MARCOOS SEMI-ANNUAL REPORT: 4/1/2011 - 09/30/2011

NOAA Award Number NA07NOS4730221 (October 2007 – September 2011)

1) PROJECT SUMMARY

The Middle Atlantic Coastal Ocean Observing Regional Association (MACOORA) formed the Mid-Atlantic Regional Coastal Ocean Observing System (MARCOOS) to generate quality controlled and sustained ocean observation and forecast products that fulfill user needs in the 5 user prioritized theme areas of: 1) Maritime Safety, 2) Ecological Decision Support, 3) Water Quality, 4) Coastal Inundation, and 5) Offshore Energy. MARCOOS (a) *collaborates* with NOAA WFOs to link existing regional coastal weather networks to evolving NOAA WRF regional forecasting capabilities – *to provide* an improved ensemble of weather forecasts, (b) *operates* the existing Mid-Atlantic HF Radar Network and leverages U. S. Coast Guard (USCG) drifters that are linked to statistical and dynamical models - *to provide* an ensemble of regional nowcasts and forecasts of 2-D surface currents, and (c) *operates* existing satellite receivers and leverages the Navy investment in a regional glider capability linked to the dynamical models - *to provide* an ensemble of 3-D circulation, temperature and salinity nowcasts and forecasts. The MARCOOS data management team facilitates implementation of an end-to-end system consistent with DMAC standards. Education & Outreach (EO) teams engage additional users and provide frequent and timely feedback, while an economic impact team assesses benefits of MARCOOS information. A management structure that establishes and monitors performance metrics ensures quality.

2) PROGRESS AND ACCOMPLISHMENTS

Years 1-3 of MARCOOS had 10 major tasks, including 49 milestones annually adjusted to match existing budget constraints. 48 milestones were previously completed with the 49th milestone, model validation, being the primary topic addressed in this final reporting period. Funds not expended during the first 3 years were carried over into Year 4 of MARCOOS through a no-cost extension. This report summarizes the activities supported by the no-cost extension. To remain consistent with the Year 1-3 MARCOOS reports, the activities supported by the carryovers in each of the 10 major tasks are summarized below.

A) Atmospheric Data Integration: All Years 1-3 tasks were accomplished and all funds were spent with no carryover into Year 4.

B) HF-RADAR Equipment: All Years 1-3 tasks were accomplished and all funds were spent with no carryover into the end of Year 4.

C) HF Radar QA/QC. All Years 1-3 tasks were completed and all funds expended with no carry over.

D) Underwater Gliders: UMass Dartmouth purchased a Slocum Glider from Teledyne Webb. UMass is progressing systematically toward an across-shelf transect south of Martha's Vineyard sometime during the fall of 2011, all the time building infrastructure. The new glider successfully transited the SMAST test tank in late September. The next goal is for a one-day sea test during the months of October and November.

E) Satellites: All tasks were completed and virtually no costs were carried over.

F) Short Term Prediction System (STPS): All tasks were completed and no costs were carried over.

G) Dynamic Models: The one milestone not met through April 2011 was the comparison of the models with drifters. The initial attempt at this resulted in the discovery that the drifter data required much more serious quality control then anyone anticipated. The quality control task was shifted to the DMAC team in MARCOOS Year 3 and was completed. In MARCOOS Year 4, the dynamical modelers are back to the model validation tasks, the results of which are elaborated on below.

HOPS: The MARCOOS-HOPS real-time ocean prediction system for the western North Atlantic (WNA) has been validated with drifter trajectories during the Shallow Water experiment, July-September of 2006 (SW06). The validation was carried out over seven weeks of simulations starting from the week of 07/24/2006 to the week of 09/11/2006. A total of sixteen drifters provided over 71 real drifter trajectories which were more than 4 days long during any of these seven weeks. Furthermore, the simulated drifters were relocated (re-initialized) to their observed position during the week-long hindcasts on a daily basis. Thus, a total of 380 four-day long virtual drifter tracks were compared with real drifter trajectories to develop a validation skill metric in terms of root mean-square difference, correlation coefficient and the ratio of their standard deviations using the Taylor diagram. The results are submitted for publication to the special issue of Continental Shelf Research on Ocean Observation.

As it turned out, eighty-five percent of the 380 drifters analyzed have mean speeds of less than 0.5 m/s, prompting us to group the drifters above and below this speed. A number of different analyses were reported by Schmidt et al. (2011) including 1-day, 2-day, and 3-day for both latitudinal and longitudinal excursions. A particularly interesting comparison of drifter trajectories against persistence is presented for the two groups in Figure 1. Assuming that the drifter stays where it was released (persistence); the persistence forecast error will be simply the distance traveled by the drifter in two consecutive time-steps. Thus, the mean separation distance between the simulated drifter location and the real drifter location at the selected time-step can be compared against a so-called “persistence forecast error". So, if the separation distance is less than the persistence error then the model would have appreciable predictability compared with persistence. These results indicate that the simulation performs better than the persistence once the dynamical model is internally adjusted during the initial period of a few hours (1.5 to 6 hours).

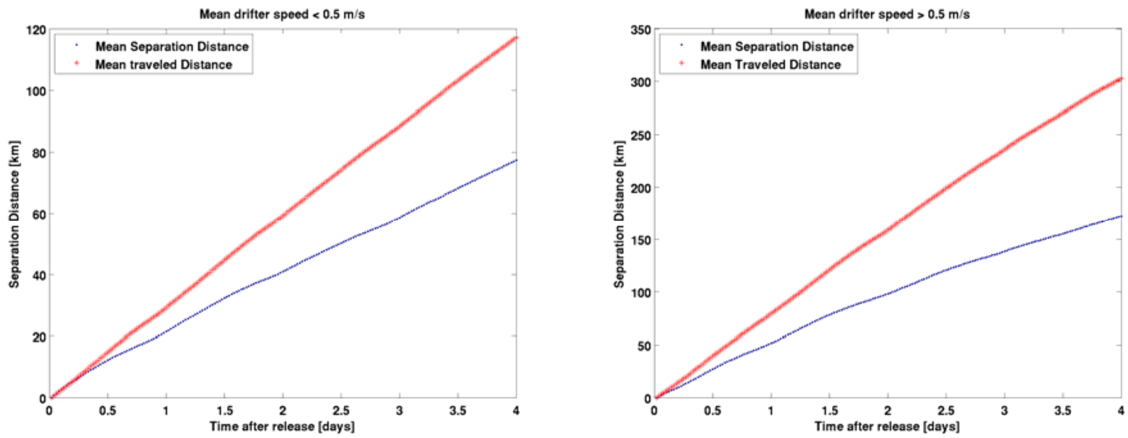
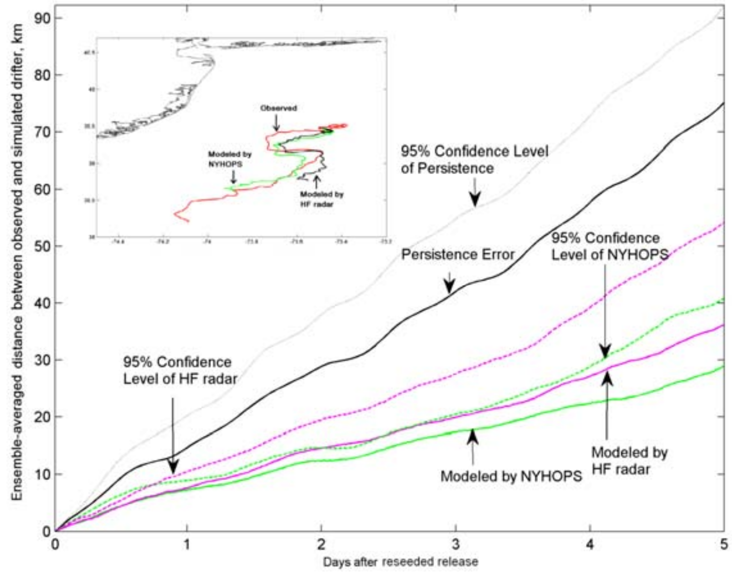


Figure 1. Simulated separation distance (blue) compared to persistence (red) as a function of time for four-day period. Drifters with mean speed less (more) than 0.5 m/s are presented in the left (right) panel.

NYHOPS: To increase confidence in the New York Harbor Observing and Prediction System’s (NYHOPS) ocean circulation predictions in the continental shelf waters of New York and New Jersey, a detailed validation exercise was carried out using HF radar and Lagrangian drifter-derived surface currents from three drifters obtained between March and October 2010. During that period, the mean RMS differences of both the east-west and north-south currents between NYHOPS and HF radar were approximately 15 cm s^{-1}. Surface currents derived independently from drifters along their trajectories showed that NYHOPS and HF radar yielded similarly accurate results. RMS errors when compared to currents derived along the trajectory of the three drifters, were approximately 10 cm s^{-1}. Overall, the analysis suggests that NYHOPS and HF radar have similar skill in estimating the currents over the continental shelf waters of the Middle Atlantic Bight.

An ensemble-based set of particle tracking simulations using one drifter which was tracked in the water for 11 days showed that the mean separation generally increases with time in a linear fashion. The separation distance is not dominated by high frequency or short spatial scale wavelengths suggesting that both the NYHOPS and HF radar currents are representing tidal and inertial time scales correctly and resolving some of the smaller scale eddies. The growing separation distance is dominated by errors in the mean flow causing the drifters to slowly diverge from their observed positions. The separation distance for both HF radar and NYHOPS stays below 30 km after 5 days and the two technologies have similar tracking skill at the 95% level. For comparison, the ensemble-mean distance of a drifter from its initial release location (persistence assumption) is estimated to be greater than 70 km in 5 days.

Figure 2. Ensemble-averaged Persistence Error (black solid line) and separation distance between the drifter and numerical drifters based on NYHOPS (green solid line) and HF radar (pink solid line) surface currents. 95% upper confidence levels for the Persistence Error (dotted black line) and the separation distance of NYHOPS (dotted pink line) and HF radar (dotted green line) are also shown, from the "reseeding" experiments described in the text. Insert shows the observed drifter trajectory (red) and the respective drifter trajectories simulated using surface currents from NYHOPS (green) and HF radar (black) over that drifter's complete deployment record.



ROMS: The Rutgers modeling group is making an IOOS-wide framework assessment of the 3 MARCOOS models and a further 4 circulation models that run operationally in the MAB: global HyCOM/NCODA, global NCOM, COAWST (USGS), and Mercator (EU). Comparisons are with respect to CTD data from gliders (8 deployments in 2010) and NOAA ECOMON cruises (2 in 2010) and CODAR currents. Figure 3 shows assessments for temperature data from 1 glider and 1 ECOMON data set. The Taylor diagrams depict centered RMS error as distance from OBS to MODEL (green contours), correlation as azimuth angle (blue lines) and standard deviation error (radius). Mean bias is tabulated. Values are normalized by data variance. No single model yet emerges as consistently performing best across all metrics (RMSE, correlation, bias, or glider vs. ship data). This holds true for the other 8 data sets. We are examining shallow/deep and inner/outer shelf skill as an approach to identifying strengths in model configuration or operation.

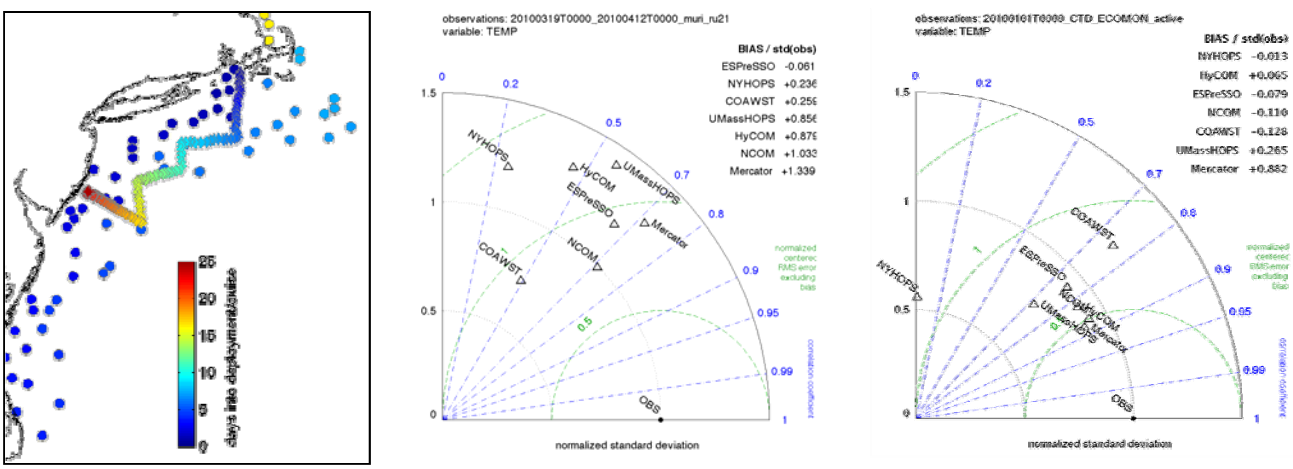


Figure 3: Left: Data locations for glider and ECOMON data. Taylor diagrams assess 7 mesoscale models covering the MAB. Center: glider temperature. Right: ECOMON temperature.

In the space available here we show velocity skill for the 3 MARCOOS models (Figure 4) but have completed comparisons for the other 4 models also.

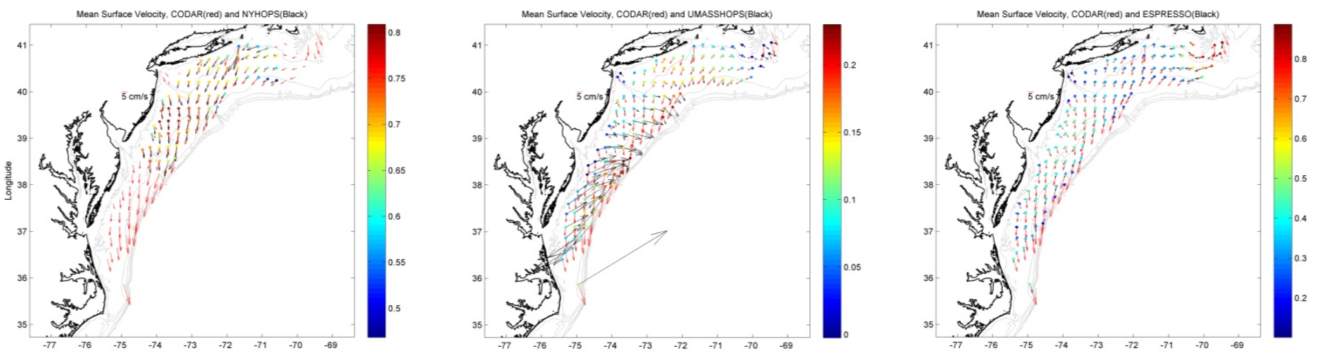


Figure 4: Comparison of CODAR velocity (red vectors) to 3 MARCOOS models (black vector). Left: NYHOPS. Center: UMassHOPS. Right: ROMS-ESPreSSO. Colored dots show vector correlation of daily variance.

The performance of the STPS in predicting surface drift trajectories was assessed using buoy data from 2006-7 when there was an extensive drifter deployment available. The HF RADAR vectors were reprocessed using the 6km OI system and the STPS computed in forecast mode. Unfortunately, the period of high drifter data availability occurred during a period when the HF RADAR coverage was limited. Drifter trajectories were broken into 24 hour segments with 12 hours overlap and these were treated as independent tests. The evolution of the location error was then averaged in forecast hour and the trend is shown in Figure 5. The error grows almost linearly and is approximately 5 km after 10 hours.

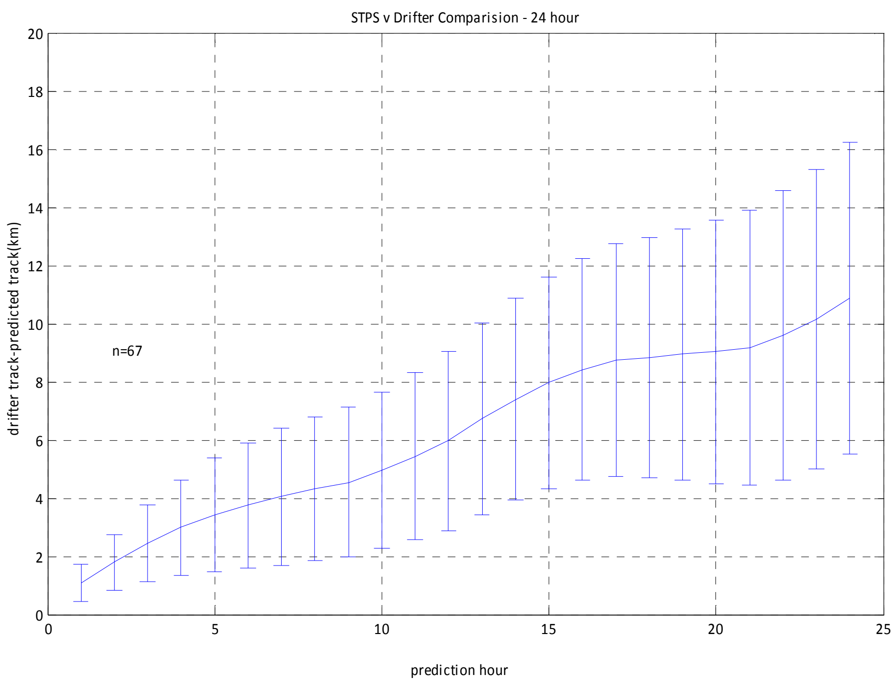


Figure 5. RMS error in drifter location predictions as a function of forecast time.

H) DMAC: All Years 1-3 tasks were completed at a cost savings that enabled purchase of a second glider. No DMAC funds were carried over into Year 4.

I) Education and Outreach: All tasks were completed and no education and outreach funds were carried over into MARCOOS Year 4.

J) Economic Benefits: The most significant portion of the Economic Benefits budget that was carried over into Year 4 were the funds dedicated to Monmouth University to establish the MARCOOS interface with

MARCO. Because of the slow development of MARCO, this has only warranted the direct involvement of the Monmouth PI at a significant cost savings. An anticipated workshop between MARCOOS and MARCO for year 3 was postponed. The workshop funds were instead used to help sponsor a MARACOOS Fisheries Workshop in Providence, RI on September 26.

K) Statistics: All statistics for MARCOOS Year 4 are reported in the MARCOOS Year 4 report and are not repeated here in the MARCOOS Years 1-3 No-Cost Extension Report.

3) SCOPE OF FUTURE WORK

This report concludes the work for MARCOOS years 1-3. Future work will be completed under the MARCOOS year 4 and MARACOOS projects.

4) LEADERSHIP PERSONELL AND ORGANIZATIONAL STRUCTURE

Leadership changes are described in the MARCOOS Year 4 report.

5) BUDGET ANALYSIS

The Years 1-3 MARCOOS budget includes $1,749,734 for Rutgers plus $3,350,266 in sub awards for a total of $5,100,000. This budget analysis covers years 1-3 plus the no cost extension year of the Mid Atlantic Regional Coastal Ocean Observing System grant NA07NOS4730014. The balance shown is what has been invoiced to date, not necessarily what has been spent to date as billing from subcontractors can lag. The base IOOS regional funding was $1,700,000 per year. Funds are slightly adjusted from previous reports from the NOAA approved transfer of funds from OpenDap to the University of Massachusetts for an underwater glider purchase in the amount of $110,000. With this change, grant NA07NOS473021 was extended through September 30, 2011.

#	Distribution	Year 1-3	Remaining Balance
	LEAD: Rutgers University	$1,749,734	$0
1	Applied Science	$206,498	$17
2	Center for Innovative Technology	$90,000	$0
3	Monmouth University	$75,000	$12,443
4	Old Dominion University	$299,000	$0
5	Stevens Institute of Technology	$343,154	$0
6	University of Connecticut	$466,000	$226
7, 8	University of Delaware (2)	$186,550	$2
9	University of Massachusetts	$798,000	$1,901
10	University of North Carolina	$56,000	$0
11	University of Rhode Island	$165,628	$923
12	Weatherflow	$270,000	$0
13	OpenDap	$49,436	$0
14,15	University of Maryland (2)	$345,000	$213
	TOTAL AWARDED	**$5,100,000**	**$15,725**