US Navy's Ice Forecast Systems

Naval Research Laboratory (NRL) Ice team:

NRL/SSC: Pam Posey, Ruth Preller, Rick Allard, Joe Metzger, Alan Wallcraft, David Hebert, Erick Rogers, Ole Martin Smedstad (Vencore) and Michael Phelps (Jacobs Technology)

NRL/MRY: Neil Barton, Shouping Wang and Yi Jin

Credit: 2013 NRL flight off Barrow, Alaska

Arctic Cap Nowcast/Forecast System (ACNFS)

www7320.nrlssc.navy.mil/hycomARC

- ACNFS consists of 3 components:
  Ice Model: Community Ice CodE (CICE v4.0)

  Ocean Model: HYbrid Coordinate Ocean Model (HYCOM)

  Data assimilation: Navy Coupled Ocean Data Assimilation (NCODA)

- Declared operational Sept 2013

- Runs daily at the Naval Oceanographic Office (NAVO)

- ACNFS produces nowcast/7-day forecasts of ice concentration, ice thickness, ice drift, sst, sss and ocean currents for the Northern Hemisphere

- Products pushed daily to the U.S. National Ice Center (NIC) and NOAA

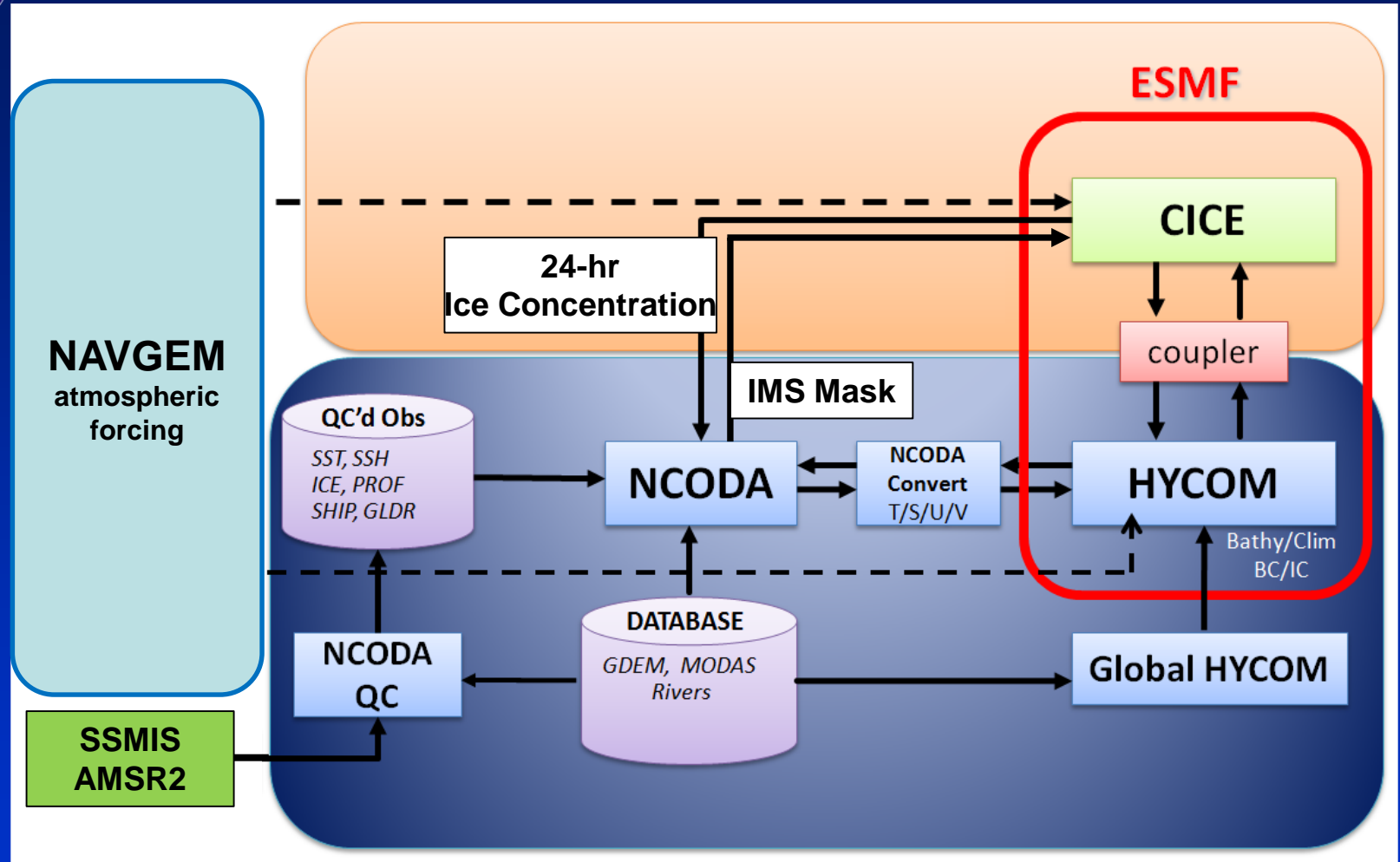ARCc0.08-04.1 Ice Concentration (%): 20160103
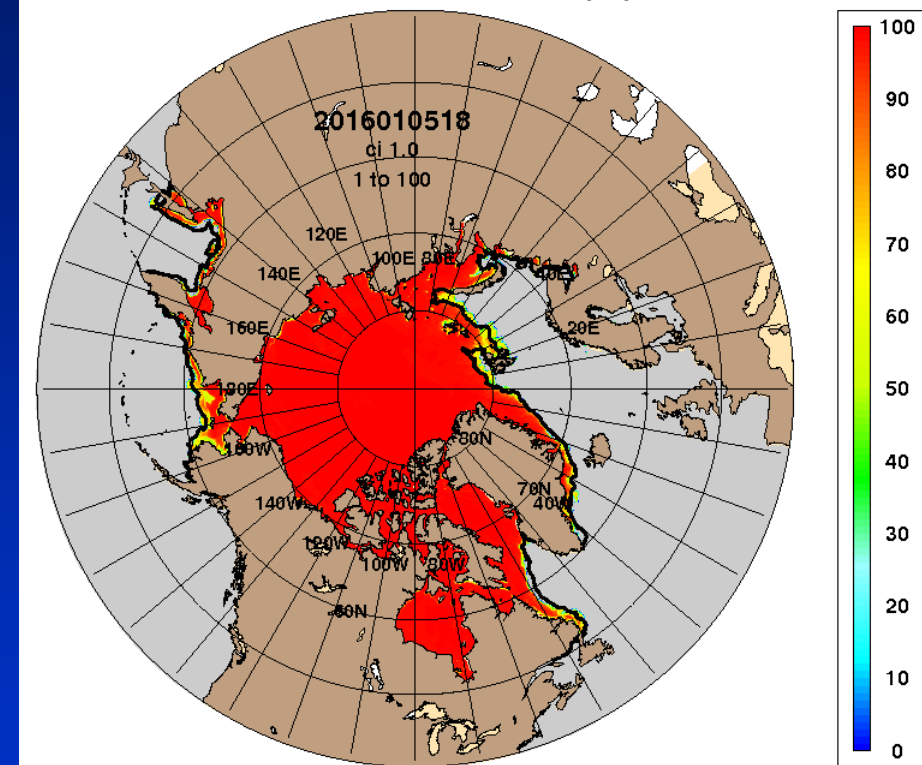
Grid Resolution ~3.5 km at the North Pole

Black line is the independent ice edge location (NIC). Animation spans January – February 2016

Arctic Cap Nowcast/Forecast System

- CICE Output: Ice concentration, ice thickness, ice drift, lead opening rate
- HYCOM Output: SSH, 3D temperature, salinity, and ocean currents

Global Ocean Forecast System (GOFS 3.1)

- 1/12° global two-way coupled HYCOM-CICE prediction system with data assimilation
  - Uses HYCOM/CICE v4/NCODA; like ACNFS but with improved HYCOM and NCODA
  - After GOFS 3.1 becomes operational, it will replace ACNFS
  - Added capability of forecasting in the southern hemisphere
  - Ongoing evaluation of GOFS 3.5 (1/25º HYCOM/CICE v5/NCODA with tides)

Ice Concentration (%) Ice Thickness (m) Sea Surface Salinity (psu) Sea Surface Temperature (C)
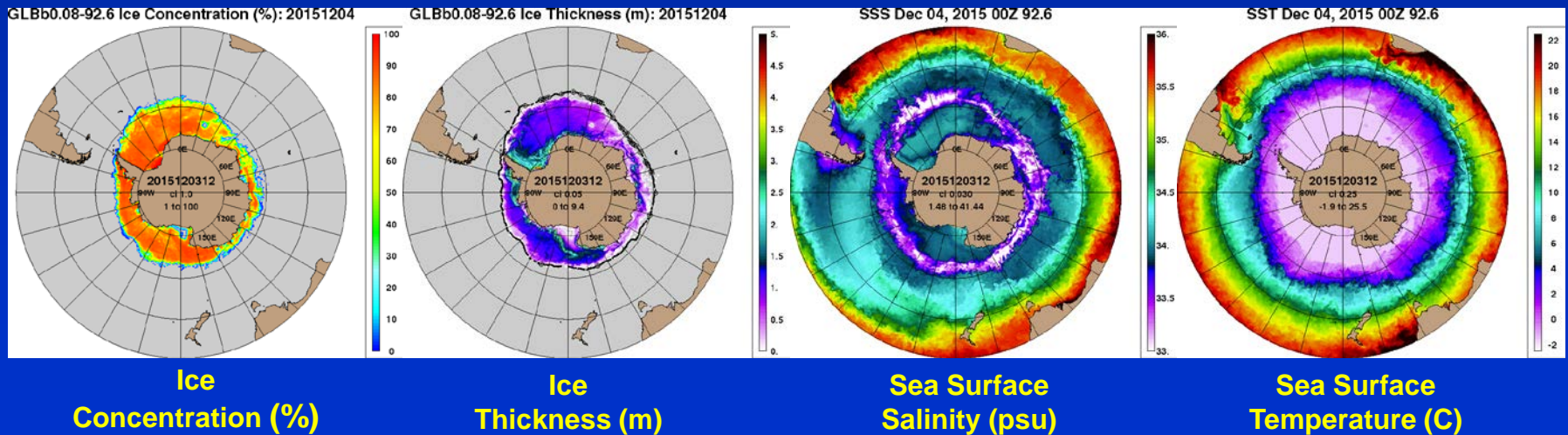
Validation metrics:

- Ice Validation:
  - Ice edge location (nowcast/forecasts) vs National Ice Center's independent ice edge observations
  - Ice thickness vs observations including: NASA IceBridge, CRREL ice mass balance buoys and WHOI upward looking sonar moorings
  - Ice Drift vs IABP drifting buoys
- Ocean Validation:
  - Temperature/salinity vs depth error analysis
  - Mixed layer/sonic layer depth error analyses
  - Surface layer trapping of acoustic frequencies
  - Upper ocean velocity validation

Navy's Earth System Prediction Capability (ESPC)

- Navy's contribution to the national, multi-agency collaborative effort to leverage resources to develop the next generation whole earth prediction system
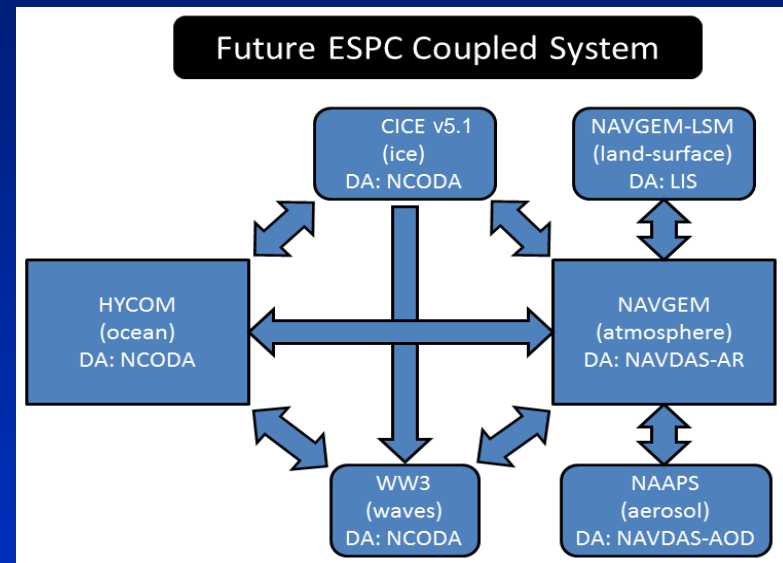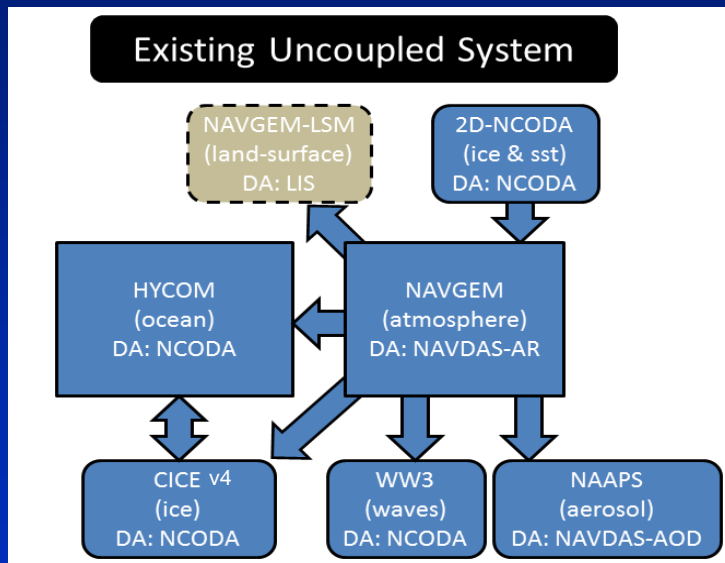
- Coupling is via NUOPC and ESMF – Permits individual components to respond to changes in other components during the course of a single forecast and allows the entire system to evolve as one unit. Components (e.g. CICE) are compatible with NEMS.

- Navy's initial operational capability (IOC) is scheduled to be running in real-time by 2018. Will use CICE v5.1.

Navy's ESPC
Initial Operational Capability (IOC)

- A deterministic system will run for 16 days at H0.04L41 (41-layer 1/25º HYCOM) + CICE + WW3 and T681 ESPC-Atm + NAVDAS-AR. Ocean, wave and ice assimilation will be through NCODA. For IOC, WW3 may not include 2-way coupling.

- An ensemble will run weekly for 30 days at H0.08L41 (41-layer 1/12 º HYCOM + CICE + WW3 and T425 ESPC-atm. Number of members to be decided later, but at least 28. For IOC, WW3 may not include 2-way coupling.

Model resources and timings:

Model	Number of processors	Runtime on IBM iDataPlex
1/12º ACNFS (1600x2520) Operational code managed by NAVO	320	~ 4 hrs (3day hindcast/nowcast/ 7day forecast)
1/12º GOFS 3.1 (4500x3298) Pre-operational code managed by NRL/NAVO	900	~ 4 hrs (12hr hindcast/nowcast/ 7day forecast)

Model	Number of processors	Runtime on Cray XC30
1/25º GOFS 3.5 (9000x6595) Code managed by NRL	4000	1 model day ~50 minutes with 20 minutes for CICE
1/12º ESPC (4500x3298) Code managed by NRL using SVN	1000	1 model day ~35 minutes with 3 minutes for CICE

Thank you! Questions?