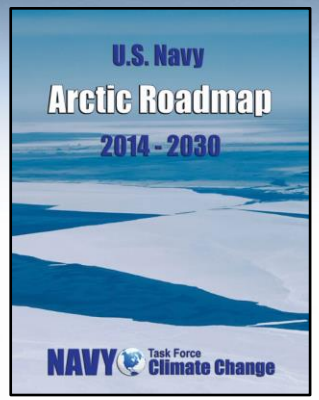
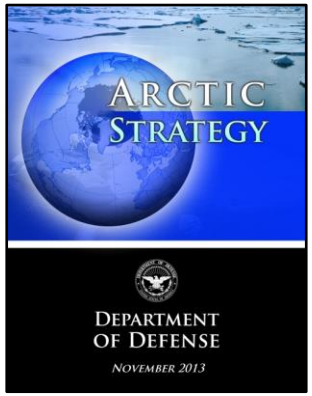
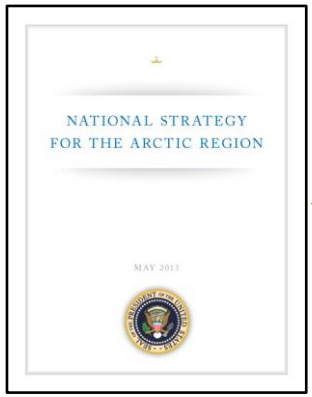
ONR Arctic Modeling Issues

Dr. Scott Harper
Office of Naval Research
Arctic & Global Prediction Program
Scott.L.Harper@navy.mil
Scott.Harper@navy.smil.mil

US Navy Arctic Requirements







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

SOURCES

- The United States Navy Arctic Roadmap for 2014 to 2030, February 2014
- National Strategy for the Arctic Region Implementation Plan, January 2014
- Department of Defense Arctic Strategy, November 2013
- COMSUBLANT/COMSUBPAC Arctic Requirements Letter, Ser N3/0644, 04 SEP 2013
- NORAD-USNORTHCOM FY18-22 S&T Integrated Priority List (STIPL)
- NORAD-USNORTHCOM Arctic Maritime Capability Requirements Study:
  - Phase 1 Final Technical Report, 15 OCT 2015
  - Appendix E, Non-releasable Material, 31 JUL 2015
- Classified Companion to the National Strategy for the Arctic Region, 2014
- N52 Arctic Engagement Plan Memo, 02 APR 2015

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

Lead Agency: Department of Defense (Navy)

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

Recognized Arctic Challenges - N2/N6

April 2015 Arctic Roadmap Implementation, RADM Jon White

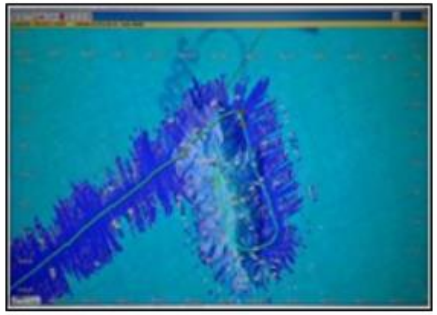
U.S. Arctic Region Challenges

- Harsh operating environment
  - Non-ice hardened ships
- Limited comms and satellite sensors
- Limited Arctic experience
- Incomplete charting
- Limited ice- breaking capabilities
- Limited SAR assets
- Limited infrastructure
- High cost of operations

AMOS

Identified Capability Gaps

- Sense environment parameters
- Forecast environmental parameters
- Predict impact of environmental conditions on naval systems
- Communications
- Multi-National MDA



Improving operational capabilities, expertise, and capacity to operate in the region….Just like every other ocean around the world

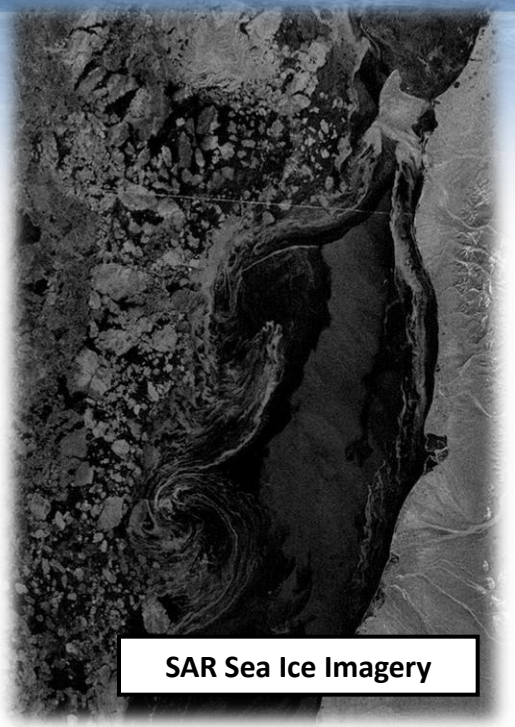
ONR's Arctic Objectives

- **Understand the physics and dynamics of the emerging Arctic Ocean 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
- **Improve predictive capabilities for the Arctic environment**
  - Develop high-resolution coupled Arctic System Models (ocean-ice-waves-atmosphere)
  - Improve assimilation of observed data (both *in situ* and remote sensing)
  - Research on extended prediction (not just days, but strategic – months to years)

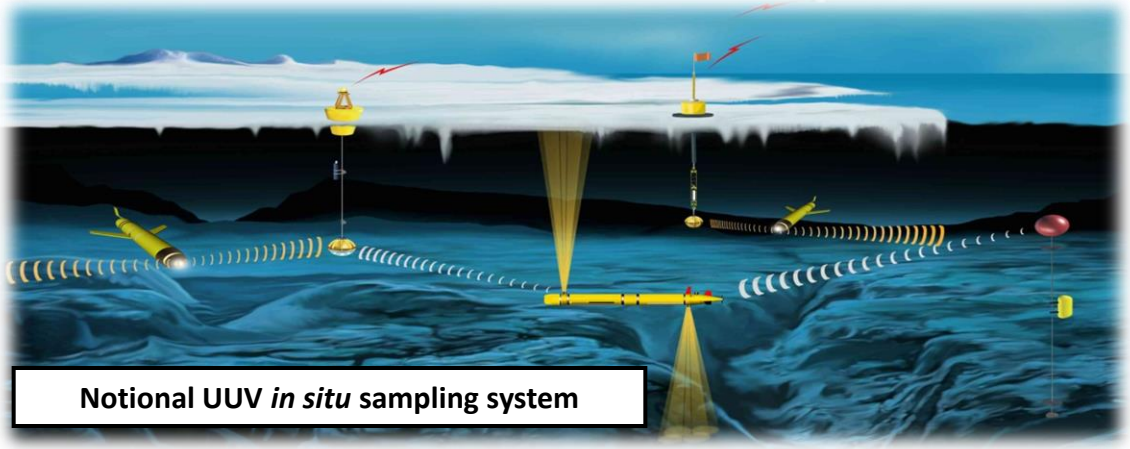
ONR Arctic Environmental Research

MAJOR THRUSTS:

1. Generation of **new observing technologies and methods** (platforms, sensors, communications) that will enable persistent observational capabilities in the Arctic
2. **Improved basic physical understanding** of the Arctic environment and the important coupled processes that drive evolution and predictability in the Arctic region
3. Development of **fully-integrated Arctic System Models** 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



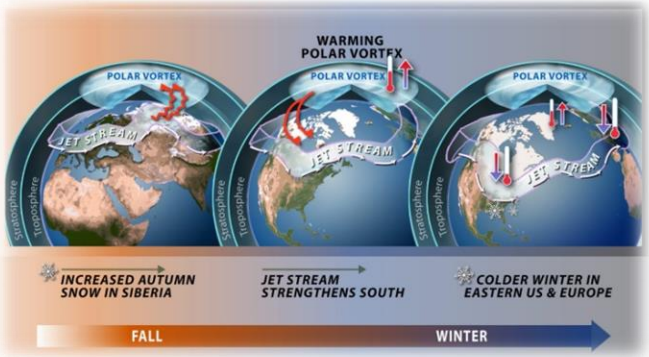
Notional UUV *in situ* sampling system

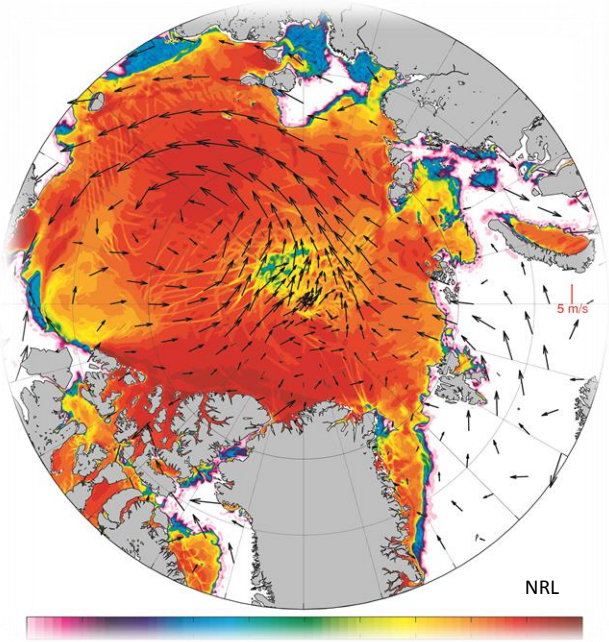
Advances in technology will be required to enable an interagency **Arctic Observing Network** that will support scientific exploration and be able to initialize predictive models of the environment

Integrated Arctic Prediction

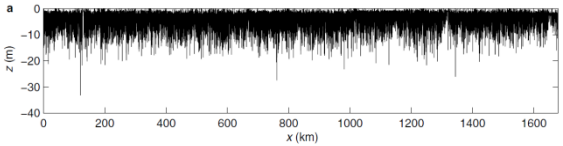
Fully-coupled ocean-wave-ice-atmosphere models with sufficient resolution to represent the relevant processes, and that assimilate in situ and remotely-sensed observations to create useful predictions of the operational Arctic environment at a wide range of lead times

Integrated Arctic System Models
ocean – ice – wave – atmosphere



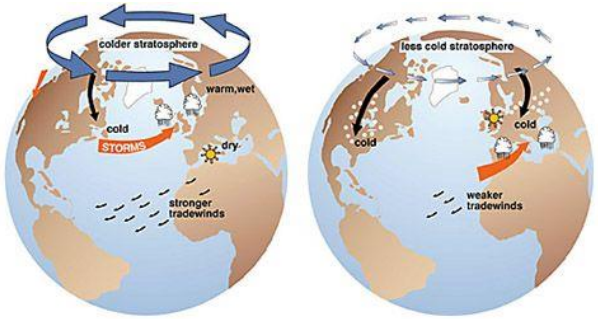


Advanced
Data Assimilation



Ice thickness measured from below

Coupling with Global Earth System Models

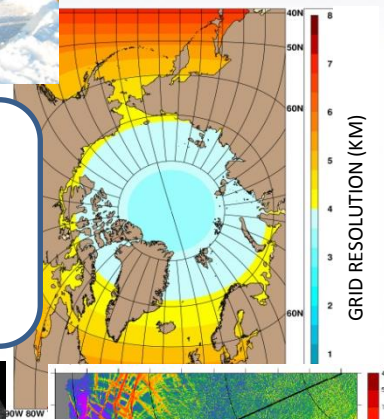


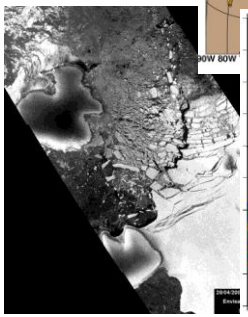
J. Wallace, University of Washington

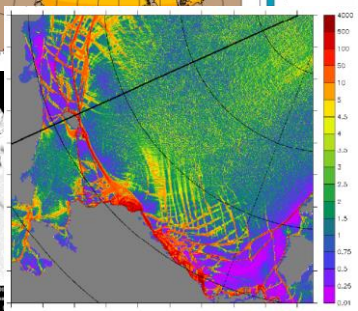
Development and Transition of Arctic Prediction Systems

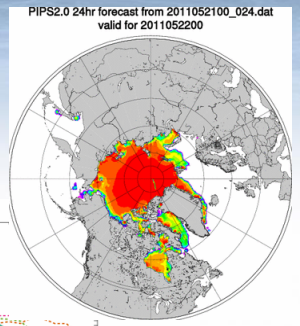
Fieldwork to better understand key physical processes

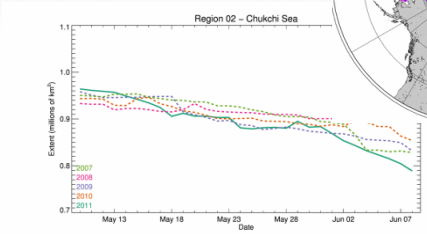
Improved physics built into data-assimilating integrated models

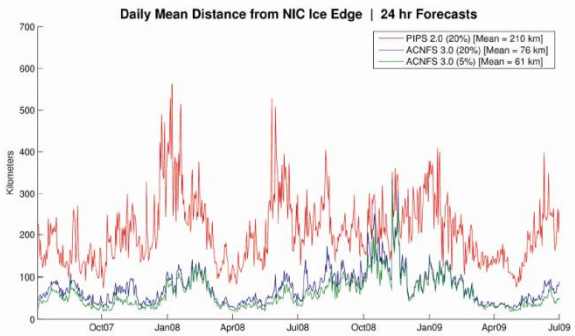












NAVAL METEOROLOGY AND OCEANOGRAPHY COMMAND

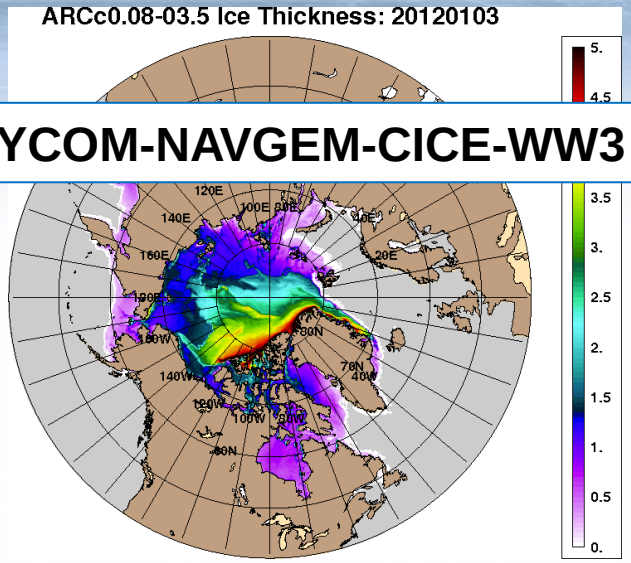
NATIONAL ICE CENTER WASHINGTON D.C.

Arctic Prediction System Development	Validation and Verification	Transition to Operational Use
Observing System Development →	Testing, Prototyping and Experimentation →	Transition to Operational Use

Cooperative Model Development

ONR is working the Arctic prediction problem on a variety of space and time scales, with NRL expertise and investment in model development with the academic performer community, including NPS, UW/APL and many others

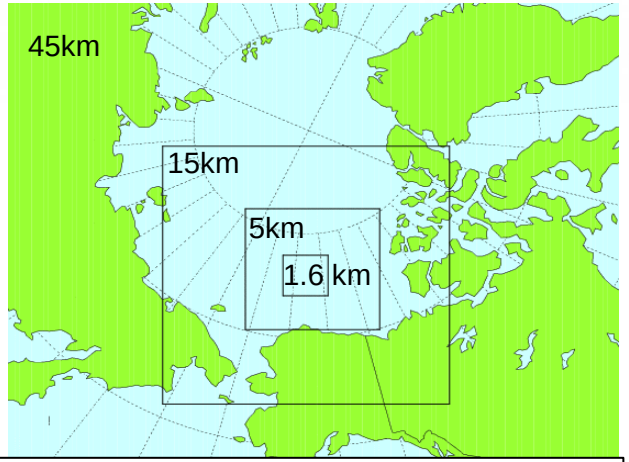
HYCOM-NAVGEM-CICE-WW3



Model grid resolution ~ 3.5 km

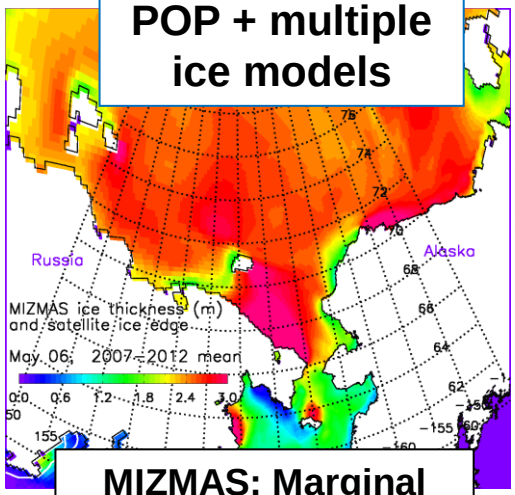
Black line is the independent ice edge location (NIC)

NCOM-COAMPS-CICE-WW3



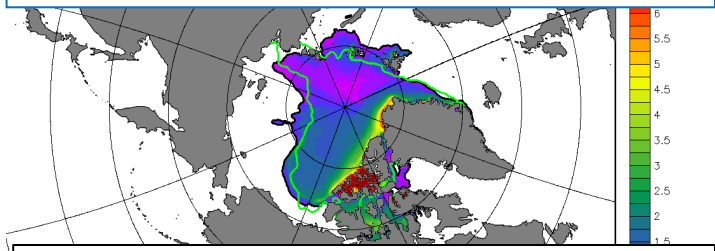
Future Regional Arctic System (RAS)
Flexible Coupled Relocatable Model Domain

POP + multiple ice models



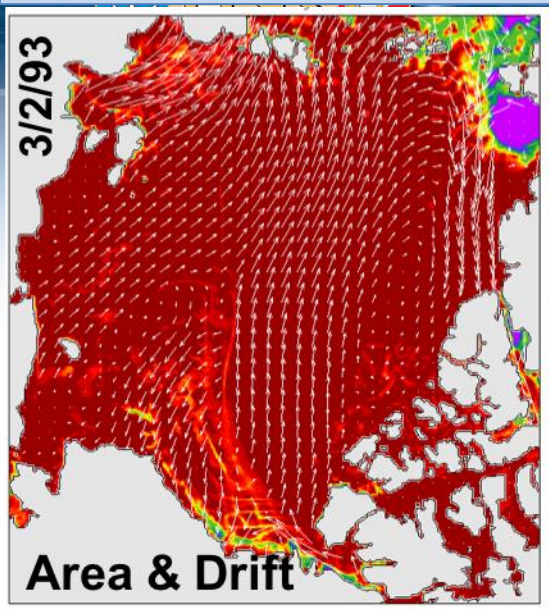
MIZMAS: Marginal Ice Zone Modeling and Assimilation system (UW/APL)

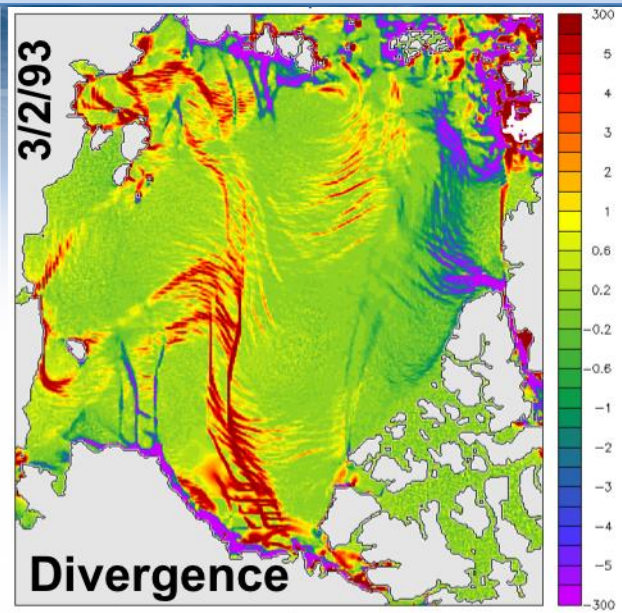
POP-Polar WRF-CICE

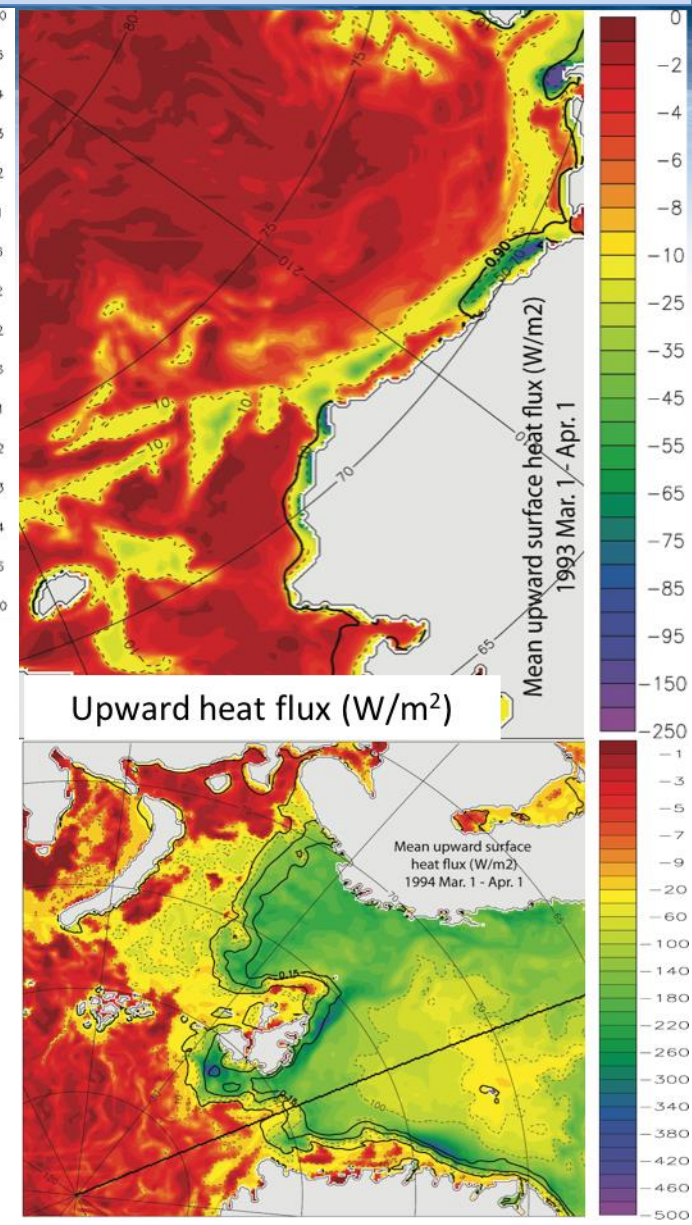


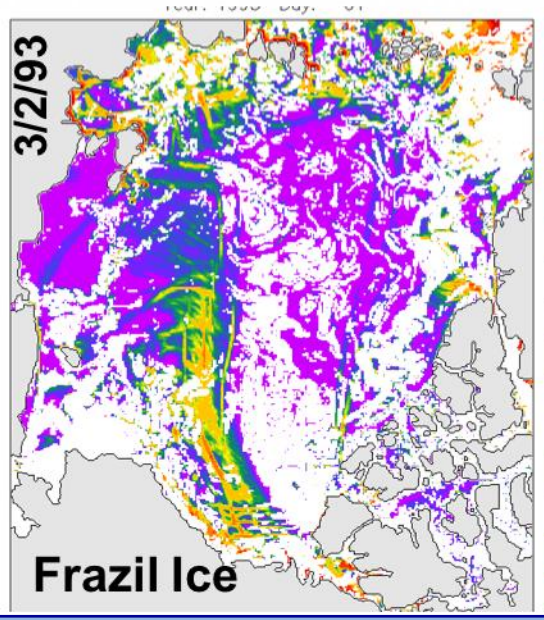
RASM: Regional Arctic System Model (NPS)

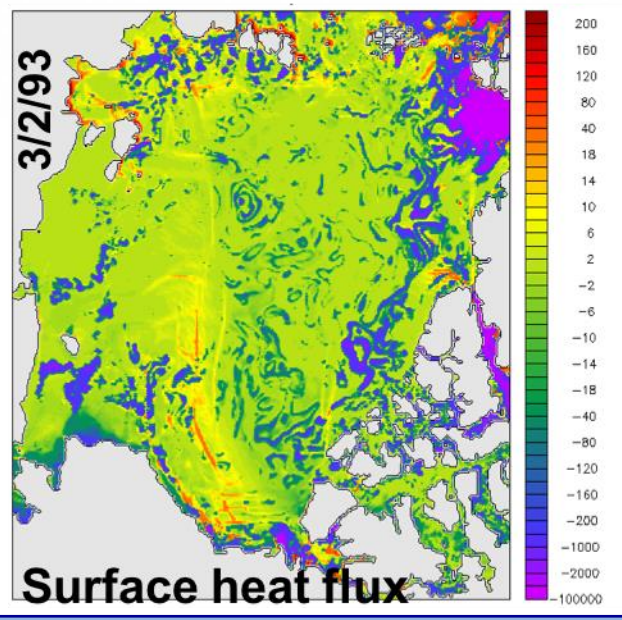
RASM deformation, ice growth and air-sea fluxes











Gaps / Issues / Needs

Not exhaustive, just a few thoughts…

- Improved resolution in Arctic System Modeling is needed to support the Navy's requirements for Arctic predictions, particularly for sea ice
- Observations for model initialization is a critical need
- Improved remote sensing algorithms for sea ice characterization will help initialize high-resolution models for forecasts on all time scales