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CONTENTS

2 **Recent Work**
2 *ITALY*
2 Alpine glaciers
7 Antarctica
8 Glacial geology and geomorphology
9 Frozen ground
10 Snow and avalanches
11 ABBREVIATIONS USED IN REPORTS
12 **International Glaciological Society**
12 Seligman Crystal Award
14 Annals of Glaciology
17 Journal of Glaciology
18 Zürich meeting, 2nd Circular
22 **Future Meetings (of other organizations)**
22 EISMINT/EPICA Symposium, 1st Circular
24 IUGG, Sea-Level Change
25 AGU, Glaciers and Ice Sheets
25 56th Annual Eastern Snow Conference
26 **Glaciological Diary**
28 **New Members**

COVER PICTURE: Natural ice stalagmites in a tunnel at Kurobe Canyon, Toyama. Katutosi Tusima reports that giant single crystals of ice (diameter 100 mm, length 300 mm) have also been grown artificially as stalamites in the laboratory. (Photograph courtesty of The Kansai Electric Power Co. Ltd.).

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

ITALY

(For abbreviations used see pages 11–12)

ALPINE GLACIERS

Monitoring of Italian glaciers

(Comitato Glaciologico Italiano, Torino)

Since 1925, the Italian Glaciological Committee (CGI) has been monitoring Italian glaciers. Systematic measurements of frontal variations are made annually for many glaciers in the Italian Alps and one glacier in the Apennines. The results are reported in *Geografia Fisica e Dinámica Quaternaria,* the *Bollettino del Comitato Glaciologico Italiano.* About 30 years ago, mass balance observations were also initiated on several glaciers.

When monitoring began glaciers were at the end of an advancing phase. Since then there has been a general retreat, apart from a minor re-advance from the 1960s to the early 1980s. In 1980, 88% of the glaciers monitored were advancing, but since 1989, on average, 92% of the glaciers have been retreating.

For the balance year 1995/96, of the 127 glaciers measured, 91% were retreating, 9 were advancing and 6 were stationary. There were some exceptional retreats in 1996 of up to 300 m where glacier fronts were affected by ice falls (e.g. Disgrazia glacier, Central Alps). This compares with the maximum retreats for valley glacier fronts of the order of 20 to 35 m.

Geologic hazards in glacial and periglacial environments, NW Italy

(G.Mortara, CNR-IRPI/CGI; M.Chiarle, G. Bottino, PTDIGET)

The catastrophic rockfall/ice-avalanche on Brenva glacier, Mont Blanc, 18 January 1997 and, a few days later, the ice-avalanche from the Grandes Jorasses hanging glacier, have highlighted the problem of instability in high mountain environments. A study has been started using historical analysis, aerial photographs, and characterization of the geotechnical properties of materials, particularly glacial deposits. The information will be used to model risk scenarios for selected sites.

The southern flank of Mont Blanc is particularly suitable for this kind of investigation because of the variety of phenomena that occur and the amount of available information. An historical analysis, not yet completed, found that more than one hundred events have occurred in the last three centuries. The analysis of a remarkable series of aerial photographs of the glaciers of Mont Blanc, covering the last 45 years, has been started. From this analysis, a catalogue of aerial photographs of the Miage glacier has been obtained.

Glacier monitoring and database, Aosta Valley

(M.Pasqualotto, RAVA; D. Bertolo, F. Pollicini, CGI)

A data-collection and monitoring program for glaciers in the Aosta valley is being undertaken by the Mountain Basin and Land Management Department of the Regione Autonoma Valle d'Aosta (Italy) Administration. This is the most glacierised basin in the Italian Alps with about 5% of its surface glacier-covered with more than 200 systems distributed over 3260 km^2. All available data (historical, physical, etc) will be collected into a database. This will be regularly updated by surveys, including remote-sensing and field investigations. The data will be analysed for information on past and present glacier dynamics, such as glacier mass and ELA variations, and periglacial environments. They will be collected according to WGI standards and maintained in electronic files and a GIS, for research and engineering purposes. The first results are expected in early 1999.

Ciardoney glacier mass balance

(L. Mercalli, G. Mortara, CGI/SMS)

In 1992, a mass-balance survey was started on Ciardoney glacier, a small glacier (0.8 km^2) in the Gran Paradiso range, with an elevation range of 2850–3140 m. The activity is supported by AEM (Turin hydroelectric board) and carried out in cooperation with LGGE. The mean annual 1992–1997 mass balance was –0.68 m w.e.

Rutor glacier volume variations 1954–91 and geo-radar survey

(G.C. Rossi, ENEL/CGI; A. Tamburini, ISMES; A. Lozej, DSTUM)

Ice surface and volume variations of Rutor glacier for 1954–91 have been evaluated for hydrological purposes, aided by data from a gauging station that has operated since 1937. Regular grid DTMs of the surface topography of the glacier, at a resolution of 50 m, have been obtained by aerial photogrammetry at intervals of about 20 years (1954, 1975, 1991). The results show an increase in the ice volume of about 13 x 10^6 m^3 for 1954–75 and a slightly greater loss from 1975–91.

The geo-radar survey used a GSSI SIR 2 system with a RADARTEAM SUBECHO 40 antenna (centre frequency 35 MHz), mounted on a slide. The antenna was geo-referenced by GPS. The survey covered the accessible parts of the surface of the glacier with 15 tracks of total length about 20 km. With an EM wave velocity of 16 cm ns^{-1}, the ice thickness was up to 50 m in the upper part of the glacier, 60 m in the branch lying on the right side of the Vedettes du Rutor and 30 m in the branch to the left. The maximum ice thickness of 70 m occurs in the terminus of the glacier.

Lys glacier mass balance

(M. Motta, CGI; with ENEL-CRIS/DSTUT)

Most of the ablation of Lys glacier appears to be due to solar radiation, influenced by exposure, according to maps of insolation and the moraine cover. A simple experimental plot, of the type normally used in agro-meteorology, though smaller, was used to study ablation on the tongue. Meltwater was collected in side channels cut into the ice and in drain pipes. The impermeability of the ice impeded losses due to infiltration. The values obtained were compared with ablation measured along a line of small stakes inserted beside the plot. The difference between the ice mass lost by ablation and the water mass collected corresponds to the amount of water lost by evaporation and sublimation. The meltwater flow was also compared with the ablation calculated from an energy-balance model using radiation data from a pyranometer beside the plot, with allowances for diurnal albedo variations. The estimated ablation values were comparable in magnitude and accuracy to the weekly values provided by conventional ablation stakes. The decidedly higher values recorded by these stakes during rainfall, compared with those estimated from the plot (which only operated in fine weather), provide an indication of the significance of rain as one factor responsible for the ablation of Lys glacier.

Colle del Lys ice-core drilling,

(V.Maggi, DSATUM; GC. Rossi, ENEL, C. Smiraglia, DSTUM; with IUP)

A new ice core was drilled, in the spring of 1996, at Colle del Lys (4250 m a.s.l.) on Monte Rosa in the Italian Alps. The objective was to obtain a record of the natural and anthropogenic effects on climate on a regional, European scale. The following analyses have been made: stable-isotope content, providing a record of past temperatures; visual stratigraphy and physical properties; chemistry for sulphates and nitrates; alpha and beta activity; electrical conductivity; and mineral dust content. Three major reference horizons have been identified and used for initial dating: a major Saharan dust deposition event in 1977 from the visual and dust particle records; the Northern Hemisphere peak of atmospheric tritium levels in 1963 associated with the thermonuclear bomb tests; and the 1986 Chernobyl nuclide release in the record of alpha and beta activity. Radiometric analyses were carried out by D. Capra (CISE) on 0.5 m core cutting increments. Radionuclides were determined using a scintillation method that separated alpha- from the beta-emitting radionuclides. Samples of 400 mL of melted ice were acidified and concentrated to 5 mL. A 15 mL scintillation cocktail was added to the samples which were measured with a low-background liquid-scintillation counter. The alpha-emitting isotopes are almost completely ^{210}Po, which derives from ^{210}Pb decay. The activity values (counts min^{-1}) were transformed into radionuclide concentration ($Bq\ L^{-1}$). The alpha-radioactivity signal has a seasonal pattern and a clear peak attributed to Chernobyl fallout.

Together with dust, visual stratigraphy and stable isotope content, $\delta^{18}O$ and δD, have been used to determine the depth–age relationship of the core. A strong seasonal variability has been found, with snow deposited throughout the year and much higher pollutant levels in summer months. The mean accumulation rate is 1.6 m w.e. a^{-1}, with a relatively high degree of variability. Acidity increased until the late 1970s and then decreased to the present. Although the time record is not as extensive as for polar ice cores, the Colle del Lys core provides a valuable record of regional and recent anthropogenic influences on climate change, with particular emphasis on apportionment of regional sources during the last 50 years. This is of particular importance in the Alps, with a high incidence of anthropogenic pollution.

Lys glacier accumulation and surface velocity rates

(G.C. Rossi, ENEL/CGI; C. Smiraglia, DSTUM/CGI)

In July 1996, taking advantage of an ice-core drilling campaign on Colle del Lys, a geodetic network of 20 stakes was laid out in the accumulation area of Lys glacier to evaluate accumulation rates and surface ice velocities. The stake positions were measured using differential GPS at time intervals of about 6 months.

From July 1996– September 1997 stake displacements ranged from 28 m in the centre to 3 m at the Colle del Lys and Colle Vincent saddles, melt ranged from –0.99 m to few cm. and net snow accumulation at the borehole site was 4.07 m (ca. 1.77 m w.e.).

Lys glacier mapping and geo-radar

(G.C. Rossi, ENEL/CGI; A. Frassoni, A. Tamburini, ISMES; I. Tabacco, A. Lozej, DSTUM)

During 1994, a geodetic network was set up in the Lys glacier basin as control for an aerial-photogrammetric survey in the late fall of the same year. The network was based on 9 datum points whose co-ordinates were determined by GPS. A Wild f/152.93 camera was used with an exposure time of 1/1000 s. The area was covered by two flight tracks flown at an absolute elevation of 5000–6000 m. Processing resulted in a map at a scale of 1:5000. The total glacier surface area of 11.375 km^2 can be compared with the 1980 estimate based on CTR 1:10,000 maps giving a surface area of 11.826 km^2.

In April 1996, a radar survey was carried out on Lys glacier to determine the bedrock topography, evaluate the total ice volume and identify a suitable site for an ice-drilling experiment in the same year. The largest ice thickness measured was 120 m (at an EM wave velocity of 16 cm ns^{-1}), and at the drilling site it was estimated to be approximately 90 m. This was in good agreement with the actual drilling that reached a depth of 80 m to dirty ice, with the bedrock depth estimated to be at approximately 85 m.

Inner structure, ice structure and dynamics of Western Alpine glaciers

(A. Biancotti, L. Motta, M. Motta, DSTUT/CGI)

Three glaciers were compared from 1984–97: the Jumeaux glacier, a conical glacier entirely situated below the snowline and avalanche-fed, and two large Alpine glaciers, the Lys and Tsa de Tsan. Examination of the structure of Jumeaux glacier, from the rocky substrate to the surface, has shown it is composed mainly of firn, nearly transformed into infiltration ice, with interbeddings of conglomerate ice derived from the collapse of séracs forming at the tip of the cone. The presence of recrystallization ice, crevasses and overthrust structures shows it is a true glacier, despite its small extent. The distribution of recrystallization ice, and direct observation, indicate ice layers in the abrasion zone move like thin sheets sliding over each other. An avalanche-dynamic model, using parameters derived from direct observation of landslide debris, was used to examine the supply processes of the glacier.

Lys glacier consists of several branches feeding a tongue that flows along a gently sloping valley. It is an Alpine glacier with a wet-base flow regime, apart from a cold base in its upper part. The inner structure is formed of superposed layers several metres thick, fed by regenerated ice that has accumulated at the base of the séracs of the upper branches of the glacier. At the base of the terminal scarp, this pile of layers rests on a 0.1–0.4 m thick bed of sand with very thin and irregular laminae parallel to the stratification and evidently glaciotectonic. Below this bed, there is granoblastic ice that has large crystals and is always devoid of diamictons. This also constitutes the substrate of the present moraine fronts formed during the most recent advance (1985–86).

The nearby Tsa de Tsan glacier, of similar size and feeding pattern (its terminal tongue is also composed primarily of regenerated ice formed at the base of a sérac), has a much simpler structure with no superposed layers and a debris substrate. The peculiar structure of the Lys glacier can probably be attributed to its cyclical tendency to have rapid advances, very similar to surge episodes, in years with high summer temperatures.

Glaciers of the Western Alps as indicators of climate change

(A. Biancotti, L. Motta, M. Motta, DSTUT/CGI; E. Biagini, DSTUG)

Recent variations of glaciers in the Western Alps have been studied using historical, cartographic and iconographic sources, chiefly from records of the CGI. The CGI photo collection provides a broad documentation of Italian glaciers. Rutor glacier, in Aosta valley, has been selected for a comparison between glaciological measurements and photographs. Differences between the changes in its front and in the AAR, revealed by the historical photographs, can be used to measure the glacier's inertia in response to climate change. It is further evidence of the usefulness of glaciological data as climatic indicators, provided they are analysed with due attention to the specific dynamic and geomorphological characteristics of the glacier in question. Another valuable climatic indicator is the extinction of small glaciers, documented both by photos and annual measurements by the CGI since 1925. The marked reduction in the extent and volume of the glaciers in the Conca del Dragone (Valtournanche, Aosta Valley), with total extinction in all but one case, has been documented by glacier surveys during the past 64 years.

Glacier monitoring, Lombardy

(A. Galluccio, G. Mainardi, E. Congiu, L. Bonardi, L. Arzuffi, A.C. Galluccio, S. Ratti, S. D'Adda, G. Catasta, SGL)

Since 1990 the SGL has been monitoring annually the 389 glacial units in Lombardy, northern Italy. Of these, 308 are glaciers, whilst the remaining 81 form a heterogeneous group of "minor glacial formations". Late-summer monitoring includes 70% of the total on average; with a complete rotation after 2 years. The research is by photographic survey from fixed stations, computerised mapping and measurements of snout variations with reference to fixed points. Based on the variable percentage sampled each year, the annual cartographic survey provides both the total surface area and the part of the glaciers covered by old snow. Final reports include notes on the meteorology, particularly snowfall, of the previous accumulation year, and on the phase of summer ablation at a regional level. After many years of uninterrupted general retreat, in 1997 8% of the glaciers in Lombardy were advancing, whilst the percentage of glaciers retreating had decreased from over 60% in 1991 to 47% in 1997.

Glacier mass balance, Lombardy Alps

(C. Smiraglia and others, DSTUM; with CSC-CAI/CGI)

Mass balance studies have been carried out on the glaciers of Lombardy since 1986/87. The direct glaciological method was first applied to determine the net annual balance of Sforzellina glacier, a small (0.41 km^2) northwestern facing cirque glacier on the western side of the Ortles–Cevedale group. The net balance was negative every year with an annual mean loss of –0.818 m w.e.

Gradually the mass balance network has been extended and today covers seven glaciers; three valley glaciers, including Forni glacier, the widest in the Italian Alps; and four mountain glaciers. For 1996/97, all balances were negative with a mean loss of –0.373 m w.e., excluding Forni glacier, for which only the ablation zone mass balance was calculated to be –2.582 m w.e. The ELA varied from 2777 m for Ventina glacier to 3189 m for Fellaria glacier, with a mean of 2985 m.

Accumulation–ablation dynamics, Monte Pasquale, Ortles–Cevedale

(G.Cola, V. Paneri, A.C.Galluccio, F. Righetti, A. Galluccio, SGL)

The northwest ice wall of Monte Pasquale, Ortles–Cevedale, Valfurva, Italy (3552 m), has been used to study the accumulation–ablation dynamics of Alpine ice walls at medium altitudes (under 4000 m). Investigations from July 1995–March 1998, have involved field surveys, including trenches and stakes. The wall has also been monitored by telescope. The results seem to confirm that these ice walls generally behave differently from glaciers. These differences relate to the following: a) ice forms rapidly on walls (within days or months) and is "warm" or temperate; b) the mass balance of the wall largely depends on ablation, especially in summer, and on the date of its first appearance (its development in June is a crucial aspect); c) accumulation, which is less important, has only been observed in summer, late spring or early autumn, and only under non-extreme thermal-wind conditions. There is no supply to the wall, except for rare cases, in winter; d) in many cases even a single meteorological event can be important for both accumulation and ablation; e) ice thicknesses are small (from a few to dozens of centimetres). The ice wall therefore behaves like a "summer" glacial element. It is not certain if the dynamic features of the northwest wall of Monte Pasquale that have been identified can be observed on all Alpine glacial slopes, especially those at altitudes greater than 4000 m, which are probably formed by "cold" ice.

Response of treeline and glaciers to climate change, Central Alps

(L. Folladori, DSATUM)

A method of evaluating the past and present treeline and outlining its recent variations has been set up and tested in selected, nearly undisturbed areas of the Central Italian Alps; particularly, at two sites close to Ventina and Forni glaciers, Valtellina. Possible evidence of climate change is tree colonisation of proglacial areas after glacier retreat. The research is based on a past and present treeline survey (survey species are *Larix decidua*, *Pinus cembra* and *Picea excelsa*), dendrochronology, age-structure analysis, growth form and vertical growth curves, reproduction capacity of trees, and the past and present ELA rise. The aim is the contemporaneous investigation of any evidence of climate change: glacier dynamics, variations of the ELA, treeline fluctuations, variations of tree growth form, and tree colonis-ation of proglacial areas. At the same time this will provide important information about climatic variations from the Little Ice Age (LIA) to the present. The dataset will be used to estimate future ice retreat and treeline rise caused by anticipated and regional warming in the next decade/ century.

Mandrone glacier, Adamello–Presanella Group, mapping and geo-radar

(G.C. Rossi, ENEL/CGI; A. Frassoni, A. Tamburini, ISMES)

In summer 1997, a geodetic network was set up as control for an aerial photogrammetric survey in September. It includes 31 datum points, with co-ordinates determined by GPS measurements.

The photos, taken along four flight tracks, have a scale of about 1:26,000 and cover all glaciers of the Adamello–Presanella Group. The cartographic restitution of Mandrone glacier was made by trilateration between 4 official datum points (IGM95) and 27 datum points of the local net, resulting in a high resolution DTM (30 x 30 m in the more regular areas and 10 x 10 m in the steeper areas). The final digital map was at a scale of 1:5000. Mandrone glacier has a broad plateau in the accumulation zone, named Pian di Neve, from which different ice streams depart and where the surface topography varies year by year. The same geodetic network was used to provide the restitution of previous surveys carried out by different agencies about every 10 years, such as in 1973, 1983 and 1991.

Comparison of the DTMs shows that for 1973–97 there was a reduction in the ice surface from 18.354 to 17.661 km^2, and a volume variation of –216.3 million m^3, of which 143.2 million m^3 came during 1991–97.

In summer 1997 and March 1998, a radar survey was carried out on Mandrone glacier to determine the bedrock topography and evaluate the total water reservoir volume. The survey was performed using a GSSI device controlled by a Mod. SR 4800 unit and a SIR 2 digital recording unit. In inaccessible areas of the glacier the device, equipped with a Mod. 3112 - 80 MHz 6 ns antenna, was transported by helicopter. In the accessible areas a more accurate survey was carried out using the same device, but equipped with a RADARTEAM SUB-ECHO 40 antenna with a frequency of 35 MHz, mounted on a sled. The antenna was geo-referenced by GPS.

The survey, with a total track length of over 70 km, covered all the glacier, obtaining good resolution of the bedrock topography. The morphological structure appears to be a sequence of glacial cirques elongated along the talweg. The maximum ice thickness is about 240 m (at an EM wave velocity of 16 cm ns^{-1}) at the end of the Pian di Neve; in good agreement with the seismic survey in 1959. The present total ice volume is approximately 870 million m^3.

Mass balance of Caresèr glacier, Ortles–Ceverdale Group, Central Alps

(G. Zanon, DGUP/CGI)

Caresèr glacier, in the Noce–Adige basin, is a mountain glacier, generally south-facing, with a surface area of 4 km^2 and a vertical range of 2860–3320 m a.s.l. The glacial stream enters a reservoir managed by ENEL. The mass balance has been estimated by direct glaciological measurements at fixed dates. For the entire period of 30 years from 1966/67 to 1995/96, a mean specific annual balance of –0.670 m w.e. was measured, with a mean value for the ELA of 3238 m (3094 m at zero balance, with an AAR slightly more than 50%). The research on mass balance is integrated periodically, and the relative trends confirmed, by comparison with aerial surveys carried out in 1967, 1980, 1990 and 1997. Digital models of the surface of the glacier were compared with the topographic situations for 1967–80, 1980–90, and 1967–90, and as many thematic maps at a scale of 1:5000 were also prepared. The latest comparison for 1990–97 is currently being prepared.

Behaviour of glaciers in the Breonie, Aurine and Pusteresi Groups, Eastern Alps, from Landsat TM images

(R. Serandrei Barbero, R. Rabagliati, I. Binaghi, A. Rampini, CNR–ISDGM)

Variations of about 100 of the more than 1000 glaciers in the Italian Alps are measured annually, with mass balance determined for a few. These field measurements only deal with larger glaciers considered to be more significant for the hydrological balance. However, nothing is known about fluctuations in all of the remaining glaciers. Analysis of Landsat image 192/27, covering the Eastern Alps, shows expansion and retreat in the 1980s based on surface area. As all measurements use the same remote-sensing technique, valid comparisons can be made. It throws light on the behaviour of smaller glaciers, which, although numerous, generally escape in-situ investigations and have modes and response times very different from the larger glaciers observed annually. Various procedures have been tested for integrating multi-source data for identifying glaciers; all are based on decision-making processes that combine partial results obtained in various pre-classification steps. The method was applied to Landsat TM bands 1, 3 and 5 and is incorporated into a user-friendly system that provides an easy, manageable and controllable tool for images analysis. The synoptic and repeated analysis of large areas using the same acquisition system reveals the behaviour of Alpine glaciers that are systematically excluded from annual field observations.

Mass balance Vedretta Pendente (Hangenderferner)

(G.L. Franchi, G.C. Rossi, CGI)

The Vedretta Pendente (Hangenderferner) is a small glacier of the Val Ridanna, Adige–Eisarck basin, next to the broader Austrian glaciers of the Stubai valley. The net mass balance was evaluated using a network of 20 snow stakes, measured at a fixed date related to a hydrological year of 1 October to 30 September.

The 1:10,000 scale technical maps of the Provincia Autonoma di Bolzano were digitised and the geographical information transferred into an ARC/ INFO GIS for accurate evaluation of the areas and of their elevation distribution. The net mass balance for 1995/96 was –0.477 m w.e., corresponding to a loss of 602,000 m^3, from a surface area of 126 ha and an ELA of 2940 m. This compares to the 1996/97 value of the net mass balance of +0.027 m w.e., corresponding to a volume gain of 34,000 m^3, with an ELA of 2780 m.

Mass balance of Weissbrunnferner (Fontana Bianca glacier), Eastern Alps

(G. Kaser, IGUI/CGI; M. Munari, C. Oberschmied, PAB–UI)

The Weissbrunnferner (Fontana Bianca glacier) is a small (0.66 km^2) east- facing glacier on the eastern side of the Ortles–Cevedale group. Mass balance studies have been carried out since 1983/84, with the exception of 1988/89–1989/90. The direct glaciological method has been applied to determine the winter balance and the annual balance. With the exception of 1983/84, there was a mean annual mass loss of –0.564 m w.e. Apart from a similar mass loss, there is little correlation with the mass-balance series of the neighbouring and south-facing Caresèr glacier. This leads to the conclusion that the continuous loss of mass is a result of low winter accumulation.

Reconstruction of former glacier extents, mapping of neighbouring permafrost features, and the analysis of climate data are still in progress. The research contributes to the study of climate variations in the southern Alps. It also benefits the hydropower company that uses glacial runoff in the Gruensee/Lago Verde, as 20% of its catchment area is covered by Weissbrunnferner and its tributaries.

Bolzano glacier register

(PAB–UI)

The glacier register for the province of Bolzano was last updated in 1980. The state of the glaciers in 1997, and favourable weather conditions, allowed a new series of measurements to be made during special observation flights. These were done in collaboration with the Institute of Meteorology and Geophysics, University of Innsbruck (M. Kuhn), to obtain data and information that can be integrated with other data already available for nearby glaciers.

Calderone glacier variations, central Appennines

(M. Pecci, ISPESL/CGI; C. Smiraglia, DSTUM/CGI)

The study of Calderone glacier, the southernmost glacier in Italy and Europe, restarted in 1994 after a break of about 3 years. Calderone glacier is unusual both because of its location, confined in a deep mountain valley with steep rock walls, and its internal dynamics, as it no longer shows movement along its borders and in its frontal area. Annual observations every summer, measure snow thickness deposited during the cold season and ablation. In the 1990s, multidisciplinary research also evaluated the role of the glacier as an indicator of the effects of human activities and of regional and global change. Data from the last three years (1995–97) have been collected in a GIS, which has allowed computation of the glacier mass balance. Preliminary results show a positive balance for 1995 and 1996 and a strong deficit for 1997. The research is still in progress and includes field activities and the collection of available images and maps. The analysis has been performed using a GIS, both for geo-reference, mainly from recent topographic maps, and for the reconstruction of glacier variations during the last two centuries from historic documents and old maps. Variations in area, volume and thickness since the end of the Little Ice Age have been evaluated. The results show an increasing rate of recession in the last two centuries, with a total reduction of about 60 % in surface area and 35 % in thickness.

ANTARCTICA

Glaciological studies in Antarctica

(G. Orombelli, PNRA)

Beginning in 1993, the project "Glaciology and Palaeoclimate" has been active within the framework of the Italian Antarctic Research Programme. Research activities concentrate on northern Victoria Land and, more generally, on the Pacific sector of the East Antarctic ice sheet. Shallow ice coring, up to 100 m deep, has been performed, from which palaeoclimatic and palaeoenvironmental records covering the last 600 years have been extracted (major ions, organic acids, trace elements, atmospheric dust, volcanic events, electrical conductivity, $\delta^{18}O$, δD, tritium). Seasonal signals, volcanic events and tritium peaks have been used for dating. The mean annual accumulation rate and its variability in the past have been used to evaluate the flux of chemical compounds. A slight increase in the annual means of $\delta^{18}O$ from –35 to –33‰ has been observed in the 20th century, accompanied by a decrease of the annual mean accumulation rate in the first half of this century, and a very slight increase in the second half. A prominent peak of dust particles has been observed in late 1930s, which correlates well with a period of drought in the Southern Hemisphere.

Mass-balance evaluations have been performed, both on small local glaciers with traditional methods and over large ice-drainage systems, estimating ice fluxes at the grounding lines and snow accumulation. The velocity of ice streams and ice shelves has been measured by GPS surveys and by the comparison of satellite images, as well as changes in the extent of ice shelves and iceberg discharge. Within the framework of EPICA, a RES survey was carried out to select the site for the deep drilling at Dome C, together with the establishment of a strain net and a topographical survey of the dome. A preliminary traverse to Talos Dome has been accomplished according to the plans of ITASE.

Glacial geomorphological studies and geomorphological and glaciological surveys have been carried out to produce 1:250,000 maps on a topographical base produced using satellite images. The first map, covering the Mount Melbourne Quadrangle, was published in 1997.

Ice-fronts and icebergs, Oates and George V Coasts, 1912–96

(M. Frezzotti, A. Cimbelli, ENEA; J. Ferrigno, USGS)

Change in ice fronts may be a sensitive indicator of regional climate change in Antarctica. We have studied the western Oates Coast, from Cape Kinsey to Cape Hudson and the entire George V Coast, from Cape Hudson to Point Alden. The glaciers here drain part of the Dome Charlie and Talos Dome areas (640,000 km^2). A comparison between various documents, dated several years apart, has given an estimate of the surface ice discharge, the ice-front fluctuation and the iceberg-calving flux during the last 50 years. The ice-front discharges here have been estimated at approximately 90 ±12 $km^3\ a^{-1}$ in 1989–91, of which 8.5 $km^3\ a^{-1}$ is from the western Oates Coast and 82 $km^3\ a^{-1}$ is from the George V Coast. From 1962/63–1973/74, the floating glaciers underwent a net reduction that continued from 1973/74–1989/91. By contrast, from 1989/91–1996 the area of floating glaciers increased. The NinnisGlacier Tongue and the western part of Cook Ice Shelf underwent a significant retreat after 1980 and 1947 respectively. Satellite-image analysis of large icebergs has provided information about ice–ocean interaction and the existence of an "iceberg trap" along George V Coast. A first estimate of the mass balance of the drainage basin of Mertz and Ninnis Glaciers shows a value close to zero or slightly negative.

Ice velocities from GPS and sequential satellite images

(M. Frezzotti, ENEA; A. Capra, L. Vittuari, ITGGUB)

Measurements from remote-sensing and field surveys have provided new ice-velocity data for the David Glacier–Drygalski Ice Tongue, and the Priestley and Reeves Glaciers. Average surface velocities have been determined by tracking crevasses and other patterns moving with the ice in two sequential satellite images. Velocity measurements were made for different time intervals, e.g. 1973–90 and 1990–92, using images from various satellite sensors (Landsat 1 MSS, Landsat TM, SPOT XS). GPS measurements were made between 1989 and 1994. A number of points were measured on each glacier: five on David Glacier; three on Drygalski Ice Tongue; two on Reeves Glacier–Nansen Ice Sheet; and two on Priestley Glacier. Comparison of the results from GPS data and feature tracking in areas close to image tie-points show that errors in measured average velocity from the feature tracking may be as little as ±15–20 $m\ a^{-1}$. In areas far from tie-points, such as the outer part of Drygalski Ice Tongue, comparison of the two types of measurements shows differences of approximately ±70 $m\ a^{-1}$.

Italian ITASE expedition, Terra Nova station to Talos Dome

(M. Frezzotti, ENEA; O. Flora, DSTUT; S. Urbini, DSTUG)

In November 1996, the Italian Antarctic Programme undertook a traverse from Terra Nova station to Talos Dome. The objectives were to develop a high-resolution interpretation and 3-D map documenting the last 200–500 years of the climate, atmosphere and surface conditions over the Talos Dome area and along the David Glacier drainage area. It was originally planned to take a 150 m deep core at Talos Dome, but the drill became stuck at 90 m (it was recovered by twice pumping 5 L of warm pure glycol into the drillhole). An additional core, 20 m deep, was drilled at the same location as an ice core taken during the 1959–60 U.S. Victoria Land traverse. Around the Talos Dome drilling site we performed snow radio soundings for 3-D spatial variations in snow accumulation, and a strain net of stakes for a deformation study was measured using the GPS technique. Along the traverse, snow accumulation stakes were placed 5 km apart, and a topographic survey, using the GPS technique, was performed. Remote-sensing ground truthing was carried out with the survey of surface micro relief, sampling of snow for grain-size, VIS-IR spectrometry measurements and near-surface temperature measurements. Snow samples for trace elements and stable isotopes were collected every 40 km along the traverse.

Chemistry of snow and firn cores, northern Victoria Land

(R. Caprioli, R. Gragnani, S. Torcini, ENEA)
Within the framework of the Italian Antarctic Research Programme, the chemical composition (Na^+, K^+, Mg^{2+}, Ca^{2+}, $CH_3SO_3^-$ (MSA), Cl^-, NO_3^-, SO_4^{2-} and H_2O_2) of snow and firn samples from the Drygalski Ice Tongue, Aviator Glacier, Campbell Glacier, Hercules Névé and Talos Dome was studied to evaluate the accumulation rates of snow and to investigate the chemical contribution from some emission sources (marine biogenic activity, sea, volcanic and crust). The sampling depth ranged from between 2.35 m at Aviator Glacier to 98 m at Talos Dome. The snow and firn samples confirmed the decrease of sea-salt concentration with higher altitude and increasing distance from the sea. The concentration of many of the elements and compounds studied (particularly MSA, nss SO_4^{2-} and NO_3^-) showed a good seasonal signal, with a higher content during late spring–summer periods. Due to the low accumulation rates at the more elevated sites, the H_2O_2 seasonal variations were smoothed out with increasing depth. A comparison of the seasonal variations observed in the isotopic and chemical profiles was carried out to provide a more reliable time-scale, using the tritium and volcanic markers as constraints. High nss SO_4^{2-} concentrations seemed to correlate well with some explosive volcanic eruptions, such as Tambora (1815) and the preceding "Unknown" (1809), as well as other important eruptions. The average snow-accumulation rates calculated for the sites ranged from 85 to 260 kg m^{-2} a^{-1}.

GLACIAL GEOLOGY, AND GEOMORPHOLOGY

Glacial geology and related landforms, Maritime Alps

(P.R. Federici, M. Pappalardo, A. Ribolini, DSTUP)
Detailed geomorphological mapping has led to the reconstruction of the extension of two important valley glaciers that occupied the Gesso and Vermenagna valleys during the Pleistocene. A fairly complete picture of the main features of the glaciation has been achieved through analysis of the morphological evidence, stratigraphic record and pollen stratigraphy. Lichenometry was used to study moraine ridges of the Little Ice Age. Glaciological investigations were performed on the six active glaciers still present in the valley, which are monitored annually.

Glacier variations in the Western Alps

(C. Vanuzzo, DSATUM)
Area reductions, ELA rises and volume contractions of glaciers in Valle d'Aosta have been calculated from the LIA maximum (1818–20) to 1975. Reconstruction of the maximum expansions reached in the LIA were determined through photointerpretation, field survey and analysis of historical documents. ELAs were calculated using the AAR method, assuming a value of 0.67. The area reduction from the LIA to1975 for all of the glaciers studied is 41.5%. The calculated rises of the ELA are very dispersed, with a mean of approximately 130 m.

Volume reduction was studied by reconstructing 3-D models of 17 glaciers in upper Valpelline and Valtournenche. This datum has been used to calculate the mean volume reduction of all of the glaciers studied in Valle d'Aosta.

The mean ELA rise was transformed into a temperature variation, giving a mean annual increase from the LIA to 1975 of approximately 0.8°C. The research is now continuing on glaciers of Piedmont and Lombardy, Western and Central Alps.

Inventory and monitoring of proglacial lakes, Central Alps

(A. Galluccio, G. Cola, G. Catasta, SGL)
The recent advance of glaciers in the Central Alps from 1975–85 has been followed by a strong phase of retreat. During this retreat some small lakes, named intra-moraine lakes, have formed between the retreating snout and the new moraine deposited by the glacier at the culmination of the advance. An inventory was made of these lakes between 1993 and 1997: there are 22 in the Lombardy region. Annual photography is used to monitor the formation process and possible developments. Both seem to be directly linked to the characteristics of the downstream bank, mostly formed by the new moraine, but less influenced by the erosion of the glacier tongue during the previous advance. Some lakes have a sloping bank made of ice, ice either under the moraine or coming from the snout, so there is the possibility of a sudden collapse of the bank followed by a local flood. However, considering the small size of the lakes, this should not cause any serious damage downstream. Researchers have also reviewed the 19 periglacial lakes in Lombardy that developed from 1920–82, based on the morphogenetic assumptions of the present research. This project will continue for a further three years (1998–2000).

Glacial geology, Adamello–Presanella and Ortles–Cevedale Groups

(C. Baroni, DSTUP/CGI; A. Carton, DSTUPV/CGI)
Studies of the glacial geology and geomorphology have been carried out in recent years, with particular attention paid to Holocene landforms and deposits. Late Pleistocene and Holocene glacial deposits have been differentiated on the basis of the morphological, sedimentological and stratigraphic characteristics, lichen cover, dendrochronological observations, soil development, and using ^{14}C dating. Important phases of the geomorphological

evolution have been reconstructed. The morphogenetic agents which have been most influential are glacial and periglacial.

Several ^{14}C dates were obtained from buried soils and peat in Val Narcanello, Val di Genova, Val Cornisello and Val di La Mare. A Neoglacial advance was documented in Val Narcanello (between 3015 ±75 and 2345 ±125 ^{14}C years BP) and in Val Cornisello (post 2745 ±110 ^{14}C years BP).

In Val di Genova the maximum extensions of the Vedretta della Lobbia and Vedretta del Mandrone in the Holocene were reconstructed, and some moraines associated with different events in the LIA were dated. In particular, an end moraine at about 1775 m a.s.l. underlies a peat deposit, the base of which was dated to 5310 ±180 ^{14}C years BP. This gives a minimum limiting age for the moraine, suggesting a Holocene age.

The top of the same peat deposit is directly underneath another end moraine, and the top has been dated to 1190 ±75 ^{14}C years BP. This is a maximum limiting age for this moraine, which suggests a glacier advance during the Middle Ages or the LIA. A moraine near Malga Matarot is evidence of an advance of the Vedretta della Lobbia ascribed to the first phases of the LIA, and is dated at around 410 ±90 ^{14}C years BP. In the same area two lichenometrical curves for the groups ***Rhizocarpon geographicum*** and ***Aspicilia cinerea*** have been reconstructed for 1864–1915. The growth rates are 0.5 and 1.7 mm a^{-1}, respectively. The colonisation times of larch have been evaluated to be approximately 15 years.

Since the middle of the last century there has been a notable recession of the glaciers, broken by brief and not very marked advances. There has been a lowering of the surface of the ice by several tens of metres in the accumulation area and marked recessions of the fronts of more than 2000 m for the Vedretta della Lobbia and approximately 1800 m for the Vedretta del Mandrone. When the glaciers were at their maximum during the LIA, the snowline was about 60 m below the present snowline (2950 m a.s.l.).

At Pian Venezia, in the Ortles–Cevedale Group, a peat-bog deposit developed on the edge of a riegel. Holocene and Late Glacial moraines outcrop close to the bog. These moraines mark the maximum position reached by Vedretta di La Mare during the LIA. A trench was excavated in the bog at about 2270 m a.s.l., and at the base of the peat succession a hydromorphic soil yielded two ^{14}C dates, 9180 ±170 BP and 9215 ±125 BP.

Glacial geology, Apuan Alps, northern Apennines

(P.P. Putzolu, DSTUP)

A geomorphological study of the northeastern part of the metamorphic basement of the Apuan Alps has led to the detailed reconstruction of the Würmian morainic ridges. The maximum expansion during Würm III is shown by remnants of frontal moraine arcs along valley bottoms at elevations of approximately 600–650 m. The permanent snowline was at about 1190–1200 m.

Drumlins, southern Alps

(G.B. Castiglioni, DGUP/CGI)

Drumlins are rarely found on the southern slopes of the Alps. However, two special kinds of drumlins, of Würmian age, have been found on a plateau southeast of Bolzano, South Tyrol. They they can be defined as "debris-cored drumlins".

Glacial remains in Albania

(G. Palmentola and others, DSTUB)

On the highest mountains of the southern Apennines and in the region stretching from Albania as far as Crete, Greece, many traces of glacial moulding are preserved, all attributable to the last great glacial age. Frontal moraines have allowed the ELA to be reconstructed. During the maximum glacial expansion the ELA reached approximately 1600 m a.s.l. on the northern side of the area examined,and increased regularly to the south by approximately 75 m per degree of latitude in the Apennines and 100 m per degree of latitude from Albania to Crete. Traces of glacial activity are no lower than 1900 m in the southern Apennines and no lower than 2200 m in the Albania–Greece region. This situation could be explained by differences in the tectonic uplift rate, which has been more than 0.15 m a^{-1} during last 18,000–20,000 years. Otherwise, these regions must have been characterised by a different snowline altitude; an altitude due to the regional climatic conditions, principally the mean annual temperature.

FROZEN GROUND

Rock glaciers in the Italian Alps

(C. Smiraglia, DSTUM/CGI; M. Guglielmin, RLSG/CGI)

A total of 1594 rock glaciers have been identified in the Italian Alps, mainly through interpretation of aerial photographs; of these, almost 60% are inactive and 19% active. Their total surface area is over 22,000 ha. Assuming a mean permafrost thickness of 12 m, the total volume of permafrost existing in these active rock glaciers is approximately one billion m^3. Most of the rock glaciers (581, 36.4%) are in the Raethian Alps. The mean minimum altitude of active rock glaciers is 2564 m, whilst the mean minimum altitude of the inactive rock glaciers is 2192 m.

Rock glaciers in the Maritime Alps

(A. Ribolini, DSTUP)

On the Italian side of the Maritime Alps, 37 rock glaciers have been identified which have been mapped and analysed. The heights of their fronts suggests they are all inactive and were formed in the Late Glacial. An evolutionary continuity was found between deposits of different origins, such as protalus ramparts, ablation morainic complexes, talus slopes, debris cones and rock glaciers.

Periglacial deposits, Monti Pisani

(M. Pappalardo, P.P. Putzolu, DSTUP)
Tongue-shaped coarse deposits on Monti Pisani, Tuscany, at an average altitude of 600 m, have been interpreted as inactive block fields by typological comparison with active forms described in the scientific literature. These deposits, made of quartzite blocks, are attributed to the Last Glacial Maximum, when the snowline in the Apuan Alps was approximately 1200 m a.s.l.

Rock glaciers in Albania

(G. Palmentola, DSTUB/CGI)
Some rock glaciers, colonised by erbaceous vegetation and with no signs of recent movement, have been identified in the Albanian Alps. Assuming a –2°C isotherm as a minimum condition for rock-glacier activity, and calculating the atmospheric lapse rate, it is estimated that rock glaciers here were active under thermal conditions 6.4°C lower than the present mean annual temperature. Because they occupied surfaces covered by ice during last great glaciation, they cannot be more than 14,000–17,000 years old, and so can probably be dated to the Dryas.

SNOW AND AVALANCHES

Monitoring snow stratigraphy

(A. Galluccio, L. Bonetti, G. Cola, L. Bonardi, SGL; with RLCNM/ CRGAL)
On Monte Sobretta (3175 m a.s.l.), Ortles–Cevedale, the stratigraphy of the monthly snow cover on a small glacier is being monitored. Data from weather stations in Lombardy are used to explain important snowfall events both in the accumulation (September–June) and ablation (June–September) seasons. The relationship between these events and changes in the snow layer at the site means the development of snowfall at a medium to high alpine site can be studied on a yearly basis. Data are also being gathered on the depth of the snowcover at higher altitudes by local operators (guides and hut owners). The research is useful for both glaciological studies and RLCNM, who use it to determine the conditions for summer avalanches. All of the data, together with descriptions, are available on the Internet.

Snowfall, Piedmont Alps, 1966–96

(A. Biancotti, L. Motta, DSTUT; S. Bovo, M. Cordola, E. Turroni, RP)
All available data on snowfall in the Piedmont Alps have been processed and a set of homogeneous time-series obtained for 16 locations. This includes: on monthly basis, the maximum and minimum snow-cover height, the total amount of snowfall, the number of days with snow precipitation; on an annual basis, the total amount of snowfall and the number of days with precipitation from November to May. The mean values of all quantities have been calculated for 30 years, together with a description of their statistical distributions. The analysis has shown that snowfall is correlated regionally with altitude. Four regimes have been identified: lower-altitude areas, below 1200 m a.s.l., show one peak in January; areas around 2000 m a.s.l. show equivalent snowfall in December, January and February; between 2000 and 2300 m a.s.l., bimodal regimes can be observed, with a peak in December or January and another in the spring; above 2300 m a.s.l., the unimodal regime returns, but with the maximum in April. Another aspect determined the snow-cover distribution across the Piedmont alpine area and its influence on the local economy and tourism. The main snowfall events in the 30 year period (winters of 1972, 1986, and 1996) have been related to the meteorological conditions that caused them and the associated avalanche phenomena.

Snow sample pollution, Central Alps

(C. Lonardo, L. Trada, C. Lugaresi, M. Butti, G. Grazzi-Lonardo, SGL; with PSI)
At three sites, at about 3000 m a.s.l., three 1 m cores were made in the deep snow-accumulation layer formed in fall–winter, immediately above the summer surface of the glaciers. The cores were taken at the end of the accumulation season at high altitude, in early June. Thus the snow samples probably did not undergo important melting phenomena. The following were analysed: conductivity, hardness, pH, lead concentration, sulphates, nitrates, nitrites, total organic carbon, atmospheric dust and colour. After two years, the results show that between 1996 and 1997 acid rain and the related conductivity decreased, and total hardness, linked to ionic calcium and magnesium coming from the erosion of rocks and town buildings, and dust, due to car traffic, increased. Nitrates, nitrites, sulphates and lead remained unchanged. The values show a small pollution at high Alpine altitudes due to industrial combustion.

Nitrogen loading of snow samples, Lombardy

(R. Balestrini and G. Tartari, IRSSA)
The critical nitrogen load to a small mountain basin (about 20 km^2), located in Val Masino, a tributary valley of Valtellina, is being measured. The area, important from a naturalistic point of view, is characterised by a high sensitivity to acidic deposition. From 1994–98, it has been widely investigated in order to understand the interactions between air pollution and the forest ecosystem.

The critical nitrogen load, as a nutrient, is being evaluated using a mass-balance method. Nitrogen input to the basin is divided into homogeneous parts based on vegetation, usage and soil type. The absorption and release of chemical species by the soil are obtained from analysis of nitrogen concentrations in the Masino river, taken to be the basin output.

Since June 1997, the sampling of dry, wet and fog deposition has been carried out, whilst throughfall deposition sampling began in June 1994. Snow samples were also collected as snow cores in the accumulation zone of the catchment, at about 2500 m a.s.l., during two consecutive years (1997 and 1998). This was done at the end of the winter season in order to study the occurrence and deposition of natural or anthropogenic atmospheric constituents under background conditions.

Nitrogen saturation has been evaluated in a qualitative way using a new experimental method designed for basins that have natural characteristics and are not largely modified by human activity. The classification is based on nitrogen concentration, as nitric species, in runoff and there are 4 stages; runoff is the capacity of nitrogen absorption by vegetation and microbiological species of the ecosystem.

Avalanche monitoring, Mount Pizzac

(F. Sommavilla, B. Sovilla, CSVDI)

The Mount Pizzac monitoring system was created by the Experimental Centre for Avalanches and Hydrogeologic Defence, to study avalanche dynamics and the effect of their impact on structures. The largest of the avalanches in the monitored corridor flows from 2200–1745 m, following a trajectory of 836 m with an average gradient of 31°. Monitoring structures have been installed along 418 meters of the corridor. They allow observation of the development of each avalanche event, and continuously record pressure, speed and the geometric variations of the body of the avalanche. Six steel poles, each one fitted with 8 pressure sensors, measure the pressure profile continually at 0.5 m intervals up to a maximum height of 5 m. In addition, five of these are equipped with measuring devices able to check the flow height, thus following the development of the avalanches both in time and space. A small wedge-shaped obstacle, with an area of 1 m^2, helps estimate the influence of the form and area over the power of the avalanche impact. Knowing when the avalanche flow passes known distances, it is possible to determine the average speed of the front in 14 tracks of the flowline. The monitoring system has three cameras that automatically record each event. Since 1993, when the monitoring system was first installed, 15 events have been recorded. The most frequent avalanches are wet-snow avalanches in springtime and dry-snow avalanches in wintertime, with average volumes of 2000 m^3. The average speeds of the avalanche fronts range from 2.5–23 m s^{-1}, and recorded pressures from 5–175 kPa.

Avalanche register, Bolzano

(PAB–UI)

The first phase of the computerisation of the Bolzano provincial avalanche register has just been completed with the recording of more than 1800 avalanche sites based on an archive of 1:10,000 scale maps. All the necessary assessments and alterations will be made in the summer of 1998. The next stage will be to link this archive with a database containing the characteristics of every single reported event. Once that has been completed, the database will be made available for members of the public to consult.

Submitted by Claudio Smiraglia

ABBREVIATIONS USED IN REPORT

CISE	Centro Informazioni Studi ed Esperienze
CGI	Comitato Glaciologico Italiano, Torino
CNR–IRPI	Consiglio Nazionale delle Ricerche – Istituto per la Protezione Idrogeologica nel Bacino Padano, Torino
CNR–ISDGM	Consiglio Nazionale delle Ricerche – Istituto di Studio delle Grandi Masse
CRGAL	Comitato Regionale Guide Alpine Lombarde
CSC–CAI	Comitato Scientifico Centrale–Club Alpino Italiano, Milano
CSVDI	Centro Sperimentale Valanghe e Difesa Idrogeologica, Arabba (Belluno)
DGUP	Dipartimento di Geografia, Università di Padova
DSATUM	Dipartimento di Scienze dell'Ambiente e del Territorio, Università di Milano
DSTUB	Dipartimento di Scienze della Terra, Università di Bari
DSTUG	Dipartimento di Scienze della Terra, Università di Genova
DSTUM	Dipartimento di Scienze della Terra, Università di Milano
DSTUP	Dipartimento di Scienze della Terra, Università di Pisa
DSTUPV	Dipartimento di Scienze della Terra, Università di Pavia
DSTUT	Dipartimento di Scienze della Terra, Università di Torino
ENEA	Ente Nazionale per la Ricerca e lo Sviluppo delle Energie Alternative, Roma
ENEL–CRIS	Ente Nazionale per l'Energia Elettrica, Centro Ricerca Idaulica e Strutturale, Mestre (Venezia)
EPICA	European Project for Ice Coring in Antarctica
IGUI	Institut für Geographie, Universität Innsbruck
IRSSA	Istituto di Ricerca sulle Acque, CNR, Brugherio (Milano)
ISMES	Istituto Spe rimentale Modelli e Sistemi
ISPESL	Istituto Superiore Prevenzione e Sicurezza sul Lavoro, Roma
ITASE	International Trans-Antarctic Scientific Expedition
ITGGUB	Istituto Topografia, Geodesia e Geofisica, Università di Bologna
IUP	Institut für Umweltphysik
LGGE	Laboratoire de Glaciologie et Géophysique de l'Environnement, Grenoble, France
PAB–UI	Provincia Autonoma Bolzano, Ufficio Idrografico

PNRA	Programma Nazionale di Ricerche in Antartide
PSI	"Paul Scherrer" Institute, Villighen, Switzerland
PTDIGET	Politecnico di Torino–Dipartimento di Georisorse e Territorio
RAVA	Regione Autonoma Valle d'Aosta, Aosta
RLCNM	Regione Lombardia Centro Nivometeorologico, Bormio (Sondrio)
RLSG	Regione Lombardia, Servizio Geologico, Milano
RP	Regione Piemonte, Torino
SGL	Servizio Glaciologico Lombardo, Milano
SMS	Società Meteorologica Subalpina, Torino
USGS	United States Geological Survey

INTERNATIONAL GLACIOLOGICAL SOCIETY

SELIGMAN CRYSTAL AWARD 1998 to Dr Sigfús J. Johnsen

18 August 1998, Kiruna, Sweden

The Society's Council agreed unanimously in 1996 that a Seligman Crystal be awarded to Sigfús J. Johnsen but the ceremony had to be deferred to 1998. The Crystal was presented, in the presence of about 50 members and friends, by the President of the Society, Norikazu Maeno, who introduced the recipient as follows:

Sigfús Johan Johnsen was born in Ogur, northwest Iceland in 1940. He received his degree in experimental physics from the University of Copenhagen in 1967, and was simultaneously appointed a research associate at the H.C. Ørsted Institute at the University. One year later he was promoted to Assistant Professor at the same institution, and in 1971 he became Assistant Professor (Lektor) and continued his research career at the Geophysical Institute. In 1979, Dr. Johnsen was appointed as an Associate Professor in geophysics at the Science Institute, University of Iceland, officially beginning his dual career in Iceland and Denmark which continues today. Finally, he was promoted to (full) Professor at the University of Iceland in 1987.

He has covered a broad range in both experimental and theoretical science, from designing and building the equipment used to obtain data, to interpreting the data, to constructing models to better understand the results. He is the author or co-author of no less than 80 papers in reviewed scientific journals.

He began his career by building a low-level counter to measure anthropogenic fallout preserved in snow and firn. This led to work on ^{14}C counters for dating icebergs and subsequently to an interest in dating ice cores. Ultimately, over 25 years, it led to the development and formulation of increasingly sophisticated ice-flow models for dating ice sheets and deep ice cores.

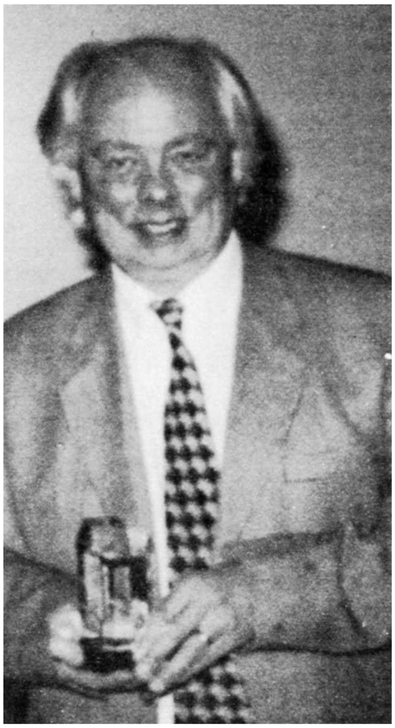
His work on the diffusion of isotopes in firn and ice remains the standard in the field. He was the one principally responsible for using deuterium excess ($d = \delta D - 8\delta^{18}O$) to demonstrate that subtropical waters are by far the dominating source of moisture for snow falling on the high-elevation areas of Greenland, in both glacial and interglacial times, whereas much of the precipitation on the low-elevation areas may well originate from local waters.

Most recently, Sigfús Johnsen has designed a combined ice-flow and heat-transport model that reproduces the measured temperature profile along the 3000 m deep borehole at Summit, Greenland, with a mean deviation of 0.03°C. This model was then used to calculate a second-degree transfer function that enabled him to interpret heavy-isotope profiles within deep ice cores in terms of dated surface temperatures of the past corrected for changes in surface elevation, rates of accumulation, and the isotopic composition of sea water: a vital link between the ice-core records and past climate.

His interest and aptitude in designing and building equipment is evident in his work on oxygen-isotope mass spectrometry. Many of his ideas have been incorporated into the system developed by the Geophysical Department in Copenhagen which measures hundreds of samples a day; surpassing the fastest commercial systems by nearly an order of magnitude in sample throughput. This has enabled the Copenhagen group to produce isotope profiles along innumerable ice cores extremely rapidly. Results from samples shipped from a core site can be waiting in the office when the party returns from the field.

Professor Johnsen's work on the technology of ice-core drilling has let to arguably the best shallow drill in use today, as well as to the deep drill used to obtain the recent GRIP ice core from Summit, in Greenland. He was in charge of the drilling for this project and demonstrated his abilities both as an excellent and valued field scientist and as a respected theoretician. He has participated in field programmes, including shallow and deep ice-core drilling in Greenland, almost every year from 1969 to the present.

His work in Iceland has included stable-isotope studies on ground-water systems, evaporation from lakes using deuterium excess and analyses of mollusc shells. His long-standing interest in throwing new light on the age of glacial deposits has been continued there through his work on ^{14}C dating.



Even as a student, Sigfús Johnsen demonstrated abilities as a skilled and imaginative technician and as a talented theoretician. Since then his broad and innovative accomplishments have continued to be seen at the University of Copenhagen, alternating with similarly creative activities at the University of Iceland. Several of his conceptual and practical ideas have provided the extremely fast Danish mass spectrometer and the ISTUK, Danish ice-core drill, with an unmatched efficiency and reliability. Results from the 23 field expeditions to the Greenland ice sheet in which he participated helped form the basis for the planning and operation of the European Greenland Ice-core Project (GRIP, 1989–92) of which has was the key scientist and engineer during its implementation. He has been a leading light in the development of the Greenland ice sheet flow models which have enabled us to date the deep parts of the GRIP and earlier cores. He developed the theory for the diffusion of isotopic water components in firn and ice, and determined the important function transferring delta values of glacier ice into temperatures at the time of deposition.

For 30 years Sigfús Johnsen has enriched glaciology with a variety of unique technical, experimental and theoretical contributions. We are delighted to be able to recognise these achievements through the award of the Seligman Crystal.

After the presentation of the Crystal, Sigfús J. Johnsen described and illustrated some of the work on deep ice cores and palaeoclimate that led to the award.

The drilling and research of deep ice cores during the last decades have unveiled a wealth of new know-ledge about the nature of our climate systems. The unexpected results obtained so far have also stimulated other palaeoclimatic disciplines to better supplement the ice-core results, thus adding even more knowledge and understanding of the processes shaping our climate.

Glaciers and ice caps greatly influence the Earth's environment and climate. For example, they can grow and shrink, change sea level, control global albedo, and shape the mountains and continents they cover. During the last glacial period, 11,000 to 115,000 years ago, the expanding glaciers of the Northern Hemisphere surged frequently and discharged vast amounts of icebergs into the North Atlantic, causing a whole suite of violent climatic oscillations (Heinrich events, Dansgaard–Oeschger cycles).

The most peculiar property of glaciers is perhaps their ability to preserve, within their "third dimension", a record of past climatic and environmental changes. Each annual layer of snow deposited on the surface of a cold ice cap carries with it, as it sinks slowly towards the bottom, a finger-print of the impurities present in the atmosphere. Even the atmospheric gases are trapped in small bubbles when the snow is transformed into glacier ice.

The isotopic ratios ($^{18}O/^{16}O$ and D/H) of the snow reflect the temperature at which the cloud vapour was transformed into ice crystals or snow, providing us with a most important proxy for past temperatures.

The temperature profiles measured in boreholes are shaped by past surface temperature changes far back in time and are used to constrain the climate history as told by the isotopes. Thus we know that the Greenland glacial climate was a shivering 20°C colder than today.

The annual layers are nicely stacked in the glacier until they reach near the bottom strata where foldings and other stratigraphic disturbances can disrupt the ordered layering. In Antarctica this can happen after some 500,000 years or more, in Greenland after about 150,000 years and in smaller ice caps from 10,000 to 120,000 years. By coring to bedrock we can recover similarly old continuous records of the Earth's environment and climate. The resolution of these records can be better than one year up to 120,000 years back in time, allowing for singular events in the Earth's history, like volcanic eruptions and sharp climatic shifts, to be studied in great detail. As an important extra bonus, mainly valid for Greenland ice cores, high-resolution records of selected constituents allows precise dating by counting annual cycles several tens of thousands of years back in time. Such a dating effort is a major undertaking but reveals the important dynamics of natural environmental change that often proceed with catastrophic rapidity. When combining the detailed records from deep ice cores with other records of palaeoclimate, like from ocean-sediment cores, it becomes clear that our climate is most unstable on both short and long time scales. Thus we have to conclude that the results of any man-made impact on our climate systems, like pollution, can be more or less impossible to predict.

The following papers from the International Symposium on Antarctica and Global Change: Interactions and Impacts held in Hobart, Tasmania, Australia, 13–18 July 1997, have been accepted for publication in *Annals of Glaciology* Vol. 27, edited by W.F. Budd:

I ALLISON
Surface climate of the interior of the Lambert Glacier basin, Antarctica, from automatic weather station data

C BARBANTE, C TURETTA, A GAMBARO, G CAPODAGLIO AND G SCARPONI
Sources and origins of aerosols reaching Antarctica as revealed by lead concentration profiles in shallow snow

R BINTANJA
The contribution of snowdrift sublimation to the surface mass balance of Antarctica

D H BROMWICH, B CHEN, K M HINES AND R I CULLATHER
Global atmospheric responses to Antarctic forcing

D H BROMWICH, R I CULLATHER AND M L VAN WOERT
Antarctic precipitation and its contribution to the global sea-level budget

W F BUDD, B COUTTS AND R C WARNER
Modelling the Antarctic and Northern Hemisphere ice-sheet changes with global climate through the glacial cycle

L H BURCKLE AND R MORTLOCK
Sea-ice extent in the Southern Ocean during the Last Glacial Maximum: another approach to the problem

G B BURNS, A V FRANK-KAMENETSKY, O A TROSHICHEV, E A BERING AND P O PAPITASHVILI
The geoelectric field: a link between the troposphere and solar variability

G B BURNS, W J R FRENCH, P A GREET, P F B WILLIAMS, K FINLAYSON AND R P LOWE
Monitoring the Antarctic mesopause region for signatures of climate change

R CALOV AND I MARSIAT
Simulations of the Northern Hemisphere through the last glacial–interglacial cycle with a vertically integrated and a three-dimensional thermomechanical ice-sheet model coupled to a climate model

R CALOV, A SAVVIN, R GREVE, I HANSEN AND K HUTTER
Simulation of the Antarctic ice sheet with a three-dimensional polythermal ice-sheet model, in support of the EPICA project

M CANALS, F ESTRADA, R URGELES AND GEBRAP 96/97 TEAM
Very high-resolution seismic definition of glacial and postglacial sediment bodies in the continental shelves of the northern Trinity Peninsula region, Antarctica

M CANALS, R URGELES, F ESTRADA AND GEBRAP 96/97 TEAM
Internal structure and seismic facies of the deep-water sediment drifts off northern Graham Land, Antarctica: results from a very high-resolution survey

A M CARLETON, G JOHN AND R G WELSCH
Interannual variations and regionality of Antarctic sea-ice–temperature associations

G CASASSA, H H BRECHER, C CÁRDENAS AND A RIVERA
Mass balance of the Antarctic ice sheet at Patriot Hills

T J CHINN
Recent fluctuations of the Dry Valleys glaciers, McMurdo Sound, Antarctica

W M CONNOLLEY AND S P O'FARRELL
Comparison of warming trends over the last century around Antarctica from three coupled models

A CORREIA, P ARTAXO AND W MAENHAUT
Monitoring of atmospheric aerosol particles on the Antarctic Peninsula

M CRAVEN AND I ALLISON
Firnification and the effects of wind-packing on Antarctic snow

M A J CURRAN, T D VAN OMMEN AND V MORGAN
Seasonal characteristics of the major ions in the high-accumulation Dome Summit South ice core, Law Dome, Antarctica

M DIEPENBROEK, D FÜTTERER, H GROBE, H MILLER, M REINKE AND R SIEGER
PANGAEA information system for glaciological data management

E W DOMACK AND P T HARRIS
A new depositional model for ice shelves, based upon sediment cores from the Ross Sea and Mac.Robertson shelf, Antarctica

DOME-F DEEP CORING GROUP
Deep ice-core drilling at Dome Fuji and glaciological studies in east Dronning Maud Land, Antarctica

DOME-F ICE CORE RESEARCH GROUP
Preliminary investigation of palaeoclimate signals recorded in the ice core from Dome Fuji station, east Dronning Maud Land, Antarctica

R EDWARDS, P N SEDWICK, V I MORGAN, C F BOUTRON AND S HONG
Iron in ice cores from Law Dome, East Antarctica: implications for past deposition of aerosol iron

J G FERRIGNO, R S WILLIAMS JR, C E ROSANOVA, B K LUCCHITTA AND C SWITHINBANK
Analysis of coastal change in Marie Byrd Land and Ellsworth Land, West Antarctica, using Landsat imagery

R FISHER AND V I LYTLE
Atmospheric drag coefficients of Weddell Sea ice computed from roughness profiles

A J FOX AND A P R COOPER
Climate-change indicators from archival aerial photography of the Antarctic Peninsula region

M FREZZOTTI, A CAPRA AND L VITTUARI
Comparison between glacier ice velocities inferred from GPS and sequential satellite images

M Frezzotti, A Cimbelli and J Ferrigno
Ice-front change and iceberg behaviour along Oates and George V Coasts, Antarctica, 1912–96

M Frignani, F Giglio, L Langone, M Ravaioli and M Mangini
Late Pleistocene–Holocene sedimentary fluxes of organic carbon and biogenic silica in the north-western Ross Sea, Antarctica

C Genthon, G Krinner and M Déqué
Intra-annual variability of Antarctic precipitation from weather forecasts and high-resolution climate models

R Gragnani, C Smiraglia, B Stenni and S Torcini
Chemical and isotopic profiles from snow pits and shallow firn cores on Campbell Glacier, northern Victoria Land, Antarctica

K Grosfeld and R Gerdes
Circulation beneath the Filchner Ice Shelf, Antarctica, and its sensitivity to changes in the oceanic environment: a case-study

G H Gudmundsson, C Raymond and R Bindschadler
The origin and longevity of flow stripes on Antarctic ice streams

G S Hamilton, I M Whillans and P J Morgan
First point measurements of ice-sheet thickness change in Antarctica

P Heil, V I Lytle and I Allison
Enhanced thermodynamic ice growth by sea-ice deformation

W D Hibler III, P Heil and V I Lytle
On simulating high frequency variability in Antarctic sea-ice dynamics models

C Hjort, S Björck, O Ingólfsson and P Möller
Holocene deglaciation and climate history of the northern Antarctic Peninsula region: a discussion of correlations between the Southern and Northern Hemispheres

C L Hulbe, E Rignot and D R MacAyeal
Comparison of ice-shelf creep flow simulations with ice-front motion of Filchner–Ronne Ice Shelf, Antarctica, detected by SAR interferometry

T H Jacka and W F Budd
Detection of temperature and sea-ice-extent changes in the Antarctic and Southern Ocean, 1949–96

H J R Keys, S S Jacobs and L W Brigham
Continued northward expansion of the Ross Ice Shelf, Antarctica

J C King and S A Harangozo
Climate change in the western Antarctic Peninsula since 1945: observations and possible causes

H Konishi, M Wada and T Endoh
Seasonal variations of clouds and precipitation at Syowa station, Antarctica

K J Kreutz, P A Mayewski, S I Whitlow and M S Twickler
Limited migration of soluble ionic species in a Siple Dome, Antarctica, ice core

P J Langhorne, V A Squire, C Fox and T G Haskell
Break-up of sea ice by ocean waves

K Lewis, A G Fountain and G L Dana
Surface energy balance and meltwater production for a Dry Valley glacier, Taylor Valley, Antarctica

Li Jun, T H Jacka and V Morgan
Crystal-size and microparticle record in the ice core from Dome Summit South, Law Dome, East Antarctica

C S Lingle and D N Covey
Elevation changes on the East Antarctic ice sheet, 1978–93, from satellite radar altimetry: a preliminary assessment

C S Lingle and E N Troshina
Relative magnitudes of shear and longitudinal strain rates in the inland Antarctic ice sheet, and response to increasing accumulation

B K Lucchitta and C E Rosanova
Retreat of northern margins of George VI and Wilkins Ice Shelves, Antarctic Peninsula

V I Lytle, A P Worby and R A Massom
Sea-ice pressure ridges in East Antarctica

V Maggi, G Orombelli, B Stenni, O Flora, R Udisti, S Becagli, R Traversi, S Vermigli and J-R Petit
70 years of northern Victoria Land (Antarctica) accumulation rate

V Maggi and J-R Petit
Atmospheric dust concentration record from the Hercules Névé firn core, northern Victoria Land, Antarctica

G J Marshall, J Turner and W D Miners
Interpreting recent accumulation records through an understanding of the regional synoptic climatology: an example from the southern Antarctic Peninsula

S Marsland and J-O Wolff
East Antarctic seasonal sea-ice and ocean stability: a model study

R A Massom, P T Harris, K Michael and M J Potter
The distribution and formative processes of latent-heat polynyas in East Antarctica

M McGuinness, H J Trodahl, K Collins and T G Haskell
Non-linear thermal transport and brine convection in first-year sea ice

K Melvold, J O Hagen, J-F Pinglot and N Gundestrup
Large spatial variation in accumulation rate in Jutulstraumen ice stream, Dronning Maud Land, Antarctica

K J Michael, C S Hungria and R A Massom
Radiometric measurements of sea-ice surface temperature in East Antarctica

U Mikolajewicz
Effect of meltwater input from the Antarctic ice sheet on the thermohaline circulation

H Miura, K Moriwaki, H Maemoku and K Hirakawa
Fluctuations of the East Antarctic ice-sheet margin since the last glaciation from stratigraphy of raised beach deposits along the Sôya Coast

S G Moreton and J L Smellie
Identification and correlation of distal tephra layers in deep-sea sediment cores, Scotia Sea, Antarctica

V Morgan, T van Ommen, A Elcheikh and Li Jun
Variations in shear deformation rate with depth at Dome Summit South, Law Dome, East Antarctica

T Motoi, A Kitoh and H Koide
Antarctic Circumpolar Wave in a coupled ocean–atmosphere model

N A Nereson, R C A Hindmarsh and C F Raymond
Sensitivity of the divide position at Siple Dome, West Antarctica, to boundary forcing

K Neumann, W B Lyons and D J Des Marais
Inorganic carbon-isotope distribution and budget in the Lake Hoare and Lake Fryxell basins, Taylor Valley, Antarctica

A Nishimura, T Nakasone, C Hiramatsu and M Tanahashi
Late Quaternary palaeoenvironment of the Ross Sea continental shelf, Antarctica

D Noone and I Simmonds
Implications for the interpretation of ice-core isotope data from analysis of modelled Antarctic precipitation

S P O'Farrell and W Connolley
Comparison of warming trends predicted over the next century around Antarctica from two coupled models

B-K Park, S-K Chang, H I Yoon and H Chung
Recent retreat of ice cliffs, King George Island, South Shetland Islands, Antarctica Peninsula

S Passchier, A L L M Verbers, F M van der Wateren and F J M Vermeulen
Provenence, geochemistry and grain-sizes of glacigene sediments, including the Sirius Group, and Late Cenozoic glacial history of the southern Prince Albert Mountains, Victoria Land, Antarctica

F Pattyn and H Decleir
Ice dynamics near Antarctic marginal mountain ranges: implications for interpreting the glacial-geological evidence

H A Phillips
Surface meltstreams on the Amery Ice Shelf, East Antarctica

H A Phillips, I Allison, R Coleman, G Hyland, P Morgan and N W Young
Comparison of ERS satellite radar altimeter heights with GPS-derived heights on the Amery Ice Shelf, East Antarctica

S F Price and I M Whillans
Delineation of a catchment boundary using velocity and elevation measurements

J Priddle, D B Nedwell, M J Whitehouse, D S Reay, G Savidge, L C Gilpin, E J Murphy and J C Ellis-Evans
Re-examining the Antarctic Paradox: speculation on the Southern Ocean as a nutrient-limited system

M Rapley and V I Lytle
Brine infiltration in the snow cover of sea ice in the eastern Weddell Sea, Antarctica

F Rémy and B Legresy
Antarctica non-stationary signals derived from Seasat ERS-1 alitmeters comparison

E Rignot
Radar interferometry detection of hinge-line migration on Rutford Ice Stream and Carlson Inlet, Antarctica

C E Rosanova, B K Lucchitta and J G Ferrigno
Velocities of Thwaites Glacier and smaller glaciers along the Marie Byrd Land coast, West Antarctica

K J R Rosman, W Chisholm, C F Boutron, S Hong, R Edwards, V Morgan and P N Sedwick
Lead isotopes and selected metals in ice from Law Dome, Antarctica

H Rott, W Rack, T Nagler and P Skvarca
Climatically induced retreat and collapse of northern Larsen Ice Shelf, Antarctic Peninsula

T A Scambos, N A Nereson and M A Fahnestock
Detailed topography of Roosevelt Island and Siple Dome, West Antarctica

C Schneider
Monitoring climate variability on the Antarctic Peninsula by means of observations of the snow cover

P N Sedwick, P T Harris, L G Robertson, G M McMurtry, M D Cremer and P Robinson
A geochemical study of marine sediments from the Mac. Robertson shelf, East Antarctica: initial results and palaeoenvironmental implications

M J Siegert, R Hodgins and J A Dowdeswell
Internal radio-echo layering at Vostok station, Antarctica, as an independent stratigraphic control on the ice-core record

I Simmonds, D A Jones and D J Walland
Multi-decadal climate variability in the Antarctic region and global change

P Skvarca, W Rack, H Rott and T Ibarzábal y Donángelo
Evidence of recent climatic warming on the eastern Antarctic Peninsula

A M Smith, D G Vaughan, C S M Doake and A C Johnson
Surface lowering of the ice ramp at Rothera Point, Antarctic Peninsula, in response to regional climate change

I N Smith, W F Budd and P Reid
Model estimates of Antarctic accumulation rates and their relationship to temperature changes

R Souchez, A Khazendar, D Ronveaux and J-L Tison
Freezing at the grounding line in East Antarctica: possible implications for sediment export efficiency

E J Steig, C P Hart, J W C White, W L Cunningham, M D Davis and E S Saltzman
Changes in climate, ocean and ice-sheet conditions in the Ross embayment, Antarctica, at 6 ka

M Stenberg, E Isaksson, M Hansson, W Karlén, P Mayewski, M Twickler, S Whitlow and N Gundestrup
Spatial variability of snow chemistry in western Dronning Maud Land, Antarctica

S Takahashi, T Kameda, H Enomoto, T Shiraiwa, Y Kodama, S Fujita, H Motoyama, O Watanabe, G A Weidner and C R Stearns
Automatic weather station program during Dome Fuji Project by JARE in east Dronning Maud Land, Antarctica

J Turner, S Leonard, T Lachlan-Cope and G J Marshall
Understanding Antarctic Peninsula precipitation distribution and variability using a numerical weather prediction model

R Udisti, S Becagli, R Traversi, S Vermigli and G Piccardi
Preliminary evidence of a biomass-burning event from a 60 year-old firn core from Antarctica by ion chromatographic determination of carboxylic acids

R Udisti, R Traversi, S Becagli and G Piccardi
Spatial distribution and seasonal pattern of biogenic sulphur compounds in snow from northern Victoria Land, Antarctica

N P M Van Lipzig, E van Meijgaard and J Oerlemans
Evaluation of a regional atmospheric model for January 1993, using in situ measurements from the Antarctic

D G Vaughan and J L Bamber
Identifying areas of low-profile ice sheet and out-crop damming in the Antarctic ice sheet by ERS-1 satellite altimetry

E R Venteris and I M Whillans
Variability of accumulation rate in the catchments of Ice Streams B, C, D and E, Antarctica

W F Vincent, I Laurion and R Pienitz
Arctic and Antarctic lakes as optical indicators of global change

W L Wang and R C Warner
Simulation of the influence of ice rheology on velocity profiles and ice-sheet mass balance

R C Warner and W F Budd
Modelling the long-term response of the Antarctic ice sheet to global warming

A B Watkins and I Simmonds
Relationships between Antarctic sea-ice concentration, wind stress and temperature temporal variability, and their changes with distance from the coast

G Weller
Regional impacts of climate change in the Arctic and Antarctic

Wen Jiahong, Kang Jiancheng, Han Jiankang, Xie Zichu, Liu Leibao and Wang Dali
Glaciological studies on the King George Island ice cap, South Shetland Islands, Antarctica

M J M Williams, R C Warner and W F Budd
The effects of ocean warming on melting and ocean circulation under the Amery Ice Shelf, East Antarctica

J-O Wolff
Antarctic sea-ice simulations with a coupled ocean/sea-ice model on a telescoped grid

J-O Wolff and J A T Bye
Drift patterns in an Antarctic channel from a quasi-geostrophic model with surface friction

A Worby and X Wu
East Antarctic sea ice: observations and modelling

X Wu and W F Budd
Modelling global warming and Antarctic sea-ice changes over the past century

N W Young, D Turner, G Hyland and R N Williams
Near-coastal iceberg distributions in East Antarctica, 50–145° E

H J Zwally, M Giovinetto, M Craven, V Morgan and I Goodwin
Areal distribution of the oxygen-isotope ratio in Antarctica: comparison of results based on field and remotely sensed data

C Zweck
Glacial isostasy and the crustal structure of Antarctica

JOURNAL OF GLACIOLOGY

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

G Aðalgeirsdóttir, K A Echelmeyer and W D Harrison
Elevation and volume changes on the Harding Icefield, Alaska

R B Alley and J J Fitzpatrick
Conditions for bubble elongation in cold ice-sheet ice

R B Alley, D E Lawson, E B Evenson, J C Strasser and G J Larson
Glaciohydraulic supercooling: a freeze-on mechanism to create stratified, debris-rich basal ice. 2. Theory

S P Anderson, K H Fernald, R S Anderson and N F Humphrey
Physical and chemical characterization of a spring flood event, Bench Glacier, Alaska: evidence for water storage

D B Bahr and M Dyurgerov
Characteristic mass balance scaling with valley glacier size

M R Bhutiyani
Mass balance studies on Siachen Glacier in Nubra Valley of the Karakorum Himalaya, India

R J Braithwaite, T Konzelmann, C Marty and O B Olesen
Errors in daily ablation measurements in North Greenland, 1993–94, and their implications for glacier-climate studies

C D Chadwell
Reliability analysis for design of stake networks to measure glacier surface velocity

M B Dyurgerov and D B Bahr
Correlations between glacier properties — in support of global glacier monitoring

G E Flowers and G K C Clarke
Trapridge Glacier surface and bed topography: digital elevation models and derived hydraulic geometry

S Gogineni, T Chuah, C Allen, K Jezek and R K Moore
An improved coherent radar depth sounder

G H Gudmundsson
A three-dimensional numerical model of the confluence area of Unteraagletscher, Bernese Alps, Switzerland

G Haardeng-Pedersen, K Keller, C C Tscherning and N Gundestrup
Modelling the signature of a transponder on the altimeter return data and determination of the reflection surface of the ice cap near the GRIP camp in Greenland

W Haeberli, A Kääb, S Wagner, D Vonder Mühll, P Geissler, J N Haas, H Glatzel-Mattheier and D Wagenbach
Pollen analysis and ^{14}C-age of moss remains recovered from a permafrost core recovered from the active rock glacier Murtèl/Corvatsch (Swiss Alps): geomorphological and glaciological implications

M J Hambrey, M R Bennett, J A Dowdeswell, N F Glasser and D Huddart
Debris-entrainment in polythermal valley glaciers

J K Hart and R I Waller
Further investigation of the deforming bed/debris-rich basal ice continuum from Worthington Glacier, Alaska

S I Hasnain and R J Thayyen
Controls on the major ion chemistry of the Dokriani glacier meltwaters, Ganga basin, Garhwal Himalaya, India

R Hock
A distributed temperature index ice and snow melt model including potential direct solar radiation

N R Iverson, R W Baker, R LeB Hooke, B Hanson and P Jansson
Coupling between a glacier and a soft bed. 1. A relation between effective pressure and local shear stress determined from till elasticity

N R Iverson
Coupling between a glacier and a soft bed. 2. Model results

N R Iverson, T S Hooyer and R W Baker
Ring-shear studies of till deformation and an hypothesis for reconciling Coulomb-plastic behavior with distribu-ted strain in glacier beds

D M McClung and J Schweizer
Skier triggering: snow temperatures and the stability index for dry slab avalanche inititation

R Michel and E Rignot
Flow of Moreno Glaciar, Argentina, from repeat-pass Shuttle Imaging Radar images: comparison of the phase correlation method with radar interferometry

M Nolan and K Echelmeyer
Seismic detection of transient changes beneath Black Rapids Glacier, Alaska, U.S.A.: I. Techniques and observations

M Nolan and K Echelmeyer
Seismic detection of transient changes beneath Black Rapids Glacier, Alaska, U.S.A.: II. Basal morphology and processes

J F Nye
Diffusion of isotopes in the annual layers of ice sheets

E C Pasteur and R Mulvaney
Laboratory study of the migration of methane sulphonate in firn

F Pauer, J Kipfstuhl, W F Kuhs and H Shoji
Air clathrate crystals from the GRIP deep ice core: a number, size and shape distribution study

E M Shoemaker
Subglacial water sheet floods, drumlins and ice sheet lobes

K Steffen, W Abdalati and I Sherjal
Faceted crystal formation in the NE-Greenland low accumulation region

R H Thomas, B M Csathó, S Gogineni, K C Jezek and K Kuivinen
Thickening of the western part of the Greenland ice sheet

INTERNATIONAL SYMPOSIUM ON THE VERIFICATION OF CRYOSPHERIC MODELS:

BRINGING DATA AND MODELLING SCIENTISTS TOGETHER

Zürich, Switzerland, 16–20 August 1999

CO-SPONSORED BY

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SECOND CIRCULAR

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Or via WWW site: http://www.geo.umnw.ethz.ch/igs-symposium

The International Glaciological Society is sponsoring an international symposium on the Verification of Cryospheric Models. The symposium will be held in Hauptgebäude F7 (Main Building F7), Eidgenössische Technische Hochschule ETH (Swiss Federal Institute of Technology), Rämistrasse 101, CH-8006 Zürich, Switzerland with registration starting on 15 August 1999, and sessions from 16–20 August 1999. For maps of Zürich, the ETH campus and information on transportation to ETH see the ETH web site: http://www.ethz.ch/search/search_en.html.

PARTICIPATION

This circular includes a form for registration, excursion deposits and accommodation. The form and accompanying payment should be returned before 22 May 1999. There will be a £45 surcharge for registrations received after 1 June. Full registration refunds will not be possible for cancellations received after 31 July 1999. The participant's registration fee covers organisation costs, copies of abstracts, the icebreaker, banquet, a bus pass and a copy of the *Annals of Glaciology*. The accompanying person's registration fee includes organisation costs, a bus pass, the icebreaker and banquet. There is an administration charge for participants who are not members of the International Glaciological Society.

REGISTRATION FEES	**£**
Participant (IGS member)	200
Participant (not IGS member)	250
Student	85
Accompanying person aged 18 or over	55
Late registration surcharge (after 1 June)	45

Refunds on registration fees will be made on a sliding scale, according to date of receipt of notification, up to 31 July 1999. After that date it may be impossible to make any refund. See booking form for methods of making payment. All who pre-register will receive a copy of the third circular and programme prior to the meeting.

TOPICS

Significant achievements have been made in the modelling of cryospheric components in recent years. Many models, however, remain untested, so their reliability is often uncertain. However, there has been an enormous increase in the amount and quality of data which might be used for testing models. This symposium will bring modellers, theoreticians and field scientists together to identify the needs and possibilities for verifying various models of the cryosphere.

The Symposium will include models and datasets covering all aspects of the cryosphere. Suggested topics include:

Ice sheets	Englacial hydrology	Avalanches
Ice shelves	Calving	Sea ice, lake ice and river ice
Ice streams	Ice in the atmosphere	Frozen soil and permafrost
Mountain glaciers and ice caps	Snow cover	Ice in the laboratory
Surges		

One session on mountain glaciers and ice caps will be dedicated to the late Fritz Müller of McGill University, Montréal and ETH, Zürich who made significant contributions to the glaciology of mountain glaciers. He died on the Rhonegletscher on 26 July 1980.

PAPERS

(I) SUBMISSION OF PAPERS

Participants who want to contribute to the Symposium should submit an abstract of their proposed paper. This abstract must contain sufficient detail to enable us to form a judgement on the scientific merit and relevance of the proposed paper. It should not exceed one page of typescript, on international-size paper A4 (210 x 297 mm). References and illustrations are not required. Place the title and author(s) names and address(es) at the top of the abstract, not on a separate sheet. Indicate at the bottom which specific topic it intends to address, and whether a poster presentation is preferred. When selecting material, authors should bear in mind that the final version of the paper should not exceed 5 printed pages in the *Annals*; extra pages will be charged at the rate of £90.00 per page. Send abstracts by E-mail, fax or regular mail to: Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K.

LAST DATE FOR RECEIPT OF ABSTRACTS: 8 February 1999

(II) SELECTION OF PAPERS

Each abstract will be assessed on its scientific quality and relevance to the topics of the Symposium. Authors whose abstracts are acceptable will be invited to make either an oral or poster presentation at the Symposium. There will be no distinction between oral or poster papers in the *Annals of Glaciology*. First or corresponding authors will be advised by mid April of the acceptance or otherwise; other authors will not be informed separately. Authors who have not received notification by the end of April should contact the IGS office in Cambridge. Acceptance of an abstract means that the paper based on it must be submitted to the *Annals of Glaciology* and not to another publication. Note: Abstracts alone will not be published in the *Annals of Glaciology*.

(III) DISTRIBUTION OF ABSTRACTS
A set of the accepted abstracts will be provided to all registered participants upon registration on 15 August 1999.

(IV) SUBMISSION OF PAPERS AND PUBLICATION
Four copies of each paper should be sent to the Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K. by 14 June 1999. ALL AUTHORS ARE EXPECTED TO ADHERE TO THIS DEADLINE. Papers should be prepared in accordance with the style instructions sent to authors with the abstract acceptance notification. Papers will be refereed according to the usual standards of the Society before being accepted for publication. Final papers, presented at the Symposium, which have been submitted and accepted by the Editorial Board, following review, will be published in English in the *Annals of Glaciology* (Vol. 31). Final, revised versions of papers, diskettes and original art work must be submitted by the end of September 1999. Speedy publication of the *Annals of Glaciology* will depend upon strict adherence to deadlines.

LAST DATE FOR RECEIPT OF PAPERS: 14 June 1999

PRE-SYMPOSIUM TOUR
A three-day excursion (Thursday, 12 August to Saturday, 14 August) to the Grimsel and Furka regions will be available for a small number of participants (less than 18) on a first-come first-serve basis. The tour will include a boat ride across Lake Grimsel to the snout of Unteraargletscher, a visit to the ongoing research and automatic theodolite stations and other measuring sites, and an overnight stay at the Lauteraarhutte of the Swiss Alpine Club. A four-hour walk will bring the tour back to Grimsel, from where it will travel to the Rhonegletscher and its "Vorfeld"; overnight will be at Hotel Belvedere near the glacier terminus. Total cost should not exceed £200.

MID-WEEK EXCURSIONS
A short two-hour walk on the afternoon of Wednesday, 18 August, will lead from the summit of Üetliberg (reached by train) back to the center of Zürich with its glacially moulded downtown area, illustrating features of Ice Age glaciation: extent, flow, mass balance and thermal conditions of glaciers, late-glacial to Holocene landscape evolution and river erosion, Quaternary sediments and ground water beneath Zürich.

POST-SYMPOSIUM TOUR
A 4-day excursion (Saturday, 21 August to Tuesday, 24 August) will take participants to the areas of Davos and the Upper Engadin (eastern part of the Swiss Alps) where intense research on various aspects of snow, ice and permafrost is presently being carried out. The first day includes travel to Davos, a visit to the Swiss Federal Institute for Snow and Avalanche Research at Flüelastrasse and on Weissfluhjoch, a short afternoon hike to sites related to avalanche defense and artificial snow, with overnight at Davos. Artificial snow and ski-run preparation will be discussed during the second day on Jakobshorn. On the way down to the Dischma Valley, temporary avalanche protection and reforestation projects, as well as results from Alpine hydrology experiments, will be presented at Stillberg. A long-established permafrost site at Flüelapass is on the way to the Engadin (second overnight). During the third day (four hours walking), the focus will be on high-mountain permafrost in the Val Muragl (rock glacier, drilling, geophysics, glacier/permafrost-interaction). The afternoon will be devoted to avalanche and debris-flow problems at Pontresina Schafberg, with special emphasis on permafrost. Overnight is again in the Engadin. The fourth and final day will illustrate features of recent glacier shrinkage, permafrost evolution and slope stability in the Bernina Group (Piz Corvatsch, Morteratschgletscher). Total cost should not exceed £250.

ACCOMPANYING PERSON'S PROGRAMME
An active programme is being developed for those accompanying participants. This will involve a half-day and two full-day excursions during the week to sites of scenic, historic and academic interest. There may be an additional charge for some of these. More details will be available on the Symposium Web site in due course and at registration.

ACCOMMODATION
A wide range of accommodation is available in Zürich. Hotel reservations should be made directly through Zürich Tourismus, Hotelreservation, Postfach, CH-8023 Zürich (Tel: [44](1)215-40-40; Fax: [44](1)215-40-44; hotel@zurichtourism.ch; www.zurichtourism.ch) using the enclosed reservation card.

If more modest accommodation is required, contact Zürich Tourismus directly, or add a special request to the card mentioning the Symposium name (IGS Symposium 99).The more economical hotels offer daily B&B rates of 50SF (single)/80SF (double) for a room with basin, but communal bathrooms. The Youth Hostel offers a daily B&B rate of 30SF for a shared room.

TOURIST INFORMATION
Information on tourist activities in and around Zürich can be obtained from Zürich Tourismus Bahnhofbrüche 1, CH-8023 Zürich (Tel: [44](1)215-40-40; Fax: [44](1)215-40-49; Infotelefon: [44](175)120-210; information@zurichtourism.ch; www.zurichtourism.ch).

IMPORTANT DATES:

Abstracts due	8 February 1999
Notification of acceptance	12 April 1999
Preregistration	22 May 1999
Papers due	**14 June 1999**
Deadline for full refund	28 June 1999
Deadline for refund	31 July 1999
Conference starts	16 August 1999
Revised papers due	27 September 1999

To avoid disappointment, please respect the above deadlines.

ASSOCIATED SYMPOSIUM CO-SPONSORED BY THE IGS

Participants may be interested in the Sixth International Symposium on Thermal Engineering and Sciences for Cold Regions to be held in Darmstadt, Germany, from 22–25 August, 1999;

For details contact Dr Yongqi Wang, Institut für Mechanik, Technische Universität Darmstadt, Hochschulstrasse 1, D-64289 Darmstadt, Germany (Tel [49](6151)163196; Fax [49](6151)164120; wang@mechanik.tu-darmstadt.de; www.mechanik.tu-darmstadt.de/ag3/ISTESCR99

INTERNATIONAL SYMPOSIUM ON VERIFICATION OF CRYOSPHERIC MODELS

Zürich, Switzerland, 16-20 August 1999

REGISTRATION FORM

Family Name: ______________________ Tel: ______________________
First Name: ______________________ FAX: ______________________
Address: ______________________ E-mail: ______________________

Accompanied by:
Name: ______________________ Age (if under 18) ________
Name: ______________________ Age (if under 18) ________
Name: ______________________ Age (if under 18) ________

REGISTRATION FEES £		£	
Participant (Member of the IGS)		200	_____
Participant (Not a member of the IGS)		250	_____
Student		85	_____
Accompanying person aged 18 or over		55	_____
Late registration surcharge (after 1 June)		45	_____
Excursion deposits:	Pre-symposium tour	50	_____
	Post-symposium tour	50	_____

TOTAL REGISTRATION FEES AND DEPOSITS SENT _____

Payment may be made by cheque, in pounds sterling drawn on a UK bank, payable to

INTERNATIONAL GLACIOLOGICAL SOCIETY

By Access/Eurocard/MasterCard or VISA/Delta

Card No. [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ] Expires [ ][ ][ ][ ]

Signature:

Payment may also be made directly to: National Westminster Bank plc,
account no: 54770084, 56 St. Andrew's Street, Cambridge CB2 3DA, UK,
or to our Post Office GIRO account no: 240 4052 (including any Bank or Transfer charges).

Mail to: Secretary General, International Glaciological Society, Lensfield Road,Cambridge CB2 1ER, UK

If payment made after 1 June 1999, add surcharge of £45 for each person.

FUTURE MEETINGS (of other organizations)

EISMINT/EPICA SYMPOSIUM ON ICE SHEET MODELLING AND DEEP ICE DRILLING

European Geophysical Society XXIV General Assembly, Den Haag, The Netherlands, 20–22 April 1999

CO-SPONSORED BY

European Science Foundation
International Glaciological Society

FIRST CIRCULAR AND CALL FOR PAPERS

The European Science Foundation (ESF) and International Glaciological Society (IGS) are jointly sponsoring an international symposium on Ice Sheet Modelling and Deep Ice Drilling to be held at the European Geophysical Society XXIV General Assembly in Den Haag, The Netherlands from 20–22 April 1999. The symposium is being held as a special session of the EGS General Assembly to attract a much wider audience than is normally the case for European glaciological meetings.

THEME AND TOPICS

This symposium combines the mutual interests of two major European funded programmes, EISMINT (European Ice Sheet Modelling Initiative) and EPICA (European Project for Ice Coring in Antarctica). It also covers the recent activities in Greenland by the GRIP and NGRIP projects and in Antarctica by non-European projects. We welcome contributions on the EISMINT aims, which have have been to improve ice sheet modelling and has concentrated on aspects such as inter-comparison of models, interactions between ice sheets and the atmosphere, ocean, bed and lithosphere, rheology of ice, etc. EPICA has begun deep drilling at Dome C in central Antarctica and has carried out site surveys in Dronning Maud Land (DML) in preparation for deep drilling there in the next few years. Contributions on preliminary results from the Dome C and Dome Fuji cores and from the site and areal surveys in both DML and Dome C are invited. Especially welcome will be contributions covering the use of modelling to select suitable drilling sites, improving interpretation of core parameters such as age, and using accurately dated core/depth data for testing models.

SESSIONS

Oral presentations will be held over the three days, 20–22 April 1999. Poster displays are welcome.

PUBLICATION

Papers from the symposium will be published in the Annals of Glaciology. All papers will be refereed and edited to the standards normally applied by the IGS to the Journal of Glaciology.

ABSTRACTS

The deadline for receipt of abstracts is 15 December 1998. Please send one copy to the IGS office (address below) and one copy to the EGS Office. Details of how to submit abstracts to EGS are given on their website, http://www.copernicus.org/EGS/. Please note that abstracts submitted in their required format will be processed and published by EGS prior to the meeting.

One copy of the abstracts should also be submitted to the IGS office:

EISMINT/EPICA Symposium
International Glaciological Society
Lensfield Road
Cambridge CB2 1ER
UK
Tel: [44](1223)355974
Fax: [44](1223)336543
Int_Glaciol_Soc@compuserve.com

PAPERS
Papers should be submitted by 26 March 1999. Please send one copy to the IGS office at the address given above. We hope that authors will be able to interact with the Annals' Editors while at the meeting to ensure rapid publication.

EGS: REGISTRATION, ACCOMMODATION, ETC.
Participants are requested to make their symposium arrangements through the EGS channels.
Details of abstract format and submission, accommodation, registration, financial support schemes, travel to The Hague (Den Haag), etc can be found on the EGS website, http://www.copernicus.org/EGS/ under EGS99: XXIV General Assembly, or on request from the EGS Office at the address below.
The EISMINT/EPICA symposium comes under the Oceans and Atmosphere section of EGS, and has been numbered OA37.

PLEASE NOTE THE FOLLOWING DEADLINES

Abstract submission: 15 December 1998.

Registration: (pre-) registration rates are cheapest before 29 January 1999 and (normal) rates before 26 March are cheaper than on-site rates. Registration rates depend on status (AGU members with an address outside Europe are regarded as full EGS members).

Hotel accommodation should be booked by 15 February 1999.

EGS OFFICE

Max-Planck-Str. 13
D-37191 Katlenburg-Lindau
Germany
Tel: [49]5556-1440
Fax: [49]5556-4709
egs@copernicus.org

FINANCIAL SUPPORT
There is limited financial support from EGS for scientists born in or after 1970. See EGS website for details. In addition, there will be support for young scientists (under 30) from ESF. Please indicate when submitting your abstract to IGS whether or not you wish to apply for an ESF award. Funding is available only to scientists who are presenting a paper of which they are the principal author. Persons applying for a grant should indicate their estimated travel costs (with estimate from travel agency) with their request. Those who are successful will be told before the meeting what expenses will be allowed (up to a maximum of 3 kFFr).

SYMPOSIUM HOMEPAGE
ESF will host a homepage about the symposium

http://www.esf.org/LESC/EISMINT/

Questions about the symposium itself should be addressed to:

Philippa Rowe. EISMINT
European Science Foundation
1 quai Lezay Marnesia
F-67080 Strasbourg Cedex
France
Tel: [33](3)88 76 71 29
Fax: [33](3)88 37 05 32
LESC@esf.org
http://www.esf.org/LESC

CONVENORS:

Dr C S M Doake
Prof C U Hammer
Dr P Huybrechts
Prof J Oerlemans
Dr D A Peel

JSH12: ICE SHEETS, OCEANS, AND THE EARTH'S SHAPE: MODERN PERSPECTIVES ON SEA-LEVEL CHANGE

IUGG General Assembly, Birmingham, UK, during the 3-day period 21–23 July

ANNOUNCEMENT

Climate models predict an overall increase in global temperature over the next century of 1–4°C. An increase of this magnitude could cause a global rise in sea level due to a combination of melting polar ice caps and continental glaciers, and the thermal expansion of sea water. On the other hand, the climate changes associated with global warming might lead to increased precipitation over ice sheets, resulting in an increase in the amount of water trapped in polar ice caps and thus a decrease in eustatic sea level.

Although the average rate of global sea level rise during the last century has apparently been between 1.5–2.5 mm a^{-1}, its causes have yet to be fully understood and quantified. How much is due to thermal expansion of the oceans? How much to input from lakes, ground water and mountain glaciers? Are the Antarctic and Greenland ice sheets gaining or losing mass? Must the stability of marine ice sheets be considered, especially given the history of so-called Heinrich events?

Approaches to these questions are manifold. Satellite-based methods now join traditional tide-gauge records in measuring the world-wide change in sea level. Careful geodetic measurements can separate the sea-level-change signal from other geophysical effects, such as post-glacial rebound. Such observations include determination of changes in mass of the ocean and the ice sheets, taking into account the effects of visco-elastic processes on geodynamically unstable shorelines, transfer of ground water to the ocean, glacial rebound, and tectonic processes. Measurements of secular changes of the different spherical harmonic coefficients of the earth's gravitational field and its rotational and orientational parameters can potentially isolate the individual effects of post- glacial rebound, changing sea level, and changing ice sheet volumes. Modeling is another vital approach – the interactions among measurements, processes, and modeling are critical to understanding these processes and their implications for sea level change.

The proposed symposium would encourage papers on all aspects of sea-level change and its causes. Topics could include:

- Measuring present-day sea-level change
- Sea-level variations through the Holocene
- Thermal expansion of the ocean
- Changes in the dynamic topography of the ocean
- Models of oceanic change
- Present-day and predicted changes in the mass and volume of the ice sheets
- The contribution of smaller glaciers and ice caps to sea-level rise
- Marine-ice-sheet instability
- The contribution of isostatic rebound to sea-level change
- Temporal changes in the geoid
- Changes in the Earth's rotational and orientational parameters

Convenor: Charles R. Bentley
Geophysical and Polar Research Center
University of Wisconsin
1215 West Dayton Street
Madison, WI 53706, U.S.A.
Tel [1](608)262-1922; Fax [1](608)262-0693; bentley@geology.wisc.edu

Co-convenors: W. Richard Peltier
Department of Physics
University of Toronto
60 St. George St.
Toronto, Ontario M5S 1A7, Canada
Tel [1](416)978-2938; Fax [1](416)978-8905; peltier@atmosp.physics.utoronto.ca

Atsumu Ohmura
Chairman, Institute of Geography
Swiss Federal Institute of Technology (ETH)
Winterthurerstrasse 190
CH-8057 Zürich, Switzerland
Tel [41](1)635 5220; Fax [41](1)362 5197; ohmura@geo.umnw.ethz.ch

The deadline for abstracts is 15 January

More information can be found on the IUGG 99 Homepage: http://www.bham.ac.uk/IUGG99/

AGU FALL MEETING — H19, GLACIERS AND ICE SHEETS

San Francisco, 6–10 December 1998

The complexity of glacier systems (mechanical, constitutive, thermal, chemical) probably precludes ever obtaining a fully deterministic understanding. Although concentration of efforts on selected aspects of glacier dynamics is essential to progress, it is often unclear what aspects should be selected. What problems in glacier dynamics promise to yield the greatest scientific benefit once solved? Which tools presently in use, or in development, can add significantly to our broad understanding of glacier processes? How can related fields, such as glacial geology, be better integrated into glacier dynamics research? This session will cover all aspects of glaciers and ice sheets but particularly those dealing with the above themes.

Conveners:

W. Tad Pfeffer
Institute of Arctic and Alpine Research
CB-450, University of Colorado
Boulder, CO 80309-0450, U.S.A.
Tel: [1](303)492-3480
Fax: [1](303)492-3480,
pfeffer@tintin.colorado.edu

Andrew G. Fountain
Department of Geology
Portland State University
Portland, OR 97207-0751, U.S.A.
Tel: [1](503)725-3386
Fax: [1](503) 725-3025
fountaina@pdx.edu

56th EASTERN SNOW CONFERENCE
Monitoring Snow and Ice: Methods and Techniques for Operational Applications and Climate Change Studies

Fredericton, New Brunswick, Canada, 2–4 June 1999

FIRST ANNOUNCEMENT AND CALL FOR ABSTRACTS

Remote sensing offers important advantages for observing snow and ice, and the current generation of high resolution microwave satellites offers important all-weather capabilities for mapping and change detection. The all-weather capability is particularly important in areas such as the east coast of Canada which are prone to persistent cloud covers. For many operational applications, surface-based observations are still required. However, the merging of satellite and surface-based observations offers many exciting possibilities for both operational applications and for climate-change related studies. The purpose of the 56th Annual Meeting of the Eastern Snow Conference (ESC) is to encourage the operational and research communities to interact, discuss and compare results on the application of traditional and remotely-sensed techniques for mapping snow and ice. As in past Eastern Snow Conferences, papers on any subject pertaining to snow and ice will also be most welcome.

The 56th Annual Meeting of the ESC will be hosted jointly by the New Brunswick Department of Environment and NB Power and Environment Canada in Fredericton, N.B., Canada from 2–4 June 1999. As the capital of New Brunswick, Fredericton is replete with history and beautiful scenery. World-renowned art, interesting architecture and crafts, and hospitable people will enhance the conference.

If you are interested in attending the meeting, please fill out the pre-registration form (see reverse) and return it to the Program Chair as shown below, or fill out the electronic form on the ESC Home page at

http://www.tor.ec.gc.ca/CRYSYS/esc/

If you plan to present an oral or poster presentation, please send in an abstract by 15 January 1999, preferably by e-mail. Please send to the Program Chair:

Dorothy Hall
NASA/Goddard Space Flight Center
Code 974
Greenbelt, MD 20771, USA.
Tel [1](301)614-5771; Fax [1](301)614-5808; dhall@glacier.gsfc.nasa.gov

As in previous years, the journal Hydrological Processes has agreed to publish up to 10 papers from the ESC. The subject matter of these papers must fit within the scope of the journal, and papers will be subject to the peer-review process of the journal. Authors who intend to submit their ESC papers to Hydrological Processes should indicate this on their abstract, attend the ESC in June to present the paper, and submit four copies of their paper to the ESC editors by 1 April 1999. Authors should consult the "Notes for Contributors" published on the inside back cover of Hydrological Processes for details on the format for submissions. Further information can be obtained from the ESC Editors:

Susan Taylor and Janet Hardy
USA-CRREL
72 Lyme Road, Hanover
NH 03755-1290, USA
Susan Taylor (Tel [1](603)646-4239; Fax:[1](603)646-4664; staylor@crrel.usace.army.mil)
Janet Hardy (Tel [1](603)646-4306; Fax [1](603)646-4397; hardy@crrel.usace.army.mil)

Student participants are encouraged to enter the Annual ESC Student Paper Competition for the best student paper describing research on a topic related to snow or ice. For conditions and details please consult the ESC homepage. Student papers will be given identical treatment to any abstract submitted to the Conference. To be considered for the student paper award, four copies of the paper with the supervisor's endorsement must reach the Chair of the Research Committee, Suzanne Hartley, postmarked not later than 28 February 1999.

GLACIOLOGICAL DIARY

** IGS sponsored * IGS co-sponsored

1999

19–22 April 1999
64th Western Snow Conference, Lake Tahoe: a Microcosm of Water Issues in the West, South Lake Tahoe, California, U.S.A.
R. Kattlemann, Sierra Nevada Aquatic Research Lab., Star Route 1, P.O. Box 198, Mammoth Lakes, CA 93546, U.S.A. (Tel [1](619)935-4903; Fax [1](619)935-4867; rick@icess.ucsb.edu; http://snobear.colorado.edu/WSC/WSC.html)

20–22 April 1999
* EISMINT/EPICA Symposium on Ice Sheet Modelling and Deep Ice Drilling, European Geophysical Society General Assembly, Den Haag, The Netherlands
Philippa Rowe, EISMINT, European Science Foundation, 1 quai Lezay Marnesia, F-67080 Strasbourg Cedex, France (Tel [33](3)88 76 71 29; Fax [33](3)88 37 05 32; LESC@esf.org; http://www.esf.org/LESC/EISMINT/

30 May – 4 June 1999
AGU Spring Meeting, Boston, Massachusetts
http://www.agu.org

30 May – 4 June 1999
ISOPE-99, 9th International Offshore and Polar Engineering Conference, Brest, France
ISOPE-99, P.O. Box 1107, Golden, CO 80402-1107, USA (Tel [1](303)420-8114; Fax: 303-420-3760)

2–4 June 1999
56th Eastern Snow Conference, Monitoring Snow and Ice: methods and Techniques for Operational Applications and Climate Change Studies, Fredericton, New Brunswick, Canada
D.K. Hall, Code 974, NASA/Goddard Space Flight Center, Greenbelt, MD 20771, U.S.A. (Tel [1](301)614-5771; Fax [1](301)614-5808; dhall@glacier.gsfc.nasa.gov; http://www.tor.ec.gc.ca/CRYSYS/esc/)

11–16 July 1999
OMAE '99, 18th International Conference on Offshore Mechanics and Arctic Engineering, St. John's, Newfoundland, Canada
J. Myrick-Harris, Conference Office, Hatcher House, Memorial University of Newfoundland, St. John's, Newfoundland, Canada (Tel [1](709)737-7922; Fax [1](709)737-3520; jharris@morgan.ucs.mun.ca; http://www.mun.ca/ccore/omae99/)

19–30 July 1999
XXII General Assembly of the International Union of Geodesy and Geophysics, Birmingham, U.K. (http://www.bham.ac.uk/IUGG99/)
Interactions Between the Cryosphere, Climate and Greenhouse Gases
M. Tranter, Department of Geography, University of Bristol, Bristol BS8 1SS, U.K. (Tel [44](117)928-8307; Fax [44](117)928-7878; tranter@bris.ac.uk; http://www.wlu.ca/~wwwiahs/index.html)

Hydrology of Ice-covered Rivers
M.G. Ferrick, CRREL, 72 Lyme Road, Hanover, NH 03755-1290, U.S.A. (Tel [1](603)646-4287; Fax [1](603)646-4785: mferrick@crrel.usace.army.mil)
Ice Sheets, Oceans, and the Earth's Shape: Modern Perspectives on Sea-level Change
C.R Bentley, Geophysical and Polar Research Center, University of Wisconsin, 1215 West Dayton Street, Madison, WI 53706, U.S.A. (Tel [1](608)262-1922; Fax [1](608)262-0693; bentley@geology.wisc.edu)

16–20 August 1999
** International Symposium on the Verification of Cryospheric Models, Zürich, Switzerland
Secretary General, International Glaciological Society, Lensfield Road, Cambridge, CB2 1ER, UK (http://www.geo.umnw.ethz.ch/igs-symposium)

22–25 August, 1999
* 6th International Symposium on Thermal Engineering and Sciences for Cold Regions, Darmstadt, Germany
Y.Wang, Institut für Mechanik, Technische Universität Darmstadt, Hochschulstrasse 1, D-64289 Darmstadt, Germany (Tel [49](6151)163196; Fax [49](6151)164120; wang@mechanik.tu-darmstadt.de; www.mechanik.tu-darmstadt.de/ag3/ISTESCR99)

27–30 July 1999
IUTAM Symposium on Scaling Laws in Sea Ice Mechanics and Sea Ice Dynamics
John P. Dempsey, Dept. of Civil and Environmental Engineering, Clarkson University, Potsdam, NY 13699-5710, U.S.A. (Tel [1](315)268-6517; Fax [1](315)268-7985; john@jpdnz.cee.clarkson.edu)

23–27 August 1999
POAC 99, 15th International Conference on Port and Ocean Engineering under Arctic Conditions, Espoo, Finland
K.A. Riska, Ship Laboratory, Helsinki University of Technology, P.O. Box 4100, FIN-02150 HUT, Finland (Tel [358](9)451-3498; Fax [358](9) 451-3493; kaj.riska@hut.fi; info@tsgcongress.fi)

7–8 September 1999
* International Conference on the Deformation of Glacial Materials, London, England
(Bryn P. Hubbard, Centre for Glaciology, Inst. of Geography & Earth Sciences, University of Wales, Aberystwyth SY23 3DB, Ceredigion, Wales, UK (Tel [44](1970)622-783; Fax [44](1970)622-780; byh@aber.ac.uk; http://www.gaber.ac.uk/~byh/dgm99.html)

27–30 September 1999
Fifth International Ice Drilling Technology Workshop, University of Nebraska, Lincoln, Nebraska
PICO, P.O. Box 830850, University of Nebraska-Lincoln, Lincoln, NE 68583-0850, U.S.A. (Tel [1](402)472-9833; Fax [1](402)472-9832; sirg-pico@unlinfo.unl.edu)

2000

22–26 May 2000
** International Symposium on Snow and Avalanches, Innsbruck, Austria
Secretary General, International Glaciological Society, Lensfield Road, Cambridge, CB2 1ER, UK

28 May – 2 June2000
ISOPE-2000, 10th International Offshore and Polar Engineering Conference and Exhibition, Seattle, Washington, U.S.A.
ISOPE-2000, P.O. Box 1107, Golden, CO 80402-1107, U.S.A. (Tel [1](303)273-3673; Fax: [1](303) 420-3760

18–23 June 2000
** International Symposium on Sea Ice and its Interactions with the Ocean, Atmosphere and Biosphere, Fairbanks, Alaska, U.S.A.
Secretary General, International Glaciological Society, Lensfield Road, Cambridge, CB2 1ER, UK (http://www.gi.alaska.edu/seaicesymposium)

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)

2001

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

to be announced
** Remote Sensing in Glaciology, Washington, DC
Secretary General, International Glaciological Society, Lensfield Road, Cambridge, CB2 1ER, UK

August 2001
** Ice Cores and Climate, Kangerlussuag, Greenland
Secretary General, International Glaciological Society, Lensfield Road, Cambridge, CB2 1ER, UK

2003

23-27 June 2003
8th International Conference on Permafrost, Zürich, Switzerland

NEW MEMBERS

Aldasoro, Inigo Auze, c/ Areso 2, 2 izgd., Lazkao, ES-20 210, Spain (ix9310@xpress)

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