Data Assimilation Experiments With The Navy Layered Ocean Model

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LONG-TERM GOALS

Our long-term objective is to contribute to the development of the components of limited area, open-boundary, coastal nowcast/forecast systems which will resolve the time and length scales of the relevant ocean dynamics in shallow coastal environments. Boundary conditions for these coastal nowcast/forecast systems will be provided by large scale ocean models. For this reason, the overall objective of this research is to improve the data assimilation component in the Navy's global and large scale basin ocean prediction system.

OBJECTIVES

Our specific objective is to improve the data assimilation schemes in the 1/4 º global thermodynamic version of the Navy Layered Ocean Model (NLOM), as well as the 1/16 º Pacific version of this model.

APPROACH

This research has been conducted in collaboration with Dr. Ole Martin Smedstad, of Planning Systems, Inc., and NRL scientists: Drs. G. A. Jacobs and H.E. Hurlburt.

Our approach is based on evaluation of performance of the existing data assimilation scheme in the Navy Layered Ocean Model, improvement of projection of surface information into subsurface layers, and estimation of the NLOM error prediction covariance matrixes and correlation scales, as well as investigation of other data assimilation schemes for incorporation into the data assimilation system with the NLOM.

WORK COMPLETED

Results from the 1/4 º global thermodynamic version of the Navy Layered Ocean Model, and the 1/16 º Pacific version of the model, have been compared to TOPEX/Poseidon altimeter data and to hydrographic data. The comparisons were made along four WOCE lines in the Atlantic, four in the Pacific, and two lines in the Indian oceans. The estimation of optimal values of the data assimilation parameters in the projection of sea surface information to the deep layers (based on the statistical inference technique, Hurlburt et al., 1990, and Shulman and Smedstad, 1998) have been conducted. Analysis, interpretation and "best fit" of the estimated model error covariances matrixes have been conducted.

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RESULTS

In Stammer et al., 1996, the 1/4 º of the Semtner-Chervin model (POCM) was compared with WOCE data and estimates from inversion of hydrographic and nutrient data. The comparisons were made along various WOCE lines. We conducted, similar to Stammer et al., 1996, comparisons of the 1/4 º global version of the NLOM and the 1/16 º Pacific version of the NLOM with TOPEX/Poseidon altimeter data and hydrographic data. For almost all WOCE lines, our comparisons show a striking agreement between the mean sea surface height slopes from the NLOM results and estimates from hydrographic data, as well as from TOPEX/Poseidon data. On Fig. 1 (top panel), the mean sea surface heights calculated from the 1/4 º model run (black curve), 1/16 º Pacific model run (red curve), TOPEX/Poseidon data (http://www.csr.utexas.edu/sst/, green curve), and climatology from hydrographic data (M. Carnes of NRL, personal communications, blue curve), are presented for the $P10^{o}N$ WOCE line. The sea surface height variances for the $P10^{o}N$ WOCE line are presented on Fig. 1, bottom panel, where the black curve represents the 1/4 º model run, blue curve - 1/4 º model run with TOPEX/Poseidon SSH data assimilation, red curve - 1/16 º Pacific model run, and green curve - TOPEX/Poseidon data. For some longitudes ($150^{o}E$ – $185^{o}E$), the model shows the level variability close to the one observed; for longitudes from $230^{o}E$ to $270^{o}E$, the model shows less than 50% of the observed SSH variance, and for longitudes from $185^{o}E$ to $215^{o}E$ the model variance is even higher than the one observed. On Fig. 1, bottom panel, the model run with data assimilation reproduced much better the observed trends in TOPEX/Poseidon data variance.

The numerical experiments with assimilation of TOPEX/Poseidon data into the NLOM show that the results of the simulations are very sensitive to the inversion of the statistically inferred subsurface pressures corrections into the corresponding correction to the layer thicknesses. This is done by using the method of singular value decomposition (SVD) of the linear matrix representing the relations between pressure and layer thickness. This creates the sensitivity of the data assimilation process to the choice of a small number μ as a threshold for the small singular values. In (Shulman and Smedstad, 1998), we developed an approach to determine the optimal value of μ. Based on data assimilation experiments with the 1/4 º global thermodynamic version of the Navy Layered Ocean Model, and the 1/16 º Pacific version of the model, the preliminary optimal values of these parameters were obtained. This work will be continued. In the NLOM Optimum Interpolation scheme of altimeter sea surface heights, a Gaussian error covariance function is used, with spatial length scales varying with latitude and longitude. It was found that the results of data assimilation experiments with the 1/16 º Pacific version of the model are sensitive to the values of the chosen correlation length scales, with the best results so far produced by using spatial length scales estimated from TOPEX/Poseidon data. Modeling and parameterization of the model error covariance matrixes are very important for the existing NLOM Optimum Interpolation scheme, as well as for the use of other, more advanced data assimilation schemes (e.g., reduced order Kalman filter). For estimation of the model error covariance structure, binned error covariance matrixes were constructed from the records of the differences between model-predicted and observed SSH along the satellite tracks throughout the model domain. The structure of those error covariance matrixes, which appears to be far from Gaussian-like functions, is being studied for purposes of parameterization for use in the existing NLOM Optimum Interpolation scheme, as well as in more sophisticated data assimilation schemes with the NLOM.

IMPACT/APPLICATIONS

This project is a contribution to the improvement of the data assimilation capability of the NRL oceanic prediction system.

TRANSITIONS

The developed techniques, software and results have been incorporated into the latest version of the NRL data assimilation system.

RELATED PROJECTS

6.2 Basin Scale Ocean Prediction System of NRL (NOMP, ONR). Close collaboration and coordination.

"An Innovative Coastal-Ocean Observing Network (ICON)", National Oceanographic Partnership Program (NOPP).

Outputs from the data assimilating global version of NLOM are used to specify open boundary conditions for the Pacific West Coast (PWC) model. The PWC model provides open boundary conditions for the high resolution Monterey Bay area model. The PI of the project is responsible for the development of the Monterey Bay area model in the NOPP project.

"HYCOM Consortium for Data-Assimilative Ocean Modeling", National Oceanographic Partnership Program (NOPP). Collaboration is planned on the data assimilation issues.

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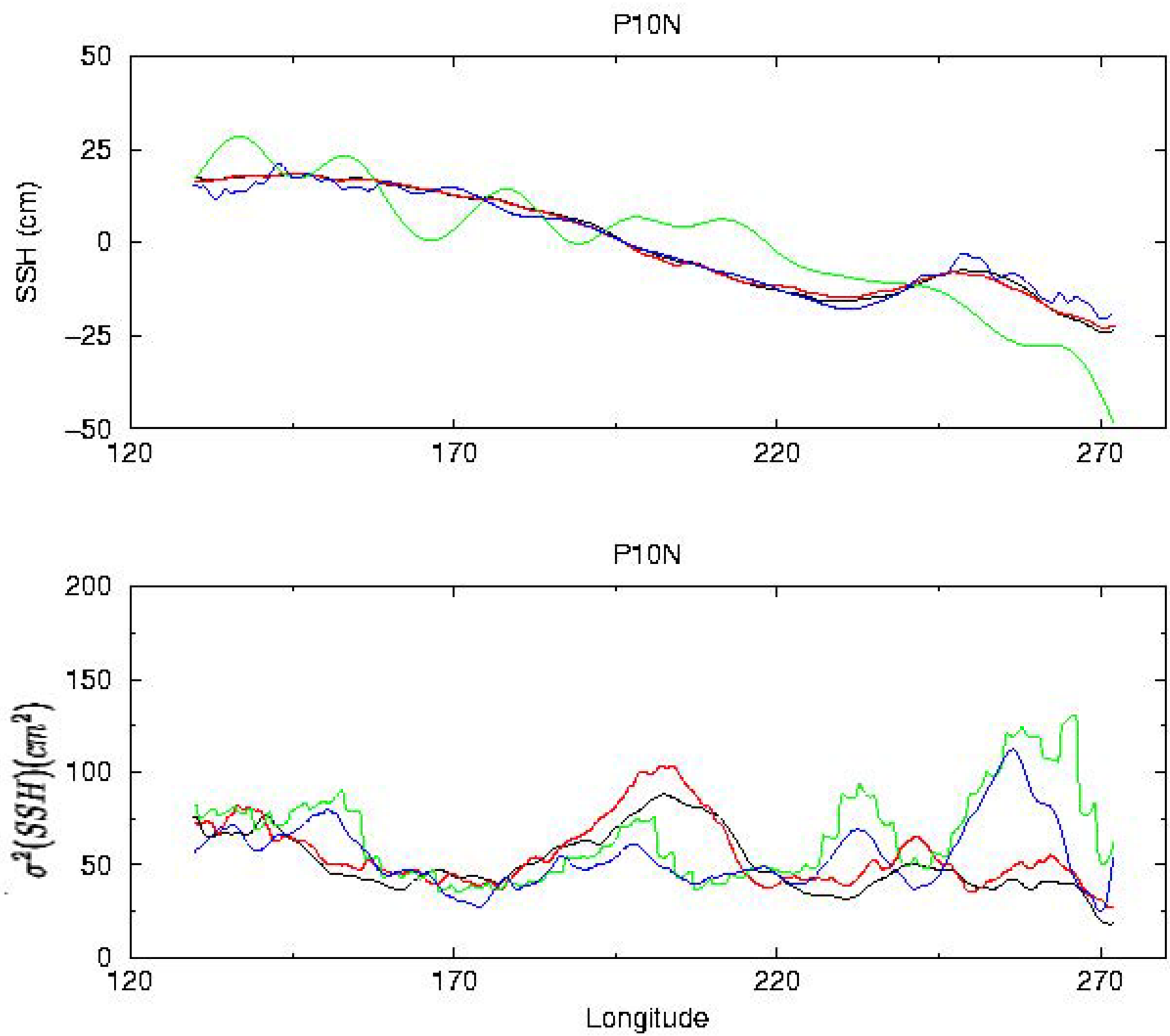
P10N
SSH (cm)
50
25
0
−25
−50
120
170
220
270
P10N
$\sigma^2(SSH)(cm^2)$
200
150
100
50
0
120
170
220
270
Longitude