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SYMPOSIA

1989

21-25 August	Ice and Climate. Seattle, WA, U.S.A. Proceedings volume: *Annals of Glaciology*, Volume 14

1990

27-31 August	Ice–Ocean Dynamics and Mechanics. Hanover, NH, U.S.A. Proceedings volume: *Annals of Glaciology*, Volume 15

1991

26-30 August	Mountain Glaciology relating to Human Activities. Lanzhou, China

Invitations have been received for symposia to be held in Boulder, CO, U.S.A., Finland, Poland, Austria and Switzerland, on topics such as remote sensing, ice engineering, glacier drainage systems, energy and mass balance of glaciers, and sediment studies relating to glacier erosion.

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CONTENTS

COVER PICTURE: Steingletscher shown during present advance into a proglacial lake. Photograph by Peter Müller, VAW, ETH-Zentrum, CH-8092 Zürich, Switzerland.

BELGIUM

ANTARCTIC

The Belgian glaciological work undertaken in the Antarctic during the last three years is part of a national research programme initially set up by the Belgian government for the period 1986–89, and presently renewed for another period of three years (1989–92). Main results and future objectives are briefly reported here by the different teams involved in the programme.

DYNAMICS OF THE ANTARCTIC ICE CAP
(H. Decleir, P. Huybrechts, L. de Vos and F. Pattijn, Geographical Institute, Vrije Universitiet Brussel, Belgium)
The role of the Antarctic ice cap in the glacioclimatic system of the earth is being investigated by a 3-D time-dependent model (with geodynamics), developed by P. Huybrechts. The model has been implemented on a CRAY-2 Super computer and experiments involving a complete glacial–interglacial cycle carried out. Explaining the glacier variations as recorded in the ice-free mountain areas and on nunataks requires more detailed modelling and additional field observations. Ice thickness measurements were carried out by H. Decleir and L. de Vos during JARE 28 (Japanese Antarctic Research Expedition) in the Sør Rondane, Dronning Maud Land, extending former Belgian investigations in that area. By simulating the glacier behaviour by flow-line modelling and with the help of TM and SPOT satellite images (F. Pattijn) it is hoped to identify the function of such marginal mountain areas.

KATABATIC WINDS IN THE ANTARCTIC COASTAL ZONE
(H. Gallée, G. Schayes, T. Fichefet and C. Tricot, Institut d'Astronomie et de Géophysique G. Lemaître (IAG G. Lemaître), Université Catholique de Louvain, Louvain-la-Neuve, Belgium)
The spatial evolution of katabatic winds along both idealized and realistic slopes representative of Antarctic terrain were examined using a hydrostatic, two-dimensional primitive equation model with high resolution. This mesoscale atmospheric model was coupled to sea ice and ice sheet surfaces. The downslope momentum forces were analysed using the simulation of the steady-state katabatic flow. This analysis shows the importance of the reversal of the pressure gradient force in the coastal zone, causing the sudden decay of katabatic winds.

Then the influence of the presence of a small offshore polynya was also investigated. Although the presence of the polynya does not influence significantly the simulated katabatic flow itself, the heat trasnfer between atmosphere and ocean is strongly enhanced when the ocean is free of ice. This leads to an enhanced sea-ice formation and salt rejection in the water column.

UPPER OCEAN–SEA ICE INTERACTIONS
(T. Fichefet and P. Gaspar, IAG G. Lemaître, Louvain-la-Neuve, Belgium)
A thermodynamic sea-ice model, including leads, has been coupled to a one-dimensional oceanic mixed layer model in order to investigate the upper ocean–sea ice interactions. The oceanic heat flux at the base of the ice layer (F_b) is predicted, not imposed, assuming a thermodynamic equilibrium between the bottom of the ice and the water just below. For testing the model, the annual cycle of the Arctic sea ice and upper ocean is simulated along the longitude 169.5°W. The model produces a realistic evolution of the sea-ice thickness and extent and of the upper ocean salinity and temperature profiles. The modelled value of F_b is far from being constant. Below thin ice, it can be larger than 5 W m^{-2} due to the important fraction of the solar irradiance that is transmitted through the ice, absorbed in the mixed layer and then returned to the ice. Below the thicker perennial sea ice, F_b takes values between 0 and 2 W m^{-2} and exhibits a well-marked annual cycle: it is maximum in March and April and vanishes during the summer months. It is also found that the changes of the sea water freezing temperature due to changes of salinity have an important effect on F_b and on the vertical density profile of the upper ocean.

ANTARCTIC OCEAN AND SEA-ICE COUPLED MODELLING
(J.P. van Ypersele, IAG G. Lemaître, Louvain-la-Neuve, Belgium)
A comprehensive coupled model of ocean circulation and sea ice has been developed to study a selected area of the Southern Ocean that includes the Drake Passage and the Weddell Sea. First, a sea-ice model including thermodynamics and simplified dynamics was developed. The results of this sea-ice model show that thermodynamics alone are insufficient to reproduce the large seasonal cycle of sea-ice extent, and that the inclusion of transport and parameterized dynamics is essential for the reproduction of the observed cycle. Then a three-dimensional oceanic general circulation model was coupled to the sea-ice model through momentum, heat, and salt fluxes. The coupled model results show a seasonal amplitude in sea-ice extent very close

to the observed one, but the most interesting feature of this simulation is the appearance of a large polynya, located approximately where the Weddell Polynya has occasionally been observed. This polynya appears to be due both to a divergent ice movement and to a large oceanic heat flux associated with water convection. These mechanisms continue to be investigated.

SEA-ICE AND MIXED-LAYER MODELLING FOR THE WEDDELL SEA

(C. Demuth, Management Unit of the Mathematical Model of the North Sea (MUMM), Brussels, Belgium, and J.P. van Ypersele, IAG G Lemaître, Louvain-la-Neuve, Belgium)
A model of sea-ice formation has been developed and applied to a sector of the Southern Ocean including the Weddell Sea and Drake Passage to describe the annual cycle of the sea-ice thickness and spatial extent on the ocean. This sea-ice model with leads is described in two parts:
- the thermodynamic component which controls the freezing and melting processes due to energy fluxes between the atmosphere, ice and ocean, and the heat and salt exchanges between the mixed layer and the deep ocean;
- the dynamic component limited to the computation of ice movement due to wind and surface current velocity.

The surface heat budget, heat and salt exchanges and momentum transfers are modelled and/or parametrized from monthly mean climatological data (wind, air temperature, dew point, cloudiness and snowfall) and annually-averaged values of temperature and salinity fields into the ocean. Results from the sea-ice model, including ice thickness, temperature, mixed layer depth and ice extent, are expressed and discussed for the whole area and for particular points (offshore and coastal).

STABLE ISOTOPES IN ANTARCTIC SEA ICE

(R. Souchez, J.-L. Tison, Université Libre de Bruxelles (ULB), Belgium, and J. Jouzel, Laboratoire de Géochemie Isotopique (LGI), Saclay, France)
Earlier work by Souchez and Jouzel (1982, 1984) has shown that samples of ice due to the freezing of water are aligned in a δD-$\delta^{18}O$ diagram on a characteristic freezing slope that does not vary with the freezing rate. However, the position of the samples on the freezing slope is dependent on the freezing rate. Recent work led to a possibility of prediction of the freezing rate in nature by using the isotopic composition of the ice in δD and $\delta^{18}O$ in a box diffusion model combined with the boundary layer concept. The method has been successfully applied to first-year sea ice sampled in Breid Bay (near Syowa Base) in the frame of the JARE 28 Japanese expedition.

An attempt is also made to estimate the variations of the conductive heat flux through first-year sea ice from the isotopic signal recorded in the ice throughout the year.

A joint programme with the British Antarctic Survey is presently concerned with the analysis of multi-year sea-ice cores from the rifts area in the southern part of George VI Sound. Sampling of first-year sea ice and synchronous monitoring of the climatic data at Rothera Base is also planned for the austral winter 1989.

ARCTIC

BASAL ICE OF THE GREENLAND ICE SHEET

(R. Lorrain, R. Souchez, J.-L. Tison, G. Fierens, ULB, Belgium, D. Sugden, University of Edinburgh, U.K., and J. Jouzel, LGI, Saclay, France)
This joint programme carried out a detailed analysis of the crystallography, oxygen and hydrogen isotope ratios and debris content of basal ice exposed at the western margin of the Greenland ice sheet (Jakobshavn Glacier and Russell Glacier). The results, compared with others obtained at the margin of three piedmont glaciers on Bylot Island (Canadian Arctic), show the wide occurrence of two mechanisms of basal ice formation in Arctic outlet glaciers, each one displaying its own co-isotopic signature. The dispersed and stratified facies of basal ice present in these glaciers are related respectively to the occurrence of regelation and to freezing-on at the glacier base. Their origin is tentatively connected with the onset of basal sliding and the zone of bed decoupling due to basal water pressure in these Arctic outlet glaciers.

Present analyses of ice cores from a new campaign aim for a better understanding of the processes involved. It is planned to stress the exact relationship between debris and ice fabrics and to achieve detailed isotopic profiles across the different types of debris layers.

SWISS ALPS

STABLE ISOTOPES AND ICE FABRICS IN BASAL ICE OF ALPINE GLACIERS

(J.-L. Tison, R. Lorrain, R. Souchez and G. Fierens, ULB, Belgium)
A review of basal ice exposures in the Alps has been carried out to understand some of the incorporation processes of unconsolidated sediments. A comparison has been made with exposures in the Arctic.

New field data were obtained at the Glacier de Tsanfleuron. This glacier has some lateral subglacial cavities in which a basal ice layer forms on the bedrock floor and is subsequently incorporated at the base of the glacier. Petrographic and crystallographic analyses show major structural changes which provide a field confirmation of the deformation mechanisms studied by several authors in laboratory experiments. Detailed isotopic analyses are currently performed on these basal ice layers.

STABLE ISOTOPES IN HIGH ALTITUDE ALPINE AREAS
(R. Lorrain, ULB, Belgium and W. Haeberli, ETH, Zürich, Switzerland)
A co-isotopic profile of ice samples from a tunnel dug in the highest part of Titliss-gletscher (3020 m a.s.l.) shows a striking decrease of δ values with depth. The observed shifts of 3.4‰ in $\delta^{18}O$ and of 28.1‰ in δD are interpreted as a recent climatic warming. However, a direct temperature effect can only explain a small part of the isotopic shift. It is proposed that the meltwater production and percolation brought up by this temperature effect may account for the major part of the trend.

RECONSTRUCTION OF THE STRUCTURE OF THE FORMER SUBGLACIAL DRAINAGE SYSTEM OF THE GLACIER DE TSANFLEURON, SWITZERLAND
(J. -L. Tison, G. Fierens, ULB, Belgium, and M. Sharp, Department of Geography, Cambridge, UK)
A well-developed subglacial drainage system consisting of large cavities present on the lee of bedrock steps connected together by a network of Nye channels is exposed on an area of recently deglaciated limestone bedrock in front of Glacier de Tsanfleuron. Sharp and others performed a detailed mapping of a selected area and used the cavity hydraulics model of Kamb to show that the geometry of the system rendered it stable against collapse by meltback of channel roofs into a tunnel-dominated system. Implications on glacier sliding velocities were estimated.

Recent work uses the geochemistry of the different types of subglacially precipitated calcite deposits, present on the bedrock surfaces adjacent to the glacier margin, to consider the role of the water film component in the overall hydrology of the glacier.

GLOBAL GLACIOLOGICAL MODELLING

ICE AGES MODELLING
(A. Berger, T. Fichefet, H. Gallée, S. Hovine, J.F. Lamarque, I. Marsiat, C. Tricot and J.P. van Ypersele, IAG Lemaître, Louvain-la-Neuve, Belgium)
A 2.5 D seasonal model has been developed for simulating the transient response of the climate system to the astronomical forcing. The atmosphere is represented by a zonally averaged quasi-geostrophic model which includes accurate treatment of radiative transfer. The atmospheric model interacts with the other components of the climate system (ocean, sea ice and land surface covered or not by snow and ice) through vertical fluxes of momentum, heat and humidity. The model explicitly incorporates surface energy balances and has snow and sea-ice mass budgets. The vertical profile of the upper-ocean temperature is computed by an interactive mixed-layer model which takes into account the meridional advection and turbulent diffusion of heat.

This model is asynchronously coupled to an ice sheet model which simulates the dynamics and the isostatic rebound of the Greenland, North American and Eurasian ice sheets. Over the last glacial-interglacial cycle, the coupled model simulates climatic changes in agreement with the low frequency part of deep-sea and ice records, and the simulated waxing and waning of the three individual ice sheets are in phase with geological reconstructions obtained independently. In future, the quasigeostrophic model will be replaced by a primitive equation model. The coupling with a deep-ocean model and a CO_2 cycle model is under investigation.

ICE SHEET MODELLING
(I. Marsiat, IAG G. Lemaître, Louvain-la-Neuve, Belgium)
A latitude and time-dependent ice sheet–lithosphere model computing the ice thickness and the isostatic rebound is used for the paleoclimate studies. The longitudinal component of the ice flow is actually represented assuming that the east-west profile of the ice sheet is parabolic, allowing many ice sheets to be represented at the same latitude. In future, this model will be extended to a 2 D horizontal model including thermodynamics.

Submitted by R. Souchez

CHINA

RECENT PROGRESS IN STUDIES OF SNOW AND ICE

COMPILATION OF THE GLACIER INVENTORY OF CHINA
The glacier inventory of Tianshan Mountains, (Liu Chao Hai and others) was published in 1987, and *The glacier inventory of the interior area of Quinghai-Xizang Plateau* (Jiao Keqing, Yang Huain and others) was published in 1988. In total, 11 books (comprising 4 volumes) have now appeared. *The glacier inventory of the Yarlung Zangbo river system* is in preparation. *The glacier*

inventories of Pamir Plateau, Kunlun Mountains, Karakoram Mountains and Hengduan Mountains is in press.

STUDIES IN REGIONAL GLACIOLOGY

During the Sino-Japanese Joint Expedition to the west Kunlun Mountains in 1987 (Xie Zichu, Higuchi), important data concerning the glacier accumulation, ablation, mass balance, motion velocity, ice temperature, and meteorological and hydrological conditions were obtained. A series of systematic meteorological data at a height of 5260 m was recorded for the period of a full year. The conditions for development for the glaciers were studied extensively. It was found that the glaciers in this region belong to the extra-continental type of glacier characterised by low ice temperature, slow motion and a low level of mass balance.

STUDIES OF ICE CORES

Three ice cores, respectively 139.8 m, 136.6 m and 138.4 m long, were drilled on the Dunde Ice Cap of the Qilian Mountains in 1987 by the joint expedition from LIGG and the Polar Research Center of Ohio State University (Wu Xiaoling, Lonnie Thompson). Hydrogen and oxygen isotopes, microparticles and chemical components have been analysed. These cores provide important information about climate and the environmental variation in high mountainous areas in Central Asia during the past 100,000 years. In addition, three shallow ice cores were extracted in 1987 on the Chongce ice cap in the western Kunlun Mountains. They provided important evidence for the recent climatic and environmental variations in the mountains of western China.

STUDIES OF SNOW AND ICE HYDROLOGY

The programme entitled "Comprehensive studies of water resources of the Urumqi River of Xinghiang" (Shi Yafeng, Qu Yaoguand, 1985–87) made systematic studies of the formation, diversion and rational utilization of water resources. It produced important scientific evidence that the over-river–basin water diversion would meet the need for water supply in the city of Urumqi. The range of the institute's hydrological research was enlarged from the original high cold mountains to arid plateau areas. Meanwhile, fixed meteorological and hydrological observations were being carried out at the headwaters of the Urumqi River (Kang Ersi and others). By contrasting the readings from a number of rain gauges set at different heights, a correction for the observed precipitation at various altitudes was proposed. A number of models concerning the relationship of glacial discharge and climatic factors was calculated.

Progress was achieved in the study of the flood caused by the outburst of glacier lakes. In 1985–87, LIGG, together with Xingjiand Water Conservancy Bureau, explored the flood caused by the outburst of glacier-dammed lakes in the Yarkant River in the Karakoram Mountains (Zhang Xiangsong). It is forecast that during the coming decade the scale of outburst floods in the Yarkant River will be smaller as a result of the successive retreat and thinning of the glaciers. In 1987, in cooperation with scientists from Nepal and Canada, LIGG studied the flood caused by the outburst of glacial moraine-dammed lakes in the Poiqu and Pumqu rivers in Tibet (Xu Daoming, Liu Chaohai, C.K. Sharma). The number, type and distribution of glacial moraine-dammed lakes were systematically investigated, the stability reviewed and the consequent process of flood or debris flow simulated.

STUDIES OF RIVER ICE AND SEA ICE

In addition to the usual observations of ice conditions in several rivers in northern China, the ice in ice dams and water was also studied. The studies of the expansile force of ice covering reservoirs and the action of floating ice upon engineering construction achieved high level results. Observations of river ice are mainly undertaken by institutions concerned with the study of hydrology. During the past few years, Hefei College of Industry and many other universities have joined in. Investigation and forecasting of sea ice conditions are mainly undertaken by the Sea Ice Research Division, affiliated to the Ocean Bureau of China. In addition to the foregoing monitoring of ice conditions, the character of the growth and disappearance of sea ice, and its mechanical properties etc., were also studied. The investigation of sea ice in the Antarctic has just taken its first step.

STUDIES OF THE ANTARCTIC ICE SHEET

A series of glaciological data was obtained at Great Wall Station in Antarctica. Analyses of several snow profiles and ice cores are being performed by LIGG and ANARE. The studies of snow profiles on Law Dome ice cap revealed clear variations in ice formation series, from the centre north: recrystallization belt, regelation-recrystallization belt, cold percolation-recrystallization belt, percolation belt, percolation-regelation belt and ablation belt (Xie Zichu, 1988). The process of densification in the snow profile and firn cores in Wilkes Land was divided into three types: warm, cold, and alternative types of densification. Quantitative criteria of the division were also given (Qing Dahe, 1987). The studies of the spatial variation of ice fabrics in BHQ ice core showed the mono-maximum fabric which exists everywhere in Antarctica principally resulted from the turn of the base of ice crystals (Li Jun, 1988). The experiment on the densification process of Antarctic ice demonstrated that the multi-maximum fabric which generally exists at the base of the Antarctic ice sheet mainly resulted from the recrystallization of ice (Huang Maohuan, 1988).

STUDIES OF PHYSICS OF SNOW AND ICE

Studies of an artificial ice tunnel at the Tianshan Glacier station showed that the strain rate is high in the continental type of glacier. Scientific interpretation about the flow deformation and base slide of glaciers was proposed (Hunag Maohuna, Wang Zhongxiang, K. Echelmeyer, 1987).

DEVELOPMENT OF INSTRUMENT AND REMOTE SENSING TECHNIQUES

Remote sensing techniques have been used in the study of snow cover and snow melt run-off in the upper reaches of the Yellow and Hiho rivers (Zeng Qunzhu, 1987), and also in the monitoring and study of glacial variation in the Qilian Mountains.

Great improvements have been made in the techniques of field remote sensing and data collection (Wang Liangwei, 1987). An effective data collecting and processing system with the SMOS Microcomputer as the main body has been widely used in the meteorological, hydrological and glaciological studies in the Tianshan and Qilian mountains. Considerable terrestrial stereographical mapping and survey was carried out on the Chongce Glacier in the western Kunlun Mountains, Dunde ice cap in the Qilian Mountains, and the Yarkant River in the Karakoram Mountains (Cheng Jianming, 1988). Repeated terrestrial stereographical survey and mapping has been applied in the studies of glacial variation in the Qilian Mountains (Liu Chaohai, 1988).

STUDIES OF SNOW COVER, SNOW DRIFT AND AVALANCHES

The studies of the mechanism and the prevention of snow drift over undulating landscapes were confined to the Yili-Huoqiang Highway, Xingjiang (Wang Zhonglong, 1987). A project for snow damage prevention was put forward after observations in the Tanggula Mountains on the Qinghai-Xizang Highway (Wang Zhonglong, 1987). Seasonal avalanches in the west of China were classified as continental, maritime and transitional, and their regional characteristics studied (Wang Yanlong, 1987). The Tianshan avalanche station built by the Xingjiang Institute of Geography continues to accumulate data (Hu Ruji, 1988).

SCIENTIFIC CONFERENCE AND PROCEEDINGS

The Fourth National Conference on Glaciology and Geocryology of China was held in Lanzhou in October 1988. 150 Chinese and foreign scientists participated, and 40 articles on snow and ice problems were presented.

During the past two years, about 60 articles have been published in *Glaciology and Geocryology* and other journals, with 10 published in related international journals. The following books were published: *Report on the first expedition to glacier lakes in the Pumqu and Poiqu River basins, Tibet* (Liu Chaohai and C.K. Sharma, 1988); *Quaternary glaciers and environment in east China* (Shi Yafeng, Li Jijun, Cui Zhijou, 1988); *Water resources and environment in the Urumqi River* (Shi Yafeng and Qu Yaoguang, 1988). In addition, *The map of snow, ice and frozen ground in China* (Shi Yafeng, 1988) has just been published.

Submitted by Xie Zichu

JAPAN

GLACIOLOGICAL ACTIVITIES

Much active glaciological research has been carried out by various institutions in Japan, both on fundamental and applied aspects of snow and ice. Results obtained have been reported and published by different meetings and journals such as JSSI (Japanese Society of Snow and Ice), Physical Society, Meteorological Society, Chemical Society and so on; the following summary is only a short introduction to these activities. Several institutions are abbreviated as follows: CERI (Civil Engineering Research Institute, Hokkaido Development Bureau), FE (Faculty of Engineering, Hokkaido University), ILTS (Institute of Low Temperature Science, Hokkaido University), KIT (Kitami Institute of Technology), NISIS (Nagaoka Institute of Snow and Ice Studies, National Research Center for Disaster Prevention), NEL (Niigata Experimental Laboratory, Public Works Research Institute), NIPR (National Institute of Polar Research), SBSIR (Shinjo Branch of Snow and Ice Research, National Research Center for Disaster Prevention), and WRI (Water Research Institute, Nagoya University).

PHYSICS OF ICE AND SNOW

(Norikazu Maeno)

An X-ray diffraction analysis of single crystals of ice, Ih, was made by A. Goto, T. Hondoh and S. Mae (FE) to gain insight into the structure of electron clouds in hydrogen atoms. A similar technique was applied by Anzai and others (FE) to ice samples drilled at Greenland Dye 3, which revealed that the air hydrates involved are cubic clathrates with a lattice constant of 17 Ångström.

Y. Mizuno (ILTS) conducted a creep experiment of polycrystalline ice under hydrostatic pressures up to 50 MPa and showed that a steady minimum-rate creep occurs at strains from about 1–2% irrespective of stress and hydrostatic pressure.

S. Murakami and N. Maeno (ILTS) measured thermal conductivities of ice/metal/rock mixtures to get a theoretical model to be used to estimate thermal evolution of icy satellites in cosmoglaciology. The vapor pressure of amorphous ice was measured by A. Kouuchi (ILTS) who showed that the vapor pressure is not a simple function of temperature, but depends on its structure.

The condensation coefficient of water vapor was measured by T. Sei (Science University of Tokyo) at 0.8% of supersaturation and temperatures near the melting point; S. Nakahara and T. Gonda of the same university measured in a diffusion-type chamber at −15°C the relation between the growth rate and curvature of a growing branch tip (and branch distance). T. Kuroda (ILTS) investigated the effect of self-diffusion in quasi-liquid layers on the growth rate of ice from vapor.

Y. Endo and others of Tokamachi Experimental station (Forestry and Forest Products Research Institute) noted the difference in depths of snow covers deposited on horizontal and inclined surfaces and suggested that the initial density of snow might be smaller on steeper slopes. Preliminary measurements of shear fracture strength of snow were made by Y. Yamada (NISIS) and K. Izumi (Niigata University) to get insight into the mechanical behavior of low-density snow in avalanche release zones. Snow properties were observed by E. Akitaya and H. Shimizu (ILTS) after the formation of cracks relating to avalanche release.

AVALANCHE AND BLOWING SNOW

(Atsushi Sato)

Kurobe Canyon in known in Japan for large-scale avalanches which caused several big disasters. A research group (K. Kawada of Toyama University, N. Maeno (ILTS), S. Kobayashi of Niigata University, and others) installed load cells, video cameras and other instruments in the avalanche shoot to investigate artificial and natural powder-snow avalanches; an avalanche wind was recorded by an ultrasonic anemometer before the front of the avalanche body came to the sensor.

C. Shimomura and Y. Sakai (NEL), intending to apply meteorological elements as a factor for avalanche forecasting, used Fuzzy theory and took up topographical and other environmental factors as well as meteorological ones. Tests of their method for several avalanches show 70% accuracy so far. They also made model experiments of avalanche deceleration fences. Small-size avalanche deceleration structures were tested using snow on a small chute in a cold room. Two types of structure, a hurdle type and a "jungle gym" type, were placed on the chute. From the impact force measurement, it was shown that a double or a 3 line system of the "jungle gym" type structure was most effective at avalanche deceleration.

Y. Yamada and others (NSIS) set a glide meter on avalanche slopes which has three glide sensors, a data logger and a micro-computer. According to the observed data of glide speed and avalanche, the glide meter telemetered three levels of avalanche danger, (a) safe for $v < 1$ cm/hr; (b) caution for $1 < v < 6$ cm/hr; (c) warning for $v > 6$ cm/hr.

Y. Nohguchi (NISIS) formulated a model for the motion of the mass center of an avalanche on an arbitrary surface. Numerical solution of this model shows that an avalanche path on complex topography is very sensitive to small disturbances. A similar numerical model was developed by N. Maeno and K. Nishimura (ILTS) to simulate avalanche motion on an arbitrary three-dimensional topography, which takes into account the velocity dependences of kinetic friction and mass entrainment rate.

Research on the motion and destructive forces of snow avalanches was conducted by H. Nakamura, O. Abe and A. Sato (SBSIR) with a 25 m long, 11 m high avalanche chute. About $0.5 \times 1.0 \times (0.7–2.5)\ m^3$ snow blocks slid down the chute and hit a post or a fence which had several load cells to measure impact force profile or two-dimensional pattern of the impact. A larger impact force was measured for the post than for the fence; this was considered to be due to shear at the edge added to the pure impact force. A high speed video camera and 16 mm high speed movie camera were used to analyze the movement of snow at the moment of impact. In most cases, snow grains flew up and away along the post or fence, and snow compaction did not occur, mainly because we used coarse- grained snow. The speed of the block was decreased after impaction; this decreasing rate increased once a critical length of the blocks was reached.

Study of snow-air mixture flow was made by K. Nishimura and others (ILTS); powder avalanche experiments were conducted in a cold room; a high speed video camera was used to measure a profile of particle density. It was revealed that the mixture flow was composed of two layers, a flow layer at the bottom with density of 250–350 kg/m^3, and a snow dust layer above it with a density of 40–100 kg/m^3. In the flow layer, a strong velocity gradient was observed, and the mixture flow fitted the Bingham model better than the Newtonian or dilatant models.

Kinetic friction between snow and snow was investigated by G. Casassa, H. Narita and N. Maeno (ILTS). The friction coefficient was measured in two ways: by sliding snow blocks on the surface of natural snow slopes, and by measuring torques induced by rotating snow blocks in touch with fixed snow in a cold laboratory. Dry Coulomb friction as well as viscous and ploughing or erosion friction were observed and discussed in reference to the Mohr-Coulomb relation.

Parameterization of critical wind speed to cause drifting snow was tried by J. Kondo (Tokoku University); the wind speed at the surface cover was parameterized as the density of snow particles. The critical wind speed to cause drifting snow decreases with the deceasing density of snow cover and size of snow particles. This means that drifting snow easily occurs in fresh snow conditions. C. Kimura, M. Higashiura and A. Sato (SBSIR) carried out systematic observations of blowing snow in Tsugaru Plain, northern Honshu Island. General meteorological observation as well as blowing snow measurements were conducted. Continuous recording of relative humidity showed a good time response to the blowing snow. Doppler radar and radiosonde were used to reveal a mesoscale condition of cloud and wind in connection with blowing snow.

T. Kimura and A. Sato (SBSIR) developed two measuring systems to measure continuously the transportation rate of blowing snow. A video image analyzer captured snow particles on a video tape recorder, which gave snow particle density in relation to the space, size distribution and particle speed. A snow-particle counter of Schmidt-type was constructed and combined with a data-processing unit which calculated size distribution of 16 levels and mass transport rates. Threshold condition of blowing snow occurrence was investigated by M. Takeuchi and K.Ishimoto and others (CERI); a visual range meter, a thermometer and an anemometer were used to make a diagram of threshold conditions of high level blowing snow occurrence. The result showed weak temperature dependence below -2° or -3°C. For wind speed above 11 m/s it was the region of continuous high level blowing snow, above 8 m/s intermittent high level blowing snow. Using this diagram and reported weather data, they made a blowing snow map of Hokkaido.

Surface patterns of snow due to blowing snow were studied by K. Kosugi, K. Nishimura and N. Maeno (ILTS). An experimental study was conducted on the formation mechanism of snow surface patterns in a cold wind tunnel and showed that the wavy patterns are perpendicular to the wind, and that the wave length, height, as well as migration speed, increased with the increasing wind velocity. S. Takahashi, T. Ooshima and S. Taniguchi (KIT) obtained velocity profiles from the windward and leeward of snow fences to make a two dimensional wind pattern for various types of fences, both in the field and for 1/4 sized model ones. The measurement of two-dimensional turbulence and power spectrum showed that no snow deposition occurred at the point of large turbulence intensity.

GLACIERS AND HYDROLOGY

(Shuhei Takahashi)

Spitsbergen and Norway The first activity of the Japanese Arctic Expedition, organized by O. Watanabe (NIPR) in 1987 was ice-core drilling in Norway and Spitsbergen Island. At Høghetta in Spitsbergen, the ice core drilled from the surface to the bottom was 85.61 m in depth. Y. Fujii (NIPR) and K. Kamiyama of Kyoto University examined soil particles, pH, electric conductivity, chemical components and oxygen-isotopic composition. K. Satow of Nagaoka College of Technology observed meteorological conditions on the glacier. K. Izumi of Niigata University made stratigraphic observations and examined the formation mechanism of super-imposed ice. At Jostedalsbreen in southern Norway, the ice core drilled from the surface to the bottom was 46.96 m in depth. T. Kawamura and K. Kameda of ILTS analyzed the ice core in terms of density, electric conductivity and stratigraphy.

West Kunlun Mountains in China

An expedition to West Kunlun Mountains was led by K. Higuchi (WRI) in the summer of 1987 in cooperation with the Lanzhou Institute of Glaciology and Geocryology, China, after the reconnaissance expedition led by 0. Watanabe (NIPR) in 1985. Around the top of the Chongce ice cap (6327 m a.s.l.), M. Nakawo (NISIS) and S. Kohshima of Kyoto University carried out ice core drillings. Y. Ageta (WRI) obtained altitudinal profiles of mass balance on the ice cap. S. Takahashi (KIT) observed heat balance components on the ice cap and found that evaporation had an important role. T. Ohata (WRI) carried out aerological observation and compared the surface meteorological conditions at five stations from the foot to the top of the ice cap. Y. Aoki (WRI) examined the distribution of permafrost and the movement of ground waters. S. Iwata investigated the periglacial topography around the northern and southern sides of the West Kunlun Mountains. H. Fushimi of the Biwa Lake Institute examined the distribution of salty lakes and analyzed the chemical components of lake water.

Nepal Himalayas

Glaciological, hydrological and meteorological observations in Central Nepal were started in 1985 as the project of the Glacial Expedition of Nepal, Langtang Himalaya. In 1985–86, Y. Fukushima and M. Suzuki of Kyoto University and T. Ohta (WRI) observed the river discharge in the Langtang valley for a whole year, and found the dependency of discharge on air temperature. S. Takahashi (KIT), K. Seko (WRI), K. Kawashima (ILTS) and Y. Morinaga of Tsukuba University obtained a complete year of meteorological conditions in the valley and analyzed the seasonal variation of the snow-line. H. Iida of Yoshida Science Museum and Y. Endo of Tokamachi Experimental Station made glaciological studies at Yala Glacier in Langtang Himalaya and investigated the formation of the dirt layer. T. Yamada, H. Motoyama (ILTS) and H. Kubota of MTS Institute analyzed the river discharge and estimated the contribution of the ablation of the glacier to the discharge.

In 1987, Ozawa and Yamada (ILTS) made core drillings at Yala Glacier and examined the mechanism of glacier feed by the re-freezing of melt water. S. Murakami (ILTS) observed the water permeability of the drilled ice cores. K. Ueno analyzed the variation of precipitation and lapse rate of air temperature.

Patagonia

The second Glaciological Research Project in Patagonia was conducted by C. Nakajima of Kyoto University and carried out in 1985–86, following the first project in 1983–84. On San Rafael Glacier, on the western side of the northern Patagonia icefield, J. Inoue of Kyoto University observed climatic conditions and wind regime. Y. Fujiyoshi (ILTS) examined precipitation and vertical structure of air temperature. T. Yamada (ILTS) got an ice core of 37.6 m in depth on the glacier and estimated the annual net accumulation as 3450 mm. On Soler Glacier, in eastern side of the northern Patagonia icefield, H. Fukami measured meteorological and hydrological conditions, and examined heat balance on the glacier surface. M. Aniya (Tsukuba University) investigated structural and morphological characteristics of the glacier, and carried out aerial surveys. S. Kobayashi (Niigata University) reported the frequent occurrence of ice avalanches due to high air temperature and much snowfall. R. Naruse measured glacial flow by a triangulation survey; flow velocity was 1.5 m/d at the upper part of the ablation area and 0.2 m/d near the terminus. T. Sweda concluded the recent retreat of the glacier by vegetation recovery. G. Casassa (ILTS) estimated ice thickness of Soler Glacier and Nef Glacier by gravity measurements. On Tyndall Glacier in the southern Patagonia icefield, R. Naruse observed transversal variation of flow speed; 0.1 m/d near the margin and 1.9 m/d at the center line of the glacier.

Antarctica

The East Queen Maud Land Project started in 1981 was completed in 1987. The results of the project will be summarized and compiled as a folio series from NIPR in the next year or two: some results are already in print.

For the 700 m ice core drilled at Mizuho Station, Y. Fujii and O. Watanabe (NIPR) measured micro-particles and electric conductivity, and gave a climatic interpretation. H. Narita (ILTS) measured the grain size and the *c*-axis orientations, and compared them with the cores at Byrd Station and Dye 3. M. Nakawo (NISIS) calculated the vertical strain of the core by a flow model, and estimated the age of the core. S. Mae and T. Hondoh (FE) measured dielectric constants of the core, and compared them with the cores at Yamato Mts and Dye 3. T. Kameda (ILTS) measured the volume of air contained in the core, and gave an interpretation for the age of air.

On the ice sheet from the coast to Dome Fuji and from Syowa Station to Asuka Station studies of the dynamics of the ice sheet were carried out in the project. F. Nishio and H. Ohmae (NIPR) measured the thickness of the ice sheet by ice radar to obtain bedrock topography, and observed surface flow speed by navigation satellite positioning. H. Ohmae inspected the existence of water at the bottom of the ice sheet by ice-radar echo. Y. Ageta (WRI) determined the location of the highest point in Queen Maud Land: Dome Fuji (3807 m, 77°22′ S, 39°37′ E).

For the surface conditions of the ice sheet, T. Kikuchi (Kochi University) studied the distribution of annual mean surface temperature from NOAA data, which agreed with the 10 m depth temperature data obtained by K. Satow (Nagaoka Technical College). From wind speed observation, J. Inoue (Kyoto University) found a dependence of surface roughness on a deflection angle between wind direction and sastrugi direction. S. Takahashi (KIT) estimated the redistribution of drifting snow on the ice sheet based on a full year's observation at Mizuho Station. K. Osada (WRI) estimated the transportation of chemical composition by drifting snow.

Mountains in Japan

In Hokkaido Island, on the Hisago snow patch in Mts. Daisetsu, K. Kawashima (ILTS) examined the water permeability of firn and observed the delay of run-off from the snow patch. In a small drainage basin at Moshiri, H. Abrakawa (Hokkaido University of Education) (Iwamizawa) and D. Kobayashi (ILTS) observed the discharge of melt water and made a run-off model for the basin, where K. Suzuki (Tsukuba University) examined the path of the water by chemical composition measurements.

In Honshu Island, I. Tsuchiya (Kagawa University) has been measuring mass balance of the Chyokai glacierlet on Mt. Chyokai since 1972. On the Kuranosuke snow patch in the northern Japanese Alps, K. Yamamoto (WRI) examined the inner structure of the snow patch by impulse radar, and H. Iida (Yoshida Science Museum) obtained an ice core and measured grain size and tritium concentration.

SEA AND LAKE ICE

(Takatoshi Takizawa)

Rapid frazil ice production in wind-generated polynya was studied in a laboratory experiment by S. Ushio and M. Wakatsuchi (ILTS). By simulating and examining the process as a function of air temperature (−10 to −30 °C) and wind speed (2 to 10 m/s) in a 0.4 × 2.0 × 0.6 m^3 tank filled with 32 ppt salt water, they found that the ice production rate was most strongly determined by the wind speed. Examination of sea ice structures was made by T. Kawamura (ILTS) with an X-ray computed tomography; he also studied the preferred growth of grains in sea ice by examining the encroachment angle of a grain as a function of *c*-axis inclination.

T. Kawamura and M. Wakatsuchi (ILTS) investigated the relation between brine drainage channels and grain boundaries in sea ice, and found that the channels form preferentially at grain boundaries toward which both the adjacent ice platelets grow, but they do not form at grain boundaries from which the platelets slant away. The crystallographic structure of sea ice near a river mouth was shown by M. Aota and others (ILTS) to have a close correlation to water salinity at the time of formation.

T. Takizawa (ILTS) studied the dynamic response of a sea ice sheet (17 cm) floating on 6.8 m deep water to a moving load at speeds of up to 14.2 m/s, and found a critical speed, 5.8 m/s, at which the deflection was markedly amplified. At speeds above the critical value two ice waves are generated, one ahead of and the other behind the load.

K. Sato (Japan Meteorological Agency) constructed a numerical model of sea ice distribution in the Okhotsk Sea, taking account of the possible thermodynamic and dynamic processes involved. Field experiments were carried out on a lake by N. Ono and S. Ushio (ILTS) to estimate the heat flux through thin sea ice. The formation mechanism of the Weddell Polynya in 1974 was studied by T. Motoi and others (ILTS) by using a one-dimensional convective mixed-layer model; they showed that the high salinity allowed deep convection driven by surface cooling, and the resulting upward transfer of heat and salt prohibited sea ice formation throughout the winter.

T. Yamanouchi (NIPR) and others determined the sea ice concentration from the visible and near infrared albedo of the AVHRR imagery, and compared the satellite results with those from air photographs in test areas near Syowa Station and Lützow-Holm Bay, Antarctica. S. Uratsuka (Communication Research Laboratory) and others applied a UHF step frequency radar to sea ice thickness measurement; depths of snow on sea ice and of the sea ice itself could be measured with this radar system.

M. Aota and K. Shirasawa (ILTS) and others conducted measurements of atmosphere and water boundary-layers at Mombetsu, Hokkaido; they used a 16 m high observation tower about 600 m off-shore, and measured drag coefficient, stability and turbulence level in the sea ice conditions of slush, and dark and light nilas. For the water boundary layer a three-dimensional ultrasonic current meter was applied, which showed a good correlation between the drag coefficient and downflow turbulence level.

Ice conditions were investigated in Lake Ogawara in the northern part of Honshu by K. Hirayama and M. Sasamoto (Iwate University) to reveal a mechanism to explain why the existence of large ice movements though the freezing index seldom exceeds 200 degree-days. It was found that the ice cover consisted of many layers of snow-ice, (water-saturated snow and ice), and thus the thickness could be much larger than that estimated by the conventional method of a freezing index. Various melt-patterns of lake ice were investigated by A. Toukairin (Hokkaido University of Education) (Kushiro). He showed that the patterns are formed by water gushing through a hole in thin snow-covered ice floating on lake water which extends outward along the water veins produced and melts the snow on the surface.

K. Ohshima and M. Wakatsuchi (ILTS) studied ice-ocean eddies off the coast of Hokkaido, Okhotsk Sea, by analysing radar images. The eddies often appeared as a vortex train with the wavelength, pf, about 50 km, and the scale of them was 20–30 km. A numerical model showed the wave motion is induced on the current because of the barotropic instability. The pack ice works as a tracer and makes the eddies visible.

Submitted by N. Maeno

SWEDEN

SWEDISH LAPPLAND

MASS BALANCE STUDIES IN THE KEBNEKAISE REGION

(W. Karlen, P. Holmlund, A. Stroeven, G. Rosqvist and H. Grudd, Department of Physical Geography, University of Stockholm, V. Pohjola, Department of Physical Geography, University of Uppsala)

The 1988 average summer temperature (June–August), as measured at the Tarfala Research Station, was 1.0 °C higher than normal, and the main reason for the strongly negative mass balance of the Kebnekaise glaciers during 1987–88. While Rabots glaciär and Storglaciären are valley glaciers, Riukojietna is an ice cap and Tarfalaglaciären is a cirque glacier. The warm summer also

Glacier	Area	Elevations	Aspect	Mass balance b_w	b_s	b_n	ELA
	km^2	m a.s.l.		m	m	m	m a.s.l.
Riukojietna	4.6	1140–1460	–	1.13	–2.04	–0.91	*
Rabots glaciär	3.8	1080–1950	W	1.08	–2.13	–1.05	1540
Storglaciären	3.0	1120–1720	W	1.42	–2.26	–0.84	1560
Tarfalaglaciären	0.9	1390–1730	E	1.59	–2.88	–1.29	*

*Net ablation all over the glacier

caused melting of most snow along the glacier snouts, which meant that accurate measurements of frontal ice changes could be made. All glacier snouts had receded since the last measurement.

Glacier	Frontal ice recession (m per year) 1987–88	average 1986–88	average 1985–88
Isfallsglaciären	9		
SE Kaskasatjåkkagl.	6		
Rabots glaciär	11		
Storglaciären		9	
Riukojietna, NE part		7	
östra Påssusglaciären			8

GLACIER DYNAMICS OF STORGLACIÄREN
(R. LeB. Hooke, B. Hansson, J. Kohler, G. Remple and D. Wiberg, Department of Geology, University of Minnesota, P. Jansson and V. Pohjola, Department of Physical Geography, University of Stockholm)
The 1988 field season on Storglaciären was generally successful. Velocity and strain measurements on nine stakes (forming three strain nets in the upper part of the ablation area) were initiated in early May, and by late June surveys were being completed daily.

More detailed measurements of the velocity of a tenth stake in the upper part of the ablation area were begun in July and continued through mid-August. These measurements were made with the use of a computer-controlled electronic distance meter at three-minute intervals. Unfortunately, the records from this experiment are discontinuous, due to rather too frequent and unexplained failures of the system. On the other hand, nearly continuous records of surface tilt and vertical strain were obtained on this part of the glacier. The tiltmeter shows a diurnal pattern of variation with a marked increase in activity around noon.

Internal deformation was measured in a borehole, starting in mid-July. Five inclinometry surveys were completed between this time and September, thus yielding deformation profiles over four separate time intervals. Evidence was found for changes in the sliding rate and in the rate of internal deformation with time.

The hydrological programme on streams draining the glacier was initiated with the installation of stage recorders in early July, and measurements were continued through mid-August. Conductivity and turbidity measurements were also undertaken. The former were used principally for salt-trace studies, using the moulins over the riegel as injection points. Dye-trace studies were also carried out, using injection points higher on the glacier.

The least successful part of the field season seems to have been the borehole water pressure measurements that were to have been made in holes situated in an area of overdeepening. Several holes were drilled, and four of these were monitored for various lengths of time but variations seem to have been minimal.

GEOMORPHOLOGICAL EFFECTS AND RECENT CLIMATIC RESPONSE OF SNOW-PATCHES AND GLACIERS IN THE WESTERN ABISKO MOUNTAINS
(L. Lindh, R. Nyberg and A. Rapp, Department of Physical Geography, University of Lund)
A number of snowpatches and very small glaciers are being studied in the Låktatjåkka area west of Abisko (800–1500 m a.s.l., mean temperature ranging from *c.*–4° to –7°C). Nivation processes are studied at an instrumented snowpatch site at 1200 m altitude. The measurements include air and ground temperature, precipitation, snow depth, run-off, sediment yield and solifluction.

GREENLAND

RENLAND
Three Swedish scientists (P. Jonsson, Department of Technical Geology, University of Lund, M. Källström and J. Ström, Department of Meteorology, University of Stockholm) took part in the second field season of the Danish-Icelandic-Swedish "Nordic Renland Glacier Project" during July 1988. A core was drilled to bedrock (325 m) on the cold ice cap on the Renland peninsula in East Greenland and the temperature was

measured down the hole. Pit studies were carried out and additional firn cores were hand-augered. The strain net established in the previous year was remeasured. Radar reflection layers were measured down to bedrock.

ANTARCTICA

DEGLACIATION AND HOLOCENE CLIMATIC CHANGE ON THE ANTARCTIC PENINSULA

(W. Karlen, Department of Physical Geography, University of Stockholm, and R. Zale, Department of Geography, University of Umeå)

During the West German expedition to the Antarctic Peninsula in late 1987 (*Polarstern:* Ant VI/2) lake sediment cores were recovered from three lakes: Lake Boeckella in Hope Bay, Midge Lake on Livingstone Island and Hidden Lake on James Ross Island. It was also found that lichenometry, using *Rhizocarpon geographicum*, can be used locally to separate moraines of different ages. The sediment cores, which have been X-rayed and sampled for ^{14}C dating, will be used for paleoclimatic studies. This project was part of SWEDARP 1987/88 (Swedish Antarctic Research Programme) and field work will be continued in the summer of 1988/89.

MASS EXCHANGE OF A BLUE-ICE AREA

(S. Jonsson, P. Holmlund and H. Grudd, Department of Physical Geography, University of Stockholm)

In connection with the second leg of the West German Antarctic expedition 1987/88 (*Polarstern:* Ant VI/3), a glaciological study was initiated in central Heimefrontfjella, Dronning Maud Land. A net of 28 stakes has been established for studies of mass balance and ice movement inside Scharffenbergbotnen, which is a 3 × 6 km large blue-ice area on the north-western side of the mountains. The ice thickness was measured by radio echo-sounding and particular care was devoted to getting the correct ice depths at the entrances to the basin.

Inflow as well as evaporation of snow and ice has been measured. Two short firn cores have been drilled in order to study the accumulation pattern in the surrounding area. In order to explain the mass balance data two automatic weather stations were operated during the field season. One of the stations was left at the bottom of the basin after having been converted into a system for satellite (Argos) transmission of weather data to Europe. The system has worked satisfactorily at least up to 31 October. This project was part of SWEDARP 1987/88 and field work will continue at least during the summer of 1988/89.

PALEOCLIMATIC STUDIES IN VESTFOLD HILLS

(C. Bronge, Department of Physical Geography, University of Stockholm)

During the summer season 1987/88 one Swedish scientist joined the ANARE programme at Davis Station in East Antarctica, but with a project of his own. Besides taking sediment cores from fresh water lakes the project included hydrological and climatological studies at Tierney Creek.

The purpose for the sediment coring was to trace Holocene climatic changes in the sediment record. Three sediment cores were retrieved from Nicholson Lake and one from Cat Lake. Coring attempts at two other lakes failed due to lack of sediments. The hydrological part of the project was aimed at investigations of a freshwater run-off system in an Antarctic oasis and to monitor the discharge of suspended load in the running water.

Submitted by S. Jonsson

UK

ICE SHEET MAPPING BY SATELLITE RADAR ALTIMETRY

(Neil McIntyre, Wyn Cudlip, Jeff Ridley, Kim Partington and Chris Rapley, Mullard Space Science Laboratory, Department of Physics and Astronomy, University College, London)

Aims of project

Satellite radar altimeter data is being analysed with a view to producing high-accuracy topographic maps of the Greenland and Antarctic ice sheets and adjacent ice shelves. This is based on an understanding of the operational characteristics of the satellite instruments, their platforms and orbits and of the scattering mechanisms of radar pulses by snow and ice surfaces. Theoretical work, modelling and empirical analyses of Seasat and Geosat data have been used in combination.

Recent progress

Evidence has been collected to show that 13.5 GHz radar pulses penetrate the surface of much of the polar ice sheets by anything up to several metres in suitable conditions. This is variable spatially and temporally and therefore must be taken into account in the calculation of surface elevations.

Analysis of data (done jointly with Jay Zwally of NASA/GSFC) over the 9 year period between Seasat and Geosat for a 2000 km strip in East Antarctica at 72°S shows residual elevation difference of up to 2 metres. The extent to which it is due to residual orbit errors, satellite off-pointing, variable degrees of penetration or real topographic variations is still unclear but places an upper limit on mass balance variations.

A 2 m contour map of the Larsen Ice Shelf has been compiled using 43 passes of Seasat data. It clearly shows flow features due to tributary glaciers and crevasse zones. The map provides a comprehensive baseline survey of elevations, margins, crevasses, grounding points and backscatter during a 17 day period in 1978.

SATELLITE RADAR ALTIMETRY OVER SEA ICE

(Seymour Laxon, Neil McIntyre and Chris Rapley, Mullard Space Science Laboratory, Department of Physics and Astronomy, University College, London)

Aims of project

The extent to which satellite radar altimetry can be used to sample and monitor sea ice areas is being investigated with Seasat and Geosat data. Variations in the character of reflected radar pulses have been used to indicate the type of surface within the altimeter footprint. This should provide a very quick and quantitative means of sampling sea ice characteristics from satellites such as ERS-1.

Recent progress

Comparisons of Geosat altimetry with AVHRR imagery and MIZEX synthetic aperture radar data have shown clear correlations between ice types and pulse characteristics. Multi-year ice can be distinguished and estimates of its roughness made.

Correction of range errors due to instrumental lags has enabled elevation estimates as accurate as those obtained over the open ocean (approximately 10 cm). Measurements to the water surface between ice floes or allowance for ice freeboard thereby enables estimates of the oceanic geoid in some ice-infested areas.

TRIAXIAL DEFORMATION EXPERIMENTS ON NATURAL SEA ICE AND PURE ICE AS A FUNCTION OF TEMPERATURE AND STRAIN RATE

(Stan Murrell, Peter Sammonds and Martin Rist, Department of Geological Sciences, University College, London WC1E 6BT)

A triaxial deformation apparatus has been constructed for 40 mm diameter ice samples, which can be subjected to confining pressures up to 300 MPa, together with an independent axial load (compressive or tensile) and temperatures down to −90°C. It is housed in an armoured cold room. Loading is servo-controlled. Current support is by means of a NERC grant, but the project was initiated by a CASE award with strong support from BP.

Peter Sammonds has been awarded his PhD for a thesis on sea ice deformation. Results were presented at OMAE '88 at Houston. Further data will be presented at the AGU Meeting in San Francisco (December '88) and at OMAE '89 (The Hague) and POAC '89 (Lulea). Martin Rist is writing up his PhD thesis on pure ice deformation. He presented some results at IAHR (Saporro, August '88). Stan Murrell visited Ice Mechanics laboratories in Newfoundland and Ottawa in September '88.

Submitted by J.C. Paren

USA

MONTANA STATE UNIVERSITY

(Robert Brown, Department of Civil and Agricultural Engineering, Montana State University, Bozeman, MT 59717-0007, U.S.A.)

Current research is proceding on the application of glycopeptide (GP) to inhibit the adhesion of ice crystals to other materials. The idea was developed from studies in animal physiology at the University of Illinois to determine why antarctic cod do not freeze. It was found that the cod naturally produce GP which acts in the blood stream to inhibit the growth of ice crystals (in contrast to antifreezes which lower the freezing temperature). Remarkably, concentrations of GP as low as 1 part in 10^7 parts of water has been found to inhibit ice crystal growth effectively. This is in contrast to upwards of 30–50 parts to 10^3 of water in applications of salt or CMA to winter road ice suppression.

The research centers on evaluation of the change in ice adhesion to materials such as steel or pavements when GP is introduced in small concentrations. A small amount of GP has been donated by Art DeVries from the University of Illinois. If shown to be effective in control of ice crystal growth, the chemical synthesis of the compound will be studied.

As a footnote, this may happen to be another good example of reason for preservation of natural species for the benefit of man.

Submitted by R.L. Brown

JOURNAL OF GLACIOLOGY

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

D R MacAYEAL
Ice-shelf response to ice-stream discharge fluctuations: III. The effects of ice-stream imbalance on the Ross Ice Shelf, Antarctica.

M E R WALFORD, M I KENNETT
A synthetic-aperture radio-echo experiment at Storglaciären, Sweden.

J L FASTOOK, J E CHAPMAN
A map-plane finite-element model: three modeling experiments.

C J VAN DER VEEN, I M WHILLANS
Force budget: I. Theory and numerical methods.

C J VAN DER VEEN, I M WHILLANS
Force budget: II. Application to two-dimensional flow along Byrd Station Strain Network, Antarctica.

I M WHILANS, Y H CHEN, C J VAN DER VEEN, T J HUGHES
Force budget: III. Application to three-dimensional flow of Byrd Glacier, Antarctica.

C SMIRAGLIA
The medial moraines of Ghiacciaio dei Forni, Valtellina, Italy: morphology and sedimentology.

J MEYSSONNIER
Ice flow over a bump: experiment and numerical simulations.

F REMY, P MAZZEGA, S HOURY, C BROSSIER, J F MINSTER
Mapping of the topography of continental ice by inversion of satellite-altimeter data.

R B ALLEY
Water-pressure coupling of sliding and bed deformation: I. Water system.

R B ALLEY
Water-pressure coupling of sliding and bed deformation: II. Velocity-depth profiles.

R B ALLEY, D D BLANKENSHIP, S T ROONEY, C R BENTLEY
Water-pressure coupling of sliding and bed deformation: III. Application to Ice Stream B, Antarctica.

M IGNAT, G RICOU
A shear-creep system for studying grain-boundary behaviour in ice.

R LeB HOOKE, P CALLA, P HOLMLUND, M NILSSON, A STROEVEN
A 3 year record of seasonal variations in surface velocity, Storglaciären, Sweden.

V L MAZO
Waves on glacier beds.

F A de SCALLY, J S GARDNER
Evaluation of avalanche-mass determination approaches: an example from the Himalaya, Pakistan.

A LETREGUILLY, L REYNAUD
Spatial patterns of mass-balance fluctuations of North American glaciers.

P G KNIGHT
Stacking of basal debris layers without bulk freezing-on: isotopic evidence from West Greenland.

D R MURRAY, W W LOCKE
Dynamics of the late Pleistocene Big Timber glacier, Crazy Mountains, Montana, U.S.A.

S C COLBECK
Air movement in snow due to windpumping.

R I GAYLEY, M RAM, E F STOERMER
Seasonal variations in diatom abundance and provenance in Greenland ice.

A J RUSSELL
A comparison of two recent jökulhlaups from an ice-dammed lake, Søndre Strømfjord, West Greenland.

P U CLARK, W H JOHNSON
Modeling the influence of till rheology on the flow and profile of the Lake Michigan lobe, southern Laurentide ice sheet, U.S.A.: discussion.

S A SABAL, E M SCHULSON
The fracture toughness of ice in contact with salt water.

D McCARROLL, J A MATTHEWS, R A SHAKESBY
"Striations" produced by catastrophic subglacial drainage of a glacier-dammed lake, Mjølkedalsbreen, southern Norway.

J A DOWDESWELL
On the nature of Svalbard icebergs.

ANNALS OF GLACIOLOGY

The following papers are published in Volume 12, Proceedings of the Symposium on Ice Dynamics held at the University of Tasmania, Hobart, Australia, 14-20 February 1988.

I ALLISON:
Pack-ice drift off East Antarctica and some implications.

R G BARRY, M W MILES, R C CIANFLONE, G SCHARFEN AND R C SCHNELL:
Characteristics of Arctic sea ice from remote-sensing data and their relationship to atmospheric processes.

W F BUDD AND D JENSSEN:
The dynamics of the Antarctic ice sheet.

T J H CHINN:
Single folds at the margins of dry-based glaciers as indicators of a glacial advance.

D DAHL-JENSEN:
Two-dimensional thermomechanical modelling of flow and depth–age profiles near the ice divide in central Greenland.

J A DOWDESWELL AND D J DREWRY:
The dynamics of Austfonna, Nordaustlandet, Svalbard: surface velocities, mass balance, and subglacial melt water.

D M ETHERIDGE:
Dynamics of the Law Dome ice cap, Antarctica, as found from bore-hole measurements.

R M FROLICH, D G VAUGHAN AND C S M DOAKE:
Flow of Rutford Ice Stream and comparison with Carlson Inlet, Antarctica.

R C A HINDMARSH, G S BOULTON AND K HUTTER:
Modes of operation of thermo-mechanically coupled ice sheets.

HUANG MAOHUAN, WANG ZHONGXIANG, CAI BAOLIN AND HAN JIANKANG:
Some dynamics studies on Urumqi Glacier No. 1, Tianshan Glaciological Station, China.

T HUGHES:
Calving ice walls.

T H JACKA AND W F BUDD:
Isotropic and anisotropic flow relations for ice dynamics.

H KEYS AND D FOWLER:
Sources and movement of icebergs in the south-west Ross Sea, Antarctica.

W KICK:
Discontinuities in a traverse velocity profile of a valley glacier measured by photogrammetry.

M A LANGE, S F ACKLEY, P WADHAMS, G S DIECKMANN AND H EICKEN:
Development of sea ice in the Weddell Sea.

M A LANGE AND D R MacAYEAL:
Numerical models of ice-shelf flow: ideal/real.

D W S LIMBERT, S J MORRISON, C B SEAR, P WADHAMS AND M A ROWE:
Pack-ice motion in the Weddell Sea in relation to weather systems and determination of a Weddell Sea sea-ice budget.

J A MASLANIK AND R G BARRY:
Short-term interactions between atmospheric synoptic conditions and sea-ice behaviour in the Arctic.

G J MUSIL:
On the underside scarring of floating ice sheets.

H OHMAE, F NISHIO AND S MAE:
Distribution of reflected power from the bed by radio echo-sounding in the Shirase Glacier drainage area, east Dronning Maud Land, Antarctica.

M S PELTO, T J HUGHES AND H H BRECHER:
Equilibrium state of Jakobshavns Isbræ, West Greenland.

U RADOK, B J McINNES, D JENSSEN AND W F BUDD:
Model studies on ice-stream surging.

C RITZ:
Interpretation of the temperature profile measured at Vostok, East Antarctica.

M A ROWE, C B SEAR, S J MORRISON, P WADHAMS, D W S LIMBERT AND D R CRANE:
Periodic motions in Weddell Sea pack ice.

W M SACKINGER, M O JEFFRIES, H TIPPENS, F LI AND M LU:
Dynamics of ice-island motion near the coast of Axel Heiberg Island, Canadian High Arctic.

V A SQUIRE:
Super-critical reflection of ocean waves; a new factor in ice-edge dynamics?

S N STEPHENSON AND H J ZWALLY:
Ice-shelf topography and structure determined using satellite-radar altimetry and Landsat imagery.

F SZIDAROVSZKY, K HUTTER AND S YAKOWITZ:
Computational ice-divide analysis of a cold plane ice sheet under steady conditions.

P WADHAMS, C B SEAR, D R CRANE, M A ROWE, S J MORRISON AND D W S LIMBERT:
Basin-scale ice motion and deformation in the Weddell Sea during winter.

R A WALTERS:
Small-amplitude, short-period variations in the speed of a tide-water glacier in south-central Alaska, U.S.A.

N W YOUNG, I D GOODWIN, N W J HAZELTON AND R J THWAITES:
Measured velocities and ice flow in Wilkes Land, Antarctica.

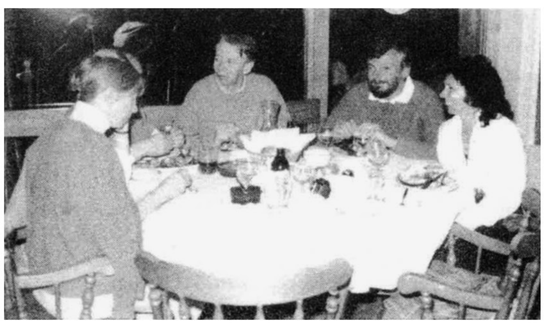
IGS SYMPOSIUM IN TASMANIA, 5 FEBRUARY 1988

The Symposium on Ice Dynamics was held in the University Centre, Hobart

A half-day tour included a visit to a wild-life park. A craybake was held at Oyster Cove

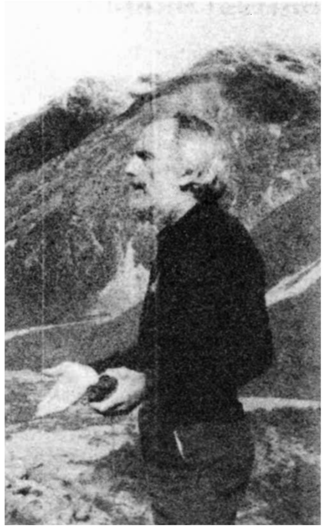
Uwe and Anita Radok enjoyed the day

Arija Schwedtfeger comforts an orphaned baby wombat



TOURS

In New Zealand, Trevor Chinn organized a 5 day tour of the glaciers of South Island. He and Martin Kirkbride wrote an excellent guidebook



Trevor Chinn

Will Harrison contemplating local features

In Hawaii, experts in geology, geomorphology, volcanology, space research and Hawaiian history and culture provided a full 6 day programme

BRITISH BRANCH

15–16 September 1988

The Annual Conference was held under a rainless sky in the Department of Geography, University of Manchester, ably masterminded by David Collins and students involved in the Alpine Glacier Project. The Conference followed the normal format with 1.5 days of lectures, the Annual Dinner and the AGM of the British Branch. The Dinner included a presentation to John Nye, who retired in the summer, in recognition of his contributions to the life of the British Branch. In his reply, John Nye admitted that much of the intellectual fun of glaciology was not necessarily always being right but being able to prove that the competing argument was wrong.

It was a pleasure to welcome visitors to the meeting from Belgium, Switzerland and India. The programme of lectures proved yet again the wide variety of topics studied by the glaciological community.

A list of papers presented is given below. If you are interested in these topics, please communicate directly with the authors.

Water content of temperate ice

Heidi Mader, (University of Bristol)
Observations on water veins in polycrystalline ice.

John Nye (University of Bristol)
Water veins and nodes.

Amedee Zryd (École Polytechnique Fédéral, Lausanne)
Water content in temperate ice.

Impurities in ice

Julian Paren (British Antarctic Survey)
An historical review of the study of the electrical properties of glaciers and ice cores.

John Moore (British Antarctic Survey)
The link between chemistry and electrical properties of ice.

Robert Mulvaney and Eric Wolff (British Antarctic Survey)
Further observations on the location of impurities in Antarctic ice.

Jean-Louis Tison (Université Libre de Bruxelles)
Isotopic, chemical and crystallographic characteristics of first-year sea ice from Breid Bay (Princess Ragnhild Coast, Antarctica): an approach to growth rates.

Ice caps and ice sheets

Jonathan Bamber (Scott Polar Research Institute)
Radio echo sounding investigations of Kvitøya Ice Cap, N.E. Svalbard.

Neil McIntyre (Mullard Space Science Laboratory), W. Cudlip, J.K. Ripley, C.G. Rapley and K.C. Partington (Marconi Research Centre, GEC, Chelmsford)
Developments in ice sheet mapping and monitoring by satellite radar altimetry.

Jane Hart (University of Manchester)
A model of ice-sheet interaction.

Richard C.A. Hindmarsh and Geoffrey S. Boulton (University of Edinburgh)
Modes of operation of thermo-mechanically coupled ice-sheets.

Julian Dowdeswell (University College of Wales, Aberystwyth)
Fast-flowing streams in Svalbard.

Jefferson Simoes (Scott Polar Research Institute)
Ice-core drilling in Svalbard.

Martin Sharp (University of Cambridge), Julian Dowdeswell (University College of Wales, Aberystwyth) and Campbell Gemmell (Christ Church, Oxford)
Reconstructing past glacier dynamics and erosion from glacial geomorphic evidence: Snowdon, North Wales.

John M. Reynolds (Plymouth Polytechnic)
Glaciological investigations of parts of the Cordillera Blanca, Peru.

Wendy Lawson (University of Cambridge)
The kinematics and deformation history of Variegated Glacier, Alaska.

Miscellany

John Moore and Rick Frolich (British Antarctic Survey)
Dolleman Island, Antarctic Peninsula: an ice rise not in steady state.

Martin Rist (University College, London)
Experimental brittle failure of ice.

Andrew Smith (British Antarctic Survey)
Trials of a percussion drilling system in Antarctic firn.

Adrian Jenkins (British Antarctic Survey)
Recent investigations of surface undulations where Rutford Ice Stream enters Ronne Ice Shelf.

David Vaughan (British Antarctic Survey)
Morphology of the grounding zone of the Rutford Ice Stream.

Glacial meltwaters and erosion

R. Raiswell (University of Leeds) and Martin Tranter (University of Southampton)
Chemical weathering reactions in alpine glacial meltwaters.

Andrew J. Russell (University of ABerdeen)
Geomorphological effects of a jökulhlaup upon a river channel in West Greenland.

Ian Smalley (University of Leicester)
The relationship between glacial action and loess deposits: retrospect and conjectures.

Geoffrey S. Boulton and C.D. Clark (University of Edinburgh)
Evidence for shifting ice divides in mid-latitude ice sheets.

Posters

Fiona S. Stewart (British Geological Survey/ Edinburgh)
Reconstructing the flow within the eastern margin of the Scottish Late-Devensian ice sheet.

Eric Wolff (British Antarctic Survey) and Claude Boutron (Laboratoire de Glaciologie,

Grenoble)
Heavy metals: the impact of human activity in Antarctica.
A. Russell (Department of Geography, University of Aberdeen)
Geomorphological effects of a jökulhlaup upon a river channel in West Greenland.

The 1989 British Branch Meeting will be held at the British Antarctic Survey headquarters, Cambridge, on 14 and 15 September 1989. Further details will be circulated to all U.K. members and to people from abroad if they express interest to:
Eric Wolff, Secretary, British Branch I.G.S., British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, U.K.

WESTERN ALPINE BRANCH

The 1988 meeting was held at Fionnay, Val de Bagnes, Switzerland, 25–28 August, and was well organized by G. Fellay and staff of Forces Electro-motices de Mauvoisin S.A. Six IGS members and 35 people listed as Branch members attended. On the first evening, a reception was given by the municipality of Bagnes. The Mayor spoke about the history of the commune and of the catastrophes caused by the hanging Giétroz Glacier (especially that of 1818).

On the second day, the participants had an agreeable walk to the Corbassière Glacier, to the sound of the alpine horn played by Louis Wuilloud. The dull grey skies allowed only occasional glimpses of the famous Combins. Pauses en route allowed M. Aellan to describe the work done by the Swiss Glacier Commission on the Corbassière Glacier, measuring annual speed of movement across two profiles and at the snout. The group stopped at a cabin at 2640 m, and discussed avalanche problems. Later, everyone walked to another cabin, in deteriorating weather, for an overnight stay.

On the third day, clouds and lower temperatures meant that the full programme of climbing could not be fulfilled. Visits to Ruinette and Brenay glaciers, and to Mauvoisin Lake and to the hanging Giétoz Glacier were made. In the evening, the Annual Banquet of the Branch was held in Fionnay.

On the morning of the fourth day, three talks (by M. Aellen, B. Kaiser and P. Montaz-Rosset) were given. Finally, the annual general meeting of the Branch was held.

Future meetings (of other organizations)

INTERNATIONAL ASSOCIATION FOR HYDRAULIC RESEARCH
10th IAHR SYMPOSIUM ON ICE

The 10th International Symposium on Ice will be held on 20–23 August 1990 at Helsinki University of Technology, Espoo, Finland. Papers are called for on the following topics:

- Ice piling and ridging
- Instrumentation and remote sensing in ice engineering
- Ice dynamics
- Ice control in inland waterways
- Navigation in ice covered waters
- Environmental aspects in ice covered waters
- Ice mechanics and ice properties
- Thermal regimes of waters in cold regions
- Ice model testing
- Ice and wave interaction
- Spray ice and atmospheric icing
- Underwater technology under ice

The abstract should emphasize the significance of the results and/or the originality, and should contain applications or direct relevance to ice problems, including what are new and what would be presented. The deadline for submitting an abstract is 15 November 1989, for preliminary acceptance 31 January 1990, and for the manuscript 15 May 1990.

Please address all inquiries and abstract in 300–400 words for review to: Dr Mauri Maattanen, Helsinki University of Technology, Otakaari 1, SF-02150 Espoo, Finland.

EASTERN SNOW CONFERENCE

46th ANNUAL MEETING

The 46th annual meeting of the Eastern Snow Conference (ESC) will take place in Québec City, Québec, Canada on 8 and 9 June 1989. The meeting will be held at the Château Frontenac Hotel, 1 rue des Carrières, Québec G1R 4P5, Canada.

It will consist of three sessions. The first session, "International Studies in Snow and Ice", will feature papers by invited speakers. The presentations will give an overview of current research on snow in various countries and regions of the Northern Hemisphere.

The second session will be "Climatic change — its influence on snow and ice cover and the repercussions on the activities of man". The papers in this session will deal with the current dependence of certain economic activities on the presence of snow and ice (hydropower production, agriculture, ski etc.) and how changes in the climate could affect these practices.

The third session is an open session. Papers on the physics, chemistry and microbiology of snow and ice covers, the hydrology of snowmelt, and other glaciological studies will be welcomed.

Further information from: Prof. Gérald Jones, INRS-Eau, C.P. 7500, 2700, rue Einstein, Sainte-Foy, Québec G1V 4C7, Canada.

Glaciological Diary

** **IGS Symposia**
* **Co-sponsored by IGS**

1989

10-19 May
3rd IAHS Scientific Assembly (Symposium S5: Stochastic processes and time series analysis in glaciology) Baltimore, Maryland, U.S.A. (A. Ivan Johnson, Chairman, Third IAHS Scientific Assembly Organizing Committee, 7474 Upham Court, Arvada, CO 80003, U.S.A.)

8-9 June
46th annual meeting of the Eastern Snow Conference, Québec City, Québec, Canada. (Prof. Gérald Jones, INRS-Eau, C.P. 7500, 2700, rue Einstein, Sainte-Foy, Québec, G1V 4C7, Canada)

12-16 June
10th International Conference on Port and Ocean Engineering under Arctic Conditions, Luleå University of Technology, Sweden.

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

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

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

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

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

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

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

Avenue, N.W., Washington, DC 20009, U.S.A.)

1990

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

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

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

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

1991

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

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

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

News

AWARDS

The Institute of Physics has awarded the 1989 Charles Chree Medal and Prize to Professor **John Nye** for his contributions to geophysics, particularly the physics of glaciers.

In October 1987 the Institute of Aeronautics and Astronautics named **Katharine Stinson** (BME Aero Technical Assistant Chief, Aircraft Engineering, Federal Aviation Administration) Aerospace Pioneer of the Year.

CONGRATULATIONS

The President of the International Glaciological Society sent the following letter of congratulation to the President of the Japanese Society of Snow and Ice on the occasion of its celebrations to mark 50 years of existence:

Dear Dr Shidei,

It is my honor and pleasure to send the congratulations of the International Glaciological Society to the Japanese Society of Snow and Ice upon the celebration of its 50th Anniversary. This date marks the achievement of fifty years of service, not only to Japanese scientists, but to the world community of glaciologists as well.

There has been much interaction with other countries through your publications, meetings and through the personal exchanges that have allowed us to become acquainted as individuals. We have benefited not only from your published work but from the opportunity to exchange ideas and experiences with you. The work of many Japanese snow and ice scientists is well known and widely respected outside of Japan.

It is our hope that the Japanese Society of Snow and Ice will continue to promote the advancement of snow and ice research in Japan so that we can benefit from your work for many years to come. Unfortunately, I am not able to be present to congratulate you on the occasion of your 50th Anniversary but perhaps it will not be long before I can once again visit Japan to enjoy the benefits of your wonderful country.

Enjoy your celebrations.

Sincerely,

Samuel C. Colbeck,
President

11 March 1988

PUBLICATIONS

The Chinese *Journal of Glaciology and Geocryology*, 10(3), 1988, is a Special Issue commemorating the 30th anniversary of the unfolding of glaciological and geocryological research in China. [In Chinese.]

FLUCTUATIONS OF GLACIERS 1980–1985 (Vol. V)
290 pages + 13 separate folded maps in a hard case. Published jointly by the International Association of Hydrological Sciences, UNEP and UNESCO, 1988. Compiled for the World Glacier Monitoring Service (WGMS) by Wilfried Haeberli and Peter Müller, ETH Zürich, as a contribution to the Global Environment Monitoring System (GEMS) and the International Hydrological Programme of UNESCO, this volume continues the series *Fluctuations of Glaciers 1959–1965 (Vol. I)* published in 1967, *Fluctuations of Glaciers 1965–1970 (Vol. II)* published in 1973, *Fluctuations of Glaciers 1970–1975 (Vol. III)* published in 1977, and *Fluctuations of Glaciers 1975–1980 (Vol. IV)*, published in 1985. The data were obtained from national correspondents and collaborators of the WGMS as well as individual glaciologists who completed standard forms on (1) general information, (2) variations in the positions of glacier fronts, (3) mass balance results, (4) changes in area, volume and thickness, (5) availability of hydrometeorological data, and (6) index measurements and special events (glacier floods, ice avalanches, eruption of ice-covered volcanoes etc.) for glaciers in Canada, U.S.A., Mexico, Colombia, Peru, Argentina, Greenland, Iceland, Norway, Sweden, France, Switzerland, Austria, Italy, Kenya, Poland, U.S.S.R., China and Antarctica. Many of the data are presented in the form of computer-generated tables. Such tables in this and in future volumes of the series will make it easier to portray the worldwide reaction of glaciers to climatic change. Information not suitable for computerization, such as important comments and sources of data, is covered in the separate chapters devoted to each data category. All glaciers are identified with a name and a number with a prefix to denote the country concerned. An alphabetical index at the end of the book makes it easy to locate the tabulated data on any glacier. The detailed information contained in this volume will be invaluable not only to glaciologists but also to many earth scientists working in related fields.

Fluctuations of Glaciers 1980-1985 (Vol. V)
290 pages + 13 separate folded maps in a hard case . . . . . US$38

Fluctuations of Glaciers 1975-1980 (Vol. VI)
265 pages + 13 separate folded maps in a hard case . . . . . US$38

Fluctuations of Glaciers 1970-1975 (Vol. III)
265 pages + 12 separate folded maps in a hard case . . . . . US$26

Fluctuations of Glaciers 1965-1970 (Vol. II)
357 pages + 7 separate folded maps in a hard case . . . . . . US$21

Fluctuations of Glaciers 1959-1965 (Vol. I) (out of print)

Please send your order, with name and mailing address and cheque in U.S.$, to:
Dr W. Haeberli, Laboratory of Hydraulics, Hydrology and Glaciology, ETH-Zentrum, CH-8092 Zürich, Switzerland.

OPPORTUNITIES IN THE HYDROLOGIC SCIENCES

The U.S. National Research Council (NRC) through its Water Science and Technology Board (WSTB) has undertaken to assess research and educational opportunities in the hydrologic sciences and to produce a report stressing the importance of the hydrologic sciences and identifying areas where improvements are needed. The committee, chaired by Peter S. Eagleson (MIT), was established in late 1987; Jeff Dozier and Sam Colbeck are members.

The committee is reviewing the current status of hydrology and its coupling with related geosciences and biosciences and is identifying promising new frontiers for the hydrologic sciences and opportunities to help improve water and environmental management. The scope of the work is concerned with the reservoirs and fluxes that comprise the global hydrologic cycle. The main focus is on continental water, including snow cover and mountain glaciers, and the physical, chemical, and biological processes interactive with continental waters including erosion, sedimentation, solute tranport, and vegetation growth. The spatial and temporal scales of concern vary from those characterizing the microprocesses of soil moisture to those of global hydroclimatological change.

The committee will issue a report which it expects will help guide science and educational policy decisions and should be of interest to the scientifically literate lay public. The document will stress the importance of the hydrological sciences and will identify needed improvements in the research and educational infrastructure. The report should lead ultimately to improved management of water and the environment.

The committee, which has met three times to develop the report structure and content and will meet in March 1989 to continue its work, anticipates the report will contain seven chapters:

Chapter I — Hydrology and life

This introductory chapter is the "attention-getter" which must make an understandable and convincing case for the importance of the Hydrologic Sciences. It should be written in an upbeat style with examples and curiosity items drawn from the role of hydrology in climate, weather, natural and man-made disasters, water supply, agriculture, the environment, etc. If possible, examples should include limits to progress caused by absence of data or understanding in specific cases.

Chapter II — The hydrologic sciences

This will contain the evolution of perception of hydrologic science, including its definition, with appropriate graphics. The unique role of water in the Earth system will be stressed, along with the unifying themes of the hydrologic cycle, scales and anthropogenic effects.

Chapter III — Critical and emerging areas

This is the intellectual core of the report and will contain a set of short unsigned "essays" on frontier research areas. Each essay will contain: scientific development to the present, outstanding historical achievements naming "heroes", intellectual frontier and scientific challenges, new data requirements, qualifications of people needed, and indication of application (if identifiable).

The essays of this chapter will be grouped in the following sections: Hydrology and Earth's Crust (i.e. ground water and associated heat and mass transfer), Hydrology and the Land Forms (i.e. erosion, deposition, and fluvial geomorphology), Hydrology and Climatic Processes (i.e. global water balance, interaction of land surface and climate, paleohydrology, etc.), Hydrology and Weather Processes (i.e. space–time precipitation, flash floods, interaction of land surface and mesoscale weather systems), Hydrology and Surficial Processes (i.e. infiltration, evaporation, snowmelt, etc.), Hydrology and Living Communities (i.e. relationships between vegetation patterns and climate, metabolism and energetics of microbial communities in water, etc.), Hydrology and Chemical Processes (i.e. geochemical characterizations of surface and groundwaters), and Additional Hydrologic Topics (i.e. applied mathematics for hydrology such as fractals, chaos, etc.).

Chapter IV — Scientific issues of data collection, handling, and storage

This will include brief discussions of why data are needed, characteristics of hydrologic data, current status of hydrologic data, and opportunities. This last section will again contain brief unsigned essays simlar to those of Chapter III but addressing such data subtopics as technology, methods of analysis, intensification of current efforts, and coordinated interdisciplinary experiments.

Chapter V — Scientific priorities

This chapter will include ranked synopses of the most important science issues or groups of issues, including the rationale behind the ranking.

Chapter VI — Education

Here the current and recent historical educational backgrounds of those classifying themselves as hydrologists will be examined as a function of their type of employment. The general scientific content of an appropriate undergraduate preparation for hydrologic science will be suggested.

Chapter VII — Resources and strategies needed

This chapter will suggest strategies and resources needed to move toward the identified research and educational goals, and will give an estimate of the current state of federal support for hydrologic science.

An Open Invitation

The committee is proceeding to "fill in the blanks" of this report outline through its own efforts and those of other identified specialists. This group is not omniscient, however, and may overlook some important examples, insights or problems. Accordingly, the hydrology community is invited to make brief, written contributions to the work of the Committee as may seem appropriate. The author of any material selected for inclusion will be recognized along with all other contributors in the general ackowledgements of the report. Such contributions should be so labelled and mailed within two months to: Stephen D. Parker, Director, Water Science and Technology Board, National Research Council, 2101 Constitution Avenue, Washington, DC 20418, U.S.A.

INTERNATIONAL ICE CORE FORUM (IICF)

A report has been prepared by the International Ice Core Forum (IICF) summarising the ice core activities of member nations. It is hoped that the summaries will help to foster international collaboration in the field of ice core research. Copies of the report may be obtained from Paul A. Mayewski, Director, Glacier Research Group, University of New Hampshire, Science and Engineering Research Building, Durham, NH 03824, U.S.A.

IICF was created in 1987 in response to the growing interest in ice core records. It is intended to stimulate and facilitate international cooperation in the field of ice core research. Member nations have agreed to provide summaries of their activities; the 1988 report is the first such volume.

New members

Giles H. Brown, Department of Geography, University of Southampton, Southampton SO9 5NH, U.K.
Jon Eiriksson, University of Iceland, Jardfraedahus Haskolans, 101 Reykjavik, Iceland.
Liz Elvidge, 29 Mount Street, Rosemount, Aberdeen AB2 4QX, U.K.
Simon K. Haslett, 40 Cheddar Drive, Parksite, Silverdale, Newcastle-under-Lyme ST5 6QR, U.K.
Katsuhisa Kawashima, Institute of Low Temperature Science, Hokkaido University, Sapporo 060, Japan.
Kenji Kosugi, Institute of Low Temperature Science, Hokkaido University, Sapporo 060, Japan.
Scott Lamoureux, 14346 Park Drive, Edmonton, Alberta T5R 5V2, Canada.
John C. Moore, Institute of Low Temperature Science, Hokkaido University, Sapporo 060, Japan.
Andrew P. Reid, British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, U.K.
Knut Sand, Norwegian Hydrotechnical Laboratory, 7034 Trondheim, Norway.
Floris Schokking, Bentveldsweg 102A, 2111 Ed Aerdenhout, The Netherlands.
Oddur Sigurđsson, National Energy Authority, Grensasvegur 9, 108 Reykjavik, Iceland.
Dominic E. Suttie, British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, U.K.
F.G.M. van Tatenhove, Pieter Lastmankade 30k, 1075 KK Amsterdam, The Netherlands.

INTERNATIONAL GLACIOLOGICAL SOCIETY

Lensfield Road, Cambridge CB2 1ER, England

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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.

ANNUAL PAYMENTS 1989

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

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

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

ICE

Editor: H. Richardson
Assisted by S. Stonehouse

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

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

Sterling £10.00

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