Eddy Variability Along the Florida Keys

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Summary

The Florida Keys Coastal Zone is a narrow, curving shelf with complex topography, especially because of its shallow coral reef tract. This region is affected by the Florida Current (FC) with its meanders and eddies. The FC is part of a complex ocean circulation that includes the Loop Current (LC) at the Gulf of Mexico. Understanding the physical mechanisms that drive water exchanges in this area is an important tool to marine resource managers’ strategies. These tools include providing model predictions of currents to support management tactics in response to ecological disasters. A recent example involves the Deepwater Horizon oil spill that may affect the Florida Keys fragile ecosystem.

This study employs hydrodynamic parameters from three-dimensional fields generated by numerical simulations using a multi-nested, high resolution (~300m) regional application of the Hybrid Coordinate Ocean Model (HYCOM). The eddy identification method consists of analysis of velocity, temperature, Sea Surface Height maps, in tandem with the Okubo-Weiss parameter to identify and characterize the cyclonic eddies. The domain was divided in four subregions according to flow properties, physical characteristics and species composition to facilitate this analysis. Using this approach it is possible to identify if there is a preferred location for eddy formation along the Florida Keys.

A total of 394 eddies were identified and tracked in the domain. Estimating the baroclinic Rossby radius of deformation at ~30 km in this region, 205 mesoscale (diameter larger than 30 km) and 210 submesoscale (diameter less than 30 km) cyclonic eddies were identified in the Florida Keys (FKEYS) domain throughout the five years (2004-2008). A histogram showing eddy activity on each subarea reveals that the mesoscale eddy activity is dominant in the Western Keys, while the submesoscale activity is dominant in the Upper Keys. Wavelet analysis of surface currents in the Western Keys and Upper Keys give similar results. It was also observed that the Florida Current location and the topographic constraints affect eddy evolution.

Eddy characteristics

The energy associated with cross-shore current fluctuations in the western Keys is primarily grouped in the 32-100 days period with peak energy centered around the 64 day period.

Eddy interaction with topography and the Florida Current

Fig. 7 FKEYS-HYCOM SSH and surface current vector maps showing a cyclonic eddy moving along the shallow isobath lines without significant changes in characteristics (100m, 200m and 500m isobaths are marked with white lines). Eddy #8 location is indicated by the magenta arrow.

Fig. 8 Snapshots of the FKEYS-HYCOM simulations showing the Relative Vorticity field. Left panel is the top view indicating the location of the cross-section and right panel is the cross-section revealing that the eddy #8 vertical structure has not changed as the eddy progresses from the lower to the upper Keys.

Fig. 9: HYCOM SSH and surface current vector maps showing a cyclonic eddy moving across the deep to shallow isobath lines with significant changes in characteristics (100m, 200m and 500m isobaths are marked with white lines). Eddy #78 location is indicated by the magenta arrow. Question mark indicates that #78 was identified as a front.

Fig. 10 Snapshots of the FKEYS-HYCOM simulations showing the Relative Vorticity field. Left panel is the top view indicating the location of the cross-section and right panel is the cross-section revealing that the eddy #78 vertical structure changed significantly as the eddy progressed downstream – apparently due to interaction with the shallow topography in the middle Keys (where the shallow isobaths extend offshore, see Fig. 1), under the conservation of potential vorticity principle.

When cyclonic eddies enter the Florida Straits at shallow depths (or are small in size), topographic effects are minimal; when they enter through the deep areas, they are subject to changes in their characteristics, as they are forced to cross isobaths, in close synergy with the meandering Florida Current.

Florida Keys Hybrid Coordinate Ocean Model (FKEYS-HYCOM)

Fig. 1 Bathymetric map of the study region including Florida Keys subregions. Western Keys (WK), Lower Keys (LK), Middle Keys (MK) and Upper Keys (UK).