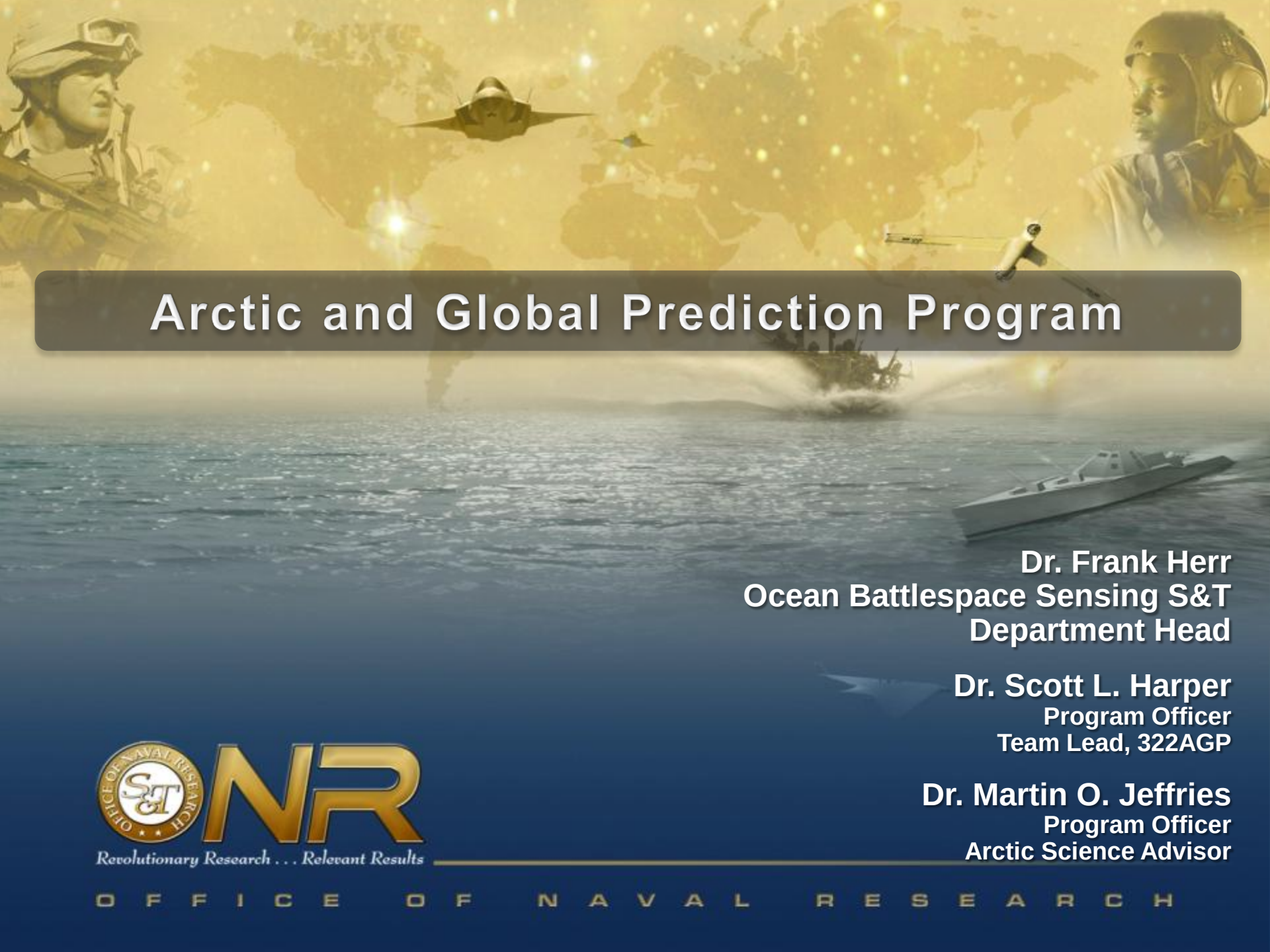


Arctic and Global Prediction Program

Dr. Frank Herr
Ocean Battlespace Sensing S&T Department Head

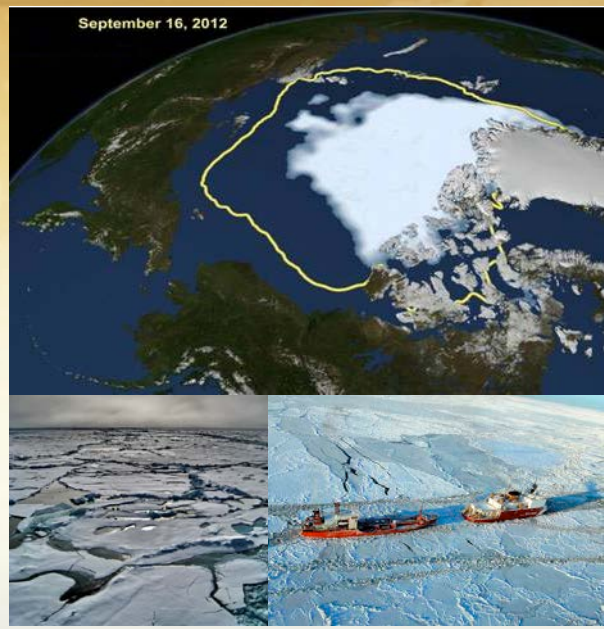
Dr. Scott L. Harper
Program Officer
Team Lead, 322AGP

Dr. Martin O. Jeffries
Program Officer
Arctic Science Advisor

ONR
Revolutionary Research . . . Relevant Results

OFFICE OF NAVAL RESEARCH

The Changing Arctic



Naval Needs and Key Questions…

Task Force Climate Change "Arctic Roadmap":

- Must have Arctic environmental information and predictions to support investment and policy decisions, and future operations

N2N6E Capabilities Based Assessment: Capability Gap in Provision of Environmental Information

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

- ❑ How little sea ice will there be, and when will the key changes occur?
  - Need better prediction capability underpinned by basic research
- ❑ How is the Arctic region as a whole going to be different?
  - Need research into how the entire Arctic environmental system functions
- ❑ What does the Navy need to know to operate in the Arctic?
  - Need sustained observations and improved predictions of the state of the Arctic
- ❑ How will the changing Arctic affect the rest of the earth, and vice-versa?
  - Need an Arctic environmental system model integrated within global prediction models

Arctic Science Program

Goal: Improve forecasts and predictions of the marine physical environment, particularly sea ice, at a variety of time and space scales.

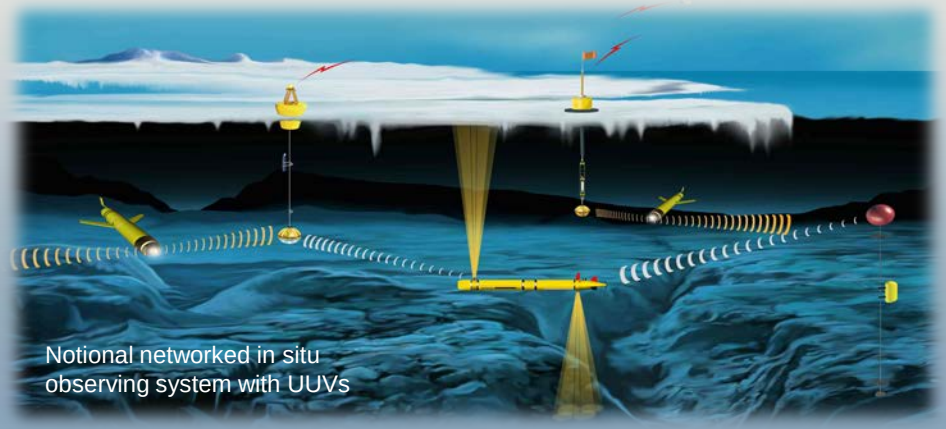
Focus Areas:

1. Develop **fully-coupled ocean-wave-ice-atmosphere models** with sufficient resolution to represent processes, and which assimilate *in situ* and remotely-sensed observations, to improve forecasting and prediction of the Arctic operational environment

2. Improve **basic understanding of the Arctic environment** and key physical processes to enable more accurate representation in numerical models, leading to improved forecasts and predictions

3. Develop an **observing system for sustained observations** that can provide long-term monitoring, further scientific understanding, and constrain predictive models for improved awareness and prediction

SAR image of sea ice & north coast of Alaska

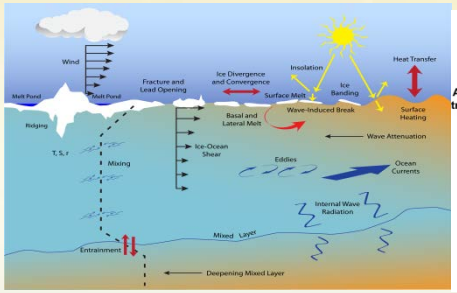

Notional networked in situ observing system with UUVs

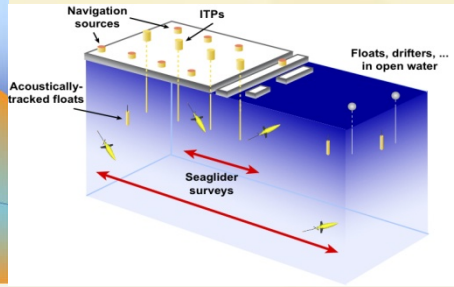

UPI/Jeremy Potter/NOAA

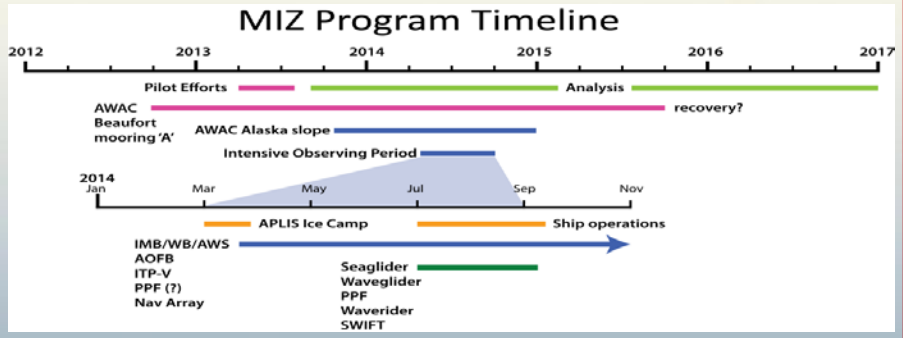
Arctic Science Research Initiatives

Marginal Ice Zone DRI (FY12-FY16)

- A study of the emerging physics of the marginal ice zone during the summer melt-back period
- FY13: Pilot observing efforts underway
- **FY14: Major field experiment** using buoys and UUVs, involving both interagency and international cooperation





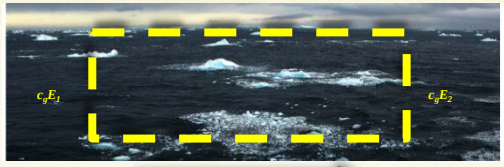


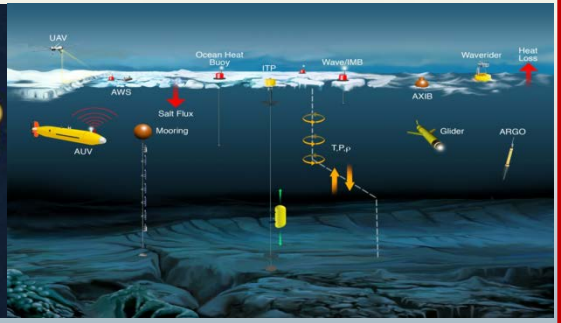
Better basic understanding of the dynamics of the Marginal Ice zone is needed to understand, model, and predict the ongoing decrease in ice coverage and volume in the Beaufort and Chukchi Seas

Arctic Waves DRI (FY13-FY17)

- A study of the impact of waves on air-sea interaction in the Arctic, and the propagation and interaction of waves and swell on sea ice
- FY14: Pilot projects to test new observing techniques
- **FY15: Major field effort** involving both autonomous sensors and sampling from the new UNOLS Arctic Research Vessel

$$d/dt\,(E) + d/dx\,(c_g E) = S_{wind} - S_{brk} + S_{nl} + S_{ice}$$



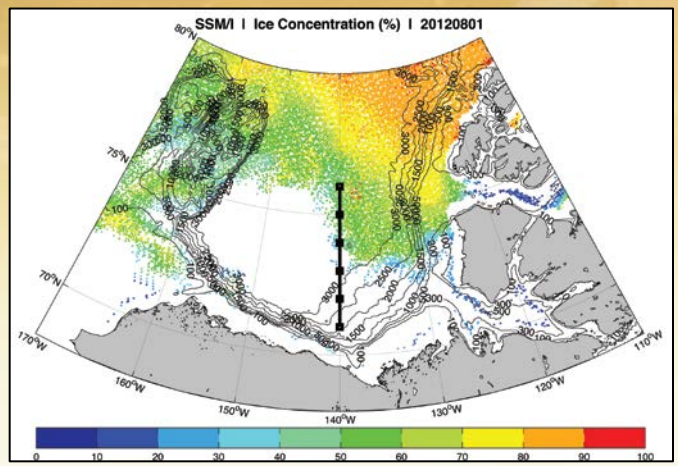


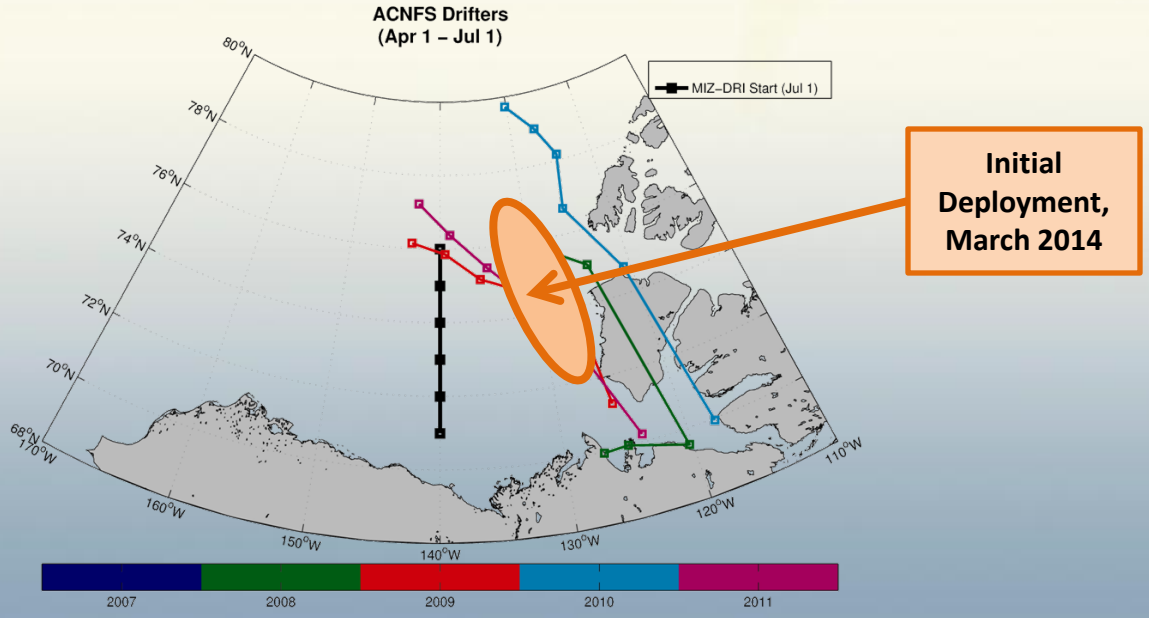
This program will lead to better forecasts of the Arctic operational environment through improvements in our understanding and modeling of the ocean, waves, ice, and atmosphere in this complex region.

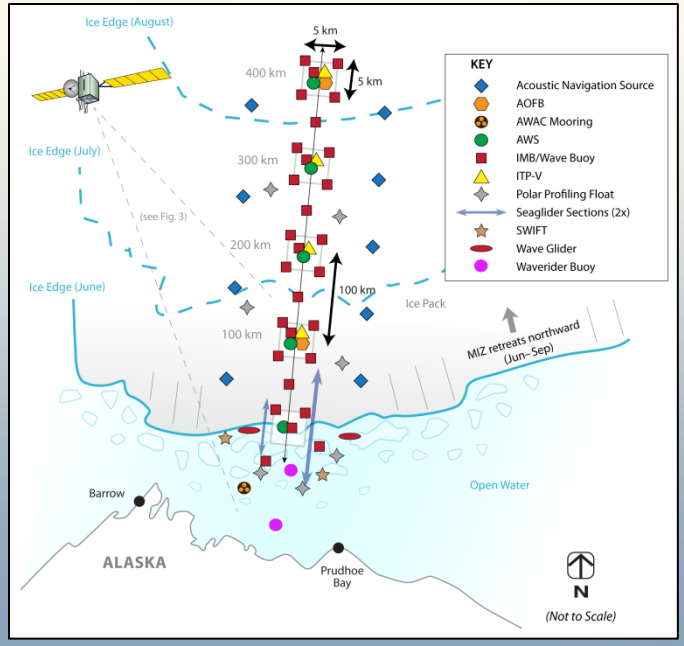
Marginal Ice Zone DRI 2014 Field Program

A sensing array for the MIZ DRI field experiment

- Initial deployment of sensors in March in the eastern Beaufort Sea
  - o Ice mass balance buoys, wave buoys, flux buoys, ice-tethered profilers, polar profiling floats, autonomous weather stations, acoustic communications and navigation beacons
- Sensor array field will drift SW through Spring and Summer 2014
- Goal is a N/S array along 140 W on July 1st
- Gliders and wave floats deployment in mid-July
- Geophysics and biogeochemistry collaboration with Korea Polar Research Institute (KOPRI) aboard *Araon* in July/August
- Other collaborations: BOEM, NASA IceBridge, ESA (tbd)

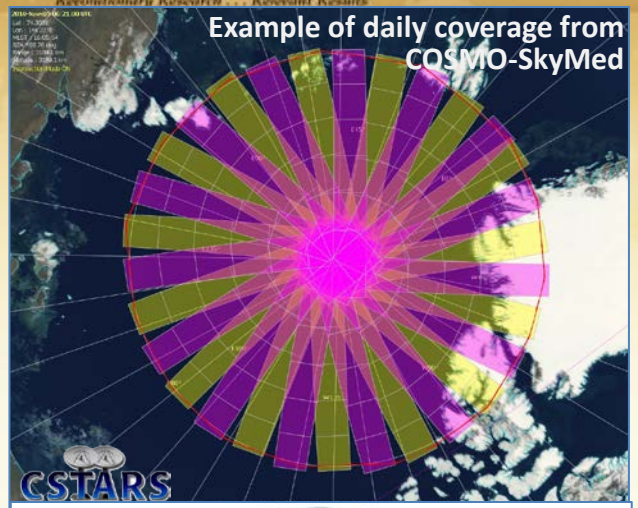


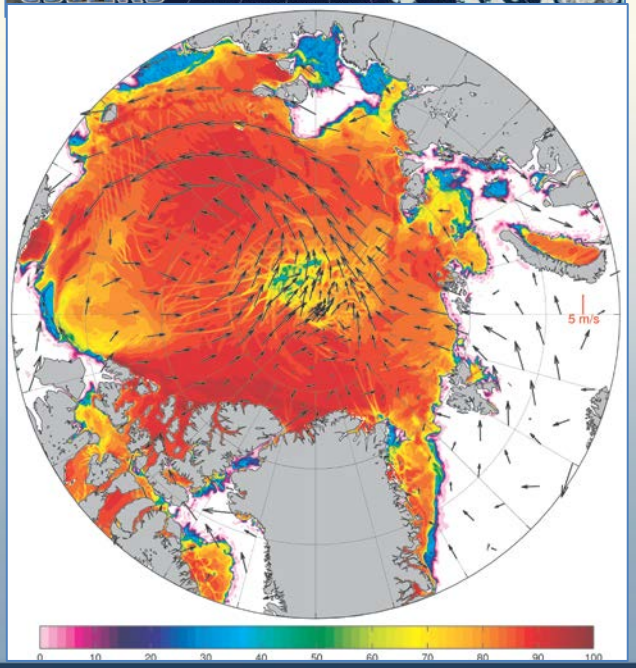




DRI Web site: http://www.apl.washington.edu/project/project.php?id=miz

High-Resolution Arctic Prediction Assimilating SAR Data





Merging data from multiple platforms will provide daily coverage of the Arctic at high spatial resolution

Develop an improved modeling capability for the Arctic for both basic understanding and prediction

- Coupling ocean models with ice, wave, and atmospheric models in the Arctic
- Data assimilation techniques for the Arctic Ocean
- Building tools to help optimize the Arctic observing system
- Role of remote sensing and *in situ* data in constraining Arctic models
- Improved models and methods for prediction of sea ice (nowcast to 6+ months)

Algorithm development for data assimilation into predictive models:

- Ice concentration and dynamics
- Ice ridges
- Ice types
- Open water waves

Data collections are beginning now, with a focus on the Bering Strait, Beaufort and Chukchi Sea areas in preparation to support the DRI field efforts in 2014 and 2015.

NRL's DISTANCE: Determining the Impact of Sea Ice Thickness on the Arctic's Naturally Changing Environment

Combined LiDAR/Radar Airborne Instrumentation for Ice Field Mapping and Thickness Determination

10 GHz High-Power, Pulse-Limited Radar Altimeter

- ~3nsec pulse-width => 32m diameter footprint @300m altitude
- Wave-form digitization for mixed (lead & ice) returns < 1 cm vertical resolution of features @ 10 kHz
- Updated for 2012 field season to be fully coherent

Scanning Topographic LiDAR

- < 1 cm range resolution
- Wave-form digitization for mixed (lead & ice) returns

Digital True Color Photogrammetry

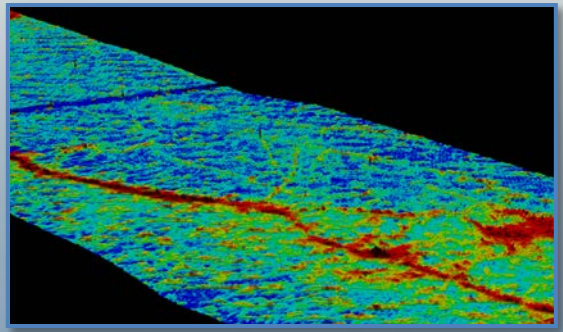
- Lead discrimination

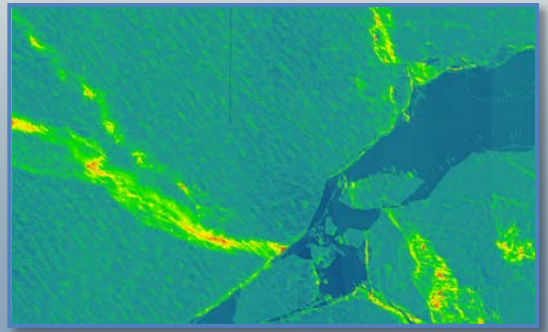
Webcam

- Lead discrimination and possible ice velocity for 2013 field season

Previous Campaigns

- Skagit Bay, Afghanistan, Arctic, Greenland, etc





NRL's Arctic Cap Nowcast/Forecast System (ACNFS)

Toward Improved Arctic System Prediction

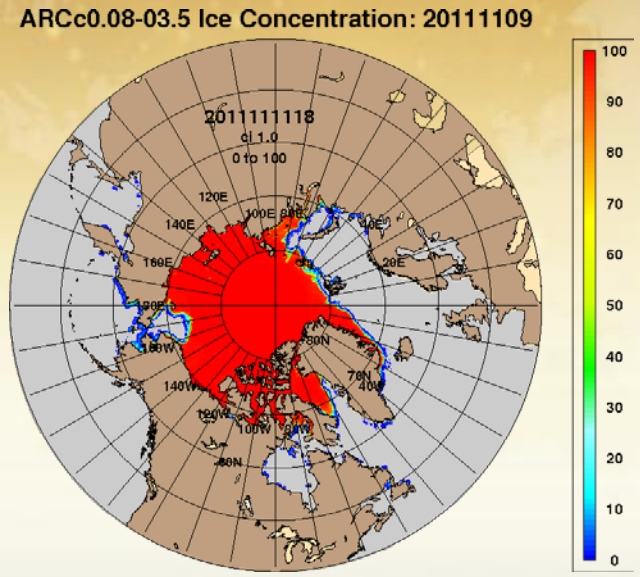
ACNFS consists of 3 components:

- Ice Model : Community Ice CodE (**CICE**) *(DOE/LANL)*
- Ocean Model: HYbrid Coordinate Ocean Model (**HYCOM**)
- Data assimilation: Navy Coupled Ocean Data Assimilation (**NCODA**)

Currently, ACNFS uses boundary conditions from GOFS 3.0

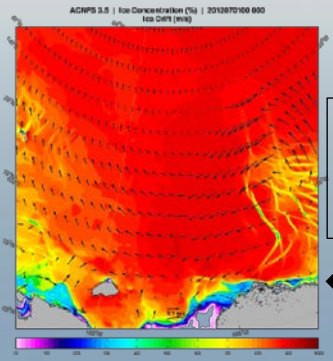
The Arctic Cap model will be integrated into the fully-coupled Navy **ESPC** model in coming years

Next improvement transitions in 2014

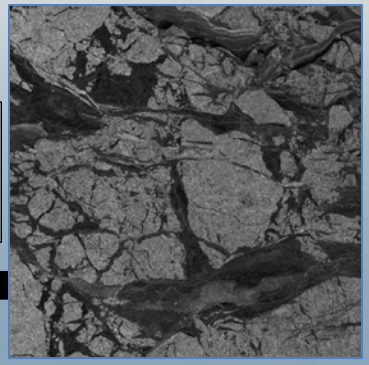


Model grid resolution ~ 3.5 km

Black line denotes independent ice edge analysis from National Ice Center (NIC). Animation spans Nov 2011 – Nov 2012.



Models will require high-resolution observations for initial conditions



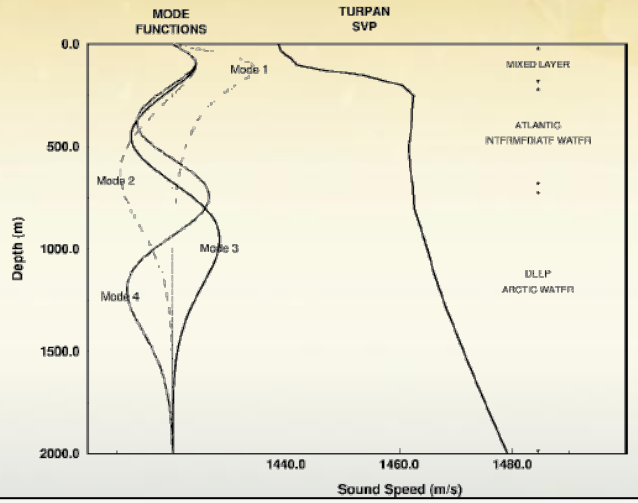
Arctic Acoustics: Previous Investigations

Russian Source, 20.5 Hz, 195 dB

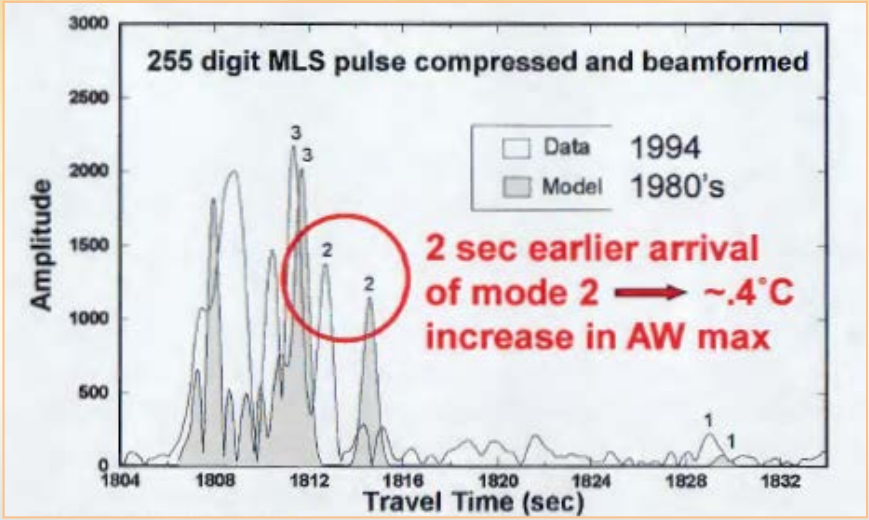
Paths to the Lincoln Sea and the Chukchi Sea in the **Arctic climate observations using underwater sound (ACOUS)** experiment. The **Transarctic Acoustic Propagation Experiment (TAP)** paths were very similar.

Results from Previous Trans-basin Acoustic Experiments

Analysis of the '94 TAP receptions at the U.S./Canadian ice camp "Narwhal," which was drifting at the edge of the continental shelf in the Lincoln Sea, 1000 km from the source



The upward-refracting sound-speed profile generates a modal structure in which successively higher modes sample deeper and deeper depths. The modes were sampled by a 16 element VLA in the Lincoln Sea.



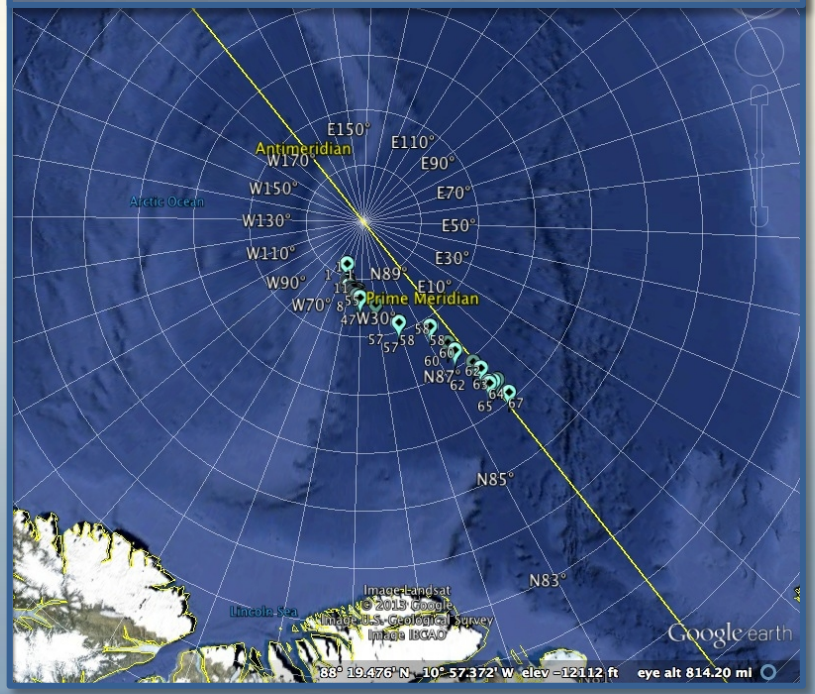
The experiment showed that it is possible to measure the integrated temperature change along the path with a precision approaching 0.1 m C, and detected an average warming along the acoustic path (Mode 2) in the AIW (200–700 m depth) of approximately 0.4 deg C.

There is interest in new trans-basin propagation experiment to measure the interior of the Arctic Ocean by low frequency (20-200 Hz) sound beginning in the 2015/2016 time frame.

- **Workshop is being planned for January 2014**
- May target the influence of the seasonal sea ice cycle on the Beaufort Gyre
- A potential collaboration between Russia, Canada, and the US?

Thin-ice Arctic Acoustic Window (THAAW) Project

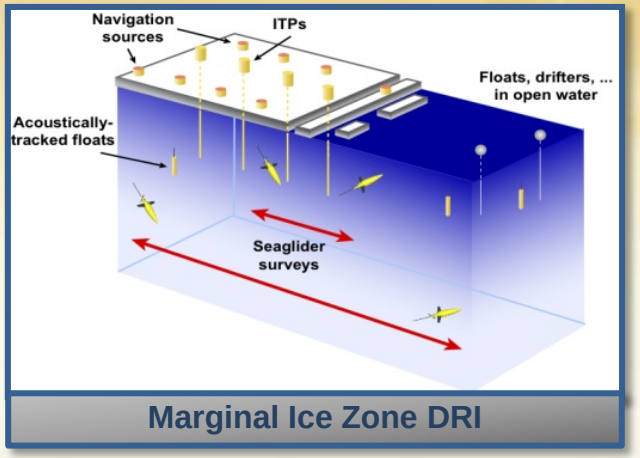
- Scripps/WHOI passive array deployed 13 April at North Pole
- 600 m hydrophone array below float
- 22 Hydrophone Modules w/precision thermistors
- 10 Seabird MicroCATs
- Records for 108 minutes beginning at 1200 UTC six days per week
- Sample rate 1953.125 Hz
- Currently drifting south



DARPA/SAIC simultaneously deployed a drifting source and a receive array further south

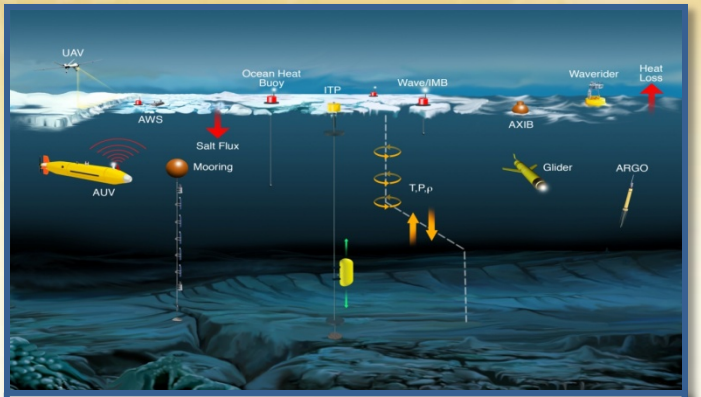
Unmanned Platforms in the Arctic

Development and utilization of UUV capabilities will occur under ONR-funded field efforts

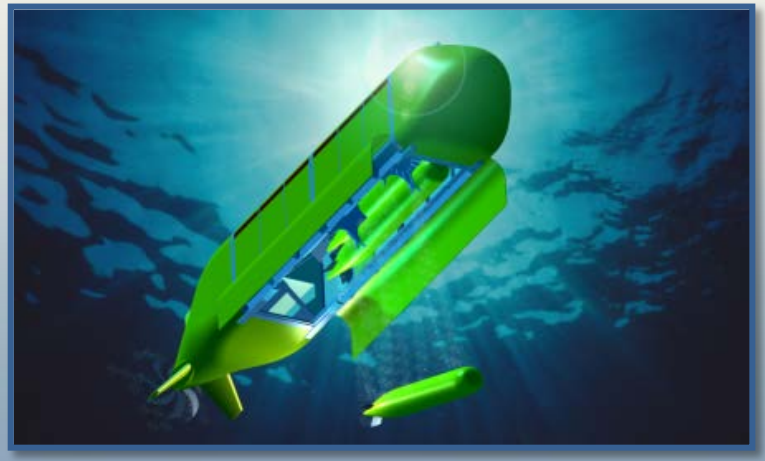


Marginal Ice Zone DRI

- SeaGliders
- Slocum gliders
- WaveGliders
- Acoustic tracking
- ARGO floats
- Drifting moorings
- Wave Buoys
- AUVs (Seabed-100)



Arctic Sea State DRI



ONR has held discussions with DRDC (Canada) about collaborative Arctic sampling efforts using UUVs

Potential activities could include:

- At-sea experimentation in the Arctic to improve UUV design and performance
- REMUS 600 hydro/bathy work or bottom/ice characterization
- LDUUV/REMUS data and power compatibility tests in the Arctic
- Under ice autonomy, risk reduction/mitigation efforts

Revolutionary Research . . . Relevant Results

~ end ~