Number 90 2nd Issue 1989

ICE

NEWS BULLETIN
OF THE INTERNATIONAL
GLACIOLOGICAL
SOCIETY

HAVE YOU ANY GAPS IN YOUR COLLECTION?

ANNALS OF GLACIOLOGY

Conference on Use of Icebergs: scientific and practical feasibility (Cambridge 1980)
Annals of Glaciology – Volume 1, 1980
Symposium on Processes of Glacier Erosion and Sedimentation (Geilo, Norway, 1980)
Annals of Glaciology – Volume 2, 1981 (Out of print at present)
Symposium on Antarctic Glaciology III (Columbus, Ohio 1981)
Annals of Glaciology – Volume 3, 1982
Second Symposium on Applied Glaciology (Hanover, New Hampshire 1982)
Annals of Glaciology – Volume 4, 1983
Symposium on Ice and Climate Modelling (Evanston, Illinois 1983)
Annals of Glaciology – Volume 5, 1984
Symposium on Snow and Ice Processes at the Earth's Surface (Sapporo, Japan 1984)
Annals of Glaciology – Volume 6, 1985
Symposium on Snow and Ice Chemistry and the Atmosphere (Peterborough, Canada 1984) *Annals of Glaciology* – Volume 7, 1985
Symposium on Glacier Mapping and Surveying (Reykjavik, Iceland 1985)
Annals of Glaciology – Volume 8, 1985
Symposium on Remote Sensing in Glaciology (Cambridge 1986)
Annals of Glaciology – Volume 9, 1987
Symposium on Ice-Core Analysis (Bern, Switzerland 1987)
Annals of Glaciology – Volume 10, 1988
Symposium on Antarctic Glaciology IV (Bremerhaven, F.R. Germany 1987)
Annals of Glaciology – Volume 11, 1988
Symposium on Ice Dynamics (Hobart, Australia 1988)
Annals of Glaciology – Volume 12, 1989
Symposium on Snow and Glacier Research relating to Human Living Conditions (Lom, Norway 1988) *Annals of Glaciology* – Volume 13, 1989

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CONTENTS

COVER PICTURE: ERTS image of the Anchorage and Western Chugach Mountain area showing a clearly defined snow line. Fog lies in the Cook Inlet lowlands on the left. ERTS image No. 1066-2045-4, 27 September 1972.

Recent work

ICELAND

HYDROLOGY OF ICE CAPS IN VOLCANIC REGIONS. RADIO-ECHO SOUNDING
(Helgi Björnsson, Science Institute, University of Iceland, Dunhaga 5, 107 Reykjavík, Iceland)
Radio-echo sounding and precision barometric altimetry are being used to map glacier surfaces and bedrock topography of Icelandic glaciers. Maps have now been prepared of the whole of Hofsjökull and all glacier outlets of northern and western Vatnajökull. In 1988, radio-echo soundings were carried out on Brúarjökull (north-eastern Vatnajökull), and in the spring of 1989 on Dyngjujökull (northern Vatnajökull). The surveying is carried out by the Science Institute, University of Iceland, in collaboration with the National Power Company.

A monograph has been compiled which represents the main results up to 1988: *Hydrology of ice caps in volcanic regions.* Helgi Björnsson. 1988. Reykjavík, Societas Scientarium Islandica, No. 45. 139 p. and 21 maps in a separate cover. (Available from the University Bookstore, University of Iceland, 101 Reykjavík, Iceland, price US$65, including postage.)

The monograph presents a wealth of new information on the geomorphology and volcanology of the subglacial part of the neo-volcanic zone in Iceland. Known subglacial reservoirs in geothermal areas and the triggering and subglacial routes of jökulhlaups are described. The application of data on the glacier mass balance in the Grímsvötn basin in estimating the rate of subglacial melting is illustrated; this yields an estimate of the thermal power of the subglacial geothermal areas. The book describes the delineation of ice catchment basins that drain glacial ice toward the various river basins. Finally, with the aid of bedrock and surface topography, an estimation of the area and location of water-drainage basins is arrived at. Glacial hydrology is an important field of applied glaciology in Iceland, where many rivers are fed by glacial meltwater.

STABLE ISOTOPES
(Árny Sveinbjörnsdóttir and Sigfús J. Johnsen, Science Institute, University of Iceland, Dunhaga 5, 107 Reykjavík, Iceland)
Stable isotope measurements ($\partial^{18}O$, ∂D) are now performed at the Science Institute, University of Iceland, on a Finngan MAT 251 mass spectrometer. A considerable amount of data has been collected on Icelandic waters and glacier ice. In the summer 1986–88, holes were drilled through the winter layer of the glacier Vatnajökull for stable-isotope measurements. The results are characteristic for temperate glaciers, where $\partial^{18}O$ ranges from −7 to −20‰ and ∂D from −52 to −149‰. The deuterium excess, which is defined as $d = \partial D - 8 \times \partial^{18}O$, generally lies between 11–17‰, but at the top and bottom of the winter layer it is <10‰ and the minimum value obtained is 4.5‰.

CHEMISTRY OF PRECIPITATION
(Sigurđur R. Gíslason, Science Institute, University of Iceland, Dunhaga 5, 107 Reykjavík, Iceland)
Studies are now being carried out on the precipitation chemistry on Vatnajökull with respect to pH and major dissolved solids.

MASS BALANCE, GLACIER VARIATIONS, GLACIER RUNOFF, SEDIMENT DISCHARGE
(Oddur Sigurđsson and Árni Snorrason, Orkustofnun (National Energy Authority), Grensásvegur 9, 108 Reykjavík, Iceland)
In the year 1988, the National Energy Authority (Orkustofnun) started mass-balance measurements on the ice cap Hofsjökull, central Iceland. The measurements were carried out on one profile from the top of the ice cap to the northern edge. The plan is to extend the studies later to a greater area on the northern part and some areas on the southern side of the ice cap. Winter accumulation was measured in May 1988 on Brúarjökull, north-eastern Vatnajökull. Internal reports on mass-balance measurements are published by NEA.

Glacier variations were measured at 35 different places by members of the Iceland Glaciological Society. Information about the glacier variation is stored by NEA and reported annually in the periodical *Jökull*. A report on the glacier variations for 1980–85 was sent to the World Glacier Monitoring Service.

NEA is running 23 water-level gauges in 11 main glacial river systems and especially monitoring five glacial rivers for jökullhlaups. 19 different glacial rivers are sampled regularly for suspended material.

RIVER AND LAKE ICE
(Sigmundur Freysteinsson, VST Consulting Engineers, Ármúli 4, 108 Reykjavík, Iceland)
Work on river and lake ice in Iceland is mainly in connection with hydro-power development. Research and investigation in this field have been carried out by the National Energy Authority (Orkustofnun) and the National Power Company (Landsvirkjun), often with the services of consultants, both Icelandic and foreign.

Collection of data on ice conditions of the main rivers and lakes has been going on for about 40 years. These investigations are, however, rather sporadic and generally not continuous for longer periods. More detailed observations have been made during planning studies for certain power plants. These observations include for instance, mapping of ice conditions, monitoring of water temperature and frazil ice formation, and surveys of ice jams.

Research programmes are closely related to practical topics. Calculations of heat losses from open water were supported by full-scale measurements. Instruments for monitoring of frazil ice discharge, ice thickness and flash floods have been developed.

Ice troubles in the operation of power plants are subject to changes with continued development of the rivers. At the first power plant in the Thjorsa basin, south-western Iceland, a run of river plant, ice flushing over a diversion dam and ice jamming were the major problems. With construction of additional powerplants and reservoirs in the Thjorsa river system, supercooling and anchor ice at the intakes has become the main problem. Repeated periods of supercooling may occur each autumn because of the alternating cold and warm weather in Iceland and interaction between "warm" water released from deep lakes and reservoirs and intense heat losses with rapid cooling from shallow reservoirs and rivers. Accurate water temperature observations are important to plan the operation and to deal with problems during supercooling episodes.

AVALANCHE RESEARCH DIVISION

(Magnús Már Magnússon, Icelandic Meteorological Service, Bústaðavegur 9, 150 Reykjavík, Iceland)

The Avalanche Division has three main duties:

(1) To issue avalanche warning for populated areas.

(2) To supervise the snow observation stations of which there are nine at present.

(3) To collect information on all avalanches, past and present, and prepare the data for avalanche-hazard zoning being done for the various towns and villages known to have avalanche starting zones located above or near them.

Plans are being made for installing automated weather and snow measurement stations at and around the danger areas. These stations would have a telemetric link to the individual snow observation posts and also to the main office. We are investigating what are the deciding factors in avalanche occurrences for the individual towns and villages so we can improve the avalanche forecasting.

We are also comparing the various avalanche run-out models available and trying to adapt the different parameters to localized Icelandic conditions, and so have joined with the Icelandic Road Authority in a research project to determine the effect of mounds on the various types of avalanche. We are looking at the starting zones and estimated initial volume of the avalanche and the actual path, and the Road Authority is surveying the run-out zone and the volume of the debris. Thus we are hoping to get an idea about the snow entrainment of the different avalanches. This would help in estimating the accuracy of the various run-out models.

SEA ICE RESEARCH DIVISION

(Thor Jakobsson, Icelandic Meteorological Service, Bústaðavegur 9, 150 Reykjavík, Iceland)

The Sea Ice Research Division at the Icelandic Meteorological Service has the obligation to keep track of all available information on sea ice off the Icelandic coasts. For this purpose, close cooperation is maintained with the Icelandic Coast Guard (in charge of sea ice reconnaissance in Icelandic waters), the Oceanographic Institute of Iceland, and the authorities for shipping, fishing, and other governmental organizations.

The main area of interest is the Iceland Sea, the ocean between Iceland, Greenland and the island Jan Mayen. The information on sea ice in the Iceland Sea is mainly received from the following sources: trawlers and fishing boats, coastal transport vessels, the patrol ships and airplanes of the Icelandic Coast Guard, coastal weather stations and satellite imagery, mainly "quick-look" AVHRR pictures obtained by mail from Tromsö Telemetric Station in Norway and APT pictures received at the institute in Reykjavík.

In addition to these information sources, one can add irregular descriptions communicated from Icelandic airline pilots passing over sea-ice areas and occasional ice charts from the Royal Danish Air Force and the Greenland Sea Ice Service as a result of observations in the Denmark Strait between Iceland and Greenland.

Based on these different origins of information, a fairly detailed knowledge of sea-ice distribution and movement in the Iceland Sea is updated continuously.

Just as the input sources are quite varied so are the output channels to users via radio, telefax etc. The main recipients are the fishing fleet, merchant ships, tourist vessels, harbour authorities, the news media and the general public.

Together with a description of the current sea-ice situation according to all available reports, a statement is given on likely developments. The outlook is based on experience and weather forecasts at the institute. Much use is also made of the weather forecasts produced at the European Centre for Medium Range Weather Forecasts (ECMWF) in Reading, England.

After this initial utilization of the sea-ice data, they are of course saved for further processing. The final product is an annual report published by the Icelandic Meteorological Service with a month-to-month description of sea ice in the Iceland Sea, displaying the ice charts made by the Coast Guard. The annual reports are written in Icelandic, but a brief English summary should make the information more widely accessible.

The arrival of sea ice at Iceland is an interesting problem from a scientific point of view. The main reason is that sea ice off the coasts of Iceland is, strictly speaking, an abnormal event.

Broadly speaking, the most common chain of events causing sea ice to reach the coasts of Iceland is based on the satisfaction of three conditions:

(1) First of all, the probabilty increases during winters with extensive sea ice in the East Greenland Current. Sea ice amount east of Greenland is quite variable depending on the ice flow from the Arctic Ocean through the Fram Strait as well as ice formation further south, for example in the area between Greenland and Jan Mayen.

(2) Secondly, ocean surface temperature and salinity conditions in the Iceland Sea are very important in the ice formation process. Surface temperature and salinity distributions in Icelandic waters are quite variable, depending very much on the strength of dominating currents surrounding the island. In years of relatively cold, fresh, surface waters more ice is formed close to home in the Iceland Sea, augmenting the danger of sea ice reaching the Icelandic coasts.

(3) The third condition to be fulfilled concerns the general circulation in the atmosphere. The normal climatic pressure configuration does not favour sea ice reaching all the way to Iceland. Either northerly winds or westerly winds have to prevail for many days in order to "push" the ice far enough towards the island. In other words, a stationary low east of Iceland or a stationary high centred south of Iceland are the primary agents. This brings us to the study of the formation and duration of atmospheric blocks, an important research topic in medium-range forecast research. This third effect (perhaps the most influential in causing sea ice to reach Iceland) will in the coming years be investigated by meteorologists in the Sea Ice Research Division of the Icelandic Meteorological Service, Eiríkur Sigurđsson and Thor Jakobsson.

The three categories are of course not always clear cut, and their importance and mutual relationship are at times more complicated than indicated above.

Finally, it should be mentioned that the Sea Ice Research Division has in the past participated in a few international sea-ice research projects and is presently involved in the Icelandic contribution to "The Greenland Sea Project" (Arctic Ocean Sciences Board). Icelandic research institutes have for a couple of years been working on a comprehensive study of sea ice, weather and biology of the Iceland Sea.

Submitted by Helgi Björnsson

USA - ALASKA

GLACIER STUDIES

LE CONTE GLACIER

(Paul Bowen, Petersburg School District, Alaska)

Le Conte Glacier is the southern-most tidewater glacier in North America. It flows from the Sitkine Icefield in the Coast Range Mountains which divide Alaska from Canada. Le Conte Glacier's terminus position has been measured for six years by students of geology and surveying from Petersburg High School.

The students, using a helicopter and surveying equipment, are responsible for planning logistics and safety procedures, making measurements, taking field notes, performing trigonometric computations, and summarizing all data. This research project provides the participants with a practical application of science and mathematics and the realization that they are contributing to basic science information. A total of 29 students have participated in this study since the project began in 1983. During this time, Le Conte Glacier has advanced about 120 m.

REDOUBT VOLCANO

(Tim Brabets, U.S. Geological Survey, Anchorage)

As part of a study dealing with the hazards of Alaskan volcanoes in Cook Inlet, work will begin this year on glacier-clad Mt Redoubt, which had a small eruption in 1966. During 1989, surveying and ice radar soundings will begin on the glaciers surrounding Redoubt.

SURGE OF THE WEST FORK GLACIER

(K. Echelmeyer and W. Harrison, Geophysical Institute, University of Alaska, Fairbanks, C. Raymond, University of Washington, Seattle, and E. Chacho, CRREL, Alaska)

One of the problems in understanding glacier surges is that only one or two have been observed in detail. We therefore have little knowledge about what features they share, and what essential differences they may have. Moreover, the effect of a large surge on the sediment regime of a large river is yet to be determined. The 1988 surge of West Fork Glacier provided an opportunity to address both of these problems, since information on pre-surge conditions exists and our monitoring of the surge began early in the initial phase.

This surge has shown characteristics typical of others: disruption of the surface, sheared margins, draw-down of 100 m or more in the upper reaches, thickening in the lower regions, propagation of a fairly well defined surge front, and copious production of suspended sediment that is obvious 250 km away in the Susitna River. By November 1988, ice speed had decreased, perhaps close to zero: automatic measurements of speed and river turbidity were being continued.

BASAL PROCESSES AND GLACIER MOTION

(W. Harrison, K. Echelmeyer and M. Sturm, Geophysical Institute, University of Alaska, Fairbanks and C. Raymond, University of Washington, Seattle)

Seasonal and short-period variations in glacier motion and its relation to stream discharge may provide information about the internal plumbing of a glacier, but the acquisition of year-round data with fine time resolution is rarely achieved. We are developing automated techniques to measure glacier velocity, strain, and seismicity year-round, and to measure stream discharge characteristics in summer. Glacier velocity is measured daily by automatic photography, with control and finer spatial resolution provided by periodic optical surveys. Photography is also used to monitor lake and "pot-hole" drainings and stream behavior. The vertical component of surface strain is measured with wire strain meters, usually at a resolution of 2 parts in 10^6, at intervals of 1 h or less; average seismicity over the same interval is also measured. Stream stage is monitored by sonic ranger; and water turbidity, electrical conductivity, and temperature are monitored by instruments on a floating platform tethered in the stream.

Measurements at Fels and Black Rapids Glaciers in the Alaska Range began in 1986 and continue. Some of the notable preliminary results are: (1) much smaller surface vertical strain rates take place than are accounted for by simple strain models, (2) evidence for discrete or inhomogeneous motion in the ice, (3) seasonal variations in speed are quite different on the two glaciers, (4) short-period motion events lasting several days or less, with diurnal variation in strain rate and seismicity sometimes modulating the short-period events, (5) events that are simultaneous on both glaciers, and (6) correlation between some motion events and stream turbidity and electrical conductivity.

WEST GULKANA GLACIER

(M.G. Marcus, Arizona State University, Tempe)

Glaciological and climatological studies were conducted on West Gulkana Glacier, Alaska, during the summer of 1986 and 1987, by a joint Arizona State University–U.S. Military Academy team. A 1986 5 m contour map of the glacier was produced for position and mass–balance comparisons to the 1957 West Gulkana map included in the IGY *Nine glacier maps in northwestern North America* series. A 29 year water loss of $62.3 \times 10\ m^3$ was determined. The terminus of this small glacier retreated about 400 m during this period. Losses in 1985–86 and 1986–87 were 1.8 and $0.98 \times 10^6 m^3$, respectively.

Climatological research included energy balance investigations over snow, ice, slush, and alpine tundra surfaces; radiation balance modeling; determination of the alpine valley wind field and its linkage to upper air patterns; and 30 year synoptic interpretations. A joint ASU-USMA research paper, "Climate and glacier studies: West Gulkana Glacier and environs, Alaska" (including the inserted 1986 map) is available while supplies last for a US $2.00 handling fee. Contact M.G. Marcus, Department of Geography, Arizona State University, Tempe, AZ 85287, U.S.A. A second volume is expected in 1990.

WOLVERINE GLACIER

(L.R. Mayo and R.S. March, U.S. Geological Survey, Fairbanks)

Monitoring continues of air temperature, precipitation, mass balance. glacier height change, and glacier flow at this maritime glacier in south central Alaska. Measurements have been made since 1966. The glacier has been growing since 1976 because of an increase in snow precipitation. At the same time, winter temperatures have become warmer and the mean annual air temperature has increased. Summer melting has not increased during the same period because summers have not become either longer or warmer. Apparently this glacier is neither behaving itself nor responding properly to the "scientific consensus" that a warming climate will cause glaciers to melt and sea level to rise. We would like to know how extensive this process is because Wolverine Glacier is at the latitude of maximum glacier coverage of North America.

EXIT GLACIER

(Bud Rice, National Park Service, Seward)

We have maintained a battery-operated camera by Exit Glacier to take daily photographs of markers to monitor rates of surface movement. We have not detected any jerky movements, only steady downhill flow.

GLACIER SEDIMENT

DETECTION OF COARSE SEDIMENT MOVEMENT USING RADIO TRANSMITTERS

(Edward F. Chacho, Jr., USACRREL, Alaska, Robert L. Burrows and William W. Emmett, USGS, Fairbanks)

The use of radio transmitters to track and locate coarse sediment (39 mm or larger) was successfully demonstrated by tracking five individual rocks through a braided glacier-fed river system. Radio-implanted rocks traveled about 1.5 km in 8 days and were tracked during periods of high flow and turbid water conditions. After flow receded and access to the bars and channels was possible, the rocks were located and recovered even though burial of up to 0.3 m had occurred. A motion-sensing device which detects whether a particle is in motion or at rest was also tested successfully.

HYDROLOGY STUDIES

WATERSHED STUDIES IN COLD REGIONS
(E.F. Chacho, Jr., USACRREL, Ft Wainwright)
Snowmelt runoff and organic and inorganic sediment yield were investigated in 1988 at three small permafrost-dominated watersheds in Alaska: near Barrow (in cooperation with USGS), at Caribou–Poker Creeks research watershed (in cooperation with U.S. Forest Service), and at Glenn Creek. Investigations continued throughout the summer at the latter two sites near Fairbanks to determine seasonal effects on run-off production and sediment yield, and in a continued effort to separate contributions from permafrost and non-permafrost source areas.

WINTER WATER SUPPLY LOCATIONS AND QUANTIFICATION
(R. Melloh, E.F. Chacho, Jr. and C.M. Collins, USACRREL)
The long-term objective of this program is to develop techniques for locating and quantifying unfrozen winter water sources in Arctic and sub-Arctic regions. Emphasis is on developing both remote and field methods. Field investigations are being carried out to define the environment and process by which the sources occur, and provide ground verification for remote-data interpretations. Active radar and passive microwave imaging techniques to detect unfrozen river channels and pools under ice and snow covers are being investigated.

Winter investigations were conducted in 1988 using synthetic aperture radars and a passive microwave radiometer operated by NASA. A digital analysis of passive microwave imagery of freshwater lakes has been completed.

PERMAFROST

THERMAL REGIME OF DISCONTINUOUS PERMAFROST TERRAIN WITHIN THE CARIBOU–POKER CREEKS RESEARCH WATERSHED, ALASKA
(C. M. Collins, USACRREL, Alaska)
A series of thermistor strings installed in bore holes at sites along a transect of the watershed was established to study the thermal regime of the discontinuous permafrost in the upland interior of Alaska. The sites, located in both permafrost and non-permafrost areas, represent a variety of slope, aspect, elevation, and vegetation conditions. Ground temperatures, along with other site parameters, are being used to model the distribution of permafrost within the watershed.

REMOTE SENSING

ALASKA SAR FACILITY
(G. Weller, W. Weeks, J. Miller, Geophysical Institute, University of Alaska, Fairbanks)
A new satellite remote-sensing facility will soon be available to snow and ice researchers around the world. The facility, constructed jointly by NASA and the University of Alaska, will be able to receive, process, and distribute synthetic aperture radar (SAR) data from ESA's ERS-1, Japan's JERS-1, and Canada's Radarsat satellites, scheduled for launch in 1991, 1992 and 1994, respectively. The receiving ground station which includes a 10 m diameter tracking antenna has been installed (see photo). The data processor and auxiliary equipment will be ready by mid-1990.

The satellite SAR data will be particularly useful for sea ice, ocean, iceberg, snow, and glacier studies. Algorithms are presently being developed; products available to investigators will include routinely processed sea-ice classification and motion analyses. Glacier and snow characteristics and dynamics can also be investigated with SAR data. Data will initially be available only within a 4000 km radius of Fairbanks, but with the launch of JERS-1, a global data set may become available.

INTERPRETATION OF RIVER AND LAKE ICE FROM AIRBORNE KRMS AND SAR IMAGERY
(L. Gatto, R. Melloh, E.F. Chacho, Jr., USACRREL)
Our objectives are to evaluate the passive and active microwave-imagery patterns produced by different river and lake ice conditions and provide interpretive keys for analyzing such patterns on existing microwave images. In March 1988, passive microwave and SAR images were acquired concurrently with field data on freshwater ice. We acquired K-band Radiometric Mapping System (KRMS), 33.6 GHz passive microwave, and multiband Synthetic Aperture Radar (SAR) images of the Tanana River and Harding Lake areas near Fairbanks, Alaska. Ground-truth observations and measurements were made within 3 days of imagery acquisition to document the physical conditions of the river and lake ice and overlying snow. We also acquired airborne videotape of the river and lake to be used in interpreting the snow and ice conditions. Cross-section and core-sample drawings have been prepared from the

groundtruth data and are currently being used to investigate the correlation between image patterns and snow and ice conditions.

SEA ICE

MEASUREMENTS AND SIMULATION OF THE PROFILE PROPERTIES OF UNDEFORMED FIRST-YEAR SEA ICE

(R. Glen, L. Shapiro and W.F. Weeks, Geophysical Institute, University of Alaska, Fairbanks)

Detailed observations of the meteorological conditions, sea-ice growth rates, salinity profiles, and physical property profiles for different structural types of sea ice are very limited. This program intends to obtain a varied set of such information at Barrow, Alaska, during the 1989–90 ice growth season. Ice growth will be initiated at several different periods during the winter by cutting out ice to make ponds. The resulting data will be compared with estimated ice property profiles calculated by a meteorologically-driven simulation model recently developed by Cox and Weeks. We hope to be able to study both aligned and unaligned congelation ice as well as frazil ice.

ICE ISLANDS AND MULTIYEAR SEA ICE

(W.M. Sackinger, M.O. Jeffries, Li Fucheng and Lu Mingchi)

Ice islands are the tabular icebergs of the Arctic Ocean, and present the most extreme hazards to offshore Arctic petroleum development. Multi-year ice is also a significant problem. The research program began in 1983 with the objective of further understanding these ice features and the hazards they represent.

Analysis of airborne synthetic aperture radar (SAR) imagery shows: (1) ice islands as small as 300–400 m across can be detected by SAR, having a ribbed texture arising from the undulating surface, and (2) as they drift, ice islands can increase in area and mass by the addition of pack ice. The calving of a 7.2 × 3.6 km multi-year landfast sea-ice floe from the front of the Milne Ice Shelf, Ellesmere Island, was detected in February 1988 in near-real-time by airborne SAR. The calving appears to have been caused by offshore winds which occurred only 7–10 days before the SAR data acquisition.

The study of ice cores from "Hobson's Choice", the largest ice island presently known in the Arctic Ocean, includes liquid electrical conductivity, density, ice crystal size, structure and fabric, tritium, $\delta^{18}O$ and δD (with H. R. Krouse, University of Calgary), and uniaxial compressive strength (with R. Frederking, N. Sinha and G. Timco, National Research Council of Canada). Hobson's Choice has a basic two-layer structure, with a 35–38 m thick layer of superimposed ice resting uncomformably on a 5 m thick layer of recently formed freshwater ice. The latter accreted from freshwater flowing beneath the East Ward Hunt Ice Shelf prior to the ice island calving. Preliminary results of uniaxial compressive strength tests at strain rates in the range $10^{3}s^{-1}$ to $10^{7}s^{-1}$ are 6.0 MPa to 1.5 MPa, respectively. These values do not differ significantly from those obtained in other studies of iceberg ice. The paleo-climatic and ice-shelf growth history implications of the ice core structural and stratigraphic variations are also being investigated.

The dynamics of movement events of Hobson's Choice during May to August 1986 have been analyzed in terms of the forces acting on the ice island. A surface wind speed of 5.25 m s^{-1} appears necessary to initiate ice island motion. The ice island moves 15-25° to the right of the surface wind direction, and the average speed ratio of the ice island to the surface wind is 0.014. The ice island moves 25-35° to the left of the geostrophic wind direction, and the average speed ratio is 0.0086. Close to mountainous shores the ice island–wind relationships and ice island movement are subject to mountain-barrier effects. A residual force (pack ice force, tidal forces and sea-surface tilt) is usually of low magnitude during the initial and final stages of a movement event, but reaches a maximum magnitude (12.5 MN) at the height of a movement event (0.16 m s).

The Monte Carlo method and a dynamic model have been combined to simulate ice-island movement and determine recurrence intervals in the Arctic Ocean. One year recurrence zones occur in the Beaufort Sea adjacent to the Canadian Arctic Archipelago and in the Arctic Ocean north of Wrangel Island. A broad region of 1–10 year recurrence interval occurs in the central Arctic Ocean. A steep gradient of 10–1000 year recurrence intervals occurs along the Beaufort Sea coast of Alaska.

Plans include: (1) periodic ground and remote sensing surveys of the Ellesmere Island ice shelves to detect ice calvings, (2) a study of the meteorological and oceanographic factors influencing calvings; (3) field and remote-sensing surveys of the spacing of failure zones in the multi-year floes, (4) field surveys of the ice thickness and ice types in the failure zones in multi-year floes, (5) remote sensing of multi-year floe sizes, (5) modeling ice island–multi-year ice–offshore structure interactions.

STUDIES OF THE SALINITY AND STRUCTURE OF SECOND-YEAR ICE FLOES IN THE MAIN POLAR BASIN

(W.F. Weeks, Geophysical Institute, University of Fairbanks)

This program is focused on the analysis of salinity, temperature and structure profiles from a series of sea-ice cores collected during two different field seasons (March–April 1986–87) from drifting ice floes located north of Greenland at latitudes between 83 and

85°N. Little information is available in the current literature on such ice. Particular emphasis is being given to refrozen melt ponds and melt holes in the ice and to the rather odd, opaque boundary that separates ice formed during the two growth seasons.

THE INTERNAL STRUCTURE, COMPOSITION AND PROPERTIES OF BRACKISH ICE FROM THE BAY OF BOTHNIA DURING BEPERS '88
(W.F. Weeks, Geophysical Institute, University of Alaska, Fairbanks, A.J. Gow, CRREL, P. Kosloff, Finnish Institute of Marine Research, and S. Digby-Argus, Radarsat)
Ice structure and properties were determined during the BEPERS remote sensing experiment. Water salinities ranged from 4 ppt to less than 0.5 ppt in the northern part of the bay where two large rivers discharge. Corresponding ice salinities ranged from a maximum of 2.0 ppt to values as low as 0.04 ppt. Ice–water interfaces invariably showed non-planer characteristics indicating the development of impurity-induced substructures. A variety of ice types was observed including *c*-axis random, *c*-axis vertical, and *c*-axis horizontal (aligned and random). Aligned ice was the most common. A variety of structural factors contributing to specific areas of high radar return have been identified.

SEA ICE RIDGING VARIATIONS IN THE ALASKAN COASTAL ZONE
(W.F. Weeks and R. Wade, Geophysical Institute, University of Alaska, Fairbanks)
Final analysis is underway of several years of multi-season laser profilometer observations of pressure ridge characteristics in the Beaufort, Chukchi, and Bering Seas. Results show a large interannual variability and a strong zonation parallel to the coast.

SNOW STUDIES

CHARACTERISTICS AND DISTRIBUTION OF REGIONAL TYPES OF SNOW COVERS
(M. Sturm, E.F. Chacho, Jr., J.B. Johnson, USACRREL, Alaska, C.S. Benson, University of Alaska, Fairbanks)
We are starting a new program in which we will try to (1) identify distinct types of regional snow covers, and quantify each type of snow by measuring its range of depth, density, grain size, air permeability, thermal conductivity, strength and emissivity, (2) measure the temperature field in the snow for each type of snow cover, in order to identify the strength of temperature gradients, and the pressure or absence of convection, and (3) determine the spatial variability of physical parameters within each type of snow cover as a function of substrate, vegetative cover, slope, and aspect.

To achieve these goals, we will install seven instrumented monitoring sites and locate about 10 several km long snow traverses through varied terrain and vegetation, on a transect from Valdez to Prudhoe Bay, Alaska. Measurements will be made starting in the winter of 1989–90, and continuing for 3 to 4 years. We will be working closely with a remote-sensing group at NASA (Goddard).

PHYSICAL PROCESSES IN SNOW COVER
(M. Sturm, J.B. Johnson, E.F. Chacho, Jr., USACRREL, Alaska and C.S. Benson, Geophysical Institute, University of Alaska, Fairbanks)
For the past four years we have monitored the 3 dimensional temperature field in the snow cover at Fairbanks to determine the prevalence and nature of convection in the snow. Measurements of heat at the snow–soil interface and ground temperatures were also made. The snow texture and depth hoar growth were studied using photographs, stereology, and sieving. Results indicate that diffuse plume-like convection is prevalent during normal winters when the snow cover is less than 0.6 m thick. Textural features (i.e., *c*-axis orientations of snow crystals) show some correlation with the probable air flow directions. We now are planning laboratory experiments to investigate further the relationships of air flow direction and snow texture.

ACID SNOW
(Gerry Young, North Pole Middle School, North Pole, Alaska)
In the fall of 1985, students at North Pole Middle School began measuring acid precipitation. Snowfall readings of 1985 averaged pH 5.5, which is normal for unpolluted rain. In 1988 the snow had a pH of 4.8. We will be attempting to trace the sources of the pollution causing this in the future. Because no regional precipitation acidity data exists, we are attempting to enlist other schools in Alaska to gather records, using standardized techniques, and to report measurements to a network. Already, 70 schools have responded and are collecting data. We plan to compile this and complete an analysis. Next year we plan to collect data at least once a month from over the entire state of Alaska.

USA–ANTARCTICA

SHORT PERIOD SPEED VARIATIONS IN ICE STREAM B, ANTARCTICA
(W. Harrison and K. Echelmeyer, Geophysical Institute, University of Alaska, Fairbanks)
A program was begun in 1988 to study short-period motion of Ice Stream B, West Antarctica, for direct correlation with borehole measurements being performed by B. Kamb, H. Englehardt and N. Humphrey of the California Institute of Technology.

Measurement consists of direct field observation of ice velocity and installation of strain meters and geophones to monitor changes in strain rate and seismicity continuously, in the hope that these instruments will be able to sense changes in the ice flow regime. They were installed in seven boreholes about 50 m deep.

Velocity measured daily for about five weeks seems to be constant within the measurement accuracy of a few per cent. The strain and seismic data will be recovered next season.

INTERRELATIONS BETWEEN THE ANTARCTIC SEA ICE AND THE GENERAL CIRCULATION

(E. Breitenberger and G. Wendler, Geophysical Institute. University of Alaska, Fairbanks)
For the period 1973–1984, sea-ice conditions in the Southern Ocean were related to circulation intensities derived from 700 mb level synoptic maps. This was done for weekly periods and for 12 sectors, each spanning 30° in longitude, For the 12 year period, a decrease in the sea ice extent was observed, with the latitudinally-averaged ice edge moving southward by 33 km over the period. 1982–83 was the only strong "El Nino" year during the observational period. The ice edge in austral summer 1982–83 was about 150 km further south than the mean for the 12 year period, a large deviation and the most southerly position for the whole period. In 1975–76. which was a weak "El Nino" year, no special sea-ice behavior was observed.

Years with heavy ice in the sectors from 120°E to 60°W (going from west to east) were correlated with light ice in the sectors from 60°W to 120°E, and vice versa. This is similar to the findings for the Arctic Ocean, where heavy ice areas in the Pacific Ocean are associated with light ice areas in the Atlantic Ocean and vice versa.

BLOWING SNOW IN ANTARCTICA

(G. Wendler and J. Gosink, Geophysical Institute, University of Alaska Fairbanks)
Snow transport by wind is being studied at South Pole and Dumont d'Urville stations and at "D57", a slope station some 100 km south of Dumont d'Urville and some 100 km inland from the Adelie Land coast. Measurements of blowing snow were carried out with a new photo-electric sensor built by the University of Alaska, after a design by Schmidt. This instrument measures the number and size of the snow particles photo-electrically, which ensures that the air flow is not disturbed as is the case with mechanical devices. Furthermore, short integration times are possible, giving a meaningful relationship between wind speed and flow. It was found that stronger winds not only pick up more particles, but also larger ones. The particle frequency typically ranged from a few hundred to a few thousand particles per cm^2/s, and the sizes ranged from 80 to 200 microns, decreasing strongly with height. Normally, drifting snow was observed with wind speeds of 8 m/s; with a speed of 14 m/s well-developed blowing snow was observed, and when the wind speed reached 20 m/s, the visibility went down to 20 m.

The fluxes can be calculated from size and frequency data, and by integrating the fluxes with height, the total flux for a specific wind speed could be determined. By using automatic weather stations, which measure the wind speed year-round, the total annual flux could be estimated. For "D57", a value of 6.3×10^6 kg per m [width across the wind path, *ed.*] per year was calculated. This is about one order of magnitude less than Loewe suggested for Port Martin, one of the windiest areas of Antarctica.

USA–GREENLAND

DYNAMICS OF JAKOBSHAVNS ICE STREAM, WEST GREENLAND

(K. Echelmeyer, W. Harrison and C. Benson, Geophysical Institute, University of Alaska, Fairbanks)
Jakobshavns Isbræ is a fast-moving outlet glacier draining a large part of the Greenland ice sheet. It extends nearly 100 km into the ice sheet as a well-defined ice stream. The glacier moves at speeds of over 7 km/yr below the grounding zone, with a gradual decrease in speed inland into the ice sheet. It moves at these high speeds continuously, making Jakobshavns the world's fastest glacier. Such high speeds are comparable to those observed on surge-type glaciers during periods of peak surge when basal sliding is the dominant flow mechanism. An important question is whether the high speeds on Jakobshavns Isbræ are due to a large sliding contribution or to some other mechanism such as an ice-flow instability near the base, and, if it is sliding, what causes these high slip rates?

A field program was undertaken on Jakobshavns Isbræ during 1984–87 to address these questions and others relating to its ice-stream dynamics. Measurements have included spatial and temporal variations of the surface-velocity field, mass balance, ice temperature, seismic activity, calving rate, terminus position, ice-fabric analysis, and ice thickness.

Surface velocity shows no seasonal variation. Calculated basal shear stresses along the ice stream are large, and if there is a basal zone of favorably oriented ice (and therefore a weak layer), then ice deformation under the large stresses may account for the fast motion in the ice stream rather than basal sliding or deformation of basal debris. Ice petrofabric analyses show strong single maximum *c*-axis fabrics near the ice stream margins (high shear strain environment) and less strong near the ice stream center (lower shear strain history). At and below the grounding zone, short-interval (½ h) surveys show that the velocity varies by as much as 35% synchronously with the level of the tide in the fjord. The phasing of harmonic speed variations with the tide suggests that basal sliding is occurring at the grounding zone and that this sliding may be directly affected by subglacial water pressure. These and other results from the field program are under analysis, and will hopefully give further insight into the dynamics of this fast-moving ice stream.

JAKOBSHAVNS GLACIER DRILLING PROGRAM
(K. Echelmeyer and W. Harrison, Geophysical Institute, University of Alaska, Fairbanks and A. Iken, ETH, Zurich)
The investigation of fast-moving Jakobshavns Glacier is continuing with a borehole drilling program. This program is a joint project with Dr Almut Iken of ETH, Zurich, Switzerland.

The mechanisms of rapid glacier motion are being studied by drilling boreholes through the ice using a hot water drill. Several down-hole measurements were made in 1988 and they will be continued in 1989; these include measurements of ice temperature through the ice column, internal deformation by borehole inclinometry, sub-glacial water pressure and sliding rates, and the nature and deformation of the glacier bed by sampling, interborehole conductivity and *in situ* deformation. At the same time, the surface velocity is being measured across three transverse profiles near the drill site that extend from the slower-moving ice sheet on the north, across the ice stream and on to the ice sheet to the south. These measurements will allow the complete force field to be determined about the boreholes. Short-term velocity measurements are also being made, as well as short-period strain and seismic event monitoring.

During 1988 several holes were drilled to 1200–1400 m, the greatest depth ever reached by hot water drilling, but the glacier bed was not reached. A seismic reflection traverse through the drill site indicates that the ice is much deeper than had been expected at this location. Thus, many of the planned borehole measurements planned for 1988 were not undertaken. Ice temperatures are colder than expected at depth, −22°C at 1000 m and decreasing at greater depths. These cold temperatures arise from rapid advection of cold ice from high in the drainage basin.

In 1989, we plan drilling closer to the ice stream margin where the ice is thinner and our drill may be capable of reaching the glacier bed. In addition, theoretical and numerical study of borehole closure and hot water drilling rates will be undertaken to help guide the planning for the 1989 field campaign and drilling programs in Antarctica and elsewhere.

HIGH-RESOLUTION SEISMIC STUDIES ON JAKOBSHAVNS ICE STREAM, GREENLAND
(T. Clarke and K. Echelmeyer, Geophysical Institute, University of Alaska, Fairbanks)
In conjunction with the 1988 borehole drilling project on Jakobshavns Glacier, a high-resolution seismic reflection traverse was made across the ice stream through the drill site. The 7 km-long traverse extended from the ice sheet on the north, across the ice stream and into the crevassed shear margin on the south. A 12 channel seismic system was used, with geophones placed every 15 m. Explosive sources were used and the entire system was moved in a stepwise manner across the profile.

The purposes of this study were to measure the glacier bed geometry near the drill site; and secondly, to determine fine-scale bed structures including any sub-glacial till or debris layers which might provide a mechanism for the rapid flow of this glacier. The survey shows that the fast ice stream is situated in a deep U-shaped trough similar to that found at valley glaciers, unlike the shallow to non-existent troughs beneath many Antarctic ice streams. Preliminary results also indicate a second seismic reflection arrival 50 to 25 ms after the first, which may indicate a subglacial debris layer. Additional seismic studies are planned for 1989.

USA-ASIA

MT EVEREST, NEPAL
(Bradford Washburn, Museum of Science, Boston)
A new map at a scale of 1 : 50,000 with a contour interval of 40 m of Mt Everest has been made by the National Geographic and distributed worldwide with the November 1988 *National Geographic* magazine. It was a project of this Museum and the *Geographic*.

Ground control was developed from British, Chinese, and Austrian maps of the area, and evaluated and adjusted by West German vertical photography taken from the US Space Shuttle "Columbia" in December 1983, from a height of 22 km. The map was compiled from air photos taken in 1984 from an altitude of 12 km. Contouring of the 940 km^2 area at a scale of 1 : 10,000 was accomplished by Swissair Photo Surveys Ltd of Zürich, and cartographic artwork added by the Swiss Federal Institute of Topography. To produce it, we made 10 sheets of this area at 1 : 10,000 with 20 m contours — which we hope will be of great value to geologists and glaciologist in the future. We are also working on a 1 : 5,000 scale map of Mt Everest itself with 5 m contours, which should prove to be of special value to geologists.

Submitted by L.R. Mayo

ANNUAL GENERAL MEETING 1988

MINUTES OF THE ANNUAL GENERAL MEETING OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY
8 September at Lom samfunnshus, Norway

The President, Dr Sam Colbeck, was in the Chair. 50 members from 11 countries were present.

1. The Minutes of the 1987 Annual General Meeting, published in *ICE* 86, p. 29-30, were approved and signed by the Chairman.

2. The President gave his report for 1987–88. On behalf of the Society, I am very pleased to see so many of you here. This meeting is characterized by an interacting mix of snow and glacier scientists, held in a charming location, and successful because of the hard work of our Norwegian collegues. The Society's major resource is those dedicated members who put the effort into hosting these meetings and I thank them for their hard work and self-sacrifice in providing us with this opportunity to get together and exchange the highlights of our work.

As a measure of the Society's state-of-health, we have an increasing list of meetings planned or proposed for the future. Those scheduled or proposed will carry us well into the next decade with the assurance that we will not only be able to sponsor the meetings, but will be able to continue to publish the proceedings in the *Annals of Glaciology*. In spite of our apparent success in this area, we are always looking for proposals for future meetings and I encourage any of you to entertain the thought of hosting an IGS meeting in your country.

Although past Presidents of IGS have used this meeting to discuss the financial health of the Society, I am going to break with tradition and only mention that our financial status has been good over the past few years and that we have no great concerns about it. The financial records are available for anyone who would like to see our bottom line, but other things are more important to discuss with the members at this time. Given that our financial situation is reasonably stable, it is time for the IGS to think about how else it might serve its members. In other words, let's make hay while the sun shines.

The *Journal of Glaciology* has experienced some problems with its new editing system, but these I view as normal growth problems and not fundamental flaws in the system. We are constantly re-examining the way we edit and produce the *Journal* to find better, faster, and cheaper ways of providing it for you. While I feel things are going reasonably well, we are entertaining the idea of choosing a senior editor who could take overall responsibility for technical standards and look to future directions for the *Journal*. In short, after four years of this international editing system, we are thinking about how well it is working and would be happy to hear your thoughts on the subject.

With the *Journal* and *Annals* evolving along normal courses of development, I think it is appropriate to look for additional roles that the Society might play in publishing. We looked at the possibility of publishing a text book on glaciology and did a survey of possible users of such a book. Unfortunately, the needs of the different users are so great and varied that it seems very unlikely that one book could find a big enough market to be successful. Out of this project grew the idea of publishing a "bench-mark" series in glaciology. These series have been well received in other fields, partly because they are useful at a variety of levels. Students get a set of classic papers in the area easily and at a low cost. Others use the volume to round-out their collection of papers in their area of interest. I am happy to say that Garry Clarke has taken on the job of putting together the first in this series, a volume on glacier flow. Unfortunately, in order to make this series attractive, we will have to use the Society's optical character reader to scan the articles and we have encountered some problems with doing this. Our reader is not capable of scanning all of the type faces used in the collection of articles, especially the older articles. Accordingly, we are going to have to either delay the start of this series until the technology provides us with better scanners or find some other way to reproduce these older papers. Stay tuned to this issue; we are continuing to work on it.

At this time I would like to hear your thoughts and concerns about the Society. What would you like to see the Society do in future? What problems have you had with the Society? What suggestions do you have for the way we do business?

3. The Treasurer, Dr J.A. Heap, submitted a report:
The general state of the Society's finances is reasonably good. As you will see from the audited accounts for 1987, there was a small surplus on the General Income and Expenditure Account of £163, following

surpluses in the four years 1983–86 of £6,136, £3,831, £4,785 and £5,272 respectively.

Over the six years 1982–87 the Accumulated Fund, an indicator of the general state of the Society's finances, has moved from showing a deficit of £13,251 in 1982 to a peak surplus of £13,155 in 1986. But in 1987 the Accumulated Fund dropped back to £8,318. In large part, both the small surplus in the General Income and Expenditure Account and the reduction in the Accumulated Fund is covered by Council's decision to transfer £5,000 to the Contingencies Fund, which now stands at £7,073.

These accounts show a similar pattern to those of previous years. While the Society's operation as a publisher remains viable, every effort needs to be made to keep the cost per published word in the *Journal* under tight control.

R. Hook proposed, and E. Morris seconded, that the audited accounts for 1987 should be adopted. This was carried unanimously.

4. Election of Auditors for the 1988 accounts. E. Morris proposed and G. Clarke seconded that Messrs Peters, Elworthy and Moore of Cambridge be elected auditors for the 1988 accounts. This was carried unanimously.

5. Elections to the Council 1988–91. After circulation to all members of the Society of the Council's suggested list of nominees, no further valid nominations were received, and the following people were therefore elected unamimously:

Vice President: (1)	G. Wakahama
Elective Members (4)	D. Collins
	S. Jonsson
	J. Oerlemans
	Xie Zichu

. . . .

After the conclusion of the formal business of the meeting, some of the members expressed concern about the fact that so many meetings had been held on one topic, the large ice sheets, in a period of two years. The President answered that the Society certainly agreed that this had been a problem, and was continuing to communicate with other organizations. But we should remember that we could not choose topics for them. Members must also remember that we respond to their suggestions for meetings made by our members and that we are not free to choose the topic, only to make minor modifications to reduce conflicts with other organizations.

SYMPOSIUM ON SNOW AND GLACIER RESEARCH RELATING TO HUMAN LIVING CONDITIONS

Lom, Norway, 4–9 September 1988

The symposium was held in the mountain village of Lom, in eastern Norway. Meetings were held in the village school, and most participants stayed in the attractive old Fossheim Hotel, run by the Brimi brothers.

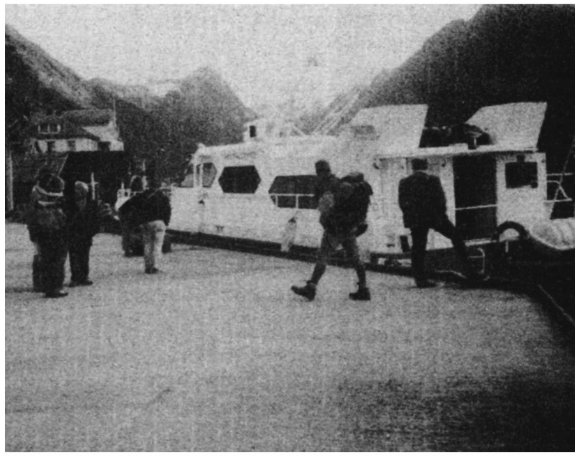
Arni (on the right) is a world-class chef:

Some people were more reluctant than others to be photographed (2nd from left, Karstein Leid, chairman of the Local Arrangements Committee).

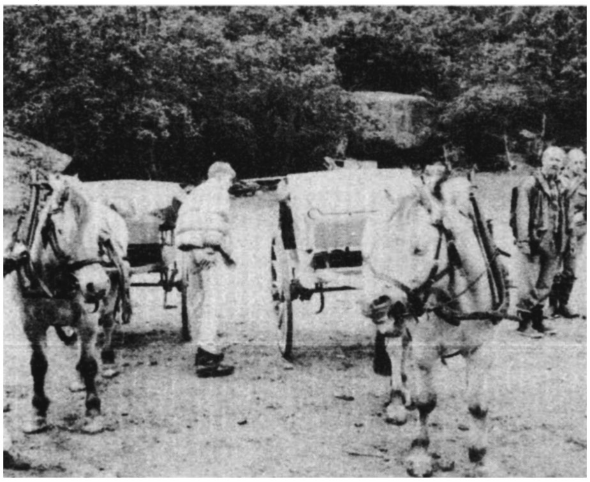
the results of his labours were appreciated by everyone.

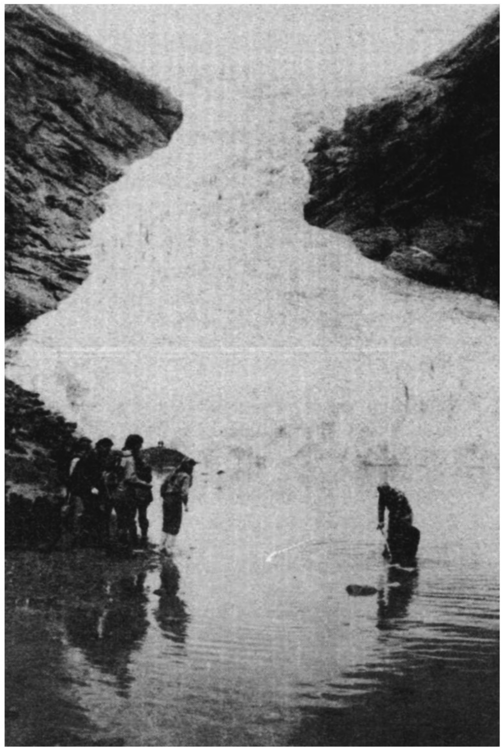
Two 4-day tours took place after the symposium ended, both groups meeting up in Mundal.

Helicopters, buses, boats



and horses were used at different stages of the journey.





Ice was collected by Olav Orheim for drinks at the final party, which was greatly enjoyed by all, including Björn Wold (Chief Editor of the proceedings volume) at right.

ANNALS OF GLACIOLOGY

The following papers are published in Volume 13, Proceedings of the Symposium on Snow and glacier research relating to human living conditions held at Lom, Norway, 4–9 September 1988.

A BEZINGE, M J CLARK, A M GURNELL, J WARBURTON
The management of sediment transported by glacial melt-water streams and its significance for the estimation of sediment yield.

J BØGEN
Glacial sediment production and development of hydro-electric power in glacierized areas.

R J BRAITHWAITE, H H THOMSEN
Simulation of run-off from the Greenland ice sheet for planning hydro-electric power, Ilulissat/Jakobshavn, West Greenland.

G BRUGNOT
Six years of snow-fence testing in France.

G BRUGNOT, F RAPIN
Recommendations for the safe use of ropeways carrying explosives in avalanche blasting.

E BRUN
Investigation on wet-snow metamorphism in respect of liquid-water content.

L BUISSON, C CHARLIER
Avalanche starting-zone analysis by use of a knowledge-based system.

O BUSER
Two years experience of operational avalanche forecasting using the nearest neighbours method.

D BUTZ
The agricultural use of melt water in Hopar settlement, Pakistan.

G CASASSA, H NARITA, N MAENO
Measurements of friction coefficients on snow blocks.

D N COLLINS
Seasonal development of subglacial drainage and suspended sediment delivery to melt waters beneath an Alpine glacier.

C L DRIEDGER, A G FOUNTAIN
Glacier outburst floods at Mount Rainier, Washington State, U.S.A.

K ELDER, J DOZIER, J MICHAELSEN
Spatial and temporal variation of net snow accumulation in a small alpine watershed, Emerald Lake basin, Sierra Nevada, California, U.S.A.

C R FENN
Quantifying the errors involved in transferring suspended sediment rating equations across ablation seasons.

A G FOUNTAIN
The storage of water in, and hydraulic characteristics of, the firn of South Cascade Glacier, Washington State, U.S.A.

M FUNK, H ROTHLISBERGER
Forecasting the effects of a planned reservoir which will partially flood the tongue of Unteraargletscher in Switzerland.

H GUBLER
Comparison of three models of avalanche dynamics.

H GUBLER, H-P BADER
A model of initial failure in slab-avalanche release.

W HAEBERLI, J-C ALEAN, P MULLER, M FUNK
Assessing risks from glacier hazards in high mountain regions: some experiences in the Swiss Alps.

K HEWITT, C P WAKE, G J YOUNG, C DAVID
Hydrological investigations at Biafo Glacier, Karakoram Range, Himalaya; an important source of water for the Indus River.

K HUTTER, S B SAVAGE, Y NOHGUCHI
Numerical, analytical, and laboratory experimental studies of granular avalanche flows.

K ISHIMOTO, M TAKEUCHI, S NAITOU, H FURUSAWA
Development and certification of a visibility-range monitor by image processing.

K IZUMI
Effects of solar radiation on the formation of weak wet snow.

R KATTELMANN
Spatial variability of snow-pack outflow at a site in Sierra Nevada, U.S.A.

K KAWADA, K NISHIMURA, N MAENO
Experimental studies on a powder-snow avalanche.

M I KENNETT
A possible radio-echo method of locating englacial and subglacial waterways.

B LACKINGER
Supporting forces and stability of snow-slab avalanches: a parameter study.

R M LANG, B R LEO, K HUTTER
Flow characteristics of an unconstrained, non-cohesive, granular medium down an inclined, curved surface: preliminary experimental results.

J O LARSEN, J LAUGESEN, K KRISTENSEN
Snow-creep pressure on masts.

A LETREGUILLY, L REYNAUD
Past and forecast fluctuations of Glacier Blanc (French Alps).

K LIED, R TOPPE
Calculation of maximum snow-avalanche run-out distance by use of digital terrain models.

K LIED, F SANDERSEN, R TOPPE
Snow-avalanche maps for use by the Norwegian Army.

D M McCLUNG, J O LARSEN
Effects of structure boundary conditions and snow-pack properties on snow-creep pressures.

D M McCLUNG, A I MEARS, P SCHAERER
Extreme avalanche run-out: data from four mountain ranges.

K I MacDONALD
Impacts of glacier-related landslides on the settlement at Hopar, Karakoram Himalaya.

L R MAYO
Advance of Hubbard Glacier and 1986 outburst of Russell Fiord, Alaska, U.S.A.

R MEISTER
Influence of strong winds on snow distribution and avalanche activity.

K NISHIMURA, N MAENO
Contribution of viscous forces to avalance dynamics.

K NISHIMURA, H NARITA, N MAENO, K KAWADA
The internal structure of powder-snow avalanches.

Y NOHGUCHI
A mathematical model for instability in snow gliding motion.

Y NOHGUCHI
Three-dimensional equations for mass centre motion of an avalanche of arbitrary configuration.

H NOREM, F IRGENS, B SCHIELDROP
Simulation of snow-avalanche flow in run-out zones.

L J ONESTI, E HESTNES
Slush-flow questionnaire.

I F OWENS, B B FITZHARRIS
Assessing avalanche-risk levels on walking tracks in Fiordland, New Zealand.

J W POMEROY
A process-based model of snow drifting.

P SCHAERER
The avalanche-hazard index.

M TAKEUCHI
Snow-collection mechanisms and the capacities of snow fences.

W H THEAKSTONE, N T KNUDSEN
Temporal changes of glacier hydrological systems indicated by isotopic and related observations at Austre Okstindbreen, Okstindan, Norway, 1976–87.

H H THOMSEN, L THORNING, O B OLESEN
Applied glacier research for planning hydro-electric power, Ilulissat/Jakoshavn, West Greenland.

A M TVEDE
Floods caused by a glacier-dammed lake at the Folgefonni ice cap, Norway.

T UEMATSU, Y KANEDA, K TAKEUCHI, T NAKATA, M YUKUMI
Numerical simulation of snowdrift development.

F VALLA
Forty years of mass-balance observations on Glacier de Sarennes, French Alps.

M VALLON
Evolution, water balance, potential hazards, and control of a pro-glacial lake in the French Alps.

C P WAKE
Glaciochemical investigations as a tool for determining the spatial and seasonal variation of snow accumulation in the central Karakoram, northern Pakistan.

M W WILLIAMS, J M MELACK
Effects of spatial and temporal variation in snow melt on nitrate ion and sulfate ion pulses in melt waters within an alpine basin.

G J YOUNG, J P SCHMOK
Ice loss in the ablation area of a Himalayan glacier: studies on Miar Glacier, Karakoram Mountains, Pakistan.

JOURNAL OF GLACIOLOGY

The following papers have been accepted for publication in the *Journal of Glaciology*:

F H M JONES, B B NAROD, G K C CLARKE
Design and operation of a portable, digital impulse radar.

R J BRAITHWAITE, O B OLESEN
Detection of climate signal by inter-stake correlations of annual ablation data, Qamanarssup sermia, West Greenland.

D V THIEL, F NEALL
VLF surface-impedance measurements for ice-depth mapping in the Antarctic.

T JOHANNESSON, C RAYMOND, E WADDINGTON
Time-scale for adjustment of glaciers to changes in mass balance.

W AMBACH, W REHWALD, M BLUMTHALER, H EISNER, P BRUNNER
Vertical dispersion of Chernobyl fall-out on Kesselwandferner, Oetztal Alps, Austria.

K SZILDER, E P LOZOWSKI
A time-dependent thermodynamic model of the build-up of sea-ice platforms.

T HUGHES, M NAKAGAWA
Bending shear: the rate-controlling mechanism for calving ice walls.

K C PARTINGTON, J K RIDLEY, G C RAPLEY, H J ZWALLY
Observations of the surface properties of the ice sheets by satellite radar altimetry.

E STANDER, B MICHEL
The development of aligned columnar sea ice: a field investigation.

P JANSSON, R LeB HOOKE
Short-term variations in strain and surface tilt on Storglaciären, Kebnekaise, northern Sweden.

D M VERE, D I BENN
Structure and debris characteristics of medial moraines in Jotunheimen, Norway: implications for moraine classification.

S HASTENRATH
Ice flow and mass changes of Lewis Glacier, Mount Kenya, East Africa: observations 1974–86, modelling, and predictions to the year 2000 A.D.

EXCLUSION CLAUSE

SYMPOSIUM ON MOUNTAIN GLACIOLOGY RELATING TO HUMAN ACTIVITIES

26 – 30 August 1991

Lanzhou, China

FIRST CIRCULAR

The Society will hold a symposium on Mountain Glaciology relating to Human Activities in 1991. Registration will take place on Sunday 25 August and sessions will be from Monday 26 August to Friday 30 August in Lanzhou, China.

TOPICS

The symposium will be concerned with the effects on human activites of the following aspects of mountain glaciology:

1. Glacier-related floods and other ice and snow hazards in mountain areas.
2. Permafrost and ground ice in high mountains.
3. Ice and snow water resources in mountain areas.
4. Fluctuations of mountain glaciers and climate.

PAPERS

Details about submission of summaries and final papers will be given in the Second Circular, to be published in May 1990. Dates for submissions are firm ones and must be adhered to.

PUBLICATION

The Proceedings of the symposium will be published by the Society in the *Annals of Glaciology*. Papers will be refereed and edited according to the Society's usual standards before being accepted for publication.

SESSIONS

Sessions will be held on four full days and one half-day. A excursion will be held during the week.

ACCOMMODATION

Details will be given in the Second Circular.

TOURS

Two post-symposium tours will be held:
(A) to Tibet (2 weeks) and (B) to major cities in the east and south of China (1 week). Details will be given in the Second Circular. These tours are for participants and accompanying persons in the symposium.

FURTHER INFORMATION

You are invited to attend the symposium. Please return the attached form as soon as possible. The Second Circular will give information about accommodation, general programme, preparation of summaries and final papers. Requests for copies of the Second Circular* should be addressed to the Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.
*Note: Members of the International Glaciological Society will automatically receive a copy.

SYMPOSIUM and TOUR ORGANIZATION

H. Richardson (Secretary General, I.G.S.)

LOCAL ARRANGEMENTS COMMITTEE

Chinese Academy of Sciences (Centre for International Scientific Exchanges).
Institute of Glaciology and Cryopedology, Lanzhou, China.

INTERNATIONAL GLACIOLOGICAL SOCIETY
SYMPOSIUM ON MOUNTAIN GLACIOLOGY RELATING TO HUMAN ACTIVITIES

Family Name/s ....

First Name/s ....

Address ....

....

I hope to participate in the symposium in 1991 [ ]

I expect to submit a summary of a proposed paper [ ]

I hope to join:
tour A (Tibet) [ ]

tour B (E. & S. China) [ ]

TO BE SENT AS SOON AS POSSIBLE TO:
Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.

INTERNATIONAL SYMPOSIUM ON
ICE-OCEAN DYNAMICS AND MECHANICS

Dartmouth College, Hanover, N.H., U.S.A. 26 – 31 August 1990

CO-SPONSORED BY

American Geophysical Union
IAPSO

SECOND CIRCULAR

June 1989

SYMPOSIUM ORGANIZATION:
H. Richardson

LOCAL ARRANGEMENTS COMMITTEE:
E.M. Schulson (Chairman)
W.D. Hibler III A.J. Gow

CHIEF EDITOR:
K. Hutter

ASSOCIATE EDITORS:
W.D. Hibler III
W.F. Weeks (others to be appointed)

INFORMATION ABOUT THE SYMPOSIUM MAY BE OBTAINED FROM:
Secretary General, International Glaciological Society, Lensfield Road,
Tel: Cambridge (code from outside U.K. = 223) 355974 Fax: (223) 336543

Registration for the symposium will take place on Sunday 26 August and sessions will be from Monday 27 to Friday 31 August on the campus of Dartmouth College. A mid-symposium half-day tour is planned.

PARTICIPATION
This circular includes forms for registration and booking of accommodation. The form and accompanying payments should be submitted in accordance with the instructions given on the forms before 1 May 1990. There will be a £15.00 surcharge for later registrations. *Participants'* registration fees cover organization costs, distribution of preprints of summaries, reception, ½-day tour, banquet and a copy of the Proceedings Volume. *Accompanying persons'* registration fees include organization costs, reception, ½-day tour and banquet. *There is an administration surcharge for participants who are not members of I.G.S. or American Geophysical Union (AGU).

REGISTRATION FEES:

Participant (IGS, AGU members	£140/US$240
*Participant (not a member of IGS, AGU	£170/US$290
Accompanying person aged 18 or over	£ 58/US$100
(There is no fee for those under the age of 18, but if they wish to attend the banquet, a ticket must be purchased when registering on Sunday 26 August.)	
Surcharge for late registration (after 1 May).............	£ 15/US$25

Refunds on registration fees can be made on a sliding scale, according to date of receipt of notification, up to 1 August 1990. After that date it may be impossible to make any refund. See booking form for methods of making payment.

TOPICS

The Symposium will be concerned with understanding the dynamics and mechanics of the ice-ocean system.

The main themes will be:

(1) Micromechanical and microphysical processes in ice.

(2) Ice constitutive relationships, including the large-scale aggregate behaviour of sea ice.

(3) Numerical, analytical and observational investigations of ice-ocean dynamics.

There will be additional discussion of the following topics as relevant to the main themes: Physical and thermodynamic ice properties relevant to ice dynamics.
Air-sea energy exchange in the presence of floating ice.
Properties and behaviour of ice shelves.

PROGRAMME

A detailed programme will be given in the Third Circular. Both plenary and poster sessions are planned. Various local tours and visits will be available for accompanying persons, and may be booked when registering on Sunday 26 August. There may be opportunities for workshops to be held during the week of the meeting, subject to availability of space.

PAPERS

(i) SUBMISSION OF PAPERS

Those participants who would like to contribute to the Symposium should first submit a summary of their proposed paper in English; this summary should contain sufficient detail to enable us to form a judgement on the likely merit of the proposed paper, but should not exceed two pages of typescript, on international size paper A4 (210 × 297 mm). References and illustrations are not required at this stage. Place the title and authors' names and addresses at the top of the first page of your summary and not on a separate sheet.

Summaries should be sent to: Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England, and should arrive there by 1 February 1990 at the latest. This is a firm deadline.

LAST DATE FOR RECEIPT OF SUMMARIES: <u>1 February 1990</u>

(ii) SELECTION OF PAPERS

Each summary will be assessed, taking into account scientific quality and relevance to the topics of the Symposium. Authors whose summaries are acceptable will be invited to present their contribution at the Symposium. We hope to write to authors of papers in early April 1990 about acceptance (or otherwise). The letter will be sent to the first author listed in multi-authored papers and not to all of those authors.

Acceptance of a summary implies that the paper based on that summary should be submitted to the proceedings volume and not to another publication. Summaries alone will not be published in the proceedings volume.

(iii) DISTRIBUTION OF SUMMARIES

The summaries of the accepted papers will be distributed to all registered participants before the Symposium.

(iv) SUBMISSION OF FINAL PAPERS AND PUBLICATION

Papers presented at the Symposium will be considered for publication in the proceedings volume (*Annals of Glaciology* Vol. 14). Final typescripts of these papers should be submitted to the Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England, by <u>1 June 1990</u>. They should be written in English and prepared in accordance with the instructions that will be sent to authors when they are notified about acceptance of papers for the Symposium. Authors will be told the maximum length for their papers when they receive notice of acceptance of their summaries. The papers will be refereed according to the usual standards of the Society before being accepted for publication. Speedy publication of the proceedings will depend upon strict adherence to deadlines.

LAST DATE FOR SUBMISSION OF FINAL PAPERS: **1 June 1990**

ACCOMMODATION

Accommodation has been booked at a special package rate in dormitories of Dartmouth College and in local hotels for the period Sunday night 26 August to Saturday morning 1 September. There will be no reduction for a shorter stay in the dormitories. The price in the dormitories includes full meal package.

College dormitories, with shared bathrooms, full meal package: approx. $270 for the 6-day period.

Hotels: (a) $120–140 per room at the Hanover Inn, including full breakfast; (b) $85 per single/$93 per double room at the Norwich Inn (1 mile away from campus); (c) $60 per single/ $80 per double at other hotels some distance away (car needed).

A deposit of £30/$50 must be paid when booking accommodation, in accordance with the instructions given on the booking form printed at the end of this circular. You will be billed for the balance of the dormitory accommodation in June 1990, when the final prices are notified by the College. Payments to hotels will be paid direct to the hotel by participants during the week of the symposium.

Cancellations: Hotels require at least 48 hours' notice of cancellation. The College by 1 August. Deposits will be refunded if cancellations are received by those dates. No deposits will be refunded after those dates.

EVENTS

There will be a RECEPTION on the evening of Sunday 26 August, and a BANQUET on Thursday 30 August. The cost of these is included in the registration fees. If accompanying persons under the age of 18 wish to attend the Banquet, tickets should be purchased at the registration desk.

On Wednesday 29 August, from 1600 – midnight, there will be a tour, for which a windproof jacket will be needed. The cost of the tour is included in the registration fees.

METHODS OF MAKING PAYMENT

- *by sterling cheque or Eurocheque to: International Glaciological Society and sent to the Secretary General at the Society's address;*
- *by sterling Bank transfer to: International Glaciological Society, Account No. 08102112 and sent to the National Westminster Bank plc. 56 St. Andrew's Street, Cambridge CB2 1ER, England.*

- *for U.S. residents, by US$ check to: E.M. Schulson, Thayer School of Engineering, Dartmouth College, Hanover, NH 03755, U.S.A.*

Make cheques payable to:

International Glaciological Society

Retain this copy for your records

IGS SYMPOSIUM in Hanover, NH, USA, August 1990

The registration form was sent to the Secretary General in Cambridge, England on

........../............./1990.
(day) (month)

On the same date, the following amount was paid to *I.G.S. Cambridge
*I.G.S. Hanover, NH

REGISTRATION

Participant: member of IGS, AGU (£140/$240)	....
Participant: not a member of IGS, AGU (£170/$290)	....
Accompanying person (£58/$100)	....
Surcharge for each late registration....£15/$25	....
TOTAL registration fees sent =	....

ACCOMMODATION

Accommodation deposit/s (£30/$50 per person)	....
Accommodation requested: *dormitory *hotel — requested category *(a)/(b)/(c)	
TOTAL sum sent	....

*delete as appropriate

NOTE: Fee/s and deposit/s are returnable on a sliding scale, according to date of receipt of notification, up to 1 August 1990. After that date it may be impossible to make refunds, because of rules laid down by accommodation managements.

IGS SYMPOSIUM ON ICE-OCEAN DYNAMICS AND MECHANICS

26 – 31 August 1990

BOOKING FORM

Mail to: Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K. — to arrive by 1 May 1990. If you send it later, the registration surcharge of £15 should be added for each person. US residents may send their checks and a copy of this form to: E.M. Schulson, Thayer School of Engineering, Dartmouth College, Hanover, NH 03755, U.S.A.

All cheques, etc. should be made payable to
INTERNATIONAL GLACIOLOGICAL SOCIETY

Name of participant (family name) ....(initials)

Address ....

....

Accompanied by (indicate age if under 18)

Name .... Name ....

REGISTRATION

*I enclose
*I have sent to Hanover
registration fees as follows:

Participant (member of IGS/AGU): £140/$240 each	....
Participant (not a member of the above): £170/$290 each	....
Accompanying person: £58/$100 each (no charge if under 18)	....
Surcharge for late submission: £15/$25 each	....
TOTAL registration fees	....

ACCOMMODATION

*I enclose
*I have sent to Hanover
deposits as follows:

£30/$50 per person .... total ....

I prefer *College dormitory / *hotel: (a) / (b) / (c) — *single / *shared occupancy

TOTAL SUM SENT = ...

U.S. RESIDENTS — may pay by US$ check to the Hanover address given above, with a copy of this booking form. This booking form must be sent to Cambridge at the same time.

ALL other cheques/bank transfers should be sent to the Cambridge address given above.

PLEASE PAY THE BANK CHARGES YOURSELF — WE NEED THE FULL AMOUNT FOR EACH PERSON

* delete as appropriate

Recent meetings (of other organizations)

NORTHWEST GLACIOLOGISTS, 2–3 DECEMBER 1988, INSTAAR, UNIVERSITY OF COLORADO, BOULDER, CO, U.S.A.

2 December 1988

Friday morning

Ron Weaver (CIRES)
Introduction to World Data Center
Roger Barry (CIRES)
Introduction to remote sensing of sea ice.
Fred McLaren (CIRES)
Under sea ice thickness distribution determined by submarines.
Jeff Key (CIRES)
Spectral analysis of under sea ice thickness distribution.
Mark Serreze (CIRES)
Ice motions in Beaufort gyre and atmospheric circulation.
Jim Maslanik (CIRES)
Variability of sea ice concentration and extent in Canada basin and associated atmospheric forcing.
Greg Scharfen (CIRES)
Snow melt on sea ice in the Arctic Basin.
Steve Connolly (AA)
Artificial ice islands.
Edwin Waddington (UW/GPHYS)
Microclimate influences on paleo-temperatures estimated from ice cores.

Friday afternoon

Eric Schribner
Remote sensing of snow using passive microwave techniques.
Tad Pfeffer (INSTAAR)
Temperature profile measurements of water percolation in cold snow.
Tissa Illangasekare (UCB/CE)
Theoretical model of water percolation through cold snow.
Peter Müller (ETH/VAW)
World Glacier Monitoring Service.
Richard Armstrong ((CIRES)
Mass balance of Blue Glacier.
Craig Thompson (WWC)
Wind borne athropogenic deposits on glaciers of the Wind River Range.
Charles Love (WWC/GEO)
Stratigraphy of Knifepoint Glacier.
Scott Lundstrom (INSTAAR)
Rates of transfer and distribution of sediment in a valley glacier.

3 December 1988

Saturday morning

Jim Cunningham (UW/GPHYS)
Boudinage.
Mike Balise (USGS/T)
Automatic finite element grid generator.
Garry Clarke (UBS/GPHYS)
Evolution of basal temperatures in Trapridge Glacier.
Eric Blake (UBC/GPHYS)
Subglacial drainage of Trapridge Glacier.
Scott Munro (UT/GEOG)
Heat transfer in a glacier's surface.
Eric Blake (UBC)
Subglacial electrical phenomena.
Joseph Walder (USGS/V)
Channelized flow in till.
Jack Kohler (UM/GG)
Subglacial hydrology of Storglaciären.

Saturday afternoon

Bob Benedict (UW/GPHYS)
Water measurements from West Fork Glacier.
Andrew Fountain (USGS/L)
Subglacial floods and other implications of borehole water levels measured at South Cascade Glacier.
Roger Hooke (UM/GG)
Glacier response to a rise in a proglacial lake.
Charles Raymond (UW/GPHYS)
Glacier memory of climate change.
Robert Krimmel (USGS/T)
Hubbard Glacier.
Ken Pierce (USGS/L)
Paleoglaciation in the Yellowstone Grand Teton area.
John Hollin (INSTAAR)
Sea level rise and the Antarctic ice sheet.

Key:

UW/GPHYS	Analytic Applications,
AA	Boulder, CO
CIRES	Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO
ETH/UAW	Eigenossischen Technischen Hochschule, Versuchsanstalt für Wasserbau, Zürich, Switzerland
INSTAAR	Institute for Arctic and Alpine Research, University of Colorado, Boulder, CO
UBC/GPHYS	University of British Columbia, Department of Geophysics and Astronomy, Vancouver, B.C., Canada
UCB/CE	University of Colorado, Boulder, CO, Department of Civil Engineering
UM/GG	University of Minnesota, Department of Geology and Geophysics, Minneapolis, MN
UT/GEOG	University of Toronto, Department of Geography, Toronto, ON, Canada
USGS	U.S. Geological Survey /L – Lakewood, CO /T – Tacoma, WA /V – Vancouver, WA
UW/GPHYS	University of Washington, Department of Geophysics, Seattle, WA
WWC	Western Wyoming College, Rock Springs, WY

Glaciological Diary

** IGS Symposia
* Co-sponsored by IGS

1989

9-19 July
28th International Geological Congress, Washington, D.C., U.S.A. (B.B. Hanshaw, Secretary General, 28th International Geological Congress, P.O. Box 1001, Herndon, VA 22070-1001, U.S.A.)

20 July-30 August
U.S. Department of the Interior, U.S. Geological Survey, and the University of Idaho in cooperation with the Foundation for Glacier and Environmental Research: Polar and Alpine Geosciences, Field training for the international Earth Science community, Juneau Icefield, Alaska, U.S.A. (Training Section, Office of International Geology, U.S. Geological Survey, 917 National Center, Reston, VA 22092, U.S.A.)

14-17 August
IUTAM/IAHR Symposium on Ice-structure interaction, Memorial University of Newfoundland, St John's, Newfoundland, Canada. (Dr Ian Jordaan, Faculty of Engineering and Applied Science, Memorial University of Newfoundland, St John's, Newfoundland, A1B 3X5, Canada)

21-25 August
23rd IAHR Biennial Congress, Ottawa, Ontario, Canada. (XXIII Congress Secretariat, Conference Services, NRCC, Bldg. M-58, Montreal Road, Ottawa, Ontario, K1A 0R6, Canada)

21-25 August
** IGS Symposium on Ice and Climate, Seattle, WA, U.S.A. (Secretary General, IGS, Lensfield Road, Cambridge CB2 1ER, U.K.)

13-15 September
* Remote Sensing Society 15th Annual Conference: Remote sensing for operational applications, University of Bristol, UK. (Mrs Krystyna Brown,

19-23 September
1989 International Conference and Exhibition on the technology of ocean development and pollution prevention (ICETODPP' 89), Shanghai, China. (Mr Pan Xinchun, The Secretariat of Chinese Society of Oceanography, 1, Fuxingmenwai Ave., Beijing, People's Republic of China)

5-9 December
* American Geophysical Union Fall Meeting, San Francisco, California, U.S.A. Sessions on snow, ice and permafrost, to be held jointly with the American Society of Limnology and Oceanography winter meeting. (A.F. Spilhaus, Jr, A.G.U., 2000 Florida Avenue, N.W., Washington, DC 20009, U.S.A.)

1990

18-23 February
9th International Conference on Offshore Mechanics and Arctic Engineering, Houston, Texas, U.S.A. (Dr Nirmal K. Sinha, Offshore Mechanics and Arctic Engineering Division (OMAE/ASME), Institute for Research in Construction, National Research Council of Canada, Ottawa, Ontario, Canada, K1A 0R6)

12 May
Royal Meteorological Society, Specialist Group on the History of Meteorology and Physical Oceanography, meeting on "The history of polar meteorology and oceanography", Scott Polar Research Institute, Cambridge, U.K. (J.M. Walker, Department of Maritime Studies, University of Wales, P.O. Box 907, Cardiff CF1 3YP, U.K.)

11-15 June
International Conference on the Role of the Polar Regions in Global Change, Fairbanks, Alaska, U.S.A. (Dr Gunter Weller, Geophysical Institute, University of Alaska Fairbanks, AK 99775-0800, U.S.A.)

12-15 June
International Symposium on Water Resources Systems Application, Winnipeg, Canada. (S.P. Simonovic, Civil Engineering Department, The University of Manitoba, Winnipeg, Manitoba, Canada, R3T 2N2)

20-23 August
10th IAHR International Symposium on Ice, Helsinki University of Technology, Espoo, Finland. (Dr Mauri Maattanen, Helsinki University of Technology, Otakaari 1, SF-02150 Espoo, Finland)

27-31 August
** IGS Symposium on Ice–Ocean Dynamics and Mechanics, Hanover, NH, U.S.A. (Secretary General, IGS, Lensfield Road, Cambridge CB2 1ER, U.K.)

18-20 September
2nd International Conference on Ice Technology, Cambridge, U.K. (Miss Elizabeth Newman, Conference Secretary, Computational Mechanics Institute, Ashurst Lodge, Ashurst, Southampton SO4 2AA, U.K.)

1991

11-24 August
20th General Assembly of the International Union of Geodesy and Geophysics, Vienna, Austria.

26-30 August
** IGS Symposium on Mountain Glaciology relating to Human Activities, Lanzhou, China. (Secretary General, IGS, Lensfield Road, Cambridge, CB2 1ER, U.K.)

1-6 September
Symposium on the Physics and Chemistry of Ice, Sapporo, Japan. (Norikazu Maeno, The Institute of Low Temperature Science, Hokkaido University, Sapporo 060, Japan)

News

AWARDS

Corresponding Member of the Academy **Professor V.M. Kotlyakov**, Director of the Institut Geografii Akademii Nauk SSSR, has been elected a Peoples Deputy [Narodnyy deputat] of the USSR. There are 2250 such Deputies, and they will elect a Supreme Soviet of 524 members. Members of the Supreme Soviet will be whole-time legislators, but it is expected that Peoples Deputies, such as Professor Kotlyakov, will retain their existing jobs.

On 9 December 1988, **Oskar Reinwarth** received the degree of Dr. rer. nat. *honoris causa* from the Ludwig-Maximilians-Universität, München.

On 20 May 1989, **C.W.M. Swithinbank** received an Honorary Doctorate in Engineering from the Milwaukee School of Engineering.

New members

Matthew Bennett, Grant Institute of Geology, University of Edinburgh, West Mains Road, Edinburgh EH9 3JW, U.K.

Howard B. Conway, Geophysics AK-50, University of Washington, Seattle, WA 98195, U.S.A.

James Cunningham, Geophysics AK-50, University of Washington, Seattle, WA 98195, U.S.A.

John F. Firestone, Geophysics AK-50, University of Washington, Seattle, WA 98195, U.S.A.

Gloria Furdada i Bellavista, Dept. Geologia Dinamica, Facultat de Geologia, Universitat de Barcelona, Zona Universitaria Pedralbes, 08028 Barcelona, Spain.

Klaus Grosfeld, Katherinenstrasse 3, 4400 Münster, Federal Republic of Germany.

A.J. Hall, Department of Meteorology, JCMB, University of Edinburgh, Kings Buildings, West Mains Road, Edinburgh EH9 3JZ, U.K.

Peter Höller, Institut für Lawinkunde, Hofburg – Rennweg 1, 6020 Innsbruck, Austria.

Matthew Huston, Department of Geology and Geography, University of Massachusetts, Amherst, MA 01003, U.S.A.

Jukka Käyhkö, Itäinen Brahenkatu 13 D 108, 00510 Helsinki, Finland.

Andrew J. Langridge, 13 (2F2) Strathfillan Road, Marchmont, Edinburgh, U.K.

Bernard Lefauconnier, Norsk Polarinstitutt, Postboks 158, 1330 Oslo Lufthavn, Norway.

Kjetil Melvold, Kveldroveien 52, 9000 Tromsø, Norway.

Donald R. Murray, 914 West Olive Street, Bozeman, MT 59715, U.S.A.

Keith W. Nicholls, British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, U.K.

Kazuhide Satow, National Nagaoka College of Technology, Nishi-Katakai, Nagaoka 940, Japan.

David Sexton, Scott Polar Research Institute, University of Cambridge, Lensfield Road, Cambridge CB2 1ER, U.K.

Alexander Wardle, 3 Charles Hill, Elstead, Surrey GU8 6LE, U.K.

Gregory C. Wiles, Department of Geology, State University of New York at Buffalo, Faculty of Natural Sciences and Mathematics, 4240 Ridge Lea Road, Buffalo, NY 14260, U.S.A.

INTERNATIONAL GLACIOLOGICAL SOCIETY

Lensfield Road, Cambridge CB2 1ER, England

SECRETARY GENERAL H. Richardson

COUNCIL MEMBERS

			Date first elected to the Council (in present term of office)
PRESIDENT	S.C. Colbeck	1987-90	1984
VICE-PRESIDENTS	G.K.C. Clarke	1987-90	1987
	P. Schwerdtfeger	1984-87	1984
	G. Wakahama	1988-91	1988
IMMEDIATE PAST PRESIDENT	H. Röthlisberger	1987-90	1978
TREASURER	J.A. Heap	1986-89	1980
ELECTIVE MEMBERS	* R. Hooke	1986-89	1986
	* N. Maeno	1986-89	1986
	* R. Perla	1986-89	1986
	* D. Sugden	1986-89	1986
	* C. Hammer	1987-90	1987
	M Kuhn	1987-90	1987
	* E.L. Lewis	1987-90	1987
	* H.J. Zwally	1987-90	1987
	* D. Collins	1988-91	1988
	* S. Jonsson	1988-91	1988
	* J. Oerlemans	1988-91	1988
	* Xie Zichu	1988-91	1988

* first term of service on the Council

CORRESPONDENTS

AUSTRALIA	N. Young	JAPAN	N. Maeno
AUSTRIA	M. Kuhn	NEW ZEALAND	T. Chinn
BELGIUM	R.A. Souchez	NORWAY	H. Norem
CANADA	W. Winsor	POLAND	S. Kozarski
CHINA	Xie Zichu	SWEDEN	S. Jonsson
DENMARK	A. Weidick	SWITZERLAND	W. Haeberli
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GERMANY	O. Reinwarth	USA (Eastern)	W.B. Tucker
ICELAND	H. Björnsson	USA (Western)	A. Fountain
ITALY	G. Zanon	USA (Alaska)	L. Mayo

SELIGMAN CRYSTAL AWARD RECIPIENTS

1963	G. Seligman	1977	W.B. Kamb
1967	H. Bader	1982	M. de Quervain
1969	J.F. Nye	1983	W.O. Field
1972*	J.W. Glen	1983	J. Weertman
1972	B.L. Hansen	1985	M.F. Meier
1974	S. Evans	1986	G. de Q. Robin
1976	W. Dansgaard		

HONORARY MEMBERS

W.O. Field	M. de Quervain
R.P. Goldthwait	U. Radok
P. Kasser	H. Richardson
R.F. Legget	R.P. Sharp
L. Lliboutry	A.L. Washburn
M.F. Meier	Z. Yosida

The Society is registered as a charity in the United Kingdom with the Charity Comissioners – number 231043

INTERNATIONAL GLACIOLOGICAL SOCIETY

Lensfield Road, Cambridge CB2 1ER, England

DETAILS OF MEMBERSHIP

Membership is open to all individuals who have scientific, practical or general interest in any aspect of snow and ice study. Payment covers purchase of the *Journal of Glaciology* and *Ice*. Forms for enrolment can be obtained from the Secretary General. No proposer or seconder is required.

ANNUAL PAYMENTS 1989

Private members	Sterling £30.00
Junior members	Sterling £15.00
Institutions, libraries	Sterling £80.00 for Volume 35 (Nos.119, 120, 121)

Annals of Glaciology – prices vary according to size of volume. For further information, apply to the Secretary General.

Note: Payments from countries other than Britain should be calculated at the exchange rate in force at the time of payment. Please ensure that sufficient money is included to cover the bank charges. The Society needs the full payment, so bank charges should be paid by you. Thank you.

ICE

Editor: H. Richardson
Assisted by S. Stonehouse

This news bulletin is issued to members of the International Glaciological Society and is published three times a year. Contributions should be sent to the Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.

Annual cost for libraries, etc., and for individuals who are not members of the Society:

Sterling £10.00

All enquiries about the International Glaciological Society should be addressed to the Secretary General of the International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England.