U.S. NAVAL RESEARCH LABORATORY

Global Ocean Forecast System

AT A GLANCE

What is it?

An operational global ocean/sea ice nowcasting and forecasting system that runs daily by Fleet Numerical Meteorology and Oceanography Center.

How does it work?

The system assimilates real-time ocean surface and subsurface observations to constrain the ocean interior at the initial time. The numerical ocean model then acts as a dynamical interpolator to accurately forecast the initial state forward in time.

What will it accomplish?

The system provides daily 7-day forecast of the 3-dimensional ocean structure, the location of mesoscale features such as eddies and ocean fronts, sea ice parameters and environmental conditions.

R&D Sponsors

Office of Naval Research

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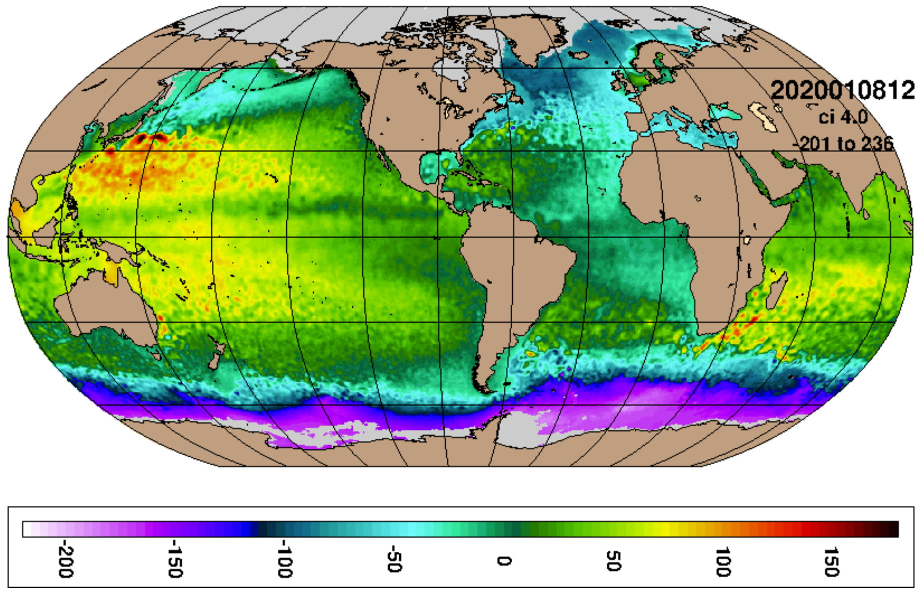
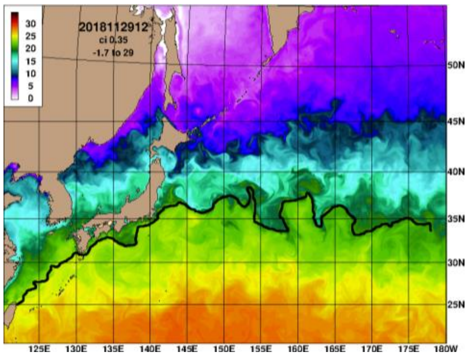


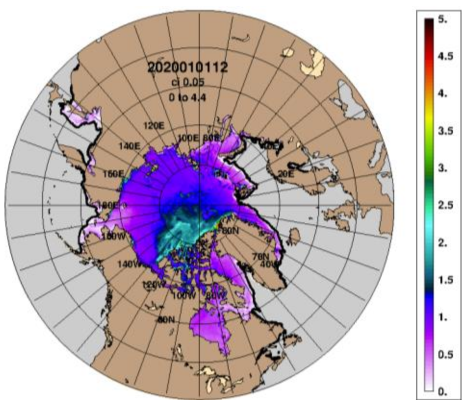
Sea surface height (cm) on 9 January 2020 from the Global Ocean Forecast System (GOFS) 3.1.The gray areas in the polar latitudes represent sea ice. In general, ocean currents flow parallel to the isolines with faster velocities found where the height gradients are tighter. Circular height contours represent mesoscale eddies.

The Global Ocean Forecast System (GOFS) is the US Navy's ocean/ice nowcasting and forecasting capability based on the HYbrid Coordinate Ocean Model (HYCOM), two-way coupled to the Community Ice CodE (CICE) and using the Navy Coupled Ocean Data Assimilation (NCODA). It runs daily at the Navy DoD Supercomputing Resource Center creating a nowcast through a 7-day forecast. The system 1) depicts the location of mesoscale features such as oceanic eddies and fronts, and provides 2) accurate 3-dimensional ocean temperature, salinity, and current structure, 3) boundary conditions for regional and nested coastal models, and 5) sea ice concentration, thickness and drift.

GOFS was declared operational in November 2018 and is based upon global HYCOM with a horizontal resolution of 1/12.5° (~9 km at the equator, ~7 km at mid-latitudes) and 41 hybrid vertical layers. The sea ice model (CICE) is two-way coupled to the ocean model and both exchange surface information to each other every hour. NCODA assimilates surface observations from satellites, such as altimeter sea surface height (SSH) anomalies, sea surface temperature (SST) and sea ice concentration, plus *in situ* SST observations from ships and buoys as well as temperature and salinity profile data from expendable bathythermographs, conductivity-temperature-depth sensors, gliders, marine mammals and Argo floats. The ocean/sea ice models use atmospheric forcing from the operational NAVy Global Environmental Model (NAVGEM) that is run daily at Fleet Numerical Meteorology and Oceanography Center (FNMOC).



Sea surface temperature (°C) for the Kuroshio Extension region from GOFS 3.1 for 30 November 2018. The black line is an independent frontal analysis of satellite SST data performed by the Naval Oceanographic Office.



Sea ice thickness (m) for the Arctic from GOFS 3.1 for 2 January 2020.The black line is an independent ice edge analysis from the National Ice Center.

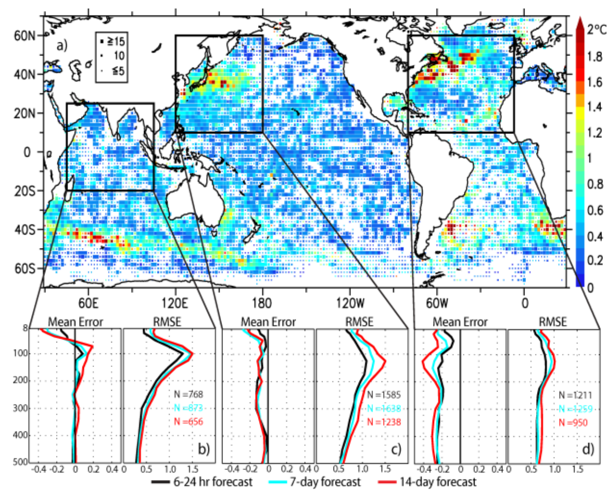
Reference:

Metzger, E.J., O.M. Smedstad, P.G. Thoppil, H.E. Hurlburt, J.A. Cummings, A.J. Wallcraft, L. Zamudio, D.S. Franklin, P.G. Posey, M.W. Phelps, P.J. Hogan, F.L. Bub, and C.J. DeHaan. 2014. US Navy operational global ocean and Arctic ice prediction systems. *Oceanography* 27(3):32–43.

http://dx.doi.org/10.5670/oceanog.2014.66.

Mesoscale eddies are ubiquitous across the global ocean and have impacts on phenomena ranging from ocean acoustic propagation to zooplankton production. Thus, it is essential that a prediction system accurately represent these features of the oceanic "weather". This is achieved mainly through assimilation of satellite altimeter data, but the ocean model itself must also be a good dynamical interpolator of this input data stream. Eddies must be properly maintained and have accurate propagation speeds when they become unobserved between altimeter tracks. For the world ocean, GOFS has been shown to have skill predicting SSH anomalies out to 30+ days, although this lessens to about 10 days for the Gulf Stream and 16 days for the Kuroshio (which are the highly non-linear western boundary currents of the Atlantic and Pacific Oceans, respectively).

Accurate forecasts of the subsurface temperature, salinity, and velocity structure are a first order requirement for Navy ocean prediction systems. The vertical distributions of temperature and, to a lesser extent salinity, determine the sound speed properties. The near-surface stratification, surface mixed layer, and thermocline gradient also play important roles in the sound propagation. Therefore, the predictability of ocean temperature and salinity is vital to accurate simulation of the underwater acoustical environment – a key Navy concern. See the figure directly below.



Temperature (°C) vs. depth error analysis against unassimilated profiles during a data-assimilative hindcast spanning 2012. (a) RMSE in 2° bins averaged over the top 500 m at 00Z. Approximately 100,000 profiles went into the analysis and the number of profiles in each bin is denoted by the legend in Asia. (b-d) Mean error and RMSE as a function of depth and forecast length for the three regions outlined in (a). The black curves are for the 6-24 hour short-term forecast, the cyan curves for the seven-day forecast, and the red curves for the 14-day forecast. The average number of observations in each analysis is denoted by N = XXX. Model-data differences greater than three standard deviations are excluded from the analysis.

This system also provides boundary conditions for even higher resolution coastal models and serve as the backbone of a globally relocatable ocean nowcast/forecast capability that will address the need for littoral or deep water support anywhere in the world, without the need for most intermediate regional models.

Future developments

Beyond GOFS, NRL's Marine Meteorology and Ocean Sciences Divisions are developing the Earth System Prediction Capability (ESPC) that consists of two-way coupling between the atmosphere (NAVGEM), ocean (HYCOM), sea ice (CICE) and surface waves (WAVEWATCH III®) . The coupling will increase the accuracy of forecasts at longer lead times. Both high horizontal resolution deterministic and lower resolution probabilistic systems are under development and moving through the transition process to eventually replace GOFS for ocean/sea ice prediction.