DEEP OCEAN EFFECTS ON OUTER CONTINENTAL SHELF FLOW:

A DESCRIPTIVE STUDY IN THE LOOP CURRENT, FLORIDA CURRENT AND GULF STREAM SYSTEMS

J. Law and G. Mitchum, University of South Florida College of Marine Science

ABSTRACT

Multi-altimeter sea surface height data is used to investigate deep-ocean forcing of continental shelf waters. The nature and extent of boundary current interactions with the outer shelf is an important consideration in understanding the flow field of the world's continental shelf regions. The bulk of previous work in addressing this question has focused on variability associated with the eastern boundary current system offshore of the United States west coast. The present study uses TOPEX/Poseidon and ERS sea surface height as well as AVHRR sea surface temperature and SeaWiFS ocean color data for the time period of 1993 through 2001 to assess the strength and frequency of interactions with shelf waters. The study region is comprised of the unique natural laboratory presented by the western boundary current system comprised of the Loop Current, Florida Current and Gulf Stream and the adjacent United States gulf and east coasts. In this region the boundary current strength varies due to the respective current transports and the neighboring shelves have widths ranging from 10 to 200 km. Only in the region of the central and southern west Florida shelf were significant interactions between the deep-ocean and outer shelves identified. Variability associated with the Loop Current is observed to provide a forcing mechanism capable of overcoming the strong vorticity constraints restricting flow of deep-ocean waters across the steep continental slope. Three types of strong interactions between the boundary current and the west Florida shelf are observed; a cyclonic circulation to the north of the Loop Current apex, a direct impingement of the Loop Current with the shelf break and a cyclonic eddy feature that sets up at the southern shelf break near the Dry Tortugas. The direct interaction and southern cyclonic eddy are the most common and strongest interactions as they were observed 12 and 11 times, respectively.

METHODS

A case study approach is taken to diagnose synoptic scale interactions between open-ocean and outer continental shelf waters in the study region (Figure 1). All available SSH, SST and OC data are composited to 5 day running means for the time period of 1993 through 2001. In each of the five sub-regions shown in Figure 1 all interactions indicating a communication mechanism between the deep water and shelf regions are identified.

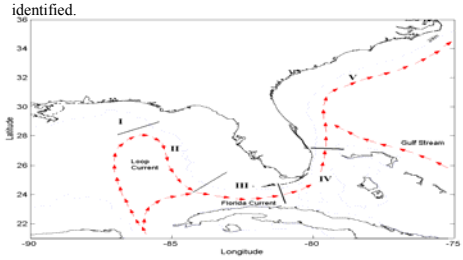


Figure 1. The Study Region.

Region I: Narrow Shelf, No BC
Region II: Wide Shelf, Variable BC
Region III: Wide Shelf, Always BC
Region IV: Narrow Shelf, Always BC
Region V: Narrow/Wide Shelf, Always Strong BC

INTERACTION TYPES

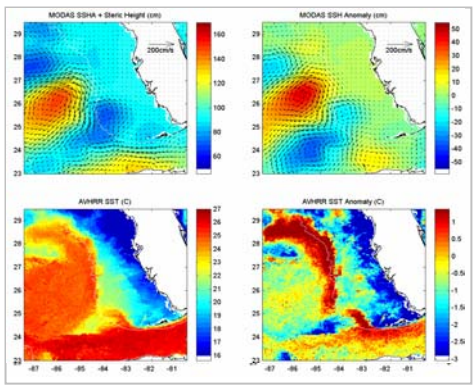


Figure 2. Cyclonic Eddy offshore of Southern WFS, near the Dry Tortugas. SSH and SST show shelf water advected off of shelf into the eddy feature, with some re-circulation of warm LC waters back onto the shelf to the east.

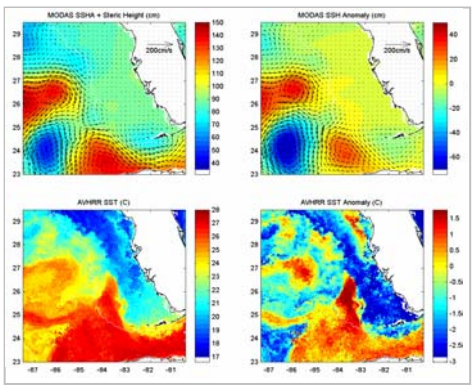


Figure 3. Direct LC interaction with the southern WFS. After the LC has shed an eddy to the west the LC impinges on the shelf near 25°N, with warm LC waters inshore of 100m.

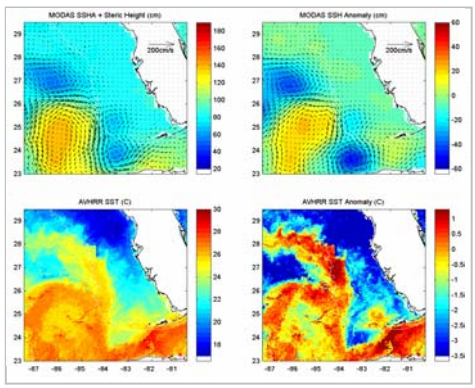
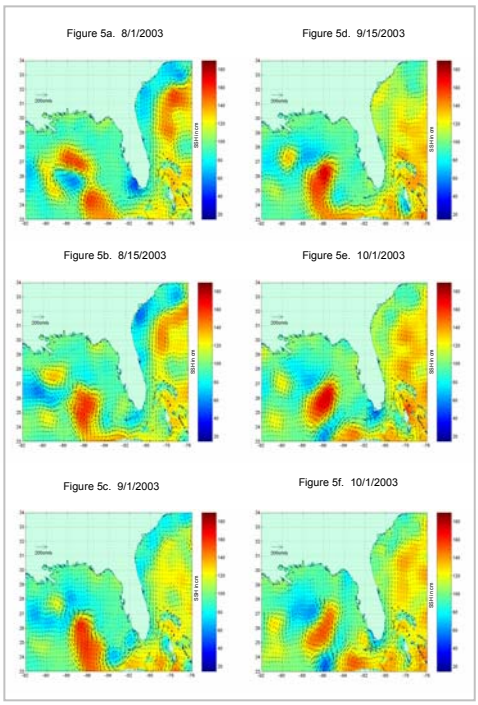


Figure 4. Cyclonic eddy to the north of the LC apex. The cyclonic feature sets up during LC instability, advecting warm LC waters across the 200m isobath near 26°N and subsequently back off of the shelf to the north.

DRIFTER BUOY ANALYSIS



Figures 5a to 5f. Absolute SSH for August-October of 2003. The SSH anomaly data is courtesy of CNES AVISO.

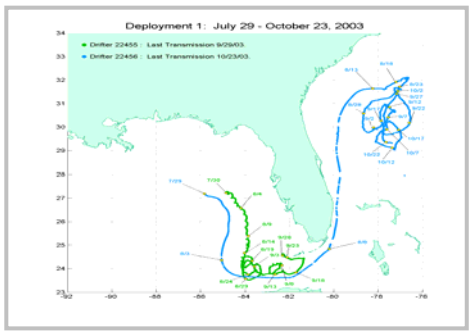


Figure 6. Lagrangian Drifter Deployment 1.
Drifter 22455 shows the presence of a cyclonic eddy offshore of the southern WFS break, with the drifter becoming entrained for nearly 6 weeks before transmissions cease. Drifter 22456 is deployed in the LC itself and is advected through the Florida Strait and joins with the Gulf Stream, becoming entrained in an eddy field offshore of the South Atlantic Bight. See Figures 5a through 5f for the corresponding altimetry fields.

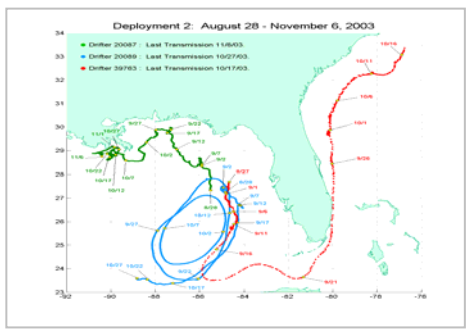


Figure 7. Lagrangian Drifter Deployment 2.
Drifter 20087 shows the northward drift possibly due to the cyclonic eddy feature to the north of the LC apex. Drifter 20089 becomes entrained into a LC eddy that separates from the main body of the LC. Drifter 39763 is advected around the eddy feature offshore of the Dry Torutugas at 24°N. See Figures 5a through 5f for the corresponding altimetry fields.

SUMMARY AND CONCLUSIONS

The case study approach succeeded in identifying three communication mechanisms between the deep water boundary current and the outer shelf region of the west Florida shelf. These are a cyclonic eddy offshore of the southern portion of the west Florida shelf, a direct impingement of the Loop Current on the mid west Florida shelf break and a cyclonic eddy feature that sets up to the north of the Loop Current apex. Loop Current induced variability represents a forcing mechanism strong enough to overcome the insulating effects of the steep continental shelf topography. Evidence for the presence of these communication mechanisms is observed in a separate drifter study undertaken by the Ocean Circulation Group at the University of South Florida.

ACKNOWLEDGEMENTS

-R.H. Weisberg and the USF Ocean Circulation Group for the drifter buoy analysis data.
-F. Muller-Karger and the Institute for Marine Remote Sensing for access to AVHRR SST and SeaWiFS Ocean Color data.
-Naval Research Laboratory for access to merged SSH Anomaly and steric height data.
-CNES AVISO for access to near real-time merged SSH Anomaly data.
-Service ARGOS for drifter buoy data transmission.