HYCOM Consortium for Data-Assimilation Ocean Modeling

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LONG-TERM GOALS

The goal of the project is to develop a hybrid coordinate ocean model (HYCOM) with assimilation of sea surface height from altimetry, sea surface temperature from MCSST and in-situ data. The ultimate goal is to have a eddy-resolving assimilative global nowcast/forecast system running in real time.

OBJECTIVES

Development and validation of global and basin scale ocean prediction systems which includes assimilation of available data, e.g. satellite altimetry, MCSST and in-situ data.

APPROACH

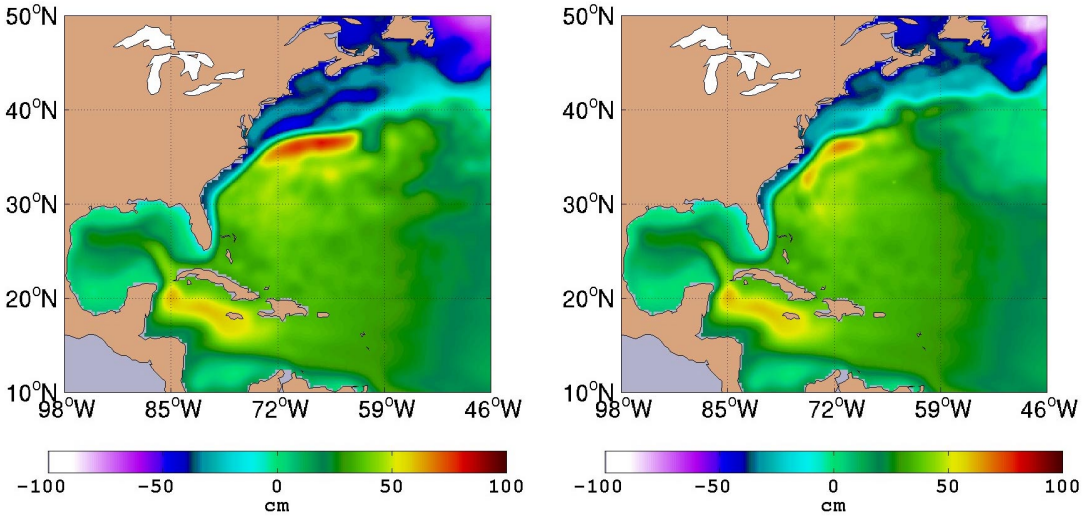
The approach is to implement a hierarchy of assimilation techniques starting with simple incremental updating. More sophisticated algorithms e.g. the parameter matrix objective analysis (PMOA, Mariano and Brown, 1992), the singular evolutive extended Kalman filter (SEEK, Pham et al., 1998) and a Markov random field information filter (MRFIF, Chin et al.1999) will also be implemented. Different vertical projections of the surface information to the deep ocean will be evaluated for the simple techniques, (e.g. Hurlburt et al. 1990, Cooper and Haines, 1996 and Gavart and De Mey, 1996). The techniques will be evaluated as a function of computational efficiency and prediction accuracy. The validation of the results from the assimilation experiments is an important part of the project. Data not being assimilated will be used to validate the model solution.

WORK COMPLETED

Our focus this year has been on the influence of the mean used in the assimilation of sea surface height (SSH) anomalies into an ocean model. While waiting for the first version of the HYCOM code, we have performed several experiments with the 1/3 degree Atlantic Ocean configuration of the Miami Isopycnic Coordinate Ocean Model (MICOM) to create a baseline experiment for later comparison

with the HYCOM. The model covers the region 19S to 70N and 98W to 17E and is forced by climatological wind and flux fields.

Experience has shown that it is important to have a mean SSH which is in agreement with available observations, (e.g. Hurlburt et al. 2000). The rubber-sheeting application suite is a collection of MATLAB scripts specifically designed to operate on SSH fields. It includes methods to move masses of water in an elastic way (hence rubber-sheeting), merge data, overlay contours from a second reference field and raise or lower the values of a region. All this is done in a completely interactive manner. To deal with the MICOM (and HYCOM) model the rubber-sheeting application suite was modified to allow fields that use a Mercator projection. A capability to overlay contours such as those obtained from an edge detection program was also added. Several different mean sea surface height fields for the Atlantic Ocean have been compared. The goal is to determine the best mean to use with the satellite anomalies in order to assimilate these anomalies into the numerical model. In earlier experiments a mean from a high resolution quasi-geostrophic (QG) model was used, so this was the starting point for the experiments. In addition to this mean field we used a MICOM 1/12 degree mean, a NLOM 1/64 degree mean, a climatological mean height determined from hydrography, altimetry standard deviation fields and the mean position of the Gulf Stream as derived from SST imagery, (e.g. Cayula and Cornillon 1995). In Figure 1 one can easily see the modification made in the region of the Gulf Stream.

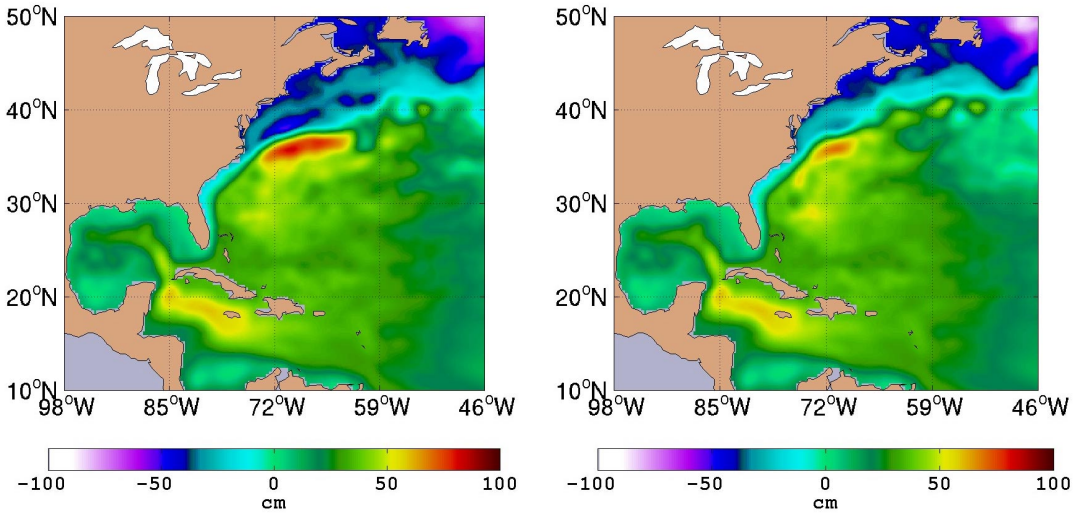


1. (a) The mean sea surface height field from the QG model, (b) the final rubber sheeted mean sea surface height field.

Remy Baraille (LEGOS/BRESM) developed the assimilation technique. It consists of a calculation of model/data differences and a projection of this information to the lower layers. We have used two different algorithms in our experiments to do the vertical projection, the Cooper-Haines technique, (Cooper and Haines, 1996) and a method based on isopycnal EOF's, (Gavart and De Mey, 1996). The differences are then inserted into the model.

The Modular Ocean Data Assimilation System (MODAS) optimally interpolates available satellite altimeter SSH anomalies onto a 1/8 degree grid. The anomaly fields for 1993 were regridded to the MICOM grid and then assimilated into the 1/3 degree North Atlantic version of MICOM using the mean SSH fields described above.

Four different experiments have been performed. The first experiment used the QG mean SSH field with the satellite altimeter anomalies from MODAS, the second experiment used the rubber-sheeted mean SSH. Both of these experiments used the Cooper-Haines technique to transfer the surface information to the lower layers of the model. Figure 2a and b show the mean SSH from 1993 for the two experiments. The mean used in the assimilation has a great impact on the model solution. The unrealistic meander around 62W seen in the QG mean SSH field (Figure 1a) is still present if this mean is used in the assimilation. Figure 2b shows that using the rubber sheeted mean in Figure 1b the assimilative mean does not have the meander at 62W.



2. (a) The model mean SSH field after assimilation of MODAS SSH anomalies using the QG mean SSH shown in Figure 1a, (b) the model mean SSH field using the rubber sheeted mean SSH shown in Figure 1b.

Software has been developed to validate different aspects of the model. This includes comparing temperature profiles from the model to those from actual BT's by computing the mean error and RMS error as a function of depth. Comparisons of the model height field to the dynamic heights from BT's can also be done. In addition software has been developed to extract frontal positions of e.g. the Gulf Stream and calculating the mean error in this position when compared to an analysis.

RESULTS

The rubber sheeting technique is a powerful method making it possible to combine different sources of information into one coherent picture. The results show the importance of having a correct mean SSH when satellite altimeter anomalies are being assimilated. The model mean SSH should be close to the rubber sheeted mean. If the assimilation has to fight the model to keep a major current in the correct

position, the forecast skill of the model will be limited. In other words, rubber sheeting the mean of a coarse resolution model to get the correct position of e.g. the Gulf Stream, will improve the models nowcasting capability, but will not help the model give good forecasts. This is the reason why the goal of the project is to have an eddy-resolving model with the major current systems in the correct position. The lower resolution experiments will be used to test different assimilation techniques.

IMPACT/APPLICATIONS

The results from the project is relevant to the Global Ocean Data Assimilation Experiment (GODAE), the multinational project designed to help justify a global ocean observing system by demonstrating useful real-time operational ocean products. The model developed in this project is planned for transition to the Naval Oceanographic Office (NAVO) as a replacement for their operational ocean model.

TRANSITIONS

The rubber sheeting technique has been successfully used to modify the model mean for the 1/16 degree global Naval Research Laboratory Layered Ocean Model (NLOM) being transitioned to NAVO in FY01.

RELATED PROJECTS

The results described here are a part of a NOPP project with participation from several different research groups, E.P. Chassignet (Coordinator), A. Mariano and G. Halliwell, T.M. Chin (University of Miami), R. Bleck (LANL), H. Hurlburt, P. Hogan, R. Rhodes, C. Barron, A. Wallcraft and G. Jacobs (Naval Research Laboratory), , O.M. Smedstad and J.F. Cayula (Planning Systems Inc.), W.C. Thacker (NOAA/AOML), M. O'Keefe (University of Minnesota).

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