The ONR Arctic Program

6th Symposium on the Impacts of an Ice-Diminishing Arctic
on Naval and Maritime Operations

July 14, 2015

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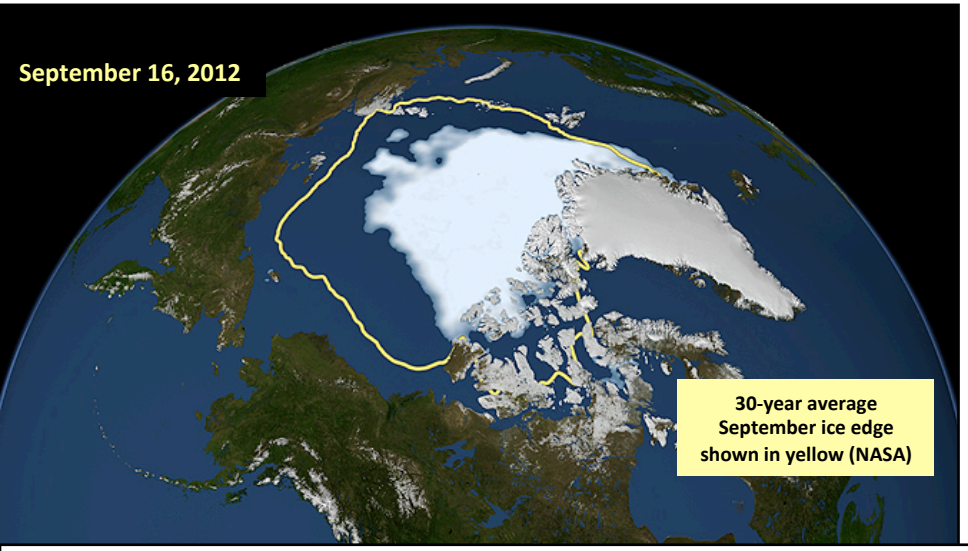
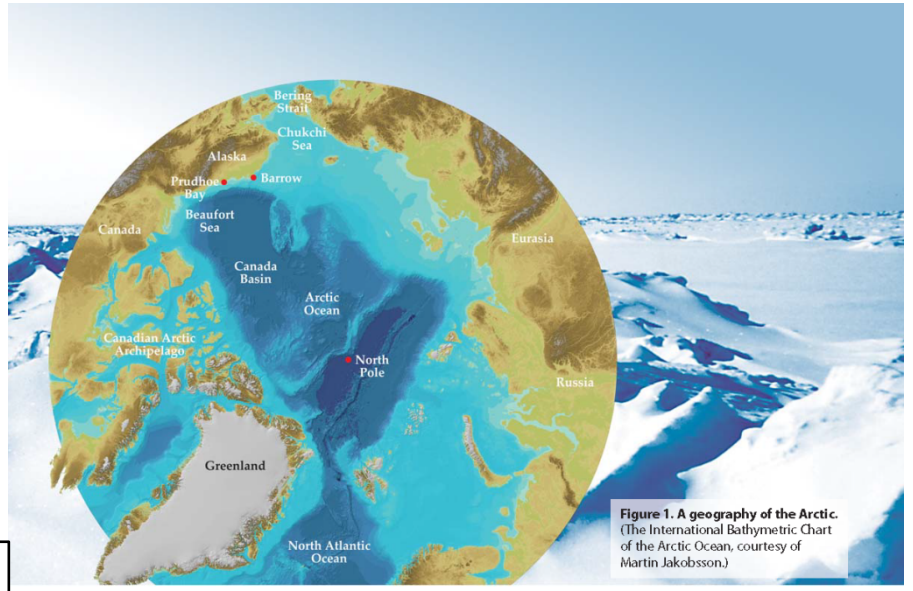
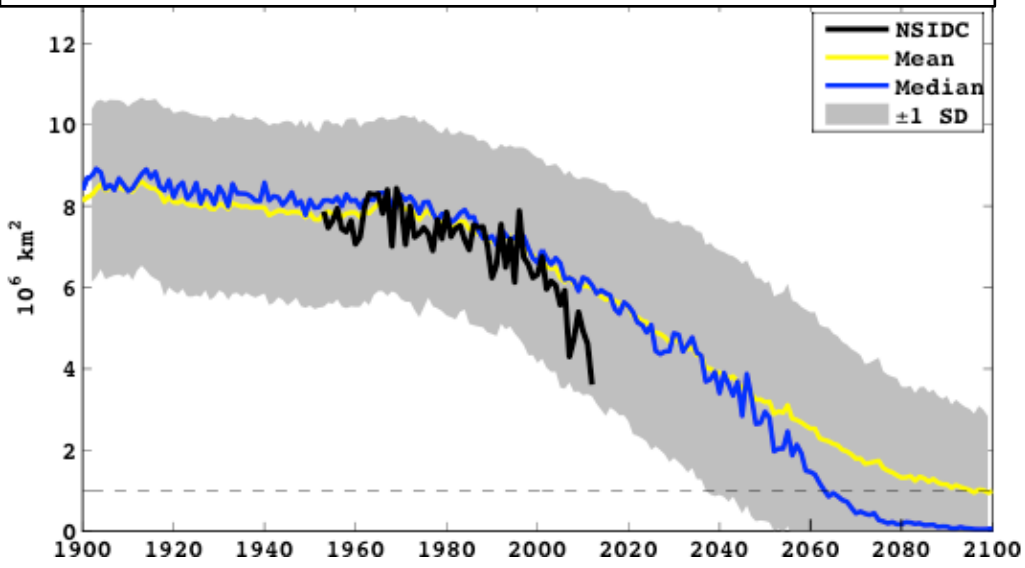
The Changing Arctic





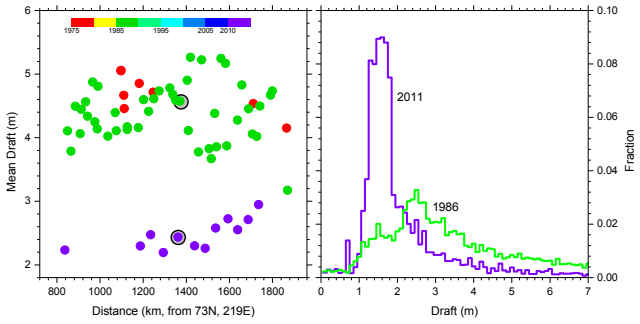
Observed & Projected Changes in Arctic Sea Ice



Jeffries at al., 2014

THE ARCTIC shifts to a new normal

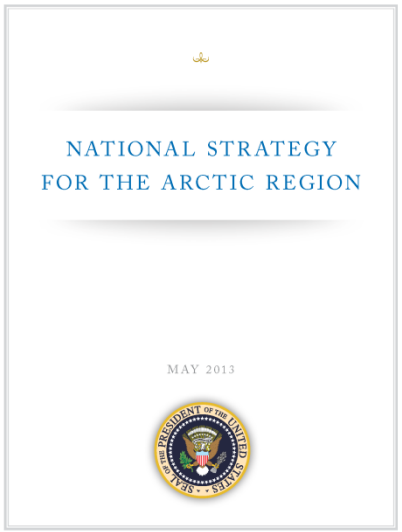
Martin O. Jeffries, James E. Overland, and Donald K. Perovich



Reduction in ice thickness recorded by US Navy submarines during polar transits

Wensnahan, UW/APL

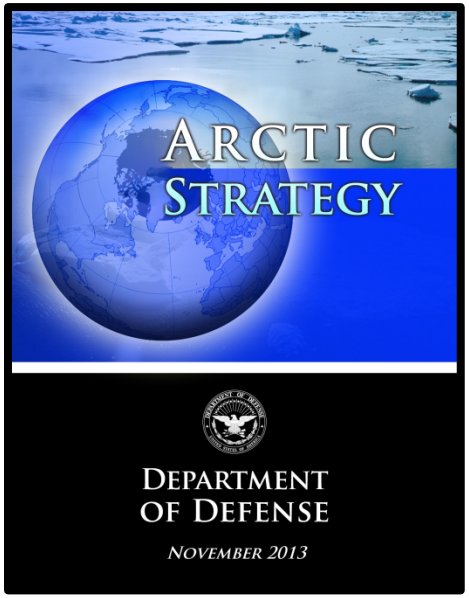
ONR's Arctic Guidance

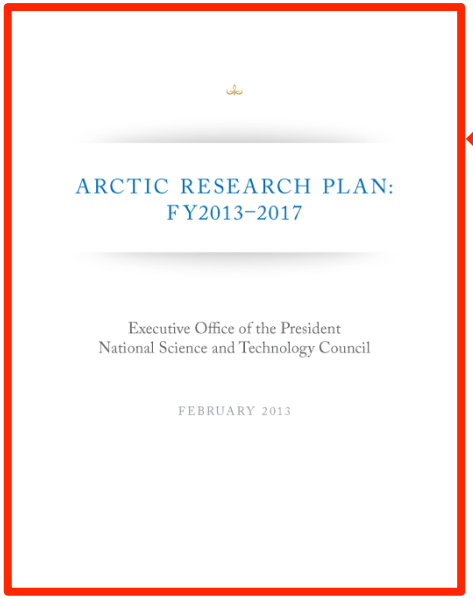


Develop a Framework of Observations and Modeling to Support Forecasting and Prediction of Sea Ice

Lead Agency: Department of Defense

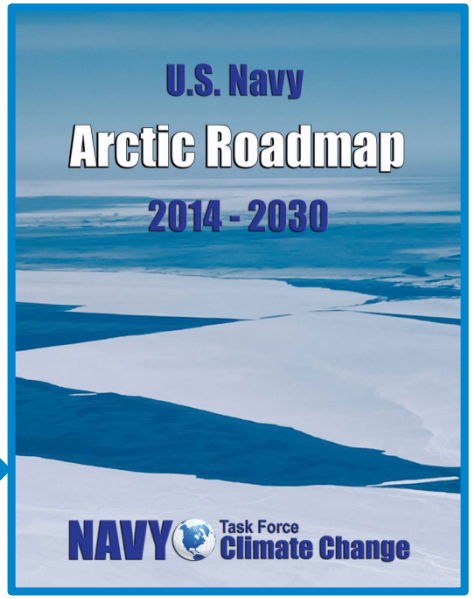
"increased certainty and accuracy of sea ice forecasts and predictions, and by showing improved understanding of feedback processes driving sea ice variability"





ONR leads two of the IARPC Collaboration Teams

- **Sea Ice (M. Jeffries)**
- **Modeling (S. Harper)**



Navy's Strategic Objectives for the Arctic Region

- **Ensure U.S. Arctic sovereignty and provide homeland defense**
- **Provide ready naval forces to respond to crises and contingencies**
- **Preserve freedom of the seas**
- **Promote partnerships within the U.S. Government and international allies**

Future Arctic Expectations

- **Continued reductions in sea ice volume and extent**
- **Increase in maritime activities**
- **Anticipate demand for increased naval presence**

What Does the Navy Need to Know?

TFCC "Arctic Roadmap":

- Must have **Arctic environmental information and forecasts** to support investment and policy decisions, and enable future operations.

NORTHCOM:

- Must improve ability to **observe and predict the Arctic environment**

N2N6E CBA: Need Better Environmental Information

- Insufficient ability to provide oceanographic information, ice reports, accurate navigation charts, meteorological analysis and forecasts

Surface Operations in the Arctic

Much of what the Navy knows about operating in other naval environments does not apply in the Arctic:

- Natural environment is far more hazardous (sea ice, low temperatures)
- Good numerical forecasts for the operational environment are not available
- Lack of significant observational capability to characterize the environment
- Climatology is not a good indicator of future operational conditions

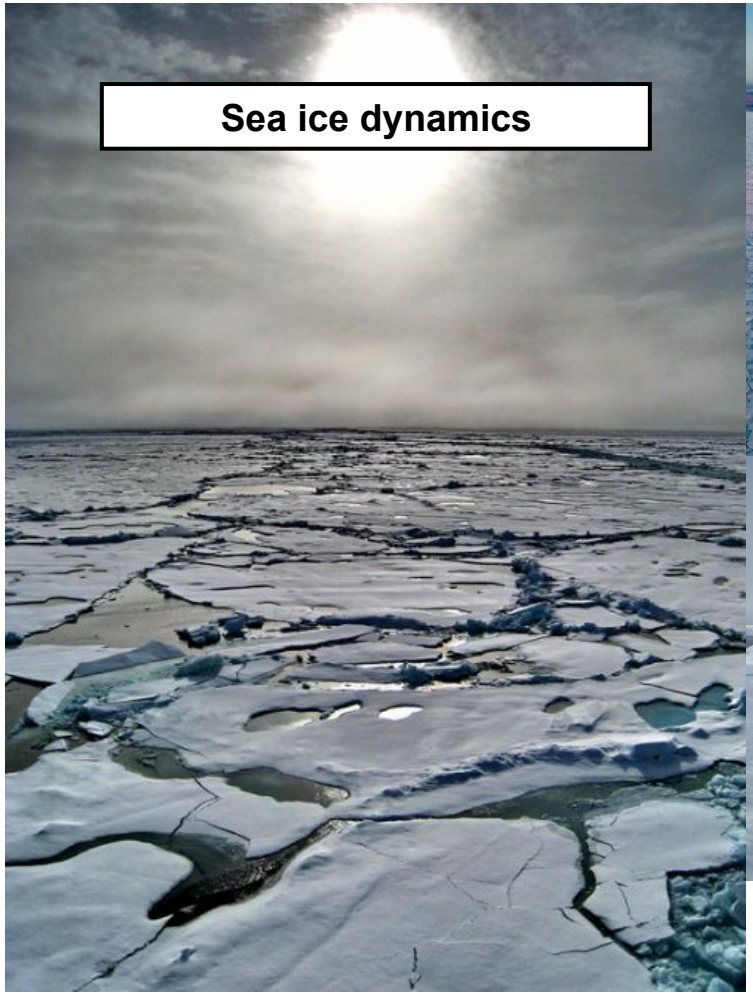
We need to <u>understand</u> the new Arctic environment in order to prepare for it

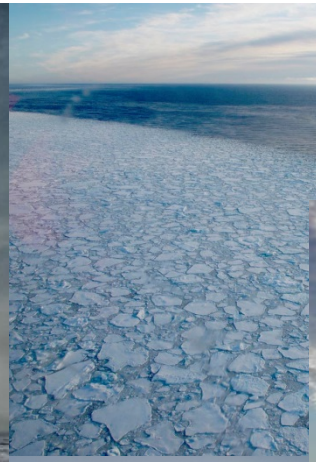
Arctic Environmental Research Program

- **Understand the physics and dynamics of the emerging Arctic environment**
  - Reduced ice cover during summer months
  - Thinner, more dynamic sea ice
  - Changes in Arctic Ocean stratification and circulation
- **Develop improved *in situ* and remote sensing capabilities**
  - Autonomous unattended platforms and sensors
  - Multi-sensor remote sensing algorithm development for sea ice
  - Real-time data availability for MDA and DA in forecast models
- **Improved Arctic Forecasting Capabilities**
  - Completely coupled Arctic System Models at high resolution
  - Improved assimilation of observed data
  - Research on extended prediction (from seasonal towards decadal)

Thrust 1: Improved Physical Understanding

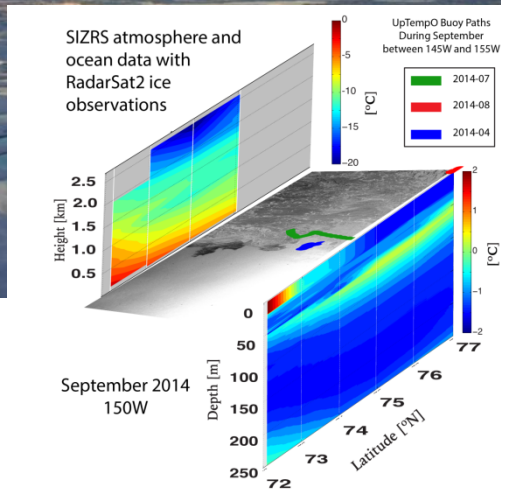
A better understanding of the integrated physics and dynamics in the Arctic will enable a more accurate representation of important processes in the models, leading to improved predictions





Changes in Surface Fluxes, Waves, Atmospheric Circulation and Overall Variability

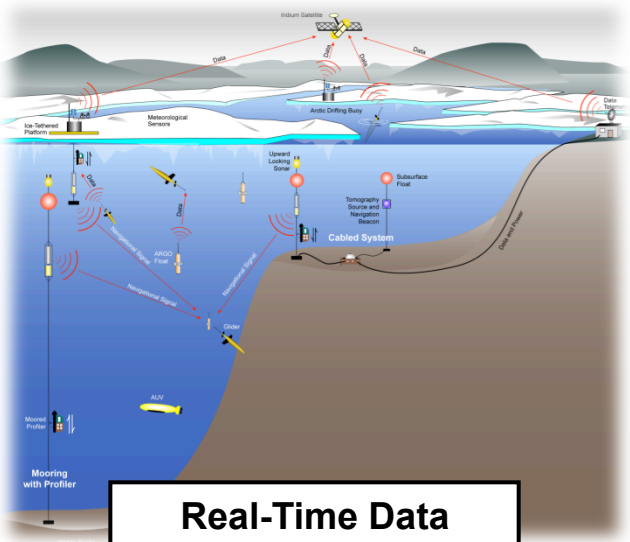
Changes in the Vertical Stratification of the Arctic Ocean



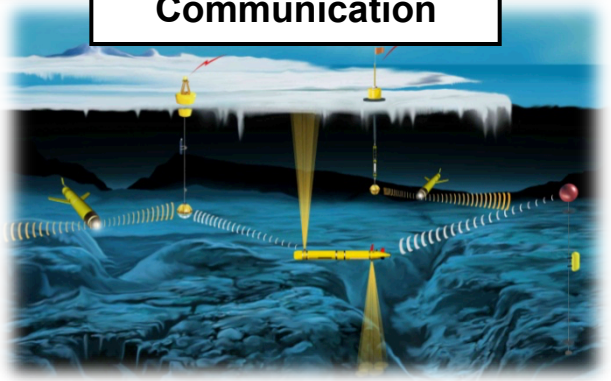
Thrust 2: Arctic Observing Systems

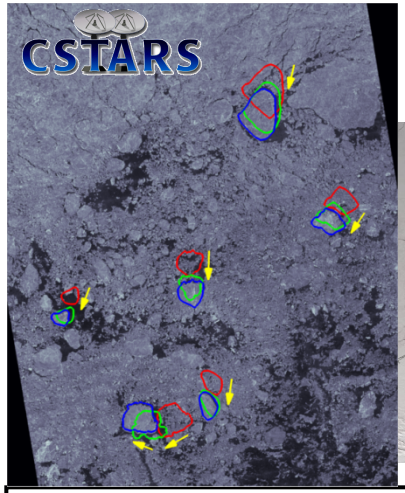
A sensing system must be developed to provide persistent observations that can further scientific understanding, provide long-term monitoring, and constrain the predictive models.

Autonomous platforms – Robust Sensors – Real-time Data Delivery – Key Environmental Variables

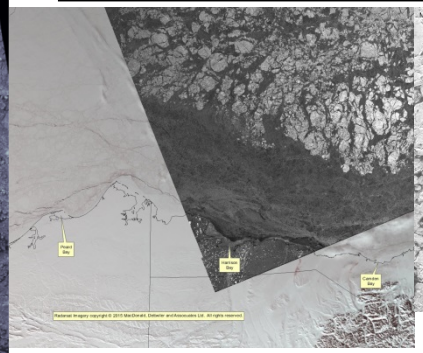


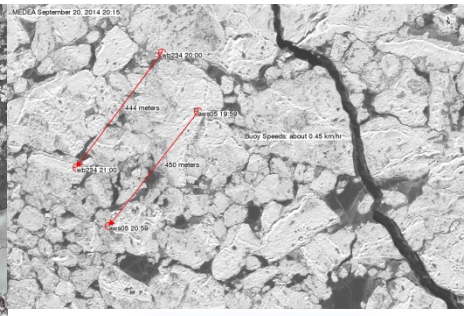
Real-Time Data Communication



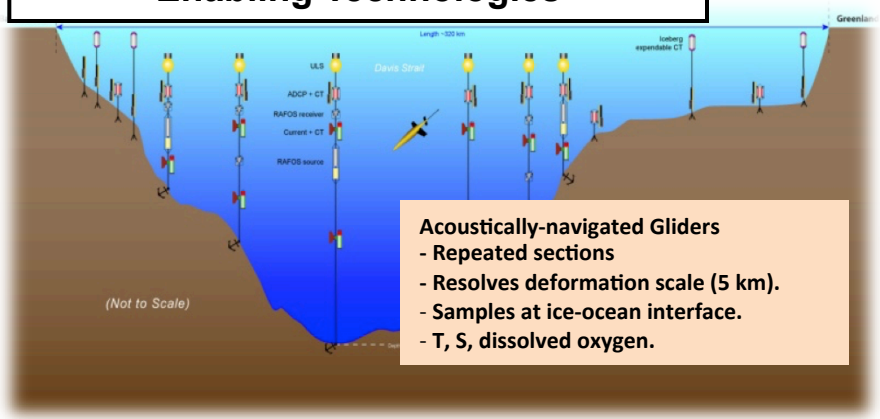


Exploitation of SAR and other remote sensing capabilities

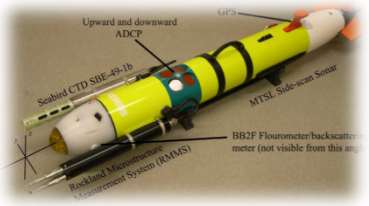




Autonomous Platforms and Enabling Technologies



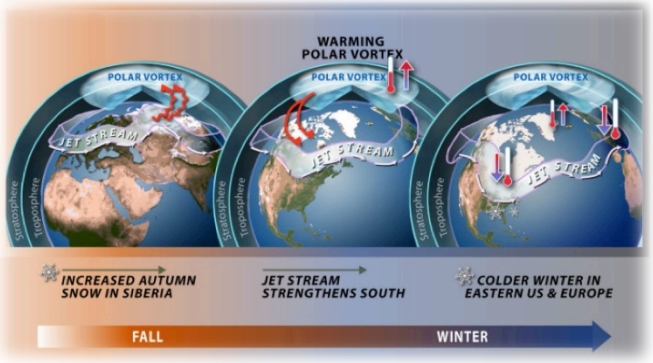
Acoustically-navigated Gliders
- **Repeated sections**
- **Resolves deformation scale (5 km).**
- **Samples at ice-ocean interface.**
- **T, S, dissolved oxygen.**



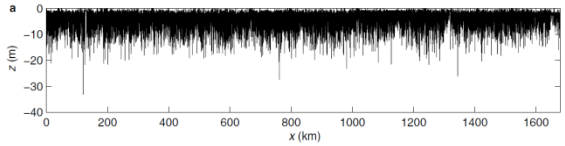
Thrust 3: Integrated Arctic Prediction

Fully-coupled **ocean-wave-ice-atmosphere models** with sufficient resolution to represent the relevant processes, and that **assimilate in situ and remotely-sensed observations** to create **useful predictions** of the operational Arctic environment at a wide range of lead times

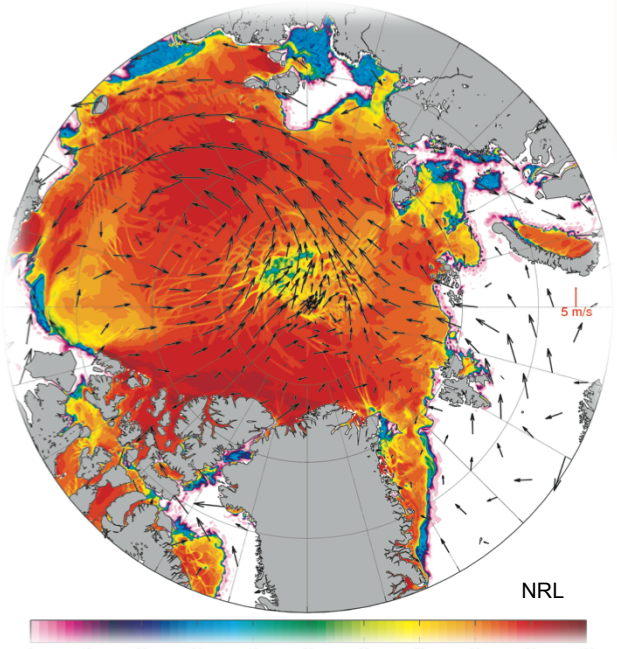
Integrated Arctic System Models
ocean – ice – wave – atmosphere



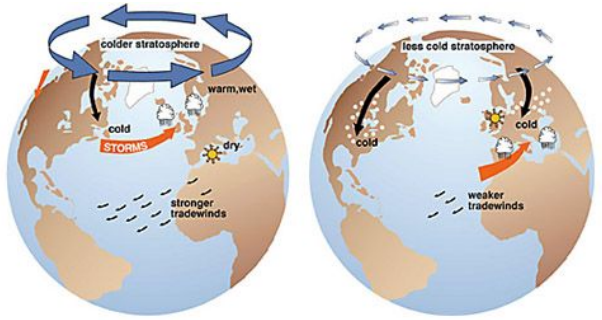
Advanced Data Assimilation



Ice thickness measured from below



Coupling with Global Earth System Models



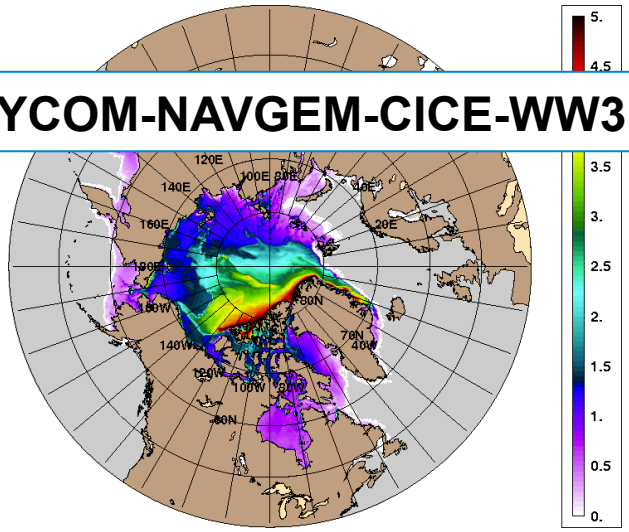
J. Wallace, University of Washington

Cooperative Model Development

ONR funds various Arctic System Models and collaborates with other federal agencies (NOAA, NASA, NSF, DOE, BOEM and others) to pursue improved predictions in the Arctic

See "Navy Sea Ice Forecasting – Recent Updates and Future Plans" by Pamela Posey on Wednesday morning @ 9:40am

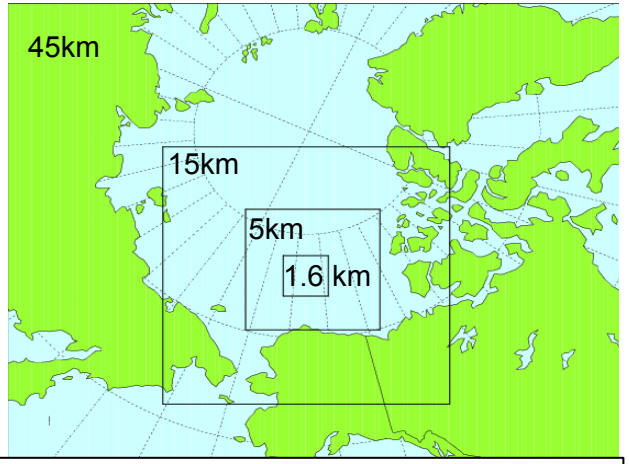
HYCOM-NAVGEM-CICE-WW3



Model grid resolution ~ 3.5 km

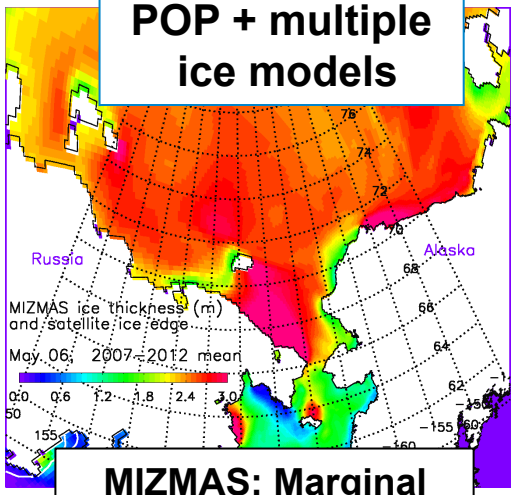
Black line is the independent ice edge location (NIC)

NCOM-COAMPS-CICE-WW3



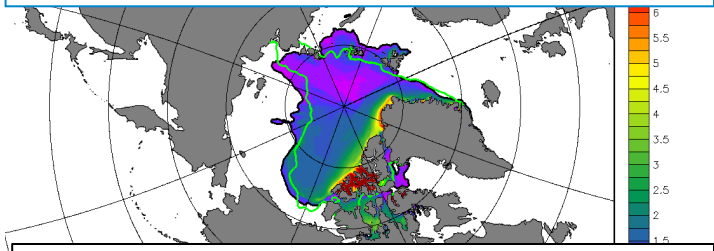
Future Regional Arctic System (RAS)
Flexible Coupled Relocatable Model Domain

POP + multiple ice models



MIZMAS: Marginal Ice Zone Modeling and Assimilation system (UW/APL)

POP-Polar WRF-CICE

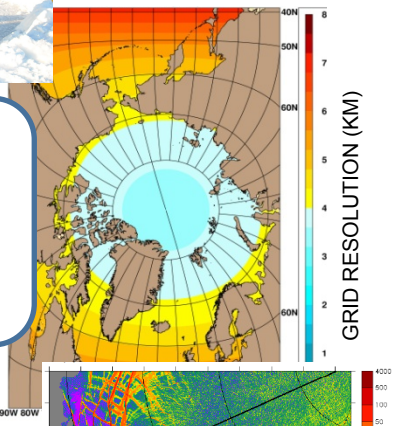


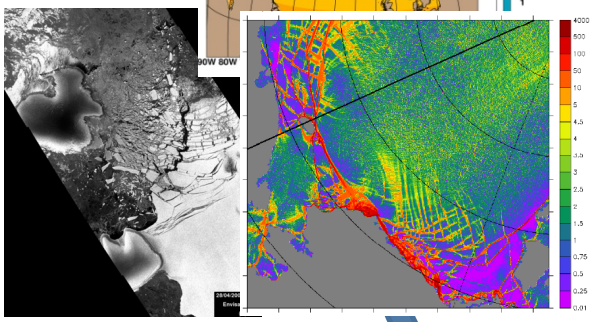
RASM: Regional Arctic System Model (NPS)

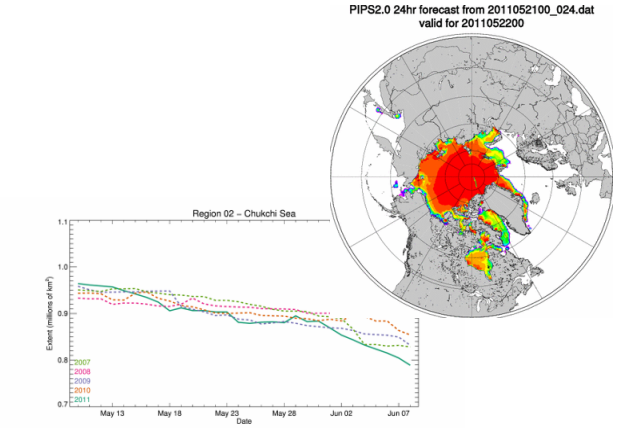
Development and Transition

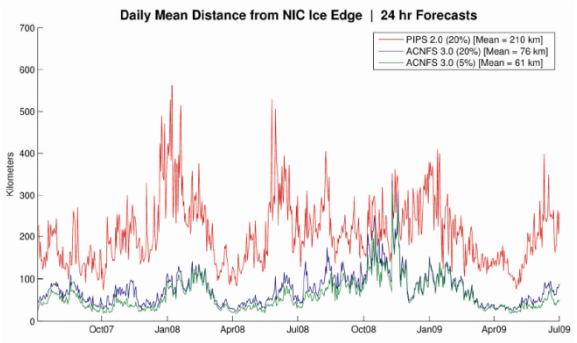
Fieldwork to better understand key physical processes

Improved physics built into data-assimilating integrated models









NAVAL METEOROLOGY AND OCEANOGRAPHY COMMAND

NATIONAL ICE CENTER
WASHINGTON D.C.

Arctic Prediction System Development

Validation and Verification

Transition to Operational Use

Major Arctic Fieldwork

2014: Emerging Dynamics of the Marginal Ice Zone DRI (FY12-FY16)

2015: Arctic Waves and Boundary Layer Physics DRI (FY13-FY17)

2016-2017: Canadian Basin Acoustic Propagation Experiment (CANAPE)

2017-2018: Stratified Ocean Dynamics in the Arctic DRI (FY16-FY20)






2014 Marginal Ice Zone DRI

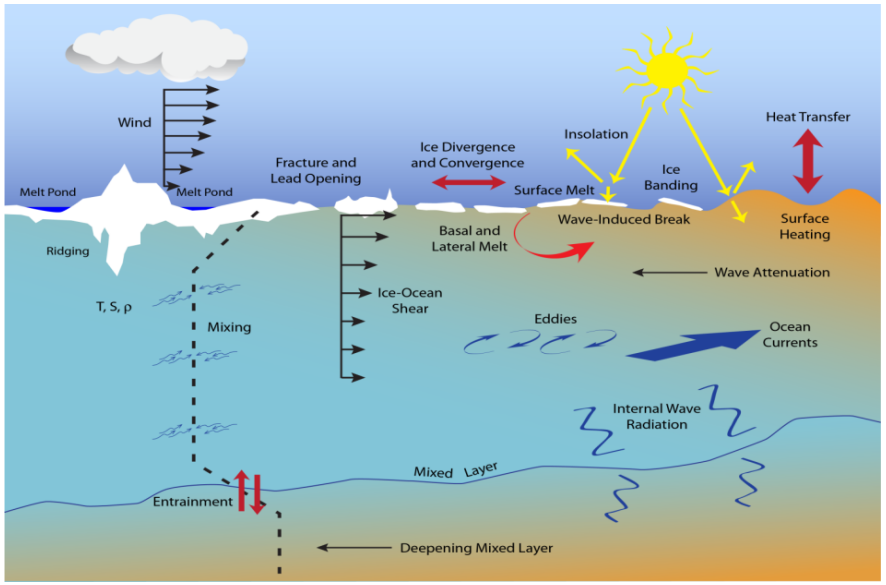
Scientific Objectives

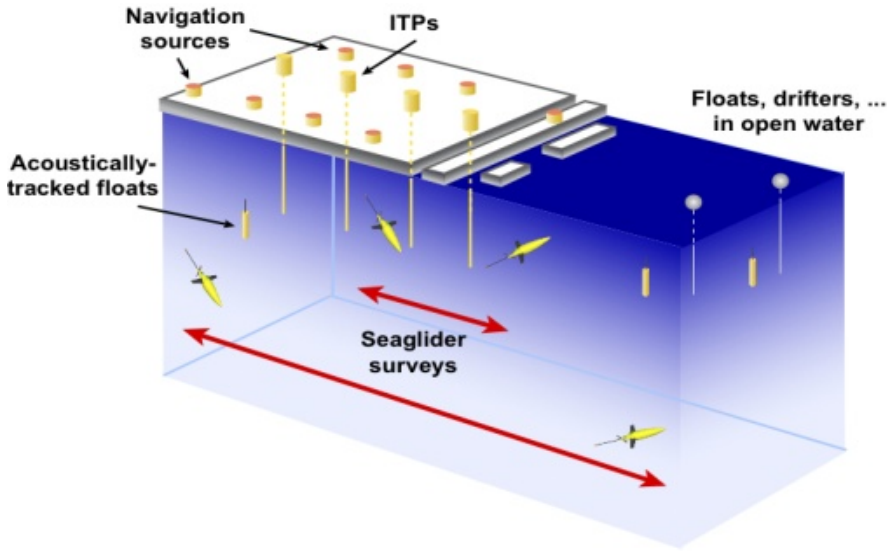
- Understand the physics that control **sea ice break up and melt** in and around the ice edge
- Characterize changes in physics associated with **decreasing ice/increasing open water**
- Explore feedbacks in the ice-ocean-atmosphere system that might increase/decrease the **rate of sea ice decline**

Technical Objectives

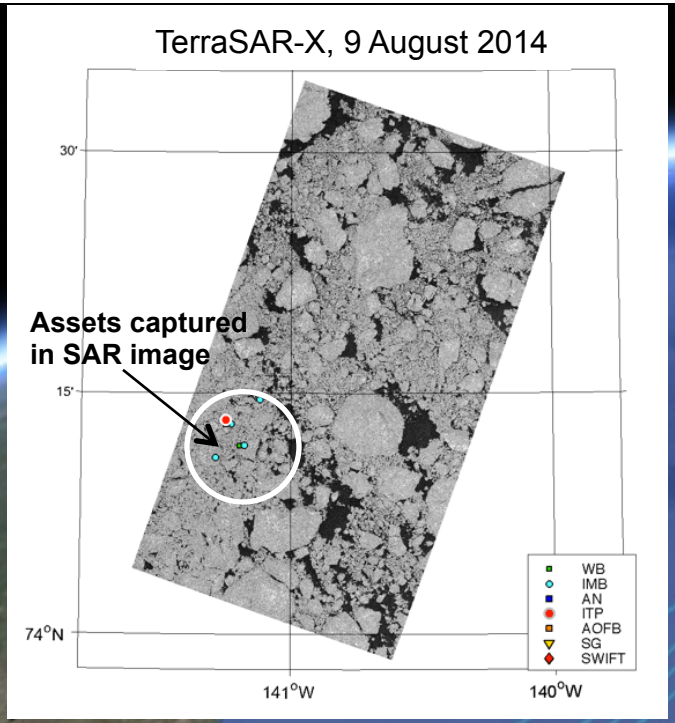
- Develop and demonstrate new **robotic networks** for collecting observations in, under, and around sea ice
- Improve interpretation of **satellite imagery** in the Arctic
- Improve numerical models to enhance **forecast capability**

See "Investigating the Beaufort Sea Marginal Ice Zone with Robotic Technology" by Craig Lee and Lee Freitag, Wednesday morning @ 10:40am





2014 MIZ Remote Sensing of Sea Ice



CSTARS

TerraSAR-X (418 images)

Radarsat-2 (69 images)

675 SAR collections (with another 464 available)

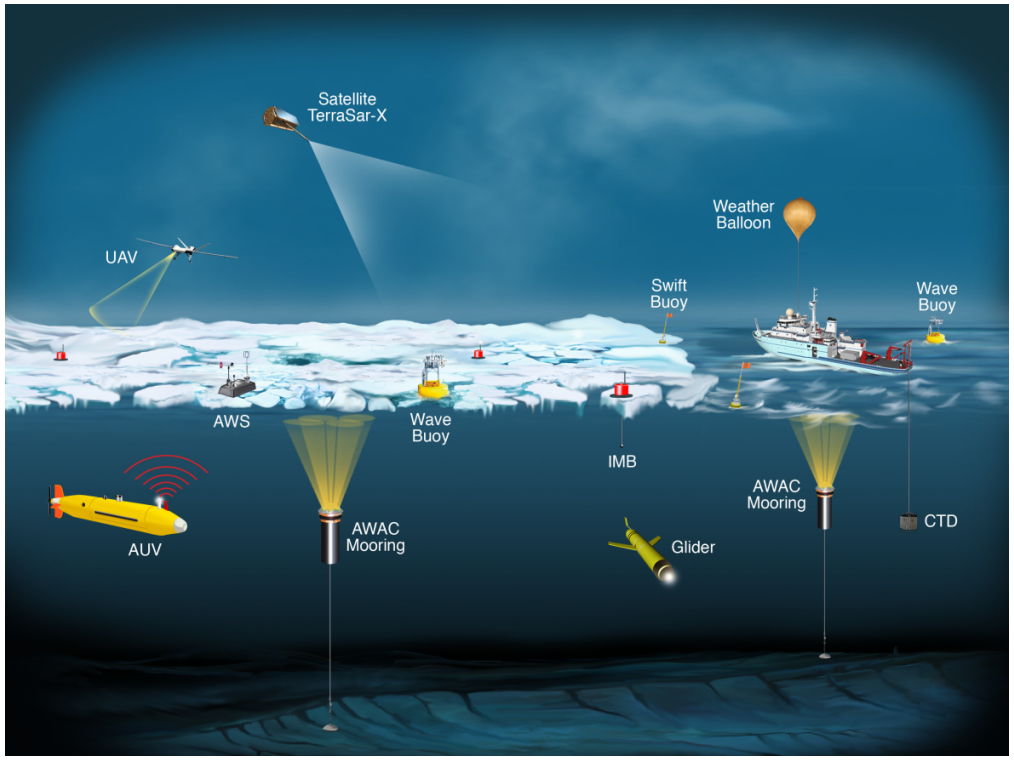
- Agile targeting to follow drifting instruments, respond to rapidly-evolving MIZ
- Targeting strategy and protocols developed & tested prior to main program
- Small targeting team (remote sensing, models, observations)
- Dedicated meteorological reports & drift forecasts inform targeting

2015 Field Effort: Arctic Waves and Sea State DRI

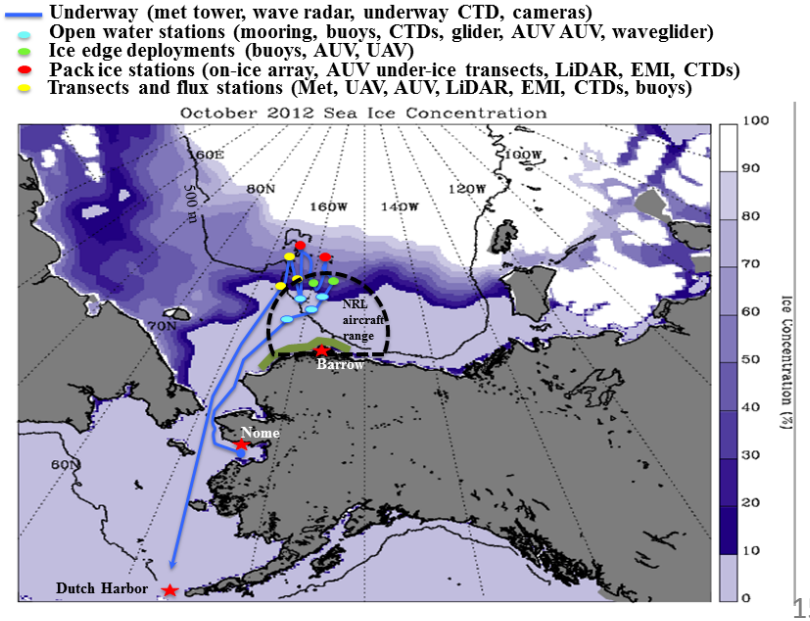
R/V Sikuliaq cruise, 01 Oct – 10 Nov 2015 in the Beaufort and Chukchi Seas

Project involves modeling, *in situ* observations, and remote sensing to:

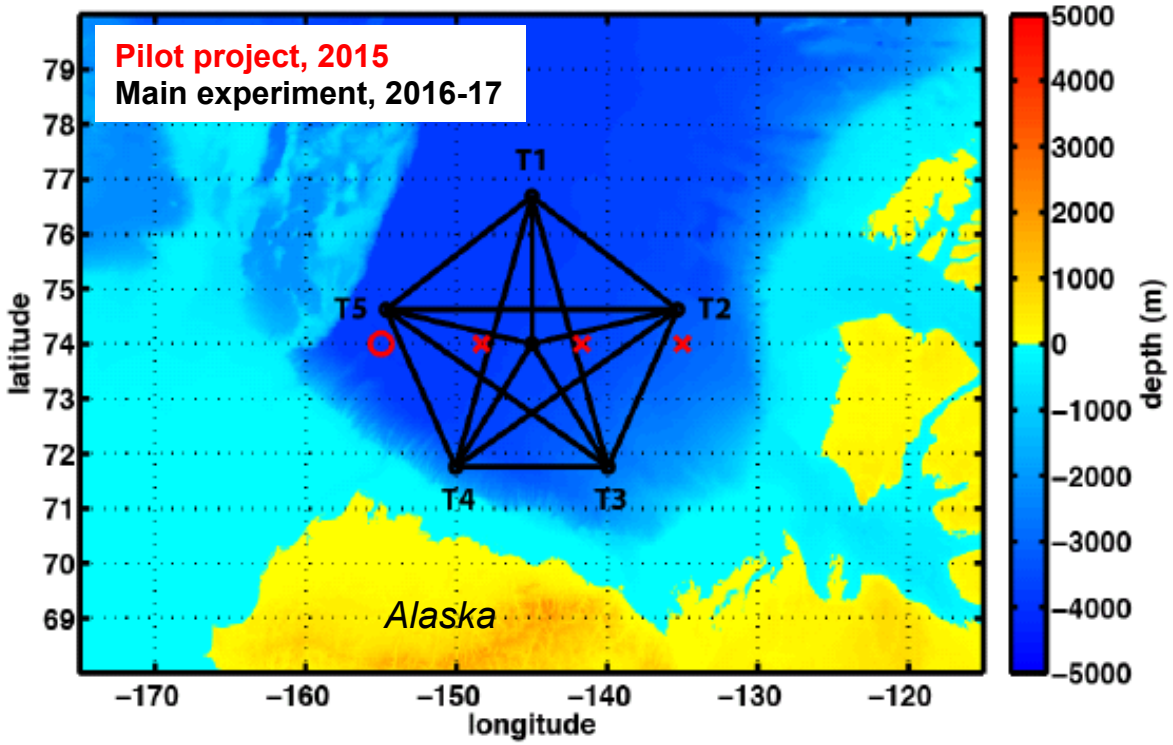
- Develop a sea state climatology for the "new" Arctic Ocean
- Improve wave forecasting in the presence of sea ice
- Improve theory of wave attenuation/scattering in the sea ice cover
- Apply wave–ice interactions directly in integrated arctic system models
- Understand heat and mass fluxes in the air–sea–ice system



See "Sea State and Boundary Layer Physics of the Emerging Arctic Ocean" poster by Jim Thomson, et al., in the lobby



CANAPE: Canada Basin Acoustic Propagation Experiment, 2015-2017



ONR POC: Dr. Robert Headrick, Bob.Headrick@navy.mil

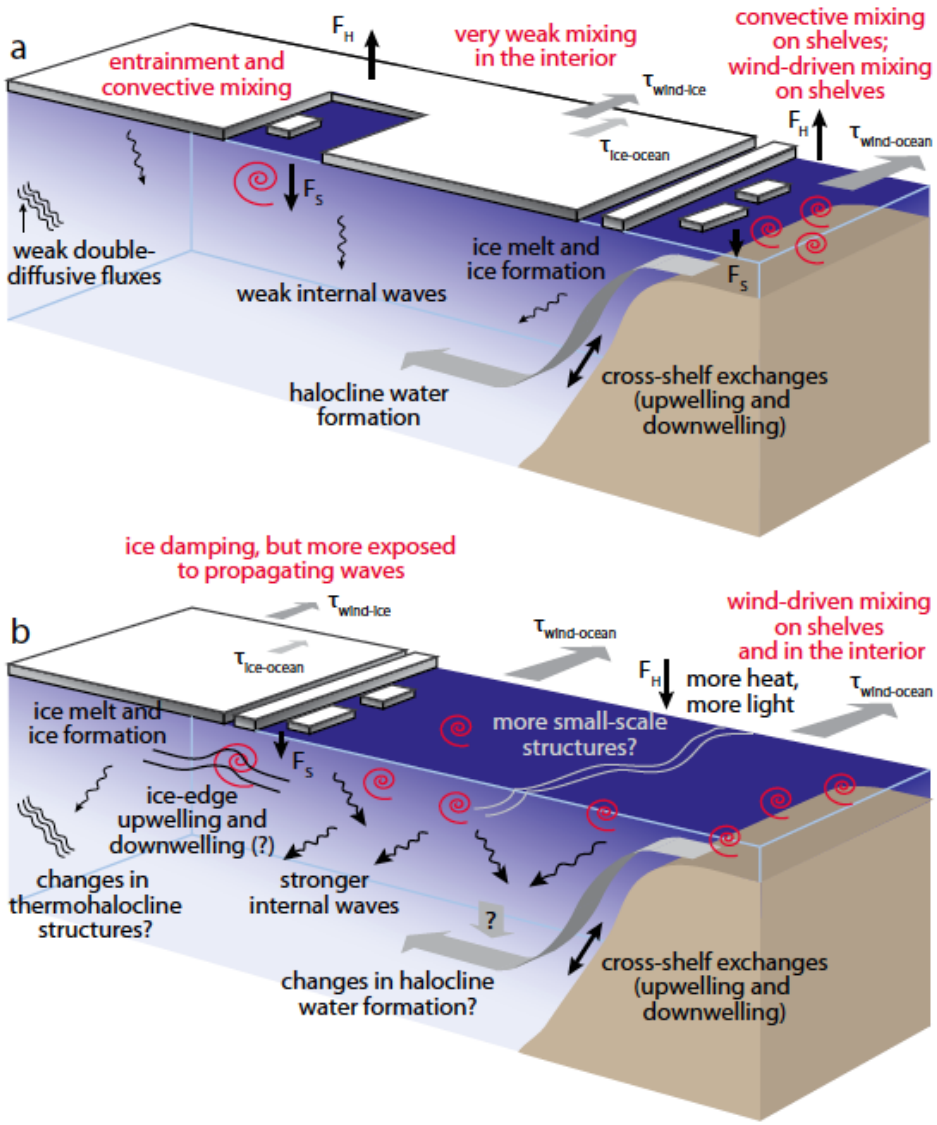
Goals

1. **Acoustic propagation:** Understand the impacts of changing sea ice and oceanographic conditions on acoustic (200-300 Hz) propagation and fluctuations.

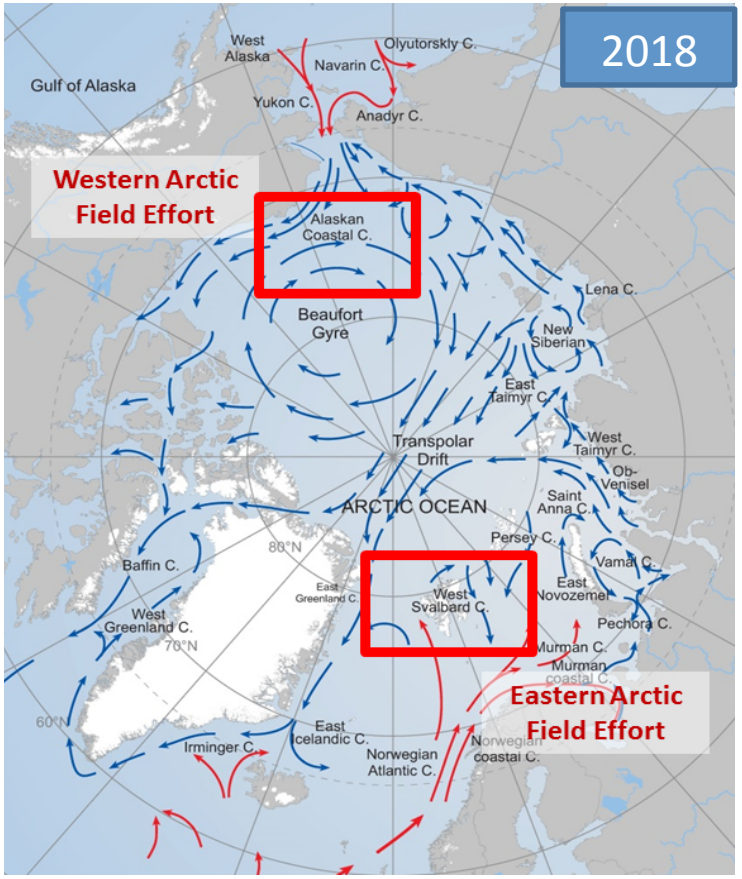
2. **Ambient noise:** Characterize the depth dependence and temporal variability of the ambient noise field.

3. **Physical oceanography:** Measure the spatial and temporal variability in the upper ocean over an annual cycle and determine whether acoustic methods, together with other measurements and ice/ocean modeling, can yield estimates of the time-evolving ocean state useful for understanding the local ocean dynamics and for making improved acoustic predictions.

Stratified Ocean Dynamics in the Arctic (SODA) FY16 – FY20



Reduced ice cover in summer may lead to changes in ocean mixing, stratification, and circulation.



USCG Coordination

Seasonal Ice Zone Reconnaissance Surveys (SIZRS)

Use Arctic Domain Awareness flights for scientific instrument deployment

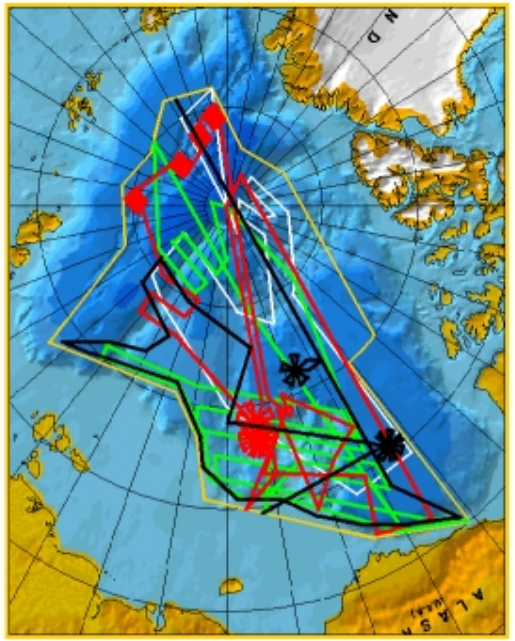
- Conduct repeat (2-4 week intervals) atmospheric and oceanographic surveys of the seasonal ice zone using US-Coast Guard ADA flights (May-Sept. 2012-2017)
- Air deployed ocean sensors (AXCTD, AXCP), drifters
- Multispectral Imaging, LIDAR
- Atmospheric sensing (Dropsondes, drifting buoys)
- Regional modeling (Atmosphere-Ice-Ocean)
- Micro-Aircraft/Smartsonde development

USCG Kodiak C-130H

SCICEX and ICEX Activities

Coordinated effort between the research community and operational Navy to take scientific-quality observations in the Arctic from submarines

- **SCICEX Phase I: Dedicated Science Missions**
  - Vital role measuring Arctic bathymetry, ice, ocean
  - Dedicated science cruises ended in 1999
- **SCICEX Advisory Committees**
  - Science Advisory Committee (SAC)
  - Inter-Agency Committee (IAC)
    - ONR, NSF, USARC, ASL
- **SCICEX Phase II Science Plan Developed in 2010**
  - Currently running "Science Accomodation Missions"
  - "Menu" of preferred measurements to be taken in desired locations, time permitting
  - 2014 ICEX (March 2014) broke up early – better environmental information will be needed for ICEX'16

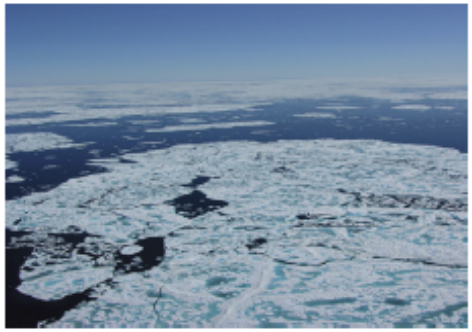


ONR Arctic Research Summary

ONR's Arctic Program is investing in research that will enable the Navy to prepare for and respond to future Arctic missions and concerns in recognition of the emerging interest in the region.

- **Enhanced <u>understanding of the emerging physical Arctic system</u>**
- **Development and use of new observing tools, with an emphasis on <u>autonomous platforms and sensors</u>**
- **Development of the Arctic component of Earth system numerical prediction models to enable <u>improved forecasts</u>**






Questions?

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Earth System Prediction Capability
Arctic and Global Prediction Program

USS Connecticut (SSN 22), ICEX 2011, Beaufort Sea.
Photograph by Dan Eleuterio, ONR