Modeling frontal instabilities in the Gulf of Mexico

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Satellite images of sea surface temperature (SST) and chlorophyll in the eastern Gulf of Mexico show filaments of relatively cold water extending from the coastal zone out towards the shelf break. Similar structures have been observed in the California Current system (Ikeda & Emery, 1984) and Portugal (Røed & Shi, 1999), and have been linked to both upwelling and topography irregularities along the coast.

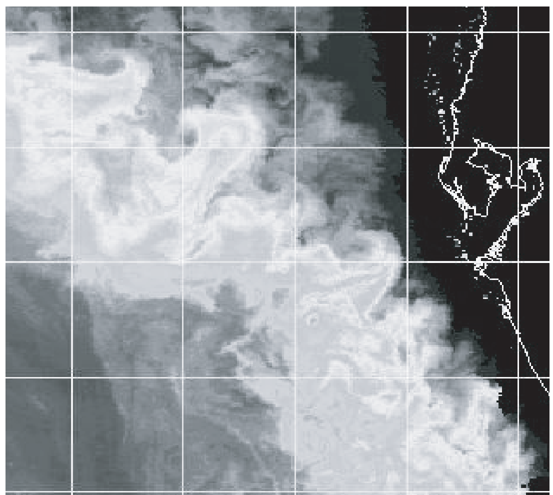

Fig. 1. Satellite image showing chlorophyll distribution on the west Florida shelf.

In this study the Navy Coastal Ocean Model (NCOM) (Martin, 1999; Morey et al, 2003) is used to investigate filaments on the west Florida shelf. The domain is a square basin with a 320 km long coastline at the eastern boundary. There are 40 vertical layers; the upper 20 are sigma levels while the bottom 20 (below 140m) are z-levels. The model is set up with idealized shelf topography uniform in the north-south direction, with a minimum (maximum) depth of 4m (1500m). The mixed layer has an initial temperature of 22°C and maximum thickness of 140m at the shelf break, 200 km from the coast. Further down, the temperature decreases linearly toward the bottom. Periodic boundary conditions are used to the north and south, and at the western boundary the model uses Orlanski radiation. The only forcing of the system is uniform surface cooling of 70 Wm^{-2}.

Starting from rest, a thermal front is almost immediately formed in the shallow water close to land (within 1-2 days). As time progresses, the density difference becomes large enough to set up an equatorward current along the coastline, which seems to become unstable after approximately 6-8 days. Small undulations rapidly grow to meanders of 40 km or more, and eddies begin to form and propagate westward, dissipating 60-80 km from the coast. The filaments have a separation distance of 20-30 km (Fig. 1 a, b).

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A suite of experiments with varying parameters are being used to explain the dynamics of the cold filaments. A steady growth of the initial undulations in the density current, along with nearly vertical isotherms, indicates the presence of baroclinic instability, however these issues require further study.

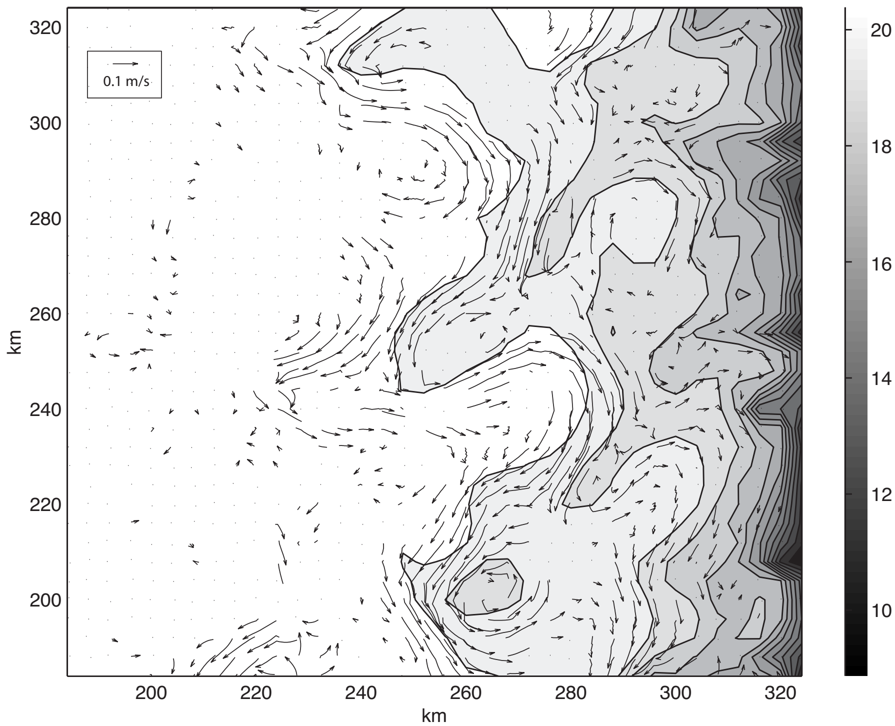

Fig 2. Modeled SST (contours) and surface currents (vectors) at day 60.

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