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In Memoriam

HILDA RICHARDSON

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ICE

NEWS BULLETIN OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

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CONTENTS

COVER PICTURE: Snowhenge, Greenland ice sheet (Photograph by Konrad Steffen).

Scanning electron micrograph of the ice crystal used in headings by kind permission of

William P. Wergin, Agricultural Research Service, U.S. Department of Agriculture

RECENT WORK

NORWAY

GLACIERS — NORWAY

Glacier mass-balance monitoring

(B. Kjøllmoen, H. Elvehøy, L. Andreassen, N. Haakensen, E. Roland, NVE)
At present, mass-balance measurements are performed on 11 glaciers in Norway. In southern Norway, six of the glaciers have been measured for 37 consecutive years or more. These glaciers constitute an west–east profile reaching from the very maritime Ålfotbreen, close to the western coast, to the very continental Gråsubreen, in the eastern part of Jotunheimen. Storbreen in Jotunheimen has the longest series of all glaciers in Norway with 51 years of measurements, while Engabreen has the longest series (30 years) in northern Norway. The mass-balance observations are based on traditional field methods using stakes and towers to measure accumulation and ablation of snow and ice at different elevations. The mass balance is calculated using the so-called stratigraphic or "traditional method". The balance is calculated between two successive "summer surfaces" (i.e. surface minima).

Glacier mass-balance modelling, 1960 to 1990

(R.V. Engeset, NVE)
Annual mass balance for all Norwegian glaciers will be modelled using a precipitation–degree-day approach. This is part of a project that will establish normal discharge values for Norway for 1960–90 with a spatial resolution of 1 km.

Glacier-front variation monitoring, 1900–98

(H. Elvehøy, NVE; A. Nesje, UBerg, S. Winkler, UWürz)
Annual measurements of glacier-front variations were started around 1900 at Jostedalsbreen, Folgefonna, Svartisen and in Jotunheimen by Rekstad from UBerg and Oyen from the Norwegian Geological Survey. Later measurements have been carried out by several institutions. At least 45 different glaciers have been monitored for shorter and longer periods and 11 glaciers have records covering the entire period. At present, 23 glaciers are monitored; 20 in southern Norway. Front-variation data are collected at NVE, are published in annual reports from NVE, and are regularly reported to the WGMS. During the last decade, many outlets from the larger ice caps close to the coast have advanced in the order of 500 m.

Response of Norwegian glaciers to climate change

(T. Laumann, K. Melvold, UOslo)
Recent and past measurements have shown large local and regional variations in glacier change in Norway. A better understanding of the response to past, present and future climate change can be obtained by numerical modelling, in which the geometry and climate settings of the individual glacier can be taken into account. A mass-balance model (first approach degree-day model) and a dynamic-glacier model (temperate glaciers) have been developed for Norwegian glaciers. The two models are coupled, as the dynamic ice-flow model will be forced by the output from the mass-balance model. The mass-balance model and the dynamic model will be calibrated against historical mass-balance records and historical records of glacier length, respectively. Datasets on glacier geometry and meteorology are needed. Historical length records and mass-balance data are also needed from some selected for calibration purposes. A standard input/ output format has been developed to facilitate easy flow of data into and out of the model.

Regional changes of glaciers

(L.M. Andreassen, B. Kjøllmoen, H.K. Sorteberg, NVE)
In 1998, vertical aerial photographs were taken of several glacier areas in northern Norway. These were Okstindan, Svartisen, Blamannsisen, Skjomen, Lyngen peninsula and Oksfjord and Seiland, covering the bulk of previously studied glaciers in these areas. The photographs were compared with older photographs, topographic maps, information from the glacier inventory, field observations and other measurements. Previous results show large local and regional variations in glacier change. In the Svartisen area, Høgtuvbreen has retreated more than 700 m since 1972, while Engabreen in the same period has had a net advance of more than 100 m. A final report describing the changes of the glaciers is in preparation. The University of Århus in Denmark and Queen's University in United Kingdom are external joint- venture partners of the project.

Selected glaciers in southern Norway were investigated to quantify changes since the 1960s based on vertical air photos from the 1960s, the 1980s and 1997. Large variations have been detected. The outlet glaciers from Folgefonna and Jostedalsbreen have either retreated, retreated until the 1980s and then advanced, or advanced through the entire period. The maximum front advance has been 920 m (Kjenndalsbreen) and maximum retreat 1050 m (Lodalsbreen), both outlets from

Jostedalsbreen. The glaciers in the Sunnmøre area show a minor increase in area from the middle of the 1960s to 1997, but no significant change in front position. Six of the seven glaciers in Jotunheimen have retreated, and their areas have been reduced up to 35%.

Storbreen symposium 1998

(L.M. Andreassen, NVE)

Annual mass-balance measurements on Storbreen, south-central Norway, were started in spring 1949 by Olav Liestol. The measurements have been carried out every year since, and Storbreen has the second longest record of mass-balance measurements of this kind in the world. The 50-year anniversary of the mass-balance measurements was celebrated with a one-day symposium. This took place on 19 November 1998 at NVE in Oslo. Several glaciologists gave short lectures at the symposium and Olav Liestol was the key speaker. Abstracts from the lectures, as well as a summary of the glaciological work on Storbreen, have been published in a report from the symposium which is available from NVE (Andreassen and Østrem, 1999).

Modelling historic variations and future mass-balance scenarios of Svartisen, northern Norway

(R.V. Engeset, H. Elvehoy, L.M. Andreassen, N. Haakensen, B. Kjøllmoen, L.A. Roald, E. Roland, NVE)

The mass balance of a 100 km^2 glacier sub-basin of Svartisen, was reconstructed for the period 1917 to 1995. This was done using three different methods: the hydrological method; the correlation between mass balance and meteorological observations; and a precipitation–degree-day model. Calibration data were derived from field observations, map comparisons and by correlating observations at different glaciers. The reconstructed series showed a total loss of ~3 x 10^9 m^3 w.e., of which most was lost between 1920 and 1950. After 1950, the net balance gradually increased and now is near equilibrium with the present climate. Suggested climate scenarios for this region gave a loss 0–5 x 10^9 m^3 w.e. up to 2050.

Svartisen Subglacial Laboratory

(M. Jackson, NVE)

Svartisen Subglacial Laboratory is situated in northern Norway under 200 m of ice. The laboratory provides a unique opportunity for direct access to the bed of a temperate glacier for measuring subglacial parameters and performing experiments on the ice.

A subglacial intake was constructed beneath Engabreen, one of the valley glaciers draining western Svartisen, for hydroelectrical purposes. Permanent tunnels were made through the rock underneath the glacier and lead to access points that open directly at the ice–bed interface. Using the laboratory beneath Engabreen, it is possible to sample ice that is unaffected by atmospheric processes, to take much larger samples than is possible using boreholes and to leave experiments in place from one year to the next, easily gaining access to them again when necessary.

Several projects have already been completed by researchers from several different institutions. Several load cells have been installed beneath the ice and the anti-correlation between basal pressure and discharge has been examined, as well as the relation between load-cell pressure and other parameters. An instrumented obstacle was installed at the bed surface and sliding speed, temperatures and stresses on the obstacle were measured. Using these data in a three-dimensional finite-element model, it was possible to determine the viscosity parameter in the flow law, which was smaller than published values for clean ice. Chemical and isotopic ($\delta^{18}O$ and δD) analyses of a 2 m long basal ice core were performed to investigate the mechanisms by which different ice facies have been formed. These and other studies examining the basal stratigraphy of the ice suggest there is considerable water movement therein. Other projects include examining the fabric of the basal ice, as well as tracing experiments performed to study the subglacial hydrology. Planned future work includes examining the basal motion of glaciers over hard beds and soft beds, as well as studies of the water-filled pockets that are present in the basal ice to learn more about their formation and evolution.

Volume changes of Langfjordjøkelen 1966–94, northern Norway

(B. Kjøllmoen, NVE)

Glaciological investigations at Langfjordjøkelen have been performed by NVE since 1989. Net balance from 1966 to 1994 has been calculated by comparison of detailed maps from these two years and show a shrinkage of the area from 9.8 km^2 to 8.4 km^2. The decrease in volume was 123 x 10^6 m^3 of water, which corresponds to 12.5 m w.e. The calculations for the eastern outlet (where the annual mass-balance measurements are performed) show a shrinkage of the area from 4.3 to 3.7 km^2, and a deficit in volume amounting to 83 x 10^6 m^3 of water or 19.3 m w.e.

Global Land-Ice Measurements from Space (GLIMS)

(R.V. Engeset, NVE)

NVE will be a regional centre for Fennoscandia within the GLIMS project. The work will focus on developing methods for automatic identification of snow, glacier ice, firn and land/water surfaces and generation of DTMs using Terra ASTER and Landsat ETM+ imagery. The remote-sensing data will be used to sample glacier-front position and extent, and transient snowline (and if possible ELA) positions on an annual basis over all glacierized areas in Norway and Sweden.

Mass-balance measurements

(E. Isaksson, B. Lefauconnier, NPI; J.O. Hagen, UOslo)
Since 1966, NPI has monitored the mass balance of Austre Brøggerbreen and Midtre Lovénbreen in Ny-Ålesund, in the Kongsfjorden area of NW Spitsbergen. These are now the longest continuous series from the Arctic. Both glaciers are small, 5–6 km^2. The measurements show a steadily negative mass balance since the start of measurements. In total, the glacier masses have decreased about 10% during this period. The winter balance has been stable, while summer ablation shows large variability. There are no trends in either the winter precipitation nor the summer melting during the measuring period.

Kongsvegen, a larger glacier in the same area, spans a higher elevation range than the two other glaciers and has been monitored since 1986. The record indicates a small positive balance for the period which is attributed to the higher elevation. It is suggested that it is building up towards a surge.

Modelling radargrams using dielectric profiling (DEP) of shallow firn cores

(J. Kohler, NPI; J.C. Moore, AC/ULap)
Using ground-penetrating radar (GPR) to measure snow thickness is a relatively new technique in operational snow hydrology. The reflection in a GPR image from the underlying surface is converted to depth using some type of travel-time vs depth calibration. Analogously, GPR is being used in glaciology to determine accumulation rates from datable reflecting horizons in firn or from blue-ice reflections in the ablation area.

Some fundamental issues remain when using GPR on snow and ice, however. One is establishing an independent travel-time vs depth relation. Another concerns the interpretation of layer reflections in firn. Our key finding showed that a single core was inadequate to successfully quantify firn properties over the area imaged by a GPR beam. We are extending the previous investigation by taking several shallow cores in the accumulation area of Kongsvegen and Midre Lovénbreen, and comparing radar images there with synthetic radargrams derived from DEP measurements on these shallow cores.

Response of Arctic ice masses to climate change (ICEMASS)

(J.O. Hagen, K. Melvold, UOslo; E. Isaksson NPI)
This is a part of a European Union project (1998-2000) with seven European partners. The goal is to predict the sensitivity and response of Arctic glaciers and caps to climate change over the next century, together with associated implications for sea level. The work includes modelling, remote sensing and field investigations of some selected ice masses in Iceland, Svalbard, Franz Josef Land and Severnaya Zemlya. The Norwegian groups work on Kongsvegen and Austfonna, Svalbard. Calibrated energy-balance models are used for this set of glaciers with input data from field measurements and an envelope of future climate scenarios.

Several subprojects are included in ICEMASS, such as: (1) net-balance gradients and mass-balance calculations of Austfonna; (2) current sea-level contribution from Svalbard glaciers; (3) snow distribution on Austfonna.

A survey of the spatial variation in snow accumulation on Austfonna was carried out in spring 1998 and 1999. Snow depth was measured with a GPR system (RAMAC/GPR) and traditional snow probing. Continuous snow-radar sounding, coupled with high-resolution positioning data, should provide information on the snow-cover distribution along profiles. This method can fill in data between more traditional point measurements, such as stake soundings, ice-core drillings and pit studies.

Austfonna ice core

(E. Isaksson, L. Karlöf, NPI; J.O. Hagen, UOslo)
In cooperation between the National Institute of Polar Research, Tokyo, and Norwegian scientists, an ice core was drilled through Austfonna in spring 1998. Due to very bad weather, only 118 m of the 600 m thick ice cap was drilled. Therefore, the project was continued in spring 1999 when a 288 m core was retrieved. ECM was measured in the field and the core was cut and subsampled. The analysis program consists of ECM, major ions, MSA, β-activity and isotopes. In addition, analysis of some metals and organic compounds are planned. The core will be prepared in Tromso and most of the laboratory analysis will be performed in Japan. The ice-coring project is run in close cooperation with the ICEMASS project.

Detection of glacier mass-balance change using SAR

(R.V. Engeset, NVE)
Synthetic aperture radar (SAR) images the Earth using a self-generated emitted electromagnetic pulse, which is not influenced by clouds. With a wavelength of about 6 cm (such as on ERS-1/2 and RADARSAT), SAR is very sensitive to volume and surface scattering in the upper layer of a glacier and thus surface and near-surface structures related to the accumulation, ablation and metamorphism of snow, firn and ice. Previous studies of winter ERS–SAR imagery have identified zones of very high and very low backscatter over glaciers.

Schematically, glacier facies developed during the accumulation and ablation seasons correspond to glacier ice, superimposed ice, firn and snow at the end of the ablation season. The central problem is how SAR backscatter during the dry winter conditions relates to mass balance. The work will assess if the ELA is identifiable on an annual basis. Kongsvegen, Svalbard, will be used as a test glacier because field observations are available and the glacier is fairly large and has an even surface. The work will assess the potential of ERS–SAR for observing relevant mass-balance information during winter.

Lomonosovfonna ice core

(E. Isaksson, L. Karlöf, NPI; J.O. Hagen, UOslo)
In April 1997, a deep ice core was retrieved from Lomonosovfonna, Spitsbergen's highest icefield (1230 m a.s.l.), in a cooperative project involving scientists from: Norway; the Arctic Center, Rovaniemi, Finland; the Department of Earth Sciences, Uppsala University, Sweden; the Institute for Marine and Atmospheric Research, Utrecht, The Netherlands; the Institute of Geology, Tallinn Technical University, Estonia; the Laboratoire de Glaciologie et Géophysique de l'Environnement, Grenoble, France; and the Centre for Isotope Research, Groningen, The Netherlands. The core is 120 m long. Radar measurements at the core site indicated an ice depth of 126.5 m, suggesting that the bottom of the ice cap was nearly reached. Our objective is to carry out an extensive program of analysis in order to retrieve a more detailed record of climatic and environmental history of the area than has been done with previous cores from the area. The ice-core analysis program includes DEP, ECM, β-activity and Cs concentrations, water isotopes, major ions and MSA, several metals and organic compounds. Preliminary dating suggests the core contains about 1000 years of environmental information. Fieldwork including radar, snow pits and shallow coring was also conducted in April 1999.

Snow and glacier studies using ENVISAT MERIS and ASAR

(J-G. Winther, E. Isaksson, M. König, S. Tronstad, NPI)
The main objective is to study the use of ENVISAT MERIS and ENVISAT ASAR for studies of snow distribution and glacier characteristics and to evaluate how these sensors can improve our present use of satellite data for studying changes of the cryosphere. The project is funded by the European Space Agency. Three sub-tasks with the following goals are identified: (1) study of snow distribution on Svalbard for regional climate studies; (2) monitoring of glaciers on Svalbard for studies of mass balance, surge mechanisms, calving and sensitivity to climate change; and (3) study of variations of the ice front of Fimbulisen, Antarctica, using 30 years of satellite imagery.

GLACIERS — ANTARCTICA

Norwegian contribution to European Project for Ice Coring in Antarctica (EPICA)

(J-G. Winther, L. Karlöf, E. Isaksson, J. Kohler, NPI)
The Norwegian contribution to EPICA has been concentrated on pre-site survey work in collaboration with the other members of the Nordic EPICA group. Fieldwork was carried out in the austral summers 1996/97 and 1997/98. During 1996/97, activities were concentrated along a 550 km long traverse line from the Norwegian station Troll and south to 75°S, 15°E. Glaciological work during that traverse was devoted to determination of accumulation rates (shallow firn cores, snow pits, snow radar), snow chemistry (snow pits), ice dynamics (stake measurements), surface topography (GPS) and meteorology (AWS). During 1997/98, a new traverse was undertaken (organized by the Swedish Antarctic Research Programme, SWEDARP) with the main activities concentrated around 76°S, 08°W and 73°S, 13°W. In 1999 fieldwork was devoted to the same sort of studies as the previous year, although three 100–120 m cores were retrieved as well. The medium long cores will be studied for electrical properties (ECM, DEP), total β-activity, $\delta^{18}O$ and ion chemistry. The dating of the cores will be based on the outcome of these studies.

Jutulstraumen mass balance and dynamics

(K. Melvold, J.O. Hagen, UOslo)
The aim is to investigate the present situation of some important mass-balance factors on Jutulstraumen, to reconstruct the previous 35 years' variations of snow accumulation and to monitor future changes. The main parameters to be studied are snow accumulation, ice movement and ice thickness. Ice-flux calculations are combined with accumulation measurements to see if the mass outflow is balanced by the mass inflow. One important element is the accumulation pattern. Accumulation rate is measured by shallow ice cores, 15–25 m deep, in a profile from the shelf edge along the centre line of Jutulstraumen up to the plateau. The ice-flow–ice-flux is studied by velocity and strain-net measurements by GPS positioning of stakes drilled into the ice and radio-echo soundings in cross profiles. The field work is conducted during the Nordic Antarctic Research Expedition (NARE) expeditions.

Jutulstraumen, remote-sensing study of drainage-area ice dynamics

(C. Rolstad, J.O. Hagen, UOslo; E. Isaksson, NPI; Ian Whillans, OHSU)
Jutulstraumen, draining an area of 124,000 km^2, represents the major ice discharge from western Dronning Maud Land. This project, on the dynamics of the Jutulstraumen drainage area, will provide information for studies of the mass balance of Jutulstraumen and its surrounding ice masses. It will characterize: (1) the surface geometry to define the borders of the drainage basin; and (2) the ice-velocity field, necessary for the ice-flux calculations.

Satellite remote-sensing data have been collected, using sequential optical images and interferometric SAR images. Numerical modelling of a "force budget" will improve understanding of the ice dynamics. A further analysis on the mechanical reactions of the ice masses to a change in sea level, due to a change of the climate, will be conducted.

National snow database

(H. Sorteberg and R.V. Engeset, NVE)
Extensive snow data, collected by NVE and hydropower companies during the previous 60 years, are now being systematically compiled and included in a national snow database. These datasets will provide the basis for flood forecasting and early warning of energy shortages (snow represents potentially available water for electricity production during the summer), as well as for testing snow models and snow remote-sensing methodologies.

Snow hydrology — snow pillows

(H. Sorteberg, R.V. Engeset and H.C. Udnæs, NVE)
NVE has deployed 18 snow pillows for real-time monitoring of snow water equivalent. Another five pillows are operated by other institutions and companies submitting data to NVE in near real time. To assess the performance of the pillows, a manual observation programme was carried out in winter 1998/99. Monthly observations of snow depth, density, moisture and grain sizes were recorded in addition to areal snow coverage and description of ice layers and snow stratigraphy. The results will be analysed by the end of 1999, as an assessment of how the pillows describe daily changes in snow water equivalent during the accumulation and ablation phases, as a basis for recommendations on the further operation of such instruments.

Snow modelling

(R.V. Engeset and H.C. Udnæs, NVE)
Modelling of snow water equivalent is being carried out for all snow-pillow locations using precipitation and air temperature as input parameters. The model is similar to the HBV model. It is calibrated against manual observations obtained during winter 1998/99 at the snow-pillow sites and is tested against the snow water-equivalent values recorded by the snow pillows. The model simulates the snow water equivalent for 15 years to establish daily reference values for a normal period (of 15 years length). The flood forecasting service at NVE then compares real-time snow-pillow data with statistics from the normal period to assess the snow situation. The model is also being calibrated for 90 synoptic meteorological stations operated by the Norwegian Meteorological Institute, from which updated values of precipitation and air temperature are available every morning. Statistics for a normal 15 year period will be used by the flood-forecasting service to assess the daily snow-equivalent estimates for these 90 locations in Norway.

Snow-accumulation distribution, Svalbard

(J-G. Winther, NPI; O. Bruland, SINTEF; K. Sand, UNIS; Å. Killingtveit, D. Marechal, NTNU; J.O. Hagen, UOslo)
A survey of the regional snow-accumulation variability on Spitsbergen, was carried out in May 1997 and 1998, along three transects from west to east approximately following 77°30'N, 78°N and 78°50'N. Data on snow accumulation were also collected in NW Spitsbergen and on Nordaustlandet in 1998. The altitudes span sea level to 1000 m a.s.l. Snow depth was measured with two different ground-penetrating radar systems, PulsEKKO (450 MHZ) and GSSI SIR System-2 (500 MHZ), drawn by snow machines. Snow characteristics, such as temperature, density and stratigraphy were measured in snow pits in nine areas, three along each transect. Data from 1997 suggest: (1) the accumulation–elevation gradients vary from 3 mm/100 m in the NE to 237 mm/100 m in the central south, with an average value of 104 mm/100 m for all measurements; (2) snow accumulation was 38–49% higher at the east coast than at the west coast; (3) a clear accumulation minimum (or continental climate) is seen for the central (inland) locations in the middle and northern transects, while no such minimum exists along the southern transect; (4) a south–north gradient produces 55% and 40% less snow accumulation at the northern locations compared to the southern locations at the western and eastern coasts, respectively. These drops in winter snow accumulation occur over a distance of >200 km. Similar campaigns were carried out in spring 1999.

Spectral reflectance of snow and sea ice, Svalbard

(J.-G. Winther, S. Gerland, J.B. Ørbæk, NPI)
Glaciological fieldwork was carried out on snow-covered tundra and on fast ice in the Kongsfjorden area near Ny-Ålesund, Svalbard, during the melt season in spring 1997 and 1998. In addition, temperatures and snow thickness were monitored automatically during autumn, winter and spring in each year. In the tundra, spectral surface albedo, surface irradiance and global radiation were measured, as well as attenuation of optical radiation in the snowpack. In snow pits, density, temperature and liquid-water content of snow were logged and the size and type of snow grains were determined. The snow reached thicknesses of up to 0.9 m at the end of the accumulation season in May. The entire snowpack melts in about three weeks. Surface albedo drops significantly with increasing grain sizes and changes in the physical properties of snow, when melting begins. Radiation measurements were made on fast ice in the inner part of Kongsfjorden, as well as under the sea ice, for data on the attenuation of solar radiation in snow and sea ice. In addition, ice cores were taken and salinity and temperature were logged. Thick and thin section analyses were undertaken on selected core samples. This project is a collaboration with researchers from Finland, Germany, Russia and the U.S.A.

SEA ICE

Solar radiation and physical properties of sea ice, Barents Sea

(S. Gerland, J-G. Winther, NPI)

Through detailed measurements of spectral reflectance of solar radiation and the physical properties of sea ice, snow and water, in the marginal ice zone of the Barents Sea, the relation between the physical properties and the absorption of solar radiation by sea ice is being analysed. Surface albedo will also be measured, with a spectroradiometer, for energy-balance calculations, climate modelling and remote-sensing ground truthing. We expect to be able to determine the amount of solar radiation (spectrally) that penetrates the sea ice and the water masses below and is therefore available for biological production. By obtaining sea-ice cores and analysing them, physical property and texture investigation will also be carried out. The measurements and sampling procedures will be performed on the May 1999 cruise of the Norwegian R/V *Lance*. This will be in collaboration with researchers from the Arctic and Antarctic Research Institute, St Petersburg, Russia.

ABBREVIATIONS

AC/ULap	Arctic Centre, Univ. of Lapland, FIN-96101 Rovaniemi, Finland
NPI	Norwegian Polar Institute, Polarmiljøsenteret, N-9296 Tromsø, Norway
NTNU	Norwegian Univ. of Science and Technology, N-7034 Trondheim, Norway
NVE	Norwegian Water Resources and Energy Administration, P.O. Box 5091 Majorstua, N-0301 Oslo, Norway
OHSU	Ohio State Univ., Columbus, OH 43210-1002, U.S.A.
SINTEF	SINTEF, N-7034 Trondheim, Norway
UBerg	Univ. of Bergen, N-5035 Bergen-Sandviken, Norway
UNIS	Univ. Courses on Svalbard, P.O. Box 156, N-9170 Longyearbyen, Norway
UOslo	Univ. of Oslo, Dept. Physical Geography, P.O. Box 1042 Blindern, N-0316 Oslo, Norway
UWürz	Universität Würzburg, D-97074 Würzburg, Germany

Submitted by Jon Ove Hagen

INTERNATIONAL GLACIOLOGICAL SOCIETY

ANNUAL GENERAL MEETING 1999

MINUTES OF THE ANNUAL GENERAL MEETING OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

19 August 1999 in the Hauptgebäude, Eidgenössische Technische Hochschule, Zürich, Switzerland

The President, Dr Norikazu Maeno, was in the Chair. 41 members from 15 countries were present.

1. The Minutes of the last Annual General Meeting, published in *ICE*, 1998, No. 118, p.9–10, were approved on a motion by K. Steffen, seconded by H. Röthlisberger and signed by the President.

2. The President gave the following report for 1998–99:

Since my last report to you in Kiruna in August 1998, there have been some sad occasions for the Society. Two of our Seligman Crystal recipients, Henri Bader and Hans Oeschger, passed away and one of our Cambridge staff, who resigned last year, died earlier in the year. Obituaries of the Crystal winners are contained in the latest issue of *ICE*.

Four issues of the Journal of Glaciology have been printed since then. The latest was printed last week and some of you will have seen it on display with other IGS material at this meeting. *Annals of Glaciology* 27 was a huge volume, with 115 papers, which is the equivalent to two normal *Annals* volumes. It came out at the beginning of the year, but its production impacted on subsequent *Annals* volumes. Although all papers for *Annals of Glaciology* 28 are now with the printer, it will probably not be ready for distribution before November. The final paper from the Sixth Antarctic Glaciology Symposium, held in Lanzhou, China, was received earlier this month so we do not expect to be distributing this volume before the end of the year. I would like to thank SCAR for inviting us to publish papers from that meeting in the *Annals*.

Earlier this year, some of you will have seen our Secretary General in The Hague working with the editorial team responsible for papers from the EISMINT/ EPICA meeting. Some of you may have had an opportunity of meeting Dave Garbett there. As I reported last year, he is working full-time for you and is being a great help to the Secretary General. Koli Hutter, the Chief Editor for that meeting, has done an excellent job with his editorial board and we hope to have that volume printed in less than a year.

Those of you attending this meeting will know how hard the editorial board has been working on papers from the Symposium on the Verification of Cryospheric Models, under the capable direction of Koni Steffen. You will doubtless have been on the receiving end of several e-mails from the Secretary General concerning your intention to submit a paper for publication or seeking an explanation as to why it had not been received on time. This follow-up has meant that, for the first time for many meetings, all papers being considered for publication in the *Annals* were received close to the deadline. This makes everyone's job much easier and I would like to thank all authors for their cooperation. Special thanks go to Koni Steffen and his team of editors – Roger Barry, Garry Clarke, Paul Föhn, Hilmar Gudmundsson, Adrian Jenkins, Michael Kuhn, Peter Lemke, Shinji Mae, Kees van der Veen and Jay Zwally – for all the work they have put into your papers, so necessary for maintaining the standards of our publications. I would also like to thank Atsumu Ohmura for the invitation to come here and for the effective way in which he has drawn on the local organizing committee of Walter Ammann, Heinz Blatter, Martin Funk, Heinz Gäggeler and Wilfried Haeberli to help put on such a successful symposium. It is always difficult to single people out but some whom you have seen throughout this week, or will be seeing again later, include Urs Fischer, Marcia Phillips, Martin Funk, Esther Jampen, Rosmarie Widmer, Christian Schneeberger, Henrik Huwald, Andreas Vieli and Margaret Ommanney.

The editorial team of Will Harrison, Matthew Sturm and Monica Court is functioning extremely well and, by increasing the size of the Editorial Board, we hope that the reviewing time of your papers will be reduced. During the past year, Helmut Rott and Michiel van den Broeke have been added to the Board and we expect other appointments to be made as needed. The demands on the office of the Chief Editor are increasing and Council will be reviewing the situation to ensure that adequate support is available. In a further effort to improve service to you, Council will be considering, at its meeting tonight, the possibility of increasing the publishing frequency of the *Journal*.

Last year, we agreed to restore *ICE* to three separate issues a year and Numbers 117, 118, 119 and 120 have all now been published; the latest in the week before this meeting. Delays are sometimes occasioned by delays in the submission of national reports on recent work. These should be submitted every two years, so please respond quickly to any request you receive from your National Correspondent or enquire when the next report is due if some time has elapsed since the last one. I would like to thank all our National Correspondents for the important work they do for the Society, particularly those who are retiring this year – Wilfried Haeberli (Switzerland), S. Kobayashi (Japan - Honshu), Renji Naruse (Japan - Hokkaido) and Matthew Sturm (U.S.A. - Alaska).

Next year, you should be seeing a revised edition of *Glacier Ice*, the book by Austin Post and Ed LaChapelle. This is a co-publication venture between the IGS and the University of Washington Press.

In the coming months, we will be working closely with the editors from this meeting to ensure timely production of *Annals of Glaciology* 31. Next year, we will be hosting meetings in Innsbruck, Austria on Snow, Avalanches and the Impact of the Forest Cover and on Sea Ice and its Interactions with the Ocean, Atmosphere and Biosphere in Fairbanks, Alaska, U.S.A. The Secretary General is already working on details of our meetings the following year on ice cores and climate to be held in Greenland, and on remote sensing in glaciology to be held in the United States. Details of all these will be available on our Web site and will be distributed to you. For timely information on papers being published, on meetings and on other matters of interest, please check the Web.

Last night, I had the pleasure of presenting the Seligman Crystal to Dr Claude Lorius and now I have the wonderful privilege of announcing that Council has unanimously approved the award of the Seligman Crystal to Dr Charles F. Raymond for his continued ground-breaking glacier research for over 30 years.

From his early studies with boreholes on the Athabasca Glacier, he provided the most thorough understanding of the internal deformation of a glacier. With his colleagues, he extended the research to other glaciers, including basal processes and hydrology. The extension of this comprehensive approach to surging glaciers, using advanced techniques, provided the primary data required to understand the processes involved. In particular, the field program and analysis of the Variegated Glacier, by the team that studied it throughout the long period of build-up and major surge making it the most thoroughly studied surging glacier, remains a landmark in the field of glaciology. Charlie Raymond also turned his attention to the study of ice streams and ice caps, particularly near the ice divides. Again, the fundamental work he undertook has provided basic information on the processes required for modelling. Finally, he has also led an outstanding program for training new glaciologists with his thorough techniques and his active research programs. This has provided a legacy for glaciology generally and led the way for the next generation of glaciologists.

I have two other excellent bits of news to report. The first is that, thanks to our Secretary General and Terry Tucker, the Institute for Scientific Information has agreed to include the *Annals of Glaciology* in its Science Citation Index®. I know that for many of you this was an important issue and I am delighted it has been resolved so successfully. The first volume to be included will be *Annals of Glaciology* 26, containing papers from our Chamonix symposium on snow and avalanches. The second is that, in an effort to shield members slightly from the effects of a rather strong pound, the Treasurer will be recommending no increase in membership dues for the coming year. We are fortunate to have him with us today and he will present his own report shortly.

This occasion is the last one at which I will be addressing you as President. I am delighted to be able to hand on to Bob Bindschadler, your new President, a Society that is in excellent shape, with increased reserves, a growing membership, and expanding *Journal* and *Annals* series which are now both included in the Science Citation Index* and which, from any analysis, contain much of the most significant glaciological literature being published today.

At the end of a three-year term of office, there are many who have helped the Society and me and to whom I would like to express my thanks. To our headquarters' staff: to Sally Stonehouse, who retired this year after many years of processing your manuscripts. She will continue to be in-volved with the glaciological community through her responsibilities as manager of the World Data Centre C for Glaciology. To Ray Adie, Ken Moxham and Sylva Gethin, our copy editors. Ray is now spending more time in South Africa, so the main burden of copy editing is increasingly being carried by Ken Moxham. To Dave Garbett and Linda Gorman, who are helping maintain the quality of our publications and service to members. Also to the members of our three committees, Nominations, Publications and Awards, chaired by Garry Clarke, Julian Dowdeswell and Bill Budd; and to Will Harrison our Chief Scientific Editor, Matthew Sturm the Assistant Chief Editor and the members of their editorial board. To those who have helped me on Council during the past year and who are now retiring: Bjørn Wold; Dorothy Hall; Per Holmlund; Paul Mayewski; Catherine Ritz and Terry Tucker. And finally to our Secretary General, Simon Ommanney.

C.B. Ritz proposed, and G.K.C. Clarke seconded, that the President's report be accepted. This was carried unanimously.

3. The Treasurer, Dr J.A. Heap, presented the following report with the audited Financial Statements for the year ended 31 December 1998.

"The state of the Society's finances is best summarised by considering the changes from 31 December 1997 to 31 December 1998 in the following funds, as shown on page 13 of the accounts:

Seligman Fund: increased from £2245 to £2354, as a consequence of interest accrual;

Contingencies Fund: maintained at the same level of £12,684;

Annals Fund: increased from £60,837 to £70,248;

Publications Fund: increased from £13,744 to £14,102, as a consequence of sales, royalties and interest accrual;

Future Volumes: decreased from £41,801 to £27,807 reflecting lesser amounts of advanced income received with respect to Annals 28 and Annals 29;

Accumulated Fund: increased from £58,266 to £112,873 (page 6) consequent upon a profit in that account for the year of £54,607 plus a gain of £171 in the value of investments due to an adjustment to market value (page 12, note 7).

In 1998 the Society published 682 pages in the *Journal of Glaciology* and 1122 pages in the *Annals of Glaciology*. In 1997, the figures were 606 for the *Journal* and 895 for the *Annals*, a year with two issues of the *Annals*. As I noted in my report for 1998, the Society's publications are still very much dependent on the provision of page charges, the revenue exceeds that derived from the total of members' dues. I wish to register the Society's warm thanks to all those authors who have been both able and ready to support the Society in this way.

May I again make a plea to all members of the Society to do all in their power to increase the membership. Although Junior memberships have increased, there has been a disturbing decline in Full memberships. If the Society is to survive and continue to serve the science, we need to increase our membership base to at least 1000. If you know of colleagues or students who are not members, please encourage them to join. I believe they will find it is extremely good value for money. Also, please ensure that libraries in any institutions in which you have influence either maintain their subscriptions or take one out."

H. Röthlisberger proposed, and P.M.B. Föhn seconded, that the Treasurer's report be accepted. This was carried unanimously.

4. Election of auditors for the 1999 accounts. D.M. McClung proposed, and H.H. Kieffer seconded, that Messrs Peters, Elworthy and Moore of Cambridge be elected auditors for the 1999 accounts. This was carried unanimously.

5. Election to the Council. After circulation to all members of the Society of the Council's suggested list of nominees, no further nominations were received, and the following people were therefore elected unanimously for the terms indicated:

President	R.A. Bindschadler (1999–2002)
Vice-Presidents	K. Hutter (1999–2001)
	T.H. Jacka (1999–2000)
	H. Björnsson (1999–2002)
Elective Members:	G. Flato (1999–2002)
	P.M.B. Föhn (1999–2002)
	T. Murray (1999–2002)
	D. Perovich (1999–2002)
	L.G. Thompson (1999–2002)

The AGM was adjourned on a motion from J.A. Heap, seconded by J.L. Bamber

Afterwards, the incoming President, R.A. Bindschadler, made a brief speech. He thanked Norikazu Maeno for his service to the Society, the other retiring Council members, Dorothy Hall, Per Holmlund, Paul Mayewski, Catherine Ritz and Terry Tucker, for having served and Simon Ommanney, John Heap and David Garbett for their continuing service at the Society's offices in Cambridge.

NORDIC IGS MEETING 1999

29–30 October 1999, Arctic Centre, Rovaniemi, Finland

The 1999 meeting of the Nordic branch of the IGS was held at the Arctic Centre in Rovaniemi on October 29 and 30th 1999.

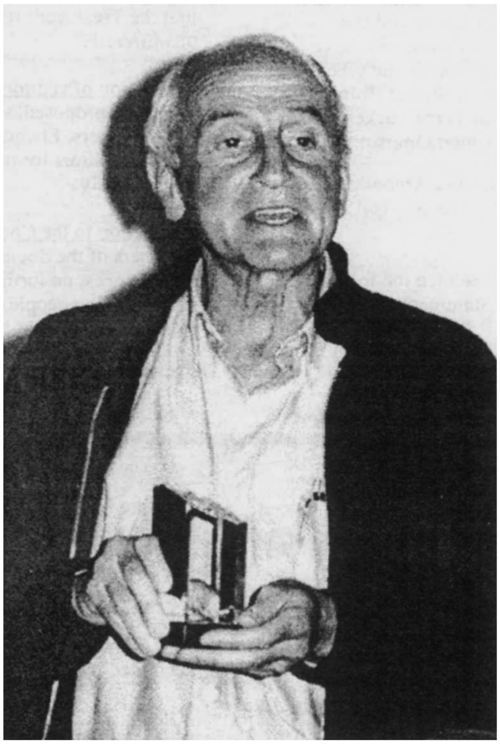
In common with all the other meetings in the series, the key element of the meeting was informality. We encouraged participation of younger scientists and PhD students in a friendly atmosphere, while of course encouraging established scientists to also present their research. In all, 45 people attended, with 25 talks and a few posters over the two days. As this was the first Nordic meeting held outside the locale of the capital cities, it was encouraging that so many were willing to travel to the Arctic for the meeting. The Arktikum exhibition at the Arctic Centre hosts a nice set of exhibitions on the Arctic and Finnish Lapland that were also an attraction (as was the sauna evening and a sample of the best beer and nightlife in Scandinavia). The next meeting will be held in Estonia, which has been associated with our Nordic meetings for several years now. The dates will be the corresponding Friday and Saturday 2000.

John C. Moore

1998 SELIGMAN CRYSTAL AWARD
Claude Lorius

17 August 1999, Zürich, Switzerland

The Society's Council agreed unanimously in 1997 that a Seligman Crystal be awarded to Claude Lorius. The Crystal was presented by the President of the Society, Norikazu Maeno, in the presence of about 75 members and friends,after the following introduction by Vice President Bob Bindschadler:



Claude Lorius was born in Besançon, France, in 1932. He obtained his first degree in physical sciences in 1953 and his Ph.D in 1963, based on his work in Terre Adélie. His contribution to Antarctic glaciology spans a long period of productive activity and has culminated with wide recognition for his role in the analysis of deep ice cores for paleo-records of global change.

Claude's work during the International Geophysical Year, in 1957–58, at the French inland Antarctic station, Charcot, is still referenced as a landmark of valuable data through an entire year at an isolated interior site. Claude and his colleagues were influential in establishing the French CNRS Laboratoire de Glaciologie et de Géophysique (LGG) at Grenoble in conjunction with Prof. Louis Lliboutry and his colleagues at the University. As director of this laboratory, Claude guided its development and growth into one of the most prominent glaciology centres in the world.

He inspired a group of excellent scientists, not only to perform the analytical work on the cores, but also to build bridges to the leading geochemists studying oceanic records and to prominent Earth-system modellers. In France, collaboration between his group and colleagues in isotope studies and at centres of meteorological research, produced innovation and leadership in research followed by others around the world. The evolution of scientific links between different fields resulted in a series of publications of the highest quality, with results that exceeded all initial expectations. The study of ice cores for paleo- climate and paleo-environmental records became the leading speciality of the centre and established the group as world leaders in many aspects of climate research. He translated the spatial ^{18}O record from Antarctica into a relative temperature proxy.

Through the 1970s and early 1980s, Claude Lorius was an active member of the planning group for the International Antarctic Glaciological Project (IAGP). This project involved nations with Antarctic activities in a large region of East Antarctic around Wilkes Land (particularly Australia, France, the United Kingdom (SPRI), the USA and the then Soviet Union). It resulted in collaboration on a wide range of studies including aerial radar sounding, oversnow traverses and deep-core drilling. In particular, traverses were carried out inland from Dumont d'Urville, Casey and Mirny.

As part of IAGP, deep-core drilling was planned and undertaken at Dome C, Vostok and Law Dome. One of the most successful products was the collaboration organized by Claude Lorius between the Soviet deep-core drilling at Vostok and collaborative French–Russian analysis of the ice cores. The detailed and sophisticated French measurements on the Vostok ice cores added immense value to the Soviet core-drilling program. He opened the door to Vostok and the important CO_2-temperature relationship that is now so famous. Glaciology owes a huge debt to Claude, for without his efforts, in conjunction with his mobilizing of French research resources, it is unlikely that the immense paleoclimatic implications of the Vostok cores would ever have been revealed. The series of papers published in Nature and elsewhere have become world-renowned and stand as landmarks in paleo-environmental records and research. It is for this immense and unique contribution that the Seligman Crystal has been awarded to Claude.

The News and Views article in the journal *Nature,* which accompanied the 1987 article, may be quoted. It stated "New results from a Soviet–French collaboration highlights the benefits to be gained from polar research ...". The collaboration of Claude and his colleagues at LGG with other groups, such as the Swiss in Berne and the Danes in Copenhagen, has been particularly productive and has led to the successful development of large drilling and core-analysis projects which would have been beyond the means of individual nations.

For demonstrating: (1) that atmospheric carbon dioxide, methane, and global temperature variability have been tightly linked during the past 160,000 years; and (2) that the reconstruction of the increase of those greenhouse gases in the atmosphere during the last century is the most dramatic and convincing evidence driving recent concerns over the likelihood of future global climate change, Claude, together with his collaborators Willi Dansgaard and Hans Oeschger, was awarded the 1996 Tyler Prize for Environmental Achievements. Since retiring as the Director of the LGG, Claude Lorius has continued to play an influential role in glaciology and polar research as head of the French Institute of Polar Research and Technology and through various European and international science groups. Claude has been a leading figure in many international science groups involving glaciology, the Antarctic and the global environment. In particular, he has served for many years on SCAR (the Scientific Committee for Antarctic Research), including periods as Secretary and as President. During his period as President, from 1986 to 1990, Claude Lorius led a strong move to focus and promote Antarctic research related to global change, to which glaciology and deep-core drilling for paleo-environment studies made major contributions. Claude's numerous and well-cited papers, his several books and other contributions leave a legacy which amply establish his place of particular eminence in the field of glaciology.

Claude is not just a scientist. It has been the privilege of many of us to delight in his stimulating and personable company. Without his personal drive, energy and vision, the Vostok drilling would not have been the success it was. Without his intuition and sense of the big connections, so fundamental to exciting science, and his ability to convey his message to the public, we would all be greatly the poorer.

Following the presentation of the Seligman Crystal, Claude Lorius gave an illustrated talk, principally highlighting various aspects of his Antarctic work.

He described his early years in Antarctica, from 1956 to 1968, working on heat balance and doing some very shallow drilling. This period included wintering over at Charcot, a small, isolated, inland station established for the International Geophysical Year, when so many valuable data were collected.

He talked about the Victoria Land traverse, in 1959 and 1960, when he was with the Americans looking at accumulation patterns and the seasonal changes in isotope ratios. Four years later, he was wintering over as station leader at Dumont d'Urville, where time was spent investigating mass balance in Adélie Land and doing some drilling in coastal ice.

The early 1970s saw him joining Louis Lliboutry in Grenoble and the expansion of the Laboratoire de Glaciologie into the Laboratoire de Glaciologie et Géophysique de l'Environnement.

He then described the International Antarctic Glaciological Programme, a major collaboration between Australia, France, the United Kingdom, the Soviet Union and the United States, that saw the establishment of a summer camp in the mid-1970s and the acquisition of a 905 m core from Dome C. The focus of the work was on using isotopes as temperature indicators, on ice-sheet modelling, and on establishing climate and atmospheric-change records over the last 40,000 years.

This early work laid the foundation for the Vostok saga, the Russian/French/American collaboration, begun in 1984/85, that has opened the window on so much of the Earth's early climate history. By 1987, a 2000 m core had provided 150,000 years of climate record and a link with the greenhouse gases. By 1998, the core had been extended to 3623 m and the climate history to 420,000 years.

The Antarctic story drew to a close with an account of the launching of the European Project for Ice Coring in Antarctica (EPICA) in 1993–95 and the plans of ten European countries to drill at Dome Concordia.

Claude Lorius concluded by saying that glaciologists have a lot to say about global environmental problems and should do so. They have a special perspective on the natural environment, global change and natural risks and should share this with others. Many of the results and conclusions have policy implications and glaciologists should join the debate.

1998 RICHARDSON MEDAL AWARD
Garry K.C. Clarke
18 August 1999, Zürich, Switzerland

The Richardson Medal was presented to Garry Clarke by the President of the IGS, Norikazu Maeno, during the banquet of the Society's International Symposium on the Verification of Cryospheric Models. The Secretary General, Simon Ommanney, introduced the award and the recipient as follows:

Many of you sitting here tonight are not members of the International Glaciological Society. I wish you were, but you probably have other professional organizations with which you are affiliated. Maybe this is your first IGS meeting and your first exposure to us. I hope it will not be your last.

However, what this means is that you probably have no idea what the Richardson Medal is. And also, you might not know that the *Seligman Crystal*, which we presented to Claude Lorius last night is

"..... awarded from time to time to one who has made an outstanding scientific contribution to glaciology so that the subject is now enriched."

The *Richardson Medal*, named after my predecessor, Mrs Hilda Richardson, who occupied the post of Secretary General for some 40 years, was conceived of in secret by a Council led by the then President of the IGS, Garry Clarke. It was to recognize, that by nurturing and running the Society on our behalf for so many years, she had performed an oustanding service to the Society and through it to glaciology. It was considered to be a fitting honour to extend to her on her retirement.

Council then had to decide whether such an award should be incorporated into the Society's awards system. This they subsequently did, deciding that it should be

"..... awarded from time to time to one who has given outstanding service to glaciology."

Maybe I should mention that this is the first actual presentation of this award, although Garry is the second recipient. The first to be recognized was Doug MacAyeal, but unfortunately we have not yet had an opportunity to make his presentation.

In my mind, a major element of this award is outstanding service to the Society. Much goes on behind the scenes of which you, as members, are not aware. It is the Secretary General, the President and Council who benefit from the hard work of many who volunteer their expertise and time most generously to further the objects of the Society and the subject that is ours.

Garry Clarke has provided outstanding service to the Society in a number of areas. In the early years of the development of the desk-top publishing system, 3B2, now used by the Society, he spent much time and effort working with the software developers to incorporate $\TeX$ into the publishing package so it would meet the needs of the Society's authors.

As President, he saw the Society through some very difficult times and it was his persuasive skills that enabled a solution to be found to the financial difficulties then troubling the Society. The fact that the Treasurer will tell you tomorrow that we have succeeded in building up our reserves is largely thanks to Garry's foresight and the imaginative way in which he tackled the crisis that faced the Society during his Presidency. It might not be stretching the point to say that otherwise I might not be with you, and that there might be no IGS to put on the symposia from which you and the science benefit.

He sought to expand our publication programme and has been the prime mover in putting together material that we hope to publish as our first source book in glaciology.

Finally, it is perhaps fitting that the person who conceived, funded, helped design and implement this important addition to the Society's awards should now be recognized through it for everything he has done to help the Society flourish and grow.

I would now like to call on our President, Norikazu Maeno to present the Richardson Medal to Garry Clarke.

JOURNAL OF GLACIOLOGY

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

J L BAMBER, R J HARDY AND I JOUGHIN
An analysis of balance velocities over the Greenland ice sheet and comparison with synthetic aperture radar interferometry

M R BENNETT, D HUDDART, T MCMORMICK AND R I WALLER
Glaciofluvial crevasse- and conduit-fills as indicators of subglacial dewatering during a surge, Skeiðarárjökull, Iceland

R BINDSCHADLER, X CHEN AND P VORNBERGER
The onset area of Ice Stream D, West Antarctica

H ENGELHARDT, B KAMB AND R BOLSEY
A hot-water ice-coring drill

A M GADES, C F RAYMOND, H CONWAY AND R W JACOBEL
Bed properties of Siple Dome and adjacent ice streams, West Antarctica, inferred from radio echo-sounding measurements

B HANSON AND R LeB HOOKE
Glacier calving: a numerical model of forces in the calving speed–water depth relation

R HODGKINS, M J SIEGERT AND J A DOWDESWELL
Geophysical investigations of ice-sheet internal layering and deformation in the Dome C region of central East Antarctica

B HUBBARD, J-L TISON, L JANSSENS AND B SPIRO
Ice core evidence of the thickness and character of clear facies basal ice at Glacier de Transfleuron, Switzerland

R W JACOBEL, T A SCAMBOS, N A NERESON AND C F RAYMOND
Changes in the margin of Ice Stream C, Antarctica

J B JAMIESON AND J SCHWEIZER
Texture and strength changes of buried surface hoar layers with implications for dry snow-slab avalanche release

J L KAVANAUGH AND G K C CLARKE
Subglacial hydraulic paradoxes and covert sensor failure

T G KOTZER, A KUDO, J ZHENG AND W WORKMAN
Natural and anthropogenic levels of tritium in a Canadian Arctic ice core, Agassiz Ice Cap, Ellesmere Island and comparison with other radionuclides

C MAYER AND M J SIEGERT
Numerical modelling of ice-sheet dynamics across the Vostok subglacial lake, central East Antarctica

J-O NÄSLUND, J L FASTOOK AND P HOLMLUND
Numerical modelling of the ice sheet in western Dronning Maud Land, East Antarctica: impacts of present, past, and future climates

N A NERESON
Elevation of ice-stream margin scars after stagnation

N A NERESON, C F RAYMOND, R W JACOBEL AND E D WADDINGTON
The accumulation pattern across Siple Dome, West Antarctica, inferred from radar-detected internal layers

B T RABUS AND D R FATLAND
Comparison of SAR-interferometric and surveyed velocities on a mountain glacier: Black Rapids Glacier, Alaska, U.S.A

A N SALAMATIN, Y D MURAVYEV, T SHIRAIWA AND K MATSUOKA
Modelling dynamics of glaciers in volcanic craters

J TSCHUMI AND B STAUFFER
Reconstructing the past atmospheric CO_2-concentration based on ice core analyses: open questions due to in situ production of CO_2 in ice

L A WILEN
A new technique for ice fabric analysis

ANNALS OF GLACIOLOGY

The following papers from the EISMINT/EPICA Symposium on Ice Sheet Modelling and Deep Ice Drilling held in Den Haag, The Netherlands, 20–22 April 1999 have been accepted for publication in *Annals of Glaciology* Vol. 30, edited by K. Hutter:

L ARNAUD, J WEISS, M GAY AND P DUVAL
Shallow-ice microstructure at Dome Concordia, Antarctica

J L BAMBER, R J HARDY, P HUYBRECHTS AND I JOUGHIN
A comparison of balance velocities, measured velocities and thermomechanically modelled velocities for the Greenland ice sheet

A CAPRA, R CEFALO, S GANDOLFI, G MANZONI, I E TABACCO AND L VITTUARI
Surface topography of Dome Concordia (Antarctica) from kinematic interferential GPS and bedrock topography

P DUVAL, L ARNAUD, O BRISSAUD, M MONTAGNAT AND S DE LA CHAPELLE
Deformation and recrystallization processes of ice from polar ice sheets

O Gagliardini and J Meyssonnier
Simulation of anisotropic ice flow and fabric evolution along the GRIP–GISP2 flowline, central Greenland

G Gödert and K Hutter
Material update procedure for planar transient flow of ice with evolving anisotropy

U C Herzfeld, H Mayer, W Feller and M Mimler
Geostatistical analysis of glacier-roughness data

U C Herzfeld, M Stauber and N Stahl
Geostatistical characterization of ice surfaces from ERS-1 and ERS-2 SAR data, Jakobshavn Isbræ, Greenland

U C Herzfeld, R Stosius and M Schneider
Geostatistical methods for mapping Antarctic ice surfaces at continental and regional scales

R C A Hindmarsh
Sliding over anisotropic beds

P Holmlund, K Gjerde, N Gundestrup, M Hansson, E Isaksson, L Karlöf, M Nyman, R Pettersson, F Pinglot, C H Reijmer, M Stenberg, M Thomassen, R van de Wal, C van der Veen, F Wilhelms and J-G Winther
Spatial gradients in snow layering and 10 m temperatures at two EPICA–DML pre-site-survey drill sites

D Howell and M J Siegert
Intercomparison of subglacial sediment deformation models: application to the late Weichselian western Barents margin

N R J Hulton and M J Mineter
Modelling self-organisation in ice streams

P Huybrechts, D Steinhage, F Wilhelms and J Bamber
Balance velocities and measured properties of the Antarctic ice sheet from a new compilation of gridded data for modeling

Li Jun, T H Jacka and W F Budd
Strong single-maximum crystal fabrics developed in ice undergoing shear with unconstrained normal deformation

P Mansuy, A Philip and J Meyssonnier
Identification of strain heterogeneities arising during deformation of ice

H Mayer and U C Herzfeld
Structural glaciology of the fast-moving Jakobshavn Isbræ, Greenland, compared to the surging Bering Glacier, Alaska, U.S.A

J Meyssonnier and A Philip
Comparison of finite-element and homogenization methods for modelling the viscoplastic behaviour of a S2-columnar-ice polycrystal

F S L Ng
Canals under sediment-based ice sheets

H Oerter, F Wilhelms, F Jung-Rothenhäusler, F Göktas, H Miller, W Graf and S Sommer
Accumulation rates in Dronning Maud Land, Antarctica, as revealed by dielectric-profiling measurements of shallow firn cores

A J Payne and D J Baldwin
Analysis of ice-flow instabilities identified in the EISMINT intercomparison exercise

W R Peltier, D L Goldsby, D L Kohlstedt and L Tarasov
Ice-age ice-sheet rheology: constraints from the Last Glacial Maximum form of the Laurentide ice sheet

C Rolstad, I M Whillans, J O Hagen and E Isaksson
Large-scale force budget of an outlet-glacier: Jutulstraumen, Dronning Maud Land, Antarctica

P R Sammonds, S Boon, N Hughes and M A Rist
Flow of anisotropic ice from the EPICA core: a new test apparatus

H Sandhäger and N Blindow
Surface elevation, ice thickness, and subglacial-bedrock topography of Ekström Ice Shelf (Antarctica) and its catchment area

A Savvin, R Greve, R Calov, B Mügge and K Hutter
Simulation of the Antarctic ice sheet with a three-dimensional polythermal ice-sheet model, in support of the EPICA project. Part II. Nested high-resolution treatment of Dronning Maud Land

R Staroszczyk and L W Morland
Plane ice-sheet flow with evolving orthotropic fabric

I E Tabacco, C Bianchi, M Chiappini, A Zirizzotti and E Zuccheretti
Analysis of bottom morphology of the David Glacier–Drygalski Ice Tongue, East Antarctica

L Tarasov and W R Peltier
On Laurentide ice-sheet aspect ratio in Glen flow law based models

L Testut, I E Tabacco, C Bianchi and F Rémy
Influence of geometrical boundary conditions on the estimation of rheological parameters

R Udisti, S Becagli, E Castellano, R Mulvaney, J Schwander, S Torcini and E Wolff
Holocene electrical and chemical measurements from the EPICA–Dome Concordia ice core

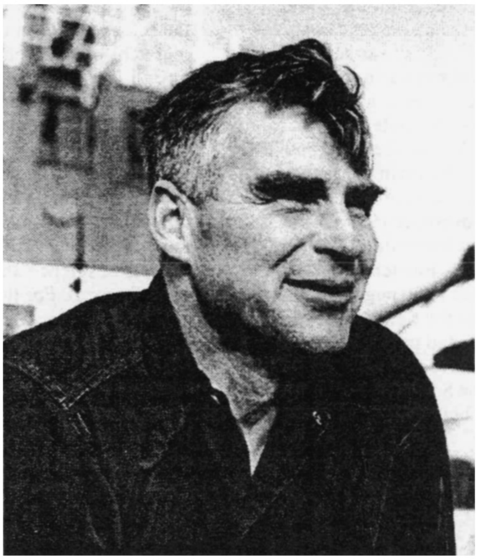
A V Wilchinsky and V A Chugunov
Ice-stream–ice-shelf transition: theoretical analysis of two-dimensional flow

M Wild and A Ohmura
Change in mass balance of polar ice sheets and sea level from high-resolution GCM simulations of greenhouse warming

NEWS

OBITUARY

Sir Vivian Ernest Fuchs, FRS (1908–1999)



Sir Vivian Fuchs, President of the International Glaciological Society from 1963–66, and best known as a polar explorer and leader of the first expedition to cross Antarctica overland, died in Cambridge on 11 November 1999, aged 91.

Vivian Ernest Fuchs was born on 11 February 1908 on the Isle of Wight. He was educated at Brighton College and at St John's College, Cambridge, where he came under the influence of his tutor, James Mann Wordie, the chief scientist of Shackleton's ill-fated Imperial Trans-Antarctica Expedition of 1914–17. He joined Wordie's expedition to Franz Josef Fjord, Greenland, as an undergraduate, in the summer of 1929 and participated in the first ascent of Petermann Peak.

Having graduated in geology, Fuchs was attracted to East Africa and participated in four pre-World War II expeditions. These African expeditions yielded a wealth of valuable scientific information and numerous publications. His thesis on the tectonic geology of the Rift Valley earned him a PhD from Cambridge University and the significance of this African work was recognized by the Royal Geographical Society through the Cuthbert Peek Grant.

At the outbreak of World War II, Fuchs went with the Cambridgeshire Regiment to the Gold Coast, participated in the North-West Europe campaign, was mentioned in despatches, joined the military government in northern Germany after the war, and in 1946 was demobilized as a major.

In 1943, the British government had established bases for the covert naval "Operation Tabarin" in Graham Land (now called the Antarctic Peninsula) to safeguard Britain's interests in the Southern Ocean. In 1946, this became the Falkland Islands Dependencies Survey and, in 1947, Fuchs was offered the post of Field Commander of the Survey. In late 1947, he and his newly recruited staff arrived in the Antarctic after a hair-raising voyage in the *John Biscoe*. In March 1948, Fuchs and six others joined the four of us who were already at Stonington Island in Marguerite Bay. We were immediately impressed by the new commander, who was both practical and prepared to absorb all possible information and advice on Antarctic matters, including dog-sledging. The year's field programme (survey, geology, meteorology and biology) was efficiently worked out and base routines put into effect to the satisfaction of all concerned. Throughout the autumn and even the winter of 1948, we were in the field. During one journey, the second-known Emperor Penguin rookery was discovered. The spring and summer journeys added much new detailed information to the topographic and geological maps. I was privileged to share a small tent with Fuchs, starting a friendship which was firmly cemented over 50 years.

Fuchs was initially appointed Field Commander for one year. However, by late March 1949, the sea ice was as solid as ever and the media became aware that the ship had failed to relieve the eleven men at Stonington Island in the Antarctic; "the lost eleven"! This could have been a time of diminishing morale, but for the continual encouragement and leadership from our base commander. Although food and fuel had to be strictly rationed, there were ample sledging rations so Fuchs astutely devised a comprehensive field programme. This allowed us to make extensive additions to both the topographic and geological maps and also enabled a detailed behavioural and embryological study of the winter-breeding Emperor Penguins to be undertaken. All in all, 1949 proved to be tremendously successful in spite of some minor hardships.

Fuchs returned to England to set up the Falkland Islands Dependencies Surveys (FIDS) Scientific Bureau in London. His immediate task was to coordinate all the existing scientific results and maps for publication. This he did with the help of his scientific staff, an assistant and a typist, and the publications began to flow.

It was in a tent in the middle of George VI Sound during a four-day blizzard that preliminary plans for the "crossing of Antarctica" were sketched on scraps of paper. Not until 1953–54, after the preparation of in-depth plans for a well-organized and comprehensive scientific expedition, and considerable lobbying, was the tedious stage of fund-raising reached. Fuchs was given leave of absence from FIDS for this so he could devote his entire attention to organizing the expedition properly, raising the necessary funds and recruiting the appropriate scientists, engineers and field assistants.

Fuchs had always envisaged an expedition with

Commonwealth members. Thus he came in contact with Sir Edmund Hillary, the New Zealand conqueror of Mount Everest. New Zealand already had plans for a scientific station, Scott Base in McMurdo Sound, where the expedition would terminate.

The final plan was for the British to establish a base (Shackleton) at the head of the Weddell Sea. From this, the route to the South Pole could be reconnoitred while survey, geology and glaciology of the hinterland was being done; an advance station, South Ice, was set up for meteorological and glaciological work and to serve as a major depot for the main journey. Meanwhile, the New Zealand contingent would recce the route from McMurdo Sound to the South Pole and lay fuel and food depots to facilitate the second half of the main journey.

With a party of 19 men, a dog team and several Sno-cats, Fuchs left Shackleton on 24 November 1957 for the South Pole via South Ice. They faced horrendous weather conditions (howling blizzards and very low temperatures) and enormous crevasse fields that had to be negotiated, delaying the journey. Hillary got into the field quickly with his modified Fergusson tractors and trailers. He made unusually good progress and established the agreed depots in record time, then pressed on to the South Pole where he arrived on 4 January 1958, 15 days before Fuchs and his party. This "race for the South Pole" attracted great excitement. The two parties then joined forces for the onward journey to Scott Base which they reached on 2 March 1958, covering 2200 miles in 99 days. Shortly after his return to England, amid tumultuous acclamation for such achievements, Fuchs was knighted by the Queen "for the first crossing of Antarctica".

Always reticent about what he called "unwarranted publicity", he made his much-quoted statement to the press: "The value of exploration lies in the gaining of knowledge, not in establishing a record". That is exactly what the Trans-Antarctic Expedition (TAE) had done; it had not only made the first successful overland crossing of Antarctica, but had gained valuable scientific results and even discovered two hitherto unknown mountain ranges. In due course, all of this work was fully written up and published.

On his return from the TAE he resumed the Directorship of the FIDS (from 1962 renamed the British Antarctic Survey (BAS)) until his retirement in 1973.

Although he claimed he was a professional geologist, Fuchs always harboured a deep interest in glaciology and was one of the early members of the British Glaciological Society. With his considerable expertise in committee work, it was no surprise that he was appointed Chairman of its Council, a position he held for several years. He initiated many changes in its Constitution, especially encouraging membership by younger people. He was responsible for the appointment of Hilda Richardson, the Society's first executive secretary. When Gerald Seligman, the Society's Founder President, retired in 1963, Fuchs succeeded him, until 1966.

The more descriptive aspects of glaciology formed part of the FIDS scientific programme for some years. Glaciology was also an important part of the TAE programme and a seismic profile was shot along the entire route across Antarctica via the Pole. It was at the instigation of Fuchs that Charles Swithinbank was enticed back to England from the United States. Under the auspices of the BAS, Swithinbank was installed in the SPRI and given the brief to form a "glaciological section" that was ultimately amalgamated with the Earth Sciences Division of the Survey. This proved to be a most satisfactory manoeuvre and, since then, the BAS glaciologists have made fundamental contributions to the science, both in the field and the laboratory.

Fuchs maintained that his profession was a means to an end — exploring new places and making his contribution to science — as he had done both in East Africa and Antarctica. One had the impression he found it irksome to be confined to an office. Nevertheless, he always put his mind to the job at hand, producing extremely clear and well-written reports which were convincingly argued and logical. He became an ultra-expert scientific administrator (clearly understanding all aspects of science and their respective importance, and even finance). For this he was recognized by Fellowship of the Royal Society. He was a much sought-after and valued member of many committees and for some years was a British representative on the Scientific Committee on Antarctic Research. Sir Vivian received recognition by awards from many learned societies, particularly the Founder's Special Gold Medal from the Royal Geographical Society. Numerous universities conferred honorary degrees on him and he became president of several other international societies: the British Association for the Advancement of Science (1972), the Royal Geographical Society (1984), The Antarctic Club, The Arctic Club and The Husky Club of Great Britain.

Fuchs was often described as an "adventurer", a term he absolutely abhorred; he much preferred to be referred to as a "scientific explorer". He loved the outdoor life, whether it be sailing, water-skiing, rock-climbing or even driving his racing green MG (and later his E-type Jaguar) car at high speed.

In addition to his many scientific papers, Sir Vivian wrote three books: with Sir Edmund Hillary *The crossing of Antarctica* (1958), the official account of the first crossing of the continent; *Of ice and men* (1982), the history of the first 30 years of the FIDS and BAS, and obligatory reading for all new recruits to the Survey; and his autobiography *A time to speak* (1990), in which he revealed many of his innermost thoughts and his opinions on important matters of the day.

In 1933, he married Joyce (née Connell) who died in 1990. He remarried in 1991, Eleanor Honnywill, a former member of the TAE staff and later his personal assistant at the BAS. She survives him, together with a son and a daughter of his first marriage.

The intention has never been to turn back

These words, inscribed on the reverse of the first Fuchs Medal, presented to Sir Vivian Fuchs on his retirement from the Directorship of the British Antarctic Survey in 1973, epitomize his attitude both to life and to science. They were the very words he used at the South Pole in 1958 in dismissing Hillary's attempt to persuade him to abandon his journey across Antarctica.

Ray Adie

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International Oil and Ice Workshop, Anchorage, Alaska, USA
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14–18 April 2000
5th International Symposium on Glacier Caves and Cryokarst in Polar and High Mountain Regions, Courmayeur, Mont Blanc, Italy
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24–29 April 2000
European Geophysical Society General Assembly, Nice, France
Dr Ludwig N. Braun, Kommission für Glaziologie, Bayerische Akademie der Wissenschaften, Marstallplatz 8, D-80539 München, Germany (Tel [49](89)23031-195; Fax [49](89)230-31-100; ludwig.braun@lrz.badw-muenchen.de; http://www.copernicus.org/EGS/egsga/nice00/nice00.htm)

Glaciology-related Symposia
Energy exchange over snow and glaciers (Dieter Scherer: scherer1@ubaclu.unibas.ch; Wouter Greuell: w.greuell@phys.uu.nl)
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Ice and permafrost drilling in high mountains (Wilfried Haeberli: haeberli@gis.geogr.unizh.ch)
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Ice core climate information on the past 10 millenniums (Claus Hammer: cuh@gfy.ku.dk)
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Non-isotropic and non-hydrostatic flows in ice sheets (Kolumban Hutter: hutter@mechanik.tu-darmstadt.de)

27–29 April 2000
Iceland 2000: Modern Processes and Past Environments, Keele University, Keele, UK
A.J. Russell, School of Earth Sciences and Geography, Keele University, Keele, Staffs, ST5 5BG, UK (a.j.russell@keele.ac.uk)

29–30 April 2000
International Symposium: Modern and Ancient Ice-Marginal Landsystems, Keele University, Keele, UK
A.J. Russell or D.J.A. Evans, School of Earth Sciences and Geography, Keele University, Keele, Staffs, ST5 5BG, UK (a.j.russell@keele.ac.uk; Devans@geog.gla.ac.uk)

15–19 May 2000
Cycles of Natural Processes in the Earth's Glaciosphere, XII Glaciological Symposium, Pushchino, near Moscow, Russia
V.N. Mikhalenko, Glaciological Association, Staromonetny per. 29, 109017 Moscow, Russia (tel: [7](095)129-44-08; Fax [7](095)230-20-90; geography@glas.apc.org)

17–19 May 2000
57th Eastern Snow Conference, Snow and Ice: Properties, Processes, Problems and Prospects,Syracuse, New York, USA
M.R. Albert, Geophysical Sciences Division, USACRREL, Hanover, NH 03755-1290, USA (Tel [1](603)646-4422; Fax [1](603)646-4397; malbert@crrel.usace.army.mil; http://www.tor.ec.gc.ca/CRYSYS/esc/)

22–26 May 2000
** International Symposium on Snow, Avalanches and Impact of the Forest Cover , Innsbruck, Austria
Secretary General, International Glaciological Society, Lensfield Road, Cambridge, CB2 1ER, UK (http://www.spri.cam.ac.uk/igs/inpages.htm; http://www.magnet.at/)

28 May – 2 June 2000
ISOPE-2000, 10th International Offshore and Polar Engineering Conference and Exhibition, Seattle, Washington, USA
ISOPE-98, P.O. Box 1107, Golden, CO 80402-1107, USA (Tel [1](303)273-3673; Fax: [1](303)420-3760; meetings@isope.org)

5–8 June 2000
Ninth International Workshop on Atmospheric Icing of Structures (IWAIS), Chester, England, UK
Paul Bagg, EA Technology Ltd, Capenhurst, Chester CH1 6ES, UK (Tel [44](151)347-2467; Fax [44](151)347-2178; events@eatl.co.uk; http://www.eatl.co.uk)

12–14 June 2000
Sixth Circumpolar Symposium on Remote Sensing of Polar Environments, Yellowknife, N.W.T., Canada
NWT Center for Remote Sensing, Department of Resources, Wildlife and Economic Development GNWT, 600 5102 - 50th Avenue, Yellowknife, NWT X1A 358, Canada (Tel [1](867)920-3329; Fax [1](867)873-0221; circumpolar2000@gov.nt.ca; http://www.gov.nt.ca/RWED/rs/circumpolar2000

13–16 June 2000
IUTAM Symposium on Scaling Laws in Ice Dynamics and Ice Mechanics, Fairbanks, Alaska, USA
J.P. Dempsey, Department of Civil and Environmental Engineering, Clarkson University, Potsdam, NY 13699-5710, USA (Tel [1](315)268-6517; Fax [!](315)268-7636; john@clarkson.edu; http://www.clarkson.edu/~john/iutam_ice.html)

18–21 June, 2000
International Workshop on Permafrost Engineering, Longyearbyen, Svalbard, Norway
K.Senneset, Department of Geotechnical Engineering, NTNU, Høgskoleringen 7a, N-7491 Trondheim, Norway (Tel [47]73-59-46-02; Fax [47]73-59-46-09; kaare.senneset@bygg.ntnu.no

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** International Symposium on Sea Ice and its Interactions with the Ocean, Atmosphere and Biosphere, Fairbanks, Alaska, USA
Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK (http://www.spri.cam.ac.uk/igs/akpages.htm)

19–22 June 2000
4th International Conference on Snow Engineering, Trondheim, Norway
SEVU-Congress Department, Norwegian University of Science and Technology (Tel [47]73-59-52-47; Fax [47]73-59-51-50; snoweng@sevu.ntnu.no; http://www.ntnu.no/sevu/)

26–30 June 2000
Interpraevent 2000, Durable Protection from Floodings, Debris Flow and Avalanches, Villach, Austria
Interpraevent 2000, Postfach 117, A-9020 Klagenfurt, Austria (Tel [43](463)536-31818; Fax [43](463)536-31828; interpraevent@ktn.gv.at; http://www.ktn.gv.at/akl/abt18/interpraevent.htm)

2–5 July, 2000
2nd International Conference on Contaminants in Freezing Ground, Fitzwilliam College, Cambridge, UK
Geotechnical Science Laboratories, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario K1S 5B6, Canada (Fax [1](613)260-3164; ConferenceSecretariat@freezingground.org; www.freezingground.org/conf2000)

17–19 July 2000
The Extremes of the Extremes: International Symposium on Extraordinary Floods, Reykjavík, Iceland
Extremes2000 Conference Secretariat, Helga P. Finnsdóttir, National Energy Authority, Grensásvegi 9, IS-108 Reykjavík, Iceland (etremes2000@os.is; www.os.is/vatnam/extremes2000): Iceland Conferences, Bryndís E. Jóhannsdóttir, Lágmúli 4, IS-108 Reykjavík, Iceland (Tel [354]562-3300; Fax [354]562-3345; congrex@itb.is; bryndis@itb.is)

21–25 August 2000
* Second International Conference on Mars Polar Science and Exploration, Reykjavík, Iceland
T. Thorsteinsson, Alfred Wegener Institute for Polar and Marine Research, P.O. Box 12 01 61, D-27515 Bremerhaven, Germany (Tel [49](471)4831-363 Fax [49](471)4831-149; tthorste@awi-bremerhaven. de; http://www.lpi.usra.edu/meetings/polar2000/)

11–13 September 2000
International Symposium on Ground Freezing and Frost Action in Soils, Université Catholique de Louvain, Louvain-la-Neuve, Belgium
J.-F. Thimus, Unité de Génie Civil, Université Catholique de Louvain, Louvain-la-Neuve, Belgium (Tel [32](10)472-122; Fax [32](10)472-179; isgf2000@gc.ucl.ac.be)

13–15 September 2000
International Workshop on Debris-Covered Glaciers, University of Washington, Seattle, Washington, USA
M. Nakawo, Institute for Hydrospheric-Atmospheric Sciences, Nagoya University, Furo-cho Chikusa-ku, Nagoya 464-8601, Japan (Tel [81](52)789-3477; Fax [81](52)789-3436; nakawo@ihas.nagoya-u.ac.jp; http://snowman.ihas.nagoya-u.ac.jp/Research/DebrisWS/1stcclr.html)

2001

4–8 June 2001
** International Symposium on Remote Sensing in Glaciology, College Park, Maryland, USA
Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK (www.spri.cam.ac.uk/igs/home.htm)

June 2001
* Heinrich Event 1: Causes, Effects, Signatures and Correlations, University of Ulster, Northern Ireland, UK
J. Knight, School of Environmental Studies, University of Ulster, Coleraine, Co Londonderry BT52 1SA, Northern Ireland, UK (Tel [44](28)7032-3179; Fax [44](28)7032-4911; j.knight@ulst.ac.uk)

23–27 July 2001
Physics and Chemistry of Ice, University of Kent, Canterbury, England
J. Dore & V. Nield (Fax [44](1227)827558; pcice@ukc.ac.uk; http://kiwi.ukc.ac.uk/physics/events.html)

19–23 August 2001
** International Symposium on Ice Cores and Climate, Kangerlussuag, Greenland
Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, UK (www.spri.cam.ac.uk/igs/home.htm)

2002

August/September 2002
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Robert G. Bingham, Department of Geographic & Topographic Science, University of Glasgow. Glasgow G12 8QQ, Scotland, U.K. (Tel [44](141)330-4445; Fax [44](141)330-4894; rbingham@geog.gla.ac.uk)

Panagiotis Christakos, 46A Devon Road, Leeds LS2 9BA, England, U.K. (Tel [44](113)233-6638; Fax [44](113)233-3308; panos@freeuk.com)

Michael Dolan, 81 Wessenden Head Road, Meltham, Huddersfield HD7 3HR, England, U.K. (Tel [44](1484)341-425; Fax [44](7957)917-860; michael_dolan_uk@hotmail.com)

Gwenn E. Flowers, Earth & Ocean Sciences (Geophysics), University of British Columbia, 2219-129 Main Mall, Vancouver, British Columbia V6T 1Z4, Canada (Tel [1](604)822-2267: Fax [1](604)822-6047; flowers@geop.ubc.ca)

Andrew Ford, Department of Geography, University of Southampton, Highfield, Southampton SO17 1BJ, England, U.K. (Tel [44](2380)592-215; Fax [44](2380)593-295; andrew.ford@soton.ac.uk)

Andrew M. Fox, Glaciology Group, Department of Geography, University of Cambridge, Downing Place, Cambridge CB2 3EN, England, U.K. (Tel [44](1223)766-563; Fax [44](1223)506-194; amf37@hermes.cam.ac.uk)

Arthur M. Greene, Lamont-Doherty Earth Observatory, Geochemistry Annex, Columbia University, Route 9W, P.O. Box 1000, Palisades, New York 10964, U.S.A. (Tel [1](914)365-8906; Fax [1](914)365-8155; amg@ldeo.columbia.edu)

Akihiro Hachikubo, Laboratory of Physics, Department of Civil Engineering, Kitami Institute of Technology, 165 Koen-cho, Kitami 090-8507, Japan (Tel [81](157)26-9522; Fax [81](157)25-8772; hachi@snow2.civil.kitami-it.ac.jp)

John Harrison, Department of Geography, School of Environmental & Life Sciences, University of Salford, Peel Building, Salford Crescent, Manchester, M5 4WT, England, U.K. (Tel [44](161)295-5000; Fax [44](161)295-5015; j.harrison6@salford.ac.uk)

Hal Hartman, 0186 Old Pond Way, Snowmass, CO 81654, U.S.A. (Tel [1](970)923-6695; Fax [1](970)923-0687; halvin@earthlink.net)

Alun Hubbard, Earth & Ocean Sciences (Geophysics), University of British Columbia, 129, 2219 Main Mall, Vancouver, British Columbia V6T 1Z4, Canada (Tel [1](604)822-3602; Fax [1](604)822-6047; ahubbard@eos.ubc.ca)

David J. Hyder, Astrophysics Research Institute, 12 Quays House, Egerton Wharf, Birkenhead CH41 1LD, England, U.K. (Tel [44](151)231-2900; Fax [44](151)231-2921; djh@astro.livjm.ac.uk)

Phillip S. Larson, Department of Geology, University of Minnesota at Duluth, 10 University Drive, Duluth, MN 55812, U.S.A. (Tel [1](218)726-7238; Fax [1](218)726-8275; plarson2@d.umn.edu)

Michael Lehning, Swiss Federal Institute for Snow and Avalanche Research (SFISAR), Flüelastrasse 11, CH-7260 Davos Dorf, Switzerland (Tel [41](81)417-0158; Fax [41](81)417-0110; lehning@slf.ch)

Gwendolyn Leysinger, Versuchsanstalt für Wasserbau Hydrologie und Glaziologie (VAW), ETH-Zentrum, Gloriastrasse 37/39, CH-8092 Zürich,Switzerland (Tel [41](1); Fax [41](1)252-0147; leysin@vaw.baum.ethz.ch)

Kelly MacGregor, Department of Earth Sciences, University of California - Santa Cruz, Applied Sciences Building, Santa Cruz, CA 95064, U.S.A. (Tel [1](831)459-2551; Fax [1](831)459-3074; kelly@es.ucsc.edu)

Roy T. Middleton, Environmental Science Department, Institute of Environmental & Natural Sciences, Lancaster University, Lancaster LA1 4YQ, England, U.K. (Tel [44](1524)65201x3534; Fax [44](1524)593-985; roy.middleton@lancaster.ac.uk)

Andrew Mitchell, Institute of Geography & Earth Sciences, University of Wales, Centre for Glaciology, Aberystwyth, Ceredigion, Dyfed, SY23 3DB, Wales, U.K. (Tel [44](1970)621-859; Fax [44](1970)622-659; acm95@aber.ac.uk)

Hamish Pritchard, School of Geography, University of Leeds, Leeds, LS2 9JT, U.K. (Tel [44](113)243-6638; Fax [44](113)233-3308; h.pritchard@geog.leeds.ac.uk)

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Christoph Schneider, Institut für Physische Geographie, Universität Freiburg, Werderring 4, D-79085 Freiburg, Germany (Tel [49](761)203-3548; Fax [49](761)203-3596; chri@ipg.uni-freiburg.de)

Owen C. Turpin, Geography Department, Sheffield Centre for Earth Observation Science, University of Sheffield, Winter Street, Sheffield S10 2TN, U.K. (Tel [44](114)222-7971; Fax [44](114)279-7912; o.c.turpin@sheffield.ac.uk)

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All enquiries about the International Glaciological Society should be addressed to:
Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, England
Tel: +44 (1223) 355974 Fax: +44 (1223) 336543
E-mail: Int_Glaciol_Soc@compuserve.com
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