a. USA – Global Ocean Forecast System (GOFS)

Background

1. Input data:
   In situ observations reported through the WMO's Global Telecommunication System (GTS) are used in the real-time system. Satellite SST and SSH observations are either generated at the Naval Oceanographic Office, Stennis Space Center, USA (NAVOCEANO), or obtained elsewhere (e.g., GHRSST GDAC at JPL). Prior to assimilation all observations are processed through the fully automated, real-time ocean quality control program that is a part of the Navy Coupled Ocean Data Assimilation (NCODA) system. The observations used include: satellite altimeter SSH (Jason-3, AltiKa-Drifting Phase (DP), Cryosat-2), satellite SST (NOAA-18, NOAA-19, METOP-A, METOP-B, GOES-13, GOES-15, MSG, MTSAT-2, COMS-1, NPP-VIIRS), fixed and drifting buoys, in situ profiles (Argo, CTD, XBT, ocean gliders), surface temperature and salinity observations from ships, sea ice concentration from SSM/I and SSMIS, AMSR2, and surface drifters. For the atmosphere, 3-hourly NAVy Global Environmental Model (NAVGEM; v. 1.3) forcing is used. Monthly river forcing is included in the model and bathymetry is obtained from the NRL DBDB-2 database.

2. Data serving:
The output from the system is available through a data server located at the Center for Ocean-Atmospheric Prediction Studies (COAPS) at the Florida State University: http://www.hycom.org.

3. Model:
The ocean model is the 1/12.5° (~9 km equatorial latitude) global HYbrid Coordinate Ocean Model (HYCOM). The model is forced by the T425L60 NAVGEM (v. 1.3).

4. Assimilation method:
NCODA is used as the assimilation component of the nowcast/system. The present version of NCODA uses a 3-D Variational technique (3DVar).

5. Assimilation products and dissemination:
See the input data and data serving sections above.

6. Systems:
NCODA v3.9: system includes observation space 3DVAR, estimation of analysis error covariance, and ensemble transform (ET) for generating ensemble perturbations (although available, the latter two are not used in the current operational system).

NCODA v4.00: This includes a parallel version of pre-processing on the observational data streams. This is pre-operational at this time.

GOFS v3.0: HYCOM/NCODA/NAVGEM. Performs a 4-day hindcast, analysis, and a 7-day forecast once per day.

GOFS v3.1: A validation test report was completed and approved by the validation test panel. Modifications were requested as a result of an OPTEST conducted by NAVOCEANO and the National Ice Center (NIC). Based on that feedback, modifications are being implemented at this time. Once completed, a new VTR and OPTEST will be conducted before GOFS 3.1 is officially declared operational. GOFS 3.1 is based on GOFS 3.0 with vertical resolution changed from 32 to 41 layers, Improved Synthetic Ocean Profiles (ISOP) for downward projection of SSH to temperature and salinity at depth, a 1-day hindcast period, and coupled to Community Ice CodE
A new bathymetry/coastline geometry is also used, based on the 30" GEBCO product. GOFS 3.1 is expected to be transitioned to NAVOCEANO during FY17-Q1 (Dec. 2017).

GOFS v3.5: Scheduled to be transitioned in FY17-Q4 (Sep. 2017). GOFS 3.1 with increased horizontal resolution (1/25 degree; ~4 km) and tidal forcing (potential, self-attraction and loading, and topographic wave drag).

ESPC: Earth System Prediction Capability. Based on HYCOM ocean, CICE ice, NAVGEM atmosphere, and WaveWatch III waves. An initial Operational Capability (IOC) is scheduled for FY18-Q4. This will include a 1/25° deterministic ocean/ice as well a 1/12° ocean-ice probabilistic (ensemble) forecast. The ocean-ice will be based on GOFS 3.x configurations. Coupling to WWIII (stokes drift) is currently being implemented. Atmospheric resolution will be either T425 or T681.

7. Observations:
The following observed quantities are assimilated by NCODA: satellite altimeter SSH, satellite (IR and MW) and in-situ SST (ships plus fixed and drifting buoys), temperature and salinity profiles, satellite sea ice concentration.

8. Internal metrics and intercomparison plans:

For the ESPC system, additional metrics (beyond those already used in GOFS 3.0) include:

- SST biases from NCODA analyses/NOAA maps (Anomaly correlations/tropical indices).
- SSH biases from altimetry/NCODA analyses (anomaly correlations).
- Equatorial winds (westerly wind bursts, TOA buoys/scatterometer/NAVGEM analyses).
- Air-sea fluxes (wind stress, heat flux, solar radiation).
- Depth of 15°C and 20°C isotherms (vs. NOAA isotherm depth).
- Upper ocean heat content (ML depth, surface drifters, NOAA heat content analyses).
- Ice analyses (concentration, thickness, drift).
- Arctic and Antarctic Ocean (circulation pathways and water mass distributions, tethered buoy profiles).
- Surface wave analyses (SWH from altimetry and buoys).

In addition, numerous internal metrics and comparisons are described in the Validation Test Reports and other publications:


E. J. Metzger, A. J. Wallcraft, P. G. Posey, O. M. Smedstad and D. S. Franklin, 2013: The Switchover from NOGAPS to NAVGEM 1.1 Atmospheric Forcing in GOFS and ACNFS *NRL Report* NRL/MR/7320—13-9486


9. Targeted users and envisioned external metrics:
US Navy will use the global system as boundary conditions for their high resolution relocatable (nested) models as well as general Fleet support. Daily analysis fields are made available to NCEP for initialization of the Real-Time Ocean Forecasting System (RTOFS).

10. Reanalysis activities:
Global 1993-2012 was completed in 2013. Ocean reanalysis using 1/12° global HYCOM/NCODA forced by the National Centers for Environmental Prediction Climate Forecast System Reanalysis using the GOFS 3.0 ocean configuration (32 layers, energy-loan for ice, MODAS synthetics for downward projection, 3DVar assimilation). Output from this reanalysis is available at hycom.org.

A new reanalysis based on the GOFS 3.1 configuration (see above) is nearly complete. This covers 1999-2015 and is forced with CFSR through 2010 and CFSV2 from 2011-2015.

11. Computing resources:
The system is running on 713 Cray XC40 processors at the Navy Department of Defense Supercomputing Resource Center (DSRC) located at Stennis Space Center. Under this configuration the system requires ~5.5 wallclock hours to perform a 4-day hindcast, analysis, and 7-day forecast.

12. Consolidation phase and transition to operational system (activities):
GOFS 3.1 Validation Test Report is currently being written (FY17-Q1 (Oct.-Dec.)). OPTEST’s will be performed by NAVOCEANO and the NIC pending the acceptance of the Validation Test Report by the Validation Test Panel.

13. GODAE OceanView related achievements and measures of success:
## System information overview

<table>
<thead>
<tr>
<th>System name: Global Ocean Forecast System (GOFS 3.0)</th>
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</thead>
</table>

### Ocean Models

<table>
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<tr>
<th>OGCM</th>
<th>1/12.5° HYbrid Coordinate Ocean Model (HYCOM)</th>
</tr>
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<tr>
<td>Domain</td>
<td>Global</td>
</tr>
<tr>
<td>Horizontal resolution</td>
<td>1/12.5° at the equator</td>
</tr>
<tr>
<td>Vertical sampling</td>
<td>32 hybrid coordinate surfaces</td>
</tr>
<tr>
<td>Atmospheric Forcing</td>
<td>T425L60 Navy Global Environmental Model (NAVGEM) (v. 1.3)</td>
</tr>
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### Assimilation characteristics

<table>
<thead>
<tr>
<th>Assimilation Scheme</th>
<th>Navy Coupled Ocean Data Assimilation (NCODA): 3DVAR</th>
</tr>
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<tbody>
<tr>
<td>SST</td>
<td>NOAA-18, NOAA-19, METOP-A, METOP-B, GOES-13, GOES-15, MSG, COMS-1, MTSAT-2, NPP-VIIRS, drifting buoys, fixed buoys, ships (ERI, bucket, hull contact)</td>
</tr>
<tr>
<td>SSH</td>
<td>Jason-3, Altika-DP, Cryosat-2</td>
</tr>
<tr>
<td>Other</td>
<td>In situ profiles, (Argo, gliders, XBTs, fixed and drifting buoys, CTDs), sea ice concentration (SSM/I, SSMIS).</td>
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</tbody>
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### System Set-ups

<table>
<thead>
<tr>
<th>Forecast range</th>
<th>7 days</th>
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<tbody>
<tr>
<td>Update frequency</td>
<td>Daily</td>
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<tr>
<td>Hindcast length</td>
<td>4 days</td>
</tr>
</tbody>
</table>

### System website links

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