Impacts of the Loop Current on the Circulation System in the Gulf of Mexico

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1. Introduction

- The Gulf of Mexico (GoM) has abundant natural resources and large surrounding populations.
- The Loop Current (LC) is as strong as the Gulf Stream (at a mean speed ~0.8 m/s) while the width of GoM is only about one-fifth of the North Atlantic Ocean.
- The circulation system in the GoM is a LC leading system.

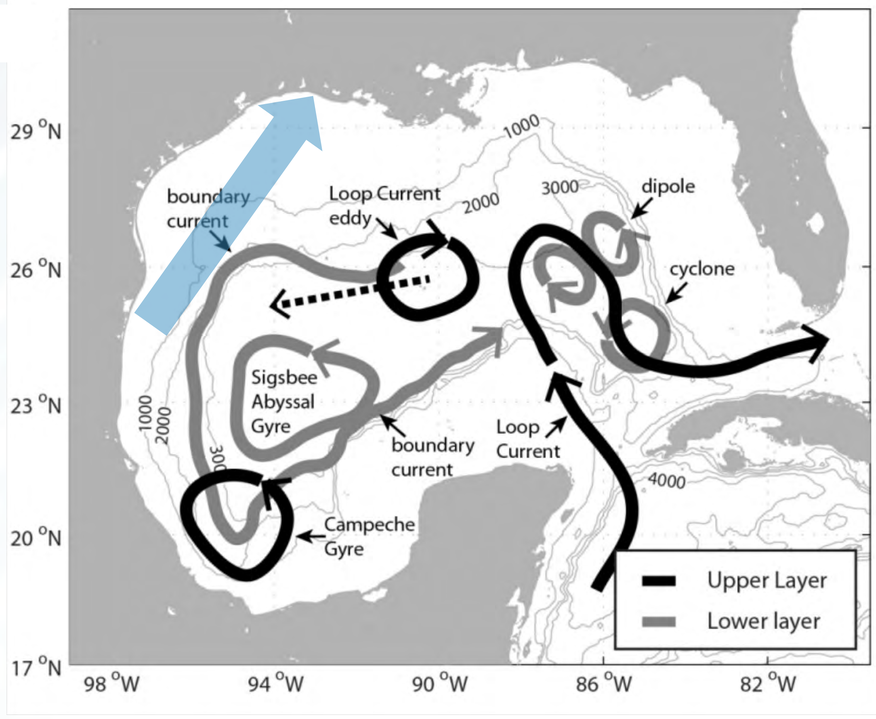

Figure 1. Modified from Furey et al., 2018. Circulation features of the upper layer (surface to ~1000m) and lower layer (~1000m to seafloor) in the GoM. Blue vector shows the shift of coastal currents during summer.

2. Loop Current Variability

- Strong variabilities in:
  - Area – meandering
  - Intensity – velocity
  - Thickness – depth
- All these variations of LC could impact on the circulation system in the GoM.

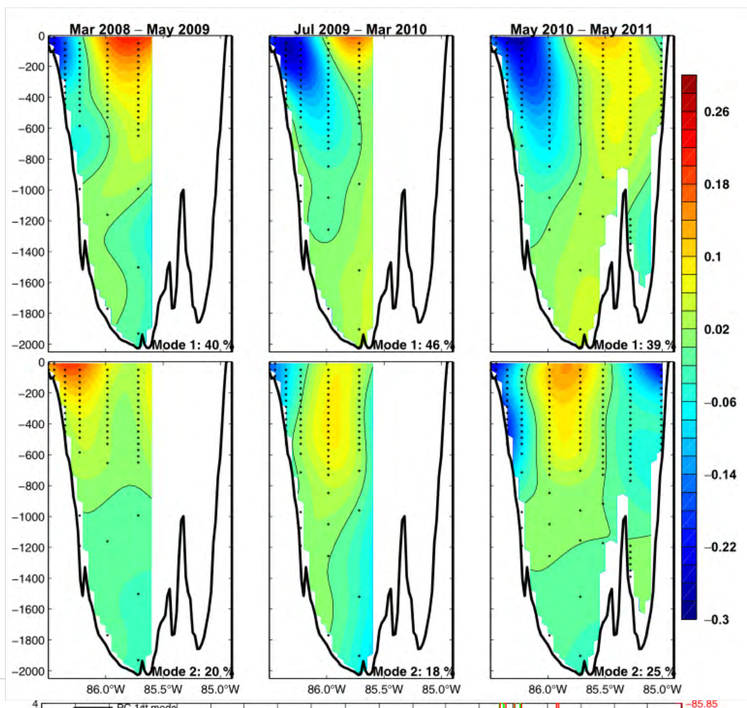

Figure 2. Modified from Sheinbaum et al., 2016. Spatial structure of the first two EOFs (top and central panels, black line indicates the zero contour) at the Yucatan Channel for each observation period separately. Bottom panel shows their corresponding principal components. The left axis is the amplitude whereas the right axis is the longitude of the Yucatan Channel core.

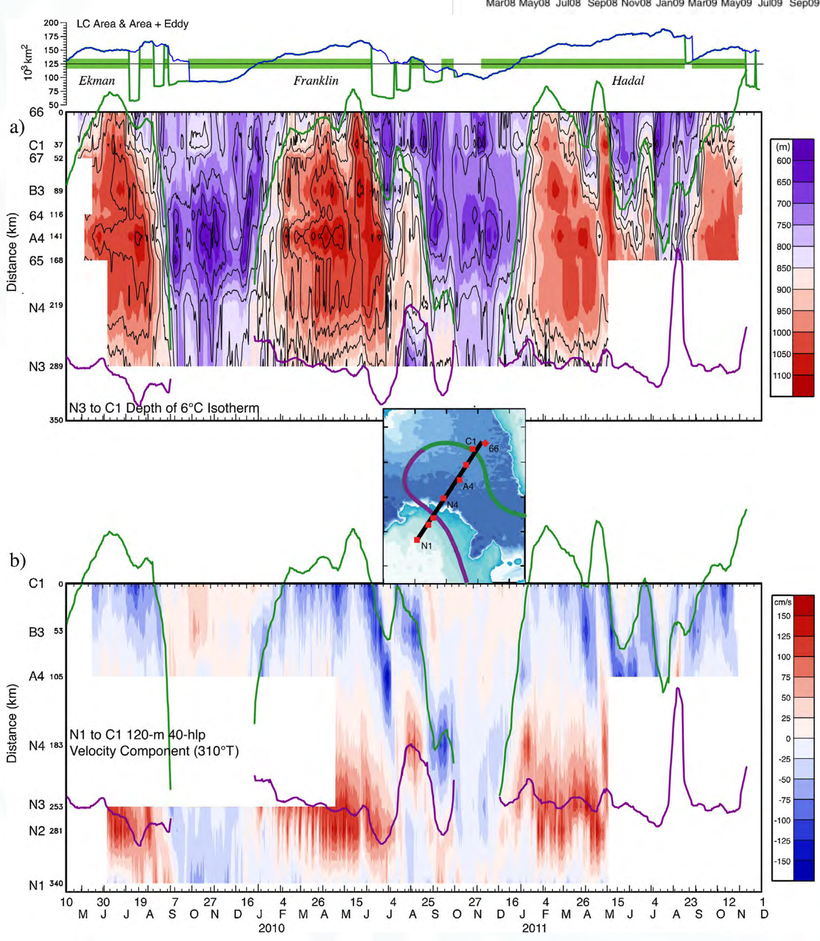

Figure 3. Modified from Hamilton et. al., 2016. (a)Depth of the 6◦C isotherm along the N3-C1 transect. The location of the transect is given in the inset (bathymetry: 250m contour interval, green and blue shades to 2000 m and 2000–3500 m, respectively), and the crossing of the SSH 17cm contours on the transect are given by the thick lines for the east (green) and west (purple) sides, respectively. (b) Velocity components, directed 310◦T, at 120m for moorings along the N1-C1 transect.

3. Upper Circulation

- Deep-water region in the GoM is dominated by the LC and the LC eddies.
- Coastal region in the GoM is influenced by the seasonal variation of wind, such as the currents along Texas-Louisiana coast shift from downcoast to upcoast every summer.
- Upper circulation is well observed by the satellites (SST & SSH).

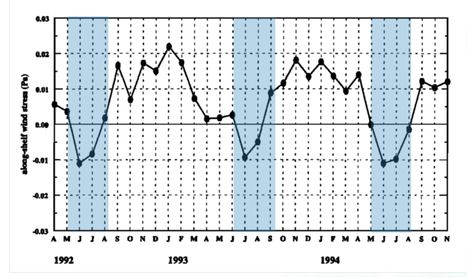

Figure 4. Modified from Cho et al., 1998. Sequence of monthly mean, along-shelf wind stress characterizing the Texas-Louisiana shelf. Blue shedding refers to summertime.

4. Lower Circulation

- Lower circulation in the GoM is dominated by:
  - Baroclinic instability – deep eddies
  - Energy propagation – topographic Rossby waves

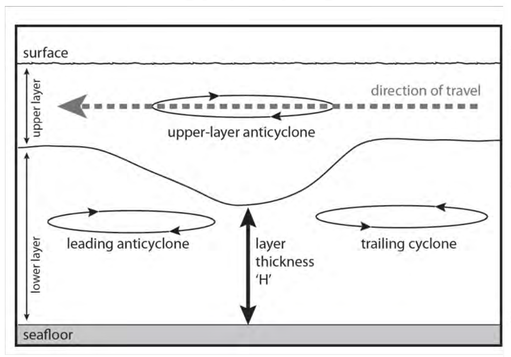

Figure 5. Modified from Furey et al., 2018. Lower layer spinup of dipole in response to drifting upper-layer anticyclone.

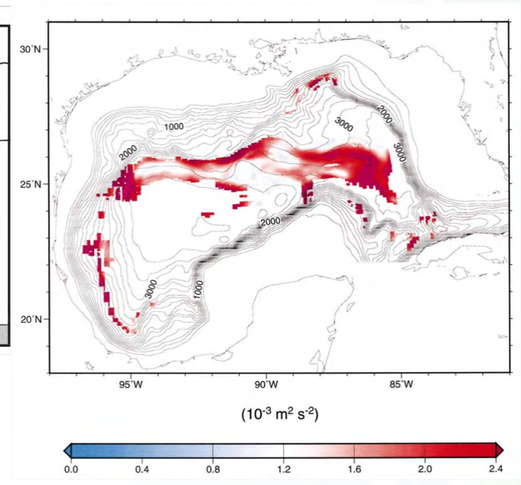

Figure 6. Modified from Oey and Lee, 2002. The lower-layer kinetic energy in the 20~100 day periods.

- Outflow through the Yucatan Channel is highly correlated with the volume change in the LC with a lag of about one week:

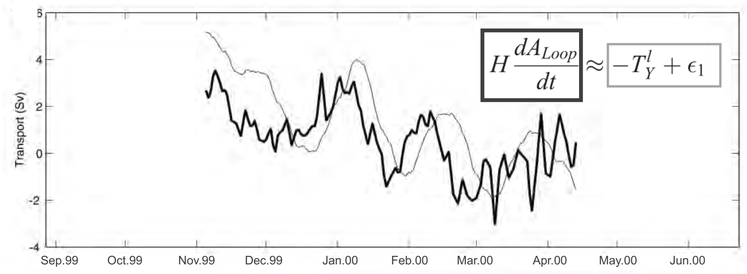

Figure 7. Modified from Bunge et al., 2002. The variation of the deep volume transport through the Yucatan Channel (gray line) and the volume change in the LC area (black line) over time. The correlation coefficient is 0.62 and reaches its maximum value (0.83) with a lag of 8.6 days.

5. Conclusions

- The dynamical mechanisms of the eddy separation and lower circulation are still poorly understood due to the limitation of deep observations.
- Some higher order baroclinic instabilities are needed to be studied further for the lower-layer system to figure out the following scientific issues, which requires more abundant and continuous observational dataset.
  - What are the effects of deep mixing in the numerical simulations?
  - What determines the intensity of the westward propagated topographic Rossby waves?
  - What causes the variations of the deep outflow through the Yucatan Channel?