Impacts of Mesoscale Eddies on Deep-Ocean Currents in the Gulf of Mexico

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Background and Questions

Coupling of surface and deep-ocean currents could exist in the Gulf of Mexico under some circumstances such as movements of Loop Current (LC) and traveling eddies. Here we used archived deep-ocean current measurements and satellite data to address the following questions:

- Are there special spatial patterns of correlation between the surface and deep-ocean currents in the Gulf of Mexico?
- What are the roles of eddies in connecting surface and deep-ocean current?

Data

- Surface currents: Derived from multimission altimeter satellite gridded sea surface heights provided by Copernicus Marine Environment Monitoring Service (CMEMS) with daily time interval and spatial resolution of 0.25 degree.
- Deep-ocean currents: Collected from mooring sites deployed after the era of satellite altimeter, and are provided by Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC) and NOAA's National Centers for Environmental Information (NCEI). 64 current records at a layer deeper than 1000 m and less than 200 m above bottom were selected. Current were low-passed with the half-amplitude period of 30 days.

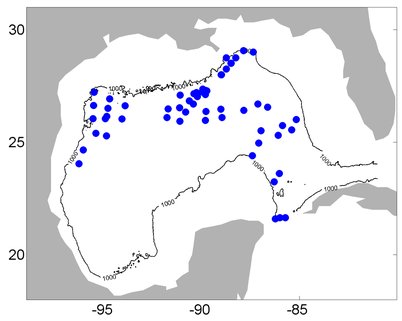

Figure 1: Locations of collected mooring sites.

Surface and deep-ocean current features

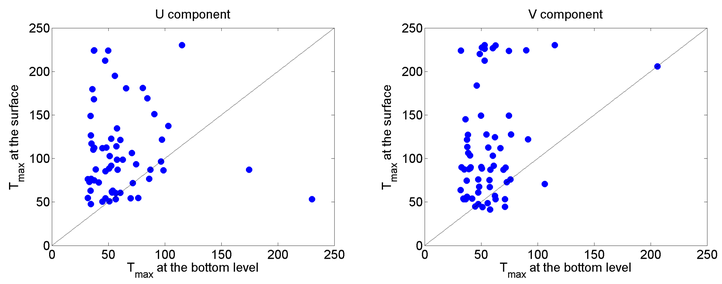

Figure 2: Scatter plots of period with maximum variance-preserving power spectrum density (PSD) at the surface versus at bottom level for u (left) and v (right) component, respectively.

- Period with peak current energy at surface is larger than that in the deep ocean at most sites.
- The average of period with peak current energy at the surface and in the deep ocean is about 110 and 60 days, respectively.

Correlation between surface and deep-ocean currents

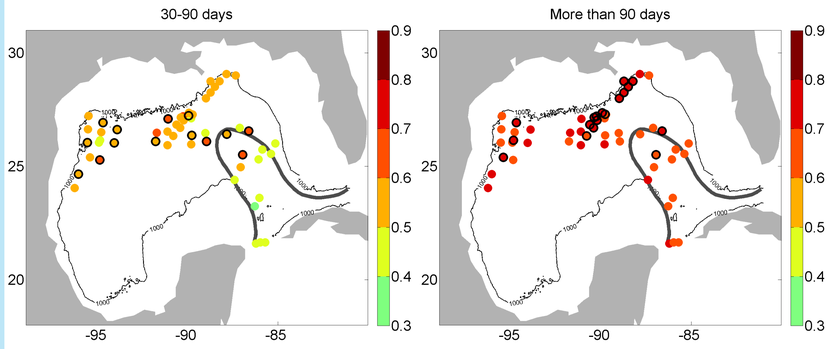

Figure 3: Average maximum time-lagged correlation between surface and deep currents in the period band of 30-90 days (left panel) and with period longer than 90 days (right panel) ; moorings with significant correlation and meaningful correlation pattern are marked with black circle; thick gray contour denotes mean SSH at 450 mm, representing the mean trajectory of Loop Current.

- Within the period band of 30-90 days, surface and deep-ocean currents are more likely correlated northwest of LC.
- Within the period band of longer than 90 days, more significant correlations appear along the continental slope of the northern GoM.

Processes responsible for correlations within the period band of 30-90 days

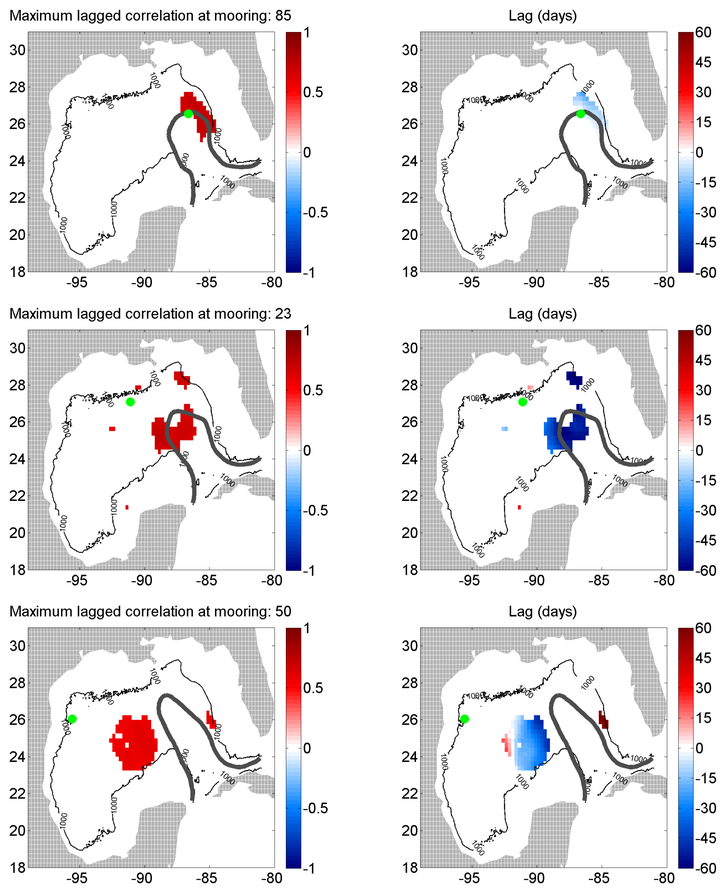

Figure 4: Smoothed maximum time-lagged correlations between surface current at all grid points and deep-ocean current speed at the mooring site (left), and associated temporal lag (right) in the period band of 30-90 days; negative (positive) lag means surface variability leading (lagging) deep-ocean current; mooring site is denoted by green dot.

- Within the period band of 30-90 days, deep-ocean current can be closely related to either the local mesoscale variability around LC or the remote mesoscale variability at surface.

Roles of eddies in deep-ocean currents

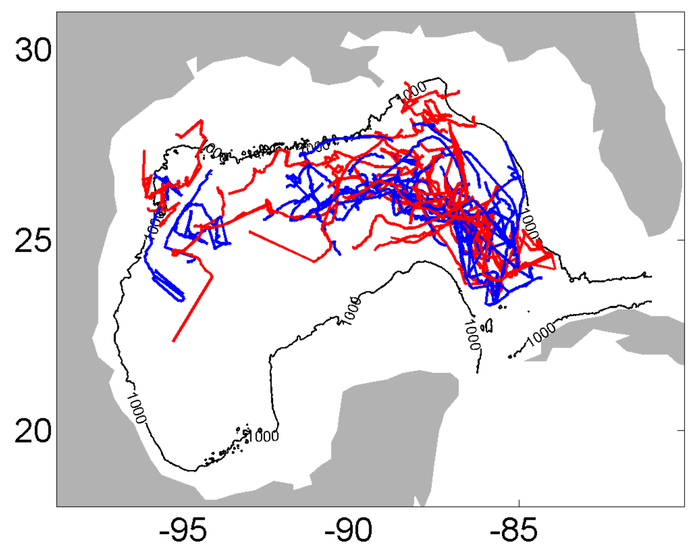

Figure 5: Trajectories of identified cyclonic (blue) and anticyclonic (red) eddies that possibly impact deep current at the mooring sites.

- Strong eddy activity appears around LC.
- Eddy propagation is also observed in the west of GoM.

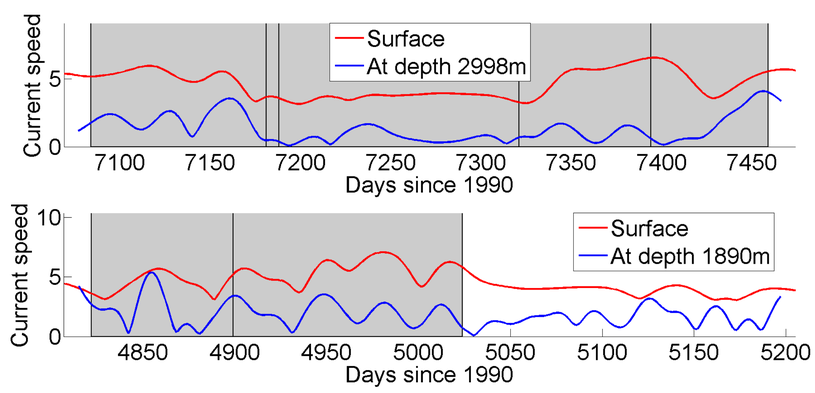

Figure 6: Surface and deep-ocean currents at the mooring 85 (upper panel) and mooring 26 (close to mooring 23; lower panel). Shaded area represents the time when eddies passed nearby the mooring site.

- Surface and deep-ocean current speed are significantly correlated as eddies passed.

Summary

- Surface and deep-ocean currents are more likely coupled northwest of LC in the band of 30-90 days, while they are often found correlated along the continental slope of the northern GoM in the band of longer than 90 days.
- Deep-ocean current can be caused by either the local mesoscale variability around LC or the remote mesoscale variability at surface.
- Mesoscale variability such as eddy is shown causing deep-ocean current variability in the GoM.

Future works

- Sea surface processes responsible for the correlation will be investigated in details.
- Future works include investigating the possible mechanism through which eddies impact deep-ocean currents.

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