Coastal Ocean Modeling & Dynamics

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LONG-TERM GOALS

The long-term goal of this research is to improve our ability to understand and predict environmental conditions in the coastal ocean.

OBJECTIVES

The central objective of the proposed research is to explore problems in coastal ocean modeling and dynamics, including Lagrangian trajectory analysis and the various roles played in coastal ocean predictability by basic physical elements of coastal ocean circulation. The research is being conducted by a graduate student, in collaboration with the PI.

APPROACH

The central activity of the proposed research is the development and analysis of a set of high-resolution numerical simulations of the Oregon coastal ocean that extend the recent work of Rivas and Samelson (2011), Kim et al. (2009), Kim et al. (2011), and Springer et al. (2009). The simulations and analysis are being carried out by graduate research assistant Rodrigo Duran, who passed the COAS physical oceanography Ph.D. qualifying exam in July 2009, and has recently finished his third year in the COAS physical oceanography graduate program. The research is currently focused primarily on describing and analyzing the dynamics of the poleward undercurrent (PUC). The PUC is a basic, persistent feature of eastern boundary current circulation regimes, but remains poorly understood and without an accepted dynamical explanation.

Research progress by Duran has so far included extension of the calculations of Rivas and Samelson (2011) by the use of Lagrangian label and simulated tracer techniques, kinematic description of the undercurrent circulation in preliminary model simulations, and development of an improved model configuration with smoothed bathymetry in preparation for detailed analysis of model PUC dynamics. Rivas and Samelson (2011) used backward integration of resolved-velocity-field trajectories to obtain information on Lagrangian motion and cross-shelf exchange in the coastal upwelling regime. Duran has, instead, used forward integrations of conserved Lagrangian label and tracer fields, in order to obtain complementary and potentially more complete information on fluid parcel motion. Such techniques have been used successfully in some previous coastal simulations (e.g., Kuebel Cervantes et al., 2003, 2004; Springer et al., 2009) and offer the promise of a more complete representation and visualization of the complex patterns of Lagrangian motion in the coastal zone. On the other hand, the complexity of the Lagrangian motion – particularly on the long-term, seasonal timescales considered by Rivas and Samelson (2011) – presents challenges for the required inversion of the tracer fields. Current simulations indicate that the Lagrangian label and tracer methods yield useful results for this model integration on time scales extending to one month. This is sufficient to allow description and analysis of the Lagrangian PUC circulation.

WORK COMPLETED

Preliminary simulations for year 2005 with passively-advected Lagrangian label fields have been completed and analyzed. A simulation with an improved model configuration including daily boundary conditions from the Naval Research Laboratory NCOM-CCS regional model, improved vertical resolution, and bathymetry that has been smoothed to reduce pressure-gradient errors from the terrain-following coordinates at the PUC depths, has been completed. Analysis of that improved simulation is in progress.

RESULTS

The results of the preliminary simulations show both Lagrangian (Fig. 1) and Eulerian (Fig. 2) PUC flows in the model. The analysis has also provided independent support for the particle-tracking conclusions regarding the locations of upwelling source waters described by Rivas and Samelson (2011), and for the adequacy of the PUC representation in those previous simulations.

IMPACT/APPLICATIONS

The results have impact and application for understanding of biological and any other related Lagrangian processes in the coastal zone, including dispersal of passive floating or submerged objects, and development of extreme biological conditions such as hypoxia or anoxia.

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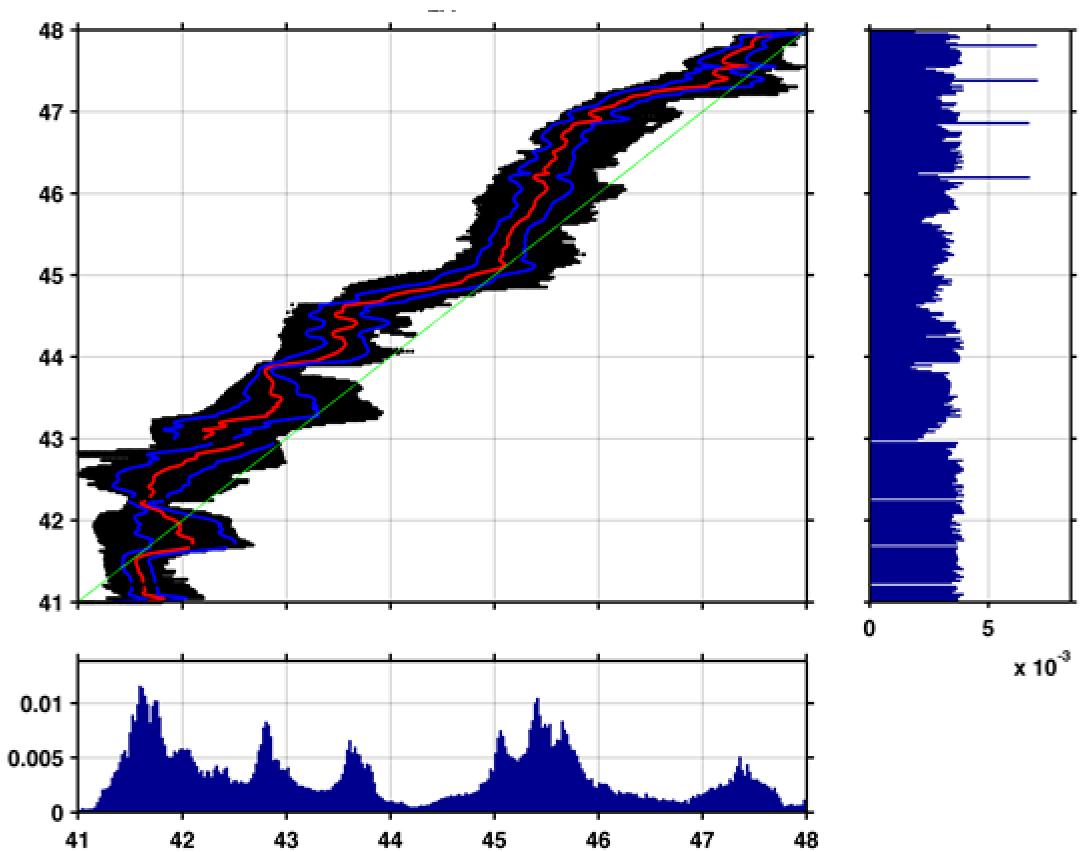

Figure 1. Scatter plot of initial (abscissa) vs. final (ordinate) latitude (^{o}N) from Lagrangian label advection over one month during summer 2005, for parcels with final positions in the PUC region, where the latter is defined at each latitude as the cross-sectional region between 150 m and 400 m depth within 20 km offshore of the 200-m isobath. The mean (red lines) and mean +/- standard deviation (blue lines) of initial latitude at each final latitude are shown. The distributions show a mean northward displacement of 50-100 km at most latitudes, with mean southward displacements occurring only for final positions south of 42 ^{o}N. The histograms along the right and bottom axes show the distributions of label values integrated over the corresponding latitudes; the right-axis histogram thus gives the relative areas of the PUC cross-sectional regions, with some aliasing due to mismatches between the model grid and the histogram bins.

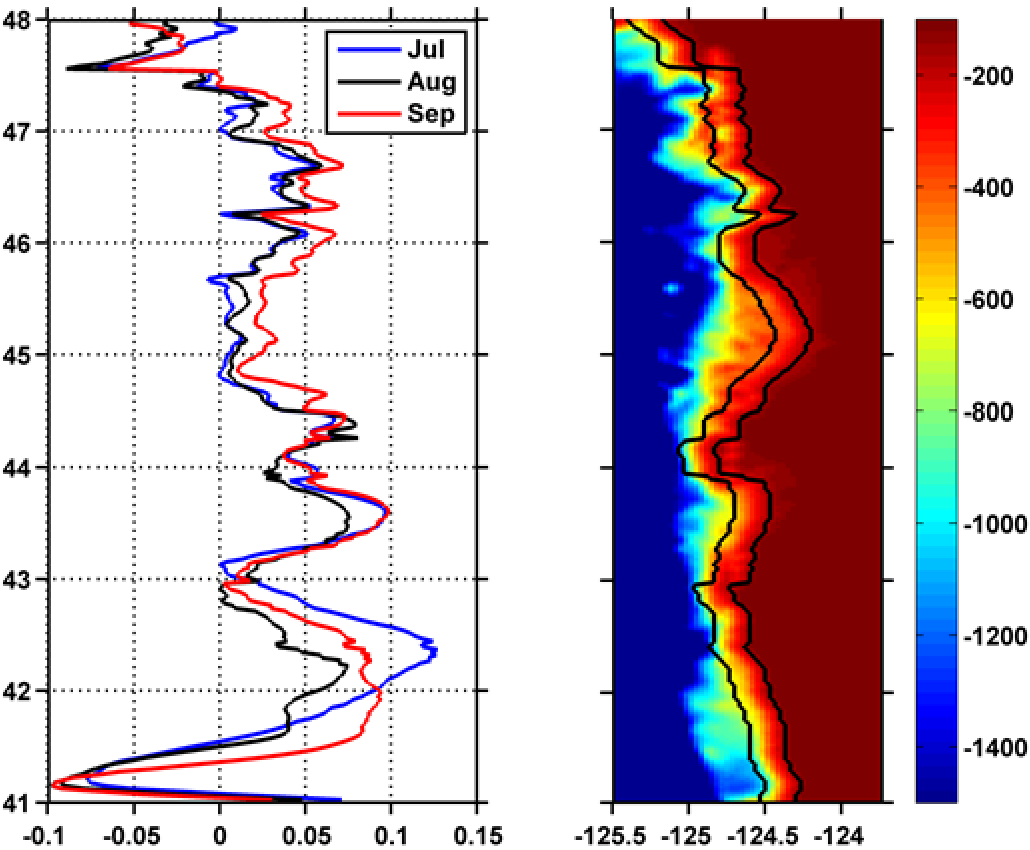

Figure 2. Left panel: Model Eulerian mean PUC-region meridional velocity (m s^{-1}) vs. latitude (41-48 ^oN) for the months of July (blue line), August (black), and September (red) 2005. Right panel: Model shelf and slope bottom depth (m) vs. longitude (^oE) and latitude (^oN), with cross-shore boundaries (black contours) of the PUC region. As in Figure 1, the PUC region is defined at each latitude as the cross-sectional region between 150 m and 400 m depth within 20 km offshore of the 200-m isobath.