Number 181 *3rd Issue 2019*

ICE

NEWS BULLETIN OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

ISSN 0019–1043

Ice

News Bulletin of the International Glaciological Society

Number 181 3rd issue 2019

Contents

Cover picture: A double-wrapped snow roll on the windshield of a Toyota RAV4 after a light snowfall in Chicago (date: 17 April, 17:30 UTC). The roll was initiated by the release of the upper half of the windshield's snow cover as heat from inside the car melted the glass/snow contact. The sliding sheet produced a fold at the junction with the still-frozen based snow on the lower half of the windshield. The fold toppled over and induced a roll which wrapped the inflowing upstream snow layer with the downstream snow being peeled up from the frozen glass interface (hence the term double-wrapped roll). Snow rolls were first discussed in the *Journal of Glaciology* in 1950 (Pierce, C., 'Snow rollers', **1**(8), 457–458.). Photo by Doug MacAyeal.

From the Editor

Dear IGS member

Welcome to the third and last issue of *ICE* for 2019. This will also be the last issue of *ICE* in its current format, as the Publications Committee has reviewed the content and publication of *ICE* and made some recommendations to Council. It is not a major overhaul, more a 'let's stop doing this' and 'let's try doing that'.

Here is a 'Contents List'. Not all of this will be in there all the time: it will depend what is available.

1. From the Editor
2. Reports on IGS symposia and branch meetings
3. Reports on IGS-sponsored workshops/summer schools, etc.
4. Announcements of IGS Awards
5. Announcements of new appointments
6. Copies of symposium circulars
7. News from IGS national correspondents and membership
8. The voice of EGG
9. Obituaries
10. AGM reports
11. Glaciological diary
12. New members

So, what has been discontinued? The national 'Recent work reports' have gone. You will no doubt have noticed that those have been getting fewer and further between of late. It was becoming more and more difficult to persuade correspondents to compile the traditional report; quite often the response was 'No need to do this, it's all on the web'. We also heard the argument that, in an era of intense international collaboration, these old-type 'national' reports no longer described the research situation adequately. While this was true, the old reports still summarized all the glaciological activity within a country. Now we need reports on the various multinational projects under way. See below under 'what is new?'.

Another thing that will disappear with the first issue for 2020 is the listing of accepted *Journal* and *Annals* papers. It was felt that this information usually appeared in *ICE* too late to be of use and that all the information was already out there in the form of Twitter and Facebook posts, as well as notifications from our publication partner, CUP.

So, what is new? Most notably, two things, 'News from IGS national correspondents and membership' and 'The voice of EGG'. Let me explain briefly.

As noted above, the traditional reports from national correspondents are to be discontinued. This is part of an initiative by the IGS President to redefine the role of the national correspondents, which is now defined as

– encouraging and keeping track of IGS membership
– promoting the publication of papers in the *Journal of Glaciology* and the *Annals of Glaciology*
– promoting attendance at IGS symposia.

These activities should be accompanied by submission to the IGS Secretary General of brief news items on glaciological activities or projects developed in their country, for diffusion though *ICE* and/or the IGS website news or social media.

Hence, we are hoping to have a steady flow of shortish news items of relevance or special interest on glaciological activities or projects and hopefully some correspondents will club together to produce rather more substantial reports on current international collaborations.

In my last editorial I discussed the formation of the Early-Career Glaciology Group (EGG) so you should be well up to speed on them. And if you are an early-career researcher, I trust you have already been in touch. The EGG will have a regular feature in *ICE* so they will rely on you EGGers out there to contribute. Please step up to the plate and make this an exciting and informative column in our newsletter.

And my final message to all of you is, let us all pull together to rejuvenate *ICE* and make it an even more interesting and, most importantly, an all-encompassing vehicle of the various activities of the IGS.

Magnús Már Magnússon
Secretary General

Recent work

Sweden

Monitoring of weather data and glacial mass balance with an aim to improve predictions of fresh water loss from Arctic glaciers
W. Van Pelt (UUppsala), V. Pohjola (UUppsala), R. Pettersson (UUppsala), S. Marchenko (UUppsala), R. Hock (UAF), C. Reijmer (UUtrecht)
We have been monitoring atmospheric and cryospheric (mass balance and ice velocity) parameters on Lomonosovfonna/Nordenskiöldbreen since 1997. We further have an automated weather station logging data continuous there since 2006. This data is now long enough to make a monitoring record useful in a climatological sense. Spitsbergen has longer records of monitoring, but none in the sector northern/eastern Spitsbergen, where most of the ice cover exists. This makes our monitored data into a valuable archive for climate studies. Our aim is to add this monitoring activities to SIOS (Svalbard Integrated Arctic Earth Observing System). The primary aim with this application is to find out whether The Swedish Polar Research Programme (SPRS) is interested in supporting our ambition to add our monitoring program to SIOS. The secondary aim is to obtain local support from the Norwegian Polar Institute, via a more formal collaboration project negotiated via SPRS. We are renting equipment mainly from NPI for our field campaigns. If we via SPRS can reach the status of a co-operation project with NPI, supported by SPRS, we will be able to cut our costs by 15%, and become a more integrated part of the NPI operations. The third aim with this proposal is to secure our financial situation in which we can maintain these observations.
Contact: ward.van.pelt@geo.uu.se

SNODDAS – Snow distribution and data assimilation for better spring flood forecasts and more sustainable regulation of hydropower reservoirs
V. Pohjola (UUppsala), B. Norell (VRF), D. Gustafsson (SMHI), J. Zhang (UUppsala), I. Clemenzi (SMHI), R. Pettersson (UUppsala)
The aim of the project is to improve spring flood forecasts by developing a methodology for more accurate determination of the snow water reservoir. The goal is to develop a methodology at the end of the project to systematically integrate information from available satellite and ground-based snow measurements into models for snow and spring flood forecasts, to develop a method for determining the size of the snow magazine within defined areas and to broaden it. the forum that has already been started on the topic in the Nordic countries to exchange experiences and knowledge.
Contact: veijo.pohjola@geo.uu.se

Firn aquifers, glacial dynamics and cryobiology
V. Pohjola (UUppsala), R. Pettersson (UUppsala), W. Van Pelt (UUppsala), J. Zhang (UUppsala), A. Hodson (UCS), C. Reijmer (UUtrecht)
The Arctic Warming is now in full swing. In the bulls-eye of the global warming is presently the area around the Barents Sea, where the warming rates over and around the Svalbard Archipelago for the last 20 years have been about 1°C per decade in terms of observed mean annual air and ground temperatures from permafrost stations. With such high rates of change observed, it can be stated that the future with respect to global warming is already knocking at the door here. Detecting and understanding the changes here can help us determine which processes are the most vulnerable and at what rates they may operate when warming reaches critical levels on the largest ice sheets, in order to prepare us for future change and such facilitate risk reductions for global society. We have been monitoring the ice field Lomonosovfonna since 1997 and observed the warming of the firn column at a similar rate as reported above from Svalbard. The key questions we would like to address are what part perennial firn aquifers (PFA) play in the routing of meltwater out from the glacial system, what controls them and how dynamic these features are, with the specific aims to assess secondary aims: 1) how the PFAs and the flow from them change with time on a regional scale, 2) how the storage in PFAs may control ice dynamics by friction reductions over the glacial system, and 3) how the PFAs drive carbon cycling and export in a hitherto overlooked cryospheric ecosystem.
Contact: veijo.pohjola@geo.uu.se

Glacier thickness estimation from satellite data
W. Van Pelt (UUppsala)
Accurate simulation of ice thickness and volume changes of glaciers and ice sheets in a changing climate is highly relevant for assessing the cryospheric contribution to sea level rise. A necessity for simulating long-term glacier geometry evolution is detailed knowledge of basal topography under

the ice. Whereas a wealth of observational data of surface processes is available, the inaccessibility of the glacier bed complicates direct observations of subglacial conditions, including basal topography. This has stimulated the development of inverse methods to indirectly estimate ice thickness from surface data from high-resolution satellite products. The main goal with this project is to develop a tool for estimating ice thickness of large sets of glaciers using high-resolution satellite data. In a first step an inverse method will be tested on three individual glaciers in Svalbard, including a slow-flowing glacier (Nordenskiöldbreen), a fast-flowing glacier (Kronebreen) and a surge-type glacier (Tunabreen). In this step, high-resolution TerraSARX satellite data of surface height and velocity will be essential for accurate bed height reconstruction, while in situ GPR bed height data are used for validation. In a next step an automated framework will be developed, enabling ice thickness estimation for large sets of glaciers. Using medium-resolution Sentinel-1A SAR data the framework will be used to estimate ice thickness evolution for all glaciers in Svalbard in a past, present and future climate (1600–2100 AD).
Contact: ward.van.pelt@geo.uu.se

A snow quality tool based on modelling, drones and Sami knowledge (Snow4all)
G. Rosqvist (UStockholm), T. Gustafsson (ÅF Sw), W. Van Pelt (UUppsala), J. Wik Karlsson (SSR), N. Inga (Laevas Sameby), D. Gustafsson (SMHI)
There is a pressing need for more accurate snow quality data at different spatial and temporal resolutions. Changes in snowpack properties (e.g. depth, density) and precipitation seasonality influence the distribution and composition of ecological communities. Consequently this affects many inherent ecological processes, functions and feedbacks, and the timing and magnitude of runoff, and probably also leads to more frequent avalanches. Although changes in snow attributes now increasingly challenge reindeer husbandry, tourism, hydropower and transport sectors in northern Sweden, there is no service that provides access to information on snow quality, i.e. thicknesses, density, layering and other attributes. Such information will support reindeer herding communities to adapt to the rapidly changing climate and will aid sustainable land use planning. Here we innovatively combine the development and application of new methods and techniques with indigenous traditional knowledge (Sámi knowledge). Our main aim is to develop new methods and services providing access to information on snow quality.
Contact: ninis.rosqvist@natgeo.su.se**;** ward.van.pelt@geo.uu.se

Retrieval of snow properties from SAR data using coupled snowpack and scattering models
M. Hovemyr (UStockholm), I. Brown (UStockholm), W. Van Pelt (UUppsala), G. Rosqvist (UStockholm)
The PhD project of Mikael Hovemyr investigates the retrieval of snowpack properties such as snow depth and snow water equivalent using coupled snowpack and electromagnetic scattering models to analyse multi-frequency synthetic aperture radar observations of snowpack properties across northern Scandinavia. Globally, seasonal snow cover extends 46 Mkm^2 annually. According to observations by SMHI, in a typical winter, a half to two-thirds of Sweden is snow-covered for most of the period December to March. Climate change means that significant changes in snow accumulation, snow melt and timing are under way. Deviation from long-term norms brings challenges for nature and society, both of which must adapt to changes in ecosystems and the water cycle. For society this means adapting or managing infrastructure such as hydropower facilities (where reservoir capacity planning must adapt to new flow regimes), road and rail infrastructure (ensuring higher river discharges do not damage bridges, embankments or flood carriageways), and maintaining adequate monitoring capacity (of, for example, river discharge, snowpack storage and melt rates). This research aims to evaluate multi-frequency SAR datasets towards algorithms for the retrieval of snowpack properties, addressing the challenges identified by NASA and ESA. The project will explore the capabilities of multi-temporal, multi-frequency, multi-polarization and interferometric synthetic aperture radar data analysed with reference to coupled snowpack and scattering models to improve our ability to monitor water storage in northern high-latitude snowpacks. The research will be performed at multiple sites across northern Sweden and Norway. It will improve our understanding of snowpack processes affecting Earth Observation (EO) datasets in the microwave region and derive algorithms to better quantify snowpack properties using sustainable EO in line with ESA future challenges. Seasonal snow is a fundamental element of the national environmental goal of a magnificent mountain landscape, supports hydropower helping Sweden meet national and international environmental goals (such as commitments to renewable energy and limitations on greenhouse gas emissions).
Contact: mikael.hovemyr@natgeo.su.se; ward.van.pelt@geo.uu.se

Ocean-induced changes at calving glacier margins: data, uncertainty, and simulation.
N. Kirchner (UStockholm), F. Holmes (UStockholm), P. Prakash (UStockholm), R. Noormets (UCS), P. Lötstedt (UUppsala), L. von Sydow (UUppsala).

The project aims to predict current and future mass losses from calving glaciers through numerical simulation with quantification of uncertainty in the results. This is in light of the fact that today's mass loss through calving and dynamic thinning of glaciers is likely to be the single largest contributor to sea level rise over the next century. However, the calving process is not yet fully understood, its representation in numerical models is difficult and uncertain, and their spread from measurements to modeled outputs is rarely quantified. Here we adopt an integrated approach and combine observed, qualitatively reconstructive and predictive numerical elements that we evaluate against geological evidence to build a foundational framework that contributes to the UN Agenda 2030 Sustainable Development Goals (SDG) 13 'Climate measures'.
Contact: nina.kirchner@natgeo.su.se

High-resolution bathymetric mapping reveals subaqueous glacial landforms in the Arctic alpine lake Tarfala, Sweden.
N. Kirchner (UStockholm), R. Noormets (UCS), J. Kuttenkeuler (KTH), E. Standell Erstorp (KTH), E.S. Holmlund (UCS), G. Rosqvist (UStockholm), P. Holmlund (UStockholm), M. Wennbom (UStockholm), T. Karlin (UStockholm)
This project aims to map bathymetry of a small sub-arctic lake using an autonomous surface vessel as well as historical mapping of neighboring glaciers using photogrammetry. Combining these methods connects the glacial landform record identified at the lake floor with the centennial-scale dynamic behavior of the glaciers.
Contact: nina.kirchner@natgeo.su.se

Glacier archeological studies in Northern Sweden
P. Holmlund (UStockholm), K. Lidén (UStockholm), M. Hansson (UStockholm)
This project combines glaciology with archeology in the Swedish mountains. It gains synergies on the knowledge of the Holocene climatic changes and human activity. Dating of archaeological artifacts melting out tells both what people did at a certain time and that the ice was no greater than it is today. Ice cores give us updates on when the climate has become colder and chronologies of climate proxy data. We focus on the mountain areas between Pite and Torne rivers. We will take ice cores from selected glaciers that will provide a semi-continuous chronology. The archaeological studies include a field inventory around the ice and snow fields where there is reason to believe that people have been active there. In pilot studies in 2017–19 we have selected more than 150 items waiting for dating (bones, wooden artefacts, etc.). We will also perform accurate measurement and photographic documentation of archaeological sites, and strengthen the ties between glaciology, climatology and archeology.
Contact: per.holmlund@natgeo.su.se

Re-photography of glaciers in Sweden and on Svalbard: a source to quantitative analyses and an extraordinary powerful way of visualizing climate change
P. Holmlund (UStockholm), T. Martinsson (UGothenburg), E.S. Holmlund (UCS)
In 2016–19 we mapped a large number of glaciers in Sweden and on Svalbard with a drone and by oblique photography from helicopter to create 3-D models using Structure from Motion – Multi View Stereo reconstructions. Structure from Motion has also been applied on old terrestrial and oblique aerial imagery, giving new uses for already existing data. With the scanned analog photographs, reconstructions as far back as the 1800s can be made, giving insight in the glaciers' thicknesses, shapes and appearances. The objectives of this project are: to improve and expand glacier monitoring by introducing new methods; to map and add new knowledge to our understanding of the dynamic response of glaciers; to make quantitative analyses of old photographs on glacier change; and to save old photos and make them available for everyone.
Contact: per.holmlund@natgeo.su.se

The impact of internal thermal regime of glaciers on climate caused advance and retreat
P. Holmlund (UStockholm), E.S. Holmlund (UCS), B. Reinardy (UStockholm), B. Chandler (UStockholm)
This project began in 2012 and will be full-scale from 2020. Radar recordings and aerial photographs are the main data sources in combination with field controls and dating. In the new development of the project four Swedish glaciers have been chosen, a number that it is planned to extend to more than 10. The aim of the study is to describe the current properties of the studied glaciers. Using this knowledge and the landform assemblages in their glacier fore fields, we suggest explanations to how they might have responded to climate change in the past and possible causes for differences in response.
Contact: per.holmlund@natgeo.su.se

A multi-method, geophysical and glacial geological approach to exploring moraines (MULTIPLEX)
B. Chandler (UStockholm), B. Reinardy (UStockholm), P. Holmlund (UStockholm), E.S. Holmlund (UCS), P. Jansson (UStockholm), H. Lovell (UPortsmouth)
This project aims to integrate near-surface geophysical methods (e.g. ground penetrating radar, electrical resistivity) with traditional glacial geological methods, as well as remote sensing, in a holistic approach to examining moraines. We

will apply this multi-method approach to moraine complexes in Sarek, northern Sweden. The large moraine complexes that typify this region are ideal test cases for examining the capabilities of the geophysical surveying methods as the moraines are thought to comprise complex sedimentary sequences and multiple substrates (e.g. sediment, water-saturated sediments, ice and debris-rich ice). Using our multi-disciplinary approach, we aim to provide new insights into the formation and significance of the moraines in Sarek.
Contact: benjamin.chandler@natgeo.su.se

The drainage of the Baltic Ice Lake
M. Johnson (UGothenburg), G. Björk (UGothenburg), J. Elam (UGothenburg), C. Öhrling (SGU), A. Ojala (GTK)
The drainage of the Baltic Ice Lake was a catastrophic event that occurred almost exactly at the Pleistocene–Holocene boundary. Although this event has been known about and studied for 100 years, its duration has been debated (from 1 year to several decades). Through modeling of the break-up of the ice dam (which initiated the drainage) as well as careful analysis of shorelines (clearly seen on lidar) and modeling based on the boulder deposits, we hope to determine the flood duration. This is important because this indicates the volume of fresh water injected into the North Atlantic at this time.
Contact: mark@gvc.gu.se

Glacial geology in the Jämtland region, west-central Sweden
G. Peterson (SGU), C.A. Smith (SGU), C. Öhrling (SGU), B. Goodfellow (SGU), H. Mikko (SGU)
Jämtland, west-central Sweden, is a large area characterized by a complex glacial history. For a better understanding of the regional glacial geology we will focus on at least three concepts; pre late-Weichselian sediments, the dynamic late-glacial ice-retreat, and ice-dammed glacial lakes. Using lidar DEMs we will map glacial landforms and deposits with the overall aim to deliver relevant geological information for society.
Contact: Gustaf.Peterson@sgu.se

Meltwater corridors (or hummock corridors)
G. Peterson (SGU), M. Johnson (UGothenburg), M., C.A. Smith (SGU)
Subglacial meltwater corridors are landforms produced by the drainage of meltwater. They are an important part of the subglacial drainage system, as are eskers. However, they are considerably larger than eskers and represent a potentially more effective part of the drainage system. We investigate the products of these features by stratigraphic and morphometric studies as well as regional mapping to better understand the formation of these landforms.
Contact: Gustaf.Peterson@sgu.se

Murtoo distribution and formation
G. Peterson (SGU), M. Johnson (UGothenburg), C. Öhrling (SGU), J. Mäkinen (UTurku), E. Ahokangas (GTK), K. Kajuutti (UTurku), A. Ojala (GTK), J.-P. Palmu (GTK)
Murtoos are unique subglacial landforms that we propose fill the gap between a distributed and channelized organization of the subglaciofluvial system. We study murtoos and associated glacial landforms on the scale of the Scandinavian ice-sheet through mapping as well as through sedimentological work in individual landforms.
Contact: Gustaf.Peterson@sgu.se

The Baltic and Bothnian basins: templates for marine ice sheet retreat
S. Greenwood (UStockholm), R. Avery (UStockholm), B. Morén (UStockholm), M. O'Regan (UStockholm), B. Wohlfarth (UStockholm), R. Gyllencreutz (UStockholm)
The Baltic Sea basins drained approximately a quarter of the area of the last Fennoscandian Ice Sheet at its maximum, and yet the style, stability and drivers of ice flow and retreat through this marine sector are almost entirely unknown. Direct geological or geophysical data with which to inform these basins' glacial history have, until recently, been lacking, while numerical ice sheet models perform poorly in this sector. This project aims to reconstruct the style and stability of palaeo-ice flow and retreat through the Bothnian–Baltic corridor, and examine the processes responsible for these dynamics. Collation and new collection of marine geophysical data enable us to document, for the first time, the distribution, characteristics and relative age of glacial landform assemblages in this marine sector, and integrate these within the wider, better-known terrestrial framework for Fennoscandian ice sheet behaviour. Systematic offshore coring of varved deglacial sequences permits connection and extension, both temporally and spatially, of the Swedish Varve Chronology in order to provide constraint on rates and timing of deglaciation. We explore evidence for melt- and/or calving-driven retreat, for feedbacks between flow and retreat events and styles, and for coupling between ice sheet behaviour and bed properties, in this way using the Baltic corridor as a template for the deglacial behaviour of shallow-marine glacial catchments.
Contact: sarah.greenwood@geo.su.se

READY (Retreat Dynamics of marine-based ice sheets)
S. Greenwood (UStockholm), L. Simkins (UVirginia), M. Winsborrow (UiT), L. Bjarnadóttir (NGU)
Ice sheets terminating in marine environments and/or grounded below sea level are highly dynamic and sensitive portions of the cryosphere,

and especially vulnerable to change. However, they are also one of the largest uncertainties in understanding the fate of ice sheets under predicted atmospheric and oceanic warming. Conditions at the ice–bed interface are widely considered one of the most important controls on ice flow and retreat behaviour, yet there have been few comprehensive attempts to systematically assess the degree to which bed conditions govern ice system behaviour across entire, largely marine-based catchments. In this project we collate high-resolution bathymetric data from 100 palaeo-glacial, marine-based catchments around the world's continental margins, from which we interpret the landform record of palaeo-ice flow and retreat dynamics. From this global dataset, we evaluate commonly-held relationships between a catchment's topographic and substrate properties and the style and stability of ice flow and grounding line retreat.

Contact: sarah.greenwood@geo.su.se

ABBREVIATIONS

ÅF Sw	ÅF Sweden
GTK	Geological Survey of Finland, Espoo, Finland
KTH	KTH Royal Institute of Technology, Stockholm
NGU	Geological Survey of Norway, Trondheim, Norway
SGU	Geological Survey of Sweden, Uppsala
SMHI	Swedish Meteorological and Hydrological Institute
SSR	Svenska Sámiid Riikkasearvi
UAF	University of Alaska Fairbanks
UCS	University Centre in Svalbard
UGothenburg	University of Gothenburg
UiT	The Arctic University of Norway, Tromsø, Norway
UPortsmouth	University of Portsmouth, Portsmouth, UK
UStockholm	Stockholm University
UUppsala	Uppsala University
UUtrecht	Utrecht University
UVirginia	University of Virginia, Charlottesville, VA, USA
VRF	Vattenregleringsföretagen AB

International Glaciological Society

JOURNAL OF GLACIOLOGY

Papers accepted for publication between 1 October and 31 December 2019. The papers are listed in alphabetical order by first author. Some of these papers have already been published.

David Ashmore, Douglas Mair, David Burgess
Meltwater percolation, impermeable layer formation and runoff buffering on Devon Ice Cap, Canada

Sebastián Echeverría, Mark Hausner, Nicolás Bambach, Sebastián Vicuña, Francisco Suarez
Modeling present and future ice covers in two Antarctic lakes

Daniele Giordan, Niccolò Dematteis, Paolo Allasia, Elena Motta
Classification and kinematics of the Planpincieux glacier break-offs using photographic time-lapse analysis

Lena Hansen, Jan Piotrowski, Douglas Benn, Heidi Sevestre
A cross-validated three-dimensional model of an englacial and subglacial drainage system in a High-Arctic glacier

Michael Imhof, Denis Cohen, Julien Seguinot, Andy Aschwanden, Martin Funk, Guillaume Jouvet
Modelling a paleo valley glacier network using a hybrid model: an assessment with a Stokes ice flow model

Christine Kassab, Kathy Licht, Rickard Pettersson, Katrin Lindback, Joseph Graly, Michael Kaplan
Formation and evolution of an extensive blue ice moraine in Central Transantarctic Mountains, Antarctica

Yuta Katsuyama, Masaru Inatsu, Tatsuo Shirakawa
Response of snowpack to +2°C global warming in Hokkaido, Japan

Astrid Lambrecht, Christoph Mayer, Pascal Bohleber, Vladimir Aizen
High altitude accumulation and preserved climate information in the western Pamir, observations from the Fedchenko Glacier accumulation basin

Ian Lee, Robert Hawley, Steven Bernsen, Seth Campbell, David Clemens-Sewall, Christopher Gerbi, Kate Hruby
A novel tilt sensor for studying ice deformation: application to streaming ice on Jarvis Glacier, Alaska

Xiaofei Li, Shichang Kang, Michael Sprenger, Yulan Zhang, Xiaobo He, Guoshuai Zhang, Lekhendra Tripathee, Chaoliu Li, Junji Cao
Black carbon and mineral dust on two glaciers on the central Tibetan Plateau: sources and implications

Carlo Licciulli, Pascal Bohleber, Josef Lier, Olivier Gagliardini, Martin Hoelzle, Olaf Eisen
A full Stokes ice-flow model to assist the interpretation of millennial-scale ice cores at the high-Alpine drilling site Colle Gnifetti, Swiss/Italian Alps

Douglas MacAyeal, Ian Willis, Alison Banwell, Grant Macdonald, Becky Goodsell
Diurnal lake-level cycles on ice shelves driven by meltwater input and ocean tidal tilt

Soroush Rezvanbehbahani, Leigh Stearns, Cornelis Van der Veen, Gordon Oswald, Ralf Greve
Constraining the geothermal heat flux in Greenland at regions of radar-detected basal water

David Rounce, Tushar Khurana, Margaret Short, Regine Hock, David Shean, Douglas Brinkerhoff
Quantifying parameter uncertainty in a large-scale glacier evolution model using Bayesian inference: application to High Mountain Asia

Daiki Sakakibara, Shin Sugiyama
Seasonal ice speed variations in 10 marine-terminating outlet glaciers along the coast of Prudhoe Land, northwestern Greenland

Thomas Schaap, Michael Roach, Leo Peters, Sue Cook, Bernd Kulessa, Christian Schoof
Englacial drainage structures in an East Antarctic outlet glacier

Louise Schmidt, Guðfinna Aðalgeirsdóttir, Finnur Pálsson, Peter Langen, Sverrir Guðmundsson, Helgi Björnsson
Dynamic simulations of Vatnajökull ice cap from 1980–2300

Thorsten Seehaus, Philipp Malz, Christian Sommer, Alvaro Soruco, Antoine Rabatel, Matthias Braun
Mass balance and area changes of glaciers in the Cordillera Real and Tres Cruces, Bolivia, between 2000 and 2016

Reza Zeinali Torbati, Ian Turnbull, Rocky Taylor, Derek Mueller
Evaluation of the relative contribution of meteorological and oceanic forces to the drift of ice islands offshore Newfoundland

Eef van Dongen, Guillaume Jouvet, Andrea Walter, Joe Todd, Thomas Zwinger, Izumi Asaji, Shin Sugiyama, Fabian Walter, Martin Funk
Tides modulate crevasse opening prior to a major calving event at Bowdoin Glacier, Northwest Greenland

Martin Wearing, Jonathan Kingslake, M. Grae Worster
Can unconfined ice shelves provide buttressing via hoop stresses?

Mauro Werder, Matthias Huss, Frank Paul, Amaury Dehecq, Daniel Farinotti
A Bayesian ice thickness estimation model for large-scale applications

Peng Yan, Zhiwei Li, Fei Li, Yuande Yang, Weifeng Hao
Antarctic ice sheet structures retrieved from P-wave coda autocorrelation method and comparisons with two other single-station passive seismic methods

ANNALS OF GLACIOLOGY 60(80)

The following papers have been selected for publication in Annals of Glaciology *60(80) (thematic issue on Glacial Erosion and Sedimentation), edited by Neal Iverson and Lucas Zoet*

Richard Alley, Kurt Cuffey, Lucas Zoet
Glacial erosion: status and outlook

Jeff Crompton, Gwenn Flowers, Brendan Dyck
Characterization of glacial silt and clay using automated mineralogy

Dougal Hansen, Lucas Zoet
Experimental constraints on subglacial rock friction

Neal Iverson, Christian Helanow, Lucas Zoet
Debris–bed friction during glacier sliding with ice–bed separation

Antti Ojala, Gustaf Peterson, Joni Mäkinen, Mark Johnson, Kari Kajuutti, Jukka-Pekka Palmu, Elina Ahokangas, Christian Öhrling
Ice sheet scale distribution and morphometry of triangular-shaped hummocks (murtoos): a subglacial landform produced during rapid retreat of the Scandinavian Ice Sheet

Kiya Riverman, Sridhar Anandakrishnan, Richard Alley, Nick Holschuh, Christine Dow, Atsuhiro Muto, Byron Parizek, Knut Christianson, Leo Peters
Wet subglacial bedforms of the NE Greenland Ice Stream shear margins

Dustin Schroeder, Emma MacKie, Timothy Creyts, John Anderson, Dustin Schroeder, Emma MacKie, Timothy Creyts, John Anderson
A subglacial hydrologic drainage hypothesis for silt sorting and deposition during retreat in Pine Island Bay

Cari Rand, Brent Goehring
The distribution and magnitude of subglacial erosion on millennial timescales at Engabreen, Norway

Neil Ross, Peter Brabham, Charles Harris
The glacial origins of relict 'pingos', Wales, UK

Haley Williams, Michele Koppes
A comparison of glacial and paraglacial erosion responses to rapid glacial retreat

Jacob Woodard, Lucas Zoet, Neal Iverson, Christian Helanow
Linking bedrock discontinuities to glacial quarrying

Annals 60(80) is now complete

ANNALS OF GLACIOLOGY 61(81)

The following papers have been selected for publication in Annals of Glaciology *61(81) (thematic issue on Five Decades of Radioglaciology), edited by Dustin Schroeder*

Emily Arnold, Carl Leuschen, Fernando Rodriguez-Morales, Jilu Li, John Paden, Richard Hale, Shawn Keshmiri
CReSIS airborne radars and platforms for ice and snow sounding

Cooper Elsworth, Dustin Schroeder, Matthew Siegfried
Interpreting englacial layer deformation in the presence of complex ice flow history with synthetic radargrams

Hafeez Jeofry, Neil Ross, Martin Siegert
Comparing numerical ice-sheet model output with radio-echo sounding measurements in the Weddell Sea sector of West Antarctica

Laurent Mingo, Gwenn Flowers, Anna Crawford, Derek Mueller, David Bigelow
A stationary impulse-radar system for autonomous deployment in cold and temperate environments

More papers for *Annals* 61(81) are expected

ANNALS OF GLACIOLOGY 61(82)

The following papers have been selected for publication in Annals of Glaciology *61(82) (thematic issue on Sea Ice at the Interface), edited by David Barber and Feiyue Wang*

Malin Johansson, Eirik Malnes, Sebastian Gerland, Anca Cristea, Anthony Doulgeris, Dmitry Divine, Olga Pavlova, Tom Rune Lauknes
Consistent ice and open water classification combining historical synthetic aperture radar satellite images from ERS-1/2, Envisat ASAR, RADARSAT-2, and Sentinel-1A/B

Changwei Liu, Zhiqiu Gao, Qinghua Yang, Bo Han, Hong Wang, Guanghua Hao, Jiechen Zhao, Lejiang Yu, Linlin Wang, Yubin Li
Measurements of turbulence transfer in the near-surface layer over the Antarctic sea ice surface from April–November 2016

Madison Smith, Jim Thomson
Pancake sea ice kinematics and dynamics using shipboard stereo video

Liuxi Tian, Hongjie Xie, Stephen Ackley, Jiakui Tang, alberto Mestas, Xianwei Wang
Sea ice freeboard and thickness in the Ross Sea from airborne (IceBridge 2013) and satellite (ICESat 2003-2008) observations

More papers for *Annals* 61(82) are expected

Five Decades of Radioglaciology

IGS Symposium, Stanford, California, USA, 9–12 July 2019

Celebrating 50 years since radio-echo sounding was pioneered as a tool for effective and efficient measurement of polar ice sheets and glaciers by mounting equipment on aircraft, 101 practitioners from 16 countries gathered at Stanford University, hosted by Dusty Schroeder, to discuss the progress made and the work urgently needed in the next decade.

In the day prior to the meeting a series of spin-out 'town hall' meetings were held to gather community interest and advice on how deep-ice radar sounders can be mounted on satellites, the future compilation of bed topography in Antarctica – Bedmap3, and how ice-sheet internal layering can be systematically mapped and used for glaciological purposes – the SCAR-supported AntArchitecture programme. Dusty and his students also put on a course for students and early-career researchers on ice-penetrating radar.

Initial business completed, the conference began with an Icebreaker involving local wines and beers on the patio of the Earth Sciences building, where old friends became reacquainted and introductions were made to those newer to radioglaciology. A lovely, informal way to begin our week's work together.

The meeting began with a poignant appreciation of one of radioglaciology's initiators – Preben Gudmandsen, who had sadly died a few months previously. Preben pioneered and refined the use of radio-echo sounding, and his instrumental advances have been responsible for the charting of the bulk of subglacial Antarctica.

Anna Broome was one of the teachers for a short background course on ice-penetrating radar provided on the day before the conference began.

The first talk was given by Bob Jacobel – who is 'in the process of retirement'. In gratitude for all his achievements in radioglaciology, he was awarded a set of cufflinks adorned with original radar data from the famous SPRI survey of the 1970s (cuttings from the recent digitization programme). Bob brilliantly provided his assessment, generous in its reference to many others involved from across

All the participants got together for a commemmorative photograph.

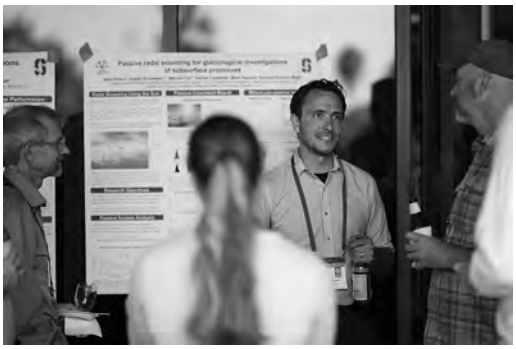
Speakers on the first day included (left to right) Nanna Karlsson, Helgi Björnsson and Joe MacGregor.

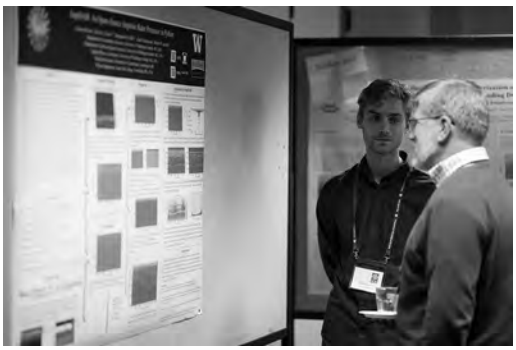
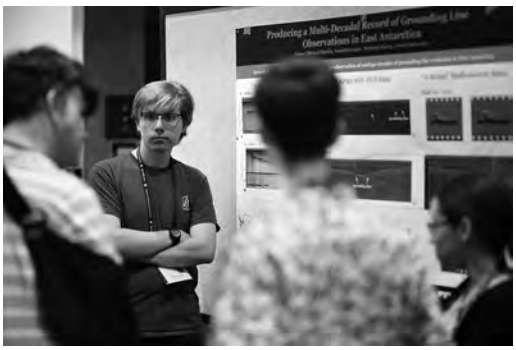
the world, of how radioglaciology began, how it has developed over 50 years and what it means today to glaciology and broader understanding of glacial processes and changes.

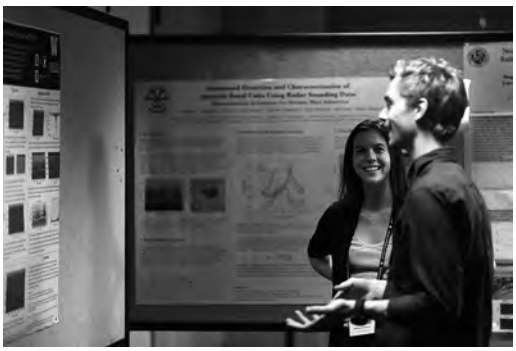
On Day 1, the first session was dedicated to the multi-decadal history of radioglaciology; with Nanna Karlsson talking about the 1970s data from Greenland (collected by Preben Gudmundsen) followed by Sergey Popov who looked at 55 years of the Russian glacier geophysics programme, Heinz Miller on 40 years of German radar activities and Helgi Björnsson on four decades of radio-echo sounding in Iceland – including a cool picture of a shaded Magnús Magnússon from the 1970s. Finally, Xiangbin Cui provided an insightful introduction to the highly successful Chinese geophysical programme, in collaboration with the US, UK and Australia, at Dome A and Princess Elizabeth Land in East Antarctica, proving that international cooperation is key to achieving outstanding scientific results; a sentiment echoed by Francisco Navarro's presentation of the glacier-thickness database (GlaThiDa), which is open to everyone to access and contribute.

The afternoon was dedicated to advances in data processing, with Joe MacGregor explaining through his keynote how radio-echo sounding was able to reveal a major impact crater in northwest Greenland. Data processing can appear a little dry, especially when being presented, but it is critical to advancing our subject, and John Paden offered a superb assessment of the problems and solutions to automatically identifying the glacier bed from radar data – an essential feature, and one often taken for granted by users of the data – paving the way for 'intelligent' data processing. This was followed by a series of talks on how to refine and improve the quality and fidelity of radar data. One striking talk was given by Kirk Scanlon on strategies for orbital radar sounders to be used in measuring the ice cover of Europa in around 8 years' time. Several students gave impressive presentations, including Richard Delf's appreciation of how to measure temperate glaciers, Shinan Lang's assessment of how to map internal layers in the snow/firn layer and Steven Bernsen's explanation of the use of numerical modelling to better plan radioglaciology field campaigns. Ed King gave an entertaining account of how glaciological settings conspire to obscure measurements, such as within steep-sided

The Secretary General was on hand as usual to man the desk. It looks as if this took quite a toll on him, but we are assured that the photographer just snapped him from the wrong side!






Some photos of the poster session.

subglacial valleys, with some advice on how to overcome the problems encountered. Day 1 ended with an extended poster session, again taking advantage of the Earth Science patio, some well-earned refreshments and the evening sunshine (in spite of the wind blowing the poster boards down beforehand, causing them to be moved inside at the last minute).

Day 2 began with a session on how radioglaciology informs us about glacier beds. Nick Holschuh gave an impressive keynote talk on how swath radar can be used to advance the mapping of subglacial topography; a challenge for glacier geophysicists for many years. Nick's talk revealed how the problem may be taken to a level where it can purposely be used in future to improve considerably the level of data acquisition from traditional radio-echo sounding, potentially avoiding data-free regions between closely aligned parallel transects. This was followed by three student presentations: Oliver Bartlett on using synthetic radar data to solve measurement bias; Wei Ji Leong on how neural networks can help resolve bed topography – with specific reference to improving the Bedmap2 map of Antarctica; and Alex Miltenberger on englacial conditions at Dome Fuji in East Antarctica.

Six talks were then given on subglacial lakes from a variety of glaciological settings: Devon Ice Cap (Anja Rutushauser); Greenland (Jade Bowling),

On the second day we heard from (left to right) Anja Rutishauser, Matt Siegfried and Winnie Chu.

Mercer and Whillans ice streams (Matt Siegfried); Iceland (Eyjólfur Magnússon); and South Pole (Ben Hills). Clearly, subglacial lakes are everywhere! Winnie Chu then gave her keynote on glacier attenuation investigations to back-out information on firn acquifers and englacial water, followed by talks from Ted Scambos on a similar theme but targeted on ice shelves, and Duncan Young, who showed how volcanics can influence englacial radio-wave absorption.

Day 2 ended with a welcome interlude in the form of a visit to the Computer History Museum – looking at the origins of computing, but more of a trip down memory lane for some of us!

Day 3 began with two sessions on how radioglaciology can detect internal structures in ice sheets, and how they can be used to determine ice accumulation rates (Brooke Medley's keynote), ice flow dynamics (Daniela Jansen) and complex ice flow changes (David Ashmore). The session also discussed how neural networks can be used to trace layering (Maryam Rahnemoonfar). An overview of a SCAR programme to draw together datasets and expertise in internal radar layer, AntArchitecture, was provided by Robert Bingham. Two talks by Kate Winter and Tyler Ming examined how englacial radar structures can be used to identify and trace sediments within the ice. They were followed by Jørgen Dall and Tom Jordan, who revealed how radioglaciology can detect ice-crystal fabrics and ice-sheet anisotropy. There is clearly a great deal of glaciological information contained within radio-echo sounding data, and while we have known

The excursion to the Computer Museum took us back to the Good Old Days. Here is Dusty Schroeder displaying a punched card and a computer printout.

The younger generation admiring the relics.

Dusty, Olaf Eisen and Marie Cavitte reminiscing.

The Secretary General was obliged to confess that he grew up with some of these gadgets.

about this for some years (decades!), and progress is being made, it still remains under-studied and under-used in our appreciation of ice-sheet processes.

In contrast to many of the papers presented on large polar ice sheets, Tyler Meng gave an excellent talk on how radar can be used to understand debris-covered and rock glaciers – revealing clear internal structures due to fractures and buried debris horizons. Finally, Melchior Grab presented a poignant paper on how future melting of Swiss glaciers over the coming decades will leave behind an informative fresh glacier bed that could be measured using helicopter-borne radar, and used to understand the bed in other glacial settings. The final talk of the morning was given by Duncan Young, who provided an assessment of how radar can be used to measure and track volcanic material within the ice over large distances (km), and how such material within the ice can lead to attenuation of the radio wave and, in some cases, misinterpretation of the bed.

After lunch, we settled in to a series of talks on how radioglaciology can be applied to understand planetary bodies. Cyril Grima gave a nice keynote on various missions over the last two decades to Mars, Titan, Europa, Ganymede, Venus and the Moon, all of which included the use of radar. The overarching goal of such work is to find life, and while radar cannot detect that it remains the instrument to establish the conditions in which life may best be found. On a similar theme, Ted Scambos talked about megadunes in Antarctica and their similarity to features found on Mars, Stefano Nerozzi examined radar evidence for ice at the northern pole of Mars and Wes Patterson discussed how radar can detect ice at the southern pole of the Moon.

Then we got on a bus and headed to San Francisco and a boat tour of the Bay. 'Be at Gate B of the Ferry Terminal at 6.15. Do. Not. Be. Late.' Message duly received and understood. We had the huge tourist cruiser (four floors) to ourselves as we braved the choppy water and headwinds towards, and under, the Golden Gate Bridge, watching the fog gently wrap around the structure in the setting sun. We were joined by seals, dolphins (apparently) and a string of pelicans. After the buffet dinner Magnús congratulated Dusty and his team of organizers and presented them with the iconic IGS Royal Worcester dishes, and announced the well-deserved winner of the student poster prize (well done, Maddie Goldberg).

The aptly named party boat *Cabernet Sauvignon Commodore*.




The ship cruised up San Francisco Bay and reached the Golden Gate as it began to be swathed in mist.

Considering our lateness back to Stanford, it was a little surprising, and pleasing, to see 18 hardy attendees line up for the 10 km 'fun' run up to the radiotelescope dish and back again. The good news is that we all got back in one piece, if slightly flushed. The less good news (for Dusty) was that he lost his bet with Don Blankenship that fewer than half of those signed up for the run (over 50) would actually show. Good for Don, but twenty bucks doesn't get you much in California….

Back to the conference, the morning of Day 4 was dedicated to interpretation of radio-echo sounding, with Gwendolyn Leysinger Vieli giving her keynote on how numerical modelling can help in the interpretation of englacial radar layering. Noting how full-Stokes models can resolve layer patterns far better than shallow-ice-approximation models over bed bumps <5× ice thickness; and how radar transect orientation is critical to resolving structures in an understandable manner (hint, avoid 45° to ice flow). Elisa Mantelli then explained how


At the banquet the Secretary General and the President thanked all the local helpers without whose efforts the Symposium would not have run so smoothly.

The award for best student poster went to Madison Goldberg ...

... while the award for best student oral presentation was won by Riley Culberg.

internal layering can be used to infer former regions of fast flow, and where bed friction is low, and Michelle Koutnik showed that layers can be used to constrain migration of ice divides.

Jamin Greenbaum started proceedings after coffee – and an obligatory enormous apple Danish – with a comprehensive assessment for how radar can provide a plethora of information on glaciological processes across grounding lines onto ice shelves. On a similar theme, Reinhard Drews discussed how ice-shelf channels are formed, and what controls their morphology and evolution. In particular, he demonstrated how some of these channels migrate laterally across ice shelves, cutting across flowlines. He explained that this was driven by accumulation mass balance, which is an under-appreciated parameter in their development and evolution.

The final session of this fabulous conference focused on radar systems. Emily Arnold's keynote provided an appreciation of the CReSIS airborne programme, including the potential for the use of drones – in questions there seems to be quite a lot of interest in autonomous drones, but at present this seems a little far away. Jack Holt discussed the merits of high-frequency radars for the measurement of temperate glaciers in Alaska and other locations, even when they are covered in debris, and Riley Culberg – who was very impressive on the fun run – provided an account of radar scattering in ice and its implications for orbital ice sounders. John Paden talked about CReSIS's new MELT radar, which will be used in the upcoming US–UK Thwaites Glacier programme, and was followed by Jilu Li, who discussed CReSIS's ka-band radar, which has smaller antenna size and can be used for surface snow measurements over ice sheets and sea ice.

The final talk of the symposium was by Andrew Romero-Wolf, who presented an innovative idea on how passive radar sounding can be accomplished with a radio-astronomy approach to detecting signals.

The meeting concluded with the award for the best student talk (congratulations to Riley Culberg on a superb paper), and our full appreciation and thanks to Dusty and his group for hosting such an excellent meeting. Let's not leave it too long before we gather ourselves together once more to discuss advances in radioglaciology.

Some of the hardy participants in the Friday morning fun run to the 'Stanford Dish' and back.

Martin Siegert

Sea Ice at the Interface

IGS Symposium, Winnipeg, Manitoba, Canada, 18–23 August 2019

In August 2019, sea ice enthusiasts from 18 countries across both hemispheres converged on Winnipeg in Canada's heartland for the 5th IGS International Sea Ice Symposium. The anticipation was high, the excitement palpable.

Traditionally held every 4–5 years (the last meeting took place in Hobart in March 2014), the IGS International Sea Ice Symposium is an absolute highlight of the Sea Ice calendar – and this wonderful meeting hosted by the Centre for Earth Observation Science (CESS, University of Manitoba) was no exception.

With a focus on 'Sea Ice at the Interface', the 5-day science programme (at the iconic Fort Garry Hotel from 18–23 August) provided a timely opportunity to address the many challenges involved in understanding, quantifying and modelling the complex sea-ice systems – and the drivers and effects of change and variability therein. The spiralling decline of Arctic sea ice and the seeming unpredictability of its southern counterpart are of major current concern, given the implications for weather and climate, ecosystems, shipping and socio-economic development, ice-sheet processes and Arctic native communities. The symposium showcased recent major findings and advances in the field, while also highlighting key gaps and challenges.

As Chair of the Science Steering Committee, Fei Wang did an extraordinary job in pulling together the abstracts and sessions into a wonderful programme of oral presentations and two poster sessions, ably aided and abetted by the committee and the session convenors and chairs. Thank you, Fei (and the committee)!

The meeting attracted a broad array of both Arctic and Antarctic sea ice 'types', comprising not only old hands and mid-career experts but also a large contingent of outstanding students and early-career scientists who greatly enriched the proceedings. Indeed, the organizers are to be congratulated for securing financial support for an unprecedented 83 graduate students and early-career researchers (48 Canadian and 35 International). It was also a privilege to spend time with, and hear the unique insights of, distinguished representatives of Arctic native communities in Manitoba (Churchill), Nunavut (Chesterfield Inlet, Sanikiluaq and Grise Fiord) and Greenland.

Following the aptly-named Icebreaker and welcome reception on Sunday evening, the meeting proper kicked off first thing on Monday morning. Proceedings were opened in style in the Grand Ballroom – resplendent with chandeliers and ornate panelling – by the equally resplendent tag team of Feiyue Wang, David Barber and Magnús Már Magnússon. In his opening address, Fei (splendid Chair of the Science Steering Committee) proudly announced that the symposium had set a new attendance record for an IGS sea ice symposium, with an imposing 360 registrants – including about 100 from the local (Manitoban) sea-ice community. This boded well for the coming days – and we were not disappointed.

The venerable David Barber (Chair of the meeting and himself a sea-ice scientist of considerable repute and pedigree) then gave a highly informative introduction to the conference venue, Winnipeg and its geographical setting (including Hudson Bay), his thriving Centre for Earth Observation Science (CEOS) and the important research carried out there, and the impressive Canadian sea-ice research programme and its goals and focus. Following this opening address, the equally venerable Magnús (IGS Secretary General) talked about the strong tradition behind this important symposium, the role of IGS and the importance of proactive member participation, and wished the attendees and organizers well for the coming days.

Fiamma Straneo (Scripps Institution of Oceanography) then took centre stage, as the first of an excellent series of keynote speakers (both established and early-career) who took us on a journey across a wide range of key research topics,

The distinguished Chair David Barber imparting his considerable wisdom while running a very tight ship (with Lucette Barber).

Not only did Lucette Barber do an outstanding job in the overall organization of this major international event, as Chair of the Local Organizing Committee. She also provided excellent daily housekeeping information that helped keep the meeting well and truly on track, and the attendees informed as to the finer practicalities. Thank you, Lucette!

issues and regions. Fiamma presented a highly illuminating review of her work investigating meltwater from the Greenland Ice Sheet and its effects on the Arctic marine environment, and provided a fascinating personal perspective of the challenges and rewards of glaciological research. This excellent talk also set the tone for the strong trans-disciplinary nature of the symposium, i.e. viewing sea ice as a key component of a larger coupled system rather than as a standalone entity.

The room was by this stage buzzing with anticipation and excitement – full of folks raring to present their exciting new research and findings, learn new things, catch up with old friends and colleagues, make new friends and elicit important new collaborations. Importantly, the meeting brought together sea-ice physicists, ecologists and biogeochemists, observationalists, theoreticians and modellers, remote sensors, glaciologists, oceanographers, meteorologists, polar shipping buffs, and distinguished representatives of native communities – all with a passion and deep concern for the sea-ice environment. This heady mix provided a wonderful opportunity for cross-disciplinary consultation and collaboration and stimulated very interesting holistic discussion. In short – 'sea ice heaven'!

Such was the number of oral presentations (175) that there were three parallel sessions (compared to two at previous symposia). In addition, two poster sessions spanned the Monday and Tuesday late afternoons, comprising 180 posters (of which 55 were student posters). Those participating were particularly appreciative of being able to leave their posters up for the duration of the symposium (please could other symposia do this!).

The sheer breadth and diversity of the material presented and discussed was quite remarkable, and mirrors how much the sea-ice research field has advanced over the past few decades. We learned about advances in sea-ice modelling and remote sensing; sea ice–atmosphere–ocean interactions and climate connections; atmospheric and oceanic drivers of sea-ice change and variability; the key role of snow; sea-ice dynamics; novel technologies; sea-ice biogeochemical processes; traditional knowledge and indigenous community engagement in sea-ice research; sea-ice habitats and ecological processes; the Hudson Bay marine environment; oil spills in sea ice; sea-ice optical properties; sea-ice impacts on shipping and operations; outreach activities; and the coupling of sea ice with glaciers, ice sheets and icebergs. I for one learned a great deal.

Sea-ice mathematician Danny Feltham sharing his considerable insights and expertise on a subject close to his heart – issues relating to resolution and realism in high-fidelity sea-ice simulation.

Andrew Roberts, as a session chair, emphasizing the importance of addressing current challenges in high-resolution sea-ice modelling.

Excellent questions from the floor, including from Nadja Steiner, kept presenters on their toes and stimulated interesting discussion.

To kick off Monday afternoon proceedings, plenary speaker Nathan Kurtz from NASA Goddard Space Flight Center showed exciting new results highlighting the extraordinary capabilities of ICESat-2. How incredible that sea-ice freeboard can now be measured to centimetre accuracy from space! In another wonderful keynote, on Tuesday, Julienne Stroeve (University of Manitoba) showed how satellite data and models can be combined to map under-ice light availability across the Arctic, and highlighted the importance of snow to the sea-ice system (music to my ears!). Wednesday began with an excellent authoritative talk by Delphine Lannuzel (University of Tasmania) on sea-ice biogeochemical processes and the role of sea ice as an ocean fertilizer. Thursday's charismatic keynote speaker Alex Fraser (also from the University of Tasmania) took us on a bewitching journey into the world of Antarctic coastal fast ice that was of major cross-disciplinary interest.

Alex Fraser ably answering questions from the floor (with strong moral support from David, Lucette and Magnús), following his outstanding plenary presentation on Antarctic fast ice.

Nathan Kurtz (NASA) beguiling a highly attentive audience with his presentation of extraordinary new data and results from the game-changing ICESat-2 satellite.

Sea-ice thickness guru Christian Haas asking characteristically challenging questions from the floor, watched over by some of his many fans.

The ever-green Steve Ackley continuing to push back the frontiers, during his excellent overview of the US-led PIPERS Ross Sea experiment.

The final keynote speaker, Dorthe Dahl-Jensen (University of Manitoba), provided a sobering exposé of the role of ice streams in the discharge of fresh water from the Greenland Ice Sheet in a warming climate.

A unique feature of this 2019 sea ice symposium was the inclusion of two fascinating lunchtime plenary panel discussions addressing important socio-economic, political and cultural issues related to sea-ice research in Canada and change in the sea-ice environment. Specifically, the two mini-colloquia focussed on: 1) Panel #1: *Arctic Economic Development: Are we prepared for both the challenges and opportunities?*; and 2) Panel #2: *The Pikialasorsuaq Partnership in the North Water Polynya: A proposed international Inuit management area*.

Distinguished participants on Panel 2 were: Professor David Barber (University of Manitoba); Debbie Ming (Fisheries and Oceans Canada); Dr Dorthe Dahl-Jensen (Panel Moderator, University of Manitoba); Larry Audlaluk (Hamlet of Grise Fiord, Nunavut); and Bjarne Lyberth (Kalaallit Nunaanni Aalisartut Piniartullu Kattuffiat, Greenland).

Distinguished participants on Panel 1 were: Mayor Simmione Sammurtok (Hamlet of Chesterfield Inlet, Nunavut); Mayor Michael Spence (Town of Churchill, Manitoba); Minister Jim Carr (Panel Moderator and Minister of International Trade and Diversification, Government of Canada); Dr Heather Exner-Pirot (research associate, consultant and policy advisor related to economic development in the Arctic); and Mr Murad Al-Katib (CEO of the Arctic Gateway Group, a public-private partnership formed to acquire and operate Canada's deepwater port, Port of Churchill, and the Hudson Bay Railway).

The symposium also played host side to a range of important side meetings prior to and during the meeting. These included the Biogeochemical Exchange Processes at Sea-Ice Interfaces (BEPSII) project; Sea Ice Model Intercomparison Project (SIMIP) for CMIP6 – CliC; Antarctic Sea ice Processes and Climate (ASPeCt); BaySys Working Groups; and Pikialasorsuaq Partnership – Community-Based Monitoring Meeting.

It was both eye-opening and humbling to hear first-hand about the unprecedented impact of sea-ice change on Arctic native communities, eloquently discussed by the panel members including Larry Audlaluk and Bjarne Lyberth.

Pat Langhorne, Marilyn Raphael, Klaus Meiners, CJ Mundy and Pat Wongpan comparing bear-evasion plans just before tackling the wilds of Sandilands Provincial Forest in search of the elusive pileated woodpecker (a major mission for Klaus).

Sebastian Gerland contemplating how to enter a Mennonite cottage without hitting his head.

Our gracious Mennonite tour guide explaining the difficulties faced by early settlers, and the importance of the sod house to the their survival and culture.

In time-honoured IGS fashion, mid-conference saw the thronging masses let loose on the unsuspecting Manitoba public and wilderness, in the form of mid-week excursions to Sandilands Provincial Forest and the Mennonite Heritage Village, Assiniboine Park Zoo and the Canadian Museum for Human Rights, and a walking tour of Winnipeg. Not only interesting, these trips further stimulated informal interaction and discussion among participants. Again, a huge thank you to all of those involved in organizing and leading these trips.

During the Thursday banquet, participants were treated to a historical presentation by Dr Harry Duckworth entitled 'Fur Traders as Explorers', which outlined how the fur traders contributed significantly to the exploration of western Canada and the Arctic. The evening was then capped off in fine style by the marvellous Asham Stompers dance troupe, who help to

High-energy traditional dancing from the wonderful Asham Stompers.

The long and the short of Belgian sea-ice research – the inimitable Martin Vancoppenolle and incomparable Jean-Louis Tison.

The Local Organizing Committee did an absolutely stellar job and are all deserving of recognition: Lucette Barber (Chair), Debbie Armstrong, David Babb, David Barber, Lauren Candlish, Linda Chow, Laura Dalman, Madison Harasyn, Jennifer Hollar, John Iacozza, Ashley Soloway, Heather Stark, Denise Whynot (also in the picture Julienne Stroeve, Fei Wang and Magnús Magnússon). A sincere thank you to one and all of them – from one and all who were fortunate to attend.

preserve the history of the Métis people of Manitoba through traditional dance. Not a still foot in the house – it was brilliant. Magnús then thanked our wonderful hosts, who rightfully took to the stage.

The final day of the symposium included the presentation of Outstanding Student Oral Presentation awards. These included: 1st Steven Fons (University of Maryland, USA); 2nd Madison Smith (University of Washington, USA); and 3rd Lisa Matthes (University of Manitoba, Canada). The following received honourable mentions: Clara Burgard (Max Planck Institute for Meteorology); Patricia DeRepentigny (University of Colorado Boulder); Hannah Director (University of Washington); Steven Duerksen (Fisheries and Oceans, Canada); Adam Garbo (Carlton University); Loïc Jacquemot (Université Laval); Mallik Mahmud (University of Calgary); and Marta Wenta (University of Gdansk, Poland).

In summary, this was without doubt a wonderfully organized and run symposium, and congratulations and immense thanks are due and extended to David, Lucette, Fei and the whole team involved. We were treated to real Canadian warmth and hospitality, and a highly stimulating sea-ice meeting that will long stay in the memory.

The final task was to hand over the baton to the irrepressible Christian Haas and the Alfred

Magnús demonstrating potential uses of the much-prized (and limited edition) Royal Worcester IGS dish – just prior to handing it over to some lucky recipient as a token of appreciation.

Pat Langhorne trying to escape without being photographed during the symposium banquet – and failing.

How many important sea-ice collaborations and discoveries owe their genesis to IGS Sea Ice Symposium tea/coffee breaks?

Wegener Institute for organizing the next sea ice symposium in May/June 2022 in Bremerhaven/ Bremen (Germany). We very much look forward to that event – and to seeing Christian performing traditional German dancing in *lederhosen*.

More detailed information about the symposium, including committees, science programme, social programme and post-symposium excursion to Churchill, can be found at: igswpg.com

Best wishes to all from Tasmania, and take care
Rob Massom (Australian Antarctic Division)

Winner of the Technical Sciences student poster award Johannes Lohse (for his work on correcting incidence angle effects for improved mapping of sea-ice types from Sentinel-1 SAR data) – flanked by (left to right) Fei Wang, David Barber and Laura Dalman (thank you Laura for doing such a wonderful job in organizing and running the poster competition). Congratulations to Johannes and all the other student poster winners: Natural Sciences – 1st Boris Wittek (ULB, Belgium); 2nd Luc Barast (IFREMER, France); and 3rd Yanique Campbell (University of Manitoba); and Technical Sciences – 2nd Bimuchan Niraula (AWI, Germany); and 3rd Satwant Kaur (University of Manitoba).

Post-symposium trip to Churchill

It was four o'clock in the morning on 24 August when 12 delegates from the Sea Ice at the Interface symposium met in the lobby of the Fort Garry Hotel. We were greeted by our guide for the next few days, Mike Gere, http://mikegerephoto.ca/. Mike is a professional nature photographer operating out of Jasper, Alberta.

Sleepily we all clambered onto the bus that was taking us to Winnipeg airport for our flight to Churchill, the polar bear capital of the world. Once in the departure lounge, we learned the flight was delayed because of bad visibility at our destination airfield but after a couple of hours we were herded onto the plane which promptly took off. It was still not certain we would landing in Churchill as scheduled because if it was still fogged in the plane would carry on to Nunavut and if we were lucky, we would be dropped off on the return leg that evening.

Fortunately, the clouds lifted and we landed in Churchill two hours after taking off from Winnipeg. We were met by representatives from our tour company, 'Frontiers North Adventures'.

While waiting for our luggage and looking around the airport, it became obvious we were in Polar Bear Country.

With the luggage all loaded up we headed for the town via the scenic route going past local and historical points of interest such as Cape Merry, Manitoba Conservation's Polar Bear holding facility and the Inuksuk at the town beach and

Churchill is liberally provided with striking and decorative murals.

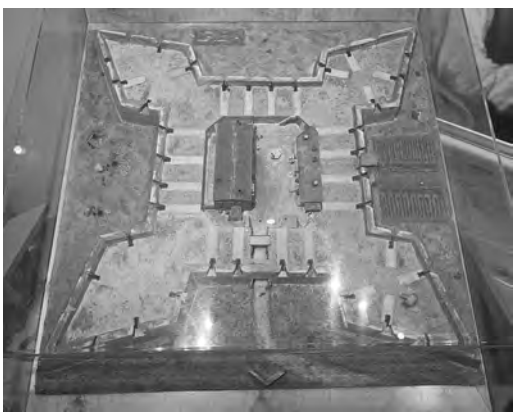
thus having our first glimpse of the town and getting our bearings. We then headed for our hotel and lunch.

After lunch, we boarded a Transport-Canada-approved vessel to view the beluga whales that migrate into the mouth of the Churchill River. Then, across the river, we went ashore to make the short walk to the Prince of Wales Fort National Historic Site, the oldest and most northerly fort in the country.

On our way we stopped by the ranger station where we were given a historic overview of the area. The short version is that a French flotilla came up to the Fort and the commandant went ashore and walked up to see his English counterpart. They had tea together where the French commandant informed the English one that his intentions were to occupy the Fort. The English response was 'I surrender. Would you like some more tea?' The Fort was destroyed, and it is only recently that it is being restored.

Feiyue Wang, one of the Annals Chief Editors and member of the Local Organizing Committee, taking it easy at the beach

Inuksuk at the town beach. An inuksuk is a figure made of piled stones or boulders constructed throughout the Arctic as a form of communication.



Model of the Prince of Wales Fort.

View from Prince of Wales Fort through one of the cannon ports.

Whilst at the Fort we became aware of something that would be accompanying us wherever we alighted from our mode of transport, namely a member of the 'Polar Bear Patrol' armed with a rifle and flares. And for good reason: while at the fort we caught sight of our first polar bear and her cub.

We then headed back across the river and made for our hotel where we were treated to a reception by the mayor of Churchill and other dignitaries. There were speeches going both ways and plenty of refreshments.

The following morning, after breakfast, we visited the site for the Churchill Marine Observatory (CMO). A globally unique, highly innovative, multidisciplinary research facility, the CMO is set to be a state-of-the-art facility located adjacent to Canada's only Arctic deep-water port. It was under construction when we were there, but it was obviously a very ambitious project and will no doubt feature prominently in future Arctic research.

After lunch we returned to the Churchill River and estuary, this time aboard a zodiac. This was

It was wonderful to view beluga whales at such close quarters. Click on the image to see a video, or if you are reading the paper copy of ICE, the link is https://www.igsoc.org/hyperlink/belugas.mov.

The Churchill Marine Observatory is under construction.

The group looking over the site.

Dorthe Dahl-Jensen and the Secretary General outside the Observatory..

We did manage to see one polar bear and her cub

The Secretary General made a new friend

definitely one of the highlights of an incredible trip – it was wonderful to see the largest beluga whale population in the world at surface level, so close you could almost reach out and touch them, although we were told in no uncertain terms NOT to do that. We were equipped with an underwater microphone so we could listen to the belugas communicating.

While on the river we caught a sight of a polar bear and her cub, presumably the same one we saw the day before but this time we were considerably closer and were able to get a reasonable picture.

Following dinner, we went on an interpretive dog-carting excursion hosted by a local resident and dog-sledding expert. We met the team of

One of the sled dogs who took us for a ride through the forest. Click on the image to see a video, or if you are reading the paper copy of ICE, the link is https://www.igsoc.org/hyperlink/dogsled.mov.

The only STOP sign in Churchill. To pass a driving test in Canada, pupils must demonstrate that they know to stop at a STOP sign. Since there was no such sign in the area the Town Council erected one so the local youth could take their driving test locally rather than having to travel to a bigger town.

friendly dogs, heard stories and enjoyed a mile-long ride on a custom-made dogcart through the northern boreal forest.

After breakfast the following morning, we took a step back in time at the Parks Canada Visitors Centre while viewing detailed wildlife dioramas and learning the remarkable history of the fur-trade. We also learned about the 1955 relocation of the local First Nations people, the Sayisi Dene, and the hardship they had to endure as a result.

The Churchill railway station, which doubles as the Parks Canada Visitors Centre

A Park ranger who is a Sayisi Dene told us about the fur trade in Churchill and also about the disastrous relocation of the Sayisi Dene.

Mint and chives in an experimental growing cabinet.

We then enjoyed lunch at a local restaurant before driving out to the Churchill Northern Studies Centre (CNSC) to tour the research facilities and enjoy educational programming. Dr LeeAnn Fishbank gave us a overview of the research undertaken at the CNSC, which includes auroral research, climate change, climatology, greenhouse gas emissions, inland water quality, marine ecosystems, community sustainability, tourism resilience, northern ecology, peatland and treeline dynamics, lake ice formation and wildlife management. We were given a tour of the facilities and ended up in the herb garden, where they grow chives, mint and Thai basil, among others. As we were there at the end of August the growing season was pretty much over. The Centre usually hosts a big feast for the townspeople where they can feast on the summer's crop.

We then went on a walking tour outside. The area was the launch site for upper-air research rockets. That has long since ceased, but there are a lot of remnants from that era. And of course we were shadowed by the 'Polar Bear Watch Brigade'.

Barbecue in the back of a tundra buggy.

Polar bear in disguise!

The 'Polar Bear Patrol' representative, with a rocket launch tower in the background.

Dorthe Dahl-Jensen and Norman Hansen partaking of a small refreshment.

Our tundra buggy.

We finished the day with a barbecue on board a tundra buggy before meandering back to town at dusk.

We spent our final day in Churchill on board a tundra buggy once more, hoping to catch a glimpse of some polar bears, but to no avail. The only wildlife we saw was a caribou crossing a shallow lake and some skuas. We did, however, get to see a polar bear in human disguise.

At the end of the buggy tour we proceeded to the airport to return to Winnipeg and thence home.

Magnús Már Magnússon

Inside our very spacious tundra buggy

News

Obituary: Gunnar Østrem, 1922–2020

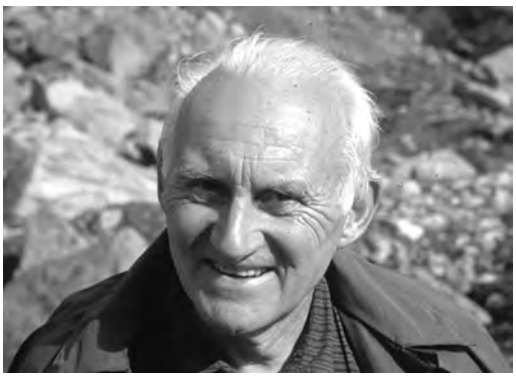
Gunnar Muldrup Østrem was born in Oslo on 25 March 1922. He died on 12 January 2020, close to 98 years old. He had been a member of the IGS since 1955 and was made an honorary member in 2001.

Gunnar was always fond of the outdoor life, understanding nature and technology. His studies at the University of Oslo were partly disrupted by the Second World War; he studied chemistry, physics and physical geography for his bachelor degree. His particular interests were geological and geophysical processes related to glaciology. He took his master's degree (Cand. real) at the University of Oslo in 1954.

Between his studies he lectured at various high schools in Oslo and participated in several minor expeditions to the Norwegian mountains and the island of Jan Mayen. In 1950, he moved to Sweden, teaching in high schools for several years. There he met his lifelong love, a Finnish girl, Britta Byström, and they married in 1952. They had four children; Britta predeceased him by a year.

Gunnar developed a stronger connection to Sweden when he became an assistant professor in physical geography at Stockholm University in 1958. Here he earned his lower doctoral degree (Fil.lic) in 1961 and a full doctorate in 1965, on the origin of ice-cored moraines in Scandinavia.

In 1961, he was employed as a glaciologist with the Hydrology Department of the Norwegian Water Resources and Electricity Board (NVE). Large-scale hydropower developments were planned for several glacierized areas in Norway and there was an urgent need to get more knowledge as to how glaciers influenced the hydrology. Since these plans were a high Norwegian priority, special funding was made available within the Hydrology Department for a glacier section (Brekontoret). Gunnar set up a network of stations for measuring mass balance and movement at several glaciers, and runoff and sediment transport in glacier-fed rivers. Many of these stations were manned by students during the summer months. Some of the mass-balance series and sediment stations operate today and are among the longest series in the world. He was the first to map Norwegian glaciers at a large scale and subsequently published the first glacier atlas for southern Norway in 1969 and for northern Scandinavia in 1973.



But Scandinavia was not big enough for him so he took on several assignments for UNESCO and others in Turkey, Argentine, Chile, India and elsewhere. Yet it was in Canada he did most of his non-Scandinavian work.

At a chance meeting in Abisko with Dr Jack Ives, on the occasion of the 19th International Geographical Congress in 1960, Gunnar discussed the former's plans for a glaciology program. At a subsequent meeting the following year, Jack, by then Assistant Director of the Geographical Branch, Canadian Department of Mines and Technical Surveys, offered Gunnar an opportunity to test his theory that the ice in the ice-cored moraines of the Barnes Ice Cap was also derived from seasonal snow. The Director, realizing this accomplished glaciologist would be a tremendous asset to the developing Canadian program, hired him as head of his new Glaciology Section.

The summer of 1962 was spent setting up a glacier-hydrology program on Lewis Glacier, a northern outlet of the Barnes Ice Cap, training students in field techniques, the use of the salt-dilution method for measuring the discharge of turbulent streams, and shipping 400 kg of Barnes Ice Cap moraine samples to Ottawa for analysis. He also wanted to ship a small quantity of ice samples south. Here his legendary love of ice cream came into play. Lacking the wherewithal to refrigerate his samples, he persuaded the chief steward on the flight south that the group would eat all the ice cream on board to free up space in the galley freezer for them. A somewhat similar approach gave him a conclusive victory in his

At Place Glacier, Coast Range, British Columbia, Canada, July 1988.

Stockholm office challenge as to who could source ice cream from the greatest distance. Gunnar arrived with ice cream made by the chief cook at Fox 2 using Barnes Ice Cap ice! When he attended the Northern Hydrology Symposium in Saskatoon in 1990, he was honoured with an ice-cream cake from the local Dairy Queen.

In January 1965, Gunnar arrived in Ottawa with his family. He immediately began the process of selecting glaciers for Canada's contribution to the International Hydrological Decade (IHD) network of representative basins. After map analysis and subsequent air-photo review, aided by Dr Stig Johnson, an initial 300 glaciers were reduced to 30 following air-photo examination. For the final selection, a helicopter was used to confirm the suitability of the sites selected. Detailed instructions on mass balance, glacier hydrology and camp construction were prepared by Gunnar and Dr Alan Stanley; a manual subsequently used by many national programs. Signature A-frame huts were built, with the assistance of Dr Wibjörn Karlén, at the chosen glaciers: Place and Sentinel in the Coast Mountains, Woolsey in the Columbia Mountains, Peyto and Ram River Glaciers in the Rockies, and Decade Glacier on Baffin Island. Later, in collaboration with Carleton University, Gunnar organized two-week training courses on glacier hydrology at Peyto Glacier in 1972, 1974 and 1978, and at Place Glacier in 1988. Dr Richie Williams, of the US Geological Survey, then aged 47, recalls taking the latter and learning about glaciological-measurement techniques in the field from two superb teachers, Gunnar and Nils Haakensen, which stood him in good stead in subsequent collaborations with Oddur Sigurðsson, Sigurður Þórarinsson and other Icelandic scientists. The two first met at the IGS Symposium on Glacier Mapping and Surveying held in Reykjavík where Gunnar, as editor of *Annals* 8, lived up to his well-earned reputation as a consummate professional, dedicated field glaciologist, with a strong yet amiable personality, and generous mentor to younger members of the profession.

In 1966, Gunnar arranged for special air-photo missions over the western Canadian mountains resulting in 1:10 000 scale maps of the IHD glaciers and information about the snowline that could be compared to his calculated glaciation levels. The map of Place Glacier was the first metric map ever produced by the Surveys and Mapping Branch. Later that year he returned to Norway, leaving an enduring legacy in Canada.

In addition to his job at the NVE, that at the University of Stockholm grew from a part-time job as associate professor, from 1966, and then full professor from 1981 at the Institutionen för naturgeografi. He gave up his duties at NVE, but still maintained an office there, commuting regularly between Oslo and Stockholm. He was editor of *Geografiska Annaler*, the Swedish scientific journal, for many years.

He understood early that satellites and remote sensing would be important tools in glaciology and became an active board member of the European Association for Remote Sensing Laboratories (EARSL). In this vein, he collaborated with Richie Williams and Jane Ferrigno on the Glaciers of Norway chapter in the *Satellite Image Atlas of Glaciers of the World* (1386-E; 1993). While visiting the United States for the final edit he had to undergo major heart surgery. Proximity to specialists, and a month recuperating in a local motel under the watchful

At Storglacier, Sweden, August 1970.

eye of Britta, ensured his survival for another three decades as a teacher, mentor and husband

Gunnar was an enthusiastic, inspiring and creative leader, but also demanding. He was very efficient at obtaining funds for his studies, but dependent on good collaborators for much of the fieldwork and for completing projects. His closest collaborators for many years were Randi Pytte Asvall (Norway's first female glaciologist), Wibjörn Karlén, Nils Haakensen and Bjørn Wold (who took over his responsibilities as head of the Glacier office). Østrem's global network was large and gave many younger Norwegians an introduction to the international glaciological world. After he retired, he continued to attend scientific meetings and inspired many students to work in glaciology.

In addition to his honorary membership of the IGS, he received wide recognition for his accomplishments, being awarded Sweden's Royal Academy of Science J. A. Wahlberg silver medal, the Hans Egede medal of the Royal Danish Geographical Society and the Norwegian King's gold Medal of Merit.

We are happy and proud to have had the opportunity to work with Gunnar and to have known him as a friend. He had a lifelong interest in glaciology and inspired many to join our scientific community and the International Glaciological Society.

Simon Ommanney, former Secretary General of the IGS
Bjørn Wold, former President of the IGS

A profile on Gunnar was published in ICE number 41 in 1973. Follow the link (https://www.igsoc.org/news/gunnarostrem/gunnar_ostrem_ice.pdf) to read more about his career.

In celebration of Gunnar's 85th birthday in 2007 NVE organised a mini-symposium. It was reported in ICE 143; follow the link (https://www.igsoc.org/news/gunnarostrem/ostremsymposium_2007.pdf) to read more.

We have also included a link (https://www.igsoc.org/news/gunnarostrem/nve_50_anniversary.pdf) to another ICE report, this time from NVE's 50th anniversary in which Gunnar played a major role.

INTERNATIONAL GLACIOLOGICAL SOCIETY

International Symposium on

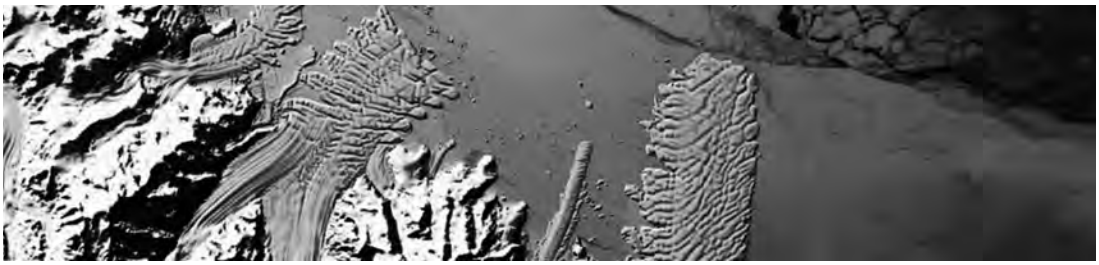
Ice Streams and Outlet Glaciers

Durham University
Durham, UK
19–24 July 2020

Co-sponsored by:
Department of Geography, Durham University

Durham University

SECOND CIRCULAR
January 2020
https: www. igsoc.org/symposia/2020/durham
Local website: https://www.dur.ac.uk/igs-durham-2020/



The International Glaciological Society will hold an International Symposium on 'Ice Streams and Outlet Glaciers' in 2020. The symposium will be hosted by the Department of Geography, Durham University, Durham, UK, and will take place on 19–24 July 2020.

THEME

Ice streams and outlet glaciers are important components of an ice sheet's mass balance and their behaviour directly impacts on sea level. These corridors of fast-flowing ice have been described as the 'arteries' of an ice sheet and their distinction is largely semantic, with ice streams bordered by slower-moving ice and outlet glaciers bordered by exposed bedrock at the surface. Since the recognition of the importance of these features in the 1970s, there has been a huge growth in their investigation. This began with the pioneering work on West Antarctic ice streams and has subsequently expanded to studies of ice streams and outlet glaciers in all of the world's major ice sheets and ice masses. Of urgent concern for society are recent observations of dynamic changes in ice streams and outlet glaciers, which are thought to be responsible for an acceleration in global eustatic sea-level rise.

In parallel, those studying palaeo-ice sheet beds have long-recognised the distinctive geomorphology of ice streams in both marine and terrestrial settings. The study of palaeo-ice streams offers an unprecedented opportunity to reconstruct their behaviour over time-scales much longer than modern observations permit, generating new insights into the spatial and temporal controls on their flow, including longer-term perspectives on retreat rates and thinning histories. The beds of palaeo-ice streams and outlet glaciers are also more accessible for investigation, leading to new insights regarding the mechanisms of sediment erosion, transport and deposition beneath fast-flowing ice, including the formation of subglacial bedforms.

In addition to empirical studies, there have been major advances in our ability to simulate ice stream and outlet glacier behaviour in numerical models. Moreover, observations and reconstructions of ice streams/outlet glaciers have provided useful data to test and calibrate numerical models and recent developments have seen improved projections of mass loss.

The aim of this symposium is to bring together scientists working on both modern and palaeo-ice streams/outlet glaciers, together with those using numerical modelling, in order to facilitate greater interaction and the cross-pollination of ideas, data and theoretical insight on one of glaciology's most important topics.

SUGGESTED TOPICS

We seek papers and presentations on any aspect of ice streams and outlet glaciers, including observations at a range of spatial and temporal scales and insights gleaned from numerical modelling. Key topics include (but are not limited to):

1. Observations of ice streams/outlet glaciers and their links to the ocean–climate system
2. Interactions between ice streams/outlet glaciers and floating ice shelves/ice tongues
3. Geophysical studies of ice streams/outlet glaciers, including englacial and subglacial observations, and processes of sediment erosion, transport and deposition
4. Reconstructions of palaeo-ice streams/outlet glaciers, including their links to the ocean–climate system and terrestrial investigations of their subglacial sediments and landforms
5. Numerical modelling studies of past, present and future ice stream/outlet glacier behaviour and/or of key processes relating to their behaviour
6. The role of ice streams/outlet glaciers in ice sheet instabilities (e.g. Heinrich events)

INVITED SPEAKERS

Chris Clark (University of Sheffield, UK), **Ellyn Enderlin** (Boise State University, USA), **Christina Hulbe** (University of Otago, New Zealand), **Ian Joughin** (University of Washington, Seattle, USA), **Eric Rignot** (University of California Irvine, USA), **Monica Winsborrow** (UiT – The Arctic University of Norway, Tromsø, Norway)

REGISTRATION FEES
All fees are in UK pounds sterling, £
Early registration until 5 May 2020

– Participant (IGS member):	£315
– Participant (not IGS member):	£365
– Student or retired (IGS member):	£200
– Student or retired (not IGS member):	£230
– Accompanying person (21+):	£90
– Accompanying person (12–20):	£70
– Accompanying person (<12):	Free
– Delegate registration after 5 May 2020:	add £50
– Delegate registration after 21 June 2020:	add further £50

The fees include the Icebreaker, the mid-conference excursion, the Symposium Banquet, morning/afternoon refreshments and lunches from Monday through Friday. Please register for the symposium through the IGS website. If you cannot do this, contact the IGS office directly at igsoc@igsoc.org. If payment by credit card is not possible, contact the IGS office to arrange for a bank transfer.

Please check whether you will require a visa to enter the UK. If you need an invitation letter, please contact the IGS office at igsoc@igsoc.org. The sooner you do this the more likely it is that your visa will be processed in time.

ACCOMPANYING PERSONS
The accompanying person's registration fee includes the Icebreaker, the midweek excursion and the Symposium Banquet. **It does not include attendance at the presentation sessions.**

PROGRAM
The symposium will include oral and poster sessions, with ample free time for discussion. Additional activities will include an opening Icebreaker (evening of Sunday 19th), a banquet dinner in the magnificent Durham

Castle (Thursday 23rd) and a midweek day-trip to explore the glacial history and glacial geomorphology of palaeo-ice stream beds in northern England, including a visit to the UNESCO World Heritage site of Hadrian's Wall.

STUDENT AND EARLY-CAREER EVENTS

The Early-Career Glaciology Group (EGG: http://igsegg.org/) will be organizing an interactive panel discussion on the evening of Tuesday 21st for Early Career Scientists (ECSs). A panel of Editors from leading glaciology/palaeo-glaciology journals will provide their top tips for successfully navigating the publication pathway. Discussion will be encouraged throughout the panel and will include ample time for questions from participants. It is anticipated that this discussion will have a duration of around 1.5 hours. This will be followed by a dinner, which will be an excellent opportunity to connect with other cryosphere ECSs. More information will follow soon on the local website and at '@egg_igs'.

IGS AWARDS

During the conference, the following IGS awards will be made:

Richardson Medal to Johannes Oerlemans
Seligman Crystal to Doug MacAyeal
Seligman Crystal to Richard Hindmarsh.

VENUE

The symposium will be held in the Department of Geography, Durham University, which is located on the Mountjoy Campus, just 10 minutes walk from the historic centre of Durham city, where there are numerous restaurants and traditional pubs, bars and cafes, as well as several tourist attractions and walking trails along the wooded banks of the River Wear. Durham University is England's third oldest and the Department of Geography (founded in 1928) is recognized as one of the leading centres of geographical research and education in the world, with a strong focus on ice sheets, ice streams and sea-level change.

LOCATION

Durham is a small (pop. 65 000) but spectacular cathedral city in north-east England with a rich heritage. Narrow cobbled streets wind their way around the rocky peninsula carved by a meander in the River Wear to the majestic Norman cathedral and castle, which are a designated UNESCO World Heritage site.

ACCOMMODATION

We are pleased to be able to offer budget bed-and-breakfast accommodation in two of the University's 16 residential undergraduate colleges:

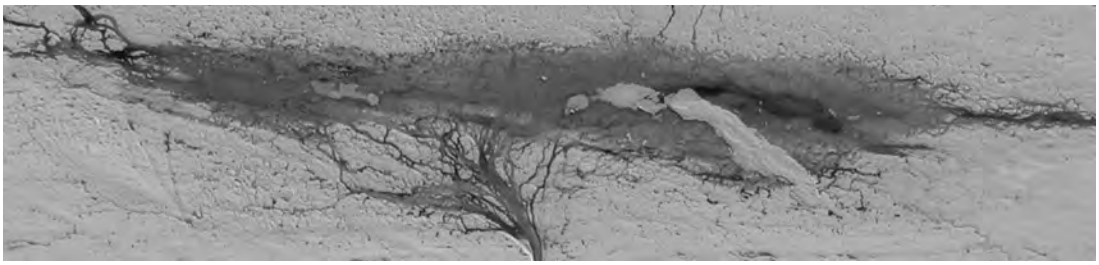
- **Single en-suite room at Collingwood College** (DH1 3LT), **£50.00 per room per night**, which includes single bed with private shower, toilet and hand basin, wif-fi access and wardrobe, together with full English breakfast
- **Single standard room at Grey College** (DH1 3LG), **£37.50 per room per night**, which includes single bed with hand basin, wi-fi access and wardrobe and shared bathroom along the corridor, together with full English breakfast.

Delegates wishing to book and pay for this accommodation directly to Durham University can do so at the following link:

https://www.dur.ac.uk/conference.booking/details/?id=1412

There are numerous hotels in Durham City but early booking is recommended because July can be busy with tourists. The following are all within 15-20 mins walking distance of the conference venue, with a range of prices, but you must make the bookings yourself:

Premier Inn, Durham City (££)
Radisson Blu, Durham (£££)
The Town House (£££)
Hotel Indigo (££££).
Travelodge, Durham (££)
Durham Marriott Hotel Royal County (£££)
Kingslodge Inn (£££)



ICEBREAKER
The Icebreaker will be held on Sunday 19 July from 19:30–21:30 pm in the magnificent surroundings of Durham Castle, which is home to University College, Durham. Light refreshments with a complimentary drink will be available. Delegates can also use this opportunity to compete their registration and collect their conference bag materials.

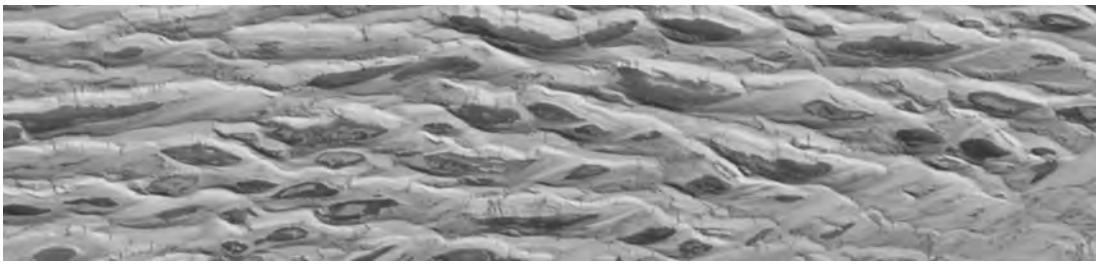
BANQUET
The Banquet will be held in the magnificent surroundings of the Great Hall in Durham Castle on the evening of Thursday 23 July. Situated on Durham's World Heritage Site opposite the Cathedral and based primarily in a Norman fortress, this stunning castle is truly unique amongst Durham University's colleges. The meal is included in the registration fee and a cash bar will be available on the night.

MID-CONFERENCE EXCURSION
On Wednesday 22 July there will be a mid-conference field trip to explore the glacial history and glacial geomorphology of palaeo-ice stream beds in northern England, including a visit to the UNESCO World Heritage site of Hadrian's Wall. All transport and a packed lunch is included in the conference registration fee.

ABSTRACT AND PAPER PUBLICATION
Participants wishing to present a paper (oral or poster) at the Symposium will be required to submit an abstract by 21 March 2020. Abstracts must be submitted via the IGS website. Accepted abstracts will be posted on the Symposium website.

The Council of the International Glaciological Society will publish a thematic issue of the *Annals of Glaciology* (vol. 62 (2020), issue 84)) on topics consistent with the symposium themes. Submissions to this issue will not be contingent on presentation at the Symposium, and material presented at the symposium is not necessarily affirmed as being suitable for consideration for this issue of the *Annals*. Participants are encouraged, however, to submit manuscripts for this *Annals* volume. Paper submissions will open on 1 May 2020 and the deadline for submitting papers is 1 November 2020.

SYMPOSIUM ORGANIZATION
Magnús Már Magnússon (International Glaciological Society)



LOCAL ORGANIZING COMMITTEE (LOC)
Chris Stokes (Chair, Durham University), Jennifer Arthur (Durham), Rachel Carr (University of Newcastle), Louise Callard (Newcastle), Dave Evans (Durham), Stewart Jamieson (Durham), Bertie Miles (Durham), Colm O'Cofaigh (Durham), Dave Roberts (Durham).

FURTHER INFORMATION
Please register your interest on line if you wish to attend the symposium, at https://community.igsoc.org/events/5d0b35dcc2cc0631d6fc8bfc. To contact the LOC, please e-mail us at: igs2020@durham.ac.uk. For enquiries relating to abstract submission and registration, e-mail the IGS at: igsoc@igsoc.org.

Postponed until 2021/22

IMPORTANT DATES

Ice Streams and Outlet Glaciers

Opening of online abstract submission:	10 February 2020
Opening of online registration:	5 April 2020
Abstract submission deadline:	21 March 2020
Notification of abstract acceptance:	5 April 2020
Early registration deadline:	5 May 2020
Deadline for full refund:	5 June 2020
Deadline for refund on a sliding scale:	21 June 2020
Late registration surcharge starts:	21 June 2020
Symposium starts:	19 July 2020

Annals of Glaciology volume 62, issue 84

Paper submission deadline:	1 November 2020
Final revised papers deadline:	1 May 2021

The Call for Papers for the *Annals of Glaciology* is posted on https://www.igsoc.org/annals/call4papers.html. Accepted papers will be published as soon as authors have returned their proofs and all corrections have been made.

Hard copy publication is scheduled for mid to late 2021.

CRYOSPHERE 2020

International Symposium on Ice, Snow and Water in a Warming World

Harpa Conference Centre
Reykjavík, Iceland
21–24 September 2020

Postponed until 2021

Organization: Icelandic Meteorological Office,
World Meteorological Organization, International Association of Cryospheric Sciences,
International Association of Hydrological Sciences, International Glaciological Society

Co-sponsors: University of Iceland, UNESCO Intergovernmental Hydrological Programme, Danish Meteorological Institute, WSL-Institute for Snow and Avalanche Research, Melnikov Permafrost Institute, University of Wisconsin, University of Alaska Fairbanks, Stefansson Arctic Institute, University of Ottawa, UNESCO-IOC, Alfred Wegener Institute, Technical University of Vienna, European Centre for Medium-Range Weather Forecasts, International Arctic Science Committee, Arctic Monitoring and Assessment Programme, Scientific Committee for Antarctic Research (SCAR), National Snow and Ice Data Center, St Petersburg State University, University of Oslo, Third Pole Environment Programme, University of Saskatchewan, National Oceanographic and Atmospheric Administration, Agrocampus OUEST

SECOND CIRCULAR
January 2020
https://www.cryosphere2020.is

The Icelandic Meteorological Office, the WMO Global Cryosphere Watch (GCW) and the International Glaciological Society (IGS) will, in cooperation with several international scientific organizations and research institutes, host a symposium on the Earth´s Cryosphere in Reykjavík, Iceland, 21–24 September, 2020. Registration will begin on 1 February 2020.

THEME

As a result of global atmospheric and ocean warming, **all components of Earth´s cryosphere** are now changing at a dramatic pace. More than a quarter of the planet´s land surface receives snow precipitation each year and declining snow cover in many parts of the world is causing concern over the future of snowmelt as a water resource. Mass loss continues from **glaciers and ice-fields** in all mountainous regions of the world and from **Arctic and sub-Arctic ice caps**. The two large **ice sheets in Greenland and Antarctica** are major contributors to rising sea-level and may have begun to show signs of irreversible mass loss. The areal extent and thickness of **Arctic sea ice** continues to decline and the resulting albedo changes may be affecting winter weather patterns in North America and Eurasia. Increasing attention is being given to hazards due to thinning of **lake and river ice cover** and **permafrost** degradation, including slope failure.

This symposium will bring together scientists and policy makers for a discussion on the latest results from studies of the entire cryosphere, which plays an important role in the hydrological cycle and the Earth System and is one of the most useful indicators of climate change. The symposium will allow ample time for panel discussions on scientific results, new technologies, research gaps and future perspectives in the light of the Paris Agreement that calls for limiting global warming to 1.5–2°C.

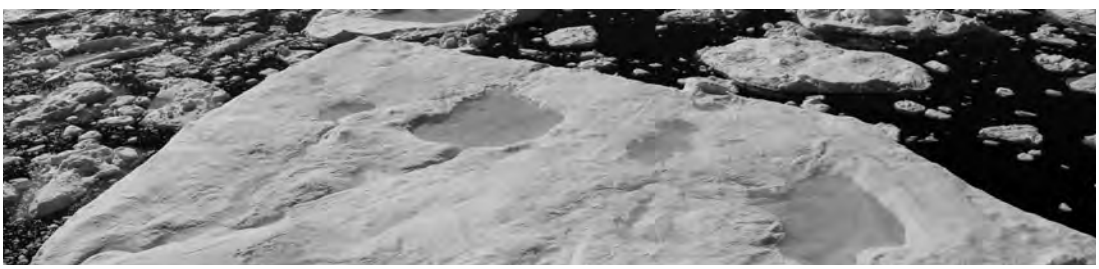
KEYNOTE SPEAKERS

Dorthe Dahl-Jensen (University of Copenhagen and University of Manitoba), **Valerie Masson-Delmotte** (Laboratoire des sciences du climat et de l'Environnement), **Eric Rignot** (University of California Irvine), **Konrad Steffen** (ETH Zürich and Swiss Federal Institute for Forest, Snow and Landscape Research), **Olga Makarieva** (St Petersburg State University and Melnikov Permafrost Institute), **Mark Serreze** (National Snow and Ice Data Center, Boulder), **Mandira Singh Shrestha** (ICIMOD, Nepal), **Julia Boike** (Alfred Wegener Institute, Germany), **Michael Zemp** (World Glacier Monitoring Service), **Regine Hock** (University of Alaska), **Robert DeConto** (University of Massachusetts), **Astrid Ogilvie** (Stefansson Arctic Institute), **Bernd Etzelmüller** (University of Oslo) and **Peter Bijl** (University of Utrecht)

TOPICS

We seek presentations and papers on timely topics related to all components of the cryosphere and its changes due to global warming. Sessions will cover the following topics:

1. **Earth's snow cover**: Snow science, recent snow cover changes in mountain and polar regions; satellite monitoring of snow cover; GPR measurements of snow thickness; importance of snow cover for tourism; avalanche hazard mitigation
2. **The cryosphere and hydrology**: Importance of snow and ice melt as a water resource for mountain region populations and for hydropower utilization; runoff changes due to atmospheric warming; monitoring of changes in lake and river ice
3. **Permafrost**: Nature and distribution; ongoing changes; impacts on the hydrological cycle; monitoring challenges; increased risks of landslides due to permafrost thawing; adaption implications for populations
4. **Ocean–cryosphere interactions**: Transfer of water between the oceans and snow and ice masses on land; changes in ocean heat content; effects of declining Arctic sea-ice cover on the climate system; effects of oceanic warming on tidewater glaciers; potential changes in deepwater formation in the North Atlantic ocean; tipping points in the ocean–cryosphere system
5. **Glaciers and ice caps**: Historical changes in glacier area and mass balance all over the world; mass-balance measurements and modelling; glacier dynamics and evolution; melt processes and glaciohydrology; glacier outburst floods (jökulhlaups); glaciers in high-mountain areas and impacts of their melting on populations; future perspectives on glacially fed rivers as water resources
6. **The Greenland Ice Sheet**: Age and history; deep ice-core records; internal structure; recent changes; likely response to near-future warming; varying contribution of Greenland mass loss to sea level in different parts of the world's oceans; research on surface melt lakes and runoff; ice velocity studies



7. **The Antarctic Ice Sheet**: History; internal structure; key data from ice cores on past atmospheric composition; vulnerability of the West Antarctic Ice Sheet to rising sea level; research on subglacial water systems; Antarctica in the climate system
8. **Sea ice**: Nature and distribution; changes in area, thickness and volume; past variations; likely changes during the 21st century; importance of sea ice in the Earth´s climate system; ongoing developments in the Arctic (e.g. shipping, settlements, research coverage)
9. **Climate variations, climate- and Earth-system modelling**: Representation of the cryosphere in climate models and Earth systems models; modelling of cryospheric variations and resulting hydrological changes on all time scales from ice ages through Holocene climate variations to centennial, decadal and annual variations; importance of the cryosphere as a trigger of rapid climate change
10. **Research gaps, monitoring programmes, new technologies**: Emerging methods and technologies in surface-based, airborne and spaceborne studies of snow, glaciers and ice sheets, lake and river ice conditions and permafrost, with special emphasis on the development of derived products for cryospheric and polar scientific research and applications
11. **Opportunities, adaptation and mitigation**: Importance of evaluating and estimating current and future cryospheric variations for the design and operation of societal infrastructure, such as coastal and hydrological infrastructure and hydropower systems
12. **Humans and the cryosphere: navigating complex change in the Anthropocene**. Adaptation of human beings to cryospheric environments through time, challenges to indigeneous communities presented by increasingly rapid environmental and social change

ABSTRACT SUBMISSION AND PAPER PUBLICATION

Participants who wish to present a paper (oral or poster) at the Symposium will be required to submit an abstract. The International Glaciological Society will publish a thematic issue of the *Annals of Glaciology* on topics consistent with the Symposium themes. Participants are encouraged to submit manuscripts for this *Annals* volume, see https://www.igsoc.org/annals/a85_call_4_papers.pdf. The abstract should not contain any figures nor references and should not be longer than 2500 characters. Abstracts should be submitted through the conference website (https://www.cryosphere2020.is/abstract-submission).

Deadline for submitting abstracts: 15 April 2020.

REGISTRATION

To register, visit https://www.cryosphere2020.is where you will be directed to the registration pages. Registration fees will be listed on the websites in January 2020. Early registration will be possible until 1 July 2020.

ACCOMPANYING PERSONS

The accompanying person's registration fee includes the Icebreaker and the Symposium Banquet. **It does not include attendance at the presentation sessions.**

VISA REQUIREMENTS

Please check whether you will require a visa to visit Iceland. If you need an invitation letter, please contact Mrs Hjördís Guðmundsdóttir at Iceland Travel (hjordisg@icelandtravel.is). The sooner you do this the more likely it is that your visa will be processed in time.

TRAVEL GRANTS FOR EARLY CAREER SCIENTISTS

Travel grants will be made available for a limited number of young scientists. Detailed information will be posted on the conference website in February 2020.

PROGRAM

The four-day symposium will be run in a single, plenary session. On Day 1, world-leading researchers will present overviews of past, present and projected future changes in all components of the cryosphere, including glaciers and ice sheets, snow cover, sea ice, lake and river ice and permafrost. Sessions on days 2–4 will cover the topics outlined above. We anticipate a total of 70 oral presentations. Panel discussions will be held on each day of the conference. Poster presentations are welcome and posters can be up all week. Additional activities will include an opening Icebreaker reception, a Banquet dinner and optional 1- and 3-day post-conference field excursions.

VENUE AND AUDIENCE

The symposium will be held in the Harpa Conference Centre, in downtown Reykjavík, the capital of Iceland. We will aim to run the entire conference in a single session, but meeting rooms will be made available for working groups. Posters will be available all week for viewing. We seek participation from the scientific community and from various sectors of society affected by snow and ice, either through utilization, hazard prevention or in other ways. See information on Harpa at: https://harpa.is/harpa

ACCOMMODATION

The conference organizers have made block bookings at hotels and guesthouses in Reykjavík. From 1 February 2020, rooms can be reserved through the registration page on the conference website. Participants can also book accommodation on their own.

PUBLIC EVENTS

Public lectures and exhibitions will be held on the symposium topics, as part of activities commemorating the 100th anniversary of the Icelandic Meteorological Office in 2020. On Sunday 20 September a public presentation will be given by writer and photographer **James Balog**, author of the award-winning documentary *Chasing Ice*.

ECMWF

UNIVERSITY OF SASKATCHEWAN

THE UNIVERSITY OF CHICAGO

ICEBREAKER

The Icebreaker will be held on Sunday 20 September at 18:00. Details will be announced later on the conference website and through the conference mailing list.

BANQUET

The Banquet will be held on Wednesday evening, 23 September. Information will be given on the conference website and through the conference mailing list.

FIELD TRIPS

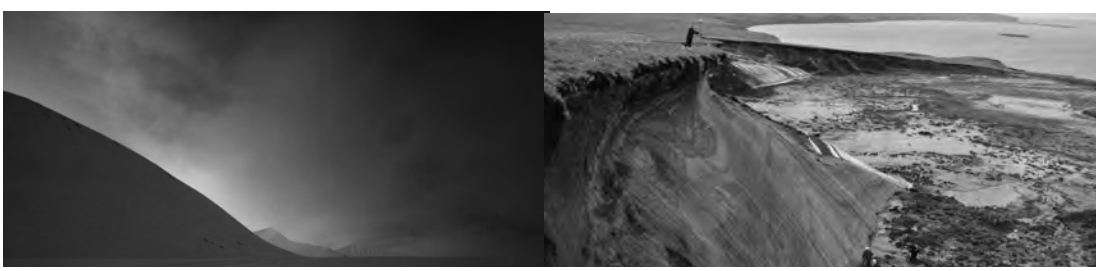
Two post-conference field trips will be arranged, starting on Friday 25 September:

1. A one-day trip to Langjökull, the second largest ice cap in Iceland, situated within Iceland's western volcanic zone. Participants will have the opportunity to visit a 400 m long tunnel dug into the ice cap. A lecture on glacier changes in Iceland will form part of the program.
2. A three-day tour through the glaciated and volcanic regions of South Iceland. Sights will include the glacier-capped volcano Eyjafjallajökull; the Mýrdalsjökull ice cap and floodplains inundated during eruptions in the subglacial volcano Katla; the 1783 lava flow from the devastating Skaftáreldar (Laki) eruption; Skeiðarárjökull and other outlets from the Vatnajökull ice cap; Skaftafell; Öræfajökull volcano and the steadily enlarging glacier lagoon in front of Breiðamerkurjökull.

Detailed information on the field trips will be given on the conference website.

EDITORIAL COMMITTEE

Chief editor: Regine Hock (University of Alaska, Fairbanks; President, IACS)
Co-editors: Christophe Cudennec (IAHS, Agrocampus OUEST, Rennes), Jeff Key (NOAA, UW-Madison), Tómas Jóhannesson (Icelandic Meteorological Office), Douglas MacAyeal (University of Chicago).



SCIENCE ORGANIZING COMMITTEE

Árni Snorrason (IMO, GCW, Chair), Barry Goodison (GCW, WMO), Charles Fierz (SLF, IACS), Guðfinna Aðalgeirsdóttir (Univ. of Iceland), Magnús Már Magnússon (Secretary General, IGS), Pavel Kabat (Chief Scientist, WMO), Olga Makarieva (Melnikov Inst. & SPSU), Mark Serreze (NSIDC), Ruth Mottram (Danish Met. Inst.), Anil Mishra (UNESCO-IHP), Christian Haas (AWI), Yao Tandong (TPE), Halldór Björnsson (IMO), John Pomeroy (Global Water Futures), Níels Einarsson (Stefansson Arctic Institute), Laura de Santis (SCAR), Patricia de Rosnay (ECMWF), Larry Hinzman (President, IASC; UAF), Bernd Etzelmüller (Univ. of Oslo), Luke Copland (Univ. of Ottawa), Rodica Nitu (GCW, WMO), Günter Blöschl (President, IAHS), Salvatore Arico (UNESCO-IOC), Peter Bulsifer (NSIDC), Thorsteinn Thorsteinsson (IMO).

LOCAL ORGANIZING COMMITTEE

Haukur Hauksson, Hjördís Guðmundsdóttir, Hrafnhildur Hannesdóttir, Jórunn Harðardóttir, Sigurlaug Gunnlaugsdóttir, Tómas Jóhannesson, Thorsteinn Thorsteinsson.

Postponed until 2021

IMPORTANT DATES

Cryosphere 2020

Opening of online abstract submission:	1 February 2020
Opening of online registration:	1 February 2020
Abstract submission deadline:	15 April 2020
Notification of abstract acceptance:	1 June 2020
Early registration deadline:	1 July 2020
Registration deadline:	1 September 2020
Deadline for field trip registration:	1 September 2020
Symposium starts:	21 September 2020

Annals of Glaciology volume 62, issue 85

Paper submission opens:	1 June 2020
Paper submission deadline:	1 December 2020
Final revised papers deadline:	1 June 2021

The Call for Papers for the *Annals of Glaciology* is posted on https://www.igsoc.org/annals/call4papers.html. Accepted papers will be pubished as soon as authors have returned their proofs and all corrections have been made. Hard copy publication is scheduled for mid-2021.

For further information please e-mail cryosphere2020@vedur.is.

Glaciological diary

** IGS sponsored * IGS co-sponsored

2020

8–10 January 2020
Quaternary Research Association Annual Discussion Meeting: Quaternary Earth System processes and feedbacks: challenges for society
Leeds, UK
Website: https://qraleeds2020.com/

13–17 January 2020
7th International Conference on Mars Polar Science and Exploration
Ushuaia, Tierra del Fuego, Argentina
Website: https://www.hou.usra.edu/meetings/marspolar2020/

28–30 January 2020
IASC Workshop on the Dynamics and Mass Budget of Arctic Glaciers
Obergurgl, Austria
Website: https://nag.iasc.info/workshopsnowhydro.eurac.edu/

28–31 January 2020
SnowHydro Conference: Challenges in Mountain Areas
Bolzano/Bozen, Italy
Website: https://snowhydro.eurac.edu/

3–5 February 2020
***New Zealand Snow and Ice Research Group (SIRG: the New Zealand branch of IGS) Annual Workshop**
Matiu/Somes Island, Wellington, New Zealand
Website: https://sirg.org.nz/about/2020-annual-meeting/

3–5 February 2020
9th Workshop on Remote Sensing of Land Ice and Snow (European Association of Remote Sensing Laboratories (EARSeL)): Remote Sensing of the Cryosphere – Monitor what is vanishing
Bern, Switzerland
Website: http://www.earsel.org/SIG/Snow-Ice/workshop/call.php.

12–15 February 2020
4th Polar Ecology Conference: Interactions between Ocean and Terrestrial Ecosystems
České Budějovice, Czech Republic
Website: https://www.agu.org/ocean-sciences-meeting/

16–21 February 2020
Ocean Sciences Meeting 2020
San Diego, California, USA
Website: https://www.agu.org/ocean-sciences-meeting/

18–21 February 2020
3rd Canadian Polar Data Workshop
Banff, Alberta, Canada
Contact Ravi Darwin Sankar <ravi.sankar@ucalgary.ca>
Website: https://www.arcus.org/sites/all/modules/civicrm/extern/url.php?u=17542&qid=3013318

27–28 February 2020
2020 Alpine Glaciology Meeting
Milan, Italy
Contact Davide Fugazza <davide.fugazza@unimi.it>

2–6 March 2020
Sixth International Symposium on Arctic Research
Tokyo, Japan
Website: http://www.jcar.org/isar-6/

2–8 March 2020
36th International Geological Congress
New Delhi, India
Theme 8: The Polar World – Past Present and Future
Theme 9: Glacier Mass Balance
Theme 12: Quaternary Environments: Sedimentation and Landform Evolution – Symposium 12.4: Glaciers Past and Present
Website: https://www.36igc.org/

10–12 March 2020
2020 Polar Technology Conference
Boulder, Colorado, USA
Website: https://www.arcus.org/logistics/2020-polar-technology

27 March–2 April 2020
Arctic Science Summit Week (ASSW2020)
Akureyri, Iceland
Website: https://www.assw2020.is/

23–24 April 2020
6th Students in Polar and Alpine Research Conference – SPARC 2020
Brno, Czech Republic
Website: https://sparc-brno.webnode.cz/

3–8 May 2020
European Geosciences Union Annual Meeting
Vienna, Austria
Website: https://www.egu2020.eu/

25–29 May 2020
2nd PalaeoArc conference:Processes and Palaeo-environmental changes in the Arctic – from past to present
Pisa, Italy
Website: http://www.palaeoarc.dst.unipi.it/

9–11 June 2020
77th Eastern Snow Conference (ESC)
Toronto, Ontario, Canada
Website: https://www.easternsnow.org/

14–19 June 2020
18th International Conference on Ground Penetrating Radar
Golden, Colorado, USA
Website: https://gpr2020.csmspace.com/

21–24 June 2020
4th Forum for Research into Ice Shelf Processes (FRISP)
Hotel Döllnsee, near Berlin/Potsdam, Germany
Website: https://eveeno.com/frisp2020

22–26 June 2020
12th International Conference on Permafrost (ICOP2020)
Lanzhou, China
Website: http://icop2020.csp.escience.cn/dct/page/1

19–24 July 2020
Workshop: Mathematics of Sea Ice in the Twenty-First Century
Cambridge, UK
Website: https://www.newton.ac.uk/event/sipw05

19–24 July 2020
****International Symposium on Ice Stream Dynamics**
Durham, UK
POSTPONED UNTIL 2021 or 2022 BECAUSE OF COVID-19 PANDEMIC
Contacts: Secretary General, IGS; Chris Stokes <c.r.stokes@durham.ac.uk>

3–7 August 2020
SCAR Open Science Conference
Hobart, Tasmania, Australia
Session 14: Integrating marine and terrestrial records of past Antarctic ice sheet and ocean behaviour. Conveners: Mike Bentley (Durham), Julia Wellner (Houston), Richard Selwyn Jones (Monash) <Richard.S.Jones@monash.edu>, Christina Riesselman (Otago)
Website: https://www.scarcomnap2020.org/

1–2 September 2020
****International Glaciological Society British Branch Meeting**
University of Edinburgh, Edinburgh, Scotland
Contacts: Robert Bingham <r.bingham@ed.ac.uk>; Secretary General IGS

3–4 September 2020
****Northeast Glaciology Meeting – A revival of the IGS Northeastern Branch**
University of Maine (Orono, ME USA)
To receive future information
Contacts: Kristin M. Schild <kristin.schild@maine.edu>; Secretary General, IGS

6–11 September 2020
37th General Assembly of the European Seismological Commission
Corfu, Greece
Session 12: Seismological and Structural Studies in Polar Regions and the Cryosphere.
Conveners: Myrto Pirli <myrto.pirli@gmail.com>, Nicolas Celli, Peter Voss, Fabian Walter
Website: https://www.escgreece2020.eu/

6–11 September 2020
28th International Polar Conference
Cologne, Germany
Website: https://polarforschung.de/events/28-international-polar-conference/?lang=en

8–19 September 2020
***Karthaus course on Ice Sheets and Glaciers in the Climate System**
Karthaus, Italy
Contact: J. Oerlemans <j.oerlemans@uu.nl>
Website: http://www.projects.science.uu.nl/iceclimate/karthaus/

21–24 September 2020
***Cryosphere 2020: International Symposium on Ice, Snow and Water in a Warming World**
Reykjavík, Iceland
Contacts: Secretary General, IGS; Þorsteinn Þorsteinsson <thor@vedur.is>

21–25 September 2020
XXI Argentine Geological Congress
Technical Session 18: Cryospheric Sciences
Chubut, Argentina
Website: http://www.congresogeologico.org.ar/inicio

24–26 September 2020
3rd International Conference on Polar Climate and Environmental Change in the Last Millennium
Toruń, Poland
Contact Przemysław Wyszyński <polarclimate2020@umk.pl>
Website: https://www.arcus.org/sites/all/modules/civicrm/extern/url.php?u=18159&qid=3116042

7–9 October 2020
****3rd Annual Chilean Cryosphere Society (SOCHICRI) meeting**
Concepción, Chile
Website: https://www.sochicri.cl/

18–23 October 2020
3rd IPICS Open Science Conference: Ice Core Science at the Three Poles
Crans-Montana, Switzerland
Website: https://indico.psi.ch/event/6697/

28–30 October 2020
****International Glaciological Society Nordic Branch Meeting**
GEUS, Copenhagen, Denmark
Contacts: Andreas Peter Ahlstrøm <apa@geus.dk>; Nanna Karlsson <nbk@geus.dk>; Secretary General, IGS

2021

23–26 March 2021
Arctic Science Summit Week 2021: The Arctic: Regional Changes, Global Impacts
Lisbon, Portugal
Website: https://www.arcus.org/sites/all/modules/civicrm/extern/url.php?u=20822&qid=3582183

27 June–2 July 2021
****International Symposium on Interactions of Ice Sheets and Glaciers with the Ocean**
La Jolla, California, USA
Contacts: Secretary General, IGS
Helen Amanda Fricker <hafricker@ucsd.edu>

18–23 July 2021
BACO-21: IAMAS-IACS-IAPSO Joint Assembly
Busan, Republic of Korea
Contact: Richard Essery <Richard.Essery@ed.ac.uk>, Regine Hock <rehock@alaska.edu>
Website: http://baco-21.org/2021/english/main/index_en.asp

5–10 September 2021
****International Symposium on Science and Mitigation of Glacier and Snow Hazards**
Davos, Switzerland
Contacts: Secretary General, International Glaciological Society (IGS)

4–8 October 2021
****International Symposium on Glaciology and Society**
Bilbao, Basque Country, Spain
Contacts: Secretary General, International Glaciological Society (IGS), Sergio Henrique Faria <sh.faria@bc3research.org>h.faria@bc3research.org>

2022

June 2022
****International Symposium on Maritime Glaciers**
Juneau, Alaska, USA
Contacts: Secretary General, IGS, Jason Amundson <jmamundson@alaska.edu>

September 2022
****International Symposium on Southern Hemisphere Glaciers under Pressure: subglacial lakes, subaquatic environments, calving glaciers and climate**
Valdivia, Chile
Contacts: Secretary General, IGS; Andrés Rivera, Centro de Estudios Cientificos, arivera@cecs.cl

2023

July 2023
IUGG General Assembly
Berlin, Germany

New members

Derek Alcorn
Civil Engineering, Montana State University
205 Cobleigh Hall, Montana State University, Bozeman, MT 59717-3900, USA
E-mail: derekalcorn@montana.edu

Ms Chimira Andres
Department of Earth Sciences, Western University, 1151 Richmond Street N. London, Ontario N6A 5B7, Canada
candres5@uwo.ca

Mr Cody Barnett
Department of Geology, Kansas University
Ritchie Hall, Earth, Energy & Environment Center, 1414 Naismith Drive, Room 254, Lawrence, KS 66045-7575, USA
codybarnett@ku.edu

Mr Antony Clay
Magazine Editor, Rotherham Advertiser Publishing Regional Media Ltd, Brookfields Way, Manvers, Rotherham, South Yorkshire, S63 5DL, UK
mingwords@tutanota.com

Miss Emma Cooper
Department of Geography, Royal Holloway University of London
Egham Hill, Egham, Surrey TW20 0EX, UK
emma.cooper.2013@live.rhul.ac.uk

Miss Katie Copley
Department of Geography, University College London
UCL Department of Geography, Gower Street, London WC1E, UK
katie.copley.19@ucl.ac.uk

Ms Ji De
Institute of Tibetan Plateau Research, Chinese Academy of Sciences
No. 16 Lincui Road, Chaoyang District, Beijing 100101, P.R. China
deji@itpcas.ac.cn

Dr Susana del Carmen Fernández Menéndez
Associate Professor, Department of Geology, University of Oviedo
Facultad de Geología, Calle Jesús Arias de Velasco s/n ES-33005 Oviedo, Spain
fernandezmsusana@uniovi.es

Miss Eva Doting
Department of Environmental Science, Aarhus University
Frederiksborgvej 399, PO Box 358, DK-4000 Roskilde, Denmark
evdo@envs.au.dk

Miss Devon Dunmire
Atmospheric and Ocianic Sciences, University of Colorado Boulder
311 UCB, Boulder, CO 80309-0311, USA
devon.dunmire@colorado.edu

Mr Kaian Fernandes
Technical University of Madrid
GSNCI, Universidad Politécnica de Madrid, Av. Complutense, 30. ES-28040 Madrid, Spain
k.fernandes@upm.es

Dr Javier Fernandez-Calleja
Associate Professor, Department of Physics, University of Oviedo
Campus de Llamaquique, Calle Federico García Lorca 18. ES-33007 Oviedo, Spain
jfcalleja@uniovi.es

Miss Rebecca Fletcher
Department of Geography and Environment
121 Geography and Environment, School of Geosciences, St Mary's Building, Elphinstone Road, Aberdeen AB24 3UF, UK
r02rf19@abdn.ac.uk

Mr Steven Franke
Division of Geosciences/Glaciology, Alfred Wegener Institute/Helmholtz Centre for Polar and Marine Science
Room D-3010 , Alfred-Wegener-Institut, Am Alten Hafen 26, DE-27568 Bremerhaven, Germany)
stvnfrnk@posteo.de

Mr Rodrigo Gomez Fell
Department of Earth and Environment, University of Canterbury
Beatrice Tinsley Building (Level 2), University of Canterbury, Private Bag 4800, Christchurch NZ-8140, New Zealand
rodrigo.gomezfell@pg.canterbury.ac.nz

Mr Juan Pablo Fuchs Arce
Institute of Hydraulics and Hydrology, Higher University of San Andrés
Campus Universitario Universidad Mayor de San Andrés, Calle 29, Cota Cota, NNAA Ciudad La Paz, La Paz, Bolivia

Mr Supratim Guha
Indian Institute of Technology Ropar
Nangal Road, Rupnagar, IN-140001 Punjab, India
supratim.guha2010@gmail.com

Miss Lena Uldal Hansen
Department of Geology, Lund University
Sölvegatan 12, SE-223 62 Lund, Sweden
lena.uldal_hansen@geol.lu.se

Miss Samantha Hordyk
Department of Physics, Reed College
3203 SE Woodstock Boulevard,
Portland, OR, 97202-8199 USA
samhordyk@reed.edu

Miss Christine Indrigo
Department of Geography and Environmental Management, University of Waterloo
Environment 1 (EV1), room 311,
200 University Avenue West, Waterloo, ON, N2L 3G1 Canada
cindrigo@uwaterloo.ca

Mr Enaut Izagirre
Department of Geodynamics, University of the Basque Country
UPV/EHU, Barrio Sarriena s/n, ES-48940 Leioa, Bizkaia, Spain
enaut.izaguirre@ehu.eus

Dr Nicole Jeffery
Los Alamos National Laboratory
P.O. Box 1663, Los Alamos, NM 87545, USA
njeffery@lanl.gov

Dr Theo Jenk
Paul Scherrer Institut
Forschungsstrasse 111, CH-5232 Villigen PSI, Switzerland
theo.jenk@psi.ch

Dr Guillaume Jouvet
Department of Geography, University of Zürich, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland
guillaume.jouvet@geo.uzh.ch

Mr Kamil Kachniarz
Centre for Polar Studies, University of Silesia
Faculty of Natural Sciences, University of Silesia, 60 Będzińska Street, PL-41-200 Sosnowiec, Poland
kachniarz.kamil@gmail.com

Mr Alexandros Kanetakis
School of Engineering, Newcastle University
Merz Court, Newcastle University, Newcastle upon Tyne, NE1 7RU, UK
a.kanetakis2@newcastle.ac.uk

Mr Johannes Landmann
Laboratory of Hydraulics, Hydrology and Glaciology (VAW), ETH-Zürich
HIA D 54.2, Hönggerbergring 26 CH-8093 Zürich, Switzerland
j_landmann@gmx.de

Dr Ivan Lavrentiev
Institute of Geography, Russian Academy of Sciences
Staromonetnyy Pereulok, 29, RU-119017 Moskva, Russia
lavrentiev@igras.ru

Mr Ian Lee
Center for Machine Learning and Applications, The Pennsylvania State University
School of Electrical Engineering and Computer Science, The Pennsylvania State University,
207 Electrical Engineering West,
University Park, PA 16802, USA
irl5041@psu.edu

Dr Jiule Li
Institute of Tibetan Plateau Research, Chinese Academy of Sciences
No. 16 Lincui Road, Chaoyang District,
Beijing 100101, P.R. China
jlli@itpcas.ac.cn

Ms Julia Liu
Department of Geosciences, Boise State University
1910 University Dr. MS 1535,
Boise, ID 83725-1535, USA
jukesliu@u.boisestate.edu

Dr Lai Bun Lok
Department of Engineering, Lancaster University
New Engineering Building, Lancaster University, Gillow Ave, Bailrigg, Lancaster LA1 4YW, UK
l.lok@lancaster.ac.uk

Mr Ryan Lunenburg
School of Geography and Environmental Sciences, Ulster University
Cromore Road, Coleraine, County Londonderry
BT52 1SA, UK
lunenburg-r@ulster.ac.uk

Mrs Michaela Mühl
Oeschger Centre for Climate Change Research, University of Bern
3rd floor WEST, Hochschulstrasse 4,
CH-3012 Bern, Switzerland
michaela_muehl@gmx.de

Mr José Manuel Muñoz
Technical University of Madrid
GSNCI, Universidad Politécnica de Madrid, Av. Complutense, 30. ES-28040 Madrid, Spain
jm.munoz@upm.es

Andrew Nolan
Department of Earth Sciences, Simon Fraser University
Technology and Science Complex 1, Burnaby, BC, V5A 1S6 Canada
anolan@sfu.ca

Mr Chris Pierce
Department of Earth Sciences, Montana State University
PO Box 173480, Bozeman, MT 59717-3480, USA
christopherpierce3@montana.edu

Mr Michael Shahin
Glaciology and Remote Sensing Laboratory, University of Kansas
Ritchie Hall, Earth, Energy & Environment Center, 1414 Naismith Drive, Room 254, Lawrence, KS 66045-7575, USA
shahinmg@ku.edu

Mr Paul Summers
Department of Geophysics, Stanford University
397 Panama Mall, Mitchell Building, 3rd Floor, Stanford University, Stanford, CA 94305-2215, USA
psummers@stanford.edu

Mr Tryggvi Unnsteinsson
Department of Earth Sciences, Simon Fraser University
Technology and Science Complex 1, Burnaby, BC, V5A 1S6 Canada
tunnstei@sfu.ca

Mr Baptiste Vandecrux
Geological Survey of Denmark and Greenland
Oester Voldgade 10, DK-1350 Copenhagen K, Denmark
b.vandecrux@gmail.com

Dr Saurabh Vijay
Byrd Polar and Climate Research Center, The Ohio State University
108 Scott Hall, 1090 Carmack Rd, Columbus, OH 4321, USA
saurabhvergia@gmail.com

Dr Mo Wang
Institute of Tibetan Plateau Research, Chinese Academy of Sciences
No. 16 Lincui Road, Chaoyang District, Beijing 100101, P.R. China
wangmo@itpcas.ac.cn

Ms Greta Wells
Department of Geography and the Environment , University of Texas at Austin
305 E. 23rd Street, A3100, RLP 3.306, Austin, TX 78712, USA
ghwells@utexas.edu

Dr Xiaoxin Yang
Institute of Tibetan Plateau Research, Chinese Academy of Sciences
No. 16 Lincui Road, Chaoyang District, Beijing 100101, P.R. China
xxy@itpcas.ac.cn

Miss Ruitang Yang
State Key Laboratory of Cryosphere Sciences
Chinese Academy of Sciences
Donggang West Road 320, Lanzhou, Gansu, 730000 P.R. China
yrt@lzb.ac.cn

Dr Chao You
Institute of Tibetan Plateau Research, Chinese Academy of Sciences
No. 16 Lincui Road, Chaoyang District, Beijing 100101, P.R. China
youchao@itpcas.ac.cn

Professor Wusheng Yu
Institute of Tibetan Plateau Research, Chinese Academy of Sciences
No. 16 Lincui Road, Chaoyang District, Beijing 100101, P.R. China
yuws@itpcas.ac.cn

Dr Huabiao Zhao
Institute of Tibetan Plateau Research, Chinese Academy of Sciences
No. 16 Lincui Road, Chaoyang District, Beijing 100101, P.R. China
zhaohb@itpcas.ac.cn

Mr Tobias Zolles
Department of Earth Science, University of Bergen
Postboks 7803, NO-5020 Bergen, Norway
tobias.zolles@uib.no

International Glaciological Society

Secretary General M.M. Magnússon

	Council Members		Concurrent service on Council, from
President	F. Navarro	2017–2020	2017
Vice-Presidents	G. Flowers	2018–2021	2014
	C. Hulbe	2019–2022	2018
	*J. Stroeve	2017–2020	2017
Immediate Past President	D.R. MacAyeal	2017–2020	2010
Treasurer	*A.A. Leeson	2018–2021	2018
Elected Members	*M. Błaszcuk	2019–2022	2019
	*K. Fujita	2017–2020	2017
	*A. Glazovskiy	2018–2021	2018
	*M.E. Hansson	2019–2022	2019
	R. Hock	2018–2021	2018
	*M. Huss	2019–2022	2019
	*I. Das	2019–2022	2019
	Kang Schichang	2018–2021	2015
	*N.B. Karlsson	2017–2020	2017
	*S. MacDonell	2018–2021	2018
	*D.M. Schroeder	2019–2022	2019
	*A. Treverrow	2017–2020	2017
Coopted Members	R. Bingham		
	G. Leysinger Vieli		

*First term of service on the Council

IGS Committees

Awards	I. Allison (Chairman)
Nominations	D.R. MacAyeal (Chairman)
Publications	G. Flowers (Chairman)

Correspondents

Australia	P. Heil	Japan	S. Sugiyama, K. Nishimura
Argentina	J.P. Milana, S. Marinsek	Netherlands	J. Oerlemans
Austria	E. Schlosser	New Zealand	H. Purdie
Belgium	J.-L. Tison	Norway	J.C. Kohler
Brazil	J. Simões	Poland	W. Dobinski
Canada	H. Jiskoot	Russia	V.N. Mikhalenko
Chile	A. Rivera	Spain	F.J. Navarro
China	Yao Tandong	Sweden	R. Petersson
Denmark	A.P. Ahlstrøm	Switzerland	F. Paul
Finland	T. Vihma	UK	B.P. Hubbard
France	C. Ritz	USA (Eastern)	T. Neumann
Germany	O. Eisen	USA (Western)	H.B. Conway and E.D. Waddington
Iceland	Þ. Þorsteinsson		
Italy	C. Smiraglia	USA (Alaska)	M.A. Nolan

Seligman Crystal

1963 G. Seligman	1989 H. Oeschger	2001 G.K.C. Clarke
1967 H. Bader	1989 W.F. Weeks	2003 K. Hutter
1969 J.F. Nye	1990 C.R. Bentley	2005 R.B. Alley
1972 J.W. Glen	1990 A. Higashi	2007 L.G. Thompson
1972 B.L. Hansen	1992 H. Röthlisberger	2009 P.A. Mayewski
1974 S. Evans	1993 L. Lliboutry	2011 A. Iken
1976 W. Dansgaard	1995 A.J. Gow	2012 D.E. Sugden
1977 W.B. Kamb	1996 W.F. Budd	2013 P. Duval
1982 M. de Quervain	1997 S.J. Johnsen	2019 R. Hindmarsh
1983 W.O. Field	1998 C. Lorius	2019 D.R. MacAyeal
1983 J. Weertman	1999 C.F. Raymond	
1985 M.F. Meier	2000 S.C. Colbeck	
1986 G. de Q. Robin	2001 G.S. Boulton	

Honorary Members

G.K.C. Clarke	J.W. Glen
V.M. Kotlyakov	G. Østrem
G. Wakahama	Yang Zhenniang

Richardson Medal

1993 H. Richardson	2013 J.W. Glen
1997 D.R. MacAyeal	2013 A. Weidick
1998 G.K.C. Clarke	2016 T. Chinn
1999 J.A. Heap	2016 E.M. Morris
2003 C.S.L. Ommanney	2017 J.M. Palais
2010 T.H. Jacka	2019 J. Oerlemans
2012 W.S.B. Paterson	

The Society is registered as a charity in the United Kingdom with the Charity Commissioners – No. 23104

International Glaciological Society

High Cross, Madingley Road
Cambridge CB3 0ET, UK

MEMBERSHIP

Membership is open to all individuals who have a scientific, practical or general interest in any aspect of snow and ice and benefits include online access to the *Journal* and *Annals of Glaciology* and *ICE*. To join please see our website at www.igsoc.org/membership.

ANNUAL MEMBERSHIP FEE 2020

	Sterling
Ordinary members	£52
Supporting members	£277
Contributing members	£137
Retired/partner members	£29
Student members (under 30 years or studying for PhD/MSc)	£26

Payment may be made on line using MasterCard, AmEx or VISA/Delta.

ICE

Editor: M.M. Magnússon (Secretary General)

This news bulletin is available to members of the International Glaciological Society and is published online three times a year. Members can purchase hard copies at discounted rates. Contributions should be sent to your National Correspondent or to the Secretary General, International Glaciological Society, High Cross, Madingley Road, Cambridge CB3 0ET, UK.

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

Sterling £50.00

All enquiries about the International Glaciological Society should be addressed to:
Secretary General, International Glaciological Society, High Cross,
Madingley Road, Cambridge CB3 0ET, UK
Tel: +44 (1223) 355974 Fax: +44 (1223) 358334
E-mail: igsoc@igsoc.org
www.igsoc.org