4DVAR and LETKF Development for NOAA’s Chesapeake Bay Operational Forecasting System

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Introduction:
- The Chesapeake Bay Operational Forecasting System (CBOFS) is NOAA’s operational hydrodynamic model used to provide two days forecasts of several oceanographic products in Chesapeake Bay
- CBOFS forecasts of sea surface temperature (SST) and salinity (SSS) can be improved
- We are evaluating the performance of both the strong constraint 4D-Var(4D-VAR, Moore et al., 2011) and Local Ensemble Transform Kalman Filter (LETKF, Hunt et al., 2007) data assimilation systems to assimilate satellite-derived sea surface temperature in order to improve SST forecasts in CBOFS
- We describe the initial implementation, testing and results of assimilating AVHRR SST into CBOFS using 4D-VAR

Model and Data:
Model Description:
- Study Domain: Figure 1
- CBOFS based on ROMS 3.6
- Resolution: 30m in rivers to 4km in coastal area
- Grid size 256 by 312, vertical 20 layers
- Time step: 10 s

Data / Input:
- IS4DVAR for adjusting initial conditions only
- Dissipation scale: 17 km (17 x 3 m/s)
- Archived CBOFS forcing and open boundary conditions
- Randomized normalization coefficient calculation
- Background error is from standard deviation calculated with yeartime CBOFS results with initial and annual signals removed
- Assimilation/Forward run window: 6 hours

Work Performed:
- Assimilate daily composite AVHRR SST dating from 08/10/2012 to 09/15/2012
- Evaluate with in-situ temperature and salinity observations from Chesapeake Bay Program (CBP, CTD US) and Chesapeake Bay Interpretive Buoy Systems (CBOFS CBIS)

Model and Data:

Results:
- Assimilating satellite-derived SST not only modifies the initial surface temperature but also changes the vertical profiles of T/S (Fig. 3). The impact to other variables mainly occurs near the lower Chesapeake Bay and its mouth area.
- One month sequential assimilation (Fig. 4) of AVHRR SST successfully lowers the SST bias by 0.5°C
- Assimilating CTD profiles with SST data significantly improves the three dimensional temperature and salinity fields even with small number of CTD observations (Fig. 5). Specifically, salinity bias is reduced from 1.09 to -0.38 at the observational locations in the next forward run window. The mean salinity over the whole model grids is reduced by 0.13 within one assimilation window.
- IS4DVAR with CBOFS is very computationally expensive (Table 1), but is likely viable in an operational mode with the current CBOFS setup.

Table 1. IS4DVAR computational cost statistics based on 96 Intel Xeon 2.6GHz CPUs. The normalization coefficients calculation is carried on one time only.

Conclusions:
- IS-4DVAR data assimilation has been successfully adapted to the CBOFS
- Assimilation of AVHRR SST into CBOFS reduces the model bias by 0.5°C
- Assimilation of SST and T/S vertical profiles reduces the salinity bias by 0.13, even though the CTD castings are sparsely distributed.

Future Work:
- Assimilate SST estimates from the the Visible and Infrared Imager and Radiometer Suite (VIIRS) of the Suomi National Polar-orbiting Partnership
- Configure LETKF with CBOFS and assess performance and computational cost in order to compare with 4DVAR results

References:

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