EUB/AGS Geo-Note 2003-16

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

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

1 Introduction

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

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

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

2 RADARSAT-1 Standard Beam Mode Images

RADARSAT-1 was launched on November 4, 1995, as a result of a joint venture between the Canadian government, private industry and NASA (RADARSAT International (RSI), 1999). As Canada's first

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

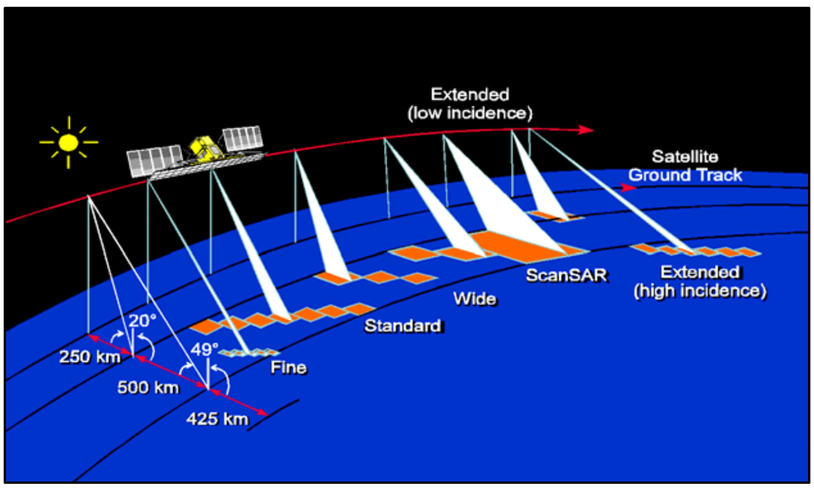

Figure 1. RADARSAT-1 beam modes (used with permision from RADARSAT International (RSI), 1997).

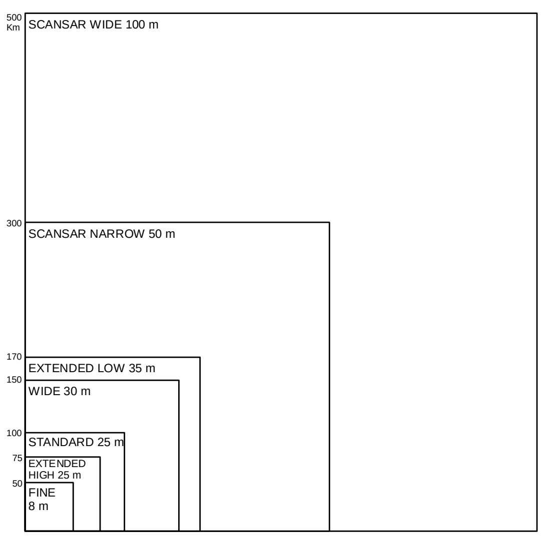

Figure 2. Coverage sizes and resolutions of RADARSAT-1 beam modes (modified after RADARSAT International (RSI), 1999).

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

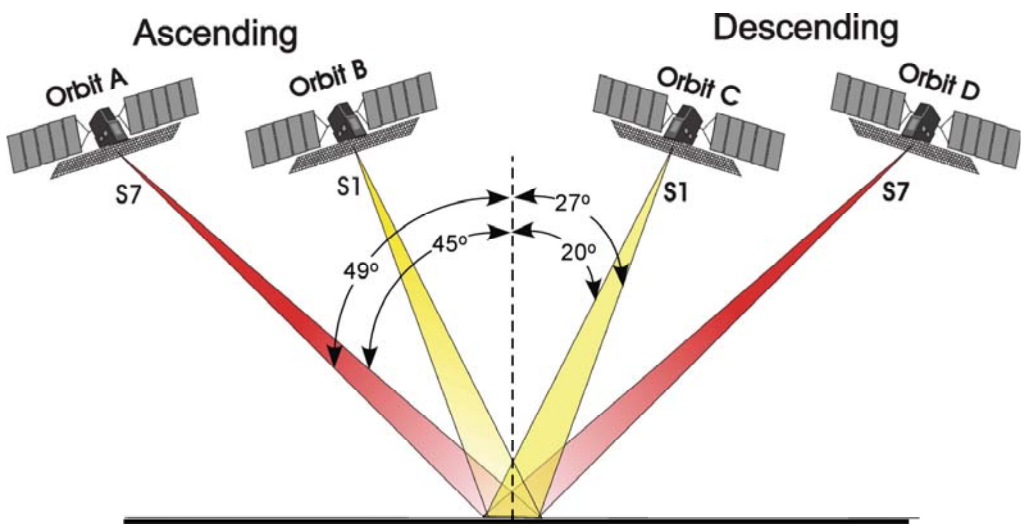

Figure 3. Multi-beam configuration of RADARSAT-1 S1 and S7 ascending/descending imagery (after Grunsky, 2002a).

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

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

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

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

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

3.1 Original RADARSAT-1 Standard Beam Mode Images

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

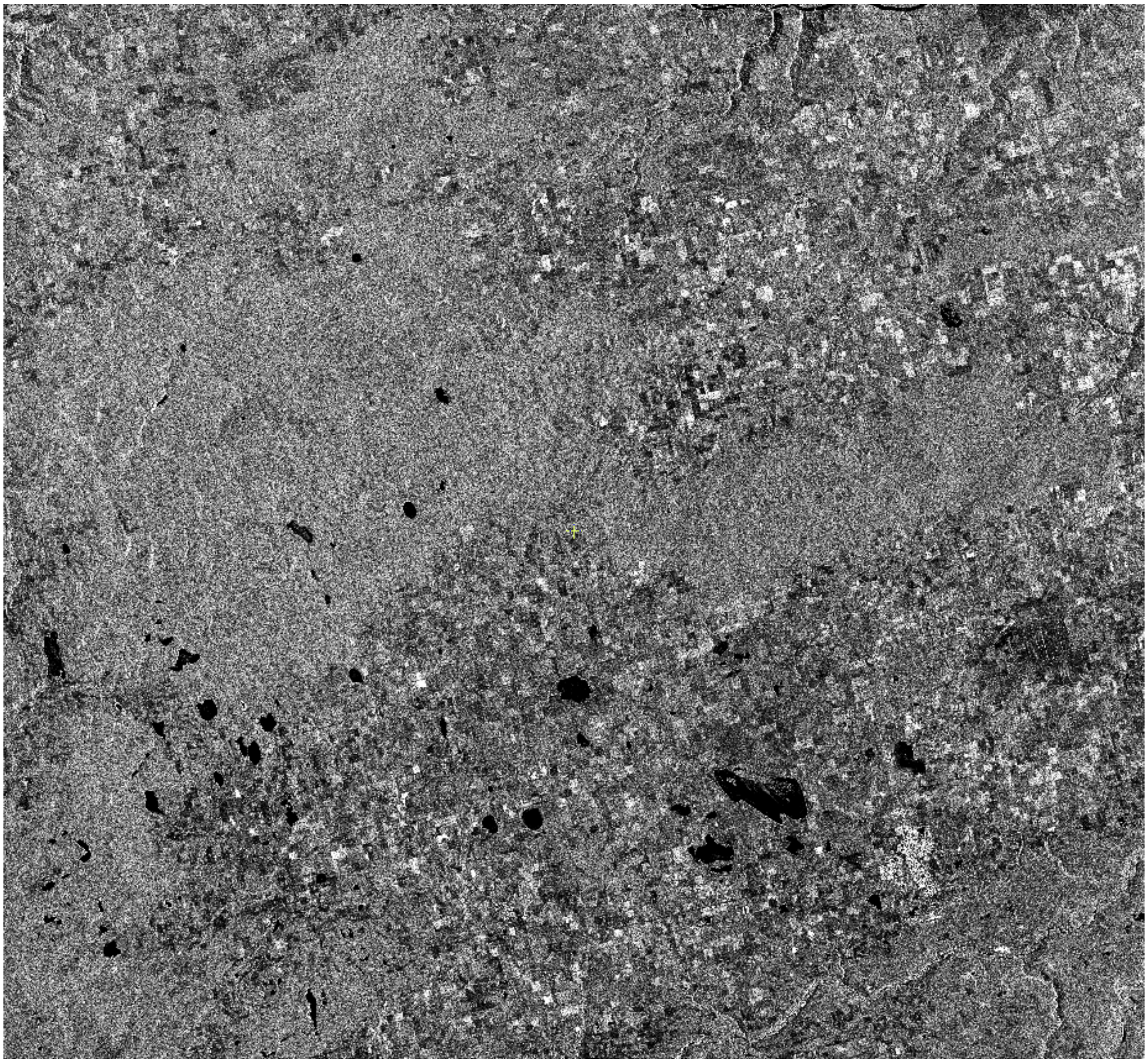

Figure 4. One of the original SGF scene images used for tiling the NTS 83M dataset: scene MO196563 of Standard Beam Mode 1 descending. RADARSAT data © Canadian Space Agency/Agence spatiale canadienne 1999, processed and distributed by RADARSAT International.

Table 1. List of the Path Images that Overlay NTS 83M

Scene ID	Beam	Path	UL_LAT	UL_LONG	UR_LAT	UR_LONG	LR_LAT	LR_LONG	LL_LAT	LL_LONG
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
M0196324	S1	ASC	55:47:48.65N	118:42:53.66W	56:02:08.44N	116:56:27.10W	55:05:25.83N	116:33:33.83W	54:51:18.28N	118:17:24.20W
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
M0195856	S1	ASC	55:41:29.84N	119:47:12.89W	55:56:02.09N	117:59:49.24W	54:57:33.79N	117:36:13.96W	54:43:14.37N	119:20:55.56W
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
M0196740	S1	DES	55:19:50.22N	118:03:57.60W	55:05:46.36N	116:20:05.47W	54:12:39.97N	116:43:21.72W	54:26:33.07N	118:24:53.64W
M0196739	S1	DES	56:09:22.48N	117:43:52.84W	55:55:07.87N	115:57:43.35W	55:00:22.27N	116:22:30.51W	55:14:25.03N	118:06:08.36W
M0196564	S1	DES	55:15:51.11N	120:10:36.20W	55:01:47.94N	118:26:54.16W	54:16:32.51N	118:46:44.05W	54:30:26.51N	120:28:26.60W
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
M0196092	S1	DES	55:22:04.09N	119:05:55.43W	55:07:59.61N	117:21:55.59W	54:15:01.76N	117:45:10.13W	54:28:55.48N	119:26:49.77W
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
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
M0198981	S7	ASC	55:44:56.82N	118:08:04.26W	55:53:21.63N	116:21:47.65W	54:55:11.86N	116:08:31.92W	54:46:45.63N	117:52:12.60W
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
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
M0195839	S7	ASC	55:22:10.63N	120:18:55.38W	56:00:34.97N	118:32:21.77W	55:00:39.97N	118:18:40.55W	54:52:14.20N	120:02:32.54W
M0200871	S7	DES	55:19:24.73N	120:28:22.38W	55:11:03.35N	118:44:00.09W	54:17:41.36N	118:58:17.52W	54:26:04.27N	120:40:21.83W
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
M0200099	S7	DES	55:17:43.85N	118:23:24.92W	55:09:22.37N	116:39:07.83W	54:15:04.32N	116:53:39.68W	54:23:27.36N	118:35:36.70W
M0200098	S7	DES	56:07:07.62N	118:12:10.84W	55:58:47.30N	116:25:38.59W	55:04:06.22N	116:40:34.81W	55:12:27.86N	118:24:38.67W
M0199675	S7	DES	55:19:14.80N	119:26:19.93W	55:10:53.23N	117:41:58.10W	54:14:49.68N	117:56:58.55W	54:23:12.86N	119:38:55.66W
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
M0198793	S7	DES	56:07:33.68N	121:21:03.91W	55:59:13.38N	119:34:30.42W	55:03:11.44N	119:49:48.60W	55:11:33.10N	121:33:50.07W
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

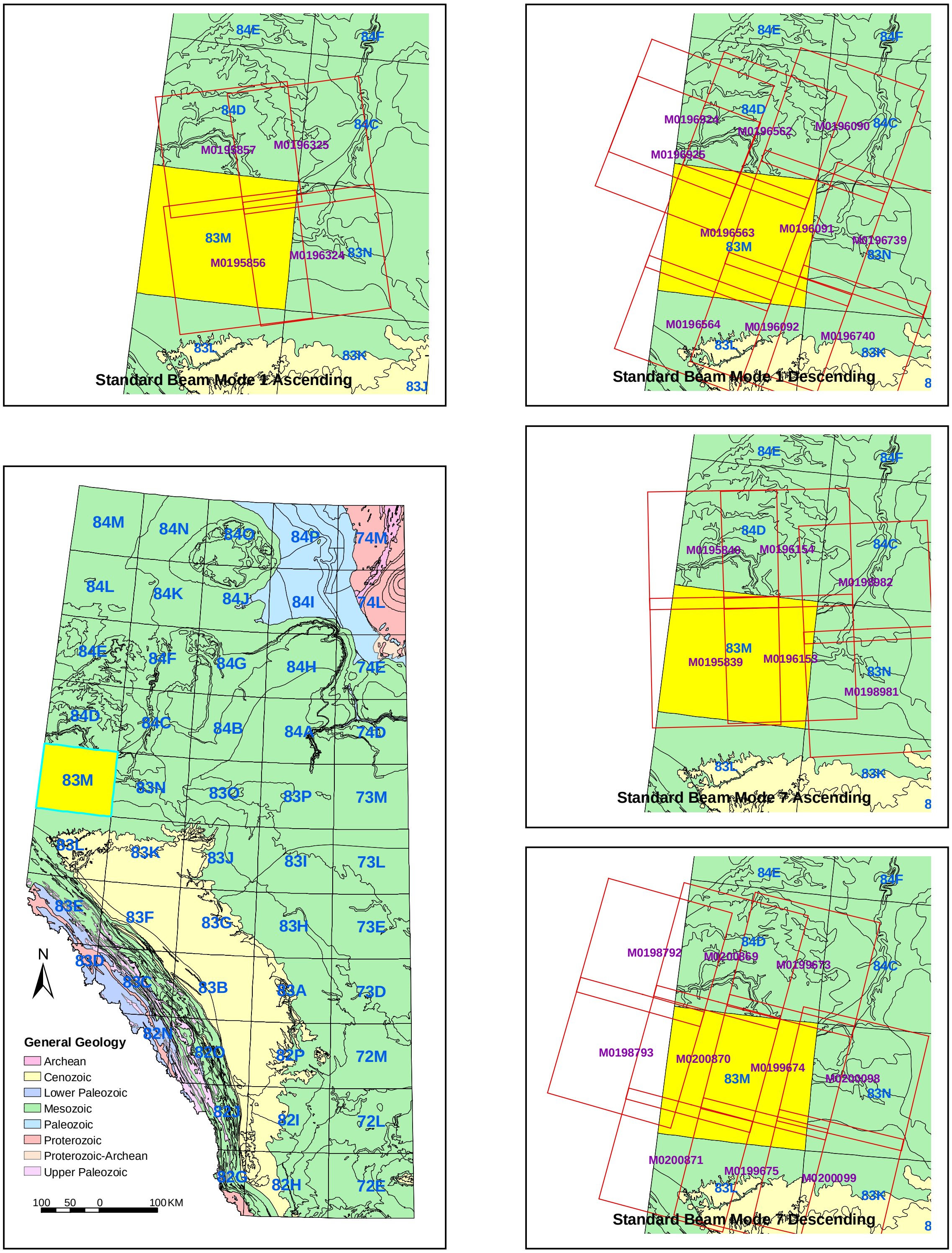

Figure 5. The scenes overlaying NTS 83M.

3.2 Orthorectification Process

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

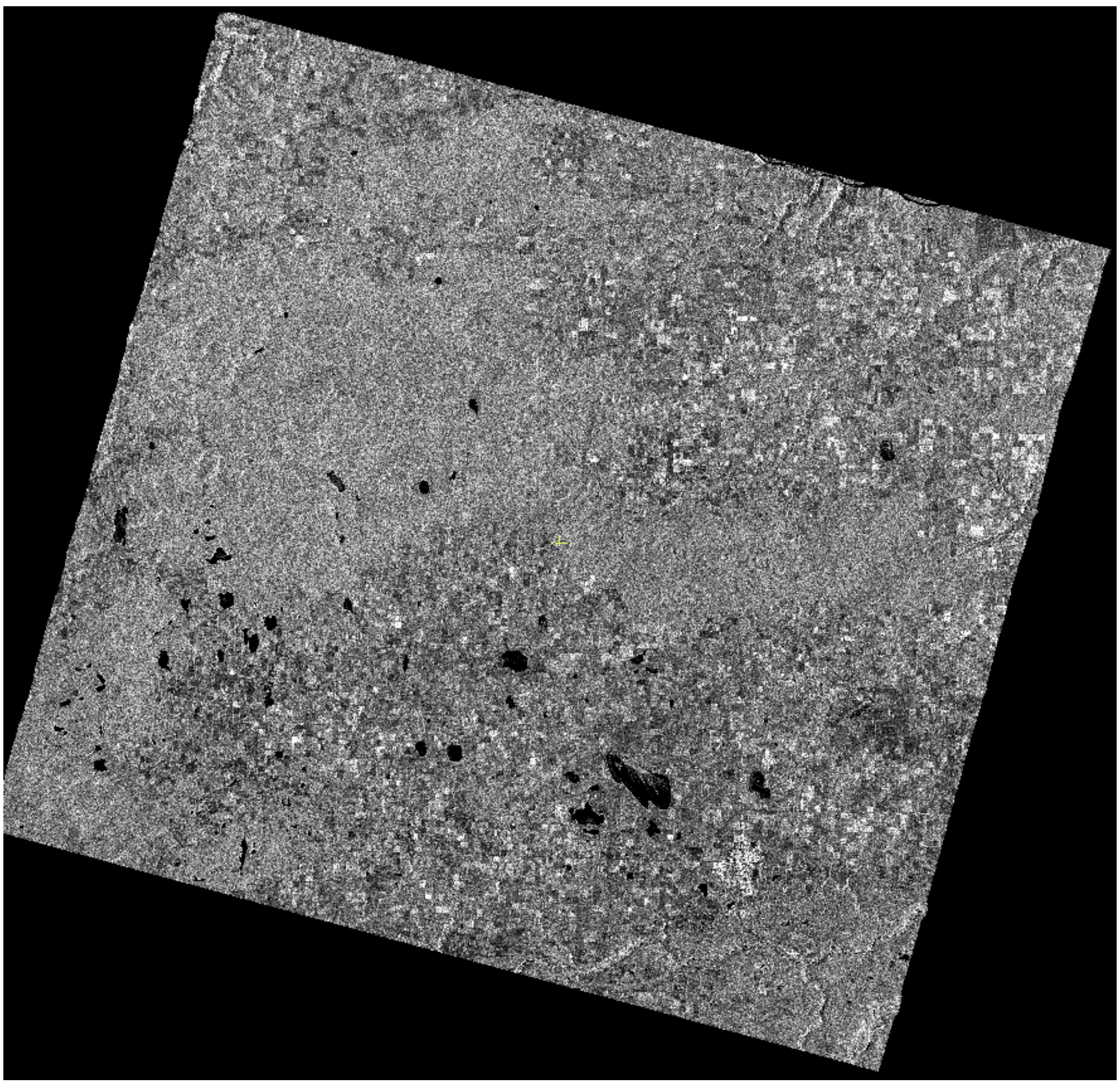

Figure 6. One of the orthorectified scene images used for tiling the NTS 83M dataset: scene MO196563 of Standard Beam Mode 1 descending.

3.3 Mosaic (Tiling) Process

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

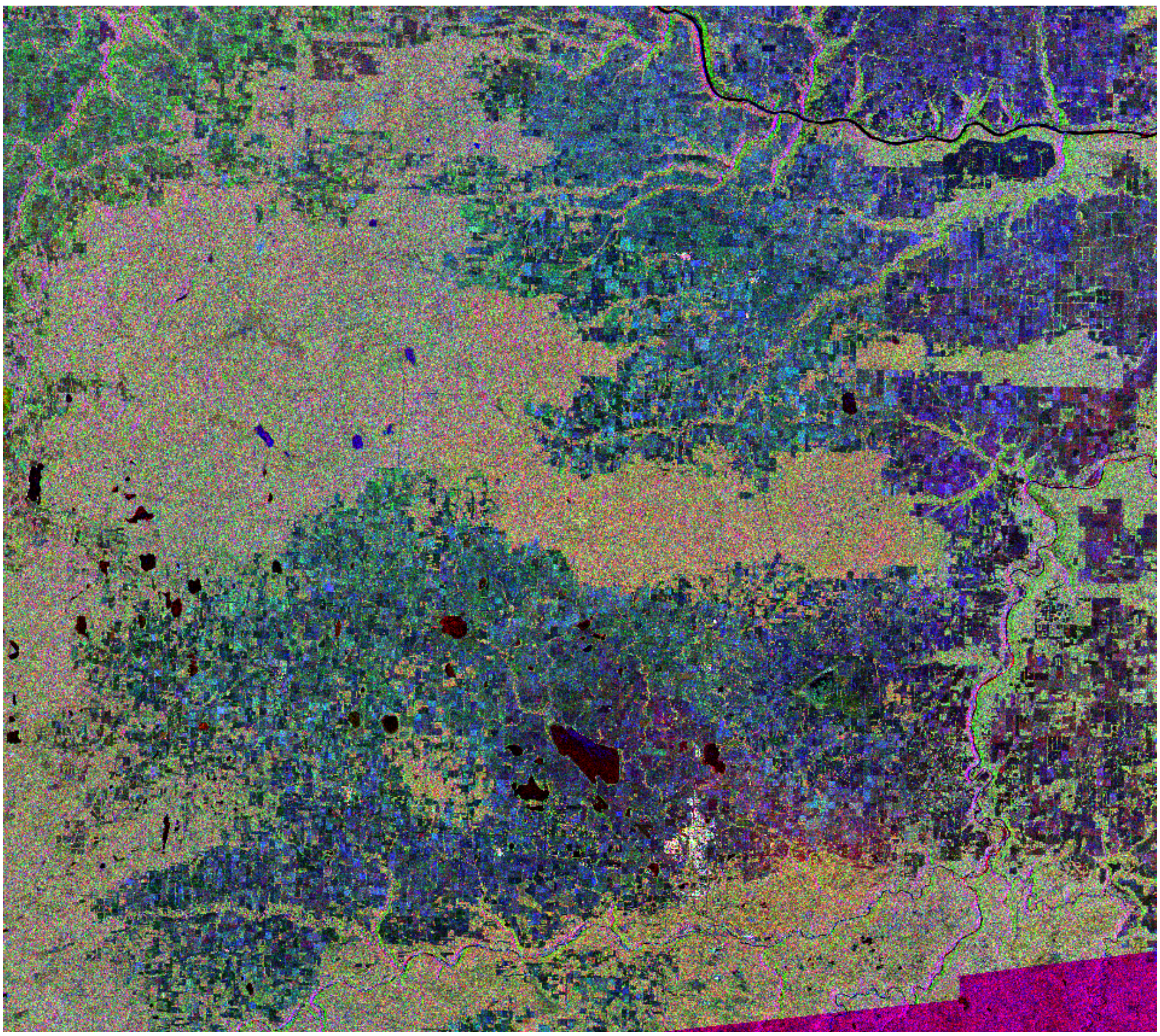

Figure 7. Pseudocolour composite of orthorectified NTS 83M image dataset of Standard Beam Mode S1/S7 ascending/descending beam positions (RGB=S7d, S7a, S1d).

3.4 Principal Component Analysis

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

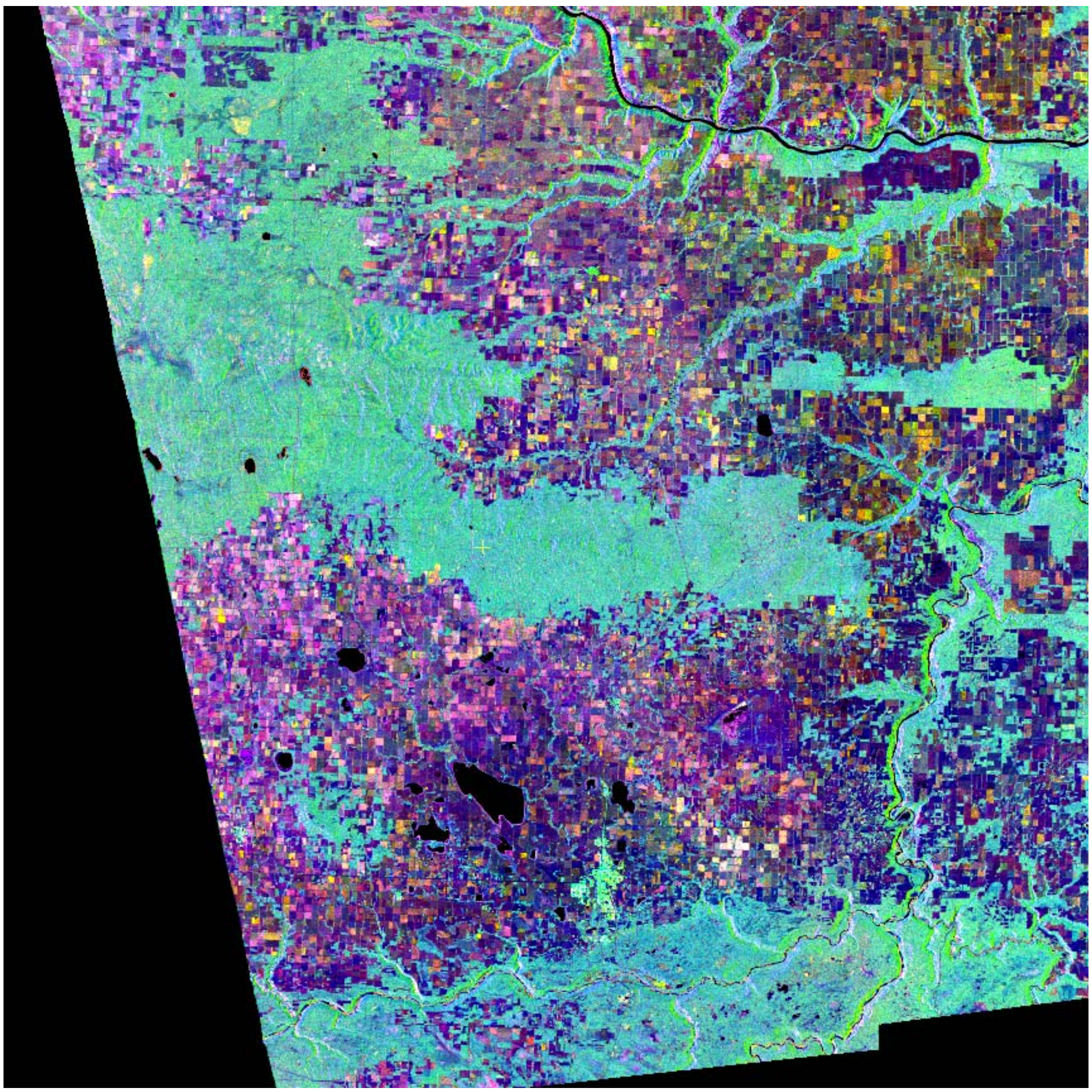

Figure 8. Pseudocolour composite of NTS 83M image dataset of principal component PC1, PC2, PC3 and PC4 (RGB=PC2, PC1, PC3).

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

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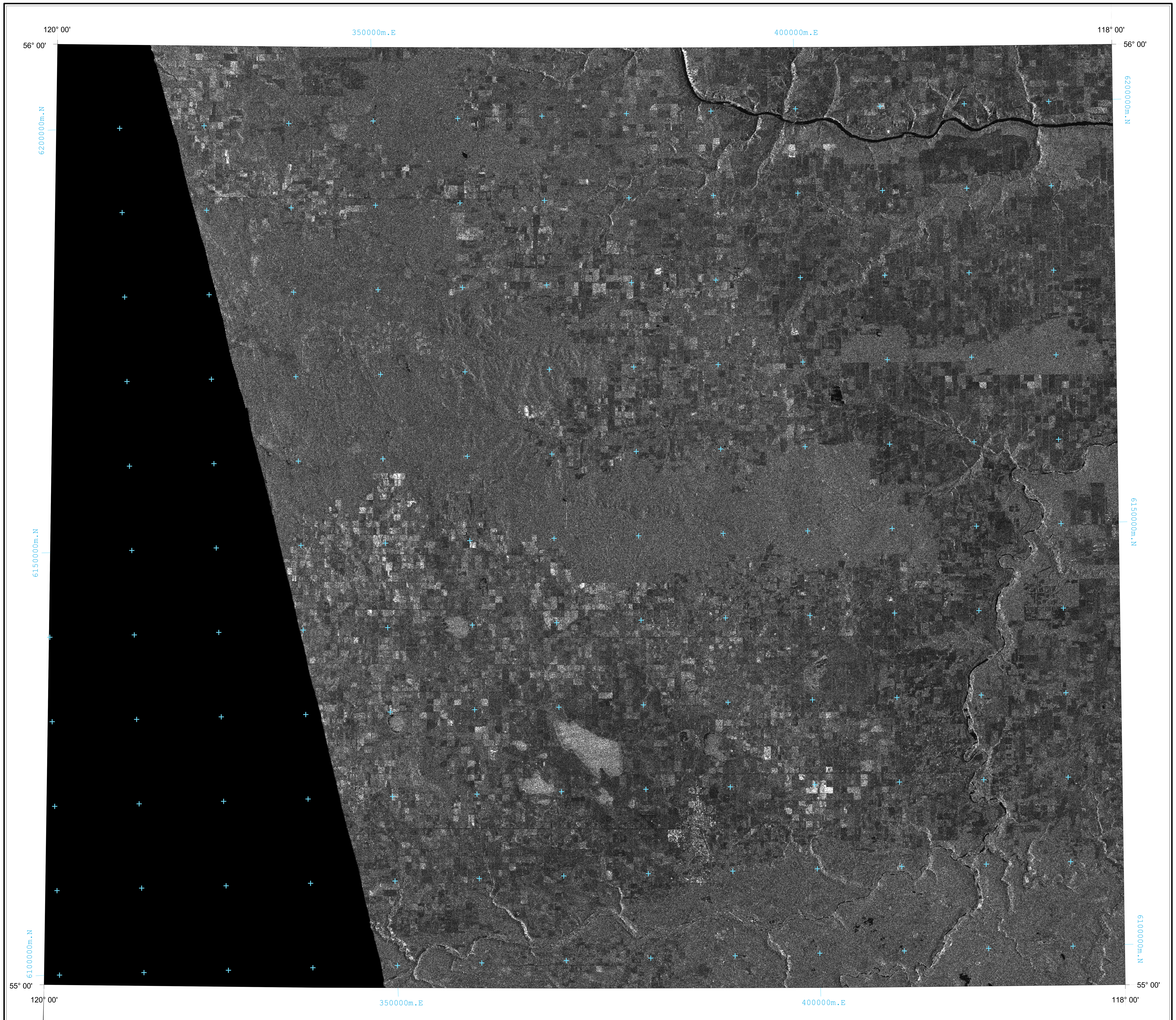
NTS 83M
RADARSAT-1



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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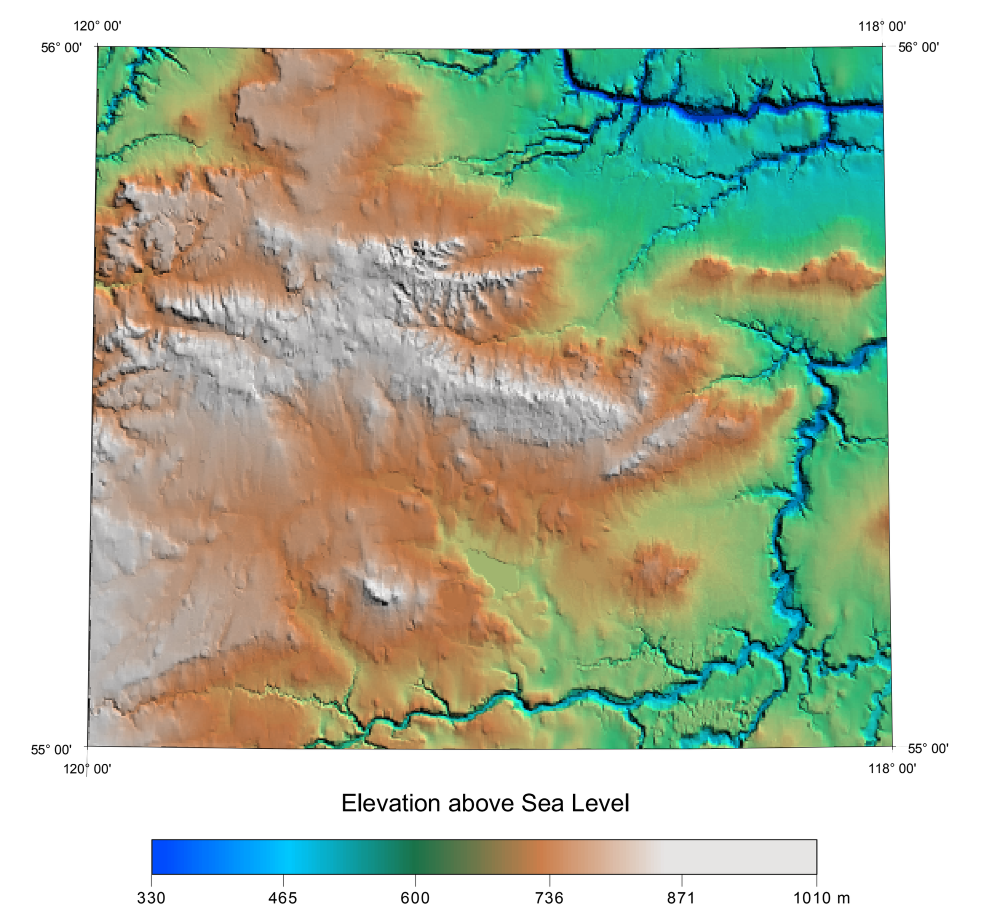
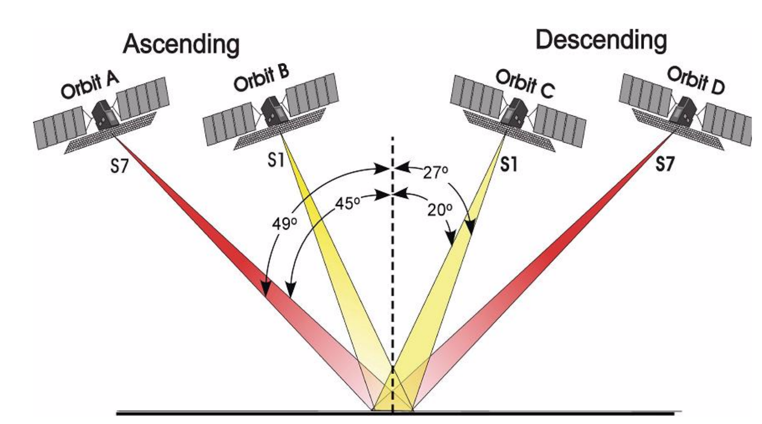
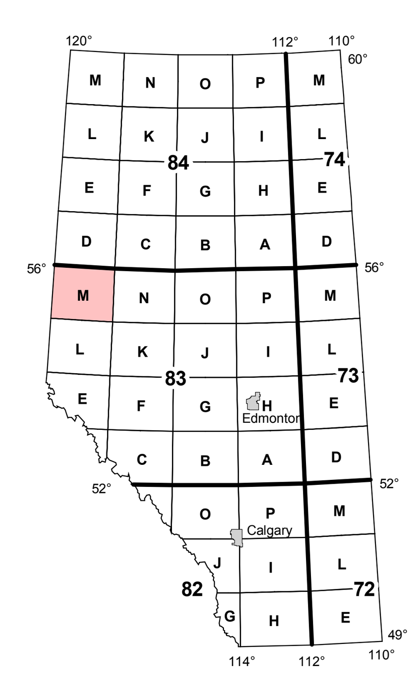
Elevation Map for NTS 83M



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





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Telephone: (780) 422-3767
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Geo-Note 2003-16, Figure 9

RADARSAT-1 Standard Beam 1 Ascending Image for Grand Prairie, Alberta (NTS 83M)

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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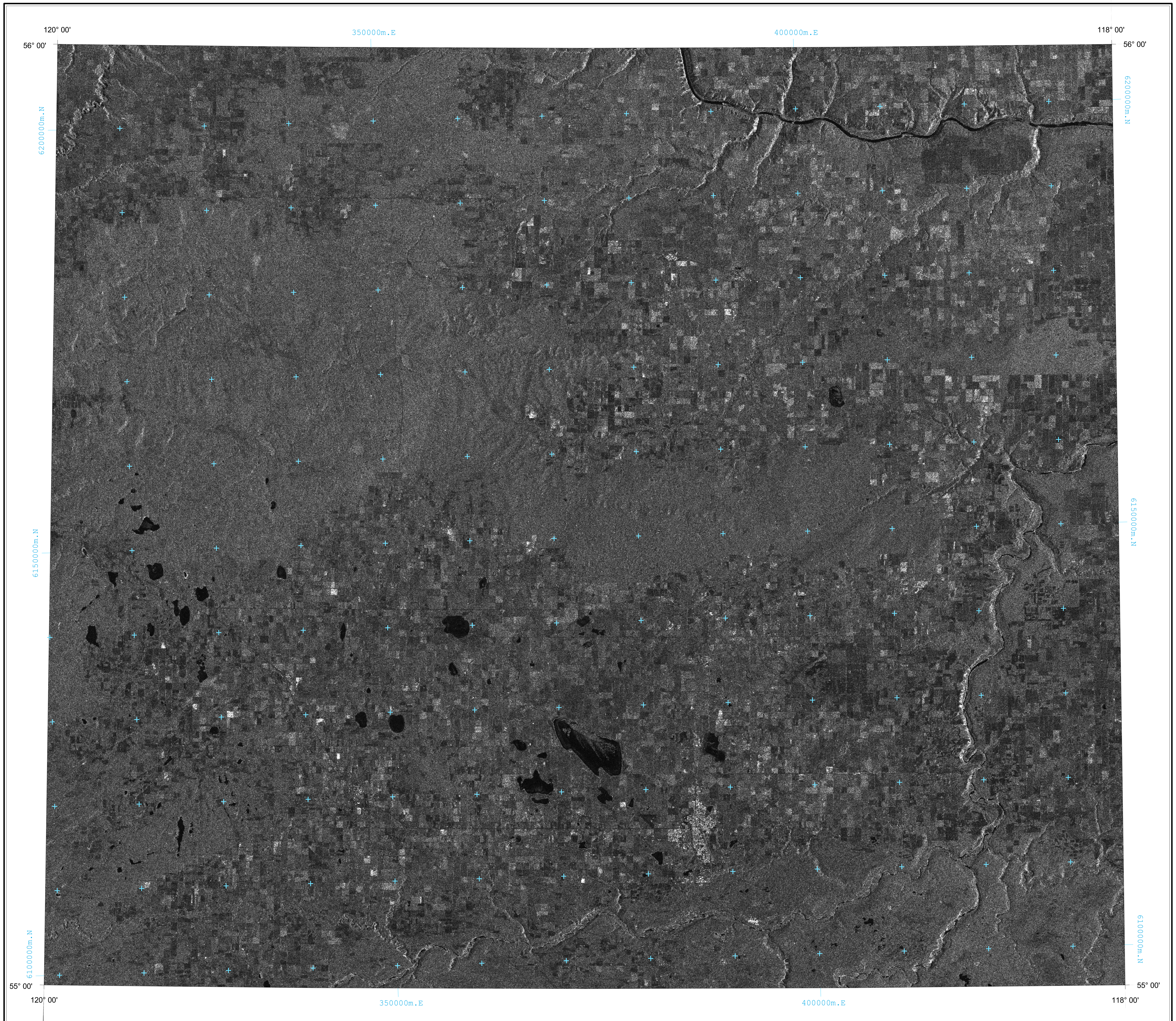
NTS 83M
RADARSAT-1



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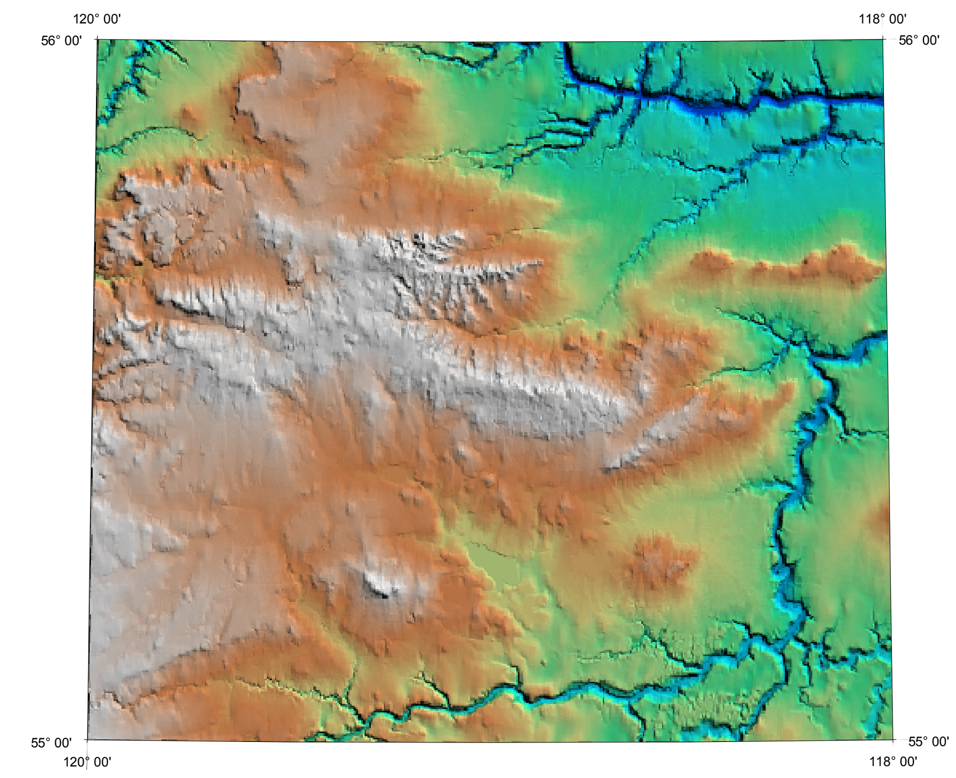
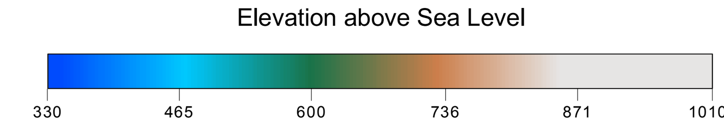
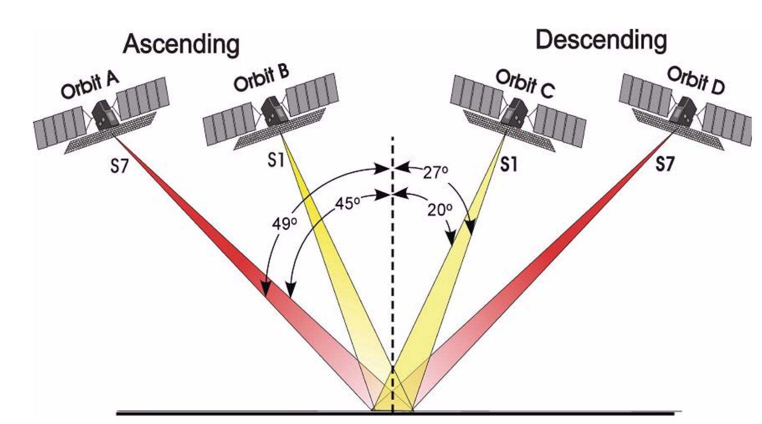


Elevation above Sea Level



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



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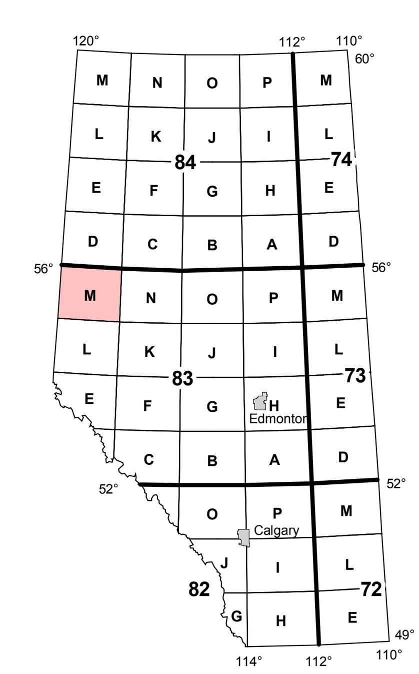
Geo-Note 2003-16, Figure 10

RADARSAT-1 Standard Beam 1 Descending Image for Grand Prairie, Alberta (NTS 83M)

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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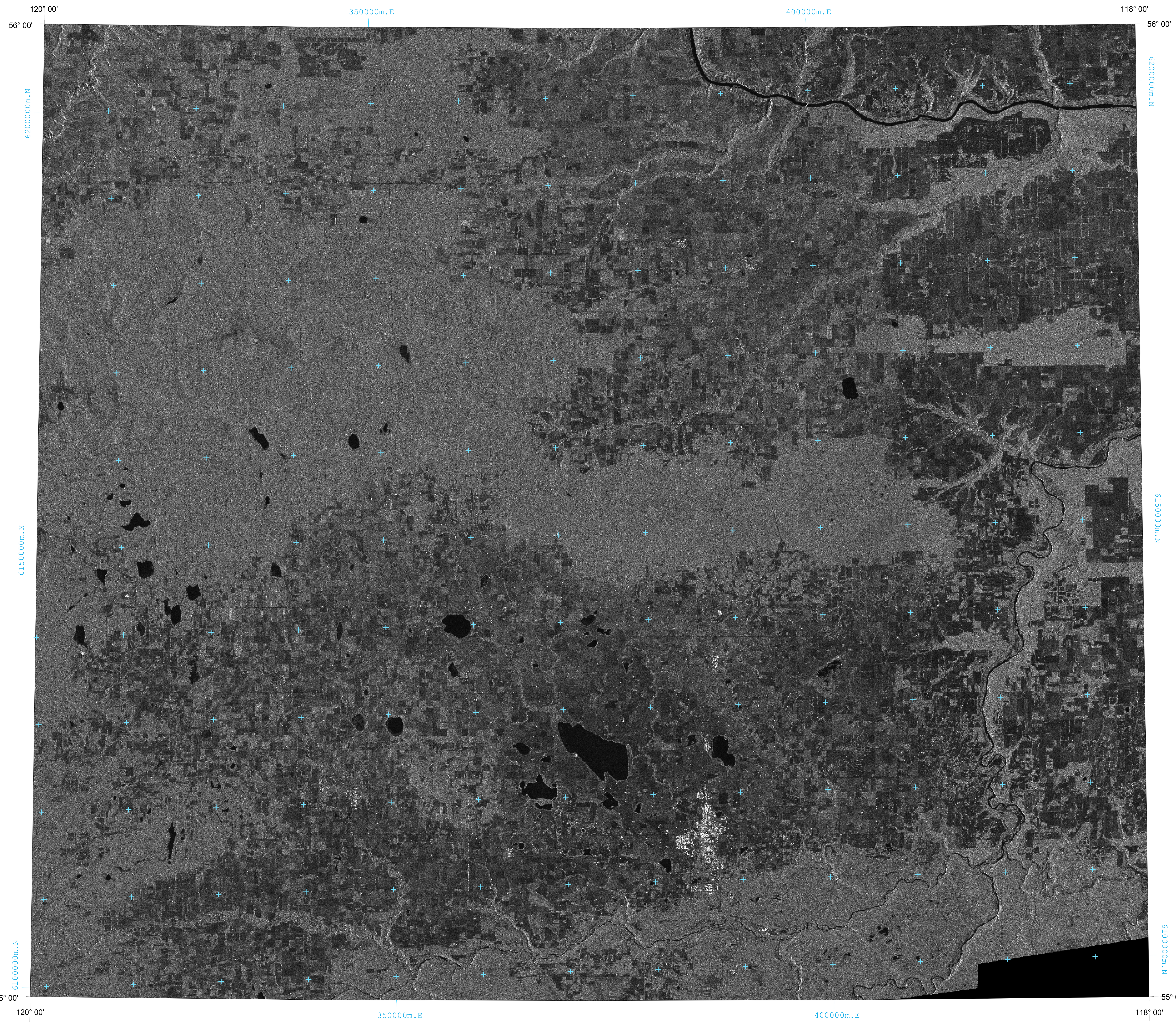
NTS 83M
RADARSAT-1



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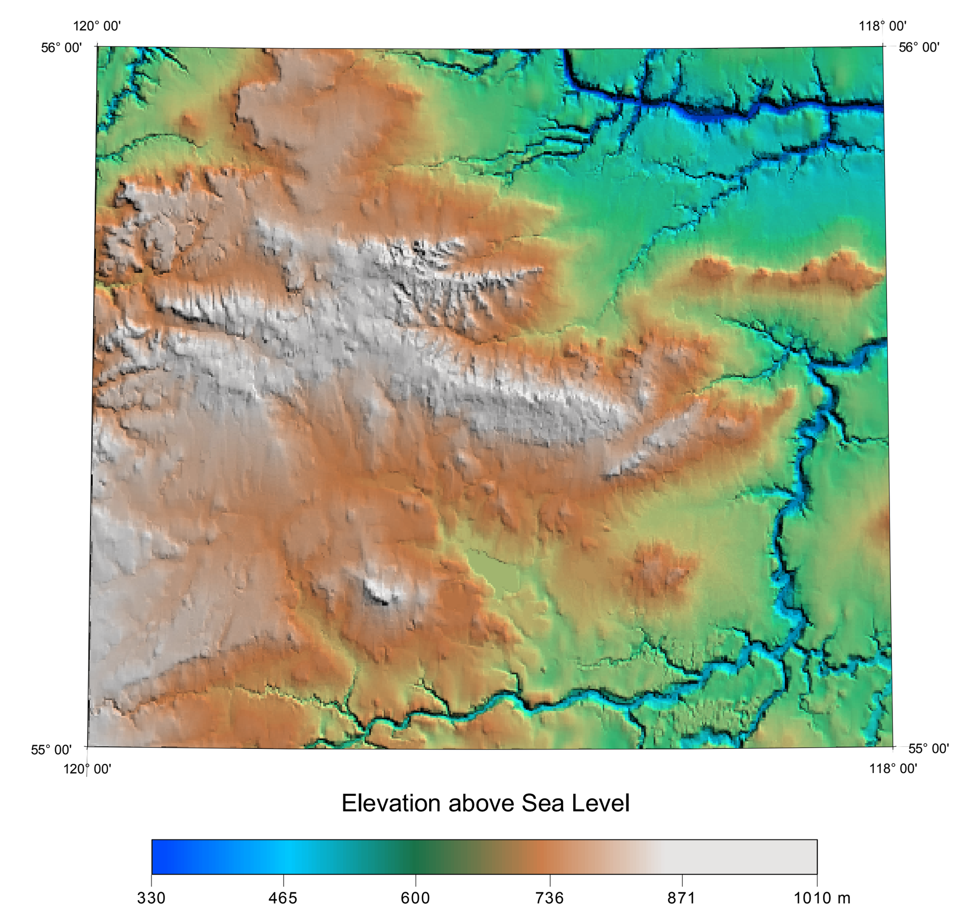

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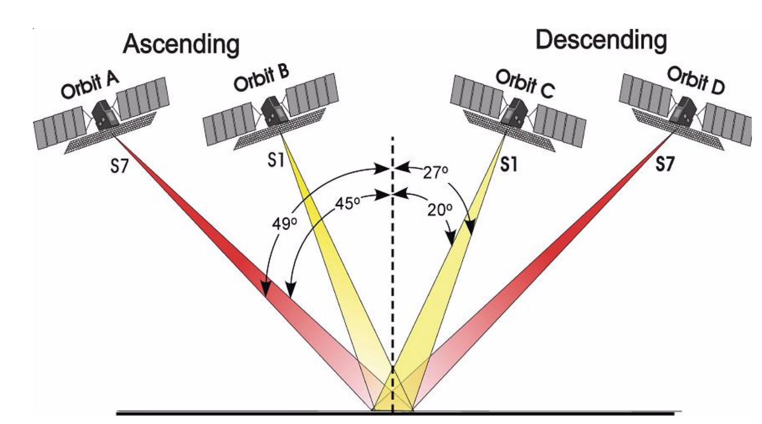

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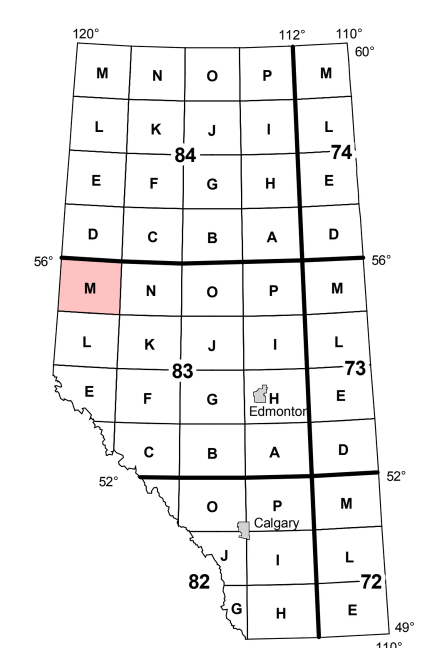
Geo-Note 2003-16, Figure 11

RADARSAT-1 Standard Beam 7 Ascending Image for Grand Prairie, Alberta (NTS 83M)

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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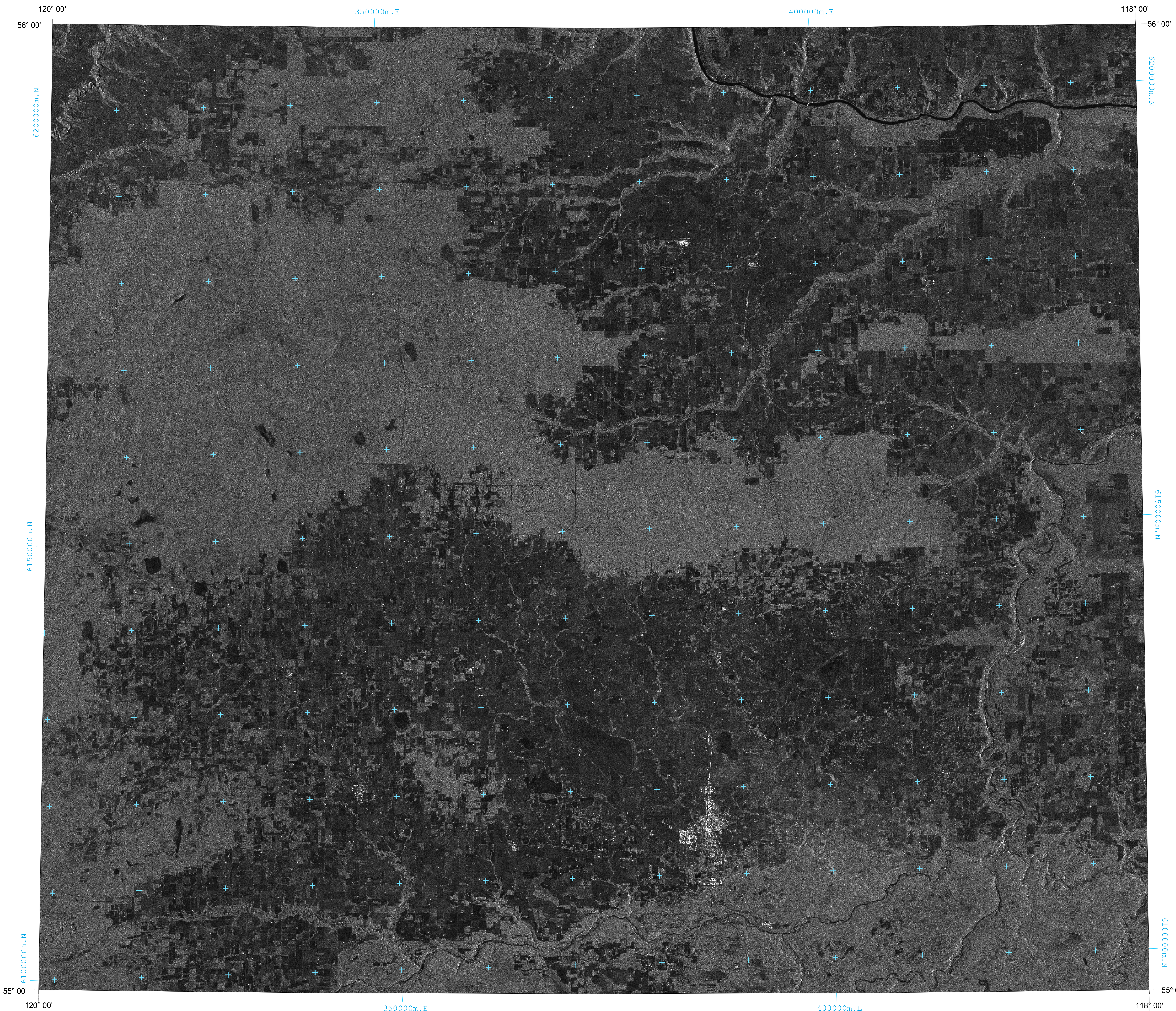
Disclaimer:

NTS 83M
RADARSAT-1



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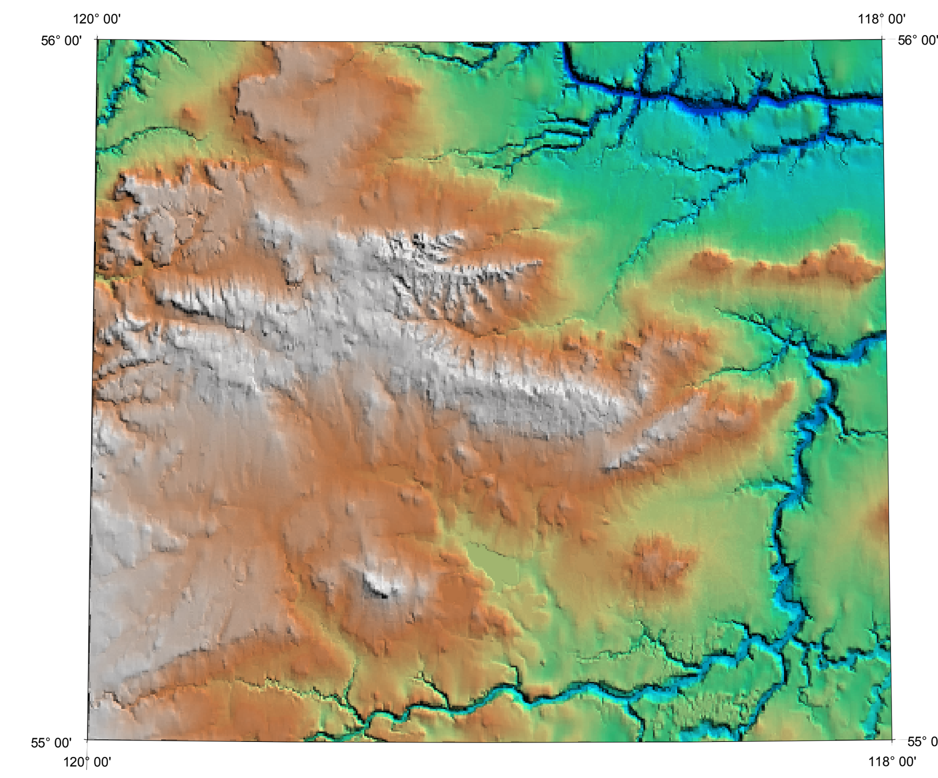
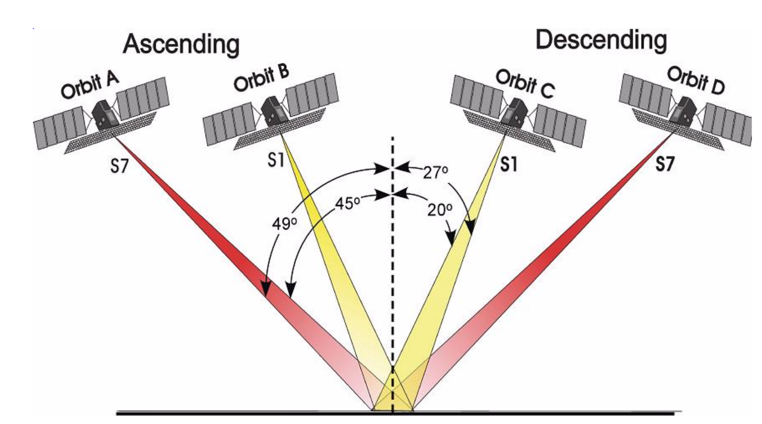


Elevation above Sea Level

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



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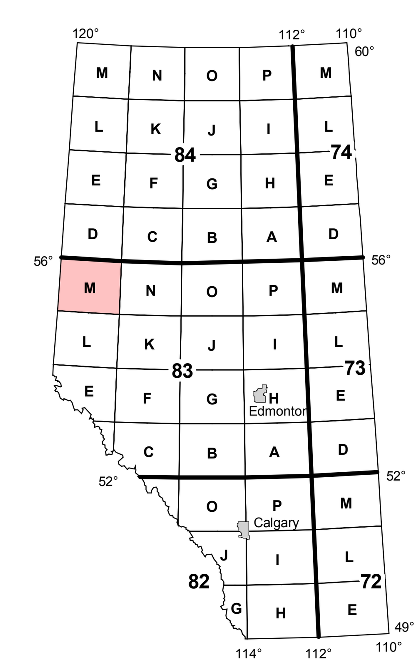
Geo-Note 2003-16, Figure 12

RADARSAT-1 Standard Beam 7 Descending Image for Grand Prairie, Alberta (NTS 83M)

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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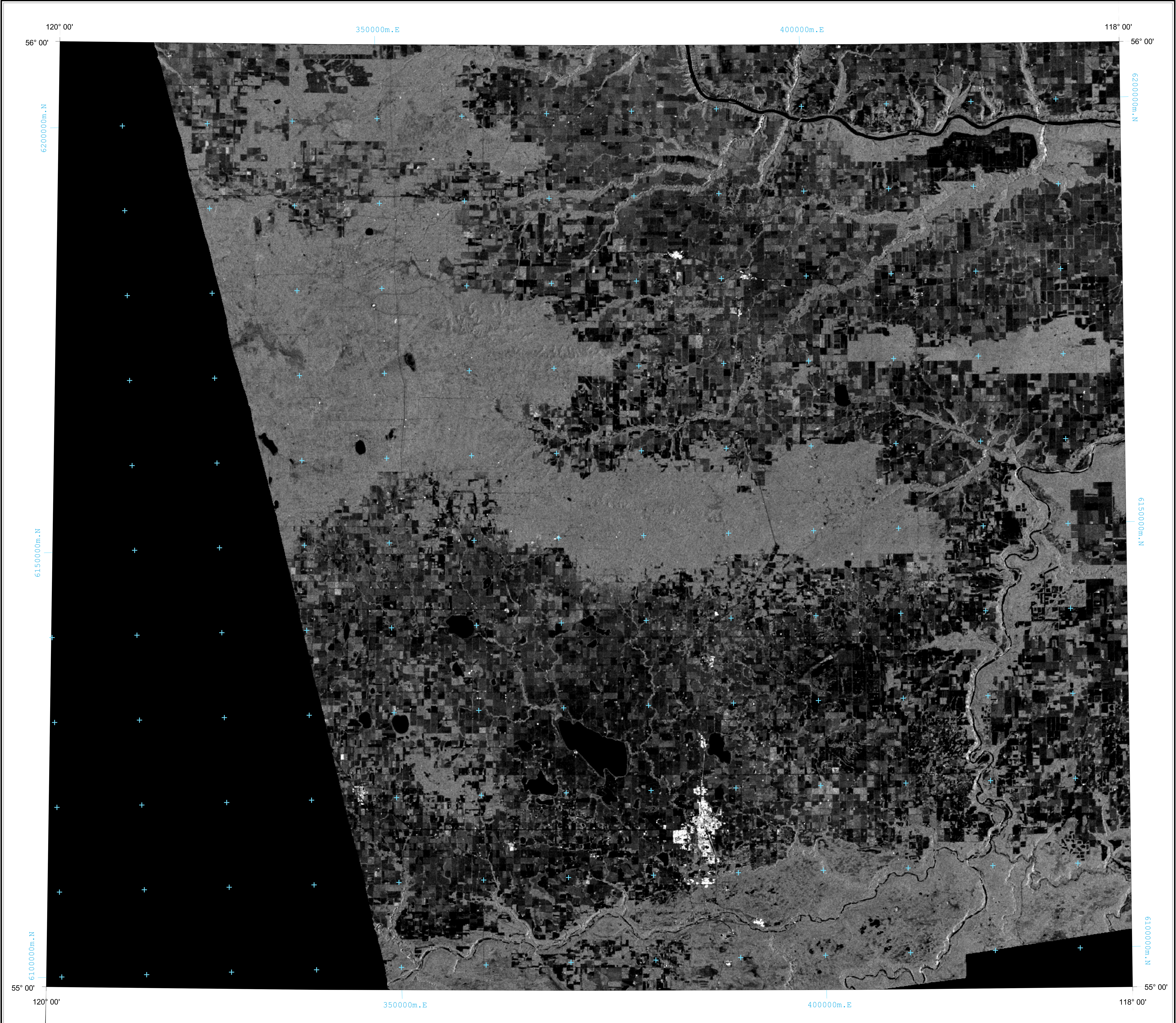
Disclaimer:

NTS 83M
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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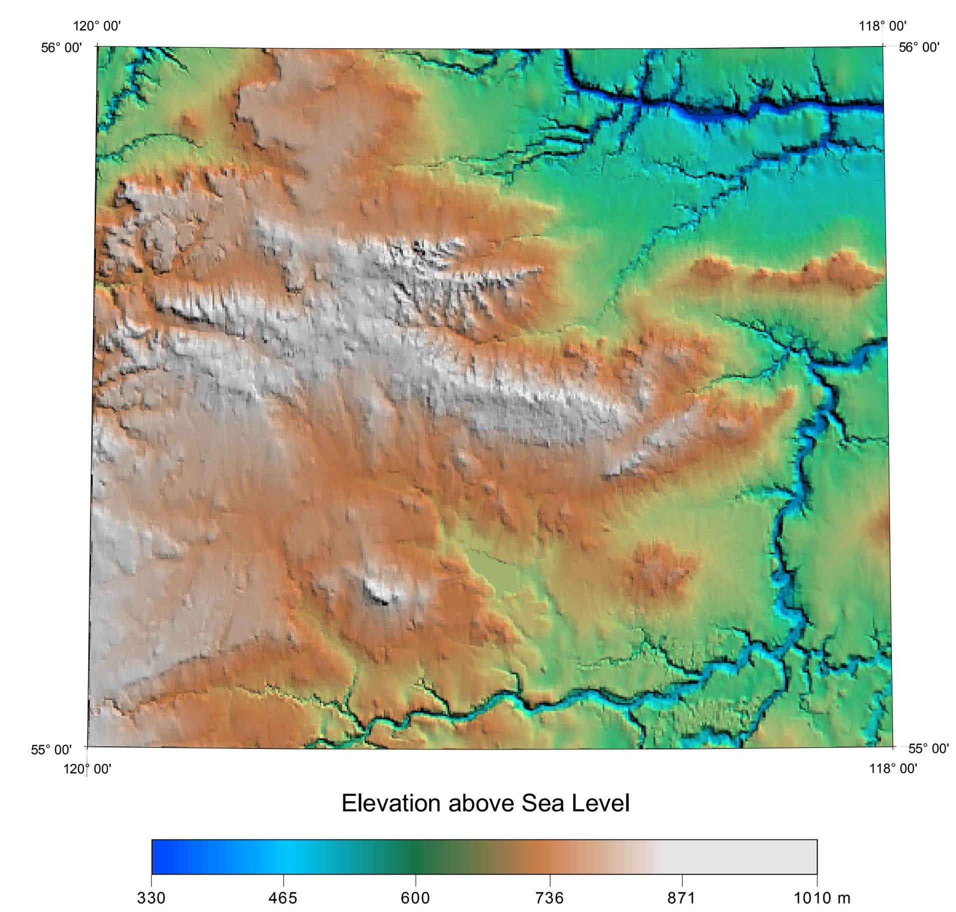
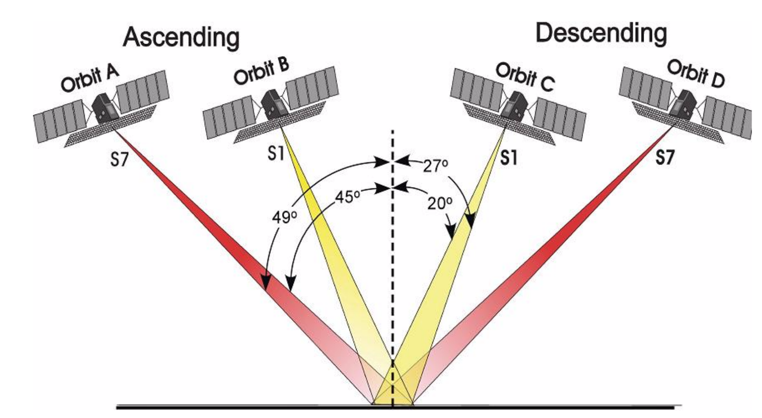
Elevation Map for NTS 83M



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



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Geo-Note 2003-16, Figure 13

RADARSAT-1 Principal Component 1 Image for Grand Prairie, Alberta (NTS 83M)

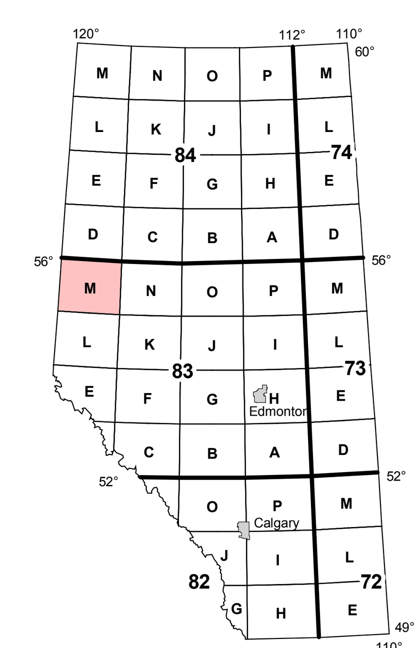
Compilation by S. Mei, 2003

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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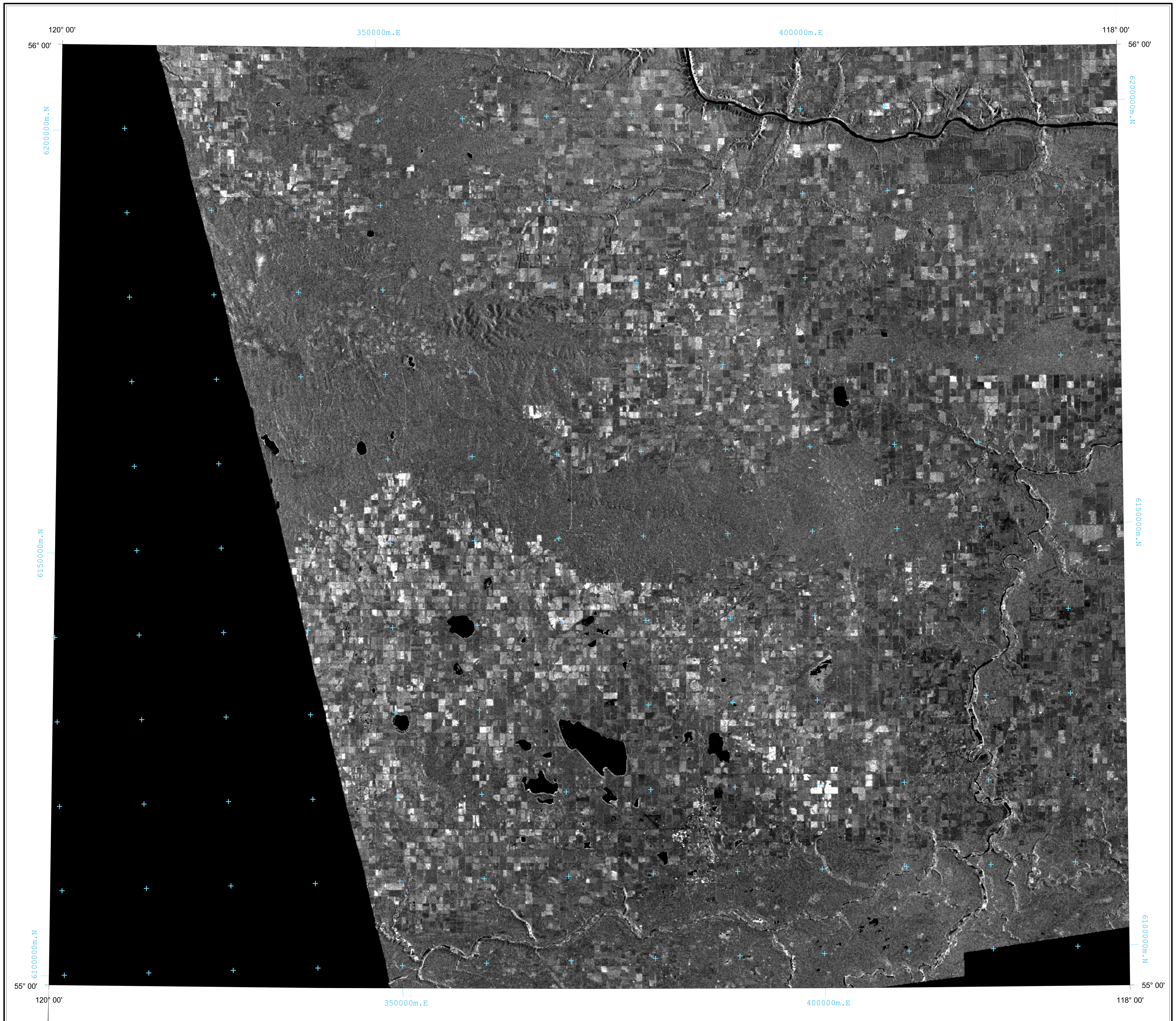
NTS 83M
RADARSAT-1



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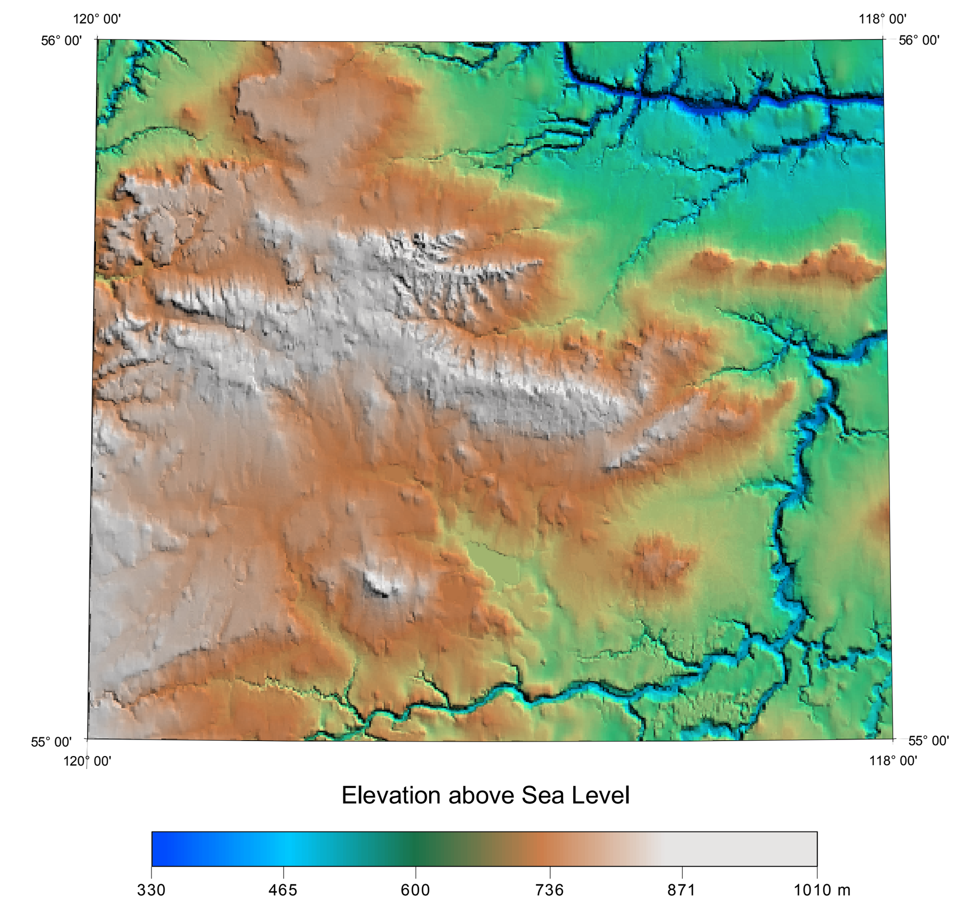
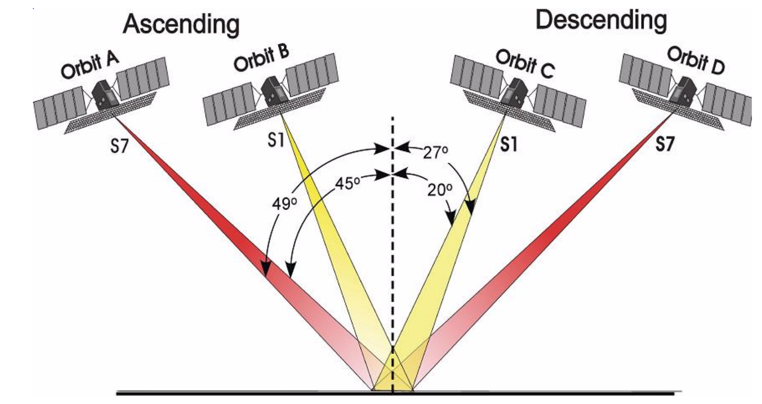
Elevation Map for NTS 83M



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



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Geo-Note 2003-16, Figure 14

RADARSAT-1 Principal Component 2 Image for Grand Prairie, Alberta (NTS 83M)

Compilation by S. Mei, 2003

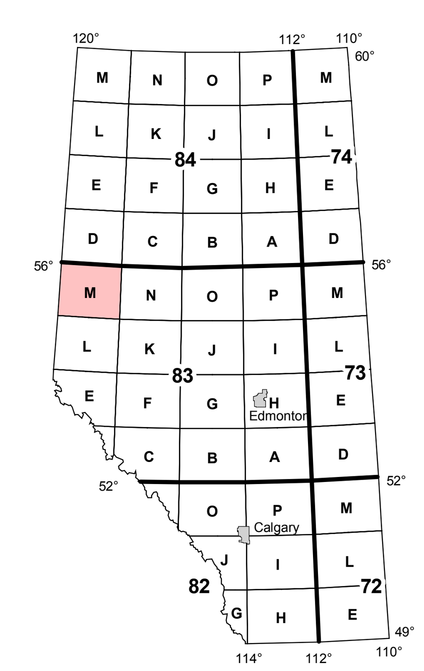
Scale 1:250 000

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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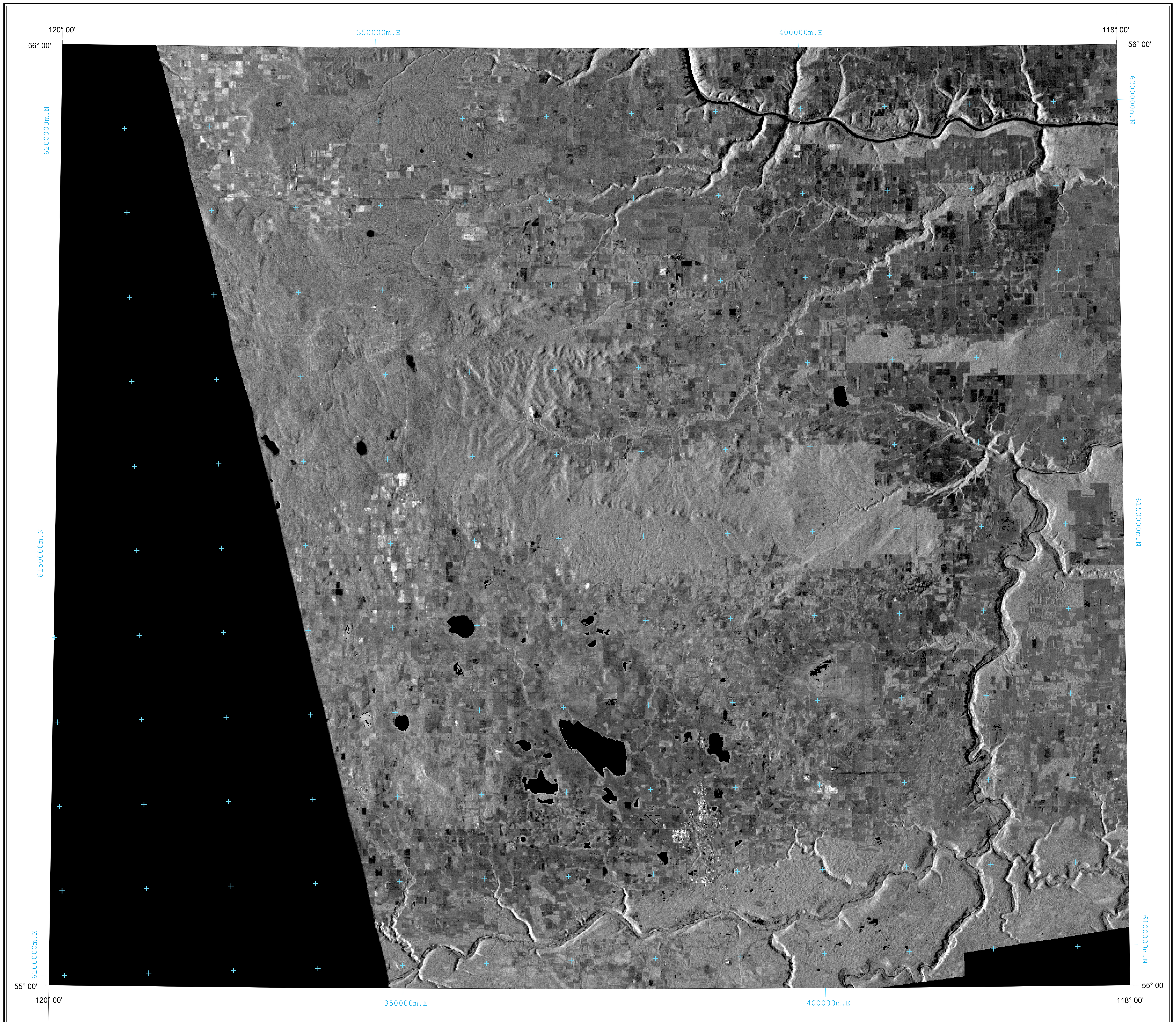
NTS 83M
RADARSAT-1



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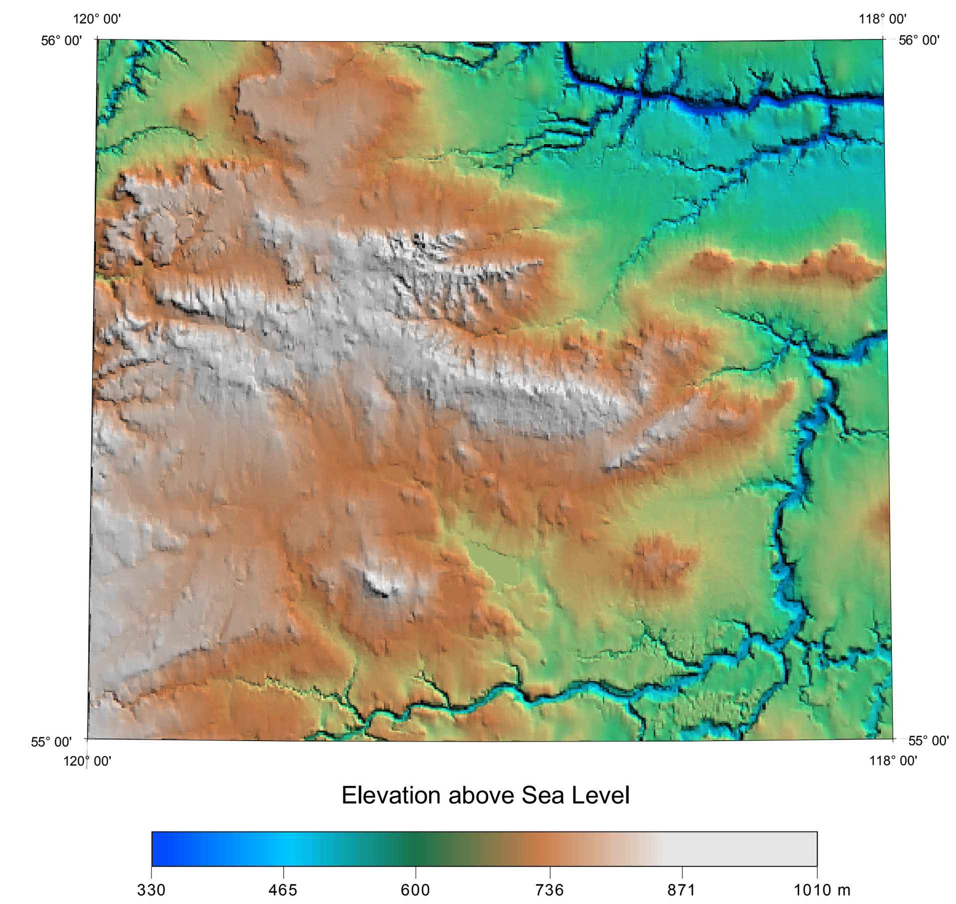
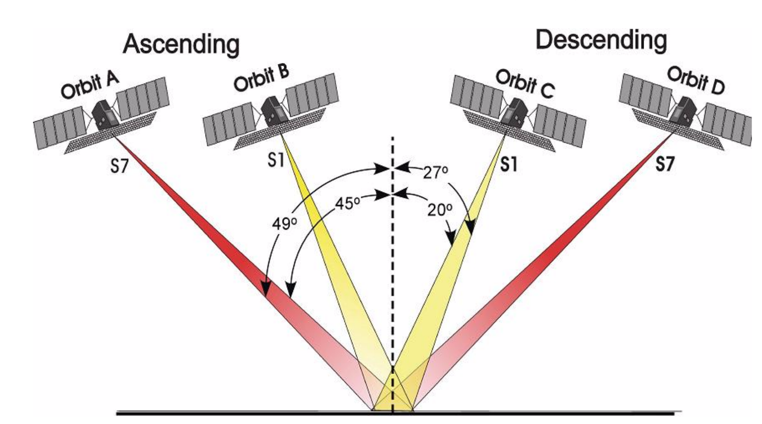


Look Directions and Incident Angles of RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-16, Figure 15

RADARSAT-1 Principal Component 3 Image for Grand Prairie, Alberta (NTS 83M)

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
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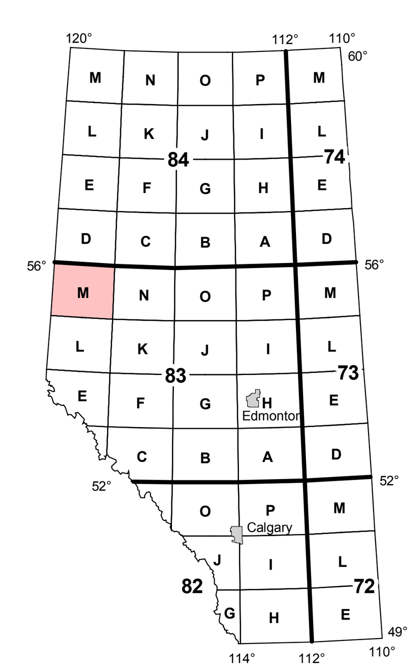

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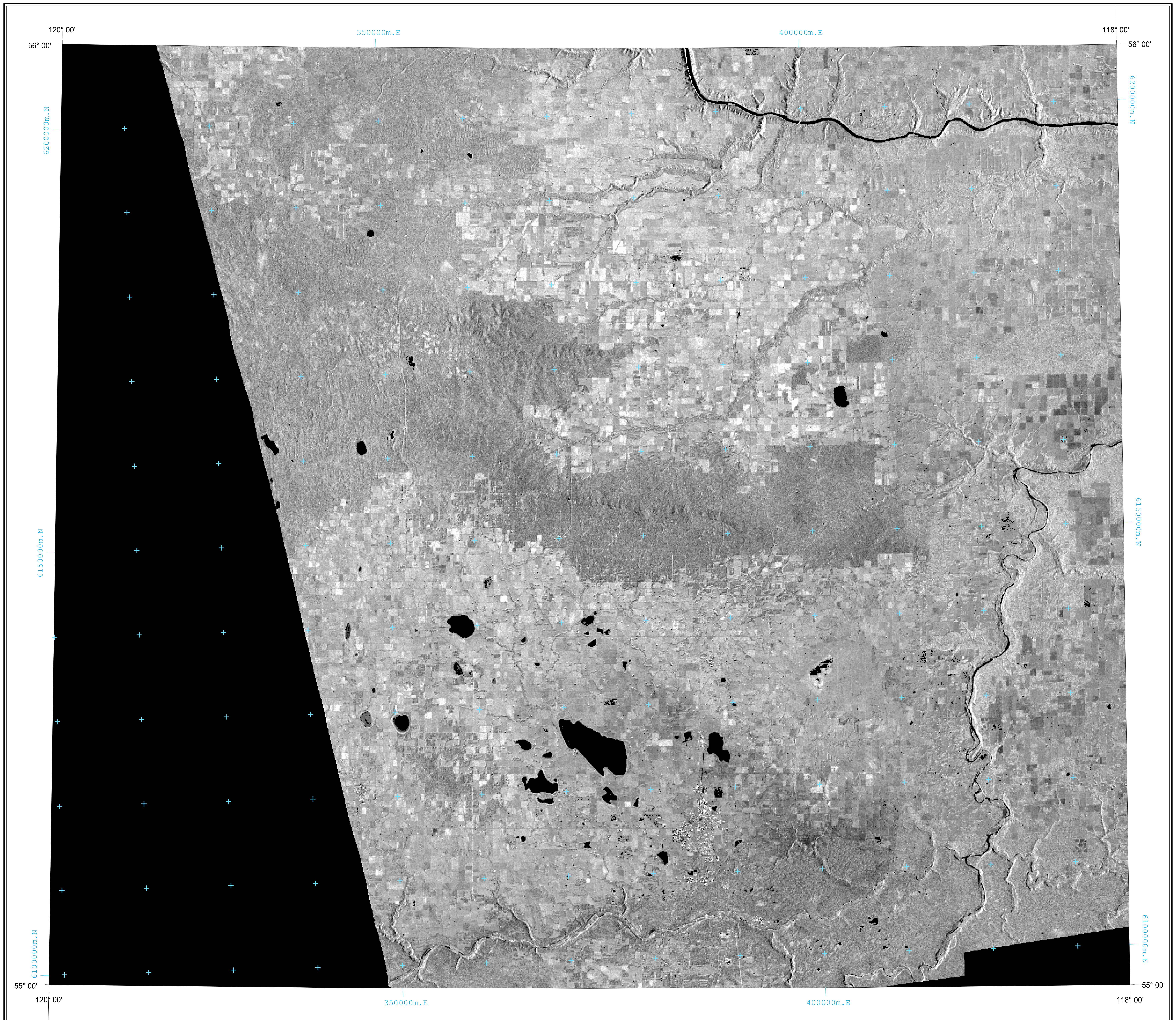
NTS 83M
RADARSAT-1



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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.

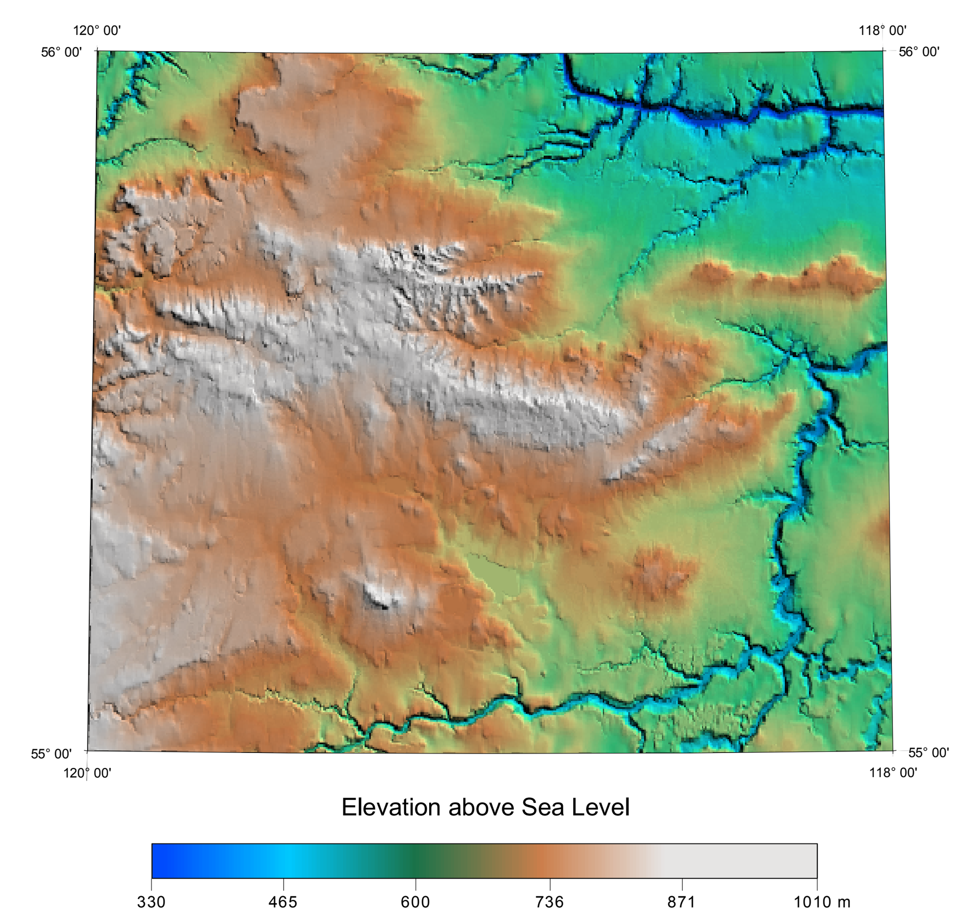
The First Principal Component (PC1) image (Figure 13) shows a range of brightness and texture that highlights features associated with differences in vegetation type and density. Areas of closed Aspen, closed Pine, open deciduous vegetation, grasslands and exposed soil appear to have a brighter tone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

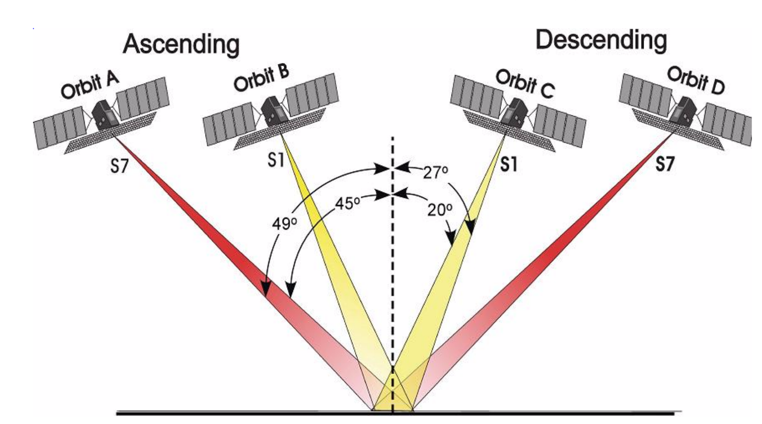
The Third Principal Component (PC3) image (Figure 15) highlights ‘surface roughness’; hence it reflects topographic effects and surface texture of the ground or vegetation canopy. In fact, the discrimination of topographic features using the PC3 image is superior to any other optical commercial satellite 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 83M



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 2003-16, Figure 16

RADARSAT-1 Principal Component 4 Image for Grand Prairie, Alberta (NTS 83M)

Compilation by S. Mei, 2003

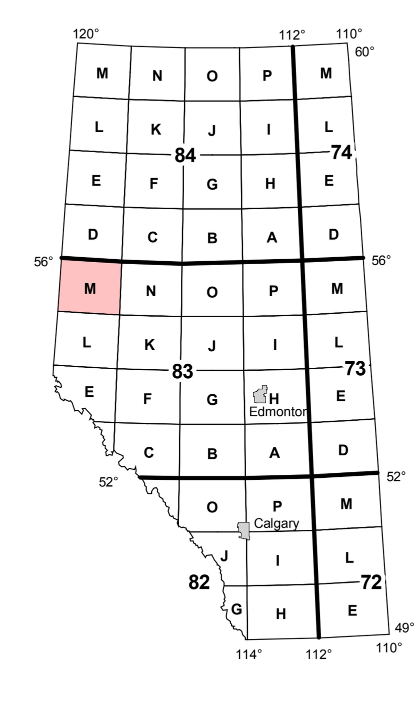
Scale 1:250 000

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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