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Impact of glider data assimilation on the Monterey Bay model

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ABSTRACT

Glider observations were essential components of the observational program in the Autonomous Ocean Sampling Network (AOSN-II) experiment in the Monterey Bay area during summer of 2003. This paper is focused on the impact of the assimilation of glider temperature and salinity observations on the Navy Coastal Ocean Model (NCOM) predictions of surface and subsurface properties. The modeling system consists of an implementation of the NCOM model using a curvilinear, orthogonal grid with 1–4 km resolution, with finest resolution around the bay. The model receives open boundary conditions from a regional (9 km resolution) NCOM implementation for the California Current System, and surface fluxes from the Coupled Ocean–Atmosphere Mesoscale Prediction System (COAMPS) atmospheric model at 3 km resolution. The data assimilation component of the system is a version of the Navy Coupled Ocean Data Assimilation (NCODA) system, which is used for assimilation of the glider data into the NCOM model of the Monterey Bay area. The NCODA is a fully 3D multivariate optimum interpolation system that produces simultaneous analyses of temperature, salinity, geopotential, and vector velocity.

Assimilation of glider data improves the surface temperature at the mooring locations for the NCOM model hindcast and nowcasts, and for the short-range (1–1.5 days) forecasts. It is shown that it is critical to have accurate atmospheric forcing for more extended forecasts. Assimilation of glider data provided better agreement with independent observations (for example, with aircraft measured SSTs) of the model-predicted and observed spatial distributions of surface temperature and salinity. Mooring observations of subsurface temperature and salinity show sharp changes in the thermocline and halocline depths during transitions from upwelling to relaxation and vice versa. The non-assimilative run also shows these transitions in subsurface temperature; but they are not as well defined. For salinity, the non-assimilative run significantly differs from the observations. However, the glider data assimilating run is able to show comparable results with observations of thermocline as well as halocline depths during upwelling and relaxation events in the Monterey Bay area. It is also shown that during the relaxation of wind, the data assimilative run has higher value of subsurface velocity complex correlation with observations than the non-assimilative run.

1. Introduction

Five Spray gliders (Sherman et al., 2001) and 10 Slocum gliders (Webb et al., 2001) were deployed in the Autonomous Ocean Sampling Network (AOSN-II) experiment in the Monterey Bay area during August–September 2003 (www.mbari.org/aosn/MontereyBay2003). Spray gliders collected temperature and salinity profiles up to 400 m depth (with occasional profiles to 700 m for instrument comparison with other measurements) from Point Año Nuevo in the north to Point Sur in the south, while the Slocum gliders profiled to 200 m closer to shore (Fig. 1). A detailed description of glider operations and data collected during the AOSN-II experiment can be found in Ramp et al. (2008).

The focus of the present paper is on the impact of the assimilation of glider temperature and salinity observations on the Navy Coastal Ocean Model (NCOM) predictions of surface and subsurface properties. Model predictions are evaluated and compared with the observed data (temperature, salinity, currents)

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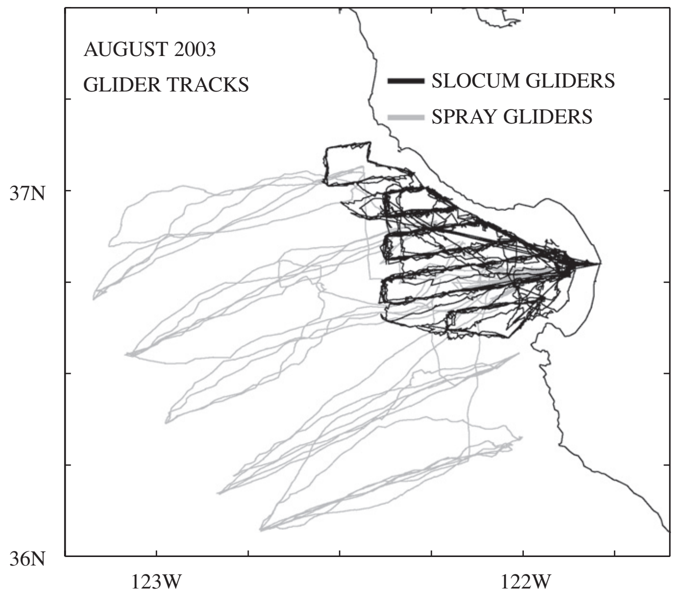

Fig. 1. Glider tracks during August 2003.

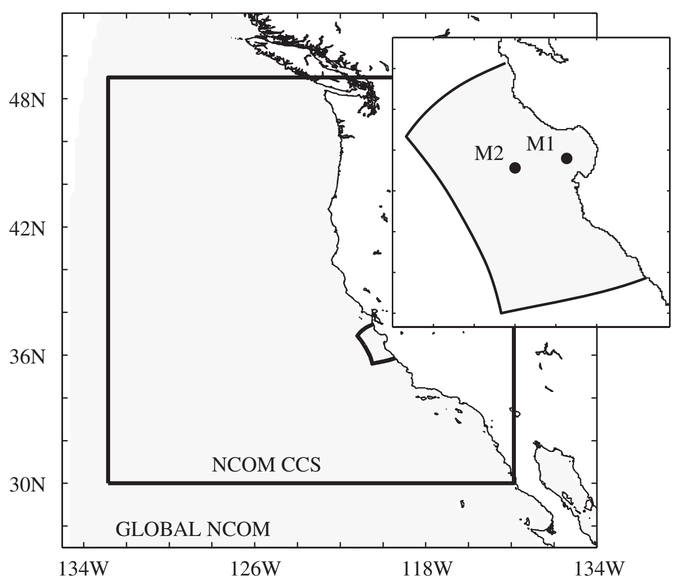

Fig. 2. Hierarchy of nested NCOM models along US west coast.

at two mooring locations M1 and M2 (Fig. 2), and with airborne SSTs. Temperature and salinity at the moorings were measured by a string of 12 SeaBird MicroCAT TCP recorders. Observed currents were measured by a 75-kHz RD Instruments acoustic Doppler current profiler (ADCP) mounted in a downward-looking configuration on the moorings. For the considered time frame, the ADCPs were set up to measure in 8-m depth bins with 60 depth bins, with the first bin at 16 m for both moorings. A detailed description of the airborne SST observations can be found in Ramp et al. (2008).

The impact of glider data assimilation is evaluated during observed upwelling and relaxation events. During northwesterly, upwelling-favorable winds, the hydrographic conditions in and around the Monterey Bay are mostly determined by the interaction between upwelling filaments formed at headlands to the north (Point Año Nuevo) and south of the bay (Point Sur) and the anticyclonic California Current meander offshore of the bay. When upwelling-favorable winds weaken (wind relaxation) and sometimes become poleward, the anticyclonic meander moves onshore and then quickly retreats back offshore when the winds re-intensify. The flow at the surface is mostly southward due to local upwelling wind and the influence of the offshore California Current. Two narrow, poleward-flowing boundary currents were observed around the Monterey Bay area: the inshore countercurrent (sometimes called the Davidson Current) and the California Undercurrent (CU). For more details on observed physical conditions in the area see, for example, Rosenfeld et al. (1994) and Ramp et al. (2005, 2008).

2. Modeling system

In the present study, the Monterey Bay model is based on the NCOM (Rhodes et al., 2002; Martin, 2000), and is triply nested inside of the global and regional (California Current) NCOM-based models (Shulman et al., 2004, 2007). The model is called NCOM ICON due to the fact that initial development of the model started under the National Oceanic Partnership Program (NOPP) Innovative Coastal-Ocean Observing Network (ICON) project (Shulman et al., 2002, 2007; Ramp et al., 2005). The model, which is set up on a curvilinear orthogonal grid with resolution ranging from 1 to 4 km, uses a sigma vertical coordinate system with 30 levels. The model is forced with surface fluxes from the Coupled Ocean–Atmosphere Mesoscale Prediction System (COAMPS) atmospheric

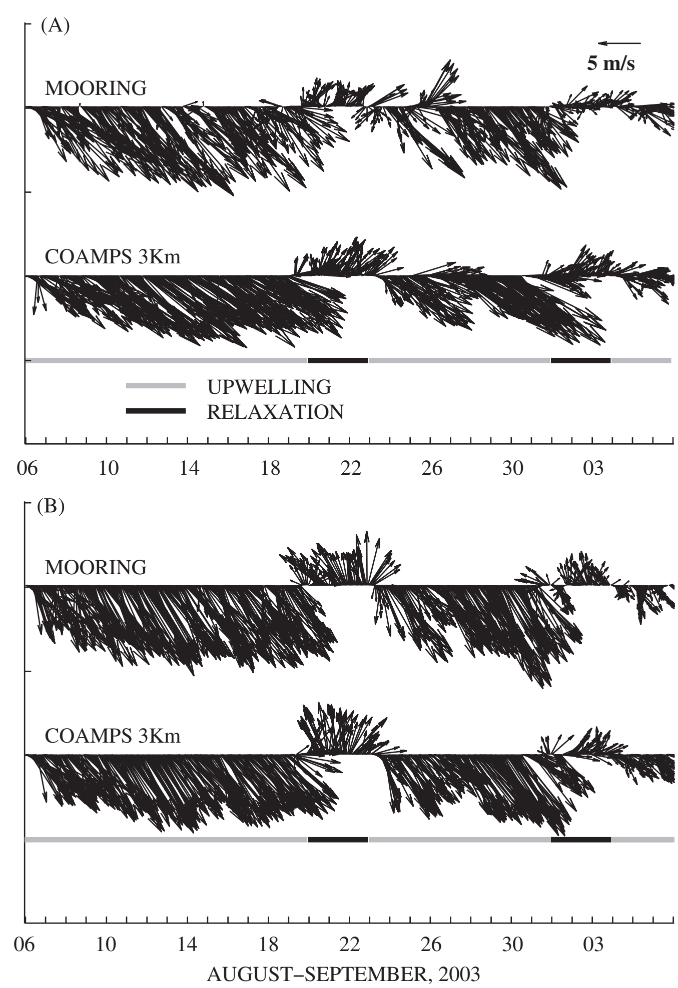

Fig. 3. Observed and COAMPS-predicted wind velocities at M1 (A) and M2 (B) moorings.