WAIS Workshop 2026 Agenda (all times EDT)

Northern Virginia 4-H Educational and Conference Center
Front Royal, VA USA

Monday, September 28

2:00 pm – 5:00 pm	Check in: Pick up badges, swag (check in Tuesday and Wednesday will be available during breaks in the agenda)	Auditorium
6:00 pm – 6:30 pm	WAIS Workshop Steering Group Meeting: All are welcome to join to discuss the status and future of WAIS Workshops	Auditorium
7:00 pm – 9:00 pm	Icebreaker and pizza dinner	Picnic & BBQ Area

Tuesday, September 29 – All oral presentations in the Auditorium
Upload your Tuesday presentation slides by 7 am here.

Breakfast: 8:00 am – 9:00 am (Dining Hall)

Session 0	Opening Business	Presenter
9:00 am	Welcome to WAIS Workshop 2026 & Goals	WAIS Committee
9:10 am	View from the Agencies	Kelly Brunt Denis Felikson

Session 1	Artificial intelligence and computational frontiers in marine ice-sheet science	Presenter
9:40 am	It's the Data, Not the Algorithm: How Greenland became AI's ice sheet (invited)	Leigh Stearns
9:55 am	DEMOGORGN Antarctica: Geostatistical Subglacial Topography for Uncertainty-Aware Ice-Sheet Investigation	Mickey Mackie
10:05 am	CryoStack: A Unified Cyberinfrastructure Platform for Reproducible Ice-Sheet Modeling, Data Assimilation, and Scientific Computing across HPC and Cloud Environments	Brian Kyanjo
10:15 am	Comparing geological interpretation and machine learning to develop parameterization of geological influence on ice sheet flow in the Amundsen Sea	Kirsty Tinto
10:25 am	Discussion	All

Refreshment Break: 10:45 am – 11:00 am

Session 2	Snow, Flow, Fracture, Friction	Presenter
11:00 am	Snow. The unlikely champion of the 2020s	Brooke Medley
11:10 am	In-Situ Measurements of Ice Shelf and Mélange Deformation Reveal Mechanical Properties of an Ice Rift in the Ross Ice Shelf	Kathrine Udell-Lopez
11:20 am	Uncertainty in CDW access to the Grounding Line from Stochastic Gravity Inversions of Sub-ice-shelf Bathymetry	Michael Field
11:30 am	Model-data investigation of Holocene retreat-readvance in the Western Ross Sea	Ruthie Halberstadt
11:40 am	Discussion	All

Lunch: 12:00 pm – 1:00 pm

Session 3	Blast from the past: the paleo perspective	Presenter
1:00 pm	An exciting new Miocene record from beneath the West Antarctic Ice Sheet: Initial Results from the SWAIS2C Crary Ice Rise Drill Core	Molly Patterson
1:10 pm	Sensitivity of the West Antarctic Ice Sheet to sea level and ocean temperature forcing during the penultimate glacial cycle: results from coupled GIA-PISM model experiments	Sam Chester
1:20 pm	Finding signal in the noise: Holocene retreat and re-advance signals revealed through legacy cosmogenic nuclide data	Ryan Venturelli
1:30 pm	Fingerprinting glacial tills with provenance tools shows the flow history of glaciers in the McMurdo Dry Valleys, Antarctica	Dan Morgan
1:40 pm	The international Ross-Amundsen Ice Core Array (RAICA) initiative: century-long Amundsen Sea annual climate variability (Canisteo Peninsula) and prospects for future ice core reconstruction of West Antarctic paleoclimate	Peter Neff
1:50 pm	Discussion	All

Refreshment Break: 2:15 pm – 2:30 pm

Session 4	Snow, Flow, Fracture, and friction	Presenter
2:30 pm	Constraining the flow law of ice with time-dependent inversions	David Lilien
2:40 pm	Ice fabric determination from quad-polarimetric radar data collected in West Antarctica	Andrew Hoffman
2:50 pm	Inversion of subglacial effective stress for till-bedded areas of Thwaites Glacier from acoustic-impedance measurements and viscous grain shearing theory	Atsu Muto
3:00 pm	The effect of topography roughness and uncertainty in the retreat of Thwaites Glacier	Niya Shao
3:10 pm	Beyond MISI: understanding marine ice sheets as components of the Earth's climate system (invited)	Olga Sergienko
3:25 pm	Discussion	All

	Poster Pitches	Presenter
3:45 pm	One minute poster teaser pitches (upload your 1 slide here by 8:00 am	Poster Presenters

Poster Session: 4:15 pm – 5:30 pm
Dinner: 5:30 pm – 6:30 pm
Post-dinner breakouts: 7:00 pm – ?? (locations TBD)

Wednesday, September 30

Upload your Wednesday presentation slides by 7 am here.

Breakfast: 8:30 am – 9:30 am (Dining Hall)

Session 5	Getting to the bottom of WAIS's future: the next decade of investigations through and beneath the ice	Presenter
9:00 am	Radar imaging of ice-sheet basal units for determining past ice flow and climate on Earth and Mars	Knut Christianson
9:10 am	Rivers of Dreams: Subglacial Water and IPY5	Britney Schmidt
9:20 am	How do we expand capacity for airborne radar sounding?	Thomas Teisberg
9:30 am	Large-scale, cross-sphere investigations of West Antarctica using NASA's 777 airborne science laboratory during IPY-5	Joseph MacGregor
9:40 am	When do solid Earth and sea-level feedbacks become important in AIS projections? (invited)	Holly Han
9:55 am	Discussion	All

Refreshment Break: 10:20 am – 10:40 am

Session 6	The next decade of ice, ocean, and climate investigations	Presenter
10:40 am	ITASE Redrilling: Bridging the Gap Between Paleoclimatic and Modern Accumulation Variability in Antarctica	Advik Eswaran
10:50 am	An IPY-5 International Observational Network to Track Antarctic Ice Sheet Mass Change	Terry Wilson
11:00 am	EDGE: Tracking Change at the Ice Margins	Helen Fricker
11:10 am	SlideRulers of the world, unite! Analyzing NASA Data in the 21st century	Tyler Sutterley
11:20 am	Discussion	All
11:40 am	Extended IPY Discussion	All

Lunch: 12:00 pm – 1:00 pm Poster Session: 1:00 pm – 2:30 pm

Session 7	Snow, Flow, Fracture, and friction	Presenter
2:30 pm	GNSS Observed Crustal Deformation Accelerations in West Antarctica	Hongzhi Yao
2:40 pm	Probabilistic Inversion of Basal Conditions Using Simulated Multi-Frequency Radar	Christopher Barbarie
2:50 pm	Modeling Accelerated Ice Loss in Transient Antarctic Simulations with Supraglacial Melt Lake Depth-Driven Calving	Danielle Grau
3:00 pm	Subglacial Groundwater Exfiltration is Negligible Today, but Substantial Under Future Antarctic Ice Loss	Rohaiz Haris
3:10 pm	Discussion	All

Leg Stretch: 3:30 pm – 3:40 pm

Session 8	Interactions between ice, ocean, and atmosphere	Presenter
3:40 pm	From Observations to Projections: Constraining Antarctic Ice Sheet Models with the Satellite Record	Sara Peters
3:50 pm	Evaluating the GSFC-FDM using GNSS-IR-derived firn burial across the Antarctic and Greenland ice sheets	Marianna Marquardt
4:00 pm	Seawater Infiltration Forms a Widespread Englacial Hydrologic System in Antarctic Ice Shelves	Ian McDowell

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4:10 pm	Coupled impacts of the coastal ocean and subglacial discharge on ice shelf basal melt	Mike Dinniman
4:20 pm	From ISMIP6 to ISMIP7: Key Developments and First Results (invited)	Helene Seroussi
4:35 pm	Discussion	All
4:50 pm	Wrap up	WAIS Workshop Committee

Posters

Title	Presenter
Tracking Changes in Water Masses of the Amundsen Sea Using Stable Oxygen Isotopes	Azmair Bains
The Open Radar Code Architecture in the Classroom as Undergraduate Education and Research Infrastructure at CU Boulder	Nicole Bienert
Biological productivity and meltwater recorded in seafloor sediments from the Amundsen Sea Embayment, West Antarctica	Colton Byrne
ICESat-2 mapping and time evolution of rampart-moat structures	Georgia Carroll
Thermal and Rheological Models Overpredict Temperatures in Antarctic Ice Stream Margins	Thatcher Chamberlin
Updates from the US Antarctic Program Data Center (USAP-DC) efforts to improve data sharing and access	Isabel Cordero
A Shelf-by-Shelf View of Antarctica's Largest Calving Events: Environmental Drivers and Temporal Trends, 2005–2020	Maile Corso
Rates of postglacial Antarctic Ice Sheet thinning rival future projections	Roger Creel
Optimizing Airborne Gravimetry Data to Investigate the Bathymetry of the Sub-Ice Shelf Continuation of Hayes Bank in the Eastern Ross Sea, Antarctica	Giselle DeSousa
Multi-instrument Calibration of Aerogravity over the Ross Ice Shelf	Caitlin Dieck Locke
Triple oxygen isotope evidence for cryogenic brine formation and low-temperature alteration of sedimentary biogenic opal in the Ross Sea	Justin Dodd
Spatiotemporal Distribution of IBRD in East Antarctic Marine Sediment Cores	Gabriela Gaarder
Atmospheric Rivers as Heat and Moisture Conduits to the West Antarctic Interior: Their Role in Driving Heat Waves and Potential Coupling to Sea Ice Variability	Sérgio José Gonçalves Jr.
Investigating Glacial Retreat and Biological Productivity in coastal settings of the Amundsen Sea: Cranton Bay, Antarctica	Megan Hansen
Revisiting Last Glacial Maximum Ice Stream Retreat Trajectories in the Amundsen Sea Embayment by Comparing Radiocarbon Reservoir Corrections on Deglacial Sediment Ages	Marianne Heberlein
1966-2023 Ice Core Annual Snow Accumulation at Canisteo Peninsula, Amundsen Sea, West Antarctica	Lilly Hinkley
Quantitatively identifying Mid-Pleistocene glacial to interglacial ice margin dynamics in the Ross Sea, Antarctica	Halima Ibrahim
Assessing the Influence of Glacial Cavity: Pb Isotopes Unveil the Amundsen Sea Pb Cycle	Yerim Kim
Unfreezing Glen's n: The Sensitivity of Antarctic Grounding-Line Flux to Ice Rheology	Siobhan Light
Funding Glaciological Research to Reduce the Risks of Sea-Level Rise	Lauren Mahle
The Polar Rock Repository: furthering knowledge of Antarctic ice sheet history using legacy collections	Erica Maletic
A novel time-dependent method to estimate sliding law parameters	Logan Mann

Title	Presenter
Modeling Firn Storage Loss and Meltwater Runoff Across Glacier Systems Using the Community Firn Model	Larissa Ramirez
Development of a High-Resolution, ECCO-Downscaled Antarctic Peninsula Regional Model	Gobishankar Sathiyamohan
Overview of Science Results of the International Thwaites Glacier Collaboration and ongoing studies	Ted Scambos
Emulating the Microphysical Dynamics of Ice Deformation	Nathan Schoedl
Geospatial Modelling of Glacier Health and Climate Sensitivity Using Multi-Source Remote Sensing: Transferable Approaches for West Antarctic Ice-Sheet Monitoring	Swati Tak
Climate-sensitive Carbon Cycling Adjacent to a Melting Ice Shelf in West Antarctica	Patricia Yager
Whatever happened to Nye channels? A case for geologic control on subglacial hydrology	Sunme Zhao

Tracking Changes in Water Masses of the Amundsen Sea Using Stable Oxygen Isotopes

Azmair Bains, Amy Wagner, Christina Wiederwohl, Elisabeth Sikes

Increased basal melt rates in the Amundsen Sea section of the West Antarctic Ice Sheet are contributing to rapid mass loss and ice shelf thinning. In the Amundsen Sea, upwelled Circumpolar Deep Water (CDW) enters the continental shelf through glacial troughs to become modified CDW (mCDW) and can melt floating ice shelves, such as the Dotson and Getz Ice Shelves, at the grounding line. Glacial meltwater (GMW) contributes to the local circulation and affects the stratification of the upper ocean, which can affect its carbon and heat exchange with the atmosphere. Freshening of the Ross Sea is partly attributed to the input of GMW originating from the Amundsen Sea, which has the potential to decrease the formation and/or density of Antarctic Bottom Water (AABW) in the Ross Sea and have impacts on global thermohaline circulation. Since GMW has an impact on the biogeochemical and physical aspects of the Amundsen Sea and the global ocean, it is important to understand the temporal variation of input of GMW to understand how it may be affecting water masses such as the surface water mass, Winter Water (WW), in the region. It is also necessary to understand the inflow of mCDW and its spatial and temporal variability, as it is the primary mechanism that is inducing the thinning of ice shelves. The principal goals of this research are to utilize stable oxygen isotopes (δ18OSW) in addition to temperature and salinity to evaluate the temporal-spatial trends and changes occurring in the water masses in the Amundsen Sea.

The U.S. GEOTRACES GP17-ANT scientific cruise collected seawater samples across the Antarctic continental shelf in the western Amundsen Sea in 2023. Samples were collected from 27 stations throughout the water column for stable oxygen isotope analysis. Using data from previous studies of the region from the span of 1994 to 2020 in combination with GP17-ANT data, the temporal variation of mCDW and WW characteristics on the shelf and ensuing glacial melt were examined. Changes in WW correlate with processes occurring at the surface with δ18OSW, salinity, and temperature tracking changes in sea ice formation and GMW input. Salinity and temperature of mCDW display interannual changes but remain in the same density regime; however, there was a significant decrease in δ18OSW from 2014 to 2023. The change in mCDW δ18OSW may indicate changes in Circumpolar Deep Water before intruding onto the shelf, possibly at the source of formation.

Probabilistic Inversion of Basal Conditions Using Simulated Multi-Frequency Radar

Christopher Barbarie, Nicole Bienert

Basal flow and the friction laws governing basal motion are crucial parameters in ice-sheet models used to predicted sea level rise, yet they remain poorly constrained. Uncertainty in the parameters governing basal friction at Thwaites Glacier has been shown to cause up to 300% differences in sea level rise predictions over the next 100 years. Basal material, hydrology, and roughness directly affect basal friction, yet measurements of these properties are limited. Boreholes provide direct measurements of the basal composition, but these surveys are limited in their spatial coverage due to their high costs. Radar surveys can provide high spatial coverage and have been used to generate basal topography maps with resolutions on the order of ~10 m. However, single-frequency radar is limited in its ability to disambiguate small-scale basal roughness and material composition. Large increases in returned basal power from radar data have previously been used as a metric for basal water detection; despite this, previous work has shown that transitions from rough beds to hard, smooth beds can exhibit identical signals to basal water. Multi-frequency radar may present a solution to disambiguating the effects of roughness and material on radar data by leveraging the differing frequency response of scattering and reflectivity.

Here, we present a Bayesian framework that imposes weak Gaussian priors, motivated by geophysical knowledge and existing literature of ice-sheet beds, on the basal roughness for differing material compositions. We simulate multi-frequency backscatter coefficients from the ice-bed interface and apply a Markov Chain Monte Carlo (MCMC) sampler to estimate the posterior distribution of the basal parameters. We present noise sensitivity studies to demonstrate the effects of SNR and radiometric uncertainty on our retrievals. We find that an SNR of 20 dB and a radiometric uncertainty of less than 2 dB, are required to achieve less than 10% error in the mean of the estimated volumetric water content at the bed. These sensitivity studies will motivate hardware development, experiment design, and calibration procedures during data collection. Our results suggest that an MCMC estimator can be used on multi-frequency radar data, in combination with Gaussian priors, to significantly reduce the ambiguity between basal roughness and material composition, providing more reliable constraints for ice sheet models and improving sea-level rise predictions.

The Open Radar Code Architecture in the Classroom as Undergraduate Education and Research Infrastructure at CU Boulder

Nicole Bienert, Zoe Worrall, Christopher Barbarie

Over the past two years, the Open Radar Code Architecture (ORCA) has been used as a teaching tool to train the next generation of radioglaciologists and radar engineers at CU Boulder, and through these educational activities, expand ORCA capabilities to facilitate glacial and environmental research. ORCA is an open-source codebase and instruction set for operating Software Defined Radios as low-cost, reconfigurable ice-penetrating radars. The ORCA initiative aims to reduce barriers to ice-penetrating radars, streamline radar research, and make new radar technologies more accessible to glaciologists. Through the Summer Undergraduate Research Program, Discovery Learning Apprenticeships, Senior Capstone, and independent studies, we have introduced 11 undergraduate students to research, and these students have dramatically expanded the capabilities of ORCA. Students have introduced new features, overhauled the codebase to improve readability and modularity, created an extensive beginner's guide, and increased robustness to community-contributed code. Automatic unit tests and code commit protocols have been introduced to facilitate community code contributions, cross-device compatibility, and easy code maintenance. Instructions were added to guide users through initial setup, basic timing calibration, and benchtop testing all the way to outdoor testing, where a user can measure distance to a reflecting object. Students are currently developing ORCA-supported radar systems, including a drone-based monostatic radar for avalanche risk detection and a bistatic drone-based system for common mid-point surveys. Here, undergraduate education is serving as research infrastructure, where undergraduate student efforts are lowering the barrier to entry for SDR radars, increasing ease of use, providing new radar technology, and directly supporting radioglaciology researchers to accelerate glaciological discovery.

Biological productivity and meltwater recorded in seafloor sediments from the Amundsen Sea Embayment, West Antarctica

Colton Byrne, Rebecca L. Totten, Claus-Dieter Hillenbrand, Marianne Heberlein, James A. Smith, Julia S. Wellner, Lauren E. Miller, Jacob Helgeson, Robert Larter

To evaluate the effects of the receding West Antarctic Ice Sheet on the surrounding ocean and its biological communities, we investigate the grain size, chemical composition, and biological remains on the seafloor of the Amundsen Sea Embayment (ASE)—spanning the Dotson Ice Shelf to the Abbot Ice Shelf, and from the outer to inner continental shelf—in a study of unprecedented spatial breadth in this sector of Antarctica. Recent expeditions by the Thwaites Glacier Offshore Research (THOR) team of the International Thwaites Glacier Collaboration recovered sediment cores near the ice margins of several major glaciers and ice shelves, including Thwaites and Pine Island glaciers. We combine these new samples with legacy cores collected by multiple international expeditions to increase spatial coverage of the ASE, and, importantly, include areas in the Amundsen Sea Polynya (ASP) and the Pine Island Bay Polynya (PIBP), which are among the most biologically productive polynyas in Antarctica. Analysis of 62 seafloor sediment samples yield a series of maps showing spatial variation in biological productivity and depositional environment. Total organic carbon and nitrogen contents, stable carbon isotopes, diatom presence/absence, and biogenic barium (Ba/Al, measured by X-Ray Fluorescence) are analyzed and compared as a proxy for biological productivity recorded on the seafloor. Grain size distributions are further analyzed to provide information that can be related to depositional energy, especially following studies that observed signatures of glacial meltwater in the ASE.

Geochemical proxies for productivity are highest within the seafloor coinciding with polynyas, with sites in the ASP showing higher productivity than in the PIBP. The highest productivity is observed in Cranton Bay, an oceanographically isolated embayment northeast of Pine Island Bay, located within the PIBP. In addition, grain size populations with a ~4.5 um mode indicate contribution from meltwater in Pine Island Trough, proximal to Thwaites Glacier, and in Cranton Bay. Other sites, including several from the ASP near the Getz Ice Shelf, are coarse-grained and include ice-rafted debris.

The modern seabed of the Antarctic continental shelf records recent conditions of the ice sheet and sea ice, and it is therefore a useful tool to evaluate changing environmental conditions. As glaciated margins continue to rapidly change, it is imperative to establish baselines for factors that shape the global carbon cycle, including glacial meltwater and polynyas, to better understand biological responses to future environmental change.

ICESat-2 mapping and time evolution of rampart-moat structures

Georgia Carroll

Rampart-moat (RM) structures are characteristic depressions and uplifts observed near the fronts of Antarctic ice shelves. First identified in high-resolution satellite laser altimetry, these features are interpreted as the surface expression of ice shelf front flexure and have been documented along extensive sections of the Ross Ice Shelf front. Their formation has commonly been attributed to bending moments at the ice front, either from buoyancy forces generated as melting at the waterline leads to submerged ice benches or internal stress gradients. While tabular iceberg calving is a leading mass loss mechanism for Antarctica's largest ice shelves (Filchner-Ronne, Ross, and Amery), small-scale calving events occur more frequently but are challenging to quantify due to their spatial and temporal scales, leaving their contribution to ice-shelf mass loss poorly constrained. Because RM structures are linked to ice-front melting and the resulting bending stresses, they are theorized to contribute to processes governing small-scale calving. Nearly seven years of ICESat-2 observations now provide an extensive dataset with which to investigate RMs prevalence and evolution around Antarctica. The repeat-track capability of ICESat-2 enables both the identification of RM structures and the examination of the temporal evolution of individual ice fronts, which may lead to a deeper understanding of submarine calving mechanisms. Here, as an initial step toward a continent-wide inventory of Antarctic rampart-moat structures, we present repeat-profile observations from Drygalski Ice Tongue and observe the RM geometry through time. These observations demonstrate the potential for ICESat-2 to monitor ice-front flexure and provide new constraints on the relationship between frontal melting, bending stresses, and calving processes.

Thermal and Rheological Models Overpredict Temperatures in Antarctic Ice Stream Margins

Thatcher Chamberlin

Ice temperature in Antarctic ice stream margins controls ice viscosity and therefore margin strength and ice stream discharge, but it is difficult to measure directly. It can be estimated with thermal models that account for viscous dissipation, conduction, and geothermal heating, or inferred from airborne radar observations of temperature-dependent attenuation. One-dimensional thermal models generally predict warmer margin ice than is supported by radar-derived estimates and limited borehole observations. Recent rheology work suggests that ice viscosity in margins is more stress-sensitive than conventional flow laws assume, with a stress exponent closer to 4 than 3. Here we use a one-dimensional thermal model to compare temperatures predicted under conventional and updated rheologies. The updated rheology increases strain heating, further widening the disagreement between the radar estimates and model predictions. Reconciling model predictions with radar estimates requires stronger cooling from processes the thermal model omits, most plausibly horizontal advection of cold ice. Improved quantification of these remaining processes is therefore necessary to better understand ice stream flow.

Sensitivity of the West Antarctic Ice Sheet to sea level and ocean temperature forcing during the penultimate glacial cycle: results from coupled GIA-PISM model experiments

Sam Chester, Jacqueline Austermann, Torsten Albrecht, William D'Andrea, Roger Creel

Determining the sensitivity of the West Antarctic Ice Sheet (WAIS) to modern and future climate change is critical for predicting relative sea-level rise around the world. Ice sheet models used to forecast WAIS response are often calibrated to past warm periods when the ice sheet was smaller than present. The penultimate deglaciation and Last Interglacial (LIG; 130 to 116 ka) are useful case studies in WAIS dynamics because existing sea-level data help constrain the timing and magnitude of ice loss during the warm period. However, the specific drivers of deglaciation during the LIG and preceding termination are debated. Previous studies point to oceanic forcing and mechanical processes–e.g. the marine ice cliff instability–to explain the magnitude mass loss. More recently, modeling of the last glacial termination indicated that sea-level rise driven by Northern Hemisphere ice sheet collapse also influences the pace of WAIS deglaciation. Here, we couple a model of sea-level change driven by glacial isostatic adjustment (GIA) to the Parallel Ice Sheet Model (PISM) to investigate the relative influence of Northern Hemisphere sea level and Southern Ocean temperature forcing on WAIS retreat preceding and during the LIG. We run transient simulations over the last two glacial cycles with a range of forcings and ice sheet/GIA model parameters, and benchmark our results against modern observations. Initial results show that the early stage of WAIS deglaciation is driven by rising global mean sea level; however, the extent of retreat/collapse during the LIG is controlled by the peak sub-ice-shelf ocean temperature anomaly.

Radar imaging of ice-sheet basal units for determining past ice flow and climate on Earth and Mars

Knut Christianson, Nicholas Holschuh, Andrew Hoffman, John Paden, David Lilien, Michelle Koutnik, Aditya Khuller, Nicholas Rathmann

The deepest portions of the Greenland and Antarctic ice sheets remain one of the most mysterious environments on Earth. Direct sampling of basal ice remains logistically challenging and costly, and generalizing results from individual ice cores across an ice sheet requires spatially distributed geophysical imaging, usually using ice-penetrating radar. Until recently, radar imaging of basal ice was challenging due to few radar echoes near the bed of the ice sheet. The lack of radar returns in this "echo free" zone was hypothesized to be due to a lack of reflective horizons at these depths or technological limitations that prevented effective radar imaging of low amplitude reflections. Here, we present data collected with new radar technologies that image basal ice. We focus in particular on elucidating potential formation mechanisms for large basal structures found in Greenland, a thin, but widespread basal unit found in West Antarctica, and a thick, spatially extensive basal unit mapped across East Antarctica. Using new radar imaging techniques, we evaluate potential formation mechanisms for basal structures and units on both ice sheets, including: (1) non-steady folding of deformed meteoric ice, (2) basal ice accretion and accompanying debris entrainment, and (3) decoupling of horizontal ice flow across an englacial interface due to rapid formation of preferred ice crystal-orientation fabric and ice grain size evolution. We find that different formation mechanisms may be responsible for different basal units. Our results have implications for understanding past and future ice flow, preservation of old ice, and interpretations of past climate from englacial stratigraphy and englacial structure. Finally, we discuss potential applications of our techniques for understanding Mars' past climate through interpretation of the basal units mapped in satellite radar data across both Martian Polar Layer Deposits.

Updates from the US Antarctic Program Data Center (USAP-DC) efforts to improve data sharing and access

Isabel Cordero, Frank O. Nitsche, Kirsty Tinto, Alexander Strong

The U.S. Antarctic Program Data Center (USAP-DC) is a data hub and repository funded by the US National Science Foundation for any data collected or created as part of the US Antarctic Program. Datasets are hosted within USAP-DC with extensive metadata, and are shared through multiple avenues to maximize findability. We offer metadata access through REST API; schema.org information harvesting; and registration through multiple metadata catalog services, including Antarctic Metadata Directory (AMD), DataONE, and Polar Federated Search. Within our own repository, the USAP-DC website offers text- and map-based search interfaces to enable dataset discovery. We also facilitate links to datasets hosted at other repositories, through our dedicated project pages for NSF awarded projects. Moreover, we register permanent identifiers with DOI for datasets archived within USAP-DC's repository, which supports data reuse and findability.

Over the last years we implemented several features to monitor and improve the quality of data submission and access to the data. We have developed a dataset assessment metric to provide users with better feedback to improve the FAIRness of their data submissions. Based on this matrix we present the quality, and issues of user provided metadata submitted to USAP-DC.

We also implemented a new API to allow direct download of data files in addition to the metadata information, which should improve access to the data. A new collection feature allows users to combine links to related datasets onto one page, making it easier to organize and find related datasets in one place.

A Shelf-by-Shelf View of Antarctica's Largest Calving Events: Environmental Drivers and Temporal Trends, 2005–2020

Maile Corso, Emma MacKie, Katherine A. Serafin, Joanna D. Millstein

Antarctic ice-shelf calving is dominated by a small number of very large events that account for a significant percentage of ice loss and strongly influence ice-shelf stability, sea-level rise, and freshwater input to the Southern Ocean. However, the trends and mechanisms driving these extreme events remain poorly understood. A prior continent-wide study, which considered only the single largest calving event each year across Antarctica as a whole, found no significant upward trend in this maximum event size over the past several decades. Yet Antarctica's ice shelves have continued to lose mass and thin overall, a trend that may instead stem from smaller, more frequent calving events, a possibility the previous approach could not test.
To address this gap, we apply extreme value theory, a statistical approach to model extreme calving events separately to 21 Antarctic ice shelves, the 20 with the most complete records in our dataset and the Ross Ice Shelf for insight into a large shelf, rather than to Antarctica be driving continued as a whole. This approach defines "extreme" as any calving event that crosses a set threshold, rather than only the single largest event each year, directly capturing the smaller, more frequent events that may mass loss.

For each shelf, we tested whether the size and timing of extreme calving events are better explained by models that incorporate environmental covariates (the Antarctic Oscillation, Southern Oscillation Index, local sea surface temperature, and Multivariate ENSO Index) than by models that assume extreme calving occurs independent of environment. We also tested, shelf by shelf, whether the risk of extreme calving is changing over time. Results varied substantially by shelf, with environmental conditions influencing different characteristics of extreme events but more often shaping their variability or behavior than the magnitude of the most extreme events. For example, sea surface temperature improved model fit for only 3 of 21 shelves when tied to event magnitude, compared to 7 of 21 for variability and 10 of 21 for upper-tail behavior. The time trend was significant for all shelves but varied in sign, unlike prior continent-scale work, which found a uniformly decreasing trend and wasn't statistically significant. These results show that extreme calving behavior, and its environmental sensitivity, is not uniform across Antarctica, emphasizing the need for shelf-by-shelf analysis. Identifying environmental drivers of extreme calving will ensure future project impacts and inform how ice-shelf stability, sea level, and Southern Ocean ecosystems respond.

Rates of postglacial Antarctic Ice Sheet thinning rival future projections

Roger Creel, Ryan Venturelli, Anna Ruth Halberstadt, Sam Chester, Ava Nordgren, John Schiavo

Reconstructions of past Antarctic Ice Sheet thinning are ground-truthed using geologic records from terrestrial cosmogenic nuclide measurements. However, rates of cosmogenic nuclide thinning have historically been oversimplified with linear approximations; and how past rates compare to projected future change remains poorly understood. We reconstruct Antarctic Ice Sheet thinning since Last Glacial Maximum using 766 quality-controlled cosmogenic nuclide measurements at 147 sites across Antarctica, then compare past thinning to modern and projected rates at adjacent ice streams using the ICESat-2 observational record and ISMIP6 projections. When aggregated, cosmogenic nuclide profiles capture regional trends that align with global climate fluctuations, are robust to modeling choices, and yield rate distributions whose time dependence offers quantitative insight into driving processes. Under sustained high emissions, maximum postglacial rates are 59% (57–61%, 95% credible interval) likely to exceed modern rates, 53% (46–60%) likely to exceed rates by 2100, but only 15% (11–21%) likely to exceed rates by 2300. Our results indicate that Antarctica may soon thin faster than it has since Last Glacial Maximum—a finding with implications for which Antarctic areas will next become ice free.

Optimizing Airborne Gravimetry Data to Investigate the Bathymetry of the Sub-Ice Shelf Continuation of Hayes Bank in the Eastern Ross Sea, Antarctica

Giselle DeSousa, Kirsty Tinto, Caitlin Dieck Locke

The Antarctic Ice Sheet has a global sea-level-rise potential of 58 m, 19% of which drains through the Ross Ice Shelf. At present, the ice shelf buttresses the flow of ice from the ice sheet to the ocean, the effect of which is significantly reduced if the ice shelf thins or collapses. Below the Ross Ice Shelf, ice-shelf-basal melting is a function of ice-ocean-Earth interactions and is influenced by the shape of the seafloor beneath the ice shelf, which controls how the ocean circulates below it. This study investigates how the seafloor bathymetry of Hayes Bank in the Eastern Ross Sea impacts the flow of warm modified Circumpolar Deep Water into the ice-shelf cavity. Airborne gravity data from four gravimeters flown during the ROSETTA-Ice and Operation IceBridge projects were analyzed to maximize reliability and resolve small-scale features, ultimately informing which data inputs and modeling process were used to resolve the bathymetry of Hayes Bank. Specifically, a 1018 m trough was identified at Hayes Bank which is at least 375 m deeper than previous bathymetry models.

Multi-instrument Calibration of Aerogravity over the Ross Ice Shelf

Caitlin Dieck Locke, Kirsty Tinto

An understanding of the bathymetry beneath floating ice shelves is important for predicting future Antarctic Ice Sheet stability and sea level rise. Bathymetry governs how ocean waters circulate and access the grounding line beneath ice shelves, and it is difficult to map in the coastal areas of Antarctica due to ice-covered waters which limit multibeam and satellite mapping. In these hard-to-map regions, airborne gravity data can be used to generate high-resolution maps of the sub-ice-shelf bathymetry beneath ice shelves. From 2015 to 2017, the ROSETTA-Ice project collected a comprehensive dataset of airborne gravity data over the Ross Ice Shelf in Antarctica with multiple gravity systems. Here we present a revised gravity map of the Ross Ice Shelf based on a combined reprocessing of old data from different instruments, including applying a temperature-based calibration to data from an iMAR strapdown gravimeter. This temperature correction method was applied to the entire iMAR gravity dataset to provide increased data coverage, refined accuracy, and a finer resolution product for the ROSETTA-Ice project. We also consider the implications of this increased resolution on former pinning points near Steershead Ice Rise.

Coupled impacts of the coastal ocean and subglacial discharge on ice shelf basal melt

Mike Dinniman, Pierre St-Laurent, Wilson Sauthoff, Matthew Siegfried

Satellite altimetry has demonstrated that a dynamic hydrologic environment exists beneath fast-flowing portions of the Antarctic ice sheet. These subglacial meltwater systems vary on timescales of months to centuries and export freshwater from the continental interior to the global ocean through an interconnected network of subglacial streams, rivers, and lakes, then across the grounding zone, where the ice sheet transitions to floating ice shelves. Freshwater export from the subglacial system modifies ice-ocean processes both locally at the outflow point, as a result of meltwater forming buoyant plumes that drive increased ice shelf basal melt at the grounding zone and beyond, and regionally, due to circulation modification in ice shelf cavities and beyond ice shelf fronts. Meanwhile, water mass modification in front of ice shelves due to sea ice formation in polynyas impacts the temperature of water flowing into ice shelf cavities and thus modifies basal melt.

Here, we adapt coupled ocean/ice shelf/sea ice models to include time- and space-varying freshwater discharge into sub-ice shelf cavities. In simulations from an idealized domain, basal melt near the outflow point increases with discharge flux as expected. However, when these simulations include active polynya processes in front of the ice shelf, the integrated melt over the entire ice shelf does not monotonically increase with discharge. The non-discharge driven portion of the melt variability is controlled by changes in the deep temperatures on the open continental shelf. The critical depth on the continental shelf for the driving temperatures varies with ice shelf morphology, which means the impacts on the basal melt of vertical mixing in the polynya also vary with ice shelf morphology.

Simulations were also performed using a realistic domain for the Amundsen Sea with time varying freshwater discharge into Thwaites Ice Shelf cavity based on satellite altimetry estimates of subglacial lake volume change (Sauthoff et al., 2026, GRL). A large discharge event in 2013-2014 not only significantly increased simulated melt under portions of the Thwaites Ice Shelf, but also decreased melt in portions of ice shelves (Crosson and Dotson) downstream from Thwaites.

Triple oxygen isotope evidence for cryogenic brine formation and low-temperature alteration of sedimentary biogenic opal in the Ross Sea

Justin Dodd, Gavine Piccione, Daniel Ibarra

The extent to which ambient seawater permeates and interacts with submarine sediments and silicate minerals is a critical constraint on the timing and rate of in situ subseafloor silicate weathering. Standard oxygen isotope ($\delta^{18}O$) values of biogenic opal in marine records often present seemingly inconsistent oceanographic and diagenetic histories. Over the past several decades the $\delta^{18}O$ values of biogenic opal in Southern Ocean sediments have been put forward as a potential high-latitude analog for other proxies (e.g., foraminiferal $\delta^{18}O$ values) that are not as prevalent in Antarctic-margin marine sediments. These uncertainties largely arise because neither formation temperature (e.g., growth, burial, or alteration) nor the modification of seawater $\delta^{18}O$ values through water–rock interactions is well constrained. However, the triple oxygen isotope ($\Delta^{17}O$) approach provides additional constraints on the diagenetic temperature and oxygen isotope values of diagenetic water.

Here we present a case study of $\Delta^{17}O$ variations in biogenic opal from marine sediment cores from the Ross Sea, Antarctica. Cores collected during IODP Expedition 374 and the ANDRILL McMurdo Ice Shelf program contain well-preserved biogenic opal (diatomite) of middle Miocene to Pleistocene age (~16.5–2.2 Ma). The mineral structure of opal from these sites (IODP U1521 and U1523; AND-1b and AND-2a) ranges from opal-A to chert, and the $\Delta^{17}O$ values reflect isotopic equilibrium with significantly modified seawater at a range of temperatures consistent with the geothermal gradient and burial depth. Measured $\Delta^{17}O$ values for all opal samples fall below the seawater equilibrium curve and likely reflect equilibration with altered seawater in pore waters. The abundance of hydrous mineral phases (e.g., mirabilite, authigenic clays) in the Ross Sea cores indicate that water-rock interactions may have also modified the pore water $\Delta^{17}O$ values in the older or more diagenetically altered sediments. Pore water $\delta^{18}O$ values and water chemistry at the ANDRILL sites suggest the presence of a cryogenic brine with a low $\delta^{18}O$ value; however, at the IODP sites on the continental shelf and slope, pore water $\delta^{18}O$ values are closer to that of modern Ross Sea Bottom Water. In Antarctic marine sediments, the $\Delta^{17}O$ variability appears to record significant in situ subseafloor modification of seawater oxygen isotope values through cryogenic brine formation. Constraining the timing and extent of these alterations is, therefore, essential for refining models of cryogenic brine formation, sea ice extent, and Ross Sea Bottom Water formation during past warmer-than-present climate intervals.

ITASE Redrilling: Bridging the Gap Between Paleoclimatic and Modern Accumulation Variability in Antarctica

Advik Eswaran, Olivia Truax, Shelley MacDonell, Kenichi Matsuoka, Peter Neff, Eric Steig, Holly Winton, T.J. Fudge

Projections of future sea level contribution from Antarctica have high uncertainties and it remains unclear whether increasing Antarctic accumulation will outpace increases in dynamic ice loss. In order to better understand the drivers and future variability of Antarctic accumulation, it is important to understand how it has changed in the past. Instrumental and satellite observations are reliable only since ~1979, leaving ice cores as the primary record of pre-satellite-era accumulation variability in Antarctica. An underappreciated challenge is that ice core records are temporally constrained in the modern era, limiting overlap with high quality reanalysis. Most ice cores were drilled in the 1990s and early 2000s as part of initiatives such as the International Trans-Antarctic Scientific Expedition (ITASE). Of 84 annually resolved accumulation records in Antarctica, only 32 extend past 2000 and only 4 past 2010. We seek to bridge the gap between paleo and present-day climate records by evaluating which Antarctic ice cores would be best to redrill to constrain the annual variability in Antarctic accumulation.

We use an optimal sensor approach which has been established in the paleoclimate field as a site selection tool, but has only recently been adapted to ice cores (Eswaran et al., under review). We find that the suite of US-ITASE cores in inland WAIS, originally drilled in the early 2000s, are the most optimal to redrill to constrain Antarctic accumulation and sea level contribution. It is not necessary to redrill every ITASE core to capture most of the potential signal. We find that drilling three ~10-15 shallow cores at the WAIS Divide, 1999-1, and 2001-2 sites is a plan that would maximize scientific return while being logistically feasible. These cores, if redrilled, would provide a valuable inland complement to recent cores drilled on coastal ice domes in the Amundsen Sea region (Neff, 2020). These potential new records would optimize our ability to bridge the gap in understanding between pre-industrial and present-day Antarctic sea level contribution, and would thus help us constrain projections of the future contribution.

Uncertainty in CDW access to the Grounding Line from Stochastic Gravity Inversions of Sub-ice-shelf Bathymetry

Michael Field, Emma MacKie

Sub-ice-shelf bathymetry influences how circumpolar deepwater moves up the continental shelf and circulates below ice shelves. Thus, the shape of the seafloor partly controls the rate of basal melting, which is responsible for destabilizing ice shelves around Antarctica. Sub-ice-shelf bathymetry is best inferred using airborne gravity, which is sensitive to the large density contrast between water and rock. However, gravity inversions are poorly constrained and require the interpolation of the Bouguer disturbance, which represents crustal density anomalies and crustal thickness. Previous inversions have typically interpolated the Bouguer field deterministically, producing a single inversion result and failing to robustly capture the spatial uncertainty of the problem. We use geostatistical interpolation to create realizations of the gravity field that represent different scenarios of subglacial geology. We solve each inversion in the ensemble with a Regularized Gauss-Newton approach that minimizes the misfit between the forward modeled and observed gravity data while preventing overfitting. Our ensemble members differ from previous estimates by hundreds of meters with important implications for sub-ice-shelf circulation. We analyze how the uncertainty in bathymetry translates to uncertainty in basal melting using a metric for Circumpolar Deep Water (CDW) access to the grounding line known as the Highest Unconnected Isobath (HUB). We present important features of the new bathymetry ensembles and discuss the implications of the uncertainty in the HUB metric on basal melting.

EDGE: Tracking Change at the Ice Margins

Helen Amanda Fricker

The Earth Dynamics Geodetic Explorer (EDGE) mission was selected by NASA in February 2026 through the Earth System Explorer competition and offers a transformative new capability for West Antarctic Ice Sheet (WAIS) science beyond its planned 2030 launch. Building on the legacy of ICESat, GEDI, and ICESat-2, EDGE is NASA's first spaceborne swath-mapping laser altimeter, combining an order-of-magnitude improvement in spatial and temporal sampling with <8 cm vertical accuracy on low slopes. Its five 120-m-wide "mini-swaths" will resolve surface-elevation change at the scale of features linked to key ice-sheet processes, including grounding zones, basal channels, rifts, and ice fronts, as well as individual sea ice floes. These features and processes govern WAIS stability and future sea level rise but are currently poorly resolved from space. As we enter the 2030s, resolving them will be critical for improving projections of future ice loss and sea-level rise. EDGE also embodies an Earth-system perspective: its common lidar measurements of land ice, sea ice, vegetation, and coastal environments provide an opportunity to connect changes across the cryosphere, terrestrial ecosystems, and ocean. EDGE establishes a scalable path toward sustained spaceborne lidar observations beyond a single mission, creating new opportunities to monitor and understand a rapidly changing WAIS within its broader Earth-system context.

Spatiotemporal Distribution of IBRD in East Antarctic Marine Sediment Cores

Gabriela Gaarder, Lauren E. Miller, Natalia Varela, Alejandra Gonzalez, Ryan Venturelli, Lindsay Prothro, Kara Vadman

The majority of Antarctic Ice Sheet (AIS) mass loss today is driven by warm-water intrusion and ice-shelf thinning and collapse. The AIS primarily loses mass through solid ice discharge, transporting terrigenous sediments deposited as iceberg-rafted debris (IBRD), a proxy for iceberg discharge, ice-sheet dynamics, and ocean conditions. IBRD in marine sediment cores spans a wide grain size range depending on subglacial sediment characteristics, but the >125 µm fraction is typically used to identify its presence. Yet, reliance on this fraction alone likely underestimates the full IBRD signal. Computed Tomography (CT) scanning is increasingly used to non-destructively identify millimeter-scale stratigraphy and sedimentary components. We couple qualitative and quantitative CT observations with laser particle size analysis (LPSA), elemental geochemistry (XRF), scanning electron microscopy (SEM) of quartz grain micro-textures, and magnetic susceptibility (MS). We adopt an index that systematically considers multiple independent analytical indicators and stratigraphy observed in CT scans to better identify the full range and distribution of IBRD. Using this approach, we examine the temporal distribution of IBRD in East Antarctic sediment cores across the continental shelf and slope, assess whether IBRD occurs as background deposition or discrete event layers, and evaluate the utility and limitations of CT scanning for legacy sediment cores. We apply these methods offshore East Antarctica near Prydz Bay, where the largest glacier–ice shelf system drains into the Southern Ocean, and marine sediments preserve a record of deglaciation since the Last Glacial Maximum (LGM). CT scans reveal increased downcore IBRD deposition among NBP0101 cores from Svenner Channel and Nielsen Basin, but severe desiccation of some cores limits their usefulness. In these cases, the IBRD index enables identification of IBRD via other analytical parameters. Across the continental shelf and Prydz Channel, IBRD occurs as background deposition, indicating frequent but low-magnitude iceberg discharge. These findings provide a more complete reconstruction of iceberg discharge during deglaciation, improving interpretations of LGM East Antarctic ice-sheet retreat and highlighting the value of legacy core data.

Atmospheric Rivers as Heat and Moisture Conduits to the West Antarctic Interior: Their Role in Driving Heat Waves and Potential Coupling to Sea Ice Variability

Sérgio José Gonçalves Jr., Heitor Evangelista, Luciana Prado, Newton de Magalhães Neto

Atmospheric rivers (ARs) are increasingly recognized as key synoptic-scale mechanisms delivering heat and moisture to the Antarctic ice sheet margins, with documented links to surface melt and ice-shelf weakening on the Antarctic Peninsula and East Antarctic coast. Far less is known about their role in the continental interior of West Antarctica, where in-situ observations remain scarce. Here we use temperature records (2013–2025) from Criosfera 1, a Brazilian automatic weather station located at 84°S, 79.5°W in the West Antarctic interior, well removed from the coastal margin that dominates existing Antarctic extreme-event literature, to characterize the atmospheric drivers of interior heat waves (HWs) and their potential relevance to the marine cryosphere.

We identified 101 HW events using a percentile-based definition (daily mean temperature exceeding the local 90th percentile for at least 3 consecutive days), consistent with ETCCDI/WMO extreme-event guidelines. Integrated water vapor and integrated vapor transport were computed to assess AR association using the Ralph et al. (2019) AR Scale, showing that 76.2% of measured HW events coincided with AR landfall, establishing ARs as the dominant synoptic mechanism behind interior warm extremes. This association strengthened over time: annual AR-HW association rates peaked at 100% in 2020 and 2021, and have remained high since (80–92% from 2022–2025), compared to a 2013 baseline of only 30%. A subset of six events displayed clear tropical-source moisture trajectories, indicating direct low-to-high-latitude teleconnections into the West Antarctic interior. To place these observations in a longer-term context, we extended the record back to 1940 using a bias-corrected ERA5 reconstruction (three-tier regression by temperature band; $R^2=0.98$), statistically indistinguishable from the measured Criosfera 1 series ($\chi^2=3.44$, $p=0.99$), revealing 453 HW events with a significant increasing trend (+0.0825 events/yr, $p<0.0001$) and long-term warming roughly seven times faster than the South Pole (+0.04°C/yr, 1940–2012). We also compared HW frequency with Antarctic sea ice area (SIA) anomalies (NSIDC Sea Ice Index v4, 1979–2025). No significant linear relationship was found (Pearson $r=-0.073$, $p=0.627$, annual series). However, the post-2016 period shows a visually coincident pattern: a sustained, unprecedented SIA decline (minima in 2017, 2022–2023, and 2025) co-occurs with the highest and most variable HW frequencies of the full 1980–2025 record (up to 13–14 events/yr, versus a 5–10 events/yr baseline in earlier decades), alongside rising ERA5-derived surface albedo variability over the >50°S domain. While this does not establish direct linear coupling, it is consistent with ARs acting as a shared atmospheric mechanism capable of simultaneously destabilizing sea ice margins and driving heat transport into the continental interior, a pathway warranting direct AR-frequency testing against SIA in future work. Correlations between HW frequency and the Antarctic Oscillation/SAM index were also non-significant ($r=0.081$–0.087, $p>0.5$), further supporting ARs, not annular modes, as the primary driver. These findings position AR-driven heat transport as an underexplored pathway linking atmospheric extremes in the West Antarctic interior to broader marine ice-sheet vulnerability.

Modeling Accelerated Ice Loss in Transient Antarctic Simulations with Supraglacial Melt Lake Depth-Driven Calving

Danielle Grau, Mattia Poinelli, Nicole-Jeanne Schlegel, Hélène Seroussi, Alexander Robel

The dynamics of supraglacial melt lakes have been linked to large-scale Antarctic ice-shelf collapse, such as that observed at Larsen A and B ice shelves in the early 2000s. As Earth's climate continues to warm, surface melt and supraglacial melt lake formation are expected to increase. Presently, there is minimal representation of the effects of supraglacial melt lakes in large-scale ice sheet models. In this work, we introduce a set of parameterizations into the Ice-sheet and Sea-level System Model (ISSM) to simulate the effects that supraglacial melt lakes have on fracture propagation and calving. We show the influence of incorporating these interactions on a benchmark ISMIP6 simulation by comparing them to simulations that (1) do not include the presence of supraglacial melt lakes and (2) model the instantaneous collapse of all floating ice in Antarctica. We discuss caveats, future directions of this work, and its implementation into the ISMIP7 protocol.

Model-data investigation of Holocene retreat-readvance in the Western Ross Sea

Anna Ruth Halberstadt, Ryan Venturelli, Roger Creel, Lindsay Prothro, Theresa King

A growing body of evidence indicates that the Antarctic Ice Sheet retreated and then readvanced during the Holocene, potentially in multiple regions and during multiple events. This behavior provides insight into both ice-sheet sensitivity to warmth as well as ice sheet resilience following retreat. Investigation of retreat-readvance behavior has so far focused primarily on the Siple Coast grounding line, where models have been used to test proposed processes driving ice sheet readvance (e.g., glacial isostatic adjustment, ocean forcing of basal melt rates; Kingslake et al., 2018, Lowry et al., 2024, for example).

Here we shift the focus to the Western Ross Sea, another location where Holocene retreat-readvance behavior has been implicated from marine seafloor landforms (Greenwood et al., 2018). We leverage marine and terrestrial datasets, numerical ice sheet modeling, and a suite of developing metrics for model-data comparison, to build a holistic picture of this grounding-line retreat and readvance sequence. Physically consistent models integrate across marine and terrestrial environments, allowing us to link the observed marine grounding line retreat-readvance event with terrestrial ice thickness changes recorded at adjacent exposure age sites along the Transantarctic Mountains. Data-consistent model simulations constrain the spatial extent and timing of this retreat-readvance sequence, and test possible processes that could have supported readvance, including changes in marine forcings as well as terrestrial outlet glacier flow through the Transantarctic Mountains.

When do solid Earth and sea-level feedbacks become important in AIS projections?

Holly Han

Extensive studies using coupled ice-sheet and sea-level/glacial isostatic adjustment (GIA) models over the past couple of decades have demonstrated that feedbacks between the ice sheet, solid Earth, and sea level can have substantial effects on the dynamic evolution of the Antarctic Ice Sheet. However, the ice-sheet modeling community focused on future projections and the GIA modeling community have adopted different levels of complexity in representing solid-Earth deformation associated with ice-mass changes. While more recent coupled 3-D GIA modeling studies have demonstrated the potential for lateral variations in Earth structure to strongly influence ice-sheet evolution, the magnitude of this influence depends not only on Earth structure, but also on the ice-evolution scenario and ice-sheet/bed configuration. An important question therefore remains: under what conditions do solid-Earth and sea-level feedbacks become important for Antarctic Ice Sheet projections, and what level of Earth-model complexity is required to capture them? In this talk, I will give an overview of the physics and modeling of interactions between the ice sheet, solid Earth, and sea level, discuss what existing coupled-model experiments tell us about when these feedbacks may become important, and suggest research directions that should be prioritized over the next decade and toward the next International Polar Year (IPY), particularly in the context of projections of ice-sheet contributions to sea level (e.g., ISMIP7).

Investigating Glacial Retreat and Biological Productivity in coastal settings of the Amundsen Sea: Cranton Bay, Antarctica

Megan Hansen, Rebecca L. Totten, Claus-Dieter Hillenbrand, Marianne Heberlein, Colton Byrne, Jacob Helgeson, Robert Larter, Julia S. Wellner, James A. Smith, Lauren E. Miller, Alastair G.C. Graham, Kelly A. Hogan, Frank O. Nitsche

With accelerated ice mass loss from the Amundsen Sea sector of the West Antarctic Ice Sheet, recent field campaigns have focused on Thwaites and Pine Island glaciers and surrounding areas offshore. Cranton Bay, a small and relatively shallow bay located within the Pine Island Bay Polynya, is a newly explored area within the Amundsen Sea Embayment (ASE). Cranton Bay deglaciated by the Early Holocene and today is characterized by the highest levels of biological productivity of the ASE, even in comparison to the productivity of polynyas offshore. This study is among the first investigations of sediment cores that aims to elucidate the drivers behind this uniquely high biological productivity in Cranton Bay.

Here we compare multiproxy data from marine sediment cores NBP19-02 KC27 and NBP20-02 JGC74 (the latter was recovered from the same site as the previously published core NBP20-02 KC72), which had been retrieved from Cranton Bay during expeditions by the Thwaites Offshore Research (THOR) Team of the International Thwaites Glacier Collaboration. To investigate trends in primary productivity and their potential drivers throughout the Holocene, we analyzed the physical, chemical, and biological stratigraphy of the sediment cores using Computed Tomography scans, magnetic susceptibility data, X-ray fluorescence (XRF) scans, laser particle size distributions, stable nitrogen and carbon isotopes of the bulk sediments, Total Organic Carbon (TOC), total nitrogen contents, diatom abundance, and foraminifera assemblages.

Two radiocarbon ages obtained from calcareous benthic foraminifera near the base of KC27 indicate that the northeastern part of the bay deglaciated by ca. 9.6 14C kiloyears Before Present (ka BP, uncorrected). XRF data show variable Fe/K, Ca/Ti, and Si/Ti ratios in the early Holocene, followed by a spike in Ca/Ti ratios in the mid Holocene. A sharp decrease in Ca/Ti ratios in the mid Holocene coinciding with increasing TOC may indicate a shift to higher rates of land-derived terrigenous input in the Late Holocene. Late Holocene-age sediments include up to 1.0 wt% of TOC, more negative sediment $\delta^{13}C$ ratios, and consistent presence of benthic foraminifera, indicating higher biological productivity in Cranton Bay during the Late Holocene. Diatom abundance is low in the basal sediments and dramatically increase in the upper core, also supporting higher biological productivity in Cranton Bay during the Late Holocene. Ongoing analysis of XRF data alongside laser particle size distributions should reveal more detailed environmental information, allowing us to test whether increased iron supply by icebergs or meltwater plumes were the main initiator of productivity in Cranton Bay. Uncovering the drivers of such patterns and changes in biological productivity will be critical to predicting how accelerating deglaciation may impact the global carbon cycle and Antarctic marine ecosystems.

Subglacial Groundwater Exfiltration is Negligible Today, but Substantial Under Future Antarctic Ice Loss

Rohaiz Haris, Matthew Siegfried, Brandon Dugan, Trevor Hillebrand, Alexander Robel, Ryan Venturelli

The influence of subglacial hydrology on ice flow is key to modeling the future evolution of the Antarctic ice sheet, but many characteristics of the system are poorly constrained. Water can permeate into sedimentary basins underlying these subglacial hydrologic systems and form a deeper (~10 m to >1000 m below the ice base) groundwater system. Magnetotelluric and seismic observations have inferred these groundwater systems beneath a fast-flowing portion of the West Antarctic Ice Sheet, with recent work suggesting exchange between groundwater reservoirs and water systems at the ice-sheet base. However, existing subglacial hydrology models do not consider groundwater systems and their potential interactions with hydrology systems at the ice-bed interface. Seasonal variations in Antarctic snowfall influence subannual ice mass changes, which may in turn modulate groundwater exfiltration — potentially introducing an uncharacterized subannual variability to the subglacial water budget. Similar subannual groundwater variability has been observed in Greenland, motivating an investigation into Antarctic subglacial groundwater processes and their potential impact on ice-sheet dynamics. Ice-sheet thinning and mass loss is projected to increase substantially under future warming scenarios, driving higher thinning rates than currently observed; since groundwater exfiltration responds to ice-sheet thinning, these projected increases motivate an assessment of how groundwater dynamics will evolve over the coming centuries.

Here, we characterize the contribution of groundwater exfiltration to the subglacial water budget in Antarctica using a newly developed, one-dimensional hydromechanical groundwater model for porous sediments overlain by glacier ice. The model incorporates more realistic geological conditions and is forced by satellite-altimetry-derived thinning rates over 2019–2024 (observational period) and by ice-sheet model output under a range of warming scenarios through 2300 (projection period). We find that groundwater exfiltration fluxes are spatially and temporally variable in the observational period, with small mean fluxes and localized rates approaching 8 mm/yr due to spatial heterogeneity. Comparison with basal melt estimates from the Ice-Sheet Model Intercomparison Project for CMIP6 (ISMIP6) shows that the subannual contribution of groundwater to the subglacial water budget is minor relative to basal melt. Under high warming scenarios, the groundwater contribution to the subglacial water budget grows to as much as 10% of the subglacial water budget in the projection period, though the timing and magnitude of this contribution vary between basins, with impacts for subglacial hydrology, solute transport, and biogeochemical processes.

Revisiting Last Glacial Maximum Ice Stream Retreat Trajectories in the Amundsen Sea Embayment by Comparing Radiocarbon Reservoir Corrections on Deglacial Sediment Ages

Marianne Heberlein, Rebecca L. Totten, Claus-Dieter Hillenbrand, James A. Smith, Robert Larter, Frank O. Nitsche, Julia S. Wellner, John B. Anderson, Alastair G.C. Graham, Lauren E. Miller, Kelly A. Hogan, Johann P. Klages

As global sea levels continue to rise, understanding the contributions of polar ice-sheet retreat to future sea-level rise is critical. Over the last three decades, grounding zones of ice streams draining the West Antarctic Ice Sheet (WAIS) into the Amundsen Sea Embayment (ASE) rapidly receded. To contextualize these recent losses, we reconstruct the timing and rates of retreat trajectories of six major ASE paleo-ice stream systems since the Last Glacial Maximum (LGM). We specifically focus on the most recent retreat of Pine Island and Thwaites glaciers.

To revise existing retreat trajectories, we compiled more than 400 published and new radiocarbon (14C) dates obtained from calcareous microfossils and organic matter (OM) in marine sediment cores recovered from the ASE, spanning the outer to inner shelf. A well-known dilemma when calibrating 14C-dates from Antarctic sediments is the choice of the marine reservoir effect, due to the lack of Antarctic calcareous remains from the 20th Century constraining the regional “pre-atomic bomb” reservoir effect in these basins. We address this by extracting minimum deglacial 14C-dates from the compilation and correcting these using pre-bomb and post-bomb reservoir effects before the calibration. As OM-derived 14C dates can often be biased by fossil carbon derived from glacial erosion, we apply an additional correction to OM dates, which compensates for the reworked, fossil OM mixed with young in situ OM at the time of deposition. We compare pre-bomb and post-bomb reservoirs and determine a systematic framework for deglacial trajectories. To identify chronological outliers, we consider the geomorphological setting of each coring location, and the depositional environment (e.g. grounding-line proximal, grounding-line distal, sub-ice shelf, or open marine) of the sampled interval that provided the minimum deglacial age.

Our results show that while different correction methods can introduce a variability of up to 500 years, most of the calibrated 14C-ages fall within statistical error (±2σ). By integrating our newly obtained 14C-dates with previously published retreat trajectories, we observe various retreat styles across the ASE, with notable differences within the easternmost ASE. The dataset improves the temporal resolution of the Holocene retreat of Pine Island and Thwaites glaciers yet remains in agreement with the 5-kyr time slices of post-LGM retreat published by the RAISED consortium (2014). Our data suggests that the rapid retreat rates in recent decades are indeed unprecedented since the LGM. However, higher temporal resolution is required to resolve short-lived periods of rapid retreat.

1966-2023 Ice Core Annual Snow Accumulation at Canisteo Peninsula, Amundsen Sea, West Antarctica

Lilly Hinkley, Peter Neff, Yeongcheol Han, Vikram Goel, Julia Andreasen, Chaewon Chang, Jangil Moon, Songyi Kim, Kenichi Matsuoka

We present preliminary results from a new 150 m ice core collected in 2024 from Canisteo Peninsula, West Antarctica as part of the international Ross-Amundsen Ice Core Array (RAICA) initiative. The core provides the first high-resolution coastal ice core record from the Amundsen Sea sector and the closest paleoclimate record to Thwaites and Pine Island Glaciers. Constraining snow accumulation history in this region is critical for understanding climate variability near two of the largest contributors to current West Antarctic Ice Sheet (WAIS) mass loss and sea level contribution, where continuous long-term observations remain sparse. Byrd Station's temperature record dates back to 1957 but is more than 500 kilometers inland. Satellite-era observations don't begin until 1979, meaning reanalysis products such as ERA5 are less observationally constrained before that date. Existing WAIS ice cores are also strongly biased toward the interior ice sheet and do not extend past the early 2000s.

The RAICA accumulation record spans 1966-2023, with the first 0-100 m currently available and the lower 50 m in progress, and shows an increasing accumulation trend of approximately 7 mm w.e. yr^{-1}, with a mean accumulation rate of 1.23 m w.e. yr^{-1}. This exceeds regional mean accumulation rates from the WAIS (0.27 m w.e. yr^{-1}, 1966-2010) and Antarctic Peninsula (0.96 m w.e. yr^{-1}, 1966-2010; Thomas et al., 2017). ERA5 net precipitation at Canisteo Peninsula shows no significant trend over the same period and substantially underestimates the observed accumulation, with a mean of 0.54 m w.e. yr^{-1}. Despite this magnitude difference, ERA5 and RAICA accumulation are significantly correlated ($r = 0.54$, $p < 0.001$, 1966-2023), indicating that ERA5 captures a large portion of the observed interannual variability, but fails to reproduce the long-term trend and magnitude of snow accumulation at the site.

Spatial correlation analyses further indicate that ERA5 precipitation variability at Canisteo Peninsula is coherent across spatial scales of approximately 100-500 km, aligned with the dominant meridional moisture transport direction. These spatial relationships provide an initial basis for evaluating the regional representativeness of the RAICA core and identifying the atmospheric processes influencing accumulation in the Amundsen Sea region. Together, these results demonstrate the importance of ice core observations for constraining coastal Antarctic accumulation and other climate variables, highlighting the limitations of reanalysis products in resolving the magnitude and long-term variability of climate in coastal West Antarctica.

Ice fabric determination from quad-polarimetric radar data collected in West Antarctica

Andrew Hoffman, Knut Christianson, Nicholas Holschuh, John Paden

Glacier ice is a polycrystalline material with properties that reflect the collective orientation of mechanically and dielectrically anisotropic ice crystals. The distribution of crystal c-axis orientations defines an ice parcel's Crystal Orientation Fabric (COF). Ice deformation drives c-axis rotation, strengthening fabrics and inducing bulk dielectric permittivity anisotropy in glacial ice. Polarization-dependent travel-time and phase differences in radar data provide a way to infer COF direction and strength. The radar-determined COF can then be used to estimate effective ice viscosity and infer the regional ice-flow history responsible for the observed COF development.

Here we present new quad-polarimetric radar measurements and polarimetric crossover analyses of legacy radar data with coincident 3D radar data across several different ice-flow settings in West Antarctica. Using an open source processing workflow implemented in the Open Polar Radar (OPR) toolbox, we co-register focused co-polarized radargrams to estimate the phase differences between orthogonally polarized returns. While these measurements cannot uniquely constrain the permittivity tensor, they provide minimum estimates of fabric strength and allow broader regional coverage where polarimetric radar data have not yet been collected. At Thwaites Glacier, Antarctica, polarimetric data suggest that strong horizontal fabric develops within the eastern shear margin, coincident with folded layers. Near the onset of the stagnating Kamb Ice Stream, fabric strengthens with depth, consistent with shutdown hypotheses for the Gould Coast Ice Streams. We use a fabric-evolution model to test whether the strength and orientation of fabrics in the Thwaites Eastern shear margin are consistent with the modern flow field, or if they require changes in margin position or flow direction over the Holocene.

Quantitatively identifying Mid-Pleistocene glacial to interglacial ice margin dynamics in the Ross Sea, Antarctica

Halima Ibrahim, Imogen Browne, Molly Patterson

Understanding West Antarctic Ice Sheet (WAIS) sensitivity to natural forcing requires detailed lithofacies classification and quantitative methods to resolve ice-marginal processes across glacial-interglacial cycles. We apply unsupervised multivariate clustering to quality-controlled, high-resolution XRF and shipboard physical property data from IODP Site U1525 (eastern Ross Sea continental slope) to build an objective lithofacies framework for Unit II, spanning the Mid-Pleistocene Transition (MPT). We then examine orbital-scale variability in the lithofacies-discriminant proxies to explore how the Ross Sea ice margin responded to orbital forcing across glacial, deglacial, and interglacial periods of the MPT. Preliminary results show the clusters carry distinct geochemical and physical property signatures that significantly correspond to independently described lithofacies from traditional methods. The stratigraphic and temporal pacing of lithofacies reveals shifting roles and combinations of forcing factors on the ice margin across glacial-interglacial cycles, consistent with an orbitally sensitive marine-based ice margin during this interval. This approach offers a transferable framework for objective, reproducible facies classification in glaciomarine archives.

Assessing the Influence of Glacial Cavity: Pb Isotopes Unveil the Amundsen Sea Pb Cycle

Yerim Kim, Teagan Bellitto, Edward Boyle, Franco Marcantonio, Jessica Fitzsimmons

Lead (Pb) in the ocean carries a natural and anthropogenic isotopic fingerprint that has been used for decades to trace the sources of the element and its circulation. Over the past 60 years, anthropogenic Pb inputs have overwhelmed the natural Pb cycle globally by gasoline additives, smelting, and various other industrial activities. The recent reductions in industrial Pb use are beginning to restore natural signatures in some regions; however, legacy anthropogenic Pb continues to circulate and reach even the most remote ocean basins, including the Antarctic margin. Here, we present dissolved Pb concentrations and isotope ratios from the Amundsen Sea continental shelf, West Antarctica, collected during the U.S. GEOTRACES GP17-ANT cruise, which is the first high-resolution characterization of Pb isotope distributions in this region. Circumpolar Deep Water (CDW), carrying a legacy anthropogenic Pb signature, intrudes onto the shelf and mixes with Winter Water to form modified CDW (mCDW). This mixing alone cannot explain the observed mCDW Pb distribution: isotope mass balance indicates that ~20% of CDW-derived Pb is removed by scavenging during transit across the shelf, and a calculated 206Pb/207Pb of 1.179 for the resulting mCDW closely matches our measured value of 1.181. As the water approaches the coast, dissolved Pb isotope ratios shift toward more lithogenic (crustal) signatures. To resolve whether this trend is a result of anthropogenic Pb removal, lithogenic Pb addition, or both, we compared Pb inventories and isotope ratios in water masses flowing into and out of the sub-ice-shelf cavity beneath Dotson Ice Shelf. The concentration difference between cavity inflow and outflow shows that meltwater–rock interaction within the cavity contributes approximately 30% of the total Pb inventory exported from the cavity. Isotope mass balance further constrains the 206Pb/207Pb ratio of this internally supplied Pb at 1.210, which is a value that accurately matches the Antarctic crustal endmember reported by Ndungu et al. (2016). This agreement identifies subglacial meltwater–rock interaction as a quantitatively significant, previously unrecognized lithogenic Pb source to the Amundsen Sea shelf. These results demonstrate that basal melting beneath Antarctic ice shelves does not merely dilute or freshen shelf waters but actively mobilizes crustal trace metals into coastal biogeochemical cycles. As ice shelf melt rates are projected to increase, this glacially sourced lithogenic Pb flux may become an increasingly important component of trace metal supply to consider in Antarctic coastal ecosystems, with implications for metal bioavailability in one of the ocean's most biologically productive and climate-sensitive margins.

Ndungu, Kuria, et al. "Lead sources to the Amundsen Sea, west Antarctica." Environmental Science & Technology 50.12 (2016): 6233-6239.

CryoStack: A Unified Cyberinfrastructure Platform for Reproducible Ice-Sheet Modeling, Data Assimilation, and Scientific Computing across HPC and Cloud Environments

Brian Kyanjo, Alexander Robel

Advances in ice-sheet science increasingly rely on computationally intensive numerical models, data assimilation systems, observational datasets, and scalable computing resources. However, deploying and managing community software remains a significant challenge. Installing complex scientific applications, configuring heterogeneous computing environments, adapting workflows across different high-performance computing (HPC) systems, and reproducing computational experiments often require substantial technical expertise. These barriers slow scientific collaboration, reduce reproducibility, and limit broader participation in computational cryosphere research.

We present CryoStack, an extensible cyberinfrastructure platform that simplifies the deployment, execution, and management of computational cryosphere workflows across HPC and cloud computing environments. Through a unified web-based interface, CryoStack enables researchers to configure, launch, monitor, visualize, and reproduce computational experiments without requiring direct interaction with the underlying computing infrastructure. The platform integrates secure user authentication, persistent workspaces, experiment tracking, configuration management, remote job execution, and cloud-enabled workflows into a single reproducible scientific environment.

Rather than serving a single modeling code, CryoStack has been designed as a general scientific computing platform capable of supporting multiple classes of cryosphere applications through a common execution architecture. Current integrations include CryoLauncher for community ice-sheet models (currently ISSM and Icepack), the ICESEE data assimilation framework, and LIVIST for living ice sheet temperature radar/borehole exploration, visualization, and analysis. The platform is designed to onboard additional community software—including PISM, Elmer/Ice, SICOPOLIS, preprocessing utilities, visualization tools, and future analysis frameworks—without redesigning the surrounding infrastructure for authentication, experiment management, storage, visualization, or execution. This modular architecture enables scientific applications to share common cyberinfrastructure while preserving their application-specific workflows and scientific capabilities.

A distinguishing feature of CryoStack is its flexible compute architecture. Researchers can execute workflows across institutional HPC clusters, national cyberinfrastructure, and cloud computing resources through a consistent interface. In addition to supporting traditional remote HPC execution, the platform provides a pathway for user-managed cloud deployments, allowing researchers to leverage their own cloud accounts, computing allocations, and credits without modifying scientific workflows. This enables computational portability across diverse research environments while preserving a consistent user experience.

CryoStack emphasizes reproducibility throughout the computational lifecycle. Computational environments, experiment configurations, execution metadata, provenance, and job histories are preserved alongside scientific results, allowing computational studies to be reproduced, compared, audited, and shared across computing platforms. By separating scientific workflows from infrastructure management, CryoStack enables researchers to focus on scientific discovery rather than software installation, system administration, or platform-specific execution details.

As computational cryosphere research continues to expand in complexity, scale, and collaboration, sustainable scientific progress will depend not only on advances in models and observations but also on the cyberinfrastructure that enables the efficient development, deployment, and sharing of these tools. CryoStack represents a step toward a community-wide computational ecosystem in which scientific applications can evolve independently while benefiting from common services for execution, reproducibility, and resource management. By reducing duplicated infrastructure development, lowering barriers to advanced computing, and providing a sustainable foundation for integrating future community models, data assimilation systems, observational analysis tools, and emerging computational methodologies, CryoStack aims to strengthen collaboration and accelerate scientific discovery across the cryosphere community.

Unfreezing Glen's n: The Sensitivity of Antarctic Grounding-Line Flux to Ice Rheology

Siobhan Light, Tamara Pico, Sam Kodama, Erica Lucas, Ching-Yao Lai, Alexander Robel

Antarctic ice flow rates dictate projections of future ice mass loss and sea level change, and ice rheology is typically modeled using Glen's power law with a stress exponent of n=3. Although studies suggest that the stress exponent n may be spatially variable across Antarctica, it is unclear how local ice rheology will affect grounding line flux, and therefore the potential location of future pinning points, as ice margins evolve over the next century.
Here, we explore the sensitivity of grounding line flux to values of n across multiple regions in Antarctica by performing an ensemble of simple marine-terminating ice-stream simulations. Our simulations calculate grounding-line flux for a range of values of upstream surface mass balance, ice shelf buttressing, and basal friction, for ice streams feeding into the Amery, Nansen, Ross, Filchner-Ronne, and Larsen C ice shelves and those draining into the Amundsen Sea Embayment. Our simple grounding-line flux model allows us to sample a wide parameter space of glaciologic conditions at high resolution (500 m), without the computational cost of 3D dynamic ice sheet models. By using high-resolution topography, we capture how ice rheology modulates the predicted location of negative or positive ice mass balance, thus informing our understanding of potential future pinning points. We also compare our predictions using n=3 to those using recent inferences of n from various Antarctic locations to identify how adopting an appropriate n value affects predicted grounding line flux.
Next, we will evolve present-day bedrock topography with predictions of glacial isostatic adjustment over the next 100 years in the Amundsen Sea Embayment, where bedrock rebound rates are rapid and spatially-variable due to 3D Earth structure. We will then examine how uncertainties in ice rheology, compounded with shifting topography, propagate into grounding line projections for the next century.

Constraining the flow law of ice with time-dependent inversions

David Lilien, Daniel Shapero, Meghana Ranganathan

The rate of ice deformation is an important control on how quickly the ice sheets move and thus lose mass in response to melt. Deformation is controlled, in part, by the flow-law exponent, which determines how sensitive strain rates are to changes in stress. Recent studies have used satellite measurements at single points in time to infer that the flow-law exponent is higher than commonly assumed. Modeling indicates that a higher exponent might cause a near-doubling of ice loss from the Amundsen Sea Embayment. However, at any single time, other uncertain factors such as ice temperature and grain size complicate the relationship between stress and strain rate. Because these factors may covary with deformation rate, their effects can be misattributed to variation in the flow-law exponent. Yet their slow evolution may allow their effects to be distinguished from those of the flow-law exponent through different temporal signatures.

Here, we present a framework for conducting time-dependent inversions to separate these effects. Using models with synthetic geometry, we show that with sufficient record length the flow-law exponent can be separated from other parameters, even in the presence of noise. We conduct inversions using surface elevation, velocity, or both as constraints; either is sufficient to infer the flow-law exponent, though there is modest benefit to using both in the presence of noise. We use these inversions to estimate the record length needed to confidently infer the exponent under observed rates of glacier retreat and in the presence of realistic noise. Without noise, 1–5 years of data are sufficient to identify the flow-law exponent; with noise, 10–20 years of data are needed. We present initial results from the Amundsen Sea Embayment, showing that such inversions are feasible in realistic settings and yield information unavailable from snapshot inversions.

Large-scale, cross-sphere investigations of West Antarctica using NASA's 777 airborne science laboratory during IPY-5

Joseph MacGregor, Michael Studinger, Lauren M. Zamora, Yuekei Yang, Rachel Tilling, Chad A. Greene, Sarah Dewey, Alex S. Gardner, Lauren C. Andrews, Patrick C. Taylor Mathieu, Morlighem Nathan T., Kurtz Kerri A., Pratt Kirsty J., Tinto Emily J., Arnold Dustin, Carroll Dong L., Wu Sahra, Kacimi Andrew F., Thompson Yasmina M., Martos Manisha, Ganeshan

Earth's polar regions are changing rapidly, creating an urgent need to document the myriad processes unfolding there and to observe undersampled boundary conditions that are critical to improve models of these systems and predictions of their impact on global climate. These regions are changing so rapidly that our ability to make measurements of this transitory state is fleeting. While polar observing capacity has improved in the past decade, satellite remote sensing either does not or cannot yet measure many critical observables, and validation opportunities for satellite retrievals are often sparse. NASA's new 777 airborne science laboratory offers an unprecedented opportunity to advance direct observations of the West Antarctic Ice Sheet, its surrounding oceans, and overlying atmosphere at both large scale and fine resolution, addressing outstanding interdisciplinary challenges there. From South America, the 777 can only travel into West Antarctica about as far as its predecessor (the DC-8) because it only has two engines, but it can survey at this outer limit for significantly longer. Here we summarize these scientific challenges and how they could be addressed using the 777 – from oceanography using air-dropped profilers, to swath-mapped subglacial topography using a mold-line radar sounder, to atmospheric composition using direct-air sampling. The upcoming Fifth International Polar Year in 2032–2033 presents a readily realizable opportunity for polar investigations with this unique observing capability that are synergistic with co-located ongoing and planned activities by national and international partners.

DEMOGORGN Antarctica: Geostatistical Subglacial Topography for Uncertainty-Aware Ice-Sheet Investigation

Emma MacKie, Michael Field, Niya Shao

We present DEMOGORGN Antarctica, a 100-member ensemble of Digital Elevation Models of Geostatistical ORiGiN. This data product provides continent-wide gridded estimates of Antarctic bed elevation at 500 m resolution. In contrast to the BedMachine and Bedmap data products that provide a single ``best'' bed reconstruction, DEMOGORGN consists of multiple geostatistical realizations that quantify uncertainty. Each realization is generated using geostatistical simulation with statistically realistic roughness and is conditioned to satisfy ice mass conservation constraints, which ensures physical coherence with ice-sheet dynamics. We also incorporate updated sub-ice-shelf bathymetric estimates that honor gravity constraints. This ensemble enables the investigation of how subglacial roughness influences ice flow, grounding-line stability, basal hydrology, and ice-ocean interactions. By capturing the range of possible topographies given available geophysical constraints, DEMOGORGN makes it possible to propagate bed uncertainty into ice-sheet models, which provides a foundation for uncertainty-aware sea-level-rise projections.

Funding Glaciological Research to Reduce the Risks of Sea-Level Rise

Lauren Mahle

Projections of sea-level rise contain significant unquantified uncertainties, creating major barriers to effective planning and adaptation in coastal communities worldwide. Sea-level rise will displace millions, with profound consequences for individuals, societies, and ecosystems. Science, especially glaciology, has an important role to play in confronting this global challenge. Yet historically, glaciology has been severely underfunded and under-resourced, limiting our ability to understand the complexities of ice-sheet evolution and to produce reliable sea-level forecasts. Arête Glacier Initiative was founded in March 2024, and officially launched March 2025, to help address this gap in funding and support. At Arête, we fund and coordinate research aimed at rapidly improving sea-level forecasts and responsibly exploring potential interventions that could slow sea-level rise - reducing harm to people and coastal ecosystems and buying critical time for global decarbonization. In this poster, we will share our guiding principles, strategic priorities, organizational model, and existing and upcoming funding opportunities. Arête was founded by glaciologists, for glaciologists, as an unconventional approach to help support and grow our field to reduce the risks of sea-level rise.

#WAISworkshop
WAIS West Antarctic Ice Sheet Workshop

The Polar Rock Repository: furthering knowledge of Antarctic ice sheet history using legacy collections

Erica Maletic, Anne Grunow

While Antarctica offers many opportunities to study ice-sheet dynamics, its remote location provides challenges in terms of logistical accessibility and environmental impacts. Use of legacy collections from remote outcrops offers researchers the ability to study this area while eliminating their environmental impact on the continent. The decrease in grants funded by federal agencies (e.g., the National Science Foundation (NSF)) as well as the ongoing construction at Antarctic research stations causes additional difficulties, both financially and logistically, in obtaining geologic samples from the continent.

The Polar Rock Repository (PRR) is a National Science Foundation funded facility that provides free and online access to rock samples, unconsolidated deposits (e.g., glacial till), terrestrial bedrock cores, and dredge samples for scientific research. The use of existing legacy samples and associated metadata from remote regions offers scientists the ability to expand the scientific and geographic scope of their research with no additional environmental impact to Antarctica. Importantly, destructive techniques are allowed on loaned samples. The PRR has also created a media archive of over 12,000 images and videos (with some dating back almost 70 years) that can provide glaciological, geological, and logistical information as well as provide a record of temporal change associated with surface features (snow cover, ponds, icebergs, streams, lichen, etc.). The media archive contains landscape photos that could be useful in future logistical planning as well as many photos associated with samples in the physical rock collection that can give additional context for how the samples were situated in outcrop.

The PRR online database (prr.osu.edu) includes a wealth of metadata on all 67,000+ samples, including field notes, sample photos, information on logistics, stratigraphy, observed minerals, and surface features that can be useful to a broad range of climate scientists (e.g., glacial striations, weathering salts, iron oxide staining, etc.). Many samples also have orientation data that has been beneficial in cosmogenic and paleomagnetic studies. The PRR website provides multi-field searchable criteria (over 30 different options) enabling researchers to filter samples relevant to their interests. By making terrestrial and marine geological materials available to the cryosphere community, the PRR represents an invaluable resource to help answer key questions involving ice sheet-ocean interactions and processes affecting glacial retreat that drastically reduces the need for duplicate sampling as well as the need for researchers to go into the field to produce high-quality research.
Antarctic Ice Sheet questions that have been addressed using PRR samples/metadata include (but are not limited to):

•Millennial-scale climate cycles in the East Antarctic ice sheet have been documented using subglacial precipitates.
•Timing of glacial reconstructions using cosmogenic nuclides and luminescence studies.
•Provenance studies suggesting sea-level oscillations in the early Neogene could be from a

large West Antarctic Ice Sheet.
•Paleotemperature proxies using coral in the Ross Sea and Southern Ocean.

A novel time-dependent method to estimate sliding law parameters

Logan Mann, Marianne Haseloff

Ice sheet models that assimilate satellite remote sensing observations are effective tools to understand and project ice sheet mass loss, but they require many model assumptions that are not directly observable from the surface, such as shear stress at the ice-bed interface, which typically requires a sliding law with multiple unconstrained parameters. Inverse methods can find parameter combinations that minimize misfit between observed and modeled ice velocity and/or thickness, either in a single snapshot or over a transient period with many snapshots. But when inverting for more than one parameter, multiple different combinations can minimize model-observation misfit to the same degree, i.e. the inverse problem has multiple, non-unique solutions. Here, we present a new inversion method that takes advantage of ice sheet change and the simple passage of time to better understand the future of the West Antarctic Ice Sheet. We hypothesize that if ice thickness and velocity have changed enough, over a sufficiently long temporal period as to represent distinct ice sheet states, minimizing the misfit for two observation snapshots can uniquely define two or more sliding law parameters, via a new method that we call sequential diagnostic inversions. We present preliminary results, using synthetic data and a multi-dimensional shooting method, to show that these sequential diagnostic inversions can determine both the basal stress and the correct form of the sliding law itself. We expect that Pine Island Glacier in West Antarctica is an ideal candidate for this method due to its widespread thinning and acceleration over the course of the satellite data record.

Evaluating the GSFC-FDM using GNSS-IR-derived firn burial across the Antarctic and Greenland ice sheets

Marianna Marquardt, Matthew Siegfried, Brooke Medley, C. Max Stevens

Across the Antarctic and Greenland ice sheets, snowfall is the primary source of mass accumulation and totals approximately 3000 Gt annually, equivalent to about 8 mm/a of sea-level decline. As old snow, or firn, becomes buried by newly fallen snow, its density increases with depth until it is compacted into glacier ice at ~830 kg/m^3. Understanding the firn column's time-varying density is essential for converting changes in ice-sheet volume, measured by satellite altimetry, into changes in ice-sheet mass and subsequent sea-level change. Mass balance studies typically use semi-empirical models to estimate firn density across Antarctica. These models are often biased (14–16% mean absolute error) because they use depth-density calibration profiles that require a steady-state assumption, introducing uncertainties since firn processes are dynamic. To improve our understanding of firn densification processes, we evaluate modeled firn evolution from the Goddard Space Flight Center firn densification model (GSFC-FDM) using observations from Global Navigation Satellite System interferometric reflectometry (GNSS-IR). We conduct this study at 32 GNSS locations across the West Antarctic Ice Sheet and 3 locations across the Greenland ice sheet. GNSS-IR uses the signal-to-noise ratio of the recorded GNSS signal, produced by interfering direct and reflected signals, to determine the relative height of the antenna phase center above the snow surface. The relative height change of the antenna, h, since an initial date, t_0, represents the relative burial of a firn layer due to snow accumulation or compaction. GSFC-FDM tracks the evolution of a firn column over time by estimating the density of each firn layer and its burial from snow accumulation (relative to the surface). By tracking the depth of the same firn layer over time, we derive a relative burial contour that we directly compare to GNSS-IR-derived burials of a firn layer of the same age. We examine temporal offsets between features in the GNSS-IR and model burials to investigate the influence of the surface-mass balance forcing, model temperature sensitivity, and initial density profiles on model accuracy. By providing key observational constraints on GSFC-FDM, this work will ultimately help to improve our mass balance and resulting sea-level change estimates.

Seawater Infiltration Forms a Widespread Englacial Hydrologic System in Antarctic Ice Shelves

Ian McDowell, Riley Culberg, Clara Nordahl, Victoria Villagomez

Antarctic ice shelf hydrology is generally viewed as a surface-driven system in which liquid water originates from surface melt. However, seawater can also infiltrate porous firn below sea level, providing an independent source of liquid water within ice shelves. Here, we compile approximately 180,000 km of airborne ice-penetrating radar observations to produce the first continent-scale assessment of englacial seawater within Antarctic ice shelves. We identify more than 5,000 km of saline aquifers across at least 35 ice shelves, demonstrating that seawater infiltration is a widespread component of Antarctic ice shelf hydrology.

Saline aquifers occur predominantly within low-density firn but form through five recurring infiltration mechanisms that produce contrasting geometries and occupy distinct structural and mechanical settings. These mechanisms are strongly organized geographically: extensive infiltration through thin or damaged ice dominates along the Antarctic Peninsula, the Amundsen–Bellingshausen sector hosts a mixture of extensive and localized infiltration pathways, whereas smaller rift-, basal crevasse-, and mélange-associated systems are more prominent across East Antarctic sectors. Aquifers formed at calving fronts and within thin or damaged ice can extend for kilometers without requiring pervasive surface fracturing, whereas rifts and basal crevasses provide localized pathways that concentrate seawater around existing fractures. These contrasting geometries create different potential interactions with ice shelf mechanics, ranging from extensive modification of hydrologic and material properties to localized effects on fracture evolution.

These regional differences may become increasingly important as Antarctic surface melting expands. Along the Antarctic Peninsula in particular, extensive and relatively shallow saline aquifers coincide with some of Antarctica's largest projected increases in surface melt. Across Antarctica, aquifer-bearing regions experience nearly four times greater projected increases in surface melt under SSP2-4.5 than regions without detected aquifers. Within regions experiencing the greatest projected melt increases, we map more than 1,100 line-km of saline aquifers, with nearly half of detections occurring within 20 m of the ice shelf surface. Future meltwater infiltrating through these regions may therefore encounter pre-existing marine-derived liquid water within the shallow firn, creating the potential for vertically connected or mixed freshwater–saltwater hydrologic systems. These observations establish seawater infiltration as an important component of Antarctic ice shelf hydrology, with implications for meltwater storage and routing, stress transmission, fracture evolution, and ice shelf response to increasing surface melt.

Snow. The unlikely champion of the 2020s.

Brooke Medley

The sea-level impact of changing ice sheets depends not just on how much mass is lost, but where. Satellite gravimetry captures total ice-sheet mass loss with high fidelity but cannot resolve the regional gains and losses impacting local coastlines; altimetry resolves that redistribution, but requires poorly constrained corrections to separate mass from volume change. We exploit these complementary sensitivities by fusing ICESat-2 and GRACE-FO with surface process models and generate the first satellite-driven partitioning of ice-sheet mass change into atmospheric and dynamic components. Post-2019 precipitation anomalies moderated mass loss across both ice sheets and drove Antarctica to near-zero net balance — yet unabated dynamic losses continue redistributing mass from West to East Antarctica, imprinting regional sea-level signatures where the global mean signal suggests none.

Assessment of crossover differences between CryoSat-2 and ICESat-2 on Amery Ice Shelf

Brendan Mills

Satellite altimeters use reflected signals to measure the surface height of land or ice, but radar and laser altimeters can measure different surfaces over the same location due to their different frequencies. This leads to a “radar vs laser” elevation bias over ice whose magnitude depends on variable surface properties. NASA’s ICESat-2 uses a green (532nm) laser which reflects off the uppermost surface of the ice-air interface, usually at the top of any present snow layer. ESA’s CryoSat-2 uses a Ku-band (13.6 GHz) radar altimeter which experiences volumetric scattering in snow and penetrates to the top of the firn layer. Depending on the effective extinction coefficient of snow, firn density and water content, the radar signal may scatter up to 10m into the snow. Firn properties are an important but poorly constrained component of the ice sheet system that affect how altimetry-derived elevation changes are interpreted in ice sheet models. Uncertainties in firn density and snow redistribution limit the ability of these models to accurately represent the surface mass balance of the ice shelf. Comparisons between different altimeters can validate firn corrections and improve the accuracy of ice sheet models. In July 2020, the CryoSat-2/ICESat-2 Resonance Campaign (Cryo2ICE) raised the orbit of CryoSat-2 to increase the number of crossovers between the two satellites in Antarctica. We focus here on Amery Ice Shelf in East Antarctica, where accumulation rates exhibit a north to south gradient with blue ice in the southern portion and elevated precipitation in the north. This causes a spatial gradient in the firn-layer height and provides an ideal location to apply this analysis. We examine the spatial and temporal variation in elevation bias over Amery Ice Shelf between ICESat-2 and CryoSat-2 from August 2020 to January 2026 and investigate how this pattern can inform our understanding of snow and firn densification. We use the “radar vs laser” elevation bias to make preliminary estimates for firn parameters at crossover locations. We show that the variability in elevation bias is connected to predictable climatological factors like snow accumulation rate, but confounded by surface expressions like melting, crevasses and steep slopes.

Fingerprinting glacial tills with provenance tools shows the flow history of glaciers in the McMurdo Dry Valleys, Antarctica

Daniel Morgan, Rebekah Stanton, Lauren Lamson, Sophie Lopez

We use provenance tools to test for changes in the source area of glacial tills in the McMurdo Dry Valleys, Antarctica (MDV), which would indicate changes in the flow patterns of the glaciers that deposited them. In Lower Wright Valley, we present evidence from detrital zircon Uranium-Lead age populations and Barium-Zirconium concentrations that suggest the sequence of eight tills in the valley were all deposited by ice coming from the Ross Ice Sheet. This would indicate that all of the glacial advances in Lower Wright Valley in the Quaternary period were caused by sea level drops that resulted in the advance of the grounded Ross Ice Sheet. In Arena Valley, similar methods show no statistical difference between tills deposited by the Taylor Glacier, which flows southwards into the valley, and tills identified as being deposited by an over-riding East Antarctic Ice Sheet that flowed northeast over the valley. Although these data cannot be interpreted as indicating that the overriding event did not occur, they do not support the interpretation of previous researchers who suggested a major glacial event in the Miocene. Additional results from Arena Valley, Vernier Valley, Lower Wright Valley, and the Royal Society Range indicate that grain size does not change with age of the till or source area; organic carbon increases in older tills, but soil mixing and erosion of surfaces may impact this trend; the Chemical Index of Alteration (CIA) generally increases with till age, but overall values are low showing little weathering by hydrolysis in this area; Barium-Zirconium and Strontium-Rubidium plots are most useful for characterizing the signature of tills derived from the East Antarctic Ice Sheet from those derived from the Ross Ice Sheet.

Inversion of subglacial effective stress for till-bedded areas of Thwaites Glacier from acoustic-impedance measurements and viscous grain shearing theory

Atsuhiro Muto, Dougal Hansen, Luke Zoet

Subglacial effective stress exerts a fundamental control on basal slip of glaciers but it is notoriously difficult to measure or predict reliably. Seismic methods provide a path for inferring the effective stress because of the sensitivity of seismic-wave propagation to the stress state of the medium through which they travel. In marine acoustics, the viscous grain shearing (VGS) theory has been developed that describes the dependence of seismic-wave speeds, and hence the acoustic impedance, on effective stress, grain diameter and porosity in saturated granular material. Laboratory-scale active-seismic experiments using cryogenic ring-shear and uniaxial-loading devices have shown a positive and nonlinear relationship between acoustic impedance and effective stress, consistent with predictions from the VGS theory. Here we apply the VGS theory to acoustic impedance measurements to calculate the subglacial effective stress along a ~210-km survey line on Thwaites Glacier. To apply the VGS theory, we choose the acoustic impedance values consistent with unconsolidated till. We constrain the grain size and the effective stress-porosity relationship with an ocean-bottom core sampled in front of Thwaites Glacier, interpreted as subglacial in origin. We find that the effective stress at most locations is at or within a few kPa of 0, and stress above ~10 kPa are found at locations corresponding to stoss side of bed bumps. This suggests that the majority of the till-bedded areas beneath Thwaites Glacier is at or very close to flotation and the ice flow is resisted by a limited number of bed topographic obstacles.

The international Ross-Amundsen Ice Core Array (RAICA) initiative: century-long Amundsen Sea annual climate variability (Canisteo Peninsula) and prospects for future ice core reconstruction of West Antarctic paleoclimate

Peter Neff, Yeongcheol Han, Vikram Goel, Julia Andreasen, Chaewon Chang, Songyi Kim, Jangil Moon, Lilly Hinkley, Kenichi Matsuoka

The Pacific coastline of West Antarctica is changing rapidly—experiencing thinning, mass loss, and retreat of ice shelves critical for stability of the West Antarctic Ice Sheet (WAIS). Despite this observed change due to ice-ocean-atmosphere interactions, there remains a paucity of terrestrial climate records and surface mass balance observations along the ~1900 km-long coastline from Ross Ice Shelf to Pine Island Glacier. Ice rises, regions of grounded ice within ice shelves, are ideal ice core sites and many are located along the WAIS coastline—providing opportunity to reconstruct coastal climate and environmental parameters back decades to millennia at annual resolution. The Ross-Amundsen Ice Core Array (RAICA) initiative is expanding the existing inland WAIS ice core array and will eventually connect to international ice coring efforts in the Ross Sea and Victoria Land regions. We discuss results from first RAICA fieldwork: collection of two 150 meter long ice cores at Canisteo Peninsula ice rise, 130 km north of Pine Island Glacier. 280 km of radar lines were traversed, observing ice thickness, internal structure, and constraining surface mass balance variability. Supported by the South Korean icebreaker RV ARAON and two AS-350 helicopters, a camp of eight people spent thirteen days at the site in mid-January 2024. Now partially chemically analyzed, these 100 year-long cores provide proxy observations of fundamental climate variables (temperature, wind, snowfall) which play a role in Amundsen Sea regional glacier change. Annual layering in hydrogen peroxide confirms high snow accumulation of ~1.2 meters per year ice-equivalent—rates not captured by climate reanalysis products—and provides accurate annual ice dating from 2024 C.E. to approximately 1920 C.E. Preliminary paleoclimate records are now emerging from this international effort, including high-resolution 20th century methane observations in air bubbles trapped in the ice. We will also discuss future fieldwork opportunities including ice rises for shallow ice core recovery as well as ideal locations for intermediate coring to recover Holocene and late Pleistocene Amundsen Sea paleoclimate records.

An exciting new Miocene record from beneath the West Antarctic Ice Sheet: Initial Results from the SWAIS2C Crary Ice Rise Drill Core

Molly Patterson, Huw Horgan, Richard Levy, Tina van de Flierdt, Gavin Dunbar, Denise Kulhanek, SWAIS2C Science Team

The Sensitivity of the West Antarctic Ice Sheet to 2°C (SWAIS2C) project aims to investigate the stability of the West Antarctic Ice Sheet by examining its past behaviour in a warmer-than-present world from geological archives. Project partners include the International Continental Scientific Drilling Program (ICDP) and a consortium of national Antarctic program and international collaborators from 10 countries (New Zealand, United States, United Kingdom, Germany, Australia, Republic of Korea, Japan, Italy, Spain, Netherlands).

Here we present the initial scientific findings from the 222 m of drill core recovered from beneath Crary Ice Rise (CIR), West Antarctica (83°1.6002'S, 172°37.5546'W; ICDP Site 5072_2_A) during the 2025/26 field season. Drilling at CIR required melting a 515 m hole through the Ross Ice Shelf, and then drilling 228 m into permafrost with NQ-sized (45mm diameter) coring tools deployed from our Antarctic Intermediate Depth Drilling Rig (AIDDR). The AIDDR is a modified geotechnical rig that includes warm water delivery through drill pipe to the bit to prevent freezing. The AIDDR successfully drilled to 228 m below seafloor (mbsf), recovering ~212 m of core. Following initial on-ice characterization of the cored material, we split and described the core at the Otago Repository for Core Analysis at the University of Otago, New Zealand in June 2026. Characterization included computed tomography (CT) imaging, collectiion of physical property data (magnetic susceptibility, bulk density, P-wave velocity, color spectrophotometry), line scan imaging, visual core description, biostratigraphic analysis (diatoms, radiolarians, and foraminifera), and X-ray fluorescence core scanning. We also sampled for paleomagnetic analysis, as well as total organic carbon and biogenic silica. The initial results allow us to divide the cored material into five lithostratigraphic units based on grain size, biogenic content, and lithological sequences representing subglacial to ice-free enviornments. Biostratigraphic age estimates indicate that the majority of the record (down to ~200 m below the base of the ice bed) is between 7 and 10 Ma, with a hiatus separating those sediments from the underlying unit with a maximum age of ~17–19 Ma. The range of lithofacies present provides direct evidence of a dynamic and climate-sensitve West Antarctic Ice Sheet since the late early Miocene.

Successful integration of hot water drilling and the AIDDR system provides a basis for future subglacial drilling in the Antarctic deep field where observations are lacking but are urgently needed to better constrain the likely repsonse of West Antarctic Ice Sheet to future warming.

From Observations to Projections: Constraining Antarctic Ice Sheet Models with the Satellite Record

Sara Peters, Anna Ruth Halberstadt, Ginny Catania

Accurate projections of Antarctica's future sea-level contribution require ice sheet models that are rigorously evaluated against the full range of modern observations. Despite the widespread availability of remote sensing data, a quantitative framework for comparing ice sheet model output to these diverse datasets is currently underdeveloped. This work aims to develop an open-source, ISMIP-compatible Bayesian model-data scoring tool that evaluates and weights Antarctic ice sheet simulations based on their ability to reproduce key ice sheet state parameters from satellite observations, including surface elevation and mass change as primary constraints (following Felikson et al., 2023, now applied to Antarctica). Moving beyond static time-slice comparisons, our approach also assesses a model's skill at capturing rates of ice sheet change. All types of observational constraints are combined into a single framework and applied to the ISMIP6 ensemble over the satellite era (2005-present) which yields a set of weights that reflect each model's fidelity to the observational record. These weights are then applied to the future extension of each simulation, ultimately producing observationally constrained future sea level rise projections. The tool is designed to be accessible for any ice sheet model output and easily updated as new satellite products emerge and as new data become available, with planned extensions to incorporate velocity change, grounding-line flux, and other observed metrics.

Modeling Firn Storage Loss and Meltwater Runoff Across Glacier Systems Using the Community Firn Model

Larissa Ramirez, Daniel Morgan

Firn stores meltwater within pore spaces before it either refreezes or contributes to runoff, making it an important control on glacier hydrology and surface mass balance. Although previous studies have examined firn evolution in individual glacier systems, particularly Greenland, fewer studies have compared runoff thresholds across glacier climates. Glacier systems representing interior Greenland (cold polar), coastal Alaska (transitional), and New Zealand (maritime) were selected using observations from the NASA ITS_LIVE velocity dataset. Firn evolution was simulated using the Community Firn Model, incorporating temperature- and accumulation-dependent densification to generate 70 m density profiles and calculate porosity, firn air content, and meltwater storage capacity. Sensitivity experiments evaluated the effects of accumulation rate and pulsed versus steady melt forcing.

The modeled glacier systems produced markedly different responses. The Greenland-like system retained 65–75% of its initial pore space and did not exceed the runoff threshold across the modeled temperature range. In contrast, the New Zealand maritime system retained less than 35% of its initial pore space, with runoff-dominated conditions occurring near −4°C. The Alaska-like transitional glacier exhibited the strongest threshold response, with runoff fraction increasing from <20% to >70% over only 2–3°C of warming and exceeding the runoff threshold near −8°C. Increasing accumulation delayed runoff thresholds by approximately 1–2°C, whereas short-duration melt pulses advanced threshold behavior by roughly 1°C relative to equivalent steady-melt scenarios. These results indicate that glacier response to warming depends strongly on climate regime, with transitional glacier systems exhibiting the sharpest runoff thresholds and the greatest sensitivity to modest climatic change.

Development of a High-Resolution, ECCO-Downscaled Antarctic Peninsula Regional Model

Gobishankar Sathiyamohan, Yoshishiro Nakayama, Shuntaro Hyogo

The Antarctic Peninsula (AP) is one of the most rapidly changing environments on Earth and among the most biologically productive regions in the Southern Ocean. In recent decades it has experienced pronounced atmospheric warming, warming of ocean temperatures on and off the continental shelf, declining sea-ice extent, and accelerated ice mass loss, with changes intensifying after 2015. Warm modified CDW (mCDW), carried toward the shelf by the Antarctic Circumpolar Current (ACC), intrudes onto the continental shelf and toward ice-shelf cavities, making ocean heat delivery a central control on ice-shelf melt. Isolating the drivers, mechanisms, and decadal variability of ocean heat transport, ice-shelf melt, and sea-ice change requires a high-resolution, observation-constrained regional model.

We have developed a regional coupled ice-ocean model of the AP using MITgcm downscaled from the data-assimilative ECCO-Darwin LLC270 v05 state estimate. The domain (100 × 150 × 70, ~13 km horizontal resolution) is integrated over 1992-2024 (33 years). The configuration couples ocean circulation with dynamic-thermodynamic sea ice and static ice-shelf cavities with thermodynamic melt. This enables direct study of on-shelf circulation, cross-shelf exchange, and how shelf-water properties respond to freshwater input from melt and to intruding warm mCDW, as well as heat and freshwater fluxes and basal melt within the AP ice-shelf cavities.

Preliminary simulations produce a physically realistic regional ocean state. In the open ocean, the simulated circulation resolves the ACC front at the shelf break (~62-63°S), a Weddell Gyre boundary current on the eastern side, and meanders in the surface temperature field. On the shelf, watermass distributions are well reproduced, with a cold, fresh surface layer overlying warm mCDW that reaches about 1.6°C at 500 m in the western AP. Antarctic Surface Water, Winter Water, CDW, and dense shelf water are recognizable in T-S space, with warm CDW intruding onto the western shelf and dense shelf water on the eastern side. Toward the ice-shelf cavities in the western part, warm mCDW reaches the ice-shelf grounding zones, the process central to basal melt, indicating that our configuration simulates processes controlling ocean heat delivery to the AP shelf and ice-shelf cavities.

The model will be refined through an iterative model-data synthesis framework, in which the simulation is repeatedly compared against observations and adjusted to reduce model-data misfit. It will be evaluated against long-term observations from the World Ocean Database (WOD) and Palmer LTER records, along with monthly climatologies, using metrics including water-mass properties, thermocline depth, cross-shelf heat transport, on-shelf vertical velocity, and physical trends. Refinement will proceed in two stages: discrepancies will first motivate physically based hypotheses, refined through expert judgment and tested with sensitivity experiments and manual parameter adjustment; a Green's-function approach will then perturb control parameters (vertical mixing, boundary conditions) to further reduce model-data misfit. This synthesis will yield a validated regional model for studying the drivers and mechanisms of change along the AP, including ocean heat delivery and ice-shelf melt, and for future biogeochemical modeling in the region.

Overview of Science Results of the International Thwaites Glacier Collaboration and ongoing studies

Ted Scambos, Christian Wild, Adrian Luckman, Chad Greene, Alex Gardner, Robert Larter, Karen Alley, Peter Davis, Marianne Karplus

Results of the 150-researcher, 7-year International Thwaites Glacier Collaboration (ITGC) have set a stage for future field, satellite, and modeling research in the region. Related work continues with remote sensing evaluations of ongoing changes. The ITGC advanced bathymetric, oceanographic, and glaciological mapping of the entire Thwaites basin and much of the adjacent Dotson-Crosson ice shelf system as well. Sediment core analysis indicates that both Thwaites and Pine Island began an accelerated pace of retreat in the mid-1940s, although the system appears to have been in balance as last as the 1970s. Earlier retreat of the system in the mid-Holocene Optimum brought the glacier elevation to 35 meters below the present level (in one region), but slowly declining temperatures since the Optimum allowed it to recover.

Rapid fracturing and acceleration of the Thwaites Eastern Ice Shelf (TEIS) appears to be a result of thinning and periodic interaction with the faster-moving main glacier trunk and the Thwaites Western Ice Tongue (TWIT, now mostly broken up) and increased shearing to the point of lateral rupture of a shear zone bounding the northern limit of the shelf. The shelf was instrumented with two multi-sensor stations and ApRES sensors that together provided weather, snow accumulation, ice shelf temperature, basal melting and internal deformation data, and oceanographic data, supporting many studies. Ocean conditions beneath the TEIS have changed as sea ice cover has changed, with a steady warming of mCDW over the period of record. However, at the ice base, in the absence of basal slope features such as bottom crevasses or steps, melting is very slow due to the presence of a relatively fresh, few-meter-thick ocean layer between it and warmer waters below it. These are a mix of Winter Water and mCDW, with both density and temperature increasing with depth. Within basal crevasses and rifts, a complex melt-induced topography is developed, as steeply sloping basal ice surfaces accelerate water flow and therefore melting, create laterally-propagating 'steps' of ~10m vertical scale. The resulting profile resembles a wedding cake, as sequential steps and progressive lateral propagation widen the base of the rift.

As the shear zone has evolved toward complete rupture, the shelf has rapidly accelerated and the wing fractures crossing it (the 'daggers' in field parlance) have extended across the shelf. At the same time, acceleration of grounded ice at the eastern end of the TEIS grounding zone (the 'Butterfly' region in field parlance) just upstream of the shelf has begun. More central areas of the TEIS grounding line and the main Thwaites glacier grounding zone have not seen much acceleration. Modelling suggests the grounded ice acceleration is coincidental, and not resulting from the loss of ice shelf backstress, but analysis of the events is continuing.

Multiple modelling efforts indicate that Thwaites will almost certainly collapse if present conditions persist, and that collapse will accelerate if conditions move toward further warming or faster circulation of basal ocean water at the grounding line. It is imperative that the region receive further study in light of its significant control of future global sea level.

Rivers of Dreams: Subglacial Water and IPY5

Britney Schmidt, Ryan Venturelli, Matthew Siegfried

Many of the highest priority questions across Antarctic and Arctic science hinge on subglacial water, encompassing lakes that hide unknown communities at the limits of life, the sediments below them recording millennia of past climate, and decoding the dance of interconnected ice streams influenced by ever warming seas. Subglacial hydrological networks are the least explored part of the cryosphere despite their critical control connecting ice, Earth, and warming ocean – and their role as couriers bearing evidence of subglacial processes. Witnesses to the changing tides and weight of ice under motion, subglacial water integrates across interdisciplinary and international interests - connecting ecology, climatology, and polar history; this topic should be at the forefront of IPY5.

IPY is an opportunity for combining capacity to achieve that which is impossible alone. With 773 subglacial lakes across Antarctica, complex subglacial hydrology in Greenland that warrants more study, and yet just a handful of measurements to date, subglacial water needs IPY levels of coordination and boasts commensurate potential impact.

From measuring melt rates in the warming ocean to uncovering isolated ecosystems in subglacial lakes, these deep horizons require expanded access under the ice, thereby necessitating collaboration. Moreover, subglacial water could uniquely leverage the diverse strengths of collaborating national partners: access drilling from some, in-situ methods and technologies from others, and national program infrastructure across the board from the ocean to inland. At the same time, these collaborations would pave the way for exchange of technologies and methods, returning investment to the collaborating programs.

We will share the excitement and interdisciplinarity of subglacial water science, lessons learned from recent programs, and recommendations for developing technologies for use in collaborative campaigns. Since deep access is necessary for these critical questions, we also discuss expanding availability and capacity of access technology and instrumentation.

Emulating the Microphysical Dynamics of Ice Deformation

Nathan Schoedl, Meghana Ranganathan, Pedram Hassanzadeh

A significant source of uncertainty in ice sheet mass loss projections is the model for ice flow. Ice flow models are known to be overly simplistic and don't incorporate key microphysical dynamics that modulate the rate of flow of ice such as alterations to ice crystal sizes, shapes, and orientations as well as the creation and destruction of microdefects within the ice. This limitation comes from the computational infeasibility of resolving ice microphysics at ice sheet scales. In order to address this limitation, we seek to use machine learning to incorporate ice microphysics into models of ice flow.

To achieve this goal, we use the microstructure model Elle to build an emulator of the microphysical dynamics of ice and integrate this into a large-scale ice flow model. Elle resolves the dynamics of microphysical properties relevant to inform viscosity such as the size and orientation of ice crystals and the distribution of defects in the crystalline lattice. We run Elle simulations for a range of strain rate and temperature configurations to construct a training dataset that contains statistics regarding the evolution of microphysical properties of ice. We then use this dataset to train an autoregressive feed-forward neural network that models the evolution of microphysical properties. The fast inference time of this neural network emulator addresses the computationally infeasibility of explicitly resolving ice microphysics at ice sheet scales. We show the initial stages of the construction of this emulator that will make it possible to incorporate ice microphysics in large-scale ice flow models. The next step is to couple this emulator with the ice flow model Icepack to develop the first ice flow model that incorporates spatially and temporally varying estimates of viscosity and obtain higher-fidelity estimates of future ice sheet mass loss.

Beyond MISI: understanding marine ice sheets as components of the Earth's climate system

Olga Sergienko

For more than fifty years, the behavior of marine ice sheets, such as WAIS, was interpreted through the lens of Weertman's marine ice-sheet instability hypothesis, which assumes that their stability depends only on the bed slope at the grounding line. Developed at a time when ice-sheet wide observations were unavailable, it makes too many simplifying assumptions that do not hold for real ice sheets, which are tightly coupled to the ocean, atmosphere and lithosphere and continuously exchanging mass and energy with them. The Earth's ice sheets are complex physical systems with intrinsic variability that cannot be separated from the rest of the climate system. Their numerous nonlinear and spatially and temporally heterogeneous internal processes, together with interactions and feedbacks operating on a variety of timescales, generate diverse modes of variability that are starting to emerge in recent observations. The results of these observations and advances in understanding of the Earth system indicate a broad range of possible behaviors of ice sheets. Irreversible decline is a conceivable future for the West Antarctic Ice Sheet, but it is only one of the multiplicities of its evolutions, and we are today far from understanding the scope of possible futures. With the wealth of observations collected since Weertman proposed MISI, and advances in climate and atmospheric sciences, oceanography, glaciology and related fields, we are in a position to move to a more advanced understanding of Earth's ice sheets.

From ISMIP6 to ISMIP7: Key Developments and First Results

Helene Seroussi, ISMIP7 Team

ISMIP6, the Ice Sheet Model Intercomparison Project for CMIP6, was the first coordinated glaciology and polar climate contribution to CMIP and has been widely regarded as a success, yielding at least 40 publications and featuring prominently in the IPCC AR6, including its Summary for Policymakers. As an exploratory first effort, however, it left clear room for improved coordination and scientific design, needs made more pressing by a decade of advances in process understanding, observations, and modeling, as well as better addressing the needs of sea-level practitioners. Building on these lessons, ISMIP7 continues to coordinate and standardize numerical modeling experimental setups to quantify the ranges of sea-level rise projections for the IPCC AR7. It also improves the representation of external forcing, ice sheet process modeling, and the inclusion of observations. These advances build on a decade of ice sheet model improvements and an improved understanding of the interaction between ice sheets and the rest of the climate system. After describing the main improvements and the overall ISMIP7 protocol, we present initial synthesis results from the ISMIP7 Antarctic ensemble, encompassing 26 modeling submissions across 12 distinct numerical modeling experiments. The multi-model ensemble demonstrates the span of Antarctic Ice Sheet dynamic responses and committed sea-level rise from the historical period through 2300. Core protocol experiments cover Shared Socioeconomic Pathways (SSPs) ranging from SSP1-2.6 through SSP5-8.5, including a likely overshoot trajectory, driven by climate forcing from multiple Earth System Models (ESMs) alongside baseline control runs. Together, these initial results will establish the baseline for the ISMIP7 Antarctic sea-level rise projections through 2300.

The effect of topography roughness and uncertainty in the retreat of Thwaites Glacier

Niya Shao, Hélène Seroussi, Mathieu Morlighem, Emma MacKie

Subglacial topography is a critical component in modeling the evolution of the Antarctic Ice Sheet. Large-scale bed geometry guides the overall ice flow, while local pinning points and troughs control the rate of grounding zone retreat. However, subglacial topography is mostly measured by airborne ice-penetrating radar, which yields sparse and unevenly distributed measurements across the ice sheet. Consequently, subglacial topography remains one of the most uncertain model parameters, and the impact of these uncertainties on ice-loss projections is not yet fully understood.

For fast-flowing glaciers, high-resolution maps of subglacial topography are typically created via inversion or interpolation. Mass-conservation inversion incorporates high-resolution ice velocity data to infer topography, but this method often yields a smoothed map that does not capture fine-scale topography features and their associated uncertainties. On the other hand, geostatistical interpolation methods generate an ensemble of topographies with realistic roughness, but these topographies are not constrained by physics, causing spurious ice flux divergences in models. Recently developed geostatistical inversion methods bridge this gap, producing mass-conserving topography maps with realistic roughness inferred from radar measurements. The probabilistic framework incorporated in geostatistical inversion allows generating an ensemble of topographies to represent uncertainty, providing an opportunity to propagate topography uncertainty to projected ice loss of Thwaites Glacier.

In this study, we evaluate how topography roughness and uncertainty affect the modeled retreat of Thwaites Glacier over the next century. We use geostatistical inversion to generate ten distinct topography realizations for Thwaites Glacier and simulate Thwaites' retreat on each topography realization. The results show a large spread of ice loss for the ensemble of models. In contrast with previous work, we find that rougher topographies consistently produce faster grounding-zone retreat. In this presentation, we will share the modelling results and explore the possible causes for the systematic differences in the retreat rate for topographies with different roughness. We will further discuss how fine-scale topography features interact with ice sheet models and affect sea-level projections.

New eyes on Antarctic subglacial lakes: Direct-access subglacial lake candidates for IPY5 and beyond

Matthew Siegfried

Active subglacial lakes beneath the Antarctic ice sheet — those that episodically fill and drain over the observational record — modulate subglacial hydrological systems, support microbial ecosystems, supply a space-and time-varying source of freshwater to the Southern Ocean, and provide century-scale geologic archives of subglacial processes. Since the discovery and initial mapping of these features two decades ago, a new generation of polar-orbiting satellite missions, targeted geophysical campaigns, and direct-access experiments have provided additional context about the evolution and timescales of these enigmatic features and their role in the coupled ice-sediment-water-microbial environment, but the full extent and range of dynamics of Antarctic subglacial lakes remain under quantified. Here, we present results from satellite altimetry observations and airborne radio-echo sounding to develop and apply new data-driven methods of mapping subglacial lake extent and identifying new areas across the continent that are likely underlain by active subglacial lakes. Our results provide improved bounds on the frequency, magnitude, and extent of fill-drain events and inform selection of candidate sites where persistent activity and favorable geophysical conditions make direct-access experiments viable. We use these results to highlight future datasets for continuing to improve constraints on active subglacial lake dynamics from space and new technologies required to continue our in situ exploration of these poorly sampled subglacial features in the 2030s and beyond.

It's the Data, Not the Algorithm: How Greenland became AI's ice sheet

Leigh Stearns

Over the past decade, machine learning has moved from novelty to workhorse in Greenland glaciology, outpacing its adoption in Antarctic research. This talk outlines how deep learning and related AI methods, particularly feature segmentation, physics-informed neural networks, and forecast methods, are providing new insight into key processes at the base and front of Greenland's tidewater glaciers.

Greenland's AI advantage rests less on algorithmic novelty than on data availability and feature dynamics. In Greenland, a longer history of densely repeated, high-resolution imagery can feed benchmark datasets and model parameterizations. Antarctica's sparser observational record and larger, more homogeneous domain present obstacles for many machine learning algorithms. However, we need not wait for the "Greenland-ification" of Antarctica to use deep learning tools. The data gap is narrowing, and new algorithms give the WAIS community concrete opportunities to adapt Greenland-tested AI pipelines to Antarctic scale.

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SlideRulers of the world, unite! Analyzing NASA Data in the 21st century

Tyler Sutterley, Benjamin Smith, David Shean, Scott Henderson, JP Swinski, Carlos Ugarte

Scientists have access to a vast and growing Earth science data record provided by NASA missions. This expanding archive is pushing the limits of traditional architectures for data analysis. SlideRule Earth is an on-demand data processing system that currently supports several NASA satellite missions (e.g. ICESat-2, GEDI) and other Earth science datasets. SlideRule enables rapid, scalable processing using efficient cloud-based infrastructure and optimized algorithms. The system is highly configurable, allowing users to generate custom, higher-level data products tailored to their own research goals and study sites. With SlideRule, users can specify an area of interest and select key algorithm parameters to return customized data products containing thousands to millions of derived measurements within seconds.

Over the past year, we have substantially improved our web client, added the ability to query SlideRule via AI agents, and introduced the capability to query mission documentation directly. These enhancements have greatly simplified the search and analysis skills researchers need to get started: with a few simple queries, users can learn about data products and visualize NASA data anywhere on Earth. In this talk, we highlight support and applications for the ICESat-2 mission, along with the benefits and lessons learned from working in an open science environment. We demonstrate the new capabilities of the SlideRule web client and its interfaces for AI pipelines. Finally, we explore how research frameworks are evolving to enable the processing of large Earth science datasets and to support more collaborative, more equitable science.

How do we expand capacity for airborne radar sounding?

Thomas Teisberg, Dustin Schroeder, Ellianna Abrahams, Anna Broome

Since the end of Operation IceBridge in 2019, the annual volume of Antarctic radar survey data has declined significantly. During this same time period, modelling studies have continued to point to bedrock topography uncertainty as a leading (and perhaps the most tractable) cause of uncertainty in future sea level rise. With attention shifted to data re-use, new methods have emerged or been advanced to characterize temperature, englacial velocity, subglacial water, ice fabric, and more. This leaves us with a well-characterized data gap, expanded potential for new discoveries and datasets, and a decreased observational capability. With the potential for accelerating changes in Antarctica, we need a strategy for expanding our capacity for radar sounder observations.

A number of emerging airborne platforms could play a role in rebuilding observational capacity, including new low-altitude UAVs, NASA's 777 aircraft, and emerging solar-powered stratospheric UAVs. Each of these platforms has a role to play. We will discuss their unique capabilities and limitations, with an eye towards two key metrics: cost per line-km and annual survey capacity.

The uncrewed aircraft operating at the altitude extremes may also require innovations in radar instrument design and data processing. We will also discuss needed advances in radar sounder systems that could better leverage the unique capabilities (and handle the unique limitations of) uncrewed airborne platforms.

Comparing geological interpretation and machine learning to develop parameterization of geological influence on ice sheet flow in the Amundsen Sea

Kirsty Tinto, Atsuhiro Muto, Louise Borthwick, Caitlin Locke, Matt Tankerlsey, Racheet Matai, David Porter, Robin Bell

The underlying geological framework of ice sheets can influence ice flow by exerting control on bed shape, sediment processes, the distribution of geothermal heat flux and the circulation of subglacial hydrology. Incorporating knowledge of subglacial geology into ice sheet models remains challenging, and requires advances in both geological understanding, and developing parameterizations of the geological conditions to be used in models.

Here we compare two approaches to geological parameterization to develop a combined onshore-offshore system of “Bedclasses” to describe the ice-rock relationship. In the first, we develop a geological interpretation of the structure Amundsen Sea Embayment by combining onshore and offshore geophysical data. In the second, we use machine-learning based tools to correlate observed geophysical properties beneath the present-day ice sheet with the basal slipperiness identified from an ice sheet model.

We quantitatively compare the two approaches identify areas where geological interpretations correlate with ice sheet basal conditions and where flow appears to be driven by more transient controls, such as the distribution of subglacial hydrology, that could be expected to change under different ice sheet configurations.

In-Situ Measurements of Ice Shelf and Mélange Deformation Reveal Mechanical Properties of an Ice Rift in the Ross Ice Shelf

Kathrine Udell-Lopez, Mong-Han Huang, Nicholas Schmerr, Terry Hurford, Kat Dapre, Zoe Schlossnagle, Emily Harkleroad, Simon Eisl

Through-cutting ice shelf rifts define critical weak zones that eventually become the nucleation points of massive tabular icebergs and ice shelf break up. A buildup of tensile stress as the Ross Ice Shelf (RIS) flows to the Ross Sea has resulted in multiple periodically spaced ice rifts that are ~100 km in length. Previous work established that tidally driven stress causes these rifts to be seismically active. The rifts are filled with mélange, a snow-ice mixture, whose role within rifts and ice shelf stability is both important and poorly understood. Here we utilize seismic and geodetic datasets from our NASA-funded Antarctic Rift Research for Ocean Worlds (ARROW) deployment in 2022-23 to determine the deformation processes of a portion of one rift zone, Western Ross 4 (WR4), of the RIS. We train a machine learning earthquake detection algorithm to identify icequakes and produce a high-resolution seismic catalog with ~4,000 icequakes, which primarily occurred within the rift. Using GPS data, we measure tidal elevation changes, calculate strain within the ice shelf and mélange, and model tidal and background tensile glacial stresses acting on the rift. With the tidal stress record, we produce a stress-strain-seismicity curve for the mélange. Our results indicate that seismicity peaks as stresses approach a bulk tensile yield strength just prior to peak extensional stress conditions. We constrain the importance of small stress fluctuations due to tidal forcing on the persistence of rift features, showing that even stresses on the scale of 1 kPa can cause brittle fracture. We propose that tidal stresses continually rework the mélange, driving rifts to expand after the initial fracture is formed, contributing to the overall weakness of the ice shelf. While the thickening and strengthening of the mélange over time may outpace this tidal weakening in some systems, any reduction of strength of the mélange due to change of temperature or thinning may allow for this process to restart. This makes mélange within rifts essential to ice shelf stability under a changing climate. This dataset provides an opportunity to better understand the deformation processes for ice beyond laboratory scales, providing important constraints for models of terrestrial rifts and planetary ice shells under varying stress conditions.

Finding signal in the noise: Holocene retreat and re-advance signals revealed through legacy cosmogenic nuclide data

Ryan Venturelli

Deglaciation following the Last Glacial Maximum provides an opportunity to explore ice dynamics of a retreating margin over a geologically short window. Though our historic perspective of deglaciation has existed through a lens of monotonic retreat, that paradigm has been eroded by over a decade of evidence for grounding line retreat and re-advance that occurred in the middle-to-late Holocene. Direct evidence of this phenomenon requires subglacial access drilling, sediment or bedrock retrieval, and geochronologic analyses—which is not logistically feasible for the assessment of circum-Antarctic grounding lines. In absence of new subglacial drilling campaigns, we leverage legacy data from three decades of cosmogenic nuclide work around Antarctica. These data, paired with a simple flowline model, illustrate that near-surface-scatter in cosmogenic nuclide records is consistent with ice thinning and thickening cycles that would have occurred alongside tens to hundreds of kilometers of grounding line retreat and re-advance in the middle to late Holocene. We identify these signatures both at known retreat-readvance sites, as well as across >30 previously sampled sites around the Antarctic Ice Sheet. Our work not only highlights the need for careful assessment of geologic noise, but also the prevalence of a dynamic Holocene Antarctic Ice Sheet characterized by pronounced periods of retreat and re-advance throughout the last deglaciation.

An IPY-5 International Observational Network to Track Antarctic Ice Sheet Mass Change

Terry Wilson

GNSS observations of bedrock displacements can track changing ice mass balance with high fidelity (see Yao et al., this conference). The same observations record the magnitude and spatial patterns of crustal displacements due to Glacial Isostatic Adjustment (GIA), a quantity required to derive ice mass balance from spaceborne altimetry and gravimetry. GNSS Interferometric Reflectometry from GNSS instruments on snow, or bedrock sites proximal to snow, can provide a time series of surface mass change on the ice sheets. Given the spatial and temporal variability of change in ice mass balance across both East and West Antarctica, in particular gains and losses in surface mass balance, it is important to have good spatial coverage of GNSS instrumentation on rock and snow and to include novel approaches to recording bedrock displacements across the fully ice-covered sectors of Antarctica. To make a step change in our knowledge of Antarctic ice sheet mass change, an international collaboration to integrate existing and new GNSS instrumentation into a network of networks across the continent is required. A collaboration with this ambitious scope can be realized if aspirations for increased funding and logistic support for the next International Polar Year materialize. Community planning for the science plan, technological needs, and shared international funding to achieve this should start now.

Climate-sensitive Carbon Cycling Adjacent to a Melting Ice Shelf in West Antarctica

Patricia Yager, Jackson Vassy

The Amundsen Sea hosts one of the most productive polynyas in all of Antarctica, with a peak atmospheric carbon dioxide (CO2) flux density previously estimated to be 10x higher than the Southern Ocean average. The region and its carbon cycle are vulnerable to climate change, with rapid sea ice losses, a changing icescape, and some of the fastest-melting glaciers flowing from the West Antarctic Ice Sheet. Although the Amundsen Sea Polynya has been explored by multiple international expeditions and shown to be a significant carbon sink, supported by the buoyant upwelling of iron-rich meltwater-modified Circumpolar Deep Water, the biogeochemical composition of the outflow from the glaciers surrounding the Amundsen Sea and the potentially important role of the coastal current have been largely unstudied beyond models. In collaboration with a UK-based physical oceanographic program (International Thwaites Glacier Collaboration: TARSAN), the ARTEMIS project (NBP22-02) collected shipboard seawater samples for the carbonate system, macro- and micronutrients, organic matter, and microorganisms to gather data needed to understand the impact of the melting ice sheet on both the coastal ecosystem and the regional carbon cycle. ARTEMIS sampled late-season conditions (January to March) for the first time. The open waters of the polynya were rich in algal biomass and highly undersaturated with CO2 (pCO2 < 200 µatm). The coastal current along the ice shelf exhibited a greater range of conditions, with low fluorescence and supersaturated CO2 observed at the surface in some but not all areas. Observations of heavy phytodetritus on the seafloor beneath both the central polynya and the coastal current confirm organic carbon export to at least 1000 m. Here, we summarize key biogeochemical findings near the Dotson Ice Shelf, differentiating the modified Circumpolar Deep Water inflow from the meltwater-modified outflow, as well as along the coastal current from east of Bear Island to the GetzB outflow. We also compare these data to those collected during previous expeditions (e.g., OSO 2007, OSO2008, NPB 10-05; ASPIRE).

GNSS Observed Crustal Deformation Accelerations in West Antarctica

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Continuous GNSS observations from 28 stations on bedrock across West Antarctica reveal that vertical crustal deformation exhibits accelerations and decelerations through time. Linear velocity models are insufficient to describe the observed deformation, while higher-order and piecewise-linear trajectory modeling of the GNSS time series identifies coherent changes in vertical velocity across the network, with common time breakpoints at 2021.02 and 2023.34. Results demonstrate regional differences in the magnitude and sense of accelerations, but show clear temporal coherence, with consistent timing of velocity changes across stations. Analysis over three periods between 2019 and 2025 documents sign reversals in both ice mass balance and deformation rates, reflecting large-scale shifts in ice mass loading. To investigate the drivers of these velocity changes, measured GNSS velocity changes are compared with modeled elastic displacements computed from satellite-derived total mass balance (TMB) and modeled surface mass balance (SMB) datasets. TMB-modeled velocity changes have better agreement with GNSS observations across the 2021.02 breakpoint, while differences between TMB- and SMB-modeled changes are much smaller across the 2023.34 breakpoint. These comparisons suggest that both dynamic ice mass changes and SMB variations drive accelerations across the 2021.02 breakpoint, while SMB variability became more important during the later period. However, mismatches between GNSS observations and modeled elastic responses remain at some stations, potentially reflecting limitations in current ice mass balance datasets or contributions from solid Earth processes. This analysis demonstrates that continuous GNSS measurements from bedrock stations provide an independent and temporally continuous constraint on ice mass variations in Antarctica, in addition to satellite observations and mass balance modeling.

Whatever happened to Nye channels? A case for geologic control on subglacial hydrology

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First proposed by John Nye in the late 1960s, Nye channels (or N-channels) describe subglacial water flowing in channels incised into underlying bedrock. Nye-channel-like bedforms are observed in multiple deglaciated areas of West Antarctica, including Pine Island Bay, Marguerite Bay, and the Dry Valleys. These bedforms are interpreted as relict channels of past subglacial meltwater, though the timing and mechanism of their formation is debated. However, most subglacial hydrology models only consider channelized flow in the form of Röthlisberger channels (or R-channels) which are melted into the overlying ice. Thus, there may be processes related to the effects of bed channels and other small-scale topography on subglacial water that are not yet included in models. Here, we use simple water routing models to demonstrate that bedforms of the scale observed in paleo N-channels could locally reroute water. We modify the bed of Thwaites glacier to gain insight on when and where such bedforms might be important for hydrology. Through this work, we seek to add perspective and invite discussion on how bed topography and geology matter for understanding basal processes such as hydrology and sliding.