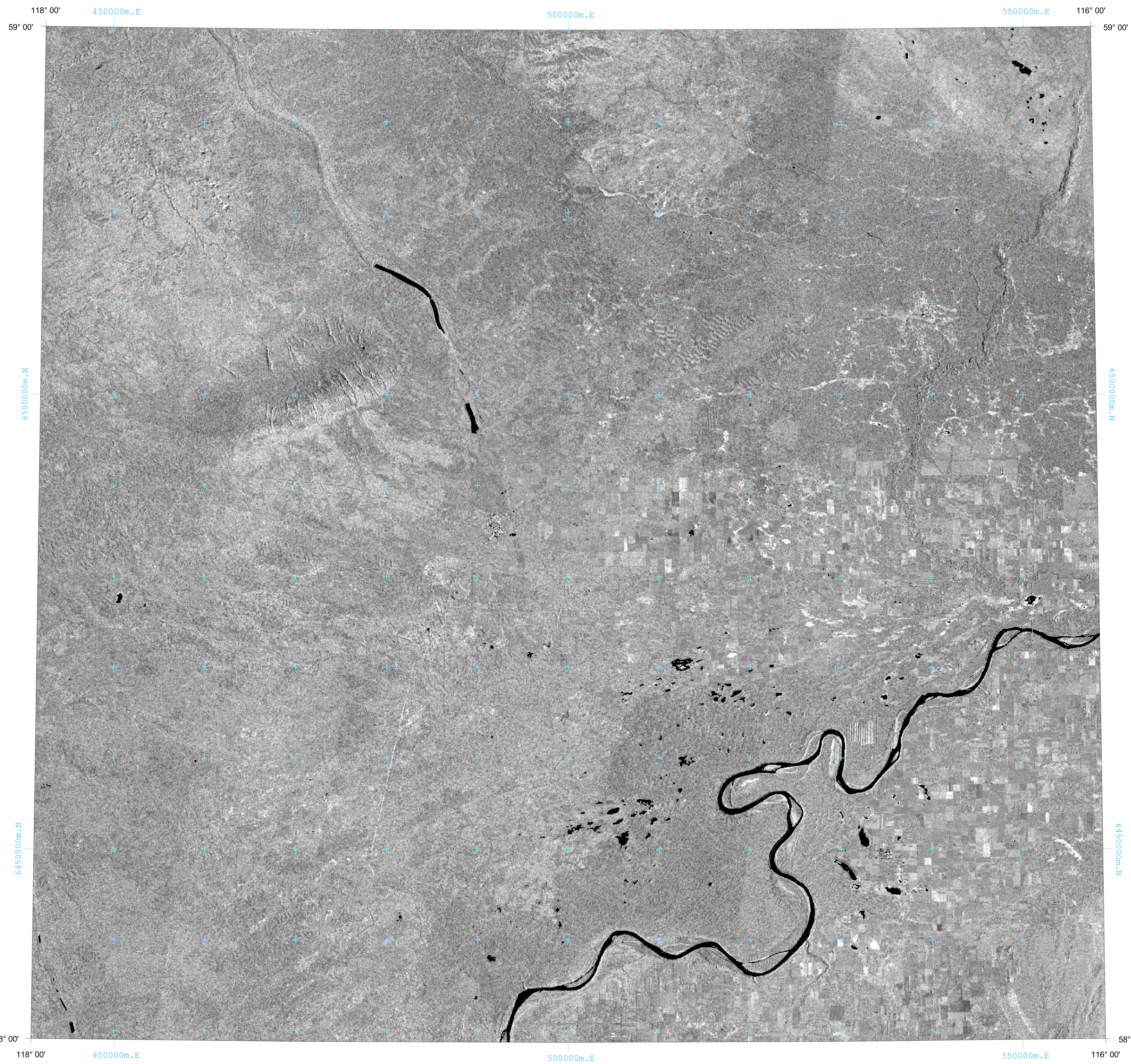
NTS 84K
RADARSAT-1



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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.

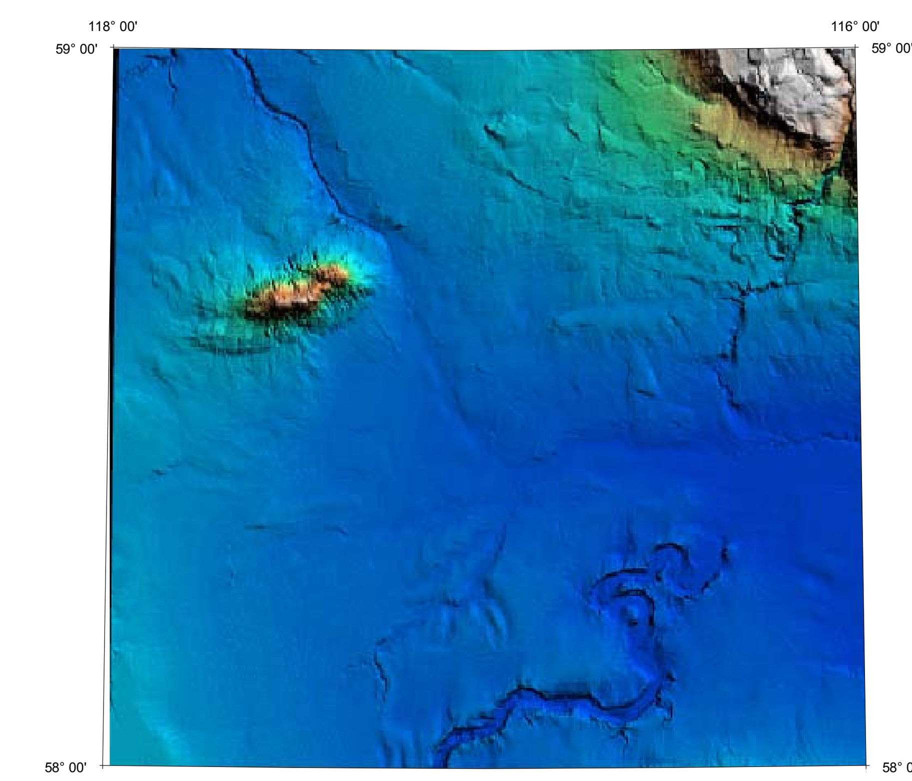
The First Principal Component (PC1) image (Figure 13) shows a range of brightness and texture that highlights features associated with differences in vegetation type and density. Areas of closed Aspen, closed Pine, open deciduous vegetation, grasslands and exposed soil appear to have a brighter tone 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.

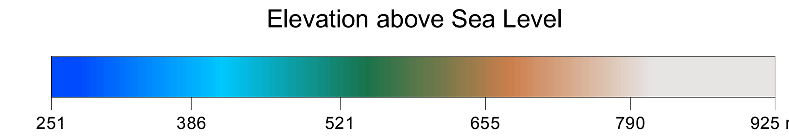
The Third Principal Component (PC3) image (Figure 15) highlights ‘surface roughness’; hence it reflects topographic effects and surface texture of the ground or vegetation canopy. In fact, the discrimination of topographic features using the PC3 image is superior to any other optical commercial satellite 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.

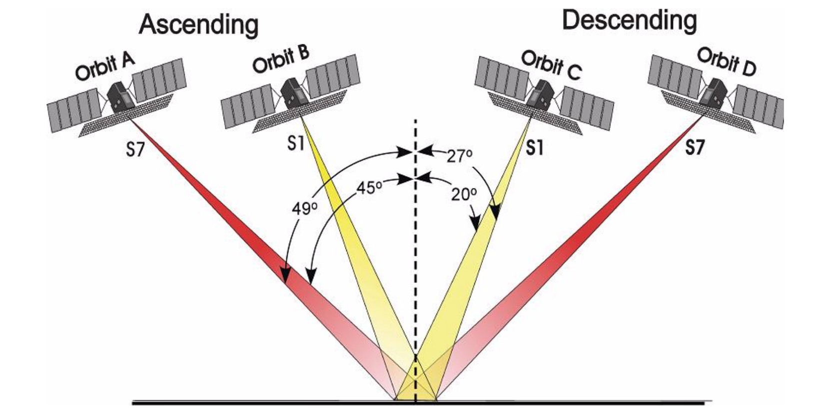
Elevation Map for NTS 84K



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 2003-30, Figure 16

RADARSAT-1 Principal Componet 4 Image for Mount Watt, Alberta (NTS 84K)

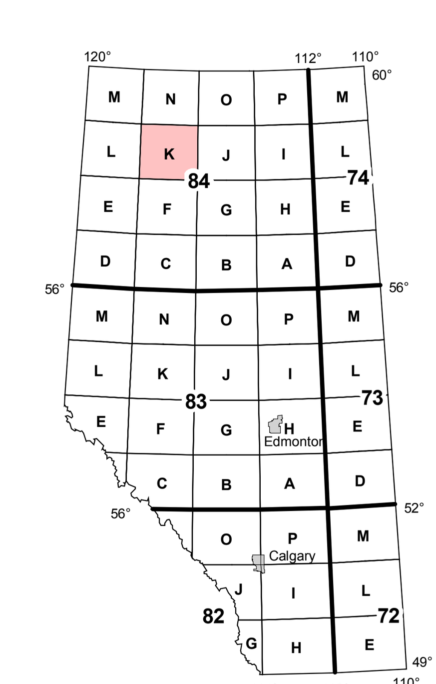
Compilation by S. Mei, 2003

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 11
Datum: North American Datum, 1983



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