



Orthorectified and Principal Component RADARSAT-1 Image Dataset for NTS 74M, Alberta

Orthorectified and Principal Component RADARSAT-1 Image Dataset for NTS 74M, Alberta

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Alberta Geological Survey

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Abstract

This report details the acquisition, characteristics and processing of the orthorectified and principal component RADARSAT-1 images for NTS map area 74M 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 74M 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 74M.

2 RADARSAT-1 Standard Beam Mode Images

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

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

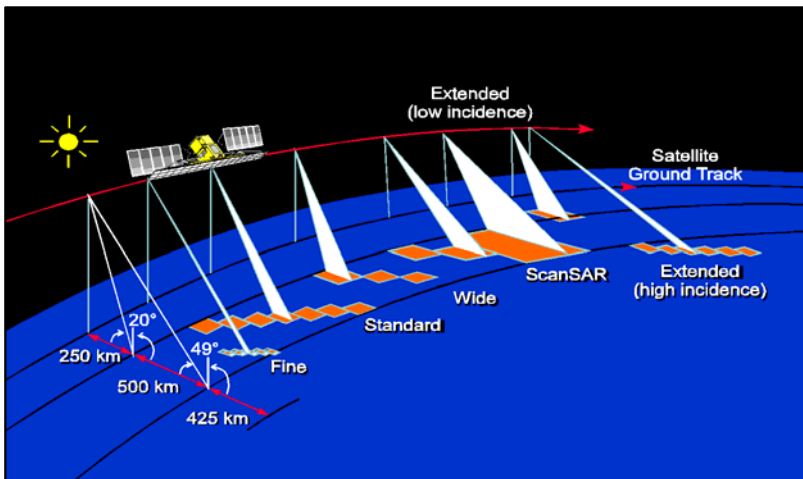


Figure 1. RADARSAT-1 beam modes (used with permission from RADARSAT International (RSI), 1997).

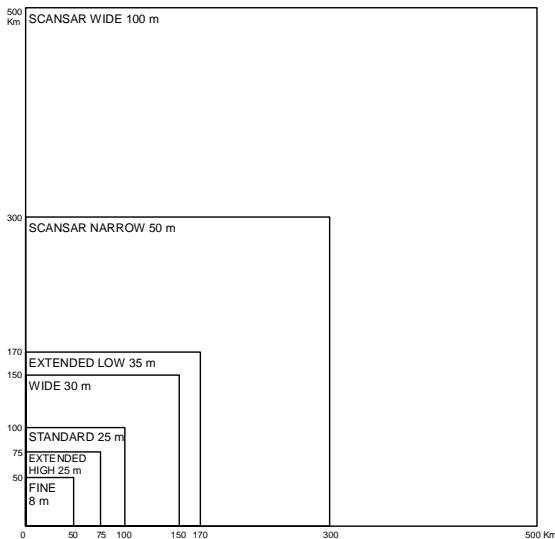


Figure 2. Coverage sizes and resolutions of RADARSAT-1 beam modes (modified after RADARSAT International (RSI), 1999).

The orthorectified and principal component RADARSAT-1 image datasets for NTS 74M 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.

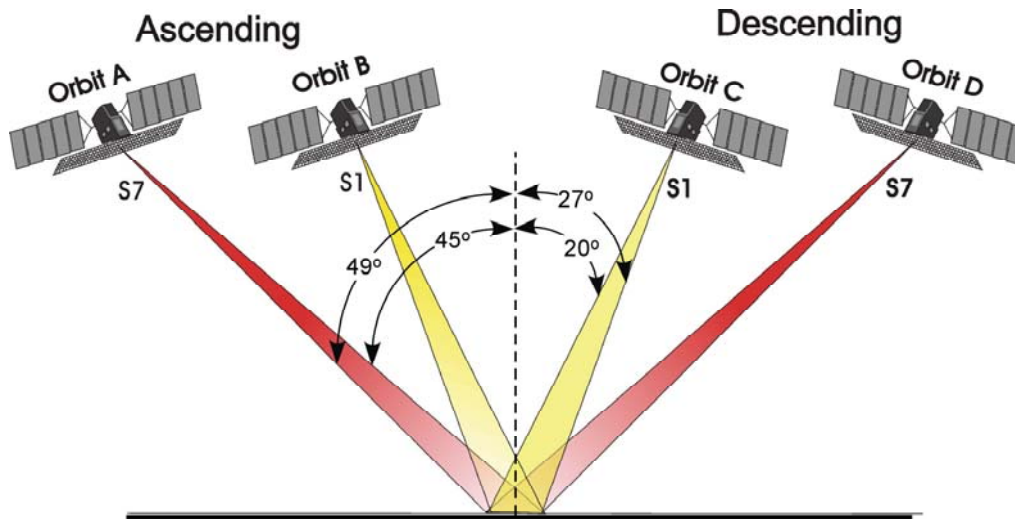


Figure 3. Multi-beam configuration of RADARSAT-1 S1 and S7 ascending/descending imagery (after Grunsky, 2002a).

3 Processes for Acquisition of the Orthorectified and Principal Component RADARSAT-1 Images for NTS 74M

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 74M 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 74M.

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 74M dataset. Table 1 lists the scenes that overlay the NTS 74M area. Figure 5 shows the spatial locations of the scenes overlaying NTS 74M. Many of these scenes were used for producing the NTS 74M orthorectified and principal component image datasets included on the CD.

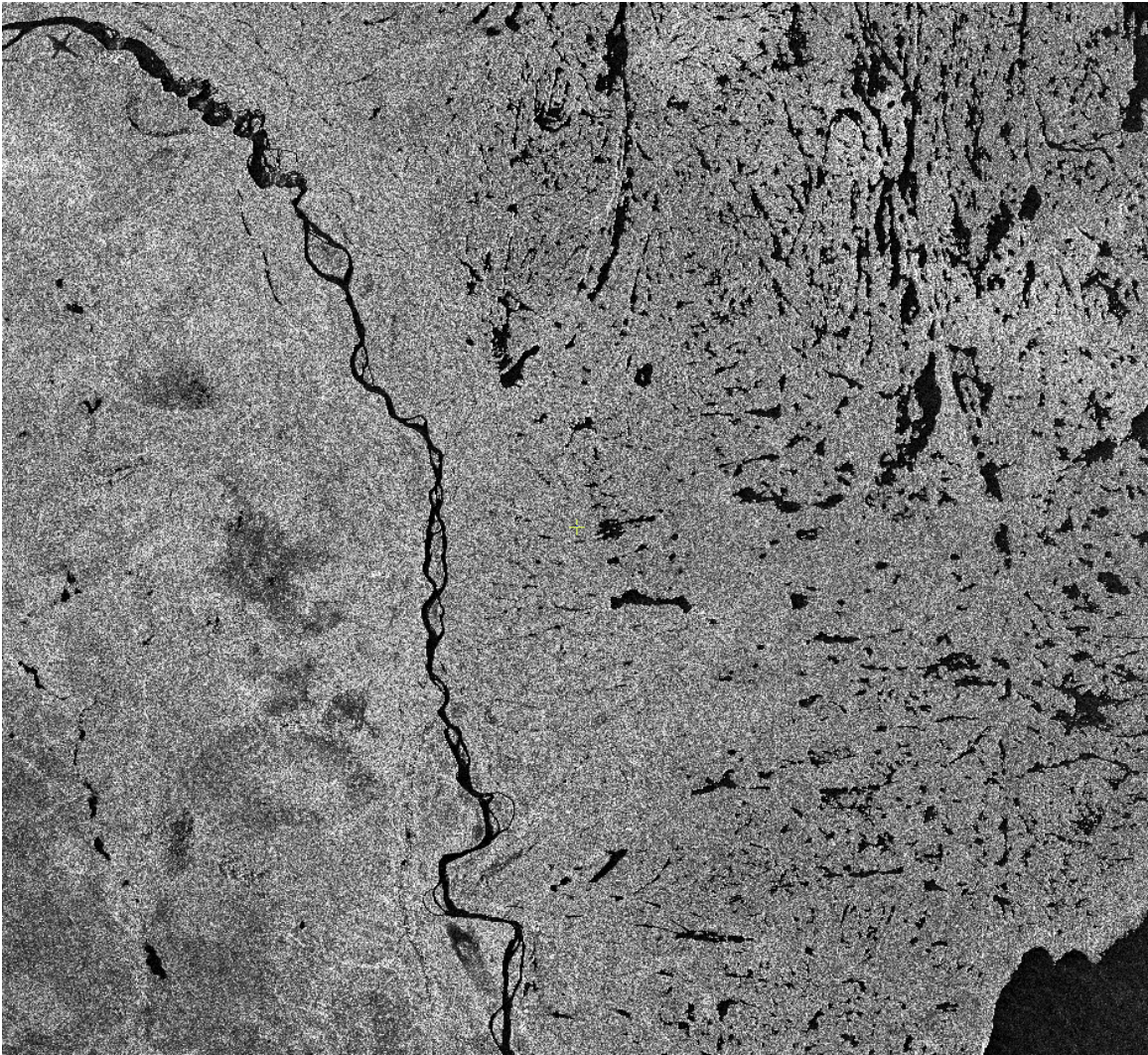


Figure 4. One of the original SGF scene images used for tiling the NTS 74M dataset: scene MO197028 of Standard Beam Mode 7 descending. RADARSAT data © Canadian Space Agency/Agence spatiale canadienne 1999, processed and distributed by RADARSAT International.

Table 1. List of the Path Images that Overlay NTS 74M

Scene ID	Beam	Path	UL_LAT	UL_LONG	UR_LAT	UR_LONG	LR_LAT	LR_LONG	LL_LAT	LL_LONG
M0196919	S1	ASC	60:11:06.99N	112:33:01.92W	60:26:38.95N	110:32:12.45W	59:34:31.05N	110:06:43.92W	59:19:15.39N	112:04:24.55W
M0196918	S1	ASC	59:24:35.60N	112:07:18.21W	59:39:52.83N	110:09:19.09W	58:45:07.14N	109:43:33.17W	58:30:05.90N	111:38:23.87W
M0196447	S1	ASC	60:37:09.61N	113:47:48.38W	60:52:41.66N	111:46:06.65W	59:58:50.69N	111:19:18.96W	59:43:35.86N	113:17:41.58W
M0196446	S1	ASC	59:48:19.44N	113:25:27.22W	60:03:50.23N	111:25:27.26W	59:09:06.29N	110:59:10.52W	58:53:52.21N	112:55:56.27W
M0196445	S1	ASC	58:59:19.13N	112:58:49.22W	59:14:34.70N	111:01:45.48W	58:19:47.40N	110:36:26.06W	58:04:47.42N	112:30:25.29W
M0195822	S1	ASC	60:09:58.93N	111:27:26.61W	60:25:27.32N	109:26:59.11W	59:28:47.44N	108:59:23.66W	59:13:36.60N	110:56:27.18W
M0195821	S1	ASC	59:18:56.97N	110:59:20.17W	59:34:09.30N	109:01:58.89W	58:39:23.10N	108:36:20.81W	58:24:26.57N	110:30:35.26W
M0199208	S1	DES	59:20:43.55N	112:04:41.84W	59:05:40.57N	110:08:35.72W	58:11:08.69N	110:36:59.82W	58:25:56.29N	112:30:02.38W
M0199207	S1	DES	60:13:30.81N	111:39:15.24W	59:58:11.83N	109:40:01.74W	59:00:17.42N	110:11:28.10W	59:15:18.84N	112:07:15.75W
M0196774	S1	DES	60:18:02.25N	113:45:32.45W	60:02:40.60N	111:45:55.69W	59:04:46.93N	112:17:29.64W	59:19:50.88N	114:13:39.37W
M0196518	S1	DES	59:22:15.27N	113:10:00.25W	59:07:11.05N	111:13:45.06W	58:12:39.38N	111:42:11.74W	58:27:28.16N	113:35:22.97W
M0196517	S1	DES	60:13:15.42N	112:45:24.39W	59:57:55.66N	110:46:07.44W	59:01:44.75N	111:16:39.19W	59:16:47.44N	113:12:36.15W
M0196266	S1	DES	59:04:43.82N	110:08:39.46W	58:49:42.14N	108:13:09.36W	57:53:25.25N	108:42:06.84W	58:08:11.35N	110:34:30.28W
M0195850	S1	DES	59:11:55.27N	111:07:59.91W	58:56:53.56N	109:12:18.05W	58:02:21.10N	109:40:31.58W	58:17:07.58N	111:33:11.38W
M0195849	S1	DES	60:04:47.20N	110:42:41.97W	59:49:29.55N	108:43:53.30W	58:51:34.10N	109:15:07.74W	59:06:34.35N	111:10:32.21W
M0199706	S7	ASC	59:55:39.08N	114:05:03.47W	60:03:59.05N	112:05:42.01W	59:09:23.37N	111:52:07.87W	59:01:03.63N	113:48:17.13W
M0199705	S7	ASC	59:06:24.73N	113:52:07.99W	59:14:47.13N	111:55:29.94W	58:20:11.01N	111:42:08.70W	58:11:48.54N	113:35:44.71W
M0199055	S7	ASC	60:16:54.02N	112:06:38.36W	60:25:16.29N	110:05:50.02W	59:33:32.58N	109:52:48.67W	59:25:10.76N	111:50:29.87W
M0199054	S7	ASC	59:30:51.75N	111:52:15.16W	59:39:13.65N	109:54:13.31W	58:44:38.00N	109:40:45.11W	58:36:16.20N	111:35:39.88W
M0198665	S7	ASC	60:37:01.36N	113:15:21.50W	60:45:21.69N	111:13:26.53W	59:55:16.07N	111:00:45.38W	59:46:56.28N	112:59:34.89W
M0198664	S7	ASC	59:52:12.60N	113:01:14.64W	60:00:32.44N	111:02:06.34W	59:05:56.12N	110:48:33.35W	58:57:36.49N	112:44:30.20W
M0198663	S7	ASC	59:02:46.96N	112:48:17.26W	59:11:09.15N	110:51:53.87W	58:16:33.00N	110:38:33.87W	58:08:10.72N	112:31:56.01W
M0197029	S7	DES	59:14:25.55N	112:15:28.27W	59:06:06.58N	110:19:11.06W	58:11:30.48N	110:35:30.48W	58:19:49.60N	112:28:46.20W
M0197028	S7	DES	60:03:53.75N	112:03:11.05W	59:55:34.64N	110:04:00.21W	59:00:59.96N	110:20:46.00W	59:09:18.85N	112:16:44.97W
M0196604	S7	DES	59:17:59.56N	113:17:49.24W	59:09:40.70N	111:21:22.23W	58:15:04.65N	111:37:43.58W	58:23:23.63N	113:31:08.42W
M0196603	S7	DES	60:09:03.06N	113:05:09.24W	60:00:43.81N	111:05:39.00W	59:04:24.00N	111:22:59.69W	59:12:42.98N	113:19:10.90W
M0195870	S7	DES	59:09:32.89N	111:13:15.09W	59:01:13.84N	109:17:15.20W	58:06:37.70N	109:33:32.34W	58:14:56.93N	111:26:31.74W
M0195869	S7	DES	60:00:44.94N	111:00:33.75W	59:52:25.71N	109:01:34.20W	58:56:04.79N	109:18:50.54W	59:04:23.82N	111:14:32.90W

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 74M dataset.

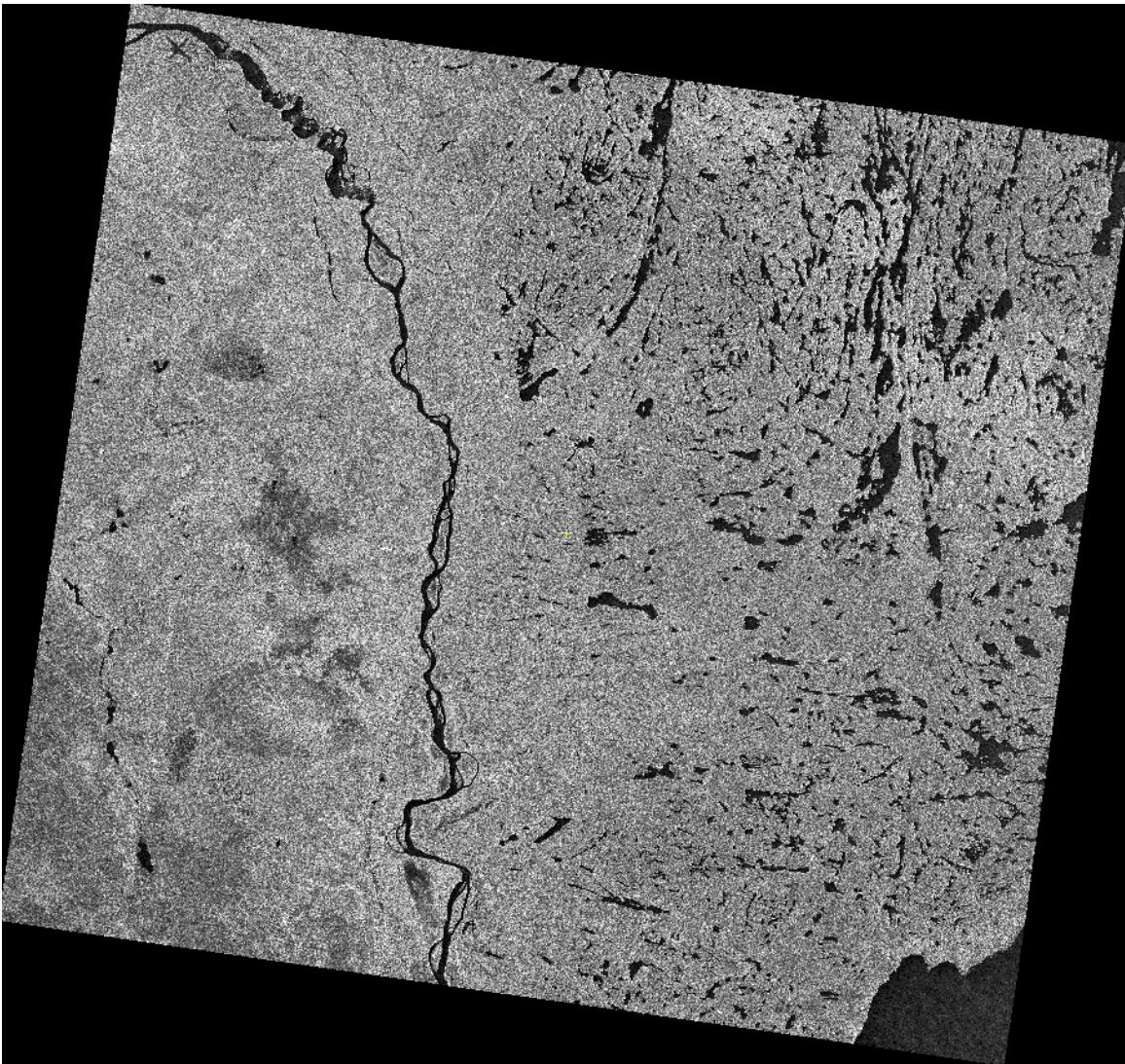


Figure 6. One of the orthorectified scene images used for tiling the NTS 74M dataset: scene MO197028 of Standard Beam Mode 7 descending.

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 74M image dataset.

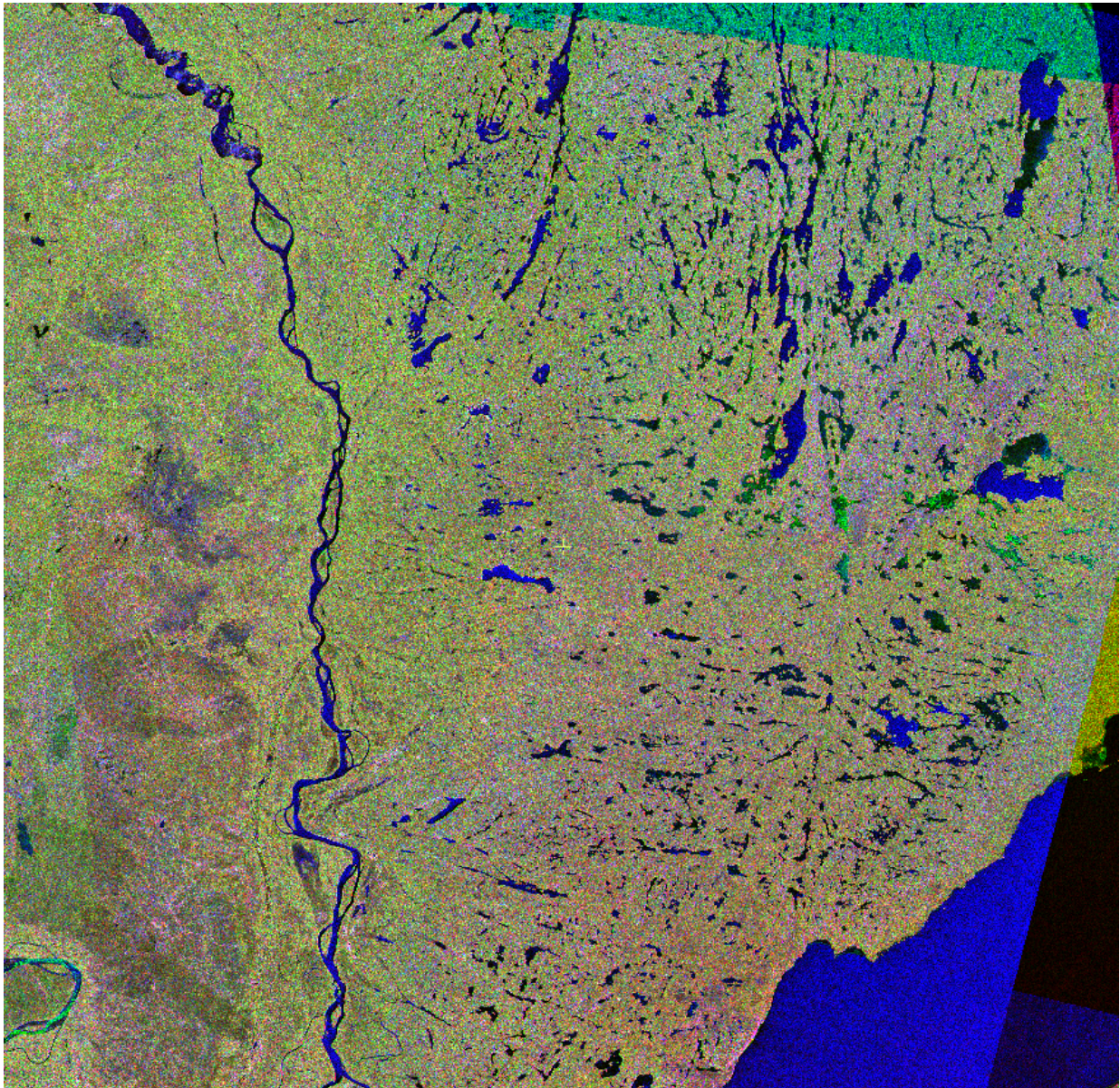


Figure 7. Pseudocolour composite of orthorectified NTS 74M image dataset of Standard Beam Mode S1/S7 ascending/descending beam positions (RGB=S7d, S7a, S1d).

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 74M.

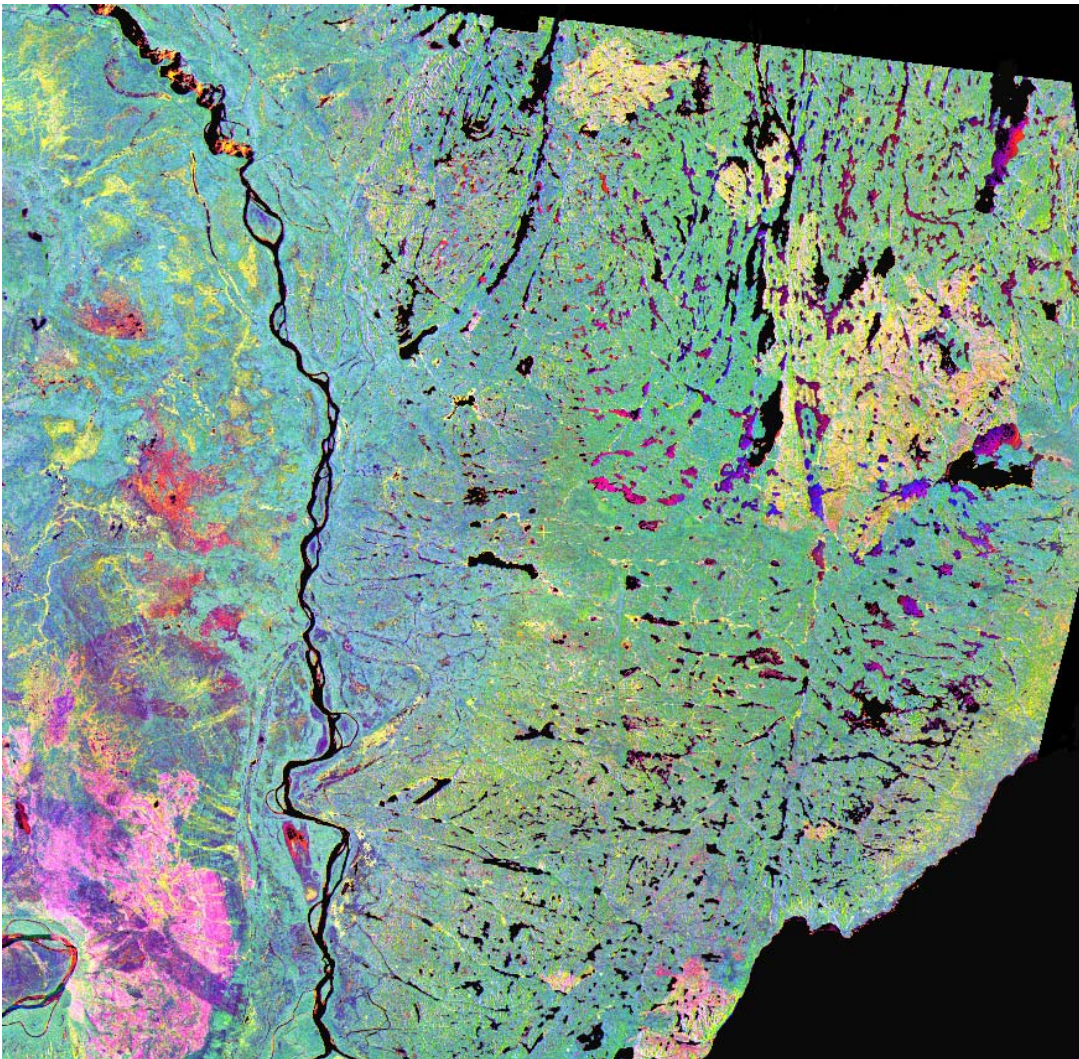


Figure 8. Pseudocolour composite of NTS 74M image dataset of principal component PC1, PC2, PC3 and PC4 (RGB=PC2, PC1, PC3).

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) S1 descending, (3) S7 ascending, (4) S7 descending, (5) PC1, (6) PC2, (7) PC3 and (8) PC4 images. The GeoTIFF images are in the same projection as the orthorectified and PCA image datasets, but have been re-sampled into 27 m pixel size in order to reduce file size. They can be used with other GIS data to generate maps of specific interests to the user.

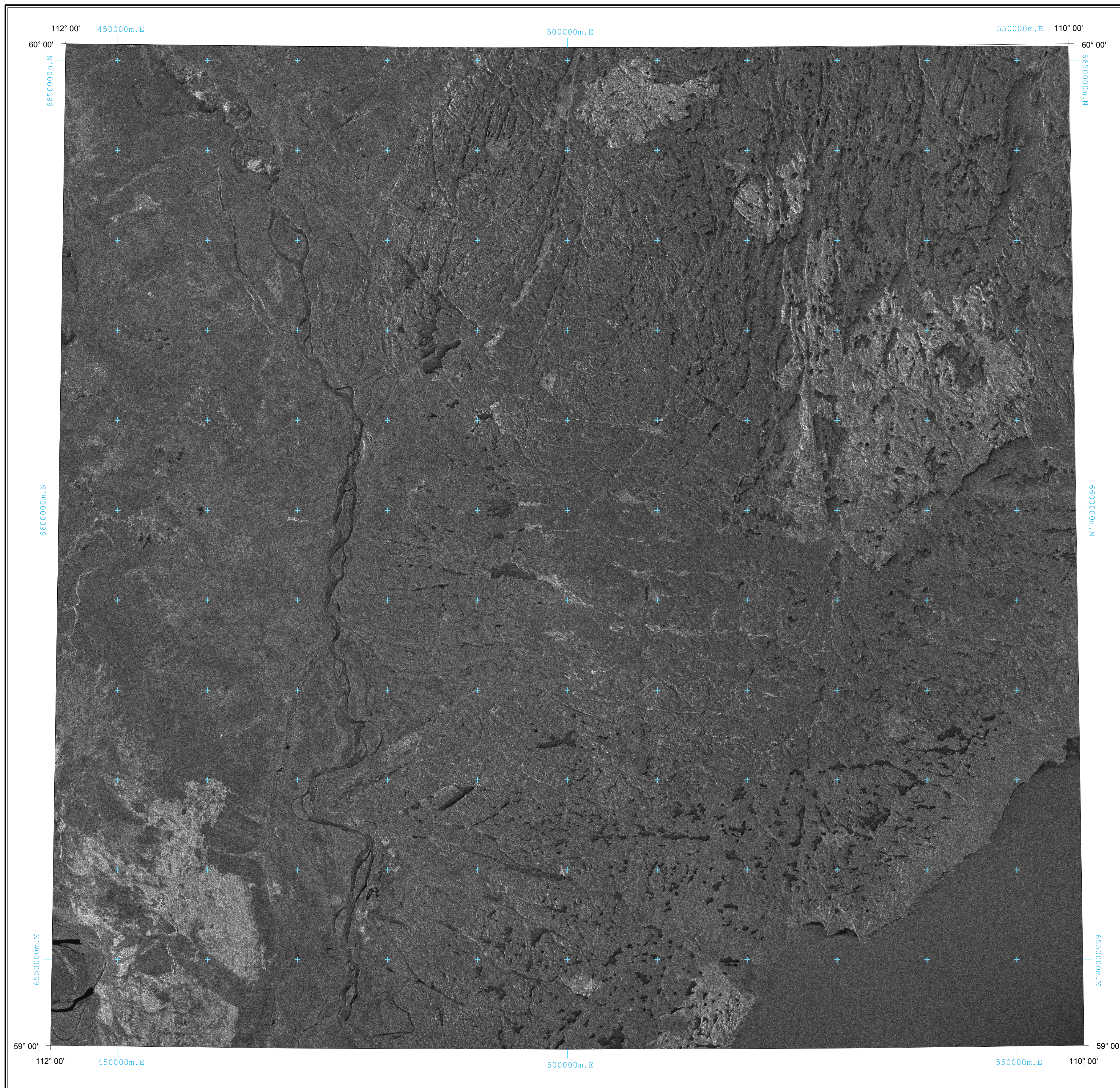
In addition, simple maps for these images were created. This results in 8 maps for each NTS map area. These maps are included on the two accompanying CDs as Figures 9 to 16. They can be printed or plotted, depending on the users' software and output capability, and each map includes some general tips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

4 Conclusion

The image datasets for NTS 74M 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 74M. 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 74M map area.

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- RADARSAT International (RSI) 1999: RADARSAT Illuminated: Your Guide to Products & Services, on-line version, 131 p.



Introduction

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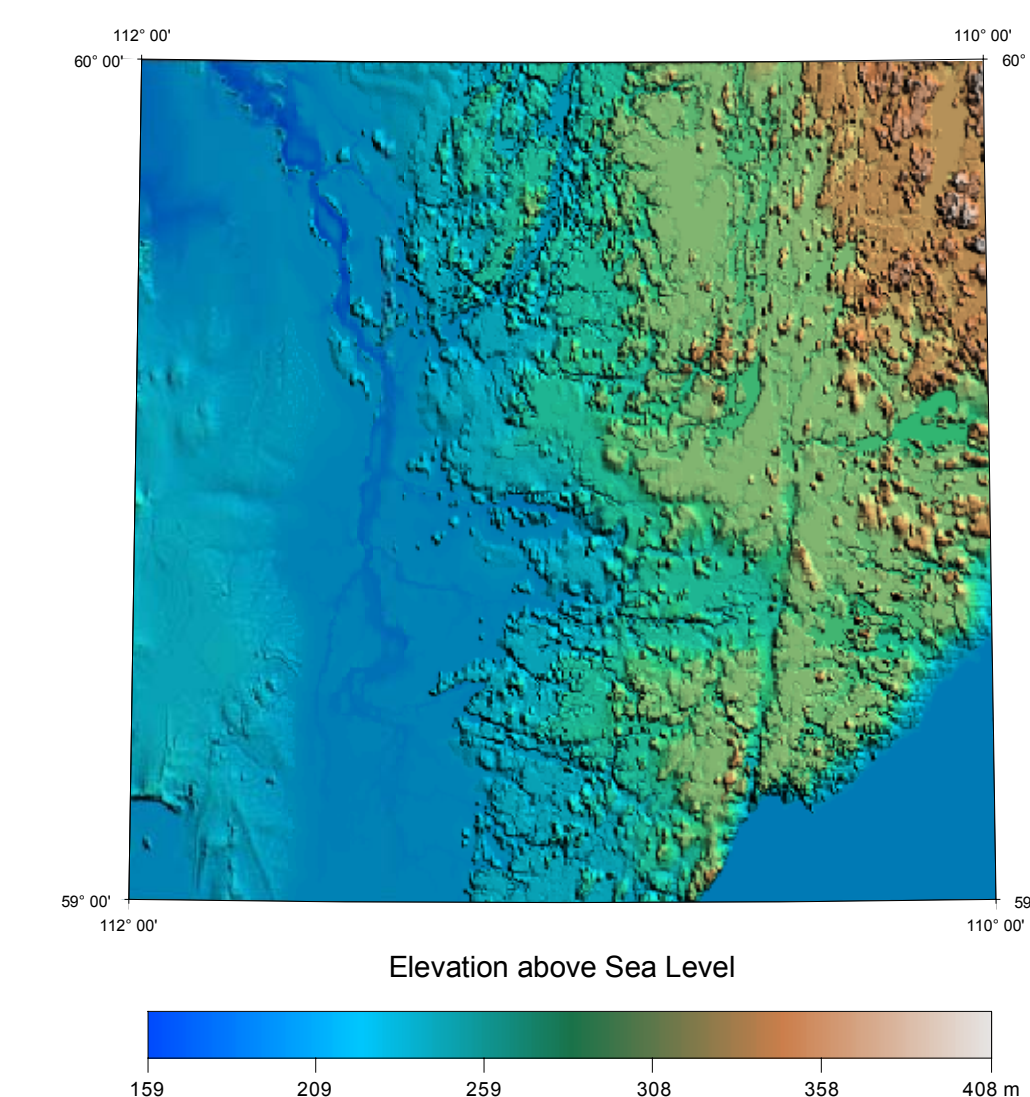
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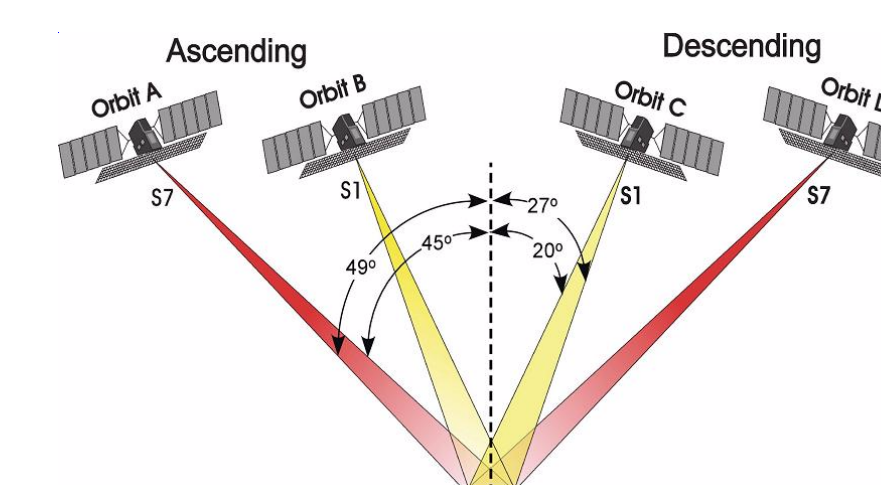
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Elevation Map for NTS 74M



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

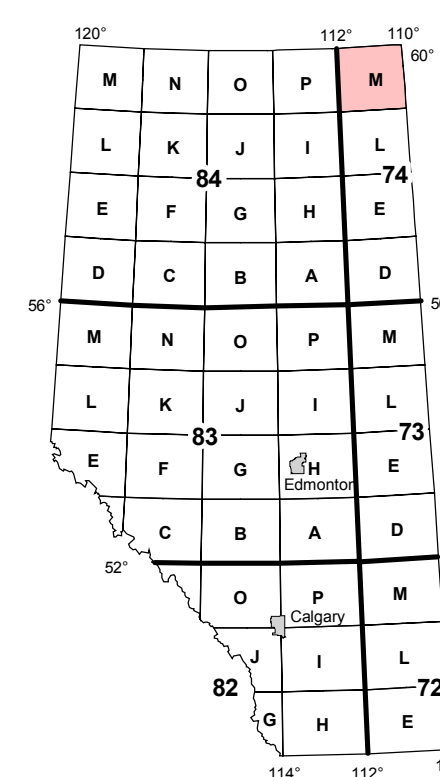
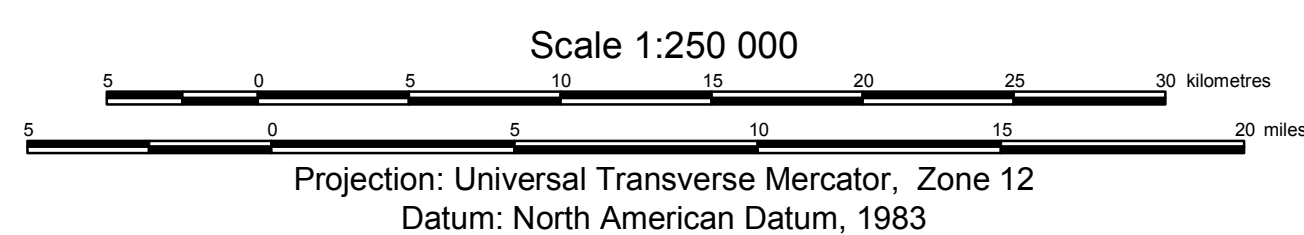


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Geo-Note 2003-15, Figure 9

RADARSAT-1 Standard Beam 1 Ascending Image for Fitzgerald, Alberta (NTS 74M)

Compilation by S. Mei, 2003

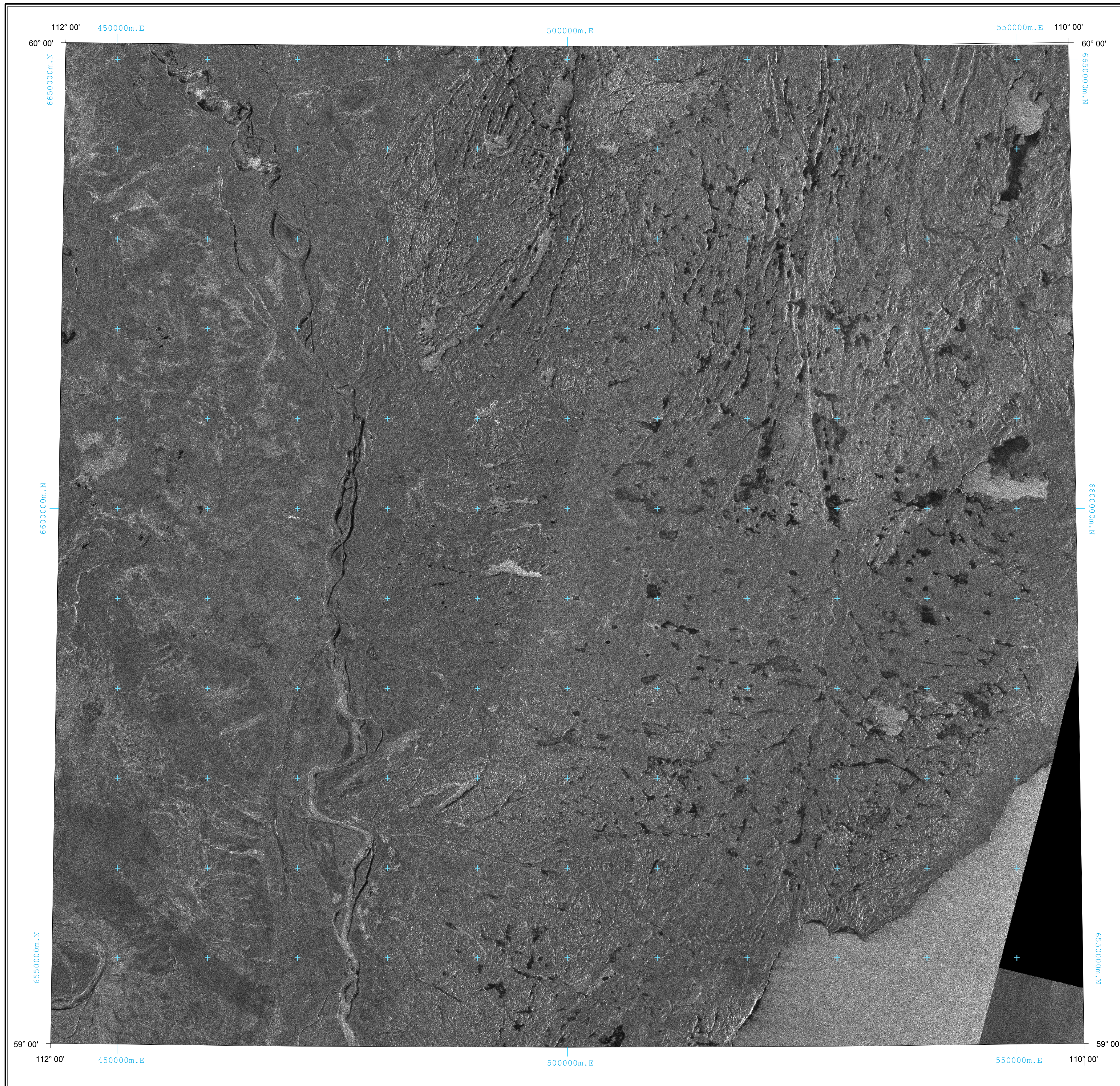


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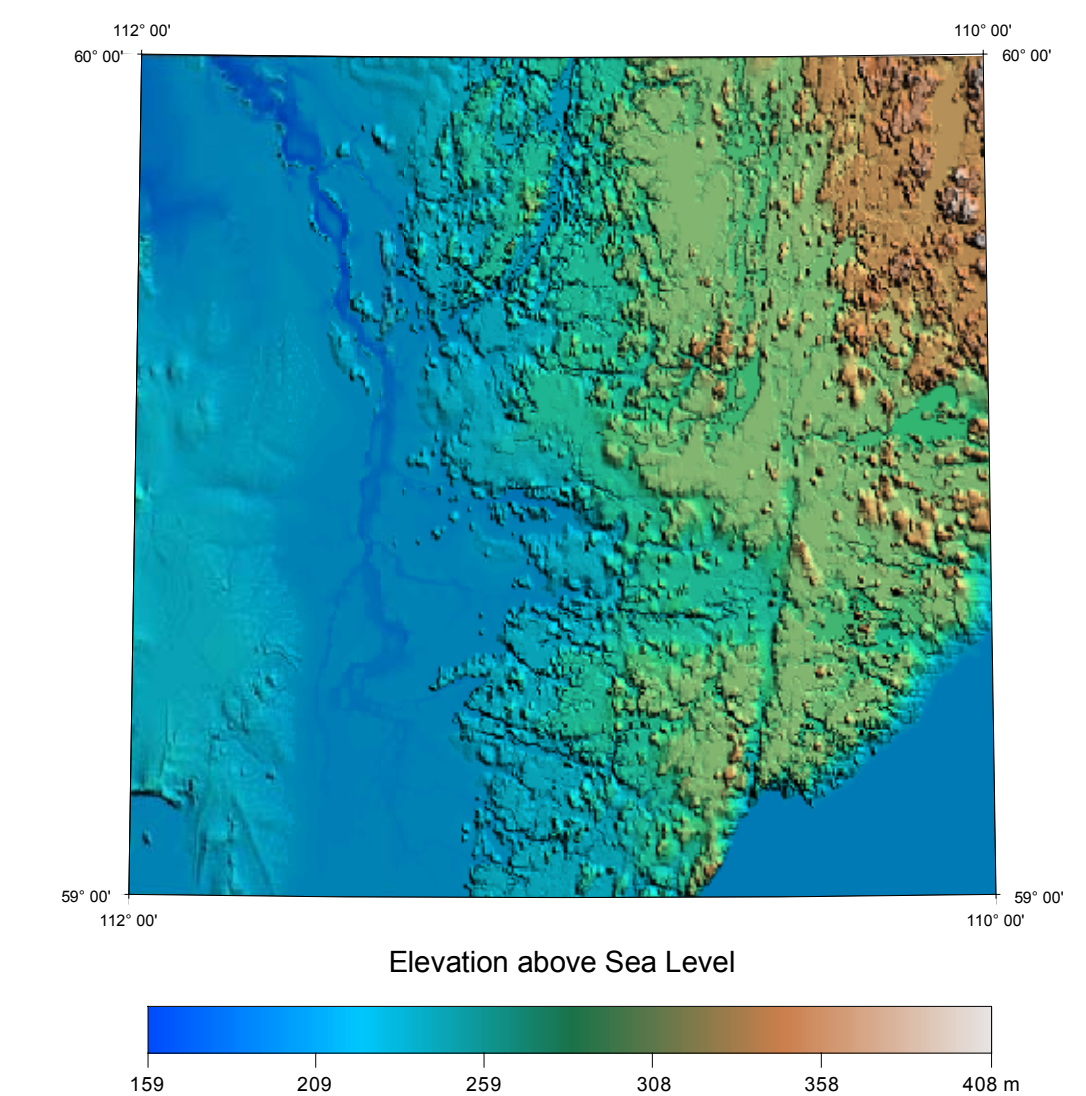
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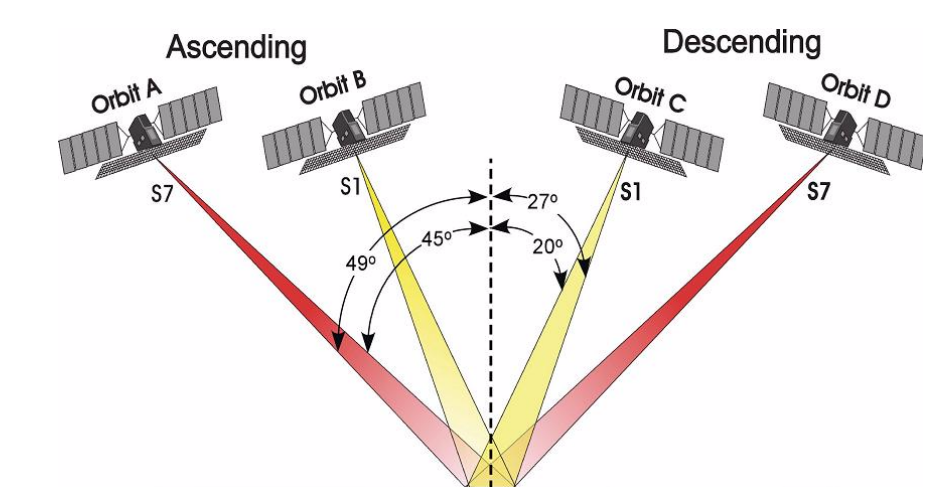
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Elevation Map for NTS 74M



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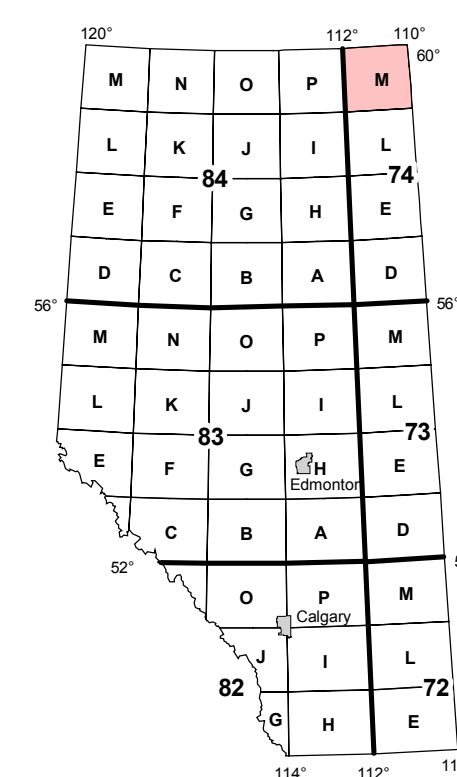
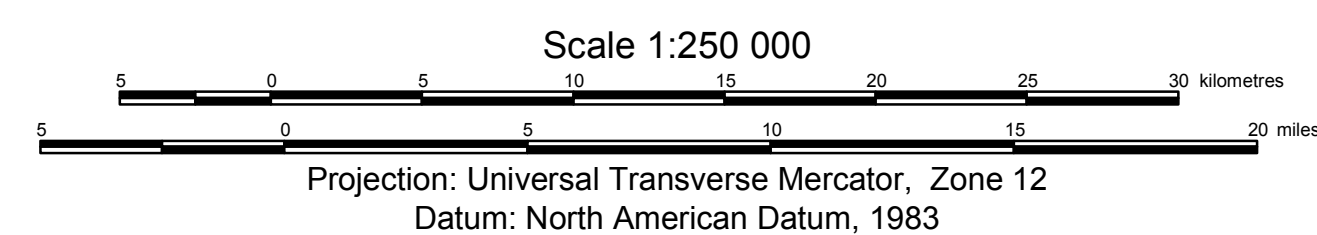


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Geo-Note 2003-15, Figure 10

RADARSAT-1 Standard Beam 1 Descending Image for Fitzgerald, Alberta (NTS 74M)

Compilation by S. Mei, 2003

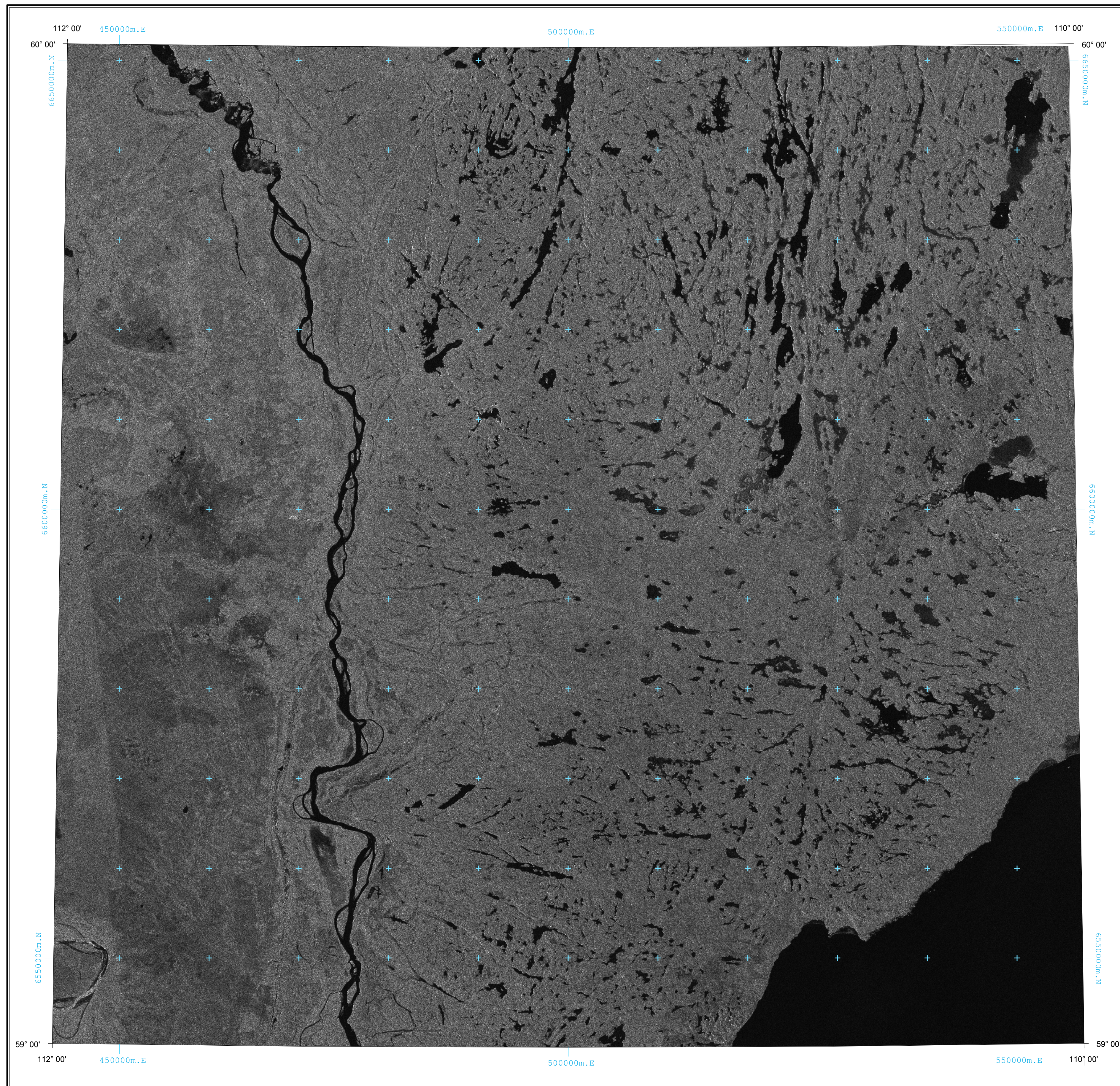


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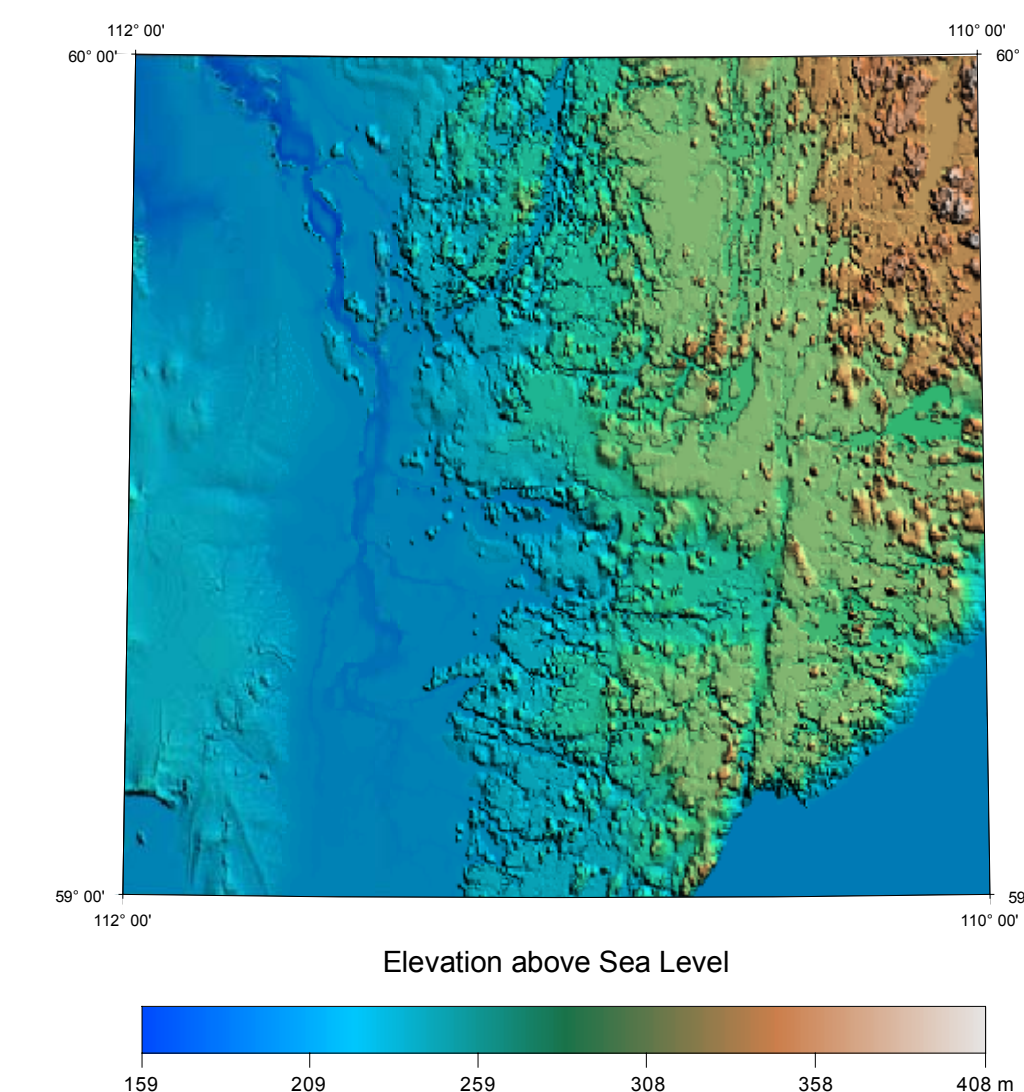
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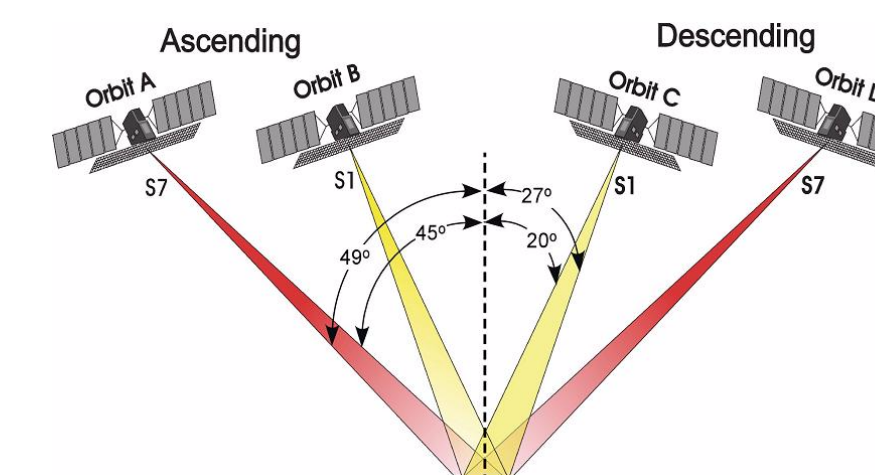
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Elevation Map for NTS 74M



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

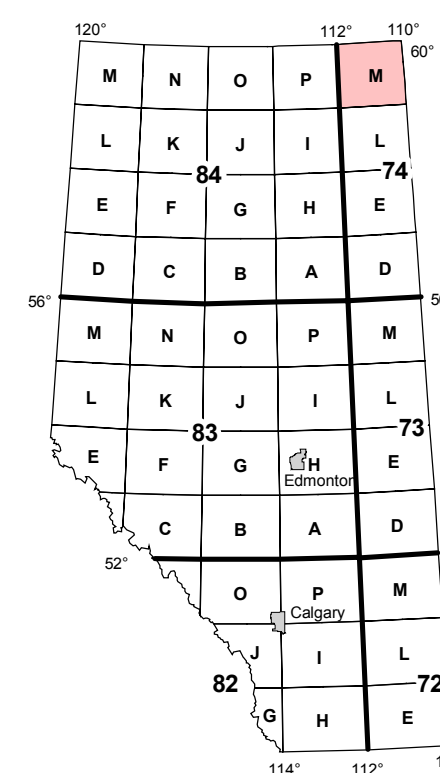
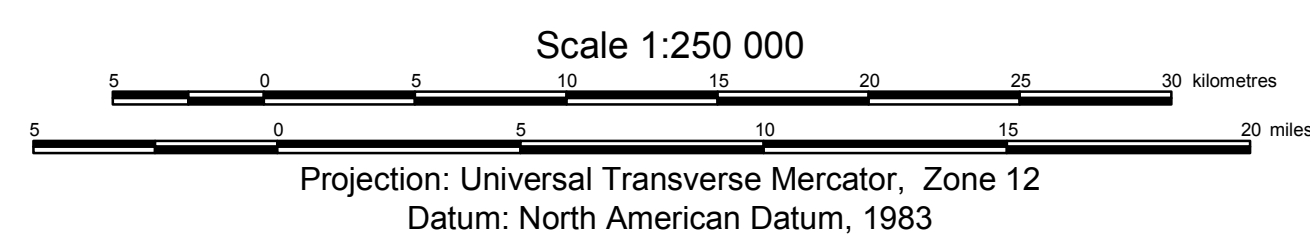


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Geo-Note 2003-15, Figure 11

RADARSAT-1 Standard Beam 7 Ascending Image for Fitzgerald, Alberta (NTS 74M)

Compilation by S. Mei, 2003

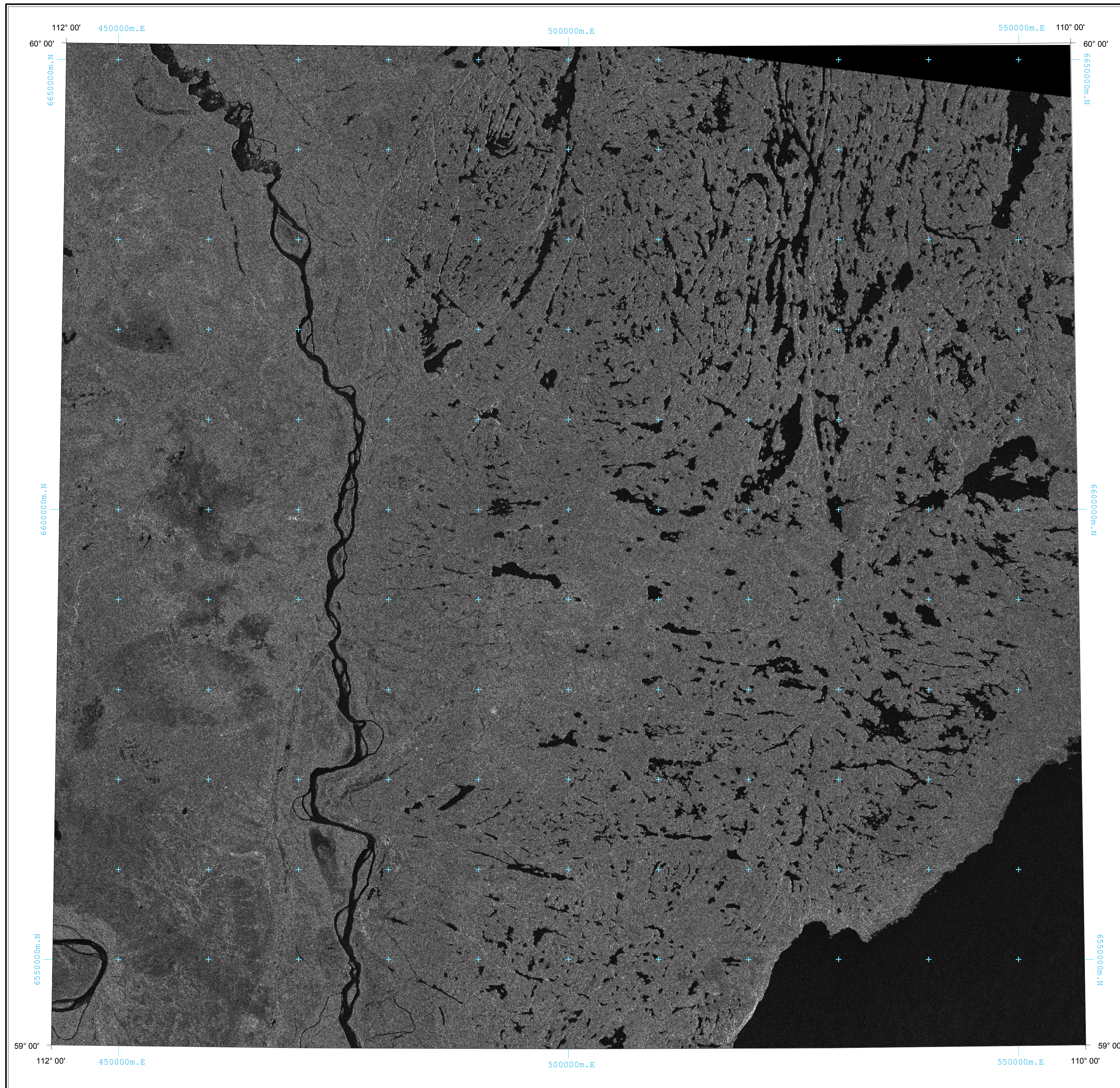


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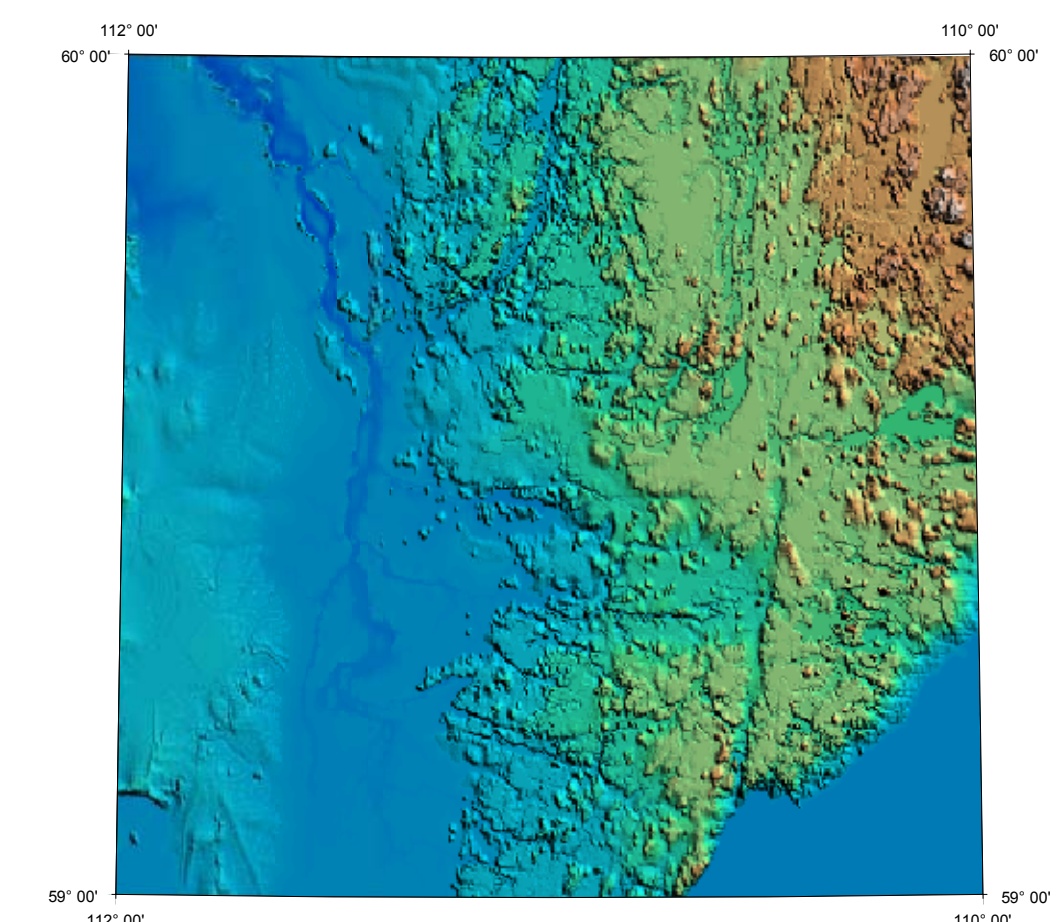
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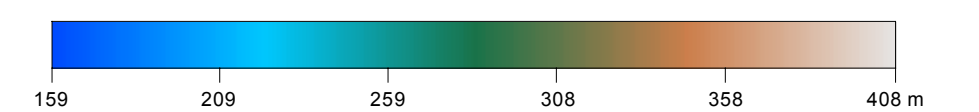
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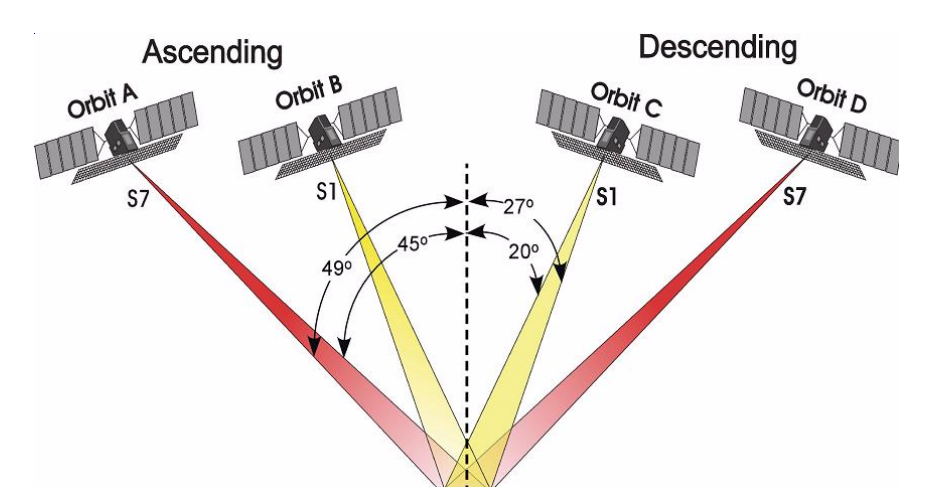
Elevation Map for NTS 74M



Elevation above Sea Level



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



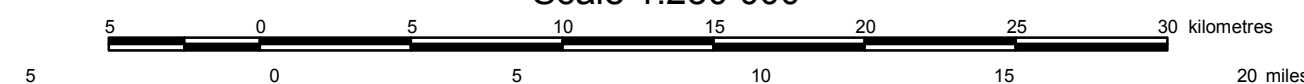
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Geo-Note 2003-15, Figure 12

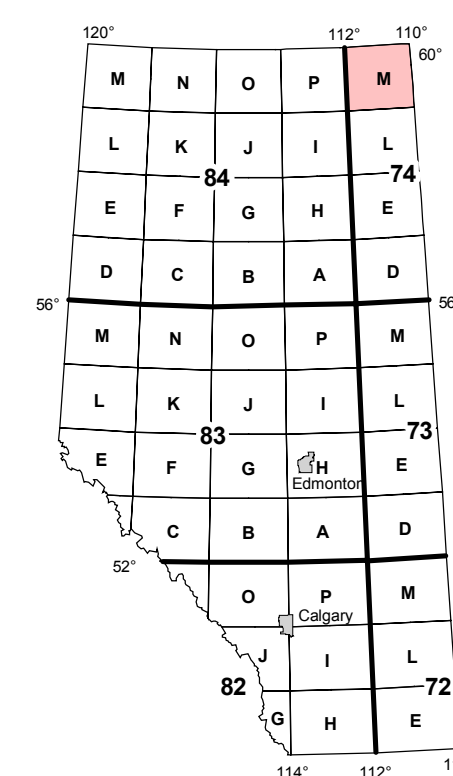
RADARSAT-1 Standard Beam 7 Descending Image for Fitzgerald, Alberta (NTS 74M)

Compilation by S. Mei, 2003

Scale 1:250 000



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

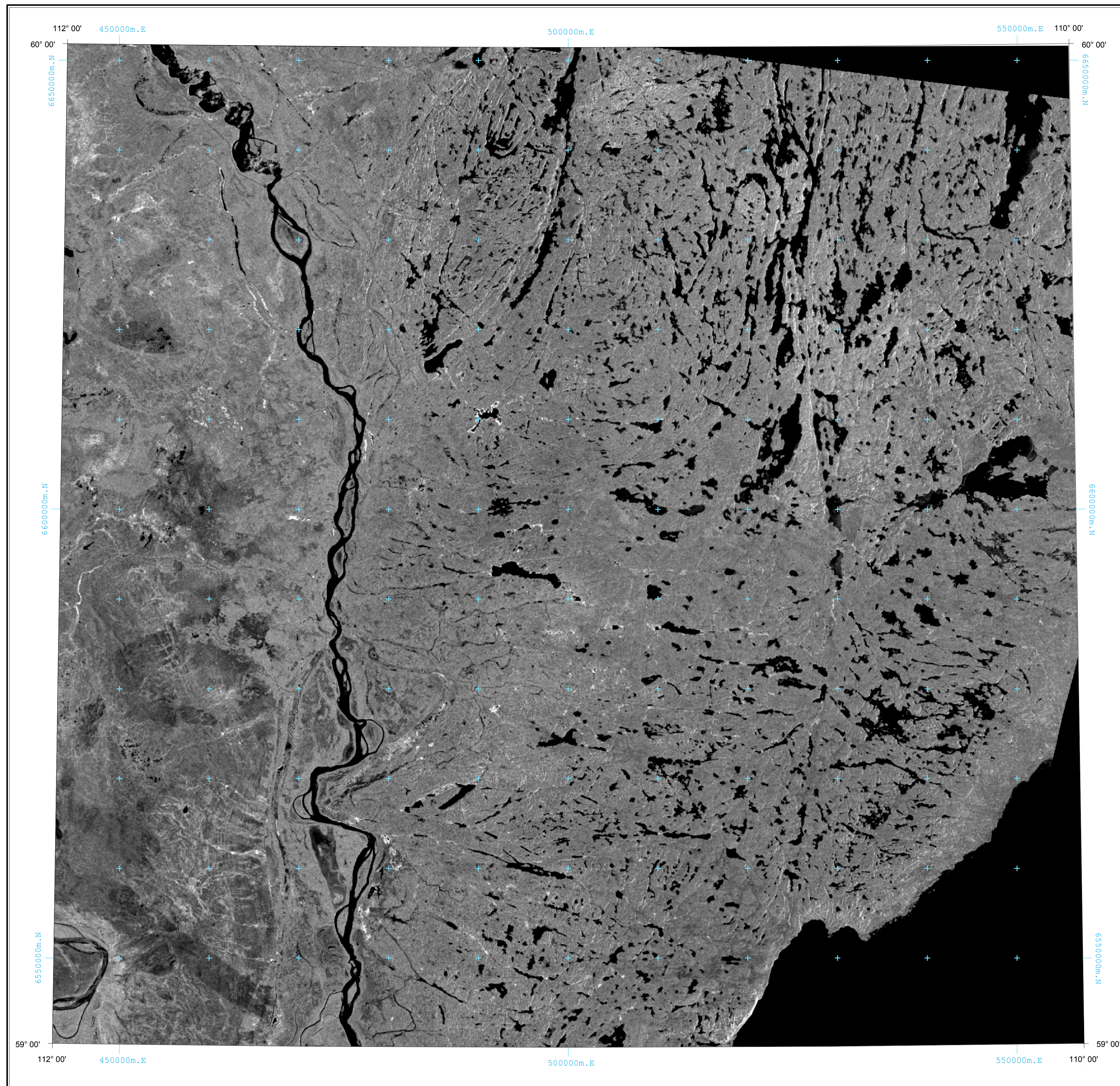


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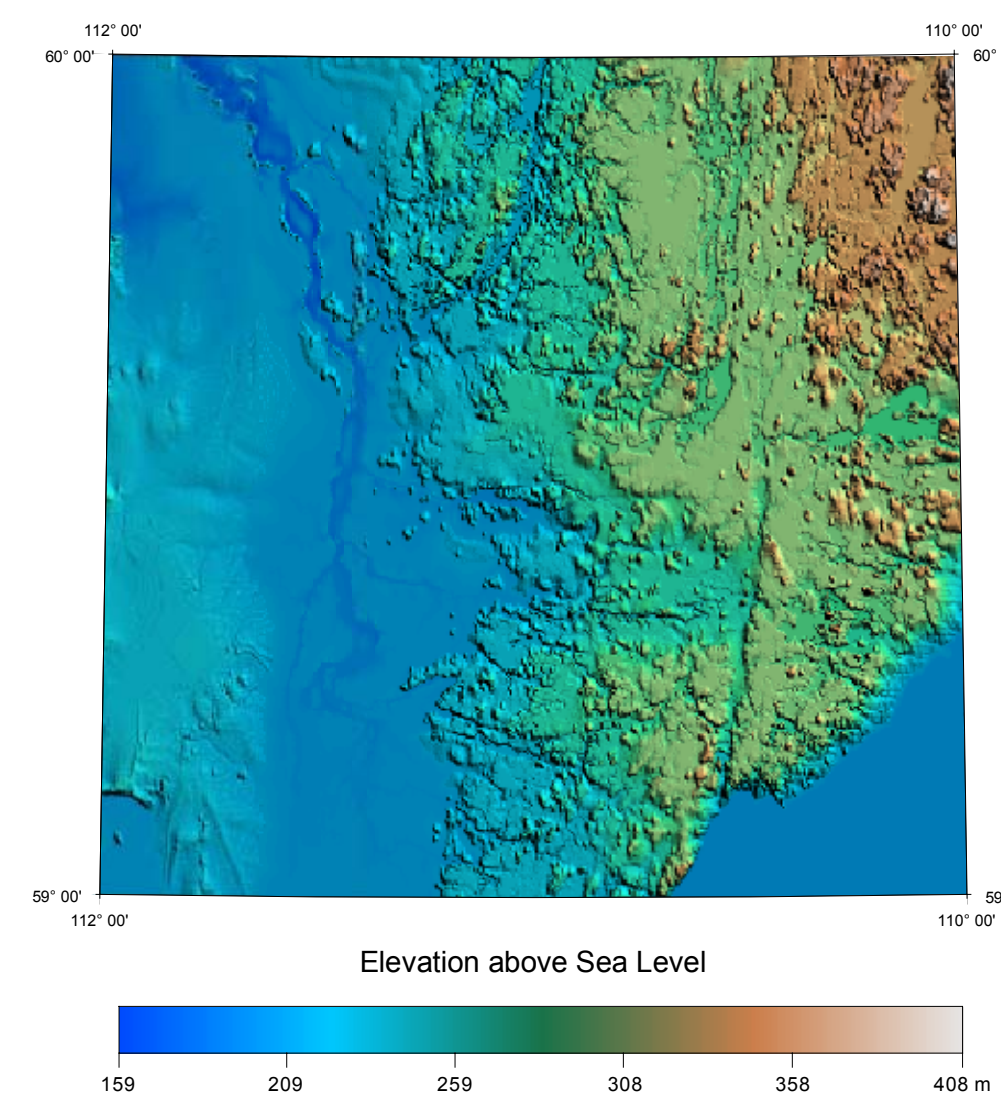
The First Principal Component (PC1) image (Figure 13) shows a range of brightness and texture that highlights features associated with differences in vegetation type and density. Areas of closed Aspen, closed Pine, open deciduous vegetation, grasslands and exposed soil appear to have a brighter tone 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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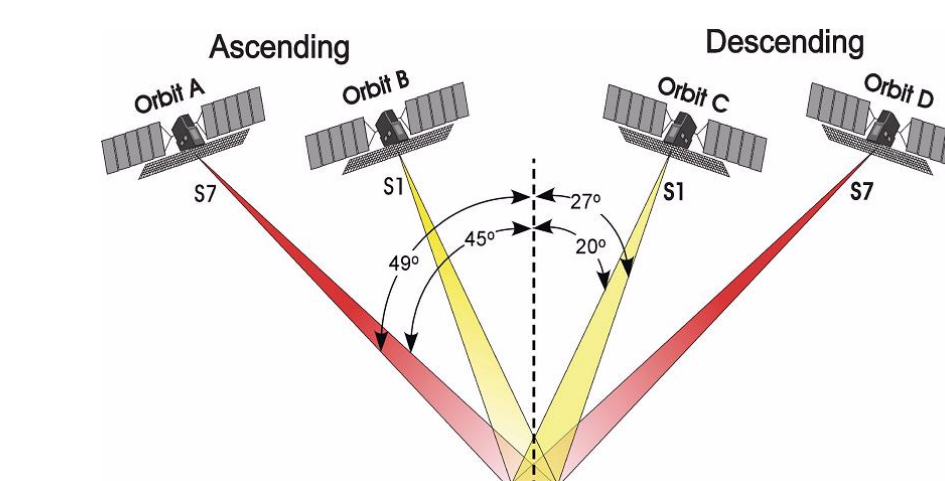
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Elevation Map for NTS 74M



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 2003-15, Figure 13

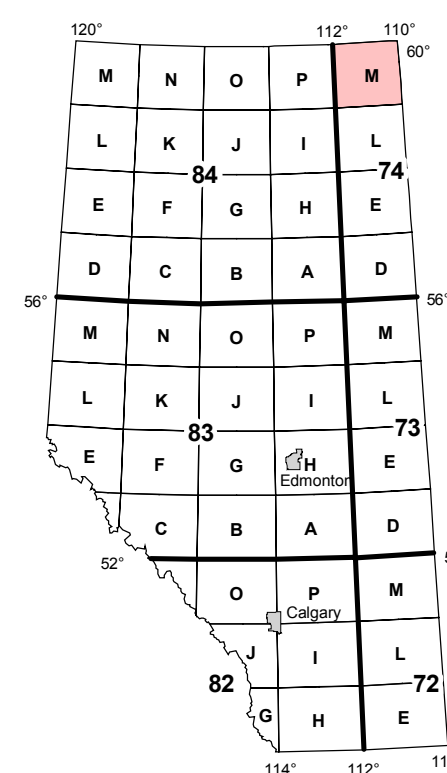
**RADARSAT-1 Principal Component 1
Image for Fitzgerald, Alberta (NTS 74M)**

Compilation by S. Mei, 2003

Scale 1:250 000



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

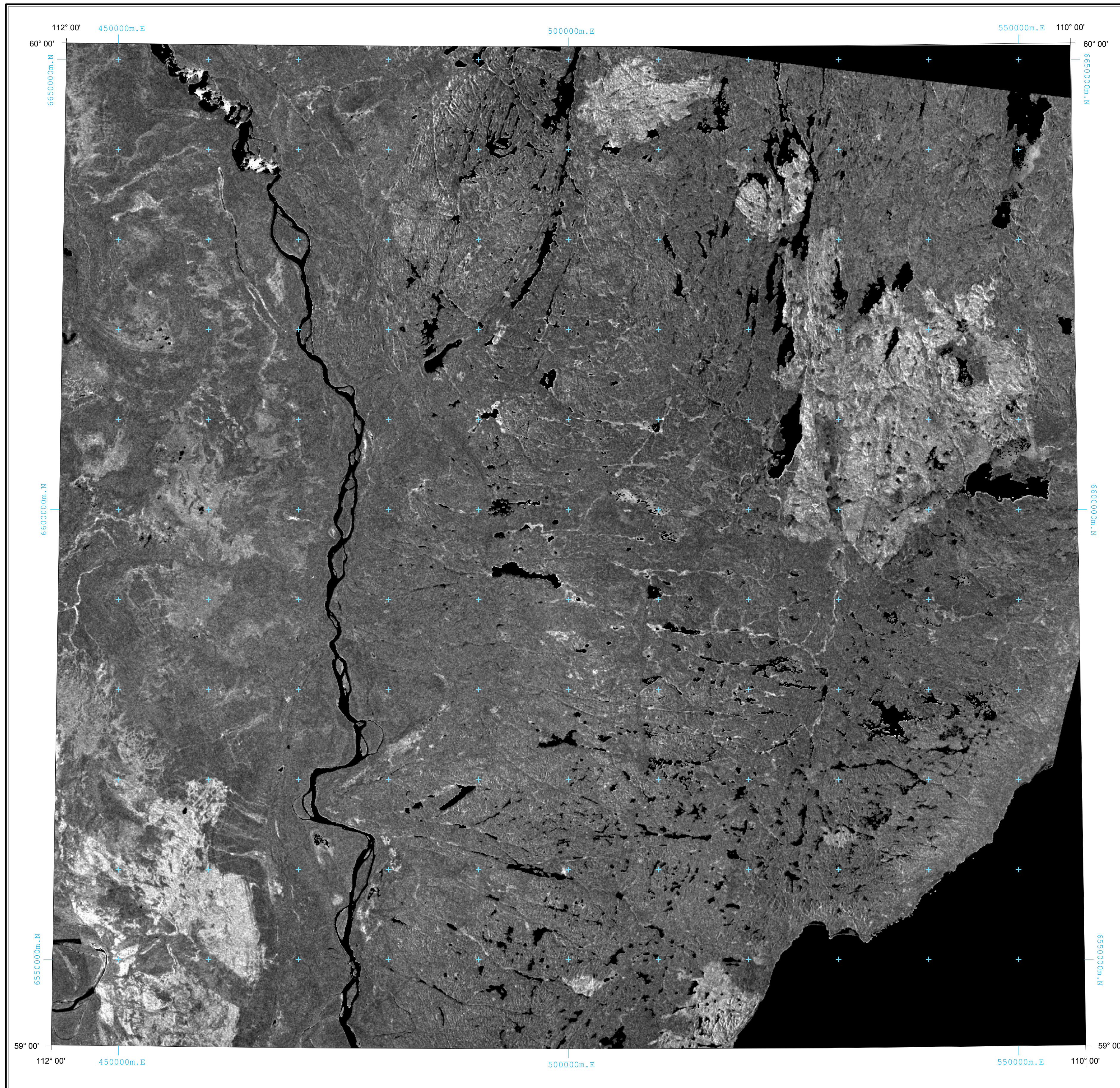


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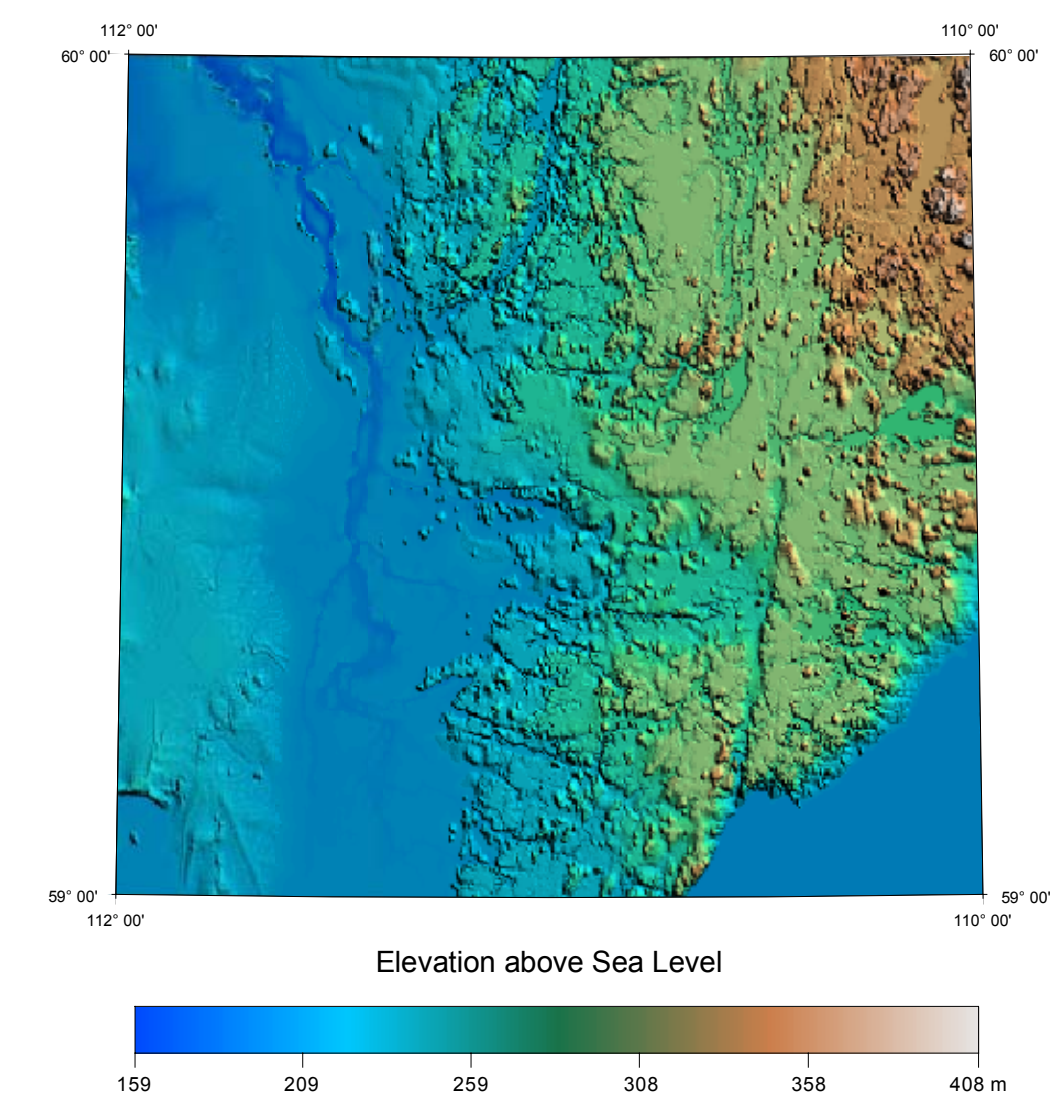
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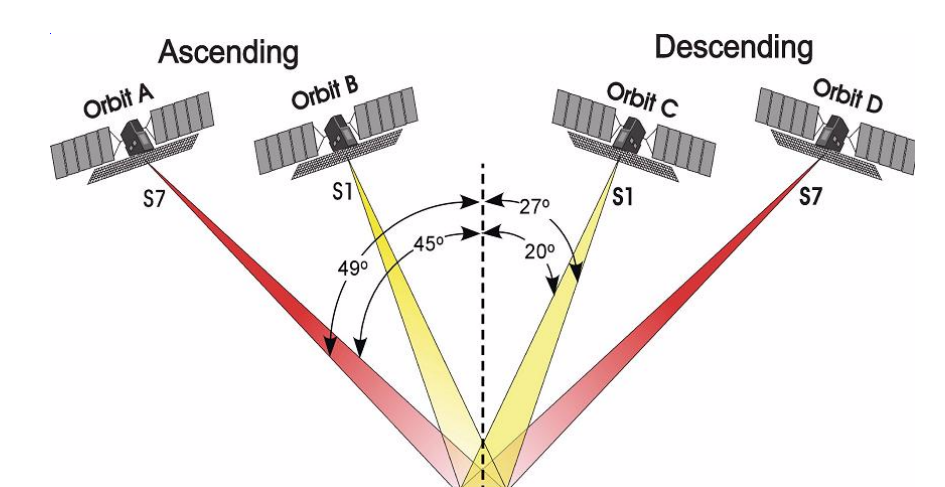
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Elevation Map for NTS 74M



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

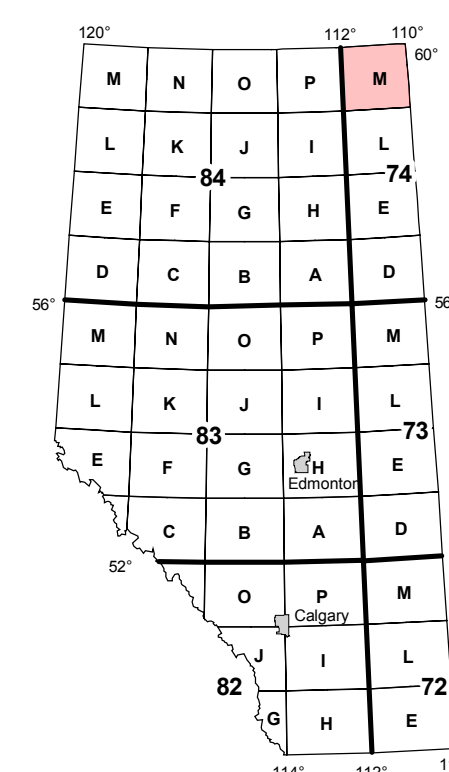


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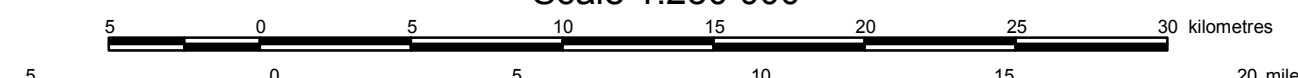
Geo-Note 2003-15, Figure 14

RADARSAT-1 Principal Component 2 Image for Fitzgerald, Alberta (NTS 74M)

Compilation by S. Mei, 2003



Scale 1:250 000



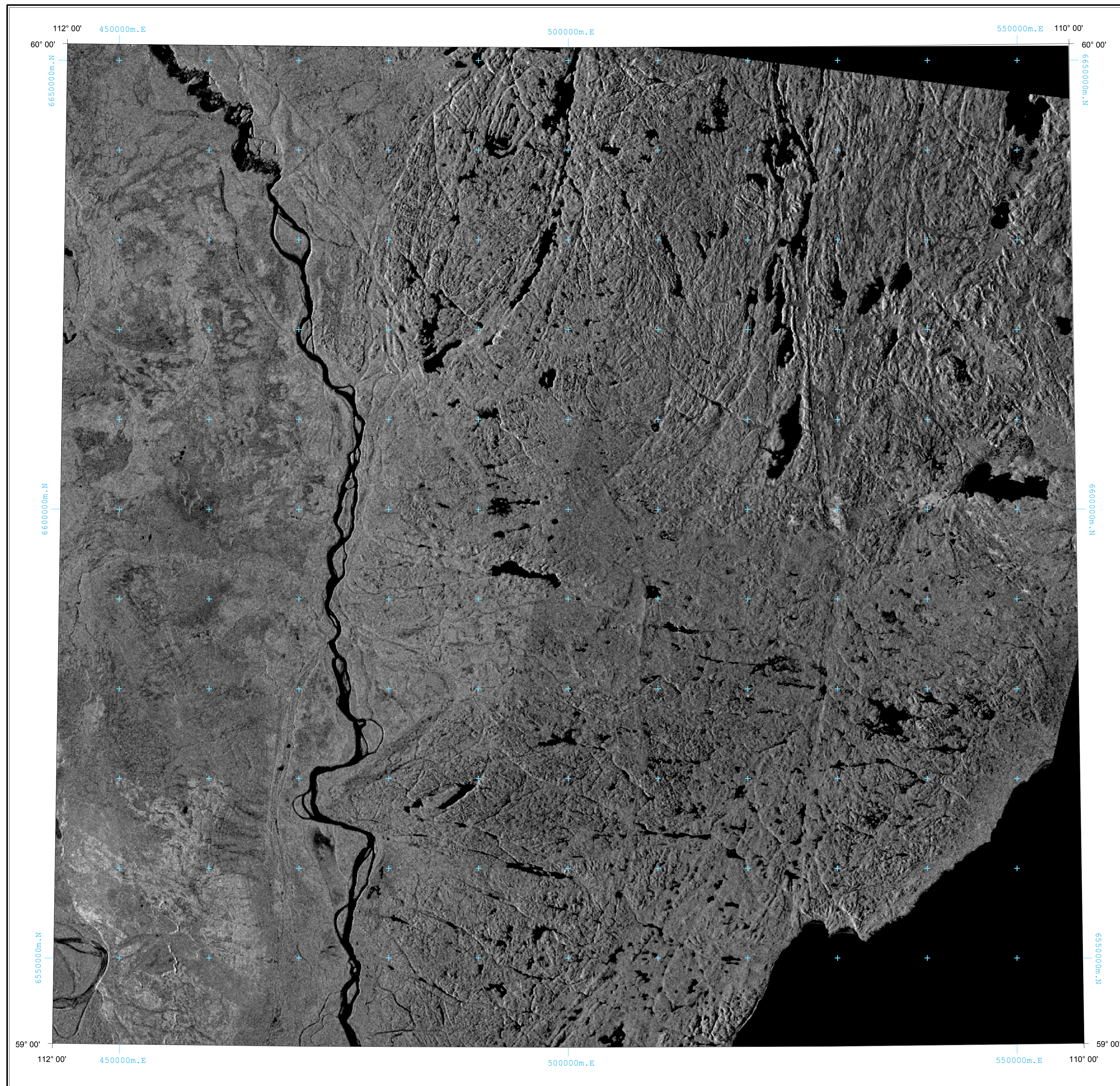
Projection: Universal Transverse Mercator, Zone 12
Datum: North American Datum, 1983

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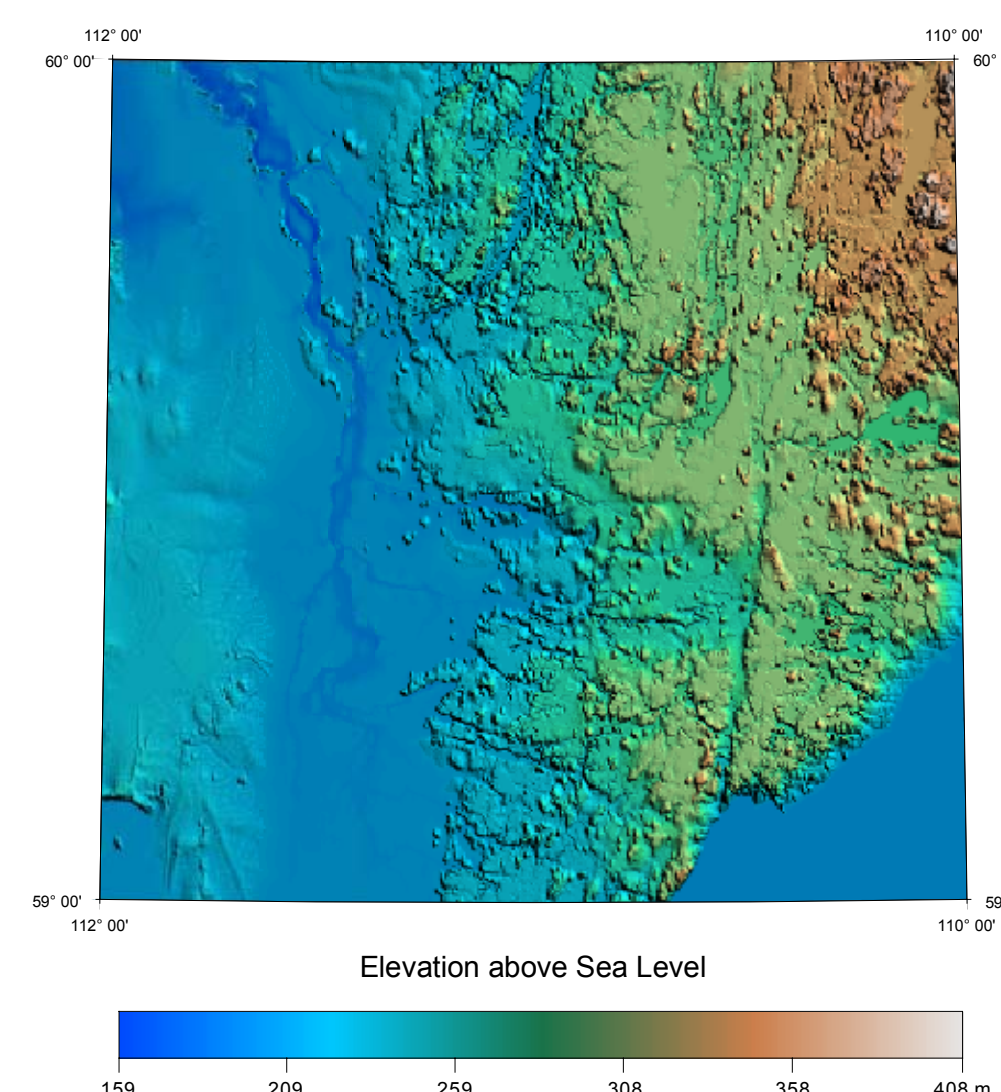
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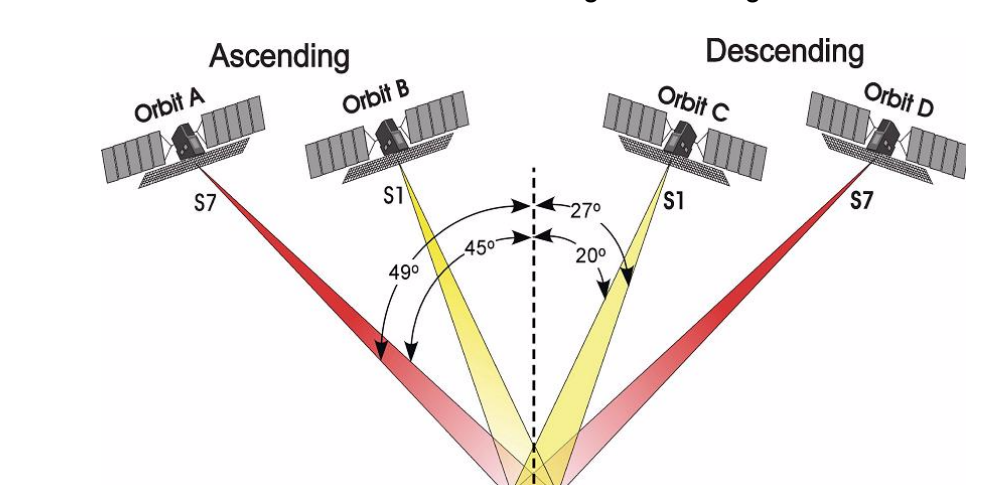
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Elevation Map for NTS 74M



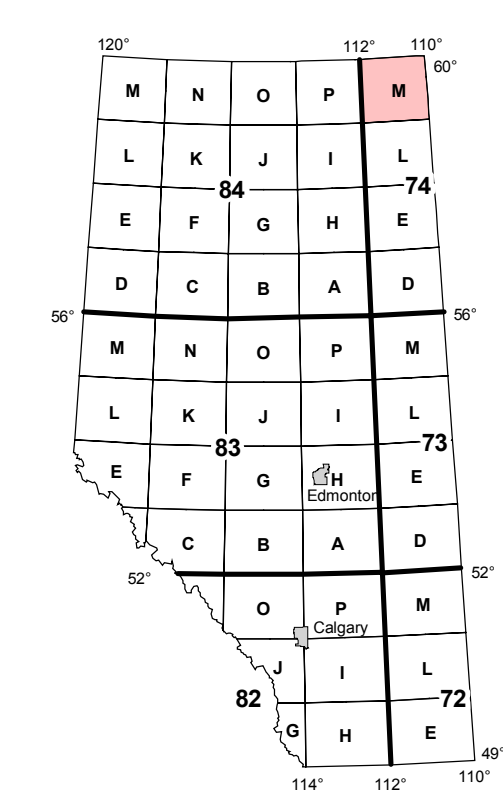
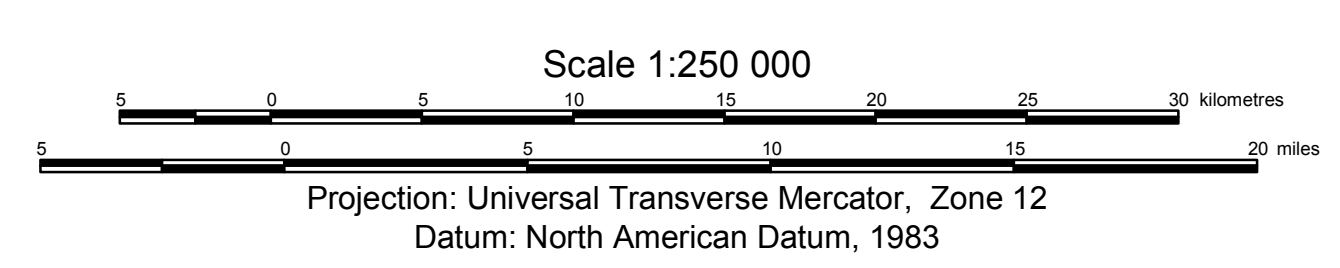
Look Directions and Incident Angles of RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-15, Figure 15
**RADARSAT-1 Principal Compont 3
Image for Fitzgerald, Alberta (NTS 74M)**

Compilation by S. Mei, 2003

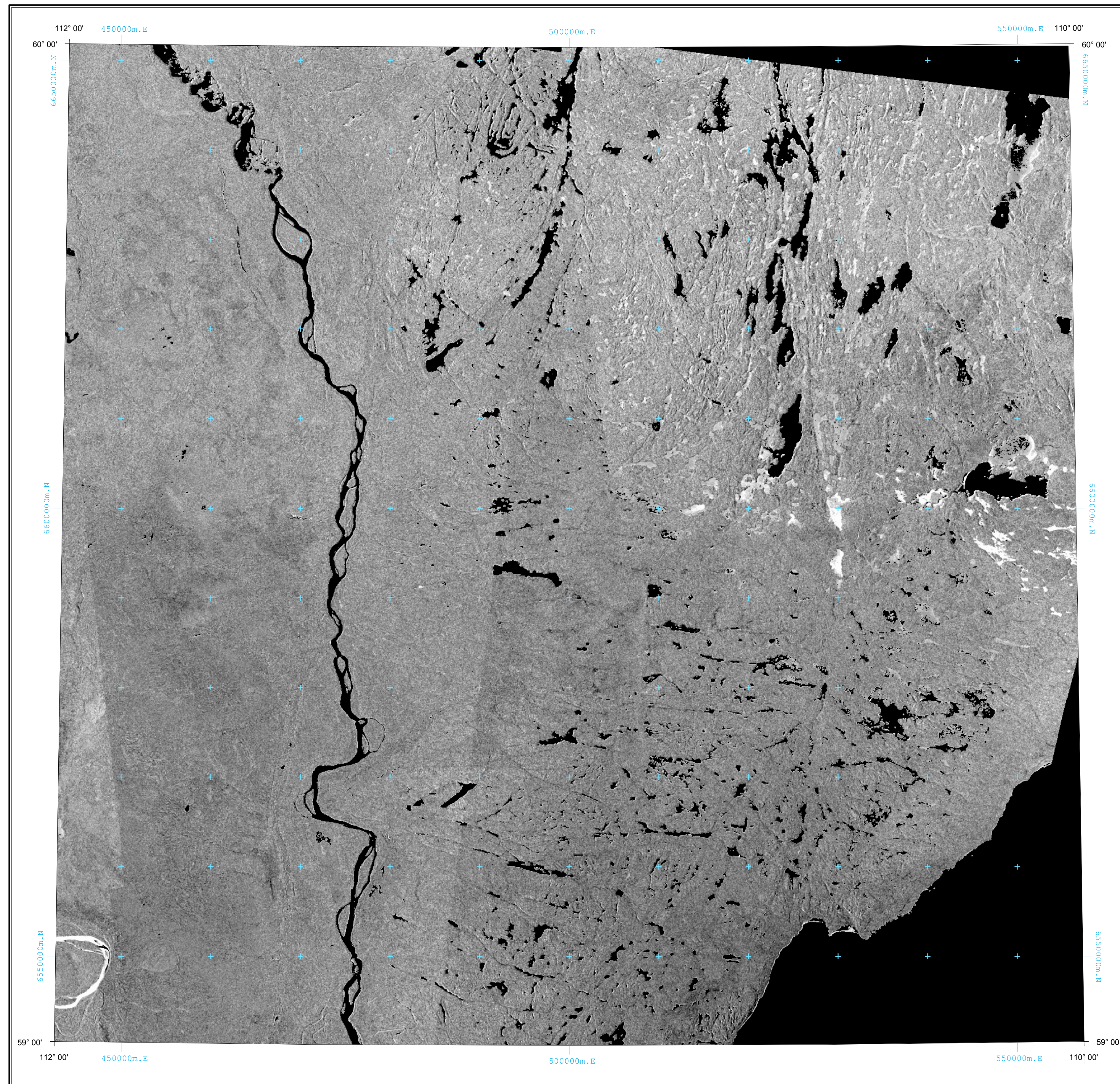


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Having said this, some general tips for interpreting the Figures 13 to 16 PCA images are provided below, but these are generalizations and intended only for assisting less experienced users to browse the image or evaluate variations on the printed map.

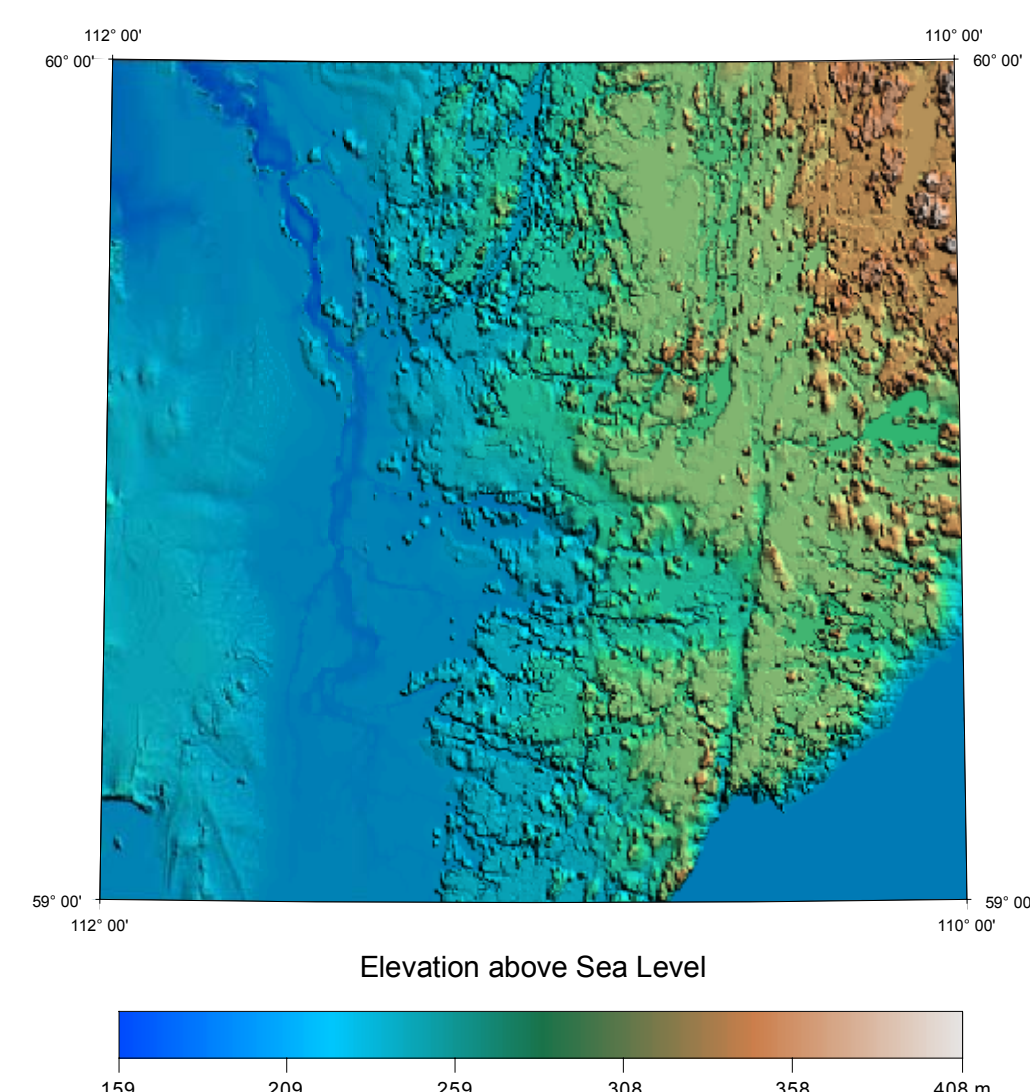
The First Principal Component (PC1) image (Figure 13) shows a range of brightness and texture that highlights features associated with differences in vegetation type and density. Areas of closed Aspen, closed Pine, open deciduous vegetation, grasslands and exposed soil appear to have a brighter tone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

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.

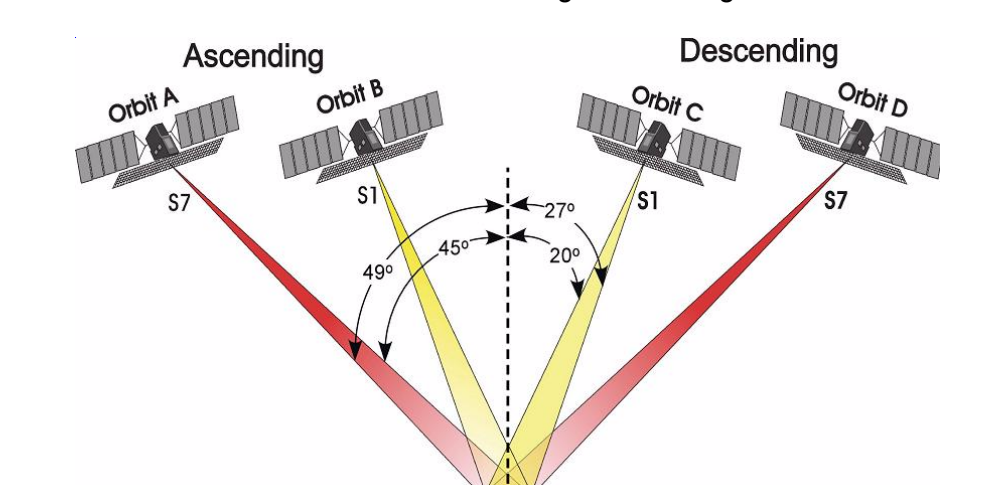
The Third Principal Component (PC3) image (Figure 15) highlights 'surface roughness', hence it reflects topographic effects and surface texture of the ground or vegetation canopy. In fact, the discrimination of topographic features using the PC3 image is superior to any other optical commercial satellite 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 74M



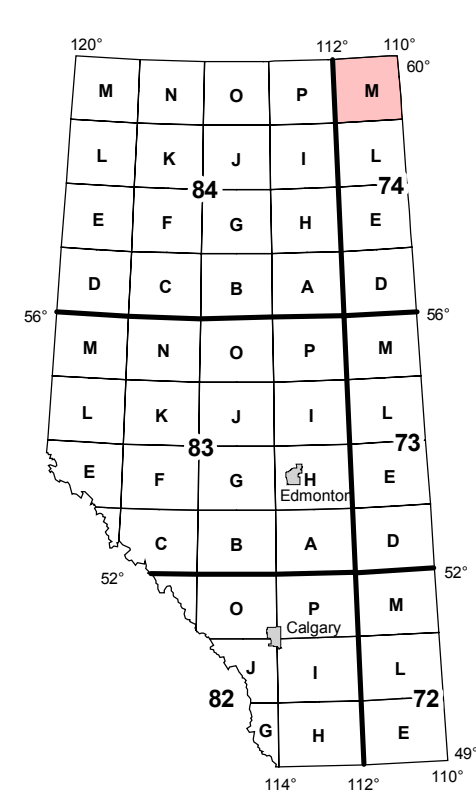
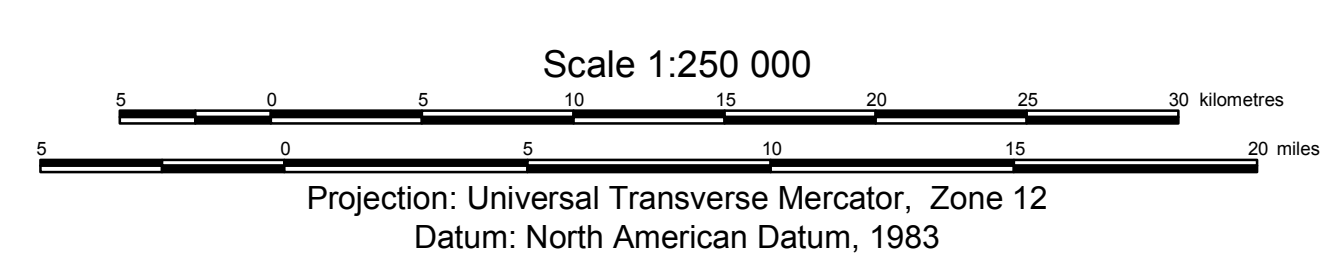
Look Directions and Incident Angles of RADARSAT-1 S1 and S7 Ascending/Descending Beam Modes



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Geo-Note 2003-15, Figure 16
**RADARSAT-1 Principal Component 4
Image for Fitzgerald, Alberta (NTS 74M)**

Compilation by S. Mei, 2003



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