Abstract

This work describes the development of an analysis and forecast system for the Mid-Atlantic Bight shelf-wide MURI Experimental System for Predicting Shelf and Slope Optics (ESPReSSO). ESPReSSO resolves mesoscale and sub-mesoscale processes in a coastal transition region (mid-shelf to adjacent deep sea) by integrating a high-resolution 3-dimensional coastal model (ROMS; the Regional Ocean Modeling System) with numerous different observations using Incremental Strong-constraint 4-Dimensional Variational [1] (IS4DVAR) data assimilation. The system has been successfully prototyped in assimilating satellite Sea Surface Temperature (SST), along-track altimeter Sea Surface Height Anomaly (SSHA), HF radar surface currents, and hydrographic data (CTD, XBT and glider observations). Preliminary comparison to withheld in-situ temperature and salinity observations indicates that ESPReSSO can provide good estimates of observed hydrographic data when just satellite information (SST and SSHA) is assimilated. The skill seems to be superior to that from operational HyCOM/NCOADS and French Mercator global analysis systems. We attribute the ESPReSSO added skill to the inclusion of climatological information in the assimilation procedure to correct for biases, and the projection of observed SST and SSHA to the subsurface by the adjoint model in the variational assimilation method.

The Mid Atlantic Bight (MAB)

• wide shallow shelf separated from Gulf Stream by the slope sea
• Shelf/Slope Front (~0.3 m/s) at shelf edge
• Gulf Stream rings frequently enter Slope Sea and impact shelf

Current data-assimilative models for the area have very poor skill in hindcasting the observed temperature and salinity. Here is an example for the HYCOM+NCOADS product:

Variational data assimilation is a very attractive methodology to correct for these deficiencies as it exploits the property of the adjoint model to transfer efficiently information from observed variables (e.g., satellite data) to unobserved variables (e.g. subsurface temperature, salinity, and currents).

Where B is the analysis covariance matrix, and M is the adjoint model acting on the delta function that targets the observation grid-point. Therefore there are two ways of transferring information between the variables:
1) Through the action of the adjoint model, and 2) through the specification of the off-diagonal elements of B.

Here is an example for a single observation of SSH in the East Australia Current using a block diagonal B, and therefore all the information to other variables is transferred through the adjoint model used in IS4DVAR:

In IS4DVAR the control variable of the assimilation system are the initial conditions of each assimilation window, and the model trajectory through each interval is deemed the best-estimate of the state of the ocean given the available observations, and can be used for a subsequent forecast. IS4DVAR data assimilation of Jason-1 along-track SSH and daily SST is applied in a sequential way during 2006 using an assimilation window (AW) of 3 days. The state at the end of each AW is the first guess for the next assimilation cycle.

Preliminary Results

Here is an example for the ROMS fit during the second AW (Jan 3 - Jan 6 of 2006):

And the mesoscale SSH now agrees better with that of the along-track data:

And there is great improvement in the prediction of the non-assimilated hydrographic data:

Future work

•Operational Prediction (prototype already in place, assimilating along-track Jason-2 SSHA and blended (microwave plus infrared) SST).
•Near coast along-track data reprocessing
•Include other observations (HF radar surface currents, CTD, XBT, glider data)
•Inclusion and assessment of impact of reprocessed data
•Observing System Simulation Experiments (OSSE)

Acknowledgments: SST produced kindly provided by Remote Sensing Systems and served by NODC CoastWatch (http://coastwatch.noaa.gov/coastwatch/)

References: