

GLACIER INVENTORIES OF ICELAND: EVALUATION AND USE OF SOURCES OF DATA

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ABSTRACT

All sources of cartographic, aerial photographic, satellite image, and related data, from the 18th century to the present, for the eight geographic groups of Iceland's glaciers, were evaluated for use in preparing a preliminary inventory of Iceland's glaciers, based on information requirements of the Temporary Technical Secretariat for World Glacier Inventory. On the basis of an evaluation of all sources of historic and modern data for the Langjökull Group, the 1:50 000 scale U.S. Army Map Service Series C762 maps of Iceland were determined to be the best maps from which to derive information for a preliminary inventory, as long as the limitations of these maps are considered and accommodated. The fluctuations of Langjökull's principal outlet glaciers on maps and Landsat images were found to be consistent with field observations at the International Hydrological Decade monitoring stations. Accumulation area ratios were calculated from late summer snow lines on 1973 Landsat images of Vatnajökull (0.70), Langjökull (0.78), and Mýrdalsjökull (0.35). Measurements of the area of the now stagnant glacier on Ok showed a rapid reduction in area (68 per cent) between 1910 and 1960, but a decline in rate of wastage since 1960 (73 per cent between 1910 and 1978). From 1910 and 1945 topographic maps, the volume of the glacier on Ok was found to be reduced by 0.62 km³.

INTRODUCTION

A great variety of maps, both historic and modern, aerial photographs, satellite images, and related information are available of Iceland and these have been used by many scientists for glaciological studies, including the preparation of glacier inventories. It is the objective of this paper to evaluate the most important of these sources of data and to assess the usefulness of the 20th century cartographic and image data for the preparation of a modified Level 4 inventory of Iceland's glaciers, according to the "Guidelines for Preliminary Inventories" set forth by the Temporary Technical Secretariat for the World Glacier Inventory (TTS/WGI) (Scherler 1983). Because of the difficulty in preparing comprehensive glacier inventories of many regions, according to the initial guidelines set forth by Müller and others (1977), Scherler (1983) developed a simplified Level 1, 2, 3, or 4 inventory scheme that is based on Landsat images with or without the supplementary use of maps and aerial photographs.

The latter part of the paper will apply the glaciological information that can be gleaned from various types of modern cartographic, image, and other data to one of Iceland's eight glacier groups, the Langjökull Group (Fig.1.). In this way the glaciological value of these diverse data for the preparation of a glacier inventory can be directly evaluated for a complex group of nine glaciers in the Langjökull Group, first studied in the mid-1700's (Vidalin 1754, Ólafsson 1975 (1772)) and first mapped in 1792 (Pálsson 1795).

DISTRIBUTION OF GLACIERS

Most of the glaciers in Iceland, both in terms of area and volume, occur as ice caps (Fig.1.). The ice caps range in area from a few square kilometers (for example, 4.0 km²

for the glacier on Ok) to several thousand square kilometers (8300 km² for Vatnajökull).

It was found convenient, from a glacier-inventory viewpoint, to group Iceland's glaciers according to eight geographic clusters (Fig.1.): Vestfirðir, Snaefellsjökull, Langjökull, Mýrdalsjökull, Hofsjökull, Tröllaskagi (Nordurlandsjökull), Vatnajökull, and Austfirðir. Rist (written communication, 1985) has also grouped Iceland's glaciers into eight clusters, although his grouping is slightly different from Fig.1. The number of glaciers in each group ranges from one in the case of Snaefellsjökull, a solitary ice cap, to about 115 Alpine-type cirque and valley glaciers (according to Björnsson 1980b) in the Tröllaskagi Group. The names of the glaciers in the glacier groups are from the 1:100 000 scale Atlas sheets of Iceland and the published works of Thorvaldur Thoroddsen, Jón Eythórsson, Sigurdur Thorarinsson (especially Thorarinsson 1943), and volumes of the journal *Jökull*.

HISTORICAL REVIEW OF GLACIER INVENTORIES

Thorarinsson (1960) provides an excellent review of the published historical record on observations of Iceland's glaciers before the beginning of the 19th century, especially with reference to the pioneering work of Sveinn Pálsson, who prepared the first detailed maps of some of the glaciers of Iceland (Pálsson 1795, Eythórsson 1945, Sigurdsson 1978). The primary basis for compiling an inventory of glaciers of any area, however, is the availability of adequate maps and, until the beginning of the 20th century, when 1:50 000 scale and 1:100 000 scale map series were initiated by Danish surveyors and cartographers, the lack of a good cartographic base to plot field observations of glaciers was a serious handicap.

Thorvaldur Thoroddsen was the first scientist to study all of Iceland's glaciers systematically (Thoroddsen 1892, 1906, 1911). Thoroddsen had a significant advantage over Sveinn Pálsson in that the 1:480 000 scale color map of Iceland by Gunnlaugsson (1844) was available. Although the Norwegian, Amund Helland (1883), used this map to calculate areas of eight of Iceland's glaciers, Thoroddsen (1892, 1906) provided information on areas, as well as information of glaciological value (for example, highest and lowest elevation above sea level, height of the snow line, and number of outlet glaciers) about Iceland's glaciers. Thoroddsen gave the total area of glaciers in Iceland as 13 530 km² (Thoroddsen 1906), but this area can only be used in a semi-quantitative sense because of geodetic deficiencies in his base map (Thoroddsen 1901), which is a modification of the 1844 Gunnlaugsson map.

In 1930, Jón Eythórsson began a systematic program of annual measurements of the fluctuation of termini of selected glaciers in Iceland (Eythórsson, 1963). Since Eythórsson's death in 1968, the annual measurements have been supervised by Sigurjón Rist (1967b, 1977, 1983). During the International Hydrological Decade (IHD) (1965-1974), glacier termini, measured on an annual basis, were assigned the numbers shown on Figure 1. At the present time, Rist and his colleagues monitor 34 termini. Eythórsson's and Rist's work provides a continuous record of fluctuation of selected glacier termini for more than 50 years, in some cases, and provides an important bridge

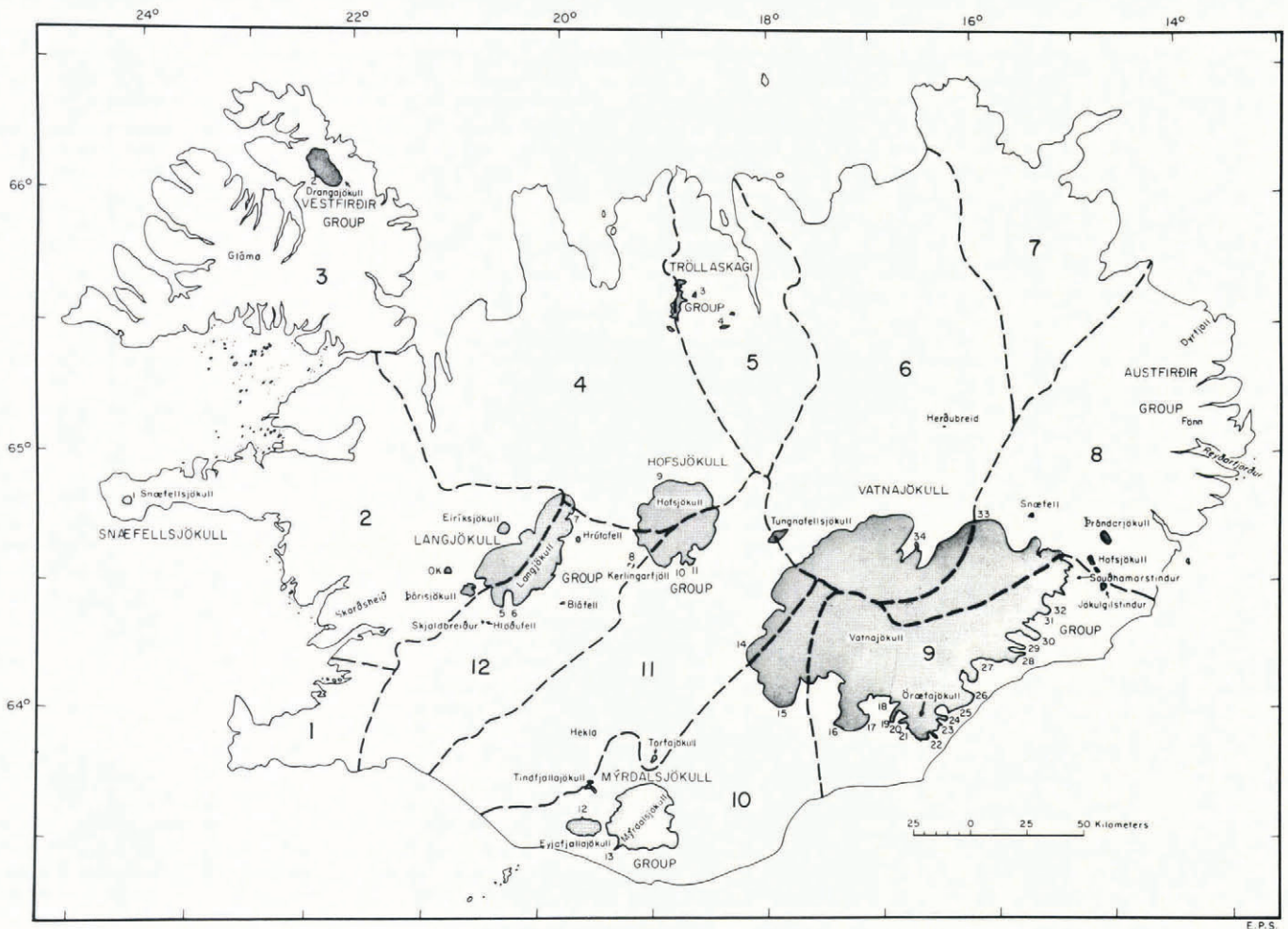


Fig.1. Index map to the 8 groups of glaciers included in an inventory of Iceland's glaciers. The drainage divides between the 12 sectors of the Hydrological Network of Iceland are shown with a dashed line (Iceland National Energy Authority, 1972). The 34 numbers associated with many of the glaciers are International Hydrological Decade (IHD) index numbers assigned by Rist (1967 and 1977) to margins of glaciers monitored annually.

TABLE I. AREA OF ICELAND COVERED BY GLACIERS (from published and unpublished sources)

Author	Source material	Publication date	Total glacier area (km ²)	Per cent of Iceland's conterminous area 102 950 km ²
Ágúst Bødvarsson	1:600 000 scale map by Thorvaldur Thoroddsen (1901)	unpublished	13 809	13.4
Thorvaldur Thoroddsen	Field observations plotted on Björn Gunnlaugsson's map (1844)	1906	13 530	13.2
Sigurdur Thorarinsson	1:500 000 scale and 1:100 000 scale Danish Geodetic Institute Maps	1943	11 785	11.4
Helgi Björnsson	Landsat images, aerial photographs, and ~ 20 km ² from an unidentified source	1980a	11 260	10.9

between the discontinuous record from maps, aerial photographs, and satellite images. Also during the 1930s, Eythórsson (1931, 1935), Eiríksson (1932), and Bárðarson (1934) prepared glacier-inventory information on a few glaciers in Iceland.

Thorarinsson (1943) used 1:50 000 scale and 1:100 000 scale Danish Geodetic Institute maps in compiling a comprehensive inventory of Iceland's glaciers and also published new areas of the 13 largest ice caps in Iceland, from later revisions to the 1:100 000 scale Danish maps (Thorarinsson 1958).

Björnsson (1974) discussed the information needs for a glacier inventory of Iceland on the basis of various sources of data and briefly reviewed previous inventories of Iceland. Björnsson (1980a) measured the area of ice caps on Landsat images and used aerial photographs, acquired by the U.S. Air Force in 1960, to measure the areas of Drangajökull, Snaefellsjökull, and 115 glaciers in the Tröllaskagi Group. He added areas of other glaciers (~20 km²) for a total of 11 260 km². Williams (1983) summarized information about the changing areas of the 13 largest ice caps in Iceland (the same 13 as discussed by Thorarinsson (1958)).

Table I gives a summary of the total area of Iceland covered by glaciers, from various sources. Although all of these are based on the best available maps at the time, or from vertical aerial photographs and satellite images, it is clear that each source of data has deficiencies that limit its usefulness in preparing a comprehensive and accurate inventory of Iceland's glaciers. Because of serious deficiencies in maps of glaciers of Iceland prior to 1903, data from such maps can only be used in a qualitative sense.

EVALUATION OF SOURCES OF DATA FOR GLACIER INVENTORIES

Maps

Table II summarizes maps of Iceland, published in the 20th century, that provide qualitative (pre-1905) and quantitative (post-1904) information needed to compile an inventory of Iceland's glaciers. Both the 1:100 000 scale Atlas sheets (Atlasblöd) and the 1:50 000 scale Quarter sheets (Fjörðungsblöd) contain glacier-inventory information but have several deficiencies. According to Nørlund (1944), the Danish General Staff started preparations for the

mapping of Iceland in 1900, with the first 1:50 000 scale map of a glacier (south-eastern Vatnajökull) surveyed in 1903. By 1920, the Danish General Staff had worked clockwise around the coast to the western part of the Tröllaskagi peninsula. In 1930, the Danish Geodetic Survey started up the mapping again, reaching the south-east coast in 1936. The central part of Iceland was mapped by a combination of field surveys and oblique aerial photogrammetry from aerial photographs acquired in 1937 and 1938 (Nørlund 1938). Figure 2 shows the course of the 37-year mapping program by the Danes. The 36-year span of the surveys of the glaciers of Iceland limits the use of these maps for glacier-inventory work for two reasons: (1) country-wide, time-restrictive comparisons of glacier area are impossible because glaciers were mapped at various times during the period, which was at a time of rapid recession of Iceland's glaciers, because of the climatic warming (Thoroddsen 1916-17, Eythórsson 1949, Sigbjarnarson 1969, Central Intelligence Agency 1974, Bergthorsson 1985), and (2) Iceland's largest ice caps were mapped piecemeal (for example, Vatnajökull from 1903 to 1939, Myrdalsjökull from 1904 to 1938). Another deficiency is in the plane-table survey method. Topographic contours and other features, such as lakes, are sketched in by the surveyor between stadia-rod positions. Geodetic monuments and summit elevations, however, are generally surveyed accurately. The determination of glacier margins from field observations or analysis of oblique aerial photographs (1937 and 1938) is necessarily subjective and depends on the experience of the surveyor, rodman and cartographer.

Those in the AMS Series C762 are the most accurate large scale maps available of the glaciers of Iceland, but several deficiencies exist for glacier-inventory work: (1) variety of compilation methods, (2) lack of ground control, and (3) time of year when surveys were made. The AMS Series C762 maps of Iceland's glaciers were compiled by photogrammetric (multiplex) methods, but each map has been compiled by one or more of the following methods: photo-stereo, photo-planimetric, Danish Atlas or Quarter sheets. The Danish maps were used where no aerial photographs were available (cloud cover) or as a base for planimetric revisions from aerial photographs, where no stereo coverage was available. Ground control for the maps was based on bench marks shown on the Danish maps and identified on the photographs. Some of the aerial

TABLE II. MAPS AND MAP SERIES USED TO COMPILE INVENTORIES OF ICELAND'S GLACIERS

Type of survey	Map scale and type	Source	Remarks	Map or map series	Number of maps that include glaciers	Publication date(s)	Survey date(s) of glaciers
Field	1:600 000	Thoroddsen (1901)	Color map	Geological Map of Iceland	2 sheets	1901	1880-1898
Plane-table	1:50 000 topographic	Danish Geodetic Institute (Dansk Geodaetisk Institut)	Coverage of Iceland incomplete. Only 118 sheets completed of the southeast, south, southwest, west, and northwest coasts by the Danish General Staff (1900-1920) and the Danish Geodetic Survey (1930-1944)	Quarter sheets (Fjörðungsblöd)	22	1905-1915 (a few sheets revised in 1950-1954)	1903-1914
Plane-table and oblique aerial photographs	1:100 000 topographic	Danish Geodetic Institute (Dansk Geodaetisk), Iceland Geodetic Survey (Landmaelinger Islands), Nørlund (1944)	Coverage of Iceland complete with 87 sheets by the Danish General Staff (1900-1920) and the Danish Geodetic Survey (1930-1944). Later revised editions by Iceland Geodetic Survey (1944 to present) (See Fig.2.)	Atlas sheets (Atlasblöd)	32	1932-1944 (a few sheets revised in post-1944 period)	1903-1939 including oblique aerial photo surveys in 1937-38 (Nørlund 1938)
Photogrammetry. Vertical aerial photos. Control by Danish Quarter and Atlas maps	1:50 000 topographic	U.S. Army Map Service, now U.S. Defense Mapping Agency	Coverage of Iceland complete with 297 sheets. New 1:50 000 scale map series (Series C761) begun by the Defense Mapping Agency and Iceland Geodetic Survey. Only southwest Iceland covered by 11 new maps.	AMS Series C762	75	1950 and 1951	Sept/Oct 1945 Aug/Sept/Oct 1946 aerial photographs

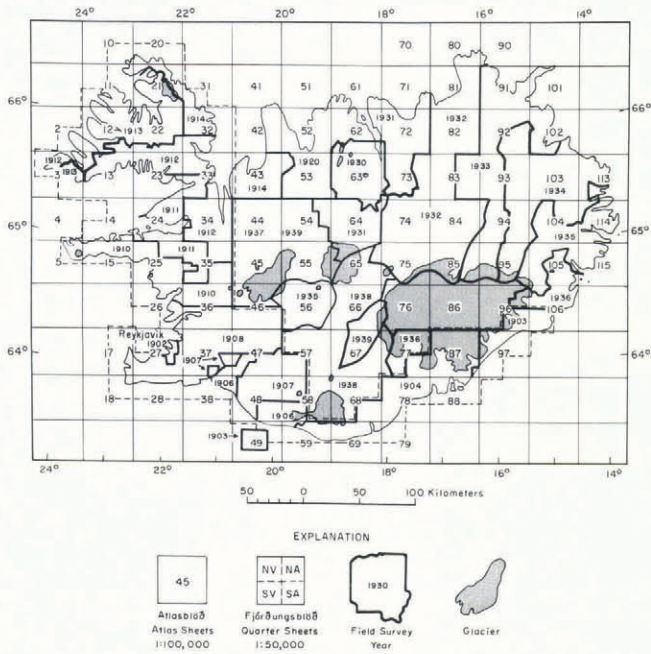


Fig.2. Index map to the 87 1:100 000 scale Atlas Sheets (Atlasblöð) (light solid lines) and 118 1:50 000 scale Quarter Sheets (Fjórðungsblöð) (dashed lines) of Iceland, mapped between 1902 and 1939 by the Danish General Staff (1900-1920), the Danish Geodetic Institute (1930-1944), and the Iceland Geodetic Survey (1944 to present) and the years in which field surveys were carried out (heavy solid lines). Modified from Nørlund (1944).

photographs were acquired in late September or October, when new snow cover masked the glaciers and surrounding terrain.

The AMS Series C762 maps have considerably more topographic and geomorphic information than the Danish maps. This is important in properly positioning the 1945-1946 and more recent aerial photographs to obtain additional glaciological information and to make measurements of marginal fluctuations. The AMS Series C762 maps also show the transient snow line on the glaciers. The greatest value of aerial photographs is in their precise historical record of a glacier on a specific date.

Aerial Photographs

The most valuable sets of vertical aerial photographs of Iceland's glaciers are the two flown by the United States military in support of the two 1:50 000 scale topographic map series of Iceland. The 1945 and 1946 aerial surveys by the U.S. Army Air Force provide nearly complete coverage of Iceland, except where cloudy weather prevented aerial photography. These photographs are the basis for the 1:50 000 scale AMS Series C762 maps of Iceland. The 1956 (no glaciers surveyed) and 1959-61 aerial photographic surveys by the U.S. Air Force also provide good coverage of the glaciers of Iceland, except for parts of Vatnajökull (persistent cloud cover). These photographs were to be the basis for a new 1:50 000 scale set of maps of Iceland (AMS Series C761), but only 11 maps of southwestern Iceland, in cooperation with the Iceland Geodetic Survey, have been completed. All other sets of aerial photographs, German (early 1930s (Iwan 1935) and 1942 (Bragason 1985)), Danish (1937 and 1938 (Nørlund 1938, 1944)), Icelandic (1954 to the present (Iceland National Research Council 1976; Thorvaldur Bragason, written communication, 1985)), U.S. Air Force Cambridge Research Laboratories (1968). U.S. Navy (1973), and National Aeronautics and Space Administration (1968 and 1973)), provide only limited coverage of Iceland's glaciers.

Satellite Images

A complete set of optimum Landsat 1, 2, and 3 multispectral scanner (MSS) and Landsat 3 return beam vidicon (RBV) images of Iceland is available for

glaciological studies. The optimum images have been gleaned from hundreds of Landsat images of Iceland, the best of which have been catalogued by Gudbergsson and Williams (unpublished). The advantages of Landsat images lie in the large area coverage, important in several ways for glaciological studies (Krimmel and Meier 1975). Some of the advantages for glacier inventories of Iceland are as follows: (1) entire glaciers or groups of glaciers of Iceland can be imaged in a single scene, (2) fluctuations in margins of glaciers can be measured, (3) areas of glaciers can be determined, (4) transient snow line positions can be delineated, and (5) each image provides a historical record on a precise date (Williams, 1979, 1983, Williams and Thorarinnsson 1974, Williams and others 1974, 1975, 1979). The main disadvantages in using satellite images for glacier inventories are (1) time of acquisition not optimum to record minimum snow cover (end of ablation season), (2) too much cloud cover, and (3) difficulty in determining the actual margin of the debris-covered glacier termini.

The delineation of the late summer snow line on Landsat images of Icelandic ice caps has important glaciological value, particularly if images permit mass-balance characteristics to be inferred (Østrem 1975). The accumulation area ratio (AAR) for Vatnajökull on the 22 September 1973 image was 0.7, while the AAR for Mýrdalsjökull on the same image was only 0.35. This may suggest that Vatnajökull was in equilibrium during 1972-73, but that Mýrdalsjökull had a negative mass balance during the same period. (c.f. Glen, 1963).

Related Data

Very few mass-balance studies have been conducted of Icelandic glaciers. Those that have been accomplished have only a short time series, such as the 1936-38 studies of Hoffellsjökull, an outlet glacier of Vatnajökull in south-east Iceland (Ahlmann 1939, Thorarinnsson 1939) and the 1967-68 studies by Björnsson (1972) of the cirque glacier, Baegisárjökull, in the Tröllaskagi Group.

During the 1950s, seismic surveys were used to determine the thickness of parts of Vatnajökull (Eythórsson 1951, 1952) and Mýrdalsjökull (Rist 1967a). In 1975,



Fig.3. Index map to the 5 principal glaciers (ice caps) in the Langjökull Group. Historic and modern geographic place-names of the glaciers, margins of Langjökull, and other features, such as nunataks (Thursaborg), have been culled from various published Icelandic sources. Outlines of glaciers from Landsat MSS image (22045-12131) of 28 August 1980.

TABLE III. LANGJÖKULL GROUP. AREA IN SQUARE KILOMETERS OF THE NINE GLACIERS IN THE GROUP FROM HISTORIC AND MODERN MAPS OF ICELAND

Glacier name	Geological map of Iceland Thoroddsen (1901)	Thorvaldur Thoroddsen (1906)	Sigurdur Thorarinnsson (1943)	Dates of surveys of Danish Atlas/Quarter sheets used by Thorarinnsson 1943	AMS Series C762 Maps	Dates of vertical aerial photographs used for AMS Series C762 and use of Danish maps	Landsat MSS Image 22045-121310 28 Aug 1980
Langjökull	1271 (includes Thórisjökull)	1300 (includes Thórisjökull)	1021	1935, 1937-1938	985.0	Sept/Oct 1945 Aug/Sept and Oct 1946 and Danish maps	954.4 ± 1.6
Thórisjökull			34.5	1938	34.0	Aug 1946, Sept/Oct 1945	31.9 ± 0.6
Glacier on Ok	50	35	15.0	1910	6.8	23 Sept 1945	3.8 ± 0.6
Eiríksjökull	90	100	23.5	1938	22.0	Oct 1945 and Danish maps	23.8 ± 0.6
Glacier on Hrutafell (Hrutafellsjökull)	22	-	11.2	1938	7.5	Oct 1946	8.8 ± 0.6
Glacier on Bláfell	No glacier indicated	-	2.0	1938	no glacier mapped	Aug/Sept 1945	If present, too small for MSS
Glacier on Hlíðufell	14	10	1.2	1908	no glacier mapped	Sept 1945	If present, too small for MSS
Glacier on Skjaldbreidur	14	5	0.0	1908	no glacier mapped	Sept 1945	No glacier present
Glacier on Skardsheiði	No glacier indicated	-	0.2	1910	0.0	Sept 1945(?)	If present, too small for MSS

Björnsson (1977) initiated a ground-based series of radio echo-sounding surveys of the major ice caps of Iceland. Parts of Myrdalsjökull and Vatnajökull have been completed (Björnsson 1978), as well as Hofsjökull (Helgi Björnsson, personal communication).

Changes in volume of Iceland's glaciers can be calculated directly from measurement of changes in thickness, or

inferred from discrepancies in measurements of precipitation and runoff (Sigbjarnarson 1967, 1971). Changes in thickness can be determined by radio echo-sounding, conventional ground traverses (Freysteinnsson 1984), or aerial photogrammetry.

USE OF DATA SOURCES FOR GLACIER INVENTORIES

Langjökull Group

The Langjökull Group is a group of nine glaciers situated in the west-central part of Iceland (Fig.1.). The following discussion of the various types of cartographic, image, and other data used to describe this group, will illuminate some of the problems associated with compiling a glacier inventory of Iceland and in merging information from different sets of data. Figure 3 shows the geographic names of 5 of the glaciers in the group that have been used on Icelandic maps and literature (for example, Thoroddsen 1911, Matthiasson 1980). The outlines of the five glaciers are drawn from the 28 August 1980 image. Table III provides a review of the mapping of the eight glaciers in the Langjökull Group, from the Danish Atlas/Quarter sheets to the 28 August 1980 Landsat image of the region.

Langjökull

Figure 4 is an overlay of maps of Langjökull from three different sources: Danish maps, AMS maps, and 19 August 1973 Landsat MSS image. The greatest changes between the glacier margins are in the recession of the Thristapajökull, Sudurjökull, Hagafellsjökull eystri, and Hagafellsjökull ytri outlet glaciers. The positions of the termini of the last two outlet glaciers in the mid-1930s, mid-1940s, and 1973 are consistent with field reports of fluctuations (Sigbjarnarson 1967, Rist 1974). Figure 5 is an overlay of two maps of Langjökull based on two Landsat images, 19 August 1973 and 28 August 1980, showing the advance of Hagafellsjökull ytri resulting from its 1980 surge (Theódórsson 1981) and the major advance of Hagafellsjökull eystri, resulting from two surges, one in 1975 (Sigbjarnarson 1977) and the other in 1980. The map positions of the termini on the Landsat images are consistent (±100 m) with the 600 m surge of Hagafellsjökull

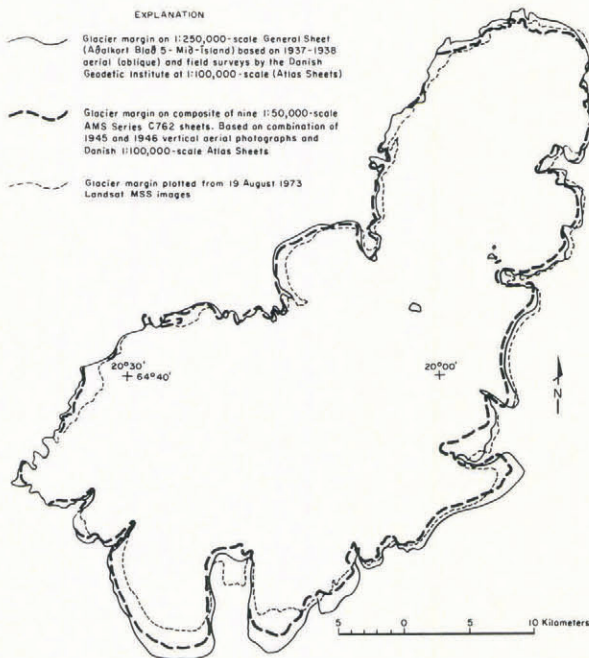


Fig.4. Outline of Langjökull, the principal glacier in the Langjökull Group, from two map series and a 19 August 1973 Landsat MSS image, indicating that the fluctuation in the margin of the ice cap has been mainly in the recession of the outlet glaciers, Thristapajökull, Sudurjökull, Hagafellsjökull eystri and Hagafellsjökull ytri (see Fig.3.).

TABLE IV. AREA OF GLACIER ON OK FROM HISTORIC AND MODERN SOURCES

Area (km ²)	Date of survey	Type of survey	Source
35	1792	Field	Pálsson (1795)
58	1831-1843	Field	Gunnlaugsson (1844)
35	1881-1898	Field	Thoroddsen (1892, 1906)
15.0	1910	Plane-table	From Thorarinnsson (1943) based on Danish General Staff Quarter sheets
6.8	23 Sep 1945	Stereophotogrammetry	AMS Map Sheet
4.8	8 Aug 1960	Stereophotogrammetry	U.S. Air Force aerial photographs
4.0	5 Sep 1978	Stereophotogrammetry	Iceland Geodetic Survey aerial photographs
3.8±0.6 km ²	28 Aug 1980	Photogrammetry	Landsat image

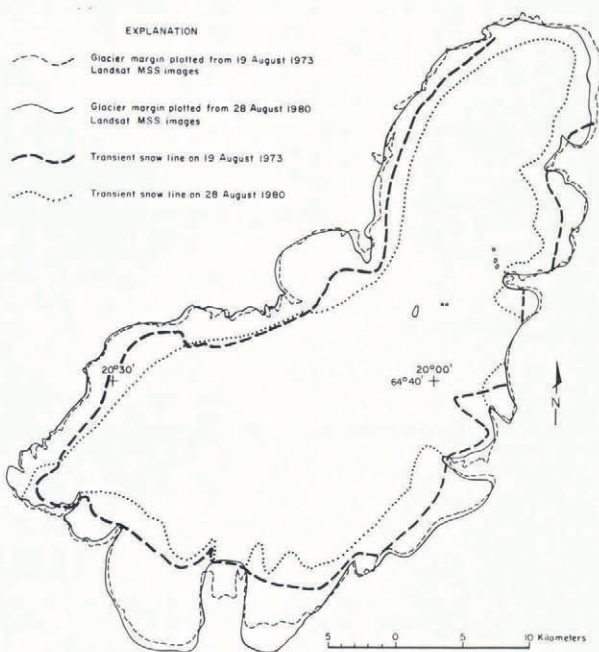


Fig.5. Outline of Langjökull, from two Landsat MSS images: 19 August 1973 and 28 August 1980. Note especially the 2.2 km advance of the terminus of Hagafellsjökull eystri and the lesser (about 0.5 km) advance of Hagafellsjökull ytri, during this period (see Fig.3.). The transient snow lines of 19 August 1973 and 28 August 1980 are also indicated, yielding an Accumulation Area Ratio (AAR) of 0.70 and 0.65, respectively.

ytri and the combined 2200 m surge of Hagafellsjökull eystri into lake Hagavatn, from which it had retreated about 2600 m between the late 1930s and late 1973.

Figure 5 also shows the transient snow lines on the 19 August and 28 August 1980 Landsat images. Although not quite at the end of the summer melt period, the accumulation area ratio (AAR) was calculated to be 0.78 for the 1973 image and 0.65 for the 1980 image.

Ok

Figure 6 shows the margins of the glacier on Ok, during four stages in its recession to about 4 km² in 1978 from 15 km² in 1910. Figure 7 is a graph of the declining

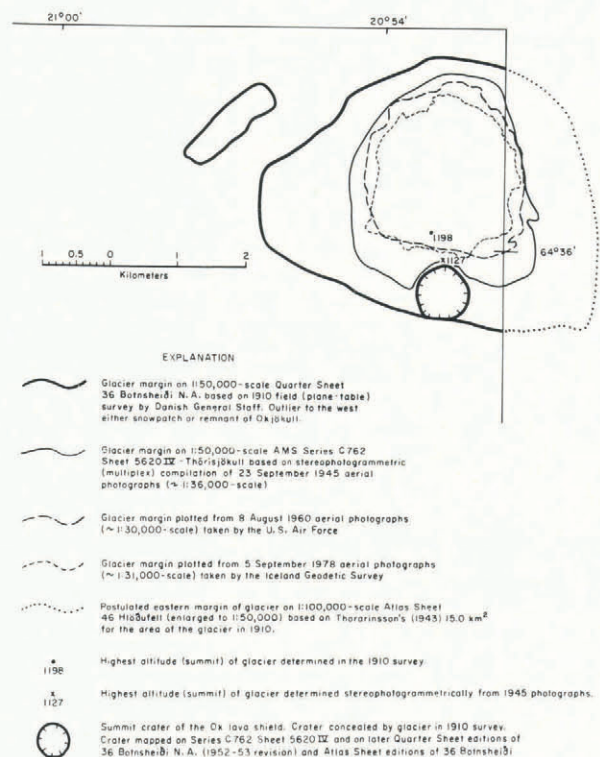


Fig.6. Outlines of the glacier on the lava shield, Ok, from two map series and two vertical aerial photographs, for a 68-year period (1910 to 1978) of recession (see Table IV). From 1910 to 1945, the ice cap was reduced in area by 8.2 km² or to 55 % of its 1910 area. The loss in volume of ice, during this 35-year period, is estimated at 0.6 km³, from comparison of the two topographic maps.

area of the glacier on Ok, showing a rapid decline in area until about 1960 and a diminishing decline since that time. The 28 August 1980 Landsat image of the glacier shows approximately the same size as depicted on the 5 September 1978 aerial photograph. If the wastage of the glacier on Ok had continued at the same rate as between 1910 and 1950, it would have completely disappeared by about 1980.

The glacier on Ok is one of only 5 glaciers in Iceland, for which the 1:50 000 scale Quarter sheet plane-table topographic maps can be compared with 1:50 000 scale AMS Series C762 aerial photogrammetric topographic maps, to

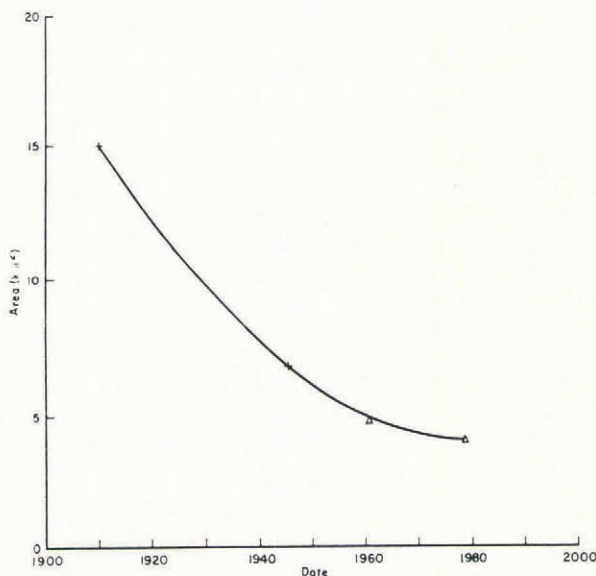


Fig. 7. Graph, showing the decrease in area of the glacier on Ok between 1910 and 1978. The recession was most rapid between 1910 and about 1960, after which it slowed appreciably; otherwise, the glacier would have disappeared by about 1980. The earlier two values of area are from maps (crosses), the latter from aerial photographs (triangles).

show reduction in volume during a 30- to 40-year interval. The others are Eyjafjallajökull, Tindfjallajökull, Snaefellsjökull, and Drangajökull. The 1910 Quarter sheet, 36 Botnsheidi N.A., shows the maximum elevation on the ice cap of 1198 m, with the summit crater of the lava shield Ok not visible. The 1945 AMS Series C762 map, Thórisjökull, shows a maximum elevation on the ice cap of 1127 m or a reduction of 71 m. When the elevation differences are computed for the two maps, for that part of the ice cap shown on the 36 Botnsheidi N.A. map (72.2 per cent of the glacier mapped in 1910), the glacier was found to be reduced by 0.45 km³ in volume. Assuming a reasonable symmetry to the ice cap, the loss from the full 15 km² in 1910 to the 6.8 km² in 1945 is 0.62 km³.

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