ISSN 0019–1043

Ice

News Bulletin of the International Glaciological Society

Number 164 1st Issue 2014

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Cover picture: Recent avalanche in the Goat's Lick area of Glacier National Park, Montana, USA. Photograph by Randal Powell, Dancing Bears Inn, East Glacier Park, Montana.

From the Editor

Dear IGS member

Before I start on the 'editorial proper', I would like to make you aware that we have rescheduled the 2014 Annual General Meeting (AGM). Originally we were planning to hold it in Edmonton but because of the unfortunate cancellation of the Edmonton symposium we have to find another venue. The reason for the cancellation was that we had insufficient abstracts submitted to sustain an international symposium. Ironically, after we had announced the cancellation we received several more 'intents to attend'.

But I digress; back to the AGM. There are a few options. We could hold it at the British Branch meeting in the UK in September or during the Nordic Branch meeting in Iceland at the end of October. At both meetings we would have a sufficient number of IGS members to reach a quorum but an insufficient demographic spread of IGS members attending. And since the Society is truly international we felt we had to find a suitable 'international' event. Hence we would like to hold the 2014 IGS AGM during the AGU Fall Meeting in San Francisco in December. But the success of such a meeting depends on the attendees and although I would be the first to admit that the annual AGM is not the most exciting event around we depend on you to attend to make it 'legal'. We do not have a venue yet but once things are a bit more finalized I will be e-mailing all our members with details of the AGM. I do hope you will join us. In a future year, we will plan to have an AGM at an EGU meeting to ensure that IGS members who attend either the AGU or EGU will have a chance to participate in an IGS AGM.

In my last editorial I talked about giving a presentation at a symposium. We have received some interesting feedback on that editorial, some of which we will try and implement in future events and which will hopefully improve the presentations at meetings. We'll see what happens at the next IGS symposium. But I would like to talk some more here about IGS symposia. From the recent survey we did (which, incidentally, was very successful, but more on that later) it is evident that the glaciological community greatly values the IGS symposia and the intimacy and high scientific standard they offer. This is a great encouragement for us to continue to organize our future meetings in a similar way. Of course we will always strive for new innovations and ways to improve the experience and we will seriously consider

any suggestion you may have. We do have a fairly tight schedule for the next few years: we are actually planning symposia as far ahead as 2020, although there are a couple of gaps in the schedule. But we do not want to make the schedule too tight either – after all, there are other things happening as well.

And this is the time of year that the Cryolist is swamped with 'calls for submissions' for the AGU Fall Meeting in December. I would like to suggest to all the convenors of AGU sessions that they look into helping the IGS organize a symposium on a theme of their field of interest. It is a very rewarding experience and a great opportunity to bring together experts with similar interests in an amicable and relaxing environment. Typically, IGS symposia are very focused and concentrate on a specific theme. We then have several 'sub-topics' where we go into even further detail. These sub-topics are then organized into dedicated sessions where one is guaranteed to have the 'state of the art' in the particular topic being presented. And then the socializing allows you to discuss the topics further with your peers and to get to know them in an 'out-of-work' environment.

And IGS symposia are almost always staged in interesting locations. Take for example our last symposium in Chamonix. It was most interesting sitting in a café with colleagues and watching other colleagues go by, sometimes stopping for a chat and sometimes joining us for a drink and a bite to eat. It was obvious the IGS was in town.

Also, at IGS symposia we quite often have 'breakaway' meetings of the various research projects that are going on. Sometimes those projects have a 'travel/meeting fund' associated with them, and combining the project meeting with the symposium can make the cost of the latter more manageable and hence enable you to attend. In addition organizing a breakaway meeting ensures that more of the 'experts' in the field attend the symposium and thus make it more interesting.

There is another important thing I would like to point out regarding IGS symposia. At what other major meetings do you get morning and afternoon refreshments, lunch, an Icebreaker (and if you were at the Chamonix meeting you would know that the Icebreaker there was a major feast), a mid-week excursion and a full Thursday evening banquet? In addition, there is quite often an additional social activity, a BBQ or similar. All of this is included in the registration fee.

To finish off, I note that the third issue of the *Journal* for 2014, issue 221, is now published. The fourth issue of the *Journal* is well on its way to completion and we are now assigning papers to the fifth issue of 2014. *Annals* 55(67) has gone to the printers, and work is progressing on the other *Annals* issues for 2014. And we are already publishing online *Annals* papers that have an 'official' publication date of 2015. In short, we are doing everything we can to get your papers out there as soon as possible.

Magnús Már Magnússon
Secretary General

Recent work

Germany

GLACIERS AND ICE CAPS

Dynamic response of glaciers on the Tibetan Plateau to climate change (DynRG-Tip)
C. Schneider, M. Spieß, E. Huintjes (RWTH), D. Scherer, F. Maussion (TUB), M. Buchroithner, J. Kropacek, B. Schröter, T. Bolch (TUDD), S. Kang, W. Yang (ITPCAS)
The DynRG-Tip project studies the dynamic response of glaciers on the Tibetan Plateau (TiP) to climate variability and change in the frame of the Priority Programme 1372 'Tibetan Plateau Research (TiP)' of the Deutsche Forschungsgemeinschaft (DFG). The major goal is to investigate atmosphere–cryosphere interactions focusing on spatial patterns of large-scale atmospheric forcing and glacier changes. Remote sensing data analyses are performed along an east–west transect on the TiP to account for competing, variable influences of monsoon and westerlies. The migration of snowlines as a proxy for the equilibrium line altitude was derived from MODIS satellite imagery. Field studies on glaciers in the Nyainqentanglha Mountains and the Gurla Mandhata Mountain Range provide observations for validation and in-depth analyses. Terrestrial time-lapse cameras were employed to generate high-resolution photographs of a glacier from which a time series of mean altitudes of the snowline was derived. These data, complemented by multiyear ablation stake measurements, were used to successfully validate a physically based, coupled energy balance and multilayer snow model.
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Geodetic observations of glaciers in Bavaria
W. Hagg, E. Mayr (LMU), C. Mayer, H. Escher-Vetter (KEG)
Since the early 1960s, five small glaciers in the Bavarian Alps have been surveyed regularly and systematically by the Commission for Geodesy and Glaciology of the Bavarian Academy of Sciences and Humanities. Within the DFG-funded project Bavarian Glaciers (www.bayerische-gletscher.de), historic maps since the late 19th century have been digitized and added to the series of geodetic glacier mass balances. In addition, a new surface survey was conducted in 2009/10 and ice thicknesses were observed by radio sounding. After the 1960s and 1970s, when positive mass balances could be observed, the glaciers experienced severe mass losses. Although the Bavarian glaciers show individual behaviour, which can mostly be explained by local topographical features, the overall trend is an intensified surface lowering during the past decades. To identify the local causes, climatological data from stations near the glaciers have been analysed. The records reveal an extensive summer warming over the period of observation, but no significant trend in winter precipitation. Correlations indicate that the mass budget of these small glaciers is mainly controlled by summer air temperatures.
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Glacier mapping in Central Asia
C. Mayer (KEG), W. Hagg (LMU), D. Kriegel (GFZ)
Within the regional research network 'Central Asian Water' (www.cawa-project.net), 507 glaciers in the Big Naryn basin, Central Tian Shan, were mapped using LANDSat and SPOT imagery from 2007. Compared to the Soviet glacier inventory based on data from the mid 20th century, the total glacier area decreased by 23.4%. Using volume–area scaling, supported by ground penetrating radar measurements on three test glaciers, a total ice loss of 6.6–8.4 km^3 (~20%) was estimated. The water equivalent of 5.9–7.6 km^3 was transformed into excess discharge and contributed to at least 7.3–9.2% of total runoff in the considered period. The mask of the glacier extent was included in the Randolph Glacier Inventory V3.2.
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Periodic observations of selected glaciers in the Eastern Alps
C. Mayer, L. Braun (KEG), W. Hagg (LMU)
In the Eastern Alps of Austria and Germany, 15 glaciers have been selected as a representative group for decadal glacier change observations. Observations date back to 1889 for some glaciers, while Watzmann glacier in the Berchtesgaden Alps joined the list in 1959 again, after being not counted as a glacier in between. In 2009, the so far last survey was made for all glaciers resulting in area and volume changes for the decade 1998/99–2009. Besides total volume change, the elevation-dependent volume change is also calculated for 50m elevation bands, documenting trends in the vertical distribution of mass balance conditions. The last decade was the most negative in the period of observations.
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Glaciological and hydrological monitoring of Vernagtferner, Austrian Alps, by KEG

L. Braun, H. Escher-Vetter, C. Gerlach, C. Mayer, M. Siebers, M. Weber (KEG)

The annual and seasonal glacier mass balances of Vernagtferner, Austrian Alps, have been determined for nearly 50 years, along with the climatological and hydrological conditions, with emphasis on discharge, for the last four decades. The monitoring effort is continued with constantly renewed instruments, data transmission and data logging. Analyses of the various terms of the water balance are being conducted and published. Since 2010 the glacier monitoring also includes gravimetry measurements for the direct determination of glacier mass changes. The observed drastic increase in runoff despite the diminution of glacier area demonstrates the impact of climate change in this high alpine environment. It results from continuously negative mass balances of this glacier since the early 1980s, caused by strong ablation during summer.

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Mass balance and dynamic conditions of the Merzbacher Lake ice dam

C. Mayer, M. Siebers, M. Juen (KEG), W. Hagg, E. Mayr (LMU), U. Wetzel (GFZ), R. Usubaliev (CAIAG)

Lake Merzbacher is one of the largest ice-dammed lakes in the world, situated in a northern tributary valley of Southern Inylchek glacier in the Kyrgyz Tian Shan. The lake usually drains every year by a subglacial flood, creating a substantial jökulhlaup. Since 2010, the part of the Southern Inylchek glacier which dams the lake has been equipped with a continuous monitoring system, observing the three-dimensional movement of the ice dam, as well as the meteorological and glaciological conditions. The aim of the project is the investigation of the dynamic response of the ice dam to the flood events and the long-term evolution of the ice dam with respect to ice flow and mass balance.

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Holocene paleo-environmental signals from Akademii Nauk ice cap (Severnaya Zemlya, Russian Arctic)

D. Fritzsche, T. Opel (AWI), D. Wagenbach (IUP), J. McConnell (DRI) , S. Merchel, G. Rugel (HZDR)

The project is focused on the analysis of a 724 m ice core drilled to bedrock (joint German–Russian project 1999–2001). Beside stable water isotope composition, major ion and black carbon content were measured to get information about the regional climate and environmental history. ^{10}Be concentration is used to further validate the age–depth relationship of the core, which up to now has been based on interpretation of volcanic signals and counting of seasonal isotopic cycles.

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Climate variability and the dynamic response of the Gran Campo Nevado Ice Cap, southern Patagonia

C. Schneider, S. Weidemann (RWTH), R. Kilian (UT), T. Sauter (UIBK)

The Gran Campo Nevado (GCN) project focuses on the impact of large-scale atmospheric forcing on the spatio-temporal variability of glacier mass balance and volume changes at the Gran Campo Nevado Ice Cap in southern Patagonia. The GCN Ice Cap and its outlet glaciers are strongly influenced by high orographic induced precipitation amounts and characterized by high mass turnover and a short response time to changes in temperature and precipitation. The main aspects of this project are the establishment of a weather station network in combination with glacier monitoring, and glacier mass balance and energy balance modelling to obtain a detailed analyses of climate variability and the dynamic response of the GCN Ice Cap to changes in atmospheric conditions. The linkage of detailed studies of paleoclimate, local climate, and glacier mass balance and glacier dynamics aims to improve the understanding of the high rates of mass loss of southern Patagonian glaciers.

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Investigations of mass balance conditions on Baltoro Glacier, Karakoram

C. Mayer, C. Lambrecht (KEG), C. Smiraglia, G. Diolaiuti, U. Minora (UMI)

Debris-covered glaciers in the Karakoram and other mountain ranges of Asia very often do not show large area variations over decades. Because of the debris cover the terminus areas of the glaciers are very well protected from ablation and easily stay close to an equilibrium state even with rather low ice flux from upstream. Mass balance conditions can thus only be inferred from the local conditions of surface ablation, ice flux measurements and knowledge about high-elevation accumulation. For this purpose the most prominent glacier of the central Karakoram, Baltoro Glacier, is observed since 2011. A stake network across the central ablation area is used to monitor the ablation conditions, automatic weather stations collect the necessary meteorological data and specific measurements in the high-accumulation basins have been carried out to specify the accumulation amount and its spatial distribution over time. These activities are integrated into a large socio-economic project coordinating different activities in the Karakoram region

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Space-borne glacier monitoring of the Aksu–Tarim catchment (Xinjiang/China, Kyrgzystan)
T. Bolch (TUDD, UZH), T. Pieczonka (TUDD), L. Shiyin (CAREERI)
Glaciers in the Aksu–Tarim catchment are resources of fresh water and are of cardinal importance both for the ecosystem and for agriculture in the arid Tarim Basin in Xinjiang (northwest China). The aim of this DFG-funded project is to investigate glacier area and mass changes of the entire catchment containing more than 2500 glaciers covering an area of almost 4000 km^2 based on multitemporal high-resolution stereo satellite imagery (such as Hexagon KH-9 and SPOT 5 data) for the period ~1970–2010. The activities are complemented by field work at selected glaciers for ground truth and velocity measurements based on feature tracking. Results revealed that glacier area changes were on average comparatively small (~–0.2% a^{-1}). The mass loss, however, was within the global mean. Some glacier surges could also be detected. Most of the debris-covered glaciers showed a significant mass loss and have stagnant parts at their termini. The additional contribution to the overall run-off of Aksu River due to the glaciers' imbalance was found to be partly more than 15%. The generated glacier inventory will be available through GLIMS and has already been included in the Randolph Glacier Inventory.
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Dynamic response of surface energy and mass balance of Vest- and Austfonna (Nordaustlandet, Svalbard) on climate change
D. Scherer, R. Finkelnburg (TUB), C. Schneider, M. Möller (RWTH), M. Braun (FAU)
The International Polar Year (IPY) 2007/08 led to the formation of large international scientific consortia for research on the response of Arctic glaciers on climate change. The project, funded by the German Research Foundation (DFG) since 2008, contributed to two endorsed IPY core activities, GlacioDyn and Kinnvika. It is closely linked with a research project funded by the BMBF as part of the international SvalGlac project (see 'SvalGlac – the German Contribution'). The study region comprises Nordaustlandet, Svalbard, where the ice caps Vest- and Austfonna are among the largest ice bodies of the European Arctic. Little was known on current variability and trends of the surface energy and mass balance of these ice caps and its sensitivity to climate change. The project aims at filling this gap by taking advantage of the international collaboration within the IPY. Based on global atmospheric analysis and reanalysis data, we developed a set of coupled numerical models for determining the climate sensitivity of surface energy and surface mass balance components on Vestfonna. Glaciological and meteorological field data for calibration and validation were acquired during field campaigns to Vestfonna taking place during the spring and summer seasons 2008–12.
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Glacier changes in the Karakoram region
M. Braun, M. Rankl, S. Vijay (FAU)
The project investigates changes in glacier positions of glacier in the Karakoram–Himalaya–Hindu Kush region with a focus on the Karakoram Range. An updated glacier inventory is generated from multispectral satellite imagery, including the distribution of surging, advancing, stable and retreating glaciers and their respective terminus changes during a 37 year period. Glacier surface velocities are computed at repeat time steps using SAR feature tracking techniques and different SAR sensors (TerraSAR-X, ALOS PALSAR, ERS, ENVISAT) over a 20 year period. Velocity fields are provided across the whole Karakoram Range and with denser time resolution for specific surge-type glaciers during their active phase. High-resolution bi-static TanDEM-X data are used to determine elevation changes by interferometric analysis.
Duration: 2011–15
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ICE SHEET DYNAMICS

Marine regions of the WAIS and their response to ocean warming
J. Feldmann, T. Albrecht, M. Mengel, A. Levermann (PIK, UP)
Several ice shelves fringing the West Antarctic Ice Sheet (WAIS) are affected by warm water flowing into their subshelf cavities and reaching towards the grounding line. A large fraction of the grounded ice in the corresponding catchment basins, drained by the ice shelves via fast-flowing ice streams, may potentially be susceptible to marine ice sheet instability. Prominent examples for observed rapid changes attributed to enhanced sub-shelf melting in recent decades, such as grounding line retreat, ice speed-up and thinning, are Pine Island and Thwaites Glaciers. The Filchner–Ronne Ice Shelf may also be subject to significantly warmer water in the future. We model these ice-sheet/shelf systems in regional set-ups using the Parallel Ice Sheet Model (PISM). Our focus is on analysing their dynamic response to increased subshelf melting and investigating the stability of these regions. Furthermore we want to make projections for the regions' future contribution to sea level, helping

to reduce the uncertainty of Antarctica's role in a warming climate.
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Gateways for marine ice discharge in West Antarctica
M.A. Martin, R. Winkelmann, A. Levermann (PIK)
Future changes in Antarctic ice discharge will be largely controlled by the fate of the floating ice shelves, which exert a back-stress on to Antarctica's marine outlet glaciers. Ice loss in response to ocean warming has been observed for some of these marine outlet glaciers in the past decades. This holds the potential to trigger a marine ice-sheet instability in West Antarctica which needs to be further assessed along with its strong implications for global sea-level rise. Using the Parallel Ice Sheet Model, we investigate the ice discharge through major West Antarctic gateways. The reaction to warm-water intrusion into the associated ice-shelf cavities depends crucially on the bedrock topography and differs qualitatively in century-scale future scenarios: ocean warming in the Weddell Sea leads to more abrupt ice discharge than the same warming in the Amundsen Sea, which also indicates a central role of the Weddell Sea in Antarctica's future sea-level contribution.
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Ice plugs and the stability of East Antarctic marine-based ice
M. Mengel, A. Levermann (PIK, UP)
Marine ice is grounded below sea level and has the potential for instability through enhanced discharge over the grounding line. Although West Antarctica is most prominent for its marine ice, East Antarctica also features extensive and deep basins below sea level with five times more marine ice than West Antarctica. The oceanic entrance of several basins is blocked by subglacial ridges covered with thinner and possibly less stable ice. The stability of these ice plugs may determine the long term fate of the large ice masses in their marine hinterland. This work aims at exploring the stability of the ice plugs, theoretically and through simulations with the ice sheet model PISM.
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RIMBAY – A multiapproximation 3D ice-dynamics model
M. Thoma, K. Grosfeld, D. Barbi, J. Determann, S. Goeller (AWI), C. Mayer (KEG), F. Pattyn (ULB)
Modeling the dynamics and mass balance of ice sheets and ice caps is an important issue to investigate the current state and the future response of the cryosphere to changing environmental conditions, i.e. global warming. Based on the well-known and established ice sheet model by Pattyn (2003, 2008), we developed the modular multiphysics (shallow ice, shallow shelf, higher order and full Stokes physics) thermomechanical ice model RIMBAY, considering a shallow-ice–shallow-shelf coupler and a full 3-D-grounding-line migration scheme based on Schoof's (2007) heuristic analytical approach. Cross-validation against previously published ice-modeling experiments and benchmarks test, and some additional sensitivity studies based on artificial set-ups demonstrate the robustness of the different solvers and their internal coupling. RIMBAY is designed for an easy adaption to new scientific issues. We demonstrate in very different set-ups the applicability and functionality of RIMBAY in Earth system science in general and ice modeling in particular, and provide RIMBAY as a new open source ice dynamics model to the scientific community.
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The role of fractures in large-scale ice dynamics
T. Albrecht, A. Levermann (PIK, UP)
The buttressing effect of floating ice shelves represents an important component for a comprehensive understanding of the dynamics of the Antarctic Ice Sheet System. Fracture processes are observed to enhance effects of atmospheric and oceanic forcing on the ice flow by altering the macroscopic mechanical properties of the ice. However, aspects of fracture mechanics has been so far widely neglected in fluid-dynamical large-scale ice-sheet models. As co-developers of the Parallel Ice Sheet Model (PISM) we implemented a first-order approach to account for the initiation and evolution of fractures and their bulk effect on the creep flow in terms of a scalar 'fracture density' state variable. This coupling provides the physical basis for an appropriate model representation of fracture-weakening, iceberg calving and even ice-shelf disintegration.
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Paleo-dynamic and physical properties of ice domes from englacial layer architecture
O. Eisen, D. Steinhage (AWI) R. Drews (ULB) C. Martín (BAS)
The local Halfvarryggen ice dome in Dronning Maud Land, Antarctica, is envisaged as a site for intermediate depth ice-coring within IPICS 2k/40k. High resolution mapping of ice-internal reflections horizons by airborne and ground-based radar and analysis thereof was performed within the LIMPICS project. The dome features a double Raymond bump with a central syncline,

high accumulation and a strong accumulation gradient. A ice-flow model capable of considering strain-induced development of anisotropy reproduced the observed layer architecture. This indicates that Halvfarryggen has been stable in the present configuration over the last 5 ka. We expected a model-based age of 11 ka at 90% ice thickness. Application of this method is also envisaged for other ice domes in the DML area.
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Interaction of ice flow dynamics, subglacial lakes and basal drainage networks

S. Goeller, M. Thoma, K. Grosfeld, H. Miller (AWI)

A balanced water layer concept for modeling subglacial hydrology has been introduced, covering two prominent features for ice sheet modeling on a continental scale: the evolution of subglacial lakes and balance water fluxes. This concept has been coupled into the thermomechanical ice-flow model RIMBAY and is applied to a synthetic model domain. In different experiments the dynamic generation of subglacial lakes and their impact on the velocity field of the overlaying ice sheet are demonstrated, resulting in a negative ice mass balance. Furthermore, an elementary parameterization of the water flux–basal sliding coupling has been derived. Its application reveals the predominance of the ice loss through the resulting ice streams against the stabilizing influence of less hydrologically active areas. It can be pointed out that established balance flux schemes quantify these effects only partially as their ability to store subglacial water is lacking.
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Feedbacks in ice flow dynamics induced by basal water

T. Kleiner, A. Humbert (AWI)

Basal water is a crucial component in the dynamic evolution of ice sheets. It affects sliding, as well as rheology and via both the ice dynamics. On the other hand, heat transport and heat generation and therefore the amount of water depend on the ice flow. To investigate the involved feedback we use the three-dimensional, thermo-coupled Stokes model TIMFD^3. Our simulations applied to the Stancomb–Wills Ice Stream region, Antarctica, show that enhanced sliding due to water cools the base and leads to more concentrated ice flow in smaller areas, while the effect of microscopic water inclusions on the rheology gives rise to a cyclic behaviour on millennial time scale. This regional and process based study is part of our multiphysics hybrid-scale approach were we aim to evaluate key factors that are driving ice dynamics on a continental scale and the contribution of the ice sheet to sea level change by coupling TIMFD^3 to the large scale Parallel Ice Sheet Model (PISM).
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Pine Island Glacier – local flow mechanisms and basal sliding

N. Wilkens (UHH), A. Humbert (AWI)

Pine Island Glacier is a fast moving outlet glacier in the West Antarctic Ice Sheet, showing strong changes over past decades. Its complex surface flow structure is created by varying basal conditions. This poses a major challenge when modelling the flow field of this glacier. Commonly this difficulty is overcome by inversion for parameters controlling basal sliding. We investigate possibilities to constrain basal sliding by physically based parameterizations instead. To achieve this, we conduct experiments of Pine Island Glacier with the diagnostic three-dimensional thermo-mechanically coupled full-Stokes model COMice. First, the model is used to identify dominant local mechanisms driving the flow of the different tributaries. Secondly, we use information from the basal roughness to constrain basal sliding. This approach is thus based on a physical parameter. The results show a good reproduction of the fast-flowing central stream, although not all tributaries are reproduced. Towards the grounding line it is important to consider a reduced normal pressure.
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Subglacial properties of ice sheet in Dronning Maud Land, Antarctica

D. Steinhage, A. Humbert (AWI), F. Bellot (HNEE, AWI), D. Kasper (UHH, AWI)

We investigate the basal roughness and the basal reflection coefficient of the East Antarctic ice sheet using some 120 000 km of airborne radio-echo sounding data acquired by AWI in Dronning Maud Land. The basal roughness is an important quantity for the description of basal sliding, while the basal reflection coefficient allows assessing if the base of an ice sheet is dry or wet. For the roughness estimation a two-parameter roughness was estimated over the whole of Dronning Maud Land, revealing areas with low roughness in the Amundsenisen area. The estimation of the basal reflection coefficient uses a modelled thermal regime based on PISM in order to correct the losses due to temperature change, as well as the conductivity of the deep ice cores for losses due to impurities. In addition to the absorption, we use the slope criterion to assess the potential for lakes.
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ICE–OCEAN INTERACTION

Monitoring the Filchner Trough as part of the Filchner Ice Shelf Project

M. Schröder, H.H. Hellmer (AWI)

Model results from IPCC scenario simulations reveal a pronounced sensitivity of the southeastern Weddell Sea to projected atmospheric changes with the continental slope current redirected into the Filchner Trough. Few hydrographic observations from the southeastern Weddell Sea show that today modified warm deep water reaches the Filchner Ice Shelf front. However, it remains speculative whether this is a permanent feature or a quite variable one. At the Filchner Trough sill the long-term water mass formation rate and its variability and sensitivity to changes in environmental conditions remains unclear. Our hydrographic observations in the Filchner Trough will be conducted in cooperation with international partners (UK and NO) and are closely related to glaciological field work on the Filchner Ice Shelf. The latter is designed to extend existing data sets, necessary for modelling the coupled ice shelf–ice sheet dynamics, and to build-up reference data for the expected changes within the ice shelf/sheet due to ocean warming.

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Assessment of present and future circumpolar ice shelf basal melting using a global ocean circulation model

R. Timmermann, H.H. Hellmer (AWI)

The finite element sea ice–ice shelf–ocean model (FESOM) was forced with atmospheric output from two climate models: HadCM3 and ECHAM5/MPI-OM. Forced with their 20th-century output, ice shelf basal melt rates compare well with observations but are consistently smaller for ECHAM5/MPI-OM. The HadCM3 projections for IPCC AR4-scenarios E1 and A1B suggest a decreasing salinity on the continental shelf and intrusions of warm water of open-ocean origin. For the Filchner–Ronne Ice Shelf, this water reaches the deep cavity by year 2100, increasing basal loss by a factor of 4–6. The evolution of the surface freshwater fluxes on the continental shelf appears to be crucial for the fate of the large cold water ice shelves. Simulations forced with output from the IPCC-AR5 models HadGem2 and MPI-ESM will help to reduce the uncertainty in projections, while coupling to a dynamic ice sheet/shelf model will allow for a consistent representation of the interaction between the Antarctic hydrosphere and cryosphere.

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Estimating melt rates in Pine Island Ice Shelf with an adjoint ocean circulation model

M. Losch (AWI), P. Heimbach (MIT)

Melt rates in ice shelf cavities around Antarctica are difficult to observe directly. Indirect methods infer melt rates from surface observations, such as flow speed or gravity from satellite missions. Here, we use in situ hydrography observation (CTD-sonde data in front of the ice shelf and AUTOSUB data within the ice shelf cavity) and a numerical ocean general circulation model (GCM) with an explicit melt rate parameterization to estimate melt rates underneath the Pine Island Glacier in West Antarctica. Adjoint methods are used to fit the complicated GCM to the available observations without modifying the model physics. The best-estimate circulation is driven by melt rates that are thus indirectly determined by observations and physical constraints.

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Ocean warming beneath Filchner–Ronne Ice Shelf raises century-scale sea-level projections

J. Determann, M. Thoma, K. Grosfeld, H. Hellmer (AWI)

The impact of a possible ocean warming beneath FRIS on the volume decrease of its catchment is investigated by coupled ice-sheet–ice shelf–ocean modelling. Simulating a time span of several hundred years, the results reveal a grounding-line retreat of 250 km at sensitive, presently still grounded regions in the southern Filchner–Ronne Ice Shelf, namely the Foundation and Möller Ice Stream tributaries. Ice volume changes would correspond to an extra sea-level contribution exceeding 0.3 mm a^{-1}. The changing sub-ice-shelf cavity will experience newly formed hot spots of high melting where today's ice is still grounded.

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The Filchner Ice Shelf Project

A. Humbert, H. Hellmer, M. Schröder (AWI)

Modelling studies have shown the potential of Weddell Sea warm water masses to drain into the cavity underneath the Filchner Ice Shelf and enhance basal mass loss. Within the Filchner Ice Shelf Project we aim to determine the recent basal melt rates of the Filchner Ice Shelf in order to be able to assess future changes, as well as to model potential grounding line migration. To this end, a German–British (AWI/BAS) team will carry out a field campaign in which hot-water drilling allows access to the sub-ice ocean at four locations. The observations range from ocean acoustics, water sampling, CTD profiling, mooring deployment and upward looking sonar to phase sensitive radar, thermistor strings, fibre optics and seismics. This logistically challenging field campaign will take place in austral summer 2015/16 and

2016/17 and involves RVIB *Polarstern* as well as AWI's aircraft Polar 5/6.
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Ice sheet/ocean interaction at the 79° Glacier, Greenland
A. Humbert, U. Schauer (AWI)
We aim at understanding the interaction between ice and ocean at an outlet glacier of the North East Greenland Ice Stream, the 79° Glacier, by investigating its dynamics, its basal conditions, and the water masses in the ice shelf cavity and in the Fram Strait. To this end an international team will carry out comprehensive glaciological and oceanographical surveys. Airborne radar surveys and seismic profiling will focus on the geometry and structure of ice, ocean and bed. Basal melt rates will be obtained by means of phase sensitive radar, upward-looking sonar and ice temperature observations. Hot-water drilling opens access for moorings and subglacial instrumentation. Sediment coring, AWS, GPS for isostatic uplift and seismometers broaden the scope of this project.
Partners: UDD, FAU, BGR, WH, UM, BAS, GEUS, DU, NP, RNI, UAB
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DYSTAP: Structural and dynamic changes of Wilkins Ice Shelf, Antarctic Peninsula
M. Braun, M. Rankl (FAU), R. Müller, C. Plate (TUKL), A. Humbert (AWI)
In this project funded in the DFG Priority Program 'Antarktisforschung' a large inventory of satellite imagery is used to map ice shelf extent and structural changes over time (e.g. fractures, flow lines, melt ponds, grounding line, shear zones and ice dolines). Surface velocities of the ice shelf and its tributary glaciers are derived from different SAR sensors (TerraSAR-X, ALOS PALSAR, ERS, ENVISAT) in order to determine changes in the motion field in the same time period. Ice thickness estimates of the ice shelf are carried out using different altimeter measurements (ICESat, CryoSAT, NASA IceBridge). The spatial pattern of those measurements shall be further improved by digital elevation models from TanDEM-X linked to concurrent CryoSAT observations. The remote sensing products feed into fracture and ice dynamic modeling.
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Fracture of Antarctic ice shelves
C. Plate, R. Müller (TUKL), A. Humbert (AWI), M. Braun, M. Rankl (FAU)
At the Institute of Applied Mechanics at TU Kaiserslautern a fracture mechanical model that uses measured as well as simulated velocity fields of different ice shelves to analyse the stability of cracks is developed. The aim of this model is to predict crack paths, large-scale calving and break up events. In this context, cracks are examined in two planes. In the vertical plane, bottom and surface crevasses are simulated, including dry and water-filled surface crevasses as well as frost wedging processes. In the horizontal plane the propagation of one or multiple rifts is analysed. The simulations are performed by finite elements in conjunction with configurational forces for the evaluation of cracks.
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Deformation state and calving rates at ice fronts of Antarctic ice shelves
J. Christmann, R. Müller (TUKL), A. Humbert, M. Rückamp (AWI)
Ice shelves are floating ice masses from which icebergs are calving off. The ice shelf is modelled as a solid body loaded by gravity and surface loads such as the buoyancy force on the bottom boundary. The stresses in the vicinity of the calving front are evaluated to estimate the position of a calving event in a two- and three-dimensional model by a linear elastic material model. The position of the maximum stress is established as being on the upper surface because of the boundary disturbance of the water pressure at the front. Thus this position is the most probable position for calving. Different parameter studies evaluate the influence of geometry and material parameters on the stress distribution. The results for the measured geometry of the Ekström Ice Shelf, Antarctica, are compared to those for a simplified geometry. The analysis of calving with a rate-dependent material model leads to a calving rate incorporating the position of maximum stress, detachment time and flow velocity of the ice shelf.
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Towards a large-scale calving law
A. Levermann, T. Albrecht (PIK, UP)
The recently proposed first-order kinematic calving law ('Eigencalving' in Levermann and others, 2012 (TC)) provides starting point for a large-scale calving representation in continental ice-sheet models and may also be applied in conceptual theoretical studies as a simple formula to capture calving from ice shelves. In the Parallel Ice Sheet Model (Bueler and Brown, 2009 (JGR)) in its Antarctic set-up (Winkelmann and others, 2010 (TC)), eigencalving is able to reproduce ice fronts of significantly different thickness and topographic constitution (Martin and others, 2010 (TC)). It is furthermore able to explain the spontaneous retreat of the Larsen-B ice shelf after the collapse of Larsen-A (Albrecht and Levermann, submitted). Eigencalving does however only represent a first-order approach to the kinematic

component of calving and therefore needs to be complemented by material properties. To this end we have introduced a two-dimensional fracture density field (Albrecht and Levermann, 2012 (J. Glac.)) which may be used for ice softening (Albrecht and Levermann, 2013 (TCD)) and to complement the kinematic eigencalving law.
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MASS BALANCE AND HYDROLOGY

Glacier surface energy and mass balance estimates for King George Island, West Antarctica
U. Falk (ZFL), H. Sala (IAA), M. Braun (FAU), G. Menz (GIUB)
The Antarctic Peninsula is amongst the fastest-warming places on Earth. It has undergone rapid environmental changes in past decades. Exceptional rates of mean surface air temperature increases (2.5 K in 50 years) are concurrent with retreating glacier fronts, an increase in melt areas, surface lowering, and disintegration of ice shelves. King George Island (KGI) is located on the northern tip of the Peninsula. So far, we have compiled a unique data set comprising climatological, glaciological and micrometeorological measurements on the Warszawa Icefield since November 2010 and ongoing. The data serves as a base to assess glacier mass balance components and melt water discharge for KGI glaciers. Remote sensing is integrated for additional model validation as well as to determine changes in mass flux and surface elevation in order to better quantify current glacier mass loss. Final goal is a refined quantification of KGI glacier mass loss and its separation into its climatic and dynamic components.
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Projections of solid ice discharge from the Antarctic Ice Sheet
R. Winkelmann, M. Martin, M. Mengel, A. Levermann (PIK, UP)
The dynamic contribution of the Antarctic Ice Sheet still imposes a large if not the largest uncertainty on future global sea-level projections. It is therefore essential to understand the processes which determine solid ice discharge and their interlinkage within the sheet-shelf system. With the Parallel Ice Sheet Model (Bueler and Brown, 2009 (JGR); Winkelmann and others, 2011 (TC); Martin and others, 2011 (TC)) we separately investigate the effects of surface warming, ocean warming and increased precipitation on the ice flow in Antarctica (Winkelmann and others, 2012 (TCD); Winkelmann and others, 2012 (Nature)). Their combined effect can be quantified in a probability distribution for future solid ice discharge, including both the model uncertainty as well as the uncertainty in the climate forcing.
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SvIMEv-CT (Svalbard Ice Mass Evolution in past and future – Climate forcing and Teleconnections)
M. Möller (RWTH)
The major Arctic ice bodies surround the Arctic Ocean at similar latitudes but nevertheless they show an inhomogeneous behavior in recent times. This suggests a spatial variability of the climate and ocean forcing mechanisms of glacier mass balance throughout the circum-Arctic regions and thus reveals the diversity of the influences of climate change. Regarding the variability of forcing mechanisms, Svalbard shows the most unique location in the Arctic. It is situated at the intersection between the cold polar air masses and ocean waters in the Northeast and the influences of the West Spitsbergen Current, which is the major warm-water conveyor to the Arctic environmental system. The aim of this project, funded by the German Research Foundation (DFG) since 2013, is to achieve a reliable estimate of the spatial and temporal variability of climatic mass balance of all glaciers and ice caps of Svalbard and to link this variability to climate and ocean forcing. To reach this aim, a spatially distributed climatic mass balance model will be set up that is driven by statistically downscaled climate data. The mass balance will then be calculated for all glacierized areas of Svalbard for the period 1948–2013 and the modeled, time-varying fields of ablation, accumulation, refreezing and climatic mass balance will be used as the basis for further geostatistical studies afterwards. These studies will identify and analyze potential influences of the spatiotemporal variability of patterns of atmospheric pressure, sea-ice coverage and sea-surface temperatures on the glacier mass-balance variability on Svalbard. Teleconnections to distant modes of atmospheric circulation will also be considered in these studies by analyzing the potential influences of specific atmospheric circulation indices.
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SvalGlac – the German contribution
D. Scherer, R. Finkelnburg (TUB), C. Schneider, M. Möller (RWTH)
Today, our knowledge about glacier mass-balance variability and the underlying atmospheric driving forces in Svalbard is still limited. SvalGlac, being part of the European Science Foundation PolarCLIMATE programme, financed in Germany by the Federal Ministry of Education and Research since 2010, aims at filling this gap. It

is closely linked with a research project funded by the German Research Foundation (DFG) since 2008 targeting on the ice caps Vest- and Austfonna on Nordaustlandet (see 'Dynamic response of surface energy and mass balance of Vest- and Austfonna, (Nordaustlandet, Svalbard) on climate change'). Based on glaciological and meteorological fieldwork on Vestfonna during the spring and summer seasons 2008–12 methodical approaches were developed combining mass-balance modelling, remote sensing and regional atmospheric reanalysis. A reanalysis data set, the EAR (European Arctic Reanalysis), was developed for the European Arctic (30 km resolution), Svalbard (10 km resolution) and Nordaustlandet (2 km resolution). Also, we were able to describe the climatic mass balance evolution of the ice cap during the ERA-Interim period (1979–2011). The interrelations between climate forcing, surface albedo, air-temperature lapse rates and glacier mass balance are studied in explicit detail. Future mass balance projections were obtained for the 21st century from downscaling output of Global Circulation Models representing the four standard SRES RCP scenarios. Analyses of the climate forcing of mass-balance variability at Vestfonna and the influence of future mass-balance variability on ice dynamics and ice-mass evolution are work in progress.
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Variability and trends in water balance components of benchmark drainage basins on the Tibetan Plateau (WET)
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The WET project investigates the coupling of climate and hydrological cycles in glaciated benchmark drainage basins on the Tibetan Plateau and adjacent mountain ranges. Our main objective is the development of an integrated system framework combining numerical models and satellite observations for monitoring and researching atmospheric, hydrological and glaciological variables relevant to climate–cryosphere interactions. The WET project provides spatially distributed data sets for the last decade such as the High Asia Reanalysis, cloud cover frequency, glacier surface and volume changes or lake level fluctuations, and will eventually release a science tool for real-time monitoring and sensitivity analysis. Current glaciological analyses focus on the Nyainqentanglha Range (south-central Tibet), the Purogangri Ice Cap (central Tibet) and the Naimona'nyi Glacier (south-west Tibet). As part of the studies a number of AWS provide field data since 2009.
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Runoff generation on debris covered glaciers in Central Asia
W. Hagg, E. Mayr (LMU), C. Mayer, M. Juen (KEG)
In the intensely arid Tarim basin, glacier meltwater is essential for agriculture and food production. The vast distribution of supraglacial moraine is an important glaciological feature of the region and has major impact on melt rates. Within the DFG-funded project AKSU-TARIM-MELT, a distributed model to reproduce ablation under moraine cover was developed by combining an empirical and a statistical approach with remote sensing techniques. Field work to quantify sub-debris melt was undertaken on the Koxkar Glacier, China and on Southern Inylchek Glacier, Kyrgyzstan. The melt model was implemented into a hydrological model, which is now capable to simulate runoff in catchments with debris covered glaciers. Scenario runs until 2100 will help to assess future changes in the hydrological cycle. The work was conducted as a part of the AKSU-TARIM project bundle.
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ice2sea: Glaciological field work
F. Wilhelms, C. Hofstede, D. Fritzsche, S. Weißbach, A. Wegner, S. Kipfstuhl (AWI), P. Smeets, R.S.W. van de Wal (IMAU), A. Hubbard (ABU), D. Dahl-Jensen (NBI)
On Russell glacier in West Greenland we study the influence of surface melt to basal lubrication. In 2010, we accessed the subglacial bed with two hot water holes and placed wireless pressure and temperature sensor probes within the glacier for refreezing and at its bed. The long-term observations of surface energy balance and ice movement complement the recorded sub-glacial pressure data. For a better characterisation of the underlying bed we recorded seismic profiles with an ice streamer, which we will continue in spring 2014. To improve our knowledge on spatio-temporal accumulation patterns across the Greenland ice sheet we revisited ice coring sites from the past 30 years and drilled new ice cores specifically to extend the accumulation and stable isotope records to the surface, thus addressing the question of changing accumulation patterns with very recent warming, as predicted by climate model simulations.
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Continuous temporal observation of snow properties utilizing upward-looking radar systems
A. Heilig (IUP), O. Eisen (AWI), J. Schweizer, L. Schmid, C. Mitterer (SLF), R. Okorn (FHJ)
Snow stratigraphy is a key contributing factor to avalanche formation. So far, only destructive methods can provide this kind of information. Conventional non-destructive sensors, which monitor the temporal evolution of snowpack properties, are limited to snow temperature and total snow depth. Since 2010, funded by the D-A-CH framework of the national science foundations of Germany, Austria and Switzerland, upward-looking radar systems were deployed to monitor temporal snowpack evolutions over entire winter seasons. We installed commercial impulse systems and custom-made FMCW radars utilizing horn and bowtie antennas at the test site Weissfluhjoch, and next to a well-known avalanche path above Davos, Switzerland. The diverse radar systems recorded correctly the snow height under dry snow conditions and liquid water infiltrations above the antennas. The impulse systems, supplementary, enabled a continuous quantification of major changes in stratigraphy, the snow water equivalent and volumetric liquid water content, if targets above the surface or additional data on the actual snow height were available.
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Field observations and modelling of spatial and temporal variability of processes controlling basin runoff during rain on snow events
S. Pohl (UF)
This DFG funded project focuses on improving the modelling and prediction of winter runoff, especially stormflow runoff, from small and mid-size river basins (<100 km^2). Special consideration is given to the prediction of 'rain on snow' events in intermediate mountain regions, as these events have been shown to frequently produce potentially dangerous floods in such basins. A reliable forecast of such stormflow events requires detailed knowledge about the spatial variability of the pre-existing snow cover and the individual factors of the snowmelt energy balance. An innovative approach of augmenting the existing monitoring stations with a network of numerous (up to 100) low-cost stations delivering continuous and highly distributed data on snow depth and climatic variables will be used to assess the naturally occurring spatial variability in snow accumulation and snow melt processes resulting from topography and vegetation. The locations of the stations are chosen to cover a wide range of slopes, elevations, expositions, and vegetation situations in a stratified sampling design. Additionally, several (up to 45) time lapse cameras are deployed delivering information on snow depth, snowpack properties, snow interception in the canopy, and state of precipitation. Finally, the acquired data is used to test and evaluate several models with different approaches to handling the spatial heterogeneity of the relevant processes. Models used will include complex, physically based research models and simpler, process- and index-based models that can be used for flood forecasting purposes.
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Modelling outlet glacier acceleration and the contribution of the Greenland ice sheet to sea-level change
M. Rückamp, J. Bondzio, A. Humbert (AWI)
Recent observations show an accelerated ice loss of the Greenland ice sheet during the past few decades, attributed to both changes in surface mass balance and ice dynamics triggered by various factors. Our work aims to enhance understanding of its internal dynamics and to quantify the causes and feedbacks of ice-sheet mass loss. We apply a thermodynamically coupled, hybrid-scale finite element ice sheet flow model (ISSM) to simulate recent and future (2100–2200) ice flow dynamics of the entire ice sheet in Greenland. Particularly, we are focusing on the major outlet glaciers Jakobshavn Isbræ and NEGIS, for which we use full-Stokes modelling. For Jakobshavn Isbræ we are developing the evolution of the calving front for ISSM and modelling the retreat, as well as the effect of rheology based on an enthalpy formulation. In the modelling of the entire ice sheet, the NEGIS is represented in high resolution in the unstructured grid, supporting the scientific goals of a field campaign at 79° glacier and the activities of a potential international coring activity at NEGIS.
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VELMAP: Velocities, elevation changes and mass budgets of Antarctic Peninsula glaciers
M. Braun, R. Seehaus (FAU), S. Marinsek, P. Skvarca (IAA), D. Steinhage (AWI)
The aim of the project is to improve the estimates of mass discharge from Antarctic Peninsula glaciers using time series of SAR satellite imagery from the archives as well as data from new sensors like TerraSAR-X and TanDEM-X. The activities funded under the DFG Priority Program 'Antarktisforschung' are further complemented by in situ surveys including DGPS surveys, surface mass balance and time-lapse cameras as well as survey flights with airborne laser altimetry and ground-penetrating radar (AWI Polar-6). Main target areas are the tributaries draining into the former Larsen-A Ice Shelf, Prince Gustav Channel and areas on the Western Antarctic Peninsula covered by TanDEM-X.
Duration: 2012–15
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IMCONet
M. Braun (FAU), U. Falk (UBN), H. Sala (IAA), J. Arigony-Neto (FURG), C. Dominguez (US), N. Barrand (BAS)
The fresh water contribution of changing glaciers and ice caps of the South Shetland Islands and Antarctic Peninsula is investigated. An automatic weather station is operated year-round on Potter Glacier, King George Island, near the Argentinian base Carlini and the German research laboratory Dallmann. Point and spatially distributed glacier melt models are developed and applied on a local to regional scale driven by AWS, standard meteorological records and GCM output. Regular stake measurements for surface mass balance are carried out and satellite imagery is analysed in regard to glacier extent and glacier surface conditions in order to improve multicriteria calibration and validation of the models. The glaciological research is part of an interdisciplinary research and exchange network funded under EU FP7 IRSES and coordinated by AWI.
Duration: 2013–16
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Mass balance of outlet glaciers in Greenland and Antarctica
V. Helm, D. Steinhage, A. Humbert (AWI)
Monitoring of the contribution of ice sheets to sea level change can be performed using satellite borne altimeters and airborne altimetry. The advantage of airborne altimetry is the flexibility in choosing the location of transects and a swath-like observation in high spatial resolution and vertical accuracy. During AWI's 5-year research programme PACESII, we are carrying out airborne campaigns along the Academy, Ryder and CH. Ostenfeld glaciers and Hagen Brae in North Greenland, and Jutulstraumen in Antarctica, at least twice in 2013–18. A laser scanner is used for surveys along central flow lines and flux gates of those glaciers. Beside an estimate of ice discharge rates, we aim to infer the spatial distribution of mass loss upstream from the grounding line in order to understand the mechanism driving mass loss for the individual glaciers.
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Inferring spatial distribution of past accumulation rates over ice sheets by means of radar stratigraphy
D. Steinhage, O. Eisen (AWI)
The changes in the surface mass balance of ice sheets are of crucial importance for the understanding of the evolution of ice sheets in the past. Radar stratigraphy combined with depth–age information from shallow, medium and deep ice cores is the tool to infer past regional spatial distributions of accumulation rates and infer paleo-dynamic features. To this end isochronous layers are traced in radargrams obtained using a 150 MHz radio-echosounding system and a higher-frequency FMCW radar on board AWI's polar aircraft, complemented by local studies using ground-penetrating radar. The airborne radar profiles are linking ice core sites in East Antarctica, ranging from Kohnen to Dome Fuji, respectively Talos Dome to Dome A, and in Greenland the NGRIP and Neem deep ice cores as well as shallow to medium deep ice cores of AWI's NGT traverse. Internal layers are linked to ice cores to determine their physical origin and thus confirm isochronity, to convert traveltimes to depths and provide density–depth distribution. Unconformities and layer undulations provide insights into past paleo-dynamic behaviour and processes. In Antarctica, these analyses provide important clues for the quest for the oldest ice.
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ICE CORES

Coldest firn – CoFi
S. Kipfstuhl, J. Freitag, T. Laepple, A. Wegner, F. Wilhelms (AWI)
The coldest firn project has already retrieved two 200 m ice cores from the ice divide between Kohnen and Dome Fuji and several more cores are planned between Kohnen and Dome A. The project studies microstructure evolution and air enclosure in very cold and low accumulation conditions. The data helps to calibrate our firn densification model in a parameter region as close to glacial conditions as we can get. By mapping the almost white spot of the East Antarctic plateau we centrally contribute to the International Partnerships in Ice Core Sciences (IPICS) 2k effort. More than ten 60–200 m ice cores in the vicinity of Kohnen station and two 50 m long trenches are our new basis for better understanding the spatial variability of the snow pack in terms of proxy signal generation.
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NEEM
AWI Glaciology
The North Greenland Eemian Ice Drilling (NEEM) is an international ice core research project that retrieved and analyses an ice core from North-West Greenland (77.45°N 51.06°W). In January 2013 the NEEM community published a climate record from Greenland that spans the past 128 000 years. Ongoing work of the AWI group comprises fabric and microstructure mapping and modelling of synthetic radargrams from the dielectric record. The analysis of fabric and microstructure aims towards formulating a new constitutive relation

for the flow of ice. The comparison of synthetic radargrams and the ice core's physical properties with actual radar mappings tells us about the genesis of radar reflections in deep and heavily deformed ice sheets.
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Long term paleo-climate signals derived from a high altitude, Alpine ice core array
P. Bohleber, D. Wagenbach (IUP)
The projects aims at deciphering climate related signals using a new ice core drilled to bedrock at Colle Gnifetti (Monte Rosa region, Western Alps). Based on existing ice core records from this site, the emphasis is on stable water isotopes, melt layer and mineral dust profiles to be analysed in extremely high depth resolution and covering a time scale of millennia. These records will be embedded in the whole suit of physical and chemical ice core parameters in an attempt to disentangle climate, dating and glaciological effects in the interpretation of the new Alpine ice core records.
Partners: KUP, AWI, UM
Duration: 2013–16
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Dating of Alpine glacier ice by micro radiocarbon analyses
H. Hoffmann, D. Wagenbach (IUP)
The project focuses on two main objectives: to narrow down age estimates of cold, sedimentary non-polar glaciers, particularly in their lower part and within the basal ice layers, and to constrain maximum ages of small scale, cold Alpine congelation ice bodies, encompassing low level miniature ice caps, ice patches and cave ice. The first attempt will greatly help to improve the suitability of the currently vague core chronologies, allowing for a more reliable evaluation of existing depth profiles (e.g. water isotopes) in the late Holocene and beyond. Current work aims to reduce the detection limit for particulate organic carbon in ice to keep the required sample mass as small as possible. First applications will be carried out on ice core samples from the Monte Rosa and Mont Blanc region and on samples from the high Arctic Academia Nauk Ice Cap.
Partners: CEZA, AWI, IGF, LIP, VERA, LGGE
Duration: 2013–16
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Exploration of microbial biodiversity in polar glacial ice cores
K. Töbe, E. Helmke, F. Wilhelms (AWI)
The polar ice caps play a key part in providing an understanding of climate variability over the last eight glacial cycles and provide information about paleoenvironmental features and changes of microbial diversity in the past. Microbiological studies on polar ice cores are rare and focused so far on silty ice or accreted ice, which does not contain a climatic record any more. The scientific aims within the DFG-funded project Biodiversity in Deep Ice Cores (BIOICE) were to detect, characterize and compare prokaryotic diversity in ice cores of different depths and different drilling projects from Antarctica, in order to learn more about relations of past and recent communities and about potential alterations of ancient communities in relation to climatic changes. Furthermore, the viability and metabolic activity of bacterial cells within the ice were evaluated to gain from the biological perspective a better understanding of survival/metabolism at subfreezing temperatures and from the geochemical perspective information about persistence of gas records in the ice. To qualify for samples for biological studies interested biologists have to focus on development of technical solutions to get positive results with as small amounts as possible of the strictly limited ice material. Therefore, besides the scientific aims, this was a major part of the work programme of this project. Decontamination, preparation and analysis methods were adapted and improved to cover as many different biological applications as possible. Laboratories, as well as the principal decontamination protocol, were established within this project and various experiments were performed with isolated DNA from the investigated ice cores and it was analysed using different methods of comparison. The ice cores were investigated and analysed using microscopical, microbiological and molecular biological methods. These analytical approaches enabled new insights into the composition of the microbial community within the investigated ice cores and information about the life cycle of uncultured microbial communities based on their coding potential.
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Long-term aerosol and trace gas observations at Neumayer Station
R. Weller (AWI), D. Wagenbach, I. Levin (IUP), A. Minikin (DLR)
The atmosphere above Antarctica constitutes the cleanest part of the Earth's troposphere, which allows the composition and temporal change of the background atmosphere to be studied here without any direct impact from civilization. Furthermore, the Antarctic continent is largely free of aerosol and trace gas sources, so these compounds have to be advected by long-range transport to Antarctica or have their source in the surrounding Southern Ocean. Because of this unique position, Antarctica is an outstanding place to document long-term

changes of the composition of our atmosphere in the so called 'Anthropocene', the era that started with the industrial revolution about 200 years ago. The Neumayer air chemistry observatory is one of the few clean air laboratories operaing in Antarctica with an extensive scientific programme, in parts established since 1982. Since 1997 the air chemistry observatory has been part of the GAW (Global Atmosphere Watch) global station network. Another important aspect of studying tropospheric trace constituents in Antarctica is the need to interpret records of particulate or reactive trace compounds observed in firn and ice cores. Addressing the coupling between climate and biogeochemical cycles, polar ice cores provide a unique archive of climate proxies from which information about past changes in temperature and atmospheric aerosol load can be derived even in sub-annual resolution, provided the controlling mechanisms of the air-to-firn transfer of relevant species are thoroughly investigated in the present atmosphere. The long-term observational programme can be divided into three categories: (1) aerosol sampling to determine the chemical composition of the aerosol, its seasonality and source apportionment, (2) in situ measurements of reactive trace gases such as ozone and physical properties of the aerosol (number concentration, light scattering, size distribution) for a comprehensive characterization of the aerosol, and (3) whole-air samples to determine the long-term concentration trends of greenhouse gases (CO_2, CH_4, N_2O) and their isotopic compositions, as well as anthropogenic tracers (SF6 and ^{85}Kr).
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Ice deformation mechanisms
I. Weikusat, D. Jansen (AWI)
The discharge of continental ice from the large ice sheets of Antarctica and Greenland is controlled by the flux through ice streams, which are continuously fed by the deformation of the main ice body. With our project 'The effect of deformation mechanisms for ice sheet dynamics', we aim to improve our understanding of the flow of the material ice by mapping traces left behind by deformation mechanisms on the microscopic scale. By using observation methods on the meso to micro scale applied to samples from deep ice cores, and modelling techniques such as the microstructure modelling platform ELLE-FFT (in cooperation with University of Barcelona), we tackle the challenge of bridging the scales and work towards a new constitutive relation for the flow of ice. The project plays a key role within the ESF MicroDICE networking program.
Partners: EKUT, UU
Duration: 2012–18
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Dielectric properties of ice in the radio-frequency range
P. Bohleber (IUP), N. Wagner (MFPA), O. Eisen (AWI, IUP)
As part of the LIMPICS project the dielectric properties of ice in the frequency range from 10 MHz to 1.5 GHz were investigated with a coaxial transmission line. Measurements on eight artificial ice samples grown from ultra-pure water within the cell yield a mean value for the real part of the relative permittivity of 3.18 ± 0.01 at –20°C. The only evidence for dispersion is detected for frequencies below 10 MHz. Investigation of the crystal orientation of the artificial ice samples reveals the *c*-axes to be predominantly parallel to the electric field inside the cell and allows to calculate a value representative for isotropic crystal orientation of 3.16 ± 0.01. Measurements on acid-doped artificial ice show a linear dependence of the real part with acidity with a gradient of (21.1 ± 3.9) [1/M]. Currently, the cell is used to determine quasi-continuously the dielectric properties of firn core for direct comparison with the established dielectric profiling method.
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Disentangling production and climate variability of ice core ^{10}Be
C. Elsässer, D. Wagenbach (IUP)
Ice core records of the cosmogenic radionuclide ^{10}Be provide important tools to understand past variations in climate, solar and geomagnetic activity. However, their proper interpretation is still matter of debate which calls for dedicated model attempts to support ^{10}Be ice core research. The project aims at improving the application of ice core ^{10}Be as a climate proxy. To this end, measurements of aerosol-borne radionuclides in air, firn and ice are combined with global and polar model attempts to simulate ^{10}Be ice core records on different time-scales.
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Measurements of fracture toughness in an Antarctic ice core
J. Christmann, R. Müller (TUKL), KG. Webber, D. Isaia, F. Schader (TUD), A. Humbert, S. Kipfstuhl, J. Freitag (AWI)
Fracture toughness is a material parameter describing the resistance of a cracked body to further crack extension. In these experiments the fracture toughness of glacier ice was measured using an ice core from Kohnen, near the Neumayer III station, Antarctica. The samples were prepared in an ice lab at –20°C and had the dimensions of thickness 14 mm, width 28 mm and length 126 mm.

The critical fracture toughness was characterized in a four-point pure bending experiment using single edge V-notch beam samples. To obtain reliable results 107 specimen were tested. An X-ray computed tomography (CT scanner) was used to determine the ice core densities prior to mechanical testing. The influence of the density on the fracture toughness was investigated. The results agree well with comparable investigations. Finally, the independence of the measured toughness with respect to thickness, width, and position deviations was investigated.
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AWI core scale microcomputer-tomography laboratory
J. Freitag (AWI)
While studying the densification of the snow pack we realized that the actual three-dimensional firn structure is a key parameter for understanding the processes. After very successful initial studies with 1 samples, we used the chance to build a core scale cryo X-ray microcomputer-tomograph in cooperation with the Fraunhofer X-ray development centre (Fraunhofer EZRT) from stimulus funds. Since its completion in 2010 we have reconstructed 100 mm diameter and 1 m long ice core sections in better than 15 µm resolution. The acquired data has revolutionized our understanding of firn stratification and the closely related air entrapment. Future applications comprise in situ densification, sintering and deformation experiments as well as mapping of air bubble distribution in the deep ice as memory of the past firn column and as proxy for accumulated strain.
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The effect of nanoparticles on the evolution of microstructure in polar ice
M. Bayer-Giraldi (AWI)
The aim of this project is to elucidate the role of nanoparticles in affecting the microstructure of polycrystalline ice. Considering that in polar ice small grain sizes are linked to softening, the overarching goal is to identify the process of softening in firn and glacial ice. The focus is set on antifreeze proteins as analogues for ice-binding nanoparticles, compared to non ice-binding proteins and inorganic nanoparticles. We compare the grain growth in the presence of these different particles looking at (1) how grain boundary migration rates are affected by nanoparticles, (2) how nanoparticles change grain boundary shape and other microstructural features of the grains and (3) where particles are located during grain boundary migration.
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PERMAFROST

Dielectric relaxation behaviour of frozen soil
A. Lorek (DLR), N. Wagner (MFPA)
A novel experimental, numerical and theoretical approach was studied for the analysis of interfacial water in frozen soils by means of broadband dielectric relaxation spectroscopy (10 Hz–1.1 MHz, 200–293 K). The developed experimental technique in combination with a broadband generalized dielectric analysis approach provides new insights into electromagnetic soil properties under cryospheric conditions. Moreover, a better understanding is achieved of the nature of interfacial water in soils below the freezing point of bulk water relevant for the understanding of physical, chemical and biological processes in permafrost regions on Earth and on other planetary bodies. However, in further studies the following issues have to be addressed: (1) the systematic analysis of soils with variation in texture and structure as well as mineralogy, (2) the broadening of the frequency range to lower (to 1 Hz) and higher frequencies (to 10 GHz), (3) the study of the influence of chemical processes in the aqueous pore solution on the dielectric relaxation dynamics of porous materials, (4) thereby assessing the dielectric relaxation behavior of equivalent pore solutions under defined temperature-pressure conditions.
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Polygons in tundra wetlands – state and dynamics under climate variability in Polar Regions (POLYGON)
S. Wetterich, U. Herzschuh (AWI)
POLYGON is a joint German–Russian (DFG–RFBR) project that focuses on investigating polygonal tundra wetlands in the northeast Siberian lowlands. Patterned ground of the polygonal tundra are sensitive indicators of environmental and climate changes. Polygon ponds, mires and cryosoils are typical components of arctic Siberian wetlands underlain by permafrost. In order to understand the functioning and dynamics of polygonal landscapes, modern ecological investigations are applied through a coherent and coordinated spectrum of methods at three typical landscape sites in the Northeast Siberian lowlands. This will be completed by a palaeoecological approach studying similar bioindicators and ecological parameters. Based on interdisciplinary research that combines modern and past environmental records, POLYGON will contribute to the understanding of small-scale variations of the climate sensitive permafrost landscapes units and allow a differentiation between external climate impact and internal polygon dynamics.
Partners: UHH, GU, MSU, NEFUY, HU
Duration: 2011–15
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PAGE21
H.W. Hubberten (AWI)
PAGE21 is an EU FP7 large scale integrated project that aims to understand and quantify the vulnerability of permafrost environments to a changing global climate, and to investigate the feedback mechanisms associated with increasing greenhouse gas emissions from permafrost zones. This research makes use of a unique set of Arctic permafrost investigations performed at stations that span the full range of Arctic bioclimatic zones. The project brings together the best European permafrost researchers and eminent scientists from Canada, Russia, the USA and Japan. PAGE21 combines field measurements of permafrost processes, pools and fluxes, with remote sensing data and global climate models at local, regional and, for the first time, pan-Arctic scales. The output from this research will help to advance the understanding of permafrost processes at multiple scales, resulting in improvements in global numerical permafrost modelling and the ensuing future climate projections, as well as in the assessment of stabilization scenarios.
Partners: UNIS, SU, FUA, TUW, UJG, UE, MPI, LU, UHH, CEA, MO, FMI, UEF, IBPC, APOR, MSU
Duration: 2011–15
Website: http://page21.eu
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COPER
H. Lantuit (AWI)
COPER is a scientific programme assessing the pace and nature of sediment and organic matter transfer in the southern Canadian Beaufort Sea and based in Herschel Island. It is sponsored by the Helmholtz Association and hosted at the Alfred Wegener Institute for Polar and Marine Research and at the University of Potsdam. At the study area, the groups is conducting field work above and under water to: (1) quantify and characterize the spatial variability of particulate and dissolved organic carbon and nutrient contents in permafrost sediments and ground ice; (2) quantify the pace of Arctic coastal erosion, the role of coastal thermokarst and of extreme events (storms) in the delivery of sediments to the sea through alongshore 3-D surveys above and under sea level using air- and space-borne photogrammetry and bathymetry; (3) assess the fate of released sediments in the nearshore zone and the deposition or export of organic matter in the nearshore environment through sediment cores taken in the nearshore zone and geophysical surveys.
Partners: MGU, GSC
Duration: 2012–18
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INTERACT
H. Lantuit (AWI)
INTERACT is an infrastructure project under the auspices of SCANNET, a circumarctic network of 33 terrestrial field bases in northern Europe, Russia, the USA, Canada, Greenland, Iceland, the Faroe Islands and Scotland. INTERACT specifically seeks to build capacity for research and monitoring in the European Arctic and beyond, and offers access to numerous research stations through the Transnational Access program. The project, which is funded by the EU, has a main objective to build capacity for identifying, understanding, predicting and responding to diverse environmental changes throughout the wide environmental and land-use envelopes of the Arctic. This is necessary because the Arctic is so vast and so sparsely populated that environmental observing capacity is limited compared to most other latitudes.
Duration: 2010–14
Website: http://eu-interact.org
E-mail: hugues.lantuit@awi.de

CARBOn in PERMafrost: production, transformation and release
EM. Pfeiffer (UHH), H.W. Hubberten (AWI)
CarboPerm is a new project, funded by the BMBF (Federal Ministry of Education and Research), with the aim of studying the formation, transformation and release of organic carbon in north Siberian permafrost. The multidisciplinary approach includes environmental and vegetation reconstruction, biogeochemical cycling studies using biomarkers, the assessment of microbial degradation in the form of CO_2 and CH_4 release, and modelling. Studies of the recent carbon cycle are combined with detailed reconstructions under different climatic conditions back to the Eemian and simulated with the help of models. It will be realized in close cooperation with Russian research institutes. This research will help to anticipate the future development of permafrost landscapes in the context of global warming and its impact on the carbon and trace gas budget.
Partners: UHH, AWI, GFZ, UP, UK, MPI, AARI, OSL, MSU, MPIY, KSC, IAP
Duration: 2013–16
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Assessing coastal dynamics
P. Overduin (AWI)
The Helmholtz Association's joint Russian–German research group on Assessing the Sensitivity of the Arctic Coastal Dynamics to Change seeks to identify those processes forcing coastal dynamics rates along Arctic coasts. Project members work jointly to combine fieldwork, mine historical data, model permafrost evolution and analyse remote sensing data across the ice-

rich coastlines of western, central and eastern Siberia. By quantifying the consequences of sediment dynamics in the nearshore zone, and in particular the release of carbon and sediment currently sequestered in permafrost, we aim to generate the capacity to understand the results of future changes in climate.
Partners: NIERSC, MPIY, HZG, MSU
Duration: 2009–14
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Permafrost investigations around the new Samoylov Island Research Station
M. Langer, A. Morgenstern (AWI)
Many permafrost research teams used the Russian–German Research Station on Samoylov Island in the north Siberian Lena River delta as the operational basis of numerous expeditions to the region from 1998 to 2012. This station has now been replaced by the new Samoylov Island Research Station, which belongs to the Siberian Branch of the Russian Academy of Science. The new facility provides excellent working and living conditions for scientists year-round despite the harsh environmental condition in the Siberian Arctic. The new station was officially opened on 21 September 2013, but had already begun scientific operations on 17 April. Several international permafrost research teams conducted their field campaigns during spring, summer and autumn, covering several disciplines and topics. These included carbon storage and turnover, trace gas emissions, permafrost degradation by thermokarst and thermal erosion, surface subsidence, water and energy balance, and snow cover properties.
Partners: AARI, UHH, SLF, SPSU, TUW, LDR, UCP, SU, MSU, UK
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Remote sensing studies of glacial and periglacial landforms on Mars: Insights from terrestrial analogs
E. Hauber (DLR)
Recent latitude-dependent landforms on Mars resemble terrestrial glacial and periglacial surface features in permafrost regions. Collectively, they are hypothesized to represent a geomorphological record of Martian ice ages. We use permafrost landscapes of Svalbard (Norway) as analogues for cold-climate landforms on Mars. A flight campaign was carried out in 2008 with a modified airborne version of our camera HRSC (High Resolution Stereo Camera), which has been in orbit around Mars since early 2004, and provides images with a resolution of ~20 cm pixel^{-1} and digital elevation models with a grid size of 50 cm. Svalbard is warmer and wetter than Mars but is an instructive morphological analogue as it offers many surface features in a close spatial context. Based on this comparison, using remote sensing and fieldwork data, we can establish testable hypotheses (e.g. scenarios that may help to understand the evolution of Martian landforms into their present state). Of particular interest in this context is whether liquid water and freeze–thaw cycles were involved or not.
Partners: DLR, WWU, UGOT, UL
Duration: 2008–ongoing
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SEA ICE – GENERAL

Properties of Arctic and Antarctic sea ice (*Polarstern* expeditions)
M. Nicolaus, I. Peeken, G. Dieckmann, R. Stein (AWI)
Expeditions to the ice covered Arctic and Antarctic Oceans are key elements of the German sea ice research programme together with national and international partners. These cruises stand out for their interdisciplinary aspects of the interaction of atmosphere, snow, sea ice and ocean. Besides manifold process studies and project-related work, time series observations of key parameters (e.g. sea ice thickness distributions) also result from these cruises. Key regions are the European sector of the Arctic and the Weddell Sea in the Antarctic.
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Influence of sea-ice surface roughness on the atmospheric boundary layer
M. Ropers, C. Lüpkes, W. Dierking, J. Hartmann (AWI)
For improving the parameterization of atmosphere–sea-ice interactions in climate and weather prediction models, local and regional studies of processes in the atmospheric boundary layer above sea ice are required. To this end, airborne measurements were carried out in the region of Svalbard, providing data about wind, air temperature, humidity and ice surface elevation. These data were used in a research project to test and improve methods for the computation of the drag coefficient, which is needed to determine the transfer of momentum from the atmosphere to the ice. Different concepts for calculating the drag coefficient as a function of ice surface roughness and atmospheric stability were compared and analysed, considering the inherent assumptions and availability of necessary input parameters.
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CryoSat-2 Arctic sea-ice thickness validation
S. Hendricks, V. Helm, R. Ricker (AWI)
One primary science goal of the ESA CryoSat-2 radar altimetry mission is the estimation of Arctic-wide sea-ice thickness. Altimeters measure sea-ice

freeboard, the height of the ice surface above the ocean surface, which is then converted into sea-ice thickness. The accuracy of sea-ice thickness from satellite radar altimetry depends on knowledge of the temporal and spatial variations of snow depth and the density of sea ice and snow, as well as on the influence of surface roughness and radar penetration on freeboard retrievals by CryoSat-2. Funded by the German Ministry of Economics and Technology, AWI has acquired CryoSat-2 validation data over Arctic sea ice since 2003. We use airborne radar and laser altimeters for the estimation of Ku-Band radar penetration and large-scale airborne electromagnetic induction measurements for reference sea-ice thickness. One result of the project is a publicly available Arctic-wide sea-ice freeboard and thickness data product from CryoSat-2 created by AWI.
Partners: UHH, MPI, GEOMAR, UB, BSH
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RACE – Regional Atlantic circulation and global change

D. Stammer (UHH), U. Schauer (AWI)
The work of RACE focuses on simulating and understanding the future Atlantic circulation, including the ice-covered northern oceans, and the repercussions on important social parameters. The main goal of RACE is to create regional high-resolution simulations of future Atlantic circulation changes (from 10 to 100 years) as a part of global change. Another goal is to estimate the repercussions of these changes on the ocean, the climate system and the European shelf area. These investigations include enhancing the understanding of observed processes, which will help to increase knowledge of the future ocean circulation and its changes. Through this, regional simulations can be improved.
Duration: 2012–15
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PAMARCMIP and TIFAX

A. Herber (AWI)
The PAMARCMIP (Polar Airborne Measurements and Arctic Regional Climate Model Simulation Project) campaigns started as a sea ice and atmospheric airborne programme in 2009 and is a joint project with different Canadian institutes, such as EC Toronto, York University and the University of Toronto. The TIFAX (Thick Ice Feeding Arctic Export) campaigns started in summer 2010 as a sea ice airborne programme. The objective of the both campaigns was to monitor ice conditions during spring and summer, especially in the main export pathway of the Arctic Ocean. The major aim of both campaigns is the large-scale measurement of sea ice thickness in key Arctic areas. The PAMARCMiP and TIFAX project is organized around the capacity of the Polar 5 aircraft to provide unique data sea ice thickness in the high Arctic, and additionally in spring during PAMARCMIP, data about aerosol, trace gases as well as meteorological conditions. Both activities are closely coordinated with the CRYOSat II satellite project.
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Project System Laptev Sea

J. Hoelemann, T. Krumpen, M. Janout (AWI)
The joint Russian–German research network System Laptev Sea investigates the role of sea-ice and ocean dynamics in the Laptev Sea for the transpolar drift system. The project combines measurements made during earlier winter and summer field campaigns, satellite-based observations and model results. Relating observed changes to recent observations made in the Central Arctic and in the Fram Strait will enable us to gain deeper insights into the contributions of the Russian shelf seas to the Arctic ocean mass and energy balance.
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EU Project SIDARUS: sea-ice data for product validation

W. Dierking, S. Linow, S. Schwegmann, S. Hendricks (AWI), S. Sandven (PI, NERSC)
SIDARUS (Sea Ice Downstream services for Arctic and Antarctic Users and Stakeholders) was a project in the FP-7 space programme involving partners from different European countries. The main objectives of SIDARUS were the development and implementation of sea-ice downstream services with respect to marine safety, environmental monitoring and climate research. A combination of remote sensing data, numerical model output and in situ, airborne and underwater data was used to develop new methods and products for sea-ice and iceberg mapping, sea-ice albedo retrieval, sea-ice thickness mapping, sea-ice forecasting, and tracking of marine mammals. Within the project, AWI was responsible for the provision of sea-ice data from in situ and airborne measurement campaigns for product validation, in particular focusing on measurements of ice thickness. Researchers from AWI contributed also to the improvement of methods for retrieving sea-ice drift from satellite images.
Partners: NERSC, NIERSC, CLS, UB, UC, MNO, IPB
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EU Project SIDARUS: sea ice albedo and melt pond fraction

G. Heygster (UB), S. Sandven (PI, NERSC)
Within the EU SIDARUS project, UB is contributing sea-ice albedo and melt pond fraction of Arcitic

sea ice from the optical satellite sensor MERIS. The applications of these data will be in atmosphere–ice–ocean models and in climate simulations to improve parameterizations of albedo and understanding of melt pond processes.
Duration: 2011–13
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Antarctic Fast Ice Network (AFIN)
M. Nicolaus (AWI)
The main objective of AFIN is to gather long-term and consistent time series measurements of sea-ice mass balance at different Antarctic sea ice sites. These measurements also include systematic measurements of snow depth and properties. In response to the need for a coordinated approach on the monitoring of Antarctic landfast sea ice, the Antarctic Fast Ice Network (AFIN) was initiated as a legacy project during the 2007–09 International Polar Year. As part of AFIN, a regular observation program was started in 2010 on the landfast sea ice of Atka Bay, in the northeastern Weddell Sea. The measurements are carried out by the wintering team of the Neumayer III station.
Partners: AAD and others
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Advancing Modeling and Observing solar Radiation of sea ice (AMORA)
M. Nicolaus (AWI), S. Gerland (NP)
To quantify the energy balance of the ice covered Arctic Ocean and to increase our understanding of mechanisms leading to observed changes in the Arctic sea ice, the AMORA project was initiated. The primary goal of the project was to develop an autonomous spectral radiation buoy, deploy it on drifting sea ice close to the North Pole, and receive a high-resolution time series of spectral radiation over and under sea ice from spring to autumn. Beyond this, in situ sea ice data were collected during several field campaigns and simulations of snow and sea ice thermodynamics were performed. A strong scientific and cultural exchange between Norway, China and the partners from the USA and Europe initiated new collaborations in Arctic research.
Partners: CRREL, PRIC, DTUC, FMI
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BMWi-project IRO-2: Sea ice albedo and melt pond fraction
P. Jochmann (PI, HSVA), G. Heygster (UB)
UB contributes retrievals of snow depth on Arctic sea ice from passive microwave sensor AMSR-E and AMSR2, and scatterometer ASCAT. Snow on sea ice reduces the heat transfer from ocean to atmosphere, reduces the formation of new ice and increases the friction of ships traveling through the ice by a similar amount to an ice cover of similar thickness. The snow information will be used for assimilation into numerical sea ice prediction models and for operational ship guidance.
Duration: 2012–14
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ESA project Sea Ice Essential Climate Variable
S. Sandven (PI, NERSC)
As part of ESA's Climate Change Initiative, the Sea Ice Essential Climate Variable project establishes time series of sea ice concentration and thickness, including error estimates, which are essential for climate modelling. UB contributes data on thin sea ice in order to investigate the influence of ice thickness on sea ice concentration retrieval.
Duration: 2012–14
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EU Project Polar Ice: Thin ice thickness charts
N. Walker (PI, EO)
The aim of Polar Ice is to develop a next generation sea ice information service by integrating and building on a wide range of European and national funded activities which incorporate many of the required components. UB will contribute end-user demonstrations of thin ice thickness charts based on observations of the L band (1.4 GHz) sensor SMOS (launched 2010, spatial resolution 30–40 km), and multisources (merged SMOS, SAR and a sea ice model products) based thickness chart showing ice thickness classes up to 1 m with 500–1000 m spatial resolution.
Duration: 2014–17
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ASI / AMSR2 ice concentration maps
G. Heygster (UB)
Daily hemispherical and regional sea-ice concetration maps based on the ASI retrieval scheme and 89 GHz observations of AMSR2 (since 2012), AMRS-E (2002–11) and SSMIS (since 2011) are provided to the public throgh the institute's website. The sea-ice extent time series are updated daily, all archive data are online, with a long-term duration envisaged.
Website: http://www.iup.uni-bremen.de:8084/amsr2/
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SIO – Sea Ice Outlook
F. Kauker (AWI)
The SEARCH Sea Ice Outlook is an international effort to provide a community-wide summary of the expected September Arctic sea-ice minimum. Monthly reports released throughout the summer synthesize community estimates of the current state and expected minimum of sea ice – at both a pan-Arctic and regional scale. The intent of the SEARCH Sea Ice Outlook effort is not to issue predictions but rather to summarize all

available data and observations to provide the scientific community, stakeholders and the public the best available information on the evolution of Arctic sea ice. Sea Ice Outlook activities are supported by the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA), and through the volunteer efforts of contributors. The Outlook is organized by the SEARCH Project Office at the Arctic Research Consortium of the U.S. (ARCUS). AWI has submitted reports every year since the start of the SIO in 2008.
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SEA ICE – BIO-GEOCHEMISTRY

Arctic sea-ice decline archived by novel multicentury annual-resolution record from crustose coralline algal proxy

J. Halfar (UG, UTO), A. Kronz (UG), W. Adey, W. Fitzhugh (SMI), S. Hetzinger (GEOMAR), E. Edinger (MU)

Northern Hemisphere sea ice has been declining sharply over the past decades and 2012 exhibited the lowest Arctic summer sea-ice cover (SIC) in historic times. While ongoing changes are closely monitored through satellite observations, we have only limited data of past Arctic SIC derived from short historical records, indirect terrestrial proxies and low-resolution marine sediment cores. Our group is currently compiling multicentury time series from extremely long-lived annual increment-forming crustose coralline algal buildups that provide the first high-resolution in situ marine proxy for sea-ice cover. Growth and Mg/Ca ratios incorporated into the skeletons of these long-lived algae are sensitive to changes in both temperature and solar radiation and decline with increasing sea ice blocking light from the shallow benthic algal habitat. The algal time series displays a robust relationship between combined annual growth rates and Mg/Ca ratios with satellite and chart-derived sea-ice cover data for the past three decades. A first 646 year multisite record from the Canadian Arctic indicates that during the Little Ice Age sea ice was extensive but highly variable on subdecadal time scales and coincided with an expansion of ice-dependent Thule/Labrador Inuit sea mammal hunters in the region. The past 150 years, in contrast, have been characterized by sea ice exhibiting multidecadal variability with a long-term decline distinctly steeper than at any time since the 14th century.
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Antifreeze proteins from a sea ice diatom and their applications

M. Bayer-Giraldi (AWI), J. Huen (TTZ)

Antifreeze proteins (AFPs) from the diatom Fragilariopsis cylindrus are a key factor in the adaptation of this organism to polar conditions. Their effect on ice is still unclear, and explanations for their role within sea ice remain speculative. However, AFPs are also interesting for potential applications in frozen food and in the medical sector, among others. In this project we aim to better understand the process of ice growth (crystallization and recrystallization) in the presence of AFPs and to create a link to possible applications. We optimized a method for the isolation of recombinant AFPs from Escherichia coli, with special attention to protein yield and purity. We applied the proteins in experimental analyses of the microstructure of ice and of their properties as inhibitors of recrystallization. Furthermore, a possible application of the proteins is tested with studies on the effect of AFPs in a frozen porous system as frozen bread dough.
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Morphogenesis of short-time frozen microstructures in sea ice

B. Kutschan, K. Morawetz (FHMS), S. Thoms (AWI), S. Gemming (HZDR)

Microstructures of salty water in sea ice are a unique habitat for microorganisms with a remarkable adaptibility to extreme environmental conditions. We model the early phase of brine entrapment in sea ice without salinity conservation by a Turing model and with salinity conservation by a phase field theory. The theory includes both macroscopic salt diffusion and microscopic order parameter dynamics describing the different symmetries, hexagonal ice and liquid water. The first structures emerging during sea-ice formation are determined by the phase instability of the ice–water system in the presence of salt. Realistic parameters allow to calculate a phase diagram and two-dimensional microstructures found in agreement with the measured samples. We extend the model to consider antifreeze proteins, proposing stabilization of the supercooled liquid state by a non-equilibrium of the thermal hysteresis. The research is supported by DFG-Priority Program 1158.
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Processes of DMSP conversion in sea ice

C. Uhlig, E. Damm, E. Helmke (AWI)

The organic sulphur component dimethylsuphoniopropionate (DMSP) is found in high amounts in both Antarctic and Arctic sea ice. Depending on the degradation processes, its turnover can result in the release of the climate cooling gas dimethylsulphide (DMS) to the

atmosphere. Our current work aims to elucidate the importance of the different microbial DMSP conversion pathways in polar sea ice with respect to bacterial species composition. Furthermore, investigations on grazing activities of zooplankton on ice algae focus on assessing sinks of DMS and DMSP as well as on trophic transfer of phytoplankton-derived DMSP up to the food web. Fieldwork during the Antarctic winter to early spring season 2013 will be complemented by laboratory experiments applying analytics of sulphur components (DMSP, DMS, methanethiol) and DNA sequencing. The overall aim is to estimate the contribution of (a) microbial conversion of DMSP to DMS or (b) further degradation products (e.g. methanethiol) and (c) zooplankton grazing to the final fate of DMSP in different sea ice environments.
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Methane production in sea ice
E. Damm, J. Hartmann (AWI)
The latitude-specific monthly mean of atmospheric methane in the high Arctic is the highest on earth and is one of the most mysterious phenomena observed in the Arctic. The sea ice covered ocean appears to be a source of atmospheric methane yet unaccounted for and little is known about the formation, uptake and conversion of methane in sea ice. A main impact of sea ice refers to the function as a 'cap' on the ocean influencing the gas exchange. This function is potentially changing due to a decreasing rate of 11% per decade in summer sea ice minima. We will examine the methane release to the atmosphere from sea ice, from leads in the sea ice covered ocean and from the marginal sea ice zone by atmospheric and oceanic measurements. The first airborne measurements of atmospheric methane in late winter over the Arctic sea ice indicate a source that is somehow connected to leads. We aim at gathering knowledge about the methane budget in sea ice and a principal understanding of methane production and consumption occurring in sea ice micro environments. In the AWI research programme Paces this work is embedded in the interdisciplinary network Methane in the Arctic – sources, sinks and pathways in the ecosystems.
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Ikaite ($CaCO_3 \cdot 6H_2O$) precipitation in sea ice and its role in sea ice biogeochemical dynamics
G. Dieckmann, G. Nehrke (AWI)
Calcium carbonate precipitation in polar sea ice has been proposed as a potential additional driving force for the carbon pump in sea ice covered regions. After decades of controversial discussion on whether calcium carbonate precipitates in sea ice, the mineral ikaite ($CaCO_3 \cdot 6H_2O$) was finally discovered in Antarctic sea ice and later also found in Arctic sea ice. However, the mechanisms of ikaite precipitation in sea ice are as yet not well known, and neither are the effects of ikaite precipitation on biogeochemical processes in sea ice. We at the Alfred Wegener institute are investigating the mechanisms under which ikaite precipitation takes place and its consequences for biogeochemical processes within the ice was well as at its peripheries. These include quantitative investigations in the field and laboratory experiments under simulated sea ice brine conditions. Questions asked are whether ikaite precipitates in quantities that may have a significant impact on the CO_2 flux from sea ice, whether ikaite is the only phase of calcium carbonate formed in sea ice and what the effects of pH, salinity, temperature and phosphate concentrations are both on the precipitation of ikaite and on other biogeochemical processes within and at the sea-ice interfaces.
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SEA ICE – SOCIO-ECONOMIC FOCUS

BMWi project IRO-2: Ice Routing Optimization
P. Jochmann (HSVA), R. Gerdes (AWI), Heygster (UB), J. Holfort (BSH), L. Kaleschke (UHH), T. Kaminski (FO), F. Kauker (OASYS)
For an economical and safe navigation along the northern sea routes and for the transport of resources from the Arctic to the south, as well as for the supply of Arctic municipalities with goods, even in months of light ice conditions, a reliable ice forecast and an optimized routing advice are essential. A group of German research centres and small and medium-sized enterprises is dealing with the implementation of such a system. The system consists of three compartments: (1) the near real time processing of remotely sensed ice observations, (2) data assimilation into an Arctic-wide ocean–sea-ice model and nesting into a local high-resolution atmosphere–sea-ice–ocean model and (3) the ice routing advising module. The project is funded by the German Federal Ministry of Economics and Technology.
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Seasonal Ice Zone Observation Network (SIZONet)
S. Hendricks (AWI)
SIZONet is a interdisciplinary project funded by the NSF with the focus on environmental and socio-economic impact of sea-ice change in the north of Alaska. As a partner of the UAF, AWI contributes regular airborne sea-ice thickness data in Arctic spring. We have compiled a dataset of sea-ice thickness in the seasonal ice zone

from drifting and landfast sea ice in the Beaufort Sea every year since 2007. In this period falls the significant decline of multiyear sea ice in the western Beaufort Sea. The airborne sea-ice thickness data serve as a basis to understand differences between perennial and seasonal sea-ice cover and will improve the predictibility of future Arctic sea ice. We contribute our data to publicly available databases to ensure the use of the data for long-term projects.
Partners: UAF
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ACCESS Arctic Climate Change, Economy and Society
J.C. Gascard (UPMC), M. Karcher (OASYS), R. Gerdes (AWI)
ACCESS is supported within the Ocean of Tomorrow call of the European Commission. Its main objective is to assess climatic change impacts on marine transportation (including tourism), fisheries, marine mammals and the extraction of oil and gas in the Arctic Ocean. ACCESS is also focusing on Arctic governance and strategic policy options. Arctic climate change will have significant impacts on both marine ecosystems and human activities in the Arctic, which in turn will have important socio-economic implications for Europe. ACCESS will evaluate Arctic climate change scenarios and their impact on specific economic sectors and human activities over the next decades. Particular attention will be given to environmental sensitivities and sustainability in the Arctic domain.
Duration: 2011–15
Website: http://access-eu.org
E-mail: michael@oasys-research.de

ICE-ARC – Ice, Climate and Economics – Arctic Research on Change
J. Wilkinson (BAS), R. Gerdes (AWI), F. Kauker (OASYS)
The ICE-ARC project (EU-FP7) aims to understand and quantify the multiple stresses involved in the change in the Arctic marine environment. Particular focus is on the rapid retreat and collapse of the Arctic sea ice cover and assessment of the climatic (ice, ocean, atmosphere and ecosystem), economic and social impacts of these stresses at the regional and global scale. A coupled atmosphere–cryosphere–ocean–ecosystem approach will be used and observations will focus on reducing the uncertainty in understanding of Arctic physical processes that are vital in climate and ecosystem change and may not be adequately represented in present models. Results of the observational program will be fed into an ice–ocean–atmosphere model, which, after validation, will make projections – with reduced uncertainty – of the rate and nature of future changes in the ice cover, ocean structure and atmospheric temperature and circulation. In parallel with this, an ecosystems model will perform the same role for marine living resources. A leading global impact model will be coupled with the physical climate model to directly assess the economic impact of observed and projected climate change events. AWI will be involved in the developement of new parametrizations and the implemantation of it into climate models.
Duration: 2014–18
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ArcRisk Arctic Health Risks: Impacts on health in the Arctic and Europe owing to climate-induced changes in contaminant cycling
J. Pawlak (AMAP), M. Karcher (OASYS), R. Gerdes (AWI), G. Lammel (MPG)
ArcRisk is an EU funded project looking at the linkages between environmental contaminants, climate change and human health. The influence of climate change on contaminant spreading and transfer and the resultant risk to human populations in the Arctic and other areas of Europe are studied. This involves modelling (including sea ice effects) of selected groups of contaminants, and possible implications for the redistribution of contaminants. Effects on contaminant uptake and transfer within food webs, leading to foods consumed by humans is investigated, and a determination of how climate-mediated changes in the environmental fate of selected groups of contaminants will result in changes in exposure of human populations, in the Arctic and in selected areas of Europe is performed.
Duration: 2009–14
Website: http://arcrisk.eu
E-mail: jpawlak@dahm.dk

REMOTE SENSING AND GEOPHYSICAL METHODS

Detection and tracking of icebergs in sea ice
C. Wesche, W. Dierking, T. Rackow, H. Hellmer (AWI)
In the Antarctic, iceberg calving amounts to more than 60% of the entire mass loss of the ice sheet. Satellite radar remote sensing is used to observe iceberg calving, drift and decay. The combination of images with different spatial coverage and resolution enables monitoring of large regions and the detection of smaller icebergs at the same time. In this project, methods for detecting icebergs drifting in open water and in sea ice were developed for different radar imaging modes and tested on data from the Antarctic. The drift of icebergs is determined using a combination

of position retrievals from radar images and computer simulations of iceberg motion. On the basis of observed drift paths, the melt water injected from icebergs into the ocean over larger time scales (months to years) is determined.
Partners: ETH
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Retrieval of accumulation rates on ice sheets using satellite remote sensing
S. Linow, W. Dierking (AWI), W. Rack (GAUC)
A reliable prediction of sea level change is only possible if the mass balance (gain versus loss) of the polar ice sheets is known. For estimating mass gain, it is crucial to quantify the rate of snow accumulation on the ice sheets of Greenland and Antarctica as accurately as possible. In this context, microwave remote sensing techniques are used to spatially upscale accumulation rates measured in the field. Together with national and international partners, AWI researchers investigate the complex interaction mechanisms between microwave radiation and polar firn and develop a robust method for deriving snow accumulation rates from microwave remote sensing data.
Partners: GAUC, UB
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ESA Antarctic CCI
V. Helm (AWI)
Mass contributions of Antarctica and Greenland to sea level change is still afflicted with high uncertainties. The goal of the Antarctic CCI project is to generate a set of long-term and reliable key parameters (mass balance, surface elevation change, ice velocity, grounding line location and calving front location) from Antarctica from existing and future satellite observations and to validate those products against in situ data.
Partners: ESA, UL, DTU, ENVEO, BAS, DLR, LMU, UCL
Webpage: ESA-CCI.org
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ESA GLitter
V. Helm (AWI)
Ice sheet mass balance is strongly affected by variations in ice stream dynamics, grounding line ice thickness and grounding line migration. To improve estimates of ice sheet contribution to sea level the recent location of the grounding line and the thickness of the ice at this position as to be improved and monitored. ESA initiated this project, which is part of the Support To Science Element (STSE), an element of the ESA's Earth Observation Envelope Program (EOEP-3). The main objective of the project is to develop a methodology using CryoSat elevation data to identify grounding line location and the accompanying elevation/thickness of ice in combination with existing airborne and situ data.
Partners: ESA, UL, UCL, ENVEO, BAS
Duration: 2013–ongoing
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Vibroseis sources for seismic operations on ice
O. Eisen, C. Hofstede, A Diez (AWI), Y. Kristoffersen (UIB), C. Mayer, A Lambrecht (KEG), U. Polom (LIAG)
Seismic measurements on land ice provide information about the properties of the ice–base interface, the underlying strata and water-column thickness under ice shelves. To overcome limitations of commonly used explosive or sledgehammer seismic surveys in terms of production speed and source-characteristic control, the DFG-funded LIMPICS project investigated the utility of vibroseismics on firn-covered ice masses. Source varied in peak force from 500 N to 120 kN. During a series of field surveys on Alpine glaciers and in Antarctica, we demonstrated that the vibroseis method is not hampered by the presence of a highly porose firn cover. It reaches penetration depths comparable to explosive sources, but with a lower technical upper-frequency limit of about 250 Hz. Production speeds reach 20 km/d for sixfold data on ice sheets. On shallow ice masses, the combination of pressure- and shear-wave excitations allows us to investigate the spatial variation of the Poisson ratio and elastic properties.
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Characterization of englacial and subglacial properties by combining seismics and radar
O. Eisen, C. Hofstede, A Diez, D. Steinhage, H. Miller (AWI) R. Drews (ULB) C. Mayer, A. Lambrecht (KEG)
The utility of radar and seismic methods was investigated in the LIMPICS project to remotely deduce the physical properties of the ice. Polarimetric radar measurements can reveal abrupt transitions in crystal orientation fabric. A change in radar bulk anisotropy at the EDML drill site conincides with the termination of the last glacial. Wide-angle seismic surveys allow us to deduce the bulk anisotropy of the ice by combining seismic pressure- or shear-wave sources with radar thicknesses. The origin of englacial reflections from changes in crystal orientation fabric or conductivity can be more readily achieved by comparing coherent seismic and radar reflectors. This complements earlier applications of multifrequency and multipolarization measurements with radar alone. In combination with radar–internal layer architecture, it was found that the crystal fabric at a stable ice dome featuring a Raymond

bump most probably changes abruptly, in addition to the gradual development of anisotropy as postulated by ice-flow models.
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CryoVEx: CryoSat calibration and Validation Experiment
V. Helm (AWI)
The CryoVEx campaigns are coordinated by ESA and include combined glaciological and altimetric airborne radar and laser observation of selected validation sites in Greenland, Arctic Sea Ice, Austfonna and Devon Ice Cap as well as in Antarctica (blue ice area in Dronning Maud Land and Law Dome in East Antarctica). The aim is to validate CryoSat's elevation measurements to improve understanding of error sources and the signal contribution to the backscattered Ku-Band Radar echoes over sea ice and land ice. The German contribution is funded by the German Ministry of Economics and Technology (Grant 50EE1008).
Partners: ESA consortium
Duration: 2003–ongoing
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ESA SMOSIce
L. Kaleschke (UHH)
The aim of the SMOSIce study was to develop, improve and validate algorithms for sea ice thickness retrieval from the 1.4 GHz (L-band) data of the European Space Agency's (ESA) Soil Moisture and Ocean Salinity (SMOS) mission. The potential to derive the ice thickness from L-band radiometry mainly depends on sea ice temperature and salinity. Several different sea ice emissivity models and retrieval algorithms have been developed and assessed using independent ice thickness estimates. A sea ice thickness product including three winter seasons has been derived from SMOS Level 1C brightness temperature and is distributed via the Integrated Climate Data Center at UHH, available at https://icdc.zmaw.de.
Partners: UHH, AWI, UB, FMI, DMI
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Derivation of environmental parameters of arctic tundra landscapes with synthetic aperture radar
J. Sobiech, W. Dierking (AWI)
The Arctic Tundra covers large areas of permafrost in the Northern Hemisphere. Typically, the treeless landscape comprises a large amount of lakes and river channels and several wetlands. This project aims to develop methods for retrieving environmental parameters such as spatial snow-melt patterns, timing of thaw onset and freeze-up of soil, lake- and river-ice formation and decay, or soil moisture using high resolution (5–250 m) radar image time series acquired in multipolarization or polarimetric mode and at different frequencies (X-, C-, and L-band). Locations of investigations are the Lena delta in Siberia, the Zackenberg valley in northeast Greenland and the Mackenzie delta in northern Canada. Field campaigns are conducted in the frame of the project, so a comprehensive dataset exists for evaluation of the SAR-based results. The goal of the project is to find strategies that enable near-real-time monitoring of the state of the Arctic Tundra all year round.
Partners: DLR, JMUW, AU
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Retrieving drift and deformation of sea ice for science and operational mapping
S. Linow, T. Hollands, W. Dierking (AWI)
This project deals with algorithms for ice drift and deformation retrieval from high-resolution space-borne radar images. One part of the project was carried out in the framework of a study in the FP-7 Space Program (Sea Ice Downstream services for Arctic and Antarctic Users and Stakeholders, SIDARUS) and was targeted on application of ice-drift products in operational sea-ice mapping and environmental monitoring. It included the development of methods to evaluate the expected accuracy of the retrieved ice drift. Another part of the project is focused on the improvement of models for simulating atmosphere–sea ice–ocean interaction. The ice drift and deformation products generated by means of the developed algorithms can resolve small-scale movements at a high level of detail (100 m–1 km). They are therefore highly valuable for process studies on local and regional spatial scales, such as dynamics of polynias and leads or the effect of forces transferred from atmosphere and ocean to the ice.
Partners: MNO, DMI, TUD, CTH
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Studying evolution of coastal polynias using remote sensing and sea ice–ocean models
T. Hollands, W. Dierking, R. Timmermann (AWI)
Coastal polynias are regions of open water in the sea ice cover, which form when katabatic winds push the ice away from the coastline. They are locations of high ice production and of strong exchange of heat and matter between ocean and atmosphere. Often, they trigger convection in the water layers below. In this study, computer simulations of polynia evolution are compared with observations from satellite. One objective was to analyse the effect of using different atmospheric forcings on the simulation results. Recently, the focus of research has moved to the potential of the upcoming ESA-Sentinel satellites for monitoring sea ice dynamics on a regional scale. Data from different sensors (radar and optical/IR sensors) are combined for the retrieval

of geophysical parameters characterizing ocean–ice–atmosphere interactions in and around polynias. The observations are used to improve wind-driven polynia models and fully coupled sea ice ocean models.
Partners: UHH, UT
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Using synthetic aperture radar for sea-ice monitoring
W. Dierking (AWI)
In several international and national studies, the capabilities of using synthetic aperture radar (SAR) for sea ice monitoring have been investigated. The emphasis is on specifying the information about ice conditions that is obtained by multipolarization or polarimetric radar systems operated at different frequency bands covering the range from L- to Ka-band. These studies form the basis to develop methods for classification of ice types, separation of ice and water, and identification of deformation structures in SAR images. Moreover, they are used to help designing satellite mission concepts, e.g. for ESA's Sentinel-1. Recent topics are detection of sea ice melt phases, retrieval of parameters that characterize snow on the ice, issues of scaling (using images of different spatial resolution), and linking classification with drift retrievals.
Partners: ESA, CTH, FMI, GAUC, CIS, DLR, NERSC, NIERSC, MNO, FIO, UT, UIT, IICWG
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Airborne geophysical and glaciological surveys in Antarctica and Greenland
D. Steinhage, W. Jokat, V. Helm, G. Eagles, A. Humbert, H. Miller, U. Nixdorf, O. Eisen (AWI), M. Braun (FAU), D. Damaske, A. Läufer (BGR), M. Scheinert (TUDD)
Since 1994 AWI has operated polar research aircraft on a regular basis in Greenland and Antarctica, equipped with various ice penetrating radar systems, altimeters, magnetics and gravity meters. Data were obtained, e.g. for the EPICA pre-site survey, studies on the reconstruction of the Gondwana break-up or the opening of the Fram Strait. Recent projects have focused on ice discharge of selected glaciers along the Antarctic Peninsula, in Dronning Maud Land and northeast Greenland, and on the topography, internal structure and basal properties of the Recovery Glacier and internal layers of the ice sheet along potential sites for the oldest ice core. Geophysical projects aim to understand the sub-ice geology and the changes in the lithosphere caused by postglacial rebound and tectonic processes. For this purpose a combination of magnetic, gravity and ice thickness measurements are carried out.
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HGF-EDA: Helmholtz Alliance Remote Sensing and Earth System Dynamics
A. Humbert (AWI), M. Braun, S. Vijay (FAU), D. Floricioiu, W. Abdel Jaber, I. Hajnsek, G. Fischer (DLR)
The glaciological research within this collaborative project aims at improving our understanding of the processes and dynamics of land ice, ice shelves and glaciers. The combination of remote sensing, field surveys and modelling is the main approach used to address this research topic. Products from SAR remote sensing, in particular X- and L-band systems, are used to derive various essential variables for glaciology such as ice dynamics, grounding line position, surface elevation changes, mass changes and contribution to sea level rise, as well as surface and internal structures. Target regions are Antarctica, Patagonia, Alaska and the Karakoram range. The activities are funded by the HGF Impulse and Network Fund within the research alliance Remote Sensing and Earth System Dynamics.
Duration: 2012–17
Website: http://hgf-eda.de/
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MISCELLANEOUS

Arctic and Antarctic habitats in reference to planetary analog research
J-P. de Vera, E. Hauber, N. Schmitz (DLR), A. Läufer (BGR), D. Wagner (GFZ), T. Leya (FIBMT), U. Szewzyk (TUB), S. Ott (UD), J. Joshi (UP) R. Demets, B. Foing (ESA)
The Arctic and Antarctic climatic zones show specific similar geomorphological and geological properties such as are observed on the surface of Mars. In a first step the geo–biological characterization of glaciers, rock glaciers, moraines, gullies, polygon-rich soils and volcanic minerals (forming specific habitats for microorganisms) are in the focus of research, because these features are also observed on Mars. The goal of these investigations is to know more about the polar niches of microorganisms on Earth, to characterize the organism's activity and the environment in the context of Mars-like environmental conditions. After the Mars-relevant characterization of these polar habitats, a collection of bio-samples is realized in the second step of this project. The collected organisms are checked by Mars simulation experiments and in space on the International Space Station (project BIOMEX) for their ability to survive and to be active under simulated Mars-like conditions. If results are positive, the field sites in the polar areas can be classified as real Mars-analog areas from an experimental perspective. In a third step the ability of instruments such as different spectroscopic analysers (Raman-, UV/VIS-, IR) are

tested for their capacity to detect microorganisms and biorelevant molecules in the lab as well as on the classified Mars- and biorelevant field sites in the Arctic/Antarctic. These instrument tests may clarify their effectiveness on biodetection under the extreme conditions of the polar environment. This type of operation serves as conceptual pretests prior to the finalization of new instrumentation set-ups for future Mars missions that will focus on the main goal the search for life on Mars. First work has been carried out during the GANOVEX 10 expedition (DLR, UD, ESA and BGR). Further investigations are planned for the next GANOVEX 11, together with ESA, the BGR and other expeditions. This work is a close cooperation realized by the Helmholtz Alliance Planetary Evolution and Life.
Partners: TUB, GFZ, UP, IBMT, UD, DLR
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IsViews – early detection of subglacial volcanic eruptions in Iceland using high resolution remote sensing data
U. Münzer, J. Jaenicke (LMU), L. Braun, C. Mayer (KEG), M. Eineder, C. Minet (DLR), F. Siegert, J. Franke (RSS), Á Gudmunðsson (FKE)
Subglacial volcanic eruptions often provide indications of activity some time before the actual catastrophic event. Surface undulations appear on top of the ice cap and meltwater torrents occur at the glacier margin. Even large-scale uplifts of ice caps have been observed. Within the project IsViews a process chain, based on high spatially and temporally resolved remote sensing imagery, is developed in order to automatically identify such early indications. The main data used for this analysis are acquired by the TerraSAR-X, TanDEM-X and RapidEye satellites. First investigations about the feasibility of the near real-time warning system and the general baseline conditions are being carried out on Mýrdalsjökull ice cap, South Iceland.
Duration: 06/2012–02/2015
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REKLIM – regional climate initiative
K. Grosfeld, P. Lemke, A. Rinke, K. Dethloff (AWI), I. Sasgen (GFZ)
The Helmholtz Climate Initiative REKLIM (Regionale Klimaänderungen/Regional climate change) is a consortium of nine research centres within the German Helmholtz Association. REKLIM is using its unique combination of competence in regional observations (in situ, airborne- and satellite remote sensing) and related process studies coupled with model simulations, to improve regional and global climate models for climate-related decision support. Moreover, the global climate simulations are used to determine the effects of climate variability and change on the regional scale with improved modeling tools for attribution and impact studies. Based on this transdisciplinary research, REKLIM focusses, among other themes, on assessing the present and near-future evolution of the ice sheets to sea level rise, from observations and modelling, considering the interaction between ice, ocean and the solid Earth. Furthermore, atmosphere, ocean, sea-ice and permafrost feedbacks in the Arctic are investigated in order to decipher the nature of sea-ice decline and the impact on the regional climate of western Europe. The Climate Initiative facilitates various scientific opportunities for improving knowledge of the regional Earth system, aiming to close the loop from global observations to local impacts.
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Observation of glaciers and snow patches in high mountains of southeastern Europe with focus on Pirin Mountains (Bulgaria)
K. Grunewald (IOER), E. Gachev, A. Gikov (BUAS)
Glacierets and their surroundings, used as archive in eastern and southeastern Europe, provide instructive information about climatic and environmental properties of the past. But little is known so far about the small glacier forms of the Balkan Peninsula. In North Albania and Montenegro there are currently glaciers which cover an area of up to 5 ha. These are all situated just above 42° latitude and considerably below the climatic snow line. We observe especially the glacieret Sneshnika, the remains of the Vihren glacier in the Pirin Mountains in Bulgaria. This glacieret (in German *Mikrogletscher*) has a size of ca. 1 ha and is currently Europe's southernmost glacieret (41°46′ N). Compared to other subjects, Sneshnika is exceptional, as it survives a relatively high annual mean temperature and low precipitation and even appears to brave the current temperature increase.
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meereisportal.de –the new knowledge platform concerning sea ice
R. Treffeisen, M. Nicolaus , R. Gerdes, K. Grosfeld (AWI), G. Heygster, C. Melsheimer (UB)
'meereisportal.de' is the first comprehensive German knowledge platform concerning sea ice. It was developed in the framework of REKLIM as a joint project of UB (IUP) and AWI under the management of the regional Helmholtz climate offices. Background information, expertise and a map and data archive constitute the three main pillars. Up to now a lot of information regarding sea ice was only available in English. The first pillar therefore primarily pursues the goal of providing comprehensive and comprehensibly prepared information on sea ice in German. The individual topics will be presented in a varying depth of analysis and detail. Another pillar is the

map and data archive. Further, the first maps on sea-ice thickness worldwide have been published on this portal as data products of ESA's CryoSat-2 satellite. The third pillar is the outstanding expertise of the partner institutions with respect to different topics relating to sea ice. The direct linkage of the topics presented at meereisportal.de to scientific questions ensures a high degree of topicality.
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ABBREVIATIONS

AAD: Australian Antarctic Division, AUS
AARI: Arctic and Antarctic Research Institute St Petersburg, RU
ABU: Aberystwyth University, UK
AMAP: Arctic Monitoring and Assessment Program
APOR: Arctic Portal, IS
AU: Aarhus University, DK
AWI: Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, DE
BAS: British Antarctic Survey, UK
BGR: Federal Institute for Geosciences and Natural Resources, DE
BSH: Bundessamt fuer Seeschifffahrt und Hycrographie, DE
BUAS: Bulgarian Academy of Science, BU
CAIAG: Central Asian Institute for Applied Geosciences, KG
CAREERI: Cold and Arid Regions Environmental and Engineering Research Institute, Lanzhou, CN
CRREL: Cold Regions Research and Engineering Laboratory, USA
CEA: Centre d´etudes Atomiques, F
CEZA: Curt-Engelhorn-Zentrum für Archäometrie, Mannheim, DE
CIS: Canadian Ice Service, CA
CLS: Collecte Localisation Satellites SA, Toulouse, F
CTH: Chalmers University of Technology, Gothenburg, DK
DLR: German Aerospace Center, DE
DMI: Danish Meteorological Insitute, DK
DRI: Desert Research Institute, Reno, US
DTU: Technical University of Denmark, DK
DTUC: Dalian Technical University, CN
DU: Durham University, UK
EKUT: Eberhard Karls University Tübingen, DE
ENVEO: Environmental Earth Observation IT GmbH, AT
EO: eOsphere
ESA: uropean Space Agency, ESTEC, EU
ETH: Eidgenössische Technische Hochschule Zurich, CH
FAU: Friedrich-Alexander University, Erlangen–Nürnberg, DE
FHMS: Fachhochschule Münster (University of Applied Sciences), DE
FHJ: FH Joanneum, AT
FIBMT: Fraunhofer-Institut für Biomedizinische Technik, DE
FIO: First Institute of Oceanography, Qingdao, CN
FKE: Fjarkönnun ehf., IS
FMI: Finnish Meteorological Institute, FI
FO: FastOpt GmbH, DE
FSUJ: Friedrich-Schiller-Universität Jena, DE
FURG: Universidade Federal do Rio Grande, BR
GAUC: Gateway Antarctica, University of Canterbury, NZ
GEOMAR: Helmholtz Centre for Ocean Research Kiel, DE
GEUS: Geological Survey of Denmark and Greenland, DK
GFZ: GeoForschungsZentrum Helmholtz Centre Potsdam, DE
GIUB: Geographisches Institut der Universität Bonn, DE
GMHP: Glaciarium – Museo del Hielo Patagónico, AR
GSC: Geological Survey of Canada, CA
GU: Greifswald University, DE
HNEE: Hochschule für nachhaltige Entwicklung Eberswalde, DE
HSVA: Hamburgische Schiffbau-Versuchsanstalt GmbH, DE
HU: Herzen University St Petersburg, RU
HZDR: Helmholtz-Zentrum Dresden–Rossendorf, DE
HZG: Helmholtz Centre Geesthacht, DE
IAA: Instituto Anártico Argentino, AR
IAP: Obukhov Institute of Atmospheric Physics Moscow, RU
IBMT: Fraunhofer IBMT Potsdam, DE
IBPC: Institute for Biological Problems of Cryolithozone, RU
IGF: Institut für Gebirgsforschung, Österreichische Akademie der Wissenschaften, Innsbruck, AT
IICWG: International Ice Charting Working Group
IMAU: Institute for Marine and Atmospheric research Utrecht, NL
IOER: Leibniz Institute of Ecological Urban and Regional Development, DE
IPB: B.I. Stepanov Institute of Physics of the National Academy of Sciences of Belarus, BY
ITPCAS: Institute of Tibetan Plateau Reserach Chinese Academy of Science, CN
IUP: Institut für Umweltphysik, Heidelberg University, DE
JMUW: Julius-Maximilians University, Würzburg, DE

KEG: Commission for Geodesy and Glaciology, Bavarian Academy of Sciences and Humanities, DE
KSC: Sukachev Forest Institute Krasnojarsk, RU
KUP: Climate and Environmental Physics, University of Bern, CH
LDR: Lena Delta Reserve Tiksi, RU
LGGE: Laboratoire de Glaciologie et Géophysique de l'Environnement, CNRS
LIAG: Leibniz Institute for Applied Geophysics, DE
LIP: Labor für Ionenstrahlphysik, ETH Zurich, CH
LMU: Ludwig-Maximilians University, Munich, DE
LU: Lund University, SE
MFPA: Materialforschungs- und -prüfanstalt Weimar (University of Weimar), DE
MGU: McGill University, CA
MIT: Massachusetts Institute of Technology, US
MNO: Norwegian Meteorological Institute, NO
MO: Met Office, UK
MPG: Max Planck Society, DE
MPI: Max Planck Institutes for Meteorology and Biogeochemistry, Jena and Hamburg, DE
MPIY: Melnikov Permafrost Institute Yakutsk, Siberian Branch, Russian Academy of Sciences, RU
MSU: Lomonossov Moscow State University, RU
MU: Memorial University, CA
NBI: Niels Bohr Institute, Ice and Climate, DK
NEFUY: North-East Federal University Yakutsk, RU
NERSC: Nansen Environmental and Remote Sensing Center, NO
NIERSC: Nansen International Environmental and Remote Sensing Center, St Petersburg, RU
NP: Norwegian Polar Institute, NO
NSF: National Science Foundation, US
OASYS: Ocean Atmosphere Systems GmbH, DE
OSL: Otto Schmidt Laboratory St Petersburg, RU
PRIC: Polar Research Institute of China, China
PUM: Philipps-Universität Marburg, DE
RHRK: Technical University of Kaiserslautern, DE
RNI: Royal Netherlands Institute for Sea Research, NL
RSS: RSS GmbH, DE
RWTH: Rheinisch-Westfälische Technische Hochschule, Aachen, DE
SLF: WSL Institute for Snow and Avalanche Research SLF, CH
SMI: Smithsonian Institution, US
SPSU: St Petersburg State University, RU
SU: Stockholm University, SE
TTZ: ttz Bremerhaven, DE
TUB: Technical University Berlin, DE
TUD: Technical University Darmstadt, DE
TUDD: Technical University Dresden, DE
TUKL: Technical University Kaiserslautern, DE
TUW: Technical University Vienna, AT
UA: Free University of Amsterdam, NL
UAB: Autonomous University of Barcelona, ES
UAF: University of Alaska Fairbanks, USA
UB: University of Bremen, DE
UC: University of Cambridge, UK
UCL: University College London, UK
UCP: University of Copenhagen, DK
UD: University of Düsseldorf, DE
UE: University of Exeter, UK
UEF: University of Eastern Finland, FI
UF: University of Freiburg, DE
UG: University of Göttingen, DE
UGOT: University of Gothenburg
UHH: University of Hamburg, DE
UIBK: University of Innsbruck, AT
UIB: University of Bergen, NO
UIT: University of Tromsø, NO
UJF: Joseph Fourier University, Grenoble, F
UK: University of Cologne, DE
UK: University of Kazan, RU
UL: University of Leeds, UK
ULZ: University of Leipzig, DE
ULB: Free University of Brussels, BE
UM: University of Maine, US
UMI: University of Milan, IT
UNIS: University Centre in Svalbard, NO
UP: University of Potsdam, DE
UPMC: University Pierre et Marie Curie, F
US: University of Salamanca, ES
UT: University of Trier, DE
UTO: University of Toronto, CA
UU: University of Utrecht, NL
UZH: University of Zurich, CH
VERA: Vienna Environmental Research Accelerator, AT
WH: Woods Hole Oceanographic Institution, US
WWU: Westfalian Wilhelms University, Münster, DE
ZFL: Zentrum für Fernerkundung der Landoberfläche, University of Bonn, DE

Olaf Eisen

International Glaciological Society

JOURNAL OF GLACIOLOGY

Papers accepted for publication between 1 January and 30 April 2014. The papers are listed in alphabetical order by first author. Some of these papers have already been published.

Kelly M. Brunt, Douglas R. MacAyeal
Tidal modulation of ice-shelf flow: a viscous model of the Ross Ice Shelf

Anne Chapuis, Tom Tetzlaff
The variability of tidewater-glacier calving: origin of event-size and interval distributions

Marie Dierckx, Mark Peternell, Christian Schroeder, Jean-Louis Tison
Influence of pre-existing microstructure on mechanical properties of marine ice during compression experiments

David Docquier, David Pollard, Frank Pattyn
Thwaites Glacier grounding-line retreat: influence of width and buttressing parameterizations

Michael E. Ewing, Carl A. Reese, Matthew A. Nolan
The potential effects of percolating snowmelt on palynological records from firn and glacier ice

J. Feldmann, T. Albrecht, C. Khroulev, F. Pattyn, A. Levermann
Resolution-dependent performance of grounding line motion in a shallow model compared with a full-Stokes model according to the MISMIP3d intercomparison

Caitlyn Florentine, Mark L. Skidmore, Marvin Speece, Curtis Link, Colin Shaw
Geophysical analysis of transverse ridges and internal structure at Lone Peak Rock Glacier, Big Sky, Montana, USA

Catriona L. Fyffe, Tim D. Reid, Ben W. Brock, Martin P. Kirkbride, Guglielmina Diolaiuti, Claudio Smiraglia, Fabrizio Diotri
A distributed energy-balance melt model of an alpine debris-covered glacier

John A. Goff, Evelyn M. Powell, Duncan A. Young, Donald D. Blankenship
Conditional simulation of Thwaites Glacier (Antarctica) bed topography for flow models: incorporating inhomogeneous statistics and channelized morphology

Narayana Golding, Scott A. Snyder, Erland M. Schulson, Carl E. Renshaw
Plastic faulting in saltwater ice

Glen Granzow
A tutorial on adjoint methods and their use for data assimilation in glaciology

Christof Gromke, Stefan Horender, Benjamin Walter, Michael Lehning
Snow particle characteristics in the saltation layer

Matthew J. Hoffman, Andrew G. Fountain, Glen E. Liston
Near-surface internal melting: a substantial mass loss on Antarctic Dry Valley glaciers

Nanna B. Karlsson, Robert G. Bingham, David M. Rippin, Richard C.A. Hindmarsh, Hugh F.J. Corr, David G. Vaughan
Constraining past accumulation in the central Pine Island Glacier basin, West Antarctica, using radio-echo sounding

Berna Köchle, Martin Schneebeli
3-D microstructure and numerical calculation of elastic properties of alpine snow with focus on weak layers

James M. Lea, Douglas W.F. Mair, Brice R. Rea
Evaluation of existing and new methods of tracking glacier terminus change

James M. Lea, Douglas W.F. Mair, Faezeh M. Nick, Brice R. Rea, Anker Weidick, Kurt Kjaer, Mathieu Morlighem, Dirk van As, J. Edward Schofield
Terminus-driven retreat of a major southwest Greenland tidewater glacier during the early 19th century: insights from glacier reconstructions and numerical modelling

Oliver J. Marsh, Wolfgang Rack, Nicholas R. Golledge, Wendy Lawson, Dana Floricioiu
Grounding zone ice thickness from InSAR: inverse modelling of tidal elastic bending

Andreas Münchow, Laurie Padman, Helen A. Fricker
Interannual changes of the floating ice shelf of Petermann Gletscher, North Greenland, from 2000 to 2012

Felix S.L. Ng, T.H. Jacka
A model of crystal-size evolution in polar ice masses

W. Tad Pfeffer, Anthony A. Arendt, Andrew Bliss, Tobias Bolch, J. Graham Cogley, Alex S. Gardner, Jon Ove Hagen, Regine Hock, Georg Kaser, Christian Kienholz, Evan S. Miles, Geir Moholdt, Nico Mölg, Frank Paul, Valentina Radić, Philipp Rastner, Bruce H. Raup, Justin Rich, Martin J. Sharp, The Randolph Consortium
The Randolph Glacier Inventory: a globally complete inventory of glaciers

Evgeny A. Podolskiy, Kaoru Izumi, Vladimir E. Suchkov, Nicolas Eckert
Physical and societal statistics for a century of snow avalanche hazards on Sakhalin and the Kuril Islands (1910–2010)

David Podrasky, Martin Truffer, Martin P. Lüthi, Mark A. Fahnestock
Quantifying velocity response to ocean tides and calving near the terminus of Jakobshavn Isbræ, Greenland

Gerard H. Roe, Marcia B. Baker
Glacier response to climate perturbations: an accurate linear geometric model

Claudia Röösli, Fabian Walter, Stephan Husen, Lauren Andrews, Martin P. Lüthi, Ginny A. Catania, Edi Kissling
Sustained seismic tremors and icequakes detected in the ablation zone of the Greenland ice sheet

Claudia Ryser, Martin P. Lüthi, Lauren Andrews, Matthew J. Hoffman, Ginny A. Catania, Robert L. Hawley, Thomas Neumann, Steen Savstrup Kristensen
Sustained high basal motion of the Greenland Ice Sheet revealed by borehole deformation

Lino Schmid, Achim Heilig, Christoph Mitterer, Jürg Schweizer, Hansruedi Maurer, Robert Okorn, Olaf Eisen
Continuous snowpack monitoring using upward-looking ground-penetrating radar technology

Jeffrey A. Vanlooy, Clément Miège, Gregory Vandeberg, Richard R. Forster
Ice volume estimation inferred from ice thickness and surface measurements for Continental Glacier, Wind River Range, Wyoming, USA

ANNALS OF GLACIOLOGY 55(65)

The following papers have been selected for publication in Annals of Glaciology *55(65) (thematic issue on Advancing clean technologies for exploration of glacial aquatic ecosystems), edited by Peter Doran*

E.A. Bagshaw, B. Lishman, J.L. Wadham, J.A. Bowden, S.G. Burrow, L.R. Clare, D.M. Chandler
Novel wireless sensors for in situ measurement of sub-ice hydrologic systems

Bernd Dachwald, Jill Mikucki, Slawek M. Tulaczyk, Ilya Digel, Clemens Espe, Marco Feldmann, Gero Francke, Julia Kowalski, Changsheng Xu
IceMole: a maneuverable probe for clean in situ analysis and sampling of subsurface ice and subglacial aquatic ecosystems

Peter Keen, Mario P. Brito
Design considerations and solutions in rapid-prototyping an ultraviolet reactor for ice borehole disinfection

P.G. Talalay, V.S. Zagorodnov, A.N. Markov, M.A. Sysoev, J. Hong
Recoverable autonomous sonde (RECAS) for environmental exploration of Antarctic subglacial lakes: general concept

Pavel Talalay, Zhengyi Hu, Huiwen Xu, Dahui Yu, Lili Han, Junjie Han, Lili Wang
Environmental considerations of low-temperature drilling fluids

Slawek M. Tulaczyk, Jill A. Mikucki, Matthew R. Siegfried, John C. Priscu, C. Grace Barcheck, Lucas H. Beem, Alberto Behar, Justin Burnett, Brent C. Christner, Andrew T. Fisher, Helen A. Fricker, Kenneth D. Mankoff, Ross D. Powell, Frank Rack, Daniel Sampson, Reed P. Scherer, Susan Y. Schwartz, The Wissard Science Team
Wissard at Subglacial Lake Whillans, West Antarctica: scientific operations and initial observations

More papers for *Annals* 55(65) will be listed in the next issue

ANNALS OF GLACIOLOGY 55(67)

The following papers have been selected for publication in Annals of Glaciology *55(67) (thematic issue on Radioglaciology), edited by David Braaten*

David W. Ashmore, Robert G. Bingham, Richard C.A. Hindmarsh, Hugh F.J. Corr, Ian R. Joughin
The relationship between sticky spots and radar reflectivity beneath an active West Antarctic ice stream

Anja Diez, Olaf Eisen, Ilka Weikusat, Jan Eichler, Coen Hofstede, Thomas Bohlen, Ulrich Polom
Influence of crystal anisotropy on seismic velocity analysis

T.J. Fudge, Howard B. Conway, Ginny A. Catania, Donald D. Blankenship, Knut Christianson, Ian R. Joughin, B. Smith, Scott D. Kempf, Duncan A. Young, Sridhar Anandakrishnan
Identifying flowlines and limitations of flux analyses in the interior of Thwaites Glacier, Antarctica

Alessio Gusmeroli, Gabriel J. Wolken, Anthony A. Arendt
Helicopter-borne radar imaging of snow cover on and around glaciers in Alaska

Ute C. Herzfeld, Brian Mcdonald, Bruce F. Wallin, Phillip A. Chen, Helmut Mayer, John D. Paden, Carl Leuschen
The trough-system algorithm and its application to spatial modeling of Greenland subglacial topography

Nicholas Holschuh, Knut Christianson, Sridhar Anandakrishnan
Power loss in dipping internal reflectors imaged using ice-penetrating radar

Ben Keisling, Knut Christianson, Richard B. Alley, Leo E. Peters, John E.M. Christian, Sridhar Anandakrishnan, Kiya L. Riverman, Atsuhiro Muto, Robert W. Jacobel
Basal conditions and ice dynamics inferred from radar-derived internal stratigraphy of the northeast Greenland ice stream

Mathieu Morlighem, Eric Rignot, Jérémie Mouginot, Helene Seroussi, Eric Y. Larour
High-resolution ice thickness mapping in South Greenland

Jérémie Mouginot, Eric Rignot, Yonggyu Gim, D. Kirchner, E. Le Meur
Low frequency radar sounding of ice in East Antarctica and Southern Greenland

Christian Panton
Automated mapping of local layer slope and tracing of internal layers in radio echograms

Clemens Schannwell, Tavi Murray, Bernd Kulessa, Alessio Gusmeroli, Albane Saintenoy, Peter Jansson
An automatic approach to delineate the cold-temperate transition surface with ground-penetrating radar on polythermal glaciers

José A. Uribe, Rodrigo Zamora, Guisella Gacitúa, Andrés Rivera, David Ulloa
A low power consumption radar system for measuring ice thickness and snow/firn accumulation in Antarctica

Nat J. Wilson, Gwenn E. Flowers, Laurent Mingo
Mapping and interpretation of bed reflection power from a surge-type polythermal glacier, Yukon, Canada

Annals 55(67) is now complete

ANNALS OF GLACIOLOGY 56(69)

The following papers have been selected for publication in Annals of Glaciology *56(69) (thematic issue on Sea ice in a changing environment), edited by Petra Heil*

Mats A. Granskog, Daiki Nomura, Susann Müller, Andreas Krell, Takenobu Toyota, Hiroshi Hattori
Evidence for significant protein-like dissolved organic matter accumulation in Sea of Okhotsk sea ice

Kristen St John, Sandra Passchier, Brooke Tantillo, Dennis Darby, Lance Kearns
Microfeatures of modern sea-ice-rafted sediment and implications for paleo-sea-ice reconstructions

Maria Zatko, Stephen Warren
East Antarctic sea ice in spring: spectral albedo of snow, nilas, frost flowers, and slush; and light-absorbing impurities in snow

More papers for Annals 56(69) will be listed in the next issue

Book received

Kolomyts EG (2013) *Theory of evolution in snow cover science* (Atlas Monogram). NOVA Science Publishers, New York. 425 pages.
ISBN: 978-1-62808-988-2 (Cloth, $157.50);
978-1-62948-027-5 (E-book, $175.00)

INTERNATIONAL GLACIOLOGICAL SOCIETY

International Symposium on

Hydrology of Glaciers and Ice Sheets

HÖFN 2015

Höfn, Iceland, 21–27 June 2015

Co-sponsored by:
- University of Iceland
- Institute of Earth Sciences, University of Iceland
- Icelandic Meteorological Office
- National Power Company of Iceland
- Icelandic Road Administration
- Iceland Glaciological Society
- Geoscience Society of Iceland

FIRST CIRCULAR
May 2014
http://www.igsoc.org/symposia/2015/iceland

The International Glaciological Society (IGS) will hold an International Symposium on 'Hydrology of glaciers and ice sheets' in 2015 in Höfn, Iceland, from 21–27 June 2015.

THEME

Glaciers and ice sheets store vast quantities of fresh water, and their hydrology is of wide-ranging importance. The hydrology of mountain glaciers has direct implications for water resources, flood risks, hydro-power, ice dynamics and erosion. The hydrology of larger ice sheets plays a critical role in their dynamics and mass balance, and has consequent importance for oceanography, biology and climate science.

This symposium will provide a forum to discuss all aspects of glacier and ice sheet hydrology and their connections to other areas of the cryosphere as well as climate sciences. It will provide an opportunity to present advances in ground-based measurements, remote sensing and modelling to stimulate discussions on their interpretation and implications. The meeting seeks to bring together scientists from around the world, to provide an overview of the current state of knowledge of glacier and ice-sheet hydrology and to provide a focus on key areas for future research.

TOPICS

This symposium will cover all aspects of glacial hydrology, including:

1. **Glacier catchment hydrology** (timing and magnitude of runoff, floods and droughts, influence of climate change, subdaily variations, applications to stakeholders, future water availability)
2. **Supraglacial and firn hydrology** (surface mass balance, meltwater retention in firn, percolation, ice lensing, supraglacial streams and lakes, supraglacial systems on ice shelves and ice tongues, aquatic biological communities, ice/dust interaction, influence on albedo)
3. **Englacial and subglacial hydrology** (crevassing and moulins, influence on thermal structure, basal melting/freezing, englacial and subglacial channels, submarine melting, subglacial lakes, thermodynamics at meltwater–ice interface, biology)
4. **Basal sliding and ice dynamics** (sliding speed, dependence on effective pressure, cavitation, sediment strength, hydrology of ice streams, calving processes)
5. **Jökulhlaups and hazards** (subglacial lakes and outburst floods, marginal lakes, moraine-dammed lakes, timing and magnitude of discharge)

6. **Erosion and landforms** (role in quarrying, deformation and transport of sediments, eskers, drumlins, mega-scale glacial lineations)
7. **Hydrology of subglacial eruptions** (meltwater production and pathways, eruption site water retention, steam and ash, floods, subglacial geothermal areas, porous media hydrology and thermodynamics)
8. **Instrumentation and methods** (remote sensing, field techniques, new technologies, geochemistry)

Potential participants are encouraged to contact the chief editors if they feel additional topics would be appropriate.

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 along with pre-, mid- and post-symposium field excursions to specifically selected, stellar locations at and around Vatnajökull and south Iceland.

ABSTRACT AND PAPER PUBLICATION
Participants intending to present at the symposium are required to submit an abstract in due time. The Council of the International Glaciological Society will publish a related thematic issue of the *Annals of Glaciology*. Participants and non-participants of the symposium alike are encouraged to submit manuscripts for this volume.

SYMPOSIUM ORGANIZATION
Magnús Már Magnússon (International Glaciological Society)

SCIENCE STEERING AND EDITORIAL COMMITTEE
Alexander H. Jarosch and Ian Hewitt (Chief Editors), Guðfinna Aðalgeirsdóttir, Gwenn Flowers, Helen A. Fricker, Joel Harper, Matt Hoffman, Bryn Hubbard, Tómas Jóhannesson, Doug Mair, Christian Schoof, Thomas Schuler, Chris Stokes.

LOCAL ORGANIZING COMMITTEE
Tómas Jóhannesson (Chair), Bergur Einarsson, Andri Gunnarsson, Magnús Tumi Guðmundsson, Eyjólfur Magnússon, Þorsteinn Þorsteinsson.

VENUE

The symposium will be held in the area of Höfn, southeast Iceland. The location is stunning and ideal for a symposium such as this one. It offers great opportunities for a mid-week excursion and pre- or post-symposium excursions. Some delegates may find it advantageous to combine the symposium with field work in the area. However, because of limited resources in the area and the fact that these are booked up a long time in advance it is imperative that potential delegates respond promptly so the organizers can best manage the event. We will impose deadlines on the accommodation so as not to incur penalties and if you do not respond in a timely fashion you may have to camp somewhere in a farmer's field. We have reserved accommodation at various locations and at different price ranges, ranging from camping through communal four-person cabins and shared hotel rooms (2–3) up to a couple of suites. We will organize a minibus service between the venue and the various accommodation sites.

SYMPOSIUM EXCURSIONS

To be determined.

FURTHER INFORMATION

If you wish to attend the symposium please register your interest online at http://www.igsoc.org/symposia/2015/hofn/.

The Second Circular will give further information about accommodation, the general scientific programme, additional activities, preparation of abstracts and final papers. Members of the International Glaciological Society will automatically receive one, as will all those who register their interest online. All information regarding this symposium will be updated on the IGS conference website, http://www.igsoc.org/symposia/2015/hofn/, and a local symposium website.

Liquid Water in Snow – Workshop 2014

Davos, Switzerland, 2–4 April 2014

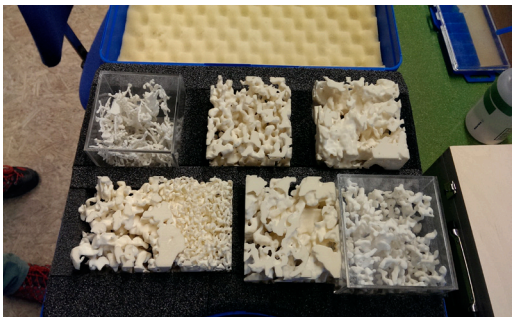
At the beginning of April 2014 about 50 researchers attended the workshop 'Liquid water in snow – measurements, techniques and modeling approaches', which took place at the WSL Institute for Snow and Avalanche Research SLF in Davos, Switzerland – the first workshop on this topic since the one held in 1982 in Innsbruck, Austria.

The workshop aimed to bring together researchers dealing with avalanche formation and remote-sensing issues, as well as other cryospheric objectives related to the snow water equivalent of snowpacks. As it was more than 30 years since the last workshop, the aims and scope were to assemble current knowledge across disciplines to compare different measurement techniques and their accuracy, discuss current assumptions on modelling liquid water transport and storage in snow, and gather ideas on how to best obtain good validation and verification data.

The first day was dedicated to measuring techniques while the second focused on modelling approaches. The third day was organized as a field day at the Weissfluhjoch field test site to deploy different measurement techniques simultaneously and compare results and interpretation. To this end some participants brought along their own equipment. The field conditions were rewarding, as about 1.5 m of initially dry snow were considerably wetted during the day.

As an important result, the workshop participants produced a synoptic overview for future research directions for studies in liquid water content in snow, grouped under measurements, models, physical understanding and joint issues. An overall list is available from the workshop website at http://www.slf.ch/dienstleistungen/events/index_EN?viewevent=Workshop_042014, which also provides access to a time-lapse movie of the field day.

On the measurement side, a 'gold standard' or compilation of methods, parameters and physical properties against which to gauge all measurement techniques is urgently needed for an objective evaluation. A long-term issue remains the application of dielectric mixing models, their homogenization and recommendations for use. The optimal combination of classical concepts (e.g. dilution, calorimetry and permittivity devices) with modern approaches such as upward-looking radar, TDR, impedance analyser, micro-CT (computed tomography), application of elastic waves and full-waveform inversion was found to be necessary. In any case, future methodological considerations have to provide high resolution simultaneously in space and time.



Christoph Mitterer explaining the metamorphism of snow using hands-on models of the pore space obtained from micro-computer tomography (Photos: O. Eisen)

As far as models are concerned, bridging the different spatial scales, from micro-scales to hydrological catchments, remains one of the biggest challenges. On larger scales simpler modelling approaches still seem appropriate, as uncertainties and shortcomings in the exact physical description are averaged out when applying such models over larger areas covering different snow regimes.

Our physical understanding of liquid water distribution within the snowpack still needs improvement. This applies to properties on the micro-scale as well as the effect of small-scale structure on emerging properties that are considered in measurements and models. On scales below the snow-cover thickness the application of more sophisticated equations (e.g.

Richards equation) than simple bucket models seems necessary for an adequate description of the distribution and lateral movement of liquid water. The related differential flow and temporal changes urgently require treatment.

For the future, all the above aspects have to be considered when establishing model calibration and validation schemes. Fully understanding the causes of the remaining differences between measurements and models requires consideration on multiple scales, spatially as well as temporally. Higher spatial coverage with several data points in an individual catchment and more experimental sites to cover all regimes to improve our insight into processes within the snowpack are one recommendation. Following the example of other fields in earth sciences (e.g. model intercomparison projects) a standard experiment and suitable datasets across multiple scales have to be developed to achieve improvements towards data assimilation.

Crowded snow pit: after initial surveys with GPR from the surface, two simultaneous sets of pit-wall profiling using several different methods were applied to get information on lateral continuity and reproducibility of water in snow over time (Photo: O. Eisen)

Olaf Eisen, Jürg Schweizer, Christoph Mitterer, Achim Heilig, Lino Schmid

We thank the funding agencies SEP and DFG for support.

Group photo (A. Heilig)

Glaciological diary

** IGS sponsored * IGS co-sponsored

2014

9 January 2014
2014 Annual Danish Greenland Ice Sheet Seminar
Copenhagen, Denmark
Contact: Ruth Mottram [rum@dmi.dk]

3–5 February 2014
IASC Workshop on the Dynamics and Mass budget of Arctic Glaciers
Ottawa, Canada
Contact: Carleen Tihm-Reijmer [c.h.tijm-reijmer@uu.nl]
Website: http://www.iasc.info/nag/

11–13 February 2014
4th DUE Permafrost User Workshop
Frascati, Italy
Website: http://www.climate-cryosphere.org/meetings/due-permafrost-2014

18–20 February 2014
Workshop for preparing applications to EUROFLEETS2 Regional Calls
Tallinn, Estonia
Website: http://www.eurofleets.eu/np4/370.html

27–28 February 2014
18th Alpine Glaciology Meeting (AGM)
Innsbruck, Austria
Contact: Irmgard Juen [irmgard.juen@uibk.ac.at.]
Website: http://imgi.uibk.ac.at/iceclim/agm2014

9–14 March 2014
Intercomparison of Snow Grain Size Measurements Workshop
Davos, Switzerland
Contact: Martin Schneebeli [schneebeli@slf.ch]
Website:
http://%20http//www.wsl.ch/dienstleistungen/veranstaltungen/veranstaltungskalender/Snow_Grain/index_EN

10–14 March 2014
****International Symposium on Sea Ice**
Hobart, Australia
Contact: Secretary General, International Glaciological Society
Website:
http://www.igsoc.org/symposia/2014/hobart/

17–20 March 2014
13th International Conference on the Physics and Chemistry of Ice (PCI-2014)
Hanover, New Hampshire, USA
Website:
http://engineering.dartmouth.edu/pci-2014

2–3 April 2014
Workshop: Liquid Water in Snow – measurement techniques and modeling approaches
Davos, Switzerland
Contact: Christoph Mitterer [mitterer@slf.ch]

7–11 April 2014
Workshop: Subglacial processes
Copenhagen, Denmark
Contact: Alexandra Messerli [messerli@nbi.ku.dk] or Nanna B. Karlsson [nbkarlsson@nbi.dk]

8–12 April 2014
Association of American Geographers Annual Meeting
Tampa, Florida, USA
Cryosphere Sessions:
Advances in Cryosphere Research
High Latitude Environments in a Changing Climate
Ice and Snow
Contact: Vena Chu [venachu@ucla.edu]

15–17 April 2014
10th Annual Polar Technology Conference
Bloomington, Indiana, USA
Website: http://polartechnologyconference.org/

27 April–2 May 2014
European Geosciences Union General Assembly
Vienna, Austria
Website:
http://meetings.copernicus.org/egu2014/

15–18 May 2014
CRIOSFERA 2014
Bucharest, Romania
Website: http://crios2014.wordpress.com/

22–24 May 2014
Joint model-data workshop for the late Pleistocene evolution of the Greenland and Antarctic ice sheets
Grenoble, France
Website: http://www.physics.mun.ca/MOCA/IceSheetModelandData2014.html

26–28 May 2014
International Conference on Cold Climate Technology 2014
Narvik, Norway
Website: http://www.iccct2014.com/

26–30 May 2014
****International Symposium on Observations, Modelling and Prediction of the Cryospheric Contribution to Sea Level Change**
Chamonix, France
Website: http://www.igsoc.org/symposia/2014/chamonix/

2–4 June 2014
2014 Ice Sheet System Model (ISSM) Workshop
Bergen, Norway
If interested, e-mail the ISSM team at issm@jpl.nasa.gov

2–6 June 2014
XIX Geological Congress of Argentina
Cordoba, Argentina
Special Session on Cryosphere Science.
Conveners: Dario Trombotto[dtrombot@mendoza-conicet.gob.ar], Lucas Ruiz [lruiz@mendoza-conicet.gob.ar]
Second Circular:
http://www.congresogeologico.org.ar//assets/pdf/XIX_CGA_2da_Circular.pdf

3–5 June 2014
71st Eastern Snow Conference
Boone, North Carolina, USA
Website:http://www.easternsnow.org/annual_meeting.html

9–11 June 2014
9th Antarctic Meteorological Observing, Modeling, and Forecasting Workshop
Charleston, South Carolina, USA
Website: http://amrc.ssec.wisc.edu/meetings/meeting2014/index.shtml

18–21 June 2014
EUCOP4: 4th European Conference on Permafrost
Évora, Portugal
Website: http://www.eucop4.org/

22–25 June 2014
28th International Forum for Research into Ice Shelf Processes (FRISP)
Schloss Wahn, Cologne, Germany
Contact: Adrian Jenkins [ajen@bas.ac.uk]

*2–4 July 2014
Snow and Ice Research Group, New Zealand (SIRG-NZ) Workshop 2014
Aoraki Mt Cook Village, New Zealand
Website: http://www.sirg.org.nz/

4–5 August 2014
Intercomparison of Snow Grain Size Measurements Workshop (follow-up to March Workshop in Davos)
Reading, UK
Contact:
Martin Schneebeli [schneebeli@slf.ch]

6–8 August 2014
Workshop on Microstructure in Snow Microwave Radiative Transfer (MICROSNOW workshop)
Reading, UK
Contact:
Melody Sandells [m.j.sandells@reading.ac.uk]
Website: http://www.esa-da.org/content/microstructure-snow-microwave-radiative-transfer-microsnow-workshop

6–16 August 2014
***Third International Summer School in Glaciology**
McCarthy, Alaska, USA
Website: http://glaciers.gi.alaska.edu/courses/summer-school/2014

11–15 August 2014
22nd IAHR International Symposium on Ice
Singapore
Website: http://www.iahr-ice2014.org/

16–21 August 2014
World Weather Open Science Conference Montréal, Canada
Cryosphere sessions:
Cryosphere and stable atmospheric boundary layers
Ocean and cryosphere observations and their assimilation
Website: http://wwosc2014.org/

16–31 August 2014
Advanced climate dynamics course: The Dynamics of the Greenland Ice Sheet
Arctic Station, Disko Island, West Greenland
Website: http://www.uib.no/en/rs/acdc/54141/acdc-2014

17–22 August 2014
International Workshop on Ice Caves (IWIC)
Idaho Falls, Idaho, USA
Website: http://www.iwic-vi.org/

22–24 August 2014
***100 Years Glacier-Climate Studies at Claridenfirn: worldwide longest glacier mass balance series 1914-2014**
Zürich, Switzerland
Contact:
Martin Lüthi [martin.luethi@geo.uzh.ch]
Website:
http://snow-ice-permafrost.ch/en/clariden100/

22 August 2014
Workshop: Antarctic Near-Shore and Terrestrial Observing System Proposal
Auckland, New Zealand (prior to the start of XXXIII SCAR meetings)
For more information, download the workshop leaflet at http://www.scar.org/events/ANTOS_Workshop_NZ_Aug14.pdf

22 August–3 September 2014
XXXIII SCAR Biennial Meetings and Open Science Conference
Auckland, New Zealand
Contact: Katrina Hall [gateway-antarctica@canterbury.ac.nz]
Website: http://www.scar2014.com/

8–9 September 2014
***International Glaciological Society British Branch Meeting**
Bristol Glaciology Centre, University of Bristol, UK
Contact:
Martin J Siegert [M.J.Siegert@bristol.ac.uk]

9–20 September 2014
Karthaus course: Ice sheets and glaciers in the climate system
Karthaus, Italy
Contact: J. Oerlemans [J.Oerlemans@uu.nl]
Website: http://www.projects.science.uu.nl/iceclimate/karthaus/

11–12 September 2014
*The UK Antarctic Research Symposium
Bristol Glaciology Centre, University of Bristol, UK
Contact:
Martin J Siegert [M.J.Siegert@bristol.ac.uk]

18–21 September 2014
International Symposium on The Future of the Glaciers: From the past to the next 100 years
Celebrating 100 years of the Bulletin of the Italian Glaciological Committee
Turin, Italy
Website: http://www.glaciologia.it/

16–17 September 2014
Workshop: Novel Mission Concepts for Snow and Cryosphere Research
Noordwijk, Netherlands
Website: http://www.congrexprojects.com/2014-events/14c19/introduction

26 September 2014
Sea ice and Climate Modeling Forum
Workshop on large-scale sea-ice simulations
Reading, UK
Website: http://www.climate-cryosphere.org/activities/groups/seaicemodeling

29 September–3 October 2014
International Snow Science Workshop (ISSW)
Banff, Alberta, Canada
Website: http://issw2014.com/

13–16 October 2014
Workshop – Past as Prologue: Holocene climate as context for future climate change
Timberline Lodge, Mount Hood, Oregon, USA
Website:
http://people.oregonstate.edu/~marcotts

13–15 October 2014
Workshop – Chemical atmosphere-snow-sea ice interactions: taking the next big step in field, lab and modelling
Darmstadt, Germany
Website: http://www.antarctica.ac.uk/about_bas/events/ca

13–17 October 2014
Climate Symposium
Darmstadt, Germany
Session: Cryosphere in a Warming World
Website: http://www.theclimatesymposium.com/

19–22 October 2014
Geological Society of America Annual Meeting
Vancouver, Canada
Session: Slope Stability and Permafrost (T96).
Convener: Stephan Gruber [Stephan.Gruber@carleton.ca]
Website: http://community.geosociety.org/gsa2014/home/

21–24 October 2014
ART Science Workshop: Integrating spatial and temporal scales in the changing Arctic System – towards future research priorities (ISTAS)
Brest, France
Contact:
Kirstin Werner [werner.192@osu.edu]

30 October–1 November 2014
***International Glaciological Society Nordic Branch Meeting**
Mýrdalsjökull , Iceland
Contact: Eyjólfur Magnússon [eyjolfm@hi.is] and Alexander H. Jarosch [alex@hi.is]

18–21 November 2014
GEORISK 2014: Improving geophysical risk assessment, forecasting and management
(IUGG Commission on Geophysical Risk and Sustainability)
Madrid, Spain
Website: www.georisk2014.com

2015

2–6 March 2015
****International Symposium on Himalayan glaciology**
Kathmandu, Nepal
Contact: Secretary General, International Glaciological Society
Website: http://www.igsoc.org:8000/symposia/2015/kathmandu/

23–26 March 2015
Workshop on the Dynamics and Mass Budget of Arctic Glaciers/IASC Network on Arctic Glaciology Annual Meeting
Obergurgl, Austria
Website: http://www.iasc.info/nag/

June 2015
****International Symposium on the Hydrology of Glaciers and Ice Sheets**
Iceland
Contact: Secretary General, International Glaciological Society
Website: http://www.igsoc.org:8000/symposia/2015/iceland

17–22 August 2015
****International Symposium on Contemporary Ice-Sheet Dynamics: ocean interaction, meltwater and non-linear effects**
Cambridge, UK
Contact: Secretary General, International Glaciological Society
Website: http://www.igsoc.org:8000/symposia/2015/cambridge/

2016

20–24 June 2016
Eleventh International Conference on Permafrost (ICOP 2016)
Potsdam, Germany
Website: http://icop2016.org/

August/September 2016
****International Symposium on Polar Sea Ice, Polar Climate and Polar Change**
Boulder, Colorado, USA
Contact: Secretary General, International Glaciological Society

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