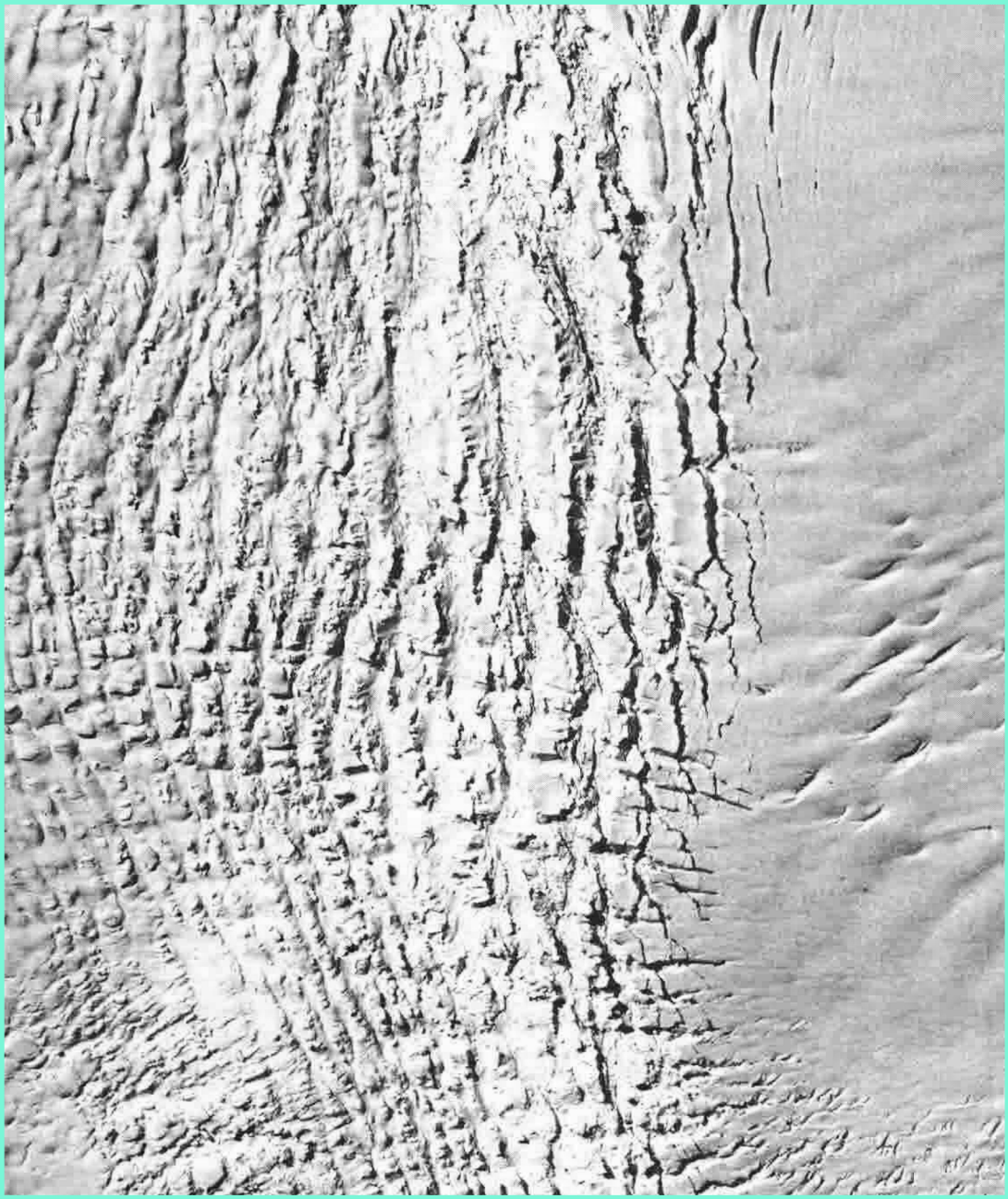
NUMBER 69

2nd ISSUE 1982

ICE



SNOW STRUCTURE AND SKI FIELDS

— BEING AN ACCOUNT OF SNOW AND ICE FORMS MET WITH IN NATURE AND A STUDY ON AVALANCHES AND SNOWCRAFT

by Gerald Seligman

THIRD EDITION
1980

The original book, published in 1936, went out of print very quickly and a second edition was printed in 1962. This edition also sold quickly. With the approval of Mr Seligman's family, the INTERNATIONAL GLACIOLOGICAL SOCIETY has now brought out a third edition. As with the second edition, no changes have been made to the text and illustrations, in spite of the enormous developments of snow and avalanche research achieved in the past decades. Marcel de Quervain, himself a world-famous expert in this field, writes in the Preface to the third edition:

"Gerald Seligman's work is a classic of unique features with respect to the richness and originality of the observations and also the personal style of the presentation and discussion. A revision would have destroyed the basic character of the monograph. The reader is introduced to a fascinating pioneer phase of snow research and confronted with opinion and contributions of eminent names well known for alpine and polar research and techniques."

This limited edition, 555 pages long, is in paperback form (an attractive photograph has been used for the cover, which is machine varnished) and may be obtained from the International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K. at a cost of: £12.00 plus £1.50 packing and postage by SURFACE MAIL.

ISSN 0019-1043

ICE
NEWS BULLETIN OF THE
INTERNATIONAL GLACIOLOGICAL SOCIETY

NUMBER 69 2nd ISSUE 1982

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The Society's highest award, the Seligman Crystal, was presented to Marcel de Quervain at the Society's 1982 Symposium on Applied Glaciology. At that time the President announced that Seligman Crystals were to be awarded to William O. Field, Jr. and to Johannes Weertman for their contributions to glaciology. These will be presented at the Society's 1983 Symposium. Read the next issue of ICE for more information on the Seligman Crystal awards.

COVER PICTURE. Columbia Glacier. Vertical air photograph of crevassed reach, 40 km above the terminus. In this reach the velocity changes from 400 to 1300 ma^{-1}, longitudinal deformation rates range between -1.2 and +3.0 a^{-1}, and up to 1.9 ma^{-1} of ice is melted internally due to the loss of potential energy. The field of view is about 3.0 by 2.6 km; the largest crevasses are about 180 m wide. The flow direction is from right to left. (Project Office – Glaciology)

CANADA

ICE RESEARCH BY GULF CANADA RESOURCES INC.

(F.J. Eley, Gulf Canada, Calgary, Alberta)

Gulf Canada is presently building a Beaufort Sea drilling system consisting of a new technology floating conical drilling unit, a mobile caisson unit, four Class IV icebreaking supply vessels and shore bases. In connection with this exploration system and anticipated production facilities, data on many aspects of the Beaufort Sea ice cover are being gathered and assessed. Efforts are now concentrating on early winter ice conditions (October to January) into which it is intended to expand the exploration drilling season.

At Tarsuit artificial island, constructed with concrete gravity caissons on a relatively steep-sided berm, Dome and Gulf are conducting an intensive study of the local ice features and their impact on the structure.

Theoretical studies and model tests are being conducted on the effects of ice on the exploratory drilling vessels and icebreakers.

CHINA

THE HALUN GLACIER

(Wang Wenying, Lanzhou Institute of Glaciology and Cryopedology)

In June 1981, a joint Chinese/West German expedition spent 21 days studying the glaciers of the Mt. Anyêmaqên area in eastern Qinghai province. Most of the Anyêmaqên glaciers have been advancing during the past few decades at rates ranging from 5-83 m/a. The 9 km long Halun Glacier has moved 790 m since 1966 and is still advancing. Spectacular ice pyramids and ogives are found here; quite different from the glaciers of the nearby Qilian Mountains but similar to some glaciers in the Himalayas and Kala Kunlun Mountains.

The density of the Halun Glacier is 0.89 Mg m^{-3} and its temperature at 8 m is -6.5°C. On the northeast slope the snow-line is at 4900 m and at 5200 m on the southwest slope. Precipitation is in direct proportion to height with an annual average near the snow-line of 800 mm whereas melt is inversely proportional ranging from 10 m w.e. at the tongue to about 800 mm above the snow-line.

Four transverse profile on the Halun Glacier revealed a region of higher flow rates 3 km from the snout. Here, flow was measured at 83 m/a but dropped to little more than 5 m/a only 1 km down-glacier. These different speeds cause pile-ups and force certain parts of the glacier upwards. The advance is expected to last from 10-20 years and to lead to increased ice melt.

(after China Reconstructs, Feb. 1982, 40/43)

CHINA AND JAPAN

CHINA-JAPAN COOPERATIVE GLACIOLOGICAL EXPEDITION TO TIAN SHAN

(X.Zichu, Lanzhou Institute of Glaciology and Cryopedology (LIGC),Academia Sinica, Lanzhou, China; O. Watanabe, Water Research Institute (WRI), Nagoya University, Nagoya, Japan)

From July 19 to August 16, 1981, an expedition to the glaciers of the Mt. Bogda and Victory Pass regions of the Tian Shan Mountains was carried out under the Cultural Exchange Agreement between China and Japan. It consisted of 12 Chinese members including X. Zichu,Z. Benxing (LIGC), W. Zhichao, Xinjiang Institute of Geography, and W. Guanghe, Lanzhou University, and two Japanese, O. Watanabe (WRI) and Y. Ageta, Faculty of Education, Yamaguchi University.

Mt. Bogda (5445 m), the highest peak in the eastern Tian Shan, is located in the north east part of the Örümqi Region. The base camp was established on a col at 3640 m. Glaciological investigations focussed on two glaciers: the Gubanbogdogole Glacier, a 10.94 km^2 cirque glacier, and a smaller cirque-valley glacier (2.96 km^2). The former, terminating at 3540 m a.s.l., originates in mountain peaks ranging from 5200-5400 m from which flow four ice streams, two of then converge (5Y725 D-5) and drain into the Sigong River, two others join (5Y822 B-10) and flow southwards into the Gubanbogdogole River (Figure 1).

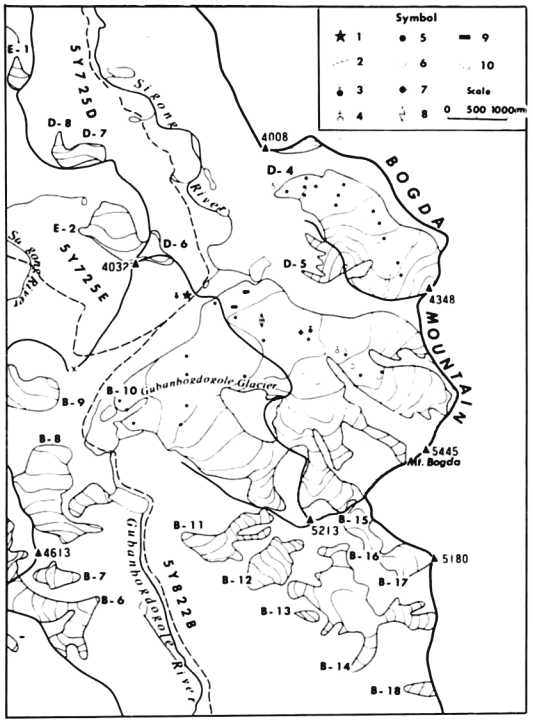

Fig.1: Glaciers of the Mt Bogda Region

(1 = base camp: 2 = expedition route: 3 = met stn: 4 = precip stn: 5 = stake: 6 = snow pit: 7 = temp hole: 8 = gl. structure observation: 9 = runoff obs. site: 10 = lake)

The expedition studied alpine meteorology, firn stratigraphy and ice formation, and the glaciers' accumulation, ablation, mass balance, movement, deformation, structure, temperature, variation and meltwater runoff, etc. Samples of precipitation, ice and snow were colleged for ^{18}O analysis. Glacial geomorphological investigations were extended beyond the glaciers to cover the valleys of the Sigong, Sangong and Gubanbogdogole rivers and included the landforms of glacier erosion and deposition, glacier sedimentation and moraine formation, the periglacial landscape and avalanches.

Victory Pass is located in the Tiangol Mountains, a branch of the Tian Shan Mountains, southwest of the Ürümqi Region. The base camp here was established at the Tian Shan Glaciological Research Station (3590 m) on the northern side of Victory Pass. This is the LIGC station described previously in ICE (No.65, p.14, 1981). In 1981, more than 50 people were undertaking multidisciplinary research. Glaciological studies included mass balance, ice formation and temperature, glacier dynamics, depth sounding, radiation etc. Of particular interest is the glacier dynamics project involving a 100 m long tunnel. The expedition visited this area twice, from 7-19 July and from 14-17 August. In addition to involvement with the ongoing programme of the station, members made observations on the structure of Glacier No.3 (0.53 km²), collected more samples for ^{18}O analysis and studied the firn stratigraphy on Glacier No.1 (1.83 km²) (Figure 2).

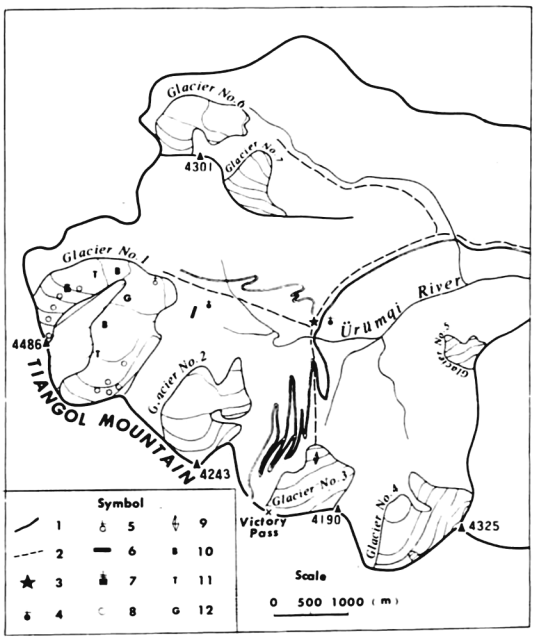

Fig.2: Glaciers on the north side of Victory Pass, the research area for the Tian Shan Glaciological Research Station in 1981

(1 = highway: 2 = expedition route: 3 = Res. Stn: 4 = met stn: 5 = precip stn: 6 = gauging stn: 7 = telemetry stn: 8 = snow pit: 9 = gl. structure observation: 10 = mass balance obs: 11 = ice temp: 12 = geophysical survey)

Data collected by the expedition is now being processed. A workshop on the results was to be held in Lanzhou in May, 1982, at which it was expected some 20 papers would be presented. The proceedings will be published in Chinese and English in the "Journal of Glaciology and Cryopedology".

This cooperative expedition provided an excellent opportunity for the exchange of ideas and techniques and their application to research in the regions studied. It is now possible to compare the results obtained by Chinese and Japanese glaciologists throughout Asia and it is hoped to gain further insights into the glacier characteristics of Central Asia and the Qinghai-Xizang Plateau. Such cooperative ventures will be continued in the future.

IMPURITIES IN THE DYE 3 DEEP CORE

(C.U. Hammer and H.B. Clausen, Geophysical Isotope Laboratory <GIL>, University of Copenhagen <UCPH>)

During the deep drilling from 1979-81, at Dye 3, South Greenland, various ice core analyses were performed in the field. GIL measured a continuous acidity (solid conductivity) profile along the ice core in cooperation with the University of Bern. The analysis took place *in situ* in order to save time and to avoid an as yet not very well understood ageing effect in the ice cores. The continuous profile corresponds to some 2 mill. acidity samples along the 2035 m core. Several large volcanic eruptions were revealed in the Holocene ice. The Wisconsin Ice Age ice was generally alkaline and a standard pH technique was used to measure the degree of alkalinity.

The pH measurements were performed as the last step in a continuous flow-system, through which water passed from a melted groove along the cleaned ice core surface. The system continuously records dust concentration, electrical conductance and pH.

The Holocene ice ends at 1785 m depth. The raw data show high and variable dust concentrations during the ice age, which vary in phase with oxygen isotope ratios. The dust is alkaline and the electrical conductance can be divided into an alkaline and a neutral part (mainly sea salts).

The [illegible] measurements of electrical conductance and pH, in a continuous flow-system, allowed corrections for atmospheric CO_2 influence and saved analysis time.

RECOVERY OF THE GISP DRILL AT DYE 3

(N. Gunderstrup, GIL/UCPH)

The GISP deep ice core drilling at Dye 3 terminated on 10 August 1981 when the drill got stuck at 2037 m after recovery of 2035 m of continuous ice core, including 22 m of silty ice.

The drill was left with a cable tension of 60% of the specified breaking value, and considerable amounts of high density tetrachlorethylene were poured into the drill hole to establish an excess pressure at the bottom.

When the drill shelter was re-visited in early June 1982, the drill had loosened and was easily hoisted to the surface with an additional 1.82 m of silty ice core.

The drill is in good condition. Only a minor amount of hole fluid had penetrated into the sealed pressure chamber during the 10 months of more than 180 bar pressure. The entire drill equipment has now been moved to Søndre Strømfjord.

A complete temperature profile was measured along the drill hole and PICO extended the casing to the present outside snow surface to save the drill hole for future measurements.

DYE 3 ICE FLOW CALCULATIONS

(N. Reeh and D. Dahl-Jensen, GIL/UCPH)

To aid the interpretation of results from the deep ice core at Dye 3 a steady state model for the ice flow upslope of the drill site has been developed. To cope with the irregular topography of the ice sheet base and the irregular distribution of the surface accumulation rate, the flow model is based on perturbation techniques: ice flow is divided into (i) a "basic" flow, accounting for the influence of the large scale trends of the ice thickness and accumulation rate upslope, and (ii) a "perturbation" flow, accounting for the influence of the upstream deviations from the trend-lines of these quantities.

Input data are: (a) the distribution along the flow line of surface- and base-elevations, (b) the distribution along the flow line of the accumulation rate, (c) the temperature depth profile, and (d) surface velocities. The dependence of ice flow properties on the stress- and temperature-fields (Glen's law) is taken into account. Flow law parameters are derived from modelling "basic" flow (given values in reasonable agreement with hitherto derived values) and are used as input to the "perturbation" flow model.

The model calculations seem to explain the essential features of the observed annual layer thickness profile along the deep core, with the exception of the deepest part where the steady state assumption probably breaks down. Also, the calculations emphasize the importance of detailed upslope studies for proper interpretation of the results from deep ice cores, recovered from sites where horizontal flow is not negligible.

UPSTREAM TOPOGRAPHY AT DYE 3

(N. Gundestrup, GIL/UCPH; S. Overgaard, Electromagnetics Institute, <EMI/TUD>)

The upstream topography from the deep drill hole at Dye 3 has been measured. The survey included radar ice thickness measurements made with a 60 MHz radar, and surface elevations as measured by a two pressure altimeter method. All measurements are performed along great circles with end points determined to within 10 m by a "geoceiver".

The survey has shown a very mountainous landscape beneath the ice, with great differences within 2 km, both along and across the flow-line. This may have a major impact on the dating of the lowest part of the deep ice core from Dye 3.

COMPLEX DIELECTRIC CONSTANT OF GLACIER ICE

(S. Overgaard and P. Gudmandsen, EMI/TUD)

Measurements of the dielectric constant have been performed on selected samples from the deep ice core recovered at Dye 3. The measurements show that the internal reflection layers in the ice sheet detected by radio echo soundings are layers of high conductivity. Furthermore, the layers are found at depths where the ice shows increased acidity, due to well dated volcanic eruptions.

SERMILIK STATION (E. GREENLAND), FIELD WORK

(B. Hasholt and H. Søgaard, Geografisk Centralinstitut, University of Copenhagen)

Measurements of precipitation distribution and climatological parameters (radiation, temperature, humidity and wind) were continued to determine run-off and sediment transport from the Midtluaqkat Glacier. Observations of the glacier snout and a stake network are also carried out to determine the glacier's mass balance.

JOHAN DAHL LAND (S. GREENLAND)

(P. Clement, Geological Survey of Greenland <GGU>, Copenhagen)

In 1981 field work was concentrated on the Nordbogletscher (1AG05001), an outlet from the Inland Ice with an area of 208 km². It terminates in the Nordbosø (660 m a.s.l.) which has been proposed as a reservoir for a hydrological project. The mean specific winter balance was estimated to be 0.71 m H_2O and the specific summer balance -0.95 m H_2O; the net balance for 1980/81 thus showed a deficit of -0.24 m H_2O on average over the whole glacier area. However, there are problems in connecting the mass balance data to the measured runoff from Nordbosø – the run-off was in fact less than the summer balance. It is believed that this discrepancy is a problem of delineation between the topographic area (based on map sheets only) and the hydrological area (which is unknown).

Measurements were also carried out on a small local glacier (1.9 km²), situated inside the Johan Dahl Land basin. The net balance for 1980/81 was negative with an average value of -0.50 m H_2O.

Other investigations in the area included meteorological observations and detailed ablation measurements on the tongue of Nordbogletscher. Inflow to an ice-dammed lake, on the eastern flank of this glacier, was continuously recorded and the outflow calculated. Observations were also made on glacier fluctuations; the outlet glaciers in the area generally speaking are growing; for instance Nordbogletscher has advanced 665 m since 1942.

QAMANÂRSSÛP SERMIA, WEST GREENLAND

(O.B. Olesen and R.J. Braithwaite, GGU)

Field work on the QamanÂrssÛp sermia (1CH-21002) continued in 1981 and consisted of measurements of annual balances in the ablation area, surveys of ice movement, and collection of climatic data from the base camp close to the side of the glacier. The average summer temperature for 1981 was almost the same as for 1980 but the 1981 summer had more precipitation, less sunshine and more ablation. Comparison of 1980 and 1981 records at QamanÂrssÛp sermia with those at Gôdthab show that the area is both warmer and drier. This may indicate greater continentality of climate compared to the coast near Gôdthab.

DENMARK (NORWAY)

OKSTINDAN, NORWAY

(N.T. Knudsen and J.T. Møller, Geological Institute, Århus University; W.H. Theakstone, Manchester University, U.K.)

Measurements of meterological variables including radiation, temperature, wind speed 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 collected twice a day during the field period in the meltwater stream were analysed for chemical constituents. Ice surface velocities were determined at 12 stakes placed in the ablation area the previous summer, and daily velocities at 5 stakes during a 3 week period. Austre Okstindbre was measured using terrestrial photogrammetry as were Fingerbreen and Lappebreen, Svartisen.

A. Weidick

INDIA

GLACIOLOGICAL STUDIES IN THE HIMALAYAS

Outside the polar regions, the Himalayas probably possess the largest glacier (water) resource in the world; roughly estimated at more than 10,000 glaciers with an ice volume about $0.0014 \times 10^6 km^3$, the largest being the Siachen Glacier some 75 km long. The melt contribution to the rivers of the northern Himalayas is as much as 25% of the annual discharge. The first attempt to assess the thickness of glacier ice was carried out by the Geological Survey of India (GSI) in 1965 on the Zemu Glacier in Sikkim.

With the formation of the Snow, Ice and Glaciology Division within the GSI, glacier studies in the Himalayas have been taken up in a comprehensive manner and besides glacier inventory include mass balance studies, hydrometeorology, suspended sediment transport, snow cover assessment, etc.

At present seven glaciers are under study; namely, the Gara, Gor Garang and Shaune (Mastrang) in the Sutlej basin, the Neh-nar in the Jhelum basin, the Tipra Bank in the Ganga basin (northern Himalayas) and the Changme Khangpu and Zemu in the Ganga basin (eastern Himalayas).

GLACIER STUDIES – GARA GLACIER

The first reconnaissance expedition to the north-facing Gara Glacier was launched in 1973 and since 1974 the glacier has been under continuous investigation of mass balance, hydrometeorology, variations, geomorphology, thickness, movement and temperature.

From 1974-75 and 1975-76 the glacier showed a positive balance but thereafter a continuously negative trend. Suspended sediment transport recorded in the glacier stream varied from 50.68 to 280.06 mg/l. The snout retreated 12 m/a from 1973-1975, advanced 5 m in 1975 and then remained almost stationary until 1977. Ice thicknesses vary from 63 m at 4817 m a.s.l. to 250 m at 5100 m. Flow rates ranged from 0.50 to 25 m/a in different parts of the glacier and the mass transfer of glacier ice showed a continuous high wave up to 1978, thereafter the wave receded.

GOR GARANG GLACIER

The mass balance calculated so far has remained negative for the balance years 1976-77 to 1980-81. Water discharge of the glacier stream is recorded continuously from July to September. The snouts of the four glaciers in the Gor Garang basin have been monitored every year since 1976. All have shown a continuous retreat varying from 2 m to 22 m.

SHAUNE (MASTRANG) GLACIER

Studies on this glacier began in the summer of 1981. Fifty-two stakes have been fixed for periodic monitoring of the ablation rate, a site selected for measurement of the discharge of the meltwater stream, geomorphological features mapped, and the snout position marked for an annual survey.

NEH-NAR GLACIER

This glacier has shown a negative mass balance for the years 1975 to 1981. The ice is 120 m thick near the base of the icefall. The position of the snout has been monitored every year since 1975 and has shown an average retreat of 3 m/a.

TIPRA BANK GLACIER

Resistivity and magnetic surveys have been conducted to assess the thickness of the glacier ice and the data is being processed.

CHANGME KHANGPU GLACIER

This glacier, in the eastern Himalayas, has been under investigation since 1976. Mass balance has shown a continuously negative trend for all these years. Ice thickness in the ablation zone has been assessed by seismic profiling. The snout has been showing a continuous retreat of 5-10 m/a.

ZEMU GLACIER

Zemu Glacier, the largest in the Sikkim Himalaya, under observation since 1975, has shown a negative mass balance. Its thickness varies from 200-400 m along the longitudinal profile. Systematic monitoring of the snout has revealed continuous retreat rates of about 16 m/a.

ARTIFICIAL AUGMENTATION OF GLACIER MELT

An experiment to augment ice melt on the Gara Glacier using coal dust was carried out in 1975. Similar experiments were carried out in 1978 on the Changme Khangpu Glacier when coal dust wetted with sodium carbonate, bicarbonate and polyphosphate and unwetted coal dust was used.

SEASONAL SNOW COVER

Snow cover assessment studies have been conducted in the Beas River basin, northern Himalayas, since April 1977. The seasonal snow cover is monitored periodically and the daily depletion rate observed through a network of ablation stakes. A gauging station on the Beas River provides hourly discharge data on snowmelt. Using satellite imagery, the interpretation of snow cover over wider areas, its accumulation, depletion, and its contribution to run-off is planned.

GLACIER INVENTORY

The glacier inventory of four sub-basins, the Baspa and Tirung khed in the Sutlej basin and the Sind and Liddar in the Jhelum basin, has been completed according to the Unesco guidelines. That of the Saraswati sub-basin, Ganga basin, is almost complete.

A glacier map of the Chenab and Ravi river basins has been prepared at the 1:250,000 scale on Survey of India topo-sheets showing drainage codes up to the 5th order, according to the new Unesco identification system. The percent glacierized area and the area of individual glaciers have been computed and shown on the map.

TERRESTRIAL PHOTOGRAMMETRIC SURVEY

Maps of the entire Neh-nar Glacier and of the snout of the Satapanth Glacier have been prepared. Similar photogrammetric surveys have been extended to the Harmukh and Tipra Bank glaciers, snout maps of which are under preparation.

TRAINING COURSE

A training course in glaciology, glacial hydrology and related disciplines like glacier inventory, snow cover assessment, etc., was held under the aegis of the GSI Training Institute at the Neh-nar Glacier and Baltal, Kashmir, from 16 August to 2 September 1981.

AVALANCHE STUDIES

A study of avalanches in the Sind valley of Kashmir was undertaken during the winters of 1979-80 and 1980-81 to assess the feasibility of certain hydro-electric proposals. The studies included demarcation, classification and zonation of active avalanches and also density determinations of avalanche snow, emphasizing the suggested structure sites.

M.N. Sehgal

The Japanese polar subprogramme, Polex-north, Polex-south and numerical experiments at home laboratories, have been conducted since 1978 in conjunction with the Global Atmospheric Research Programme (GARP). Experiments in the Antarctic are still in progress, but those in the Arctic were successfully completed at Inuvik, Arctic Canada, in the winter of 1979-1980. Modelling studies have also been going on since 1979, to study the effects of radiation, clouds, low level inversion and ice boundary in the Antarctic, effects of clouds in the Arctic, large scale interaction between Arctic ice area and Northern Hemisphere atmosphere, and ice dynamics in the Arctic.

POLEX-NORTH

Experiments in the Arctic (Polex-north) were carried out at Inuvik (68°22'N, 133°42'W), in Arctic Canada, during the period from November 1979 to January 1980. The main object of the experiments was to study the mechanism of variation of heat sink in the Arctic area through observations of clouds and precipitation. The main observations and main observers were as follows: (1) observation of the fine structure of precipitating clouds by 8.6 mm vertically pointing radar (T. Takeda and Y.Fujiyoshi, Water Research Institute, Nagoya University <WRI>), (2) observation of distribution and movement of precipitating clouds by 3.2 cm PPI radar (K. Kikuchi, Department of Geophysics, Hokkaido University <HU>), (3) observation of types and numbers of snow crystals on the ground by the use of the plastic replica method, microscopes and automatic recorder (K. Kikuchi), and (4) sampling of new snow and deposited snow for the measurement of $\delta^{18}O$ and trace elements (K. Kato, WRI). The observations were successful since various types of snowfall occurred during the observation period when the air temperature changed from 0°C to -40°C near the ground. Preliminary results obtained from the observations and the data have been reported as "Observations of clouds and precipitation in the Arctic, Canada", edited by K. Higuchi, T. Takeda and K Kikuchi (Organizing Committee for POLEX, Tokyo, 189 p., 1981). A summary of the results obtained in these field experiments was also published recently in "Memoirs of the National Institute of Polar Research" (NIPR), Special Issue No.19 (Proceedings of the Third Symposium on Polar Meteorology and Glaciology, edited by K.Kusunoki, NIPR, 1981)

POLEX-SOUTH

The 3-year Polex-south programme, previously reported in ICE (No.60, 1979), continued through 1981. The glaciological and glacio-meteorological observations were carried out by S. Mae, M. Wada and T. Yamanouchi of NIPR as the wintering members of the 20th Japanese Antarctic Research Expedition (JARE-20) from February 1979 to January 1980. An automatic weather station was constructed at St. Y100 (71°17'S, 46°19'E) to obtain meteorological data in the inland area. Net accumulation measurements and radio echo soundings were also made on the way from Mizuho Station to St. Y100. Glaciological data collected in 1979-1980 by JARE-20 were published by NIPR in JARE Data Reports No.63 (Glaciology 7), and includes net accumulation at Mizuho Station and that along the oversnow traverse route from Syowa to Mizuho and from Mizuho to St.Y100, surface synoptic observations during the oversnow traverse, and results of radio echo sounding between Mizuho and St. Y100. Meteorological data obtained in 1979-1980 by JARE-20 was published by NIPR in JARE Data Reports No.57 (Meteorology 7: Meteorological Data by M. Wada et al.), No.62 (Meteorology 8: Micrometeorological Data by M. Wada et al.), and No.61 (Meteorology 9: Radiation data by T. Yamanouchi et al.). The analysed results obtained in 1979-1980 by JARE-20 were also recently published in NIPR Memoirs, special issue No.19 (edited by K. Kusunoki, 320 p., 1981).

S. Kawaguchi and T. Ôhata (NIPR) and S. Kobayaski and N. Ishikawa of the Institute of Low Temperature Science (ILTS), Hokkaido University, stayed at Mizuho and/or Syowa Station from January 1980 to January 1981 as the wintering members of JARE-21, and conducted glaciological and glacio-meteorological observations such as heat and mass budget at the ice surface, vertical profiles of drifting snow between 0.5 and 30 m with drawer-type collectors, snow accumulation with offset markers at Mizuho, radiation and heat budget on the sea ice around Syowa Station from August to December 1980, and so forth. Together with the observations in the lower boundary layer on ice, the atmospheric structure over the katabatic wind zone was investigated at Mizuho by means of both conventional radiosondes, low-altitude radiosondes and sonic radars in conjunction with water vapour flux, general circulation of air above the ice sheet, atmospheric disturbance due to cyclones, heat balance of the ice sheet and so on. Airborne radiation measurements and ice surface morphology observations with a multi-band camera were carried out along the Soya Coast in September 1980, and airphotos were taken with a multi-band camera in the vicinity of Yamato Mountains and Sør Rondane Mountains during the 1980-1981 field season.

Artificial explosion experiments to study the structure of the earth's crust were carried out between Syowa and Mizuho in October 1980. Two ice cores were retrieved from the holes to insert explosives; about 100 m from St. H231 (69°46'S, 42°28'E, 1667 m a.s.l.) and about 143 m from Mizuho Station. These are now in cold storage at NIPR and have been analysed by core investigators.

A 3-man party (J. Inoue, Kyoto University; H. Satow, Nagoya College of Technology; H. Nishimura, NIPR) is working on air-ice sheet interactions as part of the last year's

programme of the Japanese Polex-south (JARE-22). Glaciological observations are mainly conducted at Mizuho Station and inland during oversnow traverses,for studying local weather and climate characteristics. The main glaciological items are the physical properties of the surface snow layer, snow accumulation measurement with offset markers and pits, surface flow and strain measurements with JMR, airborne observations of surface temperature with laser profiler and radiometer (summer 1981-1982), and collection of snow and ice samples for physical and chemical analyses.

EAST QUEEN MAUD LAND PROJECT

From 1982 until at least 1988, the JARE will carry out a combined research project in east Queen Maud Land with glaciologists, geologists, geomorphologists and solid earth geophysicists. For the first 5 years, the major emphasis will be on a series of glaciological observations. The proposed research area is bounded approximately by longitudes 50° and 20° E, latitude 80°S and the Antarctic coast. Mizuho Station will be maintained year-round and a temporary camp opened for one year at about 75°S and 35°E. The research area is contiguous with the IAGP area and research subjects are compatible with its objectives.

One of the aims of the Japanese project is to reveal the effect of a mountain chain (Yamato, Belgica and Sør Rondane) on the flow regime of the ice sheet in east Queen Maud Land. It is anticipated that the flow regime in the hinterland of this mountain chain may be different from the presumably unstable Mizuho Plateau where the Shirase Glacier is the major outlet. Comparative study of these two areas may permit elucidation of the regional characteristics of the east Antarctic ice sheet. Oversnow traverses and station glaciology will be the main research activities supplemented with airborne observations such as radio echo sounding, passive and active microwave measurement, radiation properties of the atmosphere and ice surface, and an aerial photogrammetric survey of the ice margins. A medium depth drilling, of about 500 m, is planned at Mizuho Station where preparations will start in the winter of 1982. Two longitudinal oversnow traverses, one in the upstream area of Shirase Glacier and the other from the southern end of the Yamato Mountains inland, will be carried out in the 1982-1983 field season. Offset markers will be installed during the traverses to measure accumulation and surface flow, and shallow drilling, to 100 m, will be conducted at several sites during the traverse. Positions will be determined by Doppler satellite navigation and radio echo soundings will be carried out. Glacio-meteorological observations will be conducted at Mizuho Station. A 5-man party (F. Nishio, N. Katsushima, NIPR; S. Takahashi, Kitami Institute of Technology; M. Ishikawa, H. Ohmae, ILTS) has joined the first year's programme of this project as the wintering members of JARE-23 from February 1982 to January 1983.

K. Kusunoki (NIPR) and G. Wakahama (ILTS)

JAPAN (NEPAL HIMALAYA)

A further volume of results from the 1978 Glaciological Expedition to Nepal (GEN) has been published as a special issue of Seppyo, the Journal of the Japanese Society of Snow and Ice (Vol.41, 1980). It deals with (1) studies of supraglacial debris on the Khumbu Glacier, (2) the mass and heat balance of glacier AX-010, Shorong Himal, (3) meteorological phenomena in the Nepal Himalaya, and (4) glacial geology of the Nepal Himalaya. Further information is available from K. Higuchi, WRI, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464, Japan.

A study of crustal movements in the central Nepal Himalaya led by K. Kizaki, Ryukyu University, with permission from His Majesty's Government (HMG) and in cooperation with the Department of Mines and Geology and Tribhuvan University (TU) during the post-monsoon season in 1980 included glacial geology, geomorphology and geology in the central Nepal Himalaya. S.Iwata and H. Yamanaka, following a trip along the Kali Gandaki and Marsyandi rivers, north of the Mt. Annapurna (8091 m) region, reported evidence of two stages of last glacial age moraines corresponding to terrace surfaces on the tributaries of the Kali Gandaki.

Glacial and geomorphological observations in the Khumbu Himal were carried out by the Japan Winter Everest Expedition 1980/1981 (leader N. Uemura). T. Koaze and S. Okazawa, Meiji University, measured rock surface temperatures and made meteorological observations at 5,400 m a.s.l. Recent fluctuations of the termini of glaciers CB-480 (Gyajo), EB-050 and ED-580 (Chukhung) were surveyed. M. Yoshida (WRI) made shallow drillings in the accumulation area of Khumbu Glacier. Two ice cores, 10 m deep from 6,000 m and 4 m from 6,500 m, were sent to Japan for study. At 6,000 m, firn temperatures below 6 m were found to be close to 0°C, although the mean annual air temperature is estimated to be around -10°C. The core from the middle part of the accumulation area (6,500 m) shows only a 40 cm thick firn layer; below this is nearly bubble-free ice with 4 dirt layers. The cores are being studied for stratigraphy and the chemical composition of particulate and dissolved matter.

K. Ikegami (WRI) and N. Azuma (HU) carried out ice drilling to 5 m at 6140 m in the firn area of the lower Barun Glacier (27°45'N, 87°E) in eastern Nepal and meteorological observations at 4980 m in December 1980, as

part of the Academic Alpine Club of Hokkaido Mt. Baruntse (7220 m) Expedition '80/81 winter. They made stratigraphic studies and determined the oxygen isotope composition of the firn,from which they estimated annual deposition at that altitude at 700-1100 mm H_2O.

T. Iozawa, a member of the Himalayan Association of Japan (HAJ) expedition to Mts. Kangchenjunga (8598 m) and Yalung Kang (8508 m), made a trigonometrical survey of the Yalung Glacier to the S and the Kangchenjunga Glacier to the N, and measured flow on the former during the pre-monsoon season of 1981.

H. Hara, of the Japan Worker's Alpine Federation and Nepal Police Mountaineering Foundation Expedition to Mt.Cho Oyu (8153 m), east Nepal, made meteorological observations and collected snow samples on Ngojumba Glacier in the pre-monsoon season of 1981.

A GEN Drilling Project, led by K. Higuchi (WRI) with permission from HMG and in cooperation with TU, has been organized for glaciological and paleoclimatological observations of glaciers in the Nepal Himalaya (Langtang, Khumbu and Dhaulagiri Himals). Activities conducted in the post-monsoon season of 1981 were: (1) drilling of glacier ice in Langtang Himal, north-central Nepal, (2) analyses of stable oxygen isotope and other chemical components (^{210}Pb,^{32}Si, solid particle concentration and gross β activity), (3) measurements of mass balance,glacier flow and hydrology, and (4) glacial geology from dating moraines, sediments and pollen analyses.

K. Higuchi (WRI)

JAPAN (CHINA)

K. Yokoyama and K. Kai, of the Japanese Alpine Club Expedition to Mt. Qomolangma (8848 m, Everest), in Xiang (Tibet), made glacio-geological and periglacial observations on the Rongbuk Glacier in the pre-monsoon season of 1980, as a continuation of the 1979 preliminary observations.

H. Wushiki, Tokyo Institute of Technology, and H. Fushimi (WRI) joined a scientific expedition from the Trans-Himalaya to the Great Himalayas after a one week symposium on the Qinghai-Xizang Plateau organized by Academia Sinica in May and June, 1980 in Beijing. Since the interior of Asia, including the Great Himalayas and the Tibetan Plateau, has risen during the late Cenozoic and the Tibetan regions are thought to have been influenced by the large changes in the topography/climate system, there is important evidence on the influence of this system on the regional and historical characteristics of glaciers in relation to the upheaval of the Qinghai-Xizang Plateau.

In August 1980, K. Higuchi (WRI) visited the glaciers at the headwaters of the Urümqi River, eastern Tian Shan, in cooperation with the Lanzhou Institute of Glaciology and Cryopedology.

S. Suizu, of the Joetsu Mountaineering Association party to Mt. Anyêmaqên (6282 m), of the Jishi Range, Qinghai Province, made glaciological observations on accumulation processes and glacier flow and found that the annual flow rate of Halong No.1 Glacier was at least 15 m at 4830 m a.s.l. and that the firn layers at a depth of 323 cm, at 5175 m a.s.l., are composed of granular snow, depth hoar, ice layers and dirt layers.

M. Abe, of the Hokkaido Mountaineering Federation party to Mt. Minya Konka (Gongga, 7590 m), in Ganzê Xizang (Tibet) Autonomous Prefecture, Sichuan Province, made meteorological and glacio-geological observations on the Hailuogou and Yanzigou glaciers during April and May, 1981, as a continuation of the 1980 reconnaissance, and found a large terminal recession of the Yanzigou Glacier of 3.4 km since the 1930s.

J Tabei and S. Kitamura, members of the Japanese Women's Climbing Club party to Mt. Xixagbangma (8012 m), in Xizang, made meteorological observations and collected snow samples along the Yebokanggle Glacier and even from the top of Mt. Xixabangma, in the pre-monsoon season of 1981.

O. Watanabe (WRI) and Y. Ageta, Yamaguchi University, joined the Chinese-Japanese Cooperative Tian Shan Glaciological Expedition in June and August, 1981. They made stratigraphical and structural observations, mass balance and glacier flow measurements, and collections of snow samples on glaciers No.1 and No.3 in the Ürümqi River headwaters and on glaciers in the Sigong River headwaters, Mt. Bogda area (see this Issue p.2).

A. Nagoshi and Y. Maruo, of the Mt. Bogda (5445 m) Expedition of the Japanese Alpine Club, Student Section, made meteorological observations, glacier flow measurements, mapping and glaciation studies on glaciers around the Mt. Bogda area in the eastern Tian Shan during August and September, 1981.

K. Yokayama, of the Kyoto Reconnaissance party to Mt. Langtang Ri (7239 m), southern Xizang, made meteorological and glacio-geological observations, and collected snow and water samples.

K. Higuchi (WRI)

JAPAN

SNOW HYDROLOGY

(K. Kojima, ILTS, Hokkaido University)

The mechanisms of snow melting and snowmelt runoff have been studied at a research basin in Moshiri, Hokkaido, where the land is covered with snow during six months of the year with the usual maximum depth of about 2 m and a daily minimum air temperature frequently

below -30°C in winter. Runoff from the basin (11.4 km² in area and ranging from 290-600 m in altitude) is observed all year round, and percolation of melt water from snow to the ground has been continuously recorded by lysimeters throughout each snow season since the 1979-80 winter. The melting rate at the bottom of the snowpack has been separately measured by observations of heat fluxes in the ground and within the snowpack. It has been found that the bottom melt of the snowpack in the basin supplies a considerable part of the base flow of the stream in winter. Delay in snowmelt runoff has also been studied in relation to the melting rate (cm-water/day), the amount of snow (cm-snow), and the areal size of the watershed (km²). The heat budget of a small stream, covered with deep snow in a very cold climate, was studied by measuring temperatures of water, snow, and the bed of the stream in detail.

Distributions of snow accumulation and ablation in the research basin are planned to be restudied by scattering many battery driven long-term snow-depth recorders (developed by H. Aburakawa) and by repeating snow surveys. This is part of a project for estimating the basin-wide melting rate and runoff on the basis of the meteorological data obtained at a station near the outlet of the basin. All of these have been done by the staff and students of the Snowmelt Section (Head: K. Kojima) of ILTS.

T. Yamada and his group (ILTS) studied snow distributions along the slopes of higher mountains, and found a linear relation between the water equivalent of snow accumulated on a slope in each one month period and the altitude below timberline, which is generally about 1400 m a.s.l. in Hokkaido. The altitude dependence of snowpack water equivalent during the melt period was also found to be linear. The inclination of the regression line of snow amount vs. altitude increases from the beginning of winter toward the beginning of the melt period at the highest place of the slope or the timberline, but after that, it is kept constant during the late melt period. These results and an empirical relation between melting rate and the mean air temperature make it possible to estimate the seasonal maximum of snow amount on a snow line at a time of melt period if meteorological data at the foot of the slope are available. LANDSAT data was applied to find the distribution of snow lines all over Hokkaido on 21-22 May 1979 and to estimate the maximum snow amounts of the 1978-79 winter at various mountainous places in Hokkaido.

A beautiful map of snow distribution around the summit of Mt. Chōkai (2230 m), in the northern part of Honshu, Japan, was recently presented by I. Tsuchiya, National Institute for Environmental Studies, in a paper entitled "Digital analyses on the seasonal change of the remnant snowpack of Mt. Chōkai based on the data of LANDSAT".

Some examples of analyses of runoff from snowy basins in Honshu using Sugawara's Tank Models for runoff computations have been reported. Direct measurements of the water equivalent of snow are being attempted by new methods, which are detection of cosmic rays absorbed by the snow pack and microwave techniques.

The problems which are not yet satisfactorily solved in Japan are, for example (1) estimation or observation of the amount of evaporation (sublimation) of snow in winter as a part of the water balance of a basin, (2) exact and reasonable transformation from snow depth data to water equivalent,and (3) effect of microscopic snow structures upon discharge of melt water.

SNOW IN URBAN AREAS

(R. Naruse, ILTS, Hokkaido University)

Heavy snowfall in urban areas sometimes causes much trouble for railway and highway traffic, as well as for life in the northern and northwestern parts of Japan. Research on snow deposition has been made over several winters in Sapporo, Hokkaido, for the study of the mechanism controlling the uneven distribution of snow deposition in the area (R. Naruse and H. Aburakawa, ILTS). Enormous snowfalls lasted from the end of December 1980 to January 1981 in the Hokuriku district, west-central Japan; the maximum snow depth reached 2 m or more in some urban areas. Snow in the district is characteristically wet and heavy; 300-450 kg/m³ mean density for newly deposited snow covers. Urban damage and disruption from these snowfalls were studied by two project groups supervised by Z. Watanabe, Fukushima University, and T. Nakatao, Fukui University.

AVALANCHES

(H. Shimizu, ILTS, Hokkaido University)

M. Ishikawa and others of the Forest Experiment Station, Ibaragi, have studied snow glide on slopes and snow pressure distribution on avalanche fences. They found that the glide motion of damp or wet snow in the southern part of northern Japan is much more active than for the usual dry snow. They obtained values of 4-5 for the glide coefficient and 2 for the edge effect coefficient, caused by less viscosity of damp/wet snow; the Swiss standard gives coefficients of 3 and 3-4 respectively. Therefore, newly designed fences effective for such damp/wet snow are required in this district.

M. Nakagawa and others, Toyama University, and H. Shimizu and others (ILTS) carried out studies on high speed avalanches which frequently break out every winter in Kurobe Canyon, North Japan Alps. The principal object of the research was to make the real motion of the high speed avalanche clear in detail, for its dynamic analysis. The maximum records obtained by an automatic recording system were 150 t/m² of impact pressure, and

more than 30 mb of instantaneous barometric depression which occurred as a high speed avalanche passed by; avalanche speed was estimated in the range of 30-150 m/s, though some problems in analysis remain. At the end of 1980, big high speed avalanches assaulted the observation site from the side, and three reinforced concrete platforms for instruments, 45, 25 and 4.5 tons in weight respectively, were all blown away into the valley.

T. Huzioka and others of ILTS have carried out fundamental observations, measurements and experiments on the behaviour of the snow cover on slopes at Toikanbetsu, northern Hokkaido. Creep- and glide-motion, and mechanical properties of the snow cover were precisely measured. The effects of ground surface topography and vegetation on the glide motion of snow, the generation of cracks, swellings and the surface folds of the snow cover were observed in relation to avalanche release. Most of this research was carried out both in the laboratory and the field.

Fluidization of snow is an interesting problem for avalanche motion, especially for high speed avalanches of dry snow. A series of experiments on this were carried out by N. Maeno and others of ILTS. Fluidization of snow occurred when wind speed came up to a certain value depending on snow condition and the viscosity of fluidized snow decreased rapidly as the wind speed increased and snow particle size decreased; in the case of 1.2 mm diameter snow particles, viscosity decreased to that of water.

FROZEN GROUND AND FROST HEAVING

(S. Kinosita, ILTS, Hokkaido University)

Joint studies on physical and biological environments in permafrost were conducted by S. Kinosita and others (ILTS) in and around Tuktoyaktuk, Mackenzie Delta,Canada, in the summer, July-August 1980, and winter, February-March 1981. The studies continued those carried out in 1974 and 1977. The physical subgroup observed the thermal regime, water permeability and micro-topography of the uppermost layer in tundra areas, together with the oxygen isotopic concentration in ground ice. The results obtained will be published in English by ILTS in 1982.

S. Kinosita and his colleagues have carried out laboratory and field studies of frost heaving and associated phenomena. They made observations at the Tomakomai field site on frost heaving of soils in four waterproof basins, making continuous measurements of heave amount throughout the winter season in relation to groundwater level, stratigraphic profiles, etc. They also made observations on ground freezing around a small model tank, 1 m wide by 50 cm deep, set in a basin with a cold liquid at -20°C. M.Fukuda made continuous measurements throughout the winter on the soil moisture profile of a freezing soil in the basin using a neutron scattering method. He also made experimental studies of coupled heat and moisture transfer in soils during freezing. A dual-beam gamma apparatus was used to measure changes in soil density and moisture content. The experimental data showed movement of water through the frozen layer. T. Ishizaki and S. Kinosita measured freezing point depression in moist soil samples for soil which is saturated and under an overburden pressure and for soil which is unsaturated and under no overburden pressure. H. Izuta and Y. Suzuki have studied heat conduction in soil near 0°C using a thermal probe method. They found that the migration of unfrozen water in frozen soils played an important role in such heat conduction.

K. Horiguchi (ILTS) worked with Prof. R.D. Miller at Cornell University from 1979-81 on the hydraulic conductivity of frozen soil in the range 0° to -0.15°C. Measurements on a 4-8 μm silt fraction confirmed expectations of strong hysteresis effects in both hydraulic conductivity and unfrozen water content.

S. Sawada, Kitami Technical College, studied the thermal conductivity of frozen and unfrozen soil in the range 20° to -170°C. Measurements were made by a non-stationary absolute method using a thermal probe for a cylindrical soil sample. The results were very discontinuous around 0°C and show a strong dependence on soil type and moisture content.

T. Takashi, Seiken Co. Ltd., made a mathematical analysis of frost heaving mechanisms, and proposed a prediction formula of maximum heaving force and location where ice-lensing occurred in freezing soil. He and his colleagues have done experimental studies on the compressive strength of frozen soil as functions of moisture content, specimen size, unfrozen water content and soil type. They have also proposed a frost heave test system and developed an artifical freezing method for excavating tunnels in soft ground.

H. Yahagi, Hokkaido Education University at Kushiro, has proposed an apparatus which easily detects the frost penetration depth of freezing ground by using the large difference of electrical resistance between the unfrozen and frozen states of freezing soil.

Many underground LNG storage tanks (-10°C) as large as 70 m in width and 50 m in depth have recently been constructed around Tokyo. The ground surrounding these tanks has been freezing and sometimes heat fences were buried at several metres distance from the peripheries of the tanks in order to suppress the advance of the freezing front. The research institutes of the Tokyo Gas Co. Ltd., Kashima Construction Co. Ltd. and Shimizu Construction Co. Ltd. have made studies on the preestimation formula for the progress of the freezing front and the heaving amount around the tank and stress distribution inside the freezing ground around the tank.

PHYSICAL PROPERTIES OF ICE & SNOW

(N. Maeno, ILTS, Hokkaido University)

Internal friction of pure single-crystal ice was measured by M. Oguro, Hokkaido University

of Education, with the flexural vibration method. He found that the strength of the second peak appearing at temperatures lower than that due to Bjerrum orientation defects increases with annealing time. Similar results were obtained in the dielectric properties by I. Takei and N. Maeno (ILTS) who have developed a dielectric loop method for measurements of three-terminal guarded ice samples at temperatures and frequencies as low as -150°C and 10^{-6} Hz respectively. According to their measurements two additional dispersions were observed besides the Debye dispersion; one at higher frequencies tended to develop and the other at lower frequencies tended to diminish with annealing time. Large anisotropy was recognized in the static dielectric constant of pure ice by S. Kawada of Kanazawa University. His result shows that the static dielectric constant is the largest in the c-axis and follows a Curie-Weiss law, but that a Curie law holds in directions vertical to the c-axis.

The preferred growth and orientation of minute crystal grains in deformed ice were studied by T. Otomo and G. Wakaham (ILTS); also the orientations of crystal grains composing a droplet frozen on an ice surface were investigated by Y. Mizuno (ILTS) who suggests a relation between the crystallographic orientations of each grain and the ice substrate.

Regelation of ice was studied by several workers. N. Tozuka and G. Wakahama (ILTS) recognized the existence of transition pressures at which the regelation speed varied abruptly, and I. Kamiishi and K. Tusima, Toyama University, conducted an experiment similar to Telford and Turner's (1963) at temperatures extending to -5°C. Pressure increase due to freezing of water was studied by Y. Horiuchi (moved to Hokkaido Development Consultant) and N. Maeno (ILTS) in a rigid closed tube and a water drop freely suspended in liquid.

A theoretical study by T. Takahaski (ILTS) showed a possible stability of minute Ic (cubic) ice grains below a critical temperature. The stability is substantiated by the energetic advantage of lower surface energy of ice Ic. T. Kuroda (ILTS) discussed the growth kinetics of snow crystals in detail: he has shown that the complex temperature variation of the growth forms can be interpreted by the combination of the vapour-quasiliquid-solid, adhesive, and two-dimensional nucleation growth mechanisms on basal and prismatic planes. Experimentally T. Gonda and others of the Science University of Tokyo measured growth rates of snow crystals at temperatures below -20°C and low pressures, obtaining a result in harmony with Kuroda's theoretical expectation of a two-dimensional nucleation mechanism. Minute structures of ice frost grown in a helium atmosphere were studied by A. Yamashita of Osaka Kyoiku University.

H. Narita (ILTS) measured the tensile strength of homogeneous snow as a function of temperature, strain rate, specimen density and volume; ductile and brittle deformation types were recognized depending on the above parameters, and strength was found to decrease with increasing volume of a snow specimen. H. Kuriyama and others, Institute of Snow and Ice Studies (ISIS), Nagaoka, applied a vane-type device to the measurement of shear strength of snow. K.Sato and others from Hirosaki University made a preliminary measurement of acoustic emission from deformed snow. Compactive viscosity of snow was estimated by N. Maeno and H. Narita (ILTS) from density profiles of Antarctic snow at Mizuho Station; it was shown that the values were two orders of magnitude larger than those of ordinary seasonal snow, which was attributed to strong bonds between constituent ice particles within Antarctic snow which had been aged for prolonged periods.

Compressive deformation experiments of wet snow were conducted by H. Ohmae and G. Wakahama (ILTS) and M. Takikawa, Toyama University, and the strength of wet snow was measured by Z. Watanabe, Fukushima University.

BLOWING SNOW

(N. Maeno, ILTS, Hokkaido University)

S. Sato, Hirosaki University, has studied the initiation condition and the strength of blowing snow, and found a simple but useful index relating them to air temperature and wind speed. Saltation of snow particles in blowing snow was studied by T. Kikuchi (moved to Kochi University), K. Araoka (moved to Kisojiban Consultants), and N. Maeno (ILTS) using a cold wind tunnel (0.5 m x 0.5 m in cross section, 8 m long). Kikuchi obtained a friction velocity from a velocity-defect equation in a boundary layer to estimate the extent of horizontal momentum transport by saltating snow particles. Araoka and Maeno developed a photographic technique for observing the trajectories of saltating particles. Since these trajectories include time marks, the velocities and accelerations of each particle at every height can be estimated conveniently. The analyses showed properties of complex forces acting on snow particles in blowing snow. It was noted that in the very thin layer on a blowing snow surface, snow particles are "fluidized", and that the wind velocity at the geometrical snow surface is not zero; that is some wind strength might be found in the thin surface snow. This kind of air motion was studied by T. Ishida (ILTS) by measurement of the propagation of pressure waves in snow.

A study of the heat transfer efficiency in blowing snow was conducted by Y. Kaneda (moved to Japan Meteorology Agency) and N. Maeno (ILTS) in terms of wind velocity, concentration of snow particles and strength of turbulence, showing the importance of the motion of snow particles in the effective heat transfer in blowing snow. A simulation of the effects of forests and snow fences on

drifting was conducted by Y. Anno, Hokkaido Development Bureau, using activated clay particles. K. Ishimoto and others, of the same Bureau, studied the growth of snow drifts on slopes, and N. Naito (moved to Japan Meteorology Agency) and D. Kobayashi (ILTS) investigated the morphological development of snow cornices finding that they seldom form at wind speeds above 8 m/s.

G. Wakahama

NORWAY

ACTIVITIES OF NORSK POLARINSTITUT (NORWEGIAN POLAR INSTITUTE, NPRI)
(O. Orheim)

SVALBARD

Mass balance measurements have been carried out on two glaciers on Spitsbergen. Broggerbreen had a balance of -0.55 m w.e., and Lovenbreen -0.46 m. This was the 16th successive year of negative balances.

Abrahamsenbreen, an outlet glacier from Holtedahlfonna in NW Spitsbergen, is now surging and cutting off moraine arcs from tributary glaciers.

Sea ice investigations of Svalbard and adjoining areas include daily studies of satellite images covering the Greenland Sea and Barents Sea. Estimates of the ice outflow through Fram Strait have been made by comprehensive floe trackings on LANDSAT and weather satellite images. Altogether 28 automatic stations have been deployed during the ongoing "Ice Drift Experiment" (ICEX),initiated in 1976. The institute's new, larger, expedition vessel "Lance",that went into operation in 1981,has allowed extensive sea ice studies east and west of Svalbard, including measurements of wave effects with accelerometers and strainmeters. The arctic weather stations send daily ICEOB, and weekly ice drillings are made at Hopen in a cooperative venture between NPRI and the Norwegian Meteorological Institute.

ANTARCTICA

Drift and behaviour of icebergs in the Weddell Sea and the South Atlantic Ocean has been studied by the deployment of altogether 13 Norwegian-built automatic stations in an ongoing programme that started in 1977. Of these, four stations have been sophisticated data-collecting platforms. Most icebergs have been followed for a period of over one year. The majority of stations were deployed from NPRI expeditions, but institute scientists have also deployed buoys from British, West German, and U.S. expeditions.

Data on the first precise positioning of the seaward limits of an extensive sector of the glaciers and ice shelves of Antarctica – from 44°E to the Greenwich Meridian, and with less precision from 0° to 29°W – are on file at NPRI and available to anyone interested.

U.S.S.R

In 1981 glaciological studies were conducted in the Caucasus, Central Asia, and Altai, the Urals, the Khibiny Mountains, in the mountains and plains of Siberia, in Kamchatka, and in the Arctic and Antarctica.

CAUCASUS

The Institute of Geography, USSR Academy of Sciences, completed lichenometric surveys in the periglacial zone of the Caucasus. Interpretation of results revealed a faster response to variations in the Holocene glaciation on the southern slope of the main (Glavniy) Caucasus Range as compared to the northern slope and the earlier intensification of glaciations when compared to the Black Sea transgressions. Field studies conducted in the Caucasus and on Spitsbergen glaciers have proved the predominance of exaration over other processes in debris formation on slopes. The zone of greatest glacial exaration is situated 3-5 km below the terminus and shifts with it.

The Institute of Geography, Georgian Academy of Sciences, continued glacio-meteorological observations of the Tbilisa Glacier (Bibistskai River basin). Surface melting rates due to dirt cover and the morphometry of the tongue were measured. At 2900-3100 m melting averaged 53 mm/d. From 26 July to 22 August the volume of glacial discharge was 4.2×10^6 m^3. Paleoglaciological investigations of glacier dynamics during the Holocene were carried out on the southern slope of the Greater Caucasus.

The Transcaucasian Hydrometeorological Institute and the Transcaucasian Hydrometeorological Service continued investigations of glaciers in the Inguri, Terek, Andiyskoye Koisu and Samur river basins. On the Gergeti Glacier studies were done under the International Hydrological Programme. They comprised measurements of the ice velocity and ablation rates, variations in the height of the glacier surface, fluctuations of the glacier tongue, liquid run-off from the glacier basin and surveys of the meteorological regime. Similar surveys were carried out on

the glaciers of Adallashukhgel' Mountain in Dagestan. Photo-theodolite surveys were conducted on the Devdoraki and Gergeti glaciers and on the glaciers of the Tviberi system. There is an obvious degradation of the glaciers of the Kazbek system. Relatively small amounts of precipitation have occurred there recently causing the glaciers to shrink considerably.

The Alpine Geophysical Institute continued investigations of snow avalanching in regions of active economic development. The institute develops methods for recording avalanches, studies the interrelationships between physico-mechanical properties of snow and the nature of avalanche releases.

The University of Kharkov studied the growth of vegetation on mudflow cones in the Baksan River valley as a dating technique. Vegetation is absent from recent mudflows, makes up 5-7% of cover on 2-year old sediments, 30% on 7-year old sediments and is 85% on 22-year old deposits. Thirty-five year old deposits are characterized by an abrupt decrease in the total number of species and the domination of pine. The dynamics of chemical compounds in the mudflow bio-complex was revealed in the Adilsu River basin. The greatest variations according to the age of the mudflow are found for Ca, Fe and Mg. The altitude of the firn line on the Khakel' Glacier was calculated from the amount of winter precipitation and the total of positive summer temperatures. The difference between the actual and computed values was 20 m.

The North Caucasus Hydrometeorological Service conducted a series of glaciological and meteorological observations on the Marikh and Sancharo glaciers. Glacier variations were determined for 16 glaciers in the Greater Caucasus.

CENTRAL ASIA

The Central Asia Hydrometeorological Institute continued working on the introduction of new telemetry equipment designed for computer aided collection of data from avalanche catchments. The design of an aerial snow survey network has been worked out as well as a system for the collection and processing of data on the snow cover. Helicopter-based gamma snow surveys have been introduced.

The Geography Department, Academy of Sciences of the Kazak SSR, continued evaluating avalanche danger in the mountains of south-eastern Kazakhstan and developed recommendations for avalanche prevention. The impact of glacio-nival processes on the formation of mudflows has been studied and the water/ice balance of the Kazakhstan glaciers calculated. The data processing of geodetic surveys on the Shumsky, Tuyuksu, Igly Tuyuksu and Shokalsky glaciers was carried out.

The Kirgiz Hydrometeorological Service continued ground surveys of the Golubin Glacier. For the first time in the last decade the glacier balance appeared positive. Results of variation surveys have been analysed. Glacier retreats measured were as follows: Aksu-Zapadniy 20-40 m (1980-81), Chong-Tur 20-25 m (1980-81), Golubin 5-10 m (1980-81), Shurovskiy 450-500 m (1968-81), Dzhukchak 25 m (1977-81), At-Dzhailau 15.6 m (1976-81), and Koeng-Tur 20-25 m (1978-81). Whereas the following glaciers advanced: Dolon-Ata 25-75 m (1979-81), Aksu-Vostochniy 5-10 m (1980-81) and Davidov 150-250 m (1965-81).

The Tien-Shan Station, Kirgiz Academy of Sciences, conducted glacio-hydrometeorological investigations of the glaciers in the upper reaches of the Sary-Dzhaz River and on the Yzhniy Inul'chek Glacier. Precipitation in the Sary-Dzhaz River basin decreases in a N-S direction and increases W-E reaching a maximum in the upper reaches of the glaciers bounded by the Meridional Range. This is reflected in the altitude of the firn line whose position varies from 4000-4500 m. The calculations show that the glacial run-off contribution in the Sary-Dzhaz River basin is very high and in certain tributaries varies from 49-81% of total discharge.

The Kazakh Hydrometeorological Service continued to develop methods for the prediction of different types of avalanches. A method for the 12-hour prediction of a fresh snow avalanche has been worked out.

The Geological and Geophysical Institute, the Uzebk Academy of Sciences, conducted glaciological, hydrometeorological, hydrological and geological-geomorphological studies on some glaciers in the Murgab River valley. New data on the regime of small glaciers, situated at 4700-5200 m in the arid region of the East Pamirs, was obtained. The major role of tectonics in the development of glacierization in these alpine arid areas was revealed. Increased tectonic activity and rate of uplift stimulates the rate of debris formation. Measurements were made on the general increase in mineralization of glacial waters and the demineralization of the ice of small glaciers. Their water regime was described and suspended sediment loads evaluated.

The Institute of Geography, the USSR Academy of Sciences, carried out photo-theodolite surveys and velocity measurements on the Medvezhiy and RGO glaciers. Field work in a representative area of the Pamirs was linked to the inventory of surging glaciers. Radio echo sounding of numerous glaciers in the Zailiysky and Dzhungarsky Alatau was undertaken from a helicopter and ice thicknesses determined along the axis of 124 glaciers. A detailed terrestrial survey of ice thickness was made on the representative Tsentralniy Tuyuksu Glacier. Accumulation and ablation were measured in the accumulation area of the Zeravshan Glacier for the first time.

The Tadzhik Hydrometeorological Service observed the fluctuations of 16 glaciers. Results suggest that the Scogach, Tro, Rama, RGO, Kyzylkul', N 507, N 517 and GGP glaciers are stationary, that the Khadyra and Mush-

ketov glaciers are advancing and that the Didal', Seravshanskiy, Dikhadang, Garmo, Mazarskiy and Medvezhiy glaciers are retreating.

The Institute of Mechanics, Moscow State University, using P.A. Cherkasov's data from the Shumsky Glacier, Dzhungarsky Alatau, established that ice flows in the direction opposite to the surface inclination of sub-siothermal glaciers. This phenomenon had been recognized before only for cold glaciers of polar regions. This necessitates further modification of mathematical models of mountain glaciers for preliminary calculations of dynamics, subglacial topography and paleoglaciological reconstructions.

The University of Tomsk, Altai, continued glacier investigations by pulse detection and radio echo sounding in the Actru River basin. Ice thickness of the Praviy Aktru Glacier was measured at 170 m. Photogrammetric surveys of the Maliy Aktru and Vodopadniy glacier snouts were performed. Reduced flow rates in the central part of the Maliy Aktru Glacier were measured as compared to 1979-1980, from 29-30 to 20 m/a. Snow surveys were conducted on the largest glaciers on the Severo-Chuyski and Uzhno-Chuyski Ranges during the period of maximum snow accumulation.

POLAR URALS

The Institute of Geography, USSR Academy of Sciences, carried out photo-theodolite surveys and ice velocity measurements on the Obruchev, IGAN, MGU, Anuchin, Oleniy and Chernov glaciers. Mass balance was also measured on the first three.

KHIBINY

The "Apatit" Industrial Association completed compilation of an inventory of avalanches in the vicinity of Kirovsk containing data on 50 sites observed from 1929 to 1979. The inventory has been compiled in a form to facilitate input and computer processing. The methodology of avalanche inventories was worked out in Khibiny together with a preliminary evaluation of "technogenic" factors influencing the glacio-nival processes, giving a general idea of the extent and results of these man-made impacts on the avalanche regime, snow transport and permafrost. The problem of the maximum value of the resistance coefficient of avalanching was studied. For dry avalanches this seems to be 0.25-0.27, much less than the previously accepted value of 0.32.

Moscow University's Avalanche and Mudslide Laboratory generalized data on climate change in Khibiny during the Holocene. Field studies were made of avalanche sites and samples collected for pollen analysis. Changes in avalanche activity were studied in sections through avalanche cones.

SIBERIA AND THE FAR EAST

The Novosibirsk Institute of Railway Transport continued to study the dynamics of snow accumulation and wind regime over experimental sites in southern Sakhalin, western Kazakhstan, Tuva, the south of west Siberia and the Taimyr Peninsula. The institute investigated the effects of natural and climatic agents on snow drifting along roads. Studies of drifting snow characteristics in strong winds were initiated in a big new wind tunnel with a cross section of 1.5 x 2 m. Snow drifts along the Noril'sk-Dudinka Railway are being investigated and recommendations made for protection. Conditions of snow cover formation at avalanche sites are also being studied. The effects of different anti-avalanche contructions were evaluated and special attention paid to comprehensive avalanche protection.

The Institute of Permafrost,Siberian Branch of the USSR Academy of Sciences, completed a study of the present-day glaciers of the Chersky Range, where 318 glaciers, with a total area of 148.3 km^2, were identified. For the first time data on the morphology and dynamics of the glaciers of this isolated area were obtained. Summaries of the data are contained in the report on the Glaci. Inventory of Chersky Range, published in 1981. Field observations were carried out to evaluate the surface stability for agricultural development of central Yakutia. Calculations have shown that forest clearance and removal of turf and the soil cover from high terraces may cause considerable deformation of the surface, especially in the case of shallow bedding of ice wedges.

The Institute of Siberian and Far Eastern Geography, Siberian Branch of the USSR Academy of Sciences, summarized long-term investigations, defined current theories and identified the main ideas and objectives of a new scientific trend in glaciology – the study of icings. Types of icing formations have been distinguished, and the place of icings in the general classification of natural ice, and the genetic and morphostructural characteristics determined. The institute developed methods of aufeis hazard investigation, revealed useful properties of icings, evaluated natural and potential icing resources and the possibilities of thier utilization in different areas of the national economy.

Results of long-term studies of glacial morphology in the mountains of Siberia and the Far East have been summarized. Different scientific conceptions of structure, genesis, age and form of corries, glacier valleys and related topography were analysed.

Moscow University's Avalanche and Mudslide Laboratory continued its study of avalanche sites in the Zabaikalsky and Central areas of the Baikal-Amur Railway. Field tests of thermo-drilling methods and the technology of ice coring for isotopes, geochemical and structural analysis were conducted on glaciers in the Khodar Range, Severnoye Zabaikalie.

KAMCHATKA

The Institute of Volcanology, Far East Branch of the USSR Academy of Sciences, continued mass balance measurements on the Kozelsky Glacier. In 1980/81 its mass balance was extremely negative at -200 g/cm². The firn line rose to 1540 m a.s.l. Methods of surveying the motion of the Kozelsky Glacier directly using light range finders have been worked out. The influence of volcanic ejections on the regime and chemical composition of the seasonal snow cover was studied on the Mutnovsky Volcano glaciers. As a result of the eruptions 0.71 kg/m² of ash was precipitated on the Goreliy and Alaid glaciers and mineralization of the snow surface reached 1270 mg/l. There was an increase in the rate of snow melt due to the ash cover. The mass balance of the caldera glaciers was negative, -60 g/cm², in 1980/81. Field studies of the mountainous parts of Bering Island revealed traces of recent glaciation and numerous permanent snow fields.

THE ARCTIC

The Arctic and Antarctic Institute carried out mass balance measurements on ice domes and studied the dynamics of permafrost over slopes of different inclination at Vavilov Dome Station, Severnaya Zemlya. A paleogeographic map of the Svernaya Zemlya glaciers at 18-20 thousand years B.P. was compiled.

The Institute of Geography, USSR Academy of Sciences, continued studies of Spitsbergen glaciers. A borehole to bedrock at 208 m was made with a thermal drill on the summit of Vestfonna Ice Dome, Nordanstlandet. Samples were taken along the length of the core for isotope and chemical analyses. The structure and temperature regimes of the firn/ice sequence were investigated. Meteorological and snow surveys were made and ablation and accumulation measured on five selected glaciers in different parts of Spitsbergen. Investigation of the Bertil' Glacier, which provides the water supply for the Soviet mine "Pyramida", were continued. At present ice is artificially frozen onto the glacier surface to prevent the water-supply tunnel from melting.

Temperature and radio echo measurements in a glacier borehole confirmed an assumption about the nature of internal radio echo returns in the Fritjof Glacier being related to changes in the temperature state of the glacier, to its transition from cold to temperate ice and to the occurrence of meltwater in the warm ice. This opens the way for the application of radio echo sounding to studies of the internal structure and temperature regime of subpolar glaciers. Paleobotanic investigations and radiocarbon datings in pits established the synchroneity of changes in vegetation, climate and glacierization in neighbouring regions of Spitsbergen.

The Geological Institute, Estonian Academy of Sciences, studied conditions of glacier formation and the areal and temporal characteristics of the extension of glacierization in Svalbard, the northwestern part of the East European Plain, and in the lower reaches of the Yenisei using isotopic and geochemical techniques. The results suggest a correlation between the oxygen isotope composition of atmospheric precipitation and long-term mean monthly temperatures. New methods for measuring the chlorine content of ice have been developed and applied, permitting evaluation of changes in the extent of ice-covered sea water in the past. The institute completed geochemical and isotope studies of a core from the Amundsen Plateau that indicated high accumulation rates of about 1 m/a. Methods for ^{14}C sampling in a deep borehole were worked out in cooperation with the Mining Institute of Leningrad.

ANTARCTICA

The Arctic and Antarctic Institute and the Geographical Institute of the USSR Academy of Sciences carried out systematic glaciological investigations. Snow surveys and surface glaciological observations in pits and shallow holes, conducted annually since 1977 along the Pioneerskaya-Dome C route, were continued. New radio echo sounding methods for obtaining glaciological information were tested along the route from Mirny to 275 km. A shipboard navigation radar was used to detect crevasses and sastrugi up to several kilometres ahead. A protype radar was tested for studies of snow/firn stratigraphy to a depth of a few metres from the surface. Return signals were recorded continuously on tape and clearly indicated horizontal boundaries between the layers of a thickness of 0.1-0.2 m. At the same time, stratigraphy was analysed in pits to compare the real structure of the snow cover with that recorded by radio echo sounding.

Continuous core drilling was carried out at Vostok Station. Variations in grain size didension with depth were used to compute temperatures at the time of formation. Results indicate that the upper layers, to a depth of 300 m, formed within the last 12,000 years at temperatures 5-6°C higher than those in the lower part at depth of 300-700 m. Changes in the surface altitude of the ice sheet, calculated from the air content in ice, show that at 3-30 thousand years B.P. the surface elevation round Vostok Station was close to that of the present day. At 30-40, 40-55 and 55-75 thousand years B.P. this was respectively 50, 100 and 500 m lower than its present height. A 305 m corehole was drilled 665 m from Pioneerskaya Station. Boreholes were also drilled to 387 m at the 43rd km south of Mirny and to a depth of 285 m at the Komsomolskaya Station.

The Mirny Observatory continued observations on the chemical composition of atmospheric precipitation. Ten-day averages of some chemical elements and data on inter-

seasonal and interannual variations of mineralization in atmospheric precipitation were obtained from analysis of ice samples from deep boreholes. Various studies of snow cover were conducted at the Vostok, Novolazarevskaya, Leningradskaya, Russkaya, Molodezhnaya stations and along the traverse Mirny-Vostok.

Studies were made of the interactions between permafrost and surface glacierization near the Druzhnaya seasonal station, in the Shackleton Mountains. Observations on King George Island (South Shetland Archipelago) made it possible to draw conclusions about the peculiar interrelationships between the surface and subsurface glacierization in the Subantarctic: the depth of the active layer is not great – from 0.35 to 1.1 m, segregation ice does not manifest itself, the apparent ice content is insignificant, active development of processes on slopes is mainly related to nivation and fluvioglacial processes, the permafrost is lacking under glaciers.

Results of geographical, geomorphological and geological interpretations of subglacial melting in central Antarctica were summarized. The main geographical conclusion drawn was that the glacial waters flowing under the rear parts of ice shelves cause stability in the ice shelf boundary between the Antarctic surface glacierization and the Ocean. This implies that under conditions of the Earth's changing climate the dimensions of the Antarctic Ice Sheet are more stable than previously thought. The main geomorphological conclusion is that the subglacial network of lakes and channels in the central part of Antarctica and of the Quaternary ice sheets of Europe and America created typical alluvial forms of topography in the centre of these sheets. These forms may serve as evidence of a large ice thickness rather than its absence. The main geological conclusion is that the subglacial waters in the central part of the ice sheets of Antarctica serve as hydraulic transmitters of high pressure into the deep layers of water-permeable mountain rocks and thus stimulate the flow of liquids and gases in these rocks to the periphery of the ice sheets. Thus oil and gas fields coincide with the periphery of the former ice sheets of Europe and America. Consequently, the margins of the Antarctic Ice Sheet and fringing parts of the Antarctic Shelf may contain relatively large deposits of oil and gas.

The studies of iceberg transportation to low latitudes were continued. The Coriolis force was calculated along the most promising routes and conclusions drawn on its role in the mechanical aspect of the problem.

SCIENTIFIC RESULTS

The principal scientific results achieved in 1981, but not reflected in the regional breakdown include the following:

1. The compilation of the World Atlas of Snow and Ice Resources was continued. Preparation of the authors' original maps was completed. These are maps of the Arctic, Scandinavia, the Alps and Antarctica, dealing with morphology and glacier regime, climate of the winter period, climate of the glacionival zone, the history of studies and glaciological knowledge of these regions. The series of large-scale maps of individual glaciers was compiled. The main scientific result has been in the matching of principles between the various subject maps of the Atlas. This has given rise to further methodological studies, introduced some refinements into compilation methods and led to the development of a new indirect method for snow cover mapping over territories with sparse data. Experience has been gained in using glacier regime maps for the compilation of maps of solid precipitation, snow cover, climate of the glacio-nival zone and melt water discharge.

2. Methods of temperature field determination in a glacierized zone and calculation of ablation from air temperature were refined. Large temporal and spatial variability in the vertical temperature gradient and temperature jumps at the "ground/ice" boundary, independent of the glaciers' dimensions, were revealed along with the domination of local and regional factors over the background averaged agents in the formation of the chemical composition of glaciers and glacial waters.

3. A model of the interaction of glacierization with the Ocean in lumped parameters permitted reconstruction of variations in past World Ocean level. The differential nature of cooling effects was revealed together with the limited scale of the impacts of mountain glacier systems on the air temperature field in the ice-free part of the mountain areas.

4. Interpretation of satellite information as well as terrestrial observations made it possible to define the characteristics of surging glaciers. The Guide for the compilation of the Surging Glacier Inventory of the USSR has been compiled and approved by the Section of Glaciology.

5. Prospects for the industrial application of spray-cone freezing of ice were analysed. Results of laboratory modelling of the field research into the structure and physico-mechanical properties of ice were summarized. Dependence of the density and strength of snow on its structure, state of stress and thermal regime was demonstrated.

6. A mathematical model of non-isothermal ice sheets was developed to describe their evolution, taking into account bottom melting, freezing, occurrence of a basal water layer and differences in their temperature regime. A model of geocryological processes was constructed to reveal their characteristics, future behaviour and to evaluate their response to man-made impact.

V.M. Kotlyakov and M.Yu. Gnedovskaya

BRITISH ANTARCTIC SURVEY, 1981-1982

One of the main causes of the observed rise in sea level this century may be increased melting of the Antarctic ice sheet. Over the same period a global warming of around 0.3°C has been found, related perhaps to the observed increase in atmospheric carbon dioxide. Some recent BAS observations call into question an American suggestion that over the last 40 years there has been a net transfer of more than 50,000 km^3 of ice into the world's oceans, raising mean sea level at an average rate of 3 mm per year. It has been claimed that there are inherent instabilities in the Antarctic ice sheet leading to periodic surging that can raise sea level and cool the climate. The area often considered most vulnerable to sudden collapse is the west Antarctic ice sheet, much of which is resting on rock well below sea level. Within this area, Pine Island Glacier has been pinpointed as being especially vulnerable because, in contrast to most other large outlet glaciers, it does not discharge into an ice shelf which could provide a stabilising restraining force. Airborne radio echo sounding carried out by C.S.M. Doake, R.D. Crabtree and H.E. Thompson in a BAS Twin Otter from an American fuel depot in the Ellsworth Mountains has investigated both Pine Island Glacier and its inland drainage basin. Using these results together with ice velocity measurements derived from satellite pictures, a simple theoretical model shows no evidence of non-equilibrium behaviour. Indeed it appears that over the Pine Island catchment there is a net surplus of accumulation over discharge. This apparent build-up of the ice sheet has been found in other large drainage basins, and while some uncertainties remain, it appears unlikely that the Antarctic ice sheet has had a net loss of 50,000 km^3 over the last 40 years; present estimates of both accumulation and loss of ice are of the order of 1000-2000 $km^3 a^{-1}$.

Thick floating ice shelves fringe much of the Antarctic coastline. They are nourished by glaciers flowing from inland and dissipated by the calving of icebergs and by melting in the sea. Summer observations by J. Loynes and J.R. Potter have shown that the ocean circulation beneath ice shelves is driven by the melting of ice and by convection from warmer water below. Our understanding of these processes has been enhanced by data collected from a current meter with temperature and conductivity sensors that was moored over a winter beneath George VI Ice Shelf. A dramatic change from summer to winter was marked by a weakening of the circulation beneath the ice shelf without any significant changes in sea water temperature and salinity. An important thermodynamic argument shows that the temperature-salinity relationship is unique to sites where there is a thorough mixing of ice melt water with the underlying sea. The melt water is characterised by an oxygen-18 isotope composition that is close to the average for the precipitation over the whole catchment. These and other results have led J. Loynes, J.G. Paren and J.R. Potter to a coherent account of the income and wastage of an ice shelf and the energy involved in maintaining its thermal regime.

Chemical analysis by J.W. Mumford of the upper section of an 83 m ice core recovered from the plateau region at the southern end of the Antarctic Peninsula has yielded profiles of mineral dusts and marine salts through the last 25 years. These data in conjunction with oxygen isotope values measured by W. Dansgaard's group at the University of Copenhagen provide a test of the calibrated link between air temperature and oxygen isotope ratio already obtained from a widespread network of shallow cores. They will in addition give detailed evidence for the value of dust and marine salt concentrations as indices of past cyclonic activity and wind speed. Whilst seasonal cycles in oxygen isotopes offer a conventional method for precisely dating the ice below recent artificial radioactivity horizons, such cycles cannot always be identified. J.W. Mumford has also analysed a shallow core from the central part of the peninsula to evaluate alternative dating methods. The evidence suggests that seasonal fluctuations in the input of marine salts can be identified although individual storm events evidently superimpose a non-regular input.

Weather and deposition processes appear to play an important part in shaping the temporal and spatial fallout pattern of global industrial pollution over the Antarctic ice sheet. Progress has been made in a study of the relationship between heavy metal concentrations in air and in snowfall. Data from a pilot programme undertaken by D.A. Peel in which simultaneous collections of snowfall and aerosol were made show a linear relationship between concentrations in air and in snow. This agrees with predictions from a simple model of aerosol depletion during precipitation. A.L. Dick is planning a more comprehensive sampling for the next field season. If the earlier results are substantiated this will simplify the interpretation of longer term changes from deep ice cores. E.W. Wolff has made improvements to the analytical techniques and methods of blank control required for measuring ultra-trace concentrations of heavy metals in ice cores. Application of these methods to a 15 m core has produced a continuous and detailed account of changes over a decade.

C.W.M. Swithinbank

Interstate Bank Building. Project Office – Glaciology is located on 8th floor.

The U.S. Geological Survey's interest in glaciology dates back to the late 19th Century, when Israel C. Russell and Harry F. Reid conducted studies on Malaspina and Muir glaciers in Southeast Alaska. The Survey's commitment to glaciological research however was sporadic and depended on the interest of individual scientists. No permanent program existed until the late 1950's when the Water Resources Division, under Luna B. Leopold, decided to investigate the connection between glaciers and water resources and hired Mark F. Meier to organize the Project Office – Glaciology. In October of 1956, Mark set up shop in clear view of the snow-covered volcano Mount Rainier in Tacoma, Washington, the most glacier-populated State in the contiguous United States. The fundamental mission of this new office was to establish a comprehensive, long-term research program on one or more glaciers, with special attention to the glaciers' hydrological and climatological environments. It is from this foundation that the office grew and expanded its interests without losing its original goal.

By the late 1960's, the office had grown to about 10 permanent employees and sprouted one subproject office in Fairbanks, Alaska, under the direction of Lawrence R. Mayo. The Alaskan office started with the International Hydrological Decade in 1965,and was responsible for monitoring glaciers in that state.

PROJECT OFFICE GLACIOLOGY

U.S. GEOLOGICAL SURVEY

Tacoma, Washington, U.S.A.

The research interests of the office in Tacoma began to diverge with the addition of personnel,and a new office, headed by William J. Campbell, to study sea ice, spun off in 1970. That office,designated the Ice Dynamics Project, also resides in Tacoma,on the campus of the University of Puget Sound. A further reorganization in 1981, administratively removed the Alaskan subproject office from the technical direction of the Project Office – Glaciology and the Fairbanks office was renamed the Cold Regions Hydrology Project Office. Thus, from its humble beginnings of one person in 1956, the glaciology research group has grown into three separate offices totalling about 25 permanent employees. The remainder of this Profile will discuss the Project Office – Glaciology.

South Cascade Glacier, Washington, USA

GLACIER RESEARCH

The principal effort of the office has been in glacier studies. From a foundation in climate-glacier relationships, many investi-

gations also have been conducted in ice dynamics, hydrology, and glacier-volcano interactions. Climate-glacier studies started on South Cascade Glacier in 1957 and continue today as year-round meteorological and runoff data are collected, in conjunction with frequent field trips to collect glaciological information. South Cascade Glacier is about 2.9 km² in area, and is located in the heart of the northern part of the Cascade Range in Washington, and a mere four hours of total travel time by car and helicopter away from the office in Tacoma. Because of its relative isolation, yet close proximity, it is the primary field site for glaciological investigations and testing new field instruments. Three small shelters have been constructed near the glacier. One is the living quarters (the "Hut") located a short walk

Living quarter ("Hut") at South Cascade Gl.

from the glacier's midsection. The Hut includes kitchen, bunk room, instrument laboratory, and small shop – all powered by either wind or diesel power from the nearby generator building (not shown) which also has some shop facilities. The third building, a gaging station was constructed to protect water-stage instruments as well as to shelter equipment needed to maintain a small dam and weir that were constructed at the outlet of the lake. The building received an architectural design award and may be the only gaging station in the world to have been so honored. Both the hut and the gaging station have instruments for meteorological observations, and the data are telemetered to the Tacoma office computer by satellite relay.

South Cascade Glacier, because of its large glacier-to-basin ratio (53 percent) and its well-defined basin and simple geometry, has provided an excellent location for glacier-hydrology studies such as water tracing, snow and ice contribution to stream discharge, basal water-pressure measurements, and detailed hydrological balance studies. One of the most important findings in the early 1970's was the considerable variation in water storage within the glacier. In pursuit of these studies, a hot-water drill capable of drilling to the bottom of the glacier in a few hours has been developed. Mass-balance measurements, continuous since 1957 and inferred back to 1955, provide the most detailed record of any glacier in the Americas. The data were used by J.F. Nye for the first quantitative analysis of glacier dynamic response to climate. A more recent study has reconstructed the mass balance back to 1884 by multiple-regression techniques and now provides a unique opportunity to examine a long climate-glacier relationship in North America.

In 1964, Austin Post joined the Project Office to continue his aerial photographic survey of glaciers in western North America from California through Alaska. That survey has been made once a year since 1957 except for only two missing years, and has produced an almost complete photographic inventory of glaciers and their changes in this part of the world. This collection of photography was the source for (1) three completed glacier inventories (North Cascades, WA; Sierra Nevada, CA; Brooks Range, AK); (2) large-scale analyses of glacier mass balances in the early 1960's; (3) identification and analysis of surging glaciers in the late 1960's; and (4) basic investigations into the mechanics of the variations of iceberg-calving glaciers. The photograph collection is also utilized by other scientific groups as well as by nature writers and climbing enthusiasts. The Project Office maintains a comprehensive photo lab to help utilize this collection.

Dynamic glaciology has also been a significant interest of the office. Projects have included study of the mechanics of Blue, Nisqually, Saskatchewan, and South Cascade glaciers. The current glacier-dynamic project that is involving everyone in the office from time to time is the study of Columbia Glacier.

Columbia Glacier, Alaska

This glacier, 1100 km² in area and 67 km long, calves into Prince William Sound of Southeast Alaska and has not had a major retreat in historic time. Columbia Glacier seems due for a rapid, drastic retreat similar to those which have occurred in historic time in Icy and Glacier bays. The production of icebergs produced by a rapid retreat would probably interfere with the oil shipping from nearby Valdez, Alaska. A project to predict the course of retreat was started in 1974. Using a unique combination of movement data supplied by aerial photographs and supported by field measurements, close to 5,300 photogrammetrically identified points have been collected and analyzed for this study. The RV *Growler*, operated by the Project Office and equipped with several kinds of sonar, is used to determine water depths at Columbia Glacier in particular, and at other calving glaciers and fiords in Southeast Alaska in general. A drone boat, the *Bergy Bit*, is used to profile the bottom near the hazardous face of these calving glaciers. One- and two-dimensional, continuity and dynamic models have been developed to predict the timing and rate of retreat. At the time of this writing, the first signs of a rapid retreat, which coincide with the predictions of the models, may be evident. The models suggest that by 1985 the glacier terminus will have receded 10 km from its 1978 position, which is thought to have been stable since Captain Vancouver's visit in 1792.

The eruption of Mount St. Helens in May 1980 has increased national interest in the volcanos of the west coast. The Project Office – Glaciology was involved in the monitoring of the volcano because of our history of northwest glacier photo flights and the fact that most of the volcanos are mantled with snow and ice. One study was already looking at Shoestring Glacier long before the eruption seemed likely. The original eruption in 1980 removed most of the accumulation zone of the glacier, and analysis of the stake measurements before and after the eruption indicate changes in the dynamics. Another ongoing volcano-related study is on the effect of ash on snowmelt. To assess better the hazards of the other Cascades volcanos in Washington, Oregon, and California, the Project Office recently has made extensive ice-volume determinations for the principle volcanos in these States. The thicknesses were done with the USGS monopulse temperate-glacier radar, developed by Geologic Division colleagues in Denver for the Columbia Glacier project.

SNOW HYDROLOGY

Snow meltwater is extremely important as a water resource in the western United States. Investigations of this resource have long been a part of the Project Office's effort. Models were developed to predict the amount and timing of spring runoff to be expected from a snowpack of a given water equivalent. These forecasting models have been applied successfully to snowpacks of the Cascades of Washington and Oregon, the Sierra Nevada of California, and the Salt River basin in Arizona. Also, a study, in cooperation with the U.S. Forest Service Central Sierra Snow Laboratory in California, on the use of microwave detection of snow wetness and its use in forecasting runoff, has just been concluded. One interesting aspect of this study was the significant difference in the microwave signature of snow with a change in liquid-water content from 0 to perhaps 1 percent, well below the threshold of any verification scheme available at this time.

REMOTE SENSING

Remote sensing has been an integral part of the glacier and snow-hydrology interests of the Project Office. Its start was with Post's systematic aerial photography already described. In the mid-1960's, the office operated the first snow and ice test site for the developing NASA program of remote sensing of Earth resources. The great potential for sensing snowpack distribution and water equivalent from passive microwave emissions was soon realized, and pioneering work was done in this field in cooperation with Aerojet-General Corporation. With the advent of satellite imagery in the early 1970's, the application to other glaciological problems was investigated. Studies then focussed on usefulness of LANDSAT images for the detection of snow, as well as glacier surges and other glacier hazards. Of these projects, one of the most successful and more generally applicable was the use of satellites for the monitoring of snow-covered areas in drainage basins. The current emphasis in remote sensing is the cataloging of glaciers and glacier hazards in the continental U.S. and Asia as a contribution to a world satellite-image atlas.

AFFILIATIONS

The Project Office – Glaciology has been blessed with fortunate working relationships with other U.S. Geological Survey offices as well as nearby universities. Tacoma is one of the three rotating hosts for annual meetings of the Northwest Glaciologists, which includes colleagues from the Universities of Alaska, British Columbia, Washington, the California Institute of Technology, and other institutions. Several visits and scientific exchanges have been held with colleagues in many countries, including the USSR, People's Republic of China, Norway, and Switzerland. The interaction and exchange with these various groups makes the Northwest one of the most exciting and fulfilling places to work in glaciology.

PERSONNEL NOTE

As of March 1982, Austin Post has retired from the Project Office. His work has been as significant as it has been prolific. One of his pioneering accomplishments was the use of oblique aerial photography for glaciological purposes, almost unknown before he transformed it into a significant tool. It has been used to obtain important new understandings of surging glaciers, and regional patterns of glacier variations and mass balances. Later, Austin Post turned his attentions to calving glaciers and fiord studies, where he first deduced why calving glacier terminus variations, such as those of Columbia Glacier, did not agree with the variations expected from glaciers ending on land. He modified the *Growler* for his specific investigational needs, and used it to profile the bathymetry in front of virtually all calving glaciers and fiords in coastal Alaska. He then deduced the past retreat history of the glaciers, and collected the data needed to confirm his intuitive knowledge of the relationship between the rate of calving and water depth. This knowledge eventually led to a prediction of the retreat of Columbia Glacier. Austin's dynamic character and creative research will be missed.

Andrew G. Fountain

INTERNATIONAL GLACIOLOGICAL SOCIETY

NORTH-EAST NORTH AMERICA BRANCH (NENA) BIENNIAL MEETING

4-6 March 1983, Waterville Valley, New Hampshire, U.S.A.

The next NENA-IGS meeting will be held in Waterville Valley, New Hampshire. Registration will take place on Friday afternoon, 4 March, with sessions starting Friday evening and proceeding through Saturday morning. A banquet followed by slides and/or movies will be held on Saturday evening.

PAPERS
Some 20 papers, of about 15 minutes duration, will be presented. These may be on any glaciological topic, preference being given to recent work. Students are encouraged to present their work. General interest slides are encouraged for Saturday evening. Room for poster presentations will be provided as needed.

ACCOMMODATIONS
Price per adult – US$120 which includes:
- Room for 2 nights (on double occupancy) single rooms are US$19 extra/night
- Dinner on Friday
- Friday night "Icebreaker"
- All meals on Saturday
- Breakfast on Sunday
- All taxes and gratuities

Prices for children (sharing adults' room)
- Under 12: room free, meals to be determined
- Over 12: room and meals to be determined

Note: If Sunday night accommodations are required, the special package price for this meeting does not apply but a third night discount is available on request. World Cup competitors will be arriving on Sunday so reservations for this evening should be made well in advance. Student room rates are available on a first come first serve basis (saving of US$10 on total package).

REGISTRATION
US$65 will be charged every adult (students US$60), US$20 to cover organizaton and banquet costs and US$45 as a room deposit.

SPORTS
Bring equipment for winter activities on Saturday afternoon and/or Sunday morning. Lift rates will be provided in the February brochure. Equipment can also be rented.

DEADLINES
Registration fees should be paid as soon as possible, preferably before 30 November 1982. Cancellation without penalty for accommodations can be made up to 1 February. Abstracts should be submitted by 31 January 1983. Payments and correspondence should be sent to:

Mariellen C. Lee,
Ocean Process Analysis Laboratory,
Earth Sciences, James Hall,
University of New Hampshire,
Durham, NH 03824 U.S.A.

JOURNAL OF GLACIOLOGY

The following papers and short notes have been accepted for publication in the last issue for 1982 and the first issue for 1983 of the Journal:

N. Reeh:
A plasticity theory approach to the steady-state shape of a three-dimensional ice sheet.

J.M. Gray:
Unweathered, glaciated bedrock on an exposed lake bed in Wales.

M. Sharp:
Modification of clasts in lodgement till by glacial erosion.

R.H. Thomas and D.R. MacAyeal:
Derived characteristics of the Ross Ice Shelf, Antarctica.

S. Shabtaie and C.R. Bentley:
Tabular icebergs: implications from geophysical studies of ice shelves.

H. Brady and B. McKelvey:
Some aspects of the Cenozoic glaciation of Southern Victoria Land, Australia.

G. Osborn:
Characteristics of the bergschrund of an avalanche-cone glacier in the Canadian Rocky Mountains.

C.J. Radl and J.P. Welsh:
Inventory of Arctic laser terrain profiles.

H. Gäggeler, H.R. von Gunten, H. Oeschger and U. Schotterer:
^{210}Pb-dating of cold alpine firn/ice cores from the Colle Gnifetti, Switzerland.

J. Weertman and G.E. Birchfield:
Basal water film, basal water pressure, and velocity of traveling waves on a glacier.

I. Beecroft:
Sediment transport during an outburst from glacier de Tsidjiore Nouve, Switzerland, 16-19 June 1981.

E.S. Robinson:
Flexural-gravity waves on floating stratified ice.

K.C. Jezek and C.R. Bentley:
Field studies of bottom crevasses in the Ross Ice Shelf.

R. Bindschadler:
The importance of pressurized sub-glacial water in separation and sliding at the glacier bed.

T. Hughes:
On the disintegration of ice shelves: the role of fracture.

A. Iken, H. Röthlisberger, A. Flotron and W. Haeberli:
The uplift of the Unteraargletscher at the beginning of the melt season — a consequence of water storage at the bed.

S. Overgaard, P. Wadhams and M. Leppäranta:
Ice properties in the Greenland and Barents Sea during summer.

I.M. Whillans and S.J. Johnsen:
Longitudinal variations in glacial flow: theory and test using data from the Byrd Station strain network, Antarctica.

J.F. Nye:
Monstars on glaciers.

Short note:

J. Boardman:
A note on the distribution of drumlins in Great Britain.

RECENT MEETINGS (of other organizations)

ANTARCTICA: WEATHER AND CLIMATE

11-13 May 1981, University of Melbourne, Parkville, Victoria, Australia

The Meteorology Department the University of Melbourne hosted a conference on "Antarctica: Weather and Climate". The meeting was organized by the Royal Meteorological Society, Australian Branch, (RMSAB) with the Australian Academy of Science and the Department of Science and Technology as cosponsors.

The conference was formally opened by the Honourable David Thomson, Minister for Science and Technology. Professor W. Budd, acting President of the RMSAB welcomed participants on behalf of the various organizations. Professor David Caro, Vice Chancellor of the University of Tasmania, and Chairman of the Australian Government's Antarctic Research Policy Advisory Committee (ARPAC) gave an opening address on ARPAC's role in Antarctic research.

While the conference included several overseas participants, it was primarily directed to Australia's role in the Antarctic. It aimed at making a "stock-take" of the nation's achievements and progress to date, particularly since the last major conference held in Melbourne on the subject of "Antarctic Meteorology", in 1959.

A wide range of topics was covered in the sessions in addressing the theme of a general study of the physical environment of the high southern latitudes: the upper atmosphere over Antarctica; physical measurements of the Antarctic atmosphere; Antarctic tropospheric processes; chemistry of the Antarctic atmosphere; palaeoclimates of Antarctica; the role of sea and continental ice in the Antarctic climate; and modelling studies of the atmos-

phere, ice and oceans of the high southern latitudes.

Professor Gunter Weller, of the Geophysical Institute, University of Alaska, a graduate of the Meteorology Department and President of the International Commission on Polar Meteorology (ICPM), presented a general review of problems in polar meteorology. He directed a discussion session at the end of the proceedings to assess Australia's present situation, the achievements and the remaining information gaps. From the conference presentations, it became clear that achievements over the past twenty years have been impressive – particularly through technological developments such as satellites, and in the development and deployment of drifting buoys released in the Southern Ocean, and automatic weather stations, positioned on the Antarctic continent or subantarctic islands. This equipment can be monitored through orbiting satellites and can provide regular and frequent measurements of surface atmospheric pressure, temperature, winds, and other parameters. The data can be relayed through data collection centres for regular operational use as well as research.

These and similar developments have enabled the behaviour of the sea ice and atmosphere to be studied and have facilitated modelling studies of the behaviour of the atmosphere, continental ice and ocean. The study of ice cores, rocks and past vegetation is permitting some palaeoclimate reconstruction to be achieved.

It became obvious that Australia's contribution to the knowledge of the polar regions is substantial, but that considerable work remains to be done. The research and development needs to be continued and expanded in selected areas to meet this challenge.

The contribution of the Meteorology Department to the proceedings and to Australia's achievements is very significant. It follows from a long association with the polar regions which commenced with the founder of the Department, Dr Fritz Loewe, who wintered in Greenland and Antarctica. These interests were continued by Dr Uwe Radok and in association with the Glaciology Section of the Antarctic Division, and presently by Professor Bill Budd. The findings and recommendations of the conference have important implications for Australia's future in Antarctica and for the University's M.U.P.A.S. program.

N.W. Young

ICE DRILLING TECHNOLOGY WORKSHOP/SYMPOSIUM

30 August – 1 September 1982, Calgary, Alberta, Canada

The Workshop/Symposium was held at the University of Calgary with local arrangements being handled by the Arctic Institute of North America. Twenty-five people from seven countries attended.

Of the 29 abstracts originally submitted only 19 papers were finally presented due to the inability of the Soviet and Australian contributors to attend. Nevertheless, it is planned to publish most of these additional papers in the proceedings.

The list of titles and authors for papers presented is as follows:

1. An over-view of ice drilling technology (B.L. Hansen).
2. The Danish "Istuk" electro-mechanical deep drill system (N. Gunderstrup).
3. Development of small mechanical drills for Japanese Antarctic Research expeditions (Y. Suzuki, N. Narita, K. Shiraishi, F. Nishio and Y. Fujii).
4. Polar Ice Coring Office 500 m drill system (J. Litwak, K. Kuivinen and L. Kersten).
5. The Canadian Rufli-Rand electro-mechanical core drill and reaming devices (G. Holdsworth).
6. Recent experience with the modified Rufli ice drill (H.L. Jessberger, R. Dorr and P. Jordan).
7. Two large diameter lightweight ice coring augers (J. Rand).
8. Lightweight hand auger (B. Koci).
9. Lightweight 50 m core drill on Mt. Warngell (C. Benson).
10. Heat buildup and motor selection for electro-mechanical drills (B. Koci).
11. Ice core quality in electro-mechanical drilling (F. Gillet, D. Donnou, C. Girard, A. Manouvrier, C. Rado and G. Ricou).
12. Deep core drilling: electro-mechanical or thermal? (D. Donnou, F. Gillet, A. Manouvrier, J. Perrin and G. Ricou).
13. An in-situ sampling thermal probe (B.L. Hansen and L. Kersten).
14. "Climatopic" thermal probe (F. Gillet, C. Rado, G. Marec, M. Maitre, J. Perrin and G. Ricou).
15. A hot water drill for temperate ice (P.L. Taylor).
16. Hot water drilling in Antarctic firn and freezing rates in water filled boreholes (B. Koci and K. Kuivinen).
17. A hot water drill for penetrating thin shelf ice (R. Verrall).
18. Solar power as an energy source for remote drilling sites (B. Koci).
19. New horizons in drill development (B. Koci).

These and other papers not presented at the Workshop will be published as a U.S. Army CRREL Report in 1983. A tentative list of the additional papers is as follows:

A. The program of deep core drilling at Vostok Station, Antarctica (B.B. Kudryashov, V.K. Christyakov, N.Ye. Bobin, A.M. Shkurko, Ye.S. Korotkevich, V.N. Petrov and N.I. Barkov).
B. Preliminary results of deep drilling at Vostok Station, 1980-81 (B.B. Kudryashov, V.K. Chistyakov, E.A. Zagrivny, V. Ya. Lipenkov).
C. Equipment and technology of borehole drilling in trans-Antarctic traverses (B.B. Kudryashov, N.Ye. Bobin, B.S. Moiseyev and V.G. Averyanov).
D. New equipment and technology for deep-core drilling in cold glaciers (V.V. Bogorodsky, V.A. Morev, V.A. Pukhov and V.M. Yakovlev).
E. Equipment and technology for drilling in temperate glaciers (V.A. Morev, V.A. Pukhov and V.M. Yakovlev).
F. The equipment and technology for moderately cold ice drilling (boreholes filled with anti-freeze) (V.V.Bogorodsky and V.A.Morev).
G. Liquid fillers for boreholes drilled in the ice sheets (V.A. Morev and V.A. Yakovlev).
H. Research and development of a low temperature filler for deep boreholes in the Antarctic Ice Sheet (B.B. Kudryashov, V.M. Pashkevich, V.K. Chistyakov and V.N. Petrov).
I. Ice drilling at C. Folger, Antarctica (V.I. Morgan, A.P. McCray and E. Wehrle).

Two concurrent working group sessions were also held after the formal paper presentations to deal with (1) the justification for past, present and future drilling activities in ice (to serve as the introduction to the proceedings), and (2) the problems of drill specifications, dimensional standardization and the achievement of optimum core quality.

G. Holdsworth

FUTURE MEETINGS (of other organizations)

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS, 18TH GENERAL ASSEMBLY

15-27 August 1983, Hamburg, Federal Republic of Germany

In conjunction with the forthcoming 18th General Assembly of the IUGG, a number of symposia and workshops are being held which may be of interest to IGS members. Prospective U.K. participants in IAHS should contact the Royal Society, particularly if they wish to apply to the Society for financial assistance.

SYMPOSIUM ON SEA ICE MARGINS
(IAHS<ICSI>, IAPSO, IAMAP)
18-19 August 1983

Seasonal and interannual variations of the positions and nature of the sea-ice limits; air-ice-ocean interaction processes associated with the sea-ice margins, oceanographic and meteorological features and processes associated with sea-ice margins, formation and deterioration processes, and characteristic properties of sea ice near the margins; regional studies including the Antarctic sea-ice margins and sea-ice boundaries on continental shelves; modeling of marginal ice zone dynamics and thermodynamics.

Convenor: R.D. Muench, Senior Research Oceanographer, Science Applications Inc., 13400B Northrup Way, Suite 36, Bellevue, Washington 98005, U.S.A.)

SYMPOSIUM ON ASSESSMENT OF
NATURAL HAZARDS
(IASPE, IAVCEI, IAHS, IAPSO, Tsunami C)
16-19 August 1983

This symposium will deal mainly with earthquakes, floods and tsunamis but a section on the hydrological effects of flooding on agricultural soils will include the assessment of avalanche risk.

Convenor: J.V. Sutcliffe, Institute of Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, Oxon OX10 8BB, UK

SYMPOSIUM ON POLAR METEOROLOGY
AND CLIMATOLOGY
(IAMAP <ICPM>, SCAR)(with IAHS <ICSI>)
16-18 August 1983

The role of the polar regions in the global meteorological and climatic systems; climate models applicable to high latitudes; ocean-ice-atmosphere interaction; radiation and energy balance in polar regions; atmospheric ice crystals and haze in the polar regions, (this will be run as a separate session, see Glaciological Diary) including processes of formation, transport and decay, optical properties, electrical properties; temporal and spatial distribution of precipitation,trajectories of haze, trace constituents in the polar regions; synoptic and local phenomena and processes.

Convenors: G.E. Weller, Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701, U.S.A.

M.Kuhn, Institut für Meteorologie und Geophysik, Schöpfstrasse 41, A-6020 Innsbruck, Austria)

SYMPOSIUM ON HYDROLOGICAL APPLICATIONS OF REMOTE SENSING AND REMOTE DATA TRANSMISSION
(ICRSDT)(cosponsored by WMO and UNESCO)
18-25 August 1983

Research, operational procedures and training related to remote sensing and remote data transmission in the general field of hydrology and water resources, such as precipitation, snow and ice, surface water, etc.

Convenor: A.I. Johnson, Woodward-Clyde Consultants, 2909 West 7th Avenue, Denver, Colorado, U.S.A.

WORKSHOP ON GLACIER MASS BALANCE AND RUNOFF
(ICSI)
25 August 1983

Review of scientific progress and knowledge gained in mass balance studies of glaciers during the past 25 years, and the relevance of these studies to major problems of glacier hydrology, glacier response to climate, and to current and likely future studies of glaciers.

Review of the report on techniques of prediction of runoff from glacierized areas produced by the ICSI Working Group convened for that purpose, and to consider the indicated directions for most profitable future work in this field, especially as it may relate to mass balance studies or studies of glacier behaviour.

Convenors: V.M. Kotlyakov, Institute of Geography, USSR Academy of Sciences, Staromonetny Str. 29, Moscow 109017,USSR

G.J. Young, Inland Waters Directorate, Environment Canada, Ottawa, Ontario, K1A 0E7, Canada

WORKSHOP ON LARGE-SCALE SNOW STUDIES
(ICSI)
26 August 1983

Review the progress and discuss future activities of the ICSI Working Group on Large-Scale Snow Cover. The Working Group will invite selected discussion reports and welcome open contributions or comments connected with the interaction between snow cover and climate on scales larger than 2500 km², the large-scale hydrological effects of snow cover, and problems and techniques of regional snow cover measurement and handling of regional snow information.

Convenor: A. Rango, Hydrological Sciences Branch, Code 929, Goddard Space Flight Center, Greenbelt, Maryland 20771, USA

SUBMISSION OF ABSTRACTS
The deadline for submission of abstracts to H.J. Liebscher, Federal Institute of Hydrology, Kaiserin-Augusta-Anlagen 15, D-5400 Koblenz, Federal Republic of Germany, was 31 October 1982. The full text of papers for preprint volumes must be submitted by 31 January 1983 and those for the other symposia volumes by 30 April 1983. The papers of all IAHS Symposia will be published in special symposium proceedings.

REGISTRATION FEES
Prepaid fees are expected to be DM 190 for attendance at the General Assembly and DM 90 for accompanying persons; reduced rates will probably be available for students.

EASTERN SNOW CONFERENCE, SNOW AND MAN

2-3 June 1983, Toronto, Ontario, Canada

The Eastern Snow Conference is an international organization, based in eastern Canada and the northeastern United States, concerned with the origin, precipitation, accumulation, character, melt, and run-off of snow. The 40th meeting will be held in Toronto, Ontario, 2-3 June 1983 with the theme "Snow and Man".

Abstracts should be sent to Donald R. Wiesnet, Program Chairman, 40th Eastern Snow Conference, NOAA/NESS S/RE12, Washington D.C. 20233, U.S.A. before January 20. Students wishing to present papers for the annual student award should send them to Jean-Louis Bisson, Eastern Snow Conference Research Committee, Hydro-Québec, 9th Floor, 2 Complexe Desjardins, Montréal, Québec, H2Z 1A4, Canada. The winner of the contest receives $100 and up to $250 in expenses to attend the meeting.

WESTERN SNOW CONFERENCE, HYDROLOGY IN A RAIN-ON-SNOW ENVIRONMENT

19-22 April 1983, Vancouver, Washington, U.S.A.

A total of 16 technical papers are planned for presentation and publication in the proceedings. The 1983 theme suggests several topics amongst which are – avalanches, mud slides, rain ripening on a snowpack, modelling, instrumentation, rain/snow loads on structures and forecasting. Abstracts were due by 1 October 1982. For further information contact:

D.D. Speers, North Pacific Division, of Engineers, P.O. Box 2870, Portland, Oregon 97208, U.S.A.

INT. SYMPOSIUM ON ISOTOPE HYDROLOGY IN WATER RESOURCES DEVELOPMENT

12-16 September 1983, Vienna, Austria

The International Atomic Energy Agency (IAEA) in cooperation with UNESCO is organizing a symposium on isotope hydrology. Topics will include water in the atmosphere, snow and ice hydrology, rainfall-runoff relationships and catchment behaviour studies including hydrograph separation, streamflow gauging, sediment transport studies, and mathematical models of hydrological systems.

Participation in the symposium, whether or not a paper is to be presented, must be through designation by the Government of a Member State of IAEA, by UNESCO or by an organization invited to participate. Extended abstracts will be required by 4 March 1983.

Further information may be obtained from:

International Atomic Energy Agency, P.O. Box 100, A-1400 Vienna, Austria.

12TH INQUA CONGRESS, CANADA, 1987

The 12th INQUA Congress will be hosted by Canada in 1987. The Congress will probably take place in August at a venue still to be decided. A pro tem organizing committee, consisting of Alan Morgan, David Piper, Pierre Richard and Denis St-Onge and headed by Nat Rutter has been set up to prepare recommendations for the organization of the Congress. Those wishing to volunteer or having ideas to contribute should contact:

Dr. N.W. Rutter,
Department of Geology,
University of Alberta,
Edmonton, Alberta, T6G 2H3

FERDINAND VON RICHTHOFEN SYMPOSIUM

5-8 October 1983, Berlin, Federal Republic of Germany

In honour of the German geographer, geomorphologist, and China expert Ferdinand von Richthofen, on the occasion of the 150th anniversary of his birth the "Gesellschaft für Erdkunde zu Berlin" will be holding their 10th annual meeting in Berlin.
There will be scientific sessions on the following topics:

- Perspectives and models in geomorphology
- Geomorphic data and cartography
- Geomorphology of arid regions
- Coastal geomorphology
- Geomorphology and neotectonics
- Polar and Quaternary geomorphology
- Reports on geomorphological field studies

For further information contact:

Prof. Dr G. Stäblein, Geomorphologisches Laboratorium, Altensteinstsse 19, 1000 Berlin 33, Germany.

GLACIOLOGICAL DIARY

1983

4-6 March
North-east North America Branch, International Glaciological Society, biennial meeting. Waterville Valley, New Hampshire, U.S.A. (M.C. Lee, Ocean Process Analysis Laboratory, James Hall, University of New Hampshire, Durham, NH 03824, U.S.A.)

5-9 April
7th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC-83). Finlandia Hall, Helsinki, Finland. (Sirpa Suomela, Secretary General POAC 83, Technical Res. Centre of Finland, Lab. of Structural Engineering, Betonimiehenkuja 1, SF-02150 Espoo 15, Finland)

19-22 April
Hydrology in a Rain-on-Snow Environment, 51st Annual Western Snow Conference. Vancouver, Washington, U.S.A. (D.D. Speers, North Pacific Division, Corps of Engineers, P.O. Box 2870, Portland, Oregon 97208, U.S.A.)

2-3 May
Snow and Man, 40th Annual Eastern Snow Conference. Toronto, Ontario, Canada. (D.R. Wiesnet, Program Chairman, 40th ESC, NOAA/NESS S/RE12, Washington D.C. 20233, U.S.A.)

26-29 May
Symposium on Correlation of Quaternary Chronologies, Sixth York University Quaternary Symposium. Downsview, Ontario, Canada. (Dr W.C. Mahaney, Department of Geography, Atkinson College, York Univ., 4700 Keele Street, Downsview, Ontario, M3J 2R7, Canada)

27 June - 1 July
Symposium on Ice and Climate Modelling. Northwestern University, Evanston, Illinois, U.S.A. (Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK)

18-22 July
Fourth International Conference on Permafrost. University of Alaska, Fairbanks, Alaska, U.S.A. (Louis de Goes, Executive Secretary, Polar Research Board, National Academy of Sciences, 2101 Constitution Avenue N.W., Washington D.C. 20418, U.S.A)

15-26 August
18th General Assembly of the IUGG. Hamburg, Federal Republic of Germany. (Dr J.C. Rodda, Secretary General IAHS, Water Data Unit, Reading Bridge House, Reading, RG1 8PS, U.K.)

16-18 August
Symposium on Polar Meteorology and Climate, 18th General Assembly of the IUGG Hamburg, Federal Republic of Germany. (Dr G.E. Weller, Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701 or Dr M. Kuhn, Institut für Meteorologie und Geophysik, Schöpfstrasse 41, A-6020 Innsbruck, Austria)

18-19 August
Symposium on Sea Ice Margins, 18th General Assembly of the IUGG. Hamburg, Federal Republic of Germany. (Dr R.D. Muench, Science Applications Inc., 13400B Northrup Way, Suite 36, Bellevue, Washington 98005, U.S.A.)

19 August
Symposium on Atmospheric Ice Crystals and Haze in the Polar Regions, 18th General Assembly of the IUGG. Hamburg, Federal Republic of Germany. (Dr M. Kuhn, Institut für Meteorologie und Geophysik, Schöpfstrasse 41, A-6020 Innsbruck, Austria)

25 August
Workshop on Glacier Mass Balance and Runoff, 18th General Assembly of the IUGG. Hamburg, Federal Republic of Germany. (Dr V.M. Kotlyakov, Institute of Geography, USSR Academy of Sciences, Staromonetny Street 29, Moscow 109017, USSR or Dr G.J. Young, Inland Waters Directorate, Environment Canada, Ottawa, Ontario, K1A 0E7, Canada)

26 August
Workshop on Large-scale Snow Studies, 18th General Assembly of the IUGG. Hamburg, Federal Republic of Germany. (Dr A. Rango, Hydrological Sciences Branch, Code 929, Goddard Space Flight Center, Greenbelt, Maryland 20771, USA)

12-16 September
International Symposium on Isotope Hydrology in Water Resources Development. Vienna, Austria. International Atomic Energy Agency, P.O. Box 100, A-1400 Vienna, Austria)

5-8 October
10th Annual meeting of the German Geomorphological Working Group. Berlin, Germany. (Prof. Dr G. Stäblein, Geomorphologisches Laboratorium, Altensteinstrasse 19, 1000 Berlin 33, Germany)

1984

18-23 August
Snow and Ice Chemistry and the Atmosphere. Trent University, Peterborough, Ontario, Canada. (Dr R.M. Koerner, Polar Continental Shelf Project, Department of Energy Mines and Resources, 880 Wellington Street, Ottawa, Ontario, K1A 0E4, Canada)

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.)

1985

(date to be announced)
Symposium on Glacier Mapping. Reykjavik, Iceland. (Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K.)

1986

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

G. Kukla, A. Hecht and D. Wiesnet (Editors). Snow Watch 1980. Glaciological Data Report GD-11, World Data Center A for Glaciology <Snow and Ice>, Boulder, Colorado, October 1981, 148 p., gratis

The importance of snow and ice covers to local microclimate is a subject which has been thoroughly researched by a variety of scientific disciplines and one for which the physical processes are relatively well understood. Following the publications of Budyko (1969) and Sellers (1969), there has been an increasing realization that many of the feedback mechanisms operating between snow/ice and the atmosphere may also play an important role in modifying climate at a much larger synoptic scale. In addition, variations in the spatial extent and seasonal fluctuation of snow and ice fields might be potentially valuable indicators of broad-scale trends in weather patterns.

Snow Watch 1980 presents the results of a two-day workshop convened at the National Science Foundation in Washington to focus on the large-scale climatic impact and climate modelling of seasonal snow cover on land and sea ice. A previous meeting on the "Mapping and Archiving of Data on Snow Cover and Sea Ice Limits" was held in 1978 at the World Data Center in Boulder, Colorado (Glaciological Data Report GD-5, 1979) and basically set the stage for the 1980 workshop. Although the 42 participants at the Snow Watch meeting represented over a 50% increase in total attendees compared to 1978,the number of representatives from outside the United States remained low (3 of 27 in 1978 and only 2 of 42 in 1980). The imbalance in international attendance figures certainly does not detract from the worldwide relevance of the material. It is hoped that the next workshop will include greater input from other countries.

Papers from the workshop were divided into three sections:

(a) the role of snow in climate diagnosis and modelling,
(b) the content and accuracy of snow and ice cover charts, and,
(c) digital products and snow cover indices,

each of which begins with a half-page introduction written by the editors. These were extremely helpful in placing a logical order to the papers and prevented one from experiencing the feeling, which is too often gained in reading proceedings, that the papers are in print only because they were 'presented' and not because they contribute to a general theme. The editors also attempted to place the material in an overall frame-work and were particularly successful in the first introduction. In one-half page of text, reference was made to twelve additional publications in order to properly introduce the subject of snow in climate diagnosis and modelling.

The first set of papers contains case studies describing large-scale interactions between snow/ice and climate (e.g. acceleration of occlusions, blocking, refrigeration of air masses, and enhanced southward movement of Arctic air). Despite the fact that the effects of snow and ice covers on climate appear to be well recognized, the authors point out that they are not given major consideration in the formulation of large-scale circulation forecasts. One of the major reasons for this is the level of sophistication of numerical climate models. They are simply not sufficiently advanced to accommodate subtle feedbacks which control the dynamics of the cryosphere. A major breakthrough could occur if the feedback mechanisms, especially at the transition zones between snow/ice and land/water, were incorporated into the models. Their ultimate utility would, however, then still depend on the availability and quality of input data, which are the foci of the second set of reports. Seven papers are included which describe the various methods of obtaining and displaying snow and ice cover data in chart form. Discussed in detail are three U.S. operational products which display snow and ice fields at a hemispherical scale and on a weekly basis: (a) the northern hemisphere charts of NOAA/NESS, (b) the U.S. Air Force snow cover charts, and (c) the sea ice charts of the NAVY/NOAA Joint Ice Center. Other papers are presented on the state of snow and ice mapping in Canada, ice distribution in the North Polar Region and the use of satellite passive microwave for delineating Antarctic sea-ice cover.

An eighth paper, by Kukla and Robinson, concludes the section of snow and ice charts and is one of the most valuable in the entire volume. In a broad overview, using numerous test comparisons, Kukla and Robinson assess the problems and ultimate value of a number of operational snow and ice charts for broad-scale climate studies. Unfortunately, their conclusions suggest that none of the operational products are ideal data sources. For example, while the NOAA charts display snow boundaries with sufficient detail for large-scale applications, during periods of persistent cloud they often underestimate the extent of snow cover especially during the autumn months. In addition, their subjective 3-level definition of snow reflectivity is considered suitable only for climate system studies at a large-scale but not at a regional level. The test results of Kukla and Robin-

son also seemed to show that despite the vast ground reporting network used in the production of the U.S. Air Force charts, they tend to over-represent snow coverage, especially when dealing with shallow(<5 cm>)snow cover. The principal advantage of the Air Force charts in comparison to the satellite derived products (visual sensors) is that they supply the best source of information concerning the spatial extent of snow cover during persistent cloudy periods. The major problems with the NAVY and NAVY/NOAA sea ice charts appears to be the limitations to discerning dark thin ice from areas of open water. However, the charts do separate boundaries and proportions of grey-white ice from combinations of open water and dark ice with sufficient accuracy for climate studies. Apparently, either further refinement of the data collection systems used in the production of snow and ice charts will have to be made or perhaps some form of composite chart can be designed specifically for large-scale climate modelling.

The last section of papers in Snow Watch 1980 describes some of the digital products and indices which are produced from the operational charts for incorporation into numerical climate models. An important point, especially in view of the range in the quality of results from the Kukla and Robinson test comparisons, and one which the editors themselves make, is that any potential user should be well aware of the limitations of the original charts as outlined above.

One added feature of the report, something which is extremely valuable yet usually missing in the proceedings of workshops, is the list of recommendations formulated by the working groups. Six pages of recommendations were made by four working groups focussing on: (a) snow and ice charts, (b) digital products and archiving, (c), climatic research applications of snow data, and (d) the need for international cooperation. Such comprehensiveness is indicative of the degree of involvement and interaction which must have occurred at the workshop and undoubtedly creates the ideal platform for a third workshop. Note must also be made of the substantive contribution of G. Kukla whose name not only appears on the list of editors but on five of the total eighteen papers.

For anyone whose snow and ice research is performed at an intra-regional scale, the broad-scale scope of this material should be very much of an eye-opener. The report swells the ranks of a diverse set of publications produced by the World Data Center A for Glaciology ranging from avalanche studies in Iceland to glaciology in China and which, amazingly, remain free of charge to interested users. The high quality and usefulness of these reports are points to be considered by readers in light of the current review by the World Data Center A for Glaciology concerning possible charges for the Glaciological Data reports.

Budyko, M.I., 1969. The effect of solar radiation variations on the climate of the earth. Tellus, Vol.21, No.5, 611-619.

Sellers, W.D., 1969. A global climate model based on the energy balance of the earth-atmosphere system. Journal of Applied Meteorology, Vo.8, No.3, June, 392-400.

T.D. Prowse

Roger G. Barry. Mountain Weather and Climate. Methuen & Co., London and New York, 1981, 313 p., 104 figures, 8 plates, £17.50.

With this book Mountain Weather and Climate Roger Barry has filled a gap in the meteorological literature. Although an enormous number of papers is available on the various aspects of mountain weather and climate no one had ever attempted to condense them all in one book. Or was it just the enormous extent of the subject that prevented others from doing it? In any case, to tackle this project was a matter of courage and assiduity. The result, a book of only 313 pages, is astonishing at first sight. Looking through the chapters we notice how this result has been achieved. From the large offering of books and papers reaching back to the beginning of this century summaries or specific abstracts related to the various problems were compiled and briefly discussed.

This book is not a textbook deriving all meteorological relations between topography and atmospheric influences from the beginning. To enjoy this book one has to bring along advanced knowledge on atmospheric processes. In general, formulae, diagrams and figures are reported from the original papers Two essential merits of the book are a worldwide coverage of the principal mountain zones and above all the detailed literature references with more than 900 quotations which extend to many languages other than English. Certainly not all resources have been exhausted – who would try? References to French papers, for example, are rather scarce, and in the German literature also some preference is noted. The references are attributed to each chapter or subchapter. As a number of original papers have to do with subjects dealt with in various chapters it would have been useful to have a central author's index guiding one to the references following each chapter.

The book is divided into seven chapters of different length and weight:

1. Mountains and their climatological study, a survey chapter (16 p.)
2. Geographical controls of mountain meteorological elements, characterizing the atmospheric parameters as related to latitude altitude and topography (72 p)
3. Circulation systems related to orography, describing dynamic and thermal influences

of mountains on the wind field (66 p)
4. Climatic characteristics of mountains, analyzing combined processes, in particular heat and mass exchange (78 p)
5. Case studies, outlining the peculiarities of the climatic features in seven mountain systems of the globe (40 p)
6. Mountain bioclimatology, covering effects of air pressure, heat exchange, weather hazards and air pollution (22 p)
7. Changes in mountain climates, discussing briefly climatic development in historic times primarily based on glacier fluctuations (8 p)

As in any book one can find some errors and shortcomings and each reviewer will have his specific sensitivity. When in Chapter 2 the main geographic factors influencing mountain climates are introduced one would expect "continentality" to be mentioned. Besides observations of this kind minor missprints or inaccuracies may puzzle the reader. A few examples: on p.24 a formula is given with vapour pressure in kg m^{-3}. On p.63 the speed up ratio reads as $\Delta S = (\Delta U/U)z$; should z not be an index? On p.84 reference is made to Figure 2.33 illustrating direct calculation of radiation from digitized topographic data; such a calculation is presented in Figure 2.24. On p.103 Scorer's parameter ℓ is introduced with the dimension m^{-1}; on p.118 (second last line) it appears with the dimension m. On p.18/19 the two diagrams should be exchanged and the same holds for Plates 6A and 6B (p.148/149).

To the mountain glaciologist interested in snow and glacier phenomena the book does not offer a detailed treatment of his particular subject, but he will find a very valuable review of the vast field of meteorological processes acting directly or indirectly on snow and ice. He will use it as a turntable guiding him to the required specialist.

M. de Quervain

NEWS

PUBLICATIONS

THE LAST GREAT ICE SHEETS
Edited by George H. Denton and Terence J. Hughes and published by Wiley. 1981, 484 pp., $96.69.
This book presents a global view of the last great ice sheets, which existed at their fullest extent about 17,000 to 21,000 years ago. It begins by reviewing the areal distribution during the last ice age of ice sheets, ice caps, and mountain glaciers and develops numerical methods for reconstructing glacier elevations. It presents over-all Northern Hemisphere results in two fundamentally different ice sheet reconstructions that reflect deeply divided opinions among Quaternary geologists concerned with the areal extent of these ice sheets. Finally it presents an hypothesis for the reconstruction and disintegration of the Antarctic Ice Sheet during the last glaciation and presents a new synthesis of the Wisconsin-Holocene glacial history of the Arctic. (from the preface)

QUATERNARY SCIENCE REVIEWS
Published quarterly by Pergamon Press. Annual subscription rate US$70.
This new journal has been launched to provide both systematic reviews of progress and techniques to enable Quaternary workers and other specialists to keep abreast of recent developments in Quaternary research. Regional reviews will form an essential part of each issue. Short items will include communications about meetings and news of particular research group activities.

HANDBOOK OF SNOW: PRINCIPLES, PROCESSES, MANAGEMENT AND USE
Edited by D.M. Gray and D.H. Male and published by Pergamon Press Canada Ltd., 1981, 796 pp., illus., $28.30 (Cdn) soft cover, $85 hard cover.
The book is divided into four parts. Part I: Snowfall and the Environment – provides facts and figures on snow's impact on climate, agriculture, plants and humans. It explains techniques for irrigation, livestock care, crop environment, flood control, etc. Part II: Snowfall and Snowcover – outlines meteorological procedures for tracing snowfall formations, measuring and analyzing data, charting snowcover patterns and properties and covers the nature of snow and ice on lakes and the movement and control of avalanches. Part III: Snow and Engineering – discusses the most efficient snow removal equipment and effective methods for snow removal and control on highways, airports and railroads, the best chemicals for snow and ice control, snow and buildings, particularly roof construction, thermal methods of snow control, vehicles for oversnow travelling, etc. Part IV: Snow and Recreation – reviews the latest information on skiing and looks at snow conditions and the mechanics of skis. (From the Publisher's release)

GEOTECHNICAL ASPECTS OF COLD REGIONS FOUNDATION AND UTILITY DESIGN

The University of Wisconsin-Extension Engineering Department will present the 3rd annual technical institute on Geotechnical Aspects of Cold Regions Foundation and Utility Design. The program has been developed in cooperation with the U.S. Army Cold Regions Research and Engineering Laboratory. It will be held in Madison, February 2-4 1983, and is for geotechnical, transportation, utility, construction, civil and other engineers interested in developing a basic understanding of foundation design and utility engineering in cold regions.

The program topics include environmental and geotechnical aspects of cold regions, frozen ground properties and thermal behaviour, design of shallow and deep foundations, cold regions earthwork, design of pavements and airfields, special foundations, and utility design.

Program and registration information is available from University of Wisconsin-Extension, Department of Engineering, 432 North Lake Street, Madison, Wisconsin 53706, U.S.A., tel: 608-262-0577.

ICEBERG RESEARCH

In order to create a forum for the disparate investigations on all aspects of icebergs and for the exchange of ideas amongst the widely scattered group of people involved in iceberg research, the Scott Polar Research Institute, with initial funding from the Office of Naval Research, has begun publication of a thrice-yearly newsletter entitled "Iceberg Research". It is intended to be informal and will include contributions covering reports on work done, abstracts of papers to appear, highlighting of problem areas, discussion of issues raised in previous articles, schemes and ideas for the use of and/or protection from icebergs, digests of data sources on icebergs, discussion of peripheral areas and announcements and summaries of meetings.

Anyone wishing to have their name placed on the mailing list or requiring further information should contact Peter Wadhams. Contributions should be sent to one of the two editors as follows:

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INTERNATIONAL GLACIOLOGICAL SOCIETY

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DETAILS OF MEMBERSHIP

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

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Institutions, Libraries	Sterling: £50.00 for Volume 28 (Nos. 101, 102, 103)

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

ICE

Editor: Simon Ommanney

This news bulletin is issued to members of the International Glaciological Society and is published three times a year. Contributions should be sent to Mr C. S. L. Ommanney, Snow and Ice Division, National Hydrology Research Institute, Environment Canada, Ottawa, Ontario, K1A OE7, Canada.

Annual cost for libraries, etc. and for individuals who are not members of the Society: Sterling £7.50.

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