Abstract
The Loop Current (LC) is the dominant dynamical feature in the Gulf of Mexico (GoM). Its journey varies with time from a retracted position to an extended one, in which it can interact with the northern GoM continental shelf. Once extended, the LC eventually closes its circulation and sheds a large anticyclonic eddy, or ring, while the base of the LC retreats. These changes in the LC extent have important economical, ecological and biophysical impacts. The ring shedding sequence of the LC is strongly influenced by the presence of smaller, cyclonic eddies, named Loop Current frontal eddies (LCFEs), which are advected along the edges of the LC.

Results from a modeling study, based on the Hybrid Coordinate Ocean Model (HYCOM), show that the specific topography of the northern GoM shelf slope is responsible for the intensification of LCFEs. This intensification allows the LCFEs to play an effective role during the ring shedding. This localized intensification is confirmed by ~20 years of surface drifter observation data, which also illustrate new aspects of the LCFE dynamics.

(1) GoM–HYCOM Model
- 1/25 degree, 26 vertical layers
- Atmospheric forcing: COAMPS (27 km, 3h)
- IC: NCODA simulation run at NRL
- BC: climatology from 4 yrs HYCOM Atl simulation
- Study period: 2004-2008, daily outputs

Main processes:
- the Loop Current (LC) flows in the GoM from a retracted stage to an extended one
- it sheds an large eddy of warm water and retreats
- Loop Current Frontal Eddies (LCFEs, cyclonic play a key role in detachment process

(2) Eddy intensification process
Use of the Potential vorticity (PV), conserved in adiabatic processes. In isopycnal layers:
- $PV = \frac{\zeta + f}{h}$ with $\zeta$ the relative vorticity (RV), $f$ the planetary vorticity and $h$ the layer thickness
- Link with the dynamics is not direct. Use of potential vorticity anomaly (PVA):
- $PVA = \int_0^h (\zeta + f) \ dz = \int_0^h (\zeta + f) \ dz$

The PVA can be inverted to estimate currents or relative vorticity:
- Intensification of an eddy = intensification in PVA
- Localized intensification of PVA might affect the whole vortex structure
- Possible sources of positive PVA:
  - Local diabatic processes
  - Remote advection of water parcel with higher PV
- Remote effect of a promontory on upwelling current (2-layer isopycnic model, Meunier et al., 2010):
  - Positive PVA generated downstream the promontory in lower layer
  - Re-arrangement of potential vorticity
- Negative PVA over the promontory
- Positive PVA generated $= H_p/H_t$ ($h_p$ the promontory height, $h_t$ the lower layer thickness)

(3) Application to the GoM case
Promontory = Mississippi Fan: downstream location of LCFEs intensification
- With $H_p = 500$ m, $H_t = 2800$ m, PVA = 0.18E
- Associated intensification in the upper layer:
  - $\zeta = PVA - f H_t$ in the first Rossby radius, $R$ the LCFE radius
  - With $H_p = 500$ m and $R = 40$ km and $R_p = 80$ km, $\zeta = 0.1f$

2-layer approach from the simulation: interface at layer 19 (~400 m), focus on a single eddy

(4) Study of GoM surface drifter data
- Data from the Global Drifter Program (GDP, aims at global coverage at 0.5° resolution, i.e. 1250 drifters)
- Positions every 6 hrs + (u, v) centered differences
- Data in the GoM: 1993-2011

Spin (rotation rate per unit of time) $= (u \cdot \nabla v - v \cdot \nabla u)/\Omega$, where $\Omega$: planetary vorticity
- Mean current: average geostrophic current from AVISO
- Mean current: time average over 3.5 days (rotation period of LCFEs)

(5) Study of a single drifter trajectory
Decomposition of the trajectory in an ambient current + ellipses evolving in time (complex wavelet analysis, Lilly et al., 2011)

- Drifter initially follows max SST gradient
- LCFE extends toward the Campeche Bank, the drifter migrates toward eddy center
- The LCFE shrinks as the drifter gets closer to the center
- The drifter trajectory suddenly shifts eastward (impossible to use SST after May)

(6) Conclusions
Eddy intensification process:
- Eddy intensification through the “promontory effect”: redistribution of PV from the Mississippi Fan
- Evidenced and quantified in model simulation
- Agreement with observations from surface drifters observations

Drifter observations:
- Show LCFE in solid-body rotation
- Intense LCFEs reaching SE GoM can migrate from NE GoM (via local intensification)
- Sudden re-arrangement of vorticity in the Southeastern GoM

Perspectives:
- Results from single drifter trajectory need confirmation: modeling + observational studies
- Observational part provide new directions for model-based process studies (eg. erosion of the LCFE by the LC)
- Upstream the deep eastern GoM, what is the source of the positive vorticity at the edge of the LC?

Bibliography and acknowledgments
- Partial support for this study was provided by the National Science Foundation (NSF OCE-0529651) and the National Oceanic and Atmospheric Administration (NOAA NA07NMF222 and NA11NOS4780045).