A41G-0130: Verification and Validation of a Navy ESPC Hindcast with Loosely Coupled Data Assimilation

E.J. Metzger[1], N.P. Barton[2], O.M. Smedstad[3], B.C. Ruston[2], A.J. Wallcraft[1], T.R. Whitcomb[2], J.A. Ridout[2], D.S. Franklin[3], L. Zamudio[4], P.G. Posey[1], C. Reynolds[2] and M.W. Phelps[5]

[1]Naval Research Laboratory, Oceanography Division; [2]Naval Research Laboratory, Marine Meteorology Division; [3]Vencore Services and Solutions, Inc.; [4]Florida State University; [5]Jacobs Technology

Abstract: The US Navy is developing an Earth System Prediction Capability (ESPC) to provide global environmental information to meet Navy and Department of Defense (DoD) operations and planning needs from the upper atmosphere to under the sea. It will be a fully coupled global atmosphere/ocean/ice/wave/land prediction system providing daily deterministic forecasts out to 16 days at high horizontal and vertical resolution, and daily probabilistic forecasts out to 45 days at lower resolution. The system will run at the Navy DoD Supercomputing Resource Center with an initial operational capability scheduled for the end of FY18 and the final operational capability scheduled for FY22.

The individual model and data assimilation components will eventually include:

- Atmosphere - NAVy Global Environmental Model (NAVGEM) and NRL Atmospheric Variational Data Assimilation System - Accelerated Representer (NAVDAS-AR);
- Ocean - HYbrid Coordinate Ocean Model (HYCOM) and Navy Coupled Ocean Data Assimilation (NCODA);
- Ice - Community Ice CodE (CICE) and NCODA;
- Waves - WAVEWATCH III™ and NCODA;
- Land - NAVGEM Land Surface Model (LSM); and
- Aerosol – Navy Aerosol and Analysis Prediction System

Currently, NAVGEM/HYCOM/CICE are three-way coupled and each model component is cycling with its respective assimilation scheme. The assimilation systems do not communicate with each other, but future plans call for these to be coupled as well. NAVGEM runs with a 6-hour update cycle while HYCOM/CICE run with a 24-hour update cycle.

The NAVGEM/HYCOM/CICE system has been integrated in hindcast mode and verification/validation metrics have been computed against unassimilated observations and against stand-alone versions of NAVGEM and HYCOM/CICE. This presentation will focus on typical operational diagnostics for ocean and ice analyses including temperature/salinity ocean depth profiles, ocean acoustical proxies, upper ocean velocities and sea ice edge. Overall, the global coupled ESPC system is performing with comparable skill to the stand-alone systems at the nowcast time.

Model components:

- NAVGEM: spectral T359, 50 vertical levels
- HYCOM: 0.08°, ~9 km at Equator, ~7 km at mid-latitudes, 41 vertical layers
- CICE: Same grid as HYCOM, ~3.5 km at the North Pole, 5 ice categories

Data assimilation components:

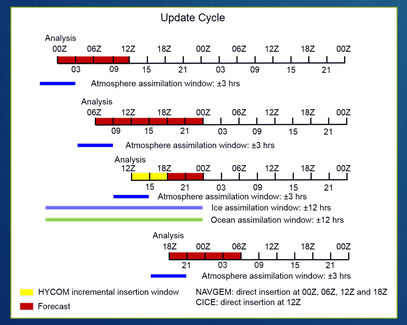
- NAVDAS-AR (atmosphere)
  - 6-hour update cycle with direct insertion at 00Z, 06Z, 12Z and 18Z
- NCODA-3DVar (ocean, ice)
  - 24-hour update cycle at 12Z, incremental insertion from 12Z to 18Z

Downward projection of surface information into the ocean:

- Uses Improved Synthetic Ocean Profiles (ISOP) to represent the vertical structure of the ocean

Hindcast time period:

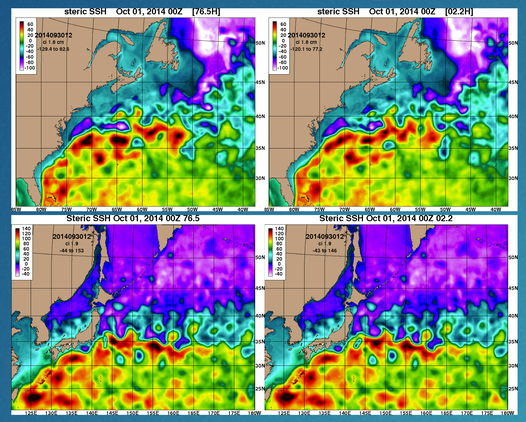
- June 2014 through September 2014 (4 months)
- Will be compared against the Global Ocean Forecast System (GOFS) 3.1 that is a two-way coupled HYCOM/CICE system with NCODA assimilation and forced by uncoupled NAVGEM 1.3 atmospheric output



Ocean and ice comparisons of the ESPC Hindcast versus stand-alone Global Ocean Forecast System 3.1

Spot checks of Western Boundary Currents: Steric SSH, 1 October 2014

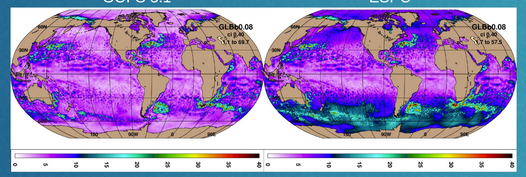
GOFS 3.1 ESPC



Would not expect these to be identical because of the highly non-linear nature of western boundary currents and there is not enough altimeter data to fully constrain the flow.

SSH Variability: July – September 2014

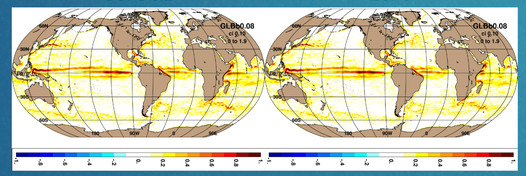
GOFS 3.1 ESPC



ESPC has dynamic surface pressure forcing as part of the coupling whereas this is not implemented in GOFS 3.1, thus we expect to see higher SSH variability in the ESPC hindcast.

Mean Speed at 15 m depth: July – September 2014

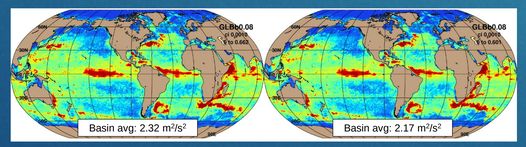
GOFS 3.1 ESPC



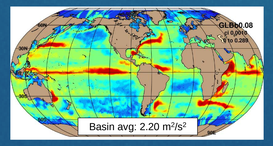
Very similar upper ocean speed → implies surface wind forcing in the coupled system is consistent with stand-alone NAVGEM 1.4.

Eddy Kinetic Energy at 15 m depth: July – September 2014

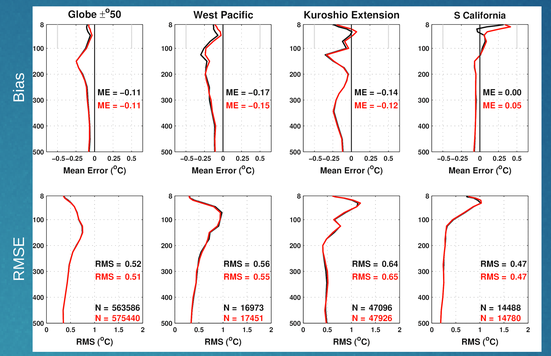
GOFS 3.1 ESPC



EKE at 15 meters depth derived from drifting buoys and averaged over the time period 1979-2012 (Lumpkin and Johnson, 2013).

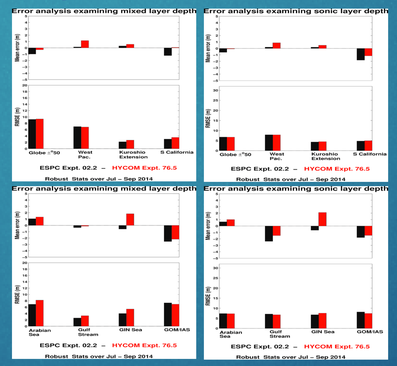


Temperature vs. Depth Error Analysis Using Unassimilated Profile Observations at the Nowcast Time

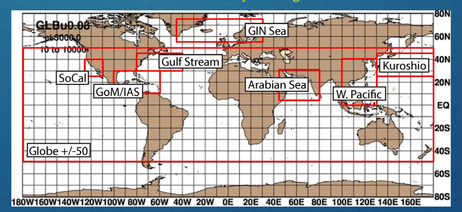


GOFS 3.1 ESPC | Depth average | # of observations

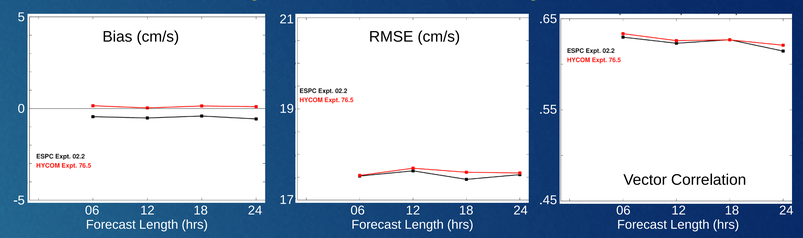
Mixed Layer Depth / Sonic Layer Depth Error Analysis Against Unassimilated Profile Observations



Ocean Error Analysis Regions



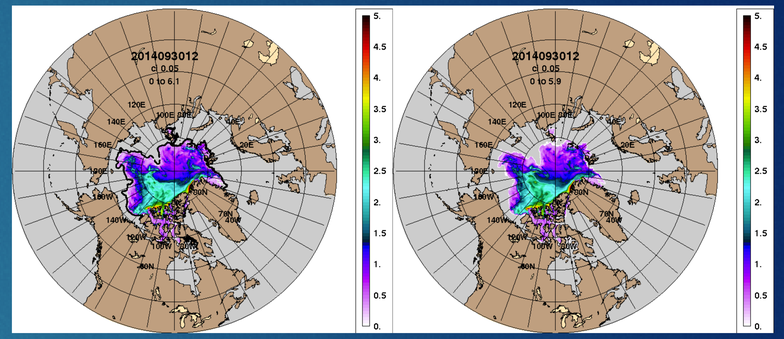
Upper Ocean Speed and Direction Error Analysis as a Function of Forecast Length Using Unassimilated NOAA Global Drifter Program Observations



GOFS 3.1 ESPC

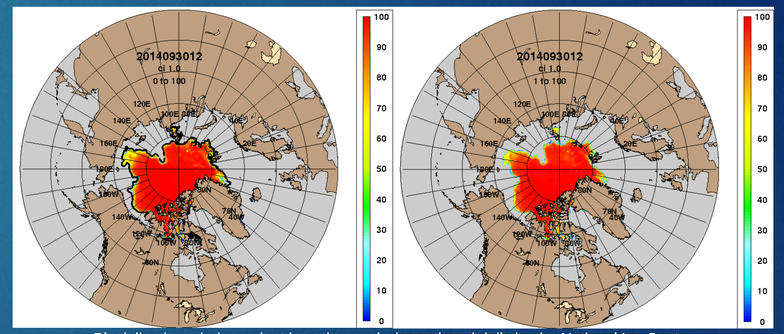
Spot checks of Arctic Sea Ice Thickness (m): 1 October 2014

GOFS 3.1 ESPC



Spot checks of Arctic Sea Ice Concentration (%): 1 October 2014

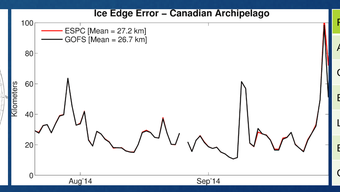
GOFS 3.1 ESPC



Black line is an independent ice edge analysis produced daily by the National Ice Center

Daily Ice Edge Location Error (km) Relative to the Independent NIC Ice Edge

NH Ice Analysis Regions



Ice Edge Error vs. Time

Region	GOFS 3.1	ESPC
Arctic	24.9	24.9
Greenland/Norwegian	21.2	21.4
Barents/Kara	21.2	21.2
Laptev/ E. Siberian	27.9	28.1
Bering/Chukchi/Beaufort	25.7	25.8
Canadian Archipelago	27.2	26.7

Ice Edge Error Statistics