Nepal's Multi-Level Governance System: Analyzing Power and Politics in Climate Adaptation Governance

Suman Acharya[1, 2, 3]

1. *Department of Anthropology, University of Maine.*
2. *Climate Change Institute, University of Maine.*
3. *Himalayan Conservation and Research Institute, Dolpa, Nepal.*

Abstract: Climate change amplifies existing challenges across social, political, economic, cultural, and environmental dimensions in the contemporary world. However, studies on climate adaptation to date are highly focused on biophysical aspects ignoring the sociopolitical determinants of adaptation. This study tries to bridge the gaps by comprehensive analysis of multi-scalar power dynamics and politics in authority, knowledge, and resources within the realm of climate change adaptation from Nepal. Despite the adoption of democratic practices through multi-level governance in climate adaptation, findings reveal a concentration of authority, knowledge, and resource access at the federal level. Moreover, the findings suggest that there was not a good relationships between three tiers of government that enhanced power differentials across governments as they were competing for authority in decision-making and accessing knowledge and resources.

Nepal is globally acknowledged as one of the most climate-vulnerable nations, necessitating adaptation programs to address the impacts of climate change. In the domain of climate adaptation addressing biophysical hazards through technical and materialistic interventions, this study asserts the importance of prioritizing socio-political dimensions in adaptation policies and programs, recognizing it as a social phenomenon shaped by power dynamics and politics across different scales.

Employing ethnographic research methods incorporating interviews, focus group discussions, oral histories, and participant observation within agrarian communities in Nepal's Karnali region engaging diverse stakeholders such as government officials at local, provincial, and federal levels, civil societies, politicians, NGOs/INGOs, donors, and community-based institutions, this research found that the power hierarchies from historical and sociopolitical structures and institutional mechanisms within governing systems that reproduce social inequalities remain overshadowed. Although Nepal transitioned to a federal system that constitutionally reformed and secured a higher level of autonomy at provincial and local governments through the distribution of authorities, in practice the authority to planning and decision-making, access to internationally generated knowledge, and resources such as international adaptation funds are hegemonically controlled by the federal government. Similarly, the national-level adaptation polices including NAPA, LAPA, and VRA developed by the federal government are almost driven by donors and bureaucrats resulting in short-termed technological solutions, enhanced power differentials and exacerbated vulnerability across scales. At the local level, adaptation programs favored elites and created statute participants rather than empowering socially marginalized, politically excluded, and disenfranchised social groups inclusively and meaningfully in planning and decision-making.

Using a multi-level governance framework, this study concludes that the decentralized political system within federal Nepal had theoretically strengthened the provincial and local governments with autonomy in decision-making, co-production of knowledge and equality in accessing resources in climate change adaptation but in practice those were centrally driven by the federal government. Moreover, the adaptation programs implemented at the local levels have benefited the elites but enhanced the vulnerability of marginalized social groups. This paper recommends that the three tiers of government should collaborate effectively by empowering vulnerable communities.

Acknowledgments: Dr. Cindy Isenhour, Churchill Exploration Funds, Lambda Alpha Research Grant, GSG grants, local collaborators, and research participants.

Developing Hyperspectral Data Processing Toolbox for Ice Cores

Caleb Ames[1], Mark E. Royer[1]

1. *University of Maine at Presque Isle.*

Abstract: **This project introduces software tools to improve ice core data analysis for data scientists. It automates error detection and speeds up visualization. The suite supports ENVI and NetCDF formats for better data management. It uses Gaussian deblending and distinct masks for accurate band separation, inpainting to maintain data integrity, and Principle Component Analysis (PCA) to highlight subtle elements. This tool makes analysis faster and more detailed.**

Project Goals: The goal of this project is to develop a user-friendly software suite for data scientists, streamlining the process of ice-core data. This aims to automate error detection and provide rapid visualization to reduce the time to receive data analysis results and speed up decision making during core sampling.

Methods: The software developed for this project uses two file formats, ENVI and NetCDF. Both are general-use file formats for storing large hyperspectral data. The main differences between them are age, support, and ease of use. ENVI requires a pair of files, a header, and a data file accompanying it. The NetCDF format allows large heterogeneous data sets and metadata to be stored in a single cohesive file.

After using Python to convert the ENVI files into Netcdf, hyperspectral data is processed, employing Gaussian deblending, and calibrated using the FWHM stored inside each file. The deblending allows the separation of bands within the ice core samples. Individual masks are created for every band of the hyperspectral image. By using a mask for every band, the final product is a visualization of the data. Hiding bubbles or scratches only on the layers in which they appear. Subsequent to the masking steps, inpainting is applied, guaranteeing that masked values are not in the final product.

The final analysis step utilized in this project is Principal Component Analysis (PCA). PCA is used to sift through the bands of data, saving and isolating components based on their variance. This method simplifies the detection of elements in the data that may be otherwise unnoticeable by bringing them to the front in a handful of images.

Results:

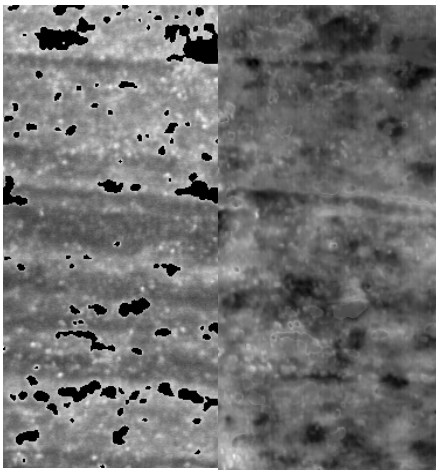

Figure 1. Figure 2.

Figure 1. This is the final step of deblending and masking just before inpainting. Figure 2. This is the final output, more specifically, PCA 4. When compared to Figure 1. it is possible to notice darkened spots due to PCA showing the hidden data.

Conclusion: The actively-developed software from this project aids data visualization. The next steps include streamlining code and inputs for data scientists to more easily use this in their work.

Acknowledgements: Many thanks to Mark Royer, University of Maine at Presque Isle, and Dr. Andrei Kurbatov, University of Maine.

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Iolite Data Reduction for LA-ICP-MS Use on Ice Core Samples

Samantha Baumgartner[1], Andrei V. Kurbatov[1,2], Elena V. Korotkikh[1], Michael Handley[1], Paul A. Mayewski[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*

Abstract: **We report testing of Iolite, a data processing software, for Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS). Data reduction schemes will be used to process ice core sample data. Upon successful implementation of an Iolite based data processing routine, the anticipated outcomes include traceability and transparency of all data processing steps and an enhancement of data reproducibility.**

Introduction

Current data processing used in the W. M. Keck Laser Ice Core Facility is time-intensive and involves several manual steps for data reduction. The Iolite software (Paton et al., 2011) provides automated features that allow: easy selection of the baseline, standards, and samples, built in data reduction schemes, the ability to use standards for data reductions, and the creation of templates for sample processing. These features permit rapid processing and ease of exporting data. In addition, Iolite utilizes Python plugins which allow the user to implement customized processing algorithms if a feature isn't included in the base software. Overall, Iolite aims to make processing of sample data user friendly and easily replicable.

Methods

After analysis with the LA-ICP-MS, the mass spectrometer generated files are imported into Iolite. Iolite allows for easy selection of desired data (Fig. 1), baseline calculations, and standards. Once selections are made, a data reduction scheme derives the corresponding concentrations. From there the user can export the data in tabulated formats.

Next Steps

We are enhancing our current LA-ICP-MS method (Korotkikh et al. 2018) to detect layers and patterns in old ice collected at the Allan Hills Blue Ice Area (BIA). Detection of layers in BIA's is difficult due to complex ice flow history. New methodology will provide us with the resolution and precision needed to identify these layers. To conclude, the implementation of the Iolite software will be an important step in processing the chemistry of Allan Hills ice cores collected using UMaine's LA-ICP-MS systems.

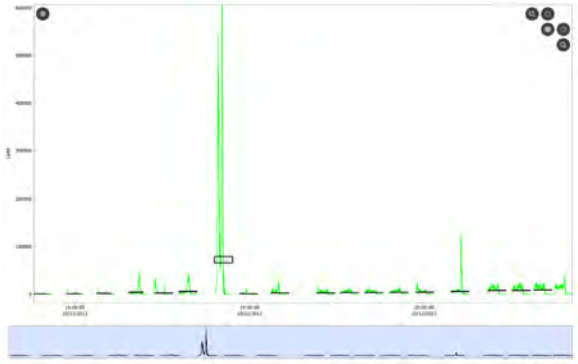

Fig. 1. Example of Iolite interface with a sequence of 19 samples (green lines), with the average intensity calculated based on specific selections (black).

Acknowledgements: The National Science Foundation (NSF) Grant: PLR–2019719, Center for Oldest Ice Exploration (COLDEX).

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Constraining the Spatial Distribution of Snowpack Properties of the Kahiltna Glacier, Denali National Park, Alaska

Keegan Bellamy[1,2], Emma Erwin[1,2,3], Claire Bicknell[4], Ingalise Kindstedt[1,2], Scott Braddock[1,2,5], Seth Campbell[1,2], Karl Kreutz[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *Cold Regions Research and Engineering Laboratory (CRREL), U.S. Army Corps of Engineers.*
4. *Outdoors Studies, Alaska Pacific University.*
5. *Department of Earth Systems and Geosciences, College of the Atlantic.*

Abstract: **High-frequency (900 MHz) common-offset ground-penetrating radar (GPR) transects collected in 2023 along the lower West Buttress of Denali on the Kahiltna Glacier in Denali National Park, Alaska, provided a comparison dataset to previous geophysical studies. We observed spatial variability of snowpack properties from the percolation to wet snow zone likely resulting from changing elevation and aspect.**

Alaska has been identified as a region with some of the highest meltwater runoff uncertainties due to complex terrain resulting in variable snowpack and the remote region resulting in a lack of field observations, therefore offering an opportunity to fill existing research gaps.

Located in Denali National Park, Alaska, Kahiltna Glacier provides one of the greatest elevation ranges of any mountain glacier on Earth (300 to 4,300 m a.s.l.). It offers a phenomenal opportunity to observe spatial variations in snowpack properties from high elevations in the dry snow zone down to the lower wet snow zone.

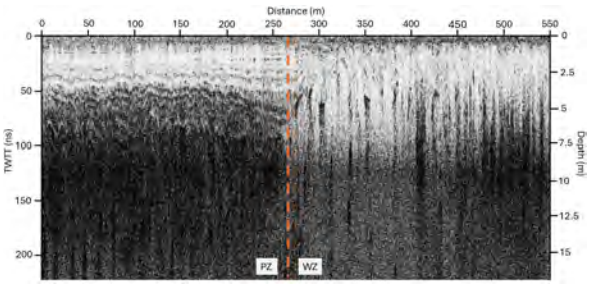

Fig. 1. Results from 900 MHz GPR survey show the transition from the percolation zone (PZ) to wet snow zone (WZ) from Kahiltna Base Camp (2,190 m a.s.l.) to the main truck of the glacier (1,990 m a.s.l.). Orange dashed line represents transition boundary.

Previous baseline mid- to high-frequency (40-900 MHz) common-offset ground-penetrating radar (CO GPR) surveys conducted on Kahiltna Glacier and Begguya Plateau from 2008-2014 and 2022 provide the foundation for this research [1, 2]. For this study, high frequency (900 MHz) common-offset ground-penetrating radar (GPR) data was collected over 9 km from Kahiltna Base Camp (2,190 m a.s.l.) to Camp 1 (2,380 m a.s.l.). These data captured the upper 15 m of the snowpack through the percolation to wet snow zones as we transitioned from an area of high elevation on the eastern tongue of Kahiltna to the main trunk of the glacier (Fig. 1). Overall, these surveys provide a unique dataset for comparison to other snowpacks across Alaska and Canada.

Acknowledgements: We thank the Robert and Judy Sturgis Family Foundation Exploration Fund, American Alpine Club, CRREL, and UMaine Graduate Student Government for financial support, Claire Bicknell for safely guiding us, and Talkeetna Air Taxi and Denali National Park Service for aerial and logistical support.

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Predictors of Large Icebergs in NW Greenland

Allie Berry[1,2], Kristin Schild[1,2], Siddharth Shankar[3], Leigh Stearns[3]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *Department of Geology, University of Kansas.*

Abstract: **Icebergs can account for up to 50% of the freshwater flux from Greenland tidewater glaciers but are largely unaccounted for in global circulation models due to limitations with models and observations. In this study, we use iceberg distributions in NW Greenland to determine the dominant environmental predictors of large iceberg abundance through Random Forest Regression analysis. In better understanding controls on iceberg abundance, we can improve parametrizations in models.**

Motivation

The recent acceleration of Greenland glaciers, and subsequent rise in iceberg production, has increased the amount of freshwater entering global oceans[1]. In addition to implications for sea level rise, icebergs also have the capacity to alter fjord circulation, heat transport to glaciers, ocean chemistry and ecology, and sea ice concentration. Despite the increasing abundance of icebergs, and their known impacts, global circulation models (GCMs) often neglect icebergs and their contributions to FWF. The current representations of FWF in GCMs leads to an over-attribution of FWF in the fjords and neglects the contributions of iceberg FWF in the open ocean, by injecting freshwater as liquid directly at the ice-ocean interface. To assess the magnitude of discrepancy in current modeling practices and improve upon them in the future, we must first determine the number of icebergs that make it out of the fjords and into the open ocean and assess what environmental factors influence these icebergs.

Methods & Results

Here, we use icebergs identified from Sentinel-1 SAR imagery to create a timeseries of iceberg distributions in NW Greenland from 2018 - 2021. We divided the timeseries by region (fjord and offshore) to determine the attrition rate with distance from terminus, and also by iceberg size, small (area < 10^4 m^2) and large (area > 10^4 m^2). From this we find that although small icebergs account for 89% of the distribution, large icebergs account for 82% of total iceberg volume (Fig. 1). We then use a random forest regression (RFR) analysis to determine what environmental variables are the dominant predictors of large iceberg abundance and assess their relationship. We find that glacier dynamics are the most important predictor for all of NW Greenland (Fig. 2).

Future Work

Next, we will work to establish time lags between glacier dynamics and iceberg distributions. With these results we can better understand what factors influence the production of the large icebergs, which is important for including in GCMs. This inclusion will allow us to understand how changes in environmental conditions will influence the amount and volume of icebergs.

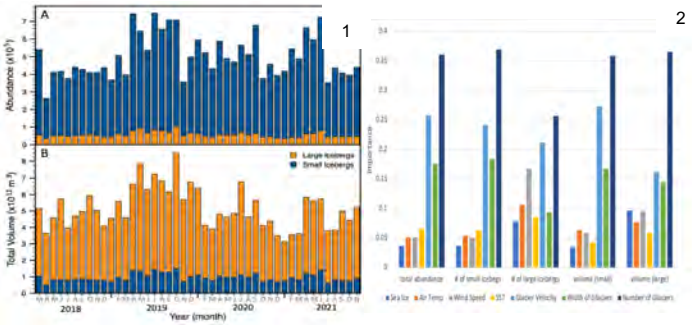

Fig. 1) Large (orange) and small (blue) iceberg abundance (A) and iceberg volume (B). Fig. 2) RFR results for iceberg metrics in fjords of NW Greenland.

Acknowledgements: This work is supported by NASA NIP Award 80NSSC21K0945.

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Digitizing the Archaeological Record: Preservation or Cultural Theft?

Emily M. Blackwood[1,2]

1. *Climate Change Institute, University of Maine.*
2. *Department of Anthropology, University of Maine.*

Abstract: This research explores the ethical considerations of digitizing techniques used to visualize and preserve archaeological data. Incorporating virtual reality, augmented reality, photogrammetry, and LiDAR in site and artifact visualizations are powerful tools that can provide a way to visualize archaeology outside of field. However, no guidelines currently exist outlining the ethical parameters when using these including who has control over what is and what is not digitized.

Background:

Accurate documentation of cultural material recovered through excavation and the site itself is a critical aspect of archaeological research. The techniques implemented to capture these data have been refined and our methodologies expand as new techniques become available. But the discipline of archaeology, intentionally or unintentionally, has a deep history of exploitation and objectification of the cultural heritage we study. Publication practices are shifting to be more inclusive and equitable, but this has not yet been initiated for 3D renderings of cultural materials or cultural spaces.

Discussion:

The enticement, and arguably the applicability, of creating digital models of archaeological material and spaces is that they can be viewed and shared globally with profound impact. They are 3D, in color, rotatable, to scale, zoomable, printable, and preservable. This provides huge potential for enhancing individual artifact and overall site analysis, for increasing public awareness and education of archaeology, and for collaborations between computer scientists and archaeologists. It allows us to reconstruct the excavation process level by level, zoom in and examine aspects of wall profiles or features we may have missed in the field from different angles, handle artifacts without fear of breaking or contaminating them, create simulations that bring excavation to the classroom, and much more. The incorporation of LiDAR and photogrammetry have been game changers for the discipline.

The caveat is permission to make these models is often not sought and the IP is not associated with the creator(s) of the cultural material or their descendants, it is associated with the creator(s) of the model. This is in part due to defining these rendered 3D models as 'digital assets' which become objects that are distinct from the original physical object or space they are modeled from. Some professional societies and associations have established principles and codes of ethics relating to best practices and standards of field work and dissemination of information, but language pertaining to digitally rendered objects is vague or absent. While these methodologies are new to the discipline, they still need to be regulated.

Seeking permission from Indigenous or descendant communities and respecting their decision to or not to digitize cultural material or spaces is straight forward and should not be difficult to adhere to. However, it is not something that is usually considered and is often an afterthought because we get excited about the potential preservation and visualizations we can create and because collaboration with these communities has not been standard practice.

Archaeology is extractive and destructive but equally as informative. It is how we sift through time to reconstruct and learn from past moments of human lifeways and ingenuity. But who is centered and has control over the research carried out needs to shift from the archaeologist to those we study. Archaeology is a privilege and a service; it is not a right.

Acknowledgements:
I thank my committee (Dan Sandweiss, Richard Corey, Alice Kelley, Kirk Maasch, Torben Rick) who challenge, encourage, and support me in exploring these ethical considerations.

Quantifying Changes in Driving Stresses for Glaciers in South Greenland Over the Past 90-Years as They Transition from Marine- to Land-Terminating

Mathilde Børch[1], Kristin M. Schild[1,2], Sarah F. Child[3]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine*
3. *Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado.*

Abstract: **Greenland glaciers has undergone rapid change over the past four decades. In this study, we investigate three glaciers in South Greenland transitioning from marine- to land-terminating utilizing remote sensing data and structure form motion (SfM) photogrammetry. With the creation of a timeseries spanning the past 90 years, we will quantify the shifts in driving stresses before, during and after the glacier transition.**

Motivation: Collectively, 485 glaciers draining the Greenland Ice Sheet as well as peripheral glaciers in Greenland, are in active retreat or have already transitioned from being marine-terminating to land-terminating over the last 35 years. Quantifying the changes in the driving stresses of glaciers as they transition will enable, not only a better understanding of the glacier behavior during transitions, but also better predictions of the changes to occur farther north. This case study will focus on three South Greenland glaciers draining the GrIS which all are outlets of the Qassimiut lobe. The three glaciers share a similar terminus environment but are in three different stages of transition today: marine terminating, transitioning and completely transitioned.

Methods: In this study we use a suite of remote sensing data (aerial, satellite, UAV) to make a detailed 90-year timeline mapping out changes in ice thickness, terminus position, slope and stresses as glaciers transition. In applying SfM photogrammetry, which is the discipline of extracting topographic information from photographs, we can expand our investigation to well before the satellite era by utilizing old aerial photographs from surveys of Greenland by the US and Denmark starting in 1932.

Anticipated scenarios: We anticipate one of two scenarios as glaciers retreat onto land: (1) an increase in surface slope as the terminus retreats but the inflow remains consistent, which would lead to an increase in driving stress and further retreat *or* (2) the driving stress decreases as resisting stresses becomes more dominant and the glacier decelerates and/or stops retreating.

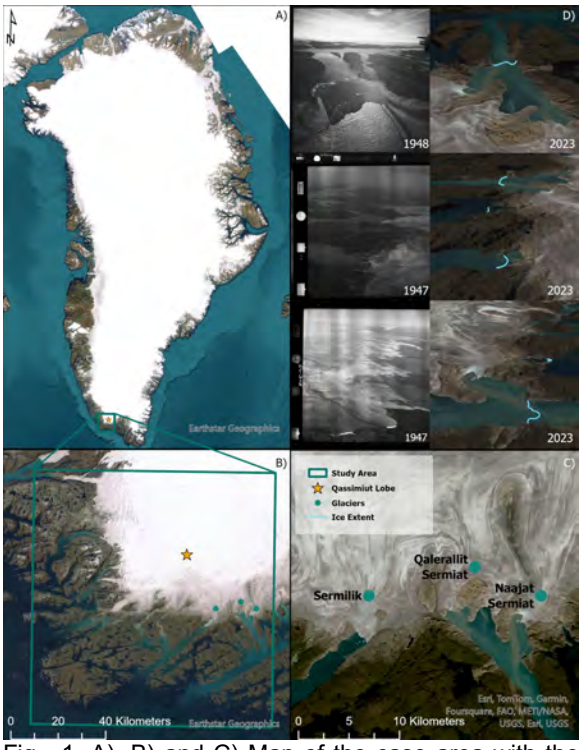

Fig. 1. A), B) and C) Map of the case area with the three studied glaciers. D) A comparison between aerial photography from 1947 and 1948 done by Agency for Data Supply and Efficiency (SDFE) and ice extent in 2023.

Acknowledgements: This MS work is funded by a CCI fellowship and builds upon the bachelor thesis by Mathilde Børch and Bjørn Timotej and supervisor Anders Anker Bjørk.

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Pleistocene Restructuring of Top-Heavy Trophic Ecologies: Paradise Lost for Large Carnivores?

Nikhil Brocchini[1], Jacquelyn Gill[1, 2]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology and Ecology, University of Maine.*

Abstract: **While the cause of the late Quaternary extinction of megafauna has been a subject of debate for decades, the mechanisms behind its geographically uneven intensity have received surprisingly little scrutiny. We introduce a new hypothesis with an ecological mechanism to explain global patterns of large mammal diversity throughout the Pleistocene.**

The cause of the global late Quaternary extinction (LQE), in which roughly half of terrestrial mammal species weighing over 45 kg went extinct, has been hotly debated for decades. This event, characterized by its unusual size-selectivity and geographically uneven intensity, has defied easy explanation, with climate change and human hunting (overkill) emerging as the two predominant and best supported causal hypotheses. Increasingly, analyses of the global evidence have come to support human expansion, not climate change, as the primary cause of the LQE. However, while prodigious amounts of scholarly effort have been devoted to understanding why many megafaunal species went extinct, there has been relatively little investigation into why some survived, and why those survivors are disproportionately found in Africa and Tropical Asia.

Proponents of the overkill hypothesis have usually cited coevolution of African megafauna with hominins to explain the geographic unevenness in the intensity of the LQE. However, this hypothesis has gone largely untested, and even in its ideal form fails to explain major elements of the phenomenon. We propose a hypothesis to explain global patterns in large mammal diversity since at least the early Pleistocene, which does not rely on a coevolutionary mechanism in surviving large animals, and is based on a synthesis of existing scholarship and established ecological theory.

Prior to the appearance of carnivorous hominins on each continent, similar trends in large mammal diversity emerged. Megaherbivore species were successful, due to their metabolic efficiency, dietary breadth, and reduced vulnerability to predation. These species are known to have substantial impacts on ecosystems, including increasing environmental heterogeneity, promoting landscape openness, increasing environmental stability, and increasing total productivity. These conditions created comparatively top-heavy trophic ecologies, which supported an abundant and diverse guild of large and often social carnivores. These highly biodiverse ecosystems were stable, largely due to highly competitive conditions within the carnivore guild. The evolution of hominin carnivores exerted a non-responsive forcing on the energetic structure of ecosystems, triggering substantial bioenergetic alteration. On continents with the earliest and mildest exposure to hominin carnivores, like Africa, ecosystems were merely 'knocked-down' to a lower energetic state which could better withstand later perturbations. Continents like the Americas experienced more total collapse.

This hypothesis is novel in its spatiotemporal scope, and in its explanatory power. It sets forth a new research agenda for quaternary paleoecology, and has substantial implications for conservation science.

Acknowledgements: We would like to thank the Climate Change Institute at the University of Maine for funding this research.

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Novel Lead (Pb) Isotope Record Tracking the Impact of Policy and the Covid-19 Pandemic on Asian Pollution Emissions Deposited in Alaskan Ice Cores

Hanna L. Brooks[1,2], Michael Handley[2], Karl J. Kreutz[1,2], Dominic A. Winski[1,2], Jacob I. Chaliff[3], Erich C. Osterberg[3]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *Department of Earth Sciences, Dartmouth College.*

Abstract: In my dissertation study, I am examining changes in lead (Pb) isotope values over the past two millennia (340 to 2022 CE) using ice cores from Begguya (Mt. Hunter), Alaska.

Project Goals: We can analyze natural climate change in the North Pacific using ice cores. Winds travel west to Begguya, carrying dust and pollution from Asia across the North Pacific. Critical changes in culture (industrialization, globalization of world markets, Covid-19 pandemic), technology (industrial recycling), and policy and legislation (phase out of leaded gasoline) have a direct impact on Pb transported to and deposited at Begguya.

Methodology: We developed this ~1,700 year dataset using ice samples from four ice cores taken on Begguya (Mt. Hunter), Alaska: DEN-13A and DEN-13B (210 m) drilled in 2013, DEN-19A (51 m) drilled in 2019, and DEN-22A (21 m) drilled in 2022. To collect the data, we melted each ice core using a melting system and ultra-clean sample preparation procedures at Dartmouth College[1]. Using the UMaine Climate Change Institute (CCI) Inductively Coupled Plasma Mass Spectrometer (ICP-MS) facility, samples were analyzed for trace metal concentrations and Pb isotope ratios following established methodologies[2]. The CCI ICP-MS facility is equipped with a Thermo Element XR with a JET interface system. With this system, samples can be analyzed directly from ice core meltwater, without the need for column chemistry.

Results: Pb concentration data from this study shows the same increasing trend from 1700 to the present seen previously in other North Pacific records[2,3]. Preindustrial levels have been recorded at Mt. Logan[2] and Begguya (this study). The record remains relatively unchanged until the 1950s when Pb concentration experiences a large increase from the 1970s to present. These records therefore reflect China's industrial revolution in 1978 and the subsequent explosion of industrial output from China over the last 45 years[4].

Preliminary Pb isotope data indicate a shift in Pb isotope ratios from previously published values[2,5]. For example, in 2021 the Pb isotopes have an average $^{208}Pb/^{207}Pb$ ratio of 2.42648 and $^{206}Pb/^{207}Pb$ ratio of 1.13571. This $^{206}Pb/^{207}Pb$ ratio is lower than Pb ratios previously published for the North Pacific. For comparison, Koffman et al. (2022) sets their 2016 pollution end-member as $^{206}Pb/^{207}Pb$ of 1.1542 and $^{208}Pb/^{207}Pb$ of 2.4386. The trend of much lower than anticipated $^{206}Pb/^{207}Pb$ values is present from the preindustrial through the present (2022 CE). The meaning of these lowered ratios is still under consideration.

Acknowledgments: The Denali Ice Cores were recovered near the summit of Begguya, within the traditional homelands of six sovereign nations who have occupied the region for thousands of years before our study. This work is funded by NSF (AGS-2002483; AGS-1806422; OPP-2002470), the UMaine GSG, and the Maine Space Grant Fellowship program.

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Artistic Approaches to the Climate Crisis: The Necessity of Creative Outlets Under Distress

Ashley Brown[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Policy and International Affairs, University of Maine.*

Abstract: Art is a critical tool of humanity; necessary in the struggle against climate change. It allows an outlet of expression for negative thoughts, making room for agency and positive change. This is evidenced by the existence of art in multiple forms at COP28.

The creation and observation of art gives voice to emotions and can create motivation for action. Climate change is a daunting concept, one that can evoke feelings of apathy and distress. Having an outlet to articulate these sentiments is crucial: in order to remain an active and strong member of the fight against climate change it is imperative not to lose hope. It has been proven that the connection between arts and emotions promotes interest and motivation, as well as inspiration for protest.

The climate change movement is rife with data, figures, and scientific jargon. But, despite the importance of quantitative research, it is not enough to result in behavioral change. The arts provide stronger persuasion to those not yet invested in mitigating and adapting to climate change.

For those that are invested, the incorporation of Art at COP28 is just as important as the negotiations themselves. The negotiations can be infuriating at times, hopeful at some, and depressing at others. So as to not be discouraged we must interact with the more creative side of the conference.

While at COP28 I encountered numerous pieces of art depicting both the woes and the solutions to climate change. The entire Women and Gender Constituency Pavilion was an in-progress mural throughout the week, the Palau pavilion was an art gallery, and the entire conference was engulfed in interactive pieces.

Figure 1 (left) depicts a painting of the ocean, with one notable detail missing. There are no fish present in the sea, a reality that may be actualized in the future if climate change is not dealt with adequately. At first, the absence of life may be missed, instead focusing on the oil slicked grass growing at the bottom. Anger, then motivation arises upon the realization. It is meant to inspire action against marine pollution and the encroachment of humans in aquatic territory.

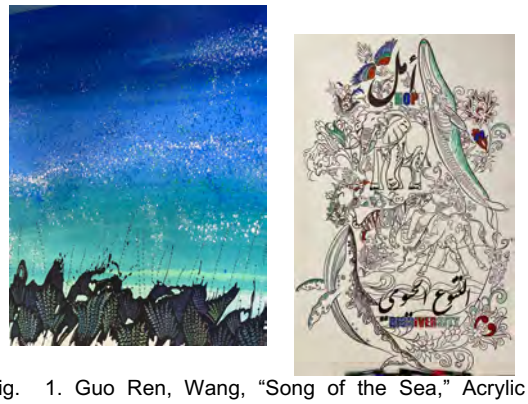

Fig. 1. Guo Ren, Wang, “Song of the Sea,” Acrylic on Canvas, 2021, Displayed at COP28. Fig. 2. Community, Marker on Paper, 2023, Displayed and Created at COP28.

Figure 2 (right) is a collaborative effort. Each person who walks by is meant to color in a small section, slowly becoming more colorful. This composition illustrates the group effort tackling climate change is and will be. Representing that we are all smaller marks in a larger artwork.

Art is empowering, something needed throughout this formidable journey mitigating and adapting to climate change.

Acknowledgements: I’d like to sincerely thank the Climate Change Institute and the School of Policy and International Affairs here at the University of Maine.

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A Comparison of Sciurid Thermoregulatory Traits

Eric Brown[1,2], Claudia Saldaña DeCamillis[3], Danielle Levesque[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology and Ecology, University of Maine.*
3. *Departamento de Biología, Universidad de Puerto Rico.*

Abstract: The evolutionary history of mammalian thermal traits is subject to much speculation. Here we constructed a phylogeny of squirrel thermoregulatory traits using basal metabolic rates and heterothermic states to determine if the two are correlated. We found that basal metabolic rate does not necessarily correlate with a particular heterothermic phenotype, which may be both a consequence of insufficient sampling and recent apomorphies.

Background:
Squirrels (Family Sciuridae) constitute the second-most speciose mammal families (N = 316), have a near cosmopolitan distribution in most terrestrial habitats, and exhibit extensive ecological diversity. They are consequently the focus of many inquiries into the physiology of endothermy. The diversity of heterothermic phenotypes in squirrels is well known, though less is known about whether specific thermal traits are correlated. Here we construct a phylogeny of select sciurid species with corresponding basal metabolic rates (BMR) and heterothermic state (e.g. no / unknown torpor use, daily torpor, and hibernation) to explore the relationship between these traits.

Methods:
We created a phylogeny from the Upham et al. (2019) mammal tree using phytools (v2.0, Revell 2024) based on species included in the Genoud et al. (2018) quality-controlled mass-specific BMR dataset. Capacity for torpor was assigned according to the criteria produced by Nowack et al. (2023), and species present in Genoud et al. but not Nowack et al. were assigned as either not being heterothermic or not yet being described as heterothermic.

Results:
Torpor (e.g. daily torpor and hibernation) consists of active metabolic suppression, so we might expect to find these phenotypes in species with low basal metabolic rates. This is not always the case (Figure 1), and some species that hibernate such as *Tamias amoenus* and *T. striatus* also have relatively high mass-specific BMR compared to other hibernators. Likewise, species with low mass-specific BMR (e.g. *Urocitellus townsendii* and *Xerospermophilus spilosoma*) are not always hibernators.

Although it is possible that species secondarily gained or lost the capacity for torpor (e.g. no described heterothermy in *U. townsendii* in a genus of hibernators), it is also possible that our phylogeny's 20 species are undersampled and do not represent a broad enough sample of Sciuridae to capture the evolutionary history of these traits. We aim to add several tropical species to this Holarctic-skewed dataset with ongoing sampling in Borneo to better understand the evolution of endothermy in squirrels.

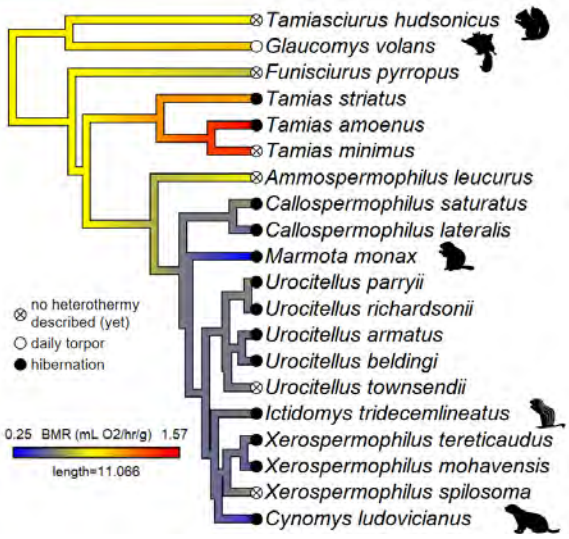

Fig. 1. Phylogeny of squirrel species with corresponding thermoregulatory traits.

Acknowledgements: Funding for this project was provided by the NSF (CAREER Grant #2045785).

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Feeding a Chariot of Fire and Lightning: Pricing Fuel-Electric Vehicle Operations

Sudarshan S. Chawathe[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Computing and Information Science, University of Maine.*

Abstract: Vehicles that may be run using combinations of fuel and electricity present the obvious questions of which combinations are to be preferred for given metrics (such as environmental or financial costs) and trip characteristics (such as length, topography, and weather). This note frames this problem, outlines some challenges, and proposes a data-driven solution that avoids the difficulties of model-based approaches.

When operating a vehicle that may be propelled by energy from fuel or electricity, which option or combination results in the lowest environmental or financial cost? Given the significant contributions of vehicles and, more generally, transportation to greenhouse gas emissions and climate change, this question and its variations are of societal importance. As well, answering the question in ways that are usable and accurate in practice poses several technical challenges. For concreteness and brevity, the rest of this note uses financial cost as the metric to be minimized; however, much of what follows is also applicable to other metrics, notably greenhouse gas emissions. For the same reasons, the focus is on plug-in hybrid electric vehicles (PHEV) of the passenger car class with an internal combustion engine powered by gasoline.

With the above specializations, an answer to the primary question may seem simple enough: Use the current prices of fuel pf and electricity pe along with the amount of each used per unit distance traveled, uf and ue , respectively, to compute the cost per unit distance using either choice and pick the option with the lower cost. Of these four parameters, the cost of fuel pf is perhaps the easiest to quantify in practice: Current (or very recent) gasoline prices at a location are typically readily discoverable, with spatial granularities down to neighborhoods and individual stations. Likewise, the cost of electricity pe is discoverable using the extant rates from electric utility companies. However, there are sometimes and increasingly complicating factors such as differential rates for EV charging and thresholds for pricing tiers. Although still conceptually quite simple, discovering accurate values for pe is not trivial in practice due to the lack of reliable and fine grained rate information. (As an illustrative exercise, one may try to discover pe for a few randomly selected ZIP codes in the US.)

The situation with the usage parameters uf and ue is more complicated. Nominal values for both are quite readily available. For instance, the US EPA maintains a Web site providing those numbers for practically all recent vehicles sold in the US. However, those numbers are, at best, accurate long-term averages for a certain mix of driving conditions, and do not translate well to specific situations such as “5 km stop-and-go in -5 C temperatures followed by 10 km at highway speeds at similar temperatures.” There is a large and growing body of work on modelling the characteristics of vehicle, roadway, driver, and environment at various levels of detail in order to yield more accurate estimates. While much of this work is technically interesting, it is unclear how it may be applied given the current state of information available to drivers.

Instead, the primary question may be answered by matching the current trip with similar trips in a database of trips to determine the key parameter values, followed by selecting the minimum-cost alternative. The similarity-based matching may be performed using diverse methods, ranging from a simple match for the entire trip based on a few characteristics such as distance, ambient temperatures, and topography. It may also be performed in a more sophisticated manner to yield further gains. For instance, one may ask whether splitting the planned trip (for the purpose of matching) into smaller subtrips with different strategies provides a better solution.

Evaluating the Spatial Distribution and Continuity of Snow and Firn Stratigraphy using Ground Penetrating Radar

Renée Clavette[1,2], Emma Erwin[1,2], Inga Kindstedt[1,2], Kailey Mannello[1,2], Seth Campbell[1,2], Karl Kreutz[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*

Abstract: **To better understand snow and firn stratigraphy at a high accumulation site, we collected common offset (CO) ground penetrating radar transects (GPR) on the Eclipse Icefield (Yukon Territory, Canada). We collected one GPR transect between two firn core locations also obtained during this field season. These data show spatially continuous layers with minimal depth variations.**

Glaciers are critical reservoirs for liquid water impacting downstream watersheds, ecosystems, and water resources[1]. As glaciers lose mass, more surface meltwater is introduced into higher elevation regions which can interfere with isotope signals and paleoclimate analyses of ice cores[2,3]. **The goal of this project is to characterize near surface stratigraphy of the snow and firn**. This provides spatial context for firn coring and potential future ice core drilling efforts at this field site. Few studies exist in Alaska and Northwestern Canada that aim to address spatial and temporal variations in snow and firn properties, and not enough exist to make conclusions about regional-scale processes.

We collected GPR data with a 900 MHz system on the Eclipse Icefield between two locations where firn cores were drilled. The Eclipse Icefield is located in the St. Elias Mountains at about 3000 meters above sea level. On average, this site has low melt rates and high accumulation rates[4]. Radar data were processed using methods and software developed by Lilien and others, (2020). We employed their semi-automatic horizon picker to analyze depth variations across the transect. Variations in layer depth may indicate changes in accumulation or melt across a small area. Our results indicate stratigraphic layers in the snow and firn are continuous between firn core sites and are at near constant depths (Fig. 1). These findings are consistent with analyses of firn density. Additionally, these data suggest accumulation and melt is relatively uniform across this area and perhaps more consistent with regional-scale trends.

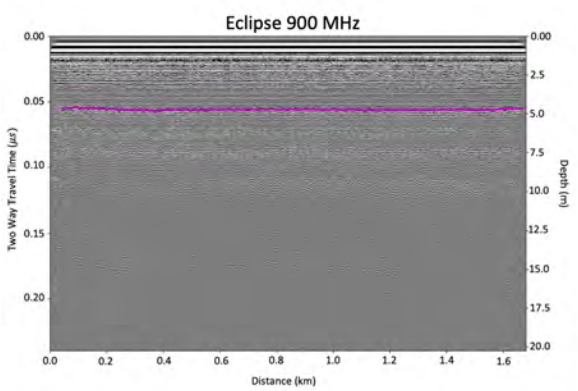

Fig. 1. Radargram from the 900 MHz GPR showing two-way travel time and depth vs. distance traveled. This transect was collected between the two firn core locations. Last year's snow accumulation surface is traced in pink and located at about 5.0 meters depth.

Acknowledgements: This research was supported by the Churchill Exploration Fund as well as the Golden Family Foundation through UMaine's Sea to Sky program, and Graduate Student Government. We thank staff at Kluane Lake Research Station and Icefield Discovery as well as James Minifie.

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Using Past Glacial Response to Climate Change to Predict Water Scarcity in the Western US

Tricia Hall Collins[1,2], Aaron Putnam[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*

Abstract: The Wind River Range (WWR) is considered a 'mountain water tower' at the headwaters of the Green River, the largest of the Colorado River's tributaries. Gaining a better understanding of how this region responds to hydrological changes associated with a warming climate has implications for western U.S. water resource management. The WWR features a landform record of the last major reduction in glacial ice caused by the atmospheric warming that ended the last ice age. Here, I employ ^{10}Be surface-exposure dating to develop a chronology of glaciation along the western front of the WWR during the last glacial maximum (LGM) and subsequent termination. This glacial reconstruction will provide model metrics for thermal and hydrological impacts of the effects of changing atmospheric patterns in the western U.S.

The Soda Lake region, located along the western flank of the WWR (fig. 1) of the northern Rocky Mountains, USA, features an exceptionally well-preserved set of moraines that were constructed during the peak of the last glaciation and at the onset of the last glacial termination. Establishing a detailed chronology of these landforms can afford insight into the drivers of ice ages and terminations. The last termination was the most recent significant global warming event prior to human-induced warming. Glaciers are highly sensitive to changes in atmospheric temperature. Thus, documenting the timing and rate of glacier change within the WWR will help to discern past temperature changes in this region.

During the summer of 2022, I collected 42 samples for ^{10}Be surface-exposure dating from the Soda Lake moraines. I selected surfaces for sampling from boulders deposited on or near the crest of terminal and lateral moraines that showed evidence of glacial polish or smoothing with limited subsequent weathering. I also recorded field observations pertinent to developing a detailed geomorphologic map of the region, aided by newly available high-resolution LiDAR topographic data.

My Soda Lake chronology will be extended into the latest portion of the LGM termination with the addition of a chronology I am developing from Lysefjorden in southwestern Norway. Lysefjorden contains some of the best preserved late-glacial moraine sequences in the world, potentially allowing me to document a cold reversal that interrupted the deglaciation near the end of the warming period. The combined chronologies from Soda Lake and Lysefjorden will allow for a full accounting of the LGM termination in the Northern Hemisphere.

My research seeks to improve projections of regional changes in Northern Hemisphere jet streams and storm tracks. To do this, I will use my glacial reconstructions to provide model metrics for thermal and hydrological impacts of the effects of changing westerlies in the western U.S. These winds govern precipitation and heat delivery patterns that determine the availability of water resources from mountain water towers for downstream users and ecosystems.

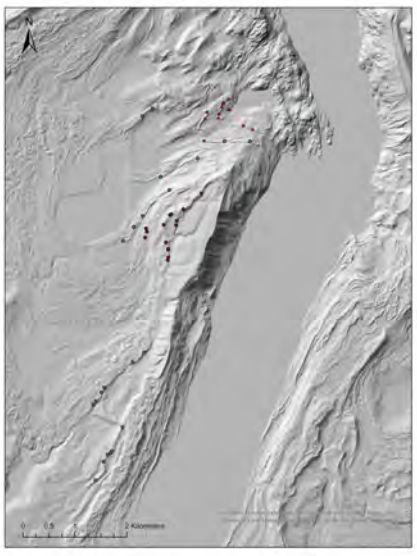

Fig. 1. Sample locations from 2022 field season in the Soda Lake area in the WWR.

Acknowledgements: Comer Family Foundation, The Robert and Judith Sturgis Family Foundation.

Reconstructing the Paleotempestology Record from the Tibes Indigenous Ceremonial Center at Ponce, Puerto Rico

Karina M. Cortijo-Robles[1]

1. *Climate Change Institute, University of Maine.*

Abstract: This research explores the paleotempestological record of the indigenous ceremonial center Tibes in Ponce, Puerto Rico, using the analog model approach through sediment cores.

Introduction

Tibes, on the south side of Puerto Rico, is one of the best-preserved Antillean indigenous ceremonial centers, and ongoing studies have shown its undeniable role as a site of past human-environment dynamics[1] (Figure 1). Hurricanes are not unknown to Antilles populations, being now more present due to climate change[2]. New emerging disciplines, such as paleotempestology, have tried to understand how hurricanes have affected the landscape and human communities in the past[3,4]. The study proposed addressed the paleotempestological record of the indigenous ceremonial center Tibes in Ponce, Puerto Rico, using the analog model approach through sediment cores. The objectives of the research are to understand the impact of major hurricanes on cultural development by (1) identifying the significant features of the two most recent catastrophic hurricanes (Hurricane Maria in 2017 and Not Named in 1929) and (2) reconstruct a paleotempestological record for Tibes and interpret how the population could have adapted to the hurricanes or how they led to the abandonment of the site.

Figure 1. Study area map of Ponce, Puerto Rico, with triangle symbols representing sample points.

Methodology & Preliminary Results

The overwash deposits preserved in the sediments of coastal lakes and marshes are the most accurate and widely used methodology of paleotempestological research[3]. Due to the fact that Tibes is around 8 km inland, soil samples were taken from the dune or bern area on La Guancha at Ponce. These samples are being correlated with soil samples collected from the Tibes and the nearby Portugues River. A loss on ignition (LOI) test and grain-size analysis was undertaken in all the samples and sediment cores. The samples collected from the Portugues River showed a significant difference in LOI. A charcoal piece was collected from the coastal zone, leading to a radiocarbon dating test with the result of 1924calAD.

Acknowledgments: The Robert and Judith Sturgis Family Foundation.

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Characterizing the Englacial Stratigraphy at the Bottom of the Denali Ice Core, Alaska: A New Geophysics Approach

Emma Erwin[1,2,3], Keegan Bellamy[1,2], Claire Bicknell[4], Karl Kreutz[1, 2], Seth Campbell[1, 2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *Cold Regions Research and Engineering Laboratory.*
4. *Alaska Pacific University.*

The Denali ice core offers a long-term climate record of the greater Alaska region; yet, to expand the record to its fullest extent, the continuity of stratigraphy at depth must be resolved. Here, we present new efforts to characterize the englacial stratigraphy at the bottom of the Denali ice core.

Background

Twin surface-to-bedrock ice cores extracted from Begguya (Mt. Hunter) in 2013, referred to as the Denali ice cores, have produced a high-resolution hydroclimate history of the greater Alaska region for the last 1200 years[1]. Carbon-14 data now confirm early Holocene-age ice in the bottom 10 m of the ~210 m cores and the full stable isotope record implies late Pleistocene, and possibly Eemian ice near the bed[2]. Stratigraphic continuity of the bottom 10 m remains uncertain and must be resolved to enable accurate interpretation of data.

Methods

During the 2023 summer field season, we used the high-resolution capabilities of the Autonomous phase-sensitive Radio Echo Sounder (ApRES)[3] to conduct a fine-scale survey across the 2013 drill site on the summit plateau of Begguya. In total, we collected 1500 discrete ApRES measurements at 10 cm intervals across a 150 m domain. The survey traversed the 2013 core in a South-North direction, using Emlid Reach 2 GPS units to capture the precise position of each measurement across the domain. Data were collected in three separate intervals over multiple days due to severe storms and inclement weather that limited survey times. Data processing is ongoing and will use synthetic aperture radar (SAR) processing techniques to profile englacial stratigraphy at depth with higher precision than is possible with standard ground-penetrating radar (GPR) methods.

Fig. 1. Field assistant Claire Bicknell posing with the ApRES on the Begguya summit plateau.

Acknowledgements: Data collection would not have been possible without the support of Denali National Park rangers and Talkeetna Air Taxi. Funding for this field work was provided by the Dan and Betty Churchill Exploration Fund, the Cold Regions Research and Engineering Laboratory, the University of Washington, Phi Kappa Phi's Graduate Research Grant, and the NOLS Rothberg-Birdwhistell Exploration Fund.

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Origin of Ice in the Medusae Fossae Formation, Equatorial Mars

James L. Fastook[1], James W. Head[2]

1. *Climate Change Institute, University of Maine.*
2. *Earth, Environmental and Planetary Sciences, Brown University.*

Abstract: **Recent radar findings have confirmed the existence of an equatorial deposit of ice with a volume equivalent to 30-50% of the total volume of the Martian North Polar Cap beneath 300-600 m of armoring debris. Results from a GCM identified an area of positive mass balance in the region used with the University of Maine Ice Sheet Model to assess its characteristics.**

Introduction:

We assess and test the recent radar-sounding findings of huge, kms-thick quantities of ice along the equatorial region of Mars covered by a thick protective cap (the Medusae Fossae Formation (MFF); [1], using atmospheric general circulation models (GCMs) [2], glacial ice accumulation and flow models (UMISM) [3], and models for ice ablation-induced accumulation residues (MSIM) [4].

Our results indicate that under Hesperian-era conditions, Mars at ~40° spin-axis obliquity is predicted to accumulate snow/ice more than a km thick in less than a few million years in the MFF region, producing cold-based glaciers with basal melting over <7% of the deposit.

We find that subsequent ablation of this ice deposit surface in the several billion year-long Amazonian during periods of episodic eolian stripping of MFF protective sublimation residues and dust/tephra deposits, provides a mechanism sufficient to form the thick capping layer. Similar, shorter-duration obliquity excursions during this period may have also contributed additional ice-sublation residue layers, consistent with the complex stratigraphy of the MFF.

Based on the estimated non-ice component of the MFF ice deposit, we suggest that ablation alone could have formed the cap unit in a minimum of ~350 million years, but was likely to have been episodic, operating in concert with periods of eolian surface lag removal over a much longer period. The tripartite subdivision of MFF stratigraphy could indicate major periods of Amazonian obliquity excursions that deposited and removed thinner layers of ice and sublimation residue.

The very high abundance of non-esker-like fluvial channels in part of the Lower Member of the MFF, combined with the paucity of ice-sheet basal melting in our analysis, suggests that ablation processes were sometimes dominated by top-down ice heating, melting and fluvial runoff. In summary, our three-part modeling approach supports the new findings, and offers new dimensions for the further analysis of the enigmatic MFF.

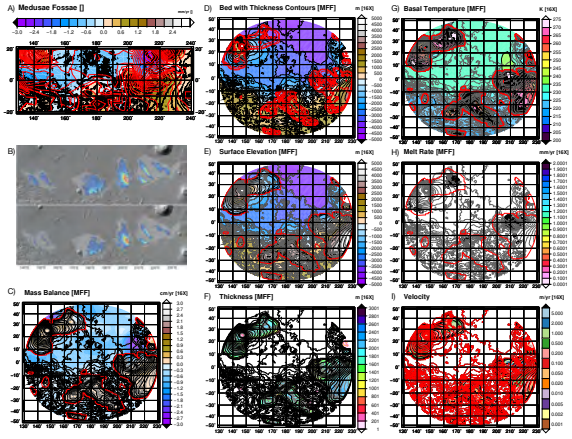

Fig. 1. A) GCM mass balance results from Scanlon et al. (2018); B) Maximum ice thickness, from Figure 5 of Watters et al. (2024); C) Mass balance as represented in UMISM, supply limited at 16X; D) Bed elevation with ice sheet thickness contours after $1X10^6$ years; E) Surface elevation: F) Ice thickness; G) Basal Temperatures; H) Basal melt rate; and I) Ice velocity.

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Reducing Uncertainty in Alpine Glacier Ice Thickness Predictions Using In-Situ Ground Penetrating Radar Measurements

Mari Fromstein[1], Mikaila Mannello[1,2], Renee Clavette[1,2], Keegan Bellamy[1,2], Tahi Wiggins[1,2], Erin Towns[1,2], Seth Campbell[1, 2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*

Abstract: **We have collected ice thickness datasets for several alpine glaciers across Alaska and northwest Canada using ground-penetrating radar (GPR). These ongoing GPR surveys are used to understand the current extent of glaciers in this region, track the ongoing changes experienced by glaciers in this region and worldwide, and reduce uncertainty in ice volume estimates. Initial results show ice thicknesses reaching over 1000 m depth across glaciers in Alaska and Canada.**

The vast majority of freshwater across Alaska and Canada is frozen in glaciers and icefields. Any changes to these glaciers or semi-permanent patches of snow and ice will have significant downstream impacts. Estimates of the total ice volume of mountain glaciers in this region range significantly. Only a handful of these glaciers have been studied well enough to understand the true volume of the ice and associated meltwater equivalent.

Between 2008 and 2023, our team has collected a large amount of ice thickness data in the form of common offset (CO) ground-penetrating radar (GPR) surveys across the Central and Eastern Alaska Range and the St. Elias and coastal ranges in southeast Alaska and Northwest Canada. These data were collected with antenna frequencies of 1, 5, 10, and 100 megahertz (MHz). Sampling rates range from ~1024 to ~8192 samples per scan, corresponding to the frequency and depth penetration of each different radar system.

Post processing results in an output showing the estimated depth by using bedrock reflectors and estimated radio wave velocity within ice (Figure 1). The depth to the bed is then picked and georeferenced. Initial results collected in June 2023 show ice thicknesses exceeding 1000 meters depth across the Juneau Icefield.

Using picked glacier bed depths and geospatial processing tools, I am interpolating ice depths across each study site. This data will be compared with modeled ice thicknesses to reduce ice thickness uncertainties and associated volume (Farinotti and others, 2019).

These in-situ data are a crucial component in reducing uncertainty in modeled ice thicknesses.

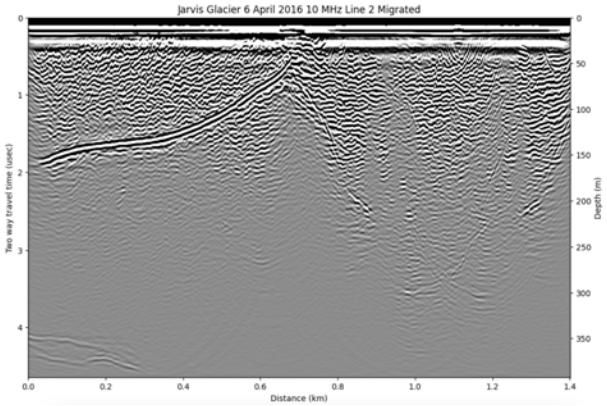

Fig. 1. Radargram showing measured ice thickness of Jarvis Glacier in eastern Alaska.

Our next steps involve processing the wide array of available ice thickness data, as well as conducting more GPR surveys across the Juneau Icefield in June 2024.

Acknowledgements: Thank you to NSF-OPP (award #2119883), the University of Maine Climate Change Institute, and collaborators from the University of Arizona and University of Alaska-Fairbanks for support of this research.

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Snowpack Sampling in Georgia for Future Geoarchaeological Framework

Lela Gadrani[1,2], Andrei V. Kurbatov[1,2], Michael Handley[1], Elena V. Korotkikh[1], Douglas Introne[1], Chris P. Loveluck[3], Paul A. Mayewski[1]

1. Climate Change Institute, University of Maine.
2. School of Earth and Climate Sciences, University of Maine.
3. Department of Classics and Archaeology, University of Nottingham.

Abstract: **This study examines surface snow glaciochemistry in the Georgian Caucasus, aiming to understand snowpack response to regional temperature increase and its implications for the reconstruction of archeological and environmental history from regional ice cores.**

Glaciers in the Greater Caucasus are potential archives that hold records of past environmental changes and past climate and anthropogenic pollution for more than 2ka (Preunkert et al. 2019). Unfortunately, recently reported accelerated melting of the region's glaciers (Tielidze et al. 2022) could comprise this archive. We investigated the integrity of this archive by sampling snow, ice and meltwater. In our field program spanning 2021 to 2023, we had two major goals: first, to identify potential sites for future ice core drilling, and second, to contribute to a framework for integration of archaeological and paleoclimate data. During our field observations in 2021, we discovered several ice layers, indicating a significant recent melting event. We obtained a 173.8 cm firn core from Mt. Kazbegi. Utilizing the University of Maine's continuous melter system, we sampled 146 intervals from this core with a resolution of 0.84 cm for ICP-MS, IC, and stable water isotope analyses. The examination of chemical species revealed fluctuations in concentrations indicative of seasonal changes (Fig.1), during the Summer-Spring transition. We are currently investigating dust events, links to past agricultural activities, and other anthropogenic pollution sources. We also conducted an archaeological survey to locate metal-ore processing sites in high elevation regions adjacent to locations where ice cores can be collected to provide associated paleoenvironmental records. We discovered circular pits, metallic slags, and ceramic pipe fragments near the riverbed in Lakhami village, indicating probable copper and iron smelting activities within the 2ka glacial archive interval.

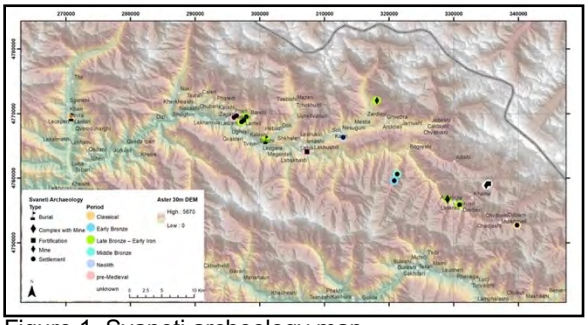

Figure 1. Svaneti archeology map

Further excavation and analysis of these sites could enhance our understanding of ore smelting in the Caucasus and its environmental impact. Retrieving paleoenvironmental and climate data from ice cores in Georgia is crucial before this valuable archive, near significant early civilization centers, vanishes.

Acknowledgements: The Robert and Judith Sturgis Family Foundation. The National Science Foundation (NSF) Grant number: 1745007. The Georgia Historical Ice Core Project (GHICP).

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Reconstructing Lake Level in South Greenland Using Fossil Diatoms and a Three-Dimensional Bathymetry Model

Amanda Gavin[1,2], Jasmine Saros[1,2]

1. *Climate Change Institute, University of Maine.*
2. *Ecology & Environmental Sciences, University of Maine.*

Abstract: Increases in drought frequency in South Greenland may impact lake water level in lakes used for drinking water and agricultural irrigation. We will use fossil diatoms in sediment cores, three-dimensional basin morphology models, and high-frequency sensors to quantify climatic drivers of water level at multiple scales.

The Arctic is experiencing an abrupt climate change event, where air temperatures are warming four times faster than the global average from 1979-2021 (Rantanen et al. 2022). Recent increases in drought frequency in South Greenland, a lake-rich region that is home to the earliest agricultural practices in the Arctic, have decreased hay yields (Caviezel et al. 2017) and Inuit sheep farmers have identified drought as a primary concern (personal communication). As the hydrological cycle intensifies in the sub-Arctic, understanding the impact of increasing drought on lakes used for drinking water and agricultural irrigation in South Greenland is critical.

Changes in lake level, a key metric for quantifying lake volume and water availability, have been observed throughout the Arctic and are attributed to changes in the hydrologic cycle. We will use a multifaceted approach to reconstruct lake level from approximately 100 years prior to the onset of contemporary farming practices to the present and quantify climatic drivers of lake level at different time scales. Historical lake level at decadal scales will be inferred through the relative changes of planktic to benthic (P:B) ratio of fossil diatoms collected from sediment cores, and a model of P:B ratio at different water levels and light environments will also be developed for each lake using three-dimensional bathymetry maps will aid (Stone and Fritz 2004) (Figure 1). Contemporary lake level at seasonal and annual scales will be measured using high-frequency, continuous pressure sensors. The integration of paleo- and neo-limnological methods will provide key insight into climate-mediated lake level changes in a unique region that is highly exposed to environmental change.

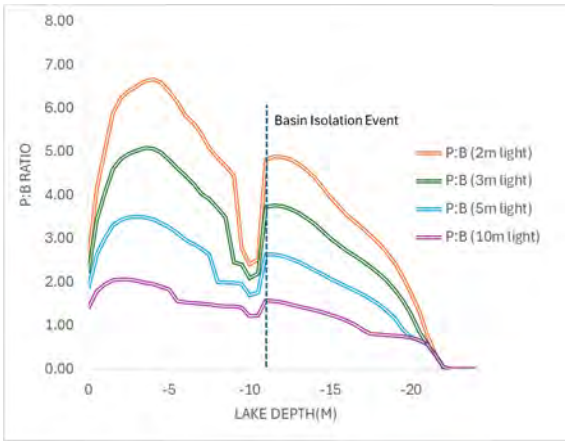

Figure 1. P:B Ratio at different lake depths and varying light levels.

Acknowledgements: NSF SAUNNA NRT.

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Alpine Plants as a Model System for Biodiversity Dynamics in a Warming World: Integrating Genetic, Functional, and Community Approaches

Jacquelyn L. Gill[1,2], Caitlin McDonough MacKenzie[1,3], Jose Eduardo Meireles[2], Andrew J. Rominger[4], Isaac Overcast[2], Stephen Keller[5]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology and Ecology, University of Maine.*
3. *Bennington College.*
4. *School of Life Sciences, University of Hawaii.*
5. *Department of Plant Biology, University of Vermont.*

Abstract: Our NSF-funded project links paleoecology, community ecology, trait ecology, population genetics, and physical geography to identify the mechanisms underlying the persistence of tundra relicts in Northeast alpine zones since deglaciation.

Alpine ecosystems are a model system for understanding how small communities of fragmented populations have responded to dynamic environments through time. In the northeastern U.S., one of the fastest warming regions in the country, alpine plants are scattered across small islands of high-elevation habitat in disjunct populations, with many taxa existing at the margins of their range and physiological tolerances. Yet, alpine plants have persisted as small populations of tundra relicts throughout millennia of regional global changes. This begs the question: ***what mechanisms allowed isolated alpine plant communities to persist during past climate changes, and will species persist into the future?***

To address this, our new study focuses on four questions t: 1) Did alpine plant lineages persist during the Holocene because of local climate refugia, metapopulation processes, phenotypic plasticity, or adaptive capacity? 2) To what extent are local microclimates supporting persistence by driving functional divergence at the trait and genomic levels? 3) How well do existing theories (e.g., island biogeography) predict alpine plant responses to long-term (post-glacial) and recent (last century) warming, and how can improved understanding of alpine plants' functional and genetic responses improve our predictions? What level of biological organization can we successfully predict (e.g., taxa, populations, functional trait space, local adaptation)?, and how can integrating data streams improve predictive power? We focus on four alpine regions: the Adirondacks (NY), the Green Mountains (VT), the White Mountains (NH), and Katahdin (ME).

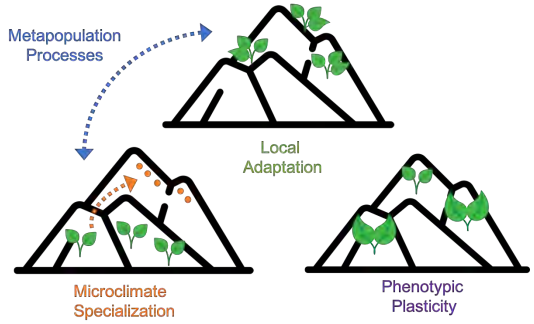

Fig. 1 Hypotheses of processes underlying alpine plant persistence during periods of regional warming.

We will first characterize post-glacial vegetation dynamics at the species level, using ancient DNA from alpine lake sediment cores. We will then conduct modern plant surveys to characterize species turnover during the last century. We will then combine common garden experiments, plant trait analyses, and coalescent modeling from population genetic data, focusing on six focal taxa representing three functional types (graminoids, herbs, and woody shrubs). The microclimates at each peak will be characterized using a high-density grid of environmental sensors, which will be compared to historic climate records and downscaled paleoclimate models to characterize the degree to which these alpine zones have maintained climate refugia during warm periods. Results will be used to create a predictive model which will be shared with regional managers, and in a podcast exploring alpine plants and the stakeholders who love them.

Acknowledgements: This project is funded by NSF-DEB-BOCP #2326020.

Assessing the Biogeochemistry of Glacially fed Lakes and Their Response to Extreme Events in Western Norway

Ansley Grider[1,2], Jasmine Saros[1,2], Jacob Yde[3]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology & Ecology, University of Maine.*
3. *Western Norway University of Applied Sciences.*

Abstract: **This research was designed to assess differences in nutrient and heavy metal concentrations between glacially fed and snow/groundwater-fed lakes in Western Norway. In addition, we assessed how the biogeochemistry of a glacial lake responded to an extreme event.**

Introduction: Glaciers are potential hot spots for atmospherically derived materials, such as nutrients and metals, that can accumulate in glaciers over hundreds or even thousands of years.[1] Materials that have accumulated in glaciers over many years are melting out at high rates due to warming temperatures in the Arctic.[1] As glacial melt increases, meltwater flux to downstream ecosystems, such as lakes, has risen, causing global glacial-lake volume to increase dramatically – by 48% – between 1990 and 2018.[2] Due to these factors, we are interested in how the biogeochemistry of glacial lakes is changing. To address this, we measured heavy metals and nutrients in the water of four glacially fed (GF) and three snow and groundwater-fed (SF) lakes in Western Norway during September of 2023 (Fig. 1). We also collected water samples from a GF lake right after (1-day post) and almost a month after (24-days post) a 50-year flood. This data allowed us to measure the biogeochemical impacts of an extreme event.

Preliminary Results: We found higher concentrations of nitrate and total phosphorus (TP) in GF lakes compared to SF lakes; however, there were no significant differences between the two lake types, but TP was leaning towards significance ($p=0.057$). Total suspended solids (TSS) and turbidity were higher 1-day post flood compared to 24-days post flood, with TSS showing a significant difference ($p<0.01$). Specifically, TSS declined by 78.5% and turbidity by 50.9% 24 days after the event. Nitrate and TP were not significantly different between 1-day post and 24-days post flood. Based on the one GF sediment core we collected, heavy metal (Cd, Cr, Co, Cu, Zn, Pb, Fe, Al, As, Hg) concentrations were relatively stable over time, and all were below concentrations that can cause adverse biological effects.[3] Data on heavy metals in the surface water is in the process of being measured on an ICP-MS.

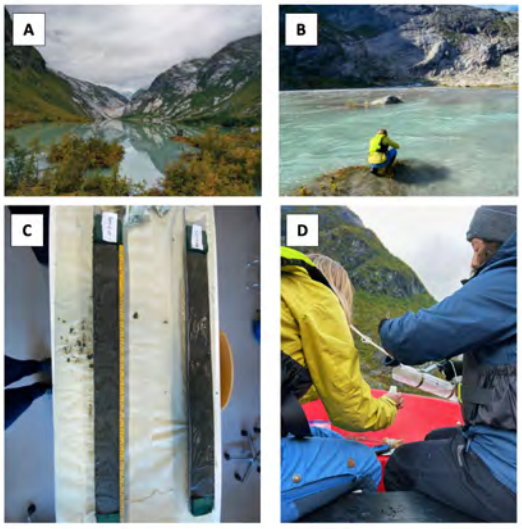

Fig. 1. Images of field work. A) Nigardbrevatnet lake, B & D) water sample collection, C) sediment core from a GF lake.

Acknowledgements: This project was supported by the Dan and Betty Churchill Exploration Fund, the NSF SAUNNA NRT, and the UMaine Graduate Student Government Grant. I would like to thank my advisor Jasmine Saros for her guidance and support, as well as our collaborator Jacob Yde for his assistance with planning and logistics during our stay and field work in Norway.

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Rapid Browning of Lakes Near Kangerlussuaq, West Greenland (Kalaallit Nunaat): A Tale of Dissolved Organic Carbon, Iron, and Suddenly Not-So-Closed Systems

Thomas Grindle[1,2], Jasmine Saros[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology and Ecology, University of Maine.*

Abstract: **In September 2022, the west coast of Greenland experienced record rainfall. The precipitation that fell on the coast allowed the many normally isolated lakes in the region to flow into each other and swept large amounts of matter off the watershed. Subsequently, the lakes began rapidly turning brown. Subsequent observations have revealed high levels of both iron (Fe) and dissolved organic carbon (DOC) in the lakes, and we aim to understand the link between DOC quality, iron, and browning, ultimately characterizing the underlying cycle affecting these lakes.**

Background:

West Greenland (Kalaallit Nunaat) is a region notable for its aridity- the average annual precipitation of Kangerlussuaq, West Greenland's major international research hub, places it in a similar category as desert cities like Phoenix, Arizona, and Baghdad, Iraq. From a hydrological perspective, the main consequence of this is very low overland flow. Many of the lakes surrounding it are closed-basin systems, bodies with little to no inflow or outflow. This makes it an ideal system for climate analysis due to the relative lack of confounding factors, so a number of lakes have been under regular observation for years by the University of Maine, among others.

During the fall of 2022, the region experienced much higher than usual precipitation. This had immediate consequences to the lakes and watershed, as formerly closed lakes flowed into each other, and large quantities of soil and organic matter were swept into the system. By July 2023, previously clear lakes had browned.

Fig. 1. Brown lake near Kangerlussuaq. Photo by Vaclava Hazukova, 07/2023.

Lake browning is not an uncommon phenomenon. Limnologists have been observing lakes in the process of browning for decades and are working to understand the chemical background of the phenomenon. Shifts in lake coloring is a subject of significant interest, as browning has potential implications for climate monitoring, indirect pollution monitoring in the watershed, and local economies based on water recreation. Strong links have been established between browning and the presence of DOC and Fe in waters, and the most common source of these materials are external, on the watershed.

We hypothesize that the rapid browning is linked to the aridity of the region. The relative lack of precipitation could allow for the slow buildup of organic matter and ferric soils on the landscape around the lake systems, ultimately being flushed into the hydrosphere by storm events like September 2022. This may be enhanced by the quickening thaw of Greenland's permafrost, which can release DOC and Fe.

By continuing regular observation and expanding our analysis to include key factors related to DOC quality and iron content, we intend to characterize the cycle that leads to lake browning and gain a deeper understanding of lake browning in Greenland and across the northern hemisphere, with the goal of predicting the intensity and duration of these events.

Acknowledgements: NSF Arctic Natural Sciences RAPID grant (#2348144), Systems Approaches to Understanding and Navigating the New Arctic NRT at University of Maine.

Indigenous Connections to Maine's Interior Landscapes: An Evaluation of the Paleoenvironmental Context of the Sebasticook Lake Fish Weir Complex

Kit M. Hamley[1,2], Reuben H. Hudson[3], Madeleine Landrum[1,2], Bonnie Newsom[1,4], Ruvan DeGraaf[3], Kaitlyn Burke[3], Beverly Johnson[5], Jacquelyn Gill[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology and Ecology, University of Maine.*
3. *College of the Atlantic.*
4. *Department of Anthropology, University of Maine.*
5. *Department of Earth Science, Bates College.*

Abstract: Here we use traditional and novel sedimentary lake core proxies to reconstruct the paleoenvironmental context of the oldest fish weir complex in North America. Our data shows a more continuous presence of people at the fish weir site than previously suggested by radiocarbon dating of fish weir stakes. This multiproxy analysis demonstrates the ability of paleoecological proxies to both complement and fill in gaps in the archaeological record.

The Sebasticook Fish Weir complex (SFWC) is the oldest known fish weir in North America and was in use for more than 5000 years. Here we use novel and traditional sedimentary paleoecological proxies to evaluate the human and ecological setting of the SFWC.

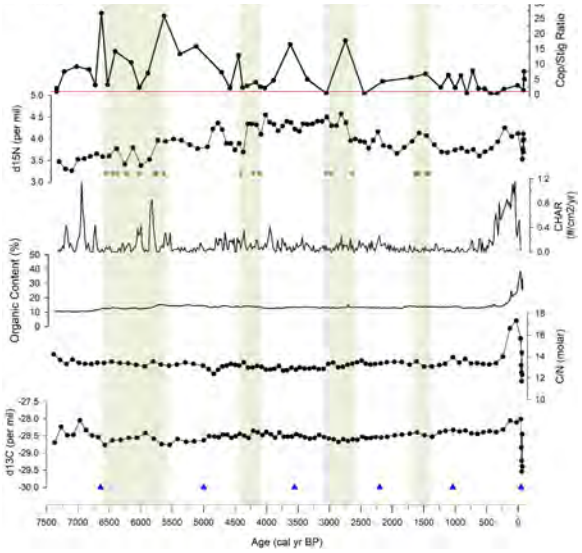

Fig. 1. Sebasticook Lake multiproxy record.

In the fall of 2021, we retrieved a 432 cm sediment core from Sebasticook Lake in the deepest basin adjacent to the fish weir complex at the mouth of the Sebasticook River. We analyzed fecal lipid biomarkers (coprostanol and stigmastanol), nitrogen and carbon stable isotopes, charcoal, and organic content (Fig. 1).

A coprostanol:stigmastanol ratio greater than 1 (Fig. 1, red line) indicates the presence of people demonstrating more continuous use of the SFWC than previously indicated by radiocarbon dating of fish weir stakes (Fig. 1: gold bars). Heightened d15N values likely indicate deposition of marine derived nutrients from anadromous fish (alewives, salmon, shad) entering the lake and broadly correspond with the establishment and period of use of the SFWC. Charcoal data indicates a major shift in fire regime around 5000 years ago and this shift does not appear to be correlated with human activity until the arrival of European settlers when widespread land use change is reflected in all of our proxies. This data demonstrates that fecal lipid biomarkers are useful for filling in gaps in the archaeological record in the Northeast where preservation is typically poor due to acidic soil and extensive land use change.

Acknowledgements: We thank the Wabanaki Nations THPOs for continued partnership on this research. We are supported in part by MSGC and NSF CAREER- Grant EAR-1753186.

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An Interdisciplinary Review - How Rapid Climate Change is Impacting Human Health, Environmental Policy, and Voter Behavior

Douglas Hasson[1]

1. *Climate Change Institute, University of Maine.*

As an interdisciplinary Ph.D. student at UMaine's Climate Change Institute, there is an obligation to review a broad set of applicable climate-related topics, while conducting unique research and tackling specific research questions, problems, and providing substantive conclusions. A case study approach has been employed where questions specific to the science, policy, and politics of climate change are addressed. The case studies are described below.

Case Study #1 - The goal of this research is to contribute to establishing a water quality framework specific to PFAS in Greenland. The Arctic is experiencing environmental changes due to climate change. These changes, including melting ice, altered precipitation patterns, and increased human activities, can impact water quality as pollutants and toxins are introduced to downstream ecosystems. Research re: Case Study #1 examines PFAS types and concentrations at 16 samples sites in southern Greenland, as well as likely transport mechanisms.

Case Study #2 - This research assesses the status, the scientific causes, and the policy and political implications of drought in the American Southwest. As global warming,

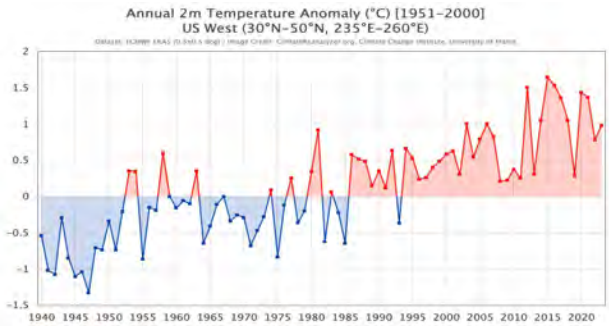

Fig. 1. Annual 2m temperature anomaly 1940-2023. Climate Reanalyzer (2024).

population expansion and economic needs continues to impact water availability in the Colorado River Basin, various interests are vying for a portion of the ever-decreasing water supply. Understanding the science behind drought, the human costs, the historic and current public opinion around climate change and drought, the changing dynamics around water policy and the likely effects that worsening drought might have on the policy and political landscapes in affected states may help climate change advocates implement more effective strategies.

Case Study #3 – The goal of this research is to determine whether messaging based on Dr. Jonathan Haidt's Moral Foundation Theory -that humans have inherent moral systems that influence decision making - is more effective in persuading Democrats, Republicans, Independents, and Moderate voters to prioritize climate change policy and/or the political candidates who support climate policy, than traditional persuasion messaging? Moreover, this research aims to assess the validity of one of Dr. Haidt's core tenets - that modern political liberals construct their moral systems based primarily upon two moral psychological foundations: Harm/Care and Fairness/Cheating, while conservatives use a broader set of moral systems.

Acknowledgements: Dr. Paul Mayewski, Dr. Sean Birkel, Dr. Mark Brewer, Dr. Charles Norchi, Dr. Alan Gerber, Dr. Mario Potocki, the 2022 National Science Foundation UMaine SAUNNA NRT Greenland team, including Dr. Jasmine Saros (PI), Dr. Kristin Schild, Dr. Kiley Daley, and Dr. Robert Northington.

Hydrological Connectivity Shapes Carbon Cycling in Arctic Lakes

Václava Hazuková[1,2], Fredrik Sundberg[3], Cristian Gudasz[4], Chunlin Song[5], Matthew Bogard[6], Josh Dean[7], Anders Jonsson[4], Erik Lundin[8], Suzanne Tank[9], Jasmine Saros[1,2], Jan Karlsson[4]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology and Ecology, University of Maine.*
3. *Ecology and Environmental Sciences, Umeå University.*
4. *Climate Impacts Research Centre, Umeå University.*
5. *State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University.*
6. *Department of Biological Sciences, University of Lethbridge.*
7. School of Geographical Sciences, University of Bristol.
8. *Swedish Polar Research Secretariat, Sweden.*
9. Department of Biological Sciences, University of Alberta.

Abstract: With increasing wetness, Arctic lakes emit less CO_2 on an annual basis while processing relatively more terrestrial carbon.

The role of Arctic lakes as sites of carbon processing is amplified with rapidly changing climate leading to permafrost thaw and altered hydrological connections. Land-to-water hydrological connections represent an important regulatory mechanism of carbon transport, especially in systems with low rainfall-runoff ratios such as the Arctic tundra (Tank et al., 2019). To better understand how hydrological connectivity controls annual carbon dioxide emissions from lakes, we collated data from 179 Arctic lakes distributed across permafrost regions in Alaska, Northern Canada, Greenland, Siberia, and Scandinavia. Increasing wetness is associated with relatively low CO_2 emissions fueled by terrestrial carbon as indicated by higher $SUVA_{254}$ (UV absorbance at 254 nm normalized for dissolved organic carbon concentration) while more arid regions exhibit higher across-lake variability: ranging from uptake to high emissions of CO_2 (Fig.1A, B). Lakes in arid regions tend to cycle predominantly internal carbon (e.g., algae, macrophytes) (Fig. 1B), suggesting high variability in CO_2 fluxes among lakes might be linked to differences in trophic status.

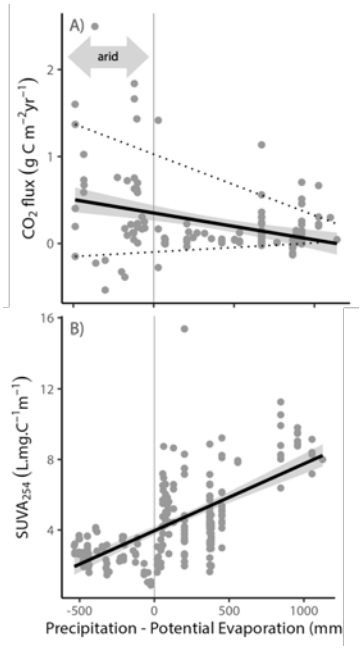

Fig. 1. CO_2 fluxes decrease in magnitude and variability along the gradient of aridity in Arctic lakes (A). Higher values of $SUVA_{254}$ indicate terrestrial sources of organic matter dissolved in the water while lower values suggest that carbon in the water has been produced locally (B; e.g., algae, macrophytes).

Acknowledgements: NSF NRT 2021713, NSF DDRIG 2113908, ASLO LOREX Fellowship, Dan and Betty Churchill Exploration Fund, The Robert and Judith Sturgis Family Foundation.

Bibliography: Tank et al., 2019, *LOL.*

Using Geophysical Survey to Reveal Patterns in Monumental Construction at Los Morteros, Peru

Kelly E. Hoover[1]

1. *Climate Change Institute, University of Maine.*

Abstract: **Geophysical survey was performed at Los Morteros in 2006 and 2010 by Dan Sandweiss and crew and beginning in 2012 Ana Cecilia Mauricio (PhD UMaine 2015) has carried out excavations at the site. Here, I re-process and analyze the GPR data collected in 2010 to reveal patterns that may help explain monumentality at Los Morteros.**

Background:

Los Morteros is a Preceramic monumental site (150 x 200 x 15 m) located in the Pampa de las Salinas on the Northwest coast of Peru, first identified as an archaeological site in 1976 by Cárdenas et al. (1995) during a larger archaeological survey of Pampa de las Salinas. Investigations at Los Morteros continued intermittently, and a preliminary ground-penetrating radar (GPR) survey done in 2006 was used to identify monumental features, such as walls. The archaeological site was identified as a built mound, rather than a natural dune formation that was utilized later by Andean inhabitants (Sandweiss et al. 2010).

Recent research on adobe bricks at the site indicate an early evolutionary stage of clay in monumental construction associated with dates older than 5,100 cal yr B.P. (Mauricio et al. 2021). In 2010, Climate Change Institute researchers collected 992 MB of raw GPR data at Los Morteros. I revisit this “legacy” data to reveal patterns consistent with monumental features, to be targeted for a more in-depth collection during upcoming field work. We hypothesize that early inhabitants may have built walls to accidentally, or deliberately, trap sand in their lee to create the massive site.

Methodology:

Reprocessing of 2010 data includes adjusting gain and filters, such as band passing and background removal to clearly define architecture of the mound from initial construction while simultaneously reducing additional noise that obscures vital information to accomplishing my objectives. Patterns consistent from line to line as we would expect to see with walls are noted to perform a targeted GPR resurvey during the 2024 field season.

Fig. 1. Satellite image of Los Morteros, captured from Google Earth Pro on 3/18/2023.

Acknowledgements: Thanks to Alice Kelley, Allen Gontz, Ana Cecilia Mauricio, and Dan Sandweiss for advice. Thanks to the Climate Change Institute for technology and workspace.

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Firn Density, Stratigraphy and Temperature on Eclipse Icefield, Yukon, Canada

Ingalise Kindstedt[1,2], Emma Erwin[1,2,3], Mikaila Mannello[1,2], Renée Clavette[1,2], Karl Kreutz[1,2], Dominic Winski[1,2], Jacob Homles[1,2], Seth Campbell[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *Cold Regions Research and Engineering Laboratory.*

Abstract: **The areal extent and behavior of alpine glacier surface melt vary widely in space and time. Here, we present density, stratigraphy and borehole temperature measurements showing the influence of surface melt production and movement through the firn at Eclipse Icefield.**

Project Goal & Motivation

The goal of this project is to evaluate the movement of liquid water through the snow and firn at Eclipse Icefield, a high-alpine accumulation zone site in the St. Elias Mountains, Yukon, Canada. Glaciers retain water in the form of snow that over time is condensed into ice. For alpine glaciers, the rate of reservoir drawdown is largely controlled by the quantity and behavior of surface melt, which vary with changes in elevation and local topography. Surface melt production is of particular concern in high-alpine accumulation zones containing records of past climate in their glacier ice, records which may be compromised by the movement of meltwater through the glacier subsurface. Here we present the results from three shallow firn cores drilled on Eclipse Icefield, a high-alpine accumulation zone site that is of interest for deep ice coring and climate reconstruction efforts.

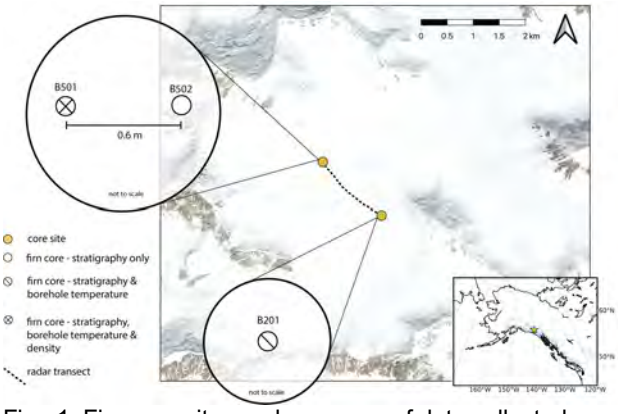

Fig. 1. Firn core sites and summary of data collected.

Data Collection

In May, 2023, we recovered three shallow (~10-15m firn cores from Eclipse Icefield. We recorded stratigraphy for all three cores (Fig. 1), borehole temperatures for two cores, and density for one. Density, stratigraphy and borehole temperatures all show evidence of present but limited meltwater movement through the now and firn. Comparison of stratigraphy among the three firn cores indicates that observations from a single core are not representative of individual features even a meter away from the drill site, but they are representative of overall firn character and annual melt-freeze cycles in the kilometers near the site.

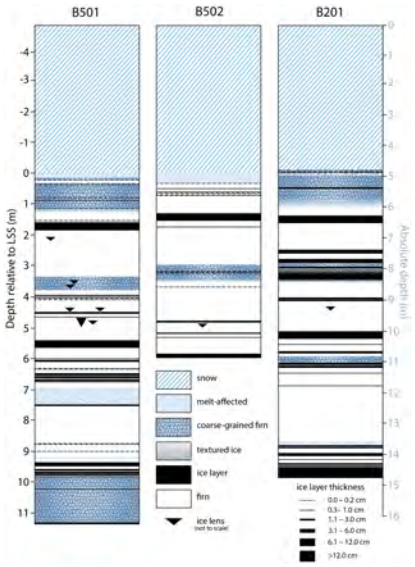

Fig. 2. Firn core stratigraphy.

Acknowledgements: University of Maine Climate Change Institute; the Robert and Judith Sturgis Family Foundation; the American Alpine Club, the American Geophysical Union, Geophysical Survey Systems Inc., the University of Maine Graduate Student Government, the University of Maine Sea-to-Sky Program.

Using Sediment Reconstructions to Determine the Relative Importance of Nutrients and Temperature on CyanoHABs in Maine Lakes

Avery N. Lamb[1,2], Jasmine E. Saros[1, 2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*

Abstract: **There is little consensus on how relatively important increasing nutrients and temperature, and their interaction, are in contributing to the frequency and severity of cyanobacterial harmful algal bloom (cyanoHAB) in Maine lakes. This research leverages paleolimnological techniques and unique Maine geology to investigate the relative effects of climate warming, long-term eutrophication trends, and trophic status on changes in historic cyanobacteria communities in Maine lakes.**

Increased nutrients and temperature are considered the most important drivers of global cyanobacterial increases, but there is no consensus on the relative importance of nutrients versus temperature or on any additional factors that might mediate their relative importance (e.g., specific cyanobacteria taxa, longer timescales, or more specific climate metrics like seasonal warming). Furthermore, there is little consensus about how nutrients and temperature may interact to affect cyanobacterial abundance, with the degree and direction (synergistic, antagonistic, additive) often scale-, taxa-, and trophic state-dependent.

To investigate the relative importance of nutrients, temperature, and nutrient/temperature interactions, sediment cores were collected from lakes that span a range of climate zones (Northern, Central, Coastal Maine), trophic states (oligotrophic, mesotrophic, eutrophic), and underlying geology (with or without Presumpscot formation in their watersheds) (Fig. 1). Long-term temperature records show that while all three of Maine's defined climate zones are warming annually and seasonally, temperatures are increasing at different rates (1). To capture lakes with different available nutrients, lakes that vary along the trophic status continuum are included in the experimental design. To differentiate long-term trends in eutrophication, lakes with differences in underlying geology were also included; accounting for the presence or absence of P-rich Presumpscot formation in lake watersheds can indicate natural and historic eutrophic conditions vs. more recent increasing eutrophic conditions due to anthropogenic activities. This unique experimental design allows comparisons of cyanobacteria abundance and community structure reconstructed from photosynthetic pigments between Maine lakes experiencing different rates of warming, long-term eutrophication trends, and trophic status.

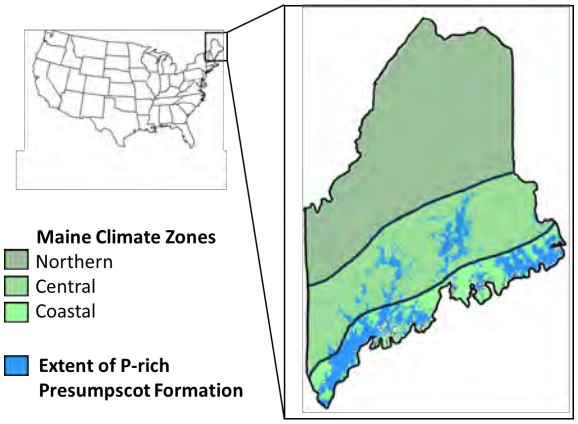

Fig. 1. Map showing Maine, USA, climate zones (Northern, Central, Coastal) and the extent of the phosphorus-rich Presumpscot Formation geologic deposit. Sediment cores of various trophic state were taken from lakes in all three climate zones, in lakes with or without Presumpscot formation in their watersheds.

Acknowledgements: USGS Grant Award #G21AP10180-00. Team members: Denise Bruesewitz, Peter Countway, Charlie Culbertson, Michael Kinnison.

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Reconstructing Human-Forest Relationships in Maine

Madeleine M. Landrum[1,2], Kit M. Hamley[1,2], Bonnie D. Newsom[1,3], Reuben Hudson[4], Chris Guiterman[5], Chris Sockalexis[6], Jacquelyn L. Gill[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology and Ecology, University of Maine.*
3. *Department of Anthropology, University of Maine.*
4. *Department of Chemistry, College of the Atlantic.*
5. *Cooperative Institute for Research in Environmental Sciences, University of Colorado at Boulder.*
6. *Penobscot Nation Tribal Historic Preservation Office.*

Abstract: Though our paleoecological understanding of Indigenous fire use is geographically and temporally limited, historical observations and Indigenous place names indicate that the Wabanaki people used fire to clear land for agriculture and improve hunting grounds. In this study, we examined possible human influences on local forest composition using lake sediment records.

Study, Results, and Interpretation:

The degree to which Indigenous people shaped fire regimes and vegetation composition prior to European contact in New England is a source of great debate[1,2]. While there is historical evidence describing Indigenous people shaping their environment[3], most studies focus on the effects of climate on regional changes[4]. In this study, we examined possible human influences on local forest composition using sediment collected from Witch Hole Pond in Acadia National Park (ANP), Maine. The core was analyzed using lipid biomarkers, pollen, and charcoal. Analysis spans 0 to 6,300 BP. At 5,200 BP, the fire regime shifts from high peak magnitude and frequency with low peak duration to low peak magnitude and long duration. Pyrophilic pine, oak, nut, and fruit pollen increases while pyrophobic species decrease. Forests return to their mesic states by 3,500 BP where they remain until 1,000 BP (fig. 1). We interpret the shift in fire regime at 5,200 BP to be transitioning from a climate-dominated to a human-dominated signal. The hemlock decline at 5,200 BP would have led to an increase in fuel loads on the landscape that, during a period of drought[5], would likely have led to a charcoal record of high magnitude and frequency peaks. Instead, we see the opposite (fig. 1). The archaeological record appears at this time[6], along with a stabilization in lipids, and increase in pyrophilic and food-rich pollen types, showing significant changes were occurring on the landscape during a period of low fire occurrence. However, as the climate cooled[7], precipitation increased[5], forests mesophied, and human influences become less clear.

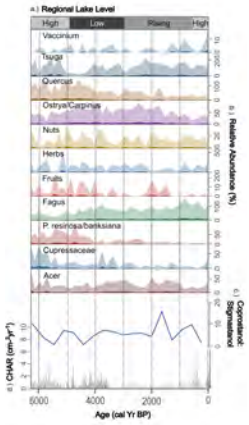

Fig. 1. (a.) ME lake levels[5] (b.) % abundance notable pollen taxa; dark colors represent actual value, lighter shading is value x10 (c.) Coprostanol to stigmastanol ratio (d.) Charcoal accumulation rate.

Acknowledgements: Thanks to A. Nurse, D. Ranco, D. Soctomah, and ANP. *Funding:* NSF GRF, Churchill Exploration Fund, CSD, GSA, and GSG Grants.

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Relating Traditional Wabanaki Knowledge and "Western" Watershed Science for Maine's Rivers

Elizabeth Leclerc[1,2,3,5], Sean M.C. Smith[2,4,5]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *Department of Anthropology, University of Maine.*
4. *Mitchell Center for Sustainability Solutions, University of Maine.*
5. *Maine Agricultural and Forest Experiment Station, University of Maine.*

Abstract: **After centuries of watershed alterations driven by European settler-colonial activities, Maine's rivers are now also responding to hydrologic changes from shifting climate conditions. Awareness of these relatively abrupt changes to river systems and their implications for Indigenous communities has inspired a collaborative research effort bringing Western and Indigenous knowledge traditions together to improve management decision-making and outcomes for Maine's surface water systems and communities inseparably connected to them.**

Background:

Water resources management in Maine over the past three centuries has typically focused on consumptive use and a limited set of objectives related to water supply, power generation, and transportation, with strategies framed around civil infrastructure, development-based planning, and problem-reactive regulation. The cumulative effects on Maine's rivers have been adverse, regardless of restorative work in recent decades.

Work in land and wildlife management contexts has demonstrated that Indigenous knowledge, often incorporating holistic perspectives, has advantages over Western approaches for addressing complex socio-ecological problems (e.g., Popp et al. 2019). Through millennia of co-existence and cultural relationships with the waters of their traditional homelands, Indigenous Wabanaki people have developed extensive knowledge and practices related to Maine's waters. Wabanaki water knowledge may help address shortcomings in contemporary watershed management, especially related to cumulative impacts, and anticipated changes to Maine's watersheds. However, Maine has a long history of aggression toward Wabanaki nations around water (Girouard and DeFrancesco 2016), and any work with Wabanaki people on water issues must respect the integrity and sovereignty of their nations and knowledge.

Research Goals:

Working with Wabanaki partners, we aim to bring Wabanaki water knowledge and "Western" science into relation to facilitate their individual, complementary, and synergistic contribution to water management decisions. Our goal is to improve the capacity for Wabanaki and settler-colonial water managers to communicate productively. As currently envisioned, the project will include three primary objectives:

1) Articulate fundamental concepts in Wabanaki water knowledge and their intersections with Western sciences using ethnographic methods.
2) Demonstrate the entanglement between Indigenous peoples and water environments using archaeology and oral traditions.
3) Describe the magnitude of settler-colonial transformation of surface water environments and cultural practices using Indigenous, hydrological, geomorphological, and geospatial approaches.

Our next steps are to work with Wabanaki partners to refine the research program and begin the Institutional Review Board process for research involving human subjects.

Acknowledgements: National Science Foundation; Phi Kappa Phi; Lambda Alpha National Anthropology Society.

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Tropical Endothermy in a Changing World: the Energetics of Small Mammals from Sarawak, Malaysia

Danielle L. Levesque[1]

1. *School of Biology and Ecology, University of Maine. Cooperating Faculty CCI.*

Abstract: **All mammals are endotherms but the cost of endothermy varies greatly depending on characteristics of both the animal and its environment. Equatorial tropical mammals experience relatively stable environmental conditions and appear relatively well adapted to high environmental temperatures. However, climate change will not have similar impacts on all species. I will discuss the costs and benefits of the different types of thermoregulatory phenotypes observed in Bornean tropical mammals and how knowledge of these factors can help predict which species will be the most vulnerable to climate change.**

Much of what is known about energetics in mammals has been derived from Holarctic species whose evolutionary history has been shaped by large changes in temperature and extreme seasonality. Unlike temperate species that must consistently generate heat to maintain an elevated body temperature, low latitude species spend more time at thermoneutrality and therefore can spend the energy elsewhere. However, diurnal and nocturnal species inhabiting the same environment can experience dramatically different thermal conditions. For diurnal species changes in ambient temperature are in-phase with circadian changes in body temperatures whereas in nocturnal species they are out of phase (Levesque *et al*. 2023). Nocturnal arboreal species are also potentially more at risk from raising temperatures as their day-time rest sites.

Of the mammals in Sarawak studied to date the diurnal treeshrews (Levesque et al 2018) shown a high level of thermotolerance and are unlikely to experience any difficulties in adapting to warmer climates. Nocturnal species have shown mixed responses with tarsiers and bats potentially showing high energy and water costs with raising daytime temperatures (Welman et al 2018) while a nocturnal murid rodent seems likely able to cope (Breit et al 2023).

Current work is underway to broaden number of species studied with ultimate goal to contribute to the broader understanding of mammals and climate by producing a global synthesis and novel framework linking thermoregulatory phenotypes to past and future climates.

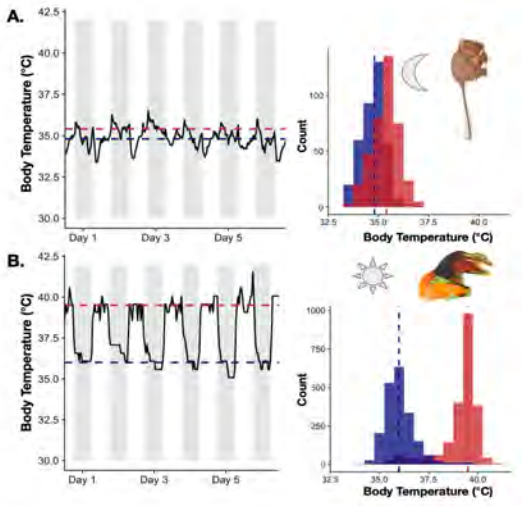

Figure 1 Body temperatures (black line) of a nocturnal small mammal the Western tarsier (A. *Cephalopachus bancanus*) the diurnal large treeshrew (B. *Tupaia tana*). Red lines indicate the mode of body temperatures during activity and blue during rest. Frequency histograms are from a number of individuals over a 2-4 month period (data modified from Welman et al 2017 and Levesque et al 2018).

Acknowledgements: This work was funded by NSF IOS-2045785, CAREER: Physiological and Behavioral Determinants of Energy Use in Tropical Mammals.

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Water Quality in the Rapidly Changing Environment of West Greenland

Cory Limberger[1,2], Ligia Naivera[1,2], Paul A. Mayewski[1,2], Mariusz Potocki[1]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*

Abstract: **Reconnaissance sampling of water from melting ice, permafrost, snow, and streams will be used to study the spatial distribution of surface water chemistry in West Greenland. This work continues to lay the groundwork for a water quality monitoring network on the coast of west Greenland.**

Greenland is undergoing a rapid change in climate, resulting in complex environmental and social impacts. Warming temperatures cause changes to the Greenland Ice Sheet (GrIS), affecting the export of freshwater, nutrients, and ions from glacier meltwater, permafrost, snow, and stream waters. Fluxes in freshwater, pollutants, and nutrients caused by increased meltwater may impact marine and coastal biogeochemical functioning. (Hendry et al., 2019). These impacts can change water quality and consequently affect human and ecosystem health.

To understand and apply knowledge of the currently undefined magnitude and rate of changes to water quality and to estimate future change, a water quality baseline is needed. Despite suggested research to create a baseline through the inclusion of monitoring throughout the Arctic (e.g., IARPC US Arctic Observing Network), water chemistry research in west Greenland has been limited to discrete spatial areas. Our work addresses the spatial distribution of water chemistry to improve understanding of baseline conditions to inform further study of changes to water quality in west Greenland.

Our team will collect water samples for the measurement of: (1) major soluble ions (Na+, K+, Ca2+, Mg2+, Cl- , NO3- , SO4 2-); (2) major elements (Al, S, Ca, Fe, Na, Mg); (3) trace elements (Sr, Cs, Ba, Bi, U, As, Hg, Tl, Li, Ti, V, Cr, Mn, Co, Cu, Zn); (4) rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Tb, Dy, Ho, Er, Tm, Yb, Lu); (5) stable water isotopes (δ18O and δD); (6) microplastics and (7) per-and polyfluoroalkyl substances (PFAS).

The spatial sampling will be conducted using the 56' sailing vessel *s/v ArcticEarth*. This summer, the sampling location will be from Sisimiut to Ilulissat. Our team will sample close to the onset of the melting season (late May to early June at these latitudes) to capture the high levels of pollutants and nutrients expected in early melting. We do not expect to sample meltwater in every single inlet but will sample a diverse subset. Samples will be both marine surface and terrestrial meltwater.

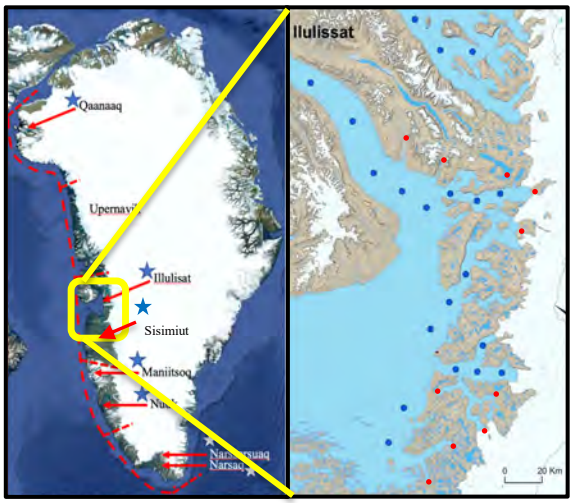

Fig. 1: Left: Spatial sampling regions bounded by dashed lines. Right: Example of the type of locations to be sampled around Ilulissat. Red marks terrestrial and ice edge locations. Blue marks marine surface water.

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Near-Surface Englacial Structure and Water Storage of Upper Seward Glacier/ Sít'Tlein

Mikaila Mannello[1,2], Seth Campbell[1,2], Michael Daniel[3], Martin Truffer[4], Doug Brinkerhoff[5], Victor Devaux-Chupin[4], Annegret Pohle[4]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *Lunar and Planetary Laboratory, University of Arizona.*
4. *Geophysical Institute, University of Alaska-Fairbanks.*
5. *Dept. of Computer Science, University of Montana.*

Abstract: Understanding where and when water is stored englacially is crucial for future sea-level rise predictions. We collected 60 km of ground-penetrating radar on Upper Seward Glacier and observe extensive firn and an englacial water table ~1700 m a.s.l. The duration of water storage and timing of meltwater release have potential implications for glacier dynamics.

The goal of this study is to constrain the spatial variability of snow and firn extent and meltwater storage capacity across Alaska and Canada. Glaciers in this region are contributing the greatest proportion of mass loss and sea-level rise from ice masses outside of Greenland and Antarctica.[1] Thus, determining annual glacier mass balance from snow and the potential for englacial water storage in firn are important in whichever climate warming scenario comes to fruition in the coming decades. This research focuses on Upper Seward Glacier which drains into Sít'Tlein (also referred to as Malaspina Glacier), located in Kluane National Park and Reserve, Canada. Field research during the early summer helps determine if water is retained in the snowpack and firn of these glacier systems during the winter months, which has been observed in other glacier locations (e.g., Greenland)[2] and currently interpreted from recent remote sensing analyses of Alaska and Canadian glaciers[3] but not yet confirmed by ground-based observations of these glaciers.

Methods & Results. We collected 60 km of 400 MHz ground-penetrating radar (GPR) in the accumulation zone via ski towing at ~1 km h^{-1} 14-21 May 2023, targeting areas we suspected would capture the best spatial variability in snow and firn thickness. From these data, we determine both the depths of the accumulation and of the firn and interpret layer properties such as density changes and water presences from the strength and phase response in radargrams. We observe englacial water tables that span approximately 2.5 and 5 km down the centerline of Upper Seward Glacier (Fig. 1).

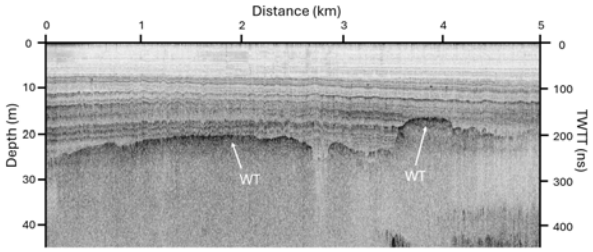

Fig. 1. Radargram traveling down-glacier with clear firn stratigraphy and water tables (WT).

Acknowledgements: Robert and Judith Sturgis Family Foundation, The Golden Family Foundation, UMaine Grad. Student Government, and University of Alaska-Fairbanks. Support of pilots at Icefield Discovery and staff at Kluane Lake Research Station. We acknowledge that this research was conducted on the lands of the Kluane, Champagne and Aishihik, and White Rivers First Nations peoples, past and present.

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[2] Forster et al., "Extensive liquid meltwater storage in firn within the Greenland ice sheet," 95.

[3] Johnson and Meyer "Detection of glacier firn aquifers across Alaska using time series of Sentinel-1 SAR," Abstract (C22F-0825).

Life-stage-partitioned Forest Inventory and Analysis (FIA) Data Reveals Multi-Directional Tree Range Shifts in Contemporary Environments

Bailey P. McLaughlin[1,2], Brian J. McGill[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology and Ecology, University of Maine.*

Abstract: A widely held assumption is that, in response to warming, species will shift their geographic ranges poleward in latitude to track favorable climates. Some evidence supports this expectation, but several studies violate this claim and demonstrate more complicated patterns than traditionally assumed. Despite this, little effort has been made to systematically summarize the *variability* embedded in range shift dynamics in a large-scale, multi-species context. Aiming to fill this gap, we use data from the U.S. Forest Inventory and Analysis (FIA) database to map the geographic ranges of 215 U.S. tree species partitioned into their distinct life-history stages (seedling, sapling, adult), in which life stage serves as a proxy for time. For each of the 215 species, we quantify a range shift as a change in range position and direction between life stages (i.e. *Adult to Sapling* and *Sapling to Seedling*). We summarize these data among all 215 species to detect prevailing range shift patterns. We find that U.S. trees are shifting the position of their ranges median distances of 52.47km and that these movements are occurring in all cardinal directions, not exclusively poleward.

Species' geographic ranges are dynamic in time and space.[1,2] A widely held assumption, that stems from longstanding ecological theory, suggests that species will migrate uniformly poleward as climates warm. While some evidence supports this pattern, several studies contradict this claim, suggesting more complicated patterns.[3] Despite this tension between expected and realized patterns, still missing from the literature is a standardized, empirical synthesis of prevailing patterns at large spatial and taxonomic scales, capable of detecting variation.

We fill this gap by partitioning species' ranges into distinct life-stage components to assess geographic range shifts in contemporary environments. Here, life stage serves as a *proxy* for time, in which each life stage represents a different *establishment* time on the landscape, thereby snapshotting a species' range at three distinct timesteps. Trees are a model taxon with which to assess range shifts via this proposed *stage-for-time* comparison given their long lifespans and clear life-stage classes (seedling, sapling, adult).

We operationalize this approach for 215 tree species using FIA data to, first, map the geographic ranges of 215 U.S. tree species using life-stage-partitioned geographic occurrence data and, next, calculate range shifts for each species as changes in range position and direction between life stages. We summarize these metrics across all species.

Results show that tree species are shifting the position of their ranges median distances of 52.47km, in all cardinal directions.

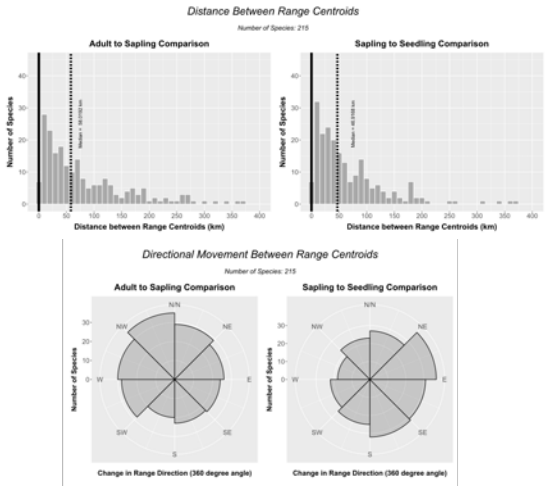

Fig. 1. Range shift metrics summarized.

Acknowledgements: Research supported by NSF, UMaine SBE, and UMaine MAEFES.

Bibliography: [1] Yalcin and Leroux, 2017; [2] Jacobson Jr. et al., 1987; [3] Lenoir and Svenning, 2015.

The Woolly Mammoth as a Keystone Species in Pleistocene Beringia

Alessandro Mereghetti[1,2], Jacquelyn L. Gill[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology and Ecology, University of Maine.*

Abstract: The woolly mammoth (*Mammuthus primigenius)* is probably the most iconic species of the Pleistocene, and the symbol of the "Ice Age". This status is due to the mammoth's charismatic appearance, wide past distribution, very recent extinction and the debate surrounding its final demise (was it because of humans or climate change?) that makes it appealing to both the general public and the scientific community. One of the most debated aspects of the woolly mammoth is its ecological role in the now-disappeared biome that carries its name, the Mammoth Steppe. By combining high resolution dietary information from mammoth coprolites and existing data on its ecology, we provide evidence to the fact that the woolly mammoth was indeed an ecosystem engineer and a keystone species, able to shape vegetation and ecosystem processes in Pleistocene Beringia.

Description: The mammoth steppe was a productive patchwork of grassland and tundra that covered most of the northern hemisphere over the last 100,000 years. The origin and disappearance of this vanished ecosystem has been reconducted to two main explaining reasons: 1) the dry, cold climate of Pleistocene glaicals 2) the action of its megafaunal guild, led by the woolly mammoth. While we know that today's large herbivores can indeed transform the environment around them via trophic interactions, the fact that both the animals and the environment of the mammoth steppe are long gone makes the puzzle difficult to solve. To understand if the woolly mammoth was actually a driving force of the mammoth steppe, we combine information from 50 coprolites collected in 2019 from Yakutia and published information about the ecology and biology of the woolly mammoth to draw the most accurate profile of the species to this day. Indeed, the woolly mammoth was able to exert a transformative influence on its ecosystem, targeting less palatable, short vegetation in the winter (and trampling/eating snow to obtain it), highly nutrient buds from shrubs in the spring and a mix of forbs, shrubs and grasses during the summer. In addition, they were able to feed on plants of the family *Ranunculaceae*, poisonous to most ungulates, making them effective at feeding on practically any plant species available in the frozen steppes of Beringia. These findings cement the idea that the mammoths were uniquely able to exploit available resources, making them a keystone species for the environment of the Mammoth Steppe and supporting the hypothesis that their disappearance altered the functioning of this lost ecosystem.

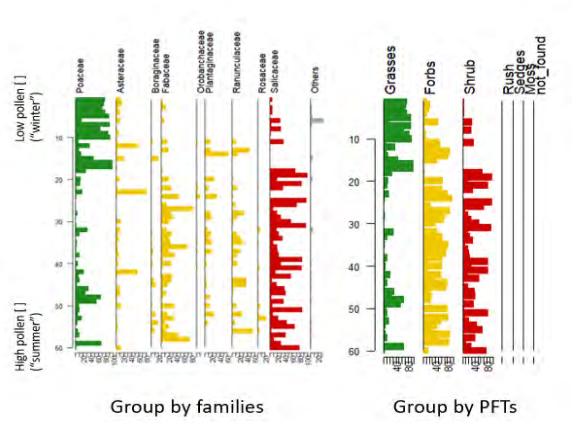

Figure 1. Plant DNA content of coprolites divided by families and Plant Functional Types.

Acknowledgement: The expedition was founded through NSF CAREER grant awarded to Jacquelyn Gill. The analysis of the samples was funded through the NSF CAREER grant, the GSA Charles A. and June R.P. Ross Research Grant and the University of Maine GSG grant.

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Evidence of Abrupt Climate Change in North-Central Maine during Termination I

Maraina Miles[1,2], Brenda Hall[1,2], Aaron Putnam[1,2], Thomas Lowell[3]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *Department of Geology, University of Cincinnati.*

Abstract: The end of the last ice age (17.8-11.7 ka) provides an analog to examine how the global climate system responds to abrupt warming. Unequal temperature changes in summer and winter, known as extreme seasonality, may have played an important role in the abrupt climate changes during the termination. However, the existence and possible implications of this seasonality remain controversial. Here, we investigate whether extreme seasonality affected the North Atlantic region during the termination. If it has, it may have skewed our interpretation of iconic climate events, such as the Bølling-Allerød (BA; 14.6-12.9 ka). Specifically, we examine changes in the extent of the Maine Ice Cap using ^{10}Be exposure ages of a newly discovered moraine sequence in northern Maine.

The climatic warming of the end of the last ice age (Termination 1, ~17.8 – 11.5 ka) marks the most recent analog for our planet's current rapidly warming temperatures. Termination I was characterized by abrupt climatic changes, including the Bølling-Allerød in the Northern Hemisphere and the simultaneous Antarctic Cold Reversal in the Southern Hemisphere (BA and ACR; 14.7 – 12.9 ka). Traditionally, it has been thought that climate during these abrupt changes was anti-phased between the hemispheres because of a 'bipolar seesaw' (Broecker, 1998). However, recent data from alpine glaciers cast doubt on this hypothesis, and instead suggest that the hemispheres may have behaved synchronously during these abrupt changes. One possible reason for this discrepancy between records is extreme differences in seasonal temperature (Denton, 2005).

New LiDAR has exposed a previously unknown moraine complex just south of Katahdin, in Baxter State Park (Fig. 1). One radiocarbon age from a nearby pond and exposure-ages of boulders located in the lowlands ~30 km south of the moraine suggest that this landform may have formed during the BA/ACR. To determine if this moraine did form during the BA/ACR, I collected samples from boulders along the moraine for cosmogenic ^{10}Be exposure dating. Together, the samples have yielded an average age of 14.6 ± 0.4 ka, indicating deposition during the beginning of the BA/ACR. This age resembles those found in the southern hemisphere, suggesting that the Maine Ice Cap advanced synchronously with glaciers in the southern hemisphere. These data add to emerging evidence suggesting globally synchronous climate and eliminating the need for a bipolar seesaw during the late glacial.

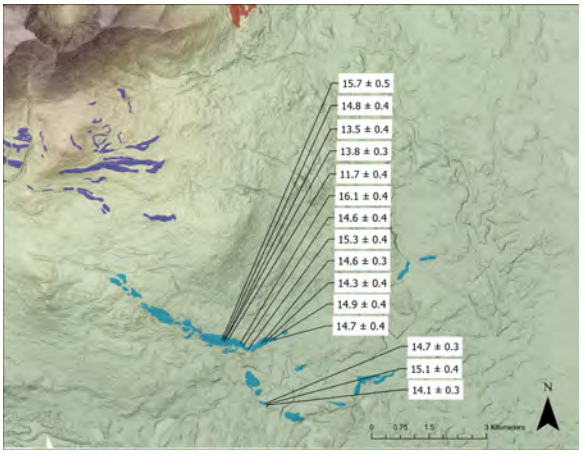

Fig. 1. Newly discovered moraine complex (blue), southern Baxter State Park. ^{10}Be exposure ages indicate deposition at beginning of the BA/ACR (14.7 - 12.9 ka) with an average age of 14.6 ± 0.4 ka.

Acknowledgements: Thank you to the Dan and Betty Churchill Exploration Fund and the Robert and Judith Sturgis Family Foundation for funding this research.

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Partial Additionality

Anthony Moffa[1,2], Joe Newlin [2]

1. *Climate Change Institute, University of Maine.*
2. *University of Maine School of Law.*

Abstract: **Partial additionality describes the situation wherein projects producing carbon offsets also generate inherent revenue (likely from the sale of energy). In such situations, the projects are thus largely financed by revenue generated outside of offset sales but are counted as additional and able to receive offsets representing the entirety of their activity. This phenomenon distorts the market for reductions-based credits in particular.**

The Problem of Partial Additionality in Carbon Markets:

This paper is the first to identify and define the novel issue of "partially additionality" of offset projects. Under the current carbon offsetting regime, additionality is calculated as a binary matter – a project is either additional or it is not, there is no in-between or continuum. Once additionality is met, the calculation of the number of offsets generated by the project completely disregards how close (or not) the project was to being non-additional. This is true for every current system of verification, including, importantly, those endorsed by the Paris Agreement's Article 6.4 mechanism. countries.

The result of this crude binary determination, as opposed to a more dynamic calculation, is that renewable energy projects that produce the majority of their revenue from energy sales can end up with a relative glut of carbon offsets. By glut, we mean that the owners of these projects do not need to sell all of the offsets, or do not need to sell the offsets at full market price, to report returns on investment at levels sufficient to satisfy creditors.

Case Study:

In 2022, construction was completed and the hydroelectric dam on the Nam Hinboun river in central Laos went into operation. This project was verified and registered in the Verified Carbon Standard voluntary registry, and generated carbon offsets calculated using approved UNFCCC methodologies. Once additionality was satisfied, the amount of offsets the project was able to create and sell was calculated.

Proposed Discounting Solution:

Here is the process as a mathematical expression:

$$(ROI_{target} - ROI_{in}) / ROI_{target} = DISC$$

$$DISC \times CRBN_{avoid} = OFFSET$$

Let's apply this to our case study. As discussed above, to be eligible for financing the Nam Hinboun hydropower project needed to reach a benchmark of 14.68% internal return. This establishes the ROI_{target} as 14.68. Given the sale of energy to the grid, the project inherently generates a 9.9% internal rate of return. This puts the ROI_{in} at 9.9. Put in terms of expected revenue, the project needs to generate $5.61m a year, but already generates $4.04m a year. The resulting discount rate (DISC), per our proposed formula, would be 0.326. The Nam Hinboun hydropower project avoids 44,615 tons of CO_2e emissions per year; absent discounting (i.e. under the current system) this is the number of carbon offsets generated by the project. Applying the discount rate to this total yields a total of 14,545 carbon offsets per year.

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Spatial Distribution of PFAS in Surface Freshwater in South Greenland

Ligia Naveira[1, 2], Paul A. Mayewski[1, 2], Mariusz Potocki[1]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*

Abstract: Reconnaissance sampling to assess the spatial distribution of PFAS in South Greenland surface waters.

Per- and poly-fluoroalkyl substances (PFAS) are a large class of artificial, highly fluorinated aliphatic compounds recognized as pervasive contaminants that are characterized by their resistance, environmental degradation, and potential adverse effects on human and environmental health. The distinctive resilience of perfluoroalkyl acids has further led to their widespread presence in the global environment, including the Arctic (Muir et al., 2019).

To date, the presence of PFAS in the Arctic marine environment has been reported in previous studies, such as in the Arctic Ocean, Greenland Sea, and Baffin Bay. Nevertheless, research on terrestrial PFAS distribution, including investigations on ice cores, snow, and glacier meltwater, has been focused primarily on the Canadian Arctic and Svalbard regions. In Greenland, PFAS contamination has been reported in terrestrial biota from East and West Greenland. PFAS levels have also been measured in humans, revealing a linkage between high PFAS concentrations and food intake of traditional Greenlandic food, particularly marine mammals (Muir et al., 2019).

By targeting 25 different PFAS analytes, the primary aim of this study is to examine surface water bodies (such as glacier meltwater streams, rivers, and lakes) as quantitative indicators of atmospheric and local sources of PFAS in South Greenland. A few mechanisms for the long-range transport of PFAS to the Arctic have been proposed and investigated: (i) ocean currents, (ii) marine aerosols, and (iii) transport and atmospheric oxidation of volatile precursor and subsequent wet and dry deposition. Several volatile neutral PFAS have been identified as atmospheric precursors to PFAS degradation compounds and have been detected in the atmosphere of the Arctic, such as fluorotelomer alcohols (FTOHs) and chlorofluorocarbons (CFC) replacement compounds (Muir et al., 2019). To our knowledge, this study represents the first assessment of PFAS concentrations in surface waters in South Greenland. In 2022, 16 samples were collected (15 from rivers and 1 from a lake), and PFAS were detected in 10 samples. Three compounds were detected: PFBA (0.509 to 1.58pg/L), PFPeA (0.517 to 1. 09pg/L), and PFNA (0.75pg/L). Results indicate that the PFAS in surface waters is likely related to atmospheric sources since PFAS was not detected in any community sampled. Future work includes expanding this research into other West Greenland regions.

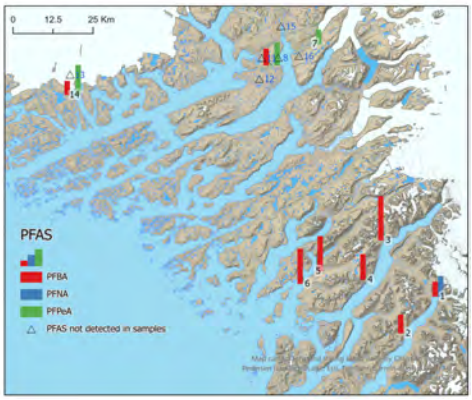

Fig. 1: Map displays PFAS sampling sites, including not detected samples.

Acknowledgments: The NSF NRT-NNA SAUNNA program (PI Saros).

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Centering Indigenous Knowledges in Climate Change Research through the Center for Braiding Indigenous Knowledges and Science

Bonnie Newsom[1], Sonya Atalay[2]

1. *Anthropology Department and Climate Change Institute, University of Maine.*
2. *Center for Braiding Indigenous Knowledges and Science and Anthropology Department, University of Massachusetts Amherst.*

Abstract: **The Center for Braiding Indigenous Knowledge and Science (CBIKS) is a new NSF funded initiative focused on climate change research. CBIKS addresses topics of climate change, food security, and heritage spaces by braiding mainstream and Indigenous sciences together in effective and ethical ways. This paper highlights CBIKS' mission, key components, and goals.**

Introduction

The climate crisis presents one of humanity's most pressing issues, with its impacts affecting Indigenous communities in disproportionate ways (Wildcat 2013:510). Indigenous peoples steward some of the planet's most biodiverse regions and for many, their lifeways contribute minimally to the factors driving climate change. Despite this, Indigenous communities are facing serious and immediate challenges to their lifeways due to climate change effects. This disparity highlights the need to bring our best collective thinking to climate change-related research. Indigenous Knowledges (IK) can offer unique insights into ecosystems and human-environment interactions. When braided ethically with Western science (WS), IK is invaluable in generating solutions to the climate crisis.

Center for Braiding Indigenous Knowledges and Science

The Center for Braiding Indigenous Knowledges and Science (CBIKS) at the University of Massachusetts, Amherst is positioned to facilitate research that intertwines IK and WS. Recognizing the need for holistic research in priority areas for Indigenous communities, CBIKS focuses on the interconnected areas of climate change, food security, and cultural spaces. Central to the mission of CBIKS are community-centered approaches to developing and disseminating methodologies for effective and ethical braiding of IK and WS.

To carry out this work, CBIKS has assembled a global team of 54 predominantly Indigenous scientists with diverse experience and specializations in environmental and anthropological disciplines. CBIKS also partners with 56 Indigenous communities — a figure expected to grow as CBIKS broadens its research circle.

CBIKS Key Components

CBIKS has several key components. They include eight regional research hubs across the globe that engage in local community-based participatory research; multiple thematic working groups that distill and disseminate lessons from place-based studies carried out by research hubs; and a publicly accessible knowledge base that hosts protocols, methods, ethics, and best practices in braiding IK and WS. Collectively, these components are envisioned as strands of a basket that carries ethical and collaborative research practices.

Conclusion

CBIKS's grand challenge rests with shifting climate change research towards creating more inclusive and equitable scientific inquiry. CBIKS' transdisciplinary and cross-cultural approach embodies a transformative model for climate change science. By recognizing and valuing Indigenous knowledges, we can enrich understandings of our changing climate and work together towards a healthy planet for people across geographies and generations.

Acknowledgements: The Center for Braiding Indigenous Knowledges and Science is funded by the National Science Foundation under Grant No. BCS-2243258, and is also supported by the University of Massachusetts, Amherst.

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The UAE Consensus – Misleading & Underachieving

Natalie Nowatzke[1]

1. *University of Maine School of Law.*

Abstract: COP28 was the culmination of the first global stocktake, which aims to coordinate climate action, including identifying and agreeing on the actions needed to ensure climate change is addressed on the global scale. This mini paper covers the resulting outcome, the UAE Consensus, and its effectiveness in addressing the role of fossil fuels in climate change.

Along with the rest of the University of Maine delegation, I attended the twenty-eighth Conference of Parties (COP28) this past December. The COP represents the annual key decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC). A deal was reached at COP28, resulting in what is called the UAE Consensus. The COP Presidency called it "an enhanced, balanced, and historic package to accelerate climate action" as it contains "an unprecedented reference to transitioning away from all fossil fuels." Other news outlets have referred to it as a "historic" and "groundbreaking" deal.

Although the UAE Consensus is the first time an agreement of this kind explicitly mentions fossil fuels, it is not the win that many want us to believe. The boasted language regarding fossil fuels comes from the final version of the Global Stocktake, and reads as follows:

"Further recognizes the need for deep, rapid and sustained reduction in greenhouse gas emissions in line with 1.5 °C pathways and calls on Parties to contribute to the following global efforts, in a nationally determined manner, taking into account the Paris Agreement and their different national circumstances pathways and approaches:

(d) Transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net zero by 2050 in keeping with the science."

The science is clear and has been for decades. Climate change is causing unprecedented global temperature rise, and 2 °C of warming is a maximum "critical threshold" for abating severe and irreversible effects. Global surface temperature has already risen 1.1 °C, with emissions continuing to increase. Even worse, the production and burning of fossil fuels is the largest contributor to this warming, and "CO_2 emissions from existing fossil fuel infrastructures without additional abatement already exceed the remaining carbon budget for limiting warming to 1.5 °C." (IPCC, 2023).

Additionally, this was done in the face of continued calls for radical climate policy. The Alliance of Small Island States (AOSIS) has long called for this radical action, including calls for leaving Dubai with a "clear roadmap" to limit warming to 1.5 °C. Other calls for this type of action were evident at COP28, from states, non-profits, and attendees alike.

Thus, this language is too little, too late to meaningfully mitigate climate change. The use of vague verbs, such as "calls" and "transitioning" are practically meaningless in the face of impending disasters from climate change. The audacity to say, "in keeping with the science," while ignoring the pleas of countless scientists, and those of us that are capable of listening to them, is particularly infuriating. The Earth cannot withstand this pace of crawling progress, especially in this critical time.

Acknowledgements: This research is supported by the Climate Change Institute and the University of Maine School of Law.

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A Comparative Study of Human-Bird Relationships at Two Ceramic Period Archaeological Sites in Wabanaki Homeland, Coastal Maine

Olivia L. Olson[1, 2], Bonnie D. Newsom[1, 2]

1. *Climate Change Institute, University of Maine.*
2. *Department of Anthropology, University of Maine.*

Abstract: **Despite their potential as a lens into past socio-environmental dynamics, birds are an understudied clade within Northeast zooarchaeology. We present a plan to establish the first dedicated study on differential human-bird interactions by comparing two Ceramic period (~2800-800 BP) sites in the central Maine coast. This study aims to center Wabanaki narratives by contextualizing archaeological evidence and exploring bird uses beyond subsistence.**

Introduction

Birds represent a culturally significant yet understudied clade within North American archaeology (Bovy et al. 2019). Human-bird interactions can provide insight into human settlement patterns, subsistence records, social status, and climate and environmental change (Serjeantson 1997). In Maine, archaeological bird remains have been interpreted as a minor seasonal subsistence resource, yet ethnohistoric records place a heavy emphasis on bird hunting strategies, human migration patterns following migratory bird populations, and the use of feathers and whole birds as personal decoration (Spiess and Lewis 2001). This thesis seeks to compare human-bird interactions at two Ceramic period-aged (~2800-800 BP) sites on the central Maine coast: Frazer Point, Schoodic Peninsula, and the Ruth Moore site, Great Gott Island.

Research Motivations and Goals

During a series of workshops held at the Schoodic Institute, Wabanaki community members, archaeologists, science communicators, and students discussed the potential to center Wabanaki narratives in archaeological research at Acadia National Park (Newsom et al. 2021). When presented with a bird bone flute recovered from Frazer Point, Wabanaki community members expressed interest in knowing more about birds in past lifeways.

The goals of this project are to:

1. Contextualize human-bird interactions within culture histories and late-Holocene climate change.
2. Assess subsistence and non-subsistence uses of birds using comparative taphonomic methods.
3. Establish the first zooarchaeological baseline for the examination of birds in the Gulf of Maine.
4. Center Wabanaki narratives and goals by consulting with Wabanaki representatives and producing research products for Wabanaki communities.

Fig. 1. Bird bone flute carved from a goose ulna recovered from Frazer Point, Schoodic Peninsula, Acadia National Park. Photo by Deirdre McGrath 2022.

Acknowledgements: This research is supported by the National Park Service, Acadia National Park, and the Schoodic Institute.

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How High Vapor Pressure Deficit and Low Soil Water Content Causes Xylem Embolism in Mediterranean Pine?

Pratima Pahadi[1,2], Yongjiang Zhang[1,2], Uri Hochberg[3]

1. *School of Biology and Ecology, University of Maine.*
2. *Climate Change Institute, University of Maine.*
3. *Agricultural Research Organization, Volcani Center, Israel.*

Abstract: **Vapor Pressure Deficit (VPD) plays a significant role in drought associated mortality events of trees, yet there are only few studies that have isolated the physiological effects of rising VPD versus temperature on plants with or without soil moisture stress, limiting our ability to anticipate future impacts on terrestrial ecosystems. We studied the cavitation resistance of well-watered and drought treated Brutia pines, growing at the dry edge of their distribution, under high VPD conditions in Israel during the spring of 2023. We found higher cumulative cavitation under high VPD conditions in both well-watered and drought treated plants limiting our ability to understand if cavitation happens on a day-to-day basis or only under low soil water content conditions.**

Project Goals:

The project goal is to understand if high VPD causes xylem embolism in drought treated plants compared to well-watered plants and if stomatal regulation plays the critical role in controlling the level of embolism under high VPD conditions.

The global land surface temperature rise is increasing the saturation vapor pressure of atmosphere with some studies highlighting a sharp increase in global VPD in recent decades (Yuan et al. 2019) and other predicting a continuous rise in VPD over the next century (Ficklin and Novick 2017). An increase in VPD affects plant physiology such as stomatal conductance, carbon dioxide assimilation rate, transpiration rate resulting in further exacerbation of plant water stress, xylem embolism and forest mortality. As such, VPD is major determinant of global water resources and plant relations and is increasingly important for vegetation dynamics due to its chronic, global, temperature driven rise.

Results:

Our result from this study indicates xylem embolism in both well-watered and drought treated plants under high VPD conditions. In drought treated plants we observed more rapid decline of stomatal conductance and stem water potential compared to well-watered plants indicating higher stomatal sensitivity to water stress under high VPD conditions of drought treated plants. We also observed 100% cavitation of drought treated plants but not of well-watered plants indicating higher sensitivity of drought treated plants and higher resilience of well-watered plants under high VPD conditions.

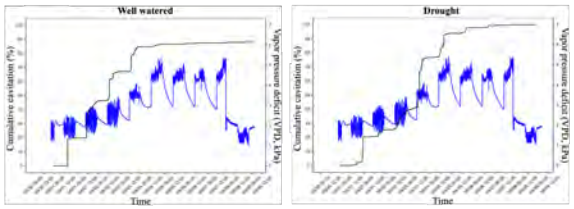

Figure 1. Cumulative cavitation (%) and vapor pressure deficit (VPD, kPa) relationship with time for well-watered and drought treated plants.

Acknowledgements: This project was supported by 2022-2023 Hodosh Graduate Fellowship, School of Biology and Ecology.

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Constructing a Be-10 Glacial Chronology on Late Holocene Glacial in the Southern Alps of New Zealand at 43°S

Alexzander Roman[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*

Abstract: During the austral summers of 2023 and 2024 I conducted fieldwork in the Southern Alps of New Zealand. Using 10Be exposure dating I am constructing a glacial chronology of my field areas in order to expand our understanding on the possible extents of the Little Ice Age.

The problem:

The abundant historical records that document the Little Ice Age's impact in Europe along with field evidence from outside that region seem to indicate that its occurrence may not have been confined to the Northern Hemisphere (Grove, 1990). Although paleoclimate records are currently insufficient to fully reconstruct the last 1000 years of climate history in the Southern Hemisphere (National Research Council (U.S.), 2002), the presence of the Little Ice Age has been identified in certain regions. Notably, evidence of its occurrence has been found in Argentina and the Tropical Andes of South America (Espizua & Pitte, 2009), highlighting the significance of the Little Ice Age outside of the Northern Hemisphere. While continuous records may be lacking, sporadic occurrences of the Little Ice Age in South America , albeit in shorter temporal stretches, provide compelling evidence for a global event.

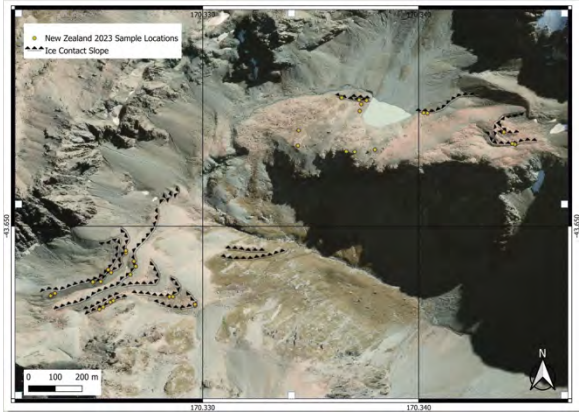

Fig.1. Satellite imagery of young moraines in the cirques of Ailsa Valley; imagery collected from ESRI World Imagery.

I have conducted fieldwork in the Southern Alps of New Zealand, located at ~43°S, targeting young moraines high in the mountains and those alongside the Tasman Glacier. Using Birkeland et al. (1982)'s subdivision of Holocene glacial deposits, I targeted the youngest features for Be-10 exposure dating.

In areas that have already been dated, the ages suggest that New Zealand alpine glaciers did experience an advance during the late Holocene (Kaplan et al. 2013;Putnam et al. 2012; Schaefer et al. 2009). Comprehending and understanding the causes and mechanisms behind this climatic phenomenon becomes critical for discerning the current and future climate trends and uncovering how our climate system functions.

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Using Modular Transfer Function to Accurately Determine Resolution in Hyperspectral Images of Ice Cores

Roisin Rumsey[1], Andrei V. Kurbatov[1,2], Daniel Breton[3], Curtis Labombard[4], Geoff Hargreaves[4]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *Signature Physics Branch ERDC-CRREL.*
4. *National Science Foundation Ice Core Facility (NSF-ICF).*

Abstract: Image quality is critical for the new SPECIM ice core research platform that uses hyperspectral cameras to analyze ice core data. Establishing standardized metrics is important for consistently capturing details in ice cores collected. By using a parameter called Modulation Transfer Function (MTF), a more accurate metric of image resolution can be gained =. MTF is used to evaluate the level of image sharpness a system can capture, allowing for confidence in recognizing fine details in ice cores imaging.

Background:

Hyperspectral imaging is a technique that collects and processes information across the electromagnetic spectrum to obtain the spectrum for each pixel in an image. This technology enables the identification of specific compounds that potentially present in ice cores: e.g., dust, volcanic and anthropogenic aerosols. Exploring the use of hyperspectral imaging to accurately map and analyze these impurities within ice cores is crucial to assess its feasibility as an emerging methodology for ice core analysis.

In the field of imaging, the Modulation Transfer Function (MTF) characterizes the transfer of contrast from an object to an image and has been used by many photographers as a metric of resolution over the less accurate measurement of pixel per given space. MTF is especially relevant in the context of spatial frequencies associated with fine details in ice core structures, like layers and microcracks. The hyperspectral imaging of ice cores necessitates a careful consideration of MTF to ensure accurate assignment of features corresponding to climate signals and impurities.

Method:

To test MTF, the Norman Koren 2003 methodology will be adapted. To do this, Figure 1 is printed using a high-resolution printer, and scanned by the hyperspectral camera. The digital photo can then be analyzed using ImageJ or Python. The resulting contrast values can be used to determine resolution based on the returned frequency.

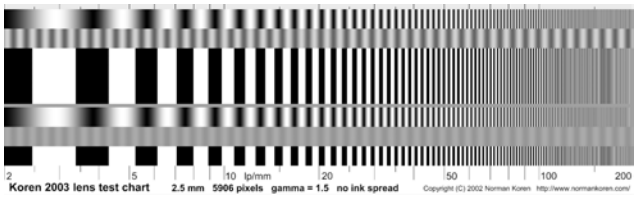

Fig. 1. Koren 2003 lens test chart.

Conclusion:

By establishing a proper metric for image quality, we will be able to assess outcomes of statistical routines required for image processing of ice core data.

Acknowledgements:

NSF grant 2149519, COLDEX, NSF grant 2019719.

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Abrupt Transformation of West Greenland Lakes Following Compound Climate Extremes in September 2022

Jasmine E. Saros[1,2], Vaclava Hazukova[1,2], Robert Northington[1,3], Grayson Huston[2], Avery Lamb[1,2], Sean Birkel[1,4]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology & Ecology, University of Maine.*
3. *Department of Biology, Elizabethtown College.*
4. *Cooperative Extension, University of Maine.*

Abstract: We demonstrate that multiple compound extreme events (record heat and precipitation) associated with atmospheric rivers in a shoulder season (autumn) coherently transformed lake ecosystems of West Greenland in less than a year.

In mid- to high-latitude systems, atmospheric rivers (ARs) can produce compound climate extreme events, as they can simultaneously transport intense moisture and heat poleward in synoptic-scale events. ARs affect many areas of the world, including western North and South America, western Europe, eastern US, east Asia, and polar regions.

In September 2022, West Greenland experienced a series of atmospheric rivers that brought record heat and rainfall to the area. This area is normally arid, and lakes here have very limited hydrologic connectivity with the landscape. We investigated the effects of these compound climate extreme events on lake ecosystems in the area by comparing annually collected data from summer 2013-2022 (pre-storms) to 2023 (post-storms).

Water isotopes revealed a shift in the hydrology of this area after September 2022, with reduced evaporation apparent. The compound climate extremes of September 2022 fundamentally altered the hydrologic connectivity of lakes, with a large influx of terrestrial materials affecting the biogeochemistry of lakes. The quality of dissolved organic material changed, reflecting a stronger terrestrial pool of material in lakes now. Concentrations of various metals, particularly iron, increased by about 1000%.

These biogeochemical changes led to a change in lake color, with lakes that were clear, blue systems for decades abruptly switching to darkly stained waters in less than a year (Fig. 1). This shift to dark waters was coherent across lakes in the area. This reduced light penetration into lakes by 50%.

The resulting physical and biogeochemical changes in these lakes led to effects on the biota, with altered phyto- and zooplankton community structure. Carbon cycling also changed, with higher methane concentrations in lakes and higher CO_2 flux from these systems.

Compound climate extreme events fundamentally altered these lake ecosystems, with long-term implications currently unclear.

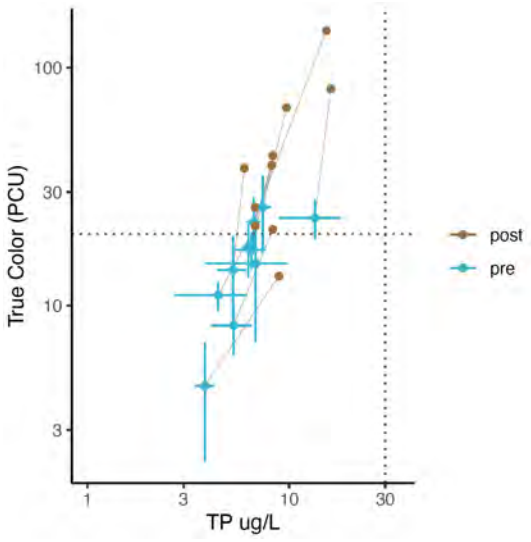

Fig. 1. Comparison of nutrient (indicated by total phosphorus (TP)) and color status of lakes pre-storms (2013-2022 data) and post-storms (2023), showing how the color of all lakes substantially increased in 2023.

Acknowledgements: NSF Arctic Natural Sciences RAPID grant (#2348144).

Modern Plant Wax Calibration at Baboon Lakes, Central Sierra Nevada, California

Meghan Spoth[1,2], Aaron Diefendorf[3], Megan Corcoran[3], Brenda Hall[1,2], Aaron Putnam[1,2], Jacquelyn Gill [2,4]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *University of Cincinnati.*
4. *School of Biology and Ecology, University of Maine.*

Abstract: The plant-wax isotope record at Baboon Lakes, Sierra Nevada, California, offers insight into the hydrology of the American West over the last 12,000 years. Here, we examine the modern isotopic values of locally produced biomarkers to calibrate the plant-wax data. This will facilitate further understanding of the position of the westerlies and the pattern of drought in the region.

Introduction:
Understanding and forecasting the complex hydrology of the American West is critical for climate change research. The International Panel on Climate Change (IPCC) predicts that warming regional temperatures will increase droughts and fire weather, while increasing extreme precipitation may cause flooding[1]. The mechanism driving these seemingly contradictory phenomena may be the Northern Hemisphere Westerlies (NHW). The position of the NHW controls the regional temperature, while the wind belt itself is associated with increased precipitation. Paleoclimate literature has associated periods of past abrupt climate change with shifts in the position and intensity of the NHW[2]. However, few records have documented past shifts in wind patterns independently from precipitation proxies.

Here, we develop a modern calibration of isotopes and plant-wax biomarkers of surface waters and local vegetation from Sierra Nevada, California. This calibration will be applied to the Baboon Lakes (fig. 1) sediment records to produce a paleoclimate and paleohydrology proxy spanning the last 12,000 years. Plant wax biomarkers can provide independent information on plant community composition and productivity, relative evapotranspiration rates, precipitation sourcing (linked to NHW position), and water availability for a specific basin[3].

Results:
Plant surveys and collections were conducted in September 2023 focused on Baboon Lakes (3.4 km asl) of the high Sierra Nevada, with the assistance of Maraina Miles. To characterize the local biomarker source to the lakes today, 22 plants were collected from 15 different taxa. To calibrate modern lake isotopic values, we also collected nine water samples from lake basins and streams. All samples are undergoing analysis in the Organic Geochemical Laboratory at the University of Cincinnati to identify the biomarkers produced by these taxa, along with the isotopic values of both hydrogen and carbon in these biological molecules.

Fig. 1. Modern organic materials, rich in plant wax biomarkers, enter Baboon Lake preserving a climate record through isotopic fractionation ratios. Basin has pines, herbs, and grasses.

Acknowledgements: Baboon Lakes field crew, Dan and Betty Churchill Exploration Fund, GSG grant, GSA Graduate Research Grant, Inyo National Forest permitting, Sturgis Exploration Fund.

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The High Seas Treaty: Modernizing International Laws for Climate Governance

Geetanjali Talpade[1]

1. *University of Maine School of Law.*

Abstract: **COP28 served both as a platform for international negotiations and a showcase of various climate policies. One of these policies, the High Seas Treaty, would expand the scope of ocean governance, an especially urgent mitigation concern. This paper examines this treaty.**

Climate change policy and traditional environmentalism intertwine in many ways. But environmental laws may be ill-suited for climate change mitigation; the 1982 United Nations Convention on the Law of the Sea, for example, requires parties to protect the marine environment, but this obligation ends 200 nautical miles from shore, leaving the high seas unregulated and thus unprotected.

This jurisdictional gap is a thorn in the side of mitigation policy. The high seas are the Earth's largest carbon sink, capturing significant amounts of excess heat and carbon. They are also highly vulnerable to climate change with complex governance challenges: even carefully tailored policies can trigger diverse responses, ecological and otherwise.

The proposed Biodiversity Beyond National Jurisdiction (BBNJ) Treaty would address this gap, by "ensur[ing] . . . sustainable use of [the high seas.]" BBNJ has four pillars: (1) marine genetic resources (MGRs); (2) area-based management tools (ABMTs); (3) environmental impact assessments (EIAs); and (4) capacity building and the transfer of marine technology (CB&TMT):

(1) Companies that collect valuable **MGRs** for product development (e.g. medicine or cosmetics) would be obligated to pay for that collection and share its benefits. The specifics of benefit-sharing and its recipients would be established by a committee, appointed based in part on gender balance and geographic and socioeconomic distribution (such as Least Developed Countries, or LDCs). MGRs notably and specifically exclude fish, despite the fishing industry's major impact on the ocean. The fishing and benefit-sharing provisions were major points of dispute during negotiations; (2) **ABMTs**, adopted by support from 75% of present parties (e.g. States, the scientific community, and local and Indigenous communities), would establish marine protected areas in the high seas to support socioeconomic and cultural objectives; (3) **EIAs**, intended to evaluate the impact of a proposed activity, would be required in two situations: (a) activities in the high seas with potential environmental impacts; and (b) activities within national jurisdiction that may impact the high seas. Domestic policy would dictate EIA mechanics, and states could additionally conduct the more holistic "strategic environmental assessment" to incorporate climate change considerations; and (4) **CB&TMT** principles, embedded through both BBNJ and COP28, would "future-proof" BBNJ. CB&TMT lacks strict textual definition; BBNJ instead chooses to provide examples of a "transparent, effective and iterative process that is participatory, cross-cutting and gender responsive," such as information sharing and awareness advocacy.

Guided by polluter-pays principles, gender equity, Indigenous Peoples' rights and knowledge, and scientific data, BBNJ applied scientific and social justice frameworks to garner broad support. Despite lingering questions and the necessarily glacial pace of international law (it took two decades to open for ratification in 2023), BBNJ could, if ratified, be a significant step towards climate mitigation and a Just Transition.

Acknowledgements: This research is supported by the Climate Change Institute and the University of Maine School of Law.

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Determining Driving Mechanisms of the Last Ice-Age Termination in South America

Sera Thomas[1,2], Brenda Hall[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*

Abstract: A series of well-defined glacial moraines in the Penhoat region of Cordillera Darwin, Chile, gives a detailed record of ice recession in South America during the last glacial termination. This study uses ^{10}Be surface exposure dating techniques to determine the timing and rate of ice recession in Cordillera Darwin. This work will test the Zealandia Switch hypothesis and other proposed drivers of the termination to improve understanding of climate change mechanisms.

Introduction:

Milutin Milankovitch proposed that changes in high-latitude northern hemisphere summer insolation are responsible for ice-age cycles[1]. This widely cited mechanism suggests that these climate cycles follow three orbital parameters, with ice-age terminations occurring when these factors combine to cause warming in the northern hemisphere high-latitude summer.

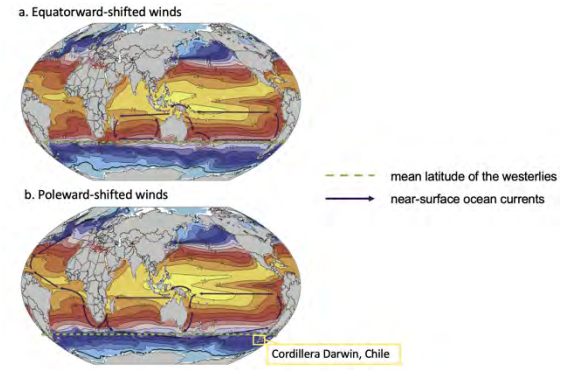

Fig. 1. Location of Cordillera Darwin in context of the westerlies, shifted north (a) and south (b) of Zealandia. Map colors represent sea-surface ocean temperatures. Modified after[2].

However, there are persistent problems with this theory. Growing evidence suggests that ice ages and terminations are globally synchronous when they should be out of phase between the hemispheres due to opposite insolation signals. The new Zealandia Switch hypothesis instead suggests that ice ages may be controlled by changing position of the southern westerly winds[2]. Due to topography, the westerlies can be locked either north or south of Zealandia and can jump between the two positions, causing an abrupt shift in global climate[2]. This concept is depicted in Figure 1. When the westerlies are locked to the north of Zealandia, this triggers global cooling through its effect on tropical heat storage. Alternatively, if the westerlies are locked south of Zealandia, global warming ensues.

Testing the Zealandia Switch hypothesis requires well-dated paleoclimate records from a variety of locations, particularly sites, such as Cordillera Darwin, which lie within the path of the westerlies.

Proposed Work:

Glaciers are reliable recorders of summer temperature; therefore, a reconstruction of glacial history will document the precise timing and magnitude of warming that ended the ice age in Cordillera Darwin. I will define moraines and perched erratic boulders at Penhoat from satellite imagery and field observation and then map them in the QGIS program. I will also collect rock samples and obtain ^{10}Be surface exposure dates. Exposure ages of moraines will give a better understanding of how the last ice-age termination transpired. This knowledge will provide critical insight into the driving mechanisms for global climate change, thus allowing for the development of improved climate models.

Acknowledgements: Cordillera Darwin field crew, National Science Foundation.

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Using Photogrammetry to Create Virtual Permanent Plots in Rare and Threatened Plant Communities

Andrea J. Tirrell[1,2], Aaron Putnam[1], Michael Cianchette[2], Jacquelyn Gill[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology & Ecology, University of Maine.*

Abstract: Many plant communities are undergoing changes due to climate change, human disturbance, and other threats. These community-level changes are often tracked with the use of permanent vegetative plots, but this approach is not always feasible. As an alternative, we propose using photogrammetry, specifically photograph-based digital surface models (DSMs), to establish virtual permanent plots in vulnerable plant communities. Digital surface models can provide effective, minimally invasive, and permanent records of plant species presence and percent coverage, while also allowing managers to mark survey locations virtually for long-term monitoring. We found that percent coverage estimated from DSMs did not differ from field estimates for most species and substrates.

Introduction:

As some of Earth's most vulnerable plant communities face growing threats due to global change, long-term monitoring remains a critical tool for understanding and tracking species responses[1,2]. Field methods such as permanent plots can be detrimental to the very communities being studied, as well as costly and non-inclusive. The creation of DSMs (digital surface models) can serve as a solution to these problems. Here, we present an approach that leverages the use of accessible technology to create “virtual” permanent plots for the long-term monitoring of vulnerable plant communities, such as in alpine ecosystems where traditional monitoring approaches may not be feasible. When more sophisticated imaging technology is not available, the images needed for DSMs can be collected by hand using widely available digital cameras, including smartphones.

Results:

The creation of photogrammetric models from field photos has many advantages for the long-term monitoring and conservation of rare and threatened plants. Not only is this process minimally destructive, avoiding disturbance to shallow soils and biocrusts that might result from emplacement of permanent structures, but the creation of virtual permanent plots allows managers to maintain records of vascular plant coverage through time with minimal resources. We found that percent coverage estimations made from DSMs did not significantly differ from field-estimations.

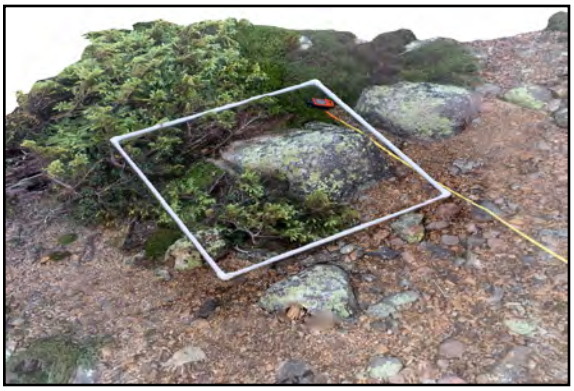

Figure 1: A completed digital surface model of a 1-m2 quadrat on Mt. Guyot, New Hampshire, USA (rendered here in two dimensions).

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Do Unprecedented Worldwide Weather Extremes Since Early 2022 have an Association to the Hunga Tonga-Hunga Ha'apai Eruption?

Ana Trueba[1], Sean Birkel[1], Kirk Maasch[1,2], Jasmine Saros[1,3]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*
3. *School of Biology and Ecology, University of Maine*

Abstract: **The January 2022 eruption of the Hunga Tonga submarine volcano injected an unprecedented amount of water vapor into the stratosphere. It remains unclear how much dynamical response may have developed in the climate system. Here, we use reanalysis and identify a series of large-scale weather extremes (sub-monthly to seasonal) since the eruption that are associated with blocking patterns and unusually weak atmospheric circulation. These events range 4–6 standard deviations from 50-year mean climatology and represent all-time record values for reanalysis beginning 1940. The development of such extreme climate anomalies in the year after the most explosive volcanic eruption since 1883 Krakatoa is notable. We hypothesize that excess water vapor in the stratosphere has weakened poleward gradients and westerly circulation, and that feedback with a developing El Niño led to particularly extreme anomalies in 2023.**

Introduction: Many record meteorological events were observed in 2022 and 2023, including a 0.3°C jump in global mean temperature summer 2023, which have thus far been primarily attributed to anthropogenic climate change and the development of El Niño in 2023 (Rhode, 2024). One possible factor receiving little attention is 10–15% excess water vapor injected into the stratosphere with the explosive eruption of Hunga Tonga 15 January 2022. Recent studies have found that lack of significant SO_4 emission (Zuo et al., 2022) and only small direct radiative forcing (Milan et al., 2022) preclude much climate impact. However, possible dynamical responses to excess water vapor are not understood (Rhode, 2024).

Methods: We used ECMWF Reanalysis Version 5 (ERA5) to examine possible Tonga associations via spatial and time series analysis of temperature, precipitable water, wind, and other variables to identify meteorological events measuring >4 standard deviations from long-term mean climatology.

Preliminary Results: Patterns with standardized anomalies ranging 4–6 standard deviations have been identified, including the March 2022 Antarctic heatwave, low stratospheric temperatures in the southern mid-latitudes April–October 2022 (Fig. 1), and record heat and moisture over Greenland in fall 2022 & 2023.

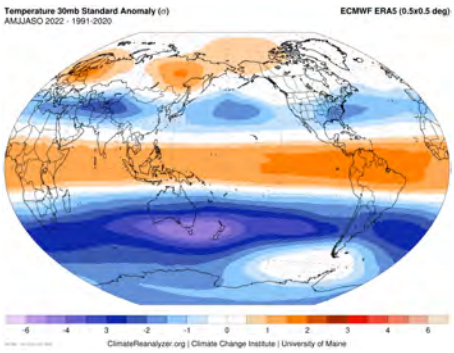

Fig. 1. 2022 Apr–Oct 30hPa temperature standardized anomaly. CCI ClimateReanalyzer.org.

Acknowledgments
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Evaluating Plastic Waste as a Potential Feedstock for "Renewable" Fuel

Erin Victor[1,2,3]

1. *Department of Anthropology, University of Maine.*
2. *Climate Change Institute, University of Maine.*
3. *Senator George J. Mitchell Center for Sustainability Solutions, University of Maine.*

Abstract: **Under the EPA's Renewable Fuel Standard (RFS) Program, fuels derived from waste feedstocks, including plastics, may be considered "renewable." However, the considerable human health risks of using waste-derived fuels raise red flags for environmental justice advocates.**

Plastics-to-fuel: an environmental win-win?

Many circular economy proponents are looking for technological solutions to address the growth of non-recyclable plastic waste. At the same time, there has been considerable investments in biofuel production in order to reduce carbon emissions in the transportation sector. Technologies that convert wastes to fuels, including plastics-to-fuel technologies such as pyrolysis and gasification[1] are thus heralded as a win-win solution. These waste-derived fuels promise to reduce the amount of waste sent to landfills, generate a valuable fuel product, and lower carbon emissions compared to petroleum-based fuels. Furthermore, unlike first-generation biofuels made from food-based feedstocks such as corn and soy, waste-derived fuels do not result in land use changes or displace farmland for food production.

Under the Renewable Fuel Standards (RFS) program, fuels made from waste feedstocks are eligible to qualify for Renewable Identification Numbers (RINs) as "advanced biofuels" if they can demonstrate 50-60% reductions in greenhouse gases compared to petroleum-based fuels. However, in January 2022 the EPA announced a new effort to streamline the review and approval of new chemicals, including waste-derived biofuels, in order to support the RFS program.[2] Under these streamlined rules, it is unclear if waste-derived biofuels will need to meet these target GHG reductions.[3]

Critiques of plastics-to-fuel technologies

Despite the optimism around plastics-to-fuel technologies, the economic feasibility and scalability of these technologies remains unproven. Even if these facilities do manage to scale, they will require a constant feedstock of plastic waste which creates a lock-in[4] effect and and detracts from solutions that address the unsustainable production and consumption of plastics. The GHG emission reductions of waste-derived biofuels are also questionable and highly dependent upon how the calculations are done. Most concerning however, is the human health hazards generated by these facilities which are predominantly sited in environmental justice communities.[5] One waste-derived fuel approved by the EPA under the new streamlined guidelines was estimated to release toxic emissions which could cause cancer in one out of every four people.[3]

Acknowledgements: Dr. Cindy Isenhour.

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Prominent Freshwater Diatom Shifts Reveal Major Climatic Changes since ~2 ka just South of the Beagle Channel (~55°S)

Leonardo A. Villacís[1,2,3], Paola Jara-Arancio[4], Patricio I. Moreno[3]

1. *Climate Change Institute, University of Maine.*
2. *School of Biology and Ecology, University of Maine.*
3. *Departamento de Ciencias Ecológicas, Universidad de Chile.*
4. *Cape Horn International Center (CHIC), Chile.*

Abstract: **A diatom record from a small pond just south of the Beagle Channel (~55°S) reveals abrupt shifts from benthic to planktic species suggesting stepwise variations in southern westerly influence superimposed on gradual warming over the last ~2000 years.**

Late Holocene climatic changes are poorly constrained in sectors adjacent to the Beagle Channel. This subantarctic temperate region is influenced by the Southern Westerly Winds (SWW) that control the regional climate variability (Garreaud et al., 2013). High-resolution records are needed to track centennial-to-decadal climatic trends and reversals. Here we present a 130-cm long continuous-contiguous fossil diatom record from a small kettle pond, Lago Mita, on the northern rim of Isla Navarino. We aim to gauge the hydroclimatic variability adjacent to the Beagle Channel through diatom assemblage changes during the late Holocene.

Lago Mita (54°56'S, 67°38'W; 2 ha; 30 masl; ~5 m depth) (Fig. 1) lies within a W-E oriented intermorainal depression that features terrestrialized sectors along the western and eastern ends and steep forested slopes surrounding the pond. Water transparency is limited (1.1 m-depth) during austral summer, while freezing during winter.

The fossil diatom record (Fig. 2) shows alternations between assemblages dominated by *Cocconeis placentula, Aulacoseira ambigua, Discostella pseudostelligera, and Asterionella formosa*. These changes suggest declines in seasonal ice-cover, lake transparency, and shifts in lake thermal structure, which likely drove the benthic-to-planktic shifts in the record. A combination of gradual warming and variations in SWW influence account for the stark transitions between diatom assemblages, the exact timing and direction of which are currently under investigation. Our preliminary results suggest westerly variability superimposed upon a warming trend that intensified during the last ~2000 years (conservative estimate for the age of this core).

Figure 1. Map of Beagle Channel and Lago Mita.

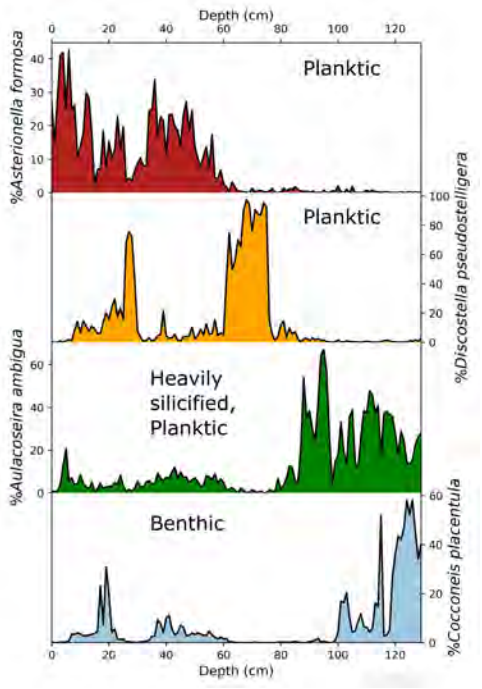

Figure 2. Lago Mita diatom stratigraphy.

Acknowledgements: FONDECYT 1230717, 1240263; ANID PIA/BASAL FB210006; CHIC-ANID PIA/BASAL PFB210018.

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Interhemispheric Comparison of the Late Glacial Climate Reversal

Katherine Westbrook[1], Aaron Putnam[1,2], George Denton[1, 2]

1. *School of Earth and Climate Sciences, University of Maine.*
2. *Climate Change Institute, University of Maine.*

Abstract: **Timing of a prominent millennial-scale climate reversal that punctuated the last glacial-to-interglacial transition in both polar hemispheres has remained controversial. The goal of my proposed research is to produce a detailed chronology for the best-preserved segment of glacial deposits, located in Lysefjorden in southwestern Norway. Such a chronology will be instrumental in comparing the hemispheric synchrony of the abrupt climate change, and in evaluating outstanding Ice Age Theories.**

Proposed Research:

After extensive retreat of the Scandinavian Ice Sheet during the termination of the Last Glacial Maximum, several pauses and resurgences deposited moraines in coastal Norway. Similar looking moraines can also be found in the Southern Alps of New Zealand. These features are artifacts of the abrupt climate changes that occurred during the late glacial transition. Determining timing of these events in both hemispheres is critical for understanding Quaternary climate change. Using ^{10}Be isotope dating, I will build a detailed chronology of the Lysefjord Mouth moraine complex to test current Ice Age theories (see figure 1 for locations of samples currently being processed).

Preliminary dating of the Esmark moraine in Norway by Putnam et al., 2023, yielded ages analogous to those found in the southern alps of New Zealand (Putnam, Denton, and Schaefer 2023). Deposition of these features is consistent with the Bølling Allerød period, which is classically interpreted as being warm in the northern hemisphere according to Greenland ice core data (North Greenland Ice Core Project members et al. 2004). Moraine construction during this time implies glacial stability and/ or advance. The similar timing between hemispheres is problematic for orbitally driven ice ages theories, since insolation peaks during opposite seasons in each hemisphere. A new mechanism is needed to explain this discrepancy, and a detailed chronology from Norway will aid in doing so.

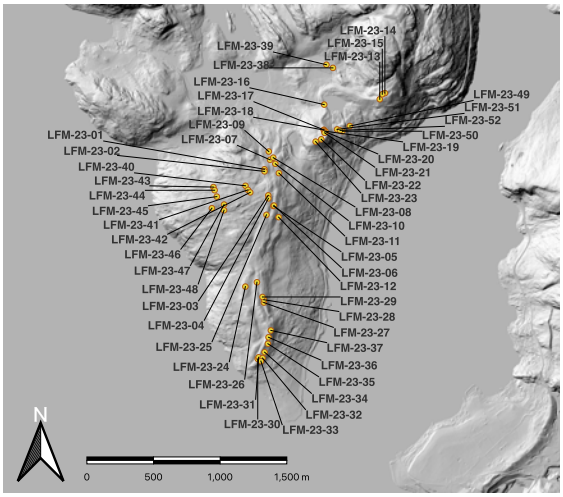

Fig. 1. LiDAR of moraines in Lysefjord Mouth, Norway. Overlain with locations of samples collected during the 2023 field season.

Acknowledgements: Thank you to the Comer Family Foundation, Peter Quesada, the School of Earth and Climate Science, and the Climate Change Institute for financial support in this project. Thank you also to Tricia Collins for efforts during the field campaign.

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Understanding Alpine Supraglacial Lake Drainage, Ice Dynamics, and Meltwater Flux Through Remote Sensing and Field-Based Geophysical Observations

Tahi Wiggins[1,2], Kristin M. Schild[1,2], Seth Campbell[1,2]

1. *Climate Change Institute, University of Maine.*
2. *School of Earth and Climate Sciences, University of Maine.*

Abstract: Here, we show seasonal supraglacial lake growth and velocity variability at Echo Glacier, southeast Alaska. This remote sensing work will combine with high-resolution, field-based geophysical data in summer 2024 to contribute to better constraining meltwater flux through transient supraglacial reservoirs, which are currently unaccounted-for in surface mass balance and runoff models and have important implications for glacier dynamics.

Motivation

Supraglacial lakes (SpGLs) are ponds of surface meltwater which can inject large volumes of water to the bed when they drain, potentially inducing ice-flow speed-up, driving sub- and englacial hydrological development, and causing local tensile stress anomalies.[1] SpGLs also play a role in glacier catchment water budgets as an ephemeral meltwater storage buffer. While their importance is well-documented, the ice dynamics and meltwater flux associated with supraglacial lake drainage is poorly constrained, particularly in alpine systems.

Methods, Study Site, and Preliminary Results

Echo Glacier, located on the margin of the Juneau Icefield in southeast Alaska (Lingít Aaní), has a series of SpGLs which reliably form and drain each year (Fig. 1a). Previous field surveys at the site indicate minimal firn and presence of an englacial hydrological system.[2,3] Preliminary remote sensing shows lake growth through the melt season before simultaneous drainage of all lakes in the late summer (Fig. 1b). Lake area displays interannual variability, with anecdotal data linking precipitation and lake size anomalies. Similar connections are not yet seen for glacier velocity, which exhibits regular seasonal variation (Fig. 1c).

During the summer 2024 field season, we will deploy a range of instrumentation to gather detailed *in situ* observations of lake drainage, including a terrestrial radar interferometry unit (cm- and min-scale),[4] an autonomous phase-sensitive radar, drone-based LiDAR surveys, and downstream pressure transducers (Fig 1a). This suite of tools will allow us to trace meltwater through the glacier and downstream.

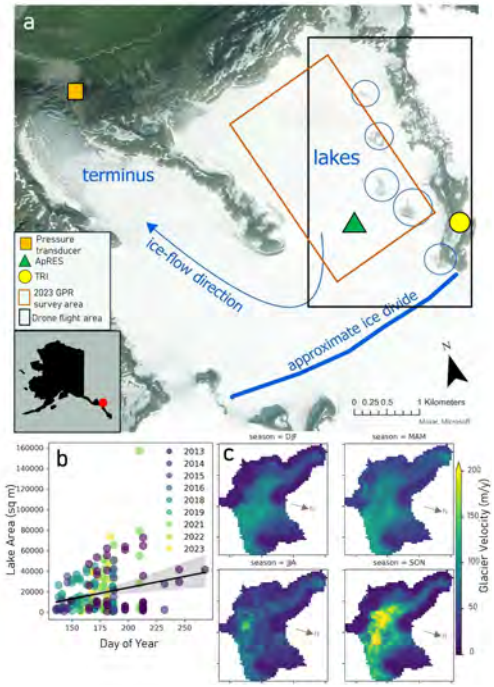

Fig. 1: (a) Study site with approximate location of field equipment and past surveys. (b) Landsat B8-derived lake growth through the melt season. (c) Echo Glacier ITS_LIVE seasonal velocity averages, 2014-2020.

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Adaption Finance Gap Continues as Current Climate Finance Commitments Prove Inadequate

Bryant Wolff[1]

1. *University of Maine School of Law*

Abstract: **COP 28 has come and gone. While USD billions has been mobilized towards climate finance, in global funds both old and new, USD trillions more must be contributed by developed country Parties to the COP to close the Adaptation Finance Gap and place Nations on track to meet their climate commitments.**

COP 28 has come to a close after two long weeks. Thousands are returning to their homes and back to their normal lives after the world's largest climate conference, but even with COP 28 over, the fight against climate change continues.

While many have reported the outcome of the first Global Stocktake as a historic achievement because of its inclusion of language which calls for Parties to begin transitioning away from fossil fuels, others feel more skeptical. Without binding language for to Parties to "phase out" or "phase down," it feels reasonable to believe the status quo will continue. It would seem the road to keeping global average temperature rise to 2°C, and the hope of 1.5°C, is becoming rockier and rockier.

The result of the Global Stocktake, while front and center, was not the only outcome with much to be desired following the close of COP 28. Climate Finance took center stage this year as efforts by Parties to implement and create more ambitious National Adaption Plans continues as an integral piece in tackling climate change. As Parties agreed within the Global Goal on Adaptation (GGA), the Adaptation Finance Gap is growing, and even with USD billions in contributions by developed countries, this falls far short of the trillions USD required to support adaptation efforts, fulfilling their climate plans, and a clean energy transition. The GGA has reiterated the "call urging developed country Parties to at least double their collective provision of climate finance for adaptation to developing country Parties from 2019 levels by 2025." Without sufficient climate finance, millions will continue to be at risk to the impacts of climate change.

While the financing gap has continued to grow, this is not to say that significant contributions have not been made:

- The Green Climate Fund received new pledges from six countries and now stands at a record total of 12.8 billion USD from 31 countries;
- The Adaptation Fund received roughly 188 million USD in new pledges at COP 28;
- The Lease Developed Countries and Special Climate Change Fund has received 174 million USD so far;
- The new Loss and Damage Fund received over 600 million USD during its first round of financing at COP 28, only one year after its creation at COP 27.

While it is clear that billions USD is being mobilized in efforts to support mitigation, adaptation, and loss and damage, we must not lose perspective that climate change will require trillions USD in financing. If we do not continue to call on developed country Parties to close the adaptation finance gap, Parties will be unable to adequately respond and adapt to climate change, leaving millions at risk to its impacts.

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PFAS Remediation in Maine: The Climate Impacts of Environmental Contamination

Charity H. Zimmerman[1,2]

1. *School of Economics, University of Maine.*
2. *School of Policy and International Affairs, University of Maine.*

Abstract: **Per-and polyfluoroalkyl substances (PFAS), often referred to as "Forever Chemicals," are a novel environmental contaminant of particular importance in Maine. Subsequently, vast amounts of resources will be needed to address the contamination, which could result in downstream impacts on Maine's Climate Action Plan.**

Background:
PFAS are a group of man-made chemicals that often have nonstick or water-repellent properties and are used in a wide array of products. These chemicals do not break down over time and have been linked to many adverse human health effects[1]. The State of Maine is expected to pay upwards of $60 million towards addressing PFAS contamination, but the environmental and climate impacts of remediation may have an even higher cost.

Treating Drinking Water:
Greenhouse gases are emitted throughout the entire life cycle of the remediation process of contamination[2]. Until 2023, Maine had no in-state labs capable of testing for PFAS, resulting in the state and individuals shipping PFAS tests out of state for analysis. The most effective way (thus far) to treat PFAS-contaminated drinking water is to use granular activated carbon (GAC), which is sourced either directly from coal or from biomass treated with high temperatures. As Maine does not produce its own supply of GAC, it must be shipped to Maine from elsewhere.

PFAS-laden Waste:
As the commonly used term "forever chemicals" implies, PFAS do not readily degrade in the environment. Destroying PFAS typically requires incineration at extremely high temperatures, which is energy intensive and costly. More frequently, PFAS-laden waste is stored indefinitely at landfill sites. As drinking water requirements become more stringent, the burden on landfills and emissions from transporting this waste increases.

Agricultural Impacts:
Maine is one of many states that historically permitted the spread of wastewater bio-solids onto agricultural fields as fertilizer. Only recently were these biosolids linked to high levels of PFAS contamination, ultimately resulting in several farms in Maine being exposed to high levels of PFAS contamination[3]. In addition to the loss of livelihood these farms face, such a decrease in local food production is likely to increase emissions as more food will be shipped from further away to compensate for the loss of local production.

Discussion:
PFAS contamination, not the necessary efforts aimed towards remediation, is the root issue. However, in our rapidly warming world, every problem must be assessed through the lens of the climate crisis. The increased climate burden that contaminants pose to the globe exacerbates the need for Maine, and the rest of world, to move more rapidly towards renewable energy. Maine should also consider strategies such as building solar fields or restoring forests for long-term conservation on the agricultural land left non-arable due to PFAS contamination to offset climate impacts.

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