THE IMPACT OF VELOCITY DATA ASSIMILATION FROM DRIFTERS USING THE NAVY COUPLED OCEAN 3D VARIATIONAL DATA ASSIMILATION SYSTEM (NCODA-VAR)

Scott Smith[1], Gregg Jacobs[1], Robert Helber[1], Pete Spence[2], Matt Carrier[1]

D. Bogocki[4], J. Beron-Vera[3], S. Chen[3], E. Coelho[1], M. Curcic,[3] A. Griffa[3], M. Gough[3], B. Haus[3], A. Haza[3], P. Hogan[1], H. Huntley[5], M. Iskandarani[3], F. Judt[3], D. Kirwan[5], N. Laxague[3], A. Levinson[6], B. Lipphardt[5], A. Mariano[3], G. Novelli[3], J. Olascoaga[3], T. Ozgokmen[3], A. Poje[7], A. Reniers[3], E. Ryan[3], C. Smith[3], M. Wei[1]

[1] Naval Research Laboratory, [2] QinetiQ North America, [3] University of Miami, [4] Texas A&M University, [5] University of Delaware, [6] University of Florida, [7] City University of New York

(1) Abstract

The Navy Coupled Ocean 3D variational Data Assimilation (NCODA-VAR) system is one of the primary tools that the Navy uses operationally to ingest, process, quality and control, and assimilate ocean observations in near-real time in order to regularly update and improve the forecast skill of several different operational ocean prediction systems. One of the deficiencies of NCODA, however, is its ability to accurately resolve small-scale features. This is primarily because the two predominant sources of data for NCODA are SST and SSH. The spatial resolution of SSH data is typically too coarse to resolve smaller eddies, and SST data lacks the vertical correlation with the subsurface to steer the analysis towards these types of features.

The capability to assimilate velocity observations is currently being added to NCODA, which primarily includes adding additional error covariances between velocity (geopotential), temperature, and salinity throughout the water column. It is hypothesized that the inclusion of velocity data assimilation will improve NCODA's ability to resolve eddies. To test this hypothesis, velocity data are inferred and assimilated from 100s of surface drifters that were released (Summer 2012) in the Northeastern Gulf of Mexico as part of the GoMRI CARTHE drifter experiment. The results are compared to altimetry to determine any improvement

(2) Relocatable NCOM

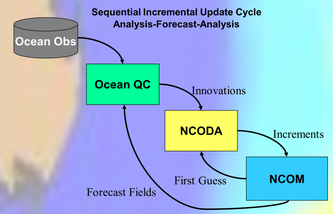
The Relocatable NCOM system is one of the primary operational tools that the Navy uses to routinely assimilate observations and forecast physical ocean properties for regional domains.

Ocean Obs: Operational data stream of sea surface temperature and salinity, profiles of temperature and salinity, and altimetry SSH.

Ocean QC: Automatic software that quality checks the incoming observations.

NCODA: The Navy coupled Ocean Data Assimilation System uses 3DVAR to compute analysis increments relative to the previous forecast.

NCOM: The Navy Coastal Ocean Model is a sigma-Z model that is similar to POM. NCOM starts with the NCODA analysis and propagates the ocean variables forward to create forecasts.



(3) Error covariances in NCODA

The calculation of correlations between variables and observations within NCODA is split into two primary components: horizontal and vertical. There are several available options within NCODA to compute these correlations; in most applications (including this experiment), the second order autoregressive (SOAR) model is used to compute horizontal correlations and density gradients are used to infer vertical correlations. In its normal form, NCODA does not allow cross-correlations between different variable types, except between geopotential and velocity. Correlations between geopotential and velocity include an additional component to insure that they are geostrophically balanced.

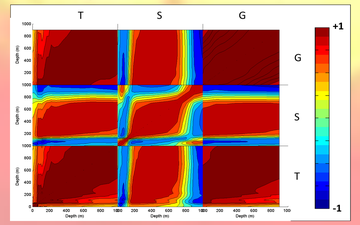
In order to properly assimilate velocity observations, cross-correlations between velocity, temperature and salinity should be included such that the resulting NCODA analyses are dynamically consistent. To achieve this, the Improved Synthetic Ocean Profile (ISOP) database is used to compute a portion of the vertical correlations.

Variable Combination	Original NCODA		New NCODA	
	Horizontal Correlation	Vertical Correlation	Horizontal Correlation	Vertical Correlation
T↔T	SOAR	Den. Grd.	SOAR	ISOP
S↔S	SOAR	Den. Grd.	SOAR	ISOP
G↔G	SOAR	Den. Grd.	SOAR	ISOP
U↔U	SOAR	Den. Grd.	SOAR	Den. Grd.
V↔V	SOAR	Den. Grd.	SOAR	Den. Grd.
U↔V	SOAR	Den. Grd.	SOAR	Den. Grd.
G↔U	SOAR/Geo. Cpl.	Den. Grd.	SOAR/Geo. Cpl.	Den. Grd.
G↔V	SOAR/Geo. Cpl.	Den. Grd.	SOAR/Geo. Cpl.	Den. Grd.
T↔U	0	0	SOAR/Geo. Cpl.	ISOP
T↔V	0	0	SOAR/Geo. Cpl.	ISOP
S↔U	0	0	SOAR/Geo. Cpl.	ISOP
S↔V	0	0	SOAR/Geo. Cpl.	ISOP
T↔G	0	0	SOAR	ISOP
S↔G	0	0	SOAR	ISOP
T↔S	0	0	SOAR	ISOP

T: Temperature **G**: Geopotential **Geo. Cpl.**: Geotrophically coupled
S: Salinity **SOAR**: Second Order Auto Regressive **Den. Grd.**: Vertical Density Gradients

(4) ISOP database

The ISOP database was constructed from numerous historical temperature and salinity profiles; and is a global, monthly-binned, 3D, gridded product that contains the 6 largest empirical orthogonal functions (EOFs) for temperature and salinity. EOFS for geopotential were computed using the equation of state and added to this database .

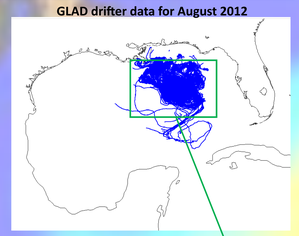


(5) Relo NCOM experiments

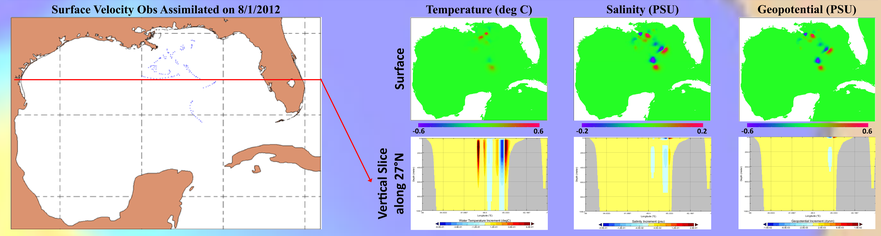
Two separate runs of the Relo NCOM system were performed for the month of August, 2012. Each day, an analysis was computed by NCODA followed by a 72 hour NCOM forecast. The grid resolution was 3km in the horizontal and 50 layers in the vertical.

The first Relo NCOM run assimilated observations from the normal operational data-stream (T, S, and synthetics from SSH). The second assimilated just velocity observations inferred from the glad drifter data set.

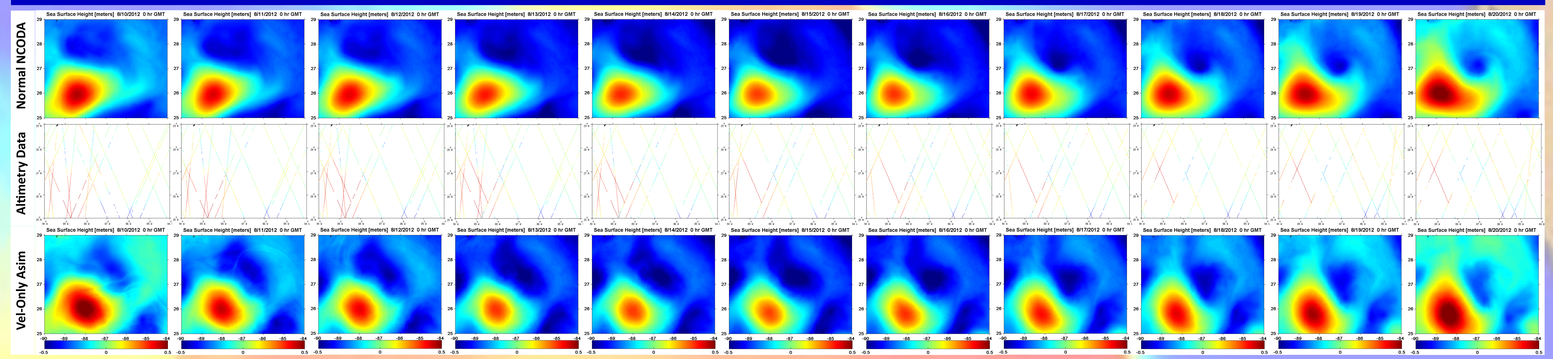
The resulting 24-hr forecasts of SSH from the 2 runs were compared with altimetry data just for the region that encompassed the majority of the GLAD drifter data (green box to the right). Comparison results for 11 of the days (Aug 10 to Aug 20) are shown below.

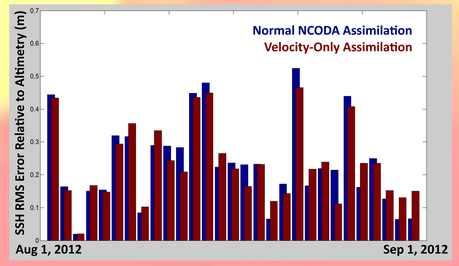


(6) NCODA analysis increments from velocity-only assimilation on Aug 1, 2012



(7) 24hr SSH NCOM forecasts computed using the normal NCODA assimilation and the velocity-only assimilation, compared with altimetry data





(8) Conclusions

The capability to assimilate velocity observations has been added to NCODA through the implementation of the ISOP database in order to compute the covariances between velocity, temperature, and salinity.

It has been demonstrated that including the assimilation of velocity observations helps improve Relo NCOM's ability to forecast eddy features. However, this work is still an ongoing effort, and more testing needs to be performed into how the ISOP covariances are computed and implemented within NCODA.

The next step of this effort will be to add the capability for velocity observations to be assimilated alongside the operational data stream.

(9) Acknowledgments

This research was made possible in part by a grant from BP/ The Gulf of Mexico Research Initiative through the Consortium for Advanced Research on Transport of Hydrocarbon in the Environment (CARTHE).

(10) Contact Information

Scott.Smith@nrlssc.navy.mil