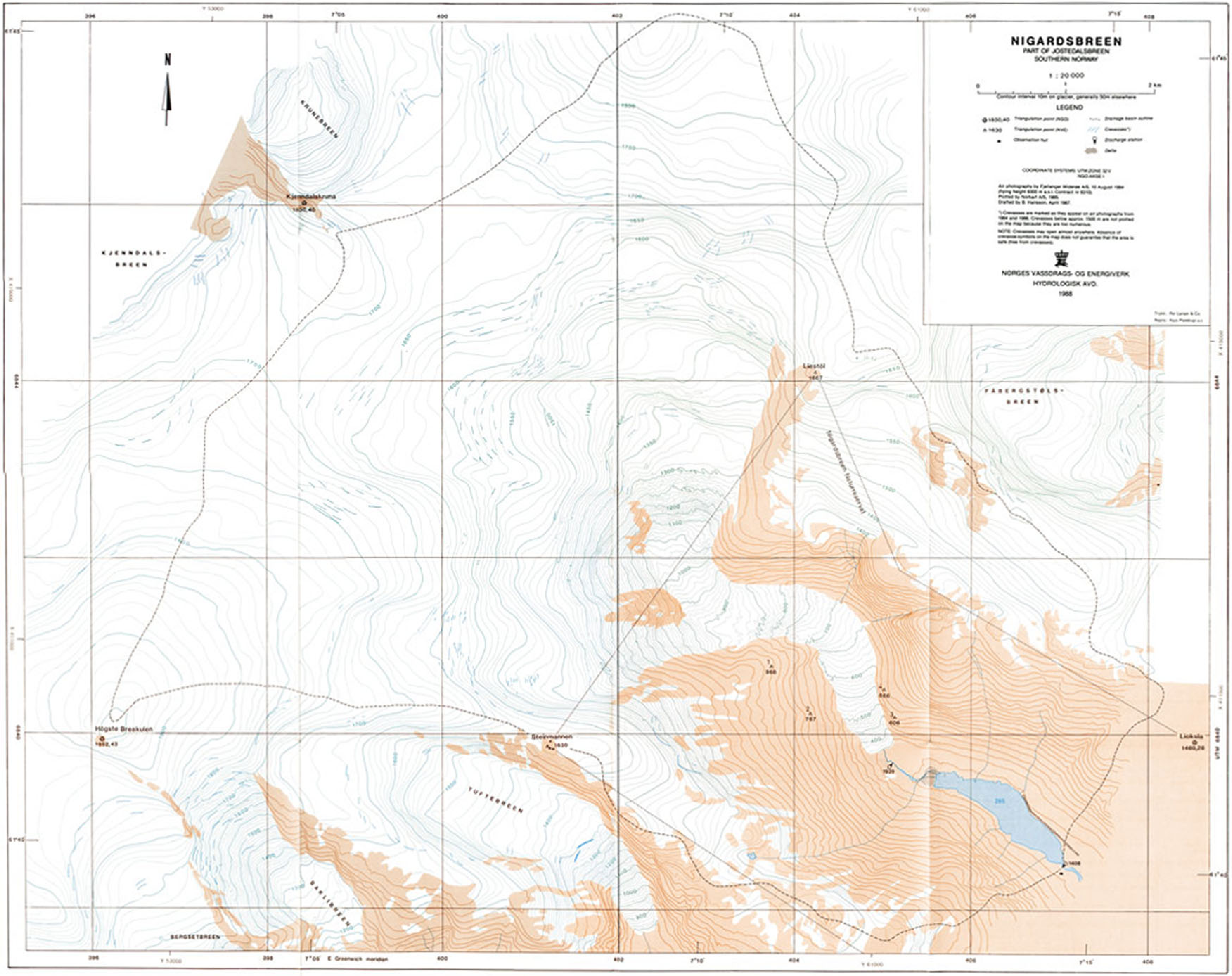
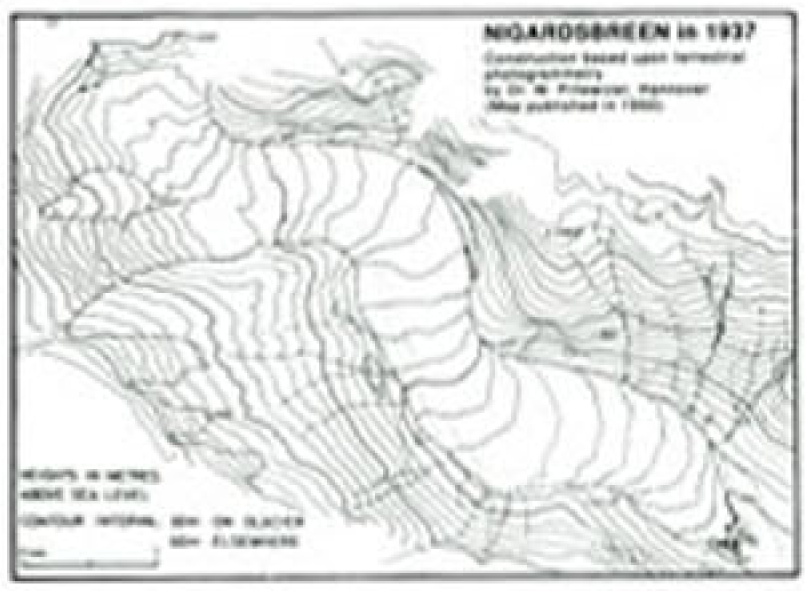
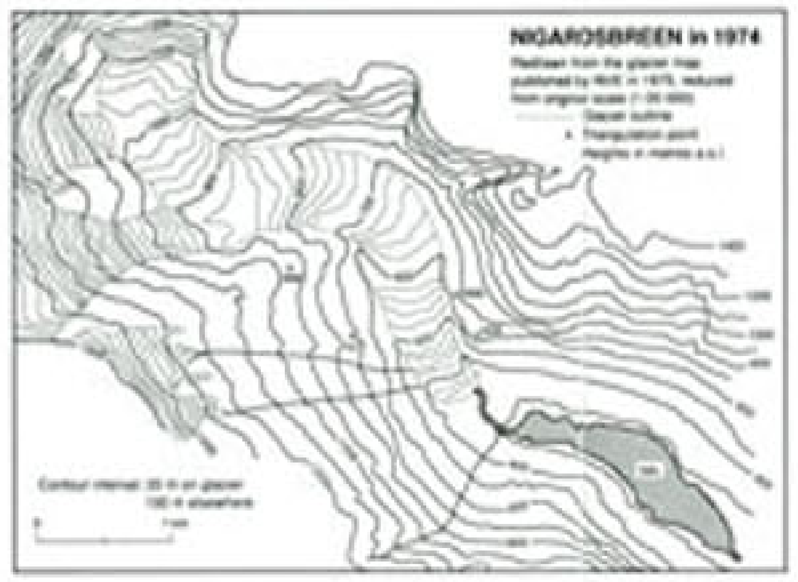
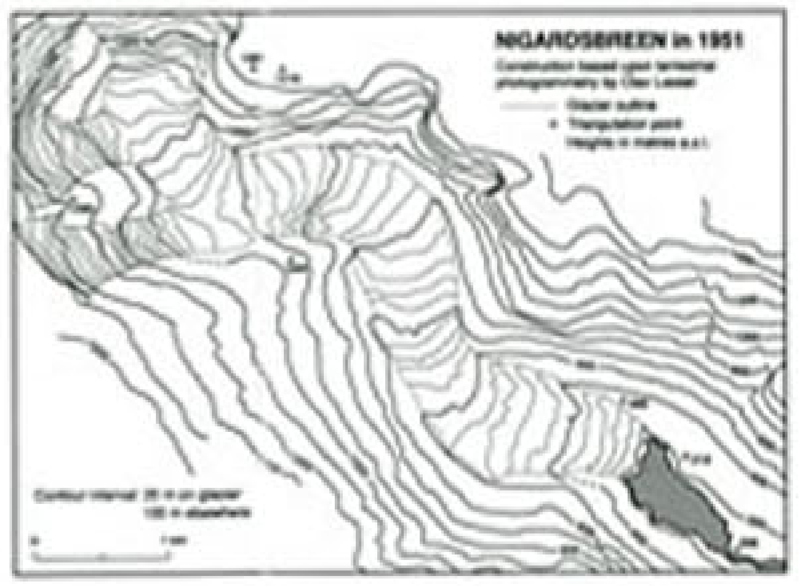
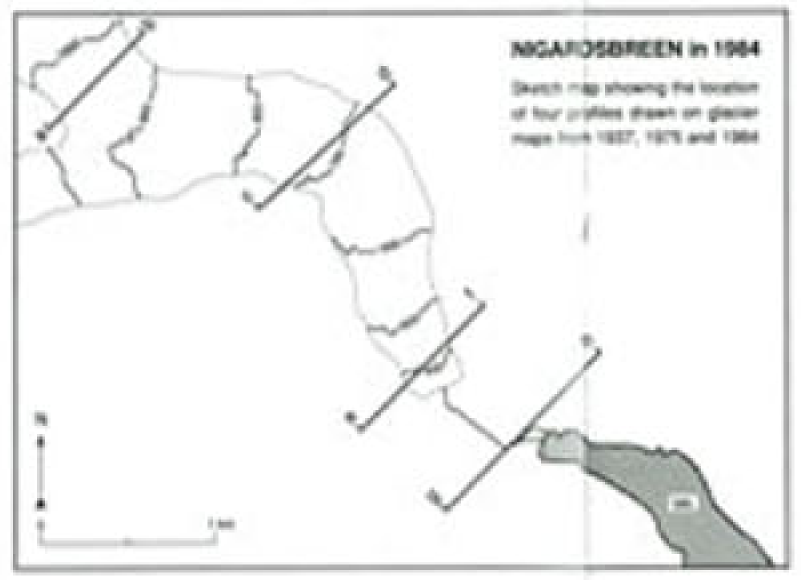

NIGARDSBREEN
PART OF JOSTEDALSBREEN
SOUTHERN NORWAY
1 : 20 000
0
1
2 km
Contour interval 10m on glacier, generally 50m elsewhere
LEGEND
Triangulation point (NGO)
Triangulation point (NVE)
Observation hut
Drainage basin outline
Crevasses*)
Discharge station
Delta
COORDINATE SYSTEMS: UTM ZONE 32V
NGO AKSE I
Air photography by Fjellanger Widerøe A/S, 10 August 1984
Plotted by Norkart A/S, 1985.
Drafted by B. Hansson, April 1987.
NORGES VASSDRAGS- OG ENERGIVERK
HYDROLOGISK AVD.
1988
N
KRUNEBREEN
Kjenndalskruna
1830,40
KJENNDALS-
BREEN
Høgste Breakulen
1952,43
Steinmannen
1630
Lisstøl
1667
FÅBERGSTØLS-
BREEN
TUFTEBREEN
BAKLIBREEN
BERGSETBREEN
Lioksla
1460,28
Y 53000
Y 61000
7°05' E Greenwich meridian
7°10'
7°15'
61°45'
61°40'
396
398
400
402
404
406
408
6844
6840
UTM 6840
285







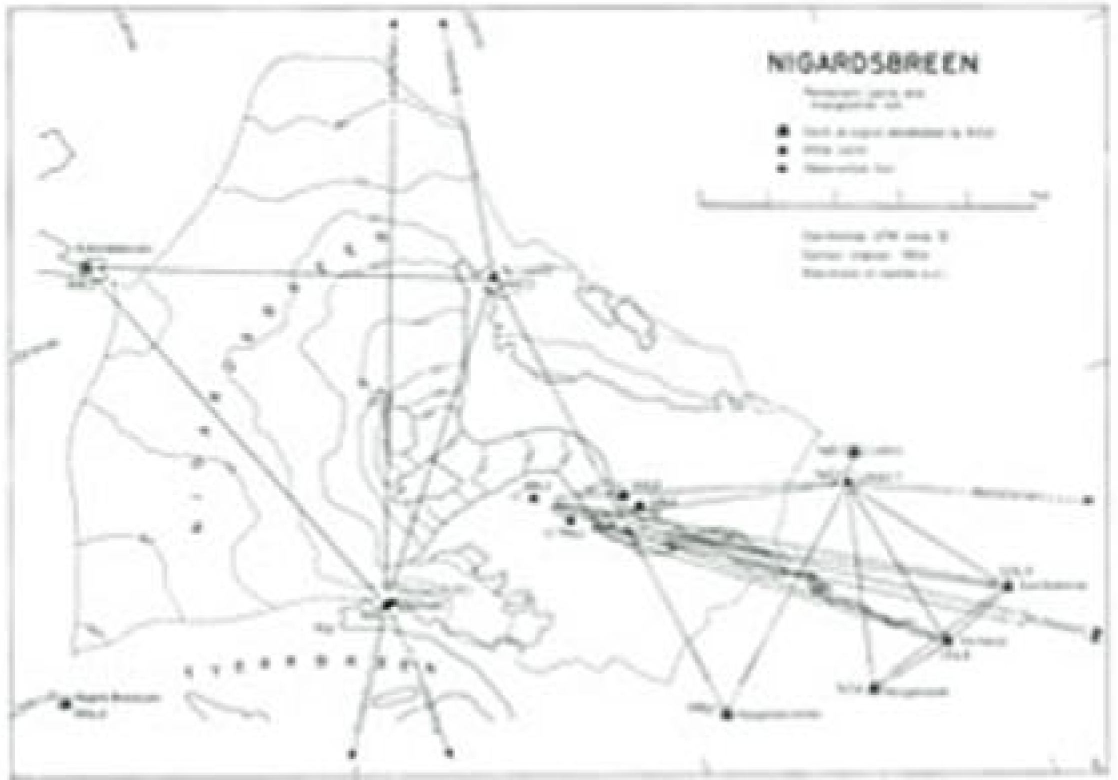


TRIANGULATION

To study the glacier's surface movement, it proved practical to establish four triangulation points, two on each side of the tongue. These points overlook most of the tongue, and are marked on the map, numbered 1-4. In the table they are numbered 130, 131, 132, and 133, respectively.

In order to find their coordinates, a triangulation program was carried out, with single or double sight-lines to cairns or signals with known coordinates, see the map above. (A dashed line indicates single sight-line to that point, unbroken line indicates that the theodolite has been used also to survey from that point.)

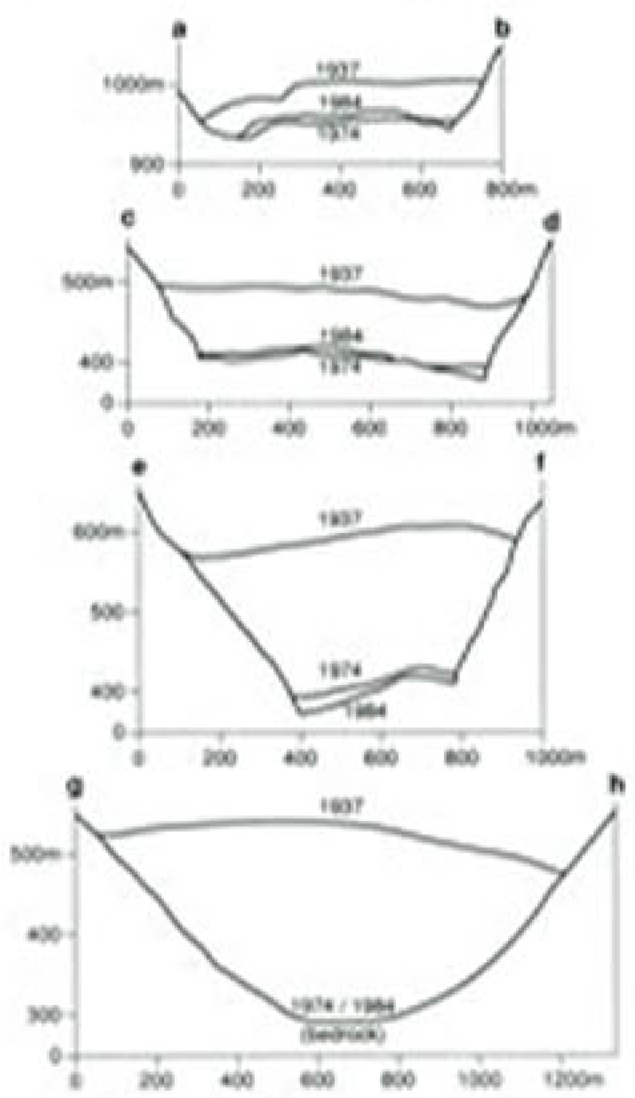
A list of UTM-coordinates, elevation and description of the various points is given in the table below.



Fastpunktoversikt - Nigardsbreen

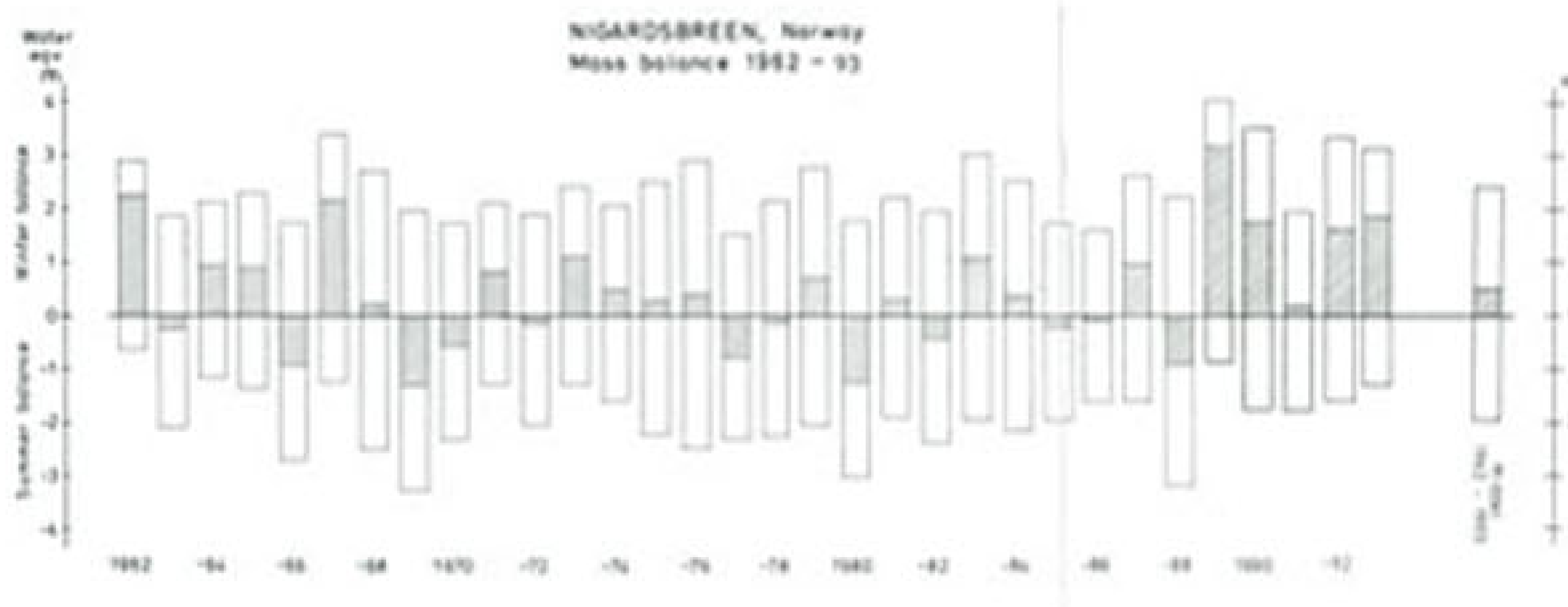
Navn	UTM-koordinater X	UTM-koordinater Y	Høyde H	Signal-høyde	X, Y og H refererer seg til
NIG 130 (1 på kartet)	6 840 755.43	403 729.55	968.23		Fot skjæretapp i fjell.
NIG 131 (2 på kartet)	6 840 229.51	404 170.12	766.47		Fot skjæretapp i fjell.
NIG 132 (3 på kartet)	6 840 193.66	405 135.01	608.0	1.00	Senter og topp bolt.
NIG 133 (4 på kartet)	6 840 498.12	405 013.47	666.0	1.00	Senter og topp bolt.
NIG 134 Steinmann	6 839 867.23	401 212.77	1629.97		Topp boltehull under rødt kors i fjell mellom hytta og varden.
NIG 135 Liakala V.	6 839 510.95	408 305.21	1345.00	1.80	Fot bardunsignal i varde over rødt kors i fjell av for TP 17.
NIG 136 TP Liestøl	6 844 099.30	404 229.35	1667.24	0.45	Senter og fot liten varde m/aluetake på høyeste bare knaus mot breen.
TP 11 Høgste Breakulen	6 839 831.38	396 108.84	1954.40	1.37	Topp varde.
TP 13 Kjenndalskruna	6 846 017.82	398 423.36	1832.19	1.99	Topp aluminiumsignal.
TP 17 Liakala	6 839 913.79	408 538.43	1460.28		Topp bolt under varde.
TP 125 Haugenosi Sr.	6 836 465.68	407 753.02	747.80	2.00	Topp bolt under bardunsignal på haugen ø for setrene.
TP 141 Haugenosi varde	6 836 768.46	405 506.95	1359.23		Topp varde ytterst på Haugenosi.
TP 142 Kvitesva	6 836 749.77	408 997.50	253.83	1.86	Topp bolt på toppen av bergknaus 100 m ø for Gjetaheimen.
TP 180 Svarthamar	6 837 230.50	410 129.26	626.34	1.89	Topp bolt på øvste nordøstre kant av fjellet 150 m under skoggrensa.

Glacier surface changes along selected profiles



The Norwegian artist J. C. Dahl made this painting in 1847. The original (25 × 35 cm) is exhibited in the National Gallery in Oslo.

An oblique air photo taken by Widerøes Flyveselskap A/S on 24 August 1954 (Picture No. 79621). At that time the glacier had retreated so far that about half the lake was visible. It became totally uncovered in 1968.



The oldest known air photo of Nigardsbreen, was taken by Widerøes Flyveselskap A/S in 1938 (contract No. 50, neg. scale 1 : 40 000) for the German expedition. The negatives were unfortunately destroyed in Berlin during the war, so only a set of paper prints is available, and they are over-exposed leaving almost all ice and snow as white areas. This picture shows the ice front at a position where the lake has its outlet today - compare the map from 1937.

Nigardsbreen photographed in 1937 from Geisdalsnosa by professor W. Pillewizer. Several end moraines formed since the maximum about 1750 are clearly visible. Their ages were determined by Fægri (1933). The steep Bersedbre can be seen in the left.

SEDIMENT TRANSPORT STUDIES

A sediment sampling program was started 1968 in the stream between the glacier front and the lake, as well as at the outlet of the lake.

Water samples were taken normally five times per day, but during rising water stage, samples were taken much more frequently, up to one sample per hour. Filtering was done in the field, and the filter papers were sent to Oslo for laboratory treatment.

Runoff was recorded continuously at both places, (water gauges Nos. 1939 and 1408, shown on the map). Thus the daily total transport of suspended sediment could be calculated, as well as the deposition of fine material on the lake bottom. On average 79% of the suspended sediment input to the lake was deposited in the lake for the years 1968-1981. The field seasons covered the main melt season each year, only minor discharge peaks in the fall may have carried un-measured amounts of sediment past the observation points.

Bed-load transported coarse material accumulated on the delta where a careful survey was made each year in late fall, to obtain a volumetric determination of annual increments on the delta. Using a general density of 2 g/cm³, comparative figures for delta accumulation could be obtained, and the total annual mass transport by the glacier stream was calculated.

In 1969 a fence was built across the stream just above its inflow into the lake, to measure the bottom load directly (Østrem 1975). All material coarser than 2 cm was captured by this fence, the accumulation above it was surveyed daily by levelling and sounding in 176 single points. Daily bottom load could then be compared to daily suspended sediment transport. During three weeks about 400 metric tons were trapped, and this was almost equal to the amount of suspended sediment transport in the same time period.

The 24 year's average indicates, however, that the bottom load accounts for about 43% of the total transport of solid matter in this glacier stream.

The results are summarized in the table. Observations at the lake outlet were terminated in 1981, so no data on bottom deposition is available since then. Further, from 1982 the manual water sampling was replaced by an automatic device, so that the results since then may not be directly comparable with those given for the period 1968-81. A description of methods is given in Bogen 1988.

Gunnar Østrem

Year	Discharge $10^6 m^3$	Susp. sedim. $10^3 kg$	Deposited on lake bottom $10^3 kg$	%	Accumul. on delta $10^3 kg$	Total transp. from glacier $10^3 kg$
1968	198	6300	4600	71	5900	12200
1969	244	15750	11750	75	9000	24300
1970	226	14750	11750	80	14250	29000
1971	198	10200	6900	66	9100	19300
1972	198	12250	8850	72	10200	21450
1973	176	11750	8600	73	14100	25850
1974	162	6000	4750	79	6500	12500
1975	186	13600	8850	65	7700	21300
1976	176	12450	10750	86	8700	21150
1977	176	7750	5750	74	5250	12950
1978	161	7750	5950	77	8250	15900
1979	161	16600	15650	85	1475	20075
1980	226	11900	9300	78	5850	17750
1981	163	8300	6300	76	6950	15250
1982	198	6100			9150	15250
1983	164	6500*			9500	16000
1984	186	10650*			5600	16250
1985	212	14600			11500	26100
1986	184	11400			10300	21700
1987	124	17600			5300	22900
1988	213	8800			7250	16050
1989	151	8300			6100	14400
1990	176	10600			7500	18100
1991	165	12600			8500	21100
1992	160	8600			5000	13600
Average	186	10800	8640	76	8300	19100

* Calculated from diagrams based on results from previous years.

BRIEF COMMENTS ON THE MAP

The compilation of this glacier map, covering a part of the Jostedalsbreen ice cap in southwestern Norway, was based on vertical air photographs taken for this purpose on 10 August 1984 by Fjellanger Widerøe A/S (contract No. 8310). The plotting was made solely for the purpose of producing a glacier map, so special attention could be made to emphasise certain features. Areas of predominant crevasses in the firn area (generally above 1500 m) were specially marked, triangulation points, used for glaciological field work, and the delta area in the lake were plotted. Although the exact form and size of each crevasse are not depicted in detail, an attempt was made to plot the main direction of crevasses. Note that one single blue line on the glacier may indicate more than one crevasse! The border line between ice-free areas and the glacier (or snow patches) was plotted with a minimum of generalization. A brown colour was used to indicate areas of "bare ground" at the time of photography.

A great number of triangulation points were used in the plotting procedure, and the quality of the air photographs, taken from 6 300 m flying height, was good. Even in the highest areas details in the snow surface made the construction of contour lines relatively easy. The plotting accuracy is assumed to be better than 5 m both in horizontal and vertical direction.

Although a scale of 1 : 10 000 was recommended for glacier maps in general at the International Symposium on Glacier Mapping held in Ottawa, Canada, in 1965, it was necessary for technical reasons to use the scale of 1 : 20 000 for this relatively large glacier. The recommended contour interval 10 m, however, could be used. The Universal Transversal Mercator grid net, Zone 32, is drawn on the map, whereas geographical coordinates and coordinates of the Norwegian Geographical Survey (Statens Kartverk) Axis No. 1, are marked in the frame.

The outlet glacier Nigardsbreen, particularly its lower part and its numerous end moraines, has been studied and mapped several times by various scientists, and the retreat of the tongue has been observed for several decades. To demonstrate this retreat, some older maps are reproduced, as well as cross-profiles at four selected locations. From these it is evident that a dramatic retreat has taken place since 1937 (profiles e-f and g-h), but a growth has later started in the higher areas (profiles a-b and c-d). Similarly, results from annual mass balance measurements indicate several years of positive mass balance, and in recent years (since the map was plotted) the glacier front has, in fact, moved forward. This map shows the minimum size of the lower tongue during the last decades, and is therefore an important historic document.

Note that similar glacier maps of Nigardsbreen were published in 1965 and in 1975. These are now replaced by the present map for glaciological field work.

Gunnar Østrem

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