

# IARPC Collaboration Team Annual Reports FY2019

This report is provided to inform IARPC Principals, the research community and other stakeholders about major accomplishments in implementing the Arctic Research Plan 2017-2021.

## **Collaboration Teams responded to the following prompt:**

**Q1:** Highlight one or two activities which your team has undertaken to support the Arctic Research Plan 2017-2021 Policy Drivers. The Policy Drivers for the Arctic Research Plan 2017-2022 are:

- o Enhance the well-being of Arctic residents;
- o Advance stewardship of the Arctic environment
- o Strengthen national and regional security; and
- o Improve understanding of the Arctic as a component of planet Earth.

This report will inform the IARPC Biennial Report due to Congress at the end of this year.

## **List of IARPC Collaboration Teams (in chapter order of Arctic Research Plan 2017-2021):**

Health and Well-being Collaboration Team (HWCT)

Atmosphere Collaboration Team (ACT)

Sea Ice Collaboration Team (SICT)

Marine Ecosystems Collaboration Team (MECT)

Glaciers & Sea Level Collaboration Team (GSLCT)

Permafrost Collaboration Team (PCT)

Terrestrial Ecosystems Collaboration Team (TECT)

Coastal Resilience Collaboration Team (CRCT)

Environmental Intelligence Collaboration Team (EICT)

Arctic Observing Systems Collaboration Sub-Team (AOOST)

Arctic Data Sub-Team (ADST)

Modeling Sub-Team (MST)

## **List of IARPC Agencies:**

Department of Agriculture (USDA)

Department of Commerce (DOC)

National Oceanic and Atmospheric Administration (NOAA)

Department of Defense (DOD)

Department of Energy (DOE)  
Department of Health and Human Services (DHHS)  
Department of Homeland Security (DHS)  
Department of Interior (DOI)  
    Bureau of Ocean Energy Management (BOEM)  
    Bureau of Land Management (BLM)  
    US Geological Survey (USGS)  
    National Park Service (NPS)  
    Fish and Wildlife Service (FWS)  
Department of State (DOS)  
Department of Transportation (DOT)  
    Federal Aviation Administration (FAA)  
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)  
US Arctic Research Commission (USARC)(ex officio)

## Health & Well-being Collaboration Team (HWCT) Annual Report 2019

**Federal Co-leaders: Michael Bruce (CDC), Dorothy Castille (NIH), Dawn Morales (NIMH)**

**Non-federal Co-leaders: Sarah Yoder (DHSS)**

**Responsible Agencies: DOC, DOD, DOI, DOS, EPA, HHS, NASA, NSF, OSTP, SI, USARC, USDA**

### **Policy Driver: Enhance the Well-being of Arctic Residents**

In 2018-2019, the Health & Well-being Collaboration Team (HWCT) undertook several activities to support the Arctic Research Plan 2017-2021 Policy Driver: **Enhance the well-being of Arctic residents**. Each research objective and performance element in the HWCT directly addresses this policy driver. Below are focal topics and associated HWCT activities that address the Policy Driver of **Enhance the well-being of Arctic residents**.

**Topic: Suicidal behavior and substance abuse.** Performance element 1.5.2: 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.

- **HWCT Activity:** HWCT held two well-attended meetings on this topic in 2018-2019. In the September 2018 meeting, HWCT discussed updates on several initiatives created to understand and improve Alaskan Native mental health, including a new toolkit from Reducing the Incidence of Suicide in Indigenous Groups – Strengths United through Network (RISING SUN). The May 2019 meeting focused on recent work by Alaska Native Collaborative Hub for Research Excellence (ANCHRR). One of the goals of ANCHRR is to conduct resilience focused research as a way to understand how to increase community health and strategically strengthen institutions and programs to prevent suicide and other associated issues. Results of the first year of the Alaska Native Community Resilience Study, an ANCHRR project, were presented from several research and community perspectives. This project works to integrate community needs; is driven, supported, and lead by communities; and seeks to understand resilience factors at a community level. In addition, the ANCHRR project hosted the Annual All Hubs meeting that included the three NIMH/NIMHD funded projects working on suicide prevention in Alaska Native and American Indian youth and a site visit to Emmonak. The first day of the All Hubs meeting coincided with the NIH Tribal Advisory Committee (TAC) meeting and provided an update on progress to date.
- **Communication/Engagement:** These meetings actively engaged members of the research community (e.g., NIH, State of Alaska, University of Alaska Fairbanks, University of Minnesota Duluth, and University of Massachusetts Amherst) and Indigenous/local knowledge holders (e.g., Southcentral Foundation) via meeting participation and invited speakers.

**Topic: One Health.** Research Goal 1.1: Support integrative approaches to human health that recognize the connections among people, wildlife, the environment, and climate

- **HWCT Activity:** The HWCT made significant progress on performance elements related to One Health, which supports integrative approaches to human health that recognize the connections among people, wildlife, the environment, and climate (P.E. 1.1.1, 1.1.2, 1.1.5). The HWCT has co-organized and participated in quarterly One Health calls to discuss One Health pressing issues in the research and health communities across the Arctic. Recent topics have included Harmful Algal Blooms (HABs), the CDC zoonosis disease prioritization efforts in Alaska, and observed climate-related changes.

- **Communication/Engagement:** The One Health meetings often have a large audience and include a wide range of representatives from U.S. Federal agencies, State of Alaska agencies, local/tribal groups, researchers, and other Arctic nations. The One Health meetings have greatly extended the network of interested researchers and agencies. The regularity of these meetings (held quarterly) and the large range of topics discussed have contributed substantially to the sustainability of one health considerations in the Arctic.

**Topic: Violence in Alaska Native communities.** Research Goal 1.4: Document the prevalence and nature of violence against Alaska Native women and youth.

- **HWCT Activity:** The HWCT addressed issues around violence in Alaska Native communities in the August meeting that included reports by DOJ researchers on the National Baseline Study (NBS) to assess Alaska Native women's experiences with violence and victimization, health responses, service needs and help-seeking; examine the contributions of Village Public Safety Offers (VPSO); and efforts to determine effective methods to assess exposure to violence and victimization among Alaska Native youth and to improve their health and well-being (P.E. 1.4.1, 1.4.2). The Office of Tribal Justice at the DOJ described Attorney General William Barr's recent visit to Alaska and the resulting initiatives advanced by him to address Alaska Native community needs.
- **Communication/Engagement:** This meeting actively engaged members of the research community (e.g., NIH, State of Alaska, Alaska Native Tribal Health Consortium (ANTHC), and Department of Justice).

Team statistics

- Number of Meetings: 9
- Number of Joint Meetings: 0
- Average Participants per Meeting: 17

## Atmosphere Collaboration Team (ACT) 2019 Annual Report

**Federal Co-leaders: Barry Lefer (NASA), Jennifer Mercer (NSF),**

**Non-federal Co-leaders: Gijs de Boer (U. Colorado CIRES)**

**Responsible Agencies: DHS, DOC, DOD, DOE, DOI, DOT, EPA, NASA, NSF, OSTP, USARC**

**Policy Driver: Improve understanding of the Arctic as a component of planet Earth**

### Observational Campaigns:

In FY2019, the ACT met to discuss highlights and progress related to the DOE and NSF-supported Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAIC). Included were discussions on Arctic aerosols, net contributions from a central-Arctic observatory including the impact of MOSAIC on model improvement, and linking MOSAIC observations to those from NSF, DOE and NOAA-funded observatories surrounding the Arctic Ocean through activities like Terrestrial-MOSAIC (T-MOSAIC). [PE 2.1.1]

Additionally, a meeting focused on current and upcoming satellite missions providing spatial context on key drivers and responses of Arctic energy budgets. Current status and issues related to deriving the radiation budget over polar regions from satellite observations were discussed, followed by an overview of the NASA Polar Radiant Energy in the Far-Infrared Experiment (PREFIRE). PREFIRE uses two Cube-Sats to document, for the first time, variability in spectral fluxes from 5-45  $\mu\text{m}$  on hourly to seasonal timescales. [PE 2.2.1, 2.3.1]

Finally, a dedicated meeting was held to learn about year-round observations of atmospheric composition, properties, and processes conducted by NOAA and the NSF-funded ICECAPS project at the only high-altitude, year-round, inland monitoring site in the Arctic (Summit Station Greenland). [PE 2.2.1, 2.2.3, 2.3.1]

### Atmospheric Forcing of the Surface Energy Budget:

The ACT held a joint meeting with the Glaciers and Sea Level Collaboration Team to discuss weather and surface radiation balance on the Greenland Ice Sheet (GrIS). This meeting focused on data obtained between 1990-2019 through the NASA/NSF Greenland Climate Network (GC-Net), and included a discussion on the role of the GrIS in development of a next-generation polar weather and climate model (HARMONIE). This work links to efforts within DOE to understand surface energy balance at high latitudes. [PE 2.1.2, 2.3.1, 2.3.2]

The ACT also highlighted NSF/NASA efforts to understand and measure transport of atmospheric tracers over the GrIS, and its impact on surface energy exchange. This includes Arctic wildfire and anthropogenic emissions, and links to research efforts leveraging DOE-supported measurements. [PE 2.2.3, 2.3.3]

Highlighting the important role that models play in predicting Arctic weather and climate, the ACT was updated on activities related to the NSF-funded Aerosol-Cloud Experiment (part of ICECAPS-ACE) occurring at Summit Station. This is one of several examples of ACT efforts to leverage Arctic observations to advance models and improve their accuracy. [PE 2.3.1, 2.3.2]

### Linkages between Arctic and Mid-Latitude Weather:

With increased awareness of Arctic and mid-latitude weather linkages, the ACT's March meeting focused on emerging scientific findings related to the Polar Vortex. Presentations covered differences between

stratospheric and tropospheric polar vortices, their increasing influence on mid-latitude weather and extreme events, and connections between these features and climate. [ACT is proposing a new high-to-mid-latitude weather PE for FY20.]

Further recognizing the symbiotic relationship between measurements and models, the ACT and Modeling collaboration teams held a joint meeting focused on the Polar Amplification Model Intercomparison Project (PAMIP). In a lightning talk format, the discussion started with an overview of PAMIP, followed by initial results from atmosphere-only experiments (including Arctic-midlatitude linkages), and finished with coupled model simulations. [PE 2.3.1, 2.3.2]

### **Policy Driver: Enhance the well-being of Arctic residents**

#### Understanding the Impacts of Pollution and Environmental Change:

The April ACT meeting focused on the Arctic-Boreal Vulnerability Experiment (ABOVE), a NASA effort focused on large-scale environmental change in Alaska and Western Canada and its implications for social-ecological systems. Understanding the vulnerability and resilience of Arctic and boreal ecosystems to environmental change provides a scientific basis for informed decision-making at local to international levels. [PE 2.2.2, 2.2.4]

#### Improving Weather and Climate Predictions:

The ACT additionally met to discuss DOE, NOAA, and NSF research efforts related to the Year of Polar Prediction (YOPP), a coordinated international campaign to improve the prediction of high latitude weather and climate. The rapid changes in weather and climate occurring in the Arctic have supported an enhanced human presence related to transportation, tourism, fisheries and natural resource extraction. [PE 2.1.1, 2.3.4]

The ACT and the Modeling sub-team met to discuss the Polar Amplification Model Intercomparison Project (PAMIP). This effort focuses on understanding the causes and impacts of the observed enhancement in Arctic warming, relative to the rest of the globe. PAMIP leverages a coordinated set of numerical experiments to focus on the roles of surface properties and their interactions with the atmosphere and ocean in driving polar amplification, helping to understand current and future impacts on Arctic residents. [PE 2.3.1, 2.3.2]

#### Team statistics

- Number of Meetings: 8
- Number of Joint Meetings: 2
- Average Participants per Meeting: 17

## Sea Ice Collaboration Team Annual Report 2019

**Federal Co-leaders: Janet Intrieri (NOAA), Olivia Lee (UAF),  
Non-federal Co-leaders: Jackie Richter-Menge (USARC), Melinda Webster (UAF)  
Responsible Agencies: DHS, DOC, DOD, DOE, DOI, NASA, NSF, USARC**

### **Policy Driver: Improve understanding of the Arctic as a component of planet Earth**

Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) launched September 15, 2018 from Vandenberg Air Force Base in California. It continues the record of polar height data that first began with the ICESat satellite, which operated from 2003 to 2009, and the airborne Operation IceBridge (OIB) mission, which “bridged the gap” between the two satellites. The mission successes of both OIB and ICESat-2 completes IARPC’s Performance Elements 3.1.3 and 3.1.4, and supports this Policy Driver by providing improved sea ice data to better understand physical, atmospheric, and oceanic processes that link the changes in the Arctic to global climate.

The sole instrument on ICESat-2 is the Advanced Topographic Laser Altimeter System (ATLAS), which collects elevation measurements along repeated ground tracks to reveal changes in sea-ice freeboard, from which sea ice thickness can then be inferred. After the launch in September, the SICT received an immediate update from ICESat-2 Science Team Members and also throughout the year on a series of discussions centered on sea ice freeboard and thickness. In June 2019, a SICT team meeting was dedicated to a discussion on available products from ICESat-2, as well as possible linkages between ICESat-2 data products and operational needs. From this discussion, an issue of ICESat-2’s 45-day latency was raised as a barrier to addressing operational needs. Since then, the ICESat-2 Project has submitted a proposal via the Satellite Needs Working Group for a low-level data product suite that would provide sea ice elevation and freeboard, inland water body height and vegetation and canopy height on a day-3 latency. This would be a substantial improvement over the nominal 45-day data latency and would support operational data products. A decision is expected early in the next fiscal year.

In April and May 2019, OIB completed its final Arctic spring airborne campaign. A key focus of this campaign was to underfly ICESat-2’s laser beams so that its performance and geolocation could be assessed relative to longer-heritage OIB instruments. In total, more than 21,000 km of ICESat-2 ground tracks were flown with latencies of seconds to hours between the aircraft and satellite over drifting sea ice. The OIB team, based out of Greenland, completed 24 science missions (both land ice and sea ice) in less than 7 weeks. On 2 September 2019, OIB conducted the first-ever science flights with both laser altimeters and the University of Kansas’ snow radar during the melt season. During this campaign, IceBridge also collaborated with NASA JPL, collecting coincident data to better understand ICESat-2 returns over different snow and sea-ice conditions during the summer successfully completing OIB’s final Arctic campaign.

More than a trillion new height measurements from ICESat-2 are now available to the public at NASA National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC). Release 001 of the ICESat-2 products was on 28 May 2019. That data now span from 14 October 2018 to 3 May 2019. The geolocation of these data is accurate to ~10 m, frequently even less. An initial paper comparing ICESat-2 sea ice elevation and freeboard data products with OIB coordinated underflights is in press at the Geophysical Research Letters journal.

**Policy Driver: Enhance the well-being of Arctic residents**

The rapid rate of sea ice loss in the Bering Sea in 2018 and 2019 prompted the SICT to actively engage the research community to identify resources that could provide timely information. A joint meeting between the Sea Ice Collaboration Team (SICT), Environmental Intelligence, and Coastal Resilience Teams was held on March 25, 2019. The cross-disciplinary discussions emphasized efforts to better coordinate fieldwork observations and leverage research activities during upcoming funded cruises. The SICT invited several Arctic residents to attend and present during the IARPC meetings, but weather disruptions to technology and travel remains a barrier for some Arctic residents to engage during scheduled meetings.

The SICT also highlighted research on the changing landfast ice which directly impacts coastal communities through impacts of safety on over-ice travel, and reduced protection of coastal infrastructure from erosion caused by storm and wave action. The April 2019 SICT meeting included updates from NSF funded projects on shorefast ice knowledge in Uummannaq Bay, Greenland (PI - J. Ryan), and modeling ice drift and deformation at the ice-coast interface (PI - J. Hutchings). These presentations were responsive to PE 3.1.1 and PE 3.2.2. The development of useful and improved ice forecasting products for Arctic stakeholders remains an ongoing effort of the SICT, and is a response to PE 3.3.2. DOD-sponsored research on co-producing sea ice tools to improve situational awareness and crisis response in the Arctic (PI Kettle) was reported in the June 2019 meeting. The research provided insight from stakeholders, including marine operators and responders, subsistence users, and service providers on needs for a sea ice notification system using real-time observations.

The intersection of sea ice loss and its role in Harmful Algal Blooms (HABs) in the Arctic is an ongoing discussion with an emphasis on developing informational products that benefit Arctic residents. A joint meeting was held in July 2019 between the Marine Ecosystem, Coastal Resilience and SICT. Opportunities were identified to link the sea ice modeling community with HAB researchers to explore development of models to predict future HABs, and sea ice as a potential source of cyst beds that may influence the intensity and distribution of HABs.

**Team statistics**

- Number of Meetings: 7
- Number of Joint Meetings: 3
- Average Participants per Meeting: 23



## Marine Ecosystems Collaboration Team (MECT) Annual Report 2019

**Federal Co-leader: Guillermo Auad (BOEM)**

**Non-federal Co-leaders: Danielle Dickson (NPRB), Jacqueline Grebmeier (UMCES)**

**Responsible Agencies: DOC, DOD, DOE, DOI, MMC, NASA, NSF, USARC**

### **Improve understanding of the Arctic as a component of planet Earth**

The MECT cooperated with the Modeling Sub-Team to host a two-part discussion of improving integration among the observational science and modeling communities to improve ecosystem models that include biogeochemistry. The discussion focused on current capabilities of models and opportunities for observations to contribute to model development and validation. The discussion included program managers from several agencies that fund modeling and the collection of observations and the discussion provided information about needs for future investment. The annual work plan for FY20 includes continued discussion of this topic.

Time series observations of the marine ecosystem, such as the Distributed Biological Observatory (DBO), Arctic Marine Biodiversity Observing Network (AMBON), Beaufort Lagoons and Seward Line Long-Term Ecological Research (LTER) sites are providing information on status and change in the Pacific Arctic in response to changing environmental drivers (reduced sea ice, increased water temperature). The DBO includes scientific efforts and objectives from multiple US Federal and non-federal organizations (NSF, NOAA, BOEM, USFWS, NASA, North Pacific Research Board (NPRB)), academic institutions, and international organizations (Pacific Arctic Group (PAG), International Arctic Science Committee (IASC)).

The Marine Ecosystems Collaboration Team has provided a forum for communicating about ongoing research programs (e.g., the [Arctic Integrated Ecosystem Research Program](#), Marine Arctic Ecosystem Study (MARES), Nansen Legacy, The Impact of Shelf Break Upwelling on Beaufort Shelf Distributions of Zooplankton and Fish) to facilitate collaboration and coordination among them. Many of these programs include Indigenous Knowledge holders and MECT meetings have included discussion of means to improve engagement with Indigenous communities and stakeholder groups.

A presentation on the status of the development of the conceptual pan-arctic model provided a description of the process of choosing the most significant variables, and understanding how these variables connect.

These activities respond to Performance Elements: 4.1.2, 4.3.1, 4.3.4, 4.3.6, 9.2.3, 9.2.4

### **Advance stewardship of the Arctic environment**

The MECT held a meeting to discuss marine sound (PE 4.3.8) underwater sound in relation to Integrated Ecosystem Assessments (IEAs) in the Arctic, such as anthropogenic and animal noises and shipping. This was a follow up to an original discussion in April of 2018. Since then two peer-reviewed papers were published which address acoustic occurrence and behavior of ribbon seals (*Histiophoca fasciata*) in the Bering, Chukchi and Beaufort Seas, as well as changes in the detections of orcas in the Pacific Arctic. The Alaska Fisheries Science Center (AFSC) continues to record and analyze long-term passive acoustic recordings from 20 subsurface moorings deployed annually in the Bering, Beaufort, and Chukchi

Seas. The Arctic moorings were redeployed during the USCGC Healy 18-01 cruise, and the Bering Sea moorings were redeployed in October and a few are being redeployed on the NOAA R/V DYSON. Over half of these recorders are co-located with oceanographic instrumentation (from NOAA/PMEL funded by BOEM/NOAA/Navy).

The MECT hosted a presentation about the BOEM-funded project Aerial Surveys of Arctic Marine Mammals (ASAMM) that has been documenting the distribution of Arctic marine mammals for decades and recently added capacity to estimate bowhead whale abundance via coordination with Canada. (PE 4.1.1, 4.1.2)

A status update on the development of the conceptual pan-arctic model was given during July 2018. It included a description of the process of choosing the most significant variables, and especially on understanding how these variables connect among them. A final presentation will be made in late 2019 or early 2020 included the already presented matrix of interactions and all other elements arranged in a Mandala configuration.

#### Team statistics

- Number of Meetings: 8
- Number of Joint Meetings: 2
- Average Participants per Meeting: 21

## Glaciers & Sea Level Collaboration Team (GSLCT) Annual Report 2019

**Federal co-leaders: Caitlyn Florentine (USGS) and Joseph MacGregor (NASA)**

**Contributing agencies: DOC, DOD, DOE, DOI, NASA, NSF, OSTP, USARC**

### **Policy Driver: Improve understanding of the Arctic as a component of planet Earth**

Highlight events for this driver for the GSLCT include three meetings held this year, which focused mostly on improved process understanding and modeling of the Greenland Ice Sheet (GrIS) and Arctic glaciers and additional elements of the Arctic cryosphere. These three meetings brought together modelers and observationalists from several disciplines in Earth Science to address outstanding atmospheric, subglacial, and operational questions concerning the present state and future of the Arctic cryosphere. These meetings addressed Performance Elements (PEs) 2.1.2, 5.1.1, 5.2.1, 5.1.3, 5.1.4, 5.2.2, 9.3.2 and 9.3.6.

Communication and collaboration were bolstered by these meetings, which consistently recruited and engaged numerous Federal and non-federal scientists. For example, Federal and academic scientists discussed the challenges of projecting the future of the GrIS, and ice-sheet modelers were exposed to the complexity and variability of sub-daily radiative forcing and sediment discharge across the GrIS.

Diverse members of the GSLCT undertook the following significant activities that we report below:

- The USGS's Landsat-8 satellite and NASA's Operation IceBridge airborne mission both continued to survey the Arctic cryosphere in detail this past year. NASA's GRACE-FO and ICESat-2 satellite both launched last year, and will soon generate more detailed measurements of the mass balance of Arctic glaciers and the Greenland Ice Sheet. (PE 5.1.1, 5.2.1).
- USGS has extended its Benchmark Glacier program to include a fifth glacier (Lemon Creek Glacier, near Juneau, Alaska), and published reanalysis results that reveal surprisingly consistent mass loss and climate forcing across maritime and continental glaciers.
- Multiple NSF projects will explore the long-term glacier behavior and glacier mechanics in the Arctic and near-Arctic. (PE 5.1.2).
- Multiple investigator-driven studies of Alaskan glaciers, Greenlandic and Canadian glaciers that aim to observe and model mass balance, including the USGS Benchmark Glacier program and NASA's Oceans Melting Greenland airborne mission. (PE 5.1.3)
- The Polar Geospatial Center released its final version of the high-resolution ArcticDEM (Release 7), which enhances international collaboration by ensuring that a consistent pan-Arctic surface-elevation database is freely available to all. (PE 5.1.4)
- The GSLCT had a meeting on the Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) in March 2019, which reported progress on modeling of future ice-sheet states and using advanced treatments of boundary conditions to better represent relevant forcings. NASA researchers/modelers continue to refine the Ice Sheet System Model (ISSM) and Parallel Ice Sheet Model (PISM), a massively parallelized, multipurpose finite-element framework to model the mass balance of the Greenland and Antarctic ice sheets in the near future. (PE 5.2.1, 5.2.3)
- Between September 2018 and September 2019, the NASA National Snow and Ice Data Center's Distributed Active Archive Center (NSIDC DAAC) published or updated numerous Arctic-related data products, including data from multiple NASA missions (e.g. Operation IceBridge). They also

released the first segments of ICESat-2 data post-launch and were instrumental in the ICESat-2 Hackweek hosted by the University of Washington in June, which connected the cryosphere research community to the tools and skills required to access and apply these datasets. (PE 5.2.2)

- Multiple NASA and NSF investigator-driven projects are focused on improving understanding of the physical processes that control land ice in the Arctic. For example, GSLCT held a meeting in August focusing on the underappreciated role of sediment in modulating tidewater glacier behavior and ecosystem impacts (PE 5.2.3). As another example, NSF-funded research featuring rare borehole measurements of englacial deformation show that ice motion across slow-flowing margins of the Greenland Ice Sheet is dominated by sliding and thus close to its maximum theoretical speed.

#### Team statistics

- Number of Meetings: 3
- Number of Joint Meetings: 2
- Average Participants per Meeting: 19

## Permafrost Collaboration Team (PCT) Annual Report 2019

**Federal Co-Leads: Miriam Jones (USGS)**

**Non-Federal Co-Leads: Christina Schaedel (NAU), Benjamin Jones (UAF)**

**Responsible Agencies: DOC, DOD, DOE, DOI, NASA, NSF, OSTP**

### **Policy Driver: Improve understanding of the Arctic as a component of planet Earth**

This year the PCT focused on the Arctic as a component of Planet Earth through several forward-thinking topics in our monthly webinars. Our first monthly webinar focused on the Terrestrial Multidisciplinary distributed Observatories for the Study of Arctic Connects (T-MOSAiC), which was developed via the working group activities of the International Arctic Science Committee (IASC) in order to study pan-Arctic climate in the terrestrial realm. This large-scale, multidisciplinary effort will address key aspects of connectivity, gradients, extreme events, and emergent properties by bringing together distributed observatories. Pan-arctic terrestrial climate and ecosystem data will be assembled over the study year and synthesized with data from the drifting observatory (MOSAiC) to link Arctic Ocean and atmospheric dynamics to terrestrial ecosystem, water, and atmospheric processes. The unique contributions of T-MOSAiC are to expand the focus on the needs of stakeholders and identification of critical services that environmental stewardship agencies provide to society. The PCT teamed up with the TECT to expand the scope of importance and breadth of this effort. This international, pan-arctic effort enhances collaborative science across Federal agencies and academic institutions.

The Arctic Futures 2050 meeting held in September 2019 aimed to bring together arctic scientists, indigenous peoples, and policymakers, and our April meeting invited organizer Brendan Kelly with the Study of Environmental Arctic Change (SEARCH) to introduce the goals of this conference, which are largely synthetic in order to determine ways to make science actionable and accessible to policymakers. Policy responses under a rapidly changing Arctic need to be well informed by science, through strong and iterative collaborations and succinct communication. Permafrost was discussed in the context of the feedback to the carbon cycle and climate warming, as well as permafrost thaw impacts to infrastructure and indigenous food storage, and coastal erosion. Topics included weaving traditional knowledge and scientific knowledge together with the need for application of science to practical problems impacting arctic communities. This last point feeds into two other policy drivers, (1) enhancing the well-being of Arctic residents and (2) advancing stewardship of the Arctic environment.

A commentary in Nature this year (Turetsky et al., 2019) highlighted the need to better understand abrupt thaw processes, as they can lead to a near doubling of permafrost carbon loss than was previously accounted for in models that typically only consider gradual permafrost thaw. A major component of understanding and predicting abrupt thaw is to better understand ground ice content in the permafrost zone and interactions between disturbance regimes, climate change, and ecosystems. The May 2019 meeting brought in three researchers studying various aspects of abrupt thaw (mapping potential abrupt thaw, quantifying ground ice content, and hydrological changes with abrupt thaw), in conjunction with academic institutions and DOE's NGEE Arctic project, whose goal is to reduce the uncertainty in the prediction of the future Earth system through improved representation of Arctic terrestrial processes in E3SM (global climate model). In order to improve prediction of permafrost processes in a warming climate, a proposed first-step future product is to generate a survey for data holders and users on metadata related to ground ice prior to try to synthesize the data themselves. One

reason is that data formats are likely diverse, and there is the potential to overlook key aspects of data needs by various end-users. The group discussed leveraging T-MOSAiC, NASA- Arctic Boreal Vulnerability Experiment (ABOVE), Rapid Arctic Transitions due to Infrastructure and Climate (RATIC), and other IASC meetings to maximize access to potential data holders. Because of the international interest in this topic, the PCT discussed moving this effort forward in the coming year by creating a working group focused on refining ground ice maps and regional responses to abrupt thaw of ice-rich permafrost through the International Permafrost Association and/or the Permafrost Carbon Network.

#### Team statistics

- Number of Meetings: 6
- Number of Joint Meetings: 1
- Average Participants per Meeting: 24

## Terrestrial Ecosystems Collaboration Team (TECT) Annual Report 2019

**Federal Co-leaders: Steve Gray (USGS), Jeremy Littell (USGS), Michael Falkowski (NASA)**

**Responsible Agencies: DOC, DOD, DOE, DOI, NASA, NSF, OSTP, USARC, USDA**

### **Policy driver: Improve understanding of the Arctic as a component of planet Earth**

Continuing efforts begun in 2018, TECT members engaged in a variety of outreach and engagement activities designed to inform work under all of the team's PEs. In particular, IARPC participants from multiple agencies leveraged the rollout of the Fourth National Climate Assessment (NCA-4) to gather information on research needs and feedback on progress under PEs 7.1.1, 7.1.2, 7.2.2, 7.2.3, and 7.3.1. Rollout events ranged from presentations at the Alaska Forum on the Environment (AFE) and Alaska Marine Science Symposium (AMSS) to a series of meetings with staff drawn from a variety of State and Federal agencies.

Performance Element 7.2.3 was also a key focus area for a number of community workshops supported by USGS and BIA. In cooperation with the Aleutian Pribilof Islands Association (APIA), the Alaska Center for Climate and Arctic Policy (ACCAP), the Scenarios Network for Alaska + Arctic Planning (SNAP), and the International Arctic Research Center (IARC), TECT members from USGS launched a series of trainings focused on building resilience in communities. These workshops highlight both the role of science in local decision making, as well as the need to fully incorporate local observations and perspectives into the scientific process. Input from these workshops will also be used to inform activities related to PEs 7.1.2 and 7.2.2 during 2020.

Several coordination activities related to research on understanding the causes and consequences of satellite observed vegetation greening and browning were conducted in 2019. The Polar Research Board (PRB) organized and held a workshop Northern Latitude Vegetation Greening and Browning on 6-7 December 2018 and a workshop report was generated. As part of the Arctic Boreal Vulnerability Experiment (ABoVE), NASA continues working with IARPC's TECT in synthesizing ongoing research in this area, focusing separate efforts on vegetation changes in boreal forests and Arctic tundra, and post-disturbance vegetation recovery. These activities fall under PEs 7.1.1, 7.1.2, 7.1.3.

The NASA ABoVE program continues to engage Arctic residents including Indigenous communities in a variety of capacities. NASA ABoVE scientists were key participants in a three-day fire workshop hosted by the Government of the Northwest Territories (GNWT) in Yellowknife Canada. Leadership from NASA ABoVE, Polar Knowledge Canada, and the GNWT met with scientists, managers, Indigenous community members, and other stakeholders to discuss ABoVE progress to date, possible future activities, and areas of potential collaboration. The Chief Support Scientist from NASA ABoVE also precipitated in a community needs workshop hosted by the Great Bear Lake community of Deline, Northwest Territories for the science plan for the Great Bear Lake Biosphere Reserve and co-authored the Workshop Report. In addition, the 2019 ABoVE Science Team Meeting included a plenary presentation on Indigenous Perspectives and Co-production of Knowledge by Mandy Bayha and Joanne Speakman, students Indigenous to the Sahtu Region of the Northwest Territories. Their presentation nicely articulated the importance of combining traditional knowledge and western science to tackle climate change issues, especially in the rapidly changing Arctic where Indigenous residents are already experiencing drastic ecosystem changes that threaten their livelihoods. Joanne and Mandy also gave a scintillating recount of their experience flying in a NASA G-III aircraft during a Uninhabited Aerial Vehicle Synthetic Aperture

Radar (UAVSAR) collect and an associated field data collection excursion in the 2018 field season. Finally, in July of 2019, NASA ABoVE's Deputy Science Team lead joined scientists and environmental managers from Territorial and Canadian Federal agencies for a Community Science day in Tuktoyaktuk, an Inuvialuit hamlet located in the Inuvik Region of the Northwest Territories, Canada, at the northern terminus of the Inuvik–Tuktoyaktuk Highway. These activities fall under PE 7.2.3.

Information and science needs of agencies and communities connect the two policy drivers **Improve understanding of the Arctic as a component of planet Earth** and **Enhance the well-being of Arctic residents**. Community and local knowledge could be used in conjunction with agency and other western science efforts to bolster community resilience and to tailor science agendas in part to adaptation needs. The BRT project (see above) and other work (for example, see section 8, Coastal Resilience) are working to develop such connections.

#### Team statistics

- Number of Meetings: 6
- Number of Joint Meetings: 2
- Average Participants per Meeting: 22



## Coastal Resilience Collaboration Team Annual Report 2019

**Federal Co-leaders: Amy Holman (NOAA), John Pearce (USGS), Colleen Strawhacker (NSF)**  
**Responsible Agencies: DOC, DOD, DOI, DOS, HHS, NASA, NSF, OSTP, SI**

In 2018-2019, the CRCT undertook several activities to support the Arctic Research Plan 2017-2021 Policy Driver: **Enhance the well-being of Arctic residents**. CRCT Performance Elements that respond to this policy driver are as follows: 8.1.1, 8.1.2, 8.1.5, 8.2.4, 8.2.5, 8.2.6, 8.3.1.

Below are focal topics and associated CRCT activities that address the Policy Driver of **Enhance the well-being of Arctic residents**.

**Topic: Harmful Algal Blooms.** This is now a commonly discussed topic with warmer ocean temperatures, warmer air temperature in coastal and marine areas, and wildlife mortality events in coastal areas. Communities and agencies frequently request more information on testing of natural resources and subsistence foods for algal toxins and there are frequent requests for information on potential impacts to human health through consumption of wildlife.

- **CRCT Activity:** In collaboration with the Environmental Intelligence Collaboration team, the CRCT made efforts to ensure broad-scale communication among agencies prior to and during field seasons in the Bering and Chukchi seas. This allowed for coordinated sampling of appropriate materials to address multiple questions.

**Topic: Wildlife and Zoonotic Diseases.** Zoonotic diseases are those that can be transferred from wildlife species to humans. This is an emerging issue in northern regions with warmer temperatures and longer seasons. Wildlife pathogens and vectors common to more southerly latitudes may become more common in the Arctic as temperatures rise.

- **CRCT Activity:** In March of 2019, the CDC hosted a One Health Zoonotic Disease Prioritization Workshop in Fairbanks, Alaska. Two members of the CRCT attended and had valuable interactions with tribal and agency partners and ranked zoonotic diseases important in the State of Alaska that could be approached through a multi-sectoral One Health perspective. The workshop was invaluable for providing a forum where Alaska Indigenous partners could voice their concerns about zoonotic diseases and make known their priorities to ensure that would ensure the health and well-being of rural residents.

**Topic: Changes in the Bering Sea.** Rapid and significant changes were witnessed in the Bering Sea in the summer of 2018 with warmer ocean temperatures, lack of a clear temperature difference between southern and northern Bering seas, northerly shift in populations of fish, and complete lack of sea ice in the central Bering much earlier than normal.

- **CRCT Activity:** Members of the CRCT quickly pulled together information from multiple rural communities and agencies into a variety of forums. These forums provided an opportunity for general communication on this topic, for rural communities to share their ground observations and for agencies to share research information. Forums where this information was shared were:
  - Alaska Federation of Natives (AFN) Bering Sea Gathering (October 2018)
  - [Unprecedented Change in the Bering Sea Town Hall](#) (December 2018)

- [Unprecedented Bering Sea Ice Extent and Impacts to Marine Ecosystems and Western Alaskan Communities I](#) (December 2018)
- Bering Sea cross-team meetings in collaboration with Sea Ice, Marine Ecosystems, Health & Well-being, and Environmental Intelligence Collaboration Teams ([March 2019](#), [July 2019](#))
- Discussions regarding Bering Sea Collaboration Self Forming Group ([August 2019](#))

**Topic: Navigating the New Arctic Big Idea at the National Science Foundation**

- **CRCT Activity:** The Navigating the New Arctic (NNA) Program at NSF sought proposals on a number of themes related to the rapidly changing Arctic, which included (but not limited to) foci on community engagement, the co-production of knowledge, and the creation of new and diverse research communities.
  - Program Officers conducted outreach to multiple communities via webinars to ensure diverse submissions
  - \$38 million dollars were awarded to organizations via the NNA Program
  - Examples of NNA awards related to CRCT Performance Elements can be found at: [8.1.1](#), [8.1.2](#), [8.1.4](#), [8.3.1](#), and [8.3.2](#)

**Topic: Following the Principles Guidelines.** The revised Principles for Conducting Research in the Arctic were released by IARPC in December 2018 and the CRCT has continued to make the Principles a central focus of its work through meetings and activities. Additionally, members of the CRCT accomplished the following activities:

- Worked with Alaska Native and Science and Engineering Program (ANSEP) student Jakob Sipary to translate the five main Principles into Yup'ik. The Yup'ik and English versions of the five Principles are now featured on a postcard that is being distributed to Alaska Native communities.
- On the IARPC page, IARPC agencies requested information on [Arctic knowledge maps](#) and received significant feedback about a diversity of sites available to inform researchers and northern residents about ongoing research.
- Invited Vera Metcalf (Eskimo Walrus Commission) and Maija Katak Lukin (National Park Service) to provide Indigenous perspectives on the well-being of Arctic residents at the annual IARPC Team Leaders Meeting in Anchorage, Alaska, June 2019.
- Members of the CRCT arranged for IARPC Collaboration Team Leader Meeting participants to be hosted by Alaska Native Science and Engineering Program students in Anchorage, Alaska, and hear their questions and comments about Arctic research.

**How this activity has promoted communication/collaboration between Federal agencies and with the research community?** The activities summarized above have significantly advanced opportunities for communication and collaboration between Federal agencies by hosting forums for information discovery, lively conversation, and realization of additional information needs to better serve the public and Indigenous communities.

**How has this activity engaged Indigenous scholars and knowledge holders?** Through the activities summarized above, the CRCT has provided opportunities and forums where Indigenous scholars and knowledge holders can share their perspectives and concerns with past and current knowledge

gathering practices, but these forums have also informed Federal researchers about current and future plans of Indigenous scholars and knowledge holders to summarize and act on their own information.

#### Team statistics

- Number of Meetings: 5
- Number of Joint Meetings: 2
- Average Participants per Meeting: 24

## Environmental Intelligence Annual Report 2019

### **Environmental Intelligence Collaboration Team (EICT)**

Co-leaders: Renee Crain (NSF), Roberto Delgado (NSF), Molly McCammon (AOOS)

Arctic Observing Systems Sub-Team (AOSST)

**Co-leaders: Sally McFarlane (DOE), Will Ambrose (CCU), Sandy Starkweather (NOAA-CIRES)**

Arctic Data Sub-Team (ADST)

Co-leader: Jonathan Blyth (BOEM)

### **Modeling Sub-Team (MST)**

Co-Leaders: Renu Joseph (DOE), Richard Cullather (NASA), Scott Harper (NRL), Wilbert Weijer (LANL)

**Contribution Agencies: DHS, DOC, DOD, DOE, DOI, DOS, DOT, EPA, NASA, NSF, OSTP, USARC, USDA**

The Environmental Intelligence Collaboration Team (EICT), charged with supporting coordinated research in response to stakeholder and decision-maker needs, is comprised of three sub-teams: the Arctic Observing System (AOSST), Arctic Data (ADST), and Modeling Sub-teams (MST). In FY19, these teams continued to make progress towards shared objectives among the Environmental Intelligence Team as well as advancing issues to the eight other the topic focused Collaboration Teams of the Arctic Research Plan 2017-2021.

The EICT and each sub-team has provided a summary of their FY19 activities in support of the Arctic Research Plan policy drivers:

### **EICT**

The Environmental Intelligence Collaboration Team supported the Arctic Research Plan policy drivers of “**Enhancing the well-being of Arctic residents**” and “**Advancing Stewardship of the Arctic environment**.” These drivers, along with Research Objective 9.5 - “Advance research, tools and strategies that improve the accessibility and usability of Arctic science for decision support” - encompass the scope of the EICT’s work in FY19.

During the 1<sup>st</sup> and 2<sup>nd</sup> quarters of FY19, EICT focused its efforts on outreach and communication of science results to Alaskan communities and Arctic researchers in relation to ecosystem changes in the Bering Sea/Strait region. At the October 2018 Alaska Federation of Natives (AFN) annual convention, EICT was key in organizing and distributing agency updates from that year’s field research campaigns at a roundtable discussion session attended by AFN participants and Federal and state researchers (PE 9.5.1: “Advance coordination among Federally-funded research programs that provide decision support to Arctic stakeholders;” PE 9.5.2: “Advance policy-relevant science communication through efforts like the annual Arctic Report Card, the Arctic Research Consortium of the United States (ARCUS), and the Study of Environmental Arctic Change (SEARCH)”). These agency one-pagers were greatly appreciated by the Alaskan community, and there will be a repeat effort in FY20. In December 2018, EICT Team Co-leads Molly McCammon and Emily Osborne (EICT co-lead in FY18) hosted a townhall event at AGU on “Unprecedented Bering Sea Ice Extent and Impacts to Marine Ecosystems and Western Alaskan Communities,” attended by more than 50 members of the research community and some coastal community residents, and streamed via Facebook live to Alaska residents (PE 9.5.2). NOAA supported

the release of the 2018 Arctic Report Card during this time (PE 9.5.2). As a final follow-up activity on the Bering Sea Harmful Algal Blooms (HABs) work from FY18, EICT hosted a 'Harmful Algal Blooms in the Bering Sea' townhall at the January 2019 Alaska Marine Science Symposium (PE 9.5.1, 9.5.2).

The 3<sup>rd</sup> and 4<sup>th</sup> quarters of FY19 were organized around continued monitoring of Bering Sea and Chukchi Sea ecosystem changes by facilitating conversations between researchers, Federal and non-federal partners, and impacted communities. EICT also co-led an Arctic research cruise coordination meeting with the Field Operations Working Group in March 2019 (PE 9.5.1). This resulted in the 2019 Vessel Matrix (<https://www.iarpcollaborations.org/members/Test-Logistics-Spreadsheets.html>). Meetings in March and July updated participants on Bering and Chukchi Sea conditions and unusual observations from the field season, as well as provided a forum for collaboration and leveraging of current and future research efforts in the area (PE 9.5.1). EICT lead Molly McCammon also presented on Bering Sea changes and impacts during the September 2019 OceanObs'19 conference. These efforts, along with the work of the Coastal Resilience Collaboration Team, have led to establishment of a Bering Sea Action Team by IARPC Staff Group. The focus of this group is to evaluate what research is already being funded in the Bering and Chukchi Seas, consider stakeholder input to determine the most critical research needs for the region, and determine how might IARPC agencies and collaborators respond to these identified needs in the short- and long-term.

## **AOSST**

The Arctic Observing Systems Sub-Team supports the Arctic Research Plan 2017-2021 Policy Drivers, **"Improve understanding of the Arctic as a component of planet Earth"** and **"Strengthen national and regional security."** AOSST is associated with Research Objective 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).

A sustained Arctic observing network is critical for providing the information needed to understand the Arctic system and to improve predictive capability for emergency response and security. In direct support of the national and regional security policy driver, AOSST hosted three meetings on maritime domain awareness. The presentations and ensuing discussions at these meetings focused on the observational needs in support of national and regional security in the Arctic and the application of multi-use observing networks for both research and domain awareness (PE 9.1.2: "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."). As a follow-on activity, the US Arctic Observing Network (US AON) Board (the Federal-only arm of the AOSST) began a thematic mapping exercise to link policy drivers to key objectives to identify actions with the goal of optimizing benefits of the observing system. AOSST's other main efforts this year focused on coordinating US contributions to a sustained observing strategy and implementation plan in support of the Sustaining Arctic Observing Network's Roadmap for Arctic Observing and Data Systems (PE 9.1.1: "Coordinate U.S. agency and outside collaborators support for and participation in the international Sustaining Arctic Observing Networks (SAON) process."). This Roadmap is a critical piece for developing a coordinated international Arctic Observing Network that will meet both of the policy drivers that AOSST supports.

## ADST

In FY19, ADST reviewed Federal tools, processes, and human capital needed to achieve the Research Objective 9.4: “Enhance discoverability, understanding, and interoperability of Arctic data and tools across Federal data centers.” The Federal tools included a variety of state-of-the-art metadata sharing and interoperability tools available to the Arctic research community. The team reviewed current data policies and data governance artifacts from a variety of Federal agencies that support and serve the Arctic research community. Finally, the team looked at key questions from across the IARPC community and assessed whether data are available to meet these needs pursuant to the Federal Data Strategy and Action Plan. These summaries of tools, processes, and human capital will inform the Arctic Data Roadmap that is planned for development in FY20.

ADST also co-led international efforts with the Arctic Observing Systems Sub-team. Former ADST Team Lead Peter Pulsifer led meetings and workshops responsive to PE 9.4.2: “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).” As part of his work on the SAON Arctic data committee, Pulsifer helped develop an architecture for a connected Arctic data system, including the Polar Data and Systems Architecture workshop in November 2018, and planning for the third Polar Data Forum in November 2019. Pulsifer also contributed to a white paper drawing on the SAON roadmap process and Arctic Observing Summit Working Group deliberations.

## MST

The overarching goal of the Modeling Sub-Team is to enhance coordination for numerical model development, evaluations, synthesis, and verification that enhances predictability and the understanding of important processes in the context of the broader Arctic system. MST has ten Performance Elements that align with Research Objective 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,” and Research Objective 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.”

In FY19, MST contributed towards completing seven of the ten Performance Elements. All Performance Elements are responsive to the Policy Driver that focuses on “**Improving Understanding of the Arctic as a component of the planet Earth.**” In addition, some recent progress towards “**Advancing stewardship of the Arctic environment**” has been made through projects initiated by NASA and DOE. For instance, NASA and DOE respectively have initiated projects that will examine how changes in the natural system will affect the Integrated Human-Earth System Modeling (PE 9.2.1, 9.2.3). NASA’s project connects with NASA’s Arctic Boreal Vulnerability Experiment (ABOVE) campaign, while DOE’s project called ‘InterFACE’ focuses on predictive and fundamental understanding between the natural and the human systems that will control the trajectory and rate of change across the Arctic coastal interface.

Over FY19, there was a concerted effort by the MST to focus on Model Intercomparison Projects (MIPs) in light of the sixth Coupled Model Intercomparison Project (CMIP6) emphasis as part of the

international World Climate Research Programme (WCRP). Several MIPs focused on the understanding of Arctic processes (e.g., Ice-sheet MIP, Sea-ice MIP, Polar Amplification MIP) were discussed at the MST meetings. Focusing on the Policy Driver for improved understanding, in the past year, several agencies (DOE, NASA, NSF, and NOAA) and interagency groups like CLIVAR have worked towards contributing understanding of how changes in the Arctic affect the mid-latitudes both in the atmosphere and ocean (PEs 9.2.1, and 9.2.2). Considerable advances have been made towards process understanding within the Arctic system across the Federal arena through synergies between the NASA ABoVE campaign, NSF's Permafrost Carbon Network, DOE's Next Generation Ecosystem Experiment (NGEE-Arctic), and DOE's International LAnd Model Benchmarking (ILAMB). All these efforts will enhance our modeling capabilities in the terrestrial Arctic (PE 9.2.3.). Model development activities pertaining to atmospheric, oceanic, terrestrial, sea-ice, and land-ice processes were discussed as part of the MST and are relevant to PE 9.3.3.

#### EICT Team Statistic:

- Number of Meetings: 3
- Number of Joint Meetings: 1
- Average Participants per Meeting: 19

#### AOSST Team Statistics:

- Number of Meetings: 7
- Number of Joint Meetings: 2
- Average Participants per Meeting: 19

#### ADST Team Statistics:

- Number of Meetings: 6
- Number of Joint Meetings: 2
- Average Participants per Meeting: 15

#### MST Team Statistics:

- Number of Meetings: 7
- Number of Joint Meetings: 6
- Average Participants per Meeting: 20