University of Alaska S&T Arctic Research Collaborative ...A Developing Construct

Presented to

Department of Defense Arctic S&T Conference,

U.S. Army Cold Regions Engineering and Research Laboratory,

Hanover N.H.

17 May 2018

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University of Alaska S&T Arctic Research Collaborative

Start with ***Why…***

#1: The US is lagging in developing Arctic capabilities.

#2: The US Federal System of sponsoring research to generate innovation is cumbersome, and certainly less agile than our adversaries.

…and may or may not generate the research actually sought

#3: A trusted research relationship that taps a capable and credentialed network…where emerging Arctic relevant research needs can quickly generate task orders

…is likely faster and more likely to generate specific research sought by the user

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University of Alaska S&T Arctic Research Collaborative

- *First…*a review and update of the current research centers and entities associated with the University of Alaska
  - Principally focused on University of Alaska Anchorage and University of Alaska Fairbanks

- *Followed by…* a brief discussion of the Research Collaborative Construct.
  - A developing construct, intending to support "unity of effort" in research collaboration for DoD, leveraging a remarkable amount of Arctic research expertise contained or connected with the University of Alaska

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Research capabilities potentially available within the collaborative

- Research to advance Arctic Maritime Domain Awareness (MDA).
- Marine related robotics and unmanned (aerial, surface and under-ice vehicles
  - (suitable for Arctic operating regimes).
- Maritime afloat research.
- Arctic/polar space launch.
- Arctic Communications.
- Arctic physical environment monitoring technologies.
- Cultural Domain Awareness and Cultural Intelligence Research.
- Arctic geophysical and maritime focused engineering.
- Environmental Prediction and Security Research.
- Research support to DoD and participating departments in policy assessments & strategy development.
- Access and analysis of a wealth of Arctic Data via the emerging "Arctic GeoData Cooperative."
- "On demand" Research support for DoD and participating U.S. Federal agencies.

Today's brief is intended to gage interest for advancing and formalizing the Collaborative

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University of Alaska S&T Arctic Research Collaborative

A Panel Overview of associated capabilities:

- Dr Hajo Eicken, International Arctic Research Center, UAF
- Dr Bob McCoy, Geophysical Institute, UAF
- Dr Cathy Cahill, Alaska Center for Unmanned Aircraft Systems (UAS) Integration, UAF
- Dr George Roe, Alaska Center for Energy & Power, UAF
- Dr Brad Moran, College of Fisheries and Ocean Science, UAF
- Dr Aaron Dotson, College of Engineering, UAA
- Dr Doug Causey, College of Arts & Sciences, UAA, and ADAC, UA
- Maj Gen (Ret) Church Kee, Arctic Domain Awareness Center, UA

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Brief overview of DoD-relevant work at the International Arctic Research Center (IARC), University of Alaska Fairbanks

Hajo Eicken
International Arctic Research Center
University of Alaska Fairbanks
Fairbanks, AK
e-mail: heicken@alaska.edu

www.iarc.uaf.edu

International Arctic Research Center (IARC), University of Alaska Fairbanks

- Roughly 90 Scientists, analysts, students, professional staff that span the physical, biological, and social sciences (ca. 1/4 w/ PhD)
- Roughly 150 research projects
- Major research units within IARC:
  - Alaska Climate Science Center
  - Alaska Center for Climate Assessment and Policy
  - Scenarios Network for Alaska + Arctic Planning
  - Cooperative Institute for Alaska Research
  - Alaska Fire Science Consortium
  - Center for Arctic Policy Studies

Key IARC program elements & activities

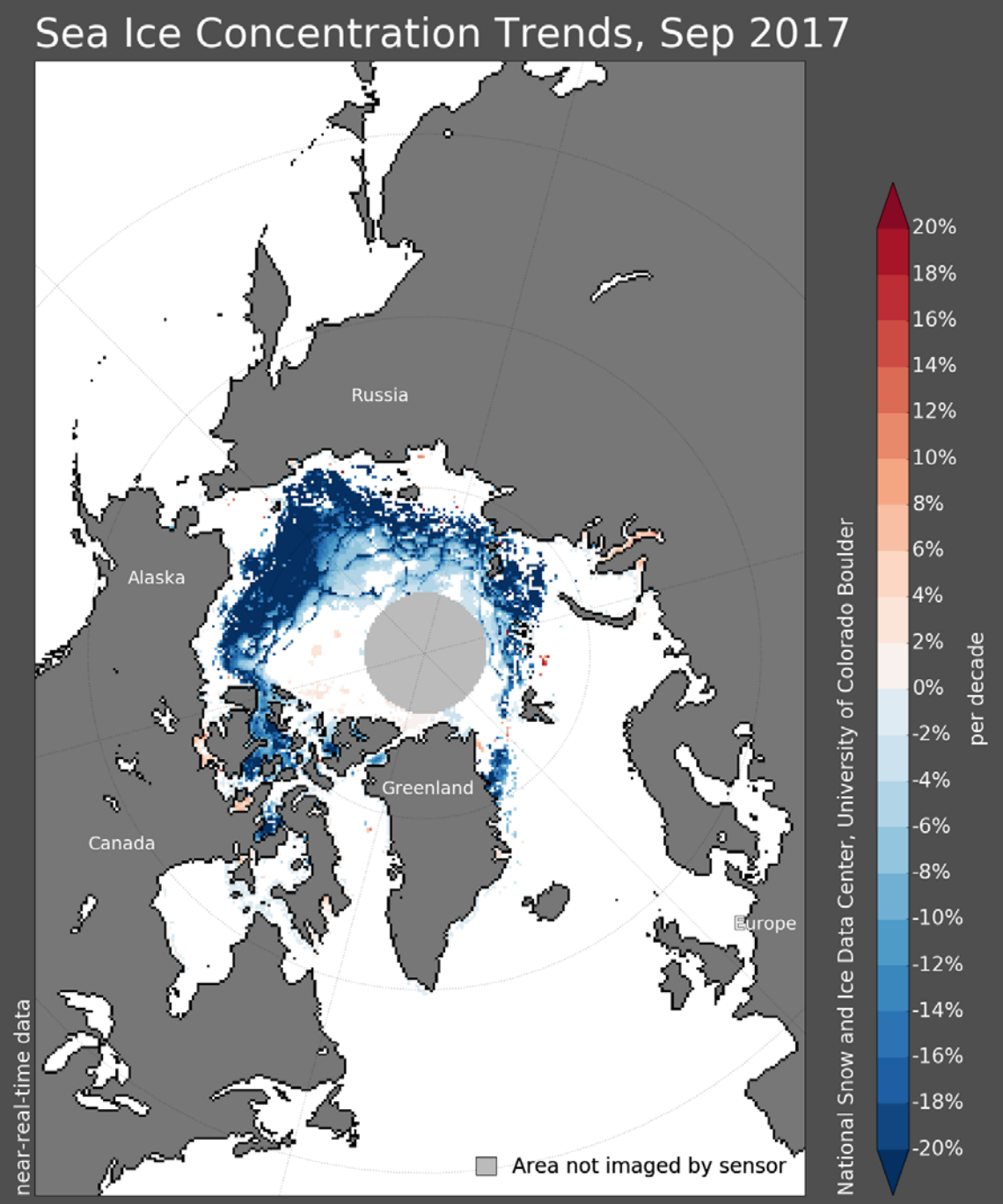
(i) Analysis, synthesis & provision of *Arctic climate information*, incl. Arctic Ocean hydrographic information for scientists, stakeholders & public;

(ii) Support & coordination of *Arctic system modeling and environmental prediction* – providing a nexus for process parameterization, model validation & assessment;

(iii) Service as a “gateway” or *Arctic Climate Science Coordination Center* for the Arctic research community through conferences, secretariat functions, & workshops.

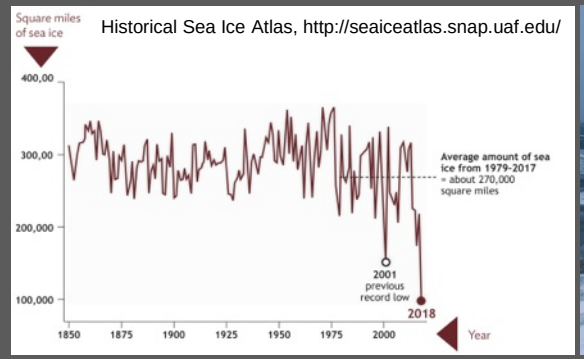
Transformative Arctic Ocean change

- **Changes and trends in Arctic sea ice extent**
- Major changes in the ice-covered Eurasian Basin: NABOS
- Long-term changes in length of operations season
- IARC Experimental Arctic Prediction Initiative
- Conclusions



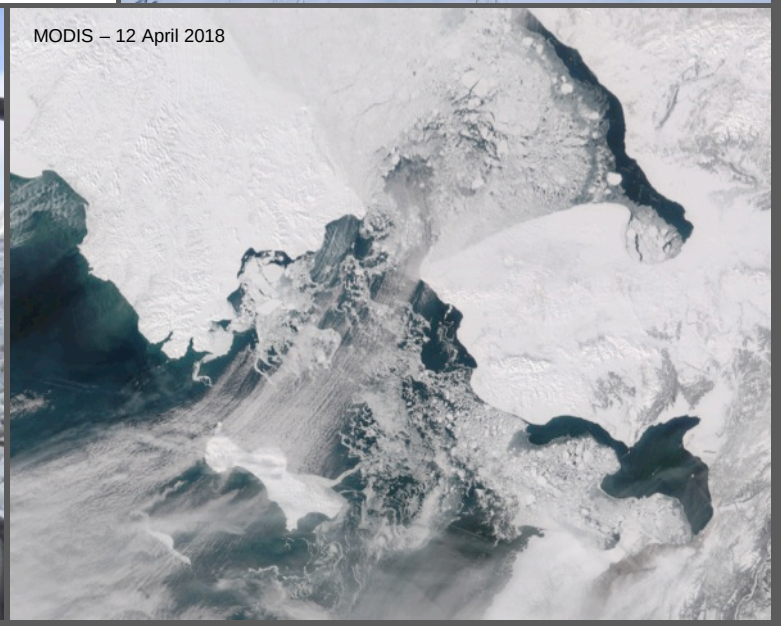
- Large swath of reduced summer ice concentration in Pacific Arctic sector
- Impacts on operating environment
- Links to land surface warming & loss of permafrost

IARC collaborations in the Bering & Chukchi Sea to improve ice information products & forecasts



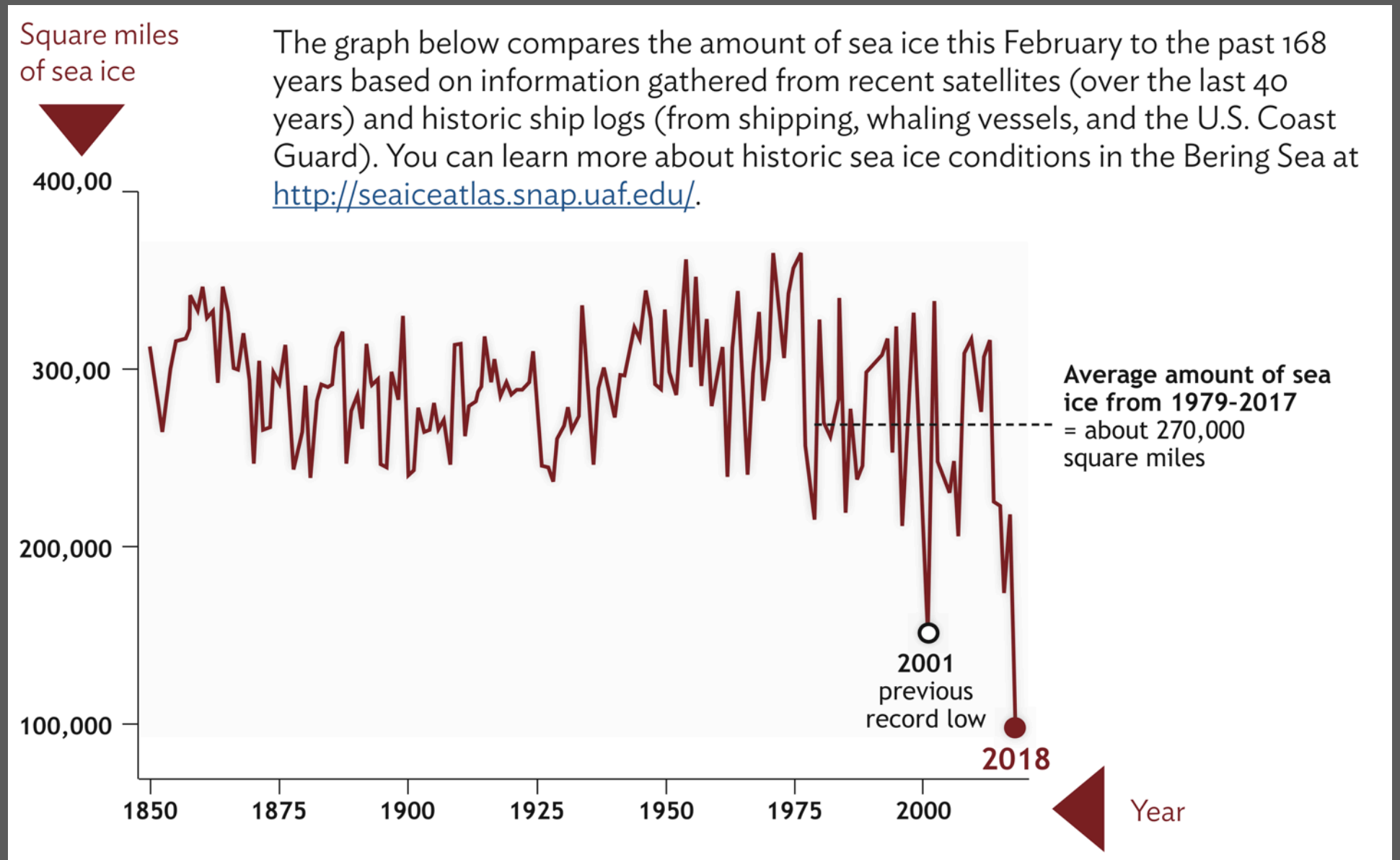
Historical Sea Ice Atlas, http://seaiceatlas.snap.uaf.edu/

© Henry Soolook

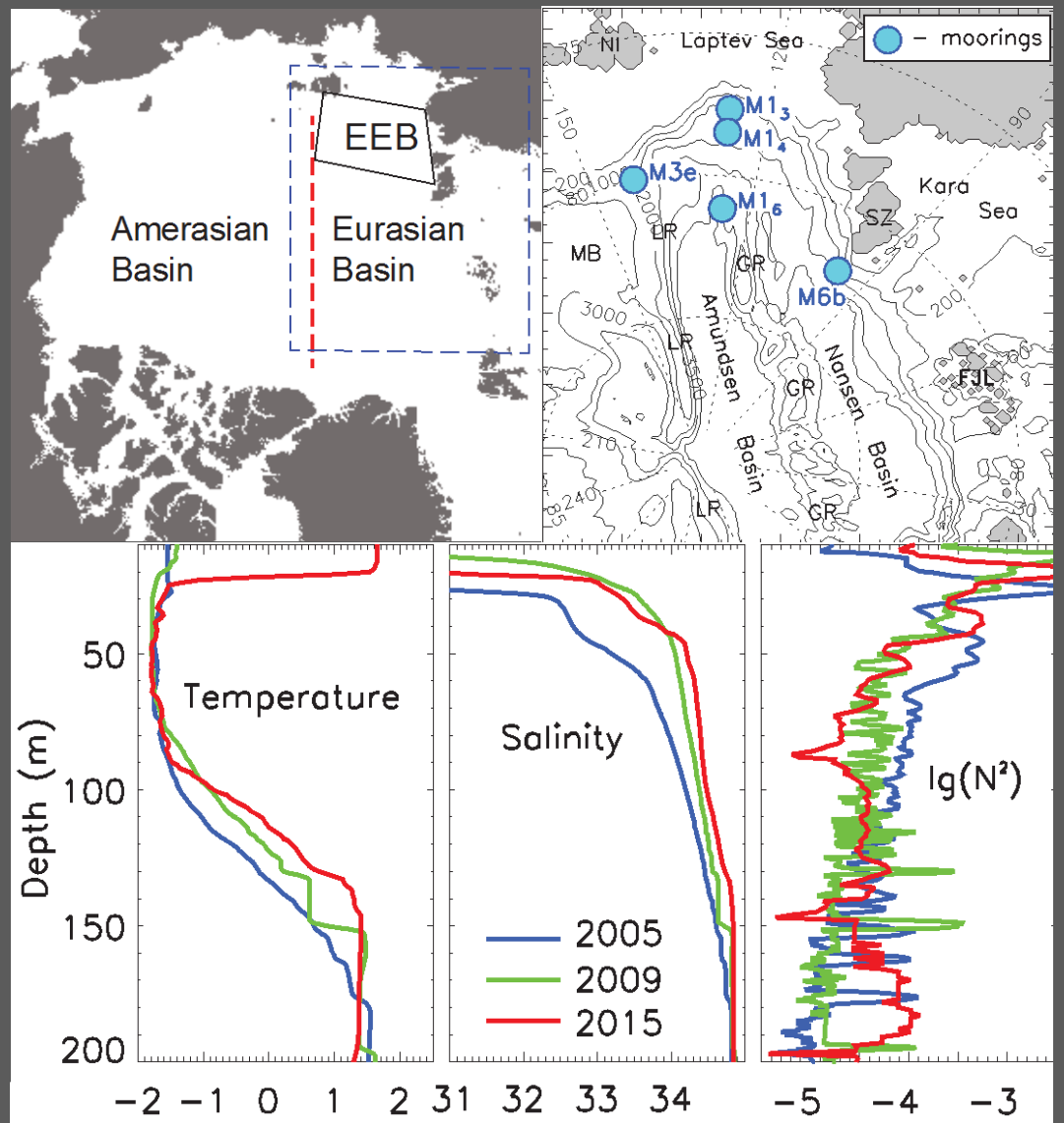

MODIS – 12 April 2018

- Regional sea ice outlook (SIWO)
- Sea Ice Prediction Network (SIPN)
- Community-based ice observations (A-OK)
- Historical ice atlas
- Downscaled reanalysis data & climate model output
- Arctic storms analysis

Historical sea ice atlas:
Record low Bering Sea winter ice 2017/18



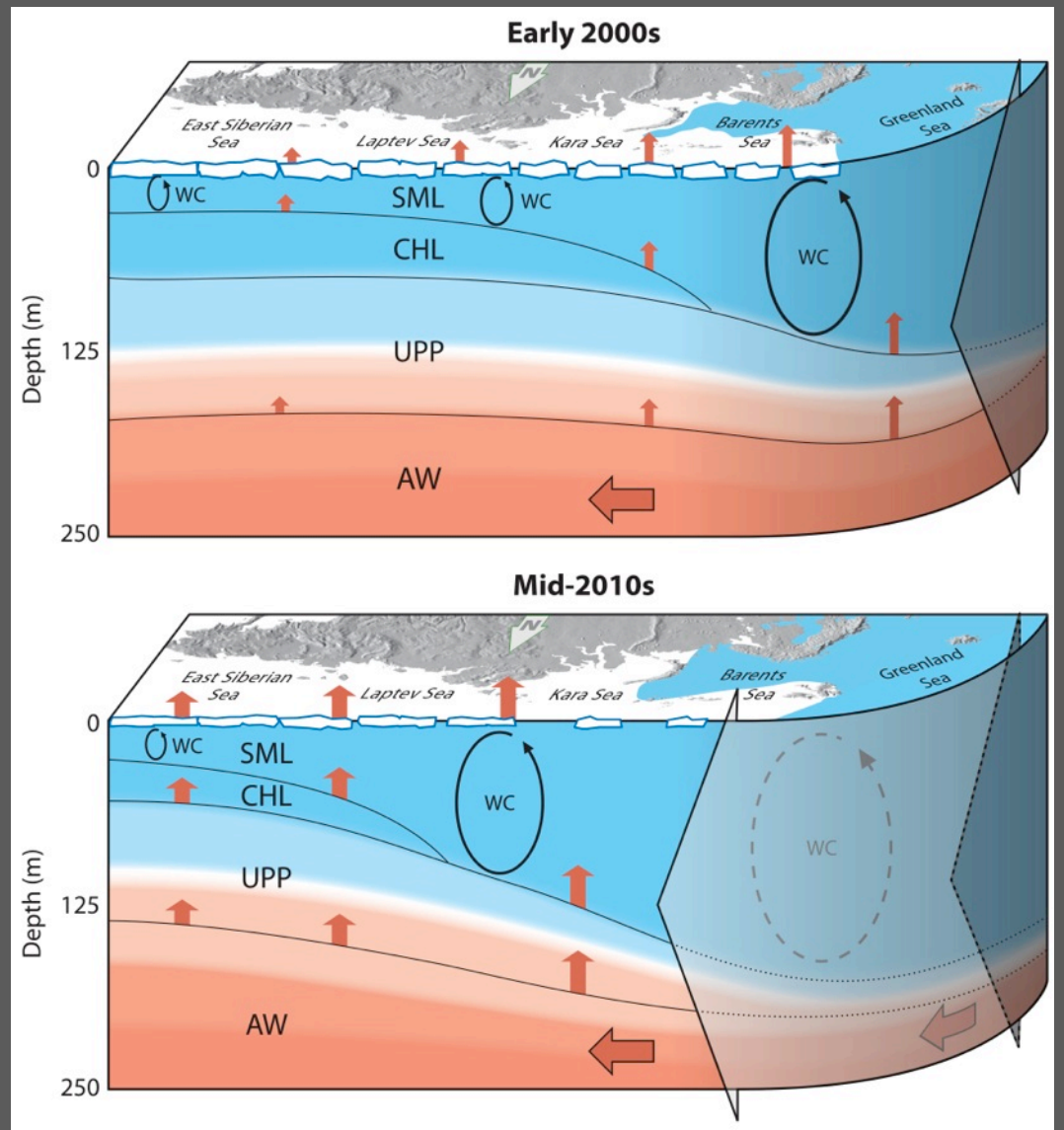
Nansen-Amundsen Basin Observing System (NABOS)



- Igor Polyakov (IARC) lead in collaboration with numerous Arctic & non-Arctic research centers
- Sustained observations (2002-today) to capture transformative Arctic Ocean change in the Eurasian Basin
- Oceanic drivers of Arctic sea ice loss & shoaling of Atlantic water layer

Polyakov et al. (2017) *Science*, 356:285ff.

Nansen-Amundsen Basin Observing System (NABOS)



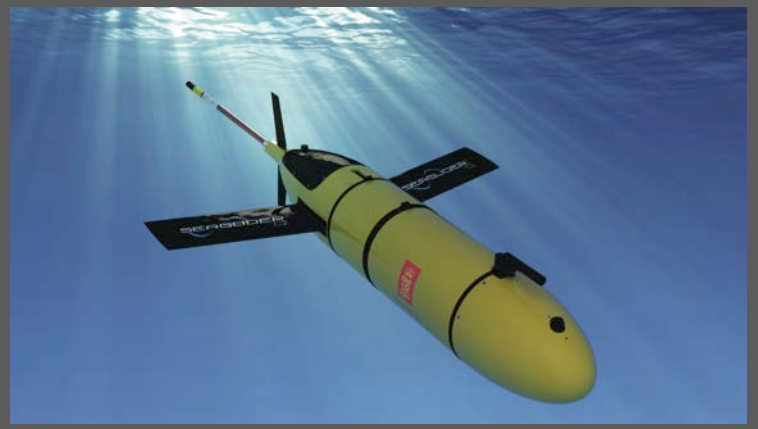
- "Atlantification" of Eurasian Basin
- Winter convection (WC) penetrates through Cold Halocline Layer (CHL) releasing Atlantic Water (AW) heat
- Heat flux increase by up to one order of magnitude → ice loss
- Implications for Arctic operations

Polyakov et al. (2017) *Science*, 356:285ff.

IARC-Kongsberg Partnership to develop Carbon Dioxide Seaglider

- **Changes and trends in marine carbon system**
- In response to ONR's call to "Improve Technology Readiness Levels (TRL) of Emerging Autonomous In-situ Ocean Sensors"

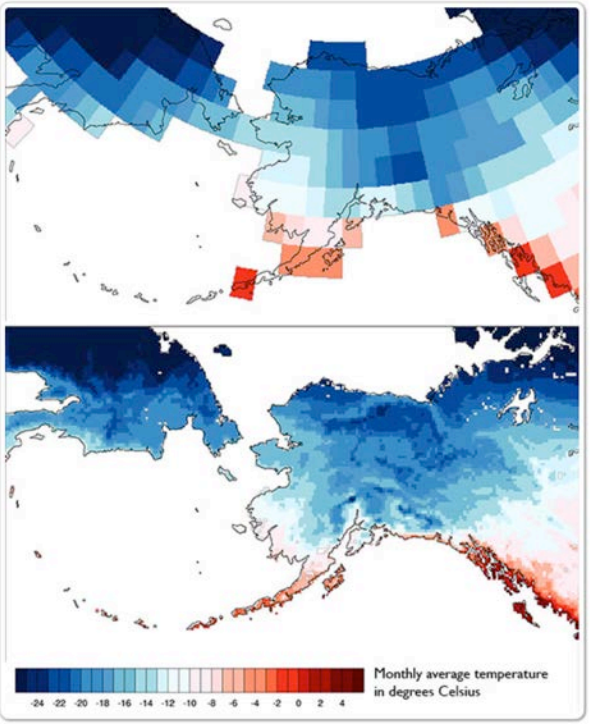
- Autonomous high-resolution pCO_2 sampling throughout water column and across large range of spatial and temporal scale



Environmental prediction at IARC

- Several IARC units involved – Alaska Center for Climate Assessment & Policy, Climate Science Center, Scenarios Network for Alaska + Arctic Planning
- Research to Operations: Partnering with NOAA
- Goal: Comprehensive experimental prediction service to test models, guide observations, improve communication
- Focus beyond current NOAA product suite: snow cover, sea ice, freeze-up/break-up timing, vegetative metrics & wildfire
- Prototype activities:
  - ACCAP Analog Forecasts
  - North Slope industry ice road support
  - USN Arctic Submarine Lab ICEX support
  - Sea Ice Prediction Network (SIPN)

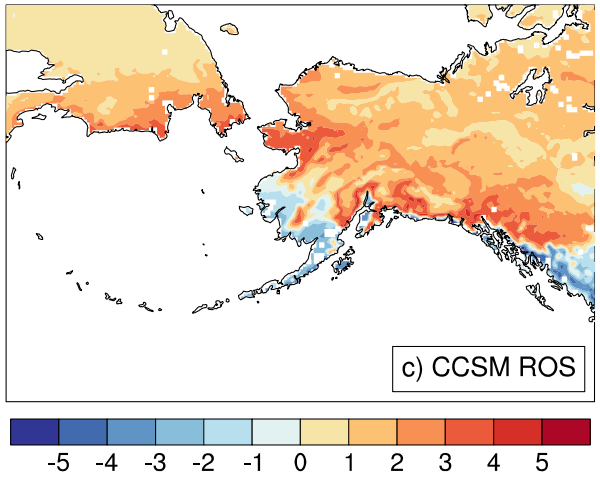
Dynamically downscale to include more local detail



https://www.snap.uaf.edu/news/climate-adaptation-model

- GCM/reanalysis data are often too coarse for local planning: downscaling helps provide the scale of information needed
- WRF downscaling for Alaska: 20km daily temperature, precipitation, humidity, winds, and radiative and turbulent fluxes (Bieniek et al. 2016, *JAMC*) suitable for evaluation of extremes and complex processes

Downscaled CCSM4 RCP8.5 Nov-Mar rain-on-snow days/decade 2006-2100 change



Completed Downscaled Products:

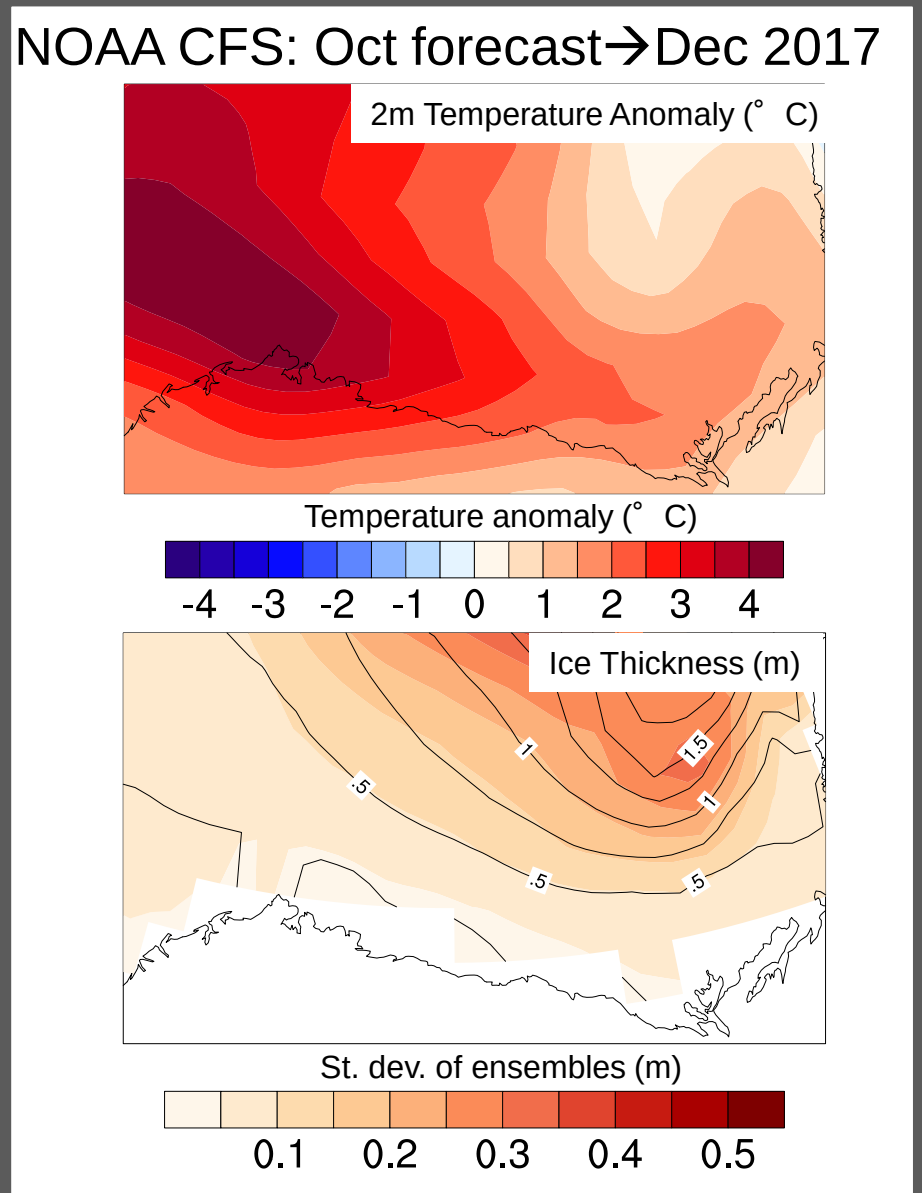
- ERA-Interim (observations): 1979-2015
- GFDL-CM3 and NCAR-CCSM4 (CMIP5 future scenario) RCP8.5: 1970-2100

Contact SNAP or P Bieniek for more info!

- Example uses:
  - Rain-on-snow/icing events (Bieniek et al. 2017, in prep)
  - Climate change attribution of fire danger (Partain et al. 2016, *BAMS*)
  - Temperature/Precipitation extremes (Lader et al. 2017, *JAMC*)
  - Glacier modeling (Kienholz et al. 2017, *Frontiers in Earth Science*)

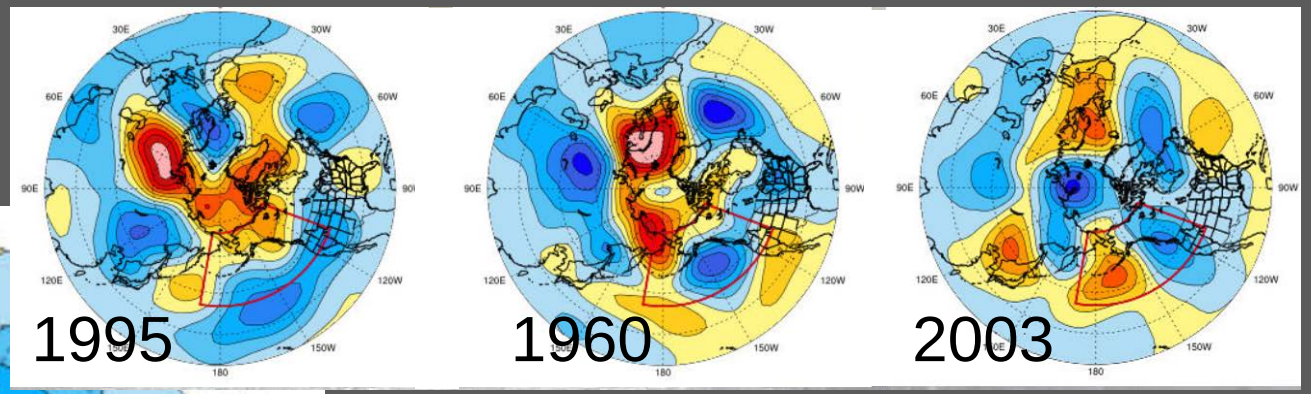
National Multimodel Ensemble (NMME) seasonal modeling & forecast system

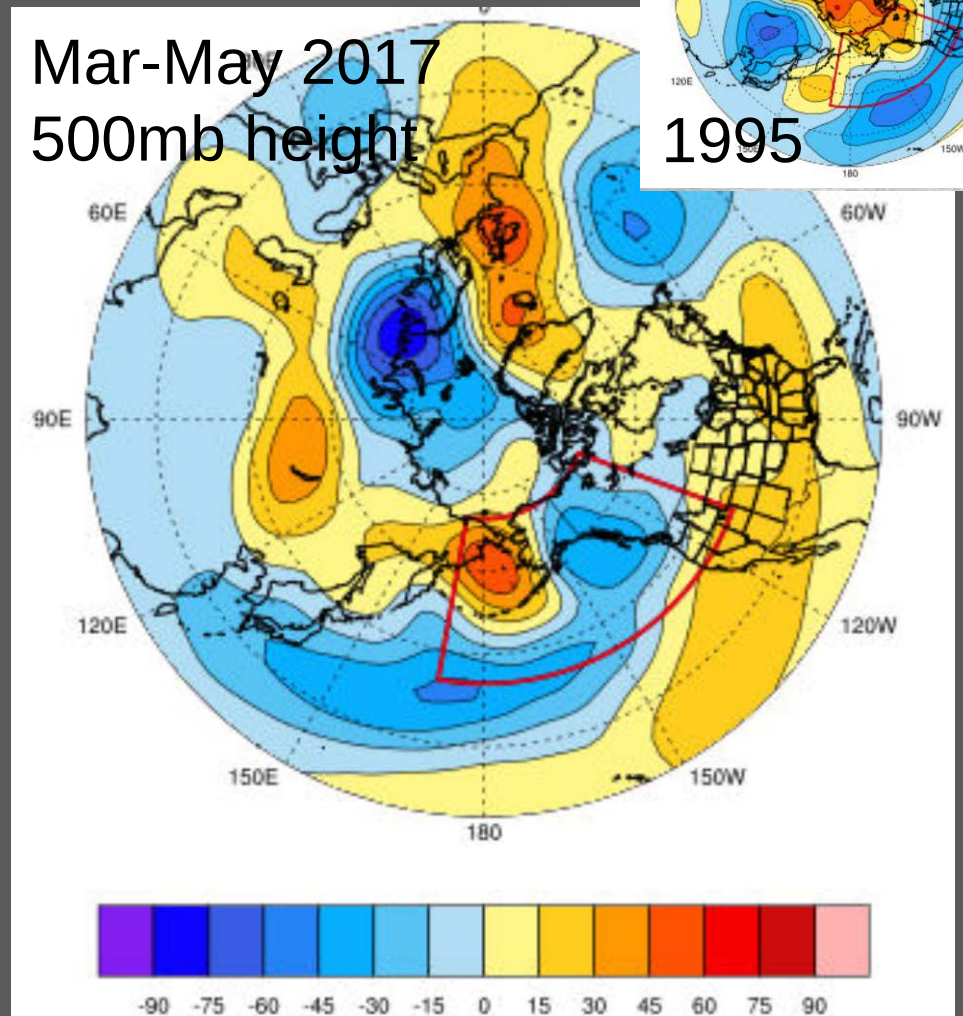
- 9-month ensemble forecasts from multiple GCMs coordinated by NOAA
- Monthly forecasts of atmosphere and ocean variables available
- 6-hr data available for sub-seasonal processes
- 1982-2011 hindcast data available for calibration & testing
- NMME output & single column model to predict ice road season in Prudhoe Bay area



Seasonal forecasts from monthly climate analogs

B. Brettschneider
J. Walsh
ACCAP-IARC

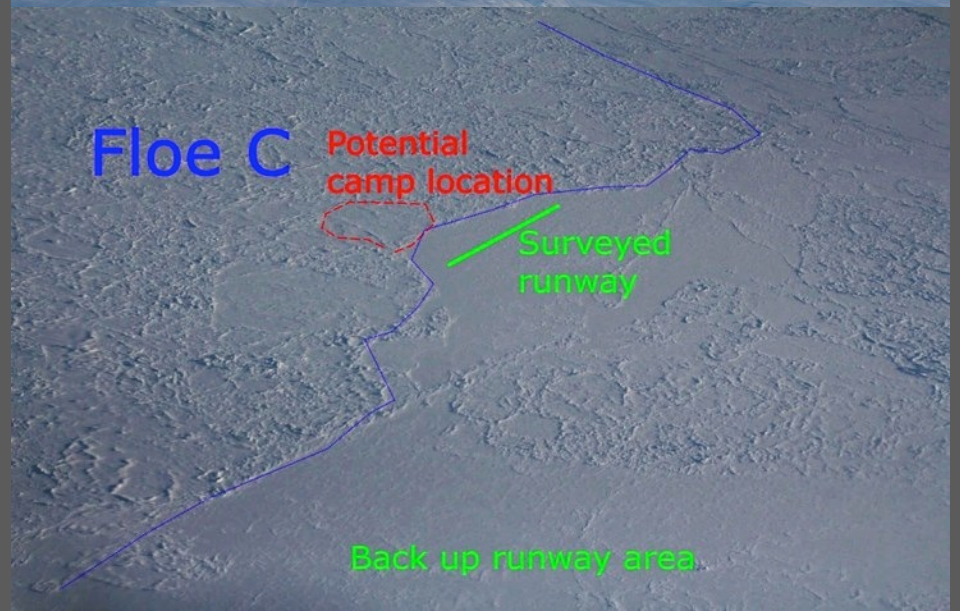




- Based on statistical pattern matching
- Look for matches in red box
- Base forecast for target region on observed evolution in years with best match

Support of USN ICEX Ice Camp 2018

- Partnership with Ukpeaġvik Iñupiat Corporation (UIC) to provide support services to USN Arctic Submarine Lab
- Seasonal to synoptic predictions & outlooks tied in with on-ice evaluation & support services

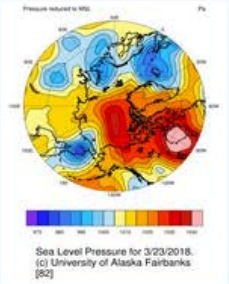
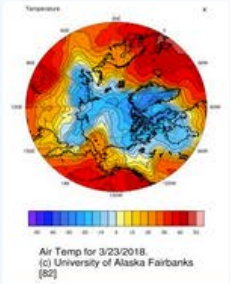
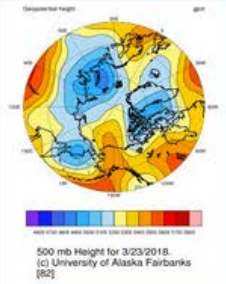
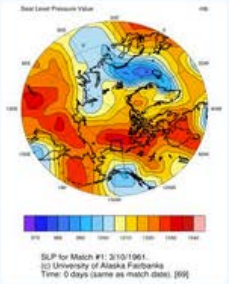
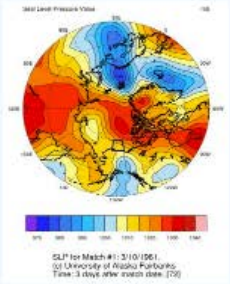
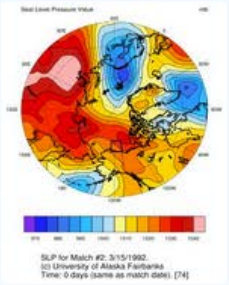
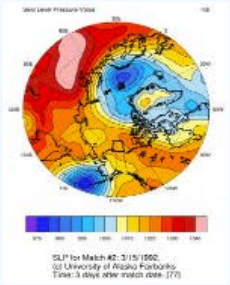


NOT AN OFFICIAL FORECAST - FOR RESEARCH PURPOSES ONLY

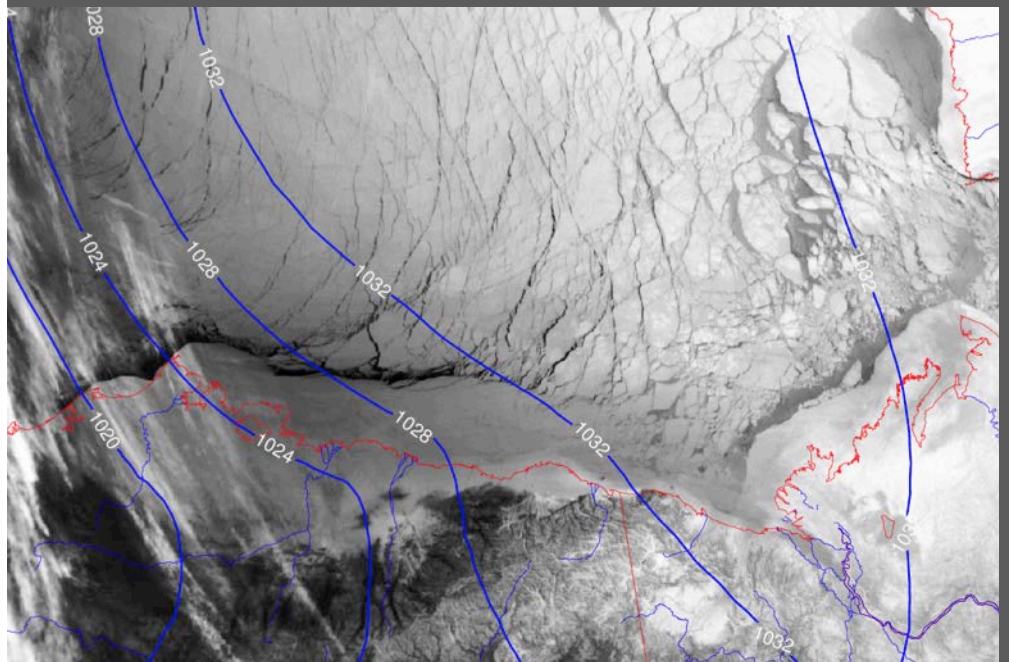
ESRL Daily Matches for 3/23/2018 12Z GFS Run (+0 hours)

Matches for Lat: 70N to 75N and Lon: 155W to 140W
Using a 20 Day Search Window Centered on Current Date.

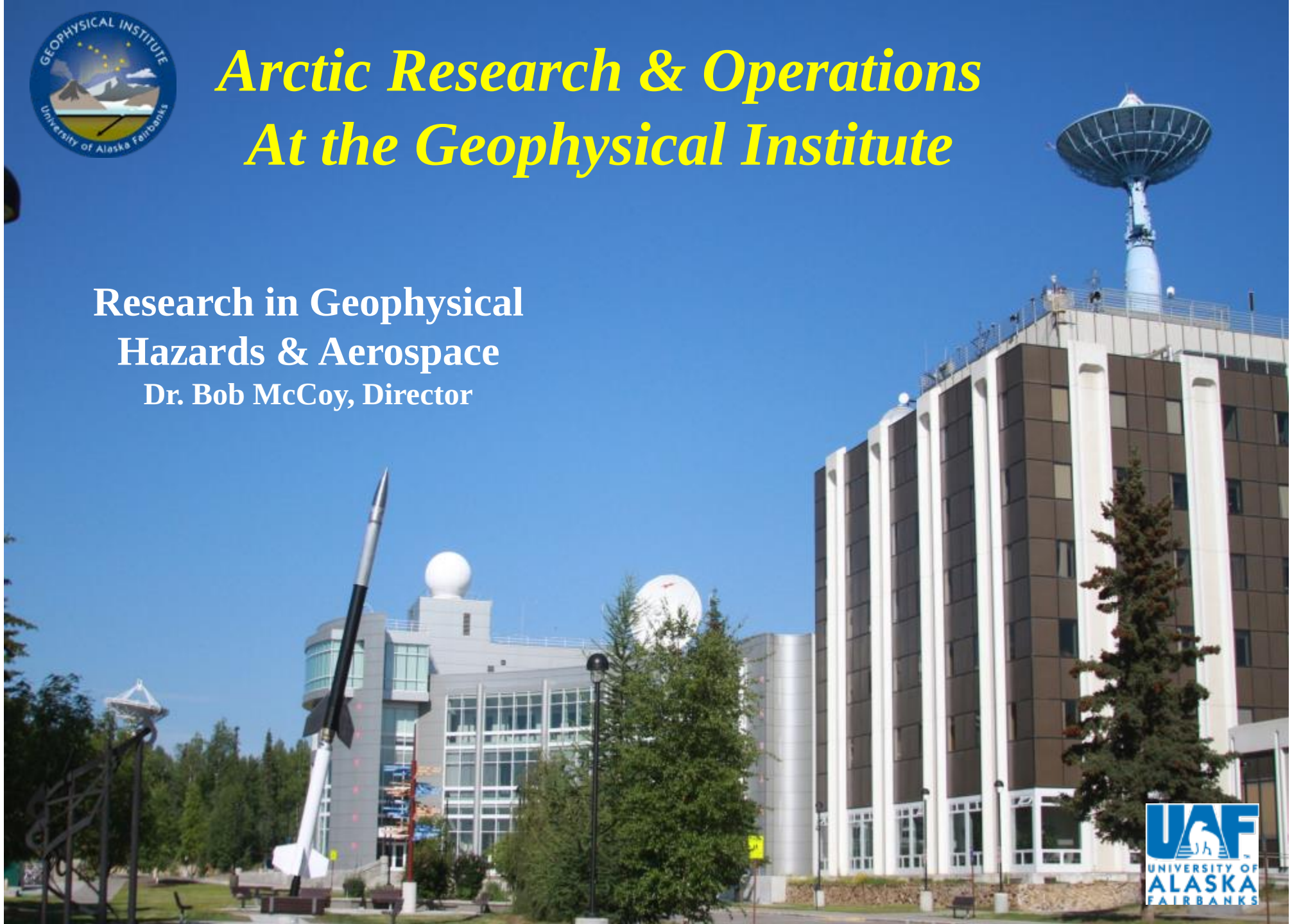
User Selected Weighting was -> SLP: 100 , Air Temp: 0 , and Z500 Height: 0

	SLP	Air Temp	500 mb Heights
1.Current GFS Conditions Click to Animate 5-Day Forecast			
2. Forecast for SLP	SLP Match Day	SLP Animated Loop	
Match 1: 3/10/1961 RMS = 0.251			
Match 2: 3/15/1992 RMS = 0.259			

- Fractures & leads forming in Barrow Arch pattern
- Analog forecast: Strong match with ICEX 2014 & 2016 break-up conditions
- Lead pattern prediction: High likelihood of new cracks forming



Arctic Research & Operations At the Geophysical Institute

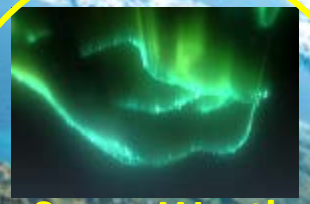


Research in Geophysical Hazards & Aerospace

Dr. Bob McCoy, Director

Alaska Geophysical Hazards

Ice Free Arctic Ocean



Space Weather & Aurora

90% Permafrost

Arctic Impacts on DoD:

- Buildings, Runways, Missile Silos
  - Earthquakes & Permafrost
  - Global Warming
- Aviation
  - Volcanic Ash
- Comm/Nav
  - Space Weather

100,000 Glaciers, 3.5M Lakes & 60% of US Surface Water

43,000 Earthquakes/yr
>M7 Every 2 years

52 Active Volcanoes
3 Eruptions/yr
80% Asian Air Traffic, 70,000 Passengers/day

Aerospace Facilities in Alaska

DoD Relevance

- Domain Awareness
  - Satellite Downlink
  - UAS, HAARP (OTHR)
- Communication
  - HAARP, CubeSats
- Comm/Nav Mitigation
  - HAARP, Sounding Rockets
- Geophysical Detection of Nuclear Proliferation
  - Infrasound Precision Geolocation, HAARP

Suborbital

Rocket Range

Satellite Downlink

Fairbanks

HAARP

UAS

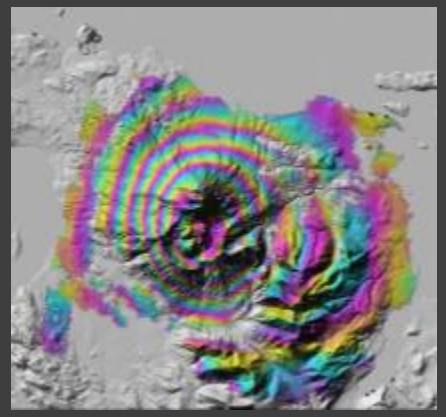
Spaceport

Orbital

Alaska Aerospace Corp

GEOPHYSICAL INSTITUTE

Major Facilities/Operational Programs



Alaska Volcano Observatory

Alaska Earthquake Center

Alaska Satellite Facility

Poker Flat Research Range

Alaska Center for Unmanned Aircraft System Integration

Research Computing Services (former DoD HPCC)

Wilson Alaska Technical Center (Infrasound)

High frequency Active Auroral Research Program

Alaska Center for Unmanned Aircraft Systems (UAS) Integration (ACUASI)

- University of Alaska's Center of Excellence for UAS Research
- 17 years experience operating UAS in Alaska, the Arctic, and elsewhere around the globe
- Highly operational – fly approximately 180 days a year
- Lead for one of the FAA's UAS Test Sites, the Alaska Test Site, a.k.a. the Pan-Pacific UAS Test Range Complex (includes AK, HI, KS, MS, and OR)
- Conducting true Beyond Visual Line Of Sight (BVLOS) operations
- Testing Command and Control (C2) links and Detect And Avoid (DAA) technologies in areas with poor GPS, no cellular coverage, and poor satellite communications (7 minute gaps in Iridium coverage)
- Developing and testing CONOPS for conducting safe UAS operations in the National Airspace System (NAS) at remote airports in the Arctic

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Alaska Center for Unmanned Aircraft Systems (UAS) Integration (ACUASI)

Strengths

- Highly experienced operational team
- All UAS pilots are also manned aircraft pilots, many are retired military flight instructors and UAS operators (Predator, ScanEagle, Raven, etc.)
- UAF owns modifiable UAS up to 300 lbs and 12-hr endurance for testing payloads and conducting scientific, domain awareness, and other missions
- Scientists and engineers for payload development
- Experience operating in harsh, remote environments, including the maritime Arctic and cold continental regions
- Access to the NAS for testing (including up to 130,000’ in specific locations and almost anywhere in the U.S. at low levels)

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Alaska Center for Energy & Power

Mission: Fostering development of practical, innovative and cost effective energy solutions for Alaska and beyond

- Applied energy research program
- Technology testing & optimization
- Energy systems modeling & analysis
- Knowledge network creation
- Commercializing energy innovation

- Industry
- Utilities
- Policy makers
- Communities
- Practitioners
- Students

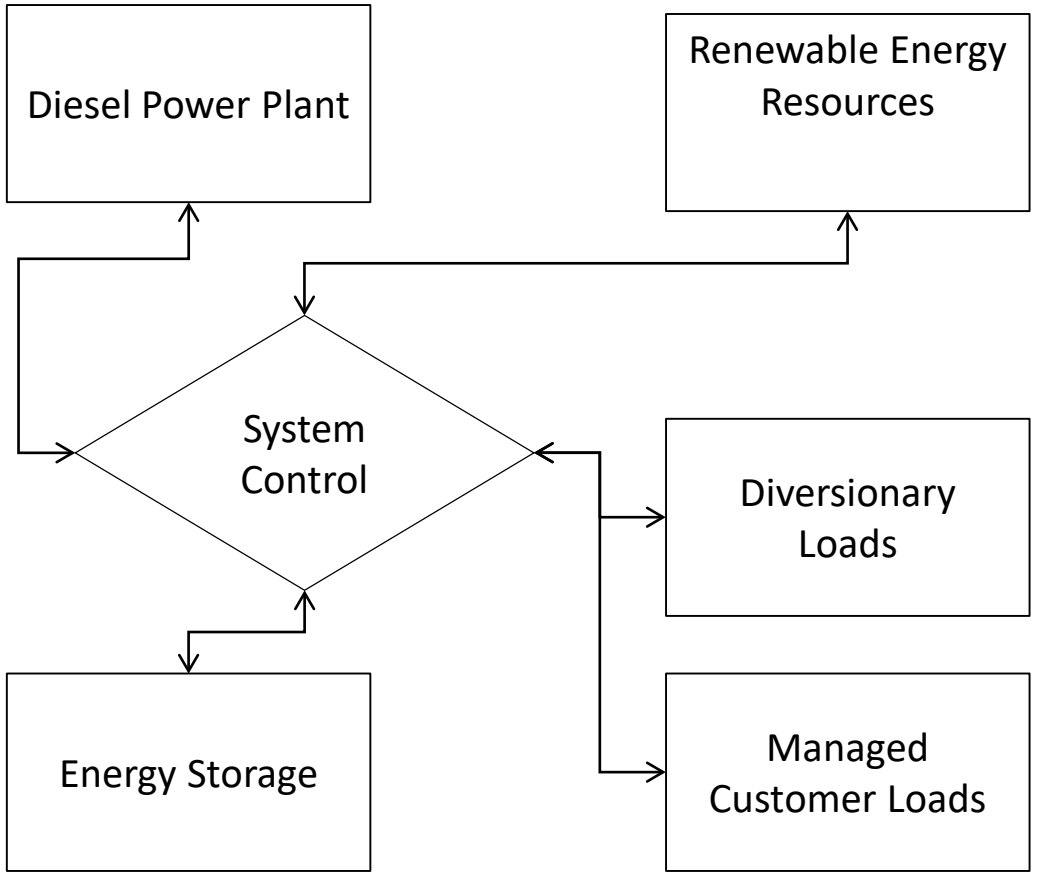
Department of Defense

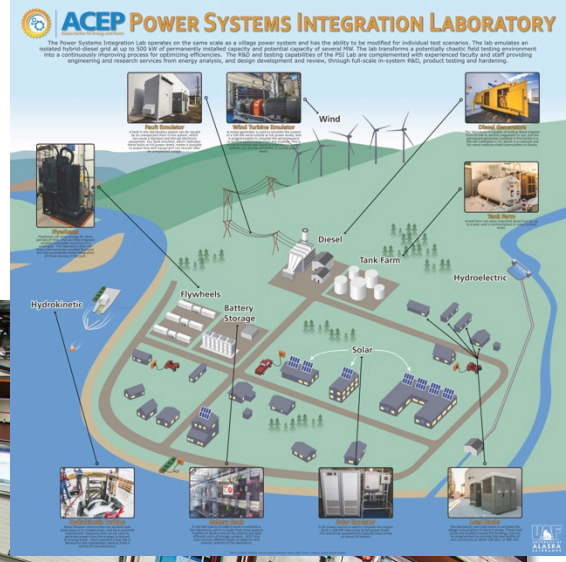
acep.uaf.edu

Alaska & hybrid energy microgrids

Alaska has >250 microgrids & 70 communities served by hybrid renewable-diesel systems

Microgrids…integrate & manage





Lab recreates a microgrid at full power levels (500 kW) and facilitates technology integration testing, control systems development and highly realistic training

Research Vessel Sikuliaq

- *Sikuliaq* is the first ice-capable vessel in the United States academic research fleet, able to cut through first-year sea ice up to 2.5 feet thick.

- The ship can accommodate up to 24 scientists and students at a time, providing researchers an opportunity to learn more about marine life and our oceans, atmosphere and global climate.

- *Sikuliaq* is owned by the National Science Foundation and operated by the University of Alaska Fairbanks.

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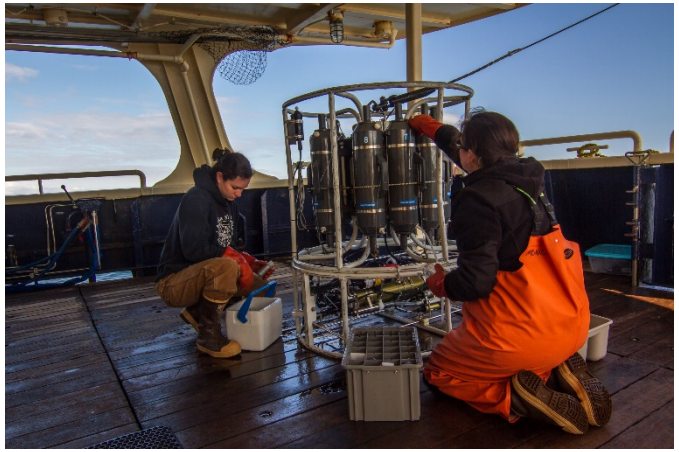
Northern Gulf of Alaska Long-term Ecological Research Site

- **Based on over two decades of data collection on the Seward Line, a set of stations between Resurrection Bay and the continental slope 140 miles offshore of Seward, AK.**

- **At these stations, researchers:**
  - **Measure ocean nutrients, chlorophyll, α, temperature and salinity**
  - **Collect and study phytoplankton and zooplankton**
  - **Count seabirds and marine mammals**



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Arctic Shelf Growth, Advection, Respiration and Deposition (ASGARD) rate measurements project

- **With faster ice retreat, does the ecosystem redistribute the spring bloom's biomass into different parts of the food web?**

- **Will the food available for seals, whales and walrus remain the same or change?**

- **Sampling on R/V *Sikuliaq* in June 2017 and 2018**

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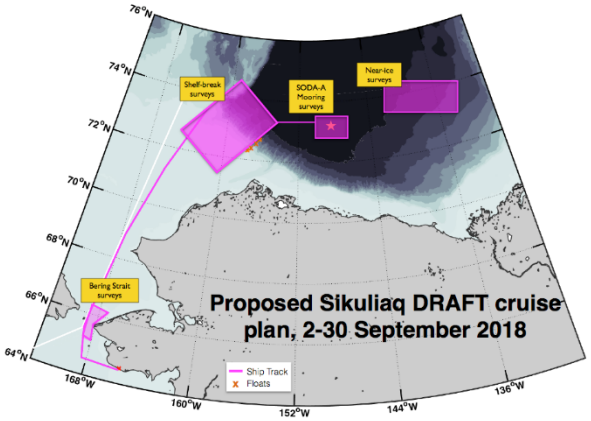
Stratified Dynamics of the Arctic Ocean (SODA)

- How do changes in atmospheric forcing (wind and solar radiation) and inflowing waters from Bering Strait alter upper ocean stratification in the Beaufort Sea?

- How does the changing response to atmospheric forcing impact the evolution of sea ice?

- Sampling on R/V *Sikuliaq* in September 2018



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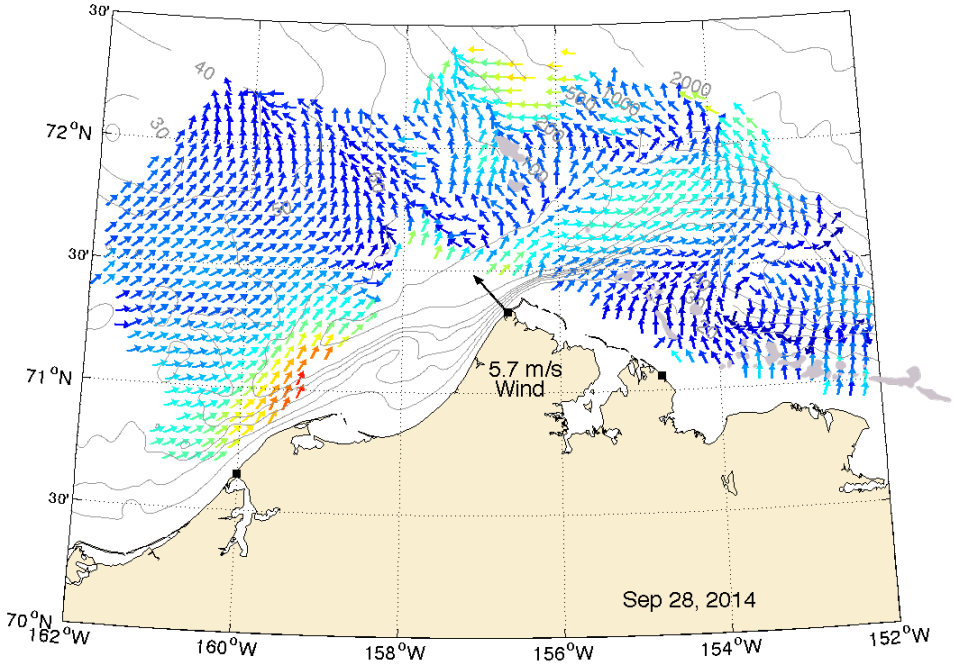
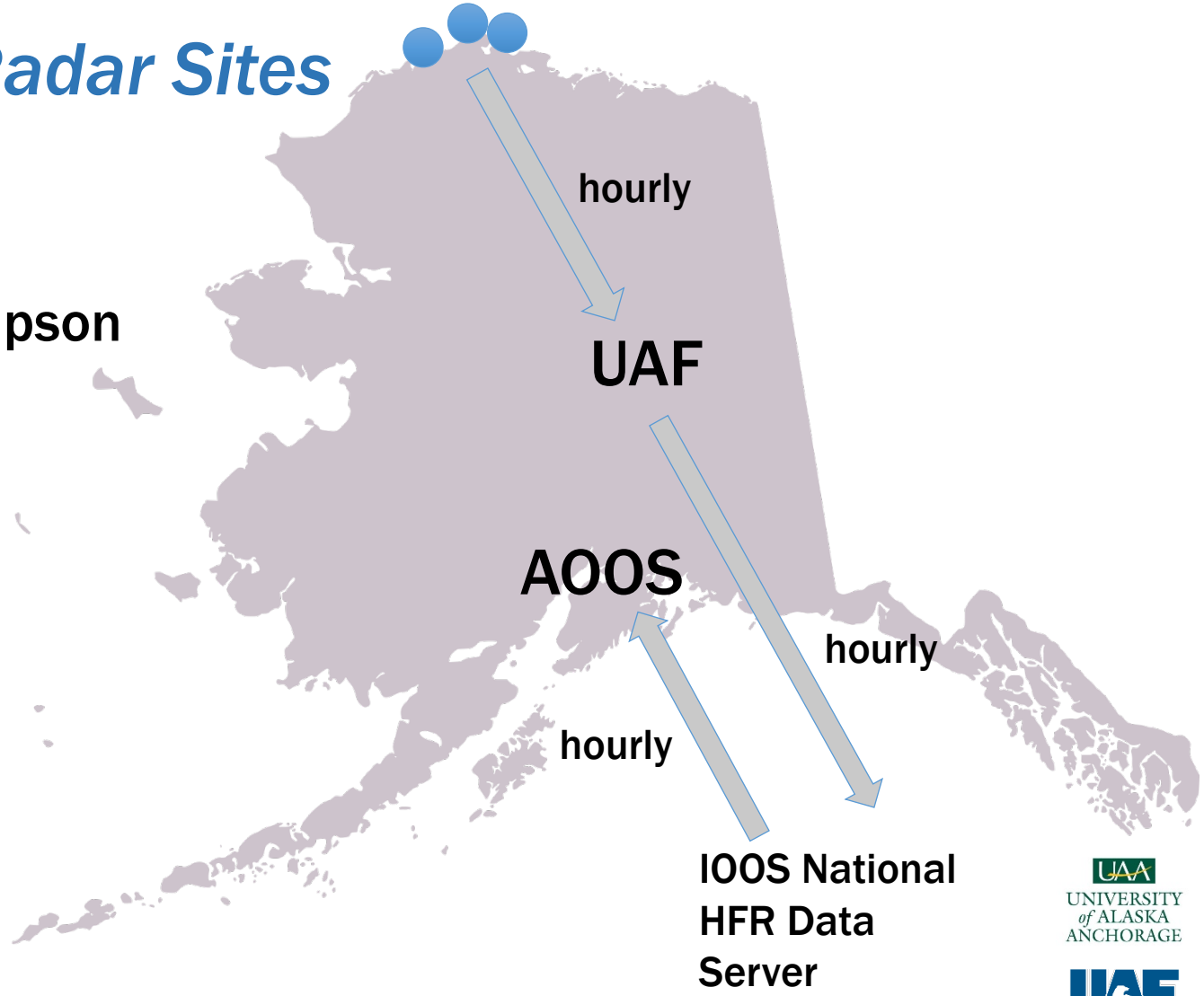
Alaska's High Frequency Radar Sites

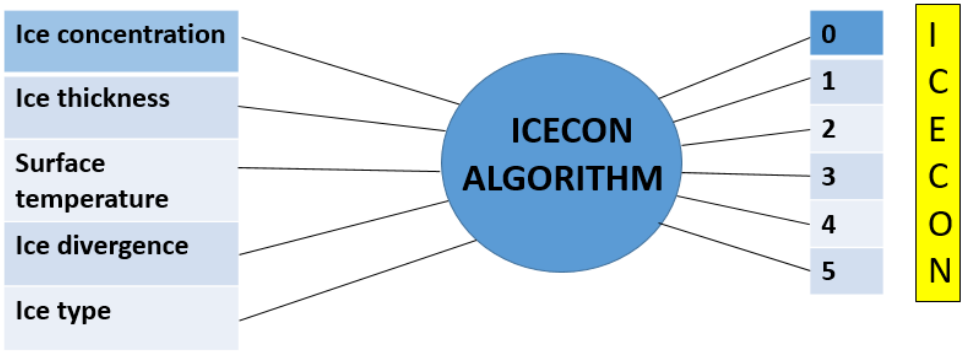
- Chukchi/Beaufort Sites
- Wainwright, Point Barrow, Cape Simpson
- Funded by AOOS
- 5 MHz systems



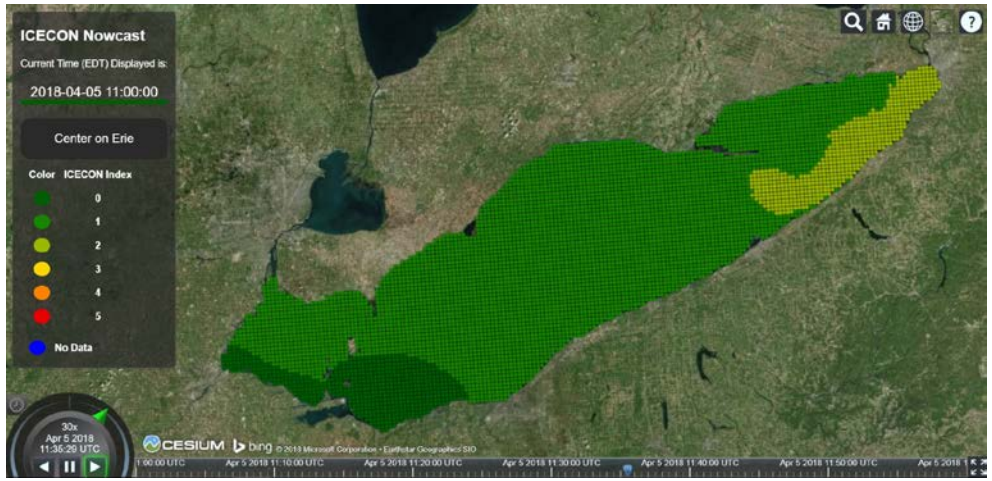


Ice Condition Index (ICECON) for the Great Lakes

1. ICECON algorithm



3. ICECON Forecasting System



2. Vessel classification in terms of ICECON

Vessel Class = f(horsepower, length,type)

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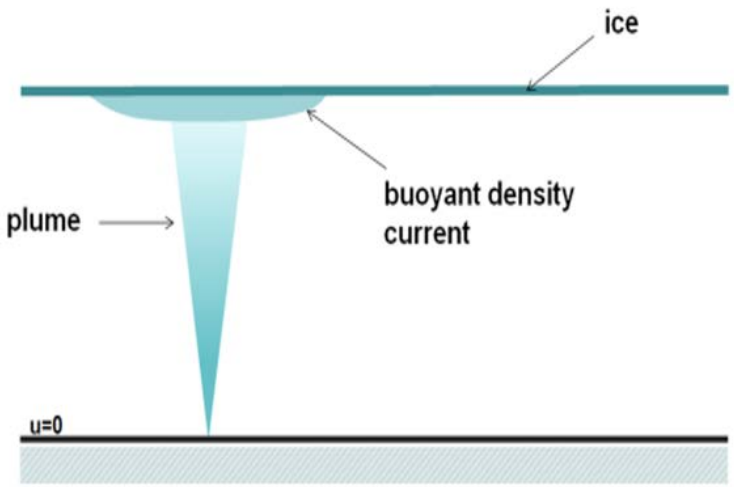
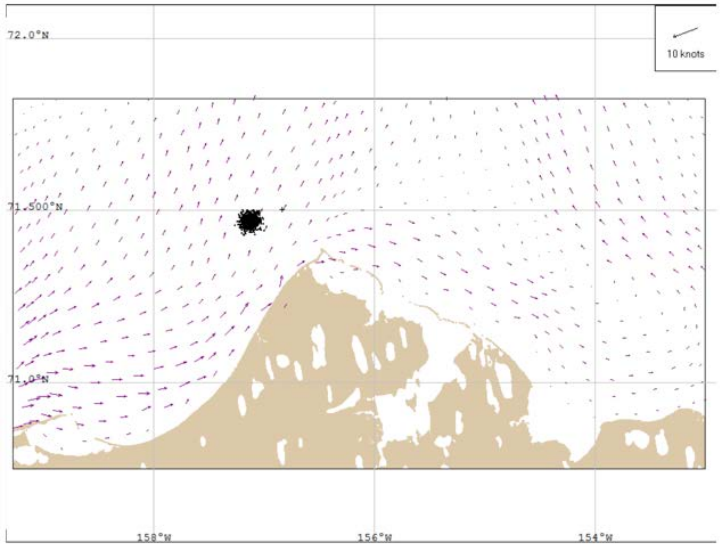
Arctic Oil Spill Modeling

Collaboration with the NOAA Office of Response and Restoration to develop an Arctic-capable GNOME oil spill model.

- Modeling surface spills accounting for the effect of ice concentration on oil movement and spreading.
- Modeling spills under sea ice accounting for the effect of under-ice roughness on under-ice oil movement and spreading.



Depiction of oil plume and buoyant density current on underside of ice



Screen shot of GNOME modeling of surface spill in Chukchi Sea

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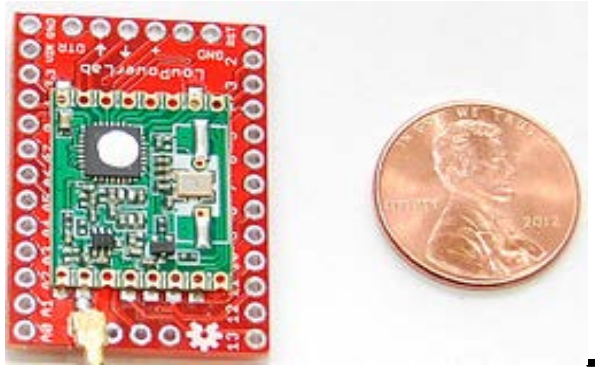
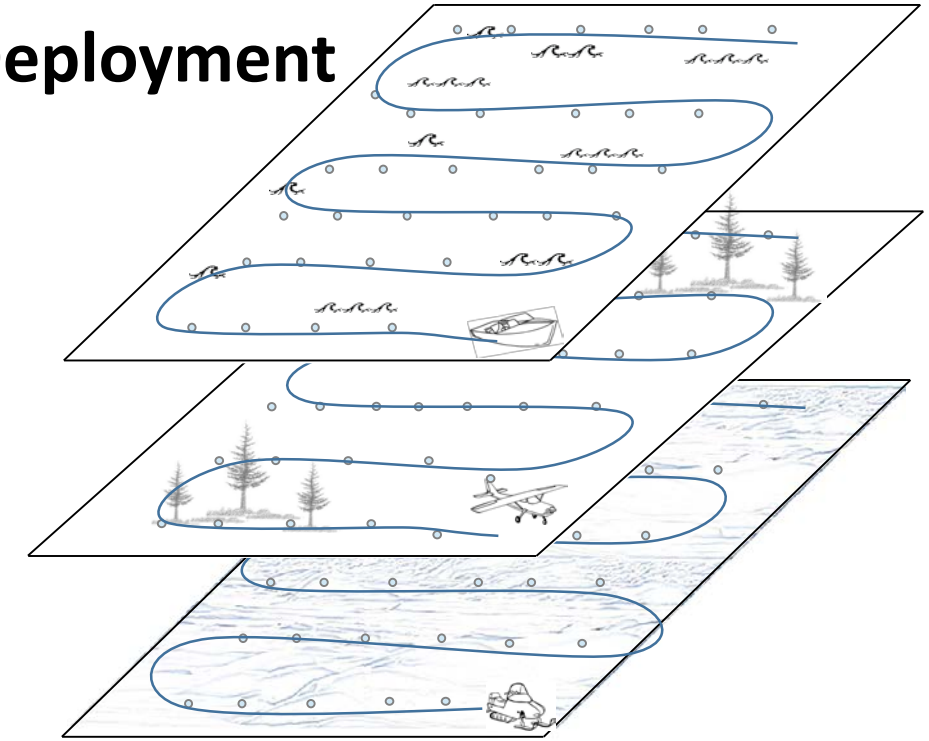
Low Cost Sensor Networks

Research Question: Can we develop robust, power aware, and cheap sensor network architecture to detect/predict the events important to the Arctic (ice breakup and a perimeter breach)?

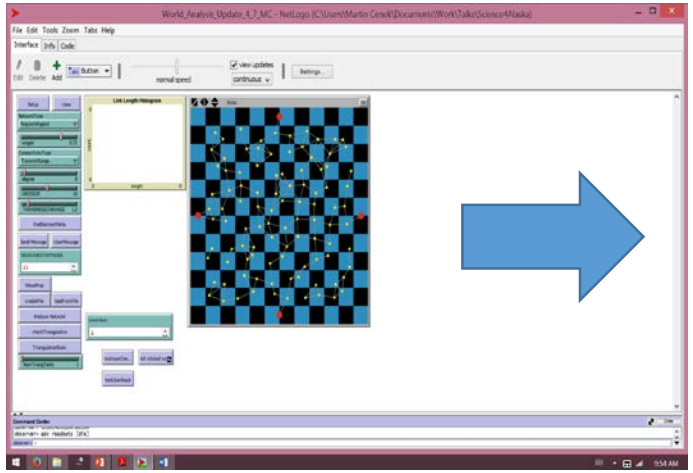


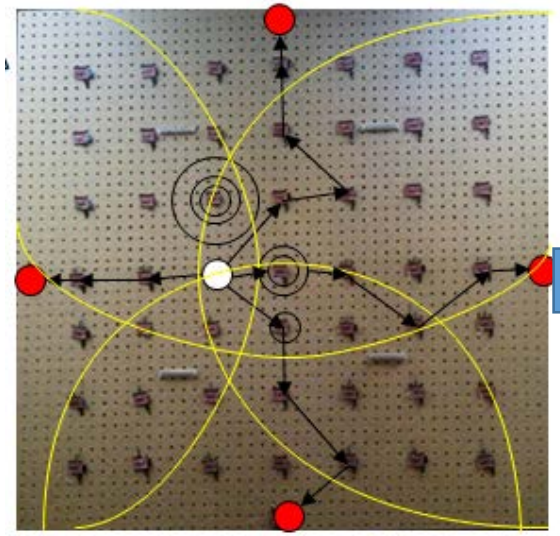
- $10 per sensor
- 3x AAA batteries = 7 months
- Range 100yard – 40km
- Add-ons: solar panel, wi-fi,
- antennae, GPS, microphone

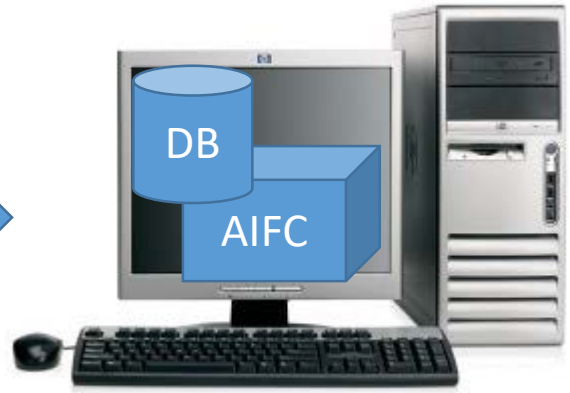
Deployment



Testing Architecture







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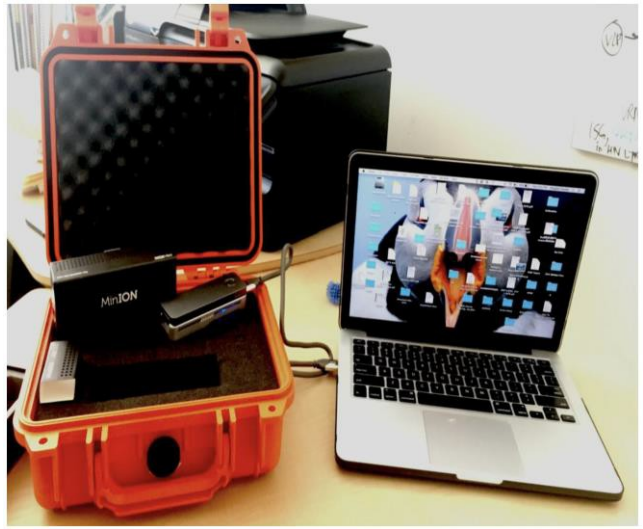
Integrated Arctic Environmental Security Studies

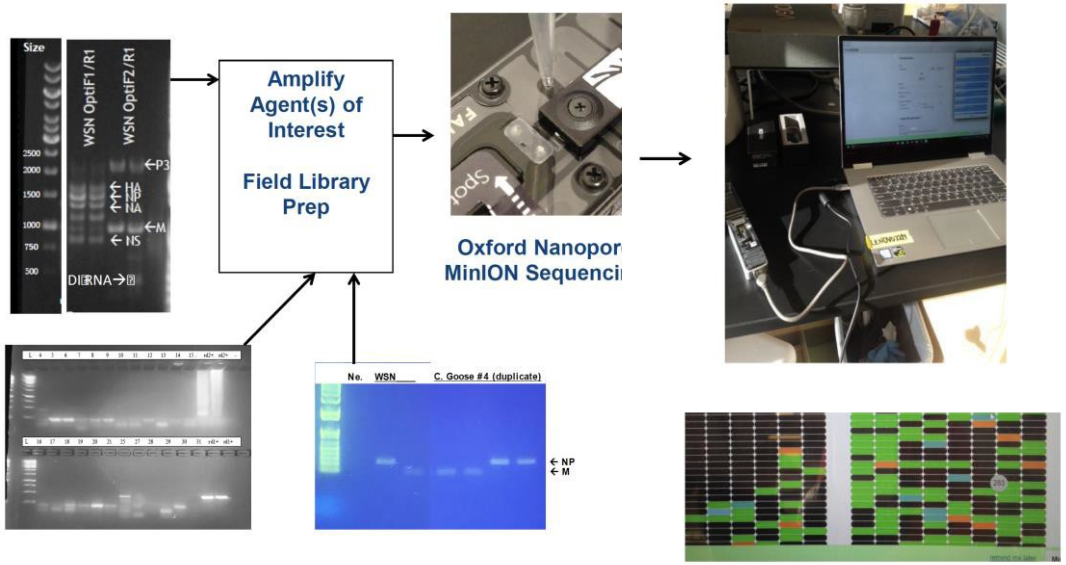
UAA College of Arts & Sciences, UAA College of Health Sciences, UAF College of Fisheries & Ocean Sciences

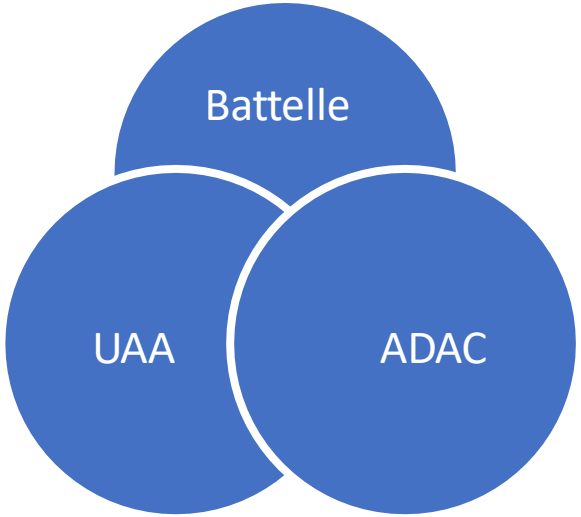
- **International educational and research outreach to remote communities and organizations**
- **Interdisciplinary approaches to complex environmental security issues of the Arctic**
- **Local, place-based, community level data and analysis that informs policy at all levels**

Integrated Arctic Environmental Security Studies

- Targeted monitoring, surveillance, and research on dynamics of change in status of the environment, health, and community resilience in the Arctic
- Partnered with Battelle, High Arctic Institute
- High Resolution detection of eDNA, water-, ice-, soil-based pathogens



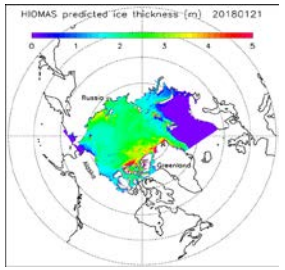




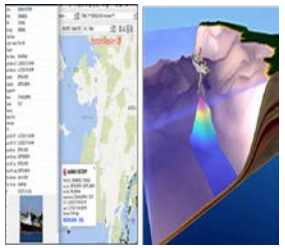
University of Alaska's Arctic Domain Awareness Center

ADAC is hosted by the University of Alaska, with work conducted at UA campuses in Anchorage and Fairbanks…and conducts research across a growing network of academic and industry partners.

Vision: The U.S. Department of Homeland Security Center of Excellence (DHS), providing networked and mission-focused support to the U.S. Coast Guard Operator in the High North.

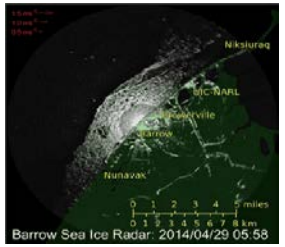


Mission: develop and transition technology solutions, innovative products and educational programs to improve situational awareness and crisis response capabilities related to maritime challenges posed by the dynamic Arctic environment.



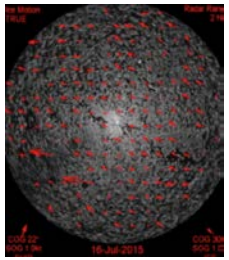
Strategy: Advance knowledge in relevant science and technology through conducting research and development in close collaboration with mission agencies' end users.

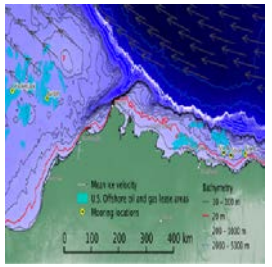
The Center also develops future leaders for the DHS enterprise through structured education programs.

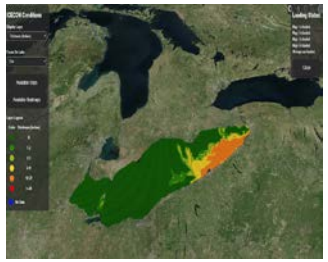


ADAC's principal customer: U.S. Coast Guard…in support of their Arctic search & rescue, disaster response, law enforcement and assistance missions.

ADAC works with an array of International, federal, state, local, tribal, industry and academic partners to advance domain awareness of the Arctic region.







ADAC activities include/have included:

- **Autonomously controlled underwater and under-ice platforms f**or environmental sensing (in particular, oil spill characterization).
- **Arctic Environmental modelling** (with increasing fine scale):
  - Arctic oil spills.
  - Arctic Ocean, Sea-ice presence, thickness, movement and ridging.
  - Western Alaska coastal surge and flooding.
- **Operator decision support tools.**
  - Ice Conditions Index for Great Lakes mariners and soon for Bering, Chukchi and Beaufort Seas.
  - Sea-Ice and Weather Forecasting Tools to Improve Arctic Situational Awareness & Crisis Response.
  - Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic.
- **Support research to improve Arctic communications and other technologies**.
  - Evaluation of Potential U.S. Coast Guard Use of Cube Satellites for Arctic Communications.
  - Low cost sensors for Arctic monitoring.
  - Maritime Domain Awareness and environmental factors information fusion.
  - Smart Camera Research in Arctic maritime regions.
- **Research of suitability of High Fidelity Observers to support USCG information needs in Arctic waters/shorelines.**
- **Create and conduct workshops that advance research** needs or targeted knowledge products for Arctic, Science and Technology, Future Strategy, and Arctic Security/Environmental Security.
- **Develop the next generation** for the Homeland Security Enterprise.

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ARCTIC DOMAIN AWARENESS CENTER
A DEPARTMENT OF HOMELAND SECURITY CENTER OF EXCELLENCE

ADAC: Research for the Arctic Operator…For Today and For the Future

University of Alaska S&T Arctic Research Collaborative

- A brief discussion of the Research Collaborative Construct.
  - A developing construct, intending to support “unity of effort” in research collaboration for DoD.
  - Leveraging a remarkable amount of Arctic research expertise contained or connected within the University of Alaska.

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As/of 23 Feb 2018

Framing a University of Alaska Response to the DoD S&T Request for Information (RFI-2018)

Introduction.

The Arctic is strategically vital to U.S. National interests. The region is rich in resources making it geographically and geopolitically essential for the nation. At the same time, the Arctic remains remote and conducting operations there safely and effectively pose re significant challenges for arctic operators. . Preserving and protecting U.S. national interests, to include securing borders and ensuring safety and security in adjoining Arctic waterways, remains an important task but also resource challenge for U.S. federal agencies.

The U.S. Federal government has both established and emerging needs in providing safety, security and defense in the Arctic. As implied by the December 2017 National Security Strategy and the January 2018 National Defense Strategy, securing and defending the U.S. Arctic region is an important, if not vital, national interest.

In order to reduce operational risk and increase mission effectiveness in the Arctic, U.S. Federal departments leverage government, industry and academic led research and development entities. Improving collaboration between Arctic research entities reduces potential for duplication of efforts. When feasible and mission appropriate, conducting joint investigations with shared responsibilities between research entities will assist the nation to gain synergy in the produced knowledge/technology/innovation development and affords the agencies across the board an opportunity for smarter resource investments.

Proposal: *Create an Arctic Science & Technology, Research* ***Collaborative*** *by leveraging the current/existing Research Centers and participating colleges of the University of Alaska. Specifically, this Arctic S&T Research Collaborative serve as a framework for the participating University of Alaska Centers and Colleges to source research teams and existing facilities and equipment, in order to conduct a series of projects approved and funded by Department of Defense. Each project would establish the Principal Investigator(s), and tailored team to prosecute the associated research. Research support to DoD and participating departments in policy assessments and strategy development. “On demand” Research support for DoD and participating U.S. Federal agencies.*

Research administration for the Collaborative, is envisioned as a composite group from participating UA Centers and Colleges, selected by UA President, Vice President for Research and

University of Alaska Arctic S&T Research Collaborative: A Comprehensive Team for DoD 1

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Proposal: University of Alaska S&T Arctic Research Collaborative

Create an Arctic Science & Technology, Research Collaborative by leveraging the current/existing Research Centers and participating colleges of the University of Alaska.

- Specifically, this Arctic S&T Research Collaborative serve as a framework for the participating University of Alaska Centers and Colleges to source research teams and existing facilities and equipment, in order to conduct a series of projects approved and funded by Department of Defense.
- Creating a standing collaborative with a credentialed set of research teams provided task orders as needed…when needed by participating DoD sponsors.
- Each project would establish the Principal Investigator(s), and tailored team to prosecute the associated research.

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Administering the UA collaborative

Research administration for the Collaborative…

…is envisioned as a composite group from participating UA Centers and Colleges, selected by UA President, Vice President for Research and University Chancellors

…guided by approved Terms of Reference.

The Collaborative would first serve to unify UA Arctic S&T endeavors by the framework

….while also encouraging research partners from participating universities and industry….join the Collaborative for specific research projects (and funded via standard sub award protocols).

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Way forward

Depending on interest…

- Refine the construct and establish the terms of reference.
- Establish proof of concept with willing customer(s) by means of agreement and task order.
- Analyze research performance in meeting customer satisfaction.
  - Key metric…Evaluate timeline from request to delivery compared to standard funded solicitation process.
- Adapt and evolve…responding to the advancing research needs.

…something to consider…a collaborative…can also include a community of research customers

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Conclusion

Arctic warming is driving opportunity and challenge.

As sea-ice diminishes, people are advancing to discover, collect, extract, transit and regrettably, exploit.

Ensuring Safety, Security and Defending the U.S. Arctic is an important, if not, vital National U.S. Interest.

Collaboratively arranged Arctic Research can reduce risk faced by mission agencies and increase effectiveness in mission accomplishment.

The combination of Arctic-focused research entities associated with the University of Alaska provides a potentially powerful and diverse team to help meet DoD Arctic S&T investigation needs.

Our adversaries are less constrained in leveraging instruments of innovation. We can and should find ways to increase velocity and agility of research.

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University of Alaska S&T Arctic Research Collaborative ...A Developing Construct

Thank you for your kind attention

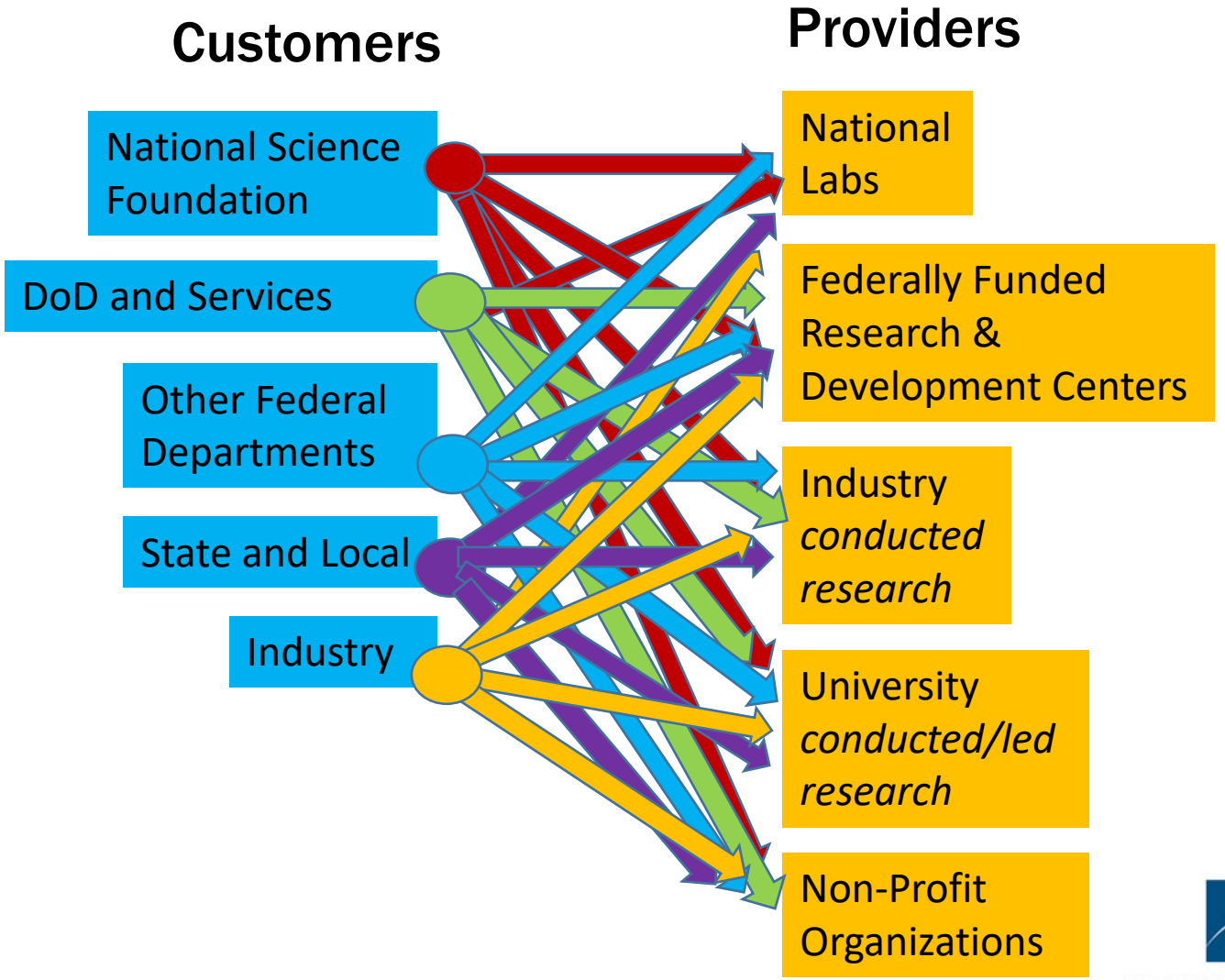
...Ready for questions

University of Alaska S&T Arctic Research Collaborative
...A Developing Construct

Backup Slides

Research needs and providers network ...An illustration

- **Each entity of the customer and research community plays a key role in creating innovation and advancing science & technology.**
- **Strategically...Is point to point the best way to advance research?**



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