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

James Cummings
Oceanography Division
Naval Research Laboratory
Monterey, CA

HYCOM NOPP GODAE Meeting
RSMAS October 2004

## 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

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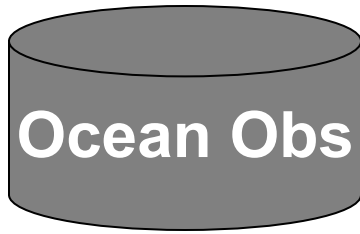
MCSST
GOES SST
LAC SST
Ship SST
Buoy SST
XBT, CTD
PALACE Float
Fixed Buoy
Drift Buoy
Altim SSHA
SSM/I Sea Ice

Ocean QC

Innovations

3D MVOI
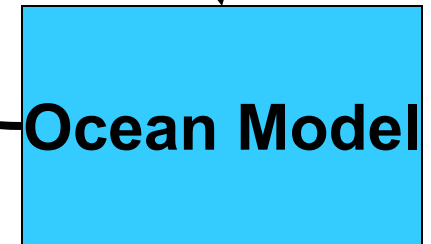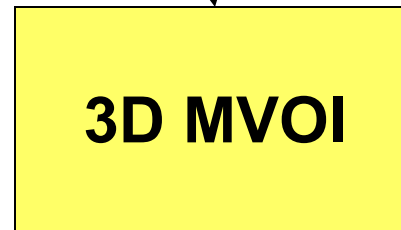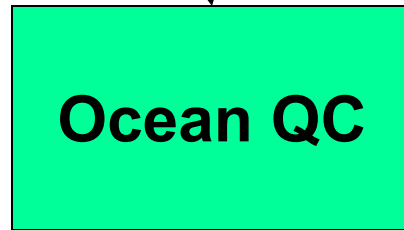
Increments

Forecast Fields
Prediction Errors

First Guess

Ocean Model

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

- **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
    - FNMOC OPTEST 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

- **FNMOC**
  - 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
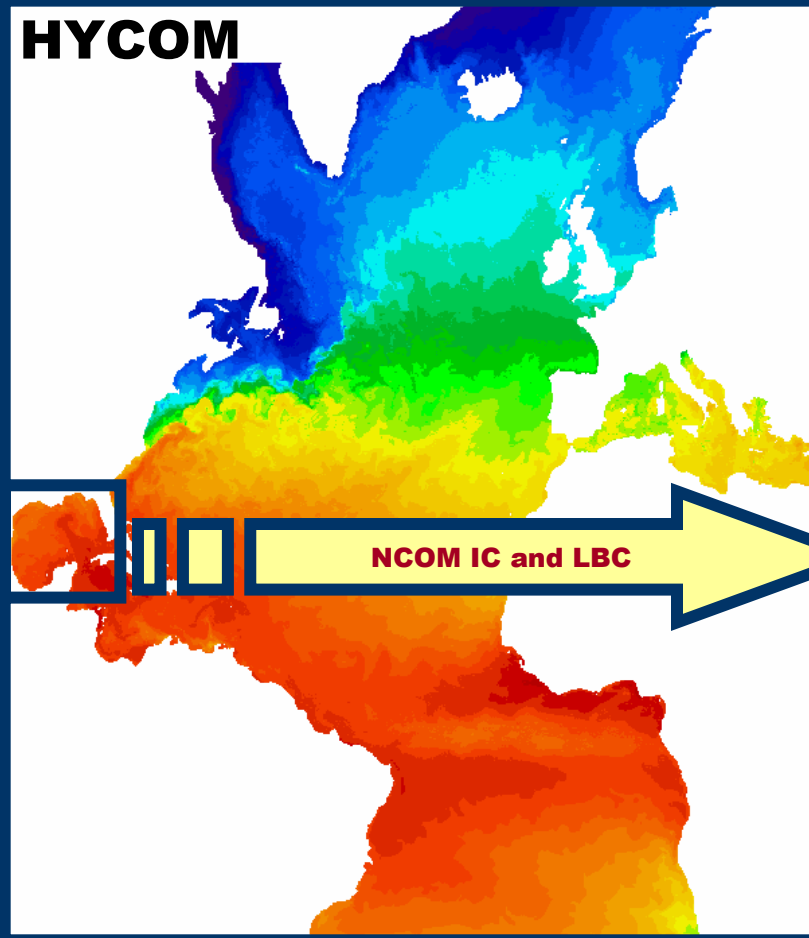
NCOM IC and LBC →

NCOM

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)**

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)
COAMPS™ is a trademark of the Naval Research Laboratory