Glaciers of North America–

GLACIERS OF CANADA

INTRODUCTION

By RICHARD S. WILLIAMS, JR. *and* JANE G. FERRIGNO, *Editors*

SATELLITE IMAGE ATLAS OF GLACIERS OF THE WORLD

Edited by RICHARD S. WILLIAMS, Jr., *and* JANE G. FERRIGNO

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Glaciers in Canada are situated in three principal locations: on several Arctic islands, in the Rocky Mountains and Interior Ranges, *and along the Pacific Coast. Landsat MSS images are most useful in studying and monitoring changes in ice caps, ice fields, outlet glaciers, and valley glaciers*

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Glaciers in Canada are located principally in three geographic settings: on several Arctic islands in Nunavut and the Northwest Territories of northern Canada, in the Rocky Mountains and the *Interior Ranges*[1], and along the coast of the Pacific Ocean, where they are sometimes contiguous with glaciers of Alaska (fig. 1, and figs. 1 and 2 in the "History of Glacier Investigations in Canada"). The area covered by glaciers is estimated to be 151,000 km^2 in the Canadian Arctic and 50,000 km^2 in the mountain ranges of Western Canada (table 1). During the Last Glacier Maximum (LGM) during the Pleistocene Epoch, the Laurentide Ice Sheet and the Cordilleran Ice Sheet covered

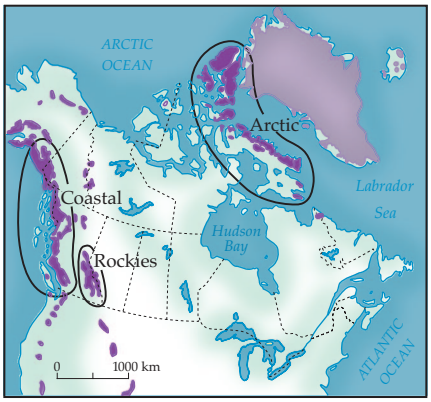

Figure 1.—*Geographic locations of the currently glacierized regions of Canada (and Greenland and Iceland), by S. Fick and A. Murray (see also Shilts and others, 1998), from the 1998 Canadian Geographic, v. 118, no. 7, Sources: Geomatics Canada, Glacier Atlas of Canada, National Hydrology Research Centre. Used with permission.*

TABLE 1.—*Estimated glacier area in Canada (from Ommanney, 1970)*
[1, Approximation from previous estimates; 2, Ommanney (1969); 3, Koerner (1968); 4, Measured value from National Topographic System (NTS) 1:250,000-scale maps; 5, Henoch (1967)]

Location of Glaciers	Estimated Glacier Area (square kilometers)
ARCTIC ISLANDS	
Ellesmere	80,000[1]
Ice Shelves (Ellesmere)	500[1]
Axel Heiberg	11,735[2]
Devon	16,200[1]
Coburg	225[1]
Meighen	85[3]
Melville	160[4]
North Kent	152[4]
Subtotal	109,057
Baffin	37,000[1]
Bylot	5,000[1]
Subtotal Arctic	151,057
MAINLAND DRAINAGE BASINS	
Pacific	37,659[5]
Nelson	328[5]
Great Slave	626[5]
Yukon	10, 564[5]
Arctic Ocean	840[5]
Labrador	24[5]
Subtotal Mainland	50,041
Total Canada	201,098

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[1] The names in this section conform to the usage authorized by the Secretariat of the Canadian Permanent Committee on Geographical Names (CPCGN) and found in the Canadian Geographical Names Data Base (CGNDB). Variant names and names not listed in the CPCGN/CGNDB are shown in italics.

virtually all of Canada (fig. 2), so present-day glaciers in Canada are present only where the regional climates have temperature and (or) accumulation/melt regimes sufficient to maintain these ice masses. Some glaciers may, in fact, be relicts from the late Pleistocene Epoch, or from the late Holocene Epoch "Little Ice Age," and could not re-form under present, regional climatic conditions, if they were to completely melt. Because of the vastness and often inaccessibility of the glacierized regions of Canada, only 176 individual glaciers of the many thousands of glaciers have been studied in the field or with airborne and satellite remote sensing technology during the past 140 years. Between the 1940's and the present, 34 of these 176 glaciers or glacierized areas have been specially mapped one or more times, at scales ranging from 1:5,000 to 1:125,000.

Dunbar and Greenway (1956) published an important book which included numerous trimetrogon aerial photographs of the glaciers of Arctic Canada; their pioneering work with available aerial photographs provided a regional overview of the most glacierized part of Canada and, in a sense, was a forerunner of the use of satellite images to document the areal extent of glacier ice in Canada. More than 120 years ago, the geologist Nathaniel Shaler and the physical geographer William Morris Davis (Shaler and Davis, 1881) pioneered in the use of ground photographs to provide a historical record of glaciers. As soon as new technology becomes available, scientists are quick to apply it to specific research needs. In the examples given, the successive technologies adopted to study glaciers were ground photography, aerial photography, and satellite imagery.

The Glaciers of Canada section of this volume is divided into several sections; two main topical sections and one subsection follow this introduction. Three main sections and two subsections cover the glaciers of the Arctic Islands; three main sections and one subsection cover the glaciers of the Canadian Rockies, Coast Mountains, and St. Elias Mountains. It is obvious that the lack of scientific knowledge about most of the glaciers of Canada precludes a comprehensive discussion of all of the glacierized regions. However, the potential of satellite remote sensing, including the higher spatial and spectral resolution imagery of post-Landsat multispectral scanner (MSS) images to investigate areal changes in Canada's glaciers, is well documented in the following sections. The emphasis on 1970's images in this introduction and the following sections is due to the goal of compiling a global baseline of glacier area (in the 1970's time frame) in this Satellite Image Atlas of Glaciers of the World series.

The first field observations of glaciers in Canada were made in 1861, nine years before Clarence R. King, the first Director of the U.S. Geological Survey (established in 1879), discovered Whitney Glacier on Mt. Shasta, Calif., and three more glaciers on the north slope of the volcano in 1870 (Williams and Ferrigno, 1997). Since that time, 176 glaciers in Canada—13 in the St. Elias Mountains, 63 in the Coast Mountains, 10 in the *Interior Ranges*, 27 in the Rocky Mountains, 41 in the High Arctic, 10 in the Low Arctic, 5 in the Torngat Mountains of Labrador (Newfoundland), and 7 outside these glacierized areas—have been studied. These studies, in the post-World War II to the 1980's period, were driven by scientific, economic, security, and sovereignty concerns, including the impetus from major cooperative international scientific programs, such as the International Geophysical Year and the International Hydrological Decade.

In 1999, the two Federal Departments having responsibilities in glaciology (Natural Resources Canada and Environment Canada) combined their glaciological expertise and resources to form a "National Glaciology Programme" (NGP). The NGP is housed at the Geological Survey of Canada [http://sts.gsc.nrcan.gc.ca] and is responsible, in part, for meeting Canada's glacier-observation commitment to the World Meteorological Organization's (WMO) Global Climate Observing System and the United Nations

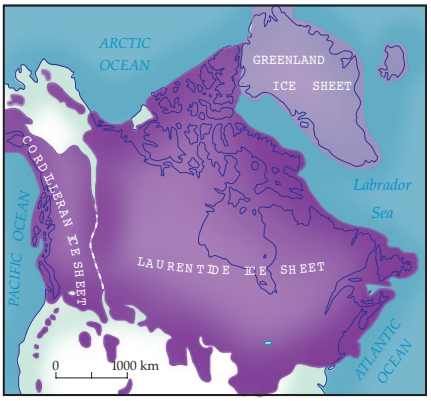


Figure 2.—*Glacierization of Canada (and Greenland and Iceland) during the Pleistocene Epoch, by S. Fick and A. Murray (see also Shilts and others, 1998), from the 1998 Canadian Geographic, v. 118, no. 7, Sources: Geomatics Canada, Glacier Atlas of Canada, National Hydrology Research Centre. Used with permission.*

Educational, Scientific, and Cultural Organization's (UNESCO) International Hydrological Programme (IHP). This activity is complemented by participation in the "CRYSYS" program (to study variability and change of the Canadian CRYospheric SYStem) [http://www.crysys.uwaterloo.ca], whose academic and government partners conduct research on the Canadian cryosphere using conventional and remote sensing methods.

As part of the glacier investigations during the past 140 years, especially between the middle 1940's and 1990's, one 1:4,000,000-scale map of the height of the glaciation level in western Canada and southern Alaska (glaciers shown in green) (Anonymous, 1978), one 1:2,000,000-scale map of glaciers and moraines in southern British Columbia and Alberta (glaciers shown in gray) (Østrem and others, 1966), seven 1:1,000,000-scale, 52 1:500,000 scale (Glacier Atlas of Canada), and 114 miscellaneous scale (1:2,500 to 1:125,000) maps of selected glaciers of Canada were published by governmental agencies and academic institutions. Satellite images, combined with digital-elevation models (DEMs) using geographic information systems (GIS) technology, are being used to produce new types of maps of Canada's glaciers. Roger D. Wheate, Robert W. Sidjak, and Garnet T. Whyte provide examples of the application of these technologies to two glaciers in the *Interior Ranges* and Rocky Mountains.

Until the preparation of this volume on the glaciers of Canada, the last effort to carry out a comprehensive review of the glacierized regions of Canada was done by William O. Field and his colleagues at the American Geographical Society (AGS) in the two-volume "Mountain Glaciers of the Northern Hemisphere," which also included an atlas containing 49 plates (Field, 1975c). The two volumes and atlas were produced by the AGS under contract with the Earth Sciences Division of the U.S. Army Engineer Topographic Laboratories and published by the Technical Information Analysis Center, Cold Regions Research and Engineering Laboratory, U.S. Army Corps of Engineers (Hanover, New Hampshire). (An earlier, similar atlas was published in 1958 (Field and Associates, 1958).) They include a comprehensive collation of published reports and maps of the glaciers of Canada (and other glacierized regions of the Northern Hemisphere) and are an excellent source of information from a variety of historical and modern sources. For all of the glacierized regions of Canada, including those regions not addressed in this volume, relevant chapters in the 1975 volumes will be cited.

In 1998, the Royal Canadian Geographical Society published, in the November/December 1998 issue of Canadian Geographic, an article on Canada's glaciers (Anonymous, 1998) and an 8-page color map foldout (Shilts and others, 1998). Several of the maps that appeared in the foldout map are reproduced, with permission and with some minor modifications, in the following sections of the "Glaciers of Canada." Another modern reference map of Canada is the 1:6,000,000-scale "New Century Map of Canada" published by Canadian Geographic in 1999 [http://www.canadiangeographic.ca]. See also the National Atlas (of Canada) Web site at [http://atlas.gc.ca], which will, in the near future, carry maps from the previously noted plates of the Glacier Atlas of Canada and contain links to available glacier-related data bases residing in government and university archives.

Topical Sections

Two topical sections follow this introduction. The two sections, written by C. Simon L. Ommanney, give a comprehensive review of "History of Glacier Investigations in Canada" and "Mapping Canada's Glaciers." The latter review is followed by a subsection on "Mapping Glaciers in the *Interior Ranges* and Rocky Mountains with Landsat Data," by Roger D. Wheate, Robert W. Sidjak, and Garnet T. Whyte.

Glaciers of the Arctic Islands

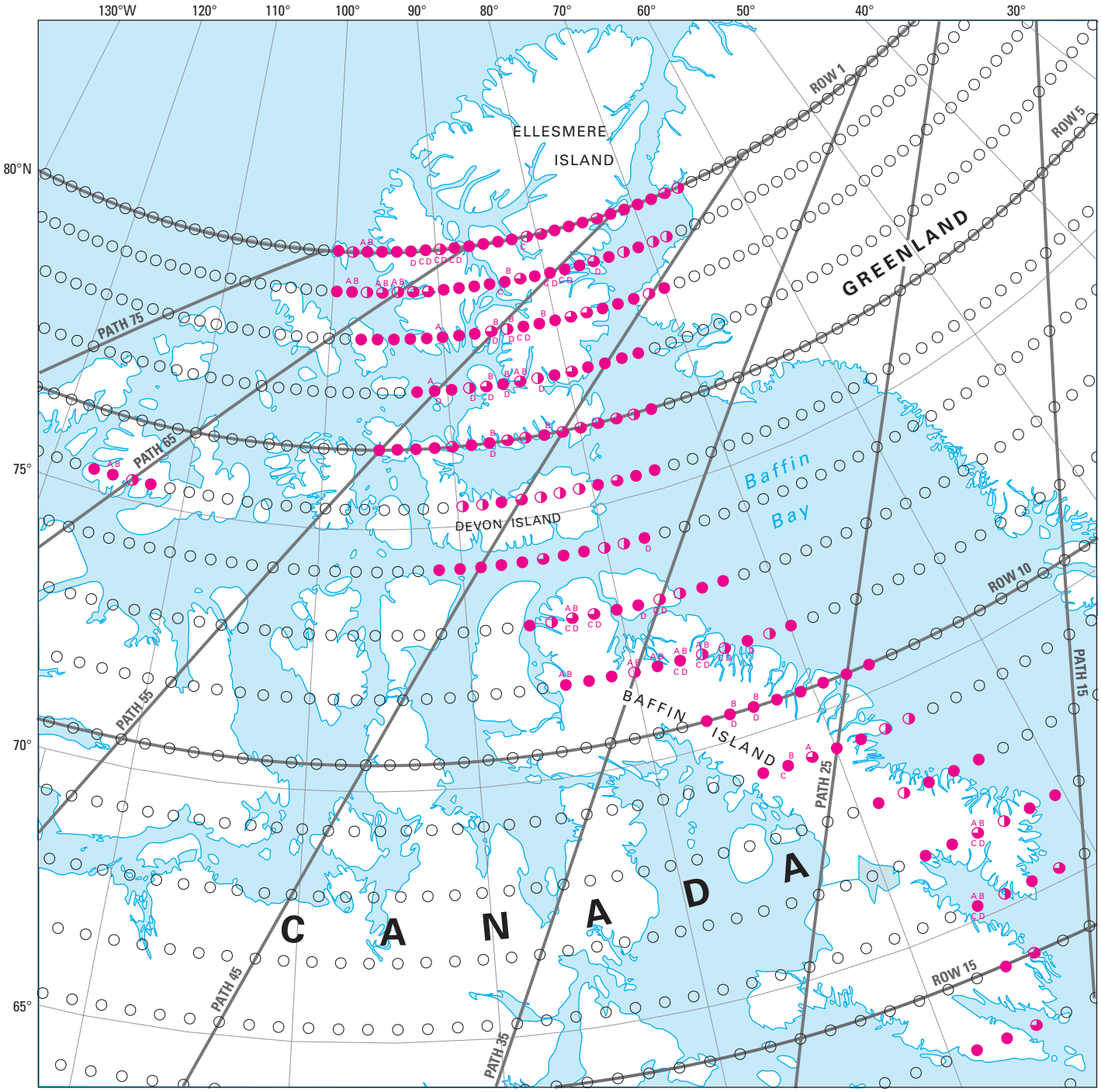
The glaciers of the Canadian Arctic represent the largest area (151,057 km^2) and volume of glacier ice in Canada and include about 5 percent of the glacierized area of the Northern Hemisphere (fig. 1, and fig. 1 in "Glaciers of the High Arctic Islands"). Ice caps and ice fields and associated outlet glaciers and smaller glaciers are present on several of the Queen Elizabeth Islands (Ellesmere, Axel Heiberg, Meighen, Coburg, Devon, and North Kent Islands, Nunavut, and in the western part of Melville Island, Northwest Territories) (Mercer, 1975b). Roy M. Koerner, in "Glaciers of the High Arctic Islands," describes both dynamic and stagnant ice caps. These ice caps exhibit a very slow response to climate change. Even though the last 150 years have been the warmest in the past millennium, only very slight changes in area and volume of the ice caps can be discerned.

Martin O. Jeffries describes historic and modern changes in the section "Ellesmere Island Ice Shelves and Ice Islands," including the use of Landsat MSS, RADARSAT synthetic aperture radar (SAR) and SPOT haute resolution visible (HRV) images to document changes in the ice shelves and ice plugs (multiyear landfast sea ice) that are located on the northwestern coast of Ellesmere Island. Although the ice shelves have been present since the middle Holocene Epoch, they were much more extensive in the past. The 20th century warming interval has resulted in a significant reduction in their areal extent.

The glaciers of the Canadian Low Arctic are located on Baffin and Bylot Islands (Mercer, 1975a). About 45 percent of Bylot Island (4,859 km^2) is covered by glaciers (see the book's cover). On Baffin Island, glaciers are found on the northern and eastern coasts, from the northeastern part of the Brodeur and Borden Peninsulas to the eastern part of the Hall and Meta Incognita Peninsulas, Nunavut (fig. 1 in "Glaciers of Baffin Island"). John T. Andrews addresses the geographic distribution and types of glaciers (ice caps and ice fields and associated outlet glaciers and smaller glaciers) in "Glaciers of Baffin Island," with specific reference to the two large ice caps, Barnes Ice Cap (5,935 km^2) and Penny Ice Cap (5,960 km^2); he concludes these two ice masses contain ice that represents the last remnants of the Laurentide Ice Sheet (fig. 2). He also concludes that the Barnes Ice Cap is slowly shrinking, a recession that could accelerate if significant regional climate warming were to occur. Gerald Holdsworth, in his discussion entitled "Barnes Ice Cap: Geomorphology and Thermodynamics," confirms that a whitish marginal strip of ice at the ice-cap margin has a $\delta^{18}O$ isotope value that indicates a late Pleistocene Epoch (Wisconsinan) age of the ice. John D. Jacobs examines "Late 20th Century Change of the Barnes Ice Cap Margin," using both Landsat and RADARSAT SAR images to document recession of Lewis Glacier and the calving ice-front in Gee Lake. Figure 3 and table 2 show the optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands.

The southernmost glaciers in eastern North America are located in the Torngat Mountains, Labrador, Newfoundland (fig. 1), but are not discussed in this chapter. Fahn (1975) states that most of the glaciers are cirque glaciers that form clusters on the slopes of the highest peaks. She further notes that the 1975 climatic conditions in the Torngat Mountains are marginal and that the glaciers have been receding since the end of the "Little Ice Age" (LIA).

Unpublished work by Ommanney (written commun., 2001) summarized the body of knowledge on the distribution of a significant number of rock glaciers in Labrador. Ommanney (written commun., 2001) and his colleagues also mapped one glacieret on the Québec side of the provincial border with Labrador, so there is (or was?) at least one glacier(et) in Québec.



EXPLANATION OF SYMBOLS

Evaluation of image usability for glaciologic, geologic, and cartographic applications. Symbols defined as follows:

- Excellent image (0 to ≤5 percent cloud cover)
- Good image (>5 to ≤10 percent cloud cover)
- Fair to poor image (>10 to <100 percent cloud cover)
- Nominal scene center for a Landsat image outside the area of glaciers
- A B / C D — Usable Landsat 3 return beam vidicon (RBV) scenes. A, B, C, and D refer to usable RBV subscenes

Figure 3.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada.*

TABLE 2.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada*

[The images archived by the Canada Centre for Remote Sensing (CCRS) are not identified on the CCRS Website (http://www.ccrs.nrcan.gc.ca) by Landsat identification number but can be located by path (track), row (frame), and date. The images archived by the EROS Data Center (EDC) (http://earthexplorer.usgs.gov) are no longer located or ordered by the Landsat identification number on the image but by a different entity number that incorporates satellite number, path, row, and date]

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
16–13	66°40'N. 60°28'W.	20202–14590	12 Aug 75	37	●	0	Baffin Island
16–14	65°20'N. 61°57'W.	20202–14592	12 Aug 75	38	●	5	
17–13	66°40'N. 61°55'W.	20185–15051	26 Jul 75	42	●	0	Image used for Andrews' figure 17
17–14	65°20'N. 63°23'W.	20185–15053	26 Jul 75	43	●	0	
17–15	63°59'N. 64°44'W.	1747–15083	09 Aug 74	40	◕	10	EDC[1]; image used for Andrews' figure 18
17–16	62°38'N. 65°58'W.	1747–15090	09 Aug 74	41	◕	10	EDC[1]; Terra Nivea and Grinnell Glacier; image used for Andrews' figure 19
18–13	66°40'N. 63°21'W.	20186–15105	27 Jul 75	42	◑	45	
18–14	65°20'N. 64°49'W.	20186–15112	27 Jul 75	43	◑	15	
18–15	63°59'N. 66°10'W.	20204–15111	14 Aug 75	39	●	0	
18–16	62°38'N. 67°24'W.	1712–15160	05 Jul 74	47	●	0	EDC
19–12	67°59'N. 63°08'W.	21663–15101	12 Aug 79	34	●	0	
19–13	66°40'N. 64°47'W.	21663–15103	12 Aug 79	35	◕	10	Penny Ice Cap; image used for Andrews' figure 16
19–13	66°40'N. 64°47'W.	30156–15172 A, B, C, D	08 Aug 78	38–39	●	5–30	Landsat 3 RBV[1]
19–14	65°20'N. 66°15'W.	21663–15110	12 Aug 79	36	●	0	
19–14	65°20'N. 66°15'W.	30156–15174 A, B, C, D	08 Aug 78	39–40	●	0	
19–16	62°38'N. 68°50'W.	21303–14584	17 Aug 78	~39	●	0	
20–12	67°59'N. 64°34'W.	11488–14431	19 Aug 76	32	●	0	Penny Ice Cap; extensive snow cover
20–13	66°40'N. 66°13'W.	11488–14434	19 Aug 76	33	●	0	Extensive snow cover
21–12	67°59'N. 66°00'W.	11453–14515	15 Jul 76	41	●	0	Penny Ice Cap
21–13	66°40'N. 67°39'W.	11453–14521	15 Jul 76	42	●	0	
22–11	69°17'N. 65°37'W.	11829–14232	26 Jul 77	37	◑	40	
22–12	67°59'N. 67°26'W.	11829–14234	26 Jul 77	37	◑	30	
23–11	69°17'N. 67°03'W.	20911–15163	21 Jul 77	40	◑	30	

TABLE 2.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
23–12	67°59'N. 68°52'W.	20911–15165	21 Jul 77	41	●	0	
24–10	70°35'N. 66°28'W.	20912–15214	22 Jul 77	39	●	0	
24–11	69°17'N. 68°29'W.	20912–15221	22 Jul 77	40	●	0	
25–10	70°35'N. 67°54'W.	11850–14380	16 Aug 77	30	●	0	
25–11	69°17'N. 69°55'W.	11850–14382	16 Aug 77	31	●	5	Southeastern end of Barnes Ice Cap
26–10	70°35'N. 69°20'W.	21292–15355	06 Aug 78	~36	●	0	
26–11	69°17'N. 71°21'W.	21328–15380	11 Sep 78	22	◕	10	Southeastern end of Barnes Ice Cap
26–11	69°17'N. 71°21'W.	30721–15514 A, B	24 Feb 80	10	◑	30	Landsat 3 RBV; subscene B used for Andrews' figure 15
27–10	70°35'N. 70°46'W.	1379–16124	06 Aug 73	36	●	0	Barnes Ice Cap
27–11	69°17'N. 72°48'W.	1379–16130	06 Aug 73	37	●	0	Barnes Ice Cap
27–11	69°17'N. 72°48'W.	30722–15572 B, C	25 Feb 80	~11	●	0	Barnes Ice Cap; Landsat 3 RBV
28–09	71°50'N. 69°54'W.	10380–16180	07 Aug 73	35	●	0	
28–10	70°35'N. 72°12'W.	10380–16182	07 Aug 73	36	●	0	Barnes Ice Cap; image used for Andrews' figure 5
28–10	70°35'N. 72°12'W.	30525–16065	12 Aug 79	32	●	0	Barnes Ice Cap; image used for Andrews' figure 8A
28–11	69°17'N. 74°14'W.	10380–16185	07 Aug 73	37	●	0	Barnes Ice Cap
28–11	69°17'N. 74°14'W.	30525–16071	12 Aug 79	33	●	0	Barnes Ice Cap
29–09	71°50'N. 71°20'W.	30526–16120	13 Aug 79	31	◑	20	
29–10	70°35'N. 73°38'W.	11119–15585	16 Aug 75	33	●	0	
29–10	70°35'N. 73°38'W.	30526–16122 B, D	13 Aug 79	30	●	0–20	Landsat 3 RBV
30–09	71°50'N. 72°46'W.	11855–15054	21 Aug 77	28	●	0	Extensive snow cover
30–09	71°50'N. 72°46'W.	30491–16174 D	09 Jul 79	41	●	0	Landsat 3 RBV
30–10	70°35'N. 75°04'W.	11855–15060	21 Aug 77	29	●	5	Barnes Ice Cap
30–10	70°35'N. 75°04'W.	30491–16181 B	09 Jul 79	41	●	0	Landsat 3 RBV
30–10	70°35'N. 75°04'W.	30725–16141 D	28 Feb 80	11	◑	20	Landsat 3 RBV

TABLE 2.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
31–09	71°50'N. 74°13'W.	11463–15471	25 Jul 76	37	◑	15	
31–09	71°50'N. 74°13'W.	30546–16232 C, D	02 Sep 79	26	◑	15–20	Landsat 3 RBV
31–10	70°35'N. 76°30'W.	11463–15473	25 Jul 76	37	●	0	
32–08	73°04'N. 73°03'W.	11464–15522	26 Jul 76	36	●	0	
32–09	71°50'N. 75°39'W.	11857–15170	23 Aug 77	27	◑	40	
32–09	71°50'N. 75°39'W.	30547–16290 A, B, C, D	03 Sep 79	25–26	●	0–10	Landsat 3 RBV
33–08	73°04'N. 74°29'W.	1403–16455	30 Aug 73	26	●	0	
33–09	71°50'N. 77°05'W.	1403–16461	30 Aug 73	27	●	0	Image used for Andrews' figure 4
33–09	71°50'N. 77°05'W.	30548–16345 A, B, C, D	04 Sep 79	25–26	◑	20–30	Landsat 3 RBV
34–08	73°04'N. 75°55'W.	11841–15294	07 Aug 77	32	◑	50	
34–09	71°50'N. 78°31'W.	1404–16515	31 Aug 73	27	●	0	
34–09	71°50'N. 78°31'W.	30549–16403 A, B	05 Sep 79	25	◑	20–50	Landsat 3 RBV
35–08	73°04'N. 77°21'W.	11842–15352	08 Aug 77	31	◑	15	
35–08	73°04'N. 77°21'W.	30586–16445 C, D	12 Oct 79	10	◕	10–20	Landsat 3 RBV
35–09	71°50'N. 79°57'W.	11125–16323	22 Aug 75	30	◑	20	
35–09	71°50'N. 79°57'W.	30586–16452 A, B	12 Oct 79	10	◑	20–40	Landsat 3 RBV
36–08	73°04'N. 78°47'W.	20204–16513	14 Aug 75	31	●	0	Bylot Island
36–08	73°04'N. 78°47'W.	30173–16525 D	25 Aug 78	28	◑	20	Landsat 3 RBV
36–09	71°50'N. 81°23'W.	11468–16152	30 Jul 76	35	●	0	
37–07	74°16'N. 77°14'W.	20943–16332	22 Aug 77	27	●	0	
37–07	74°16'N. 77°14'W.	30516–16572 D	03 Aug 79	33	◑	50	Landsat 3 RBV
37–08	73°04'N. 80°13'W.	20943–16335	22 Aug 77	28	●	0	Image used for Andrews' figure 3
37–09	71°50'N. 82°49'W.	20943–16341	22 Aug 77	29	●	0	
38–06	75°25'N. 75°14'W.	20944–16384	23 Aug 77	26	●	0	

TABLE 2.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
38–07	74°16'N. 78°40'W.	20926–16400	05 Aug 77	32	◑	50	Eastern end of Devon Island
38–08	73°04'N. 81°39'W.	11827–15540	24 Jul 77	35	◕	10	
38–08	73°04'N. 81°39'W.	30589–17020 C, D	15 Oct 79	9	◕	10–20	Landsat 3 RBV
38–09	71°50'N. 84°15'W.	30589–17023 A, B	15 Oct 79	9	●	0	Landsat 3 RBV
39–06	75°25'N. 76°40'W.	11147–16525	13 Sep 75	19	●	0	
39–07	74°16'N. 80°06'W.	20207–17081	17 Aug 75	29	◑	15	
39–08	73°04'N. 83°05'W.	1733–17123	26 Jul 74	36	◕	10	
39–08	73°04'N. 83°05'W.	30482–17091 A, B, C, D	30 Jun 79	40	●	0	Landsat 3 RBV
40–05	76°31'N. 74°08'W.	11130–16591	27 Aug 75	24	●	0	
40–06	75°25'N. 78°06'W.	11130–16593	27 Aug 75	25	◕	10	Eastern end of Devon Island
40–07	74°16'N. 81°32'W.	11130–17000	27 Aug 75	26	●	0	Eastern end of Devon Island
40–08	73°04'N. 84°31'W.	11130–17002	27 Aug 75	27	◑	15	
41–05	76°31'N. 75°34'W.	20209–17184	19 Aug 75	26	◑	40	Southeastern corner of Ellesmere Island
41–06	75°25'N. 79°33'W.	20551–17124	26 Jul 76	34	●	5	Devon Ice Cap
41–07	74°16'N. 82°58'W.	20551–17130	26 Jul 76	35	●	0	Extensive snow cover
41–08	73°04'N. 85°57'W.	21307–17015	21 Aug 78	~28	●	5	
42–05	76°31'N. 77°00'W.	20948–17010	27 Aug 77	24	◕	10	Southeastern corner of Ellesmere Island
42–06	75°25'N. 80°59'W.	20948–17012	27 Aug 77	25	◑	25	Devon Ice Cap
42–07	74°16'N. 84°24'W.	1376–17372	03 Aug 73	33	◕	10	EDC
43–04	77°33'N. 73°49'W.	20553–17231	28 Jul 76	31	●	5	
43–05	76°31'N. 78°26'W.	20553–17234	28 Jul 76	32	◕	10	
43–06	75°25'N. 82°25'W.	20553–17240	28 Jul 76	34	◑	30	Devon Ice Cap
43–07	74°16'N. 85°50'W.	20553–17243	28 Jul 76	35	●	0	Extensive snow cover

TABLE 2.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
44–03	78°29'N. 69°53'W.	20554–17283	29 Jul 76	30	●	5	
44–04	77°33'N. 75°15'W.	11458–17000	20 Jul 76	33	●	0	Extensive snow cover
44–05	76°31'N. 79°53'W.	11458–17003	20 Jul 76	34	◕	10	Extensive snow cover
44–06	75°25'N. 83°51'W.	30523–17365	10 Aug 79	28	◑	20	Image used for Koerner's figure 2
44–07	74°16'N. 87°17'W.	1378–17485	05 Aug 73	32	●	0	EDC
45–03	78°29'N. 71°19'W.	20555–17341	30 Jul 76	30	◑	25	
45–04	77°33'N. 76°41'W.	11459–17054	21 Jul 76	33	●	0	Extensive snow cover
45–05	76°31'N. 81°19'W.	11459–17060	21 Jul 76	34	◕	10	Extensive snow cover
45–06	75°25'N. 85°17'W.	20951–17183	30 Aug 77	23	◕	10	Extensive snow cover
45–07	74°16'N. 88°43'W.	30524–17430	11 Aug 79	29	●	0	
46–03	78°29'N. 72°45'W.	11514–17063	14 Sep 76	15	●	0	Eastern side of Ellesmere Island
46–04	77°33'N. 78°07'W.	1758–17500	20 Aug 74	25	●	0	Eastern side of Ellesmere Island; image used for Koerner's figure 5
46–05	76°31'N. 82°45'W.	1758–17503	20 Aug 74	26	●	0	Southeastern corner of Ellesmere Island
46–05	76°31'N. 82°45'W.	30561–17473 A, B, D	17 Sep 79	15–16	◕	10–20	Landsat 3 RBV
46–06	75°25'N. 86°43'W.	1758–17505	20 Aug 74	27	●	0	
46–07	74°16'N. 90°09'W.	1758–17512	20 Aug 74	28	●	0	
47–02	79°19'N. 67°56'W.	2520–17403	25 Jun 76	33	◑	20	EDC; Landsat 2 RBV
47–03	78°29'N. 74°11'W.	11461–17163	23 Jul 76	32	●	0	Extensive snow cover
47–04	77°33'N. 79°33'W.	11854–16411	20 Aug 77	25	◕	10	Southeastern Ellesmere Island
47–05	76°31'N. 84°11'W.	11497–17142	28 Aug 76	23	◑	15	
47–06	75°25'N. 88°09'W.	30184–17552	05 Sep 78	~20	◑	40	Devon Island
47–07	74°16'N. 91°35'W.	1399–18054	26 Aug 73	26	●	0	Extensive snow cover
48–02	79°19'N. 69°22'W.	2558–17505	02 Aug 76	27	◑	30	EDC; Landsat 2 RBV

TABLE 2.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
48–03	78°29'N. 75°37'W.	1760–18010	22 Aug 74	23	●	0	Ellesmere Island; Prince of Wales Icefield; image used for Koerner's figure 5
48–04	77°33'N. 81°00'W.	1760–18013	22 Aug 74	24	●	0	Ellesmere Island; Prince of Wales Icefield
48–05	76°31'N. 85°37'W.	1760–18015	22 Aug 74	25	◕	10	Ellesmere Island; Sydkap Ice Cap; image used for Koerner's figure 4
48–06	75°25'N. 89°35'W.	1760–18022	22 Aug 74	26	◑	40	
49–02	79°19'N. 70°48'W.	2559–17563	03 Aug 76	27	●	0	EDC
49–03	78°29'N. 77°03'W.	20559–17570	03 Aug 76	29	◕	10	Ellesmere Island; Prince of Wales Icefield
49–04	77°33'N. 82°26'W.	20559–17573	03 Aug 76	30	◑	40	Ellesmere Island; Prince of Wales Icefield
49–04	77°33'N. 82°26'W.	30546–18043 D	02 Sep 79	21	◑	30	Landsat 3 RBV
49–05	76°31'N. 87°03'W.	11463–17284	25 Jul 76	33	●	0	Ellesmere Island; Sydkap Ice Cap
49–05	76°31'N. 87°03'W.	30546–18050 B, D	02 Sep 79	21–22	◕	10	Landsat 3 RBV
50–01	80°01'N. 65°04'W.	2614–18002	27 Sep 76	6	◑	50	EDC
50–02	79°19'N. 72°14'W.	2597–18070	10 Sep 76	14	◑	50	EDC
50–03	78°29'N. 78°29'W.	30511–18100	29 Jul 79	28	◕	10	Ellesmere Island; Prince of Wales Icefield
50–04	77°33'N. 83°52'W.	11839–17000	05 Aug 77	29	◕	10	Ellesmere Island; Sydkap Ice Cap
50–04	77°33'N. 83°52'W.	30187–18114 A, B	08 Sep 78	18	◕	10–50	Landsat 3 RBV
50–05	76°31'N. 88°29'W.	11839–17002	05 Aug 77	30	●	0	
51–01	80°01'N. 66°30'W.	2548–18361	23 Jul 76	27	◕	10	EDC; northeastern Ellesmere Island; Landsat 2 RBV
51–02	79°19'N. 73°40'W.	2543–18083	18 Jul 76	31	●	0	EDC; northeastern Ellesmere Island; Landsat 2 RBV
51–03	78°29'N. 79°55'W.	11465–17391	27 Jul 76	31	●	5	Ellesmere Island; Prince of Wales Icefield
51–04	77°33'N. 85°18'W.	11465–17394	27 Jul 76	32	●	5	
51–04	77°33'N. 85°18'W.	30206–18174 B, D	27 Sep 78	11	◑	20	Landsat 3 RBV
51–05	76°31'N. 89°55'W.	11465–17400	27 Jul 76	33	◕	10	
52–01	80°01'N. 67°56'W.	2544–18135	19 Jul 76	29	●	0	EDC; northeastern Ellesmere Island; Landsat 2 RBV

TABLE 2.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
52–02	79°19'N. 75°06'W.	20544–18142	19 Jul 76	31	◕	10	
52–02	79°19'N. 75°06'W.	30531–18211 D	18 Aug 79	24	◑	70	Landsat 3 RBV
52–03	78°29'N. 81°21'W.	20904–17595	14 Jul 77	33	●	0	
52–03	78°29'N. 81°21'W.	30521–18213 B	18 Aug 79	24	◑	20	Landsat 3 RBV
52–04	77°33'N. 86°44'W.	20904–18002	14 Jul 77	34	◕	10	
52–04	77°33'N. 86°44'W.	30207–18232 B, D	28 Sep 78	10	◑	20–30	Landsat 3 RBV
52–05	76°31'N. 91°21'W.	20904–18004	14 Jul 77	35	●	0	
53–01	80°01'N. 69°22'W.	2550–18474	25 Jul 76	27	●	5	EDC; Landsat 2 RBV
53–02	79°19'N. 76°32'W.	11860–17141	26 Aug 77	21	●	5	
53–03	78°29'N. 82°47'W.	11860–17144	26 Aug 77	22	●	0	
53–03	78°29'N. 82°47'W.	21265–18063	10 Jul 78	~34	●	0	Ablation area visible
53–03	78°29'N. 82°47'W.	30208–18284 C, D	29 Sep 78	9	◕	10–40	Landsat 3 RBV
53–04	77°33'N. 88°10'W.	30514–18274	01 Aug 79	28	◑	30	
53–04	77°33'N. 88°10'W.	30208–18291 D	29 Sep 78	10	◑	20	Landsat 3 RBV
53–05	76°31'N. 92°47'W.	30514–18280	01 Aug 79	29	●	0	
54–01	80°01'N. 70°48'W.	2583–18295	27 Aug 76	18	●	0	EDC; Ellesmere Island; eastern Agassiz Ice Cap; Landsat 2 RBV
54–02	79°19'N. 77°58'W.	11843–17214	09 Aug 77	26	●	5	
54–02	79°19'N. 77°58'W.	30191–18335 C, D	12 Sep 78	14	◕	10–20	Landsat 3 RBV
54–03	78°29'N. 84°13'W.	21644–18270	24 Jul 79	29	◑	20	
54–03	78°29'N. 84°13'W.	30191–18342 B, D	12 Sep 78	15	◕	10–30	Landsat 3 RBV
54–04	77°33'N. 89°36'W.	20546–18263	21 Jul 76	33	●	0	
54–05	76°31'N. 94°13'W.	20924–18111	03 Aug 77	31	●	0	
55–01	80°01'N. 72°14'W.	2601–18292	14 Sep 76	11	●	0	EDC; Ellesmere Island; Agassiz Ice Cap; Landsat 2 RBV

TABLE 2.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
55–02	79°19'N. 79°24'W.	11109–18251	06 Aug 75	27	●	0	
55–02	79°19'N. 79°24'W.	30192–18394 C, D	13 Sep 78	14	◑	20–50	Landsat 3 RBV
55–03	78°29'N. 85°39'W.	30516–18384	03 Aug 79	27	◕	10	Southern Axel Heiberg Island
55–03	78°29'N. 85°39'W.	30516–18384 B, C, D	03 Aug 79	27	●	0–5	Southern Axel Heiberg Island; Landsat 3 RBV
55–04	77°33'N. 91°02'W.	30516–18391	03 Aug 79	28	●	0	
55–04	77°33'N. 91°02'W.	30516–18391 A, D	03 Aug 79	28	●	0	Landsat 3 RBV
55–05	76°31'N. 95°39'W.	1371–18511	29 Jul 73	~31	◑	50	EDC
56–01	80°01'N. 73°40'W.	2591–19151	04 Sep 76	14	◕	10	EDC; Ellesmere Island; Agassiz Ice Cap; Landsat 2 RBV
56–02	79°19'N. 80°50'W.	20548–18371	23 Jul 76	30	●	0	
56–03	78°29'N. 87°05'W.	20926–18214	05 Aug 77	28	◑	20	Southern Axel Heiberg Island
56–03	78°29'N. 87°05'W.	20548–18373	23 Jul 76	31	●	0	Southern Axel Heiberg Island
56–04	77°33'N. 92°28'W.	30517–18445	04 Aug 79	27	●	0	
57–01	80°01'N. 75°06'W.	2548–18364	23 Jul 76	29	●	0	EDC; Ellesmere Island; Agassiz Ice Cap; Landsat 2 RBV
57–01	80°01'N. 75°06'W.	2609–19144	22 Sep 76	7	◕	10	EDC; Ellesmere Island; Agassiz Ice Cap; Landsat 2 RBV
57–02	79°19'N. 82°16'W.	11864–17364	30 Aug 77	20	◕	10	
57–03	78°29'N. 88°31'W.	20945–18262	24 Aug 77	22	●	0	Southern Axel Heiberg Island
58–01	80°01'N. 76°32'W.	2550–18480	25 Jul 76	28	●	0	EDC; Ellesmere Island; Agassiz Ice Cap; Landsat 2 RBV; image used for Koerner's figure 8
58–02	79°19'N. 83°42'W.	20550–18483	25 Jul 76	30	●	0	
58–02	79°19'N. 83°42'W.	30123–18560 B, C	06 Jul 78	33	◕	10	Landsat 3 RBV
58–03	78°29'N. 89°57'W.	20154–18563	25 Jun 75	35	●	0	Southern Axel Heiberg Island
58–03	78°29'N. 89°57'W.	30123–18563 A	06 Jul 78	34	◑	20	Landsat 3 RBV
59–01	80°01'N. 77°58'W.	20551–18535	26 Jul 76	28	●	0	Ellesmere Island; Agassiz Ice Cap
59–02	79°19'N. 85°08'W.	20551–18541	26 Jul 76	30	●	0	

TABLE 2.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
59–03	78°29'N. 91°23'W.	20947–18374	26 Aug 77	22	●	0	Southern Axel Heiberg Island
60–01	80°01'N. 79°24'W.	20552–18593	27 Jul 76	28	◕	10	Ellesmere Island; Agassiz Ice Cap
60–02	79°19'N. 86°34'W.	20948–18430	27 Aug 77	20	●	5	Axel Heiberg Island
60–03	78°29'N. 92°49'W.	20948–18432	27 Aug 77	21	●	0	
61–01	80°01'N. 80°50'W.	2596–19434	09 Sep 76	12	◑	20	EDC; Landsat 2 RBV
61–01	80°01'N. 80°50'W.	30198–19134 C	19 Sep 78	10	◑	20	Landsat 3 RBV
61–02	79°19'N. 88°00'W.	20949–18484	28 Aug 77	20	●	0	Axel Heiberg Island
61–03	78°29'N. 94°15'W.	20949–18490	28 Aug 77	21	●	0	
62–01	80°01'N. 82°16'W.	2559–19390	03 Aug 76	25	●	5	EDC; Landsat 2 RBV
62–02	79°19'N. 89°27'W.	20950–18542	29 Aug 77	20	●	0	Axel Heiberg Island; image used for Koerner's figure 7
62–03	78°29'N. 95°42'W.	20950–18545	29 Aug 77	21	●	0	
63–01	80°01'N. 83°42'W.	2196–19292	06 Aug 75	25	●	0	EDC; Ellesmere Island
63–02	79°19'N. 90°53'W.	2196–19295	06 Aug 75	26	◕	10	EDC; Axel Heiberg Island
63–03	78°29'N. 97°08'W.	30506–19243	24 Jul 79	29	●	0	
64–01	80°01'N. 85°08'W.	1758–19320	20 Aug 74	21	●	0	
64–02	79°19'N. 92°19'W.	20196–19295	06 Aug 75	27	◕	10	Axel Heiberg Island
64–06	75°25'N. 112°32'W.	21654–19254	03 Aug 79	30	●	0	Melville Island
65–01	80°01'N. 86°35'W.	1759–19375	21 Aug 74	21	●	5	
65–02	79°19'N. 93°45'W.	30508–19354	26 Jul 79	27	◑	20	
65–02	79°19'N. 93°45'W.	30202–19365 A, B	23 Sep 78	~9	◑	40–69	Landsat 3 RBV
65–06	75°25'N. 113°58'W.	1723–19411	16 Jul 74	36	◑	20	
66–01	80°01'N. 88°01'W.	1760–19433	22 Aug 74	21	●	5	Axel Heiberg Island
66–01	80°01'N. 88°01'W.	30563–19403 C, D	19 Sep 79	10	●	0	Axel Heiberg Island; Landsat 3 RBV

TABLE 2.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Arctic Islands of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
66–02	79°19'N. 95°11'W.	11855–18292	21 Aug 77	23	◕	10	Meighen and Axel Heiberg Islands
66–02	79°19'N. 95°11'W.	30563–19405 A, B, C, D	19 Sep 79	11–12	●	0–10	Axel Heiberg Island; Landsat 3 RBV
66–06	75°25'N. 115°24'W.	11855–18310	21 Aug 77	26	●	0	Melville Island; image used for Koerner's figure 16
66–06	75°25'N. 115°24'W.	30527–19431 A, B	14 Aug 79	29	●	0	Melville Island; Landsat 3 RBV
67–01	80°01'N. 89°27'W.	30510–19464	28 Jul 79	28	◑	40	
67–01	80°01'N. 89°27'W.	30204–19481 C, D	25 Sep 78	8	◕	10–20	Landsat 3 RBV
67–02	79°19'N. 96°37'W.	30510–19471	28 Jul 79	27	◑	30	
67–06	75°25'N. 116°50'W.	1725–19523	18 Jul 74	35	●	0	EDC; Melville Island
68–01	80°01'N. 90°53'W.	11857–18401	23 Aug 77	21	●	0	Axel Heiberg Island
68–01	80°01'N. 90°53'W.	30187–19534 C, D	08 Sep 78	15	●	0	Axel Heiberg Island; Landsat 3 RBV
68–02	79°19'N. 98°03'W.	1762–19551	24 Aug 74	20	●	0	EDC; Meighen Island
68–02	79°19'N. 98°03'W.	30187–19534 A, B	08 Sep 78	15	●	0–10	Axel Heiberg Island; Landsat 3 RBV
69–01	80°01'N. 92°19'W.	11858–18455	24 Aug 77	21	●	0	Meighen and Axel Heiberg Islands; image used for Koerner's figures 7 and 9
69–01	80°01'N. 92°19'W.	30188–19593 D	09 Sep 78	14	◕	10	Axel Heiberg Island; Landsat 3 RBV
69–02	79°19'N. 99°29'W.	1763–20005	25 Aug 74	20	●	0	EDC; Meighen Island
70–01	80°01'N. 93°45'W.	11859–18513	25 Aug 77	21	●	5	Meighen and Axel Heiberg Islands
71–01	80°01'N. 95°11'W.	11860–18570	26 Aug 77	20	●	0	Meighen and Axel Heiberg Islands
72–01	80°01'N. 96°37'W.	11861–19024	27 Aug 77	20	●	0	Meighen and Axel Heiberg Islands
72–01	80°01'N. 96°37'W.	30191–20164 A, B	12 Sep 78	12	●	0–40	Axel Heiberg Island; Landsat 3 RBV
73–01	80°01'N. 98°03'W.	11862–19082	28 Aug 77	20	◑	20	Meighen and Axel Heiberg Islands
74–01	80°01'N. 99°29'W.	11863–19140	29 Aug 77	19	●	5	

[1] Most of the images in this table were acquired by the Canada Centre for Remote Sensing (CCRS). Those acquired by the U.S. Geological Survey's EROS Data Center (EDC) are indicated by the EDC acronym. Unfortunately, all of the Return Beam Vidicon (RBV) images acquired by both CCRS and EDC are no longer available from either of the two national Landsat image archives. However, all of the Landsat RBV images listed are archived by the U.S. Geological Survey's Glacier Studies Project.

Glaciers of Western Canada

The glaciers of the Rocky Mountains of Canada were discussed by Denton (1975a) in "Mountain Glaciers of the Northern Hemisphere." In this volume, C. Simon L. Ommanney provides a comprehensive review entitled "Glaciers of the Canadian Rockies." He subdivides the Canadian Rockies into four mountain ranges, Border, Continental, Hart, and Muskwa Ranges, and discusses the extent of glacierization within the many smaller ranges and mountain groups that comprise these ranges. The Continental Ranges are heavily glacierized and include a number of major ice fields and outlet glaciers; the Columbia Icefield, with an area of 325 km^2, is the largest glacier in the Rocky Mountains. In addition to the large ice fields and associated outlet glaciers, many smaller mountain glaciers are distributed throughout the ranges.

The *Interior Ranges* (fig. 4) of British Columbia, situated between the Rocky Mountains on the east and the Coast Mountains on the west, are not

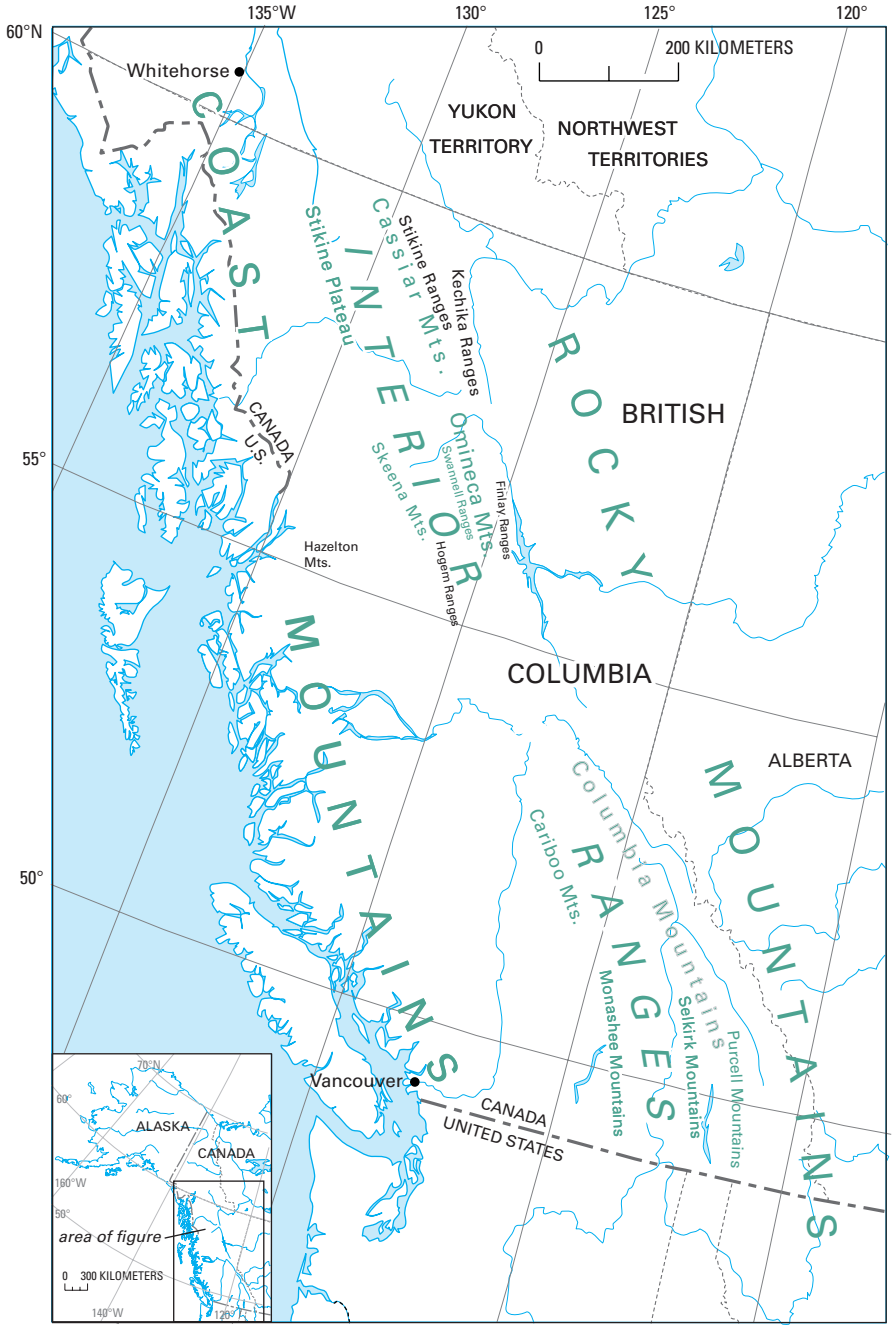


Figure 4.—*Map of the major mountain ranges in the* Interior Ranges *of British Columbia. Glacierized ranges indicated in green, non-glacierized in black.*

discussed in this volume, except with reference to glaciological research and glacier mapping in the "History of Glacier Investigations in Canada" and in "Mapping Canada's Glaciers," by C. Simon L. Ommanney and for an analysis of the Illecillewaet Glacier and Illecillewaet Névé in the Selkirk Mountains within the Columbia Mountains in the section on "Mapping Glaciers in the *Interior Ranges* and Rocky Mountains with Landsat Data," by Roger D. Wheate, Robert W. Sidjak, and Garnet T. Whyte. Figure 5 and table 3 provide a list and assessment of the optimum Landsat 1, 2, and 3 MSS images of the glaciers of the Canadian *Interior Ranges* and Rocky Mountains.

A brief review of the "Interior Ranges of British Columbia" by Denton (1975c) will provide some perspective, however. Denton (1975c) stated that the Selkirk, Purcell, Cariboo, and Monashee Mountains within the Columbia Mountains are glacierized. Part of the Omineca and Cassiar Mountains, including the Swannell Ranges, the Skeena Mountains, and the Stikine Plateau, also contain glaciers (fig. 4). Denton (1975c) concluded that the Finlay, Hogem, Stikine, and Kechika Ranges of the Omineca and Cassiar Mountains and the Hazelton Mountains did not have glaciers (fig. 4).

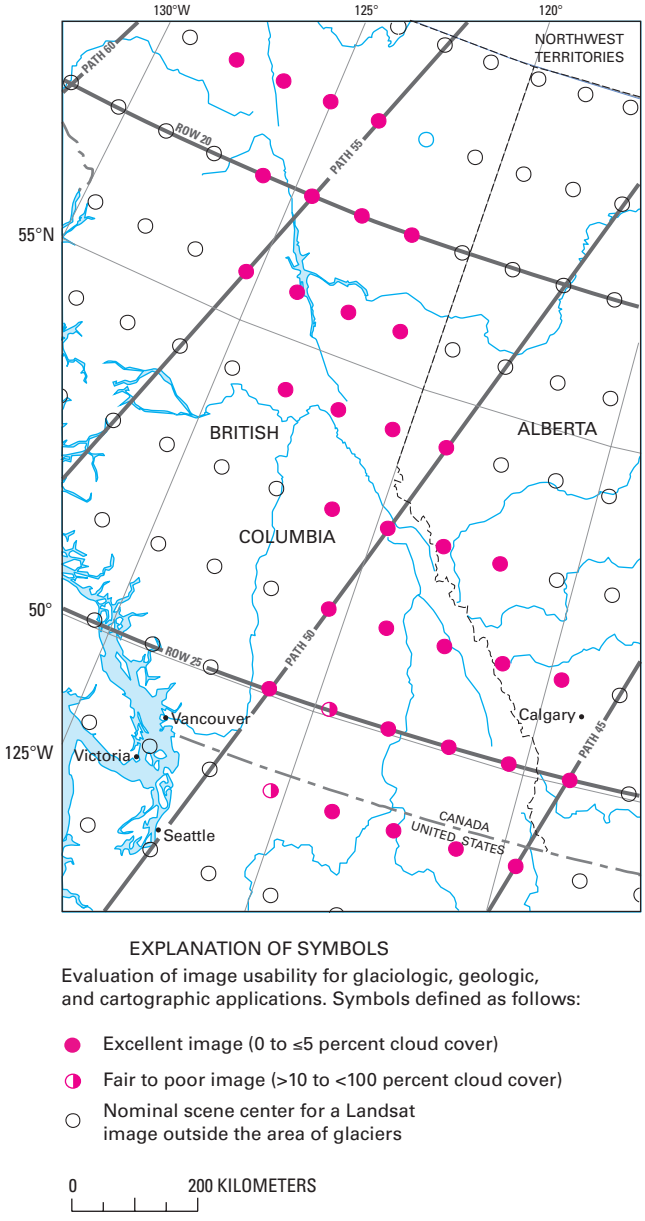


Figure 5.—*Optimum Landsat 1, 2, and 3 MSS images of the glaciers of the Canadian Rocky Mountains and* Interior Ranges.

TABLE 3.—*Optimum Landsat 1, 2, and 3 MSS images of the glaciers of the Canadian Rocky Mountains and* Interior Ranges

[**, The images archived by the Canada Centre for Remote Sensing (CCRS) are not identified on the CCRS Website (http://www.ccrs.nrcan.gc.ca) by Landsat identification number but can be located by path (track), row (frame), and date. The images archived by the EROS Data Center (EDC) (http://earthexplorer.usgs.gov) are no longer located or ordered by the Landsat identification number on the image but by a different entity number that incorporates satellite number, path, row, and date]

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
45–25	50°09'N. 113°58'W.	**	14 Sep 81	~38	●	0	Archived by CCRS[1]
45–26	48°44'N. 114°36'W.	22427–17465	14 Sep 81	39	●	0	Archived by EDC
46–24	51°34'N. 114°43'W.	30561–17552	17 Sep 79	36	●	0	Archived by EDC
46–25	50°09'N. 115°24'W.	**	17 Sep 79	37	●	0	Archived by CCRS
46–26	48°44'N. 116°02'W.	30561–17561	17 Sep 79	38	●	0	Archived by EDC
47–24	51°34'N. 116°09'W.	1741–18044	03 Aug 74	49	◑	30	Columbia to Waputik Icefields; archived by EDC
47–24	51°34'N. 116°09'W.	**	11 Aug 81	~46	●	5	Columbia to Waputik Icefields; archived by CCRS
47–25	50°09'N. 116°50'W.	1741–18050	03 Aug 74	50	◑	40	Archived by EDC
47–25	50°09'N. 116°50'W.	**	11 Aug 81	~47	●	0	Archived by CCRS
47–26	48°44'N. 117°28'W.	22393–17584	11 Aug 81	48	●	5	Archived by EDC
48–23	52°58'N. 116°52'W.	**	13 Sep 75	~36	●	0	Archived by CCRS
48–24	51°34'N. 117°35'W.	**	13 Sep 75	~37	●	0	Columbia to Waputik Icefields; archived by CCRS
48–24	51°34'N. 117°35'W.	2252–18062	01 Oct 75	31	●	0	Columbia to Waputik Icefields; image used for figure 7; archived by EDC
48–25	50°09'N. 118°16'W.	2234–18070	13 Sep 75	38	●	0	Archived by EDC
48–26	48°44'N. 118°54'W.	2234–18073	13 Sep 75	39	●	0	Archived by EDC
49–23	52°58'N. 118°18'W.	1419–18233	15 Sep 73	36	●	0	Mount Robson area to Clemenceau Icefield; archived by EDC
49–24	51°34'N. 119°01'W.	1419–18235	15 Sep 73	37	●	0	Archived by EDC
49–25	50°09'N. 119°42'W.	1419–18242	15 Sep 73	39	◑	20	Archived by EDC
49–26	48°44'N. 120°20'W.	1419–18244	15 Sep 73	40	◑	20	Archived by EDC
50–22	54°22'N. 118°59'W.	1420–18285	16 Sep 73	35	●	0	Mount Sir Alexander; archived by EDC
50–23	52°58'N. 119°44'W.	1420–18291	16 Sep 73	36	●	0	Mount Robson area; image used for figure 29; archived by EDC
50–24	51°34'N. 120°27'W.	1420–18294	16 Sep73	37	●	0	Archived by EDC
50–25	50°09'N. 121°08'W.	1420–18300	16 Sep 73	38	●	0	Archived by EDC
51–22	54°22'N. 120°26'W.	1385–18351	12 Aug 73	46	●	0	Mount Sir Alexander; archived by EDC
51–23	52°58'N. 121°11'W.	1385–18353	12 Aug 73	47	●	0	Cariboo Range; archived by EDC
52–21	55°45'N. 121°04'W.	21696–18241	14 Sep 79	34	●	0	Archived by EDC

TABLE 3.—*Optimum Landsat 1, 2, and 3 MSS images of the glaciers of the Canadian Rocky Mountains and* Interior Ranges—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
52–22	54°22'N. 121°52'W.	**	14 Sep 79	~35	●	0	Archived by CCRS
52–22	54°22'N. 121°52'W.	2544–18223	19 Jul 76	50	●	0	Archived by EDC
53–20	57°08'N. 121°39'W.	1783–18355	14 Sep 74	33	●	0	Archived by EDC
53–20	57°08'N. 121°39'W.	**	17 Aug 81	~43	●	0	Archived by CCRS
53–21	55°45'N. 122°30'W.	1783–18361	14 Sep 74	34	◑	40	Archived by EDC
53–21	55°45'N. 122°30'W.	**	17 Aug 81	~44	●	0	Archived by CCRS
53–22	54°22'N. 123°18'W.	1783–18364	14 Sep 74	35	◑	30	Archived by EDC
53–22	54°22'N. 123°18'W.	**	17 Aug 81	~45	●	0	Archived by CCRS
54–20	57°08'N. 123°05'W.	1082–18515	13 Oct 72	23	●	0	Great Snow Mountain; extensive snow cover; archived by EDC
54–20	57°08'N. 123°05'W.	**	14 Aug 75	~44	●	5	Great Snow Mountain; archived by CCRS
54–21	55°45'N. 123°56'W.	1082–18522	13 Oct 72	24	●	0	Extensive snow cover; archived by EDC
54–21	55°45'N. 123°56'W.	**	14 Aug 75	~45	●	5	Archived by CCRS
55–19	58°31'N. 123°37'W.	1767–18473	29 Aug 74	37	◑	30	Mount Roosevelt, Churchill Peak; archived by EDC
55–19	58°31'N. 123°37'W.	**	11 Sep 75	~32	●	5	Mount Roosevelt, Churchill Peak; archived by CCRS
55–20	57°08'N. 124°31'W.	1767–18475	29 Aug 74	39	◑	20	Mount Lloyd George, Great Snow Mountain; archived by EDC
55–20	57°08'N. 124°31'W.	**	11 Sep 75	~33	●	0	Mount Lloyd George, Great Snow Mountain; archived by CCRS
55–21	55°45'N. 125°22'W.	1767–18482	29 Aug 74	39	●	0	Archived by EDC
55–21	55°45'N. 125°22'W.	**	11 Sep 75	~34	●	0	Archived by CCRS
56–19	58°31'N. 125°03'W.	1750–18535	12 Aug 74	43	◕	10	Mount Roosevelt, Mount Lloyd George; image used for figure 33; archived by EDC
56–19	58°31'N. 125°03'W.	**	12 Sep 75	~32	●	5	Mount Roosevelt, Mount Lloyd George; archived by CCRS
56–20	57°08'N. 125°57'W.	1750–18542	12 Aug 74	44	◕	10	Image used for figure 33; archived by EDC
56–20	57°08'N. 125°57'W.	**	12 Sep 75	~33	●	0	Archived by CCRS
57–19	58°31'N. 126°29'W.	1769–18585	31 Aug 74	37	◑	20	Mount Roosevelt; archived by EDC
57–19	58°31'N. 126°29'W.	**	07 Aug 82	~44	●	0	Archived by CCRS
58–19	58°31'N. 127°55'W.	5865–17492	31 Aug 77	30	●	0	Archived by EDC

[1] The cloud cover and evaluations of images archived by CCRS are based on the CCRS World Wide Web page listing (http://www.ccrs. nrcan.gc.ca). There is no browse image for these scenes, but the cloud cover evaluation has been reliable when compared with images that have been inspected directly.

The "Glaciers of the Coast Mountains (Pacific Ranges and Cascade Mountains) and Coast Ranges of British Columbia" were previously discussed by Denton (1975b). Ommanney (1972) provided comprehensive information about glaciers on Vancouver Island [Canada: Environment: Inland Waters Branch (1971a, b)], considered to be part of the Coast Ranges (fig. 1). Field (1975a) also addressed the "Glaciers of the Coast Mountains: Boundary Ranges (Alaska, British Columbia, and Yukon Territory.)" In this volume, Garry K.C. Clarke and Gerald Holdsworth discuss some aspects of the "Glaciers of the Coast Mountains," with special emphasis on glaciological hazards, such as jökulhlaups, the use of small glaciers as recreational resources, and the special problems associated with carrying out mining operations in glacierized regions.

The St. Elias Mountains are considered to be the most spectacular series of mountain ranges in North America. They are heavily glacierized and include three of the six highest mountain peaks on the continent. Mt. Logan, Yukon Territory, Canada, at 5,959 m [http://www.ice2001.com], is second only to Mt. McKinley (6,194 m), Alaska, in elevation. The St. Elias Mountains lie along the international border of the United States and Canada, between Alaska and Yukon Territory (fig. 1 in "History of Glacier Investigations in Canada," and fig. 1 in "Glaciers of the St. Elias Mountains"). Field (1975b) described the St. Elias Mountains in his compilation. Garry K.C. Clarke and Gerald Holdsworth, in the "Glaciers of the St. Elias Mountains" section of this volume, describe some of the valley glaciers, plateau glaciers, ice fields and associated outlet glaciers, and piedmont glaciers that characterize the region. The glaciers are classified as temperate, subpolar, and cold; at least 136 of the subpolar glaciers are surge-type glaciers. In a special section, "Quantitative Measurements of Tweedsmuir Glacier and Lowell Glacier Imagery," Gerald Holdworth, Philip J. Howarth, and C. Simon L. Ommanney discuss the application of sequential Landsat images to two surging glaciers. Figure 6 and table 4 provide a list and assessment of the optimum Landsat 1, 2, and 3 MSS and RBV images of the Coast and St. Elias Mountains of Canada.

Several mountain groups in the Yukon and Northwest Territories (fig. 7) have glaciers according to Horvath (1975), including the Hess and Wernecke Mountains in the Selwyn Mountains, the Ogilvie Mountains, and the Backbone and Canyon Ranges of the Mackenzie Mountains. The Logan Mountains, located in the Selwyn Mountains, have glaciers according to provisional (as of 1985) NTS 1:50,000-scale map sheets (Demuth, written commun., 2001). Demuth (written commun., 2001) is evaluating the feasibility of establishing a glacier mass-balance-monitoring site near the Cirque of the Unclimbables in the Logan Mountains. The Yukon Plateau and the Kluane Ranges may also have glaciers (Ommanney, written commun., 2001). None of the these mountains are covered in this volume. Ommanney (1993) reported on an inventory of Yukon glaciers based on hydrologic basins. Glaciers on the Alaska side of the hydrologic divide account for about 7,250 km^2 of ice; those within the Yukon divide, feeding the Yukon River, about 3,000 km^2, and those within the Alsek River basin, draining through the Panhandle into the Pacific Ocean, account for about 3,800 km^2 of ice.

Landsat MSS images are most useful in the study of changes in large glaciers, ice caps and ice fields, and associated outlet glaciers in Arctic Canada, and of ice fields and associated outlet glaciers, and valley glaciers in western Canada. The retreat of glaciers in western Canada can be delineated on Landsat images, time-lapse image coverage that now spans three decades of data acquisition beginning in 1972 with Landsat 1, followed by Landsats 2, 3, 4, 5, and 7. The trend toward an increase in the number of spectral bands and spatial resolution (15 m with the Landsat 7 enhanced thematic mapper (ETM+) and multispectral stereoscopic sensor on the

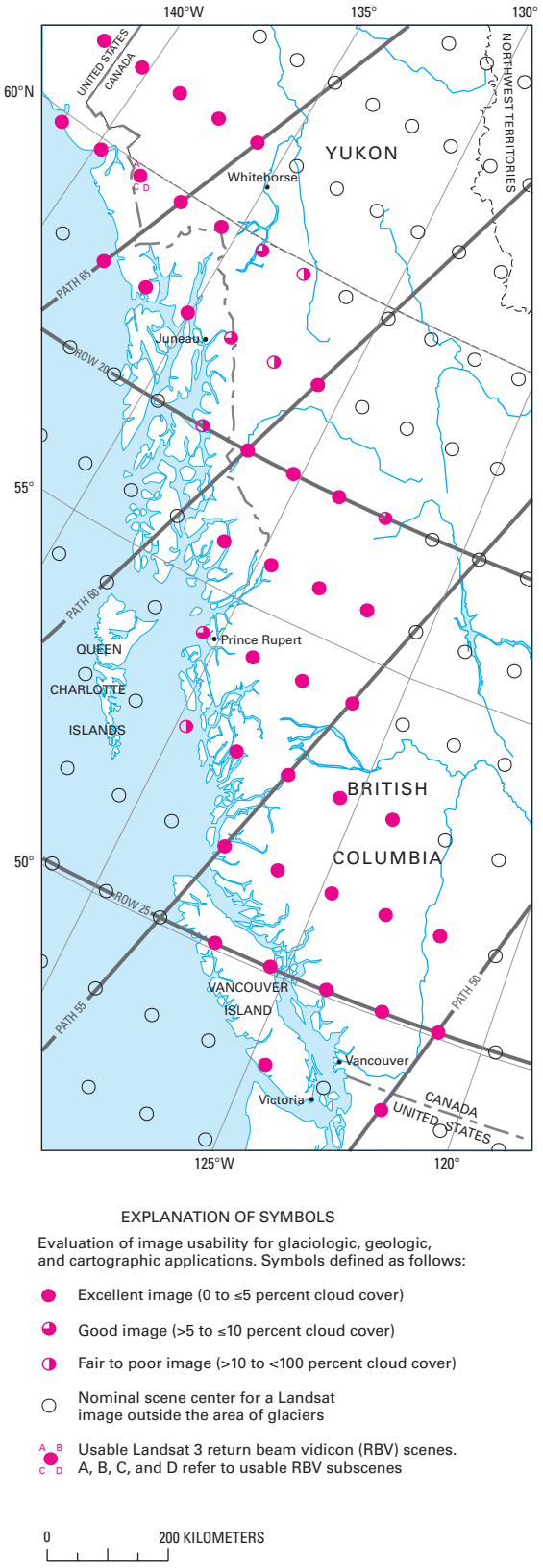


***Figure 6.**—Optimum Landsat 1, 2, and 3 MSS and RBV images of the glaciers of the Coast and St. Elias Mountains of Canada.*

TABLE 4.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of glaciers of the Coast and St. Elias Mountains of Canada*

[The images archived by the Canada Centre for Remote Sensing (CCRS) are not identified on the CCRS Website (http://www.ccrs.nrcan.gc.ca) by Landsat identification number but can be located by path (track), row (frame), and date. The images archived by the EROS Data Center (EDC) (http://earthexplorer.usgs.gov) are no longer located or ordered by the Landsat identification number on the image but by a different entity number that incorporates satellite number, path, row, and date]

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
50–25	50°09'N. 121°08'W.	2596–18105	09 Sep 76	39	●	0	
50–26	48°44'N. 121°46'W.	2596–18111	09 Sep 76	40	●	0	Garibaldi Park area
51–24	51°34'N. 121°53'W.	1385–18360	12 Aug 73	48	●	0	
51–25	50°09'N. 122°34'W.	1385–18362	12 Aug 73	49	●	0	Pemberton Icefield
52–24	51°34'N. 123°19'W.	5877–17154	12 Sep 77	30	●	0	
52–25	50°09'N. 124°00'W.	5841–17195	07 Aug 77	40	●	0	Pemberton and Homathko Icefields
52–26	48°44'N. 124°38'W.	1764–18332	26 Aug 74	45	●	0	Vancouver Island
53–23	52°58'N. 124°03'W.	1027–18472	19 Aug 72	46	●	0	
53–24	51°34'N. 124°45'W.	1027–18475	19 Aug 72	43	●	0	Klinaklini Glacier, Mount Waddington, Homathko Icefield
53–25	50°09'N. 125°26'W.	2203–18360	13 Aug 75	48	●	0	
54–23	52°58'N. 125°29'W.	1766–18433	28 Aug 74	42	●	0	
54–24	51°34'N. 126°11'W.	1766–18435	28 Aug 74	43	●	0	Monarch Icefield, Klinaklini Glacier, Mount Waddington
54–25	50°09'N. 126°52'W.	1766–18442	28 Aug 74	44	●	0	Vancouver Island
55–22	54°22'N. 126°10'W.	1767–18484	29 Aug 74	40	●	0	
55–23	52°58'N. 126°55'W.	1767–18491	29 Aug 74	41	●	0	
55–24	51°34'N. 127°37'W.	1767–18493	29 Aug 74	42	●	0	
56–21	55°45'N. 126°48'W.	1768–18540	30 Aug 74	39	●	0	
56–22	54°22'N. 127°36'W.	1768–18543	30 Aug 74	40	●	0	
56–23	52°58'N. 128°21'W.	1768–18545	30 Aug 74	41	●	0	
57–20	57°08'N. 127°23'W.	1769–18592	31 Aug 74	38	◕	10	
57–21	55°45'N. 128°14'W.	1769–18594	31 Aug 74	39	●	0	Cambria Icefield
57–22	54°22'N. 129°02'W.	1769–19001	31 Aug 74	40	●	0	
57–23	52°58'N. 129°47'W.	1049–19101	10 Sep 72	38	◑	50	

TABLE 4.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of glaciers of the Coast and St. Elias Mountains of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
58–20	57°08'N. 128°49'W.	1770–19050	01 Sep 74	38	●	0	
58–21	55°45'N. 129°40'W.	21288–18435	02 Aug 78	45	●	0	Cambria Icefield; image used for Coast Mountains, figure 2
58–22	54°22'N. 130°28'W.	1788–19050	19 Sep 74	33	◕	10	
59–20	57°08'N. 130°15'W.	5848–17571	14 Aug 77	36	●	5	
59–21	55°45'N. 131°06'W.	5848–17574	14 Aug 77	36	●	0	
60–19	58°31'N. 130°47'W.	1772–19160	03 Sep 74	36	●	0	
60–20	57°08'N. 131°41'W.	1722–19162	03 Sep 74	37	●	0	Stikine Icefield; image used for Coast Mountains, figure 3
61–19	58°31'N. 132°13'W.	5850–18080	16 Aug 77	35	◑	25	Juneau Ice Field, Canadian glaciers cloudfree
61–20	57°08'N. 133°07'W.	2931–18571	10 Aug 77	42	◑	15	Stikine Icefield, Canadian glaciers cloudfree
62–18	59°54'N. 132°41'W.	21670–19193	19 Aug 79	39	◑	20	Archived by CCRS[1]
62–19	58°31'N. 133°39'W.	21670–19195	19 Aug 79	40	◕	10	
63–18	59°54'N. 134°07'W.	1775–19324	06 Sep 74	34	◕	10	
63–19	58°31'N. 135°05'W.	1775–19330	06 Sep 74	35	●	0	Juneau Ice Field
64–18	59°54'N. 135°33'W.	30147–19373	30 Jul 78	45	●	0	
64–18	59°54'N. 135°33'W.	1416–19473	12 Sep 73	32	●	0	Band 6 evaluated, Band 7 missing
64–19	58°31'N. 136°31'W.	30147–19375	30 Jul 78	46	●	0	Glacier Bay
64–19	58°31'N. 136°31'W.	1416–19480	12 Sep 73	33	●	0	Glacier Bay
65–17	61°16'N. 135°56'W.	1417–19525	13 Sep 73	30	●	0	
65–18	59°54'N. 136°59'W.	1417–19531	13 Sep 73	32	●	0	Image used for St. Elias Mountains, figures 9 and 12
65–19	58°31'N. 137°57'W.	1417–19534	13 Sep 73	33	●	0	
66–17	61°16'N. 137°22'W.	21314–19293	28 Aug 78	35	●	0	Archived by CCRS
66–18	59°54'N. 138°25'W.	21314–19295	28 Aug 78	36	●	0	Image used for St. Elias Mountains, figures 1, 9, and 12
66–18	59°54'N. 138°25'W.	30167–19491 A, C, D	19 Aug 78	39	◕	10	Landsat 3 RBV; subscene A used for St. Elias Mountains, figure 6; archived by USGS Glacier Studies Project
67–17	61°16'N. 138°48'W.	2955–19285	03 Sep 77	32	●	0	Image used for St. Elias Mountains, figures 2 and 4

TABLE 4.—*Optimum Landsat 1, 2, and 3 MSS and RBV images of glaciers of the Coast and St. Elias Mountains of Canada*—Continued

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (degrees)	Code	Cloud cover (percent)	Remarks
67–18	59°54'N. 139°51'W.	2955–19292	03 Sep 77	33	●	0	Seward Glacier; image used for St. Elias Mountains, figure 2
68–17	61°16'N. 140°14'W.	2956–19343	04 Sep 77	32	●	0	Image used for St. Elias Mountains, figure 1
68–18	59°54'N. 141°17'W.	2956–19350	04 Sep 77	33	●	5	Seward Glacier; image used for St. Elias Mountains, figure 1
69–17	61°16'N. 141°40'W.	21677–19593	26 Aug 79	36	●	5	

[1] The cloud cover and evaluations of images archived by CCRS are based on the CCRS World Wide Web page (http://www.ccrs.nrcan.gc.ca) listing. There is no browse image for these scenes, but the cloud cover evaluation has been reliable when compared with images that have been directly inspected.

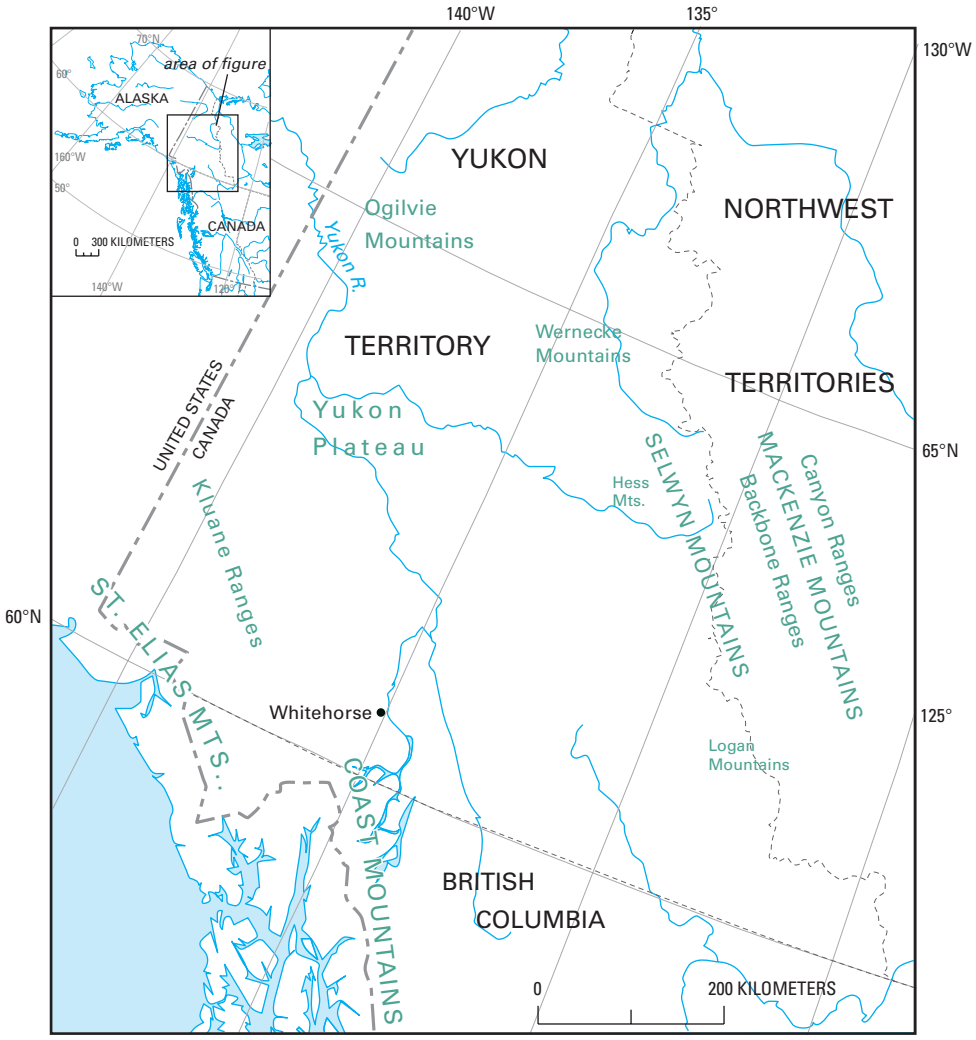


Figure 7.—*Map of the major mountain ranges in the Yukon and Northwest Territories of Canada. Glacierized ranges indicated in green.*

advanced thermal emission and reflectance radiometer (ASTER) on the Terra Spacecraft); the surface-elevation profile capability of the Ice, Cloud, and land Elevation Satellite (ICESat), estimated to be ±1 m; the all-weather radar sensors, such as the Canadian RADARSAT; and high-resolution panchromatic IKONOS and QuickBird-2 images [1-m picture elements (pixels) and 61-cm pixels, respectively) will provide new opportunities for glaciologists to use satellite remote sensing and GIS technologies to monitor changes in the area and volume of glaciers in the future (Williams and others, 1997; Williams and Hall, 1998). The following sections are directed primarily at an analysis and evaluation of Landsat MSS (and RBV) images of selected Canadian glaciers, in the context of the history of glacier investigations and glacier mapping in Canada, as a contribution to the objective of establishing a global baseline of glacier area during the 1970's. Although the pixel resolution of Landsat MSS images (79 m) generally precluded analysis of changes in small glaciers, the MSS images do provide an objective historical, time-precise record of the areal extent of large glaciers (that comprise most of the glacier area in Canada) during the 1970's.

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