An aerial photograph of a coastline, likely Monterey Bay, California. The water is a deep blue, and the land is green with some urban areas. The text is overlaid on the water and land.

*Description of Recent Updates to the NRL
Coupled Ocean Data Assimilation System
(NCODA)*

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*HYCOM NOPP GODAE Meeting
RSMAS October 2004*

Report Documentation Page

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NRL Coupled Ocean Data Assimilation System

Advanced DA Technique Based on Optimal Estimation Theory

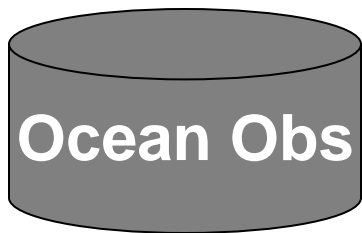
- oceanographic version of MVOI method used in NWP systems Lorenc (1981), Daley (1991)
- simultaneous analysis of five ocean variables: temperature, salinity, geopotential, and u-v velocity components (T, S, Φ , u, v)
- developed as part of the ONR sponsored coupled modeling projects at NRL MRY (COAMPS/NCOM and NOGAPS/POP)

Flexible System

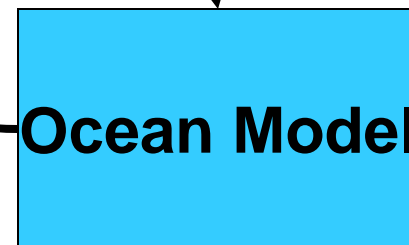
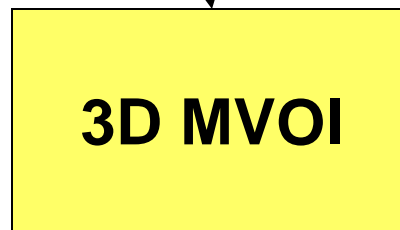
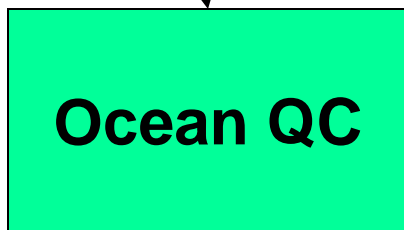
- supports variety of map projections
- performs multi-scale analyses on nested, successively higher resolution grids
- initialize/update ocean forecast model or run stand-alone
 - 2D analyses of sea ice and SST (NWP boundary conditions)
 - 3D temperature and salinity analysis (geostrophic currents)
 - 3D MVOI sequential incremental update cycle

NRL Coupled Ocean Data Assimilation

**Sequential Incremental Update Cycle
Analysis-Forecast-Analysis**



- MCSST
- GOES SST
- LAC SST
- Ship SST
- Buoy SST
- XBT, CTD
- PALACE Float
- Fixed Buoy
- Drift Buoy
- Altim SSHA
- SSM/I Sea Ice



**Forecast Fields
Prediction Errors**

First Guess

Innovations

Increments

**Forecast fields and prediction errors
can be used in the QC of new data**



FNMOC Quality Controlled Operational Ocean Observation Data Sources

- **AVHRR GAC Satellite SST** **~800,000 obs/day**
 - 8-km resolution (NOAA 16,17 day, night, relaxed day retrievals)
- **GOES Satellite SST** **~3,000,000 obs/day**
 - 12-km resolution (GOES 10 day, night retrievals)
- ***In Situ* SST/SSS** **~15,000 obs/day**
 - surface ship, fixed and drifting buoys, CMAN, TRACKOB
- **Subsurface Temperature and Salinity Profiles** **~1000 profiles/day**
 - XBTs, CTDs (TESACS), Argo floats
 - fixed buoys (TAO, PIRATA), thermistor chain drifting buoys
- **Sea Surface Height Anomaly (SSHA)** **~100,000 obs/day**
 - altimeter (GFO, ENVISAT, Jason-1), XBTs, CTDs, Argo Floats
- **Sea Ice Concentration** **~1,000,000 obs/day**
 - SSM/I (DMSP F13, F14, F15)

All QC data files available on Monterey GODAE server in real-time



New Ocean Observation Data Sources

- **AVHRR LAC Satellite SST** **~3,200,000 obs/day**
 - 2-km resolution (NOAA 17 day, night retrievals)
- **GOES Satellite SST** **~3,000,000 obs/day**
 - 12-km resolution (GOES 12 day, night retrievals)
- **AMSR-E Microwave SST** **~180,000 obs/day**
 - 25-km resolution (day, night retrievals)
- **AATSR Skin SST** **~90,000 retrievals/day**
 - 16-km resolution (day, night retrievals)

AVHRR LAC and GOES 12 satellite SST retrievals operationally available at NAVOCEANO (and GODAE server)

AMSR-E and AATSR satellite SST available on GODAE server



New Analysis Capabilities

- **Irregular Grid**

- supports global stitched grid (Global NCOM)
- analysis currently supports Mercator, Polar Stereographic, Lambert Conformal, Spherical, Cartesian grid projections

- **Enhanced QC Tests**

- SSM/I land contamination
 - flags spurious positive sea ice concentration retrievals near land during summer melt season
- satellite SST diurnal warming
 - detects warm biased daytime satellite SST retrievals due to diurnal warming events (collocates NWP winds and solar radiation)
- Argo salinity profile bias correction
 - corrects salinity profile to GDEM 3.0 climate salinity offset at depth
- profile cross validation
 - checks new profiles with analysis performed using nearby profiles



New Analysis Capabilities

- **Reduced Resolution Assimilation Grid**
 - compute innovations from full model resolution grid; perform analysis on coarser resolution analysis grid
 - cost of assimilation mainly in post multiplication (observation to grid space); reduced resolution analysis grid improves throughput
- **Improved Memory Management**
 - required for large model grids on IBM architecture
- **Wave Model Data Assimilation**
 - altimeter/buoy significant wave height (SWH) data in Wavewatch III
 - **FNMOG OPTTEST planned for 2004/2005 northern hemisphere winter**
 - wave model spectra update using choice of methods (BMRC or NCEP)
 - includes new SWH observation QC module



NCODA Operational Status

- **FNMOCC**
 - Ocean QC system operational March 2004
 - NCODA 3D analysis-only capability operational August 2004
 - near global analysis running daily in real-time (27-km mid-latitude resolution Mercator grid)
 - 2D sea ice and SST analyses running daily in real-time on 27-km northern and southern hemisphere polar stereographic grids
- **NAVOCEANO**
 - RTP project transitioned QC and analysis to NAVOCEANO
 - Ocean QC nearing operational status
 - biggest issue is connecting to NAVO data streams
 - global sea ice and SST analyses run daily on NAVOCEANO IBMs to support QC
 - NCODA analysis being used in exercise support within NAVOCEANO



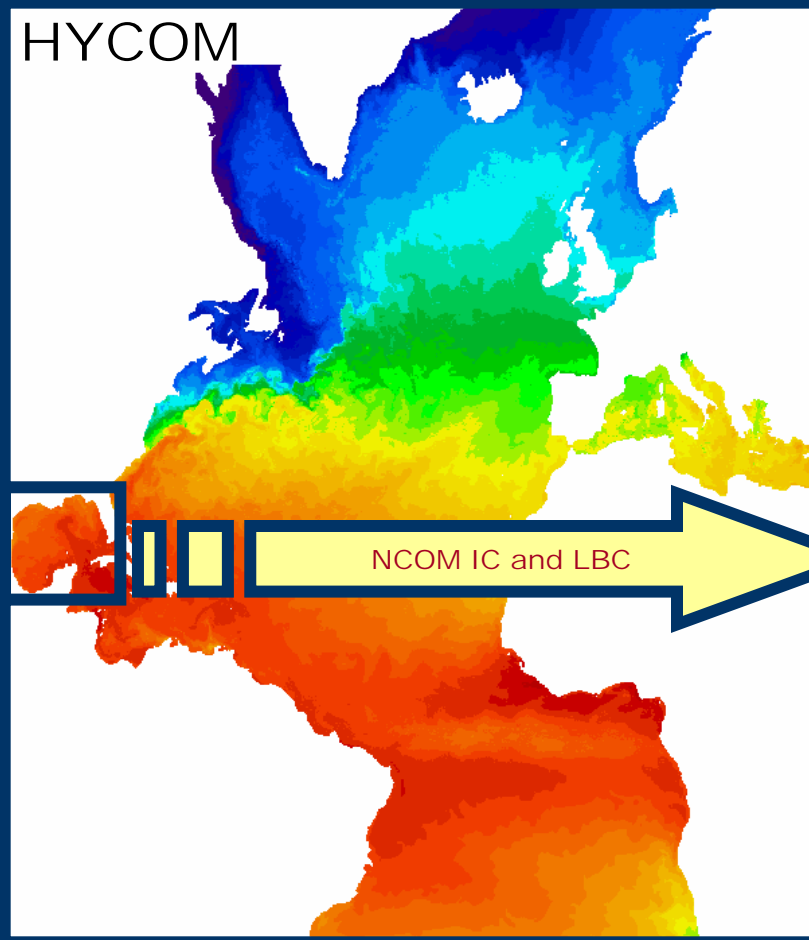
NCODA Plans

- **Conversion to 3DVar - adapt NAVDAS solver to the ocean**
 - allows for greater flexibility for assimilating different observation data types (possibly non-linearly related to the forecast model state)
 - eliminates the need to spilt the analysis domain into sub-domains (all observations can influence the analysis at every model grid point)
 - provides a clear development path towards more advanced 4D assimilation techniques
- **Velocity Observation Data Assimilation**
 - quality control and pre-processing module development
 - model velocity background checks
 - speed, direction conversion to u,v vectors; analysis grid rotation
 - observation error - instrumentation and representation
 - develop sources of velocity observations in real-time
 - Argo float drift, HF radar, current meters, drifting buoys, wide swath altimetry

HYCOM Tasks

Naval Research Laboratory, Marine Meteorology Division (NRL MMD)

HYCOM

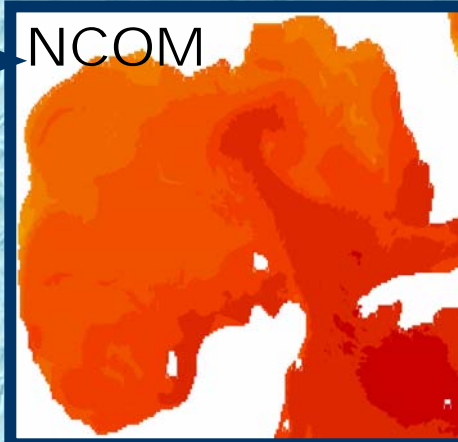


NCOM IC and LBC

On-Going Research

- **Restructure COAMPS™ CM and Code Structure**
 - **ESMF, WRF compliance (FY04-FY06)**
 - **Adapt Flux Coupler to force HYCOM (FY05+)**
 - **Add HYCOM as ocean model (FY06+)**
- **Test HYCOM fields as IC and LBC for NCOM (FY05)**

NCOM



Needs:

- Daily real-time HYCOM forecast runs to 72 h, w/3 h interval (T, S, u, v, SSH)
- Standardized I/O (filenames, format)
- Areas of interest: Med/Atlantic, east and west Pacific
- Interpolation code (HYCOM-to-NCOM vertical grids)
- HYCOM ported to ESMF

ESMF: **Earth System Modeling Framework**

WRF: **Weather Research and Forecast (Infrastructure)**

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