



ONR's Arctic S&T Program

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Chief of Naval Research

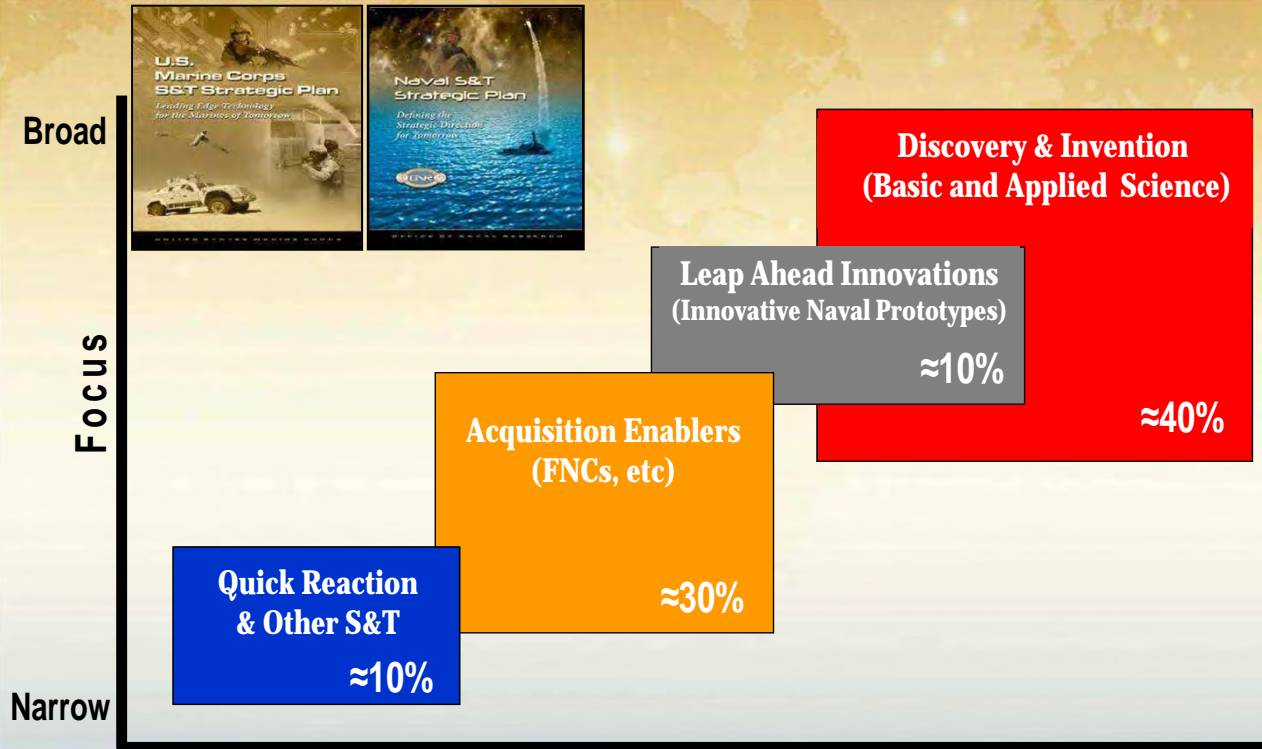


Revolutionary Research . . . Relevant Results

O F F I C E O F N A V A L R E S E A R C H

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Naval S&T Strategic Plan



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



ONR Global

FFRDCs

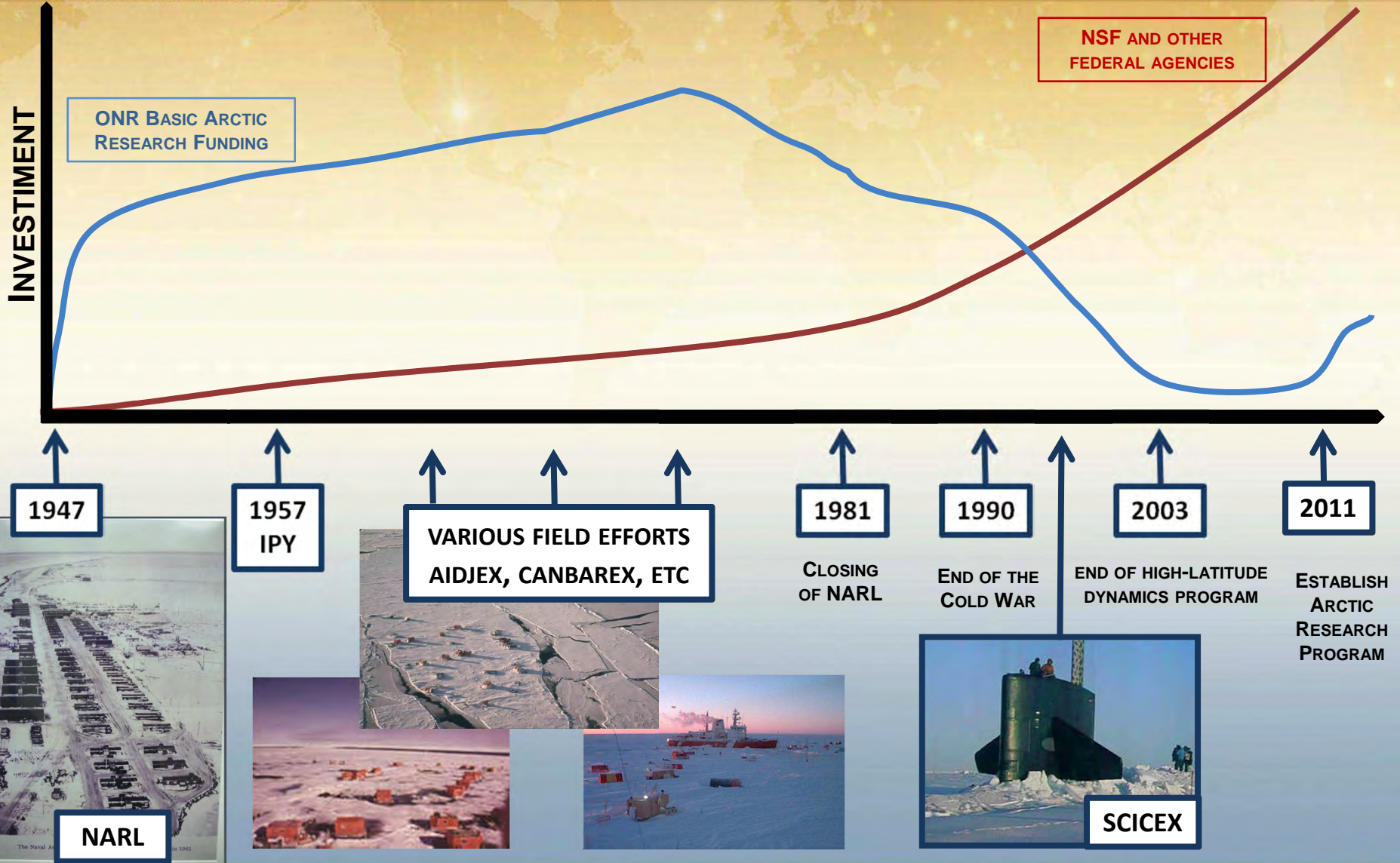
UARCs/Academia

Industry

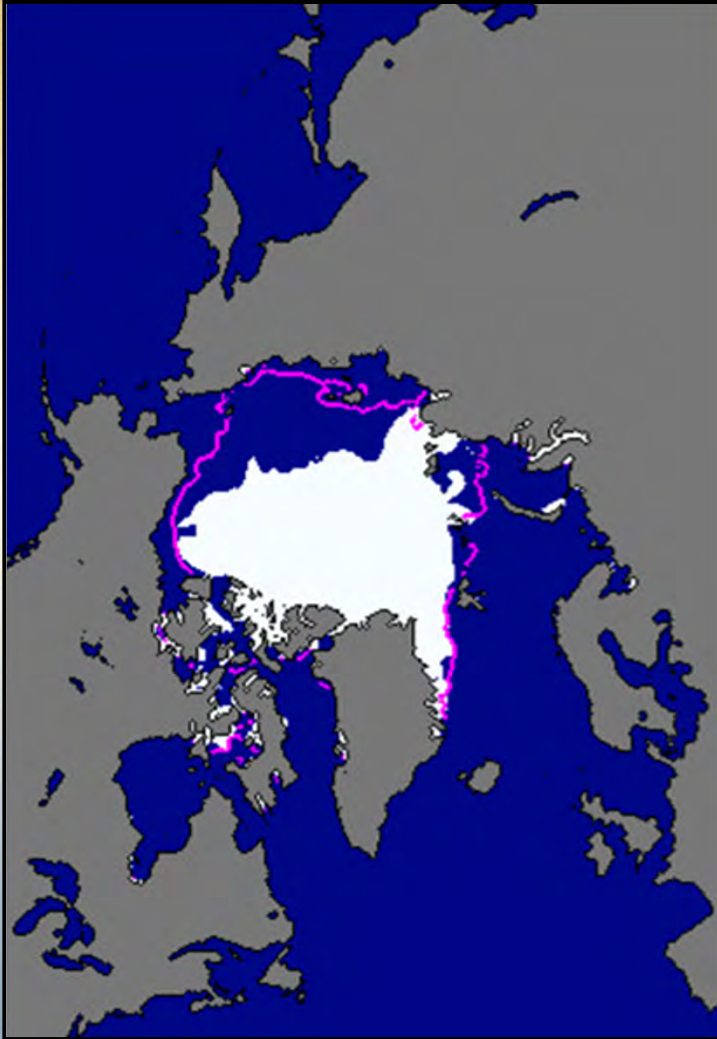
NRL/Warfare Centers

- **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



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

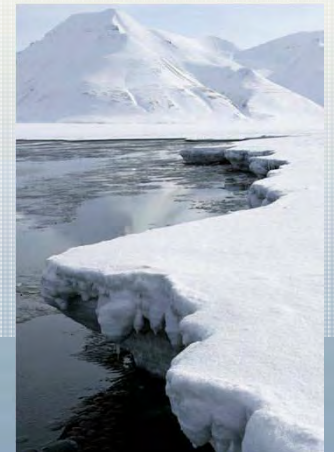


- When is the sea ice going away?
 - Requires improved physical knowledge and a better prediction capability
- How is the Arctic going to be different?
 - Need comprehensive knowledge of the fully-integrated Arctic system
- What does the Navy need to know to operate in the current and future Arctic?
 - 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?

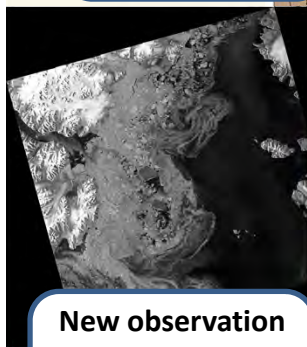
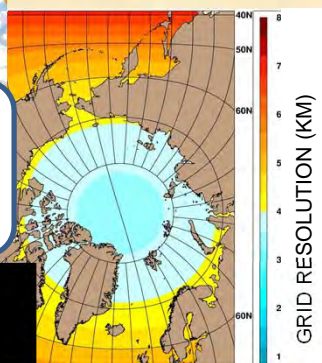


Development & Transition

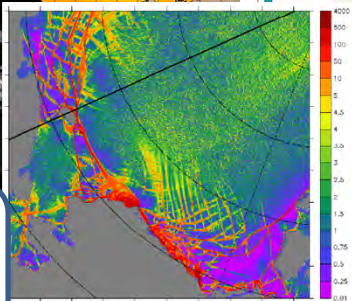


Fieldwork to better understand key physical processes

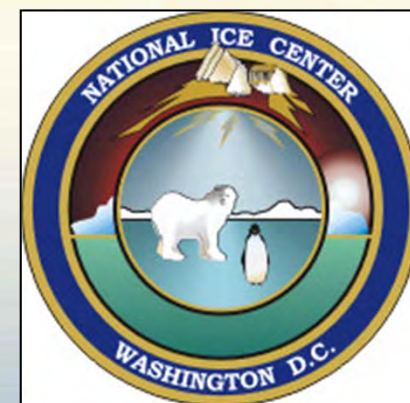
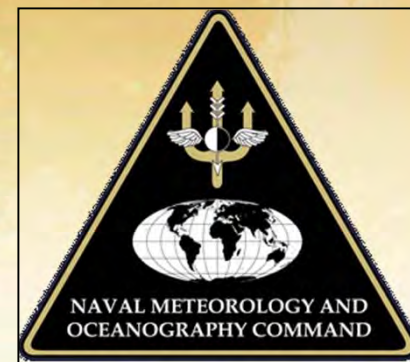
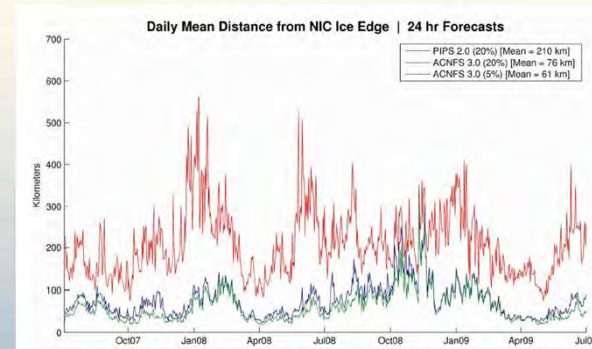
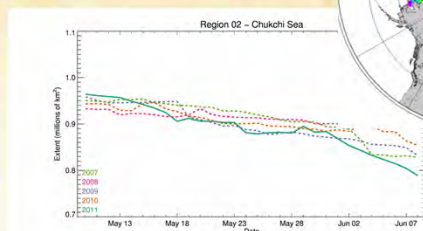
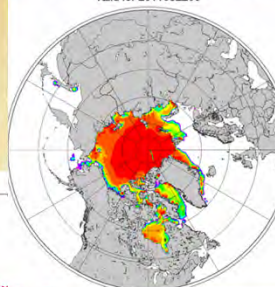
Improved physics built into Arctic system models



New observation types used to constrain model predictions



PIPS2.0 24hr forecast from 2011052100_024.dat valid for 2011052200



Arctic Prediction System Development

Validation and Verification

Transition to Operational Use

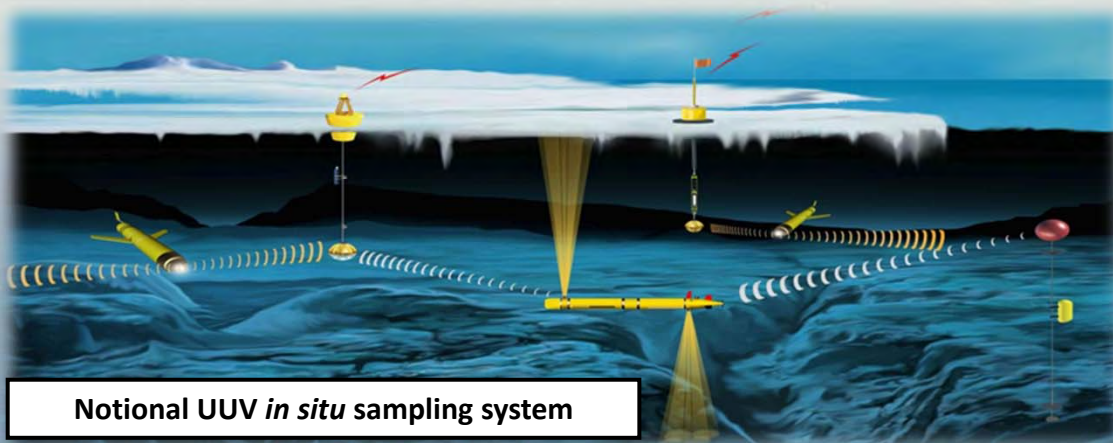
ONR Arctic Research Program

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



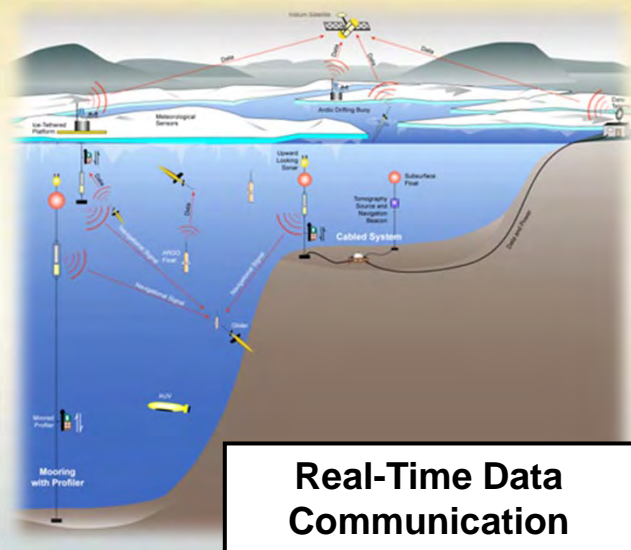
Notional UUV *in situ* sampling system

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

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

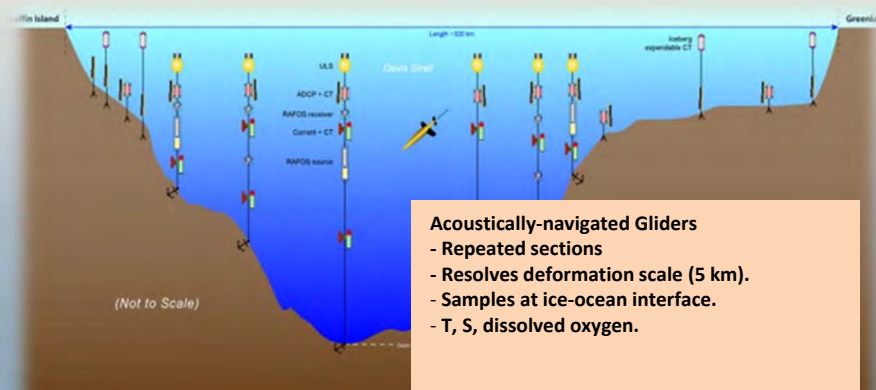
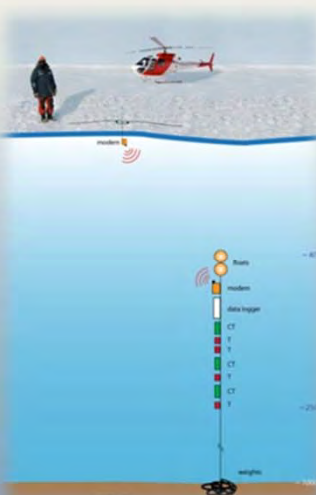
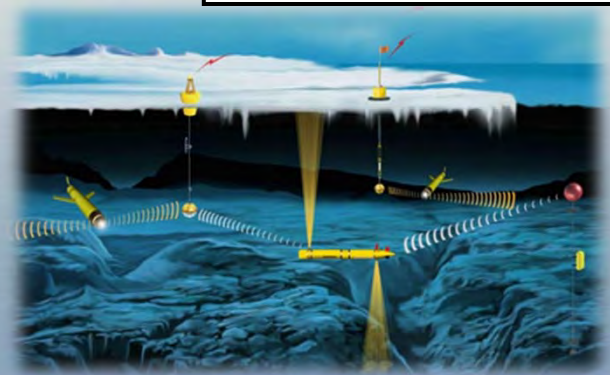
Autonomous platforms – Robust Sensors – Real-time Data Delivery – Key Environmental Variables



Novel Sensing Systems



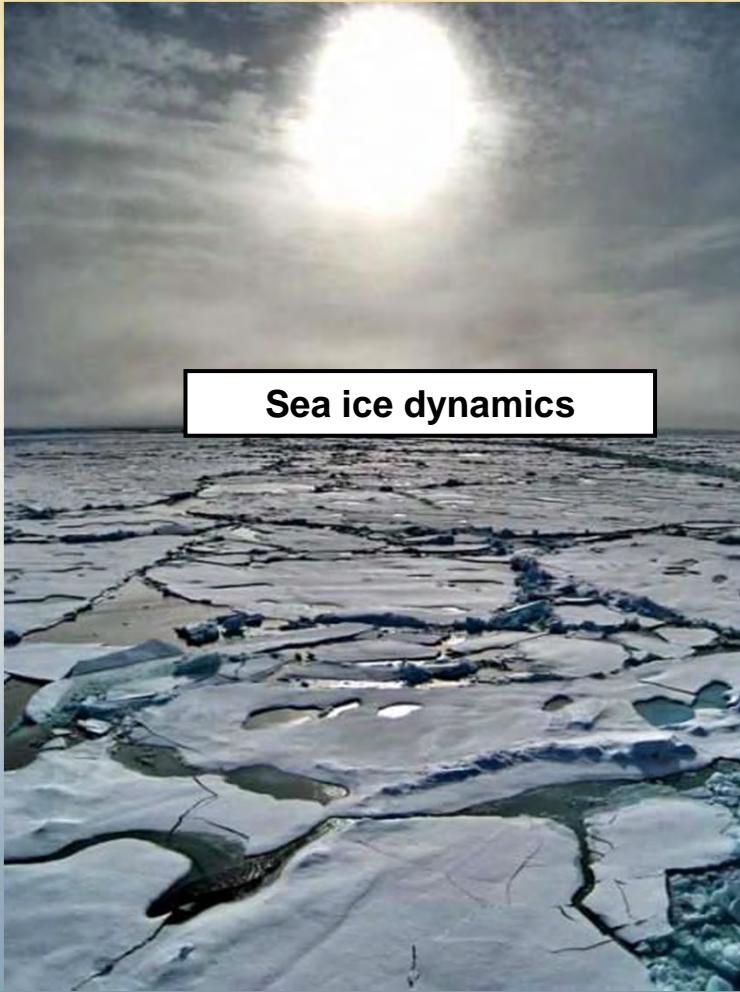
Autonomous Platforms and Enabling Technologies



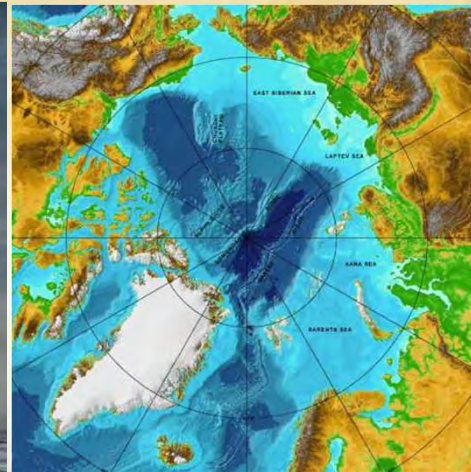
Improved Physical Understanding

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

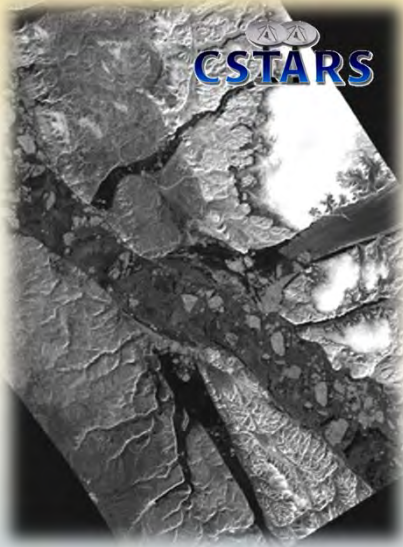


Changes in the Acoustic Structure of the Arctic Ocean

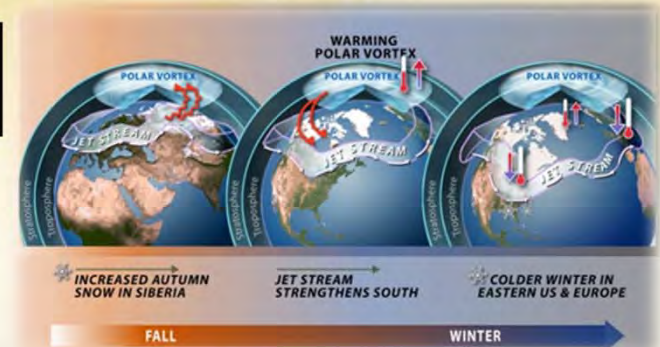


Integrated Arctic Modeling and Prediction

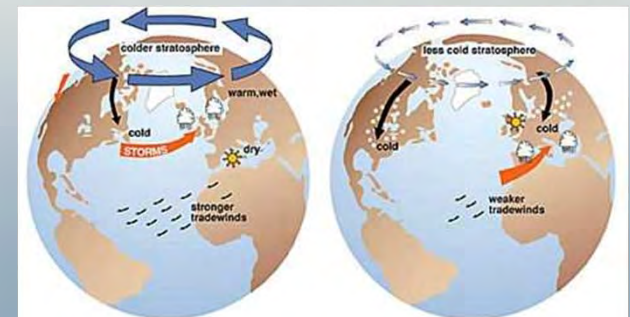
Fully-coupled ocean-wave-ice-atmosphere models with sufficient resolution to represent the relevant processes, and that assimilate in situ and remotely-sensed observations to create useful predictions of the operational Arctic environment at a wide range of lead times



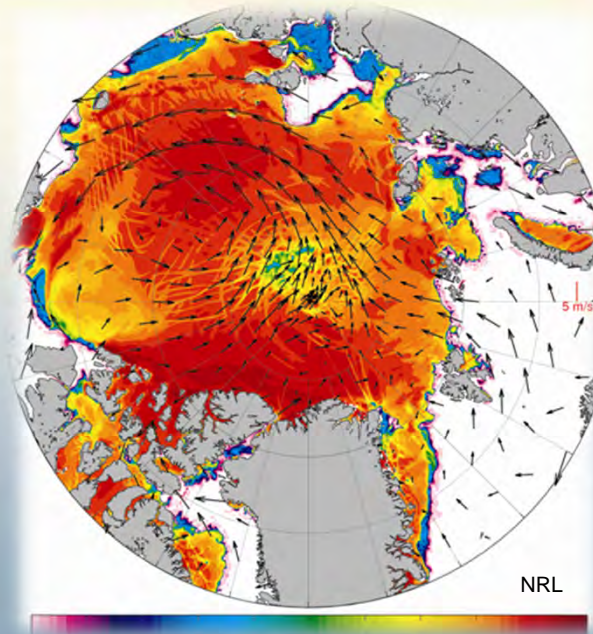
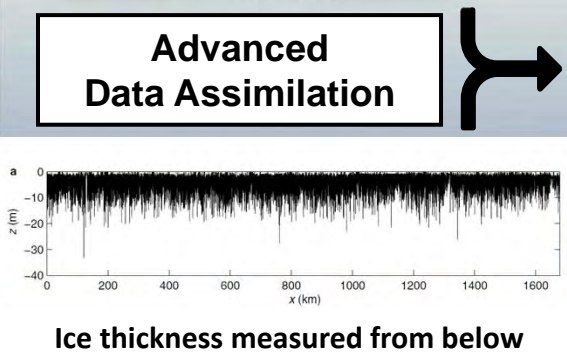
Integrated Arctic System Models
ocean – ice – wave – atmosphere



Coupling with Global Earth System Models

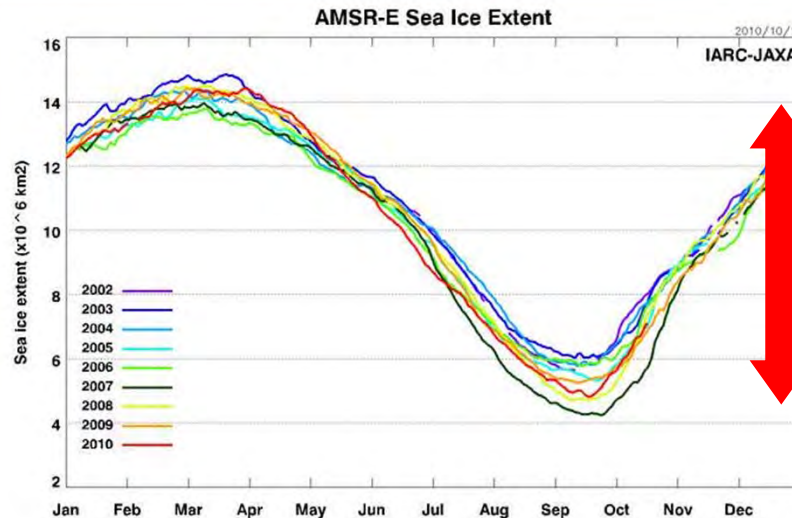
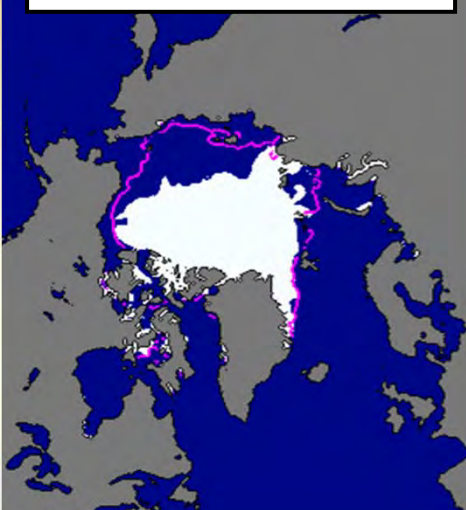


J. Wallace, University of Washington



First Field Effort: Emerging Dynamics of the Marginal Ice Zone

**Reduction in Summer
Sea Ice Cover since 1979**



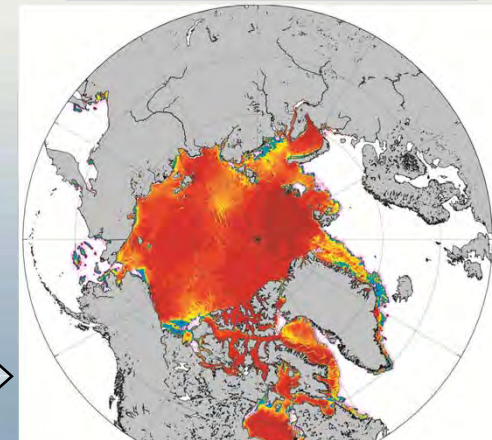
**The Arctic is becoming
more ice-dynamic, with
a larger area of sea ice
melt and re-freeze on
an annual basis.**

**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



Questions?



Backup Slides

Formulating Arctic S&T Priorities

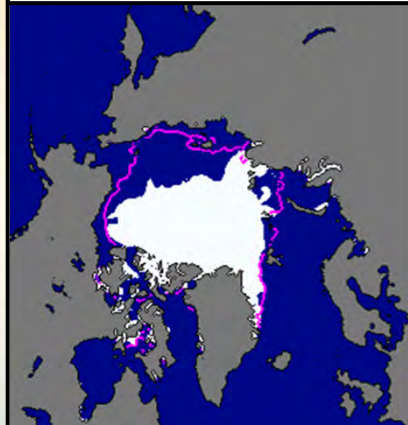


Establishment of an Arctic Research Program

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



FY12-start DRI: Dynamics of the Marginal Ice Zone

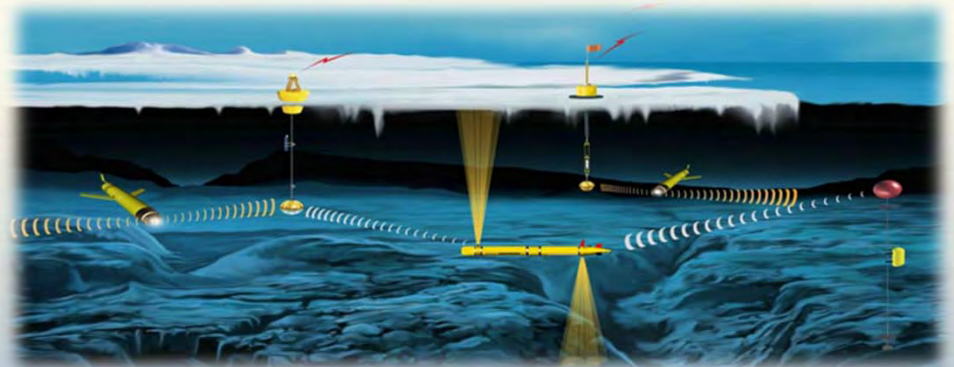


Reduction in Summer Sea Ice Cover since 1979



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

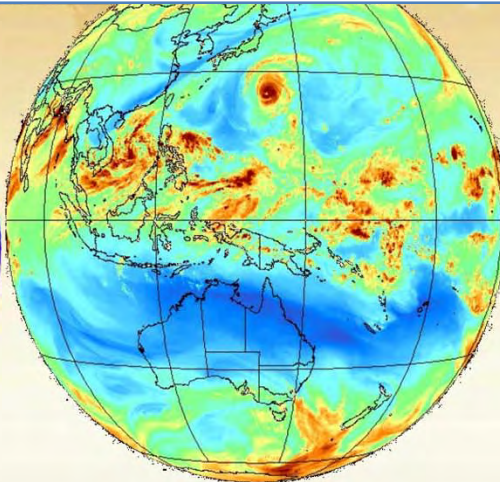
- Funding NRL-DC to make airborne measurements of sea ice thickness
- Testing new submarine-launched XCTD system
- Enabling calibration of on-board biogeochemical sampling equipment
- Processing ice draft information from sub-based Upward Looking Sonar (ULS) data

Seamless Global Prediction

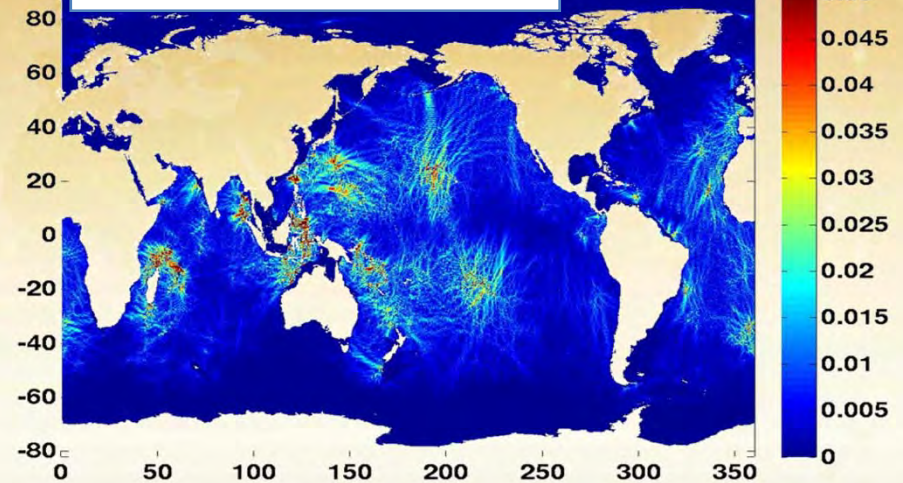
Adaptive Grid Capability



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

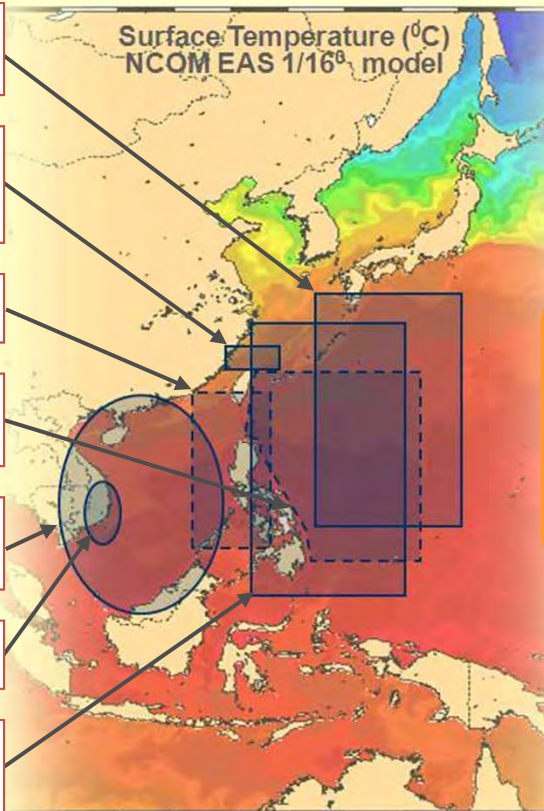
Internal Waves in
Straits Experiment

Origins of the
Kuroshiro and
Mindanao Currents

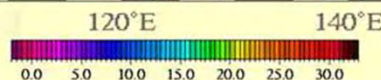
Vietnamese Shelf
and South China Sea
Variability

Remote Sensing of
Deltas

Typhoon Impacts on
the Western Pacific
Ocean



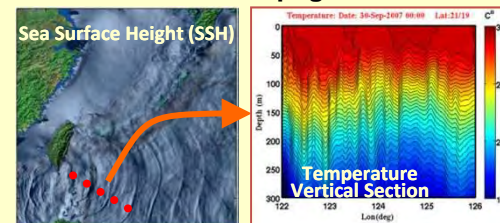
* Ongoing FY11



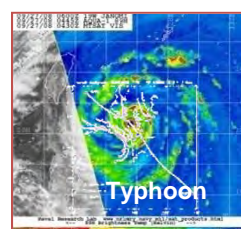
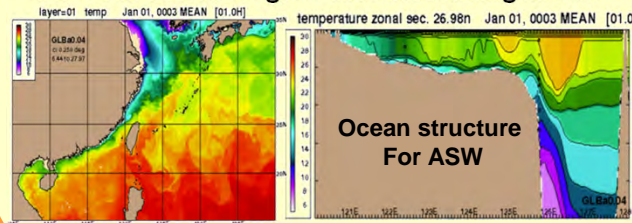
Navy R&D focus on OCONUS areas of
special operational interest and for specific
Warfare missions

ONR Model Development

Internal Waves = Propagation Variability



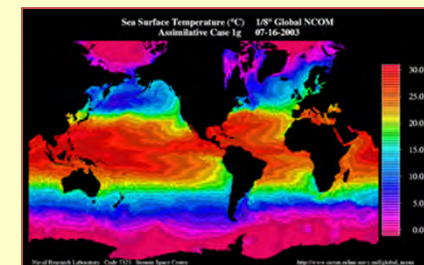
HYCOM 1/25th Degree Tide Resolving Model



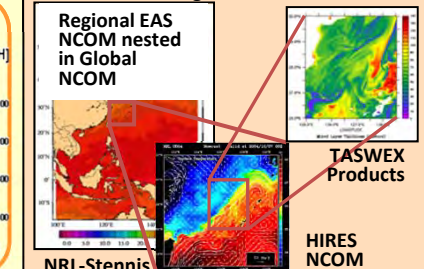
New technology



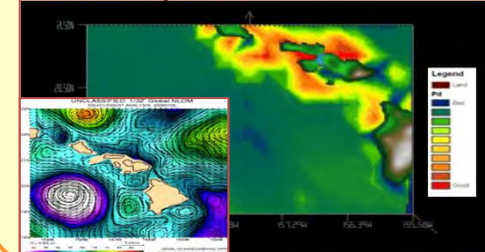
CNMOC Transitioned Predictions



TASWEX-04 Nesting in East Asian Seas NCOM



Probability of Submarine Detection



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