NUMBERS 72 & 73

2nd & 3rd ISSUES 1983

ICE

INTERNATIONAL GLACIOLOGICAL SOCIETY

JOURNAL OF GLACIOLOGY

The Journal will soon appear in a new format. The Council of the Society, after thorough investigations, decided that several changes were necessary in order to reduce the costs of setting and printing.

The size will be larger: 210 x 297mm (A4 international paper size). There will be 1200 words per page, in double columns, compared with 750 words in a single column for the old format. The text will be set on a word-processor and made up into camera-ready copy for printing. The cover has been re-designed, too.

The first issue of the new-look Journal (Volume 30, Number 104, 1984) will be published in early June, and the second issue soon after that.

The process of change will continue. The Council is looking for ways of speeding up publication of articles, in order to give better service to authors and readers. We hope that authors will help by following the new guidelines for the preparation of papers, which have been prepared by the editors and designed to help achieve speedier publication.

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ICE

NEWS BULLETIN OF THE

INTERNATIONAL GLACIOLOGICAL SOCIETY

NUMBERS 72 & 73 2nd & 3rd ISSUES 1983

CONTENTS

Members will be saddened to hear of the recent deaths of two of our members. Dr Daisuke Kuroiwa passed away on 28 October 1983. He played an important role in ICSI (he was a Vice President at the time of his death), in the affairs of the Society, and in the work of the Institute of Low Temperature Science. A profile of him was published in ICE, No.34, p.7. Col. Pat Baird died on New Year's Day, 1984, in Ottawa. He was known to many for his long association with the Arctic Institute of North America and with Baffin Island, following his two expeditions there in the 1950s. He was the first Secretary of The Commission of Snow and Ice, a position he held from 1948-1960. Obituaries will be appearing in the **Journal of Glaciology** shortly.

Photo credits: The photographs appearing on pages 46, 47 and the lower left of page 48 were taken by Tom Lascher of Evanston. Photographs appearing in articles were provided by the respective authors. Other photographs were taken by the editor of **ICE**.

Last year Council decided to award Seligman Crystals to two of our members. William Osgood Field, former Chief of Exploration and Field Research with the American Geographical Society, and Johannes Weertman, Professor of Materials Science and Engineering at Northwestern University. The awards were presented by our President at the recent meeting in Evanston. Profiles of the two award winners have been included in this issue of **ICE**.

COVER PICTURE: A "brincicle" hanging from a block of ice rafted up in the rubble field around Tarsuit Island, in the Canadian Beaufort Sea. Brincicles appear to form when the brine in sea ice drains out of the ice block and freezes. The overall length of this brincicle is about 10 cm and its shape differs from the usual stalactite form. Photographed by Garry Timco.

DENMARK

EXTRACTION OF PILES BY FLOATING ICE SHEETS
(F.T. Christensen and P. Tryde, IHHE/TUD)
This investigation is performed in collaboration with the Cold Regions Research and Engineering Laboratory (USACRREL). The aim of the project is to give a detailed description of the lifting mechanism and the force variation when a pile is extracted step by step during repeated water level fluctuations, e.g. tidal variations. In order to explain the successive lifting as a result of repeated actions it is necessary to take into account the refreezing of any cracks developed. In time, the fracture zones will slowly regain their strength. Although numerous sophisticated theoretical solutions are available, none of them have included the refreezing of cracks, i.e. they all describe one single lift. A mathematical model describing successive lifts is being developed, and experiments are planned at CRREL in the spring of 1984.

DENMARK — GREENLAND

REGIONAL GLACIOLOGICAL WORK IN W. GREENLAND
(A. Weidick, GGU)
Glacier mass balance measurements were made in 1983 by the Geological Survey of Greenland at 8 localities in West Greenland, covering local coastal glaciers, local inland glaciers, and also sectors of the Inland Ice (see Figure 1).

The results from these selected glaciers are integrated in the current regional work on mapping and monitoring of glacier changes in West Greenland. In this context, the work on an "Atlas of West Greenland Glaciers" has continued in collaboration with the TTS for the World Glacier Inventory, Zürich. The atlas is expected to be completed in 1985 and consists of about 100 atlas sheets at a scale of 1:250,000. A contribution to the atlas by the Geological Institute, Århus University, covers a selected area between 60°30'N and 61°30'N in greater detail and is expected to be finished in 1984.

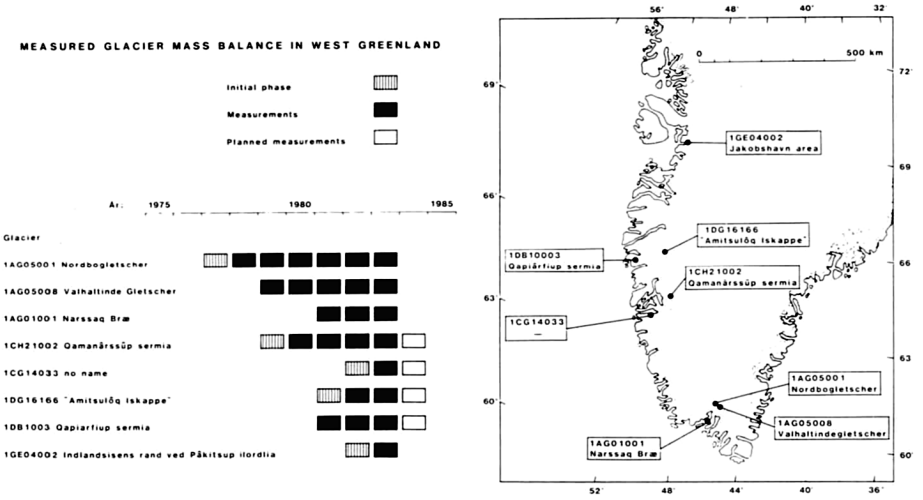


Figure 1. Location of present and planned investigations on glacier mass balance in West Greenland by the Geological Survey of Greenland

RUNOFF MODELLING IN WEST GREENLAND
(R.J. Braithwaite and H.H. Thomsen, GGU; T. Thomsen and G. Jørgensen, GTO)
In connection with the planning of hydropower projects in Greenland, simulations of runoff have been made for highly glacierized areas near to Jakobshavn and Christianshåb. Parallel investigations have been made by GGU using the MB1/SM1/RO1 model and by GTO using an improved version of the NAM-II model. The results confirm the continuing difficulties in delineating the hydrological boundaries of basins on the Inland Ice, although great progress has been made by using Landsat pictures as a supplement to existing topographic maps. Results from both the GGU and GTO simulations show that the 1980-1983 measured runoff values in the area are relatively low compared to the long-term average. Similar simulations will be made for other areas in Greenland in the future.

REMOTE SENSING AND PHOTOGRAMMETRIC MAPPING

(H.H. Thomsen, GGU)

Using digitally processed Landsat data, surface feature maps of the Inland Ice were plotted on the basis of Applicon ink plots at a scale of 1:100,000. The maps show surface features related to ice and meltwater drainage as well as subtle features related to the subglacial topography. The maps cover the Inland Ice in the inner part of the Disko Bugt area between 68°35'N to 70°00'N and 47°20'W to 50°30'W, and in the Godthåb area between 63°30'N to 64°36'N and 48°35'W to 50°05'W.

Detailed topographic maps have been produced covering the ice margin of the Inland Ice and the adjoining ice-free area northeast of Jakobshavn between 69°20'N and 69° 33'N and northeast of Frederikshåb between 62°11'N and 62°26'N. The plotting was based on vertical aerial photographs and the scale is 1:25,000 with contour intervals of 50 m in the ice-free area and 10 m on the ice. The maps include information about drainage patterns, lakes, moraines, etc.

PRESENT AND PAST GLACIATION, DISKO, CENTRAL WEST GREENLAND

(O. Humlum, ARS/UCPH)

Starting at the end of the 1983 ablation season, frontal variations are being studied at 7 outlet glaciers from the 20 km^2 Lyngmarkens Iskappe on southern Disko Island. This programme will be supplemented with studies on accumulation and ablation at selected points. Temperature, humidity and precipitation are being measured at the equilibrium line. Glacial and fluvio-glacial transport are being studied at four glaciers. Areal changes in a number of perennial snow banks are being followed.

Based on maps (1:100,000 and 1:250,000) and aerial photographs, maps showing present and past glaciation limits and equilibrium line altitudes are being prepared. The distribution of rock glaciers and Late-glacial and Neoglacial moraines are also being mapped. Dating of Neoglacial moraines is attempted using lichenometry.

At selected points in the terrain, the build-up and decay of naledi (icings, aufeis) are being followed throughout the year. Also, temperatures at bedrock are continually being recorded at selected points.

DISKO BUGT MASS BALANCE MEASUREMENTS AND RECONNAISSANCE

(H.H. Thomsen, GGU)

Stakes for measuring mass balance were drilled into the Inland Ice northeast of Jakobshavn in August 1982, starting on the outlet glacier 1GE07001, lying at 69°28'N, 50°12'W. The stakes cover the altitude band from 300 to 1500 m a.s.l.

The stakes were visited by helicopter on May 12th and on August 11th, 1983 to measure the mass changes during the winter and summer period. The annual equilibrium line was at approximately 1000 m a.s.l.

The margin of the Inland Ice from Eqip sermia (1GF06001) at 69°48'N down to Jakobshavn Isbrae (1GC06002) at 69°08'N and the glaciers in Blaesedalen, Brededal and Daugaard-Jensens Dal on Disko were photographed to update the glacier registration in these areas.

TASERSIAQ & QAPIARFIUP BASINS, W. GREENLAND

(O.B. Olesen, GGU; J.-O. Andreasen and N.T. Knudsen, ÅU)

In 1981, field work was started in both the Tasersiaq and Qapiarfiup basins located at 66°6'N, 50°7'W and 65°36'N, 52°15'W respectively.

At Tasersiaq, mass balance and hydrological measurements are carried out on a local ice cap, Amitsulôq ice cap, which covers an area of 165 km^2 at altitudes between 700 and 1400 m a.s.l. Climatological elements are recorded at two weather stations during the ablation period.

A new map, based on terrestrial photogrammetry, is on the drawing board at the University of Åarhus which also carried out the underlying field work.

Qapiarfiup sermia covers an area of 21 km^2 between 500 and 1050 m a.s.l. and only mass balance studies are carried out here.

While both 1981 and 1982 showed slightly negative balances, 1983 came out with a fair surplus at both places. Measurements will continue at least through 1984.

QAMANÂRSSUP SERMIA - FIELD WORK 1983

(R.J. Braithwaite, GGU)

Fieldwork was carried out for the fourth consecutive summer at QamanârssUp sermia, an outlet glacier from the Inland Ice. The field station is located at approximately 64°28'N, 49°30'W, at the head of Godthåbsfjord. The fieldwork included mass balance measurements over the ablation area of approximately 150 km^2, collection of climatic data, twice-yearly surveys of ice movement, and collection of daily ablation readings near to the field station. The 1982/83 winter in the Godthåb area was exceptionally cold and wet and was followed by a cool, cloudy, and wet summer. As a result, the equilibrium line lay 200-300 m lower than "normal".

JOHAN DAHL LAND, S. GREENLAND - FIELD WORK

(P. Clement, GGU)

Since 1977 glacier-hydrological studies have been carried out in the Johan Dahl Land area, South Greenland, as a basis for mapping hydropower potential.

The field work has mainly been concentrated on the Nordbogletscher, an outlet from the Inland Ice. The measurements have included determination of accumulation and ablation with elevation, ice velocities, drainage of ice-dammed lakes, climate-ablation relationships and observations of glacier fluctuations.

As Nordbogletscher is part of the Inland Ice the glacier is far from being well-defined and special attention has been given to solving the problem of its delineation. The measurements have shown the existence of two different areas, a topographic area (208 km^2) and a hydrological area (57 km^2). While the topographic area has been based on topographic map sheets the hydrological area has been based on satellite images, radio-echo soundings (subglacial thresholds) and measurements of refreezing of meltwater in the accumulation area.

Five years of complete mass balance data have been collected on a nearby glacier, Valhaltindegletscher. The summer of 1983 was the coldest in South Greenland during the last 20 years and the 1982/83 mass balance was positive.

MITDLUAGKAT GLACIER - FIELD WORK 1983
(B. Hasholt and H. Søgaard, GCI/UCPH)
The glacier is located on Angmagssalik Island at approximately 65°42'N and 38°50'W and covers an area of 30 km^2. The first observations on the glacier date from 1937 when the snout was photographed. In 1970 the University of Copenhagen built a research station, the Sermilik Station, 2 km west of the snout and, from then on, continuous measurements have been carried out. These have mainly been concentrated on glacio-hydrological and -climatological subjects. The 1983 field work comprised snow cover observations during the winter, and a summer survey with mapping of the glacier snout and measuring of the summer mass balance. The hydrological programme on the outlet from the glacier has been continued with measurements of discharge and transportation of suspended load. The distribution of the summer precipitation has been investigated using precipitation totalizers.

RESPONSE OF THE WEST GREENLAND ICE SHEET MARGIN TO MASS BALANCE CHANGES
(N. Reeh, GIL/UCPH)
A model based on the theory developed by Nye has been used to estimate the response of the west Greenland ice sheet margin around 69.5°N to a given mass balance history. The study was contracted by the Geological Survey of Greenland in connection with hydropower investigations in Greenland.

Model parameters are estimated by means of data collected along the EGIG-line, and these data are also used to define a datum state for the ice sheet sector considered. The ice sheet sector is divided into individual sub-glaciers. For each of these, the response during the last 1,000 years is calculated using an ablation history generated by means of a 2,600-year-long climatic record determined from stable isotope measurements along an ice core retrieved at Dye 3 on the south Greenland ice sheet. The calculated response is in agreement with observed and estimated - by other means - ice margin fluctuations.

The model is used to predict the ice-margin response for the future decades. It is concluded that, most likely, the present general ice margin recession will continue for the next decades unless a dramatic deterioration of the climate occurs in the near future.

DYE 3 ICE FLOW CALCULATIONS
(N. Reeh and D. Dahl-Jensen, GIL/UCPH)
The efforts to improve the modelling of the ice flow leading to the deep core hole at Dye 3, south Greenland, continue. The effect of the limited width of the basal undulations has been studied by means of a linear, three-dimensional, perturbation model. Further improvements of the curved flow line course will be considered and incorporation of the additional data obtained from the logging of the bore hole and upstream surface investigations.

PERIGLACIAL GEOMORPHOLOGY OF ARCTIC COASTS
(N. Nielsen, GCI/UCPH)
Investigations have been continued on the dynamics of the ice-foot and sea ice and the resulting morphological effects on arctic coasts in Greenland.

On the basis of detailed coastal observations during the freezing-up and melting period, the study is focussing on the mechanism creating thermokarst-like phenomena on the shore.

The purpose of the research is to throw light on the extent of disturbances of beach and nearshore sediments in this special environment and, furthermore, to estimate the influence of ice as a sediment-transporting agent.

DENMARK — NORWAY

METEOROLOGICAL AND HYDROLOGICAL INVESTIGATIONS AT OKSTINDAN AND SVARTISEN, NORWAY
(N.T. Knudsen & J.T. Møller, GeoII/AU;
W.H. Theakstone, Manchester Univ.)
Measurements of meteorological variables including radiation, temperature, windspeed and humidity profiles and precipitation at and around Austre Okstindbre were continued. Meltwater flow and ablation were measured together with variations in meltwater conductivity. Water samples were collected for determination of O^{18}/O^{16} and chemical constituents. Work has started on the development of a run-off model using meteorological data, ablation and flow characteristics as input data. Ice surface velocities were determined at 10 stakes placed in the ablation area. Terrestrial photogrammetric surveys were performed at Austre Okstindbre and at Austerdalsisen, Svartisen.

An investigation of recent changes of some glaciers of East Svartisen (Fingerbreen and Lappebreen) has been finished. Since 1945, a gradual increase in surface slope of the lower part of Fingerbreen has been accompanied by a fairly uniform decrease in thickness (about 3 ma^{-1}). Above 500 m, however, the surface slope has changed little and the rate of decrease in ice thickness has not exceeded 2 ma^{-1}. At Lappebreen, retreat almost ceased between 1975 and 1981; above 600 m the glacier thickness increased. Future studies of glacier change will be a valuable contribution to water resource investigations.

Anker Weidick

ICELAND

RADIO ECHO SOUNDINGS

(Helgi Björnsson, SI/UI)

In the years 1980-1982 about 1500 km^2 of Vatnajökull were mapped in detail by radio echo soundings. Maps have been drawn of the bedrock and the surface of the ice of Tungnájökull, Sylgjujökull, Köldukvíslarjökull and Eyjabakkajökull at a scale of 1:50,000 with a 50 m contour interval. In 1983 the whole of the ice cap Hofsjökull (925 km^2) was mapped in the same way. The work was financed by the Iceland Power Company and the State Electrical Power Works as hydrological studies for the planning and development of power plants.

In August 1983, eight World War II aircraft were located by radio echo sounder in SE Greenland, 150 km southwest of Kulusuk. They landed on the ice on 15th July 1942.

GLACIER VARIATIONS

(Sigurjón Rist, NEA)

Longitudinal glacier variations were measured at about 40 localities. Most of the large outlet glaciers are still retreating, but a number of steep, valley glaciers have been advancing for some years.

JÖKULHLAUPS

(Helgi Björnsson,SI/UI; Sigurjón Rist,NEA)

In May/June every year the Iceland Glaciological Society has sent expeditions to Grímsvötn to measure the height of the water level in order to predict when the next jökulhlaup on Skeidarársandur is likely to occur. In February 1982 a jökulhlaup was discharged from Grímsvötn. The total water volume discharged was estimated at 1.3 km^3 and the accompanying fall of the lake level was about 50 m. In January 1982 and September 1983 jökulhlaups were discharged to the river Skaftá from the cauldrons NW of Grímsvötn.

GLACIER-VOLCANO STUDIES

(Helgi Björnsson, Thorbjörn Sigurgeirsson, Páll Einarsson, SI/UI; Gudmundur E. Sigvaldason, Nordic Volcanological Institute)

On the 28th or 29th of May 1983 an eruption started in Grímsvötn and was active for five or six days. The eruption was not observed from outside the ice cap and did not cause a jökulhlaup.

Since the summer of 1983 a seismometer and a tiltmeter have been operated at Grímsfjall (1721 m a.s.l.) and a 2 W UHF-transmitter sends the readings down to Skeidarársandur. The equipment is run by a power generator which was built at the Science Institute and installed in a steam-hole where the temperature difference is used to generate a current in Peltier elements.

SEDIMENT TRANSPORT

(Haukur Tómasson, NEA)

Sediment transport in most glacier rivers is frequently measured for estimation of total transport both in suspension and as bed load.

RUNOFF PREDICTION

(Elías B. Elíasson, Iceland Power Company; Kristinn Einarsson, NEA)

Models of runoff from glacierized basins have been developed for use in the planning of hydro-power plants and flood forecasting. The models operate with linear reservoirs and degree-day input.

SNOW AVALANCHES

(Haflidi H. Jónsson, Meteorological Office)

The Meteorological Office collects and keeps records of avalanches, correlates their occurrence with weather parameters, evaluates avalanche danger and sends out warnings.

On 22 January 1983 the fishing village of Patreksfjördur on the NW Peninsula (Vestfirdir) was hit by two catastrophic avalanches. Four people were killed and many houses destroyed.

SEA ICE

(Thor Jakobsson, Meteorological Office)

Sea ice reconnaissance in Icelandic waters is carried out by the Icelandic Coast Guard and the data are processed by the Meteorological Office.

GLACIAL GEOLOGY

Late glacial and Weichselian glacier variations

The following areas are being studied:

1. Skagafjördur to Hofsjökull, N. Iceland (Inga Kaldal, Skúli Víkingsson, NEA).
2. Fnjóskadalur, N. Iceland (Hreggvidur Norddahl, University of Lund, Sweden)
3. Borgarfjördur, W. Iceland (Olafur Ingólfsson, UI, University of Lund).
4. Melrakkaslétta, N.E. Iceland (Halldór Pétursson, UI, Univ. of Tromsö, Norway).
5. Dýrafjördur, N.W. Iceland (Jón R. Sigurvinsson, Jón Eiríksson, UI).

Middle and lower Quaternary glacial and interglacial cycles

1. Tjörnes area, N. Iceland (Jón Eiríksson, Leifur A. Símonarson, Thorleifur Einarsson, SI/UI).
2. Borgarfjördur, W. Iceland (Jón Eiríksson, Aslaug Geirsdóttir, UI).

Recent glacier variations

Studies of glacier variations over the last 10,000 years are in progress at the outlets of Heinabergsjökull and Fláajökull, S. Vatnajökull (Sigfinnur Snorrason, Univ. of Oslo, Norway)

PUBLICATION OF JÖKULL

Since 1978, the journal Jökull, edited by Helgi Björnsson and Leó Kristjánsson, has been published jointly by the Iceland Glaciological Society and the Geoscience Society of Iceland. A special issue on the geology of Iceland was published in 1979; the 1982 and 1983 issues are dedicated to Professor Sigurdur Thorarinsson.

Helgi Björnsson

ITALY

The following reports have been taken from abstracts of articles published in the 1982 editions of Geografia Fisica e Dinamica Quaternaria published by the Comitato Glaciologico Italiano (Editor).

LATE HOLOCENE FLUCTUATIONS OF BRENVA GLACIER

(G. Orombelli, Istituto di Geologia dell' Università di Milano and Centro di Studio per la Stratigrafia e Petrografia delle Alpi Centrali, C.N.R., Milano; S.C. Porter, Quaternary Research Center/WASH)

Fluctuations of the terminus of Brenva Glacier during the last several centuries have been reconstructed using documentary evidence in the form of maps, paintings, lithographs, drawings, written accounts, photographs, and instrumental surveys, supplemented by geologic mapping and botanical dating. The glacier terminus lay close to its present position during the late 18th century and advanced to its Holocene maximum in 1818. Following this culmination the glacier retreated several hundred meters before readvancing in the 1840's to reach a new maximum about 1850 only slightly short of the earlier one. During the next three decades the terminus receded about 1 km upvalley but then readvanced sharply during the 1880's to a secondary culmination about 1890-1895. Slow persistent retreat until about 1914 was then followed by renewed advance. Massive rockfalls from M. Bianco in 1920 thickly mantled the ablation zone with granitic rubble. This debris cover inhibited ablation of ice and caused the terminus to continue its advance until a new maximum was reached in 1940-41 only about 50 m behind the 1818 limit. From 1940-41 until the mid-1960's the glacier front receded some 400 m, but renewed advance was detected between 1965 and 1967 which has continued to the present.

The terminal fluctuations of Brenva Glacier show a consistent relationship to a meteorological record from Great St. Bernard Pass (1818 - present) and to a long temperature record from Milano (1763 - present). Glacier advances followed intervals when winter accumulation was above average and air temperature, especially during the ablation season, was below average.

RECENT GLACIOLOGICAL RESEARCH IN THE ORTLES-CEVEDALE REGION (ITALIAN ALPS)

(G. Zanon, Istituto di Geografia, Università di Padova)

The Caresèr Glacier (4.829 km^2, 2857 m a.s.l.) has been under observation since the end of the last century. During the period 1966-67 to 1977-78, although the net balance was moderately negative (-140 mm H_2O or a mass of about 8 x $10^6 m^3$) and the equilibrium line was only 28 m above its steady-state position, the accumulation area ratio was quite different (1:1.6 as opposed to 1:1). The ability of the glacier to amplify variations in its net balance, and thus the effect of climate, results in a state of imbalance, though of a lesser extent than in the past. This continues to cause changes in the ablation area and persistent snout retreat, in contrast with the current prevailing tendency of Italian glaciers to advance.

LEWIS GLACIER, MOUNT KENYA, EAST AFRICA

(C. Smiraglia, Istituto di Geografia dell'Università Cattolica di Milano)

A new, large-scale map of Lewis Glacier has been published by S.Hastenrath and R.A.Caukwell. The map, based on aerial photogrammetry, can be compared to their previous one of 1974. There has been a 2% reduction in the area of the glacier, an average thinning of 4 m and a volume loss of 1200 x $10^3 m^3$.

SUMMARY OF GLACIER VARIATIONS IN ITALY

Glacier #	Mountain Group	Survey Year	Glacier activity +	-	0	?
26-27-29	Sommeiller-Ambin	1980		1	2	
34	Rocciamelone	1977			1	
40-46	Bessanese-Ciamarella	1974/77			1	1
61	Levanna	1971		1		
86	Rosa dei Banchi	1980			1	
128-129	Gran Paradiso	1976/80		1		1
147-148	Tsanteleina - Gr. Parei	1976/79	1			1
162-163-166	Grande Rousse	1978				2
168-171-172-173-174	Sassière-Traversière	1980 and pre-			1	5
189	Rutor	1980			1	
208-209-211-219-221	Monte Bianco (Val Veni)	1980 and pre-	3			2
225-226-229-235-236	Monte Bianco (Val Ferret)	1980	5			
259-260	Gr. Murailles (Valpell.)	1980	2			
271 to 282	Gr. Murailles (Marmore)	1980			2	12
283 to 289	Cervino - G. Rollin	1980	3	1	3	
290 to 294	Gr. Sommetta - Tournalin	1980			1	4
295 to 301	M. Rosa (Evançon)	1976	2		4	1
304	M. Rosa (Lys)	1980	1			
312-314	M. Rosa (Sesia)	1972	2			
318 to 332	M. Rosa (Anza)	1980	7	2	4	2
334-335-336	Andolla	1979	1		2	
337 to 344	Leone - Mottiscia	1978	1	4	4	
345 to 361	Arbola	1979/80	1	7	4	
Total			29	17	31	31

SWEDEN

Since our last report we have refined our analysis of the data from our 20-stake strain net on Storglaciären. This net was surveyed between April 1981 and September 1983 at intervals of about 10 days from mid-May to mid-September and 45 days at other times of the year. It was in the form of a 4 x 5 grid with 125 m spacing between stakes. We found that if we subtracted the vertical velocity due to flow up an adverse bed slope and that due to vertical strain over a known ice thickness from the measured vertical velocities, we could calculate the rate of cavity opening at the bed. By integrating these rates over time we determined the mean separation of ice from the bed as a function of time. Taking the separation as zero in late May, we found an average separation of 270 mm in August 1981 and 180 mm in August 1982. These results are reported in greater detail in recent papers by Hooke and others.

During the summer of 1983 we continued measurements on a 32-stake network that was established in June 1982 and surveyed at intervals comparable to those used for the smaller strain net. Preliminary results from these surveys suggest that, in accordance with earlier evidence, the summer acceleration begins earlier in the lower half of the ablation area than in the upper half or in the accumulation area. This is also the case during short-term accelerations associated with periods of warm weather. These accelerations are attributed to increases in subglacial water pressure.

In contrast, during a period of good weather in late July, 1983, a 10-m long strain meter emplaced near the middle of the ablation area showed diurnal variations, with tension beginning at about 0600 hrs. This is too early in the day to be attributed to an increase in subglacial water pressure in the lower part of the ablation area. For example, water levels in boreholes near the strain meter did not begin to rise until about 1200 hrs, at which time the strain meter began to show compression. These results can be interpreted if we assume a rather constant speed in the lower part of the ablation area, with strain rates in the vicinity of the strain meter modulated by diurnal velocity variations in the upper part. This would require that the velocity in the upper part begin to decrease at about 0600 hrs, slightly after water levels in the boreholes near the strain meter reach their minima. It seems reasonable that there should be a time lag between the decrease in water pressure near the strain meter and that further up-glacier, as time is required for the hydraulic system to empty itself through channels leading to the glacier terminus. The compression that begins between 1400 and 1800 hrs would then be attributed

to acceleration in the upper part of the ablation area. This coincides rather well with the peak water levels in holes near the strain meter, and suggests a lag of 3 to 5 hours between the beginning of the water level rise near the strain meter and the time when the upper part of the glacier has accelerated enough to change the sign of the strain at the site of the meter.

Further work will be directed toward clarifying the spatial variations in strain rates.

In addition to these studies, the usual mass balance measurements were made on Storglaciären, extending our record of the mass balance to 38 years, and surveys of the 23-stake network on nearby Rabots Glaciär were done at roughly weekly intervals. Finally, studies of ice structures were initiated on Rabots Glaciär.

V. Schytt and R. LeB. Hooke

SWITZERLAND

GLACIERS

ANNUAL SURVEY OF GLACIERS
(M. Aellen, GK/SNG; H. Siegenthaler, VAW)
The results of the 102nd and 103rd annual surveys (1981 and 1982) of the behaviour of glacier snouts are summarised as follows: the 1981 survey gave 52 advancing, 5 stationary and 42 receding glaciers, and the 1982 survey gave 44 advancing, 6 stationary and 58 receding glaciers. A maximum number of advancing glaciers was observed in 1978, 76 out of 108. This was almost equalled in 1980 with 73 out of 109 glaciers advancing. In recent years, the percentage of glaciers advancing was above average on the northern slopes of the central part of the Swiss Alps (Aare, Reuss and Linth river basins), near to average in the Rhone River basin and below average in the Rhine River basin.

Mass balance measurements follow a similar regional pattern. These were established, as usual, for the glaciers of four drainage basins, and range from positive values for both years in the central part of the Alps (Aletsch - average balances for the glacierised area: b_a = 1270 and 351 kg m^{-2} respectively) to negative values for both years in the southern part of the Alps (Gries: b_a = -232 and -879 kg m^{-2} respectively). Everywhere, the same tendency of decreasing mass gains or increasing mass losses has been observed during the last three years.

SPATIAL DISTRIBUTION OF WINTER AND NET BALANCES OF THE RHONEGLETSCHER
(M. Funk, GGEZ)
In the years 1979-1982, a systematic study of winter and net balances was performed on the Rhonegletscher. A digital terrain grid was used to calculate morphological parameters (altitude, slope, azimuth, concavity and convexity). The balance measurements served as dependent variables and the morphological parameters as independent variables to determine functions f_1 and f_2 for the winter and net balances. For the period investigated, it was possible to explain between 55% and 65% of the variation in the winter balance and between 70% and 80% of that in the net balance. Measured balance values were +220, +198 and +266 g cm^{-2} for specific winter balance, and +87, +6 and -37 g cm^{-2} for specific net balance during the observation periods 1979/80, 1980/81 and 1981/82 respectively. A study to obtain the net balance from the difference between the winter balance and the ablation is in preparation. The ablation is calculated from the energy income in the ablation period. For this purpose, the spatial distribution of direct and sky diffuse radiation has been studied.

GLACIER WIND, RHONEGLETSCHER(ALPEX-RHON/EX)
(A. Ohmura, GGEZ)
The results of the 1979 field experiments (aerology and heat balance) on the Rhonegletscher have been evaluated. The glacier wind above the mean equilibrium line of the Rhonegletscher is, on average, 200-300 m high. The height of the advancing head of this wind ranges between 5 and 50 m. Above the cold air which forms the glacier wind, is a layer of minimum wind speed which extends up to about 500 m below the average height of mountain ridges in this region. Above this layer, wind speed increases almost linearly up to 1-2 km above the ridges. Within the layer of minimum wind speed, the wind direction changes either clockwise or counterclockwise with increasing height. Most of the momentum exchange between the external atmosphere and the mountain body also takes place in this layer. This fact, together with the strong stability which develops within the layer of minimum wind, contributes to the isolation of the layer of cold air above the glacier surface, resulting in a semi-permanent existence of the glacier wind.

ABLATION STUDIES ON ALETSCHGLETSCHER
(P. Müller and H. Röthlisberger, VAW)
Diurnal ablation was measured on a large number of stakes on the snout of Aletschgletscher, at an elevation of some 1,000 m below the equilibrium line. A statistical analysis showed variations of ablation with exposition and albedo. An inter-comparison of different types of stakes and stake arrays showed that an appropriate method for reliable short-term ablation studies (e.g. daily variations) is still lacking.

ADVANCE OF FINDELENGLETSCHER

(A. Iken, H. Röthlisberger & W.Schmid, VAW)
The relatively rapid advance of Findelengletscher, which is now approaching a large water intake of the Grande Dixence power company, has been studied since 1980. Glacier movement and deformation rates are measured at several stakes in the ablation area, at intervals of 2-3 months. Annual aerial photographs (courtesy of the Eidgenössische Vermessungsdirektion) are evaluated. Displacement and deformations at the snout are recorded with an automatic camera.

DIRECT MEASUREMENT OF VERTICAL MOTION OF NEAR-BASAL ICE IN UNTERAARGLETSCHER

(A. Iken, VAW)
In May 1981, in order to investigate the hypothesis of seasonal, subglacial water storage, the vertical motion of the ice at the bottom of 160-260 m deep boreholes was measured relative to the ice motion at the surface by means of heatable wires anchored in the boreholes. It was found that a large part of the upward motion of the ice, measured at the surface near the centre line in a period of strong melt, was due to the upward motion of the basal ice. This finding corroborates the hypothesis of subglacial water storage.

RELATIONSHIP BETWEEN SUBGLACIAL WATER PRESSURE AND GLACIER MOVEMENT

(A. Iken, VAW; R.A. Bindschadler, NASA/USA)
In May and June 1982, 25 boreholes were drilled to the glacier bed in the ablation area of the Findelengletscher. One third of these holes connected with the subglacial drainage system. Surface velocities of the glacier were measured at 4 transverse lines of stakes, 1 to 5 times daily. Surface velocities correlated well with subglacial water pressure; the functional relationship suggests an undeformable bed, a very low separation pressure and a small bed roughness in the studied area.

RADIO-ECHO SOUNDING ON SWISS GLACIERS

(H.P.Wächter, W. Haeberli and H. Röthlisberger, VAW)
The U.S. Geological Survey monopulse ice radar was successfully tested in Alpine ice and firn and is now employed for ice thickness determinations in connection with scientific projects and consultant work. Glacier bed topography was studied, for example, on Colle Gnifetti (ice core studies), Grubengletscher (ice-dammed lake), Rhonegletscher and Griesgletscher (mass balance observations), Findelengletscher (advance and movement studies) and Allalingletscher (glacier observations for the Mattmark-Mauvoisin power company). The future behaviour of Allalingletscher was modelled using statistical relationships between air temperature, mass balance, thickness changes, ice discharge variations and fluctuations of the glacier front.

GEOELECTRICAL RESISTIVITY SOUNDINGS OF GLACIER BEDS

(W.Haeberli, VAW; W.Fisch, Wettswil, Zürich)
A method combining hot water drilling and geoelectrical resistivity soundings was tested to study glacier bed characteristics. Electrodes for the resistivity soundings are installed in boreholes drilled down to the glacier bed and have direct contact with the bed. A first experiment, involving a 400 m profile at the bed of Grubengletscher, proved the usefulness of the method. The glacier bed in the region of the studied glacier snout consists of unfrozen, unconsolidated sediments with groundwater - subglacial sediment thickness varying from 0 to more than 100 m.

FORMATION AND DEFORMATION OF ICE ARCHES

(B. Ott, H. Röthlisberger, K. Hutter and A. Iken, VAW)
Ice arches occur in different forms in glaciers and can be more or less directly related to ice avalanching. Strain rates are measured on lamellae between curved crevasses and on arches forming at ice cliffs. Comparable structures are modelled using finite elements. It is hoped that a better understanding of the formation and destabilisation of ice arches may improve risk estimations concerning avalanching from steep glaciers.

ICE AVALANCHES

(J. Alean & W. Haeberli, VAW; B. Salm, SLF)
Approximately 90 ice avalanches in the Western Alps have been mapped using aerial photographs (and terrestrial photographs in a few cases). Existing models of rockslides and snow avalanches are being tested for their applicability to ice avalanches of varying volumes (10^2 to $5 \times 10^6 m^3$). A reliable model is sought which will predict maximum runout distances as a function of terrain parameters and avalanche size. Characteristics of glaciers are being studied in order to discriminate between those which do, or do not, produce avalanches of a given size.

TEMPORARY TECHNICAL SECRETARIAT FOR THE WORLD GLACIER INVENTORY

(K. Scherler, GGEZ)
In 1982, three voluminous glacier inventories (Austria, Peru's Cordillera Blanca and Scandinavia) were added to the TTS data bank. Some more glacier inventories will be finished by the end of 1985 (USSR, Italy, New Zealand, Peru, Bolivia and possibly others), but others will only be completed well after this deadline of the TTS activities, when this project will merge with the Permanent Service on the Fluctuations of Glaciers (PSFG). In order to arrive at a more precise picture of the distribution of glacierised areas, preliminary glacier inventories will cover those regions where no detailed glacier inventories can be compiled

before 1985. A working group, convened in October 1982 (Chairman, Dr.Gunnar Østrem), developed New Guidelines for Preliminary Glacier Inventories based upon the satellite imagery now available.

SNOW AND ICE HYDROLOGY

GLACIER FLOODS
(W. Haeberli, VAW)
Historical records of glacier floods in the Swiss Alps were collected and analysed to improve risk estimations and early recognition of flood hazards. Simple, empirical relationships were investigated to predict maximum possible peak discharge, erosion and sedimentation, and expected reach of damage for debris flows and flood waves. The frequency of damaging events is actually increasing due to increased human activity in previously avoided zones.

GLACIER RUNOFF FORECASTING
(H. Lang and H. Jensen, VAW; Kang Ersi, Lanzhou Institute of Glaciology and Cryopedology, People's Republic of China)
Previously developed forecasting models are being revised on the basis of 10 years of improved data collection and forecasting experience, in cooperation with Grande Dixence S.A. Hydropower Company (G. Dayer). Special emphasis is placed on variations in the net radiation; a special study on the radiation conditions in the Alps, including albedo of the glacier surface, has been performed for this purpose (H. Müller). Another aspect of these activities is the comparison of the glacio-hydrological conditions in different climatic regions, such as the Himalayas and the Chinese Tien Shan Mountains.

DRAINAGE FROM THE FINDELENGLETSCHER
(Ch. Leibundgut, GGB)
In the summer of 1982, the drainage from another Alpine glacier, the Findelengletscher, was studied using tracers in order to examine the development of a subglacial drainage system. The flow-through velocities, as well as the concentrations of tracers coming out of the glacier, show clear seasonal fluctuations. The site of maximum development of the intra- and sub-glacial drainage systems moves, during the summer months, from the lowest to the highest part of the ablation area.

LABELLING THE WATER FROM THE OUTBURST OF THE GORNERSEE USING 3 FLUORESCENT DYE TRACERS
(Ch. Leibundgut, GGB)
In order to obtain further information about the mechanism of subglacial water drainage, water from the outburst of the ice-dammed Gornersee (Swiss Alps) was labelled using three different dye tracers for the initial, main and final stages of the outburst. The concentration-time curves showed that during the preliminary stage of the drainage from the lake, the drainage system was not completely developed. However, for the main stage, a fully formed drainage system existed. This drainage system is very similar to karst drainage systems, except that frictional heat causes ice to melt from the walls of the water channels instead of, in the case of karst, the corrosion of limestone.

SNOW HYDROLOGY - LYSIMETER
(J. Martinec, SLF)
The snow hydrology programme has been improved by the construction of a new, automatically recording snow lysimeter (5 m^2).

VARIABILITY OF SNOW COVER IN THE SWISS LOWLANDS AND LOWER ALPINE AREAS
(L. Braun, VAW)
Spatial variability in the depth, density and water equivalent of snow has been investigated in the lowlands and lower Alpine areas of eastern Switzerland (Thur catchment) during the winter 1981/82. Snow depth was measured weekly at snow stakes situated on slopes of different aspects at about 80 locations, and snow density measurements were carried out at about 15 locations using the gravimetric method. These measurements try to fill the gap which exists in the information about the water equivalent of snow cover in lowland and lower Alpine areas, and should eventually help to model runoff from snow cover in order to forecast stream flow.

REMOTE SENSING OF SNOW
(W. Good and J. Martinec, SLF)
Applying digital image analysis and pattern recognition techniques to orthophotographs, a semi-statistical model has been developed to estimate the quantity of water stored in an Alpine watershed.

SNOW AND AVALANCHES

EROSION AND DEPOSITION OF WIND-BLOWN SNOW
(P. Föhn, SLF)
Areal patterns of deposition or erosion of wind-blown snow on the flanks of elongated mountain ridges have been evaluated over five winters. Various snow deposition patterns have been found, depending on crest shape and slope angle (10-35°). Theoretical approximations based on potential flow theories and empirical plume models explain the presumable dispersion of snow around crests.

REGIONAL PATTERNS OF SNOW LOADS
(J. Martinec, SLF)
Analysis of roughly 30 years of snow data in Switzerland has resulted in the preparation of a new regional map of snow loads, which takes into account the altitude above sea level.

"GROUND TRUTH" OBSERVATIONS FOR REMOTE SENSING
(C. Mätzler, Univ. Bern; W. Good, SLF)
Basic work on radiation properties of the snow cover is continuing in collaboration with the MW-group of the University of Bern. Scattering of electromagnetic energy is modelled using the geometric structure from thin section analysis.

STRUCTURAL INVESTIGATIONS OF SNOW
(W. Good, SLF)
Standard thin sections and serial cuts are used to study natural seasonal and firn snow. New parameters are generated according to specific physical questions.

ACOUSTICAL PROPERTIES OF SNOW
(O. Buser, SLF)
A reasonable agreement has been found between parameters describing snow in a rigid frame approximation and parameters from geometric analysis. A computerised experimental setup will control the duration of the experiments and the alteration of the snow samples.

SNOW RHEOLOGY AND STRUCTURE
(H. Gubler and W. Good, SLF)
A computer program is now being developed to find mechanically weak points in the snow structure. The aim was to find the distribution of the weakest bonds of a grain to a neighbouring grain from thin sections.

STABILITY OF SNOW COVER
(H. Gubler, SLF)
At Gaudergrat (near Weissfluhjoch), a method was tested to detect formation of surface hoar. The analysis of acoustic emissions was continued. Such signals seem adequate for the discrimination between gliding on the ground and confined fractures in the snow.

AVALANCHE MECHANICS
(H. Gubler, SLF)
The speed distribution of flowing avalanches was measured with a Doppler-radar system and the flow depth with an FMCW-radar. The latter system also measures the total water equivalent of the snowpack and detects individual snow layers. Studies of powder avalanches (in cooperation with VAW) started with theoretical work on a two-phase flow.

SNOW DISTRIBUTION AND ACTIVITY OF AVALANCHES
(J. Rychetnik, SLF)
Snow distribution and avalanche activity are determined by using photographic enlargements with the desired accuracy.

SNOW COVER AND SNOW MOTION IN FOREST STANDS PROVIDING AVALANCHE PROTECTION
(H. in der Gand and W. Frey, SLF)
Guidelines are elaborated for silvicultural measures to maintain the mountain forests and their protective functions.

NUMERICAL AVALANCHE FORECAST
(W. Good, O. Buser and C. Jaccard, SLF)
The model which compares analogous nivo-meteorological situations becomes a valuable tool for the local forecaster providing, in addition, insight into the problem of a historical data set of observed and measured parameters.

COMPUTATIONAL AND LABORATORY STUDY OF POWDER SNOW AVALANCHES
(K. Hutter and T. Scheiwiller, VAW)
Powder snow avalanches are modelled as a binary turbulent mixture of particles suspended in a Navier-Stokes fluid. Experiments are conducted with plastic particles suspended in water and sliding down an inclined chute; numerical computations are performed explaining these.

AVALANCHE FORECASTING
(P. Föhn, SLF)
The statistical-deterministic avalanche forecasting model for large, fresh snow avalanches, conceived in 1978, has been checked on several occasions. Whereas dry snow periods are simulated successfully, warm-up periods show clearly that the mechanical behaviour of the snowpack is not described in sufficient detail in order to warrant a day-to-day operational run of this model. In order to conceive a new, physically-based forecasting model, periodic shear-frame measurements (frame area = 0.05 m^2) have been initiated on various slopes. Despite the large standard deviation of such measurements (±30%), there is some hope of improving future forecasting models by integrating periodic shear strength index evaluations.

SNOW, AVALANCHES, TEMPORARY SUPPORTING STRUCTURES AND RE-FORESTATION
(W. Frey, J. Rychetnik & H.in der Gand, SLF)
A 100,000-tree test plantation is being used in order to develop suitable biological, technical and economical re-forestation techniques in starting zones of avalanches, and to test temporary (wooden) supporting structures and their influence on snow cover, avalanche activity and development of forested plants.

ICE CORE STUDIES

COLLE GNIFETTI
(H. Oeschger and collaborators, LLC; various members of VAW)
The Colle Gnifetti, 4450 m a.s.l., located on the Monte Rosa, is covered by a cold (-14°C) glacier. In summer 1982, a Swiss-German team (in cooperation with the Institute for Environmental Physics, Heidelberg) succeeded in drilling through this glacier, reaching the bedrock at two sites at depths of 124 m and 66 m.

The ice cores cover a time span of at least 500 to 1,000 years, and contain information supplementary to that from polar ice. Ice core parameters can be directly compared with historical, central European, climatic data. Chemical trace contents reveal man's increasing influence on the mid-latitude atmospheric composition. Observations of surface balance, firn temperature and ice flow were continued; these observations are part of an ongoing project to study the age distribution within the ice at the core drilling sites and to investigate snow accumulation processes at high altitudes.

SOUTH GREENLAND
(H. Oeschger and collaborators, LLC)
In summer 1981, in connection with the U.S.-Danish-Swiss Greenland Ice Sheet Program (GISP), drilling to bedrock at 2037 m depth was achieved at the radar station Dye 3 in South Greenland. The ice cores recovered contain approximately 50,000 years of information about the history of the ice cap, the earth and the planetary system. Ice core properties were investigated in the field. Visual stratigraphy, continuous electrical conductivity measurements and chemical analysis of selected samples enabled major features like seasonal variations, volcanic eruptions and transitions from periods of glacial to those of interstadial climatic regimes to be observed.

The Swiss team assisted in the construction of the new Danish drill and participated in the drilling operations. The team constructed and operated a core processing line consisting of a band saw and a platform for electrical conductivity measurements.

SOUTH POLE
(H. Oeschger and collaborators, LLC)
Members of LLC had an opportunity to take part in a U.S.-funded combined core-drilling and core-analysis project at the South Pole. In December 1982, core drilling reached a depth of 237 m. The main goals of this project are: (1) to reconstruct the history of atmospheric CO_2 concentration by analysing air extracted from ice samples of different ages, (2) to reconstruct the history of solar activity by measuring the ^{10}Be and ^{36}Cl concentrations in ice samples, and (3) to reconstruct the history of volcanic activity by measuring continuously the acidity of ice cores as a function of depth.

CO_2 CONCENTRATION OF THE ATMOSPHERE IN THE PAST
(H. Oeschger and collaborators, LLC)
The CO_2 concentration measurements on air extracted from ice cores show the following major results:

- The concentration of CO_2 in air bubbles in young ice from very cold areas corresponds closely to the atmospheric CO_2 concentration at the time of ice formation.

- Data sets from three ice cores (Camp Century and Dye 3, Greenland, and Byrd Station, Antarctica) show, for the glacial-postglacial transition, a shift in CO_2 concentration from 180-220 ppm to 260-300 ppm.

- For the last 1,000 years, values in the range 260-280 ppm are observed, indicating a lower pre-industrial value than previously assumed (290-300 ppm) and showing that the presently higher concentration of CO_2 is a man-induced phenomenon.

^{10}Be CONCENTRATION MEASUREMENTS
(H. Oeschger and collaborators, LLC)

Three sets of ^{10}Be samples have been investigated in ice cores from Dye 3 and Milcent:

- The first set from Dye 3, covering a time period 3,000 B.P. to 30,000 B.P., indicates a significant change in the concentration of ^{10}Be at the glacial-postglacial transition.

- The second set from Dye 3 consists of biannual samples covering the period 1900 to 1976. The 11 year solar cycle modulation is reflected in the data set.

- The third set from Milcent (1300-1800) shows an increased ^{10}Be concentration during the Maunder and Spoerer Minima.

SEA ICE

TEMPERATURE DISTRIBUTION - NORTH WATER POLYNYA, BAFFIN BAY
(K. Steffen, GGEZ)
Analysis of remote sensing data for the winters 1978/79 and 1980/81 has been completed. Surface temperature distribution maps were plotted for the months of November to March of both winters on the basis of low level, thermal infrared measurements from an airplane, and NOAA-VHRR satellite images. A temperature increase of 10°C from west to east was noticed in northern Baffin Bay. In the North Water area, the 20 km means of surface temperature are in the order of 10-20°C warmer than those for the surrounding fast ice regions. Areas of abnormally high mean temperatures (-5°C) were recorded in Smith Sound at Cape Alexander, in Baffin Bay between the Carey Islands and Wolstenholme Island, in Lady Ann Strait south of Coburg Island, and in Barrow Strait (only in winter 1980/81). From the temperature distribution, the existence of warm water cells was found. These temperatures of -1.5° to -0.1°C were observed in the North Water mainly along the Greenland coast, in Lady Ann Strait and Barrow Strait. The profile length varied from a few hundred metres up to 30 km. The frequency distribution has its maximum in the interval -1.0° and -0.75°C.

FROZEN GROUND

SKI RUNS IN ALPINE PERMAFROST

(W. Haeberli, VAW; C. Bucher and G. Patzelt, Alpine Forschungsstelle Obergurgl der Universität Innsbruck)

The removal of coarse, surface material from vast areas and the compaction of snow, both of which occur in connection with the preparation of ski runs, become more and more common in the belt of discontinuous permafrost within the Swiss Alps. Short- and long-term effects of the mutual interaction between ski runs and Alpine permafrost are being studied in test areas of the Swiss and Austrian Alps by mapping permafrost distribution, snow cover characteristics and geomorphological processes. The main processes studied are: (1) in regions of existing permafrost, thermokarst/soil erosion effects due to the removal of the active layer, and (2) in regions previously free of permafrost, increased winter cooling and formation of underground ice due to snow compaction.

ROCK GLACIER STUDIES

(W. Haeberli, VAW)

Shallow core drillings and geophysical soundings (seismic refraction, electrical resistivity, radar) have been performed over the last few years on several rock glaciers of the Swiss Alps (in collaboration with D. Barsch and L. King, Geographisches Institut, Universität Heidelberg; W. Fisch, Wettswil, Zürich; H.P. Wächter, VAW). Movement studies over time periods of years, months and even days were carried out at the well-studied rock glacier near the Grubengletscher (with W. Schmid, VAW). A comprehensive study is being prepared showing that Alpine rock glaciers provide natural large-scale/long-term experiments on the creep behaviour of perennially frozen sediments, rich in ice.

GLACIAL GEOLOGY AND PALEOGLACIOLOGY

SEDIMENTOLOGICAL IMPLICATIONS OF THE FINDELENGLETSCHER ADVANCE

(C. Schlüchter, IGB)

Sedimentological aspects of the re-advance of Findelengletscher have been recorded. The increased glacier activity resulted in a surprisingly low production of new till, but induced a voluminous remobilisation of older glacial deposits at the ice margins. These remobilisation processes are predominantly controlled by glaciotectonic activity, and the influence of melt water has remained minimal. Future studies will include observations of the relationships between flow patterns and the resulting till facies, analysis of small scale variations in the till facies at the ice front, and investigations of the origin of glacially-sculptured clasts.

EROSION STUDIES AT FINDELENGLETSCHER

(H. Röthlisberger and W. Schmid, VAW)

Photographs for a photogrammetric precision survey have been taken of a roche moutonnée in front of the advancing Findelengletscher. Control markers have been placed in drill holes, below the rock surface, on a peripheral polygon surrounding the area of investigation. It is planned to repeat the survey when the glacier has again retreated sufficiently to evaluate erosion. The work is being carried out in collaboration with the Institute of Geodesy and Photogrammetry of the ETH (J.Rady, H.Schmid & H.Zollinger) and with Grande Dixence S.A. (A. Bezinge).

HISTORY OF ALPINE GLACIERS FROM 16TH TO 19TH CENTURY SOURCES

(H.J. Zumbühl, GGB)

The reconstructed curve showing the variations of the two Grindelwald glaciers was extended back to 1535, on the basis of written sources and maps. A study of the historical variations of glaciers in the Mont Blanc region, the central and the eastern Alps has been started. In collaboration with the Gletschergarten, Luzern, and the Alpines Museum Bern, an exhibition showing a large number of historical representations of Alpine glaciers was organised.

HISTORY OF WEATHER AND CLIMATE IN SWITZERLAND - 1525 TO THE PRESENT

(Ch. Pfister, GGB)

Data on snowcover and snowfall are drawn from historical documents (chronicles, weather diaries, etc.). For the lowlands, the duration of the snowcover has been estimated since the late 18th century. Extremely snowy winters or those with barely any snow are recorded in the statistics as far back as 1525. Reliable data for higher latitudes originate in the later 18th century. The publication also includes a detailed list of the winters during which lakes in the Alpine borderland were covered with ice.

POSTGLACIAL AND LATE-WORM VARIATIONS OF GLACIERS AND CLIMATE

(G. Furrer and collaborators, GGUZ)

The research programme on glacier and climate fluctuations during the postglacial and late-Würm periods continued. This programme was started about 10 years ago and aims to reconstruct a detailed chronology of events by collecting and analysing historical records, ^{14}C datings of soils and trees, dendrochronological information and pollen studies, and by mapping geomorphological phenomena (moraines, solifluction lobes). Processes of solifluction and their paleoclimatic significance are also studied. Results are published in volumes of the Institute's "Physische Geographie".

QUANTITATIVE RECONSTRUCTIONS OF PALEOCLIMATE USING PERMAFROST-GLACIER RELATIONSHIPS
(W. Haeberli, VAW)
A model was developed to reconstruct paleotemperature (mean annual air temperature) and paleoprecipitation (annual precipitation) using permafrost-glacier relationships (in collaboration with H. Kerschner, Geographisches Institut, Universität Innsbruck). The model uses permafrost phenomena such as rock glaciers, push moraines (in the strict sense) or ice wedges, to fix isotherms in space for a considered time period and then to estimate mean temperature at the equilibrium line of glaciers, the latter being reconstructed from maps of moraine distribution. The model is mainly based on earlier thoughts and observations by Ahlmann and Russian authors, and was calibrated with data from the recently finished Austrian glacier inventory. Analysis of geometrical parameters of reconstructed late-Würm glaciers confirmed that precipitation was strongly reduced in the Swiss Alps during this time (with M. Maisch, GGUZ).

CONSULTANT WORK OF SLF AND VAW
Practical consultant work of the SLF mainly concerned aspects of avalanche protection in collaboration with political authorities (federal, cantonal and communal), private companies and private individuals. The work involved the following aspects: construction of support structures in the release zone of an avalanche, deviation dams in the trajectory, retention structures in the deposition zone,galleries for roads and railroads, protection of single objects such as buildings and electricity pylons,avalanche danger zoning,afforestation in snowglide and avalanche regions, artificial avalanche release, avalanche forecasting (over mass media) and snow loads on buildings.

Consultant work of the VAW was carried out in connection with the operation of hydroelectric power stations, on behalf of cablecar and railway companies, and in collaboration with political authorities and the Swiss Alpine Club (SAC). The work was mainly concerned with the effects of ice avalanches (Allalin,Giétro), glacier floods (Macugnaga/Italy, Gruben), foundations in permafrost (Jungfraujoch, Finsteraarhornhütte), and safety aspects of lake ice (Katzensee).

Wilfried Haeberli

UNITED KINGDOM

SINGULARITIES IN E.M. FIELDS AND CATASTROPHE OPTICS
(J.F. Nye, Physics Department, Bristol University, Bristol BS8 1TL)
Although the current theoretical and experimental work on these topics is of general application, it has been partly motivated by a wish to understand more clearly the wavefields of radio echoes from glaciers. The singularities of interest on the wavelength scale are wave dislocations (analogous to crystal dislocations) and wave disclinations (analogous to liquid crystal disclinations). On a larger scale, where geometrical optics is appropriate, the relevance of catastrophe optics to radio echoes is that it provides insight into focussing effects, with their associated patterns of caustics.

PHYSICAL & CHEMICAL PROCESSES DURING SNOWMELT
(E.M. Morris and A.G. Thomas, Institute of Hydrology, Wallingford, Oxon OX10 8BB)
The physical and chemical processes that occur when snow melts are being investigated both theoretically and in the field. The aim is to determine the effect of preferential discharge of pollutants during the first snowmelt of spring ("flush-out") on stream water chemistry and to establish the rates of denudation for a sub-arctic non-glacierised catchment in an area of high airborne pollution. The study area is a small (0.4 km^2) corrie on the side of Cairngorm mountain in Scotland. Continuous measurements of stream discharge and total dissolved load are made at the catchment outlet at 960 m a.s.l. Meteorological data and vertical properties of snow chemistry, density and grain size are measured within the catchment. These data are being used to develop a physically-based model of snowmelt and the movement of pollutants through snow.

LABORATORY STUDY OF PROCESSES AT ICE/BEDROCK INTERFACE
(H.Lister, Geography/University of Newcastle upon Tyne)
Experiments have been made with 15 cm diameter discs of randomly oriented ice crystals over 1 cm in diameter. A 1 cm wide annulus of smoothed rock with apparent loading of 1-10 bars rotates concentrically at sliding speeds of 10-50 m a^{-1}. Below -5°C ice patches adhere to the rock providing an ice/ice sliding so the ice/rock sliding is run at -1° to -5°C. Apparently identical specimens give different results, some showing no wear for weeks,some for months. Part of the rock surface can be polished whereas adjacent areas are eroded. Values of sliding friction are erratic but the characteristic stick/slip motion has been almost completely eliminated by a very rigid apparatus. Thin sections of ice show recrystallisation at the sliding surface, often incorporating products of rock wear. The c axes of these crystals are rarely normal to the sliding surface; mean angles of 15° to 30° are common.

STUDIES OF DISLOCATIONS IN ICE
(J.W. Glen and R.W. Whitworth, Physics/Univ. of Birmingham)
Electron microscopy and synchrotron radiation are being used to study dislocations in ice crystals.

GLACIER BASIN HYDROLOGY AND GEOMORPHOLOGY
(C. Fenn, Worcester Coll. of Higher Educa.)
Discharge, sediment transport, channel form, runoff and sediment transfer systems, and the dynamics of proglacial streams are under investigation.

SNOW MELT FORECASTING AND POLLUTION IN SNOW
(L. Morris, Institute of Hydrology,)
Field studies are underway of turbulent transfer in the atmospheric boundary layer above snow and of the mass and energy flux in melting snow including the passage of pollutants. The behaviours are being modelled mathematically.

SNOW CHARACTERISTICS AND RADAR BACKSCATTER AT MM WAVELENGTHS
(D.E. Sudgen and L.D. Williams, Geog./Univ. of Aberdeen; R.V.Birnie, Macaulay Res.Inst.)
A joint programme with the Macaulay Research Institute for Soil Research is underway. Fieldwork is planned for Scotland and Europe.

THERMOMECHANICALLY COUPLED ICE SHEET FLOW
(L.W. Morland, School of Mathematics and Physics, University of East Anglia)
Steady plane flow equations of mass, momentum and energy balance for a non-linearly viscous heat conducting fluid with a strongly temperature dependent rate factor are being reduced. The equations provide the basis for a numerical solution for the form of an ice sheet. The theory has been extended using perturbation analysis to model unsteady flow, and solutions have been obtained for uncoupled flow after the temperature field has been prescribed.

UNITED KINGDOM — ANTARCTICA

BRITISH ANTARCTIC SURVEY
(C.W.M. Swithinbank, British Antarctic Survey, Cambridge CB3 0ET)

Geophysics
Changes in size of the Antarctic ice sheet have world-wide consequences through their effect on sea level. Studies of the mass balance are hindered by the uncertainty of how much ice is lost by melting into the sea at the base of the large ice shelves which fringe the coastline. Radio echo studies by C.S.M. Doake and R.D. Crabtree have shown that the reflection coefficient for radio waves at the ice-sea boundary can vary by a factor of 1000. Mapping the coefficient indicates areas of low signal strength where salty ice is frozen to the bottom and areas of high signal strength where melting occurs. By combining BAS data with those obtained by the Scott Polar Research Institute and the West German Antarctic Expedition, a comprehensive picture emerges, for the first time, of the ice flow of the Ronne and Filchner ice shelves and the water circulation underneath. Taken together, they are smaller than the Ross Ice Shelf but contain more ice. The area has remained relatively unexplored because of its remoteness from any logistic support base.

S.N. Stephenson has continued analysing data collected on the Rutford Ice Stream. Tidal flexing near the grounding line, measured by tiltmeters, could be described by simple elastic bending theory using a modified value for the flexural rigidity. It appears that ice first lifts off the sea bed at a position where the surface elevation is higher than it would be under hydrostatic equilibrium, because the ice is supported by shear stress gradients associated with bending.

G.J. Musil operated a synthetic aperture radar (SAR) over a grounding line region of Bach Ice Shelf in Alexander Island. Three intersecting lines were sounded to give different views of one area. Preliminary results from one line show that there is a distinctive pattern of the backscatter coefficient and that the results are internally consistent.

R.D. Crabtree has compiled all radio echo sounding data over Alexander Island and George VI Ice Shelf for the production of a map of ice thickness and bedrock elevation at a scale of 1:500,000.

Physics
Over much of Antarctica, weak radar echoes have been detected from within the body of the ice sheet. Although their origin is not fully understood, the reflecting horizons are thought to be sedimentary layers subsequently deformed by ice movement. One possible explanation is that slight melting and refreezing could change the electrical properties of the ice, it being known that ice grown from water in the laboratory differs from ice found in cold polar ice sheets. To investigate this, J.M. Reynolds undertook georesistivity measurements in an area of George VI Ice Shelf where flooding by melt water lakes occurs each summer. The measurements showed that ice formed by compaction of dry firn and ice formed by refreezing of melt water have the same direct-current resistivity. However, J.M. Reynolds' detailed analysis of the dielectric properties of ice and firn core samples which he collected implied that there was a large variability in the resistivity at radio frequencies used in echo sounding. This spread in resistivity values could provide sufficient contrast to reflect radio waves.

Chemistry

Also trapped in layers within the ice sheet is a record of the changing composition of the atmosphere, showing how climate has changed and pollution has grown. D.A. Peel has analysed the stable oxygen isotope data from an 83 m deep core recovered from Palmer Land. He found a clear relationship over the last 20 years between the isotopic ratio in the ice layers and air temperature at Faraday Station, 700 km to the north. This gives greater confidence in interpreting isotope variations found in deeper cores. E.W. Wolff is studying the heavy metal content of snow to understand how industrial pollutants such as lead are dispersed globally. Although typical concentrations are 1-2 mg per 100 tons of snow, BAS analytical procedures only need 2 g samples of ice. He has thus been able to profile concentrations inwards from the surface of a core sample to show whether significant surface contamination has occurred. The relationship between trace element concentrations in air and in snow, important for interpreting ice core records of pollution, is being studied by A.L. Dick in a programme of simultaneous air and snowfall sampling at field sites in Antarctica.

Oceanography

The objective of a coordinated glaciological and oceanographic study directed by J.G. Paren is an understanding of the heat exchange at the sea water/ice shelf boundary. Two current meters which were moored by J. Loynes in the thermocline beneath George VI Ice Shelf two years earlier have now been retrieved. Profiling has been carried out by J.R. Potter during the summer in the sea at sites near both ice fronts and in the middle of the ice shelf 200 km from the open sea. These show that George VI Sound is a deep channel and that sea floor temperatures exceed 1°C even beneath the middle of the ice shelf. All currents are weak, a factor contributing to the survival of the ice shelf in a singularly warm sea.

TOPOGRAPHY OF THE ANTARCTIC ICE SHEET

(D. Drewry, P. Cooper and N. McIntyre, Radio Echo Group, Scott Polar Research Institute)
Aircraft altimetry, radio echo sounding and satellite data are being used to investigate the surface form of the ice sheet. A revised model of the topography is being produced. The flow of ice through ice streams and outlet glaciers is also being investigated. Altimetry from satellites is being actively pursued for glacier studies.

UNITED KINGDOM — ARCTIC OCEAN

BP TOTAL ICE LOAD PROGRAMME, TARSUIT ISLAND

(T.J.O. Sanderson, British Petroleum)
BP carried out a major full-scale field experiment in 1983 to determine the load exerted by sea ice on an offshore artificial island. Tarsuit Island was surrounded by strainmeters and continuously monitored for 2 months.

STUDIES OF SEA ICE PROCESSES IN ARCTIC MARGINAL ICE ZONES

(P. Wadhams and A. Cowan, Sea Ice Group, Scott Polar Research Institute, Cambridge)
During 1983 the sea ice group participated in two Arctic cruises. The first, to the ice edge in the Bering Sea, took place in January-March with the NOAA ship "Discoverer" and the USCG icebreaker "Westwind". The second in July-August, was the (Marginal Ice Zone Project) MIZEX '83 cruise to the Greenland Sea in the Norwegian ship "Polarbjørn". In both cases studies were made on ice drift and deformation using radar transponders; wave penetration into ice; and the mechanisms for ice band and eddy formation. Aerial photography was undertaken to supplement data collected using an airborne radar altimeter flown by NASA and the Rutherford Appleton Laboratory. The analysis of submarine sonar profiles of ice thickness from the Arctic was continued.

UNITED KINGDOM — CANADA

GLACIATION OF THE SOUTHERN COAST MOUNTAINS

(I.S. Evans, Geography/Univ. of Durham)
The distribution of glaciers and of cirques has been mapped at 1:50,000 and is being analysed in relation to aspect and to altitudinal thresholds. Further work covers variation in cirque form and relations between cirque development and ice sheet development.

UNITED KINGDOM — GREENLAND

CHARACTERISTICS OF A SURGE-TYPE GLACIER, ROSLIN GLACIER, EAST GREENLAND

(V. Haynes, Geography/Univ. of Strathclyde)
Fieldwork carried out in 1977 on the velocity field and hydrology of Roslin Glacier is being interpreted in the light of geological data, earlier fieldwork and good aerial photographs.

UNITED KINGDOM — SCANDINAVIA

RADIO ECHO STUDY OF WATER DISTRIBUTION IN TEMPERATE ICE, STORGLACIÄREN, SWEDEN
(M.E.R. Walford and M. Kennett, H.H. Wills Physics Laboratory/University of Bristol)
Since November 1982 a 5 MHz, single antenna, back-packable, monocycle radio echo system has been developed. Echoes are recorded on a stereo cassette recorder which can then be loaded into a portable microcomputer. In September 1983 the equipment was tested at Tarfala, Sweden. Comparison of borehole depths, radio depths and englacial echoing targets suggests Storglaciären contains 0.4% water with a typical target diameter of 5 m.

ENTRAINMENT AND THE CHARACTERISTICS OF THE BASAL ICE OF TEMPERATE GLACIERS
(J.C. Gemmell, Geography/Univ. of Aberdeen)
Sedimentological, chemical and isotope analyses on systematic, small-scale samples from subglacial cavities at Nigardsbreen, central Norway, are directed at understanding entrainment processes.

PALEOCLIMATOLOGY - GLACIAL GEOLOGY
(M.J. Hambrey, W.B. Harland and P. Waddams, Dept. of Earth Sciences/Univ. of Cambridge)
Following the completion of Earth's Pre-Pleistocene Glacial Record (eds. Hambrey and Harland, Cambridge University Press 1981), an analysis of the data is underway to determine the essential characteristics of the main glacial eras, periods and epochs. Data have been plotted by computer on paleocontinental maps.

Field work has been undertaken by Hambrey (1981-1982), T.H. Jefferson (1981) and I.J. Fairchild (1982) on the Late Proterozoic (Varangian) tillites of Ny Friesland and Olav V Land, Spitsbergen. These are undeformed and retain most primary glacial characteristics. They are interpreted as having been primarily deposited in a shallow shelf sea beneath glacier tongues, but periodic rises of sea level gave rise to periglacial and glaciolacustrine conditions. Two main horizons of tillites are represented and these have correlatives in much of the North Atlantic region.

P. Waddams worked in the west of Spitsbergen (1977-1979) where the tillites are very different - marine sediments with an ice-rafted component and remobilised tills, deposited in an unstable subsiding marine basin.

UNITED KINGDOM — SWITZERLAND

MELT WATER CHARACTERISTICS AS INDICATORS OF INTERNAL HYDROLOGY OF ALPINE GLACIERS
(D. Collins and S. Hall, Geography/Univ. of Manchester)
Electrical conductivity, pH, temperature and suspended sediment concentration characteristics of melt water draining from Gornergletscher and Findelengletscher, Switzerland, were recorded continuously throughout extended periods of the ablation season of 1983. Z'muttgletscher was added to the monitoring system for electrical conductivity. The pH measurements suggest that firn and snow melt water acquires considerably more soluble material than that derived from ice melt in the ablation area. Individual cations and anions in the discharge have been correlated with electrical conductivity.

CONTROLS ON SUSPENDED SEDIMENT CONCENTRATION IN PROGLACIAL STREAMS
(A. Gurnell, Geography/Univ. of Southampton)
Work on suspended sediment concentration in the proglacial stream of the Glacier de Tsidjiore Nouve has concentrated on establishing the relationship between sediment concentration and discharge using sediment rating curves, time series analysis and flow separation. Anomalies of suspended sediment concentration from predictions based on a transfer function between the two series are also being studied in an attempt to understand the influence of source areas and rates of supply on suspended sediment concentration patterns in the proglacial stream.

J. Paren

GLACIER STUDIES

THEORETICAL GLACIOLOGY
(A. Fowler, MIT)
The Nye-Kamb sliding problem (constant ice viscosity, small bedrock undulations) has been solved, in the presence of cavitation. For a sinusoidal bedrock, the velocity $\mu \to \infty$ as the stress increases to a critical value τ_c.

A mathematical model for moisture transport through temperate ice has been developed, for possible use in dynamical studies of temperate glaciers.

THEORETICAL ANALYSES OF ICE SHELF FLOW
(K. Jezek, USACRREL)
A theory by H. Weertman which estimates the height of bottom crevasses in ice shelves has been extended by K. Jezek of USACRREL. The new theory incorporates a back stress term (σ_b) that describes the net effects of side drag and ice rises on the flow of the ice shelf. In areas where the heights of bottom crevasses and total ice thickness are known, the theory can be inverted to yield σ_b. Using these estimates of σ_b and strain rates measured on the Ross Ice Shelf, K. Jezek, R. Alley and R. Thomas have computed the flow law constant and exponent. The results are in good agreement with Thomas's earlier work on the flow law of glacier ice.

"HAZEN ICE CAPS", ELLESMERE ISLAND, N.W.T.
(R.S. Bradley and M. Serreze, MASS/Amherst)
Topoclimatic, energy balance and mass balance measurements were carried out on and around two small ice caps on northeastern Ellesmere Island, N.W.T., Canada, in the summers of 1982 and 1983 (at 81°57'N, 64° 15'W). A basic stake network, established by G. Hattersley-Smith and H. Serson in 1972, was greatly extended. Net mass balance on the eastern ice cap from 1972 to 1982 was -1300 kg m^{-2} and from 1958 to 1978 the western and eastern ice caps were reduced in area by ~7% and ~11% respectively. Mass balance in 1981-82 was strongly negative and in 1982-83 was strongly positive. The two seasons thus provided an interesting range of conditions for energy balance and topoclimatic studies. Meteorological stations were established on and around the two ice caps, recording barometric pressure, incoming short- and long-wave radiation, net radiation, reflected short-wave radiation, air temperature, relative humidity and wind speed at 15 cm and 150 cm and 300 cm and at various depths in the snow and ice. In addition, hourly synoptic observations were maintained. A low-level, tethered balloon system was used at irregular intervals to record vertical profiles of temperature, humidity, wind speed and direction above the ice cap.

GREENLAND - DYE 3
(P.A. Mayewski and W.B. Lyons, GRG/UNH); T. Hinkley, USGS/Denver; G. Larson, MICH)
A coring program will be undertaken in Spring 1984 to provide a detailed record of acidic anions for the period AD 1900 to present as a means of documenting anthropogenic effects for this period.

CLIMATE HISTORY FROM POLAR/TROPICAL ICE CORES
(L.Thompson and E.Mosley-Thompson, IPS/OHIO)
In the microparticle laboratory, we are conducting a detailed comparative study between a microparticle profile established for a 100 m South Pole core, drilled in 1974 and covering the last 911 years, and a microparticle profile being established from a 200 m South Pole core drilled in 1981. We have also continued our analysis of shallow cores from the Quelccaya Ice Cap, Peru.

Since 1976, we have conducted a field research program on the Quelccaya Ice Cap at 5670 m in the Andes of Southern Peru with one central objective; to recover an ice core to bedrock from which an approximate 100 year climatic history for tropical South America could be reconstructed. This year we accomplished that central objective recovering one core 154.8 m containing over 1350 years and a second core to bedrock 163.6 m containing 1500 years of climatic history. Both cores were drilled using a solar-powered drill designed by PICO. From these cores, over 6000 samples were collected for microparticle, oxygen isotope, total β radioactivity, specific conductivity and chemical studies. These samples are currently being analyzed. These data promise to provide, when properly interpreted, a very important 1500 year climate record for this part of tropical South America.

HIMALAYAS - LADAKH AND KASHMIR
(P.A. Mayewski and W.B. Lyons, GRG/UNH)
Ice coring and surface sampling programs have been conducted on several glaciers to provide glaciochemical data usable in assessing the current activity of these glaciers and as a means by which monsoonal air masses can be tracked.

ANTARCTICA - NORTHERN VICTORIA LAND
(P.A.Mayewski,W.B.Lyons & B.Allen,III,GRG/UNH)
Glacial geologic, glaciologic and glaciochemical studies of the Rennick Glacier and Evans Neve covering three field seasons are being used to assess the current and former activity of glaciers in these areas as proxy indicators of climatic change.

ANTARCTICA - SOUTHERN VICTORIA LAND
(P.A. Mayewski and J. Hassinger, GRG/UNH)
Observations of several rock glaciers over a several year period including velocity, strain, morphology, seismic and resistivity are being used to establish baseline data on these features and assess their potential as proxy indicators of climate.

REMOTE SENSING

SEA ICE MICROWAVE SIGNATURES FROM SATELLITE DATA

(J.C. Comiso, NASA/GSFC)

The dual polarization Scanning Multichannel Microwave Radiometer (SMMR) and the Temperature Humidity Infrared Radiometer (THIR), both of which are on board the Nimbus 7 satellite, were used to study the microwave signature of sea ice in the Arctic region. The emissivities in several study areas are observed to be approximately constant during the late fall, winter and early spring months. During the onset of surface melting in spring, the emissivity increases by as much as 30% at 37 GHz for multiyear ice with the effect decreasing with frequency, and is less than 5% at the 6.6 GHz channel. Multispectral cluster analysis was employed to study spatial variability over very large regions. Considerable variability in the emissivity for the multiyear ice was observed at 37 GHz and about one-third as much at 18 GHz. A wide cluster of data points corresponding to a signature which is intermediate to first year and multiyear ice signatures was also observed. While many of these data points correspond to mixtures of first year and multiyear ice, a considerable fraction of these data likely correspond to second year ice signatures. Some of the ambiguities were resolved when analysis was focussed to smaller study areas.

ATMOSPHERIC ICE AND CLIMATE

AEROSOLS & ICE CRYSTALS IN POLAR ATMOSPHERES

(A. Hogan, ASRC/SUNY/Albany)

Richard Townsend completed his MS research at South Pole, where he measured ice crystal size distribution in precipitation, as a function of the depth and saturation of the precipitating layer.

We have continued our study of particle transport to layers near the surface of the ice caps, in both Antarctica and Greenland. Interestingly, silicon and aluminum "dusts" do not arrive at the surface simultaneously with sulphur. The maximum sulphur concentration arrives at the surface during lower layer mixing, early in storms, and "dust" reaches a maximum as S diminishes, in post frontal, subsident mixing.

We are also studying, in Albany, the relation of several substances in snow pack, relative to elapsed time and the character of the original precipitation.

ATMOSPHERIC FORCING OF A COASTAL POLYNYA IN ANTARCTICA

(D. Bromich, IPS/OHIO)

Analysis of thermal infrared satellite imagery established the persistence of open water in Terra Nova Bay throughout the winter of 1979. This recurring polynya was responsible for not only the winter standing but also the survival of the Northern Party of Captain R.F. Scott's British Antarctic Expedition 1910-1913. A model for the maintenance and fluctuations of this open water area has been formulated from available historical records, satellite imagery, regional data, and theoretical considerations. During the 1983/1984 austral summer, an automatic weather station and a mooring will be deployed in Terra Nova Bay. The latter is part of the Ross Sea Heat Flux Experiment being conducted by colleagues at Lamont-Doherty Geological Observatory. The in situ observations, in conjunction with regional and remotely-sensed data, will test current understanding of polynya processes and should identify the interaction between the polynya and the atmospheric and oceanographic circulation in the western Ross Sea.

ICE PHYSICS/ENGINEERING

DARTMOUTH'S ICE RESEARCH LABORATORY

(E. Schulson, Ice Res. Lab., Dartmouth College, Hanover, New Hampshire)

In July 1983, following a series of awards from government and industry over the past three years, the Thayer School of Engineering at Dartmouth College established an Ice Research Laboratory. The laboratory is currently being equipped with two cold rooms (0° to -10°C, 0° to -50°C),a materials testing system (MTS 810.14) and a data acquisition system. Plans include expanding the testing system to allow measurements of the mechanical properties of ice under triaxial states of stress. The Ice Research Laboratory complements the facilities of the U.S. Army's Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, and serves as an on-campus presence of the collaborative CRREL/Thayer graduate program in Cold Regions Science and Engineering. Studies currently underway (using CRREL facilities) include an investigation of the effects of grain size on the tensile and compressive strengths of ice at temperatures from -3 to -5°C at strain rates from 10^{-6} to $10^{-1}s^{-1}$.

BUCKLING LOADS OF CRACKED ICE SHEETS

(D. Sodhi and M. Adley, USACRREL)

Experimental and theoretical studies were conducted to determine the buckling loads of floating ice sheets with cracks from the edge of a structure in different directions. The agreement between the theoretical and experimental results is reasonable.

CRUSHING ICE FORCES ON CYLINDRICAL STRUCTURES

(D. Sodhi and C. Morris, USACRREL)

Small-scale experiments were conducted to determine the magnitude and nature of ice forces that are generated during the crushing failure of an ice sheet against a cylindrical structure. The main parameters varied during the experiments were the diameter and

the velocity of the the structure with respect to the ice. The results are presented in nondimensional form. We have found the maximum and mean forces to be dependent on the aspect ratio and the velocity. The characteristic frequency of ice crushing is found to be dependent on the velocity and ice thickness. The size of the damage zone as determined from the characteristic frequency of ice failure is about 30% of the ice thickness.

THERMAL PATTERNS IN ICE UNDER DYNAMIC LOADING
(A. Fish, S. Marshall & R.H.Munis, USACRREL)
Heat emission patterns in the infrared spectrum were discovered in ice cantilever beams subjected to cyclic loading. The patterns first appeared at the fixed end of the ice plate and migrated gradually to the free end. The temperature difference between the ends was found to depend on the duration and frequency of excitation.

FLOW WAVES IN ICE-COVERED RIVERS
(M. Ferrick, USACRREL)
We are attempting to quantitatively describe rapidly varying flow waves in ice-covered rivers. These waves commonly originate at dams where the flow release can be changed abruptly. Work accomplished to date has established a basis for understanding these waves in rivers without an ice cover. Data from a series of experiments with rapidly varying flow in a 35-m long, ice-covered, laboratory flume are being used to help identify the physical processes of primary importance.

ICE FORCES
(F.D. Haynes, USACRREL)
A study of ice forces on model bridge piers has been continued at CRREL's test basin. Tests on sloped structures are currently being conducted. The laboratory data is compared with field data from the Ottauquechee River in Vermont and the Yukon River in Alaska.

SNOW

SNOW METAMORPHISM
(S. Colbeck, USACRREL)
The growth of ice crystals in a snow cover at subfreezing temperatures is studied by several methods. First, the growth of individual ice crystals under controlled conditions are observed in order to quantify the conditions under which rounded (equilibrium form) and faceted (kinetic growth form) crystals grow. The growth of faceted crystals at higher growth rates or supersaturations corresponds to the development of depth hoar at higher temperature gradients in the snow cover. Second, the growth of crystals in the snow cover is modeled as particle-to-particle vapor transfer due to temperature differences among neighboring particles. This work is currently being extended to describe the statistics of the particle population and the effects of thermal convection. Third, a field and laboratory program of analysis of snow particles is being started to collect data on the evaluation of the ice particle population as metamorphism proceeds.

ACIDITY OF SNOW AND ITS REDUCTION BY CATIONS IN AEROSOLS
(M. Kumai, USACRREL)
Simultaneous measurements of pH and electrical conductivity of fresh and old snow from New Hampshire and Alaska, and elemental analysis of aerosols in the snow samples were conducted by an energy dispersive x-ray analyzer. In New Hampshire, characteristically, relatively high acid snow was found for south winds, and low acid snow for north winds from less populated areas. Rimed snow crystals were higher in acidity than non-rimed crystals, because of the high acidity of supercooled cloud droplets. The highest acidity was pH 3.96 (5271 $\mu S\ m^{-1}$) with southwest winds, and the lowest acidity was pH 5.45 (361 $\mu S\ m^{-1}$). At the end of March, snow cover near the roadside was contaminated with soil and salt, which were spread on the snowy road. An old snow sample had a pH of 7.29 (3000 $\mu S\ m^{-1}$). The old snow samples were always lower in acidity than those for fresh snow, because of cations in the soils and salts.

In snow samples collected near a coal-fired power plant in Fairbanks, Alaska, calcium-rich flyashes and clays were always found. The average pH was 7.2. The acid snow was changed to alkaline by cations in the calcium-rich flyashes.

MOUNT WASHINGTON - NEW HAMPSHIRE
(B. Allen, III, P.A. Mayewski and W.B. Lyons, GRG/UNH)
A preliminary surface snow sampling program will begin in the winter of 1983-84 in order to develop a time-series record of the chemistry of fresh snow at this site.

GREAT BAY, NEW HAMPSHIRE
(D. Meese and P.A. Mayewski, GRG/UNH)
Sampling of ice in this estuarine environment during the winter of 1983-84 will be used to help in the understanding of estuarine ice chemistry.

COLORADO ROCKIES
(J. Kauer, P.A. Mayewski & J.James, GRG/UNH)
Sampling of the seasonal snowpack during winter-spring 1983-84 will be used to assess the chemistry of a melting snowpack.

SNOW RUNWAYS IN ANTARCTICA
(C. Abele, USACRREL)
CRREL is assisting NCEL in evaluating the feasibility of constructing snow runways suitable for wheeled C-141 aircraft operations at McMurdo and South Pole Station.

We also reviewed the proposed design criteria (required snow pavement strength characteristics) for constructing a snow runway suitable for wheeled C-130 aircraft operations at Law Dome near Casey Station, Antarctica (for University of Melbourne).

A monograph on snow roads and runways is near completion.

MICROSPHERULES IN SNOW AND PACK ICE FROM THE WEDDELL SEA
(M. Kumai, S. Ackley, D. Clarke, USACRREL)
Silicon- and titanium-rich microspherules (2 to 12 μm diameter) from the Weddell Sea were similar to those found in flyashes of terrestrial origin. The concentration of microspherules in the Antarctic snow was about three orders of magnitude smaller than that in the New Hampshire snow.

FLOATING ICE/LAKE, RIVER AND SEA

EM PULSE PROPAGATION IN ICE
(S. Arcone, USACRREL)
Over the past year I have conducted a field investigation into the propagation of electromagnetic pulses in the VHF band through freshwater ice sheets. The intent was to find ways of analyzing pulse propagation data for dielectric information; ultimately to be used for analyses of sea ice covers. The results have shown the slabs to be highly dispersive due to wave guide effects (as expected) with the refracted surface air wave providing the best diagnostic of dielectric permittivity. Studies of an ice sheet in mid-Spring in Alaska revealed a high dielectric constant (4.6) due to the 2-phase nature of the slab.

MULTI-YEAR SEA ICE
(A. Kovacs, USACRREL)
Multi-year pressure ridges have been studied to determine their cross-section geometry, the temperature distribution within the ridge and the unconfined, compressive strength of the ice. Determinations of the ice porosity, brine volume, salinity and density have also been made. Impulse radar profiling of ice thickness in the ridges and surrounding floe was attempted using antennas operating at a center frequency of about 75, 120, 250 and 550 MHz. The results indicate that (1) the sail height to keel depth ratio of multi-year pressure ridges is about 1 to 3.2, (2) the coldest ice in the ridges in the spring was found, as expected, in the center of the sail where the ice may reach -20°C, (3) the ridges are for the most part voidless, (4) the mean density of the ice in the ridge sails is about 0.84 Mg m^{-3} but the ice in the ridge keels varies from about 0.86 to 0.93 Mg m^{-3} and (5) there exists moist, saline ice at the bottom of thick multi-year ice that,because of its high conductivity, prevents electromagnetic energy from travelling to the ice bottom and returning to the surface. The latter has limited the profiling of multi-year ice.

SHORE ICE PILE-UP AND RIDE-UP
(A. Kovacs, USACRREL)
Observations of shore ice pile-up and ride-up were made in April 1983 along the Bering, Chukchi and Beaufort Sea coast and in late July along portions of the Beaufort Sea coast. Significant shore line modification was noted in the Camden Bay area of the Beaufort Sea. Here sea ice had pushed large boulders, driftwood logs and tundra matting up to 20 m inland. At four Beaufort Sea barrier island locations sea ice was found driven over the islands and onto the lagoon ice on the southern side.

POROSITY & SALINITY MEASUREMENTS ON SEA ICE
(W. Tucker, USACRREL)
A device has been developed to rapidly detect cavities in ice rubble features. Voids are detected by lowering the simple electromechanical instrument into a 5.7 hole drilled into the rubble. The total porosity of the feature can be estimated if enough holes are drilled. Preliminary results from tests on rubble piles in the Alaskan Beaufort Sea show porosities at discrete locations along rubble features that range from 7 to 30%.

Salinity variations over a small horizontal scale (1.0 m) in smooth, first-year sea ice have been examined. Differences of up to 2.0‰ were found between small segments of closely spaced cores taken from the same ice depth. A simple one-dimensional model in which salinity differences are based on brine drainage channel density produces results similar to those observed for a mean channel spacing of 10 cm.

ELECTROMAGNETIC PROPERTIES OF SEA ICE
(A. Kovacs, R. Morey and G. Cox, USACRREL)
Investigations of the in-situ complex dielectric constant of sea ice were made using time-domain spectroscopy techniques. It was found that (1) for sea ice with a preferred horizontal crystal c-axis alignment the anisotropy or polarizing properties of the ice increased with depth, (2) brine inclusion conductivity increased with decreasing temperature down to about -8°C, at which point the conductivity decreased with decreasing temperature, (3) the DC conductivity of sea ice increased with increasing brine volume, (4) the real part of the complex dielectric constant is strongly dependent upon brine volume but less dependent upon the brine inclusions orientation, and (5) the imaginary part of the complex dielectric constant was found to be strongly dependent upon brine inclusion orientation but much less dependent upon brine volume. Because the electromagnetic properties (EM) of sea ice are dependent upon the physical state of the ice, which is constantly changing, it appears that only trends in the relationships between the EM properties of natural sea ice and its brine volume and brine inclusion microstructure can be established.

MECHANICAL PROPERTIES OF SEA ICE
(A. Kovacs, USACRREL)
A new axial double point load test technique is being investigated for determining the tensile and unconfined compressive strength of sea ice. Over five hundred multi-year and first-year sea ice samples have been tested to date. The results have been compared with conventional, unconfined, compression tests made on the same ice. Indications are that the new test provides strength values which agree with conventional, unconfined, compression tests performed at a strain rate of 10^{-3}. The new test has been found to be very easy to perform in that sample preparation is extremely easy and unlike conventional unconfined compression tests, sample-load apparatus alignment is a relatively minor problem. A major attribute of the new test is that ice strength determinations can be performed in the field as soon as the ice core is retrieved and cut to appropriate length with a hand saw.

GLACIAL GEOLOGY

BEAUFORT LAKES, ELLESMERE ISLAND, N.W.T.
(M. Retelle and R.S. Bradley, MASS/Amherst)
Laboratory studies of several sediment cores recovered from low elevation coastal lakes on northeastern Ellesmere Island have continued, providing a valuable record of conditions during the uplift of this coastline. The lakes were formerly submerged in a marine environment beyond the late Wisconsin ice margins and were uplifted as a result of isostatic readjustments when the ice retreated. The cores thus include marine sediments, the marine lacustrine transition and the later lacustrine sediments. ^{14}C dates indicate that some cores extend back to >30,000 B.P. though the record may not be continuous due to ice scouring. Studies of the cores so far include: sediment and pore water geochemistry, foraminifera, organic carbon content, sediment grain size and pollen.

Stephen F. Ackley

U.S.A. — ALASKA

GLACIERS

VARIEGATED GLACIER
(W. Harrison, ALASKA; C. Raymond, WASH; B. Kamb and H. Engelhardt, CIT)
Variegated Glacier has been known to advance roughly once every 20 years. A major surge was detected in 1964 and another in 1982/83, this time under intense observation, including short period surveying, a network of time-lapse cameras, special geophysical and outlet stream measurements and boreholes to observe subglacial water pressure. The surge started, surprisingly, in the middle of winter, January 1982 and stopped abruptly on 5 July 1983. The maximum speed of glacier movement observed was 70 m per day. Water vapor streaming from crevasses in midwinter, and a close correlation between drops in glacier speed and floods originating under the glacier, leave little doubt that water is the key factor in the surge process.

COLUMBIA GLACIER
(M. Meier, R. Krimmel, A. Post, C. Dreidger, L. Mayo, D. Trabant and R. March, GPO/USGS)
Columbia Glacier has gradually receded from its sub-marine terminal moraine shoal over most of the glacier front, which led to a warning that drastic retreat due to rapid calving in deep water was imminent (Meier and others, 1980. Predicted timing of the disintegration of the lower reach of Columbia Glacier, Alaska. USGS Open-File Report 80-582, 47 pp.). During this period, the glacier experienced increased snowfall, ablation, runoff, calving, surface gradient, and glacier speed. Thus, the entire system has become significantly more active over the decade and may begin its rapid retreat phase at a later date than predicted. Increases in the number, frequency, and size of icebergs from Columbia Glacier are a growing hazard to oil tanker traffic into the Port of Valdez.

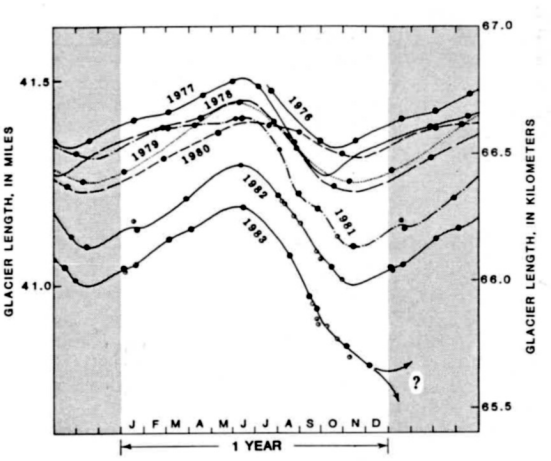


Fig.2. Seasonal activity of Columbia Glacier

Figure 2 summarizes the seasonal advance and retreat of Columbia Glacier for each year since observations began in 1976. Advance has taken place in winter, retreat in summer, but each year the glacier was a little shorter than the year before (the lack of much summer retreat in 1980 is an anomaly). The last data point shown is 8th December 1983.

BLACK RAPIDS GLACIER

(L.Mayo, D.Trabant & R.March,USGS/Fairbanks)
The Black Rapids Glacier is increasing in mass and steepening gradually in preparation for its next surge which is expected within the next 10 years. Winter and summer speeds have been monitored for a decade at 10 locations along the flow center-line. The difference in winter speed (slow) and summer speed (faster) is interpreted as sliding at the glacier bed. Sliding probably does not occur in winter. The annual displacement by sliding has approximately tripled from 1973 to 1983 with most of the increase occurring during 1979. Daily photography of a stake by Will Harrison and Rod March in 1983 shows that a peak glacier speed occurs at approximately the same time as peak glacier runoff, which indicates that sliding is controlled by basal liquid.

GULKANA GLACIER

(L. Mayo, D. Trabant & R. March, GPOF/USGS)
Glaciers of the Alaska Range have been thinning rapidly since the beginning of this century. This has contributed about 5 percent of the flow to the large glacier-fed rivers of interior Alaska. Thinning ceased in 1979 in the accumulation zone and in 1980 at the equilibrium line of Gulkana. Only the lower part of the ice tongue is still thinning. Balance and ice flow are reaching a new equilibrium over most of the glacier.

WOLVERINE GLACIER

(L. Mayo, D. Trabant & R. March, GPOF/USGS)
Wolverine Glacier began thickening gradually in 1970. Since 1976 it has thickened rapidly due to large accumulations of snow in the winters. Surprisingly, this period of rapid glacier growth corresponds with an increase in average air temperature and precipitation. Glacier runoff has been greater during this period of glacier growth than before because the increases in precipitation were greater than those in ablation. Thus, a positive correlation between air temperature, precipitation, glacier balance, and glacier runoff is indicated for southern Alaska, which means that many glaciers may grow if increased CO_2 loading of the atmosphere causes a warmer climate.

BERING GLACIER

(L. Mayo, D. Trabant & R. March, GPOF/USGS)
The piedmont bulb area of the Bering Glacier is thinning during the quiescent phase between glacier surges. This thinning has resulted in the first two historic outbursts of Berg Lake. The outbursts pass through two subglacial channels into two different river systems. The peak discharge into the Bering River system was between 20,000 and 30,000 $cm^3 s^{-2}$. Water bursting into the Gandil River caused erosion of a recent ice-cored moraine that had dammed an extensive lake system. These lakes are now drained.

KNIK GLACIER

(L. Mayo, D. Trabant & R. March, GPOF/USGS)
The terminus of Knik Glacier has been thinning for decades. The last year that it dammed Lake George, Alaska's largest glacier-dammed lake, was in 1966. Precise altitude measurements along the centerline in the upper part of the glacier show that it is currently thickening. This suggests that flooding from outbursts of Lake George are a distinct possibility in the future.

STRANDLINE LAKE JÖKULHLAUPS

(C. Benson and M. Sturm, ALASKA)
Strandline Lake is dammed by the Triumvirate Glacier which flows from Mt. Spurr (3374 m) and Mt. Gerdine (3431 m). Jökulhlaups occur at irregular time intervals when the lake breaks out of its glacier dam. In anticipation of a jökulhlaup, vertical aerial photographs were taken on 21 August 1982, the jökulhlaup occurred on 17 September and a second set of aerial photos was taken on 23 September. Photogrammetric analysis is now underway, showing the draining of about $7 \times 10^8 m^3$ of water to have occurred in less than two days.

GLACIERS AND HYDROELECTRIC POWER

(W. Harrison, ALASKA; S. Bredthauer, R & M Consultants)
Some of the effects of glaciers in basins proposed for hydroelectric development are being studied. The 36% glacierization of the Bradley Lake project seems to have contributed only a minor part of basin runoff out of long-term ice volume change, the average thickness change being estimated at only 5 ± 7 m over the period 1952-1979. An impressive retreat of the termini is almost balanced by a thickening in the upper basins. A runoff precipitation model was used to estimate annual glacier balance over that period; the approach was checked against USGS measured balances on Wolverine Glacier. A similar approach was used to estimate the combined balances of the glaciers of the Susitna River basin, where mass balances are being monitored. These glaciers have shrunk since runoff measurements commenced in 1948, with significant runoff having come out of permanent ice loss.

GLACIER MELT MODEL

(P. Marshall and K. Voos, ALASKA)
A glacier melt model is being developed to be used as a subroutine in river forecast models during break-up. Since many of Alaska's rivers are glacier-fed, a subroutine to predict this contribution to river flow is important. Testing and calibration of the model will use meteorological and stream data collected by the USGS for the Gulkana Glacier.

SEDIMENTOLOGY OF ACTIVE GLACIERS
(D.E. Lawson, CRREL)
Matanuska Glacier and Nelchina Glacier were examined to define the depositional processes and characteristics of the deposits. Results from each glacier will be compared for development of regional models of glacial sedimentation.

ALASKA VALLEY GLACIERS
(D.E. Lawson, CRREL)
On Matanuska Glacier, Nelchina Glacier, Nuka Glacier, Kachemak Glacier and Spencer Glacier, the processes of subglacial debris entrainment and deposition were studied through direct observation in subglacial caverns and through indirect analyses, such as quantitative study of the debris and ice of the glacier and of the deposits formed subglacially. Oxygen and hydrogen isotope analyses are to be made of ice in the terminus region and in the upper ablation area. Temperature profiling began in 1982 and drilling of Matanuska Glacier in 1983.

GLACIER BAY
(R.D. Powell, Northern Illinois University)
Processes of deposition of glacial debris on land and in the sea from rapidly retreating tidewater glaciers were studied to provide information on the continuum from source to land deposition to fjord deposition. Deposition processes were described and sampled for textural and structural characteristics. Samples of different bedrock lithologies have been obtained to study compositional variations from source to glacial deposit. Detailed sedimentologic study is being made of sand and silt laminae found in grab samples and gravity cores in the postglacial fjords.

BROOKS RANGE HOLOCENE GLACIATION
(P.E. Calkin and J.M. Ellis, SUNY/Buffalo)
The magnitude and chronology of the Holocene glaciation in the high, northeastern, Brooks Range have been investigated to define the Holocene glacial record and north-south paleoclimatic gradient across the west central Brooks Range. Direct lichenometric and glaciologic measurements begun in 1977 in the east central Brooks Range (Atigun Pass area) were continued in order to extend the data base for conclusions of past, present, and future hydrologic regimes.

(P.E.Calkin, SUNY/Buffalo; L.J.Onesti, INDI)
Holocene and current hydrologic regimes of the small cirque glaciers of the Atigun River valley and of the headwaters of the Atigun River and North Fork Chandalar River, on opposite sides of the Continental Divide, have been studied. These and other cirque glaciers of the Brooks Range have generally been wasting away in recent decades. Mass balances were clearly negative in 1982-83 and glaciers bare of snow on July 1; however a -0.09 m water equivalent balance for 1981-82 marked a reversal in a trend of decreasing summer temperature and ELA's observed from 1977 that brought the ELA down near the lower part of Grizzly Glacier in 1981. The study also mapped the surficial/glacial deposits of the Atigun River valley as far as Galbraith Lake and recorded the slope forms in this area of the basin.

GLACIER-VOLCANO INTERACTIONS

MOUNT WRANGELL
(C.Benson, R.Motyka & M.Sturm, ALASKA et al)
Field studies continued on Mount Wrangell to determine the effects of increased volcanic activity on ice melt and the glaciological regime. Repeated photogrammetric surveys have allowed ice losses to be calculated in the caldera, and ortho-photo sets now show variations in glacier termini from 1957 to 1981. The termini of glaciers on the northeast flank, where most of the meltwater is likely to run off, have been advancing, but others appear to be in steady state. Radio echo sounding of ice thickness was performed and ice core drilling will allow the determination of climatic and volcanic history through microparticle and isotope ratio analysis. Geochemical analysis of both volcanic gases and water indicates that a magma body is within a few kilometers of the surface under the North Crater and that it is responsible for the changes in activity observed at the summit.

MOUNT REDOUBT
(C. Benson, M. Sturm and J. Kienle, ALASKA)
Mount Redoubt,a glacier-clad volcano, 3108 m high, has erupted at least five times since 1778. One of its glaciers (unnamed) is undergoing changes in which a bulge of ice is thickening and flowing downglacier at speeds well in excess of the normal ice flow speeds for this glacier. Stake measurements and aerial photography are used to determine the nature of the rapidly moving bulge and the possibility of it damming the Drift River.

SPURR VOLCANO
(L. Mayo, D. Trabant & R. March, GPOF/USGS)
Mount Spurr is an active volcano located near proposed hydropower and coal mine sites. Ice radar measurements at surveyed locations on the glaciers that flow from this volcano indicate that more than 100 km^3 of glacier ice are associated with the mountain. Furthermore, a 10 to 50 m thickening of the glaciers has been measured from 1950 to present while the terminus areas have thinned.

SEASONAL SNOW

SNOW SURVEY FOR ALASKA
(G.P. Clagett, US Soil Conservation Service plus other cooperating agencies)
Snow surveys are conducted routinely at approximately 200 locations in Alaska. The snow depth and water content data are published in "Snow Surveys and Water Supply Outlook for Alaska", issued by the U.S. Soil Conservation Service.

SNOW SURVEY - SEWARD PENINSULA
(J.D. Swanson and G.P. Clagett, US Soil Conservation Service; V. Severns, ALASKA)
Snow surveys are conducted on the Seward Peninsula to evaluate snow depth, distribution, density, and crusting factors. Major impetus is directed towards making interpretations on the range for forage availability and use by the various local reindeer herds. Snow crusting is checked with a ram penetrometer and snow density is obtained at permanently located stations. An automated data recording facility and telemetry system are installed near Nome to record on-site snow data.

WINTER PRECIPITATION, ARCTIC SLOPE
(C. Benson, ALASKA)
Weather Bureau records of snowfall on Alaska's North Slope are known to underestimate winter precipitation. By comparing these records with "Wyoming" shielded gauges, they are found to be too low by a factor of 3 at Barrow and Barter Island. Snowdrift has also been studied since 1961 in natural drift traps, where 72 $\pm$ 25 metric tons w.e. m^{-1} normal to the wind are deposited by east winds and 31 $\pm$ 12 by west winds.

SNOW COVER PROPERTIES
(M.A. Bilello, USACRREL)
Research continues on snow cover properties and ice conditions throughout Alaska, including the thickness of lake, river and sea ice at several locations.

SNOWPACK STRUCTURE AND AVALANCHES
(E.R. La Chapelle and S.A. Ferguson, WASH)
The role of snowpack structure is analyzed for the Chugach and Talkeetna Mountains for inclusion in regional avalanche forecasting. A computerized pattern recognition program is applied to a large data base in order to isolate snowpack features that discriminate stable from unstable conditions. This information can then be synthesized with meteorological data into an operational guidance model for avalanche forecasting.

AVALANCHE STUDIES
(T. Nelson, Municipality of Anchorage; A. Mears, State of Alaska)
Avalanche zones, runout zones, and wind blast zones near Anchorage are identified and mapped in order to prepare appropriate zoning ordinances to regulate land uses within such areas.

(D.S. Fesler, Alaska Division of Parks)
This project is compiling a historical data base of Alaska avalanche events which have affected man.

AVALANCHE FORECASTING
(J.Fredston, J.L.Wise & A.L.Comiskey,ALASKA)
Daily forecasts are prepared in winter, for state and federal agencies and the public, of weather and snow stability pertinent to avalanches. These forecasts are based on data collected from varied and remote meteorological stations, measured profiles of the snowpack, including pits and fracture line profiles as well as precipitation gradients and ground temperatures between roads and ridge tops.

SNOW AND ICE CONTROL STUDY
(D. Esch, Alaska DTPF)
Various aspects of snow and ice control are investigated to develop new and more cost-effective techniques and policies. Specific projects include snow fence studies at Thompson Pass, sand-ice friction evaluation studies, benefit of chip seals for increased traction, and culvert icing control.

SNOW COVER ON AGRICULTURAL LANDS
(J.Holty, K.Kawasaki & T.Osterkamp, ALASKA)
Agriculture in Interior Alaska is marginal due to the relatively short growing season and low annual precipitation. Studies of the soil/snowpack temperature profiles and soil moisture content on agricultural land before and after breakup are being conducted in conjunction with acceleration of the melt rate of the snowpack using mixtures of lamp black and fertilizer. Preliminary analyses suggest such earlier than normal melting of the snow allows earlier spring planting and greater entrainment of snowpack moisture in the soil.

RIVER AND LAKE ICE

FRAZIL AND ANCHOR ICE
(T. Osterkamp and J. Gosink, ALASKA)
This project studies frazil and anchor ice, including their formation (nucleation or sources), growth, characteristics and evolution in form and dynamics. Frazil ice can significantly affect river velocity and discharge by altering the effective viscosity of the river. A simple, force-balance model was developed for the rise velocity of a frazil crystal which affects the buoyant flow. Field measurements included supercooling observations in turbulent streams during periods of frazil ice production.

DECAY OF LAKE, RIVER AND LANDFAST SEA ICE
(M.A. Bilello, USACRREL)
Statistical analyses have been performed on the amount and rate of ice ablation observed on lakes, rivers, and along coastlines throughout northern North America. The study

has provided specific information on maximum ice thicknesses that can be expected and an evaluation of the subsequent deterioration and ablation of the ice sheet.

FREEZE-UP AND BREAK-UP DYNAMICS
(T. Osterkamp and J. Gosink, ALASKA)
Observations have been made of the processes responsible for the formation, decay and break-up of annual ice covers on Alaskan rivers. Floe production mechanisms have been shown to play a key role in freeze-up processes. Five floe production mechanisms have been identified. Break-up is usually controlled by the river stage with first ice movement occurring coincident with a sharp rise in stage. This is sometimes preceded by a change in river water characteristics. Break-up proceeds from upstream to downstream in most Alaskan rivers.

STREAM ICING (AUFEIS)
(K. Dean, ALASKA)
Maps of stream icings have been compiled from LANDSAT satellite imagery available since 1972 for most of the State of Alaska. The data are displayed on 1:250,000 USGS Quadrangles and are analyzed. Aufeis occurs throughout the State, but is most extensive and persistent on the northeast coastal plains, the Brooks Range and the Alaska Range. Often the icings are associated with braided stream channels.

HYDROELECTRIC ICING PROBLEMS
(T.Osterkamp, J.Gosink & K.Kawasaki, ALASKA)
Ice problems associated with hydroelectric power schemes were investigated. These include winter flooding caused by hanging ice dams, blockage of inlet structures and turbines, ice jams downstream due to fluctuating discharge rate, and others. Ice production was modeled, based on temperature stratification, discharge and frazil ice production. The model can also predict the length of open water reach downstream from the dam.

ICE FORCES ON YUKON RIVER BRIDGE
(D. Esch, Alaska DTPF with other agencies)
This project measures the ice forces on the Yukon River bridge during break-up; it evaluates the maximum forces than can be expected, and develops design data for future bridge design considerations and modifications to current code requirements for river crossing structures.

SEA ICE

SATELLITE ANALYSIS OF SEA ICE FEATURES
(W. Stringer, ALASKA)
Mapping of sea ice features on Alaska's continental shelf continued, using LANDSAT imagery. Ice motion in Norton Sound, distribution of ice floe sizes and massive ridges, the location of the shear zone, summertime ice concentrations and the occurrence of multiyear ice in the Beaufort Sea have been studied, using the satellite data, as have the width and persistence of polynyas in the Chukchi Sea. Repeated day-to-day satellite coverage at these high latitudes allows ice flow trajectories to be determined.

MICROWAVE SIGNATURES OF SEA ICE
(T.C. Swift, MASS; L.W. Jones, General Electric Space Division)
Studies were conducted in the Beaufort Sea and Bering Sea to obtain active and passive microwave signatures of sea ice from airborne platforms to develop a data base for future satellite systems.

ALASKA MARINE ICE ATLAS
(J.C. LaBelle & J. Wise, ALASKA; R. Voelker, ARCTEC Inc.)
Maps, photos, charts and text comprise this 300 page volume with information on the geographical distribution and characteristics of both sea ice and calving glacier ice for all coastal waters of Alaska. The contents include data on ice edge locations, ice concentrations, ice floe drift, first-year ice thickness, pressure ridges, leads and polynyas, ice push, fast ice zones, ice gouging, ice islands, floating glacial ice, superstructure icing, climatic factors, etc. It is available for $15 from the University of Alaska, AEIDC, 707 A Street, Anchorage, Alaska 99501, U.S.A.

PRESSURE RIDGE CHARACTERISTICS
(W.B. Tucker, USACRREL)
The sizes of ice blocks contained in first year pressure ridges have been analyzed to establish whether a relationship exists between ridge height and block size.

DYNAMICS OF NEARSHORE ICE
(W. Weeks and A. Kovacs, USACRREL)
The study of deformation and movement of nearshore ice by means of laser profilometers flown on aircraft and surface-based measuring systems has continued for several years. Ice push and override of northern Alaskan beaches has also been documented and ice gouging statistics have been published, based on side-scan sonar records collected by Barnes and Reminitz (see below). The mean number of gouges (deeper than 0-2 m) per kilometer, measured normal to the trend of the gouges, varies from 0 to 2 for protected lagoons to 80 in water between 20 and 38 m deep in unprotected offshore regions. Limited data on gouging rates give an average of 5 gouges per kilometer per year.

ICE-SEA FLOOR INTERACTIONS
(P. Barnes, E. Reminitz, R. Hunter and R. Phillips, USGS)
The role of various sea ice forms in determining processes at the sea floor continue to be studied. Ice gouging occurs extensively over the continental shelves of the Beau-

fort and Chukchi Seas, and ongoing studies have provided data on the distribution, depth, orientation and frequency of these gouges. The role of frazil and anchor ice formation in sediment transport has also been investigated and research is being conducted on the mechanics and geotechnical character of ice gouging and on the control of ice zonation by seabed morphology.

MECHANICAL PROPERTIES OF MULTIYEAR SEA ICE
(G. Cox, M. Mellor and W. Weeks, USACRREL)
The variation of ice strength within and between multiyear sea ice ridges and variation of ice strength with salinity, temperature, structure, strain-rate, and confining pressure have been determined in the laboratory.

IN-SITU MECHANICAL PROPERTIES
(L. Shapiro, ALASKA)
In-situ shear, indirect tension and uniaxial compression tests have been performed on annual and multiyear sea ice samples, using flatjacks frozen into the ice. A non-linear viscoelastic stress-strain law has been derived from these results.

ICE FORCES
(T. Vinson, Oregon State University)
The purpose of this study is to determine ice forces and ice floe failure mechanisms on offshore structures. Experimental variables include ice salinity, ice temperature, ice thickness, floe velocity, strain rate, structure geometry, and foundation characteristics.

ICE ISLANDS
(W. Sackinger, ALASKA)
The icebergs or ice islands of the Arctic, generated from the Ward Hunt and other ice shelves on Ellesmere island, constitute a potential hazard to offshore structures on the northern coast of Alaska. This project has begun to locate ice islands off Ellesmere Island and in the Beaufort Gyre, to track them by means of satellite-navigation buoys installed on the islands, and to estimate the probability of encounters with offshore structures.

SPRAY ICE ACCRETION
(W. Sackinger, ALASKA)
A program has been initiated to determine the shear strength of the bond between spray ice and various structure coatings. A study of accretion of spray ice onto cylindrical substrates under natural conditions in the Bering Sea is to be followed by torsion tests of the bond strength in the lab.

ICE ELECTRICAL RESISTIVITY
(W. Sackinger, ALASKA)
Measurements of sea ice resistivity for both small samples and large regions of the ice sheet are being made, to provide background data for future corrosion protection designs for Arctic offshore production installations.

BERING SEA ICE DYNAMICS
(C. Pease, J. Overland & R. Reynolds,USPMEL)

The functional relationships between water, wind and ice velocities have been determined from drifting ice station studies. Air/ice drag coefficients have been calculated from direct measurements of the heat and momentum vertical profiles over the ice made by aircraft. A NOAA Bering Sea ice edge forecast model is in operation by the National Weather Service.

MARGINAL ICE ZONE EXPERIMENT (MISEX WEST)
(S. Martin, WASH; R. Muench, Science Applications Inc.; J. Overland, USPMEL, D. Cavalieri, GFSC/NASA and others)

MIZEX is an interdisciplinary, multi-institutional effort to understand the physical interactions between the atmosphere, sea ice, and the ocean in the marginal ice zones of the Northern Hemisphere. This program addresses these problems in the Bering Sea through MIZEX West. MIZEX East addresses similar problems in the East Greenland Sea.

Problems of particular interest include ice edge-related ocean fronts, ice dynamics near the ice edge, and modification of the atmospheric boundary layer near the ice edge.

The Bering Sea Marginal Ice Zone Experiment (MIZEX-West), which took place in February 1983, was a collaborative effort by American, British and Canadian scientists to study the regional air-sea-ice interactions.

The microwave remote sensing portion of the experiment centered on a series of 7 flights by NASA's Convair-990 airborne laboratory. The aircraft was equipped with several passive microwave radiometers, ranging in frequency from 10 GHz to 183 GHz, an infrared radiometer, two cartographic cameras, and a version of the radar altimeter planned for the European Space Agency satellite ERS-1. The flights were coordinated with other observations made from the NOAA WP-3D research aircraft, the USCG icebreaker Westwind, and the NOAA R/V Discoverer as well as with overpasses by the Nimbus-7 satellite.

An early result of the field experiment was the successful demonstration by NASA and the Canadian Atmospheric Environment Service of providing near real-time sea ice concentration charts derived from the Nimbus-7 SMMR data during the course of the experiment.

A comparative analysis of the observations from the NASA aircraft, the Nimbus-7 satellite, and the surface vessels is expected to provide a better understanding of the multispectral microwave characteristics of new, young, and first-year sea ice types and to improve the capability of determining sea ice properties from satellite observations.

PERMAFROST FEATURES IN ALASKA
A number of guidebooks on permafrost and related features and Quaternary geology have been written for the Fourth International Conference on Permafrost which took place in Fairbanks, Alaska, in July 1983. Some of these guidebooks contain detailed strip maps at the scale of 1":1 mile exhibiting permafrost features. The guidebooks are sold by the Division of Geological and Geophysical Surveys, 794 University Avenue, Fairbanks, Alaska 99701, U.S.A.

MASSIVE GROUND ICE
(D.E. Lawson, USACRREL)
The distribution and configuration of massive ground ice continues to be studied, by examining the chemical characteristics of representative ice types (including oxygen and hydrogen isotope composition) by dating organics and sediments adjacent to and within the ice, and by defining the origins of each ice type.

GEOPHYSICAL METHODS FOR DETECTING PERMAFROST AND GROUND ICE
(T. Osterkamp and K. Kawasaki, ALASKA; R.W. Jurick, Alaska DTPF)
This project evaluates and compares several geophysical methods for detecting permafrost and ice in frozen ground and continues to review geophysical instruments as they become available. Electrical resistivity measurements, for example, have proved useful in the identification of subsurface trends and are now being incorporated into site investigations. To establish a permanent evaluation site of known ground truth, a mass of ice approximately 26 inches wide, 10 feet thick, and 120 feet long and buried 3.5 feet deep was constructed in an area of nearly homogeneous frozen silt near Fairbanks. This field site is now being used to evaluate the various geophysical means for detecting subsurface ice from surface measurements.

ELECTROMAGNETIC GEOPHYSICAL METHODS
(S. Arcone and P. Sellmann, USACRREL)
Dielectric properties of cold regions materials have been measured at several sites in Alaska, using radar and time domain reflectometry. Radar responses from permafrost features, such as thaw margins and ice masses, have been analyzed.

PERMAFROST THICKNESS MEASUREMENTS
(T.Osterkamp, K.Kawasaki & G.Walker, ALASKA)
Surface exploration geophysics methods are being evaluated for their usefulness in determining permafrost thickness. Approximately 35 measurements have been made with a transient electromagnetic induction device along the trans-Alaska pipeline from Prudhoe Bay to Valdez.

BOREHOLE LOGGING METHODS IN PERMAFROST
(T. Osterkamp and K. Kawasaki, ALASKA; J. Scott, USGS/Denver)
A number of borehole logging methods are being evaluated for their suitability to determine permafrost properties. These include natural gamma, gamma-gamma, electrical, acoustical, temperature and neutron logs.

AGE OF ICE WEDGES & PERMAFROST IN N. ALASKA
(R.F. Black, University of Connecticut)
Organic matter from ice wedges and the interface between them has been re-examined for radiocarbon dating and pollen studies and electrical resistivity and chemical studies have been conducted to quantify the change from marine to freshwater deposition in the stratigraphy of the Gubik Formation. The results will be integrated in a comprehensive report on the age and climatic significance of the permafrost and its associated ice wedges, the thaw-lake cycle of the Arctic Coastal Plain, and the geomorphic history of the region.

PALSAS AND ROTATED FROST MOUNDS
(S.I. Outcalt, University of Michigan)
The dynamics of growth and decay of palsas and rotated frost mounds continues to be investigated in northern Alaska. The annual heave regime and perennial growth patterns are documented to aid in a more advanced physical descriptive model of these features.

CREEP OF SOILS ON PERMAFROST
(T.H. Wu, OHIO)
Studies in the Caribou-Poker Creeks Research Watershed, near Fairbanks, aim to evaluate creep movement of soils on subarctic, permafrost-underlain slopes and to evaluate the applicability of existing theoretical models of soil creep for permafrost conditions.

DYNAMIC PROPERTIES OF NATURALLY FROZEN SOILS
(T.S. Vinson, Oregon State University)
The dynamic properties of naturally frozen soils were studied. Test parameters included temperature, confining pressure, strain amplitude, and frequency. The material parameters included soil type and composition, soil structure and density (or void ratio), ice content, water content, and anisotropy.

PALEOCLIMATES FROM PERMAFROST
(W. Harrison and S.A. Bowling, ALASKA)
The permafrost onshore at Prudhoe Bay contains paleotemperature information on several time scales. From known information of permafrost thickness, geothermal heat flow and the thermal properties of the permafrost (as determined by Lachenbruch et al. below) a temperature amplitude for several paleotemperature models going back to the Sangamon was obtained. Pre-Holocene temperatures were not greatly different from those existing in the last century.

NATURAL & MAN-INDUCED THERMOKARST PROCESSES
(D.E. Lawson, USACRREL)
This project evaluates through field studies the processes and controlling factors causing thermokarst of permafrost terrain. Natural and man-induced causes are examined.

PERMAFROST GEOTHERMAL REGIME
(A. Lachenbruch and B. Marshall, USGS/Calif)
The geothermal regime of permafrost has been monitored in wellholes on the North Slope of Alaska. Observations indicate a surface warming of 1.5° to 3.0°C in the last 100 years or so with a net accumulation of heat by the solid earth surface of 5-10 Kcal cm^{-2} during this period.

PERMAFROST ROAD RESEARCH
(D. Esch, Alaska DTPF)
A series of research projects continue on road problems in permafrost terrain. Continuous air temperature recordings, monthly subsurface temperature measurements, and annual thaw and settlement surveys are made at several sites. The effects of pavement color and texture on surface temperature were investigated and various ways are being studied to improve the performance of embankments, including toe berms, insulation layers, and aircooling ducts. A study was recently conducted to determine what surface modifications (e.g. removal of vegetation layers and application of surface treatments, etc.) are needed in summer, prior to road construction, to achieve adequate thawing and consolidation of soils, thereby reducing post-construction settlements.

INSTRUMENT DEVELOPMENT AND EVALUATION
(D. Esch, Alaska DTPF)
New types of frost heave laboratory test cells are being developed that will permit materials engineers to test various soils and pavement layer materials under conditions closely duplicating actual field exposure, including the ability to cyclically freeze and thaw the samples, vary the vertical loads and lateral pressures, and duplicate different conditions of water availability and freezing rate. Also, to fulfill the need for a lightweight probe system to determine the depth to permafrost, all available electric impact hammers and hammer drills were reviewed and evaluated for suitability in driving and retrieving steel probe rods.

PERMAFROST DEGRADATION
(R. Berg, USACRREL)
Analytical methods were developed to predict the rate and magnitude of permafrost degradation.

THERMAL ANALYSIS COMPUTER MODELING
(K. Kawasaki, T. Osterkamp and J. Gosink, ALASKA; W. Conner, Alaska DTPF)
The purpose of this project is to select and verify the most appropriate computerized thermal analysis model to predict ground temperatures over long periods of time and allow engineers to compare the long-range effects of various design alternatives on the thermal origin of permafrost.

THERMAL EXPANSION COEFFICIENTS OF PERMAFROST
(T.Osterkamp, J.Gosink & K.Kawasaki, ALASKA)
Measurements of the thermal expansion coefficients of large natural permafrost samples are being made. These are supplemented by field studies of ground contraction during winter. A model of permafrost contraction and cracking is being developed.

SUBSEA PERMAFROST

OFFSHORE PERMAFROST CHARACTERISTICS
(R. Lewellen, Arctic Research)
This study continues to determine the extent and characteristics of subsea permafrost and sea ice interactions from Demarcation Point to Cape Lisburne along the northern Alaska coast. One aim of the study is to determine how sea ice cover physically affects the characteristics of subsea permafrost and how the occurrence of shallow subsea permafrost affects the physical properties of shoal sea ice covers.

OFFSHORE PERMAFROST - GEOLOGY
(D.M. Hopkins and P. Smith, USGS)
The geologic history associated with subsea permafrost has been analyzed by examining cores obtained by various projects investigating subsea permafrost in the Beaufort and Chukchi Seas. Analyses have been conducted of the lithology, stratigraphy, geochronology, paleoecology and ice content of the samples.

OFFSHORE PERMAFROST - THERMAL REGIME
(T.Osterkamp, W.Harrison & S.Swift, ALASKA)
These studies in the Beaufort Sea and Chukchi Sea aim to develop the capability to predict the presence or absence of subsea permafrost, its thickness, and thermal, mechanical, and chemical states, also massive ice bodies and the presence of gas hydrates from thermal and other data. To aid in this process a coupled heat and salt transfer model has been developed.

OFFSHORE PERMAFROST - ENGINEERING CHARACTERISTICS
(P. Sellmann and E. Chamberlain, USACRREL)
The occurrence and depth of subsea permafrost in the Beaufort and Chukchi seas has been studied by using available shallow seismic records. Geotechnical properties of the substrate have also been determined. These studies are designed to assess the hazards which subsea permafrost presents to offshore petroleum development.

OFFSHORE PERMAFROST - SEISMIC INVESTIGATIONS
(J.Morack,ALASKA; J.Rogers,Michigan Tech.U.)
This project has investigated the occurrence of permafrost in the shallow waters of the Beaufort and Chukchi Seas, its roughness and other properties that affect geophysical investigations. Permafrost beneath the barrier islands of the Beaufort Sea has also been investigated through the use of seismic reflection and refraction methods.

Acknowledgements:

In the compilation of these reports, the "Current Research Profile of Alaska", issued annually by the Arctic Environmental Information and Data Center of the University of Alaska, Anchorage, was very helpful.

Gunter Weller

U.S.S.R.

In 1982 glaciological investigations embraced the Caucasus, Central Asia, Altai, Khiny, Siberia, the Arctic and the Antarctic.

CAUCASUS

The **Institute of Geography, USSR Academy of Sciences,** carried out investigations of glaciers along the southern edge of the central Caucasus. Surveys of glacier snouts were repeated in Svanetya. Results of the investigations suggest that the Khalde, Adishi and Kvishi glaciers are receding by 4-6 m per year. Geodetic methods were used to determine surface velocities, their vectors, the values of ablation and strain rates. A programme of glaciological and meteorological measurements, aimed at understanding the ablation regime and glacier runoff, was carried out on the Tbilisa Glacier and in the Bubitskhali River basin. Snow cover was also investigated.

Kharkov University has perfected a technique for determining the altitude of the firn line from the amount of precipitation during the winter period and the total of positive temperatures in the summer. Multifactor analysis was applied to autocorrelation effects. The difference between the observed and calculated height of the firn line on the Khakel' Glacier averaged 3 m. The firn line of the glacier was also determined from indices of solar activity (Wolf numbers); in this case the difference between the observed and calculated data was 15 m. Sums of the positive temperatures in summer, and precipitation during the summer and winter periods, were calculated from annual tree-growth in the upper reaches of the Baksan and Teberda rivers.

The **Alpine Geophysical Institute** investigated the pollution of glaciers and the seasonal snow cover. Snow stored in the seasonal layers of the glaciers was compared to the amount of deposited precipitation and showed quite satisfactory agreement. Conclusions were drawn about the mixing processes in the glacier stratigraphy and about the correspondence between dry cooling and the wash-out of aerosols by liquid precipitation. The data from 15 years of observation of the sequence and density of the snow cover at the stations and at observation points in the Baksan River basin were interpreted.

CENTRAL ASIA

The **Central Asia Hydrometeorological Institute** developed some principles for the effective arrangement of a snow survey network and improved the computation methods for determining glacier regime characteristics in regions of sparse data. Regional maps of snow cover were compiled. Macro-scale models of snow cover formation were created using remote aerial and satellite information. The characteristics of glacier systems under different climatic and orographic conditions were revealed together with the effects of glacier recession in reducing water resources in Central Asia. A map of ice resources in the Pamir-Alai and the potential for managing glacier runoff has been compiled. Observations on the pollution of snow and ice were started on the Abramov Glacier, as part of a programme of stations for Global Monitoring of the Natural Environment.

The **Institute of Geography, USSR Academy of Sciences,** in cooperation with **Leningrad University** and the **Kirgiz Hydrometeorological Service,** continued investigations of the Golubin Glacier, where a programme of heat balance and aerological studies of the mountain glaciers' effects upon climate was undertaken.

Field studies by the **Institute of Geography, USSR Academy of Sciences,** confirmed the intensive erosional activity of glaciers in this region, where they were previously believed to be passive. A sequence of loose icy deposits below the glaciers was detected and measured during geophysical profiling of glaciers in the Zailiysky and Dzhungarski Alatau.

Based on information from field investigations by the Section of Geography, Kazakh Academy of Sciences, the **Institute of Mechanics, Moscow University,** developed a mathematical description of the Shumsky Glacier, Dzhungarski Alatau; a large mountain-valley glacier of compound form and structure. It was established that, due to the quick dynamic response of the glacier, the changes in its form and dimensions are almost completely determined by variations in the accumulation/ablation rates. The existence of "quickly responding glaciers", varying their quasi-stationary regime under conditions of slow climatic change, was revealed. This

glacier regime, involving the transport of large quantities of morainic material, is typical of the active area during a period of continuous retreat. It is possible to predict the induced variations of these "quickly responding glaciers" from climatic forecasts.

The **Section of Geography, Kazakh Academy of Sciences**, studied the influence of glacio-nival processes on the occurrence of mud flows in the mountains of south-eastern Kazakhstan. Using the water recession curve at the basin outlet, methods have been worked out for calculating the agents responsible for mud flows and water storage in glacier/moraine complexes. Methods for integrated mud flow prediction, based on a variety of computerized hydrometeorological data, have also been worked out. Long-term data on the distribution of precipitation and snow cover in alpine areas have been used to determine the proportions of glacierized and non-glacierized surfaces contributing to the river discharge. In cooperation with the **Institute of Geography, USSR Academy of Sciences**, depth data from glaciers in the Zailiysky Alatau, determined by terrestrial and aerial radar soundings, have been interpreted.

The **Institute of Geology and Geophysics, Uzbek Academy of Sciences**, continued to investigate the relationship between mountain glaciers and their geological environment. Glaciers in zones of active fracturing, where there were deep tectonic faults, were found to be the most debris-laden. The glaciers have been classified on the basis of their debris-forming character; the influence of their dynamic state on the formation of the moraine cover was revealed. Data have been obtained on the development of permafrost between 4000-5000 m a.s.l. in the East Pamirs.

The **Institute of Limnology, USSR Academy of Sciences**, studied the dynamics and state of the Tien-Shan glaciers. Most of the glaciers on the northern slope of Terskey Alatau were found to be stationary. Of the fifteen glaciers situated on the left side of the Maliy Naryn River only the three largest were advancing; the rest were retreating. Small glaciers in the Chatirkel' Lake basin are evidently shrinking, which has led to a decrease in runoff and caused a perennial and steady lowering of the lake level. For the last five years, the permafrost zones along the banks of the Chatirkel' Lake have degraded, quickly altering the look of the coastline.

The **Tien-Shan Physico-Geographical Station** undertook aerial observations of glaciers in the Issik-Kul' Lake basin, in the upper reaches of the Sary-Dzhaz, Bol'shoi and Maliy Naryn rivers and at the head of the Chu River. Of all the glaciers observed only one is evidently advancing; the rest are retreating or stationary. Year-round observations of the Karabatkak Glacier were continued. The glacier continues to shrink and its balance remains negative, which has caused an increase in the volume and area of its ice-dammed lake, threatening an outburst through the dam and a heavy mud flow. Photo-theodolite surveys of the lake and surface levelling of its dam were performed and the volume of impounded water calculated.

The **Kirgiz Hydrometeorological Service** continued observations on the Golubin Glacier and short-term studies of other glaciers in this region. Expansion and an advance of the Aksu-Zapadniy, Aksu-Vostochniy and Chong-Tur glaciers was noted. The Dolonat, Dugov, Davidov, Petrov and Keng-Tur glaciers were retreating.

The **Tadzhik Hydrometeorological Service** observed glacier fluctuations. Annual ice velocities were measured on the Khadyrsha and Skodach glaciers. Observations indicate that the Kyzylkul', Khadyrsha and Mushketov glaciers are advancing. The Didal' Glacier, N-517, Zeravshan, Garm, Mazarskiy, Medvezhiy and Scogach glaciers are retreating. The Tro, Rama, RGO and N-507 glaciers are stationary.

SIBERIA AND THE FAR EAST

The **Institute of Geography of Siberia and the Far East** studied the mechanism of mud flow formation on the rivers of southern East Siberia and introduced functional models of aufeis development. The distribution of mud flow characteristics has been shown to be related to morphometric indices developed from a stake network. Comprehensive field measurements were made on an aufeis polygon in the northern part of the Baikal area. Theoretical and experimental studies of the desalination of salt water by freezing were undertaken. Experiments have shown that primarily saline ice (salt content of 30 g l^{-1}) can be reduced to 10 g l^{-1} in a week; the process later stabilizes without any pronounced redistribution of salts.

Experiments were made on the effect of surface active substances on water crystallization. Maximum supercooling of a 10 ml purified water sample was 19.5°C. Admixture of any substance lowered the temperature down to 5-10°C. The effect of vibration on the temperature of initial melting was great. Studies of the characteristics of crystallization of small water samples in the atmosphere were continued. The rate of cooling of the water drop was shown to greatly influence the process of crystallization. Calculations have shown that dispersed water can cool at the rate of several degrees per second although experimental tests on this phenomena are lacking. Kinetic effects are thought to play a special role in the crystallization of small amounts of water, cooling at a rate of 10-40°C per second.

The **Novosibirsk Institute of Railway Transport** investigated snow drifts and avalanches and developed methods and guide-

lines for their prevention on highways and railways. Dynamic impacts of snow on engineering structures were measured. A study and erection of structures were completed in two avalanche starting zones on an avalanche prone slope along the Novokyznetsk-Abakan Railway. The effects of explosions on the stability of snow slabs over the slope and on the velocity of snow flowing down the slope were studied. The influence of orographic effects on the effectiveness of different snow retention structures was investigated.

The **Altai University** studied snow and ice formations in the Altai-Sayany mountain region. The existence of icings was noted everywhere. Snowfall in the 1981/82 winter was close to average. Analysis of dendrochronological data indicated large contrasts in precipitation, even on neighbouring mountain ranges. A recent decrease in precipitation was noted from tree-ring evidence and confirmed by glacier shrinkage. Initial phototheodolite surveys were made of the glaciers on Topographers Peak, Grandiozniy Peak, and the Munku-Sardyk Mtn in the Eastern Sayans. The separation of some tributaries from the large valley glaciers was observed.

The **Pacific Ocean Institute of Geography** studied snow cover and seasonally frozen ground in some typical environments. Two types of seasonal freezing of soils were described for the valleys of the eastern part of the Baikal-Amur Railway. Regional and local variations in the spatial distribution of snow fall and snow storage during periods of maximum accumulation have been noted in the southern regions of the Far East. A "landscape/statistical" method was used to compile the first map of regional snow cover for the Far East.

Modelling of the individual components of the global "glaciers-ocean-atmosphere" system was continued. Numerical experiments were made on relating the quasi steady-state thermal regime of a simulated ice sheet to the morphometric properties of the present day Antarctic and Greenland ice sheets under contemporary climatic conditions. Using different rheological properties of ice it was possible to bring the regimes generally close to steady-state conditions. The significant role of basal sliding both at the margins and in the centre of the ice sheets was revealed. Calculations of the seasonal thermal characteristics of sea ice in the Arctic Ocean showed changes in the evolution of the ice cover over time for different climatic zones.

The **Institute of Volcanology** continued studies of glacier regime in the volcanic areas of Kamchatka to aid in predicting the development of glaciation for the next 15-20 years. Observations on the glaciers of the Mutnovski Volcano showed that the 1981/82 balance was positive. Koryto Glacier had a negative balance for the same period. In cooperation with the Institute of Geography, USSR Academy of Sciences, the Institute of Volcanology investigated the surge of the Bil'chenok Glacier, in the Kluchevskaya group of volcanoes. Combined geodetic, photogrammetric and geophysical measurements of the surge and the glacier regime were made during its advance. By April 1982, the terminus of the glacier had advanced 1 km compared to its 1980 position, and from April to September it advanced a further 70-130 m. The Institute also explored glaciers on the northern slope of the Kluchevskoi Volcano. The continuing advance of the Erman Glacier was noted. Glaciometeorological and hydrological observations, carried out on Glacier N-272, situated in the Pinachevskiy Range, indicated a positive mass balance.

THE ARCTIC

The **Institute of Geography, USSR Academy of Sciences,** observed the mass balance of glaciers on Spitsbergen. Ice storage in the archipelago was determined as exceeding 4000 km^3. The ice discharge from calving was also estimated. Thermal drilling was successfully repeated on the Lomonosov Ice Plateau and was accompanied by coring for stratigraphic studies and by sampling for isotope and geochemical analyses. Runoff investigations on the Bertil' Glacier, to determine the withdrawal of winter runoff and its effect on water supply sources, included studies of the role of englacial tunnels and freezing within them, lacustrine ice, floating ice and icings. Experiments were performed on the desalination of sea water by spray-cone freezing. It was established that the salinity of artificially frozen ice was two to three times less than that of sea water.

The **Institute of Geology, Estonian Academy of Sciences,** studied variations of stable and radio-active isotopes,and of some chemical elements, in glaciers and buried ice in the Atlantic sector of the Arctic. Seasonal variations of chlorides were determined at different depths along a glacier profile from Nordaustlandet which, together with reference layers in the firn/ice sequence, permitted determination of the stratigraphy and an estimate of the mean annual accumulation. At the top of Vestfonna it was 81 g cm^{-2}. Together with Moscow University, the Institute began to study permafrost on Spitsbergen, and, in cooperation with the Institute of Geography, USSR Academy of Sciences, paleogeographic evidence from the Holocene in the Spitsbergen archipelago.

The **Arctic and Antarctic Institute** investigated the petrographic structure of the core from, and temperature changes in, the 466-m and 146-m boreholes on the Vavilov Dome,Severnaya Zemlya. The temperature curve showed a warming in the 1920's and 1930's which was followed by a cooling and then

again by a subsequent warming in the 1970's. Analysis of repeated aerial photography showed a reduction in the glacierization of Severnaya Zemlya, which is confirmed by the dominant negative mass balances of the Vavilov Glacier. A close relationship was revealed between the rate of accumulation in lakes near the glacier and the sum of positive summer air temperatures. For the last 100 years the accumulation rate increased at the turn of the century, at the end of the 1920's and beginning of the 1930's, as well as in the 1950's and 1970's. Cyclical variations in accumulation with periods of 3, 4-5 and 11 years were distinguished.

ANTARCTICA

The **Institute of Geography, USSR Academy of Sciences**, under the IAGP programme, continued investigations of the surface regime of the Antarctic Ice Sheet, along the routes Pionerskaya-Dome C and Mirnyy-Vostok Station, and also glaciological and geocryological studies in the Shirmakher Oasis. Evaluations of accumulation and the present state of mass balance in a large ice catchment basin, comprising the greater part of East Antarctica, were completed. A new type of air humidity sensor was tested and moisture supersaturation of the air up to 150-160% was registered in Central Antarctica.

Thermophysical and hydrodynamic modelling of the ice sheet on the basis of the main flow lines was continued as an aid to mapping the conditions at the bed of the Antarctic Ice Sheet. A hydroacoustic method of mass exchange gauging at the lower surface of ice shelves and icebergs has been developed and tested. A theoretical model of the interactions between the ocean and the lower surface of ice shelves was constructed, permitting an estimate of the direction and rate of mass and energy exchange at their boundary, depending on the thermodynamic properties of the ice body and the ocean. Based on the analysis of silt contained in the basal moraines of the present-day Antarctic glaciers, conclusions have been drawn about the active frost weathering at the glacier bed, especially in the Subantarctic zone. Oxygen-isotope analysis of the deep core from the Vostok Station revealed conditions during the last 115,000 years and showed that fluctuations of the Antarctic climate in the Late-Pleistocene were not uniform.

The **Arctic and Antarctic Institute** carried out methodological studies along the Mirnyy-Pionerskaya Route which proved it was possible to continuously record the stratigraphy of the snow cover from moving vehicles using radio-echo sounding techniques. Comparison of the profiles obtained with the real stratigraphy of the snow cover shows the applicability of this method to snow accumulation measurements. Deep borehole drilling for core recovery was continued at Vostok Station. By 1 January 1983, the borehole had reached a depth of 2083 m. Engineering studies on the modification of the snow cover were continued, aimed at providing the physical snow properties necessary for the construction of airfields for heavy (wheeled) aircraft and for wharfs at the edge of the ice sheet.

Evaluation of changes in the dimensions and regime of the Ice Sheet, related to climatic changes of the 20th Century, have been accomplished. The following conclusions were reached:

a) the limit of surface melting on the ice sheet in the neighbourhood of the Mirnyy Station, coinciding with a mean summer air temperature of -10°C for a long-term period, may vary within + 30 km and an altitude of + 225 m;

b) for the last 25 years summer ablation over the slope of the ice sheet has dramatically increased; with a 2°C temperature increase the volume of meltwater runoff increases three times, while with a 5°C increase it grows by ten times. Precipitation on the ice sheet showed two maxima, at the end of the 1920's and beginning of the 1930's, and at the beginning of the 1970's. Three minima were observed, at the beginning of the century, at the end of the 1950's and at the end of the 1970's;

c) the ice coasts of Antarctica have a tendency to retreat. For the last 25 years the edge of the ice sheet in the vicinity of the Mirnyy and Molodezhnay stations has retreated 100-200 m, and over the last 60-70 years the ice front has fluctuated by 50-100 km;

d) the temperature records from Vostok Station indicate a fall of air temperature at the end of the 1950's and a rise at the beginning of the 1970's.

The **Institute of Mechanics, Moscow University**, used numerical methods to study the dynamics of ice divides on the ice sheet. Proceeding from hydrological and thermal conditions at the bed the occurrence of four different regimes is assumed. Calculations covering the whole range of possible variations in Antarctica have been performed for each of the four regions. This work and data from radio-echo sounding has enabled the dating of the ice which constitutes the main ice divide of Antarctica.

AVALANCHES

The **Section of Geography, Kazakh Academy of Sciences**, continued to evaluate avalanche hazards in the mountain basins of Kazakhstan and Central Asia. Maps of the areal extent of snow cover and the avalanche hazard were prepared for the mountainous regions of south-eastern Kazakhstan and the Chimkent Region. The **Kazakh Hydrometeorological Service** developed methods for predicting ava-

lanches of different origins. Snow storage and indices of the stability of the snow cover were calculated for the avalanche hazard maps of the mountainous territory of South Kazakhstan.

The **Alpine Geophysical Institute** carried out field investigations of avalanche genesis in the Caucasus. This revealed a relationship between the density and the structural strength of snow layers giving rise to an avalanche hazard. The Institute worked out guidelines for avalanche prediction using physical and mechanical characteristics. Data on avalanches in the El'brus area and along the highway crossing the main Caucasus Range through the Rokskiy Mountain Pass were organized. Methods were developed for measuring avalanche speed using self-contained transmitters placed at intervals along an avalanche path.

Moscow University developed methods for long-term forecasting of avalanche activity in the Khibins and El'brus areas and in the Terskey Alatau Range. Techniques were also developed for obtaining historical geomorphological, glaciological and other data on the history of avalanches and climatic fluctuations; existing data was analysed. By relating data on avalanches, climate and snow distribution it was possible to identify those winters of excessive snowfall and avalanche activity in the Caucasus over the last 20 years and in the Khibins over the last 50 years. Some remote sensing images of mountainous areas along the Baikal-Amur Railway for different seasons was analysed and a preliminary map of avalanche hazards prepared for this area.

The **Central Asia Hydrometeorological Institute** studied the snow and avalanche characteristics of a relatively unknown area in Central Asia, worked out empirical and statistical methods for predicting different types of avalanches, compiled avalanche maps, inventories, and reference books and built up a data bank of snow avalanche information. Techniques and equipment to record sound transmission through the snow have been developed with a view to predicting avalanche hazards.

The **"Apatit" Mining Service** investigated the effect of a single, irregularly-shaped, object in the avalanche run-out zone. It was calculated that the run-out of an avalanche interacting with an artificial obstruction was 25-30% less than that of an avalanche encountering no obstacle. The greatest deceleration was observed for low density avalanches formed from fresh drifting snow. A series of maps summarizing the results of glaciological studies in the Khibins for 1930-1980 were compiled.

The **Mining Institute of the Kola Branch, USSR Academy of Sciences,** continued studies on the physico-mechanical properties of rock fill and snow which made it possible to work out new techniques for stabilizing dumps on the high and steep slopes of the Khibins.

WORLD ATLAS OF SNOW AND ICE RESOURCES

Most of the planned maps for the World Atlas of Snow and Ice Resources have now been draughted. These include glaciological maps of Antarctica; glaciological, hydrological and climatological maps of non-Soviet Asia, the mountainous regions of North and South America, the Alps and Scandinavia; maps of snow cover in Siberia and the Far East and in the western areas of the United States, in Canada, the Alps and Scandinavia. Compilation of maps for the introductory section of the Atlas has begun. Based on principles established in 1981, methods have been devised for the coordination of related subject matter in the Atlas. Guidelines for the coordination of existing maps were prepared. Special efforts have been made to coordinate the set of maps for the Pamir-Altai, Tien-Shan, Hindukush and Karakorum, Scandinavia and the mountains of South America.

It was possible to develop and test a new technique for computing the duration and mass of the snow cover in rugged terrain with little or no data. The initial parameters used are totals of solid precipitation, duration and temperature regime of the cold period, as mapped in the Atlas. The method has been used to determine the position of the equilibrium line and the quantity of accumulation for all the mountainous areas of Asia and for those of South America. This is the first time such maps have been prepared and they permit an analysis of the extent and regime of glaciers in these regions.

The main scientific results obtained in 1982 and not reported earlier are as follows:

a) Creation of computer algorithms, using numerical methods based on mathematical theory as applied to glaciers. These permitted processing of field data at a number of different levels; from calculation of the simplest integral parameters and kinematics of the surface up to complicated analysis of ice sliding conditions and three-dimensional non-isothermal mechanics of glaciers. A theory describing the occurrence of streams in ice sheets due to erosive instability was advanced.

b) Summary of the the results of the cooling effect of mountain glaciers and glacier systems. However, it was concluded that this effect is somewhat limited in extent. Work on establishing the relation between glaciers and climate during the Late-Pleistocene was continued. The idea of former glaciations of polar seas saw further development in the reconstruction of the "marine" South-Beringian Ice Sheet.

c) The influence of the sea ice cover and of continental ice sheets on the temperature of the ocean, particularly through normal ice discharges and from surges, was evaluated. It is comparable to the thermal effect of a large sea current. The erosion of con-

tinental margins by ice, increasing the interaction of glaciers with the ocean, was estimated numerically. It was calculated that about 10^6 km^3 of mountain rocks were removed from the margins of Europe by such processes.

d) Satellite remote sensing made it possible to detect fluctuations of the edges of ice shelves and the drift of icebergs in the Antarctic, to analyse in real-time the drift of ice in the Arctic Ocean over almost all its area, to identify surging glaciers and new ice-dammed lakes, to determine the position and height of glacier termini and the firn line in Patagonia, the Karakoram and the Pamirs. Interpretation of information from previous investigations and of existing data collections on glacier fluctuations was completed. Work started on the compilation of a Surging Glacier Inventory of the USSR.

e) It was found possible to use radio-echo sounding techniques to evaluate the temperature regime of glaciers. An important relationship between periglacial icings and the temperature regime of glaciers was revealed. The theory of spray-cone ice formation and sea water desalination by sprinkling in cold air was further developed.

f) The results of laboratory simulations and field studies of the structure and physical properties of snow were summarized and showed the dependence of snow density and strength on its structure, state of stress and thermal regime. Techniques for calculating snow slab stability on slopes and the movement of an avalanche in the deceleration and accumulation zones were developed and applied.

V.M. Kotlyakov and M.Yu. Gnedovskaya

ABBREVIATIONS USED IN REPORTS ON RECENT WORK

ALASKA - University of Alaska, Fairbanks, Alaska 99701, U.S.A.
ARS - Arctic Research Station, Box 102, 3953 Godhavn, Greenland, UCPH
ASRC - Atmospheric Sciences Research Center, SUNY, Albany, New York 12210, U.S.A.
ÅU - Åarhus University, Langelandsgade Bygn. 521, DK-8000 Århus C, Denmark
CRREL - Cold Regions Research and Engineering Laboratory, U.S. Army Corps of Engineers, Hanover, New Hampshire 03755, U.S.A.
DTPF - Department of Transportation and Public Facilities, Alaska, U.S.A.
EMI - Electromagnetics Institute, TUD
GCI - Geografisk Centralinstitut, UCPH
GeolI - Geological Institute, ÅU
GGB - Geographisches Institut der Universität Bern, Bern, Switzerland
GGEZ - Geographisches Institut der ETH, Zürich, Switzerland
GGU - Geological Survey of Greenland, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark
GGUZ - Geographisches Institut der Universität Zürich, Zürich, Switzerland
GIL - Geophysical Isotope Laboratory, UCPH
GK/SNG - Gletscher-Kommission der Schweizerischen Naturforschenden Gesellschaft, c/- VAW, Zürich, Switzerland
GPO - Glaciology Project Office, USGS, Tacoma, Washington 98402, U.S.A.
GPOF - Glaciology Project Office, USGS, Fairbanks, Alaska 99701, U.S.A.
GRG/UNH - Glacier Research Group, University of New Hampshire, Durham, New Hampshire 03824, U.S.A.
GSFC - Goddard Space Flight Center, Greenbelt, Maryland 20771, U.S.A.
GTO - The Greenland Technical Organization, Copenhagen, Denmark
IGB - Institut für Grundbau und Bodenmechanik, ETH Zürich, Switzerland
IHHE - Inst. of Hydrodynamics and Hydraulic Engineering, TUD
INDI - University of Indiana, Bloomington, Indiana 47405, U.S.A.
IPS - Institute of Polar Studies, OHIO
LLC - Abteilung "Low Level Counting" und Nukleare Geophysik, Physikalisches Institut, Universität Bern, Bern, Switzerland
MASS - University of Massachusetts, Amherst, Massachusetts 01003, U.S.A.
MICH - Michigan State University, East Lansing, Michigan 48824, U.S.A.
MIT - Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, U.S.A.
NASA - National Aeronautics and Space Administration, U.S.A.
NEA - National Energy Authority, Iceland
OHIO - The Ohio State University, Columbus, Ohio 43210, U.S.A.
SI - Science Institute, Univ. of Iceland
SLF - Eidgenössisches Institut für Schnee- und Lawinenforschung, Weissfluhjoch, Davos, Switzerland
SUNY - State University of New York, U.S.A.
TUD - Technical University of Denmark, Building 115, DK-2800 Lyngby, Denmark
UCPH - University of Copenhagen, Haraldsgade 68, DK-2100 Kobenhavn Ø, Denmark
UI - University of Iceland, Iceland
USGS - United States Geological Survey
USPMEL - U.S. Pacific Marine Environment Laboratories, U.S.A.
VAW - Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie der ETH, CH-8092 Zürich, Switzerland
WASH - University of Washington, Seattle, Washington 98195, U.S.A.

Mawson, Australia's first station in Antarctica

MELBOURNE GLACIOLOGY

(AUSTRALIA)

If one were to name a single moment for the start of glaciology as a major research topic in the Meteorology Department of Melbourne University and in the Australian Government Antarctic Division, it would have to be an evening in July 1955, the precise date being recorded in the guest book of the CSIR Ski Club on Mount Buller. That evening, while members sat around the fire in the primitive après-ski style of those days, two guests experimented outside with a thermos flask of hot water and a thermometer, dropping samples of snow into the flask to measure the free water content of the snow around the hut. The book shows that the guests were Malcolm Mellor (ICE, No.54, 1977) and Uwe Radok (ICE, No.27, 1968).

To regard this as the start of what has become one of the world's leading programs in glaciology requires justification. Australian scientific interest in snow and ice goes back at least to Mawson's first expedition to Antarctica (1911) and was fostered later by prominent scientists, such as Sir Raymond Priestley (one-time Vice Chancellor of the University of Melbourne) and Fritz Loewe (ICE, No.17, 1965), as well as by the geologists who took part in the early Australian National Antarctic Research Expeditions (Lambeth, Crohn, McLeod).

The studies of these pioneers remained isolated ventures which ended when the worker left Australia or turned to other problems. Fritz Loewe's 40 years of contributions to the knowledge of the ice in Greenland, Antarctica, and the Himalayas are on a different plane, however. While strictly a personal effort, which was readily transplanted to the Institute of Polar Studies at Ohio State University in 1962, Loewe's work certainly created Melbourne's essential awareness of glaciology as a fascinating research field from which a broader program could develop. He drew up the first detailed mass balance of the Antarctic ice sheet, defined the problem and the basic physics of snow drift, and described from his own experience the katabatic wind at one of the windiest places on earth, Port Martin. Moreover he suggested the work on snow "quality" which became,for some years, a strand in the developing Australian glaciological program.

The July evening on Mount Buller led the Director of the Antarctic Division, Phillip Law, to appoint (10 years after the start of the expeditions) Malcolm Mellor as first glaciologist of the Australian National Antarctic Research Expeditions (ANARE) at Mawson in 1957/58. That year Malcolm measured ice flow, built and perfected gadgets to catch drifting snow, and observed sea ice.

Malcolm Mellor with his drift snow traps

Meanwhile in Melbourne, Uwe Radok turned his attention to the problems of heat conduction in glaciers and ice sheets. Again the first impulse for these thermodynamic studies came

from Fritz Loewe; in 1931 as a frostbitten invalid in the Eismitte cave in Greenland he had witnessed measurements by Sorge and Georgii which showed the temperatures to decrease with depth in the ice. The first explanation of this puzzling feature was provided 25 years later by Gordon Robin and now gained further theoretical support from Radok's work which was extended with the help of the first Australian electronic computer CSIRAC (passed down to Melbourne University from the more affluent CSIRO) by Dick Jenssen, then a young graduate student. This new "computer glaciology" became a second strand of Australian glaciology.

A third strand, the study of drifting snow, again was inspired by Loewe's earlier studies, first in Greenland with Wegener and later, at Port Martin, with Barré during the 1951 French Antarctic Expedition. The results obtained with the "Mellor snow trap" at Mawson in 1957 and their analysis by Mellor and Radok set the stage for more elaborate measurements at Wilkes by Bob Dingle in 1959 and by Harry Black in 1960; both added this major effort to their main duties as "Oic" (Officer in Charge). Radok extended the theory of turbulent drift snow diffusion and confirmed the fact, familiar to Wegener and Loewe, that the bulk of the snow drift transport occurs at considerable heights above the snow surface. This was in conflict with the established engineering view (encouraged by reports coming out of the Soviet Union) that snow drift is essentially a "saltation" phenomenon restricted to a few centimeters above the surface - a preconceived notion, which created a major problem when it was used to guide the initial management of the early-warning radar buildings on the Greenland ice sheet.

The three early lines of glaciological research in the Meteorology Department of Melbourne University (known for purposes of communication with Antarctica as "Unimet", a name which also alludes to the Department's singular status in Australian academe at that time) were presented to the world at the 1960 Helsinki Colloquium on Antarctic Glaciology of the International Association of Scientific Hydrology. The three papers were read, not by one of their authors, but by Fred Jacka, Assistant Director of the Antarctic Division (now Director of the Mawson Institute in the University of Adelaide), who alone was able to travel to Helsinki. But no one had a better claim to do so, for it was Fred Jacka who first recognized the promise of the growing glaciological research and made glaciology a continuing part of the ANARE program by creating two positions for glaciologists. Under Radok's direction these expeditioners prepared themselves,from then on,in the University of Melbourne for the research to be done, spent a year on the ice, and finally worked up their results again in the University, often gaining higher degrees for their reports.

Some of these early glaciologists are shown at work in postage stamps for the "Australian Antarctic Territory" and symbolize the elevation of Australia's territorial claim to the more enduring spiritual level of polar science.

Ian Landon-Smith recording snow stratigraphy

The first two of the new series of expedition glaciologists left Australia at the end of 1960. One of them, Bob Wyers, was an engineer who went to Mawson, where he could not add substantially to Malcolm Mellor's major achievements, and on his return faded from the glaciological scene. The other was a school teacher with an honours degree in mathematics, who had just absolved his military service, and went to Wilkes as successor to the American IGY glaciologists Dick Cameron and John Hollin. His name was Budd (ICE, No.51, 1976), and, by a pleasant coincidence, it had for more than a century been attached to that part of the coast of East Antarctica. That name became, in due course, inseparable from Australian glaciology itself.

Around that time the Meteorology Department gained a new member in Peter Schwerdtfeger, who later became the first Australian full professor of meteorology in the Flinders University of Southern Australia. Schwerdtfeger put his experience with arctic sea ice to use in developing an extensive research program on energy transfers in and through polar ice and snow (as well as in plant layers). This work was taken into the ANARE by a physics undergraduate named Gunter Weller, who later explored the full range of conditions from sea ice to the high central plateau of Antarctica, before joining the Geophysical Institute of the University of Alaska and becoming in due course its Deputy Director.

Meanwhile Bill Budd prepared outstanding reports on his work at Wilkes and, during another year (1964) at Mawson and on the Amery Ice Shelf, for M.S. and Ph.D. degrees. The Ph.D. thesis was translated into Russian and Japanese and later with other publi-

cations, brought him the Edgeworth David Medal of the Royal Society of New South Wales and a share in the 1978 Medal of the Royal Society of Victoria. In 1970 he took over from Radok the direction of the ANARE Glaciology Program; but already, before then, he had become its unquestioned leader and he retained that role even after he left the Antarctic Division in 1979 to become the first full Professor of Meteorology in the University of Melbourne.

Bill Budd

The glaciological research carried out in Melbourne University during the past 30 years is enshrined in many publications. At the beginning stand Loewe's monumental "Etudes de Glaciologie en Terre Adélie,1951-1952", which would have made a much larger impact in English than they did in French. Mellor's papers followed and featured in all the glaciological "media" just after the IGY. The 1960 Helsinki papers have already been mentioned; they reported a new technique for measuring free water in snow, the numerical modeling of heat conduction in ice sheets and ice shelves, and a new form of dependence of snow drift on wind speed. The last of these topics was treated further in a large report on the "Byrd Drift Project" organized by Radok as part of the 1963 U.S. Antarctic Research Program. To this Bill Budd contributed a mathematical analysis of non-uniform particle drift which has remained the definitive word on the subject and formed a further stepping stone to the Budd era in Australian glaciology.

One of its prominent developments has been the extension of Jenssen and Radok's early computer studies of glacier thermodynamics into comprehensive dynamic models of different types of large ice masses. These studies have fully exploited Dick Jenssen's programming ingenuity, developed in the CSIRAC days of 24 bit 512 word central memories, to create a new level of sophistication in describing the physical characteristics of the large polar ice sheets, the flow and surging of real glaciers, and the waxing and waning of the Laurentide glaciation. Of equal importance have been coordinated field programs of coring and ice flow measurements on the Wilkes ice cap (now called Law Dome) and further inland on the flowline ending in the Vanderford-Totten ice stream system (Black, Budd, Battye,Simon,Morgan,McLaren, Pfitzner,

The new streamlined Casey Station near the site of the IGY Wilkes Station (U.S.A.)

Carter, Young); the surveys of the Lambert Glacier/Amery Ice Shelf system(Landon-Smith, Wishart, Budd, Corrie, Nickols, Allison) and of the ice streams of Enderby Land (Allison, Morgan, Jacka); and the studies of surface energy exchanges over the ice sheet (Dingle, Weller, Illingsworth, Schwerdtfeger) and over sea ice (Weller, Allison, Akerman,Tan).

Some major activities outside Antarctica also deserve mention: the laboratory experiments on ice flow and sliding (Mellor, Budd, Lile, Russell-Head, Jacka with visitors Kizaki, Wakahama, Matsuda); the modeling contributions to Ossi Reinwarth's Bavarian Academy studies of the Vernagtferner in the Austrian Alps (Jenssen, Kruss, Smith); and the exploration of the equatorial glaciers of New Guinea which began in Unimet (Champion, Radok) and drew together a number of workers (Peterson,the Hopes,Bennett, Muggleton, Anderson, Allison, Mustamou, to mention again only the most prominent names) from five Australian universities and the Cenderwasih University of Irian Jaya. Furthermore, graduates from the "Unimet/ANARE" Glaciology program are now working in several institutes in the United States, while others have made substantial contributions to the research of almost all the Antarctic expeditions cooperating in the International Antarctic Glaciological Project (IAGP). In all these ways the Australian research, with its unique blend of coordinated field work, laboratory experiments, and modeling, has become an essential and substantial part of modern glaciology.

By an American observer

THE INSTITUTE OF POLAR STUDIES

THE OHIO STATE UNIVERSITY

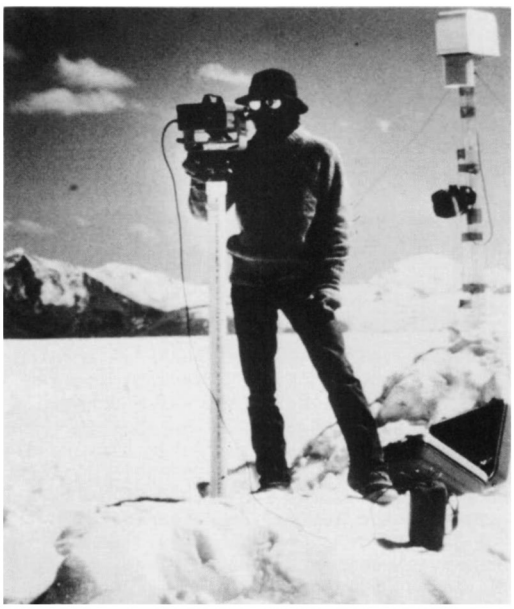
COLUMBUS, OHIO, U.S.A.

Glaciology at the Institute of Polar Studies (IPS) has been in a growth phase during recent years. We have endeavored to build a group of senior researchers and students directed towards two large problems: (1) the measurement and interpretation of ice core records in terms of past surface climate, and (2) the controls on ice sheet size and flow and reasons for changes. Of course, each researcher would define these goals somewhat differently, but only one is writing this!

The organizational structure is very informal. The glaciologists are all affiliated with the IPS, a multidisciplinary research unit within The Ohio State University. The IPS contains non-glaciologists also and it is good sometimes to learn about soil development in permafrost regions or the origin of basalt. Some of the scientists work almost entirely within the IPS, others such as Ian Whillans also hold regular faculty appointments in a teaching department. The Director is David Elliot, a benevolent igneous petrologist, and he now understands that the "flow law" is not a stricture of the International Glaciological Society. He works with the scientists to establish policy, and this includes scientific directions as well as issues related to the working environment.

Each scientist is considered an equal and is expected to be an independent researcher establishing his or her own position in the scientific world. Part of this is development of research proposals which will bring in sufficient grant monies to support her or himself. Thus, because the target date for Antarctic proposals is June 1, every May the IPS becomes a factory of research proposals. Even the students are encouraged to participate in proposal writing. The result is that there is little competition between the scientists, rather we are all aligned with or against the granting agencies! We are good at consoling one another when a research proposal is rejected.

Current glaciological research is in six areas, of which the showpiece is the microparticle laboratory. Ellen Mosely-Thompson and Lonnie Thompson study the stratigraphy of ice cores and have found major differences, compared to today, in the abundance and size distribution of the dust in ice deposited near the end of the last glaciation. They have also looked at more recent variations, and in many places there is a seasonal dust stratigraphy; Lonnie is using this to great advantage for an ice cap in the Andes of Peru and in China.



Movement surveying near automatic weather station, Quelccaya Ice Cap, Peruvian Andes

Sample processing, microparticle laboratory

Ellen Thompson and Phillip Kruss are concerned with processes in the development of snow stratigraphy at the South Pole. Ian Whillans is also involved because of his work at Dome C. He began by maintaining that

Snow pit excavation, Dome C, Antarctica

processes in the snowpack are more important than processes leading to the snow fall.

Field party, Greenland Ice Sheet
(author is on the right)

However, he has been beaten back by Richard Alley (who studied stratigraphy at Dome C to 50 m depth), by Julie Palais and Bill Bow (who studied shallow stratigraphy at Dome C and in southern Greenland, respectively), and even by good field data. He now maintains that diagenetic processes should not be forgotten.

Someone hungry for dinner, Greenland Ice Sheet. The rings around the eyes are because they are **not** windburned.

Julie Palais is now working with volcanologists to determine source and transport mechanisms for volcanic debris in ice cores.

A new area for us is glacio-meteorology and David Bromwich, Phil Kruss and Jeff Rogers are concerned with that. David is interested in the controls on snow accumulation and its stable isotopic ratio. Just now he is working on the problem of winds in Terra Nova Bay, which caused a British party in 1912 to be trapped on Inexpressible Island for seven months. Jeff has been studying the general circulation of the Arctic and sub-Antarctica in part to learn how climatic changes in one sector are related to changes in other sectors. Phillip is involved with Lonnie on the interpretation of meteorological data from the Quelccaya Ice Cap.

Others (John Bolzan, Henry Brecher, Jeff DeFreest, Andrea Donnellan, Joe Kosteka, Patricia Vornberger, and Ian Whillans) are working on ice flow dynamics or, according to the local journalists, on when the next ice age will arrive, and how quickly. We have had programs in East and West Antarctica and in Greenland, of which the Greenland program was by far the most ambitious. Seven satellite receivers working simultaneously

Start of new camp, Greenland Ice Sheet

were used to accurately measure ice movement. The data are still being reduced and we still can't tell the journalists when Ohio will be overrun by glacial ice. In West Antarctica, we are studying the ice streams and hope to learn why they form, what controls their flow, and, of course, what changes can occur.

Movement survey, ice streams in W.Antarctica

Our glacial geologist, John Mercer, works in South America as the political situation allows and, in conjunction with paleontologists like Peter Webb, in Antarctica. John chides the rest of us for supposing that the record of glaciation in Ohio applies to the whole world and he has very effectively described possible glacial catastrophes for West Antarctica.

We can also sometimes enjoy extended visits by scientists from other groups. To those people we try to impart an appreciation of bluegrass music and the joys of soaking up warm solar energy on the banks of the Olentangy River in preparation for a future polar field season.

If you are interested in more information on the IPS please write. There is a quite different profile on the IPS published in Antarctic Journal of the U.S. (Vol.9, No.2, p.41, 1974).

To answer a common question: the IPS is not a teaching department and cannot offer degrees, thus students have dual affiliations, with a teaching department and with the IPS. Recent graduates in glaciology have been in Geology and Mineralogy, Atmospheric Science and Geodetic Science and Surveying. We also enjoy close ties with Geography and Mathematics.

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Ian Whillans

ANNUAL GENERAL MEETING 1983

MINUTES OF THE ANNUAL GENERAL MEETING OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

30 June in Northwestern University, Evanston, Illinois, U.S.A.

The President, Dr C.W.M. Swithinbank, was in the Chair. 50 members from 11 countries were present.

1. The Minutes of the 1982 Annual General Meeting, published in ICE No.70, 3rd Issue 1982, p.10-13, were approved and signed by the Chairman.

2. The President gave his report for 1982-83: We meet on the occasion of the Society's Symposium on Ice and Climate Modelling. Some of us come here in trepidation because the subject is rather far from the more traditional realms of glaciology. But we need not have worried: there are more than 100 registered participants from 14 countries. I am particularly pleased that, having selected an interdisciplinary subject of wide interest, we are able to welcome more new faces than have ever before been seen at one of the Society's meetings. Glaciology was always an interdisciplinary subject but glaciologists sometimes need to be reminded of it. It is also good to see so many young faces here.

While the Society continues to flourish, these are not easy times for small learned societies involved in scientific publishing. What keeps us going is the quality of our publications, the cost-effectiveness of the whole operation, and the loyalty of our members in 30 countries. Earlier this week a distinguished Evanston member referred to the **Journal of Glaciology** as the "best-edited journal in the world". This is a widely held view and ought to please John Glen, the Senior Editor, who is here to take a bow. I hope he will carry the message back to his team, which includes Ray Adie, Doris Johnson, and David Homer. The number of pages in the three issues for the year totalled 508. The backlog caused by Council's decision to limit the number of pages on grounds of cost shows signs of diminishing, and for 1983 we hope that the interval from submission to publication will be 12-13 months.

The **Journal of Glaciology** faces serious problems due to rising costs. Last year Council appointed a Printing Committee to look into the operation and to recommend substantial changes which would bring about a solution. The committee consisted of two Past Presidents - Professors John Nye and Valter Schytt - together with the President, Treasurer, Secretary General and the Senior Editor of the **Journal**. After much research and correspondence, including a meeting in Birmingham in December 1982, the committee recommended a change of format to international A4 size paper with two columns of type. Articles should be set in the Society's Cambridge office and offered to the printer as camera-ready copy. Council accepted these proposals at its meeting on 26 June 1983 and they will come into effect with the first issue of 1984. The format will be essentially the same as that of the **Annals of Glaciology**. All of us are saddened by the necessity to depart from the format and from the high quality of printing to which we have been accustomed for the past 36 years. None of us wish to buy a new bookcase to house the **Journal**, although some members have already done so to house their volumes of the **Annals**.

Now for the good news. Savings in cost will be substantial, so that membership dues need not rise as fast as would have been necessary to maintain the present style. The benefits will be ploughed back by publishing more articles and by removing the page limit imposed on the editors. The net effect should be to cut the elapsed time between submission and publication. Not satisfied with these changes, Council also voted to make the **Journal** more attractive by including a picture on the front cover. An important purpose of this innovation will be to draw the attention of the casual readers to the scope of glaciology as defined by the Society and to enlighten those misguided souls who equate glaciology with glacierology. Whilst the specialization of individuals within glaciology is inevitable, Council feels that the Society and the **Journal** have a part to play in drawing the subject together, or at the least in keeping its readers aware that ice and snow occur in many forms on Earth, in the atmosphere, and indeed elsewhere in the solar system. I would urge all members who have or who know of good pictures, and who might like to see them spread across the cover of the **Journal**, to submit them to the Society's office. Full acknowledgement will be made of the source or provenance. Printing will generally be in black and white, but if the additional costs can be found from elsewhere, we shall be only too pleased to print in colour.

Council is concerned that the **Journal** should continue to evolve with the times. With this in view it has appointed a Working Group to consider the implications of changes in publishing technology, the possibility of wider international participation in editing, the functions of the Editorial Board, the editing style (including references) and such other points as may be appropriate. The Working Group will recommend policy and guidelines so that Council may establish these at its 1984 meeting and may consider their implications for the Society's other publications. Members are Bill Budd, Sam Colbeck, Keiji Higuchi, Mike Kuhn, the President, the Senior Editor of the **Journal**, and the Secretary General as Secretary. We hope for the widest possible participation of the membership-at-large in these deliberations, and I would ask you to communicate your ideas in any form to me or to any member of the Working Group.

Annals of Glaciology volume 4 was published in June 1983, 10 months after the Second Symposium on Applied Glaciology held in New Hampshire, 23-27 August 1982. Both in timing and in quality it maintains the standard set by earlier volumes, and for this we must thank the Chief Editor Sam Colbeck, the Associate Editors Steve Ackley, Bob Frederking, Bruno Salm, Joachim Schwarz, and Peter Schwerdtfeger, the House Editor Ailsa Macqueen, and very many anonymous referees. We are also grateful to the U.S. Army Research Office for helping to defray publishing costs.

Having carved its niche in glaciological publishing, it is a pleasure to record that we are receiving a healthy stream of enquiries and invitations from other organizations to publish conference proceedings in the **Annals of Glaciology**. Provided that the subject matter falls within our sphere of interest, that the outside body accepts our standards, that costs can be met, and that the Society's office can cope with the work load, we believe that it will serve the best interests of glaciology and of the Society to accede to the majority of these requests. Volume 5 of the **Annals** will contain the results of the Evanston symposium.

Three issues of **ICE** were published last year and for this we must thank the editor Simon Ommanney. Simon reminds us that the content of **ICE** depends on what is fed into it by the Society's National Correspondents and by those who report, or should report, through them on things that are happening in the world of glaciology.

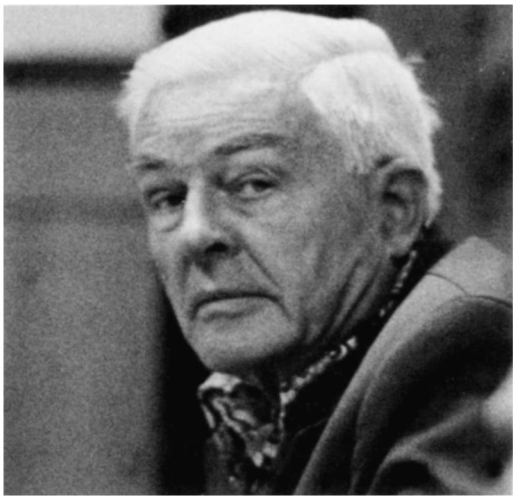
There have been meetings of the British, the North-east North America, and the Western Alpine branches this year, and we know that other meetings are planned. Branch meetings are valuable in themselves and they serve to attract new members, so let us all do what we can to support them.

Plans for future symposia are in a healthy state. For 1984 we have a Symposium on Snow and Ice Processes at the Earth's Surface to be held in Sapporo, Japan, 2-7 September. This will be followed by a study tour of China, 10-21 September. It will be the Society's first meeting in Japan and, together with the China tour, it should offer a memorable experience to all who take part. The second circular is now in the mail. For 1985 we have a Symposium on Glacier Mapping and Surveying to be held in Reykjavik, Iceland, 26-29 August. The first circular was distributed in May and reminds us that the meeting will be followed by a 3-day study tour of southern Iceland. In 1986 we celebrate the Society's 50th anniversary with a Symposium on Remote Sensing in Glaciology to be held in Cambridge, England, 7-12 September. Invitations for subsequent years are under active consideration.

We shall continue to hold symposia in different parts of the world. But we depend on glaciologists everywhere to lead us to the right places, and we depend on members in the host country to undertake the local arrangements. At the same time we cannot seek new pastures at any price. The registration fee is proportional to costs and we render a disservice to glaciology if we set our prices beyond the means of younger members and students. Over the years we have been offered the use of meeting rooms free, cheap, or expensive; yet we have never paid so much as we are paying here at Northwestern University. If universities claim to be in business, as we do, for the promotion and diffusion of knowledge, than I feel it is wrong that a small learned society with the legal status of a charity should be asked to pay sums that it would be quite appropriate to charge a commercial enterprise for the same service.

On Tuesday we had the pleasure of presenting the Society's highest award, the Seligman Crystal, to Bill Field and also to Hans Weertman. They are only the 10th and 11th glaciologists in the history of the Society to achieve this distinction. The Council has decided to make no award for 1984, but I would remind all of you that it is open to any member to put names forward to the Council for consideration.

Our other way of recognizing those who have made outstanding contributions to glaciology is to add them to the select band of Honorary Members. These are limited by our Constitution to 12. The sad loss of Sigurdur Thorarinsson earlier this year left a vacancy which Council has decided to fill with Professor Richard P. Goldthwait. Dick Goldthwait has had a long and distinguished career in glaciology and glacial geology and is well-known to many of you. We offer him our congratulations.



Prof. Richard P. Goldthwait, Honorary Member

The new Council that takes office at the conclusion of this meeting will have on it representatives of 12 different countries. That is not a bad showing for a management structure limited by Constitution to 12 elective members. The Society has 613 paid-up members and rather too many others still owing for 1983. The services that we can render to members are very much affected by the total of membership income, and I ask all of you to help by recruiting new members. We have a library circulation of 528 and this too represents a vital source of revenue.

It is the first, and sadly the last time, that we can thank Terence Armstrong for housing the headquarters of the Society for another year. He replaced Gordon Robin as Director of the Scott Polar Research Institute in October 1982 and plans himself to retire at the end of September 1983. We hope the new director will be equally sympathetic to the needs of the Society. The spokes of our organization stretch in every direction but the hub is firmly in Cambridge, managed by Secretary-General Hilda Richardson, who is ably assisted by Pat Lander, Mary Parker, and Ailsa Macqueen. To them all we offer our heartfelt thanks for their loyalty, for their efficiency, for their forbearance in times of stress, and, the rest of the time, for sheer hard work. We are grateful that three of them are here in Evanston to carry that message back to the fourth.

We look forward to seeing many of you in Japan. The meeting holds promise of being of exceptional interest.

3. The Treasurer, Dr J.A. Heap, submitted a report which was read by the President:

"I regret that, once again, I cannot be with you to give my report.

As you will see from the audited Accounts for 1982 there was a deficit on the Income and Expenditure Account of £2,120 in 1982. The estimated deficit for 1983 is £4,930. This clear downward trend in the Society's finances was known to you at the Council meeting on 22 August last year and it was against this background that you took certain key decisions to maintain subscription rates and seek financial viability for the Society by continuing to search for reductions in costs.

You will see from the Audited Accounts for 1982 that the Annals Fund was in surplus of £1,896 at the end of 1981 and that this surplus had increased to £18,910 by the end of 1982. It is for this reason that a Balance Sheet deficit of £6,948 at 31 December 1981 had changed to a surplus of £7,955 at 31 December 1982. The sum in the Annals Fund reflects surpluses on three Annals volumes, including sales of back issues and reprints. Of the sum in the Fund, £3,608 will go to support a future Annals volume, by agreement with the grant-giving body. I propose that the £4,183 which arose from favourable currency movements be retained as a hedge against unfavourable movements. Thus £11,119 is the unrestricted sum in the Annals Fund, an amount which should be used to finance development of the Society's publishing and other activities.

The Contingencies Fund currently stands at £73. We are therefore living from hand to mouth and have very little flexibility. We need to repair this situation and I hope that the steps taken to reduce costs of printing the **Journal** will enable us to achieve this.

I recommend that you accept the audited accounts for 1982."

U. Radok proposed the adoption of the accounts; this was seconded by O. Orheim and carried unanimously.

4. Election of Auditors for the 1983 accounts. S. Ommanney proposed and R. Williams seconded that Messrs. Peters, Elworthy and Moore of Cambridge be elected auditors for the 1983 accounts. This was carried unanimously.

5. Elections to the Council 1982-85: After circulation to all members of the Society of the Council's suggested list of nominees, no further nominations had been received. The following people were therefore elected unanimously:

Treasurer	J.A. Heap
Elective Members (4)	R.L. Brown
	R. Frederking
	G. Wakahama
	M.E.R. Walford

The President thanked the retiring Council members for their years of service: A. Gow, D.J. Drewry, S. Kinosita and C.S.L.Ommanney.

SELIGMAN CRYSTAL RECIPIENT — DR WILLIAM O. FIELD

28 June 1983, Evanston, Illinois, U.S.A.

Many glaciologists consider William Osgood Field the integrator and catalyst of North American glaciology.

Bill Field was born in New York City January 30, 1904. He graduated from Harvard College in 1926 with a B.S. degree, majoring in geology.

While still in school, he made his first trip to the Canadian Rockies and climbed in the Alps, including a traverse of the Matterhorn in 1923.

In 1924 he made the first ascent of South Twin in the Rockies,with his brother and several companions. Two years later he travelled to Glacier Bay with two friends, trying to relocate observation stations of previous scientists.

Bill was extremely interested in reports he read on the variations of Alaskan glaciers observed by H.F. Reid in 1890 and 1892, G.K. Gilbert in 1899, and R.S. Tarr and L. Martin from 1905 to 1913. Photographic programs and surveys of termini had been initiated, based on established reference points.

By 1926 none of these men had returned to continue their studies and Bill wanted to determine what changes had occurred during their absence. His main objective was to record the glacier variations by photography, surveying and visual observations.

In 1931, Bill began studying the glaciers of Prince William Sound, following up on studies initiated by the Harriman Alaska Expedition of 1899.

In 1940, he became a research associate on the staff of the American Geographical Society, but his work there was interrupted for three years while he served in the Photographic Branch of the U.S. Army Signal Corps. He then returned to the Society where he remained head of the Department of Exploration and Field Research until his retirement in 1969.

At the AGS, Bill helped initiate and direct glaciological projects, including the Juneau Icefield Research Project and studies of the fluctuations of some 200 glaciers in Alaska, the Southern Andes, Greenland and Western Canada.

During the IGY, he visited the U.S. bases in Antarctica. He also directed the World Data Center A for Glaciology, an organization which has since been transferred to the Cooperative Institute for Research in Environmental Sciences, of the University of Colorado.

He was Vice-President of the Commission of Snow and Ice from 1960-63 and of the Glaciological Society from 1962-64. He has been a staunch supporter of the Society and was made an Honorary Member in 1970. Field Glacier in the Antarctic (67°09'S, 66°23'W) is named after him.

Although officially retired in 1969, Bill continued to serve the AGS as editor and writer of a compendium of glaciers entitled Mountain Glaciers of the Northern Hemisphere published in 1975. He has also written articles for several scientific journals.

Bill's encyclopaedic knowledge of glaciers is legendary, although his quiet, unassuming manner conceals the vast amount of personal effort he has devoted to their study.

While his contributions are great in unravelling the story of North American glaciers, many people consider that his most valuable gift has been his service on committees and panels.

He has been a member of the Committee of Glaciers, Section of Hydrology of the American Geophysical Union, for most of its existence since 1931 and was its Chairman from 1948-54. He served as reporter on glaciology of the U.S. National Committee for the IGY and later became Chairman of its Technical Panel on Glaciology. He continued as Chairman when that panel became the Glaciology Panel of the Committee on Polar Research, National Academy of Sciences, National Research Council.

He is a member of the Council of the AGS, a Fellow of the Geological Society of America, and a member of numerous scientific and professional societies. His many honours include the Charles P. Daly Medal of the AGS and the Busk Medal of the Royal Geographical Society.

During his Seligman Crystal lecture,he relived some of his 57 years of study through slides depicting many of the glaciers he surveyed.

In giving Bill this award, his colleagues have paid tribute to his pioneering work,his cataloging of glaciers, his leadership in developing world-wide programs and his positive influence on many young scientists.

SELIGMAN CRYSTAL RECIPIENT — DR JOHANNES WEERTMAN

28 June 1983, Evanston, Illinois, U.S.A.

Johannes Weertman was born in Fairfield, Alabama, May 11, 1925. Hans served as a Corporal in the U.S. Marine Corps from 1943 to 1946. In 1948, he obtained a B.S. in Physics at the Carnegie Institute of Technology in Pittsburg and a D.Sc. in Physics three years later.

He studied at the Ecole Normale Supérieure in Paris, France and worked at the US Naval Research Laboratory in Washington, D.C. from 1952-58.

At the end of 1958, Hans was appointed Scientific Liaison Officer for the U.S. Office of Naval Research at the American Embassy in London. In 1959, he returned to the USA, joining the Department of Materials Science at Northwestern University.

He was appointed to a full professorship in that department in 1960 and to one in the Geology Department in 1963. The following year, he became Chairman of the Department of Materials Science and in 1968, was appointed Walter P. Murphy Professor of Materials Science and Engineering.

In addition to teaching and research, Hans has served as a consultant to the Bain Laboratory of the US Steel Corporation and to Oak Ridge National Laboratory. He has also been a consultant to the US Army Cold Regions Research and Engineering Laboratory, the U.S. Naval Research Laboratory and to the Los Alamos Science Laboratory.

The expertise he offers these organizations concerns the physics of metals: creep of crystals, internal friction, fatigue cracks and the influence of the atmosphere on their growth, the dislocation morphology of fatigue, experimental studies of high-speed dislocations and theoretical studies using the concept of infinitesimal dislocations.

Hans is the author of many publications and glaciologists know him for his numerous articles on specialized aspects of ice mechanics.

His interest in glaciology apparently began in 1956 during a chance conversation with Peter Haasen, a professor at Chicago University. Haasen told Weertman that results from his experimental work on the creep of metals were similar to findings on the creep of ice, obtained by John Glen.

When Hans moved to London in 1958, he learned more about the characteristics of ice. He talked with John Glen, attended meetings of the Glaciological Society and met glaciologists from many countries.

His interest in ice deformation problems grew and he contributed many articles on this subject to the Journal of Glaciology.

During 1970-71, Hans held a Guggenheim Fellowship and was a visiting professor at the Scott Polar Research Institute in Cambridge. His research involved the development of a unified theory on water flow at the base of an ice sheet or glacier. He also wanted to explore surging glaciers and surging ice sheets, as well as their reaction to climatic changes.

Hans has received numerous awards and honours over the years including the Robert E. Horton Award of the AGU, the Champion H. Mathewson Gold Medal of the Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers and the Acta Metallurgica Gold Medal. He has visited many countries and has served on countless committees and organizations. Among others, he has been elected to the Council of the I.G.S. and is an editorial advisor for the Journal of Glaciology. He has contributed to the Glaciological Society's lecture program and has joined many other groups for discussions. Weertman Island in the Antarctic (66°58'S, 67°44'W) is named after him.

During Hans' Seligman Crystal address, he reviewed his career as a glaciologist and the circumstances that led to the formulation of certain theories. There was also a rather special moment. Hans linked his early development in the science to fellow recipient, Bill Field, and to the Society's Founder, Gerald Seligman, and showed some slides of a visit to Seligman's home.

Hans is a formidable protangonist in verbal duels with the few glaciologists who work in his highly-specialized area. However,his soft-spoken comments reveal a lively humour that delights his colleagues, who appreciate the pleasure he derives from his own work and congratulate him for receiving the Seligman Crystal - their highest honour.

SYMPOSIUM ON ICE AND CLIMATE MODELLING

28 June 1983, Northwestern University, Evanston, Illinois, U.S.A.

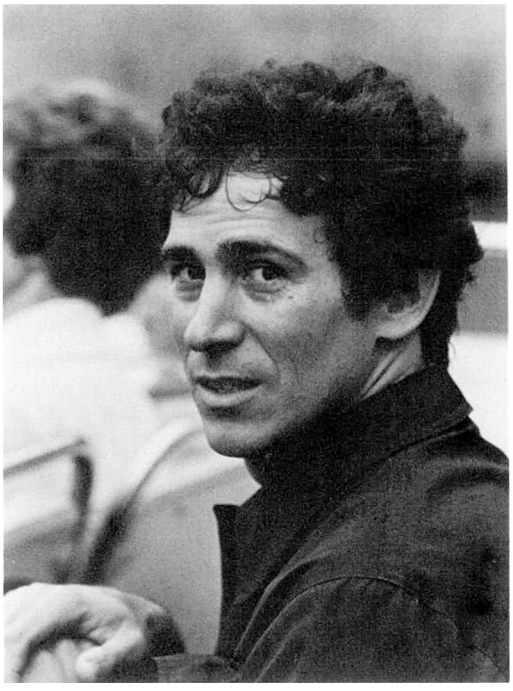
The annual symposium of the Society, this year dealing with ice and climate modelling, was held in the Norris University Center on

Norris University Center

the Evanston campus of Northwestern University. Co-sponsored by the American Meteorological Society, the symposium was attended by some 110 participants from 14 countries who heard papers on continental and marine ice sheets, sea ice and snow cover, modelling of the present and past climates and ice ages, and the data required for such models. The intent of this interdisciplinary meeting was to bring together glaciologists and climatologists in order to compare and improve their respective models. In addition to the scientific papers, there were two special lectures by last year's recipients of the Seligman Crystal award, Bill Field and Hans Weertman, after the presentation of their awards by the President of the Society, Charles Swithinbank.

Following the meeting, a number of registrants participated in the post symposium tours to Madison, Wisconsin, and northern Illinois.

Seligman Crystal lectures



Stephen Schneider, Chief Scientific Editor

The proceedings of the Symposium on Ice and Climate Modelling, consisting of some 50 edited articles and extended abstracts, will be published in mid-1984 in the **Annals of Glaciology.**

BRITISH BRANCH MEETING

29-30 September 1983, Cambridge, England

The British Branch of the Society held its annual meeting at the British Antarctic Survey in Cambridge on 29-30 September, 1983. A very full programme of work-in-progress papers was organised for the 60 participants and is listed below.

As usual, the meeting covered a wide range of glaciological topics, which included ice physics, hydrology, oceanography and geomorphology. An extra feature this year was a session of invited speakers who discussed the implications for glaciology of satellite altimetry. In lighter vein, the delegates also enjoyed audio-visual presentations of the work of B.A.S. and of its glaciologists, a film, a tour of the Scott Polar Research Institute, and the annual dinner.

At the Branch A.G.M., Dougal Goodman was confirmed as President for the next two years, with David Collins as Deputy-President. Next year's meeting is to be held on September 20-21 in Aberdeen. Details will be available from the new Secretary-Treasurer, Campbell Gemmell, at the Dept. of Geography, Univ. of Aberdeen, St. Marys, High Street, Old Aberdeen, AB9 2UF, U.K. A two day field course in the Cairngorms will follow the meeting.

Physics of Ice

J.F. Nye: Ice flow around basal bumps.
L.W. Morland & D.G. Smith: Infuence of non-uniform temperature distribution on the steady motion of ice sheets.
J.M. Reynolds & J.G.Paren: Relaxation in ice.
E.W. Wolff & J.G. Paren: Concentrated acids at grain boundaries in polar ice - a conductivity model.

Oceans and Ice

J. Potter: A little nearer an understanding of George VI Ice Shelf and the sea beneath.
J. Rouse: Flow and rotation of Brunt Ice Shelf.
S. Stephenson: Glacier flexure and the position of grounding lines: measurements by tiltmeter on Rutford Ice Stream.

Glaciological melange

R.D.Crabtree: A combined geophysical assault on George VI Sound, Antarctic Peninsula.
J.C. Gemmell: South Georgia: a reappraisal of the extreme event!
D.A. Peel: Ice cores and climate in the Antarctic Peninsula.
N. McIntyre: Ice flow through Antarctic outlet glaciers.
J. Dowdeswell: The glaciology of Nordaustlandet from Landsat.
P. Wadhams: The kinematics of ice floes in the marginal ice zones of the Bering and Greenland seas.
S. Stephenson: Flow data from Rutford Ice Stream, Antarctica.
C.S.M. Doake: Interactive ice shelf modelling.
D.J. Goodman: Sea-ice studies in the Arctic Ocean by B.P.
M.E.R. Walford: Phase-sensitive detectors in radio-echo sounding.

Snowmelt and Glacial Meltwater

A. Thomas & E.M. Morris: The chemistry of snowmelt.
D.N. Collins: pH and electrical conductivity of meltwaters draining from an alpine glacier.
A.M. Gurnell & C.R. Fenn: Flow separation, sediment source areas and suspended sediment transport in a pro-glacial stream.

Satellite Altimetry in Glaciology

C. Swithinbank: Glaciological applications of satellite altimetry.
C. Rapley: Potential and limitations of radar altimeter wave-form data over ice.
D. Drewry: ERS-1: evaluation of satellite radar altimetry.

Glacial Erosion and Deposition

R.J. Small, I. Beecroft & D. Stirling: Rates of deposition on lateral moraine embankments, Glacier de Tsidjiore Neuve, Switzerland.
J.S. Gill: Computer simulation of cirque glacier distribution.
I.S. Evans: Distribution of glaciers and cirques in the Southern Coast Mountains, B.C.
R. Hindmarsh: Glacial erosional landforms.
M. Sharp: A model for sedimentation by surging glaciers.

J.G. Paren

The following papers and short notes have been accepted for publication in the second and third issues of the **Journal** for 1983:

R.J.Ray, W.B.Krantz, T.N.Caine and R.D.Gunn:
A model for sorted patterned-ground regularity.

R.D. Ketchum, Jr:
Dual frequency radar ice and snow signatures.

V.G. Averyanov:
The energy-balance structure of the Antarctic ice sheet/atmosphere system.

J. Pickard:
Surface lowering of ice-cored moraine by wandering lakes.

T. Scheiwiller and K. Hutter:
Avalanche dynamics. Review of experiments and theoretical models of flow and powder-snow avalanches.

S. Bolsenga:
Spectral reflections of snow and fresh-water ice from 340 through 1100 nm.

W.L. Stockton:
Submarine ice cliffs on the west side of McMurdo Sound, Antarctica.

G.F.N. Cox and W.F. Weeks:
Equations for determining the gas and brine volumes in sea-ice samples.

R.J. Small:
Lateral moraines of glacier de Tsidjiore Nouve: form, development and implications.

W. Haeberli, U. Schotterer, W. Wagenbach, H. Haeberli and S. Bortenschlager:
Accumulation characteristics of a cold, high-Alpine firn saddle from a snowpit study on Colle Gnifetti, Monte Rosa, Swiss Alps.

L.A. Rasmussen:
Calculation of a velocity distribution from particle trajectory endpoints.

L. Lliboutry:
Modifications to the theory of intraglacial waterways for the case of subglacial ones.

D. Hantz and L. Lliboutry:
Waterways, ice permeability at depth, and water pressures at glacier d'Argentière (French Alps).

P.H. Gammon, H. Kiefte, M.J. Clouter and W.W. Denner:
Elastic constants of artificial and natural ice samples by Brillouin spectroscopy.

C. Raymond:
Deformation in the vicinity of ice divides.

M. Burkimsher:
Investigations of glacier hydrological systems using dye tracer techniques: observations at Pasterkengletscher, Austria.

J. Weertman and G.E. Birchfield:
Stability of sheet water flow under a glacier.

W. Wenying:
Glaciers in the north-eastern part of the Qinghai-Xizang (Tibet) plateau and their variations.

S. Hastenrath:
Net balance, surface lowering and ice flow pattern in the interior of Lewis Glacier, Mt. Kenya.

J. Grabczaik and others:
Isotope stratification in high mountain glaciers: examples from the Peruvian Andes and Himalaya.

G.F.N. Cox:
Thermal expansion of brine.

J. Shaw:
Drumlin formation related to inverted meltwater erosional marks.

I.J. Smalley:
Early Discoverers: John Hardcastle on glacier motion and glacial loess.

H. Björnsson:
Obituary: Sigurdur Thorarinsson.

Instruments and Methods:

R. Perla and T.M.H. Beck:
Experience with shear frames.

G. Cloud and E. Conley:
A whole-field interferometric scheme for measuring strain and flow rates of glacier and other natural surfaces.

Short Notes:

D.M. McClung:
Derivation of Voellmy's maximum speed and run-out estimates from a centre of mass model.

M. Mellor:
Snow concentration and effective air density during snowfalls.

R.S. Liebling and H.S. Scherp:
Systematic unequal dissection of opposing valley arms.

J.N.J. Visser:
A lacustrine glacier retreat sequence from the Permo-Carboniferous Dwyka Formation, Republic of South Africa.

M. Ohtomo and G. Wakahama:
Correlation between crystallographic axes and the shape of single crystals in glaciers.

A. Judson and R.M. King:
Spatial variation in snow stability inferred from artillery control.

RECENT MEETINGS (of other organizations)

EUROMECH 172: MECHANICS OF GLACIERS

18-23 September 1983, Hotel Mattenhof, Interlaken, Switzerland

The aim of this colloquium was to bring together those scientists who are active in research on the mechanics of glaciers and ice in a geophysical environment, from the point of view of fundamental mechanical foundation as well as from that of field and laboratory observations. In spite of its (narrow) title, snow and ice were equal partners. I think the objective was achieved, because most presentations were well attended. There were 26 participants (plus a few accompanying family members) from 10 countries: Australia (1), Austria (2), Canada (1), Denmark (1), France (2), Germany (4), Italy (1), United Kingdom (3), Switzerland (7) and U.S.A. (4). Unfortunately, no one from any Eastern European countries attended. However, the most prominent active modellers in glacier mechanics and in snow avalanches were present and their theoretical emphasis was counterbalanced by some well known observationalists. This set a high standard to the meeting right from the start and led to fruitful discussions which were generally longer than originally anticipated. An excursion to the Jungfrau-Grindelwald-Oberer Grindelwaldgletscher was planned and took place in fair to good weather conditions. I regarded this excursion as an important integrating part of the conference, as I wanted to bring every theoretical modeller close to and on a glacier.

The topics covered were:

Glaciers:
- creep flow of ice, simple phenomena
- large scale phenomena
- glacier and ice sheet geometry
- basal features and glacier sliding
- water in glaciers, polythermal ice

Snow:
- flow avalanches
- powder snow avalanches
- gliding avalanches
- hydrology of snow

A detailed scientific report of the presentations will be given in a paper by Hutter and Morland.

K. Hutter

FUTURE MEETINGS (of other organizations)

HYDRAULIC EFFECTS AT THE GLACIER BED AND RELATED PHENOMENA

16-19 September 1985, Hotel Mattenhof, Interlaken, Switzerland

PURPOSE
To provide a forum for the discussion of observational and theoretical findings in the field outlined below.

TOPICS
Mechanics of glacier surges.
The effect of subglacial water pressure on the sliding motion.
The effect of glacier movement on the drainage system.
Conditions of the glacier bed and the basal ice affecting sliding motion.
Subglacial water storage.
Sliding: instability and friction.
Hydraulics of water outbursts.

PROGRAM
Presentation of recently finished work or work under progress.
Free and round table discussions.
1-day tour during the conference and a 2-day excursion before or after the conference.

LANGUAGE
English

CONFERENCE PUBLICATION
A summary of the conference results, the general discussion and the individual abstracts will be published as a VAW Report soon after the conference.

ORGANISATION
Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie, Eidgenössische Technische Hochschule, Zürich, Switzerland

ACCOMMODATION
Park-Hotel Mattenhof in Interlaken (situated between Thuner and Brienzer See) is ideal as a congress center. It offers comfortable congress facilities, and full board and lodging at a very reasonable price.

DATES

Registration:	Sunday,15 September 1985
Workshop (incl. 1-day tour):	Monday, 16 September - Thursday, 19 September
2-day excursion:	Friday/Sat., 13/14 Sept. or Friday/Sat., 20-21 Sept.

Preliminary registration information is available from:
Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie, z.H.v. Dr A. Iken, ETH-Zentrum, CH-8092 Zürich, Switzerland

THIRD SYMPOSIUM ON ARCTIC AIR CHEMISTRY

7-9 May 1984, Atmospheric Environment Service, Downsview, Ontario, Canada

The Third Symposium on Arctic Air Chemistry will be held at the offices of the Atmospheric Environment Service, Downsview, Ontario, from 7-9 May 1984. It will deal with all aspects of Arctic air chemistry, including gases and aerosols, natural and pollution sources, transport, transformation, deposition, and radiative and nucleational effects. Further information may be obtained from either:

L.A. Barrie,
Atmospheric Environment Service,
4905 Dufferin Street,
Downsview, Ontario, M3H 5T4, Canada

or

K.A. Rahn,
Graduate School of Oceanography,
University of Rhode Island,
Narragansett, RI 02882-1197, U.S.A.

FORTY-FIRST EASTERN SNOW CONFERENCE

7-8 June 1984, New Carrolton, Maryland, U.S.A.

The 41st Eastern Snow Conference will be held in Washington, D.C. on 7 and 8 June 1984. The principle themes for the meeting are **"Snow and Buildings"** and **"Remote Sensing of Snow and Ice"** but any appropriate topics will be considered. Abstracts should be sent before March 15 to:-

Peter Adams, Program Chairman,
41st Eastern Snow Conference,
c/o Watershed Ecosystem Program,
Trent University,
Peterborough, Ontario, K9J 7B8, CANADA

Student participation is encouraged through the annual ESC Student Paper Contest ($100 prize and up to $350 in expenses to attend the Conference). Interested students should contact:-

Don Taylor, Chairman,
Research Committee,
Eastern Snow Conference,
National Research Council of Canada,
M-20, Montreal Road,
Ottawa, Ontario, K1A OR6, CANADA

FOURTH INTERNATIONAL SYMPOSIUM ON GROUND FREEZING (ISGF 85)

5-7 August 1985, Keio-Plaza Hotel, Sapporo, Japan

Over the last few decades artificial freezing of the ground has been used increasingly to stabilize earth materials and control ground water seepage in geotechnical construction. Several excellent theoretical, experimental and case history studies have been reported in the past three symposia on ground freezing and many advances have been made in the state of the art. However, it is felt that a gap between theory and practice still exists. Therefore, the theme of this symposium is to emphasize the relation between theory, design and application in construction.

TOPICS
The symposium will be concerned with the following topics:

1. Thermal properties and processes in earth materials (thermal properties, thermal analysis, etc.)
2. Mechanical properties and processes in earth materials (strength and stress-strain behaviour, long-term strength and creep, change in properties by freezing and thawing, thawed soils and rocks, etc)
3. Frost action (modelling, mechanism of heaving, frost susceptibility tests and heave pressures, movement due to frost action, thaw consolidation, etc.)
4. Engineering design and case histories (shafts and open excavations, shaft linings, tunnels, pipelines, foundations and slopes, mathematical simulation of freezing processes and refrigeration systems, heat pipes, permafrost engineering, LNG/LPG-tanks, etc.

FURTHER INFORMATION
You are invited to attend the symposium and to advise the organisers of your interest as soon as possible. The second announcement will give information about accommodation, general programme, preparation of summaries and final papers. Requests for copies should be directed to the conference address given below.

ISGF 85 Sapporo Family name .....
First names .....
Address .....
.....

I hope to participate in symposium 1985 ( )
I expect to submit the summary of a proposed paper on Topic No.... ( ) Send to:

ISGF 85,
Inst. of Low Temperature Science,
Hokkaido University,
Sapporo 060, JAPAN

ANTARCTIC PLACE NAME DECISIONS

Members may be interested in the following place names which have been approved by the U.K. Antarctic Place-names Committee and the U.S. Advisory Committee on Antarctic Names; they are listed with their citations.

Bauer Buttress (67°25'S, 66°58'W), an important geological locality and a useful landmark in sledging. Named after Albert Bauer (b.1916), French engineer and glaciologist who has carried out research on glaciers in Greenland, Iceland, Iles Kerguelen and Terre Adélie; formerly with Expéditions Polaires Françaises.

Kosiba Wall (67°31'S, 66°55'W), an extensively sampled geological area. Named after Alexander Kosiba (1901-1981), Polish climatologist and glaciologist; Professor of Meteorology and Climatology, University of Wroclaw, 1945-71; leader of first Polish expedition to Greenland, 1937, and of Polish glaciological expeditions to Svalbard, 1957-60.

Lliboutry Glacier (67°29'S, 66°42'W). Named after Louis Antonin François Lliboutry (b. 1922),French physicist and glaciologist who has investigated the mechanical deformation of ice and the micro-metrological properties of ice surfaces, and has published in Spanish a general study of glaciers in "Territorio Antárctico Chileno"; Director, Laboratoire de Glaciologie,University of Grenoble.

Richardson Peak (67°20'S, 67°19'W), an important geological locality and landmark. Named after Mrs Hilda Richardson, Secretary General, International Glaciological Society since 1962 (Secretary, British Glaciological Society, 1953-62).

Saussure Glacier (67°11'S, 67°00'W). Named after Horace-Bénédict de Saussure (1740-1799), Swiss physicist and geologist, who, in 1787, first recognised that erratic boulders had been moved great distances by ice; he made the second ascent of Mont Blanc in 1787.

INQUA '87 IDEAS SOLICITED

The XIIth Congress of the International Quaternary Union (INQUA) will be held in Ottawa, Ontario, Canada, from Friday, July 31 to Sunday, August 9, 1987. Initial planning for this meeting is now being undertaken. The Program Committee is interested in the ideas of scientists in Quaternary and related disciplines regarding the technical program for the meeting. Therefore, the Committee solicits your opinions and ideas concerning symposium themes, session format, and other matters relevant to the program. Suggestions for symposia on topical, even controversial, issues of interest to a broad spectrum of Quaternary scientists are especially welcome. Mail or phone your suggestions to:

J.J. Clague, (604-666-6565)
Chairman, Program Committee,
Geological Survey of Canada,
100 West Pender Street,
Vancouver, British Columbia,
V6B 1R8, Canada

or

Dr Alan V. Morgan,
Secretary General XII INQUA Congress,
Department of Earth Sciences,
University of Waterloo,
Waterloo, Ontario, N2L 3G1, Canada,

as soon as possible.

ICE COMMUNITY NEWSLETTER

The **Ice Community Newsletter** is a bulletin designed to provide information on the current status of sea ice activities conducted as part of the microwave research programme of the Canada Centre for Remote Sensing. The newsletter is produced approximately four times per year, depending upon activities.

Contributions concerning the remote sensing of sea ice are welcome and should be addressed to:

S. Digby,
RADARSAT Project Office,
Suite 200, 110 O'Connor Street,
Ottawa, Ontario, K1P 5M9, Canada

INTERNATIONAL COMMISSION ON SNOW AND ICE

At the recent meeting of the International Association of Hydrological Sciences in Hamburg, the following officers of the Commission and members of the Bureau were appointed for the 1983-1987 period.

President: Prof. Louis Lliboutry, Lab. de Glaciologie et Géophysique de l'Environnement, 2 rue Très-Cloîtres, 38031 Grenoble-Cedex, France

Vice-Presidents: Dr Malcolm Mellor, Cold Regions Research and Engineering Laboratory, 72 Lyme Road, Hanover, New Hampshire 03753, U.S.A.

Dr Bruno Salm, Eidgenössisches Institut für Schnee- und Lawinenforschung, 7260 Weissfluhjoch, Davos, Switzerland

Dr William Budd, Dept. of Meteorology, Univ. of Melbourne, Parkville, 3052 Victoria, Australia

Secretary: Dr Gorow Wakahama, Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan 060

Chairman of Division of Snow Cover and Avalanches: Dr Elizabeth M. Morris, Inst.of Hydrology, Wallingford, Oxon OX10 8BB, U.K.

Chairman of Division of Glaciers and Ice Sheets: Dr Vladimir M. Kotlyakov, Inst.of Geog., USSR Academy of Sciences, Staromonetny 29, Moscow 109017, U.S.S.R.

Chairman of Division of River, Lake and Sea Ice: Dr Robin D. Muench, Science Applications Inc., 13400B Northrup Way, #35, Bellevue, WA 98005, U.S.A.

Chairman of Division of Ground Ice: Dr Cheng Guodong, Institute of Glaciology and Cryopedology, Lanzhou, People's Republic of China

Dr Kotlyakov was also elected a Second Vice President of the International Association of Hydrological Sciences.

ICSI WORKING GROUP ON SNOW AND ICE HYDROLOGY OF GLACIERIZED BASINS

During the IUGG General Assembly in Hamburg, FRG, the former "Working Group on Prediction of Runoff from Glacierized Areas" was dissolved and a new Working Group on "Snow and Ice Hydrology of Glacierized Basins" was established. This WG has a mandate to encourage discussion and research in basin processes of mass balance, glacial hydrology and glacier runoff. Prime attention will be given to:-

- Basin scale description and parameterization of
  1. Snow melt and runoff
  2. Accumulation, especially redistribution by avalanches and wind.
- Effect of long range, climatic changes, e.g. lag of water supply due to storage.

Glacier mass balance will be dealt with implicitly in the above problems, but not as an explicit objective.

The immediate goals are to review the state-of-the-art and establish connections with existing groups with similar objectives, to compile instructions for field work relating to snow and ice hydrology at the engineering level and for use in developing countries, and to support the symposia in Alma Ata (1985), Budapest (1986) and Vancouver (1987).

More information on the WG may be obtained from the Chairman, Dr M. Kuhn, Institut für Meteorologie und Geophysik, Univ. Innsbruck, Schöpfstrasse 41, A-6020 Innsbruck, Austria

MOVE OF TEMPORARY TECHNICAL SECRETARIAT FOR THE WORLD GLACIER INVENTORY

In anticipation of the proposed amalgamation of the Permanent Service on the Fluctuations of Glaciers with the TTS in 1985, the latter will now be housed in the offices of VAW. Karl Scherler will continue to function as the Executive Secretary of the TTS. Correspondence should now be addressed to:

Temporary Technical Secretariat for World Glacier Inventory (TTS),
Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie,
ETH-Zentrum,
Gloriastrasse 37/39,
8006 Zürich, SWITZERLAND (Tel: 01 256 4094)

GLACIOLOGICAL DIARY

1984

4-6 April
Third International Cold Regions Engineering Specialty Conference: Northern Resource Development. Edmonton, Alberta, Canada. (Dr D.W. Smith, Dep. of Civil Engineering, Univ.of Alberta, Edmonton, Alberta, T6G 2G7, Canada)

17-20 April
52nd Annual Western Snow Conference: Hydrometeorological Instrumentation and Automation. Sun Valley, Idaho, U.S.A. (D. Lute, U.S. Bureau of Reclamation, Box 043, 550 West Fort Street, Boise, Idaho 83724, U.S.A.)

7-9 May
Third Symposium on Arctic Air Chemistry. Toronto, Ontario, Canada. (L.A. Barrie, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario, M3H 5T4, Canada)

4-7 June
Symposium on Climate and Paleoclimate of Lakes, Rivers and Glaciers. Igls, near Innsbruck, Austria. (Dr M. Kuhn, Institut für Meteorologie und Geophysik, Schöpfstrasse 41, A-6020 Innsbruck, Austria)

5-12 June
Interpraevent 1984 (prevention of avalanche and flood danger). Villach, Austria. (Forschungsgesellschaft für vorbeugende Hochwasserbekämpfung, Postfach 85, A-9021 Klagenfurt, Austria)

6-9 June
Second American Conference on Ice Nucleating Bacteria. Flagstaff, Arizona, USA. (Ralph M. Bilby Research Center, Box 6013, Northern Arizona University, Flagstaff, Arizona 86011, U.S.A.)

7-8 June
41st Annual Eastern Snow Conference. Washington, D.C., USA. (Dr W.P. Adams, Associate Dean of Arts & Science, Trent University, Peterborough, Ontario, K9J 7B8, Canada)

20-21 June
Third Workshop on Hydraulics of River Ice. Fredericton, New Brunswick, Canada. (Dr K.S. Davar, Dept. of Civil Engineering, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick, E3B 5A3, Canada)

16 July - 7 August
Western Alpine Branch, International Glaciological Society. Alaska, U.S.A. (F. Valla, Division Nivologique du CEMAGREF, B.P. 76, 38402 St Martin d'Hères, France)

14-17 August
ASCE Hydraulics Division Specialty Conference on Ice Engineering. Coeur d'Alene, Idaho, U.S.A. (Dr H.T. Shen, CRREL, 72 Lyme Road, Hanover, New Hampshire 03755, U.S.A.)

19-24 August
Snow and Ice Chemistry and the Atmosphere. Trent University, Peterborough, Ontario, Canada. (Dr W.P.Adams, Assoc. Dean of Arts & Science, Trent Univ., Peterborough, Ont., K9J 7B8, Canada)

27-31 August
7th International Symposium on Ice, Int. Assoc. for Hydraulic Research. Hamburg, West Germany. (Dr J. Schwarz, Ice Engineering Division, Hamburgische Schiffbau-Versuchsanstalt, P.O. Box 600 929, 2000 Hamburg 60,West Germany)

27-31 August
25th International Geographical Congress. Paris, France. (Comité d'organisation du 25e Congrès International de Géographie Paris-Alpes 1984, 19 [illegible]e Isidore Pierre, 14000 Caen, France)

2-7 September
Symposium on Snow and Ice Processes at the Earth's Surface. Tokyo and Sapporo, Japan. (Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K.)

20-21 September
British Branch, International Glaciological Society. University of Aberdeen, Aberdeen, U.K. (C. Gemmell, Department of Geography, University of Aberdeen, St. Marys, High Street, Old Aberdeen, AB9 2UF, U.K.)

17-19 October
CRREL/ARO Workshop on the Interaction of Microwaves with the Seasonal Snow Cover. Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, U.S.A. (Dr S.C. Colbeck, CRREL, 72 Lyme Road, Hanover, New Hampshire 03755, U.S.A.)

24-27 October
International Snow Science Workshop: a Merging of Theory and Practice. Aspen, Colorado, U.S.A. (ISSW Conf. Comm., c/o Mountain Rescue - Aspen Inc., Box 4446, Aspen, Colorado 81612, U.S.A.)

1985

March
North-eastern North America Branch, International Glaciological Society. Eastern Townships, Québec, Canada. (Dr S.J.Jones, Snow and Ice Division, Nat. Hydr. Res. Inst., Environment Canada, Ottawa, Ontario, K1A OE7, Canada)

April
IAWPRC International Conference on Water and Ice Pollution in Arctic Regions. Yellowknife, N.W.T., Canada. (Prof. W.A. Bridges, International Association on Water Pollution Research and Control, Box 3161, Halifax, Nova Scotia, B3J 3H5, Canada)

5-7 August
The Fourth International Symposium on Ground Freezing. Sapporo, Japan. (ISGF 85, Institute of Low Temperature Science, Sapporo 060, Japan)

26-29 August
Symposium on Glacier Mapping and Surveying, Reykjavik, Iceland. (Secretary General, Inter. Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK)

16-19 September
Hydraulic Effects at the Glacier Bed and Related Phenomena. Interlaken, Switzerland. (Dr A. Iken, Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie, ETH-Zentrum, CH-8092 Zürich, Switzerland)

September
ICSI Symposium on Glacier Mass Balance, Runoff, Water Storage in Glaciers and Climate. Alma Ata, U.S.S.R. (Prof. V.M. Kotlyakov, Inst. of Geog., USSR Academy of Sciences, Staromonetny Street 29, Moscow 109017, U.S.S.R.)

1986

March or April
IHP 6th Northern Research Basins Workshop:River Ice Measurement Techniques. Canada. (Dr B. Goodison, Atmospheric Environment Service, 4905 Dufferin Str., Downsview, Ont, M3H 5T4, Canada)

July
I.A.H.S. 2nd Scientific General Assembly. Budapest, Hungary. (Dr A. Szöllósi-Nagy, VITUKI, H-1453 Budapest, Pf 27, Hungary)

30 August - 5 September
Symposium on Physics and Chemistry of Ice. Grenoble, France. (J. Klinge, Laboratoire de Glaciologie, B.P.53X, 38041 Grenoble Cedex, France)

7-12 September
Symposium on Remote Sensing in Glaciology, 50th Anniversary of the International Glaciological Society. Cambridge, England. (Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK)

1987

31 July - 9 August
12th Congress of the International Union for Quaternary Research. Ottawa, Ontario, Canada. (J.J. Clague, Program Comm., Geological Survey of Canada, 100 West Pender Street, Vancouver, British Columbia, V6B 1R8, Canada)

9-25 August
General Assembly of the International Union of Geodesy & Geophysics (IUGG). Vancouver, Canada. (Prof. P. Melchior, Observatoire Royal de Belgique, Avenue Circulaire 3,B-1180 Brussels, Belgium)

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INTERNATIONAL GLACIOLOGICAL SOCIETY

Lensfield Road, Cambridge CB2 1ER, England

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ICE

Editor: Simon Ommanney

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

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