

INTERAGENCY ARCTIC RESEARCH POLICY COMMITTEE

2016 MILESTONE REPORTING LOGS

The milestone reporting logs described here represent actions taken for all IARPC collaboration team during FY 2016, presented in order of appearance in the 5-Year Plan.

IARPC Collaboration Teams

Sea Ice Collaboration Team	Atmosphere Collaboration Team
Distributed Biological Observatory Collaboration Team	Arctic Observing Systems Collaboration Team
Chukchi & Beaufort Seas Ecosystem Collaboration Team	Arctic Data Collaboration Team
Glaciers & Fjords Collaboration Team	Modeling Collaboration Team
Terrestrial Ecosystems Collaboration Team	Arctic Communities Collaboration Team
Wildfires Collaboration Team	Human Health 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).

Sea Ice

Milestone Reporting Log 2016

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

3.1 Sea ice and marine ecosystems

3.1.1 Develop a framework of observations and modeling to support forecasting of sea ice extent on seasonal to annual scales for operational and research needs

- **3.1.1.a (Milestone met) Convene interagency expert group on sea ice forecasting to develop multi-year implementation plan, coordinate on-going observation and modeling, and determine needed improvements to reduce uncertainty in forecasts; DOD-ONR (Lead), DOE, DOI, NOAA; Target Date 2013**
 - Completion Statement: At the June 2014 meeting, the Sea Ice Collaboration Team determined that this milestone was completed, as the team is the interagency expert group on sea ice forecasting that is coordinating observations and modeling, and the milestones are the multi-year implementation plan. The team added a modified milestone for reducing forecast uncertainty: Milestone 3.1.1.h "Hold a workshop on Reducing Uncertainty in Sea Ice Forecasts." (Sep 20, 2016 - Completed)
 - During 2015, three (3) meetings took place to find common ground in order to move forward with this milestone. The sea ice forecasting aspect of this milestone would be part of a larger effort geared towards environmental forecasting. To promote further collaboration, the NOPP office (which facilitated those meetings) has created the following page: <http://www.nopp.org/2015/arctic-environmental-forecasting-study/>. (Sep 25, 2015 - Completed)
 - BOEM and NOAA will try to develop a common list of objectives to design a more integrated approach for their joint study. More agencies should be involved in order to broaden participation. (Dec 29, 2014 - Target)
 - With NSF support, SEARCH began a new phase in late summer 2014, when action teams were formed to address four new SEARCH goals. Goal #4 is relevant to the Sea Ice team: Improve understanding, advance prediction and explore consequences of changing Arctic sea ice. The IARPC Sea Ice Collaboration Team will collaborate with the SEARCH Sea Ice Action Team responsible for Goal #4. (Sep 29, 2014 - Completed)
 - The demonstration project for the Earth System Prediction Capability Project is in its first year, which is focused on the writing of an implementation plan. (Jul 2, 2014 - Completed)

- Presented NOAA activities to WMO's Polar Prediction Project. (Jul 2, 2014 - Completed)
- The Sea Ice Prediction Network (SIPN, www.arcus.org/sipn) was initiated in late summer 2013 with funding from NSF, ONR, ONR Global, DOE and NASA, and in-kind support from NOAA. The primary institutions in the network are the University of Washington, University of Colorado, University of Alaska Fairbanks, Arctic Research Consortium of the U.S., Los Alamos National Laboratory and NOAA Pacific Marine Environmental Laboratory. The first SIPN workshop was held in March 2014, and a workshop report was presented to the Sea Ice team during the May meeting. SIPN is a contribution to the inter-agency Study of Environmental Arctic Change (SEARCH). (Jul 2, 2014 - Completed)
- As a result of the June 2014 meeting, the team determined that this milestone was completed. They added a new milestone as a carry-on activity. Milestone 3.1.1.h "Hold a workshop on "Reducing Uncertainty in Sea Ice Forecasts" with a due date of 2015. (Jun 30, 2014 - Completed)
- NOAA ESRL hosted a NOAA Science Challenge Workshop on "Predicting Arctic Weather and Climate and Related Impacts" in Boulder, CO, on 13-15 May 2014, and released the workshop report in September 2014. Workshop recommendations include "Focus intensive efforts on improving sea ice forecasts" and "Enhance observing system capabilities to meet the diverse and growing needs for Arctic environmental forecasts and related services". (May 26, 2014 - Completed)
- **3.1.1.b (Milestone met) Engage with stakeholders and users to determine needs for sea ice forecasts and products through venues such as the Alaska Marine Science Symposium and Alaska Forum on the Environment; NOAA; Target Date 2017**
 - Completion Statement: The Alaska Ocean Observing System (AOOS) conducted a survey of key stakeholders and sea ice product providers to delve deeper into the needs for additional products. AOOS published the survey report in September 2013. Adrienne Tivy (Canadian Ice Service) and Chris Petrich (Norut Narvik, Norway) conducted a survey of the needs of the oil and gas industry, and the shipping industry. The results are summarized in a report to the Arctic Observing Summit 2016. (Sep 14, 2016 - Completed)
 - Adrienne Tivy is leading a white paper for the Industry Collaborations Theme that is part of the March 2016 Arctic Observing Summit (www.arcticobservingsummit.org), summarizing key aspects of stakeholder information needs assessment. White papers will be made public prior to summit for review and discussion. (Mar 31, 2016 - Completed)
 - Martin will discuss with Molly and the NWS in Anchorage whether or not there should be further analysis of the survey results. (Dec 29, 2014 - Target)
 - The Alaska Ocean Observing System (AOOS) conducted a survey of key stakeholders and sea ice product providers to delve deeper into the needs for

additional products. The survey was distributed in June 2013 and preliminary results were presented to the Sea Ice team in July 2013. AOOS published the survey report in September 2013. The report is available at <http://www.aos.org/workshops-and-reports/>. Sea Ice team leadership, AOOS and National Weather Service (Anchorage, AK) are discussing possible additional analysis of the survey results. (Jul 2, 2014 - Completed)

- Continuation Statement: During their June 2014 meeting, the team decided to leave this milestone as open and ongoing since they wish to continue to engage stakeholders and users. The new due date is 2017. (Jun 20, 2014 - Completed)
- **3.1.1.c (Milestone met) Continue the Sea Ice Outlook and Sea Ice for Walrus Outlook to evaluate diverse sea ice forecasting approaches and fill a valuable user need; NOAA (Lead), DOD-ONR, NSF, USARC; Target Date 2017**
 - Completion statement: This milestone has been completed. The Sea Ice Prediction Network (SIPN), which is responsible for the Sea Ice Outlook and the Sea Ice for Walrus Outlook, has been very active and productive. The Sea Ice Outlook for 2016 was the 9th successive outlook, which has attracted progressively more contributions and insights into sea ice predictability since it started in 2008 in response to the then record low minimum ice extent of 2007. The SIP has organized numerous workshop, all with international participants, presented its work at conferences, and published the results of its research in peer-reviewed journals. (Oct 7, 2016 - Completed)
 - The Sea Ice Prediction Network led a wide-ranging series of activities in the last 12 months. The leadership team published 3 peer-reviewed team papers about the SIO and SIPN intercomparison projects. The SIPN leadership team continues to organize and run the SIO, which routinely has about 35 participants who submit forecasts of the September pan-Arctic sea ice cover. Forecasts are submitted in June, July and August. About a half-dozen participants submit full-fields of more detailed sea ice quantities. The SIPN leadership prepared reports for each month in summer synthesizing the Outlooks and current Arctic sea ice conditions. A post-season report was written with conclusions, lessons-learned, and recommendations for the next year. Among those recommendations, network members wanted the SIO to collect more information about how forecasts were made (which we have done in 2016) and recommended more funded prediction Network studies (which has been accomplished to some extent in Europe by the success of grants won by the APPLICATE, Arctic –UNION, and ARCPATH teams). The SIPN team organized additional community activities to share research and resources about sea ice prediction. SIPN held its annual workshop in spring 2016 at Lamont with 70 participants, and SIPN ran bi-monthly webinars with presentations about current research and SIO results. SIPN hosted a Network meeting at 2015 Fall AGU and participated in a science session at the spring 2016 EGU. Sea ice forecasts are increasing in rigor, as the overwhelming majority of the Outlooks from dynamical model are from coupled prediction system now. Our Network team study showed the importance of post processing to reduce uncertainty, but the lack of archived retrospective forecasts prevents the SIPN

team from being able to undertake post processing. The Sea Ice Prediction Network led the following major activities in the last 12 months:

(1) Three peer-reviewed papers were published about the SIO/SIPN activities:

(A) Results of the SIPN Intercomparison of a common experiment across 8 prediction systems initialized with common sea ice thickness conditions. All groups forecast the summer of 2015. This paper is to appear in *Climate Dynamics* by Blanchard-Wrigglesworth et al. (2016)

(B) Results of the Sea Ice Challenger Experiment of 2013, which was an intercomparison of prediction systems to a 1 m thickness perturbation. This paper was published in late 2015 (Blanchard-Wrigglesworth et al., 2016).

(C) Analyzing the SIO Outlooks for 2008-2015 by Hamilton and Stroeve (2016)

(2) Consistent near record level of participation in the SIO, approximately 35 contributions each month for June, July, and August.

(3) Synthesis reports of the SIO in June, July, and August written by leadership team members and a Post-Season report written with participation from 11 Network members.

(4) The 2016 observed September mean extent was essentially right on the long-term trend, while the extent on the day of the minimum tied for the second all-time low. The ensemble-mean September mean extent across the SIO went low, more in-line with the minimum.

(5) About a half-dozen participants continue to contribute full spatial fields of Sea Ice Probability and First Ice Free Day. Research shows the importance of post processing spatial fields, which cannot be done until more years are archived, especially for retrospective forecasts.

(6) Polar Prediction Workshop held at Lamont Dohery Earth Observatory in May 2016, joint with the Polar Climate Prediction Initiative and Polar Prediction Workshop. There were 70 participants, with about half of the 53 presentations by international participants.

(7) European Geophysical Union session joint with the Polar Climate Prediction Initiative and Polar Prediction Workshop.

(8) Network meeting at AGU with discussion of observational needs for predictions

(9) Bi-monthly webinars were held in spring and summer with approximately 60-80 participants. SIPN team publications:

Blanchard-Wrigglesworth, E., R.I. Cullather, W. Wang, J. Zhang, and C.M. Bitz, 2015: Model skill and sensitivity to initial conditions in a sea ice prediction system, *Geophys. Res. Lett.*, 42, doi:10.1002/2015GL065860.

Blanchard-Wrigglesworth, E., A. Barthélemy, M. Chevallier, R.I. Cullather, N. Fučkar, F. Massonnet, P Posey, W. Wang, J. Zhang, C. Ardilouze, C.M. Bitz, G. Vernieres, A. Wallcraft, and M. Wang, 2016: Multi-model seasonal forecast of Arctic sea-ice forecast uncertainty at pan-Arctic and regional scales, in press in *Climate Dynamics*.

Hamilton, L.C. and J. Stroeve, 2016: 400 predictions: The SEARCH Sea Ice Outlook 2008-2015, *Polar Geography*, DOI: 10.1080/1088937X.2016.1234518. (Oct 3, 2016 - Completed)

- Several publications by SICT members contribute to the completion of this milestone:
 - (1) Ray, G.C., G.L. Hufford, J.E. Overland, I. Krupnik, J. McCormick-Ray, K. Frey, and E. Labunski (2016): Decadal Bering Sea seascape change: Consequences for Pacific Walruses and indigenous hunters. *Ecol. Appl.*, 26 (1) 24–41, Available at: <http://onlinelibrary.wiley.com/doi/10.1890/15-0430/abstract>.
 - (2) Overland, J.E., and M. Wang (2016): Recent extreme Arctic temperatures are due to a split polar vortex . *J. Climate* , 29 (15), 5609–5616. Available at: <http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-16-0320.1>.
 - (3) Overland, J.E., J. Francis, R. Hall, E. Hanna, S.-J. Kim, and T. Vihma (2015): The melting Arctic and mid-latitude weather patterns: Are they connected? *J. Climate* , 28 (20), 7917–7932. Available at: <http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-14-00822.1>.
 - (4) Wang, M., and J.E. Overland (2015): Projected future duration of the sea-ice-free season in the Alaskan Arctic . *Prog. Oceanogr.*, 136, 50–59. Available at: https://www.researchgate.net/publication/270914143_Project_Future_Duration_of_the_Sea-Ice-Free_Season_in_the_Alaskan_Arctic.
 - (5) Overland, J.E., M. Wang, J.E. Walsh, and J.C. Stroeve (2014): Future Arctic climate changes: Adaptation and mitigation timescales. *Earth's Future*, 2 (2), 68–74. Available at: <http://onlinelibrary.wiley.com/doi/10.1002/2013EF000162/abstract>.
 - (6) Jeffries, M.O., J.E. Overland, and D.K. Perovich (2013): The Arctic shifts to a new normal. *Physics Today*, 66 (10), 35–40. Available at: <http://scitation.aip.org/content/aip/magazine/physicstoday/article/66/10/10.1063/P T.3.2147>.
 - (7) Overland, J.E., and M. Wang (2013): When will the summer Arctic be nearly sea ice free? *Geophys. Res. Lett.*, 40 (10), 2097–2101. Available at: <http://onlinelibrary.wiley.com/doi/10.1002/grl.50316/abstract>. (Sep 28, 2016 - Completed)
- EOS Transactions published an article titled "Developing user-oriented seasonal ice forecasts in a changing Arctic" summarizing how well the September forecasts submitted to the annual Sea Ice Outlook (SIO) are doing and discussing needs for further research. <https://eos.org/features/improving-predictions-of-arctic-sea-ice-extent>. (Sep 22, 2015 - Completed)

- On 24 June 2015 the September Sea Ice Outlook based on May data was posted: <http://www.arcus.org/sipn/sea-ice-outlook/2015/june>. In 2015 the sea ice for walrus outlook (SIWO) provided weekly updates from 3 April to 5 June with current high-resolution satellite conditions, local observations, and 5 and 10 day forecasts: <http://www.arcus.org/search-program/siwo>. (Jun 30, 2015 - Completed)
- Jim will notify the Collaboration Team when the 2015 calls for input to the SIO and SIWO are made. (Jun 29, 2015 - Completed)
- Call for the 2014 Sea Ice Outlook was issued in May. Sea Ice Outlook post-season report will be available in December. The 2014 Sea Ice for Walrus Outlook will concluded at the end of the summer season 2014. Report when results are available. (Jan 29, 2015 - Completed)
- Starting with 2014, the Sea Ice Outlook will be available through the Sea Ice Prediction Network (SIPN). The Sea Ice Outlook, operating for six years, was an international effort to provide a community-wide scientific discussion for the causes of the expected September arctic sea ice minimum. SIPN increases the activity from an informal effort to a major project to improve seasonal sea ice forecasts, including stakeholders and the public. Key 2014 SIPN activities were a spring planning workshop and increased coordination of modeling activities by many research and operational groups. The post season report was available 19 December 2014. In 2014 SIPN had 28 groups contribute pan-arctic outlooks and 5 groups contribute regional outlooks. This year had the 6th lowest September sea ice extent since satellite observations began in 1979. The eight lowest minimum ice extents have occurred in the last eight years, 2007-2014. The observed extent for September 2014 suggests that in the absence of anomalous patterns of weather and wind that results in large ice loss, such as occurred in 2012, sea ice extent will tend to stay near the downward linear trend line. The median September outlook estimates of 4.7 million square kilometers from the June report and 4.8 million square kilometers for the July report were below the observed September value of 5.3 million square kilometers. For the modeling contributions specifically, the later the prediction date, the more confident the predictions, and the inter-model spread is reduced as the prediction start dates get closer to the month of September. The median value of all the models' outlooks combined each month was remarkably close to the observed extent. (Jan 29, 2015 - Completed)
- The SEARCH Sea Ice Outlook and the Sea Ice Outlook for Walrus are now the responsibility of the inter-agency Sea Ice Prediction Network (SIPN), which was initiated in summer 2013. See milestone 3.1.1.a. (Aug 25, 2014 - Completed)
- Call for the 2013 Sea Ice Outlook was issued in May 2013. Sea Ice Outlook post-season report for 2013 was issued on Dec. 30, 2013. <http://www.arcus.org/search-program/seaiceoutlook/2013/summary>. The 2013 Sea Ice for Walrus Outlook was concluded at the end of the summer season 2013. Available at <http://www.arcus.org/search-program/siwo>. (Jul 2, 2014 - Completed)
- In June 2014 the Sea Ice team decided to change the target date to 2017 (from 2013) as the Sea Ice Outlook and Sea Ice for Walrus Outlook effort of SEARCH

(Study of Environmental Arctic Change, and IARPC program) will continue. (Jun 30, 2014 - Completed)

- **3.1.1.d (In progress) Launch Ice, Cloud, and land Elevation Satellite (ICESat) 2 satellite altimetry mission to continue the record of sea ice thickness measurements and land ice elevation change; NASA (Lead); Target Date 2016**

- Continuation Statement: Work on this milestone will continue under the implementation of Arctic Research Plan 2017-2021 as ICESat-2 is scheduled for launch in 2018. There is an ICESat-2 performance element in the new plan. (Sep 14, 2016 - Completed)
- ICESat-2 remains an important mission for science and for NASA. The mission addresses key issues in climate and cryospheric science while providing foundational supporting measurements for ecosystem/carbon/vegetation studies. Most of the design, manufacturing and integration have been completed, but the majority of testing still lies ahead. The Advanced Topographic Laser Altimeter System (ATLAS) instrument components have been mostly completed and integrated including the flight lasers. Testing of the completed instrument is scheduled to commence in January 2016. The spacecraft build was completed during the past year, and it has entered a phase of pre-integration testing and storage while awaiting completion of the ATLAS instrument. After the instrument and spacecraft are integrated, the resulting observatory will go through a one-year period of testing. The Launch Readiness Date for ICESat-2 is scheduled for June 2018 with operations continuing through 2021. (Aug 7, 2015 - Completed)
- A SMAP/ICESat-2 workshop was held at the NASA Stennis Space Center in August 2014. SMAP is short for Soil Moisture Active-Passive. The workshop aim was to inform stakeholders and end-users about the science and data products expected from the missions, and to encourage additional stakeholders and end users to identify sea ice products. NASA is working with other agencies and institutions towards that end. (See August 2014 meeting notes for more details.) (Aug 26, 2014 - Completed)
- Some issues emerged with ICESat-2's photon-counting lidar instrument, resulting in increased cost and schedule delays. Most of the design risk has been retired during the past year. The spacecraft build will complete later this year (2014). The instrument will then be integrated with the spacecraft, and the resulting observatory will go through a one-year period of testing. The Launch Readiness Date for ICESat-2 is scheduled for June 2018. (Aug 6, 2014 - Completed)
- In July 2014, NASA flew the MABEL (Multiple Altimeter Beam Experimental Lidar) instrument aboard a high altitude ER-2 aircraft to investigate summer sea ice in the Arctic Ocean. MABEL provides a new capability for airborne altimetry measurements and serves as a prototype and simulator for the ICESat-2 satellite instrument. As such, it enables NASA to develop algorithms to derive information about the summer sea ice cover from ICESat-2. (Jul 28, 2014 - Completed)

- **3.1.1.e (In progress) Launch Gravity Recovery and Climate Experiment (GRACE) follow-on satellite mission to continue the record of changes in Arctic Ocean circulation and land ice mass loss; NASA (Lead); Target Date 2017**

- Continuation Statement: Work on this milestone will continue under the implementation of Arctic Research Plan 2017-2021 as the GRACE Follow On satellite is scheduled for launch in 2017. But note that there is not a GRACE Follow On performance element in Arctic Research Plan 2017-2021. (Sep 28, 2016 - Completed)
- GRACE-FO recently completed its System Integration Review and will now enter into its Integration and Test phase at the Airbus Defense and Space facility in Friedrichshafen, Germany. Spacecraft construction has already begun and the flight instruments are completing their final integration before delivery to Airbus. The mission elements - the Mission Operations System and the Science Data System - have completed their respective Critical Design Reviews as scheduled, with the remaining Launch Vehicle CDR planned to be completed before the end of the year. The Launch Readiness Date for GRACE-FO is August 2017 on a Dnepr launch vehicle from Yasny, Russia. (Aug 7, 2015 - Completed)
- GRACE Follow ON is on schedule for its Spacecraft/Mission Critical Design Review (CDR) in February 2015. Two of the three instruments, the Microwave Instrument and the Laser Ranging Interferometer, have completed their respective CDRs, and the remaining Accelerometer CDR is scheduled for September 2014. The mission elements - the Mission Operations System and the Science Data System - have completed their respective Preliminary Design Reviews as scheduled, with the remaining Launch Vehicle PDR scheduled to be completed by 31 July 2014. Spacecraft subsystem CDRs are also being conducted, as well as interface testing between elements using engineering models, where appropriate. The Launch Readiness Date for GRACE Follow On is August 2017. (Aug 6, 2014 - Completed)

- **3.1.1.f (Milestone met) Develop algorithms for Advanced Microwave Scanning Radiometer 2 (AMSR2), recently launched on Japan's GCOM-W, to continue and enhance passive microwave record of sea ice extent; NASA; Target Date 2016**

- Completion Statement: This milestone has been completed. By December 2015 the NASA LANCE team had acquired and tested the sea ice concentration algorithm code, and by April 2016 the AMSR2 sea ice concentration products were available through the NASA LANCE near-real-time distribution system: <https://earthdata.nasa.gov/earth-observation-data/near-real-time>. Browse images are available through the NASA WorldView system: <https://worldview.earthdata.nasa.gov>. (Oct 6, 2016 - Completed)
- The AMSR2 sea ice concentration products are now available through the NASA LANCE near-real-time distribution system. Browse images are also now available

through the NASA WorldView system. Data access through LANCE: <https://earthdata.nasa.gov/earth-observation-data/near-real-time>. Browse imagery through WorldView: <https://worldview.earthdata.nasa.gov>. (Apr 27, 2016 - Completed)

- The NASA LANCE team has acquired and tested the sea ice concentration algorithm code and all looks good. The concentration fields should be available via LANCE very soon (at the meeting a time frame of "about a month" was given). When it is available, it should be available seen here: <https://earthdata.nasa.gov/earth-observation-data/near-real-time/download-nrt-data/amsr2-nrt>. As well as becoming available to browse on NASA WorldView: <https://earthdata.nasa.gov/labs/worldview/>. (Dec 1, 2015 - Target)
- Intercalibration has been completed between AMSR-E and AMSR2 and AMSR2 concentration algorithms have been adjusted for consistency with AMSR-E. The software is now adapted for ingestion into the LANCE near-real-time system. The software will be delivered soon and it is expected that AMSR2 sea ice concentration will be implemented within LANCE and available to users in the next few months (dependent mostly on priorities and resources of the LANCE team after the software is delivered). Also, a new sea ice motion algorithm has been obtained and is being evaluated as a replacement for the AMSR-E algorithm that no longer has support at Goddard. The new algorithm will be integrated into the AMSR2 product suite over the coming year. The algorithm has been successfully implemented at NASA Goddard with positive data test runs completed. Next, NASA will conduct more testing and quality control, investigating the best output format for users. After the September 2015 AMSR2 Science Team Meeting takes place, additional updates will be available, including new details on the status of LANCE implementation. (Oct 26, 2015 - Target)
- The milestone due date was extended to 2016 to accommodate the completion of the development and testing. (Oct 6, 2015 - Completed)
- In 2013, NASA funded a science team to adapt and implement almost all of the same science products that were developed for AMSR-E, including the NASA Team 2 and Bootstrap concentration products. Sea surface temperature will be discontinued. A replacement sea ice drift product is being investigated as the original developers have left NASA. To date, (February 2015) the team has completed inter-comparisons of AMSR2 with AMSR-E and derived regressions to match-up the AMSR2 fields with AMSR-E from the NASA Team 2 algorithm (NASA's standard AMSR product). The regressions have been applied to adjust the brightness temperatures so that the NASA Team 2 algorithm products are consistent between AMSR-E and AMSR2. These have been shared at meetings of the NASA AMSR2 Science Team and the JAXA AMSR2 Science Team. These will also be provided to NASA Marshall to be used in the LANCE system to provide NRT sea ice products within LANCE, GIBBS, and WorldView. The NASA Science Team has also been working together to better integrate across all AMSR products to provide better interoperability between ocean, ice, and land products. There are also other funded projects to develop, implement, and test enhancements to the sea ice products, including concentration uncertainty

estimates. Over the past few months, initial validation/calibration of the uncertainty estimates has been done via comparison with MODIS fields. Finally, NOAA is supporting the development (at NSIDC) of an operational concentration product for use in their forecasting models; an initial version of the code was delivered and revised version will be delivered in winter 2015. Adjustments have also been made to the Bootstrap algorithm and a research-level product is being updated by the PI; the Bootstrap algorithm has also been implemented as the standard JAXA product. (Feb 19, 2015 - Completed)

- 1. NASA has a funded science team to implement almost all of the same science products (except SST) that were developed for AMSR-E, including the NASA Team 2 and Bootstrap ice concentration products. A replacement sea ice drift product is being investigated. Work continues to cross-calibrate the AMSR2 fields with AMSR-E and to make parameters more consistent across the AMSR2 product suite. There are also other funded projects to develop, implement and test enhancements to the sea ice products, including concentration uncertainty estimates. 2. ONR, NASA, NRL and NSIDC are investigating combined AMSR-E and MODIS, and AMSR2-MASIE products to obtain better ice edge definition and ice concentration for the Navy operational model (ACNFS: Arctic Cap Nowcast/Forecast System). MASIE is a NSIDC daily ice edge product based on the operational analysis of the National Ice Center. An initial test of the AMSR-E/MODIS ice edge product showed a 17% improvement in the Navy ACNFS (Arctic Cap Nowcast/Forecast System) ice edge prediction compared to ACNFS runs using the older SSMI/S ice edge product. 3. NOAA has an MOA with the Japanese Space Agency to develop AMSR2 operational products to support NOAA weather products. NOAA is supporting NSIDC to develop an operational ice concentration product for use in NOAA forecast models. (Aug 6, 2014 - Completed)
- **3.1.1.g (Deactivated) Improve knowledge of sea ice melting through various activities such as ONR's marginal ice zone program and NASA's Operation IceBridge mission; DOD-ONR; Target Date 2017**
 - Deactivation Statement: This Operation IceBridge component of this milestone will carry over to the implementation of Arctic Research Plan 2017-2021, as Operation IceBridge will continue to 2019 and there is a Performance Element that covers this continuing activity. The status of the ONR marginal ice zone component of this milestone is described under Milestone 3.1.2d. (Sep 20, 2016 - Completed)
 - During 9-12 August 2014, the ONR team aboard the R/V Araon of the Korea Polar Research Institute (KOPRI) successfully deployed the fifth, and final, cluster of instruments for the marginal ice zone project array. Deployed in the vicinity of 77.3°N, 146°W, the fifth cluster comprises the following: 10 wave buoys; 5 ice mass balance buoys; 1 ice-tethered profiler; 1 Arctic Ocean flux buoy; 1 automatic weather station. In addition to the drifting instrument deployment, there was a successful 5-day deployment of the Naval Postgraduate

School entrainment frame to investigate small-scale boundary layer flow and turbulent fluxes to the underside of the ice. (Aug 26, 2014 - Completed)

- Between 24 July and 2 August 2014, ONR-funded scientists completed a brief field campaign as part of the larger marginal ice zone research project. Using the R/V Ukpik sailing out of Prudhoe Bay, the team deployed 4 Seagliders, 2 Wavegliders and 1 moored Waverider buoy, and did a number of CTD casts and took water samples for biogeochemical analysis. Each Seaglider is equipped with a CTD and microstructure sensor and bio-optical sensors. Each Waveglider is equipped with an automatic weather station and an underseas acoustic source. The latter supplement 8 sources that were deployed in March 2014 in the eastern Beaufort Sea to provide acoustic communication and navigation services for the Seagliders and 8 polar profiling floats (Arctic Argo floats), also deployed in March 2014. (Aug 2, 2014 - Completed)

- **3.1.1.h (Milestone met) Hold a Workshop on "Reducing Uncertainty in Sea Ice Forecasts"; Target Date 2015**

Completion Statement. This milestone has been completed. The interagency Sea Ice Prediction Network organized three workshops that collectively addressed the issue of reducing uncertainty in sea ice forecasts. The workshops were: 1) Sea Ice Modeling, September 2014; 2) Data Needs for Sea Ice Forecasting, December 2015; 3) Polar Prediction, May 2016. (Oct 6, 2016 - Completed)

- The interagency Sea Ice Prediction Network held a Polar Prediction workshop in May 2016 at the Lamont Doherty Earth Observatory of Columbia University, New York. Attended by 74 U.S. and overseas scientists, with a further 62 participants joining via a Web stream, the workshop focused on (1) sources of polar predictability on sub-seasonal to inter-annual timescales, (2) sea ice prediction, and (3) operational and research efforts. The agenda, abstracts of talks and posters, participant list, and other information are available online at <https://www.arcus.org/sipn/meetings/workshops/may-2016>.
- The interagency Sea Ice Prediction Network held a 1-day workshop on "Data Needs for Sea Ice Forecasting" in conjunction with the American Geophysical Union Fall Meeting in December 2015 in San Francisco, CA. The goal of the workshop was to identify data needs for model initialization and verification, which available data products are useful (and why), what improvements to existing data products would make for better utilizations (e.g., change in formatting), what additional observations are needed, and how limited spatial scale data from ship observations etc. are being used. There were 45 attendees at the workshop.
- A workshop was held adjacent to the Royal Society Sea Ice Meeting in September 2014 to discuss sea ice modeling. It was organized by Alex Jahn, Dirk Notz, and Danny Feltham. Some highlights from the report (according to Cecilia Bitz): Sea ice models in global climate models lack diversity. Many derive from CICE or LIM. Some new physics expected in CMIP6 are mushy-layer physics, melt ponds, and biogeochemistry in sea ice. Variables that should be saved in CMIP6 were

discussed. Variables for process and/or budget-based analyses were emphasized. A subgroup spun off to provide coordinated input to CMIP6 by the end of January. The challenges of using observational data for validation were discussed. Another meeting in 2015 was mentioned. (Jan 15, 2015 - Completed)

- This milestone was created when milestone 3.1.1.a was completed. It will be undertaken with support from SIPN. (Jun 30, 2014 - Completed)

3.1.2 Identify and study sites in Beaufort and Chukchi Seas and the contiguous Arctic Ocean where climate feedbacks are active

- **3.1.2.a (Milestone met) Report of a workshop on sea-ice forecasting; NOAA (Lead), DOD-ONR, DOE, DOI, NASA, NSF, OSTP, SI, USCG; Target Date 2012**

- Completion Statement: The workshop took place on 19-21 September 2011 in Anchorage, AK. It was attended by representatives of multiple Federal agencies and laboratories, academe and the private sector. The workshop report was released in December 2011 and is available at http://www.arctic.noaa.gov/docs/NOAA_Sea_Ice_Forecasting_Workshop_Summary.pdf. Day 1 of the workshop was devoted to reviewing the current forecast capabilities at three temporal scales: scale. On Day 2, break-out groups were formed to discuss four themes: 1) user and stakeholder needs; 2) current state of predictability at each scale; 3) current state of in situ observations and unmet needs; and 4) current state of satellite observations and needed improvements. After review of these four thematic discussions, plenary discussions were held on requirements for observations and model improvements. On the final day, two breakout groups were formed to develop specific recommendations and priorities for improving sea ice forecasting at the weather- and seasonal-scales. A NOAA Sea Ice Forecasting Implementation Plan will be developed that describes specific steps, assigns responsibilities, and estimates a timeline and resources required to address recommendations. (Jul 2, 2014 - Completed)

- **3.1.2.b (Milestone met) Report of a workshop on the future of Arctic sea-ice research and forecasting, National Academy Polar Research Board; NASA (Lead); Target Date 2012**

- Completion Statement: The National Academy Study was released in December 2012. Jackie Richter-Menge reported on the Study to the SICT in February 2013. (See meeting notes). (See PowerPoint presentation). The report is available at: http://www.nap.edu/catalog.php?record_id=13515. Large reductions in the extent and thickness of Arctic sea ice caused by a warming climate are expected to continue into the coming years, creating widespread environmental and economic changes in the region and globally. Although forecasts and models of Arctic sea ice have steadily improved, a limited understanding of the coupled and complex interactions between Arctic sea ice, oceans, and the atmosphere is hampering accurate predictions, even as the demand for them has increased. For example, seasonal outlooks from 21 research groups all underestimated the drop in the

extent of summer sea ice that was measured in September 2012. Establishing sustained communication between the user, modeling, and observation communities could help reveal gaps in understanding, help balance the needs and expectations of different stakeholders, and ensure that resources are allocated to address the most pressing sea ice data needs. (Jul 2, 2014 - Completed)

- **3.1.2.c (Deactivated) Apply sea ice research and forecasting results to oil spill response planning; USCG (Lead); Target Date 2015**

- Deactivation Statement: This milestone has been de-activated. IARPC avoids duplication of effort with other interagency groups that have Arctic responsibilities. In the case of sea ice and oil spills, the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR) has 23 priorities that are specific to the Arctic and/or extreme environments. In October 2015, ICCOPR briefed the IARPC Staff on those priorities, which are available for download at <http://www.iarpcollaborations.org/members/documents/3333>. Information about ICCOPR is available at <http://www.uscg.mil/iccopr/>. (Oct 6, 2016 - Completed)
- The SICT and the CBCT are working together to form a small team to address oil spill milestones and to respond the IARPC Principals' to look into the need for coordination around oil spill in ice infested waters research. More work on this activity will be reported as the oil spill group forms. (Aug 27, 2015 - Completed)
- During the January meeting of the SICT Jackie noted that there is a CRREL project looking at detection of oil in ice. It is a joint industry project. For more information, see the Arctic Response Technology Joint Industry Project and the Oil Spill Detection and Mapping in Low Visibility and Ice. (Jan 16, 2015 - Completed)
- During the January 2015 meeting of the SICT, Martin identified Lori Medley from BSEE who gave a report at the North COM Arctic S&T workshop in May 2014 at CRREL regarding work on oil under ice. (Jan 15, 2015 - Completed)
- The U.S. Department of the Interior's Bureau of Safety and Environmental Enforcement (BSEE) solicits White Papers of not more than five (5) pages in length in specific areas of interest to BSEE's Oil Spill Response Research (OSRR) Program on Oil Spill Response Operations on the U.S. Outer Continental Shelf (OCS). FBO link: https://www.fbo.gov/index?s=opportunity&mode=form&id=ce0bc9baa12db301197957defd01124f&tab=core&_cvview=0. (Jan 14, 2015 - Completed)
- The Bureau of Ocean Energy Management (BOEM) funded the University of Alaska Fairbanks to perform targeted dye release experiments in the northeast Chukchi Sea, beginning in 2014, to examine applications for mapping spilled oil in Arctic waters. These experiments are designed to test available observational technology, their capability to map a dye plume in time and space, and provide real-time data to response agencies. (Oct 27, 2014 - Completed)
- An oil spill and clean-up simulation was conducted during the U.S. Coast Guard Arctic Shield exercise in August 2014. (Sep 29, 2014 - Completed)

- Milestone edited and re-scoped July 14, 2014 to better reflect abilities of IARPC agencies. Original language: "Work thorough the Oil Spill Recovery Institute (OSRI) in conjunction with State of Alaska and response organizations to apply research results to oil spill response planning." New language: "Apply sea ice research and forecasting results to oil spill response planning." (Jul 14, 2014 - Completed)
- The National Academies published a report on "Responding to Oil Spills in the U.S. Arctic Marine Environment." <http://dels.nas.edu/Report/Responding-Spills/18625>. (Released April 23, 2014) (Jul 2, 2014 - Completed)
- **3.1.2.d (Milestone met) Investigate the Marginal Ice Zone processes in summer in the Arctic Ocean; DOD-ONR, NASA, NOAA; Target Date 2017**
 - Completion Statement. With the formal conclusion of the ONR 5-year Marginal Ice Zone Department Research Initiative on 30 September 2016, this milestone is completed. The results of the study will be published in a special issue of the online journal "Elementa" in 2017, and in other peer-reviewed journals. These publications will be reported under the relevant performance elements for Arctic Research Plan 2017-2021. (Oct 6, 2016 - Completed)
 - The ONR "Marginal Ice Zone science team met on 22-23 September 2016 in Crystal City, VA. The purpose of the meeting was to report progress on data analysis and preparation of papers for publication. ()
 - The ONR "Marginal Ice Zone" and "Arctic Sea State and Boundary Layer Physics" science teams organized a 1-day symposium on 21 September 2016 in Crystal City, VA. The purpose of the symposium was to share the results of these multiyear investigations, which each involved significant fieldwork, remote sensing and numerical modelling components. The following topics were discussed: GENERAL OVERVIEW Motivation, regional context, ice trends—Craig Lee Seasonal cycle and change: Simulations—Jinlun Zhang Seasonal cycle and change: Observations—Mike Steele SPRING Surface melt, ice-albedo feedback—Jeremy Wilkinson Basal melt—Ted Maksym Upper ocean processes—Tim Stanton Wave penetration—Martin Doble SUMMER Internal Waves and Mixing—Sylvia Cole Ice Edge Effects—Luc Rainville Waves and Fetch—Jim Thomson AUTUMN Atmospheric influence, surface heat budget—Ola Persson Ocean influence (NSTM)—Sharon Stammerjohn Wave influence, pancake ice—Steve Ackley EXPERIMENTAL DESIGN AND OBSERVATIONS Autonomy—Craig Lee Remote sensing—Ben Holt Forecasting—Erick Rogers SYNTHESIS Wave effects—Hayley Shen Regional simulations—Wieslaw Maslowski Regional simulations—Wieslaw Maslowski Ocean influence (NSTM)—Sharon Stammerjohn Wave influence, pancake ice—Steve Ackley EXPERIMENTAL DESIGN AND OBSERVATIONS Autonomy—Craig Lee Remote sensing—Ben Holt Forecasting—Erick Rogers SYNTHESIS.
 - The ONR Marginal Ice Zone & Sea State projects are organizing a "Marginal Ice Zone Processes" session (HE009) at the AGU Ocean Sciences meeting in February 2016 in New Orleans. Additional information is available online.

- Three members of the ONR marginal ice zone project team visited the Korea Polar Research Institute (KOPRI) on 18 May 2015 to share initial results of their collaboration aboard the R/V Araon in August 2014, discuss preparation of papers for publication, and plan for continued collaboration, particularly aboard the R/V Araon in August 2015. There was a lengthy discussion of the phytoplankton signatures captured in the Seaglider sections in 2014, especially the indications of a secondary bloom during freeze-up.
- The ONR marginal ice zone (MIZ) project team met on 18-19 June 2015 at the Applied Physics Laboratory, University of Washington. The meeting provided the opportunity to assess progress on data analysis and data availability since the field experiment in 2014, discuss data integration and synthesis for a comprehensive understanding of the atmosphere-ice-ocean-waves processes in the MIZ, and discuss preparation of papers for publication. It was subsequently agreed that the online journal "Elementa" will be the venue for a special issue on the ONR MIZ investigation.
- Craig Lee provided an overview of the Marginal Ice Zone experiment at the January 2015 meeting of the SICT. His presentation and the MIZ Program Science and Experiment Plan are available at: <http://www.iarpcollaborations.org/members/events/1406>. (Jan 14, 2015 - Completed)
- During the January 2015 meeting of the SICT, Craig and Martin explained about MIZ Experiment data. The marginal ice zone DRI data policy calls for holding the data within the team for the duration of the program (FY12-FY16), primarily in the interests of graduate student and post-doc research. But, that is not to say that the data aren't available to anyone outside the team. If someone sees a need for the data, they can contact Craig and describe how they want to use the data and that would be discussed with the science steering committee and the data holder. The ITP data are publicly available now. Ultimately, all data will be packaged in a usable form for broader use. Martin noted that the DRI data policy is not very different from NSF data policy. (Jan 14, 2015 - Completed)
- The ONR Marginal Ice Zone DRI team met on 16 December 2014 in San Francisco. The meeting focused on (1) PI reports on early results of the main field experiment between March and October 2014, and (2) identifying topics for collaborative data analysis and synthesis, and publication. The meeting coincided with the American Geophysical Union Fall Meeting, where DRI team members also convened a session on Marginal Ice Zone. (Jan 14, 2015 - Completed)
- The ONR marginal ice zone project concluded in late September/early October 2014 with a 1-week cruise aboard the Norseman II to recover Seagliders, Wavegliders and wave floats, and to make CTD casts and obtain water samples for instrument calibration. (Oct 27, 2014 - Completed)
- During the ONR marginal ice zone experiment, the NOAA National Weather Service in Alaska provided weekly weather outlooks that contributed to safe and effective field operations, and targeted remote sensing image collection. (Oct 27, 2014 - Completed)

- Between April and September 2014 the intelligence community obtained high resolution, visible band imagery in support of the ONR marginal ice zone and SIZRS (Seasonal Ice Reconnaissance Surveys) projects. The declassified images are openly available at the online USGS Global Fiducials Library: http://gfl.usgs.gov/gallery_main.shtml?current=3. (Oct 27, 2014 - Completed)
- The first peer review of Arctic research funded by the ONR Arctic and Global Prediction Program occurred during 28-30 October, 2014. Over 50 different investigators described the results of their research to a 3-person, independent review panel. The review included reports by scientists participating in the Marginal Ice Zone Department Research Initiative (DRI), the Sea State and Boundary Layer Physics DRI, and the Seasonal Ice Zone Reconnaissance Surveys (SIZRS) project. ONR peer reviews enable program officers and senior management to evaluate the quality, merit, performance and relevance of research funded by the agency's many programs. (Oct 27, 2014 - Completed)
- Between 24 July and 2 August 2014, ONR-funded scientists completed a brief field campaign as part of the larger marginal ice zone research project. Using the R/V Ukpik sailing out of Prudhoe Bay, the team deployed 4 Seagliders, 2 Wavegliders and 1 moored Waverider buoy, and did a number of CTD casts and took water samples for biogeochemical analysis. Each Seaglider is equipped with a CTD and microstructure sensor and bio-optical sensors. Each Waveglider is equipped with an automatic weather station and an undersea acoustic source. The latter supplement 8 sources that were deployed in March 2014 in the eastern Beaufort Sea to provide acoustic communication and navigation services for the Seagliders and 8 polar profiling floats (Arctic Argo floats), also deployed in March 2014. (Aug 25, 2014 - Completed)
- During 9-12 August 2014, an ONR team aboard the R/V Araon of the Korea Polar Research Institute (KOPRI) successfully deployed the fifth, and final, cluster of instruments for the marginal ice zone project array. Deployed in the vicinity of 77.3°N, 146°W, the fifth cluster comprised the following: 10 wave buoys; 5 ice mass balance buoys; 1 ice-tethered profiler; 1 Arctic Ocean flux buoy; 1 automatic weather station. In addition to the drifting instrument deployment, there was a successful 5-day deployment of the Naval Postgraduate School entrainment frame to investigate small-scale boundary layer flow and turbulent fluxes to the underside of the ice. (Aug 25, 2014 - Completed)
- Between 24 July and 2 August 2014, ONR-funded scientists completed a brief field campaign as part of the larger marginal ice zone research project. Using the R/V Ukpik sailing out of Prudhoe Bay, the team deployed 4 Seagliders, 2 Wavegliders and 1 moored Waverider buoy, and did a number of CTD casts and took water samples for biogeochemical analysis. Each Seaglider is equipped with a CTD and microstructure sensor and bio-optical sensors. Each Waveglider is equipped with an automatic weather station and an underseas acoustic source. The latter supplement 8 sources that were deployed in March 2014 in the eastern Beaufort Sea to provide acoustic communication and navigation services for the Seagliders and 8 polar profiling floats (Arctic Argo floats), also deployed in March 2014. (Aug 2, 2014 - Completed)

- At the June 2014 meeting, the team agreed to combine milestones 3.1.1.g, 3.1.2.d and 3.12.e into a single re-scoped milestone. The due date was extended to 2017 to allow time for field campaigns to be completed and for data analysis and synthesis to begin. (Jul 2, 2014 - Completed)
- May 2014: The ONR Marginal Ice Zone Departmental Research Initiative entered a crucial phase in March 2014 when the main field experiment began. Working out of Sachs Harbour, Nunavut, Canada, and two camps on the sea ice, a small team deployed an array of instruments and platforms on, in and under the pack ice of the eastern Beaufort Sea. The array included: sea ice mass balance buoys; wave buoys; ocean flux buoys; weather stations; ice-tethered profilers; polar profiling floats; and an acoustic communication and navigation system. The ONR ice camps also supported a small team of NASA Operation IceBridge and European Space Agency CryoVEx scientists. They were making a series of snow and ice measurements as aircraft flew overhead measuring along the same snow and ice transect with radars and LIDARs. (Jun 30, 2014 - Completed)
- **3.1.2.e (Milestone met) Investigate the marginal ice zone: Marginal Ice Zone Observations and Processes Experiment (MIZOPEX); NASA (Lead), USARC; Target Date 2013**
 - Completion Statement: During the June 2014 meeting, Tom Wagner confirmed that the MIZOPEX experiment is completed. Here are links to the project web site and to the main project report: <http://ccar.colorado.edu/mizopex/> http://ccar.colorado.edu/mizopex/reports/NNX11AN57G_MIZOPEX_annual_report_Y2_v6.pdf. This milestone is combined with others on the marginal ice zone. For more information, see 3.1.2.d. (Sep 20, 2016 - Completed)
 - Jim Maslanik and Bill Emery provided an overview of the MIZOPEX project and use of UASs in the experiment to the team during the October 27, 2014 meeting. (Oct 27, 2014 - Completed)
 - Here are links to the project web site and to the main project report: <http://ccar.colorado.edu/mizopex/>; http://ccar.colorado.edu/mizopex/reports/NNX11AN57G_MIZOPEX_annual_report_Y2_v6.pdf. (Oct 22, 2014 - Completed)
- **3.1.2.f (Deactivated) Develop and test large-class, heavy payload UAS (unpiloted aerial systems) for sea ice characterization; NASA (Lead), NOAA; Target Date 2013**
 - Deactivation Statement: During the June 2014 meeting it was agreed to deactivate this milestone. The mission became prohibitively expensive and the UASs couldn't be flown at the appropriate altitude. The team may add a new milestone to reflect a partnership between NASA and NOAA focusing on a Global Hawk mission with a meteorological payload for the weather service. (Jul 2, 2014 - Completed)

- **3.1.2.g (Milestone met) Investigate sea-state and boundary layer physics in the emerging Arctic Ocean; DOD-ONR; Target Date 2017**

- Completion Statement: The ONR "Arctic Sea State and Boundary Layer Physics" science team met on 19-20 September 2016 in Crystal City, VA. The primary purpose of the meeting was to report progress on data analysis since early November 2015 when the project cruise aboard the R/V Sikuliaq in the Chukchi and Beaufort seas ended. The main topics for discussion were: Sea Ice; Wave-Ice Interaction; Ocean-Atmosphere Interaction; Remote Sensing and Underway Data Processing, Products and Availability. Results of the study will be published in a special issue of the Journal of Geophysical Research - Oceans in 2018.
- The ONR "Marginal Ice Zone" and "Arctic Sea state and Boundary Layer Physics" science teams organized a 1-day symposium on 21 September 2016 in Crystal City, VA. The purpose of the symposium was to share the results of these multiyear investigations, which each involved significant fieldwork, remote sensing and numerical modelling components. The following topics were discussed: GENERAL OVERVIEW Motivation, regional context, ice trends—Craig Lee Seasonal cycle and change: Simulations—Jinlun Zhang Seasonal cycle and change: Observations—Mike Steele SPRING Surface melt, ice-albedo feedback—Jeremy Wilkinson Basal melt—Ted Maksym Upper ocean processes—Tim Stanton Wave penetration—Martin Doble SUMMER Internal Waves and Mixing—Sylvia Cole Ice Edge Effects—Luc Rainville Waves and Fetch—Jim Thomson AUTUMN Atmospheric influence, surface heat budget—Ola Persson Ocean influence (NSTM)—Sharon Stammerjohn Wave influence, pancake ice—Steve Ackley EXPERIMENTAL DESIGN AND OBSERVATIONS Autonomy—Craig Lee Remote sensing—Ben Holt Forecasting—Erick Rogers SYNTHESIS Wave effects—Hayley Shen Regional simulations—Wieslaw Maslowski Regional simulations—Wieslaw Maslowski Ocean influence (NSTM)—Sharon Stammerjohn Wave influence, pancake ice—Steve Ackley EXPERIMENTAL DESIGN AND OBSERVATIONS Autonomy—Craig Lee Remote sensing—Ben Holt Forecasting—Erick Rogers SYNTHESIS Wave effects—Hayley Shen Regional simulations—Wieslaw Maslowski ()
- On 9 November 2015 the R/V Sikuliaq docked in Dutch Harbor, Alaska, 41 days after leaving Nome, Alaska, in support of the Office of Naval Research “Sea State and Boundary Layer Physics” project main field experiment. Between 2 October and 3 November, the 25-person science team worked round the clock to observe the autumn ice advance and the interactions with winds and waves in the northeastern Chukchi Sea and western Beaufort Sea. Those interactions were exemplified by extensive pancake ice fields waxing and waning in seas with waves as much as 5 m high and air temperatures as low as -21°C. To aid ship operations and science planning, weather, waves and ice forecasts were generated aboard the ship as well as being received from shore. Spaceborne synthetic aperture radar (SAR) images (COSMO-SkyMed, RADARSAT -2, TerraSAR-X) were also used to support ship operations and science planning. And, the Naval Research Laboratory and NASA conducted airborne SAR overflights by Twin Otter and UAV, respectively. But, the bulk of the team’s effort went into a

comprehensive program of atmosphere, ice, ocean and surface waves measurements from the ship and on the ice. By the numbers, the team accomplished the following: 32 days (559 hours) of visual ice observations 228423 ice camera images 467 ice samples 4292 casts of the underway CTD (Conductivity, Temperature, Depth) 478 hours of flux measurements from the meteorological mast 35 days of wave and ice measurements from the ship's Rutter radar (2,325,000 images) 153 weather balloon (radiosonde) launches 12 ice stations 7 wave experiments A full description of the measurement program, and some examples of the weather/ice/wave conditions, is available online in the illustrated cruise report , which is also attached to this Update. The Sea State project Web site is also a source of useful information about the cruise and the project as a whole. The 5-year "Sea State and Boundary Layer Physics" project has now entered the data analysis and synthesis, and writing and publication phase (years 4 and 5). On 9 November 2015 the R/V Sikuliaq docked in Dutch Harbor, Alaska, 41 days after leaving Nome, Alaska, in support of the Office of Naval Research "Sea State and Boundary Layer Physics" project main field experiment. Between 2 October and 3 November, the 25-person science team worked around the clock to observe the autumn ice advance and the interactions with winds and waves in the northeastern Chukchi Sea and western Beaufort Sea. Those interactions were exemplified by extensive pancake ice fields waxing and waning in seas with waves as much as 5 m high and air temperatures as low as -21°C. To aid ship operations and science planning, weather, waves and ice forecasts were generated aboard the ship as well as being received from shore. Spaceborne synthetic aperture radar (SAR) images (COSMO-SkyMed, RADARSAT -2, TerraSAR-X) were also used to support ship operations and science planning. And, the Naval Research Laboratory and NASA conducted airborne SAR overflights by Twin Otter and UAV, respectively. But, the bulk of the team's effort went into a comprehensive program of atmosphere, ice, ocean and surface waves measurements from the ship and on the ice. By the numbers, the team accomplished the following: 32 days (559 hours) of visual ice observations 228423 ice camera images 467 ice samples 4292 casts of the underway CTD (Conductivity, Temperature, Depth) 478 hours of flux measurements from the meteorological mast 35 days of wave and ice measurements from the ship's Rutter radar (2,325,000 images) 153 weather balloon (radiosonde) launches 12 ice stations 7 wave experiments A full description of the measurement program, and some examples of the weather/ice/wave conditions, is available online in the illustrated cruise report . The Sea State project Web site is also a source of useful information about the cruise and the project as a whole. The 5-year "Sea State and Boundary Layer Physics" project has now entered the data analysis and synthesis, and writing and publication phase (years 4 and 5).

- The ONR Marginal Ice Zone & Sea State projects are organizing a "Marginal Ice Zone Processes" session (HE009) at the AGU Ocean Sciences meeting in February 2016 in New Orleans. Additional information is available online.
- The ONR Sea State project team met on 21-22 May 2015 at the Applied Physics Laboratory, University of Washington. The primary purpose of the meeting was

to finalize the cruise plan, and ensure that all participants are ready, for the field experiment to be conducted aboard the R/V Sikuliaq in October 2015 in the Chukchi and Beaufort seas. The meeting was also an opportunity for team members to provide updates on the status of the research to date, and discuss the preparation of a team paper on the climatology of the atmosphere, ocean surface waves, ice and ocean in the Chukchi and Beaufort seas. (Oct 6, 2015 - Completed)

- The following publications describe work done under the auspices of the ONR "Sea State and Boundary Layer Physics " Department Research Initiative. J. Thomson & W. E. Rogers. 2014. Swell and sea in the emerging Arctic Ocean. *Geophysical Research Letters*, 41, 3136–3140, doi :10.1002/2014GL059983. Abstract: Ocean surface waves (sea and swell) are generated by winds blowing over a distance (fetch) for a duration of time. In the Arctic Ocean, fetch varies seasonally from essentially zero in winter to hundreds of kilometers in recent summers. Using in situ observations of waves in the central Beaufort Sea, combined with a numerical wave model and satellite sea ice observations, we show that wave energy scales with fetch throughout the seasonal ice cycle. Furthermore, we show that the increased open water of 2012 allowed waves to develop beyond pure wind seas and evolve into swells. The swells remain tied to the available fetch, however, because fetch is a proxy for the basin size in which the wave evolution occurs. Thus, both sea and swell depend on the open water fetch in the Arctic, because the swell is regionally driven. This suggests that further reductions in seasonal ice cover in the future will result in larger waves, which in turn provide a mechanism to break up sea ice and accelerate ice retreat. V. C. Khon & 6 others. 2014. Wave heights in the 21st century Arctic Ocean simulated with a regional climate model. *Geophysical Research Letters*, 41, 2956–2961, doi:10.1002/2014GL059847. Abstract: While wave heights globally have been growing over recent decades, observations of their regional trends vary. Simulations of future wave climate can be achieved by coupling wave and climate models. At present, wave heights and their future trends in the Arctic Ocean remain unknown. We use the third-generation wave forecast model WAVEWATCH-III forced by winds and sea ice concentration produced within the regional model HIRHAM, under the anthropogenic scenario SRES-A1B. We find that significant wave height and its extremes will increase over different inner Arctic areas due to reduction of sea ice cover and regional wind intensification in the 21st century. The opposite tendency, with a slight reduction in wave height appears for the Atlantic sector and the Barents Sea. Our results demonstrate the complex wave response in the Arctic Ocean to a combined effect of wind and sea ice forcings in a climate-change scenario during the 21st century. X. Zhao & H. H. Shen. 2015. Ocean wave transmission and reflection by viscoelastic ice covers. *Ocean Modelling*, 92, 1-10, doi:10.1016/j.ocemod.2015.05.003. Abstract: Modeling ice covers as viscoelastic continua, Zhao and Shen (2013) applied a two-mode approximate method to determine the transmission and reflection between two different ice covers. This approximate solution considered only two modes of the dispersion relation. In addition, the horizontal boundary conditions were simplified by matching mean

values over the interfaces. In this study, we employ a variational method (Fox and Squire, 1990)) to calculate the wave transmission and reflection from two connecting viscoelastic ice covers of different properties. The variational approach minimizes the overall error function at the interface of two ice covers, hence is more rigorous than the previous approximate method that minimized the difference between mean values at the interface. The effect of additional travelling and evanescent modes are also investigated. We compare results from different matching methods, as well as the effects of including additional modes. From this study, we find that additional modes do not always improve the results for our model. For all cases tested, two modes appear to be sufficient. These two modes represent the open-water-like and the elastic-pressure wave-like behavior. The two-mode approximate method and the variational method have similar results except at very short wave periods. L. G. Bennetts & five others. 2015. An idealised experimental model of ocean surface wave transmission by an ice floe . Ocean Modelling, in press. Abstract: An experimental model of transmission of ocean waves by an ice floe is presented. Thin plastic plates with different material properties and thicknesses are used to model the floe. Regular incident waves with different periods and steepnesses are used, ranging from gently-sloping to storm-like conditions. A wave gauge is used to measure the water surface elevation in the lee of the floe. The depth of wave overwash on the floe is measured by a gauge in the centre of the floe's upper surface. Results show transmitted waves are regular for gently-sloping incident waves but irregular for storm-like incident waves. The proportion of the incident wave transmitted is shown to decrease as incident wave steepness increases, and to be at its minimum for an incident wavelength equal to the floe length. Further, a trend is noted for transmission to decrease as the mean wave height in the overwash region increases. (Oct 6, 2015 - Completed)

- In October 2014 NOAA and ONR used a NOAA P-3 aircraft to make meteorological measurements over the open and ice-covered Beaufort and Chukchi seas to determine heat flow from ocean to atmosphere during freeze-up and the impact on atmospheric temperature and pressure and far-field effects at mid-latitudes. (Oct 27, 2014 - Completed)
- As part of the NASA ARISE (Arctic Radiation - Icebridge Sea&Ice Experiment) project a C-130 aircraft deployed in late-August through September to measure sea ice properties, radiative fluxes and atmospheric variables, particularly clouds, near the end of the Arctic sea ice melt season. Further information is available at <https://espo.nasa.gov/home/arise/content/ARISE> & http://www.nasa.gov/mission_pages/icebridge/news/arise14/ . See also milestone 3.1.2.j (Sep 29, 2014 - Completed)
- Between 24 July and 2 August 2014, ONR-funded scientists completed a brief field campaign as part of the larger marginal ice zone research project. Using the R/V Ukpik sailing out of Prudhoe Bay, the team deployed 4 Seagliders, 2 Wavegliders and 1 moored Waverider buoy, and did a number of CTD casts and took water samples for biogeochemical analysis. Each Seaglider is equipped with a CTD and microstructure sensor and bio-optical sensors. Each Waveglider is

equipped with an automatic weather station and an underseas acoustic source. The latter supplement 8 sources that were deployed in March 2014 in the eastern Beaufort Sea to provide acoustic communication and navigation services for the Seagliders and 8 polar profiling floats (Arctic Argo floats), also deployed in March 2014. (Aug 2, 2014 - Completed)

- The ONR sea state research initiative Web site is at http://www.apl.washington.edu/project/project.php?id=arctic_sea_state. The Science Plan was completed in September 2013 and is available at http://www.apl.washington.edu/research/downloads/publications/apluw_tr1306.pdf. (Jul 2, 2014 - Completed)

- **3.1.2.h (In progress) Improve integration and assimilation of remote sensing and buoy/mooring data into sea ice forecast models, and the use of those data for evaluating forecast skill.; NOAA (Lead), DOD-ONR, USCG; Target Date 2017**

- Continuation Statement: Work on this milestone will continue under the implementation of Arctic Research Plan 2017-2021 as this topic is the subject of continuing research, and it relates to a number of performance elements in the new plan.
- The Naval Research Laboratory, in collaboration with the National Snow and Ice Data Center and the NASA Goddard Space Flight Center, have developed a technique to implement the AMSR2 high resolution ice concentration product and the National Ice Center's Interactive Multisensor Snow and Ice Mapping System (IMS) ice mask into the Navy's ice forecasting systems. Assimilating the blended high resolution ice concentration product has shown significant improvements in the ice edge location forecast by the operational Arctic Cap Nowcast/Forecast System (ACNFS) and pre-operational Global Ocean Forecast System (GOFS 3.1). The overall ice edge error in the Pan-Arctic region was reduced by 36% for a year-long time period, while a decrease of 56% occurred during the summer melt season, compared to results using ice concentration derived from the older and lower resolution SSMI and SSMIS satellite sensors. The results of this work are published in "The Cryosphere" (Posey et al., doi:10.5194/tcd-9-2339-2015, <http://www.the-cryosphere-discuss.net/9/2339/2015/tcd-9-2339-2015.html>). (Oct 6, 2015 - Completed)
- With ONR support, the Naval Research Laboratory and NASA Goddard Space Flight Center have developed an algorithm to retrieve sea ice concentration from MODIS (Moderate Resolution Imaging Spectroradiometer) and implemented AMSR2 (Advanced Microwave Scanning Radiometer 2) processing to combine with the MODIS product. It is anticipated that preparation of a full-year (2008) of the blended MODIS-AMSR2 product will be completed by mid-August 2015 and then implemented in the Navy Arctic Cap Nowcast Forecast System to evaluate the impact on improved ice edge forecasting. The results should be available in September. Future plans include creating a blended sea ice product from AMSR2 and VIIRS (Visible Infrared Imaging Radiometer Suite), an

operational sensor, as opposed to a research sensor such as MODIS. (Oct 6, 2015 - Completed)

- A press release was occasioned by the publication of a paper by Posey et al. titled Improving Arctic sea ice edge forecasts by assimilating high horizontal resolution sea ice concentration data into the US Navy's ice forecast systems (<http://www.the-cryosphere.net/9/1735/2015/tc-9-1735-2015.html%20>). The press release highlights improvements brought about by blending a product based on National Ice Center analyst interpretation with passive microwave AMSR ice concentration data. The new technique plays a role in supporting the Healy in 2015. (Sep 29, 2015 - Completed)
- Pablo reported that this milestone was advanced in 2014, particularly as it relates to the remote sensing component by working with NRL-Stennis and NSIDC on "assimilation" of NIC daily IMS ice edge analyses into ACFNS. Significant improvement has been shown leading to a recent update of the operational ACFNS code. In some sense, I would say that we are beyond initiation in that regard and are now further engaged with NASA GSFC and NRL on trying to develop additional analyst-assisted improvements to PMW sea ice products for further assimilation into ACFNS. Of course, these analysis-based approaches could be applied to other sea ice forecast modeling efforts if the concept of assimilation of human analyses with difficult to assess errors can be accepted by the modelers. Where we do not have much to report is in on any additional improvement in the application of the in-situ data, at least yet. (Feb 26, 2015 - Completed)
- During the February 2015 meeting the team agreed to the new language which reads: "Improve INTEGRATION AND assimilation of remote sensing and buoy/mooring data into sea ice forecast models, and the use of those data for evaluating forecast skill." See the meeting notes for the detailed discussion. <http://www.iarpccollaborations.org/members/documents/1850>. (Feb 24, 2015 - Completed)
- The Naval Research Laboratory used data from buoys deployed during the ONR marginal ice zone field experiment in 2014 to evaluate the ice drift forecast skill of two U.S. Navy forecast models: 'Arctic Cap Nowcast Forecast System (ACNFS)' and 'Global Ocean Forecast System (GOFS) 3.1'. The GOFS ice drift speed compared better with observed drift speed than ACNFS, and GOFS had a lower 24-hour drift error than ACNFS. The next step is to evaluate the models' 5-7-day drift forecast skill, and compare model ice thickness with ice thickness observed in the marginal ice zone. (Feb 18, 2015 - Completed)
- **3.1.2.i (In progress) Characterize the circulation on the continental shelf areas of the northeast Chukchi and western Beaufort Seas; DOI (Lead), NSF; Target Date 2016**
 - Continuation Statement: This milestone will be carried over to the implementation of Arctic Research Plan 2017-2021. Research on ocean circulation in the Chukchi

and Beaufort seas is the subject of continuing research, and ocean circulation is the subject of a performance element in the new plan. (Oct 7, 2016 - Completed)

- The following publications contribute to this milestone:

(1) Ladd, C., C.W. Mordy, S.A. Salo, and P.J. Stabeno (2016): Winter waterproperties and the Chukchi polynya . J.Geophys. Res., 121. Available at: <http://onlinelibrary.wiley.com/doi/10.1002/2016JC011918/full>.

(2) Martini, K.I., P.J. Stabeno, C. Ladd, P. Winsor, T.J. Weingartner, C.W.Mordy, and L.B. Eisner (2016): Dependence of subsurface chlorophyll on seasonal water masses in the Chukchi Sea . J. Geophys. Res., 121 (3), 1755–1770. Available at: <http://onlinelibrary.wiley.com/doi/10.1002/2015JC011359/abstract>.

(3) Wood, K.R., N.A. Bond, J.E.Overland, S.A. Salo, P. Stabeno, and J. Whitefield (2015): A decade of environmental change in the Pacific Arctic region . Prog. Oceanogr. , 136 , 12–31. Available at: <http://www.sciencedirect.com/science/article/pii/S0079661115001020>.

(4) Overland, J.E., J. Wang, R.S. Pickart, and M. Wang (2014): Recent and future changes in the meteorology of the Pacific Arctic. In The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment, J.M. Grebmeier and W. Maslowski(eds.), Springer Science+Business Media, Dordrecht, 17–30. Available at: <http://www.springer.com/gp/book/9789401788625>.

(5) Danielson, S.L., T.J. Weingartner, K.S. Hedstrom, K. Aagaard, R.Woodgate, E. Curchitser, and P. Stabeno (2014): Coupled wind-forced controls of the Bering-Chukchi shelf circulation and the Bering Strait throughflow: Ekman transport, continental shelf waves, and variations of the Pacific-Arctic sea surface height gradient . Prog. Oceanogr., 125, 40–61. Available at: <http://www.sciencedirect.com/science/article/pii/S0079661114000548>.

(6) Wang, J., H. Eicken, Y. Yu, X.Bai, J. Zhang, H. Hu, D.-R. Wang, M. Ikeda, K. Mizobata, and J.E. Overland(2014): Abrupt climate changes and emerging ice-ocean processes in the Pacific Arctic region and the Bering Sea . In The Pacific Arctic Region:Ecosystem Status and Trends in a Rapidly Changing Environment , J.M.Grebmeier and W. Maslowski (eds.), Springer Science+Business Media, Dordrecht, 65–99. Available at: <http://www.springer.com/gp/book/9789401788625>.

(7) Wood, K.R., J.E. Overland,S.A. Salo, N.A. Bond, W.J. Williams, and X. Dong (2013): Is there a "new normal" climate in the Beaufort Sea? Polar Res., 32, 19552. Available at: <http://www.polarresearch.net/index.php/polar/article/view/19552>.

(Sep 28, 2016 - Completed)

- Robert Pickart continues analysis of CTD collected in the Chukchi Sea with the objective of characterizing the two mixed layers (surface and bottom) as well as the barrier layer between them, and determining how poised the water column is to convective overturning that reaches the bottom of the shelf. Robert Pickart

continues his analyses of data from the DBO program and recently published an analysis of data from summer 2010 (Itoh, M., R.S. Pickart, T. Kikuchi, Y. Fukamachi, K. I. Ohshima, D. Simizu, K. R. Arrigo, S. Vagle, J. He, C. Ashjian, J. T. Mathis, S. Nishino, and C. Nobre (2015). Water properties, heat and volume fluxes of Pacific water in Barrow Canyon during summer 2010. Deep-Sea Research I). Robert Pickart has continued maintain a slope mooring in the Beaufort Sea. It has been determined that the seasonality of the winds along the Beaufort slope has been changing. The winds during storm season are now stronger earlier in the fall (October), and, surprisingly, the monthly-mean winds are strongest during the summer (June). This is consistent with the calculated wind-driven (westward) transport of the current, which is sharply peaked in June. Furthermore, the strongest measured upwelling now occurs during this month. Recently, he has received funding to maintain this mooring for an additional three years, thus extending the time series that has been ongoing since 2002, albeit with two one-year gaps. (May 3, 2016 - Completed)

- Rebecca Woodgate maintains three oceanographic moorings monitoring the inflow of Pacific water into the Arctic Ocean (via Bering Strait). The northern most mooring is located on the western Chukchi Sea shelf. The moorings measure water temperature, salinity, and velocity and sea-ice thickness and velocity. The data add to a long-term data set that dates back to 1990 (with gaps). She recently published an analysis of these data (Woodgate, R.A., K.M. Stafford, and F.G. Prahl. 2015. A synthesis of year-round interdisciplinary mooring measurements in the Bering Strait (1990–2014) and the RUSALCA years (2004–2011). *Oceanography* 28(3):46–67). Her work shows a 70% increase in the volume flux of water between 2001 and 2014. This increase cannot be explained from local or remotely sensed data and appears to be due to larger-scale, far-field forcing changes. Long-term moorings are the only means to quantify these changes. (May 3, 2016 - Completed)
- Carolyn Ruppel at USGS' Gas Hydrates Project contributed a list of work on methane from her group at <http://www.iarppcollaborations.org/members/people/2618>. However, it represents work done before the implementation of the Arctic Research plan began. It includes: 1) First regional map of subsea permafrost extent on the US Arctic margin (Barrow to US-Canada border)--published 2012; 2) 6000 km of continuous sea-air flux data for methane and CO₂ in the Chukchi and Beaufort Seas, including the inner shelf, outer shelf and deep water, from the Bering Strait to Amundsen Gulf. We also have independent sea-air flux measurements in the atmospheric marine boundary layer during these cruises and have coastal zone measurements that reveal the likely source of higher methane emissions confined to this zone; 3) Water column (aerobic) methane oxidation rate measurements (Mox) from shelf to upper continental slope (approximately offshore Flaxman Island), the first ever obtained in the Western Arctic Ocean. These data critically constrain the sink for methane in the Arctic Ocean; 4) Water column methane measurements using CTDs on Beaufort shelf and upper continental slope; 5) Modern high-resolution seismic imaging (approx. 500 km) on Beaufort shelf and upper continental slope to image distribution of gas/ gas hydrate, study slope

cryogenic features, and identify Holocene sediment packages; 6) Chirp high-frequency imaging of the inner Beaufort shelf, identifying nearly ubiquitous shallow gas, cryogenic features, relationship of near surface sediment packages; 7) Leadership of an Integrated Ocean Drilling Proposal (~18 proponents) to drill from the nearshore across the Beaufort shelf and to the upper continental slope to study permafrost and methane dynamics related to climate change (particularly the inundation of the shelf over the past 15,000 years); 8) Published reassessment (first in 30 years) of the distribution and amount of gas hydrate at high northern latitudes (onshore and just offshore) in areas associated with continuous permafrost; 9) Onshore studies of methane dynamics since the LGM using records from lake sediments (e.g., Lake Teshekpuk). Also have geophysical data imaging the shallow sub-lakebed of the northern part of Lake Teshekpuk, some data on seawater incursion into thermokarsts just NE of Teshekpuk, and a complete geophysical/geochemical/oxidation rate (with seasonal controls) dataset for a thermokarst lake near Atqasuk that is leaking substantial methane directly to the atmosphere during open water season; 10) Extensive onshore drilling related to gas hydrates and permafrost (most recently in 2011/2012). We anticipate new drilling in the Prudhoe Bay area in cooperation with DOE /State of AK/Japan starting within the next 12 months, to eventually include a long-term test to attempt to produce methane from gas hydrates; 11) Sea-air methane flux measurements over the Svalbard (West Spitsbergen margin) seeps. Ruppel is on the Advisory Committee for the University of Tromso Centre of Excellence related to the study of gas hydrates on this high-latitude margin. (Oct 1, 2015 - Completed)

- Latest updates from the BOEM funded Chukchi & Western Beaufort Circulation Study can be found at: <http://dm.sfos.uaf.edu/chukchi-beaufort/>. New publication: K. Lu, T. Weingartner, S. Danielson, P. Winsor, E. Dobbins, K. Martini, and H. Statscewich (2015), Lateral Mixing across Meltwater Fronts of the Chukchi Shelf, *Geophys. Res. Lett.*, 42, doi:10.1029/2015GL064967. (Sep 25, 2015 - Completed)
- Michael Spall has initiated a study of Shelf-Basin Exchange in the Chukchi Sea. Thus far, a theory for the halocline that balances lateral eddy fluxes with Ekman pumping has been developed and tested against idealized numerical model calculations. The theory considers both adiabatic and weak mixing regimes. It is found that the Arctic is in a regime in which the halocline depth is very sensitive to changes in wind stress, unlike the Southern Ocean which is in a nearly "eddy saturated" regime. The dynamics also introduce a natural time filter that suppresses variability on short time scales which, for current wind forcing, is time scales less than a few years. A paper on the idealized halocline model and theory has been submitted to *Geophysical Research Letters* and is currently under review. A second paper that explores the theory in more detail, to be submitted to the *Journal of Physical Oceanography*, is being written now. (Sep 3, 2015 - Completed)
- During the last field season (2014) scientists from UAF have acquired information about ocean currents in the NE Chukchi and Western Beaufort seas from different platforms: a cruise which included ADCP measurements,

moorings, gliders, high-frequency radars, and drifters. This multi-platform approach will allow scientists to provide a more comprehensive description of the local circulation than previously known. For more info, see:

<http://catalog.northslope.org/catalogs/3000-characterization-of-the-circulation-on-the-cont> (Jul 21, 2015 - Completed)

- 2015 paper: Ying-Chih Fang, T. J. Weingartner, R. A. Potter, P. R. Winsor, and H. Statscewich (2015), Quality Assessment of HF Radar Derived Surface Currents Using Optimal Interpolation, *J. Atmos. Ocean Technol.*, 32:282–296, doi: 10.1175/JTECH-D-14-00109.1. <http://journals.ametsoc.org/doi/abs/10.1175/JTECH-D-14-00109.1>. Abstract: This study investigates the applicability of the optimal interpolation (OI) method proposed by Kim et al. for estimating ocean surface currents from high-frequency radar (HFR) in the northeastern Chukchi Sea, where HFR siting is dictated by power availability rather than optimal locations. Although the OI technique improves data coverage when compared to the conventional unweighted least squares fit (UWLS) method, biased solutions can emerge. The quality of the HFR velocity estimates derived by OI is controlled by three factors: 1) the number of available incorporating radials (AR), 2) the ratio of the incorporating radials from multiple contributing site locations [ratio of overlapping radial velocities (ROR) or radar geometry], and 3) the positive definiteness [condition number (CN)] of the correlation matrix. Operationally, ROR does not require knowledge of the angle covariance matrix used to compute the geometric dilution of precision (GDOP) in the UWLS method and can be computed before site selection to optimize coverage or after data processing to assess data quality when applying the OI method. The Kim et al. method is extended to examine sensitivities to data gaps in the radial distribution and the effects on OI estimates. (Jul 21, 2015 - Completed)
- Kathy Crane reported that NOAA will have a new solicitation in July relevant to this milestone. She will circulate it as soon as it is made available. In early August, Kathy circulated the solicitation and it is available on this site. (Aug 26, 2014 - Completed)
- In May and June 2014, during the NSF-funded USCG Healy cruise HLY 14-01, 230 CTD casts and simultaneous vessel-mounted ADCP measurements were made. This information, together with that obtained during previous Healy cruises, will allow characterization of circulation on the Chukchi Shelf in a way that has not been previously possible and, specifically, to elucidate pathways of Pacific-origin water – see also the previous bullet. During the same cruise, a dataset describing the state and spatial variability of the morphological and optical properties of the melting first year ice was collected. Measurements at ice stations included spectral incident irradiance, albedo and transmittance; snow depth and ice thickness; vertical profiles of ice temperature, salinity, density and crystallography; aerial and under ice photographs; water temperature and salinity just below the ice bottom; and ice permeability. An ice watch characterizing ice conditions (ice type, ice thickness, ice concentration, and pond fraction) was conducted while the ship was underway. Additional information including the

state of melt, sediment content, algae concentration, and fauna present was also collected. (Jul 2, 2014 - Completed)

- During the June 2014 SICT meeting, the team agreed to revise the language of this milestone to more accurately reflect the capabilities of agencies and to extend the due date. (Jun 30, 2014 - Completed)
- By 2010/2011 it was clear to scientists and managers that the ocean circulation to the NE and E of Hanna Shoal was poorly understood. In 2012 BOEM funded the study entitled “Characterization of the Circulation on the Continental Shelf Areas of the Northeast Chukchi and Western Beaufort Seas” which objectives are: • Extend the present Chukchi Sea HF radar, mooring and glider study to include the western Beaufort shelf slope and Barrow Canyon to investigate the spatial and temporal structure of ocean currents within the western Beaufort and northeast Chukchi shelves and the exchange of waters between these areas. • Characterize the flow regimes and surface water exchange among areas of the inner and outer Chukchi shelf and the western Beaufort shelf under varying conditions of wind forcing and sea ice coverage. • Describe the oceanic response, at different levels in the vertical, using all available wind observations, as well as those generated by atmospheric and/or coupled models. This study has nearly completed most of its data gathering phase with some instruments needing recovery during the current summer of 2014 and a few others in the summer of 2015. The data analysis/post-processing tasks of all data acquired is underway (as of 7/1/2014). Additional information about the study is available online at <http://dm.sfos.uaf.edu/chukchi-beaufort/background.php>. (Feb 7, 2014 - Completed)

- **3.1.2.j (In progress) Continue operation IceBridge acquisition of sea-ice surface elevation and supporting data and expand Arctic sea ice observations to constrain melting processes; NASA (Lead); Target Date 2017**

- Continuation Statement: This milestone will carry over to the implementation of Arctic Research Plan 2017-2021, as Operation IceBridge will continue to 2019 and there is a Performance Element that covers this continuing activity.
- NASA completed the first autumn campaign in the Arctic during the week of Oct 19, 2015 and is completing the Antarctic campaign. The Arctic campaign is the first autumn IceBridge campaign. Sea ice flights were limited due to weather, but an underpass of a CryoSat-2 orbit, a high priority, was successfully completed. (Oct 30, 2015 - Completed)
- The NASA IceBridge LVIS POS/AV L1B Corrected Position and Attitude Data now include data for the Alaska 2014 Arctic Radiation – IceBridge Sea&Ice Experiment (ARISE) campaign became available at the end of April 2015. This data set contains georeferencing data from the Applanix 510 and 610 POS AV systems flown with the Land, Vegetation, and Ice Sensor (LVIS) over Greenland, Antarctica, and Alaska. For further information and to access the data from the NASA National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC), see theIceBridge LVIS POS/AV L1B landing page:

<http://nsidc.org/data/ipplv1b>. This description was originally posted at: <https://nsidc.org/the-drift/data-update/update-for-nasa-icebridge-lvis-posav-11b-data/>. Data Set DOI: <http://dx.doi.org/10.5067/2NWNMDSG5EPJ>. (Sep 22, 2015 - Completed)

- Operation IceBridge flew a total of 25,000 km during 10 missions over the Arctic Ocean in March-May 2015. The Quicklook ice freeboard, ice thickness and snow depth data are available at the National Snow and Ice Data Center (http://nsidc.org/data/docs/daac/icebridge/evaluation_products/sea-ice-freeboard-snowdepth-thickness-quicklook-index.html). In addition to the QuicklookIceBridge data, a pan-Arctic sea ice thickness data product from CryoSat-2 and IceBridge data was made available for the month of March 2015 (http://nsidc.org/data/docs/daac/icebridge/evaluation_products/cryosat-2-sea-ice-frebrd-thick-snowdepth-quicklook-index.html). Operation IceBridge also flew coincident missions in conjunction with several in-situ validation sites which measured snow depth, ice freeboard and ice thickness. These and other in situ data are being used to validate the airborne data (Webster et al., 2014), and the larger-scale airborne data are being used to develop and improve algorithms for deriving ice freeboard and ice thickness from Cryosat-2 data (Kurtz et al., 2014; Kwok and Cunningham, 2015) and ICESat-2. IceBridge is scheduled to obtain fly over sea ice at the end of the melt season in September 2015 which will provide further data to constrain the role of melt processes on multiyear sea ice. References: Kurtz, N. T., Galin, N., and Studinger, M., An improved CryoSat-2 sea ice freeboard retrieval algorithm through the use of waveform fitting, *The Cryosphere*, 8, 1217-1237, doi:10.5194/tc-8-1217-2014, 2014. Kwok, R. and G.F. Cunningham, Variability of Arctic sea ice thickness and volume from CryoSat-2, *Phil. Trans. R. Soc. A*, 2015 373 20140157, doi:10.1098/rsta.2014.0157, 2015. Webster, M. A., I. G. Rigor, S. V. Nghiem, N. T. Kurtz, S. L. Farrell, D. K. Perovich, and M. Sturm, Interdecadal changes in snow depth on Arctic sea ice, *J. Geophys. Res. Oceans*, 119, 5395–5406, doi:10.1002/2014JC009985, 2015. (Jul 14, 2015 - Completed)
- New data for the 2015 spring season of NASA's Operation IceBridge campaign in the Arctic are available as of late May 2015 via NSIDC. Two data products are available:
 - 1) High resolution sea ice thickness, snow depth, and ancillary data products from the Operation IceBridge spring campaign:
https://nsidc.org/data/docs/daac/icebridge/evaluation_products/sea-ice-freeboard-snowdepth-thickness-quicklook-index.html.
 - 2) A basin-wide sea ice thickness and snow depth data set utilizing data from CryoSat-2, IceBridge, and MERRA reanalysis:
http://nsidc.org/data/docs/daac/icebridge/evaluation_products/cryosat-2-sea-ice-frebrd-thick-snowdepth-quicklook-index.html. In an effort to increase transparency in the derived basin-wide Arctic sea ice thickness data set, we have also provided full resolution retrievals of surface elevation from CryoSat-2 data which are used to produce the monthly mean 25 km gridded data. Within a few

- months the quick look product will be replaced by the archival version, which will be available at <http://nsidc.org/data/idcsi2.html>. (Jun 30, 2015 - Completed)
- Tom Wagner will write a separate milestone for the ARISE campaign being carried out in the 2014 field season. <http://beta.iarpccollaborations.org/members/documents/568>. It was decided to keep ARISE under this milestone. (Oct 27, 2014 - Completed)
 - William Smith gave a presentation on ARISE during the October 27 meeting of the SICT. The slides are attached. Science papers can be found at <https://espo.nasa.gov/missions/arise/mission-flight-docs>. (Oct 27, 2014 - Completed)
 - Between late August 2014 and early October 2014, the Arctic Radiation – IceBridge Sea and Ice Experiment (ARISE) campaign (<https://espo.nasa.gov/missions/arise>) completed 17 science flights over Alaska with multiple instruments collecting sea ice properties, radiative fluxes, and atmospheric variables (particularly clouds) during the end of the Arctic melt season. High resolution airborne measurements of the shortwave, longwave, microwave, cloud, and aerosol microphysical properties were made coincidentally with satellites. These data will provide new insights into the processes and feedbacks connecting changes in sea ice cover, cloud extent and properties, and the Arctic radiation budget. (Jul 11, 2014 - Completed)
 - Christy Hansen gave a summary of the ARISE mission status during the May 27th 2014 meeting of the SICT: <http://www.iarpccollaborations.org/members/documents/1352>. (May 27, 2014 - Completed)
 - Operation IceBridge flew a total of 30,642 km during 15 missions over the Arctic Ocean in March and April 2014. The Quicklook ice freeboard, ice thickness and snow depth data are available at the National Snow and Ice Data Center (<http://nsidc.org/data/icebridge/index.html>). In March 2014, Operation IceBridge and European Space Agency CryoVEX project scientists used the ONR ice camps (see above) for a snow depth, ice freeboard and ice thickness measurement campaign as aircraft flew overhead measuring the same variables. The in situ data and airborne data are used to develop and improve algorithms for deriving ice freeboard and ice thickness from ICESat-2 and Cryosat-2 data. (Apr 28, 2014 - Completed)
 - Nathan Kurtz (NASA) reported on the 2013 field season and availability of 2012 data and 2013 quicklook data. His presentation is available here: <http://www.iarpccollaborations.org/members/documents/568>. (Sep 30, 2013 - Completed)
- **3.1.2.k (In progress) Investigate Methane Release from the continental shelf, and evaluate trends and significance of methane flux to the atmosphere; NOAA (Lead), DOD-ONR, DOE; Target Date 2017**

- Continuation statement: Milestones 3.1.2.k, 3.1.2.l and 3.1.2.m have not been met, but work will continue under Performance Element 6.2.5 in Arctic Research Plan 2017-2021. This Permafrost Goal performance element reads "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." (Oct 6, 2016 - Completed)
- The first decade of RUSALCA synthesis will present observations of methane sources and sinks in the Chukchi Sea. (Oct 31, 2015 - Target)
- The AMAP Expert Groups on Methane and Black Carbon released a summary for policy makers in April, 2015: <http://www.amap.no/documents/doc/Summary-for-Policy-makers-Arctic-Climate-Issues-2015/1196>. Their full report will be released later this fall. The state of knowledge of the impact of methane released from marine hydrates is part of this report. (Sep 23, 2015 - Completed)
- Ed Dlugokencky reported that the Odin and Carolyn Ruppel's group (USGS) are involved in measurements on a Coast Guard icebreaker, and that strong emissions were reported in the Russian part of the Arctic Ocean by a group from UAF. Last summer there was a Russian-Swedish expedition on the Odin but they weren't able to get to the regions they really wanted to. Overall there haven't been a lot of cruises in areas where they need to be made independent of the UAF group that's done a lot of work. Martin will ask Carolyn Ruppel to report on past activities. (Aug 31, 2015 - Target)
- On 26 June 2015, Dr. Ed Dlugokencky (NOAA ESRL) presented a Webinar (Atmospheric Constraints on Arctic CH₄ [Methane] Emissions) to a joint meeting of the Atmosphere and Sea Ice collaboration teams (<http://www.iarpccollaborations.org/members/events/652>). He described the important role that methane plays in the climate system due to its strong radiative forcing, and discussed the current state of knowledge and understanding (based on measurements and modelling) of emissions, and the sources and sinks of global and Arctic atmospheric methane. In summary, he reported: 1. High-quality observations provide strong constraints on the global CH₄ budget. Total global CH₄ emissions are well-known and the global CH₄ burden and emissions/sink imbalance are well-determined. 2. The increase in methane since 2007 is due to emissions from tropical wetlands and anthropogenic (man-made) emissions. 3. There is no evidence that emissions from Arctic sources have increased and contributed to rising atmospheric methane concentrations in the Arctic. The latter are due to advection from lower latitudes (Jul 26, 2015 - Completed)
- Phil Jones and Renu Joseph will get an update on DOE methane activities. (Jul 28, 2014 - Target)
- A multi-institutional group from the University of Alaska and the University of Georgia has been funded to evaluate present and future methane flux potential from sediments of the East Siberian Sea shelf. Two cruises have been completed. Sediment samples were recovered by drilling to depths of up to 65 m. Sediment temperatures were below 0 C. Methanogenesis and anaerobic methane oxidation

were detected in all samples to the deepest depth sampled (52m) on the first cruise. Rates of methanogenesis exceeded methane oxidation in all samples except for the surficial sediment samples, where methanogenesis rates were below detection but methane oxidation rates were measurable, albeit low. Surprisingly, rates of methanogenesis were of comparable magnitude in sediments and permafrost soil, though the average rates of methanogenesis in sediments exceeded those in permafrost by about a factor of two. During the following year's cruise, 69 samples from 3 cores were collected for measuring $^{13}\text{C}/^{12}\text{C}$ stable isotope ratios in methane. Light $\delta^{13}\text{C}$ values in CH_4 were detected in the samples analyzed so far, indicating methane in these sediments was from slow microbial methanogenic activity, probably via the hydrogenotrophic pathway. Methane in the seawater around this area was significantly heavier, indicating a strong influence of aerobic methane oxidation or different source(s) of CH_4 to the seawater. Key results from this project are 1) much of the methane in the permafrost is of biogenic origin, which means it has accumulated over long (100-1000's of year) time scales and 2) methane oxidation is an efficient sink for methane in sediments with slow methane fluxes but a poor sink for methane under conditions of high methane flux. A second project involving the same participants and University of California-Santa Barbara, was funded to investigate the migration pathway characteristics and identify the controlling factors of CH_4 flux from the seabed, in the water column, and to the atmosphere. Important results include the observation that 1) Methane oxidation in waters along the shelf is low and inefficient except near river deltas; this means that ESAS waters are an inefficient sink for methane and that methane escaping from the seafloor is likely vented to the atmosphere, 2) multiple pathways of oxic methane production exist in the surface waters of the Chucki Sea, with nutrient and light availability as major regulators of oxic methane production, and 3) both methane and carbon dioxide are actively cycled within sea ice and that the relative production of each trace gas is a function of light/dark conditions. Water column methane concentrations during ice-covered conditions were high due to trapping of methane that fluxed from the seafloor beneath sea ice. The lower methane concentrations observed during the fall likely reflect accelerated mixing and loss of methane to the atmosphere due to frequent storm activity. The shallow average depth of this area (< 50 m) facilitates mixing-induced atmospheric transfer of methane during periods of accelerated storm activity. Methane concentration did not exhibit a strong increase with depth at these stations, supporting the idea of a well-mixed and ventilated water column. One member of the University of Georgia team will accompany the Swedish-Russian SWERUS expedition this summer to collect additional samples for analysis, while a team from the University of New Hampshire will use newly developed acoustic water-column imaging techniques to map the distribution (and to help quantify the flux) of methane gas seeps from the seafloor. (Jul 2, 2014 - Completed)

- Phil Jones provided information about a new call on the fossil energy side of DOE on methane. (Jul 2, 2014 - Completed)
- During the June 2014 meeting it was decided to consolidate 3.1.2.k, 3.1.2.l and 3.1.2 m into one milestone on methane. (Jul 2, 2014 - Completed)

- Rick Coffin reported on the Arctic Coastal Carbon Flux Impedance on DoD Optics and Acoustics Program just funded by NSF that includes a study of methane and carbon dioxide ebullition impacts on underwater optical and acoustic sensing capabilities. (May 27, 2013 - Completed)
- **3.1.2.l (Deactivated) Initiate a dialogue with Roshydromet and Russian Academy of Science on a potential investigation of the current rate of methane release from the shallow shelves off northern Siberia; NOAA (Lead), DOD-ONR, DOE, NASA; Target Date 2013**
 - Deactivation Statement: During the June 2014 meeting it was decided to consolidate this milestone with 3.1.2.k. (Jul 2, 2014 - Completed)
 - Report on RUSALCA Methane project available on the RUSALCA Website (www.arctic.noaa.gov/aro/russian-american) (Dec 30, 2013 - Completed)
- **3.1.2.m (Deactivated) Initiate a dialogue with Canadian agencies on collaborative methane research along the Beaufort Sea coast; NOAA (Lead); Target Date 2013**
 - Deactivation Statement: During the June 2014 meeting, the team deactivated this milestone and combined it with milestone 3.2.1.k. (Jul 2, 2014 - Completed)
- **3.1.2.n (In progress) Undertake short-term process studies underpinned by long-term observations; NSF (Lead), DOD-ONR, DOI, NASA, NOAA; Target Date 2017**
 - Continuation Statement: This milestone will be carried over to the implementation of Arctic Research Plan 2017-2021, as sea ice processes are the subject of continuing research, and the new plan includes sea ice process studies in a number of performance elements.
 - Through discussion at various team meetings and on the milestone's page on the website (<http://www.iarpccollaborations.org/members/milestones/35>), the team elected to change the wording of this milestone from "Identify optimal sites for short-term process studies underpinned by long-term observations" to "Undertake short-term process studies underpinned by long-term observations." Federal members of the team approved this change. The target date was extended from 2015 to 2017 to allow for additional reporting of these studies. (Oct 9, 2015 - Completed)
 - Mary-Louise and Wieslaw provided revised language based upon the SICT discussions. See their revised language in the comment box below. All SICT members are urged to consider the new language and provide feedback. The milestone language will be finalized at the March meeting. (Sep 23, 2015 - Completed)
 - Neil Swanberg suggested changing the wording from: "Identify optimal sites for short-term process studies underpinned by long-term observations," to the new

wording: "Identify optimal short-term process studies underpinned by long-term observations," (which omits the word "sites"). He also suggested that we update the milestone to "met and continuing" rather than "no progress" because: Agencies (mostly ONR, NSF and NASA) used their normal review process to identify over 100 optimal projects annually to carry out short-term process studies on various sea ice topics. Topics in 2013 and 2014 included detailed biological and chemical processes in the ice, ice physics and sea ice modeling at a range of scales, ground truth data for remote sensing. Many of these studies are tied to long term and extensive observations of sea ice parameters. (Sep 23, 2015 - Completed)

- At the June 2014 meeting a discussion was initiated to reword this milestone to make it actionable and useful. At the January 2015 meeting Martin noted that he will continue the discussion with other team members and see if resolution can be found. (Feb 24, 2015 - Completed)
- **3.1.2.o (In progress) Undertake a sea ice model intercomparison project in order to improve sea ice prediction at a variety of time and space scales; DOE (Lead), DOD-ONR, NASA, NOAA, NSF, USARC; Target Date 2017**
 - Continuation statement: This milestone has not been met, but work will continue as part of the implementation of Arctic Research Plan 2017-2021, Research Objective 9.3, which addresses model intercomparisons and evaluations to enhance Arctic System prediction capabilities. (Oct 6, 2016 - Completed)
 - 1) Joint meeting with the modeling group to hear report on SEARise and AOMIP. 2) Report on the Sea Ice Prediction Network (Bitz) and FAMOS (Proshutinsky) in June. 3) Decision taken to postpone any action on a sea ice MIP until these activities have had an opportunity to mature (July 2013) (Jul 2, 2014 - Completed)
 - During the June 2014 meeting it was decided to keep this milestone active in light of the work of the SIPN. (Jul 2, 2014 - Completed)
 - The Sea Ice Prediction Network (SIPN, www.arcus.org/sipn) was initiated in late summer 2013 with funding from NSF, ONR, ONR Global, DOE and NASA, and in-kind support from NOAA. The primary institutions in the network are the University of Washington, University of Colorado, University of Alaska Fairbanks, Arctic Research Consortium of the U.S., Los Alamos National Laboratory and NOAA Pacific Marine Environmental Laboratory. The first SIPN workshop was held in March 2014, and a workshop report was presented to the Sea Ice team during the May meeting. (Sep 30, 2013 - Completed)

Team Leads: Martin Jeffries, OSTP; Scott Harper, ONR

Agencies: DHS, DOC, DOD, DOE, DOI, NASA, NSF, OSTP, USARC

Distributed Biological Observatory

Milestone Reporting Log 2016

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

3.1 Sea ice and marine ecosystems

3.1.3 Complete deployment of a Distributed Biological Observatory (DBO) in the Arctic Ocean to create long-term data sets on biological, physical, and chemical variability and ecosystem response

- **3.1.3.a (Milestone met) DBO partners conduct pilot research cruises (<http://www.arctic.noaa.gov/dbo>); NOAA (Lead), DOI, NSF; Target Date 2014**
 - Completion Statement: This milestone has been met annually. Cruises from 2010-2016 have been completed (<http://arctic.noaa.gov/dbo>), with results summarized in the annual PAG meeting reports (<http://pag.arcticportal.org/>) (Aug 25, 2016 - Completed)
 - An updated list of all DBO-related cruises is available on the DBO website at (<http://www.arctic.noaa.gov/dbo/cruise-data>). (Aug 5, 2014 - Completed)
 - Pilot cruises 2010-2013 completed (<http://www.arctic.noaa.gov/dbo>). DBO activities summarized in annual PAG meeting reports (<http://pag.arcticportal.org/>). (Jul 31, 2014 - Completed)
 - Team agreed to extend the pilot phase through 2013 field season. (Jul 31, 2014 - Completed)
 - BOEM provided AMIDA and BSMP historical maps. (<http://www.iarpccollaborations.org/members/documents/784>) (<http://www.iarpccollaborations.org/members/documents/783>) (Jul 31, 2014 - Completed)
 - 33 graphic images from the Arctic EIS project were uploaded in early June. BOEM added funds to put the data from the Arctic EIS program into a separate AOOS/Axiom workspace, which may facilitate future integration with DBO data. Even though the EIS stations are not consistent with DBO transect sampling locations, it is helpful to have the Arctic EIS data for broader background, including information about the distribution and relative abundance of fishes. (Jun 10, 2014 - Completed)

- **3.1.3.b (Milestone met) Creation of DBO-focused satellite sea ice, SST, SSH and ocean color products; NASA (Lead); Target Date 2014**

 - Completion Statement: Working with the DBO CT, NASA has made DBO-related satellite products available to the science community since 2013. These NASA-generated products, which are updated every week, include satellite sea ice, sea surface temperature, ocean color, wind and cloud fraction images focused on the pan-Arctic region with the DBO study sites identified. Sea surface height and surface salinity weekly images were added in mid-2016 to provide even more comprehensive data products. Time series animation of the products are also provided to effectively visualize recent changes in sea ice and wind directions, sea surface temperature, and chlorophyll a concentration. (<http://neptune.gsfc.nasa.gov/csb/index.php?section=270>). More recently, the NASA products were further enhanced with the introduction of weekly images of sea surface height from JASON-2 (radar altimeter) and surface salinity from SMOS (Soil Moisture and Ocean Salinity). (Aug 30, 2016 - Completed)
 - In addition to the current parameters, NASA is contributing measurements of sea surface salinity (SSS), winds, and clouds in its DBO data products. (Oct 1, 2015 - Completed)
 - NASA provided images with ocean color in the various study regions. There are some features within the study regions, including the high chl signal in DBO Region 2 and along the Beaufort coast. (Aug 15, 2014 - Completed)
 - NASA DBO Website update and improved. (<http://neptune.gsfc.nasa.gov/csb/index.php?section=270>) (Mar 11, 2014 - Completed)
 - DBO team members will be working with NASA to make the ocean color record more available to DBO scientists. NASA is making progress to have DBO-related data available on the NASA website. NASA data is available on <http://neptune.gsfc.nasa.gov/csb/index.php?section=27> (Jul 9, 2013 - Completed)

- **3.1.3.c (Milestone met) The Arctic Observing Network (AON) subcommittee established by the IAPRC organizes the DBO interagency working group to develop U.S. plans and priorities; NSF (Lead), DOC, DOI, NASA; Target Date 2012**

 - Completion Statement: Creation of the DBO Collaboration Team which began meeting in 2012 fulfills this milestone. The team continues to meet on a regular basis throughout the year. (Dec 10, 2013 - Completed)

- **3.1.3.d (Milestone met) Initiate a dialogue with Roshydromet and Russian Academy of Science on developing DBO stations in Russian territory as a complement to those in U.S. waters; NOAA (Lead), NSF; Target Date 2013**

 - Completion Statement: The RUSALCA program was approved by the Russian Academy of Sciences for another 10 years

(<http://www.arctic.noaa.gov/aro/russian-american/>). In 2014, the RUSALCA project deployed moorings on the Russian side of the Bering Strait, and sampled the full DBO Line 3 from Russia to the Alaska coast. Participants at the RUSALCA PI meeting (Feb 2014) and ASSW 2015 PAG meeting in Japan discussed the possible extension of the DBO Line 4 westward to Wrangel Island and the initiation of a Pacific Arctic Climate Ecosystem Observatory (PACEO) that will be sampled in concert with DBO sampling in the Chukchi and Beaufort seas. (June 2015 - Completed). Note: the RUSALCA program was suspended for logistical reasons in June 2016; continued efforts are needed to facilitate RUSALCA activities identified within the MOU between the Russian Academy of Science and NOAA on World Oceans and Polar Regions Studies, which was approved for a decade starting April 2013.

- RUSALCA PI meeting in February 2014. Linkages on DBO Line 3 were highlighted. RUSALCA data to be included on the AOOS site. (Jul 31, 2014 - Completed)
- At the international RUSALCA conference held in Pt. Petersburg in May 2013 (<http://rusalcaproject.com/>), it was agreed that RUSALCA 2014 will put moorings into the Russian side of the Bering Strait, and sample DBO Line 3. In 2015, RUSALCA hopes to extend the US DBO Line 4 Westward to Wrangel Island; this suggestion will be the focus of discussion in the DBO IT. The RUSALCA decadal synthesis will be underway in 2014; a 5-year research summary from CIFAR is available online (<http://www.cifar.uaf.edu/research/rusalca.php>) (Jun 11, 2013 - Completed)
- The Russian Academy of Sciences and NOAA renewed the Memorandum of Understanding (MOU) on World Oceans and Polar Regions Studies in April 2013. The RAS has requested another decade of observations in the Pacific Arctic together with the U.S. agencies. The RUSALCA decadal synthesis will commence in 2013. RUSALCA was approved by the Russian Academy of Sciences for another 10 years. (Nov 6, 2012 - Completed)
- **3.1.3.e (Milestone met) Pacific Arctic Group (PAG) meets annually to review results from DBO sampling activities; NOAA (Lead); Target Date 2013**
 - Completion Statement: The PAG meets twice annually (in spring and autumn) and Team Lead, Jackie Grebmeier, reports to them on the DBO Collaboration Team and also reports back to the Collaboration Team on PAG activities. (Dec 10, 2013 - Completed)
- **3.1.3.f (Milestone met) Report in 2014 on International DBO activities and results to date; NOAA (Lead), NSF; Target Date 2012**
 - Completion Statement: PAG coordinates the international aspects of DBO. All annual reports can be found on PAG website (<http://pag.arcticportal.org/>). In 2012, this milestone was completed in conjunction with milestone 3.1.3e. (Aug 30, 2016 - Completed)

- **3.1.3.g (Milestone met) Updated DBO concept and national/international plan for decadal-scale implementation release in 2014 will include identification of satellite resources that will be critical to the DBO. Ocean color, SST, SSH, SS salinity, and winds are all key measurement; NOAA (Lead), DOI, NASA, NSF; Target Date 2014**

- Completion Statement: J. Comiso's (NASA) presented NASA resources available for DBO PIs in his November 20, 2015 presentation, available on the IARPC collaborations website at <http://www.iarpcollaborations.org/members/events/1122> and on the NASA DBO website: <http://neptune.gsfc.nasa.gov/csb/index.php?section=270> Sea surface height and sea surface salinity are currently being added as part of the data products; see milestone 3.1.3b. (Sep 19, 2016 - Completed)
- NASA resources were made available for DBO PIs in a November 20, 2015 presentation, available on the IARPC collaborations website at <http://www.iarpcollaborations.org/members/events/1122> and on the NASA DBO website: <http://neptune.gsfc.nasa.gov/csb/index.php?section=270> Sea surface height and sea surface salinity are currently being added as part of the data products; see milestone 3.1.3b. (Aug 30, 2016 - Completed)
- NASA also added cloud fraction data to the list of data products it is providing to the DBO. (Oct 1, 2015 - Completed)
- During the January 2015 meeting of the DBO CT, it was agreed that identification of new DBO regions would be handled under this milestone. No new milestone will be created to address new regions. (Jan 14, 2015 - Completed)
- A presentation was provided by a NASA representative to the DBO CT on remotely sensed large scale oceanographic data from all DBO regions and across the Arctic. This presentation included many graphics and visualizations, and covered sea ice concentration and winds, chlorophyll, SST, cloud cover fraction, and plots of historical data. The presentation is available at (<http://www.iarpcollaborations.org/members/events/1122>). (Nov 20, 2014 - Completed)
- A second DBO Data Workshop took place in Seattle at NOAA's PMEL from October 29-31, 2014. An updated DBO concept plan for decadal-scale implementation will be prepared subsequent to the workshop. (Nov 18, 2014 - Completed)
- The Earth Observing Laboratory (EOL) is archiving DBO data in support of the NSF/AON-DBO program. Discussions between Jackie Grebmeier (lead NSF DBO project) and Jim Moore of the EOL have resulted in development of a DBO data portal for DBO data submissions that will go public in fall 2014 (Oct 15, 2014 - Completed)
- The first DBO Data Workshop was held from February 27 through March 1 2013, at NOAA's Pacific Marine Environmental Laboratory (PMEL) in Seattle. A key product of that workshop was the development of a DRAFT Data Policy,

published as Appendix C in the workshop report found at
(<http://www.arctic.noaa.gov/dbo/workshop-products>) (Jun 11, 2013 - Completed)

- **3.1.3.h (Milestone met) Starting in 2015, DBO partners execute decadal-scale plans and prepare periodic assessments on physical and ecological state of Pacific Arctic marine environment using not only DBO data, but also data from BOEM, NPRB and other sources; NOAA (Lead), DOI, NASA, NSF; Target Date 2015**
 - Completion Statement: This milestone has been met with the completion of the draft Implementation Plan version 1. The plan is available at: (<http://www.iarpccollaborations.org/members/documents/4530>). (May 24, 2016 - Completed)
 - A draft decadal-scale Implementation Plan for the DBO was prepared and distributed it for discussion during the August and September meetings of the DBOCT: (<http://www.iarpccollaborations.org/members/events/2817>). (Sep 15, 2015 - Completed)
 - In 2015, three new DBO transects were established in the Beaufort Sea, based on discussions held over a ca. 2-year period, expanding the DBO framework to eight regions. (Sep 15, 2015 - Completed)

- **3.1.3.i (Milestone met) Report annually on DBO-related developments at the Alaska Marine Science Symposium and seek coordination with Alaska state agencies, oil industry and other non-Federal organization; NOAA (Lead); Target Date 2014**
 - Completion Statement: Since 2010 summaries of DBO -related work have been presented at a wide variety of science conferences (including the AMSS) and research planning venues. DBO team members also sought opportunities to collaborate and coordinate with state agencies, industry and other stakeholders. (Aug 30, 2016 - Completed)
 - A presentation on DBO was given to the Arctic Change meeting in Ottawa in December and at the December 2014 AGU in San Francisco, CA. The title of the presentation was "Tracking Biological and Ecosystem Responses to Changing Environmental Conditions in the Pacific Arctic". DBO, specifically its formation, sea ice changes, seawater warming, and biological and ecosystem response, was discussed. The presentation to AGU is available at (<http://www.iarpccollaborations.org/members/documents/1592>). (Jan 14, 2015 - Completed)
 - Team Leader, Sue Moore, presented a poster at the AMSS 2014. See the poster on the DBO website at (<http://www.arctic.noaa.gov/dbo/workshop-products>). (Feb 11, 2014 - Completed)

- 3.1.3.j (Milestone met) Ensure DBO data access and archiving are coordinated across agencies and among international partners; NOAA (Lead), NASA, NSF; Target Date 2014**

 - Completion Statement: This milestone is complete with the development of the ACADIS website. Reference: Jim Moore's (NCAR) presentation to the DBO CT on January 12, 2015: <http://www.iarpccollaborations.org/members/events/1321> and Don Stott's presentation to the DBO CT on 19 May 2015: <http://www.iarpccollaborations.org/members/events/2319>. Also see the ACADIS DBO website: https://www.eol.ucar.edu/field_projects/dbo. (Aug 30, 2016 - Completed)
 - A presentation on The ACADIS Special Requirements Data Collection (SRDC) was given for the DBO: a dataset inventory and archive during the May 19, 2015 meeting of the DBOCT. Notes from the presentation are available on the event page. (<http://www.iarpccollaborations.org/members/documents/1949>) (May 21, 2015 - Completed)
 - A poster on the DBO data policy was presented at the 2015 AMSS. (Feb 13, 2015 - Completed)
 - During the January 2015 meeting of the DBO CT, an overview was given of the draft DBO data policy which is under consideration. For a summary of the discussion, see the meeting notes and the PowerPoint presentation. Agencies are invited to comment on the draft data policy. (<http://www.iarpccollaborations.org/members/documents/1592>) (Jan 14, 2015 - Completed)
 - The Earth Observing Lab (EOL), with NSF support, is working to create focused DBO AON site. There were discussions about migrating the DBO AOOS/Axiom workspace data to the EOL site when it becomes publicly available. The goal of the EOL DBO site is to create a long-term archive and to make all data publicly available over the long-term. (Nov 18, 2014 - Completed)
 - A DBO Workspace was created on the AOOS website in spring 2014. Access to the workspace is password protected to encourage DBO participants to post data or data products to facilitate interdisciplinary collaboration (May 14, 2014 - Completed)
 - DBO data sets are being collated by topic-area leads, to the extent possible. Topic area leads include: Pickart: physical; Cooper: chemical; Grebmeier: benthic; Varela: phytoplankton, Ashjian: zooplankton; Kuletz: sea birds; Frey: satellite Moore: mammal (May 14, 2014 - Completed)

- 3.1.3.k (Deactivated) Update and augment DBO regions and transects to accommodate interest in sampling expansion and support full implementation of the DBO; NOAA (Lead), DOI, NASA, NSF; Target Date 2014**

 - Deactivation Statement: This milestone had been added after the publication of the IARPC 5-year plan. However, during the January 2015 meeting of the DBO

CT, the team agreed to not create a new milestone to update and augment regions, but rather, fold this activity into milestone 3.1.3.g. "Updated DBO concept and national/international plan for decadal-scale implementation..." <http://www.iarpccollaborations.org/members/milestones/43> and milestone 3.1.3. h "Starting in 2015, DBO partners execute decadal-scale plans..." <http://www.iarpccollaborations.org/members/milestones/44> (Sep 19, 2016 - Completed)

- During the January 2015 meeting of the DBO CT, the team agreed to not create a new milestone to update and augment regions, but rather, fold this activity into milestone 3.1.3.g. "Updated DBO concept and national/international plan for decadal-scale implementation..." (Jan 14, 2015 - Completed)
- The DBO Collaboration Team (CT) has initiated discussions regarding the expansion of DBO-type sampling to the Beaufort and northern Chukchi seas. Provisional discussions have focused on regions along the Alaskan Beaufort Sea slope, and areas near Cape Bathurst in the Canadian Beaufort Sea. Linkages between the DBO and the RUSALCA program include plans for an extended DBO transect line from Region 4 westwards to Wrangel Island, and the establishment of a DBO region on the Chukchi Plateau, possibly to contribute to an international Climate Line from the Plateau to the Beaufort Sea basin being discussed within PAG. Concurrently, interest in DBO-type sampling in the Atlantic sector of the Arctic has been expressed by Norwegian colleagues, with plans developing for sampling regions in the northern Barents Sea. (Nov 18, 2014 - Completed)
- A master map of new DBO lines in the Beaufort Sea was created and discussed it with the Canadians (Aug 15, 2014 - Completed)
- DBO team members attended the Arctic Council PAME workshop. Cathy reported that Takashi Kikuchi from Japan (JAMESTEC), co-chair on the PAG (Pacific Arctic Group), gave a comprehensive overview of DBO with a presentation co-author by Jackie Grebmeier. European and Russian participants were impressed with DBO. Specifically, there seems to be a consensus that now is a good time to look at identifying some trans-boundary regions with Canada too. (Aug 15, 2014 - Completed)
- It was reported that the ArcticNet Phase IV call for proposals is out (www.arcticnet.ulaval.ca/research/call-2014.php) (Aug 15, 2014 - Completed)
- Two historic maps were provided from the ANIMIDA and BSMP programs. Sampling sites for these programs were very close to shore. (Aug 15, 2014 - Completed)
- Team Lead, Jackie Grebmeier, provided the 'master map' of potential new DBO regions in the Beaufort Sea. This provides a Beaufort-wide view, including sampling stations overlain on a benthic biomass interpolated map and notional transect lines. (<http://www.iarpccollaborations.org/members/documents/784>) (<http://www.iarpccollaborations.org/members/documents/783>) (Aug 15, 2014 - Completed)

- On July 28th BOEM sent AMIDA and BSMP historical maps. Attached are two maps, one from the Beaufort Sea Monitoring Project and one from the historical ANIMIDA collections of ANIMIDA I and II (ANIMIDA, cANIMIDA). They do not have good detail, but at least allow a visualization of past projects that are of importance to regional collections. (Jul 31, 2014 - Completed)
- A January 2014 small group meeting was held to discuss potential sites. Meeting notes discuss merits/downsides of each. (Jul 31, 2014 - Completed)
- Discussion of expansion of DBO sampling to new regions and update of Lat/Lon for existing regions initiated at DBO Data Workshop. Tables summarizing 2010-2013 cruise information were shared and are available on the DBO website. However, the group needs to explore ways to make a clearer presentation of where and when cruises are occupying DBO lines. An interactive map would be helpful, and potentially available via the DBO Research Workspace. (Jun 11, 2013 - Completed)

Team Leads: Sue Moore, NOAA; Jackie Grebmeier, UMCES

Agencies: DOC, DOD, DOI, MMC, NASA, NSF, OSTP, USARC

Chukchi & Beaufort Seas

Milestone Reporting Log 2016

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3.1 Sea ice and marine ecosystems

3.1.4 Develop integrated ecosystem processes research in the Beaufort and Chukchi seas region

- **3.1.4.a (Milestone met) Conduct interagency and international workshops and consultations during 2012 to identify high priority research themes and objectives and coordinate funding and logistic plans; DOI, NASA, NOAA, NSF, USARC; Target Date 2014**
 - Completion Statement: During the August 6, 2014 meeting of the CBC, it was agreed that this milestone has been completed. The Conceptual Model Workshop report is available on this website (linked to this milestone) and the framework document was posted on the website in January 2015. (Sep 15, 2016 - Completed)
 - The Framework document (<http://www.iarpccollaborations.org/members/documents/1723>) and accompanying brochure (<http://www.iarpccollaborations.org/members/documents/1722>) have been published and are available on the website. (Feb 10, 2015 - Completed)
 - Community workshop held April 30-May 2 2013 to develop a conceptual model of the Chukchi and Beaufort ecosystems. A workshop report was developed and is available at <http://www.iarpccollaborations.org/members/documents/1723>. (Aug 1, 2014 - Completed)
 - Drafting team met to draft a research framework document. The document is drafted and circulated to the team for comments. (Aug 1, 2014 - Completed)
 - A Gantt chart was developed of all activities <http://www.iarpccollaborations.org/members/documents/798>. (Jun 17, 2013 - Completed)
- **3.1.4.b (Milestone met) Perform synthesis and assessment during 2013-2014 on existing data and information to provide foundation for new research activities; NOAA (Lead), DOI, NSF; Target Date 2014**

- Completion Statement: The SOAR (<http://www.arctic.noaa.gov/soar>) and PacMARS (<http://pacmars.cbl.umces.edu/>) synthesis are concluding and publications are forthcoming. (Sep 15, 2016 - Completed)
- **Impacts of Climate on the Eco-Systems and Chemistry of the Arctic Pacific Environment (ICESCAPE)** was a multi-year NASA shipborne project. The bulk of the research took place in the Beaufort and Chukchi Seas in the summers of 2010 and 2011 and the project ended in 2014. The central science question of this program was “What is the impact of climate change (natural and anthropogenic) on the biogeochemistry and ecology of the Chukchi and Beaufort seas?” While both of these regions are experiencing significant changes in the ice cover, their biogeochemical response will likely be quite different due to their distinct physical, chemical, and biological differences. ICESCAPE pursued the above central science question and associated issues through an interdisciplinary, cross-cutting approach integrating field expeditions, modeling, and satellite remote sensing. Central to the success of this program was a quantitative and reliable determination of chemical and biological fluxes to and from open water, ice and snow surfaces, as a function of relevant environmental conditions such as the nature of the surfaces. This was done by coupling remotely-sensed information to that obtained via state-of-the-art chemical, physical and biological sensors located in water, on or under ice, and in the atmosphere. Additional details about this project are available at: https://espo.nasa.gov/icescape/content/ICESCAPE_0. In August 2015, Deep-Sea Research Part II: Topical Studies in Oceanography published a special issue volume on ICESCAPE. The first volume is available at <http://www.sciencedirect.com/science/journal/09670645/118/supp/PA> and a second volume is forthcoming. The first volume contains 10 articles discussing the research results from the 2010 – 2011 efforts. (Sep 29, 2015 - Completed)
- PacMARS released its final report, available at <http://pacmars.cbl.umces.edu/>. (Apr 20, 2015 - Completed)
- SOAR released a second synthesis paper on bowhead whales by John Citta (Alaska Department of Fish and Game). <http://www.sciencedirect.com/science/article/pii/S0079661114001438> (Apr 20, 2015 - Completed)
- Sue Moore (NOAA) reported that the first SOAR synthesis paper on ocean acidification by Jeremy Mathis is now available on the SOAR website (<http://www.arctic.noaa.gov/soar/>). (Aug 7, 2014 - Completed)
- The Synthesis Of Arctic Research (SOAR) brings together a multidisciplinary group of Arctic scientists and residents to explore and integrate information from completed and ongoing marine research in the Pacific Arctic. Initial papers are being released on the SOAR website (<http://www.arctic.noaa.gov/soar/>). (Aug 1, 2014 - Completed)
- The Pacific Marine Arctic Regional Synthesis (PacMARS <http://pacmars.cbl.umces.edu/>) is a research synthesis effort funded by Shell Exploration & Production Company and ConocoPhillips and administered and managed by the North Pacific Marine Research Institute through the North Pacific

Research Board in consultation with the U.S. National Science Foundation Office of Polar Programs. The synthesis assembles up-to-date written documentation that contributes to understanding the Pacific-influenced coastal shelf ecosystem of the Arctic Ocean. Our study area extends from Saint Lawrence Island in the Bering Sea through Bering Strait into the Chukchi and Beaufort Seas and our objective is to compile the best available knowledge from local communities, peer-reviewed social and natural sciences, as well as less readily available knowledge sources. The PacMARS report is available as of January 2015 (http://www.nprb.org/assets/images/uploads/PacMARS_Final_Report_forweb.pdf) (Aug 1, 2014 - Completed)

- RUSALCA (<http://www.arctic.noaa.gov/rusalca/>) is planning a synthesis of the first decade of its work due out in 2015. More information is available on their website. (Aug 1, 2014 - Completed)
- Workshop held April 30-May 2 2013 to develop a conceptual model of the Chukchi and Beaufort ecosystems. A workshop report was developed and is available under documents. (Aug 1, 2014 - Completed)
- **3.1.4.c (Milestone met) Initiate 3-5 year research activities starting in 2013 with interagency/international results integration mechanisms; BOEM (Lead), DOI, NASA, NOAA, NSF, USARC; Target Date 2014**
 - Completion Statement: Research projects were launched by different federal agencies after 2013 with interagency/international integration mechanisms embedded in their management structure. An example of this is the Marine Arctic Ecosystem Study (MARES), a NOPP partnership (BOEM, ONR, USARC, USCG, USGS, NSF, Shell, NSB, ArcticNet) that brings together federal and state agencies, as well as the private sector which is represented by 3 Canadian firms as well as international ones with a large presence in the US, e.g., Shell. MARES not only will integrate physical, chemical and biological information but also management directives across sectors and different entities. More information about MARES can be found on under the tag "MARES" <http://www.iarpcollaborations.org/members/tags/334>. Additionally, North Pacific Research Board, BOEM, and North Slope Borough/Shell Baseline Studies Program issued a call for pre-proposals for an Arctic Integrated Ecosystem Research Program in late May 2015. Updates on the NPRB call can be found on the IARPC website at: <http://www.iarpcollaborations.org/members/tags/485>. (Sep 15, 2016 - Completed)
 - North Pacific Research Board, BOEM, and North Slope Borough/Shell Baseline Studies Program issued a call for pre-proposals for an Arctic Integrated Ecosystem Research Program in late May 2015. Pre-proposals will be reviewed in September 2015, full proposals invited in October 2015, and final funding decisions will be made in May 2016. (May 16, 2015 - Target)
 - The team determined that it would be useful to collect an inventory of all current activities. An inventory template has been completed and program officers are populating it with details of ongoing activities. At the February meeting, Danielle

reported that NASA and NOAA have contributed. NSF and BOEM sent information but that needs to be copied into the Google doc (<https://docs.google.com/spreadsheets/d/1tWY4hAk2IIfhicvsjNDtH417tGdpX1NU7hLBFuQXt2w/edit#gid=670129791>). For the remainder of agencies, please fill in the inventory (<http://www.iarpccollaborations.org/members/documents/1723>). (Mar 3, 2015 - Target)

- Candace Nachman (NOAA) and Walt Meier (NASA) will consult with NOAA and NASA and supply the name of a representative to the Steering Group prior to the next meeting of the CBCT. Doug DeMaster will be the representative from NOAA. (Mar 3, 2015 - Target)
- The Framework document was produced (thanks to layout and design assistance from NPRB) and is available here: <http://www.iarpccollaborations.org/members/documents/1723>. A brochure to accompany the framework document is available here: <http://www.iarpccollaborations.org/members/documents/1722>. Agency representatives are asked to brief their upper management about the framework. (Feb 10, 2015 - Completed)
- Based upon the framework document (<http://www.iarpccollaborations.org/members/documents/1723>), the CBCT is developing a brochure to accompany the framing document. (Feb 5, 2015 - Completed)
- A small sub-group has formed to define the parameters and role of the proposed synthesis group for the framework. They will report back at the August meeting (<http://www.iarpccollaborations.org/members/documents/802>). The sub group reported to the August meeting. (see accompanying meeting notes for lengthy discussion about the synthesis group.) They will circulate new language around the synthesis group (now called Chukchi/Beaufort Marine Steering Group) and finalize the language at the September meeting. A steering group has been formed. (Feb 5, 2015 - Completed)
- The Framework document (produced with assistance from NPRB) has been posted at: <http://www.iarpccollaborations.org/members/documents/1723>. This document identifies two overarching goals and five inter-locking science themes that should be used to guide future research in the U.S. Chukchi and Beaufort Seas. The document recommends coordination among those funding ongoing and future research programs and outlines partnership mechanisms. (Feb 5, 2015 - Completed)
- The Steering Group (as called for in the framework document) has been formed. Members include Neil Swanberg (NSF/Chair); Martin Jeffries (ONR); Cathy Coon (BOEM); Michael Macrander (Shell); Danielle Dickson (NPRB). Other members will be added from NOAA and NASA. (Feb 4, 2015 - Completed)
- Danielle Dickson (NPRB) and Guillermo Auad (BOEM) will pull together documentation to support a CBCT workshop including needs, scope, goals, as well as an agenda and will circulate this information prior to the next meeting.

CBCT members will send information about upcoming meetings in the next six months that might create a conflict with participation in the proposed CBCT workshop. Based upon input received, Danielle will create a Doodle Poll to identify possible workshop dates. A decision was made during the November meeting not to proceed at this time with a workshop. Further consideration will be given in 2015. (Dec 16, 2014 - Completed)

- BOEM awarded a contract to Stantec Consulting Services, Inc., to integrate social, physical, chemical and biological information in the Beaufort Sea (August 2014). This is an international (US-Canada) partnership with focus on ecosystem functioning and monitoring, climate change and ecosystem services. The Marine Arctic Ecosystem Study (MARES) is a 5-year project. (Sep 26, 2014 - Completed)
- Danielle Dickson (NPRB) announced that last month NPRB committed \$6M (over 5-6 years) to develop an Arctic research program. Staff at NPRB, with assistance from a small working group, are developing a handful of scenarios to define the research scope. The NPRB Board will meet in September and identify one or two of the scenarios as focal points, and then a RFP will be developed and considered for approval at the spring 2015 NPRB Board meeting. NPRB welcomes potential partners to develop an integrative program. Contact Danielle directly if you are interested in partnering. (Jun 16, 2014 - Completed)
- Danielle Dickson (NPRB) announced funding decisions for the Arctic Integrated Ecosystem Research Program. This program will coordinate and collaborate with several existing U.S. research projects and will also cooperate with international collaborators. The program includes plans to contribute to sampling the Distributed Biological Observatory. (Jun 16, 2014 - Completed)
- **3.1.4.d (Milestone met) Demonstrate new and updated cyberinfrastructure tools to enhance data integration and application and identify opportunities for sharing of technology and tools among interagency partners; NSF (Lead), DOI, NOAA; Target Date 2013**
 - Completion Statement: At the September 2016 meeting, the team considered this milestone completed based upon the work taken place to date. Most importantly, they pointed to the cyber-infrastructure tools produced by Axiom Data Science for support of the Arctic research community. For more information, see <http://www.iarpccollaborations.org/members/documents/6027>. (October 7, 2017)
 - At the CBCT meeting/call of Sept 8, 2016, Rob Bochenek gave a presentation (<http://www.iarpccollaborations.org/members/documents/6027>) that outlined information and cyber-infrastructure tools produced by Axiom Data Science for support of the Arctic research community. With funding from several IARPC agencies (NSF, BOEM, NOAA) and private sources (Shell, NPRB), Axiom has developed a set of tools to leverage applications, systems and hardware across several partners. Their shared cyberinfrastructure can provide functional improvements that can be funded by one partner and shared with the collective. Axiom capabilities includes standardizing systems and interfaces

across partners for specific projects. A scientific collaboration and data management platform was presented. This workspace allows users to generate scientific metadata for information resources (ISO 19115-1/2). Users can then elect their project and selected data files to be published to publicly accessible portals. For more information contact Rob Bochenek, rob@axiomdatascience.com. (Sep 30, 2016 - Completed)

- Determine ways in which data discovery, management and accessibility can be addressed to ensure that the data being generated as part of collaborative efforts are being appropriately handled. (Sep 23, 2016 - Completed)
- The update of this milestone is being considered by the CBCT's Steering Group. A resolution is expected during June-July 2015. (Sep 23, 2016 - Completed)

- **3.1.4.e (Milestone met) Conduct initial science integration conference in 2016; BOEM, DOD-ONR, NSF, USARC; Target Date 2016**

- A work-session has been organized for the fall of 2016 with the goal of integrating scientific concepts and theories. (Nov 30, 2016 - Target)
- The work-session: "Towards a Unifying Pan-Arctic Perspective: Concepts and Theories" to be held this November 7-11, is part of an NSF grant and emerged from the collaboration framework provided by the IARPC teams, specifically by agencies participating in the Chukchi-Beaufort and Sea Ice Collaboration Teams: http://www.nsf.gov/awardsearch/showAward?AWD_ID=163848. This is a closed-door meeting and a public briefing will be held on Nov 9 in Solomons Island, MD at a time to be decided. Updates to follow. At the Sept 7th 2016 call the team agreed on closing this milestone. ABSTRACT: This NSF grant is to support an international group of scientists, including a significant number from the US, to develop a shared, high-level conceptual model of the functioning of the Arctic Ocean that synthesizes our understanding of the key processes and elements governing the responses of the Arctic marine ecosystems to current pressures and changes. The development of a unified pan arctic conceptual model for the Arctic Ocean, which may include a nested array of additional models addressing specific regions and processes, will enable improved coordination of research efforts addressing the Arctic Ocean in a time of change. The Arctic Ocean is a region of peaceful and constructive political and economic cooperation, which can be improved through science-based knowledge sharing and unifying concepts. The outcome of this workshop will be reported in two publications: (1) an extended revision of conceptual models of the Arctic Ocean, and (2) a compact and distilled version of the unified conceptual model to be developed at the workshop identifying the key processes and levers governing the response of the Arctic Ocean ecosystem to change. The workshop will be held and its products developed during the period of the US Chairmanship of the international Arctic Council, to reach a broad research community, including researchers and research managers nationally and internationally. Addressing the conceptualization of Arctic processes must focus on the pan arctic marine environment but encompass the full marine - land - atmosphere system. Many

nations, both Arctic and non-Arctic, are elaborating major research programs aimed at advancing our understanding of the Arctic Ocean system in a time of change, as a pre-requisite to managing the imminent pressures derived from the forecasted increase in industry operations in the Arctic. However, these programs, involving great efforts and resources, are largely lacking a shared paradigm, or understanding to help identify the key processes that such programs should aim to resolve. There is a risk that these research programs will suffer from a lack of focus and their outcomes, as well as fail to achieve synergy with one another. As a result, while each effort may be scientifically relevant and sound, collectively they may fall short of providing the high level understanding required, leaving us in a marginal position to manage the impacts of economic growth and industry operations in the future Arctic. This effort aims to address that by providing the high level thinking needed to help guide scientific planning in the Arctic. (Sep 23, 2016 - Completed)

- Guillermo Auad (BOEM) is in conversations with Neil Swanberg (NSF) and Martin Jeffries (ONR) to meet this milestone. (Jun 22, 2016 - Completed)

- **3.1.4.f (Milestone met) Conduct environmental and integrated risk assessments to evaluate the potential impacts of oil/natural gas production on ecosystems in the Beaufort Sea; DOI (Lead), DOE; Target Date 2014**

- The briefings presented before the Chukchi Beaufort Seas Ecosystem Collaboration Team by BSEE (June, 2016) and BOEM (July 2016), and the Oil Spill Recovery Institute Research Plan 2016-2020 uploaded to the website (<http://www.iarpccollaborations.org/members/documents/3439>) have provided information needed to close this milestone. Videos: BOEM (Dr Li): <http://www.iarpccollaborations.org/members/documents/4744> BSEE (Bill Vocke): <http://www.iarpccollaborations.org/members/documents/4577> (Sep 20, 2016 - Completed)
- In the past we have heard about some small discrete projects but funds haven't been forthcoming. Candace Nachman will go back to NOAA and get an update and some suggestions on how to revise this and milestone 3.1.4.g. The sea ice team also has a milestone related to oil spill interactions with sea ice; possibly merge these efforts. Laura Medley, BSEE is a contact. Martin Jeffries (ONR) and Danielle Dickson (NPRB) will coordinate on this. (Mar 3, 2015 - Target)
- The NRC report on Responding to Oil Spills in the US Arctic marine Environment is available at <http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/Arctic-Oil-Spill-Brief-Final02.pdf>. (Nov 11, 2014 - Completed)

- **3.1.4.g (In progress) Evaluate ecosystem impacts of oil and gas development and the potential for oil spills and especially the effects of oil, dispersants used in response to an oil spill, and to a mixture of oil and dispersants on the early life history stages of Arctic cod; NOAA (Lead), DOI; Target Date 2013**

- At the September call, the CBCT agreed that this milestone shall remain as "in progress" despite the partial and recent progress made by SEA consulting through BOEM funding.
- At the Sept 7 2016 CBCT call, the presentation of the BOEM-funded study "Physical & Chemical Analyses of Crude and Refined Oils: Laboratory and Meso-scale Oil Weathering" was referenced as available at this site, i.e.: <http://www.iarpccollaborations.org/members/documents/6020>. Since the speaker had a last minute conflict and could not present, the co-chairs tentatively scheduled the oral presentation for the November call. (Nov 2, 2016 - Target)
- BOEM is funding the study Physical and Chemical Analyses of Crude and Refined Oils; Laboratory and Mesoscale Oil Weathering which includes work with crude oils from different locations off the North Slope coast, and dispersants. The study is expected to conclude in September 2016. (Oct 12, 2016 - Target)
- The Alaska Science Center wasn't able to complete related research due to the lack of funding. (Sep 7, 2016 - Completed)
- The Alaska Science Center is conducting limited laboratory-based research but they would like to extend the research further when funds are available. (Aug 7, 2014 - Completed)

Team Leads: Guillermo Auad, BOEM; Danielle Dickson, NPRB

Agencies: DOC, DOD, DOE, DOI, MMC, NASA, NSF, OSTP, USARC

Terrestrial Ecosystems

Milestone Reporting Log 2016

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

3.2 Terrestrial ice and ecosystems

3.2.2 Coordinate and integrate terrestrial ecosystem research efforts

- **3.2.2.a (Milestone met) Databases Project metadata (information about projects) currently maintained by NSSI, NSF, USGS, the Arctic LCC, and non-governmental groups are made available on one website or via one access point web services that conform to the Alaska Data Integration working group (ADIwg) standards. These data are available from both the original source agency or from any of several designated data aggregators; DOI, NSF; Target Date 2013**
 - Completion Statement: Through the ACCER-formed ADIwg, a common set of project metadata standards have been produced, allowing users to “discover” project data on one of three data aggregators (NSSI-GINA, AOOS and ARMAP). Current partners agreeing to ADIwg, metadata standards include: Arctic LCC, ARMap (NSF), BLM, BOEM, FWS, NSSI/GINA, NPRB, NPS, USARCE, USGS (Sep 2, 2016 - Completed)
 - ADIwg produced a toolkit that will provide the capability to serve project records in the preferred ISO format. (May 22, 2015 - Completed)
 - ADIwg has developed a set of flexible, open source tools that organizations can integrate into their existing workflows and computer systems to generate ISO metadata without the necessity of mastering the complex ISO standard. (Nov 21, 2014 - Completed)
 - The CAFF CBMP, UAF GINA, NSSI and the Polar Data Catalog are working on sharing geospatial information with other circumpolar Arctic entities. (Jul 15, 2014 - Completed)
 - The NSSI is working with Aboriginal Affairs and Northern Development Canada, as part of the US/Canada Northern Oil and Gas Research Forum(s) to share geospatial information in the Beaufort and Mackenzie areas. (Jul 15, 2014 - Completed)
- **3.2.2.b (Milestone met) Review of completed and summarized high level summary documents involving cross-disciplinary collaboration that have been produced by groups like NSSI and ACCER to ascertain 1) what has been done, 2) what is being done, and then 3) identify any outstanding gaps and needs.; DOI (Lead); Target Date 2014**
 - Completion Statement: This milestone was rescoped in January 2015 to acknowledge the ongoing work of several organizations and the need to identify gaps and needs. This

milestone has been discussed in TECT monthly meetings with six documents reviewed (attached). This milestone is complete, however, comments and additions continue to be added. <http://www.iarpccollaborations.org/members/documents/3098>. (Sep 1, 2016 - Completed)

- The gaps and needs summary has been revised and will be posted it on the website for further additions by the collaboration team. Discussion took place on how this effort compliments a similar effort of the CBCT to develop an ecosystems framework in the marine realm. (Sep 17, 2015 - Completed)
- This milestone has been discussed in TECT monthly meetings with six documents reviewed. This milestone is complete, however, comments and additions continue to be added. <http://www.iarpccollaborations.org/members/documents/3098>. (Sep 17, 2015 - Completed)
- Review of high level summary documents that have been produced by groups like NSSI and ACCER, or that may be in recent published literature, that have identified what priorities are needed to address outstanding Arctic study gaps and needs within the U.S. Arctic region. (Jan 20, 2015 - Completed)
- During the January 2015 meeting, the team agreed to re-scope the milestone to acknowledge the work of many organizations, take an assessment of what is being done, and to identify gaps and needs. (Jan 20, 2015 - Completed)
- Draft a definition of "cross-disciplinary." Philip Martin provided a possible definition which can be further considered by the collaboration team. See the definition under documents associated with milestone 3.2.2.b (Jul 14, 2014 - Completed)
- Provide list of activities using ARMAP. (Jun 26, 2014 - Completed)
- ARMAP serves as a database where we can see what activities are ongoing. However, the issue remains about what is meant by cross-disciplinary. (Jun 20, 2014 - Completed)
- NSSI is called to coordinate and summarize information so that it is accessible and discoverable. The milestone language was accepted during the June 2013 discussion. (Jun 21, 2013 - Completed)
- **3.2.2.c (Milestone met) Data metadata (information about data) currently maintained by NSSI, NSF, USGS, the Arctic LCC, and non-governmental groups are made available via web services that conform to the Alaska Data Integration working group (ADIwg) standards. These data are available from both the original source agency or from any of several designated data aggregators; DOI (Lead); Target Date 2016**
- Completion Statement: An ISO Developer's Toolkit is now completed, tested, and published as version 1.0 products that allows data metadata (information about data) currently maintained by NSSI, NSF, USGS, the Arctic LCC, and non-governmental groups are made available via web services that conform to the Alaska Data Integration working group (ADIwg) standards. (Sep 1, 2016 - Completed)

- Data metadata (information about data) currently maintained by NSSI, NSF, USGS, the Arctic LCC, and non-governmental groups are made available via web services that conform to the Alaska Data Integration working group (ADIwg) standards. These data are available from both the original source agency or from any of several designated data aggregators. These data can be made available by using a series of metadata transformation associated tool kits - Open Source code on GitHub (<https://github.com/adiwg>), publicly hosted mdTranslator (<http://mdtranslator.adiwg.org/>), mdTools (understanding and testing mdJson) - mdJson schema definition, mdJson file validation, Submit mdJson to mdTranslator (<http://www.adiwg.org/mdTools/>), RubyGems (code libraries; <https://rubygems.org/>). (Jul 1, 2015 - Completed)
- An ISO Developer's Toolkit is now completed, tested, and published as version 1.0 products that allows data metadata (information about data) currently maintained by NSSI, NSF, USGS, the Arctic LCC, and non-governmental groups are made available via web services that conform to the Alaska Data Integration working group (ADIwg) standards. The tools have been extended to include support for data entities and attributes. Entities and attributes are documented in ISO using the ISO 19110 Feature Catalog standard. Some work still remains to complete documentation for the toolkit. A new metadata output was added to the toolkit that generates a 'human-readable' metadata format in HTML. One more tool is planned for the ISO toolkit intended to assist independent researchers with access to the ISO Tools. This is an online metadata editor linked to the toolkit. Work will begin on the editor this summer after the ISO Standards in Action presentation. (Apr 13, 2015 - Completed)
- ADIwg (Alaska Data Integration working group) is working on a multi-year, open source toolkit to help organizations become ISO metadata compliant. ADIwg received \$50K as partial financial assistance in FY2013 from the National Climate Change Wildlife Science Center (NCCWSC) and \$45K from USGS Community for Data Integration (CDI) in FY2014. We are currently writing a supplemental proposal to CDI for additional FY2014 funding and FY2015 funding. The toolkit allows both project and data metadata to be encoded in simple ADIwg JSON (JavaScript Object Notation) to be translated into the complex ISO XML metadata structure without having to learn ISO metadata. The prototypes, schema, JSON readers, and ISO writers have been completed for delivery of a robust ISO 19115-2 metadata record. Our current tasks are to document the toolkit for developers and establish hosted web services for these tools. (May 16, 2014 - Completed)
- **3.2.2.d (Milestone met) Facilitate the completion of the Alaska portion of a Circumboreal Vegetation Map as a baseline ecological documentation of boreal watersheds which contribute significantly to the Arctic through freshwater inputs, including carbon compounds and nutrients, and impact climate through carbon release due to changes in boreal forest permafrost.; USGS (Lead); Target Date 2016**
- Milestone 3.2.2.d has been completed with the publishing of The Alaska-Yukon Region of the Circumboreal Vegetation Map (CBVM) report and map by the Arctic Council CAFF Working Group. The report is available at <http://caff.is/strategies-series/359-the->

[alaska-yukon-region-of-the-circumboreal-vegetation-map-cbvm](#). The map and geospatial data are available at

<http://geo.abds.is/geonetwork/srv/eng/catalog.search#/metadata/58c9b318-e7a2-41d2-ae9b-4f0fb1e8d300>. (Sep 15, 2016 - Completed)

- The original scope of Milestone 3.2.2.d was circumpolar in nature. Due to a lack of international capacity to complete the remaining non-U.S. portions of the map, the TECT has decided that this milestone will be de-scoped to only include the U.S., i.e. Alaska, portion of the map. The original milestone was written as: Facilitate the completion of a Circumboreal Vegetation Map- a global map of the circumboreal forest biome with a common legend- as a baseline ecological documentation of boreal watersheds which contribute significantly to the Arctic through freshwater inputs, including carbon compounds and nutrients, and impact climate through carbon release due to changes in boreal forest permafrost. The updated milestone will read: Facilitate the completion of the Alaska portion of a Circumboreal Vegetation Map as a baseline ecological documentation of boreal watersheds which contribute significantly to the Arctic through freshwater inputs, including carbon compounds and nutrients, and impact climate through carbon release due to changes in boreal forest permafrost. (Sep 15, 2016 - Completed)
- Team Leader, Rebecca Anderson (USGS), provided an update on the CBVM project. Mapping of the Alaska-Yukon boreal region is complete and the project report was accepted by the Arctic Council CAFF Management Board, a partner on the project, at their September 2015 meeting in Tromsø, Norway. The report will be available in print on the CAFF website in early 2016. For more information, see <http://www.iarpcollaborations.org/members/documents/3340>. (Oct 19, 2015 - Completed)
- The report for the Alaska and Northwest Canadian Boreal portion of the CBVM map has been published and is available on the CAFF website: <http://caff.is/strategies-series/359-the-alaska-yukon-region-of-the-circumboreal-vegetation-map-cbvm>. The data is available at <http://geo.abds.is/geonetwork/srv/eng/catalog.search#/metadata/58c9b318-e7a2-41d2-ae9b-4f0fb1e8d300>. (Oct 1, 2015 - Completed)
- The report on the Alaska and Northwest Canadian Boreal portion of the Circumboreal Vegetation Map (CBVM) was accepted by the Arctic Council CAFF Management Board at their September 2015 meeting in Troms, Norway. The CBVM is a project under the CAFF Flora Group. (Sep 18, 2015 - Completed)
- The Alaska and Northwest Canadian Boreal portion of the CBVM map has been completed and the project report will go to the Arctic Council CAFF Management Board for approval at their Sept 2015 meeting in Tromsø, Norway (Sep 7, 2015 - Completed)
- This milestone was added by the Federal members of the TECT in August 2015. For a full description and background documents, please see <http://www.iarpcollaborations.org/members/documents/2949>. (Sep 2, 2015 - Completed)
- **3.2.2.e (Deactivated) Harmonize the Circumpolar Arctic Vegetation Map and the Circumboreal Vegetation Map into one map, available as a geospatial**

dataset, for use in applications such as climate modeling, studies of boreal biota and biodiversity, and landscape-level analysis.; BOEM; Target Date 2016

- Due to a lack of international capacity to complete the Circumboreal Vegetation Map (CBVM) portion of this project, this Milestone 3.2.2.e cannot be accomplished and has been deactivated. (Sep 15, 2016 - Completed)
- A CBVM position paper was presented to the CAFF Management Board Meeting in Tromsø to garner more international support for the completion of this milestone. (Sep 18, 2015 - Completed)
- This milestone was added in August 2015 by the Federal members of the TECT. Full description of the discussion and background information at <http://www.iarpccollaborations.org/members/documents/2950>. (Sep 2, 2015 - Completed)

3.2.3 Identify and study key sites where climate feedbacks are active, including permafrost, snow, hydrates, and glaciers

- **3.2.3.a (Milestone met) Consult with local communities on the geographical areas of traditional use that are most impacted by changes in the terrestrial cryosphere, as well as the types of changes—permafrost thaw, coastal erosion, vegetation—most relevant to local communities.; DOI (Lead); Target Date 2014**
- (Completion Statement): Given the breadth of research, workshops, and reports document on engaging community members about the areas of traditional use most impacted by changes in the terrestrial cryosphere, this milestone has been closed as completed. (Sep 27, 2016 - Completed)
- This milestone, 3.2.3.a, was decoupled from milestone 3.2.3.b and reinstated as the original milestone language (Milestone 3.2.3.b was also reinstated to the original milestone language) to most accurately report on the original intent of the Arctic Research Plan: FY2013-2017, Section 3.2.3 Identify and study key sites where climate feedbacks are active, including permafrost, snow, hydrates, and glaciers. The combined milestone language: Use local traditional knowledge, GIS data and integrated models layers to help understand the relationships among climate, land use changes, ecosystem services, village subsistence systems, and food security. Use that information to explore the implications of possible futures with local and regional decision makers. This milestone was reinstated to the original milestone language: Consult with local communities on the geographical areas of traditional use that are most impacted by changes in the terrestrial cryosphere, as well as the types of changes— permafrost thaw, coastal erosion, vegetation —most relevant to local communities. (Sep 15, 2016 - Completed)
- Yukon-Kuskokwim Delta Berry Outlook: Identifying berry vulnerabilities to climate and landscape change using local knowledge and other ecological data Contact: Rachel Loehman (U.S. Geological Survey, Alaska Science Center, rloehman@usgs.gov). Berry-

producing plants are extremely important to human and wildlife communities of the Yukon-Kuskokwim (YK) Delta. Snow cover, rainfall, soil moisture, air temperature, availability of insect pollinators, and seasonal weather extremes influence berry yield can be influenced by. Increased frequency of storm surges, tidal inundation, and permafrost deterioration alter berry habitat. Climate changes significantly impact all of those variables, and thus berry yields. We currently lack necessary tools and data to predict how climate change can alter the distribution and productivity of berry-producing plants. Rachel Loehman, USGS, is leading the development of a data- and observer-driven ecological monitoring and modeling framework that forecasts changes in berry habitat and abundance with climate and environmental change (“Berry Outlook”). She constructs the Berry Outlook using Bayesian Network models that are ideal for representing ecological relationships in systems where quantitative data are complemented by local ecological knowledge (LEK), as is the case in the YK Delta. This project provides important information on the relationships among climate, land-use changes, ecosystems, and village-subsistence systems in formats that can address the implications of possible futures with local and regional decision makers. (Sep 12, 2016 - Completed)

- Changing times, changing stories: generational differences in climate change perspectives from four remote indigenous communities in Subarctic Alaska Contact: Nicole M. Herman-Mercer (U.S. Geological Survey, National Research Program, Lakewood, Colorado, nhmerc@usgs.gov). Indigenous Arctic and Subarctic communities currently are facing a myriad of social and environmental changes. In response to these changes, studies concerning indigenous knowledge (IK) and climate change vulnerability, resiliency, and adaptation have increased dramatically in recent years. Risks to lives and livelihoods are often the focus of adaptation research; however, the cultural dimensions of climate change are equally important because cultural dimensions inform perceptions of risk. Furthermore, many Arctic and Subarctic IK climate change studies document observations of change and knowledge of the elders and older generations in a community, but few include the perspectives of the younger population. These observations by elders and older generations form a historical baseline record of weather and climate observations in these regions. However, many indigenous Arctic and Subarctic communities are composed of primarily younger residents. We focused on the differences in the cultural dimensions of climate change found between young adults and elders. We outlined the findings from interviews conducted in four indigenous communities in Subarctic Alaska. The findings revealed that (1) intergenerational observations of change were common among interview participants in all four communities, (2) older generations observed more overall change than younger generations interviewed by us, and (3) how change was perceived varied between generations. We defined “observations” as the specific examples of environmental and weather change that were described, whereas “perceptions” referred to the manner in which these observations of change were understood and contextualized by the interview participants. Understanding the differences in generational observations and perceptions of change are key issues in the development of climate change adaptation strategies. Herman-Mercer, N. M., E. Matkin, M. J. Laituri, R. C. Toohey, M. Massey, K. Elder, P. F. Schuster, and E. A. Mutter. 2016. Changing times, changing stories: generational differences in climate change perspectives from four remote indigenous communities in

Subarctic Alaska. Ecology and Society 21(3):28. <http://dx.doi.org/10.5751/ES-08463-210328>, <http://www.ecologyandsociety.org/vol21/iss3/art28/>. (Sep 9, 2016 - Completed)

- This milestone was re-scoped and combined with 3.2.3.b (3.2.3.b was then deactivated). The due date was moved to 2014 in order to accommodate extra work required. The new milestone reads: "Use local traditional knowledge, GIS data and integrated model layers to help understand the relationships among climate, land use changes, ecosystem services, village subsistence systems, and food security. Use that information to explore the implications of possible futures with local and regional decision makers." (Sep 1, 2016 - Completed)
- **Exchange for Local Observations and Knowledge of the Arctic (ELOKA)** Contact: ELOKA, National Snow and Ice Data Center, eloka@nsidc.org. ELOKA facilitates the collection, preservation, exchange, and use of local observations and knowledge of the Arctic. ELOKA provides data management and user support, and fosters collaboration between resident Arctic experts and visiting researchers. <https://eloka-arctic.org/>. (Sep 1, 2016 - Completed)
- **The North Slope Arctic Scenarios Project (NASP): Envisioning Desirable Futures and Strategizing Pathways for Sustainable Healthy Communities.** Contact: Amy Lovecraft (Project Coordinator, University of Alaska Fairbanks, alovecraft@alaska.edu). The North Slope Arctic Scenarios Project (NASP) engages representatives from sectors across Northwest Arctic Borough and North Slope Borough in scenarios development related to key aspects of healthy communities: "peace, shelter, education, food, income, a stable ecosystem, sustainable resources, social justice and equity". As state, national, and international pressures on decision-making in the North Slope geographic region rise, our project facilitates local-scale self-definition, policy discussion, and planning through a futures visioning process. Our primary objectives are to learn from the communities of the two boroughs their vision for healthy sustainable communities, to foster novel communication and organization across different decision-makers, and to move beyond narrative discussions to plausibility and consistency analysis of the scenarios in order to develop locally significant social and environmental variables to monitor for desired long-term outcomes. Our project fosters cross-borough development of "communities of practice" across social, environmental, education, health, government, and economic sectors to facilitate better communication of policy needs and goals. Furthermore, our project targets the young people of the region to engage in the scenarios process. Often overlooked but vital to shaping the future we will include them in age-appropriate roles throughout the process as future leaders. The participatory scenario workshops for NASP are completed. The team is currently working on a report and several papers that will be completed in the spring of 2017. <https://sites.google.com/a/alaska.edu/north-by-2020/current-projects/nasp>. (Sep 1, 2016 - Completed)
- **The Local Environmental Observer (LEO) Network: The eyes, ears, and voice of our changing environment** Contact: Center for Climate and Health, Alaska Native Tribal Health Consortium, ask.leonetwork@gmail.com. LEO is a network of local observers and topic experts who share knowledge about unusual animal, environment, and weather events. With LEO, you can connect with others in your community, share observations, raise awareness, and find answers about significant environmental events. You can also engage with topic experts in many different organizations and become part

of a broader observer community. LEO tracks locally reported events of unusual change (LEO), which does include observations related to subsistence resources. LEO has also performed local interviews to describe climate - subsistence connections.

<https://www.leonetnetwork.org/en/> (Sep 1, 2016 - Completed)

- **Scenarios for North Slope Development and Related Science Needs** Contact: John Payne (North Slope Science Initiative, jpayne@blm.gov) The use of scenarios was identified by the North Slope Science Initiative (NSSI) Oversight Group as a potentially important tool in helping identify future research and monitoring needs. Scenarios can provide a means to identify a plausible range of pathways by which an uncertain future may unfold. In that way, they can then be used to help guide agency considerations for how to effectively target research and monitoring efforts in a manner that will be most useful for resource management decision-making under uncertain future conditions. A collaboration to undertake that scenarios project was formed between NSSI, the University of Alaska Fairbanks, and GeoAdaptive, LLC, an internationally experienced geospatial scenarios consultant. The focal question for the scenarios effort is: “What is the future of energy development, resource extraction, and associated support activities on the North Slope and adjacent seas through 2040?” Scenarios meetings and workshops included participation from community interests such as the Arctic Slope Regional Corporation [ASRC], the Alaska Eskimo Whaling Commission Nuiqsut City Council, Kaktovik City Council, Atkasuk City Council, Inupiat Community of the Arctic Slope, North Slope Borough. This work with the NSSI Scenarios Project is relevant because input was given from communities on shifts in areas of use. Project Reports: Prioritizing Science Needs Through Participatory Scenarios – Summary Report: http://www.northslope.org/media/doc/2016/Aug/NSSI-Summary_report-2016-08-FINAL.pdf. Prioritizing Science needs “Through Participatory Scenarios – Technical Report”: http://www.northslope.org/media/doc/2016/Aug/NSSI-Final_revised_report-with_annex2016-08.pdf <http://northslope.org/scenarios/>. (Aug 1, 2016 - Completed)
- **Arctic Observatory & Knowledge Hub (A-OK) Workshop Summary** Contact: Olivia Lee (University of Alaska Fairbanks, olee@alaska.edu) The Alaska Observatory and Knowledge Hub (A-OK) is meant to support information exchange and environmental observations by Iñupiaq experts in coastal communities. The A-OK planning workshop was hosted by the International Arctic Research Center (IARC) at UAF as the first step in obtaining input and guidance from community and organizational leaders in Alaska’s coastal Arctic about what specifically A-OK should focus on. Concerns and ideas identified during the workshop will become the starting point for developing specific goals and objectives for the A-OK project. Tentative goals of the A-OK project identified prior to the planning workshop included, 1) expanding current community-based observing efforts to further support the integration of local knowledge in climate change observing networks (with changing permafrost, snow and ice as a center of attention) and 2) developing a collaborative framework among communities, organizations, and researchers that link scientific data with local and traditional knowledge in ways that might support North Slope communities in climate change adaptation. Detailed projects objectives of the A-OK project had not been identified prior to the planning workshop in an effort to provide adequate flexibility in shaping the direction and focus on the project to fit the concerns of North Slope communities. Focus questions for the A-OK planning workshop that guided the discussion and presentations

included: • How can the A-OK project strengthen and sustain an Iñupiaq snow & ice experts observing network? • What key community concerns or hazards related to changes in snow, sea ice, permafrost or lake & river ice conditions should the A-OK project address such as impact on food security, access to subsistence resources, safety, etc.? • Which of these identified concerns or hazards can be measured through the deployment of measuring packets to community snow and ice experts and users? • How can the information that is collected and shared contribute to emergency response and search & rescue efforts? <http://www.iarpcollaborations.org/members/documents/7134>. (Aug 1, 2016 - Completed)

- AFE Session on Traditional Knowledge in Ecosystems Models An Alaska Forum on the Environment 2016 session presentation was coordinated by Vanessa Skean, USGS, on the use of traditional knowledge in ecosystems models covering 1) ecosystem modeling (Jeremy Littell); 2) WILDCAST (Tony DeGange); and 3) the intersection of local knowledge, subsistence and ecosystem models (Henry Huntington). <http://www.iarpcollaborations.org/members/updates/3652>. (Jan 25, 2016 - Completed)
- **General List of Citations Related to Milestone 3.2.3.a**
 - Adams, Megan S., Jennifer Carpenter, Jess A. Housty, Douglass Neasloss, Paul C. Paquet, Christina Service, Jennifer Walkus, and Chris T. Darimont. 2014. “Toward Increased Engagement between Academic and Indigenous Community Partners in Ecological Research.” *Ecology and Society* 19 (3): 5.
 - Ambrose, William G., Lisa M. Clough, Jeffrey C. Johnson, Michael Greenacre, David C. Griffith, Michael L. Carroll, and Alex Whiting. 2014. “Interpreting Environmental Change in Coastal Alaska Using Traditional and Scientific Ecological Knowledge.” *Frontiers in Marine Science* 1 (40): 1–15.
 - Beach, Dylan, and Douglas A. Clark. 2015. “Scenario Planning during Rapid Ecological Change: Lessons and Perspectives from Workshops with Southwest Yukon Wildlife Managers.” *Ecology and Society* 20 (1): 61.
 - Bone, Christopher, Lillian Alessa, Mark Altaweel, Andrew Kliskey, and Richard Lammers. 2011. “Assessing the Impacts of Local Knowledge and Technology on Climate Change Vulnerability in Remote Communities.” *International Journal of Environmental Research and Public Health* 8: 733–61.
 - Carothers, Courtney, Caroline Brown, Katie J. Moerlein, J. Andres Lopez, David B. Anderson, and Brittany Retherford. 2014. “Measuring Perceptions of Climate Change in Northern Alaska: Pairing Ethnography with Cultural Consensus Analysis.” *Ecology and Society* 19 (4): 27.
 - Cater, Timothy C., Charles Hopson, and Bill Streever. 2015. “The Use of the Iñupiaq Technique of Tundra Sodding to Rehabilitate Wetlands in Northern Alaska.” *Arctic* 68 (4): 435–44.
 - Cruikshank, J. 2001. Glaciers and climate change: perspectives from oral tradition. *Arctic* 54(4):377-383. <http://dx.doi.org/10.14430/arctic795>

- Fox, S. 2002. These are things that are really happening: Inuit perspectives on the evidence and impacts of climate change in Nunavut. Pages 12-53 in I. Krupnik and D. Jolly, editors. *The earth is faster now: indigenous observations of Arctic environmental change*. Arctic Research Consortium of the United States, Fairbanks, Alaska, USA.
- Gadamus, Lily, Julie Raymond-Yakoubian, Roy Ashenfelter, Austin Ahmasuk, Vera Metcalf, and George Noongwook. 2015. "Building An Indigenous Evidence-Base for Tribally-Led Habitat Conservation Policies." *Marine Policy* 62: 116–24.
- Herman-Mercer, N., P. Schuster, and K. Maracle. 2011. Indigenous observations of climate change in the Lower Yukon River Basin, Alaska. *Human Organization* 70(3):244-252.
<http://dx.doi.org/10.17730/humo.70.3.v88841235897071m>
- Hupp, Jerry, Michael Brubaker, Kira Wilkinson, and Jennifer Williamson. 2015. "How Are Your Berries? Perspectives of Alaska's Environmental Managers on Trends in Wild Berry Abundance." *International Journal of Circumpolar Health* 74 (28704): 9.
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- Moerlein, K. J., and C. Carothers. 2012. Total environment of change: impacts of climate change and social transition on subsistence fisheries in northwest Alaska. *Ecology and Society* 17(1):10.
<http://dx.doi.org/10.5751/es-04543-170110>
- Nuttall, M. 2001. Indigenous peoples and climate change research in the Arctic. *Indigenous Affairs* 4/01:26-33.
- Vinyeta, Kristen, and Kathy Lynn. 2013. "Exploring the Role of Traditional Ecological Knowledge in Climate Change Initiatives." General Technical Report PNW-GTR-879. USDA Forest Service Pacific Northwest Research Station.
- Wilson, N. J. 2014. The politics of adaptation: subsistence livelihoods and vulnerability to climate change in the Koyukon Athabascan village of Ruby, Alaska. *Human Ecology* 42:87-101.
<http://dx.doi.org/10.1007/s10745-013-9619-3> (Dec 31, 2015 - Completed)
- **Projected changes in wildlife habitats in Arctic natural areas of northwest Alaska**
This Wildcast publication explores the implications of possible future scenarios.
<http://link.springer.com/article/10.1007%2Fs10584-015-1354-x>. (Sep 3, 2015 - Completed)
- New wording for this milestone was introduced. Comments can be found at
<http://www.iarpccollaborations.org/members/documents/2186>. (Completed Sep 3, 2015)
(Sep 3, 2015 - Completed)

- NSSI has started a scenario planning exercise including an effort related to ecosystem services and village subsistence systems. (Sep 3, 2015 - Completed)
- **A needs assessment and work plan development for coastal change outreach on the Beaufort Sea coast, Alaska** Contact: Li Erikson (U.S. Geological Survey, lerikson@usgs.gov). Maureen Correll (University of Maine, maureen.correll@maine.edu) with funding from the Arctic LCC (<http://arcticlcc.org>). The Beaufort Sea coast in arctic Alaska and neighboring northern Canada has recently experienced extreme and accelerated climate change, including a dramatic reduction in summer sea ice. This absence of ice allows increased wind and wave energy to directly affect the coast, resulting in island and mainland flooding, coastal erosion, and further movement of barrier islands and beaches. The period each year in which the arctic is free of summer ice is increasing and is predicted to increase non-linearly in the future. This suggests a “tipping point” has been reached, producing internal feedback mechanisms that will further accelerate coastal change. This needs assessment for arctic coastal managers, which included informal interviews with representatives from the federal and state government, as well as community organizations including the Native Village of Kaktovik (NVK), Kaktovik Inupiat Corporation (KIC), and the City of Kaktovik, will specifically: 1) Identify current, broad interests for ongoing coastal research in the arctic; 2) Identify the best mechanisms and format for communicating coastal research outcomes to area stakeholders; 3) Define the characteristics and requirements for a visualization tool for Beaufort/Chukchi Sea coastal change that addresses stakeholder concerns and questions. (Mar 4, 2015 - Completed)
- Identify available GIS-format data sets that describe geographical areas of traditional use and important subsistence resources. NW Arctic Borough Subsistence Mapping Project presentation to the Collaboration Team. (Jun 26, 2014 - Completed)
- **Strategic Needs of Water on the Yukon: An Interdisciplinary Approach to Studying Hydrology and Climate Change in the Lower Yukon River Basin** Contact: Nicole M. Herman-Mercer (U.S. Geological Survey, National Research Program, Lakewood, Colorado, nhmerc@usgs.gov). Strategic Needs of Water on the Yukon (SNOWY) is an interdisciplinary research project funded by the National Science Foundation (NSF; <http://www.nsf.gov/>). The SNOWY team is made up of a diverse group of researchers from different backgrounds and organizations. This partnership between scientists from different disciplines (hydrology, geography, and social science), government agencies, nonprofit organizations, universities, and Lower Yukon River Basin (LYRB) and Yukon-Kuskokwim (YK) Delta communities provided an opportunity to study the effects of climate change using a holistic approach. The Arctic and Subarctic are experiencing environmental change at a rate faster than the rest of the world, and the lack of historical baseline data in these often remote locations makes understanding and predicting regional climate change difficult. This project focused on collecting data to fill in these gaps by using both quantitative and qualitative methodologies to tell the story of environmental change in this region as told by the physical data and the people who rely on this landscape. The researchers conducted participatory mapping workshops in three communities and conducted interviews both focused on climate change, landscape change, and subsistence (including species, seasonal timing, and impacts of climate change). Interview questions covered the themes of seasonal shift and water resources (in

all its forms: snow, ice, lakes, rivers, ocean, and other forms of precipitation). An online atlas was created for this project with the folks at Exchange for Local Observations and Knowledge of the Arctic (ELOKA): <http://staging.eloka-arctic.org/communities/snowy/atlas/index.html>
<http://www.iarpccollaborations.org/members/documents/7132>
<http://www.iarpccollaborations.org/members/documents/7133> (May 30, 2014 - Completed)

- **Project Jukebox: Digital Branch of the University of Alaska Fairbanks Oral History Program** Contact: Leslie McCartney (Curator of Oral History, University of Alaska Fairbanks, lmccartney@alaska.edu). Project Jukebox is the digital branch of the Oral History Program at the University of Alaska Fairbanks. Project Jukebox integrates oral history recordings with associated photographs, maps, and text. They have over 50 projects from throughout Alaska, each specific to a topic or an area, including recorded oral histories on sea ice and other landscape changes. They are constantly creating more and eventually hope to make all the recordings in their oral history collection digitally available. Permission and ethical issues about making people's recordings so widely accessible have slowed the process of putting more projects online. Contact Leslie McCartney, the Curator of Oral History, at lmccartney@alaska.edu for more information about the Project Jukebox. <http://jukebox.uaf.edu/site7/>. (May 31, 2013 - Completed)
- **A needs assessment and work plan development for coastal change outreach on the Beaufort Sea coast, Alaska** Contact: Maureen Correll (Bird Conservancy of the Rockies, Fort Collins, Colorado, maureen.correll@birdconservancy.org)

The Beaufort Sea coast in arctic Alaska and neighboring northern Canada has recently experienced extreme and accelerated climate change, including a dramatic reduction in summer sea ice. This absence of ice allows increased wind and wave energy to directly affect the coast, resulting in island and mainland flooding, coastal erosion, and further movement of barrier islands and beaches. The period each year in which the arctic is free of summer ice is increasing and is predicted to increase non-linearly in the future. This suggests a “tipping point”; has been reached, producing internal feedback mechanisms that will further accelerate coastal change.

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- 1) Identify current, broad interests for ongoing coastal research in the arctic
- 2) Identify the best mechanisms and format for communicating coastal research outcomes to area stakeholders

3) Define the characteristics and requirements for a visualization tool for Beaufort/Chukchi Sea coastal change that addresses stakeholder concerns and questions

Correll, M.D. 2014. A needs assessment and work plan development for coastal change outreach on the Beaufort Sea Coast, AK. Final Report. Arctic Landscape Conservation Cooperative, Fairbanks, AK, USA.

<http://www.iarpccollaborations.org/members/documents/7144>

- **3.2.3.b (Deactivated) Identify and compile Geographic Information Systems (GIS) data layers of existing climate feed-back research in the Arctic and compare with areas of important traditional use; DOI (Lead); Target Date 2014**

- (Continuation statement) The original intent of Milestone 3.2.3.b Identify and compile Geographic Information Systems (GIS) data layers of existing climate feed-back research in the Arctic and compare with areas of important traditional use, was to ensure important information regarding geographic extent of traditional use areas and changes to the landscape from climate impacts, were being understood. Since the establishment of this milestone, the dialog regarding appropriate, respectful, and meaningful ways for researchers to engage with Arctic residents, including community members, traditional knowledge holders, and local ecological knowledge holders has moved from requesting information such as GIS data layers, to engagement. Rather than identifying, compiling, and comparing GIS data layers, the forthcoming Arctic Research Plan: FY2017-2021 contains performance elements related to the engagement of community members, traditional knowledge holders, and local ecological knowledge holders throughout the research process (from project inception to delivering results) and in knowledge co-production processes that involve multiple knowledge systems. The important work on started with this milestone will continue with the aforementioned performance elements under the next Arctic Research Plan: FY2017-2021. (Sep 16, 2016 - Completed)
- This milestone was decoupled from milestone 3.2.3.a and reinstated as the original milestone language (Milestone 3.2.3.a was also reinstated to the original milestone language) to most accurately report on the original intent of the Arctic Research Plan: FY2013-2017, Section 3.2.3 Identify and study key sites where climate feedbacks are active, including permafrost, snow, hydrates, and glaciers. (Sep 15, 2016 - Completed)
- This milestone was combined with 3.2.3.a and re-scoped. The due date was extended to 2014 to accommodate work plan. (Jul 15, 2014 - Completed)

- **3.2.3.c (Milestone met) Complete Wildlife Potential Habitat Forecasting Framework (WILDCAST) projections of potential land cover and habitat changes in Northern Alaska; DOI (Lead); Target Date 2012**

- In August 2015, NASA selected 21 proposals for the initial research investigations to begin the Arctic-Boreal Vulnerability Experiment (ABOVE) field campaign—a large-

scale study of ecosystem responses to environmental change in western North America's Arctic and boreal region and the implications for social-ecological systems. In the coming year, this program should begin contributing to progress in achieving this milestone. A recently awarded NASA-project for ABoVE addresses this milestone as follows: "Assessing Alpine Ecosystem Vulnerability to Environmental Change Using Dall Sheep as an Iconic Indicator Species" project. This project will investigate how changes in snow and vegetation cover have affected Dall sheep populations throughout their entire range in Alaska and Canada. (Completed Oct 2, 2015) (Oct 2, 2015 - Completed)

- Completion Statement: WILDCAST was a combined effort of the USGS, NPS, and USFS, resulting in three publications. This project has been completed. Initial report is at: http://www.nps.gov/akso/nature/science/ak_park_science/PDF/Vol12-2/APS_Vol12-Issue2_66-73-DeGange.pdf. Other information on project products: www.iarpcollaborations.org/members/documents/6025. (Sep 17, 2014 - Completed)
- **3.2.3.d (Milestone met) Assess existing tools and methods for measuring and mapping the effects of cryosphere changes on Arctic ecosystems and communities, including water levels, sea level rise, salt water intrusion, and coastal inundation; DOI (Lead); Target Date 2013**
 - Completion Statement: A spreadsheet developed by agencies assessing existing tools and methods for measuring the mapping the effects of cryosphere changes on Arctic ecosystems is completed and available <http://www.iarpcollaborations.org/members/documents/2377>. (Sep 7, 2016 - Completed)
 - Milestone 3.2.3.d was created under the IARPC Arctic Research Plan to help the science community better understand and quantify the intensity and rate of changes to the cryosphere and Arctic environment, which may include terrestrial ice processes, ecosystem processes, ecosystem services, and climate feedbacks. This information could also be used to help better understand how climate-driven changes in different parts of the Arctic may affect a particular species, subsistence activities, and/or ecosystem services. To achieve this milestone, the TECT produced a spreadsheet developed by agencies that contains information on existing research activities that are, or can be used, for measuring the effects of cryosphere changes on Arctic ecosystems, and includes legacy deep borehole permafrost temperatures and long-term climate (site) data; water related databases (e.g., streamgauging, glacier mass balance, and water samples); information on terrestrial components (e.g., terrestrial plants, animals, soil, aquatic organisms, and sediment); remote sensing imagery on fire, permafrost, and other associated cryospheric physical parameters); coastal erosion; and geochemical and geophysical surveys. For a complete list of these activities, contact information, and websites, the spreadsheet can be found at <http://www.iarpcollaborations.org/members/documents/2377>). This completes the milestone. (Sep 5, 2016 - Completed)
 - Compile existing measuring and mapping information by creating and distributing a spreadsheet (<http://www.iarpcollaborations.org/members/documents/1807>) requesting information on current assessments, mapping, long/short term monitoring assessment

programs, models, etc. Federal members of the collaboration team provide their input to the Tools and Methods Spreadsheet. (May 22, 2015 - Completed)

- Inundation modeling for portions of the Beaufort, Chukchi, and Bering seas coasts is in progress, under partnerships between Western Alaska LCC, NOAA, USGS, and University of Alaska, Anchorage. (Nov 21, 2014 - Completed)
- Gary Clow (USGS) gave a presentation on DOI's Global Terrestrial Network for Permafrost (GTN-P), which addresses DOI needs and national priorities by helping track environmental change across the Arctic Slope. The network includes a deep borehole array and a climate station network that have observed multi-decadal data on air temperature, active layer temperature, and permafrost temperature. Key findings include a statistically significant warming trend of air temperature across the western Arctic Slope during autumn, increasing active-layer temperatures during all seasons except summer, permafrost temperatures warming 2-3K since 1990, and a jump of the discontinuous permafrost boundary to north of the Brooks Range. The presentation is available on this page as well as in the webinar archive for IARPC. (Nov 21, 2014 - Completed)
- The first ever comprehensive land-cover database has been completed and validated and will be available on GINA by the end of October. Baseline documentation and ecological mapping for 85% Alaska coastal zone has been accomplished through the ShoreZone project (<http://alaskafisheries.noaa.gov/shorezone/>) and high-resolution LiDAR Digital Elevation mapping of the Beaufort and Chukchi coast line was obtained by USGS and partners and available for download (<http://earthexplorer.usgs.gov/>). (May 17, 2013 - Completed)
- **3.2.3.e (Milestone met) Work with the Alaska Mapping Roundtable to Complete improved coastal map and high precision Digital Elevation Models (DEM) for western and northern Alaska in order to better understand coastal erosion, storm surges, and sea level rise; Target Date 2013**
 - (Completion Statement) Several primary outcomes of the Alaska Mapping Executive Committee (AMEC; formerly the Alaska Mapping Roundtable) official meetings held February 9, 2016 in Washington D.C. and June 21, 2016 in Anchorage, Alaska, have moved this milestone to completion, including the establishment of an 18-month tactical plan centered on enhanced coordination and acceleration of statewide Alaska mapping activities. In response to the plan, Federal agencies and the State of Alaska committed significant resources to realize several priority mapping goals that AMEC set for itself in the plan. These include:
 - Elevation data for all of Alaska north of 65-degrees now has been funded and acquired;
 - Over 78,300 square miles of 5-m resolution elevation data (IfSAR – Interferometric Synthetic Aperture Radar) funded and acquired in Alaska.
 - IfSAR acquisition was funded for significant portions of coastal Alaska including major segments of the Alaska National Wildlife Refuge and the Yukon- Kuskokwim Delta coastlines.

- 1660 square miles of high resolution lidar elevation data was funded for acquisition over a coastal region in the Yukon-Kuskokwim Delta where no IfSAR data is yet available. The acquisition specifies lidar collection at 2-4 points per square meter, and was funded by a consortium of partners through a 3D Elevation Program grant. (Sep 16, 2016 - Completed)
- While the due date indicates 2013, this is an ongoing activity. The TECT has continued to hear reports from the USGS on the progress of this milestone. (Sep 1, 2016 - Completed)
- The Polar Geospatial Center (PGC) has released the initial version of the Alaska portion of ArcticDEM, providing a valuable elevation product over many areas currently lacking IfSAR coverage, including portions of the Aleutians and the Alaska Peninsula. Future releases will provide additional coverage. The Arctic Spatial Data Infrastructure Board approved a position statement endorsing the PGC ArcticDEM product as a first generation solution for the Arctic Council's Pan-Arctic Digital Elevation Map Initiative. (Sep 1, 2016 - Completed)
- Following up after a February 9, 2016 meeting in Washington D.C., the Alaska Mapping Executive Committee (AMEC) met in Anchorage, Alaska on June 21, 2016. An 18-month tactical plan was reviewed and approved with multiple goals, including the acceleration of topographic mapping acquisition. As a result, a large influx of funding was contributed in fiscal year 2016 and used to acquire IfSAR elevation data over 63,400 square miles in northeast Alaska, which completed IfSAR acquisition for all Alaska lands north of 65-degrees latitude. (Jun 22, 2016 - Completed)
- The USGS coordinated a second international workshop to discuss development of an Arctic-wide elevation dataset in response to the Arctic Council's Pan-Arctic Digital Elevation Map Initiative. Elevation mapping experts from seven of the eight Arctic nations met with members of the Polar Geospatial Center (PGC) at the University of Minnesota in St. Paul, Minnesota, to discuss options for supporting PGC's ArcticDEM elevation data project. Several nations, including the United States, provided ancillary data and data reviews in support of ArcticDEM. (Apr 29, 2016 - Completed)
- This milestone is ongoing until all data have been acquired by the State of Alaska. Rebecca Anderson, team leader, will continue to report to this team on an annual basis. (Apr 15, 2016 - Completed)
- In October, 2015, the USGS coordinated an international workshop to discuss development of an Arctic-wide elevation dataset in response to the Arctic Council's Pan-Arctic Digital Elevation Map Initiative. Elevation mapping experts from the eight Arctic nations participated in a meeting (either in person or via remote connection) with members of the Polar Geospatial Center (PGC) in Waterloo, Canada to discuss options for supporting PGC's ArcticDEM elevation data project. Several nations, including the United States, provided ancillary data and data reviews in support of ArcticDEM. (Oct 30, 2015 - Completed)
- Along with the ifsar elevation data previously reported on for this milestone, an additional, related elevation product created jointly by NSF, the National Geospatial-Intelligence Agency (NGA) and the University of Minnesota Polar Geospatial Center

(PGC) will also be reported on for this milestone in the future. The ifsar elevation data is now 76% complete or in work (138,080 square miles) for Arctic Alaska (defined as 66 degrees latitude and above), with 24% remaining (43,211 square miles) at a cost estimate of \$5.2M. The NSF/NGA/PGC elevation dataset has not yet been released. For more information, see <http://www.iarpcollaborations.org/members/documents/3342>. (Oct 19, 2015 - Completed)

- The National Science Foundation (NSF), in collaboration with the National Geospatial-Intelligence Agency and the University of Minnesota's Polar Geospatial Center, is supporting development of high-resolution digital surface models of the Arctic that for the first time will provide repeatable coverage of the entire globally significant region, including Alaska. These Digital Elevation Models (DEMs), supported by a recent NSF award, will allow researchers to see in detail how warming in the region is affecting the landscape in remote areas by allowing them to compare changes to elevation in the region over time. This effort will complement the on-going Alaska Mapping Initiative, led by the U.S. Geological Survey (USGS)'s 3D Elevation Program with support coordinated through the Alaska Mapping Executive Committee (formerly Roundtable) and State of Alaska Geospatial Council to acquire high-resolution elevation data from interferometric synthetic aperture radar (ifsar), data that will be used to update topographic mapping in Alaska and used as a baseline for elevation data in Alaska.
<https://www.whitehouse.gov/blog/2015/09/02/using-new-elevation-data-explore-arctic>. (Sep 14, 2015 - Completed)
- The Alaska Mapping Executive Committee (formerly Roundtable) met in Anchorage on August 20, 2015 to continue coordination of updated digital elevation data for Alaska, including for western and northern Alaska. This meeting came just days after the Skybreaking II event in Anchorage, a celebration of achieving over 50% new digital elevation data coverage for Alaska, with presentations by Alaska Governor Bill Walker, Department of the Interior Secretary Sally Jewell and Senator Lisa Murkowski. It is estimated that new digital elevation data over Alaska will have been acquired for 60% of Alaska by the end of the 2015 federal fiscal year. (Sep 14, 2015 - Completed)
- The State of Alaska Statewide Digital Mapping Initiative (SDMI) and Alaska Mapping Executive Committee (AMEC) have been coordinating on the collection and purchase of new statewide 5-meter digital elevation data for Alaska using radar (ifsar) technologies. Data products include a Digital Terrain Model (DTM) portraying the bare surface of the earth, a Digital Surface Model (DSM) depicting the highest features on the landscape such as tree tops and buildings and an Orthorectified Radar Image (ORI). This data collection improves upon the Alaska statewide National Elevation Dataset (NED) which is at 60-meter resolution, was created from information on 1950s and 1960s era 1:63,360-scale topographic maps and contains significant errors. To date, 5-meter elevation data has been funded for over 255,000 square miles (44% of Alaska) mostly in northwest and central Alaska, and also including over 25,000 square miles in southeast Alaska funded in FY14. Near-term elevation data acquisitions and purchases will most likely continue to concentrate on southeast Alaska and the arctic, moving to southcentral and southwestern Alaska in subsequent years. The total cost to acquire statewide 5-meter elevation data for the state is estimated to be approximately \$52M. Given current funding assumptions, it is predicted that there will be a total funding gap around \$14.8M. As of FY13, the federal

government has provided over \$18M and the State of Alaska has contributed over \$9M to the data acquisition, closely matching the proposed federal 2/3-state 1/3 funding split based off of land status in the state. This new digital elevation data is being used to improve surface water mapping, or hydrography, in several areas of the state. Surface water mapping is coordinated through the Alaska Hydrography Technical Working Group (AHTWG), a statewide coordination body comprised of 10 federal and State agencies chartered under the Alaska Climate Change Executive Roundtable (ACCER). The elevation data is also a key input to the US Topo maps being developed for statewide coverage of Alaska. Currently, there are 412 US Topo maps available in Alaska, and over 600 are in production for FY14. US Topo maps are only created where the new digital elevation data and new SPOT 5 satellite imagery is available. Statewide Satellite Imagery Coverage and Higher Resolution Historical Aerial Photography Scans Available. The State of Alaska SDMI project to collect statewide coverage of SPOT 5 satellite imagery is in its final year and has collected 99% of Alaska. Due to cloud covered areas of the state, some off-specification scenes were assessed and accepted. All processed orthoimagery tiles are expected to be available in early 2015. EROS Data Center Long Term Archive (LTA) project has undertaken a project to rescan all of the Alaska historical aerial photography in conjunction with the scanning of the entire USGS/EROS film archive at 1000 dpi (1-meter pixel resolution for photos flown at 40,000 ft). Previously, these data were available at 400 dpi (2.5-meter pixel resolution for photos flown at 40,000 ft).

- The LTA has scanned 162,700 aerials out of the 184,000 Alaska frames accounting for over 88% of the Alaska aerials in the USGS/EROS archive, with plans to scan the remaining 21,000 frames by the end of FY14 in cooperation with the University of Minnesota's Polar Geospatial Center.
- The USGS/EROS archive includes the Alaska Aerial Photo Single Frames and High Resolution OrthoImagery categories in EarthExplorer. The USGS/EROS Alaska aerial photography collections span flight years from 1948 through the AHAP years of 1978-1986 and out to a 2013 flight over Anchorage. The pre-AHAP coverage includes U.S. Navy, Air Force, and other USGS mapping flights (ie; SEA, TAL, BAR, etc.). Also included is 2007 and 2010 coverage of the North Slope. The LTA is working with NOAA/NGS Remote Sensing Division to scan 1964 earthquake photography of Alaska, as well as aerial photography of the Denali fault from the 1970s.
- The data are available through Earth Explorer (<http://earthexplorer.usgs.gov>). Scanning will continue at USGS/EROS for years as long as funding is available. On-demand scanning services for a fee of \$30 per frame are also available for EROS film collections not already scanned or to support user requests for higher resolution scans (up to 7 micron for black & white film and 14 micron for color film). If other Alaska aerials are available to be scanned, the LTA will consider them as USGS/EROS continues to open up aerial photos for better access through EarthExplorer. (Jun 9, 2015 - Completed)

- The biennial report on digital elevation mapping effort highlighting linkages was submitted to the State and IARPC. (Sep 26, 2014 - Completed)
- Present updated information as needed on the Alaska Mapping Roundtable, Alaska Statewide Digital Mapping Initiative, and U.S. Geological Survey's Alaska Mapping Initiative. Rebecca Anderson, USGS, presented to the Collaboration Team in June. The full report is available under this milestone. (Jun 26, 2014 - Completed)
- **3.2.3.f (Milestone met) Conduct a pan-arctic analysis of permafrost dominated Arctic and boreal regions to: 1) identify gaps in our understanding of the magnitude and distribution of permafrost carbon stores; and 2) identify areas of permafrost that are potentially most vulnerable to carbon loss with continued warming; DOD, DOE, DOI, NASA, NSF; Target Date 2015**
 - (Completion Statement) Gaps in our understanding of permafrost carbon and the spatial distribution of permafrost vulnerability to degradation have been organized and addressed through multiple efforts across Federal and state agencies, academia, and international collaborators. These advances in process-based knowledge and in pan-Arctic quantification of permafrost-related parameters are framed and organized by activities of the Permafrost Carbon Network (PCN), which has completed its 5-Year Synthesis Report describing these advances. Research Goal 6 (Permafrost) within the Arctic Research Plan: FY2017-2021 Plan coordinates ongoing interagency efforts, and relates these efforts with U.S. Arctic Research Policy Drivers for the coming five-year period. (Sep 16, 2016 - Completed)
 - NASA's Arctic Boreal Vulnerability Experiment (ABOVE) research is contributing to this milestone in the following areas: Supporting the continuing collection of CO₂ and methane eddy covariance flux tower data at Barrow and Atkasuk. Continuing the collection of wintertime methane emissions from frozen lakes located in permafrost regions. Collection of winter soil respiration measurements in selected ecosystems across Alaska. Continuing to analyze atmospheric methane and CO₂ data collected during NASA's CARVE study over permafrost dominated landscapes. Installing weather stations and soil temperature probes at US Array-Alaska sites to increase the data needed to measure permafrost vulnerability. Conducting research at multiple tundra and boreal sites underlain by permafrost to quantify vulnerability of soil carbon to burning during fires. Conducting studies in recently burned tundra and boreal forest sites to monitor post-fire vulnerability of permafrost and soil carbon, including sites that are funded by NSF. Coordinating with research being funded by other U.S. Federal agencies, including research at the NGEE-Arctic sites in Barrow and the Seward Peninsula (funded by DOE), at the Healy permafrost warming site (funded by NSF), at the Bonanza Creek and Arctic LTERs (funded by NSF and USFS), and with a thermokarst modelling study (funded by USGS). (Aug 16, 2016 - Completed)
 - Permafrost Research Goal submitted for review in Federal Register within IARPC Strategic Plan FY17-21. Research Goal 6: Advance Understanding of Processes Controlling Permafrost Dynamics and the Impacts on Ecosystems, Infrastructure, and Climate Feedbacks. Authors: Andrew Balsler (USACE), Benjamin Jones (USGS), April

Melvin (AAAS-EPA). Coordinating federal research efforts within the Arctic for the next five years, and aligning them with U.S. policy drivers, is the essential function of this plan. Research Goal 6 addresses efforts to advance permafrost research across federal agencies, and identifies lead and cooperating agencies. The plan, as submitted to the Federal Register on July 26, 2016, is available at <http://www.iarpccollaborations.org/members/documents/5848> (Jul 26, 2016 - Completed)

- The Arctic Data Collaboration Team Meeting included a presentation on "Bridging across data barriers: From Arctic permafrost to global connections." . Of critical importance to the ultimate success of Arctic data efforts is the ability to connect data across geospatial and temporal scale, domain, and national boundary among other dimensions. While rarely can a project or program address all of these at once, partnering and collaboration offer mechanisms to advance data efforts. In this talk we present one example of this type of partnership and opportunity by looking at connections within the national and international permafrost data communities, and then between permafrost efforts and broader global cross-disciplinary work. Partnering permafrost and data management expertise, the NSF -funded PermaData project led by the National Snow and Ice Data Center (NSIDC) has the goal of making existing permafrost data easier to access and use across scales. PermaData has partnered with national and international teams from the Arctic Observing Viewer (AOV) the international Global Terrestrial Network for Permafrost (GTN-P), the Arctic Data Committee and others to ensure a widely useful approach that will support meaningful change to make permafrost data easy to use. The Research Data Alliance is a community-driven, distributed organization committed to enabling the open sharing of data by building social and technical bridges. With similar goals and communities, collaboration and partnership across Arctic and global efforts present a natural path forward to advance the work of data and research more broadly. <http://www.iarpccollaborations.org/members/events/4594>. (Jun 30, 2016 - Completed)
- ICOP 2016: The International Conference on Permafrost (ICOP) 2016 was held at the Alfred Wegener Institute in Potsdam, Germany, June 20-24. The premier event in global permafrost research, ICOPs are held every four years hosted by a country with a leading permafrost research program. All aspects of permafrost research, synthesis, scaling, engineering, etc are presented and discussed. A full listing of conference content is available from the ICOP2016 website: <http://icop2016.org/index.php/program>. (Jun 24, 2016 - Completed)
- Permafrost Carbon Network 5 Year Synthesis Report. PCN 5-Year Synthesis Report Christina Schaedel, David McGuire, Ted Schuur This report highlights the results of 5-years of synthesis research spanning multiple federal and state agencies, academia, and international collaborators. After a short description of the network, the report highlights three synthesis efforts using different approaches to assess the potential climate feedback from permafrost carbon. The Nature review article (Schuur et al. 2015) summarizes the findings across a range of individual synthesis products produced by the Permafrost Carbon Network. The Proceedings of the Royal Society paper (Koven et al. 2015) combines a number of individual synthesis products with Earth System Model projections of future climate and permafrost thaw. The Permafrost Carbon Model Intercomparison Project projects both the response of permafrost carbon and the offsetting response of plant carbon uptake across a range of land surface models under

scenarios of global change. These highest-level synthesis papers are followed by an example of using expert assessment, made possible by the development of the network, to outline the potential climate impacts from thawing permafrost carbon. The report then highlights some of the individual synthesis papers that have been published with other citations available at the end of the report and the website. After the science highlights, there are details on our workshops and the efforts of the network to develop both the science community through engagement of early career scientists, and the various outreach products that have arisen from the network. The contents of this report are not exhaustive but do illustrate different facets developed across the network.

http://www.permafrostcarbon.org/documents/PCN_5_year_synthesis_report.pdf. (Jun 1, 2016 - Completed)

- Workshop Reconciling Methane Budgets. During the Terrestrial Ecosystem Collaboration Team monthly webinar, Dr. David McGuire briefly introduced a planned workshop reconciling methane budgets (as described below). The Permafrost Action Team of the Study of Environment Arctic Change (SEARCH) proposes to reconcile methane budgets in the northern permafrost region by synthesizing data brought together by groups focused on: (a) terrestrial sources (primarily wetlands and lakes), (b) coastal sources, and (c) inferences from atmospheric methane data. A key first step is to hold a 2.5 day international workshop in Seattle with the following objectives: (1) Recruit additional scientists into the synthesis effort; (2) Communicate the state of the science and synthesis plans among the terrestrial, coastal, and atmospheric groups; (3) Communicate the synthesis plans of each group and the progress made to date; (4) Identify potential roles for the SEARCH Sea Ice and Land Ice Action Teams in the syntheses; (5) Refine the synthesis plans based on discussions at the workshop; and (6) Outline an overall synthesis of methane budgets in the northern permafrost region after completing synthesis work of the three groups. The workshop is planned for the fall in Seattle. Additional funding for the workshop is being sought. If you are interested in learning more about the workshop and joining our organizing team, please contact David McGuire at adm McGuire@alaska.edu.
<http://www.iarpcollaborations.org/members/updates/4492>. (May 10, 2016 - Completed)
- Dr. Donald A. (Skip) Walker presented ongoing research on climate change impacts to Arctic infrastructure, for which permafrost is the most important single factor. Cumulative Effects of Arctic Infrastructure and Climate Change | Walker | Presentation . This PowerPoint titled "Cumulative Effects of Arctic Infrastructure and Climate Change" was presented to the Polar Research Board at their meeting, 16 March during ASSW. This was in response to their request for an update on recent cumulative impact activities as they debate if there are ways for the PRB to facilitate renewed interest in the cumulative effects of development and climate change.
<http://www.iarpcollaborations.org/members/documents/4411>. (Apr 26, 2016 - Completed)
- Permafrost Degradation Vulnerability at Regional to Arctic Scales - dual presentation webinar by TECT. Questions concerning permafrost vulnerability across the arctic are inherently interdisciplinary and benefit from well-considered synthesis efforts. This webinar presented two talks aimed at achieving those goals using complementary approaches. Thermokarst Sensitive Terrain: Circumpolar Distribution and Soil Carbon

Vulnerability | Olefeldt | Presentation

<http://www.iarpccollaborations.org/members/documents/3999>. Terrain Suitability for Hill Slope Thermokarst | Balsler | Presentation

<http://www.iarpccollaborations.org/members/documents/4003>. Active layer detachment sliding and retrogressive thaw slumping are important modes of upland permafrost degradation linked with climate warming trends, ecosystem impacts, and permafrost carbon release. In the Brooks Range and foothills of northwest Alaska, these features are widespread, with distribution associated with multiple landscape properties. Co-varying terrain properties, including surficial geology, topography, geomorphology, vegetation and hydrology, are key drivers of permafrost landscape characteristics and responses to climate perturbation. However, these inter-relationships as collective drivers of terrain suitability for active layer detachment (ALD) and retrogressive thaw slump (RTS) processes are poorly understood in this region. We empirically tested and refined a hypothetical model of terrain factors driving ALD and RTS terrain suitability, with final results generating synoptic terrain suitability estimates across the region. Spatial terrain data were examined against locations of 2,492 ALDs and 805 RTSs using structural equation modelling and integrated terrain unit analysis. Factors significant for model fit substantially constrained region-wide terrain suitability estimates, suggesting that omission of relevant factors leads to broad overestimation of terrain suitability. Mapped estimates and spatial masks of terrain suitability were used to quantify and describe landscape settings typical of these features. 51% of the study region is estimated suitable terrain for retrogressive thaw slumps, compared with 35% for active layer detachment slides, and 29% of the region estimated suitable for both. Results improve current understanding of arctic landscape vulnerability and responses to climate warming, and enhance the capability to estimate permafrost carbon stocks subject to release through these modes of permafrost degradation. (Feb 9, 2016 - Completed)

- NGEE-Arctic, US Dept of Energy NGEE-Arctic 2015 All Hands Meeting: Sir Francis Drake Hotel, San Francisco, CA. The Department of Energy's NGEE-Arctic Team held its annual all-hands meeting in conjunction with the AGU Fall Meeting in San Francisco the weekend of December 12-13, 2016. NGEE-Arctic continues to scope, coordinate, and execute leading process-based research on landscape responses to short and long term climate perturbations focused on permafrost landscapes, and key linkages influencing biogeochemistry, vegetation dynamics, hydrology, and permafrost evolution and degradation. The coupled model/experiment 'modex' approach is generating a number of peer-reviewed publications, and is progressing rapidly toward targeted upscaling and synthesis for arctic landscapes. <http://ngee-arctic.ornl.gov/>. (Dec 13, 2015 - Completed)
- The 5th annual meeting of the Permafrost Carbon Network took place on Sunday, December 13, 2015 in San Francisco. We had 120 scientists participate with again a strong representation of early career scientists. In the morning we had three longer talks about: 1) the new methane syntheses 2) geospatial analyses: dynamic landscape controls on permafrost carbon vulnerability 3) Yedoma carbon stocks and other deep permafrost carbon. The second half of the morning was focused on eight speed talks that introduced break-out topics for the afternoon. In the afternoon we split into break-out groups and discussed in smaller groups ongoing and new synthesis products. The full agenda may be found here: .

http://www.permafrostcarbon.org/documents/Agenda_5th_Annual_Meeting_Permafrost_Carbon_Network_2015_final.pdf. (Dec 13, 2015 - Completed)

- Ben Gaglioti gave a presentation to the Wildfires team on the sensitivity of permafrost carbon to climate change and disturbance in the Arctic: lessons from the past. For his slides go to <http://www.iarpcollaborations.org/members/documents/3499>. (Nov 18, 2015 - Completed)
- In August 2015, NASA selected 21 proposals for the initial research investigations to begin the Arctic-Boreal Vulnerability Experiment (ABOVE) field campaign—a large-scale study of ecosystem responses to environmental change in western North America's Arctic and boreal region and the implications for social-ecological systems. Several of these projects are focused on the interactions of permafrost and carbon cycling, and members of these types are active participants in the Permafrost Carbon Research Network, which has been focused on addressing this milestone. In the coming year, this program should begin contributing to progress in achieving this milestone. (Oct 2, 2015 - Completed)
- Ted Schuur provided a comprehensive overview of the Permafrost Carbon Network during the September meeting of the TECT. His presentation is available at <http://www.iarpcollaborations.org/members/documents/3123>. The PCN is addressing both aspects of this milestone. 1) Stock estimate have been done. (See slides 13 & 14). Including a map showing where the data is collected which provides an excellent overview of where the data gaps are. 2) Vulnerability: PCN is looking at how fast could the stocks change and end up in the atmosphere. Look retrospectively and then do a vulnerability analysis. There are a number of diagnostic papers looking at the output of the retrospective analysis. Models project large decreases in permafrost; more when climate is warming faster. PCN has spatial estimate of where the most vulnerable carbon is located. (See slide 20). The PCN is being folded into the SEARCH umbrella. (Sep 23, 2015 - Completed)
- Ted gave a presentation on the Permafrost Carbon Network and the SEARCH Permafrost Action Team. His presentation can be found at <http://www.iarpcollaborations.org/members/documents/3123>. (Sep 18, 2015 - Completed)
- The Permafrost Research Network (PRN) involves a large group of scientists working on permafrost with the objectives to synthesize and link existing research about permafrost carbon and climate in a format that can be assimilated by biospheric and climate models, and that will contribute to future assessments of the Intergovernmental Panel on Climate Change (IPCC). Recent accomplishments that are in progress in the upscaling and modeling of permafrost carbon working group involving 8-12 models with common input drivers include: The response of permafrost carbon to historical variability in climate and atmospheric CO₂ between 1960 and 2009 Assessment of the vulnerability of permafrost carbon to projected climate change Permafrost Regionalization Map (PeRM) It is clear that these models do not address many permafrost carbon processes and other processes are not adequately represented. The future outlook is to try to see if we can add and/or change the processes represented in the models to better represent permafrost carbon. In April 2015, the group published a paper in Nature (see uploaded article) synthesizing the

various aspects and progress made by the group: Climate change and the permafrost carbon feedback. This article summarizes the newest understanding of processes involved in permafrost carbon dynamics and improved estimates of stocks. For instance, the permafrost carbon pool is much better quantified and observations of the carbon pools in deep layers (>3m) are of greater magnitude and importance than previously assumed but there are vast areas where sampling is extremely sparse making estimates of stocks highly uncertain. The decomposeability of the carbon in melting permafrost has been studied via incubations under controlled conditions including one that was 12 years in duration. These studies also provide insight into processes, and projections of quantities, and rates of release of both CO₂ and methane from decomposition of carbon from melting permafrost. However, the importance and role of abrupt permafrost thawing via thermokarst and upland rapid thaw processes (thermal erosion) processes that are not gradual and reach to deep layers of permafrost, are difficult to quantify and there is a separate working group that seeks to improve the inventory and understanding of these processes and to integrate these dynamics into regional ecosystems and earth system models. One key directions for this network is model-data integration, with more observations to more effectively benchmark and parameterize models. Thus, although “current evidence suggests a gradual and prolonged release of greenhouse gas emissions in a warming climate (see article cited)” there are several aspects of permafrost carbon dynamics that need to better understood in order to assess, model and project and the resulting climate feedbacks. Shuur 1 2015 nature14338 (PDF, 4.3 MB) (Sep 17, 2015 - Completed)

- David Olefeldt solicited and coordinated an expert assessment of pan-arctic permafrost landscapes for vulnerability to different specific modes of permafrost degradation. For each mode of degradation (e.g. hillslope thermokarst/cryogenic landslides, lowland thermokarst/aldas), a set of five independent topical experts rated a series of 100 pre-selected locations using Google Earth and ancillary information to rate the proportion of that landscape prone to permafrost degradation, and to estimate their individual confidence in assessing that landscape using this method. Tabulated results from the expert assessment for these diverse locations were then redistributed to the participants, and are submitted for peer-reviewed publication. (Aug 4, 2015 - Completed)
- During the February meeting of the TECT, Joel Rowland (Los Alamos National Laboratories) updated the team on the 1st year of the Next Generation Ecosystem Experiment (NGEE) Arctic activities. The slides from this presentation are available for download here. Broadly, NGEE activities seek to inform understanding of how permafrost thaw and the associated changes in hydrology, soil biogeochemical processes, and plant community succession affect feedbacks to the climate system. This interdisciplinary research program encompasses geomorphology, geophysics, hydrology, biogeochemistry, vegetation dynamics and multiscale modeling. (Mar 5, 2015 - Completed)
- Philip Martin and Sara Bowden attended the SEARCH kick off meeting in September 2014. SEARCH is standing up a permafrost Action Team lead by Ted Schuur. Sara and Philip will identify ways to ensure that these the TECT and the SEARCH activity are coordinated. (Jan 20, 2015 - Completed)

- During the September 2014 meeting, the team revised the language of this added milestone to the following: "Conduct a pan-arctic analysis of permafrost dominated Arctic and boreal regions to 1) identify gaps in our understanding of the magnitude and distribution of permafrost carbon stores; and 2) identify areas of permafrost that are potentially most vulnerable to carbon loss with continued warming." (Sep 18, 2014 - Completed)
- During the September 2014 meeting, the team approved the language change of this milestone. The old language was "Conduct a pan-arctic analysis to identify tundra and boreal regions that are most vulnerable to carbon loss with continued warming, thereby highlighting regions that pose the greatest risks with respect to positive feedbacks to climate change." (Sep 18, 2014 - Completed)
- The USGS will release the National Geologic Carbon Sequestration Assessment during the last week of June 2013, including assessment numbers for geologic CO₂ storage in Alaska. 1) Geologic Framework for the National Assessment of Carbon Dioxide Storage Resources—Alaska North Slope and Kandik Basin, Alaska (<http://pubs.usgs.gov/of/2012/1024/i/>); 2) Geologic CO₂ Sequestration Interactive Web Map (<http://energy.usgs.gov/GeneralInfo/EnergyNewsroomAll/TabId/770/ArtMID/3941/ArticleID/1027/USGS-Updates-the-Geologic-CO2-Sequestration-Interactive-Web-Map.aspx>). A separate Ecosystem Carbon Sequestration assessment for the state of Alaska of existing carbon stock in relation to warming, permafrost thaw, changing hydrology, and changing fire and other disturbance regimes is to complete by Sept 2014. A modified methodology will be used for Alaska developed by an interagency of scientists from the U.S. Forest Service, University of Alaska at Fairbanks, and USGS. (Jul 15, 2014 - Completed)
- The Arctic LCC has partnered with USGS to complete a study that reviews current and past efforts to monitor thermokarst at broad spatial and temporal scales. This background information will then be used to outline possible study designs for a thermokarst monitoring program for the North Slope. <http://arcticlcc.org/projects/geophysical/thermokarst-monitoring-feasibility-study/>. (Jul 19, 2013 - Completed)
- The Arctic LCC and Alaska Climate Science Center have partnered with UAF to develop a new permafrost map for northern Alaska. Researchers will compile existing soil and permafrost data from available sources to create a region-wide permafrost database and landscape-level (1:1,000,000 scale) map that is suitable for regional modelling and climate impact assessments. <http://arcticlcc.org/projects/geospatial-data/permafrost-mapping/>. (May 17, 2013 - Completed)

Team Leads: Rebecca Anderson (USGS); Andrew Balsler (USACE)

Agencies

DOC, DOD, DOE, DOI, HHS, NASA, NSF, OSTP, USARC

Glaciers & Fjords

Milestone Reporting Log 2016

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

3.2 Terrestrial ice and ecosystems

3.2.1 Perform glacial-process studies targeting specific dynamic regimes

- **3.2.1.a (Milestone met) Define observational requirements (essential variables, spatio-temporal sampling) for each of the components (ocean/fjord/ice-ocean interface/glacier/atmosphere) for process studies and sustained monitoring; NSF (Lead), DOD-ONR, DOE, DOI, NASA, NOAA; Target Date 2013**
 - Completion Statement: An international workshop was held, in June 2014, where long-term observations and process studies were discussed and priorities identified.
(<http://www.usclivar.org/sites/default/files/announcement/2014/2013GreenlandWorkshopReport.pdf>). An international community workshop was held during the December 2015 AGU meeting to discuss the establishment of a Greenland Ice Sheet Ocean Observing System and a report will be published soon.
 - Agencies are asked to consider the funding program options in light of planned budgets and speak to Hedy and Bill about their investments in 2016 and beyond. (Nov 25, 2014 - Completed)
 - The international workshop report entitled “Understanding the Response of Greenland’s Marine-Terminating Glaciers to Oceanic and Atmospheric Forcing” defines the essential variables to be observed for process studies and “megsites” where the community would coordinate the simultaneous collection of the full range of glaciological, oceanographic, and atmospheric observations necessary to characterize and understand the intrinsically coupled ice-ocean-atmosphere system. These discussions were further honed at a town hall meeting held during the Fall AGU meeting in December 2013. In a related discussion, the report defines the components of a Greenland Ice-Ocean Observing System (GrIOOS). Peripheral to these discussions, the report stresses the importance of a comprehensive and freely accessible international data archive related to Greenland glacier-fjord processes and lists a number of data types that are of immediate importance, if they could be collated from various sources. (Sep 11, 2014 - Completed)
 - NSF co-funded with CLIVAR the GRISO workshop where long-term observations and process studies were discussed and priorities identified.

- (<http://www.usclivar.org/meetings/griso-workshop-agenda>). (Sep 2, 2014 - Completed)
 - Mike Studinger reported that NASA has a competition to look at new instruments to observe changes at the glacier face. (May 8, 2014 - Completed)
 - The Beverly meeting report is published at <http://www.usclivar.org/sites/default/files/announcement/2014/2013GreenlandWorkshopReport.pdf>. (Mar 13, 2014 - Completed)
 - GFCT held a community workshop during the December AGU meeting. Notes are attached. (Dec 12, 2013 - Completed)
- **3.2.1.b (Milestone met) As appropriate, initiate 3-5 year research initiatives that draw together observational and process modeling expertise to accelerate progress on specific process understanding and parameterization; NSF (Lead), DOD-ONR, DOE, DOI, NASA, NOAA; Target Date 2013**
 - Completion Statement: Activities supporting this milestone are funded by the IARPC agencies and can be found in the inventory of funded activities. (Insert link)
 - A presentation was given by Sophie Nowicki (NASA) on an ice sheet model intercomparison project for the CMIP6. The presentation is available at: <http://www.iarpccollaborations.org/members/events/595>. (Nov 13, 2014 - Completed)
 - Jesse Johnson gave a presentation on Greenland outlet glaciers and what ice sheet modelers would like from observationalists and Gordon Hamilton gave a presentation on how modelers can guide observationalists. Johnson presentation at: <http://www.iarpccollaborations.org/members/documents/895>. Hamilton presentation at: <http://www.iarpccollaborations.org/members/documents/892>. (Sep 11, 2014 - Completed)
 - Interagency discussions continue to look at opportunities when budgets permit. (May 8, 2014 - Completed)
 - NASA has a competition to look at new instruments to observe changes in the glacier face. (Apr 10, 2014 - Completed)
 - Activities are being funded by agencies and can be found in the inventory. (Jan 9, 2014 - Completed)
 - The team modified the language of this milestone in order to better reflect the intended work of agencies and not limit the discussion to only Earth system models. Original language: "As appropriate, initiate 3-5 year research initiatives that draw together observational, process modeling, and Earth system modeling expertise to accelerate progress on specific process understanding and their parameterizations in U.S. Earth system models." Revised language: "As appropriate, initiate 3-5 year research initiatives that draw together observational and process modeling expertise to accelerate progress on specific process understanding and parameterization." (May 9, 2013 - Completed)

- **3.2.1.c (Milestone met) Report strategies to feed results of process studies into Earth system models; DOE (Lead), NSF (Lead), DOD-ONR, DOI, NASA, NOAA; Target Date 2014**

 - Completion Statement: A variety of ice sheet models are being developed and improved through the regular CESM Land Ice Working Group (<https://www2.cesm.ucar.edu/working-groups/liwg>) meetings of the observational and modeling communities. Furthermore, an international effort to inter-compare ice sheet models (<http://www.climate-cryosphere.org/activities/targeted/ismip6>) has been established.
 - Phil Jones of LANL provided a presentation on ice sheets in coupled climate models. The presentation is available at <http://www.iarpcollaborations.org/members/events/1042>. (Dec 11, 2014 - Completed)
 - NASA sponsored an initial meeting for an international ice sheet model intercomparison project. (Oct 9, 2014 - Completed)

- **3.2.1.d (Milestone met) Foster a U.S. and international research focus on ice/ocean interactions, especially with regards to the Greenland Ice Sheet; NSF (Lead), DOD-ONR, DOE, DOI, NASA, NOAA; Target Date 2015**

 - Completion Statement: The International Greenland Ice Sheet-Ocean Interactions (GRISO) Network (<http://web.whoi.edu/griso/>) an international, open network of scientists has been established and will address recent changes in the Greenland Ice Sheet through the compilation and shared analysis of legacy data and the initiation of new observational projects. The SEARCH Land-Ice Action Team has been established to improve predictions of future land-ice loss and associated impacts on sea level.
 - NASA's OMG mission completed its first year of the sonar ship survey in september of 2015, collecting multibeam sonar data over more than 4000 nautical miles along Greenland's NW coast and 300 conductivity, temperature, depth (CTD) casts. All of this data is currently available on the mission website at <http://omg.jpl.nasa.gov>. Preliminary results were presented at the 2015 Fall AGU Meeting in San Francisco. In March of 2016, the first survey of the glacier margins was completed using the airborne swath altimeter, GLISTIN-A. Maps of elevation over the last 5 to 10 km of marine terminating glaciers were collected at over 200 glacier faces around the island. Processing of these data are ongoing, but we expect them to be available for public download from the OMG website this summer. Beginning in April of 2016, OMG's airborne gravity survey over the shelf also began. This survey of the marine gravity field will complement the bathymetry data collected from the ship in the northwest, southeast and northeast coastal areas of Greenland. As of September 2016 more than 50% of this survey had been completed and the first data from the survey will be posted within a few weeks on the OMG website. In August 2016, the ship survey will resume to

complete its survey of the fjords and shelves in the south east. In addition, this September will mark the beginning of the first OMG ocean survey, which will consist of deploying 250 one-time use conductivity, temperature and depth sensors on the continental shelf surrounding Greenland. For additional updates, check the mission website: <http://omg.jpl.nasa.gov> (Jul 27, 2016 - Completed)

- New Paper: Bathymetry Data Reveal Glaciers Vulnerable to Ice-Ocean interaction in Uummannaq and Vaigat Glacial Fjords, West Greenland Rignot, E., Fenty, I., Xu, Y., Cai, C., Velicogna, I., Cofaigh, C. & Duncan, D. (March 2016). *Geophysical Research Letters*, 43(6), 2667-2674 <http://onlinelibrary.wiley.com/doi/10.1002/2016GL067832/abstract>. NASA funded researchers and collaborators presented a multibeam echo sounding survey of 14 glacial fjords in the Uummannaq and Vaigat fjords, west Greenland, which extends from the continental shelf to the glacier fronts. This constitutes the first relatively complete bathymetry mapping of two large fjord systems in west Greenland, which host a number of major outlet glaciers that control nearly 10% of the ice sheet discharge. The data revealed valleys with shallow sills, overdeepenings (>1300 m) from glacial erosion, and seafloor depths 100–1000 m deeper than in existing charts. Paper Abstract: Marine-terminating glaciers play a critical role in controlling Greenland's ice sheet mass balance. Their frontal margins interact vigorously with the ocean, but our understanding of this interaction is limited, in part, by a lack of bathymetry data. Here we present a multibeam echo sounding survey of 14 glacial fjords in the Uummannaq and Vaigat fjords, west Greenland, which extends from the continental shelf to the glacier fronts. The data reveal valleys with shallow sills, overdeepenings (>1300 m) from glacial erosion, and seafloor depths 100–1000 m deeper than in existing charts. Where fjords are deep enough, we detect the pervasive presence of warm, salty Atlantic Water (AW) (>2.5°C) with high melt potential, but we also find numerous glaciers grounded on shallow (<200 m) sills, standing in cold (<1°C) waters in otherwise deep fjords, i.e., with reduced melt potential. Bathymetric observations extending to the glacier fronts are critical to understand the glacier evolution. (Jul 12, 2016 - Completed)
- OMG's Bathymetry sonar survey ship activity began at the end of July 2015 and continues to survey the North West coast of Greenland while dealing with fall storms and high winds and seas. Since departing Aasiaat on 3 September, the ship has survey over 1210 nautical miles. Conductivity, Temperature, Depth (CTD) profiles are taken as well. As of August 14, 79 CTD casts were completed. More recently, during the week of September 14, the ship supported 11 CTD profiles. In early October, OMG's 2015 Western Greenland survey will be finished and the survey ship will head to port. Melville Bay quick look survey plots are available here [attached](#). Melville Bay Quick look survey plots OMG (PNG, 712 KB) (Sep 29, 2015 - Completed)
- NASA-funded research led by Eric Rignot produced the paper, "Undercutting of Marine-Terminating Glaciers in West Greenland" in the July 2015 *Geophysical Research Letters*. The paper is available at:

<http://onlinelibrary.wiley.com/doi/10.1002/2015GL064236/full>. Brief summary: Side-looking, multi-beam echo sounding (MBES) observations of fjord bathymetry and submerged ice faces of three west Greenland glaciers were collected in August 2012 and 2013. The data reveal that their frontal ice cliffs are grounded deeper below sea level than previously measured, and that their faces are neither vertical nor smooth, but instead, are often undercut by ocean water and rough. Cavities undercutting the base of the calving faces were detected at sites of subglacial water discharge predicted by a hydrological model. The pattern of undercutting is consistent with models of ice melt in which this discharge transports warm Atlantic waters to the ice faces. This glacier undercutting likely enhances iceberg calving, impacting ice front stability, and thus, glacier mass balance. (Sep 28, 2015 - Completed)

- Alan gave a presentation on the Petermann Fjord Study. His PowerPoint is and the recording of his presentation are available at <http://www.iarpccollaborations.org/members/events/603>. (Jul 2, 2015 - Completed)
- Josh Willis gave a presentation during the February 2015 GFCT meeting on the Oceans Melting Greenland mission. The video is available at <http://www.iarpccollaborations.org/members/events/599>. (Feb 26, 2015 - Completed)
- Shad O'Neel gave a presentation on glacierized fjords: analogues to Greenland and important in their own right. The presentation provides information on active research opportunities. The presentation is available at: <http://www.iarpccollaborations.org/members/events/593>. (Sep 11, 2014 - Completed)
- Walt Meier gave a presentation on activities of the IASC Crossphere WG and CliC to see if there are possibilities for collaboration. The presentation is available at: <http://www.iarpccollaborations.org/members/documents/891>. (Jul 10, 2014 - Completed)
- Fiama Straneo (WHOI) gave a presentation on possible collaborations with AWI in Germany. The presentation is available at: <http://www.iarpccollaborations.org/members/documents/897>. (Jul 10, 2014 - Completed)

3.4 Observing systems

3.4.1 Facilitate observing system design for the arctic

- **3.4.1.c (Milestone met) Develop an inter-agency (and international) planning strategy for an Arctic land ice monitoring system informed by process studies and with focus on outlet and tidewater glaciers and their surroundings; NASA (Lead), NSF (Lead), DOD-ONR, DOE, DOI, NOAA; Target Date 2015**
 - Completion Statement: An international community workshop was held during the December 2015 AGU meeting to discuss the establishment of a Greenland Ice

Sheet Ocean Observing System and a report will be published soon. The International Greenland Ice Sheet-Ocean Interactions (GRISO) Network (<http://web.who.edu/griso/>) an international, open network of scientists has self-organized to address the large, complex, interdisciplinary questions associated with recent changes in the Greenland Ice Sheet and its surrounding environment.

- A Greenland Ice Sheet Ocean Observing System (GrIOOS) Workshop was held on December 12-13, 2015 in San Francisco. Workshop details were posted here: <http://web.who.edu/griso/greenland-ice-sheet-ocean-observing-system-griooos-workshop/>. A report on outcomes is expected. (Jul 12, 2016 - Completed)
- This milestone was completed in March 2015. In June 2013 US CLIVAR, with support from NSF, NASA, NOAA and DOE, sponsored a workshop on discussing the problem of “Understanding the Response of Greenland’s Marine-Terminating Glaciers to Oceanic and Atmospheric Forcing” and the challenges to improving observations, process understanding and modeling. The workshop had broad participation from a wide range of US and international scientists including oceanographers, glaciologists, atmospheric, paleo and climate scientists, including observationalists, modelers, and theoreticians. Several IARPC team members were also in attendance. One outcome of the workshop was a planning strategy for obtaining long-term time series of critical in situ glaciological, oceanographic and atmospheric parameters to provide information on the time-evolving relationships between the different climate forcings and the glacier flow, called the Greenland Ice-Ocean Observing System (GrIOOS). The proposed GrIOOS system documented in the workshop report (<http://web.who.edu/griso/documents/>) is a comprehensive planning strategy for an Arctic land ice monitoring system informed by process studies and with focus on outlet and tidewater glaciers and their surroundings and meets the requirements of milestone 3.4.1.a. The SEARCH Land-Ice Action Team (<http://www.iarpccollaborations.org/members/events/598>) was organized as part of the IARPC SEARCH activities. As an initial action, it will hold a meeting in San Francisco on 12 and 13 December 2015 to discuss the design and implementation of a Greenland Ice Sheet Ocean Observing System. (Mar 16, 2015 - Completed)
- The paleo study of glacier-fjord interactions in the vicinity of Petermann Glacier (see ‘future plans’ below) will involve scientists from the United States, Canada, Denmark, and the United Kingdom. (See presentation by Alan Mix to the GFCT at: <http://www.iarpccollaborations.org/members/events/603>. (Oct 30, 2014 - Completed)
- International planning is ongoing for larger, coordinated studies in the same region in coming years. A logistics planning workshop for a fjord-glacier field effort was recently held in Europe. (Sep 11, 2014 - Completed)
- International workshops have taken place focused on process understanding and modeling, as mentioned under milestones 3.2.1.a and 3.2.1.c. As an outgrowth, contacts have been made that allowed initial funding of a collaborative effort with

German colleagues focused around 79N Glacier and Zachariae Isstrom, North-East Greenland. (Aug 14, 2014 - Completed)

Team Leads: Bill Wiseman, NSF; Gordon Hamilton, University of Maine

Agencies

DOC, DOE, DOI, NASA, NSF, OSTP, USARC

Wildfires

Milestone Reporting Log 2016

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

3.2.4 Investigate the frequency and severity of wildfires in the Arctic

- **3.2.4.a (Milestone met) Identify and inventory existing scientific research on Arctic wildfires; DOI, NASA; Target Date 2012**
 - Completion Statement: An inventory provides an overview of past and current federally-funded wildfires research. A gap analysis identifies activities which might be addressed by the interagency group. A NASA catalogue provides a readily accessible inventory of NASA assets that can be obtained by wildfires researchers. (Sep 7, 2016 - Completed)
 - ABoVE (Arctic Boreal Vulnerability Experiment) has initiated a wide-range of research on wildfires and their impacts on tundra and boreal forests: Field-based studies are collecting data to quantify biomass directly consumed during fires in a number of boreal forest and tundra sites. Field-based studies are quantifying the impacts of fire on permafrost warming and thawing and post-fire emissions of carbon dioxide in boreal forest and tundra sites (in cooperation with an NSF-funded study). Field-based studies are quantifying how variations in fire severity influence post-fire vegetation regrowth in boreal forest and tundra sites (in cooperation with an NSF-funded study). Remote sensing data products are being developed and validated to quantify fire severity. Improvements are being implemented on models to estimate direct carbon emissions from fires. (Aug 15, 2016 - Completed)
 - In August 2015, NASA selected 21 proposals for the initial research investigations to begin the Arctic-Boreal Vulnerability Experiment (ABoVE) field campaign—a large-scale study of ecosystem responses to environmental change in western North America’s Arctic and boreal region and the implications for social-ecological systems. Several of the selected proposals focus on topics related to wildfires and in the coming year, this program should begin contributing to progress in achieving this milestone as follows: The following projects are being funded by NASA as part of the ABoVE Field campaign: Long-Term Multi-Sensor Record of Fire Disturbances in High Northern Latitudes. This project will develop and implement a new approach to produce medium resolution (30m) records of fire disturbances guided by moderate resolution (250 to 1000m) datasets. Quantifying long-term impacts of single and repeated wildfire burning in North American tundra on organic soil carbon stocks and ecosystem functioning. The proposed project will focus on investigating and quantifying fire-induced changes in Alaskan tundra with a specific aim to assess the region’s vulnerability to on-going and future environmental change and the changes to carbon cycling in this ecosystem. Increasing fire severity and the loss of legacy

carbon from forest and tundra ecosystems of northwestern North America This project will conduct research in tundra ecosystems north of Denali National Park and boreal forest and peatland ecosystems in the Northwest Territories to determine factors controlling fires that burn organic soils common to these ecosystems in order to understand the role of fire in terrestrial carbon cycling. (Oct 2, 2015 - Completed)

- **3.2.4.b (Milestone met) Consult with local communities and indigenous groups on science needs pertaining to Arctic wildfires and their impacts on cultural and subsistence needs; DOI (Lead), NASA, NSF, USDA; Target Date 2016**
 - Completion statement: The WCT report Community Knowledge and Research Needs Relating to Arctic Wildfires completed by Alyssa Shanks Rodrigues on behalf of the WCT completes action on this milestone. The report is available at: <http://www.iarpcollaborations.org/members/documents/6051>. (Sep 20, 2016 - Completed)
 - Alyssa Shanks Rodrigues (UAF) reported during the May 2016 meeting of the WCT that her research is nearly done and she will be prepared to report at the September meeting of the WCT. (Sep 19, 2016 - Completed)
 - Alyssa provided her report to the WCT during the September meeting. It can be found at <http://www.iarpcollaborations.org/members/documents/6051>. (Sep 19, 2016 - Completed)
 - Research has been initiated to investigate the impacts of boreal forest fires on subsistence for interior Alaskan Native Communities which involves direct consultation with these communities. Research has been initiated on the socio-ecological impacts of environmental change, including the 2015 wildfires, in the Yukon-Kuskokwim Delta region that involves direct consultation with local indigenous groups. (Aug 15, 2016 - Completed)
 - Alyssa Shanks Rodrigues (UAF) prepared a literature review, spoke with subject experts, and communicated with several stakeholder groups. She presented to the North Slope Subsistence Advisory Panel Meeting in Anaktuvuk Pass, to a diverse group at the Alaska Forum on the Environment, and to the Alaska Village Initiatives board. From these groups, she received feedback on the research stakeholders would like to see pursued. The research that was a priority for stakeholders is in line with current research already being considered or completed by researchers. Additional outreach will be carried out via phone for the communities identified to have had a tundra fire within a 20-mile radius. These communities will be contacted and asked if they have an interest in tundra fires. If they do, she'll talk with them about their research interests. The full report of stakeholder feedback will be presented in the final report given to this body and any communities that participated. (Mar 20, 2016 - Completed)
 - Several of NASA's Arctic-Boreal Vulnerability Experiment (ABoVE) field campaign funded proposals (August 2015) focus on topics related to wildfires and

in the coming year, this program should begin contributing to progress in achieving this milestone as follows: Biophysical Characteristics and Mechanisms of Environmental Disturbances Influencing Human Access to Ecosystem Services in Boreal Alaska. (While this study focuses on boreal forest fires, it is taking place in communities within the IARPC Region, e.g., north of the Yukon River). This project will investigate how disturbances from fire influences the ability of subsistence harvesters within the ABoVE domain to move across landscapes and access traditional hunting, fishing, and gathering areas. (Oct 2, 2015 - Completed)

- BLM funding has been received by Alaska Fire Science Consortium to support UAF Resilience and Adaptation Program (RAP) master's student Alyssa Shanks to do the work during the academic year 2015-16. (Sep 17, 2015 - Completed)
- Kent Slaughter (BLM) circulated the statement of work for an intern in at UAF to undertake this activity on behalf of the team. The statement will be sent to UAF to be formalized. Team members will provide feedback and Kent will revise. One final discussion at the October meeting. (Apr 10, 2015 - Completed)
- A statement of work has been completed, a UAF student has been identified and funding from BLM is in hand. The work which will focus on a literature search, synthesis and community consultations will begin in the summer of 2016. (Apr 10, 2015 - Completed)
- The milestone target date was changed to 2016 because work was underway but completion was taking longer than expected. (Oct 10, 2014 - Completed)
- Publication pertaining to the effects of fire to winter habitat for caribou. Gustine, D.D., Brinkman, T., Lindgren, M., Schmidt, J.I., Rupp, T.S., and Adams, L.G., 2014, Climate-driven effects of fire on winter habitat for caribou in the Alaskan-Yukon Arctic: PLOS One, v. 9, no. 7 100588, doi:10.1371/journal.pone.0100588. (Oct 9, 2014 - Completed)
- The CT will engage a summer intern in 2015 to do the consultation through the Resilience and Adaptation Program (RAP) at UAF. A draft RAP internship proposal has been generated. (Sep 30, 2014 - Completed)
- The team agreed to circulate a spreadsheet to identify what is already known. A comprehensive summary of all consultations has been completed. (Sep 30, 2014 - Completed)
- **3.2.4.c (Milestone met) Develop strategies/projects to identify succession stages of tundra communities following a wildfire; DOI (Lead), NASA, USDA; Target Date 2016**
 - Completion statement: Several projects to identify succession stages of tundra communities following a wildfire have been supported and are listed below. A literature review of existing information has been written. Variations on this milestone may reappear after the WCT absorption into the TECT and as ongoing work uncovers new information gaps. (Oct 6, 2016 - Completed)

- Since discussion began on this topic, a number of projects and research efforts have been developed to address identified knowledge gaps with respect to tundra fires. Additionally, Eric Miller and Randi Jandt have secured funding to revisit the largest known burn in Alaska's arctic, the 2007 Anaktuvuk River fire in 2017. Study of this particular fire will provide important additional information on potential vegetation shifts due to severe, or deep-burning fires in tundra (Sep 22, 2016 - Completed)
- Research for NASA's ABoVE campaign is now ongoing at a number of field sites across Alaska and northwestern Canada. Information on ABoVE can be found at: <http://above.nasa.gov/>. Specific activities and results related to this milestone include: ABoVE is carrying out field and remote-sensing based studies to quantify variations in fire severity in a range of tundra ecosystems in Alaska which will provide the foundation for future studies on the impacts of fire on vegetation regeneration A NSF-funded project affiliated with ABoVE is continuing research on post-fire regeneration in the 2007 Anaktuvuk River fire. ABoVE is carrying out field research on the impacts of fire on permafrost warming and thawing in 2015 fires in the Yukon-Kuskokwim Delta region, which will provide the foundation for future research on the impacts of fire on vegetation regeneration (Aug 15, 2016 - Completed)
- A webinar series has been identified as a useful format to understand what is going on and then a face-to-face meeting to flesh out strategies. Possibly work with the Alaska Fire Science Consortium as a partner for the webinar series. (Dec 14, 2015 - Completed)
- A webinar on tundra fire successional research was provided by WCT member Teresa Hollingsworth (UFSF) with Amy Breen (UAF). The recorded presentation "Effect of tundra fires on post-fire vegetation" (<https://www.frames.gov/partner-sites/afsc/events/previous-events/previous-webinars/breen-webinar/>) has been recorded and hosted on the Alaska Fire Science Consortium website (May 14, 2015 - Completed)
- The team has developed a list of sources of information and key Alaska studies on post-fire succession in tundra. (May 8, 2014 - Completed)
- **3.2.4.d (Milestone met) Develop a model that incorporates feedback from fire models with models of surface vegetation and organic layer properties, permafrost and soil conditions, incorporating hydrologic information as appropriate; DOI (Lead); Target Date 2016**
 - Completion Statement: Since discussion began on this topic, modeling work at the University of Alaska and USGS Alaska Climate Science Center has progressed rapidly, resulting in new integrated models and scenario-building capacity for GCM's. It is now possible to estimate total future carbon balance for large areas such as the entire state of Alaska. Several publications explain this work—find links to key resources under WCT member Dave McGuire's USGS profile (<https://csc.alaska.edu/users/david-mcguire>). (Oct 5, 2016 - Completed)

- The IEM is now in the final year of this five-year phase of the project. It is anticipated that it will be renewed for another five years starting approximately 1 September 2016. We have recently completed a linear coupling of ALFRESCO with TEM for Alaska and Northwest Canada, which we refer to as a Generation 1 set of simulations. We are near completion of the linear coupling of TEM with GIPL for Alaska and Northwest Canada, which will complete the Generation 1 set of simulations. We are now laying the groundwork for the cyclical coupling of ALFRESCO, TEM, and GIP, which we refer to as the Generation 2 set of simulations. We are also involved in a number of impact projects that are using IEM results to evaluate the potential effects of climate change on natural resources. Finally, we are continuing to make progress on the Alaska Thermokarst Model, which is a state-and-transition model to simulate how thermokarst disturbance causes landscape transitions among ecosystems in lowlands. This model will be important to conducting impact studies of natural resources associated with lowlands (for example, waterfowl). (Jan 12, 2016 - Completed)
- Ben Gaglioti (UAF) gave a presentation on the sensitivity of permafrost carbon to climate change and disturbance in the Arctic: lessons from the past. For his slides go to <http://www.iarpcollaborations.org/members/documents/3499>. Gaglioti has been funded by the Joint Fire Science Program to implement his proposal “Alaskan tundra fires during a time of rapid climate change” with his collaborators Dan Mann, Ben Jones, and Eric Miller. Field work starts in April 2017. (Nov 18, 2015 - Completed)
- The Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada is an active area of research being spear-headed by PI Dave McGuire of UAF and a star-studded science team. There is an informative website hosted at the Alaska Climate Science Center (<https://csc.alaska.edu/projects/integrated-ecosystem-model-iem-alaska-and-northwest-canada>) with the full list of participants, links to data and reports, posters, etc. (Oct 9, 2015 - Completed)
- The USGS Alaska Climate Science Center and the Arctic, Western Alaska, and Northwest Boreal Landscape Conservation Cooperatives have established the "Integrated Ecosystem Model of Alaska and Northwest Canada" to develop a model with these capabilities (project duration 2011-2016). The project is coupling a model of fire disturbance (ALFRESCO) with a model of ecosystem dynamics (DVM-DOS-TEM) and permafrost dynamics (GIPL). The project has a sequence of products that it has laid out for making progress on the model development that it has labeled as Generation 1 (one-way coupling of models) and Generation 2 (two-way coupling of models). The first set of one-way coupled simulations has been conducted and is currently being analyzed and will be made available through the USGS Alaska Climate Science Center and the Scenario Network for Alaska and Arctic Planning websites. (Oct 9, 2014 - Completed)
- During the Sep 2014 meeting of the team, it was reported that papers related to the Al Fresco model are due out shortly and will inform this milestone. (Sep 11, 2014 - Completed)

- Amy Breen (UAF) and Becky Hewitt provided information about two related modeling undertakings. Their presentations are attached. (Jun 12, 2014 - Completed)
- **3.2.4.e (Milestone met) Identify existing knowledge and quality of data on wildfire frequency, extent, and severity in the Arctic. If needed, develop strategies/projects to improve data to monitor changes in wildfire frequency, extent, and severity in the Arctic; DOI; Target Date 2013**
 - Completion Statement: An inventory of data/resources for fire frequency, extent and severity for Alaska has been developed and is available. <http://www.iarpccollaborations.org/members/documents/426>. (Sep 7, 2016 - Completed)
 - In August 2015, NASA selected 21 proposals for the initial research investigations to begin the Arctic-Boreal Vulnerability Experiment (ABOVE) field campaign—a large-scale study of ecosystem responses to environmental change in western North America’s Arctic and boreal region and the implications for social-ecological systems. Several of the selected proposals focus on topics related to wildfires and in the coming year, this program should begin contributing to progress in achieving this milestone through the following project: Long-Term Multi-Sensor Record of Fire Disturbances in High Northern Latitudes. This project will develop and implement a new approach to produce medium resolution (30m) records of fire disturbances guided by moderate resolution (250 to 1000m) datasets. (Oct 2, 2015 - Completed)
- **3.2.4.f (Milestone met) Develop an inventory of NASA fire sensors; NASA (Lead); Target Date 2014**
 - Completion Statement: A report detailing orbital and sub-orbital (airborne) imaging / sensing system assets that have applicable uses for the wildfire observations has been produced. The imaging assets are research or operational systems operated by a variety of agencies and international groups including NASA, NOAA, ESA, JAXA, DLR and others. The accompanying table and systems descriptions are provided to support the Interagency Arctic Research and Policy Committee (IARPC), Wildfire Implementation Team (WIT). (Sep 6, 2016 - Completed)
 - Proposal was submitted to NASA for funding for a workshop in conjunction with ASSW 2016. Funding will support travel for invited speakers and young investigators, as well as production of proceedings. (Apr 1, 2016 - Target)
 - The satellite fire sensor inventory was completed in November 2014. It will be periodically updated by Vince Ambrosia (NASA) and posted on this site. This report details orbital and sub-orbital (airborne) imaging / sensing system assets that have applicable uses for the wildfire observations. The imaging assets are research or operational systems operated by a variety of agencies and international groups including NASA, NOAA, ESA, JAXA, DLR and others. The accompanying table and systems descriptions are provided to support the

- Interagency Arctic Research and Policy Committee (IARPC), Wildfire Implementation Team (WIT). (Nov 17, 2014 - Completed)
- Vince Ambrosia (NASA) provided version 3 of the inventory of NASA fire sensors. The team will review and discuss at it Sep. 2014 meeting. They will discuss whether or not this version is ready to be made public. (Sep 11, 2014 - Completed)
 - **3.2.4.g (In progress) Convene an international, interdisciplinary workshop with remote sensing scientists, ecologists, hydrologists, agency fire managers and decision-makers on new opportunities to use remote sensing in boreal/arctic wildfire management and science; DOI, NASA; Target Date 2016**
 - Continuation Statement: Funding for a workshop “Opportunities to apply remote sensing in boreal/arctic wildfire management and science” was awarded by NASA in September, 2016. Date of workshop has been set for April 4-6, 2017 and the call has gone out for abstracts and travel grants. Members of the WCT are participating in organizing committees for the workshop. This milestone will remain open until the workshop is held in April 2017. (Oct 5, 2016 - Completed)
 - The scientist-manager Steering Committee met in June and made several key decisions about the scope and direction of the workshop proposal: a draft-in-progress is being worked on <http://www.iarpccollaborations.org/members/documents/2838>. The proposal has been submitted to NASA in NSPIRES as of October 5, 2015. (Oct 9, 2015 - Completed)
 - Randi Jandt (Alaska Fire Science Consortium) will pull together a steering group to draft a workshop proposal to be submitted in September. She reported at the August 2015 WCT meeting. (Aug 17, 2015 - Completed)
 - **3.2.4.h (Milestone met) Draw upon the interdisciplinary diversity to prepare an executive summary (and poster) summarizing ongoing and hypothesized human impacts of increased fire disturbance in arctic/subarctic environments; DOI; Target Date 2016**
 - Completion Statement: A poster was produced and shown at the ASSW 2016 summarizing ongoing and hypothesized human impacts of increased fire disturbance in arctic/subarctic environments. The poster can be found at <http://www.iarpccollaborations.org/members/documents/4157>. (Mar 9, 2016 - Completed)

Team Leads: Eric Miller, BLM; Randi Jandt, UAF

Agencies: DOC, DOI, NASA, NSF, OSTP, USARC, USDA

Atmosphere

Milestone Reporting Log 2016

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3.3 Atmospheric studies of surface heat, energy, and mass balances

3.3.1 Improve understanding of short-lived climate forcers (SLCFs); source regions, direct and indirect effects and net impact on Arctic warming

- **3.3.1.a (Milestone met) Support sustained process studies and campaigns to obtain detailed knowledge of the Arctic atmospheric composition and structure including validation and refinement of current satellite observations; NOAA (Lead); Target Date 2016**
 - Completion Statement: The team has provided descriptions of several aerial measurement campaigns and of documented data in the IASOA portal (<http://www.esrl.noaa.gov/psd/iasoa/home2>). Post-campaign analyses are ongoing and include evaluation of satellite data in the context of these campaign measurements. (Sep 22, 2016 - Completed)
 - Since the conclusion of the fall 2014 field campaign portion of NASA's Arctic Radiation-IceBridge Sea & Ice Experiment (ARISE), the key accomplishments in 2015 include: data calibration, reduction and archival activities; preliminary analyses and comparisons of the aircraft measurements with satellite analyses and model simulations; development of level-2 datasets; and submission of a manuscript to the Bulletin of the American Meteorological Society overviewing the mission operations, the available datasets, and early results. More details can be found at 3.2.2.a. (Sep 28, 2015 - Completed)
 - From June 1 through September 15, 2015, the ARM Aerial Facility (AAF) deployed the G-159 (G-1) research aircraft and flew over the North Slope of Alaska (38 flights, 140 science flight hours), with occasional vertical profiling over Prudhoe Bay, Oliktok Point, Barrow, Atkasuk, Ivotuk, and Toolik Lake. The aircraft payload included Picarro and Los Gatos Research (LGR) analyzers for continuous measurements of CO₂, CH₄, H₂O, and CO and N₂O mixing ratios, and a 12-flask sampler for analysis of carbon cycle gases (CO₂, CO, CH₄, N₂O, 13CO₂, and trace hydrocarbon species). The aircraft payload also included measurements of aerosol properties (number size distribution, total number concentration, absorption, and scattering), cloud properties (droplet and ice size information), atmospheric thermodynamic state, and solar/infrared radiation. Additional information can be found at: <http://www.arm.gov/publications/programdocs/doe-sc-arm-16-031.pdf>. (Sep 24, 2015 - Completed)

- The NASA-funded Atmospheric Tomography Mission (ATom) will study the impact of human-produced air pollution on greenhouse gases and on chemically reactive gases in the atmosphere. Reductions of atmospheric concentrations of methane (CH₄), tropospheric ozone (O₃) and black carbon (BC) are effective measures to slow global warming and to improve air quality. Instruments on board the DC-8 aircraft will measure reactive gases and aerosols to understand how atmospheric chemistry is transformed by various air pollutants and at the impact on global CH₄ and O₃. The DC-8 will sample from 65° S to 85° N over the Atlantic and Pacific Oceans with nearly continuous vertical profiles from near surface to 12 kilometers altitude in four deployments in four separate seasons. All flights originate in Palmdale, CA, with Arctic stopovers at Anchorage, AK, and Thule, Greenland. The Arctic flights (north of 50°) will allow sampling into the upper troposphere and lower stratosphere. ATom flights will be coordinated with satellite measurements and ground sampling networks. Additional information can be found at: <http://science.nasa.gov/missions/atom/>. (Sep 24, 2015 - Completed)
- In a project designed to advance the understanding of impacts of particles in the Arctic atmosphere, scientists from NOAA PMEL deployed the Manta unmanned aerial system (UAS) with different instrument packages from PMEL, NOAA/ESRL/CSD, and academic and international partners to acquire data on atmospheric particles, solar radiation fields, and trace chemical species. The study took place in April, 2015, at Svalbard, Norway, as part of the international Coordinated Investigation of Climate-Cryosphere Interactions (CICCI) Study. The use of UAS for atmospheric sampling is increasing, especially in remote regions like Svalbard (79° N) where deploying conventional aircraft can be prohibitive. Development of miniature research-grade instruments, such as CSD's printed optical particle spectrometer used here, is also accelerating the use of UAS as more instruments can be accommodated on board. The UAS part of the study (there were other aspects) was highly successful, as shown by the high quality measurements of aerosol distributions and the effects on solar radiation. (Aug 7, 2015 - Completed)
- ESRL/GMD has taken an active role in the Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) (<https://ilma.jpl.nasa.gov/portal/>) which is a NASA Earth Venture Mission. From 2011 to present over 700 flight hours of CH₄ measurements have logged both north and south of the Brooks Range. Most of the flights have focused on boundary layer measurements to understand the magnitude, spatial distribution and temporal variability of CH₄ emissions. In addition to aircraft-based measurements our group has lead a collaboration with the NOAA/NESDIS Office of Satellite and Product Operations (OSPO) to take advantage of a tower run by the Fairbanks Command and Data Acquisition Station (FCDAS) near Fox, AK. At this tower we have maintained continuous measurements of CO₂, CO, CH₄ as well as flask measurements of multiple trace gases since the end of 2011. We expect to continue these measurements and incorporate them into the rest of our tall tower network. (Aug 7, 2015 - Completed)

- On-Going Aircraft Programs - US Coast Guard Collaboration: Alaska (ACG) – (<http://www.esrl.noaa.gov/gmd/ccgg/aircraft/alaska.html>). This is a joint collaboration with the US Coast Guard and ESRL/GMD that has produced more than 75 flights in the last 6 years that cover boundary layer and high altitudes up to 8000 masl between Kodiak and Arctic Ocean North of Barrow Alaska. These flights measure CO₂, CO, CH₄ and O₃ at high resolution as well as take flask samples of multiple halogen and hydrocarbon species to better identify the source of emissions of CH₄ and CO₂. Poker Flat, Alaska (PFA) – (<http://www.esrl.noaa.gov/gmd/ccgg/aircraft/#PFA>). These ESRL/GMD flights have been done every two weeks out of Fairbanks, AK and 12 flask samples from 500 to 8000 masl since 2000. These flights provide a very important understanding of the air flowing on to the continent from Siberia and Asia. (Aug 7, 2015 - Completed)
- A new NASA project, the Atmospheric Tomography Mission (ATom), will study the impact of human-produced air pollution on greenhouse gases and on chemically reactive gases in the atmosphere. ATom will deploy an extensive gas and aerosol payload on the NASA DC-8 aircraft for systematic, global-scale sampling of the atmosphere. The data set will be used to improve the representation of chemically reactive gases and short-lived climate forcers in global models of atmospheric chemistry and climate. Profiles of the reactive gases will also provide critical information for validation of satellite data, particularly in remote areas where in situ data is lacking. ATom will conduct flights in the western Arctic and in Greenland. The mission is currently in its formulation stage with a confirmation review scheduled for February 2016. Flights will begin, then, later in 2016. (Aug 5, 2015 - Completed)
- The IASOA data portal is providing integrated access to hundreds of data sets from ground-based observatories ringing the Arctic Ocean. The innovative technologies for creating the portal are being adopted by Global Cryosphere Watch; in tandem, these portals will provide integrated observational support for the WMO Polar Prediction Project. (Apr 25, 2014 - Completed)
- IASOA has initiated topical scientific working group (WG) structure that is contributing to the development of foundational datasets for aerosols from the pan-Arctic observatories. The IASOA radiation WG is collaborating with ECMWF on forecast model validation; next steps will involve satellite validation. The aerosol working group is looking for opportunities to collaboration with AMIP on validation. (Apr 25, 2014 - Completed)
- The ACT organized two webinars on Arctic black carbon. A summary of the webinars is available under at <http://www.iarpccollaborations.org/members/documents/750>. (Apr 25, 2014 - Completed)
- NOAA, NSF and DOE contributed to the development of the International Arctic Systems for Observing the Atmosphere (IASOA) data portal which is providing quick access to over 800 Arctic research-grade data sets from 10 observatories (Apr 25, 2014 - Completed)

- **3.3.1.b (Milestone met) Develop pan-Arctic synthesis of SLCF's from current observations focused on concentrations, trends, sources, and radiative impacts and assess future needs for improved transport-modeling capability; DOE, EPA, NASA, NOAA, NSF; Target Date 2016**
 - Completion Statement: The Arctic Council's Arctic Monitoring and Assessment Program (AMAP) published a report (AMAP 2015; <http://www.amap.no/documents/doc/AMAP-Assessment-2015-Methane-as-an-Arctic-climate-forcer/1285>) synthesizing the state of knowledge on methane – climate impacts in the Arctic. A pan-Arctic climatology of black carbon led by the IASOA Aerosol Working Group is also nearing completion and data is now at the World Data Center for Aerosols. Discussions on future needs for improved understanding and modeling capability will continue into the next IARPC plan period. (Sep 22, 2016 - Completed)
 - Continuation Statement: This milestone is being extended past its original due date of 2014 to 2016. The recent AMAP report provides a synthesis for much of the work being done on SLCFs in the Arctic, however we are awaiting the submission of a black carbon climatology, an effort led by the IASOA Expert Group on Aerosols that is nearing completion that will complement the recent report. (Sep 15, 2016 - Completed)
 - The International Arctic Systems for Observing the Atmosphere (IASOA) Expert Group on aerosols has been championing the consistent processing of the 7 aethalometers at Arctic observatories, which monitor equivalent black carbon. Their efforts resulted in the addition of 7 level 0 new products to the World Data Center for Aerosols (<http://ebas.nilu.no>). They have also verified the use of a correction scheme for Arctic sites that will allow the development of Level 1 data products, also to be housed at WDCA. Building on this work, the group is developing a pan-Arctic climatology from the 7 sites that includes both scattering and absorption properties of aerosols. Publication and data set to be released in FY2017. (Aug 16, 2016 - Completed)
 - The Arctic Council's Arctic Monitoring and Assessment Program (AMAP) has convened two separate expert groups to synthesize and assess the state of knowledge about the impacts of SLCF's on Arctic climate. Their efforts involve modeling and analysis of long-term monitoring observations. NOAA funds two US participants in the AMAP expert group on black carbon and ozone: Trish Quinn (NOAA) and Mark Flanner (NOAA). They have been working on an expansion of their earlier assessment report. DOE funds Mike Kuperberg (OSTP) to chair the AMAP expert group on methane; NOAA funds Lori Bruhwiler (NOAA) as an expert on this group. The full report can be found here: <https://oaarchive.arctic-council.org/handle/11374/1469>. (Aug 15, 2016 - Completed)
 - An international Arctic workshop, sponsored by the International Arctic Science Committee (IASC) was co-led and coordinated with support from NOAA's Arctic Research Program from 3-5 February in Boulder, CO. The workshop focused on

the joint observation-modeling issues of understanding the changing composition of the Arctic atmosphere, with an emphasis on identifying the collaborative efforts required to improve critical knowledge in the decade ahead. This group has now developed into the air Pollution in the Arctic: Climate, Environment and Societies (aPACES) initiative under the auspices of the International Global Atmospheric Chemistry project (<http://www.igacproject.org/PACES>). They have published the following to outline the research agenda for this initiative: <https://www.elementscience.org/articles/104> (Aug 15, 2016 - Completed)

- NASA's Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) experiment carried out a study to determine the relative contribution of wildland fires to black carbon emissions during the summer. See: Mouteva, G. O., Czimczik, C. I., Fahrni, S. M., Wiggins, E. B., Rogers, B. M., Veraverbeke, S., Santos, G. M., Henderson, J., Miller, C. E., and Randerson, J. T., Black carbon aerosol dynamics and isotopic composition in Alaska linked with boreal fire emissions and depth of burn in organic soils, *Glob. Biogeochem. Cycles* 29: 1977-2000, doi: 10.1002/2015GB005247, 2015. (Aug 15, 2016 - Completed)
- This article provides a comprehensive assessment of the ability of models to capture the seasonality and concentrations of BC and other aerosols in the Arctic. The assessment involved 11 different models, surface measurements from 5 stations and aircraft data from 6 campaigns. The most pronounced model underestimates were for Siberia indicating significant underestimates in Russian emission inventories. www.atmos-chem-phys-discuss.net/15/1/2015/ doi:10.5194/acpd-15-1-2015 Contributing agencies: NOAA, NASA, DOE through generation of surface and aircraft data sets using agency supported (surface) facilities and aircraft campaigns including ARCTAS (Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) – NASA; ARCPAC (Aerosol, Radiation, and Cloud Processes affecting Arctic Climate) NOAA and NASA; HIPPO (High-Performance Instrumented Airborne Platform for Environmental Research Pole-to-Pole Observations) DOE. (Aug 7, 2015 - Completed)
- A small subgroup will form to summarize work on SLCFs completed by the ACT in 2014. The SLCF subgroup met on 3/26/15. Notes are available here: <http://www.iarpccollaborations.org/members/documents/2123>. (Mar 27, 2015 - Completed)
- An inventory of Arctic Black Carbon surface-based measurements and a cost analysis of installation of additional monitoring systems has been completed. A Russian site on Bolshevik Island has been identified as a particular location of interest. (Sep 26, 2014 - Completed)
- The Arctic Report Card included a report on status and trends in black carbon in the Arctic. There was a synthesis for that as a part of developing that report. http://www.arctic.noaa.gov/reportcard/black_carbon.html. (Jun 27, 2014 - Completed)
- Two black carbon webinars held. March 28th, 2014 focused on Arctic black carbon mitigation initiative with the Russian Federation and organized by the

Department of State. The April 18 webinar focused on in-situ ground sensing, remote sensing and transport modeling. Archives available at <http://www.arcus.org/iarpc-research-collaborations/webinars/archive>. (Jun 27, 2014 - Completed)

- Workshop at AOS in Vancouver identified coherent error correction schemes for BC data from 7 Arctic Observatories; new corrected & average pan-Arctic BC data set will be available through IASOA archive. (Oct 25, 2013 - Completed)
- **3.3.1.c (Deactivated) Develop needs assessment for improved transport-modeling capability; Target Date 2014**
 - Deactivation Statement: This activity was deemed too complex and cross-cutting for the team to address at this time. However, the next set of IARPC Atmosphere objectives include better understanding of transport of atmospheric constituents to the Arctic. (Sep 22, 2016 - Completed)
- **3.3.1.d (Milestone met) Support SLCF source identification through development of emissions inventories, and their evaluation through transport and regional modeling constrained by satellite and suborbital data; EPA (Lead), NOAA; Target Date 2017**
 - Completion Statement: The ACT agreed in 2015 that this milestone language should read 'Support SLCF source identification through development of emissions inventories constrained by satellite and sub-orbital data.' An EPA effort produced a black carbon emissions inventory for an area in Russia (Evans et al. 2015, doi:10.5194/acp-15-8349-2015), but other Arctic work is lacking. Related objectives in the next 5-year plan will emphasize work to better understand sources and transport to the Arctic. (Sep 22, 2016 - Completed)
 - At the August 2015 meeting of the ACT, it was agreed that the milestone language should be modified to include "through development of emissions inventories" in the milestone language. (Sep 15, 2016 - Completed)
 - Provide final status when project winds down in 2016. Reduction of Black Carbon from Diesel Sources in the Russian Arctic (EPA). This EPA-led effort is funded by DOS's 2009 Arctic Black Carbon Initiative, and is organized under the auspices of the ACAP SLCFC EG, the NSAR Implementation Plan, and the Interagency Arctic Research Policy Committee. This was previously part of work plan of the US-Russia Bilateral Presidential Commission Environment Working Group, which is currently on hold. The project is winding down and will come to an end in 2016. The project has produced an emissions inventory for black carbon from diesel sources in the Murmansk region (see Evans et. al. (2015). Black carbon emissions from Russian diesel sources: case study of Murmansk, Atmos. Chem. Phys., 15, 8349–8359, doi:10.5194/acp-15-8349-2015). An effort is being planned to extend this inventory of diesel sources to all of Russia. The project included two mitigation demonstration projects focused on the top two sources of emissions in the inventory: off-road vehicles at mines and on-road

diesel vehicles. The mines project has produced a set of guidelines for mines purchasing off-road vehicles and an article in the Russian journal, Mining Industry, to be published in August 2015. The on-road project upgraded part of the fleet of Murmanskavtotrans, the largest bus company in the Murmansk region. Circumpolar policy and financing recommendations report, Circumpolar Best Practices: Policy and Financing Options for Black Carbon Emission Reductions from Diesel Sources, is under review and is expected to be published in late 2015 as Arctic Council publication. Russian specific policy and financing recommendations are expected to be published in an international journal in early 2016. DOE- John.Cabaniss@ee.doe.gov USDA- Brad Kinder, USDA (blkinder@fs.fed.us) (Sep 1, 2016 - Target)

- At the August 2015 meeting of the ACT, it was agreed that the milestone language should be modified to include "through development of emissions inventories" in the milestone language. The new language reads: Support SLCF source identification through development of emissions inventories, and their evaluation through transport and regional modeling constrained by satellite and suborbital data (Aug 27, 2015 - Completed)
- Workshop on Improving Black Carbon Emission Estimates and Abatement, Milan, 13-14 May 2015. This workshop was co-hosted by DOE's Office of Energy Efficiency & Renewable Energy, the European Commission's Joint Research Centre, Regione Lombardia, and ARPA Lombardia. It was organized as part of the annual meeting of the Task Force on Emissions Inventories and Projections of the Convention on Long-Range Transboundary Air Pollution (LRTAP). The workshop was intended to improve information sharing between black carbon inventory and abatement efforts under the LRTAP Convention, the Arctic Council, and the Climate and Clean Air Coalition (CCAC). Meeting agendas and presentation materials are available at <http://tfeip-secretariat.org/2015-meeting-milan/>. Although a number of sources and impacts were discussed, the discussion highlighted the significant impact in the Arctic of black carbon emissions from flaring in oil and gas operations in Russia. (May 15, 2015 - Completed)
- A climatology of source regions is being developed for IASOA observatories using back trajectory calculations. (Sep 26, 2014 - Completed)
- **3.3.1.e (Milestone met) Support black-carbon source identification through chemical composition measurement at key observatory locations (NOAA, DOE) and aerosol mapping from space with MODIS and MISR; NASA, NOAA; Target Date 2017**
 - Completion Statement: Airborne and ground-based composition measurements have been used in conjunction with satellite data to understand sources of black carbon in the Arctic and reported in the literature. This work is on-going as projects continue and new campaigns are deployed. In conjunction with ARCTAS, NASA created the capability to use satellite aerosol optical depth with regional transport models for predicting aerosol concentration in the deep Arctic where

observations are sparse, and this capability remains available at NASA. (Sep 22, 2016 - Completed)

- The following NASA-funded publication is relevant to this milestone. Black Carbon Aerosol Dynamics and Isotopic Composition in Alaska Linked with Boreal Fire Emissions and Depth of Burn in Organic Soils Mouteva, G. O., Czimczik, C. I., Fahrni, S. M., Wiggins, E. B., Rogers, B. M., Veraverbeke, S., & Randerson, J. T. (Nov 2015) *Global Biogeochemical Cycles*, 29(11), 1977-2000. <http://onlinelibrary.wiley.com/doi/10.1002/2015GB005247/abstract>. Researchers from JPL-NASA and other research institutions analyzed direct measurements of black carbon (BC) and organic carbon aerosols from wildfires in interior Alaska during the summer of 2013, collected as part of NASA's Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE). The authors compared CARVE measurements with satellite data (MODIS), measurements from an aerosol network, and predicted concentrations from a fire inventory coupled to an atmospheric transport model. The results indicated that fires were the dominant contributor to variability in carbonaceous aerosol mass in interior Alaska during that period. Black carbon aerosol is a major climate forcing agent with the potential to accelerate losses of snow and ice in many areas of the Arctic, yet the importance of this source relative to fossil fuel BC emissions from lower latitudes remains uncertain. The study's measurements constrain the boreal forest fire contributions to aerosol deposition in the Arctic and may ultimately reduce uncertainties related to the impact of a changing boreal fire regime on the climate system. (Jul 12, 2016 - Completed)
- DOE/NOAA have collaborated on funding a project led by Kerri Pratt to characterize the concentrations, chemistry, and sources of summertime aerosols impacting the Oliktok Point and Barrow ARM sites on the North Slope of Alaska during summer 2015 and 2016. In particular, the project will greatly improve the characterization and differentiation of local, regional, and long-range transported summertime aerosols on the NSA. Uniquely, the specific project deliverables will include: the chemistry and number concentrations of particles individually identified as being emitted from Arctic oil and gas extraction activities, as well as apportioned black carbon, organic carbon, sulfate, and nitrate mass concentrations, at Oliktok Point and Barrow, AK. Specific techniques to be used include: aerosol time-of-flight mass spectrometry for single-particle chemistry and source identification, an aethalometer for on-line black carbon mass concentrations, thermo-optical elemental carbon/organic carbon analysis, ion chromatography analysis for inorganic ions, particulate radiocarbon analysis for differentiation between fossil and modern carbon, and particulate organic molecular tracer analysis (Sep 28, 2015 - Completed)
- Remote sensing of aerosol in the Arctic from space is challenging due to a bright underlying surface, persistent cloudiness, low levels of sunlight, and steep sun angles. Even so, aerosol mapping using MODIS and MISR from NASA is valuable for understanding aerosol concentration and transport to the Arctic when used in event-driven studies and to constrain chemical transport models with information from the sub-Arctic and lower latitudes. In preparation for the 2008

ARCTAS campaign, MODIS and MISR data were used to produce maps of aerosol optical depth at locations where such retrievals were possible. Forward simulations and back-trajectories from several aerosol transport models were used to predict the aerosol distribution toward the pole. Operational MODIS and MISR products are acquired operationally, and can be used for these purposes for any desired time period. (Sep 28, 2015 - Completed)

- The NASA-funded Atmospheric Tomography Mission (ATom) will study the impact of human-produced air pollution on greenhouse gases and on chemically reactive gases in the atmosphere. Reductions of atmospheric concentrations of methane (CH₄), tropospheric ozone (O₃) and black carbon (BC) are effective measures to slow global warming and to improve air quality. Instruments on board the DC-8 aircraft will measure reactive gases and aerosols to understand how atmospheric chemistry is transformed by various air pollutants and at the impact on global CH₄ and O₃. The DC-8 will sample from 65° S to 85° N over the Atlantic and Pacific Oceans with nearly continuous vertical profiles from near surface to 12 kilometers altitude in four deployments in four separate seasons. All flights originate in Palmdale, CA, with Arctic stopovers at Anchorage, AK, and Thule, Greenland. The Arctic flights (north of 50°) will allow sampling into the upper troposphere and lower stratosphere. ATom flights will be coordinated with satellite measurements and ground sampling networks and will begin in summer 2016. Additional information can be found at: <http://science.nasa.gov/missions/atom/>. (Sep 28, 2015 - Completed)
- DOE/ARM has funded Arctic Methane, Carbon Aerosols, and Tracers Study, which takes place from September 2014 – September 2016 led by Hope Michelsen (CRF), Ray Bambha, Brian Lafranchi. Black carbon and methane are believed to be significant climate forcers, but the sizes of their various sources and sinks remain highly uncertain. The Arctic region is known to have large reservoirs of carbon that can potentially be released as methane as the region warms. Black carbon may have a strong influence on snow and ice albedo. The sensitivities of emissions of CH₄ and BC to changes in climate are also poorly understood and, therefore, cannot be included with confidence in climate models. Multiple sources of methane and black carbon contribute to concentrations of these species in the Arctic, which complicates the source attribution problem. Measurements of co-emitted species that act as natural tracers for sources of CH₄ and BC can help to connect atmospheric concentrations to source emission rates. The Arctic Methane, Carbon Aerosols, and Tracers Study involves the deployment of instruments to measure CH₄, BC, and source tracers. We will deploy three in situ instruments to measure BC (an SP2, our new instrument CALIIOPI, and a PAX). We will also deploy in situ instruments to measure methane and the ratio of its isotopologues ¹³CH₄/¹²CH₄. In addition, we will measure other tracers for its sources, including CO, BC, and volatile organic compounds (using a PTRMS) for combustion sources and ethane for petroleum sources. Changes in emissions across different regions and seasons will be inferred using atmospheric transport and inverse techniques modeling. (Aug 7, 2015 - Completed)

- MODIS and MISR are NASA resources for aerosol mapping. (Sep 26, 2014 - Completed)
- **3.3.1.f (Milestone met) Support black-carbon radiative impact studies through in-situ measurements at key observatory locations and modeling of light scattering, absorption, surface albedo, and aerosol optical depth; NOAA (Lead), DOE, DOT, EPA, NASA, NSF, USDA; Target Date 2017**
 - Completion Statement: Several published studies have addressed the radiative impact of black carbon and both long-term continuous and detailed campaign-based measurements continue to be supported. A pan-Arctic study of near-surface black carbon concentrations have unified long-term datasets at seven locations and archived this data at the World Data Center for Aerosols (<http://www.gaw-wdca.org/>). (Sep 22, 2016 - Completed)
 - DOE Atmospheric System Research Program (ASR) held a workshop on absorbing aerosol science research needs on January 20-21, 2016. The goal of the workshop is to identify high value science issues and knowledge gaps regarding absorbing aerosols, including BC and dust, and potential actions to make progress in these areas. Topics discussed included several of specifically arctic relevance, including absorbing aerosol effects on snow, clouds and on atmospheric stability. Draft report of the workshop should be released by June, 2016. The workshop report has been approved and may be accessed at: <http://science.energy.gov/~media/ber/pdf/workshop%20reports/CESD-AbsorbingAerosol2016.pdf>. (Aug 4, 2016 - Completed)
 - On-going ground-based monitoring through NOAA and international partners continuously measure equivalent black carbon with optical methods at seven Arctic sites. These measurements have been on-going since the late 1980's at two of the sites, but records at the other stations are generally less than ten years long. The international Arctic Systems for Observing the Atmosphere (IASOA) Expert Group on aerosols has been championing the consistent processing of the 7 aethalometers at Arctic observatories, which monitor equivalent black carbon. Their efforts resulted in the addition of 7 level 0 new products to the World Data Center for Aerosols (<http://ebas.nilu.no>). They have also verified the use of a correction scheme for Arctic sites that will allow the development of Level 1 data products, also to be housed at WDCA. Building on this work, the group is developing a pan-Arctic climatology from the 7 sites that includes both scattering and absorption properties of aerosols. (Jan 26, 2016 - Completed)
 - A study funded by DOE/NASA/NSF addressed impacts of black carbon on snow/ice surfaces: Qian, Y., T.J.Teppei, S.J. Doherty, M.G. Flanner, W. K-M. Lau, M. Jing, H. Wang, M. Wang, S.G. Warren, and R. Zhang. Light-absorbing Particles in Snow and Ice: Measurement and Modeling of Climatic and Hydrological impact. *Advances in Atmospheric Sciences*, 2015, (32): 64-91. (Aug 28, 2015 - Completed)
 - NASA's AERosol RObotic NETwork (AERONET) program has maintained a federated circumpolar arctic network of sun and sky scanning spectral

photometers since the mid-1990's to establish a baseline record of aerosol optical depth and document changes over time. Overall measurements of aerosol optical depth, particle size distribution, and (during episodic events) single scattering albedo are retrieved capturing aerosol properties from spring time arctic haze and episodic biomass burning aerosol transported to the high latitudes. Sites include central and northern Alaska (3), the Canadian Arctic (4), Greenland and Spitzbergen (5), Scandinavia (4) and Russia (2). Given the rapidly increasing temperatures experienced by arctic regions, these data are particularly important to support IARPC for process studies, atmospheric correction of satellite data, improved retrieval of surface reflectance and assimilation in chemical transport models. Beginning in 2016, several lunar enabled photometers will be established to retrieve AOD during the polar night. All data are available in near real time at the AERONET website <http://aeronet.gsfc.nasa.gov>. (Aug 27, 2015 - Completed)

- EPA Grants: Black Carbon's Role In Global To Local Scale Climate And Air Quality (RFA: 2010, Funding: 2011-2015) In 2011, the EPA's National Center for Environmental Research funded a series of 10 research grants addressing black carbon and impacts on climate and air quality. The funded projects are now coming to an end and results are being published. Some of the publications to date that contribute to a better understanding of black carbon's radiative impacts in the Arctic include: Heald CL, Ridley DA, Kroll JH, Barrett SRH, Cady-Pereira KE, Alvarado MJ, Holmes CD. Contrasting the direct radiative effect and direct radiative forcing of aerosols. *Atmospheric Chemistry and Physics* 2014;14(11):5513-5527. Doherty SJ, Grenfell TC, Forsstrom S, Hegg DL, Brandt RE, Warren SG. Observed vertical redistribution of black carbon and other insoluble light-absorbing particles in melting snow. *Journal of Geophysical Research–Atmospheres* 2013;118(11):5553-5569. Schwarz JP, Doherty SJ, Li F, Ruggiero ST, Tanner CE, Perring AE, Gao RS, Fahey DW. Assessing single particle soot photometer and integrating sphere/integrating sandwich spectrophotometer measurement techniques for quantifying black carbon concentration in snow. *Atmospheric Measurement Techniques* 2012;5(11):2581-2592. Wang X, Doherty SJ, Huang J. Black carbon and other light-absorbing impurities in snow across Northern China. *Journal of Geophysical Research–Atmospheres* 2013;118(3):1471-1492. Zhang R, Hegg DA, Huang J, Fu Q. Source attribution of insoluble light-absorbing particles in seasonal snow across Northern China. *Atmospheric Chemistry and Physics* 2013;13(12):6091-6099. (Mar 27, 2015 - Completed)

- **3.3.1.g (In progress) Develop needs assessment for an Arctic methane-observation network; NASA (Lead), DOE, EPA, NOAA; Target Date 2017**

- Incomplete milestone statement: A specific needs assessment was de-scoped due to a lack of time and resources, however, the Arctic Council's Arctic Monitoring and Assessment Program (AMAP) published a report (AMAP 2015) synthesizing the state of knowledge on methane – climate impacts in the Arctic provides a strong foundation for such an assessment.

- The Arctic Council's Arctic Monitoring and Assessment Program (AMAP) has convened two separate expert groups to synthesize and assess the state of knowledge about the impacts of SLCF's on Arctic climate. Their efforts involve modeling and analysis of long-term monitoring observations. NOAA funds two US participants in the AMAP expert group on black carbon and ozone: Trish Quinn (NOAA/PMEL) and Mark Flanner (University of Michigan). They have been working on an expansion of their earlier assessment report. DOE funds Mike Kuperberg (OSTP) to chair the AMAP expert group on methane; NOAA funds Lori Bruhwiler (NOAA) as an expert on this group. The full report is found here: <https://oarchive.arctic-council.org/handle/11374/1469>. (Aug 15, 2016 - Completed)
- NASA research can be used help provide data for such a needs assessment through the following field campaigns: NASA's CARVE experiment, completed in the fall of 2015, provides an archive of data of atmospheric methane concentrations and flux based on airborne remote sensing measurements and flux towers NASA's ABoVE field campaign will continue to collect methane fluxes from selected towers Other field based research during ABoVE will improve estimation of wintertime methane fluxes from frozen lakes Fire-related research during ABoVE will improve estimates of direct methane emissions from wildfires (Aug 15, 2016 - Completed)
- We move to extend this milestone past the target date of 2013. The global budget for methane is reasonably well-known, but the strength of regional sources and sinks carries large uncertainties. Processes in the Arctic may cause these sources and sinks to shift, but the current observational network is not adequate to capture the relevant information. This milestone was developed with the intent of being executed as part of the current AMAP activities, but the methane team did not have the input or time to include an assessment as part of the upcoming report. While an assessment is not currently in development, expressing specific needs for observation is critical to providing future measurements that will allow for quantification of regional processes related to the methane budget and forcing in the Arctic. Current and near-future activities will provide the input for such a needs assessments and this milestone will be developed as results from those activities come on-line. (Sep 24, 2015 - Completed)
- There is no official NASA needs assessment underway or planned. However, as part of NASA's August 2015 selection of solicited proposals for the initial research investigations to begin the Arctic-Boreal Vulnerability Experiment (ABoVE) field campaign—a large-scale study of ecosystem responses to environmental change in western North America's Arctic and boreal region and the implications for social-ecological systems—three of the selections may help inform a future needs assessment for an Arctic methane-observation network. These are: Satellite Data Driven Model Assessment of Landscape Variability and Environmental Controls on the Arctic-Boreal Carbon Budget Characterizing Methane Emission Response to the Past 60 Years of Permafrost Thaw in Thermokarst Lakes Quantifying CO₂ and CH₄ Fluxes from Vulnerable Arctic-Boreal Ecosystems Across Spatial and Temporal Scales More details on each of

these projects can be found on the IARPC collaborations website under milestone 3.3.1.g comments. (Sep 24, 2015 - Completed)

- NOAA ESRL Global Monitoring Division (GMD) carbon cycle group monitors atmospheric CH₄ from discrete air samples at 10 sites and continuously with in situ analyzers at 2 sites. At a few sites, stable isotopes of CH₄ ($\delta^{13}\text{C}$ and δD) are also determined by University of Colorado INSTAAR from NOAA samples. Available NOAA data help quantify and constrain Arctic-wide CH₄ emissions and how they change with time, especially within the context of NOAA's cooperative global air sampling network. To better understand processes responsible for emissions, greater spatial coverage is needed, especially quasi-continuous measurements. Our quasicontinuous measurements from Pleistocene Park near Cherskii are now complemented by measurements ~100 km away on the coast by Max Planck Institute (MPI) for Biogeochemistry (Jena). (Aug 7, 2015 - Completed)
- Ed Dlugokencky (NOAA) gave a presentation on Atmospheric Constraints on Arctic CH₄ Emissions . You can view his presentation at: <http://www.iarpccollaborations.org/members/events/652>. (Jul 9, 2015 - Completed)
- Two groups under AC doing this work (AMAP, Task force on SLCF which assesses the overall cost and benefits of mitigation, and ACAP, which is doing mitigation projects.) AMAP is doing the science work. Moving from solely focused on black carbon to also looking at ozone and methane. (Nov 28, 2014 - Completed)
- An inventory of Arctic methane surface-based measurements and a cost analysis of installation of additional monitoring systems has been completed. A Russian site on Bolshevik Island has been identified as a particular location of interest. (Nov 28, 2014 - Completed)
- **3.3.1.h (In progress) Increase spatial density of Arctic in-situ and columnar methane measurements and establish linkage with satellite observations; DOE, NOAA; Target Date 2017**
 - Incomplete milestone statement: This effort was largely not met due to a lack of resources to institute new, long-term measurements. Better understanding of methane sources and variation have, however, provided a basis for choosing new measurement locations if the opportunity arises. (Sep 22, 2016 - Completed)
 - Ed Dlugokencky (NOAA) gave a presentation on Atmospheric Constraints on Arctic CH₄ Emissions. You can view his presentation at: <http://www.iarpccollaborations.org/members/events/652>. (Jul 9, 2015 - Completed)
 - Ed Dlugokencky (NOAA) reported that methane is not the highest priority on the global budget, but it is more important on regional scales like in the Arctic. Environment Canada has enhanced measurements of methane in Canada, there are a few European sites, but much of Siberia not being measured. NOAA has one

Siberian site begun in 2008. A German group starting measurements in Siberia, and there is some new Russian work. Ed Dlugokencky also reported NOAA has collaborated with NASA CARVE campaign, which was somewhat useful for understanding processes behind methane emission but not as useful as long term monitoring. (Jul 9, 2015 - Completed)

- Work with Russian Federation to establish methane measurements at Cape on Bolshevik Island. (Oct 24, 2014 - Completed)
- DOE methane measurements expand to Olikitok. (Sep 16, 2014 - Completed)
- NOAA supports ongoing methane measurements at Barrow GMD facility (ftp data site) and methane measurements in Tiksi (and Cherskii) are ongoing. DOE: supports ongoing methane measurements at Barrow DOE-ARM facility (data archive). (Jun 27, 2014 - Completed)

- **3.3.1.i (Milestone met) Support activities to improve understanding of transport of gases and aerosols from remote regions to the Arctic and assess source regions through regional modeling studies using models constrained by all available sub-orbital/orbital observations; DOE, EPA, NASA, NSF; Target Date 2017**

- Completion Statement: EPA, NOAA, and NASA are contributing to the work of the Task Force on Hemispheric Transport of Air Pollution, which has produced a new global emissions inventory for 2008 and 2010 and new technology-explicit air pollutant emissions scenarios out to 2050 (<http://www.htap.org/>). The TF HTAP is currently conducting a set of multi-model global and regional modeling experiments to assess intercontinental source-receptor relationships and their impacts. Reports of further progress and outcomes will be added to the activities listed below. (Sep 22, 2016 - Completed)
- This milestone was created from a synthesis of 3.3.1.c-e, 3.3.2.f: Develop needs assessment for improved transport-modeling capability. Support SLCF source identification through transport and regional modeling constrained by satellite and suborbital data. Support black-carbon source identification through chemical composition measurement at key observatory locations (NOAA, DOE) and aerosol mapping from space with MODIS and MISR . Support black-carbon radiative impact studies through in-situ measurements at key observatory locations and modeling of light scattering, absorption, surface albedo, and aerosol optical depth. Support observations and modeling activities to improve understanding of transport of aerosols from remote regions to the Arctic. (Sep 15, 2016 - Completed)
- Provide update on special issue in 2016: EPA, NOAA, and NASA are contributing to the work of the Task Force on Hemispheric Transport of Air Pollution under the LRTAP Convention. The Task Force has produced a new global emissions inventory for 2008 and 2010. (see G. Janssens-Maenhout et al. HTAP_v2: a mosaic of regional and global emission gridmaps for 2008 and 2010 to study hemispheric transport of air pollution. <http://www.atmos-chem-phys->

discuss.net/15/12867/2015/). Through a European Union-funded project, the Task Force has also produced a set of new, technology-explicit air pollutant emissions scenarios out to 2050. The TF HTAP is currently conducting a set of multi-model global and regional modeling experiments to assess intercontinental source-receptor relationships and their impacts, including transport to the Arctic. Initial results from these experiments can be browsed at http://aerocom.met.no/cgi-bin/aerocom/surfobs_annualrs.pl?PROJECT=HTAP. The TF HTAP is organizing a special issue of the journal, Atmospheric Chemistry and Physics, entitled “Global and regional assessment of intercontinental transport of air pollution: results from HTAP, AQMEII and MICS.” The special issue is accepting submissions until 1 December 2016 and is open to all publications related to the intercontinental transport of air pollution and its impacts, including impacts in the Arctic. (Aug 1, 2016 - Target)

- Results were published for a DOE funded study to assess transport to the Arctic: H. Wang, P.J. Rasch, R.C. Easter, B. Sing, R. Zhang, P.-L. Ma, Y. Gian, S. Ghan, and N. Beagley. Using an explicit emission tagging method in global modeling of source-receptor relationships for black carbon in the Arctic: Variations, sources, and transport pathways. JGR, 119 (22), 12,888–12,909. doi: 10.1002/2014JD022297. (Aug 28, 2015 - Completed)
- With funding from the State Department’s-Arctic Black Carbon Initiative, DOE has produced an analysis of Russian contributions to black carbon in the Arctic based on analysis of observations at Alert and Tiksi. ○ Cheng, Meng-Dawn (2014). Geolocating Russian sources for Arctic black carbon. Atmospheric Environment 92:398-410, doi: 10.1016/j.atmosenv.2014.04.031 ○ Kan Huang, Joshua S. Fu, Elke L. Hodson, Xinyi Dong, Joe Cresko, Vitaly Y. Prikhodko, John M. Storey, Meng-Dawn Cheng (2014). Identification of missing anthropogenic emission sources in Russia: implication for modeling Arctic haze. Aerosol and Air Quality Research, accepted. (Oct 24, 2014 - Completed)
- EPA, NOAA, and NASA are contributing to the work of the Task Force on Hemispheric Transport of Air Pollution, which has produced a new global emissions inventory for 2008 and 2010 and new technology-explicit air pollutant emissions scenarios out to 2050. The TF HTAP is currently conducting a set of multi-model global and regional modeling experiments to assess intercontinental source-receptor relationships and their impacts. Initial results from these experiments are expected in 2015. (Sep 26, 2014 - Completed)

3.3.2 Improve understanding of processes that control the formation, longevity, and physical properties of Arctic clouds, including the effects of—and sensitivities to— aerosols

- **3.3.2.a (Milestone met) Support and possibly enhance sustained ground-based measurements of cloud and aerosol properties; NOAA (Lead), DOE, NASA, NSF; Target Date 2013**
 - Completion Statement: NASA, NOAA, and DOE have maintained ground-based in situ and remote sensing measurements at Barrow, Eureka, Tiksi, Alert, Summit,

and MPLNET and AERONET locations and the ARISE aircraft campaign was completed. A new mobile station was deployed by DOE at Oliktok Point, Alaska. Planning for MOSAiC and other activities to be implemented in the Year of Polar Prediction was undertaken. (<http://aeronet.gsfc.nasa.gov/>, <http://mplnet.gsfc.nasa.gov/>, <http://www.esrl.noaa.gov/gmd/>, <http://www.esrl.noaa.gov/psd/arctic/data/>, <http://www.archive.arm.gov/armlogin/login.jsp>, <http://www.mosaicobservatory.org/>). (Sep 22, 2016 - Completed)

- The team has provided a comprehensive accounting of NASA , DOE, and NOAA measurements and the likelihood of any major new programs in ground-based measurements is low. If new activities or projects commence they will be added to the activities listed below. (Sep 15, 2016 - Completed)
- NASA’s Arctic Radiation-IceBridge Sea and Ice Experiment (ARISE) completed the following actions in 2016 that help contribute to the milestone as follows: A paper entitled "Simulation of late summer Arctic clouds during ASCOS with Polar WRF" by Keith M. Hines and David H. Bromwich has been provisionally accepted to Monthly Weather Review. This is in preparation for detailed simulations compared to ARISE observations, and demonstrates the great importance of cloud condensation nuclei for low level Arctic water-cloud formation. (Aug 15, 2016 - Completed)
- The NASA IceBridge LVIS POS/AV L1B Corrected Position and Attitude Data now include data for the Alaska 2014 Arctic Radiation – IceBridge Sea&Ice Experiment (ARISE) campaign. This data set contains georeferencing data from the Applanix 510 and 610 POS AV systems flown with the Land, Vegetation, and Ice Sensor (LVIS) over Greenland, Antarctica, and Alaska. For further information and to access the data from the NASA National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC), see the IceBridge LVIS POS/AV L1B landing page (<http://nsidc.org/data/ipp/v1b>). Data Set DOI: <http://dx.doi.org/10.5067/2NWNMDSG5EPJ>. (Sep 29, 2015 - Completed)
- Since the conclusion of the fall 2014 field campaign portion of NASA’s Arctic Radiation-IceBridge Sea & Ice Experiment (ARISE), the key accomplishments in 2015 include: data calibration, reduction and archival activities; preliminary analyses and comparisons of the aircraft measurements with satellite analyses and model simulations; development of level-2 datasets; and submission of a manuscript to the Bulletin of the American Meteorological Society overviewing the mission operations, the available datasets, and early results. More details follow: A unique dataset on Arctic clouds, atmospheric radiation, atmospheric thermodynamic state, and sea-ice properties obtained from aircraft during the Arctic Radiation-IceBridge Sea and Ice Experiment (ARISE, Sept 2014) was calibrated, processed, reviewed at an ARISE science team meeting, and submitted for archival status in the public domain at the NASA Langley Atmospheric Sciences Data Center and at the National Snow and Ice Data Center. The development of several new level-2 datasets commenced using ARISE aircraft measurements. These include cloud property estimates (phase, optical thickness, particle size) from the aircraft radiometric sensors and cloud heights inferred from

the new atmospheric channel implemented on the NASA Land, Vegetation, and Ice Sensor (LVIS). These datasets are being used to help interpret the aircraft radiative flux measurements, to better understand cloud radiative effects in the Arctic, and to validate and improve long-term observational cloud datasets developed from satellite retrievals, which are often problematic over snow and ice surfaces. An initial study was conducted that compares the ARISE aircraft radiative flux measurement to those contained in NASA's Clouds and the Earth's Radiant Energy System (CERES) level-2 and level-3 satellite data products. The CERES observations, available since 2000, provide the most spatially complete and accurate depiction of radiant energy exchanges in the Arctic; however, sea-ice contributes to larger uncertainties in CERES data products compared to those over other surface conditions. Results from this study indicate that the agreement between the aircraft and satellite measurements over the open Arctic ocean is excellent, confirming the individual instrument accuracies and the experimental approach developed for ARISE. Poorer agreement was found over sea-ice as expected. The rich ARISE datasets are being used to examine the potential sources for the radiative flux disparities over sea-ice and to develop robust corrections that will yield improved CERES data products for the polar regions. A manuscript entitled "Arctic Radiation-IceBridge Sea and Ice Experiment (ARISE): The Arctic Radiant Energy System During the Critical Seasonal Ice Transition" was submitted to the Bulletin of the American Meteorological Society. The manuscript, which provides an overview of the mission operations, descriptions and examples of the data that were collected along with some early results, was co-authored by over two dozen scientists from more than a dozen U.S. government, university and private sector institutions. (Sep 28, 2015 - Completed)

- ASA MPLNET and AERONET activities described below: 1) MPLNET NASA has one Arctic station through MPLNET. The MPLNET station is at Ny Alesund, Svalbard Norway. Its run by the program's Japanese network partner from National Institute of Polar Research. The partner, in turn, has a connection to the local site. The location is: Ny Alesund: 78° 55' 0" N, 11° 55' 59" E. Elevation: 0.040 k. NOTE: This site is not coincident with the AERONET sun photometer on Svalbard. Looking forward, there are plans for a new MPLNET site in Fairbanks, Alaska starting next year. It will be setup and run by the network partner from Naval Research Labs Monterey. There is no specific site information yet, but it will probably be located at a field site run by the University of Alaska, Geophysical Institute. Description of the MPLNET program: The NASA Micro-Pulse Lidar Network (MPLNET) is a federated network of Micro-Pulse Lidar (MPL) systems designed to measure aerosol and cloud vertical structure continuously, day and night, over long time periods required to contribute to climate change studies and provide ground validation for satellite sensors in the Earth Observing System (EOS) (<http://eosps.nasa.gov/>) and related aerosol modeling efforts. Most MPLNET sites are co-located with sites in the NASA Aerosol Robotic Network (AERONET) (<http://aeronet.gsfc.nasa.gov/index.html>). These joint super sites provide both column and vertically resolved aerosol and cloud data, such as: optical depth,

single scatter albedo, size distribution, aerosol and cloud heights, planetary boundary layer (PBL) structure and evolution, and profiles of extinction and backscatter. MPLNET results have contributed to studies of dust, biomass, marine, and continental aerosol properties, the effects of soot on cloud formation, aerosol transport processes, and polar clouds and snow. MPLNET data has been used to validate and help interpret results from NASA satellite sensors such as GLAS, MISR, and TOMS. MPLNET also serves as a ground calibration network for space-based lidars such as the Geoscience Laser Altimeter System (GLAS) (<http://attic.gsfc.nasa.gov/glas/>), on the ICESat spacecraft (<http://icesat.gsfc.nasa.gov/>) (launched in 2003), and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) (launched in 2006) (http://www.nasa.gov/mission_pages/calipso/main/index.html). The main website is: <http://mplnet.gsfc.nasa.gov/>. List of site stations: <http://mplnet.gsfc.nasa.gov/sites> 2) AERONET The AERONET program has maintained a federated circumpolar arctic network of sun and sky scanning spectral photometers since the mid-1990's to establish a baseline record of aerosol optical depth and document changes over time. Overall measurements of aerosol optical depth, particle size distribution and during episodic events single scattering albedo are retrieved capturing aerosol properties from spring time arctic haze and episodic biomass burning aerosol transported to the high latitudes. Sites include central and northern Alaska (3), the Canadian Arctic (4), Greenland and Spitzbergen (5), Scandinavia (4) and Russia (2). Given the rapidly increasing temperatures experienced by arctic regions, these data are particularly important to support IARPC for process studies, atmospheric correction of satellite data, improved retrieval of surface reflectance and assimilation in chemical transport models. Beginning in 2016, several lunar enabled photometers will be established to retrieve AOD during the polar night. All data are available in near real time at the AERONET website <http://aeronet.gsfc.nasa.gov>. Description of the AERONET program: The AERONET (AErosol RObotic NETwork) program is a federation of ground-based remote sensing aerosol networks established by NASA (<http://www.nasa.gov/>) and PHOTONS (<http://loaphotons.univ-lille1.fr/photons/>) (PHOtométrie pour le TraitementOpérationnel de Normalisation Satellitaire; University of Lille 1 (<http://www.univ-lille1.fr/>), CNES (<https://cnes.fr/fr>), and CNRS-INSU (<http://www.cnrs.fr/>) and is greatly expanded by networks (e.g., RIMA (<http://www.rima.uva.es/index.php/en/>), AeroSpan (<http://www.csiro.au/en/Research/OandA/Areas/Assessing-our-climate/Aerospan-aerosol-characterisation>), AEROCAN (<http://www.aerocanonline.com/>), and CARSNET) and collaborators (http://aeronet.gsfc.nasa.gov/new_web/collaborators.html) from national agencies, institutes, universities, individual scientists, and partners. The program provides a long-term, continuous and readily accessible public domain database of aerosol optical, microphysical and radiative properties for aerosol research and characterization, validation of satellite retrievals, and synergism with other databases. The network imposes standardization of instruments, calibration, processing, and distribution (http://aeronet.gsfc.nasa.gov/new_web/system_descriptions.html). AERONET

collaboration provides globally distributed observations of spectral aerosol optical depth (AOD), inversion products, and precipitable water in diverse aerosol regimes. Aerosol optical depth data are computed for three data quality levels: Level 1.0 (unscreened), Level 1.5 (cloud-screened ; http://aeronet.gsfc.nasa.gov/new_web/Documents/Cloud_scr.pdf), and Level 2.0 (cloud-screened and quality-assured : http://aeronet.gsfc.nasa.gov/new_web/Documents/Quality_Control_Checklist.pdf) Inversions, precipitable water, and other AOD-dependent products are derived from these levels and may implement additional quality checks. The main website is: <http://aeronet.gsfc.nasa.gov/index.html>. Site map of stations is: http://aeronet.gsfc.nasa.gov/cgi-bin/site_info. (Sep 28, 2015 - Completed)

- The NOAA ESRL Global Monitoring Division makes long-term, continuous measurements of radiation, aerosol, and cloud properties at two Arctic Observatories: Barrow, Alaska and Summit Greenland as part of the Global Observatories Network. These measurements include upwelling and downwelling broadband shortwave and longwave radiation as well as global, diffuse and direct components of the shortwave radiation and allow for the retrieval of cloud radiative properties such as cloud fraction and cloud optical depth as well as surface albedo. Aerosol measurements made in situ at 10 m above the surface include number concentration (Barrow only), light scattering, and light absorption. Spectral radiation measurements also allow for the retrieval of aerosol optical depth through the full column at Barrow. These data can be used understand trends and variability in aerosol and cloud properties and processes related to aerosol-cloud interactions. NOAA Global Observatories measurements are enhanced by detailed atmospheric state, cloud microphysical, and dynamical properties supported by DOE at Barrow and by NSF at Summit. Observed properties include (but are not limited to) liquid and ice water paths, cloud phase, cloud base heights, and vertical air velocities. A recent addition to the DOE site at Barrow is the High Spectral Resolution Lidar that is capable of providing vertical profiles of aerosol extinction and aerosol types. Useful enhancements to these on-going measurements would be the addition of aerosol optical depth at Summit, enhanced aerosol in situ measurements (especially cloud condensation nuclei concentrations and aerosol humidification factors) at both sites, and lunar photometers at both sites to complete the annual cycle of aerosol optical depth. Spectral surface albedo and black carbon concentrations in snow would also be valuable in informing the role of aerosol in surface darkening and loss of snow and ice cover. (Sep 22, 2015 - Completed)
- Cloud measurements at Summit Station have been maintained from 5/2010 and are anticipated through 8/2018. In 2014 enhanced lidar and precipitation measurements were added. The work is supported by NSF, DOE, and NOAA. Data is archived at: www.archive.arm.gov. Web page: <http://www.esrl.noaa.gov/psd/arctic/observatories/summit/>. (Aug 31, 2015 - Completed)
- DOE hosting a workshop in September to look at developing the linkage between Oliktok and Barrow. (Oct 24, 2014 - Completed)

- Arctic Radiation Ice Bridge Sea & Ice Experiment completed 16 successful flights to acquire well calibrated data sets using aircraft and surface-based sensors to support the use of NASA satellite and other assets for developing a quantitative process level understanding of the relationship between changes in Arctic ice and regional energy budgets as influenced by clouds.
http://www.nasa.gov/mission_pages/icebridge/news/arise14/#.VC7QR_1dXIM. (Oct 24, 2014 - Completed)
- On-going support for existing sites at Barrow (NOAA, DOE), Eureka (Canada and NOAA), Alert Canada (Canada and NOAA), Tiksi (Russia, NSF, and NOAA), and Summit (NSF, NOAA and DOE) will be continued. (Jun 30, 2014 - Completed)
- Conduct planning workshops for internationally coordinated multi-year Arctic Ocean drifting stations with atmospheric studies emphasis (e.g. Multi-disciplinary Drifting Observatory for the Study of the Arctic Climate (MOSAIC), (DOE, NOAA, NSF, 2012-2013). Some workshops have been held. AOS 2013 white paper provides summary of activities. Matt Shupe presented to IARPC on May 6 and will be visiting several agencies during that week. (Jun 30, 2014 - Completed)
- DOE's Atmospheric Radiation Measurement (ARM) program has deployed a mobile facility at Oliktok Point, AK starting in 2013 for an extended term deployment of at least 5 years. The Oliktok site is located approximately 300 kilometers southeast of the North Slope of Alaska (NSA) fixed ARM site in Barrow. The new site is gathering data using about two dozen in situ and remote sensing instruments, including radiometers, lidars, and radars, that obtain continuous measurements of clouds, aerosols, precipitation, energy, and other meteorological variables. It is expected that the site will also host unmanned aerial system (UAS) and tethered balloon flights to take measurements of atmospheric structure, aerosol, and cloud properties. (Sep 3, 2013 - Completed)
- **3.3.2.b (Milestone met) Conduct intensive, short-term, ground-based and airborne (including UAS) field experiments to quantify the impact of aerosols on clouds, conduct detailed process studies, and provide validation data sets for remote sensing data; DOE, NOAA, NSF; Target Date 2016**
 - Completion Statement: The team has provided descriptions of several ground-based and airborne measurement campaigns, which have now been completed. If new activities or projects commence they will be added to the activities listed below. (Sep 22, 2016 - Completed)
 - From June 1 through September 15, 2015, the ARM Aerial Facility will deploy the Gulfstream-159 (G-1) research aircraft to fly over the North Slope of Alaska, with occasional vertical profiling to measure trace-gas concentrations between Prudhoe Bay, Oliktok Point, Barrow, Atkasuk, Ivotuk, and Toolik Lake. The aircraft payload also includes instruments for measuring aerosol properties (number size distribution, total number concentration, absorption, and scattering), cloud properties (droplet and ice size information), atmospheric thermodynamic state, and solar/infrared radiation. (Sep 28, 2015 - Completed)

- The DOE-funded Evaluating Routine Atmospheric Sounding Measurements using Unmanned Systems (ERASMUS) campaign will operate a variety of instrumented Unmanned Aerial Systems (UAS) during two, two-week campaign periods in the summer of 2015 and spring of 2016 at Oliktok Point, Alaska, the current deployment for the third ARM Mobile Facility (AMF3). The campaign will support the collection of a detailed set of atmospheric measurements designed to complement those concurrently obtained by the ARM Facility AMF3. This set of measurements will provide researchers with a focused case-study period for future observational and modeling studies pertaining to Arctic atmospheric processes. Measurements will be geared toward improved understanding of Arctic moisture, aerosol and radiation budgets. In particular, the campaign aims to collect data to address the following science questions: How do profiles of temperature and humidity evolve during transitions between clear and cloudy atmospheric states? How do aerosol properties vary with height at high latitude locations? What role do moisture inversions play in the life cycle of Arctic mixed-phase clouds, and how does their structure evolve in space and time? How well do current remote-sensing retrievals perform in the Arctic environment? What is the spatial variability of heat and moisture fluxes over ice and land surfaces? (Sep 28, 2015 - Completed)
- Since the conclusion of the fall 2014 field campaign portion of NASA's Arctic Radiation-IceBridge Sea & Ice Experiment (ARISE), the key accomplishments in 2015 include: data calibration, reduction and archival activities; preliminary analyses and comparisons of the aircraft measurements with satellite analyses and model simulations; development of level-2 datasets; and submission of a manuscript to the Bulletin of the American Meteorological Society overviews the mission operations, the available datasets, and early results. More details can be found at 3.3.2.a. (Sep 28, 2015 - Completed)
- Arctic Clouds in Summer Experiment (ACSE) occurred July to October of 2014. This involved cloud measurements from an icebreaker cruising from Norway to Barrow and back via the Siberian sector of the Arctic Ocean. The work was supported by NOAA with in kind contributions and personnel support. Relevant publication: Tjernström, M., M. D. Shupe, P. Achtert, B. J. Brooks, I. M. Brooks, P. Johnston, P. O. G. Persson, J. Prytherch, D. Salisbury, J. Sedlar, G. Sotiropoulou, and D. Wolfe, 2015: Warm-air advection, air mass transformation, and fog causes rapid ice melt. *Geophys. Res. Lett.*, 42, doi:10.1002/2015GL064373. (Aug 31, 2015 - Completed)
- The milestone due date was extended from 2014 to 2016 to accommodate ongoing and planned campaigns. (Aug 31, 2015 - Completed)
- During the May 2015 meeting of the ACT, Matt provided an overview of MOSAiC (<http://www.iarpccollaborations.org/members/documents/2359>). (May 22, 2015 - Completed)
- In May 2015, DOE plans to host a workshop on aerial measurements (May 15, 2015 - Completed)

- Europeans - US comparison with our LIDARS is underway. (Dec 16, 2014 - Completed)
- Arctic Radiation Ice Bridge Sea & Ice Experiment completed 16 successful flights to acquire well calibrated data sets using aircraft and surface-based sensors to support the use of NASA satellite and other assets for developing a quantitative process level understanding of the relationship between changes in Arctic ice and regional energy budgets as influenced by clouds.
http://www.nasa.gov/mission_pages/icebridge/news/arise14/#.VC7QR_IdXIM. (Oct 24, 2014 - Completed)
- DOE's Atmospheric Radiation Measurement (ARM) program has deployed a mobile facility at Oliktok. (Oct 24, 2014 - Completed)
- Construction and Testing in progress for UAS DataHawks and tethered sondes sampling at Oliktok Point. (DOE, NOAA) (Oct 24, 2014 - Completed)
- The DOE Atmospheric Radiation Measurement Mobile Facility (ARM AMF) – conducted a field campaign in Hyytiälä, Finland, to investigate the formation and evolution of organic aerosols from northern boreal forests and their impact on cloud formation. The campaign was conducted at the station for Measuring Ecosystem-Atmosphere Relations (SMEAR-II) in Hyytiälä, Finland, which has a long-term measurement suite. EU partners also contributed aerial and precipitation measurements. The field experiment included a snowfall measurement campaign focused on understanding snowfall microphysics and characterizing performance of surface based snowfall measurement instruments. (Jun 30, 2014 - Completed)
- **3.3.2.c (Milestone met) Support synthesis activities to develop long-term observational cloud and aerosol data sets from ground-based and satellite platforms to evaluate model parameterizations; DOE, NASA, NOAA, NSF; Target Date 2016**
 - Completion Statement: Ground-based observations and aircraft campaigns have provided information for evaluating reanalyses and satellite products. Several publications reported in the milestone log have resulted that evaluate satellite and model products and provide better process understanding for model development efforts. (Sep 22, 2016 - Completed)
 - NASA's Arctic Radiation-IceBridge Sea and Ice Experiment (ARISE) completed the following actions in 2016 that help contribute to the milestone as follows: A unique dataset on Arctic clouds, atmospheric radiation, atmospheric thermodynamic state, and sea-ice properties obtained from a NASA C-130 during the Arctic Radiation-IceBridge Sea and Ice Experiment (ARISE, Sept 2014) is available at the NASA LaRC Airborne Science Data for Atmospheric Composition and at the National Snow and Ice Data Center. In order to consolidate the data and to simplify their use, daily merge files were created containing 1-, 10-, and 60- second composites of key parameters. These and other ARISE data and information are available at <http://www->

air.larc.nasa.gov/index.html. A number of studies continue that compare the ARISE aircraft measurements to satellite and model analyses. The detailed observations obtained during ARISE are guiding the development of correction procedures and more robust retrieval and analysis methods that will lead to improved long-term satellite records and model reanalyses of clouds and their radiative effects in polar regions. For example, aircraft measurements of radiative fluxes and cloud properties are being compared to those in NASA's Clouds and the Earth's Radiant Energy System (CERES) level-2 and level-3 satellite data products. While the CERES observations (available since 2000) provide the most accurate spatially complete depiction of radiant energy exchanges in the Arctic, the uncertainty associated with the CERES products are currently larger over sea ice than any other scene type. The comparisons indicate good agreement between the aircraft and satellite measurements over the open Arctic ocean, confirming the individual instrument accuracies and the experimental approach developed for ARISE. Poorer agreement was found over sea-ice as expected. The ARISE measurements are helping to pinpoint and quantify the problem areas in satellite retrievals and model analyses which generally include poor knowledge and/or characterization of surface properties (e.g. skin temperature and albedo), boundary layer thermodynamic state, cloud properties and cloud physical processes. The results of these studies are also being used to help formulate a potential follow-on mission in 2017 or 2018. A paper entitled "Improving our understanding of surface radiative flux bias in Arctic reanalysis over the marginal ice zone: Observationally based sensitivity analysis during ARISE" by Michal Segal Rosenhaimer and co-authors was prepared for submission to the special MERRA2 issue in Journal of Climate. This paper focuses on comparisons of ARISE aircraft measurements with data from the MERRA-2 reanalysis. A manuscript entitled "Arctic Radiation-IceBridge Sea and Ice Experiment (ARISE): The Arctic Radiant Energy System During the Critical Seasonal Ice Transition" was accepted for publication in the Bulletin of the American Meteorological Society. The manuscript provides an overview of the mission operations, descriptions and examples of the data that were collected, along with some early results. It was co-authored by over two-dozen scientists from more than a dozen U.S. government, university and private sector institutions. (Aug 15, 2016 - Completed)

- The Global Modeling and Assimilation Office (GSFC) at NASA/GSFC produces historical global re-analysis for the satellite era (1980-present). Version 2 of the Modern Era Retrospective Analysis for Research and Applications (MERRA-2) to be released in late September/early October for the first time assimilates aerosol satellite data from the AVHRR, MODIS and MISR sensors and in-situ AERONET data. MERRA-2 is based on data assimilation and as such its estimates are based on a combination of observational data and a short term model forecast. Among the many applications of MERRA-2 is the evaluation of model parameterizations. The GEOS-5/MERRA-2 reanalysis dataset that will be released in late September/early October includes a much better representation of the cryosphere than does MERRA (and, perhaps, all other global reanalyses). The GMAO's seasonal forecast products include sea ice. In 2014, GMAO's multi-

month prediction of September Arctic Sea Ice was rather strong in terms of area covered. As we increase the complexity of Earth-System components in GEOS-5, the sea-ice and ice-sheet models (and data analysis) are increasingly important aspects of this work. Website for more details:

<http://gmao.gsfc.nasa.gov/products/>. (Sep 29, 2015 - Completed)

- Since the conclusion of the fall 2014 field campaign portion of NASA's Arctic Radiation-IceBridge Sea & Ice Experiment (ARISE), the key accomplishments in 2015 include: data calibration, reduction and archival activities; preliminary analyses and comparisons of the aircraft measurements with satellite analyses and model simulations; development of level-2 datasets; and submission of a manuscript to the Bulletin of the American Meteorological Society overviewing the mission operations, the available datasets, and early results. More details can be found at 3.3.2.a. (Sep 28, 2015 - Completed)
- Development of multi-year datasets of radiation and cloud radiative forcing at Summit, Greenland. This has been used to evaluate ERA-Interim performance and NCAR CESM cloud parameterizations. Support was provided by NSF and NOAA. Relevant papers: 1) Cox, C.J., V.P. Walden, G.P. Compo, P.M. Rowe, M.D. Shupe and K. Steffen: 2014: Downwelling longwave flux over Summit, Greenland, 2010-2012: Analysis of surface-based observations and evaluation of ERA-Interim using wavelets. *J. Geophys. Res.*, 119, 12 317-12 337, doi:10.1002/2014JD021975. 2) Miller, N. B., M. D. Shupe, C. J. Cox, V. P. Walden, D. D. Turner, and K. Steffen, 2015: Cloud radiative forcing at Summit, Greenland. *J. Climate*, 28, 6267-6280, doi:10.1175/JCLI-D-15-0076.1. (Aug 31, 2015 - Completed)
- During the August 2015 meeting the team extended this milestone from 2014 to 2016 and created a sub group to specifically address milestones related to clouds and aerosols. (Aug 31, 2015 - Completed)
- AERONet has publicly available. DOE has long term cloud and aerosol data available. (Jul 25, 2014 - Completed)
- The AeroCom group is using the following long-term data from the Arctic: Mainly SO₂ and sulfate from the EMPEC surface network. Also BC, OC, and PM from EMPEC, but starting in the 2000s. Other data under the AMAP (Arctic Monitoring and Assessment Program) umbrella (which includes EMPEC): Canada and Alaska data (mostly sulfate); Aeronet has long-term data set; NOAA aerosol extinction and absorption data at Barrow from the mid-1990s; Russian station data is not accessible. Satellites: CALIPSO profiles; there are no other satellite aerosol retrievals due to the combination of very bright surface, low sun angle, and very low AOD. (Jun 30, 2014 - Completed)
- See Ralph Kahn's presentation from the Black Carbon Webinar (<http://www.iarpccollaborations.org/members/events/572>). Slides 13, 16, 17 are especially relevant. Also, see these publications: DEVASTHALE, A.,M. TJERNSTRO, and A.H. OMAR, 2011. The vertical distribution of thin features over the Arctic analysed from CALIPSO observations. *Tellus* 63B, 86–95 Di Pierro, M., L. Jaegle, E.W. Eloranta, and S. Sharma, 2013. Spatial and seasonal

distribution of Arctic aerosols observed by the CALIOP satellite instrument (2006–2012). *Atmos. Chem. Phys.*, 13, 7075–7095. Fisher, J.A., et al., 2010. Source attribution and interannual variability of Arctic pollution in spring constrained by aircraft (ARCTAS, ARCPAC) and satellite (AIRS) observations of carbon monoxide. *Atmos. Chem. Phys.*, 10, 977–996. (Jun 30, 2014 - Completed)

- **3.3.2.d (Milestone met) Use observational data sets to constrain process-model studies and conduct detailed model inter-comparisons to advance parameterization development; DOE; Target Date 2017**

- Completion Statement: Large Eddy Simulation and observational studies examined processes in mixed-phase clouds. (Sep 22, 2016 - Completed)
- We move to extend this milestone to a Target Date of 2017 (from 2014) to capitalize on current and on-going observational and high-resolution modeling analyses along the North Slope of Alaska. (September 30, 2015) (Sep 30, 2015 - Completed)
- 1) Large-eddy simulation model intercomparison examining parameterizations of cloud ice in mixed-phase clouds based on measurements from near Barrow. Supported by DOE. Ovchinnikov, M., A. S. Ackerman, A. Avramov, A. Cheng, J. Fan, A. M. Fridlind, J. Harrington, C. Hoose, S. Ghan, A. Korolev, G. M. McFarquhar, H. Morrison, M. Paukert, J. Savre, B. J. Shipway, M. D. Shupe, A. Solomon, and K. Sulia, 2014: Intercomparison of large-eddy simulations of Arctic mixed-phase clouds: Importance of ice size distribution assumptions. *J. Adv. Model. Earth Systems*, 6, 223-248, doi:10.1002/2013MC000282. 2) Large-eddy simulation study examining aerosol recycling in mixed-phase clouds and working towards parameterization development. Supported by DOE. Solomon, A., G. Feingold, and M. Shupe, 2015: The role of ice nuclei recycling in the maintenance of cloud ice in Arctic mixed-phase stratocumulus. *Atmos. Chem. Phys.*, submitted. (Aug 31, 2015 - Completed)
- During the May 2015 meeting Matt provided an overview of the MOSAiC program (<http://www.iarppcollaborations.org/members/documents/2359>). (May 22, 2015 - Completed)
- Model and observation studies on Arctic Mixed Phased Stratus (AMPS) have identified an aerosol recycling process for maintaining Arctic stratus cloud. (Sep 26, 2014 - Completed)
- Team produced a catalogue of available data sets organized by upper and lower atmosphere and clouds. Now that the catalogue is complete, Atmosphere and modeling teams will look for collaboration on the modeling aspects of this milestone. (Jul 1, 2014 - Completed)

- **3.3.2.e (Milestone met) Support laboratory studies to examine cloud-particle nucleation processes; DOE (Lead), NASA, NSF; Target Date 2017**

- Completion Statement: The team has provided descriptions of several laboratory and field studies on droplet and ice crystal nucleation funded by research grants,

while new projects will likely be initiated in the coming years. (Sep 22, 2016 - Completed)

- NSF reports 12 active grants involving studies of ice or droplet nucleation research studies, three of which were started in FY2016 (Aug 19, 2016 - Completed)
- The team extended the Target Date to 2017 to take advantage of future relevant laboratory studies. Several (7-10) grants were initiated by DOE and NSF addressing key aspects of nucleation processes, with others likely in FY2016. While the current grants satisfy the milestone, the team extended the Target Date to 2017 to take advantage of the current and future relevant laboratory studies. (Sep 30, 2015 - Completed)
- DOE has four grants and a lab project totaling \$700,000 addressing cloud and ice nucleation. these were augmented by two new research grants and a workshop in FY 2015-16 (Jul 1, 2014 - Completed)
- The ACCRI laboratory work studying the evolution of soot into contrail particles was done by: H.-W. Wong, A. J. Beyersdorf, C. M. Heath, L. D. Ziemba, E. L. Winstead, K. L. Thornhill, K. M. Tacina, R. C. Ross, S. E. Albo, D. L. Bulzan, B. E. Anderson, and R. C. Miake-Lye. Laboratory and Modeling studies on the effects of water and soot emissions and ambient conditions on the formation of contrail ice particles in the jet regime. *Atmos. Chem. Phys.*, 13, 10049–10060, 2013. doi:10.5194/acp-13-10049-2013. (Jul 1, 2014 - Completed)

- **3.3.2.f (Milestone met) Support observations and modeling activities to improve understanding of transport of aerosols from remote regions to the Arctic; Target Date 2017**

- Completion Statement: Publications addressed the issue of aerosol transport to the Arctic emphasizing the need for better understanding in this area. Under the PACES initiative, a working group is planning for airborne measurements and process studies that will be directed towards these knowledge gaps. (Sep 22, 2016 - Completed)
- X. Yue, L. J. Mickley, J. A. Logan, R. C. Hudman, M. V. Martin, and R. M. Yantosca. Impact of 2050 climate change on North American wildfire: consequences for ozone air quality. *Atmos. Chem. Phys.*, 15, 10033–10055, 2015 www.atmos-chem-phys.net/15/10033/2015/ doi:10.5194/acp-15-10033-2015. ()
- PACES (air Pollution in the Arctic: Climate and Environment and Societies) is an initiative to better understand the sources and impacts of air pollution in the Arctic. Within PACES, a working group on understanding model deficiencies is discussing plans for future aircraft deployments that will target sources and locations of pollution that ends up the Arctic, processing of pollution as it is transported to the Arctic, and both the physical and societal impacts of that pollution within the region. A publication laying out the related scientific and societal challenges has recently been published: S. R. Arnold, K. S. Law, C. A. Brock, J. L. Thomas, S. M. Starkweather, K. von Salzen, A. Stohl, S. Sharma, M.

T. Lund, M. G. Flanner, T. Petaäjä, H. Tanimoto, J. Gamble, J. E. Dibb, M. Melamed, N. Johnson, M. Fidel, V.-P. Tynkkynen, A. Baklanov, S. Eckhardt, S.A. Monks, J. Browse, H. Bozem, Arctic air pollution: Challenges and opportunities for the next decade , *Elementa: Science of the Anthropocene* , doi:10.12952/journal.elementa.000104, 2016 ()

- Results were published for a DOE funded study to assess transport to the Arctic: H. Wang, P.J. Rasch, R.C. Easter, B. Sing, R. Zhang, P.-L. Ma, Y. Gian, S. Ghan, and N. Beagley. Using an explicit emission tagging method in global modeling of source-receptor relationships for black carbon in the Arctic: Variations, sources, and transport pathways. *JGR*, 119 (22), 12,888–12,909. doi: 10.1002/2014JD022297. (Aug 28, 2015 - Completed)

3.3.3 Develop an integrated understanding of Arctic atmospheric processes, their impact on the surface energy budget, and their linkages with oceanic, terrestrial, and cryospheric systems

- **3.3.3.a (Milestone met) Support model-component development and advancement of fundamental knowledge of the key processes that regulate aerosol and cloud impacts on the atmospheric- and surface-energy budgets; DOE, NOAA, NSF; Target Date 2015**
 - Completion Statement: A range of observations and models have been used in studies to better understand aerosol-cloud-radiation dynamics. Recent and on-going interaction with the reanalysis community is expected to contribute to the transfer of this information to model components into the future. (Sep 22, 2016 - Completed)
 - New Publication: Taylor, P. C., S. Kato, K-M, Xu, and M. Cai, January 2015, Covariance between Arctic sea ice and clouds within atmospheric state regimes at the satellite footprint level. *J. Geophys. Res. Atmos.*, 120, doi:10.1002/2015JD023520. Importance: Arctic climate change is progressing at rapid, unprecedented, and dangerous rates. Current climate models are unable to capture the observed rates of Arctic climate change. A major reason for this model shortcoming is the inability to accurately represent Arctic low cloud processes and specifically the interactions with sea ice. Science Question: Do clouds respond to changes in sea ice concentration? Data: C3M data fusion product (Kato et al. 2010): CALIPSO, CloudSat, CERES, and MODIS, and MERRA Reanalysis Uniqueness: Arctic low cloud characteristics are strongly constrained by meteorology. This is the first study removing the impact of meteorology on cloud characteristics to study cloud-sea ice interactions using instantaneous, satellite footprint data. The only way to completely deconvolve the impacts of meteorology and sea ice on Arctic low clouds is to perform the analysis at the instantaneous satellite footprint level. The use of instantaneous satellite footprint data additionally retains process-level information of cloud-sea ice interactions that has been obscured in previous work using monthly, gridded data. The process-level quantification of the sensitivity of clouds to sea ice is the fundamental constraint needed to improve process models (e.g., cloud microphysics, and turbulence). Key Results: No evidence of a summer time

Arctic cloud response to reduction in sea ice. Found evidence for a weak Arctic low cloud response to sea ice in Autumn. The sensitivity of clouds to sea ice changes depends upon atmospheric conditions. Meteorology is an order of magnitude larger constraint on Arctic low cloud characteristics than sea ice. Implications: The lack of an Arctic low cloud response to sea ice loss in summer suggests that clouds WILL NOT dampen the amplification of Arctic climate changes by sea ice loss. Additionally, other research has shown that the current generation of GCMs simulate a summer cloud increase to Arctic sea ice loss, which dampens surface albedo feedback suggesting a low bias in projected Arctic warming by climate models. (Jul 12, 2016 - Completed)

- Since the conclusion of the fall 2014 field campaign portion of NASA's Arctic Radiation-IceBridge Sea & Ice Experiment (ARISE), the key accomplishments in 2015 include: data calibration, reduction and archival activities; preliminary analyses and comparisons of the aircraft measurements with satellite analyses and model simulations; development of level-2 datasets; and submission of a manuscript to the Bulletin of the American Meteorological Society overviewing the mission operations, the available datasets, and early results. More details follow: A unique dataset on Arctic clouds, atmospheric radiation, atmospheric thermodynamic state, and sea-ice properties obtained from aircraft during the Arctic Radiation-IceBridge Sea and Ice Experiment (ARISE, Sept 2014) was calibrated, processed, reviewed at an ARISE science team meeting, and submitted for archival status in the public domain at the NASA Langley Atmospheric Sciences Data Center and at the National Snow and Ice Data Center. The development of several new level-2 datasets commenced using ARISE aircraft measurements. These include cloud property estimates (phase, optical thickness, particle size) from the aircraft radiometric sensors and cloud heights inferred from the new atmospheric channel implemented on the NASA Land, Vegetation, and Ice Sensor (LVIS). These datasets are being used to help interpret the aircraft radiative flux measurements, to better understand cloud radiative effects in the Arctic, and to validate and improve long-term observational cloud datasets developed from satellite retrievals, which are often problematic over snow and ice surfaces. An initial study was conducted that compares the ARISE aircraft radiative flux measurement to those contained in NASA's Clouds and the Earth's Radiant Energy System (CERES) level-2 and level-3 satellite data products. The CERES observations, available since 2000, provide the most spatially complete and accurate depiction of radiant energy exchanges in the Arctic; however, sea-ice contributes to larger uncertainties in CERES data products compared to those over other surface conditions. Results from this study indicate that the agreement between the aircraft and satellite measurements over the open Arctic ocean is excellent, confirming the individual instrument accuracies and the experimental approach developed for ARISE. Poorer agreement was found over sea-ice as expected. The rich ARISE datasets are being used to examine the potential sources for the radiative flux disparities over sea-ice and to develop robust corrections that will yield improved CERES data products for the polar regions. A manuscript entitled "Arctic Radiation-IceBridge Sea and Ice Experiment (ARISE): The Arctic Radiant Energy System During the Critical Seasonal Ice

Transition" was submitted to the Bulletin of the American Meteorological Society. The manuscript, which provides an overview of the mission operations, descriptions and examples of the data that were collected along with some early results, was co-authored by over two dozen scientists from more than a dozen U.S. government, university and private sector institutions. (Sep 28, 2015 - Completed)

- As part of NASA's ARISE campaign, high resolution airborne measurements of the shortwave, longwave, microwave, cloud, and aerosol microphysical properties have been made coincidentally with satellites. Comparison of coincident aircraft and satellite measurements will contribute to improvement of the long-term satellite data record, which will be useful for comparison to and advancement of clouds and aerosols in numerical models. (Dec 16, 2014 - Completed)
- FAA has begun (Jan, 2014) a one year program to compute surface air quality from cruise emissions worldwide. Five teams from MIT, Stanford, UIUC, NASA/GSFC/USRA, and Yale are participating. The project will provide worldwide distribution of PM2.5 and ozone (at a minimum), including the arctic. (Jul 1, 2014 - Completed)

- **3.3.3.c (Milestone met) Coordinate interdisciplinary campaigns to study the Arctic climate system as a whole; Target Date 2016**

- Completion Statement: Planning and coordination of two, major interdisciplinary campaigns has taken place during this IARPC plan period. MOSAiC, the Multidisciplinary Drifting Observatory for the Study of Arctic Climate (<http://www.mosaicobservatory.org/>) is an international initiative to drift an icebreaker through the deep Arctic for one year with measurements to target many aspects of the Arctic climate system including sea ice, surface energy fluxes, and cloud and aerosol processes. Outcomes will include better understanding of physical processes for improving model representation. PACES (air Pollution in the Arctic: Climate and Environment and Societies, <http://www.igacproject.org/PACES/>) is an initiative to better understand the sources and impacts of air pollution in the Arctic. Within PACES, three working groups target relevant aspects of social science, the Russian Arctic, and physical model deficiencies. (Sep 22, 2016 - Completed)
- PACES (air Pollution in the Arctic: Climate and Environment and Societies) is an initiative to better understand the sources and impacts of air pollution in the Arctic. Within PACES, three working groups target relevant aspects of social science, the Russian Arctic, and physical model deficiencies. These efforts will bring together socio-economic and physical aspects of the Arctic atmosphere by taking observations to improve atmospheric predictions in the Arctic. A publication laying out the PACES initiative has recently been published: S. R. Arnold, K. S. Law, C. A. Brock, J. L. Thomas, S. M. Starkweather, K. von Salzen, A. Stohl, S. Sharma, M. T. Lund, M. G. Flanner, T. Petaäjä, H. Tanimoto, J. Gamble, J. E. Dibb, M. Melamed, N. Johnson, M. Fidel, V.-P. Tynkkynen, A. Baklanov, S. Eckhardt, S.A. Monks, J. Browse, H. Bozem, Arctic air pollution:

Challenges and opportunities for the next decade , Elementa: Science of the Anthropocene , doi:10.12952/journal.elementa.000104, 2016 (<http://elementascience.org/article/info:doi/10.12952/journal.elementa.000104>) (Aug 25, 2016 - Completed)

- Develop an Arctic FluxNet product. (Jun 26, 2015 - Target)
- During the May 2015 meeting of the ACT, Matt Shupe provided an overview of MOSAiC (<http://www.iarpccollaborations.org/members/documents/2359>). (May 22, 2015 - Completed)
- **3.3.3.d (Milestone met) Increase use of UAV platforms for targeted observations of Arctic processes; Target Date 2015**
 - Completion Statement: DOE was granted special-use airspace around their ground-based facility at Oliktok Point. Several campaigns for testing instrumentation and platforms, including small aircraft and tethered balloon systems, were conducted and initial scientific campaigns have been completed. NOAA continues to miniaturize instruments for critical measurements of aerosol in the Arctic. If new activities or projects commence they will be added to the activities listed below. (Sep 22, 2016 - Completed)
 - The DOE ARM program has started routine small UAS and tethered balloon operations at Oliktok. Activities are occurring June - October 2016, and are expect in the summer of 2017 as well. (Jun 15, 2016 - Completed)
 - The DOE-funded Evaluating Routine Atmospheric Sounding Measurements using Unmanned Systems (ERASMUS) campaign will operate a variety of instrumented Unmanned Aerial Systems (UAS) during two, two-week campaign periods in the summer of 2015 and spring of 2016 at Oliktok Point, Alaska, the current deployment for the third ARM Mobile Facility (AMF3). The campaign will support the collection of a detailed set of atmospheric measurements designed to complement those concurrently obtained by the ARM Facility AMF3. (Jun 7, 2016 - Completed)
 - The DOE ERASMUS campaign was conducted as planned at Oliktok Point, Alaska. Data and more information is available at <http://www.arm.gov/campaigns/amf2015erasmus>. (Jun 7, 2016 - Completed)
 - NOAA has developed and tested several miniaturized instruments for UAV platforms designed to measure vertical profiles of ozone, aerosol size distribution, aerosol absorption and black carbon concentration, and aerosol optical depth. In 2015, the aerosol instruments were mounted on a Manta and successfully flown at the Ny Alund station, showing consistency in the various measured aerosol properties. A sonde and glider configuration (the GOA2HEAD Network Initiative: Global Ozone and Aerosol profiles and Aerosol Hygroscopic Effect and Absorption optical Depth) has also been developed to carry these instruments to a height of ~5 km and be dropped, with a homing device that would return the glider and instruments to their original launch position. The system is intended to pass FAA regulations and to provide a cost efficient means for semi-routine

vertical profiling in the Arctic and elsewhere. Support for a year-long proof-of-concept is currently being sought for locations in the Arctic. (Sep 25, 2015 - Completed)

- DOE ARM conducted engineering tests of small unmanned aerial system (UAS) and tethered balloon instrumentation in Fall 2014 at Oliktok Point to develop plans for future routine UAS and tethered balloon sampling (Aug 28, 2015 - Completed)
- DOE was granted special-use airspace by the FAA to enable climate and atmospheric research in the Arctic. Called Warning Area W-220, the airspace is 40 miles wide. It starts just offshore of the Atmospheric Radiation Measurement (ARM) Climate Research Facility's Oliktok Point, Alaska, site and stretches 700 miles north ending 400 miles short of the North Pole. The new area expands the DOE research footprint in the Arctic and provides a safety margin for both manned and unmanned aerial research operations in the Arctic. (Aug 28, 2015 - Completed)
- **3.3.3.e (Milestone met) Comparison of CO₂ and other GHG surface flux budgets between Barrow and Oliktok, Alaska and Tiksi, Russia; DOE, NOAA; Target Date 2016**
 - Completion Statement: A manuscript comparing components of the turbulent, radiation, CO₂ and H₂O fluxes between Tiksi and Eureka has been submitted. The major conclusion of the study is that the primary driver of seasonal and latitudinal variations in temperature and other parameters in the Arctic is the seasonally varying pattern of incident sunlight. (Sep 22, 2016 - Completed)
 - A manuscript comparing components of the turbulent, radiation, CO₂ and H₂O fluxes between Tiksi and Eureka has been submitted. The major conclusion of the study is that the primary driver of seasonal and latitudinal variations in temperature and other parameters in the Arctic is the seasonally varying pattern of incident sunlight. Tiksi and Eureka are in markedly different regimes (inside the Canadian Archipelago vs on the edge of the Eurasian continent). One would expect these different regimes to have significant influences that would mask the latitudinal difference of 6 degrees, but the latitudinal control on the insolation is the primary driver. Seasonal and Latitudinal Variations of Surface Fluxes at Arctic Terrestrial Sites Andrey A. Grachev • Taneil Uttal • P. Ola G. Persson • Elena A. Konopleva-Akish • Sara M. Crepinsek • Christopher J. Cox • Christopher W. Fairall • Robert S. Stone • Glen Lesins • Alexander P. Makshtas • Irina A. Repina ()

Team Leads: Ashley Williamson (DOE); Allison McComiskey (NOAA)

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

Arctic Observing Systems

Milestone Reporting Log 2016

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

3.4 Observing systems

3.4.1 Facilitate observing system design for the arctic

- **3.4.1.a (Milestone met) Support diverse, multi-disciplinary observing teams that include representatives from state, local, and tribal governments, academia, the private sector, the international Arctic community and other stakeholders; Target Date 2014**
 - Completion Statement: Federal agencies have sustained and expanded the host of thematic and interdisciplinary observing teams over the Plan's period of performance. The AOSCT and other Federally-sponsored fora have increased the visibility of these teams and succeeded in driving a diversity of participation. While there are persistent gaps in Arctic observations, the network of researchers making and sharing those observations has been greatly enhanced during FY13-16. (Sep 26, 2016 - Completed)
 - The team has convened two meetings to organize white paper contributions to the Arctic Observing Summit - 2016 in Fairbanks on the topic of Community Based Observing. This was in response to Arctic Executive Steering Committee interest in advancing this topic. A framework document outlining AESC interests was posted to the website to prompt discussion and community organization. (Sep 14, 2016 - Completed)
 - The follow efforts demonstrate progress on this milestone as related to Community Based Observing: A newly sponsored NSF RCN "Eyes North" will serve to further enhance connections across CBO projects and advance the science of CBO. An October 2015 DHS sponsored workshop advanced best practices for CBO and established a common ground for diverse communities to move forward in support of this important observing infrastructure. Several white papers were submitted to the Arctic Observing Summit on the topic of CBO, and an entire theme within the workshop was dedicated to advancing this important topic. These fed back into and advanced important discussions with the Arctic Executive Steering Committee in November 2015. (Sep 1, 2016 - Completed)
 - Planning for a resilient future in the rapidly changing Arctic requires a co-developed process that is informed by many disciplines and types of knowledge, understanding of the interrelated systems, scalable solutions, and community-relevant decision-making tools. The Belmont Forum Arctic Call brought together

fundings from both Arctic and Arctic-interested nations to leverage existing investments and spur new multi-national partnerships to advance and innovate sustainability science theory and approaches. Efforts supported by this international call will unite the expertise of natural science, social science, and stakeholders to build collaborative teams, synthesize available information, and develop research capacity to address one or more key themes in resilience in the Arctic: the interactions of the natural and living environment; the built environment and infrastructures; natural resource management and development; and governance. The call was well-subscribed, showing the strong interest across disciplines to partner internationally and with communities to inform resilience strategies in the Arctic. The successful projects and research teams include participants and support from Canada, China, Denmark, Finland, France, Greenland, Iceland, Italy, Japan, Norway, Russia, Sweden, and the US. Research teams include a breadth of stakeholders, including indigenous communities, local governments, industry, and NGOs. Many students and early career scientists within and outside the Arctic will receive training through these research projects in interdisciplinary and transdisciplinary science, building new capacity and opportunities for lessons learned from the Arctic to have global reach. (Mar 15, 2015 - Completed)

- Funding and Collaborative Observing accomplishments: Consortia funding for Long-Term Monitoring Program assets including partners from federal, state, academic, and industry organizations (Lead: NPRB, AOOS, UAF, and Chukchi Sea Environmental Studies Program, 2014-2019) <http://project.nprb.org/view.jsp?id=7aa35369-ffdf-45a5-b8cc-5d0f524059f6>. Belmont Forum Collaborative Research Action for Observing and Science for Sustainability (Lead: NSF, with BOEM / collaborative with 11 other international agencies, in process, to be completed in early 2015). Collaborative implementation of Northeastern Chukchi Sea Survey for Coastal Impact Assistance Program (Lead: AK DEC, NOAA National Status and Trends Program, UAF Institute of Marine Science, 2010-2012). Collaborative implementation of Arctic Wetlands Survey for National Wetland Condition Assessment (Lead: AK DEC, UAA Alaska Natural Heritage Program, NRCS Soil Science, BLM, and the North Slope Borough with funding from EPA, 2011). Collaborative implementation of Arctic Lakes Survey for the National Lakes Assessment (Lead: AK DEC, UAA Alaska Natural Heritage Program, BLM, The Wilderness Society, and Barrow Arctic Science Consortium, with funding from EPA, 2013-). Multi-agency and academic implementation of Terrestrial Environmental Observing Network (TEON) using a focal watershed framework for long-term measurement of change in key ecosystem components (Lead: Arctic LCC) <https://sites.google.com/a/arcticlcc.org/teon/>. Collaborative observations of Cold Regions Lakes and Landscapes, (Lead: USGS, with BLM, Arctic LCC, Western Alaska LCC, North Slope Borough Wildlife Department, UAF, NASA-JPL, University of Nebraska-Lincoln, University of Cincinnati). Co-funding of Russian American Long-Term Census in the Arctic (Lead: NOAA, NSF, 2004-). Co-funding of Distributed Biological Observatory (Lead: NSF, NOAA, with

contributions from Pacific Arctic Group member nations, 2010-). (Sep 26, 2014 - Completed)

- Documents and syntheses contributing to this milestone: Interorganizational synthesis of ecological observations in the Chukchi and Beaufort Seas (Leads: Audubon Society, Oceana, Ocean Conservancy, Pew Charitable Trusts, WWF, with BOEM). Interorganizational synthesis of Bering Strait Marine Life and Subsistence Use Data (Leads: Oceana, Kawerak) <http://oceana.org/en/news-media/publications/reports/the-bering-strait-marine-life-and-subsistence-data-synthesis>. (Sep 26, 2014 - Completed)
- Contributions to best practices, shared protocols/methodologies, common metadata, measurement standards which support this milestone: Metadata for all AK DEC marine projects provided to AOOS data portal, AKMAP data to the IMIQ data portal (Lead: Arctic LCC), and all data to STORET (Lead: EPA). Data from RUSALCA contributed to the Circumpolar Marine Biodiversity Monitoring Program (Lead: NOAA, with other data provided by CAFF working group members) and also archived by AOOS. (Sep 26, 2014 - Completed)
- Coordination, strategy, and planning activities which support this milestone: International and interagency science planning and coordination at the Arctic Observing Summit (Lead: SAON, 2014). Planning for Arctic Observing Network Open Science Conference (Lead: SEARCH, 2014-2015). Support for distributed discussion of best practices for long-term observing governance (Lead; NSF/ARCUS, in process, to be completed by early 2015). Science discussions on planned North Slope surveys (Lead: AK DEC, with North Slope Borough Wildlife Department, North Slope Borough Fish and Game Management Council). Leadership of the CAFF Coastal Expert Monitoring Group (CEMG), whose goal is to “promote, facilitate, coordinate, and harmonize coastal biodiversity monitoring activities among circumpolar countries and Permanent Participants”, with a plan to be released in 2015, (Lead: USGS, with participation from ICC-Alaska, NSSI, and other national agencies, 2014-2015). Hosted a Community Based Monitoring Workshop which resulted in a manual of best practices and lessons for release at the Alaska Forum of the Environment in February 2014 (Lead: AOOS, with Alaska Sea Grant, Alaska Center for Ocean Science Education Excellence). Scoping meeting for the next AOOS 5-year plan, focused on Ocean Observations for Maritime Domain Awareness, including Navigation and Forecasting (Lead: AOOS, 2014-). Collaborative workshop on Planning for and Forecasting Coastal Arctic Storms (Lead: AOOS, NOAA/National Weather Service, 2014). Special sessions planned on Integrating Arctic Ocean and Coastal Observations at the Alaska Marine Science Symposium and Alaska Forum on the Environment (Lead: AOOS, 2014-2015). (Sep 26, 2014 - Completed)
- Community tools which support this milestone: Developed Help Wanted capability on ArcticHub to support collaborative interaction to develop interdisciplinary, interagency proposals (2014). Developed searchable resource catalog on ArcticHub to provide access to relevant tools, community documents,

- and visualization packages for best practices in observing. (Sep 26, 2014 - Completed)
- Terri Lomax (AK DEC) presented the Alaska Monitoring and Assessment Program. (Jul 16, 2014 - Completed)
- **3.4.1.b (Milestone met) Assess the state of the nine observing system/network themes and identify knowledge gaps and establish sites or regions for key observations; NSF (Lead); Target Date 2015**
 - Completion Statement: Several efforts over the Plan's period of performance have addressed this complex issue; while no comprehensive and unified framework was identified several were explored. These led to enhanced discoverability of Arctic observing assets, comprehensive summaries of the state of observing system and considerable literature on knowledge gaps. The most comprehensive summary of these efforts were reported at AOOSM 2015, Seattle, WA and AOS 2016 Fairbanks, AK. (Sep 26, 2016 - Completed)
 - The Arctic Observing Assessment is under way. (Lead: NSF/IARPC/SAON, in process, to be completed in 2015) (Sep 1, 2016 - Completed)
 - The Arctic Observing Open Science Meeting, held in Seattle in Fall 2015, provides a comprehensive summary of progress on this milestone for the plan period of performance. In all, 206 attendees participated in 99 parallel session presentations, 42 posters, and an interagency observing panel. Presentations and abstracts can be found here: <https://www.arcus.org/search-program/meetings/2015/aosm>. A summary of the meeting will be presented at the Fall AGU 2016. Organizers intend to reconvene the meeting biennially. (Sep 1, 2016 - Completed)
 - Created a resource catalog on the Hub with search capability and connectivity with social media (YouTube, Twitter, Facebook) to better publicize available tools for observing development, analysis, design, and data reduction. (Sep 26, 2014 - Completed)
 - Discussion at EC-PORS Polar Space Task Group about long-term observing for satellite calibration and validation. (Lead: NASA, with inputs from ESA, CSA, NSF, and WMO, 2014) (Sep 26, 2014 - Completed)
 - Meeting with OMB and OSTP to discuss agency contributions to observing and information science. (Feb 28, 2014 - Completed)
- **3.4.1.d (Milestone met) Develop action plans to implement an integrated design, including connections with other national and international observing systems, sustain current and planned operations, and use system models to identify observing contributions and needs for forecast; NOAA; Target Date 2016**
 - Completion Statement: Important progress has been made at the international, national and regional level on initiating action plans for integrated observing system design. A diversity of efforts at the international level leverage off of

SAON and the WMO; national efforts have been propelled through communities like SEARCH; regional efforts have been supported by scenario planning through efforts like NSSI. These efforts will serve as valuable models and platforms for advancement under the next Plan. (Sep 26, 2016 - Completed)

- The North Slope Science Initiative Scenarios Project was initiated to address: What is the future of energy development, resource extraction and associated support activities on the North Slope and adjacent seas through 2040? The results of project are summarized in the technical report: <http://northslope.org/scenarios/>. The scenarios approach was a valuable means to broadly identify 41 monitoring priorities on the North Slope of Alaska and serves as model for other integrated observing system designs. (Sep 1, 2016 - Completed)
- The Arctic Observing Summits (AOS: 2013, 2014, 2016) have sought to broadly address coordinate and integrated international actions plans for Arctic Observing. The goals of the AOS are: Provide community-driven, science-based guidance for the design, implementation, coordination and sustained long-term (decades) operation of an international network of Arctic observing systems that serves a wide spectrum of needs. Create a forum for coordination and exchange between academia, government agencies, local communities, industry, non-governmental organizations and other Arctic stakeholders involved in or in need of long-term observing activities. Major recommendations from the AOS can be found in a special issue of Arctic, in >80 whitepapers on the website: www.ArcticObservingSummit.org. (Sep 1, 2016 - Completed)
- The Year of Polar Prediction (YOPP) is a WMO-led initiative to improve sub-seasonal to seasonal environmental forecasting in the Arctic. It has served to catalyze international observing action plans for the YOPP period (2018-2019) and to inform changes to sustained observing. A recent summary can be found here: <http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-15-00270.1>. (Sep 1, 2016 - Completed)
- Presentation on TEON (<http://www.iarpcollaborations.org/members/events/1179>) by Philip Martin (USFWS). (Dec 17, 2014 - Completed)
- Lil Alessa gave a presentation on the Arctic Adaptation Portal, which can be found at <http://www.iarpcollaborations.org/members/events/660>. (Oct 15, 2014 - Completed)
- Creation of two SAON committees on information and data services (CDIS) and observations and networks (CON). First meeting of CDIS, led by Peter Pulsifer (NSIDC) will be on 10-11 November, 2014 in Potsdam, Germany. First meeting of CON, led by Lisa Loseto (DFO) will be on 9 December, 2014 in Ottawa, Canada (Sep 26, 2014 - Completed)
- Conducted monthly series of discussions on various agency and organizational perspectives on observing, including presentations from Local Environmental Observer (LEO) Network, Inuit Circumpolar Council, Shell Oil, DOE-Atmospheric Radiation Measurement Program, State of Alaska Department of

Environmental Conservation, Next Generation Ecosystem Experiments, and the
Community-Based Observation Network for Adaptation and Security (Sep 26,
2014 - Completed)

Team Leads:

Jeremy Mathis (NOAA); Sandy Starkweather (IARPC/NOAA)

Agencies

DHS, DOC, DOD, DOE, DOI, EPA, HHS, NASA, NSF, OSTP, USARC

Arctic Data

Milestone Reporting Log 2016

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3.4 Observing systems

3.4.8 Improve data access

- **3.4.8.a (Milestone met) Develop milestones for Arctic Observing System data; NSF (Lead); Target Date 2016**
 - Completion Statement: This milestone was completed with the creation of the Arctic Data Collaboration Team and the identification of several milestones listed below. The team also compiled a master list of Federal activities and archives. (<https://docs.google.com/spreadsheets/d/166OBSil08CftAAhQv9uQTzO6fMzID2p9U267gKZCNxs/edit#gid=119795022>). (Sep 21, 2016 - Completed)
 - Master list of Federal Arctic activities and archives is compiled and expanding (<https://docs.google.com/spreadsheets/d/166OBSil08CftAAhQv9uQTzO6fMzID2p9U267gKZCNxs/edit#gid=119795022>). (Sep 20, 2016 - Completed)

- **3.4.8.b (Milestone met) Creation of a pilot portal for Arctic data access; NSF; Target Date 2015**
 - Completion Statement: NSF has funded the Arctic Data Center (see <https://arcticdata.io/>). This goes well beyond a pilot portal by providing a production level facility, connected to other facilities (i.e. NOAA NCEI). Several million dollars has been invested. (Sep 23, 2016 - Completed)
 - During Arctic Science Summit Week, ADCT leads convened a Town Hall meeting that brought together a number of data providers and users. A number of key providers that can contribute to a more comprehensive portal were identified and engaged in a process that will see expansion of existing infrastructure such as the NSF Arctic Data Center. Examples of contributors include the Arctic Collaborative Environment (ACE) platform and the Arctic Domain Awareness Center. (Jun 24, 2016 - Completed)
 - Project funded by NSF and beta version of the portal implemented. NSF funded the development of a Polar Portal for discovering and accessing data through metadata catalogue discovery and harvesting. The project is developing a geo-spatial platform for discovering and accessing polar data. (Sep 26, 2014 - Completed)

- **3.4.8.c (In progress) Arctic and Antarctic Data Consortium (A2DC) coordination effort; NSF cyber polar funded projects focusing on metadata; adherence to the Alaska Data Integration Working Group (ADIwg standards); DOI, NSF; Target Date 2016**
 - Continuation Statement: NSF Research Coordination Network (RCN) proposal was funded under title “Antarctic and Arctic Data Consortium (a2dc) Research Coordination Network: Scientific Research Support and Data Services for the Polar Community.” Commonly known as a2dc, the RCN members are actively participating in community activities such as engaging the broader science community at the American Geophysical Union conference, engaging at the Second Polar Data Forum (October 27-29, 2015), planned active participation in the Polar Connections Interoperability Workshop and Assessment Process (8-9 November 2016, <http://arcticdc.org/meetings/adc-meetings/interoperability-workshop>), as well as a planned meeting in the U.S. early in 2017. These ongoing activities will engage members of a2dc including those involved with the Alaska Data Integration Working Group. (Oct 6, 2016 - Completed)
 - Metadata crawling project funded and in progress. (Sep 26, 2014 - Completed)

- **3.4.8.d (In progress) Data standards; NSF; Target Date 2017**
 - Continuation Statement: This milestone remains in progress as activities will continue under the next IARPC Arctic Research Plan 2017-2021. (Oct 6, 2016 - Completed)
 - The NSF RCN proposal funded for A2DC for identifying standards and practices among NSF-funded polar projects (Awarded 1 September 2014 - Award completion 31 August 2017). A2dc participated and met at Second Polar Data Forum which focused on further developing community standards and practices. Recommendations from the Forum were published and provide a foundation for future standards and practice development. (Oct 5, 2016 - Completed)
 - IARPC is co-convening the Polar Connections Interoperability Workshop and Assessment Process. See <http://arcticdc.org/meetings/adc-meetings/interoperability-workshop>. This workshop will make a significant contribution to establishing the status of polar data interoperability and standards requirements both nationally and globally. (Sep 23, 2016 - Completed)
 - In part, through combined NSF (Pulsifer salary) and NASA funding (Casas), the IARPC Arctic Data Coordination Team became active, holding a series of meetings and webinars highlighting data management activities in the community as well as identify the needs of various communities of practice (e.g. wild fires). (Aug 26, 2016 - Completed)
 - NSF partly funded the Second Polar Data Forum (grant to PI P. Pulsifer, Co-Chair of the Forum) held on October 27-29, 2015. The Forum was very successful, engaging more than 100 people from around the world. See <http://www.polar-data-forum.org>. (Nov 27, 2015 - Completed)

- NSF RCN proposal funded for A2DC for identifying standards and practices among NSF-funded polar projects (Sep 26, 2014 - Completed)

Team Leads: Joe Casas, NASA; Peter Pulsifer, NSIDC

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

Modeling

Milestone Reporting Log 2016

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

3.3 Atmospheric studies of surface heat, energy, and mass balances

3.3.3 Develop an integrated understanding of Arctic atmospheric processes, their impact on the surface energy budget, and their linkages with oceanic, terrestrial, and cryospheric systems

- **3.3.3.b (Milestone met) Support research activities that integrate Arctic processes in regional and global models; DOE, NASA, NOAA, NSF; Target Date 2015**
 - Completion Statement: During the July 2015 meeting, the team agreed that this milestone is completed and that additional activities will take place under other modeling milestones to ensure that Federal agencies continue to support research activities that integrate Arctic process in regional and global models. (Sep 27, 2016 - Completed)
 - A session has been organized for the 2016 AGU Fall meeting in San Francisco, entitled “Advancing Science of the Arctic System through Integration and Coordination of Observations and Modeling”. (Sep 26, 2016 - Completed)
 - The DOE/RGCM-funded HiLAT project (High Latitude Application and Testing of Regional and Global Climate Models) started in July 2015 with the overarching aim to study regional and global climate responses to changes in the cryosphere. A central focus is to improve our understanding of the response of Arctic cloud extent and characteristics (and hence radiative budgets) to changes in natural aerosol emissions, both from sea spray and from marine ecosystems (DMS, organic matter). Among other themes that are being explored by the HiLAT team are the response of mid-latitude weather systems to reductions in Arctic sea ice cover; and feedbacks between the Greenland Ice Sheet and the overlying atmosphere and surrounding ocean. (Sep 2, 2016 - Completed)
 - The RASM team has found important sensitivity of the atmospheric simulations in WRF to sea ice state when run in a fully coupled mode, as in RASM, compared to stand-alone WRF. This and other coupled model sensitivities, including feedbacks between declining Arctic sea ice cover and atmospheric variability as well as their potential teleconnections to mid-latitudes, are being further explored as part of the ongoing RASM investigations. (Sep 2, 2016 - Target)
 - The RASM WRF has been updated to the version 3.7.1 which allows a number of advanced physical parameterization schemes, including radiation, microphysics, cumulus clouds as well as planetary boundary layer and surface layer physics, all of which are of

relevance to simulations of Arctic climate. This update also simplifies future WRF upgrades subject to their significance in polar regions. (Aug 26, 2016 - Completed)

- RASM has been updated with the optional reading in of time-varying GHGs into WRF's radiation schemes, and time-varying extended ocean SSS and SST into the flux coupler (CPL). These new features allow RASM to simulate future Arctic climate forced with output from an Earth System Model, e.g. CCSM4/CESM, which will advance studies and understanding of future climate change and its amplified effects on the Arctic climate system. RASM has used output from the NCEP CFSv2 seasonal global forecasts to force its sea ice and ocean model components in forward simulations and to produce September Sea Ice Outlook projections (starting in June, July and August) in contribution to the Sea Ice Prediction Network (SIPN) (https://www.arcus.org/files/sio/25804/sio_aug2016_rasm-kamaletal_6ens.pdf). Output from several RASM ensemble members has been bias corrected and averaged to produce this first RASM projection. Analyses of RASM results and CFSv2 forcing is underway to better understand model limitations and improve seasonal projection. Summary and findings of this research will be presented at the 2016 Fall AGU meeting. (Aug 25, 2016 - Completed)
- In support of the IARPC Research Plan, a session was held at the Fall 2015 AGU meeting entitled "Advancing Science of the Arctic System: Exploring the Past and Present to Predict the Future". (Dec 24, 2015 - Completed)
- The fully coupled Regional Arctic System Model (RASM), has been developed, tested, and extensively evaluated over the past 5-plus years with the primary supported from DOE/RGCM and additional support from as well as ONR/AGP and NSF/ARCSS programs. RASM uses the Weather Research and Forecasting (WRF) as its atmospheric model component. WRF has undergone considerable development and testing for high-latitude use, including demonstration of stability in long duration (years) simulations. Its standard configuration in RASM uses a polar stereographic grid at a resolution of 50 km and 40 vertical levels, with the finest vertical resolution in the boundary layer. A higher resolution grid configuration at 25 km has already been tested in WRF as well and will be used in the ongoing studies, as part of two new DOE and ONR funded projects. As implemented in RASM, WRF uses spectral nudging in the upper half of the model atmosphere to constrain large-scale features (wavenumbers less than 4) to be similar to the driving reanalysis data. This allows use of WRF for downscaling GC/ESMs and atmospheric reanalyses for focused studies of the coupled Arctic System on seasonal to decadal timescales, while allowing sea ice-ocean-atmosphere interactions across the coupled boundary layer to freely evolve. The RASM WRF configuration includes several important changes from other standard WRF implementations, including options for either the CAM (Collins et al. 2004) or RRTMG (Clough et al. 2005) radiation schemes, which are coupled to Morrison microphysics (Morrison et al. 2009) via modeled liquid and ice effective particle sizes, which have been found to be important for the surface radiation balance over sea ice. The RASM team has also found important sensitivity of the atmospheric simulations in WRF to sea ice state when run in a fully coupled mode, as in RASM, compared to stand-alone WRF. This and other coupled model sensitivities will be further explored as part of the ongoing RASM investigations. (Aug 7, 2015 - Completed)

- NGEE-Arctic is the first, large-scale terrestrial ecosystem project that explicitly links process and large-scale modeling research. This activity has been highlighted to IARPC, and as such would fulfill this milestone. However, complementary activities are in the final stages of development, including NASA's ABoVE project. As such, the MCT has extended the target date to 2016 at which time ABoVE is expected to be operational as a second example of this integrated approach to Arctic terrestrial ecosystem process and modeling research. (Sep 25, 2014 - Completed)

3.5 Regional climate models

3.5.1 Inventory Arctic modeling activities

- **3.5.1.a (Milestone met) Conduct and disseminate a survey of Federal, Arctic modeling efforts; DOE (Lead), DOD-ONR, DOT, NASA, NOAA, NSF, USARC; Target Date 2013**
 - Completion Statement: An inventory of all Federally-funded Arctic modeling efforts has been developed. The inventory/census is posted at <http://www.iarpcollaborations.org/members/documents/2682>. (Sep 14, 2016 - Completed)
- **3.5.1.b (Milestone met) Evaluate the results of the survey and identify opportunities for collaborative development and/or joint campaigns; DOE (Lead), DOD-ONR, NASA, NOAA, NSF, USARC; Target Date 2014**
 - Completion Statement: The inventory is being used by program managers to identify areas for collaboration and coordinated activities. (Sep 14, 2016 - Completed)
 - The inventory and later analysis led to a 2014 AGU session on Observing and Modeling Critical Processes in the Arctic. (Oct 23, 2014 - Completed)
 - The MCT agreed that the inventory is useful to program managers and the public. (Oct 25, 2013 - Completed)

3.5.2 Encourage coordinated approaches that better represent Arctic processes in Earth-system models

- **3.5.2.a (Milestone Met) Identify critical Arctic processes for dedicated field and modeling campaigns across agencies; DOE (Lead), NASA; Target Date 2017**
 - Completion Statement: This milestone specifically focuses on multi-agency coordinated field and modeling campaigns. There were many successfully coordinated efforts across the agencies that we can highlight to indicate that there has been sufficient progress to indicate this milestone as closed. The activities include: 1) NASA's *Arctic-Boreal Vulnerability Experiment* (ABoVE) with broad participation from U.S. universities and federal agencies (e.g., NOAA, NPS, USGS); 2) The activities relating to the *Permafrost Research Network* (PRN) or the Permafrost Carbon Network; 3) The efforts related to the *Multidisciplinary drifting Observatory for the Study of Arctic Climate* (MOSAIC) that focuses on processes that transfer heat, moisture, density, and momentum through the

system; 5) ARISE (Arctic Radiation - Icebridge Sea & Ice Experiment) that focused on sea ice properties, radiative fluxes and atmospheric variables, particularly clouds, near the end of the Arctic sea ice melt season.

The focus of NASA's ABoVE field campaign is to collect the data needed to make critical improvements to the terrestrial ecosystem components earth system models in Arctic and boreal regions. Priorities for these improvements can be found in the ABoVE Concise Experiment Plan: <http://above.nasa.gov/acep.html> (Aug 15, 2016 - Completed)

- Below is an update on NASA's new ABoVE program. The second paragraph discusses the development of the program's experiment plan that included representation from across multiple agencies and helped define the program's research focus and science questions to pursue in the Arctic region. In August 2015, NASA selected 21 proposals for the initial research investigations to begin the Arctic-Boreal Vulnerability Experiment (ABoVE) field campaign—a large-scale study of ecosystem responses to environmental change in western North America's Arctic and boreal region and the implications for social-ecological systems. The NASA-sponsored research projects for ABoVE involve 231 scientists from 43 universities, 14 federal agencies, and 2 state agencies, and 2 Native organizations. ABoVE is a major NASA field campaign to be conducted for 8 to 10 years. The research for ABoVE will link field-based, process-level studies with geospatial data products derived from airborne and satellite sensors, building a foundation for improving the analysis and modeling capabilities needed to understand and predict ecosystem responses and societal implications. It is envisioned that a successful ABoVE will (1) contribute to greater scientific understanding of the vulnerability and resilience of ecosystems and societies to environmental change in western North America, and (2) provide the scientific basis for informed decision-making at local-to-international levels. Prior to these selections, in 2013 and 2014, the ABoVE science definition team wrote a concise experiment plan. The team's membership included a broad representation from U.S. universities and federal agencies (e.g., NOAA, NPS, USGS) as well as from Canada. The plan refines the science questions and rationale for ABoVE, poses a next tier of science questions, and lays out a top-level study design. The study design defines the ABoVE study domain and research areas, identifies the types of studies and observations needed to address the ABoVE science questions, and provides guidance for study implementation. (Oct 2, 2015 - Completed)
- The Permafrost Research Network (PRN) involves a large group of scientists working on permafrost with the objectives to synthesize and link existing research about permafrost carbon and climate in a format that can be assimilated by biospheric and climate models, and that will contribute to future assessments of the Intergovernmental Panel on Climate Change (IPCC). Recent accomplishments that are in progress in the upscaling and modeling of permafrost carbon working group (<http://www.permafrostcarbon.org/modeling.html>) involving 8-12 models with common input drivers include: The response of permafrost carbon to historical variability in climate and atmospheric CO₂ between 1960 and 2009 Assessment of the vulnerability of permafrost carbon to projected climate change Permafrost Regionalization Map (PeRM) It is clear that these models do not address many permafrost carbon processes and other processes are not adequately represented. The future outlook is to try to see if we can add and/or change the processes represented in the models to better represent

permafrost carbon. In April 2015, the group published a paper in Nature (see uploaded article) synthesizing the various aspects and progress made by the group: Climate change and the permafrost carbon feedback (<http://www.nature.com/nature/journal/v520/n7546/full/nature14338.html>). This article summarizes the newest understanding of processes involved in permafrost carbon dynamics and improved estimates of stocks. For instance, the permafrost carbon pool is much better quantified and observations of the carbon pools in deep layers (>3m) are of greater magnitude and importance than previously assumed but there are vast areas where sampling is extremely sparse making estimates of stocks highly uncertain. The decomposability of the carbon in melting permafrost has been studied via incubations under controlled conditions including one that was 12 years in duration. These studies also provide insight into processes, and projections of quantities, and rates of release of both CO₂ and methane from decomposition of carbon from melting permafrost. However, the importance and role of abrupt permafrost thawing via thermokarst and upland rapid thaw processes (thermal erosion) processes that are not gradual and reach to deep layers of permafrost, are difficult to quantify and there is a separate working group that seeks to improve the inventory and understanding of these processes and to integrate these dynamics into regional ecosystems and earth system models. One key directions for this network is model-data integration, with more observations to more effectively benchmark and parameterize models. Thus, although “current evidence suggests a gradual and prolonged release of greenhouse gas emissions in a warming climate (see article cited)” there are several aspects of permafrost carbon dynamics that need to be better understood to assess, model and project and the resulting climate feedbacks. (Sep 24, 2015 - Completed)

- The DOE Atmospheric Radiation Measurement (ARM) program has committed support for detailed atmospheric measurements using the ARM Mobile Facility (AMF-2) during the planned Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC: <http://www.mosaicobservatory.org/>) initiative. This program is centered on the sea ice life cycle and climate processes affecting its evolution, variability, and change. The MOSAiC is planned for year-round, detailed, and comprehensive and cross-disciplinary set of coordinated measurements, extending from the atmosphere through the sea-ice and into the ocean of the central Arctic Basin to improve understanding and modeling of Arctic climate and weather, and enhance Arctic sea-ice predictive capabilities. These observations will be designed to provide a process-level understanding of the present-day central Arctic coupled climate system, consisting of dramatically less and thinner sea-ice than in the recent past, as well as a more detailed understanding of the processes leading to these sea-ice changes. Scientific emphasis will be placed on processes that transfer heat, moisture, density, and momentum through the system. To obtain the needed measurements, a manned, transpolar drifting observatory is proposed, wherein an ice-hardened ship serves as a central hub for intensive observations of atmospheric, oceanic, sea-ice, and biogeochemical properties over a full annual cycle. (Sep 22, 2015 - Completed)
- During the July 2015 meeting, the team agreed that this milestone will be ongoing until 2017. The due date was accordingly changed. (Aug 21, 2015 - Completed)

- ABoVE is a 10-year study beginning in 2015. An interagency science definition team was formed and worked together to write the solicitation. The science definition team identified the topics for research in the Arctic (ABoVE is also reported under 3.3.3.b). (Aug 20, 2015 - Completed)
- NASA returned to the Arctic Ocean in September 2014, when the ARISE (Arctic Radiation - Icebridge Sea & Ice Experiment) project used a C-130 aircraft to measure sea ice properties, radiative fluxes and atmospheric variables, particularly clouds, near the end of the Arctic sea ice melt season. The end of the ARISE mission overlapped with the beginning of a NOAA-ONR project that used a NOAA P-3 aircraft to make meteorological measurements over the open and ice-covered Beaufort and Chukchi seas. The aim was to determine heat flow from ocean to atmosphere during freeze-up and the impact on regional atmospheric temperature and pressure, and far-field effects at mid-latitudes. (Sep 25, 2014 - Completed)
- **3.5.2.b (Milestone Met) Coordinate Federal activities to develop, implement, and test improved parameterizations of Arctic physical processes and feedbacks; DOE (Lead); Target Date 2015**
 - Completion Statement: Progress has been made on all six milestones (3.5.2.b, part of 3.5.2.c, 3.5.3.a, 3.5.3.b, 3.5.3.c, and 3.5.6.d) that relate to developing, testing improved parameterizations to indicate completion. While 3.5.2b particularly focuses on interagency coordination, 3.5.3b and 3.5.3c focus on including in Regional and Global earth system models respectively. 3.5.3a focuses on evaluating these in observations. However in reality all these activities are interlinked. Progress and success have been indicated in all these and are reported in a combined manner in this continuation statement since this work will be continued as part of research objective 9.3 in the 2017 and 2021 Arctic Research Plan. Salient points about the progress and successes in these milestones are: 1) Sea ice morphology has been improved in the CICE model and will be incorporated into the Regional and Arctic System (RASM – Regional model for which different components are supported by individual agencies) model and other Global models; 2) The Regional Arctic System Model (RASM) funded jointly by DOE, ONR, NSF focusses on understanding and representing critical Arctic physical processes and feedbacks, guide future field campaigns and Earth System Model development, reduce model uncertainty and improve predictive capability in the Arctic region. Several improvements in model components have been included in it. Improved marine Biogeochemistry, the Variable Infiltration Capacity (VIC) land surface model, and Non-hydrostatic Unified Model of the Ocean (NUMO; <http://numo.ucsc.edu/>) have been tested and incorporated into RASM. Several tests of the Atmosphere and Coupled components of RASM have been evaluated and these improved components captures physical processes and feedbacks more realistically; 3) The Sea Ice Prediction Network (SIPN) has developed standardized model formulation to test and evaluate models in a consistent manner for seasonal ice forecasts.; 4) Spatially Continuous Riverbank Erosion and Accretion Measurements (SCREAM) has been developed to analyze river metrics regardless of river morphology; 5) Ice Sheet System Model (ISSM) has been improved and incorporated into NASA’s GEOS 5 Global Model. Similarly a new ice-sheet model

has been incorporated into DOE's Accelerated Climate Model for Energy (ACME) and the Community Earth System Model (CESM). 6) NOAA's climate Test Bed- Accelerating Transition of Research into Operations funded many proposals that evaluated and incorporates new components into Earth System Models; 7) There were several NSF funded activities that address this goal; 8) FAMOS renewal project "Forum for Arctic Modeling and Observational Synthesis (FAMOS) – facilitated the development and testing of several components of Arctic model parameterizations and components; 9) DOE's NGEA-Arctic program and the USGS have developed and used the Advanced Terrestrial Simulator (ATS) for performing these studies, linking observational data and models; 10) The Permafrost Research Network (PRN) involves a large group of scientists working on permafrost with the objectives to synthesize and link existing research about permafrost carbon and climate in a format that can be assimilated by biospheric and climate models, and that will contribute to future assessments of the Intergovernmental Panel on Climate Change (IPCC).

- A project to develop a new description of sea ice morphology is underway, led by Andrew Roberts of the Naval Postgraduate School in collaboration with Elizabeth Hunke and Bill Lipscomb of Los Alamos National Laboratory. The new approach incorporates fundamental ideas from soil mechanics in a first-principals theoretical framework for sea ice ridge and keel formation, which will be implemented into the Los Alamos sea ice model (CICE) and the Regional Arctic System Model (RASM). This work is funded by the Office of Naval Research and the DOE Regional and Global Climate Modeling program. (Sep 27, 2016 - Completed)
- A special session is scheduled at the 2016 Fall AGU meeting, focusing on 'Advancing the Science and Simulation of the Coupled Arctic System using Observations and Models'. This session invites presentations that (i) advance the system-level understanding of the Arctic through observations or simulations of processes and their interactions that impact Arctic climate variability and trends and (ii) discuss efforts, including those coordinated by IARPC, that have been initiated to improve the representation of critical processes, understand their role in evolution of the Arctic system, and enhance the utility of future projections for societal use. (Sep 23, 2016 - Completed)
- Additional new RASM publications are of relevance to this milestone.
 - (1) DuVivier et al. (J. Climate 2016) published the first study of air-sea interactions around Greenland with a high-resolution, coupled Arctic model in a region where there are few in-situ observations. Because of the coupling the ocean and atmosphere evolve together, leading to physically consistent earth system results and the ability to realistically evaluate the direct impact of winds on the ocean.
 - (2) Hamman et al. (J. Climate 2016) have focused on the implementation of the Variable Infiltration Capacity land surface model (VIC) in RASM and evaluated the ability of RASM to capture key features of the land surface climate and hydrologic cycle for the period 1979–2014 in comparison with uncoupled VIC simulations, reanalysis datasets, satellite measurements, and in situ observations.

(3) Cassano et al. (J. Climate, in review) presented analysis and evaluation of the near surface climate in RASM version 1.0, including the atmosphere, ocean, sea ice, and land state and fluxes. They investigated sensitivity of the RASM near surface climate to changes in atmosphere, ocean, and sea ice parameters and physics is evaluated in four simulations. One of their important findings is related to the diagnosis of biases in surface temperature as caused by biases in downward surface radiative fluxes. Such errors in radiative fluxes are due to biases in simulated clouds with different versions of RASM simulating either too much or too little cloud radiative impact over open ocean regions and all analyzed model versions simulating too little cloud radiative impact over land areas.

(4) Hamman et al. (JGR-Oceans, submitted) introduce the RVIC streamflow routing model, detailed its application within RASM and its advancements in terms of representing high-resolution streamflow processes. They evaluate model simulated streamflow relative to in-situ observations and demonstrate a method for improving model performance using a simple optimization procedure. The RVIC produced spatially and temporally consistent, high-resolution dataset of coastal freshwater fluxes for the Arctic drainage basin and surrounding areas that is based on a fully-coupled RASM simulation is intended for distribution and use in other Arctic Ocean modeling applications.

(5) Brunke et al. (J. Climate, in preparation) evaluate the performance of RASM with respect of interface processes in comparison with reanalysis and with coarser resolution Earth system models. (Sep 23, 2016 - Completed)

- The CICE Consortium, a proposed network of CICE sea ice model stakeholders and developers, is being organized to maintain and further develop the model as a community resource. Federal agencies and institutions with strong interests in the Consortium include DOE, NSF, NOAA, the US Navy and international partners in the UK and Canada. Elizabeth Hunke is coordinating the new effort with support from DOE. (Sep 2, 2016 - Completed)
- The following publications are of relevance to this milestone and they are the result of the Regional Arctic System Model (RASM) efforts funded by DOE, ONR and NSF.

(1) Maslowski et al. (Annu. Rev. Earth Planet. Sci. 2012) published a review of the climate model limitations in representing physical processes and feedbacks controlling the Arctic sea ice regimes, polar amplification and climate change. They argued that in order to advance an Arctic system-level understanding, modeling and prediction it's critical to advance hierarchical regional climate modeling and coordinate it closely with the design of an integrated Arctic observing system to constrain models.

(2) Maslowski et al. (2014) reviewed the regional circulation patterns, spatial and temporal variability, critical processes and property fluxes from the North Pacific into the western Arctic Ocean, with emphasis on their impact on sea ice. They hypothesized that the northward advection of Pacific water together with the excess oceanic heat accumulated below the surface mixed layer in the western Arctic Ocean due to diminishing sea ice cover and subsequently increased solar insolation are critical factor affecting sea ice growth in winter and melt the

following year. They argued that process-level understanding and improved model representation of ocean dynamics and ocean-ice-atmosphere interactions in the Pacific-Arctic region are needed to advance knowledge and improve prediction of the accelerated decline of sea ice cover and amplified climate warming in the Arctic. Several more papers (Frey et al., Williams et al., Clement Kinney et al., Deal et al.) co-authored by the RASM PIs and focusing on sea ice, shelf-basin interaction, exchanges through Bering Strait and marine biogeochemistry processes are included in this Springer book on “The Pacific Arctic Region – Ecosystem Status and Trends in a Rapidly Changing Environment” co-edited by J.M. Grebmeier and W. Maslowski (2014).

(3) DuVivier and Cassano (Mon. Wea. Rev. 2013 and Clim. Dyn. 2015) investigated the potential impact of strong, mesoscale tip jets and barrier winds that occur over the ocean near southern Greenland on deep convection in the ocean. They found that the difference in coastal winds is likely related to model resolution and the resulting ability of each model to simulate strong mesoscale winds that are driven by Greenland’s steep terrain. Their findings highlight the importance of high-resolution simulations for properly capturing the structure and high wind speeds associated with mesoscale wind events and surface fluxes of latent and sensible heat.

(4) Roberts et al. (Annals of Glaciol. 2015) have evaluated the fidelity of the polar marine Ekman layer in the Regional Arctic System Model (RASM) and Community Earth System Model (CESM) using sea-ice inertial oscillations as a proxy for ice-ocean Ekman transport. Their results suggest that processes associated with the passage of storms over sea ice (e.g. oceanic mixing, sea-ice deformation and surface energy exchange) are underestimated in Earth System Model that do not resolve inertial frequencies in their marine coupling cycle. (Sep 22, 2015 - Completed)

- Two new research efforts, jointly supported by DOE and ONR for 2015-2018 and involving the Regional Arctic System Model (RASM), share the overarching science hypothesis that mesoscale processes and resulting feedbacks are critical to improved representation of the Arctic climate system state and prediction of polar amplification of climate change. Those studies will involve testing and evaluation of physical parameterizations (e.g. sea ice rheologies, coupling with atmosphere/ocean, cloud physics) and use of high spatial and temporal resolution to advance model component representation of processes and feedbacks within and across model components. (Sep 22, 2015 - Completed)
- A workshop is being planned for mid-May 2015 to discuss operational Arctic forecast support for several Arctic research cruises taking place this summer. In return, in situ data will be collected on the cruises that can be compared against the forecasts for validation or verification. (May 1, 2015 - Completed)
- **3.5.2.c (Milestone Met) Develop standardized model components, meta-data, and data products; DOE (Lead), DOD-ONR, NASA; Target Date 2016**

- Completion Statement: There are two components to this milestone and both have been addressed to indicate that the milestones have been met.
 - Component 1: Progress has been made on all six milestones (3.5.2.b, part of 3.5.2.c, 3.5.3.a, 3.5.3.b, 3.5.3.c, and 3.5.6.d) that relate to developing, testing improved parameterizations to indicate completion. While 3.5.2b particularly focuses on interagency coordination, 3.5.3b and 3.5.3c focus on including in Regional and Global earth system models respectively. 3.5.3a focuses on evaluating these in observations. However in reality all these activities are interlinked. Progress and success have been indicated in all these and are reported in a combined manner in this continuation statement since this work will be continued as part of research objective 9.3 in the 2017 and 2021 Arctic Research Plan. Salient points about the progress and successes in these milestones are: 1) Sea ice morphology has been improved in the the CICE model and will be incorporated into the Regional and Arctic System (RASM – Regional model for which different components are supported by individual agencies) model and other Global models; 2) The Regional Arctic System Model (RASM) funded jointly by DOE, ONR, NSF focusses on understanding and representing critical Arctic physical processes and feedbacks, guide future field campaigns and Earth System Model development, reduce model uncertainty and improve predictive capability in the Arctic region. Several improvements in model components have been included in it. Improved marine Biogeochemistry, the Variable Infiltration Capacity (VIC) land surface model, and Non-hydrostatic Unified Model of the Ocean (NUMO; <http://numo.ucsc.edu/>) have been tested and incorporated into RASM. Several tests of the Atmosphere and Coupled components of RASM have been evaluated and these improved components captures physical processes and feedbacks more realistically; 3) The Sea Ice Prediction Network (SIPN) has developed standardized model formulation to test and evaluate models in a consistent manner for seasonal ice forecasts.; 4) Spatially Continuous Riverbank Erosion and Accretion Measurements (SCREAM) has been developed to analyze river metrics regardless of river morphology; 5) Ice Sheet System Model (ISSM) has been improved and incorporated into NASA’s GEOS 5 Global Model. Similarly a new ice-sheet model has been incorporated into DOE’s Accelerated Climate Model for Energy (ACME) and the Community Earth System Model (CESM). 6) NOAA’s climate Test Bed-Accelerating Transition of Research into Operations funded many proposals that evaluated and incorporates new components into Earth System Models; 7) There were several NSF funded activities that address this goal; 8) FAMOS renewal project "Forum for Arctic Modeling and Observational Synthesis (FAMOS) – facilitated the development and testing of several components of Arctic model parameterizations and components; 9) DOE's Ngee-Arctic program and the USGS have developed and used the Advanced Terrestrial Simulator (ATS) for performing these studies, linking observational data and models; 10) The Permafrost Research Network (PRN) involves a large group of scientists working on permafrost with the objectives to synthesize and link

existing research about permafrost carbon and climate in a format that can be assimilated by biospheric and climate models, and that will contribute to future assessments of the Intergovernmental Panel on Climate Change (IPCC).

- Component 2: Milestone 3.5.7b that focuses on developing and implementing standards for gridded observational data sets along with part of milestone 3.5.2c focused on developing metadata are similar in intent and the following activities help us meet this milestone. They are: 1) the OBS4MIP activity has focused on developing metadata standards and regridding observational (satellite) data to enable easier evaluation of climate models; 2) At meeting organized by CLiC, observational data that would be most useful for climate model evaluation and improvement were identified from the point of view of evaluating Sea-Ice Models.

- Satellite imagery has greatly expanded our understanding of river morphology and dynamics. However, the majority of GIS and automated systems to analyze rivers has been developed for single-threaded river systems, with limited applicability to rivers with complex multi-channel planforms, like those typical for the Arctic. Funded by DOE's RGCM program, Rowland et al. (doi:10.1016/j.rse.2016.07.005) developed an analysis toolbox called Spatially Continuous Riverbank Erosion and Accretion Measurements (SCREAM) to analyze planview river metrics regardless of river morphology. SCREAM quantifies river-floodplain erosion, accretion, river width, sinuosity, curvature and a number of other properties to analyze river characteristics and controls on their dynamics. (Sep 27, 2016 - Completed)
- A streamflow routing scheme (RVIC) has been developed, implemented and evaluated in RASM to deliver the freshwater flux from the land surface to all coastal grid cells. This routing scheme is implemented separately from the land model and communicates directly with the CPL-7 coupler, which means that it can be used with multiple land and climate models. (Hamman et al. 2016: The Coastal Streamflow Flux in the Regional Arctic System Model, J. Geophys. Res. Ocean, in review) (Sep 23, 2016 - Completed)
- Ocean and sea ice biogeochemistry (BGC) components, similar to those of the NCAR CESM model, have been implemented in RASM model and evaluation of fully coupled simulations with BGC extensions is currently underway (Sep 22, 2016 - Completed)
- A new prototype stand-alone module (NUMO; <http://numo.ucsc.edu/>) is being developed with support from DOE, to realistically represent ice-sheet / ocean interactions in narrow Greenland fjords. While this effort is still in the developmental phase and focusing on the Sermilik Fjord, it has a potential to address a major science challenge in understanding, modeling and prediction of ice-sheet / ocean interactions where ocean general circulation models are not applicable. (Sep 21, 2016 - Completed)
- NASA (Bob Fischer at GISS) has developed and tested a new firn model and coupled it to ModelE. NASA has also finished the coupling of PISM and ModelE in the sense that the 2 models talk to each other. NASA (Richard Cullather and Bin Zhao at GSFC) are working on two way coupling of ISSM to GEOS-5. This might not fall under the "standardized model component" in the sense that the coupling is designed for ANY ice

sheet model, but it is not necessarily transferable to ANY climate model (GEOS-5 and ModelE are too different from each other that we need a separate strategy for both, however ModelE is a more typical climate model, so what is developed there is more transferable to other models). NASA is developing new data products in the Arctic in addition to the improved cryospheric fields in MERRA2. These include: 1) a phytoplankton library in the Arctic (by Cecile Rousseau, GSFC), although publication of this research is pending and can be updated later; and 2) ISMIP6 (Ice Sheet Model Intercomparison Project for CMIP6) is developing new meta-data and asking climate modeling centers to save new fields over the arctic (such as runoff). (Sep 23, 2015 - Completed)

- NASA is funding the parallel ice sheet model at University of Alaska and also the ice sheet system model at JPL. Both are used for Arctic research. Models have been developed and are being used. (Aug 21, 2015 - Completed)
- NASA funded a study of 6 global reanalyses products from NOAA, NASA and a European reanalyses. (Aug 21, 2015 - Completed)
- SIPN is working toward the goal of this milestone. One goal is to develop a standardized model formulation to test and evaluate models in a consistent manner and to develop data products for seasonal ice forecasts. NSIDC has Quicklook data and Cryosat II data. (Nov 25, 2014 - Completed)
- Obs4MIPs was initiated by JPL and they continue to coordinate it as it broadens into an international effort endorsed by the WCRP Data Advisory Council (WDAC). (Nov 25, 2014 - Completed)
- **3.5.2.d (Milestone Met) Conduct model inter-comparisons to foster collaboration between modeling groups and identify high-priority Arctic model improvements; DOE (Lead), NOAA; Target Date 2018**
 - Completion statement: Milestone 3.5.2 d and 3.5.7a are closely related. Both focus on model intercomparisons, the first to enhance process understanding while the latter, to evaluate coupled models. There have been substantial contributions highlighted under both. They include: 1) Model Intercomparisons initiated by NASA's Boreal Arctic Vulnerability experiment (ABOVE); 2) [POLARCAT Model Intercomparison Project \(POLMIP\)](#) which evaluated the capability of global and regional atmospheric chemistry and transport models to simulate the chemistry and composition of the Arctic atmosphere; 3) Ice Sheet Model Intercomparison Project (ISMIP6) for the next phase of the Coupled Model Intercomparison Project (CMIP6); 4) Intercomparison efforts initiated through Forum for Arctic Modeling and Observational Synthesis (FAMOS) and the Sea-Ice Prediction Network (SIPN). Some of these activities will be continued as part of research objective 9.3 that focuses on intercomparisons of coupled regional and global earth system models.
 - NASA's ABoVE field campaign is carrying out two model inter-comparison studies as follows: One study is focused on carrying out comparisons fluxes from eddy covariance towers to the outputs from several terrestrial biosphere models in order to identify needed

improvements in these models. One study is focused on exercising and inter-comparing a suite of terrestrial biosphere models to identify critical data gaps for informing and prioritizing ABoVE remote sensing and field data collection, and developing and employing a flexible but consistent data integration, simulation and evaluation framework for ABoVE modeling research (Aug 15, 2016 - Completed)

- In August 2015, NASA selected 21 proposals for the initial research investigations to begin the Arctic-Boreal Vulnerability Experiment (ABoVE) field campaign—a large-scale study of ecosystem responses to environmental change in western North America's Arctic and boreal region and the implications for social-ecological systems. Two projects recently funded by NASA as part of its ABoVE Field Campaign will contribute to this milestone:
 - 1) A Model-Data Integration Framework (MoDIF) for ABoVE Phase I research: simulation, scaling and benchmarking for key indicators of Arctic-boreal ecosystem dynamics. This project will coalesce a suite of modeling teams to provide a meta-synthesis of Terrestrial Biosphere Model requirements, parameter and structural uncertainties, and the associated data type, range, and co-variables necessary to improve Arctic-Boreal-Region-specific simulations with respect to the ABoVE Tier 2 science questions
 - 2) Quantifying CO₂ and CH₄ Fluxes from Vulnerable Arctic-Boreal Ecosystems across Spatial and Temporal Scales. This project will deliver validated atmospheric CO₂, CH₄, and CO observations for 2015 - 2019 from the NOAA tower in Fox AK, as well as geostatistical inverse model analyses that leverage recent atmospheric observations to evaluate the process-level representation of land-atmosphere carbon exchange inside terrestrial biospheric models (TBMs). In addition, the project will identify the environmental parameters that optimally explain the observed spatiotemporal variability in carbon flux patterns across the ABoVE domain. (Oct 2, 2015 - Completed)
- Nine global and two regional chemical transport models participated in a model intercomparison study named "POLMIP," an effort to evaluate the capability of global and regional atmospheric chemistry and transport models to simulate the chemistry and composition of the Arctic atmosphere. The study exploited the large suite of observations made during the POLARCAT campaign (Polar Study using Aircraft, Remote Sensing, Surface Measurements and Models, of Climate, Chemistry, Aerosols and Transport), conducted during the International Polar Year in 2008, which included a variety of surface, balloon, aircraft and satellite observations. Participants included agency representatives from NASA, NOAA, and NSF, the university community, and multiple international organizations. The study found that while each type of measurement has some limitations in spatial or temporal coverage or in composition, together they allowed quantification of the capabilities of the models in the Arctic and surrounding regions. Despite using the same emissions, large differences were seen among the models. The largest differences were seen in the nitrogen oxide species and in oxygenated volatile organic compounds. These differences were attributed to intermodel differences in chemical mechanisms, as well as physical parameterizations such as convection, boundary layer mixing and ventilation, and wet and dry deposition. This intercomparison

effort provides insight which will lead to increasingly representative models of the chemistry and composition of the Arctic atmosphere. The paper is available at: <http://www.atmos-chem-phys.net/15/6721/2015/acp-15-6721-2015.pdf>. (Sep 23, 2015 - Completed)

- ISMIP6 is now an official player of CMIP6. The website is <http://www.climate-cryosphere.org/activities/targeted/ismip6/about>. No intercomparison yet (as CMIP6 modeling starts in 2016), but we are fostering collaboration between modeling groups (11 climate centers are taking part in ISMIP6 ranging from GFDL, CESM/NCAR, ModelE in the USA, to groups in Europe, Russia and Japan). As part of ISMIP6, these groups have therefore committed to improving their models in the polar regions. ISMIP6 fostering of collaboration between modeling groups and disciplines was in the form of drafting the ISMIP6 proposal and meetings last year, all which can be found on the website. (Sep 23, 2015 - Completed)
- At the March meeting Daniel Barrie reported: The MIP is now called ISMIP6 (Ice Sheet Model Intercomparison Project for CMIP6) and it has a website (<http://www.climate-cryosphere.org/activities/targeted/ismip6>). - The experiment has endorsement from CliC (Climate and Cryosphere) and the WCRP sea-level grand challenge. - A new proposal is being submitted to CMIP6 by 3/31. Will hear about acceptance on 4/30. - The team plans to share the first experiment with the ice sheet community at EGU in April, then analyze output during the summer at the IGS meeting. - Full runs would start in 2016 with CMIP6. - Modeling centers include: CESM (USA), CNRM (France), EC-Earth (many EU countries), GFDL (USA), INM (Russia), IPSL (France), MIROC-ESM (Japan), MPI-ESM (Germany), UKESM (UK). Centers that are on the fence include CanESM (Canada), and GISS (USA). - For the ice sheet side, we expect to have about 10-15 models. US models include: ISSM, PISM, PennState2D, PennState3D, UMISM, and AIF. (Apr 3, 2015 - Completed)
- While the ISOMIP was primarily a 2003-04 activity, it did develop a series of idealized experiments that continue to be used as part of model validation and active ice sheet/ice shelf/ocean model development. http://www.princeton.edu/~cmlittle/test_cavities.pdf. (Oct 23, 2014 - Completed)
- Sophie Nowicki (NASA) presented information about a proposed ice sheet model intercomparison project for CMIP6. The presentation can be viewed under webinar archive. (Oct 9, 2014 - Completed)
- FAMOS, CMIP5 and SIPN are conducting model inter-comparisons. The team heard reports from FAMOS and SIPN. (Jul 24, 2014 - Completed)
- **3.5.2.e (Deactivated) Review report from the third session of the WMO Executive Council Panel of Experts on Polar Observations, Research, and Services on the development of the Global Integrated Polar Prediction System; NOAA (Lead); Target Date 2012**
- Deactivation Statement: After several discussions, the team was unable to identify a lead contact for this item. It was deactivated after a significant period of time elapsed with no lead. (Sep 14, 2016 - Completed)

3.5.3 Build Arctic and subsystem models for coupling with regional and global approaches

- **3.5.3.a (Milestone met) Develop and evaluate stand-alone subsystem components of the Arctic System, incorporating mechanistic processes derived from experiments and/or observations; DOE (Lead), NASA, NSF; Target Date 2014**

- Completion Statement: Progress has been made on all six milestones (3.5.2.b, part of 3.5.2.c, 3.5.3.a, 3.5.3.b, 3.5.3.c, and 3.5.6.d) that relate to developing, testing improved parameterizations to indicate completion. While 3.5.2b particularly focuses on interagency coordination, 3.5.3b and 3.5.3c focus on including in Regional and Global earth system models respectively. 3.5.3a focuses on evaluating these in observations. However in reality all these activities are interlinked. Progress and success have been indicated in all these and are reported in a combined manner in this continuation statement since this work will be continued as part of research objective 9.3 in the 2017 and 2021 Arctic Research Plan. Salient points about the progress and successes in these milestones are: 1) Sea ice morphology has been improved in the CICE model and will be incorporated into the Regional and Arctic System (RASM – Regional model for which different components are supported by individual agencies) model and other Global models; 2) The Regional Arctic System Model (RASM) funded jointly by DOE, ONR, NSF focusses on understanding and representing critical Arctic physical processes and feedbacks, guide future field campaigns and Earth System Model development, reduce model uncertainty and improve predictive capability in the Arctic region. Several improvements in model components have been included in it. Improved marine Biogeochemistry, the Variable Infiltration Capacity (VIC) land surface model, and Non-hydrostatic Unified Model of the Ocean (NUMO; <http://numo.ucsc.edu/>) have been tested and incorporated into RASM. Several tests of the Atmosphere and Coupled components of RASM have been evaluated and these improved components captures physical processes and feedbacks more realistically; 3) The Sea Ice Prediction Network (SIPN) has developed standardized model formulation to test and evaluate models in a consistent manner for seasonal ice forecasts.; 4) Spatially Continuous Riverbank Erosion and Accretion Measurements (SCREAM) has been developed to analyze river metrics regardless of river morphology; 5) Ice Sheet System Model (ISSM) has been improved and incorporated into NASA's GEOS 5 Global Model. Similarly, a new ice-sheet model has been incorporated into DOE's Accelerated Climate Model for Energy (ACME) and the Community Earth System Model (CESM). 6) NOAA's climate Test Bed- Accelerating Transition of Research into Operations funded many proposals that evaluated and incorporates new components into Earth System Models; 7) There were several NSF funded activities that address this goal; 8) FAMOS renewal project "Forum for Arctic Modeling and Observational Synthesis (FAMOS) – facilitated the development and testing of several components of Arctic model parameterizations and components; 9) DOE's NGEA-Arctic program and the USGS have developed and used the Advanced Terrestrial Simulator (ATS) for performing these studies, linking observational data and models; 10) The Permafrost Research Network (PRN) involves a large group of scientists working on permafrost with the objectives to synthesize and link existing research about permafrost carbon and climate in a format that can be assimilated by biospheric and

climate models, and that will contribute to future assessments of the Intergovernmental Panel on Climate Change (IPCC).

- The FAMOS renewal project "Forum for Arctic Modeling and Observational Synthesis (FAMOS) - Phase 2: Focus on High and Very High Resolution" was awarded by NSF. The award period is September 1, 2016 through August 31, 2019. (Sep 27, 2016 - Completed)
- Researchers from LANL and the University of Colorado in Boulder performed a comparative study of sea ice ridging in Fram Strait. They compared results from the Los Alamos sea ice model, CICE, with high-resolution observations, collected during the NASA-funded Characterization of Arctic Sea Ice Experiment (CASIE) in 2009. A new data analysis approach yielded spatial parameters that capture ridging from laser altimetry and imagery, an approach that can be scaled up to the one degree resolution typical of the current generation of climate models (Herzfeld et al., 2015; doi:10.1016/j.coldregions.2015.05.001). (Sep 27, 2016 - Completed)
- Identifying and understanding the key processes governing permafrost degradation in the Arctic requires process-rich models which can be quickly and efficiently developed and studied for model structure uncertainty. Scientists in the DOE's NGEE-Arctic program and the USGS have developed and used the Advanced Terrestrial Simulator (ATS) for performing these studies, linking observational data and models. (Sep 2, 2016 - Completed)
- NASA's ModelE and GEOS-5 research activities are relevant here and reported on in 3.5.2.c. Specifically, NASA's Bob Fischer @ GISS has developed and tested a new firm model and coupled it to ModelE. He has also finished the coupling of PISM and ModelE in the sense that the 2 models talk to each other. NASA's Richard Cullather and Bin Zhao @ GSFC are researching two way coupling of ISSM to GEOS-5. As part of Sophie Nowicki's research funded by NASA's Interdisciplinary Studies (IDS) project, evaluation of stand-alone subsystem components include:
 - Melt area and runoff from a few reanalysis versus melt area derived from MODIS and Passive Microwave observations. Richard Cullather and Nowicki are about to finish a paper on this. Work was presented at the 2015 PARCA meeting: Characterization of Recent Greenland Melt Events in Atmospheric Analysis and Satellite Data by Cullather et al.
 - Comparison of model and observation of sea surface salinity (GEOS-5 ocean and Aquarius) in the Arctic. Work was presented at the 2015 PARCA meeting: The 2012 record melt over the Greenland ice sheet led to an anomalous ocean freshening by Brucker et al.
 - Comparison reanalysis Temperature from ASR, CFSR, ERA-I and MERRA to in situ observations. Work was presented at the 2015 PARCA meeting: Comparison of Reanalysis Temperatures to NOAA in Situ Data at the Greenland Summit by Shuman et al. (Sep 23, 2015 - Completed)
- The Permafrost Research Network (PRN) involves a large group of scientists working on permafrost with the objectives to synthesize and link existing research about permafrost

carbon and climate in a format that can be assimilated by biospheric and climate models, and that will contribute to future assessments of the Intergovernmental Panel on Climate Change (IPCC). For more information see milestone 3.5.2a (Sep 17, 2015 - Completed)

- The NSF-funded Forum for Arctic Modeling and Observational Synthesis (FAMOS) is focused on development of a better understanding of the Arctic climate system (with a focus on the marine environment) through the use of improving numerical models and observational tactics and strategies. FAMOS supports synthesis across the suite of Arctic models and observations by (i) Holding scientific workshops and schools for new investigators including virtual teleconferences; (ii) Creating teams of modelers, theoreticians, and observationalists to work on topical issues of Arctic sea ice and oceanic dynamics and thermodynamics; (iii) Conducting collaboration with other similar projects focused on other aspects of arctic/global climate (atmospheric, terrestrial, cryospheric); (iv) Disseminating findings to broader communities and involve the larger community in discussions, coordinated modeling and observational field experiments; (v) Training a new generation of ocean and sea-ice observationalists and modelers. The 2013 FAMOS workshop included 114 participants from USA, Canada, UK, France, Finland, Sweden, Norway, Russia, China, and Japan. Presentations are archived. Six directions of coordinated research were identified as mostly important for 2013-2014 coordinated community experiments and discussions, namely: Atlantic water circulation, Beaufort Gyre freshwater tracer experiment, Freshwater heat and volume budgets, Sea ice retreat and forecasting, Ecosystem modeling, Greenland melt and climate. Details of these experiments are outlined at posted at project website: <http://www.whoj.edu/projects/famos/experiments>. (Sep 25, 2014 - Completed)
- The team heard a report on the FAMOS project. A pdf of the presentation can be found at <http://www.iarpcollaborations.org/members/documents/> (Jul 24, 2014 - Completed)
- **3.5.3.b (Milestone met) Couple, test, and validate the above against observations of subsystem components within a regional Arctic climate-system model; DOE (Lead), NSF; Target Date 2016**
 - Completion Statement: Progress has been made on all six milestones (3.5.2.b, part of 3.5.2.c, 3.5.3.a, 3.5.3.b, 3.5.3.c, and 3.5.6.d) that relate to developing, testing improved parameterizations to indicate completion. While 3.5.2b particularly focuses on interagency coordination, 3.5.3b and 3.5.3c focus on including in Regional and Global earth system models respectively. 3.5.3a focuses on evaluating these in observations. However in reality all these activities are interlinked. Progress and success have been indicated in all these and are reported in a combined manner in this continuation statement since this work will be continued as part of research objective 9.3 in the 2017 and 2021 Arctic Research Plan. Salient points about the progress and successes in these milestones are: 1) Sea ice morphology has been improved in the CICE model and will be incorporated into the Regional and Arctic System (RASM – Regional model for which different components are supported by individual agencies) model and other Global models; 2) The Regional Arctic System Model (RASM) funded jointly by DOE, ONR, NSF focusses on understanding and representing critical Arctic physical processes and feedbacks, guide future field campaigns and Earth System Model development, reduce

model uncertainty and improve predictive capability in the Arctic region. Several improvements in model components have been included in it. Improved marine Biogeochemistry, the Variable Infiltration Capacity (VIC) land surface model, and Non-hydrostatic Unified Model of the Ocean (NUMO; <http://numo.ucsc.edu/>) have been tested and incorporated into RASM. Several tests of the Atmosphere and Coupled components of RASM have been evaluated and these improved components captures physical processes and feedbacks more realistically; 3) The Sea Ice Prediction Network (SIPN) has developed standardized model formulation to test and evaluate models in a consistent manner for seasonal ice forecasts.; 4) Spatially Continuous Riverbank Erosion and Accretion Measurements (SCREAM) has been developed to analyze river metrics regardless of river morphology; 5) Ice Sheet System Model (ISSM) has been improved and incorporated into NASA's GEOS 5 Global Model. Similarly, a new ice-sheet model has been incorporated into DOE's Accelerated Climate Model for Energy (ACME) and the Community Earth System Model (CESM). 6) NOAA's climate Test Bed-Accelerating Transition of Research into Operations funded many proposals that evaluated and incorporates new components into Earth System Models; 7) There were several NSF funded activities that address this goal; 8) FAMOS renewal project "Forum for Arctic Modeling and Observational Synthesis (FAMOS) – facilitated the development and testing of several components of Arctic model parameterizations and components; 9) DOE's NGEE-Arctic program and the USGS have developed and used the Advanced Terrestrial Simulator (ATS) for performing these studies, linking observational data and models; 10) The Permafrost Research Network (PRN) involves a large group of scientists working on permafrost with the objectives to synthesize and link existing research about permafrost carbon and climate in a format that can be assimilated by biospheric and climate models, and that will contribute to future assessments of the Intergovernmental Panel on Climate Change (IPCC).

- The Regional Arctic System Model (RASM), funded jointly by DOE and ONR, has been developed as a tool to address the IARPC, U.S. Navy and national Arctic climate modeling and prediction priorities. RASM is under evaluation as a contribution to a climate model hierarchy to: (i) understand and represent critical Arctic physical processes and feedbacks, (ii) guide future field campaigns and Earth System Model development, (iii) reduce model uncertainty and (iv) improve predictive capability in the Arctic region. See the milestone 3.5.2.b for additional information. (Sep 22, 2015 - Completed)
- The Bering Sea Project, a collaboration between the North Pacific Research Board, NSF, and NOAA, has developed an ecosystem modeling framework for the eastern Bering Sea shelf that includes atmospheric forcing, ROMS-based physical oceanography, a nutrient-phytoplankton-zooplankton-detritus model, and an upper trophic level model including age and size structure of fish and bioenergetics. These models are run in a fully coupled framework and have proven successful in hindcasting conditions on the shelf. (Oct 23, 2014 - Completed)
- Marine biogeochemistry ocean and sea ice components, similar to those in the NCAR CESM models, have been implemented and tested in the Regional Arctic System Model (RASM-mBGC). Output from multi-decadal simulations of the fully coupled RASM-mBGC is currently evaluated and publications on model-data comparison and synthesis are in preparation. This activity is funded by the NSF/ARCSS program, and its objectives

are to: (i) evaluate and refine the established ocean marine biogeochemistry model, and (ii) add a newly developed sea ice algal biogeochemistry component within the existing model infrastructure. These enhancements will help quantify variability, complexity, and change in arctic marine primary production. The overarching goal of this study is to achieve a comprehensive understanding of interactions between physical system components and the arctic marine carbon cycle, and to advance arctic system prediction at seasonal to centennial time scales with quantified uncertainty. (Sep 12, 2014 - Completed)

- Wieslaw Maslowski (NRL) and Phil Jones (DOE) provided presentations on observational needs to constrain and advance models for polar regions <http://www.iarpcollaborations.org/members/documents/876>. (Aug 21, 2014 - Completed)
- **3.5.3.c (Milestone met) Couple and evaluate Arctic subsystem components within global Earth-system models; NOAA (Lead), DOE, NASA; Target Date 2017**
 - Completion Statement: Progress has been made on all six milestones (3.5.2.b, part of 3.5.2.c, 3.5.3.a, 3.5.3.b, 3.5.3.c, and 3.5.6.d) that relate to developing, testing improved parameterizations to indicate completion. While 3.5.2b particularly focuses on interagency coordination, 3.5.3b and 3.5.3c focus on including in Regional and Global earth system models respectively. 3.5.3a focuses on evaluating these in observations. However in reality all these activities are interlinked. Progress and success have been indicated in all these and are reported in a combined manner in this continuation statement since this work will be continued as part of research objective 9.3 in the 2017 and 2021 Arctic Research Plan. Salient points about the progress and successes in these milestones are: 1) Sea ice morphology has been improved in the CICE model and will be incorporated into the Regional and Arctic System (RASM – Regional model for which different components are supported by individual agencies) model and other Global models; 2) The Regional Arctic System Model (RASM) funded jointly by DOE, ONR, NSF focusses on understanding and representing critical Arctic physical processes and feedbacks, guide future field campaigns and Earth System Model development, reduce model uncertainty and improve predictive capability in the Arctic region. Several improvements in model components have been included in it. Improved marine Biogeochemistry, the Variable Infiltration Capacity (VIC) land surface model, and Non-hydrostatic Unified Model of the Ocean (NUMO; <http://numo.ucsc.edu/>) have been tested and incorporated into RASM. Several tests of the Atmosphere and Coupled components of RASM have been evaluated and these improved components captures physical processes and feedbacks more realistically; 3) The Sea Ice Prediction Network (SIPN) has developed standardized model formulation to test and evaluate models in a consistent manner for seasonal ice forecasts.; 4) Spatially Continuous Riverbank Erosion and Accretion Measurements (SCREAM) has been developed to analyze river metrics regardless of river morphology; 5) Ice Sheet System Model (ISSM) has been improved and incorporated into NASA's GEOS 5 Global Model. Similarly, a new ice-sheet model has been incorporated into DOE's Accelerated Climate Model for Energy (ACME) and the Community Earth System Model (CESM). 6) NOAA's climate Test Bed-

Accelerating Transition of Research into Operations funded many proposals that evaluated and incorporates new components into Earth System Models; 7) There were several NSF funded activities that address this goal; 8) FAMOS renewal project "Forum for Arctic Modeling and Observational Synthesis (FAMOS) – facilitated the development and testing of several components of Arctic model parameterizations and components; 9) DOE's NGEA-Arctic program and the USGS have developed and used the Advanced Terrestrial Simulator (ATS) for performing these studies, linking observational data and models; 10) The Permafrost Research Network (PRN) involves a large group of scientists working on permafrost with the objectives to synthesize and link existing research about permafrost carbon and climate in a format that can be assimilated by biospheric and climate models, and that will contribute to future assessments of the Intergovernmental Panel on Climate Change (IPCC).

- WCRP CliC is sponsoring an effort for a Sea Ice MIP to evaluate biases in sea ice parameters within global models. (Jul 12, 2016 - Completed)
- Ice sheet models have been coupled into both the Community Earth System Model and the new DOE ACME model and have been used for numerous publications on Greenland mass balance, future mass loss and anthropogenic signal detection (e.g. Fyke et al., 2014, GRL, doi: 10.1002/2013GL058172; Fyke et al., 2014, GRL, doi: 10.1002/2014GL060735). (Sep 22, 2015 - Completed)
- In response to this milestone, the Modeling, Analysis, Predictions, and Projections program in the NOAA Climate Program Office is soliciting proposals for an FY16 competition titled "NOAA Climate Test Bed - Accelerating Transition of Research into Operations". One of the priority areas of this call is to "test the performance of modeling components, schemes, or methodologies developed in the broader community when included experimentally in operational monitoring and dynamical prediction systems, with specific focal areas of a) data assimilation for Earth system components, including ice to improve to improve monitoring and prediction capabilities, and b) improvements in the representation and prediction of sea ice conditions." Four letters of intent received for project on sea-ice data assimilation and prediction in the context of global Earth system modeling were evaluated as being highly responsive or somewhat responsive to the call. Full proposals for this competition are due October 7th 2015. (Sep 16, 2015 - Completed)
- A session was submitted to the Fall AGU Meeting on "Advancing Science of the Arctic System: Exploring the Past and Present to Predict the Future." An excerpt from the proposed text includes: "The IARPC Science Plan identifies some necessary steps for model improvements that may lead to improved projections of variability in sea ice, snow cover, ocean, atmosphere and land states. An integrated and coordinated effort is required to improve the fidelity of Arctic system models, their capability to project future changes, and to enable informed use of those projections. We solicit papers that advance understanding of the Arctic system through simulation and comparison of global and regional climate models with observations of the past and present behavior of the Arctic system. We also solicit presentations that identify and evaluate individual parameterizations, model components, and coupled feedbacks that control variability and affect uncertainty in Arctic climate predictions." (Apr 30, 2015 - Completed)

- Walt Meier (NASA) reported that the WCRP CliC SSG held a workshop to discuss model data intercomparison. There is a report from that meeting. Obs4 MIPs is moving along. Global Cryosphere Watch is making progress. Arctic Data portal is being developed. Ocean Flux data is also being developed. NCAR is working on a climate data tool. SMAP is launched. SIPN is getting ready for the sea ice outlook. Polar Predictability workshop in Reading next year. International coordination. WWRP and WCRP polar prediction school taking place in May in Sweden. (Apr 3, 2015 - Completed)
- Two studies completed with funding by NASA provided two journal articles:
 - 1) Fischer, R., S. Nowicki, M. Kelley, and G. A. Schmidt, A system of conservative regridding for ice-atmosphere coupling in a general circulation model (GCM), *Geosci. Model. Dev.*, 7, 883-907, 2014.
 - 2) Cullather, Richard I., Sophie M. J. Nowicki, Bin Zhao, Max J. Suarez, 2014: Evaluation of the Surface Representation of the Greenland Ice Sheet in a General Circulation Model. *J. Climate*, 27, 4835–4856, doi: <http://dx.doi.org/10.1175/JCLI-D-13-00635.1>.

These papers describe recent efforts to couple ice sheet models into GCMs, for the GISS model (Fischer), which describes the coupling of Ed Beuler's Parallel Ice Sheet Model (PISM) into GISS Model E, and the GEOS 5 model (Cullather). The articles above are described in more detail: The coupling of dynamic ice sheet models to the NASA's climate models (ModelE and GEOS-5) has required substantial changes to both of the climate models. However, this year the implementation of a 2-step downscaling that conserves mass and energy in both GEOS-5 and ModelE was completed. This is not easy because artifacts are created at the edges of different surface types in the GCM (ice sheet, ocean etc.). The ice-atmosphere coupling strategy is distinct for GEOS-5 and ModelE, because the 2 models differ in their representation of land surface. For ModelE, height classes were implemented. These allow for the computation of surface fields (e.g. temperature, surface mass balance) for the ice sheet on fixed height, which can be transferred to the ice sheet via our new coupler (Fischer et al. 2014). Atmospheric fields over the ice sheets in GEOS-5 are now computed on elevation tiles, instead of fixed elevation classes. The new snow model that was implemented in GEOS-5 (Cullather et al., 2014) gives results that are in good agreement with what is considered the "holy-grail" i.e.: regional climate models, and was included in the recently completed high resolution Nature Run and the ongoing Modern Era Reanalysis for Research and Applications – 2 (MERRA2) assimilation. (Sep 25, 2014 - Completed)

3.5.4 Develop models of Arctic land ice mass loss, connections to ocean and atmospheric variability, and implications for sea level

- **3.5.4.a (Milestone met) Support surveys of existing modeling capabilities by participating agencies that tackle the ocean/land ice coupling problem, including parameterization and moving geometry approaches; NOAA (Lead), DOE; Target Date 2014**

- Completion Statement: These set of milestones focus exclusively on Land-ice. Activities in support of this milestone are funded by agency and are listed in the inventory available on the website. This topic is of interest to the MCT agency members. DOE is funding the development of an ice-sheet / ocean interaction model (NUMO; <http://numo.ucsc.edu/>), to become a component of the global and regional Earth system models, such as the DOE-ACME, CESM or RASM model.
- DOE is funding the development of an ice-sheet / ocean interaction model (NUMO; <http://numo.ucsc.edu/>), to become a component of the global and regional Earth system models, such as the DOE-ACME, CESM or RASM model. The current research is aimed to develop and demonstrate the new model ability to realistically represent such interactions in Sermilik Fjord. Future efforts will be needed to expand it to Greenland – wide and other polar regions where narrow fjords are connected to tidewater glaciers. (Sep 23, 2016 - Completed)
- The Climate Variability and Predictability Program of the NOAA Climate Program Office supports several three-year projects starting in FY15 that are relevant to the ocean/ice coupling problem. These include: (i) “Advancing understanding of sea ice predictability with sea ice data assimilation in a fully-coupled model with improved region-scale metrics” (University of Washington), which involves comparing ice-ocean coupling in NCAR and GFDL global climate models; (ii) “Oceanographic controls on Arctic sea ice and its future evolution” (Johns Hopkins University), to develop and test parameterizations of ice-ocean heat transfer in high-resolution GFDL ice models, (iii) “Improving seasonal predictability and prediction of Arctic sea ice and associated feedbacks on mid- and high-latitude climate in CFSv2” (University at Albany), to incorporate a prognostic model of melt ponds in the sea-ice model component of the NOAA CFSv2, which allows for changing pond conditions, with implications for the ice-albedo feedback; and (iv) “Assessing the impact of model formulation and resolution on Arctic sea ice variability and regional predictability” (GFDL), which in part addresses sea ice thickness sensitivity in GFDL models to atmosphere and ocean components or data assimilation. The Modeling, Analysis, Predictions and Projections Program of the NOAA Climate Program Office is funding the NOAA GFDL/ESRL Earth System Modeling initiative, a project that, in part, supports the development, implementation, and testing of the GFDL sea-ice model (SIS2). Specific modeling implementation and testing efforts concern model representation of iceberg and calving, and ice-shelf ocean coupling. (Sep 21, 2015 - Completed)
- International workshops have been held to better understand glacier calving and the interaction of land ice with the ocean, including in 2014 the International Workshop on Calving, June 2014, Grenoble, France: <http://www-igge.obs.ujf-grenoble.fr/calving2014/>. Several U.S. researchers participated in the workshop. (Nov 25, 2014 - Completed)
- Activities in support of this milestone are funded by agency and are listed in the inventory available on the website. This topic is of interest to the MCT agency members. (Sep 25, 2014 - Completed)

- **3.5.4.b (In progress) Help coordinate the implementation of multi-disciplinary test suites and scenarios for idealized and realistic model verification, validation and intercomparison (a combination of ISOMIP and SeaRISE, but extended to the coupled problem); foster exchange of codes, inputs, experiences; DOE (Lead); Target Date 2014**

 - Continuation Statement: Several initial tasks have been accomplished but work will continue as part of the implementation of Arctic Research Plan 2017-2021, Research Objective 9.3, which addresses model intercomparisons and evaluations to enhance Arctic System prediction capabilities. The tasks include presentations to the IARPC MCT group and an initial workshop
 - DOE, NOAA, and ONR are discussing next steps and will report back in early 2015. (Feb 19, 2015 - Target)
 - Sophie Nowicki (NASA) presented information about an ice sheet model intercomparison project for CMIP6.
<http://www.iarpccollaborations.org/members/documents/1288> (Nov 13, 2014 - Completed)
 - A workshop on “Ice Sheet Modeling for CMIP6” was held at NASA Goddard in July 2014. The workshop focused on developing a plan to allow ice sheet and glacier models to better integrate with the CMIP6 project. An expected outcome of the workshop is a proposal to CMIP6 for ice sheet and glacier intercomparisons
<http://www.iarpccollaborations.org/members/documents/2630>. (Aug 28, 2014 - Completed)

- **3.5.4.c (In progress) Translate results from process studies into parameterizations for use in Earth System Models; DOE (Lead); Target Date 2015**

 - Continuation Statement: This activity exclusively focuses on parametrizations for Land-ice modeling. Though there have been some publications listed here, will continue as part of the implementation of Arctic Research Plan 2017-2021, Research Objective 5.2, which addresses development of improved numerical models.
 - Field studies of basal hydrology in Greenland (e.g. Andrews et al., Nature 2014, doi:10.1038/nature13796) have been critical in the development of new basal parameterizations for ice sheet models (Hoffman and Price, 2014, JGR-Earth Surface). (Sep 22, 2015 - Completed)

- **3.5.4.d (Milestone Met) Development of new-generation modeling approaches into the coupled forward and inverse problem; DOE (Lead); Target Date 2018**

 - Completion Statement: This activity exclusively focuses on development of next-generation modeling approaches for Land-ice modeling. Several land-ice model

improvements have been listed under this milestone that include coupling of Community Ice Sheet Model to Community Earth System Model, version 2 and use of adaptive grid techniques, advanced solvers, for improved ice sheet dynamics and creating of optimal initial conditions coupling between ice sheets and ocean and atmosphere components in DOE's Accelerated Climate Model for Energy. In the next plan this will continue as part of the implementation of Arctic Research Plan 2017-2021, Research Objective 5.2, which addresses development of improved numerical models

- Version 2.1 of the Community Ice Sheet Model is scheduled for release in fall 2016, and will be included in the late-2016 release of the Community Earth System Model, version 2. CESM2 has capabilities for two-way coupling between the Greenland ice sheet and the land and atmosphere. (Sep 27, 2016 - Completed)
- Regional Arctic System Model (RASM) has contributed for the first time its September Sea Ice Outlook projection to the Sea Ice Prediction Network (SIPN). This bias corrected projection is based on the mean of 6 RASM ensemble members forced with NCEP CFSv2 seasonal global forecast output. (https://www.arcus.org/files/sio/25804/sio_aug2016_rasm-kamaletal_6ens.pdf). (Sep 23, 2016 - Completed)
- The DOE ACME model is nearing completion of full dynamic coupling between ice sheets and ocean and atmosphere components and will include this capability as part of its release in late 2016, providing full forward simulations that include ice sheet/ocean coupling as well as improved surface mass balance in a global model. (Sep 22, 2015 - Completed)
- The DOE PISCEES project is developing new adaptive grid techniques, advanced solvers, assimilation and UQ approaches for improved ice sheet dynamics and creating of optimal initial conditions. These developments are nearly complete and will be released as part of the DOE ACME model in late 2016. (Sep 22, 2015 - Completed)
- **3.5.4.e (In progress) Completion of observing system studies using improved models to further inform observing system design; DOE (Lead); Target Date 2016**
 - Deactivation Statement: This topic was a target for interagency collaboration. However, this milestone is part of a research objective that was focused primarily on land-ice. Budget constraints and competing priorities have not allowed progress on this milestone and hence this milestone is being deactivated.
 - Budget constraints and competing priorities have delayed progress on this milestone. This topic continues to be a target for interagency collaboration in future observing studies. MCT is extending the milestone to allow additional time for progress. (Oct 23, 2014 - Completed)

3.5.5 Increase Arctic model resolution to improve prediction and inform future research and observations

- **3.5.5.a (In progress) Conduct ensemble simulations of future Arctic climate change at kilometer spatial scales; DOE (Lead); Target Date 2018**

- Continuation Statement: This milestone has made sufficient progress during this period. Several projects have been initiated during the timeframe of this plan and will produce results during the course of the Arctic Research Plan 2017-2021 under research objective 9.2. The Regional Arctic System Model (RASM) is currently able to produce reliable simulations of the Arctic at kilometer scale resolution. Progress in this milestone will continue during the next phase of the IARPC plan under research objective 9.3
- A newer RASM version, including 1/48-deg spatial resolution configurations for the ocean and sea ice model components, which is eddy-resolving at least in the basin, has completed a 100-year spin up and close to 300 years of sensitivity testing to investigate and optimize its space dependent parameterizations of physical processes and coupling among model components. This is one of the finest ocean and sea ice model configurations for the entire pan-Arctic region integrated for multi-decades, including realistic reanalyzed forcing for 1948-2009. (Sep 23, 2016 - Completed)
- A new sea-ice model, based on the Model for Prediction Across Scales (MPAS) will provide a capability for enhanced resolution in the Arctic within a global model. This new model is nearly complete with validation starting and a planned release in late 2016 as part of the DOE Accelerated Climate Model for Energy (ACME). The model will then be configured for regional Arctic modeling under the DOE HiLAT project. (Sep 22, 2015 - Completed)
- Two new research projects, jointly supported by DOE and ONR for 2015-2018 and involving the Regional Arctic System Model (RASM) are underway and will apply RASM at process resolving configurations (e.g. 1/48o or 2.4km for the ocean and sea ice components) to (i) advance understanding of physical processes and feedbacks involved in Arctic amplification of global climate change and (ii) understand and potentially reduce uncertainty in prediction of arctic climate change at synoptic (5-7 days) to seasonal and decadal scales. Some of the specific objective of this research include evaluation of RASM skill in seasonal ensemble prediction using past atmospheric (reanalysis) forcing as well as downscaling output from selected Earth System models for decadal scales (2016-2030). (Sep 22, 2015 - Completed)
- **3.5.5.b (Milestone met) Engage the Arctic (and Earth system) modeling community in planning and designing future field campaigns; DOE (Lead), DOD-ONR, DOI, NASA, NOAA, NSF; Target Date 2012**
 - Completion Statement: Collaborative engagement of Arctic modeling and field research communities (NGEE-Arctic & ABoVE) are advancing a predictive understanding of the Earth system. It will be some years before the full impact of these new projects are seen, but their high-profile nature has garnered extensive attention within the Arctic science community and more broadly. While the milestone is marked as “Complete”, this approach will continue to be championed and applied to Arctic research through IARPC activities. (Sep 14, 2016 - Completed)
 - In the fall of 2015, NASA initiated the Arctic Boreal Vulnerability Experiment (ABoVE), a field campaign that will continue through at least 2023. As of July 2016, ABoVE consists of 46 different research projects, which have been funded or logistically

supported by NASA as well as other U.S. Federal (including DOE, USGS, USFS, BLM, and NSF) and State of Alaska agencies, as well as Canadian Federal and Territorial agencies. There are > 240 researchers participating in ABoVE, with 45 of these coming from U.S. Federal agencies other than NASA. The ABoVE Science Team (consisting of all investigators) has developed the ABoVE Science Implementation Plan to coordinate the research from all projects. To coordinate research being sponsored by NASA with that being supported by other agencies, NASA has signed memorandum of agreements with the Department of Energy and Polar Knowledge Canada, and is in the process of developing additional agreements with other U.S. and Canadian agencies. Research for ABoVE is now ongoing at a number of field sites across Alaska and northwestern Canada. Information on ABoVE can be found at: <http://above.nasa.gov/>. (Aug 15, 2016 - Completed)

- Modeling investigations were one type of research activity solicited as part of NASA selections made in August 2015 for the initial research investigations to begin the Arctic-Boreal Vulnerability Experiment (ABoVE) field campaign—a large-scale study of ecosystem responses to environmental change in western North America’s Arctic and boreal region and the implications for social-ecological systems. Examples of some of the modeling efforts to be part of this field campaign, representing the diversity of representation from the modeling community, include:

- 1) **Animals on the Move: Remotely Based Determination of Key Drivers Influencing Movements and Habitat Selection of Highly Mobile Fauna Throughout the ABoVE Study Domain.** This project will build empirically-based statistical movement and habitat selection models for multiple groups of animals across the ABoVE Study Domain. The geospatial tools and products will be made accessible to natural resource agencies, wildlife managers, First Nations, Alaskan natives, and other stakeholders to aid them in management and adaptation decisions.

- 2) **A Model-Data Integration Framework (MoDIF) for ABoVE Phase I Research: Simulation, Scaling and Benchmarking for Key Indicators of Arctic-Boreal Ecosystem Dynamics.** This project proposes to coalesce a suite of modeling teams to provide a meta-synthesis of terrestrial biosphere model (TBM) requirements, parameter and structural uncertainties, and the associated data type, range, and co-variables necessary to improve Arctic Boreal Region-specific simulations with respect to the Tier 2 science questions.

- 3) **Evaluating Growing Season Length and Productivity Across the ABoVE Domain Using Novel Satellite Indices and A Ground Sensor Network.** This project will develop a new light-use efficiency (LUE) model of ecosystem productivity, based on a new combination of satellite indices provided by reprocessed MODIS products.

- 4) **Satellite Data Driven Model Assessment of Landscape Variability and Environmental Controls on the Arctic-Boreal Carbon Budget.** This project will apply a satellite data driven carbon model framework to improve understanding and quantification of carbon (CO₂ and CH₄) fluxes and environmental controls

on the net ecosystem carbon budget (NECB) over the ABoVE domain. (Oct 2, 2015 - Completed)

- The primary objective of the planned MOSAiC program is to develop a better understanding of important coupled-system processes so they can be more accurately represented in regional- and global-scale models. MOSAiC observations will serve as a testbed for models at many scales, providing the constraints that are needed to improve process-based, sub-grid-scale model parameterizations for sea-ice environments. This testbed will facilitate detailed studies using high-resolution process models, while serving as a centerpiece for Regional Climate Model activities, both of which will contribute towards the development of Global Climate Models that are better able to represent Arctic processes. Such enhancements will contribute to improved modeling of global climate and weather, and Arctic sea-ice predictive capabilities. Model guidance is critical for the basic design of MOSAiC, by identifying specific processes that contribute to model uncertainty and guiding the deployment of observational assets. (Sep 22, 2015 - Completed)
- As evidenced by the DOE NGEE-Arctic program and the NASA ABoVE program, the modeling community is integrally involved in the planning of field campaigns. (Oct 1, 2014 - Completed)
- Steve Gray (USGS) provided three USGS reports as examples of engaging the modeling community in designing future field campaigns.
<http://www.iarpcollaborations.org/members/documents/882>,
<http://www.iarpcollaborations.org/members/documents/881> (Aug 28, 2014 - Completed)
- Diane Wickland (NASA) provided a report on NASA's Earth System Modeling in the Arctic Boreal Zone Workshop.
<http://www.iarpcollaborations.org/members/documents/883>. (Aug 28, 2014 - Completed)
- **3.5.5.c (Milestone met) Provide mechanisms for rapid access to processed (quality controlled, formatted / gridded) observational data sets for model-data inter-comparison; NASA (Lead), DOD-ONR, DOE; Target Date 2015**
- Completion Statement: Several Quick Look products have been made available by NASA that satisfy the goals of this milestone. [National Snow and Ice Data Center](#) has made sea-ice products from IceBridge and CryoSat. In Obs4MIP activities coordinated by NASA and DOE makes observational products available for model-observation intercomparison.
- Operation IceBridge Quick Look sea ice products for 2016 are now available from NSIDC: https://nsidc.org/data/docs/daac/icebridge/evaluation_products/sea-ice-freeboard-snowdepth-thickness-quicklook-index.html. (Jul 5, 2016 - Completed)
- Within a few months, the QuickLook products will be replaced by the archival version, which is available at <http://nsidc.org/data/idcsi2.html>. (Sep 15, 2015 - Completed)

- NASA continued to provide QuickLook products for IceBridge and CryoSat-2 thickness. Both were provided within 6 weeks of the data collection and used for the Sea Ice Outlook model forecasts. The datasets are available at: https://nsidc.org/data/docs/daac/icebridge/evaluation_products/sea-ice-freeboard-snowdepth-thickness-quicklook-index.html, http://nsidc.org/data/docs/daac/icebridge/evaluation_products/cryosat-2-sea-ice-frebrd-thick-snowdepth-quicklook-index.html. (Aug 31, 2015 - Completed)
- Obs4MIPs, coordinated by NASA JPL, is continuing to ramp up and has been endorsed by the WCRP Data Advisory Council (WDAC). NOAA is now working to put many of their Climate Data Record products, including sea ice, into the Obs4MIPs framework. Also, the WCRP GEWEX SeaFlux project, also organized at JPL, is putting together in situ and satellite data sets that can be applied to investigate ocean fluxes. <https://www.earthsystemcog.org/projects/obs4mips/> (Feb 26, 2015 - Completed)
- SIPN is addressing rapid access to data for seasonal forecasts. (Oct 23, 2014 - Completed)

3.5.6 Use insights from models to inform process research; use process research to evaluate and improve models

- **3.5.6.a (Milestone met) Publish SeaRise ice sheet model intercomparison results; NASA (Lead), DOE, NSF; Target Date 2013**
 - Completion Statement: Produced to inform the IPCC AR5 to provide a credible estimate of ice sheet contribution to future sea level rise. Initiated in 2008 with publication in July 2012. The effort resulted in the following benefits: 1) met a critical need; 2) new consensus data sets were created; 3) cohesive community was formed; 4) a set of benchmarks for evaluation of future advanced models was formed; 5) some surprising model behaviors were discovered. (Dec 26, 2013 - Completed)
- **3.5.6.b (In progress) Analyze model output to determine future needs for data collection and process studies; DOE (Lead); Target Date 2016**
 - Completion Statement: Milestones 3.5.6b and 3.5.6c are intricately linked- Model analysis informs data collection process studies (3.5.6b) and leads to model informed observational campaigns (3.5.6c). There are several success stories as part of these milestones. Some examples are: 1) Parameter estimation using the CICE (Sea-ice Model developed at Los Alamos) points to the need for improved process representation of snow processes; 2) The need for ‘Multidisciplinary Drifting Observatory for the Study of Arctic Climate’ (MOSAIC) campaign was justified through the use of the Regional Arctic System Model (RASM); 3) The Sea Ice Prediction Network (SIPN) has resulted in improved modeling of sea-ice predictions; 4) DOE’s Next Generation Ecosystem Experiment and NASA’s Arctic Boreal Vulnerability Experiment (ABOVE) have been informed by model simulations; 5) RASM participated in the Arctic Marginal Ice Zone (MIZ) Program.
 - Outputs from many RASM multi-decadal simulations have been analyzed and provided insights on the critical data needs and process studies in the Arctic, including cloud

microphysics – radiation coupling, air-sea fluxes under changing sea ice cover, mesoscale eddies, upper ocean – sea ice coupling, shelf-basin exchanges, and runoff – ocean coupling. (Sep 23, 2016 - Target)

- RASM is one of the key models guiding the development of observational strategies for the planned MOSAiC field campaign, concentrated around the drifting German icebreaker RV Polarstern. (Sep 23, 2016 - Completed)
- A large CICE parameter estimation study (see 3.5.6d below) is underway with early results pointing to the need for improved modeling of snow processes. (Sep 22, 2015 - Completed)
- SIPN continually analyzes predictions against observed extent to inform the need for improved processes. This has improved in recent years with an increase in models providing full maps in addition to total ice extent prediction. (Sep 22, 2015 - Completed)
- RASM existing and new simulations are being / will be analyzed and their findings shared with observational community regarding the need for additional data, process studies and improved parameterization. (Sep 22, 2015 - Completed)
- The NOAA Arctic Test Bed (ATB) is in the final step of being approved as NOAA Test Bed. The initial charter has been submitted and, once approved, the ATB will become an official NOAA Test Bed. The ATB is in the initial steps of setting up a verification / evaluation system. We should have some components of this system working by the end of the year, in particular the sea ice model evaluation component. (Sep 18, 2015 - Completed)
- The analysis of model output (i.e., performance) is key to the cycle of study, understand, model, evaluate that characterizes the concept of “predictive understanding.” Model analysis has informed, and is informing several large Arctic research projects (e.g., DOE’s Atmospheric Radiation Measurement (ARM) facility in Barrow, AK; NGEE-Arctic and NASA’s ABoVE). As this approach is expected to be an ongoing mechanism to integrate Arctic modeling and process research, the MCT has extended the target date to 2016 and expects additional successes as additional model analyses are completed. (Sep 25, 2014 - Completed)
- **3.5.6.c (Milestone Met) Design and implement integrated modeling and field campaigns focused on specific high-priority processes to improve process understanding and representation in models; DOE (Lead), DOD-ONR, DOI, NASA; Target Date 2016**
- Completion Statement: Milestones 3.5.6b and 3.5.6c are intricately linked- Model analysis informs data collection process studies (3.5.6b) and leads to model informed observational campaigns (3.5.6c). There are several success stories as part of these milestones. Some examples are: 1) Parameter estimation using the CICE (Sea-ice Model developed at Los Alamos) points to the need for improved process representation of snow processes; 2) The need for ‘Multidisciplinary Drifting Observatory for the Study of Arctic Climate’ (MOSAiC) campaign was justified through the use of the Regional Arctic System Model (RASM); 3) The Sea Ice Prediction Network (SIPN) has resulted in

improved modeling of sea-ice predictions; 4) DOE's Next Generation Ecosystem Experiment and NASA's Arctic Boreal Vulnerability Experiment (ABoVE) have been informed by model simulations; 5) RASM participated in the Arctic Marginal Ice Zone (MIZ) Program

- RASM participated, as one of the three models, in the ONR funded Western Arctic Marginal Ice Zone (MIZ) Program. It has contributed to the ongoing model-data synthesis. It is also expected to be one of the first fully coupled climate models to implement and test new observational findings from the MIZ program, related to wave-ice-ocean coupling, sea ice deformation, and evolution and variability of the upper ocean hydrography. (Sep 23, 2016 - Completed)
- In the fall of 2015, NASA initiated the Arctic Boreal Vulnerability Experiment (ABoVE), a field campaign that will continue through at least 2023. For more information see Milestone 3.5.5b (Aug 15, 2016 - Completed)
- In August 2015, NASA selected 21 proposals for the initial research investigations to begin the Arctic-Boreal Vulnerability Experiment (ABoVE) field campaign—a large-scale study of ecosystem responses to environmental change in western North America's Arctic and boreal region and the implications for social-ecological systems. The NASA-sponsored research projects for ABoVE involve 231 scientists from 43 universities, 14 federal agencies, and 2 state agencies, and 2 Native organizations. ABoVE is a major NASA field campaign to be conducted for 8 to 10 years. The research for ABoVE will link field-based, process-level studies with geospatial data products derived from airborne and satellite sensors, building a foundation for improving the analysis and modeling capabilities needed to understand and predict ecosystem responses and societal implications. It is envisioned that a successful ABoVE will (1) contribute to greater scientific understanding of the vulnerability and resilience of ecosystems and societies to environmental change in western North America, and (2) provide the scientific basis for informed decision-making at local-to-international levels. From September 29 – October 2, the program will hold its first Science Team meeting with a focus on project presentations, discussions of common themes and potential synergies across projects, and development of a projection implementation plan. (Oct 2, 2015 - Completed)
- RASM is a key modeling component of the planned MOSAiC program, whose the primary objective is to develop a better understanding of important coupled-system processes so they can be more accurately represented in regional- and global-scale models. Guidance from such models as RASM is critical for the basic design of MOSAiC, identifying specific processes that contribute to model uncertainty and guiding the deployment of observational assets. (Sep 22, 2015 - Completed)
- NGEE-Arctic is a demonstration of just this type of integrated modeling and field project, focused on the future of permafrost in a changing Arctic. This activity has been highlighted to IARPC, and as such would fulfill this milestone. However, complementary activities are in the final stages of development, including NASA's ABoVE project. As such, the MCT has extended the target date to 2016 at which time ABoVE is expected to be operational as a second example of this integrated approach to Arctic terrestrial ecosystem process and modeling research. (Nov 25, 2014 - Completed)

- NASA returned to the Arctic Ocean in September 2014, when the ARISE (Arctic Radiation - Icebridge Sea & Ice Experiment) project used a C-130 aircraft to measure sea ice properties, radiative fluxes and atmospheric variables, particularly clouds, near the end of the Arctic sea ice melt season. The end of the ARISE mission overlapped with the beginning of a NOAA-ONR project that used a NOAA P-3 aircraft to make meteorological measurements over the open and ice-covered Beaufort and Chukchi seas. The aim was determine heat flow from ocean to atmosphere during freeze-up and the impact on regional atmospheric temperature and pressure, and far-field effects at mid-latitudes. (Sep 25, 2014 - Completed)

- **3.5.6.d (In progress) Develop, test and evaluate new/improved parameterizations; DOE (Lead), DOD-ONR, NSF; Target Date 2015**

- Completion Statement: Progress has been made on all six milestones (3.5.2.b, part of 3.5.2.c, 3.5.3.a, 3.5.3.b, 3.5.3.c, and 3.5.6.d) that relate to developing, testing improved parameterizations to indicate completion. While 3.5.2b particularly focuses on interagency coordination, 3.5.3b and 3.5.3c focus on including in Regional and Global earth system models respectively. 3.5.3a focuses on evaluating these in observations. However in reality all these activities are interlinked. Progress and success have been indicated in all these and are reported in a combined manner in this continuation statement since this work will be continued as part of research objective 9.3 in the 2017 and 2021 Arctic Research Plan. Salient points about the progress and successes in these milestones are: 1) Sea ice morphology has been improved in the CICE model and will be incorporated into the Regional and Arctic System (RASM – Regional model for which different components are supported by individual agencies) model and other Global models; 2) The Regional Arctic System Model (RASM) funded jointly by DOE, ONR, NSF focusses on understanding and representing critical Arctic physical processes and feedbacks, guide future field campaigns and Earth System Model development, reduce model uncertainty and improve predictive capability in the Arctic region. Several improvements in model components have been included in it. Improved marine Biogeochemistry, the Variable Infiltration Capacity (VIC) land surface model, and Non-hydrostatic Unified Model of the Ocean (NUMO; <http://numo.ucsc.edu/>) have been tested and incorporated into RASM. Several tests of the Atmosphere and Coupled components of RASM have been evaluated and these improved components captures physical processes and feedbacks more realistically; 3) The Sea Ice Prediction Network (SIPN) has developed standardized model formulation to test and evaluate models in a consistent manner for seasonal ice forecasts.; 4) Spatially Continuous Riverbank Erosion and Accretion Measurements (SCREAM) has been developed to analyze river metrics regardless of river morphology; 5) Ice Sheet System Model (ISSM) has been improved and incorporated into NASA's GEOS 5 Global Model. Similarly, a new ice-sheet model has been incorporated into DOE's Accelerated Climate Model for Energy (ACME) and the Community Earth System Model (CESM). 6) NOAA's climate Test Bed-Accelerating Transition of Research into Operations funded many proposals that evaluated and incorporates new components into Earth System Models; 7) There were several NSF funded activities that address this goal; 8) FAMOS renewal project "Forum for Arctic Modeling and Observational Synthesis (FAMOS) – facilitated the development

and testing of several components of Arctic model parameterizations and components; 9) DOE's NGEE-Arctic program and the USGS have developed and used the Advanced Terrestrial Simulator (ATS) for performing these studies, linking observational data and models; 10) The Permafrost Research Network (PRN) involves a large group of scientists working on permafrost with the objectives to synthesize and link existing research about permafrost carbon and climate in a format that can be assimilated by biospheric and climate models, and that will contribute to future assessments of the Intergovernmental Panel on Climate Change (IPCC).

- The parameter estimation study of the CICE model has been published as Urrego-Blanco et al. (10.1002/2015JC011558). (Sep 27, 2016 - Completed)
- A team from LANL and LLNL recently included the high-latitude phytoplankton species *Phaeocystis* in a leading simulator of marine biogeochemistry, the Biogeochemical Elemental Cycling (BEC) model (10.1002/2015JG003017). *Phaeocystis* is a strong producer of DMS, and studies to explore its impact on the Arctic climate system are currently in progress. (Sep 26, 2016 - Completed)
- Funded by DOE, a team from LANL has recently coupled sea ice aerosol and biogeochemical tracers (CICE-zbgc) with the ocean Biogeochemical Elemental Cycling (BEC) model. The sea ice model is unique in global studies in that it is capable of simulating ice biogeochemical processes in both Polar Regions. With full ice-ocean biogeochemical coupling in place, the team is now in a position to quantify the impact of sea ice on CO₂ sequestration and trace gas production in Polar Regions. (Sep 23, 2016 - Completed)
- A streamflow routing scheme (RVIC) delivering the freshwater flux from the land surface to all coastal ocean grid cells has been developed, implemented and evaluated in RASM. This routing scheme improves land hydrology – ocean coupling in RASM and yields large improvements in the model representation of the upper ocean hydrography over the vast Arctic shelves and in the adjacent basins. RVIC is implemented separately from the land hydrology model and communicates directly with the RASM flux coupler, which means that it can be used with multiple land models and ocean models. (Sep 23, 2016 - Completed)
- A collaboration between the RASM and HiLAT projects aims to improve the treatment of the surface mass balance of the Greenland Ice Sheet in the Regional Arctic System Model (RASM). It will also study ice/ocean interactions along the Greenland margin. (Sep 22, 2016 - Completed)
- As part of the RASM efforts, an improved ice-ocean-atmosphere coupling technique was developed and instituted in the community flux coupling software, CPL, which eradicated a fundamental problem with the way interfacial stresses were calculated and communicated within RASM and the Community Earth System Model (CESM). It also highlighted a potential problem in several other earth system models. Previously in RASM and CESM, coupling software had disregarded timestep lags in communicating state variables and fluxes between the sea ice, the atmosphere and the ocean models. This allowed high frequency inertial oscillations (period of ~12 hours near the North Pole) to become chaotic and numerically unstable. A theoretical understanding of the problem was developed, and hence the practical problem of instabilities was fixed in CPL. The

changes were passed to both Los Alamos National Laboratory for development of the Accelerated Climate Model for Energy (ACME) and also to the National Center for Atmospheric Research for CESM. A paper was published showing success of the coupling technique both in RASM and CESM. (Sep 22, 2016 - Completed)

- NSF award to Meibing Jin (UAF) and Marika Holland (NCAR) addresses this milestone. The goals of the project are to investigate the influence of high spatial heterogeneity in sea ice on ice-ocean flux exchange and climate conditions. This includes the development of a multi-column ocean grid (MCOG) capability within the Community Earth System Model (CESM). The sea ice component of CESM includes a subgridscale ice thickness distribution and computation of ice-ocean fluxes for multiple (typically 5) subgridscale ice categories which have considerably different thickness and surface properties, such as snow cover. The MCOG implementation allows for this subgridscale flux information to be passed to the ocean model. This enables subgridscale calculations to be performed within the ocean model and the MCOG implementation includes the computation of multiple subgridscale ocean boundary layer calculations. This can modify ocean mixing with potential impacts on simulated climate conditions. (Sep 23, 2015 - Completed)
- A new version of the CICE model (v5) was released in 2014 and version 5.1 released in March, 2015. These versions included new parameterizations for melt ponds, ice hydrology (brine channels, mushy layer) and ridging. New snow parameterizations are under active development and will be included in the next release. (Sep 22, 2015 - Completed)
- Under the DOE HiLAT project, a large parameter estimation study has begun. A large ensemble of over 500 CICE simulations forced by reanalysis over the period 1980-2009 to explore sensitivity to 40 input parameters. These results were also used to train Gaussian Process Models to further expand the ensemble to improve sensitivity estimates. Results from this study will be presented at the 2015 AGU and are being prepared for a JGR publication. In the Arctic, the highest parameter sensitivities were to melt pond drainage and snow radiative properties, pointing to the need for improved snow models as described above. (Sep 22, 2015 - Completed)
- RASM has recently implemented the latest version 5 of the sea ice (CICE) model, which includes new parameterizations of sea ice rheology (i.e. anisotropic or EAP), melt ponds and form drag. Additionally, new parameterizations of the atmospheric boundary layer and cumulus clouds in WRF are also tested. These parameterizations are currently evaluated and inter-compared with the old/earlier ones to demonstrate gains, publish findings and guide improvements of Earths System Models. (Sep 22, 2015 - Completed)
- **3.5.6.e (Milestone met) Plan and conduct inter- and intra-agency conferences, workshops and campaigns designed to bring process researchers and predictive scientists together to solve Arctic grand challenges; DOE (Lead), DOD-ONR, NSF; Target Date 2015**
 - Completion Statement: Several workshops were held in which process researchers and modelers were involved. E.g., Forum for Arctic Modeling & Observational Synthesis (FAMOS), Sea-Ice Prediction Network (SIPN), Next Generation Ecosystem Experiment-Arctic (NGEE-Arctic) etc.

- Activities to include FAMOS, SIPN, NGEE-Arctic, Science Team for ABoVE and the AGU session (Sep 18, 2015 - Target)
- **3.5.6.f (Milestone met) Develop funding solicitations that require integrated process-prediction research approach; DOE (Lead), NASA; Target Date 2013**
- Completion Statement: This milestone calls for the MCT to develop funding solicitations that integrate process, prediction and research. This was done with the DOE NGEE-Arctic solicitation. In addition, the currently active NASA ROSES Carbon Cycle solicitation calls for proposals that integrate process and modeling research. This explicit requirement for coupled process/modeling research is a recent change for some research funding programs. The examples cited are either recent awards or active solicitations. As such, it is early to evaluate the outcomes. However, it is clear that this approach will more rapidly and efficiently translate understanding between the process and modeling communities. (Sep 14, 2016 - Completed)
- The MARES program is supporting the modeling of integrated ocean, atmosphere, ice and biogeochemistry processes and inter-system feedbacks. (Sep 25, 2014 - Completed)

3.5.7 Integrate Arctic climate-model results with observational validation and verification to understand the principal drivers and uncertainties of Arctic climate changes

- **3.5.7.a (Milestone met) Coordinate model experiments and inter-comparisons to critically evaluate regional model results against observations; DOD-ONR (Lead), DOE, NSF; Target Date 2014**
- Completion statement: Milestone 3.5.2 d and 3.5.7a are closely related. Both focus on model intercomparisons, the first to enhance process understanding while the latter, to evaluate coupled models. There have been substantial contributions highlighted under both. They include: 1) Model Intercomparisons initiated by NASA's Boreal Arctic Vulnerability experiment (ABOVE); 2) [POLARCAT Model Intercomparison Project \(POLMIP\)](#) which evaluated the capability of global and regional atmospheric chemistry and transport models to simulate the chemistry and composition of the Arctic atmosphere; 3) Ice Sheet Model Intercomparison Project (ISMIP6) for the next phase of the Coupled Model Intercomparison Project (CMIP6); 4) Intercomparison efforts initiated through Forum for Arctic Modeling and Observational Synthesis (FAMOS) and the Sea-Ice Prediction Network (SIPN). Some of these activities will be continued as part of research objective 9.3 that focuses on intercomparisons of coupled regional and global earth system models.
- ONR will host the "Arctic Forecast Demo 2015 Workshop" at the NOPP Office in Arlington, VA, on May 12-14. The workshop will involve participants from ONR/NRL, NOAA/NWS, USCG, BOEM, and Canada. It is intended as a planning meeting to arrange developmental forecast support for the upcoming Summer 2015 research cruises on the USCGC Healy and the R/V Sikuliaq, and a chance to discuss current and future

forecast capability with operational forecasters and stakeholders. A larger "Integrated Arctic Prediction Science Workshop" is suggested for later in the year, probably after the YOPP Summit and perhaps after the summer field efforts are complete. Scott Harper (ONR) will report on the workshop at the May Modeling CT meeting. (May 28, 2015 - Target)

- The Sea Ice Prediction Network (SIPN, www.arcus.org/sipn) was initiated in late summer 2013 with funding from NSF, ONR, ONR Global, DOE and NASA, and in-kind support from NOAA. The primary institutions in the network are the University of Washington, University of Colorado, University of Alaska Fairbanks, Arctic Research Consortium of the U.S., Los Alamos National Laboratory and NOAA Pacific Marine Environmental Laboratory. The first SIPN workshop was held in March 2014, and a workshop report was presented to the Sea Ice team during the May meeting. SIPN is a contribution to the inter-agency Study of Environmental Arctic Change (SEARCH) <http://www.iarpccollaborations.org/members/documents/566>. (Sep 25, 2014 - Completed)
- Identified and heard reports on the Sea Ice Prediction Network and FAMOS. Determined that these should develop further before acting on specific sea ice model intercomparison project <http://www.iarpccollaborations.org/members/documents/392>, <http://www.iarpccollaborations.org/members/documents/567>. (Jul 25, 2013 - Completed)
- **3.5.7.b (In progress) Develop and implement standards for gridded observational data sets; DOD-ONR, DOE, NASA; Target Date 2014**
 - Completion Statement: Milestone 3.5.7b that focuses on developing and implementing standards for gridded observational data sets along with part of milestone 3.5.2c focused on developing metadata are similar in intent and the following activities help us meet this milestone. They are: 1) the OBS4MIP activity has focused on developing metadata standards and regridding observational (satellite) data to enable easier evaluation of climate models; 2) At meeting organized by CLiC, observational data that would be most useful for climate model evaluation and improvement were identified from the point of view of evaluating Sea-Ice Models. Based on these, sufficient progress has been indicated to close this milestone.
 - At the CliC Science Steering Group workshop in Boulder in February, several modeling and observation topics were discussed, as summarize in the CliC Annual Report: <http://www.climate-cryosphere.org/news/clic-news/1367-2014-clic-annual-report-available>. Most relevant here is the Sea Ice and Modeling Forum (p. 53 of the Annual Report), which had a workshop in September 2014. At this workshop a Sea Ice Model Intercomparison Project (SIMIP) was discussed and a proposal was submitted to CMIP in January. A second workshop will be planned for 2015 bringing together modelers and observationalists with the focus to develop a concrete list of observational data that would be most useful for climate model evaluation and improvement. Also, the Obs4MIPs project is continuing to develop. The goal is to collect and document (primarily) satellite gridded data sets into a framework that is easily accessible by the

modeling community. A new website has been developed and some datasets have already been published: <https://www.earthsystemcog.org/projects/obs4mips/> (Jul 21, 2015 - Completed)

- NASA has an effort to take observational data sets and grid them up and making them available to CMIP5. (Aug 28, 2014 - Completed)
- **3.5.7.c (In progress) Implement a common data portal for both observational data and common model experiments and projections; NASA (Lead), DOD-ONR, DOE; Target Date 2017**
 - Completion Statement: Progress has been made on this milestone to indicate successful completion of this milestone. More work will proceed under research goal 9.4 in the 2017-2021 IARPC plan. The following activities are contributions under this period: 1) Gridded OBS4MIP data is made available on the Earth System Grid Federation (ESGF) to facilitate easy evaluation of Climate Model output; 2) NASA scientists have developed a new set of online climate data resources to help Arctic communities with climate change planning, adaptation and management. The new data sets, introduced today as part of an online Climate Resilience Toolkit, comprise more than 250 Arctic-related datasets and more than 40 maps, tools, and other resources designed to support climate-resilience efforts in the Arctic; 3) Sea Ice Prediction Network (SIPN) data is available at <http://nsidc.org/data/sipn/snapshot-of-the-arctic.html>.
 - Updates have been made to the Sea Ice Prediction Network (SIPN) data portal hosted by NSIDC: <http://nsidc.org/data/sipn/snapshot-of-the-arctic.html>. (Jul 12, 2016 - Completed)
 - Obs4MIPS is of considerable interest within the CMIP community and is also attracting attention among other observational communities, such as in-situ (Obs4MIPS is focused on satellite observations, but is considering broadening the scope). The key for bringing the data together is the Climate and Forecasting (CF) metadata conventions (e.g., such as can be included in NetCDF4). The Obs4MIPS people are still trying to define protocols for how to select datasets for inclusion. There are several datasets proposed for inclusion that need to be reviewed. Obs4MIPS is geared specifically towards well-documented, mature, high-quality datasets that can be incorporated into CMIP studies, but there is discussion to include a broader portal for other data to be submitted and shared. Obs4MIPS is organized under the Earth System Grid Federation (ESGF), which hosts CMIP output as well as now Obs4MIPS. There is also a similar effort for reanalysis fields, called Ana4MIPS and is a subset of a broader ESGF reanalysis effort. Michael Bosilovich, at NASA GMAO, is leading this effort and NASA is supporting inclusion of NASA reanalysis (MERRA) in the effort, including providing visualization and analysis tools. (Sep 28, 2015 - Completed)
 - Walt Meyer (NASA) has been involved with GCW for several years as a “focal point” and is still technically in that role. GCW has been an influence on comparing satellite-derived snow products and Dorothy Hall has been involved with that, along with Chris Crawford at NASA, particularly in terms of snow product inter-comparison experiments. On September 2, the administration "announced a new set of online climate data

resources to help Arctic communities with climate change planning, adaptation and management. The new data sets, introduced today as part of an online Climate Resilience Toolkit, comprise more than 250 Arctic-related datasets and more than 40 maps, tools, and other resources designed to support climate-resilience efforts in the Arctic."

<https://www.doi.gov/pressreleases/obama-administration-unveils-new-climate-resilience-tools> (Sep 15, 2015 - Completed)

- Obs4MIPS and SeaFlux and the SIPN portal are on NSIDC website. (Apr 3, 2015 - Completed)
- SIPN is addressing the need for a common data portal for observational data and common model experiments and projections. OBS4MIPS and ACADIS are as well. (Oct 23, 2014 - Completed)

Team Leads: Renu Joseph (DOE); Scott Harper (ONR)

Agencies

DOC, DOD, DOE, DOI, DOT, NASA, NSF, OSTP, USARC, USDA

Arctic Communities

Milestone Reporting Log 2016

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

3.2.5 Conduct socio-economic research to understand ecosystem services as increased warming changes the Arctic tundra

- **3.2.5.a (Milestone met) Support the outcomes and recommendations of the Arctic Social Indicators Project within the U.S.; Target Date 2013**
 - Completion Statement: Support for the outcomes and recommendations of the Arctic Social Indicators Project within the U.S. is now completed. (Sep 26, 2016 - Completed)
 - **NSF is funding Social Indicators for Rural Alaska Communities (SIRAC):** The project aims to determine how social conditions for Alaska Natives living in small arctic communities have changed since 2000, and differ among communities and small regions. The Census Long Form Survey historically provided much of the data for measuring social and economic conditions in the U.S. Its replacement with the American Community Survey (ACS) after the 2000 Census has raised serious concerns about whether Census data continue to provide accurate measures of well-being in rural Alaska communities, at a time when the region faces unprecedented environmental and socio-economic change. The project addresses the uncertainty with ACS data by developing a new set of social, economic, and cultural indicators with increased capability to detect differences at local scales. (Sep 16, 2016 - Completed)
 - The NSF (Arctic Social Sciences Program, Division of Polar Programs) is currently funding a Research Coordination Network, under its Science, Engineering, and Education Program (SEES) program, titled Arctic-FROST: Arctic Frontiers of Sustainability – Resources, Societies, Environments, and Development in the Changing North (Award Abstract #1338850). This is an international interdisciplinary collaborative network and platform for research exchange, developing an interdisciplinary synthesis and establishing a future international research program about Arctic and sub-Arctic sustainability and sustainable development. Arctic-FROST fosters partnerships among environmental and social scientists, local educators and community members from all circumpolar countries to enable and mobilize research on sustainable Arctic development, specifically aimed at improving health, human development and well-being while conserving ecosystem structures, functions and resources. (Sep 30, 2015 - Completed)
 - USDOJ BOEM AKOCS obtained OMB approval for the ESP study, "Social Indicators in Coastal Alaska: Arctic Communities," which includes questions

regarding effects of climate change. The survey data will be collected in FY2016. (Jun 29, 2015 - Completed)

- The Arctic Social Indicators Project is available at <http://www.sdwg.org/media.php?mid=1599>. (Dec 16, 2014 - Completed)

3.4 Observing systems

3.4.2 Assess local-resident priorities for addressing change

- **3.4.2.a (Milestone met) Assess local-resident priorities for addressing change; Target Date 2017**
 - Completion Statement: The Arctic Observing Assessment is now completed and includes priorities for addressing change. (Aug 30, 2016 - Completed)
 - NSF funded a KAWERAK Workshop that addresses local priorities for science. **Workshop: Research Processes in Western Alaska Indigenous Communities Abstract:** https://www.nsf.gov/awardsearch/showAward?AWD_ID=1624041. The workshop is designed to explore indigenous perspectives on scientific research and research processes in western Alaska. The workshop will focus on: a) the types of scientific research being conducted in and near indigenous communities of the Kawerak region; b) how these studies are being conducted, whether collaboratively with communities or not; c) and to elicit the impressions and suggestions of indigenous communities about the science being conducted in their region and how they might engage more directly with the scientists and their projects. (Jul 29, 2016 - Completed)
 - Being addressed as part of the Arctic Observing Assessment undertaken with the Observing Collaboration Team. (Jun 15, 2015 - Completed)
 - The Arctic Observing Assessment has been completed and its data visualization and resources are available on: <https://www.arctichub.net/> (Jun 15, 2015 - Completed)

3.4.9 Engage indigenous observers and communities in monitoring environmental parameters

- **3.4.9.a (Milestone met) Engage indigenous observers and communities in monitoring environmental parameters; EPA; Target Date 2015**
 - Completion Statement: The Local Environmental Observer Network (Alaska Native Tribal Health Consortium) is active and a new Community Based Observer Networks for Situational Awareness (UAA- DHS Center of Excellence / Center for Maritime Research) project has been developed. (Sep 19, 2016 - Completed)
 - **Collaborative Research: ELOKA Phase IV: Optimizing Data Management Support for Community-Based Research and Observations Contributing to Arctic Science (NSF award).** The mission of the Exchange for Local Observations and Knowledge of the Arctic (ELOKA) is to provide data management and user support services to facilitate the collection, preservation,

exchange, and use of local observations and knowledge of the Arctic. Collecting, documenting, preserving, and sharing knowledge is a cooperative endeavor, and there is an urgent need to manage Local and Traditional Knowledge so that: (1) the information is not lost, but rather protected and preserved; (2) the information is discoverable, and (3) the information has influence on environmental research, policy, and public awareness. Local and traditional knowledge and community-based observations are critical components of Arctic science, a comprehensive Arctic observing network, and informed management and policy. Numerous studies and operational projects clearly demonstrate the value of community data in understanding recent environmental, social, and cultural changes in the Arctic based on knowledge and observations that are not readily available through scientific methods. Examples of this knowledge are fine-scale observations of change from areas not monitored, and knowledge from areas that pre-date mapping and satellite records. ELOKA's research and products result in lasting broader impacts, including making community data available to support research in a number of areas including social sciences, health research, environmental science, adaptation studies, and others and supporting environmental and wildlife management. The focus on user-friendly interfaces will allow the general public to easily access community data, increasing public knowledge and literacy of Arctic Indigenous peoples, science and the environment; one example are projects that support Indigenous language and cultural preservation and maintenance. Publications and the education and training activities will result in improved Science, Technology, Engineering and Mathematics (STEM) training and education while supporting Indigenous peoples, an underrepresented minority in STEM. ELOKA has and will continue to focus on partnerships between academia and other sectors including Indigenous organizations and science and observing coordination bodies. (Aug 26, 2016 - Completed)

- **Yukon River Chinook Salmon Declines: Learning From Tradition (NSF Award).** This award to the Yukon River Drainage Fisheries Association (YRDFA) will support an interdisciplinary workshop with Yup'ik Elders from the Yukon River Delta, social scientists, and natural resource managers investigating the natural history, environment, and health of the cultural keystone species whose numbers are in precipitous decline, the Chinook salmon of the Yukon River, Alaska. The focus of the workshop will be Elder knowledge of the salmon and salmon fishing; discussing the history, changes, traditional place names, harvest patterns, diet and food preparation, traditional fishing practices, weather, river conditions, other animal and plant communities related to these practices, as well as other relevant topics. This project is modeled after the very successful Yup'ik Environmental Knowledge Project (YEKP) carried out by Calista Education and Culture (CEC). Part of the project will be to transcribe all of the recordings from the knowledge workshop. Following the workshop resulting data will be analyzed and compared with other data sources, e.g., Alaska Department of Fish and Game, US Fish and Wildlife Service, scientific research reports and publications, etc. in order to gain a more complete picture of the natural history, environment, and health of Chinook salmon. Information produced through the

workshop will be shared widely among Yup'ik communities, stakeholders, resource managers, and scientists. (Aug 26, 2016 - Completed)

- Through the Belmont Forum's Arctic Observing and Research for Sustainability program, NSF provides support to the US team members of the COPERA project – C Budget of Ecosystems, Cities, and Villages on Permafrost in the eastern Russian Arctic. The research team will establish a permafrost, hydrological, and meteorological observing network in cooperation with local communities to estimate CO2 sequestration by the permafrost ecosystem (tundra and taiga) and CO2 emission from cities and villages. *Note – other NSF investments to funded projects of the Belmont Forum's Arctic Call may also be relevant to observing and environmental monitoring by indigenous communities:
<http://www.belmontforum.org/cra-2014-arctic-observing-and-research-sustainability/funded-projects>. (Sep 30, 2015 - Completed)
- NSF funded a RAPID (Rapid Response Research) grant to utilize the extensive video footage and qualitative data collected through Elder interviews and participatory ethnography in 2013 and 2014, for the production of a series of short topic oriented films on the ethnobotanical knowledge of Alaska Native peoples. This extensive ecological knowledge is at risk of loss as the pressures of globalization affect food sources and food choices by Alaska Native peoples. The ethnobotanical knowledge recorded through this project is one key to long-term food security in the Arctic. (Sep 30, 2015 - Completed)
- The Arctic Hub <http://www.arctichub.net> “a new collaborative space for people interested in Arctic Observations,” including engagement with indigenous communities. Created with seed funding from NSF. One of the projects is the Arctic Observing Assessment data visualization tools, Data Visualization and Data Explorer, accessible under the AOA tab on the Arctic Hub website. (Sep 30, 2015 - Completed)
- Transitioning the Bering Sea Sub-Network to the Community-based Observation Network for Adaptation and Security (NSF Award): Over the past two years members of the Bering Sea Sub-Network (BSSN, <http://www.bssn.net/>) have provided input and achieved consensus that BSSN needs to evolve toward a broader range of data for the purpose of developing more tangible metrics and guidelines for adaptation. This evolution, entitled the Community Observing Network for Adaptation and Security (CONAS) requires a bridging period of approximately one year. The team will build off of the key elements of the BSSN data collection mechanisms but expand these to include more variables of interest and place them in a sociocultural context so that arctic communities and governments will be able to anticipate, plan and respond to these changes through the development of Adaptive Capacity Indices (ACIs). A transition year will allow the research team and participating Bering Sea communities to plan for full implementation of CONAS. CONAS will examine environmental change and response within a framework of social-ecological system (SES) science. In an SES context, the ability of a community to respond successfully to change is referred to as its adaptive capacity. Adaptive capacity reflects both the sensitivity of community members to their environment and their ability to institute changes

that make them less vulnerable to a given perturbation (Ensor and Berger 2009, Wilkinson 2012). This framing of adaptive responses is critical to better enable communities to identify the spectrum of tradeoffs and their consequences during unusual or rapid change (Alessa et al 2008). (Sep 30, 2015 - Completed)

- Collaborative Research: **ELOKA Phase III: Toward Sustainable Data Management Support for Community-Based Observations Contributing to the Arctic Observing Network (NSF award)**: The project builds on the successes of prior phases that resulted in operational research data infrastructure that crosses disciplinary boundaries and provides users with the ability to access community data and supports a circumpolar network of researchers, practitioners, and knowledge holders. Three objectives support sustaining and enhancing ELOKA: 1) Provide core data management services to researchers and organizations involved in community-based research; 2) collaboratively enhance the existing ELOKA technology platform to better support collection and sharing of community data; 3) ensure a sustained and interoperable long-term preservation system for community data. Objectives are achieved first by providing data management planning support, developing community data Websites, and hosting an inventory of community-based research projects. Second, by adding advanced administrative, mapping, and multimedia functions to existing technology to enhance ELOKA services and increase the number of projects served. Third, by securing community data over the long-term by building on interoperable, data-curation. (Sep 30, 2015 - Completed)
- Collaborative Research: **Community based permafrost and climate monitoring in rural Alaska (NSF Award)**: The specific objectives of this project are to 1) engage traditionally-underserved tribal communities of the Upper Kuskokwim region in permafrost and climate change research, 2) build community capacity to monitor changes in local climate and permafrost, 3) model the state and distribution of near-surface permafrost, and 4) develop a geo-hazard map. The high-resolution land cover, permafrost, and geo-hazard maps will serve the communities' need to identify sites experiencing rapid changes and could be hazardous. (Sep 30, 2015 - Completed)
- **Visions of Adaptation: Indigenous Video Production in a Transforming Greenland (NSF Award)**: Utilized qualitative and quantitative methods to investigate fishing and hunting livelihoods and strategies in West Greenland. The study deepens our understanding of how small-scale communities adapt to industrialization and alternative livelihoods.
(http://www.nsf.gov/awardsearch/showAward?AWD_ID=1438097) (Sep 30, 2015 - Completed)
- Roberto Delgado (NIMH) will reach out to Carl Markon (USGS, chair of the Terrestrial Ecosystems team) to assess working together on this issue. He will also discuss how this fits in with the Arctic Observing Assessment of the Arctic Observing Collaboration Team chaired by Erica Key. (Jun 15, 2015 - Completed)
- The Local Environmental Observer Network (LEO) Network of the Alaska Native Tribal Health Consortium - <https://www.leonetwork.org/en/leo/about> - and

the Community Based Observer Networks for Situational Awareness (CBONS-SA) of the newly established Arctic Domain Awareness Center (ADAC), a joint UAA- DHS Science & Technology Center of Excellence, Center for Maritime Research, help to fulfill this milestone. For more information on the Arctic Domain Awareness Center, please go to:

<https://adac.hsuniversityprograms.org/centers-of-excellence/adac/> (Jun 15, 2015 - Completed)

- The TECT milestone 3.2.3.a will continue to address incorporating indigenous knowledge and observing into monitoring environmental parameters. (Jun 15, 2015 - Completed)
- The NSF Arctic Social Science Program funds numerous individual research projects that engage communities in monitoring environmental parameters. For example:
 - Kawerak Ice Seal and Walrus Mapping Project Community-Based Documentation of Ice Seals and Walrus in the Bering Strait Region
http://www.nsf.gov/awardsearch/showAward?AWD_ID=1023686
 - Strategic Needs of Water on the Yukon (SNOWY)
http://www.nsf.gov/awardsearch/showAward?AWD_ID=1118397 & NIK Yukon to Yakutia - connects indigenous people in Alaska and Russia to look at how environmental change is affecting their rivers and the quality of their water
http://www.nsf.gov/awardsearch/showAward?AWD_ID=1445218
 - Bodenhorn project: Learning about environmental research in the context of climate change: an international scholastic interchange
http://www.nsf.gov/awardsearch/showAward?AWD_ID=0813635
 - Pulsifer ELOKA III Collaborative Research: ELOKA Phase III: Toward Sustainable Data Management Support for Community-Based Observations Contributing to the Arctic Observing Network Abstract:
http://www.nsf.gov/awardsearch/showAward?AWD_ID=1231638
 - Gearheard Collaborative Research: Preserving weather information from Inuit Elders and remote weather stations at Clyde River, Nunavut (Sep 26, 2014 - Completed)
- Michael Brubaker (ANTHC) presented the LEO network to the IARPC. The Local Environmental Observer (LEO) Network of the Alaska Native Tribal Health Consortium (ANTHC) provides a model for engaging communities and connecting with technical experts and resources. It also informs about specific events and the impacts, needs, and responses. (May 30, 2014 - Completed)
- The ARCTIC Section funded the “workshop on Improving Local Participation in Research in Northwest Alaska in 2013. (Feb 28, 2013 - Completed)
- NSF supported the ICC “Assessing the Vitality of Arctic Indigenous Languages Research Development Workshops” in Ottawa 2012. (Dec 28, 2012 - Completed)

3.6 Adaptation tools for sustaining communities

3.6.1 In collaboration with local communities, develop methods for assessing community sustainability and resilience and determine the efficacy of current adaptation strategies

- **3.6.1.a (Milestone met) Identify and develop a database on past and current adaptation strategies used by Arctic communities to combat climate change impacts; DOE, DOS; Target Date 2013**
 - Completion Statement: Identification and development of adaptation strategies used by Arctic communities to combat climate change impacts is now completed. (Oct 5, 2016 - Completed)
 - **Resilient Alaska Native Communities: Integrating Traditional Ecological Knowledge with Risk Assessment through Local Monitoring (NSF Award).** This award supports an EAGER research project that has the potential to transform understandings and support the adaptive capacity of Alaska Native communities experiencing the impacts of environmental change on their health and well-being. Through this project the investigator, PI Bronen, will address one of the most urgent challenges facing Alaska Native communities impacted by natural hazards by constructing a methodology to determine whether and when community relocation needs to occur to protect the lives and livelihoods of community residents. The researcher will work with four Alaska Native communities and governmental and non-governmental organizations to design and implement a methodological framework that can assess when protection in place is no longer possible and relocation is required. It is expected that the communities will represent a continuum of adaptation responses including "protection in place," migration of some infrastructure, and relocation. The broader impact of this project is to provide a model for the design and implementation of a relocation institutional framework that protects the health and well-being of community residents and can be applied by other communities facing displacement because of environmental change (Sep 30, 2016 - Completed)
 - The U.S. Climate Resilience Toolkit now includes an Arctic component with a framework, resources, and tools to understand and address climate issues that impact people and their communities - <https://toolkit.climate.gov/topics/arctic>. (Sep 25, 2016 - Completed)
 - In September 2014, the team combined milestones 3.6.1.a-d as they all relate to the database on past and current adaptation strategies. The target date was updated to 2014 to accommodate additional work. In addition, the report, "Taking Stock of Adaptation Programs in the Arctic (AACA -B), provided an overview of existing adaptation activities. (Sep 19, 2016 - Completed)
 - Through the Belmont Forum's Arctic Observing and Research for Sustainability program, NSF provides support to the US team members of the ASUS consortium. ASUS (Arctic Sustainability: A Synthesis of Knowledge) unites a team of diverse international expertise to develop a framework that highlights the state of current understanding, best practices, and metrics for achieving sustainability in the Arctic (<http://www.belmontforum.org/funded-projects/asus->

[arctic-sustainability-synthesis-knowledge](#)). *Note – other NSF investments to funded projects of the Belmont Forum’s Arctic Call may also be relevant to indigenous adaptation strategies and sustainability in the face of climate change: <http://www.belmontforum.org/cra-2014-arctic-observing-and-research-sustainability/funded-projects> (Sep 30, 2015 - Completed)

- Component B of the Arctic Council initiative on "Adaptation Actions for a Changing Arctic" (AACCA), completed in May 2013; the Arctic Monitoring and Assessment Program (AMAP) working group provides a snapshot of the adaptation activities
<http://www.iarppcollaborations.org/members/documents/1059>. (Dec 16, 2014 - Completed)
- In May 2013 the Arctic Council decided to continue its work on the AACCA initiative and requested the AMAP Working Group to “produce information to assist local decision-makers and stakeholders in three pilot regions in developing adaptation tools and strategies to better deal with climate change and other pertinent environmental stressors”. This has resulted in the AACCA-C project which will deliver its overall integrated report to the 2017 Arctic Council Ministerial Meeting. (Dec 16, 2014 - Completed)
- **3.6.1.b (Deactivated) Determine which strategies have been most successful; DOE, DOS; Target Date 2013**
 - Deactivation Statement: In September 2014, the team combined milestones 3.6.1.a-d as they all relate to the database on past and current adaptation strategies. The target date was updated to 2014 to accommodate additional work. (Sep 15, 2014 - Completed)
- **3.6.1.c (Deactivated) Document unintended consequences of previous strategies and responses to change; DOE, DOS; Target Date 2013**
 - Deactivation Statement: In September 2014, the team combined milestones 3.6.1.a-d as they all relate to the database on past and current adaptation strategies. The target date was updated to 2014 to accommodate additional work. (Sep 15, 2014 - Completed)
- **3.6.1.d (Deactivated) All will be explored by the Adaptation Actions for a Changing Arctic Report; DOE, DOS; Target Date 2013**
 - Deactivation Statement: In September 2014, the team combined milestones 3.6.1.a-d as they all relate to the database on past and current adaptation strategies. The target date was updated to 2014 to accommodate additional work. (Sep 15, 2014 - Completed)

3.6.2 Identify the current vulnerabilities of Arctic communities and ecosystems to climate change and explore their interactions with socio-economic and other stressors

- 3.6.2.a (Milestone met) Establish research and community collaborations aligned with local priorities and needs, including in planning, data collection, conceptualization, and interpretation of research results and recommendations; Target Date 2013**

 - Completion Statement: The Institute of Social and Economic Research (ISER) at UAA enhances the well-being of Alaskans and others, through non-partisan research that helps people understand social and economic systems and supports informed public and private decision-making. Research areas include Applied Social Policy, Arctic Social Sciences, Economy, Education, Energy and Environment, Fiscal Policy, and Fisheries. ISER's research findings can be searched and obtained online at: <http://www.iser.uaa.alaska.edu/publications.php> (Sep 19, 2016 - Completed)
 - In fall 2015, as part of its chairmanship of the Arctic Council, the U.S. launched the RISING SUN initiative. RISING SUN is designed to create a common way to evaluate suicide prevention interventions across the Arctic. The use of common assessment measures – developed in collaboration with indigenous peoples' organizations, community leaders, and mental health experts – will facilitate data sharing, evaluation, and interpretation of interventions across service systems in the Arctic region. RISING SUN is a joint effort of the National Institute of Mental Health, in collaboration with the Substance Abuse and Mental Health Services Administration, the Centers for Disease Control and Prevention, the Office of Global Affairs in the Department of Health and Human Services, the Department of State, and international co-sponsors. For more information, e-mail: RISING-SUN@mail.nih.gov. (Oct 1, 2015 - Completed)
 - The NSF funds individual projects that are within this Milestone.

ASSP Project: Social Indicators for Rural Alaska Communities (SIRAC) http://www.nsf.gov/awardsearch/showAward?AWD_ID=1216399.

Johansen Arctic Survey on Adaptation to Climate Change http://www.nsf.gov/awardsearch/showAward?AWD_ID=1237614.

AFN project in collaboration with U Illinois and the community of Togiak Bridging the Divide: Exploring Native Approaches to Science Through Analysis of Implementation of a Complex Information Technology in Alaska Native Communities http://www.nsf.gov/awardsearch/showAward?AWD_ID=1345026. (Dec 16, 2014 - Completed)

- 3.6.2.b (Milestone met) Assess vulnerability of Arctic communities and ecosystems to climate change and socio-economic stressors; Target Date 2014**

 - Completion Statement: Vulnerability assessments to climate change and socio-economic stressors of Arctic communities and ecosystems is now complete. (Sep 26, 2016 - Completed)
 - The North Slope Science Initiative recently completed their report titled Prioritizing Science Needs Through Participatory Scenarios for Energy and

Resource Development on the North Slope and Adjacent Seas (June 2016) - http://www.northslope.org/media/doc/2016/Aug/NSSI-Summary_report-2016.08-FINAL.pdf (Aug 5, 2016 - Completed)

- The World Climate Research Programme's (WCRP) Climate and Cryosphere (CLiC) Project and the Arctic Monitoring and Assessment Program (AMAP) working group of the Arctic Council produced an Arctic Freshwater Assessment (2016) - http://iasc.info/images/news/2016/AFS_Report.pdf - to synthesize our current scientific understanding of Arctic freshwater sources, fluxes, storage and effects, structured around 5 major components: atmosphere, ocean, terrestrial hydrology, terrestrial ecology and resources. (Feb 26, 2016 - Completed)
- ICC-Alaska has completed their report titled Alaskan Inuit Food Security Conceptual Framework: How to Assess the Arctic from an Inuit Perspective. - <http://iccalaska.org/wp-icc/wp-content/uploads/2016/05/Food-Security-Full-Technical-Report.pdf>. This topic was chosen because food security was identified as a top priority within ICC-Alaska's strategic plan: http://iccalaska.org/wp-icc/wp-content/uploads/2016/01/ICC-StratPlan-2014-2018_v9-low-res.pdf. (Oct 9, 2015 - Completed)
- The Northwest Arctic Borough of Alaska has completed their Subsistence Mapping Project (Jan 2016) - <http://www.nwabor.org/subsistence-mapping-program/digital-atlas/>. The project produced an atlas documenting subsistence-use areas (where people hunt, fish and gather by season) and important ecological areas (places where animals feed, breed, raise young and migrate) in seven of the region's coastal communities -- Kivalina, Noatak, Selawik, Noorvik, Deering, Buckland and Kotzebue. It also identifies resource development opportunity areas (places where the surface, subsurface, landscape, freshwater or marine environment could be altered for the purpose of economic development). (Oct 9, 2015 - Completed)
- NASA's Terrestrial Ecology Program is conducting a major field campaign, the Arctic-Boreal Vulnerability Experiment (ABOVE), in Alaska and western Canada, for 8 to 10 years, starting in 2015, that seeks a better understanding of the vulnerability and resilience of ecosystems and society to this changing environment (<http://above.nasa.gov>). (Sep 30, 2015 - Completed)
- There are six active NSF's Arctic Science, Engineering, and Education for Sustainability (ArcSEES) awards totaling over \$8.5 million. ArcSEES is a multi-year, interdisciplinary program which seeks both fundamental research that improves our ability to evaluate the sustainability of the Arctic human-environmental system as well as integrated efforts which will provide community-relevant sustainability pathways and engineering solutions. These projects - <http://www.nsf.gov/awardsearch/simpleSearchResult?queryText=arcsees&ActiveAwards=true> - are scheduled to be completed between 2016 and 2018. (Jun 15, 2015 - Completed)
- People in the Arctic and sub-Arctic continue to face uncertain livelihoods as they contend with environmental variability and changes operating at multiple scales. The Arctic Water Resources Vulnerability Index (AWRVI) is an adaptive

capacity tool for Arctic communities to assess their susceptibility to changing biophysical and socioeconomic conditions affecting their water resources. AWRVI has been applied in seven communities in Northwest Alaska and Southcentral Alaska, and five communities on Chukotka Peninsula in the Russian Far East. AWRVI is an adaptive capacity index that integrates a range of community-specific water data to provide a holistic profile of vulnerability to changing water resources and a measure of adaptive capacity to respond to change – AWRVI version 2.0 is currently under development at the University of Idaho's Center for Resilient Communities in partnership with the University of Alaska Fairbanks' International Arctic Research Center. The Arctic Water Resource Vulnerability Index: An Integrated Assessment Tool for Community Resilience and Vulnerability with Respect to Freshwater, Alessa et al. (<http://www.iarpcollaborations.org/members/documents/2414>) (Jun 15, 2015 - Completed)

- BOEM funded the in 2014. Environmental Studies Program Social Indicators in Coastal Alaska-Arctic Communities Study. (Jul 22, 2014 - Completed)
- Arctic Sustainability (ArcSEES) initiative (BOEM, EPA, NSF, USFW, USGS, and a consortium of French science funding agencies funded in 2013. (Jul 22, 2014 - Completed)
- **3.6.2.c (Milestone met) In collaboration with other Arctic nations develop a standardized set of quantifiable socio-economic indicators of vulnerability: Arctic Social Indicators II Study; NSF; Target Date 2012**
 - Completion Statement: The Arctic Social Indicators Report II was released in 2013 and is available <http://www.svs.is/en/links/all-news/113-arctic-social-indicators-ii>. (Jun 15, 2014 - Completed)

3.6.3 Develop projections of future climate scenarios and demographic conditions to forecast potential strengths and weaknesses of human and ecological systems in the Arctic

- **3.6.3.a (In progress) In collaboration with other Arctic nations, develop a standardized set of socio-economic indicators to measure future community resilience (2020 and 2030 projections), including input of local resources, population fluctuations and migration, communication networks, and capacity to adapt via the Arctic Council's Arctic Social Indicators II Study 2012 and Arctic Resilience Report; DOI, DOS; Target Date 2015**
 - Continuation Statement: The Arctic Resilience Assessment, the circumpolar telecommunications infrastructure assessment, and the final ECONOR III summary for policymakers are on target to be completed between October 2016 and May 2017. (Oct 5, 2016 - Completed)
 - Socio-Economic indicators: The ECONOR III project - The Economy of the North 2015 - will provide an updated overview of the economy, socioeconomic living conditions and environmental issues in the circumpolar Arctic, as impacted by the global economy and climate change. The report was published in March

2016, and its results are being presented at the SDWG/SAO meeting in October 2016; a summary for policymakers will be released in spring 2017 ahead of the Arctic Council Ministerial. (Oct 3, 2016 - Completed)

- An Arctic Council Task Force on Telecommunications Infrastructure in the Arctic (TFTIA) is coordinating a circumpolar assessment of telecommunications infrastructure and networks to identify the requirements to meet demands for communities, regional connectivity, human services, scientific observations, navigation and support for potential search and rescue or oil spill response. This assessment will include recommendations for public-private partnerships to enhance telecommunications access and service in the Arctic. To be presented at international fora in late 2016 /early 2017. (Oct 3, 2016 - Completed)
- The Sustainable Development Working Group of the Arctic Council is exploring projects that enhance energy security through renewable energy and energy efficiencies during the US Chairmanship. (Oct 3, 2016 - Completed)
- DOI is leading the production of an Arctic Resilience Assessment (formerly the Arctic Resilience Report) as a deliverable for the U.S. Chairmanship of the Arctic Council. The ARA provides a novel assessment of Arctic change and resilience, including factors that appear to support or weaken resilience. It also provides an overview of tools and strategies that can be used to assess and build resilience in the Arctic, and considers how the Arctic Council can contribute to those efforts (Oct 3, 2016 - Completed)
- An online Arctic Adaptation Exchange portal has been created with a focus on innovative approaches to climate change adaptation and the enhancement of adaptive capacity. The portal facilitates access to resources for community decision-makers and establishes a space for circumpolar residents to exchange best practices and experiences with adaptation strategies - <http://arcticadaptationexchange.com/> (Oct 9, 2015 - Completed)
- Capacity to adapt: The SDWG will work on exploring and developing projects that enhance energy security through renewable energy and energy efficiencies over the course of the U.S. Chairmanship and beyond. This work will include a project aimed at developing a modular system pairing renewable energy technology with diesel generators and energy-storage devices to power micro-grid systems in small Arctic communities. This project cluster may be expanded into a mechanism for clean energy practitioners to share knowledge and promote capacity building in rural communities. (Sep 30, 2015 - Completed)
- **3.6.3.b (Milestone met) Link climate models with projections of ecological and socio-economic change that include community dependence on harvesting local food sources; DOI; Target Date 2017**
 - Completion Statement: Activities and studies that inform projections of ecological and socio-economic change in response to climatic factors, including with respect to community dependence on harvesting local food sources, have been completed. (Oct 3, 2016 - Completed)

- BOEM funded two projects completed in 2016 that addressed scenarios and demographic conditions in human and ecological systems in the Arctic. First, the “Social Indicators in Coastal Communities” project conducted surveys asking questions directed explicitly at the impacts of climate change on infrastructure and households, as well as its effects on subsistence harvest and food storage; these data can be used to link climate models with ecological and socio-economic change. The second project, “Subsistence Sharing Networks and Cooperation,” provides data about how changes in subsistence would affect the Inupiat, highlighting resilience, vulnerability, and concerns regarding food security. (Sep 30, 2016 - Completed)
- Cyber-Enabled Understanding of Complexity in Socio-Ecological Systems via Computational Thinking (NSF funding through Arctic Social Sciences Program). This project assessed how the level of vulnerability of a particular system or population plays an extremely important role in developing adaptive strategies to lessen and sometimes negate detrimental effects of climate change. Specifically, this study first looked at the generally accepted definition of vulnerability, and the importance of specifying the types of vulnerability measured within a coupled socio-natural system. Secondly, noteworthy general conceptual and analytical frameworks were recognized and evaluated for effectiveness, accuracy, and relevancy, then were detailed further into vulnerability frameworks tailored for particular analyses, such as heat or coastal vulnerability. The new suite of models focused on two geographic regions where climate change has significant consequences for humans and ecosystems: Sub-Saharan Africa (over a billion people at high risk of displacement, disease, starvation) and the Arctic Circumboreal region (where the fastest ecological changes are now occurring with shifting patterns comparable to earlier major climate events). (Sep 30, 2015 - Completed)
- Team hosted a food security webinar in June 2014: <http://www.iarpcollaborations.org/members/events/351> (Dec 16, 2014 - Completed)
- **3.6.3.c (Milestone met) Test existing scenarios of the status of certain wildlife species of value to local consumers, according to available climate change models; DOI; Target Date 2017**
 - Completion Statement: Scenario workshops and subsequent summaries that report on the status of wildlife species, according to available climate models, have been completed. (Oct 5, 2016 - Completed)
 - NSF is investing in a new program “Innovations at the Nexus of Food, Energy and Water Systems (INFEWS)” and soliciting projects focused on Arctic systems. In this context, the importance of understanding the interconnected and interdependent systems involving food, energy, and water (FEW) has emerged. In 2015, NSF issued a Dear Colleague Letter (DCL): SEES: Interactions of Food Systems with Water and Energy Systems to accelerate fundamental understanding

and stimulate basic research on the connections and interdependencies among these three systems. (Sep 30, 2015 - Completed)

- The Smithsonian's Arctic Studies Center initiated a major research initiative called "Arctic People and Animal 'Crashes': Human, Climate, and Habitat Agency in the Anthropocene" with the Smithsonian funding for 2014-2015. (Sep 26, 2014 - Completed)
- The USFWS, together with USGS and the Wildlife Conservation Society, completed a report titled "Considering Multiple Futures: Scenario Planning to Address Uncertainty in Natural Resource Conservation - <https://www.fws.gov/home/climatechange/pdf/Scenario-Planning-Report.pdf> The report presents a broad synthesis of scenario planning concepts and approaches, focused on applications in natural resource management and wildlife conservation in the face of changes in land use, biodiversity, and climate. (Sep 26, 2014 - Completed)
- The National Park Service (NPS/DOI) convened a workshop and published a report titled "Climate Change Scenario Planning for Interior Alaska Parks - <https://www.nps.gov/akso/nature/documents/NPS-CCSP-Report-InteriorArctic.pdf> (Jul 25, 2014 - Completed)

3.6.4 Assist Arctic communities in documenting, revitalizing, and strengthening indigenous languages and cultural heritage

- **3.6.4.a (Milestone met) In concert with local communities, strengthen partnerships between researchers, Alaska Native organizations, Federal, state, and NGO entities through strategic projects, workshops, and conferences; NSF, SI; Target Date 2013**
 - Completion Statement: Through efforts of the NSF Arctic Social Sciences Program and the Smithsonian Institutes Arctic Studies Center progress has been made to strengthen partnerships between researchers and Federal, state and local organizations. For example, the Animal Crashes and Human interventions workshops in Anchorage and DC as well as the workshop on Indigenous scholarship have helped address this issue. (Oct 5, 2016 - Completed)
 - Smithsonian Arctic Studies Center conducted two workshops on Animal Crashes and Human interventions in 2015 (Anchorage) and 2016 (Washington DC) and has a publication in press documenting results. http://naturalhistory.si.edu/arctic/html/Arctic_crashes_home.html (Sep 9, 2016 - Completed)
 - The Smithsonian Handbook of American Indian summary volume contains chapters on museums and heritage, and online collection networks and exhibits. (Sep 9, 2016 - Completed)
 - NSF, through the Arctic Horizon's process supported, the **Arctic Social Sciences in the 21st Century: Indigenous Scholarship in the North: Decolonizing Methods, Models and Practices in Social Science Research** workshop [March 23-25] in Fairbanks bringing Indigenous scholars together the Fairbanks

workshop explored recent advances and innovations in indigenous science and scholarship in the circumpolar north and its neighbors. The workshop brought together indigenous experts and researchers from diverse academic and cultural backgrounds to explore the role and contributions of indigenous frameworks and knowledge systems in advancing fields of science and informing global solutions. The workshop moved the academic discourse beyond exploring intersections of indigenous knowledge and science to explore indigenous knowledge and practice as a framework of science. Additionally, participants discussed how knowledge produced within indigenous systems has the potential to contribute to community adaptation and resilience within multiple global contexts and settings. The workshop also highlighted innovative, community-driven, and decolonizing methodologies that demonstrate how indigenous frameworks can shape both knowledge and practice within social science research. (Mar 31, 2016 - Completed)

- NSF, NEH, and Smithsonian partnership in the Documenting Endangered Languages Program (DEL) started in 2003. The Arctic Social Sciences Program has co-funded projects on Arctic Languages since the inception of DEL. Active Arctic projects include: Integrated Audio-Visual Documentation of Itelmen [itl]; Collaborative Research: Comprehensive Itelmen [itl] Dictionary; Linguistic Ethnography: Gwich'in Caribou Anatomy and Cultural Ecology [ISO 639 gwi]; Multi-disciplinary Conference Investigating Tlingit Indigenous Place Names, Language and History; The Alutiq Language Archive and Speaker Registry; The Verbal Morpho-semantics and Clausal Architecture of Tlingit; Digital Infrastructure for Alaskan and Neighboring Languages; Completion of Eyak (ISO 693-3 eya) Grammar, Dictionary, Texts (Sep 30, 2015 - Completed)
- EAGER: Documenting Gwich'in indigenous astronomy (NSF award): This project takes advantage of a unique opportunity to assess the feasibility of documenting indigenous astronomy in Alaska and Canada. Although astronomy is a fundamental component of all Alaska Native cultures, there has so far been no systematic effort to document indigenous knowledge of the Alaskan sky. The project materials created will be accessible through the Alaska Native Languages Archive and it is anticipated will be utilized by Gwich'in communities in the revitalization of their language and cultural knowledge. (Sep 30, 2015 - Completed)
- The US assisted the AC with the development of "Keeping Our Traditions Alive. Compendium of Best Practices in Promoting the Traditional Ways of Life of Arctic Indigenous Peoples." It contains three entries submitted by the US on work in Alaska. The document is available on the Arctic Council website at: <https://oaarchive.arctic-council.org/bitstream/handle/11374/435/TWoL%20PDF%20EN.pdf?sequence=1&isAllowed=y>. (Jul 8, 2015 - Completed)
- Possibly develop a catalogue of ongoing efforts building on the one begun by the Alaska Native Language Center. (Jun 26, 2015 - Target)

- The Team hosted a webinar in spring 2015 on preserving Alaskan native languages. Lenore Granoble (University of Chicago), B. Yaayuk Alvanna-Stimpfle (University of Alaska Fairbanks), and Kathy Sikorski (University of Alaska Fairbanks) gave presentations. The video is available at: <http://www.iarpccollaborations.org/members/events/2251> (Jun 9, 2015 - Completed)
- The Smithsonian hosted the Inuit Studies Conference in 2013 and is publishing some of the results in Early Inuit Studies (Smithsonian Scholarly Press). (Nov 22, 2013 - Completed)
- The ARCTIC Section funded the “workshop on Improving Local Participation in Research in Northwest Alaska in 2013. (Oct 25, 2013 - Completed)
- NSF supported the ICC “Assessing the Vitality of Arctic Indigenous Languages Research Development Workshops” in Ottawa 2012. (Sep 27, 2013 - Completed)
- **3.6.4.b (Milestone met) Develop tools that Arctic communities can use to more effectively support indigenous languages, traditional ecological knowledge, and natural resource harvesting activities - Native language restoration and Native language immersion programs; NSF, SI; Target Date 2014**
 - Completion Statement: Support by the National Science Foundation Arctic Social Sciences Program and the Smithsonian's Arctic Studies Center for work in this area has helped advance our understanding in this area. The Digital Infrastructure for Alaskan and Neighboring Languages as well as the Comprehensive Itelmen [itl] Dictionary are tools that support Indigenous languages. (Oct 5, 2016 - Completed)
 - **Collaborative Research: Comprehensive Itelmen [itl] Dictionary (NSF Award).** Under this international collaborative project, Jonathan Bobaljik, David Koester, Michael Krauss and Chikako Ono (Chiba University, Japan) will work towards the completion and publication of a comprehensive dictionary of the Itelmen language, comprising all known lexical resources, work that was begun under the aegis of a 2012 RAPID award (ARC-1155973). The centerpiece of the project is the large lexical card file (12,000 + cards) assembled by A. P. Volodin (St. Petersburg) from 1962 into the 1980s. The project is coordinated with a larger effort to publish comprehensive dictionaries of the languages of "Beringia" (the Bering Sea region), and comes at a key juncture in the language's history. Itelmen is critically endangered: at this time, the number of native speakers has dwindled to fewer than 10. At the same time, there is growing interest in the Itelmen language within the Itelmen community, as well as growing scholarly attention to the languages of this region in the context of language contact across the Bering Strait. (Sep 30, 2016 - Completed)
 - **Digital Infrastructure for Alaskan and Neighboring Languages (NSF Award).** Under this project, PI Gary Holton, will create a digital repository providing access to the unique and world-renown collection of Native American language documentation housed at the Alaska Native Language Archive (ANLA)

at the University of Alaska Fairbanks. The comprehensive scope of the ANLA collection is unparalleled among linguistic archives across the world.

Approximately three quarters of the material consists of original archival manuscripts, including field notes of prominent scholars of Alaskan languages, including Knut Bergsland, Michael Krauss, James Kari, Jeff Leer, Irene Reed, and Eliza Jones. The collection also includes copies of items found elsewhere only in private hands or in obscure archives in Russia. Much of the collection has never been cataloged. The creation of a digital repository will enhance arctic research infrastructure by providing real-time digital access to archival documents for a broad range of researchers and Native peoples across Alaska, the arctic, and beyond, thereby providing the foundation for a new era of language and culture scholarship in the arctic. (Sep 30, 2016 - Completed)

- Smithsonian is publishing a report on electronic methods for recording and preserving native languages in the final volume of the Handbook of North American Indians. (Sep 9, 2016 - Completed)
- **Collaborative Research: Linking Maps, Manuscripts, and Place Names Data to Improve Environmental Knowledge in Alaska (NSF award).** This award supports a project that will compile a geographic database linking place name data found on historic Alaskan maps, manuscripts, and within oral histories and printed materials. The project builds on the existing, proven infrastructure of the Exchange for Local Observations of and Knowledge of the Arctic (ELOKA) project to create a sustainable platform accessible to both current and future researchers and community members. A collaborative approach brings together researchers with expertise in Alaska Native languages and geography and in web-based mapping and (Sep 9, 2016 - Completed)
- Increased attention to Native language preservation has been highlighted during the recent years by the passage of the Alaska State Indigenous Language bill recognizing native languages as official state languages. (Dec 16, 2014 - Completed)
- **3.6.4.c (Deactivated) Create community profiles that highlight continuity of indigenous languages and knowledge systems; Target Date 2014**
 - Deactivation Statement: While there have been specific activities undertaken by agencies to understand the continuity of indigenous languages and knowledge systems, there are insufficient resources to create community profiles that highlight this continuity. Therefore, this milestone has been deactivated. ()
 - The Arctic Studies Center Newsletter issues 22-23 provided updates on Smithsonian research and educational activities in Arctic regions.
http://naturalhistory.si.edu/arctic/html/pdf/23%20ASC_NL2016.pdf
http://naturalhistory.si.edu/arctic/html/pdf/ASC_NL22%20FINALJuly12015.pdf
(Dec 16, 2014 - Completed)
 - The Smithsonian's Arctic Studies Center Anchorage office held a series of language and native craft workshops that feature cultural and language

preservation and is conducting a major research project on linking Yakutat Tlingit history, language, and archaeology with environmental and climate change (<http://www.iarpccollaborations.org/members/documents/756>) and <https://www.arcus.org/witness-the-arctic/2015/2/article/23162> <http://naturalhistory.si.edu/arctic/html/yakutat-seal-camps/index.html> (Sep 26, 2014 - Completed)

- The Smithsonian published a retrospective analysis of 19th -century Inuit ethnological and zoological collections of Lucien Turner in consultation with northern Quebec Inuit. (Sep 26, 2014 - Completed)
- **3.6.4.d (Deactivated) Identify and strengthen Federal, state, and local efforts related to indigenous languages, traditional knowledge, and cultural heritage; Target Date 2014**
 - Deactivation Statement: Progress on language preservation and tools are reported under milestones 3.6.4.a-c. (Oct 6, 2016 - Completed)
- **3.6.4.e (Deactivated) Develop research programs to monitor the status of indigenous languages and knowledge systems and to better understand factors affecting language and cultural resilience; Target Date 2016**
 - Deactivation Statement: While progress has been made to understand factors affecting language and cultural resilience as reported below, there is no agency with a mandate to develop research programs around this topic. (Oct 6, 2016 - Completed)
 - Smithsonian is publishing the summary volume of the Handbook of American Indians with chapters on language and heritage documentation and preservation. (Oct 5, 2016 - Completed)
 - There is a major Arctic Council’s initiative in progress called Arctic Languages Vitality project (full title “Assessing, Monitoring, & Promoting the Vitality of Arctic Indigenous Languages” sponsored by the Arctic Council (<http://www.arcticlanguages.com/the-project.php#self>) Vera Metcalf (ICC-Canada) is a part of the team, as is also Lenore Grenoble, formerly with Dartmouth College, now at U Chicago. They will be part of the language webinar in January 2015. (Dec 16, 2014 - Completed)
 - There is the NSF/NEH Documenting Endangered Languages Program that has funded a number of Arctic Language projects with Co-funding from SI. (Sep 26, 2014 - Completed)

Team Lead: Bill Fitzhugh (SI)

Agencies: DOC, DOD, DOI, DOS, HHS, NASA, NSF, OSTP, SI, USARC

Human Health

Milestone Reporting Log 2016

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

3.7 Human health

3.7.1 Continue and expand circumpolar surveillance of and research on infectious and non-communicable diseases, trauma, and injuries

- **3.7.1.a (In progress) Publish a comprehensive report on Circumpolar Surveillance of Infectious Diseases for the Arctic Council Ministerial.; HHS (Lead); Target Date 2016**
 - Continuation Statement: This report is under review and is expected to be published in 2017. (Oct 6, 2016 - Completed)
 - Pending completion. The revised plan is to report on infectious disease incidence among countries participating in the International Circumpolar Surveillance system through 2012. Completion of the report awaits data submission from several countries for 2012. Anticipate completion by Dec 31, 2015 (Dec 31, 2015 - Target)
 - A draft has been prepared summarizing data from 1999-2010. The draft is in review at CDC. Draft to be reviewed by stakeholders (IBDWG) and publication is anticipated in Summer 2014. (Oct 20, 2015 - Completed)
 - The deadline for this milestone was updated to 2014 because the comprehensive report on Circumpolar Surveillance of Infectious Diseases for the Arctic Council Ministerial will not be completed until summer 2015. (Apr 9, 2014 - Completed)

- **3.7.1.b (Milestone met) Conduct 5-year retrospective review of tuberculosis in northern Canada, the U.S. Arctic, Greenland and northern regions of the Russian Federation; HHS (Lead); Target Date 2016**
 - Completion Statement: A report was published on this effort: “Descriptive review of tuberculosis surveillance systems across the circumpolar regions”, citation: Int J Circumpolar Health 2016, 75 : 30322 - <http://dx.doi.org/10.3402/ijch.v75.30322>. The second report, comparing data from circumpolar countries, has been approved and is being submitted with anticipated publication in 2017. (Oct 6, 2016 - Completed)
 - Two reports have been prepared. One on a comparison of TB surveillance among Arctic Countries and the other looking at the epidemiology of TB disease. Both

have been reviewed by the respective countries and a final report is being prepared for publication. (Dec 31, 2015 - Target)

- The draft of the Data Retrospective Study (2006-2012), was reviewed by working group in Copenhagen September 16, revisions to be made and approval needed from jurisdictions. Publication 2015. Also draft of the review of surveillance systems by country. (Sep 26, 2014 - Completed)
 - Two projects are underway: 1) The Data Retrospective Project with a goal of collecting data from the last 5 years to produce a retrospective report (in 2014) on the epidemiology of tuberculosis in the circumpolar region, and 2) A review of the TB surveillance systems on the circumpolar region is being created. Abstracts are accepted for presentation at World Congress of Epidemiology, August 2014, Anchorage Alaska. (Apr 9, 2014 - Completed)
 - The deadline on this milestone was changed to 2014 because the project was still underway. (Apr 9, 2014 - Completed)
- **3.7.1.c (Milestone met) Maintain Alaska's compliance with standards of the National Program of Cancer registries and the National Association of Central Cancer Registries; HHS (Lead); Target Date 2015**
 - Completion Statement: Several activities under Surveillance and Research were conducted by the Alaska Native Epidemiology Center funded by CDC (Alaska Native Tumor Registry, Colorectal Cancer Screening (See 3.7.1.1)). (<http://www.iarpccollaborations.org/members/updates/2983>) (Sep 26, 2014 - Completed)
 - **3.7.1.d (Milestone met) Draft and publish a Helicobacter pylori treatment consensus document for high-prevalence. Validate Helicobacter pylori bacterial markers of virulence and host and environmental risk factors associated with peptic ulcer disease and gastric cancer in Arctic; HHS (Lead); Target Date 2015**
 - Completion Statement: The Consensus Statement for treatment of H. pylori infections in Arctic regions with high prevalence has been published. Reference; McMahon, B, et al., Epidemiology and Infection, 2015. DOI 10.1017/S0950268815001181. (Sep 24, 2015 - Completed)
 - The treatment guideline (now expert opinion) paper has been submitted to Lancet in February 2014. The working group continues to develop circumpolar collaborations in the area of helicobacter pylori and gastric cancer, and peptic ulcer disease. There is a potential collaborative AC HHEG project between US, Greenland, Canada, Russia. The Working Group met in Copenhagen on September 17, 2014. (Sep 26, 2014 - Completed)
 - The milestone target year was changed to 2014 because the consensus document was not completed. (Apr 9, 2014 - Completed)

- **3.7.1.e (Milestone met) Increase screening and vaccination for hepatitis B, improved management of chronic hepatitis B, and identification and enhanced screening of risk groups as well as treatment of hepatitis C in the Arctic and design collaborative research programs on virology and pathogenesis of hepatitis B and C in the Arctic; HHS (Lead); Target Date 2018**
 - Completion Statement: These objectives have been met. Prevention and control of viral hepatitis is an ongoing challenge, so these activities will continue. Specific outcomes related to this milestone are included below.
 - 1) Antibody Levels and Protection After Hepatitis B Vaccine: Results of a 30-Year Follow-up Study and Response to a Booster Dose. Bruce MG, Bruden D, Hurlburt D, et al. *J Infect Dis*. 2016 Jul 1;214(1):16-22. doi: 10.1093/infdis/jiv748.
 - 2) Incidence of hepatocellular carcinoma according to hepatitis B virus genotype in Alaska Native people. Ching LK, Gounder PP, Bulkow L, et al. *Liver Int*. 2016 Oct;36(10):1507-15. doi: 10.1111/liv.13129. Epub 2016 Apr 6.
 - 3) Cost-effectiveness analysis of hepatocellular carcinoma screening by combinations of ultrasound and alpha-fetoprotein among Alaska Native people, 1983-2012. Gounder PP, Bulkow LR, Meltzer MI, et al. *Int J Circumpolar Health*. 2016 May 18;75:31115. doi: 10.3402/ijch.v75.31115.
 - 4) A Longitudinal Hepatitis B Vaccine Cohort Demonstrates Long-lasting Hepatitis B Virus (HBV) Cellular Immunity Despite Loss of Antibody Against HBV Surface Antigen. Simons BC, Spradling PR, Bruden DJ, et al. *J Infect Dis*. 2016 Jul 15;214(2):273-80. doi: 10.1093/infdis/jiw142.
 - 5) Hepatocellular Carcinoma Risk in Alaska Native Children and Young Adults with Hepatitis B Virus: Retrospective Cohort Analysis. Gounder PP, Bulkow LR, Snowball M, Negus S, Spradling PR, McMahon BJ. *J Pediatr*. 2016 Aug 30. doi: 10.1016/j.jpeds.2016.08.017.
 - 6) Hepatocellular Carcinoma Risk in Alaska Native Children and Young Adults with Hepatitis B Virus: Retrospective Cohort Analysis. Gounder PP, Bulkow LR, Snowball M, Negus S, Spradling PR, McMahon BJ. *J Pediatr*. 2016 Aug 30;doi: 10.1016/j.jpeds.2016.08.017. (Oct 6, 2016 - Completed)
 - The Working Group met in Oulu, Finland on June 8, 2015. A survey of viral hepatitis in the Arctic was completed to evaluate surveillance for Hepatitis A, B, C and the associated vaccination or screening recommendations. The comparative results are being prepared for publication. (Dec 31, 2015 - Target)
 - The Working Group met in Copenhagen on September 15, 2014. (Sep 26, 2014 - Completed)
 - In April 2014, the team agreed to change the wording of this milestone from "Increase screening and vaccination for hepatitis B in Arctic and the design collaborative research programs on virology and pathogenesis of hepatitis B and C in the Arctic." The new wording is "Increase screening and vaccination for

hepatitis B, improved management of chronic hepatitis B, and identification and enhanced screening of risk groups as well as treatment of hepatitis C in the Arctic and design collaborative research programs on virology and pathogenesis of hepatitis B and C in the Arctic." They also extended the due date to 2018 because the scope of work was much larger. (Apr 9, 2014 - Completed)

- Funding has been extended for another 5 years. Proposals for 2014 to enhance HCV screening for Alaska Natives born 1945-65, and prioritize treatment of HCV (ANTHC Supported). Studies determining the Cellular Immune Correlates of HBV vaccine protection, and a study of HBV immunology in chronic infection are planned. A collaborative study involving Alaska, Canada, Greenland, Russia, Denmark and Japan to examine the sequences of HBV genotypes found in the Arctic. (Apr 9, 2014 - Completed)
- **3.7.1.f (Milestone met) Measure indoor air quality before and after home-based intervention strategies in homes of children with chronic respiratory diseases. Measure severity and frequency of respiratory symptoms in children before and after the interventions; HHS (Lead); Target Date 2016**
 - Completion Statement: Enrollment and data collection have been completed for this study; data analysis is ongoing and results will be disseminated in 2017. A manuscript summarizing the baseline health status of enrolled children and the indoor air quality measures of their homes has been published: "Housing Characteristics and Indoor Air Quality in Households of Alaska Native Children with Chronic Lung Conditions." Indoor Air, DOI: 10.1111/ina.12315 (Oct 6, 2016 - Completed)
 - This project is in the 5th and final year of data collection. The intervention is to identify children who have repeated pneumonia or chronic lung disease problems and conduct simple home renovations aimed at improving indoor air quality. Family education, before and after measurements of pollutants and measuring clinic visits for respiratory disease are all components of the field study. Baseline data are being prepared for publication. Follow-up of participating families continues.
 - Early results have been encouraging and have informed participants of potential sources for increased CO₂ (low ventilation) and high particulates (woodstove practices) and volatile organic compounds (using homes as workshop) Healthy Homes concepts have been shared with families, tribal leaders and environmental engineers and housing funders at several conferences and forums. Collaborations and information sharing have been developed between the Alaska Native Tribal Health Consortium's Division of Environmental Health and Engineering and the Division of Community Health Services, rural tribal health corporation's village housing, Centers for Disease Control and Prevention's Arctic Investigations Program, Environmental Protection Agency, Housing and Urban Development, Alaska Housing and Finance, and other interested agencies. (Sep 26, 2014 - Completed)

- This project is in its 4th year of the study. We have been able to enroll the expected number of patients each year for the first 3 years and we are on track with enrollment for the 4th year. We will be analyzing data after this year. (Sep 26, 2014 - Completed)
- During the first two years of the Healthy Homes study (Dec 2011-Feb 2013), 30 households including 117 children were recruited. Indoor air monitoring, respiratory symptom questionnaires, and chart reviews for respiratory visits were completed before and after household remediation (replacing leaky woodstoves, adding vents, replacing malfunctioning Toyo stoves, adding range exhausts, adding bathroom fans) and education. All activities and data collection were completed. Home remediation and all visits have been completed and we are entering and analyzing data. We have completed home remediation in 16 homes in 2 villages for Year 3 of the Healthy Homes study. We received funding for years 3 and 4 from Housing and Urban Development (HUD). Early results have been encouraging and have informed participants of potential sources for increased CO2 (low ventilation) and high particulates (woodstove practices) and volatile organic compounds (using homes as workshop) Healthy Homes concepts have been shared with families, tribal leaders and environmental engineers and housing funders at several conferences and forums. Collaborations and information sharing have been developed between the Alaska Native Tribal Health Consortium's Division of Environmental Health and Engineering and the Division of Community Health Services, rural tribal health corporation's village housing, Centers for Disease Control and Prevention's Arctic Investigations Program, Environmental Protection Agency, Housing and Urban Development, Alaska Housing and Finance, and other interested agencies. (Apr 9, 2014 - Completed)
- The deadline on this milestone was changed to 2014 because the project was still underway. (Apr 9, 2014 - Completed)
- **3.7.1.g (In progress) Together with the Alaska Department of Environmental Conservation's Village Safe Water Program conduct stakeholder meetings to address scientific, technological, and policy challenges associated with lack of sanitation services in Alaska. Conduct scientific activities to determine health and economic consequences associated with lack of sanitation services in Alaska using epidemiologic studies and economic models; HHS (Lead); Target Date 2016**
 - Completion Statement: An international conference was held Sep 18 – 21, 2016 in Anchorage, Alaska. Titled "Water Innovations for Healthy Arctic Homes (WIHAH)" the meeting brought together engineers, health experts, policy makers and community members to discuss new approaches to address this issue. A final report will be presented to the Arctic Council Sustainable Development Working Group in February, 2017. Details on the conference, including presentations can be found at <http://wihah2016.com/>. A publication summarizing Arctic the health issues associated with lack of access to water and sanitation services in the Arctic

can be found here: “Improving health in the Arctic region through safe and affordable access to household running water and sewer services: an Arctic Council initiative.” Int J Circumpolar Health 2016, 75: 31149 - <http://dx.doi.org/10.3402/ijch.v75.31149> Ongoing activities of the Alaska Rural Water and Sanitation Workgroup can be tracked at: <https://www.arctic.gov/water-san/index.html>. Ongoing activities of the Alaska Water and Sewer Challenge can be found at <http://watersewerchallenge.alaska.gov/steeringmembers.html>. This topic will be included in the 2017-21 IARPC Plan (Oct 6, 2016 - Completed)

- The Sustainable Development Working Group of the Arctic Council has a Water & Sanitation project that will focus on decentralized water and wastewater treatment, recycling, and usage efficiency. A workshop will be convened to facilitate collaboration between researchers, engineers, manufacturers, vendors, and health experts on measures to increase access to, and reduce the operating costs of, in-home running water and sewer in remote communities, attract investment, improve public health, and spur public-private partnerships. The workshop will also serve as a platform to report on a circumpolar health assessment of existing community systems, water quality and quantity, utilization of traditional water sources and related health indicators (Oct 9, 2016 - Complete)
- The deadline on this milestone was changed to 2016 because the project was still underway. (Sep 19, 2016 - Completed)
- The fifth annual Alaska Rural Water and Sanitation Workshop was held on January 30, 2015. This address rural wastewater treatment including current status and research needs. <http://www.arctic.gov/water-san/watersan5.html>. Water and Sanitation needs and progress were featured at the GLACIER Conference in Anchorage on Aug 31, 2015. The presentations can be found here: <https://www.youtube.com/watch?v=73g4v7LQHWE&feature=youtu.be>. This topic has been included as an initiative for the Arctic Council during the US Chairmanship. An International meeting on innovations in water and sanitation services is being planned for Anchorage in late 2016 and a report on the status of water/sewer and related health measures is being developed for presentation at that meeting.
- Working group meetings are ongoing. 4th annual workshop on water/sanitation was held January 30, 2014. Focus on Washeteria design’s Water Security and Sanitation to be included in a special session at the World Congress on Epidemiology, August 2014, Anchorage Alaska. Water Security and Sanitation being considered as a human health theme for the 2015-17 US Arctic Council Chairmanship. (Sep 26, 2014 - Completed)
- The fifth annual workshop on water and sanitation is to be held January 30, 2015 and will focus on Village Sanitation systems. Special session on Water and Sanitation held at the World Congress on Epidemiology August 19, 2015. Proposal submitted to DOS as an Arctic Council Project 2015-15. (Sep 26, 2014 - Completed)
- The deadline on this milestone was changed to 2014 because the project was still underway. (Apr 9, 2014 - Completed)

- **3.7.1.h (Deactivated) In collaboration with other Arctic nations and the State of Alaska, publish a supplement to the Arctic Council’s Field Guide for Oil Spill Response in Arctic Waters, which will contribute understanding and control of the unique hazards that exist to workers responding to an oil spill in the Arctic; HHS (Lead); Target Date 2013**

 - Deactivation Statement: This activity has been stopped due to data quality that is insufficient to support an assessment or recommendations. (Oct 6, 2016 - Completed)
 - Oil spill response activities involve individuals working in dangerous conditions, sometimes exposed to hazardous materials or handling complex equipment. The Arctic Council’s “Field Guide for Oil Spill Response in Arctic Waters,” published in 1998, provides oil spill response guidance to circumpolar countries highlighting the environmental factors in the Arctic region that exacerbate the exposure hazards and include additional operational considerations. Some of these hazards include cold temperature effects on efficiency of equipment and personnel; on-ice operations in winter; seasonal daylight variability; permafrost during land-based staging and cleanup operations; logistical support for remote locations; and safety in cold, remote areas. The guide provides recommendations in responding to oil spill disasters but does not discuss how to mitigate the various hazards to worker safety. Recognizing this gap, the National Institute for Occupational Safety and Health (NIOSH) proposed to assess the status of safety hazards to oil spill response workers in the circumpolar north and collaborated with the Institute of Social and Economic Research (ISER) at the University of Alaska Anchorage (UAA) to conduct a preliminary assessment of data availability, accessibility, and quality of such data. A report has been drafted and is currently going through a review process for publication. (Sep 14, 2015 - Completed)

- **3.7.1.i (Milestone met) Maintain the Alaska Occupational Injury Surveillance System in cooperation with the State of Alaska. Publish 20 years of occupational safety research to document progress and set goals for the next 10 years; HHS (Lead); Target Date 2014**

 - Completion Statement: Twenty years of occupational safety research was published: Lincoln JM, O’Connor MB, Retzer KD, Hill RD, Teske TD, Woodward CC, Lucas DL, Somervell PD, Burton JT, Mode NA, Husberg BJ, Conway GA. Occupational Fatalities in Alaska: Two Decades of Progress, 1990-1999 and 2000-2009. Journal of Safety Research 44 (2013) 105-110 (Sep 19, 2016 - Completed)
 - Ongoing surveillance activity and setting goals for the next 10 years. (Sep 26, 2014 - Completed)

- **3.7.1.j (Milestone met) Continue work with the USCG and Native Community Development Groups to identify ways to encourage the use of personal**

flotation devices and personal locator beacons while commercial and recreational fishing. Continue partnerships with marine-safety educators to provide cold-water survival classes in remote Native villages; HHS (Lead); Target Date 2014

- Completion Statement: The “Live to be Salty” project was launched in May 2014. This project targets commercial fishermen and encourages the use of PFDs. Evaluating the campaign for impact. (Sep 19, 2016 - Completed)
- Evaluation of the impact of the “Live to be Salty” campaign is continuing. The final survey is slated to happen in mid-October with crab fishermen in Dutch Harbor. Results will be reported in 2016. (Sep 14, 2015 - Completed)
- **3.7.1.k (Milestone met) Conduct focus groups with pilots and company owners flying to remote villages to identify strategies to combat pilot fatigue, particularly in the high-risk summer months; HHS (Lead); Target Date 2014**
 - Completion Statement: The focus groups have been completed. The fatigue prevention tool is still working through the clearance process. Evaluation of the toolkit will begin in 2015. (Sep 19, 2016 - Completed)
 - The pilot fatigue prevention training has been evaluated by pilot users, safety director stakeholders and subject matter experts. Edits are currently being made to the training; it is on track to be available to operators this winter when the majority of pilot training takes place. (Sep 14, 2015 - Completed)
 - The fatigue prevention tool is still working through the clearance process. We are planning to start its evaluation after the first of the calendar year. (Sep 26, 2014 - Completed)
 - The deadline on this milestone was changed to 2014 because the project was still underway. (Apr 9, 2014 - Completed)
- **3.7.1.l (Milestone met) Conduct a demonstration project “Determining acceptability of the Fecal Immunochemical Test (FIT) for Colorectal Cancer (CRC) Screening Among Alaska Native People” to begin in 2013; HHS (Lead); Target Date 2014**
 - Completion Statement: The study concluded that the FIT had a significantly higher specificity than the traditional, guaiac-based Fecal Occult Blood Test (gFOBT), especially in Alaska Natives with current H. pylori infection. As such, the FIT represents a strategy for expanding CRC screening among Alaska Native and other populations with elevated prevalence of H. pylori, especially where access to screening endoscopy is limited. (Sep 19, 2016 - Completed)
 - See published manuscript; Redwood DG, Provost E, Asay E, Roberts D, Haverkamp D, Perdue D, Bruce MG, Sacco F, Espey D. Comparison of guaiac-based and immunochemical fecal occult blood tests for colorectal cancer screening in an Alaska Native population with high prevalence of Helicobacter pylori infection. Prev Chronic Disease 2014;11:E56. Available on the website at:

<http://www.iarpccollaborations.org/members/documents/3183>. (Sep 24, 2015 - Completed)

- In 2013, FIT was incorporated into the revised Alaska Native Medical Center Colorectal Cancer Screening & Surveillance Guidelines. Prior to this guideline update, endoscopy was the only screening method being used for Alaska Natives, due to a high prevalence of Helicobacter pylori infection in the stomach, which is thought to be associated with false positive gFOBT results. (Sep 26, 2014 - Completed)
- Building on results from the FIT study, as well as the updated CRC screening guidelines at the Alaska Native Medical Center, CDC is currently supporting implementation of a pilot project, “Determining acceptability of the Fecal Immunochemical Test (FIT) for Colorectal Cancer (CRC) Screening among Alaska Native People”, which seeks to support implementation of FIT in Alaska Native communities. The purpose of the project is to evaluate the acceptability (to providers and patients) of the FIT as a CRC screening option in the Alaska Native population. The main objective of the project is to introduce FIT in at least two rural/remote sites in Alaska and determine the feasibility and acceptability of the test among Alaska Native people and Alaska Native Health System providers. The inclusion of the FIT as a colorectal cancer screening option in Alaska Native communities, especially those in rural/remote areas, will lead to an increase in screening and will contribute to a reduction in colorectal cancer incidence and mortality. (Sep 26, 2014 - Completed)

3.7.2 Continue interagency collaboration to monitor the impacts of climate change and environmental contaminants on human health

- **3.7.2.a (Milestone met) Conduct community health assessments and initiate training and deployment of monitoring technology. Develop a web-based monitoring network and village adaptation strategies, and establish the monitoring database. Conduct statistical analysis of laboratory specimens and share data with agencies and jurisdictions. Provide feedback to tribal leaders and tribes and tribal organizations. Continue planning with interested agencies to develop support for ongoing monitoring and extension to interested communities in Alaska. Disseminate program results to other circumpolar communities and affected communities in the lower 48 states (IHS; EPA, DOI FY2015); HHS (Lead), DOI, EPA; Target Date 2016**
 - Completion Statement: The community-based monitoring systems are in operation and are providing data that is being collected and used at the local level. For more details on the RAMP program, described below, go to <http://anthc.org/what-we-do/community-environment-and-health/climate-change-food-security/>. For more details on the Alaska Local Environmental Observer program, go to www.leonetnetwork.org These activities will be continued and tracked in the 2017 – 2021 IARPC plan. (Oct 6, 2016 - Completed)
 - Update from Dr. Jim Berner, Project lead at the Alaska Native Tribal Health Consortium; The RAMP is a program funded by a 3-year grant from the UA EPA

to the Alaska Native Tribal Health Consortium, entering the second year of funding. The RAMP will establish a community-based, resident-operated environmental monitoring network in the Alaska Native communities in the Bering Strait region. The program is designed to enable community hunters to sample the blood of subsistence-killed land and sea mammals, using strips of filter paper. These samples will be tested for the presence of antibodies to zoonotic pathogens, mercury, and organic contaminants. The methodology for determination of antibodies, and mercury, is developed, and cooperating academic laboratories are now testing specimens collected this season. The methodology for organic compound analysis using filter paper samples is in development, and will begin when the process is fully developed, and tested, and QA/QC protocols are in place. In addition, the RAMP will gather and test marine bivalves for contaminants, mercury, saxitoxin (the toxin responsible for paralytic shellfish poisoning) and domoic acid (the toxin responsible for amnesic shellfish poisoning). Village mosquitoes and their larvae, will be tested by PCR for *Franciscella tularensis* bacteria, the agent of tularemia. Community source water will be tested for total mercury, methyl mercury, N, P, oxygen, pH, and dissolved organic carbon, as well as two cyanobacterial toxins, microcystin and nodularin. These data will be sampled each of the grant years, and data shared with the participating communities, federal, state and tribal agencies, and health agencies. The communities will be able to develop adaptation strategies to reduce exposure, track trends in established threats, and detect the emergence of new threats. The techniques will be shared with all circumpolar populations that wish to establish environmental monitoring programs aimed at rural food and water security. The data on seroprevalence of zoonotic pathogen antibodies, contaminants and metals of the key migratory subsistence species can, when combined over years of observation of climate, atmospheric and oceanographic data, provide the basis of useful models of climate influence on the variables being monitored, and allow regional and circumpolar adaptation and perhaps mitigation strategies to be developed. (Oct 6, 2015 - Completed)

- Published reports in ten communities and the reports are available on the website for the Center for Climate and Health. Ten others have been assessed and will be included shortly in regional reports about the Bering Strait region and Bristol Bay, Upper Nushagak River region. The LEO Network provides community based observations of environmental change. There are now over 150 communities participating across Alaska and in Western Canada. (Sep 26, 2014 - Completed)
- Partnered with CDC to develop a One Health Group in Alaska (see 3.2.7.e below). The group includes environmental, wildlife and public health officials who meet quarterly to review recent events, perform event specific analysis and consult on individual and collaborative actions to address priority topics. Feedback is provided at regional conferences such as the LEO Network Climate Change Track that will occur later this month in Anchorage at the 20th annual Alaska Conference on Tribal Environmental Management. Weekly feedback is also provided through the Climate and Health E-News. This publication reaches over 1500 subscribers around the circumpolar north. An archive is available at the

Alaska Medical Library (<http://www.consortiumlibrary.org/aml/>). (Sep 26, 2014 - Completed)

- Currently fifteen communities have been visited in Alaska as part of the Community Climate Change Health Assessment program. Seven reports have been published and are available on the ANTHC Center for Climate and Health website. These include five assessments in the NWA region (IHS and EPA funded) and three works in Bristol Bay (WALCC Funded), three in Bering Straits (WALCC Funded) and four in North Slope (NSB funded). (Apr 9, 2014 - Completed)
- **3.7.2.b (Milestone met) Develop, deploy, and assess a surveillance and response Toolkit for Alaska to promote community based adaptation planning for climate change. Deliverables will include training protocols, a web portal, a surveillance dataset organized by region, adaptation and mitigation recommendations, and reports/manuscripts for peer-reviewed publication; HHS (Lead); Target Date 2014**
 - Completion Statement: This project was conducted by the Institute for Circumpolar Health Research at U of Alaska, Anchorage. They report: The project successfully developed, deployed, and assessed results from a surveillance and response Toolkit for Alaska to promote community based adaptation planning for climate change. The project deliverables included training protocols, a web portal, a surveillance dataset organized by region, adaptation and mitigation recommendations, and reports/manuscripts for peer-reviewed publication (in review). The study team is now conducting formative research to refine a community-based surveillance system of injuries from travel and transportation during unusual environmental conditions potentially associated with climate change. A highlights report can be found here: http://www.uaa.alaska.edu/instituteforcircumpolarhealthstudies/publications/reports/climate_change.cfm. (Oct 5, 2015 - Completed)
 - Received additional funding from CDC NCEH to continue sentinel surveillance in an expanded list of communities across the state. We are currently receiving approximately 90 structured surveys monthly from residents in 14 communities. We are also providing risk communications via email and Facebook to our community participants daily, and a newsletter quarterly, warning them of dangerous conditions or exposures. We began our second round of surveillance data collection in the spring, and hope to complete data collection, and start analysis in March of 2014. Publication of results in Circumpolar Health: Int J Circumpolar Health 2013, 72: 21405 - <http://dx.doi.org/10.3402/ijch.v72i0.21405>. (Sep 26, 2014 - Completed)
 - There will be a colloquium at which findings will be presented and next steps discussed in December. (Sep 26, 2014 - Completed)
 - The milestone target year was changed to 2014 because the project was still ongoing. (Apr 9, 2014 - Completed)

- **3.7.2.c (Milestone met) Recruit a cohort of 200 Alaska Native women for collection of blood samples, patient interview, and medical-chart information. Collect and chemically analyze salmon tissue samples; HHS (Lead); Target Date 2015**
 - Completion Statement: Update from the Project Lead, Dr. Jim Berner at the Alaska Native Tribal Health Consortium. The MOM Study is the US maternal monitoring program participating in the Arctic Council AMAP Human Health Assessment Group (HHAG) longest monitoring program. The US Arctic maternal population participating, since 1998, is the Yupik maternal population of the Yukon-Kuskokwim River Delta, in western Alaska, on the Bering Sea coast. The program has samples three cohorts of Yupik women, now totaling almost 500 women and their children. Participants have had the standard panel of AMAP HHAG analytes analyzed, as well as key micronutrients. The Pacific salmon of the Yukon and Kuskokwim Rivers has also been sampled with each cohort, so contaminant trends in the seawater environment of the North Pacific and Bering Sea could be followed. The data has been published in past HHAG Arctic Human Health Assessments, and the most recent results will be in the new Assessment to be published in 2015. Funding has been provided by the US EPA, and the Alaska Native Tribal Health Consortium, as well as in the form of laboratory services by the US Center for Disease Control and Prevention, in Anchorage, and Atlanta. (Sep 24, 2015 - Completed)
 - The labor-intensive monitoring program and time-intensive methodology utilized by the HHAG maternal biomonitoring effort over the last 20 years is not sustainable, but the data is critical to international efforts at pollution control, and health risk exposure information for Arctic residents. Recognizing this disparity between needs and resources, the HHAG will undertake development of a modified monitoring regime, that takes advantage of technology developed since the biomonitoring program was initiated in 1995. Ideally, the new regime would be far less resource and labor-intensive, and give much the same information. This would simplify efforts to generate support in federal, regional and local agencies to continue this critical monitoring effort.
 - Recruitment was completed in November 2013. The salmon tissue analyses have been received by ANTHC, and comparisons with the 2001 salmon tissue samples, are in progress. The organohalogen results have not yet been received, and final analysis of patient records and organohalogens and heavy metals will start when they are received. (Dec 17, 2014 - Completed)
 - EPA has funded a project on environmental monitoring and food security in Alaska. (Dec 17, 2014 - Completed)
 - The MOM Study cohort, which turned out to be 160 mothers and infants. Health records reviews are complete, salmon tissue analyses have been received, and maternal and infant metals have been received. Final analysis will be completed when the organohalogen results are received, later this fall. (Sep 26, 2014 - Completed)

- 3.7.2.d (In progress) Conduct surveillance evaluations and sero-prevalence studies on humans and wildlife for potentially climate-sensitive infectious diseases such as those caused by brucella, trichinella, echinococcus, toxoplasma, francisella, giardia, and cryptosporidium species; HHS (Lead); Target Date 2016**

 - Continuation Statement: A report suitable for publication is in preparation and is expected to be completed in 2017. (Oct 6, 2016 - Completed)
 - The milestone target date has been changed from 2014 to 2016 because the work is ongoing. (Sep 19, 2016 - Completed)
 - Additional testing on Giardia antibodies has been added. Analysis is ongoing and a report is being prepared for the Tribal partners, then for publication (Sep 24, 2015 - Completed)
 - Seroprevalence analysis on pilot study is ongoing. (Sep 26, 2014 - Completed)
 - Serological testing has been completed, and analysis is underway. The Circumpolar working group was established and a paper was published; Climate change and infectious diseases in the Arctic: establishment of a circumpolar working group. Citation: Int J Circumpolar Health 2014, 73: 25163 - <http://dx.doi.org/10.3402/ijch.v73.25163>. (Sep 26, 2014 - Completed)
 - The milestone target year was changed to 2014 because the project was still ongoing. (Apr 9, 2014 - Completed)
 - A manuscript describing zoonotic infections that occur in humans and animals in Alaska was published Hueffer K, Parkinson AJ, Gerlach R, and Berner J. Zoonotic infectious in Alaska: Disease prevalence, potential impact of climate change and recommended actions for earlier disease detection, research, prevention and control. Int J Circumpolar Health 2013 72: 19562 <http://dx.doi.org/10.3402/ijch.v72i0.19562>. (Apr 9, 2014 - Completed)

- 3.7.2.e (Milestone met) Implement a NOAA-CDC memorandum of agreement for environmental and public health impacts providing exchange of scientific expertise and resources in the areas of climate, weather, water, and environmental, oceanographic, and atmospheric health as it relates to public health; HHS (Lead), DOI, EPA; Target Date 2015**

 - Completion Statement: This ongoing Alaska One Health working group meets regularly and posts its activities through the Alaska Native Tribal Health Consortium website: <http://www.anthc.org/chs/ces/climate/aohg.cfm>. (Sep 24, 2015 - Completed)
 - Group initiated May 14, 2013. Representation from ANTHC, CDC, NOAA, USGS, F&W, SOE, ADF&G, UAF, EPA. Alaska Working Group initiated May meets quarterly, comprised of representatives from: Tribal (ANTHC); Federal (CDC, NOAA, US Fish and Wildlife, US Geological Survey); State of Alaska, (Public Health, Veterinary, Fish and Game); University. Share information of

activities related to impact of environmental change on human and wildlife health. Provide a forum for identifying areas of common interest and collaboration Determine linkages between weather climate and infectious diseases, biotoxin and pollutant prevalence and distribution. Develop collaborative work plans. Monitor hot topics: H7N9, Salmon Fish Health, Rabies, Tickborne illness, Q fever, Cryptosporidium, Mercury, Fukushima Featured topics: Coxiella, rabies Linkage with Arctic Communities Meeting with ICC Amy Holman NOAA) (Apr 9, 2014 - Completed)

3.7.3 Continue to support investigator-initiated research in major health-priority areas

- **3.7.3.a (In progress) Continue to support investigator-initiated research in major health priority areas such as mental health including substance abuse and suicide, obesity, diabetes, and cancer; HHS (Lead); Target Date 2017**
 - Continuation Statement: The RISING SUN project has held two of three planned workshops. The third will take place in early 2017. A final report to the Arctic Council is expected to be complete for the May 2017 meeting. Details on this project can be found at <https://www.nimh.nih.gov/about/organization/gmh/risingsun/index.shtml>. (Oct 6, 2016 - Completed)
 - In Fall 2015, as part of its chairmanship of the Arctic Council, the U.S. launched the RISING SUN initiative. RISING SUN is designed to create a common way to evaluate suicide prevention interventions across the Arctic. The use of common assessment measures – developed in collaboration with indigenous peoples’ organizations, community leaders, and mental health experts – will facilitate data sharing, evaluation, and interpretation of interventions across service systems in the Arctic region. RISING SUN is a joint effort of the National Institute of Mental Health, in collaboration with the Substance Abuse and Mental Health Services Administration, the Centers for Disease Control and Prevention, the Office of Global Affairs in the Department of Health and Human Services, the Department of State, and international co-sponsors. For more information, e-mail: RISING-SUN@mail.nih.gov (Oct 1, 2015 - Completed)
- **3.7.3.b (Milestone met) Maintain an inventory of the NIH-funded projects in behavioral and mental health (including suicide, substance dependence and abuse), obesity, diabetes and cancer. Update the inventory on an annual basis; HHS (Lead); Target Date 2014**
 - Completion Statement: NIH-funded research in the Arctic region can be found on this website for Fiscal Years 2011 - 2014: http://report.nih.gov/categorical_spending.aspx. The specifics of the Arctic research projects for 2014 can be found here: http://report.nih.gov/categorical_spending_project_listing.aspx?FY=2014&ARRA=N&DCat=Arctic. These sites are updated regularly by NIH. (Sep 19, 2016 - Completed)

- Report published “Risk factors for suicide at the community-level Alaska 2003-2011”. http://www.epi.alaska.gov/bulletins/docs/rr2013_01.pdf. (Apr 9, 2014 - Completed)
- **3.7.3.c (Deactivated) HHIT will examine the inventory on an annual basis and determine any major gaps in research and make recommendations/explore potential opportunities to limit these gaps; HHS (Lead); Target Date 2014**
 - Deactivation Statement: This milestone was not in the original plan but was added by the team in 2013. After further review by the team, it was deactivated. (Oct 6, 2015 - Completed)
- **3.7.3.d (Milestone met) Develop collaborations with other Arctic Nations focused on supporting, expanding, or seeding biomedical and behavioral research projects relevant to human health in the Arctic; HHS (Lead); Target Date 2015**
 - Completion Statement: During the US Chairmanship of the Arctic Council, three new health initiatives have been started. These are being tracked through the Arctic Human Health Experts Group AHHEG. (www.sdwg.org) The projects are all joint efforts between US Government and other Arctic Nations or Indigenous Organizations (Permanent Participants to Arctic Council). Activities will be ongoing throughout the 2015-2017 US chairmanship, with outcomes reported to the Arctic Council Sustainable Development Working Group.
 - The projects include: 1) Reducing the Incidence of Suicide in Indigenous Groups – Strengths United through Networks (RISING-SUN) Lead Agency: Pamela Collins (US, NIMH). AHHEG POC: Cody Chip (AIA), Solfrid Johansen (NO), Christina Viskum-Larsen (DK). 2) Improving Health through Safe and Affordable Access to Household Running Water and Sewer. Point of Contact: Tom Hennessy (US CDC) 3) Arctic One Health Initiative Lead: Bruce Ruscio, Josh Glasser (US DOS), Tom Hennessy (US CDC) (Sep 25, 2015 - Completed)

3.7.4 Continue to engage indigenous communities and tribal groups in research activities and projects in the Arctic

- **3.7.4.a (Milestone met) NIH and CDC supports research through CANHR where researchers collaborate with tribal and local communities on a number research topics, including nutrition, alcohol consumption and abuse prevention, drug abuse and prevention, and others; HHS (Lead); Target Date 2012**
 - Completion Statement: Projects Include: 1) Negotiating Pathways to Adulthood: Social Change and Indigenous Culture in Five Circumpolar Communities. 2) Elluam Tungiinun; 3) The Qungasvik Projects; 4) Obesity studies; 5) The Qungasvik Projects; 6) Exploring how Alaska Native cultural values are interconnected with cancer. (Sep 26, 2014 - Completed)

- **3.7.4.b (Milestone met) Alaska Native Health Regional Conference in (2014); HHS (Lead); Target Date 2014**
 - Completion Statement: The fourth Alaska Native Health Regional Conference was held in March 2014. Brought together people from the native communities interested in health to talk about health research initiatives. The theme was support of health research in Alaska. Presentations are available at (<https://www.signup4.net/public/ap.aspx?EID=20133021E&OID=50%20>). . (Dec 17, 2014 - Completed)

Team Lead: Tom Hennessy, CDC

Agencies: DOC, DOI, EPA, HHS, NASA, NSF, OSTP, USARC