EUB/AGS Geo-Note 2003-23

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

Alberta Energy and Utilities Board
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 84D 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 84D 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 84D.

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.

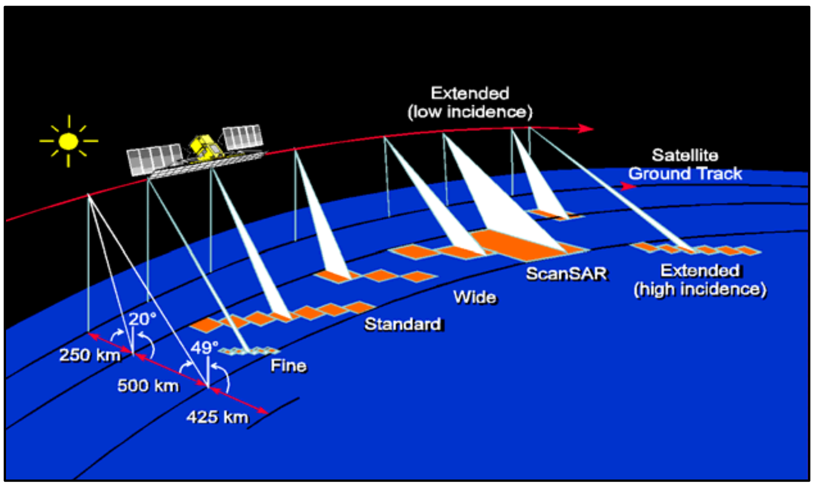

Figure 1. RADARSAT-1 beam modes (used with permision from RADARSAT International (RSI), 1997).

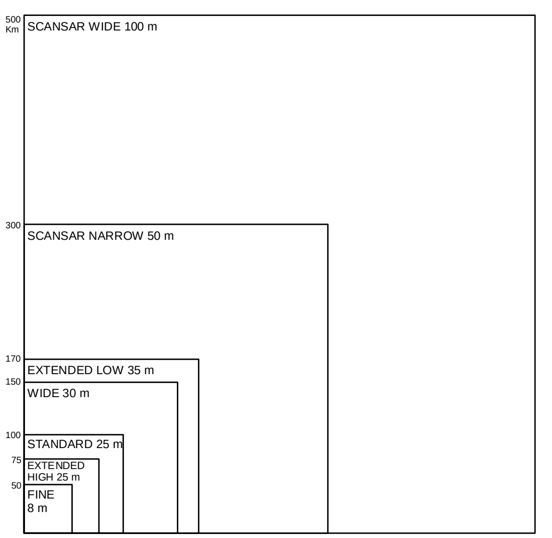

Figure 2. Coverage sizes and resolutions of RADARSAT-1 beam modes (modified after RADARSAT International (RSI), 1999).

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

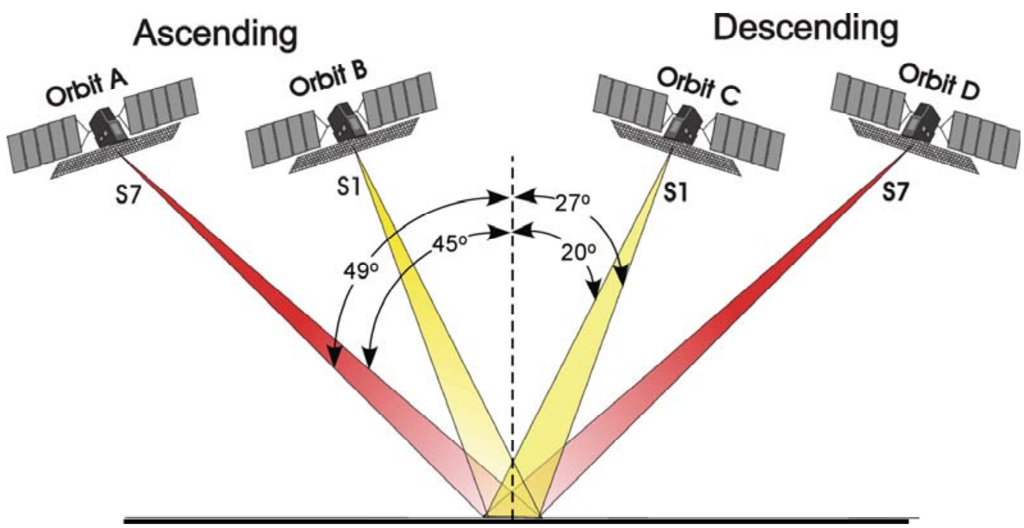

Figure 3. Multi-beam configuration of RADARSAT-1 S1 and S7 ascending/descending imagery (after Grunsky, 2002a).

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

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 84D 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 84D.

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

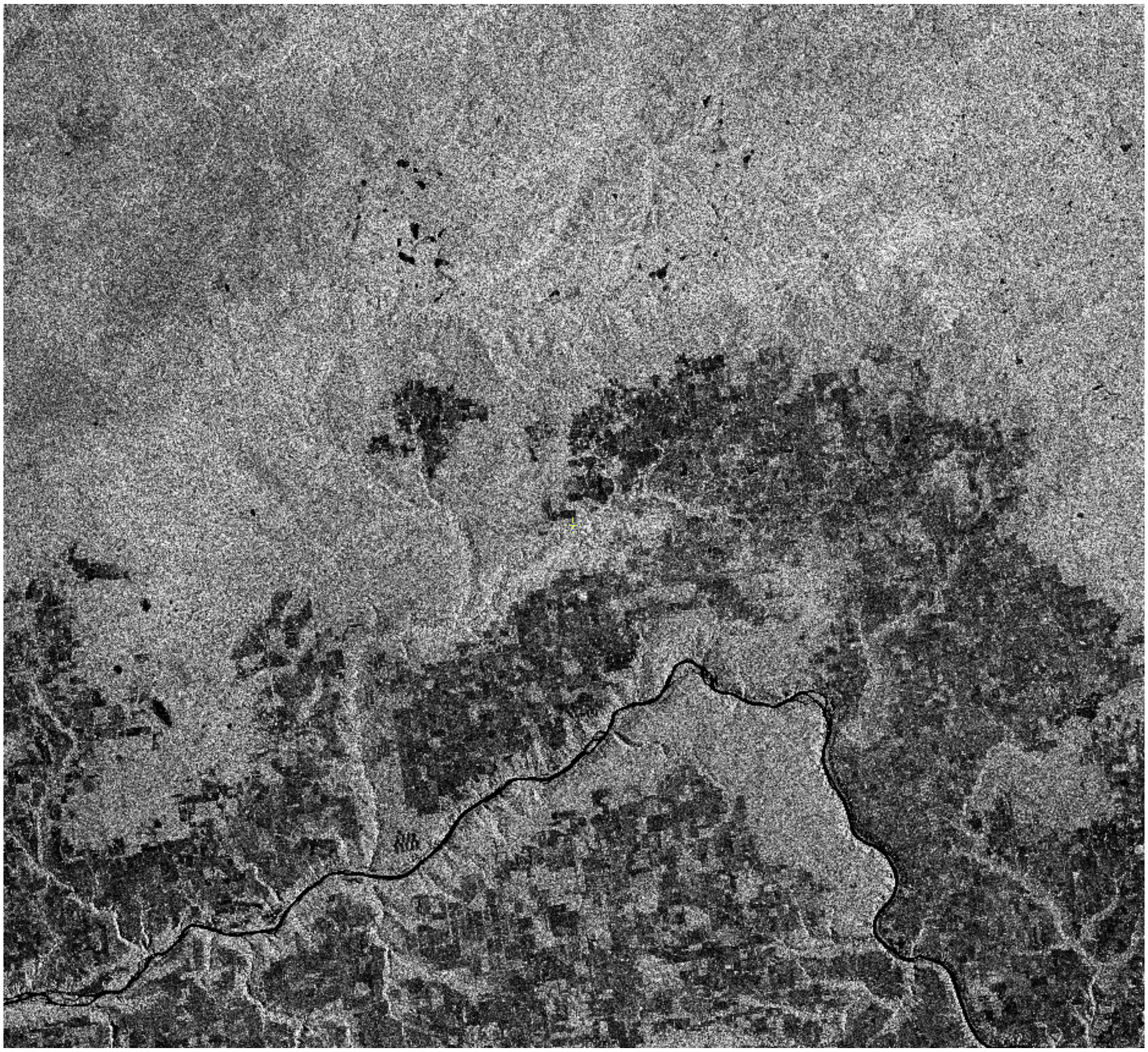

Figure 4. One of the original SGF scene images used for tiling the NTS 84D dataset: scene MO200869 of Standard Beam Mode 7 descending. RADARSAT data © Canadian Space Agency/Agence spatiale canadienne 1999, processed and distributed by RADARSAT International.

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

Scene ID	Beam	Path	UL_LAT	UL_LONG	UR_LAT	UR_LONG	LR_LAT	LR_LONG	LL_LAT	LL_LONG
M0198314	S1	ASC	57:22:32.30N	118:25:03.84W	57:37:14.97N	116:33:54.79W	56:42:21.75N	116:10:18.18W	56:27:52.59N	117:58:40.93W
M0196326	S1	ASC	57:26:27.61N	119:29:52.78W	57:41:11.37N	117:38:29.91W	56:46:18.33N	117:14:49.69W	56:31:48.15N	119:03:25.55W
M0196325	S1	ASC	56:37:11.87N	119:05:59.69W	56:51:43.24N	117:17:08.60W	55:56:47.79N	116:54:14.27W	55:42:29.12N	118:40:26.35W
M0195858	S1	ASC	57:20:45.14N	120:29:34.33W	57:35:27.63N	118:38:29.03W	56:40:34.33N	118:14:54.03W	56:26:05.33N	120:03:13.25W
M0195857	S1	ASC	56:31:22.66N	120:05:44.15W	56:45:52.82N	118:17:10.08W	55:50:57.35N	117:54:20.76W	55:36:39.79N	119:40:16.72W
M0196925	S1	DES	56:38:17.22N	120:40:31.79W	56:23:55.68N	118:52:.57.50W	55:30:30.32N	119:17:38.37W	55:44:39.80N	121:02:40.25W
M0196924	S1	DES	56:56:15.74N	120:32:56.37W	56:41:49.92N	118:44:28.76W	55:47:06.67N	119:10:04.14W	56:01:19.84N	120:55:52.91W
M0196923	S1	DES	57:45:46.19N	120:11:32.13W	57:31:08.11N	118:20:33.40W	56:36:28.93N	118:47:02.55W	56:50:53.49N	120:35:14.46W
M0196563	S1	DES	56:05:22.82N	119:50:33.87W	55:51:09.04N	118:04:35.71W	54:56:22.61N	118:29:19.33W	55:10:24.59N	120:12:46.40W
M0196562	S1	DES	56:54:52.77N	119:29:54.22W	56:40:27.48N	117:41:31.88W	55:45:44.51N	118:07:05.48W	55:59:57.18N	119:52:49.25W
M0196561	S1	DES	57:44:16.66N	119:08:33.68W	57:29:39.16N	117:17:40.81W	56:34:59.86N	117:44:08.13W	56:49:23.87N	119:32:14.49W
M0196424	S1	DES	57:48:05.99N	121:13:38.38W	57:33:27.10N	119:22:30.51W	56:45:29.46N	119:45:50.87W	56:59:56.38N	121:34:31.45W
M0196091	S1	DES	56:11:33.24N	118:45:49.36W	55:57:18.07N	116:59:32.66W	55:02:31.98N	117:24:22.18W	55:16:35.26N	119:08:06.85W
M0196090	S1	DES	57:00:56.60N	118:25:06.99W	56:46:29.84N	116:36:25.52W	55:51:47.24N	117:02:05.38W	56:06:01.28N	118:48:07.29W
M0196089	S1	DES	57:50:20.28N	118:03:41.31W	57:35:41.20N	116:12:28.35W	56:41:02.30N	116:39:02.41W	56:55:27.77N	118:27:27.79W
M0198983	S7	ASC	57:23:37.78N	118:35:53.53W	57:32:01.01N	116:44:49.14W	56:37:23.27N	116:31:56.96W	56:28:59.29N	118:20:18.59W
M0198982	S7	ASC	56:34:18.00N	118:21:49.56W	56:42:41.86N	116:33:13.20W	55:48:03.13N	116:20:33.47W	55:39:38.22N	118:06:35.34W
M0196155	S7	ASC	57:35:35.26N	119:45:42.38W	57:43:57.92N	117:54:02.88W	56:49:19.58N	117:41:07.83W	56:40:56.23N	119:30:02.48W
M0196154	S7	ASC	56:46:06.65N	119:31:31.76W	56:54:29.88N	117:42:22.60W	55:59:51.55N	117:29:40.50W	55:51:27.33N	119:16:13.30W
M0196153	S7	ASC	55:56:40.82N	119:17:41.72W	56:05:04.92N	117:30:54.96W	55:06:55.14N	117:17:36.82W	54:58:29.69N	119:01:45.81W
M0195841	S7	ASC	57:31:08.10N	120:46:54.27W	57:39:30.96N	118:55:29.23W	56:44:53.24N	118:42:35.16W	56:36:29.66N	120:31:16.19W
M0195840	S7	ASC	56:41:34.13N	120:32:44.10W	56:49:57.61N	118:43:48.93W	55:55:18.88N	118:31:07.50W	55:46:54.40N	120:17:27.06W
M0200870	S7	DES	56:08:44.27N	120:17:08.02W	56:00:24.09N	118:30:31.28W	55:05:44.02N	118:45:27.69W	55:14:05.51N	120:29:35.83W
M0200869	S7	DES	56:58:06.36N	120:05:44.04W	56:49:47.04N	118:16:44.12W	55:55:07.81N	118:32:00.06W	56:03:28.18N	120:18:23.49W
M0200868	S7	DES	57:47:29.32N	119:54:07.65W	57:39:10.63N	118:02:37.50W	56:44:32.69N	118:18:14.45W	56:52:52.13N	120:06:59.67W
M0200097	S7	DES	56:56:31.19N	118:00:46.08W	56:48:11.79N	116:11:51.54W	55:53:32.56N	116:27:07.00W	56:01:53.02N	118:13:25.32W
M0199674	S7	DES	56:08:47.28N	119:15:03.14W	56:00:26.92N	117:28:26.31W	55:05:46.48N	117:43:23.12W	55:14:08.15N	119:27:31.33W
M0199673	S7	DES	56:58:02.12N	119:03:40.11W	56:49:42.60N	117:14:40.45W	55:55:03.81N	117:29:56.56W	56:03:24.36N	119:16:19.77W
M0199672	S7	DES	57:47:24.24N	118:52:03.55W	57:39:05.35N	117:00:33.72W	56:44:26.44N	117:16:11.24W	56:52:46.07N	119:04:56.11W
M0198792	S7	DES	56:55:09.93N	121:10:04.03W	56:46:50.51N	119:21:13.40W	55:52:11.31N	119:36:28.25W	56:00:31.79N	121:22:42.89W
M0198791	S7	DES	57:44:27.11N	120:58:29.21W	57:36:08.32N	119:07:09.09W	56:41:29.39N	119:22:45.10W	56:49:48.95N	121:11:20.80W

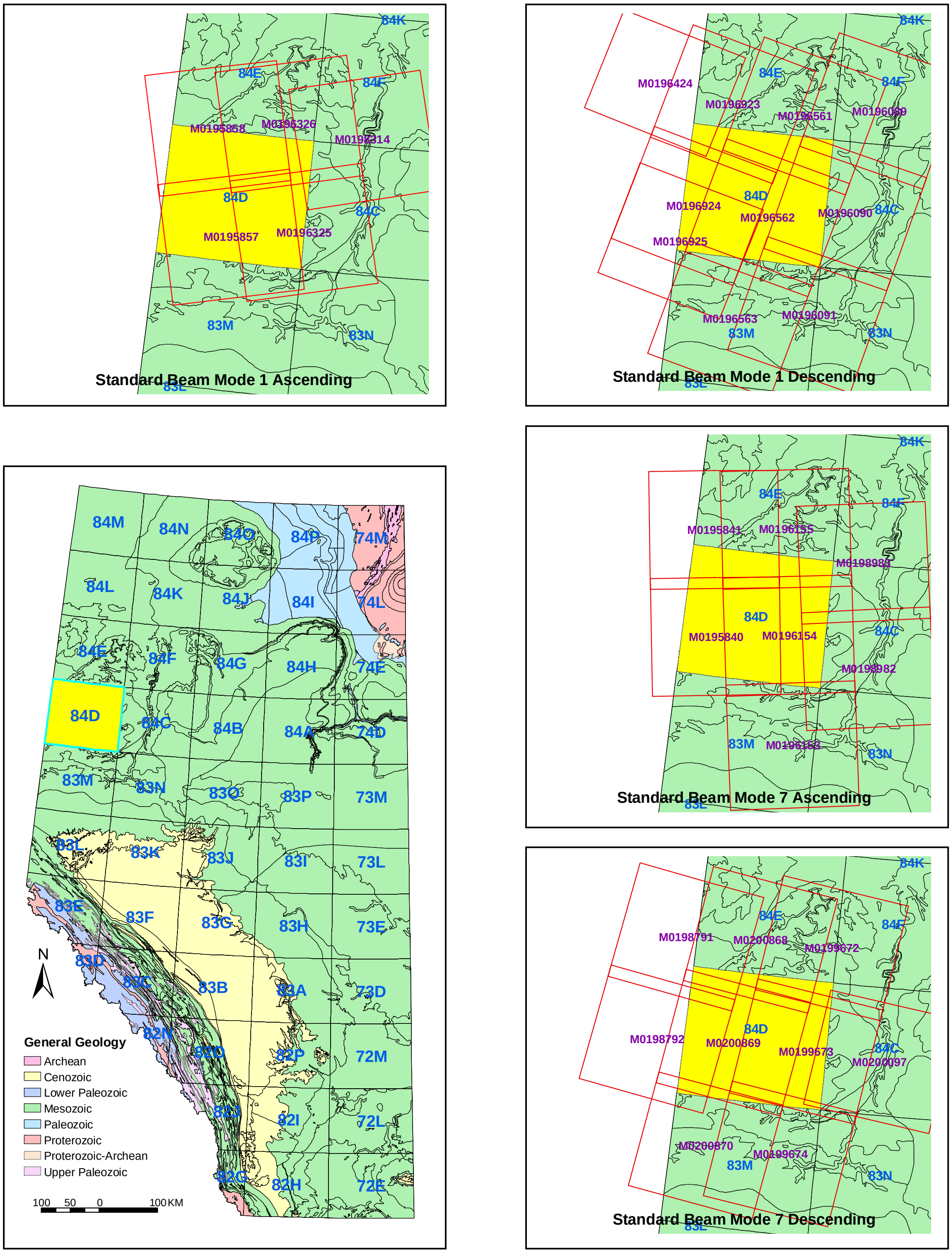

Figure 5. The scenes overlaying NTS 84D.

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 84D dataset.

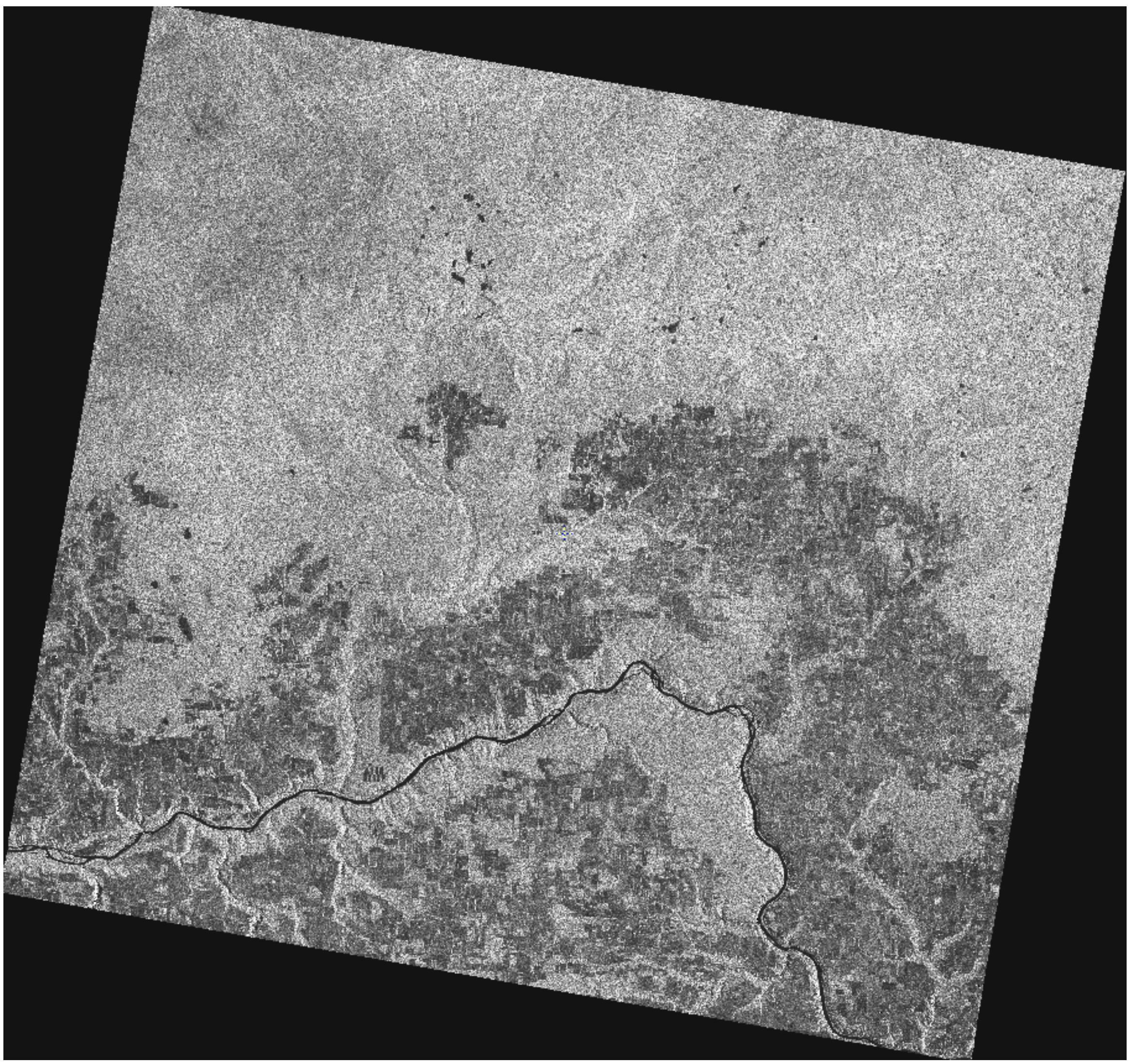

Figure 6. One of the orthorectified scene images used for tiling the NTS 84D dataset: scene MO200869 of Standard Beam Mode 7 descending.

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 84D image dataset.

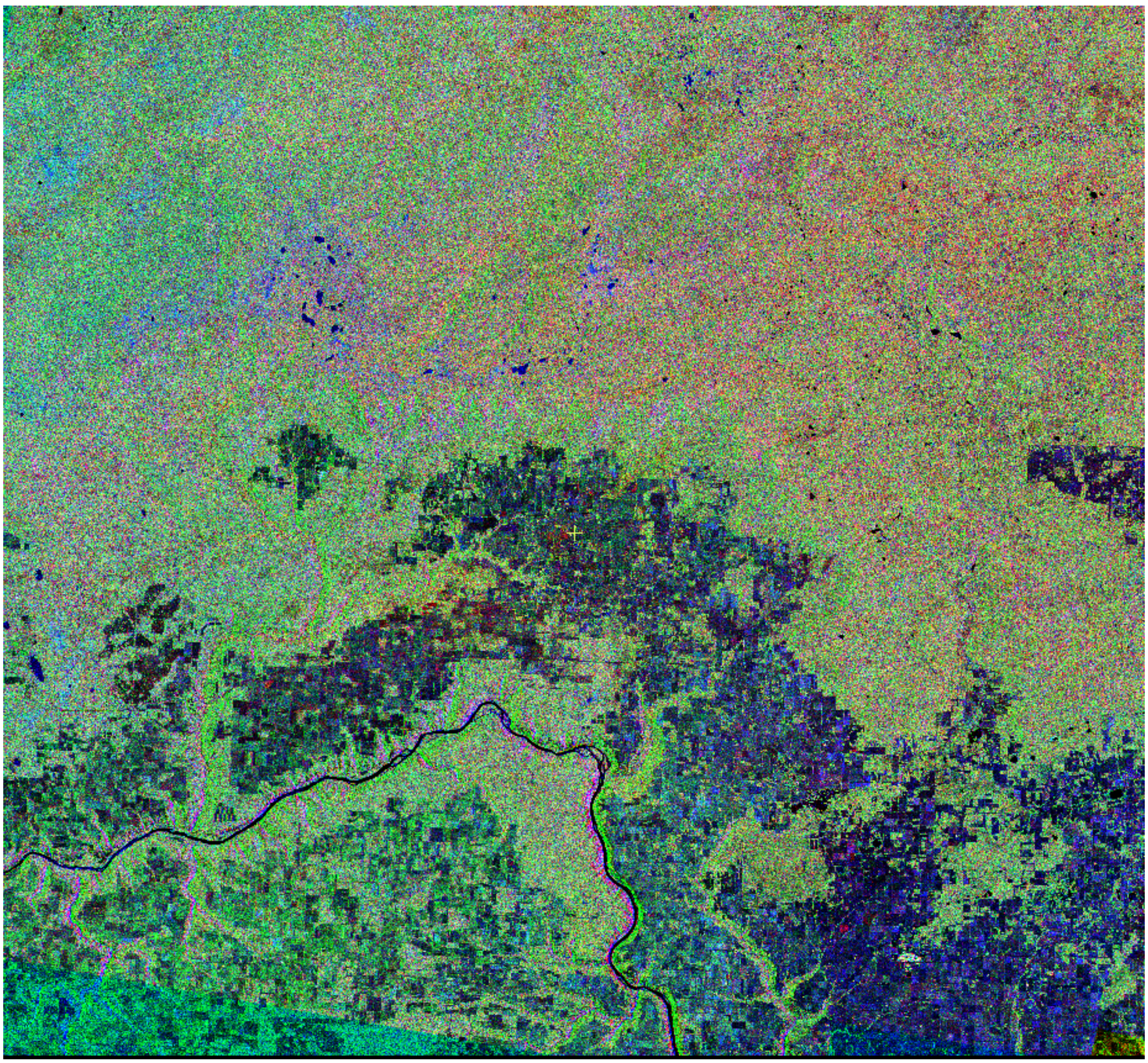

Figure 7. Pseudocolour composite of orthorectified NTS 84D image dataset of Standard Beam Mode S1/S7 ascending/descending beam positions (RGB=S7d, S7a, S1d).

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 84D.

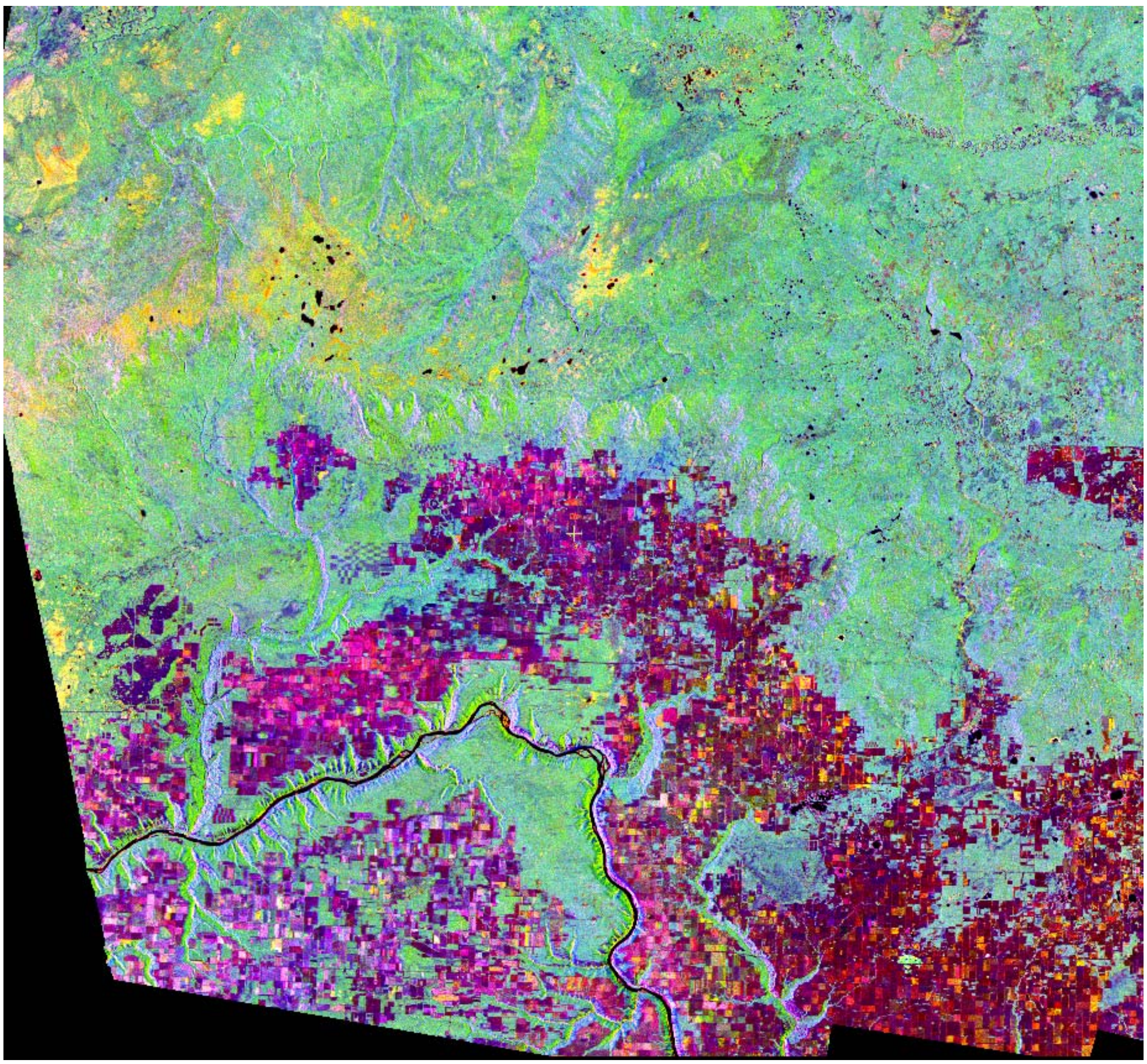

Figure 8. Pseudocolour composite of NTS 84D image dataset of principal component PC1, PC2, PC3 and PC4 (RGB=PC2, PC1, PC3).

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 84D 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 84D. 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 84D map area.

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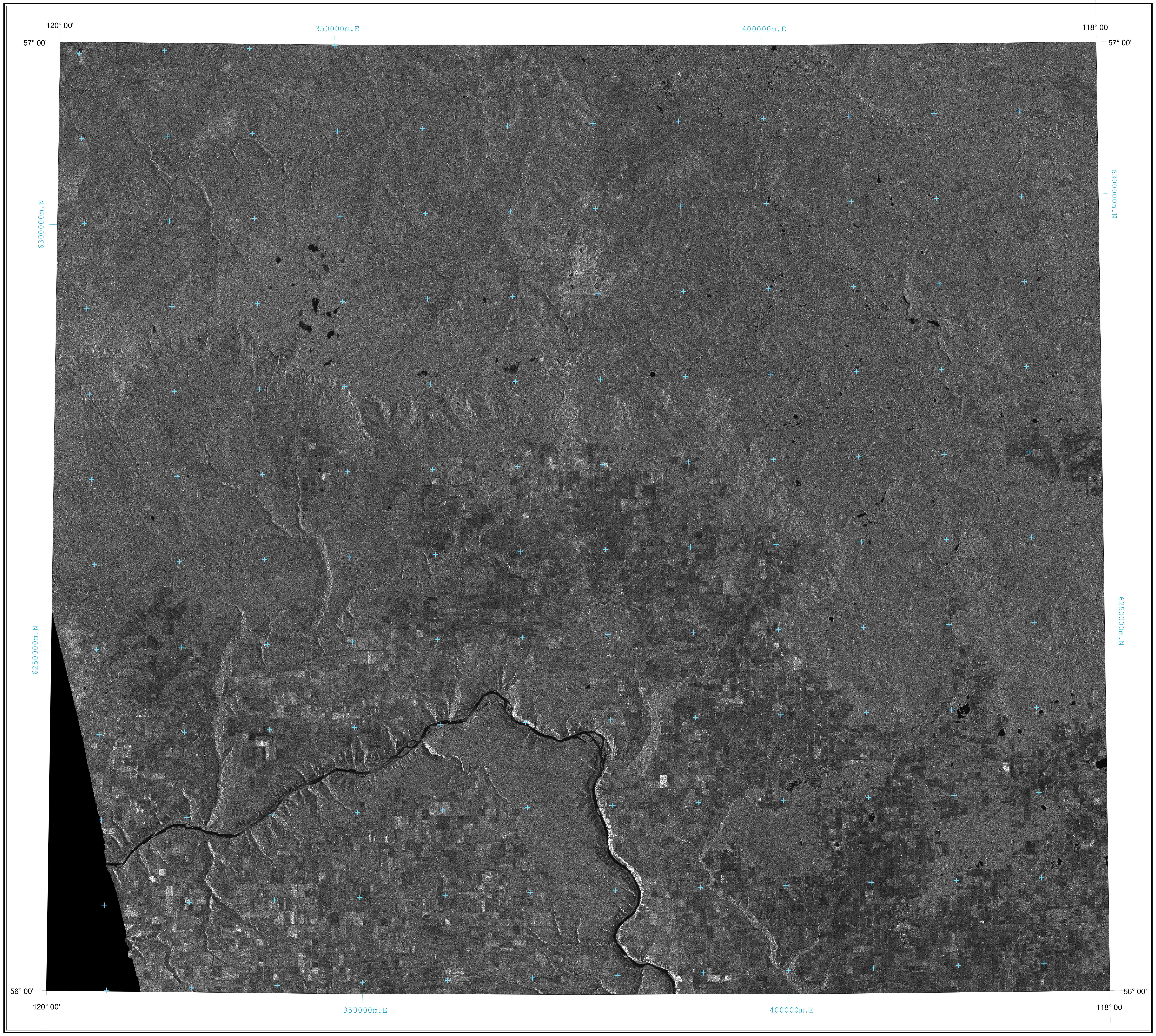
NTS 84D
RADARSAT-1



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.

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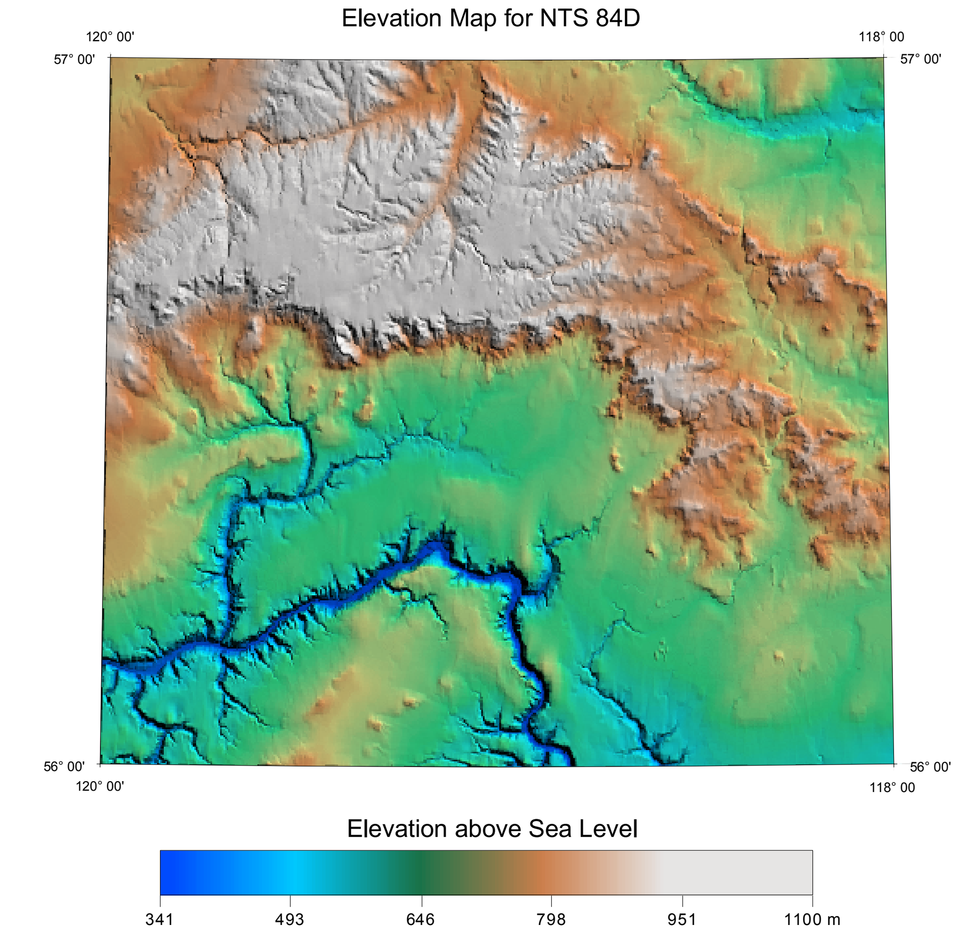
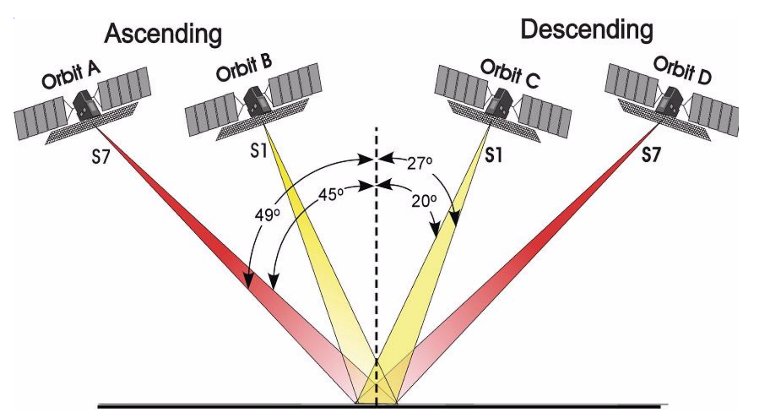
Elevation Map for NTS 84D



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



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Geo-Note 2003-23, Figure 9

RADARSAT-1 Standard Beam 1 Ascending Image for Clear Hills, Alberta (NTS 84D)

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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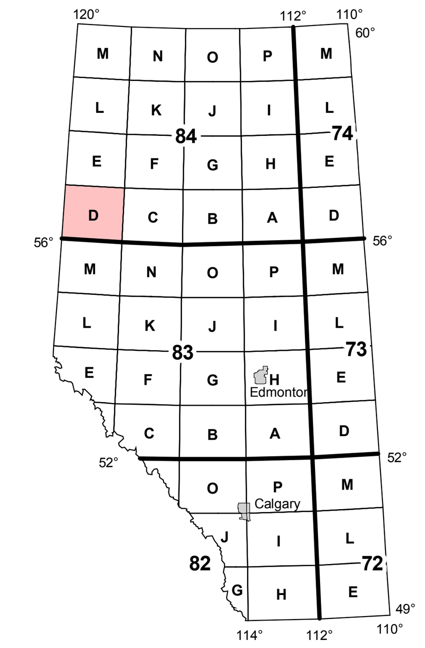

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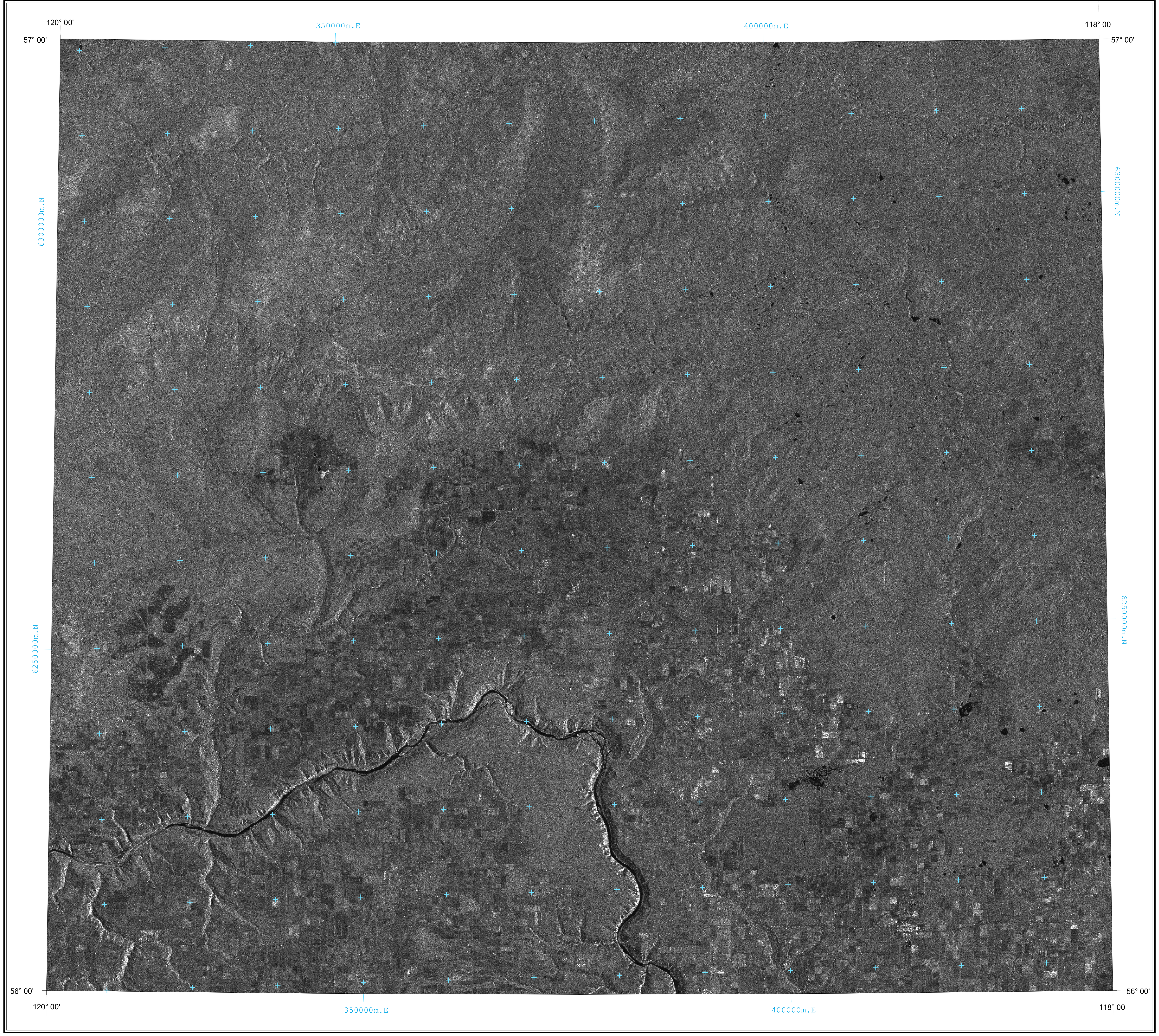
Disclaimer:

NTS 84D
RADARSAT-1



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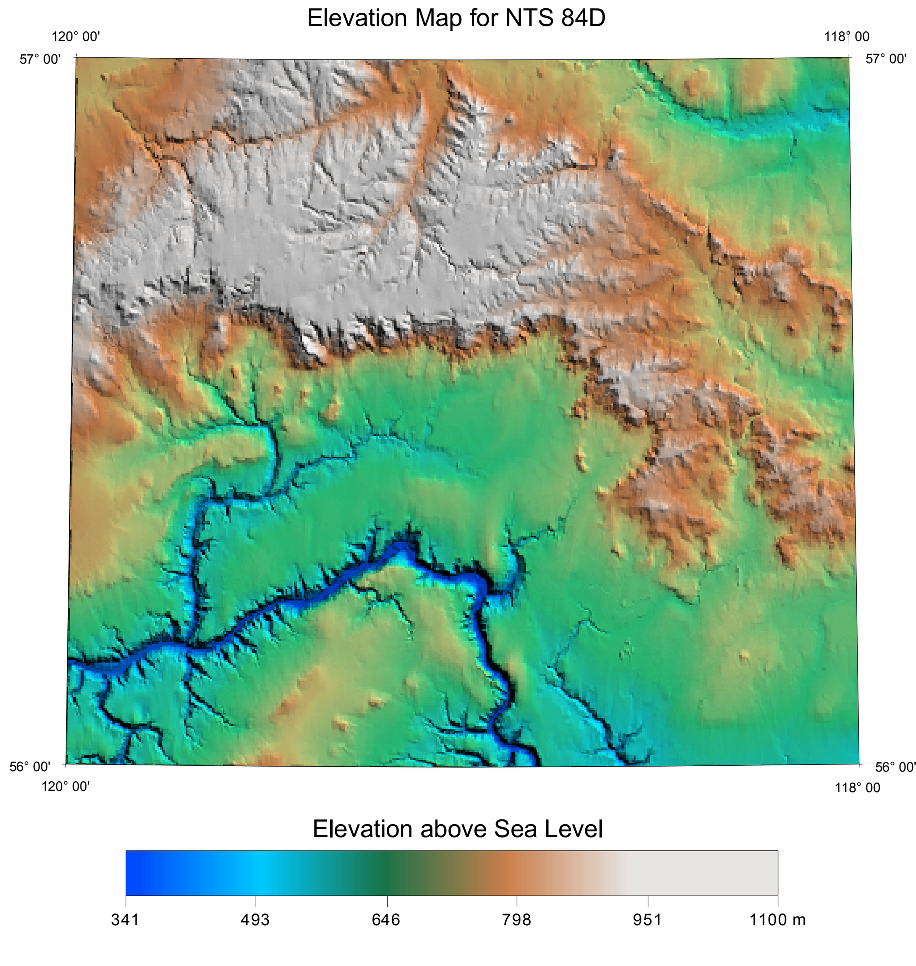
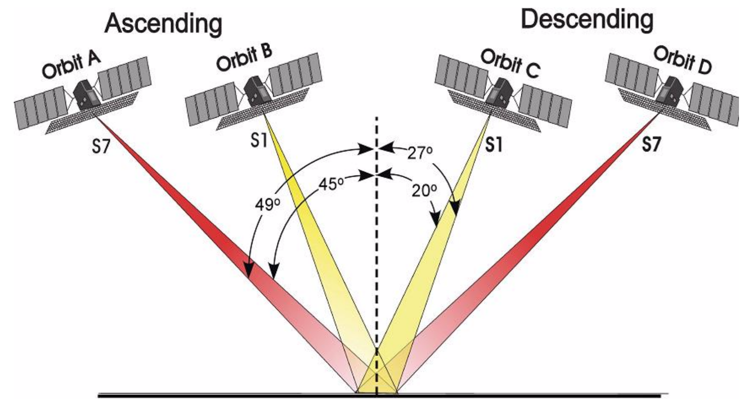
Elevation Map for NTS 84D



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



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Geo-Note 2003-23, Figure 10

RADARSAT-1 Standard Beam 1 Descending Image for Clear Hills, Alberta (NTS 84D)

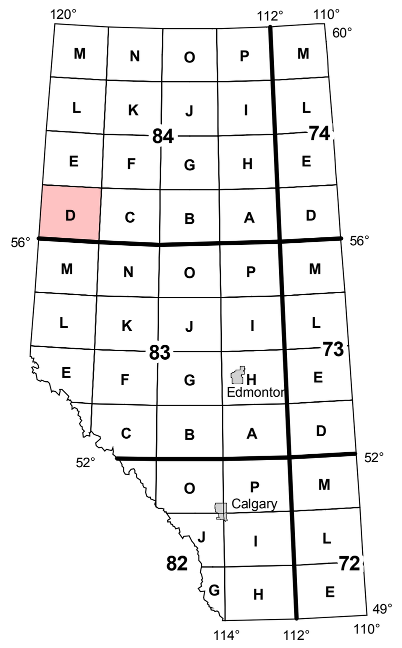
Compilation by S. Mei, 2003

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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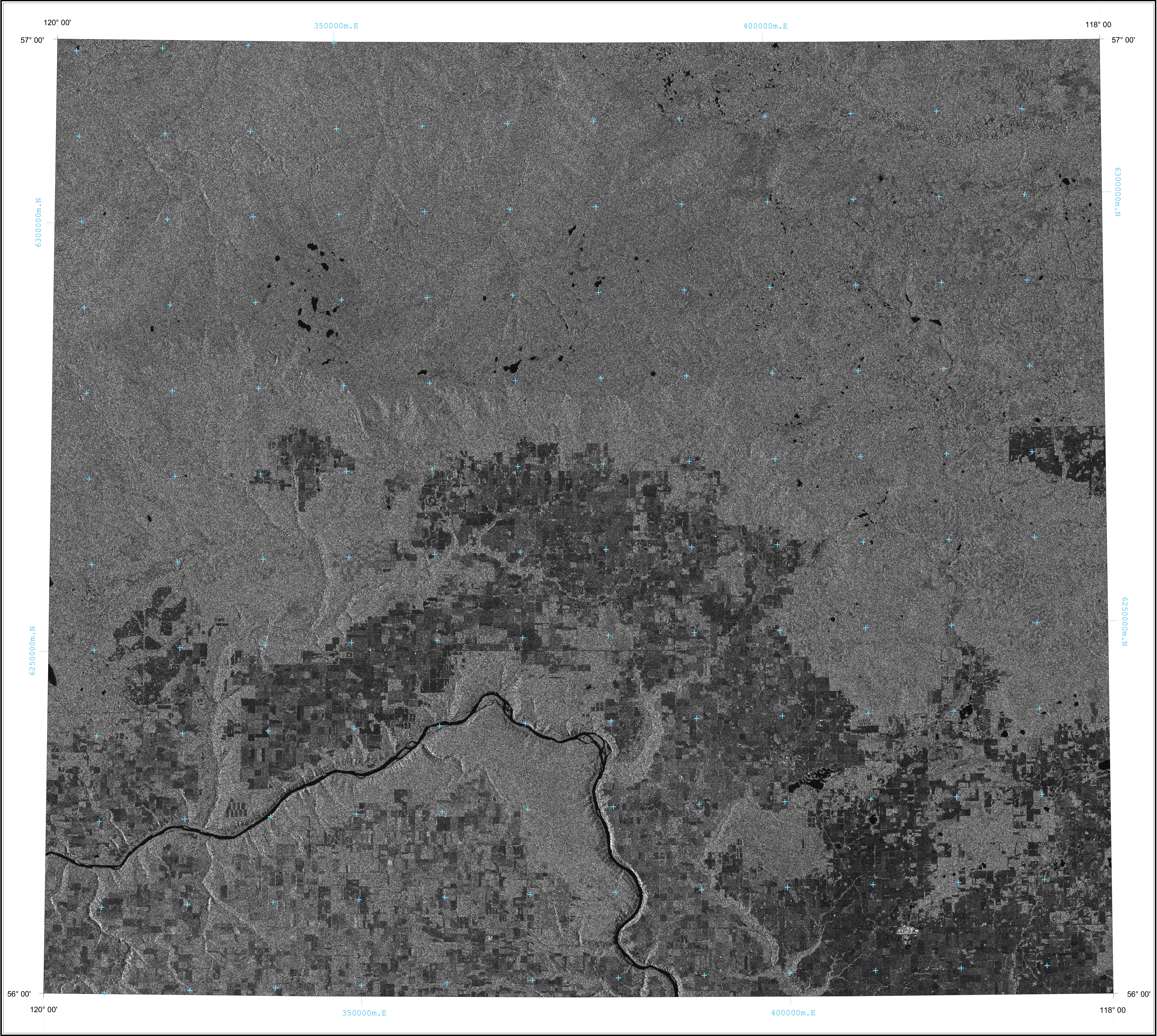
NTS 84D
RADARSAT-1



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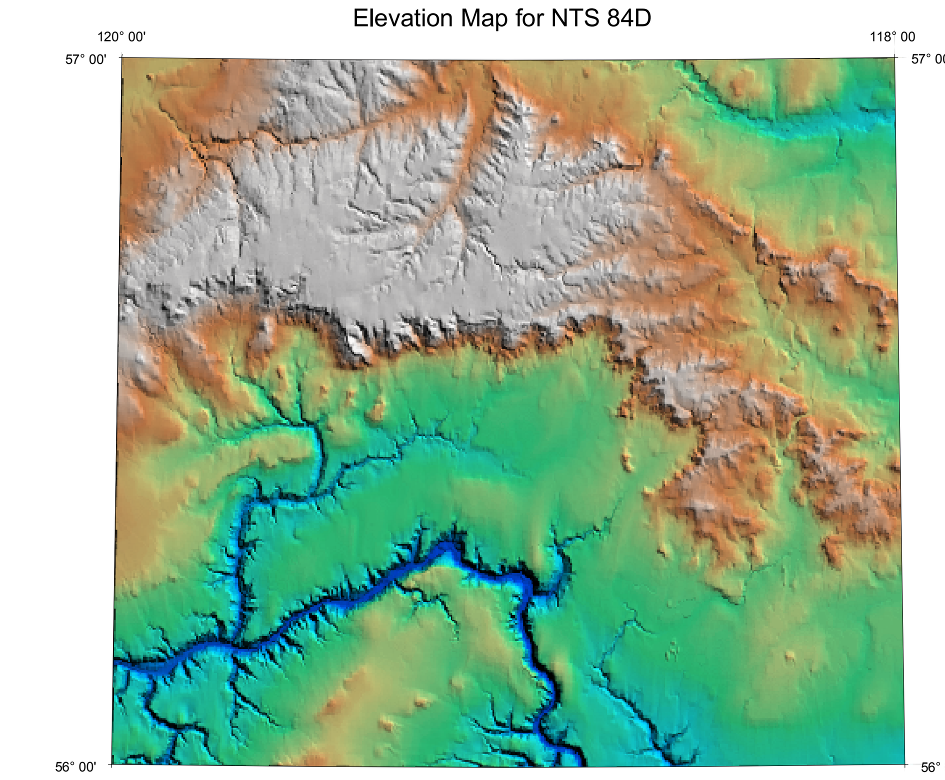
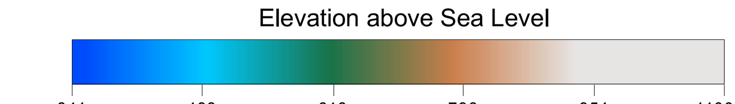
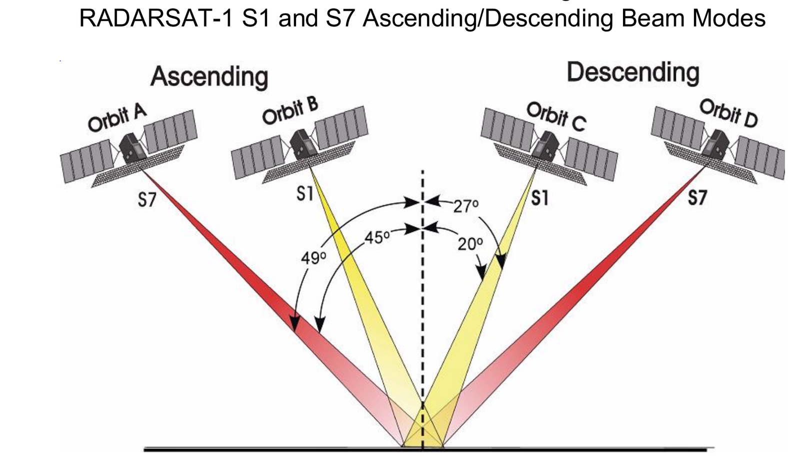


Elevation above Sea Level



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



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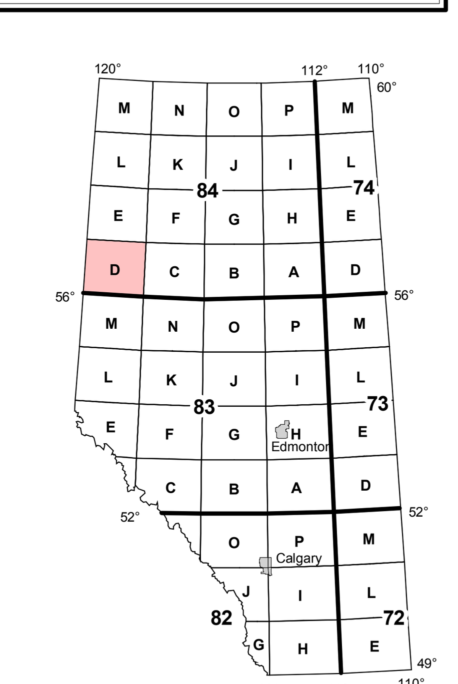
Geo-Note 2003-23, Figure 11

RADARSAT-1 Standard Beam 7 Ascending Image for Clear Hills, Alberta (NTS 84D)

Compilation by S. Mei, 2003

Scale 1:250 000

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



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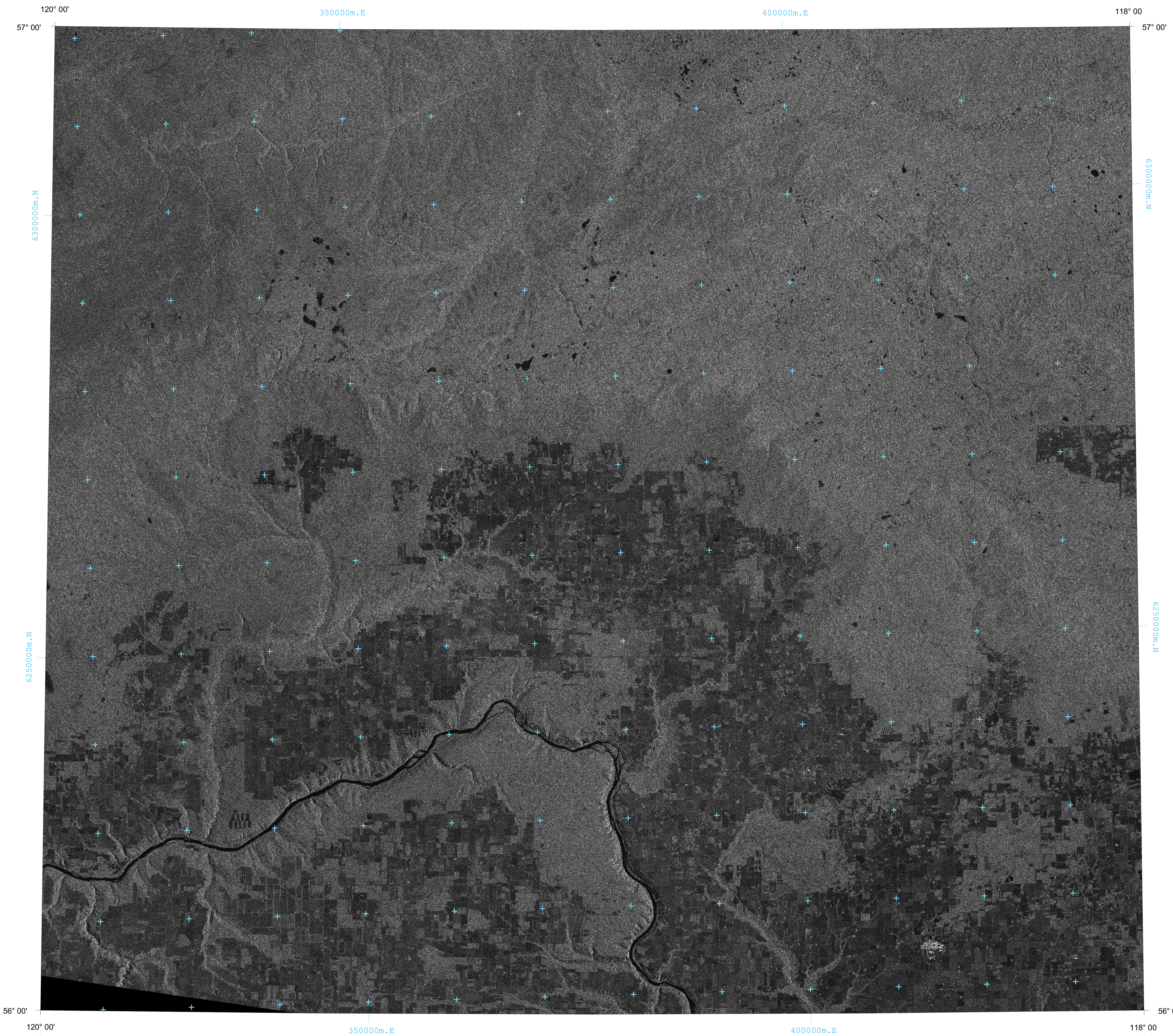
Disclaimer:

NTS 84D
RADARSAT-1



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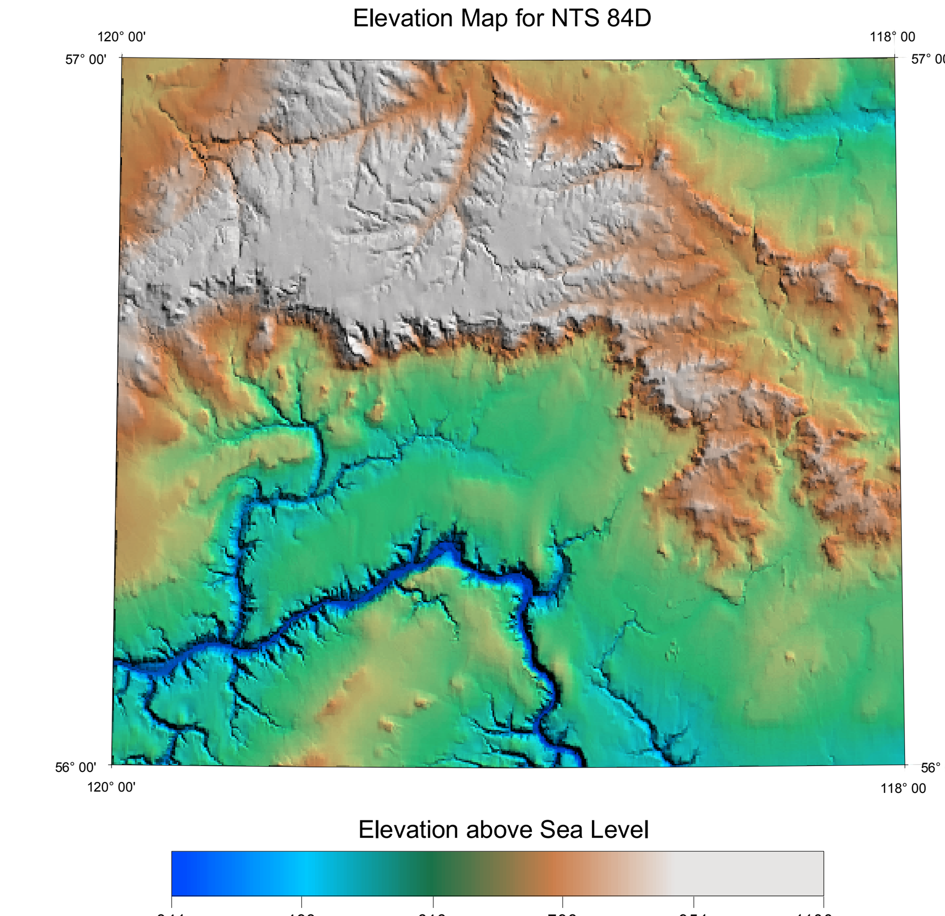

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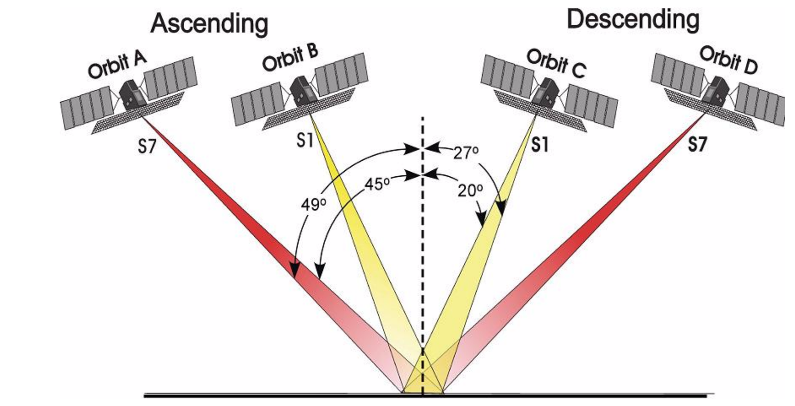

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Geo-Note 2003-23, Figure 12

RADARSAT-1 Standard Beam 7 Descending Image for Clear Hills, Alberta (NTS 84D)

Compilation by S. Mei, 2003

Scale 1:250 000

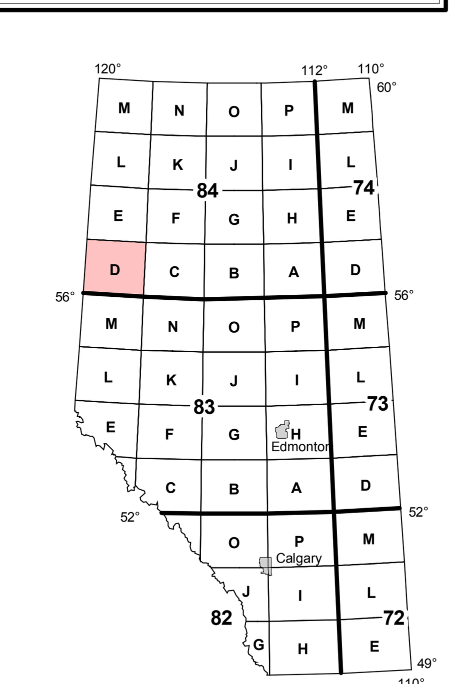
5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

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

EUB
Alberta Energy and Utilities Board

AGS
Alberta Geological Survey



Acknowledgements:

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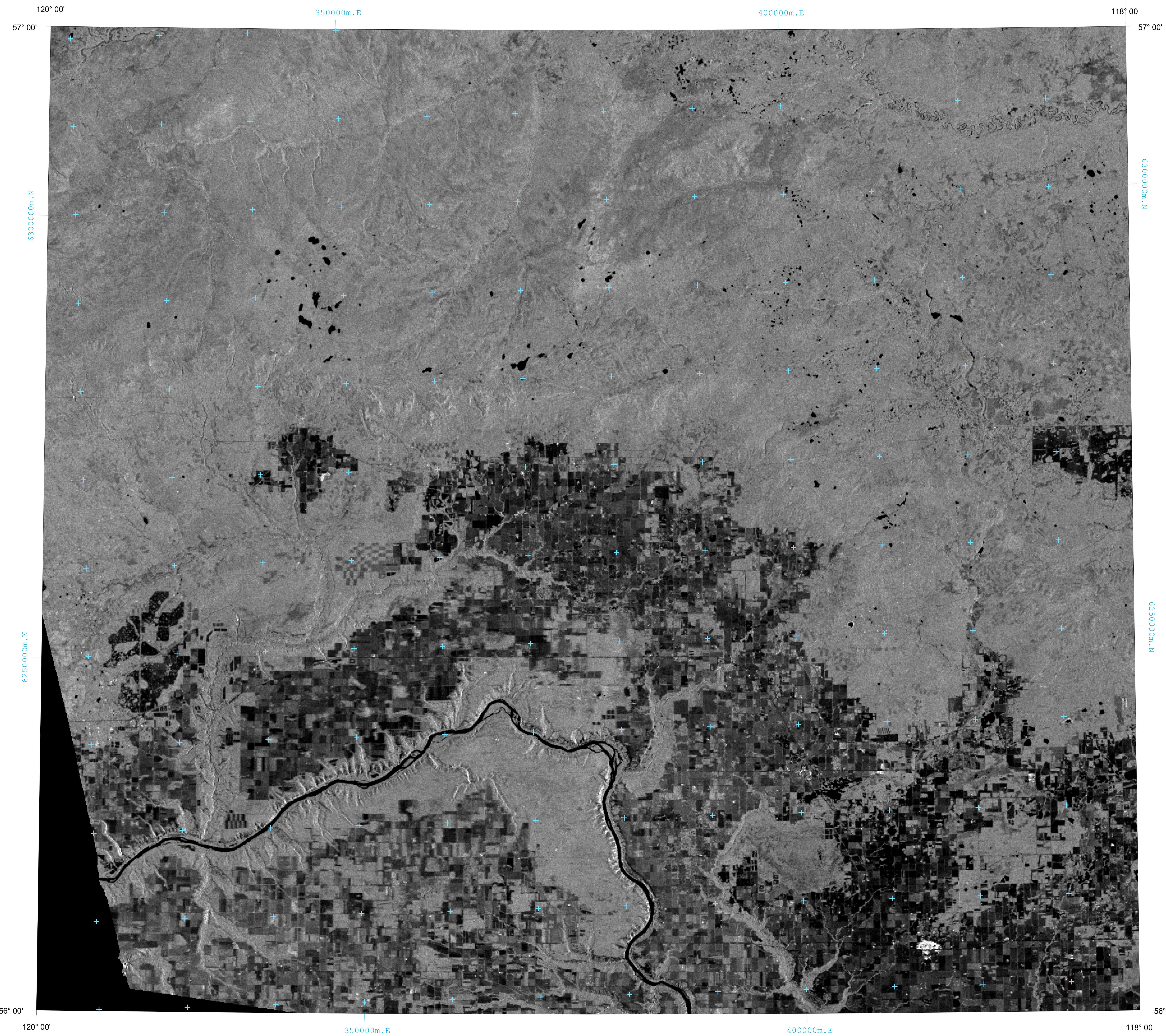
Disclaimer:

NTS 84D
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).

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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).

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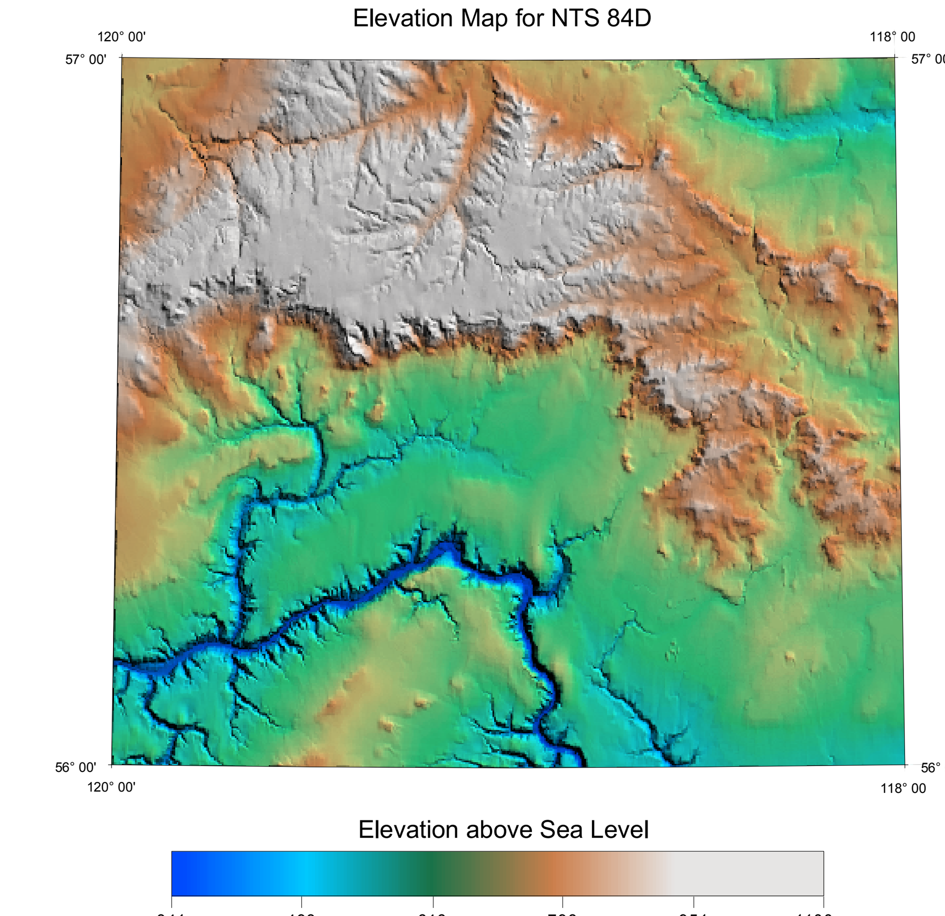
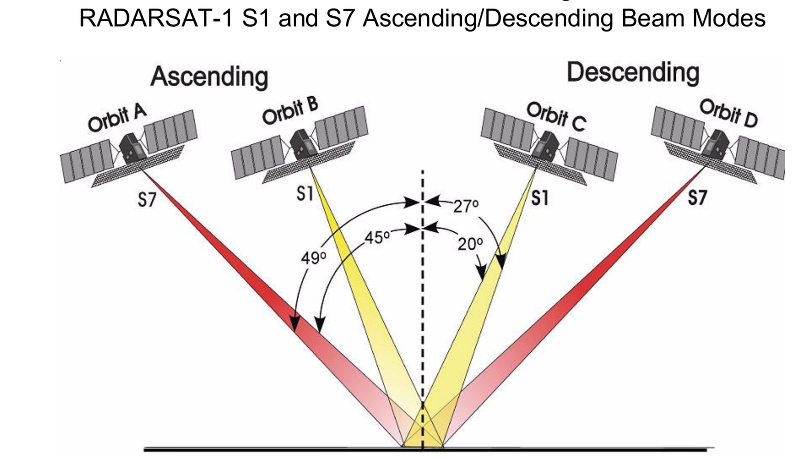
Elevation Map for NTS 84D



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



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Geo-Note 2003-23, Figure 13

RADARSAT-1 Principal Component 1 Image for Clear Hills, Alberta (NTS 84D)

Compilation by S. Mei, 2003

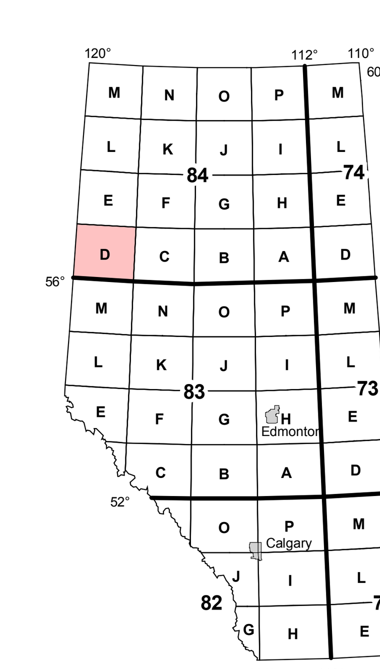
Scale 1:250 000

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

EUB Alberta Energy and Utilities Board
AGS Alberta Geological Survey



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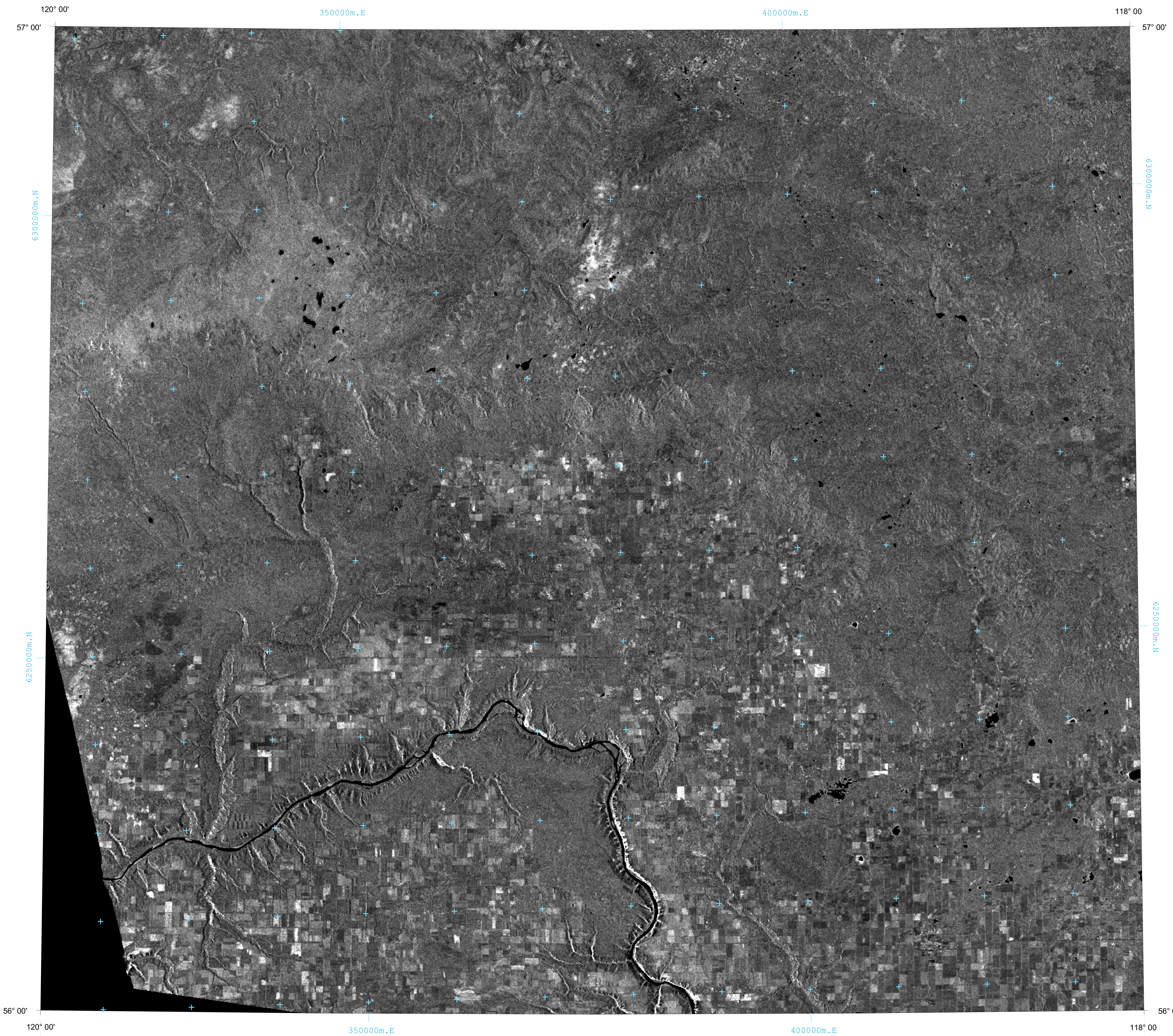
Disclaimer:

NTS 84D
RADARSAT-1



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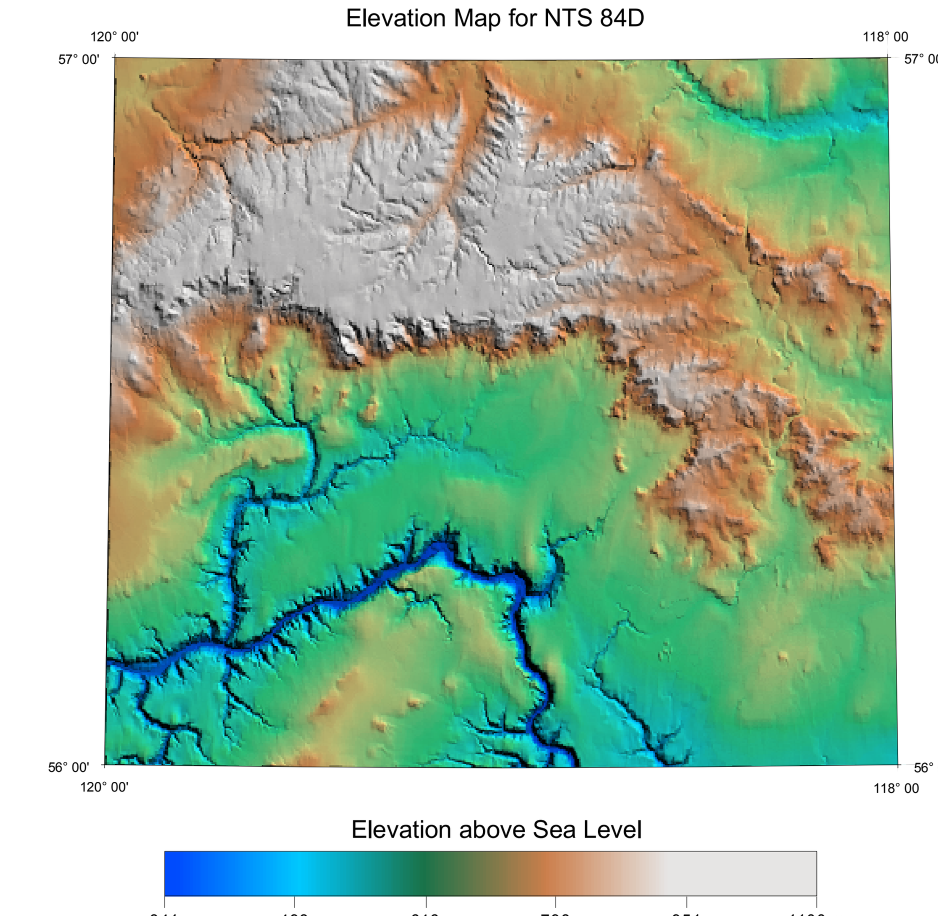
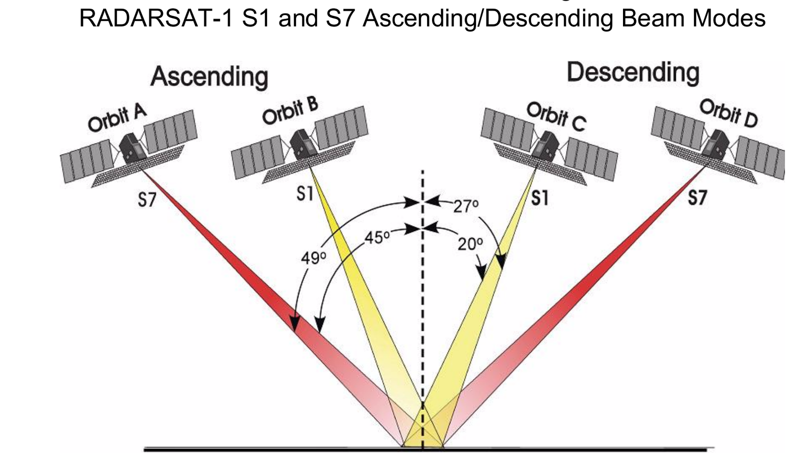
Elevation Map for NTS 84D



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



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Geo-Note 2003-23, Figure 14

RADARSAT-1 Principal Component 2 Image for Clear Hills, Alberta (NTS 84D)

Compilation by S. Mei, 2003

Scale 1:250 000

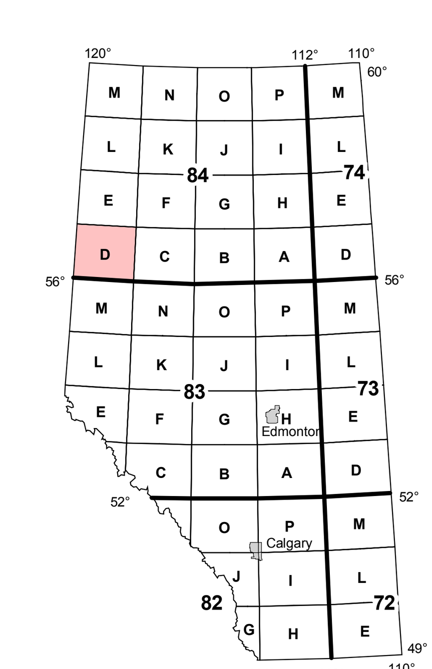
5 0 5 10 15 20 25 30 kilometres

5 0 5 10 15 20 miles

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

EUB
Alberta Energy and Utilities Board

AGS
Alberta Geological Survey



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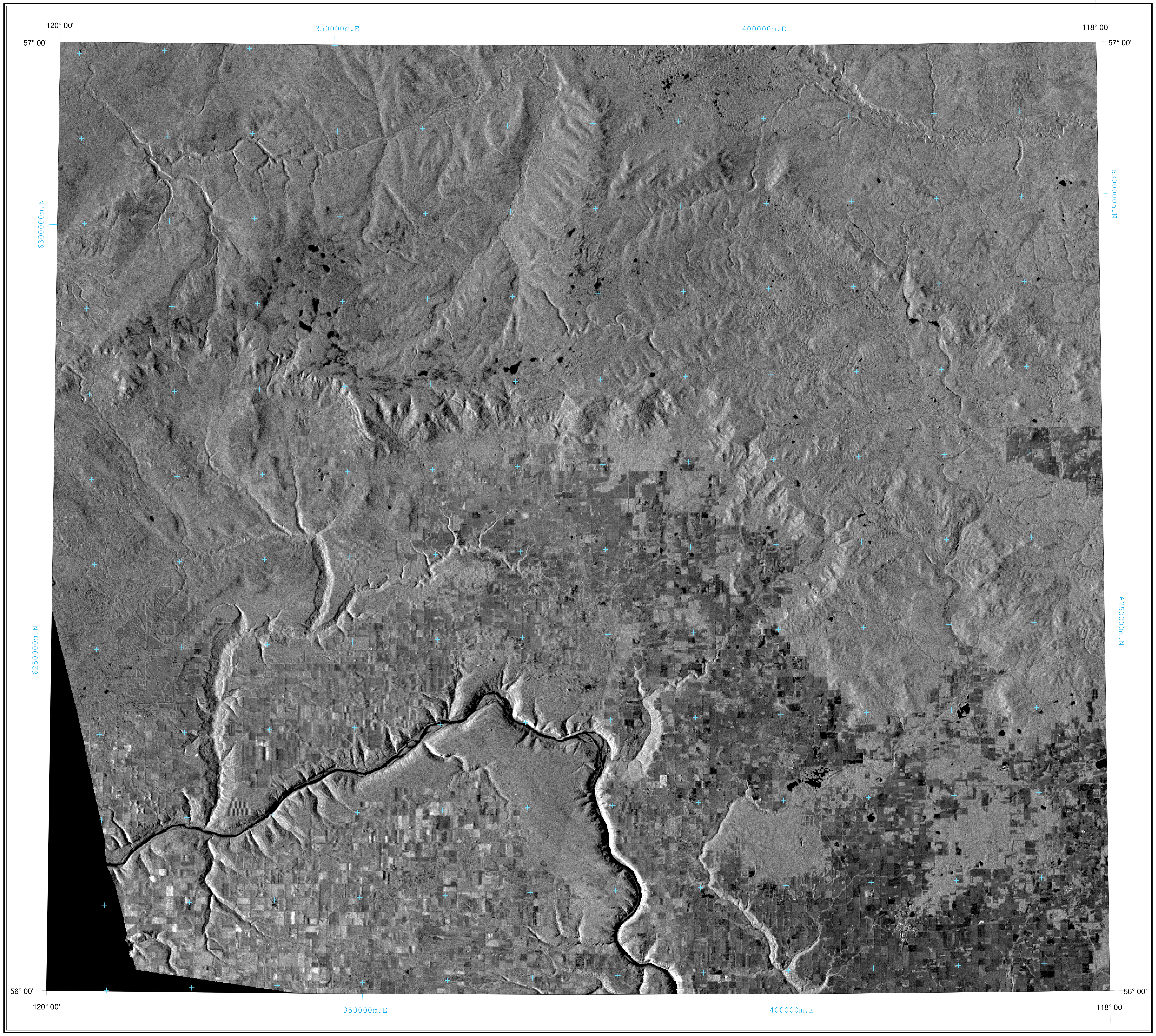
NTS 84D
RADARSAT-1



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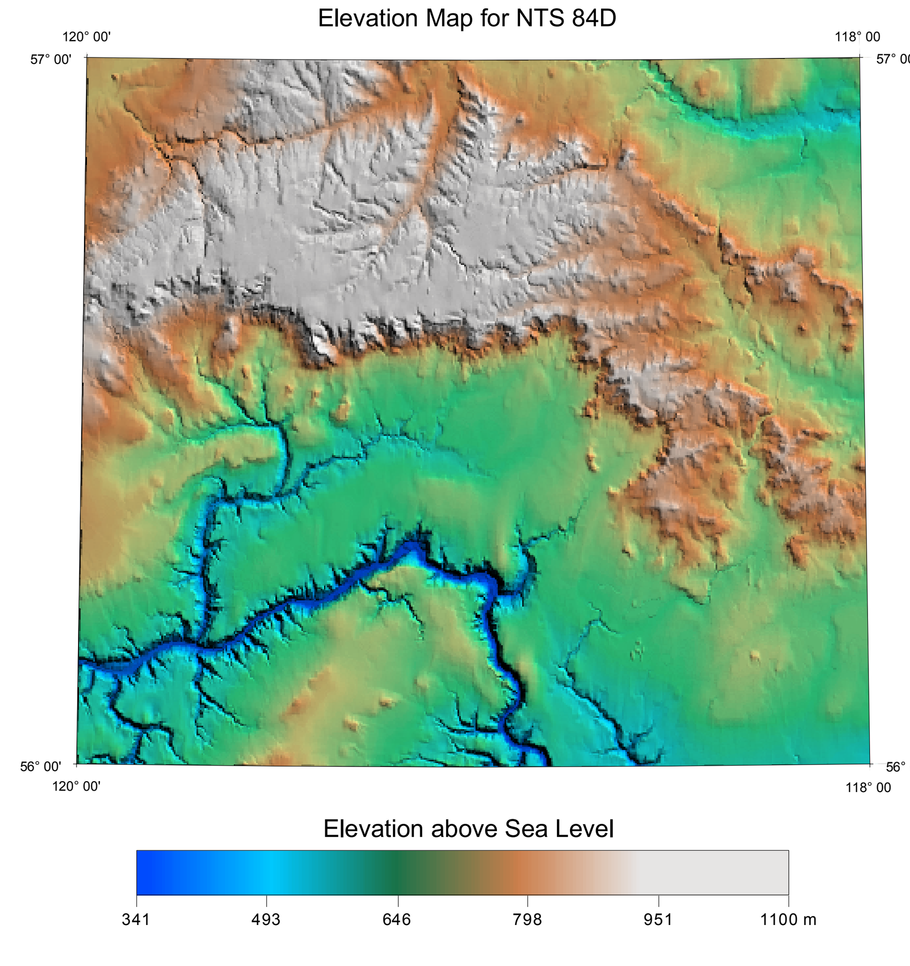
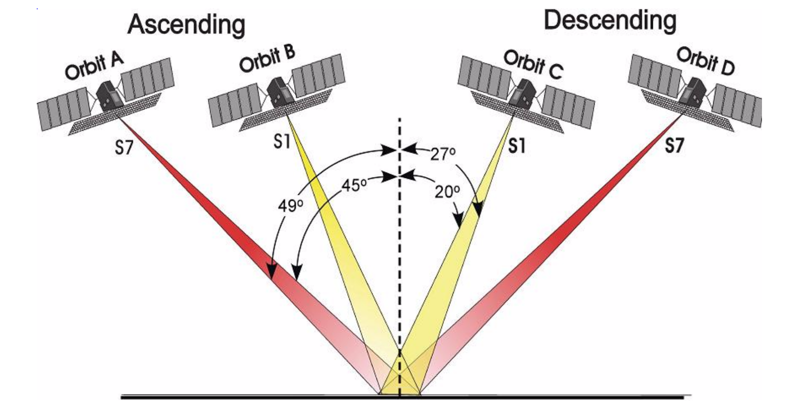
Elevation Map for NTS 84D



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



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Geo-Note 2003-23, Figure 15

RADARSAT-1 Principal Component 3 Image for Clear Hills, Alberta (NTS 84D)

Compilation by S. Mei, 2003

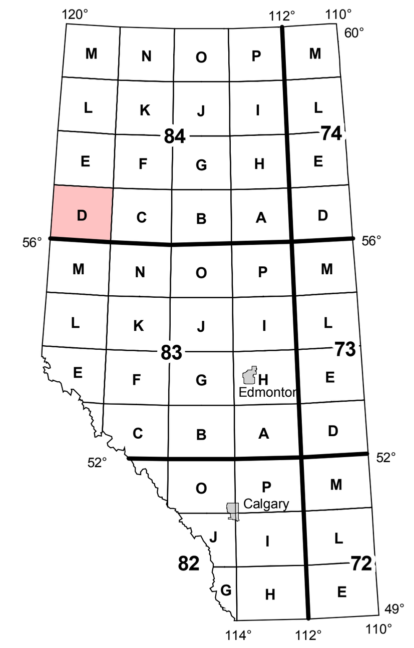
Scale 1:250 000

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

Alberta Energy and Utilities Board
Alberta Geological Survey



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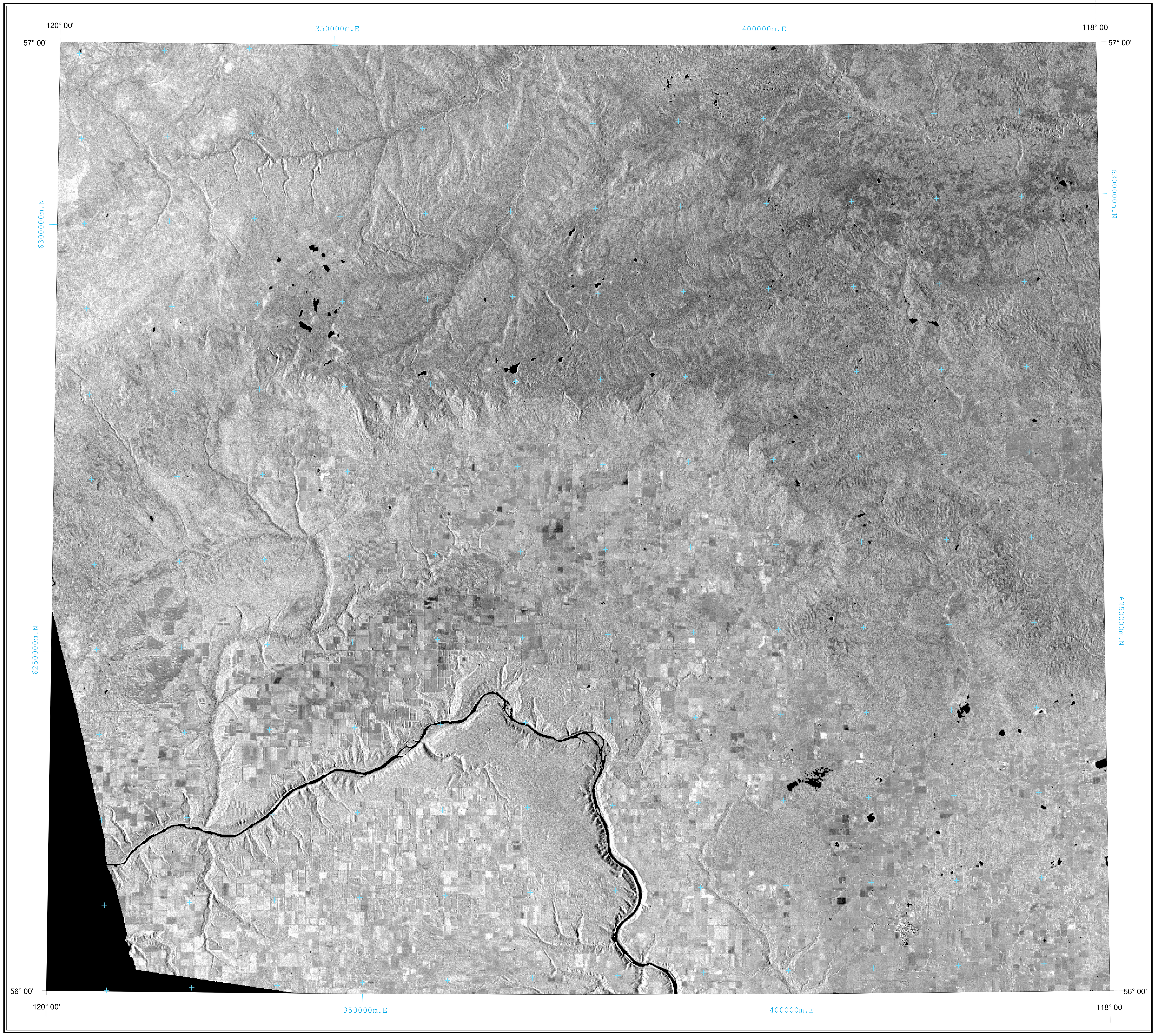
Disclaimer:

NTS 84D
RADARSAT-1



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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.

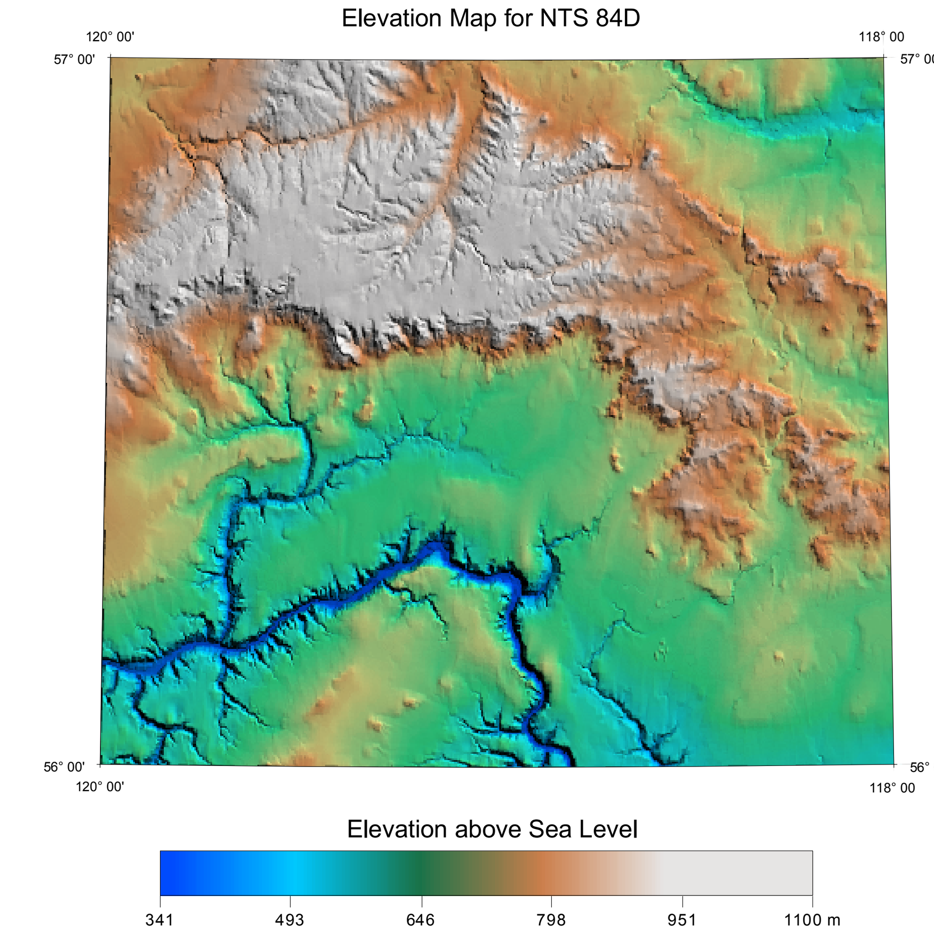
The First Principal Component (PC1) image (Figure 13) shows a range of brightness and texture that highlights features associated with differences in vegetation type and density. Areas of closed Aspen, closed Pine, open deciduous vegetation, grasslands and exposed soil appear to have a brighter tone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

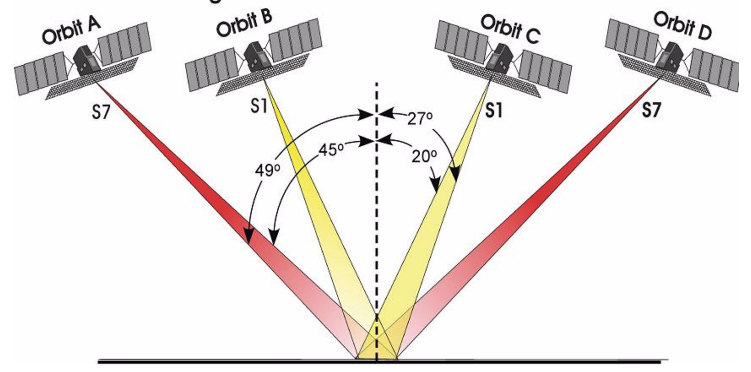
The Third Principal Component (PC3) image (Figure 15) highlights ‘surface roughness’; hence it reflects topographic effects and surface texture of the ground or vegetation canopy. In fact, the discrimination of topographic features using the PC3 image is superior to any other optical commercial satellite 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 84D



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



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

Geo-Note 2003-23, Figure 16

RADARSAT-1 Principal Component 4 Image for Clear Hills, Alberta (NTS 84D)

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

Alberta Energy and Utilities Board
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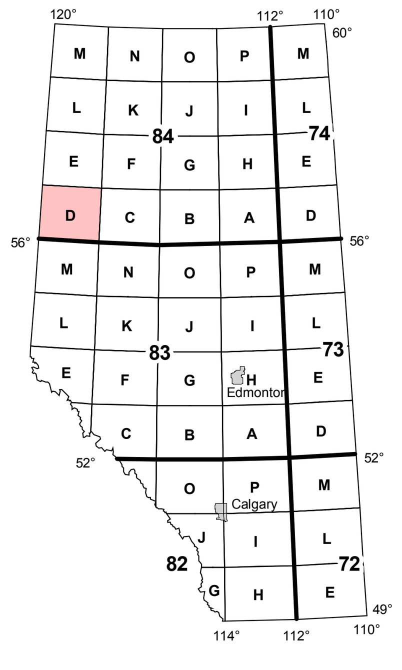

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