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Ice

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Contents

Cover picture: An outlet glacier of the Greenland ice sheet. The glacier front is vertical, not because the glacier calves like many well-known counterparts in Greenland, but because the dry air blowing against the front causes sublimation of the ice, a faster process than ice deformation. Photo: Dirk van As.

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

With this first ICE issue of 2011 I would like to inform you that, as some of you may already know, we have now implemented our IGS members site. To gain access you have to log in using your IGS id number and password, which you should obtain from our portal. The system is set up so that only those that are paid up members for that particular year will gain access. We will be operating a short grace period at the beginning of each year to allow you to renew. We do hope this will encourage you to renew promptly.

So what is and what will be on the IGS member's site? First and foremost we will keep our 'back issues' there. That is all *Journal* and *Annals of Glaciology* issues, dating back to 1947 in the case of the *Journal*. These are already on the site. As before, we will publish new articles online as 'open access' as soon as we have received the author proofs back and we have made whatever corrections are needed and the article has been proof-read. Once the issue is complete and the printed copy has been published we will send the relevant files to Ingenta. Once the issue is published on the Ingenta website, we will move the issue files onto our membership site.

So what else should we put on the members site? In light of the 'online only' discussion below, Council considered the possibility of 'polling' members on the issue (to find how many of you would opt for online only). I think the members site would serve us well for that. I believe the members site will enable us to interact more directly with you and ask your opinion on various issues. By going through the members site we are certain only paid-up members will be able to respond, i.e. Mickey Mouse will not be able to cast a vote.

We received some very pleasant news last week. Thomson published the much awaited impact factors for 2010. The *Journal* jumped 55%, from 1.680 to 2.603. I believe this is the first time we have been over 2. This is of course thanks to our authors who are submitting important and innovative articles that their fellow authors use to build up their own research. Our submission rate has not diminished either, so our supply of quality articles should continue and hopefully further enhance our future impact factor results.

Unfortunately we will have to wait a further year before the impact factor for the 'new' *Annals* will appear. The *Annals* was accepted for coverage in Thomson Reuters Journal Citation Reports (JCR) in July 2010, commencing with 2009 publication year issues. The calculation of a journal's impact factor is dependent on Thomson having three consecutive years of data: the total number of 'citable items' (articles and reviews) published within a journal during two consecutive years, and the total number of times that all items within the journal have been cited during the year (the 'JCR Year') immediately subsequent to those two years. Therefore, the first impact factor of the *Annals of Glaciology* will appear next year.

Another issue that has come up recently is the 'online only access'. In response to several requests from members and libraries we were looking into the option of having 'online only' access to the *Journal*. Council had

intended to discuss this at its meeting in La Jolla in early June. But what we unexpectedly discovered was that 'electronic copies' are subject to sales tax or VAT as it is called here in the UK. A paper copy is not. This is so even when the journal is a 'members' benefit' i.e. something one gets by becoming a member. Not only is the sales tax applicable to the UK but to the whole of the European Union. The rest of you do not have to worry about this.

What this means is that we will have to attribute every cost of producing the *Journal* to either 'online copy' or to 'paper copy' or both and apply sales tax to everything relating to the online version. This has complicated our pricing structure considerably but it is the wish of the IGS Council we should offer this: we are currently analysing data so the 2012 membership rates will include the option of not receiving a paper copy of the *Journal*. The cost of such a membership will be somewhat less.

Talking about 'online access' and electronic copies, the IGS staff attended an e-conference where the subject was e-publishing. Several experts were discussing which of the various formats currently in use would be the one to go for. The consensus seemed to be that html would end up on top. We are curious as to what sort of an e-reader you see yourselves using, as we would like to investigate how best to serve you on that front. We should perhaps use the online members site for such a poll. Watch this space.

I would again like to ask all of you to encourage your colleagues and students to join the IGS. We now have as many members as we did over the whole of 2010 so we are hoping to go well beyond that before the year-end is up. But we are still short of the previous maximum set in 2001.

Magnús Már Magnússon
Secretary General

Recent work

Iceland

SURVEY AND MAPPING OF ICELANDIC GLACIERS

RES and DEM

Helgi Björnsson, Finnur Pálsson, Sverrir Guðmundsson, Eyjólfur Magnússon (IES), Etienne Berthier (UT)

Glaciers cover about 11000 km^2 of Iceland, four of those are large ice-caps: Vatnajökull 8100 km^2, Langjökull and Hofjökull ~900 km^2 and Mýrdalsjökull ~600 km^2.

Bedrock DEM´s have been created for all those from RES data surveyed from ~1976 to date. Surface DEM´s have also been made from surface profile data obtained in the same survey campaigns. Ice and water divides have been delineated for various outlets and watersheds. Recently we started an effort to modify DEM´s from all older published maps (the ambiguities due to bad base triangulation network corrected, and gaps in accumulation zone filled in). A DEM's for some glaciers has been derived from EMI- SAR (1998), from satellite data (mainly SPOT5 HRS and HRG) and most recently all the large ice caps are now being mapped by airborne LiDAR in a joint effort with the glaciology group at IMO. From the sequence of multi-temporal surface DEM's volume change and thus average mass balance of several small glaciers was estimated ; close 0 in the 1980-1990, but highly negative during the last decade (-1 to -2 m/year). The average mass balance of Langjökull has been tracked back to 1937-1945 yielding similar numbers as for the past 10 years; 1935-1945 was the warmest period in the 20th century in Iceland.

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LIDAR mapping

Tómas Jóhannesson (IMO), Helgi Björnsson (IES)

Icelandic glaciers store a total of ~3600 km^3 of ice, corresponding to ~1 cm rise in global sea level. As a part of and following the International Polar Year (IPY), an accurate DTM of Icelandic ice caps is being produced with airborne LiDAR technology. It is important that the glaciers are accurately mapped now when rapid changes have started in response to warming climate. The mapping is organized by the Icelandic Meteorological Office and the Institute of Earth Sciences of University of Iceland and financial support has been provided by The Icelandic Centre for Research and by institutes and companies that are affected by glacier changes or benefit from accurate knowledge of snow and ice covered areas of Iceland. As of now more than 4500 km^2 have been surveyed in this effort including Hofsjökull, Mýrdalsjökull, Eyjafjallajökull, Snæfellsjökull, Eiríksjökull and the southeastern outlet glaciers of the Vatnajökull ice cap. In addition, most of Langjökull (~900 km^2) was mapped by LiDAR in 2007 by the Scott Polar Research Institute. Preliminary comparison of the LiDAR DEMs with older maps confirm the rapid ongoing volume changes of the Icelandic ice caps which have been shown by mass-balance measurements since 1995/1996.

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Glacier front variations monitoring

Oddur Sigurðsson (IMO), JÖFRI

Monitoring of glacier front variations has been carried out in Iceland since the year 1930. It was initiated by Jón Eyþórsson, meteorologist at the Icelandic Met Office. The project is now the responsibility of the Iceland Glaciological Society in close collaboration with the Icelandic Met Office. Presently 50-60 glacier termini are monitored. Volunteers visit the glacier terminus every fall and make a tape measurement from a bench mark to the glacier margin and send a report on the results and other observations for each measurement site. Report is made annually to Jökull, the periodical of the Iceland Glaciological Society, and to the World Glacier Monitoring Service every five years. Included in the data set are non-surge- type glaciers, surge-type glaciers and tidewater glaciers. The non-surge-type glaciers show front variations in very close connection to mass balance and thereby to climate variations.

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Mass balance, surface velocities and AWS

Helgi Björnsson, Finnur Pálsson, Sverrir Guðmundsson (IES)

The mass balance of Vatnajökull (since 1991-92) and Langjökull (since 1997-98) has been monitored, and was slightly positive till 1995, but has been negative since (~–0.8 m w.eq./year ~–1.5m w.eq./year, respectively).

Automatic weather stations (AWS) have been run during summer on Vatnajökull (1-10 stations since 1995) and Langjökull (2 since 2001). The

AWS data have been used to estimate surface energy balance components, their variability and dependence on elevation and location. Spatially distributed energy balance models have been successfully created for Vatnajökull northern outlet to study the details of two flooding events. The data have also been used to evaluate several degree-day ablation models.
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The average summer surface flow velocity has been measured at all mass balance sites (since 1991-92), continuous records of surface flow has been measured at several sites on Vatnajökull. In addition, flow field has been derived from tens of SAR scenes (interferometry, feature tracking; in collaboration with Helmut Rott, UI, Thomas Nagler, Enveo and Dana Floricioiu, DLR) and optical satellite images (feature tracking; in collaboration with Etienne Berthier, UT). The velocity fields have been used to study glacier hydrology; especially in connection to the sub-glacial lakes in the geothermal active areas of western Vatnajökull and in the paths of jökulhlaups from these areas. The velocity data have also been used to constrain the parameters of Glen´s law of flow in numerical flow models.
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Mass balance and ice flow modeling
Sverrir Guðmundsson, Þröstur Þorsteinsson, Helgi Björnsson (IES), Guðfinna Aðalgeirsdóttir (DMI), Tómas Jóhannesson (IMO)
In recent years a coupled mass-balance ice-flow model has been run for south-Vatnajökull (the none surging part of the ice-cap), Hofsjökull and Langjökull (a collaborative effort with Guðfinna at DMI and the glaciology group at IMO). The model runs have been forced with a variety of climate predictions. In today's climate the glaciers recede fast but for almost all the predicted scenarios of climate warming the main glaciers may disappear in 150-300 years. Model runs starting at about 1900 (at the LIA max.), using measured temperature and precipitation from nearby meteorological stations and comparison of the resulting volume and extension to the existing sequence of DEM's is now in progress.
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Mass balance of Hofsjökull and Drangajökull
Thorsteinn Thorsteinsson, Oddur Sigurðsson (IMO)
The mass balance of Hofsjökull, a 860 km2 ice cap located between elevations of 600 m and 1800 m in Central Iceland, has been measured annually since 1988. The mass balance of the ice cap has been negative since 1995 and the ice cap has lost approximately 5% of its total volume during the last 15 years. Very high melting rates were observed in the summer of 2010 due to the effects of volcanic ash from the Eyjafjallajökull eruption. The mass balance of Drangajökull, a ~150 km2 ice cap at relatively low elevation in NW Iceland, has been measured since 2005. The data have been used in studies of the impacts of climate changes on glaciers and glacial runoff in Iceland.
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Water terminating glacier
Helgi Björnsson, Sverrir Guðmundsson, Eyjólfur Magnússon, Finnur Pálsson (IES)
The front of the southeast Vatnajökull outlet Breiðamerkurjökull calves into a frontal lake. A one dimensional coupled mass balance ice flow model including a simple calving model was developed to predict the future development of the calving front. Further studies of this outlet from time series of accurate DEM's, temporally dense satellite derived velocity flow fields and in situ continuous GPS velocity measurements is ongoing.
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Basal sliding
Þröstur Þorsteinsson, Eyjólfur Magnússon (IES)
Basal sliding of glaciers has the potential to alter their velocities significantly; basal sliding includes both sliding at the ice-bed interface and deformation within sub-glacial till. Studies of basal sliding, including modeling, measurement of surface velocity, and development of theoretical approaches are being conducted at IES. Measurements have shown significant short term velocity changes associated with the onset of melting, intense rainfall and jökulhlaups.
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ICE PROPERTIES

Sonic velocities
Þröstur Þorsteinsson (IES)
Work on interpretation of measured sonic velocity in terms of fabric, c-axis orientations, is in progress. Theoretical calculations of sonic velocity as a function of different fabric types serves to estimate when sonic logging can be used to obtain information about the fabric.
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Anisotropy
Þröstur Þorsteinsson (IES)
The development and effects of the strong plastic anisotropy of ice on deformation are modeled. Work on including processes at the grain scale, such as grain growth, polygonization, and recrystallization, is ongoing.
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ICE–VOLCANO INTERACTION

Studies in volcano-ice interaction at IES

Magnús Tumi Guðmundsson, Thórdís Högnadóttir, Björn Oddsson, Alexander Jarosch, Helgi Björnsson, Sverrir Guðmundsson, Eyjólfur Magnússon, Finnur Pálsson and more (IES).

Research on how volcanoes affect glaciers has been ongoing at the University of Iceland's Institute of Earth Sciences (IES). A volcanic eruption or sustained geothermal activity under a glacier affects ice flow, changes ice-divide boundaries and modifies the glacier in several ways. Conversely, the presence of ice and meltwater affects volcanic activity profoundly in many cases. Steep-sided hyaloclastite mountains may form in some cases and broader and wider formations in other cases. The work therefore involves application of glaciological methods, methods of physical volcanology and geophysics. Among projects worked on recently are the response and evolution of glacier and volcano during and after the Gjálp eruption in Vatnajökull in 1996, eruptions in Grímsvötn in 1998 and 2004, response of the ice in the Katla caldera to changes in geothermal activity, and the April-May 2010 explosive eruption in Eyjafjallajökull in south Iceland. Regular overflights using KGPS and ground clearance radar are used to monitor the Katla caldera. Ice flow modeling of the response of an ice sheet to a long-lived eruption is underway in collaboration with the University of Innsbruck, and calorimetric studies of energy consumed by glacier melting during eruptions and implications for eruption mechanisms are underway in collaboration with the colleagues at the UE (UK), Würzburg (Germany), Bari (Italy) and Otago (New Zealand).

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GLACIER RIVERS AND LAKES

Jökulhlaup

Helgi Björnsson (IES), Gwenn Flowers (SFU)

A program of studying jökulhlaups from the subglacial lakes within Vatnajökull has continued. The waterlevel of Grímsvötn subglacial lake is continually monitored; since the hypsometry of the lake is known the hydrographs of the output from the lake in several jökulhlaups is now known. Study of the extraordinary jökulhlaup in November 1996 lead to improved jökulhlaup theory in collaboration with Gwenn Flowers (SFU). Data have been collected to estimate the power of the geothermal systems sustaining the subglacial lakes, such as surface mass balance and surface elevation change of the water sheds, ice flow towards the surface depressions, and ice thickness change of the floating ice shelf.

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Research on jökulhlaups in Skaftá

Bergur Einarsson, Tómas Jóhannesson, Thorsteinn Thorsteinsson, Matthew J. Roberts (IMO)

Jökulhlaups in the river Skaftá were investigated in parallel with the research on the subglacial lakes beneath Skaftárkatlar (the Skaftá cauldrons) in Vatnajökull. The jökulhlaups originate in the lakes and occur at 1–2 year intervals. Their volumes are 0.05–0.4 km3 and the maximum discharge is 50–2000 m3s-1. The rapid initial increase in discharge during most jökulhlaups in Skaftá is difficult to explain with traditional jökulhlaup theories without invoking an above-freezing temperature for the lake water. The outflow from the lake beneath the western Skaftá cauldron and the discharge in Skaftá were monitored during one flooding event to investigate the behavior of a fast rising jökulhlaup. To investigate the thermal energy balance of the jökulhlaups water temperature measurements were carried out in both of subglacial lakes and at the glacier snout in number of jökulhlaups. The results indicate that the volume of the subglacial flood path cannot be melted out by initial heat of the lake water and heat formed in the flood path by potential energy dissipation. Jökulhlaup water temperature at the glacier snout was always found to be at or very close to freezing point confirming effective heat transport from the flood water to the surrounding ice. Ice movement during two jökulhlaups was measured via a network of three continuously recording GPS stations, positioned above the flood route. The passage of both jökulhlaups was associated with enhanced down-glacier movement of the ice surface, followed by sudden vertical uplift.

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Annals of jökulhlaups

Oddur Sigurðsson (IMO)

Jökulhlaups are very frequent on Iceland (on average about 5-10 each year) and they pose a great hazard to the society. Jökulhlaups with peak discharge exceeding 10,000 m^3s^{-1} may be expected about 10 times per century and one or two per century may exceed 100,000 m^3s^{-1}. Information on all jökulhlaups is gathered in a database at the IMO. Many of those occur in rivers with water level gauges. A great number of hydrographs of jökulhlaups are on record. Two main types of jökulhlaups have been identified: exponentially rising jökulhlaups and fast rising jökulhlaups. During the 2010 eruption of Eyjafjallajökull, southern Iceland, several jökulhlaups were recorded on water level gauges combined with conductivity meters and thermometers. All of them were fast rising with great range of temperature. Advancing velocity of up to about 20 km per hour was recorded. Many images, both satellite, aerial

and ground-based time-laps facilitate the analysis of these phenomena.
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Changes in glacial rivers and marginal lakes
Oddur Sigurðsson (IMO), Helgi Björnsson, Finnur Pálsson, Eyjólfur Magnússon (IES)
During the first decade of the 21st century glaciers in Iceland have retreated faster than ever before during historical time. Consequently, discharge of glacial rivers has increased and is expected to do so even more during this century. That has to be taken into account by hydropower companies and for the design and operation of other types of infrastructure. Marginal lakes at glaciers have changed substantially and so does the danger of jökulhlaups. Rivers, both large and small, have changed course and more rivers will do so in the near future and cause both problems and benefits for the road authorities. In some cases these changes can be predicted. The situation at several of the most critical sites of changes has been assessed and in some cases tried to forecast what the implications might be in terms of increased or diminished jökulhlaups and shift of river courses.
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Research on subglacial lakes beneath Vatnajökull
Thorsteinn Thorsteinsson, Tómas Jóhannesson, Eric Gaidos (Univ. of Hawaii), Bergur Einarsson (IMO), Andri Stefánsson (IES), Viggó Marteinsson (MATIS)
A recent research program has focused on the subglacial lakes beneath Skaftárkatlar, the two ~2 km wide and typically 100-150 m deep surface cauldrons located in the NW-part of Vatnajökull. The cauldrons are formed as geothermal heat melts the ice at the base of the ice cap and water is collected in subglacial lakes that reach a depth of ~120 m before emptying out in jökulhlaups. The residence time of the water in the lakes is 2 years on average. A hot-water drill has been used to penetrate through the 300 m thick ice cover into both subglacial lakes. Temperature profiles have been measured in both lakes and samples have been obtained for geochemical and microbiological analyses. The presence of microbial life in both lakes has been confirmed. Modelling studies based on temperature profiles and data on lake composition indicate that vertical overturning occurs in the western lake and estimates of the relative amounts of glacial melt (from the ice-shelf base), geothermal fluids and basal meltwater in the lake have been produced. The program has also involved surveying of ice-velocities and surface mass balance within the catchment areas of the Skaftá cauldrons.
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GEOMORPHOLOGY

Glacial geology and geomorphology of surge type outlet glaciers
Ívar Örn Benediktsson, Ólafur Ingólfsson (IES)
Brúarjökull, Vatnajökull ice cap, research in the forefield with the main focus on processes of erosion and deposition and the formation of landforms. The overall goal is to increase current knowledge on surge mechanism and the signature of glacial surges in the geological record. The emphasis is on the formation of end moraines and ice-marginal sediment wedges and their link to the ice-flow mechanism during surges. Eyjabakkajökull, Vatnajökull ice cap, research in the forefield of with the main focus on ice-marginal and subglacial processes and landforms, including the morphology, architecture and formation of end moraines, and the sedimentology and structure of the subglacial bed. The overall goal is to increase current knowledge on the link between surge mechanism and landform associations. Múlajökull, Hofsjökull ice cap, research in the forefield with the main focus on surge-related till stratigraphy, formation of end moraines and drumlins.

In addition, ongoing research in the forefields of Sólheimajökull, Gígjökull and Kvíárjökull with emphasis on glacial history and the formation and development of landforms in time and space.
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MULTINATIONAL PROJECTS

SVALI
The IMO and the IES are partners in the NCoE SVALI project, which was established as a part of the Top-Level Research Initiative (http://www.toppforskningsinitiativet.org) under the auspices of the Nordic Council of Ministers (www.norden.org). The center will operate from 2010 to 2015 and has a total budget of 37 million NOK (6.1 million USD). The center is established to study cryospheric processes using remote sensing, airborne and in-situ measurements, and to carry out advanced Earth Systems Modeling with focus on glaciers in the Arctic/N-Atlantic area. The NCoE will constitute a platform for joint process studies, analyzes, sharing of methods, researcher training and outreach activities and for reporting of scientific results regarding the impact of climate change on terrestrial ice. Institutes and research groups in the Nordic countries will pool their efforts to study:

- current ice-volume changes, underlining their contribution to sea level rise,
- mass-balance and ice-dynamic processes to improve Earth System Models,

- future changes in terrestrial ice and their societal implications.

Fellowships for PostDocs and PhD students are a substantial part of the proposed budget for the SVALI NCoE, which will serve as a platform for international collaboration of Nordic scientists in cryospheric research.
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Ice2sea
The ice2sea program is funded by the European Union Framework-7 scheme and consists of 24 participant institutions, with the aim of improving projections of the contribution of ice to future sea-level rise by reducing the uncertainties concerning continental ice. Targeted studies of key processes in mountain glacier systems and ice caps (e.g. Iceland and Svalbard), and in ice sheets in both polar regions (Greenland and Antarctica) will be undertaken to improve the understanding of how these systems respond to future climate change. Using newly developed ice-sheet/glacier models, we will generate detailed projections of the contribution of continental ice to sea-level rise over the next 200 years, and identify thresholds that commit the planet to long-term sea-level rise. The IES is a partner institution.
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SNOW

Snow avalanches
Tómas Jóhannesson, Harpa Grímsdóttir (IMO)
The Icelandic Meteorological Office conducts research on snow avalanche warnings, hazard zoning, protection measures and snow avalanche dynamics. The institute operates a microwave CW Doppler radar on a deflecting dam at Flateyri, northwestern Iceland, which has recorded several medium-sized avalanches since the installation of the radar but none of those has reached the dam. The deflecting dam was built after a catastrophic snow avalanche in 1995 that killed 20 people. An experimental installation of supporting structures at Siglufjörður, northern Iceland, is instrumented with tension and compression sensors for investigating the appropriate dimensioning of such structures for Icelandic conditions. Recently, several snow avalanches have been artificially released with explosives in avalanche paths in northwestern Iceland and their velocity, as they pass pre-installed markers, measured with video recordings. These velocity data are being used in a modeling study with the two-dimensional SAMOS snow avalanche model. Impending avalanche danger on roads and communication lines and avalanche warnings targeted at drivers will be studied in a recently funded 3-year research project in collaboration with NGI and Norut in Norway, LUT in Sweden and the FMI.
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ABBREVIATIONS

AWS:	Automatic Weather Stations
DLR:	German Aerospace Center
DMI:	Danmarks Meteorologiske Institut
ENVEO:	Environmental Earth Observations, Innsbruck, Austria
FMI:	Finnish Meteorological Institute
IES:	Glaciology Group, Institute of Earth sciences, Science Institute, University of Iceland
IMO:	Icelandic Meteorological Office
JÖRFI:	Jöklarannsóknafélag Íslands (Iceland Glaciological Society)
LUT:	Luleå University of Technology
NCoE:	Nordic Centre of Excellence
SFU:	Simon Frazer University, Vancouver, Canada
SVALI:	Stability and Variations of Arctic Land Ice
UE:	Universities of Edinburgh
UI:	University of Innsbruck
UT:	University of Toulouse

Throstur Thorsteinsson

International Glaciological Society

JOURNAL OF GLACIOLOGY

Papers accepted for publication between 1 March and 30 June 2011. The papers are listed in alphabetical order by first author. Some of these papers have already been published.

Identifying annual peaks in dielectric profiles with a selection curve
Kenneth McGwire, Kendrick C Taylor, John R Banta, Joseph Robert McConnell

Greenland Ice Sheet surface melt extent and trends, 1960–2010
Sebastian H Mernild, Thomas L Mote, Glen E Liston

Using borehole logging and electron backscatter diffraction to orient an ice core from the upper Fremont Glacier, Wyoming
Rachel W Obbard, T Cassano, K Aho, Gregory Troderman, Ian Baker

Progress in satellite remote sensing of glacier and ice sheet change
Hamish Pritchard, Scott B Luthcke, A Fleming

Evidence towards a thermal lag in the response of Kårsaglaciären, Northern Sweden, to climate change
David Rippin, Jonathan L Carrivick, Christopher Williams

2001–2009 elevation and mass losses in the Larsen A and B embayments, Antarctic Peninsula
Christopher Shuman, Theodore Scambos And Etienne Berthier

Advanced microstructural characterization of four East Antarctic firn/ice cores
Nicole E Spaulding, Debra A Meese, Ian Baker

Controls on the recent speed up of Jakobshavn Isbræ, west Greenland
C J van der Veen, J C Plummer, L A Stearns

Tomography-based determination of permeability and DupuitForchheimer coefficient of characteristic snow samples
Emilie Zermatten, Sophia Haussener, Martin Schneebeli, Aldo Steinfeld

ANNALS OF GLACIOLOGY 52(58)

The following papers have been selected for publication in Annals of Glaciology *52(58) (thematic issue on Snow, Ice and Humanity in a Changing Climate), edited by Douglas R. MacAyeal and Perry Bartelt*

Local terrain topography and thermal properties influence on energy and mass balance of a snowcover
Edward E Adams, Andrew E Slaughter, Ladean R McKittrick, Daniel A Miller

Snow avalanche flow regime transitions induced by mass and random kinetic energy fluxes
Perry Bartelt, Lorenz Meier, Othmar Buser

Seasonal development of spatial snow depth variability across different scales in the Swiss Alps
Luca Egli, Nena Griessinger, Tobias Jonas

Measuring snow in 3-D using X-ray tomography and improved methods to visualize its structure
Martin Heggli, Berna Köchle, Margret Matzl, Bernd R Pinzer, Fabienne Riche, Stephen Steiner, Daniel Steinfeld, Martin Schneebeli

Snow entrainment in different rheologies
Dieter Issler, Manuel Pastor Pérez

Wet-snow instabilities: comparison of measured and modelled liquid water content and snow stratigraphy
Christoph Mitterer, Hiroyuki Hirashima, Jürg Schweizer

Sea-ice extent variation along the coast of Hokkaido in the Sea of Okhotsk
Shuhei Takahashi, Tomofumi Kosugi, Hiroyuki Enomoto

Annals 52(58) is now complete

ANNALS OF GLACIOLOGY 52(59)

The following papers have been selected for publication in Annals of Glaciology *52(59) (thematic issue on Earth's Disappearing Ice: Drivers, responses and impacts), edited by Kees van der Veen*

A new satellite-derived glacier inventory for Western Alaska
Raymond Le Bris, Frank Paul, Holger Frey, Tobias Bolch

Modeling the evolution of small-scale surface topography under the influence of solar radiation induced ablation
L Mac Cathles, Dorian S Abbot, Jeremy N Bassis, Douglas R MacAyeal

A paleoclimatic perspective on the 21st Century glacier loss on Kilimanjaro
Lonnie G Thompson, Ellen S Mosley-Thompson, Mary E Davis

Use of historical elevation data to calculate surface elevation and volume changes of Ha-Iltzuk Icefield, Southwest British Columbia, 1970–mid-1980s
Jeffrey A Vanlooy, Richard R Forster

More papers for *Annals* 52(59) will be published in the next issue

Linda Gorman

Recently Linda Gorman, the Assistant to the Secretary General, left the International Glaciological Society. We are very grateful for the many years of service that Linda gave to the society and for her contribution as part of the team that won the 2007 ALPSP/Charlesworth Award for Best Learned Journal. She is in her element when dealing with people and was the person with whom many members had most contact. Linda will be missed at IGS meetings, where she was a friendly and familiar face to many in the glaciological community. She provided a warm welcome to new faces and made a point of remembering the personal circumstances of regular participants. Anyone who has taken part in the organisation of an international conference knows that it entails a huge amount of work. Linda has shared this burden with local organising committees from all over the world.

I am sure that you will join me in wishing Linda all the best for the future.

Pat Langhorne

NOMINATIONS FOR THE SELIGMAN CRYSTAL AND THE RICHARDSON MEDAL

THE SELIGMAN CRYSTAL

> *The Seligman Crystal shall be awarded from time to time to one who has made an outstanding scientific contribution to glaciology so that the subject is now enriched.*

There have been seven recipients since 2000. They are: Sam Colbeck (2000), Geoff Boulton (2001), Garry Clarke (2001), Kolumban Hutter (2003), Richard Alley (2005), Lonny Thompson (2007) and Paul Mayewski (2009). The full list of recipients can be found at http://www.igsoc.org/awards/seligman/.

The current Awards Committee wishes to maintain the tradition of making occasional awards of the Crystal to candidates who have made both an outstanding scientific contribution to glaciology and an enrichment of the subject. Nominations are solicited for individuals who have excelled in both areas, and who are recognised by their broad peer group for their achievements in both areas. Nominations should be in confidence and without the knowledge of the nominee. Nomination packages should include three elements: an abridged CV, a nomination letter and three other letters of support. The abridged CV should be created by the nominator for the purpose of complimenting the nomination and supporting letters, highlighting the principal achievements of the nominee throughout their career. The nomination letter should outline the case for an award, including the contribution that the nominee has made to the discipline in terms of academic leadership (highlighting the pivotal papers and including some citation analysis), training of the next generations of scientists, and the contribution that he/she has made to the organisation of national and international science. The letters of support could be multi-signatory if a large number of people wish to support the nomination. It seems sensible that a small group of younger scientists write one of these letters stating how the nominee has inspired and/or encouraged their career development.

Nominations should be sent to the Chair of the Awards Committee, copied to the Secretary General, and enquiries can be made to any of the Committee (see below). Awards are not made annually, but from time to time as the IGS Council believes in appropriate. Hence, there is no annual deadline for nominations. The timing of the nomination should be dictated by the eminence of the nominee and the activation energy of the nominators.

Nominations will be considered periodically by the Awards Committee, and recommendations will be made to the IGS Council when appropriate. Unsuccessful nominations will carry forward to the next period of consideration, for a maximum of five years after receipt. Thereafter they will lapse. The Chair of the Nominations Committee will contact the nominator from time to time to provide information about the status of the nomination.

THE RICHARDSON MEDAL

> *The Richardson Medal is awarded from time to time in recognition of outstanding service contributions to the International Glaciological Society and to glaciology.*

The Medal will be awarded normally to members of the International Glaciological Society, although this is not a strict requirement of the award. The term 'service' is to be interpreted broadly and is not exclusively restricted to service to the Society, although such service should receive greatest weight. Examples of outstanding service contributions could include service to the Society, scientific editorial service to Society publications, noteworthy contributions to the international outreach of the Society, educational service (e.g. the writing of an influential text book), institutional service (e.g. establishing or maintaining a world-class scientific research centre), organisation of pivotal symposia, authorship of landmark international glaciological reports and promotional services to scientific glaciology (e.g. through communications media).

There have been six recipients of the medal to date: Hilda Richardson (1993), Doug MacAyeal (1997),Garry Clarke (1998), John Heap (2000), Simon Ommanney (2003), Jo Jacka (2010)

The current Awards Committee wishes to maintain the tradition of making occasional awards of the Medal to candidates who have made outstanding service contributions to the International Glaciological Society and to international glaciology in general. Nominations are solicited for individuals who have excelled in either or both areas, and who are recognised by their broad peer group for their achievements in either or both areas. Nominations should be in confidence and without the knowledge of the nominee. Nomination packages should include three elements: an abridged CV, a nomina-

tion letter and three other letters of support. The abridged CV should be created by the nominator for the purpose of supplementing the nomination and supporting letters, highlighting the principal achievements of the nominee throughout their career. The nomination letter should outline the case for an award, including the service contribution that the nominee has made to the discipline in terms of leadership, encouragement of the next generations of scientists, and the contribution that has made to the organisation of national and international science. The letters of support could be multi-signatory if a large number of people wish to support the nomination. It seems sensible that a small group of younger scientists write one of these letters stating how the nominee has inspired and/or encouraged their career development.

Nominations should be sent to the Chair of the Awards Committee, copied to the Secretary General, and enquiries can be made to any of the Committee (see below). Medals are not awarded annually, but from time to time as the IGS Council believes is appropriate. Hence, there is no annual deadline for nominations. The timing of the nomination should be dictated by the eminence of the nominee and the activation energy of the nominators.

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CURRENT AWARDS COMMITTEE

(2010–2011)

Chairman

Martyn Tranter
m.tranter@bristol.ac.uk (2010–2013)

Members

Kumiko Goto-Azuma
kumiko@pmg.nipr.ac.jp (2010–2011)

Regine Hock
regine@gi.alaska.edu (2010–2011)

Jo Jacka
jglac@bigpond.com (2010–2011)

Doug MacAyeal
drm7@midway.uchicago.edu (2010–2011)

Rob Massom
r.masssom@add.gov.au (2010–2011)

Eric Brun
eric.brun@meteo.fr (ex-officio)

Magnús Már Magnússon
magnus@igsoc.org (ex-officio)

Magnus Magnússon and Eric Brun are the Secretary General and President of the IGS respectively. Further information about the IGS can be found at http://www.igsoc.org/.

Books received

Johannes Oerlemans. 2011. *Minimal glacier models. Second edition.* Igitur, Utrecht Publishing & Archiving Services, Universiteitsbibliotheek, Utrecht. 103pp (ISBN: 978-90-6701-022-1).

Johannes Oerlemans. 2010. The microclimat of valley glaciers. Igitur, Utrecht Publishing & Archiving Services, Universiteitsbibliotheek, Utrecht. 138pp (ISBN: 987-90-393-5305-5).

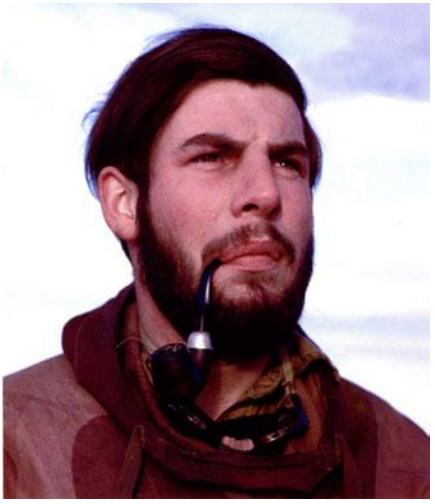
News

Obituary: Colin Bull, 1928–2010

Colin Bruce Bradley Bull (CBBBull as some of us liked to call him) was born in Birmingham, England, on 13 June 1928. When I met him in 1968, I saw a short, compact, ruddy, enthusiastic man with black hair and grey eyes who first reminded me of 'John Bull' the all-business symbol of Britain. But Colin had a twinkle in his compelling eyes and an infectious humour that soon (partly) dispelled that image. He said he was a 'Hereford Bull' because he grew up in Herefordshire, and he loved composing limericks.

Colin obtained a PhD in solid state physics from the University of Birmingham in 1952, after getting a first-class honours degree in physics, followed by an MSc degree. But as a boy, Colin marvelled at the Antarctic exploits of Robert Scott and Ernest Shackleton, so in 1951 he conceived, organized, financed on a shoestring, and led the Birmingham University Expedition to Spitsbergen, sailing from Cork, Ireland, in an unseaworthy vessel, *Miss Mabel*, which had to be abandoned in Tromsø, Norway. His team members were mostly students supervised by Philip Garrett, a lecturer at the university and the brother of Diana Gillian Garrett, who was destined to be Colin's wife. Their expedition is captured in Colin's 1995 book, *Innocents in the Arctic* (University of Alaska Press).

Colin quickly moved on to bigger things. From Cambridge University he joined the 1952–54 British North Greenland Expedition, conducting gravity geophysics, glaciology and meteorology and finishing as its Chief Scientist. It included a traverse of the Greenland Ice Sheet. Colin used a Worden gravity meter to measure ice thicknesses along the traverse route. Then in 1955 he joined the Cambridge expedition to Austerdalsbræ, a glacier in Norway. In 1956 Colin married Gillian and they emigrated to New Zealand, where Colin became a Senior Lecturer in Physics at Victoria University of Wellington (VUW). He soon conceived, organized, financed (this time for US$1000), and led the 1958–59 VUW Antarctic Expedition to the Dry Valleys, concentrating work in one largely unexplored valley he named Wright Valley, after Sir Charles Wright of the 1910–13 Scott Expedition. Again, his research team was a variegated lot, two graduate students in geology (Peter Webb and Barrie McKelvey) and a biologist (Richard Barwick). Their expedition is captured in Colin's 2009 book, *Innocents in the Dry Valleys* (Victoria University Press).



Colin Bull, 1951. This photograph appeared in his book *Innocents in the Arctic*

At the end of that expedition, Colin met the American geologist, Richard 'Dick' Goldthwait at Scott Base, Antarctica. Dick invited Colin to join him in founding an Institute of Polar Studies at The Ohio State University (OSU) in Columbus, Ohio. Colin moved there in 1961. Dick served as Director from 1961–65, followed by Colin from 1965–69. He then succeeded Dick in chairing the Department of Geology from 1969–72, when Colin became Dean of the College of Mathematical and Physical Sciences, a post he held until he retired in 1986 and he and Gillian moved to Bainbridge Island, near Seattle, Washington. Colin developed a successful business selling polar books through his own catalogues. With Patricia Wright, the daughter of Sir Charles, he published in 1993 *Silas: The Antarctic Diaries and Memoirs of Charles S. Wright* (The Ohio State University Press).

While at VUW, Colin had almost succeeded in sending a team of female scientists to Antarctica, and he was determined to accomplish that at OSU. He did, in 1969–70. They were Lois Jones, Kay Lindsay, Eileen McSaveney and Terry Tickhill. Colin continued to promote the role of women in Antarctic expeditions Two examples are Clair Parkinson, whose glaciological career started at OSU, and Julie Palais, who came to OSU from Paul Mayewski's group at the University of New Hampshire.

By the time Colin retired, he had led or participated in 25 polar expeditions, andd had received the Polar Medal and the US Antarctica Service Medal. One expedition was to Sukkertoppen Ice Cap in southwest Greenland in 1962. Another was to Kaskawulsh Glacier in Canada's Yukon Territory with Gerald Holdsworth in 1964. Always, Colin used his gravity meter to measure ice thickness. He returned several times to Wright Valley, most notably in 1965–68 with Gerald Holdsworth to tunnel under Meserve Glacier, and again with Paul Mayewski in 1968–69 to study glacial history.

Colin Bull is still alive for me, so I'll describe in the present tense the three sterling qualities that capture the essence of his character.

1. Colin is the most unselfish scientist I've known. He always subordinated his own scientific career to advance the careers of others, particularly those just getting started. This is how Colin got his personal fulfilment as a scientist and a human being.

2. Colin is a visionary with few equals. Although I believe Colin considered himself a glaciologist foremost, his background was in physics and his scientific interests encompassed all the earth sciences. At the University of Birmingham Colin became convinced that the theory of continental drift advocated by the German meteorologist, Alfred Wegener, and British geologists/geophysicists Arthur Holmes and Keith Runcorn was correct. Colin pursued these interests primarily by promoting the careers of people he recruited. It's a long list.

3. Colin has remarkable administrative skills. He initiated, promoted and organized a great variety of scientific investigations as Director of the old Institute of Polar Studies and then as Dean of the College of Mathematical and Physical Sciences at OSU, enhancing these skills he honed earlier in his career.

Very few people have all three of these qualities. Colin is the only one who comes immediately to my mind. I am aware of several others who have two of them, but all three? The names of those who have all three won't appear prominently in the scientific literature. But their prominence grows in the minds of those whose careers they promoted and who are prominent in the literature. When we get toward the end of our own careers, we finally realize whom it was who got us started and kept us going. For me and many, many others that man is Colin Bull. Because Colin kept in the background, the best way to highlight his influence is to showcase some of those whom he brought to the IPS and nurtured.

John Mercer. John was already an established glacial geologist when Colin brought him to the IPS in 1961, obtaining for him the first hard-money position for a purely research scientist at OSU.

Fritz Loewe. Colin brought meteorologist/glaciologist Fritz Loewe from Australia (where he had founded the Meteorology Department at the University of Melbourne) to the IPS in 1961. Fritz was the hero of Alfred Wegener's German Greenland Expedition across the ice sheet in 1930–32.

Henry Brecher. Henry is a graduate of Rensselaer Polytechnic Institute in mechanical engineering.

John Splettstoesser. IPS Assistant Director, later Associate Director. John served from 1967–74.

Roy 'Fritz' Koerner. Colin recruited Roy from England to be an IPS glaciologist.

Olav Orheim. A Norwegian who did his PhD under Colin, Olav went on to head the Norsk Polarinstitutt in Tromsø, Norway in 1993.

Lonnie Thompson and Ellen Mosley-Thompson. Lonnie and Ellen came to IPS from the mountains of West Virginia.

Paul Mayewski. Paul came to OSU in 1968 after being mentored by Parker Calkin at SUNY-Buffalo, and got his doctorate under Colin and Dick Goldthwait.

Ian Whillans. Ian was a Canadian who had worked on Baffin Island ice caps before Colin coaxed him to undertake has doctorate at IPS.

Gerald Holdsworth. Gerry arrived at IPS from New Zealand in 1964 to study glaciology under Colin and glacial geology under Dick Goldthwait.

All of the above are either glaciologists or glacial geologists. I should also mention hard rock geologists Colin brought to the IPS: David Elliot from England to study Jurassic basalts; Peter Barrett, a New Zealand graduate student at IPS.

Directors of IPS/BPRC have spanned disciplines that demonstrate Colin's holistic vision of polar research that encompasses glaciology, glacial geology, geophysics, tectonics, botany, biology, meteorology and climatology.

Colin and Gillian had just begun a cruise through Alaska's Inside Passage when, on 7 September 2010, Colin told Gillian he felt tired and went to their cabin to lie down. He never got up, leaving her and their grown children, Nicholas, Rebecca, and Andrew, and grandchildren Ellen, Simon, Eric, and Eileen. Look at the list of scientists noted above and contemplate what they did. They are just a few I knew briefly from 1968–74. They show what unselfish mentoring can accomplish.

Terence Hughes

Obituary: Shi Yafeng, 1919–2011

Honorary member of the International Glaciological Society, Academician Shi Yafeng, passed away in Nanjing, China, on 13 February 2011. Professor Shi was an initiator of glaciology in China, opening the Chinese glaciological community up to the outside world. He gave foreign scientists the opportunity to work with Chinese glaciologists on a number of glaciers in China.

Professor Shi was born in Haimen County, Jiangsu Province, China, on 21 March 1919, and graduated from the Department of History and Geography, Zhejiang University, China. He was awarded his MSc degree from the same university in 1944. After several junior academic positions, Shi Yafeng became director in charge of the Research Section of Glaciology and Geocryology of the Institute of Geography at the Chinese Academy of Sciences in 1958. He initiated and headed scientific expeditions to the Qilain Shans, Tien Shan, Karakorum and Himalayas. These investigations not only became the starting point of Chinese glaciology but also made indispensable contributions to the knowledge of glaciology in the interior region of the Eurasian continent. His scientific contributions during this period covered not only glaciers but also a much broader area including avalanches, permafrost and mud-debris flow. These investigations made a valuable contribution to the planning of the fresh water supply and the prevention of snow and ice disasters.

During the cultural revolution he was removed from his position, separated from his family and sentenced to manual labour, including 2 years of street construction. Talking about these years later he was obviously angry about what happened to his country, but never showed resentment against the individuals who caused his personal hardship.

In mid-1970s, when the Gang of Four was expelled from power, and China resumed relations with the outside world, Shi Yafeng became the director of the newly re-organized Institute of Glaciology, Cryopedology and Desert at the Chinese Academy of Sciences. Professor Shi's pioneering efforts to become part of the international glaciological community led the way in Chinese science. He started the internationalization of Chinese glaciology in 1978 by visiting centres of glaciological research, ending at

Rieder Alp beside the Aletschgletscher, where the first International Workshop on Glacier Inventory was being held. This workshop was the first occasion in which the international community heard about the recent status of glaciers in China. At that time, Professor Shi had proposed a method for predicting glacier advance and subsequent retreat in the 1970s and 1980s. His work proved to be accurate and contributed toward fixing the route of the Sino–Pakistan Highway through a region that was frequently subject to glacial hazards.

Two years later Shi Yafeng was again travelling the world with a concrete plan for advancing glaciology in China, with the aim of organizing postgraduate studies abroad for senior Chinese students. It was obvious that Professor Shi thought the completion of the Chinese and the world glacier inventories was very important for Chinese glaciology and also for his institute. He considered the glacier inventory to be a useful introduction to the discipline of glaciology for young scientists in China. He had the far-sighted perspective to lead Chinese glaciology for the coming decades. He combined scientific drive with political diplomacy, and his initial research was to stress the importance of glaciers as fresh water resources for the interior region of China. In 1980 Professor Shi

was made an Academician, the highest honour in Chinese academia.

Through his well-thought-out plan, a number of scientists of the following generation, both in China and abroad, got the chance to participate in glaciological research projects in China. This was a tremendous opportunity for scientists outside China to become acquainted with continental-type glaciers and their Quaternary development. Shi Yafeng published more than 200 scientific papers and edited more than 20 professional monographs as a chief editor. His monographs, Quaternary Glaciations and Environmental Variations in China (2005) and Abridged Illustration of Chinese Glacier Inventory (2005, published in 2008 in English with the title Concise Glacier Inventory of China), are two important works in the international glaciological community and are the key to Quaternary science and glaciology in China. The latter work in reality is not just an inventory, as the modest title might indicate, but a high-level scientific presentation of important aspects of glaciers from all glacierized regions of China.

We shall all miss this enlightening and generous scientist, who led a very colourful life.

Atsumu Ohmura

Obituary: Barclay Kamb, 1931–2011

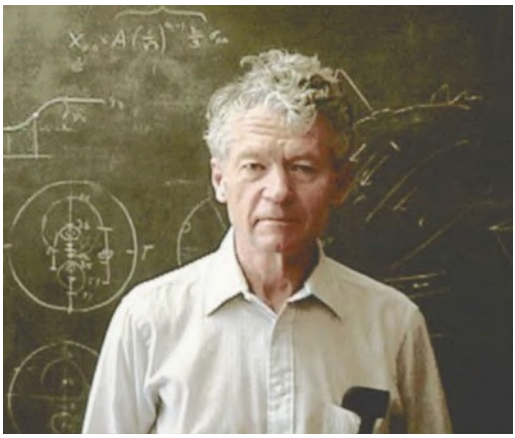
Walter Barclay Kamb, the Barbara and Stanley R. Rawn Jr Professor of Geology and Geophysics at Caltech, Pasadena, California, died at his home in Pasadena on 12 April 2011. He courageously battled Parkinson's disease for a long time with great dignity.

We honor Barclay partly for his many contributions to science and to his University, the California Institute of Technology (Caltech), where worked for more than 60 years, but even more for the devotion and guidance, friendship and love he gave freely to his students, colleagues, friends, and family.

Barclay was born on 17 December 1931 in San Jose, California. He grew up in the San Francisco Bay area and in Pasadena in Southern California. He was a child prodigy, a Wunderkind who absorbed enormous knowledge of every kind, especially mathematics. At age 14 he applied for admission to Caltech. Because of a large influx of much older veterans returning from World War II, Caltech admission thought it would be better if Barclay waited a year before enrolling. Barclay wasted no time and promptly registered for classes at the Pasadena City College, where he took courses in geology, physics and mathematics among other things.

When he entered Caltech in 1948 he decided to major in physics and immediately proved to be a genius. He completed exams and walked away well ahead of time, while his peers were still struggling. He also kept his interest in geology, taking the famous geology and glaciology courses taught by the legendary Bob Sharp, with whom he developed a lifelong friendship. By the time he graduated with honors in 1952, Barclay's intellectual prowess was already legendary on the Caltech campus. He was urged to stay on for graduate studies in physics along with his good friend Ron Shreve.

However, after a year in physics, and a lot of prodding from Bob Sharp, Barclay and his friend Ron, both decided to transfer from physics to geology to do their PhD studies. This was a real triumph and gain of stature for the Geology Division of Caltech, since physics was regarded on the top of the academic hierarchy at the time. Nevertheless, Barclay regarded himself as a physicist, religiously attending the physics seminars all his life. He was especially drawn to the physics lectures



of Feynman, who taught physics in an unconventional, captivating style. Barclay had a broad interest in science; the latest and newest advances in physics and astronomy fascinated him. He engaged in discussions about quantum chromodynamics, the inner structure of elementary particles with the colorful quarks popping up, the Big Bang, Black Holes, etc. Barclay always wanted to understand the frontiers of science and how to push the limits. Moving to the Geology Division allowed Barclay to combine his pursuits in academic disciplines with his passion for the outdoors, exploring the spectacular scenery and geologic formations of the South West of the US. Working in geology immediately aroused his interest in the atomic structure of these fascinating minerals. He became interested in mineralogy and X-ray crystallography, and so he decided to do his PhD thesis on the structure of the extremely complex mineral zunyite, with Linus Pauling his advisor in the Chemistry Division. Leaving his mark in three divisions, physics, geology and chemistry, Barclay was offered many choices. By the time he finished his PhD, Bob Sharp won him over again to be appointed assistant professor of geology in 1952. However, Linus Pauling did not let him go either. He put Barclay to work to unravel the beautiful crystalline structures of the many different high-pressure phases of ice, Ice II to Ice IX, except Ice IV, which was added later. This required extraordinary skills because it encompassed producing single crystals of these ice phases and working with them at liquid nitrogen temperatures in the

goniometer stage of the X-ray machine. Linus Pauling, a two times Nobel laureate, regarded these ice structures held together by hydrogen bonds to be crucial for understanding the nature of the hydrogen bond. Barclay of course excelled in this task. He showed the beauty and relevance of the substance most common on earth and most relevant to life. He later presented his findings at the First International Symposium on the Physics of Ice in Munich, Germany. This event introduced him to the community of ice physicists and glaciologists. After that debut he contributed to most international meetings of glaciology and physics of ice. In recognition of his outstanding work, he received the highest reward in the field of glaciology, the Seligman Crystal, from the International Glaciological Society. He also received the Mineralogical Society of America Award.

Recognizing Barclay as his best student ever, Linus Pauling thought of how to arrange the marriage of his only and most beautiful daughter Linda with Barclay. He hired Linda as a lab assistant – never mind that Linda was mostly interested in the Fine Arts – and asked Barclay to help her develop X-ray photos in the darkroom. In 1957 the two were married and produced twins, Barclay (Barky) and Alexander (Sasha), and Anthony and Linus. During this time of active parenting Barclay and Linda introduced the four boys to nature and the joys of backpacking in the near San Gabriel Mountains and the South West National Parks. He regularly organized backpacking trips along the John Muir trail in the high Sierras and skiing trips to the Pear Lake Hut in Sequoia National Park for his family and friends.

Barclay was especially attracted to landscapes still covered by glaciers or formed by glacial activity. He always searched for and pointed out the striations and polish left behind on rocks by glacier motion. On field trips in the evening at campfires, Bob Sharp fascinated everyone including Barclay with his story telling about geology, local lore and the history of settlers and miners. Barclay was thrilled when Bob Sharp invited him to apply his knowledge of ice and its properties to the study of glaciers, their flow laws, the fabric, crystalline metamorphosis, folding, faulting, fracturing and regelation of glacier ice. The study of glaciers was considered exemplary for the understanding of geologic processes. Under Bob Sharp's leadership, Blue Glacier in Mount Olympus National Park in Washington was chosen for this purpose. It was so popular that many professors in the Division of Geology and most graduate students at the time made the pilgrimage to this picturesque high mountain glacier. Barclay soon took over the project, and, with his friend Ron, started drilling boreholes to the bed of the ice using thermoelectric hotpoints. Many novel instruments were built to study the internal deformation of the ice. Taking photos from the base of the glacier and studying basal conditions became Barclay's core interest and focal point. At the same time an extensive array of stakes was set up on the glacier surface to be surveyed from stations on the lateral moraines. Barclay was a master surveyor who treated his Wild theodolite like his baby. Blue Glacier early on was also seen as an instrument to monitor climate change. Every year a marker was posted at the terminus to monitor the ongoing retreat of the ice. As new striations on exposed rock surfaces came into view, they were meticulously recorded. For ten years Barclay maintained a cache of equipment and camping gear well hidden under a pile of rocks on the left lateral moraine. These Blue Glacier studies established Barclay as a superb glaciologist, who catapulted glaciology into the forefront of modern environmental sciences.

In between his many activities, Barclay took a short sabbatical in Switzerland visiting leading glaciological institutes, especially the top Institute of Snow and Avalanche Research on the Weissfluhjoch above Davos. While there, he also brushed up his German language skill, giving it a sweet Swiss twang. You have to be a good skier to keep up with the locals. Fearless Barclay pushed his limits on the steep slopes just a little too much and broke his leg. In the Davos hospital he shared a room with a dozen other casted daredevils. It must have been much fun telling jokes of every kind, and Barclay took the opportunity to expand his vocabulary of Swiss swear words! In his presence, language was always very civilized and certain words and phrases were absolutely taboo, but on rare occasions, when an equipment failure occurred or human error happened, Barclay's special skills acquired in Davos came in handy. He turned around belching out for a minute or two a tirade of the strongest Swiss curses nobody could understand; he probably himself did not know the deeper meaning. But the effect was dramatic; he turned around laughing and clapping his hands, ready to fix the darn problem. Barclay was an excellent troubleshooter, knowing every detail of his equipment to the last screw and washer.

After Blue Glacier and the discovery of the elusive metastable Ice IV crystalline structure, Barclay initiated a sequence of glaciological projects, each orders of magnitude bigger than the previous one, which led to many leading papers that changed the scope of glaciology entirely. The tool of trade was a hot-water ice drill that was built in the Caltech machine shops and grew over the years from a small 200 m to a powerful 1600 m deep ice drill. With the hot-water drill, access boreholes reaching the bed of the glaciers could be drilled in a short time to accommodate

borehole instruments that were also designed and build in-house at Caltech. The key to understanding fast glacier flow lies at the bottom of the ice.

The Variegated Glacier project in Alaska, near Yakutat, encompassed the first detailed study of a galloping or surging glacier during its active period. The glacier increased its speed to over 300 times of normal, to a maximum of 65 m per day, with high-pitched ice quakes and new crevasses opening overnight under the sleeping tents and the drilling platform. The drilling revealed the pivotal contribution of water storage, basal lubrication by water at high pressure, and the total reorganization of the basal hydraulic system of the glacier. The ice accumulation of 20 years was swept through the valley in just three months. The Variegated was extensively surveyed even at night, when lights at the stakes on the glacier were remotely activated by pushing a radio button. Barclay called it his Christmas tree. And it took the nerve of a Barclay to see such a project through – it was undoubtedly not without risks.

In the same fearless spirit, Barclay reached for one of the largest and most active glaciers in Alaska, the Columbia Glacier. It is a tidewater glacier that flows directly into the ocean and has a bed well below sea level. It is not only fast flowing at a speed of 9 m per day, but also catastrophically starting to retreat into its fjord at a rate of 1 km per year. This was the last chance to extract the secrets of a most powerful river of ice. The Columbia Glacier is huge, 6 km wide, 1 km deep, and several hundred km long. The surface of this glacier was heavily jumbled with crevasses, huge ice blocks, séracs and icy pinnacles next to deep chasms and gaping holes. It took many hours of helicopter circling to find a suitable spot where a drilling camp could be established. It required people to step out of the hovering helicopter onto the slippery uneven ice surface. Fortunately, Barclay hired experienced ice climbers, who were used to climbing up icefalls, and who regarded the new task as a piece of cake. Little platforms were hewn with ice axes from the ice to accommodate the drilling equipment and the living tents. Ladders were used to bridge over the abysses between the separate perches. Not one false step was allowed. The equipment and supplies were delivered in sling loads dropped from the helicopter.

Again, the phenomenon of basal sliding as the main contribution to fast glacier motion was demonstrated in detail. The high basal water pressure at or near the ice overburden pressure kept the glacier afloat and well lubricated at the bed. The boreholes were 900–1000 m deep. The glacier rumbled along again at a speed 100 times normal speed expected by internal deformation of the ice alone. Big chunks of ice, treacherous icebergs, were calving off the ice cliffs at the terminus into the ocean and menacing the oil tankers plowing their way from Valdez to the Gulf of Alaska. A few years later, these drill sites were gone and most of the tidewater part of Columbia Glacier is now open ocean.

The Columbia Glacier Project had another purpose. It served as a credible place for testing a hot-water drilling system capable of rapidly drilling to substantial depths. It also created a pool of hardened experienced and highly motivated field assistants.

Finally, Barclay was ready for the biggest adventure; to go where nobody had gone before, to gather absolutely new data, to study the basal conditions of the biggest glaciers on earth, the fast moving Antarctic ice streams. The ice streams are huge currents of ice within the ice, like ocean currents within the ocean. Antarctica is the coldest, windiest and remotest place on earth, and the base of the ice is certainly the remotest destination in Antarctica. Only Barclay had the vision, the stature and the courage to launch such an ambitious project and to see it through. It requires well-defined science goals, a team of competent people and a huge commitment of logistic resources. Barclay's field team drilled hundreds of boreholes 1000–1600 m deep and 100–150 mm in diameter to the bed of several ice streams and ice ridges in between. Drilling was so efficient and successful that teams of three people on three shifts per day were able to drill 1000 m of ice in less than 24 hours. Since the boreholes are filled with water and the ice is very cold, refreezing is fast. After completion of a borehole, instruments had to be inserted instantly and quickly, or in case of the borehole camera taking videos from the base of the ice, the downhole working time was limited to guarantee safe return of the camera to the surface. If needed, a hot-water reamer was used to widen a borehole for repeat access. The Antarctic Project lasted from 1988 to 2001, twelve field seasons each during the South summer from October to February with 24 hours of daylight. A hallmark of Barclay's operation was that a relatively small group of nine or ten participants handled the drilling as well as the science part each field season. Everyone was involved in every task. Over the years in Antarctica a good hundred of highly motivated field assistants participated in the project, sharing the everyday challenges and scientific triumphs. In the beginning Barclay was his own survival expert, safety officer and environmental protection agent, but in later years external supervisors had to prove their existence by enforcing all kind of rules and regulations; however by then Barclay's team had established such a good reputation that it was left alone

most of the time. Only once, as Barclay's team prepared to drill in the heavily crevassed Southern shear margin of Whillans Ice Stream, Barclay was called back to McMurdo, the American base station in Antarctica, to explain to the director of the National Science Foundation that he knew exactly what to do and that he had people who could handle the most complicated situations. He prevailed and the prepared drilling could continue. One secret of Barclay's harmonious camp life was that there was always an inexhaustible quantity and rich variety of cookies available as well as copious amounts of Swiss chocolate. To give the cook free hand and to allow for high quality cooking, the rule was that the cook must never do the dishes. When Barclay was cooking, he kept it simple. His favorite meal was Macaroni Coconino enriched with mountains of cheese and spam, the nutritious kind.

Overall the project was extremely successful; it led to many new discoveries and a series of seminal papers published in Science and Nature and other professional journals. It was established that the ice streams draining the West Antarctic ice sheet have the characteristics of surge glaciers and tidewater glaciers combined. They move fast by sliding over their beds lubricated by water at high pressure. The geothermal flux is elevated. In samples of basal till volcanic rocks of volcanic origin are present, pointing to volcanic activity in the interior. The till also contains an abundance of diatoms showing that West Antarctica was an open ocean in the recent Pleistocene. This happened under CO_2 concentrations in the atmosphere much lower than today. Barclay's results could not indicate more clearly that catastrophic decay of West Antarctica is a possibility, with the consequence of a sea level rise of 6 m, if climate change is not taken seriously and reversed responsibly.

In recognition of his important contribution to Antarctic glaciology and its implications, the central ice stream flowing into the Ross Ice Shelf, formerly known as Ice Stream C, was renamed Kamb Ice Stream.

Most of the borehole instruments used in his work on glaciers and ice streams, all one of a kind, were designed by Barclay and built in-house at Caltech from scratch, from simple components. They had to meet requirements not available commercially. Barclay did not like black boxes; he needed to understand every detail of his instruments down to the tiniest screw. Barclay's character required that every experiment was thoroughly planned, every procedure meticulously thought through. Every grant proposal and every paper Barclay ever wrote was executed to such a high standard that none was ever rejected.

Barclay had an enormous impact on his students and colleagues. He mentored a small, but very successful group of graduate students; some became influential glaciologists. At meetings and seminars Barclay was well known for his penetrating questions aimed at the very center of the topic. This constructive challenge, mostly directed to students and colleagues, but also to the broader community, is one of Barclay's great contributions to the advancement of scientific thinking. During the past few decades there were not many students of glaciology or professionals in the field who have not had their thinking importantly reshaped by short conversations with Barclay after their meeting talk or in front of their posters. Barclay's work is cited in almost every important glaciological paper. Moreover, Barclay's influence was widespread around Caltech where he was admired for his breadth and depth of knowledge, his friendliness, as well as his physical stamina and ruggedness. Once he appeared a little late to a meeting of the Board of Trustees of Caltech. Coming directly from a field trip, unshaven, in dusty boots, and in his field outfit, he stood in crass contrast to the distinguished men and women in their elegant business attire, but he immediately picked up the conversation and contributed to the deliberations. They all arrived in their expensive cars, Mercedes, BMWs and Porsches; Barclay just stepped out of his ancient beat-up yellow carryall Continental truck.

Barclay could do anything: sleeping in a tent in the middle of Antarctica for three months; leading a group of geology students to a place called Devils Punch Bowl, teaching them the most convoluted geological processes, sleeping next to a camp fire under the stars; tracking along the Muir trail carrying gear and food for ten days; playing Chopin on the grand piano at home, and playing dance pieces and folk songs on a set of harmonicas on the glaciers; he loved to recite the poems of Robert Service, especially the ballad The Cremation of Sam McGee; his favorite drink was water, next to buttermilk, but he also enjoyed the rich bouquet of a fine glass of Pinot Noir from his own vineyard; digging up his compost and planting a vegetable garden; riding his old heavy steel bike to work at Caltech and back home up the steep road to his ranch above Pasadena in the San Gabriel Mountain foothills like good old Einstein did during his time at Caltech; repairing his truck and bike or solving any problem around the old house; talking to the people in the machine shops, conversing comfortably with people of the highest education, influence, or power; he lunched sometimes on his homemade sandwich, but most of the time with students at the common Chandler Cafeteria, also known as the Greasy Spoon, but he also indulged in fine dining at the

elegant Caltech faculty club, the Athenaeum, at a round table with Nobel laureates; caring for the environment by picking up trash anywhere, putting up the first solar collectors on his house, living green long before everyone else; Barclay was always busy, his pastime was writing and studying. Barclay set an example in all situations in life.

So again, his seminal work on the crystallographic structures of all the known high pressure ice phases, his bold field observations of the critical processes controlling fast flow of glaciers and ice streams, always investigated with unique creative theoretical analysis, have set a high bar for a new era of glaciological research. He definitely created an incredible body of profound lasting scientific literature.

And finally, in addition to his extraordinary contributions as a scientist and educator, Barclay provided critical leadership and service to Caltech. In his eleven years as chairman of the Division of Geological and Planetary Sciences, he oversaw the hiring of many young faculty members, who helped to define the new modern Division, as it is known today. His fairness, humility and decency were key attributes that inspired others and guaranteed the smooth running of a multifaceted institution. When Caltech needed a Provost at short notice, then president Murph Goldberger did not hesitate to turn to Barclay, who led the academic program of the Institute with the same devotion, generosity, intellect and passion that characterized his approach to science, and, at the same time, started up his Antarctic Program. This was a double feat only Barclay could pull off. Barclay was also a fantastic fundraiser for the Institute's endowment fund to create new professorships. He organized an extravagant river raft trip through the Grand Canyon for a group of distinguished people, who happily paid a million dollars each for the privilege to experience the thrill of a lifetime. Having a tour guide of the caliber of Barclay on board was exhilarating. He captivated his audience with the history of Earth as exposed on a gigantic scale in the sedimentary layers from the upper Kaibab Formation down to the Urgestein, the Vishnu group and Zoroaster granite.

The recipient of many honors and distinctions, Barclay was both a Guggenheim Fellow and an Alfred P. Sloan Fellow during his tenure at Caltech. He was a fellow of the Mineralogical Society of America, the Geological Society of America, the American Geophysical Union, the American Association for the Advancement of Science, and the International Glaciological Society. Barclay was a fellow of the American Academy of Arts and Sciences and the National Academy of Science. He served in countless committees, advisory panels and boards, commissions on geosciences, environment and resources.

Barclay had a remarkable career and a wonderful life filled with love and devotion to his family and friends, and an exceptionally rich experience of nature and people. Even during his last years of life, slowly climbing down from his mountaintop of scientific achievements and his peak of physical strength, Barclay was strong, gentle and graceful. He created unforgettable memories in all who got to know him. His legacy will certainly live on forever. After a heroic life he has reached his final goal to rest in peace.

Hermann Engelhard

For Whom the Ice Melts

Report from the IGS conference on 'Earth's Disappearing Ice: Drivers, Responses and Impacts'

Columbus, Ohio, USA, 15–20 August 2010

Any information on the true nature of 'the smell of calving icebergs' is greatly appreciated.

Posted on the CRYOLIST, 9 July 2009, by Sune Olander Rasmussen

The dignity of movement of an iceberg is due to only one-eighth of it being above water.

Ernest Hemingway, *Death in the Afternoon*, 1932

Beach front property: good view of London.

A six-word short story about disappearing ice

Magnús lay flat on the green, soft grass of the *The Oval*, his chin on his folded arms, and an unusual wind blew whitecaps on *Mirror Lake*. It had been a long trip to Columbus from Sapporo, where the last IGS mission had been. The 35 kilos of IGS snowflake ties had been a hard carry. Soon a woman with long, golden hair approached him and said, '*Don Magnússon*, you are the first of the glaciological reinforcements. I will lead thee to the Icebreaker where you can take refreshment (*Laphroaig*) and fresh air (*Cohiba*) .'

'Is that the *Byrd Polar Research Center* (BPRC) ?' he asked.

'Yes.'

'I do not remember it.'

'It has grown since '82 (*Third International Symposium on Antarctic Glaciology*) and '95 (*International Symposium on the Role of the Cryosphere in Global Change*) when the IGS had its last big operations in this sector. But most of it has been unchanged (dedication to the pursuit of polar studies). They've been dug-in on this campus for 50 years.'

Lynn, the woman with the golden hair, led him to the Icebreaker, where he met *Ellen*, the leader of the mission about to unfold. At the Icebreaker, the glaciologists were gathering their ice axes and PowerPoint presentations, readying themselves for the operation – a symposium on disappearing ice – that would begin in the morning. Despite their banter, *Magnús* could tell they were worried. Fear had a way of creeping up on a person when they realize that the ice is disappearing. But the people of the BPRC stayed because Ellen told them to. They did what Ellen ordered. She was the one who kept them from running in '85 when the ice core started cracking up at the South Pole.

Ellen looked at *Magnús* closely, the way Pilar must have looked at Robert Jordan before he blew the bridge on the way to Segovia. '*Don Magnússon*, I fear that the ice is losing. Even *Comrade Lonnie* has become sullen and cross with the field workers,' said Ellen, looking at the sky. 'How can you say such a thing?' replied Magnús. 'Why not? The climate does not know the way of ice. It only does what the gas tells it to do.' 'But what of the surveys? What of the remote sensing? And the ice cores?' he said. 'Surely the ice can't be losing everywhere.' 'Just the same, Don Magnússon,' she said to him, 'now that the weight of 400 ppt has come to the air, you can smell that death is on the ice.'

He shook his head, because he knew that Ellen was right. She read the ice with a 6th sense. '*Que va, Don Magnússon*, I began to smell it back in '73 when Mercer spoke of the West Antarctic Ice Sheet. I could smell it too when *Comrade Lonnie* was mapping the *Furtwängler* up on Kilimanjaro.' 'Smell? The smell of dying ice?' 'Yes. The smell of death was on that ice,' she said. 'Tell me, Ellen. Tell me what is this smell?' She looked at him closely. 'There are three main ingredients to the odour of dying ice, *Don Magnússon*. These are the smells that a field glaciologist is well familiar with. To know the first ingredient, *Don Magnússon*, you must wake up early in the morning when the night shift is being turned out from the bars in *McMurdo Station*. It is best that you do so when you are faint and hollow in the stomach, and you have a part of that smell in your nose already. You must walk up the hill behind the old DFA fuel pit and find the place where they put the old snow tractors. You must find the oldest that is there. The one that had fallen in a crevasse and had been crushed. If you can, you must unscrew the cap on the fuel tank. Then you must place your nose squarely and tightly into the opening of the tank, and you must inhale with all your might. The smell of greasy diesel, combined with the smell of old rubber from the discarded tires of trucks, *Don Magnússon*, that is the first part of the smell of dying ice.'

'It would be impossible for me to recognize such a smell, because I will go on no walk into the junkyards of McMurdo Station,' Kees, the *chief of editors* said, as he loaded his word processor for

Fig. 1. Henry Brecher has smelled the smell of disappearing ice. Julie Palais and Steve Price discuss the symposium that will start in the morning.

Fig. 2. David Elliot, Charlie Bentley and Mohammad Baloch sitting below the bust of Admiral Byrd at the BPRC open house.

Fig. 3. Christina Hvidberg explains to Olivier Gagliardini that 'ice is not made for defeat. It can be destroyed but not defeated'.

another night of editing work on the *Annals*.

'What's the rest of it?' *Magnús* asked.

Ellen, remembering now, proudly, her trips to South Pole, reached above the Coulter counters in the Icebreaker, and pulled down the *Laphroaig*. She poured a glass for *Magnús*. 'All right, *Don Magnússon*. Learn. That's the thing. Learn. All right. After that of the snow tractor, you must climb up the mountain valleys near Juneau, up to the ice field.' She paused to fill her own glass. 'You must go there early in the morning, and stand on the wet ice when there is a fog from the valley below, and wait for the old field glaciologists who go before daylight to check the data loggers before the sun makes the valley sides dangerous for avalanche. When such an old field glaciologist comes back to his tent, holding his parka around himself, with his face gray and his eyes hollow, and the whiskers of age on his nose and ears set in the waxen white of his face, as the sprouts grow from the seed of the bean, not bristles but pale sprouts in the death of his face; put your arms tight around him, *Don Magnússon*, and hold him to you and kiss him on the mouth and you will know the second part of the odour of dying ice.'

'That one has taken my appetite,' said *Lynn*, the one with the golden hair, and the organizer of the mid-week excursion. 'That of the sprouts is too much.'

'Leave it!' *Ellen* said. 'What I am saying is that climate change brings on its own form of ugliness to all parts of the ice, including the old glaciologists who work on it.'

The *Magnús* shuddered, and took a draught from his *Cohiba* as *Ellen* continued. 'Then, *Don Magnússon*, thou must walk along the shoreline of a Greenland fjord, past where the fishermen normally go. There you must wait, in the hot sun, with sand flies swarming about your face. When the time is right, you will feel a rumble in the earth below you. The earth will move, and you will feel it only three times in your life, if you are lucky. That rumble will be the seismic wave of a calving event. If it is a rare moment, and if you are at one with the calving ice, you will detect the pungent smell of ozone being released when the ice drops its calf and the bergs fragment.'

'No!'

'Yes,' *Ellen* said. 'Thou will breathe deeply and then your nose shall sting with the sharp odour of a 100-foot high mound of smelly grey mud that has squirted up through a crack at the ice sheet's glassy edge. This will smell awful, like a pig farm. A pig farmer smell on the ice cap.*'

*http://www.theworld.org/2011/05/greenland-ice-sheets-melting/

Fig. 4. Chief Editor of the Annals of Glaciology (No. 59) Kees Van der Veen and Regine Hock make an example of Hemingway's dictum about writing: 'good writing is good conversation, only more so.'

Fig. 5. Jason Box, member of the local organizing committee, explains the break-up of the Petermann Glacier Ice Shelf in Northeast Greenland.

'All of this is of the utmost repugnance!'

'Yes,' *Ellen* agreed. She swallowed from her glass and said, 'Mix all these odours together and you will have it. The smell of disappearing ice.'

'Well, if that is true,' *Magnús* replied, 'it is a good thing that I did not become an ice-core geochemist. And you say that the Quelccaya had this odour too?'

'Yes.'

Magnús looked out across the campus of The Ohio State University. 'It is clear,' he said. 'The symposium will begin in the morning.'

And so the great symposium on *Disappearing Ice* hosted by the *International Glaciological Society* and the *Byrd Polar Research Center* began in a conference room adjacent to the student union, in a clean and well-lighted place.

The symposium began with a welcome from the Ohio State University VP for the Office of Research on Monday 16 August 2010, and quickly dove into oral presentations on ice streams and outlet glacier dynamics, which lasted the rest of the day. Tuesday continued with oral presentations on records of past glacier changes coming from ice cores and proglacial proxies. Of particular interest were the presentations on the unique problems of temperate and tropical ice masses, which continued into Wednesday morning. Poster sessions on all themes of disappearing ice were held on Tuesday and Thursday afternoon, and were the locus of lively debate on the factors that drive glacier change worldwide, both past and present. The oral sessions on Thursday and Friday covered the large variety of glacier and ice sheet mass-balance presentations, and ended with presentations on dynamics of tidewater glaciers, ice shelves and ice sheets, as a step towards understanding the causes of disappearing ice.

Fig. 6. Ian Howat, local organizing committee, looks on with incredulity as Stephen Price explains how, when there is a bug in his model, ice can disappear by being launched into earth orbit.

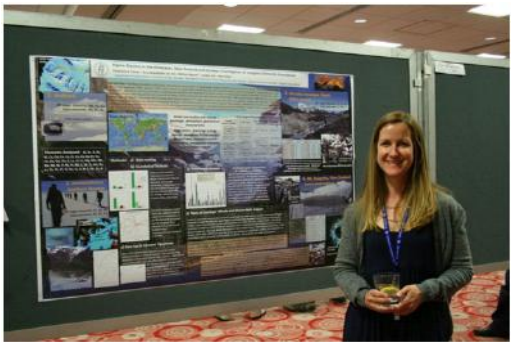


Fig. 7. Kimberley Casey explains the way of disappearing ice in the Himalaya.

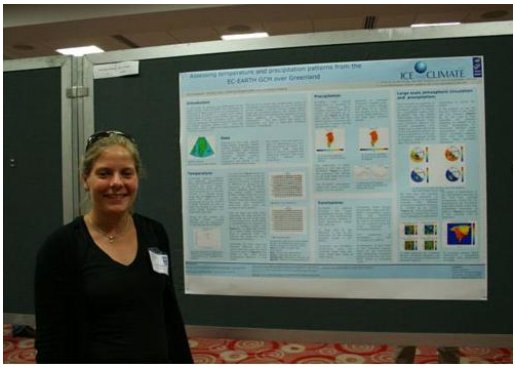


Fig. 8. Anne Munck Solgaard describes her poster and contemplates Hemingway's dictum: 'There is no rule on how to create a poster. Sometimes it comes easily, sometimes it's like drilling ice and then blasting it out with charges'.

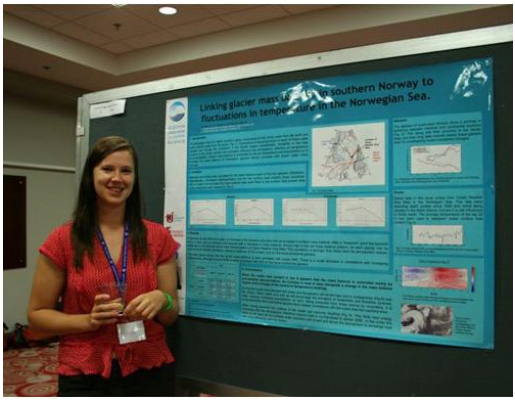


Fig. 9. Marie Porter presents a poster that links the effect of disappearing ice with the climate-change drivers in the Norwegian Sea.

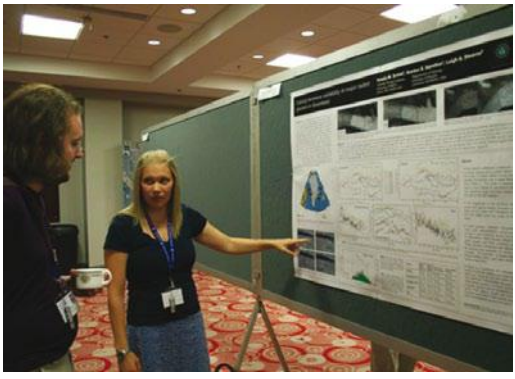


Fig. 10. Martin O'Leary and Kristen Schild compare notes on the smell of calving ice in a Greenland Fjord.

Fig. 11. Ellen Thompson orders IGS guerillas to shield Jay Zwally's bared arms from excessive sunlight. Jay, a high-ranking operative in the battle against disappearing ice, is too valuable to be sunburned.

Experienced with great enjoyment during the week's activity were a tour of the BPRC research facilities, the midweek excursion and symposium banquet. The open-house at the main BPRC facility featured interactive presentations on lab activities and ongoing research, as well as a tasty cake baked to honour the 50 years of BPRC's existence.

The excursion was extremely well planned and executed, and was devoted to the *visualization of changing landscapes*: disappearance of the *Scioto Lobe* of the *Laurentide Ice Sheet*, Ohio. Of particular interest was the degree to which glaciation had rearranged the river drainage of the mid-Ohio landscape. Various kames, kettles and stratified outwash features were seen along a pleasant bus ride through the rolling terrain of Central Licking County. Eventually the excursion stopped at the Great Circle Earthworks State Memorial in Newark, Ohio, for a view of the mysterious constructions of the Hopewell people about 2000 years ago. It is thought that these earthworks allowed ceremonial observation of the 18-year moonrise cycle. A stop at the Burning Tree Golf Course allowed symposium participants to see the site of one of the most complete mastodon finds in the world (the result of which is now on display at the Kanagawa Museum in Yokohama, Japan). Also at this site was an odd, but enjoyable museum of paleontology, where dinosaurs, cavemen and large Pleistocene megafauna replicas

Fig. 12. Symposium participants are educated on the sedimentary record of ice that once covered Ohio.

Fig. 13. The mid-week symposium excursion featured the geology of the southern margin of the Laurentide Ice Sheet. Dan Leavell and Mike Angle, the excursion leaders, were helped by Miriam Jackson and Kaitlin Walsh to display the map in front of a typical field of Ohio corn.

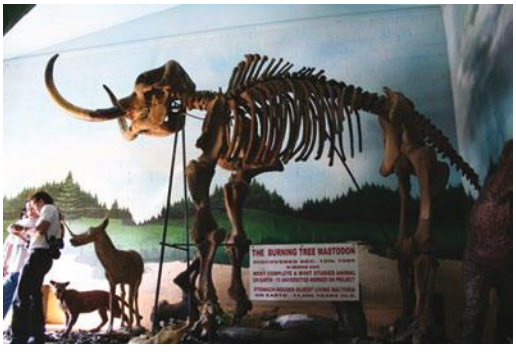


Fig. 14. During the mid-week symposium excursion, IGS members were exposed to a unique form of Pleistocene paleontology at the Burning Tree Museum.

Fig. 15. Wang Youqing, Wang Weili, Yao Tandong and Li Jun enjoy the symposium banquet and contemplate possible future IGS symposia to occur in China.

Fig. 16. Paul Wineberry contemplates the feast held at the banquet, and reflects that, for a glaciologist, drinking wine is not snobbism or a sign of sophistication, it is a simple necessity. Symposium organizer Ellen Mosley-Thompson speaks to the banquet from the podium and reminds: 'always do sober what you said you'd do drunk. That will teach you to keep your mouth shut.' (quote from E. Hemingway)

Fig. 17. Ellen Mosely Thompson presents Doug MacAyeal with the Goldthwait Polar Medal of the BPRC. Doug, still not having learned how to keep remarks short, follows with a speech reflecting on the role of glacier ice in Mary Shelley's *Frankenstein*.

Fig. 18. *Don Magnússon*, the Secretary General of the IGS and Field Operative in the operation on disappearing ice, hugs Lynn Everett, the one with the long golden hair, and Lynn Lay on the occasion of the successful conclusion of the Symposium. Lynn's composure is temporarily suspended as she realizes she is being asked to join a Council of Elders meeting posthaste at the shore of Mirror Lake.

were on display. The excursion ended with a barbecue at the Dawes Arboretum, where the fatigue of a full day of geological and anthropological study could be soothed with a cold, frothy brew.

The banquet was held at the Ohio State University Faculty Club, and featured appetizing food in an elegant setting. During the dinner various presentations and awards were made to commemorate the 50th anniversary of the founding of the Byrd Polar Research Center. The *bard* of the *ICE*, Doug MacAyeal, gave a brief presentation on references to polar exploration in gothic fiction in honour of the presentation of the Goldthwait Polar Medal of the BPRC.

100 registered participants from 13 countries attended the symposium.

Doug MacAyeal

REPORT FROM THE NEW ZEALAND BRANCH MEETING

Fox Glacier, New Zealand, 9–11 February 2011

The annual meeting of the New Zealand Branch of the International Glaciological Society, known locally as the Snow and Ice Research Group (SIRG) http://www.sirg.org.nz/ was held at Fox Glacier on the West Coast of New Zealand, within a few kilometres of the ice. The conference was hosted by Victoria University of Wellington, and organised by PhD student Alice Doughty with assistance from Katrin Sattler and Karen McKinnon. It was held over three days, and included two days of talks and a field trip to Fox Glacier. We had sessions on 'Glacier behaviour and dynamics', 'Fox and Franz Josef Glaciers', 'Antarctica' (including sea ice), 'Modelling' (numerical and analytical) and 'Climate and permafrost'. We also carried out a public lecture entitled 'Glaciers in our backyard 'which featured three people who live on the West Coast of New Zealand and have different perspectives of the glacier; Cornelia Vernoorn from the New Zealand Department of Conservation (DOC), who manages the ~7000 visitors who visit the glacier each day, and is responsible for safety and promotion of education; Graham Wilcox, who guides tourists on the glacier and assists scientists in monitoring ablation; and Dr Brian Anderson, a glaciologist from Victoria University of Wellington, who monitors mass balance on the Fox and Franz Josef Glaciers with an interest in modelling the interactions between glaciers and climate.

We were blessed by lovely weather and the majority of participants walked on the glacier during the field trip. Guiding was carried out by Graham Wilcox and Dr Heather Purdie, a recent PhD graduate from Victoria University. The Fox Glacier terminus is particularly beautiful, located at ~300 m elevation within a deep valley, surrounded by temperate rainforest, with the ocean visible a short distance away. This glacier, along with its nearby companion Franz Josef Glacier, probably ablates more than any other glacier on Earth (>20 metres per year), and flows at up to 1 km/year. Snow accumulation rates in the névé can exceed 10 m/year of water equivalent. The participants, some of whom were walking on a glacier for the first time, inspected and debated the origin of surface features such as ice pressure arches, conduits, crevasses, entrained debris and ice foliation.

Members of the IGS at the 2011New Zealand Branch Meeting gather for a group photograph in the summer sunshine.

50 people from five countries attended the meeting. A total of 13 institutions were represented included Victoria University (Wellington), Otago University (Dunedin), Canterbury University (Christchuch), Massey University (Palmerston North), and the National Institute for Water and Atmospheric Research (NIWA). Internationally, scientists attended from the University of Fribourg (Switzerland), Swiss Federal Institute for Snow and Avalanche Research (Switzerland), Bristol Glaciology Centre (UK), University of Victoria (CA), University of Washington (USA), two people from University of Alaska, Fairbanks (USA), University of Queensland (Australia), and Curtin University (Australia). A professional photographer and a mountain guide also attended.

Andrew Mackintosh and Alice Doughty

Participants enjoying a field trip walking on Fox Glacier.

INTERNATIONAL GLACIOLOGICAL SOCIETY

International Symposium on

Seasonal Snow and Ice

Lahti, Finland
28 May–1 June 2012

Co-sponsored by:
❄ Department of Physics, University of Helsinki
❄ Micro-Dynamics of Ice (MicroDICE) network of European Science Foundation)

FIRST CIRCULAR
May 2011
http://www.igsoc.org/symposia/
http://www.gastro.physics.helsinki.fi/IGS2012/

The International Glaciological Society will hold an International Symposium on 'Seasonal Snow and Ice' in 2012. The symposium will be held in Lahti, Finland, from 25 May to 1 June 2012.

THEME

Seasonal ice covers wide zones around the globe, mostly in sub-polar latitudes. The main forms are seasonal snow, sea ice, lake and river ice and frozen ground. The extent of the seasonal ice zone is highly sensitive to climate as small climatic variations can have a large impact on the environment as well as human living conditions. Ice–climate feedback mechanisms are important to study, as they are often first identified in the seasonal ice zone.

New technologies have broadened our ability to examine the seasonal ice zone, though large uncertainties about its current state remain. Numerical modelling is advancing but thin ice and seasonal snow covers close to the climatological ice margin remain difficult to model because of their transient nature. Ecological impact studies in the seasonal ice zone have increased over the past ten years, and serve to further highlight the important role seasonal ice has on the many physical, chemical and biological systems of the sub-polar latitudes.

In view of these advancing technologies, modelling improvements and ecological studies, we announce a symposium focussed on the understanding of seasonal snow and ice. The goal of the symposium is to progress further in understanding how seasonal snow and ice is responding to changes in the environment and climate, and what changes can be expected in the future. This meeting seeks to address these problems by bringing together scientists from diverse communities engaged in research on snow, sea ice, freshwater lake and river ice and frozen ground.

TOPICS

Topics include, but are not limited to

1. Observations of temporal changes of seasonal snow and ice cover, including snow and ice phenomenology, in situ observations and mathematical modelling techniques.
2. Physical, chemical and biological processes of seasonal snow and ice, including snow metamorphosis, snow structure models and the effect of snow quality on the biosphere.
3. Micro-dynamics of ice, including analysis, modelling and interpretation of ice microstructures, and linking microstructures to geophysical signals.
4. Seasonal sea-ice dynamics and the impact of seasonal sea ice on the ocean, including scaling of ice dynamics, mathematical models, ice ridges, and the oceanic boundary layer under sea ice.
5. Frozen ground and permafrost, focussing on observations, theoretical advances and modelling.
6. Lake and river ice, including ecology of frozen lakes, river ice models, estuaries.
7. Ecological impact of snow cover and snow quality.
8. Remote sensing techniques applied to seasonal snow and ice, including sea and lake ice and snow-mapping technology.
9. Theoretical and numerical advances in modelling seasonal snow and ice, including coupling of cryosphere models with regional climate models and intercomparison of models.

10. Projections and forecasts of seasonal snow and ice in a changing climate, including downscaling methods and evaluations.

ABSTRACT AND PAPER PUBLICATION
Participants wishing to present a paper at the workshop are required to submit an abstract. There will be oral as well as poster presentations. A pre-print 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 and non-participants alike are encouraged to submit manuscripts for this volume.

SYMPOSIUM ORGANIZATION
Magnús Már Magnússon (International Glaciological Society)

SCIENCE STEERING AND EDITORIAL COMMITTEE
Matti Leppäranta, Chief Editor (University of Helsinki, Finland). Associate editors will be determined later.

LOCAL ORGANIZING COMMITTEE
Matti Leppäranta (chair), Lauri Arvola, Jari Haapala, Kari Kajuutti, Esko Kuusisto, Sirpa Rasmus, Jukka Tuhkuri

ADDITIONAL ACTIVITIES
A half-day mid-week excursion will be organized to explore some of Finland's lake district and cultural surroundings. Details will be forthcoming in the second circular.

POST-SYMPOSIUM EXCURSION
To be determined.

VENUE
The meeting will be held at Sibeliustalo Hall, Lahti, Finland. The surroundings offer plenty of scope for geophysical, geological and geographical excursions.

FURTHER INFORMATION
If you wish to attend the symposium please log onto the IGS website at
http://www.igsoc.org/symposia/2012/finland/preregistration/
and register your details and interest to attend the symposium.

Although we strongly encourage prospective attendees to register online it can also be done by filling in and returning the form on the back page of this circular as soon as possible.

The Second Circular will give further information about accommodation, the general scientific programme, additional activities, preparation of abstracts and final papers. Copies of the Second Circular will be sent to those who pre-register or return the attached reply form. Members of the International Glaciological Society will automatically receive one. Information will be updated on the conference website, http://www.igsoc.org/symposia/2012/finland/ and the local website http://www.gastro.physics.helsinki.fi/IGS2012/ (a link will be introduced on the IGS site).

INTERNATIONAL SYMPOSIUM ON SEASONAL SNOW AND ICE

Lahti, Finland
28 May–1 June 2012

Family name: _____

Given name(s): _____

Address: _____

_____

_____

Tel: _____ Fax: _____

E-mail: _____

☐ I hope to participate in the Symposium in May/June 2012

☐ 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
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Cambridge, CB2 1ER, UK

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Fax: +44 (0)1223 354 931

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

Glaciological diary

** IGS sponsored * IGS co-sponsored

2011

28 February–1 March 2011
Community Earth System Model – Polar Climate Working Group Meeting
Boulder, Colorado, USA
Website: http://www.cesm.ucar.edu/working_groups/Polar

28 February–11 March 2011
Canadian Society of Hydrological Sciences Short Course: Physical Principles of Mountain and Cold-Climate Hydrology
Kananaskis, Alberta. Canada
Website: http://www.cwra.org/Branches/CSHS/Principles_of_Hydrology_Workshop.aspx

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]

16–17 March 2011
Water in Mountain Areas: Better Observations for Better Forecasting
200th session of the Comité Scientifique et Technique de la Societé Hdydrotechnique de France
Lyon, France
Website: http://www.igsoc.org:8000/www.shf.asso.fr/117-1-les_manifestations-16.html

20–25 March 2011
Gordon Research Conference on Polar Marine Science: Exploring Complex Systems in Polar Marine Science
Ventura, California, USA
Website: http://www.grc.org/programs.aspx?year=2011&program=polar
For the first time, this conference will be preceded (19–20 March) by the new Polar Marine Science Gordon-Kenan Research Seminar on Contributing to the Understanding of Complex Polar Marine Systems, for early-career scientists
Website: http://grc.org/programs.aspx?year=2011&program=grs_polar

23–26 March 2011
IASC Workshop on automated measuring systems on glaciers
Pontresina, Switzerland
Website: http://www.projects.science.uu.nl/iceclimate/workshop/
Contact: Carleen Tijm-Reijmer [c.tijm-reijmer@uu.nl]

24–25 March 2011
7th Annual Polar Technology Conference
Albuquerque, New Mexico, USA
Website: http://polartechnologyconference.org/

27 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
Website: http://meetingorganizer.copernicus.org/EGU2011/sessionprogramme/CR

10–14 April 2011
Symposium on the Application of Geophysics to Environmental and Engineering Problems
Charleston, South Carolina, USA
Session: Cold Regions Geophysics.
Conveners: Beth Astley [Beth.Astley@usace.army.mil], Bruce D. Smith [bsmith@usgs.gov]
Website: http://www.eegs.org/sageep

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

15–16 April 2011
Ice Drilling Science Community Planning Workshop
Herndon, Virginia, USA
Website: http://icedrill.org/science-planning-workshop-2011/
Contact: Mary Albert [Mary.Albert@Dartmouth.Edu]

22–27 April 2011
International Polar Year (IPY) 2012 Conference: From Knowledge to Action
Montréal, Québec, Canada
Website: http://www.ipy2012montreal.ca/

27–28 April 2011
Antarctic Science Symposium: Celebrating the completion of the IceCube Neutrino Detector
Madison, Wisconsin, USA
Website: http://internal.icecube.wisc.edu/meetings/2011/antsci/
Contact: Kim Kreiger [kim.kreiger@icecube.wisc.edu]

2–4 May 2011
American Meteorological Society: 11th Conference on Polar Meteorology and Oceanography
Boston, Massachusetts, USA
Website: http://www.ametsoc.org/meet/
Contact: John Cassano [john.cassano@colorado.edu]

3 May 2011
Association of Polar Early Career Scientists Early Career Research Workshop: Shaping the Future of AMAP
Copenhagen, Denmark
Website: http://apecs.is/workshops/amap-2011
Contact: Jennifer Provencher [ipy-outreach@apecs.is]

23 May–4 June 2011
2011 Summer School: Modeling of the Arctic Climate System
Fairbanks, Alaska, USA
Contact: Tohru Saito [saito@iarc.uaf.edu]

30 May–2 June 2011
European Association of Remote Sensing Laboratories (EARSeL) Symposium 2011
Prague, Czech Republic
Website: http://www.igsoc.org:8000/www.earsel.org/symposia/2011-symposium-Prague/

31 May–3 June 2011
Sixth International Conference on Arctic Margins
Fairbanks, Alaska, USA
Website: http://www.gi.alaska.edu/icam6
Contact: B. Coakley [bernard.coakley@gi.alaska.edu]

1–3 June 2011
European Association of Remote Sensing Laboratories (EARSeL) Workshop on Remote Sensing of the Coastal Zone
Prague, Czech Republic
Website: http://www.igsoc.org:8000/www.earsel.org/symposia/2011-symposium-Prague/

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

6–9 June 2011
WHISPERS: 3rd Workshop on Hyperspectral Image and Signal Processing – Evolution in Remote Sensing
Lisbon, Portugal
Website: http://www.ieee-whispers.com/

12–17 June 2011
***International Symposium on Physics, Chemistry and Mechanics of Snow**
Yuzhno-Sakhalinsk, Russia
Website: http://snowphysics.fegi.ru/en/main.html
Contact: Sergey Sokratov [sokratov@geol.msu.ru]

19–24 June 2011
International Offshore and Polar Engineering Conference:
ISOPE Arctic Science & Technology Symposium
ISOPE Arctic Materials Symposium
Maui, Hawaii, USA
Website: http://www.isope2011.org/
Contact: Simon Prinsenberg or Howie Ji

22–24 June 2011
6th Antarctic Meteorological Observation, Modeling, and Forecasting Workshop
Hobart, Tasmania, Australia
Website: http://cawcr.gov.au/events/amomfw_2011

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], Jon Haukur Ingimundarson [jhi@unak.is], Joan Nymand Larsen [jnl@unak.is]

27 June–9 July 2011
Norwegian Research School for Climate Dynamics Summer School:
Role of sea ice in the climate system
University Centre in Svalbard
Website: http://www.resclim.no/

28 June–7 July 2011
IUGG XXV General Assembly: Earth on the Edge: Science for a Sustainable Planet
Melbourne, Australia
Website: http://www.iugg.org/assemblies/2011melbourne/

29 June 2011
Final Conference of the PermaNET project
Chamonix Mont-Blanc, France
Flyer: http://www.igsoc.org:8000/symposia/Flyers_etc/PermaNET210411.pdf

10–14 July 2011
Advances in Sea Ice Forecasting: 21st International Conference on Port and Ocean Engineering under Arctic Conditions
Montreal, Canada
Website: http://www.poac11.com/

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

20–22 July 2011
Summer School: Remote Sensing for Polar Scientists
University of Reading, Reading, UK
Website: http://www.surveymonkey.com/s/VPYRWJX
Contact: Jennifer Hall [j.hall@sheffield.ac.uk]

20–27 July 2011
International Union for Quaternary Research Congress
Bern, Switzerland
Website: http://www.inqua2011.ch/
Contact: Christian Schluchter [christian.schluechter@geo.unibe.ch]

20–27 July 2011
Geohydro 2011
Canadian Quaternary Association/International Association of Hydrogeologists
Québec, Canada
Website: http://geohydro2011.ca/

1–12 August 2011
Bert Bolin Centre's Arctic Climate Summer School
Abisko Research Station, Lake Tornatrask, Sweden
Website: http://www.bbcc.su.se/2011-summer-school-on-arctic-climate.html
Contact: Anna Krusic [anna@krusic.org]

15–20 August 2011
18th Northern Research Basins Symposium
Starting in Bergen, Norway
Website: http://www.18thnrb.com/

22–26 August 2011
Second International Symposium on Mountain and Arid Land Permafrost
Ulaanbaatar, Mongolia
Website: http://www.geography.mn/

28 August–1 September 2011
Air-Surface Interactions: Chemistry from Molecular to Global Climate Scales
American Chemical Society National Meeting
Denver, Colorado, USA
Contact Amanda Grannas [amanda.grannas@villanova.edu]

29 August–1 September 2011
Climate Change in High Mountain Regions – From Understanding of the Past to Modelling of the Future
Salzburg, Austria
Website: http://www.zamg.ac.at/veranstaltungen/125jahresonnblick
Contact Wolfgang Schöner [wolfgang.schoener@zamg.ac.at]

5–9 September 2011
Avalanches and Related Subjects IV International Conference: The contribution of theory and practice to avalanche safety
Kirovsk, Murmansk region, Russia
Website: http://cas.apatit.com/

9 September 2011
Workshop for UK scientists: observations of 20th/21st Century changes in Antarctic Peninsula glaciers
Cambridge, UK – immediately following the IGS British Branch Meeting
Website: http://www.antarctica.ac.uk/about_bas/events/igs2011/index.php

13–24 September 2011
Karthaus course on Ice Sheets and Glaciers in the Climate System
Karthaus, Italy
Website: http://www.phys.uu.nl/~wwwimau/education/summer_school/

19–21 September 2011
MOUNTAINHAZARDS 2011: Climate Changes and Natural Hazards in Mountain Areas
Dushanbe, Tadjikistan
Website: http://www.mountainhazards2011.com/

21–23 September 2011
Eighteenth Annual WAIS Workshop
Loveland, Colorado, USA
Website: http://www.waisworkshop.org/pastmeetings/workshop2011.html

21–24 September 2011
Ecosystems: Understanding the Cycle AAAS Arctic Division 2011 Annual Meeting
Dillingham, Alaska, USA
Website: http://www.arcticaaas.org/meetings/2011/

23–24 September 2011
ICSU Polar Science Symposium
Siena, Italy
Website: http://www.mna.it/english/News/ICSU_symposium

14–15 October 2011
2011 Northwest Glaciologists Meeting
Portland, Oregon, USA
Contact Andrew Fountain [andrew@pdx.edu]

24–28 October 2011
World Climate Research Programme Open Science Conference: Climate Research in Service to Society
Denver, Colorado, USA
Website: http://conference2011.wcrp-climate.org/
Contact the conference secretariat at [info.conf2011@wcrp-climate.org]

25–26 October 2011
10th Ny-Ålesund Seminar
Kjeller, Norway
Website: http://nyalesund-seminar.nilu.no/

27–29 October 2011
****International Glaciology Society Nordic Branch Meeting 2011**
NVE, Oslo, Norway
Website: http://www.nve.no/en/Water/Hydrology/Glaciers/IGS-Nordic-Branch-Meeting-2011/

7–9 November 2011
***Ice Deformation: from the model material to ice in natural environments – Conference in honour of Paul Duval (part of the ESF project MicroDICE)**
Grenoble, France
Website: http://microdice.eu/activities/ice-deformation-from-the-model-material-to-polar-ice/

5–9 December 2011
American Geophysical Union Fall Meeting
San Francisco, California, USA
Website: http://www.agu.org/meetings/

2012

10–13 January 2012
Workshop on the Dynamics and Mass Budget of Arctic Glaciers/IASC Network on Arctic Glaciology Annual Meeting
Zieleniec, Poland
Website: http://www.szarotka.eu/

22–27 April 2012
IPY From Knowledge to Action Conference Montreal, Québec, Canada
Website: http://www.ipy2012montreal.ca/index.php

23–26 April 2012
Interpraevent 2012 – 12th Congress: Protection of Living Spaces from Natural Hazards
Grenoble, France
Website: http://www.interpraevent2012.fr/

28 May–1 June 2012
****International Symposium on Seasonal Snow and Ice**
Lahti, Finland
Contact: Secretary General, International Glaciological Society

3–8 June 2012
XV Glaciological Symposium: Past, Present and Future of the Cryosphere
Arkhangelsk, Russia
Contact: Stanislav Kutuzov [s.kutuzov@gmail.com]

25–29 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://www.ticop2012.org/

13–25 July 2012
SCAR 2012: Antarctic Science and Policy Advice in a Changing World
Portland, Oregon, USA
Conference website available soon
Contact: Andrew Fountain [andrew@pdx.edu]

1–5 October 2012
***International Symposium on Ice Core Science**
Giens, France
Website: http://www.ipics2012.org/

2013

8–13 July 2013
Joint IACS/IAMAS Conference: Air and ice – interaction processes
Davos, Switzerland
Contact: Charles Fierz [fierz@slf.ch]

2014

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

New members

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