Glacier Lagoon, Iceland Above ↑

Abstracts IGSBB-2025

An Operation Icebridge flight observed the terminus of the Zachariæ Isstrøm Glacier in northeast Greenland in August 2017. Credit: NASA/LVIS. *Above* ↑

Session 1
Earth Observation

Tomos Morgan
Karla Boxall
Devin Harrison
Noel Gourmelen
Adrian Luckman

Elephant Island   Below

TOMOS MORGAN

Assessing lake-terminating glacier classification in Svalbard from 1985-2024 using an Object-Based Image Analysis (OBIA) approach in Google Earth Engine (GEE)

In this study, we apply an Object-Based Image Analysis (OBIA) approach to 1255 multispectral Landsat 5-9 top-of-atmosphere (TOA) satellite images in Google Earth Engine (GEE) to document the number of lake-terminating glaciers inside of the summer season (June-August) on Svalbard between 1985-2024. The glaciers in Svalbard have experienced the second highest glacier mass loss of any glaciated region in 2024. This suggests that this method has the potential to map glacial lakes accurately and rapidly over larger regions.

It remains necessary to monitor both glaciers and their lakes due to Arctic amplification over the last two decades that has led to the warming of the Arctic at twice the rate of the global average. Our results show that the total size of glacier terminating lakes has increased from 59.2 ± 1.4 km^2 in 1985-1989 to 200 ± 4.3 km^2 in 2020-2024, representing a % increase of 255.9 ± 4.1 %. During our study, we identified 217 individual lake-terminating glaciers. Excluding the 97 lake-terminating glaciers identified previously by Steiner et al., 2025 between 1999-2002, we identified the presence of 120 new lake-terminating glaciers that formed between 1985 and 2024. By the end of the summer season of 2024, we identified the presence of 136 lake-terminating glaciers in Svalbard. Out of the 97 lake-terminating glaciers identified between 1999-2002, 78 out of the 97 lake-terminating glaciers remained lake-terminating. We attribute the omission and/or lack of lake-terminating glacier classification data between

2003 to 2012 down to the scan line corrector (SLC) failure on Landsat ETM+ that occurred May the 31st, 2003 (Storey et al., 2005), leading to less suitable satellite imagery being readily available for inspection. The results derived for the accuracy of Landsat 4-9 satellite imagery resulted in an overall accuracy of 93.6%, and user's accuracy of 94.3% and 94.5% respectively, for water. This suggests that this method has the potential to map glacial lakes accurately and rapidly over larger regions. We emphasise the importance of monitoring these glacial lakes in the coming century, as many glaciers exhibit early stages of proglacial lake growth which may indicate the early stages of transitioning from a land-to-lake-terminating glacier, which may speed up ice-thinning and retreat and affect important glacial processes, particularly glacial mass balance and response times.

KARLA BOXALL

Using CryoSat-2, ICESat-2 and airborne data to prepare for ice-sheet monitoring with CRISTAL

Three decades of routine satellite altimetry have provided a near-continuous observational record of polar topography, offering unparalleled insights into ice sheet elevation change. The ability of CryoSat-2, Sentinel-3 and ICESat-2 to simultaneously and continually monitor Earth's ice surfaces is critical towards understanding the ongoing and future imbalance of the ice sheets in a changing climate. The launch of the Copernicus Polar Ice and Snow Topography Altimeter (CRISTAL), currently scheduled for the end of 2027, will mark a new era of operational polar-orbiting radar altimeters. CRISTAL's novel and innovative dual-frequency Ku-Ka radar altimeter, large-scale Ku interferometric SAR acquisitions over ice surfaces, increased bandwidth, and Open Loop tracking will drive significant improvements in the measurement and monitoring of ice sheet elevation. Scientific and technical questions remain, however, with regards to how best to exploit CRISTAL data in domain-specific Level-2 processing.

Here, we provide an overview of several Land Ice Research & Development activities conducted as part of the CRISTAL LEVel-2 procEssor prototype and R&D (CLEV2ER) project. These activities utilise in-orbit CryoSat-2 and ICESat-2 data, and are designed to contribute to the development of the Level-2 Ground Processor Prototype for Land Ice and Inland Water surfaces. Here, we will provide highlights from several of the R&D studies, including analysis and improvements of the methodology used for uncertainty estimation, the retrieval of penetration depth from dual band altimetry, and the role of snowpack properties on penetration depth estimates. Ultimately, these findings will enhance the scientific readiness of the CRISTAL mission and help to ensure the timely exploitation of its data for the improved measurement and monitoring of ice sheet elevation.

DEVIN HARRISON

The recent collapse of Endurance Glacier, Elephant Island

Elephant Island is synonymous with Antarctic exploration through its role as a refuge for the crew of the Endurance during their remarkable journey to safety from the ill-fated

Imperial Trans-Antarctic Expedition. However, there has been limited research characterising the historic and contemporary glaciological regime of the region. Antarctic Periphery Glaciers (APGs), including those on Elephant Island, contribute towards the largest global glacier area outside of the ice sheets. Understanding the behaviour of APGs remains a critical knowledge gap and is of vital importance due to their high sensitivity to short-term fluctuations in the ocean-climate system. Here, we use remote-sensing products to examine the recent (1980s onwards) change of Endurance Glacier, a marine-terminating outlet on Elephant Island. Observations from Landsat, ASTER, Sentinel-1 and Sentinel-2 data reveal the ice margin has retreated ~7 km between 1989 and 2025 with 70% of the terminus retreat occurring during the last 10 years. Analysis of co-registered 2 m gridded REMA DEM strips reveal thinning rates of up to 10 m yr-1 during a 13 year period. During this time numerous peaks in ice velocity can be observed, ranging between 1000 and 2000 m yr-1 with peak accelerations of up to 400% over a six-month period. A transient pulse of increased snowfall combined with warming ocean waters appears to be driving this change, which has been further enhanced by continually increasing trends in air temperature. The exceptional collapse of Endurance Glacier highlights the vulnerability of APGs to recent climatological and oceanographic changes, and showcases the importance of future study to understand the dynamic behaviour of these systems.

Devin Harrison, Thomas R. Chudley, James M. Lea and Beatriz Recinos Rivas

NOEL GOURMELEN

The influence of subglacial lake discharge on Thwaites Glacier ice-shelf melting and grounding-line retreat

The retreat of the Antarctic Ice Sheet is conventionally attributed to increased ocean melting of ice shelves, potentially enhanced by internal instability from grounding lines near retrograde bed slopes. Ocean melting is enhanced by increased intrusion of modified Circumpolar Deep Water (mCDW) into ice shelf cavities. Upwelling from the release of subglacial meltwater can enhance mCDW's melting ability, though its efficacy is not well understood and is not represented in current ice sheet loss projections. Here we quantify this process during an exceptional subglacial lake drainage event under Thwaites Glacier. We found that the buoyant plume from the subglacial discharge temporarily doubled the rate of ocean melting under Thwaites, thinning the ice shelf. These events likely contributed to Thwaites' rapid thinning and grounding line retreat during that period. However, simulations and observations indicate that a steady subglacial water release would more efficiently enhance basal melt rates at Thwaites, with melt rate increasing like the square root of the subglacial discharge. Thus, it remains unclear whether increased subglacial flooding events provide a stabilizing influence on West Antarctic ice loss by reducing the impact of subglacial water on ocean melting, or a destabilizing influence by triggering rapid changes at the grounding zone.

ADRIAN LUCKMAN

Ongoing dynamic change at Thwaites Glacier from Sentinel-1

Thwaites Glacier drains a large area of the West Antarctic Ice Sheet and is rapidly losing mass, so understanding the ongoing changes is a priority. Its size means that there are many processes of change going on at the same time, including thinning and break-up of the Eastern Ice Shelf (TEIS), sea-water intrusion under the main tongue (TWIT), grounding-line retreat at ice shelf channels, increased melting when subglacial lakes discharge, and sporadic calving at the western calving front (TWCF) controlled by floating ice. This variety of processes can make it difficult to communicate ongoing changes.

With renewed ability to image the whole glacier every six days, the Sentinel-1 SAR mission is ideally placed to detect and visualize dynamic change at Thwaites as it is happening. This presentation will illustrate recent changes in surface velocity at key zones of Thwaites Glacier and present animations of rifting and calving activity. There has been much speculation about the instability of marine ice sheets, including hypothetical processes of ice-cliff instability. We argue that instability of Thwaites Glacier is playing out in real time, and that the Sentinel-1 archive provides a unique opportunity of observe key mechanisms and feedbacks.

Charlotte Bay, Antarctica

Above ↑

Session 2
Antarctica

Kasia Warburton
Felipe Napoleoni
Alex Bradley
Harry David
Clara Nyqvist
Bernd Kulessa

KASIA WARBURTON

Mechanics of the Thwaites grounding zone inferred from GPS and tiltmeter data

Co-authors: Kiya Riverman (University of Portland), the ITGC-MELT fieldteam

Grounding zones mark the transition between floating ice shelves and grounded ice. Across grounding zones, ice transitions from fully floating, to partially (tidally) grounded, to fully grounded. Identifying the location and width of the grounding zone is key for parameterizations of basal traction and basal melt. We used month-long continuous GPS elevation and tiltmeter records collected along an 8km transect through the Thwaites grounding zone as an in-situ record of grounding-zone mechanics over tidal cycles.

We used a flow-line elastic ice sheet model that incorporates high-resolution ice thickness and bathymetric profiles across the grounding zone from geophysical surveying by the ITGC-MELT project from 2018-20. By forcing the model with local ocean tides, we inverted for the elastic stiffness of the ice and compressibility of the basal sediment, with our two-parameter model accounting for over 95% of the GPS elevation signal through the grounding zone. This modelling suggests that the Thwaites grounding line does not act as a completely fixed fulcrum, but migrates short distances during the tidal cycle. Further, we identify a much wider kilometre-scale zone of weakly grounded ice inland the grounding line where a large water lens appears to experience out-of-phase waves of tidally-pumped water, indicating partial connectivity to the ocean tides. We use our best-fit ice and bed properties to consider how this weakly-grounded region may be vulnerable to fast grounding line retreat under even small amounts of future thinning.

FELIPE NAPOLEONI

Linking Bed Reflectivity and Englacial Stratigraphy to Subglacial Hydrology beneath Thwaites Glacier

We present updated interpretations of subglacial hydrology along the central flowline of Thwaites Glacier, based on radar-derived bed reflectivity and subglacial topography. Potential drainage pathways were inferred from spatial variations in bed reflectivity, with particular focus on the margins of Subglacial Lake Thw 124 (LTG), first delineated by Smith et al. (2009) using laser altimetry. High bed reflectivity is linked to subglacial water bodies (lakes or saturated sediments) and/or actively lubricated zones that enhance basal sliding, whereas low reflectivity generally indicates frozen bed conditions or highly attenuating, dry till. The relative bed reflection shows marked spatial heterogeneity, suggesting lateral variability in basal conditions, possibly reflecting transitions between rough and smooth patches or contrasting hydrological regimes.

A hydropotential simulation was used to identify probable water routing around the active lake. Results suggest that the previously defined lake boundary is likely overestimated, implying that lake expansion occurs episodically rather than remaining stable through time.

We also present a coherence analysis of the bed relative power to support interpretations of localised water storage and drainage events. These findings refine current understanding of subglacial water transport beneath Thwaites Glacier and provide new constraints on subglacial lake evolution in this region.

ALEX BRADLEY

To what extent is climate change responsible for retreat of the Pine Island Glacier?

At least since we started measuring in detail, the West Antarctic Ice Sheet has lost a lot of ice, but we don't know if climate change is responsible. In this work, we put a number on the role of climate change in retreat of the Pine Island Glacier in this ice sheet, for the first time. We show that climate change made the shrinking of this glacier much worse. Our work also suggests that what happened on very long timescales (the last 10,000 years) might also matter for retreat of the ice sheets today.

HARRY DAVIES

A combined radiostratigraphy- and ice-core- derived age scale for a new ice core at the divide between the Amundsen, Bellingshausen and Weddell seas, West Antarctica

Harry Davis[1], Robert G. Bingham[1], Andrew Hein[1], Anna E. Hogg[2], Carlos Martín[3], Elizabeth R. Thomas[3]

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3. British Antarctic Survey, Cambridge

Northern Ellsworth Land, where the West Antarctic Ice Sheet meets the Antarctic Peninsula Ice Sheet, has experienced significant ice thinning and grounding-line change over the satellite observation period; yet, the current deglaciation history of this region throughout the last glacial period and Holocene remains poorly constrained, and the onsets of these dynamic changes are unclear. With much of the region grounded in marine basins to 2000 m below sea level, the area is highly susceptible to rapid mass loss in the future under climate warming.

One way to better understand these contemporary thinning trends in the context of longer-term changes is with an ice core. We identify a new deep ice-core drilling site at the triple-ice divide point between the Amundsen, Bellingshausen, and Weddell Seas (74o 34' 37S, 86o 54'16W). Using a transient 1-D ice-flow model, constrained by shallow-ice-core data and new dated radar stratigraphy, we infer the accumulation rate history at the site to derive a full age scale for the ice at this location.

We find that the accumulation rates at the site are up to three times greater than the WAIS Divide record during the Holocene, with a large decrease in accumulation between 4.72 ka and present day. The maximum modelled age at the site is 30 ka, assuming no basal melting, with a high resolution of 0.6 ka m-1 at 95% depth. In subsequent analyses of the model sensitivity to basal melting, we find that a full Holocene record could still be recovered even when high geothermal heat flux (GHF) input values, exceeding the mean GHF across five datasets, are prescribed.

An ice core at this site could provide a new high-resolution Holocene climate record that would exceed the current longest records from this region. The record would also provide precise constraints to reconstruct climatic changes and glacial extent during the Holocene, helping to resolve the onset of the extensive dynamic thinning observed today.

CLARA NYVIST

Stability of East Antarctica's upper Wilkes Subglacial Basin since before the Last Glacial Maximum investigated by radar-imaged englacial stratigraphy

Clara J. Nyqvist[1], Robert G. Bingham[1], Andrew S. Hein[1], Neil Ross2, Johannes C. R. Sutter[3, 4], Julien A. Bodart[3], Tom Jordan[5], Fausto Ferraccioli[6], Egidio Armadillo[7]
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Wilkes Subglacial Basin is one of three marine basins underlying the East Antarctic Ice Sheet, suggested in some recent studies as an area that may be vulnerable to marine ice-sheet instability due to indications of significant deglaciation during past interglacials. The basin is flanked by two deep ice cores: EPICA Dome C Ice Core to the west of the basin and towards the ice-sheet interior, and Talos Dome Ice Core to the east of the basin and closer to Ross Sea. Using radio-echo sounding data, englacial horizons can be dated at intersections with deep ice cores and traced extensively across the ice sheet, therefore providing three-dimensional evidence of the palaeo-behaviour of past ice-sheet behaviour.

Here, we use the WISE-ISODYN survey to investigate the englacial stratigraphy of Wilkes Subglacial Basin. This airborne radio-echo sounding dataset contains over 61,000 km of radar profiles, and was jointly acquired in 2005-06 by the British Antarctic Survey and the Italian Programma Nazionale di Ricerche in Antartide. We trace several englacial horizons through upper Wilkes Subglacial Basin, across the more than 1,100 km between Dome C and Talos Dome ice cores, to map the englacial stratigraphy of Wilkes Subglacial Basin and englacially connect the two ice cores.

The englacial architecture of the upper Wilkes Subglacial Basin confirms that ice has pervasively covered the upstream region of the basin for at least 60 ka. We trace englacial horizons up to 90 ka throughout the upper basin, however these show a great variation in fractional depth and traceability, making it challenging to determine the extent to which the basin may have been deglaciated towards the end of the Last Interglacial, 130 – 115 ka. Future work will focus on extending the older traced horizons further down towards the grounding line of Wilkes Subglacial Basin, to investigate how the englacial stratigraphy changes downstream in the basin.

BERND KULESSA

New insights into West Antarctic sedimentary basins and crustal structure from magnetotelluric imaging

We acquired new magnetotelluric (MT) geophysical data on Thwaites Glacier and at the West Antarctic Ice Sheet (WAIS) Divide in the austral summers of 2022/23 and 2023/24, as part of the International Thwaites Glacier Collaboration's GHOST project. These data complement an archive of existing MT data acquired previously by others along profiles on Whillans Ice Stream, near the South Pole and from the Ross Ice Shelf across the Transantarctic Mountains. Using state of the science forward and inverse solvers, we produce new depth-resistivity models for the uppermost crust beneath the ice at each location, and interpret these models in terms of geological, geothermal and hydrogeological conditions beneath each profile. Where the presence of sedimentary basins is inferred from airborne geophysical observations, crustal resistivities are relatively low (< 100 Ωm). This includes selected locations on Thwaites Glacier, along Whillans Ice Stream and at the South Pole. In contrast, the resistivity structures at WAIS Divide and on Ghost Ridge show a relatively resistive crust (> 100 Ωm). Inferred differences in resistivity could be caused by spatial changes in lithology, groundwater saturation, groundwater salinity or geothermal heat flow. Here, we quantify the impacts of these four factors on our resistivity models by interpreting our observations in conjunction with complementary airborne and ground-based geophysical data and existing geological templates and geothermal heat flow models. We furthermore extend a simple empirical model for geothermal heat flow estimation from MT data for the impact of different subglacial crustal lithologies. Our inferences of significant spatial variability in subglacial conditions beneath the lower Thwaites Glacier – which we set within a new WAIS-wide MT template – have implications for current ice dynamic models of the glacier's retreat.

Glacier metling in North Russia

Above ↑

Session 3
Ice Flow

Ryan Strickland
Joseph Mallalieu
Connie Harpur
Yefan Wang
William Harcourt

RYAN STRICKLAND

Ice stream bifurcation: A simple framework for revealing flow instability

Ice stream bifurcations—where a fast-flowing glacier splits into two or more outlets—are widespread in Greenland and Antarctica and play a key role in controlling how ice is delivered to the ocean. Despite their importance, the geometry and stability of these bifurcations remain poorly understood. Using satellite-derived surface velocity fields from NASA ITS_LIVE, we mapped over 280 bifurcations across the two ice sheets and measured their branching angles. The resulting distributions reveal preferred geometries: bifurcations in Antarctica are bimodal, with peaks near 30° and 120°, while Greenland bifurcations cluster around 30°, suggesting distinct dynamical regimes or topographic influences.

To explain these patterns, we develop a simple geometric framework inspired by the weighted Fermat point problem. In this model, the bifurcation point migrates to minimize total energy dissipation from basal friction and lateral shear in each stream branch. A parameter sweep across realistic ice stream geometries shows that the model reproduces observed bifurcation angles and captures key features of bifurcation stability. In particular, we find that dissipation asymmetries between branches promote instability and that stream width-to-depth ratios exert a strong control on angle selection.

Finally, we compare these idealized predictions to full-Stokes Elmer/Ice simulations of bifurcating glaciers and find strong agreement in the predicted response to perturbations. Together, our results demonstrate that even a minimal energetic framework can offer powerful insights into ice stream bifurcation geometry, stability, and evolution—key components for understanding long-term ice sheet change and sea level rise.

JOSEPH MALLALIEU

Global influence of terminus environment on glacier velocity and mass loss

Glacier terminus environments can influence ice dynamics and geometry through the propagation of thermo-mechanical forces from the margin, particularly in marine- and lake-terminating settings. However, the influence of terminus environment on glacier dynamics at global scales remains poorly constrained. Here we use existing glacier and glacier lake inventories to present the first complete classification of RGI 6 terminus environments that includes lake-terminating glaciers in all RGI regions. We integrate this classification with records of glacier geometry, dynamics and climate to investigate associations between terminus environment, glacier velocity and mass change at a global scale. We find that although land-termini predominate globally (accounting for 96.8% of all termini), more than half of global glacier area drains to non-terrestrial margins (31.0% to marine-, 11.5% to lake , and 11.3% to shelf-termini). These margins also accounted for over half of global mass loss from 2000 to 2019 (24.0% at lake-, 22.8% at marine- and 3.9% at shelf-termini). When controlling for key climatic and morphometric drivers of glacier dynamics, we show that lake- and marine-terminating glaciers flow significantly faster than land-terminating glaciers, by 10% and 44% respectively. Finally, when accounting for climatic and topographic controls, we also show that lake-terminating glaciers experienced significantly greater mass loss per unit area than land-, marine- or shelf-terminating glaciers in the period 2000-2019. Our results suggest that terminus environment may play a key role in regulating glacier dynamics and mass loss, and highlight the need for improved monitoring and process understanding at non-terrestrial termini to refine projections of glacier change and sea-level rise. As climate warming drives increased transitions between terminus environments, our results also illustrate how dynamic responses may differ depending on the new setting.

CONNIE HARPUR

Ice-marginal lakes enhance outlet glacier velocities across Greenland

Glaciers terminating in lakes typically lose mass more rapidly than those that terminate on land. This is due to a range of thermomechanical processes exerted at the lake-ice interface, where lake waters drive melt-induced undercutting, enable flotation and facilitate calving. In Greenland, ice marginal lakes (IMLs) have increased in size and number over recent decades and now occupy more than 10% of the ice sheet margin. Despite this, very few observations of their effects on ice dynamics exist, meaning they remain largely unaccounted for in models of ice sheet change.

Here, we use ITS_LIVE ice surface velocity data and the How et al. (2021) IML inventory to compare the flow characteristics of 102 lake-terminating outlet glaciers and 102 neighboring land-terminating outlet glaciers across the Greenland Ice Sheet. We find that along-flow decelerations are much less pronounced at lake- versus land-terminating glaciers, and that some lake-terminating glaciers (n= 33) accelerate towards the ice margin. In turn, lake-terminating glaciers are on average 295% times faster than their land-terminating counterparts within the terminus region. Moreover, the fastest flowing glaciers are found to terminate in the largest lakes, suggesting that lake influence evolves with lake development. Ultimately, these observations demonstrate the capacity of IMLs to enhance the surface velocity of Greenlandic outlet glaciers, highlighting their potential to accelerate future mass loss from the GrIS.

YEFAN WANG

Catastrophic drainage from ice-marginal lakes regulates ice-motion at a Greenlandic lake-terminating glacier

Yefan Wang, Peter Nienow, Jaime Otero & Daniel Goldberg*
School of GeoSciences, University of Edinburgh

Isortuarsuup Sermia (IS), a lake-terminating glacier in southwestern Greenland, drains into Isortuarsuup Tasia, a major proglacial lake, and interacts with two ice-dammed lakes 10 km upglacier from its terminus. Recent studies noted a >150% acceleration and thinning at the calving terminus from 2013–2021, suggesting that the proglacial lake facilitates the dynamic change of IS

This study examines the long-term influence of the northern and southern ice-dammed lakes on IS dynamics from 1987 to 2024. The northern lake (draining threshold: ~29–31 km²) drained catastrophically four times at 9–10-year intervals, releasing ~1.5 km^3 outburst floods in <24 hours, with water levels dropping over 100 m. The southern lake (draining threshold: ~4–6 km^2) drained eight times at 3–7-year intervals. Northern lake drainage caused a brief (<1 month) acceleration of the lower glacier tongue, followed by a velocity drop to ~50 m/yr from ~200 m/yr. Observations of ice surface elevation change pre- and post-lake drainage reveal the lake waters drained primarily through a large subglacial channel generated rapidly by the substantial outburst flood. We infer that following peak drainage, this channel operated as an axis of low subglacial water-pressure enabling the wider glacier bed to 'de-water' and de-pressurise extensively, thereby increasing effective pressure and slowing basal sliding. Over subsequent years, the glacier terminus re-accelerates gradually, presumably as the ice-bed interface re-pressurises. Our observations highlight the ability of catastrophic drainage from large ice-marginal lakes, to impact subsequent ice-dynamics over decadal time-scales, through substantial perturbations in effective pressure at the ice-bed interface.

WILLIAM HARCOURT

The distribution of glacier surge behaviour in Svalbard and implications for understanding unstable ice flow

Glacier surges are periods of significantly increased ice flow due to ice-dynamic feedbacks, in contrast to more conventional advances or other responses due to changes in mass balance. In Svalbard, estimates of the number of surge-type glaciers across the archipelago range between 10% and 90% depending on the classification technique used. In this contribution, we review the benefits and limitations of different approaches for monitoring and detecting glacier surges in Svalbard. We use this to compile a new database of surge-type glaciers in Svalbard, which also contains data on surge characteristics e.g. terminus change and velocity. We find that 36% of glaciers in Svalbard have displayed surge-type behaviour throughout our observational and landform record, rising to 51% when removing glaciers smaller than 1 km2. Of all the glaciers in Svalbard, only 9% have been directly observed to surge in Svalbard. Improvements in our ability to detect surges has started to reveal more complex surge dynamics that suggests the binary classification of a glacier as surge-type or not breaks down. This has implications for how we understand the mechanisms through which glaciers build up energy during quiescence which enables ice flow acceleration during a surge.

Perito Moreno Glacier, Lake Argentino, Argentine Patagonia

Above ↑

Session 4
Calving

Doug Benn
Tim Hageman
Daniel Richards
Jaime Otero
Andrew Mackintosh
Tryggvi Unnsteinsson

DOUG BENN

Calving laws and where to find them

Current prognostic ice-sheet models cannot predict future calving losses because they lack a robust calving law. We argue that the key to finding the general calving law is to recognise that calving glaciers are stochastic dynamic systems that exhibit self-organisation. Collectively, calving events have statistical properties that reflect underlying fragmentation processes. These reflect distinct styles of calving and give rise to persistent patterns of advance and retreat, including fluctuations around pinning points and periods of instability and transition. These patterns motivate a stochastic calving law scaled to the stress within the ice, which we demonstrate in a set of model experiments with Elmer/Ice. Self-organising behaviour emerges spontaneously from the model, including predicted calving-size distributions and system convergence on quasi-stable states. The model simulates calving behaviour over a wide range of scales, and produces short calving cycles for a Greenland-type geometry and long cycles for an Antarctic shelf-type geometry.

TIM HAGEMAN

Computational models of ice to capture both shear and tensile fracture, applied to ice-cliff collapses

While many materials typically are either brittle or ductile, ice exhibits different behaviour depending on the loading: Under tensile stresses ice is extremely brittle and easily develops crevasses, but when shear loads are applied it softens, develops shear bands, and fails in a ductile manner, and when the rate of loading is sufficiently slow it only exhibits viscous creep without this leading to any damage. This difference in behaviour has a strong impact on the stability of ice-cliffs, with vastly different failure modes being predicted depending on the exact failure criterion used.

Here, several modelling frameworks able to capture both these different regimes will be presented, allowing for complex fracture patterns and intersecting cracks. Shear bands are captured through Von Mises plasticity, which accumulates damage leading to eventual fracture. Power-law creep is included with the plastic strains resulting from this creep being considered as non-damaging. Application will be shown to both small-scale tri-axial compression tests, demonstrating the accuracy of the model and its ability to reproduce experimental results, as well as large-scale cliff failure to showcase the impact of using this material model on predictions of ice-cliff failure. Finally, two simplified models will be presented, one aimed at short-term cliff failures and the other for longer-term tensile crevasses, with these models being computational cheaper and applicable to larger domains/times.

DANIEL RICHARDS

A viscoelastic phase-field model for calving and fracture in ice

Iceberg calving due to fracture accounts for around half of the ice lost annually from Antarctica, but physically based models representing this process are not currently included in ice sheet models. By using a phase-field viscoelastic model for fracture we can model both slow deformation of ice and the distribution and evolution of cracks leading to calving. The model solves equations for non-linear viscous flow, elastic displacement and a phase-field variable which allows cracks to nucleate and propagate in response to the evolving stress field. Without making any assumptions about the type of calving, we apply this model to a simulate fracture of an iceberg, giving both insights into parametrisations and a pathway to including fracture directly in ice sheet models.

JAIME OTERO

On the modelling of transition from land- to lake-terminating glaciers

Jaime Otero, Daniel Goldberg, Peter Nienow & Yefan Wang School of GeoSciences, University of Edinburgh

The Greenland (GRIS) and Antarctic Ice Sheets are projected to be the primary contributors to sea level rise throughout the 21st Century. However, these projections are subject to significant uncertainties, primarily due to limited understanding and representation of key dynamical processes. One such process, currently not incorporated into GRIS model projections, involves, the transition of glaciers from land- to lake-terminating termini in response to the formation of proglacial lakes, and the associated dynamic changes. Glaciers interact with adjacent proglacial lakes through a range of thermomechanical processes. These interactions occur in addition to climate-driven ablation but are capable of amplifying or modifying climatic effects through various feedback mechanisms. For example, calving events can temporarily destabilize glacier margins, partially decoupling glacier behaviour from direct climate forcing. Furthermore, the connection between lake water and the subglacial hydrological system can reduce basal friction, which in turn leads to increased glacier flow speeds and dynamic thinning. This creates a positive feedback loop in which decreased effective pressure enhances flow velocity, in line with similar processes observed at marine-terminating glaciers. Accurately modelling the transition from land- to lake-terminating glaciers presents significant challenges, as it requires the inclusion of the aforementioned complex processes. In this study, we investigate the behaviour of Skaftafellsjokull in Iceland, which has undergone such a transition over the past twenty-five years. The objective was to simulate the dynamic changes associated with this transition. Various modelling approaches, including full-Stokes and SSA-SIA hybrid models, were tested in order to evaluate their performance, capture the glacier's evolving behaviour and develop an approach that can be extended to other lake-terminating glaciers.

ANDREW MACKINTOSH

Global Glacier Climate Disequilibrium: Committed Mass Loss and Sea Level Rise

Glaciers have exhibited global-scale and accelerating retreat over the past century, impacting river flows, mountain hazards, biodiversity, and sea-level rise. However, the full impact of global warming on glaciers is underestimated due to their lagged response to climate change. Here, we quantify global glacier disequilibrium in the present-day climate using a parameterisation approach, leveraging global ice thickness, geodetic mass balance, debris cover, and frontal ablation data. We show that even if warming ceases, ~33 ± 0.6 % of remaining glacier ice will be lost relative to 2020, contributing 101.2 ± 2.9 mm to sea-level rise. Large marine-terminating glaciers are key contributors, yet remain poorly observed, especially in the Antarctic region. Comparisons with glacier model simulations reveal systematic differences in long-term projections, highlighting the benefits of observation-constrained parameterisations. Our findings emphasise that historical warming has caused severe and unsustainable impacts on glaciers, with much of committed loss still unrealised

TRYGGVI UNNSTEINSSON

Running from the heat: glacier velocity oddities near volcanoes

Matteo Spagnolo, Donal Mullan, Brice R. Rea, Iestyn Barr, and Társilo Girona

Glacierised volcanoes pose a range of hazards to communities and infrastructure. However, snow- and ice-cover can often impede traditional volcanological monitoring surveys. There currently exist a handful of observations where glaciers have undergone a speed-up prior to volcanic eruptions – likely driven by increased melting and subsequent enhanced sliding along the glacier bed. More complex velocity responses have also been documented where existing subglacial water reservoirs modulate the interactions. Here we look into the possibility of using the glaciers overlying volcanoes, and changes to their velocity in response to volcanic activity, as a monitoring tool. We present our current work on utilising open global datasets to find glacier velocity anomalies and linking them to unrest and eruptions of glacierised volcanoes on a global scale.

Kanchenjunga peak
Photo taken from Kanchenjunga Base Camp in the Nepalese Himalayas.

Above ↑

Session 5
Supraglacial processes

Doug Mair
Emily Glen
Laura Stevens
Holly Wytiahlowsky
Ben Graves

DOUG MAIR

Modelling the evolution of near-surface ice layers and their impact on runoff generation processes across a High Arctic ice cap

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Near-surface ice layers in the lower accumulation zone of Arctic glaciers and ice sheets may significantly affect deep meltwater percolation and runoff availability. This study develops a modelling framework to evaluate alternative approaches for characterising near-surface ice layer permeability and its influence on mass balance and runoff. The performances of three permeability criteria are evaluated for the Devon Ice Cap using 1999-2022 field data. For the most effective method, the permeability of ice layers is controlled by temperature and thickness: they remain permeable above a threshold temperature (Tth = –0.15 °C) and become impermeable once they exceed a critical thickness (Himp = 1 m). Our modelling replicates ice layers that are typically thinner in the upper accumulation zone and thicker in the lower accumulation zone. Additionally, we simulate an observed increase in the number of ice layers in the upper accumulation zone after 2007. The evolution of thicker (more than 1 m) ice layers (or ice slab) in the lower accumulation zone reduces meltwater retention through refreezing, making surface mass balance and runoff more sensitive to climate changes. Simulated mean surface mass balance ranged from -0.09 to 0.26 m w.e. yr $^{-1}$ from 1999 to 2022. Our model can be applied to simulate the long-term evolution of ice slab and project its impact on ice sheet runoff.

EMILY GLEN

Uncovering Widespread Slush on the Greenland Ice Sheet: Insights from a Nine-Year Satellite Record

Surface melt on the Greenland Ice Sheet (GrIS) has intensified in recent decades, reshaping supraglacial hydrology. Yet, the extent and variability of slush - fully saturated firn or snow - remain poorly quantified. Here, we present the first GrIS-wide classification of slush using Sentinel-2 imagery and a Random Forest machine learning model implemented in Google Earth Engine. We produce a near-decadal (2016–2024), high-resolution (10 m) dataset capturing slush distribution across six major drainage basins across the ice sheet. On average, slush covers ~4.2% of the GrIS each summer, peaking at 8.3% (144,800 km^2) during the extreme melt year of 2019. We show that slush is strongly influenced by melt intensity and timing, with widespread late-season formation during anomalous events such as September 2022. Our findings show that slush alone accounts for meltwater areas up to 14.5 times greater than those identified in lake- and stream-only studies, revealing it as a dominant yet underrepresented component of GrIS hydrology. As climate change drives more frequent and prolonged melt seasons, slush is likely to become a defining feature of the melt regime, promoting lateral meltwater flow, surface refreezing, and albedo reduction, necessitating its inclusion in hydrological models and ice-sheet mass balance projections.

LAURA STEVENS

Inland advance of ice-sheet hydro-fracture not accelerated by low-elevation lake drainages

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A rapid inland advance of supraglacial lake drainage via hydro-fracture is often posed as a mechanism for destabilization of grounded ice-sheet flow during periods of climate warming. This hypothesis is attractive: hydro-fracture events generate large, short-timescale ice-sheet flow accelerations, and inter-lake triggering of lake drainage by hydro-fracture demonstrably occurs between neighbouring lakes. However, the hypothesis hinges on applications of theoretical work on longitudinal stress coupling within the ice to argue that surface-melt-driven ice-flow acceleration at low elevations produces ice-flow acceleration—and hydro-fracture beneath surface lakes—at high elevations. Here, we present the observations needed to test this hypothesis. With a 22-station Global Navigation Satellite System array installed around seven lake basins in Central West Greenland, we observe eleven hydro-fracture events at adequate temporal sampling rates to discern inter-lake, hydro-fracture-event triggering potential along a transect spanning the entire ice-sheet ablation zone. We repeatedly observe unperturbed strain rates across higher-elevation lake basins while multiple hydro-fracture events transpire at lower elevation. Our ground-truth ice-deformation observations corroborate the short interaction length scales between hydro-fracture events suggested by physics-based constraints and validate our satellite-imagery classification of lake-drainage mechanism for the hundreds of lakes surrounding our array. Our findings support a simple model for the inland progression of surface-to-bed meltwater pathways beneath lakes: pathway initiation migrates alongside advancing surface melt, but is not accelerated by drainage activity at lower-elevation lakes.

HOLLY WYTIAHLOWSKY

Insights into the physical properties and detection of supraglacial channels on mountain glaciers.

Chris R. Stokes, Rebecca A. Hodge, Caroline C.Clason

Supraglacial channels play a fundamental role in efficiently transporting surface meltwater into and away from glacier systems, influencing ice flow dynamics, surface mass balance, and the hydrochemistry of glacier runoff. While such channels have been studied on ice sheets, considerably less work has focused on smaller mountain glaciers, and field observations are particularly scarce. Here, we combine high-resolution unmanned aerial vehicle (UAV) imagery, field measurements, and historical aerial photographs to provide new insights into the distribution and characteristics of channels on Glacier du Brenay in the Swiss Alps. Our results reveal a dense pattern of broadly dendritic channel networks influenced by ice surface structures, such that most first-order channels are intercepted by crevasses. Many

smaller channels, visible only in UAV imagery, terminate englacially, demonstrating that englacial routing is more widespread than coarser resolution imagery might suggest, which typically captures only larger channels reaching the terminus. Channel size and distribution are influenced by the glacier's surface profile, which dictates catchment location and size. Larger upstream catchments positively correlate with increased channel dimensions, and when deeply incised channels from these catchments run off at the terminus, they are associated with rapid retreat at the proglacial margin. We also find that continuous debris cover produces shallow, wide channels, increases channel roughness, decreases water velocity, and can reduce surface lowering rates. In contrast, discontinuous debris is associated with the highest rates of surface lowering and can produce pitted topography, where channel roughness is greatest. Future research should therefore consider small-scale hydrological processes as well as the distinct differences between channels on mountain glaciers and those on ice sheets.

BEN GRAVES

Modelling Surface Ablation of a Central Himalayan Glacier

The performance of existing empirical glacier ablation modelling approaches is limited when applied to glaciers in the Central Himalaya (Litt et al., 2019) due to high rates of sublimation and a disconnect between air temperatures and ablation. Energy balance models provide an alternative approach (e.g., Khadka et al., 2024), but extensive data requirements and a high degree of parameterisation may limit the robustness of energy balance modelling when applied to remote high-altitude glaciers. We bridge the gap between these approaches, developing a new empirical model which requires minimal in-situ data and parameterisation, but accurately accounts for ablation on Central Himalayan glaciers, including sublimation.

High-altitude on- and off-glacier in-situ data from the Khumbu Valley, Nepal, were used to drive models of varying complexity, including simple temperature index models, an enhanced temperature index model (Pellicciotti et al., 2005), a simplified energy balance model (Giesen & Oerlemans, 2012), and the full energy balance model COSIPY (Sauter et al., 2021). Using COSIPY as a reference, each of the other models were assessed for their ability to simulate ablation on daily timescales, and the temperature sensitivities of each model were compared.

Antarctic islands

Above ↑

Session 6
Subglacial processes

Michael Prior-Jones
Rob Storarr
Harry Stuart
Hanwen Zhang
John Hillier
Jonathan Hawkins

MICHAEL PRIOR-JONES

Cryoegg and friends: wireless instruments reveal subglacial and moulin hydrology

During 2024 we successfully deployed our wireless instruments in glaciers in Greenland and Canada to study glacial hydrology and ice dynamics. These instruments have now run for 12 months. We present a brief overview of results from Cryoegg deployments in moulins on Isunnguata Sermia in west Greenland and also from Cryowurst instruments deployed in Dän Zhùr (Donjek) Glacier in Yukon, Canada. Both datasets include water pressure and electrical conductivity, with the Cryowurst data also including borehole tilt. We present plans for a deep deployment of these wireless instruments at Isunnguata Sermia in 2026 using hot-water drilled boreholes to access a subglacial lake.

ROB STORRAR

SHARDS: Subglacial Hydrological Analysis using Repeat Drone Surveys

Subglacial hydrological systems exert significant impacts on glacier velocity, and are notoriously difficult to observe directly. This paper presents a new method for mapping diurnal changes in proxies for subglacial hydrology, using high spatial and temporal resolution Uncrewed Aerial Vehicle (UAV) surveys. By conducting repeat photogrammetric surveys across a glacier it is possible to detect subtle changes in ice surface elevation and velocity, which can reveal insights into the pressure regime of the subglacial meltwater drainage system and response of the glacier to meltwater-induced changes.

These results provide strong evidence that the UAV method is capable of detecting and mapping subtle changes in subglacial hydrological systems at temporal scales of hours and spatial scales of cm. A framework for best practice in future surveys is presented. This method has the potential to enable proxy mapping of subglacial drainage systems in unprecedented detail.

HARRY STUART

Modelling of Subglacial Discharge from a Surface Lake Drainage Event

With warming climates the number of meltwater ice-surface lakes in Greenland is growing, both in density and at higher altitudes. These lakes can rapidly drain in situ to the bedrock where they then discharge millions of tonnes of water within only a few hours. Such a drainage event overwhelms any pre-existing subglacial drainage system and hydraulically jacks the ice from the bedrock. Current subglacial drainage system models are unable to resolve such a massive, rapid event.

Drawing on analysis of hydrofractures in the oil industry we present a pure-mathematical model for the evolution during and after a surface lake drainage event. The model incorporates turbulence, a background hydraulic potential influenced by bed and ice topography, and the ability for water to ‘leak-off’ into the wider subglacial drainage system. We also present results for different ice thicknesses and compare these against observed results from GPS measurements.

HANWEN ZHANG

A Unified Framework for Blister Dynamics and Subglacial Hydrology Following Lake Drainage Events

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On the Greenland Ice Sheet, rapid drainage of supraglacial lakes via hydrofracture can transport substantial volumes of meltwater into the subglacial drainage system within hours. When the input exceeds the capacity of the local subglacial cavities and channels, it generates elastic uplift of the overlying ice, forming subglacial "blisters" that transiently accelerate adjacent ice flow. The blisters subsequently dissipate, with their thickness diminishing as water spreads laterally and leaks into adjacent components of the subglacial drainage system. Although field observations show surface-elevation and velocity anomalies associated with blisters, subglacial hydrology models routing water flow via linked cavities and channels do not incorporate blister formation and decay. Consequently, these models cannot account for the coupled evolution of subglacial water pressure and ice deformation following rapid lake-drainage events.

We propose a novel framework that integrates the dynamics of blisters —modelled as viscous water flow beneath an elastically bending ice sheet—with an established subglacial hydrology model of linked cavities and channels. Further coupling this framework to a depth-integrated ice flow model for a landterminating region of western Greenland, we simulate the resulting transient surface-uplift and velocity anomalies under both summer and winter drainage conditions, delivering a comprehensive study of lake-drainage impacts. This unified model provides a robust approach for interpreting remote-sensing and in situ observations of drainage events, thereby enhancing projections of Greenland's sea-level contribution in a warming climate.

JOHN HILLIER

Symmetrical till-cored drumlins highlight where past ice sheets flowed faster

For over 100 years, from school textbook to research, glacially sculpted landforms called drumlins have been considered asymmetrical, tear-drop shaped. Recent work has securely demonstrated that, in the absence of bedrock, this asymmetry is measurable but tiny – non-existent to visual inspection. High-resolution DEMs and a novel application of statistics to flow-sets demonstrate that a well-studied Swedish site exhibits a transition from asymmetrical bedrock-cored drumlins to symmetrical till-cored ones within just a few 10s of m of till. We believe that this is the first direct observational constraint upon the thickness of till required to effectively decouple flowing ice from rough bedrock topography. Understanding where till lubrication has the potential to speed up ice flow has large implications for modelling current ice sheets and Antarctic deglaciation, so we are hoping for ideas of how to best assess this last part.

Subglacial hydrology at Isunnguata Serma, West Greenland: insights from new geophysical observations

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Changes in ice surface elevation (elevation anomalies) observed from differencing satellite altimetry timeseries (2014 to 2019), along with evidence of proglacial flooding (2015), suggest the presence of three hydrologically-active subglacial lakes on the southern margin of Isunnguata Sermia, West Greenland. The SLIDE project investigates the dynamics and evolution of these potential lakes. New geophysical datasets, including ice penetrating radar and active seismic datasets, were collected to constrain ice thickness and characterise basal conditions. These datasets were acquired over the western and central elevation anomalies, just south of an east-west trending overdeepened trough.

Radar data were collected using a 10 MHz Blue Systems Integration ice-penetrating radar (IPR). Bed reflections were picked from the radar dataset and interpolated using a linear Kriging method to produce a detailed ice thickness model, ranging from 326 m to 707 m. Comparing our ice thickness model to models derived from Bedmachine and the Greenland Analogue Project, we show the ice thickness is underestimated across the study site by an average of 98 metres. Our ice thickness model was combined with an ArcticDEM strip surface elevation model (dated 2024-07-27) to generate a bed elevation model. This reveals complex topography beneath both elevation anomalies and a steep adverse bed slope on the western (down icef low) margin of the central elevation anomaly.

Active source seismic surveys were conducted over three field seasons at the central elevation anomaly, which exhibits the largest surface elevation change (~30 m). Seismic data were acquired with a hammer and plate source and 48 100 Hz vertical component geophones. Bed reflections from the seismic data generally align well with ice thickness derived from the radar data. Seismic lines acquired in 2025 are coincident with, and perpendicular to, a draw in the basal topography located beneath the central elevation anomaly. The seismic data show a clear bed reflection outside the draw, and a low-amplitude, attenuated reflection within the draw, suggesting spatially variable bed properties.

Subglacial hydraulic potential was calculated from the radar-derived ice thickness and the ArcticDEM surface elevation model to investigate the subglacial hydrological system. Within the largest anomaly, there are two sinks in the hydraulic potential: one located near the area of maximum surface elevation change and another coincident with a bright basal reflector identified in the 2024 radar and seismic data. These sinks persist over a range of modelled values for subglacial water pressure inferred from an englacial pressure record. The dimensions of the persistent sinks are of similar magnitude to the resolution of existing bed elevation products and therefore may have been discarded or not properly resolved in standard hydropotential processing.

Antarctic islands

Above ↑

Posters

Rapid Proglacial Lake Response to Weather Events at Fjallsjökull, SE Iceland

Proglacial lakes can be used to infer the dynamics of subglacial systems, an otherwise inaccessible region which is a key component in understanding glacier response to climate change. The use of moderate-resolution satellite imagery, and even commercial high-resolution satellite imagery, struggle to resolve short-lived (diurnal) variations in proglacial lake behaviour meaning these variations are omitted from long-term records. We use high spatial resolution Uncrewed Aerial Vehicle (UAV) surveys from summer 2023, 2024 and 2025 alongside PlanetScope (3 m) satellite imagery to monitor diurnal volume changes in Fjallsárlón, a large proglacial lake in SE Iceland. By combining UAV-acquired imagery with bathymetric data, we were able to observe shoreline shifts of up to ~12 meters and increases in lake volume of up to ~1,108,000 m^3 across a 24 hour period, in response to weather events such as high temperatures and rainfall. The response of Fjallsárlón to these events provides insights into the efficiency of the hydrological system, which can be used to gain a more complete understanding of the subglacial system of Fjallsjökull, a soft-bedded glacier in SE Iceland

Live action meltdown: added value of telemetry for improving the management of in situ sensors

Liz Bagshaw, Mike Prior-Jones, Jonathan Hawkins, Lisa Craw, Matt Peacey, Sarah Mann, Ben Geertsma-Dolton, Joseph Fawsett, Leon Comstive, the SLIDE team

As technology has advanced, the options for data retrieval from remote field locations have significantly increased in availability and decreased in cost. Despite this, many researchers rely on periodic downloading of data via a physical connection. This has significant drawbacks for resource use: field sites are visited regardless of maintenance requirements; researchers must spend time and money accessing monitoring equipment, wasting energy and potentially increasing risk exposure; and the status of equipment is unknown prior to site access, resulting in data loss if sites are not visited after sensor malfunction and/or the correct tools are not available during scheduled maintenance visits. In many glaciated areas, mobile phone coverage has significantly improved, enabling use of mobile phone (LTE: long term evolution, or 4G) networks. When cellular data is not available, satellite communications providers with polar data coverage have proliferated. Here, we will present data from mobile phone and satellite networks that provide coverage in Greenland, to show the potential for smart management of sensors and the excitement of real-time monitoring of melt events.

JONATHAN BARNSLEY

Sensitivity of Sea-Level Projections to Regularisation during Ice Sheet Initialisation

Ice sheet model initialisation is a key uncertainty in projections of future sea level rise. For contemporary Antarctica, initialisation often employs data assimilation methods, which solve an inverse problem to match model state with observations. However, the selection of a regularisation parameter, which controls the solution to the inverse problem, is typically done via heuristics and the associated uncertainty is not explored. Here, we investigate the sensitivity of Antarctica's projected sea level contribution to this initial regularisation choice. Using the BISICLES ice sheet model under a high emissions scenario to 2300, we find that while the uncertainty arising from the regularisation is not insignificant, it is considerably smaller than that from other commonly perturbed parameters. Our results contrast with similar work done using the Uà ice sheet model, indicating some potential model, domain, or resolution-dependance of this uncertainty.

GIANLUCA BIANCHI

Modelling Supraglacial Meltwater Channels

Supraglacial channels are a major system for the movement of surface meltwater across ice sheets and ice shelves. Understanding their geomorphology is essential in predicting meltwater routing. Often meltwater flows into glaciological features such as supra- or subglacial lakes which can have large effects on glacier stability. These effects are in part dependant on the meltwater inputs, which will increase as the rate of surface melt increases with the warming climate. Previous studies have modelled channel evolution; however, few have considered the effects of solar radiation and the variation in shear stresses on the shape of the channel. A new model is presented which can evolve the cross section of a meltwater channel over time, accounting for daily variations in atmospheric conditions and water discharge. The sun's angle of incidence and shade are accounted for, allowing for the effects of variations in shortwave radiation to be properly modelled. A method for the distribution of shear stress along the channel boundary, traditionally applied to bedrock channels, is applied to ice meltwater channels.

GRACE BROWN

Laboratory-Based Snow/Firn Compression Experiments for Improved presentation of Refrozen Firn densification within models of ice sheet surface mass balance.

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Understanding snow and firn compression is critical for accurately modelling the long-term evolution of firn, surface mass balance, and the storage and transmission of meltwater in glacier systems. Many large-scale models incorporate parameterizations of snow densification derived from measurement and theory appropriate for dry snow densification or that rely on poorly constrained model coefficients, particularly at the earliest stages of compaction.

Distinct from other studies, this research investigates the compaction of metamorphized snow that has undergone a melt–refreeze cycle and has material properties more akin to firn found in the percolation and wet snow facies of ice sheets. In this study we undertake novel laboratory experiments that characterize the response of such metamorphized snow/firn to vertical loading under controlled temperature conditions. Using uniaxial compression tests on snow/firn samples with known grain sizes and densities, we simulate expected ranges of overburden pressures to c. 10 m depth to establish the stress -strain rate relationship that defines firn viscosity. We see that early-stage compaction is sensitive to applied overburden pressure but insensitive to temperature within the range of –3°C to –10°C. Our findings are applicable to numerical models investigating the long-term effects of climate change on melt-affected regions of the accumulation zones of ice sheets, particularly across the Greenland Ice Sheet where seasonal melt and refreezing is having an increasing influence on early-stage firn development.

ISAAC BROWN

Elliptical Conduits in Subglacial Drainage: Modelling Melt, Flow and Channel Evolution

Subglacial water flow plays a critical role in basal sliding and, consequently, in glacier and ice-sheet dynamics. However, modelling the coupled evolution of subglacial drainage and ice motion at scale remains challenging due to its inherent multi-scale nature. This study investigates the evolution of the basal ice–water interface by analysing heat and fluid flow in idealised subglacial channels. We extend the classical Röthlisberger model for circular channels to elliptical conduit geometries. A hybrid turbulent–laminar flow scheme captures heat generation from both viscous and turbulent dissipation, while a viscous flow law models the creep closure of the surrounding ice. We solve for the flow and temperature profiles in elliptical channels and calculate the modified resistance to flow relative to the circular case, finding differential melting between the roof and walls of the channel. Initially, elliptical channels tend towards a circular shape when melting dominates, whilst the creep flow of ice tends to increase the initial eccentricity of the conduit. The analysis of these idealised channels hints at possible simplifications to modelling more general subglacial drainage networks. Such simplifications could inform an efficient reduced model for coupling subglacial hydrology with ice-sheet models.

SAMMIE BUZZARD

Modelling the surface hydrology of George VI Ice Shelf, Antarctica

Remote sensing and modelling studies have shown several Antarctic Ice Shelves to be vulnerable to damage from surface meltwater. With surface melting predicated to increase, understanding the surface hydrology of ice shelves in the present and the future is an essential first step to reliably project future vulnerability of Antarctic ice shelves to meltwater driven hydrofracture. This has implications for sea level rise from ice sheet melt due to the loss of the buttressing effect provided by ice shelves on the grounded ice sheet.

Here we present a surface hydrology modelling study focused on the George VI Ice Shelf on the Antarctic Peninsula. George VI is the second largest ice shelf remaining on the Antarctic Peninsula and experiences significant melt including the formation of surface lakes.

We use MONARCHS: a 3-D model of ice shelf surface hydrology. MONARCHS is the first comprehensive model of surface hydrology to be developed for Antarctic ice shelves, enabling us to incorporate key processes such as the lateral transport of surface meltwater.

This community-driven, open-access model has been developed with input from observations, and allows us to provide new insights into surface meltwater distribution on Antarctica's ice shelves. This enables us to answer key questions about their past and future evolution under changing atmospheric conditions and vulnerability to meltwater driven hydrofracture and collapse. We solicit community feedback on future additions of processes to the model, or case studies of interest.

TOM CHUDLEY

Parameterising crevasse field drainage into meltwater routing models for the Greenland Ice Sheet

Nearly all meltwater produced on the Greenland Ice Sheet surface is routed through the ice sheet, and the spatial and temporal patterns – as well as the mode of delivery – of discharge to the bed can have significant consequences for processes including ice fracture, rheology, and basal sliding. Existing modelling studies suggest that a majority of meltwater in Greenland is transferred to the bed via surface crevasse fields, rather than lakes or moulins. However, in contrast to well-observed phenomena such as supraglacial lake drainages, little work has been done to explore how this process should be parameterised in regional-scale models that route meltwater from the surface to the bed. Here, we explore: (i) how well observations of crevasse field filling and drainage support existing parameterisations based upon linear elastic fracture mechanics (LEFM); (ii) what modifications may need to be implemented to better represent crevasse field hydrology, including the choice of proxy for resistive stress (R) and the inclusion of seasonally-varying stress; and (iii) the potential consequences for effective pressure and sliding at the glacier bed, as represented through subglacial hydrological models.

ROMILLY CLOSE

Combining Altimetry and Digital Elevation Models to Map Antarctic Peninsula Glacier Evolution

Mal McMillan1 –Dominic Hardy1 Emma Woolliams2 –
1. Lancaster University/CPOM 2. NPL Teddington

The Antarctic Peninsula is among the fastest-warming regions on Earth, yet estimates of its glacial mass loss remain highly uncertain. This is due to its complex topography, variable climate, and numerous small, fast-flowing, marine-terminating glaciers, which challenge in-situ, airborne, and satellite-based observations. While digital elevation models (DEMs) derived from satellite imagery, such as the 2 m resolution Reference Elevation Model of Antarctica (REMA), offer potential for improved mass change estimates, their use is limited by georeferencing challenges and large data volumes.

In mountainous regions like the Alps, DEMs can be co-registered to reference data using stable ground, significantly improving accuracy. However, the Antarctic Peninsula lacks sufficient exposed bedrock for this approach. Hugonnet, McNabb et al. (2021) highlighted this limitation, excluding two-thirds (5900) of REMA tiles from their mass balance analysis due to lack of stable surfaces.

Building on methods by Shean, Joughin et al. (2019), we develop a scalable approach for 'on-ice' co-registration of REMA tiles using coincident satellite altimetry. We test this over Fleming and Drygalski glaciers, using auxiliary datasets (ice velocity and surface height change) to identify altimetry points where the ice surface does not significantly change. This circumvents the need for exposed bedrock and enables broader DEM usage.

We assess the impact of different co-registration methods and altimetry sources (e.g., ICESat-2 vs. CryoSat-2 swath data) on DEM accuracy. Our results demonstrate the feasibility of this approach for improving elevation change estimates in complex glaciated terrain.

Ultimately, this work contributes to the development of scalable processing pipelines that integrate altimetry and DEM data to better constrain mass loss from dynamic, mountainous regions of the Antarctic Ice Sheet.

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LISA CRAW

The Wurst-case Scenario: observations of glacier hydrology and kinematics using “cryowurst”, a wireless borehole instrument

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Making in situ measurements of hydrological conditions and internal deformation in glaciers is important for improving our understanding of glacial hazards and the impacts of climate change. The most direct way to make these measurements is to install sensors within a glacier, and collect data over long time periods. However, it is difficult to collect these observations continuously for longer than a few months, as instruments are rapidly destroyed by ice movement. We have developed a new wireless borehole sensor, the “cryowurst”, which is designed to withstand high pressures and transmit data continuously to the surface for up to ten years. We deployed four cryowurst sensors in a hot-water-drilled borehole near the terminus of D¨ an Zh´ur (Donjek) Glacier, a surge-type glacier in the Yukon territory of Canada. D¨ an Zh´ur is in the quiescent phase of its surge cycle, but based in the historical record it is likely to surge before 2027. We collected half-hourly measurements of water pressure, electrical conductivity, temperature and instrument tilt at four depths, including directly at the glacier bed, from mid-summer through to mid-winter. Pressure and conductivity data clearly show the transition from summer to winter hydrological regimes. Water pressure increases steadily throughout the winter, but as it approaches the overburden pressure it drops suddenly, implying that the hydrological system is still changeable even during the ‘shutdown’ period. We have also interpolated data from the tilt sensors to infer where shear strain is concentrated within the ice column, and show that this is linked to the basal water pressure. This dataset reveals the hydrological and kinematic state of a surge-type glacier in the later stages of its quiescent phase. As all four sensors are still functioning, there is potential for an longer timeseries extending into the next surge phase, which would give an unprecendented insight into surging glacier dynamics

KATHERINE DEAKIN

A comprehensive inventory of Antarctic ice tongues and controls on their development

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Ice tongues are unconstrained, floating extensions of marine-terminating outlet glaciers which are found intermittently around the Antarctic coastline. They may extend tens of kilometres into the Southern Ocean and can therefore act as a barrier to sea ice movement and ocean surface currents, making them highly important for coastal polynya formation and ice marginal ecosystems. While largely composed of passive ice, future reductions in their extent, potentially resulting in their disappearance, could have significant implications for the dynamics of grounded ice, affecting Antarctic ice sheet contributions to sea level rise. Previous studies suggest that basal melt and landfast sea ice may be important controls on their stability; however, much is still unknown about their spatial and temporal prevalence around Antarctica. Here we present preliminary results from the first attempt to map all Antarctic glacier tongues and investigate factors contributing to their development and persistence. Using optical and synthetic aperture radar imagery within Google Earth Engine, our aim is to identify and digitise all of the major outlet glacier tongues around the Antarctic ice sheet present during the 2024 austral summer. We then calculate ice tongue areas and combine these with existing datasets of glacier surface velocities and grounding line thickness to create a comprehensive database of ice tongue characteristics. These measurements will be used alongside secondary oceanographic and sea ice datasets to investigate potential controls on ice tongue formation. In doing so, we will produce a valuable dataset for future investigations into outlet glacier change and contribute to improving understanding of how recent and future changes in sea ice and ocean conditions may impact Antarctic outlet glacier dynamics

Lateral meltwater export from Bach Ice Shelf resumes after 10-year hiatus

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Supraglacial meltwater on Antarctic ice shelves largely refreezes within the firn pack at the end of each melt season. However, in some cases it may drain vertically by hydrofracture, or drain laterally as surface run-off. Despite being a major component of ice-sheet mass loss for the Greenland Ice Sheet, lateral surface run-off and export is currently a rarely observed phenomenon across Antarctica. Here, we present evidence for the re-initiation of lateral meltwater export off the Bach Ice Shelf, following a 10-year hiatus. We utilise optical imagery from Landsat 4-9, and Sentinel-2 to investigate the extent of lateral surface run-off between 1982 and 2025. For the later years (2013-2025) we use spectral thresholding techniques to quantify the area of surface meltwater bodies across the ice shelf for Landsat 8 and 9 images. These observations are supported by 2 m air temperatures and modelled melt from the Regional Atmospheric Climate Model (RACMO2), forced by ERA5 atmospheric reanalysis data, to provide a broad overview of the melt conditions across the ice shelf during the study period.

Prior to 2013, lateral surface run-off and export was a commonly observed phenomenon across Bach Ice Shelf. In 1997, observational evidence revealed surface meltwater run-off extending from Boccherini Inlet to the ice-shelf edge, covering a distance of >50 km. At the same time, surface meltwater run-off from Weber Inlet appeared to be feeding a small rift system. By 2003, a calving event along this rift had occurred. Lateral meltwater run-off remained extensive for many of the austral summers up until March 2013. However, from 2013 to 2022, spectral thresholding methods returned no evidence of large-scale lateral meltwater export, and the overall extent of surface meltwater across the ice shelf was reduced relative to the preceding decade.

More recently, in both 2023 and 2025, lateral surface meltwater run-off and export across Bach resumed. This run-off extended into a large rift system, which was first observed in 2004, whilst also flowing off the ice-shelf edge. Our ongoing work will consider this re-initiation of lateral meltwater export in the context of synoptic climate patterns, with consideration for the repercussions of such lateral meltwater export on (i) the acceleration of ice-shelf damage, and (ii) ice-shelf mass loss.

FRANK DONACHIE

Towards Continent-Wide Mapping of Antarctic Supraglacial Hydrology Dynamics

Seasonal surface melting of the Antarctic Ice Sheet leads to the formation of supraglacial meltwater features, such as lakes, streams, and slush. Forming predominantly on ice shelves, these features can influence both ice shelf stability and the overall mass balance of the ice sheet. The filling and draining of lakes can trigger hydrofracture – where water-driven fractures penetrate the ice shelf – potentially contributing to ice shelf collapse. It is thought that this mechanism played a role in the collapse of Larsen B Ice Shelf in 2002. Despite the significance of supraglacial meltwater features, our understanding of their spatial and temporal dynamics – and especially the volume of meltwater stored in lakes – remains poorly characterised. As part of the European Space Agency's Dynamic 5D Antarctica project, we aim to improve understanding of the inter- and intra-year dynamics of these supraglacial meltwater features, and to estimate lake volumes more accurately across the continent. To achieve this, we are developing a dataset of monthly melt-season supraglacial lake and slush extents and volume across all Antarctic Ice Shelves. Supraglacial meltwater features will be mapped using a random forest classifier applied to Sentinel-2 optical imagery, similar to a successful deployment in Greenland. Estimating meltwater volumes from mapped lake areas requires reliable lake depth data. However, this remains challenging as the commonly used radiative transfer equation is known to have large inaccuracies, while the ATL03 photon-level data product from ICESat-2, though more accurate, offers limited spatial and temporal coverage. To address this, we are building a deep learning model trained on an existing dataset of ICESat-2 derived lake profiles paired with concurrent Sentinel-2 imagery. This model will be used to predict lake depths from Sentinel-2 pixels in regions where ICESat-2 data are unavailable, producing consistent volume estimates across the ice sheet. Together, these products will support large-scale meltwater monitoring, improve understanding of meltwater-related ice shelf vulnerability, and enhance future projections of ice shelf stability under climate change.

SAMUEL DOYLE

Greenland Runoff Monitoring from Passive Seismology: The GRuMPS Project

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Greenland Ice Sheet runoff is a large (>50%) and increasing component of ice mass loss and sea level rise, and a fundamental parameter controlling ice velocity and the physical, chemical and biological properties of the ocean system. Runoff could also trigger tipping points such as the collapse of the Atlantic Meridional Overturning Circulation (AMOC). Long-term monitoring of runoff from Greenland's outlet glaciers is, however, limited to ~10 sites accounting for just ~3% of total runoff due to the difficulties of installing and maintaining traditional, hydrological gauging stations. Here we report initial results from measurements of discharge using passive seismometers at large, land-terminating glaciers in Greenland. We quantify discharge from the seismic power using simple scaling relationships which we calibrate against existing gauging stations and discharge measurements from lapse-time video. By determining the acoustic properties of the river margin using active seismics we can determine discharge directly from seismic power. At one test site we combine these three approaches to evaluate these methods. As seismometers are low power and can be deployed in a safe location away from the riverbank they enable continuous, multi-year measurements of discharge at low cost. The next phase of the project is to deploy seismometers targeting the highest discharge proglacial rivers around Greenland. We also intend to apply the methods to marine-terminating outlet glaciers.

VICTORIA DUTCH

An investigation into the transferability of different CO2 flux measurement types for cold environments

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The Arctic, and indeed cold and polar environments more broadly, are at the forefront of global climate change, with Arctic warming taking place approximately 4 times faster than the global average. With this warming comes a change in environmental conditions, including the potential for changes in the (poorly quantified) Arctic carbon budget. However, high uncertainty surrounds our knowledge of CO2 fluxes from the polar regions, due in large part to limited measurements. Additionally, these limited measurements span a wide range of measurement techniques, many of which are logistically and financially unviable to implement on a large scale – further compounding existing uncertainties. Measurements from diAerent approaches contribute to diAerences in estimated carbon fluxes from both tundra and marine environments. We tested 3 diAerent types of instruments for CO2 flux measurement across a selection of cold environments spanning the terrestrial, cryosphere and marine environments of Hokkaido, Northern Japan in order to investigate a) if low-cost CO_2 sensors developed for the Arctic tundra could be used across a broader range of cold environments, and b) how comparable this approach was to other currently used approaches for the measurement of CO_2 fluxes from sea ice environments. We find that low-cost sensors can be used to measure CO_2 fluxes from all but the lowest flux environments (e.g. snow-covered sea ice). Although broadly similar, the magnitude of the fluxes detected with the low-cost sensor approach is slightly lower than that from expensive, more conventional, smart chamber systems. However, the low-cost sensor approach has the potential to enhance spatial and temporal coverage of flux measurements, and would allow such measurements to made with fewer resources, after some additional refinements.

MHAIRI HALLFORD

Measuring Snowline Altitudes from Remote Imagery

Brice R. Rea, Donal Mullan, Matteo Spagnolo, Lydia Sam, Shaktiman Singh

Previous studies have mapped end-of-season snowlines (ESS) on glaciers from satellite imagery to find their snowline altitudes (SLA) to use as a proxy for the glacier equilibrium line altitude (ELA). A line is traced along the boundary between snow and ice, then, from a digital elevation model (DEM), elevation values are extracted at regular intervals along the line. The average elevation of these points is taken to be the SLA. While this approach would be advantageous, as it offers a solution to measuring glacier ELAs in inaccessible regions, it is prone to an oversampling bias. Where snow cover is irregular or patchy, in shaded areas or where avalanching has occurred, a greater length of line is mapped in order to follow the snow-ice boundary than is required for smoother segments. This is regardless of whether the region contributes a larger area of accumulation or not. Consequently, SLA calculations are prone to oversampling from areas of irregular snow cover. Even when the ESS is mapped accurately and precisely, the SLA value may differ significantly from the true ELA. This poster investigates alternative methods of calculating the SLA from mapped ESSs to address this bias.

PHOEBE JACKSON

Atmospheric River Influence on Ice-Shelf Surface Processes: A Case Study from Dronning Maud Land, East Antarctica

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Abstract Atmospheric Rivers (ARs) are narrow bands of intense water vapour transport that occur in the lower levels of the troposphere. Favourable synoptic conditions can steer ARs poleward toward the Antarctic coastline, delivering anomalously warm, moisture-laden air alongside high wind speeds and strong radiative forcing to the ice sheet's peripheral ice shelves and, occasionally, into the interior. Thus, Antarctic AR landfall events are associated with a range of strong surface impacts including extreme precipitation, widespread surface melt, and heatwaves. At present, ARs play a key role in shaping Antarctica's mass balance, contributing more to mass gain than mass loss through the delivery of

intense snowfall. While this precipitation helps to offset global sea level rise, the mixed impacts of landfalling ARs on ice shelves can lead to the opposite effect.

Previous studies of AR-induced melt that leverage remote-sensing have primarily focused on the West Antarctic Ice Sheet and the Antarctic Peninsula, with far less known about the occurrence and nature of localised AR-driven surface melt on East Antarctic ice shelves. For a case study AR landfall event in Dronning Maud Land, East Antarctica – a regional hotspot of AR activity - we use an ensemble of high-resolution optical and cloud-penetrating radar satellite imagery, in-situ automatic weather station observations, and the Regional Atmospheric Climate Model (RACMO2) to examine the influence of landfalling ARs on ice-shelf surface processes. In doing so, we examine the local-scale interplay between ARs and the ice-shelf surface to identify potential drivers behind regional, inter-event, and local-scale surface impact variability. This research also explores the temporal and spatial response of ice-shelf surface processes to a landfall event to improve our understanding of the 'fingerprint' (temporal) and 'footprint' (spatial) of AR surface impacts. With an expected increase in AR activity and intensity under future climate scenarios, this research will serve to better our understanding of the role of ARs in driving ice-shelf (in)stability, and hence feed into the wider research of Antarctica's contribution to future sea level

High spatial and temporal resolution analysis of ice dynamics at isunnguata sermia, west greenland using a dense gnss array.

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Between 2023-25, the Subglacial Lakes at Isunnguata Sermia Dynamics and Evolution (SLIDE) project deployed an array of glaciological and geophysical instruments including a dense network of 11 on-ice GNSS stations spanning an inferred persistent subglacial drainage channel. Here we present GNSS observations over a 16 day period of high melt in July. During this period, several transient velocity events are recorded, including two associated with strong overnight melt, and one occurring following the drainage of a large, upstream supraglacial lake. Each of these events is marked by a distinct horizontal acceleration, uplift of the ice surface, and ice flow deflection towards the south (away from the centre line of the subglacial drainage channel). The dense array of GNSS stations allows comparison of the magnitude of speed, uplift and direction deviation signatures across the glacier. Uplift is greatest at sites closest to the sub-glacial drainage channel, indicating a bulging ice surface during pressurisation, while direction deviation changes are greatest at more distant sites, suggesting a larger variation in surface ice gradient. Similar signatures in ice dynamics have been reported in alpine contexts, where periodic pressurisation of a subglacial channel results in a cross-channel variable pressure axis, and we suggest this as a possible mechanism to explain our observations.

MÓRRIGAN JONES

Comparative Glaciology: Reconstructing Glaciers on Earth and Mars to understand landscape evolution with respect to climate change

Mid-latitude glaciation is a process which has seen increasing interest from the scientific community over the last the last few decades. Throughout these investigations, one sub-group of these features have come to be known as 'Glacier-like forms', which are defined as lobate, kilometre-scale viscous flow features which bare a resemblance to terrestrial valley glaciers. Investigations into these features have considered debris-covered glaciers as a best-fit proxy for investigating GLF dynamics, however, they also share many morphological similarities to terrestrial rock glaciers. As such, this project aim to reconstruct Martian GLFs and consider their morphology and dynamics with respect to rock glaciers in an effort to improve our understanding of the following question: 'How does the formation, evolution, morphology, and rheology of Martian GLFs compare with terrestrial rock glaciers?'. In this effort, here we present some reconstructions of Martian GLFs based on a morphometric analysis of their setting, and estimation of ice thicknesses using a physics-based model of glacier deformation adapted to the Martian environment.

JIM JORDAN

Results from phase one of CalvingMIP

The implementation of ice shelf calving in numerical ice models is a recent development in the field of cryospheric modelling. As roughly half of Antarctica's ice mass loss is due to calving a thorough understanding of the process is required to make accurate predictions of the future Antarctic mass balance. As yet, there has been no comprehensive investigation into the capabilities and robustness of these models for simulating the complicated physical process that is ice shelf calving.

CalvingMIP is an ongoing model intercomparison project that seeks to address this with a series of experiments and tests of increasing complexity, starting from simplified, idealised simulations before expanding to real world predictions. We make a clear distinction between calving algorithms (how a model numerically represents the physical process of ice calving) and calving laws (how much ice should calve at a given time). The recently completed phase one of CalvingMIP focussed on calving laws with the next phase investigating calving laws. Results from phase one are shown from ten different modelling groups across the cryospheric community.

SOURAV LAHA

Modelling Ice Slab Evolution and Runoff on the Greenland Ice Sheet

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In the accumulation zones of the Greenland Ice Sheet (GrIS), not all surface meltwater becomes runoff. A significant portion refreezes within the firn, moderating overall mass loss. Near-surface refreezing densifies the firn and forms ice layers, with permeability governed by firn density and temperature. Thick, shallow ice layers (>1 m, or ice slabs) inhibit deeper percolation, promoting runoff. Since 2001, the expansion of ice slabs has increased the runoff-contributing area by nearly 30%, underscoring the importance of developing models that accurately simulate their formation and evolution. We present a 1-D physically distributed model with high vertical resolution (1 cm), simulating surface mass balance, refreezing, ice layer formation, and runoff. The model includes a novel, temperature-dependent criterion for ice layer permeability, validated against field data from the Devon Ice Cap. We apply the model across the GrIS from 1999 to 2024 at 0.25° spatial and 15-minute temporal resolution. Model results show good agreement with observed ice slabs in ice core density profiles and from remote sensing data. Our studies provide new insights into ice slab evolution and its influence on runoff magnitude and spatial extent. We also assess how climate variability drives shifts in the runoff limit and affects firn processes in the accumulation area.

ROBERT LAW

Snapple turnover: fractures and convection in icy moons and the Greenland Ice Sheet

Icy realms are not unique to Earth -- our solar system harbours planetary bodies featuring extensive ice sheets or global ocean-covering ice shelves, with a potentially unlimited plethora of forms found elsewhere in the universe. Here we present interplanetary work taking terrestrial ideas to space, and ideas from space back down to Earth. First, we sketch out the requisite conditions for rapid hydrofracture of icy moons (Europa, particularly) finding hydrofracture can occur in the situation of a mechanically weak lid and sufficient water supply. As, for example, would be prompted by a meteorite strike. Second, we take convection theories applied to Europa and explore the conditions under which they may occur in Greenland, possibly explaining widespread stratigraphic plumes in the ice sheet's northern extent. To our surprise, we find that the northern Greenland ice sheet is very close to, or at, the limit for ice convection. Plausibly, this offers a unique method for determining ice effective viscosity, and could suggest that an enhancement factor of

50, rather than the oft stated 5, is more appropriate in the North. Finally, we outline a few areas that could benefit from collaboration between planetary science and glaciology.

YILIANG MA

Comparison of ice sheet mass loss in Earth System Model simulations with and without an interactive Greenland Ice Sheet

The Greenland Ice Sheet (GrIS) contains enough ice to raise global sea levels by 7 metres. The rate at which this contribution will be added to the global ocean under future climate change is dependent on ice-climate feedbacks, so the representation of these feedbacks in Earth System Models (ESM) is crucial. The UK Earth System Model (UKESM) is a state-of-the-art ESM which includes dynamic models of the Greenland and Antarctic ice sheets, as well as a sophisticated climate - ice sheet coupling based on the explicit exchanges of water and energy. This study compares UKESM simulations which either enable or disable the interactivity of the ice sheet component to assess its impact on climate projections. We investigate changes in the GrIS snowfall, runoff, surface mass balance and sea level rise contribution. This study highlights the importance of coupled ice sheet-climate modelling to improve predictions of future climate and sea level changes.

SARAH MANN

Cryoegg: a year under the ice in Greenland Moulin water pressure and electrical conductivity revealed by wireless instruments

The SLIDE Team Liz Bagshaw (2), Matthew Peacey (2,3), Ryan Ing (7), Gialuca Bianchi (1), Thomas Chudley (4), Samuel Doyle (3,5), Laura Edwards (6), Angus Moffatt (5), Rob Storrar (8), Sian Thorpe (5), Stephen Livingstone (5), Guilhem Barruol (9), Adam Booth (10), Sammie Buzzard (11), Caroline Clason (4), Adrien Gilbert (9), Florent Gimbert (9), Adam Hepburn (3), Siobhan Killingbeck (12), Andrew Jones (8), Tifen Le Bris (9), Alexandre Michel (9), Neil Ross (13), Andrew Sole (5), Remy Veness (8), Tun Jan Young (14)

Subglacial and englacial hydrology plays a critical role in controlling ice movement within glaciers and ice sheets. However, measuring water storage in these environments, particularly within moulins, is extremely challenging, resulting in a scarcity of long-term observational data. The transition from the summer melt season to the winter drainage system shutdown is rarely observed. In July 2024, we instrumented two moulins on Isunnguata Sermia in West Greenland using Cryoegg instruments. Cryoegg is a spherical, wireless sensor designed to monitor the englacial and subglacial conditions of glaciers and ice sheets. It records hourly data on temperature, pressure, and electrical conductivity (EC) of water. Three Cryoeggs were deployed: two at different depths within a single moulin, and one in a nearby moulin (this device failed in September 2024). We present a continuous timeseries from the remaining two instruments from July to December 2024. As of July 2025, one device remains operational with continuous data collection resuming in June 2025. Data points are sporadic between December 2024 and June 2025 due to damage to the datalogger over the winter. These instruments captured the evolving hydrological conditions from summer to winter. During the summer, warm, sunny days drive daily fluctuations in pressure and EC. Peak melt water input produces high water pressure and low EC in the afternoon and evening. As winter approaches, we observed signs of stored, high-EC water being released into the drainage network, followed by a gradual shift to a high-pressure, high-EC state characteristic of midwinter conditions. With the return of melt water in Summer 2025, we observe diurnal cycles in water pressure within this moulin, but EC remains elevated, indicating that this now inactive moulin remains hydraulically connected to the subglacial system.

KATIE MILES

Structure of suture zones in the McMurdo Ice Shelf, West Antarctica, from a comprehensive suite of geophysical data

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Antarctic ice shelves are the floating extensions of the continental ice sheet into the ocean, buttressing the flow of inland, grounded ice from the continent's interior. Over 50% of the Antarctic margin is fringed by such ice shelves, which are formed of alternating bands of meteoric glacier ice and suture zone ice. Suture zone ice is softer and fractures less easily than meteoric ice – understanding the structure and mechanical state of ice shelves is crucial to assessment of their vulnerability to thinning, rift propagation, and potential disintegration. During our field season on McMurdo Ice Shelf, West Antarctica, from November 2024 to February 2025, we collected a suite of geophysical data, including: i) over 200 km of ground-penetrating radar profiles; ii) TEM and ApRES at 24 sites; iii) active seismics at two sites; iv) optical televiewer logs of seven hot-water drilled boreholes, up to 110 m in depth; and v) ice samples from suture zone boreholes. These data, currently undergoing analysis, will elucidate the structure and mechanical properties of meteoric and suture zone ice on McMurdo Ice Shelf.

BERTIE MILES

Retreat of Getz Ice Shelf driven by ocean wave processes

The calving fronts of the eastern outlets of the Getz Ice Shelf have been steadily retreating since the earliest satellite observations in the 1970s. This retreat has occurred despite minimal changes in ice shelf damage over the past 50 years, limited changes in ice velocity seaward of the grounding zone, and only modest thinning in the outlet experiencing the most significant retreat. Analysis of calving events using the Sentinel-1 archive (2014–2024) reveals a distinct seasonal cycle: frontal advance during winter and retreat in summer, a pattern reminiscent of many Greenland outlet glaciers influenced by the seasonal breakup of ice mélange. We attribute the seasonal calving at Getz to wave-driven undercutting of the ice front, which promotes rampart–moat style calving. Since 1978, the number of sea ice–free days in the polynya adjacent to the Getz Ice Shelf has doubled. The resulting seasonal increase in surface ocean heat content and wave activity provides a plausible mechanism for the ongoing retreat of the eastern outlets.

AMY MORGAN

Insights into the Automated Delineation of Glacier and Ice-Shelf Calving Fronts and associated Datasets from Multi-Sensor Radar

Accurate calving-front locations of ice shelves and tidewater glaciers in Antarctica and Greenland are necessary observations for monitoring dynamic changes of ice-sheet margins. Floating ice shelves buttress the flow of the interior ice sheet, and their frontal locations are critical indicators of long-term changes in ice-sheet dynamics. Continuous monitoring of calving fronts has been historically challenging due to the scarcity and discontinuity of satellite data over the polar regions, and the time-consuming nature of manually delineating calving-front positions. Recent advances in edge detection and deep learning techniques have enabled automatic calving-front extraction from synthetic aperture radar (SAR) and optical satellites. We evaluate the performance of multi-class semantic segmentation techniques for 681 SAR scenes of glaciers located in Greenland, Antarctica, and Alaska using the CaFFe dataset of calving fronts. We aim to compare different model architectures such as vision transformers and foundation models to the baseline UNet model, with initial results showing promising performance metrics. The results of this study will be applied to an in-progress, novel benchmark dataset of Antarctic ice shelf satellite imagery that will provide the first, long-term record of calving-front locations for the continent and improve our understanding of historical and present-day frontal changes.

JACQUELINE OTTO

Advancing Year-Round Supraglacial Lake Monitoring on the Greenland Ice Sheet by utilising Sentinel-1 C-Band Radar Data

Supraglacial lakes on the Greenland ice sheet are expanding in number, size, and drainage frequency, influencing ice flow and the hydrological system. Traditional monitoring of these lake features using optical satellite imagery is limited by cloud cover and the polar night. Independent of these constraints, radar remote sensing data offers a promising alternative to fill the temporal gaps and unknows in current lake process understanding. Recent insights based on radar data reveal the occurrence of winter lake drainage and the presence of buried lakes uncaptured by optical imagery, emphasizing the need for year-round lake monitoring and improved lake mapping methods. However, the potential of radar data for supraglacial lake investigations strongly relies on the interpretation of complex radar backscatter signals. Decomposing and accurately interpreting radar backscatter remains a significant challenge that we are aiming to tackle in this project.

Based on Sentinel-1 C-band SAR data, we assess the radar backscatter signal associated with supraglacial lakes across the Greenland ice sheet during the years 2018 and 2019 which present two contrasting melt seasons. We argue that differentiating between different types and evolutions of lakes over the course of a lake cycle is essential for accurately representing the ice-dynamical feedback from lake processes. Whether a lake drains or retains water over the course of a lake cycle determines its effect on ice rheology, ice flow and the drainage system. Therefore, we investigate the evolution of the backscatter signature over lakes throughout the season to differentiate between such lake types. We deploy timeseries data analysis techniques, in combination with clustering methods, to explore the radar backscatter signal across the range of observed lake processes. By refining our understanding of radar backscatter from lake processes, this research aims to inform and advance automated techniques for year-round and ice sheet-wide supraglacial lake detection and monitoring, contributing to an improved assessment of the glaciohydrological system under the ongoing climatic changes.

SUNIL NAMDEV OULKAR

Design and Implementation of Robust Data Logging and Telemetry Systems for High-Altitude Cryospheric Research

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High-altitude cryospheric research presents unique challenges for data acquisition and transmission systems, requiring robust, autonomous solutions capable of operating in extreme environments with minimal maintenance. This study presents the design and implementation of a comprehensive data logging and telemetry system deployed in the Western Cwm of Mount Everest, utilising the integration of Campbell Scientific data loggers with satellite communication technology. Drawing on recent advances in satellite IoT connectivity, particularly Ground Control's implementation of the Iridium Certus 100 networks through their compact satellite-enabled RockREMOTE Mini, powered by Iridium's 9770 modem, this study demonstrates how modern telemetry solutions can overcome the fundamental challenges of data transmission from remote, extreme environmental locations, including those in polar, alpine, and high-mountain research. The system is currently operating at 6650 m asl, above Camp II in the Western Cwm of Mount Everest, providing continuous monitoring of ice temperature and meteorological conditions, transmitted every 24 hours. Data integrity and transmission reliability have been consistently maintained despite the extreme weather conditions and limited power availability. The successful deployment of this integrated system establishes a robust methodological framework for cryospheric research in remote locations, demonstrating the potential for sustained, high-resolution climate observations across remote regions where traditional communication infrastructure is unavailable.

DAVID PARKES

Assessing and projecting ice sheet catchment hydrology for Greenland's rivers – a digital twin component approach

The hydrology of the Greenland ice sheet is evolving in complex ways in response to increasing regional temperatures. This includes changes in supraglacial, subglacial, and basal hydrology, all of which contribute to changes in the total runoff at the ice sheet margins. For land-terminating outlet glaciers, this drives changes in the outflow of rivers fed by the melting ice, both in terms of the total annual discharge and patterns of discharge in time, including the timing and magnitude of extreme discharge. This is important as a mechanism for enhancing mass losses from the ice sheet, as well as enhancing sediment transport and increasing the input of fresh water into local marine ecosystems. There is human interest in these changes for communities in Greenland, including interest in the potential for hydropower they represent. In the DTC (Digital Twin Component) Ice Sheets project, modular components for ice sheet digital twins are being developed from existing models of physical processes and statistical/machine learning techniques. These include modules for ice sheet mass balance, damage forecasting, super-resolution modelling, and sea level rise emulation, amongst others. Modules can be selected and connected as required by a particular use case; the project has four use cases in its initial design, of which this abstract covers one. For this use case we utilise a module assimilating multiple hydrological datasets with different spatial scales using a Gaussian Random Field process and a module that models spatio-temporal data using a Functional Time Series approach. The Functional Time Series module also uses an additional extremes model layer on top to give a distribution of extreme values within the modelled time series. Training these modules on earth observation data for catchments on the Greenland ice sheet allows us to independently characterise the annual pattern of changes in hydrology and the interannual variability. In a forward-looking mode, the trained model uses projections for regional climate to determine expected changes – and associated uncertainties – in these patterns over the coming decades. At LPS 2025 we will show the results of our digital twin component for a test catchment of the Watson River basin in south-west Greenland.

Motivated by the use case of hydropower potential, we show estimates for changes in expected annual discharge over the coming decades and distribution of this discharge through the year (both important for expected hydropower output), and the likely 'Once-per-X-years' extreme highs in discharge (important for engineering solutions that are robust to extreme scenarios).

MATT PEACEY

Losing Their Cool: Observing firn characteristics in the Western Cwm of Mount Everest, Nepal.

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Over half of the ablation area of Khumbu Glacier, Nepal, comprises ice that is at the melting point. Moreover, previous studies found that ice within the upper ablation area has warmed by 2–3°C over the last 40 years and is out of equilibrium with local climate. These observations indicate that high-elevation Himalayan glaciers are particularly vulnerable to 21st Century climatic warming and are approaching a tipping point beyond which greatly accelerated mass loss will occur. However, the processes that determine ice temperatures within this region remain poorly understood, making projections of future glacier change uncertain. Losing their Cool aims to investigate the physical interactions between the atmosphere and the glacier surface at high-elevation (>6,000 m a.s.l.) glaciers, where we aim to provide insight into the snow and firn processes that govern Himalayan ice temperatures. To this end, we instrumented the Western Cwm of Mt Everest during the pre-monsoon period of 2025 with a series of thermistor strings and an automatic weather station, with the aim of monitoring snow, firn and weather conditions over a 12-month period. Our study site is located ~400 m from the bottom of the Lhotse Face, in the centre of the Cwm, at an elevation of ~6,650 m.a.s.l. We used a portable steam-driven ice drill to establish a borehole 12 m deep and installed 30 thermistors that will provide a continuous record of the seasonal variability in firn and ice temperatures at sub-degree resolution. To augment these data, we also installed an automatic weather station that measures temperature, relative humidity, snow depth, incoming shortwave radiation, and incoming and outgoing longwave radiation. In addition, while at the site, we extracted, logged and weighed ~ 6m of ice core. From the resulting borehole we used a 360° high-resolution optical televiewer to derive a geometrically accurate, full-colour image to characterise the structural and textural composition of the firn layers at this extreme elevation. Initial data and analysis look promising for advancing our understanding of the processes that determine ice temperatures in these high-mountain environments.

MENGER PENG

Calving mechanisms of lake-terminating glaciers in the southeastern Tibetan Plateau

Comprehending glacier–lake interactions is essential for forecasting future water resources and managing related risks. Yet, the processes governing the dynamics of high-altitude proglacial lakes and their associated glaciers are less understood than those of tidewater glaciers interacting with marine environments. This study investigated calving mechanisms of lake-terminating glaciers in the southeastern Tibetan Plateau, specifically at Jiongpu Co, Yanong Co, and Guangxie Co. By integrating remote sensing data, field observations, and multibeam bathymetric surveys, we tracked calving events from 2000 to 2023 and measured lake temperature, subglacial morphology, and bathymetry. The results indicate that the extent and timing of calving are primarily controlled by lake depth, thermal conditions, and glacier bed geometry. Although a weak linear correlation is observed between calving magnitude and lake depth ($U_c = 0.48H_w + 28.81$, Pearson's $r = 0.4$), retreat of glacier termini in shallow, grounded lakes such as Guangxie Co is strongly linked to lake depth ($r = 0.74$). In contrast, at deeper sites like Yanong Co, where a floating ice front features a submerged ice thickness of ~115.8 m and a 48.6 m lake water gap beneath, the frequency and scale of calving events are driven by buoyant forces, water temperature, and frontal geometry. Multibeam bathymetric profiles at Yanong Co and Guangxie Co reveal subaqueous terraces (10–20 m to ~140 m depth) and sloped ice formations, likely resulting from vertical temperature gradients. Glacier–lake geometry critically influenced the calving process. Calving typically initiates at thinner lateral ice margins and advances toward the central terminus, where enhanced lateral stress and cross-cutting crevasses increase the likelihood of ice loss. Jiongpu Co's deep basin with a reverse bed slope encourages extensive calving, while the shallow, sediment-laden basin of Guangxie Co acts to inhibit it. The relatively cold lake waters of the Tibetan Plateau (e.g., 2–3 °C at Yanong Co) further contribute to slower calving rates than those observed in other glaciated regions.

This study underscores the spatial and temporal complexity of environmental controls on calving and lake evolution. We advocate for the integration of glacier–lake geometry and calving dynamics into predictive modeling frameworks to enhance glacial hazard assessments and support sustainable water resource management for downstream populations.

TINA RAI

Bacterial community structure differs with the granule size in cryoconite on NyÅlesund glacier

Cryoconite, the loose or granular dark coloured sediment found on the surface of glaciers or ice sheets consists of minerals, organic matter, and microbes. They result in different form aggregates, referred as cryoconite granules, connected by extracellular polymeric substance (EPS) produced by filamentous autotrophs mainly cyanobacteria. There have been studies on the bacterial communities of different granule size but limited understanding or research on Ny-Ålesund glacier granules. In this study, we used the bulk sample i.e. surface cryoconite granules of Midtre Lovenbreen to observe the bacterial community structure with different granule size. Different size pluristrainers (30 µm, 50 µm, 100 µm, 250 µm, 500 µm, 750 µm and 1000 µm) applied in this research resulted on their respective size granules. Additionally, we measured the organic carbon content of each granule to explore the relationship between granule size and organic carbon. Our results show there is change of bacterial communities with the increase in size as we find increase of cyanobacteria and chloroflexi from lower to higher granules. In similar way, organic carbon increases with granule size which imply that the cyanobacteria and chloroflexi being the source of organic carbon in extreme cold environment. We find the observed values decrease with the higher granule size, which shows the number of different taxa (genera) decreasing with higher granule size. This study demonstrates the bacterial community structure differ with the increase of granule size along the increasing trend of organic carbon with it.

BEATRIZ RECINOS

Towards an updated Inventory of Antarctic Peripheral Glaciers and their connectivity with the Ice Sheet

Antarctic Peripheral Glaciers and Ice Caps (APGs) cover ~132,867 km², making them the largest glacierised area outside the ice sheets. Situated mainly around Antarctic islands, APG’s experience strong spatial temperature gradients, making them highly sensitive to short-term ocean–climate variability. Their potential sea-level rise contribution remains uncertain, as regional modelling studies disagree on total ice volume. This uncertainty stems largely from current glacier inventories’ inability to reliably distinguish the link between APGs and the Antarctic Ice Sheet.

Here, we use 2 m resolution REMA mosaic DEMs to re-compute glacier drainage units for APGs, following methods from Cook et al. (2014), and integrating previous regional inventories and connectivity assessments (Cook et al., 2014; Hubbard et al., 2017; Bliss et al., 2017) into the Randolph Glacier Inventory (RGI). Leveraging the latest satellite data, we reassess APG connectivity with the ice sheet and the ocean, producing an improved, connectivity-aware

RGI for Antarctic islands. Initial model simulations show that inaccuracies in the current inventory can significantly impact estimates of ice thickness, volume, and sea-level rise potential for these glaciers.

JACOB SESTON

Leveraging self-supervised learning for sea ice segmentation in the Arctic to reduce labelling

The rapid decline of Arctic sea ice driven by climate change poses significant challenges and opportunities for global shipping, ecosystems, and coastal communities. Understanding and mapping sea ice variability is crucial for assessing its implications on navigability and ensuring maritime safety in this dynamic region. One of the most significant challenges in applying machine learning (ML) to cryospheric sciences is the reliance on large quantities of human-labelled data, which is both costly and time-intensive to produce, particularly in remote and harsh environments like the Arctic. This contribution addresses this challenge by leveraging self-supervised learning (SSL) techniques and Convolutional Neural Network (CNN) to reduce the dependency on labelled data while maintaining high levels of model performance. We used the well-known UNet model, a CNN designed for pixel-wise segmentation tasks, and integrate BYOL (Bootstrap Your Own Latent), an SSL technique that leverages unlabelled data to learn features without requiring explicit labels. BYOL trains the model to match representations of the same image under different transformations, allowing it to learn useful features from unlabelled data without needing explicit labels.

We apply these models to Sentinel-1 SAR imagery in the Canadian Arctic Archipelago, a region of critical importance due to its role in global shipping routes, where sea ice variability directly impacts navigability and maritime safety.

We created binary ice and open water labels to serve as a benchmark for evaluating model performance. Early preliminary results suggest that using BYOL reduces the labelling requirement by approximately 50% compared to models trained without self-supervised pretraining. By pretraining the UNet model on unlabelled Sentinel-1 SAR imagery and fine-tuning it for sea ice segmentation, this approach demonstrates how leveraging unlabelled data can significantly minimise the need for human annotation while maintaining robust segmentation accuracy. These methods optimise the use of limited labelled datasets, enabling efficient and scalable models that potentially generalise to sea ice segmentation tasks where high-quality labels are often scarce or imprecise. These techniques enhance the adaptability of ML models, allowing them to be applied to new datasets and tasks with minimal retraining, further reducing the computational and data requirements. By reducing reliance on labelled data, this approach improves efficiency and opens up possibilities for tackling broader challenges, such as real-time ice monitoring, assessing shipping route viability, and conducting long-term trend analysis.

POLINA SEVASTYANOVA

Attributing the retreat of Pine Island Glacier using a novel ice sheet calibration technique

KASTURI SHAH

Stability of subglacial sediment systems

Mechanisms for triggering glacier surges, which are quasiperiodic episodes of fast ice flow, are poorly understood. Surges principally occur due to increased slip at the ice-bed interface, and many surge-type glaciers lie on beds with layers of deformable sediment. Here, a physically consistent model for deformable subglacial sediment systems is presented that draws on the earthquake mechanics literature to formulate a rate-and-state description of sediment that is coupled to an overlying ice layer. The formulation is shown to have stabilising and destabilising effects that can produce positive feedback between the sediment dynamics and ice flow, with criteria for stability. The mechanisms identified here have scope to be tested in field campaigns and laboratory experiments.

PAULA SUCHANTKE

Towards an Automated Detection of Buried Meltwater Lakes on Antarctic Ice Shelves

Three quarters of the Antarctic coastline is fringed by ice shelves, which are crucial for moderating Antarctica's contributions to global mean sea level rise, as they buttress the flow of grounded ice into the ocean. Ice shelves are vulnerable to both basal melting, primarily driven by rising ocean temperatures, as well as surface melting, which is currently a less significant contributor to mass loss, but is projected to increase significantly under future warming scenarios. Meltwater storage at the ice-shelf surface and within the subsurface are potential contributors to present and future ice-shelf instability, as they promote an accelerated depletion of firn air content and may provide the means for ice-shelf hydrofracture.

Extensive meltwater networks on the surface of Antarctic ice shelves are now well-documented, and their distribution and evolution across various geographical and environmental settings have been investigated thoroughly. Meltwater storage within the shallow subsurface in the form of buried lakes was first documented in Greenland a decade ago. These Greenland buried lakes have since been mapped at the continental scale, but they remain widely understudied in an Antarctic context. The insulating properties of overlying snow and firn layers can allow meltwater to persist perennially in the liquid phase within the ice-shelf subsurface, introducing the possibility of water-induced fracture propagation outside of the peak melt season. Buried lakes cannot reliably be detected in optical satellite imagery, which has limited the large-scale assessment of their occurrence and dynamics in Antarctic settings.

Here, we build on a pilot study which applied a previously published deep learning methodology for the detection of buried lakes on the Greenland Ice Sheet to Wilkins Ice Shelf on the Antarctic Peninsula, where early-stage visual interpretations of Sentinel-1 SAR imagery had revealed buried lakes near the north-western grounding line of the ice shelf. The Greenland-trained model is based on an AlexNet architecture and is used to classify individual three-band false-colour image tiles composed of Sentinel-1 and Sentinel-2 data. Thresholding of the Sentinel-1 HV band is then used to derive lake outlines in detected lake locations.

Following the promising results of adapting this approach in the pilot study, here, we present our workflow to generate training data and prepare the model for transfer learning. Additionally, we incorporate a digital elevation model as an input feature, and test whether this improves the model's ability to detect buried lakes. Future work will see the establishment of a methodology pipeline to detect buried lakes across Antarctic ice shelves, utilising the originally established model to generate training data for an image segmentation model with a U-Net architecture.

ERIC TAYLOR

Quantifying supraglacial debris evolution on Rongbuk Glacier using an energy balance model, thermal imagery, and climate reanalysis data

A key challenge in predicting future glacier behaviour and dynamics is accounting for the effects of supraglacial debris on debris-covered glaciers, which modifies surface ablation and remains poorly constrained in its extent, thickness, and future evolution. Under climate warming, debris cover is projected to expand up-glacier and form at a faster rate due to the accelerated meltout of englacial debris. Increased landslides and avalanches from mountainsides due to weaker slopes are also predicted to contribute to increased debris cover extent.

Of particular interest is the initial emergence of debris below the equilibrium line, where clean ice transitions into debris-covered ice due to debris meltout. These areas are typically characterised by thin and discontinuous debris, which enhances ice melt due to the non-linear relationship between debris thickness and melt. Such transition areas are understudied at the glacier scale and are often excluded from existing distributed debris thickness datasets. Tracking debris evolution enables a clearer understanding of the transition of a glacier surface from clean to debris-covered ice.

This study applies an energy balance model to retrieve debris thickness across Rongbuk Glacier, Tibet, between 2001 and 2020, using Landsat 7 thermal imagery and ERA5 reanalysis data. A Monte Carlo framework quantifies the uncertainty in debris thickness and the rate at which it is thickening, yielding a novel spatially distributed 'debris accumulation rate'. Results show that debris is not only thickening in the ablation zone but also in sections of the accumulation zone, suggesting enhanced debris delivery from adjacent mountainsides. Consequently, the concentration of debris entrained in englacial ice may be increasing, resulting in the accelerated development of debris cover independent of, and in addition to, enhanced meltout due to climate warming. Such trends are not captured in most glacier evolution models.

Limitations in energy balance modelling are observed in the upper ablation area, where sparse debris cover is poorly represented in satellite imagery due to sub-pixel discontinuity. Novel methods for resolving sub-pixel fractional debris cover from moderate-resolution thermal data are needed to better constrain debris evolution and improve projections of glacier longevity under climate change.

Fjord circulation and glacier submarine melting due to an instantaneous iceberg capsize-driven ocean mixing event

Oscar Tovey Garcia, Andrew Wells

Fjords act as gateways between the Greenland Ice Sheet and the surrounding seas, setting the conditions near glacier fronts that influence glacier melt rates. It has been suggested that the calving of large icebergs from some of Greenland's largest and fastest flowing glaciers may be able to vigorously mix the stratified waters within fjords and thereby affect fjord circulation. We run an ocean model configured as an idealised fjord to predict the circulation generated by the instantaneous mixing of a small region near the glacier front, emulating the effect of an iceberg capsize event. We report the profiles and time series for volume transport and glacier submarine melt rate calculated from the model output. We find relationships for how the melt rate scales with the buoyancy frequency of the initial fjord stratification, the length over which the instantaneous iceberg-driven mixing takes place, and the strength of the mixing, and estimate upper bounds on the impact of glacier calving on glacier melt rates.

Variable thermal characteristics of two adjacent Greenlandic ice-marginal lakes

Pete Tuckett, Connie Harpur, Alex Scoffield, Josh Abrahams, Joe Mallalieu, Lauren Rawlins, Duncan Quincey, Chris Merchant, Iestyn Woolway, Laura Carrea, Niall McCarroll, David Rippin.

Large parts of the land-terminating sectors of the Greenland Ice Sheet are fringed by ice-marginal (or ice-contact) lakes. These lakes are increasing in number and size as a result of enhanced ice melt and ice sheet retreat over recent decades. It has traditionally been assumed that ice-marginal lakes exist at a relatively uniform temperature of around 1°C, thus having minimal influence on ice dynamics and subaqueous melt rates at the ice-water interface. However, to date, almost no in-situ temperature measurements have been gathered at ice-marginal lakes in Greenland, meaning their influence on future ice sheet behaviour remains unclear. Here, we present results from the first in-situ, continuous time series of water temperatures in Greenlandic ice-marginal lakes throughout a summer melt season. Lake surface temperatures reached highs of 8°C, whilst water temperatures greater than 4°C were observed throughout the entire water column of one study lake. Our results also show how neighbouring lakes can have markedly differing thermal characteristics, likely due to differences in size, localised topography and variable meltwater inputs. These results highlight how uniform temperature values are likely unsuitable when modelling ice-lake dynamics, and that lake terminating sectors of the ice sheet may be experiencing greater rates of frontal ablation than previously realised.

MARIAPINA VOMERO

Mapping wintertime surface lid collapses of Antarctic lakes using Sentinel-1

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Wintertime observations of supraglacial lake dynamics on Antarctic Ice shelves have been limited due to the reliance of optical satellite sensors on solar illumination and cloud-free conditions, thereby preventing continuous monitoring from late March until late September. Since Sentinel-1 satellite synthetic aperture radar (SAR) provides surface images at high spatial resolution unaffected by cloud cover and light conditions, it enables frequent monitoring during the winter months. Sudden lid collapses are usually the result of ice-covered lake drainages, with the resultant ice debris enhancing the intensity of the radar backscatter. We used a known doline formation during the winter months on the Amery Ice Shelf, and neighbouring lake drainages in the same winter, to investigate the potential of Sentinel-1 Interferometric Wide IW imagery for monitoring such events during the months of darkness in Antarctica. A change detection approach was developed using the backscatter intensity change to identify the timing of surface lid collapses in winter. Texture analysis of optical imagery immediately prior to and after the winter of 2019, enabled identification and quantification of the area collapsed and the filtering of false positives. Validation was carried out using Reference Elevation Model of Antarctica-2m differencing and NASA ICESat-2 laser altimeter tracks when available during the winter

ANDREW WELLS

Linear Response of an Ice Shelf and Ocean Plume to Temporally-Oscillating Forcing

Christopher MacMackin, Andrew Wells (University of Oxford). *presenting.*

In many locations ice shelves extend from the grounded Antarctic and Greenland ice sheets, to float upon the ocean. These ice shelves feel changes in ocean temperature and can modify the ice loss from the Antarctic and Greenland ice sheets and impact their contributions to sea level rise. Recent observations have shown the base of ice shelves have a complicated geometry, with channels, ripples and step-like terraces in the ice-shelf base which can impact the rate of ice shelf melting or the propensity of ice shelves to fracture. However there is an incomplete understanding of how these geometrical features form. We use a simple ice shelf model to explore how the ice shelf geometry is shaped by variations over time of the ice flowing from the neighbouring grounded ice sheet, and by variations in melting rate due to changing

conditions in the ocean

ISABELLE WICKS

Modelling the impact of surface melt on Amery Ice Shelf, East Antarctica, 1941-2024

Current Antarctic mass loss trends are leading to more significant contributions to global mean sea level. This is only set to continue, with warming at the South Pole over the past three decades being three times the global average. However, individual Antarctic ice shelf responses to a warming climate are highly variable, and the stability of ice shelves is still poorly constrained. East Antarctica especially tends to be understudied in favour of West Antarctica and the Antarctic Peninsula, where more dramatic and rapid mass losses are occurring. Here, we investigate the formation, development, and impact of surface meltwater networks across a region of the grounding zone of Amery Ice Shelf, East Antarctica over an 80-year period, using a numerical model specifically developed to model individual meltwater lake evolution. This study aims to understand the impact of current climate conditions on and contribute to improved quantification of the stability of Antarctica's third-largest ice shelf.

TILLY WOODS

The role of subtemperate regions in ice-stream sliding onset

Tilly Woods, Sophie Brass, Elisa Mantelli, Thomas Zwinger, Christian Schoof

Subtemperate sliding plays a key role in ice stream formation. Ice streams are fast-flowing "rivers" of ice that can turn on and off over time (like a surging glacier) and form spatial patterns of alternating fast-flowing ice streams and slow-moving ice. Ice-stream motion - in particular ice-stream formation - is associated with the transition from a cold bed to a temperate bed, via a subtemperate region in which a small about of sliding occurs before the melting point is reached. This transition results in sliding onset and hence fast flow. Here, we explore the physical mechanisms behind sliding onset and the temporal instabilities associated with the subtemperate sliding region, using a combination of theory and numerical simulations. We run transient, numerical simulations of an idealised, 2D ice-sheet flowline in Elmer/Ice, using a Stokes flow model coupled to a basal hydrology model, and a subtemperate sliding law. We observe that different temporal instabilities occur depending on the sliding speed, and relate these observations to predictions from previous linear stability analysis. We consider the effect of domain size, mesh resolution, and the choice of basal hydrology model. We also explore details of the numerical implementation in Elmer/Ice of frozen-temperate boundaries at the bed.

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THANK YOU
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