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Contents

Cover picture: Marginal lake caused by ablation, Kersten Glacier near Uhuru Peak, Kilimanjaro, Tanzania. A white, 1.5 m long ablation stake is visible lying horizontally on the rocks at the far end of the meltwater pond. Photo: Douglas Hardy.

Scanning electron micrograph of the ice crystal used in headings by kind permission of William P. Wergin, Agricultural Research Service, US Department of Agriculture

From the Editor

Dear IGS member

As you may already have heard through our submission to the Cryolist or our Twitter and Facebook pages, the new thematic *Annals of Glaciology* is now included in the following Thomson Reuters products beginning with Volume 50, Issue 50:

Science Citation Index – Expanded (SCIE), including the Web of Science

ISI Alerting Service

Current Contents/Physical, Chemical & Earth Sciences (CC/PC&ES)

This of course is fantastic news and a great relief to us all. We had seen a decline in submissions to the *Annals* but the revamping of the *Journal*, the change in editorial policy and the decision to publish the *Annals* as a thematic journal have paid off. Already we are seeing an increase in submissions. And let me thank all of you who showed patience and submitted papers to the *Annals* when we were unsure when it would be back in SCIE.

We have now had the opportunity of using our online registration system for three symposia and from our point of view it has worked very well. All payments are easier to process (you, the delegate, are doing the work) and we have a much better handle on what you are registering for. We are planning to take this one step further now and will be opening up the system very soon for you to register your 'interest' in attending the IGS symposium to be held at the Scripps Institute in La Jolla, California, next June. Once you know definitely whether you will be able to attend, you can go online again and confirm your attendance. This will further reduce the amount of paperwork and faxes required. But let me also reassure those of you who are not able to do all those fancy things on the internet that we will, of course, continue to accept manual registrations and we are able to register you on the system manually.

We have now been running the online submission system for the *Journal* for a couple of months. We are still ironing out some glitches and getting your Scientific Editors familiar with using it. As soon as everything has been smoothed out we will also introduce the submission system for the *Annals*. We anticipate that the first *Annals* papers to go through the system will be the papers for the thematic issue on 'Interactions of Ice Sheets and Glaciers with the Ocean', which we will start processing at the beginning of 2011.

As I mentioned in my last editorial, the 200th issue of the *Journal* will be published near the end of the year. We will be revisiting some classic past papers published in the *Journal* and offering some insights into those papers and the reasons that they are now considered 'classic'. Another issue I mentioned was the picture for the cover. We are holding a competition for the cover picture and invite you to send in your best 'snow and ice'-related photograph for consideration. Some restrictions, however: the picture has to be 'portrait' format, to have no people in the foreground, to be very sharp and of excellent quality. The winner will receive a year's membership to the IGS with all the attendant perks and a framed picture of the *Journal* cover showing their winning entry. A low-resolution version should be sent to journal@igsoc.org by 31 October.

Finally I would ask all of you to encourage your colleagues and students to join the IGS. We have been able to turn the drop in membership around and are now approaching the 2004 level and hope to surpass that shortly. But we are still short of the previous maximum, set in 2001.

Magnús Már Magnússon
Secretary General

Recent work

Canada

Requests for contributions to this report were sent to some 500 individuals with Canadian affiliations known to have worked on, or reported on, some aspect of snow and ice from 2007–09. This was about ¼ of those identified through a bibliography of more than 2000 items compiled for this period. They were associated with 9 federal departments, 50 universities, more than 20 provincial departments and agencies, and at least 50 private companies. As the response rate was only 6%, it seemed necessary to highlight some organizations known to be active whose work was not reported. Canadian glacier work, however, is reasonably well covered in the reports below. The principal organizations are included in the Western Canadian Cryospheric Network (http://wc2n.unbc.ca), though mention should be made of the following that are not part of WC²N: COGS, TrentU, ULav, ULeth, UOtt and UWO. Very few reports on permafrost research are included here because scientists have become accustomed to submitting their annual reports to Frozen Ground (http://ipa.arcticportal.org/index.php/Frozen-Ground), the newsletter of the International Permafrost Association. Research in the federal government takes place mainly in NRCan, INAC and EC, the latter in support of northern hydrology investigations. Work through the CSA and NRCC is looking at planetary analogue sites and microbial populations. The main universities involved would be: CU, McGU, QueensU, UCal, ULav, UOtt, UWO and WLU. Snow research falls into a number of categories including: meteorology and monitoring of the snow cover, physics and modelling of processes, and avalanche-related work. The MSC and various provincial agencies cover the first. Universities such as UMAN, UAlb, UNBC, USher, WLU and YorkU are involved in all aspects, particularly remote sensing, with the CH at USask being particularly strong on the process side, and UBC and UCal being a focus for avalanche studies, with the Canadian Avalanche Centre in Revelstoke (www.avalanche.ca) and the Centre d'avalanche de la Haute-Gaspésie (www.centreavalanche.qc.ca) in Quebec. Atmospheric ice studies relate to icings on power lines and aircraft for which a major centre is UQAC, but also include hail and snow and its properties for which the following are involved: DU, McGU, UAlb, UQAM, USher, UTor and NRCan. Problems of marine icing are mainly addressed at CHC, IOT, MUN and UAlb. Work on floating ice incorporates both the marine sector and ice on lakes and rivers. The CIS is a principal agency for the former. One noticeable omission from the reports below is any mention of the Circumpolar Flaw Lead (CFL) system study (www.ipy-cfl.ca), a major initiative for the IPY led by the UMAN. Marine-sector ice work is mainly carried out at IOT, IOS, CHC, MUN and ULav. Major players, principally on the freshwater side, are at NWRI/Sask, UVic, UAlb, UCal, UWat, ISMER and INRS-ETE. The physics of ice, as it relates to activities in the marine sector, is being investigated by CHC, IOT and MUN. Several groups are also involved in attempting to understand extraterrestrial glaciological features and these include scientists at ConcU, CSA, McGU, NRCan, NRCC, UOtt, UWO and YorkU. Although there are many other organizations and groups in Canada involved in snow and ice work, only the major ones are identified above.

GLACIERS – GENERAL

The state and evolution of Canada's glaciers
M.N. Demuth, D.O. Burgess, C.M. Zdanowicz, GSC; and others
A Glacier-Climate Observing System (GCOS) is being delivered through an integrated monitoring and research collaborative comprised of federal government and university researchers. Observations are derived from in-situ measurements at a network of reference glaciers in the Cordillera and the Canadian Arctic Islands. Air- and space-borne remote sensing are used to generate regional perspectives on the state of land ice and its responses to climate variations. The State and Evolution of Canada's Glaciers initiative (http://pathways. geosemantica.net/WSHome. aspx?ws=NGP_SECG&locale=en-CA) documents information and data products produced by GCOS (monitoring, assessment and data portal) and related freshwater vulnerability research in western and northern Canada. It also provides leadership and co-ordination for Canada's contributions to the WMO's Global Terrestrial Observing System (GTOS) and Global Terrestrial Network for Glaciers (GTN-G).
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Global glaciology
J.G. Cogley, Geog/TrentU
A dataset containing time series of annual mass balance, measured by the glaciological method, is being maintained. Recently it has been expanded to include measurements, mostly multi-annual, by geodetic methods. The aim of the project, which is to include all published measurements, is substantially met for glaciological measurements and nearly met for geodetic measurements. About 650 glaciers and glacierized regions are represented in the augmented dataset. Geodetic balances, although they have poor temporal resolution, provide greater historical depth and coverage. The dataset was the principal source for contributions to the IPCC Fourth Assessment (Working Group I) and to the current Arctic Council assessment project SWIPA (Snow, Water, Ice and Permafrost in the Arctic). A more complete version of the World Glacier Inventory, called WGI-XF, is now available. It includes records for 131,000 glaciers, compiled from the existing WGI, recently published, regional inventories, some older inventories that had been lost from the WGI, and some new inventories completed at Trent University. WGI-XF has an extended format that is described quite precisely, the aim being to improve the comparability of records from different sources. A global dataset of rates of glacier shrinkage (reduction of area) is being developed. Preliminary results from 152 published sources, representing more than 600 glaciers and glacierized regions, have been presented at conferences. As for the mass-balance dataset and WGI-XF, digital files are available (www.trentu.ca/geography/glaciology/glaciology.htm).
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Glaciological applications of geomatics
C.D. Hopkinson, COGS/NSCC
Recent and ongoing work is developing new geomatics technologies and methodologies for glaciological applications. This has involved airborne and terrestrial LIDAR in the past, but now includes looking at data-fusion applications such as LIDAR, AWS and oblique temporal thermal imagery to investigate glacier motion and periglacial energy-balance dynamics and thus to model ice contributions to melt runoff.
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GLACIERS – NUNAVUT

Internal accumulation
T. Clérac, J.G. Cogley, Geog/TrentU
Internal accumulation, the refreezing of percolating meltwater below the summer surface, is the largest single unquantified bias affecting mass-balance measurements at large (regional and global) scales. A project to develop post-hoc corrections for this bias has begun. It will rely principally on DEMs of the ice cover and records of temperature and geopotential height from meteorological re-analyses. In a pilot project covering the Queen Elizabeth Islands, Nunavut, these records have been used to construct 6-hourly series and monthly sums of positive degree-days, which are interpolated 3-dimensionally to the DEMs. The ELA is estimated from independent sources. It has been shown that on a climatological, but not in general an annual, timescale the dry snowline (where the annual positive degree-day sum is zero) lies above the surface in the Queen Elizabeth Islands. Internal accumulation is likely to be non-zero between the wet snowline and the snowline. Simple models for the identification of these two features, and for the quantification of internal accumulation in the zone between them, are under development.
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Arctic ice shelf changes
L. Copland Geog/UOtt; D.R. Mueller, CIS; and Canatec Associates Ltd
Investigations are currently underway into the extent and causes of recent breakups of ice shelves along northern Ellesmere Island. These features have lost over of their area in the last 5 years, with the complete loss of the Ayles and Markham Ice Shelves. A new field site has been established that provides direct access to the Milne and Petersen Ice Shelves. Recent fieldwork has focused on GPR surveys of ice depths and measurements from ground-truth to high-resolution satellite imagery.
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Re-visiting Agassiz Ice Cap, Ellesmere Island
D.A. Fisher, GSC
Since the Agassiz and Renland Ice Caps have given the best picture of Holocene climate history, and since the ice cores from both were mainly analyzed for stable isotopes, melt features and ECM, they should be re-drilled to provide thorough high-resolution records of chemistry, pollen and biological markers. Detailed radar mapping of their internal layer structure and ice-flow modelling should also be re-done with more powerful modern methods. A consortium of partners is being organized to carry out this project, and greatly augment the considerable body of knowledge we already have about the Agassiz Ice Cap, using new technologies developed since the ice cap was last drilled.
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Mass balance of Prince of Wales Icefield, Ellesmere Island

D.W.F. Mair, GEnv/UAber; D.O. Burgess, GSC; M.J. Sharp, EAS/UAlb; J.A. Dowdeswell, T.J. Benham, SPRI; S.J. Marshall, Geog/UCal; F.G.L. Cawkwell, UCC

The total mass balance of Prince of Wales Icefield, Ellesmere Island, was estimated from long-term surface mass balance (SMB) and iceberg-calving data. Shallow-ice-core net-accumulation measurements and annual mass-balance stake measurements were used in conjunction with a DEM, and knowledge of the location of the dominant moisture source for precipitation over the ice cap, to interpolate and extrapolate potential spatial patterns of SMB across the icefield. The contribution of iceberg calving to the mass balance was calculated from estimates of both the annual volume of ice discharged at the major tidewater glacier termini and the annual volume loss or gain due to terminus fluctuations. The overall mass balance of the icefield from 1963–2002 was estimated at –0.11 m w.e. a^{-1}, equating to ~0.2 mm of global sea-level rise.

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Mass balance of White and Baby Glaciers, Axel Heiberg Island

J.G. Cogley, M.A. Ecclestone, Geog/TrentU

Measurements of annual mass balance continue on White Glacier. Measurements on the smaller Baby Glacier have become irregular due to lack of resources. Digital files are available (www.trentu.ca/geography/glaciology/glaciology.htm). On White Glacier, the average decadal balance (kg m^{-2} a^{-1} ± 2 standard errors) has been growing significantly more negative since the 1970s:

Decade	Mass balance	Number of years
1960–1969	–123 ± 126	10
1970–1979	–14 ± 126	10
1980–1989	–111 ± 151	7
1990–1999	–257 ± 126	10
2000–2008	–321 ± 133	9

The annual mass balance for the balance year 2006–07, –818 kg m^{-2} a^{-1}, is the most negative ever measured, slightly exceeding in magnitude the value for 1961–62.

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Axel Heiberg Island glacier inventory

L. Thomson, ES/UWO

Ommanney's highly detailed inventory of Axel Heiberg Island glaciers, based on aerial photography from 1958–59, has been updated into digital format and compared with glacier extents from satellite imagery acquired in 2000. The Ommanney inventory recognized 1121 glaciers and ice masses (as small as 0.01 km^2) and assigned as many as 18 attributes to each feature. In this study, the values from the 1958–59 photography were integrated into a GIS database along with spatial extents of the glaciers measured in 2000. Regional assessment of ice gain or loss, not glacier by glacier, revealed two dominant trends. Foremost, retreat was the most abundant trend across the island, being exhibited by 75% of the regions considered. However, the level of advance prevailing from the remaining regions was extensive enough to essentially counterbalance the ice coverage lost in the retreating regions. As a result, the overall change in ice coverage over the 42 year period was only of the order of –1%. Thanks to the specific glacier attributes available from the Ommanney inventory, statistical analysis was able to recognize correlations between glacier characteristics and subsequent retreat or advance. Advance was exhibited by regions having the largest glaciers and the highest accumulation altitudes. Regions comprising small glaciers, and in particular low-elevation and independent mountain glaciers, exhibited the greatest retreat. Surprisingly, 25 of the glaciers recognized in the Ommanney inventory went un-mapped in the 2000 inventory. Visits to these sites revealed that 13 had no ice present and were deemed to have disappeared, 6 sites had minimal ice present and are predicted to disappear within the next 5 years. Four other sites had enough ice to be mapped as glaciers, but were in a state of retreat and lacked any well-defined accumulation area. From this study it has been concluded that measuring spatial coverage in glacier inventories alone is not enough to assess regional climate change; much more can be gained for both glaciological and climate studies if correlations between glacier characteristics and retreat are also considered.

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47 years of research on the Devon Ice Cap

S.M.H. Boon, Geog/ULeth; D.O. Burgess, R.M. Koerner†, GSC; M.J. Sharp, EAS/UAlb

The Devon Ice Cap has been the subject of scientific study for almost half a century since the first mass-balance measurements in 1961. It was the site of the first investigations of the role of meltwater in seasonal ice velocity variations on a polythermal Arctic ice cap; of the use of air temperature, rather than net radiation, as a proxy for the energy driving surface melt; and of the influence of the changing frequency of specific synoptic configurations on glacier melt and mass balance. Current knowledge of the Devon Ice Cap, derived from almost 50 years of research, has been summarized, and some of the outstanding questions that continue to limit our understanding of climate–ice cap response in Arctic regions identified.

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Preparation for CryoSat-2 validation – Devon Ice Cap, Nunavut

D.O. Burgess, M.N. Demuth, GSC; M. Sharp, EAS/UAlb; A.L. Gray, CCRS

Cryosat calibration and validation (Cal/Val) campaigns have been conducted by the GSC, UAlb, and UAber since 2004. The campaigns, involving simultaneous ground measurements and overflights of the ASIRAS radar altimeter (an airborne version of Cryosat), have verified the potential for Cryosat-2 to map with precision the ice-surface elevation as well as snow accumulation and near-surface density of land ice in the polar regions. Post-launch Cal/Val campaign sites will expand to include more temperate glacierized regions in Canada, and will focus on quantifying uncertainties related to measurements at the spatial scale of the Cryosat-2 radar footprint. The expected launch date for Cryosat-2 is 8 April 2010.

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Tidewater glacier response: Belcher Glacier, Nunavut

S.M.H. Boon, Geog/ULeth; D.O. Burgess, GSC; L. Copland Geog/UOtt; G.E. Flowers, ES/SFU; J.L. Kavanaugh, M.J. Sharp, EAS/UAlb; S.J. Marshall, Geog/UCal; L. Tarasov, PPO/MUN

Field and remote-sensing studies are being employed to develop and test a high-resolution coupled mass balance–hydrology–ice dynamics model for the Belcher Glacier (75°39′ N; 81°30′ W), a large tidewater outlet glacier accounting for 17% of the total annual mass loss from the Devon Ice Cap. Results will provide a new state-of-the-art model for integrated glacier studies, and will give new information on ice dynamics and glacier evolution in cold Arctic glacier systems.

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Glacier–permafrost interactions, Bylot Island

B.J. Moorman, P.A. Wainstein, K. Whitehead, Geog/UCal

The interaction of glaciers and permafrost, and how their relationship affects hydrological process and permafrost stability within the proglacial environment are being studied on Bylot Island; during the past 4 years the focus has been on 'Fountain Glacier' and its proglacial icing. Interferometric analysis based on TerraSar X satellite images, and time-lapse photogrammetric modelling, have been used to describe the dynamics of 'Fountain Glacier' during different seasons. Areas of the glacier where interferometric anomalies correlate with areas of a high concentration of subglacial water suggest a localized interaction between subglacial water storage and vertical ice movement. Hydro-thermal finite-element modelling, ground-penetrating radar surveys, high-accuracy RTK topography surveys and time-lapse photography have been used to describe the icing's annual erosion/accretion cycle and understand how subglacial water feeds the icing through a proglacial pressurized fountain.

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GLACIERS – WESTERN CANADA

Glaciers in Kluane National Park, Yukon

N. Fox, L. Copland Geog/UOtt; C.M. Zdanowicz, GSC; C. Wong, Kluane N.P./PC

Research is currently underway to quantify the changes in thickness and dynamics of the Kaskawulsh Glacier, one of the largest in Kluane National Park. A LIDAR survey of the main glacier was undertaken in summer 2007, which enabled comparison with earlier surveys made by the University of Alaska Fairbanks in 1995 and 2000, together with an earlier DEM from 1977. Results indicate overall volume losses since 1977, but an increase in thickness in the accumulation area between 2000–07. Long-term climate and mass-balance measurements are also being made along the Kaskawulsh Glacier.

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Tributary–trunk interactions and glacier dynamics

H. Jiskoot, R. Caruso, S. Darling, Geog/ULeth

An analogue glacier model time-lapse analysis of ice flow and strain-rate response to valley obstructions, and a remote-sensing analysis of tributary–trunk interaction, have been used to investigate the relationship of tributary-system configuration to ice-flow dynamics and glacier surging in the Yukon.

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Glacier inventory: Selwyn Mountains/Ragged Range, NWT

M.N. Demuth, V. Pinard, P. Wilson, GSC; D. Haggarty, Nahanni N.P./PC; D. Murray, PC; D.P. McCarthy, ES/Brock; A. Pietroniro, NWRI/Sask; J. Gibson, ARC; S. Nedelcu, CCRS

An inventory of glaciers lying at the headwaters of the South Nahanni River, above Virginia Falls, has been completed. Results from change detection and morphometric analyses were used in the 2009 State of the Park Report for Nahanni National Park Reserve of Canada Nahʔą Dehé. Documentation of the glacier cover and its significance to the Greater Nahanni Ecosystem played a role in the recent expansion of the boundaries of the park. A glacier mass-balance program has been initiated on 'Bologna Creek Glacier'. The significance of meltwater to seasonal river flows is being investigated using hydrological modelling and hydrochemical methods.

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Wedgemount and Overlord Glaciers, Garibaldi Park, Coast Mountains

K.E. Ricker, D. Lyon; R. Tupper, MSG; I. Lloyd, E. Wood, BCIT

The original investigator of the Wedgemont project (W.A. Tupper, BCIT) passed away in 2005, having carried out analytical work from 1987–2003. During this period Ricker did the cursory fieldwork, continuing alone thereafter to 2006. Son, Robert Tupper, a BC surveyor, took over the project in 2007, assisted by Karl Ricker and David Lyon. Surprisingly, BCIT's Geomatics Department resumed field studies in 2009 after a 23-year hiatus with one of Tupper's students, Ian Lloyd, supervising a GPS re-survey of the triangulation net and traverse of the ablation zone to measure down-wasting. Recession of Wedgemount Glacier has averaged 15.5 m a–1 from 2005–09. It slowed to 2.5 m in 2006–07, possibly reflecting the arrival of the exceptional snowfall of 1998–99 at the snout. Annual stereo photos of the lower glacier will be scanned for possible hint of a kinematic wave. The 2009 GPS traverse of the ablation zone showed an average down-wasting of the glacier surface of 40 m for 1973–2009, or about 1 m a–1. The Overlord Glacier snout, measured by Ricker from 2005–09, retreated on average 11.3 m a–1, but slowed to 6.4 m for 2007–08 (all measurements in September). Recession of both glaciers, however, was much greater in 2008–09 than the annual average, although not as much as some years during the 1940s.

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Regional-scale distributed modelling of glacier meteorology and melt, southern Coast Mountains

J.M. Shea, R.D. Moore, Geog/UBC

Meteorological quantities for glacier-melt modelling are being estimated for the development of a portable model that can consider the varying complexities between sites. Meteorological and glaciological data were collected at four sites in the southern Coast Mountains, Place, Helm, Bridge and Weart Glaciers, British Columbia, from 2006–08.

Models to estimate the effects of katabatic boundary layer (KBL) development on near-surface meteorological variables were developed using statistical methods and topographic indices derived from digital elevation data. The effects of KBL development on near-surface temperature, vapour pressure, and wind speed are determined in part by flow-path length and the ambient temperature forcing which drive KBL development. Methods for distributing radiative fluxes for energy-balance modelling in alpine terrain were also examined, with a focus on atmospheric transmissivity, snow and ice albedo, and incoming longwave radiation.

To generate datasets for testing glacier-melt models, standard glaciological mass-balance measurements were made at Place and Helm Glaciers with the assistance of the GSC. To supplement these data, initial SWE measurements were made at Weart and Bridge Glaciers, and surface-temperature loggers were used to monitor snowline retreat at all four locations. Melt models of varying complexity (degree day, radiation-indexed degree day, simple energy balance, and full energy balance) were tested against (a) mass-balance data and (b) cumulative melt data which can be inferred from the date of snowline retreat. Using the simplest melt model as a benchmark, the performance of the other models was compared.

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Field research on Shackleton Glacier, British Columbia

H. Jiskoot and team, Geog/ULeth

A yearly field campaign on an 8 km long outlet glacier from the Clemenceau Icefield has yielded new results on ice velocity, strain rates, and structural glaciology at a tributary–trunk confluence, as well as general glaciological parameters such as melt rates, ice-surface temperatures, surface hydrology and long- and short-term thickness and length changes.

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Changes from a new Rockies glacier inventory

H. Jiskoot, C.J. Curran, D.L. Tessler, Geog/ULeth

A new glacier inventory was compiled for the Clemenceau and Chaba Icefield groups (340 km^2) that included area–elevation distributions and classification of tributary glacier systems. The icefield groups have lost 70 km^2 since the mid-1980s. Average retreat rates were 14 m a^{-1} from the LIA to 2001, and 21 m a^{-1} for 1980s–2001, hence retreat rates are accelerating. Glacier complexes, where several tributaries have detached since the LIA, retreated at a faster rate than others. Different methods of deriving steady-state ELAs and AARs were juxtaposed, and glacier hypsometries were used to compare glacier sensitivity to future rises in ELA.

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Implications of rockslides on glaciers

H. Jiskoot, Geog/ULeth

A large rockslide was discovered on a Clemenceau Icefield region cirque glacier. The timing, and possible causes and effects of this event were analyzed. These include seismic and glaciological implications, as well as an analysis of the controls on the large runout of rockslides over glaciers.

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Volume and mass balance of the Columbia Icefield, Alberta/British Columbia
M.N. Demuth, D.O. Burgess, C.M. Zdanowicz, GSC; A. Chichagov, CCRS; D. Petersen, D.J. Zell, Banff N.P./PC; B. Shepherd, Jasper N.P./PC; S.J. Marshall, Geog/UCal; B. Sandford, WWCRC; C.D. Hopkinson, COGS/NSCC
The past volume changes of the Columbia Icefield are being defined and a first estimate made of the icefield-scale mass balance using a flux-gate approach combined with LIDAR, ice-penetrating radar and accumulation studies. A substantial ground and aerial program is scheduled to begin in April 2010. Current analysis is concentrating on the water equivalency of that portion of the regions' glaciers currently out of balance with today's climate. Meltwater from the icefield feeds the Mackenzie, Columbia and Nelson Rivers, thus flowing into three oceans.
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Changes in glacier water resources, Nelson River basin, Alberta
M.N. Demuth, V. Pinard, GSC; N.H. Short, CCRS; A. Pietroniro, NWRI/Sask; B.H. Luckman, Geog/UWO; C.D. Hopkinson, COGS/NSCC; P.F. Dornes, L.E.L. Comeau, CH/USask
Late 20th-century glacier volume changes were determined for ~1500 glaciers in the Park and Front Ranges of the Rockies using the Bahr area–volume scaling approach and were related to river-flow volumes. The results reveal significant small-glacier diminution during this period, and provide approximate ice-wastage contributions. The recent changes were placed in context using historical vertical aerial photography to characterize the rate of change in glacier extent since the Neoglacial maximum (c. 1850 AD). Morpho-stratigraphic and geo-botanical evidence, and reconstructed and observed glacier mass-balance histories, were used to further illustrate the nature of these changes. Glacier-cover contraction is evolving at an unprecedented pace, leading to a state not in evidence for several millennia.
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GLACIERS – ICE CORES

Evidence of forest fires in Mount Logan ice core
R.D. Field, G.W.K. Moore, Phys/UTor; G. Holdsworth, AINA; C. Tymstra, ASRD
Trajectory analysis indicates that the large 1950 NO_3^- spike in the Mt. Logan ice core can be attributed to the Chinchaga wildfire that burned 1.4 M ha in September 1950 and is probably the largest wildfire in North America's recorded history. This would be the earliest documented instance of pyrocumulonimbus injection of wildfire smoke into the stratosphere, circumpolar smoke transport, and of a single wildfire detected in an ice core.
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Circulation controls on Yukon stable isotopes
R.D. Field, G.W.K. Moore, Phys/UTor; G. Holdsworth, AINA; G.A. Schmidt, NASA
A GCM analysis of atmospheric circulation in the NE Pacific that identifies controls on the stable-isotope values of precipitation in SW Yukon has been undertaken to aid in the interpretation of data from local ice cores. Elevated 18O was found to be associated with a deeper Aleutian Low and stronger southerly moisture flow, while lower 18O was associated with the opposite meteorological conditions. This suggests that the lower 18O values seen in mid-19th century paleoclimate records are associated with a weaker Aleutian Low.
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Connecting Eastern Arctic and Pacific North West ice-core isotope records
D.A. Fisher, GSC
Mount Logan, Yukon (Pacific North West), stable isotopes seem to respond to the state of ENSO and vary over the Holocene much more than the Eastern Arctic (Greenland and Canadian) isotopes. Statistical and physical linkages are being built between the Atlantic and Pacific sector ice-core records.
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Trace-metals histories (Pb, Hg and Cd), Canadian Arctic
J. Zheng, GSC
Trace-metal histories at ultra low levels have been measured in the eastern Arctic (Devon, Mount Oxford and Agassiz Ice Caps). The different temporal patterns in the modern era can be interpreted as changes in trajectory, climate and source strengths. Source locations can be attributed by flux history and isotopic ratios. The Pb history for all of the Mount Logan ice core (Yukon) has been measured.
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Reconciling Ellesmere Island and Greenland ice-core records
D.A. Fisher, R.M. Koerner†, GSC
The partnership with the Danish and French ice-core groups to reconcile the time scales of Canadian Holocene ice-core records with those of Greenland and Renland, using the canonical Greenland Ice Core time scale version 5 (GIC005), has been concluded. The results, and their implications, have been widely reported and it is now understood that the early Holocene was the warmest and that the thickness of the

Greenland ice sheet changed substantially over the Holocene. The 'elevation constant Holocene record' for Greenland is not that of GRIP or GISP2, but is taken as an average of the Agassiz and Renland Ice Cap records.
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North Greenland Eemian Ice Drilling project (NEEM)
J.C. Bourgeois, J. Zheng, D.A. Fisher, GSC
In collaboration with the Danish NEEM project, scientists from GSC will analyze pollen, trace metals (Pb, Cd and Hg) and contribute to stable isotope and modelling work. The Greenland ice core should provide a stratigraphically continuous sequence through the Eemian interglacial, a period that at its warmest was 4˚ warmer than the early Holocene, which was 3˚ warmer than now; thus offering a partial analogue to a 7˚ warmer Arctic, when sea level was 6 m higher.
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GLACIERS – NON-CANADIAN

Glacier change and sensitivity in central East Greenland
H. Jiskoot, D.T. Juhlin, Geog/ULeth
The Geikie Plateau region has 300 valley, outlet and cirque glaciers >2 km², and a total glaciated area >40,000 km² (about half of that peripheral to the Greenland ice sheet). A glacier inventory was compiled by semi-automated digitization from ASTER and LS7 imagery, and the ASTER World DEM. About 90% of the glacier area drains through tidewater glaciers, while 30–70% of the glaciers are surge-type. Changes in the glacier area of calving fronts since the 1990s have been measured, and glacier sensitivity to future climate change assessed through snowline, hypsometry and calving-front characteristics.
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Dynamics of recent glacier surge, East Greenland
H. Jiskoot, D.T. Juhlin, Geog/ULeth
The dynamics and advance of the 2001–07 surge of a small valley glacier was analyzed using remote-sensing techniques. The surge characteristics of this glacier resemble those of the slower Svalbard-type surges. This is in contrast with nearby Sortebrae, whose 1992–95 surge was of the fast Alaskan-type. The occurrence of both types of surges in this region confirms that the Svalbard- and Alaskan-type surge mechanisms are thermally differentiated.
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Glacier dynamics in the Karakoram Himalaya
L. Copland, Geog/UOtt; M.P. Bishop, J.F. Shroder, UNO; D.J. Quincey, ACG
Glacier dynamics across the Karakoram are being assessed. Surface motion has been determined using feature tracking of ASTER and SPOT optical satellite images, intensity tracking of ERS and Envisat scenes, and differential GPS measurements on the ground (mainly on Baltoro Glacier). An updated inventory of surge-type glaciers across this region has also been undertaken, identifying a total of 88 glaciers with features indicative of surge behaviour, more than doubling the previous number identified in the Karakoram.
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Chile-Canada Glaciology Collaborative
M.N. Demuth, J.C. Bourgeois, D.A. Fisher, GSC; L. Copland, K.J. Gajewski, A. White, Geog/UOtt; A. Rivera, CECS; C.C. Kinnard, CEAZA; C.D. Hopkinson, COGS/NSCC
To further scientific exchange and a consensus approach to measurement and the application of technology, a bilateral agreement has been negotiated to make expertise and technology available in each others' season of opportunity and to develop a series of studies. These include: historical change and the evolution of debris-covered ice reservoirs; recent variations of Hielo Patagónico Sur glacier fronts; paleo-hydrological intensity derived from sediment cores retrieved from the Jorge Montt Fjord region of Chile and the headwaters of the South Nahanni River, Northwest Territory, Canada.
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Cartographic glacier inventory of the Subantarctic islands
J.G. Cogley, Geog/TrentU
A glacier inventory of the Subantarctic islands based mainly on maps is nearing completion. The islands covered are Scott Island, Peter I Island, the South Shetland Islands and South Orkney Islands, the South Sandwich Islands, South Georgia, Bouvet Island, Marion Island, Kerguelen, Heard Island and the Balleny Islands. Of these, Deception Island and King George Island in the South Shetlands remain to be completed, although a complete inventory is already available from the King George Island GIS Project, and South Georgia has not yet been inventoried. Total glacier area in the Subantarctic during the late 20th century is estimated to be 7876 km².
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PERMAFROST

Nature and significance of perennial springs in polar desert environments

W.H. Pollard, Geog/McGU

Eight groups of highly mineralized, cold, perennial springs have been confirmed on Axel Heiberg Island, despite the conventional wisdom that thick permafrost, common in the Arctic Islands, provides an effective aquitard preventing groundwater discharge and resulting in the separation of groundwater into sub-, intra-, and suprapermafrost systems. The occurrence of perennial spring activity, together with discharge-related phenomena like travertines, tufas, fresh and brine icings, and frost mounds, raise a number of interesting questions about the unique nature of the geologic, geocryologic, hydrologic, and biologic conditions of this area. Some of these are being addressed by investigations (1) of high Arctic spring hydrogeology and geochemistry to assess the origin and age of groundwater; (2) of surface flow and carbonate mineralization under extreme cold temperatures; (3) of the physical and chemical dynamics of icing and frost-mound formation; and (4) of High Arctic springs as analogues for ancient groundwater systems on Mars.

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Geomorphic impact of climate change on ice-rich permafrost

W.H. Pollard, Geog/McGU

The primary focus of this research is the detection and analysis of climate-change impacts on (1) high latitude polar desert systems with an emphasis on permafrost dynamics and surface hydrology (Ellesmere Island) and (2) ice-rich coastal landscapes of the southern Beaufort Sea. The goal is to determine how High Arctic permafrost will respond to climate change by: (a) characterizing, at a landscape scale, surface energy inputs to the active layer and near surface permafrost; (b) modelling active-layer response to microclimate; (c) distinguishing active-layer processes based on isotopic and ionic variations of precipitation, active-layer moisture and ground ice; (c) assessing the sensitivity of different types of permafrost landscapes to warming; (d) establishing baseline measurement sites conforming to established climate change protocols (CALM, ITEX), and (e) characterizing the behaviour of key permafrost features (ice wedges, icings, frost mounds).

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Microbial ecology of permafrost materials

W.H. Pollard, Geog/McGU; L.G. Whyte, NRS/McGU; C.R. Omelon, GeolS/Texas U; F.G. Ferris, Geol/UTor

Microbial communities and the limits of their occurrence in permafrost samples and cores have been characterized. Fluorescent microspheres are used to assess patterns of sample contamination during coring and sample handling. In a related study, cryptoendoliths in sandstones are being studied in an investigation of microhabitats in both permafrost soils and porous sandstones.

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Shallow soil moisture–ground thaw interactions and controls

C.D. Spence, NWRI/Sask; X.J. Guan, C.J. Westbrook, CH/USask

The presence of frozen ground in cold regions creates a unique dynamic boundary issue for subsurface water movement and storage. The interrelations of spatiotemporal shallow soil moisture and ground thaw patterns are being examined. Detailed shallow soil-moisture and thaw-depth surveys were taken from multiple sites in 2008 in the Baker Creek watershed near Yellowknife, NWT. Water and energy fluxes were computed for each site to determine the key controlling hydrological processes. Correlation analysis found significant positive relationships between soil moisture and frost-table depth at some, but not all, sites. Water and energy flux calculations showed the key control was the presence of surface water. At the peatland and wetland sites, accumulated water in depressions maintained higher soil moistures longer than the hummock tops. The wettest soils were often the locations of deepest thaw depth due to the transfer of latent heat accompanying lateral surface runoff. Modified Péclet numbers indicated the external and internal hydrological processes at each site were different. Continuous inflow of water can increase the importance of advective thermal energy to ground thaw. The absence of continuous surface flow leads to dominance of conductive thermal energy over advective energy for ground thaw. Overall results did not show the expected simple relationship between soil moisture and ground thaw patterns. Instead, a scale of correlation existed among the sites with a variable wetness scale. The drier the site, the more random the interaction between soil moisture and ground thaw. This indicates all soil-filled areas cannot be treated equally in subarctic hydrological models. As well, results show that the modified Péclet number can be a very useful parameter to differentiate landscape components in modelling frost-table heterogeneity.

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SNOW – GENERAL

IP3 – Improved processes and parameterization for prediction in cold regions

J.W. Pomeroy, N. Kapphahn, CH/USask

P3 is a research network funded by the Canadian Foundation for Climate and Atmospheric Science (CFCAS) for 2006–10, comprised of several dozen investigators, collaborators and students from across Canada, the US and Europe and headquartered at the University of Saskatchewan's Centre for Hydrology. IP3 research is devoted to an improved understanding of water processes in cold regions, particularly the Rockies and western Arctic. Research basins include alpine tundra, alpine forest and alpine glacierized watersheds, permafrost wetlands, taiga woodlands, boreal forest and small lake drainage basins. IP3 process investigators collected field data from these research basins for the first 2 years of the networks' mandate, which were used to develop parameterizations and conceptual models for the following various cold-regions processes; forest effects on snowmelt (shortwave absorption and transfer of longwave emissions from heated foliage to the subcanopy to estimate shortwave irradiance energy); turbulent transfer over snow (conceptual model of air–snow temperature profiles); sublimation and air temperature effects on glacier-melt modelling (boundary-layer experiments); snow-cover redistribution in both alpine and shrubland environments (shrub/vegetation and blowing-snow parameterizations); water storage and cycling in a wetland-dominated discontinuous permafrost basin (conceptual modelling); snow-covered area in alpine environments (use of oblique terrestrial photography to derive daily measurements); and, SWE (design and use of an acoustic sounding device for in situ measurements). Parameterizations and conceptual models developed from the process data are being applied to diverse research basins for validation and model testing within the Cold Regions Hydrological Model (CRHM). Further details can be obtained from the www.usask.ca/ip3.

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Snowmelt models, Prairies

T.Y. Gan, A.K. Gobena, C&EE/UAlb; P.R. Singh, Golder Assoc/Abbotsford

Three semi-distributed snowmelt models (SDSM) have been developed and applied to the Paddle River basin, Alberta: (1) a physics-based, energy-balance model (EBM) that considers vertical energy exchange processes in open and forested areas, and snowmelt processes that include liquid and ice phases separately; (2) a modified temperature-index model (MTI) that uses both air (Ta) and near-surface-soil temperatures (Tg); and (3) a standard temperature-index method. Both EBM and MTI simulated reasonably accurate snowmelt runoff, SWE, and snow depth. The advantage of MTI is Tg showed a stronger correlation with solar radiation than Ta during the spring snowmelt season. If reliable Tg data are available, they should be used to model snowmelt processes in a prairie environment, particularly if the temperature-index approach is adopted.

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Climate trends and spatial variation from high-altitude snow records

H. Jiskoot, K.E. Pigeon, D.L. Tessler, Geog/ULeth

Snowpit and meteorological data in the southern Canadian Rocky Mountains were analyzed to assess small-scale spatial variability in snowpack characteristics, and the relationship to mountain temperature lapse rates. High-altitude automatic snow-pillow data in a south–north transect of the Rockies were used to derive climate trends in snow cover over the last 30–40 years.

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Snow redistribution impacts on glacier mass balance

S.J. Déry, P.L. Jackson, S. MacLeod, M.J. Beedle, B. Ainslie, A. Yadghar, ES&E/UNBC; A. Clifton, WSL/SLF

The potential impact of snow redistribution on the mass balance of glaciers is being studied in the Cariboo Mountains of British Columbia. In-situ measurements of wind and snow depth confirm the occurrence of intense blowing-snow episodes at many sites. Simulations with the PIEKTUK-D numerical model, forced by meteorological observations from 2006–09, reveal a high frequency of blowing-snow episodes at three high-elevation sites. This process is especially prominent on the exposed ridge of Browntop Mountain (2031 m a.s.l.), where snow transport by wind is calculated to occur as much as two thirds of the time during some winter months. Simulated blowing-snow fluxes remain high at this site with monthly transport and sublimation rates reaching 5301 Mg m^{-1} and 31 mm snow w.e., respectively. Blowing snow is also shown to be a dominant process affecting snow accumulation at the upper 'Castle Creek Glacier' site (2105 m a.s.l.), with strong winds generating sharp declines in snow depth and the erosion of more than 200 cm of snow during two successive winters. The results presented in this study suggest that blowing snow contributes significantly to snow accumulation and the mass balance of glaciers in the Cariboo Mountains. More comprehensive analyses of these processes using a mesoscale atmospheric model have been initiated to simulate the high-resolution wind field over the complex mountain terrain. In conjunction with the PIEKTUK-D model, and continuing expansion

and improvement of our network of meteorological towers, these simulations will provide a better understanding of the complex nature of snow transport by wind and its contribution to glacier mass balance and the hydrology of the Cariboo Mountains.
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Spatial averages of acids, metals and pollen
J. Zheng, D.O. Burgess, J.C. Bourgeois, C.M. Zdanowicz, R.M. Koerner†, GSC
Sampling near-surface snow and ice over the whole polar region at various times and measuring the pollen, acids, and trace metals was a project of the late Roy Koerner that is continuing. The first survey done in the mid 1990s is being re-sampled and changes are evident.
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Characterizing firn processes using high-resolution instruments
M.N. Demuth, D.O. Burgess, GSC; H.-P. Marshall, G&G/Boise State U.; E.M. Morris, SPRI
The problem of measuring glacier mass balance, in the context of nested scales of variability where the auto-correlation structure varies with the scale, is being investigated. In particular, high-resolution instruments are used to characterize the variability of firn in the field. Data collected from scanning LIDAR, snow micro-penetrometers, neutron probes and ground-penetrating radar include micro-topography, snow hardness, and snow density and texture. The analysis suggests corresponding scales of correlation related to antecedent conditions (surface roughness and hardness, and stratigraphic variability) and post-depositional processes (percolation and refreezing of surface melt water).
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SWE retrieved from SSM/I passive microwave data
T.Y. Gan, C&EE/UAlb; O. Kalinga, Golder Assoc/Calgary; P.R. Singh, Golder Assoc/Abbotsford
An artificial neural network called Modified Counter Propagation Network (MCPN), a Projection Pursuit Regression (PPR) and a nonlinear regression (NLR) were used to retrieve SWE data for the Red River basin of North Dakota and Minnesota from passive microwave SSM/I sensors on the US Defense Meteorological Satellite Program (DMSP) satellites. Airborne gamma-ray measurements of SWE for 1989 and 1997 were used as observed SWE, and 19 and 37 GHz SSM/I data, in both horizontal and vertical polarization, were used for calibration and validation. The MCPN model produced better results in both calibration (C) and validation (V) than PPR, which was better than NLR (for C, R^2 was ~0.9, 0.86 and 0.78, respectively and for V, R^2 was ~0.9, 0.62 and 0.71, respectively). MCPN is probably better because of its parallel computing structure resulting from neurons interconnected by a parallel network and its ability to learn and generalize information from complex relationships.
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ATMOSPHERIC ICE

Marine icing monitoring system
R.E. Gagnon, IOT
First results from a Marine Icing Monitoring System were presented at POAC 2009 in Sweden. This new technology has been under development and field proofing over several years at IOT. The optical-based system provides time series records of marine-icing accumulations covering extensive areas of vessels or structures during icing events. The quantitative thickness measurements, obtained from automated image analysis, for arbitrarily large numbers of locations within the views of the system's two cameras, are useful for the development and validation of marine-icing models. Furthermore the system has potential for serving as a real-time warning device for vessel/structure crews. The system has been deployed on three vessels and presently, through PetroCanada/Suncor's assistance, the device is installed on the Atlantic Eagle.
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FLOATING ICE – FRESH-WATER ICE

Characterizing ice behaviour in Nunavik
M. Bernier, INRS-ETE with KRG
Past and present ice behaviour around the marine infrastructure of three villages on Hudson and Ungava Bays and the Koksoak River, is being characterized. Traditional knowledge is gathered from local interviews and in situ cameras provide hourly records. At the regional scale, high-resolution RADARSAT-2 images are used to map ice features every 3 days during freeze-up and breakup and data are then incorporated with historical and current data from the Canadian Ice Service. The expected products are ice-on and ice-off dates, ice patterns, ice events, ice concentration and ice-type maps, inter-scale analysis and climate indicators.
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Adaptation of a radar-based river-ice-mapping technology to Nunavik
M. Bernier, INRS-ETE with KRG and TrentU
A basic radar-satellite ice-mapping technology is being adapted for the Koksoak River area. Workshops were conducted in Kuujjuaq to better understand the ice processes and the client needs. Ice maps were produced every week during freeze-up and breakup and distributed through

the web and in print. Validation was achieved through ground photos, aerial surveys and field measurements; local high school students were involved in the entire process.
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River-ice classification algorithms for quad-polarized SAR data
M. Bernier, INRS-ETE with Univ. de Rennes I, France
A hierarchical classification algorithm has been developed to classify quad-polarized SAR data into different river-ice types based on polarimetric parameters; an electromagnetic river-ice model was used to select the best ones. In comparison with others, the support vector machine algorithm seems to be more adaptable and shows slightly better results than a Wishart classification. Results from RADARSAT-2 data applied to the Saint-François and Koksoak Rivers shows no ambiguity between water and ice.
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Use of GPR to characterize river-ice type and thickness
N.E. Bergeron, M. Bernier, INRS-ETE
Ground-penetrating radar (GPR) is being used to measure the thickness of shallow ice covers of the St-Charles and Batiscan Rivers to insure safe operation when conducting hydrometric measurements in winter. Measurements from various ice covers and GPR signal frequencies were analyzed to determine if GPR could be used for the indirect determination of river-ice type. A model capable of measuring the relative proportions of different types of ice on Nordic rivers has been developed. Different types of ice are discriminated according to the absorption coefficient of the electromagnetic waves. The model measures the proportions of clear ice in relation to the total ice thickness based on the relative intensity of the multiple echoes from the ice/water interface. Correlations between the estimated and observed values gave an R^2=0.98 for snow-free ice and R^2=0.85 for snow-covered ice.
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Ice-mapping algorithm
M. Bernier, INRS-ETE
Work has been undertaken on the transfer of a radar ice-mapping algorithm to Quebec's Ministry of Public Safety (SPQ) for integration into its operational river surveillance program for the des Prairies and Chaudière Rivers. It included an automated procedure to derive georeferenced river-ice maps from single polarization RADARSAT-1 and 2 images using Geomatica® software, a detailed user's guide, adaptation to specific requirements, training and support.
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The FRAZIL Project
M. Bernier, INRS-ETE with UAlb, ÉTS, Univ. de Rennes I, BC Hydro, CRREL, SPQ, CSA and EC
The FRAZIL project is a first step towards an early warning system for ice-jam related floods on the Saint-François, Peace and Athabasca Rivers in Canada and the Connecticut River in the USA, involving the development of tools to better characterize some of the main variables used in winter flood forecasting, i.e. river-channel geometry, river flow and ice cover. The first of the six parts of the FRAZIL system includes a GIS component (ArcObject language) to build the river-channel geometry (channel's centreline, top width, sinuosity, overflow) and prepare data for a 1-D hydraulic routing model with rectangular channel approximation. It includes an automated RADARSAT image classification scheme to produce an ice-cover map from which information such as ice coverage, ice roughness and ice-jam length over river reach can be derived. All tools are mostly automated and based on easily available data. The second part is a theoretical model aimed at better understanding the interaction of the radar signal with a river ice cover. The model has been improved to process polarimetric data. The third is a controlled experiment on the effect of ice growth on the radar signal (FMCW). The fourth is an analysis and classification approach to multipolarization, polarimetric and multifrequency radar data for river ice mapping. The fifth is a quantitative validation of the radar ice maps. The final part is an artificial neural network model for estimating river-ice thickness using easily available climate data.
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Miquelon Lake, Alberta
C. Haas, EAS/UAlb
Ice and snow formed on a saline lake has been studied as a sea-ice analogue since the winter of 2008/09. Continuous autonomous in-situ measurements and irregular ice core sampling of snow and ice properties are complemented by active microwave remote sensing studies and observations of biogeochemical processes in the ice.
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River ice mapping and monitoring using SAR
J.J. van der Sanden, CCRS; with NWRI/Sask, DFO, UAlb and SFU
Research and development activities regarding the application of SAR satellites to the mapping and monitoring of river ice focus on the Mackenzie River near Inuvik, NWT, in support of the development of an hydraulic model. Information acquired includes: channel network layout, ice-type distribution, ice-jam locations, ice-cover

break-up sequence, and extent/location/duration of break-up flooding. The capacity of second-generation SAR satellites (e.g. RADARSAT-2, ALOS PALSAR, TerraSAR-X) to simultaneously acquire images in multiple polarizations considerably improves their potential for mapping winter ice cover.
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FLOATING ICE – SEA ICE

Canadian Arctic Sea Ice Mass Balance Observatory (CASIMBO)
C. Haas, EAS/UAlb
A long-term sea-ice observation program has been initiated at UAlb to observe and understand sea-ice variability between the coast of Canada and the North Pole. Research includes in-situ and remote sensing studies of sea ice and snow, to detect changes and improve parameterizations and the validation of climate models. The main activity is ice mass balance measurement north of Ellesmere Island. However, collaboration with other Canadian researchers is sought to extend the study region. Extensive national and international collaboration led to participation in a pan-Arctic airborne survey in April 2009 which showed that ice thickness had slightly increased recently, and to participation in the summer cruise of a Coast Guard ice breaker into Nares Strait, which allowed observations of seasonal ice thickness changes.
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Sea ice reconstructions
C.M. Zdanowicz, C.C. Kinnard, D.A. Fisher, GSC
A 1000 year Arctic sea-ice reconstruction has been made using multivariable inputs and training the database with existing measured sea-ice extents; regional reconstructions are underway.
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Historical sea-ice records
B.T. Hill, IOT
In a collaboration with the INSTAAR's (UCO-B) project SYNICE (Syntheses of Sea Ice, Climate & Human Systems in the Arctic & Subarctic; http://synice.colorado.edu/) data from the past 1000 years is being analyzed with a major emphasis on the period c. AD 1800 to the present. Sea-ice and iceberg data since the 1800s, for the Grand Banks area of the North Atlantic, is being collated. Of particular interest are the ice records contained in the Hydrographic Bulletins, a weekly publication of the U.S. Hydrographic Office dating from 1889, that preceded the publications of the International Ice Patrol, and which appear to have been largely forgotten.
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Iceberg scour
T. King, C-CORE
A probabilistic burial analysis for protection against iceberg scouring of the seabed has been developed for a hypothetical pipeline on the Grand Banks off Canada's East Coast. The analysis procedure combines a probabilistic characterization of the iceberg-scour regime with a deterministic analysis of pipeline stress/strain response for a range of iceberg scour widths, depths and iceberg keel/pipeline crown clearances, allowing a pipeline burial depth to be defined that satisfies specified stress/strain limits and target reliability levels.
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Ice-impact panel
R.E. Gagnon, IOT
A completely new type of ice-impact panel has been developed at IOT. A 1/6th portion of the full impact panel, referred to as the impact module, has been fabricated and tested during ice-drop experiments that confirmed its high-resolution pressure-sensing capability. The impact module has also been successfully loaded up to 700,000 lbs (3.1 MN) to confirm its robustness. The full impact panel, with sensing area of 3 m x 2 m, is intended for use during a Phase II Bergy Bit Impact Field Study using the CCGS Terry Fox within the next few years.
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Sea ice thickness in McMurdo Sound, Antarctica
C. Haas, EAS/UAlb
Airborne ice-thickness measurements and mapping of the distribution and thickness of platelet ice has been added to an extensive New Zealand project studying ocean–ice–atmosphere processes and interactions in the Ross Sea. The initial field campaign took place in November 2009, and funds are being sought to continue the program.
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OTHER

Subglacial freeze-tolerant bacterium
M. Baker, Biol/UAlb
Some microorganisms that thrive in cold conditions secrete extracellular polymeric substances (EPS) that may play a role in cold tolerance and colonization of cold environments. A model organism called Flavobacterium that was isolated from a subglacial environment is being used. This bacterium, which produces EPS, and a mutant strain defective in EPS production are being compared to study the role of EPS in survival of freeze-thaw conditions. EPS also may be important in sequestering ions, particularly in low-nutrient subglacial ecosystems. Therefore, we are performing pH titrations and cadmium adsorption assays with whole cells and cells mechanically stripped or EPS using another psychrotolerant

bacterium, *Hymenobacter aeophilus*, to determine how EPS alters the surface chemistry of psychrotolerant bacteria.
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EXTRATERRESTRIAL

Mars glaciology and paleoclimate
D.A. Fisher, GSC
David Fisher was part of the PHOENIX Mars Polar Lander Science team. Discovery of magnesium perchlorate at the ~1% level by mass in the soil led him to hypothesize that this hydrated salt at the bed of the North Polar Cap could 'melt' the ice down to 205 K resulting in a deforming bed or bed flow by sliding. The stable isotopes of water in Mars' water cycle vary greatly with climate change and with solar change, and these are in principal measureable within the North Polar Cap. Fisher and JPL have partnered in several studies and proposals whose eventual goal is to sample this rich history on Mars.
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ABBREVIATIONS:

†	Deceased
AAR	Accumulation–Area Ratio
ACG	Centre for Glaciology, Aberystwyth Univ., SY23 3DB, UK
AINA	Arctic Inst. of North America, Calgary, AB T2N 1N4
ARC	Alberta Res. Council, 250 Karl Clark Rd, Edmonton, AB T6N 1E4
ASIRAS	Airborne Synthetic Aperture and Interferometric Radar Altimeter System
ASRD	Alberta Sustainable Resource Dev., 9920 - 108 St., Edmonton, AB T5K 2M4
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AWS	Automatic Weather Station
BC Hydro	6911 Southpoint Dr., Burnaby, BC V3N 4X8
BCIT	British Columbia Inst. of Technology, 3700 Willingdon Ave, Burnaby, BC V5G 3H2
Brock	Brock Univ., 500 Glenridge Ave., St. Catharines, ON L2S 3A1
CALM	Circumpolar Active Layer Monitoring Program
C-CORE	Centre for Cold Ocean Research and Engineering (MUN)
C&EE	Civil and Environmental Engineering
CCRS	Canada Centre for Remote Sensing (NRCan), Ottawa, ON K1A 0Y7
CEAZA	Centro de Estudios Avanzados en Zonas Áridas, La Serena, Chile
CECS	Centro de Estudios Científicos, Valdivia, Chile
CH	Centre for Hydrology
CHC	Canadian Hydraulics Centre (NRCC), Ottawa, ON K1A 0R6
CIS	Canadian Ice Service (MSC), Ottawa, ON K1A 0H3
COGS	Centre of Geographic Sciences (NSCC)
ConcU	Concordia Univ., 1455 de Maisonneuve O., Montréal, QC H3G 1M8
CRREL	Cold Regions Res. & Eng. Lab., 72 Lyme Rd, Hanover, NH 03755, USA
CSA	Canadian Space Agency, 6767 route de l'Aéroport, Saint-Hubert, QC J3Y 8Y9
CU	Carleton Univ., 1125 Colonel By Dr., Ottawa, ON K1S 5B6
DEM	Digital Elevation Model
DFO	Dept of Fisheries and Oceans
DU	Dalhousie Univ., Halifax, NS B3H 4J1
EAS	Earth and Atmospheric Sciences
EC	Environment Canada
ECM	Electrical conductivity method
ELA	Equilibrium-Line Altitude
Envisat	Environmental Satellite
ERS	European Remote-sensing Satellite
ES	Earth Sciences
ES&E	Environmental Science & Engineering
ÉTS	École de Technologie Supérieure, 1100 rue Notre-Dame O., Montréal, QC H3C 1K3
G&G	Geology and Geophysics
GCM	General Circulation Model or Global Climate Model
GEnv	Geography and Environment
Geog	Geography
Geol	Geology
GeolS	Geological Sciences
GET	Geomatics Engineering Technology (BCIT)
GIS	Geographic(al) Information System
GPR	Ground Penetrating Radar
GSC	Geological Survey of Canada (NRCan), 562 Booth St., Ottawa, ON K1A 0E4
GRIP	Greenland Icecore Project
GISP	Greenland Ice Sheet Project
INAC	Indian & Northern Affairs Canada, 4916 - 47th St., Yellowknife, NT X1A 2R3
INRS-ETE	Inst. nat. de la rech. scientifique, Centre Eau, Terre & Env., 490 de la Couronne, Québec, QC G1K 9A9
INSTAAR	Inst. of Arctic and Alpine Research (UCO-B)
IOS	Inst. of Ocean Sciences (DFO), Sidney, BC V8L 4B2
IOT	Inst. for Ocean Technology (NRCC), St. John's, NL A1B 3T5
IPCC	Intergovernmental Panel on Climate Change

ISMER	Inst. des Sciences de la Mer de Rimouski (UQAR)
ITEX	International Tundra Experiment
KRG	Kativik Regional Government, Kuujjuaq, QC J0M 1C0
LIA	Little Ice Age
LIDAR	Light detection and ranging
McGU	McGill Univ., Montréal, QC H3A 2T5
MSC	Meteorological Service of Canada (EC), Downsview, ON M3H 5T4
MSG	Monashee Surveying & Geomatics, 3710A 28th St., Vernon, BC V1T 9X2
MUN	Memorial Univ. Newfoundland, St John's, NL A1B 3X5
NASA	NASA Goddard Space Flight Center Greenbelt, MD 20771, USA
NRCan	Natural Resources Canada
NRCC	National Research Council of Canada
NRS	Natural Resource Sciences (McGU), 21111 Lakeshore Rd, Ste. Anne de Bellevue, QC H9X 3V9
NSCC	Nova Scotia Community College, Middleton, NS B0S 1M0
NWRI/Sask	National Water Research Inst. (EC), 11 Innovation Blvd, Saskatoon, SK 7N 3H5
PC	Parks Canada (EC)
Phys	Physics
PPO	Physics and Physical Oceanography
QueensU	Queen's Univ., Kingston, ON K7L 3N6
RTK	Real time kinematic
SAR	synthetic aperture radar
SFU	Simon Fraser Univ., 8888 University Dr., Burnaby BC V5A 1S6
SPOT	Système Probatoire pour l'Observation de la Terre (SPOT)
SPQ	Ministère de la Sécurité publique du Québec, 2525 blvd Laurier, Québec, QC G1V 2L2
SPRI	Scott Polar Research Inst., Cambridge CB2 1ER, UK
SSM/I	Special Sensor Microwave/Imager
SWE	snow water equivalent
TrentU	Trent Univ., Peterborough, ON K9J 7B8
UAber	Univ. of Aberdeen, Elphinstone Rd, Aberdeen AB24 3UF, UK
UAlb	Univ. of Alberta, Edmonton, AB T6G 2E3
UBC	Univ. British Columbia, Vancouver, BC V6T 1Z4
UCal	Univ. Calgary, AB T2N 1N4
UCC	Univ. College Cork, Ireland
UCO-B	Univ. Colorado, Boulder, CO 80309, USA
ULav	Univ. Laval, Québec, QC G1K 7P4
ULeth	Univ. Lethbridge, AB T1K 3M4
UMAN	Univ. Manitoba, Winnipeg, MB R3T 2N2
UQAM	Univ. du Québec à Montréal, QC H3C 3P8
UNBC	Univ. Northern British Columbia, Prince George, BC V2N 4Z9
UNO	Univ. Nebraska at Omaha, NE 68182, USA
UOtt	Univ. Ottawa, ON K1N 6N5
UQAC	Univ. du Québec à Chicoutimi, QC G7H 2B1
UQAR	Univ. du Quebec à Rimouski, QC G5L 3A1
USask	Univ. Saskatchewan, 117 Science Place, Saskatoon, SK S7N 5C8
USher	Univ. de Sherbrooke, QC J1K 2R1
UTor	Univ. Toronto, 60 St. George Street, Toronto, ON M5S 1A7
UVic	Univ. Victoria, BC V8W 3R4
UWat	Univ. Waterloo, ON N2L 3G1
UWO	Univ. Western Ontario, 1151 Richmond St., London, ON N6A 5C2
WLU	Wilfrid Laurier Univ., Waterloo, ON N2L 3C5
WSL/SLF	WSL Inst. Snow & Avalanche Res. SLF, Flüelastrasse 11, CH-7260 Davos Dorf, Switzerland
WWCRC	Western Watersheds Climate Research Collaborative
YorkU	York Univ., 4700 Keele St., Toronto, ON M3J 1P3

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International Glaciological Society

JOURNAL OF GLACIOLOGY

Papers accepted for publication between 1 April and 15 August 2010. The papers are listed in alphabetical order by first author. Some of these papers have already been published.

Ice velocity at west Greenland tidewater glaciers from timelapse photos
Yushin Ahn, Jason E. Box

A unifying framework for iceberg calving models
Jason M Amundson, Martin Truffer

Initialisation of ice sheet forecasts viewed as an inverse Robin problem
Robert J. Arthern, G. Hilmar Gudmundsson

Spatiotemporal variability in elevation changes of two high Arctic valley glaciers
Nick E Barrand, Timothy D James, Tavi Murray

Hamilton-type principles applied to ice sheet dynamics: new approximations for large-scale ice sheet flow
J. N. Bassis

Basal melt rates below ice stream shear margins, Whillans Ice Stream, west Antarctica
Lucas H. Beem, Ken C. Jezek, C.J. van der Veen

Volume loss of Bering Glacier during 1972–2003: a comment on 'Airborne and spaceborne DEM- and laser altimetry-derived surface elevation and volume changes of the Bering Glacier system, Alaska, USA, and Yukon, Canada, 1972–2006' by Muskett and co-authors published in the Journal of Glaciology, 55(190), 316–326
E. Berthier

An optimal stability test spacing for assessing snow avalanche conditions
Karl W Birkeland, Jordy Hendrikx, Martyn P Clark

Snow grain size profiles deduced from microwave snow emissivities in Antarctica
Ludovic Brucker, Ghislain Picard, Michel Fily

Results from the ice sheet model intercomparison project – Heinrich event intercomparison (ISMIP HEINO)
Reinhard Calov, Ralf Greve, Ayako Abe-Ouchi, Ed Bueler, Philippe Huybrechts, Jesse V. Johnson, Frank Pattyn, David Pollard Catherine Ritz, Fuyuki Saito, Lev Tarasov

Identification and characterization of alpine subglacial lakes using InSAR, Brady Glacier, Alaska
Denny Capps, Bernhard T Rabus, John Clague, Dan Shugar

Grounding line basal melt rates determined using radar-derived internal stratigraphy
Ginny Catania, Christina Hulbe, Howard Conway

Consistent approximations and boundary conditions for ice sheet dynamics from a principle of least action
John K. Dukowicz, Stephen F. Price, William H. Lipscomb

Integration of a deep-averaged fluid propagation model in a hierarchical Bayesian framework for avalanche predetermination: probabilistic calibration, Monte Carlo simulations, and pressure computations
N. Eckert , M. Naaim, E. Parent

Temporal and spatial variation of 18O and D composition and of accumulation rates in the hinterland of Neumayer Station, East Antarctica
Francisco Fernandoy, Hanno Meyer, Hans Oerter, Frank Wilhelms, Wolfgang Graf, Jakob Schwander

Rate effect experiments on round-tipped penetrometer insertion into uniform snow
James A. Floyer, J. Bruce Jamieson

The importance of considering depth-resolved photochemistry in snow: A radiative-transfer study of NO2 and OH production in Ny-Ålesund snowpacks
J. L. France, M. D. King, J. Lee-Taylor

Light propagation in firn: application to borehole video
T.J. Fudge, Ben Smith

Seasonal variability in the dynamics of Greenland's marine-terminating outlet glaciers
Ian M. Howat, Jason E. Box, Yushin Ahn, Adam Herrington, Ellyn M. McFadden

Propagation of long fractures in the Ronne Ice Shelf investigated using a numerical model of fracture propagation
Christina L. Hulbe, Christine LeDoux, Kenneth Cruikshank

Evidence of past migration of the ice divide between the Shirase and Sôya drainage basins derived from chemical characteristics of the marginal ice in the Sôya drainage basin of East Antarctica
Yoshinori Iizuka, Hideki Miura, Shogo Iwasaki, Hideaki Maemoku, Takanobu Sawagaki, Ralf Greve, Hiroshi Satake, Kimikazu Sasa, Yuki Matsushi

Flow, fracture and modelled present stabilities of the Larsen C and northernmost Larsen D ice shelves
D. Jansen, B. Kulessa, P. R. Sammonds, A. Luckman, E. C. King, N. F. Glasser

Discovery of a nanodiamond-rich layer in the Greenland Ice Sheet
Andrei V. Kurbatov, Paul Andrew Mayewski, Jørgen P. Steffensen, Allen West, Douglas J. Kennett, James P. Kennett, Ted E. Bunch, Mike Handley, Douglas S. Introne, Shane S. Que Hee, Christopher Mercer, Marilee Sellers, Feng Shen, Sharon B. Sneed, James C. Weaver, James H. Wittke, Thomas W. Stafford, Jr, John J Donovan, Sujing Xie, Joshua J. Razink, Adrienne Stich, Charles R. Kinzie, Wendy S. Wolbach

Greenland flow variability from ice-sheet-wide velocity mapping
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Ice layers as an indicator of summer warmth and atmospheric blocking in Alaska
Eric P. Kelsey, Cameron P. Wake, Karl Kreutz, Erich Osterberg

Comparison of satellite, thermochron and station temperatures at Summit, Greenland during the winter of 2008–09 with implications for global-change monitoring
Lora S. Koenig, Dorothy K. Hall

Characterization of subglacial landscapes by a two-parameter roughness index
Xin Li, Bo Sun, Martin J. Siegert, Robert G. Bingham, Dong Zhang, Xiangbin Cui, Xueyuan Tang, Xiangpei Zhang

The impact of topographically-forced stationary waves on the local ice-sheet climate
Johan Liakka, Johan Nilsson

Enhancement factors for grounded ice and ice shelves inferred from an anisotropic ice flow model
Ying Ma, Olivier Gagliardini, Catherine B Ritz, Fabien Gillett Chaulet, Yves Durand, Maurine Montagnat

Sediment plumes as a proxy for local ice sheet runoff in Kangerlussuaq Fjord, West Greenland
Daniel McGrath, Konrad Steffen, Irina Overeem, Sebastian H Mernild, Bent Hasholt, Michiel R Van Den Broeke

A physically based calving model applied to marine outlet glaciers and implications for the glacier dynamics
Faezeh Maghami Nick, Cornelis J van der Veen, Andreas Vieli, Douglas I Benn

Instruments and Methods
A portable software-based ice-penetrating radar system
Laurent Mingo, Gwenn E. Flowers

AMSR-E melt patterns on the southern Patagonian icefield
Patricia A. Monahan, Joan Ramage

Volume change of Jakobshavn Isbræ, west Greenland: 1985-1997-2007
Roman J. Motyka, Mark Fahnestock, Martin Truffer

A rebuttal to E. Berthier 'Volume loss of the Bering Glacier 1972–2003'
Reginald R. Muskett

Formation of air clathrate hydrates in polar ice sheets: heterogeneous nucleation induced by micro-inclusions
Hiroshi Ohno, Vladimir Ya Lipenkov, Takeo Hondoh

Earthquake-induced snow avalanches: I. Historical case studies
Evgeny A Podolskiy, Kouichi Nishimura, Osamu Abe, Pavel A Chernous

Earthquake-induced avalanches: II. Experimental study
Evgeny A. Podolskiy, Kouichi Nishimura, Osamu Abe, Pavel A. Chernous

An energy-balance model for debris-covered glaciers including heat conduction through the debris layer
Tim D. Reid, Ben W. Brock

Effects of debris on surface melting rates on glaciers: an experimental study
Natalya Reznichenko, Tim Davies, James Shulmeister, Mauri McSaveney

Microstructural change around a needle-probe to measure thermal conductivity of snow
Fabienne Riche, Martin Schneebeli

Analysis and forecast of extreme new-snow avalanches: a numerical study of the events of

February 1999 in France
Marie Rousselot, Yves Durand, Gérald Giraud, Laurent Merindol, Luc Daniel

Changes in the elevation and extent of two glaciers along the Yanglonghe River, Qilian Mountains, China
Donghui Shangguan, Shiyin Liu, Yongjian Ding, Yingsong Zhang, Jing Li, Xiangying Li, Zhen Wu

Post-surge elevation changes of Black Rapids Glacier derived from a multi-baseline InSAR DEM
Dan H. Shugar, Bernhard T. Rabus, John J. Clague

Sky long wave radiation on tropical Andean glaciers: parameterization and sensitivity to atmospheric variables
Jean Emmanuel Sicart, Regine Hock, Pierre Ribstein, Jean Philippe Chazarin

Slow drag in wet snow avalanche flow
B. Sovilla, M. Kern, M. Schaer

Meteoric and marine ice crystal orientation fabrics from the Amery Ice Shelf, East Antarctica
Adam Treverrow, Roland C. Warner, William F. Budd, Mike Craven

Origin of the outburst flood from Tete Rousse glacier in 1892 (Mont-Blanc area, France)
C. Vincent, S. Garambois, E. Thibert, E. Lefèbvre, E. Le Meur, D. Six

Review: Bennett, M.R. and Glasser, N.F. 2009. *Glacial Geology: Ice Sheets and Landforms*, Second Edition.
John Woodward

Stochastic reconstruction of snow microstructure and computation of effective elastic properties of snow
Hongyan Yuan, Jonah H Lee, James E Guilkey

ANNALS OF GLACIOLOGY 52(57)

The following papers have been selected for publication in Annals of Glaciology *52(57) (thematic issue on Sea Ice in the Physical and Biogeochemical System), edited by Mats Granskog*

Selective retention in saline ice of extracellular polysaccharides produced by the cold-adapted marine bacterium *Colwellia psychrerythraea* strain 34H
Marcela Ewert, Jody W. Deming

Laser altimetry sampling strategies over sea ice
Sinéad L. Farrell, Thorsten Markus, Ron Kwok, Laurence Connor

Sea-ice drift characteristics revealed by measurement of acoustic Doppler current profiler and ice-profiling sonar off Hokkaido in the Sea of Okhotsk
Yasushi Fukamachi, Kay I. Ohshima, Yuji Mukai, Genta Mizuta, Masaaki Wakatsuchi

Local and floe-scale seasonal thickness changes in the Transpolar Drift
Christian Haas, Herve Le Goff, Samuel Audrain, Don Perovich, Jari Haapala

Sea ice thickness variability in Storfjorden, Svalbard archipelago
S. Hendricks, S. Gerland, C. Haas, A. A. Pfaffhuber, F. Nilsen

Spatial and temporal characterization of sea ice deformation
Jennifer K. Hutchings, Andrew Roberts, Cathleen A. Geiger, Jacqueline Richter-Menge

Verification of a polynya flux model by means of thermal infrared satellite observations
Thomas Krumpen, Sascha Willmes, Miguel Angel Morales Maqueda, Christian Haas, Jens A. Hölemann, Rüdiger Gerdes, David Schröder

Seasonal ice mass balance buoys: adapting tools to the changing Arctic
Chris Polashenksi, Don Perovich, Jackie Richter-Menge, Bruce Elder

Interaction between Antarctic sea ice and synoptic activity in the circumpolar trough: implications for ice interpretation
Elisabeth Schlosser

Untangling processes of ice-edge movement in the Southern Ocean
R.P. Stevens, P. Heil

Modelling the re-orientation of sea ice faults as the wind changes direction
Alexander V. Wilchinsky, Daniel L. Feltham, Mark A. Hopkins

More papers for *Annals* 52(57) will be published in the next issue

REPORT FROM THE NEW ZEALAND BRANCH ANNUAL MEETING

15–17 February 2010, Queenstown, New Zealand

The IGS New Zealand Branch held its annual meeting from 15-17 February 2010 in Queenstown, New Zealand. A record 48 attendees travelled from all over the country to participate in sessions on the latest snow and ice research in New Zealand, Antarctica, and other locations. The meeting was held at Lakeland Park, a camping ground on the sunny Kelvin Heights Peninsula, with stunning lake and mountain views.

28 talks spread over a day and a half covered aspects of glaciology including snow monitoring, modelling, and remote sensing, sea ice, glacier dynamics, and rock and debris interaction with glaciers and ice sheets. The full set of abstracts can be downloaded from the website: www.sirg.org.nz.

As well as the talks, 3 mini-workshops were held to update participants on snow and ice research at the various institutions around New Zealand, career opportunities for students within and outside of glaciology, and upcoming student glaciological research.

Fabien Montiel and Lawrence Kees were awarded a certificate and a year's membership to IGS each as the prizes for the best student presentations. Students Alice Doherty and Nicolle Britland were also highly commended for their talks.

On the second night of the workshop, a well-received public lecture entitled 'Climate change, snow, ice, and tourism' by Emeritus Professor Blair Fitzharris (University of Otago) and Dr Jordy Hendrikx (NIWA) attracted an audience of 91 people. The public lecture was held at the Copthorne Hotel in Queenstown itself and was reported on in the local newspapers. The workshop dinner was held at the local pizza restaurant Winnie Bagoes, aptly with the Winter Olympics silently showing on the big screen.

A field trip on the glacial history of the Wakatipu Basin was held on the final day of the meeting, organized and led by Royden Thompson and Trevor Chinn. The field trip culminated with a visit to the Hillocks at the Dart Bridge, which had been a topic of discussion during the talks earlier in the week.

The meeting was organized by Dr Inga Smith, Dr Sarah Mager, Associate Professor Pat Langhorne, Dr Greg Leonard, and Dr Nicolas Cullen of the University of Otago. Generous financial sponsorship by the Polar Environments Theme at the University of Otago, NIWA, and Antarctica New Zealand, as well as transport provision by the geography departments at the University of Canterbury and University of Otago, ensured that the costs were kept at an affordable level for most students and researchers who wanted to attend the workshop.

The 2011 meeting is being organized by Wellington-based staff and students from the Victoria University of Wellington and GNS. Details will be posted on the website: www.sirg.org.nz.

Inga Smith and Sarah Mager

2010 Seligman Crystal award

The Society's Council agreed unanimously in 2009 that a Seligman Crystal be awarded to Paul Andrew Mayewski. The Crystal was presented at the International Symposium on Sea Ice in the Biogeochemical System, held in Tromsø in June 2010, after the following introduction by the IGS President, Eric Brun.

Dear Colleagues

On the unanimous proposal of the Awards Committee, the Council of the International Glaciological Society has awarded Paul Andrew Mayewski the Seligman Crystal. Awarding a Seligman Crystal is a rare and very important event in the life of our Society. Excellent work in the discipline of glaciology, pioneering work, outstanding results, worldwide scientific recognition are some of the criteria which merit the attention of the Awards Committee. It's obvious that Paul not only fulfils all of these criteria but he has also proved himself an exceptional scientific leader and manager. Indeed his initiative saw some of the most important cooperative international projects through to resolution. For these reasons I am very grateful to the Awards Committee, and particularly to Pat Langhorne, who chaired this committee, for the excellence of their choice.

Pat Langhorne then read out the citation for the award of the Seligman Crystal to Paul Andrew Mayewski, which can be read in full in *ICE* 150, page 22. This was followed by the presentation ceremony itself, after which Professor Mayewski gave the following address.

Fig. 1. Paul Mayewski is awarded the Seligman Crystal by Eric Brun, as Pat Langhorne looks on.

Seligman Crystal acceptance speech:
ICE CORE GLACIOLOGY – ADVENTURE, RESEARCH, AND SOCIAL VALUE

My sincere thanks to Eric Brun, President of IGS, Magnús Már Magnússon, Secretary General of IGS, Pat Langhorne, Chair of the IGS Awards Committee, the Awards Committee and the local organizing committee of the Tromsø Sea Ice Meeting.

Greetings, fellow members of the International Glaciological Society.

Several weeks ago I returned from our joint Chilean–US expedition to the central Andes where we conducted a reconnaissance expedition to find a new ice core site. The glacier we visited filled a volcanic crater and the climb into the site regaled us with amazing panoramas of the highest mountains in the Southern Hemisphere. We found an excellent site at 5700 m that, based on radar, borehole temperature and recently completed laboratory results, fits all of the requirements necessary for us to return in early 2011 to recover an ice core to bedrock. The deeper ice core we plan to recover from this site ought to provide a climate record that captures the changes in precipitation needed to assess future water availability for the growing urban needs of Santiago, the impact of changes in major atmospheric circulation features such as the El Nîno Southern Oscillation (ENSO)

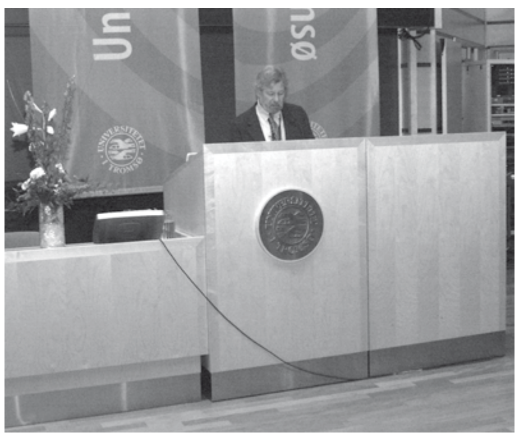

Fig. 2. Professor Mayewski delivering his acceptance speech.

Fig. 3. Paul's talk was accompanied by a slideshow including many spectacular photographs. This photo shows the Northern Victoria Land traverse of 1974/75.

and the Southern Hemisphere westerlies, and the impact of human activity on the chemistry of the atmosphere in this region. This was our third foray into South American ice coring. The first two were into Tierra del Fuego. One by sailboat looking for access points to the small ice caps in the area during which there was not enough wind to raise the sails, followed by a second the following year where we learned a great deal about storms in the region during a 17 day long period of near sustained winds in excess of 100 km per hour.

Our expeditions – and I stress the word 'our' because, despite being the leader of more than 50 expeditions into the remotest parts of the world, I am fully aware of the fact that everything accomplished in these endeavors requires several different types of team effort (planning, field, laboratory, interpretation). So before I continue with this presentation I will attempt to thank the groups and provide a few examples of the many individuals who have been significant to the findings I will describe this evening. It is these groups and individuals who deserve the Seligman Crystal and it is on their behalf that I accept this honor. If I listed all of their names it would take the remainder of my 45 minutes so, to those not explicitly named, my apologies. The groups include a collection of extremely talented and impressive people without whom it would have been impossible for us to collect the global array of ice cores that we now utilize for our climate reconstructions. Graduate students and post-doctoral students, more than 40 so far, of which the most recent include Dan Dixon, Bjorn Grigholm, Elena Korotkikh, Susan Kaspari, Eric Osterberg, Mario Potocki and Nicky Spaulding. Colleagues such as: Tony Gow, Andrei Kurbatov, Michel Legrand, Berry Lyons, Kirk Maasch, Dave Meeker, and Michael Morrison, who worked with me to unravel the intricacies and interactions of the diverse array of disciplines necessary to produce, interpret and disseminate climate change information. Collaborators like Naseer Ahmad from India, Sharad Adhikary from Nepal, Qin Dahe, Shichang Kang, Ren Jiawen, Shugui Hou, and Xiao Cunde from China, Ian Goodwin and Tas van Ommen from Australia, Nancy Bertler and Uwe Morgenstern from New Zealand, Jefferson Simões from Brazil, and Gino Casassa, Ricardo Jana, Stefan Kraus and Jose Retamales from Chile. Super-talented analytical, technical, and organizational support from Betty Lee, Sharon Sneed, Cap Introne, Mike Handley, Mark Wumkes, and Mike Waskiewicz. I have had superb mentors, notably Parker Calkin, Dennis Hodge, Richard Goldthwait, Colin Bull, George Denton and Claude Lorius. Amazing support and advice from program managers Julie Palais and David Verardo, and from logistics suppliers: the 109th Air National Guard, PICO/ICDS, the arrieros (cowboys) of the Andes, sherpas in Nepal, and porters from places like Tongul, in the Ladakh Himalayas, who are no doubt now long gone because the average lifespan for the men of this village was 35 and for women it was 23.

None of us go into the field for months every year or stay bound to our labs and computers day after day without the support of family, friends, and the public, who tell us regularly that what we are doing has value to society. Without the understanding, support and love of my wife Lyn and our family I would not be able to go into the field for the long stays and frequency that have characterized my career. They appreciate the reality associated with the timing of every field season – each is a consequence of the weather, special events like earthquakes and politics that make every field season memorable, but not always predictable or easy to plan around.

In addition to our recent expeditions to South America's central Andes and Tierra del Fuego we have worked in many other of Earth's remotest places. In Asia we opened the doors to ice coring by conducting the earliest expeditions to several sites in the Indian Himalayas. We have also conducted expeditions in well-known sites like Mount Everest plus others up to and exceeding 6700 m in Nepal and China. In the high northern latitudes our research has taken us to North America and notably to Greenland where, as leader of the Greenland Ice Sheet Project Two (GISP2), I had the honor to direct the involvement of 25 US institutions. GISP2 required several seasons preceding the drilling to conduct reconnaissance traverses and five long summers to build the camp, drill the deepest ice core ever recovered from the Northern Hemisphere, penetrate bedrock and many years of analysis and interpretation. In Antarctica we have traversed by foot, ski, snowmobile, and tractor more unexplored territory than ever before and I have had the honor to initiate and chair the 21 countries that participate in the International Trans Antarctic Scientific Expedition (ITASE) and lead all of the US ITASE traverses plus lead many smaller expeditions throughout the East and West Antarctic ice sheets and the Transantarctic Mountains.

A great deal of time is spent living and working in the places we study – something I believe to be essential to those interpreting environmental records. Realizing that the remotest parts of the planet still hold the sound, smell, and sights of the natural world is the first step in identifying the details of anthropogenic impact on our environment. Realizing that what we believed right up through the 1970s and even the early 1980s was not true, that the polar regions are not timeless, unchangeable, nor too large for humans to disturb, has been essential to understanding change. We were wrong then: these regions are highly dynamic and fragile. We are fortunate that several decades ago working in the polar regions was even more difficult than it is now – if not, we might have actually stored nuclear waste in the Antarctic ice sheet, as suggested only a few decades ago by some.

Today we also know how interconnected the climate system really is and that atmospheric circulation features like ENSO, thought for decades to only impact the tropics and mid latitudes, has impacts well beyond the tropics – impacts that penetrate right to the South Pole. Interestingly, Sir Gilbert Walker, in his 1920s research that first described the Southern Oscillation portion of ENSO, suggested looking to the polar regions for teleconnections related to this atmospheric feature.

So how did we arrive at the realization that our planet's remotest regions hold information that reveals the state of our climate system, information about the workings of the ocean–atmosphere–biosphere–anthrosphere, and the fact that mountain glaciers and ice sheets are dynamic first responders and complex players in this system? Who knows where, when and how the realization actually started, but a likely important step for our modern environmental awareness could very well have been the 19th-century Impressionist movement championed by Claude Monet that captured on canvas the reality of human occupation at the onset of the Industrial Revolution, followed by other Impressionist outlets such as music and literature. Exploration in the polar and high mountain regions was in full swing as of the 19th and early 20th centuries and it is from this exploration that the desire to venture more frequently and farther was spawned. Exploration has motive, but the motives can be highly varied from the search for material riches to scientific curiosity to adventure. Throughout much of the 20th century remote regions offered great potential for wealth in the form of forests, mining, drilling and waste repositories. As of the latter portion of the 20th century we realize that protection and balance are essential and that our activities can yield surprises in the form of greenhouse gas warming, the Antarctic ozone hole, acid rain, other forms of pollution, and much more. Some of these key findings and many others come from our field – glaciology.

Fig. 4. The ascent of Nun Kun, Ladakh, Himalaya, 1980.

Glaciology has advanced remarkably over the last few decades. For purposes of this talk I will only focus on the ice core glaciology highlights, or more correctly transformations that have been instrumental in our current state of knowledge of the climate system. My research teams have contributed substantially to almost every single one of these transformations. None would have been possible without support from the National Science Foundation Office of Polar Programs and Division of Atmospheric Sciences, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the W.M. Keck Foundation, and many others.

The ice core glaciology transformations are remarkable and the underpinning for them includes dramatic advances in analytical tools, sample resolution capability, calibration techniques, environmental statistics, cyberinfrastructure and much more.

Analytical tools for ice core investigation have exploded onto the scene in the last two decades. Measurements of one or several chemical species at the ppt range were considered state-of-the-art in the 1980s and now, from just 1–2ml of sample it is possible to measure tens of elements in the ppq range (one part in 1015). Who would have ever thought that ice held anything worth analyzing, much less having any value at the ppq level?

Sample resolution for chemical analyses has transformed from discontinuous – meaning one sample every now and then down the core – to more recently one sample roughly every centimeter to our newly emerging capability of one sample every few microns. So today we can look at 100 samples per meter and soon we will routinely be able to examine 100,000 samples per meter. This means that very low accumulation sites in interior East Antarctica, highly compressed ice near the beds of ice sheets or in emerging blue ice regions may yield climate information at the scale of annual and finer right down to storm events.

Calibration of ice core climate records. This was without a doubt pioneered by the stable isotope community, but the breadth of calibration for ice core measurements has now been greatly expanded to include calibrated ice core reconstructions for atmospheric circulation systems such as ENSO, the westerlies, major lows including the Icelandic Low, the Amundsen Sea Low, the Aleutian Low, as well as stratosphere/troposphere interactions, biological activity in the oceans and on land, solar activity, biomass burning and much more. The calibrations are possible because of our ability to produce annually and sub-annually resolved ice core records and the availability of a wide variety of data that provides the instrumental component for the calibrations such as reanalyses including NCEP/NCAR, ERA40 and a remarkable range of remote sensing data.

Environmental statistics for ice cores. When ice core data was sparse, sample resolution was coarse, and multi-variate measurements were rare, basic statistical tools were adequate. However, ice core data arrays are now dense and the signals are complex so basic statistical tools designed for uniformly behaving systems are inadequate. Ice core time series exhibit diverse signal behavior and statistical tools have had to be borrowed from disciplines such as meteorology and oceanography plus new ones developed through intense collaborations between ice core glaciologists, mathematicians, and computer scientists.

Cyberinfrastructure. Ice core data is not the only past and modern climate data out there and access to other forms of data for comparison with ice core data and for climate reconstructions requires examination of diverse data formats, diverse visualization tools, and new search tools. All of these are now rapidly evolving in the explosive arena of cyberinfrastructure.

The scope of major transformations in the field of climate science as deciphered through ice core glaciology has been nothing less than mind altering. It has included, just to mention a few broad examples: verification of the greenhouse gas–temperature association back to nearly one million years, identification and significance of abrupt climate change, and demonstration of the human impact on the chemistry of the atmosphere with consequences for the health of humans and the ecosystem.

The greenhouse-gas–temperature association. East Antarctic ice cores investigated by French, Russian, Australian and US researchers among others provide the basis for demonstrating the significance of this association utilizing ice core measurements of carbon dioxide, methane, nitrous oxide and the stable isotope proxy for temperature that extend back over 850,000 years. Future deep drilling and possibly investigation of old ice emerging in the blue ice areas of Antarctica could extend this record back to well over one million years. There is no dispute that modern greenhouse gas levels exceed natural levels of the last 850,000 years and greater and that the modern rise is unprecedented. Comparisons conducted by Australian scientists like David Etheridge between greenhouse gas levels in the modern atmosphere and those in ice cores that overlap the observational greenhouse gas records that started during the International Geophysical Year (1957/8) remove any doubt that the ice core measurements capture true atmospheric levels.

Abrupt climate change. Prior to the early 1990s many climate scientists believed that the climate system responded extremely slowly to forcing – so slowly, hundreds to many thousands

Fig. 5. The US ITASE traverse to the South Pole across West Antarctica in 2002/03. This was followed in 2007/08 by the US ITASE traverse to the South Pole across East Antarctica.

of years, that one could assume that even massive perturbations to the climate system such as the anthropogenic rise in greenhouse gases would be slowly and imperceptibly dissipated with minimal immediate or near-term, decade scale and much longer, response. With the recovery and analysis of the central Greenland ice cores (GISP2) and its European counterpart (GRIP), abrupt climate change was verified and characterized. It would not have been possible to definitively exclude ice dynamics for the cause of these abrupt events without these two deep cores, separated by ten ice thicknesses. The most dramatic of these abrupt climate change events are those that occurred during the last glacial and the deglaciation. These events have been named after two of the fathers of the ice core field, Willi Dansgaard and Hans Oeschger, Claude Lorius and Chet Langway being the other two fathers of the field. These most dramatic of the abrupt climate change events are characterized by changes in temperature exceeding 10°C and massive shifts in precipitation and storminess with onsets and decays of less than 1–2 years and durations in their altered states of many decades to centuries. During our current interglacial, abrupt climate change events have been far more subdued, scaled down to 1–2°C and to shifts in precipitation and storminess equivalent to adding or subtracting days to weeks to winter or summer duration, and shifts of tenths to degrees of latitude and longitude to the effectiveness of moisture and heat bearing storms. The Little Ice Age/Medieval Warm Period transition in North Atlantic that occurred close to ad1400 and changes in the frequency and intensity of El Niño/La Niña and the Pacific Decadal Oscillation provide recent examples of abrupt climate change. Several abrupt climate change events coincide with major disruptions to ecosystems and to civilization, notably the collapse of Mesopotamian culture in modern-day Syria 4200 years ago, of the Mayan culture in central America 1100 years ago, and of the Norse colonies in Greenland 600 years ago. These events provide clear lessons concerning the fragility of regions susceptible to drought and changes in sea-ice extent. The forcing for these abrupt climate events is in some cases closely linked to mechanisms controlling ocean circulation and in some cases may be driven solely by shifts in atmospheric circulation with sustainability invoked through sea ice and the hydrologic cycle. What appears clear now is that abrupt climate change can be triggered by threshold breaking events superimposed on longer-term climate forcing. The likely threshold forcing in the 21st century is anthropogenic rise in greenhouse gases. The important message from ice cores is the fact that the instrumental climate record of the last ~100 years does not capture abrupt change, but nevertheless

Fig. 6. Hitting bedrock in central Greenland in 1993.

abrupt climate change is a reality. Examination of just the instrumental record could have lulled us into considering a model for future change that invoked linearity. Response to our massive assault on the climate system could, and indeed is very likely to, be abrupt and predictions for future climate change must include this alternative.

Human impact on the chemistry of the atmosphere. The human source rise in greenhouse gases such as carbon dioxide, methane, and nitrous oxide has been well documented using ice core records and humans have made many other significant changes to the chemistry of the atmosphere. Yet, unfortunately today greenhouse gas impact is debated in the political arena. Knowledge of the current and future impact of humans on the physical, chemical, and biological climate system must be expanded and delivered more robustly to the public and governments rather than stagnating in the throes of political agendas. The anthropogenic source rise in greenhouse gases is undeniable, but the full facts concerning human impacts have only been partially impressed upon the public and our governments. Related to and in addition to the rise in greenhouse gases are many other human contributions to modern climate change. These include the springtime depletion of stratospheric ozone over Antarctica and surrounding regions, as a consequence of ozone-destroying humanly engineered CFCs, that has not only impacted human and ecosystem health but has also altered the thermal gradient of the atmosphere over Antarctica and the Southern Ocean, resulting in the intensification of the Southern Hemisphere westerlies. This intensification has consequences for the duration and location of sea ice surrounding the continent, drought over Australia, and glacier mass balance in New Zealand and southern South America. Ice cores tell us that the recent CFC-forced state of stratospheric ozone over Antarctica is unparalleled by naturally occurring springtime ozone holes. Analogs for past dramatic intensifications of the westerlies reveal abrupt terminations to these events, as might be expected in the future when the Antarctic ozone hole heals and lower tropospheric greenhouse gas warming combines to weaken the thermal gradient by the middle of the 21st century, allowing the full force of warming to invade Antarctica. This is an abrupt climate change event ready to happen and in the past when climate has changed over Antarctica fluxes of meltwater were transmitted through the ocean contributing to abrupt climate change in the Northern Hemisphere. Based on examination of past abrupt climate change events we know that the greatest magnitude and most abrupt occurred in the North Atlantic, very likely effected through changes in sea ice extent in the North Atlantic.

The sort of ‘ climate surprises’ I just described, where human activity (in this case the Antarctic ozone hole) temporarily offsets another human forcing (greenhouse gas warming) of the climate system, have already played out once before as the rise of industrial-source, radiation-reflecting sulfur aerosols demonstrated in the 1940s–1970s through cooling of much of the Northern Hemisphere. Yes humans can warm and cool the planet, plus do much much more. The sulfur aerosol and CFC stories have a silver lining – both have responded well to legislation calling for reduced levels, the Clean Air Act and the Montreal Protocol, respectively. However, we also need to remember that these ups and downs demonstrate the fragility of the climate system. The increase in sulfur aerosols well above natural levels is a story verified and regionally differentiated by ice cores. Similarly the rise in toxic metals (e.g. lead and mercury), radioactivity (including above-ground atomic bomb testing and the identification of Chernobyl nuclear accident fallout as far away as Antarctica), organic compounds, particulate matter, nitrogen and phosphate loading – the perspective allowing differentiation between natural and anthropogenic perturbation of the foregoing all comes from ice core records. Our most recent findings include dramatic rises in uranium, cesium, and barium in some polar regions. For many trace elements and compounds a basis for assessing naturally varying levels is still not available nor are the health standards for humans and the ecosystem.

The impacts of warming, such as vector-borne diseases, drought, intensification of storm frequency and intensity, toxic pollutants, particulates, and much more, all have dramatic consequences for human and ecosystem health. Incidences of asthma, neurological and coronary disease, and cancers are all increased as a consequence of the foregoing. Knowledge of the differences between natural variability and human impact on all components of the physical, chemical, and biological climate system has been uncovered using ice core records and more emerges on a regular basis.

What does the field of ice core glaciology need to consider and aspire to in the future? The task of recovering ice core records is far from over. Unfortunately, the urgency for collection is real since so many sites are losing viable records through melting. In the early 1980s we could recover viable ice core environmental records in the Himalayas from elevations close to 5500 m. Today, to find unaltered ice core environmental records requires recovery from sites several hundred meters higher. These records do still exist and in some cases, like the New Zealand Alps, where the upper parts of some records may have disappeared, the older portion of the environmental record is still intact. Analytical capabilities will undoubtedly continue to emerge yielding new techniques for age dating of ice, and new ways to measure ice core properties, such as our latest endeavor with colleagues at our university to employ surface chemistry sensor technology. Innovations in remote sampling and analysis will further the expectations for recovery of environmental ice core records from inaccessible sites on Earth and beyond. Improved data search engine and data handling technology will greatly expand the use of ice cores as a framework for environmental perspective. Explicit in all future research will be the necessity for full transparency and data sharing to counter accusations by skeptics and, more importantly, to allow full disclosure to others so that scientific data can be easily accessed for building blocks toward new understanding.

So if you want to see the world, experience the smell, taste, sound, temperature, winds, cultures, and lifestyles of remote places, become a glaciologist. If you want to provide perspective to a fast moving world, travel through time, and experience memorable adventures, become a glaciologist. If you want to work with some of the finest scientists and most dependable colleagues in the world and do something that has significant social value, become a glaciologist. Who would have ever thought that a field that might have appeared to be so specialized in the past could now have value to so many other disciplines, the public, and governments?

Thank you for sharing part of your evening with me.

Paul Andrew Mayewski
Professor and Director, Climate Change Institute, University of Maine, USA

Report from the VICC Conference

The IGS co-sponsored conference on
'Ice and Climate Change: A View from the South'
Valdivia, Chile, 1–3 February 2010

The IGS co-sponsored conference on 'Ice and Climate Change: A View from the South' was held at Centro de Estudios Científicos (CECS) in southern Chile in early February 2010, and was primarily sponsored by Fundación Imagen de Chile. Over 130 talks and posters were presented on all aspects of glaciology, with the spotlight mainly, but not exclusively, on the state of the cryosphere in the Southern Hemisphere. CECS is located in the beautiful 'city of rivers', Valdivia. For many of us this provided a welcome escape from the economic woes and gloom of the Northern Hemisphere winter to the optimism and vitality of the Chilean midsummer. Certainly the 'icebreaker' held in the Sky Bar of the new Hotel Dreams, overlooking the Rio Valdivia, was a flamboyant affair and included representatives of Chile's four indigenous cultures in traditional dress, and canapés washed down with Chile's national drink, the ubiquitous pisco sour.

CECS is a private research organization located in a distinctive bright yellow building (a former hotel) that is easily identifiable from all parts of the city. Presentations and posters were held in the impressive new Carpa de la Ciencia (Tent for Science) annex to the main building. This had only recently been erected and was not yet fully completed, but no one noticed a few rough edges given the high quality and diversity of presentations on offer, and wonderful hospitality from our Chilean hosts.

There was an unusually high security and strong media presence for the start of the conference, but the reason quickly became clear as the President of the Republic of Chile, Michelle Bachelet, arrived to give the opening address. Ms Bachelet is a long-standing supporter of CECS and she spoke knowledgeably and passionately about the state of the cryosphere and the importance of glaciological research, particularly in a country in which people and glaciers have a strong interdependence due to mining activities, glacier volcano hazards and freshwater resources. This was one of the most memorable openings to a conference that many delegates had witnessed and set a buzz that was maintained throughout the meeting.

The opening formalities over, the first day's sessions were grouped under the title of 'global topics' with a focus on global and regional glacier monitoring, hazards, climate change and economic and social impacts. It is difficult to summarize such a geographically and thematically diverse range of talks and posters. One of the many highlights was Andrés Rivera's government-funded work on defining the word 'glacier', which is less straightforward than it may seem. This made us wonder if some of the long-lying snow patches in Scotland, in the north of our home country Great Britain, might need to be included in the world glacier inventory! John Reynolds, Cunde Xiao and Luis Miguel Galindo further emphasized the economic and social importance of glaciers, particularly in developing nations, while Gino

Fig. 1. The poster section of the 'Tent for Science' at CECS.

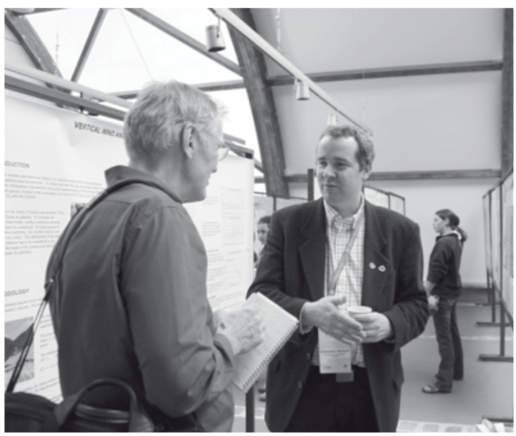

Fig. 2. There were many fruitful discussions during the poster sessions.

Fig. 3. Andrés Rivera gets his teeth into some ignimbrite.

Casassa reported the sad news of the imminent demise of Venezuelan glaciers. Paul Leclercq presented a new 400-year global temperature reconstruction based on glacier length records and flow modelling, which broadly agrees with other proxy records, except in the last 20 years.

At the end of such a full and inspiring day, delegates were understandably thirsty and eager to discuss the day's events over some liquid refreshment. In anticipation, the organizers had thoughtfully laid on a wine tasting event at Hotel Dreams, which provided an introduction to the principal wine varieties and regions of Chile, and illustrated the good use Chilean winemakers make of glacial runoff.

The second day continued with the 'global topics' theme with a set of presentations from diverse geographical regions including New Zealand, Patagonia, the Chilean Lakes district, the Antarctic Peninsula and, in Bernard Hallet's excellent summary of the 'buzzsaw' hypothesis, the entire planet. Reinhard Dietrich informed us of some astonishingly high isostatic uplift rates recently recorded in Patagonia due to the unloading effect of glacier shrinkage.

Fig. 4. The New Zealand contingent patiently wait for their pisco sours on the boat trip to Isla Haupi.

Fig. 5. Pisco sour was in plentiful supply on the boat trip.

The remainder of the second day was devoted to presentations on Antarctica. Two impressive talks by Steven Arcone and Bob Jacobel showed us how the careful processing of high-resolution long radar profiles across the continent can be used to identify stratigraphic structures within and thermal/hydrological characteristics at the base of the ice sheet. Using ICESat and GRACE satellites respectively, Jay Zwally and Rene Forsberg told us about the current mass balance of Antarctica confirming that large parts of the Peninsular and W Antarctica in particular are loosing mass, likely at a faster rate now than a decade ago, although uncertainties are still large. We also had talks on the dynamics of ice streams which vary at frequencies associated with tidal forcing (Hilmar Gudmunsson) and due to the collapse of ice shelves (Helmut Rott; Anja Wendt) as well as several talks on both the climatology of parts of the continent and sea-ice extent.

There were a large number of early career researchers and graduate students in evidence at VICC 2010 and a special lunchtime session for this group: 'Careers in glaciology: research and opportunities', was hosted by Shelley MacDonell. This workshop took the form of a panel discussion, drawing on the experience of scientists at various stages of their careers. The panel fielded questions about the challenges and rewards of a career in glaciology. The session also provided the

Fig. 6. The pace takes its toll on members of the Organizing Committee.

opportunity to make contacts and hear about new opportunities.

That evening we were treated to a boat trip and banquet at Isla Haupi some 15 km downriver from Valdivia. Isla Haupi is a private nature park of just 8 hectares, which contains the entire flora of the endemic Valdivian rain forest. The restaurant there specializes in traditional Chilean cuisine, although the free-flowing pisco and snacks on the boat meant we were quite well fed and watered before we even reached the island.

On the final day, the focus shifted to ice cores, tropical glaciers and paleoclimatology. The first oral session was kicked off by Joergen Steffensen who asked of the NEEM deep ice core project in Greenland: 'Do we get an ice core record of the previous interglacial, and why do we want it?'. The remaining talks focused mainly on the high Andes, highlighting the fact that in several cases, current research here represents the last opportunity to extract useable ice core records before they are lost to climatic warming. The climate change theme, albeit over longer timescales, was picked up again in the final session before lunch on palaeoclimatology.

After lunch, there was a special session focussing on work at the Centro de Estudios Avanzados en Zonas Aridas (CEAZA) in Chile. It highlighted the important applied aspects of glaciology in this part of the world, in large part due to the close proximity of mine workings and glaciers in the high Andes, and the importance of glaciers as a water resource. Much useful research has been funded by large mining companies, enabling scientists to conduct pioneering investigations on the climate response of high altitude glaciers in the arid north of Chile. More controversially, Geostudios Ltda., of Santiago, has conducted a series of experiment involving the movement, burial and creation of artificial glaciers.

The final session of talks was devoted to Patagonia, ending with a wonderful presentation

Fig. 7. Members of the Scientific Committee at the closing address (l-r: R. Sinclair, K. Steffen, G. Casassa, A. Rivera).

by the charismatic Jorge Quinteros, who gave a personal view of the Patagonian Icefields, including pictures and recollections of his pioneering west–east crossing of the Southern Icefield with Harold Tilman in 1955–56. Members of the Scientific Committee (Gino Casassa, Andrés Rivera, Konrad Steffen and Rolf Sinclair) brought matters to a conclusion in a feedback and summary session, which once again featured a strong media presence.

This overview has concentrated on the talks, identifying only a few of the 58 talks given. It should be stressed that there were also 75 posters presented over the three days on all of the topics associated with the oral sessions mentioned above. The standard of posters was very high throughout and provided the inspiration for a lot of engaging discussion and the seeds of new collaborations between attendees. At this point it is worth noting the wonderful catering, including breads, pastries, cakes and fresh fruit, provided in the coffee breaks and during the poster sessions,

Fig. 8. Jorge Clavero & Gino Cassasa.

Fig. 9. Paul Leclercq and Hilmar Gudmundsson.

which helped counteract the inevitable 'conference fatigue' which does have a tendency to set in following long sessions of presentations and even longer evening sessions of glacial discussion.

Our thanks go to Gino Casassa and Andrés Rivera and the members of the Scientific and Local Organizing Committees (too numerous to mention here) for the warm welcome and excellent hospitality we enjoyed in Valdivia. The support team dealt tirelessly with the numerous queries and requests from delegates with unfaltering courtesy, and the programme struck the perfect balance between presentations, opportunities for discussion and entertainment. At the end, many of us reflected that this was probably the most enjoyable and best organized conference we had attended. Videos of oral presentations, together with a book of abstracts can be viewed at the conference web site: http://www.cecs.cl/vicc/.

VALDIVIA PRE CONFERENCE TOUR

The conference was preceded by a 2-day glaciological and volcanological tour to Villarrica Volcano, located 120 km northeast of Valdivia, with field lectures given by Jorge Clavero, Andrés Rivera and the 1-year-old Emilia Rivera, attending her very first IGS symposium tour. Volcán Villarrica is one of the most active in Chile, with over 50 eruptions recorded in historic times. The volcano is covered by c. 30 km^2 of permanent ice and these glaciers have been the subject of mass and energy balance and radar and remote sensing investigations, together with the assessment of the risk from glacier-volcano hazards. These studies suggest that accelerated basal melting due to sub-glacial geothermal hotpots is at least partly responsible for the rapid shrinkage of the glaciers in recent years.

On the first day we were guided around several sites in the vicinity of the Volcano to examine geological formations and volcanic deposits. Several towns in the region have been affected by lahars due to glacier-volcano interaction. Notably, in Coñaripe, part of the town was completely destroyed in March 1964 by a lahar, killing over 20 people. Buildings were washed out into Lago Calafquén and a large area of the town buried in mud and silt. Further damage and loss of life was caused by a 2 m tsunami in the lake triggered by the lahar. We visited a monument to those killed in the disaster at a site on the lake shore. Moving on, we took in the lava flows from the 1971 eruption and examined distal deposits from the largest postglacial explosive eruption of Volcán Villarrica: the Licán Ignimbrite at Licán Ray, some 20 km from the western caldera rim. A particularly interesting feature at the base of the unit is the carbonized remains of trees fired and eventually buried by the pyroclastic deposits. We completed the day

Fig. 10. Members of the pre-conference tour visit the memorial to those killed in the 1964 Coñaripe lahar on the shore of Lago Calafquén.

Fig. 11. Volcán Villaricca.

Fig. 12. Ascending Volcán Villarrica.

at the Villarrica ski centre taking in magnificent views of the volcano and surrounding landscape of mountains and lakes.

At the end of the day, some of the party, including the IGS committee members, returned to Valdivia, while the rest of us stayed overnight in the town of Pucón, the 'adventure capital' of southern Chile, which was buzzing with holiday makers and 'adrenaline junkies'. After dining al fresco on some succulent Chilean steaks and wine we were hoping to enjoy the famous Pucón nightlife, but alas, due to our early start the next day, we had to retire to bed well before most Chileans would have considered going out for the evening.

The following day we were blessed with blue skies, light winds and a comfortable temperature – perfect for ascending the Volcano to the Pichallancahue Glacier – and we left our hotel at dawn in eager anticipation. The first part of the ascent took us through the magnificent *Araucaria* (monkey-puzzle tree) forest and after climbing past the tree-line we were rewarded with a spectacular vista of snow-capped volcanoes including the 3776 m high Lanin on the Argentinian border. After walking up the gentle tephra slopes of the Pichillancahue valley we reached the caldera rim and the glacier terminus, for a brief lunch stop. One of us (BB) had camped here in the 2004 and 2005 summers during glaciological expeditions, but barely recognized the glacier due to its dramatic retreat since then. Alas, there was no time to go to the automatic weather station on the glacier, but we were able to visit the CECS gauging station on the proglacial stream on our return to Pucón.

VALDIVIA POST-CONFERENCE TOUR

This two-day tour first involved a 5 hour drive east from Valdivia through Máfil, Los Lagos and Panguipulli to the Huilo Huilo Reserve, a total of 160 km. Thankfully, the journey was interrupted by a stop at Malihue Bridge spanning the San Pedro River. In May 1960, this stretch of the river was dammed by landslides and rockfalls triggered by an earthquake centred on Valdivia, the most powerful earthquake ever recorded at 9.5 on the Richter Scale. Failure of the natural dams caused several floods to the already devastated settlements, including Valdivia, downstream. The second stop, just west of Panguipulli, was at the prominent Late Glacial Maximum terminal moraine, more than 50km from the main crest of the Andes showing just how extensive the glaciation was in this part of the world during the Pleistocene. Once we arrived at Huilo Huilo we were taken on a short walk among towering trees and past thundering waterfalls to look at a series of late Pleistocene/early Holocene basaltic andesite lavas, occasionally showing spectacual columnar jointing, overlain by ~2000 year old pyroclastic flow deposits containing impressive lapilli structures. We stayed the night at the extraordinary Baobab Hotel, a round cone shaped spiralling structure which appeared to be made entirely of wood and glass, got wider as it got higher, was built around the trees and all in all looked like something out of Lord of the Rings.

Day two of the tour had us travel by a convoy of 4x4s to the flanks of the nearby Mocho-Choshuenco Volcano, which last erupted in 1864. It is covered by ~17 km^2 of glacier ice and is the site of a recently initiated glacier climate and mass balance monitoring programme run by CECS. We had a choice of transport to get us from the edge of a glacier on the east side of the Volcano up to the weather station (1995 m a.s.l.). Some chose to hike, while others chose to be hauled up by the

Fig. 13. Porto Huilo Huilo.

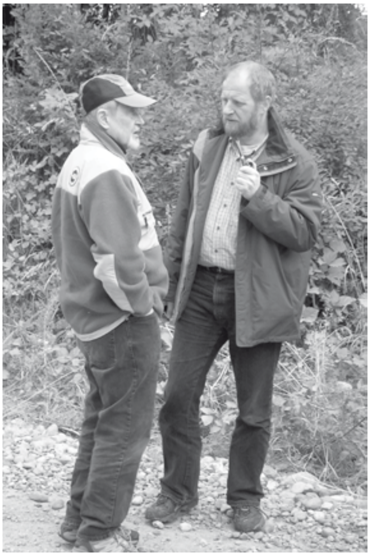

Fig. 14. Jay Zwally and Joergen P Steffensen (JP).

Fig. 16. Paulina López & Paul Leclercq.

Fig. 15. Ascending Volcán Mocho-Choshuenco.

Fig. 17. Weather Station on Volcán Mocho-Choshuenco.

motorized cable sledge, which has to be seen to be believed. Unfortunately, visibility was down to about 50 m at the weather station, it was cold, the wind was quite strong and so despite the collective enthusiasm and experience of (most of) the assembled glaciologists, we did not hike to the top as planned, but slowly returned to the 4x4s that whisked us back to the warmth of a sumptuous barbeque back at Porto Huilo Huilo. We eventually returned to the buses and slept most of the way back to Valdivia.

On behalf of all the delegates, we would like to thank our excellent guides and organizers, who produced an informative, comfortable and highly enjoyable few days prior to and after the conference.

Ben Brock and Ian Willis

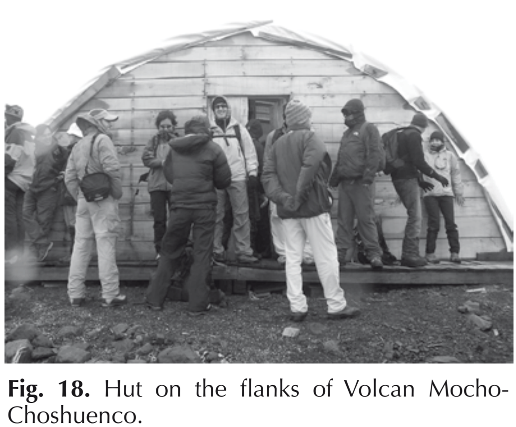

Fig. 18. Hut on the flanks of Volcan Mocho-Choshuenco.

Report from the University of Alaska Fairbanks International Summer School in Glaciology

At the end of a bumpy, 60-mile dirt road, still strewn with hidden tyre-endangering railroad spikes, lies the small Alaskan community of McCarthy. According to the wishes of its residents, it is publicly accessible only via footbridge across the Kennicott River; no roads lead into the town itself. Above the town stands Kennicott Glacier, dominating the valley. Once a year, glacier-dammed Hidden Creek Lake bursts free and drains out from beneath the glacier, tripling the flow of the river for 24 hours.

What better setting could there be for the University of Alaska Fairbanks to spend a week imparting glaciological knowledge to a class of eager students? On 8 June 2010, with the weather obligingly sunny, 27 students and ten lecturers disembarked from their long road journey and marched down McCarthy's main street to the old hardware store that houses the Wrangell Mountain Center. Here they would spend the next week bathed in a sea of glaciological knowledge at the first University of Alaska Fairbanks International Summer School in Glaciology.

UAF faculty designed the summer school to give students a good base of knowledge in their field and an introduction to some of their future colleagues. Several sponsors provided the generous support that allowed students to travel from far away and spend two weeks concentrating on learning: the UAF International Arctic Research Center (IARC), the International Arctic Science Committee (IASC), the National Aeronautics and Space Administration (NASA), the International Union of Geodesy and Geophysics (IUGG), and of course our friends at the International Glaciological Society (IGS.)

The Wrangell Mountain Center (WMC) acted as classroom, kitchen, gathering-place and general summer school headquarters. Its unfailingly friendly staff cooked three meals a day for the glaciologists, whose intensive studies worked up quite an appetite ('We're making enough for sixty people,' the staff were heard to remark, 'and they're still eating it all!') The food was mostly vegetarian and vegan, yet of such quality (and quantity) that even the most dedicated omnivores barely missed the meat. The WMC was also the location of the only bathing facilities available to the students: a choice between washing in the glacier-fed stream out back, or filling a spigot-equipped bucket from the wood-fired water heater and then propping it up in a small outdoor enclosure to approximate a shower. Such shared deprivations were one of many ways in which students bonded.

UAF chose participants carefully to achieve a varied student body, with research interests stretching from ocean influences on tidewater glaciers to

Fig. 1. Don't be fooled by the Hardware Store's elderly facade; there's cutting-edge science in there.

Fig. 2. Bernhard Hynek describes his research to an interested crowd.

Fig. 3. Solar-powered physics calculations.

glacial features on Mars. Ice core analysis, remote sensing, ice sheet modeling, subglacial dynamics, glacier–climate interactions, and a wide variety of other subjects filled out the list. The diversity of origins matched the diversity of interests, with students hailing from institutions in eight US states (Alaska, Arizona, California, Colorado, New York, Texas, Washington, and Wisconsin) and 12 different countries (Argentina, Austria, Belgium, Canada, Denmark, the Netherlands, New Zealand, Norway, Sweden, the Russian Federation, the UK and the USA). A poster session on the first day in McCarthy got students acquainted with each other's research topics, and was also well attended by interested townsfolk.

Fig. 4. Erin Pettit and Katie Boldt pry out a large ice crystal.

Each morning the students woke to a sun already well up in the sky and made their way from the riverside tent city to the Wrangell Mountain Center for a hearty breakfast and a cup or three of coffee to kick-start their mental faculties. Mornings were devoted to classes on glaciological topics both theoretical and practical, from the mathematical rigors of continuum mechanics to more practical discussions of glacial geomorphology and hydrology. After lunch, eaten outdoors except in the rainiest of weather, students would complete exercises based on the morning's lessons and gather in small groups to work on projects. These bite-sized research projects, designed to be completed within the week, included data analysis projects, modeling exercises and one or two tasks involving fieldwork.

Not every day was taken up with coursework. The Kennicott glacier and its tributaries, visible from almost every part of town, demanded closer investigation. The whole school hiked up one sunny day to clamber across one tributary, the Root, and observe its properties firsthand. For some students, who specialized in remote sensing or modeling, the trip represented their first opportunity to experience a glacier 'in person'. The Root Glacier provided examples of crevasses and moulins, cryoconite holes, supraglacial streams and other icy phenomena; the trip also gave students a chance to observe the debris-covered foot of the Kennicott, climb over the Root's large medial moraine, and investigate a small mostly-dry lake next to the glacier whose level rises 40–50 meters when the yearly outburst flood traverses the subglacial hydrological system.

After a long day of classes, students had no trouble filling their evenings. A long-time McCarthy resident gave a talk on the town, its character and its peculiar history, from its geological creation to the present; the local saloon's open mic night drew participation from both summer school students and WMC staff; INSTAAR's Bob Anderson gave a public lecture in Kennicott on glaciology and its application to the local glacier's particular morphology and annual outburst floods; a Europe vs. North America soccer game competed for space with the local softball team. On nights when no organized activity presented itself, students (and sometimes faculty) gathered around the bonfire in the midst of Tent City, talking, singing, and occasionally breaking out into fits of dancing, long into the twilit Alaskan night.

On the last day in McCarthy students presented the results of their projects, most of them having made gratifying progress with just a few days' hard work. A banquet at the McCarthy Lodge capped things off, providing students with their first red meat in a week and an opportunity to win

Fig. 5. Students and lecturers chat about the day's classes, or perhaps about which students the bears will get first.

one of four student memberships kindly donated by the International Glaciological Society by demonstrating their talent, skill or luck. From the songs, poems, and other performances presented, Dr Hock selected four winners: one for a set of excellent Russian refrigerator jokes; one for a suite of limericks based on the week's lecture subjects; one for the design of a t-shirt to commemorate the camp; and one selected by a lottery.

The camp participants embarked on the long drive back to Fairbanks in good spirits, despite their sadness at leaving McCarthy behind and tiredness from a week of mental and physical exertion. The school ended with a one-day conference at UAF covering a variety of icy topics, going beyond the glaciology covered in the camp to encompass permafrost, natural disasters and other related fields of study. Along with the lectures, students visited the CRREL Permafrost Tunnel to learn about permafrost phenomena and investigate the intriguing icy structures therein.

The first UAF International Summer School in Glaciology was a rousing success by any measure. Students left with a better and more comprehensive grounding in their chosen field of study, as well as solid hands-on experience in collaborative projects. We had a great opportunity to get to know a classic Alaskan town while developing a little more hands-on familiarity with glaciers and the landscapes around them. And each of us was privileged to be able to work and socialize with so many excellent scientists, both the accomplished faculty from University of Alaska, University of Colorado, and University of Washington and the dedicated students from around the world. We're all looking forward to the next one!

Fig. 6. A group of glaciologists in their natural habitat.

In closing, by popular demand, here are a few of the limericks written by me describing some of the subjects taught at the school.

Ice dynamics
Though its speed is exceedingly low,
Ice is fluid, as glacier shapes show.
Non-Newtonian viscosity
Determines velocity
According to Glen's law of flow.

Ice fabric and anisotropy
At the microscale, ice grain migrations
Derive from crystalline dislocations
Anisotropies cause
New constitutive laws
To account for in our simulations.

Subglacial hydrology
Water flows through the glacier like blood
Makes it slide over bedrock and mud
When a tunnel melts through
Or ice dam breaks in two
Out comes pouring a Biblical flood

Tidewater glaciers
When these tidewater glaciers retreat
The destruction's both fast and complete
It advances again
On a borrowed moraine
Like a leveraged bank on Wall Street

Mass balance
Adding up rain, wind, heat, cloud and sun
To get melt isn't very much fun
You could try degree-day
It's an easier way
But a somewhat less accurate one

Glacial thermodynamics
Now the species of glacier are three
Cold is fully below zero C
Temperate's always at freezing
Polythermal's a pleasing
Combination of types A and B

Remote sensing with ICESat
When inspecting the tracks of ICESat
Look for spots that are curiously flat
Or locations that flex
From concave to convex
It's a subglacial lake doing that!

Gravitational remote sensing
For the weighing of glaciers, a scale
Is inevitably much too frail
But science saves face
By celestial GRACE
Which delivers the mass-balance Grail

Laser altimetry
To determine an ice-surface height
Send out regular pulses of light
Measure time to bounce back
Then, repeating your track
Demonstrates warming glaciers' dire plight

Inverse methods
To extrapolate former conditions
Using presently measured positions
Although methods inverse
May inspire you to curse
They'll reveal past climatic transitions

Debris-covered glaciers
Grand white Kennicott looms above town
But its foot is all filthy and brown
If we clean off the sand
It'll look mighty grand
Till, uncovered, it melts, and we drown.

The consequences of setting forty glaciologists loose on a small town's alcohol supply
There's a flow law for ice strain and shear
What we need is a flow law for beer
Given glacier grads, *N*,
And a drink rate *X*, when
Will all booze on the shelves disappear?

Regina Carns
University of Washington, Earth and Space Sciences Department
With thanks to Andy Aschwanden, Regine Hock and Tim Bartolomeus for the use of their photos.

Meetings of other societies

SPIRIT Workshop, Toulouse France, 29–30 April 2010

SPIRIT (SPOT 5 stereoscopic survey of Polar Ice: Reference Images and Topographies) is an IPY project co-managed by the French Space Agency (CNES), Spot Image and the French Mapping Agency (IGN), with LEGOS (Laboratoire d'Etudes en Géophysique et Océanographie Spatiales) as the scientific PI. For 2 years, the project has covered more than 4 million km^2 of polar regions with 40-metre digital terrain data derived from SPOT 5 stereoscopic pairs, freely supplied to polar glaciologists. The prime rationale was to enable more accurate calculation of recent ice volume changes. The data cover portions of Alaska (with adjacent parts of Yukon and British Columbia), Iceland, Svalbard, Novoya Zemlya, Canadian Arctic Islands and the margins of the Greenland and Antarctic ice sheets. This workshop assembled around 30 researchers to share their applications using these data and included representatives from France, Germany, Iceland, Norway, Russia, USA and the UK. It was convened at the LEGOS facilities, Observatoire Midi-Pyrénées.

The opening address was given by IGS President, Eric Brun (Météo France), before the morning session in which six presentations described the achievements of the SPIRIT and prospects of future related satellite missions. Six talks after lunch covered the use of SPIRIT DEMs in combination with other data such as ICESAT, ENVISAT, ERS and GRACE in studying the Antarctica Ice Sheet, ice shelves and outlet glaciers. The evening included a reception at the Capitole city hall and a group dinner.

The second day discussed the Greenland Ice Sheet, mountain glaciers and ice caps (11 presentations). The first talk by Anny Cazenave (LEGOS) on sea level budget over the altimetry era gave an excellent overview of the relative contributions of glaciers and ice sheets to sea level rise. Two up-to-date talks by Eyjolfur Magnusson and Sverrir Gudmundsson, University of Iceland, described the use of the SPIRIT DTMs to deduce ice volume changes and ice-volcano interactions in Eyjafjallajökull volcano (we all learnt the right

Fig. 1. A very enthusiastic group of participants.

Fig. 2. Two mandatory ingredients for a successful glaciological workshop in France: croissants et vin.

Fig. 3. Reception in one of the oldest rooms at the Capitole city hall, downtown Toulouse.

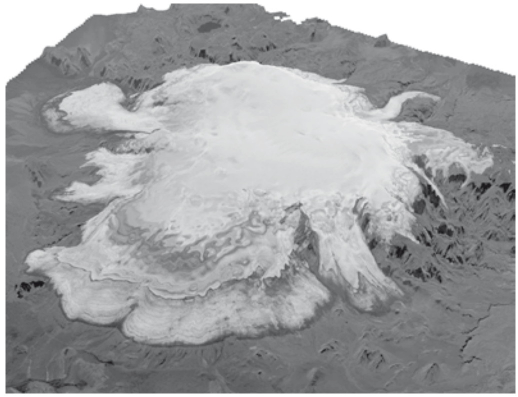

Fig. 4. Spot5 3-D view of the Mýrdalsjökull ice (590 km^2), Iceland (©CNES 2004/Distribution Spot Image/Spirit project).

Icelandic pronunciation!), following the eruption one week earlier that impacted the flight patterns of several of the participants.

All presentations stressed the value and quality of the SPOT products in enabling the calculation and modeling of more accurate ice elevation and volume changes in recent years. All attendants are now looking forward to repeat (post Fourth IPY) acquisitions of Spot5 data in the polar regions. Some friendly open discussions stressed that there is still room for some methodological improvements in the processing of the DEMs over flat and textureless snow-covered areas, in particular on the Antarctic ice sheet. The excellent workshop organization by Etienne Berthier (LEGOS), and superb breakfast and lunches were much appreciated, especially the croissants and bottles of wine.

The program can be viewed online at: (presentations are also posted) http://etienne.berthier.free.fr/SPIRIT/Scientific_Program.html.

Roger Wheate

Books received

W.F. Weeks. 2010. *On sea ice*. University of Alaska Press, Fairbanks, Alaska, USA. 600 pp, 354 graphs and figures (ISBN: 978-1-60223-079-8 (Cloth), ISBN 978-1-60223-101-6 (e-book); USD $85.00).

IGS

INTERNATIONAL GLACIOLOGICAL SOCIETY

International Symposium on

Interactions of Ice Sheets and Glaciers with the Ocean

Scripps Seaside Forum
Scripps Institution of Oceanography
La Jolla, California, USA
5–10 June 2011

Co-sponsored by:
Forum for Research into Ice Sheet Processes (FRISP)
Institute of Geophysics and Planetary Physics
Scripps Institution of Oceanography
National Science Foundation
NASA

FIRST CIRCULAR

August 2010

http://www.igsoc.org/symposia/

Registered Charity

The International Glaciological Society will hold an International Symposium on 'Interactions of Ice Sheets and Glaciers with the Ocean' in 2011. The symposium will be held on the oceanfront in La Jolla, California, USA, from 5–10 June 2011.

The Symposium is held in conjunction with the annual Forum for Research into Ice Shelf Processes (FRISP) meeting. FRISP (http://folk.uib.no/ngfso/FRISP/index.html) is a subcommittee of the Scientific Committee on Antarctic Research (SCAR) Working Group of Glaciology.

THEME

The mass balance of the Antarctic and Greenland ice sheets and the circulation of the adjacent oceans are strongly coupled through physical processes occurring at the ice-ocean interfaces (i.e., the fronts and bases of ice shelves and glacier tongues, and the termini of tidewater glaciers). Improved understanding of these processes is essential so that they can be realistically represented in models of how ice sheets and glaciers would evolve in a changing climate, and to improve predictions of global sea level change. The goals of this symposium are: (1) to assess the status of our knowledge of ice–ocean interactions; and (2) to discuss what is needed for development of reliable, quantitative models of ice sheet evolution and associated changes in ocean circulation. We hope this symposium will attract experts in ice shelf, ice sheet, glacier, ocean and climate studies whose research addresses interactions of the ocean and ice in the global climate system using in situ observations, remote sensing and/or modeling. Come and attend what will be a stimulating and productive symposium in a beautiful setting in Southern California.

ABSTRACT AND PAPER PUBLICATION

Participants wishing to present a paper (either oral or poster) at the Symposium will be required to submit an abstract by around 1 February 2011. A collection of submitted abstracts will be provided for all participants at the Symposium. The Council of the International Glaciological Society has decided to publish a thematic issue of the *Annals of Glaciology* on topics consistent with the Symposium themes. Participants are encouraged to submit manuscripts for this *Annals* volume.

SYMPOSIUM ORGANISATION

Magnús Már Magnússon (International Glaciological Society)

SCIENCE STEERING EDITORIAL COMMITTEE

Chief Editor: Slawek Tulaczyk (University of California, Santa Cruz).
Associate Editors include: Helen Amanda Fricker, Adrian Jenkins, Laurie Padman, Eric Rignot and Ted Scambos.

LOCAL ORGANISING COMMITTEE

Helen Amanda Fricker (Chair), Sarah Gille, Laurie Padman, Eric Rignot and Slawek Tulaczyk.

VENUE
The symposium will be held at the Scripps Seaside Forum, an extraordinary, oceanfront conference center facility located in the heart of Scripps Institution of Oceanography, with a breathtaking view over the Pacific Ocean. Just steps from the sand, it offers a relaxed and comfortable atmosphere, yet provides conference support through state-of-the-art audio-visual equipment ranging from 3D projection systems, multiple computer connections, and surround-sound. The beachfront location offers plenty of opportunity for mid-week leisure activities such as surfing, sea-kayaking, sailing, volleyball, walking, etc.

LOCATION
San Diego is renowned for its idyllic climate, enjoying beautiful weather year round with an average daily temperature of 70.5ºF (21.4ºC). California's second largest city and the United States' eighth largest, San Diego has a citywide population of nearly 1.3 million. As well as its beaches, San Diego has an impressive array of world-class family attractions, such as the San Diego Zoo and Wild Animal Park, Sea World San Diego and LEGOLAND California. San Diego offers an expansive variety of things to see and do, appealing to guests of all ages. This would be the ideal destination for an accompanying family! The most difficult decision to make regarding a trip to San Diego is determining what to do and see among the region's vast and diverse offerings.

FURTHER INFORMATION
Those interested in attending the symposium will be able to register their interest online after 1 October 1010. It is also possible to fill in the form on the back of this circular and fax it to the IGS office. The second circular will appear on the IGS website early in 2011. A notification will be sent to the Cryolist to that effect. Copies of the second circular will be sent to all IGS members and also to those who have expressed an interest in attending, either by registering online or by returning the overleaf form. Information will be updated on the conference website, http://www.igsoc.org/symposia/2011/Scripps/ as it becomes available.

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UCSD

INTERNATIONAL SYMPOSIUM ON INTERACTIONS OF ICE SHEETS AND GLACIERS WITH THE OCEAN

La Jolla, California, USA
5–10 June 2011

Family name: ____

Given name(s): ____

Address: ____

____

____

Tel: __________________________ Fax: ______________________

E-mail: ____

☐ I hope to participate in the Symposium in June 2011

☐ I expect to submit an abstract

My abstract will be most closely related to the following topic(s):

____

____

PLEASE RETURN AS SOON AS POSSIBLE TO:

Secretary General, International Glaciological Society
Scott Polar Research Institute
Lensfield Road
Cambridge, CB2 1ER, UK

Tel: +44 (0)1223 355 974
Fax: +44 (0)1223 354 931

E-mail: igsoc@igsoc.org
Web: http://www.igsoc.org

News

APECS Polar and Cryosphere Mentorship Programme

14 April 2010

Since its inception, APECS activities have aimed to help provide a continuum of knowledge in polar and cryospheric research and foster interactions between our members and experienced polar researchers and professionals. We would like to thank the many of you who have already participated in an APECS event by giving guidance to early-career researchers.

In an effort to help young researchers around the globe develop relationships with senior mentors, we have created an on-line database of mentors who are willing to share their knowledge with early-career researchers (http://www.apecs.is/mentors). The initiative is an extension of the mentor panels that APECS already runs at major conferences, and will provide an unprecedented opportunity for mentors to network with early-career scientists and meet talented young researchers in their field.

The level of involvement is totally up to the individual, but activities may include meeting students at conferences, providing general career guidance and responding to the occasional e-mail enquiry.

Signing up is easy and can be done online at: http://www.apecs.is/mentors/sign-up.

Feel free to contact Kate Sinclair (k.sinclair@gns.cri.nz) or any other APECS Executive Committee members (excom@apecs.is) for more information.

Kate Sinclair

Glaciological diary

** IGS sponsored * IGS co-sponsored

2010

2–7 May 2010
EGU General Assembly
Vienna, Austria
Website: http://meetingorganizer.copernicus.org/EGU2010

12–14 May 2010
American Polar Society annual meeting
Boulder, Colorado, USA
Contact: Wendy Roth[Wendy.Freeman@Colorado.edu]

17–20 May 2010
Seventh International Workshop on the Micromorphology of Glacial Sediments
Queen Mary University of London, London, UK
Contact: Jaap JM van der Meer [j.meer@qmul.ac.uk]

18 May–11 June 2010
Summer Field Course in Arctic Science
University of Alaska Fairbanks and Toolik Field Station
Contact: Anja Kade [ankade@alaska.edu]

20 May–4 June 2010
Arctic in a Changing Climate: Physical and Biological Linkages to Permafrost
Summer School program organized by the International Arctic Research Center at the University of Alaska Fairbanks
Fairbanks, Alaska, USA
Website: http://www.iarc.uaf.edu/education_outreach/summer/2010/
Contact: Tohru Saito [saito@iarc.uaf.edu]

30 May 2010
SCAR/AGCS Antarctic Sea Ice Workshop II
Tromsø, Norway
Contact: Stephen Ackley [Stephen.ackley@utsa.edu]

31 May–4 June 2010
International Glaciological Symposium: Ice and Snow in the Climatic System
Kazan, Russia
Website (address to be announced) will open on 15 December 2009

31 May–4 June 2010
****International Symposium on Sea Ice in the Physical and Biogeochemical System**
Tromsø, Norway
Contact: Secretary General, International Glaciological Society

5–11 June 2010
4th International Workshop on Ice Caves
Obertraun, Austria
Workshop theme: meteorology, glaciology and paleoclimatology in ice caves
Website: http://www.iwic2010.info/
E-mail: office@iwic2010.info

8–10 June 2010
67th Eastern Snow Conference: Here today gone tomorrow, the Eastern North America Cryosphere
Jiminy Peak Mountain Resort, Hancock, MA USA
Website: http://www.easternsnow.org/annual_meeting.html
Contact: Mauri Pelto [mspelto@nichols.edu]

8–12 June 2010
IPY Oslo Science Conference
Session T2-3: Snow and ice dynamics and processes
Oslo, Norway
Website: http://www.ipy-osc.no/
Contact: Jon Ove Hagen[joh@geo.uio.no]

8–19 June 2010
Advanced Climate Dynamics Course on Ice-Sheet Ocean Interactions
MIT FabLab, Lyngen, northern Norway
Website: http://www.bccr.no/filer/318.BYQIEx.pdf

13–17 June 2010
Third European Conference on Permafrost (EUCOPP2010)
Longyearbyen, Svalbard
Website: http://www.eucop2010.no/

14–16 June 2010
2nd Workshop on Hyperspectral Image and Signal Processing
Reykjavík, Iceland

14–18 June 2010
The 20th IAHR International Symposium on Ice
Lahti, Finland
Website: http://www.geo.physics.helsinki.fi/IAHR2010/IAHR2010_2.html

21–24 June 2010
24th international Forum for Research into Ice Shelf Processes (FRISP)
Evangelisches Bildungszentrum, Bad Bederkesa, Germany
Website: http://www.gfi.uib.no/forskning/frisp/
Contact: Adrian Jenkins[ajen@bas.ac.uk]

21–25 June 2010
****International Symposium on Snow, Ice and Humanity in a Changing Climate**
Sapporo, Japan
Contact: Secretary General, International Glaciological Society

11–14 July 2010
Workshop to develop a Science and Implementation Plan on Land-Ice Contributions to Future Sea Level
Sterling, VA, USA
Those interested in participating in the workshop should submit a one-page statement of interest explaining their background and how it fits within the context of the workshop goals.

Contact: Peter Clark [clarkp@onid.orst.edu]

22–23 July 2010
6th Antarctic Peninsula Climate Change workshop
Leeds, UK
Contact: Noel Gourmelen [n.gourmelen@leeds.ac.uk]
A follow-up announcement will appear shortly on the 2010 APCC workshop website

3–6 August 2010
4th SCAR Open Science Conference: Witness to the Past and Guide to the Future
Buenos Aires, Argentina
Website: http://www.dna.gov.ar/scar2010/

8–13 August 2010
AGU Meeting of the Americas: Dynamic Cryosphere session
Foz do Iguaçu, Brazil
Convened by Drs.Paul Winberry & Audrey Huerta (CWU) and Slawek Tulaczyk (UCSC)
Website: http://www.agu.org/meetings/ja10/

12–14 August 2010
Cryospheric Changes and Influence – Cryospheric Issues in Regional Sustainable Development
International Joint Conference by CliC/IACS
Lijiang, Yunnan Province, China
Website: http://www.casnw.net/
Contact: Xie Aihong [xieaih@lzb.ac.cn]

16–20 August 2010
****International Symposium on Earth's Disappearing Ice: Drivers, Reponses and Impacts: A celebration of the 50th Anniversary of Byrd Polar Research Center**
Byrd Center, Ohio State University, USA
Contact: Secretary General, International Glaciological Society

5–10 September 2010
24th International Polar Conference
Obergurgl, Austria
Website: http://imgi.uibk.ac.at/polartagung-2010/

6–10 September 2010
12th International Conference on the Physics and Chemistry of Ice
Sapporo, Japan
Contact: Chairperson Yoshinori Furukawa (Hokkaido University)
Website: http://www.lowtem.hokudai.ac.jp/PCI-2010/

12–16 September 2010
6th Canadian Conference on Permafrost
Calgary, Alberta, Canada
Website: http://ninja.pro.net/disk2/geocalgary10/index.php?lang=en
Contact: Jim Henderson [permafrost@geo2010.ca]

14–25 September 2010
Karthaus course on Ice Sheets and Glaciers in the Climate System
Sponsored by: The Institute for Marine and Atmospheric Research, Utrecht University, The Netherlands The Niels Bohr Institute, University of Copenhagen, Denmark Ice2Sea project, European Union
Karthaus, Italy
Website: http://www.phys.uu.nl/~wwwimau/education/summer_school (coming soon)

15–17 September 2010
****International Glaciology Society: British Branch Meeting**
Centre for Glaciology, Institute of Geography & Earth Sciences, Aberystwyth University, Aberystwyth, UK
Website: http://www.aber.ac.uk/en/iges/igsbb2010

20–23 September 2010
HydroPredict'2010
2nd International Interdisciplinary Conference on Predictions for Hydrology, Ecology, and Water Resources Management: Changes and Hazards caused by Direct Human Interventions and Climate Change
Prague, Czech Republic
Website: http://www.natur.cuni.cz/hydropredict2010/

20–24 September 2010
11th International Circumpolar Remote Sensing Symposium
Cambridge, UK
Prior to the conference (Monday 20 September 2010), there will be a 1-day UK Polar Network Workshop on Circumpolar Remote Sensing
Website: http://alaska.usgs.gov/science/geography/CRSS2010/
Contact: Allen Pope [allen.pope@polarnetwork.org]

23–25 September 2010
17th Annual WAIS (West Antarctic Ice Sheet) Workshop
Lake Raystown Resort, Raystown, PA, USA
Website: http://www.eesi.psu.edu/WAISWorkshop.shtml

26–30 September 2010
International conference: Global Change and the World's Mountains
Perth, UK
Website: http://www.perth.uhi.ac.uk/mountainstudies/2010

27–30 September 2010
Remote Sensing in Hydrology 2010 Symposium
Jackson Hole, Wyoming, USA
Website: http://www.remotesensinghydrology.org/
Contact: Christopher Neale (VP ICRS) [christopher.neale@usu.edu]

30 September–1 October 2010
Autonomous Polar Observing Systems Workshop
William F Bolger Center, Potomac, Maryland, USA
Website: http://www.iris.edu/hq/polar_workshop2010/index.php
Contact: Leigh Sterns [stearns@ku.edu]

8–9 October 2010
Northwest Glaciologists Meeting 2010
University of Alaska Fairbanks, Fairbanks, Alaska, USA
Website: http://glaciers.gi.alaska.edu/events/northwest/

15–17 October 2010
4th Graduate Climate Conference
Pack Experimental Forest, Mount Rainier, Washington, USA
Website: http://uwpcc.washington.edu/gcc

24–27 October 2010
Northern Research Forum 6th Open Assembly – Our Ice Dependent World
Oslo and Kirkenes, Norway
Website: http://www.nrf.is/

27–30 October 2010
II International Symposium: Reconstructing Climate Variations in South America and the Antarctic Peninsula over the last 2000 years
Valdivia, Chile
Website: http://www.cecs.cl/pages2010/
Contact: [pages-valdivia@cecs.cl]

3–6 November 2010
Circumpolar Ecosystems in a Changing World: Outcomes of the International Polar Year
Edmonton, Alberta, Canada
Website: http://www.eas.ualberta.ca/ipy/

8–10 November 2010
MicroPerm Workshop:
An international workshop to initiate the circumpolar integration of permafrost microbiological studies
Potsdam, Germany
Website: http://microperm.org/
Contact: Dirk Wagner [Dirk.Wagner@awi.de]

12–13 November 2010
18th Arctic Conference
Bryn Mawr, Pennsylvania, USA
A conference website for program information and registration will be available soon.
Contact: [pages-valdivia@cecs.cl]

22–23 November 2010
International Arctic Conference: Geopolitical Issues and Equations in the 21st Century
Lyon, France
Website: http://www.pacte.cnrs.fr/spip.php?article2268

7–9 December 2010
Second International Symposium on Arctic Research
Tokyo, Japan
Website: http://www-arctic.nipr.ac.jp/isar2/toppage/isar2top.htm

13–17 December 2010
American Geophysical Union Fall Meeting
San Francisco, California, USA
Session B24: Cryospheric Biogeochemistry – microbially mediated processes within ice, water and till. Conveners: Martyn Tranter [m.tranter@bristol.ac.uk], John Priscu [jpriscu@montana.edu]
Session B25: Biogeochemical Cycling in Glacial Ecosystems. Conveners: Eran Hood [eran.hood@uas.alaska.edu], Diana Nemergut [Diana.Nemergut@colorado.edu], Durelle Scott [dscott@vt.edu]
Session B63: The Dynamics of Trace Gas Exchange in Northern Ecosystems During Spring Thaw and Fall Freeze. Conveners: Torben Christensen [torben.christensen@nateko.lu.se], Patrick Crill [patrick.crill@geo.su.se], Thomas Friborg [tfj@geo.ku.dk]
Session C06: Advances in Glacier Seismology. Conveners: Jason Amundson [amundson@gi.alaska.edu, Fabian Walter [fwalter@ucsd.edu], Richard Aster [ster@ees.nmt.edu], Shad O'Neel [soneel@usgs.gov]
Session C11: Innovations in Field and Laboratory Data Acquisition for Snow Science and Cold Season Hydrology. Convener: Ann Nolin [nolina@science.oregonstate.edu]
Session C12: Ice Cores, Climate, and Ice Sheets: New Frontiers. Conveners: James White [james.white@colorado.edu], Dorthe Dahl-Jensen [ddj@gfy.ku.dk], Eric Wolff [ewwo@bas.ac.uk]
Session C15: Seasonal Snowcovers in a Changing Climate: Implications for Hydrological, Biogeochemical, and Ecological Processes. Convener: Ann Nolin [nolina@science.oregonstate.edu]
Session C25: Scientific Inquiry Using Cryospheric Climate Data Records. Conveners: Thomas Mote [tmote@uga.edu], Mark Anderson [mra@unl.edu]
Website: http://agu-fm10.abstractcentral.com/index.jsp.

2011

23–29 January 2011
Arctic Frontiers 2011: Arctic Tipping Points
Tromsø, Norway
Website: http://www.arcticfrontiers.com/

14–18 March 2011
5th Zooplankton Production Symposium
Pucon, Chile
Special session: Zooplankton in Polar Ecosystems and Extreme Environments:
Contact: Julie Keister [jkeister@u.washington.edu]

23–26 March 2011
Workshop on automated measuring systems on glaciers
Tromsø, Norway
Contact: Carleen Tijm-Reijmer [c.tijm-reijmer@uu.nl]

28 March–1 April 2011
Arctic Science Summit Week 2011
Coex Center, Seoul, South Korea
ASSW 2011 will have an integrated Science Symposium covering the theme: 'The Arctic: The New Frontier for Global Science', which will take place. 29–31 March.
Website: http://www.assw2011.org/

3–8 April 2011
General Assembly of the European Geosciences Union (EGU 2011)
Vienna, Austria
You are invited to take an active part in organizing the scientific programme of the conference at the meeting website: http://meetings.copernicus.org/egu2011/call_for_sessions/how_to_submit_a_session_proposal.html

12–12 April 2011
Association of American Geographers 2011 Annual Conference
Seattle, Washington, USA
Website: http://www.aag.org/

2–4 May 2011
11th Conference on Polar Meteorology and Oceanography
Boston, Massachusetts, USA
Contact: Jessie Ellen Cherry [jcherry@iarc.uaf.edu]

5–10 June 2011
****International Symposium on Interactions of Ice Sheets and Glaciers with the Ocean**
Scripps Institution of Oceanography, La Jolla, California, USA
Contact: Secretary General, International Glaciological Society

22–26 June 2011
7th Congress of the International Arctic Social Sciences (ICASS VII)
Akureyri, Iceland
Website: http://www.iassa.org/meetings/60-icass-vii-
Contact: Lara Olafsdóttir [larao@svs.is]

27 June–8 July 2011
International Union of Geodesy and Geophysics
IUGG XXV General Assembly
Earth on the Edge: Science for a Sustainable Planet
Melbourne, Australia
Website: http://www.iugg.org/assemblies/2011melbourne/
Contact: Regine Hock (Regine.hock@gi.alaska.edu)

10–16 July 2011
11th International Symposium on Antarctic Earth Sciences
Edinburgh, UK
See conference website

20–27 July 2011
International Union for Quaternary Research Congress
Bern, Switzerland
See conference website
Contact: Christian Schluchter [christian.schluechter@geo.unibe.ch]

24–28 October 2011
World Climate Research Programme Open Science Conference: Climate Research in Service to Society
Denver, Colorado
Website: http://www.wcrp-climate.org/conference2011

2012

22–27 April 2012
IPY From Knowledge to Action Conference
Montreal, Québec, Canada
See news release at: http://www.ainc-inac.gc.ca/ai/mr/nr/s-d2009/23301-eng.asp

June 2012
****International Symposium on Seasonal Snow and Ice**
Helsinki, Finland
Contact: Secretary General, International Glaciological Society
25–29 June 2012

June 2012
****International Symposium on Glaciers and Ice Sheets in a Warming Climate**
Fairbanks, Alaska, USA
Contact: Secretary General, International Glaciological Society

25–29 June 2012
Tenth International Conference on Permafrost
Tyumen, Russia
Website: http://ticop2012.org/

24–28 September 2012
****International Symposium on Ice Core Science**
Giens, France
Contact: Secretary General, International Glaciological Society

March–April 2014
****International Symposium on Sea Ice**
Hobart, Australia
Contact: Secretary General, International Glaciological Society

New members

Dr Yushin Ahn
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