Real-time data assimilation in a coastal ocean forecast system

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An experimental Coastal Ocean Forecast System (COFS) is being developed and tested at the National Centers for Environmental Prediction (NCEP). The forecast model runs daily, using surface wind forcing and energy fluxes taken from NCEP's high resolution, regional atmospheric Eta model. Sea surface temperatures (SSTs), sea surface height anomalies (SSHAs) derived from satellite altimetry, and the location of the north wall of the Gulf Stream (NWGS), are assimilated in the COFS model to produce nowcasts and 24-hour forecasts of temperature, salinity and current at 19 model levels, and sea surface height.

The first major step was daily assimilation of sea surface temperatures (SSTs) from the Advanced Very High Resolution Radiometer, ships and buoys. Using a variational objective analysis technique applied to model-minus-observation increments, this assimilation produces a temperature correction field for the top model level, and corrections through the mixed layer by downwards extrapolation of surface corrections along with nudging. (See Kelley, Behringer and Thiebaux, 1999, for a detailed description of the assimilation technique.) The strongly positive impact of this assimilation, on nowcast SST, was reported by Thiebaux et al (1998).

The second step inserted the SSHA-assimilation algorithm of Mellor, Ezer and Kim (1998), in the COFS computational stream just prior to SST-assimilation. This new algorithm ingests anomalies derived from TOPEX altimetric measurements, through correlations of SSHA with temperatures at subsurface model levels. The significant impacts are primarily on subsurface nowcast and forecast temperature fields, as the sequential assimilation schedule would suggest. Table 1. presents verification statistics at the sites of Northwest Atlantic moored buoys. At four of the five sites for which data were withheld from model assimilation, for independent comparison, the two-stage assimilation sequence out performed assimilation of SSTs only, although the overall differences between nowcast and observed surface temperatures are small. Figures 1 and 2 illustrate comparisons between the two systems for subsurface temperatures, in which the impact of SSHA and NWGS assimilation proved to be very significant. Figure 1.a. and b. are examples of the 200 meter temperature fields; and Figure 2.a. and b. compare nowcast temperature profiles with (unassimilated) BATHY profiles at two locations in the region.

Work is presently underway to assimilate altimetry data from ERS2 in addition to TOPEX data.

References

Kelley, John G. W., David W. Behringer and H. Jean Thiebaux (1999): Description of the SST data assimilation system used in the NOAA Coastal Ocean Forecast System (COFS) for the U.S. East Coast. **Technical Note, U.S.D.Commerce, NOAA, NWS.**

Mellor, George L., Tal Ezer and Namsoug Kim (1998): A methodology of assimilating sea surface height data into ocean models. Informal manuscript.

Thiebaux, H. Jean, John G.W. Kelley, Dmitry Chalikov, David W. Behringer, and Bhavani Balasubramaniyan (1998): Impact of assimilating observations into the Coastal Ocean Forecast System (COFS). **Research Activities in Atmospheric and Oceanic Modelling, Report No. 14**, 8.43.

Table 1. Statistics relative to buoy reports: May through July 1999

	SST assimilation only			SST, SSHA and NWGS assimilation		
Buoy	bias	ABSbias	RMSE	bias	ABSbias	RMSE
*44007	0.94	1.04	1.22	0.83	1.00	1.22
44005	0.92	0.97	1.07	0.72	0.79	0.93
44011	2.81	3.11	3.46	3.27	3.44	3.78
*44008	1.26	1.47	1.95	2.28	2.29	2.71
44025	0.11	0.39	0.51	-0.02	0.48	0.61
44009	-0.44	0.76	0.97	-0.33	0.57	0.74
44004	0.91	1.30	1.69	0.23	0.83	1.15
44014	1.24	1.91	2.73	1.48	2.12	3.03
41001	0.33	0.43	0.54	0.21	0.35	0.46
*41002	0.67	0.73	0.86	0.60	0.64	0.81
41010	0.06	0.35	0.46	-0.01	0.35	0.46
41009	-0.01	0.69	0.80	-0.11	0.64	0.77
44137	0.34	0.76	0.88	1.11	1.13	1.30
*44138	0.41	0.63	0.79	0.37	0.58	0.73
44139	0.94	1.10	1.32	1.21	1.21	1.41
44140	3.49	3.49	3.66	3.22	3.22	3.38
44141	1.19	1.19	1.31	1.18	1.18	1.31
44142	0.91	1.43	1.70	1.37	1.63	2.00
*50002	-0.53	1.19	1.49	-0.33	0.86	1.07
50001	0.24	0.53	0.68	0.31	0.58	0.72
Averages:	0.79	1.17	1.41	0.88	1.19	1.43

* indentifies independent evalutation: buoy reports were not assimilated by the analysis algorithm.