The Navy's Real-time Global Nowcast/Forecast System

Real-Time and archived results (updated daily): http://www.ocean.nrlssc.navy.mil/global_nlom

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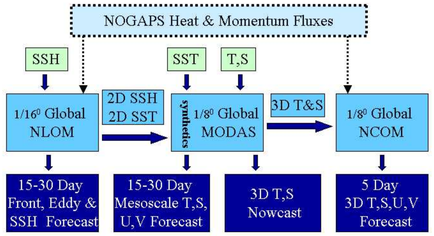
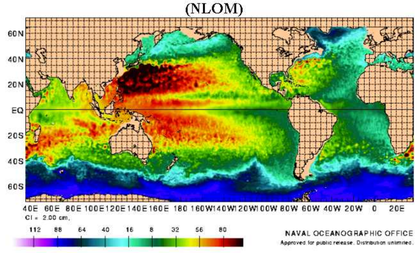
Abstract

The Naval Research Laboratory (NRL) has developed a first-generation real-time global ocean nowcast/forecast system that runs daily at the Naval Oceanographic Office (NAVOCEANO). The system is built around the operational Modular Ocean Data Assimilation System (MODAS), which is an optimum interpolation analysis system including a climatological data base that has the ability to produce synthetic temperature and salinity profiles from sea surface height (SSH) and sea surface temperature (SST) data. The system's model components are the eddy-resolving 1/16 global NRL Layered Ocean Model (NLOM) and a 1/8 global version of the NRL Coastal Ocean Model (NCOM). The version of NLOM described here, which is now operational at NAVOCEANO, is wind and thermal forced with assimilation of satellite derived SSH and SST. NCOM is a fully global model that assimilates temperature and salinity profiles from the MODAS analysis and is now running in real-time with delivery to NAVOCEANO planned for 2002. Nowcast/forecast results from the system will be shown including examples of the ability of the MODAS synthetic profiles to represent the 3-D structure of ocean mesoscale features. NLOM's skill in nowcasting and forecasting SSH and the positions of major ocean fronts and eddies out to 30 days will be discussed. The ability of the NCOM model to provide skillful short-term (~5-7 day) forecasts of the upper ocean including SST and mixed-layer depth is also investigated.

Global Ocean Prediction Baseline



1/16⁰ Global NRL Layered Ocean Model (NLOM)

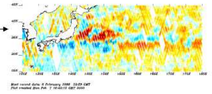


- 6 layers with embedded mixed layer model
- assimilation of SSH from TOPEX, ERS-2 and GFO. Assimilation of SST from MODAS 2-D SST analysis.
- NOGAPS wind stress and thermal forcing
- Climatological wind and thermal forcing used to extend forecast beyond 5 days.
- In forecast mode, SST is relaxed to the nowcast SST with a climatological correction applied and an e-folding time scale of ¼ the forecast length.

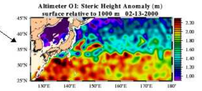
Transitioned Systems

Running operationally at NAVO

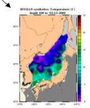
- ***ALPS*** **processes real time altimeter data**



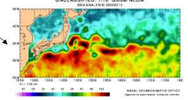
- ***MODAS 2-D*** **interpolates the altimeter SSH horizontally to provide a SSH nowcast**



- ***MODAS 3-D*** **extends the surface information to vertical temperature and salinity profiles**



- ***1/16⁰ Global NLOM*** **assimilates altimeter SSH and MODAS SST to provide SSH, SST nowcasts and 30-day forecasts**



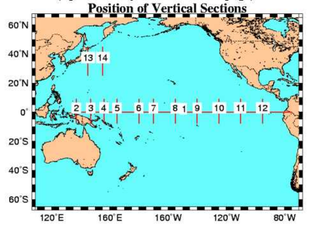
Global NLOM Data Assimilation Methodology

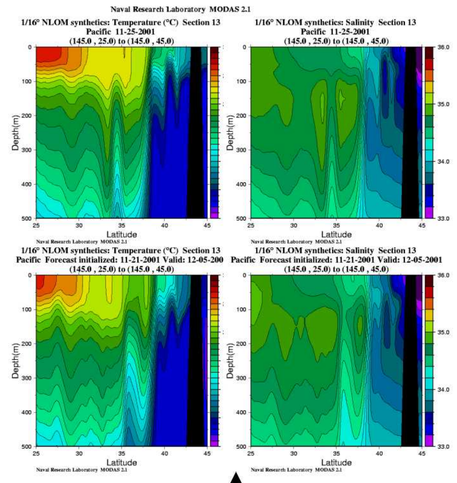
- **OI deviation analysis using the model as first guess**
  - * Mesoscale data covariance from T/P + ERS-2 data calculated by Jacobs et al. (2001, JGR-O)
  - * 3-day window for altimetry
- **Subsurface statistical inference via EOF regression**
  - * Including the abyssal layer which has a major impact on the upper ocean circulation, Hurlburt et al. (1990, JGR-O)
- **Velocity changes via geostrophy**
  - * Outside of equatorial band
- **Incremental updating to minimize gravity wave generation**
- **Assimilation cycles need to go back approximately 3 days to pick up altimeter data with improved orbit removal**
  - * More recent altimeter data with less accurate orbits are also used
- **Relaxation to the daily MODAS SST analysis**

MODAS synthetic temperature and salinity profiles derived from NLOM SSH, SST real-time analysis and forecast

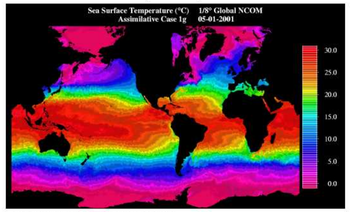
(Updated daily on NLOM web page)

Position of Vertical Sections





1/8⁰ Global Navy Coastal Ocean Model (NCOM)

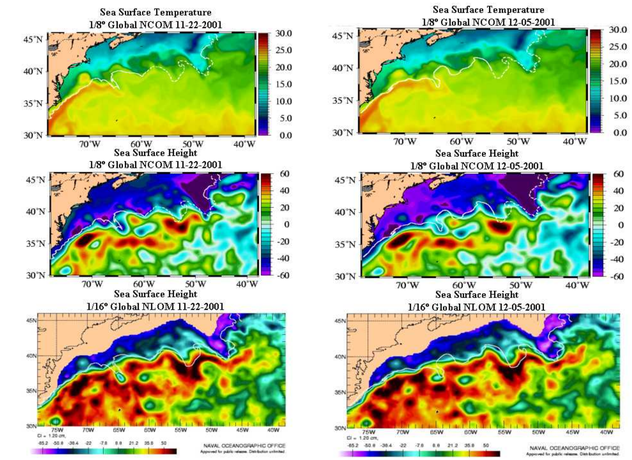


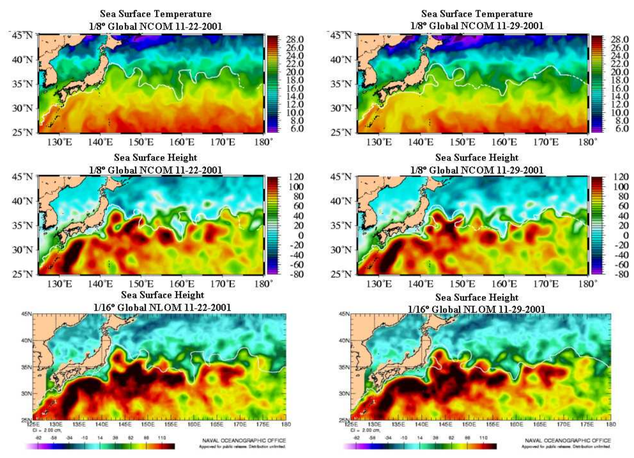
- 41 sigma-z levels in the vertical
- 20 sigma/1m deep-water upper level thickness
- assimilation of SST, SSS, 3-d T&S from MODAS using 1/16° NLOM SSH
- NOGAPS wind stress, radiation, heat flux
- generic grid extraction capability

Global NCOM Data Assimilation Methodology

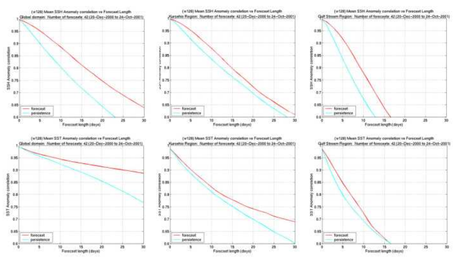
- Acquire sea surface temperature (sst)
  Use daily SST analysis from the Naval Oceanographic Office (NAVOCEANO) MODAS2D optimal interpolation (OI) of MCSST observations.
- Acquire sea surface height (ssh)
  Use either daily SSH analysis from the NAVOCEANO MODAS2D OI of TOPEX, ERS and GFO altimetry or daily steric-SSH nowcast from the 1/16⁰ Navy Layered Ocean Model (NLOM)
  A mean correction is added to the height fields so that the resulting ssh is a deviation from the MODAS climatological mean steric height anomaly.
- Produce 3D T&S fields
  Estimate subsurface temperature and salinity using MODAS3D synthics
  Regressions relate sst and /or steric ssh deviations from climatology with subsurface temperature deviations. Since the non-steric fraction of altimetric ssh tends to increase in shallow water and the NLOM boundary is at the 200m isobath, ssh is smoothly removed from synthetic temperature estimates as depths become shallower than 600m. Salinity is estimated using climatological T & S relations.
- Assimilate in-situ observations
  MODAS3D OI can assimilate subsurface observations to improve the analysis.
- Adjust for vertical stability
  Convert to potential temperature, adjust salinity to produce vertical stability.
- Modify surface heat and freshwater fluxes
  Surface temperature and salinity is assimilated by adjusting surface freshwater and heat fluxes.
  *Relax 3d potential temperature and salinity toward the specified fields using weighting functions which allow 3d variability.
  Present weighting decays to 0 at the surface and is e^{-1} at 200m.

Real-time snapshots of SSH, SST from NCOM and NLOM systems for Gulf Stream and Kuroshio regions overlayed by independent NAVOCEANO frontal analysis obtained from AVHRR images (white line)

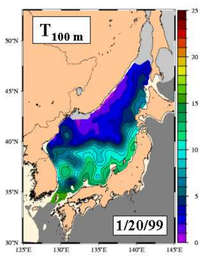




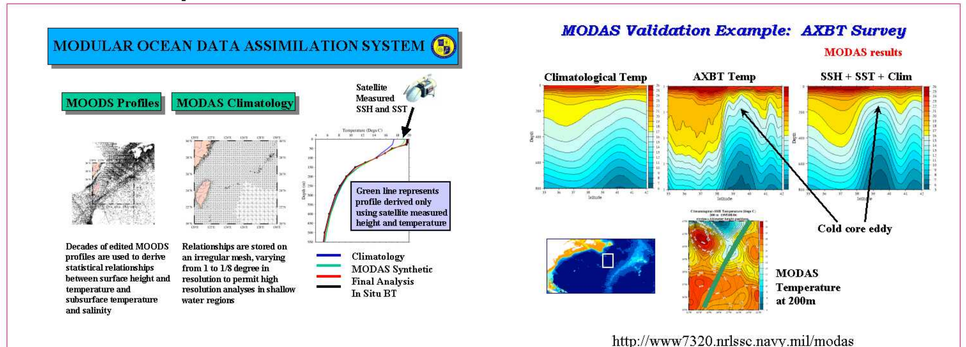
NLOM 30-day Prediction Metrics



Modular Ocean Data Assimilation System (MODAS)



- *Ocean thermal data assimilation model*
- *Combine climatology, altimetry, MCSST, and on-scene data to produce 3D ocean thermal structure nowcasts*
- *Operational global & relocateable, regional implementations*
- *Based on Optimum Interpolation (OI) technique*

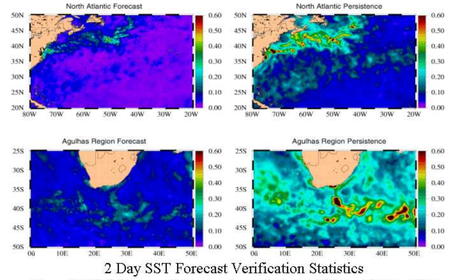


MODAS Validation Example: AXBT Survey

http://www7320.nrlssc.navy.mil/modas

SST Prediction Metrics from 1/4° Global NCOM System

(Prototype testing for 1/8° Global NCOM System)



2 Day SST Forecast Verification Statistics
Mean RMS (°C) over 40 forecasts made 4 Jan 2001 – 12 Feb 2001