Ocean Current Structures and Sea Surface Height Estimates Across the West Florida Shelf

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1. Abstract

The cross-shelf structures of the ocean circulation and the associated sea surface height (SSH) variability are examined on the west Florida Shelf (WFS) for the three-year interval September 1998 to December 2001. Five sets of characteristic circulation patterns are extracted from these data using the Self-Organizing Map (SOM) method. The patterns include steep upwelling and downwelling structures of strong currents, asymmetric upwelling and downwelling structures with moderate currents, and nonlinear structures with weak currents. The temporal variations of these structures are coherent with the local winds on synoptic weather time scales. On seasonal time scales they are related to the local winds and the water density variations. The circulation is predominantly reversed during fall in spring months (October to April) and downwelling during summer months (June to September). Coastal sea level fluctuations are related to the dynamical responses of the inner shelf circulation to nonlinear forcing and the offshore SSH. On long time scales, the offshore SSH variations appear to dominate, whereas on synoptic to seasonal time scales, the inner-shelf wind-driven circulation responses are larger. We estimate the cross-shelf distribution of SSH from remote sensing data, hydrography, wind, and coastal sea level data, and we compare the results with satellite altimetry data, thereby providing a means for constraining satellite altimetry on the shelf.

2. Observations

Fig. 1 WFS map showing radials (m), ADCP recordings, and CTD and wind stations relative to the entire Gulf of Mexico.

Fig. 2 Timeline of available time series data and location of ADCP currents (.....) and monthly CTD data along the Sarmiento (--) and Tampa Bay (---) transects.

3. Time Domain EOF Analysis

Fig. 3 First mode along-vector EOF and its principle component (ordinate) from a time domain EOF analysis of 2-day low-pass filtered currents, related to 30-day low-pass filtered, 2-day spectrally concentrated events. The cross- and along-shelf components are shown as vectors and filled contours, respectively. Positive contour values indicate upwelling and along-shelf currents.

Fig. 4 SOM representation of the 2-day low-pass filtered velocity data. The 4-3 SOM (top) and the best matching unit (BMU) time series (bottom). The clockwise and along-shelf components are vectors and filled contours, respectively. The relative frequency of occurrence (%) of each pattern is shown in the lower-left corner of each SOM unit.

4. SOM Analysis

5. Sea Surface Height Equation

Fig. 5 Sea surface height equation.

η = ηi + ηo + ηs + ηn + ηd

6. Across-shelf Sea Surface Height Estimates (15-d low-pass filtered)

Fig. 6 Across-shelf sea surface height estimates.

7. Sea Surface Height Estimates (Synoptic weather band)

Fig. 7 Wind (inset) and SSH time series for the synoptic weather band (2-day band-pass filtered). The total relative SSH (9) estimated at the 50 m isobath and the sea level (9) obtained at St. Petersburg, FL. The slope along-shelf ECI (estimated from bottom pressure records) are shown in the bottom panel. The difference between the observed and estimated SSH (9) are shown in the top panel. The three SSH components estimated at the 50 m isobath, due to baroclinic currents (9), baroclinic currents (9), and across-shelf wind stress (9), are shown in the bottom panel.

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Observed on synoptic and seasonal time scales are coherent upwelling/downwelling flow structures, with a coastal jet located around the 25-30 m isobath. The inner shelf currents tend to be upwelling (downwelling) in winter (summer), which is visually coherent with the local winds, suggesting that the local winds are the main driver for the inner WFS currents.

Over the synoptic weather band the BMU variations are related to the local winds.