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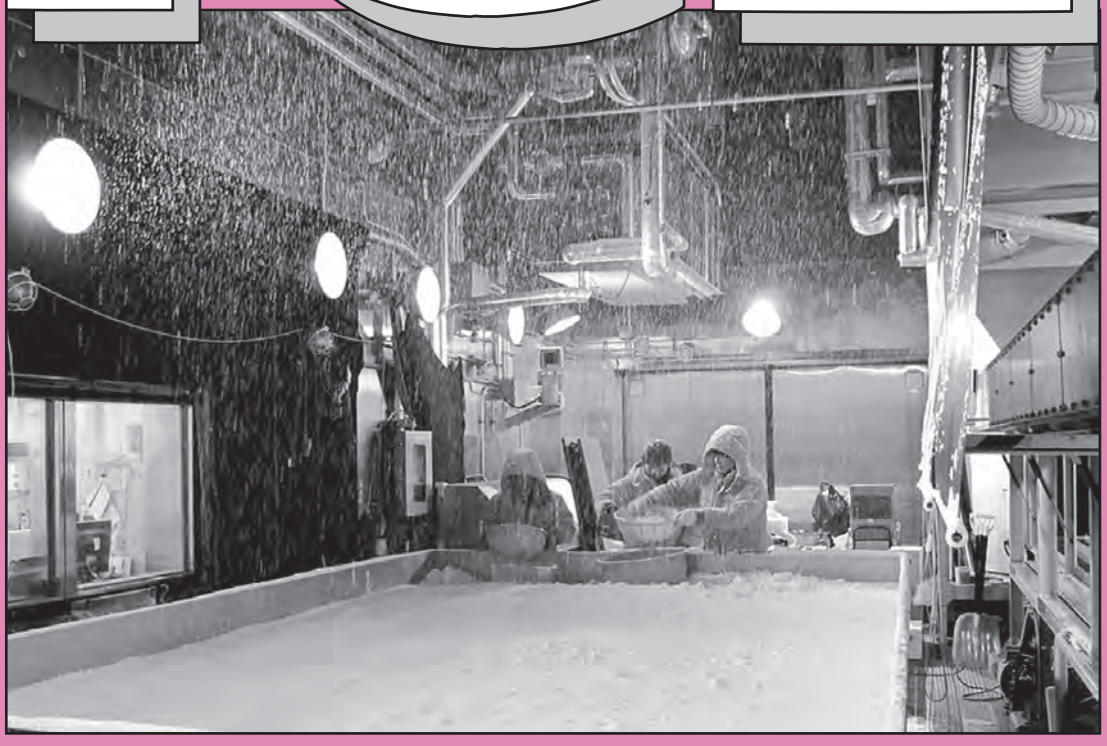

NEWS BULLETIN OF THE INTERNATIONAL GLACIOLOGICAL SOCIETY

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Cover picture: Cryospheric environment simulator in operation at Shinjo Cryospheric Environment Laboratory, Japanese National Research Institute for Earth Science and Disaster Resilience. Photo by G. Okawa.

From the Editor

Dear IGS member

Welcome to this double issue of *ICE*. It contains a lot of interesting articles and information which we trust you will enjoy. In this editorial I would like to discuss the IGS Awards. As you know the IGS has three awards, the Seligman Crystal, the Richardson Medal and Honorary Lifetime Membership. All of these are awarded on an irregular basis dependent on what nominations we receive. The IGS has a permanent committee, the Awards Committee, that reviews the nominations and makes recommendations to the IGS Council. When the immediate past Chair of the Awards Committee, Martyn Tranter, stepped down, Council decided to take the opportunity to review the whole awards procedure.

The IGS Council appointed Lora Koenig as the new Chair of the Awards Committee and she promptly set about reorganizing things. The membership of the committee was revised as it is important to bring fresh blood into it on a regular basis. The committee now consists of the following IGS members.

- Chair: Lora Koenig, appointed for three years (2016–19)
- Regular members, appointed for one year at a time: currently Regine Hock, Elisabeth Isaksson, Shelley MacDonell, Kouichi Nishimura, Dirk Notz and Martin Sharp.
- Ex-officio members are the IGS President and Secretary General. Contact details for all members are on the IGS website.

The first task of the new committee has been to clarify what the awards are for. A new description has been drafted and will be published on the IGS website very soon. The committee has set down a timeline as to when nominations should be submitted by. The first recommendation the committee made to the IGS Council was to award Julie Palais the Richardson Medal 'for insightful and steadfast service to the US and international glaciological and ice core science communities by enabling discoveries that have impacted the course of climate science and enlightened understanding of the important role of glaciology and the polar regions in global climate change'.

The committee is also looking at how to expand the IGS awards and what we need to do to make them more 'visible'. But I will leave further explanations to the new Chair, Lora Koenig, as she is planning to write a 'report' on the committee and its future procedures for the next issue of *ICE*.

Magnús Már Magnússon
Secretary General

Recent work

Japan

ALPINE GLACIERS

Studies on glacier biology
In order to evaluate the impact of recent climate warming on glacier ecosystems, biological studies on glaciers were conducted in central Asia, Siberia, Kenya, Alaska, Svalbard and Greenland by a group from Chiba University and the National Institute of Polar Research. Monitoring of the microbial community and geochemistry has been carried out every August on Urumqi Glacier No.1 in China in collaboration with the Tienshan Glaciological Station of the Chinese Academy of science, and has been now ongoing for 10 years in 2016. Cryoconite and the snow algal community and their effect on surface albedo were investigated on Svalbard glaciers in collaboration with Aberystwyth University, UK. They were further investigated on Qaanaaq Ice Cap in northwest Greenland to understand the biological darkening process of the glacier surface, as a part of the SIGMA and GRENE projects.
Nozomu Takeuchi (Chiba University, ntakeuch@faculty.chiba-u.jp)

Dynamics and ice–water interaction of calving glaciers in the Southern Patagonian Icefield
Lake and ocean terminating glaciers in the Patagonian Icefield are retreating and thinning under the influence of ice–water interactions at the calving termini. To quantify the changes in the calving glaciers and understand the mechanism driving the glacier changes, field and satellite-based observations are carried out in the Southern Patagonian Icefield. Satellite data are analysed to measure ice speed and frontal positions of major calving glaciers since the 1980s. More detailed analyses are performed on Glaciar Perito Moreno to investigate frontal ablation. Field researches are carried out near the termini of Glaciar Perito Moreno, Upsala and Viedma. Field work includes measurements of ice-flow speed, lake-water temperature, turbidity and bathymetry. The focus of recent study is glacier–lake interaction at Glaciar Grey, where subaqueous ice geometry is surveyed with a side-scan sonar and lake properties are monitored with a mooring system. These studies are performed in collaboration with the Glacier Interpretive Center, El Calafate, Argentina, and the Austral University and University of Magallanes, Chile. The projects are funded by JSPS Grants-in-Aid for Scientific Research (KAKENHI).
Shin Sugiyama (Institute of Low Temperature Science, Hokkaido University, sugishin@lowtem.hokudai.ac.jp)

Glacier inventory in High Mountain Asia
We completed the Landsat-based GAMDAM Glacier Inventory covering High Mountain Asia. Part of the inventory is incorporated in the latest version of the Randolph Glacier Inventory covering the globe. The GAMDAM Glacier Inventory is used to estimate precipitation regime at high elevation and to analyse the heterogeneity of the mass balance sensitivity of Asian glaciers. We also generated an ALOS-based glacier inventory covering the Himalaya of Bhutan and eastern Nepal, in which debris-covered areas and potential debris supply slopes are identified. The ALOS-based inventory is used to analyse the topographic effect on the formation of debris-covered glaciers and change in glacier area in eastern Nepal.
Akiko Sakai (Nagoya University, shakai@nagoya-u.jp)

Himalayan glacial lakes and glaciers
A project investigating glacial lakes in the Bhutan Himalaya was conducted for the period 2009–12. During the project, bathymetries of dozens of glacial lakes were surveyed. Hazard potential for more than 2300 glacial lakes for the entire Himalayas was assessed with moraine stability and potential flood volume. Mass-balance observation of Ganju La Glacier, a small debris-free glacier in the Bhutan Himalaya, was conducted between 2011 and 2014, and then in-situ decadal mass balance (2003–14) is obtained for the first time in Bhutan. To understand the mass balance process of debris-covered glaciers, interaction between a calving glacier and its proglacial lake, and precipitation regime at high elevation up to 6000 m a.s.l., a long-term observation has newly been launched for Trambau Glacier, a debris-covered glacier in the Rolwaling region of the Nepal Himalaya. Prior to the observation, we established and tested a model to calculate the mass balance and runoff of a debris-covered glacier. As a proxy of debris thickness, which affects ice melting underneath, thermal resistance (defined as debris thickness divided by thermal conductivity of debris) is estimated from remotely sensed surface temperature and albedo with reanalysis climate data.
Koji Fujita (Nagoya University, cozy@nagoya-u.jp)

Co-seismic avalanches and rock falls induced by the 2015 Gorkha earthquake destroyed the village of Langtang in Nepal. To reveal the volume and structure of the deposit covering the village, we conducted an intensive in-situ observation in October 2015. Multi-temporal digital elevation models generated from photographs taken by a helicopter and unmanned aerial vehicles revealed the deposit volumes of the event, which is consistent with those estimated from observed 'unusual' winter snow at a high-elevation glacier. We suppose that the anomalous winter snowfall may have amplified the disastrous effects induced by the earthquake.

Koji Fujita (Nagoya University, cozy@nagoya-u.jp)

Glacier lake hazards and associated workshop in Tien Shan

The mountain research group of Niigata University has investigated glacial and periglacial environments in central Asia, the Indian Himalaya and the northern Japanese Alps. Glacial lakes in the central Asian mountains are relatively small, compared with the huge lakes (0.1–1 km^2) distributed in the eastern Himalaya. However, several large drainages from these small glacial lakes have caused severe damage in the central Asian mountains. Previous studies of large drainages from glacier lakes in the central Asian mountains have found no correlation between the scale of damage (disaster) and the size of the glacial lake (hazard). To share our knowledge of the current situation, we arranged a glacier lake workshop in Domkhar (2012), Stok (2014) and Gya (2015) villages in the Ladakh region, India, and Jerui (2015), a village in Kyrgyzstan. Many local residents and governmental employees discussed countermeasures for floods in the workshop.

Chiyuki Narama (Niigata University, narama@env.sc.niigata-u.ac.jp)

Identifying three newly active glaciers in the northern Japanese Alps, central Japan

The research group of Tateyama Caldera Sabo Museum identified three active glaciers (Sannomado, Komado and Gozenzawa glaciers) in the northern Japanese Alps in 2012. The research group studied the surface flow velocity and ice thickness of the other three perennial snow patches in the northern Japanese Alps from 2011–16. The Kakunezato and the Ikenotan perennial snow patches have large ice masses (>30 m thick and 800–900 m long). They measured the surface flow velocity and found that both the ice masses had flowed over 10 cm per month in the autumn of 2013 and 2015. Hence, they regard both the snow patches as active glaciers. The Kuranosuke perennial snow patch too has a large ice mass (25 m thick and 350 m long). They measured the surface flow velocity and found that the ice mass had flowed slightly (2–3 cm a^{-1}) during the period between the autumn of 2011 and the autumn of 2016. Hence, they regard this snow patch also as an active glacier.

Kotaro Fukui (Tateyama Caldera Sabo Museum, fukui@tatecal.or.jp)

Debris on glaciers

Distribution of debris on glaciers is an important component to accurately estimate response of glaciers to climate change, since it alters the reflectivity of solar radiation and conductive heat flux on the ice surface. However, measurement of the spatial distribution of the thickness and thermal properties of glacier debris has been limited at local scales mainly conducted by field measurements. Recently, as a part of a new high-resolution land-surface model development project led by the University of Tokyo, a dataset of the thermal resistance of debris on glaciers at 90 m resolution has been developed from multi-temporal satellite images, satellite-derived radiation and climate data on a global scale excluding Greenland, Antarctica and part of the Arctic. The newly developed global distribution of the thermal resistance of debris on glaciers can be incorporated into glacier models, and thus provides a solid basis for evaluating the effects of debris on glacier melting. The database is now planned to be opened to the public.

Yukiko Hirabayashi (University of Tokyo, hyukiko@rainbow.iis.u-tokyo.ac.jp)

Tropical glaciers and water resource availability in the Andes, Bolivia

We have evaluated tropical glacier change and availability of water resources since 2010, because glacial meltwater is one of the stable water resources in the Andes. The study area is Tuni reservoir catchment, which is partially covered by several glaciers: Tuni glacier, Condoriri glacier and Huayna Potosi glacier. They are located in the upper stream region of an urban area and supply around 30% of the water used in the urban area. In order to understand the impact of glacial change on water resource availability, we conducted (1) estimation of long-term change in glacial area using satellite remote sensing, (2) establishment of hydrological and meteorological monitoring network in this catchment, (3) development of a glacier melt and runoff model and (4) comparison between potential water resources in the study area and water demand in the urban area. These activities are a collaboration with the Institute of Hydrology and Hydraulics, Universidad Mayor de San Andrés (IHH-UMSA), Bolivia. Results suggest

that the glacial area has decreased by around 40% over the past three decades and that the annual decrease was especially larger during El Niño events. Moreover, they suggest that the water supply in the urban area is vulnerable to glacier retreat and the problem becomes more serious during extreme dry periods.
Yoshihiro Asaoka (Nihon University, asaoka@civil.ce.nihon-u.ac.jp)

POLAR GLACIOLOGY

SIGMA Project
Field observations on the Greenland Ice Sheet (GIS) were carried out by the project 'Snow Impurity and Glacial Microbe effects on the abrupt warming in the Arctic' (SIGMA) during 2011–15. The goal of this study is to clarify the quantitative effects of snow impurities and glacial microbes on the recently warming Arctic, especially on GIS. The main activity area is northwest Greenland around Qaanaaq, where we established three automatic weather stations at SIGMA-A (1490 m), -B (940 m) and -D (2100 m). From the glaciological, meteorological and biological observations performed in this area, it was found that the contribution to albedo reduction in accumulation area of snow impurities such as black carbon (BC) is smaller than that of snow grain growth. A drastic surface melting event in July 2012 was accelerated by downward longwave radiation from low cloud. In the ablation area, glacial microbes were contained in surface impurities and contribute remarkably to the albedo reduction. Satellite remote sensing confirmed that the cause of darkening of the ice-sheet surface after 2000 is snow grain growth in the accumulation area and the expansion of bare ice and dark areas including glacial microbes in the ablation area. We also drilled a 223 m ice core at SIGMA-D and analysed the BC concentrations since 1660, which show a peak around 1920–30 several times higher than the present value. The follow-on project SIGMA-II (2016–20) is currently being implemented in the same area on GIS.
Teruo Aoki (Okayama University, teaoki@okayama-u.ac.jp)

Japanese Arctic research projects: from GRENE Arctic (2011–16) to ArCS (2015–20)
The Japanese GRENE Arctic Climate Change Research Project, 'Rapid Change of the Arctic Climate System and its Global Influences' was carried out in 2011–16. This project focused strategic targets on studies of Arctic warming amplification and the role of the Arctic system for global climate and future change, evaluation of the impacts of Arctic change on weather and climate in Japan, marine ecosystems and fisheries in the Arctic, and projection of sea ice distribution and Arctic sea routes, and completed in 2016. http://www.nipr.ac.jp/grene/e/index.html.

As a new Japanese Arctic research project, Arctic Challenge for Sustainability (ArCS) was started in 2015 to provide opportunities for research co-designing with domestic and international stakeholders, with the ideas of social and cultural studies, for future bridging industry and the Arctic. ArCS has three aspects: expansion of research bases/stations, sending experts and young scientists, and international research collaborations. ArCS carries out eight international collaborative research programmes: (1) Predictability of weather and sea-ice forecasts linked with user engagement, (2) Variations in the ice sheet, glaciers, ocean and environment in the Greenland region, (3) Atmospheric climate forcers in the Arctic, (4) Arctic Ocean environmental changes, (5) Arctic climate predictability, (6) Response and biodiversity status of the Arctic ecosystems under environmental change, (7) People and community in the Arctic and (8) Arctic Data archive System (ADS). http://www.arcs-pro.jp/en/index.html

Hiroyuki Enomoto (National Institute of Polar Research, enomoto.hiroyuki@nipr.ac.jp)

Glacier changes and interaction with the ocean in northwestern Greenland
To quantify recent mass loss of glaciers and ice caps in northwestern Greenland, we studied ice caps and outlet glaciers in the Qaanaaq region as a part of a Japanese integrated Arctic research project, GRENE Arctic Climate Change Research Project. Field and satellite observations were performed to study the ice-mass loss and the driving mechanism of glacier changes. We also investigated processes occurring near the front of outlet glaciers to better understand ice–ocean interactions. Our study includes mass balance monitoring of Qaanaaq Ice Cap since 2012, intensive field observations at Bowdoin Glacier and ocean measurements at Bowdoin Fjord since 2013. Since 2016, the project is carried out under the framework of a new Arctic research project ArCS (Arctic Challenge for Sustainability Project). In the new ArCS project, we focus on the ice–ocean interaction and extend our study to the changing ocean environment and its consequenced for human activity in the Qaanaaq region. The GRENE and ArCS projects are funded by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT).
Shin Sugiyama (Institute of Low Temperature Science, Hokkaido University, sugishin@lowtem.hokudai.ac.jp)

Hot-water drilling at Langhovde Glacier, East Antarctica

To study the subglacial environment of an Antarctic outlet glacier, we performed measurements through boreholes drilled in the grounding zone of Langhovde Glacier. The glacier is located at 69°12′ S, 39°48' E near the Japanese research station Syowa. In the 2011/12 austral summer season, we operated a hot-water system to drill through the floating part of the glacier within a few hundred meters of the grounding line. Subshelf ocean measurements indicated that warm coastal water is actively transported to the grounding zone, and is efficiently melting the floating ice bottom. A video camera suspended in the boreholes captured crustaceans and krill beneath the grounding zone. A second drilling campaign is scheduled for the 2017/18 summer season to install mooring sensors for more detailed and longer measurements beneath the ice shelf. The new project is a part of ROBOTICA (Research of Ocean–ice BOundary InTeraction and Change around Antarctica) (PI: Aoki Shigeru, Hokkaido University), one of the core programmes of the Japanese Antarctic Research Expedition.

Shin Sugiyama (Institute of Low Temperature Science, Hokkaido University, sugishin@lowtem.hokudai.ac.jp)

Ice-core paleoclimate in East Antarctica

To reconstruct paleoenvironmental changes in a coastal region over more than a millennium, intermediate ice drilling and other activities were conducted at the H128 site (69.4° S, 41.5° E), located along the traverse route from the Syowa Station to Dome Fuji durin the 2015/16 austral summer season. The activities included 261 m ice coring, firn air sampling, pit observation and installation of an automatic weather station. The ice core will cover more than 1000 years, and has been measured for dielectric profiling. Various measurements will be conducted, including water isotopes, major ions, aerosol particles, trace elements, physical properties and gases. In the next phases of Antarctic glaciological research, the National Institute of Polar Research, together with the Dome Fuji Ice Core Consortium, plans inland activities related to the next deep ice coring in the vicinity of Dome Fuji, in order to obtain a deep ice core significantly older than 800 000 years. It is also a contribution to the International Partnership in Ice Core Sciences (IPICS) 'oldest ice core' project. During the current 6-year program (JARE Phase IX), investigations of glaciological conditions (ice-sheet surface conditions, englacial conditions and subglacial conditions) in the candidate areas, some of which are planned as international collaborations, will be conducted to identify the best coring site.

Kenji Kawamura (National Institute of Polar Research, kawamura@nipr.ac.jp)

Shallow ice core project on the Southeastern Dome, Greenland

The Southeastern Greenland Dome (SE Dome) has both a high elevation and a high accumulation rate, which are suitable properties for reconstructing past environmental changes with a high temporal resolution. We measured a 90 m long ice core drilled from the SE Dome region in 2015 and obtained a distinct densification mechanism until close-off and records of aerosol fluxes from 1957–2014.

Yoshinori Iizuka (Hokkaido University, iizuka@lowtem.hokudai.ac.jp)

Ice sheet and climate modelling studies

Two large-scale numerical ice-sheet models are being actively developed in Japan: SICOPOLIS (SImulation COde for POLythermal Ice Sheets; mainly at ILTS, Hokkaido University) and IcIES (Ice-sheet Model for Integrated Earth-system Studies; mainly at AORI, University of Tokyo and JAMSTEC). Both are shallow-ice/shallow-shelf models that focus mainly on the long-term evolution of ice sheets in the climate system. They have been applied to various problems for Greenland, Antarctica and the past Northern Hemisphere ice sheets, as well as to idealized process studies. Ice-sheet–climate dynamics for various time scales from the past to future are studied combining these ice sheet models and global climate models, mainly MIROC AOGCM (Model for Interdisciplinary Research on Climate Atmosphere and Ocean General Circulation Model). The work is applied to investigate the mechanism of the 100 ka ice-age cycle, the mechanism of ice-sheet changes on each continent and the irreversibility of ice sheets.

Ayako Abe-Ouchi (Atmosphere and Ocean Research Institute, University of Tokyo, abeouchi@aori.u-tokyo.ac.jp), Ralf Greve (Institute of Low Temperature Science, Hokkaido University), Fuyuki Saito (Japan Agency for Marine–Earth Science and Technology)

SNOW AND ICE PHYSICS

Clathrate hydrates

Clathrate hydrates are ice-like crystalline substances, in which guest molecules are trapped in hydrogen-bonded water frameworks. Natural gas hydrate (methane hydrate) distributed in oceanic sediments or permafrost environment is one of the representative clathrate hydrates. Natural gas hydrate traps huge amounts of methane in the crystals. Japan, the USA, China and other countries are expecting methane hydrate to be

a new natural gas resource and have conducted surveys on the distribution of offshore methane hydrate and research and development for natural gas recovery from methane hydrate layers. Gas hydrate can be formed by contact between ice/water and gas, so gas hydrates are expected to be applied as gas storage or gas separation materials. Although a better understanding of hydrate formation/dissociation is required for application technologies using gas hydrates, the formation/dissociation process of gas hydrates is complicated. Many research projects to elucidate its mechanism are being carried out in Japan. Recently, it was revealed that gas nanobubbles in water have a role of promoting nucleation of gas hydrates. As studies on gas hydrate dissociation, gas hydrates' metastable state, the so-called self-preservation phenomenon relating to ice formation during gas hydrate dissociation has been studied. Gas hydrates can be stored by self-preservation under even thermodynamically unstable conditions. Recent studies have revealed that morphology of ice on gas hydrate surface or internal structure of bulk gas hydrates are involved in the self-preservation phenomenon.
Masato KIDA (National Institute of Advanced Industrial Science and Technology (AIST), m.kida@aist.go.jp)

SNOW AND ICE CHEMISTRY

Chemical compositions of soluble particles in snow and ice
A system of ice sublimation at –50°C has been developed since 2009. This system extracts soluble micro-particles on a filter or metal plate from snow and ice without melting, so that we can identify the chemical compositions of the particles by using spectroscopy.
Yoshinori Iizuka (Hokkaido University, iizuka@lowtem.hokudai.ac.jp)

Chemical compositions and fractionations during formation of frost flowers on sea ice
Frost flowers (FF) are formed on new and thin sea ice by water vapor sublimation at low temperatures. Recent studies have shown that FF is a major source of sea salt aerosols in the polar regions and could affect the interpretations of ice core studies, and that FF played a role as a releaser of halogens, which could decompose ozone in the troposphere. We conducted sampling and observation of frost flowers around Siorapaluk, northwestern Greenland, from February to March 2014. We measured the water-soluble constituents of frost flower and brine. Concentration factors of constituents of frost flowers and brine relative to seawater were 1.14–3.67. Sea-salt enrichment of Mg^{2+}, K^{+}, Ca^{2+} and halogens (Cl^{-}, Br^{-} and I^{-}) in frost flowers was associated with sea-salt fractionation by precipitation of mirabilite and hydrohalite.
Sumito Matoba (Hokkaido University, matoba@pop.lowtem.hokudai.ac.jp)

Chemical compositions of the snow pits at Mt Tateyama, Japan
Measurements of the concentrations of major ions, formaldehyde (HCHO) and hydrogen peroxide (H_2O_2) in snow pits at Murododaira (36.6° N, 137.6° E, altitude 2450 m), Mt Tateyama, near the coast of the Japan Sea in central Japan, have been performed each spring. Snow cover more than 6 m thick is formed every April at Murododaira. The mean concentrations of $nssSO_4^{2-}$ and NO_3^{-} in the 2000s were higher than those in the 1990s. The highest mean concentration of $nssSO_4^{2-}$ was detected in 2007. The $nssCa^{2+}$ was usually high in the upper 2–3 m of snow deposited in spring when Asian dust is actively transported. The peaks of HCHO corresponded well with the high $nssSO_4^{2-}$ layers above a 3 m depth. HCHO with sulphate particles may be transported to a mountainous site in central Japan from the Asian continent. Post-depositional modification of H_2O_2 is more significant than that of HCHO in snow in an alpine region.
Koichi Watanabe (Toyama Prefectural University, nabe@pu-toyama.ac.jp)

Chemical analysis of metal elements in polar ice cores
We have carried out an analysis of the total concentration (dissolved + particulate) of metal elements in ice cores and investigated the relationship between aerosol transport and climate and environmental change. The particulate matter contained in an ice core is decomposed by the microwave acid digestion method and the metals, including Al, Na, etc., are measured by ICPMS. The obtained data of total concentrations are analysed together with the concentrations of ion, dust, gas and oxygen isotopic ratio and possible causes of fluctuation in transport and source of aerosol accompanying the changes in Earth's climate and environment. We use Antarctic ice cores, including the Dome Fuji core, and Arctic ice cores obtained from Greenland. Analysis of the Dome Fuji deep ice core revealed that concentrations, fluxes and composition of aerosols vary with climate change over the past 720 000 years. Analytical results of the shallow core obtained from the southeastern Greenland ice sheet suggest not only evidence of global air pollution and volcanic eruption in the past 50 years but also a rapid increase in mineral aerosol in the coastal ice sheet in recent years.
Toshitaka Suzuki (Yamagata University, suzuki@sci.kj.yamagata-u.ac.jp)

METEOROLOGY AND HYDROLOGY

Arctic terrestrial models compared for validation, development and mutual understanding of modelling and field scientists

The GRENE-TEA model intercomparison project (GTMIP), initiated as a part of the 'Terrestrial Ecology in Arctic (TEA)' theme under the GRENE Arctic Climate Change project in Japan (2011–16; funded by MEXT) with 22 domestic and international models included (1) illustrated the similarities and differences among the models in physical (i.e. energy and water budget, seasonal snow pack, subsurface hydrological and thermal regimes) and biogeochemical (i.e. phenology, and carbon budget) simulations, (2) identified issues for future model development and (3) enhanced mutual understanding within and across modelling and field scientists. The project consists of two stages. The stage 1 simulations were conducted at four GRENE-TEA sites (Fairbanks, Alaska, USA; Kevo, Finland; Tiksi and Yakutsk, Siberia, Russia), and the observed meteorological data at each site were integrated with the ERA-Interim reanalysis data to create the common driving data for the sites (1980–2013). The circum-arctic stage 2 driving data were prepared from CMIP5 outputs (1850–2100. $0.5 \times 0.5^{\circ}$). The results show smaller inter-model variations in energy budget calculation than in water budget, whereas snow-pack differences (especially snow water equivalent or snow depth, and snow-melt date) are large among the models largely owing to complexity of the implemented snow physics (e.g. density and thermal conductivity evolution due to metamorphosis and/or compaction). These differences in snow pack influence the subsurface thermal regime to lead to larger variations in the coldest ground temperature than in the warmest, depth of the active layer (seasonally thawed upper soil), and presence/absence of permafrost.

Kazuyuki Saito (Japan Agency for Marine–Earth Science and Technology)

Research activities in Siberia

In order to understand the hydrological cycle in Siberia, Russia, Suzuki *et al.* (2016) analysed terrestrial water storage (TWS) in the Lena River Basin using satellite–gravimetric observations by the Gravity Recovery and Climate Experiment (GRACE). We examined the lag correlation between TWS values and annual runoff from the Lena River and found a strong linear relationship between river runoff for a given year and the TWS during November of the previous year. This relationship persisted throughout the winter until the following May. We also found a negative trend in TWS in the downstream portion of the Lena River Basin, which may be explained by increasing evapotranspiration associated with warming summer air temperatures. To investigate the large-scale hydrological cycle in Siberia, reanalysis data sets are necessary, but such available data are only atmospheric reanalysis data and do not include coupled atmosphere–land processes. Therefore, we cannot understand the way in which coupled atmosphere–land processes affect the hydrological cycle in Siberia using current reanalysis data. In order to overcome this problem, Suzuki et al. (2017) developed a strongly coupled atmosphere–land data assimilation system and tested it in snowy Siberia. We found that the error covariance and correlation between the atmosphere and the land are complex and are strongly dependent on both weather conditions and the land surface scheme, indicating a need for further investigation of the relevance of flow-dependent ensemble covariance in coupled systems. We also demonstrated that the use of coupled error covariance methods improves the efficiency of information transfer between the atmosphere and the land surface by allowing the well-observed atmosphere to influence land surface variables. Our next step is to carry out an extended analysis of different cross-component covariance structures at various times and locations and to assimilate real observations and examine the land-surface–atmosphere system through coupled data assimilation experiments.

Kazuyoshi Suzuki (Japan Agency for Marine–Earth Science and Technology, skazu@jamstec.go.jp)

BLOWING AND DRIFTING SNOW

Modelling and field observations of the spatiotemporal structure of drifting snow

Aeolian transport, typified by drifting snow and sandstorms, exhibits a spatially inhomogeneous structure and temporal intermittency in nature. To elucidate the non-stationary dynamics of drifting snow, we propose a new turbulent transport model coupling particle trajectory calculations and turbulence: the Large-eddy Simulation-based Lagrangian Snow Transport Model (LLAST). This model includes four important physical sub-processes in aeolian transport: (1) aerodynamic entrainment, (2) particle dynamics, (3) splash (particle-bed collision) and (4) wind modification. Numerical simulations using the LLAST model assume a static flat surface, which remains fixed during the simulation. The wind velocity field is formed by an upper wall moving at constant speed (5 m/s) at a height of 0.5 m. The LLAST model reproduces intermittent transport streaks extending in the predominant wind direction. To verify the simulation results, we began field observations of drifting snow at the Ishikari Blowing Snow Test Field

in Hokkaido (northern Japan) during last winter. We placed 15 snow particle counters (SPCs) and 16 ultrasonic anemometers perpendicular to the prevailing wind direction to obtain the horizontal wind structure and time variation. We performed a quantitative analysis of the resulting data to determine the relationship between turbulent structure and particle dynamics.

Detection of blowing snow using X-band multi-parameter radar

Blowing snow is characterized by localized occurrences and large variability over time. To mitigate damage caused by blowing snow, it must be detected spatially and in real time. To investigate the possibility of using X-band multi-parameter radar to detect blowing snow during snowfall, we conducted observations of blowing snow at the Ishikari Blowing Snow Test Field. These observations included the atmospheric conditions over the test field. By comparing surface and high-altitude snowfall observations, we found that the surface directly below 'heavy precipitation' observations by radar did not always receive a corresponding heavy snowfall. This result may be explained by the slow descent of snow particles, which are lighter than raindrops and more easily affected by lateral wind. The Civil Engineering Research Institute for Cold Regions will continue observations to further clarify the relationship between radar and surface snowfall observations.

Snow fence improvement

Snow fences are widely used in cold, snowy regions to prevent falling and drifting snow from covering roads. Land area is limited in Japan, such that snow fences are frequently installed at roadsides to control snow distribution. However, when the incident wind is oblique, or when the bottom clearance of the fence is narrowed by snow accumulation, snow fences can become ineffectual. To address these problems, the Civil Engineering Research Institute for Cold Regions has developed a snow fence similar to conventional snow fences in design and installation, but which fulfils its function even under conditions of oblique incident wind and accumulated snowfall.

Numerical simulation of blowing snow to model snow accretion

Snow accretion on electric wires due to snowfall or blowing snow can result in disconnections or short circuits. Snow accretion on buildings may cause human casualties or infrastructure damage (e.g. trains, cars or buildings) due to falling snow. Thus, forecasting snow accretion is important for the prevention of such accidents. In this study, we evaluated the application of numerical simulations of blowing snow to estimate snow accretion. We conducted wind tunnel experiments to investigate the relationship between the snow accretion ratio and the wind speed, turbulence and mass flux of blowing snow. We then used these results to develop a model of blowing incorporating snow accretion based on an Euler–Euler simulation (Reynolds-averaged Navier–Stokes equations coupled with a diffusion–convection model of snow transport). In a future study, we will compare simulation results with observations of snow accretion on actual structures.

A simple snow transport estimation method based on closed-circuit television road images

Snow transport models are commonly used to assess hazardous conditions that may result from snowdrifts on roads; however, it is difficult for a model to estimate snow transport based on meteorological data, due to the complexity of the onsite snow conditions. We propose a model for estimating snow transport based on the differential weighted intensity of power spectrum (DWIPS) method, using road images recorded by closed-circuit television (CCTV) cameras installed along roads. Snow transport models using DWIPS better reflect actual snow surface conditions due to the incorporation of onsite conditions. In Hokkaido, over 1300 CCTV cameras are already available. This model has the potential to contribute to effective countermeasures for hazardous winter road conditions.

SNOW AVALANCHES

Avalanche prediction and liquid water transport into snowpack

The transport of liquid water in snow affects snow stability and can cause wet snow avalanches. The water transport process is classified into two flow regimes – matrix flow and preferential flow. Matrix flow, empirically estimated from capillary pressure and hydraulic conductivity measurements, is used to develop the numerical water transport model, which is subsequently implemented into the SNOWPACK model. Recent laboratory experiments have shown that water entry suction is related to grain size and affects the formation of preferential flow. This result was utilized in developing a three-dimensional water transport model to reproduce preferential flow formation. Liquid water transport into layered snowpack was also studied through laboratory experiments and three-dimensional modelling. Furthermore, three-dimensional imaging using magnetic resonance imaging (MRI) and three-dimensional modelling is expected to provide useful data to improve the SNOWPACK model and lead to more accurate predictions of wet snow avalanches.

Hiroyuki Hirashima (National Research Institute for Earth Science and Disaster Resilience, hirasima@bosai.go.jp)

Full-scale snow avalanche experiment in Niseko
Large-scale, disaster-causing avalanches in Japan are generally quite rare. Therefore, full-scale but small avalanche experiments have been conducted in Niseko, a ski resort in Hokkaido. Although the altitude of the resort's summit is only about 1300 m a.s.l., the snow in the area is completely dry in the winter. Thus, we expect dry avalanches before March and wet ones during March. The relatively short vertical drop (maximum 100 m) at the test site was advantageous, as it enabled relatively easy access to the site. Moreover, it allowed for a closer look at the phenomenon along with the detailed investigation of avalanche structures and mechanisms. In the winter season of 2017, still and video cameras, including those mounted on UAVs; three seismographs; three infrasound microphones; a radiation thermometer; and accelerators were used to investigate the dynamics and internal structures of avalanches. Our research plans for the coming winter include further expansion of the study and the use of instruments such as a Doppler radar system.
Kouichi Nishimura (Nagoya University, knishi@nagoya-u.jp)

Snow avalanches in non-snowy areas induced by extratropical cyclones
In February 2014, heavy snowfall caused serious damage to the Kanto–Kohshin area in Japan, a region that typically receives little snow. The heavy snowfall was induced by two extratropical cyclones passing along the Pacific Ocean side of the Japanese islands. Observations of the accumulated snow particles revealed that the main snow type was columns and non-rimed plates, which is different from the snow types generally observed during winter monsoon snowfalls. Moreover, it has been suggested that the snow crystals had a lower angle of repose, indicating multiple occurrences of the avalanche along the same avalanche path. The influence of snow crystal shape brought by extratropical cyclones on avalanche release, as well as avalanche dynamics, is being investigated through avalanche surveys in non-snowy areas.
Yoichi ITO (National Research Institute for Earth Science and Disaster Resilience, y_ito@bosai.go.jp)

GROUND FREEZING

Impacts of wildfire on the permafrost soil
Wildfire affects the ground surface condition of permafrost due to its heat and the disappearance of vegetation; these may cause degradation of te permafrost. To understand variations of permafrost distribution and condition, and of thermal and water conditions in the active layer after severe wildfires, field observations have been carried out at the Kougarok site near Nome, Alaska, USA, since 2005.
Koichiro Harada (Miyagi University, haradak@myu.ac.jp)

Larch forest growth and ground freezing
In order to evaluate the influence of ground freezing on the growth of larch, a correlation analysis was conducted between tree-ring width and meteorological factors in Tokachi district, eastern Hokkaido. The results show that the changes of tree-ring width standardized have a correlation coefficient of 0.646. The 32-year series of TRI (Tree Ring Index) show a negative relation with the annual maximum frost depth with $r = -0.451$ and $p < 0.01$. The correlation with the freezing index was insignificant, while it shows a weak correlation (0.312, $p = 0.08$) with the annual maximum snow depth.
Kazuo Takeda (Obihiro University of Agriculture and Veterlnary Medicine, takeda3@obihiro.ac.jp)

Long-term monitoring of permafrost dynamics in Svalbard
Long-term monitoring of the dynamics of patterned ground (ice-wedge polygons, mudboils and hummocks) and a polar rock glacier is continuing in Svalbard, as well as UAV mapping of these periglacial features.
Norikazu Matsuoka (University of Tsukuba, matsuoka@geoenv.tsukuba.ac.jp)
Tatsuya Watanabe (Kitami University of Technology, twata@mail.kitami-it.ac.jp)

Periglacial slope processes in the Swiss Alps and Japanese Alps
A Swiss-Japanese collaboration called the UV-project has continued in an attempt to compare geomorphic dynamics between U-shaped valleys (Mattertal) in the Swiss Alps and V-shaped valleys (Oi river basin) in the Japanese Alps. A multi-method approach evaluates the long-term dynamics of valley-side slopes in both situations, including permafrost creep, frost weathering, rockfalls, landslides and debris flows.
Norikazu Matsuoka (University of Tsukuba, matsuoka@geoenv.tsukuba.ac.jp)

Thermokarst processes
Active layer and thermokarst monitoring at central Yakutia was conducted in eastern Siberia, Russia. Thermokarst development and ground subsidence rate in natural dry grassland and boreal forest damaged by insects were investigated by levelling land surface terrain and active layer thickness at Churapcha in central Yakutia. The annual subsidence ratio in the dry grassland was calculated ranging from 2.4–6.0 cm a^{-1} (average 3.8 ± 1.4 cm a^{-1}) during the 25 years since 1990. This subsiding ratio is comparable to thermokarst

depression formed at thermokarst lakes in Yukechi (7–12 cm a^{-1} 1992–2008).
Yoshihiro Iijima (Mie University, yiijima@bio.mie-u.ac.jp)

Mapping of permafrost temperature in Mongolia
In the summers 2015 and 2016 ground temperatures at 1 m depth were measured at multiple points in diverse geographical settings across Hovsgol, Khangai Altay Mountains, Mongolia. The data, together with the deeper ground temperatures monitored synchronously at more than 80 borehole sites, are used to map and characterize southern marginal permafrost of Eastern Siberia
Mamoru Ishikawa (Hokkaido University, mishi@ees.hokudai.ac.jp)

Borehole observations at Japanese permafrost
A 10 m deep borehole on the summit of Mt Fuji has been maintained. The borehole temperatures have been successfully monitored since the summer of 2011. Boreholes were newly drilled around the lower limit of permafrost in the Daisetsu Mountains. The 10 m deep borehole temperatures have been successfully monitored since 2015.
Atsush Ikeda (University of Tsukuba, aikeda@geoenv.tsukuba.ac.jp)

Toshio Sone (Hokkaido University, tsone@pop.lowtem.hokudai.ac.jp)

Database for ground temperature and frost depth in Japan
Although there numbers of active and inactive ground temperature measurements and frost depth monitoring have been conducted in Japan by various bodies, including governmental agencies and institutes as well as private companies, only a limited amount of data archive had been collected and organized for open access and use. Thus, domestic historical ground temperature and frost data has been mined and archived into an open-access database in recent years. Ground temperature data from seven meteorological stations has been newly added to the database.
Kazuyuki Saito (Japan Agency for Marine–Earth Science and Technology, ksaito@jamstec.go.jp)

Artificial ground freezing technique
Japan has considerable experiences of applying frozen ground technologies to civil works of neighboring constructions and tunnels, especially in the urban areas. The technologies use mainly artificially frozen grounds, the characteristics of which have been studied in various ways. They include one-dimensional and three-dimensional frost heave tests to estimate ground deformation and freezing earth-pressure due to freeze–thaw cycles, unconfined compression tests of frozen soil samples to evaluate mechanical properties and three-dimensional hydrothermal simulations.
Masato Oishi (Seiken Co. Ltd., ohishi.m@seikenn.co.jp).

Water, heat and solute transport in freezing and thawing soils
An understanding of water and heat flows associated with the freezing and thawing of unsaturated soils is important when considering hydrological processes in cold regions, and management of microbial activity and fertilizer use on farmland. Directional column soil freezing and thawing experiments were carried out, and hysteresis of soil freezing curve and hydraulic conductivity of frozen soil were obtained. The effect of macropores on soil freezing and thawing with infiltration, and unfrozen water potential under non-equilibrium soil freezing and thawing were also investigated.
Kunio Watanabe (Mie University, kunio@bio.mie-u.ac.jp)

Outreach program by measuring frost depth in Japan
Since November 2011, the project 'Frost tube in Japan' has been conducted in collaboration with the project 'Permafrost Outreach Programs' operated by the University of Alaska Fairbanks. By winter 2016, frost tubes had been installed at 32 schools in the Hokkaido area, northern Japan, and frost depth measurement will be performed by school children and teachers.
Koichiro Harada (Miyagi University, haradak@myu.ac.jp)

Shin Sugiyama

International Glaciological Society

JOURNAL OF GLACIOLOGY

Papers accepted for publication between 1 January and 31 July 2017. The papers are listed in alphabetical order by first author. Some of these papers have already been published.

A. Ayala, F. Pellicciotti, N. Peleg, P. Burlando
Melt and surface sublimation across a glacier in a dry environment: distributed energy-balance modelling of Juncal Norte Glacier, Chile

Jessica A. Badgeley, Erin C. Pettit, Christina G. Carr, Slawek Tulaczyk, Jill A. Mikucki, W. Berry Lyons, MIDGE Science Team
An englacial hydrologic system of brine within a cold glacier: Blood Falls, McMurdo Dry Valleys, Antarctica

Douglas I. Benn, Jan Åström, Thomas Zwinger, Joe Todd, Faezeh M. Nick, Susan Cook, Nicholas R.J. Hulton, Adrian Luckman
Melt-undercutting and buoyancy-driven calving from tidewater glaciers: new insights from discrete element and continuum model simulations

Jorge Bernales, Irina Rogozhina, Maik Thomas
Melting and freezing under Antarctic ice shelves from a combination of ice-sheet modelling and observations

M.L. Chester, B. Kulessa, A.J. Luckman, J.N. Bassis, P. Kuipers Munneke
Systems Analysis of complex glaciological processes, and application to calving of Amery Ice Shelf, East Antarctica

Jamie Davis, Wesley Van Wychen, Luke Copland, David O. Burgess, Laurence Gray, Martin Sharp, Julian A. Dowdeswell, Toby J. Benham
Variability in ice motion and dynamic discharge from Devon Ice Cap, Nunavut, Canada

Bergur Einarsson, Tómas Jóhannesson, Thorsteinn Thorsteinsson, Eric Gaidos, Thomas Zwinger
Subglacial flood path development during a rapidly rising jökulhlaup from the western Skaftá cauldron, Vatnajökull, Iceland

Markus Engelhardt, Al. Ramanathan, Trude Eidhammer, Pankaj Kumar, Oskar Landgren, Arindan Mandal, Roy Rasmussen
Modelling 60 years of glacier mass balance and runoff for Chhota Shigri Glacier, Western Himalaya, Northern India

Olga Erokhina, Irina Rogozhina, Matthias Prange, Pepijn Bakker, Jorge Bernales, André Paul, Michael Schulz
Dependence of slope lapse rate over the Greenland Ice Sheet on background climate

W. Gajek, J. Trojanowski, M. Malinowski
Automating long-term glacier dynamics monitoring using single-station seismological observations and fuzzy logic classification: a case study from Spitsbergen

Eythor Gudlaugsson, Angelika Humbert, Karin Andreassen, Caroline C. Clason, Thomas Kleiner, Sebastian Beyer
Eurasian ice-sheet dynamics and sensitivity to subglacial hydrology

Simon Horton, Bruce Jamieson
Spectral measurements of surface hoar crystals

Daniel Iliescu, Andrii Murdza, Erland M. Schulson, Carl E. Renshaw
Strengthening ice through cyclic loading

Kerry Key, Matthew R. Siegfried
The feasibility of imaging subglacial hydrology beneath ice streams with ground-based electromagnetics

Dan Kluskiewicz, Edwin D. Waddington, Sridhar Anandakrishnan, Donald E. Voigt, Kenichi Matsuoka, Michael P. McCarthy
Sonic methods for measuring crystal orientation fabric in ice, and results from the West Antarctica ice sheet (WAIS) divide

Guillaume Jouvet, Julien Seguinot, Susan Ivy-Ochs, Martin Funk
Modelling the diversion of erratic boulders by the Valais Glacier during the last glacial maximum

Conrad Koziol, Neil Arnold, Allen Pope, William Colgan
Quantifying supraglacial meltwater pathways in the Paakitsoq region, West Greenland

A.A Leeson, J.M. van Wessem, S.R.M. Ligtenberg, A. Shepherd, M.R. van den Broeke, R. Killick, P. Skvarca, S. Marinsek, S. Colwell
Regional climate of the Larsen B embayment 1980-2014

Guang Liu, Huadong Guo, Shiyong Yan, Rui Song, Zhixing Ruan, Mingyang LV
Revealing the surge behaviour of the Yangtze River headwater glacier during 1989–2015 with TanDEM-X and Landsat images

Adrian McCallum
Assessing mass balance with the cone penetration test

Michael McCarthy, Hamish Pritchard, Ian Willis, Edward King
Ground-penetrating radar measurements of debris thickness on Lirung Glacier, Nepal

Joseph Mallalieu, Jonathan L. Carrivick, Duncan J. Quincey, Mark Smith, William H.M. James
An integrated Structure-from-Motion and time-lapse technique for quantifying ice-margin dynamics

Michael H. Meylan, Luke G. Bennetts, Roger J. Hosking, Elliot Catt
On the calculation of normal modes of a coupled ice-shelf/sub-ice-shelf cavity system

Daniele Peano, Florence Colleoni , Aurélien Quiquet, Simona Masina
Ice flux evolution in fast flowing areas of the Greenland Ice Sheet over the 20th and 21st centuries

Jean Rabault, Graig Sutherland, Olav Gundersen, Atle Jensen
Measurements of wave damping by a grease ice slick in Svalbard using off-the-shelf sensors and open-source electronics

Sebastian H.R. Rosier, Oliver J. Marsh, Wolfgang Rack, G. Hilmar Gudmundsson, Christian T. Wild, Michelle Ryan
On the interpretation of ice-shelf flexure measurements

Nicole Schaffer, Luke Copland, Christian Zdanowicz
Ice velocity changes on Penny Ice Cap, Baffin Island, since the 1950s

Sonam Futi Sherpa, Patrick Wagnon, Fanny Brun, Etienne Berthier, Christian Vincent, Yves Lejeune, Yves Arnaud, Rijan Bhakta Kayastha, Anna Sinisalo
Contrasted surface mass balances of debris-free glaciers observed between the southern and the inner parts of the Everest region (2007–15)

Robert D. Storrar, Andrew H. Jones, David J.A. Evans
Small-scale topographically controlled glacier flow switching in an expanding proglacial lake at Breiðamerkurjökull, SE Iceland

Laura I. Thomson, Luke Copland
Multi-decadal reduction in glacier velocities and mechanisms driving deceleration at polythermal White Glacier, Arctic Canada

Ilona Välisuo, Thomas Zwinger, Jack Kohler
Inverse solution of surface mass balance of Midtre Lovénbreen, Svalbard

Sharon Van Geffen, Johannes Oerlemans
The 1982/83 surge and antecedent quiescent phase of Variegated Glacier: revising the original dataset for application in flow line models

Luisa von Albedyll, Thomas Opel, Diedrich Fritzsche, Silke Merchel, Thomas Laepple, Georg Rugel
^{10}Be in the Akademii Nauk ice core – first results for CE 1590–1950 and implications for future chronology validation

Denis Voytenko, Timothy H. Dixon, David M. Holland, Ryan Cassotto, Ian M. Howat, Mark A. Fahnestock, Martin Truffer, Santiago de la Peña
Acquisition of a 3 min, two-dimensional glacier velocity field with terrestrial radar interferometry

Sheng Wang, Tandong Yao, Lide Tian, Jianchen Pu
Glacier mass variation and its effect on surface runoff in the Beida River catchment during 1957–2013

Xin Wang, Kaiguo Chai, Shiyin Liu, Junfeng Wei, Zongli Jiang, Qionghuan Liu
Changes of glaciers and glacial lakes implying corridor-barrier effects and climate change in the Hengduan Shan, southeastern Tibetan Plateau

C. Scott Watson, Duncan J. Quincey, Mark W. Smith, Jonathan L Carrivick, Ann V. Rowan, Mike R. James
Quantifying ice cliff evolution with multi-temporal point clouds on the debris-covered Khumbu Glacier, Nepal

Mareike Wiese, Martin Schneebeli
Early-stage interaction between settlement and temperature-gradient metamorphism

Christian T. Wild, Oliver J. Marsh, Wolfgang Rack
Viscosity and elasticity: a model intercomparison of ice-shelf bending in an Antarctic grounding zone

Chunhai Xu, Zhongqin Li, Feiteng Wang, Huilin Li, Wenbin Wang, Lin Wang
Using an ultra-long-range terrestrial laser scanner to monitor the mass balance of Urumqi Glacier No.1, eastern Tien Shan, China, at the monthly scale

Baojun Zhang, Zemin Wang, Fei Li, Jiachun An, Yuande Yang, Jingbin Liu
Estimation of present-day glacial isostatic adjustment, ice mass change and elastic vertical crustal deformation over Antarctic ice sheet

ANNALS OF GLACIOLOGY 58(74)

The following papers have been selected for publication in Annals of Glaciology *58(74) (thematic issue on Interactions of ice sheets and glaciers with the ocean), edited by Helen Amanda Fricker*

Nicholas Beaird, Fiamma Straneo, William Jenkins
Characteristics of meltwater export from Jakobshavn Isbræ and Ilulissat Icefjord

Mark Brandon, Richard Hodgkins, Helgi Björnsson, Jón Ólafsson
Multiple melt plumes observed at the Breiðamerkurjökull ice face in the upper waters of Jökulsárlón lagoon, Iceland

Adam J. Campbell, Christina L. Hulbe, Choon-Ki Yi
The shape of change: an EOF approach to identifying sources of transient thickness change in an ice shelf

Hermann Engelhardt, Michael Engelhardt
An equatorial force acting on large floating ice masses: Polfluchtkraft

Sam Pimentel, Gwenn E. Flowers, Martin J. Sharp, Bradley Danielson, Luke Copland , Wesley Van Wychen, Angus Duncan, Jeffrey Kavanaugh
Modelling intra-annual dynamics of a major marine-terminating Arctic glacier

Alexander A. Robel , Victor C. Tsai, Brent Minchew, Mark Simons
Tidal modulation of ice shelf buttressing stresses

Daniel J. Sulak, David A. Sutherland, Ellyn M. Enderlin, Leigh A. Stearns, Gordon S. Hamilton
Iceberg properties and distributions in three Greenlandic fjords using satellite imagery

More papers for *Annals* 58(74) will be listed in the next issue

ANNALS OF GLACIOLOGY 59(75)

The following papers have been selected for publication in Annals of Glaciology *59(75) (thematic issue on The cryosphere in a changing climate), edited by Ian Allison*

John R. Appleby, Martin S. Brook, Travis W. Horton, Ian C. Fuller, Katherine A. Holt, Duncan J. Quincey
Stable isotope (δD-$\delta^{18}O$) relationships of ice facies and glaciological structures within the mid-latitude maritime Fox Glacier, New Zealand

Alison F. Banwell, Ian C. Willis, Grant J. Macdonald, Becky Goodsell, David P. Mayer, Anthony Powell, Douglas R. MacAyeal
Calving and rifting on McMurdo Ice Shelf, Antarctica

Emiliano Cimoli, Arko Lucieer, Klaus M. Meiners, Lars Chresten Lund-Hansen, Fraser Kennedy, Andrew Martin, Andrew McMinn, Vanessa Lucieer
Towards improved estimates of sea-ice algal biomass: experimental assessment of hyper-spectral imaging cameras for under-ice studies

Markus Engelhardt, Paul Leclercq, Trude Eidhammer, Pankaj Kumar, Oskar Landgren, Roy Rasmussen
Meltwater runoff in a changing climate (1951–2099) at Chhota Shigri Glacier, Western Himalaya, northern India

Prateek Gantayat, Anil V. Kulkarni, J. Srinivasan, Maurice J. Schmeits
Numerical modelling of past retreat and future evolution of Chhota Shigri glacier in Western Indian Himalaya

Florian Herla, Gerard H. Roe, Ben Marzeion
Ensemble statistics of a geometric glacier length model

Kathleen Huybers, Gerard Roe, Howard Conway
Basal topographic controls on the stability of the West Antarctic Ice Sheet: lessons from Foundation Ice Stream

Christine M. LeDoux, Christina L. Hulbe, Martin P. Forbes, Ted A. Scambos, Karen Alley
Structural provinces of the Ross Ice Shelf, Antarctica

Marzena Osuch, Tomasz Wawrzyniak
Variations and changes in snow depth at meteorological stations Barentsburg and Hornsund (Spitsbergen)

Sayli Atul Tawde, Anil V. Kulkarni, Govidasamy Bala
An estimate of glacier mass balance for the Chandra basin, western Himalaya, for the period 1984–2012

Shun Tsutaki, Shin Sugiyama, Daiki Sakakibara, Teruo Aoki, Masashi Niwano
Surface mass balance, ice velocity and near-surface ice temperature on Qaanaaq Ice Cap, northwestern Greenland, from 2012 to 2016

Tomasz Wawrzyniak, Marzena Osuch, Adam Nawrot, Jaroslaw Napiorkowski
Runoff modelling in an Arctic unglaciated catchment (Fuglebekken, Spitsbergen)

More papers for *Annals* 59(75) will be listed in the next issue

The Cryosphere in a Changing Climate

IGS Symposium Wellington, New Zealand, 12–17 February 2017

Kia Ora!

The effects of climate change are a dominant theme in cryospheric science in this day and age; however, the distinctive feature of this international symposium was that it was the first to bring together three of the leading international organizations for promoting cryospheric research: the International Glaciological Society (IGS), the International Association of Cryospheric Sciences (IACS) and the World Climate Research Programmme Climate and Cryosphere Project (CLiC). Conceived and planned for at least 5 years, this meeting of over 227 participants from 27 countries represented yet another example of how a small island nation, Aotearoa New Zealand, can attract the participation of the entire world community of glaciologists and climate change experts. The symposium was held at Victoria University in New Zealand's capital city of Wellington during a prime period of summer weather (not altogether without its share of cold and rain, and even one small earthquake).

The Symposium began with a traditional Maori *mihi whakatau*, a welcome to the assembled guests, which is an important part of Aotearoa New Zealand culture. Representing Victoria University of Wellington, Te Temara McKenzie delivered an engaging piece of oratory that welcomed the participants to Aotearoa and to Whanga-nui-a-Tara Wellington, and described the strong cultural connection between *tangata whenua* and the environment. The Deputy Vice Chancellor of the university, Professor Rawinia Higgins, echoed these sentiments in the English language, and expressed the wish on behalf of the entire University community that our symposium be successful in examining the mysteries and impacts of the cryosphere in a changing climate. Traditional speeches of this nature require active engagement from the audience, so the symposium participants responded with a *waita*, a song, in *Te Reo Māori,* the Maori language. The words of the *waita* were simple enough for the entire group of delegates to sing with some skill:

Te aroha	Love
Te whakapono	Faith
Me te rangimarie	and Peace
Tatou tatou e	For us all

Before beginning with the first plenary session of the symposium, the recent passing of several notable glaciologists, Gordon Hamilton, Willy Weeks and David Collins, was marked with a reading and a moment of silence.

The symposium consisted of 114 oral presentations and 99 poster presentations keynoted by seven distinguished speakers who gave plenary lectures at the beginning of each day. Dorthe Dahl-Jensen and Eric Rignot keynoted the start of the symposium with talks on the latest in ice-core science and the mass balance of the Antarctic Ice

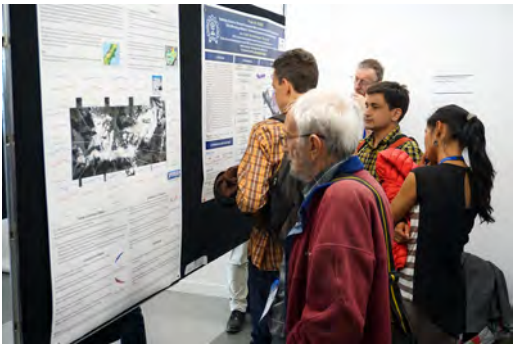
Te Temara McKenzie got the proceedings off to a flying start with a traditional Maori welcome.

Deputy Vice Chancellor Professor Rawinia Higgins, supported by Vice Provost Professor Kate McGrath. extended a welcome from the University of Wellington to the IGS, here represented by the persons of Secretary General Magnús Magnússon and President Doug MacAyeal.

The lecture theatre was well filled with enthusiastic participants.

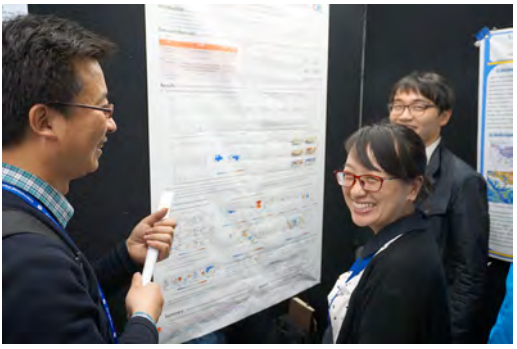
Tuesday evening was the occasion for Eric Rignot's S. T. Lee public lecture.

'New Zealand's glaciologist', Trevor Chinn, gave the keynote talk on Wednesday morning 'On the interpretation of the fluctuations of Alpine glaciers in response to the climate'.

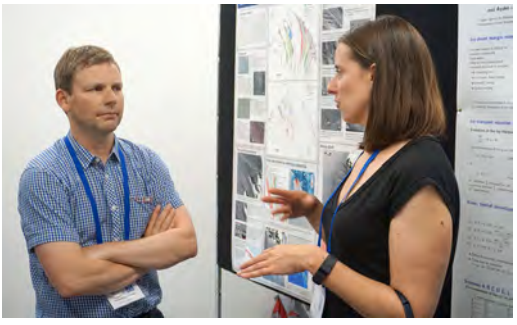


On Tuesday and Thursday afternoon, the poster sessions were as popular as ever.

Sheet from 1979–2016. Rob DeConto opened the second day of the symposium with a talk on the numerical model forecasts of ice-sheet behaviour across the various scenarios of future greenhouse forcing. Trevor Chinn and Ben Marzeion kicked off the third day with keynote talks on the interpretation of alpine glacier response to climate change and sea level response to past and present glacier mass balance. Violaine Pellichero and Marilyn Raphael



Deukwon Seo (right) discusses the finer points of his poster with two interested associates.



Among the posters, Bronwyn Wake, editor of *Nature Climate Change*, is eloquent about something, but Andrew Mackintosh clearly takes some convincing!

Meanwhile the Secretary General was busy promoting IGS merchandise to random passers by.

keynoted the final two days of the symposium with talks on sea ice and its relation to both oceanic and atmospheric environment and processes.

The symposium experience was replete with enjoyable and informative trips and chances to engage in informal discussion with delegates. Just before the start of the symposium there was a 2-day trip to Tongariro National Park. All the delegates who participated in this excursion managed to complete the famous Tongariro Alpine Crossing, a demanding hike over the top of a volcano on the North Island, Te Ika a Māui.

Food breaks provided a valuable opportunity to network and discuss the day's presentations.

The Wednesday mid-symposium excursion started with a walk, led by Rodney Grapes, an expert on neotectonics (in the brown jacket), to the fault scarp of the M8 1855 Waiarapa earthquake ....

...incorporated a visit to a vineyard....

... which involved a good deal of product testing....

... and ended in a mini-banquet.

A good time was had by all!

On Wednesday afternoon of the symposium, a mid-week excursion was arranged to look at local geology around Wellington and to sample the wines of one of New Zealand's prime vineyard districts. After seeing 'Rivendell', the fictional location depicted in the film *Lord of the Rings* and visiting the Wairarapa Fault, site of the 1855 M8.2 earthquake, the delegates sat down to a delightful dinner in the wine-growing town of Martinborough, famous for its pinot noir. Following the symposium, a post-symposium excursion on the South Island, Te Waipounamou, was arranged for some participants to visit Aoraki/Mt Cook and to see its many glaciers, including Tasman and Hooker and their proglacial lakes.

The symposium banquet was held on Thursday evening at Mac's Brewery on the Wellington waterfront. In addition to good food, good drink and good conversation, the highlight of the evening was the award of the IGS Richardson Medal to 'New Zealand's glaciologist', Trevor Chinn. In his acceptance remarks, Trevor encouraged young glaciologists in the audience to stay true to their scientific convictions and to believe in themselves.

Tim Naish, Richard Levy and Rob DeConto making the most of the social side of the symposium.

The week culminated in the symposium banquet, which was, as usual, a very convivial occasion.

Jo Jacka, Roger Braithwaite and Trevor Chinn took the opportunity to set the world to rights.

All in all, the symposium was a delightful and informative chance to catch up on the latest research in cryosphere/climate interaction. The IGS thanks Andrew Mackintosh, chair of the local organizing committee and Secretary General of the International Association of Cryospheric Sciences, Ian Allison, chief of the associated editorial board, and all the people who helped to make the symposium such a success.

Doug MacAyeal
Christina Hulbe

Photos by Regine Hock

At the banquet, IGS president Doug MacAyeal presented Trevor Chinn with the Society's Richardson Medal for services to glaciology.

David Prior from the University of Otago presented the award for the best student poster presentation to Emiliano Cimoli, with Pat Wongpan second and Michelle Ryan third.

Ian Allison, Chair of the Scientific Steering Committee (second from left), thanking some of the symposium's keynote speakers (from the left: Trevor Chinn, Rob DeConto, Ben Marzeion, Christian Zammit and Marilyn Raphael).

Pre-symposium tour, 10–12 February 2017
Tongariro National Park

Twenty-six participants joined the 3-day pre-symposium excursion to Tongariro National Park, ~250 km north of Wellington, 120 years after Chief Te Heuheu Tukino IV gifted the sacred volcanic peaks of Tongariro, Ngauruhoe and part of Ruapehu to the people of New Zealand. Tongariro is the country's oldest national park and one of the few places in the world to achieve dual World Heritage recognition for both cultural and natural significance. Thus, largely preserved from development, the park's Tongariro Alpine Crossing is one of the best accessible single-day hikes available in New Zealand, if not the world, with dramatic, awe-inspiring natural scenery and spectacular volcanic landforms.

After a 4-hour drive to our accommodation in National Park Village, our excursion chief Shaun Eaves presented an excellent and highly informative overview of the park's volcanoes and glacier fluctuations. The next morning the group awakened to a completely clear sky, and was dropped at the trailhead eager to embark on the strenuous and long hike through unique and diverse volcanic landscapes. The group quickly dispersed into ever smaller subgroups, each mastering at their own pace the well-marked 19.5 km trail with a total ascent of 900 m along rugged volcanic rock formations, recent lava flows and eerie barren landscapes.

Halfway there, a splinter group of six led by Jamey Stutz could not resist adding another 600 vertical meters above the main trail in order to summit the near-perfect volcanic cone of Mt Ngauruhoe, one of New Zealand's most active volcanoes, also known as Mt Doom from the *Lord of the Rings* films. The group struggled to gain elevation: sliding half a step downhill with each step up due to the free-flowing scree underfoot on the steep, unmarked slope. But we were finally rewarded with breathtaking panoramic views over the park's adjacent volcanoes, lakes and beyond, while resting on the rim of the summit crater close to steaming vents.

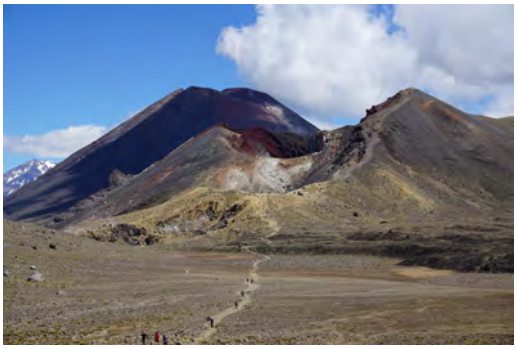
Ready to hit the trail.

Everybody is eager to get under way in the morning sun with Mt Ngauruhoe (2290 m a.s.l.) in the background.

Exhausted but happy, Kjetil Melvold, Dorota Medrzycka, Evgeny Podolskiy, Jamey Stutz, Charles Fierz and Regine Hock on top of Mt Ngauruhoe.

Kjetil Melvold wishes there was some powder snow and he had skis to navigate the steep, slippery descent from the peak.

The Red crater, which last erupted ash in 1926 and contains active fumaroles.



Looking back at Ngauruhoe, which last erupted in 1977.

Miraculously, by the end of the day, and just in time for the scheduled bus ride back to the Village, all participants had emerged more or less exhausted, but happy, from the densely forested last kilometers of the trail, much to the relief of Shaun, Jamey and Ross Whitmore, who successfully managed the nearly impossible task of making sure that nobody got lost!

Overall the excursion was immensely enjoyable due to spectacular scenery, exceptionally good weather and its flawlessly perfect organization by Shaun and his helpers Jamey and Ross.

Regine Hock

The intense green color of the Emerald Lakes provides a stark contrast to the barren landscapes around them.

Dorota, Kjetil, Evgeny, Charles and Jamey just about to start the long descent to the trail end.

Post-symposium tour, 18–21 February 2017 Aoraki/Mount Cook National Park

Immediately after the symposium, 30 participants flew to Christchurch, and arrived after a very scenic >340 km drive in Mount Cook Village, our home for the next 3 days. The views from the tiny village, surrounded by precipitous mountain walls, numerous steep glaciers,and Aoraki/Mount Cook (3724 m a.s.l.) towering above all the surrounding mountains, were stunning. Our two guides, Heather Purdie and Alice Doughty, took excellent care of us, and the next morning with hardly a cloud in the sky began with an informative introduction to the park by Park Ranger Ray Bellringer followed by a day-long hike approaching Aoraki/Mount Cook along the beautiful Hooker Valley. The easy 5 km track followed the Hooker River, passing a suite of gigantic glacial moraines and lakes, and ended at the Hooker Glacier pro-glacier lake with

Alice Doughty pointing in the direction the glaciers once were on our way up the Hooker Valley and introducing us to cosmogenic dating.

floating icebergs and amazing close views of Aoraki/Mount Cook.

The next day was no less fabulous. We explored the neighboring Tasman valley, which provided spectacular views of Aoraki/Mount Cook from the other side and the rapidly growing pro-glacial lake fed by Tasman Glacier, New Zealand's large glacier, containing 30% of the country's glacier ice. After a short hike up the tall 1800s terminal moraine we found ourselves in small, wobbly Zodiaks cruising around the Tasman lake. The boats took us to the glacier's calving face and provided us with not only an exhilarating and fun experience but also a different water-level perspective of our surroundings, including an appreciation of the enormously tall bordering moraines on either side as well as the feel of a lake-calving front up close. Back on solid ground, we hiked 5 km along the western lateral moraine, which further emphasized the dramatic recent downwasting and retreat of the glacier, and provided a closer look at the calving front.

Heather Purdie explains some of the interesting adaptations of local flora on our excursion up the Hooker Valley.

Markus Engelhardt, Charles Fierz and Miriam Jackson can't believe how much the Mueller glacier has retreated since the date of the old photo.

The next morning participants were free to explore different hiking options or simply relax their sore muscles from the last two days of hiking. Most chose the Red Tarns trail, rising steeply behind the village to beautiful alpine pools glittering in the sun high above the valley

Markus Engelhard, Suruchi Aggarwal, Charles Fierz, Regine Hock and Samuel Nussbaumer enjoying the view over lake-calving Hooker Glacier, with Aoraki/Mt Cook in the background.

The peak of Mt Cook seen from our dinner location.

Heather explains the retreat history of Tasman Glacier to a somewhat skeptical audience.

floor. The group was rewarded with spectacular views into both the Hooker and the Tasman valley as well as Aoraki towering in the background, before quickly descending to the village to catch our bus ride back to Christchurch.

On top of the huge 1800s moraine with Aoraki/ Mt Cook to the left and Tasman glacier and lake at the back.

Combating dehydration after another grand day of hiking.

This excursion (just like the pre-symposium excursion) was a rousing success and extremely enjoyable by all measures. Our enthusiastic guides, Heather and Alice, had put together a terrific, well-organized program introducing us to stunning diverse and steep glacial landscapes with the perfect mix of guided activities, freedom to explore on our own and interesting information about the area's glacial history and latest research.

On top of that we were extremely lucky with the weather. Both excursions experienced warm, sunny weather with largely blue skies throughout their entire duration, making us wonder whether our hosts possessed some magic long-term weather prediction skills when they decided on the dates of the symposium years ago.

Regine Hock

Cruising Tasman Lake close to the glacier's calving front.

High above the valley floor with spectacular panoramic views. Heather scouts the route for the final climb of this steep trail.

Nordic Branch Meeting 2016

Norwegian Polar Institute, Tromsø, Norway, 26–28 October 2016

The 24th Annual meeting of the International Glaciological Society Nordic Branch was hosted this year by the Norwegian Polar Institute in Tromsø between 26 and 28 October. The IGS Nordic Branch meeting is an opportunity for researchers primarily from the Nordic countries, but also from many other countries, to meet and discuss current research.

The three-day meeting spanning mid-day to mid-day had eight oral sessions and two poster sessions with a total of 33 talks and 23 posters, a large percentage of them given by students and early-career scientists. The first session was opened by the meeting's organizer Jack Kohler, who welcomed everyone. The day continued with a wide range of presentations, covering topics from mass balance of glaciers in various part of the world, snow conditions in the Arctic Ocean and glacial mapping using remote sensing techniques to the legal status of ice cores. The day ended with poster presentations accompanied by pizza and drinks and engrossing discussions.

The second day consisted of four intense sessions with oral presentations and poster discussions including many interesting subjects such as the use of UAVs, calving and subglacial processes, and glacial fluctuations. During the lunch break on this second day, APECS held a well visited and lively panel discussion about balancing work and personal life. As always the social events are the heart and soul of these meetings and this year the meeting dinner at the end of the second day was held at the nearby Ølhallen with a rich buffet of sushi and a wide selection of local and other good tasting drinks.

The participants were attentive and interested in all the presentations.

Jack Kohler was there to welcome everybody.

The poster session was as lively as always.

The lunches were good too!

With a somewhat smaller attendance on the third day, the last two sessions were held before the meeting closed with a short discussion and announcements, including the 'Ýmir' prizes for the best oral student presentation, which went to Penelope (Penny) How, and the best student poster presentation, which went to Calvin Shackleton.

This year's IGS-NB meeting was very much appreciated and successful, with many interesting talks, posters and stimulating discussions. The organization of the meeting was well oiled and smooth and Jack Kohler and the organizing committee are greatly acknowledged for their willingness to host the meeting and their work in organizing it. Next year's (2017) meeting will be held in Uppsala, Sweden and we look forward to seeing you there.

Rickard Pettersson

The presentation of the Ýmir awards. From the left. Liss Marie Andreasson, Tómas Jóhannesson, Penny How and Henry Patton, accepting the award on behalf of Calvin Shackleton, who had already left. Well done all and thank you!

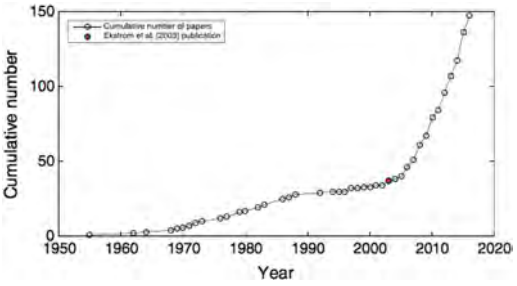
Group photo!

News

Report from the Glacial Seismology Training School

Fort Collins, Colorado, USA, 11–17 June 2017

Although it has been at the core of glaciological inquiry since the International Geophysical Year in the late 1950s, glacial seismology has, during the last approximately 15 years, become one of the fastest growing sub-fields of glaciology. While seismology, particularly active 'shot' seismology used to determine ice thickness and bed structure, has always had a strong presence in glaciology, the rate at which glacial seismology papers have been published has skyrocketed since about 2003 (see the recent review articles by Podolskiy and Walter (2016) and Aster and Winberry (in press)). As shown in the figure below, the number of papers reporting the use of 'passive' seismology to study glaciers and ice sheets more than tripled between 2003 and 2016. This incredible growth began around the time of the publication of the first reports of globally detectable 'glacial earthquakes' by Ekström and others (2003) emanating from the termini of Greenland outlet glaciers, which was discovered accidentally in the course of studying 'low-frequency' earthquakes. This accidental discovery helped spur more purposeful inquiry into the types and varieties of signal emitted from dynamic processes occurring in or at the boundaries of glacial ice in a wide range of settings, and the results have been extremely rewarding.

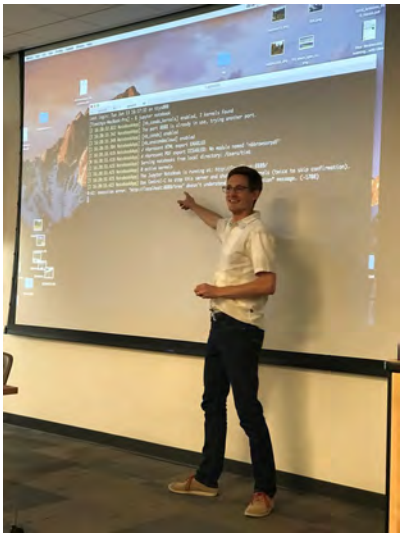


Cumulative number of papers published on studies employing passive seismology to investigate glaciers and ice sheets 1950-2016 (reprinted with permission from Podolskiy and Walter, 2016).

Home institutions of participants at the 2017 Glacial Seismology School at Colorado State University.

In recognition of the growing interest in glacial seismology in the communities of both glaciology and seismology, members of the US National Science Foundation (NSF; www.nsf.gov)-sponsored POLENET Antarctic research program (polenet.org) organized a training workshop focused on teaching rescent advances and best practice in this rapidly growing sub-field to a varied group of participants – particularly emphasizing graduate students and early career professionals. The IGS was delighted to be given the opportunity to assist as a co-sponsor (providing nominal financial support to augment support from the NSF, the Scientific Committee on Antarctic Research (SCAR; scar.org) and the International Association of Cryospheric Sciences (IACS; www.iugg.org/associations/iacs.php)).

Two 'pros' in the study of glacial seismology, Rick Aster (left) and Doug Wiens (right).

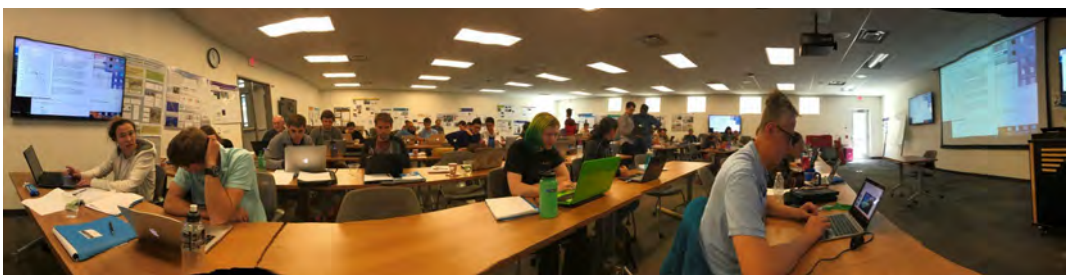


Tim Bartholomaus leads the class in practical uses of Unix and Python commands to process seismological data.

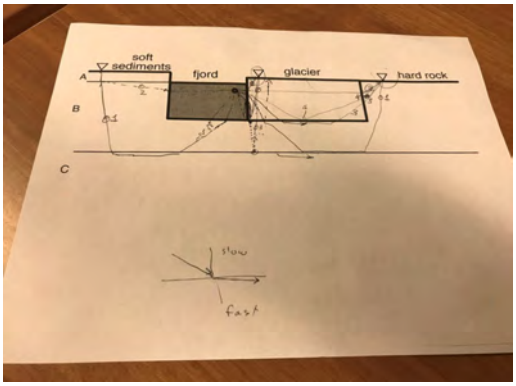
The afternoon field trip to view glacial landforms of the Rocky Mountains provided a spectacular respite from the lecture hall and classroom activities, and facilitated further informal discussions on glacial seismology.

The workshop was held on the campus of Colorado State University (CSU), located in Fort Collins, Colorado, USA, and was ably organized by Rick Aster, Dan McGrath and Patti Uman (CSU Department of Geosciences), with strong assistance from Terry Wilson, David Saddler and Stephanie Konfal (The Ohio State University). A total of 44 workshop 'students' from 15 countries were led by ten 'instructors' from three countries through a week of lectures, practical tutorials and a field trip to the Colorado Rocky Mountains. All lecture presentations are available in an on-line archive (http://polenet.org/glacial-seismology-school-presentations). Much of the week was devoted to practical training involving hands-on analysis of seismological data guided by the expert teachers.

The 5-day workshop began with general introductions to glacial seismology, glaciology basics and seismological basics by Rick Aster, Dan McGrath and Doug MacAyeal (University of Chicago), respectively, and included a practical training session on visualizing the ice flow of Antarctica using data from Bedmap 2 and NASA MEaSUREs. The morning of Day 2 featured presentations on active seismology methods and objectives as well as on the synergism between seismological and radar methods for studying ice sheets given by Sridhar Anandakrishnan (Penn State University). Sridhar led a practical exercise in using an open software package (Seismic Unix, or SU) for analysing reflection seismology data from Antarctica. That afternoon, Tim Bartholomaus (University of Idaho) and Victor Tsai (California Institute of Technology) delivered a group of lectures on how seismology has become commonplace in the study of glacial hydrology and iceberg calving. Tim and Victor illustrated the points made in their lectures with exercises done with both 'paper and pencil' as well as with Python software. Day 3 featured Doug Wiens (Washington



Workshop activities were split between a well-appointed lecture room and a computer workstation teaching classroom. Here students are using open-source software package SU to look at seismic data provided by Sridhar Anandakrishnan.

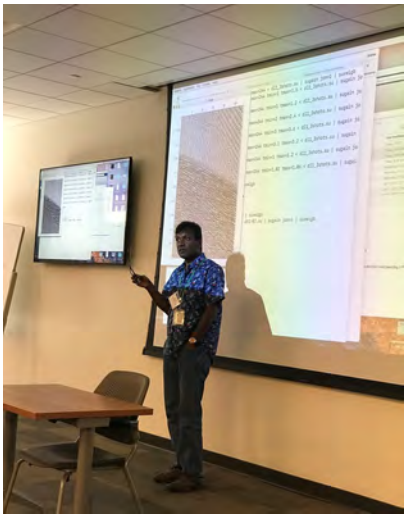


Doug MacAyeal and Sridhar Anandakrishnan's worksheet for one of the 'paper and pencil' exercises assigned by Victor Tsai.

Michael Baker (CSU) providing a demonstration of a broad band seismograph. Instrumentation provided by provided by IRIS PASSCAL.

University, Saint Louis) and Paul Winberry (Central Washington University) presenting a case study of the extraordinary stick-slip cycles of the Whillans Ice Stream, Antarctica, and their seismological signals and physical interpretations. Their data analysis activity was augmented by a brief tutorial on 'what glacial seismologists should know about GPS' given by Doug MacAyeal. The morning of Day 4 was devoted to continued examination of seismological signals associated with subglacial processes and basal sliding, led by Paul Winberry and Fabian Walter (ETH Zürich); and the afternoon was devoted to a field trip to examine mountain glacial geological features within Rocky Mountain National Park just west of Fort Collins. The field trip was led by Dan McGrath and featured remarkable scenery both within the lower elevations of the park and along Trail Ridge Road, which reaches 3713 m in elevation, in addition to fine weather. The workshop closed on Day 5 after Vera Schlindwein (Alfred Wegner Institute) and Rick Aster held forth on seismological signals observed on floating sea ice, on ice shelves, and generated by colliding and shoaling icebergs.

In addition to the field trip as a means of allowing informal interaction among the workshop participants, the rich and diverse culture of beer brewing in Fort Collins was explored every evening at local breweries to further the discussions and social cohesion of the group.



Sridhar Anandakrishnan leads a tutorial on how to use open software system SU to process shot data from the South Pole.

Doug Wiens, Robert Smalley (University of Memphis), and Agostina Lia Venerdini (CONICET-Universidad Nacional de San Juan) discussing Argentinian glaciology and seismology.

Through the week, workshop participants gathered in the evening at various brewing facilities around Fort Collins to examine the glaciological significance of effervescent fluids.

Overall, the training workshop was very useful for bringing a diverse group of participants up to speed on the various new frontiers of glacial seismology, emphasizing both the scientific questions as well as the practical techniques and societal importance. The IGS looks forward to a time in the future when another workshop on glacial seismology can be held.

Rick Aster, Doug MacAyeal and Terry Wilson

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Obituary: Gordon Hamilton, 1966–2016

Gordon Stuart Hamilton, Research Associate Professor at the University of Maine, died 22 October 2016 as the result of an accident in the McMurdo Shear Zone, near Ross Island, Antarctica. Gordon was a creative and dedicated scientist who never forgot to pause and see the beauty in the environments where he worked and in the people with whom he worked. Gordon is sorely missed by his colleagues, his wife Fiona and his sons Martin and Callum.

Gordon was born in Dundee, Scotland, a small city that is proud of its scientific heritage and its connection to the Antarctic. Scott's ship *Discovery* was built there and of course, Gordon grew up there. It's a place to which he felt connected his whole life.

Gordon pursued undergraduate studies in Geography at the University of Aberdeen (also in Scotland) and earned his PhD at Cambridge (which is not in Scotland but was Norman for a while). He completed his PhD in 1992 and took up a Royal Society Postdoctoral Fellowship at the Norwegian Polar Institute. He moved on to a research associate position at the Ohio State University in 1994.

Gordon and I shared an office together in the basement of the Byrd Polar Research Center at Ohio State. We sat on opposite sides of a big open lab and we'd email each other just to make jokes and see the other person laugh. We were part of a great cohort that gathered around Ian Whillans to read papers, test ideas and, I suppose, reassure each other that we knew what was going on. We weren't all Ian's students or postdocs, but we liked listening to each other.

Gordon moved on to Maine, where he climbed the academic ladder, mentored excellent students and made important contributions to polar glaciology. His CV is a study in how to add new tools to your kit while maintaining focus on your own scientific priorities. He was interested in ice sheet mass balance, and approached this from an ice mechanics point of view. Not content with one hemisphere, Gordon worked in two. He observed ice sheets from space and he got up close and personal, using ice penetrating radar, GPS tracking of motion, and related measurements. He was the consummate field glaciologist.

Gordon was a surge-type glacier expert when he moved to Ohio State, but his view quickly expanded to include the ice sheets in Greenland

and Antarctica as he picked up and flew, literally, with a new method for making precise point measurements of ice-thickness change by comparing firn compaction with vertical motion measured near the surface. He spent a lot of time with firn, thanks to all the cores he collected for that work, which makes the move into high-frequency, ground-based radar seem pretty obvious. He used radar to examine firn stratigraphy and surface mass balance; and then GPS and satellite remote sensing to examine where that ice was going and how it was changing over time. His detailed measurements on East Greenland outlet glaciers produced important time series in environments that change not only year to year but day to day. His work on the ground helped validate new methods and opened new pathways to connect careful observation of surface processes with change at the glacier terminus. He knew how to get where he wanted to go and make the measurement he needed to make once he got there.

You would not be surprised to find that Gordon's CV is also a study in how to be a good colleague. His partnerships spanned the globe. And the shear zone research he was conducting at the time of his accident connected right back to some of his earliest work at Ohio State.

My friend Derrick Lampkin wrote soon after the accident: 'Gordon was the very best of us all… he was an exemplary scientist and a humble person. He […] made himself available […] to chat about science and was an advocate… more importantly he was filled with levity and good will.'

Gordon died doing a job that we all think is important. He died doing something that he loved and for which he had an immense talent. I'm left with two irreconcilable thoughts about this. No, the end should not come this way, not at all. But what great fortune he had, to follow his passion and make the world a better place for it. Steve Price, another compatriot from Ohio State days, wrote: 'You visited amazing places, did amazing things, and had a positive impact on everyone you mentored and worked with.'

If we want to honour Gordon's memory, we should strive to have the same kind of independence of spirit, honest humility, drive to provide meaningful answers to hard questions, and care for the communities in which we work.

Remarks presented by Christina Hulbe at the opening of the joint IGS/IASC/CliC Symposium on the Cryosphere in a Changing World, Wellington, New Zealand, in February 2017

Obituary: Wilford Frank (Willy) Weeks, 1929–2017

On a cold February day in Portland likely reminiscent of the Arctic, longtime IGS member and former President and Seligman Crystal recipient Wilford Frank (Willy) Weeks passed from this Earthly realm. Two Zen-like quotes from the Phase Transition section of his book on *Arctic Sea Ice* (University of Alaska Press) immediately come to mind. 'If you don't know where you are going you may end up somewhere else' and 'Wherever you go, there you are'.

Coming from the midwestern United States, Willy Weeks's path to making the study of sea ice a respected disciplinary component of the venerable International Glaciological Society was not at all direct. His undergraduate education was at one of the great midwestern Big 10 State Universities, the University of Illinois, along with ~40K other students. While they have transitioned somewhat, these Universities were inexpensive and designed to provide education at low cost to anyone with the will (and perhaps more important, the essential curiosity) to learn and self-discipline to negotiate the overwhelming size and diversity of choices. These were essential skills Willy either naturally had or developed.

Perhaps because of Illinois or perhaps because of growing up in the midwestern United States Willy was unusually endowed with common sense and humility, particularly notable in today's world. These and other characteristics enabled him to move from relatively humble origins to practically remaking the IGS in terms of sea ice. Being a life-time bass player in both orchestras and rock bands, he wasn't too bad at partying either.

After surviving the University of Illinois with flying colours, Willy then moved north to Illinois's answer to the Ivy League, the University of Chicago, where he got his PhD in the somewhat obscure Geology discipline Geomorphology. I do remember Willy saying his advisor told him that he had better study this subject because he was interested in it, since the likelihood of getting a job in this particular area was very low.

With this elite background Willy took a shot at classic academia by taking a faculty position at Washington University, a smaller private university of high reputation in St Louis, Missouri. Fortunately for the IGS Willy didn't quite fit there and didn't make tenure. (Better send a thank you note to Wash. U.). For some this might have stalled their career, but not Willy Weeks. He licked his wounds, set out on life's adventure and never looked back. 'Wherever you go, there you are.'

After a stint I believe with the US Geological Survey (Willy pretty much walked all over the White Mountains doing something out there), the irrepressible W. Weeks ended up at the Cold Regions Lab in Hanover, New Hampshire, where I first encountered him. When I arrived there in the fall of 1970 it was rock and roll time. Having gone on the Exon Super Icebreaker as an ice scientist on a cruise through the Arctic in previous years, Willy had teamed up with his long-time partner in sea ice crime (oops, I mean sea ice physical properties and thermodynamics), Norbert Untersteiner (an Austrian survivor of being drafted into the wrong side of World War II whose ashes are currently in the Arctic Ocean), to help out putting together an ambitious program to study the dynamics of the Arctic pack ice: AIDJEX. Interest in the Arctic was heating up because of North Slope oil and the Cold War was still on. As everywhere, but

especially in the USA, science runs on money, private and public and you have to be quick to get your bid in when the opportunity hits.

Putting together a diverse (but capable and some with pack-ice experience) group of Arctic scientists to measure pack-ice motion and deformation, as well as sampling sea ice itself by drilling holes and cores and occasionally falling through leads on snowmobiles and scrambling out, we joined an eclectic group of oceanographers from the Navy and UW on an ice flow camp In the 1971 AIDJEX pilot study. Who does this stuff – well, glaciologists of course. Who knew science could be fun, demanding, interesting and exciting all at the same time. It was my first exposure to the glaciological community and diverse wild polar scientists. I was hooked.

One anecdotal note says a lot about Willy. We were sharing a cook shack with a military oceanographic group, I believe from NRL. I can't remember the details but they were running a tight military operation with food at set times. In one humorous incident their chief, who was a good guy but liked very organized schedules, came over and talked to Willy, our nominal leader, and requested that we eat only at certain hours: our catch-as-catch-can schedule was messing up his team's schedule. (Can't remember if he also complained about us getting the Great Eskimo cook drunk one night by sharing drinks, wiping out all food for a day, but maybe.) Willy told us he replied that he would tell us, but his group of scientists took orders from him in a manner ranging from very poorly to not at all! A typical Weeksian response.

Really great to have a mentor scientist with a sense of humour and exuberance for life and an appreciation of diverse views and opinions – rare in today's world but certainly not rare at a well organized IGS symposium. For those that haven't experienced these symposia I highly recommend it; you won't be sorry.

For the record, the AIDJEX program was one of the first programs to fully integrate women into the previously almost all male pack ice field programs without making a big deal of it. Norbert (and probably also Willy), for example, just told the graduate students (say, two men, one woman, or vice versa) at remote satellite camps to go out there and get good data and take responsible care of your personal life. They did, sent the data back in, and didn't complain about living conditions – ah, the good old days. Real equality.

In terms of the rough and tumble of scientific reviewing and publishing, I was once having trouble reviewing a paper and asked Willy – seemed like there were big errors. Willy's response was, well, do what you can to point out problems, errors and misstatements but let them publish it. At the end of the day, they will have to be responsible for their nonsensical publications, not you – you did what you could. Those of you aware of the infamous fallacious 'hockey stick paper' purported to prove the climate is warming can see he was dead on. A bad paper can ruin your reputation. A good thing to have in your head at both ends of the review process.

As for field work, a totally different kind of leadership from what you might expect from an accomplished scientist of exalted stature. In 1972 we would be sharing a small prefab wooden hut on the pack. Willy would take any bunk no one wanted and on round the clock manning of laser sea ice deformation measurements whatever measurement period no one else wanted – he was not a prima donna. He certainly walked the walk, didn't just talk the talk and was very good at defusing tense scientific standoffs – who is right is not the issue; what is the correct physics is.

That's of course but a sketch from a productive life that has had a positive influence on a lot of us and without which many of us would not have had a significant scientific career. I could certainly come up with many more anecdotes and I recommend you page through Willy's sea ice text just to read all the literary and obscure quotes. Great fun! What was Willy's *Weltanschauung?* – hard to say. There are no ice streams or anything like that named after him, but I doubt that he would be worried about it. As an old Arctic navy hand from the military spy days once told me, yes, everyone in the naval Arctic community knew Willy Weeks and he had left a trail through the Arctic sea ice community a mile wide. Indeed he did, at many levels. The detailed significance: I don't know but it was certainly a mile wide, that I can attest to! He will be missed but not forgotten, especially in the IGS community.

Willyam (Bill) D. Hibler III

Opening of the IGS Southern Hemisphere Library, Valdivia, Chile

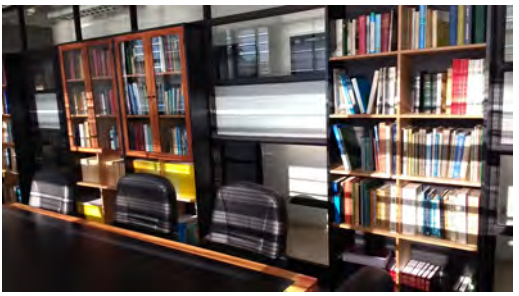
Dear *ICE* readers,

It is with great pleasure that I report that in February 2017 we opened the IGS Southern Hemisphere Library, located on the second floor of the brand new glaciology laboratory building of Centro de Estudios Científicos (CECs) in Valdivia, Chile.

In 2016, the Secretary General was looking for a new home for the IGS book collection. This valuable group of texts needed to be together, in a safe, secure and comfortable place, where scholars, students and general public interested in glaciology could access them for teaching or research.

The collection, comprising nearly 500 volumes published between the end of the 19th century and the present day, covers a wide variety of interesting glaciological research carried out all over the world. Among the numerous amazing texts that might be mentioned are several classic texts such as *Louis Agassiz: sa vie et sa correspondence* (1887), Ahlmann's *Land of ice and fire* (1938), Flint's *Glacial and Pleistocene geology* (1957), Lliboutry's *Nieves y glaciares de Chile* (1956) or Nakaya's *Snow crystals* (1952). Also, it must be mentioned that most of these books have no digital versions and are therefore unique publications with high historical value. Most are in English, French or German, but there are several texts in Russian and Polish.

The quest for a new home came just at the right time for us, since our glaciology laboratory of CECs was building new facilities, including a three-storey edifice where many rooms were available. After discussing this initiative with Claudio Bunster, CECs director, we realized that our new building was the ideal location for such a prestigious collection, not only because its brand new construction was of good enough quality to accommodate all the books, but also for the meaning of moving the old texts from the North to the New World in the South.

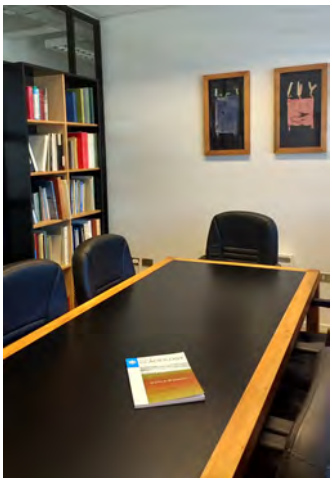


The main book shelves.

We immediately volunteered ourselves to take care of the library, funding all the expenses related to shipping and moving the collection to Southern Chile. This was formally proposed to the Secretary General, who after consulting with the IGS Council approved this initiative in June 2016.

Once the decision was made, the IGS headquarters worked very hard with the books, organizing the shipment and preparing the boxes for transportation. The shipment finally arrived in perfect shape in Valparaiso, Chile, at the end of July. Then we transported everything by truck to Valdivia, where we received the collection in early August. The selected room for the collection was designed by Fernando Basilio, our Architect in Residence, who finalized the construction by November 2016. Then our Antarctic season delayed the final phase of the project until January, when we unpacked the books, organized

General view of the Valdivia Science walkway (notice Antarctica on the ground and a Foucault's pendulum tower on the right) and CECs facilities at the back. On the left, the building with the flag is the Schuler house (biology laboratory), in the centre is the three-story glaciology building (the IGS Southern Hemisphere Library is on the second floor).



There is a table with eight seats for meetings or readers. On the wall behind are some old flags.

Keith Makinson, (BAS), Mike Bentley (Durham University), David Vaughan (BAS) and Andy Smith (BAS) visiting the library during a workshop at CECs in early March 2017.

The commemorative plaque at the main entrance to the library.

them on the specially designed shelves and adorned the walls with flags and banners used by CECs in Antarctica and Patagonia.

The IGS Southern Hemisphere Library, as it will be called from now on, was finally opened to the public in February 2017. The Library comprises the 485 books donated by the IGS together with nearly 100 more from our own collection. The library is a 40 m^2 space with a reading area and a table with eight seats. The room has a privileged view of the Science walkway on the Valdivia riverside, which in front of our premises has a square with a map of Antarctica and the Chilean glaciers carved on the floor. At the main entrance there is a commemorative plaque with the IGS logo welcoming all visitors.

The Library has been already visited by several members of the IGS in recent weeks and all have enjoyed the general design and the view of the river. I have included some photos.

IGS Council member Shin Sugiyama visiting the new library on 15 March 2017.

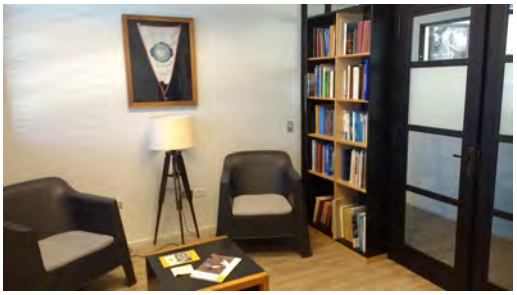
Please don't hesitate to contact me if you have glaciological books to share or need a new home. I will be very happy to receive more texts, especially if you have some numbers of *Annals of Glaciology* and *Journal of Glaciology* that are missing from our collection. We are now building a new exhibition area with old equipment and tools used in early glaciological research, so we can grow a bit more with books and memorabilia. For this new project we will also welcome any donation.

I would like to use this opportunity to thank our IGS President and all the members of the Council for approving this initiative. Also, I would like to thank Magnús and Louise for their help and hard work towards the success of this nice idea.

I hope to see you in Valdivia soon,

Andrés

Dr Andrés Rivera
Centro de Estudios Científicos
Valdivia, Chile



The reading area boasts a couple of comfortable chairs and an old field campaign banner on the wall.

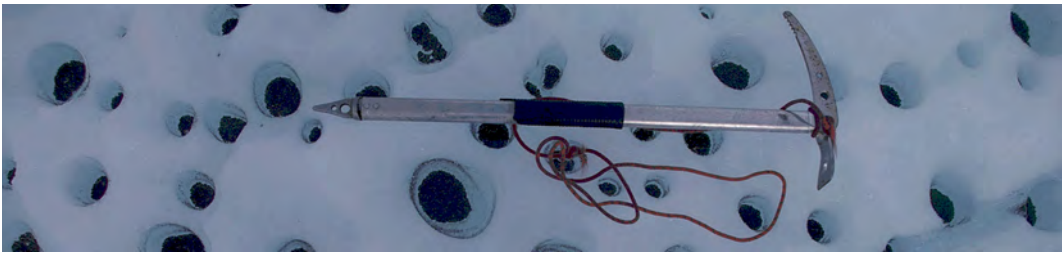
INTERNATIONAL GLACIOLOGICAL SOCIETY

International Symposium on Cryosphere and Biosphere

Kyoto Prefectural University
Kyoto, Japan
14–19 March 2018

Co-sponsored by:
- Japanese Society of Snow and Ice (JSSI))
- Japan Consortium for Arctic Environmental Research (JCAR)
- Kyoto Prefectural University
- Climate and Cryosphere (CliC)
- MEXT KAKENHI Project on Innovative Areas: 'Giant Reservoirs – Antarctic'

SECOND CIRCULAR
August 2017
http://www.igsoc.org/symposia/ 2018/kyoto



The International Glaciological Society will hold an International Symposium on 'Cryosphere and Biosphere' in 2018. The symposium will be held in the heart of Kyoto, former imperial capital of Japan, on 14–19 March 2018

THEMES

The cryosphere is now acknowledged as a unique biome that, in spite of the cold and harsh conditions, is inhabited by a diverse range of micro- and macro-organisms. The organisms play important roles in the cycling of carbon, nutrients and other elements within and around the cryosphere. The cryosphere ecosystem is sensitive to recent climate change, such as changes in snow and ice cover under warming conditions. Melting and the crystallization of snow and ice are not purely physical phenomena, but are enhanced or even induced by the presence and activity of organisms. For example, supra-glacial microbes can darken and increase melting on glaciers and ice sheets, while some species of bacterium can act as ice nucleators. Microorganisms have also been shown to be important in englacial systems and beneath glaciers and ice sheets. Biological processes on, within and under the ice are still insufficiently understood, and therefore not well considered in present models of the Earth system. Most organisms in the cryosphere are physiologically adapted to low temperatures and an improved understanding of these mechanisms has great potential for application to agriculture, food science, medical and material engineering. This symposium will provide an opportunity for glaciologists and biologists to meet each other to discuss the various phenomena of life in the cold. The goals of this symposium are: (1) to provide a forum for presenting the current knowledge of life and ecosystems in the cryosphere; (2) to discuss the important gaps in our understanding of interactions between biological activity and physical/chemical phenomena in the cryosphere, from molecular to system level; and (3) to encourage participants to form a new scientific community, discussing the state and direction of glacial-biology or bio-glaciology.

TOPICS

We welcome all submissions for presentation under the broad topics of glaciology in the biosphere and/or biology in the cryosphere. The key focus areas are:

1. **Microbes and biogeochemistry in glaciers and ice sheets**, including algae and bacteria in supra-, en- and subglacial environments; darkening and melt enhancement of glaciers by biogenic impurities; biogeochemistry in subglacial aquatic environments; the nutrient cycle in glaciers; biogeography of glacial microbes; microbes on seasonal snow and lake ice
2. **The role of sea ice, icebergs and glacier calving fronts in marine ecosystems**, including the effects of sea ice and glacial melt water on marine biota; glacier fjord ecosystems; ecology of ice algae; changing polar marine ecosystems in global warming
3. **Permafrost and terrestrial biota**, including the ecology of tundra and forest in polar and alpine regions; vegetation and soil microbes in permafrost; the ecological succession of glacier forefields; microbes in seasonal snow and lake ice; the carbon cycle of the permafrost region
4. **Interaction between snow cover and forest**, including: snow cover in forested regions; forest ecology in snow-covered regions; living snow fences; avalanche protection forests
5. **Cryosphere ecosystems and climate change**, including observations, data gathering and modelling of ecosystems across different time scales, including glacial–interglacial cycles and Snowball Earth events; projection of polar and alpine ecosystems in future global warming scenarios
6. **Biological ice nucleation**, including ecology of ice nucleation bacteria; global and local impact of biological ice nucleation; dynamics of bio-aerosol; ice crystallization or ice segregation in plant and fungi; ice nucleation activity in vertebrates and invertebrates

7. **Biomarkers and biogeochemistry in ice cores and frozen ground**, including analysis of microbes, pollen grains and other organic substances as a proxy of past environments; modifications of chemical compositions of soluble ions and air in ice by microbial activity; analytical technology of DNA and other biogenic substances for ice core study
8. **Physiology of cold adaptation and applications of biogenic material to low temperature technology**, including adaptation of organisms to low-temperature environments at the whole-organism, system or molecular level; anti-freeze and/or ice-binding proteins; cryopreservation of organisms; applications to food processing
9. **Emerging areas of cryosphere/biosphere research**

ABSTRACT AND PAPER PUBLICATION

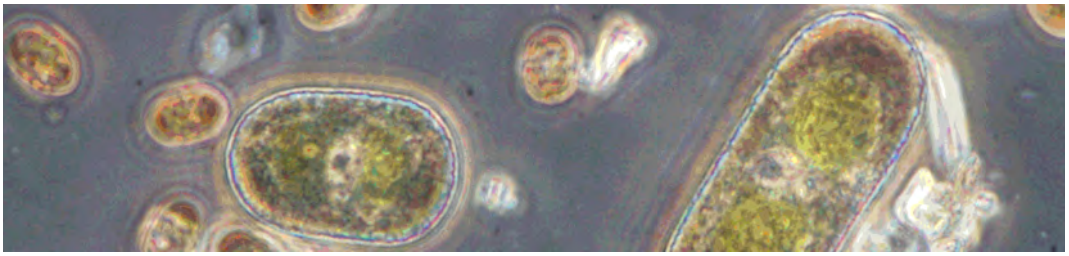
Participants wishing to present a paper (either oral or poster) at the Symposium must submit an abstract by Tuesday 14 November 2017. Abstracts need to be submitted via the IGS website. A collection of submitted abstracts will be provided for all participants at the Symposium.

The Council of the International Glaciological Society has decided to publish a thematic issue of the Annals of Glaciology on topics consistent with the Symposium themes. 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. The deadline for submission of Annals papers is 28 January 2018.

GRANTS FOR STUDENTS AND EARLY CAREER SCIENTISTS

Funding is available to partially support student and postdoc attendance at this symposium, in particular for early-career scientists from developing countries. Applications should be sent by e-mail to igs.kyoto.2018.grant@gmail.com, and include:

- A copy of your submitted abstract
- A short CV (max. one page)
- A brief statement of motivation, including why attendance at the conference will be beneficial (-1/2 page)
- A specification of your financial needs (must include a budget and disclosure of other sources of funding).



REGISTRATION FEES
All fees are in Japanese Yen, ¥
Early registration until 29 December 2017

– Participant (IGS member):	¥55 000
– Participant (not IGS member):	¥65 000
– Student or retired (IGS member):	¥25 000
– Student or retired (not IGS member):	¥30 000
– Accompanying person (18+):	¥20 000
– Accompanying person (7–17):	¥15 000
– Accompanying person (<7):	Free
– Delegate registration after 29 Dec 2017:	add ¥11 000
– Delegate registration after 21 Feb 2017:	add further ¥11 000

All prices will be charged in UK£ equivalent at the exchange rate valid near the date of transaction.

The fees include the Icebreaker, the mid-conference excursion, the Symposium Banquet (including some wine and beer) and daily morning/afternoon refreshments. 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 on the website of Minister of Foreign Affairs of Japan (http://www.mofa.go.jp/j_info/visit/visa/index.html) whether you will require a visa to enter Japan. 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 Saturday afternoon excursion and the Symposium Banquet. **It does not include attendance at the presentation sessions.**

PROGRAMME
A mixture of oral and poster sessions, interlaced with ample free time, forms the general framework of the symposium, which is intended to facilitate exchange of scientific information between participants in an informal manner. Additional activities include the customary Icebreaker, a symposium banquet and a selection of activities for the Saturday afternoon mid-symposium break.

VENUE

The symposium will be held at the *Kyoto-gaku-Rekisaikan* (Kyoto Institute, Library and Archives), located next to the Kyoto Prefectural University, Shimogamo Campus, in Kyoto city. Kyoto is located in the western (Kansai) area of Japan and is connected by railways, including the *Shinkansen*, the high speed railway line through Japan's major metropolitan areas such as Tokyo and Osaka. The nearest international airport is Kansai Airport. The venue, *Kyoto-gaku-Rekisaikan*, is within walking distance of the Kitayama subway station, which is accessible in 15 minutes by the subway from the Kyoto railway station (JR). The venue is surrounded by cultural facilities such as the Botanical Garden, the Prefectural Museum for Historical and Literary Research Materials and Kyoto Concert Hall. The quiet environment near the Kamo River and Mount Hiei offers a comfortable atmosphere for the symposium.

LOCATION

Kyoto is often called 'Japan's heartland', and it is said that no one understands the real Japan without knowing Kyoto. The city of Kyoto has more than 1200 years of history. For 1100 years it was the imperial capital of Japan. A place nurtured by time, Kyoto is also changing into a modern city, where great ideas are born and culture continues to develop. No visitor can help but appreciate the wonder of this special city. You will enjoy its natural scenery, temples, shrines, towns, homes, people and food. March is one of the best seasons in Kyoto, with beautiful weather and an average daily temperature range of 4–13˚C. The cherry blossom may be in full bloom shortly after the symposium.

ACCOMMODATION

The Local Organizing Committee has reserved a number of rooms for symposium participants. The booking web site for the hotels involved will open from the symposium local web site in October 2017. All the hotels are located in the downtown area of Kyoto and can be accessed by subway from the venue within 15 minutes. They are listed below and detailed information will be found on the web site. There are many other hotels in Kyoto city, as well as less expensive backpacker accommodation, which can be found on other travel web sites. You must make the booking yourself either on the symposium web site or elsewhere. Note that the venue

is accessible from Kitayama subway station, so we recommend booking a hotel near another station on the subway. March is peak tourist season and we recommend that you book as early as possible. All unbooked hotel rooms will be released on 24 February 2018 to prevent us incurring penalty charges. After that date we cannot guarantee the availability of hotel accommodation for delegates.

- **Aranvert Hotel Kyoto**, 2 min walk to Gojyo subway station. Room size 17–25m^2, Room price: ¥8500–16 000 per night.
- **Karasuma Kyoto Hotel**, 1 min walk to Shijyo subway station. Room size 15 m^2, Room price: ¥10 460–12 600 per night.
- **Hearton Hotel Kyoto**, 1 min walk to Karasumaoike subway station. Room size 15–23 m^2, Room price: ¥13 000–28 160 per night
- **Hotel Gimmond Kyoto**, 2 min walk to Karasumaoike subway station. Room size 14 m^2, Room price: ¥11 000–12 000 per night
- **Kyoto Central Inn,** 6 min walk to Shijyo subway station. Room size 13 m^2, Room price ¥11 000–15 800 per night.
- **Diwa Roynet Hotel Kyoto** Shijo Karasuma, 2 min walk to Shijyo subway station. Room size 18–23.8 m^2, Room price ¥11 664–33 104 per night.

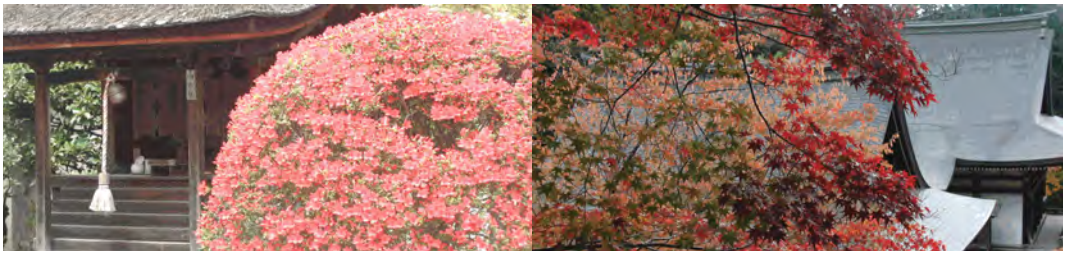
Room rates are the reference rates for 2017 and may be subject to change for 2018.

ICEBREAKER

The Icebreaker will be held on Wednesday 14 March, 5–7 pm at the Deli Café Tamago in the Inamori-Kinen-Kaikan building of the Kyoto Prefectural University, which is located next to the venue. Food and beverages, including soft and alcoholic drinks, will be available from 5 pm to 7 pm. Delegates can also use this opportunity to complete their registration and collect their conference materials.

BANQUET

The banquet will be held at a restaurant, 'In The Green', on the evening of Sunday 18 March. The restaurant is located within walking distance of the venue and near the Kyoto Botanical Gardens. The banquet will include a full dinner meal, dessert and free beverages, including soft and alcoholic drinks.



MID-CONFERENCE EXCURSION
An excursion will be organized on 17 March (Saturday). The half-day excursion will visit cultural spots in Kyoto and its vicinity. Details will be updated on the conference website.

SYMPOSIUM ORGANIZATION
Magnús Már Magnússon (International Glaciological Society)

SCIENCE STEERING AND EDITORIAL COMMITTEE
Alex Anesio, Andrew J Hodson and Martyn Tranter (Co-chairs), Nozomu Takeuchi, Liane Benning, Catherine Larose, Dirk Wagner, Beat Frey. Further editors will be announced as they are appointed.

LOCAL ORGANIZING COMMITTEE
Nozomu Takeuchi (Chair), Shiro Kohshima, Kumiko Azuma, Tetsuo Ohata, Shin Sugiyama, Kazunari Ushida, Teruo Aoki, Yuji Kodama, Jumpei Kubota, Kazuo Takeda, Kenji Kawamura, Koichi Watanabe, Konosuke Sugiura, Naoko Nagatsuka, Rigen Shimada, Sumito Matoba, Keisuke Suzuki, Koji Fujita, Tsutomu Uchida, Jun Uetake, Satoru Yamaguchi, Yukihiko Onuma, Akane Tsushima, Takahiro Segawa

FURTHER INFORMATION
Please register your interest online if you wish to attend the symposium at http://www.igsoc.org/symposia/2018/kyoto. Information will be updated on the conference website, http://www.seppyo.org/~igs2018/index.html

IMPORTANT DATES

Cryosphere and Biosphere

Opening of online abstract submission:	5 October 2017
Opening of online registration:	29 November 2017
Abstract submission deadline:	14 November 2017
Notification of abstract acceptance:	29 November 2017
Notification of acceptance for grant:	10 December 2017
Early registration deadline:	29 December 2017
Deadline for full refund:	29 January 2018
Deadline for refund on a sliding scale:	21 February 2018
Late registration surcharge:	21 February 2018
Symposium starts:	14 March 2018

Annals of Glaciology volume 60, issue 77

Paper submission deadline:	28 January 2018
Final revised papers deadline:	2 May 2018

INTERNATIONAL GLACIOLOGICAL SOCIETY

International Symposium on

Timescales, Processes and Glacier Dynamics

Hotel Lafayette
Buffalo, New York, USA
3–8 June 2018

Co-sponsored by:
- National Aeronautics and Space Administration (NASA)
- US National Science Foundation (NSF)
- Center for Geohazards, University at Buffalo
- Department of Geology, University at Buffalo

FIRST CIRCULAR
July 2017
http://www.igsoc.org/symposia/2018/buffalo

The International Glaciological Society will hold an International Symposium on 'Timescales, Processes and Glacier Dynamics' in 2018. The symposium will be held at the Lafayette Hotel in downtown Buffalo, New York, USA on 3–8 June 2018.

THEME

The physical processes controlling glacier dynamics form the basis of modern glaciology. In spite of the rapid growth in observational data, the ultimate scientific challenge continues to be relating processes to observations. Time-series data are essential to understanding processes; however, their analysis often reveals processes operating on timescales ranging from diurnal to millennial. Individual processes may underpin long-term glacier stability, promote instability or drive natural variability in the glacier state. For example, gravitationally driven flow is among the most fundamental processes in glaciology and controlled by ice-surface slope and thickness. The evolution of the ice surface, in turn, reveals processes related to the mechanical controls on ice flow, firn compaction, development of supraglacial meltwater flow networks, basal melt, isostasy and surface mass balance. Each of these processes alters the surface elevation and is characterized by a different timescale. Assessment of the processes producing changes over a particular time interval poses a major challenge. Hence, even routinely acquired data are difficult to reason about. Interpretation of other data, such as surface velocity, climatological data, radar stratigraphy, glacier history, ice core records, paleoclimate proxies and in situ observations, are also confounded by relations between processes and timescales.

SUGGESTED TOPICS

We seek papers and presentations that advance the understanding of ice sheets and glaciers and glacier dynamics on different timescales. Key focus areas include (but are not limited to):

1. Identification of processes that exert significant control on glacier dynamics
2. Differentiation of processes that are manifestations of natural variability from those that are critical to glacier stability
3. Attribution of physical processes to observations
4. Analyses of data that reveal processes operating on a characteristic timescale
5. Models of processes that help identify the timescales they operate on
6. Characterization of glaciological processes giving rise to hazards such as sea level rise to glacial outburst floods
7. Linking paleoclimate research on timescales of 100–10 000 years to contemporary observations or models of glaciers.

PROGRAM

True to tradition, the symposium will include oral and poster sessions interlaced with ample free time to facilitate the interactions of the participants. Additional activities include an opening icebreaker, a banquet dinner and a trip to Niagara Falls during the mid-symposium afternoon break. A pre- or post-symposium glacial geology and landscape excursion is also planned.

ABSTRACT AND PAPER PUBLICATION

Participants who wish to present a paper (oral or poster) at the Symposium will be required to submit an abstract by 1 February 2018. Accepted abstracts will be posted on the Symposium's website. The Council of 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.

SYMPOSIUM ORGANIZATION

Magnús Már Magnússon (International Glaciological Society).

SCIENCE STEERING AND EDITORIAL COMMITTEE

Co-chairs: Jesse Johnson (University of Montana) and Cornelis van der Veen (University of Kansas).
Scientific Editors include: Joel T. Harper (University of Montana) and Toby Meierbachtol (University of Montana) Further editors will be announced as they are appointed.

LOCAL ORGANIZING COMMITTEE

Beáta Csathó (University at Buffalo (UB); Chair), Jason Briner (UB), Kristin Poinar (NASA/GSFC), Ted Scambos (National Snow and Ice Data Center), Elizabeth Thomas (UB).

VENUE

The symposium will be held at the Lafayette Hotel in downtown Buffalo, in the heart of Buffalo's brewery district and within a mile of historic Canalside on Lake Erie. The magnificent historical hotel was designed by the first professional female architect in the US, Louise Blanchard Bethune, and built in 1904, during Buffalo's industrial heyday. It is located minutes from Shea's Performing Arts Center, Coca-Cola Field and the First Niagara Center. There are excellent restaurants just a short walk away and several hotels within walking distance.

LOCATION

Early summer in Buffalo is consistently pleasant, with warm weather on most days. 'The City of Good Neighbors' is home to about 259 000 Buffalonians, with over 1.13 million residents in the surrounding Buffalo–Niagara Falls metropolitan area. Indeed, it is the second-largest metropolitan area in New York State.

By the late 19th/early 20th century, the burgeoning grain, steel, and automobile industries had transformed Buffalo into a prominent trade center. Some of the greatest examples of the American architecture of this period, as well as Frederick Law Olmsted's Buffalo Park system, make Buffalo an exciting destination. Buffalo is also home to the world's oldest fireboat, the third-oldest Zoo in the USA, the historic site of Theodore Roosevelt's Inauguration Ceremony and the Anchor Bar – the birthplace of the Buffalo chicken wing. The redeveloped waterfront of the former Erie Canal Harbor, Canalside, is a popular destination, with hundreds of events in the summer, including concerts, artisan markets and countless other activities. Located just 17 miles north-northwest of the city is Niagara Falls, one of the most popular tourist sites in the world, famed for its beauty and as a source of hydroelectric power.

FURTHER INFORMATION

If you wish to attend the symposium, please register your interest online at http://www.igsoc.org/symposia/2018/buffalo/
The Second Circular will give further information about accommodation, the scientific programme, additional activities, preparation of abstracts and final papers. Members of the International Glaciological Society, as well as all those who have pre-registered, will automatically receive the Second Circular. Information will also be updated on the IGS conference website, http://www.igsoc.org/symposia/2018/ buffalo/ as it becomes available. A local website will open later in 2017.

Big Yellow Storage

Following on from the update in the last issue of *ICE*, which documented our move to our new office at the British Antarctic Survey, another major step for the IGS recently was the relocation of the archive and storage from the basement of our old offices at Hills Road.

What a task! After 23 years of accumulation, three Secretary Generals, innumerable committee meetings, tens of symposia and years of production of the *Annals*, *Journal* and *ICE* there was a lot of sorting out to be done and many trips to the charity shop and recycling centre, and that was even before we started to look for a suitable alternative storage facility. Luckily Cambridge can supply a range of self-storage options, and the one to offer the IGS the best terms was Big Yellow Storage.

The IGS has taken out a 12-month rolling lease for a storage room in which we were able to install some of our own shelving, of which there was a plentiful supply! Big Yellow Storage were wonderful in offering a range of storage options, great value and easy access to our storage room. In return we may post our thanks to them on social media from time to time. Not only is the storage facility cheaper than the Hills Road basement, but it is brighter and cleaner too! We were helped on the day of the move by Trevor Newling Removals Ltd, who were wonderful.

As you can see we are very organized now. Here's to the next 23 years!

Louise Buckingham

Glaciological diary

** IGS sponsored * IGS co-sponsored

2017

3–5 April 2017
SLAM3 (Slab Avalanche Multi-scale Mechanical Modeling) Workshop
Davos, Switzerland
Website: http://www.slf.ch/dienstleistungen/events/slab_avalanche/index_EN

19–21 April 2017
International Workshop: Airborne Geodesy and Geophysics with Focus on Polar Application
Dresden, Germany
Second Circular at https://tu-dresden.de/bu/umwelt/geo/ipg/gef/die-professur/ws-polar-airborne-geo

23–28 April 2017
European Geosciences Union General Assembly 2017
Vienna, Austria
Website: http://egu2017.eu/home.html

8–11 May 2017
Minisymposium MS3.5: X-ray Micro-tomography of Snow and Porous Ice Media
to be held at the 9th International Conference on Porous Media & Annual Meeting
Rotterdam, Netherlands
Website: http://www.interpore.org/116-event-booking/9th-international-conference-on-porous-media-annual-meeting/319-minisymposia14

9–13 May 2017
Past Global Changes (PAGES) Open Science Meeting (OSM)
Zaragova, Spain
Website: http://www.pages-osm.org/

15 May–2 June 2017
Arctic Field Summer Schools: Norway-Canada-USA collaboration
Svalbard and Tromsø, Norway
Website: http://cirfa.uit.no/intpart-project-to-cirfa-arctic-field-summer-school

22–25 May 2017
International Conference on High Latitude Dust 2017
Reykjavík, Iceland
Website: http://www.geomorphology.org.uk/meetings/international-conference-high-latitude-dust-2017

22–26 May 2017
Úa user meeting and course for new users
Cambridge, UK
Contact Hilmar Gudmundsson <ghg@bas.ac.uk>

22–26 May 2017
5th International Conference of the IASC thematic network 'Palaeo-Arctic Spatial and Temporal (PAST) Gateways'
Kristineberg Research Station,
Gullmmarsfjord, Sweden
Website: http://rechenknecht.natgeo.su.se/PGW2017/

23–25 May 2017
Community Surface Dynamics Modeling System (CSDMS) Annual Meeting
Modeling Permafrost: a new software toolbox to explore frozen grounds
Hands-on Permafrost Modeling Clinic
Boulder, Colorado, USA
Website: http://csdms.colorado.edu/wiki/Form:Annualmeeting

28–31 May 2017
Canadian Geophysical Union Annual Scientific Meeting
Vancouver, British Columbia, Canada
Website: cgu-ugc2017meeting.ca/destination/

28 May–1 June 2017
Joint UK–Russia Workshop: Climate Change Impacts on Surface Water and Groundwater Hydrology in Cold Regions
Yakutsk, Russia
Website: sites.google.com/view/cold-regions-hydrology
Contact Liudmila Lebedeva <ru.uk.coldregionshydrology@gmail.com>

4–8 June 2017
Permafrost conference – Earth's Cryosphere: Past, Present and Future
Pushchino, Russia
Website: www.cryosol.ru
Contact cryoconference@gmail.com

6–8 June 2017
74nd Eastern Snow Conference
Ottawa, Canada
Website: www.easternsnow.org/

11–17 June 2017
2017 Glacial Seismology Training School
Fort Collins, Colorado, USA
Sponsored by the National Science Foundation through the ANET component of the POLENET project, by the Scientific Community on Antarctic Research through the SERCE program, by the IGS and by the International Association of Cryospheric Sciences of the International Union of Geodesy and Geophysics

19–22 June 2017
Forum for Research into Ice Shelf Processes: 31st FRISP workshop
Bergen, Norway
Website: folk.uib.no/ngfso/FRISP/news.html

22 June 2017
Workshop on X-ray micro-tomography of porous ice media
Trondheim, Norway

26–29 June 2017
International conference Snow cover, atmospheric precipitation, aerosols: climate and ecology
Irkutsk, Russian Federation
Website: conf.istu.edu/event/6/

2–6 July 2017
2nd Asian Conference on Permafrost
Sapporo, Japan
Website: acop2017.arc.hokudai.ac.jp/#excursion

7–9 July 2017
International youth scientific and practical conference: Innovations in Geology, Geophysics and Geography
Sevastopol, Russia
Website: folk.uib.no/ngfso/FRISP/news.html

10–12 July 2017
Third Pole Science Summit: TPE-CSTP-HKT Joint Conference
The Coupled Physical, Chemical, Biological and Social Systems in the Third Pole: Impacts, Feedbacks and Adaptation Pathways
Kunming, China
Website: tpss2017.tpe.ac.cn/

14–19 July 2017
***Climate Impacts on Glaciers and Biosphere in Fuego-Patagonia**
Berlin, Germany
Contact: Christoph Schneidern <christoph.schneider@geo.hu-berlin.de>
Website: https://www.geographie.hu-berlin.de/en/professorships/climate_geography/patagonia_workshop

1–2 August 2017
International Workshop on Cryospheric Change and Sustainable Development
Lanzhou, China
2nd circular at http://www.igsoc.org/symposia/lanzhouworkshopsecondcircular_0316.docx

1–4 August 2017
Polar HPDC Research Coordination Network computer skills training mornings
Stony Brook, New York, USA

6–12 August 2017
21st Northern Research Basins (NRB) symposium and workshop: Cold-region hydrology in a non-stationary world
Yakutsk, Russia
Website: http://www.nrb2017.ru/

14–19 August 2017
****International Symposium on Polar Ice, Polar Climate and Polar Change: Remote sensing advances in understanding the cryosphere**
Boulder, Colorado, USA
Contact: Secretary General, International Glaciological Society

4–8 September 2017
European Conference for Applied Meteorology and Climatology 2017
Session UP2.4: The cryosphere and its interactions with meteorology and the climate system. Convener: Renato R. Colluci
Dublin, Ireland
Website: http://www.ems2017.eu/

5 September 2017
Workshop on Cryoturbation
Oslo, Norway
Contact Ivar Berthling <ivar.berthling@ntnu.no>

5–7 September 2017
International Workshop on Glacial Isostatic Adjustment and Elastic Deformation
Reykjavik, Iceland
Website: http://www.polar.dtu.dk/english/workshop-on-glacial-isostatic-adjustment-and-elastic-deformation-2017

6–7 September 2017
****International Glaciological Society British Branch Meeting**
Lancaster University
Contact: Amber Leeson <a.leeson@lancaster.ac.uk>
Website: http://wp.lancs.ac.uk/igs-bb/registration/

10–15 September 2017
SCAR/Past Antarctic Ice Sheet (PAIS) conference
Trieste, Italy
Website: http://pais-conference-2017

11–12 September 2017
Greenland Ice Sheet stability workshop
Buffalo, New York, USA
Website: http://www.glyfac.buffalo.edu/Faculty/briner/greenlandworkshop/

11–15 September 2017
Geo Hackweek
Five days of tutorials, data exploration, software development and community networking, focused on open source tools to analyze and visualize geospatial data
Seattle, Washington, USA
Website: https://geohackweek.github.io/ghw2017

11–15 September 2017
Workshop: Multi-scale modelling of sea ice characteristics and behaviour
Isaac Newton Institute, Cambridge, UK
Website: https://www.newton.ac.uk/event/sipw01

12–23 September 2017
Karthaus course: Ice Sheets and Glaciers in the Climate System
Karthaus, Italy
Website: http://www.projects.science.uu.nl/iceclimate/karthaus/

19–21 September 2017
UK Arctic Science Conference
Oban, UK
Website: www.arctic.ac.uk/research/uk-arctic-science-conference-2017/

20–22 September 2017
Workshop: Modeling meltwater in snow and firn: processes, validation, intercomparison and model uses of optical remotely sensed data
Copenhagen, Denmark
Contact Peter Langen <pla@dmi.dk>

25–30 September 2017
2.5 ECTS Ice Core Analysis and Techniques (ICAT) PhD school
Copenhagen, Denmark
Contact Helle Astrid Kjær<hellek@fys.ku.dk>
Website: http://www.iceandclimate.nbi.ku.dk/outreach/icat-phd-school-2017/

4–5 October 2017
1st International SCAR–ANTPAS workshop
Varese, Italy
General information as PDF at http://www.igsoc.org/symposia/istinternationalantpasworkshopgeneralinfo.pdf

8–11 October 2017
2017 West Antarctic Ice Sheet Workshop
Camp Casey Conference Center, Washington, USA
Contact waisworkshop@nsidc.org
Website: https://www.waisworkshop.org/workshop-2017

9–11 October 2017
Workshop: Improved Satellite Retrievals of Sea-ice Concentration and Sea-ice Thickness for Climate Applications
Hamburg, Germany
Contact Stefan Kern <stefan.kern@uni-hamburg.de> or Dirk Notz <dirk.notz@mpimet.mpg.de>

10–12 October 2017
Finse International Snow Workshop
Finse Alpine Research Center, Norway
Contact: workshop-geohyd@geo.uio.no
Flyer: http://www.mn.uio.no/geo/english/research/projects/escymo/snowhow_escymo_workshop_flyer.pdf

18–20 October 2017
Polar CORDEX (Coordinated Regional Dynamical Experiment – Arctic and Antarctic domains) meeting
Cambridge, UK
Website: http://www.climate-cryosphere.org/activities/targeted/polar-cordex/meetings/1554-2017polarcordexmeetings

22–25 October 2017
Geological Society of America Fall Meeting
Seattle, Washington, USA
Session T42. Glacier and Ice Sheet Grounding Lines: Contemporary and Past Observations of Grounding Line Processes, Behavior, and Landforms.
Contact Nick Holschuh
Session T179. New Concepts in Glaciation of the Western Cordillera of North America.
Contact Jonathan Cripps <jecripps@sfu.ca>

25–27 October 2017
****International Glaciological Society Nordic Branch Meeting**
Uppsala, Sweden
Contact: Veijo Pohjola <veijo.pohjola@geo.uu.se>

6–8 November 2017
Svalbard Science Conference 2017
Oslo, Norway
Website: https://forskningsradet.pameldingssystem.no/svalbard-science-conference-2017

8–9 November 2017
Liestøl Symposium: Integrating field measurements, remote sensing, and models of Svalbard glacier mass balance
Oslo, Norway
Website: https://forskningsradet.pameldingssystem.no/svalbard-science-conference-2017

11–15 December 2017
Conference: Arctic Change 2017
Québec, Canada
Website: http://www.arcticnetmeetings.ca/ac2017

2018

3–5 January 2018
QRA Annual Discussion Meeting
Plymouth, UK
Website: https://www.plymouth.ac.uk/whats-on/qra-annual-discussion-meeting-2018
Contact: Caroline Clason <caroline.clason@plymouth.ac.uk>

8–12 January 2018
4th International Conference on the Physics and Chemistry of Ice
Zurich, Switzerland
Website: http://indico.psi.ch/event/PCI2018
Contact: Thorsten Bartels-Rausch <thorsten.bartels-rausch@psi.ch>

9–11 January 2018
Snow Measurement Field School
Fraser, Colorado, USA
Website: http://cuahsi.memberclicks.net/message2/link/0d746cfd-b984-45ba-97ab-9da13705b52c/9

15–18 January 2018
Fifth International Symposium on Arctic Research (ISAR-5)
Tokyo, Japan
Website: http://https//jcar.org/isar-5/

11–16 February 2018
Ocean Sciences Meeting 2018
Portland, Oregon, USA
Website: https://www.arcus.org/sites/all/modules/civicrm/extern/url.php?u=3981&qid=263607

12–15 February 2018
International Conference on Snow Hydrology (SnowHydro18)
Heidelberg, Germany
Website: http://www.geog.uni-heidelberg.de/hydro/snow2018.html

14–19 March 2018
****International Symposium on Cryosphere and Biosphere**
Kyoto, Japan
Contacts: Secretary General, IGS
Professor Nozomu Takeuchi, Chiba University, Chiba, Japan <ntakeuch@faculty.chiba-u.jp>

21–23 March 2018
Taking the Temperature of the Antarctic Continent: Workshop on Antarctic geothermal heat flux
Hobart, Tasmania, Australia
First circular as PDF: http://www.igsoc.org/symposia/ant_ghf_wkshp_firstcirc1.pdf

25–29 March 2018
27th International Polar Conference
Rostock, Germany
First circular as PDF: http://www.dgp-ev.de/pdf-2017/International-Polar-Conference-2018_First_Circular.pdf

17–27 April 2018
Second Polar Prediction School 2018
Abisko Scientific Research Station, Sweden
Website: http://www.apecs.is/events/upcoming-event-highlights/polar-prediction-school-2018.html

3–8 June 2018
****International Symposium on Timescales, Processes, and Ice Sheets Changes**
Buffalo, NY, USA
Contacts: Secretary General, IGS
Beáta Csathó; University at Buffalo, NY, USA <bcsatho@buffalo.edu>

15–26 June 2018
POLAR2018 – the SCAR and IASC/ASSW Conference
15–18 June SCAR and IASC/ASSW Business & Satellite Meetings
19–23 June SCAR/IASC Open Science Conference
24–26 June SCAR Delegates Meeting & 2018 Arctic Observing Summit
Davos, Switzerland
Website: http://www.polar2018.org/
Contact: Anja Schilling Hoyle, conference manager <polar2018@slf.ch>

24–29 September 2018
Symposium: 25 years of Progress in Radar Altimetry
Ponta Delgada, São Miguel Island, Azores (Portugal)
Contact: Jérôme Benveniste <jerome.benveniste@esa.int>

9–11 October 2018
2nd Arctic Biodiversity Congress
Rovaniemi, Finland
Website: https://www.arcticbiodiversity.is/congress
Contact: CAFF <caff@caff.is

2019

12 –17 May 2019
****International Symposium on Erosion and Sedimentation**
Madison, Wisconsin, USA
Contacts: Secretary General, IGS
Neal Iverson <niverson@iastate.edu>

24–28 June 2019
****International symposium on Five Decades of Radioglaciology**
Stanford, California, USA
Contacts: Secretary General, IGS
Dustin Schroeder <Dustin.M.Schroeder@stanford.edu>

August 2019
****International Symposium on Sea Ice**
Winnipeg, Manitoba, Canada
Contacts:
Secretary General, IGS
David Barber University of Manitoba <David.Barber@umanitoba.ca>

22–27 September 2019
****International Symposium on Snow and Avalanches**
Chandigarh, India
Contact: Secretary General, IGS

2020

Late August/early September 2020
****International Symposium on Ice Stream Dynamics**
Durham, UK
Contacts: Secretary General, IGS
Chris Stokes <c.r.stokes@durham.ac.uk>

2021

September 2021
****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

New members

Dr Thomas Ballinger
Department of Geography, Texas State University
601 University Drive,
San Marcos, TX 78666-4684, USA
Tel: +1 512 245 3202
tballinger@txstate.edu

Ms Gemma M. Brett
Gateway Antarctica, University of Canterbury
Private Bag 4800, Christchurch,
Canterbury 8140, New Zealand
Tel +64 212342158
gemma.brett@pg.canterbury.ac.nz

Mr Julien Brondex
Glaciology, Université Grenoble Alpes
IGE, Domaine Universitaire, 54 rue Molière, BP 96,
F-38402 Saint-Martin-d'Héres Cedex, France
julien.brondex@univ-grenoble-alpes.fr

Mr Zhao Chen
Scripps Institution of Oceanography, University of California San Diego
9500 Gilman Drive, La Jolla, CA 92093-0238, USA
Tel: +1 858 900 6954
zhc031@ucsd.edu

Dr Paul Cutler
Office of Polar Programs, National Science Foundation
2415 Eisenhower Ave, Alexandria, VA 22314, USA
pcutler@nsf.gov

Mr Theo Diamandis
Electrical Engineering, Stanford University
531 Lasuen Mall, PO Box 16967,
Stanford, CA 94309, USA
Tel: +1 813 417 4475
tjdiamandis@gmail.com

Dr Sinéad L. Farrell
Laboratory for Satellite Altimetry, NOAA Center for Weather and Climate Prediction (NCWCP)
NOAA/NESDIS/STAR/SOCD - E/RA3,
5830 University Research Ct, Room 3748,
College Park, MD 20740, USA
Tel +1 301 683 3332
sinead.farrell@noaa.gov

Associate Professor Yasushi Fukamachi
Institute of Low Temperature Science
Hokkaido University, Kita-19, Nishi-8, Kita-ku,
Sapporo, Hokkaido 060-0819, Japan
Tel +81 11 706 7432
yasuf@lowtem.hokudai.ac.jp

Mr Wojciech Gajek
Institute of Geophysics, Polish Academy of Sciences
Ksiecia Janusza 64, PL-01-453 Warsaw, Poland
Tel: +48 510433017
wgajek@igf.edu.pl

Mr Shane Grigsby
Research Assistant, CIRES
University of Colorado Boulder, 216 UCB,
Boulder, CO 80302, USA
shane.grigsby@colorado.edu

Mr Andrew Hilger
Geophysics, Stanford University
Mitchell Earth Sciences Bldg, 397 Panama Mall,
Radio Glaciology Lab, B73, Stanford, CA 94305, USA
Tel: +1 303 502 6521
amhilger@stanford.edu

Mr Alexander Kendrick
Geophysics, Stanford University
Mitchell Earth Sciences Bldg, 397 Panama Mall,
Stanford, CA 94305, USA
Tel +1 505 412 1927
alexkend@stanford.edu

Dr Kerry Key
Lamont-Doherty Earth Observatory, Columbia University
61 Rt 9W, IGPP/SIO/UCSD,
Palisades, NY 10964, USA
Tel: +1 845 365 8604
kkey@ldeo.columbia.edu

Ms Michalea King
School of Earth Sciences, Ohio State University
275 Mendenhall Lab, 125 South Oval Mall
Columbus, OH 43210, USA
Tel+1 330 401 5928
king.1534@osu.edu

Dr Javier J. Lapazaran-Izargain
Departamento de Matemática Aplicada,
Universidad Politecnica de Madrid
E.T.S.I. de Telecomunicacion, desp. A302-4,
Av. Complutense, 30 (Ciudad Universitaria),
ES-28040 Madrid, Spain
javier.lapazaran@upm.es

Dr Brent Minchew
British Antarctic Survey
High Cross, Madingley Road,
Cambridge CB3 0ET, UK
minchewb@gmail.com

Ms Lynn Montgomery
Atmospheric and Oceanic Science, University of Colorado Boulder
311 UCB, Boulder, CO 80309-0311, USA
Tel: +1 301 256 8512
lymo1328@colorado.edu

Dr Rachael Mueller
Earth & Space Research
114 W. Magnolia St., Suite 505,
Bellingham, WA 98229, USA
Tel: +1 541 231 7204
mueller@esr.org

Mr Jean Negrel
Norwegian Polar Institute
Fram Centre, Postbox 6606 Langnes,
NO-9296 Tromsø, Norway
jean.negrel@npolar.no

Mr Sean Peters
Electrical Engineering and Geophysics, Stanford University
397 Panama Mall, Mitchell Building 101
Stanford, CA 94305-2210 USA
Tel: +1 928 581 5397
stpeters@stanford.edu

Mr Martin Rongen
Physics, RWTH Aachen University
Otto-Blumenthal-Straße, D-52074 Aachen,
Germany
rongen@physik.rwth-aachen.de

Dr Anja Rösel
Norwegian Polar Institute
Fram Centre, PO Box 6606 Langnes,
Tromsø NO-9296, Norway
Tel: +47 40578950
anja.rosel@npolar.no

Ing. Pablo Sánchez Gámez
Applied Mathematics, Universidad Politécnica de Madrid
ETSI Telecomunicación, Av. Complutense 30,
ES-28049 Madrid, Spain
pablo.sgamez@upm.es

Ms Erika Schreiber
Geography, University of Colorado Boulder
GUGG 110, 260 UCB, Boulder, CO 80309-0260, USA
Tel: +1 631 707 1662
erika.schreiber@colorado.edu

Dr Mark C. Serreze
National Snow and Ice Data Center, CIRES/CU Boulder
Campus Box 449, Boulder, CO 80309, USA
Tel: +1 303 492 7867
serreze@nsidc.org

Mr Thomas Teisberg
Electrical Engineering, Stanford University
David Packard Building, 350 Serra Mall,
Stanford, CA 94305, USA
Tel: +1 434 322 0360
teisberg@stanford.edu

Mr C. Scott Watson
School of Geography, University of Leeds
Garstang North, Leeds LS2 9JT, UK
scott@rockyglaciers.co.uk

Mr Tomasz Wawrzyniak
Institute of Geophysics,, Polish Academy of Sciences
Ksiecia Janusza 64, PL-01-452 Warsaw, Poland
Tel +48226915843
tomasz@igf.edu.pl

Dr Michael Willis
CIRES, University of Colorado, Boulder
216 UCB, Boulder CO 80309, USA
Mike.Willis@Colorado.Edu

Mr Baojun Zhang
Chinese Antarctic Center of Surveying & Mapping, Wuhan University
129# Luoyu Road, Wuhan 430079, P.R. China
bjzhang@whu.edu.cn

Ms Valentina Zorzut
IANIGLA
Av. Ruiz Leal s/n Parque General San Martín,
Mendoza CP 5500, Argentina
Tel: +54 0261153477991
zorzut.valentina@gmail.com

International Glaciological Society

Secretary General M.M. Magnússon

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	*A. Mackintosh	2015–2018	2015
	*M. Montagnat	2014–2017	2014
	*D. Notz	2016–2019	2016
	*A. Pope	2016–2019	2016
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	P. Langhorne		
	C Ritz		

*First term of service on the Council

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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
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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		
1983	W.O. Field	1998	C. Lorius		
1983	J. Weertman	1999	C.F. Raymond		
1985	M.F. Meier	2000	S.C. Colbeck		
1986	G. de Q. Robin	2001	G.S. Boulton		

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K. Higuchi	V.M. Kotlyakov
G. Østrem	G. Wakahama
Yang Zhenniang	

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

International Glaciological Society

High Cross, Madingley Road
Cambridge CB3 0ET, UK

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ICE

Editor: M.M. Magnússon (Secretary General)

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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