NCODA Status
NRL Coupled Ocean Data Assimilation

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Outline
1. NCODA System Overview
2. New Analysis Capabilities
NCODA Status NRL Coupled Ocean Data Assimilation

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Approved for public release; distribution unlimited

Same as Report (SAR)
NCODA System Overview

Flexible System
- global or regional applications
- re-locatable, multi-scale analyses on nested, successively higher resolution grids (3:1 nest ratios)
- 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 (model-based)

Designed as Complete End-to-End Analysis System
- data quality control, analysis, performance diagnostics
- operational at Navy Centers in analysis-only mode
  - Naval Oceanographic Office
  - Fleet Numerical Meteorology and Oceanography Center
Ocean Obs

NCODA Implementation
Sequential Incremental Update Cycle
Analysis-Forecast-Analysis

Ocean QC

3D MVOI

Ocean Model

SST: Ship, Buoy, AVHRR (GAC/LAC), GOES, AMSR-E, MSG, AATSR

SSS: TSG

Temp/Salt Profiles: XBT, CTD, Argo Float, Buoy (Fixed/Drifting), Gliders

SSH: Altimeter, T/S profiles

Sea Ice: SSM/I

Model forecast fields and prediction errors are used in the QC of newly received ocean observations.
New NCODA Capabilities

Analysis

– first guess appropriate time (FGAT)
– flow dependent correlations
– analysis error
– model climate error variance fields
– age of data on grid analysis variable
– pressure correction analysis variable
– data restriction in boundary areas

Observing Systems

– MeteoSat SST (MSG) from MeteoFrance (CMS-Lannion)
– Microwave SST (AMSR-E) from Remote Sensing Systems
– Ocean Gliders (up/down profiles, position varies with depth)
Sequential Incremental Update Cycle

Data Window (+/- 12 hours)

24 Hour Forecast

Innovations

Length update cycle user defined
All observations considered synoptic regardless length update cycle
First Guess at Appropriate Time

Data Window (+/- 12 hours)

12 Hour Forecast 18 Hour Forecast 24 Hour Forecast 30 Hour Forecast 36 Hour Forecast

Innovations

Length update cycle user defined
Interval of forecast periods user defined
Eliminates component of mean analysis error that occurs when comparing observations and forecasts not valid at same time
Flow Dependent Correlations

\[ h_s = 0.2 \]

small (large) \( h_s \) produces strong (weak) flow dependence

\[ s_h = \frac{x_o - x_b}{x_s} \]
\[ s_v = \frac{z_o - z_b}{z_s} \]
\[ s_f = \frac{h_o - h_b}{h_s} \]

\[ C_h = (1 + s_h) \exp(-s_h) \]
\[ C_v = (1 + s_v) \exp(-s_v) \]
\[ C_f = (1 + s_f) \exp(-s_f) \]
\[ C_b = C_h C_v C_f \]

\( x_s \) = horizontal scale (km)
\( z_s \) = vertical scale (m)
\( h_s \) = flow scale (dyn. m)

C\(_h\) = horizontal correlation
C\(_v\) = vertical correlation
C\(_f\) = flow correlation

Geopotential Valid 5 August 2005 00Z
Contour Interval 0.1 dyn m

100 M Temperature Increments
6 August 00Z
Analysis Error Reduction (%)

\[
P_a = P_b - P_b H^T [H P_b H^T + R]^{-1} H P_b
\]

estimates the forecast error reduction due to the observing networks

- \( P_a \) - analysis error
- \( P_b \) - background error
- \( R \) - observation error
- \( H \) - measurement functional

Will be used in ETKF to determine impact of glider data assimilation (adaptive sampling RTP)
**Model Based Error Variances**

- computed from differences of free running model states at analysis update cycle
- provides estimates of model error (variability) for all analysis variables \((T, S, u, v, h)\)
- used by NCODA in time evolution of background error variances

**NCODA Background Error Variances**

- vary by position, depth, analysis variable
- evolve with time, updated continuously using analyzed increment fields
- error growth parameterization in data void areas
  - function of age of data on grid and temporal autocorrelations
  - background errors asymptote at model (climate) variability in long term absence of observations
New Analysis Variable: Age of Data on Grid (hrs)
number hours since grid point influenced by an observation

Satellite SST

In Situ SST

MODAS Synthetics

Profiles

Age of Data at Surface
Age of Data at 400 M Depth

2 June 2005 00Z
New Analysis Variable:
Pressure Correction (db)

- compute pressure innovation ($OmF$) of forecast density in observed density profile
- compute pressure innovation error from $T, S, \rho$ errors scaled by observed potential density pressure gradient

$$e_p = (e_\theta \cdot \frac{\partial \rho}{\partial \theta} + e_S \cdot \frac{\partial \rho}{\partial S}) / (\frac{\partial \rho}{\partial p})$$

- assimilate pressure innovations using $T/S$ covariances in $T, S, \phi, u, v, p$ analysis
- correct HYCOM forecast interface pressures when layers are at target density
  - positive: move the layer down, forecast density shallower than observed
  - negative: move the layer up, forecast density deeper than observed
- correct HYCOM forecast $T, S, \rho$ when layers are not at target density
- apply constraints before initializing model
  - layer thickness is always positive
  - no bottom pressure change
Data Restriction in Lateral Boundary Areas

- Model forecast not accurate in lateral boundary areas
- Innovations (OmF) can be large in boundary areas
- Analyzed increments from boundary areas can degrade forecast in active regions
END