The performance element reporting logs described here represent actions taken for all IARPC Collaboration Teams during FY 2017, presented in order of appearance in Arctic Research Plan 2017-2021

**IARPC Collaboration Teams**

- Health & Well-being Collaboration Team
- Sea Ice Collaboration Team
- Permafrost Collaboration Team
- Glaciers & Sea Level Collaboration Team
- Environmental Intelligence Collaboration Team (includes Arctic Observing, Data and Modeling Sub-teams)
- Atmosphere Collaboration Team
- Marine Ecosystems Collaboration Team
- Terrestrial Ecosystems Collaboration Team
- Coastal Resilience Collaboration Team

These Federal agencies comprise IARPC: Department of Commerce (DOC), Department of Defense (DOD), Department of Energy (DOE), Department of Health and Human Services (HHS), Department of Homeland Security (DHS), Department of Interior (DOI), Department of State (DOS), Department of Transportation (DOT), Environmental Protection Agency (EPA), Marine Mammal Commission (MMC), National Aeronautics and Space Administration (NASA), National Science Foundation (NSF, Chair), Office of Management and Budget (OMB), Office of Science and Technology Policy (OSTP), Smithsonian Institution (SI), and United States Department of Agriculture (USDA). Other agencies also contribute to implementation of the Arctic Research Plan.
1.1 Health & Well-being

1.1 Support integrative approaches to human health that recognize the connections among people, wildlife, the environment, and climate.

- **1.1.1 (In progress)** In collaboration with the Alaska Native Tribal Health Consortium (ANTHC), advance and support a regional One Health approach for assessing interactions at the Arctic human-animal-environment interface to enhance understanding of, and response to, the complexities of climate change for Arctic residents; DOI-FWS (Lead), EPA (Lead), HHS-CDC (Lead), NOAA (Lead), USDA-NIFA (Lead), DOI-USGS, DOS, NASA
  
  o Alaska Native Tribal Health Consortium (ANTHC) continues to hold quarterly One Health Group meetings at the CDC Arctic Investigations Program Office in Anchorage, Alaska. The next meeting is scheduled for mid-December 2017. EPA along with other sponsors support sessions and speakers at the annual Alaska Forum on the Environment (AFE), held each February in Anchorage, Alaska, where topics like One Health receive a broader community engagement by environmental professionals, educators, Alaskan youth, community leaders and elders. February 12-16, 2018, marks the twentieth anniversary of AFE. (Oct 6, 2017 - Completed)
  
  o Ongoing collaborations are fostered through the quarterly Alaska One Health Workgroup, which is both an in-person and webinar-based meeting for information sharing and cross-sectoral interaction. A One Health Table Top exercise was held in Anchorage in February, 2017. As part of the One Health activities under the US Chairmanship of the Arctic Council, this 3-day meeting trained participants in the OH Smart tool created by USDA and the University of Minnesota as means to facilitate interdisciplinary discussions and problem-solving about public threats arising at the interface of animal, human and environmental health. Participants from 4 Arctic Nations (US, Canada, Greenland, Finland) then applied the tool to scenarios of a marine mammal die-off and an extensive wildfire affecting subsistence food sources. US participants included state, federal, tribal, university and local representatives engaged in scientific and response activities related to OH. (Sep 28, 2017 - Completed)
  
  o ABoVE research supported this Performance Element in the following ways: a. Numerous ABoVE projects have assessed how changing wildlife habitat are
impacting key wildlife species in the IARPC domain, including caribou habitats in northeastern Alaska, Alaska’s North Slope, and the NWT, nesting habitats in the Yukon-Kuskokwim Delta, and Dall Sheep habitat across its entire range. All this research involves direct interactions with local and regional native organizations, including development and carrying out of research activities and consultation regarding information needs. b. Research is being conducted on how changes to ecosystem and environmental conditions caused by wildfires are impacting access to ecosystem services in Interior Alaska. This research involves collaborations with subsistence harvesters. c. One issue identified by the HWB Collaboration Team is to improve the ability to predict the probability of smoke events from wildland fires. ABoVE researchers are supporting a cross-cutting activity (between the Atmospheric, TE, and HWB CTs) to improve information on wildland fire smoke. ABoVE research on improving wildland fire emissions is discussed in PE 7.3.2. d. The ABoVE Science Team is carrying out a synthesis activity focused on a major scientific data and analysis gap that is specific to Arctic and Boreal regions - the role of snow and snow datasets to enable understanding of wildlife movement & human accessibility to ecosystem services. e. The ABoVE Science Team has initiated a synthesis activity focused on both the response of wildlife and the availability of ecosystem services to productivity changes (i.e. greening and browning trends) in Arctic and Boreal regions. (Sep 15, 2017 - Completed)

1.1.2 (In progress) In collaboration with the ANTHC, support community-based monitoring and IK and LK by maintaining and strengthening the Local Environmental Observer (LEO) Network to help describe connections between climate change, environmental impacts, and health effects.; DOI-BOEM (Lead), DOI-FWS (Lead), EPA (Lead), NOAA, NSF

- Test action (Nov 3, 2017 - Completed)
- BOEM has entered into a multiyear cooperative agreement, Community Based Monitoring: LEO Network with ANTHC. PI is Dr. Michael Brubaker. (Oct 9, 2017 - Completed)
- There is continued steady growth recorded in the LEO Network (https://leonetwork.org/en/reports), and new feature development is on-going. The system is now beginning to gather environmental data and imagery for enhancing community-based observational data, e.g., capture of webcam imagery. Also, there's new community pages that provide summaries. (Oct 9, 2017 - Completed)
- The LEO network continues to grow and attract domestic and international collaborators. The network continues to collect local observations and to link communities with subject matter experts and resources to assess health threats and response options. An IARPC sponsored webinar focused on wildfires highlighted opportunities for researchers and LEO network observers to share information about wildfire events, both active fire areas and downwind smoke hazards. LEO data could support modeling efforts through verification of prediction models and modelers could assist communities with short and long-term preparation and hazard reduction activities. Further discussions within the IARPC framework are
anticipated for 2018. For more information about LEO, go to www.leonetwork.org (Sep 28, 2017 - Completed)

- The September joint meeting on the health impacts of wildfires in the Arctic by the Health & Well-being CT, Atmosphere CT, and Terrestrial Ecosystems CT (https://www.iarpccollaborations.org/members/events/9144) began a cross-team conversation on places for potential interdisciplinary/interagency collaborations. Follow-up actions will be reported as they occur. (Sep 25, 2017 - Completed)

- A BOEM funded study having to do with well-being and social indicators was recently published: Social Indicators in Coastal Alaska: Arctic Communities, prepared by Stephen R. Braund & Associates, OCS Study BOEM 2017-035. The study assesses impacts by community, in addition to social indicators (a) by community (2016); (b) for the North Slope Inupiat over time (1977, 1988, 2003, and 2016); (c) by gender, and (d) for Arctic Indigenous peoples across regions and countries (2003 and 2016). It can be downloaded at this link: https://www.boem.gov/BOEM-2017-035/ (Sep 25, 2017 - Completed)

- In 2016, the DOI Bureau of Ocean Energy Management (BOEM) entered into a cooperative agreement with ANTHC to support community-based monitoring by maintaining and strengthening LEO, and provide more engagement among residents in the North Slope and Kenai Peninsula Boroughs. This multi-year study seeks to refine and expand the existing program to better connect existing efforts, achieve improvements, and provide continuity for this valuable program. Other objectives include enhancing our understanding of environmental change, enhance resources available at the community, regional and federal level to address effects by expanding the scale of the community-based monitoring program and enhancing the rigor, quality, and consistency of data collection by leveraging scientific expertise outside the communities from the greater region and the nation, further refine a joint monitoring effort to promote healthy and effective adaptation strategies to identified environmental changes through a regionally appropriate outreach and education effort, and perform analysis and interpretation of recorded observations with improved scientific rigor and develop lessons learned. (Sep 20, 2017 - Completed)

1.1.3 (No progress) In coordination with the ANTHC, use the Alaska Native Maternal Organics Monitoring Study (MOM) to monitor the spatial distribution, contaminant levels, and biological effects in species having body burdens of human caused Persistent Organic Pollutants (POPs) at or above levels of concern; and improve understanding of the adverse effects of POPs on human populations, especially on child development.; EPA (Lead), HHS-CDC (Lead), NOAA

1.1.4 (In progress) Increase understanding of how both natural climate change and the effects of human activities are affecting the ecosystem by documenting observations of changing sea ice conditions, with implications for development and subsistence. Efforts like Arctic Crashes: Humans, Animals in a Rapidly-Changing World and Northern Alaska Sea Ice Project Jukebox are examples of contributions to this performance element.; DOI-
BOEM (Lead), NOAA (Lead), NSF (Lead), SI (Lead), USDA-NIFA (Lead), DOI-NPS

- BOEM has entered into a cooperative agreement, Northern Alaska Jukebox - Phase III with the Coastal Marine Institute, University of Alaska, Fairbanks. PI is Leslie McCartney, Elmer E. Rasmuson Library. (Sep 21, 2017 - Completed)

- "Narwhal: Revealing an Arctic Legend" exhibition is in production and will open 3 August. See news release at https://naturalhistory.si.edu/exhibits/narwhal. A book by the same title authored by W. Fitzhugh and F M. Nweeia has been completed and is being printed. Arctic Crashes: The introduction and 90% of the manuscripts for the Arctic Crashes volume are in and being edited by Igor Krupnik and Aron Crowell. Burch Lecture: The annual Burch lecture was held on April 27, 2017 with presentations by Hannah Voorhees and Rhonda Sparks. Description available by googling Smithsonian events calendar Burch lecture. (May 17, 2017 - Completed)

- **1.1.5 (In progress)** Support the Rural Alaska Monitoring Program (RAMP), a community-based environmental monitoring network in Alaska Native communities to collect samples and data on zoonotic pathogens, mercury, and organic contaminants in land and sea mammals used for subsistence.; DOI-FWS (Lead), EPA (Lead), HHS-CDC (Lead), NOAA (Lead)
  - EPA grantee (ANTHC) is in third year of research activity (grant ends in 2018), and has made presentations at the International Conference on Arctic Science (Reston, VA, April 2017) and the Arctic Council annual meeting of the International Circumpolar Surveillance Workgroup (Copenhagen, Denmark, September 2017). They have completed development of a field methodology to test zoonotic pathogen antibodies on filter paper blood specimens of subsistence-killed land and sea mammals. These specimens are used to analyze zoonotic exposure, blood Mercury and Selenium, and stable isotopes of Carbon and Nitrogen. Other sampling utilizes stomach and intestinal contents of sea mammals for the harmful algal toxins, saxitoxin, which is associated with paralytic shellfish poisoning, and domoic acid, which is associated with amnesic shellfish poisoning. The gathered data is used by communities to develop adaptation strategies that enable them to continue to utilize traditional food species and reduce risk, while maintaining the cultural and population health benefits of the northern marine traditional diet, and the economic advantages of local foods in remote villages. (Oct 9, 2017 - Completed)

1.2 Promote research, sustainable development, and community resilience to address health disparities associated with underlying social determinants of health and well-being.

- **1.2.1 (In progress)** In collaboration with the ANTHC and the State of Alaska, support development of Arctic Water, Sanitation and Hygiene (WASH) innovations and characterize the health consequences associated with decreased access to in-home water and sanitation services.; EPA (Lead), HHS-CDC (Lead), HHS-IHS (Lead), USARC (Lead), USDA (Lead), DOS
The 6th Rural Alaska Water and Sanitation workshop was held in January 2017 and focused on understanding environmental change and the threats posed to water/sanitation systems and to human health via degradation of those services. For more information go to: https://www.arctic.gov/water-san/index.html. The Denali Commission is funding a research activity to catalog permafrost thaw and its impact on water/sanitation services in rural Alaska, with work commencing in 2017. (Sep 28, 2017 - Completed)

1.2.2 (In progress) Together with the ANTHC, the Commission for Environmental Cooperation, the Yukon Kuskokwim Health Corporation, and Bristol Bay Health Corporation, support research on the health impacts of poor indoor air quality, especially in children. Support source testing and technologies to improve indoor air quality.; EPA (Lead), HHS-CDC (Lead), HHS-IHS (Lead), HUD (Lead)

- Alaska Native Tribal Health Consortium (ANTHC) and partners completed their healthy homes research study involving home assessments, patient education, and minor home modifications for children with severe or chronic lung disease in rural Alaska. They are in the process of publishing the study results. The baseline data were published earlier this year in the journal Indoor Air; the data indicated that high indoor air pollutant levels were associated with respiratory symptoms in household children, likely related to overcrowding, poor ventilation, wood stove use, and tobacco smoke. http://onlinelibrary.wiley.com/doi/10.1111/ina.12315/abstract (Oct 6, 2017 - Completed)

- The research study evaluating whether improving indoor air quality can reduce exacerbations of respiratory conditions in rural Alaska children has been completed. Following home ventilation enhancements, improvements were seen in cough, wheezing, and decreases in clinic visits for respiratory conditions. ANTHC has begun to implement a referral system for health care providers to request a home assessment and, if needed, home improvements for at-risk children. (Sep 28, 2017 - Completed)

- Indoor air quality in poor Alaskan homes has exacerbated respiratory problems, especially in children. ANTHC started programmatic system for children repeatedly hospitalized for respiratory problems can improve homes indoor air quality through housing authority consultation (EPA, CDC, HUD) (Jun 24, 2017 - Target)

1.2.3 (In progress) Support educating and connecting Arctic residents with museum collections and archival materials to improve community mental health and well-being through efforts such as The Health of Heritage.; ED (Lead), LC (Lead), NOAA (Lead), SI (Lead), DOI-NPS, NSF

- In August 2017, the Smithsonian National Museum of Natural History opened “Narwhal: Revealing an Arctic Legend”. This exhibit contributes to health and heritage by revealing the close relationship of the Inuit with this charismatic animal, especially in Arctic Canada and Greenland, but also in Alaska, where
these animals are occasionally seen and hunted. The exhibition is open until mid-2019. Arctic Studies Center staff have also produced a fine book (with the same title, available in December 2017) documenting the topic. Themes of the exhibit and book include the biology and ecology of the Narwhal, new findings on the function of its mysterious tusk, the Narwhal through history and Inuit mythology, the Inuit and their close association with the narwhal, and the effects of present and future climate change. The Smithsonian developed the exhibit and book in partnership with Canadian Inuit (especially Pond Inlet), anthropologists, biologists, paleontologists, and historians. For more information, please see https://naturalhistory.si.edu/exhibits/narwhal/ (Oct 2, 2017 - Completed)

- **1.2.4 (In progress) Synthesize knowledge on sustainable development among Arctic communities; develop a state-of-the-art understanding of social-ecological systems in the Arctic context; and amass case studies of best practices that support well-being and sustainable development across the Arctic. ; NSF (Lead)**
  
  o Arctic FROST and ASUS aim to develop knowledge synthesis on sustainable development and will be publishing a synthesis book. There will be a workshop in Santa Fe and meeting at ICASS. By December the synthesis book will be submitted for publishing. Each chapter has a team of specialists writing a synthesis. Workshop in Greenland focusing on community sustainability. (Dec 2, 2017 - Target)

  o The Arctic Youth and Sustainable Futures project follows up on a key recommendation presented in AHDR (2014) to address gaps in knowledge on understanding youth and their aspirations, and the issues and challenges they face in a time of global change. Core participation: 25 Arctic scholars from a range of disciplines & from 22 institutions in 10 countries. Funding provided by the Nordic Council of Ministers’ Arctic Cooperation Programme (2016-2018). Project international co-leads: Joan Hyman Larsen (Icenald) and Diane Hirshberg (USA). Andrey N Petrov is a U.S. co-lead. The project's premise is that the future of the Arctic will be determined to a great extent by today’s youth, as they make choices around the opportunities and challenges they face, their priorities in terms of culture and identities, where to study and where to live, what occupations and lifestyles to pursue, and factors affecting their social and physical. Objectives:  
    •To investigate and conduct research on the needs, opportunities, aspirations and perspectives of Arctic youth ages 18-26,  
    •To fill identified gaps in knowledge on the lives, ambitions, challenges and wellbeing of youth – indigenous and non-indigenous – across the circumpolar Arctic.  
    •To advance our understanding of sustainable options for Arctic communities and localities, urban and rural.  
  The Arctic Youth project seeks to: (1) research the literature and existing knowledge; (2) conduct focus groups, in-depth individual interviews; (3) develop a set of social indicators and future scenarios based on perspectives of Arctic Youth; (4) deliver an edited volume presenting the results of discussions with youth, data statistics and literature synthesis, and in-depth analysis and discussion of the most pressing issues and knowledge gaps concerning Arctic youth and sustainable futures. environment, such as the impacts and responses to climate change and
economic and cultural globalization. To date multiple focus groups with young Arctic residents (18-26 years old) were held in 2017 Nuuk, Greenland (2), Akureyri, Iceland (1), Umea, Sweden (1), Bodo, Norway (1), Whitehotse and Inuvik, Canada (2), Juneau, Alaska (1) and an on-line focus group with Indigenous youth from Russia (Murmansk, Khanty-Masni and Chukotka) (1). (Oct 31, 2017 - Completed)

- Arctic Youth and Sustainable Futures, funded by Nordic ministers but developing a US component, and looks at young people of the Arctic and their aspirations of the future (Jun 24, 2017 - Target)

1.3 Promote food, water, and energy security in rural/remote Arctic regions.

- 1.3.1 (In progress) In collaboration with the State of Alaska, coordinate investigations and reporting on food security in the Arctic, to include shifting patterns of food consumption, the safety of subsistence foods, and successful adaptation strategies being employed by northern residents.; DOI-BOEM (Lead), NOAA, NSF


- 1.3.2 (In progress) In collaboration with the Alaska Department of Environmental Conservation (ADEC) and the Alaska Rural Water and Sanitation Working Group, support the ADEC “Alaska Water and Sewer Challenge” and provide input and support for the Conference on Water Innovations for Healthy Arctic Homes (WIHAH) and its resultant research activities and recommendations.; EPA (Lead), HHS-CDC (Lead), HHS-IHS (Lead), USARC (Lead), USDA (Lead), DOS

  - The State of Alaska Water and Sewer Challenge entered Phase 3 in 2017 and has funded three teams to develop and test decentralized options for home water/sewer services and these projects will be moving into the field testing phase in 2018. For more information: http://watersewerchallenge.alaska.gov/. The WIHAH meeting proceedings and summary of suggested future directions has been posted and can be accessed here: http://wihah2016.com/. A thematic network has been created under the University of the Arctic to carry on the collaborations from WIHAH conference. Participating universities from the US, Canada, Greenland, Denmark, Russia, Norway will work on cross-disciplinary exchange of information, collaborative research and education projects. For more go to: http://www.uarctic.org/organization/thematic-networks/arctic-wash/ (Sep 28, 2017 - Completed)

- 1.3.3 (No progress) Together with the Alaska Energy Authority (AEA), the Cold Climate Housing Research Center (CCHRC), and UAF, promote
research on renewable, efficient, and sustainable (resource, maintenance, and cost) energy systems, including microgrid technology development and application in remote Arctic communities via USARC’s Arctic Renewable Energy Working Group activities.; USARC (Lead)

1.4 Document the prevalence and nature of violence against Alaska Native women and youth; evaluate the effectiveness of Federal, State, tribal, and local responses to violence against Alaska Native women and youth; and propose recommendations to improve the effectiveness of such responses.

- 1.4.1 (In progress) Conduct a National Baseline Study (NBS) to assess Alaska Native women’s experiences with violence and victimization, health and wellness, community crime, service needs, and help-seeking behaviors and outcomes. ; DOJ-NIJ (Lead), DOJ-OVW (Lead)
  - National baseline study ongoing and will be completed at the end of the year. DOJ (NIJ) (Dec 2, 2017 - Target)
  - Awards from I-LEAD issued, including one for Alaska, and ties into work NIH is doing around suicide prevention. (Apr 22, 2017 - Completed)

- 1.4.2 (No progress) Examine the contributions Village Public Safety Officers (VPSO) make to their rural communities and the criminal justice responses to violence committed against Alaska Native women. Evaluate and document the impact that the Alaska VPSO initiative is having on the investigation and prosecution of those who commit acts of sexual and domestic violence against Alaska Native women in rural communities.; DOJ-NIJ (Lead), DOJ-OVW (Lead), NSF

- 1.4.3 (No progress) Together with the AIDA, determine effective methods to assess exposure to violence and victimization among Alaska Native youth, ultimately to improve their health and well-being. Develop and test a survey instrument and different administration modes that can effectively evaluate exposure to violence and victimization and determine the feasibility of using these procedures in tribal communities.; DOJ-NIJ (Lead), DOJ-OJJDP (Lead), DOJ-OVC (Lead)

1.5 Increase understanding of mental health, substance abuse, and well-being for Alaskan youth; and support programs that address those impacts and strengthen youth resilience.

- 1.5.1 (In progress) Increase knowledge and the evidence base for effective community-determined approaches that contribute to the health and well-being of children and youth as they move into adulthood. Efforts like Native Youth Initiative for Leadership, Empowerment, and Development (I-LEAD) and Generation Indigenous are examples of contributions to this performance element.; DOI-BIA (Lead), ED (Lead), HHS-ACF (Lead), USDA-NIFA (Lead)
Roberto provided an overview of RISING SUN, an Arctic Council initiative that ended in May 2017, during the June 20th HWCT meeting. Roberto’s PowerPoint presentation is available at http://www.iarpccollaborations.org/members/documents/9464. The video of his presentation is posted at: http://www.iarpccollaborations.org/members/events/9141. (Jun 26, 2017 - Completed)

Angela Mark's presentation on SAMHSA mental health and suicide prevention programs with Alaska Natives at the June 20th HWCT meeting relates to this Performance Element. See Angela’s presentation at http://www.iarpccollaborations.org/members/documents/9435. The video of his presentation is posted at: http://www.iarpccollaborations.org/members/events/9141. (Jun 26, 2017 - Completed)

As part of the Native Youth Initiative for Leadership, Empowerment, and Development (I-LEAD), the Administration for Native Americans, an Office of the Administration for Children and Families (ACF) awarded the Alaska Native Heritage Center a grant to develop and implement an inter-generational cultural identity project that reconnects Alaska Native Youth to their indigenous traditions and fosters the growth of a "survival kit" of knowledge based on their ancestral ways of living. The project period is until September 2021. See https://www.acf.hhs.gov/ana/resource/active-i-lead (Jun 20, 2017 - Completed)

1.5.2 (In progress) Support tribal behavioral health programs and collaborative research hubs to prevent and reduce suicidal behavior and substance abuse and to reduce the burden of suicide and promote resilience among Alaska Native youth.; HHS-CDC (Lead), HHS-NIH (Lead), HHS-NIMH (Lead), HHS-NIMHD (Lead), USARC (Lead), DOS, NSF

Andrea Horvath Marques' presentation on NIMH/NIMHD collaborative research hubs to reduce the burden of suicide among American Indian and Alaska Native youth at the June 20th HWCT meeting relates to this Performance Element. For more information on these programs see Andrea’s presentation available at http://www.iarpccollaborations.org/members/documents/9476. The video of his presentation is posted at: http://www.iarpccollaborations.org/members/events/9141. (Jun 26, 2017 - Completed)

NIMH issued Notice of Award on 31 May 2017 to the University of Alaska, Fairbanks for Alaska Native Collaborative Hub for Resilience Research (ANCHRR). (Jun 9, 2017 - Completed)

1.5.3 (No progress) Conduct surveys to document and report on adverse childhood experiences (ACEs) in Alaska children, including among American Indian and Alaska Native children.; Census (Lead), HHS-CDC (Lead), HHS-HRSA (Lead)
1.6 Support the reduction of occupational safety and health (OSH) hazards in the Arctic, particularly in the commercial fishing, water, and air transportation industries as well as for those workers exposed to occupational hazards from climate change impacts.

- **1.6.1 (In progress)** Together with the State of Alaska, document and describe occupational risks using epidemiologic surveillance.; DHS-USCG (Lead), DOL-OSHA (Lead), FAA (Lead), HHS-CDC (Lead), NTSB (Lead)
  
  o Conduct surveillance of occupational fatalities in collaboration with the State Department of Public Health. Expanded to non-fatal data, through partnership with State Department of Labor. Study completed on injuries among loggers. (Apr 22, 2017 - Completed)

- **1.6.2 (In progress)** Together with the State of Alaska, conduct prevention-oriented research addressing fatal and nonfatal injuries and illnesses in high-risk worker populations.; DHS-USCG (Lead), DOL-OSHA (Lead), FAA (Lead), HHS-CDC (Lead), NTSB (Lead)
  
  o Computer-based training program on fatigue prevention for Alaska commercial pilots. Three studies in analysis stage investigating non-fatal injuries to workers in seafood processing, aviation, and commercial fishing that will identify hazards and propose interventions. Completed portion: The fatigue prevention training program for Alaska pilots (Feb 1, 2018 - Target)


1.7 Improve the quality, efficiency, effectiveness, and value of health care delivery in the Arctic.

- **1.7.1 (No progress)** In collaboration with the ANTHC, promote research on how telemedicine applications can improve health care delivery and patient outcomes.; HHS-AHRQ (Lead)

**Agencies**

DOC, DOI, DOS, EPA, HHS, NASA, NSF, OSTP, SI, USARC
Atmosphere Collaboration Team

Performance Element Reporting Log 2017

(Some links in this summary require an account on IARPC Collaborations Website. Please visit www.iarpccollaborations.org to request an account.)

2.1 Atmosphere

2.1 Advance understanding of Arctic atmospheric processes and their integrated impact on the surface energy budget.

- **2.1.1 (In progress)** Support planning, preparation, and implementation for the Multi-disciplinary drifting Observatory for the Study of the Arctic Climate (MOSAiC), including deployment of the DOE Atmospheric Radiation Measurement (ARM) mobile atmospheric measurement facility and other coupled measurements on the drifting German icebreaker, RV Polarstern.; DOE (Lead), NSF (Lead), DOD-ONR, NOAA
  - Funding from several US agencies supported development of the following document: MOSAiC Consortium, 2016: Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) Implementation Plan, Version 1. International Arctic Science Committee, pp. 81. (Oct 30, 2017 - Completed)
  - IASC supported M. Ovchinikov to present at the MOSAiC workshop in Prague. His presentation was titled: Ovchinnikov, M.: "Arctic cloud process modeling: Goals, insights, challenges, and opportunities", The Artic Science Summit Week 2017, MOSAiC workshop, Prague, 4-5 April 2017. (Oct 30, 2017 - Completed)
  - NSF funding support of MOSAiC-related projects. These projects can be reviewed at the links below.
  - There was a 2-day MOSAiC workshop from April 4th to April 5th 2017 during the ASSW in Prague. The Agenda for this meeting can be viewed here: [http://www.assw2017.eu/mosaic-workshop.htm](http://www.assw2017.eu/mosaic-workshop.htm). (Aug 21, 2017 - Completed)
  - The presentation by Matthew Shupe at the June Atmosphere Collaboration meeting is relevant to this Performance Element [http://www.iarpccollaborations.org/members/documents/9447](http://www.iarpccollaborations.org/members/documents/9447). (Jul 24, 2017 - Completed)
2.1.2 (In progress) Improve uniformity and accessibility of surface radiative and heat flux information from satellite retrievals and airborne and ground-based measurements to quantify spatial variability of the surface energy budget over land, ice, and open ocean environments in the Arctic. Augment efforts through IARPC Collaborations to integrate surface radiative and heat flux measurements with cryospheric process understanding and modeling efforts.; NOAA (Lead), DOE, NASA, NSF


- Presentation by Tristan L'Ecuyer titled "Contrasting Satellite and Model Perspectives on the Role of Clouds in Arctic Surface Energy Balance" relates to this performance element: http://www.iarpccollaborations.org/members/events/7691 (May 31, 2017 - Completed)

2.2 Improve understanding of the composition of the Arctic atmosphere – moisture, clouds, precipitation, aerosols, and gases—their net radiative effects and impact on Arctic climate.
• 2.2.1 (In progress) Maintain and enhance support for fixed ground sites that contribute to long-term observations of Arctic atmospheric components using in situ and remote sensing measurements of atmospheric state parameters, gases, aerosols, and clouds. Improve uniformity in the suite of measurements and data products across sites to provide “network” information for increased physical understanding and representation of the Arctic climate system.; DOE (Lead), NOAA (Lead), NASA, NSF


- Continued US DOE support for operation of ARM facilities at Barrow and Oliktok Point. (Sep 28, 2017 - Completed)

2.2.2 (In progress) Continue support for and planning and analysis of past and potential future aircraft missions (e.g., NASA Atmospheric Tomography Mission—ATom—and air Pollution in the Arctic: Climate, Environment, and Societies—PACES24) that contribute observations of atmospheric composition and relevant processes such as transport, deposition, and radiation.; DOE (Lead), NOAA (Lead), NASA, NSF

- Current models have difficulty predicting the radiative effect of clouds, and aerosol effects contribute some of the largest uncertainties in radiative forcing. In August 2017, Lauren Zamora gave an overview of research she is doing with Ralph Kahn at NASA Goddard Space Flight Center, funded by NASA that aims to reduce this uncertainty. This research includes: Combining data from four different past aircraft campaigns in the Arctic to better quantify the in situ response of Arctic/subarctic liquid clouds to smoke aerosols, and developing research experiments for future field campaigns to better quantify aerosol transport to the Arctic. (Oct 25, 2017 - Completed)

- Data from NASA's first round of Atmospheric Tomography (ATom) flights in July - August 2016 are now available at: [https://espo.nasa.gov/home/atom/archive/browse/atom](https://espo.nasa.gov/home/atom/archive/browse/atom). ATom-2 data from flights in January - February 2017 will be released in a few months. ATom-3 flights are scheduled for fall 2017. (Sep 7, 2017 - Completed)

2.2.3 (In progress) Improve vertical and regional characterization of atmospheric gases, aerosol, and cloud properties through the use of existing, long-term data sets, together with new measurements, in underrepresented Arctic regions. Develop a better understanding of the representative nature of fixed sites by describing the range of conditions that exist across the Arctic.; NOAA (Lead), DOE, NASA, NSF


The NSF supported deployment of a micro-rain radar and snowflake particle imagers (Precipitation Imaging Package and Multi Angle Snow Camera) to high latitude research sites at Haukelister, Norway (winter 2016-17) and Kiruna, Sweden (winter 2017-18). (Oct 30, 2017 - Completed)

Current models have difficulty predicting the radiative effect of clouds, and aerosol effects contribute some of the largest uncertainties in radiative forcing. In August 2017, Lauren Zamora gave an overview of research she is doing with Ralph Kahn at NASA Goddard Space Flight Center, funded by NASA that aims to reduce this uncertainty. This research includes: Providing valuable context for future aircraft campaigns by using remote sensing data to discern the relative importance of aerosols vs. meteorological dynamics at different heights over the under-sampled Arctic Ocean. (Oct 25, 2017 - Completed)

The US DOE Atmospheric System Research program supported the Oliktok Point Site Science team, which assembled the following relevant publications: J. Creamean, M. Maahn, G. de Boer, A. McComiskey, A.J. Sedlacek, Y. Feng, 2017: The influence of local petroleum exploration, regional wildfires, and long range transport on summer 2015 aerosol over the North Slope of Alaska, Atmos. Chem. Phys. Discuss., doi: 10.5194/acp-17-594. Maahn, M., G. de Boer, J.M. Creamean, G. Feingold, G.M. McFarquhar, W. Wu and F. Mei, 2017: The

- ABoVE research supported this PE in the following ways.  a. NASA supported the year-round operation of the UCSD flux tower at Atqasuk, and Barrow, Alaska in order to provide continuing measurement of methane and CO2, as well as environmental conditions such as soil temperature and moisture.  b. During May through September 2017, NASA supported monthly data collections of key greenhouse gases by an airborne sensor which flew transect across Alaska and northwestern Canada.  c. In July, NASA flew its ASCENDS sensor to collect atmospheric CO2 profiles across key regions of the IARPC domain.  d. The ABoVE Science Team initiated a synthesis of field-observed CO2 and CH4 fluxes in tundra and boreal forests, both from ABoVE investigators and the broader scientific community, aimed at improved understanding of seasonal CO2 fluxes, where long-term atmospheric measurements document rather dramatic changes over the past 50 years, including increased productivity in the growing season and higher respiration in the winter and shoulder seasons. The ABoVE Science team is carrying out statistical models of CO2 and CH4 fluxes to shed light on major drivers of seasonal changes. These analyses will be compared with coarser-scale models to increase our predictive capabilities of boreal-arctic carbon cycling. (Sep 15, 2017 - Completed)

- 2.2.4 (In progress) In collaboration with efforts described under the Permafrost Goal, support observation syntheses of atmospheric carbon to provide better process understanding of the relationships between warming and soil carbon release in the Arctic. Integrate atmospheric measurements with related observations and modeling of land surface and environmental parameters to advance this process understanding.; NASA (Lead), NOAA (Lead), DOE, NSF

- As part of the DOE NGEE-Arctic project, output of CH4 fluxes from a land surface model was compared with eddy flux data for sites on the Arctic coastal Plain. Comparisons highlighted needed changes to how processes related to CH4 emissions were described (Xu et al., 2016). In particular, ground-based measurements from eddy covariance towers near Barrow, AK revealed that the greatest uncertainties in predicting the seasonal CH4 cycle originated from a lack of knowledge on the wetland extent, cold-season CH4 production and CH4 transport processes. Further improving the CH4 biogeochemical components of
the model will require that we better understand environmental controls on above- and belowground physiological processes and how vegetation controls gaseous transport (e.g., CH4 production under low temperatures). Citation: Xu, X, WJ Riley, CD Koven, DP Billesbach, RY-W. Chang, R Commone, ES Euskirchen, S Hartery, Y Harazono, H Iwata, KC McDonald, CE Miller, WC Oechel, B Poulter, N Raz-Yaseef, C Sweeney, M Torn, SC Wofsy, Z Zhang, and D Zona. 2016. A multi-scale comparison of modeled and observed seasonal emissions in northern wetlands. Biogeosciences 13: 5043-5056. http://dx.doi.org/10.5194/bg-13-5043-2016 (Sep 20, 2017 - Completed)

- Since 2012, the Next-Generation Ecosystem Experiments (NGEE-Arctic) project, working at field sites on the North Slope and more recently on the Seward Peninsula, has applied a multi-scale measurement and modeling scheme to assess important controls on methane cycling in high-latitude ecosystems. As an integral part of this research, flux measurements from two eddy covariance towers near Barrow, Alaska, including one maintained by the Atmospheric Radiation Measurement (ARM) program and another on the Barrow Environmental Observatory (BEO), revealed large emissions of methane that preceded snow melt (Raz-Yaseef et al., 2017). These pulses, previously observed but not explained, were linked to unique meteorological events where freezing rain on snow provided a physical barrier to methane emissions from underlying soils. The observed flux of carbon dioxide and methane to the atmosphere is of sufficient size to offset a significant fraction of the Arctic tundra carbon sink. Knowledge derived from long-term measurements complemented by targeted field and laboratory investigations, is being incorporated into the DOE Energy Exascale Earth System Model (E3SM). Citation: Raz-Yaseef N, MS Torn, Y Wu, DP Billesbach, AK Liljedahl, TJ Kneafsey, VE Romanovsky, DR Cook, and SD Wullschleger (2017). Large CO2 and CH4 emissions from polygonal tundra during spring thaw in northern Alaska. Geophysical Research Letters 44: 504-513. http://dx.doi.org/10.1002/2016GL071220 (Sep 20, 2017 - Completed)

- ABoVE and NASA supported this PE in the following ways. a. In collaboration with NSF’s SEARCH, NASA funded a workshop that focused in synthesizing research on how variations in permafrost control methane emissions in Arctic and boreal ecosystems. b. ABoVE research is supporting a number of the Permafrost CT PEs, including 6.1.1, 6.1.2, 6.1.4, 6.2.1, 6.3.1, 6.3.2, 6.3.3, 6.3.4 (related Performance Elements). (Sep 15, 2017 - Completed)

- In March 2017, NASA funded the following project through its Interdisciplinary Science 2016 ROSES (Research Opportunities in Earth and Space Science) solicitation. Research resulting from this project may contribute to progress on this milestone going forward. Ruth Varner /University of New Hampshire From Archaea to the Atmosphere: Integrating Microbial, Isotopic and Landscape-Scale Observations to Quantify Methane Emissions from Global High-Latitude Ecosystems16-IDS16-0060 https://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=566986/solicitationId=%7BE4A4A77E6-5A41-B75E-5DA8-61724BC35768%7D/viewSolicitationDocument=1/IDS16%20selectionsUPDAT
High latitude peatlands are a significant source of atmospheric methane. These sources are spatially and temporally heterogeneous, resulting in a wide range of global estimates for the atmospheric budget. At these high latitudes, increasing atmospheric temperatures are causing degradation of permafrost, creating changes in surface moisture, hydrology, vegetation and microbial communities resulting in dynamic changes to methane cycling. The temporal and spatial scale of disturbance from permafrost degradation varies depending on the transfer of heat and the hydrological connectivity of an ecosystem. The primary goal of our proposed work is to combine remote sensing data and biogeochemical modeling to quantify methane emissions and isofluxes at the pan-Arctic scale. We will accomplish this goal by addressing the following objectives:

1. Improve the ability of biogeochemical models to reliably estimate emissions of methane and 13CH4 from high latitude ecosystems by linking above and belowground processes through measurements and modeling.
2. Improve the estimate of water table and land cover using remote sensing techniques to be able to scale CH4 and 13CH4 emissions.
3. Produce multi-scale maps of emissions and isofluxes and errors associated by using remote sensing (Landsat, MODIS, PALSAR-2, Sentinel-1, WorldView2, UAS, G-LIGHT) to scale to the pan-Arctic region.

Using this combination of a validated biogeochemical process-based-model with ground verified multi-temporal and spatial remote sensing platforms, we will estimate the spatial distribution of methane emissions and its C isotopes across the high latitude peatland ecosystems. This project will quantitatively reduce uncertainties in the global methane budget related to these ecosystems and will allow us to link below and above ground processes on large spatial scales using cutting edge microbial, isotopic and remote sensing techniques. (Sep 12, 2017 - Completed)

In December 2016, NASA funded the following projects through its Carbon Cycle Science 2016 ROSES (Research Opportunities in Earth and Space Science) solicitation. Research resulting from these projects may contribute to progress on this milestone going forward.


J.William Munger /Harvard College Multi-Scale Data Assimilation and Model Comparison for ABoVE to Identify Processes Controlling CO2 and CH4 Exchange and Influencing Seasonal Transitions in Arctic Tundra Ecosystems16-CARBON16-0047

Background and Objectives

Transition seasons in Arctic tundra are particularly important for the ecosystem’s short-and long-term carbon balance and for the long-term carbon balance. Climate-driven changes in the timing of seasonal transitions can affect whether the annual carbon balance for an ecosystem is positive or negative, but detailed understanding of processes that control arctic carbon cycling during this period lags behind understanding of growing season processes. Year-round eddy flux tower and seasonal aircraft observations of CO2 and CH4 fluxes at far northern tundra sites demonstrate previously unrecognized carbon exchange during transition seasons. Notably, the spring onset of carbon uptake is not accurately
predicted using vegetation greenness defined by traditional satellite vegetation indices, and elevated carbon emissions extend well into the cold season when air and surface soil temperatures have fallen below freezing. We propose an in-depth analysis that integrates surface and airborne in situ data for CO2 and CH4 concentrations, remote sensing of vegetation and soils, satellite observations of Solar Induced Fluorescence (SIF) and CO2 and CH4 columns, tower fluxes, and meteorological products into a model-data synthesis framework that will improve our understanding of how the large pool of carbon stored in frozen tundra soils is responding to changing climate conditions. We will examine whether observed changes in transition season carbon exchange at local scales are occurring throughout the entire region and identify the environmental state variables that can best predict the timing of seasonal transitions across the tundra. Methodology We will test empirical functional models and process-based terrestrial ecosystem models against observations by comparing measured atmospheric CO2 and CH4 concentrations to concentrations predicted from applying atmospheric mixing and transport models to predictions of carbon uptake and emission. Using atmospheric data rather than flux measurements at a particular site tests whether the models accurately represent the regional mix of different environmental conditions and vegetation characteristics. Significance- The proposed work responds to the call for carbon research in the critical arctic ecosystem. Specifically, we will use an array of observational data to challenge and improve ecosystem models at scales from individual landscape patch up to regional scales. By quantitatively assessing model simulations against observations at regional scales we will identify gaps in our understanding of carbon dynamics and climate feedbacks, and contribute to an improved quantitative and predictive understanding of processes that regulate carbon cycling from northern terrestrial ecosystems. Ralph Keeling /University of California, San Diego Detection, Quantification, and Analysis of Changes in Boreal and Arctic Ecosystems Using Measurements and Models of CO2 and Its Isotopes16-CARBON16-0034. This proposal seeks to understand terrestrial ecosystem processes that control the exchanges of CO2 with the atmosphere on decadal and longer time scales. The approach makes time series measurements of CO2 concentration and isotopes and uses these and other datasets to challenge and improve carbon cycle models, including earth system models. This proposal is responsive to the solicited research Theme #1, relating to carbon cycling in Arctic and boreal regions, particularly to changes brought about by warming, CO2 and nitrogen fertilization, and associated changes to hydrology and carbon storage. It is also responsive to the need for “cross-cutting research activities”, e.g. for improving observations by providing an archive of CO2 samples to support development of novel isotopic applications related to land carbon cycling, and it is responsive to the need for modelling studies in relation to atmospheric transport modelling, ecosystem component modelling, regional and global modelling. This proposal would provide core support for the measurement activities of the Scripps CO2 program, which sustains measurements from a flask sampling program from an array of ten stations distributed from the Arctic to the Antarctic including the iconic Mauna Loa continuous record. The program complements the larger NOAA ESRL program by providing critical redundancy for state of the art
measurements, by ensuring continuity of the longest records of critical importance, and providing interpretive capabilities for understanding the data significance. The program also complements the DOE modeling (ACME) and measurements programs (NGEE Arctic, FACE, Ameriflux) by providing cross-cutting constraints on large-scale carbon cycling and it is highly relevant to the DOE Scientific Focus Area on Biogeochemistry “Climate Feedbacks. By sustaining the longest records of CO2 and isotopes and advancing related interpretive capabilities, the Scripps program is well positioned to make agenda setting discoveries related to carbon cycling and carbon/climate feedbacks. In addition to supporting the continuation of these observations and their improvement, this proposal will support a collaboration with Drs. Peter Thornton and Lianhong Gu of ORNL which builds on two recent significant discoveries from the program. The first is the evidence of the large increase in the seasonal amplitude at high northern latitudes documented by Graven et al. (2013). The second is emergent evidence for a shift towards higher photosynthetic discrimination both globally and at high northern latitudes. Both discoveries are highly relevant for understanding ongoing changes in arctic and boreal ecosystems. Both potentially provide critical insights into the coupled carbon, nitrogen, and water cycling in the context of ongoing changes. The collaboration will entail combined data synthesis and modeling activities, taking advantage of recent advances in global and plant-level modeling capabilities at ORNL. The collaboration is aimed at answering these key questions: 1) How can the observed seasonal cycles in CO2 concentration be used to constrain the representation of nitrogen cycling within land surface models? 2) How does the formulation of nitrogen cycling in models impact the predicted photosynthetic discrimination on seasonal time scales? 3) What plausible changes in leaf level processes can account for the long-term changes in photosynthetic discrimination suggested by atmospheric data? (Sep 12, 2017 - Completed)

In January 2017, NASA funded the following project through its Atmospheric Composition: Aura Science Team and Atmospheric Composition Modeling and Analysis Program 2016 ROSES (Research Opportunities in Earth and Space Science ) solicitation. Research resulting from this project may contribute to progress on this performance element going forward. Note: if this is placed under the wrong performance element, please let me know. Jianglong Zhang/University of North Dakota, Grand Forks Evaluating Model Reanalyses of Arctic Aerosol Surface and Atmospheric Forcing by Assimilating OMI over Ice16-ACMAP16-0086

(https://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=554049/solicitationId=%7B2CA9C467-DBE7-1438-E69D-2BB5CC9D4E1F%7D/viewSolicitationDocument=1/ACMAP16%20Selections.pdf) We will develop a ten-year Arctic (60°-90° N) three-dimensional aerosol extinction and optical depth reanalysis product for summer months based on numerical modeling simulations. Applying this product, we will study regional trends in summertime absorptive aerosol transport to/within the Arctic and corresponding aerosol direct surface forcing and particle mass deposition to investigate correlative relationships between regional aerosol presence and
seasonal sea ice melting. The novelty in this work comes from developing a new
data assimilation (DA) capability for the Naval Aerosol Analysis and Prediction
System (NAAPS) based on adapting the under-utilized OMI Aerosol Index (AI)
product to track ultraviolet absorbing aerosols (dust and smoke) regionally over
bright surfaces (ice, snow and cloud). The use of OMI AI will complement
traditional aerosol DA conducted with MODIS, MISR and CALIOP aerosol
datasets that have proven extremely limited near the poles. The ten-year product
will cover 2007-2016 to match the concurrent availability of all four satellite
aerosol datasets, with regional summertime months (defined here simply as April-
October) chosen to coincide with the availability of each of the passive aerosol
datasets introduced. Current MODIS, MISR and CALIOP Level 2 datasets are
extremely limited in the Arctic, making traditional aerosol model DA challenging
and degrading regional model skill overall. MODIS and MISR aerosol optical
depth (AOD) retrievals over bright surfaces like ice, snow and cloud are very
difficult. CALIOP retrievals are limited by complications in isolating aerosol
scattering signal relative to high levels of molecular background scattering near
the polar surface. Whereas the unprecedented value in newly-available global
aerosol reanalysis products to the community is quickly becoming obvious, there
exists a significant knowledge gap in the Arctic aerosol system that lessens model
fidelity for land-atmospheric process study in this critically-sensitive domain. The
opportunity to test our hypothesis that direct aerosol surface forcing trends and
properties are significantly influencing seasonal sea ice melt in the Arctic is thus a
compelling initial application of an OMI AI-constrained summer reanalysis
product. To conduct a ten-year NAAPS model run, and thus develop the Arctic
summer reanalysis product, prerequisite tasks will be performed. We will develop
and verify a Level 3 OMI AI DA-friendly data product, accounting for anomalies
induced by cloud fraction, vertical aerosol profile, aerosol type, and viewing
angle. A Level 3 CALIOP aerosol product will be designed based on resampling
that optimizes signal-to-noise and increases aerosol retrieval skill in the Arctic.
An OMI AI simulator for NAAPS will be built based on work conducted with the
NASA GEOS-5 aerosol modeling system. Jacobians for OMI AI relative to
NAAPS aerosol mass concentration for UV-absorbing smoke and dust will be
derived using the VLIDORT radiative transfer model. The current NAAPS
assimilation system will be adapted to process OMI AI. MODIS, MISR,
CALIOP, AERONET and MPLNET datasets will be used as necessary to conduct
these tasks and provide verification context. Further, a potential system
verification exercise using NASA aircraft observations, tentatively scheduled for
collection during the 2017 Arctic summer is described. (Sep 12, 2017 -
Completed)

2.3 Improve understanding of the processes that control the formation, longevity,
precipitation, and physical properties of Arctic clouds; the spatio-temporal
distributions of aerosol types; and Arctic cloud and aerosol modulation of the
surface radiation budget.

- 2.3.1 (In progress) Support and synthesize multi-platform observations of
cloud and aerosol properties from surface, airborne, and space-borne
instruments (integrated with models as appropriate) to describe the physical and radiative characteristics of cloud and aerosol over a range of spatio-temporal scales and over a range of Arctic land cover domains. DOE (Lead), NASA, NOAA, NSF


Current models have difficulty predicting the radiative effect of clouds, and aerosol effects contribute some of the largest uncertainties in radiative forcing. In August 2017, Lauren Zamora gave an overview of research she is doing with Ralph Kahn at NASA Goddard Space Flight Center, funded by NASA that aims to reduce this uncertainty. This research includes: Combining aircraft aerosol measurements and aerosol transport model output to better quantify the detection limit of CALIPSO aerosol observations over the Arctic. (Oct 25, 2017 - Completed)


2.3.2 (In progress) Support integrated observational and modeling studies of atmospheric processes and their relationship to land cover that will increase understanding of the characteristics, evolution, and radiative properties of Arctic clouds and their interactions with aerosol, leading to advancement in representing clouds in models at many scales.; DOE (Lead), NASA, NOAA, NSF

NASA supported the following research project: 2017 NASA CloudSat-CALIPSO Science Team Annual Report for the Project “Representing Cirrus Clouds in GCMs Using CALIPSO IIR and CALIOP Lidar Data” (Oct 30, 2017 - Completed)


Current models have difficulty predicting the radiative effect of clouds, and aerosol effects contribute some of the largest uncertainties in radiative forcing. In August 2017, Lauren Zamora gave an overview of research she is doing with Ralph Kahn at NASA Goddard Space Flight Center, funded by NASA that aims to reduce this uncertainty. This research includes: Using remote sensing data to provide evidence for the ability of aerosols to affect cloud freezing processes
(which is helpful for developing accurate cloud droplet freezing mechanisms in regional climate models), and contributing upcoming field campaign experiment ideas for how to understand the relevant mechanisms better. (Oct 25, 2017 - Completed)

2.3.3 (In progress) Understand the impacts of Arctic and Boreal Forest wildfires on emissions, distributions, weather, and climate impacts of biomass burning plumes through improved use of emissions databases and chemical transport modeling. Gain better understanding of deposition processes through studies and better characterization of the spatial distribution of biomass burning aerosol.; NOAA (Lead), DOE


- The US DOE Atmospheric System Research program supported the Oliktok Point Site Science team, which assembled the following relevant publication: J. Creamean, M. Maahn, G. de Boer, A. McComiskey, A.J. Sedlacek, Y. Feng, 2017: The influence of local petroleum exploration, regional wildfires, and long range transport on summer 2015 aerosol over the North Slope of Alaska, Atmos. Chem. Phys. Discuss., doi: 10.5194/acp-2017-594. (Sep 28, 2017 - Completed)

- The September joint meeting on the health impacts of wildfires in the Arctic by the Health & Well-being CT, Atmosphere CT, and Terrestrial Ecosystems CT (https://www.iarpccollaborations.org/members/events/9144) began a cross-team conversation on places for potential interdisciplinary/interagency collaborations. Follow-up actions will be reported as they occur. (Sep 25, 2017 - Completed)

2.3.4 (In progress) In collaboration with efforts described under the Environmental Intelligence Goal, support evaluation of reanalyses and their ability to represent Arctic clouds and controlling parameters with fidelity
using satellite, aircraft, and ground-based observations.; NASA (Lead), NOAA, NSF


- Current models have difficulty predicting the radiative effect of clouds, and aerosol effects contribute some of the largest uncertainties in radiative forcing. In August 2017, Lauren Zamora gave an overview of research she is doing with Ralph Kahn at NASA Goddard Space Flight Center, funded by NASA that aims to reduce this uncertainty. This research includes: Development of a new method to quantify regional aerosol indirect effects on the Arctic Ocean surface energy budget, as demonstrated first in a subset of Arctic clouds and currently being addressed in a more representative dataset. This activity is an important early step toward obtaining the first observation-based estimate of regional cumulative aerosol indirect effects on the Arctic surface – information that is critically needed for constraining models of the Arctic energy balance. (Oct 25, 2017 - Completed)

- The Systematic Improvements to Reanalyses in the Arctic (SIRTA) team published a white paper on reanalyses in the Arctic. It can be found at: https://www.iarpccollaborations.org/uploads/cms/documents/sirta-white-paper-final.pdf (Sep 1, 2016 - Completed)

Agencies
DOC, DOD, DOE, DOI, DOT, EPA, NASA, NSF, OSTP, USARC
3.1 Sea Ice

3.1 Conduct coordinated/integrated atmosphere-ice-ocean observations and research to understand the processes that determine the spatial and temporal variation of the thickness, extent and volume of sea ice, and their effects on atmosphere-ice-ocean interactions and feedbacks over multiple time scales (daily, weekly, seasonal, inter-annual, decadal).

- 3.1.1 (In progress) Support investigator-driven observations and process studies of the pack ice (e.g., ice thickness distribution, topography/surface roughness and strength; ice motion and deformation; snow depth distribution and melt pond characteristics; surface albedo and energy balance) and landfast ice (e.g., extent, stability, and break-up); NASA (Lead), NSF (Lead), DOD-ONR, DOI-BOEM, NOAA
  
  
  o Don Perovich's presentation giving a review of the Year of Polar Prediction (YOPP) open session and steering group meeting at the March Sea Ice Collaboration Team meeting relates to this Performance Element [http://www.iarpccollaborations.org/members/events/7679](http://www.iarpccollaborations.org/members/events/7679) (Jul 24, 2017 - Completed)

- 3.1.2 (In progress) Continue to support the U.S. Interagency Arctic Buoy Program (US IABP) to provide meteorological, ice, and oceanographic data for research purposes and to meet real-time operational requirements. US IABP, coordinated by the National Ice Center and the Polar Science Center, Applied Physics Laboratory, University of Washington, contributes to the International Arctic Buoy Programme.; DHS-USCG (Lead), DOD-Navy (Lead), NOAA (Lead), NSF (Lead), DOD-ONR, NASA
  
  o At-sea measurement are key to the success of many sea-ice research efforts. During 2016, USCGC Healy deployed mooring to collect data on how climate change and decreased sea ice is affecting the Arctic Ocean. (Oct 4, 2017 - Completed)
  
  o NASA continues to provide funding for IABP (Sep 29, 2017 - Completed)
The International Arctic Buoy Programme (IABP, http://iabp.apl.uw.edu) maintains the fundamental Arctic Observing Network (AON) of drifting buoys which observe meteorological, oceanographic and ice conditions. The USIABP coordinates most of the US contributions to the IABP. So far in 2017, the USIABP has deployed 35 buoys and owns 57 of the 117 buoys currently reporting in the IABP AON. IABP receives funding or in-kind support from NSF, NOAA, NASA, ONR, Navy and the National Ice Center (NOAA, Navy, USCG.) (Sep 26, 2017 - Completed)

3.1.3 (In progress) Continue Operation IceBridge (OIB) to measure sea ice freeboard and thickness and to measure the depth of snow on the ice in late winter 2017, 2018, and 2019 in the western Arctic Ocean.; NASA (Lead)

Using a fleet of research aircraft, NASA’s Operation IceBridge images Earth's polar ice to better understand connections between polar regions and the global climate system. IceBridge studies annual changes in thickness of sea ice, glaciers and ice sheets. IceBridge bridges the gap between the ICESat missions. NASA is planning to continue OIB through FY20. NASA’s annual survey of changes in Arctic ice cover greatly expanded its reach this year in a series of flights that began on March 9 and wrapped up on May 12. It was the most ambitious spring campaign in the region for Operation IceBridge (OIB), an airborne mission to monitor ice changes at Earth’s poles. Geographically, OIB covered a wider area than ever before, and the new instruments deployed provided denser and more precise measurements. The mission carried out 39 eight-hour flights in 10 weeks. Of those, 13 focused on surveying sea ice. Several flights included collaborations with international Ice, Cloud and land Elevation Satellite (ICESat) missions teams to collect and compare measurements of snow and ice. The first part of the campaign was dedicated to overflying the Arctic Ocean’s sea ice cover. In this campaign, the IceBridge team added an extra base: Longyearbyen, Svalbard. From there, the mission was able to reach areas of the Eurasian side of the Arctic Ocean that had not been explored by IceBridge before. IceBridge also expanded its scope westward with a flight to the western side of the Chukchi Sea, a sea situated between Alaska and Russia. It was the first time the mission ever crossed the International Date Line. Operation IceBridge (OIB) launched a short campaign on July 17, 2017 from Thule Air Base, in northwest Greenland. The IceBridge scientists completed six flights focusing on the convergence of sea ice north of Ellesmere Island. The sea ice flights surveyed melt ponds, the pools of melt water on the ice surface that may contribute to the accelerated retreat of sea ice. IceBridge also flew a set of tracks to locate areas of sea ice that the mission already flew over in March and April, during its regular springtime campaign, to measure how the ice has melted since then. (Sep 29, 2017 - Completed)

NASA plans to continue Operation IceBridge through FY 2020. ()

3.1.4 (In progress) Launch (1) the NOAA/NASA Joint Polar Satellite System in 2017 to enhance understanding of the sea ice age/thickness, ice concentration, ice surface temperatures, snow cover, and snow water equivalent; and (2) the NASA Ice, Cloud, and land Elevation Satellite 2
ICESat-2 in 2018 to estimate sea ice thickness over the entire Arctic Ocean and adjacent seas.; NASA (Lead), NOAA (Lead)

- The launch date for ICESat-2 is officially confirmed for September 12, 2018. (Nov 1, 2017 - Completed)
- The NOAA/NASA JPSS is scheduled to launch in late 2017. No substantive updates available at this time on either satellite until they have launched. (Sep 29, 2017 - Completed)
- Thorsten Markus' presentation at the March Sea Ice Collaboration Team meeting relates to this Performance Element http://www.iarpccollaborations.org/members/events/7679. (Jul 24, 2017 - Completed)

3.1.5 (In progress) Use multiple remote sensing data sets to: (1) investigate sea ice properties and processes and atmosphere-ice-ocean interactions; and (2) develop algorithms for automated ice edge detection and delineation of the marginal ice zone, landfast ice extent, ice classification (e.g., age/type of ice, melt ponds, floe size), and ice motion and deformation.; DOD-ONR (Lead), DOI-BOEM, NASA, NOAA, NSF

- Improved instrumentation on Operation IceBridge in 2017 includes the snow radar and airborne topographic mapper, allowing for more accurate snow depth retrievals and, from the ATM, higher sample density and measurement precision of surface elevation. (Sep 28, 2017 - Completed)
- Delivered the ATBD (Algorithm Theoretical Basis Document) for AMSR2 sea ice products. Also, we finished implementing the sea ice motion algorithm for AMSR2 and are getting ready to transition it for operational implementation. (Sep 4, 2017 - Completed)
- Working on with Mark Tschudi, University of Colorado, to enhance sea ice age and sea ice motion products at NSIDC and extend their utility to other geophysical parameters. An updated product was delivered to NSIDC and will soon be public and a new version is being readied and should be released in a couple of months. (Sep 4, 2017 - Completed)
- At the February meeting of the SICT Walt Meier gave an overview of current and future polar-orbiting passive microwave sensors. His presentation is available at: http://www.iarpccollaborations.org/members/documents/7695. (Mar 30, 2017 - Completed)

3.1.6 (In progress) Develop and deploy new technologies that enable persistent data collection on a variety of environmental variables using mobile platforms and sensors operating above, on, in, and under the Arctic sea ice cover to support a framework of observations that will improve forecasting and prediction of sea ice.; DOD-ONR (Lead), DOI-BOEM, NASA, NOAA, NSF
ADAC is developing a long-range autonomous underwater vehicle for under-ice mapping of oil spills and environmental hazards. (Oct 5, 2017 - Completed)

For 2017, improved instrumentation on Operation IceBridge includes the snow radar and airborne topographic mapper, allowing for more accurate measurements and, for the ATM, higher sample density and measurement precision. (Sep 29, 2017 - Completed)

NASA Center staff initiating a new data calibration effort between Operation IceBridge and TanDEM-X (https://directory.eoportal.org/web/eoportal/satellite-missions/t/tandem-x) data. A description of this effort will be forthcoming.

The presentation given by Rick Allard at the July Sea Ice Collaboration team meeting on utilizing CryoSat-2 ice thickness to initialize the Navy's ice modeling systems is relevant to this Performance Element and helps progress the understanding of different models and their predictive output http://www.iarpccollaborations.org/members/events/8934. (Aug 1, 2017 - Completed)

3.1.7 (In progress) Investigate Arctic Ocean processes, interactions and feedbacks that affect the dynamics and thermodynamics of the sea ice cover, including ocean circulation and stratification, turbulence and mixing, horizontal and vertical heat transport, and freshwater transport and storage. The ONR Stratified Ocean Dynamics of the Arctic (SODA) project (FY16-FY20) is an example of a contribution to this Performance Element.; DOD-ONR (Lead), DOI-BOEM, NASA, NOAA, NSF

The NASA Operation IceBridge 2017 summer campaign targeted a convergence event, capturing a sequence of repeat measurements over the same collection of ice floes. These data will be used to investigate sea ice dynamic processes, including the redistribution of sea ice thickness.

ONR Stratified Ocean Dynamics of the Arctic DRI program: Initial plans have been developed for the 2018-2019 intensive observing phase, resulting in the production of the SODA Science Plan which has been published as a technical report (http://www.apl.washington.edu/research/downloads/publications/tr_1601.pdf). An enhanced version of the acoustic navigation system used in the 2014 Marginal Ice Zone Experiment has been developed to provide regional-scale geolocation in the central Beaufort Sea. Additional efforts have focused on improvements to the under-ice capabilities of floats and gliders, and on adapting ice-based platforms for deployments that require operation on ice and in open water. The intensive field program will begin in autumn 2018 with a process cruise aboard R/V Sikuliaq and deployment of moorings, gliders and ice-based instruments from USCG icebreaker Healy.

ONR Sea State DRI program: Key accomplishments of 2017 have been the data processing and early publications from our Autumn 2015 campaign. The observations show a prevalence of pancake ice, which is formed by strong wave forcing during Autumn storms. Although this is generally a formation mode, there
are examples of autumn storms releasing ocean heat and causing episodic reversals of the advancing ice edge. Beyond the storms, the autumn evolution appears controlled by 1) atmospheric conditions, especially rapid freezing during off-ice winds, and 2) preconditioning of ocean heat content. Alongside the data processing, there has been significant model development. The WAVEWATCH III model now supports five different advanced schemes for wave-ice interaction, each with evaluations from the field campaign. An experimental coupled atmosphere-ice-ocean model from NOAA is also being evaluated with the field data. The efforts are culminating in a special issue of JGR Oceans, which closes on 1 Nov 2017 . (Sep 26, 2017 - Completed)

- ONR Marginal Ice Zone DRI Program: Investigators spent 2017 analyzing observations from the 2014 field program, many of which are accumulating in a special section of the journal Elementa. Sustained observations documented the role of wintertime storm-driven breakup events, and their impact on ice composition and fracturing, on flow size distribution in the subsequent summer. Observations though the spring revealed a thermodynamic MIZ, where increasing insolation drove snow and surface ice melt, reducing albedo and leading to more efficient absorption of solar radiation and more melt. Fresh water generated by ice melt formed a thin, buoyant surface layer that inhibited mixing, thus isolating the sea ice from heat stored below. Surface waves and wind-driven mixing modulated the evolution of the thermodynamics MIZ in spring and summer of 2014. (Sep 26, 2017 - Completed)

3.2 Improve models for understanding sea ice processes and for enhanced forecasting and prediction of sea ice behavior at a range of spatial and temporal scales.

- 3.2.1 (In progress) Support investigator-driven modeling studies designed to understand and parameterize key sea ice properties and processes, including ice thickness distribution, topography, and strength; ice motion, deformation and mechanics; snow depth distribution and melt pond characteristics; surface albedo and energy balance; and biogeochemistry.; DOD-ONR (Lead), NSF (Lead), DOE, DOI-BOEM, NASA, NOAA

- NSF -funded MOSAiC projects are listed below. NSF is funding MOSAiC at the level of ~ $6.8M from the science program (Arctic System Science, Program Director Neil Swanberg) and $ 2.5 M in logistics. Project Title: Collaborative Research: Thermodynamic and dynamic drivers of the Arctic sea ice mass budget at MOSAiC. Lead PI Matt Shupe, U of Colorado Boulder. Other collaborators Jennifer Hutchings, Oregon State University; Timothy Stanton, San Jose Univ. Foundation; and Donald Perovich, Dartmouth College. Award Abstract at https://www.nsf.gov/awardsearch/showAward?AWD_ID=1724551&HistoricalA wards=false Project Title: Chemical, Physical and Biological processes linking snow and sea ice to the Arctic Ocean mixed layer: Improving models through the MOSAiC platform. PI Robert Rember, U of Alaska Fairbanks Award Abstract at https://www.nsf.gov/awardsearch/showAward?AWD_ID=1735862&HistoricalA
Project Title: Collaborative Research: Improving the Prediction of Sea Ice through Targeted Study of Poorly Parameterized Sea Ice Processes at MOSAiC and Responsive Model Development. Lead PI Donald Perovich, Dartmouth College. Other collaborators Bonnie Light, Univ. of Washington; and Marika Holland, UCAR. Award Abstract at https://www.nsf.gov/awardsearch/showAward?AWD_ID=1724540&HistoricalAwards=false (Sep 29, 2017 - Completed)

- NASA’s annual omnibus research announcement, Research Opportunities in Space and Earth Sciences (ROSES), solicits proposals for cryospheric research. ROSES 2016 announced opportunities under the program element Studies with ICESat and CryoSat-2, which solicited investigations to derive geophysical information from NASA’s Ice, Cloud, and land Elevation Satellite (ICESat) and the European Space Agency’s CryoSat-2, and link these records with the initial data stream from ICESat-2, scheduled for launch in 2018. Proposals selected in late 2016 include a variety of studies using ICESat, IceBridge, CryoSat-2, and planned ICESat-2 altimetry data to examine the decadal trends in Arctic sea ice thickness and volume. In ROSES 2017, NASA solicited proposals under its Cryospheric Science element due in June 2017. For the Arctic portion, the program’s focus is to characterize and understand sea ice processes and the observed changes—in extent, concentration, thickness, character, and dynamics—in the context of their couplings to the Earth system. Understanding the feedback mechanisms associated with sea ice—and the atmosphere, ocean, land, and incident sunlight—is intended to improve models of the Arctic. (Sep 29, 2017 - Completed)

- The Operation IceBridge 2017 summer campaign targeted a convergence event, capturing a sequence of repeat measurements over the same collection of ice floes. These data will be used to investigate sea ice dynamic processes, including the redistribution of sea ice thickness. New Operation IceBridge science team members will be evaluating model predictive skill through the application and assimilation of sea ice thickness observations from Operation IceBridge. (Sep 29, 2017 - Completed)

- Wieslaw Maslowski’s presentation to the June Joint SICT, ACT, and MST meeting on MOSAiC and modeling is related to this Performance Element http://www.iarpccollaborations.org/members/documents/9447. (Jul 24, 2017 - Completed)

- **3.2.2 (In progress) Enhance operational sea ice forecasting and research-oriented prediction capabilities through improvements to model physics (explicit and parameterized); initialization techniques; assimilation of observations, model evaluation and verification; evaluation of model skill, post-processing techniques and forecast guidance tools used in operational forecasts and decision support.; NOAA (Lead), DOD-NRL, DOD-ONR, DOE, DOI-BOEM, NASA, NSF**

- NOAA’s Earth System Research Laboratory (ESRL) Physical Sciences Division (PSD) is providing daily, 0-10 day, Arctic Sea Ice Forecasts using a fully-
coupled, ice-ocean-atmosphere model for the 3rd straight fall freeze-up season. Ice, ocean, atmosphere, and coupled forecast guidance products in addition to time-height cross sections and meteograms for selected locations are posted daily at https://www.esrl.noaa.gov/psd/forecasts/seaice/ 2017 Project Updates Extended domain includes Bering and Fram Straits Ice thickness initialization uses spring CryoSat-2 Weekly sea ice concentration updates with AMSR-2 Ensemble runs using Global Ensemble Forecast System (GEFS) members (in progress). Updated website with new guidance products, meteograms, and cross-sections Collaboration with NOAA National Weather Service (NWS) Alaska Testbed staff to evaluate model results and understand utility, usage, and interpretation of ensemble data and uncertainty information for stakeholders (Nov 30, 2017 - Target)

- The presentation by Edward Blanchard-Wrigglesworth at the October Sea Ice Collaboration Team meeting on the latest results from the Sea Ice Prediction network's (SIPN) 2017 Sea Ice Outlook (SIO) is relevant to this Performance Element (https://www.iarpccollaborations.org/members/events/8937) (Oct 27, 2017 - Completed)

- NASA's ICESat-2 satellite has an "Early Adopters" program (https://icesat-2.gsfc.nasa.gov/early_adopters), which includes sea ice and global climate modelers who will apply ICESat-2 data for sea ice forecasts and tests of model predictive skill. The 2016 Operation IceBridge new science team members have outlined the following objectives for the remaining sea ice campaigns: (1) assess and improve the quality of snow and sea ice thickness measurements, (2) evaluate the predictive skill of models through application and assimilation of Operation IceBridge observations, and (3) support the continuity of sea ice thickness observations for linkage between the ICESat and ICESat-2 missions. (Sep 29, 2017 - Completed)

- NASA Operation IceBridge science team members will be evaluating model predictive skill through the application and assimilation of sea ice thickness observations from Operation IceBridge (in progress). ()

- NOAA Research and Weather Service have two ongoing projects to improve sea ice forecasts during fall in the Alaskan Arctic. This will improve safety in the vicinity of Bering Strait and for seasonal planning for the timing of freeze-up. A one week sea ice forecast model is under development at NOAA Boulder. (Sep 26, 2017 - Completed)

- A NOAA aircraft operation during early September (2016 & 2017), with NOAA Seattle scientists, deployed ocean temperature buoys that give real time temperature profiles during fall. These "warm ocean" temperatures in recent years need to cool before Chukchi Sea sea ice can form. A seasonal freeze up forecast for November is being developed based on the September ocean data and fall weather outlooks. Data are available at: https://www.pmel.noaa.gov/arctic-heat/ (Sep 26, 2017 - Completed)

- The presentations given by Rick Allard and Alek Petty at the July 2017 Sea Ice Collaboration Team meeting are relevant to this Performance Element as they
suggest research about improving models and sea ice forecasting
http://www.iarpccollaborations.org/members/events/8934. (Aug 1, 2017 - Completed)

3.3 Support collaborative networks of researchers to advance knowledge, understanding, and prediction of the sea ice system.

- 3.3.1 (In progress) Support the Study of Environmental Arctic Change (SEARCH) Sea Ice Action Team to synthesize the results of multiple agencies’ and other stakeholders’ investments in sea ice observations and process studies and communicate results, information, and the societal implications of sea ice change to broader audiences; NSF (Lead), DOD-ONR
  
o At the February meeting of the SICT, Matthew Druckenmiller gave a presentation on the SEARCH Sea Ice Action Team and their knowledge exchange workshop held in September 2016. SICT members suggested several potential collaborators for their next workshop, tentatively planned for fall 2017. They include the Arctic Domain Awareness Center at the University of Alaska Fairbanks (Church Key) and the National Weather Service in Anchorage (Renee Tatusko). Matthew's presentation can be found at: http://www.iarpccollaborations.org/members/documents/7696. (Mar 30, 2017 - Completed)

- 3.3.2 (In progress) Support a collaborative network of scientists and stakeholders to advance research on sea ice predictability and prediction at a variety of time and space scales and communicate new knowledge, understanding, and tools to broader audiences.; NSF (Lead), DOD-ONR, DOE, NASA, NOAA
  
o The Sea Ice Collaboration Team leadership is participating in an American Geophysical Union (AGU) special session discussing topics including Arctic system modeling and synthesis, Indigenous ways of knowing and the co-production of knowledge, and the application of Earth observing networks and indicators for delivering information products and societal benefits. (Dec 20, 2017 - Target)
  
o The Sea Ice for Walrus Outlook (SIWO; https://www.arcus.org/search-program/siwo) is a resource for Alaskan Native subsistence hunters and coastal communities of Alaska’s Bering Strait region. SIWO provides weekly reports on spring sea ice and weather conditions to promote hunter safety, food security, and preservation of cultural heritage. Weekly outlooks integrate weather and ice forecasts, satellite imagery, and local observations from Alaska Native sea ice experts. The 2017 SIWO season lasted from late March through early June. Project collaborators include ARCUS, National Weather Service - Alaska Sea Ice Program, Eskimo Walrus Commission, University of Alaska Fairbanks - International Arctic Research Center, and local sea ice experts. Funding for core SIWO activities is provided to ARCUS by the National Science Foundation's Division of Arctic Sciences (PLR-1304316), with in-kind support from other partners. Additional funding is currently being sought for networking activities
and meetings with local observers, a formal evaluation, and an expansion in the use of local observations for validating and improving sea ice and weather forecasts. (Oct 19, 2017 - Completed)

- The Sea Ice Prediction Network (SIPN) held a wide-ranging series of activities in the last 12 months. The leadership team published 3 peer-reviewed team papers and 4 reports, and gave 7 presentations about the Sea Ice Outlook (SIO) and other SIPN activities. Network participants published papers about sea ice prediction in another 6 peer-reviewed papers and one book chapter. The SIPN leadership team continues to organize and run the SIO and a spring Polar Prediction Workshop (the fourth in as many years), This year the workshop was organized jointly with the Polar Prediction Project, and was held in Bremerhaven, German, at the Shipping Museum and hosted by the Alfred Wegener Institute. The workshop was back-to-back with a Sea Ice MIP (SIMIP) workshop. Approximately 100 attended at the peak of the two workshops. SIPN also hosted a Network meeting at the 2016 Fall AGU and participated in organizing a science session at the spring 2017 EGU. The SIPN leadership team submitted a grant proposal to continue support for the SIO and other SIPN activities. The SIO collected Outlooks in June, July and August 2017, and we received about 35 Outlooks of the September pan-Arctic sea ice cover. For the second year, we also called for Outlooks of the Alaskan region, and this year we received about a dozen. In addition, over a half-dozen participants submitted full-fields of more detailed sea ice quantities. The SIPN leadership team and guest authors prepared reports in each month that synthesized the Outlooks and current Arctic sea ice conditions. The Outlooks were provided as a spreadsheet linked to each report. A post-season report was written about the SIO and sea ice in the summer of 2016 with conclusions, lessons-learned, and recommendations for the next year. Recommendations for SIO and SIPN were requested at the spring workshop as well. Among those recommendations, network members wanted the SIO to streamline the data collection process as more information has been requested than in earlier years. We responded by requesting Outlooks via a Google form and Dropbox folder. We have now received 695 Outlooks in the decade since the SIO inception. Outlooks in the last few years have maintained rigor in their methods, as the overwhelming majority of the Outlooks are from objective methods (statistical or dynamical models) and among the dynamical model, most are from coupled prediction system now. (Sep 21, 2017 - Completed)

- The latest report of the Sea Ice Prediction Network and the Sea Ice Outlook for August was released on August 24. It is available at: https://www.arcus.org/sipn/sea-ice-outlook/2017/august. NASA (through Meier) contributed to the August report. Meier led the July report. NASA sea ice concentrations are used for initialization fields and for validation of the seasonal prediction. Also, IceBridge data has been provided for initialization of models as well. (Sep 4, 2017 - Completed)

- The Sea Ice Collaboration Team tracked demographics of membership participation in meetings in order to understand membership attendance and where diverse voices could be strengthened. (Aug 18, 2017 - Completed)
The Sea Ice Collaboration Team invited several early career scientists to present their research at monthly meetings. (Aug 18, 2017 - Completed)

The Sea Ice Collaboration Team has participated in two joint meetings 1) with the Marine Ecosystems Collaboration Team on the pan-Arctic conceptual model and Walruses and 2) with the Atmosphere and Modeling Collaboration Teams on MOSAiC. (Aug 18, 2017 - Completed)

Agencies
DHS, DOC, DOD, DOE, DOI, NASA, NSF, OSTP, USARC
Marine Ecosystems Collaboration Team

Performance Element Reporting Log 2017

(Some links in this summary require an account on IARPC Collaborations Website. Please visit www.iarpccollaborations.org to request an account.)

4.1 Marine Ecosystems

4.1 Increase knowledge on the distribution and abundance of Arctic marine species across all trophic levels and scales, including an improved understanding of the formation and maintenance of biological hotspots and proximate causes of shifts in range.

- **4.1.1 (In progress) Continue distribution and abundance surveys of Arctic marine species, for example, concurrent monitoring of polar bears and their ice seal prey.; NOAA (Lead), DOI-BOEM, DOI-USGS, MMC**
  
  o  The presentation given at the October 2016 team meeting (https://www.iarpccollaborations.org/members/documents/7149) by Danielle Dickson about the Arctic Integrated Ecosystem Research Program is relevant to this Performance Element. (Oct 30, 2017 - Completed)

  o  USGS-led Forecasts of Polar Bear Persistence: Effective conservation planning requires understanding and ranking threats to wildlife populations. We developed a Bayesian network model to evaluate the relative influence of environmental and anthropogenic stressors, and their mitigation, on the persistence of polar bears (Ursus maritimus). Overall sea ice conditions, affected by rising global temperatures, were the most influential determinant of population outcomes. Accordingly, unabated rise in atmospheric greenhouse gas (GHG) concentrations was the dominant influence leading to worsened population outcomes, with polar bears in three of four ecoregions reaching a dominant probability of decreased or greatly decreased by the latter part of this century. Stabilization of atmospheric GHG concentrations by mid-century delayed the greatly reduced state by ≈25 yr in two ecoregions. Prompt and aggressive mitigation of emissions reduced the probability of any regional population becoming greatly reduced by up to 25%. Marine prey availability, linked closely to sea ice trend, had slightly less influence on outcome state than sea ice availability itself. Reduced mortality from hunting and defense of life and property interactions resulted in modest declines in the probability of a decreased or greatly decreased population outcome. Minimizing other stressors such as trans-Arctic shipping, oil and gas exploration, and contaminants had a negligible effect on polar bear outcomes, although the model was not well-informed with respect to the potential influence of these stressors. Adverse consequences of loss of sea ice habitat became more pronounced as the summer ice-free period lengthened beyond four months, which could occur in most of the Arctic basin after mid-century if GHG emissions are not promptly reduced. Long-term conservation of polar bears would be best supported by
holding global mean temperature to ≤2°C above preindustrial levels. Until further sea ice loss is stopped, management of other stressors may serve to slow the transition of populations to progressively worsened outcomes, and improve the prospects for their long-term persistence. Citation: Atwood, T. C., B. G. Marcot, D. C. Douglas, S. C. Amstrup, K. D. Rode, G. M. Durner, and J. F. Bromaghin. 2016. Forecasting the relative influence of environmental and anthropogenic stressors on polar bears. Ecosphere 7(6):e01370. doi:10.1002/ecs2.1370.

- USGS-led Study of Increased Land Use by Polar Bears: In the Arctic Ocean's southern Beaufort Sea (SB), the length of the sea ice melt season (i.e., period between the onset of sea ice break-up in summer and freeze-up in fall) has increased substantially since the late 1990s. Historically, polar bears (Ursus maritimus) of the SB have mostly remained on the sea ice year-round (except for those that came ashore to den), but recent changes in the extent and phenology of sea ice habitat have coincided with evidence that use of terrestrial habitat is increasing. We characterized the spatial behavior of polar bears spending summer and fall on land along Alaska's north coast to better understand the nexus between rapid environmental change and increased use of terrestrial habitat. We found that the percentage of radio-collared adult females from the SB subpopulation coming ashore has tripled over 15 years. Moreover, we detected trends of earlier arrival on shore, increased length of stay, and later departure back to sea ice, all of which were related to declines in the availability of sea ice habitat over the continental shelf and changes to sea ice phenology. Since the late 1990s, the mean duration of the open-water season in the SB increased by 36 days, and the mean length of stay on shore increased by 31 days. While on shore, the distribution of polar bears was influenced by the availability of scavenge subsidies in the form of subsistence-harvested bowhead whale (Balaena mysticetus) remains aggregated at sites along the coast. The declining spatio-temporal availability of sea ice habitat and increased availability of human-provisioned resources are likely to result in increased use of land. Increased residency on land is cause for concern given that, while there, bears may be exposed to a greater array of risk factors including those associated with increased human activities. Citation: Atwood, T. C., E. Peacock, M. A. McKinney, K. Lillie, R. R. Wilson, D. C. Douglas, S. Miller, and P. A. Terletzky. 2016. Rapid environmental change drives increased land use by an Arctic marine predator. PLoS One 11(6):e0155932. doi:10.1371/journal.pone.0155932

- Publication on Diet Shift from Seals to Whales Drives a Decline in Mercury Concentrations in Southern Beaufort Sea Polar Bear: We evaluated total mercury (THg) concentrations and trends in polar bears from the southern Beaufort Sea subpopulation from 2004 to 2011. Hair THg concentrations ranged widely among individuals. Concentrations differed among sex and age classes. No variation was observed between spring and fall samples. For spring-sampled adults, THg concentrations declined by 13% per year, contrasting recent trends observed for other Western Hemispheric Arctic biota. Concentrations also declined by 15% per year considering adult males only, while a slower, nonsignificant decrease of 4.4% per year was found for adult females. Lower THg concentrations were associated with higher body mass index (BMI) and higher
proportions of lower trophic position food resources consumed. Because BMI and diet were related, and the relationship to THg was strongest for BMI, trends were re-evaluated adjusting for BMI as the covariate. The adjusted annual decline was not significant. These findings indicate that changes in foraging ecology, not declining environmental concentrations of mercury, are driving short-term declines in THg concentrations in southern Beaufort Sea polar bears. Citation: McKinney, M. A., T. C. Atwood, S. Pedro, and E. Peacock. 2017. Ecological change drives a decline in mercury concentrations in Southern Beaufort Sea polar bears. Environmental Science and Technology 51(14):7814-7822. doi:10.1021/acs.est.7b00812

- The presentation given by Katrin Iken at the September Marine Ecosystems meeting on the Chukchi Borderland project is relevant to this performance element (https://www.iarpccollaborations.org/members/events/8929) (Sep 18, 2017 - Completed)

- The presentation given by Elizabeth Labunski titled "Long-term at-sea seabird surveys for a changing Arctic" at the March Marine Ecosystems Collaboration Team meeting is relevant to this performance element. https://www.iarpccollaborations.org/members/events/7587 (Aug 21, 2017 - Completed)

- The presentation given at the July Marine Ecosystems Collaboration Team meeting (http://www.iarpccollaborations.org/members/events/8927) by Marcel Babin titled "The Green Edge Project: a deep dive into the mechanics of the Arctic phytoplankton phenology" is relevant to this Performance Element (Jul 17, 2017 - Completed)

- **4.1.2 (In progress) Continue studies to document Arctic marine species biodiversity (e.g. Arctic Marine Biodiversity Observation Network—AMBON—and programs that monitor loss of sea ice) and habitat use in the Arctic. Ensure datasets will be available through open access data portals.; NOAA (Lead), DOD-ONR, MMC, NASA, NSF

  - The presentation given by Katrin Iken at the September Marine Ecosystems meeting on the Chukchi Borderland project is relevant to this performance element (https://www.iarpccollaborations.org/members/events/8929) (Sep 18, 2017 - Completed)

  - The presentation given by Elizabeth Labunski titled "Long-term at-sea seabird surveys for a changing Arctic" at the March Marine Ecosystems Collaboration Team meeting is relevant to this performance element (https://www.iarpccollaborations.org/members/events/7587). (Jun 15, 2017 - Completed)

- **4.1.3 (In progress) Assess winter distributions of key Arctic species, via passive acoustic sampling and satellite tagging for marine mammals to include further development of autonomous, unmanned surface and underwater vehicles equipped with sensors capable of recording marine mammal vocalizations.; NOAA (Lead), DOI-FWS, DOI-USGS, MMC
4.2 Improve understanding of basic life history of Arctic marine species to support multi-agency decision-making.

- **4.2.1 (In progress)** Assess feeding ecology of Arctic species and fill seasonal data gaps. One such project will identify walrus prey based on an innovative approach using molecular markers.; NOAA (Lead), DOI-BOEM, DOI-USGS, MMC, NSF

  - USGS Genomic Study of Walrus Fecal Material to Determine Diet: With declines in sea ice and Pacific walrus shifting distributions to onshore haulouts instead of on ice, questions were raised about the energetics of walrus being further from preferred prey areas in northwestern Alaska. Key to understanding energetics is prey items, which are difficult to obtain either from benthic sampling or from walruses themselves. This USGS Alaska Science Center-led project examined the application of next generation sequencing technologies as an approach to detect prey items consumed by Pacific walruses. Work conducted in 2016-2016 found that dietary profiles for walrus in the Chukchi Sea can be generated from fecal material collected off of ice floes where walruses had recently rested. Taxonomic resolution of genomic markers was sufficient to identify prey items to family level. Final results from this project will be available in 2018. ()

  - The presentation by Peter Thomas to the Marine Ecosystems Collaboration Team at the August meeting on the role of the Marine Mammal Commission in the Arctic is relevant to this Performance Element (https://www.iarpccollaborations.org/members/events/8928). (Aug 11, 2017 - Completed)

- **4.2.2 (In progress)** Determine basic life history information on age and growth rates of key links in the food web.; NOAA (Lead), DOI-USGS, NSF

  - The presentation given at the October 2016 team meeting (https://www.iarpccollaborations.org/members/documents/7149) by Danielle Dickson about the Arctic Integrated Ecosystem Research Program is relevant to this Performance Element. As part of this program incubation experiments will be conducted to measure rates of plankton and sediment community growth and respiration. (Oct 30, 2017 - Completed)

- **4.2.3 (In progress)** Assess the value of recent interdisciplinary programs and data synthesis efforts to guide management decisions and allocation of
resources.; DOD-ONR (Lead), USARC (Lead), DOI-BOEM, DOI-FWS, MMC, NASA, NOAA

- Paul Wassmann's presentation titled "Concepts and Theories for a Unifying Pan-Arctic Perspective: Conceptualizing Arctic Ecosystems and Processes in an Era of Climate Change" (http://www.iarpccollaborations.org/members/documents/9149) made at the May MECT meeting (http://www.iarpccollaborations.org/members/events/8926) is relevant to this performance element. (May 11, 2017 - Completed)

4.3 Advance the understanding of how climate-related changes, biophysical interactions, and feedbacks at different scales in the marine ecosystems impact Arctic marine resources and human communities that depend on them.

- 4.3.1 (In progress) Continue Distributed Biological Observatory (DBO) sampling in regions 1-5 and make data publicly available through upload of metadata to the Earth Observing Laboratory/DBO data portal.; NOAA (Lead), NSF (Lead), DOI-BOEM, DOI-FWS, NASA

  - The presentation given at the October 2016 team meeting (https://www.iarpccollaborations.org/members/documents/7149) by Danielle Dickson about the Arctic Integrated Ecosystem Research Program is relevant to this Performance Element. This program is contributing to sampling the DBO. (Oct 30, 2017 - Completed)

  - 1. NSF provides core research support for the annual July DBO cruise and scientific collections with Canadian colleagues on the CCGS Sir Wilfrid Laurier (SWL) in DBO regions 1-5. Both NOAA and USFWS are also involved in upper trophic level surveys on this cruise. The annual SWL cruise is co-supported with scientists in DFO/Canada who also occupy DBO4 and DBO5 lines in the Beaufort Sea later in the season. 2. NOAA provides core research support for the Aug-Sept USCGC Healy 2017 and planned USCGC Healy 2018 cruises for both DBO sampling and NCIS (Northern Chukchi Integrated Study) process efforts. 3. BOEM through the AMBON (Arctic Marine Biodiversity Observing Network) project occupied DBO3 and DBO4 in 2015 and 2017 on the RV Norseman II. NOAA, NSF and USFWS and previous Shell Oil supports science in AMBON. 4. NPRB Arctic Integrated Ecosystem Research projects occupy DBO2 and 3 lines within larger project study projects in 2017-2019 (Oct 13, 2017 - Completed)

  - NASA has continued to provide support for the DBO project by providing up-to-date data and visualization of weekly sea ice cover, winds, chlorophyll a distribution, surface temperature and cloud cover in the study regions and the entire Arctic. Sea surface salinity, which is very relevant to the project, is now included as one of the parameters. The values have been validated in a recent study published in JGR Oceans (on line in September 2017). (Oct 12, 2017 - Completed)

  - USCGC Healy will provide platform support for a variety of DBO efforts. (Oct 4, 2017 - Completed)
The presentation given at the July Marine Ecosystems Collaboration Team Meeting titled "Experimenting with autonomy: Arctic biogeochemistry and the DBO through autonomous sensors" by Jessica Cross is relevant to this Performance Element (http://www.iarpccollaborations.org/members/events/8927). (Jul 17, 2017 - Completed)

**4.3.2 (In progress) Continue DBO coordination activities including annual workshops, via participation in the Pacific Arctic Group (PAG), and produce the first Pacific Arctic Regional Marine Assessment (PARMA) in 2018.; NOAA (Lead), DOD-ONR, DOI-BOEM, NASA, NSF**

- 1. NOAA sponsored DBO data meetings, such as the upcoming 4th DBO data meeting in November 2017 in Seattle, Washington, USA. 2. US national and international agency support for scientists to attend DBO data workshops. 3. International Arctic Science Committee (IASC) Marine Working Group (MWG) providing early career support for participants to the 2017 4th DBO data meeting, similar to previous DBO data workshops. 4. New paper outlining the development of the DBO project to be published in the journal Arctic (Moore and Grebmeier, 2017), including a description of a 10-year DBO implementation plan and the PARMA. 5. Jackie Grebmeier and Sue Moore in discussions with the IASC MWG to coordinate the first Pacific Arctic Regional Marine Assessment (PARMA) in 2018. 6. Participation in annual fall and spring PAG meetings for coordination of DBO studies. (Oct 13, 2017 - Completed)

The presentation given at the July Marine Ecosystems Collaboration Team meeting titled "The Arctic Marine Pulses Model: Linking Annual Oceanographic Processes to Contiguous Ecological Domains in the Pacific Arctic" by Sue Moore is relevant to this Performance Element (http://www.iarpccollaborations.org/members/events/8927). (Aug 22, 2017 - Completed)

**4.3.3 (In progress) Build connections between DBO and existing community-based observation programs and encourage data sharing. For example, the DBO Implementation Plan discusses fostering connections to existing community-based observation programs in an effort to link offshore observations of biological change to local observations and IK.; NOAA (Lead), NSF (Lead), DOI-BOEM**

- "The Arctic Marine Pulses Model: Linking Annual Oceanographic Processes to Contiguous Ecological Domains in the Pacific Arctic" MECT presentation by Sue Moore is relevant to this PE (http://www.iarpccollaborations.org/members/events/8927). Continuing efforts to develop connections of conventional science mode with local community groups evaluating seasonal events by conventional science and indigenous knowledge. (Oct 13, 2017 - Completed)

The presentation given at the July Marine Ecosystems Collaboration Team meeting titled "The Arctic Marine Pulses Model: Linking Annual Oceanographic Processes to Contiguous Ecological Domains in the Pacific Arctic" by Sue
Moore is relevant to this Performance Element (http://www.iarpccollaborations.org/members/events/8927). (Aug 22, 2017 - Completed)

- **4.3.4 (In progress)** Continue research and make simultaneous observations of biological, chemical, and physical variables to examine linkages among marine species, oceanographic and sea ice conditions, and climate change to understand the mechanisms that affect performance and distribution. Quantify feedbacks and interactions of bottom-up and top-down processes that regulate production. Several projects require the integration of IK.; NOAA (Lead), NSF (Lead)
  - The presentation given at the October 2016 team meeting (https://www.iarpccollaborations.org/members/documents/7149) by Danielle Dickson about the Arctic Integrated Ecosystem Research Program is relevant to this Performance Element. (Oct 30, 2017 - Completed)
  - Nicole Misarti's presentation at the May MECT meeting titled "It’s in their Bones: A Multi-disciplinary, Long-term Investigation into the Sustainability of an Important Subsistence Species—the Pacific Walrus" (http://www.iarpccollaborations.org/members/events/8926) is relevant to this performance element. (May 11, 2017 - Completed)

- **4.3.5 (In progress)** Implement the Regional Action Plan for Southeastern Bering Sea Climate Science and prepare Regional Action Plans for Aleutian Islands and High Arctic Large Marine Ecosystems (LMEs); NOAA (Lead)
  - The presentation given to the Marine Ecosystems Collaboration team in June by Kirstin Holsman and Mike Sigler titled "Climate Science Strategy for the Southeaster Bering Sea Region & the Alaska Climate Integrated Modeling Project (ACLIM)" relates to this Performance Element (http://www.iarpccollaborations.org/members/events/8925). (Jun 15, 2017 - Completed)

- **4.3.6 (In progress)** Conduct numerical simulations using coupled models to evaluate feedbacks across disciplines and systems.; NOAA (Lead), NSF (Lead), DOD-ONR, DOI-BOEM
  - The presentation given to the Marine Ecosystems Collaboration team in June by Kirstin Holsman and Mike Sigler titled "Climate Science Strategy for the Southeaster Bering Sea Region & the Alaska Climate Integrated Modeling Project (ACLIM)" relates to this Performance Element (http://www.iarpccollaborations.org/members/events/8925). (Aug 21, 2017 - Completed)

- **4.3.7 (In progress)** Continue development, testing, and runs of prognostic models that use Intergovernmental Panel on Climate Change (IPCC) scenarios in a regional context to explore current understanding of biophysical interactions and feedbacks, such as perturbations across several modeled food webs from the subarctic to the Arctic to estimate relative
ecosystem sensitivities and rates of change. ; NOAA (Lead), DOD-ONR, DOI-USGS, NSF

- The presentation given to the Marine Ecosystems Collaboration team in June by Kirstin Holsman and Mike Sigler titled "Climate Science Strategy for the Southeaster Bering Sea Region & the Alaska Climate Integrated Modeling Project (ACLIM)" relates to this Performance Element (http://www.iarpccollaborations.org/members/events/8925). (Aug 21, 2017 - Completed)

**Agencies**

DOC, DOD, DOE, DOI, MMC, NASA, NSF, OSTP, USARC
5.1 Glaciers & Sea Level

5.1 Coordinate and integrate observations to improve understanding of the processes controlling the mass balance of Arctic land ice.

- **5.1.1 (In progress)** Maintain support for aircraft and satellite missions that contribute to long-term observations of land ice, including: Landsat-8, ICESat-2, OIB, and the NASA-ISRO Synthetic Aperture Radar (NISAR) mission.; NASA (Lead), DOI-USGS

  Joe MacGregor delivered an OIB update to the G&SLCT during 2017. Using a fleet of research aircraft, NASA’s Operation IceBridge images Earth's polar ice to better understand connections between polar regions and the global climate system. IceBridge studies annual changes in thickness of sea ice, glaciers and ice sheets. IceBridge bridges the gap between the ICESat missions. NASA is planning to continue OIB through FY20. NASA’s annual survey of changes in Arctic ice cover greatly expanded its reach this year in a series of flights that began on March 9 and wrapped up on May 12. It was the most ambitious spring campaign in the region for Operation IceBridge (OIB), an airborne mission to monitor ice changes at Earth’s poles, which also included a rapid-response flight over a new crack in Petermann Glacier, one of the largest and fastest-changing glaciers in Greenland. Geographically, OIB covered a wider area than ever before, and the new instruments deployed provided denser and more accurate measurements. The mission carried out 39 eight-hour flights in 10 weeks. Of those, 13 focused on surveying sea ice, while the remaining 26 flights targeted land ice. Several flights included collaborations with international Ice, Cloud and land Elevation Satellite (ICESat) mission teams to collect and compare measurements of snow and ice. The first part of the campaign was dedicated to overflying the Arctic Ocean’s sea ice cover, plus several fast-changing land ice areas from two sites: Thule Air Base in northwest Greenland and Fairbanks, Alaska. In this campaign, the IceBridge team added an extra base: Longyearbyen, Svalbard. From there, the mission was able to reach areas of the Eurasian side of the Arctic Ocean that had not been explored by IceBridge before. IceBridge also expanded its scope westward with a flight to the western side of the Chukchi Sea, a sea situated between Alaska and Russia. It was the first time the mission ever crossed the International Date Line. Operation IceBridge (OIB) launched a short campaign on July 17, 2017 from Thule Air Base, in northwest Greenland. The IceBridge scientists completed six flights focusing on sea ice that has survived at
least one summer. The sea ice flights surveyed melt ponds, the pools of melt water on the ice surface that may contribute to the accelerated retreat of sea ice. IceBridge also flew a set of tracks to locate areas of sea ice that the mission already flew over in March and April, during its regular springtime campaign, to measure how the ice has melted since then. For its third and final Arctic campaign of 2017, starting in early September, OIB operated from both Thule and Kangerlussuaq to replicate land ice missions that IceBridge completed this past spring. They completed 15 flights over a broad swath of Greenland's ablation, percolation and dry snow zones. (Nov 2, 2017 - Completed)

- NASA focus on High Mountain Asia (Imerzeel group), delineating debris cover is particularly emphasized. Sentinel 2 and other micro satellites are being used extensively to maximize image acquisition due to expanded opportunity to image. Altena and Kaab provide overview of advances using optical and multispectral imagery to estimate ice flow. (Oct 30, 2017 - Completed)

- ArcticDEM Release 6 (Polar Geospatial Center) brings terrain coverage of the Arctic to 97.4% at 5m resolution. (Sep 29, 2017 - Completed)

- Tom Neumann delivered a talk at the July GSLCT meeting, progress continues towards launch which is now projected for Dec. 2018. The SV will greatly improve data quality as compared to ICESat-1. (Sep 29, 2017 - Completed)

- As of August 2017: The assembly of the two GRACE-FO satellites was completed at the Airbus Defense and Space facility in Friedrichshafen, Germany and the spacecraft were shipped to the IABG (INDUSTRIEANLAGEN-BETRIEBSGESELLSCHAFT MBH) environmental test facilities in Ottobrun, Germany. Environmental testing is almost complete and final preparations will begin soon to ship the satellites to the Vandenberg Air Force Base by the end of the year. The GRACE-FO spacecraft will be launched with five Iridium NEXT satellites on a SpaceX Falcon 9 rocket in Spring 2018. (Sep 29, 2017 - Completed)

- NASA continues to work in partnership with the Indian Space Research Organization (ISRO), to develop the NASA-ISRO Synthetic Aperture Radar (NISAR) mission, to measure time-varying displacements of ice-covered surfaces to infer ice flow and extent in Arctic glaciers, ice caps, and the Greenland Ice Sheet. NISAR is proceeding on schedule with Critical Design Reviews through FY18, contracts for major subsystems are in place, and engineering and flight models of subsystems are in fabrication towards a launch readiness date at the end of 2021. (Sep 29, 2017 - Completed)

- Presentations at the June 15th Glaciers and Sea Level Collaboration Team meeting (http://www.iarpccollaborations.org/members/events/7787) by Joe MacGregor, Tom Neumann, and Ian Howat relate to this Performance Element (5.1.1). (Jun 16, 2017 - Completed)

- The MEaSUREs Greenland Ice Mapping Project (GIMP) Digital Elevation Model from GeoEye and WorldView Imagery data set is now available at the NASA National Snow and Ice Data Center Distributed Active Archive Center (NSIDC
DAAC). This data set, part of the Making Earth System Data Records for Use in Research Environments (MEaSUREs) Program, consists of an enhanced resolution digital elevation model (DEM) for the Greenland Ice Sheet derived from sub-meter resolution, panchromatic stereoscopic imagery collected by the GeoEye-1, WorldView 1, WorldView 2, and WorldView 3 satellites operated by DigitalGlobe Inc. Data Acknowledgements - Data authors: Ian Howat, Adelaide Negrete, Ben Smith. Data set DOI: http://dx.doi.org/10.5067/H0KUYVF53Q8M Data center: NSIDC DAAC (http://nsidc.org/daac)

- 5.1.2 (In progress) Enable the collection of ground-based observations and associated aircraft measurements documenting variability of land ice on a variety of spatial and temporal scales, including: the Greenland Ice Sheet Monitoring Network (GLISN), the Oceans Melting Greenland (OMG) mission, the U.S. Geological Survey (USGS) Benchmark Glaciers Program in Alaska (and the the Ice2O project in Alaska.; NASA (Lead), DOI-USGS, NOAA, NSF

- On Jan 25 - 27, 2017 the workshop on The Future Shape of a Greenland GNSS Observation Network was held at NASA's Goddard Space Flight Center (https://www.dartmouth.edu/~ice/GNET_workshop.php). The purpose was to define a path forward for a Global Navigation Satellite System (GNSS) observation network in Greenland. There are many means for determining Greenland ice mass loss, but almost all rely on some form of satellite positioning, generally using GNSS or its subset Global Positioning System (GPS). Thus, a network of geodetic-quality GNSS receivers is desirable. The goals of the workshop were: Elucidate the current state of the network, Illustrate the current uses of network data (e.g. Geodessey, Crustal deformation, Campaign GNSS reference, atmospheric modeling, Space weather/ionsphere), Identify potential new utility of the data, Determine the optimal configuration moving forward: Ideal number of stations, Placement of stations, Replacement and upgrade of stations, data management. The workshop brought together: investigators using data produced by the current network, potential new investigators who can make use of GNSS network data, experts in the use of GNSS data for positioning, experts in the use of GNSS as a remote-sensing tool (atmospheric water vapor, ionospheric electron content, and multipath utilization for sensing of conditions proximal to the station such as snow depth, vegetation, and mapping of transient areas covered by liquid water), and the people involved in actually deploying GNSS reference stations around Greenland. A 37-page white paper was produced by the workshop participants with five specific recommendations: 1) Continue to support the continuous and autonomous operation of the current configuration of GNET; 2) Maximize the utility of the current data by promoting the existing data distribution model; 3) Encouraging new uses of GNET data, such as tropospheric zenith delay analyses to improve atmospheric models; 4) Densify the current network to better resolve those areas of maximum gradient in GIA and/or regions of rapid glacier change; and 5) Consider a scoring scheme for evaluating the relative importance of existing stations. The report discusses: the current state of the network; current and future science using GNET data; data management; and
the best configuration moving forward. A paper using GNET data also was published in Geophysical Research Letters by S. Adhikari, E. R. Ivins, and E. Larour in May 2017 available at: http://onlinelibrary.wiley.com/doi/10.1002/2017GL073478/full. The abstract is below. The annual cycle and secular trend of Greenland mass loading are well recorded in measurements of solid Earth deformation. Horizontal crustal displacements can potentially track the spatiotemporal detail of mass changes with great fidelity. Our analysis of Greenland crustal motion data reveals that a significant excitation of horizontal amplitudes occurs during the intense melt years. We discover that solitary seasonal waves of substantial mass transport \((1.67 \pm 0.54 \text{ Gt/month})\) traveled at an average speed of 7.1 km/month through Rink Glacier in 2012. We deduce that intense surface melting enhanced either basal lubrication or softening of shear margins, or both, causing the glacier to thin dynamically in summer. The newly routed upstream subglacial water was likely to be both retarded and inefficient, thus providing a causal mechanism for the prolonged ice transport to continue well into the winter months. As the climate continues to produce increasingly warmer spring and summer, amplified seasonal waves of mass transport may become ever more present with important ramifications for the future sea level rise. (Sep 29, 2017 - Completed)

Since the beginning of the year NASA’s Ocean Melting Greenland (OMG) campaign: Flew its second year of the GLISTIN survey, which is designed to collect elevation maps overall marine terminating glaciers in Greenland. We are still processing the 2017 data, but we are beginning to look at elevation changes between 2016 and 2017 for a number of glaciers around Greenland. Had its third science team meeting, where early results were presented from the ship-based bathymetry surveys in 2015 and 2016. With these data, we are beginning to get a sense of which glaciers sit in deep fjords and work is ongoing to connect these observations of seafloor depth with estimates of the bedrock depth below the glaciers. This is a key activity for helping us understand how much of the ice sheet could be affected by changes in the oceans. In addition, early looks at the airborne gravity observations, collected in 2016 are providing additional estimates of seafloor depth. Finally, we are beginning to analyze oceanographic data from the ship surveys and last year’s AXCTD survey. Early indications suggest long-term warming in East Greenland. Three initial OMG publications are as follows: 1) Oceans Melting Greenland: Early Results from NASA’s Ocean-Ice Mission in Greenland, Ian Fenty, Josh K. Willis, et al. Early results suggest that many glaciers terminate in deep water and are hence vulnerable to increased melting due to ocean-ice interaction. Fenty, I., J.K. Willis, A. Khazendar, S. Dinardo, R. Forsberg, I. Fukumori, D. Holland, M. Jakobsson, D. Moller, J. Morison, A. Münchow, E. Rignot, M. Schodlok, A.F. Thompson, K. Tinto, M. Rutherford, and N. Trenholm. 2016. Oceans Melting Greenland: Early results from NASA’s ocean-ice mission in Greenland. Oceanography 29(4):72–83, https://doi.org/10.5670/oceanog.2016.100. ABSTRACT. Melting of the Greenland Ice Sheet represents a major uncertainty in projecting future rates of global sea level rise. Much of this uncertainty is related to a lack of knowledge about subsurface ocean hydrographic properties, particularly heat content, how
these properties are modified across the continental shelf, and about the extent to which the ocean interacts with glaciers. Early results from NASA’s five-year Oceans Melting Greenland (OMG) mission, based on extensive hydrographic and bathymetric surveys, suggest that many glaciers terminate in deep water and are hence vulnerable to increased melting due to ocean-ice interaction. OMG will track ocean conditions and ice loss at glaciers around Greenland through the year 2020, providing critical information about ocean-driven Greenland ice mass loss in a warming climate. 2) Improving Bed Topography Mapping of Greenland Glaciers Using NASA’s Oceans Melting Greenland (OMG) Data, Mathieu Morlighem, Eric Rignot, and Josh K. Willis et al. Northwest coast of Greenland reveals complex structural features in bed elevation, such as valleys, ridges, bumps, and hollows, which have important implications for both channeling ice flow toward the continental margin, and for controlling the amount of warm, salty Atlantic Water that reaches the glaciers. Morlighem, M., E. Rignot, and J.K. Willis. 2016. Improving bed topography mapping of Greenland glaciers using NASA’s Oceans Melting Greenland (OMG) data. Oceanography 29(4):62–71, https://doi.org/10.5670/oceanog.2016.99. ABSTRACT. Melting of the Greenland Ice Sheet has the potential to raise sea level by 7.36 m and is already contributing to global sea level rise at a rate higher than 1 mm yr−1. Computer models are our best tools to make projections of the mass balance of Greenland over the next centuries, but these models rely on bed topography data that remain poorly constrained near glacier termini. Accurate bed topography in the vicinity of calving fronts is critical for numerical models, as the shapes of the glacier bed and of the nearby bathymetry control both the ocean circulation in the fjord and the stability and response of the ice sheet to climate warming. NASA’s Oceans Melting Greenland (OMG) mission is collecting bathymetry data along Greenland fjords at several glacier termini. Here, we show that these measurements are transforming our knowledge of fjord and glacier depths. Using a mass conservation approach, we combine OMG bathymetry with observations of ice velocity and thickness to produce estimates of bed depth and ice thickness across the ice-ocean boundary with unprecedented accuracy and reliability. Our results along the northwest coast of Greenland reveal complex structural features in bed elevation, such as valleys, ridges, bumps, and hollows. These features have important implications for both channeling ice flow toward the continental margin, and for controlling the amount of warm, salty Atlantic Water that reaches the glaciers. 3) The Ice Shelf of Petermann Gletscher, North Greenland, and Its Connection to the Arctic and Atlantic Oceans, Andreas Münchow, Laurie Padman, Peter Washam, and Keith W. Nicholls. Floating ice shelf is strongly coupled to the ocean below and to Nares Strait at time scales from tidal to interannual. Münchow, A., L. Padman, P. Washam, and K.W. Nicholls. 2016. The ice shelf of Petermann Gletscher, North Greenland, and its connection to the Arctic and Atlantic Oceans. Oceanography 29(4):84–95, https://doi.org/10.5670/oceanog.2016.101 Abstract: Petermann Gletscher in North Greenland features the second largest floating ice shelf in the Northern Hemisphere. This paper describes the history of its exploration and presents new ocean and glacier observations. We find that the floating ice shelf is strongly
coupled to the ocean below and to Nares Strait at time scales from tidal to interannual. Our observations cover the 2012 to 2016 period after two large calving events took place in 2010 and 2012 that reduced the ice shelf area by 380 km² to about 870 km² today. A potential third breakup, of an additional 150 km², is anticipated by a large fracture that extends from the margin to the center of the glacier. (Sep 29, 2017 - Completed)

- USGS Benchmark Glacier Mass Balance project was successful in 2017, all trips completed at to 4 glaciers (Gulkana, Wolverine, SouthCascade, Sperry). Method development for consistent and combined geodetic analysis being developed. Project funding was cut by 5% in FY17, and was prioritized for funding in FY18 within the USGS land Resources program (formerly climate and land use change). (Sep 29, 2017 - Completed)

- USGS funded Ice2O in 2017, and glaciological, hydrological, geochemical, ecological, and oceanographic components occurred. Two NSF Graduate Research Fellows were sponsored for internships in this program. (Sep 29, 2017 - Completed)

- Presentations given by Kristin Lairde (http://www.iarpccollaborations.org/members/documents/9180) and Mayumi Arimitsu (http://www.iarpccollaborations.org/members/documents/9179) given at the May GSLCT Meeting on the biophysical linkages between glaciers and coastal ecosystem (perspectives from Alaska and Greenland) (http://www.iarpccollaborations.org/members/events/7688) are relevant to this PE (May 11, 2017 - Completed)

- 5.1.3 (In progress) Support investigator-driven studies of land ice process studies across the Arctic, including ocean-glacier interactions, surface and subglacial hydrology, surface mass balance, local surface melt and refreezing, firn densification, glacial isostatic adjustment, iceberg melting, surface energy budget, and related observations.; NSF (Lead), DOI-USGS, NASA, NOAA

  - The presentations given by Max Stevens, Clement Miege, Kristin Poinar and Shad O'Neel on the current efforts to model and observe wet firn at the October Glaciers & Seal Level Collaboration Team meeting are relevant to this Performance Element (https://www.iarpccollaborations.org/members/events/7791) (Oct 27, 2017 - Completed)

  - NPS mass balance- long-term on Kahiltna (Denali), and Exit/Harding (Kenai fjords), plus new initiatives in Wrangell-St. Elias intended for remote sensing and model validation. USGS initiated a wet firn densification project, and has continued GPR collection over several glaciers in Alaska. USGS has supplemented and re-analyzed SMB data from Taku and Lemon Creek glaciers, expanding the long-term mass balance coverage to additional datasets. NASA's 2016 Cryospheric Sciences program solicitation (https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solfld={83430ECB-D429-AD41-4BD1-2BF5F8C50768}&path=closedPast) released in Feb 2016 and closed in April 2017 seeks to understand the mechanisms of
change in ice in the polar regions and their implications for global climate, sea level and the polar environment. To accomplish this, supported studies will use space-based and aircraft-based remote-sensing techniques to understand the factors controlling the retreat and growth of the world’s sea ice and major land-based ice sheets, and their interactions with the ocean, atmosphere, solid Earth and solar radiation. Specifically, the program seeks to: Determine the mechanisms controlling sea-ice cover, including quantification of the connections between sea ice and the ocean and atmosphere; Use remote sensing to validate and improve predictive models of changes in sea-ice cover, especially on decadal timescales and to elucidate connections to the global system; Determine the mechanisms controlling mass balance and dynamics of the Greenland and Antarctic ice sheets, including studies aimed at improving fundamental understanding of ice flow, ice shelves, grounding lines, bed, melt water formation and role, and connections to the ocean, sea-ice cover and atmosphere; Use remote-sensing data to validate and improve predictive models of the contribution of land-based ice to sea-level change, especially in the coming century. The Studies with ICESat and CryoSat-2 program (https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&sollid={B491EC6F-24F3-507F-F7D9-E35D75745853}&path=closedPast) solicited investigations to derive geophysical information from NASA’s Ice, Cloud, and land Elevation Satellite (ICESat) and the European Space Agency’s CryoSat-2, and link these records with the initial data stream from ICESat-2, scheduled for launch in 2018. These altimetry missions were optimized to characterize changes in the Greenland and Antarctic ice sheets, and the sea ice of the Arctic and Southern Oceans. The missions’ primary goals are to understand the contributions of polar land ice to current and future sea level rise, and the coupling of changes in polar sea ice cover to the Earth system. Selections made in Dec 2016 of relevance to the performance element include: Using ICESat/OIB Elevation and Satellite-Derived Velocity Changes to Constrain Time-Varying Basal Motion; Decadal-Scale Variability and Trends in Arctic Sea Ice Thickness and Volume; Integration of Altimeter Data from ICESat, IceBridge, CyroSat-2 and IceSat-2 -- Mathematical Approaches and Applications to Glacial Change; West Antarctic Elevation History Leading up to ICESat 2: Multi-Sensor Observation and Model-Based Analysis; Constraining Mass Balance Uncertainties in East Antarctica from 2003 to the Present with Laser and Radar Altimetry Observations; Data Assimilation of Altimetry Signals Using the Ice Sheet System Model; Combining Satellite Altimetry, IceBridge and Atmospheric Reanalyses to Map Antarctic Ice Sheet Surface Mass Balance at Very High Resolution; Understanding the Climate Drivers of Antarctic Ice Shelf Changes Through Analyses of Multi-Mission Satellite Altimetry, Airborne Remote Sensing and Models; Investigating Snow Accumulation Variability for Development of a Multi-Sensor Elevation Time Series Pole-Ward of 86°S in Support of Altimetry Validation and Ice Sheet Mass Balance Studies; and Combining Altimetry with Electromagnetic and Regional-Climate Models for Improved Estimation of Greenland Ice Sheet Mass Balance. (Sep 29, 2017 - Completed)
• **5.1.4 (In progress) Enhance national and international communication and collaboration concerning land ice state and processes, for example, through support of the activities of the SEARCH Land Ice Action Team.**; NSF (Lead), NASA
  - A workshop for the GLIMS (Global Land Ice Measurements from Space) initiative was held in Boulder, CO during August 2017, with the purpose of getting input from the GLIMS team and greater community on future needs and directions for GLIMS. USGS briefed congressional staffers on glacier change and glacier ecosystem linkages. (Sep 29, 2017 - Completed)

5.2 Improve numerical models to enhance projection of ice loss from Arctic land ice and the consequent impact on global sea level, and to better understand the predictability of these processes.

• **5.2.1 (In progress) Enable the development and assessment of ice sheet models, both as stand-alone models and within the context of earth system models, including: the Ice Sheet System Model (ISSM), the Community Ice Sheet Model (CISM), the Community Earth System Model (CESM), the Accelerated Climate Modeling for Energy (ACME) project, the Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) and the Land Ice Verification and Validation (LIVV) Toolkit.**; NASA (Lead), NSF (Lead), DOE
  - Continued to develop the Ice Sheet System Model (ISSM), a massively parallelized, multipurpose finite-element framework to model the mass balance of the Greenland and Antarctica Ice Sheets in the near future. Deploy new data assimilation capabilities to best integrate NASA satellite data as well as in-situ data into reconstructions and projections of the state of the Cryosphere. Beginning to understand interactions between the Cryosphere and other components of the Earth System, in particular, ice/ocean and ice/atmosphere interactions, to better constrain projections of the contribution of ice sheets to future sea-level. (Sep 29, 2017 - Completed)
  - GSLCT hosted a meeting where several CISM model developers shared insight into the effort. (Sep 29, 2017 - Completed)
  - This focuses on Greenland from Aug 2016 - Aug 2017: The Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) published experimental and data request protocols as part of the CMIP6 special issue in Geoscientific Model Development in Dec 2016. The first set of experiments targeting the Greenland standalone ice sheet modeling community, initMIP-Greenland, were completed by 17 international groups, and the results submitted to the journal “Cryosphere” in July 2017. initMIP-Greenland seeks to understand and reduce the uncertainty in sea level projections due to the choice of model initialization methods. The

- The Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) published experimental and data request protocols as part of the CMIP6 special issue in Geoscientific Model Development in Dec 2016. The first set of experiments targeting the Greenland standalone ice sheet modeling community, initMIP-Greenland, were completed by 17 international groups, and the results submitted to the journal “Cryosphere” in July 2017. initMIP-Greenland seeks to understand and reduce the uncertainty in sea level projections due to the choice of model initialization methods. The ISMIP6 and initMIP-Greenland efforts were presented at national and international conferences (AGU 2016, EGU 2017, International WCRP/IOC Conference on Regional Sea Level Changes and Coastal Impacts) and to the IARPC Glacier and Fjord CT and Modeling CT in March 2017. ISMIP6 organized two workshops in Dec 2016 -Initialization of ice sheet models, and oceanic forcing for ice sheet models- and one splinter meeting at EGU2017. (Sep 29, 2017 - Completed)

- Presentations by Sophie Nowicki, Helene Serroussi, Jeremy Fyke, and Andy Aschwanden at the March Glaciers & Sea Level CT meeting on the Ice Sheet Model Intercomparison Project (ISMIP6) contribution to CMIP6 (a programatic and participant point of view) are relevant to this Performance Element. [http://www.iarpccollaborations.org/members/events/7496](http://www.iarpccollaborations.org/members/events/7496) (Jul 24, 2017 - Completed)

5.2.2 (In progress) Develop data sets to be used as boundary and forcing functions for ice sheet, ice cap, and glacier models, including improving regional reanalyses focused on the greater Arctic, improving global reanalysis systems in ways that are relevant to the Arctic, and promoting joint observation-modeling-reanalysis-forecasting activities.; NASA (Lead), DOD-NRL, DOD-ONR, NOAA, NSF

- In 2016, the NASA Global Modeling and Assimilation Office (GMAO) released the MERRA-2 atmospheric reanalysis for the period 1980 to the present. MERRA-2 provides an improved representation of cryospheric processes including an advanced surface representation over glaciated land and the application of a cubed-sphere model grid to better resolve high latitude circulation. The GMAO has also produced the M2R12K, which is a global, 12.5km grid-spaced “replay” analysis of MERRA-2 spanning the years 2000-2014. The higher spatial resolution allows for an improved representation of atmospheric circulation along the steep topography of the
Greenland Ice Sheet. As part of an update to the seasonal forecasting system, the GMAO is currently integrating a new ocean reanalysis: MERRA-2/Ocean, which has an improved representation of Arctic ice thickness and a more detailed suite of diagnostics for use in passive tracer simulations. (Sep 29, 2017 - Completed)

- The September Glaciers & Sea Level Collaboration Team meeting on open data featuring the following speakers is relevant to this Performance Element:
  Anthony Arednt (University of Washington) who has been working with the NASA High Mountain Asia project, and is currently hosting a geohack at UW where participants are exploring open source collaboration tools among other topics. Lora Koeing (NSIDC) just released the SUMup data set through NSF ’s Arctic Data Center which contains a synthesized inventory of snow/firn observations primarily from Greenland. Fiamma Straneo (Woods Hole) who has worked with the GRISO Research Coordination Network Group to make data from Greenland available to anyone. ([https://www.iarpccollaborations.org/members/events/7790](https://www.iarpccollaborations.org/members/events/7790)) (Sep 26, 2017 - Completed)

5.2.3 (In progress) Support investigator-driven modeling projects designed to understand and parameterize important land ice processes, including studies of mélange rheologies and dynamics, wet and dry firn processes, meltwater infiltration and refreezing, interactions between the glacier front and subglacial outflow plumes, and basal sliding laws.

- The GMAO has also produced the M2R12K, which is a global, 12.5km grid-spaced “replay” analysis of MERRA-2 spanning the years 2000-2014. The higher spatial resolution allows for an improved representation of atmospheric circulation along the steep topography of the periphery of the Greenland Ice Sheet. Oregon State runoff model output (D. Hill) widely requested, especially among oceanographic community. Two papers published in WRR. Several impactful publications link observations and models for example, Brinkerhoff 2017 developed a numerical model that captures the tidewater glacier cycle even under steady climate. (Sep 29, 2017 - Completed)

- As part of an update to the seasonal forecasting system, the GMAO is currently integrating a new ocean reanalysis: MERRA-2/Ocean, which has an improved representation of Arctic ice thickness and a more detailed suite of diagnostics for use in passive tracer simulations. (Sep 29, 2017 - Completed)

**Agencies**
DOC, DOE, DOI, NASA, NSF, OSTP, USARC
6.1 Permafrost

6.1 Improve understanding of how climate, physiography, terrain conditions, vegetation, and patterns of disturbance interact to control permafrost dynamics.

- 6.1.1 (In progress) Continue to conduct and coordinate monitoring and modeling of permafrost temperature across a wide range of terrain units and climatic zones and to use obtained data to refine relationships between the ground thermal regime of shallow and deep permafrost and terrain properties.; NSF (Lead), DOD-USACE, DOE, DOI-NPS, DOI-USGS, NASA, NOAA, USDA-NRCS

- Related publications in FY2017:
  

- Miriam Jones' (USGS) presentation at the October Permafrost Collaboration Team meeting on Holocene permafrost dynamics and implications for permafrost thaw is relevant to this Performance Element. (https://www.iarpccollaborations.org/members/events/7798) (Oct 16, 2017 - Completed)

- Ronald Daanen's (Alaska Department of Natural Resources) presentation at the September Permafrost Collaboration Team meeting on permafrost remote sensing through airborne electromagnetic geophysics and thermal anomalies is relevant to this Performance Element. (https://www.iarpccollaborations.org/members/events/7797) (Sep 25, 2017 - Completed)
ABoVE Contributions: Monitoring of ground temperature and/or soil moisture at multiple sites across the ABoVE Study Domain in order to study factors controlling permafrost dynamics (Sep 15, 2017 - Completed)

Torre Jorgenson gave a presentation titled “Progress Toward Understanding the Response of Permafrost to Climate Change in Alaska” at the May Permafrost Collaboration Team meeting relates to this performance element: http://www.iarpccollaborations.org/members/events/7687 (May 11, 2017 - Completed)

6.1.2 (In progress) Conduct field-based research that examines and quantifies relationships among surface topography, vegetation composition, hydrology, disturbance effects (including fire and thermokarst), and geophysical processes in permafrost soils to feed directly into models, decision support tools, and predictive analyses.; DOE (Lead), NSF (Lead), DOI-NPS, DOI-USGS, NASA

Related publications in FY2017:

ABoVE contributions: The ABoVE Science Team is carrying out a community assessment of active layer conditions, including active layer depth and soil moisture, and their spatial heterogeneity as represented by different types of measurements at different spatial scales, ranging from local ground measurements to landscape and regional scale observations from airborne and satellite remote sensing. (Sep 15, 2017 - Completed)
- Torre Jorgenson gave a presentation titled “Progress Toward Understanding the Response of Permafrost to Climate Change in Alaska” at the May Permafrost Collaboration Team meeting relates to this performance element: http://www.iarpccollaborations.org/members/events/7687 (May 11, 2017 - Completed)

- **6.1.3 (In progress)** Support field-based research to improve understanding of how changes to Arctic lake and river ecosystems affect permafrost stability, water availability, and habitat provision, with a particular focus on wintertime ice regimes.; NSF (Lead), DOI-BLM, DOI-FWS, DOI-NPS, DOI-USGS, NASA

- Related publications in FY2017:

- **6.1.4 (In progress)** Integrate field, laboratory, and remote sensing information to map local, regional, and global permafrost-influenced landscape dynamics and their impact on vegetation, hydrology, terrestrial and aquatic ecosystems, and soil carbon dynamics in the Arctic. Develop
spatially-explicit decision support systems and predictive tools.; DOE (Lead), DOI-FWS, DOI-NPS, DOI-USGS, NASA, NOAA, NSF

- Related publications in FY2017:
  


Special Issue on Remote Sensing of Dynamic Permafrost Regions: This special issue will appear open access in the journal Remote Sensing and guest editors are Benjamin Jones, Annett Bartsch, and Guido Grosse. For more information on the special issue (http://www.mdpi.com/journal/remotesensing/special_issues/Dynamic_Permafrost) and manuscript preparation and related matters can be found in the instructions for authors (http://www.mdpi.com/journal/remotesensing/instructions) (Oct 30, 2017 - Completed)

ABOVE contributions: Monitoring of key ecosystem characteristics in areas with different permafrost dynamics in order to understand the role of permafrost in key ecosystem processes, including vegetation dynamics and soil carbon cycling (Sep 15, 2017 - Completed)

Torre Jorgenson gave a presentation titled “Progress Toward Understanding the Response of Permafrost to Climate Change in Alaska” at the May Permafrost Collaboration Team meeting relates to this performance element: http://www.iarpccollaborations.org/members/events/7687 (May 11, 2017 - Completed)

- 6.1.5 (In progress) Support activities, including the SEARCH Permafrost Action Team, to foster continued efforts to link multi-agency investments while expanding empirical datasets and synthesizing information that will inform the development of an updated permafrost ground ice content map for Alaska.; NSF (Lead), DOD-USACE, DOE, DOI-BLM, DOI-FWS, DOI-NPS, NASA, NOAA


- The steering group of the Permafrost Action Team met on June 26, 2017 in Fairbanks, AK: The purpose of the meeting was to discuss material needed for three different types of Knowledge Pyramids and to produce a short 2-page written brief that can be distributed to a wide variety of interested people. The short briefs provide scientific information on societally-relevant questions in formats usable by a variety of stakeholders, including policy- and decision-makers. During the workshop, we focused on these three top-level questions: 1) What is the impact of permafrost carbon release on climate change? 2) How does permafrost thaw impact infrastructure? 3) How will ecosystem services critical to human livelihood in the Arctic be affected by permafrost thaw? The second half of the workshop was dedicated to brainstorming new synthesis products that focus on issues involving infrastructure and ecosystem services in the permafrost zone. (Oct 30, 2017 - Completed)

6.2 Improve and expand understanding of how warming and thawing of permafrost influence the vulnerability of soil carbon, including the potential release of carbon dioxide (CO2) and methane (CH4) to the atmosphere.
• 6.2.1 (In progress) Support field-based research and monitoring focused on quantifying the key processes controlling soil carbon cycling at northern latitudes and potential carbon release to the atmosphere, including temperature and hydrological effects.; NSF (Lead), DOD-USACE, DOE, DOI-BLM, DOI-FWS, DOI-NPS, DOI-USGS, NASA

  o Relevant publications in FY2017:


  o Digital Database and Maps of Quaternary Deposits in East and Central Siberia: The primary goal for creating this digital database was to enhance current estimates of organic carbon stored in deep permafrost, in particular Late Pleistocene syngenetic ice-rich loess permafrost deposits, called Yedoma. This digital database is the product of collaboration between the U.S. Geological Survey, the Alfred Wegener Institute for Polar and Marine Research Potsdam, Foothill College GeoSpatial Technology Certificate Program, and the Geophysical Institute at the University of Alaska. With many thanks to Umakant Mishra and Andrew Balser for their thoughtful, thorough reviews. Here is the link to the database: 
    https://www.sciencebase.gov/catalog/item/587546b3e4b0a829a325a276 (Oct 30, 2017 - Completed)

  o Robyn provided an overview of work on permafrost microbiology spanning the late Pleistocene to the present, with linkages to, and implications for, shifting ecosystem processes and community dynamics through that timeframe at the June 17th PCT meeting. Her presentation is available at: 
    http://www.iarpccollaborations.org/members/documents/9462. The recording of her presentation is available at: 
    http://www.iarpccollaborations.org/members/events/7794. (Jun 26, 2017 - Completed)

• 6.2.2 (In progress) Support research to improve scaling methods for estimating CO2 and CH4 emissions from the permafrost region (including that which is conducted by the SEARCH Permafrost Action Team) to link multi-agency investments in soil carbon research that culminates in synthesis publications.; NSF (Lead), DOD-USACE, DOE, NASA, NOAA

  o Relevant publications in FY2017:


- Resolving a methane mystery in the Arctic: The Permafrost Carbon Network together with the Study of Environmental Arctic Change organized the International Workshop to Reconcile Methane Budgets in the Northern Permafrost Regions. The workshop was funded by the National Science Foundation, NASA, the U.S. Geological Survey, and the U.S. Arctic Research Commission. There is a clear need for the scientific community to better understand the sensitivity of methane emissions to ongoing climate change in the northern permafrost region. Read more in Eos article: (https://eos.org/meeting-reports/resolving-a-methane-mystery-in-the-arctic). (Oct 30, 2017 - Completed)

- Arctic Answer Brief on ‘Climate Change and the Permafrost Carbon Feedback’: As part of the Study of Environmental Arctic Change, the Permafrost Action Teams has prepared short science briefs centered on relevant topics related to degrading permafrost. All Arctic Answers provide scientific information in a format that can be used by scientists, stakeholders, policy- and decision-makers, as well as students and journalists. This is a great resource for short and up to date summaries of various Arctic related topics. Here is the link to the brief on Climate Change and the Permafrost Carbon Feedback (https://www.arcus.org/files/page/documents/19092/arctic-answers-2017permafrost.pdf). (Oct 30, 2017 - Completed)

- **6.2.3 (In progress) Utilize empirical, multi-scale approaches to make spatially-explicit estimates of vulnerability of permafrost carbon and release of both CO2 and CH4.; DOE (Lead), DOD-USACE, DOI-USGS, NASA**

  - Related publications in FY2017:

- **6.2.4 (In progress) Utilize empirical, multi-scale approaches to make spatially explicit estimates of the potential extent and modes of abrupt permafrost**
thaw, including thermokarst and cryogenic landslides, and of the downstream effects of these events on microbial processes and carbon fluxes.; DOI-USGS, NSF

- Related publication in FY2017:

- 6.2.5 (In progress) Better understand the rate of subsea permafrost degradation and its role in methane gas hydrate decomposition and feedbacks to the climate system. Develop estimates of contributions to atmospheric carbon from subsea permafrost sources at present and under future scenarios.; DOI-USGS (Lead), DOI-BOEM, NOAA, NSF

- Related publications in FY2017:


- Expert assessment on subsea permafrost: Ben Abbott from Brigham Young University, Jennifer Frederick from Sandia National Laboratory, and Brett Thornton from Stockholm University are leading an expert assessment on subsea permafrost. Questions will concern the current extent of subsea permafrost, carbon type and stocks, and potential changes in emissions. The Permafrost Carbon Network is supporting this activity and has sent out a request for participation with the survey design and background information. There will be a breakout discussion on this topic at the 7th Annual Meeting of the Permafrost Carbon Network on December 10, 2017 in New Orleans (Oct 30, 2017 - Completed)

- A collaboration between USGS Coastal and Marine Geology Program researchers and Bruce Herman, now retired from the Bureau of Ocean Energy Management (BOEM) in Anchorage, Alaska, has produced the most complete information to date about the seaward extent of remaining subsea permafrost and possible relict gas hydrate beneath the U.S. Beaufort Sea margin at the edge of the Arctic Ocean. Using industry seismic reflection data

6.3 In collaboration with efforts described under the Terrestrial Ecosystems Goal, continue to improve integration of empirically measured permafrost processes into models that predict how climate change, hydrology, ecosystem shifts and disturbances interact within terrestrial and freshwater aquatic systems to impact permafrost evolution, degradation, and feedbacks from local landscapes to the circum-Arctic.

- **6.3.1 (In progress)** Conduct field-based research and monitoring needed to improve understanding of the linkages between key terrestrial ecosystem processes and permafrost properties and to incorporate empirical information into modeling efforts at various scales.; DOE (Lead), NSF (Lead), DOD-USACE, DOI-BLM, DOI-NPS, DOI-USGS, NASA, USDA-USFS
  
  o The presentation by Robyn Barbato titled "The permafrost microbiome to reveal past biodiversity patterns in Alaskan soils representing the Holocene and the late Pleistocene" at the June Permafrost Collaboration Team Meeting relates to this Performance Element [http://www.iarpccollaborations.org/members/events/7794](http://www.iarpccollaborations.org/members/events/7794). (Jul 24, 2017 - Completed)

- **6.3.2 (In progress)** Carry out research to quantify and integrate across scales, the effects of warming permafrost on ecosystem processing related with disturbance regimes, including fire, thermokarst, and landscape changes.; DOI-BOEM (Lead), DOI-USGS (Lead), NSF (Lead), DOD-USACE, DOI-BLM, DOI-NPS, NASA, USDA-USFS
Related publications in FY2017:


ABoVE contributions: Developed approaches to utilize knowledge from field based studies and remote products to improve models in order to assess the impacts of variations in the permafrost regime on ecosystem processes (Sep 15, 2017 - Completed)

6.3.3 (In progress) Facilitate and harmonize the production of key geospatial datasets from extensive field measurements, remotely-sensed, and other data sources needed for model initialization, calibration, and validation. Organize and host workshops to enable this activity across agencies engaged in data development with attention to data congruity and scalability.; NASA (Lead), DOD-USACE, DOE, DOI-NPS, NSF

Related publications in FY2017:


ABoVE contributions: a. Continued research on the development and validation of InSAR approaches to estimate annual active layer thickness using spaceborne SAR data. b. Carried out the collection of airborne P- and L-band SAR data along with surface observations in May to September 2017 at sites across the ABoVE Study Domain to develop new remote sensing products for monitoring of permafrost characteristics (Sep 15, 2017 - Completed)

6.3.4 (In progress) Support continued development of robust modeling tools and approaches to integrate models of ecosystem processes at various scales since permafrost dynamics are integral to these processes and vice-versa.; DOE (Lead), DOD-USACE, DOI-BLM, DOI-NPS, NASA, NOAA, NSF

Related publications in FY2017:

6.4 Determine how warming and thawing permafrost impacts infrastructure and human health.

- **6.4.1 (In progress)** Survey Federal research agencies and non-Federal partners/stakeholders on their use of tools, methods, and means to monitor changes in landscape conditions due to changes in permafrost with a focus on hazards to infrastructure and health. Develop, enhance, and update “Best Practices” guides for mitigation of impacts to building foundations and other infrastructure.; DOD-OSD, DOD-USACE, DOI-BIA, EPA, HHS

  - Related publications in FY2017:

- **6.4.2 (In progress)** In collaboration with relevant Indigenous organizations, survey local communities and regional agencies—those which maintain infrastructure and monitor health—on the impacts of warming and thawing permafrost. Integrate these responses within a document characterizing and summarizing overall impacts of warming and thawing permafrost.; DOD-USACE, DOI-BLM, EPA, HHS, NOAA

  - Related publications in FY2107:

**Agencies**
DOC, DOE, DOI, NASA, NSF, OSTP
Terrestrial Ecosystems Collaboration Team

Performance Element Reporting Log 2017

(Some links in this summary require an account on IARPC Collaborations Website. Please visit www.iarpccollaborations.org to request an account.)

7.1 Terrestrial Ecosystems

7.1 Improve understanding of and ability to model feedbacks and interactions among the large-scale processes causing change (climate, natural disturbances, and human-caused perturbations) and the responses of terrestrial and freshwater ecosystems.

- 7.1.1 (In progress) Carry out and synthesize results from field-based research and monitoring needed to improve understanding of important ecosystem processes and feedbacks, including their responses to environmental changes.; DOI-FWS (Lead), DOI-USGS (Lead), NSF (Lead), DOE, DOI-BLM, DOI-NPS, NASA, USDA-NRCS, USDA-USFS
  
  a. The ABoVE Science Team is carrying out a community assessment of recent changes in boreal-arctic land surface hydrology. This activity is examining and comparing a diversity of multi-scale remote sensing and ground observations representing key hydrological parameters to determine regional trends and associated gaps and uncertainties in the surface water budget, and underlying drivers of the observed changes. b. The ABoVE Science Team is carrying out a synthesis of research from field sites (including those from ABoVE researchers) on tree regeneration after fires, which exerts a large control on long-term post-fire properties such as vegetation dynamics, carbon cycling, and energy budgets. The science team has assembled data from over 18 projects and is developing conceptual models to understand the controls on tree species-specific seedling composition and density after fires across different boreal forest types in Alaska, Yukon, and the Northwest Territories. c. Research has been carried out to determine factors controlling freshwater carbon loss in Alaska from river lateral carbon transfer to coastal regions and river CO2 emissions. (Sep 15, 2017 - Completed)

- 7.1.2 (In progress) Carry out and synthesize research on and monitoring of the disturbance processes responsible for changes to key landscapes, including fire, warming permafrost, insects and pathogens, and human activities.; DOI-BLM (Lead), NASA (Lead), NSF (Lead), DOD-USACE, DOE, DOI-FWS, DOI-NPS, DOI-USGS, USDA-USFS
  
  o NGEE Arctic continued research in Barrow and the Seward Peninsula on the role of thermokarst formation in CO2 and CH4 flux, and changing distribution of water and vegetation across tundra ecosystems. (Oct 4, 2017 - Completed)
Wildfires are the principal disturbance in the boreal forest, and their size and frequency are increasing as the climate warms. Impacts of fires on boreal wildlife are largely unknown, especially for the tens of millions of waterfowl that breed in the region. Waterfowl populations across the western boreal forest of North America have been monitored annually since 1955 by the Waterfowl Breeding Population and Habitat Survey (BPOP). From 1955 to 2014, >1100 fires in the western boreal forest intersected BPOP survey transects, and many transects burned multiple times. Nonetheless, fires had no detectable impact on waterfowl abundance; annual transect counts of dabbler and diver pairs remained stable from the pre- to post-fire period. Waterfowl populations appear largely resilient to forest fires, providing initial evidence that current policies of limited fire suppression, which predominate throughout much of the boreal forest, have not been detrimental to waterfowl populations. Likewise, fire-related management actions, such as prescribed burning or targeted suppression, seem to have limited impacts on waterfowl abundance and productivity. For waterfowl managers, our results suggest that adaptive models of waterfowl harvest, which annually guide hunting quotas, do not need to emphasize fires when integrating climate change effects. Citation: Lewis, T. L., J. A. Schmutz, C. L. Amundson, and M. S. Lindberg. 2016. Waterfowl populations are resilient to immediate and lagged impacts of wildfires in the boreal forest. Journal of Applied Ecology. doi:10.1111/1365-2664.12705 (Sep 28, 2017 - Completed)

Effects of Industrial and Investigator Disturbance on Arctic-Nesting Geese.
Direct encounters with humans can increase the likelihood that nesting geese will lose their eggs to predators, according to a U.S. Geological Survey (USGS) study. As part of a study to understand reasons for the rapid increase of geese across northern Alaska and to understand potential impacts to nesting-geese from oil and gas development on the Arctic Coastal Plain of Alaska, USGS researchers used remote cameras to assess the behavioral response of Greater White-fronted geese to disturbance. Results of the study indicate that effects of both industrial and research activity can be minimized through practices that limit direct encounters with nests, such as minimizing travel on the tundra during the nesting season, using established travel routes during the summer, and minimizing the research study area to reduce impact. The article and associated data release are listed below: Publication citation: Meixell, B. W. and P. L. Flint. 2017. Effects of industrial and investigator disturbance on Arctic-nesting geese. Journal of Wildlife Management Early View. doi:10.1002/jwmg.21312 Data citation: Meixell, B. W., 2017, Greater White-fronted Goose (Anser albifrons) Nest Characteristics and Nesting Behavior Classifications from Time-lapse Photographs and Nest Visit Data; Point Lonely, Alaska, 2013-2014: U.S. Geological Survey data release, https://doi.org/10.5066/F7NV9GP9.

EPA researchers are conducting a citizen science study called Smoke Sense to:
Determine the extent to which exposure to wildland fire smoke affects health and productivity and develop health risk communication strategies that protect public health during smoke days. Individuals who want to contribute to science can participate in the study by using the Smoke Sense app, a publicly available mobile application on Google Play Store. The study will be the first of its kind known to
use a mobile application to evaluate health effects from wildland fires experienced by those who participate, and to test whether such an app communicates health risks effectively. Data gathered through Smoke Sense is anticipated to help EPA researchers and communities determine how smoke from fires impacts our health and productivity and gain important insights needed to develop health risk communication methods during smoky days. The study is being conducted during the 2017 fire season. At the end of the study, the Smoke Sense app will go offline temporarily for updates. The Smoke Sense app can be used on Android phones and will be available for use on Apple devices in the future. Smoke Sense app user identities will be anonymous and non-identifiable.

https://www.epa.gov/air-research/smoke-sense-study-citizen-science-project-using-mobile-app (Sep 21, 2017 - Completed)

- ABoVE and NASA supported this PE in the following ways:  
  a. Research was carried out on the distribution of thermokarst in the Yukon Flats.  
  b. Research was carried out on factors controlling the wildfire regime in Alaska and western Canada, including the role of lightning and inter-annual climate variability. (Sep 15, 2017 - Completed)

- Karen Murphy's presentation to the May Terrestrial Ecosystems Collaboration Team meeting titled "Recent and upcoming activities advancing understanding & response to climate impacts in western Alaska" is relevant to this Performance Element http://www.iarpccollaborations.org/members/events/7689. (Jul 24, 2017 - Completed)

- Alison York's presentation at the June Terrestrial Ecosystems Collaboration Team meeting titled "Alaska Fire Science Consortium Remote Sensing Workshop Outcomes" is relevant to this Performance Element http://www.iarpccollaborations.org/members/events/7801. (Jul 24, 2017 - Completed)

- **7.1.3 (In progress) Facilitate and harmonize the production, integration, and distribution of key geospatial datasets from remotely-sensed and other data sources that are needed for monitoring key ecosystem processes and landscape changes and for model initialization, calibration, and validation.**  
  NASA (Lead), DOE, DOI-BLM, DOI-FWS, DOI-NPS, DOI-USGS

  - ABoVE contributed to this Performance Element in the following ways:  
    a. A number of new information products have or are being generated for the ABoVE Study domain, including vegetation dynamics from Landsat, fire products from Landsat and MODIS, pond and lake area change products from Landsat, forest and shrub cover products in tundra/taiga transition areas from Landsat and fine resolution satellite imagery, active layer thickness products from spaceborne SAR data, and DEM products from fine resolution satellite imagery. (Sep 15, 2017 - Completed)

  - Presentations by Tatiana Loboda, Elizabeth Hoy, and Jan Eitel at the July Terrestrial Ecosystems Collaboration Team meeting on satellite-based data products for Arctic and Boreal biomes from the ABoVE campaign are relevant to this Performance Element.
7.1.4 (In progress) Improve existing and develop advanced models for integrating climate, disturbance, above- and below-ground dynamics and interactions and feedbacks to characterize and predict Arctic landscape and ecosystem change.; DOE (Lead), NSF (Lead), DOI-BLM, DOI-FWS, DOI-NPS, DOI-USGS, NASA

- NGEE Arctic continued the development of fine, intermediate, and climate-scale models based upon field research sponsored by DOE. (Oct 4, 2017 - Completed)

- ABoVE contributed to this Performance Element in the following ways: a. Research continues on using the information derived from field-based research and new geospatial information products to improve models of key terrestrial ecosystem processes (see INPUTS from WORKING GROUP) (Sep 15, 2017 - Completed)

7.2 Advance understanding of how changes to ecosystems alter animal and plant populations and their habitats and subsistence activities that depend on them.

7.2.1 (In progress) Coordinate the development of maps from remotely-sensed data and synthesize available data to document changing plant, fish, and terrestrial animal populations and their habitats.; DOI-NPS (Lead), DOI-USGS (Lead), DOI-BLM, DOI-FWS, NASA

- ABoVE contributed to this Performance Element in the Following ways: a. A number of data products on changes to wildlife habitat are being developed, including changes in habitat in the Yukon Flats and Yukon-Kuskokwim Delta, caribou habitat in numerous locations, and Dall Sheep habitat across its entire range. (Sep 15, 2017 - Completed)

7.2.2 (In progress) Compare trends in aquatic and terrestrial animal populations and movements with changing patterns of vegetation cover, lake, pond, and wetland extent and characteristics to determine whether and how shifting habitats are influencing animal behaviors and population dynamics.; DOI-FWS (Lead), DOI-BLM, DOI-NPS, DOI-USGS, NASA, NSF

- NGEE Arctic generated data products that characterize lakes and ponds across Arctic landscapes in Alaska. (Oct 4, 2017 - Completed)

- Shrinking lakes were recently observed for several Arctic and Subarctic regions due to increased evaporation and permafrost degradation. Along with lake drawdown, these processes often boost aquatic chemical concentrations, potentially impacting trophic dynamics. In particular, elevated chemical levels may impact primary productivity, which may in turn influence populations of primary and secondary consumers. The U.S. Geological Survey, the U.S. Fish and Wildlife Service, and university partners examined trophic dynamics of 18 shrinking lakes of the Yukon Flats, Alaska, that had experienced pronounced increases in nutrient (>200 % total nitrogen, >100 % total phosphorus) and ion concentrations (>100 % for four major ions combined) from 1985-1989 to 2010-
2012, versus 37 stable lakes with relatively little chemical change over the same period. We found that phytoplankton stocks, as indexed by chlorophyll concentrations, remained unchanged in both shrinking and stable lakes from the 1980s to 2010s. Moving up the trophic ladder, we found significant changes in invertebrate abundance across decades, including decreased abundance of five of six groups examined. However, these decadal losses in invertebrate abundance were not limited to shrinking lakes, occurring in lakes with stable surface areas as well. At the top of the food web, we observed that probabilities of lake occupancy for ten waterbird species, including adults and chicks, remained unchanged from the period 1985-1989 to 2010-2012. Overall, our study lakes displayed a high degree of resilience to multi-trophic cascades caused by rising chemical concentrations. This resilience was likely due to their naturally high fertility, such that further nutrient inputs had little impact on waters already near peak production. Citation: Lewis, T. L., P. J. Heglund, M. S. Lindberg, J. A. Schmutz, J. H. Schmidt, A. J. Dubour, and M. R. Bertram. 2016. Trophic dynamics of shrinking Subarctic lakes: naturally eutrophic waters impart resilience to rising nutrient and major ion concentrations. Oecologia 181(2):583-596. doi:10.1007/s00442-016-3572-y


- USGS-led Study of Surface Water Connectivity and Richness and Composition of Fish in the Arctic: Surface water connectivity can influence the richness and composition of fish assemblages, particularly in harsh environments where colonisation factors and access to seasonal refugia are required for species persistence. To increase understanding of how surface water connectivity and related hydrologic variables influence assemblage patterns, the U.S. Geological Survey, Bureau of Land Management, and collaborators investigated species richness and composition of Arctic lake fishes over a large region, 8500 km2, of the central Arctic Coastal Plain, Alaska. We collected fish presence/non-detection data from 102 lakes and used a hierarchical multispecies occupancy framework to derive species richness and inform species composition patterns. Presence of a permanent channel connection was an overriding factor affecting species richness, presumably driving lake colonisation potential. In lakes without a permanent channel connection, data suggest richness increased with the availability of in-lake winter refugia and with the potential of ephemeral connections during spring floods. Fish species functional traits and environmental faunal filters contributed to patterns of richness and assemblage composition. Composition corresponded with richness in a coherent manner, where each...
successive level of richness contained several discrete assemblages that showed similar responses to the environment. Lakes with permanent channel connections contained both widespread and restricted species, while the species-poor lakes that lacked a connection contained mainly widespread species. This work provides useful baseline information on the processes that drive the relations between patch connectivity and fish species richness and assemblage composition. The environmental processes that organise fish assemblages in Arctic lakes are likely to change in a warming climate. Citation: Laske, S. M., T. B. Haynes, A. E. Rosenberger, J. C. Koch, M. S. Wipfli, M. Whitman, and C. E. Zimmerman. 2016. Surface water connectivity drives richness and composition of Arctic lake fish assemblages. Freshwater biology. doi:10.1111/fwb.12769

o USGS-led Study of Temperature Shifts, Vegetation, and Caribou Response in the Arctic: Climate-induced shifts in plant phenology may adversely affect animals that cannot or do not shift the timing of their reproductive cycle. We evaluated the long-term changes in the temperatures and characteristics of the growing seasons (1970–2013), and compared growing conditions and dynamics of forage quality for Central Arctic caribou at peak parturition, peak lactation, and peak forage biomass, and plant senescence between two distinct time periods over 36 years (1977 and 2011–13). Despite advanced thaw dates (7–12 days earlier), increased growing season lengths (15–21 days longer), and consistent parturition dates, we found no decline in forage quality and therefore no evidence within this dataset for a trophic mismatch at peak parturition or peak lactation from 1977 to 2011–13. In Arctic ungulates that use stored capital for reproduction, reproductive demands are largely met by body stores deposited in the previous summer and autumn, which reduces potential adverse effects of any mismatch between food availability and timing of parturition. Climate-induced effects on forages growing in the summer and autumn ranges, however, do correspond with the demands of female caribou and their offspring to gain mass for the next reproductive cycle and winter. Therefore, we suggest the window of time to examine the match-mismatch framework in Arctic ungulates is not at parturition but in late summer-autumn, where the multiplier effects of small changes in forage quality are amplified by forage abundance, peak forage intake, and resultant mass gains in mother-offspring pairs. Citation: Gustine, D. D., P. S. Barboza, L. G. Adams, B. Griffith, R. D. Cameron, and K. R. Whitten. 2017. Advancing the match-mismatch framework for large herbivores in the Arctic: Evaluating the evidence for a trophic mismatch in caribou. PLoS One 12(2):e0171807. doi:10.1371/journal.pone.0171807

o U.S. Geological Study on Bird Response to Changing Habitats in the Arctic: Climate change is facilitating rapid changes in the composition and distribution of vegetation at northern latitudes, raising questions about the responses of wildlife that rely on arctic ecosystems. One widely observed change occurring in arctic tundra ecosystems is an increasing dominance of deciduous shrub vegetation. Our goals were to examine the tolerance of arctic-nesting bird species to existing gradients of vegetation along the boreal forest-tundra ecotone, to predict the abundance of species across different heights and densities of shrubs, and to identify species that will be most or least responsive to ongoing expansion of
shrubs in tundra ecosystems. We conducted 1,208 point counts on 12 study blocks from 2012-2014 in northwestern Alaska, using repeated surveys to account for imperfect detection of birds. We considered the importance of shrub height, density of low and tall shrubs (i.e. shrubs >0.5 m tall), percent of ground cover attributed to shrubs (including dwarf shrubs <0.5 m tall), and percent of herbaceous plant cover in predicting bird abundance. Among 17 species considered, only gray-cheeked thrush (Catharus minimus) abundance was associated with the highest values of all shrub metrics in its top predictive model. All other species either declined in abundance in response to one or more shrub metrics or reached a threshold where further increases in shrubs did not contribute to greater abundance. In many instances the relationship between avian abundance and shrubs was nonlinear, with predicted abundance peaking at moderate values of the covariate, then declining at high values. In particular, a large number of species were responsive to increasing values of average shrub height with six species having highest abundance at near-zero values of shrub height and abundance of four other species decreasing once heights reached moderate values (≤ 33 cm). Our findings suggest that increases in shrub cover and density will negatively affect abundance of only a few bird species and may potentially be beneficial for many others. As shrub height increases further, however, a considerable number of tundra bird species will likely find habitat increasingly unsuitable. Citation: Thompson, S. J., C. M. Handel, R. M. Richardson, and L. B. McNew. 2016. When winners become losers: Predicted nonlinear responses of arctic birds to increasing woody vegetation. PLoS One 11(11):e0164755. doi:10.1371/journal.pone.0164755

- 7.2.3 (In progress) Incorporate scientific observations and the perspectives of IK and/or LK knowledge holders into assessments of how changing Arctic ecosystems, flora, and fauna are affecting important subsistence activities, lifestyles, and well-being of northern residents.; DOI-FWS (Lead), DOI-BIA, DOI-BLM, DOI-NPS, DOI-USGS, NASA

  o Over the past year, through ABoVE NASA has established research collaborations with a large number regional government scientists and have made presentation of research results to local communities. In order to incorporate LK and IK into the ongoing research projects, NASA -sponsored researchers have discussed observations of environment change with community elders in Bethel, Alaska, with community members in Emmonak, Alaska, and established an environmental monitoring station at the Meade River School in Atqasuk, Alaska. (Sep 27, 2017 - Completed)

7.3 Evaluate how changes in fire activity are impacting rural and urban communities, and atmospheric emissions and carbon budgets and other feedbacks to climate.

- 7.3.1 (In progress) Evaluate how changing fire regimes have and are likely to impact northern communities, via impacts to infrastructure, health, and subsistence opportunities.; DOI-BLM (Lead), DOI-BIA, DOI-FWS, DOI-NPS, DOI-USGS, NASA, NSF, USDA-USFS
The September joint meeting on the health impacts of wildfires in the Arctic by the Health & Well-being CT, Atmosphere CT, and Terrestrial Ecosystems CT (https://www.iarpccollaborations.org/members/events/9144) began a cross-team conversation on places for potential interdisciplinary/interagency collaborations. Follow-up actions will be reported as they occur. (Sep 25, 2017 - Completed)

- ABoVE contributed to this Performance Element in the following ways: a. Research is being conducted on how changes to ecosystem and environmental conditions caused by wildfires are impacting access to ecosystem services in Interior Alaska. This research involves collaborations with subsistence harvesters. (Sep 15, 2017 - Completed)

- Alison York's presentation at the June Terrestrial Ecosystems Collaboration Team meeting titled "Alaska Fire Science Consortium Remote Sensing Workshop Outcomes" is relevant to this Performance Element http://www.iarpccollaborations.org/members/events/7801. (Jul 24, 2017 - Completed)

- 7.3.2 (In progress) Coordinate research on the observations, geospatial dataset generation, and model improvement needed to estimate emissions from wildland fires and the potential for those emissions to affect atmospheric carbon budgets and climate feedbacks.; NASA (Lead), DOI-BLM, DOI-FWS, DOI-NPS, DOI-USGS, NSF, USDA-USFS

- ABoVE contributed to this Performance Element in the following ways: a. Field-based observations of ground-layer fuel consumption were carried out at multiple sites. A workshop was convened to develop a plan to integrate these measurements with others data collected in the ABoVE Study Domain in order to improve models of greenhouse gas and particulate matter emissions from wildland fires. b. New geospatial data products needed to quantify burned area and fuel loads have or are being developed for Alaska and other portions of the ABoVE Study domain  c. The field observations and geospatial products are being used to improve wildland fire emission models. (Sep 15, 2017 - Completed)

- Presentations by Tatiana Loboda, Elizabeth Hoy, and Jan Eitel at the July Terrestrial Ecosystems Collaboration Team meeting on satellite-based data products for Arctic and Boreal biomes from the ABoVE campaign are relevant to this Performance Element. (http://www.iarpccollaborations.org/members/events/7802) (Jul 21, 2017 - Completed)

- Alison York's presentation at the June Terrestrial Ecosystems Collaboration Team meeting titled "Alaska Fire Science Consortium Remote Sensing Workshop Outcomes" is relevant to this Performance Element http://www.iarpccollaborations.org/members/events/7801. (Jun 16, 2017 - Completed)

**Agencies**
DOC, DOD, DOE, DOI, HHS, NASA, NSF, OSTP, USARC, USDA
8.1 Coastal Resilience

8.1 Engage coastal communities in research and advance knowledge on cultural, safety, and infrastructure issues for coastal communities.

- 8.1.1 (In progress) Engage coastal community members in research by seeking cooperative opportunities between community members, IK holders, and/or LK holders, and researchers in knowledge co-production research processes. Employ IK and/or LK to jointly conceive of and plan research activities and to report research results back to communities.; DOI-BLM (Lead), DOI-BOEM (Lead), DOI-FWS (Lead), EPA (Lead), NOAA (Lead), NSF (Lead), DHS, DOI-NPS, DOI-USGS

- BOEM has entered into a multiyear cooperative agreement, Traditional Knowledge Implementation: Accessing Arctic Community Panels of Subject Matter Experts with the North Slope Borough Department of Wildlife Management. Co-PI’s are Qaiyaan Harcharek and Robert Suydam. (Sep 21, 2017 - Completed)

- USGS and USFWS Present at the Waterfowl Conservation Committee: USGS Alaska Science Center and USFWS Yukon Delta National Wildlife Refuge scientists attended the Association of Village Council Presidents Waterfowl Conservation Committee (WCC) on Friday, September 15, 2017 in Bethel, Alaska. The WCC is a Yukon-Kuskokwim Delta regional group of the state-wide Alaska Migratory Bird Co-management Council and discusses issues of migratory bird regulations, subsistence harvest, and needed information by both residents and agencies. The USGS and USFWS gave a presentation on status of waterfowl populations on the Delta and long-term research on annual survival and avian influenza prevalence in Emperor Goose on the Yukon-Kuskokwim Delta as well as an update of a collaborative studies on how use of different Aleutian Island wintering areas by Emperor geese may influence their nesting success and survival.

- USGS Research Updates to the North Slope Borough Planning and Wildlife Management Departments. On June 12th, 2017, John Pearce provided updates of planned and on-going terrestrial ecosystems research by the USGS to the North Slope Borough Planning and Wildlife Management Departments in Utqiagvik. Participants were informed of USGS research projects, how those projects are conducted to reduce disturbance to coastal subsistence activities, and sought
feedback from participants on current and future research activities. Opportunities for joint workshops and future informational meetings were discussed.

- USGS Attends North Slope Borough Planning Commission Meeting: USGS Supervisory Wildlife Biologist John Pearce was invited to present at the North Slope Borough Planning Commission Meeting on August 31st in Utqiagvik, Alaska, and provide an update on USGS research in the National Petroleum Reserve - Alaska (NPR-A) that may have implications for North Slope Borough's planning and permitting actions in the NPR-A. Included in Pearce's presentation was a discussion of a recent USGS Alaska Science Center paper on the response of Arctic-nesting geese to industrial and investigator disturbance. More information on that research can be found at the USGS technical release here: https://www.usgs.gov/news/wildlife-cameras-offer-insight-geese-industry-and-researchers-arctic.

- The CRCT meeting on May 3rd addressed this Performance Element by beginning the meetings of the newly formed CRCT by engaging diverse participants and soliciting input from Arctic communities for their thoughts on Performance Element interpretation and research needs: http://www.iarpccollaborations.org/members/events/7686. Meredith is keeping track of the action items recorded in the team meeting notes: http://www.iarpccollaborations.org/members/documents/9209 (Aug 28, 2017 - Completed)

8.1.2 (In progress) Engage coastal community members in research by supporting community-based monitoring focused on measuring physical and biotic information by strengthening initiatives led by groups such as the Arctic-focused LCCs, BOEM, NOAA, and FWS.; DOI-BOEM (Lead), DOI-FWS (Lead), NOAA (Lead), NSF

- Scientists Establish Long-term Ecological Monitoring Sites in the Yukon-Kuskokwim Delta of Western Alaska: Scientists with USGS and US Forest Service installed remote, automated weather stations in the Tribal Villages of Chevak and Kotlik in the Yukon-Kuskokwim Delta of western Alaska as part of a growing network of long-term ecological monitoring sites established in this rapidly-changing region. The weather stations and monitoring sites, installed in collaboration with local scientists from the Chevak Traditional Council and the Kotlik Tribal Council, will be used by local villages to monitor changing environmental conditions relevant to subsistence activities. The sites are co-located with USGS-Yukon River Inter-Tribal Watershed Council Active Layer Network grid sites where permafrost monitoring has taken place since 2009. These sites will allow researchers to relate changes in vegetation, permafrost, erosion, wildlife habitat, and other landscape attributes to changes in seasonal weather patterns and long-term climate. Data will then be used to build models to project further changes to landscapes, subsistence resources, and communities in the coming decades. (Contact: Rachel Loehman, 907-786-7089, Anchorage, AK) USGS Researchers Collaborate to Document Landscape and Subsistence Changes in the Yukon-Kuskokwim Delta, Alaska: USGS scientists Nicole Herman-Mercer
and Rachel Loehman in collaboration with the Chevak Traditional Council recently held a series of workshops focused on landscape change in the Alaska Native Village of Chevak in the Yukon-Kuskokwim Delta region. Workshop participants ranging in age from 18 to 86 described observed landscape changes and identified the impacts of those changes to subsistence, health and safety, infrastructure, and the local economy. Additionally, participants identified the location of specific landscape changes such as erosion, permafrost thaw, and changing vegetation on maps. These workshops allow USGS researchers to document slow moving changes that cannot be identified through traditional methods as historical baseline data and imagery is sparse in this region. The findings from these workshops will enable researchers to investigate causes of landscape change and make recommendations to the Traditional Council and the community about anticipated future changes as well as identify gaps in existing data in order to implement future data gathering activities. (Contact: Rachel Loehman, 907-786-7089, Anchorage, AK)

- BOEM has entered into a multiyear cooperative agreement, Community Based Monitoring: LEO Network with the Alaska Native Tribal Health Consortium. PI is Dr. Michael Brubaker. (Sep 21, 2017 - Completed)

- Understanding Environmental Change in the Yukon River Basin through the Indigenous Observation Network and Citizen Science. On September 19th, 2017, Ryan Toohey (USGS Alaska Climate Science Center) will present a seminar on the Indigenous Observation Network in the Yukon Basin. The Yukon River Basin (YRB), underlain by discontinuous permafrost, has experienced a warming climate over the last century that has altered air temperature, precipitation, and permafrost. A collaborative effort between the Yukon River Inter-Tribal Watershed Council (YRITWC) and the U.S. Geological Survey (USGS), the Indigenous Observation Network (ION) has developed two projects that focus on water quality and permafrost research. More than 300 community environmental technicians have been trained to participate in ION by effectively monitoring and investigating their local environments with global implications. These local observations, obtained over the past decade, have contributed to the global understanding of climate change and ultimately its impacts on Alaska Native Villages. Combined with historical data from the USGS, the ION database now covers over 30 years of historical water quality data in key locations. Trend analysis of this database suggests increased active layer expansion, weathering and sulfide oxidation due to permafrost degradation throughout the YRB. Changing geochemistry of the YRB may have important implications for the carbon cycle, aquatic ecosystems, and contaminant transport. With predicted environmental changes, the efforts of ION and the integration of Indigenous knowledge will become critical to assess, mitigate and adapt to changing local environments. ()

- The presentation given by Alex Whiting at the June 7th Coastal Resilience Collaboration Team Meeting titled "Native Village of Kotzebue: Addressing Local Research Priorities: A Tribal Centered Approach" is relevant to this Performance Element
Alaska Ocean Acidification Network Formed. In FY2017, AOOS launched the Alaska Ocean Acidification Network (http://www.aoos.org/alaska-ocean-acidification-network/) which is a collaboration of scientists, resource managers, fishing industry representatives, Tribes, and others who are committed to expanding the understanding of ocean acidification processes and consequences in Alaska. The network facilitates interaction between scientists to maximize research efforts, helps connect stakeholders with researchers to answer local questions, and strategizes on how best to synthesize OA information for use by decision makers and the public. (Dec 2, 2016 - Completed)

- **8.1.3 (In progress) Support economic development research for the sustainable development of resilient communities.** For example, create comprehensive economic planning strategies by DOC Economic Development Administration (EDA) planning grantees in Alaska coastal communities.; DOC-EDA (Lead), NSF
  - Kawarek submitted an initial report to the Economic Development Administration that summarizes and highlights the EDAT meeting that took place in Nome December 2016.
  - The August meeting of the Coastal Resilience Collaboration team focused on activities, reports, and barriers to relocation and adaptation initiatives. There were updates by Vanitha Sivarajan on the AESC relocation framework, Nathan Kettle on the ACCAP Adaptation Synthesis Report, and Amy Holman on the Research Needs Work Group: https://www.iarpccollaborations.org/members/events/7847. (Aug 23, 2017 - Completed)
  - Bering Strait Economic Development Assessment Team Site Visit The Economic Development Administration hosted an Economic Development Assessment Team trip to Nome and Shaktoolik December 6-8, 2017 Press Release.
  - Comprehensive Economic Development Strategy for the Bering Strait Region EDA invested $70,000 to support the development and implementation of a comprehensive economic development strategy (CEDS) for the region which includes the communities of Brevig Mission, DiomedeElim, Gambell, Golovin, Koyuk, Nome, Shaktoolik, Stebbins, St. Michael, Unlakleet, Teller, Wales and White Mountain. The CEDS process is designed to bring together the public and private sectors in the creation of an economic development roadmap to diversify and strengthen the regional economy.
8.1.4 (In progress) Investigate and protect cultural resources through research to identify and document archaeological sites in high-risk, rapidly eroding Arctic coastal areas.; DOI-BLM (Lead), DOI-NPS (Lead), NSF

- National Petroleum Reserve - Alaska (NPR-A), Coastal Erosion Mitigative Excavations: The Bureau of Land Management (BLM) Arctic District Office (Alaska) archaeologist Joe Keeney, along with BLM archaeologists Crystal Glassburn (Central Yukon Alaska Field Office), Robin Mills, and Steve Lanford (Eastern Interior Alaska Field Office), and Kevan Cooper (BLM Alaska realty specialist) conducted excavations in the summer of 2017 at three known archaeological sites along the north coast of Alaska, inside the boundaries of the NPR-A (managed by BLM’s Arctic District Office). Coastal erosion has dramatically affected areas along Alaska’s northern coast over the past century, which has had unknown but potentially disastrous effects upon cultural resources. Following surveys and assessments of sites along the Beaufort Sea coast in 2016 and successful consultations with Alaskan Native tribes on the North Slope, BLM staff returned in 2017 to three of the most threatened sites to record information. Two sites are located on BLM-managed lands: the remains of a sod house occupied in the early 20th Century, that belongs to Horace Ahsogeak, and an historic reindeer corral that operated during the early 20th Century. The third site, which is located on an Alaska Native allotment owned by Lillian Nageak of Utqiagvik (formerly Barrow), contains the remains of several structures, including the well-preserved and partially-standing sod house Ms. Nageak lived in up until the early 1940s. The crews were accompanied and assisted by Charlotte Ahsogeak and Kunneak Nageak of Utqiagvik. Work is planned to continue at other threatened sites in 2018, and will include continued cooperation with Iñupiat tribes and living descendants to preserve site materials and information.

- For decades to centuries Arctic historic sites remained relatively isolated and frozen, protected from human and environmental degradation. The extreme climatic conditions in the Arctic have allowed the preservation of organic structures and artifacts that can provide a glimpse into history and cannot be found elsewhere on Earth. However, many Arctic archeological sites, located nearshore, are threatened by coastal erosion due to reduction in sea ice cover, increased storm frequency, and melting permafrost. And both nearshore and inland sites are affected by the warmer temperatures that are accelerating the decomposition of organic structures. Beyond the cultural importance for Indigenous Arctic communities, these sites are an important piece of mankind history, they tell the story of how humans spread from Asia to the Americas and the coasts of Greenland. Furthermore, these sites are home to large amounts of environmental, biological, climate and social/cultural data that could be useful to our understanding of the current world, particularly how people adapted to rapid environmental change in the past during the Little Ice Age or the Medieval Warm Period. The information gathered from the Arctic heritage sites can be used to design better resilience strategies for modern Arctic communities, and coastal communities globally. Indigenous heritage traverses multiple countries, thus preserving the sites requires international cooperation and close collaboration.
with local communities. The strategy to preserve the historical information of the sites broadly falls into 2 categories: 1. Preserve sites and/or move artifacts or 2. Sample and study the sites before they disappear; this requires collaborations across agencies, with researchers and local communities. The National Science Foundation funds research to support both local and international efforts to investigate and protect archeological sites in high-risk coastal areas. Funds are granted through regular and Rapid Response Research (RAPID) awards. Below are examples of awards addressing the aforementioned issues:

Example 1. Comparative Island Ecodynamics in the North Atlantic (Award # 1449616)  The researchers seek to understand how differences in response to rapid environmental change of two closely related northern communities resulted in the collapse of one and survival of the other. Findings may help understand what makes a community resilient to environmental change and apply to current and/or future communities.  

Example 2. RAPID: Walakpa Archeology Rapid Response Project (Award # 1646865)  Here, the researchers seek to rescue a large multi-component archaeological site dating to at least 1200 years ago, the Walakpa, or Ualiqpa, site, from the rapidly eroding coastline. This site contains records of the migration and evolution of Birnirk and Thule cultures.

Example 3. RAPID: Archeological Investigation at Iita (Award # 1623802)  This team of researcher is investigating the interactions between the Dorset and Thule (ancestor of the contemporary Inuit) people in the prehistoric Arctic at the threatened site of Iita in Greenland.

Example 4. RAPID: Gardar Collaborative Rescue Project (Award # 1119354)  This award supported the rescue efforts of the unique site of Gardar (a UN World Heritage Site) in the former Norse Eastern settlement in Greenland. The warmer temperatures are accelerating the decomposition of the organic material used in the construction of the 11th century church and manor farm.
https://www.nsf.gov/awardsearch/showAward?AWD_ID=1119354&HistoricalAwards=false (Sep 27, 2017 - Completed)

- Judith Ramos' presentation in May to the Coastal Resilience Collaboration Team (https://www.iarpccollaborations.org/members/events/76860) is relevant to this Performance Element. (Sep 25, 2017 - Completed)

8.1.5 (In progress) Advance the understanding of storm surge and saline inundation impacts on infrastructure and human safety. Multiagency partners include the Alaska Department of Geological and Geophysical Surveys and the ACCER.; NOAA (Lead), DOD-USACE

- A new low-cost water level sensor was installed in Bethel to produce high quality, real-time data.

8.2 Advance knowledge of ecosystems and environmental health in coastal areas by monitoring trends and modeling biological processes.
8.2.1 (In progress) Monitor and conduct studies to understand trends, processes, and biotic-abiotic feedback loops affecting the distribution, abundance, and ecology of coastal species in relation to food security, biodiversity, and ecosystems through projects such as the Arctic Council Conservation of Arctic Flora and Fauna working group Coastal Biodiversity Monitoring Programme.; DOI-BOEM (Lead), DOI-USGS (Lead), NOAA (Lead), DOI-BLM, DOI-FWS, DOI-NPS, MMC

- New Analysis of Pacific Walrus Demography: USGS Alaska Science Center researchers Rebecca Taylor, Mark Udevitz and Chadwick Jay collaborated with U.S. Fish and Wildlife Service and Alaska Department of Fish and Game to synthesize information on Pacific walrus population sizes, age structures, reproductive rates, and harvests for 1974-2015. The walrus population underwent a multi-decade decline which began moderating in the 1990s. Reproduction and calf survival rose over time; however, juvenile survival may have decreased over time. Depending on whether juvenile survival decreased, the population growth rate either increased during the 2000s or stabilized at a lesser level of decline than seen in the 1980s. An early view of the paper is currently available at https://onlinelibrary.wiley.com/doi/10.1111/mms.12434/full. (Contact: Rebecca Taylor, 907-786-7004, Anchorage, AK). Citation: Taylor, R. L., Udevitz, M. S., Jay, C. V., Citta, J. J., Quakenbush, L. T., Lemons, P. R. and Snyder, J. A. (2017), Demography of the Pacific walrus (Odobenus rosmarus divergens) in a changing Arctic. Mar Mam Sci. doi:10.1111/mms.12434 (Oct 4, 2017 - Completed)

- Marine Arctic Ecosystem Study (MARES) - Pilot Program Marine Mammals Tagging and Tracking. The objectives for this pilot-program were successfully met. We established productive relationships with the North Slope Borough and several native hunters, and we garnered support for our study and approach from the Ice Seal Committee, co-management groups in Canada, and the communities of Wainwright and Kaktovik. We also established effective collaborations with other researchers, thereby minimizing the impact of the research on communities and the animals they rely on for subsistence. Successful deployment of satellite CTD-fluorometer tags revealed insights concerning tag configuration and communication protocols. Capture methods and locations were also refined by bringing together knowledge and experience from MARES, NSB, and other scientists experienced in capturing and tagging ice-associated seals around the world. The direct link to the full report is: https://www.boem.gov/BOEM-2017-017/ (Sep 26, 2017 - Completed)

- Social Indicators in Coastal Alaska: Arctic Communities: In 2011, the U.S. Department of the Interior (USDOI), Bureau of Ocean Energy Management (BOEM) contracted Stephen R. Braund & Associates (SRB&A) to develop and implement a social indicator (SI) system which would provide baseline data on the well-being of residents on the North Slope of Alaska. The title of this study is Social Indicators in Coastal Alaska: Arctic Communities (SICAA). The scope of work for the study called for the identification of a set of SIs—variables which measure the well-being and life quality of a given population. These SIs were collected through a household survey in the six coastal North Slope communities
(Point Hope, Point Lay, Wainwright, Utqiagvik [formerly Barrow], Nuiqsut, and Kaktovik). Between January 8 and March 9, 2016, SRB&A interviewed 684 randomly selected heads of household (HHs) in the selected North Slope communities. The purpose of the interviews was to develop a baseline understanding of the well-being of North Slope residents before major offshore oil and gas (O&G) development activity. The interview, which took about an hour, used structured questions to measure SIs of well-being in seven domains: economic well-being, physical environment, health and safety, cultural continuity, education, local control, and overall well-being. The interview also included a suite of questions about the type, timing, cause, and appropriate mitigation action associated with any impacts of O&G exploration and development on subsistence activities in the prior year. The survey questions were reviewed by the North Slope Management Board, a group of North Slope residents formed to oversee the study. The survey was approved by the federal Office of Management and Budget as well as BOEM. Seventy-nine percent of the selected HHs completed the interview. The direct link to the final report is: https://www.boem.gov/BOEM-2017-035/ (Sep 26, 2017 - Completed)

Seabird Distribution and Abundance in the Offshore Environment: Seabirds are wide-ranging upper trophic level foragers and good indicators of changes in marine ecosystems. Seabirds spend most of the year offshore, yet our data gaps are greatest for the pelagic aspect of their lives. The goal of the Seabirds Offshore Project was to conduct at-sea surveys in lease sale areas and adjacent ocean planning areas, to provide current temporal and spatial data on marine birds and mammals, and submit the data to the North Pacific Pelagic Seabird Database (NPPSD). During this project, 2010-2016, we placed seabird observers on 45 research and monitoring vessels, usually in association with multidisciplinary ecosystem projects. Because many of these cruises transited from southern Alaska ports, we included all surveyed routes in this report. We surveyed a total of 97,525 km, with the majority (31,497 km) in the Chukchi Sea, followed by the southern Bering Sea (30,265 km), northern Bering Sea (26,326 km) and Beaufort Sea (9,438 km). Our survey coverage extended from the northern GOA shelf to the eastern Aleutian Islands, north throughout the Bering Sea shelf, into the eastern Chukchi Sea, and the western Beaufort Sea shelf, including the Arctic Basin. The seabird survey data collected under the Seabirds Offshore Project has been included in over 30 presentations and 17 publications to date, as well as at least 12 public outreach and education venues and 7 websites. We have described seasonal distribution patterns of seabirds in offshore waters of Alaska, and identified ‘hotspots’ of foraging and migration activity. Through several collaborative projects, including on-going efforts, we have linked seabird survey data to oceanographic and prey data collected during concurrent cruises, and from remote sensing data. These efforts test hypotheses about the distribution of upper trophic level predators in response to changes in prey and ice cover. All seabird data collected during this project has been submitted to the NPPSD, to the Alaska BOEM office, and to affiliated ecosystem projects (available via Alaska Ocean Observing System work spaces). The direct link to the report is: https://www.boem.gov/2017-004/ (Sep 26, 2017 - Completed)
Arctic Marine Biodiversity Observing Network (AMBON) - a BOEM and NOAA partnership under National Ocean Partnership Program led by Katrin Iken professor at University of Alaska Fairbanks. Project is ongoing. More information about the project can be found at the following sites: [https://www.uaf.edu/cfos/research/projects/arctic-marine-biodiversity/](https://www.uaf.edu/cfos/research/projects/arctic-marine-biodiversity/) [https://www.youtube.com/watch?v=d4MpyMopEBM](https://www.youtube.com/watch?v=d4MpyMopEBM) [http://ambon-us.org/about/](http://ambon-us.org/about/)

A BOEM-funded study that was completed recently addresses food security in Wainwright, Kaktovik, and Venetie, Alaska. This study, Subsistence Sharing Networks and Cooperation: Kaktovik, Wainwright, and Venetie, Alaska, by G. Kofinas, S. BurnSilver, J. Magdanz, R. Stotts, and M. Okada, OCS Study BOEM 2015-023 can be accessed here: [https://www.boem.gov/](https://www.boem.gov/) BOEM -2015-23/ (Sep 21, 2017 - Completed)

New USGS-led Publication on Factors Associated with Increasing Goose Populations on the North Slope of Alaska: The authors measured body mass of black brant and lesser snow goose goslings on the Colville River Delta of northern Alaska to determine if there was evidence of density-dependent declines in gosling growth following recent population increases of those species. The authors conclude that the establishment of nesting snow geese on the Colville River Delta has not negatively affected brant gosling growth. The authors also predict that goose populations will continue to increase in northern Alaska. However, snow geese are increasing more rapidly than brant in the region. Because the black brant population has periodically been below management objectives, the effects of the increasing snow geese on brant goslings in northern Alaska should be monitored. Citation: Hupp, J. W., D. H. Ward, K. R. Hogrefe, J. G. Sedinger, P. D. Martin, A. Stickney, and T. Obritschkewitsch. 2017. Growth of black brant and snow goose goslings in northern Alaska: implications for increasing goose populations. Journal of Wildlife Management 81(5):846-857. doi:10.1002/jwmg.21246 (Sep 13, 2017 - Completed)

New USGS Publication on Habitat Use of Geese During Molt within the National Petroleum Reserve - Alaska: Numerous Greater White-fronted geese molt within the National Petroleum Reserve – Alaska (NPR-A) and proposed development in this area raised questions about possible impacts to molting geese and their habitats. We used GPS transmitters to record fine-scale location data to assess patterns of movement and resource selection relative to vegetation type, year (2012, 2013), and body mass at capture. Flightless White-fronted geese maintain fairly small home ranges across a gradient of habitats, suggesting that suitable habitat is widely distributed. The only constraint was the apparent need to molt within 100 m of a wetland (i.e., potential escape habitat). Citation: Flint, P. L. and B. W. Meixell. 2017. Movements and habitat use of White-fronted geese during the remigial molt in Arctic Alaska, USA. Waterbirds 40, In Press. (Sep 13, 2017 - Completed)

New Publication on Wildlife Harvest and Climate Change: Scientists with the USFWS, USGS and the University of Washington present a novel modeling approach to evaluate the interactive effects of climate change and harvest on large
mammals. The model is coupled with a management framework that recognizes the potential for climate-induced habitat degradation. Together, these methods can be used to balance tradeoffs between population persistence and opportunities for human use. This will become increasingly important for polar bears and other species for which near-term management is focused on harvest and other secondary factors while the global community seeks solutions to the primary threat of climate change. Citation: Regehr, E. V., R. R. Wilson, K. D. Rode, M. C. Runge, and H. Stern. 2017. Harvesting wildlife affected by climate change: a modelling and management approach for polar bears. Journal of Applied Ecology In Press. doi:10.1111/1365-2664.12864 (Sep 13, 2017 - Completed)

- Presentations by Raphaela Stimmelmayr and Vera Metcalf given at the July 6th Coastal Resilience Collaboration Team Meeting (http://www.iarpccollaborations.org/members/events/7846) are relevant to this Performance Element (Jul 7, 2017 - Completed)

- Presentations by Kenneth Dunton and Alex Whiting given at the June 7th Coastal Resilience Collaboration Team Meeting (http://www.iarpccollaborations.org/members/milestones/2809) are relevant to this PE. (Jun 13, 2017 - Completed)

- **8.2.2 (In progress) Develop ecological modeling capabilities to understand issues related to the coastal Arctic. Develop online eco-informatics tools such as Coastal Biodiversity Risk Analysis Tool (CBRAT) for Arctic coastal areas to deliver, at a regional scale, predicted relative vulnerability of coastal species and ecosystems to climate change, including temperature increases, sea level rise, and ocean acidification.; EPA (Lead)**

  - OA Impacts on Alaska Species Poster Goes Viral  A new one page document describing the impacts of OA on researched Alaska species (http://%20www.aoo.org/alaska-oceanacidification-network/) has gone viral. This publication also includes a long list of many Alaska species that have yet to be researched for impacts from OA. As part of the OA Network, five topic-specific working groups have been convened and are actively working to help implement the network’s mission. More information can be found at www.aoo.org/alaska-oceanacidification-network/ (Nov 2, 2017 - Completed)

  - BOEM has entered into a cooperative agreement, Coastal Community Vulnerability Index and Visualizations of Change in Cook Inlet, Alaska with the Coastal Marine Institute, University of Alaska, Fairbanks. PI is Davin Holen, SEAGRANT. (Sep 21, 2017 - Completed)

  - Alaska Ocean Acidification Network  In FY2017 AOOS launched the Alaska Ocean Acidification Network (http://www.aoo.org/alaska-ocean-acidification-network/) which is a collaboration of scientists, resource managers, fishing industry representatives, Tribes, and others who are committed to expanding the understanding of ocean acidification processes and consequences in Alaska. The network facilitates interaction among scientists to maximize research efforts, helps connect stakeholders with researchers to answer local questions, and
strategizes on how best to synthesize OA information for use by decision-makers and the public.

- HABs monitoring expands to Arctic - The Alaska Harmful Algal Bloom Network (AHAB), co-led by AOOS, received funding in FY2017 from the U.S. Arctic Research Commission to expand its activities into the Arctic. The funding will support a pilot shellfish testing, opportunistic marine mammal sampling, and water monitoring programs, as well as community outreach.

- An expanded version of the OA brochure, which is now two-sided and includes OA basics, monitoring platforms, general findings and the role of the network. Three new members have signed on to the network; the U.S. Arctic Research Commission, the Alaska Marine Highway System, and the Alaska Department of Fish & Game.

- The Alaska Harmful Algal Bloom (AHAB) network tool was released at the beginning of the month of June. http://www.aoos.org/k-bay-hab/ See the current conditions in the AOOS data portal

- Ocean Acidification Network Update: Alaska State Ferry monitoring project set for October. The seasonal start of the M/V Columbia (newly equipped with an OA sensor package) was delayed again due to technical problems with the vessel, and is now set to begin its weekly round trip from Bellingham to Skagway on October 2, 2017. This project has been consistently delayed since its anticipated start of April. However, the new plan to operate through the winter will provide unprecedented insights into a different season - an opportunity we may not have again.

- Ocean Acidification Network Update: New funding from the U.S. Arctic Research Commission. USARC is providing the network with $20K to produce data synthesis products and provide outreach to Arctic communities. Data synthesis efforts will focus on creating a data-rich, interactive storyboard illuminating the impacts of OA on crab based on data produced at the Kodiak Lab. We are also looking into other possible products, including maps that overlay existing seasonal data with at-risk species distribution. With regard to Arctic outreach, we will be looking for speakers to attend events in Barrow, Kotzebue, or Nome over the next year. If you are interested in representing the OA community at these venues, please contact Darcy Dugan.

- Ocean Acidification Network Update: Alaska OA Monitoring Inventory. Thank you to everyone who submitted information on their research assets to the west coast inventory that was circulated earlier this year. Oregon and California have created an interactive web-based map showing their assets, and Alaska’s will be added soon, thanks to the time and talent of Wiley Evans. We will keep you posted as this project moves forward.

- Ocean Acidification Network Update: Plans and priorities template. To help assemble the framework to develop an OA monitoring build-out plan in 2018 we will be circulating a template this fall to collect information from researchers to
make sure their near and long-term plans and research interests are incorporated in the plan.

- Ocean Acidification Network Update: Fishing community engagement: The fishing working group has been active this summer, organizing a number of the events listed below. We are also developing a list of key industry contacts to whom we will be introducing the network, providing resources, and discussing ways to get involved. We hope to establish relationships with some of the larger commercial fishing players and explore possibilities of partnering to fund research in areas of highest importance to fishermen. ()

- Presentations by Kenneth Dunton and Alex Whiting given at the June 7th Coastal Resilience Collaboration Team Meeting (http://www.iarpccollaborations.org/members/milestones/2809) are relevant to this PE. (Aug 28, 2017 - Completed)

- 8.2.3 (In progress) Continue to develop a general Arctic-wide wildlife response model that relates to species-specific models of Arctic coastal organisms.; DOI-USGS (Lead)

- The USGS delivered a presentation to the IARPC Coastal Resilience Collaboration Team on October 4th, 2017, regarding the framework and content of Arctic-wide and species-specific response models for wildlife that the USGS and collaborators have developed. These models are being used to not only characterize and prioritize research on coastal wildlife species in the Arctic, but also to capture expert knowledge, acknowledge areas of uncertainty, and produce forecasts of future population status for Pacific walrus, polar bears, and Arctic-nesting geese. (Oct 5, 2017 - Completed)


- 8.2.4 (In progress) Understand and monitor processes to manage and mitigate potential and realized threats from coastal invasive species, biotoxicoses, and wildlife diseases by leveraging research under initiatives and programs such as One Health, the DBO network, AMBON, and Aerial Surveys of Arctic Marine Mammals (ASAMM) work.; HHS (Lead), NOAA (Lead), DOI-BOEM, DOI-FWS, DOI-USGS, MMC
  - New Publication Evaluates Factors Influencing the Health of Polar Bears: USGS Alaska Science Center scientists, along with colleagues from Colorado State University, University of Connecticut, USDA- Veterinary Services, USDA-National Wildlife Research Center, and USDA- Agricultural Research Service authored a paper investigating factors influencing the exposure of polar bears to pathogens and persistent organic pollutants. The authors found that seroprevalence of Brucella spp. and Toxoplasma gondii antibodies likely increased through time, and provide the first evidence of exposure of polar bears (and Arctic marine mammals) to Coxiella burnetii, Neospora caninum, and Francisella tularensis. Additionally, the odds of exposure to T. gondii were greater for bears that used land than for bears that remained on the sea ice during summer and fall, while mean concentrations of the pollutant chlordane were lower for land-based bears. The study suggests that changes in polar bear behavior brought about by climate-induced modifications to the Arctic marine ecosystem may increase exposure risk to certain pathogens and alter contaminant exposure pathways. Citation: Atwood, T.C., C. Duncan, K. Patyk, P. Nol, J. Rhyan, M. McCollum, M. McKinney, A. Ramey, O.H. Kwok, S. Hennager, and J.P. Dubey. 2017. Environmental and behavioral changes may influence the exposure of an Arctic apex predator to pathogens and contaminants. Scientific Reports, in press.
  - The Arctic Nearshore Impact Monitoring in Development Area (ANIMIDA) III: This program broadens understanding of contaminants, sources, and bioaccumulation in the Beaufort Sea area. The program includes a comprehensive sampling plan to characterize the lease area and surrounding area's chemistry and biota, generating data that are comparable to current and past sampling efforts in the lease area (e.g., past ANIMIDA and cANIMIDA work). A team of scientists from The University of Texas at Austin, the Florida Institute of Technology, the
University of Alaska-Fairbanks, Battelle, and Oligoink-Fairweather conduct the work, which includes sampling in summers 2014 and 2015, with data synthesis in 2015-2016. This work is funded by the Bureau of Ocean Energy Management (BOEM). More information can be found here: http://arcticstudies.org/animida_iii/ (Sep 26, 2017 - Completed)

- Ongoing-Steffansson Sound Boulder Patch: The Stefansson Sound Boulder Patch is a kelp bed community located in the central Alaska Beaufort Sea coast at water depths ranging from 5-7 m. Geographically isolated from other areas of hard rock substrate in the Arctic Ocean, the Boulder Patch is a regional biodiversity hotspot dominated by the kelp Laminaria solidungula. This research program is funded by the Bureau of Ocean Energy Management (BOEM) to establish an integrated knowledge of this biologically productive and diverse ecosystem. Studies began in 1978 and continue through the present. We are currently supported through BOEM Award Number M12AS00001 to The University of Texas at Austin Marine Science Institute. More information can be found here: http://www.arcticstudies.org/boulderpatch/index.html

- Ongoing—Aerial Surveys of Arctic Marine Mammals (ASAMM) a NOAA led BOEM partnership: The Aerial Surveys of Arctic Marine Mammals project is a continuation of the Bowhead Whale Aerial Survey Project (BWASP) (https://www.afsc.noaa.gov/nmml/cetacean/bwasp/archive.php) and Chukchi Offshore Monitoring in Drilling Area (COMIDA) (https://www.afsc.noaa.gov/nmml/cetacean/bwasp/archive.php) marine mammal aerial survey project. The goal of these studies is to document the distribution and relative abundance of bowhead, gray, right, and fin whales, belugas, and other marine mammals in areas of potential oil and natural gas exploration, development, and production activities in the Alaskan Beaufort and northeastern Chukchi Seas. The 2017 ASAMM field season will run from 1 July to 31 October (daily survey reports available at: https://www.afsc.noaa.gov/nmml/cetacean/bwasp/flights_2017.php). Data from the ASAMM surveys will be used to relate variation in marine mammal distribution or abundance to other variables, such as physical oceanographic conditions, indices of potential prey density, and anthropogenic activities, if information on these variables is available. More information can be found here: https://www.afsc.noaa.gov/nmml/cetacean/bwasp/

- New Publication on Disease Baselines in Arctic Foxes from Utqiagvik (Barrow): In a new paper, scientists from USDA and the USGS Alaska Science Center, examined Arctic fox carcasses from Utqiagvik (Barrow) Alaska, to determine baseline levels of disease. Muscles of herbivores commonly harbor sarcocysts of parasites belonging to parasitic species in the genus Sarcocystis, but such muscle parasites are rare in carnivores such as foxes. This paper reports Sarcocystis arctica-like sarcocysts in muscles of Arctic foxes for the first time. We provide evidence that sarcocysts are common in Alaskan Arctic foxes suggesting that these carnivores are serving as intermediate hosts, and we also provide ultrastructure of S. arctica from the Arctic fox for the first time. Implications for wildlife health and disease transmission are being determined. Citation:

New Publication on Bacteria Responsible for Nonviable Goose Eggs on the North Slope of Alaska: In a recent paper, scientists from the USGS Alaska Science Center and the University of Alaska Fairbanks describe how during the summers of 2013 and 2014, isolates of a novel Gram-stain-negative coccus in the genus Neisseria were obtained from the contents of nonviable greater white-fronted goose eggs on the Arctic Coastal Plain of Alaska. Genetic results suggested that these Alaskan isolates are members of a distinct species, with the name Neisseria arctica. This bacteria does not appear to occur in eggs at a level that is thought to be harmful to populations. Ongoing work is examining whether this is a new bacteria in the Arctic, possibly transmitted by migratory geese from wintering grounds in the lower-48 United States. Citation: Hansen, C. M., E. A. Himschoot, R. F. Hare, B. W. Meixell, C. R. Van Hemert, and K. Hueffer. 2017. Neisseria arctica sp. nov. isolated from nonviable eggs of greater white-fronted geese (Anser albifrons) in Arctic Alaska. International Journal of Systematic and Evolutionary Microbiology 67:1115-1119. doi:10.1099/ijsem.0.001773 (Sep 13, 2017 - Completed)

- 8.2.5 (In progress) Conduct research that informs changes in wildlife hunt, harvest, and conservation management such as the Arctic-related LCC-funded moose sightability correction factor model development effort.; DOI-FWS (Lead), NOAA

  New USGS publication: Effects of Industrial and Investigator Disturbance on Arctic-Nesting Geese. Direct encounters with humans can increase the likelihood that nesting geese will lose their eggs to predators, according to a U.S. Geological Survey (USGS) study. As part of a study to understand reasons for the rapid increase of geese across northern Alaska and to understand potential impacts to nesting-geese from oil and gas development on the Arctic Coastal Plain of Alaska, USGS researchers used remote cameras to assess the behavioral response of Greater White-fronted geese to disturbance. Results of the study indicate that effects of both industrial and research activity can be minimized through practices that limit direct encounters with nests, such as minimizing travel on the tundra during the nesting season, using established travel routes during the summer, and minimizing the research study area to reduce impact. The article and associated data release are listed below: Publication citation: Meixell, B. W. and P. L. Flint. 2017. Effects of industrial and investigator disturbance on Arctic-nesting geese. Journal of Wildlife Management Early View. doi:10.1002/jwmg.21312 Data citation: Meixell, B. W., 2017, Greater White-fronted Goose (Anser albifrons) Nest Characteristics and Nesting Behavior Classifications from Time-lapse Photographs and Nest Visit Data; Point Lonely, Alaska, 2013-2014: U.S. Geological Survey data release, https://doi.org/10.5066/F7NV9GP9.

- 8.2.6 (In progress) Improve knowledge of phenology in relation to coastal climate and plant and animal life to better understand issues related to
mismatches between prey, predators, hunters, and gatherers in the context of and in collaboration with Arctic coastal communities. This element includes a Western Alaska LCC-funded project on subsistence berry availability.; DOI-FWS (Lead), DOI-USGS (Lead), NSF

- New USGS-led Publication on Mismatches with Caribou and Forage in Alaska: Climate-induced shifts in plant phenology may adversely affect animals that cannot or do not shift the timing of their reproductive cycle. Caribou rely heavily on maternal energy stores to reproduce and give birth near the onset of the growing season but are they vulnerable to trophic mismatch? We evaluated the long-term changes in the temperatures and characteristics of the growing seasons, and compared forage quality for caribou at peak parturition, peak lactation, and peak forage biomass at two distinct time periods over 36 years (1977 and 2011–13). We found no decline in forage quality and therefore no evidence within this dataset for a trophic mismatch at peak parturition or peak lactation from 1977 to 2011–13. Citation: Gustine, D. D., et al. 2017. Advancing the match-mismatch framework for large herbivores in the Arctic: Evaluating the evidence for a trophic mismatch in caribou. PLoS One 12(2): e0171807. doi:10.1371/journal.pone.0171807 (Sep 13, 2017 - Completed)

- Yukon-Kuskokwim Delta Berry Outlook: Identifying berry vulnerabilities to climate and landscape change using traditional and scientific ecological knowledge. This project began in 2016 and continued in 2017. Berry-producing plants play an important role in human and wildlife communities in the Yukon-Kuskokwim Delta. Berries provide food for subsistence and are a preferred food source for birds. Berry yield can be influenced by snow cover, rainfall, soil moisture, and air temperature, and availability of insect pollinators, all of which may be significantly altered by climate change. Additional information and tools are necessary to predict how the distribution and productivity of berry-producing plants may be altered by climate change. The overreaching goal of this project is to develop a Yukon-Kuskokwim Berry Outlook: a data- and observer-driven ecological monitoring and modeling framework that forecasts changes in berry abundance with climate and environmental change. This project will 1) solicit local observations of patterns of change in berry abundance, including hot spots that are highly sensitive or highly resilient; 2) develop models relating berry cover and abundance to climatic and environmental drivers, based on observer information and extensive, existing vegetation, salinity, storm surge, and climate data; 3) produce a spatially-explicit “Berry Outlook” using map layers of current and predicted climate and environmental conditions; and 4) share results with stakeholders and identify priorities, potential points of management intervention, and future activities. Contact: Rachel Loehman, USGS Alaska Science Center.

8.3 Advance knowledge on the physical coastal processes impacting natural and built environments.

- 8.3.1 (In progress) Improve understanding of coastal erosion and deposition, including related geomorphic changes due to permafrost degradation, reduced sea ice extent, storm surge, increased wave action, and sea level rise.
This Element includes work by the USGS Coastal and Marine Geology Program, USGS Alaska Science Center, U.S. Army Corps of Engineers (USACE), and others.; DOD-USACE (Lead), DOI-USGS (Lead), DOI-BOEM, NOAA, NSF

- BOEM has entered into a cooperative agreement, Northern Alaska Jukebox - Phase III with the Coastal Marine Institute, University of Alaska, Fairbanks. PI is Leslie McCartney, Elmer E. Rasmuson Library. (Sep 21, 2017 - Completed)

- New Publication on Historical Record of Climate Change in Alaska and Implications for Permafrost Thaw: A recent publication with co-authors from USGS, Columbia University, University of Alaska Fairbanks, The College of Wooster, and Reanier & Associates Inc., examined how declining sea-ice extent is currently amplifying climate warming and permafrost thaw in the Arctic. The authors used the oxygen isotope values of wood cellulose in living and sub-fossil willow shrubs that have been radiocarbon-dated to produce a multi-millennial record of climatic change on Alaska's North Slope during the Pleistocene-Holocene transition (13,500–7500 years before present). Based on these results and on the effects that sea-ice have on climate today, we infer that ocean-derived feedbacks amplified temperature changes and enhanced precipitation in coastal regions of Arctic Alaska during warm times in the past. Today, isotope values in willows on the North Slope of Alaska are similar to those growing during the warmest times of the Pleistocene-Holocene transition, which were times of widespread permafrost thaw and striking ecological changes. Gaglioti, B. V., D. H. Mann, M. J. Wooller, B. M. Jones, G. C. Wiles, P. Groves, M. L. Kunz, C. A. Baughman, and R. E. Reanier. 2017. Younger-Dryas cooling and sea-ice feedbacks were prominent features of the Pleistocene-Holocene transition in Arctic Alaska. Quaternary Science Reviews 169:330-343. doi:10.1016/j.quascirev.2017.05.012 (Sep 13, 2017 - Completed)

- New USGS Publications on Shoreline Change in Northern Alaska: Alaska’s north coast is predominantly erosional, averaging a loss of 1.4 meters a year (http://pubs.usgs.gov/of/2015/1048/pdf/ofr2015-1048.pdf). Along a much smaller stretch (60 kilometers) (http://soundwaves.usgs.gov/2009/05/research2.html) of this coastline, USGS found that average annual erosion rates doubled from historical levels of about 20 feet per year between the mid-1950s and late-1970s, to 45 feet per year between 2002 and 2007. The study along that stretch of the Beaufort Sea also verified the disappearance of cultural and historical sites (http://arctic.journalhosting.ucalgary.ca/arctic/index.php/arctic/article/view/44), including Esook, a hundred-year-old trading post now underwater on the Beaufort Sea floor, and Kolovik (Qalluvik), an abandoned Inupiaq village site that may soon be lost. The change in erosion rates is likely the result of several changing Arctic conditions, including declining sea-ice extent, increasing summertime sea-surface temperature, rising sea level, and possible increases in storm power and corresponding wave action. More information is here: https://walrus.wr.usgs.gov/climate-change/hiLat.html Recent publications on this work are listed below: Gibbs, A.E., and Richmond, B.M., 2015, National

- **8.3.2 (In progress) Increase understanding of coastal freshwater hydrologic changes in rivers, lakes, snow, and permafrost through projects such as the Soil Climate Analysis Network (SCAN) soil moisture and temperature site monitoring.; DOI-USGS (Lead), NOAA (Lead), USDA-NRCS (Lead), DOI-BLM, DOI-BOEM, DOI-NPS, NASA, NSF

  - New Publications on Lake and Pond Databases for Northern Alaska:

  - Below is information for three recently funded NASA projects. Their research going forward is likely to contribute to progress in achieving this milestone. Arctic Biogeochemistry: Laney, Samuel, Woods Hole Oceanographic Institution. “Riverine Carbon Contributions to Alaskan Arctic Coastal Margins”, funded under Carbon Cycle Science in ROSES 2016. An abstract is available at: https://cce.nasa.gov/cgi-bin/obb/pi_list.pl?project_group_id=3615. This research seeks to better quantify the seasonality and variability in the riverine contribution of organic carbon into Arctic Ocean coastal margins. Rivers feeding the coastal Arctic Ocean drain several types of biomes and represent a major source of particulate and dissolved organic carbon (POC and DOC) to Arctic coastal margins. Climate-driven changes to Arctic terrestrial biomes will almost certainly alter the magnitudes and relative contributions of POC and DOC that different rivers transport into their adjacent coastal oceans. Direct assessment of river-specific baselines for this terrestrial carbon input has been challenging because
much of this carbon is delivered by the spring freshet that occurs while the coastal ocean is still covered by landfast sea ice. This project will examine the seasonality and magnitude of this carbon transport and its relationship to coastal hydrography and circulation, the spring freshet, seasonal ice dynamics, and remote sensing variables available during the freshet such as sea ice cover and ice morphology. This research involves a two-year observational study on the Alaskan Beaufort Shelf using bio-optical moorings and direct, through-ice monitoring to assess the magnitude and timing of riverine POC and DOC contribution into the coastal Arctic. Six moorings will be deployed near Prudhoe Bay at the mouths of two rivers that drain terrestrial biomes with different vegetation and precipitation characteristics: the Kuparuk River which drains a primarily tundra biome, and the Sagavanirktok River which drains the coastal plain and the north slope of the Brooks Range. Sensors will measure optical proxies for POC and DOC over two full annual cycles, most critically in the period encompassing the spring freshet when riverine transport of POC and DOC is largest but when these coastal waters remain ice-covered and thus not yet directly observable by remote sensing. Monthly-scale field studies will be conducted in the late spring, immediately prior to the freshet, to deploy sensor clusters through the sea ice to directly measure these optical proxies over the course of the freshet until sea ice cover degrades and coastal waters become visible to remote sensors. These two observational efforts will generate unique and valuable time series of proxies for POC and DOC as well as key environmental parameters related to coastal circulation, sea ice cover, and river discharge dynamics. These will be used in a subsequent analysis to quantify how the spatial and temporal evolution of riverine DOC and POC injection by these two rivers relate to physical factors such as riverine seasonal flow and freshwater runoff, coastal hydrography and circulation, and importantly, seasonal sea ice cover. By examining two representative rivers that drain different types of terrestrial biomes, this study will provide insight into possible source-river differences in organic carbon transport into these seasonally ice-covered Arctic coastal margins. Having such direct, long-term observations of proxies for the POC and DOC delivered by the spring freshet is essential for reducing uncertainties about key aspects of the organic carbon cycle on the Alaskan Arctic coastal margin: What is the timing and magnitude of POC and DOC injection into Arctic coastal margins? How can autonomous systems help to assess differences in POC-DOC contributions by rivers that drain such different types of biomes (e.g., tundra vs. alpine)? How do ice cover, hydrography, circulation, winds, and freshwater input affect the areal distribution of water column POC and DOC on this shelf, during the freshet? How might available remote sensing variables during this time of year be used to better understand similar riverine contributions of POC and DOC more broadly across Arctic coastal margins in the Beaufort Sea and beyond? Coastal Resilience focus: Peter Hernes, University of California, Davis. “Impacts of estuarine processes on delivery of Arctic riverine materials to the near coastal environment: Implications for water quality and biogeochemical cycling in Preparation for Arctic-COLORS”. Funded under Remote Sensing of Water Quality in ROSES 2016. Environmental systems do not wait until it is convenient for humans to respond to perturbations, and a prime example of this is
the rapidly changing Arctic that has science and policy scrambling to keep up. This highlights a critical need for programs such as NASA’s Arctic-Boreal Vulnerability Experiment (ABoVE) and Arctic-Coastal Land Ocean inteRactionS (Arctic-COLORS) that aim to characterize the extent of change to terrigenous and coastal systems in the Arctic, respectively, and the strength of associated feedbacks. However, it also highlights the issue of timing that these programs need to be fully implemented as quickly as possible for maximum impact on future policy decisions. The proposed research outlined here seeks to jumpstart Arctic-COLORS while filling major gaps in our understanding of the linkages between aquatic optical and biogeochemical properties and our knowledge about the transformation of inland water quality constituents from the ABoVE domain through estuaries to the near coastal environment. Our overarching goal is to use new and enhanced remotely sensed water quality observations to better understand biogeochemical fluxes and transformations across terrestrial-aquatic interfaces in the Arctic. Specifically, we propose to: 1) Lay the foundation for Arctic-COLORS by establishing current baseline water quality conditions from the head of tides to the near coastal environment in two larger river systems (Yukon and Mackenzie Rivers) and a smaller river system on the North Slope of Alaska. 2) Characterize the transformation of riverine material through estuarine gradients across different seasonal and hydrologic conditions in order to model delivery of materials to the near coastal environment from more than a decade of past river measurements from the Arctic Great Rivers Observatory (Arctic-GRO) dataset. 3) Refine and develop algorithms for water quality concentrations from remote sensing data, which can then be used to hindcast coastal Arctic conditions back to 2002 and quantify the extent and rates of change in delivery of riverine materials to the near coastal environment. The validity of these hindcast values will be assessed through data synthesis efforts of past measurements and modeled exports as outlined in item #2. To link optics to aquatic biogeochemistry across the continuum of Arctic rivers, estuaries and the coastal ocean, we plan intensive field sampling on the Yukon River-delta for three transects in spring, early and late summer, acquisition of additional transect samples during similar flow regimes through our collaborators on the North Slope and Mackenzie River, and a period of continuous monitoring in the Yukon River. These study regions are part of both the ABoVE and Arctic-COLORS core study domains. In addition to the proposed new field observations, we will conduct a series of controlled salinity mixing experiments on samples from all three systems that will simulate transport through estuarine gradients during seasons in which we are not collecting transects. This is crucial for understanding the fate of terrigenous organic matter in the Arctic Ocean. Finally, we propose to synthesize existing bio-optical, hydrological and biogeochemical datasets in coastal and inland Arctic ecosystems collected as part of our prior work in the framework of Arctic-GRO and ABoVE, and through our proposed collaborations. These new and existing observations will allow us to develop new and refined remote sensing bio-optical retrievals and atmospheric corrections that will allow regional scaling and temporal hindcasting. Through the proposed integration of field sampling, satellite algorithm development, hindcasting, and synthesis efforts the proposed study will provide
critical new knowledge of biogeochemical transformations across Arctic terrestrial-aquatic interfaces and an urgently needed link between the ABoVE and Arctic-COLORS field programs, both on the spatial and temporal domain. Michael Rawlins, University of Massachusetts, Amherst. “Merging Satellite Data and Models to Investigate Soil Freeze-Thaw Dynamics Influencing Terrestrial Water and Carbon Exports from the Western Arctic”. Funded under Remote Sensing of Water Quality in ROSES 2016. Manifestations of climate change in the Arctic are expected to include an intensified hydrologic cycle and thawing permafrost, with likely impacts on river discharge and associated constituents. Changes in the quantity and quality of water and carbon exported from terrestrial areas are expected as the Arctic undergoes a transition to a more groundwater-dominated system. The limited number of observations challenges our understanding of the magnitude and spatio-temporal variability in these exports, particularly for unmonitored rivers in northern Alaska. We will leverage available records of river discharge and surface soil freeze/thaw (FT) state from satellite data, and hydrological modeling to improve understanding of the temporal and spatial dynamics in freshwater export into coastal margins from the Yukon to Mackenzie (Y2M) Rivers. We will use remote sensing data sets for key spatially distributed geophysical quantities and will quantify interannual variability and the sign, magnitude, and significance of changes in freshwater export over recent decades. Our project will advance understanding of changes likely to occur as a result of declining frozen seasons, soil active layer deepening, permafrost thaw and hydrological cycle intensification. We will integrate multi-frequency satellite microwave remote sensing and other synergistic geospatial data using a novel machine learning Bayesian data fusion framework for probabilistic estimation of soil FT daily dynamics. We will develop a database of freshwater export across the western Arctic, focusing on export to coastal margins from the Yukon to Mackenzie rivers. We will merge available measurements with model simulated hydrography to derive exports in unmonitored areas. For areas lacking observed data our derived freshwater export time series will leverage a permafrost-hydrology model specifically adapted for studies of the terrestrial arctic water cycle. An ensemble of model simulations validated with gauge data from monitored rivers will be used to document uncertainties in export. Model simulations will make use of the growing collection of high resolution datasets being developed under NASA 's Arctic-Boreal Vulnerability Experiment (ABoVE). Synergistic satellite data for FT timing, soil moisture, and surface water extent dynamics will be employed to constrain the process modeling. The project will advance mechanistic and predictive understanding of freshwater export with a central focus on physical processes operating within high latitude watersheds. This synthesis of data and models will advance understanding of how warming manifested through water cycle intensification and permafrost degradation is likely to impact terrestrial water and carbon exports to Arctic coastal areas. (Sep 4, 2017 - Completed)

8.4 Improve observations, mapping, and charting to support research across the coastal interface.
8.4.1 (In progress) Update the National Spatial Reference System in the Arctic to enable integration of baseline geospatial datasets in coastal areas to support research and predictive capabilities across the coastal interface.; NOAA (Lead), DOD-NGA

- In FY17, NOAA's National Geodetic Survey (NGS) continued acquiring airborne gravity measurements over Alaska as part of the nationwide Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project. GRAV-D data collection is now at 78.4% for all of Alaska, 89% excluding the Aleutians; areas of data coverage may be viewed here: https://www.ngs.noaa.gov/grav-d/data_products.shtml. In support of improved GPS-based access to accurate and consistent vertical heights in coastal areas of Alaska, NGS also released a new experimental geoid product in FY17 (xGeoid17) that is a preview of what the geoid will look like in the new North American-Pacific Geopotential Datum of 2022 (NAPGD2022): https://beta.ngs.noaa.gov/GEOID/xGEOID17/. This updated experimental product incorporates the data from 2 additional GRAV-D survey blocks in Alaska. In February, 2017 NOAA provided a webinar to summarize these recent developments and the effects that these new data will have on positioning tools in Alaska. The GRAV-D Update and Experimental Geoid in Alaska webinar recording is available online: https://www.ngs.noaa.gov/web/science_edu/webinar_series/gravd-xgeoid.shtml. (Sep 13, 2017 - Completed)

8.4.2 (In progress) Develop new sensor technologies and data collection and application methods specific to understanding and characterizing relationships within coastal systems across all seasons for natural resource, community, and emergency response planning and management.; NOAA (Lead), DOI-FWS, DOI-NPS

- Oblique iGage Water Level R&D Demonstration Underway  An iGage is being tested in Whittier, AK this year to see if it can provide accurate water levels looking obliquely rather than the standard nadir view. If successful, it will provide an inexpensive method for monitoring water levels in remote areas and communities without the infrastructure (bridges, piers) needed for nadir looking systems.

- 2017 Rapid Deployment Inundation Platform (RDIP) Deployments NOAA and AOOS supported UAF’s development of Rapid Deployment Inundation Platforms (RDIP) to measure storm tide water levels in areas without continuous water level monitoring systems. Community members in Shishmaref, Shaktoolik and Kivalina are being trained to deploy the units in advance of coastal storms. Supports the Strategic Management Plans of Shishmaref, Shaktoolik and Kivalina.

- Rapid Deployment Storm Surge Gauges The Coastal Hazards program at Alaska Department of Natural Resources contracted with JOA Surveys LLC to install Rapid Deployment Storm Surge Gauges in Hooper Bay and Nunam Iqua for the fall 2017 storm season. These consist of an in-ground vault where water level loggers can be placed in less than 10 minutes.
- Rapid Deployment Storm Surge Gauges  The Coastal Hazards program at Alaska Department of Natural Resources contracted with JOA Surveys LLC to install Rapid Deployment Storm Surge Gauges in Hooper Bay and Nunam Iqua for the fall 2017 storm season. These consist of an in-ground vault where water level loggers can be placed in less than 10 minutes.

- 2017 iGage Water Level Instrument Installations  Three new iGage water level sensors were deployed this summer in Kaktovik (replacement), Unalakleet (replacement), and Dillingham (new). (Sep 1, 2017 - Completed)

- Emerging Technologies workshop – Axiom’s Kyle Wilcox presented on behalf of IOOS, AOOS and partners CeNCOOS and SECOORA at NOAA’s second Emerging Technologies workshop August 22-23. (Aug 23, 2017 - Completed)

- Ice Detection Buoy Deployed  An Ice Detection Buoy was deployed August 14, 2017 ~70 miles northwest of Wainwright, Alaska and is transmitting data through the Global Telecommunication System (GTS) for evaluation in real-time ice forecasting models. For more information on the buoy see http://www.aoos.org/ice-detection-buoy/ (Aug 14, 2017 - Completed)

- New Arctic Marine Atlas Released – Audubon Alaska’s massive update to this atlas, describing bird, fish, and marine mammal habitats and migration routes as well as human uses, was released at an event August 4. AOOS is working with Audubon to incorporate the database and a version of the map layers into the AOOS Ocean Data Explorer. (Aug 4, 2017 - Completed)

- Presentations by Raphaela Stimmelmayr and Vera Metcalf given at the July 6th Coastal Resilience Collaboration Team Meeting (http://www.iarpccollaborations.org/members/events/7846) are relevant to this Performance Element (Jul 7, 2017 - Completed)

- AOOS-UNAVCO Water Level Joint Venture– Molly and Carol met with representatives of UNAVCO to discuss the results of their scoping project aimed at identifying potential locations in western Alaska for deployment of GPS reflectometry sensing devices. These systems that can be used for measuring water levels in remote regions. Potential recommended sites include St. Michael, Hooper Bay and Toksook Bay. The first site for installation will be selected soon, and with the goal to instrument all three locations over the next two years. For more info: http://www.aoos.org/new-aoos-projects-to-test-land-based-water-level-techniques/

- Trial Water Level Sensing Devices Installed - In early April two dual-frequency GPS receivers were installed in Seward near the Alaska SeaLife Center by ASTRA LLC. This AOOS project, funded by the Alaska region of the National Weather Service, will evaluate this system’s suitability for land-based water level measurements prior to extending the technology to a broader monitoring network in remote locations. Immediately following installation this eagle decided it was a good lookout platform. (Apr 7, 2017 - Completed)
8.4.3 (In progress) Produce modeled tidal predictions for the U.S. Arctic. Involve multiagency collaborators, including Alaska Ocean Observing System (AOOS) representatives.; NOAA (Lead)

- UNAVCO contract- Molly and Carol met with representatives of UNAVCO to discuss the results of their scoping project aimed at identifying potential locations in western Alaska for deployment of GPS reflectometry sensing devices. These systems that can be used for measuring water levels in remote regions. Potential recommended sites include St. Michael, Hooper Bay and Toksook Bay. The first site for installation will be selected soon, and with the goal to instrument all three locations over the next two years. For more info: [http://www.aoos.org/new-aoos-projects-to-test-land-based-water-level-techniques/](http://www.aoos.org/new-aoos-projects-to-test-land-based-water-level-techniques/)

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**Agencies**
DOC, DOI, DOS, HHS, NASA, NSF, OSTP, SI
9.1 Environmental intelligence

9.1 Enhance multi-agency participation in new and existing activities to improve best practices, coordination, and synthesis of Arctic observations toward a fully integrated interagency "U.S. Arctic Observing Network" (U.S. AON).

- 9.1.1 (In progress) Coordinate U.S. agency and outside collaborators support for and participation in the international Sustaining Arctic Observing Networks (SAON) process.; NOAA (Lead), DHS-USCG, DOD-ONR, DOE, NASA, NSF
  
  - SAON is rewriting strategic plan for the next 5-years, will send it to IARPC to distribute for comment and engagement. Would be good to have alignment between US priorities for observing and SAON strategic plans. New SAON chair Gunnerson (Iceland), Larry Hinzman new Vice Chair. STPI value tree has been really helpful in developing SAON plan. Would like to encourage more US involvement in SAON by connecting IARPC community into SAON - will improve engagement with IARPC community over the next year.
  
  - ADAC is developing a long-range autonomous underwater vehicle for under-ice mapping of oil spills and environmental hazards. (Oct 4, 2017 - Completed)
  
  - The AOSST and ADST teams conducted joint SAON collaboration team meeting to introduce the IARPC community to the Arctic Data Committee and the Committee on Observations and Networks. This meeting was held prior to the Arctic Observing Summit meeting in order to obtain input from the research community on SAON progress and future directions.

- 9.1.2 (In progress) Work with the research community and other stakeholders to develop the concept of multi-agency research coordination networks to advance observational science and promote broad synthesis within thematic research communities.; NOAA (Lead), NSF (Lead), DOD-ONR, DOE, NASA
  
  - Eyes North Program is an NSF-funded research coordination network that initiated last October and has primarily hosting workshops and meetings. Intentions are to develop best practices and coordinate observations across the community-based observer continuum. A write up of activities have been
summarized and posted on the IARPC website. (Some workshops: Earth X workshop, Northern Boarders Workshop, Evergreen Workshop (May), Coastguard Workshop) Synergies between Eyes North and IARPC: the assessment framework could be very useful in identifying how community based observing can feed into informational products. Framework could also be used to guide community based work within Arctic. (NSF Contact: David Griffith)

- EPA is working with US-AON to identify points of leverage for observing efforts. Our goal is to find where we can improve human health aspect by combining different independent observing assets. An existing EPA networks include the LEO Network-ANTHC. We presented two topical areas- HABs and wildfires with some positive feedback from NOAA, NWS and IARPC. Internal EPA call to identify all of the resources currently dedicated to Arctic observing that can be used to continue progress on these efforts. We hope to continue discussion of potential partnerships.

- NOAA supported a 2017 NOAA DBO cruise to the northern Chukchi Sea on the USCGC HEALY. 21-day cruise, 4 of the 5 primary DBO lines as well as a high-resolution Northern Chukchi shelf survey. Plan to fund an annual DBO cruise in the future. First successful deployment of Arctic Saildrones, large remotely piloted vehicles into the Arctic in conjunction with the DBO cruise. Welcome collaboration and partnerships- number of NSF scientists that were onboard the 2017 cruise. Hope to make the platform and datasets available to the rest of the IARPC community.

- Atmospheric Radiation Measurement (ARM) program: activities at the Barrow Site are going well and moving forward with collaborating with NWS for radiosonde launches. At the Oliktok Point site due to power and logistical issues during the winter we plan to remove some instruments including LIDAR and scanning cloud radar while also limiting to one radiosonde launch per day. Assuming positive congressional appropriations for FY18 we are planning to continue maintaining the measurements at Oliktok site. Plans to do tethered balloon observations at Oliktok site in the spring and summer. Logistical efforts to support the MOSAiC campaign are continuing with a planning meeting scheduled for November. In addition to the field work doing on in Barrow, NGee Arctic they’ve established three field sites on the Seward Peninsula with permafrost monitoring, active layer thickness and landscape heterogeneity. They’ve been moving forward with using LIDAR and aerial photography for micro tomography and vegetation structure. The field at Seward has been coordinated with the Nasa ABoVE campaign. Ngee Arctic has also been contributing to pan-Arctic datasets by reporting out to the permafrost region pond and lake database.

- Stratified Ocean Dynamics of the Arctic (SODA) project, which is the directors research initiative, aims to understand how the upper Beaufort Sea responding to changes in inflow and surface forcing. That team has been pulled together and recently met to develop their plan for the FY18-19 field program (APL UW website for details). Also, looking for LOIs and proposals for that broad inter-agency announcement for sensor development or improvement.
Arctic Observing Viewer (AOV) is in the process of updating two apps that can be helpful with Arctic science planning: Arctic Research Mapping (ARMAP) application and Arctic Observing Viewer (AOV). The new version of ARMAP is much more powerful for searching and filter interface. These apps have the potential to help guide planning and strategic observations in the Arctic.

The inaugural year of the US AON realized great strides in cross-agency engagement, community outreach, task scoping and coordination, and international framework development. FY18 will build upon this base of engagement, outreach, and development, but focus more particularly on scoping and fostering US AON Tasks and developing US AON Framework discussions in order that the community can make stronger, independent contributions to the effort. US AON integrates and translates Arctic observations (routine + research) into improved products and services in support of NOAA’s mission service areas and its Arctic Vision and Strategy; Implications for humans, society, security and economy. The following focal areas will be executed by the US AON Executive Director, in coordination with US AON Committee members; (1) Advancing a guiding strategy for interagency US AON, (2) Advancing US AON Task and US AON Framework Teams, (3) Serving as the US coordinating nexus for SAON and relevant international activities and (4) Advancing the diversity of US AON activities through promoting dialog on diversity and inclusion in Arctic field science and sustained observations.

The AOSST held a collaboration team meeting on the observational efforts in the terrestrial carbon sphere. Speakers from the ABoVE, NGEE Arctic and SEARCH campaigns were invited to speak on carbon observations. Participants brainstormed research/knowledge gaps and identified future directions for bridging marine-terrestrial-atmospheric carbon cycle science. This activity also contributed to the overall EI carbon cycle effort.

The AOSST held a collaboration team meeting on networks and invited speakers from the Arctic Observing Viewer to help guide a community discussion on developing a US AON network. The participants brainstormed about how a network inventory activity can be used to identify essential variables for US AON using a bottom-up approach.

The AOSST hosted a collaboration team meeting entitled "Fostering First Followers" lead by Dr. Sandy Starkweather on engaging partners for the US Arctic Observing Network. This meeting identified an existing Arctic observing effort, AOOS (Alaskan Ocean Observing System), that can be used to provide guidance and leadership during the formation of US AON.

The AOSST provided an overview of the new US Arctic Observing Network effort led by Dr. Sandy Starkweather. A portion of the meeting was also opened up to a community discussion on identifying future observing observing themes. Existing networks and observing programs identified in this discussion were Earth Scope USArray, the Distributed Biological Observatory Program and the LEO Project.
9.2 Advance understanding of the Arctic System by using global and regional models with detailed Arctic processes to understand feedbacks and interactions within the components of the Arctic system and with the climate system as a whole.

- 9.2.1 (In progress) Support and coordinate research to advance understanding of the connections between the Arctic and mid-latitude weather patterns and vice-versa.; DOE (Lead), NOAA (Lead), NSF (Lead), DOD-ONR, NASA

  - The MST invited speakers to discuss their current research efforts to evaluate the influence of Arctic change on mid-latitude weather. Presentations were given by:
    - Arctic Change and Possible Influence on Mid-latitude Climate and Weather: Synthesis of the recent CLIVAR workshop (Cohen, 10 min) http://www.iarpccollaborations.org/members/documents/9329. What are the different pathways/physical mechanisms of Arctic to mid-latitude linkages that should be targeted in modeling studies? (Magnusdottir, 10 min) http://www.iarpccollaborations.org/members/documents/9321. Modeling Studies of Arctic Change Influence on Mid-latitude Climate and Weather: Progresses and Challenges (Zhang, 10 min) http://www.iarpccollaborations.org/members/documents/9323 (Nov 3, 2017 - Completed)

  - The Workshop on Arctic Change and Its influence on Mid-latitude Weather and Climate was organized by CLIVAR through joint support by US agencies like NSF, NOAA, NASA, and DOE, and the WWRP (https://usclivar.org/meetings/2017-arctic-midlatitude-workshop). A white paper from the CLIVAR workshop is in preparation and it includes the summary of findings as well as discusses opportunities and recommendations for additional observations and coordinated model experiments to advance research on the mechanisms of Arctic to mid-latitude linkages.

  - NASA -funded paper looks at links between Arctic and North American warming: Full Citation: Kim, Jin-Soo, J-S. kug, S-J. Jeong, D.N. Huntzinger, A.M. Michalak, C.R. Schwalm, Y. Wei, K. Schaefer, “Reduced North American terrestrial primary productivity linked to anomalous Arctic warming,” Nature Geoscience, DOI: 10.1038/NGEO2986, 2017. Funding for the Multi-scale synthesis and Terrestrial Model Intercomparison Project (MsTMIP; http://nacp.ornl.gov/MsTMIP/shtml) was provided through NASA ROSES Grant #NNX10AG01A. Data management support for preparing, documenting and distributing model driver and output data was performed by the Modeling and Synthesis Thematic Data Center at Oak Ridge National Laboratory with funding through NASA ROSES Grant#NNH10AN681. Finalized MsTMIP data products are archive at ORNL DAAC (http://daac.ornl.gov). Background: Warming in the Arctic can lead to severe cold events and changes in precipitation in the continental U.S. due to atmospheric teleconnections. Analysis: Evaluates the link between Arctic temperatures and terrestrial ecosystem productivity in North America (NA).Uses Arctic temperature (ART) index derived from HadCRUT4; along with temperature and precipitation from CRU. Estimates of
GPP obtained from three products: 1) NDVI; 2) up-scaled GPP from flux tower data; and 3) terrestrial biospheric model simulation output from MsTMIP. Findings: Warmer than normal springtime temperatures in the Arctic → decreased plant productivity over most of North America. Decline is explained by two factors: 1) severe cold temperatures in northern NA; and 2) decreased precipitation in the South Central U.S. Translates into a reduced crop yield of 1 to 4% across U.S., with some states experience crop yield declines of up to 20%. Significance: Demonstrates for the first time, the linkage between Arctic temperature variations and ecosystem and agricultural productivity in the continental U.S. (Oct 12, 2017 - Completed)

- **9.2.2 (No progress) Support and coordinate research to enhance the understanding of connections between Arctic and global ocean circulation.**
  DOE (Lead), NOAA (Lead), NSF (Lead), DOD-ONR, NASA

  - DOE, NASA, NSF, and NOAA funded scientists are currently contributing to the activities of the US AMOC Science Team, an interagency group under the auspices of US CLIVAR that aims to formulate research priorities and coordinate activities related to the Atlantic Meridional Overturning Circulation. As an example, in the past 2 years, Wilbert Weijer (LANL) was member of the Executive Committee, and chaired the science team’s annual meeting in Santa Fe, May 23-25, 2017. He also initiated and coordinated a series monthly webinars to enhance information exchange and facilitate collaboration between science team members. In addition, the AMOC science team conducted a science-team-meeting ([https://usclivar.org/meetings/2017-us-amoc-science-team-meeting](https://usclivar.org/meetings/2017-us-amoc-science-team-meeting)) focusing on understanding and better predicting AMOC. One of the four foci of the meeting was on improving both prediction capabilities and understanding the impacts of AMOC on the climate and ecosystems. ()

  - A project, jointly funded by DOE’s Regional and Global Climate Modeling (RGCM) program and NOAA, is studying the Atlantic freshwater budget (including exchanges with the Arctic) and its impact on the Atlantic Meridional Overturning Circulation. The project is led by Wei Cheng (U, Washington), and involves scientists from LANL, NCAR, and UC Berkeley. A first paper “On the salt-advection feedback and its effects on AMOC stability and decadal variability” is being prepared for submission.

  - FAMOS (Forum for Arctic Modeling and Observational Synthesis) is an NSF-funded project (PIs Andrey Proshutinsky and Mike Steele) that brings together US and international Arctic scientists. FAMOS coordinates activities that combine observations and models to enhance our understanding of Arctic Earth System processes. They conducted an annual workshop in Woods Hole, October 25-27, 2017, and plans for coordinated activities and papers were discussed. Scientists funded by several agencies focused on different aspects of the Arctic system. As an example, DOE funded HiLAT and DOE and ONR funded Regional Arctic System Model (RASM) scientists focused on studies of freshwater exchanges between the Arctic Ocean and subpolar North Atlantic in a suite of models. (involving scientists from HiLAT and RASM).
DOE’s RGCM program is supporting a webinar series on High-Latitude Climate Processes and Feedbacks, organized by Wilbert Weijer (LANL). Monthly webinars feature two presentations on similar topics from different perspectives, to foster collaboration amongst different RGCM-funded projects.

- HiLAT and RASM PIs (Weijer, Rasch and Maslowski) –with significant community input- wrote a white paper on High-Latitude Climate Processes and Feedbacks, to identify knowledge gaps, capabilities and research priorities regarding high-latitude climate science.

- **9.2.3 (In progress) Enhance understanding of processes and their interactions and feedbacks within the Arctic System itself, including the complex relationships between the ocean, sea ice, land, and atmosphere; impacts of snow on ice; interactions between Arctic clouds and aerosols; effects of thermal forcing of sea ice; changes in ocean stratification; stratosphere-troposphere interactions; and radiative exchanges of energy throughout the system.; DOD-ONR (Lead), DOE (Lead), NOAA (Lead), NSF (Lead), NASA**

- DOE supported research by Xianglei Huang (U-Michigan) will improve the treatment of long-wave emissivity important over the bright surfaces of the Arctic: [https://climatemodeling.science.energy.gov/research-highlights/observationally-based-global-band-band-surface-emissivity-dataset-climate-and](https://climatemodeling.science.energy.gov/research-highlights/observationally-based-global-band-band-surface-emissivity-dataset-climate-and)

- Arctic deltas buffer and filter riverine fluxes before they reach the ocean, with important consequences for Arctic ocean circulation, sea ice processes and biogeochemistry. However, the timing and contents of these fluxes will likely change as deltas respond to higher temperatures, higher sea levels, and reduced sea ice. In 2017, DOE funded HiLAT project made progress on this topic by performing a systematic comparative analysis of the morphology of the major Arctic deltas using satellite imagery (Morphologic variability of Arctic deltas: Implications for fluxes to the coast and delta response to climate change. Piliouras and Rowland, in prep.). (Nov 3, 2017 - Completed)

- The DOE funded HiLAT project made progress on a project to study the complex interactions between cryospheric change, marine and sea ice ecosystems, aerosol emissions, and cloud responses. In particular, several new capabilities were implemented in the E3SM-HiLAT model framework in preparation for the experimentation phase; including: i) a high-latitude phytoplankton species (Phaeocystis ) that is specifically important for the emission of dimethyl-sulfide (DMS), an important source of biogenic aerosols; ii) a 3-dimensional model of biogeochemistry in sea ice, including two-way exchanges with the ocean physics and biogeochemistry; iii) explicit coupling of DMS from the ocean model to the aerosol module in the atmosphere model. An evaluation of the sea ice biogeochemistry module was performed in the context of Norwegian’s N-Ice project (Duarte, …, Jeffery, Elliott, Hunke…, 2017: Sea- ice thermohaline-dynamics and biogeochemistry in the Arctic Ocean: empirical and model results. J. Geophys. Res. Biogeosci.,122, doi:10.1002/2016JG003660). (Nov 3, 2017 - Completed)
The RASM project, in collaboration with HiLAT and with support from DOE-RGCM and NSF-OPP, have expanded its ocean and sea ice model components with marine biogeochemistry (mBGC), including the latest 3-d sea ice and ocean biogeochemistry within the high-resolution (~9-km) pan-Arctic RASM-mBGC. A paper evaluating improvements in RASM-mBGC compared to a coarse resolution model configuration is under revision for publication in JGR-Oceans.

A paper describing a new river routing scheme (RVIC) implemented and evaluated in RASM was published (Hamman et al. JGR-Oceans, 2017). In addition, a new runoff data set produced by RASM-RVIC scheme has been published and made publicly available as an alternative Arctic runoff reanalysis. (Nov 3, 2017 - Completed)

A paper on near-surface atmospheric climate sensitivity in RASM has been published by Cassano et al. in J. Climate, 2017. (Nov 3, 2017 - Completed)

The MST hosted a joint meeting with the Atmosphere and Sea Ice collaboration teams on the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) project. Presentations included: “Enhanced Process Understanding of the Coupled Arctic System through MOSAiC” (Matthew Schupe) MOSAiC and modeling (Wieslaw Maslowski)

9.2.4 (In progress) Conduct a survey and identify investigator-driven modeling projects designed to understand important local and global Arctic System feedbacks.; NSF (Lead), DOD-ONR, DOE, NASA, NOAA

The MST reviewed the previous modeling efforts survey and discussed the format and information that will be included in the updated modeling inventory. ()

9.3 Enhance climate prediction capabilities for the Arctic system from sub-seasonal to decadal timescales and climate projection capabilities up to centennial timescales by focusing on improving earth system models and their interactions, and assessing the strengths and weaknesses of the various coupled regional arctic and earth system models by conducting intercomparison and model evaluations.

9.3.1. (In progress) Support the configuration and the initial development of a global variable resolution model with very high resolution in the Arctic that will allow high-resolution interactions within the Arctic System and interactions between the Arctic and mid-latitudes; DOE (Lead), NSF

DOE has started to configure the E3SM with regional refinement of atmosphere, ocean, sea-ice and land over the Arctic. ()

The DOE funded HiLAT and RASM projects have started discussions with the E3SM team on potential collaborations regarding the development of an Arctic-focused version of the E3SM model.

9.3.2 (In progress) Support model development activities in global earth system models focusing on increased resolution, better coupling techniques, and inclusion of new process models in the Arctic for improved predictions, projections, and better representation of extreme events. In addition to
developing models for CMIP6, this will include routine global ocean data assimilation capabilities linked to Global Ocean Observing System observations.; NASA (Lead), NOAA (Lead), NSF (Lead), DOE

- DOE made a new award to a project that will develop a new “granular” sea-ice model that will be valid for very high resolution, and will perform well enough on HPC to be feasible in global models: https://climatemodeling.science.energy.gov/projects/new-discrete-element-sea-ice-model-earth-system-modeling

- The Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) published experimental and data request protocols as part of the CMIP6 special issue in Geoscientific Model Development in Dec 2016. The first set of experiments targeting the Greenland standalone ice sheet modeling community, initMIP-Greenland, were completed by 17 international groups, and the results submitted to the journal “Cryosphere” in July 2017. initMIP-Greenland seeks to understand and reduce the uncertainty in sea level projections due to the choice of model initialization methods. The ISMIP6 and initMIP-Greenland efforts were presented at national and international conference (AGU 2016, EGU 2017, International WCRP /IOC Conference on Regional Sea Level Changes and Coastal Impacts) and to the IARPC Glacier and Fjord CT and Modeling CT in March 2017. ISMIP6 organized two workshops in Dec 2016 -Initialization of ice sheet models, and oceanic forcing for ice sheet models- and one splinter meeting at EGU2017. More information: http://www.climatecryosphere.org/wiki/index.php?title=ISMIP6_wiki_page. Paper reference:

- DOE has made a new award to a project that will improve ice sheet physics and thermodynamics, and coupling with bedrock, ocean and atmosphere, and include uncertainty analysis of the major sources of sea-level-rise uncertainty: https://climatemodeling.science.energy.gov/projects/probabilistic-sea-level-projections-ice-sheet-and-earth-system-models; https://doe-prospect.github.io/

- A paper constraining basal conditions for the Greenland ice sheet was published: https://climatemodeling.science.energy.gov/research-highlights/leaky-plumbing-impedes-greenland-ice-sheet-flow (Nov 3, 2017 - Completed)
CICE Consortium: DOE together with other agencies support this Consortium to develop and coordinate community sea ice capabilities. [https://github.com/CICE-Consortium](https://github.com/CICE-Consortium)


Under the DOE-RGCM program support, RASM is implementing and evaluating a satellite emulator in the CICE model to allow intercomparison with satellite altimetric measurements of sea ice freeboard and to offer a new method to quantitatively assess the skill of predictive models of sea ice for the Arctic. This will help improve sea ice prediction by quantifying model limitations as well as maximize the usefulness of future freeboard measurements, such as those from ICESat-2, after that satellite is launched 2018.

- **9.3.3 (No progress)** Foster interactions between the Arctic Testbed and Environmental Modeling Center’s weather modeling efforts to facilitate the improvement of model guidance at higher latitudes.; NOAA (Lead), DOD-ONR

- **9.3.4 (In progress)** Support model development of Regional Arctic System Models focusing on improved resolution, better coupling, inclusion of new process models, and better assimilation techniques for improved seasonal predictions.; DOD-ONR (Lead), DOE, NSF

  - The RASM project has contributed predictions of September 2017 sea ice extent to the SIPN with support from the ONR-AGP and DOE-RGCM programs. Significant progress has been made in 2017 compared to the RASM predictions in 2016, by improving both the initial conditions and predicted sea ice extents and eliminating the need for bias corrections, which were necessary in 2016 ([https://www.arcus.org/files/sio/27252/sio2017_june_kamal_etal.pdf](https://www.arcus.org/files/sio/27252/sio2017_june_kamal_etal.pdf); [https://www.arcus.org/files/sio/27309/sio2017_july_rasm_kamal_etal_pdf.pdf](https://www.arcus.org/files/sio/27309/sio2017_july_rasm_kamal_etal_pdf.pdf); [https://www.arcus.org/files/sio/27365/sio2017_aug_rasm_kamal_etal.pdf](https://www.arcus.org/files/sio/27365/sio2017_aug_rasm_kamal_etal.pdf)).

  - Marine biogeochemistry (mBGC) components have been included in the RASM model and are currently evaluated against observations in preparation for publications. This work was funded by NSF.

  - Two DOE-RGCM supported projects, HiLAT and RASM, have held a joint meeting (in Seattle, May 2017) to find possible overlaps in respective project research and consider joint future activities to advance regional Arctic system modeling.

  - An eddy-resolving (2.4-km) RASM configuration of the ocean and sea ice component has been completed and simulations are being evaluated for improvements in ocean circulation, shelf-basin exchange, mixing and air-ice-ocean interactions under support of the ONR-AGP and DOE-RGCM programs. In
addition, extensive studies of sensitivities of Arctic climate and sea ice states to varying model parameter space have continued using computer resources provided by the DOD High Performance Computing Modernization Office (HPCMO).

- The fully coupled RASM forced with NCEP CFSR reanalysis for 1979-2017 and with NCEP CFSv2 forecasts was used to provide seasonal forecasts of the September 2017 Arctic sea ice extent. The ongoing work is supported by the ONR-AGP program and leverages model development and research supported by the DOE-RGCM program.

- The MST hosted a collaboration team meeting on regional Arctic models with a focus on carbon cycling models in alignment with the EI carbon effort. Invited speakers discussed current carbon modeling efforts and the associated issues within the modeling community-resolution, scaling and systems level marine-terrestrial-atmospheric integrated models. Speakers included: Challenges/what expect to learn/understanding the system as a whole-ABOVE (Abhishek Chatterjee, NASA) Land Modeling Efforts in NGEE-Arctic (Bill Riley, Berkeley National Lab) (Jul 27, 2017 - Completed)

- **9.3.5 (In progress) Support Systematic Improvements to Reanalyses of the Arctic (SIRTA) to address the need for improved models of Arctic weather, sea ice, glaciers, ecosystems, and other components of the Arctic System.; NASA (Lead), NOAA (Lead), DOD-ONR, DOE, NSF**
  - The Systematic Improvement of Reanalyses in the Arctic (SIRTA) was initiated as an ‘IARPC’ panel to assess strengths and weaknesses of atmospheric reanalyses. The panel held four open meetings to share ideas and provide input, which served as a basis for a white paper that was submitted to IARPC principals in August. The white paper describes reanalyses, provides an overview of observations currently being used in the Arctic region, gives an overview of recent studies evaluating reanalyses, and describes areas of future development. The paper identified topics for the potential improvement of Arctic reanalyses, including the development and improvement of cloud prediction, the coordination of observation-modeling-reanalysis-forecasting activities, and the improvement of satellite remote sensing over ice and snow. (Oct 9, 2017 - Completed)

- **9.3.6 (In progress) Coordinate and support the ISMIP6 efforts in the U.S. by integrating ice-sheet models into coupled climate and earth system models to both: (1) improve sea level projections due to changes in the cryosphere; and (2) enhance scientific understanding of the cryosphere in a changing climate.; NASA (Lead), DOE, NOAA, NSF**

The HiLAT project (Jeremy Fyke; LANL) led the implementation of the CISM ice sheet model into the Community Earth System Model version 2 (CESM2). This implementation allows for a two-way coupling between the Greenland Ice Sheet and the rest of the climate system. In addition, Fyke developed a new iterative procedure to spin up ice sheets models in fully-coupled Earth System Models. ()

The Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) published experimental and data request protocols as part of the CMIP6 special issue in Geoscientific Model Development in Dec 2016. The first set of experiments targeting the Greenland standalone ice sheet modeling community, initMIP-Greenland, were completed by 17 international groups, and the results submitted to the journal “Cryosphere” in July 2017. initMIP-Greenland seeks to understand and reduce the uncertainty in sea level projections due to the choice of model initialization methods. The ISMIP6 and initMIP-Greenland efforts were presented at national and international conference (AGU 2016, EGU 2017, International WCRP /IOC Conference on Regional Sea Level Changes and Coastal Impacts) and to the IARPC Glacier and Fjord CT and Modeling CT in March 2017. ISMIP6 organized two workshops in Dec 2016 -Initialization of ice sheet models, and oceanic forcing for ice sheet models- and one splinter meeting at EGU2017. More information: [http://www.climate-cryosphere.org/wiki/index.php?title=ISMIP6_wiki_page](http://www.climate-cryosphere.org/wiki/index.php?title=ISMIP6_wiki_page), Paper reference:

Joint Glaciers & Sea Level and Modeling Collaboration Teams meeting with presentations on ISMIP6.

9.4 Enhance discoverability, understanding, and interoperability of Arctic data and tools across Federal data centers.

- 9.4.1 (In progress) Advance system models of U.S. observing inventories and data centers to further understanding of these capacities so that informed,
optimal, strategic decisions and design, and spending plans can be made.;
NOAA (Lead), NASA, NSF

- Progress is being made on this performance element through the support of the Polar Geospatial Center, which provides remote sensing imagery, GIS, and logistics support for Polar research activities.

- Progress is being made on this performance element through two NSF-funded tools for Arctic science planning: the Arctic Research Mapping Application (ARMAP; [http://armap.org](http://armap.org)) and the Arctic Observing Viewer (AOV; [http://www.arcticobservingviewer.org](http://www.arcticobservingviewer.org)). ARMAP provides a map-based perspective for interagency project tracking, whereas AOV conveys details on thousands of specific observation sites. Together they enable a comprehensive view of Arctic research across a spectrum from project inception through network activities to data access. In this way, these tools help planners and others to assess status, coordinate logistics, find overlap, fill gaps, and clarify directions. Beyond these specific tools, the IARPC Environmental Intelligence team has been instrumental with communication, cooperation, and coordination across agencies – much more so than was achieved with previous efforts. The paired sub-teams have helped greatly to get the word out and foster connections, and thus to better inform decision making.

- A presentation by Peter Pulsifer provides a high level overview of the "Arctic Data Ecosystem" at a variety of scales including international, national and local. The presentation concludes by indicating the need for infrastructure thinking, enhanced interoperability, and recognition of the importance of mediators. A variant of this presentation was made at the Transatlantic Ocean Research Alliance Arctic Meeting 03-30-17, Brussels; Arctic Science Summit Week, 04-03-17, Prague; and US Global Change Research Program, Washington DC, 04-19-2017. (Aug 30, 2017 - Completed)

- Sharing data and information across systems, or "interoperability" as this sharing is often called, is an important and popular topic. Advances have been made in this area, however there are still challenges, particularly in effectively sharing between different communities or communities of practice that do not share the same language or definitions of terms or concepts. Even researchers in the same areas of research may not fully agree on all definition of terms or the relationships between phenomena. In some cases, as was pointed out in a recent IARPC Collaborations post by Jessica Rohde, terms may be misused. There are a number of methods emerging to help enhance semantic interoperability and there are a number of members of the IARPC and international community that are working on related projects. Based on lively discussion during our last meeting, the Arctic Data Sub-team (a part of the Environmental Intelligence Coordination Team) will be meeting on April 27th at 13:00 Eastern Time to discuss language, meaning and data sharing across disciplines. There will be a number of presentations on projects related to Arctic vocabularies and semantics (including sea ice, permafrost, Indigenous terminology and others). There will also be discussion of the formation of a joint project between Arctic Data Sub-team and the international Arctic Data Committee. (Aug 30, 2017 - Completed)
9.4.2 (In progress) Promote a nationally and internationally interoperable Arctic data sharing system that will facilitate data discovery, access, usage in many contexts, and long-term preservation, building off the efforts of NSF’s Arctic Data Center, the AOOS Regional Data Assembly Center and the Alaska Data Integration Working Group (ADIWG).; DOI-BLM (Lead), DOI-BOEM (Lead), NSF (Lead), DOE, DOI-USGS, NASA, NOAA

- A particularly vexing challenge for the Arctic science community is to document and share scientific data in ways that are compatible – to avoid tremendously redundant effort. At this time, the Environmental Intelligence sub-teams are providing the most fruitful pathways forward for interoperability within and among various US agencies, tied also to international efforts. Progress is being made for example with “essential variables” as well as with vocabularies, semantics, and metadata brokering technologies. ARMAP and AOV are contributing to these efforts, particularly with regard to project-level and site-level metadata standards and crosswalks. Progress on this performance element is also underway through a somewhat separate interagency initiative, the Alaska Data Integration Working Group (ADIwg). Formed several years ago with technical specialists from the USGS, FWS, and other state and federal agencies, ADIwg has taken steps toward interoperability with an established project-level metadata standard, coordination toward a data-level standard, and release of an open source tool for metadata translation across standards. Though not connected directly to IARPC, progress made by ADIwg is communicated through the ARMAP/AOV Team as liaison.

- NASA-derived datasets from the Arctic-Boreal Vulnerability Experiment (ABoVE) will be archived in the Oak Ridge National Laboratory NASA DAAC (ORNL DAAC) or other long-term archive center. NASA continues to work with the ORNL DAAC to ensure these datasets are accessible and discoverable through common metadata search methods.

- NCEI Arctic Data Viewer: The NOAA NCEI Arctic Action Team has developed a prototype web map viewer, the NCEI Arctic Data Viewer (ADV) at [https://maps.ngdc.noaa.gov/viewers/ncei_arctic/](https://maps.ngdc.noaa.gov/viewers/ncei_arctic/), to increase awareness of NCEI data and products that play a critical role in supporting scientific research, ecosystem health, community resilience, vibrant economies, and emergency response efforts in the region. Over the course of this two year cross-NCEI pilot project, the team compiled representative geospatial data sets from the Center for Weather and Climate (CWC) and Center for Coasts and Oceans (CCOG) that can be simultaneously selected and displayed in the Arctic-centric map viewer. This project demonstrated the integration of datasets hosted using disparate software including ArcGIS Server, GeoServer, and THREDDS. By employing standards-compliant services, non-NCEI organizations can easily ingest the NCEI services into their own viewers, enhancing their own products and increasing exposure to NCEI data. These include NOAA and federal platforms such as the NSF Arctic Data Center Discovery Portal and Upload Tool, NOAA Geoplatform, Digital Coast, data.gov, Alaska Ocean Observing System (AOOS), and Arctic Environmental Response Management Application (ERMA). Through this initial
The team identified compatibility issues and explored ways to informatively display diverse data types, which will guide the ways in which we make our data useful and available to users. We also continue our collaboration with the Southern Ocean Observing System to identify in-situ Southern Ocean data at risk of loss and work with the PIs and project staff to convert it to standard formats (CF-compliant netCDF) with complete ISO-19115-2 metadata, archive it at NCEI, and make it discoverable and downloadable through our Geoportal and web services. SOOS will federate this data into their SOOSmap application for discovery and re-use, and it may be added to other services. This work was supported by the NOAA Big Earth Data Initiative (BEDI). We're also continuing our work with the NSF Arctic Data Center and the DataOne network, which is in the tool-building phase to facilitate data transfer from the network to NCEI for long-term archival. You can contact Sheekela Baker-Yeboah for more information: sheekela.baker-yeboah@noaa.gov

Progress on this performance element is underway through a number of currently funded NSF grants. Notable awards that are currently active are 1) CAREER: Cyber-Knowledge Infrastructure for Geospatial Data, 2) Earthcube Building Blocks: Collaborative Proposal: Polar Data Insights and Search Analytics for the Deep and Science, 3) Development and innovation of the Barrow Area Information Database (BAID): A cyberinfrastructure that supports arctic science, outreach and education, 4) Towards a Tiered Permafrost Modeling Cyberinfrastructure, and 5) Scientia Arctics: A Knowledge Archive for Discovery and Reproducible Science in the Arctic.

The ADST hosted a collaboration team meeting to discuss data vocabularies and governance. Invited participants included research scientists, data aggregators and data managers to contribute to a discussion on data interoperability and the feasibility of conducting data synthesis using current data bases. Data managers from the Arctic Data Center described the current efforts to encourage database contributors to map their datasets, providing a universal data vocabularies that would improve the feasibility of large scale data synthesis.

The ADST hosted a collaboration team meeting on surveying Arctic carbon datasets. The focus of this meeting aligns with the EI Arctic Carbon focus. Presentations included: Matt Jones: NCEAS, NSF Arctic Data Center (5 - 10 min) Christina Schädel: Northern Arizona University, Permafrost Carbon Network (5-10 min) Deb Agarwal: Lawrence Berkeley National Laboratory, AmeriFlux (5 - 10 min)

The ADST hosted a collaboration team meeting on data interoperability with a focus on semantics and vocabularies. Presentations included: “Overview of Arctic Vocabularies and Semantics Projects”, Peter Pulsifer, NSIDC University of Colorado “Polar Insights”, Ruth Duerr, Ronin Institute “Improving discovery and integration of Arctic research products through semantic annotation” Bryce Mecum, NSF Arctic Data Center.
9.4.3 (In progress) Enhance the timely availability, diversity of content, and inclusion of international contributions to the Arctic data sets and resilience tools within the Arctic Theme for the Climate Data Initiative (CDI) and CRT.; DOI (Lead), NASA (Lead), NOAA (Lead), NSF (Lead)

- Sharing data and information across systems, or "interoperability" as this sharing is often called, is an important and popular topic. Advances have been made in this area, however there are still challenges, particularly in effectively sharing between different communities or communities of practice that do not share the same language or definitions of terms or concepts. Even researchers in the same areas of research may not fully agree on all definition of terms or the relationships between phenomena. In some cases, as was pointed out in a recent IARPC Collaborations post by Jessica Rohde, terms may be misused. There are a number of methods emerging to help enhance semantic interoperability and there are a number of members of the IARPC and international community that are working on related projects. Based on lively discussion during our last meeting, the Arctic Data Sub-team (a part of the Environmental Intelligence Coordination Team) will be meeting on April 27th at 13:00 Eastern Time to discuss language, meaning and data sharing across disciplines. There will be a number of presentations on projects related to Arctic vocabularies and semantics (including sea ice, permafrost, Indigenous terminology and others). There will also be discussion of the formation of a joint project between Arctic Data Sub-team and the international Arctic Data Committee. (Apr 13, 2017 - Completed)

9.4.4 (In progress) Advance agile situational awareness and decision support for Arctic operators through efforts like ADAC's Arctic Information Fusion Capability28, ERMA, and NASA ACE project.; DHS (Lead), DOE, NASA, NOAA

- DHS Science & Technology Arctic Domain Awareness Center (ADAC ) will focus on developing sea-ice and weather forecasting tools to improve situational awareness and crisis response. The Arctic Domain Awareness Center (ADAC ), sponsored by DHS S&T and focused on United States Coast Guard (USCG ) missions, develops and transitions technology solutions, innovative products and educational programs to improve situational awareness and crisis response capabilities related to emerging maritime challenges posed by the dynamic Arctic environment. (Oct 4, 2017 - Completed)

- ADAC's Arctic Information Fusion Capability (AIFC) project has been discontinued as a result of formal review of the Arctic Domain Awareness Center of Excellence program. AIFC is one of several projects that were reviewed. As a result of the review, AIFC will be discontinued 30 June 2017. ADAC will be issuing an RFP to solicit project proposals to address the same research questions that created AIFC. (Apr 21, 2017 - Completed)

9.4.5 (No progress) Update baseline mapping and charting across the Arctic, including additional charting in Arctic waters, updates to baseline topographic mapping and supporting data, and updating high resolution imagery-derived elevation data repeated coverage. Multiagency partners
include Alaska Mapping Executive Committee, Alaska Geospatial Council, and Arctic-related LCCs.; DOI-USGS (Lead), NOAA (Lead), NSF (Lead), DOD-NGA, DOI-BLM, DOI-FWS, DOI-NPS

- Progress is being made on this performance element through the support of the Polar Geospatial Center as it relates to the construction of the first high-resolution Pan-Arctic Digital Elevation Model and the numerous SEARCH (Study of Environmental Arctic Change) related activities, which include the description of and the elucidation of the mechanisms that drive permafrost change and an Arctic synthesis of soil carbon storage.

9.5 Advance research, tools and strategies to improve the accessibility and usability of Arctic science for decision support.

- 9.5.1 (In progress) Advance coordination among Federally-funded research programs that provide decision support to Arctic stakeholders.; NOAA (Lead), DHS, DOI-BLM, DOI-FWS

- The Arctic Domain Awareness Center (ADAC), sponsored by DHS S&T and focused on United States Coast Guard (USCG) missions, develops and transitions technology solutions, innovative products and educational programs to improve situational awareness and crisis response capabilities related to emerging maritime challenges posed by the dynamic Arctic environment. (Oct 4, 2017 - Completed)

- The EI team held an Arctic Carbon forum open to the IARPC and greater Arctic research community to discuss the progress and future plans of EI regarding the carbon focus. Presentations included: Science to Decision Making: Results from Pan-Arctic Options (Berkman, 15 minutes) Updates from EI Sub-Teams (30 minutes) Arctic Observing Systems (Starkweather and Ambrose) Arctic Data (Pulsifer and Stieglitz) Modeling (Joseph and Harper)

- 9.5.2 (No progress) Advance policy-relevant science communication through efforts like the annual Arctic Report Card,29 the Arctic Research Consortium of the United States (ARCUS), and SEARCH.; NOAA (Lead), NSF (Lead), DOD-ONR, DOI-BOEM, NASA

Agencies
DHS, DOC, DOD, DOE, DOI, DOS, DOT, EPA, HHS, NASA, NSF, OSTP, USARC, USDA