

A Landsat image database for Greenland

Final report

Tapani Tukiainen and
Leif Thorning

Open File Series 95/12

December 1995



GRØNLANDS GEOLOGISKE UNDERSØGELSE
Ujarassioṛtut Kalaallit Nunaanni Misissuisoqārfiat
GEOLOGICAL SURVEY OF GREENLAND



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ABSTRACT

This report concludes a project aimed at the establishment of a database of selected Landsat images suitable mainly for geological work. The resultant new Landsat Image Database for Greenland now contains the digital data from 47 Landsat TM covering most of the ice-free area of Greenland and 35 Landsat MSS images covering selected parts of Greenland. The purpose of the new database is to ease the use of remote sensing techniques in geoscientific and environmental research in Greenland by providing easy access to Landsat data of optimal quality. The database also contains digital image previews of the selected scenes in a standard format suited for use by standard software tools in the PC/Windows environment. Several CD-ROM products with previews and original data in digital form have been produced and can be obtained from GGU and Satellitbild AB. The database also contains information on 866 other scenes visually inspected on black and white photographic previews, but not further utilized in this project.

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1. INTRODUCTION

Experience from project "Geological Information from Remote Sensing" (GIRS) (Tukiainen *et al.*, 1993) emphasized the necessity for easy and fast access to remote sensing data in order to fully utilize remote sensing techniques within the narrow time window of a typical GGU field project. It was a recommendation of the GIRS project to find and acquire Landsat Images from Greenland suited for geological interpretation. To make such data more readily available for geoscientific research in Greenland by GGU, research institutions, universities or industry, it was decided to establish a database of carefully selected Landsat Images at GGU, and make these available for all potential users of the Landsat data at the standard conditions and price of the Eurimage Corporation.

2. PROJECT HISTORY

With the help of funds from the Mineral Resources Administration for Greenland, Ministry of Environment and Energy, a project with the purpose outlined in the introduction was started early in 1994 and for the major part concluded at the end of 1994. The company Satellitbild, Swedish Space Corporation (SSC), also a part of the Eurimage Corporation, was contracted for the work. The authors spent eight days early in 1994 at the SSC/Esrang Satellite Tracking station in order to screen and evaluate the available data. The SSC was again briefly visited in November 1994 to resolve the last issues concerning the production of digital data and previews. The bulk of the ordered data was received by the middle of October 1994. Since then, the SSC has corrected minor errors and omissions in the data detected by GGU's quality control. Since the conclusion of the project SSC has undertaken the responsibility to further develop - without extra cost - a more sophisticated user interface to preview the image data. For practical reasons this delayed the final production of the image previews and this report.

3. LANDSAT SATELLITES

The five Landsat satellites belong to two generations of technology with different platform and orbital characteristics. The satellites operate in a repetitive, circular, sun-synchronous, near-polar orbit. The characteristics of the Landsat satellites are summarized in Table 1. The launch of Landsat 6 in 1994 unfortunately failed, and only Landsat 5 is currently operative. This satellite, belonging to the second generation of Landsat satellites with the Thematic mapper (TM) instrumentation, has exceeded its expected operational lifetime and has produced

Table 1. First and second generations of Landsat satellites

Subject	Landsat MSS	Landsat TM
<i>Orbital information:</i>		
Satellites	Landsat 1, 2 and 3	Landsat 4 and 5
Altitude	918 km	705 km
Orbits per day	14	14.5
Number of orbits (paths)	251	233
Image sidelap at equator	14 pct	7.6 pct
Crosses 40° latitude at (local sun time, approx.)	9.30 a.m.	10.30 a.m.
Operational from	1972-1984	1982 to future
On board data storage	yes	no
<i>Imaging systems:</i>		
Multispectral scanner	yes	yes
Return beam vidicon, panchromatic	yes (Landsat 3)	no
Thematic mapper	no	yes
<i>Spectral region:</i>		
Visible and reflected IR	0.5 to 1.1 μm	0.45 to 2.35 μm
Thermal IR (TM band 6)		10.5 to 12.5 μm
Spectral bands	4	7
<i>Instantaneous field of view:</i>		
Visible and reflected IR	0.087 mrad	0.043 mrad
Thermal IR (TM band 6)		0.17 mrad
<i>Ground resolution cell:</i>		
Multispectral scanner	79 by 79 m	78 by 79 m
Return beam vidicon	40 by 40 m	
Thematic mapper		30 by 30 m
Thermal IR (TM band 6)		120 by 120 m
<i>Number of picture elements:</i>		
Single band	7.6×10^6	39×10^6
All bands	10.4×10^6	273×10^6
<i>Terrain coverage:</i>		
East-west direction	185 km	185 km
North-south direction	185 km	170 km

Table 2. *Some main Landsat Thematic Mapper applications*

Band	Wavelength (μm)	Characteristics
1	0.45 - 0.52	Blue-green - No MSS equivalent. Maximum penetration of water, which is useful for bathymetric mapping in shallow water. Useful for distinguishing soil from vegetation and deciduous from coniferous plants.
2	0.52 - 0.60	Green - coincident with MSS band 4. Matches green reflectance peak of vegetation, which is useful for assessing plant vigour.
3	0.63 - 0.69	Red - coincident with MSS band 5. Matches a chlorophyll absorption band that is important for discriminating vegetation types.
4	0.76 - 0.90	Reflected IR - coincident with portions of MSS bands 6 and 7. Useful for determining biomass content and for mapping shore lines.
5	1.55 - 1.75	Reflected IR. Indicates moisture content of soil and vegetation. Penetrates thin clouds. Good contrast between vegetation types.
6	10.40 - 12.50	Thermal IR. Night time images are useful for thermal mapping and for estimating soil moisture.
7	2.08-2.35	Reflected IR. Coincides with absorption band caused by hydroxyl ions in minerals. Ratios of bands 5 and 7 are potentially useful for mapping hydrothermally altered rocks associated with mineral deposits.

immense amounts of high quality data. The launching of these satellites started the new era of remote sensing for the earth sciences. The main applications of TM data are summarized in Table 2.

4. COVERAGE OF LANDSAT DATA IN GREENLAND

Landsat TM

The first query of the EOSAT Landsat database showed that approximately 15 000 Landsat images from Greenland were recorded until the present date. The number of scenes potentially useful for geology were reduced to c. 7 000 by selecting only the scenes recorded between the 1st of June and 30th of September and covering the areas of exposed rocks between the Inland Ice and the coastal waters. Apart from some scenes from EOSAT/USA and

Radarsat/Canada, the black and white photographic previews of these Landsat TM and MSS scenes were available at the Esrange satellite tracking station in Kiruna. The visual screening of the c. 7 000 TM scenes reduced the number of the interesting ones to c. 866 reasonably good scenes.

From these, the final selection was carried out by the authors. This resulted in a total of 47 Landsat TM scenes with a coverage shown in Fig. 1. An example of a preview is shown in Fig. 3. The lack of coverage above latitude 81°N is due to the orbital characteristics of the Landsat Satellites. The areas south of latitude 68°N and 65°N on the west and east coast, respectively, are beyond the range of the Kiruna satellite tracking station. The images available from the North American stations make up a reasonable, but not complete coverage for most of southern and southwestern Greenland. It was attempted to request the programming of the Landsat 5 to cover the areas of missing data during the summer 1994. However, due to malfunction of the on-board storage device and very poor weather conditions during the satellite passages no new data were acquired. GGU will be looking for ways to cover the remaining gaps in the coverage.

Landsat MSS

Though Landsat TM data was the primary concern of this project the authors also included 35 good quality MSS scenes (Landsat 1, 2 and 3) in the selection for this project. The coverage of the historical MSS data is shown in Fig. 2, and an example of a preview in Fig. 4.

5. PRODUCTS AND DATA STORAGE

Digital Landsat image previews

The primary aim of this project was to establish a database of digital image data stored on a suitable and secure media, and to make these readily available. To assist users, the previewing of the digital data has been improved by the preparation of digital preview images for each Landsat TM and Landsat MSS scene.

The preview images have been produced as re-sampled colour composites of the Landsat TM bands 4, 3 and 2 and Landsat MSS bands 3, 2 and 1, respectively. They are stored as portable bitmaps (file extension .BMP); the preview of a full Landsat TM scene takes up about 0.6 Mbytes of disk space, i.e. it can be transported on a normal diskette. The BMP-format was chosen to ensure that the preview images could be viewed and treated by a

number of viewing and desk top publishing facilities on standard PCs.

Each Landsat image preview consists of two files: one containing the proper image as portable MS-Windows bitmaps (.BMP) and another containing the general information on the image as a ASCII-file (file extension .TXT). The file names are composed to be indicative for the type of sensor/platform and also convey the relevant information on track and frame numbers. The digital Landsat image previews are stored together on CD-ROMs: one for the 47 Landsat TM previews and another one for the 35 Landsat MSS previews.

Digital Landsat image data

The original digital data for both the MSS and TM images are also stored on CD-ROM. For practical reasons the Landsat TM images totalling 48 are each on one CD-ROM. The less voluminous Landsat MSS images, 36 altogether, are stored on two CD-ROMS.

The digital image data for the Landsat TM and Landsat MSS bands are stored sequentially; a characteristic collection of the files for one Landsat TM image stored on one CD-ROM is summarized in Table 3.

Information on other Landsat images

GGU maintains a database of basic information and a subjective evaluation of the c. 866 images found during this project to be reasonably good. The existence of the digital data corresponding to these images has not been confirmed, but the database may be a good starting point for locating other scenes for other uses.

Table 3. Summary of datafiles for TM scene

File name	contains data for	format
BAND1.DAT	0.45 - 0.52 μm	(BINARY)
BAND2.DAT	0.52 - 0.60 μm	(BINARY)
BAND3.DAT	0.63 - 0.69 μm	(BINARY)
BAND4.DAT	0.76 - 0.90 μm	(BINARY)
BAND5.DAT	1.55 - 1.75 μm	(BINARY)
BAND6.DAT	10.40 -12.50 μm	(BINARY)
BAND7.DAT	2.08 - 2.35 μm	(BINARY)
SIZE.TXT	Image size as lines and pixels/line	(ASCII)
HEADER.TXT	Detailed image info	(BINARY)

6. AVAILABILITY OF DATA

GGU has two sets of CD-ROMs for all the Landsat TM and Landsat MSS images. Due to the usual conditions for the use of Landsat data these can only be used by GGU and GGU's co-workers in specific projects. The digital data cannot be lent or given to any third parties. However, the Landsat TM and MSS image data are available and can be purchased according to ambient commercial prices and conditions of use (as defined by Eurimage). As a result of the cooperation in this project, Satellitbild has the images on file and can deliver quickly on CD-ROM (preferred) or tape without previous search and control. The full sets of Landsat TM or MSS previews on two CD-ROMs can be also purchased at a price of 120 ECU for the Landsat TM image preview CD-ROM and 95 for the Landsat MSS preview CD-ROM.

Orders for the products can be forwarded to either GGU or SSC, but will be delivered and invoiced directly from Satellitbild AB.

The database on other Landsat TM images at GGU can also be consulted by guests at GGU. It will also be possible to visit GGU and inspect the previews and the data on GGU's image processing facilities, provided prior arrangements have been made. Please contact GGU for this.

In the future GGU will establish a home page on the World Wide Web. The image preview data will then become available for Internet multimedia browsers using a touch sensitive index map as access route to the previews.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

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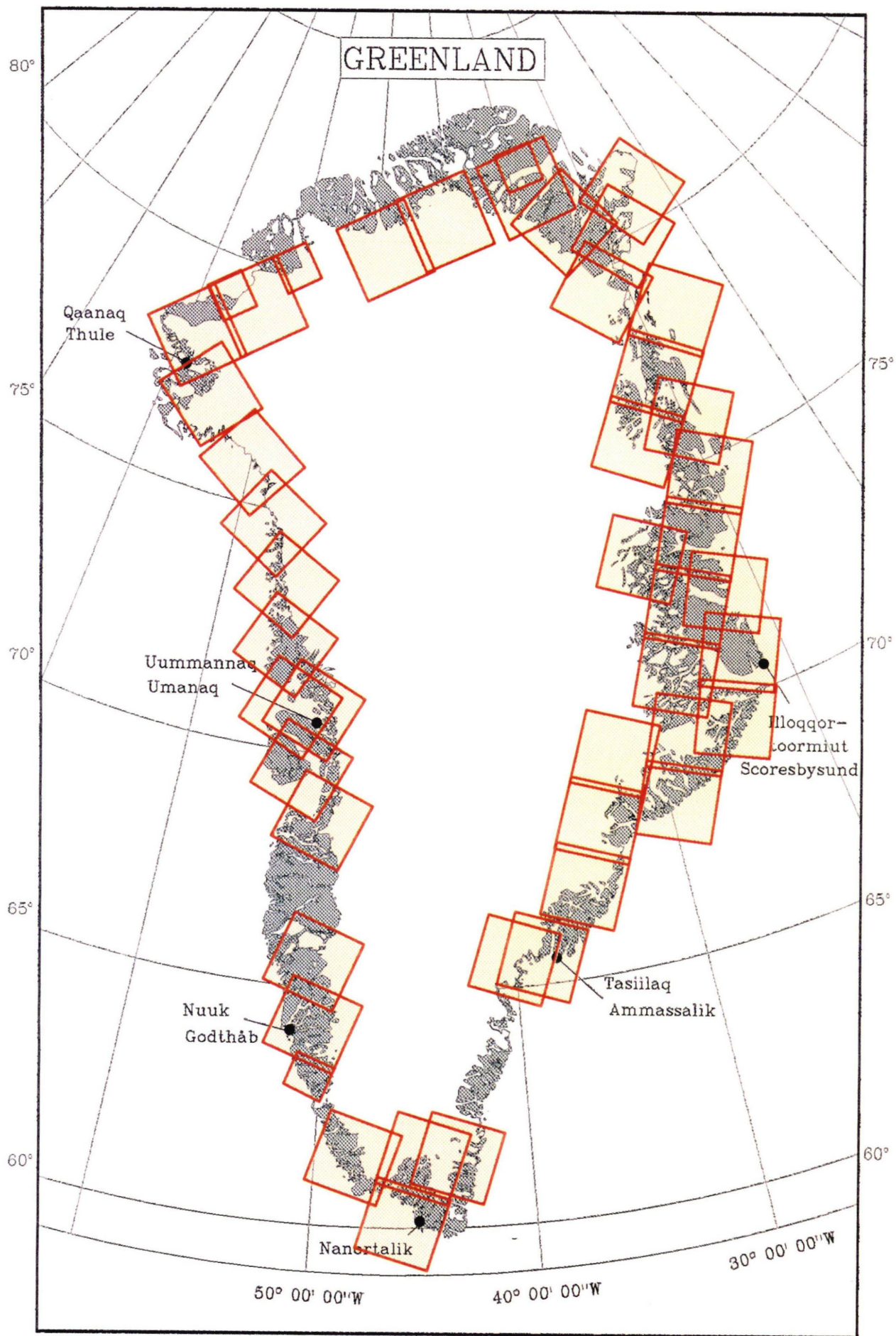


Fig. 1. Index map showing the coverage of the digital Landsat TM data (predominantly Landsat 5) in the database. Corresponding previews exist.

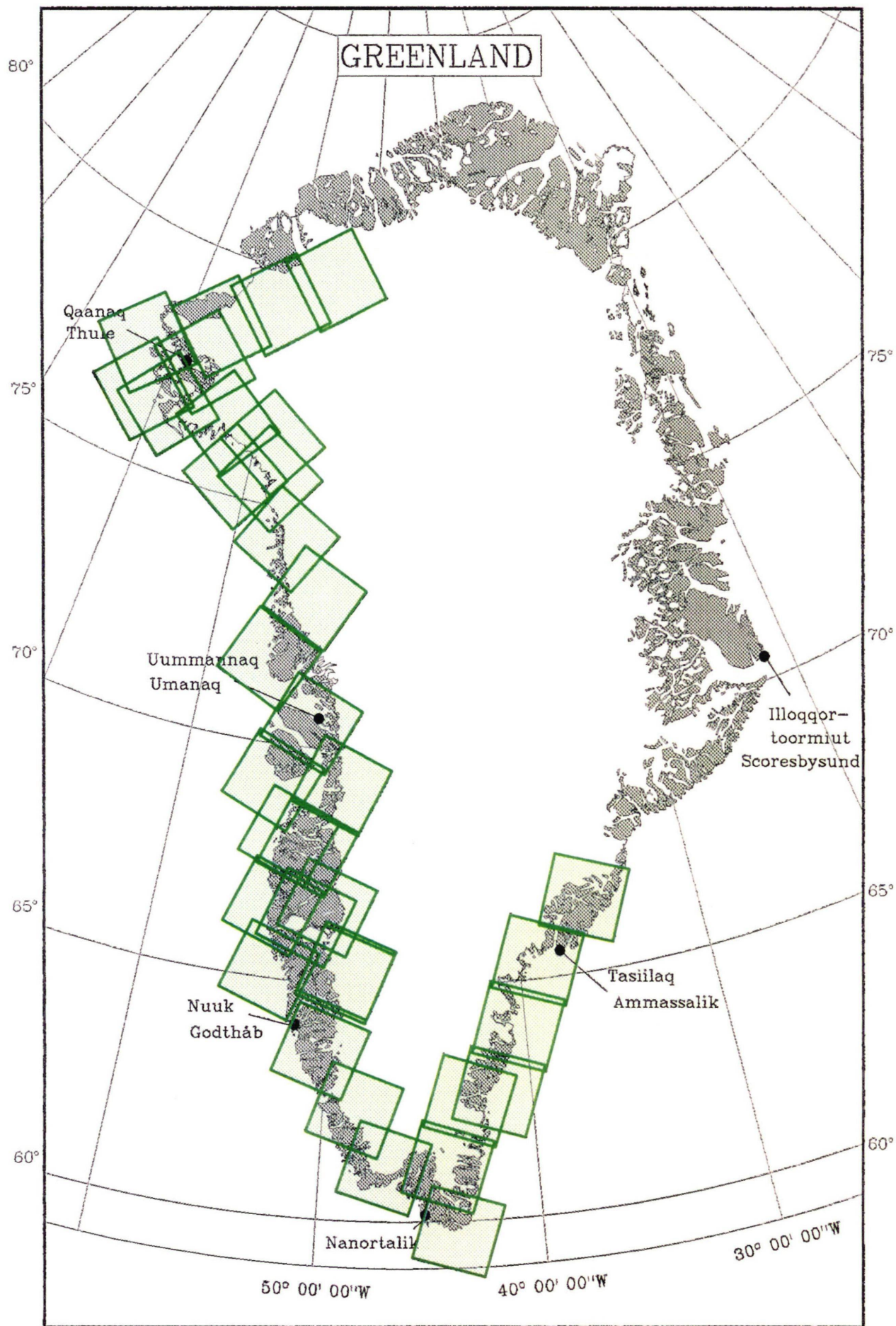
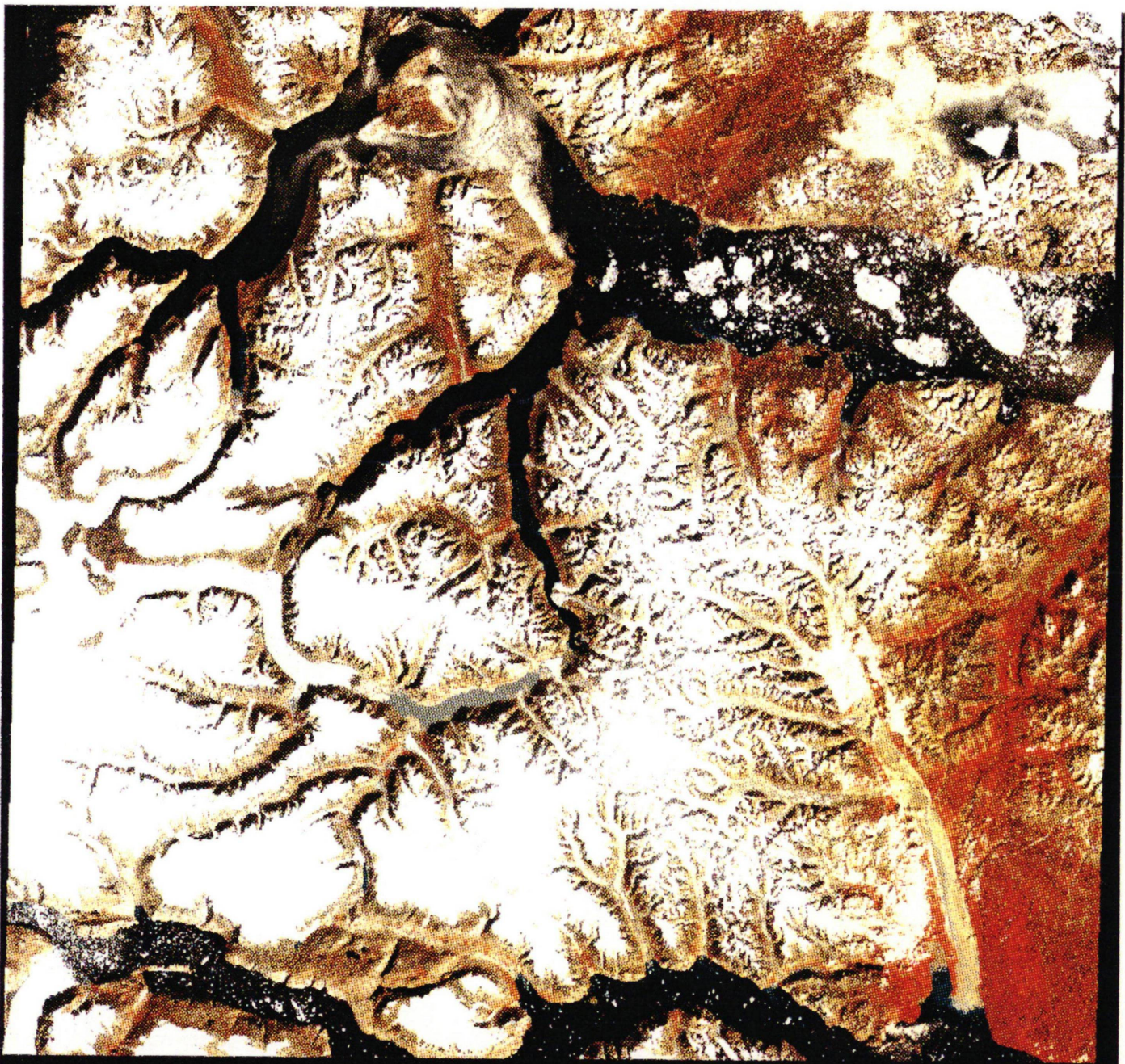


Fig. 2. Index map showing the coverage of the Landsat MSS data (Landsats 1, 2 and 3).
Corresponding previews exist.



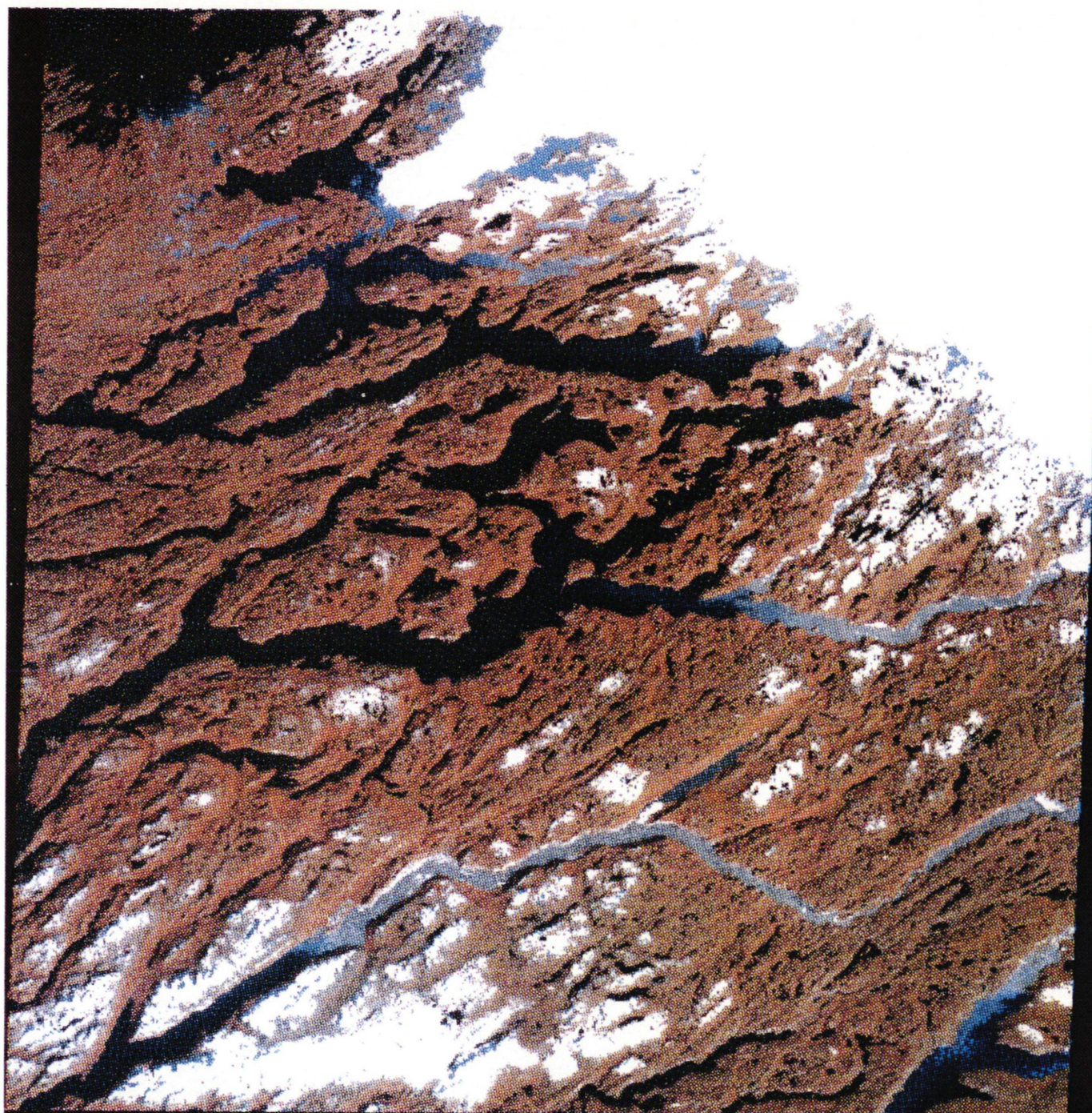
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Path-Row	229-009
Date	1988-08-01

Fig. 3. Example of Landsat TM image preview.



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Date 1982-09-02

Fig. 4. Example of Landsat MSS image preview.

