ONR's Arctic S&T Program

RADM Nevin Carr
Chief of Naval Research

Revolutionary Research . . . Relevant Results

OFFICE OF NAVAL RESEARCH

Naval S&T Strategic Plan

Revolutionary Research . . . Relevant Results

Focus Areas

- Power and Energy
- Operational Environments
- Maritime Domain Awareness
- Asymmetric & Irregular Warfare
- Information Superiority and Communication
- Power Projection
- Assure Access and Hold at Risk
- Distributed Operations
- Naval Warfighter Performance
- Survivability and Self-Defense
- Platform Mobility
- Fleet/Force Sustainment
- Total Ownership Cost

Near

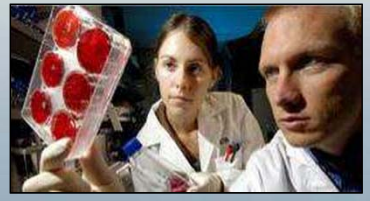
Solid State Lights for Submarines

Mid

Advanced Materials

Long

LD UUV



D&I

How We Execute

- 70 Countries
- 50 States
- 1,078 Companies
  - 859 small businesses
- 1,035 Universities & Nonprofit Entities
  - 3,340 principal investigators
  - 3,000 grad students

Historical Perspective

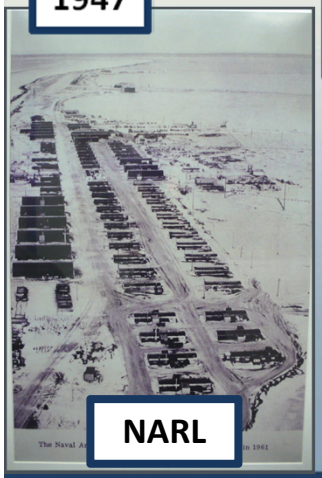
Revolutionary Research . . . Relevant Results

INVESTIMENT

ONR BASIC ARCTIC RESEARCH FUNDING

NSF AND OTHER FEDERAL AGENCIES

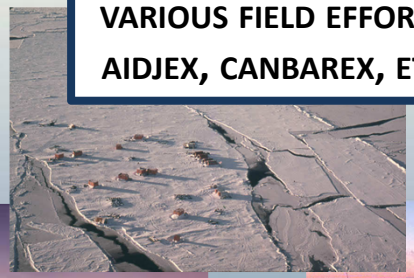
1947

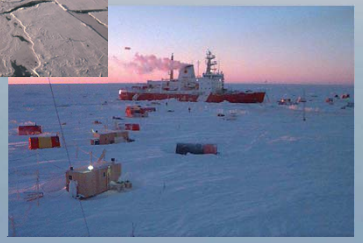


NARL

1957 IPY

VARIOUS FIELD EFFORTS
AIDJEX, CANBAREX, ETC





1981

CLOSING OF NARL

1990

END OF THE COLD WAR

2003

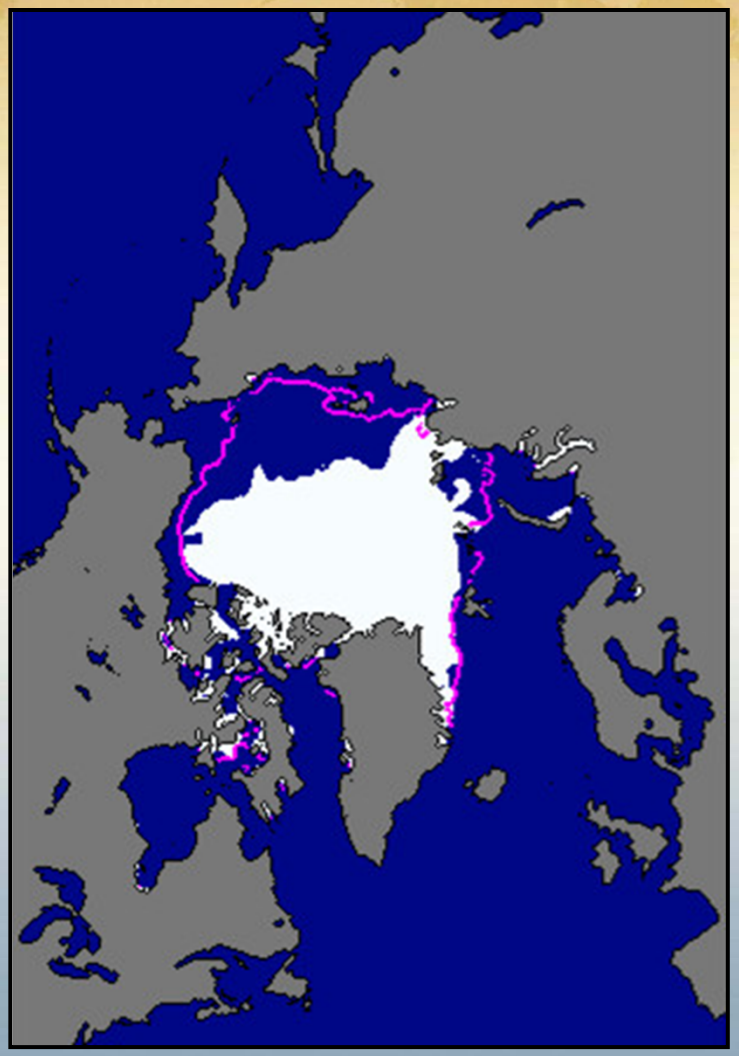
END OF HIGH-LATITUDE DYNAMICS PROGRAM

SCICEX

2011

ESTABLISH ARCTIC RESEARCH PROGRAM

Historical Perspective



Reduction in Summer Sea Ice Cover since 1979

Emerging Requirements

N2N6E's Task Force Climate Change: Must have Arctic environmental information to support future operations

NORTHCOM: Must have "improved ability to observe and predict the Arctic environment"

S&T required to enable Arctic domain awareness

Arctic Questions
Operational

- When is the sea ice going away?

  -Requires improved physical knowledge and a better prediction capability

- How is the Arctic going to be different?

  - Need comprehensive knowledge of the fully-integrated Arctic system

- What does the Navy need to know to operate in the current and future Arctic?

  - Will require the ability to observe and predict the Arctic environment, and a better understanding of how platforms, sensors, and systems will be impacted

- How will the changing Arctic impact the rest of the globe?

  - Arctic system model must be part of global seamless prediction

Arctic Questions
Naval S&T

- If the Arctic sea ice volume continues to diminish, what are the implications of the shift from a "cold desert" to a "lake effect" climate?
  - impact on waves, snowfall, surface fluxes, storm strength and frequency, etc

- Can we extend our synoptic forecast skill by using earth system models developed for climate?

- How can we capture these new processes in a model constrained by remote sensing and sparse in situ data (AUVs)?

- How can we effectively use commercial imaging radars (like SAR)?

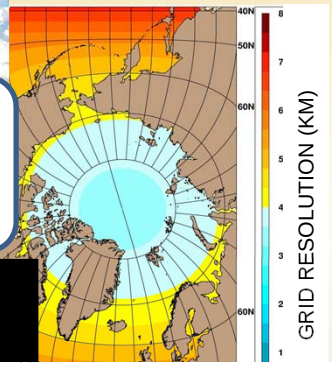
- How is Arctic acoustic propagation and scattering changing?

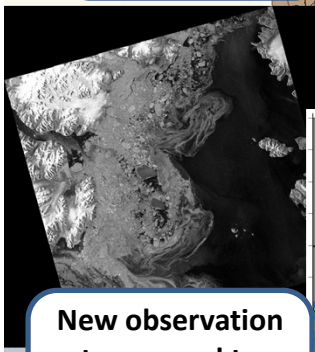
Development & Transition

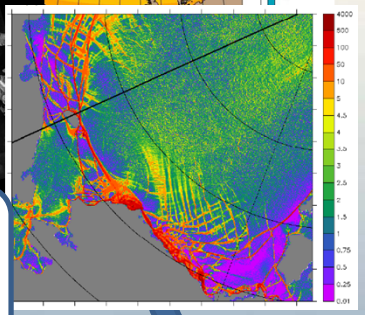
Revolutionary Research . . . Relevant Results

Fieldwork to better understand key physical processes

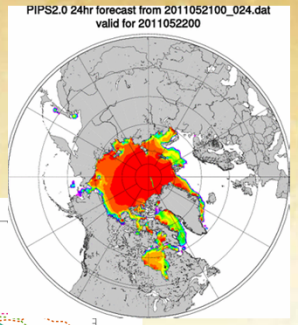
Improved physics built into Arctic system models

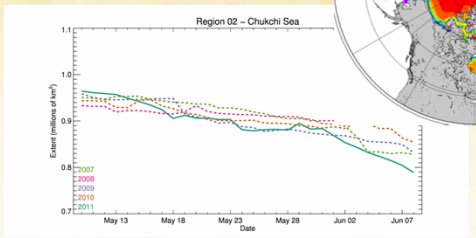


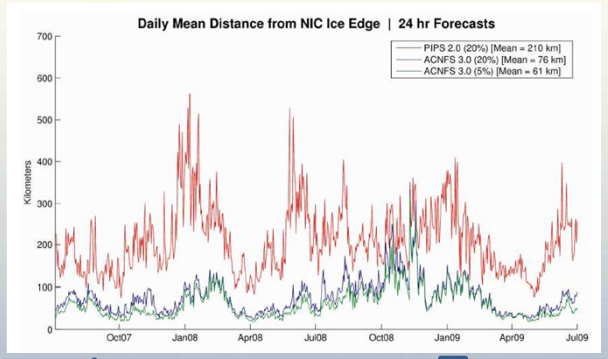




New observation types used to constrain model predictions







NAVAL METEOROLOGY AND OCEANOGRAPHY COMMAND

NATIONAL ICE CENTER
WASHINGTON D.C.

Arctic Prediction System Development

Validation and Verification

Transition to Operational Use

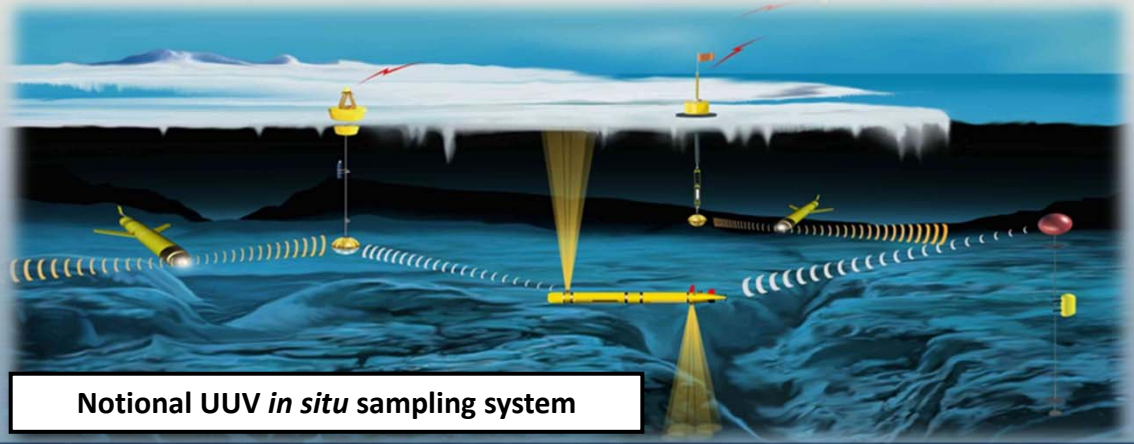
ONR Arctic Research Program

Revolutionary Research . . . Relevant Results

MAJOR THRUSTS:

- Generation of **new technologies** (platforms, sensors, communications) that will enable **persistent observation and operation** in the Arctic
- **Improved basic physical understanding** of the Arctic environment and important coupled processes operating in the Arctic region
- **Development of a new, dynamic, fully-integrated Arctic System Model** incorporating the ocean, sea ice, waves and atmosphere for improved prediction at longer lead times, including the use of **satellite SAR data** for assimilation into integrated models

SAR Sea Ice Imagery



Notional UUV *in situ* sampling system

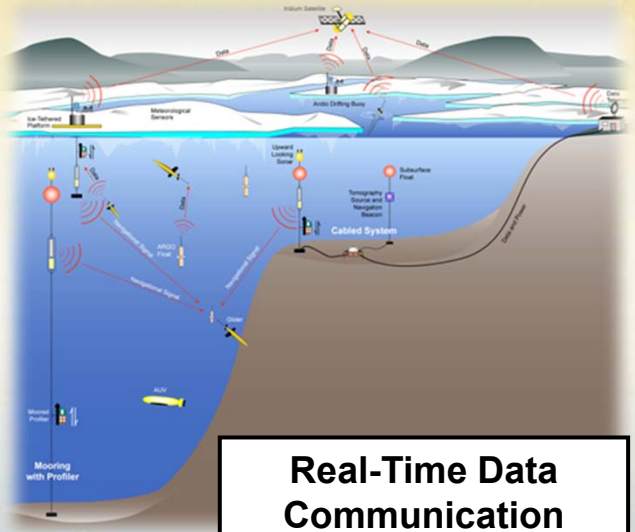
Advances in technology will be required to develop an Arctic Observing Network that will support scientific exploration and be able to initialize predictive models of the environment

Technology Development

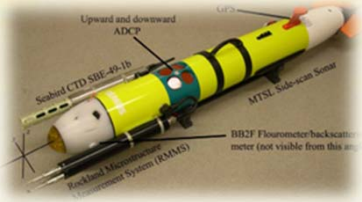
Revolutionary Research . . . Relevant Results

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

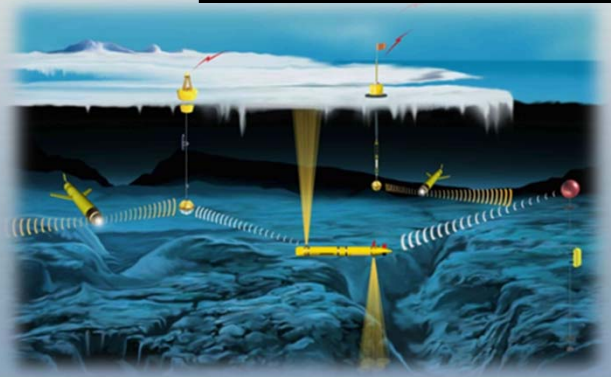
Autonomous platforms – Robust Sensors – Real-time Data Delivery – Key Environmental Variables

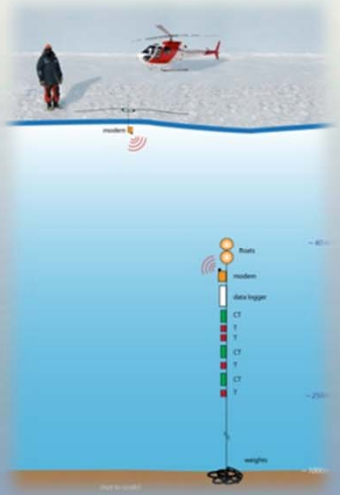


Novel Sensing Systems

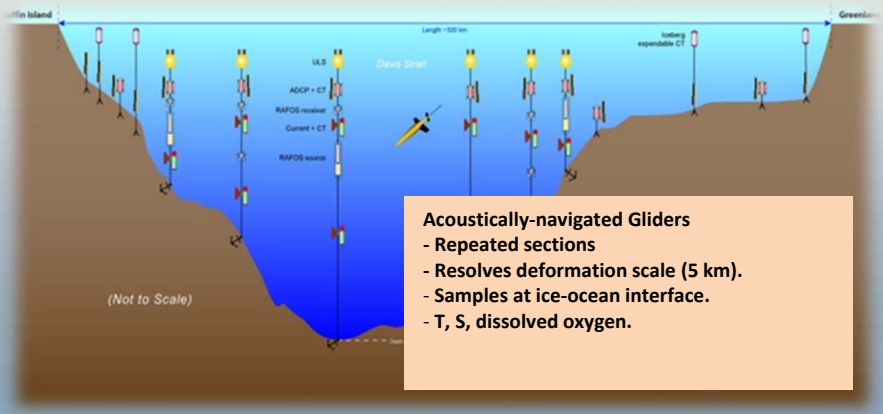


Real-Time Data Communication





Autonomous Platforms and Enabling Technologies



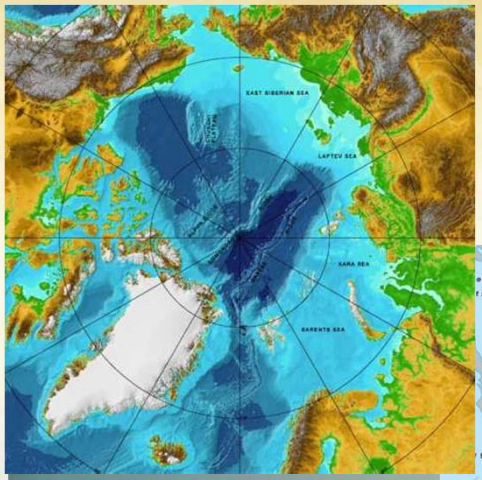
Acoustically-navigated Gliders
- **Repeated sections**
- **Resolves deformation scale (5 km).**
- **Samples at ice-ocean interface.**
- **T, S, dissolved oxygen.**

Improved Physical Understanding

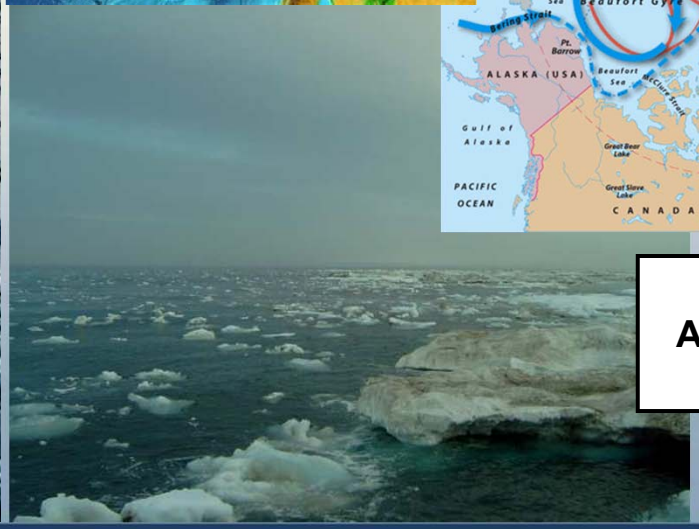
Revolutionary Research . . . Relevant Results

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

Sea ice dynamics



Changes in Atmospheric Circulation and Variability



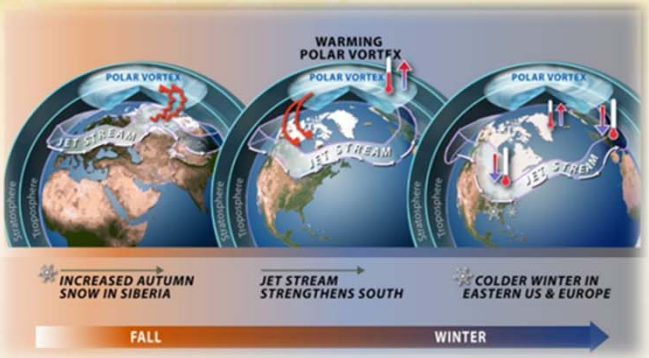
Changes in the Acoustic Structure of the Arctic Ocean

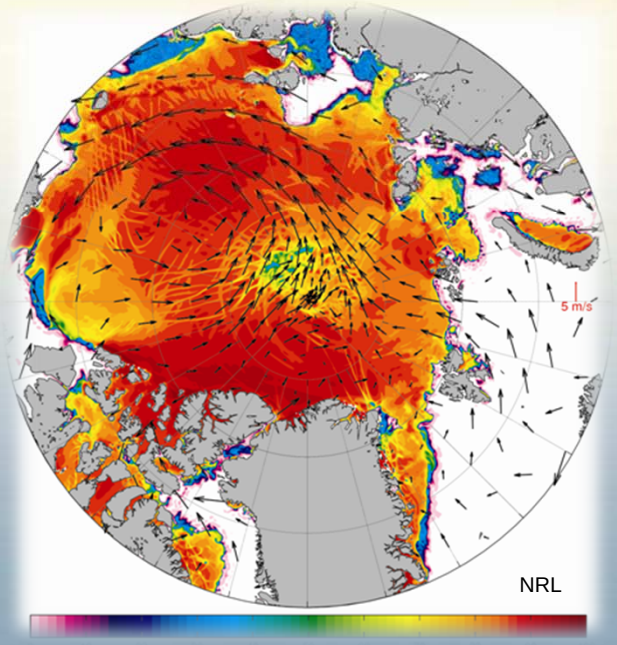
Integrated Arctic Modeling and Prediction

Revolutionary Research . . . Relevant Results

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

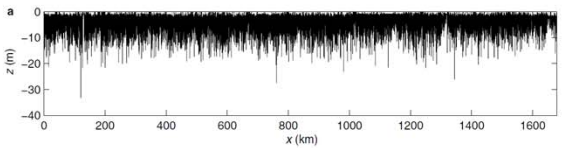
Integrated Arctic System Models
ocean – ice – wave – atmosphere



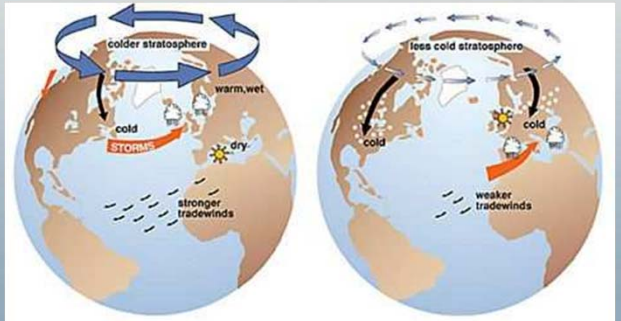


Coupling with Global Earth System Models

Advanced Data Assimilation



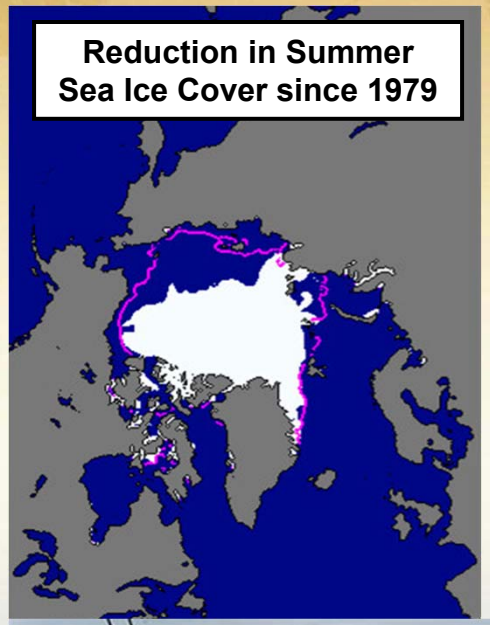
Ice thickness measured from below



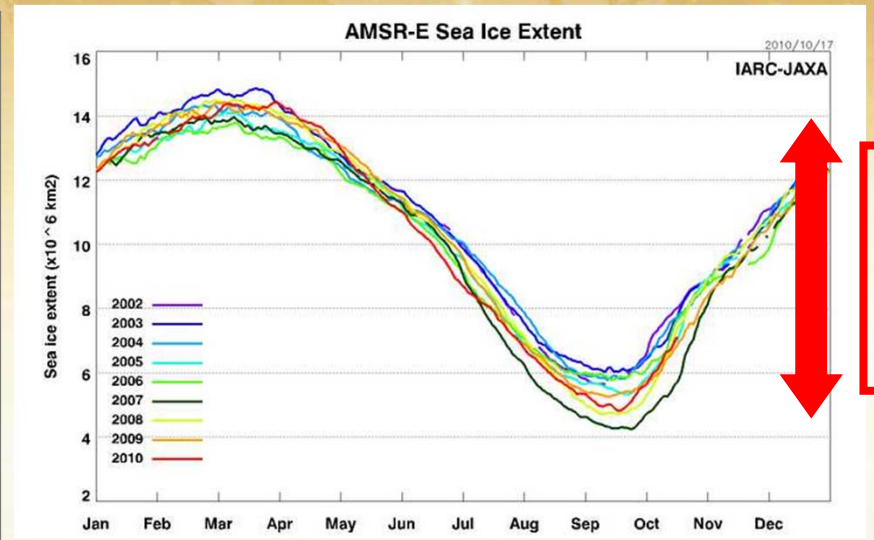
J. Wallace, University of Washington

First Field Effort:
Emerging Dynamics of the Marginal Ice Zone

Revolutionary Research . . . Relevant Results



Reduction in Summer Sea Ice Cover since 1979

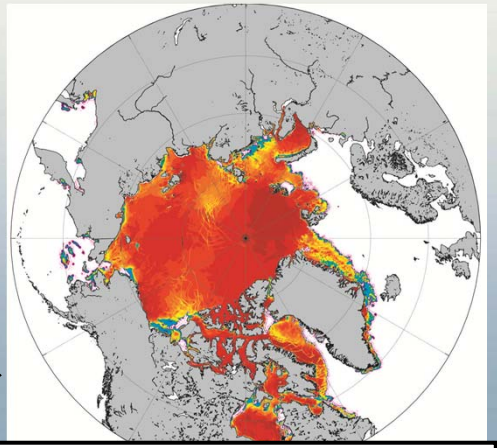


The Arctic is becoming more ice-dynamic, with a larger area of sea ice melt and re-freeze on an annual basis.

Targeting 2014 for a major observational field program

GOAL: Better understanding of the coupled physical processes operating in the Marginal Ice Zone

Better understanding of the MIZ physics will enable improved ice-dynamic models of the Arctic

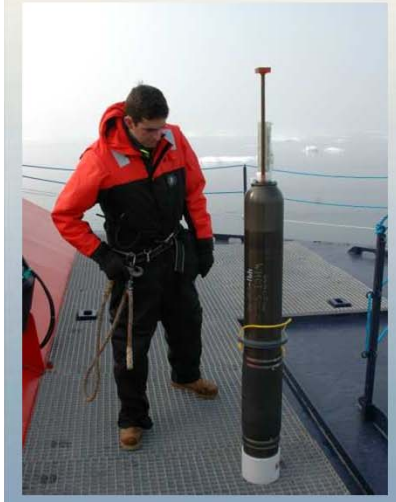


Snapshot of Ice Concentration from coupled HYCOM / CICE model

ICEX 2011

ONR
Revolutionary Research . . . Relevant Results

Questions?

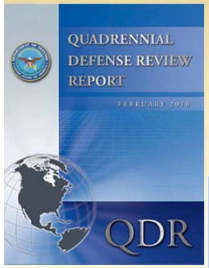


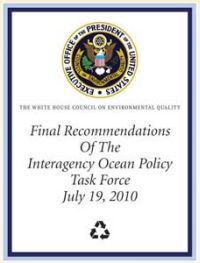
Revolutionary Research . . . Relevant Results

Backup Slides

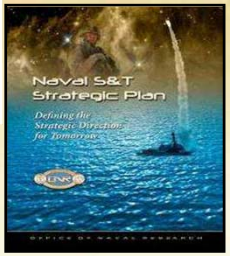
Formulating Arctic S&T Priorities

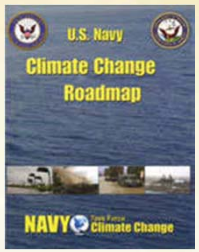
Revolutionary Research . . . Relevant Results



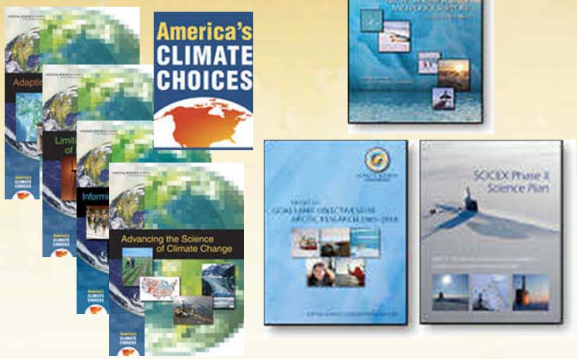


High Level DOD, Navy, and Executive Branch Priorities





Specific Strategic Naval Needs



Academic Recommendations

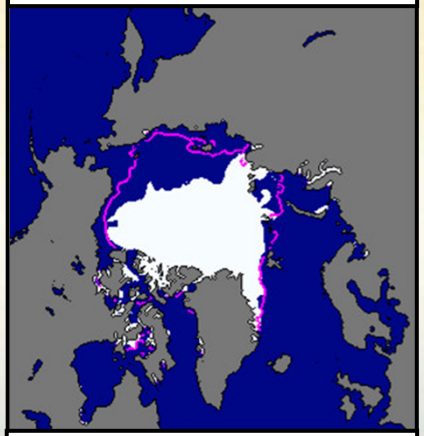
ONR Arctic Program Research Goals

Establishment of an Arctic Research Program

ONR — Revolutionary Research . . . Relevant Results

In response to priorities identified by N2/N6 Task Force Climate Change

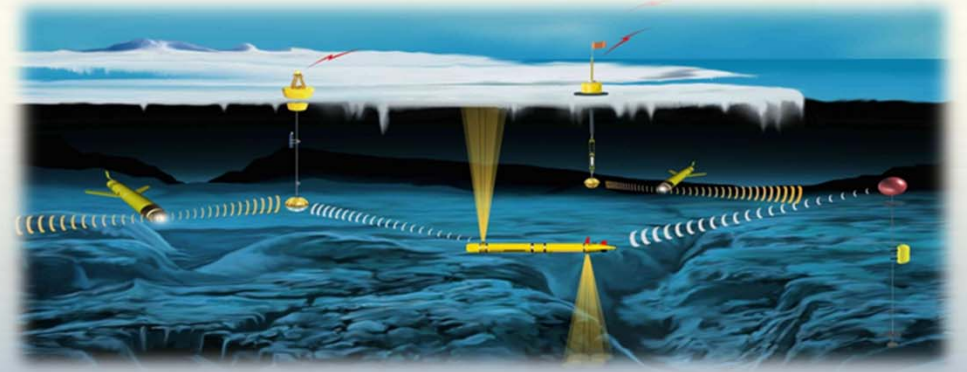
FY12-start DRI: Dynamics of the Marginal Ice Zone



Reduction in Summer Sea Ice Cover since 1979

Program Goals:

- Improved basic understanding of the physical environment and relevant processes in the Arctic region
- Development of integrated (ocean-ice-wave-atmosphere) earth system models for improved prediction of the Arctic operational environment at longer lead times
- Exploration of new technologies (platforms, sensors, communications) required for persistent observation and operation in the harsh Arctic environment



FY11 Activities: Begin fund realignment by supporting observations related to the Arctic Submarine Lab's SCICEX Program (SCience ICe EXercise) and 2011 ICEX Ice Camp

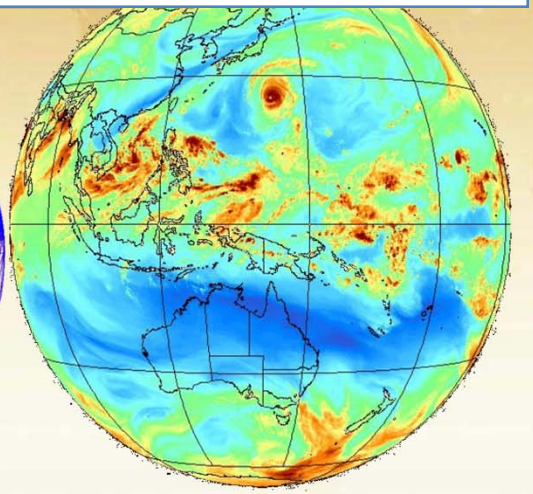
- Funding NRL-DC to make airborne measurements of sea ice thickness
- Testing new submarine-launched XCTD system
- Enabling calibration of on-board biogeochemical sampling equipment
- Processing ice draft information from sub-based Upward Looking Sonar (ULS) data

Seamless Global Prediction

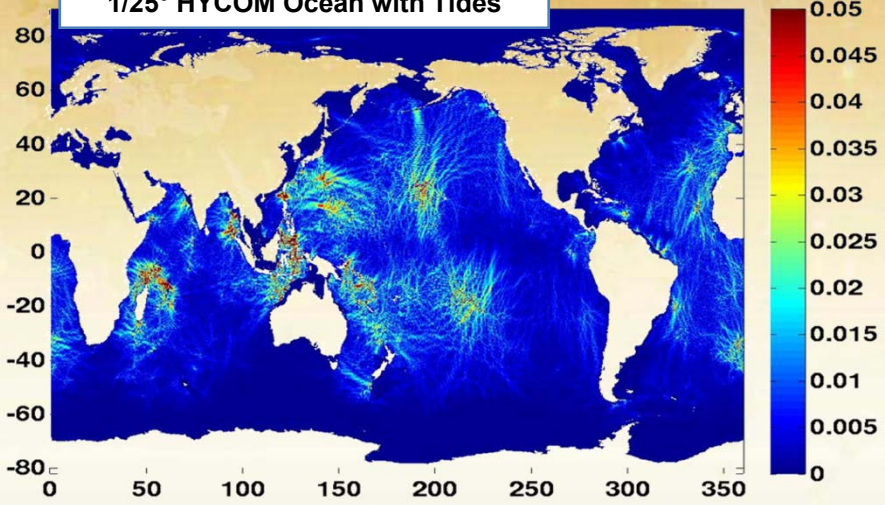
Revolutionary Research . . . Relevant Results

Adaptive Grid Capability

High-res Global Water Vapor Forecast



1/25° HYCOM Ocean with Tides



ONR's new effort will focus on building the next-generation integrated global prediction system to support the needs of the US Navy in 2020:

- **Fully-integrated** ocean-wave-ice-atmosphere model
- Appropriately coupled across a **wide range of space and time scales**
- Provide **improved short-term (< 7 days) predictions** of the physical environment in support of safe, efficient, and effective naval operations
- Provide **extended-range predictions** for Navy strategic resource decisions
- **Understand relevant physics** to inform and enable longer (decadal+) predictions
- Define the **limits of predictability** for different physical variables and processes

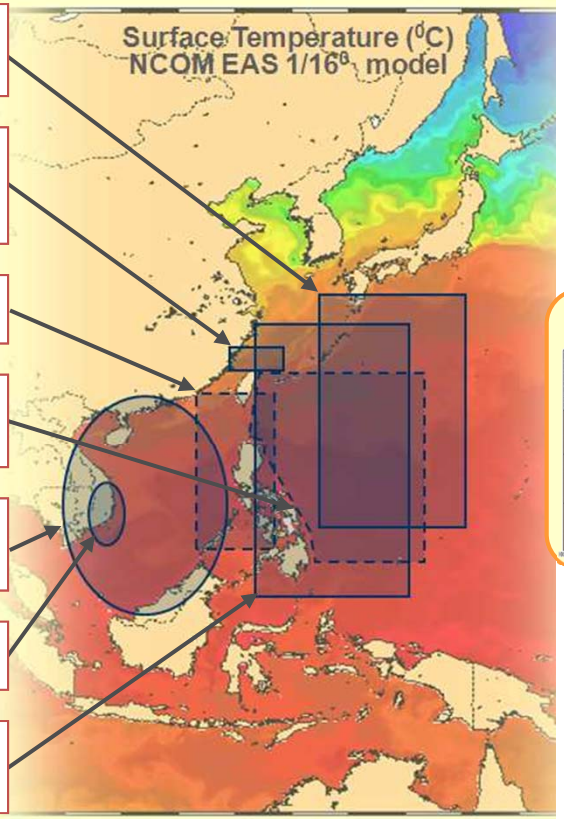
Basic and Applied Research for Building the Navy's Environmental Prediction System

(The world's largest operational, integrated environmental prediction system)

WESTPAC Basic Environmental Research → **Observations, Discoveries, Inventions** → **Develop/Improve 25+ Operational Prediction System Components**

*ONR Field Studies**

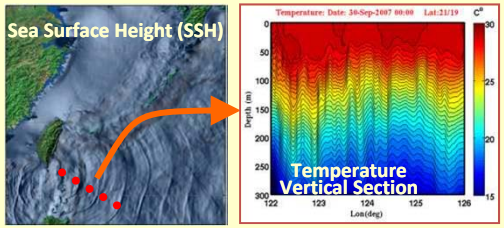
- Impacts on Western Pacific Typhoon Predictability
- Quantifying, Predicting, Exploiting Uncertainty
- Internal Waves in Straits Experiment
- Origins of the Kuroshiro and Mindanao Currents
- Vietnamese Shelf and South China Sea Variability
- Remote Sensing of Deltas
- Typhoon Impacts on the Western Pacific Ocean



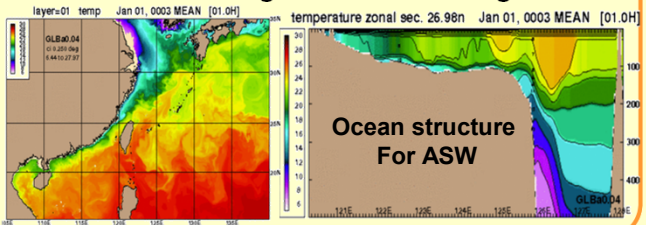
** Ongoing FY11*

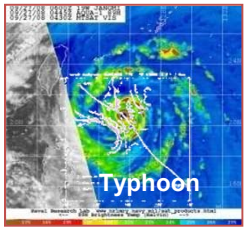
ONR Model Development

Internal Waves = Propagation Variability



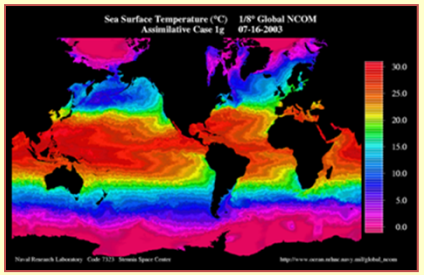
HYCOM 1/25th Degree Tide Resolving Model



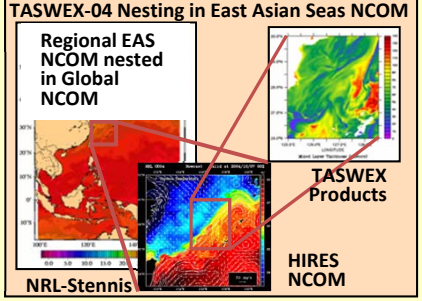


New technology

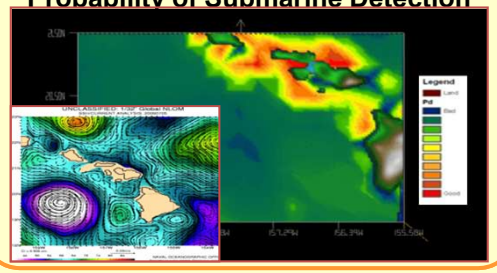
CNMOC Transitioned Predictions



TASWEX-04 Nesting in East Asian Seas NCOM



Probability of Submarine Detection



FNMOC &NAVOCEANO distribute 1000s of product sets per day to Support Navy and other DoD users in Peace and war

Navy R&D focus on OCONUS areas of special operational interest and for specific Warfare missions