Navigating The New Arctic

Project Update Reports

April 2020

Bridging the Atomistic Deformation Mechanisms to the Microscopic Adhesive-to-Cohesive Fracture at the Ice-Metal Interfaces

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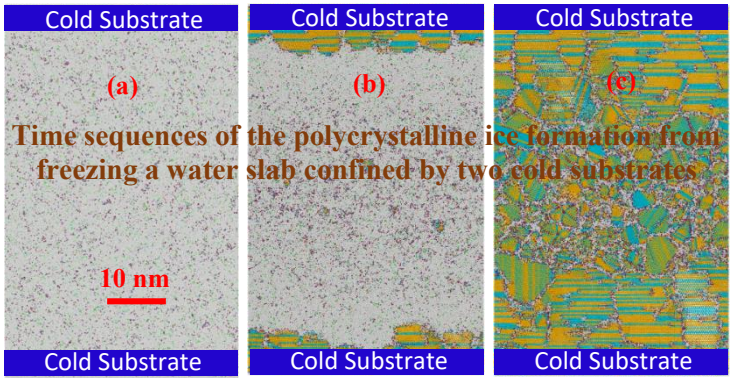
Project Objectives: Ice accretion over the surfaces of materials exposed to the cold environment is a topic of great concern for airplanes, wind turbines, and marine vessels sailing near the arctic area. However, a strategy of de-icing (detaching ice from cold surfaces) with minimal power cost is not well-established yet due to the lack of answers to a fundamental question on how the ice forms and sheds from a material surface. **The goal** of this project is to answer this question by identifying the atomistic mechanisms responsible for the fracture of the ice-metal interface. **Two specific aims** are: (i) to correlate the ice adhesion strength with the ice-metal interface structure; and (ii) to support the search of de-icing strategies that consume far less power than existing approaches. A series of high-fidelity computer simulations will be performed under a correspondence with the relevant experimental measurements in an Icing Research Tunnel at the PIs' institute. *This project will facilitate a rational design of materials that inhibit ice adhesion, with implications for safety-critical infrastructures operating in arctic areas, including telecommunication equipment, power lines, automotive vehicles, marine vessels, offshore oil platforms, and among many others*.

Keywords: icing and de-icing, ice-metal adhesion, crack propagation in ice, multiscale simulation



Progress to Date/Future Plans: through atomistic simulations, the PIs recently found a microstructure transition from "the columnar grain structure" to "the equiaxed grain structure" nearby the ice-substrate interface. Such a microstructure transition in turn, may dictate the commonly observed "adhesive-to-cohesive" fracture involved in a de-icing process. This is to be confirmed by experiments and higher length scale computer models in the next, which may be then utilized to guide the design of novel de-icing strategies.

Highlights of the Expected Outcomes: one main expected outcome of this research will be an integrated experimental and computational platform that can be used to understand how the ice is formed and how it should be removed from the surfaces of engineering infrastructures exposed to the cold environment in arctic areas.

NNA Community Collaboration and Research Coordination: the PIs do not conduct field experiments in any geographic areas nearby the arctic region yet, the gained knowledge thus far may not be directly applicable to understand the ice accretion on the infrastructures in arctic areas due to the lack of the information about the humidity, temperature, wind speed, water droplet size and chemistry in the field. If the support from the NNA community on this aspect is provided, an experimentally-validated computer software can be expected and will be delivered for predicting how the ice is formed from water freezing and how it fractures in arctic areas. This may also enable researchers to explore how the glacier fractures under current global warming conditions from the bottom up.

Advice for Overcoming NNA Project Challenges: if the support from the NNA community is not leveraged, it remains impossible for the PIs to directly use their platform on the infrastructures in arctic areas, although they have practiced in engineering, especially in computational mechanics of materials and experimental icing physics, for tens of years. The PIs believe that all the ongoing and overcoming NNA projects are multidisciplinary in nature, which remains as a challenge to each NNA project team, and should be clearly addressed whenever possible.

NNA Track 1: Collaborative Research: Arctic Urban Risks and Adaptations (AURA): a co-production framework for addressing multiple changing environmental hazards

Key Project Contact(s): Name, Institution, Email Address, & Role
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Project Website Urls & Social Media Accounts:
Website: https://www.respondtorisk.com/
Facebook Page:@respondtorisk
https://www.facebook.com/respondtorisk/
Facebook Group:

Respond to risk logo.

Project Objectives: Briefly explain the overall goals of the project, specific aims, methods, and broader impact activities/

Climate change is increasing vulnerability of arctic urban communities to natural hazards such as unstable permafrost, wildfire, and rain-in-winter events. These hazards put residents and property at risk and impose economic costs. Households, businesses, and governments must adapt to these multiple co-occurring hazards, which may have compound or off-setting interactions. The proposed research undertakes a spatially explicit assessment of the three natural hazards as they have evolved *simultaneously* in the Municipality of Anchorage and the Fairbanks North Star Borough, Alaska, and Whitehorse, Yukon, Canada over the past several decades, and how they might change over the next 40 years. Our interdisciplinary research team of economists, permafrost, fire, weather/climate, environmental scientists, and policy experts will conduct transdisciplinary research on arctic natural hazards and their impacts on the natural and built environments and society. The research team will work closely with local governments and non-governmental organizations (NGOs), Indigenous groups, insurance companies, and residents to co-produce knowledge on the costs, risks and actions taken to mitigate and adapt to these hazards. They will work with these stakeholders to identify trade-offs and interactions, develop a multiple-hazard risk assessment, and generate options for future adaptive planning. Research activities over four years include: (1) spatial modeling and mapping of natural hazards and their interactions; (2) gathering data to assess perceived risks, values at risk, and adaptation costs with interviews, property owner surveys, and citizen science; (3) economic modeling of costs and risks; and (4) developing in a series of scenario planning workshops an adaptive policy framework that can be used to adapt to and mitigate multiple hazards and reduce future costs and risks.

Keywords:
Arctic, risk, natural hazards, economics, urban, wildfire, permafrost, rain-in-winter

Progress to Date/Future Plans: Provide a brief research update describing progress to date or future plans.

We have created a website for the project and social media outlets (e.g. Facebook page and group). Monthly team meetings have been occurring since the start of the project and in November 2019 we had our in-person team kickoff meeting in Anchorage. A kickoff meeting

was also held with the Fairbanks North Star Borough. Kickoff meetings were scheduled with Anchorage and Whitehorse but have been called off due to the virus.

We have been working with Sustainable Earth, LCC. and the Anchorage Waterways Council, a NGO, to monitor water quality along Chester Creek in Anchorage since November. The goal is to assess the effect of chemicals used to treat icing on water quality. One November 22, 2019 we hosted a water quality monitor training with the Anchorage Watershed Council for residents and students to assist with data collection.

Highlights or Expected Outcomes: Provide a brief overview of any noteworthy deliverables or expected outcomes related to research or broader impacts.

We expect to produce vegetation and hazard maps showing location of historical and likely future permafrost thaw, annual fuel loads, and rain-in-winter frequency 10-year increments from 1980-2060. Then spatial data on the interaction of wildfire, permafrost, and rain-in-winter hazards with the social and built environment; measurements of environmental effects of actions to respond to rain-in-winter events; estimated total community costs associated with these hazards and maps showing the spatial distribution of costs and tax payments from property owners to cover estimated public costs; quantification of economic impacts on property values and risk associated with hazards at the individual property and community levels. By combining the hazards produce multiple hazard and risk maps; risk model that allows for the quantification of the effects, including interactions with other hazards, of actions taken to reduce risks; integrated costs of multiple hazards. Finally a consensus place-based management strategies for developing multiple-hazard plans, co-produced with stakeholders in each community.

NNA Community Collaboration and Research Coordination: What would you like to get from the NNA Community? Is there anything you would like to offer? Is your project working in any specific communities or geographic areas? When will you be there? What kind of resource sharing or project coordination opportunities would you like to explore?

Given that we are forced to do more distance-based interactions with communities what tools are there out there to help facilitate this new type of communication and outreach. From the NNA community I think we can learn valuable lessons on how to work with communities, both successes and struggles. It should be the responsibility of the PI/individual projects to gather feedback from communities and partners as to how the partnership is going. I would welcome advise about how to best do this so I can get real-time feedback without overwhelming them. A deeper reflectance on how community partnerships happened by an outside research project is appropriate after projects have been completed, but not during. The communities are already taxed enough and the COVID-19 virus is further limiting their resources. We work with Anchorage and Fairbanks Alaska and Whitehorse, Yukon. I had visits planned, but they are now postponed until an unknown time. Insights as to how to hold a community meeting virtually would be appreciated. This would include technology, but also how to keep them engaged and leave feeling the meeting was successful.

It seems that some of the projects might be using the same data and if we can find a way to share that data among projects without the communities having to compile the data for multiple

projects that would be in everyone's best interest. Some examples are property, real estate, historic infrastructure, etc. that might not be publicly available and thus require effort on the part of the community to get. Maybe a clearinghouse of data collected with the project/PI to contact about accessing.

Advice for Overcoming NNA Project Challenges: Are there any unique challenges that your project has had to overcome or is facing now? Are there any lessons learned or things you would suggest others do/do differently?

I am not sure why but providing funding from NSF to communities seems to be difficult for communities. Maybe one solution is to figure out a way money can go directly to communities rather than routed through universities. I don't have a good solution.

Emergency Response in the Arctic (ERA): Investments for Global Capacities and Local Benefits

Key Project Contacts: Engineering Team: Thomas Sharkey, Rensselaer Polytechnic Institute (RPI), sharkt@rpi.edu; Martha Grabowski, RPI, grabom@rpi.edu; Al Wallace, RPI, wallaw@rpi.edu; **Social Science Team:** Tom Birkland, North Carolina State University, tabirkla@ncsu.edu; Marie Lowe, University of Alaska Anchorage, mlowe@alaska.edu.

Project Objectives: Create operations research (OR) models that determine and co-produce knowledge on where, when, and how to build infrastructure that both (i) improves Emergency Response in the Arctic (ERA) and (ii) benefits local Arctic Alaska communities. In order to achieve this objective, we need to both understand how infrastructure improves ERA and how the local community would be impacted by the infrastructure (including the discourse around such investments). The team has formed community partnerships across Arctic Alaska in order to accomplish this research.

Keywords: Oil Spill Response, Search and Rescue, Mass Rescue, Governance, Infrastructure Planning, Community-Based Participatory Research

Progress to Date/Future Plans/Expected Outcomes:
Community-Based Research: We have formed an advisory committee of representatives from the North Slope Borough, the Northwest Arctic Borough, City of Nome, NANA Regional Corporation, the U.S. Coast Guard, and Alaska Clean Seas. The first meeting of this committee (March 2019) resulted in identifying several classes of "dual-use infrastructure" – infrastructure that both improves ERA and benefits communities – and community partners in Utqiagvik (visit in June 2019), Kotzebue (visit in July 2019), and Nome (visit in July 2019).

Dual-Use Infrastructure: In initial analysis and coding of community visits, *port infrastructure* and *telecommunications* emerged as both relevant and timely. Additional themes included the community's ability to maintain new infrastructure into the future and talked with us about how it might impact subsistence activities, either positively or negatively. Current research in this area is examining the discourse around Arctic infrastructure in the communities.

OR Modeling: We have created OR models to understand response capabilities to mass rescue events from cruise ships and oil spill response in remote regions. Our future plans are to model the benefits that different types of dual-use infrastructure bring to the community. We are creating an OR model that can assess how infrastructure development across the region could be accomplished that both benefits communities and improves ERA. The model will be able to answer "what-if" questions like "What level of (outside) investment is necessary in order to ensure that each community receives certain benefits?" The output of the OR modeling efforts will be validated through our community partners and adaptations will be made based on their concerns.

NNA Community Collaboration and Research Coordination: Our team would like to coordinate data, both from engineering and the social sciences, on discussions around infrastructure in Arctic Alaska. We are currently working in Utqiagvik, Kotzebue, and Nome; however, we have postponed visits to these communities until a vaccine for the coronavirus has been created.

Advice for Overcoming NNA Project Challenges: The key issue right now is altering our timeline in response to not visiting the communities. We are currently exploring remote visits (e.g., through Skype/Zoom/etc.); however, this can only partially address our research process as we seek to validate our research findings.

POLARIS: Pursuing Opportunities for Long-term Arctic Resilience for Infrastructure and Society (Award #1927827)

Key Project Contact(s): Guangqing Chi (gchi@psu.edu), Davin Holen (dlholen@alaska.edu), Lance Howe (elhowe@alaska.edu), Chris Maio (cvmaio@alaska.edu), Ann Tickamyer (art14@psu.edu)

Project Objectives:
Goal: POLARIS investigates how interconnected environmental stressors and infrastructure disruptions are affecting coastal Arctic Alaskan communities and identifies the important assets (social, environmental, infrastructural, institutional) to help them adapt and become more resilient to climate-related changes.
Specific Aim: We integrate our interconnected research pillars—(1) environmental hotspots of disruption to communities and infrastructure, (2) food in complex adaptive systems, and (3) migration and community relocation—to predict system responses and uncertainties under several socio-environmental scenarios.
Method: The team will combine data from proposed surveys, interviews, focus groups, and economic experiments with environmental and secondary social data, to be analyzed with a combination of spatial analysis, agent-based modeling, and scenario planning within a complex systems framework.
Broader Impact: POLARIS takes a deeply transdisciplinary approach to create significant impacts through the integration of research, education, outreach, community engagement, and international collaboration activities.

Keywords: Arctic, Indigenous communities, transdisciplinary, coastal, Alaska, convergence

Progress to Date/Future Plans: Progress: (1) The entire team has completed a successful trip to Dillingham, Alaska. We met with a panel of community leaders, held an evening community meeting and potluck for the community, and met with individual community members including educators and tribal representatives. (2) We are planning a scoping trip to Wainwright in Fall 2020 with data collection to begin in early Spring 2021. Plans: (1) We are also exploring multiple datasets, both publicly available and restricted data, for data analysis before we go to the field to collect quantitative and qualitative data. (2) We are in the process of developing questionnaires and interview instruments and securing IRB approval.

Highlights or Expected Outcomes: (1) A virtual museum of local Alaskan geography, landscape, and communities consisting of films (short 3-minute films for each community and one 30-minute film tying the project together), podcasts, photos, and 360° photos facilitated by a project website (arcticpolaris.org) and shared with other relevant sites. (2) Curricula to be co-developed with local teachers. (3) A user-friendly field protocol and training video module that provides a workflow to establish observation sites and conduct coastal hazard risk assessments.

NNA Community Collaboration and Research Coordination: POLARIS will have in-depth study of the Bristol Bay region and Wainwright, covering the sociological, demographic, economic, anthropological, and ecological aspects. We would like to collaborate with other projects in field work coordination and data sharing.

Advice for Overcoming NNA Project Challenges: One challenge is the possible resistance to scientists flooding into local communities. This is a challenge perhaps for all NNA projects especially given the ongoing COVID-19. One solution is that all NNA projects should be coordinated. We are happy to see that the NNA program is creating a center for this purpose.

Arctic Coastal Risk Network

Key Project Contact(s):

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Project Website Urls & Social Media Accounts:

https://www.arcticcoastalrisk.net/

Community-engaged coastal research

Project Objectives: The overall project objective is to converge natural science, social science, and indigenous knowledge to define and communicate Arctic coastal risk. This objective is achieved with outreach activities at meetings and conferences, with the development of a project website where we communicate project activities, and with a demonstration project where we develop tools to define and communicate Arctic coastal risk. Broader impact activities include support of student research and direct engagement with coastal community members facing Arctic coastal hazards and risks.

Keywords: Arctic coastal risk, coastal hazards, community-engagement.

Progress to Date/Future Plans: Progress to date includes the following. (1) We have done outreach at conferences and meetings. (2) We have developed a project website (arcticcoastalrisk.net). (3) We have established a demonstration project at Hooper Bay Alaska, where we are developing methods to define and communicate Arctic coastal risk. In particular, following engagement with the Hooper Bay community, we have identified four critical coastal hazards/risks: coastal flooding, coastal erosion, permafrost thaw, and salinity intrusion. We are currently working to define the coastal flooding hazard, the risk (cost) of flooding to the community, and the risk reduction achieved by implementing countermeasures (raising the road elevation). We have simulated historic storm surge and flooding events and we have projected future flooding, identifying transportation infrastructure (roads) vulnerable to flooding. In the future, we will continue to develop methods to define and communicate Arctic coastal risk, including risks due to erosion, permafrost thaw, and salinity intrusion. We will also deepen our engagement with the community of Hooper Bay (site of demonstration project) to better understand their perception of risk.

Highlights or Expected Outcomes: The ongoing research incorporates indigenous knowledge and converges physical science and social science to define/project the Arctic coastal hazards and risks (costs) born by Arctic communities under both current and future conditions. The research will generate tools to support risk management and decision-making, in this rapidly changing environment.

NNA Community Collaboration and Research Coordination: There are a number of active NNA projects with a coastal focus. We would like to understand the efforts of these projects to achieve better collaboration and coordination. The PI's of five NNA RCN's are planning a joint workshop in 2021 entitled: "2021 Workshop on Arctic Coastal Communities, Hazards Remediation, and Resilience (2021 Arctic Coastal Workshop)", which will help to achieve this goal.

Advice for Overcoming NNA Project Challenges: Our project emphasizes collaboration with the Alaskan coastal community of Hooper Bay, which is a community of native Alaskans. We decided to develop a Memorandum of Understanding (MOU) with Hooper Bay entities in order to clarify the roles and contributions of the various parties in the collaborative relationship. An MOU was required for the Institutional Research Board (IRB) review of our project. Our advice to other researchers is to reach to research administrators to get advice on how to develop an MOU. Typically, researchers lack the authority to sign an MOU on their own.

NNA Track 1: A Systematic Pan-Arctic Analysis of Rain on Snow and Extreme Precipitation Events and their Impacts on Human-Environment Systems

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Mark C. Serreze

Project Website Urls & Social Media Accounts:
https://nsidc.org/rain-on-snow

Project Objectives: This project, a collaboration between the University of Colorado Boulder, the Alaska Pacific University and the University of Lapland, seeks to better understand the distribution, severity, and changes in the frequency of rain on snow (ROS) events and melt-refreeze events in the Arctic and their impacts, with a focus on hunting and in particular, reindeer herding livelihoods. By integrating with the NSF-funded ELOKA (Exchange for Local Observations and Knowledge of the Arctic) project, long-time research collaborations with Inuit hunters, communities in Northern Alaska, ecological research in Lapland and Russia, and language and cultural translation skills, this study will provide a truly pan-Arctic perspective of the effects of ROS and extreme precipitation events.

Keywords: Arctic, snow, rain, reindeer, hunting, Lapland, Alaska, Canada

Progress To Date/Future Plans: A project website has been set up. Papers were published on (1) quality of precipitation forecasts from atmospheric reanalyses and (2) ROS events over Alaska. A review paper is in preparation. Coordination has been initiated with the LEO project with Alaska Pacific University. ROS detection algorithms are under development.

Highlights or Expected Outcomes: A Data and Knowledge Hub, serving as the project website and a resource on knowledge regarding Arctic ROS and extreme precipitation events and their impacts, will also become the project's extension to the US Arctic Observing Network.

NNA Community Collaboration and Research Coordination: We are working with partners in Alaska, Canada and Lapland. We want to connect with other groups that may be involved with ungulate studies. ROS events also have impacts on hydrology, permafrost and sea ice conditions, and we want to connect with these groups in addition to climate modelers.

Advice for Overcoming NNA Project Challenges: None yet, provided that travel restrictions ease.

Integrating Language Documentation and Computational Tools for Yupik, an Alaska Native Language

St. Lawrence Island, Alaska

Key Project Contact(s):
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Project Website URLs & Social Media Accounts:
https://github.com/SaintLawrenceIslandYupik/
http://dowobeha.github.io/
http://www.sylvialrschreiner.com/research/yupik-project/

Project Objectives: Digitization, archiving, & community dissemination of legacy Yupik texts and audio. Development of foundational tools including finite-state morphological grammar & speech recognition system. Research to improve Yupik language documentation, including Yupik phonology, morphology, and syntax. Support of community-based language revitalization and education efforts.

Keywords: St. Lawrence Island, Alaska, Yupik, computational linguistics, language documentation, polysynthetic language, Bering Strait, phonology, morphology, syntax, morphosyntax

Progress to Date: Multiple trips to St. Lawrence Island for linguistic fieldwork & community consultation. Successful digitization of dozens of Yupik legacy texts & 100s of hours of audio. Successful development of 2 generations of finite-state morphological analyzer & prototype neural network-based analyzer. Preliminary work completed on speech technologies. Initial research on Yupik phonology, morphology, and syntax.
Successful creation of prototype interactive e-book delivered to local community school.

Future Plans: Continue language documentation efforts. Distribute technology & resources to local community.

Highlights or Expected Outcomes: Successful development of Yupik morphological analyzer coupled with successful use of this tool during fieldwork, resulting in quicker analyses of data & identification of gaps in existing language documentation.

NNA Community Collaboration and Research Coordination: We would like to connect with other researchers & communities involved in research and/or revitalization efforts involving other Inuit-Yupik languages.

Advice for Overcoming NNA Project Challenges: One extremely important factor contributing to the success of our project to date is the development and maintenance of strong personal connections with individuals and stakeholder groups in the local community where we conduct our research. We spent a non-trivial amount of time before the project began, at the beginning of the project, and continuing throughout the project, travelling to St. Lawrence Island and meeting with local stakeholder groups, talking with them about our proposed work, listening to their priorities and concerns, requesting their permission to conduct the research, and updating them throughout the project on project status. It is impossible to overstate the importance of actually spending time in the local community and taking the time to build relationships and earn the trust of the local community. There is a long and dark history of outside researchers swooping in, doing their work, and leaving without acknowledging or contributing to the local community and the local culture. As outside researchers, we have a crucial obligation to be highly cognizant of the negative history of colonialism, and to be proactive in shaping our research in such a way as to be highly sensitive to local Native culture, local Native needs, and to ensure that our research positively and concretely contributes to the local communities where we do our work in intentionally and actively anti-colonialist ways.

Co-production of shorefast ice knowledge in Uummannaq, Greenland

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Project Website Urls & Social Media Accounts:
Twitter: https://twitter.com/johnny_ryan_
Project summary: https://www.nsf.gov/awardsearch/showAward?AWD_ID=1836473
Fieldwork: https://sarah-cooley.com/uummannaq-greenland-2019

Different modes of shorefast ice travel in Uummannaq Bay

Project Objectives: The overarching goal of the project is to understand the impacts of environmental change and how they matter to individuals, communities, and institutions in the Arctic by co-producing salient, timely and credible knowledge about shorefast ice in the Uummannaq region of West Greenland. To complete this goal, we will leverage large satellite remote sensing datasets, community-based monitoring and local and Indigenous knowledge. The involvement of residents and institutions in Uummannaq at all stages of the project, in combination with ongoing observations, will lay the foundations for ongoing community support and enable new insights into the complex repercussions of climate change. The findings will also enhance the ability of local residents and institutions to make informed and embedded choices concerning natural resource governance and management, as well as choices about individual and collective trajectories towards a desirable and sustainable future.

Keywords: sea ice, climate change, unmanned aerial vehicles (UAVs), drones, satellite remote sensing, community-based monitoring, Indigenous knowledge, Greenland

Progress To Date/Future Plans: Completed field campaign (April-May 2019) in Uummannaq which achieved many of the initial project goals. Made first major steps towards understanding the importance of shorefast ice for livelihoods and lifestyle of people in Uummannaq. Learned a lot from our outreach events and initiated some good relationships with local people. Conducted repeat drone surveys investigate shorefast ice melt and breakup at high spatial and temporal resolution. Documented shorefast ice breakup timing over the last twenty years in Uummannaq Bay using Landsat, Sentinel-2 and Moderate Resolution Imaging Spectroradiometer (MODIS).

Highlights or Expected Outcomes: Our satellite remote sensing research demonstrates that springtime air temperature is the dominant control on shorefast ice breakup, allowing us to make empirical predictions of shorefast ice breakup into the future using CMIP5 outputs. This work was recently accepted in Nature Climate Change, keep an eye out for the paper in May! One of the major findings of the fieldwork was learning that human activities may have an important impact on shorefast ice breakup in Uummannaq Bay. In some years, an ice-strengthened vessel breaks up the ice so that cargo ships can come to export frozen fish. The human impact on shorefast ice breakup was something we had not anticipated and adds another interesting dimension which may be important for understanding the impacts of environmental change in Uummannaq Bay.

NNA Community Collaboration and Research Coordination: We are working in Greenland and hope to be there every spring, although we had to cancel this year because of the virus. We have developed some good relationships with residents in Uummannaq and are interested to learn about how our experiences compare with other projects in other regions of the Arctic.

Advice for Overcoming NNA Project Challenges: Building relationships with local residents takes time. This can be difficult when there are other expectations of us as researchers (e.g. reports, articles, teaching). We would be interested to learn about ways of ensuring continuation of research and outreach activities beyond the 3-year project timeline. Perhaps some Navigating the New Arctic super-sites?

Sustainably Navigating Arctic Pollution – Through Engaging Communities (SNAP-TEC)

Key Project Contact(s): Bill Simpson, University of Alaska Fairbanks (UAF), wrsimpson@alaska.edu, lead PI, Jingqiu Mao, Nathan Kettle, Laura Conner, Krista Heeringa (UAF), Kerri Pratt (U. Mich.), Peter DeCarlo (JHU), Brent Williams (WUStL), Jochen Stutz (UCLA), Rodney Weber (GaTech)

Project Website Urls & Social Media Accounts: https://fairair.community.uaf.edu/; https://alpaca.community.uaf.edu/

Project Objectives: This project focuses on improving understanding of wintertime Arctic outdoor and indoor air pollution. The motivation for this study arose from public feedback from Fairbanks and North Pole residents, who are concerned about the air quality and spend large amounts of time indoors during cold winter months. We will address: 1) natural science aspects related to how pollution behaves under cold and dark conditions through a field study in Fairbanks, Alaska; 2) the built environment through sampling air from a house and comparing to outdoor air while varying indoor sources (e.g. wood / oil heat), and 3) social science aspects through surveys and a public participation in science (PPSR). These efforts focus on studying and co-producing knowledge about resident's attitudes, beliefs, and actions around air quality issues.

Keywords: Air pollution, Arctic, Communities, Societal attitudes, Co-production of Knowledge

Progress to Date/Future Plans: The project formally began in Fall 2019, although it has built from prior workshops and studies. Most of our current efforts have been building the framework for the various elements of the study and hosting two community meetings (one in Fairbanks, one in North Pole) in February 2020. These meetings started the process of identifying members to be involved in a community advisory group, finding people to be involved in the PPSR study, and identifying people / groups to be engaged in the survey development and deployment. We have now shifted to planning of the field intensive study, which was planned for Jan/Feb 2021. Due to the coronavirus situation, we are considering if a delay might be appropriate.

Highlights or Expected Outcomes: We expect the project will increase community engagement around air quality in Arctic cities, including developing appropriate solutions. Our field study will also deepen scientific understanding of pollution in cold and dark environments. The indoor air aspect will improve understanding of transformation of infiltrating particulate matter upon warming to indoor temperatures and how indoor sources affect indoor air quality. The results of the field study and social science work should help community planners with solving these air quality problems in locally appropriate ways.

NNA Community Collaboration and Research Coordination: We look forward to working with other NNA projects to understand implications of the changes to the New Arctic. We are interested in expanding our project, which has field studies in the Fairbanks North Star Borough, AK, to other communities and considering similarities and differences between communities that affect locally appropriate solutions to these problems.

Advice for Overcoming NNA Project Challenges: We are trying to determine how to do the field work and public meetings in the light of the coronavirus situation and needing to assure safety for participants and the community. Another challenge is that economic consequences of the shutdown could lead to increased woodburning and pollution, making the intended field study year an anomaly.

NNA: Collaborative Research: MSB-FRA: Peat Expansion in Arctic Tundra - Pattern, Process, and the Implication for the Carbon Cycle (TundraPEAT)

Key Project Contact(s): Julie Loisel, Texas A&M University, julieloisel@tamu.edu, PI and representative at the NNA meeting; other PIs: Zicheng Yu (lead), Steve Frolking, Phil Camill, Qianlai Zhuang.

Project Website Urls & Social Media Accounts: n/a.

Project Objectives: Overview: This new project looks at "peat patches", which have been observed in areas beyond the northern peatland biome limit. These patches may represent the initial stage of peatland formation under a warming climate. This warming-induced increase in belowground carbon storage can be seen as the equivalent of aboveground vegetation greening phenomenon. We want to find out how widespread these peat patches are, why they are there, and what factors control their formation, distribution, and dynamics. Main question: will the warming Arctic evolve into a peatland-rich landscape, as the boreal zone is now, or are there some essential conditions missing in a warming Arctic that will prevent this? Aims: (1) collect new data from multiple tundra sites along the northernmost peat-forming frontiers of the North American Arctic (north slope of Alaska 1 (Yu), Victoria Island (Loisel), Baffin Island (Camill); (2) perform lab incubations of soil and peat cores to analyze their decomposability under different temperatures (Loisel); (3) synthesize existing peat core data from the boreal and tundra biomes and develop empirical models (Yu and Loisel); (4) model ecosystem-scale peat accumulation process using HPM (Frolking) and P-TEM as well as LPJ-STM (Zhuang). Methodological approaches: (1) field observations, (2) lab analyses, (3) lab experiments, (4) data synthesis of existing literature, (5) ecosystem modeling, (6) data and model integration, (7) training, dissemination, and outreach. Broader impacts: STEM education and outreach includes a new project for the Texas Science Olympiads (for high school students) that will consist of calculating C stocks in soils from the Arctic on the basis of our own datasets, two to three annual visits to public schools to talk about climate change in the Arctic as well as the importance of science in addressing and mitigating the rapid climate changes, and an outreach symposium on what a greening Arctic means to the natural world and human cultures in collaboration with Bowdoin College's Peary-MacMillan Arctic Museum; we will also organize a photo exhibition at the museum. The team will also disseminate project information and results via townhalls and workshops (led by all PIs), and will present project results to conferences and in peer-reviewed literature.

Keywords: greening, carbon cycling, soil, recent warming, Toolik, Alaska, Cambridge Bay, Baffin, Canada.

Progress To Date/Future Plans: Completed/Progressing: (1) Field collection in Alaska and on Victoria Island (2019); (2) lab incubations and peat soil-core lab analysis (2019-20); (3) data synthesis (in progress); (4) HPM peatland simulations across a permafrost gradient (2019-20) and P-TEM peatland simulations (in progress). Future: (1) Field collection on Baffin Island (postponed to 2021 due to covid-19); (2) more lab incubations (2021) and soil-core lab analyses (2020-22); (3) continued development and validation of HPM, P-TEM, and LPJ-STM (2020-23); (4) model intercomparison and data-model integration (2021-23); (5) townhalls and outreach activities (2020-23).

Highlights or Expected Outcomes: we are still too early in the process to report any highlights!

NNA Community Collaboration and Research Coordination: we are interested in sharing datasets, expertise, and outreach material. The development of a framework within which datasets and other types of knowledge would be shared could benefit (and augment) everyone's work.

Advice for Overcoming NNA Project Challenges: work towards permits early! Have local contacts! A lot of the interactions we've had with local people are informal and difficult to plan for. Having extra time while in the field for unforeseen delays is key.

Dynamic Vehicle-Terrain Modeling and Control of Lightweight Ground Robots in Soft Terrain

Key Project Contact(s):
Laura Ray
Thayer School of Engineering, Dartmouth College
lray@dartmouth.edu
Principal Investigator

Project Website Urls & Social Media Accounts:
N/A

Project Objectives:
The objective of our research is to advance lightweight autonomous robots for long duration operation in soft terrain through an integrated approach to design, modeling, and control of such robots to *maximize mobility*. Specifically, we will advance vehicle-terrain interaction models for lightweight wheeled robots operating on low cohesion terrain, and we will develop approaches to control such robots based on these models that enable a robot to purposefully modify the terrain under its tractive elements and/or modulate a towed load to avoid immobilization. Advances in modeling and control for mobility in soft terrain will enable ground-based observing platforms to travel hundreds of kilometers with mobile instruments that measure physical change in snow-covered Arctic regions.

Keywords: Robotics, terramechanics, mobility

Progress To Date/Future Plans:
We have fabricated and fielded a low ground pressure robotic platform for developing and assessing vehicle-terrain interaction models for lightweight wheeled robots. We have completed our first field season this past winter in northern Quebec and are presently developing models to predict and avoid incipient immobilization.

Highlights or (Un)Expected Outcomes:
An international partnership organized through the Geological Survey of Denmark and Greenland (GEUS) provided an opportunity for team members to use robotic survey to find the fan hub of an Airbus A380 engine that failed in 2017 over the Greenland ice sheet in 2017. Robotic operations allowed the international team to safely find the buried part. With the failure identified, all A380 aircraft underwent rigorous inspection for and correction of the flaw.

NNA Community Collaboration and Research Coordination:
I am interested in collaborating with scientist whose Arctic fieldwork would benefit from long-distance robotic operations, e.g., towing scientific instruments to collect data over large spatial, temporal regions of the Greenland ice sheet or other Arctic regions.

Advice for Overcoming NNA Project Challenges:
Are there any unique challenges that your project has had to overcome or is facing now? Like others, we are currently faced with a pause owing to COVID-19. All graduate students are working from home. We are fortunate to have data from the winter field season during this time. Stay safe.

Navigating Disturbance Regimes in the New Arctic

(NSF Awards 1927772 and 1928048)

Key Project Contact(s):

Melissa L. Chipman, Assistant Professor, Syracuse University, mlchipma@syr.edu, Co-PI

Mark J. Lara, Assistant Professor, University of Illinois, mjlara@illinois.edu, Co-PI

Project Website Urls & Social Media Accounts:

https://mlchipma.expressions.syr.edu
http://go.illinois.edu/LaraLab
Twitter: @mchipman5 and @mjlara71

Project Objectives:

Objectives: The primary objective of our project is to evaluate the vulnerability and/or resilience of Arctic tundra in northern Alaska to multiple interacting disturbances. We will use a combination of ***remote sensing, chronosequence surveys, and lake-sediment archives*** to investigate the interactions between ***climate warming, wildfire, permafrost degradation, and shrub expansion*** in the Arctic on decadal to millennial time-scales.

Methods: (1) High-resolution time-series image analyses will detect permafrost degradation and tall shrub expansion over the past 70+ years, used to develop spatially explicit models of landscape evolution. (2) Above and belowground parameters measured from field to airborne (UAS hyperspectral/LiDAR) chronosequence surveys will unravel disturbance-climate interactions/feedbacks linked with landscape evolution. (3) Paleoecological reconstructions from lake sediments will be used to evaluate linkages between climate, wildfire, permafrost degradation, and shrub expansion, and to validate spatially-derived models.

Broader Impacts: We will develop tundra vulnerability maps for 18 Alaskan villages to optimize inter-village navigation, hunting routes, infrastructure development, and preservation of heritage sites. We will also develop STEM educational and outreach initiatives focused on training and collection of drone imagery to capture seasonal patterns of permafrost degradation processes using structure-from-motion photogrammetry techniques.

Keywords: wildfire, permafrost degradation, shrub expansion, time-series analysis, paleoecology

Progress to Date/Future Plans: We will focus on sample collection from two regions of the Alaskan Arctic. Our first field campaign will occur in late July 2020 and will include UAS acquisitions, soil/vegetation surveys, and lake-sediment coring from six sites near the Toolik Field Station. Our second field season is planned for summer 2021, and will repeat measurements in the Noatak River Watershed. Both PIs and 2-3 graduate students will conduct field activities. Additionally, we have launched a special issue in *Remote Sensing* entitled, "Dynamic Disturbance Processes in Permafrost Regions" and will be accepting submissions through 30 Sept. 2021.

Highlights or Expected Outcomes: Our research will result in several key deliverables, including new and extended spatial and temporal observations and interactions between permafrost degradation, wildfire, and shrub expansion in the Alaskan tundra. In addition, we will provide education, training, and technology to indigenous high school classrooms and provide new permafrost vulnerability products/maps to many Arctic communities.

NNA Community Collaboration and Research Coordination: Because one of the overall goals of this project is to advance knowledge of Arctic disturbances, we are very interested in leveraging the knowledge and experiences of other NNA scientists to learn of successful approaches for engaging with native Alaskan communities. We aim to develop synergistic educational and research activities with these communities to combine the perspectives of both scientists and residents in understanding these rapidly changing landscapes.

Advice for Overcoming NNA Project Challenges: N/A --this is a new project.

Maritime transportation in a changing Arctic:
Navigating climate and sea ice uncertainties

Key Project Contact(s):
Hiba Baroud, Vanderbilt University, hiba.baroud@vanderbilt.edu, PI
Alice DuVivier, University Corporation for Atmospheric Research (UCAR), duvivier@ucar.edu, PI
Ralf Bennartz, Vanderbilt University, ralf.bennartz@vanderbilt.edu, Co-PI.

Project Website Urls & Social Media Accounts:
https://www.nsf.gov/awardsearch/showAward?AWD_ID=1928112&HistoricalAwards=false
Twitter: @HibaBaroud

Project Objectives:
Goal: This project is developing and applying a risk-based framework integrating an analysis of environmental conditions, an assessment of navigation risk, and an evaluation of the consequences of incidents. Specific *Aim*: Identify climate and sea ice risk factors and calculate the likelihood and impact of Arctic maritime navigation incidents. *Method*: Probabilistic analysis of climate and sea ice projection models to evaluate environmental and navigability conditions. Predictive and economic models will integrate such projections with multiple data sources to evaluate the probability of an incident and assess the local and global economic impacts. *Broader Impact*: Support a safe, reliable, and resilient navigation system for shippers, emergency responders, local communities, and Arctic researchers.

Keywords:
Maritime navigation, sea ice, climate models, risk analysis, interdependent economic modeling

Progress to Date/Future Plans: We have started collecting and evaluating necessary model data (CESM-LE and others). Currently we are evaluating sea ice concentration in these climate projections against observed sea ice concentration for the period 1980-2019 to establish a baseline for the validity of the models in the context of this study.

Highlights or Expected Outcomes: Recommendations will be provided for how climate models can be useful to stakeholders assessing the risk and weighing the costs and benefits of Arctic navigation. The outcome of this research will guide the scientific community towards providing information to stakeholders on safe and reliable Arctic maritime expedition. While the focus of this proposal will be on specific Arctic routes, the framework can be applied to any maritime shipping route.

NNA Community Collaboration and Research Coordination: The NNA community can help us build a network of connections with shippers and other Arctic navigation stakeholders. Given the lack of data for such extreme events, some of the model parameters for the risk factors will rely on stakeholders' elicitation.

Advice for Overcoming NNA Project Challenges: The project just started, the main challenge at this point has been in the recruitment of personnel.

NNA Track [2] Planning Grant: Developing Arctic Village Resilience to Future Water Cycle, River Systems, and Coastal Change

Key Project Contact(s): Julie Brigham-Grette, Colin Gleason, James Temte University of Massachusetts-Amherst, and Alaska Native Tribal Health Consortium (ANTHC)/Alaska Pacific University (APU), Co-PIs. **juliebg@geo.umass.edu; cjgleason@umass.edu; jtemte@alaskapacific.edu**

Project Website Urls & Social Media Accounts: Facebook page and website planned. https://www.nsf.gov/awardsearch/showAward?AWD_ID=1927644

Project Objectives: *Goal:* As arctic people navigate the new arctic, it is essential that communities chart a course that holistically considers both the physical world and human dimensions of these new realities. Accordingly, any rigorous study of the New Arctic must be grounded in the lived experience of its inhabitants and provide opportunity for tribes to take ownership over their own short- and long-term response to these grand challenges. *Aim:* This planning grant will set the foundation for a larger Phase 1 Navigating the New Arctic project to be proposed at the completion of this planning period *in collaboration with Native communities*. While the content of this future proposal is purposefully not set given the established need for planning and dialogue, we expect that our three focus areas will yield hypotheses and science goals that will answer important open science questions, while at the same time serving local communities as they look to the future. Specifically, we hope to gain a comprehensive view of community needs and prepare community members for responding to three areas of the New Arctic: (1) The impact of a changing climate on the municipal water cycle, (2) The impacts of coastal erosion, sea level rise, flooding, and river derived sediment delivery to harbor facilities, infrastructure, and health, and (3) The future of community water resources in an uncertain Arctic future. *Broader Impact:* This planning grant will identify new and exciting science questions as conceived by Arctic residents from their observations. In partnership, we will use the intersection of their knowledge and needs and our expertise to develop a integrated science plan that both addresses emerging issues but also serves to build capacity in the tribes and villages as the Arctic continues to change in the coming decades.

Keywords: NW Alaska, YK Delta, coastal erosion, river erosion, permafrost thaw, water supply, sanitation, managed retreat, education.

Progress to Date/Future Plans: Our planning process is now somewhat more challenging because of COVID-19. Given the planning that has already been done by villages and tribes and the current travel restrictions, we have worked by Zoom/email with community leaders already involved with planning and resilience issues. We are working through them to gather input on the greatest needs for research and observation that can be done as a future partnership and capacity building program.

Highlights or Expected Outcomes: Partnerships have been developed and zoom notes shared with all participants to maintain open dialog as we plan with communities using existing documentation.

NNA Community Collaboration and Research Coordination: We suggest starting with community needs and how an RFP might be focused on that. We are focused on the region of Kotzebue and the YK Delta. What protocols does NNA have for projects in the same regions?

Advice for Overcoming NNA Project Challenges: Our planning process is now somewhat more challenging because of COVID-19. We believe that the Kawerak et al. 2020 letter to NSF needs strong consideration for restructuring the proposal process.

The Role of New England in Navigating the New Arctic

Key Project Contact(s):

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Jack Dibb, UNH, jack.dibb@unh.edu, SP
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2018 NSF Convergence NNA workshop at the University of New Hampshire

Project Website Urls & Social Media Accounts:

http://nearctic.net
facebook.com/neanconvergence; @neanconvergence

Project Objectives: Assess the socio-economic and bio-physical links between Arctic change and New England; identify transformational convergent research that will anticipate, prepare for, and adapt to future challenges and opportunities.

Keywords: Convergence, North Atlantic Arctic, Regional Network

Progress to Date/Future Plans: Continued progress underway in the following areas:

- *Predict Socioeconomic Scenarios* for New England and the Arctic during ongoing major Arctic change, *Strategically Balance* environmental ethics and social justice with economic considerations and fully *Engage Stakeholders* in the design and execution of research.
- Include the *knowledge of Indigenous peoples* and promote *citizen science* to understand the scale and rate of change of inter-linked systems in the Arctic and connected regions.
- Develop a *collaborative Regional Network* (New England Arctic Network, NEAN) to support research and informed decision-making in response to Arctic change.
- *Train the next generation of Arctic researchers,* including Arctic System Change, Convergence Research with community partners and field experiences in the Arctic.

Highlights or Expected Outcomes:

- Developed visions of how Arctic change might create opportunity, risks, and hazards along the eastern coast of North America over a continuum of time scales from urgent to intergenerational.
- Established a New England Arctic Network to prepare for multi-institutional convergent response to the coming cascade of changes across all systems in the broadly defined region.
- Created core collaborative teams in line with NSF Navigating the New Arctic.

NNA Community Collaboration and Research Coordination:

- There is a critical need to support large-scale research initiatives focused on changes in the North Atlantic sector of the Arctic and resultant impacts on communities in eastern North America, including Greenland.
- Continue building a collaborative regional New England hub of Arctic researchers and educators to bring greater understanding of the global impacts of Arctic change to all communities and community members.

Advice for Overcoming NNA Project Challenges:

The following are barriers and needs to ensure continued progress:

- Ways to secure funding for planning grants to engage Arctic communities with researchers who do not yet have solid community relationships in order to identify priorities and collaborations (capacity-building).
- New pathways for funding international research (cooperative agreements among nations to overcome the barrier that NSF is unable to fund international collaborators)
- Provide opportunities for funding interagency collaborations (e.g., research initiatives that include FFRDCs)

Project Unangam Ulaa

Project Update April 2020

APIA & NSF

Award #1928254

Detail from "*Natives of Oonalashka and their Habitations*" Webber 1778

Oral tradition says the Unangax people have lived in the Aleutian Islands since the beginning of time. Unangax created dwellings – Unangam Ulaa – from locally available resources (driftwood, whale ribs, grass, and dirt) that provided shelter and spiritual comfort for eons.

Key Project Contacts:

	Michael Livingston		Millie McKeown		Karen Pletnikoff		Vincent Tomalonis
	PI		Co-PI		Co-PI		Research Assistant
	mikel@apiai.org		milliem@apiai.org		karenp@apiai.org		vincentt@apiai.org
	Cultural Heritage		Cultural Heritage		Environmental		Cultural Heritage
	907-276-2700		907-276-2700		907-276-2700		907-276-2700

Aleutian Pribilof Islands Association (APIA*) 1131 East International Airport Road Anchorage, Alaska USA 99518

*APIA is an Alaska Native non-profit organization formed pursuant to the Federal Alaska Native Claims Settlement Act (ANCSA) of 1971

Project Website URLs & Social Media Accounts:

https://www.apiai.org/departments/cultural-heritage-department/culture-history/

https://www.facebook.com/APIAI/

https://www.nsf.gov/awardsearch/showAward?AWD_ID=1928254&HistoricalAwards=false

Project Objectives: Briefly explain the overall goals of the project, specific aims, methods, and broader impact activities.

The hypothesis being tested in this project is whether ancient construction techniques of the Unangam Ulaa can be applied to modern materials to build energy efficient dwellings. We are in the two-year planning phase for the five-year field research. Our methods focus on interviewing elders and reviewing literature for strong cultural-based foundation; see outcomes below.

Keywords: Unangam Ulaa, Aleut Barabara, Traditional Sod House, Aleut, Aleutian, Pribilof, Unangaŷ

Progress to Date/Future Plans: Provide a brief research update describing progress to date or future plans.

For the two-year planning phrase, we have assembled a team of Unangaŷ/Aleut people, engineers, archaeologists, architects, and social scientists to form a strong cultural appreciation of the traditional dwelling and the surrounding spirituality. In Nov 2019, we all met, and everyone introduced themselves, talking about or "superpowers." We hired research assistant Vincent Tomalonis in Feb 2020. We presented a preliminary report at the Alaska Anthropological Association annual conference in Fairbanks in Feb 2020. Dr. Doug Veltre gave an awesome presentation of the archaeological history of the Unangam Ulaa in Feb 2020. We are working on our elder questionnaire, our community SWOT (strengths, weaknesses, opportunity, and threats) surveys. We are rough drafting our preliminary report to submit for publication. We are working on a rough draft of a web site and pushing ourselves to learn 3D animation (Blender 2.82a). We hope to soon interview elders and plan for field research. We are working on five papers (linguistic, archival, anthropological, construction, social science).

Highlights or Expected Outcomes: Provide a brief overview of any noteworthy deliverables or expected outcomes related to research or broader impacts.

If we can design and build an energy-efficient dwelling based upon a design from the Aleutians that is thousands of years old, these designs may be replicated in other regions to stave the decimation of Arctic villages with eons of cultural knowledge.

NNA Community Collaboration and Research Coordination: What would you like to get from the NNA Community? Is there anything you would like to offer? Is your project working in any specific communities or geographic areas? When will you be there? What kind of resource sharing or project coordination opportunities would you like to explore?

We would like to know more about the other projects, research questions, goals, challenges, how challenges overcame.

Advice for Overcoming NNA Project Challenges: Are there any unique challenges that your project has had to overcome or is facing now? Are there any lessons learned or things you would suggest others do/do differently? Advice Stay optimistic. Consult with optimistic people. (We really did not expect to win the award.) Don't pin yourself into the box. Don't say, "We will do A." Instead, say, "We will do A, but we also have Plan B and Plan C. Oh, and we also have Plan D and E." Challenges In Nov 2019, a plane crashed in Unalaska (first commercial plane fatality in US in ten years), stymying travel to our villages. In Mar 2020, COVID-19 struck, thwarting travel and causing concern for Unangaŷ elders.

NNA: NSFGEO-NERC: Collaborative Research: The Integrated Characterization of Clouds, Energy, Atmospheric state, and Precipitation at Summit, Aerosol-Cloud Experiment (ICECAPS-ACE) - Award #: 1801764

Key Project Contact(s):

Von P. Walden, Washington State U., v.walden@wsu.edu, PI
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Matt Shupe, U. Colorado, matthew.shupe@noaa.gov, PI
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Project Website URLs & Social Media Accounts:

https://psl.noaa.gov/arctic/observatories/summit/browser/
https://psl.noaa.gov/arctic/observatories/summit/
http://icecaps.ssec.wisc.edu/

Project Objectives:

This project is an international collaboration that between the original ICECAPS researchers through the U.S. National Science Foundation's Arctic Observing Network and a team of aerosol researchers through the U.K. Natural Environment Research Council. The ICECAPS project has continuously operated a suite of ground-based instruments at Summit Station, Greenland since 2010 for observing clouds, precipitation, and atmospheric structure. The project has significantly advanced understanding of cloud properties, radiation and surface energy, and precipitation processes over the Greenland Ice Sheet (GrIS), while also supporting process-based model evaluation, development of new measurement techniques, ground comparisons for multiple satellite measurements and aircraft missions, and operational radiosonde data for weather forecast models. The ICECAPS-ACE project is pursuing two new major goals between 2018 and 2021: 1) provide a better understanding of aerosol-cloud interactions over the GrIS and how they impact the surface energy budget, and 2) provide observations that can be used for numerical model assessment as part of the Year of Polar Prediction (YOPP).

As society begins to acknowledge the implications of climate change, it is necessary to understand how the physical climate system operates and evolves. Greenland is of critical importance to human society because it is currently a large contributor to sea-level rise, and the GrIS is melting at an accelerating rate. Providing a better understanding of the interactions between aerosols and clouds is of direct societal value because of their ultimate impact on the GrIS mass budget.

Keywords:

Greenland, Summit Station, clouds, aerosols, precipitation, surface energy budget, climate

Progress to Date/Future Plans:

Data archives:

- https://arcticdata.io/catalog (Search on PIs names)
- https://psl.noaa.gov/arctic/observatories/summit/browser/
- https://www.arm.gov/data (Search on "Summit Station")

Publication list:

- http://icecaps.ssec.wisc.edu/pubs.html

Highlights or Expected Outcomes:

- Description of ICECAPS concept and instrumentation (Shupe et al, 2013),
- Processes that affect the surface energy budget (Miller et al, 2017) including near-surface temperature inversions (Miller et al, 2013),
- Downwelling infrared radiation (Cox et al, 2014),
- Cloud radiative forcing (Miller et al, 2015),
- Humidity trends in the Arctic (Cox et al, 2015),
- Relationship to large-scale circulation (Gallagher et al, 2018),
- The annual cycle of snowfall at Summit (Castellani et al, 2015),
- Precipitation regimes over the GrIS and their relation to large-scale circulation (Pettersen et al, 2016; Pettersen et al, 2018),
- The importance of supercooled, liquid water clouds to the 2012 melt event (Bennartz et al., 2013; Van Tricht et al, 2016) and the GrIS and Arctic, in general.
- Importance of large-scale circulations and continental heat anomalies to Greenland melt events in 1889 and 2012 (Neff et al, 2014).

Currently working on research related to aerosol direct and indirect effects on cloud properties, aerosol radiative effect of the surface energy balance and the two surface melt events that occurred in 2019 at Summit Station.

NNA Community Collaboration and Research Coordination:

The ICECAPS-ACE research team has a long list of international collaborators that use ICECAPS data. The data are freely available in near-real time, and we encourage researchers to contact us if they have an interest in any of the ICECAPS data products or in collaborating with us on research projects that might benefit the larger NNA community.

Advice for Overcoming NNA Project Challenges:

Like many research field teams, we are facing the possibility of reduced field access and operations this summer (2020). These are present serious challenges to the continuation of certain aspects of our project.

Our team has a lot of experience with successfully operating instrumentation in low-temperature environments, so we would be happy to advise others that might be considering future instrument deployments in the Arctic.

Closing the Water Vapor Exchange Budget Between the Ice Sheets and Free Atmosphere

Key Project Contact(s):
Bruce Vaughn
INSTAAR, University of Colorado
Bruce.vaughn@colorado.edu
Principal Investigator NNA: AON: EAGER: #1833165

Project Website Urls & Social Media Accounts:
https://instaar.colorado.edu/people/bruce-h-vaughn/

Project Objectives: This project has deployed the first UAV with a gas-sampling pod optimized for water vapor collection and analysis in the field following flight. In doing so, the project stands to provide the first detailed and high-resolution airborne measurements of water vapor isotopes in the critical atmospheric boundary layer just above the Greenland Ice Sheet. The exchange processes across the interface between atmosphere and the surface of the ice sheet control the climate signal archived in ice cores, and vapor flux constrains sublimation and by extension, a portion of ice sheet mass balance.

Keywords: Water vapor, Isotopes, Arctic, Greenland ice sheet, Hydrology, Snow surface, Mass balance

Progress To Date/Future Plans: We have successfully deployed a multi-rotor UAV and a 3 meter fixed wing UAV aircraft for proof of concept to obtain profiles above the Greenland Ice sheet of temperature, pressure, humidity and made measurements of discrete samples for water vapor content and isotopic signature. Future plans include new and improved sample collection payload, better and faster temperature and humidity sensors, automated boundary layer detection, and improved flight control. Team has expanded to include expertise with MAR models and will return to Greenland for final season in 2021 to obtain high-resolution data in space and time.

Highlights or Expected Outcomes: We have helped pioneer the pathway for overcoming challenges associated with flying UAV aircraft in the cold and challenging high Arctic environment. We have identified and solved a number of hurdles in collecting and making accurate measurements of water vapor isotopes from the surface to 1500 m aloft including low humidity samples. This has potential applications to help validate other ground based and satellite measurements of water vapor (eg. TCCON). With the addition of more data, we hope to inform regional atmospheric models (MAR) for higher quality outputs. The sample collection method may also be applied to sampling other gases of interest. The fixed wing UAV with a modular configuration will also leverage new applications that can employ on-board instruments for in situ measurements, such as methane.

NNA Community Collaboration and Research Coordination: I am interested in connecting with other NNA researchers exploring water vapor isotopes, near surface atmospheric measurements or other surface processes. Since we have a proposal pending to extend our work to measuring methane other parts of the Arctic, I would be interested in leveraging projects of mutual interest that could couple our measurements with others at different scales across thermokarst environments.

Advice for Overcoming NNA Project Challenges: We've learned a bit about operating UAV aircraft in the Arctic environments and happy to share what we've learned. In general: Design, plan, fabricate, build, test, evaluate, and repeat until satisfied. A balance tenacity and patience is helpful.

NNA Track 2: Collaborative Research: Interactions of Environmental and Land Surface Change, Animals, Infrastructure, and Peoples of the Arctic

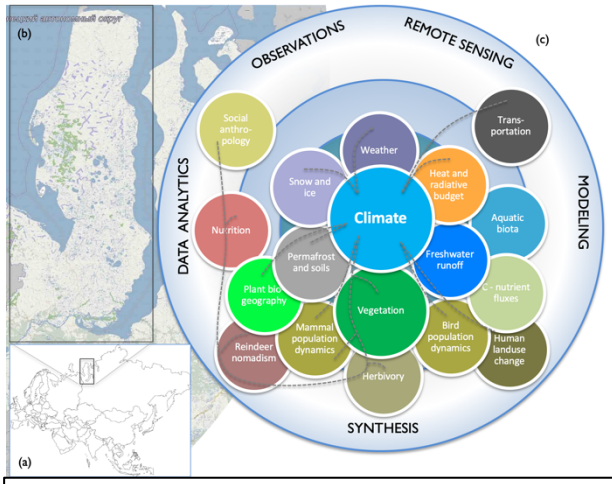
Key Project Contact(s): Name, Institution, Email Address, & Role

Valeriy Ivanov, University of Michigan, ivanov@umich.edu (PI, Abiotic systems & Infrastructure)

Peter Ungar, University of Arkansas, pungar@uark.edu (Co-PI, Biotic systems)

John Ziker, Boise State University, jziker@boisestate.edu (Co-PI, Social systems)

Project Website Urls & Social Media Accounts:
No centralized accounts but active on:
Ivanov: **Twitter**: @hydrowit
Instagram: valeriy_ivanov2208
Peter Ungar: **Twitter**: @PeterSUngar, @Ungarlab
Instagram: pungar
https://ungarlab.uark.edu/arctic-research/
Sokolov: **Instagram**: arctic_lab_yamal
Ziker: **Twitter**: @drziker



The study region of Yamal, Russia (a, b) and an overview of *land* Arctic system elements (c) specific to this region. The innermost circle (Level 1): connection between climate and geophysical processes. The second circle (Level 2): biological elements that respond to abiotic drivers with feedback mechanisms. The outer circle (Level 3): the elements of social system and built environment that interact with the abiotic and biotic constituents.

Project Objectives: Briefly explain the overall goals of the project, specific aims, methods, and broader impacts
The project aims at developing a Track 1 proposal for the study of the Yamal region of northern Russia as an ideal natural laboratory for transdisciplinary work to understand the complexity and adaptation of Arctic biotic and abiotic systems to climate change, and the feed-forward and feedback mechanisms modulating the co-evolution of human society and natural systems. The participants focus on developing research ideas and approaches for testing the hypothesis that displacing Arctic systems from their historic state of dynamic equilibrium under changing environment stimulates further changes to abiotic, biotic, and socio-cultural elements, particularly when combined with the spread of industry infrastructure, to increase the role of feed-forward and feedback mechanisms. Planned activities include two workshops, monthly virtual conferences, international capacity building, a synthesis paper, and the submission of Track 1 proposal in 2021. Broader impacts of this project. *Scientific community*: This project has strong international collaboration, engaging scientists representing various disciplines from USA, Europe, and Russia. *Education and outreach*: Our planned, on-site workshop will include outreach and educational programs for the public in Salekhard, Russia. We are developing curricula for a collaborative, transdisciplinary online inter-institutional course emphasizing a transdisciplinary view of Arctic science. The course will be team-taught by PI Ivanov and co-PIs Ungar and Ziker along with academic collaborators in the US, Europe, and Russia and having both classroom and online components. Registration for the Fall of 2020 has begun and the course is open to students at the University of Michigan, University of Arkansas, and Boise State University. *Community engagement*: this project will engage stakeholders, those representing government and industry in Yamal and the indigenous Nenets people of the region.

Keywords: Arctic, Yamal, reindeer, snow, permafrost, vegetation

Progress To Date/Future Plans: Provide a brief research update describing progress to date or future plans.
The team has been meeting virtually on a monthly basis between September 2019 and March 2020. We have developed comprehensive disciplinary summaries from numerous fields of expertise that are part of this planning project representing nearly 30 people (of which 22 are senior personnel). We have held a virtual 5-day project in late March synthesizing knowledge and crystallizing ideas and research threads for the Track 1 proposal. We will continue with monthly virtual meetings before a Workshop in Labytnangi, Russia, in October 2020.

Highlights or Expected Outcomes: Provide a brief overview of any noteworthy deliverables or expected outcomes related to research or broader impacts.

This planning project is developing ideas allowing the integration of earth system sciences, biological sciences, engineering, and social sciences within two outlined transdisciplinary "transects" of Arctic dynamics in the context of Yamal region: (1) gradual warming, and (2) extreme weather events. This project focuses on developing approaches related to feed-forward dependencies and feedbacks between 1) vegetation, snow, and the permafrost, 2) plant biogeography and changes in mammal – bird populations, including predator – prey relationships, 3) reindeer nomadism and nutritional status and livelihoods of indigenous communities and 4) their interactions with built environments.
We will continue with integration activities as planned, actively engaging students at peer institutions in synthesis and preliminary work. We are developing curricula for a collaborative, transdisciplinary online inter-institutional undergraduate and graduate course that will be administered at the University of Arkansas and co-taught at partner institutions.

NNA Community Collaboration and Research Coordination: What would you like to get from the NNA Community? Is there anything you would like to offer? Is your project working in any specific communities or geographic areas? When will you be there? What kind of resource sharing or project coordination opportunities would you like to explore?

- Best strategies for integration of social system, natural environment, and built-in environment components.
- Definition of "convergence research" in the context of NNA
- Definition of "built environment" – can reindeer economy represent this?
- What are priority funding areas for NNA (either geographically or topically)? In other words, are we better focusing on a confined set of questions/themes or trying to do it all in a circumscribed area?
- How can we best integrate international participants into the project in terms of funding? Work in the Russian Arctic requires logistics only possible with a large international team and formal partnerships with the Russian Academy of Sciences (Urals Branch, Arctic Research Station). Will substantive international participation put us at a competitive [dis]advantage?

Advice for Overcoming NNA Project Challenges: Are there any unique challenges that your project has had to overcome or is facing now? Are there any lessons learned or things you would suggest others do/do differently?
COVID-19 situation obviously has changed the landscape of project activities. We would like to learn how other groups are adjusting to the constraints.

Modeling Risk from Black Carbon in a Coupled Natural-Human System at the Arctic Ice Edge

Key Project Contacts:

Amanda Lynch, David Bailey, Michael Goldstein, Xueke Li, Scott Stephenson, Siri Veland

Project Website/Social Media:

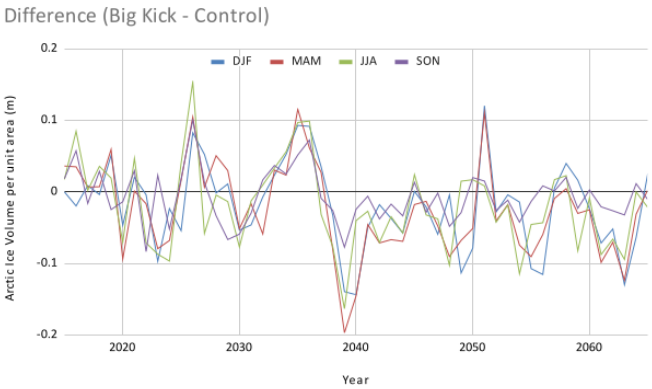
Some results have/will be posted at:
https://www.amandalynch.org/research/

Project Objectives:

The project is designed to address four hypotheses:

- BC emissions from all classes of shipping contribute a positive feedback affecting the rate of retreat of sea ice.
- Pricing the interannual variability in shipping access affects the financial risk and expected value of Arctic shipping and investments.
- Regulation of BC emissions will affect the near-term profitability of Arctic shipping routes.
- Expectations of Arctic shipping viability are conditioned on time scales that are influenced by natural system variability.

Time series of ice volume per unit area for control and "big kick" experiments.



Methods:

- Shipping modeling using ATAM (Stephenson et al. 2011)
- Climate modeling using CESM2 (Danabasoglu et al. 2020)
- Estimating financial risk using modified option pricing (Sturm et al. 2017)
- Interviews and surveys (Lynch et al. 2014)

Keywords: shipping, risk management, climate simulation and analysis

Progress To Date/Future Plans:

- First round interviews with shipping company managers, port operators, and financial services providers conducted in Oslo, Svalbard and Bodø.
- Winter Session field course held with 18 students (from Brown, Babson and Nord universities), one teaching assistant, and three professors. The experience was reported on in the following, among others (Wellesley local newspaper, newsbreak.com, etc):
  - https://www.brown.edu/academics/institute-environment-society/news/story/students-visit-arctic-pioneering-wintersession-course
  - https://www.browndailyherald.com/2020/01/30/newbury-wintersession-course/
- BC emissions for SSP scenarios refined.
- Control simulation and ensemble of BC perturbation experiments have been completed (see figure above) and are being analyzed.

Highlights or Expected Outcomes:

- Arctic-specific social and economic insight for investment and policy.
- Harvesting experience for risk management in systems with high natural variability.
- Training environmental sciences, finance and business students in inter-disciplinary complex systems analysis, using the Arctic as a natural laboratory.

NNA Community Collaboration and Research Coordination:

- Sharing of open source simulation capacity and data sets
- best practices for inclusive education
- facilitation of networking among Arctic communities

Advice for Overcoming NNA Project Challenges:

- hiring junior scientists with appropriate skills is a real challenge, especially in the context of slow and uncertain working visa processes.
- Regular virtual communication is obviously key.

NNA Track 2: Collaborative Research: Planning for Climate Resiliency Amid Changing Culture, Technology, Economics, and Governance

Key Project Contact(s):

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Heavy equipment being used to launch a boat big enough for large waves but too big for the boat ramp when the water is low at Utqiaġvik, Alaska

Project Website Urls & Social Media Accounts:

- N/A

Project Objectives:

As a research planning project, we are using a knowledge coproduction approach to assemble a body with the necessary expertise to identify the research needed to:

1) address the most significant challenges to subsistence activities faced by residents of communities in today's Arctic, where the rapid environmental change of recent decades is taking place against a backdrop of social and cultural change spanning multiple generations.
2) evaluate adaptation strategies that are being adopted or considered on an individual or community basis and identify which of these are driven by environmental change and which are likely to be effective or sustainable

Keywords: co-production, drivers of change, research plan, adaptation strategies,

Progress to Date/Future Plans:

- We have visited the communities of Kotzebue and Utqiaġvik, both located on the Alaska Arctic coast.
- We met with a variety of community members who are both involved in various aspects of subsistence harvesting and knowledgeable about the social and environmental changes taking place in their homeland.
- We sought residents who are familiar with NSF-style research projects as well as those not usually contacted by researchers. We spoke with both male and female residents from a variety of age groups.
- Our discussions were informal, largely unstructured, and primarily intended to inform the topics, structure, and participant list for a subsequent workshop involving members of both communities and academics with knowledge relevant to the issues identified by the communities.

Highlights or Expected Outcomes:

- Our most significant finding to date is a near-consensus from community members that environmental Arctic change is disrupting subsistence activity, but is not the source of the most pressing challenges they are facing.
- Compared to widespread problems related to health, wellbeing, cultural vitality and identity, education, economy, infrastructure, and transportation (none of which are new to the Arctic), community members seem to feel capable of adapting to climate change.

NNA Community Collaboration and Research Coordination:

- Coordination between different NNA research groups is essential to avoid "research fatigue" and other negative outcomes from the incoming tide of researchers to Arctic communities.
- The program solicitation and funding profile to date focus heavily on environmental change and its direct implications. This does not appear well aligned with concerns and challenges shared by community residents.

Advice for Overcoming NNA Project Challenges:

- We are learning that the NNA program may have missed the mark by tacitly focusing attention on the popular narrative that rapid environmental change is the primary driver of disruption in the Arctic
- It is unlikely that any single project, within NNA or otherwise, can fully address the information needs of Arctic residents, even on narrow topics. Aggregating results to better meet the needs of Arctic residents is imperative if NNA is to fill its promise of helping society navigate the uncharted waters of the new Arctic.

Energy and Empowerment in Arctic Fishing Villages

P.I. and contact: Dr. Mary Albert, Professor at Dartmouth Thayer School of Engineering, Hanover, N.H., Mary.R.Albert@Dartmouth.edu
Co Investigators: Lene Kielsen Holm (Greenland Climate Research Center, Nuuk, Greenland), Toku Oshima (Hunter-Fisher, Qaanaaq, Greenland), Fiona Li and Chris Polashenski (Dartmouth)

Project Objectives
Many small communities in the Arctic are reliant on expensive fossil fuel for their energy needs. In Avanersuaq, Greenland the joint impacts of energy cost, changes in fisheries and the environment, and a young self-rule national government are intertwined in ways that are currently threatening the culture and lifestyles of people who have long called the region home. An iterative, systems-based approach that is driven by stakeholder values and objectives is being used to define and solve energy and fishery-related research needs faced by communities in northern Greenland. Initiated by an invitation from local hunter-fishers to the P.I., this project represents stakeholder-driven science and engineering. Engineers, scientists, hunter-fishers, citizens, students, utility managers and local government representatives will collaborate to address challenging interdisciplinary problems in this region where planning and adaptation to environmental change is not already in place. Energy and fishery-related issues will be pursued in ways that will embrace energy self-reliance, identify an achievable and sustainable pathway to a resilient future, and contribute to capacity-building for engineering in changing conditions.
Keywords: Arctic, energy, fisheries, engineering, policy

Progress to Date/Future Plans
This project started on 1 April 2020. We had planned to travel to Qaanaaq this month for discussions and planning with community members, however due to the COVID19 pandemic, our first field trip has been postponed to late August or later. We continue to plan and do background research virtually.

Highlights or Expected Outcomes
We are working collaboratively to solve the research problems that are stumbling blocks in the pathway to an affordable, resilient future for Qaanaaq and surrounding settlements. Educational activities with youth and schools in the Arctic include inquiry-based, societally-relevant hands-on activities for learning about renewable energy systems. Use of affordable renewable energy will enable cultural continuity, enhance health and safety, build capacity, and will strengthen community resilience. After this NSF-funded research, we aim to pursue foundations and the government of Greenland for funding to implement research results.

NNA Community Collaboration and Research Coordination
Our primary partners are in Qaanaaq, Greenland, but many of the challenges present there also exist in other small Arctic communities, so we are interested in sharing knowledge and research results with others working in small villages in the Arctic.

Highlights or Expected Outcomes:

- Improved GIA model for Greenland, improved estimates of present-day mass loss from GRACE, estimates of current and future sea level change around Greenland and their drivers, better constraints on the past evolution of the Greenland ice sheet, better understanding of the lithospheric structure and sublithospheric mantle below Greenland including mantle derived heatflow estimates.
- New maps of bathymetry and habitat near four different Greenlandic communities, vertical transects of habitat within the intertidal zone, new models of vulnerability and resilience of species to changing sea level.
- New continuous records of tidal variations from tide gauges installed at each community.
- Educational material and community engagement focused around changing sea level, including observations of tidal variations and shoreline life, community records of long-term changes in sea level.
- Developing a template for communities around the Arctic to adapt to the forthcoming change.

NNA Community Collaboration and Research Coordination:

- Combining community and education contacts to establish an ongoing framework that integrates different NNA projects working in similar regions.
- We will be working within four Greenlandic communities: Nuuk, Aasiaat Kullorsuaq and Tasiilaq, with visits in each year of the project.

Advice for Overcoming NNA Project Challenges:

- In person meeting was tremendously valuable for developing communication between international partners
- Investigating ways of contributing to distance learning, and developing/continuing partnerships remotely

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NNA Track 2: Responding to the Housing Crisis in the Arctic: A Transdisciplinary Approach across Physical, Natural and Social Systems

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Bora Cetin, Michigan State University, cetinbor@msu.edu, Co- PI

Project Objectives and Methods:

- Form a multi-disciplinary research team to assess housing vulnerabilities (biophysical changes and household exposure to substandard living conditions)
- Form community partnerships based on meetings with and approval of tribal councils
- Determine needs regarding household living conditions (i.e. indoor air quality) and vulnerabilities using interviews and surveys with external stakeholders (i.e. government agencies, non-profits, engineering firms, etc).
- Organize workshops with community partners and the research team to facilitate feedback on vulnerability assessments and create summary reports of issues and preliminary resolutions.
- Use climate model output to estimate future impacts of warming on permafrost and the resulting damage to infrastructure.
- Develop case study curriculum for civil engineers with education professors regarding the housing issues in the Arctic to support critical engagement by future engineers

Keywords: Housing Vulnerability, Climate Change, Community Based Participatory Research, Rural Alaska
Progress To Date/Future Plans:

- The research team has bi-weekly/monthly meetings to coordinate and to build cultural competency and capacity for community based participatory research. Meetings are being arranged to determine the communities that we plan to reach out to over the next year.
- The case study curriculum has being developed with a team of education scholars. The case study will be piloted in the Fall in one civil engineering course. The goal is to increase awareness of housing issues in the Arctic and to improve critical consciousness among civil engineers.
- Stakeholders who work with rural Alaska communities have being interviewed (N=25) to identify the climate change adaptation barriers and drivers to address issues of infrastructure/housing. Data has been coded and will be submitted to a conference in May Preliminary results of interviews indicate that external stakeholders believe community leadership, funding, inclusion of local knowledge, and baseline data of environmental risks are essential to addressing biophysical risks to infrastructure in rural Alaska.
- A questionnaire is being developed for community stakeholders to identify the

Highlights or Expected Outcomes: This research will support the development of multi-disciplinary, culturally appropriate research to address housing vulnerability in rural Alaska. By providing an integrative understanding of housing vulnerability, targeted responses can be developed to address key vulnerabilities. Further, this project will design a case study curriculum for civil engineers regarding the housing issues in the Arctic using critical pedagogy perspectives to support critical engagement by future engineers.

NNA Community Collaboration and Research Coordination: The NNA community provides a unique community to better understand the contextual needs of research in rural Alaska and existing projects for potential collaboration. We are interested in learning more about ways researchers are better supporting the priorities of rural communities through research. The reports developed through this planning grant will provide insight for other researchers into research priorities as identified by community representatives.

Advice for Overcoming NNA Project Challenges: Due to the remote nature of many Alaska communities and cultural diversity, our research team has spent additional time building cultural competency and forming intentional management plans to ensure appropriate engagement with tribal councils. Working with collaborators who have strong, existing relationships with rural communities has supported this process.

Environmental monitoring, community-led research, Indigenous and local knowledge, landscape-scale, network, coordinated monitoring

Progress To Date/Future Plans: Provide a brief research update describing progress to date or future plans.

We've secured 14 partners from U.S. and Canada-based entities including nonprofits, tribes/First Nations, Indigenous Organizations and Universities to co-develop our approach and assist us with implementation.

We've presented our project and asked for feedback on our approach and interest in participation at venues frequented by our target audience including: The Alaska Tribal Conference on Environmental Management; Bureau of Indian Affairs Tribal Providers Conference; Alaska's Just Transition Summit and the Alaska Forum on the Environment.

We had also organized our first workshop planned for late April of 2020 which is now being rescheduled for fall of 2020 and will be held ideally in person but we are exploring options to shift to a virtual platform as well.

Highlights or Expected Outcomes: Provide a brief overview of any noteworthy deliverables or expected outcomes related to research or broader impacts.

Over a period of two years, the team will regularly engage participants from multiple stakeholder groups involved in environmental and climate change monitoring programs, including Indigenous peoples, scientists, engineers, and resource managers. The project will provide opportunities for cross-border and cross-sector learning and networking through two in-person convenings.Together the group will co-develop coordinated monitoring networks that will bring together data and information collected across Alaska and western Canada, and apply this information toward tackling critical challenges linked to food security, infrastructure vulnerability, human safety, land and resource management, climate adaptation and planning, sustainable economic development, and Indigenous lifeways sustained by the land and resources.

Working groups will co-create and implement strategies to tackle commonly-shared challenges in order to leverage resources, build capacity and expertise, reduce duplication, and facilitate synergy among programs. Drawing from best practices and strategies developed through this project, an education curriculum containing tools, resources, and training will also be developed in order to strengthen community-based monitoring programs, including the ability for Indigenous communities and scientific researchers to successfully collaborate.

NNA Community Collaboration and Research Coordination: What would you like to get from the NNA Community? Is there anything you would like to offer? Is your project working in any specific communities or

geographic areas? When will you be there? What kind of resource sharing or project coordination opportunities would you like to explore?

Our project could benefit by becoming connected to NNA grantees who are also working with community-based environmental monitoring efforts, or would like to connect with such programs. We are working across Alaska, northwestern Canada and coastal British Columbia and we had initially planned two in-person workshops and would be asking participants to travel to a couple of centralized locations (Anchorage for one and the second in Canada, location TBD).

We are happy to share contacts for managers and scientists working in coll

Advice for Overcoming NNA Project Challenges: Are there any unique challenges that your project has had to overcome or is facing now? Are there any lessons learned or things you would suggest others do/do differently?

Our biggest challenge will be finding ways to safely bring workshop participants together from across our study region which would require travel from numerous communities in Alaska and Canada. We are considering virtual gatherings so hearing about meaningful ways others have conducted those successfully for diverse audiences (researchers, local observers, environmental managers, Indigenous Knowledge holders, etc.) would be helpful to us.

We also recognize the immense challenge in leveraging the precious time spent in workshops to facilitate the ability for numerous and diverse groups to bridge common needs and priorities, and establish tangible steps to coordinate their work. Any insights on facilitation approaches would be appreciated.

Indigenous Foods Knowledges Network

Key Project Contact(s):
Noor Johnson, Ph.D, Research Scientist, National Snow and Ice Data Center, University of Colorado, PI, IFKN Co-Lead
Mary Beth Jäger (Citizen Potawatomi Nation), MSW, Research Analyst, Native Nations Institute, University of Arizona, Research Coordination Team member, IFKN Co-Lead

Project Website Urls & Social Media Accounts:
https://ifkn.org/

Project Objectives:
Goal: The goal of the Indigenous Foods Knowledges Network (IFKN) is to develop a network in the Arctic and US Southwest comprised of Indigenous leaders, citizens, and scholars (both Indigenous and non-Indigenous) who are focused on research and community capacity related to food sovereignty and resilience, and who will collectively work to promote and carry out research that 1) utilizes the Indigenous research processes, 2) embraces and respects Indigenous Knowledge systems, and 3) supports Indigenous communities. See IFKN's charter to learn more about our guiding principles and specific goals. Methods: In-person meetings where we spend time on the land learning from demonstration projects; Zoom meetings and webinars; blog and satellite gatherings at conferences. Broader impact: Our network is building connections between Indigenous scholars and practitioners by focusing on concrete solutions and creating a space for shared learning and inspiration.

Keywords:
Indigenous Food Sovereignty, Governance, Arctic, Indigenous Knowledge, Networks, U.S. Southwest

Progress to Date/Future Plans: IFKN has hosted 3 in-person meetings at the in Gila River Indian Community (March 2018), Tohono O'Odham Nation (March 2019), Nay'dini'aa Na'Kayax (June 2019) and sent a delegation to the Festival of Northern Fishing in Torino, Finland (September 2018). In the spring of 2018, IFKN invited nine Indigenous Peoples from both regions to be part of the Steering Committee. IFKN has written a charter (Spring 2018) and published a commentary in the Journal of Agriculture, Food Systems, and Community Development (December 2019), and has a profile piece in Witness the Arctic Community Highlights. IFKN members have presented about the Network at various venues such as the American Geophysical Union Fall Meeting. r. IFKN has hosted two webinars this year. Due to the COVID-19 pandemic, we have suspended in-person meetings this year, but we plan on continuing the webinars and investigating other ways to stay in touch.

Highlights or Expected Outcomes: IFKN has found that meeting on the land facilitates deeper conversations and understanding of the relational foundation of food sovereignty than would occur in a conference room. Participants learn about each other's work, which can be helpful in their own work in their own communities. Commonalities have been found in multiple areas such as land and water rights and the key role of governance in limiting or facilitating community efforts. There is power in bringing together multiple Indigenous scholars in one space. The Network is yielding new connections and initiatives within as well as between regions - participants have spent time with each other at other meetings & endeavors.

NNA Community Collaboration and Research Coordination: It would be helpful to connect with other projects who are working with Indigenous communities to learn how they building relationships with Indigenous Peoples and implementing Indigenous research methods. If other projects have a significant focus on food and leadership from Indigenous communities, we may be interested in scheduling a webinar so we can exchange learnings.

Advice for Overcoming NNA Project Challenges: A strong component of our success has been to have an Indigenous steering committee and to invite community partners to plan and host our gatherings. Collectively developing a charter at the beginning of our work helped create a strong framework based on Indigenous, community-centered values.

Persistent, Long-Range, Autonomous Under-Ice Observations of Arctic Change

Key Project Contact(s):
Rich Camilli, Woods Hole Oceanographic Institution, rcamilli@whoi.edu (PI, vehicle systems design)
Ted Maksym, Woods Hole Oceanographic Institution, tmaksym@whoi.edu (Co-I, sea ice observations)
Brian William, Massachusetts Institute of Technology, williams@csail.mit.edu (Co-I, mission planning)

Project Website URLs & Social Media Accounts:
https://www.youtube.com/watch?v=JaIWi0HgdkA
https://www.whoi.edu/news-insights/content/navigating-the-changing-arctic/

Project Objectives: Build and trial a low cost, long-range hybrid autonomous vehicle for sustained under-ice operation. This includes key technological and operation advancements, including:

- Terrain-aided navigation during long-duration under ice operations without GPS or the need for acoustic beacons.
- Capability of operating in water with currents in excess of 1 m/s or rapidly changing ice cover
- Continuously optimized vehicle velocity enabling energy-efficient use of adaptive propulsion.
- Automated risk-aware mission replanning to rapidly adapt to evolving environmental conditions
- Low cost operation without need for icebreaker support, or acoustic transponder networks.

This will provide capability for:

- Continuous observation of ice-ocean interactions such as the seasonal ice advance and retreat
- Characterization of ice thickness variability along transects up to hundreds of kilometers
- Coincident observation ice thickness, waves, and upper ocean variability
- Eventual goal of sustained operation under ice over thousands of kilometers.

Broader Impacts – has involved several WHOI summer student fellows, 2 grad-students, and been incorporated into WHOI Summer Introduction to Engineering and Scientific Research (SIESR) for high school students in underserved communities.

Keywords: Hybrid underwater glider, sea ice, upper-ocean, sustained autonomous observations

Progress to Date/Future Plans:

- Vehicle built and sea trialed; mission planning computer installed; new nose cone with scanning sonar built; improved thruster designed and in production
- Demonstrated terrain-aided navigation during cruises of opportunity (simultaneous localization and mapping using Doppler sonar at Eastern Pacific shelf margin in Dec 2018 and within an active volcano in the Eastern Mediterranean Nov 2019)
- Completed initial lab and field testing for sonar detection and classification of ice (presence, thickness, and composition) as well as wave spectra (frequency, amplitude, and direction). This is important for science data gathering, surfacing for communication with satellites, and vehicle survivability.

Highlights or Expected Outcomes:

- Demonstrated unattended adaptive AUG operation in regions containing obstacles.
- Demonstrated improved AUG navigation (more than 10X decrease in navigation uncertainty).
- Demonstrated the ability of an automated process to quantify ice thickness to 2cm resolution, and ability to characterize marginal ice (ice floes in the presence of ice free areas) as well as frazil ice. This process is currently being integrated into the vehicle's onboard interpreter & mission planner to autonomously adapt mission plans in response to environmental state.

NNA Community Collaboration and Research Coordination: Currently funded for development and testing; science deployment will require subsequent funding. Are there marine projects we could leverage to expand scope of test deployment opportunities? Could provide some limited observations in return. Target is late summer 2020 in Beaufort/Chukchi, but flexible.

Advice for Overcoming NNA Project Challenges: Challenges in completing engineering and test deployments with COVID-19 restrictions.

NNA: Collaborative Research: Interactions of the Microbial Iron and Methane Cycles in the Tundra Ecosystem

Key Project Contact(s): David Emerson, Bigelow Laboratory for Ocean Sciences, demerson@bigelow.org, PI; Nicholas Record Bigelow Laboratory for Ocean Sciences, nrecord@bigelow.org, co-PI; William Bowden, University of Vermont, breck.bowden@uvm.edu, co-PI

Project Website Urls & Social Media Accounts:
https://www.bigelow.org/news/articles/2020-02-10.html

Project Objectives: The tundra is rusting due to production of biogenic iron oxides by iron-oxidizing bacteria. Our goal is to understand the role of microbes in the iron cycle both through oxidation of iron and it's reduction, and how this may impact the carbon cycle, and in particular the production of methane. Two key aims are: 1) to the identify the microbial communities driving the iron cycle and underlaying reasons for their ubiquity in the tundra ecosystem; 2) elucidate interactions of biogenic rust with carbon cycling in moist tundra and associated water bodies.

Keywords: microorganisms, iron, methane, active layer, permafrost, microbial community

Progress To Date/Future Plans: During the summer 2019 field season for 6 weeks we sampled a diversity of sites to monitor microbial community composition, along with associated samples for methane and iron quantification. All geochemical samples have been analyzed and samples for DNA-based microbial community analysis have been sequenced. The DNA sequence data are being analyzed. Our future plans are to use this data to better understand important ecological and biogeochemical associations among microbes, and design experiments to further test hypotheses we develop for the coming field season.

Highlights or Expected Outcomes: Our first field season demonstrated that iron cycling communities are prevalent in moist tundra, and host diverse microbial communities predominated by genera of iron-oxidizing and iron-reducing microbes. Methane-consuming genera were also abundant. Compared to temperate habitats, photosynthetic microbes were surprisingly abundant. Overall, our combined biogeochemical and microbial data show a tight coupling between iron cycling microbes, and provide hints about coupling to methane, as well as other important processes like phosphorus regeneration. A unique aspect of our broader impacts is a collaboration with local artists from Maine who accompanied us in the field and are producing a book and an exhibit of fine art that couple's rational explanation with impressionistic art to enhance our sense of the Arctic ecosystem and its importance, and covey this to the public.

NNA Community Collaboration and Research Coordination: Continuous permafrost and shallow (~<1m) active layer depths in the summer are likely to be hotspots of iron cycling. We hope to hear from many researchers, of all kinds, of reports of the tell-tale sign of biological iron oxidation, rusty plants, boots (see photo above). We believe these habitats and their biogeochemical importance is likely to be more widespread than previously considered. It would be of great interest if you would share a quick photo or story of where you found these rusty spots in the Arctic.

Advice for Overcoming NNA Project Challenges: There was a project funded to study very similar geochemical processes in the tundra ecosystem. Through an in-person meeting and a few zoom meetings the two

projects were able to more clearly define goals and locations of study. These collaborations and discussion before data collection will improve the science that results. This is was possible through collegiality from both projects.

Track 1 – Collaborative: The climate impacts on Alaskan and Yukon rivers, fish, and communities as told through co-produced scenarios

Key Project Contact(s):
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Project investigators hold an artist's doodle sketch of our six-talk session at the 2020 Alaska Forum on the Environment.

Project Website Urls & Social Media Accounts:
Coming this June! Email: arcticrivers@colorado.edu

Project Objectives: Our goal is to converge indigenous knowledge and western science to strengthen collective understanding of terrestrial hydrologic change in the Arctic and the potential impacts on rivers, fish and Indigenous communities in Alaska and upstream western Canada. We use specific conductance and temperature measurements of major rivers to assess changes in groundwater contribution. The sensors innovate Indigenous community-based monitoring networks and the USGS AK gage network. Through ethnographic methods and a Arctic Rivers Summit (2022) we seek to collectively identify vulnerabilities of fish and river ice to climate change. Participatory mapping of fish habitat and river-transport corridors merges existing spatial information into a common geofabric of indigenous knowledge and western science. A physically based model chain consisting of the Regional Arctic System Model (RASM) and NCAR's Community Terrestrial Systems Model (CTSM), a dynamic streamflow routing model, a river ice and water temperature model, and a fish bioenergetics model are used to assess historical hydrologic conditions and possible future climate vulnerabilities of river ice and fish species. Guided by a Native Advisory Council consisting of Elders and indigenous community leaders, we co-develop descriptive and quantitative narratives, or storylines, of past and plausible future hydroclimatic, river ice, and fish conditions jointly based on Indigenous baseline knowledge and physical principles / western science. The project will support three Indigenous interns at the USGS Alaska Science Center and the Yukon River Inter-Tribal Watershed Council; a Ph.D. student, a postdoctoral associate, and numerous undergraduate researchers at CU Boulder; and one postdoctoral researcher at NCAR.

Keywords: Arctic rivers, Indigenous communities, Monitoring, Alaska, Yukon, Climate modeling, Groundwater, Hydrology, Fish, River ice

Progress to Date/Future Plans: We've successfully hired students and a postdoc despite the COVID-19 challenges. We convened a session of six project talks at the AFE in Feb., 2020 and 31 indigenous community members signed up for our new listserv: nna-arcticrivers@colorado.edu. We have successfully coupled RASM and CTSM models at the global scale and are preparing tests of high-resolution runs over Alaska and western Canada.

Highlights or Expected Outcomes: We expect to make important advances that include assessment of climate change impacts on river and groundwater transformation, the sustainability of arctic river fish populations, the reliability of winter river ice travel, and the integrated impacts on communities dependent upon the resources.

NNA Community Collaboration and Research Coordination: We seek to form a Native Advisory Council consisting of indigenous leaders and professionals over interior and northern Alaska and the Yukon.

Advice for Overcoming NNA Project Challenges: Tribal leadership requests compensation for their time.

Atautchikkun Iḷitchisukłuta
Coming Together to Learn

Key Project Team: *University of Alaska Fairbanks:* Courtney Carothers (clcarothers@alaska.edu), Jessica Black (Gwich'in), Peter Westley, Seth Danielson
First Alaskans Institute: Liz La quen náay Kat Saas Medicine Crow (Haida and Tlingit), Barbara'Wáahlaal Gidáak Blake (Ahtna, Haida and Tlingit)


Team meeting in Fairbanks, February 2020

Project Objectives

-Build and strengthen the relationships necessary to ethically and meaningfully engage western and Indigenous scientists fully in collaborative research to holistically understand Arctic change.
-Develop a mutually respectful process for co-creating research questions and conceptual model that will guide and form the centerpiece of a grant proposal.
-Provide a safe space for mutual learning through the inclusion and mentorship of Indigenous youth as the next generation of scientists and community leaders.

Keywords: Indigenous science, self-determination, decolonization, Beaufort Sea, Arctic coastal riverine domain

Progress To Date/Future Plans

Our project team and partners are spending our first year of this planning grant building and strengthening existing relationships between Indigenous and non-Indigenous university scientists, Indigenous Tribes and organizations, international collaborators, and communities in the Beaufort Sea regions of the U.S. and Canadian Arctic (visit to Inuvik and the Inuvialuit Game Council in December 2019). In collaboration with sovereign Tribal governments, we are planning a workshop and learning event, likely to be hosted in Utqiaġvik in winter 2021. This workshop will center on indigenizing and decolonizing approaches in Arctic sciences and practices, and considering how to best collaboratively develop an NNA Track 1 research proposal.

Highlights or Expected Outcomes

This approach sets the stage for building responsible and intentional relationships utilizing both Indigenous and western knowledge and science, co-conceiving how to most appropriately address the Arctic's most pressing questions and needs, and thus providing a roadmap towards the implementation of future research. This framework is intended to serve as a blueprint for developing other Arctic research activities that not only improve science, but work to advance Indigenous self-determination and wellness. Our early dialogues have revealed many tensions in this work that must be addressed, e.g., "*The word "co-production" is squirrelly. It feels like knowledge extraction.* ***The goal should be "plan not to plan" until you have the Native community in the room."*** We need to change the paradigm on how science happens. There are many examples of scientists taking ownership and design over Native knowledge. Addressing and healing historical and current racial traumas should be central in this work.

NNA Community Collaboration & Advice for Overcoming NNA Project Challenges

The premise of this program has been the topic of considerable discussion among our team. Team members have shared concern and frustration about the framing of the work as *Navigating the New Arctic*. From Indigenous experiences, it feels more like "*the Iñupiat of the Arctic experience the gold rush*." We need to reframe the relationship where the place of power is from the communities. We need to right the relationship. What would it look like to indigenize this? Indigenous solutions should be dictated by the Tribe and community. Indigenous team members see the potential transformation of this kind work, e.g., *"our young people don't have to be subjected to attacks on their psyche."* The discussion of abstract academic or scientific debates: "should villages continue?" or "debate whaling" are so offensive. We see a key need for Indigenous-led community liaison office for the NNA community. What will the Tribes require of scientists engaged in this initiative?

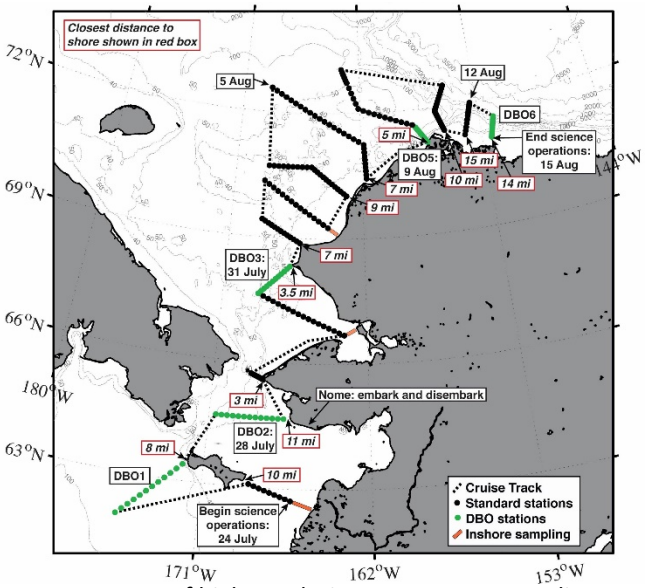
Origin and Fate of Harmful Algal Blooms in the Warming Chukchi Sea

Key Project Contacts: Donald Anderson, Robert Pickart, Woods Hole Oceanographic Institution, danderson@whoi.edu; rpickart@whoi.edu

Project Website URLs & Social Media Accounts:

https://www2.whoi.edu/site/andersonlab/current-projects/arctic-habs/

Project Objectives: Our project is a joint physical-biological field program to study the relationship between harmful algal bloom (HAB) species distribution/dynamics and the physical environment of the Chukchi Sea region. The overall goal is to determine how extensive HAB cell distributions are across the shelf, what their origins and dynamics are, and how long they have been in the region. The hypothesis is that HABs in Alaskan Arctic waters are not only advected from the south through Bering Strait but are now originating locally on the Chukchi shelf due to warming temperatures, circulation features, and water mass structure that influence bloom magnitude, duration, toxicity, and recurrence. In July-August 2020 we will conduct a 25-day cruise on the USCGC *Healy*, sampling from the northern Bering Sea to the western Beaufort Sea (see the Figure). This will be the first-ever field program undertaken in the Pacific Arctic dedicated to the study of HABs. For broader impacts, the cruise will include an outreach component with a writer, photographer, and teacher-at-sea, as well as multiple visits to indigenous communities to communicate project results.



Keywords: Harmful algal blooms; Cyst seedbeds; Circulation; Water masses; Alexandrium; Pseudo-nitzschia; saxitoxin; domoic acid; paralytic shellfish poisoning; PSP; amnesic shellfish poisoning; ASP

Progress to Date/Future Plans: The cruise will embark/disembark from Nome, AK. The tentative plan is to occupy a set of high-resolution transects proceeding south to north (see the Figure). This includes occupation of four Distributed Biological Observatory (DBO) lines. We will collect physical, chemical, and biological measurements of the water column using a CTD package, net tows, and underway systems. Benthic sampling will be done with van Veen grabs, box cores, and gravity cores. We will do adaptive sampling if/when HAB blooms are encountered, and using *Healy's* small boat we will extend several of the transects close to shore.

Highlights or Expected Outcomes: We expect to (1) document the prevalence of HAB species throughout the study region; (2) characterize the connectivity and fate of *A. catenella* and *Pseudo-nitzschia* populations using toxin profiling and molecular markers; (3) determine cyst deposition histories in sediments using radionuclide tracers; and (4) develop a conceptual model of the origin, transport, and fate of HABs in the Chukchi Sea region, emphasizing linkages to the flow pathways and characteristics of the different water masses.

NNA Community Collaboration and Research Coordination: We are accommodating numerous ancillary projects on the cruise, including: a study of mezoplankton and larval fish; a multi-tracer biogeochemical component; ocean acidification; nitrogen dynamics; sea bird and marine mammal observers; a study of atmospheric ice-nucleating particles; and deployments of floats and drifters. We will have an indigenous observer on the cruise who will interface between the science party and coastal communities along our sampling route. We also hope to benefit from cruises in the region conducted by other NAA projects. This would allow us to get water column and sediment samples that would complement the ones to be collected during our project. Note that we have only a single cruise scheduled for our project, but would benefit greatly from data from ships of opportunity in other years to sustain this important database of HAB species distribution and abundance.

Advice for Overcoming NNA Project Challenges: We suggest identifying platform/timing requirements early in the process.

Permafrost Discovery Gateway

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Project Website Urls & Social Media Accounts:
permafrost.arcticdata.io
Permafrost Discovery Gateway on Facebook

Project Objectives: We aim to empower the broader Arctic community with an online platform, the Permafrost Discovery Gateway (PDG) that will make big imagery permafrost products accessible and discoverable to enable knowledge-generation by researchers and also the public. This will include 1) developing and optimizing automated remote sensing workflows that includes machine and deep learning techniques, 2) producing big imagery products of permafrost across the Arctic, and 3) enabling discovery and knowledge-generation through visualization and analysis tools designed with input from users of the PDG. We are building upon existing remote sensing, visualization (Fluid Earth Viewer, for example), and cyberinfrastructure tools (Clowder and the Arctic Data Center) and are tapping into the Local Environmental Observers Network, which is an established virtual environment for co-production of knowledge. Training of the future workforce will include the participation of graduate students, and postdocs, while the K-12 education community will receive online teaching resources.

Keywords: Science gateway, big data, cyberinfrastructure, visualization, discovery

Progress To Date/Future Plans: The effort has centered on communication within the core-team, familiarizing team members with project components spanning modelling, visualization, machine learning, cyberinfrastructure and, from there, establishing a more detailed path of action/overall architecture to be implemented. The effort has thus far identified opportunities for workflow optimization in the big imagery remote sensing analyses and the project recently successfully gained access to a Leadership Resource Allocation at Texas Advanced Computing Center. We also listed existing geospatial data to ingest into the PDG and identified visualization tools to either bring in or to build upon.

Highlights or Expected Outcomes: The expected outcome will be a tool, accessible via a regular web browser that will enable science and informed decisions by making big imagery products discoverable, accessible and actionable.

NNA Community Collaboration and Research Coordination: The PDG can offer the NNA community a platform to access and explore big data from satellite imagery, while the NNA community can help make the PDG more effective by providing feedback on its content and design.

Advice for Overcoming NNA Project Challenges: PDG is a large and diverse team (~20 people, eight institutions) and as such bridging different expertise is key. We implemented bi-weekly Zoom meetings that center upon the technical, visualization, or outreach aspects of the project instead of having one large team meeting, aiming to identify the common architecture and team consensus for each aspect. As plans mature best practices with regards to development/deployment will additionally be employed across the team.