

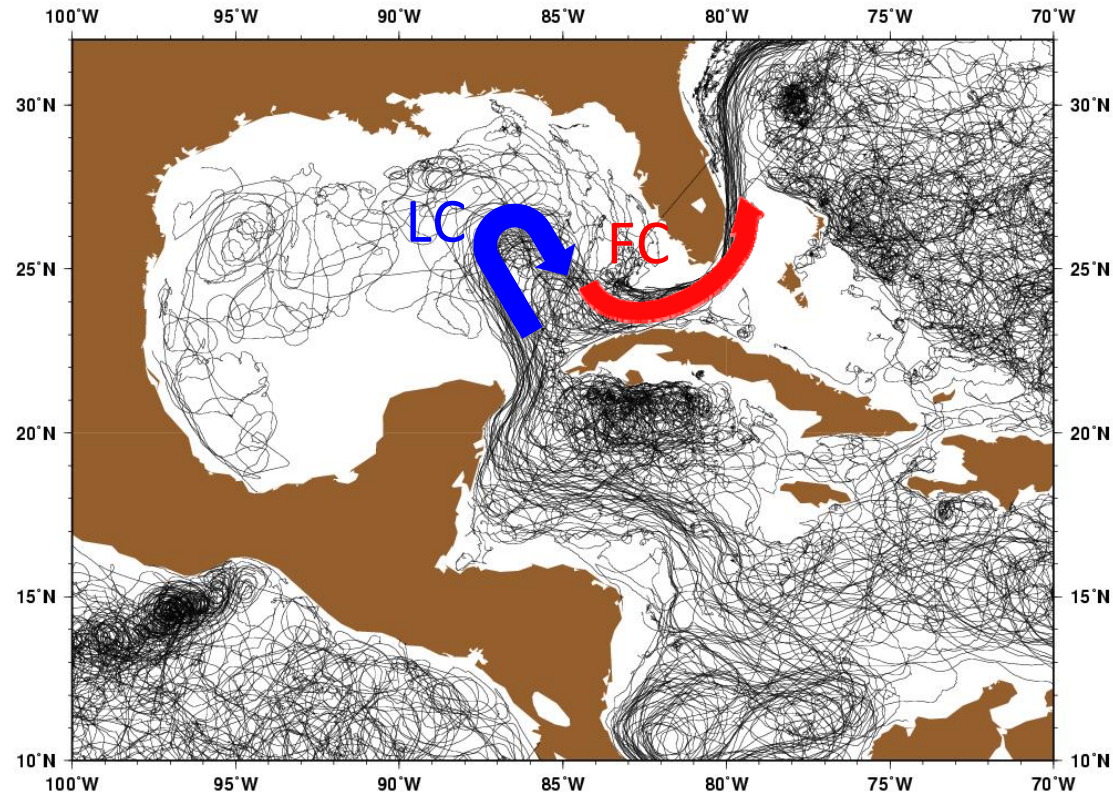
**Physical factors driving
the oceanographic regime around
the Florida Keys**

Villy Kourafalou

University of Miami/RSMAS

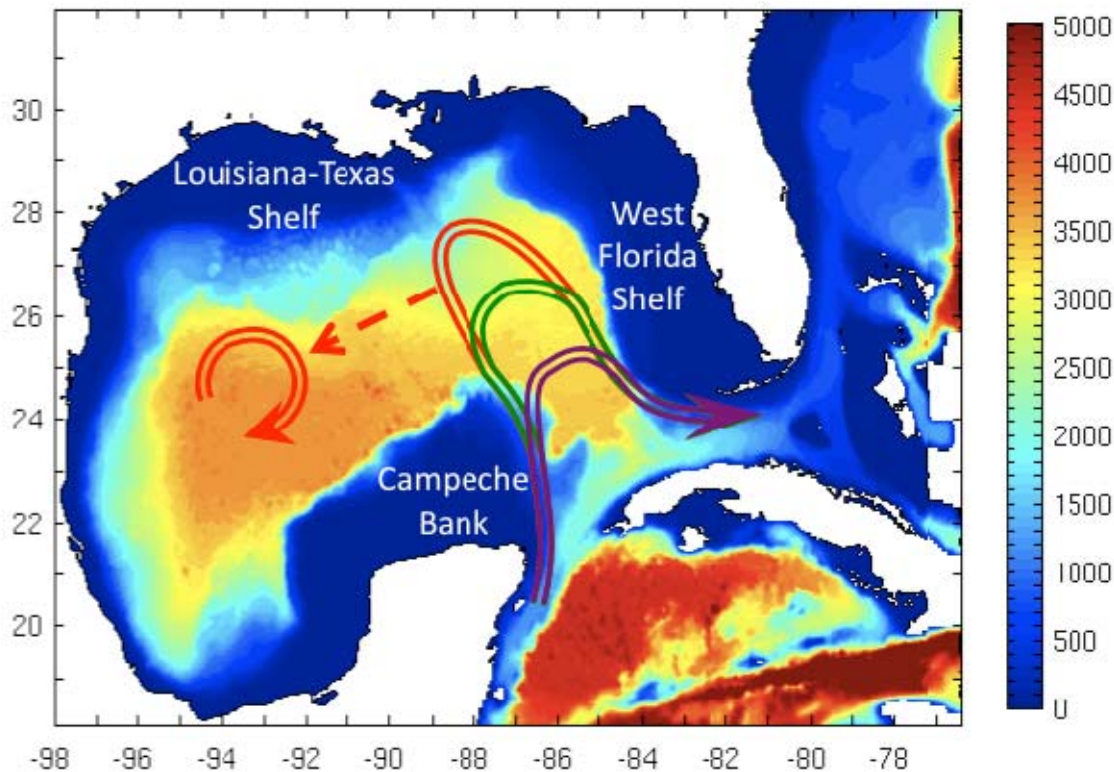


Oceanographic connectivity around the Florida Keys



http://oceancurrents.rsmas.miami.edu/atlantic/loop-current_2.html

Regional processes: Loop Current extension/growth



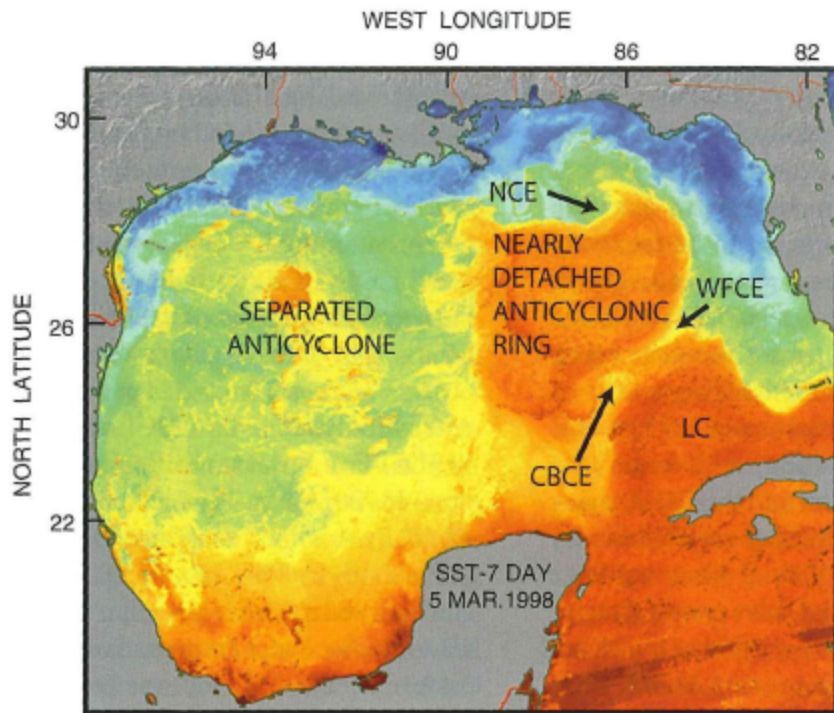
Le Hénaff et al., (2010)

➤ Controlled by
“Loop Current Eddy”
formation/detachment

(“ring” separation and
westward propagation
under β effect)

Hurlburt and Thompson (1980,1982)
Pichevin and Nof (1997)
Nof and Pichevin (2001)
Nof (2005)
Oey (2005)
...

Regional processes: Loop Current Frontal Eddies



Satellite SST 7-day composite 3/1998

Schmitz (2005)



Vukovich and Maul (1985)
Fratantoni et al. (1998)
Zavala-Hidalgo et al. (2003)
Chérubin et al. (2006)
Hyun and Hogan (2008)

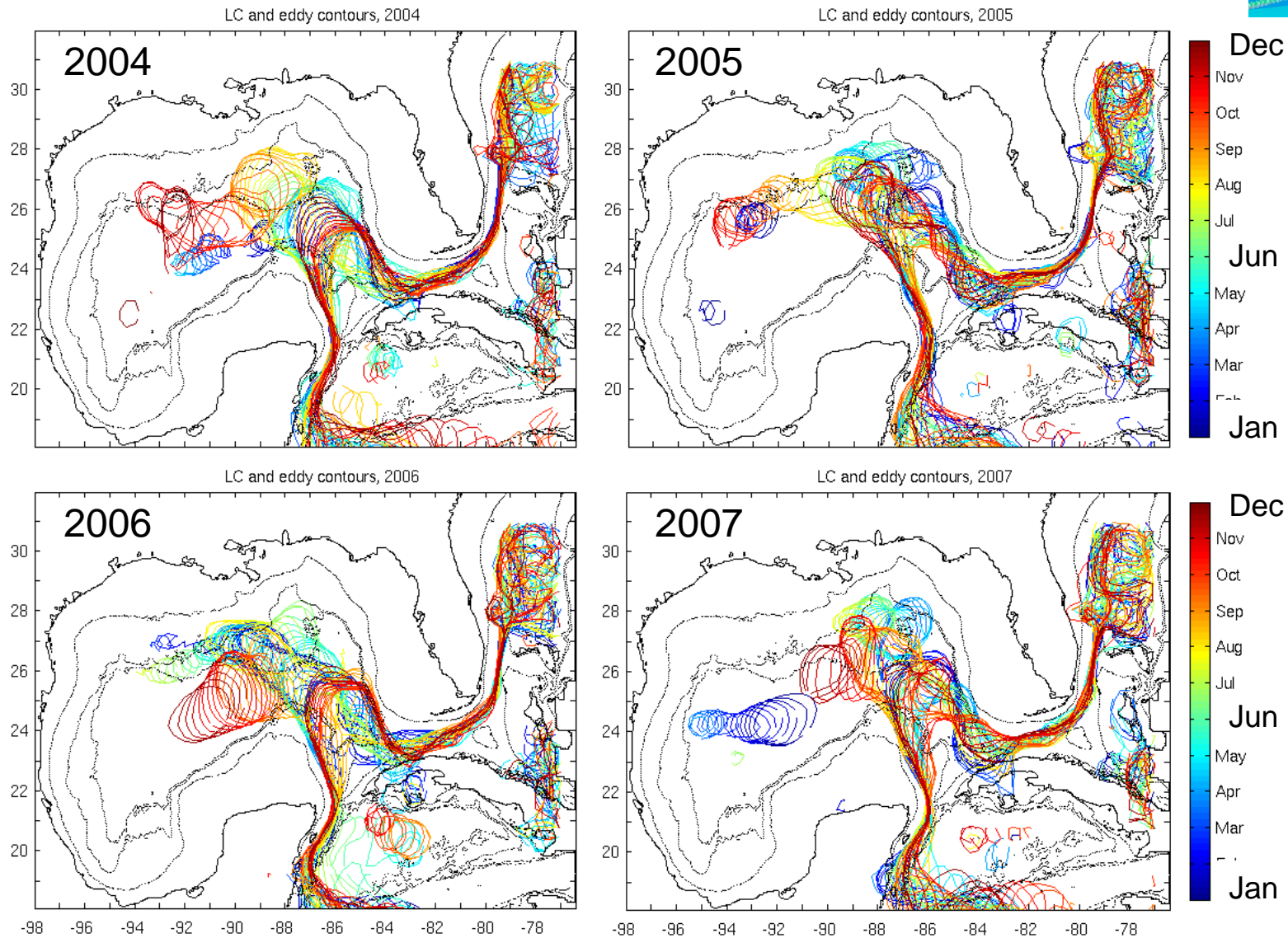
...

➤ LC ring separation statistics from altimetry:
peaks at 6, 9 and 11.5 months

Sturges and Leben (2000)
Leben (2005)

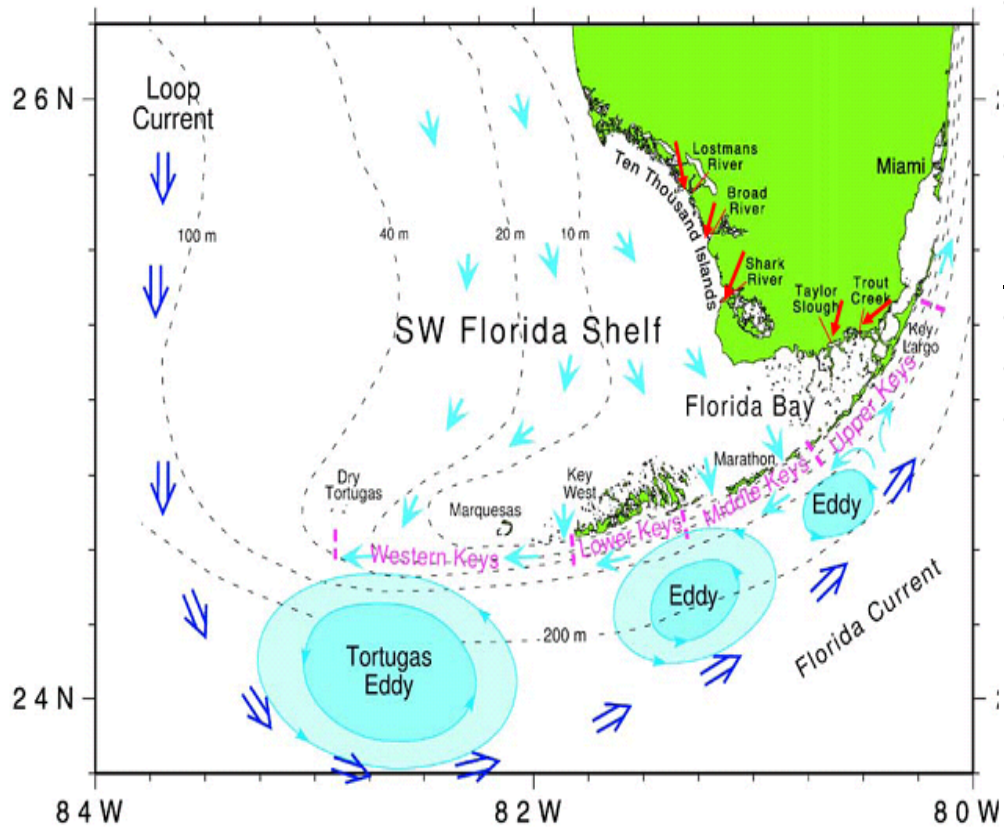
➤ Connectivity implications

Strong variability in the observed LC tracks: direct link to connectivity variability



AVISO weekly Maps of Absolute Dynamic Topography (MADT) *Le Hénaff et al., (2010)*
MADT = mean SSH from *in situ* measurements + Sea Level Anomaly from satellite observations, *Rio and Hernandez (2004)*

“Local” processes: Circulation around the Florida Keys



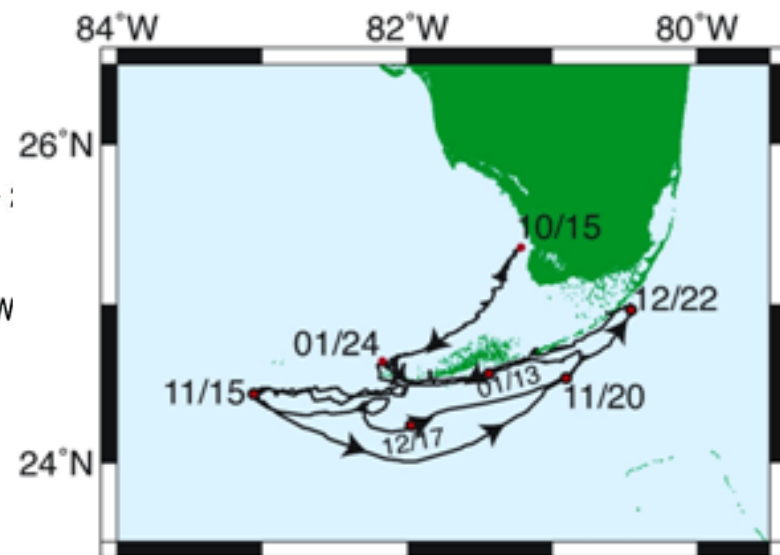
Adapted from Lee et al. (2002)

COMPLEX TOPOGRAPHY

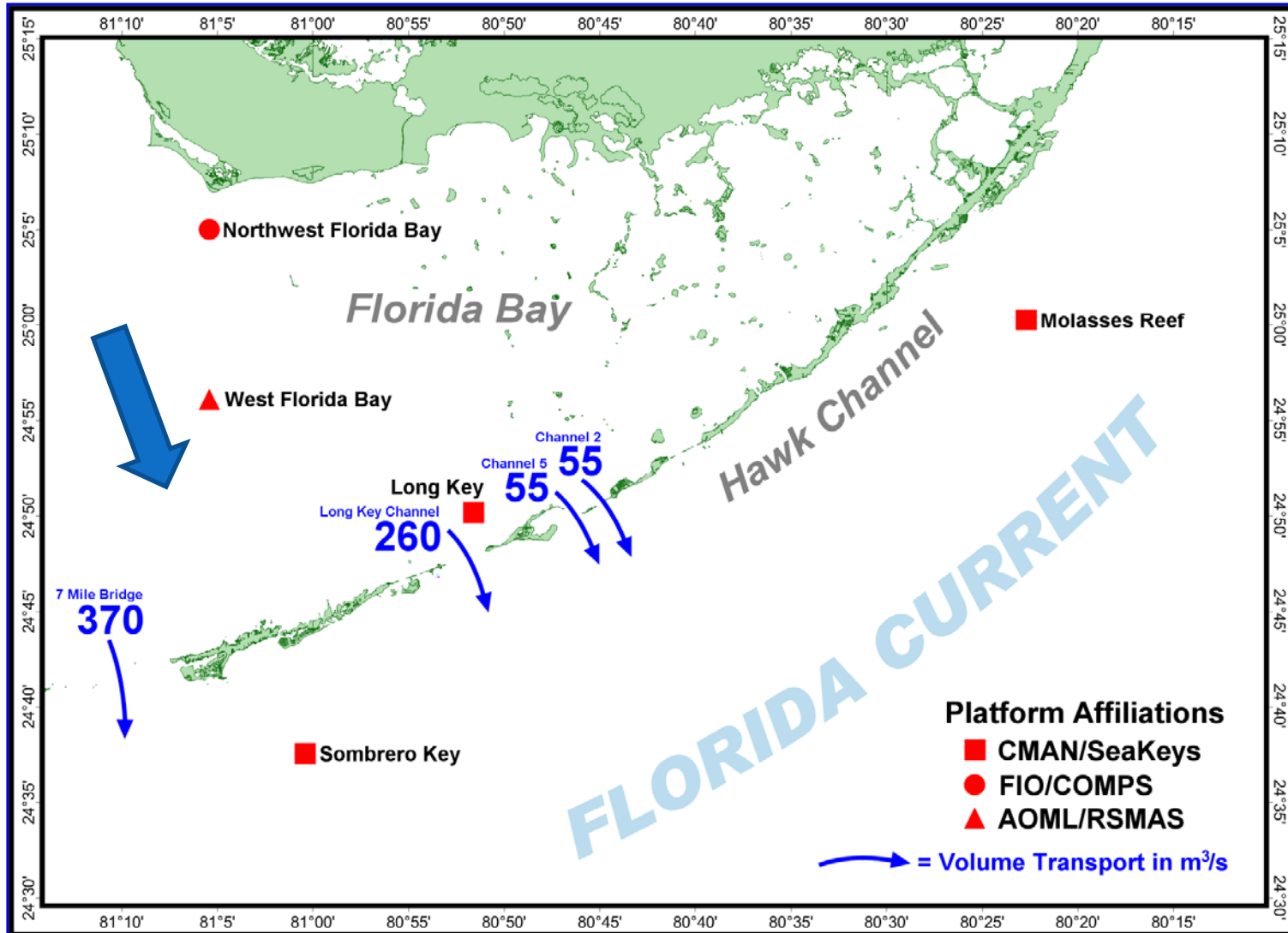
- Broad SW Florida shelf
- Narrow Atlantic Florida Keys shelf
- Shallow Florida Bay
- Deep Straits of Florida

COMPLEX DYNAMICS

- Wind-driven shelf flows
- Buoyancy-driven shelf flows (river runoffs)
- Intense coastal to offshore interactions (Loop Current / Florida Current front and eddies)

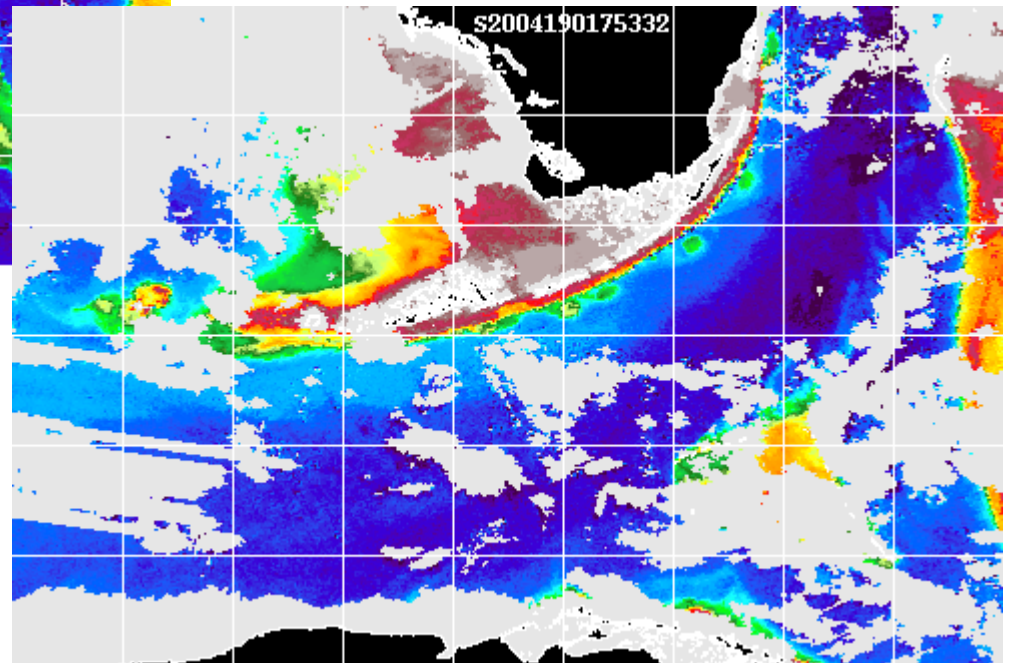
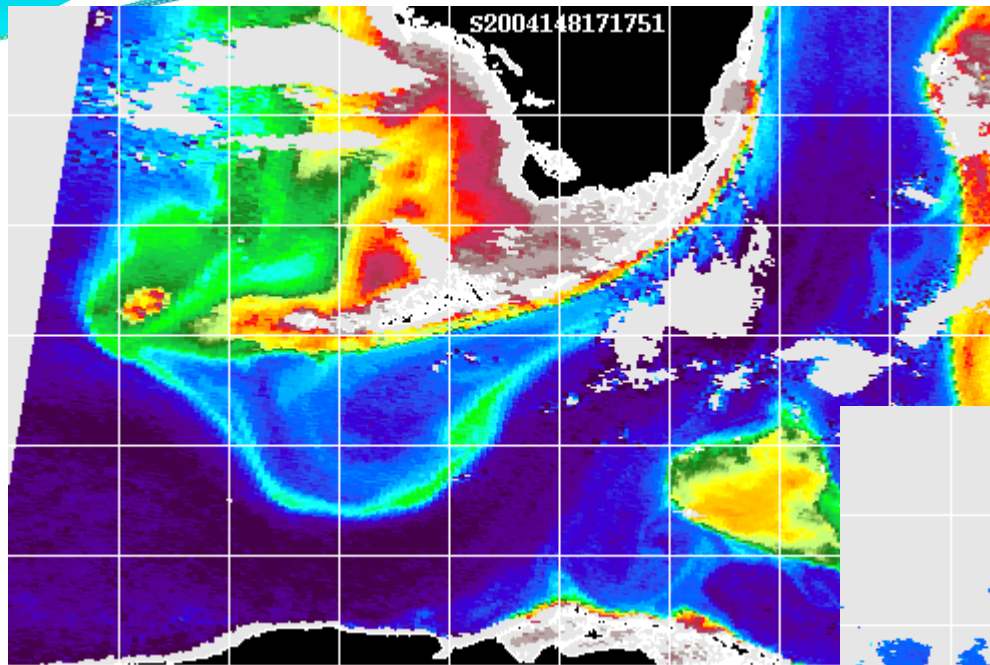


“Local” processes: Connectivity between the SW Florida Shelf, Florida Bay and the Florida Keys



Provided by T. Lee

Mesoscale and submesoscale eddies along the Florida Keys



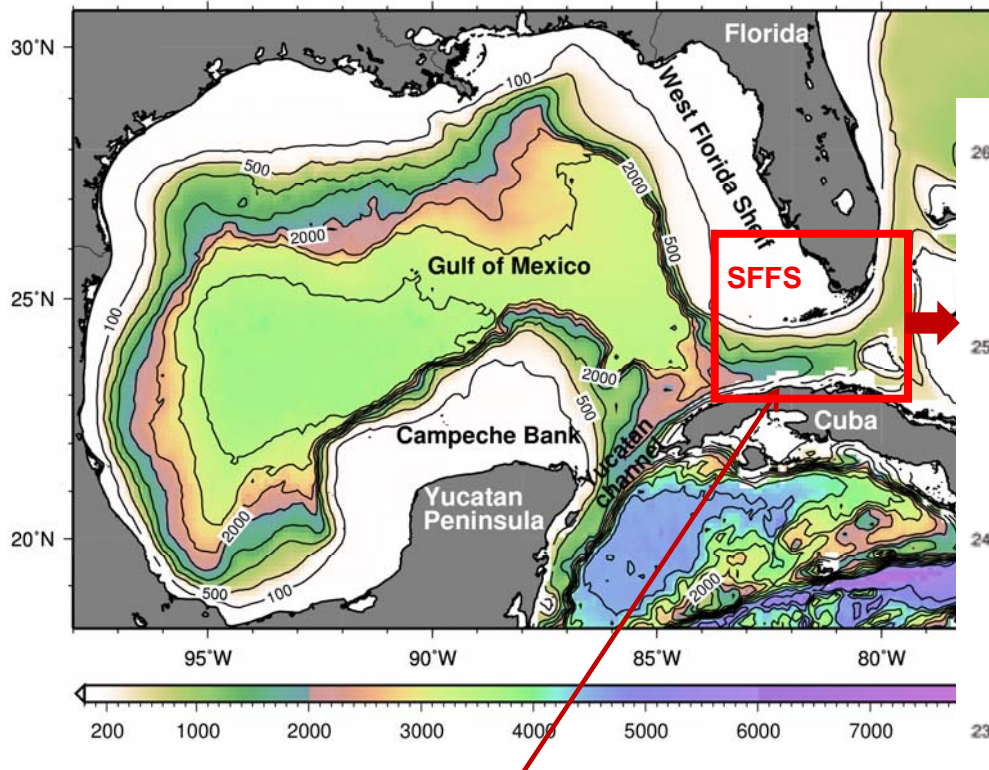
Provided by C. Hu (USF/IMARS)



Gulf of Mexico and South Florida numerical models

<http://coastalmodeling.rsmas.miami.edu>

➤ Prediction as a management tool

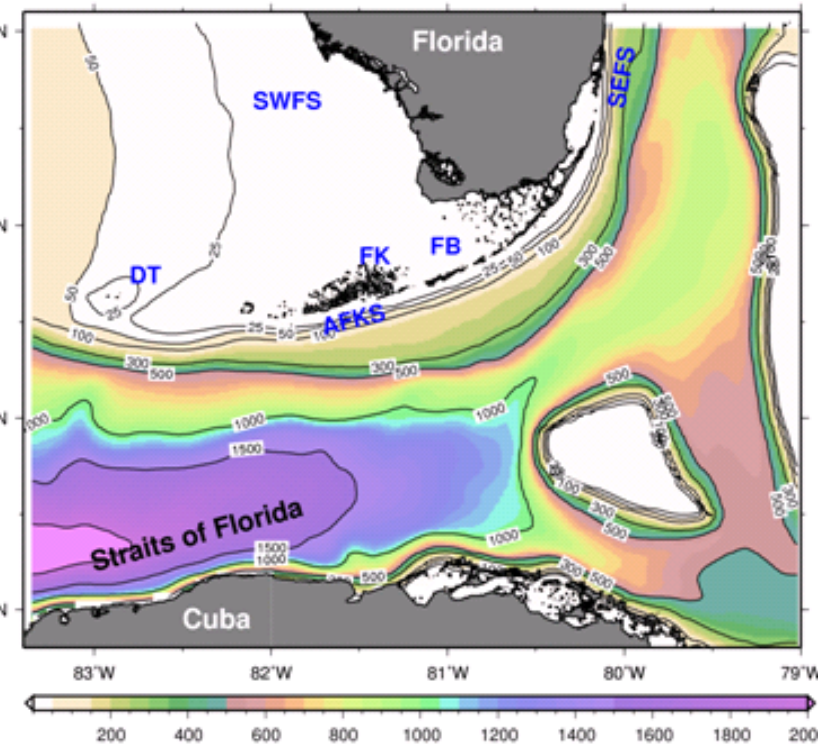


**NESTED HIGH RESOLUTION MODEL
(now giving predictions in Real Time)**

*GoM-HYCOM 3.5 km simulations provided by
P. Hogan and Ole-Martin Smedstad, NRL-SSC*

**GULF OF MEXICO (GoM)
HYCOM**

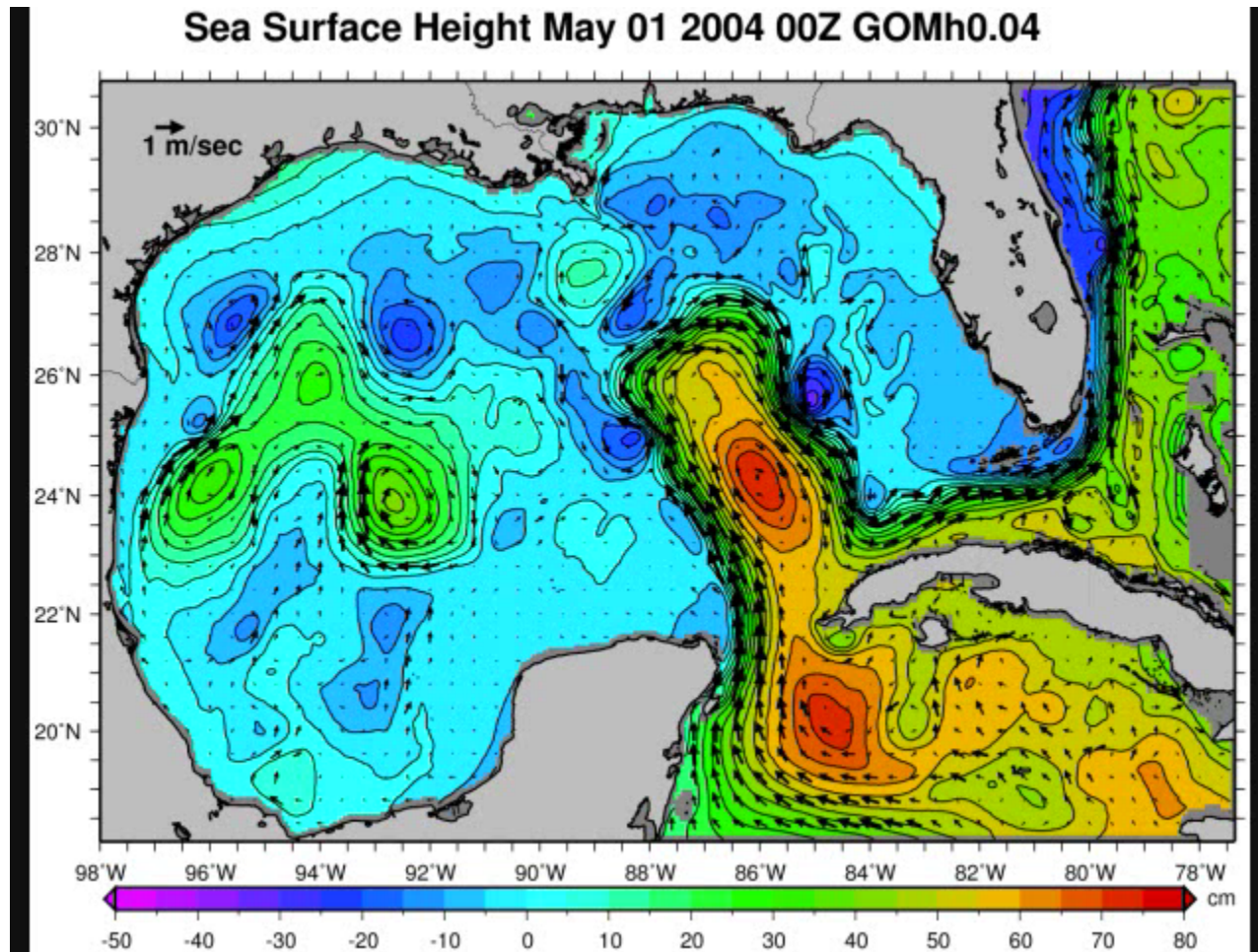
Resolution ~ 1.8 km



**SOUTH FLORIDA and FLORIDA
STRAITS - HYCOM (SFFS)**

Resolution ~ 900 m

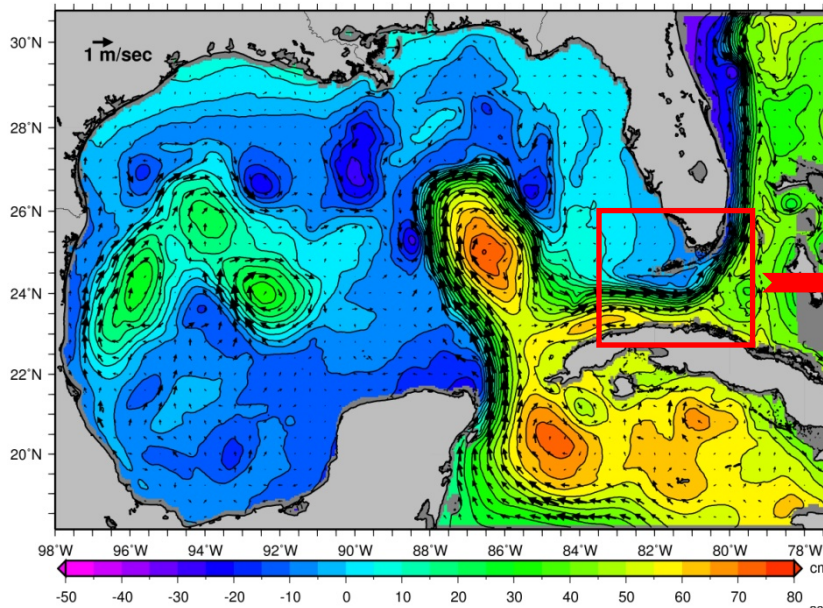
Model animation of Sea Surface Height and Currents in the Gulf of Mexico



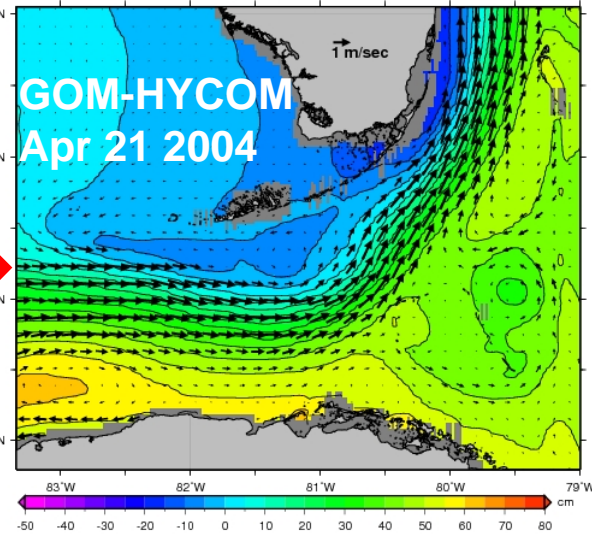
➤ *Ring separation in late August*

Influence of eddies on FC meandering (which happens first?)

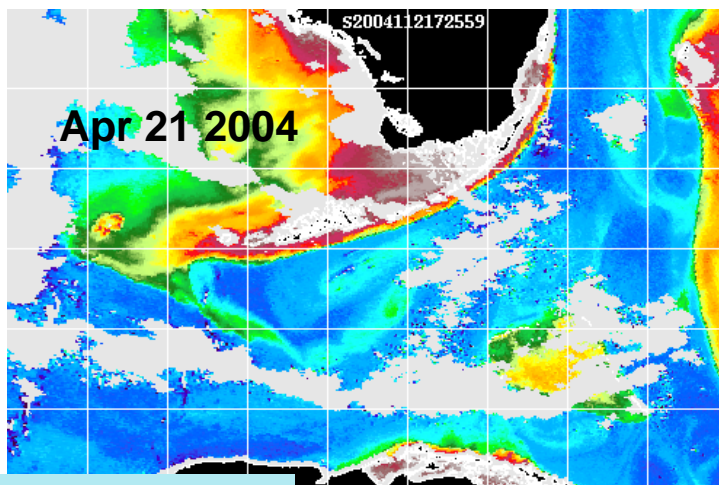
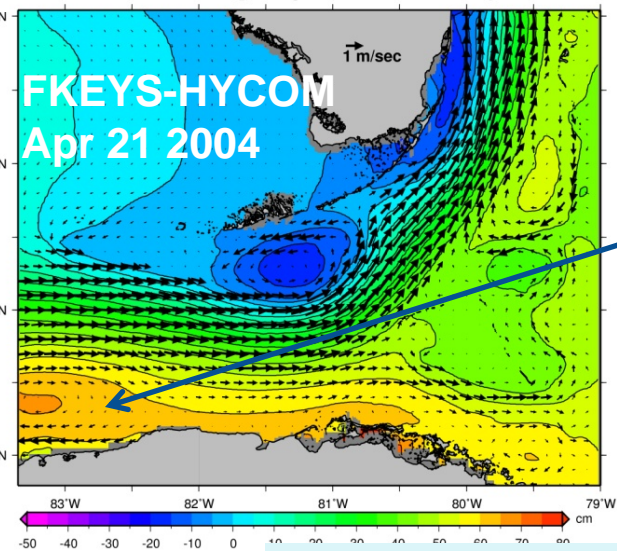
Sea Surface Height Apr 21 2004 00Z GOMh0.04



Sea Surface Height Apr 21 2004 00Z GOMh0.04



Sea Surface Height Apr 21 2004 00Z Keyb0.01



(provided by C. Hu, USF)

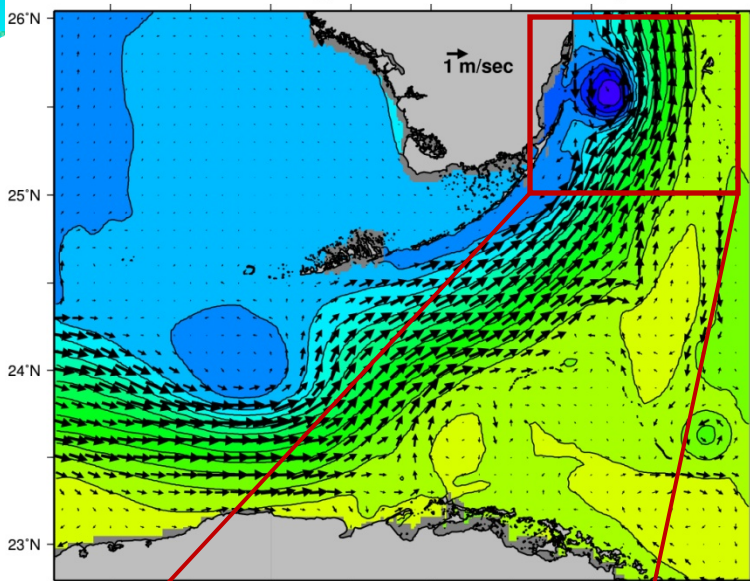
Kourafalou and Kang (2010)

Evolution of eddies along the Florida Keys

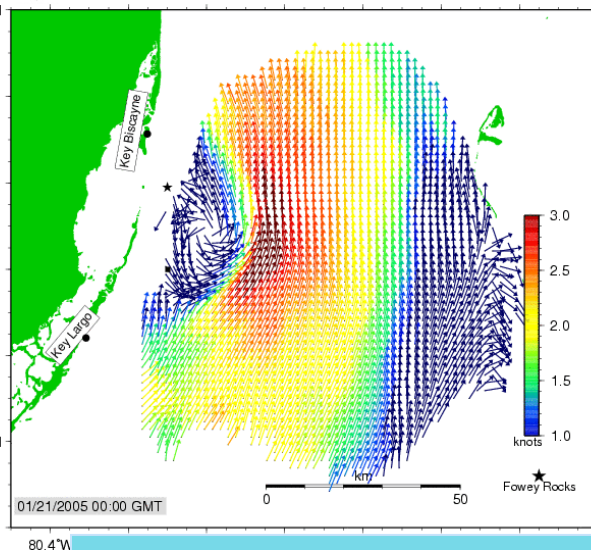
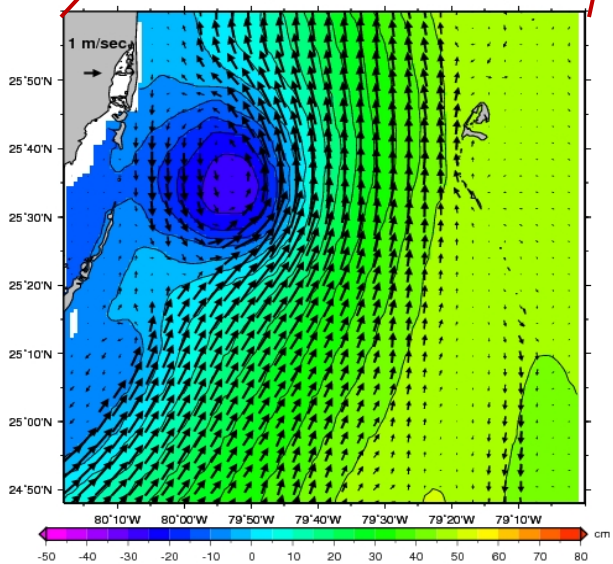
➤ Synergy with the Florida Current meandering

Jan 21, 2005

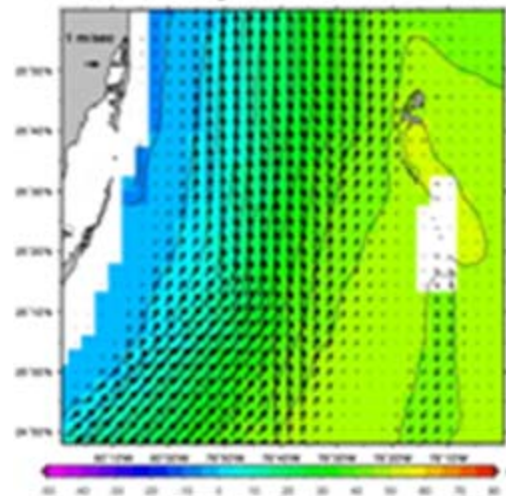
Sea Surface Height Jan 21 2005 00Z Keyb0.01



Sea Surface Height Jan 21 2005 00Z Keyb0.01



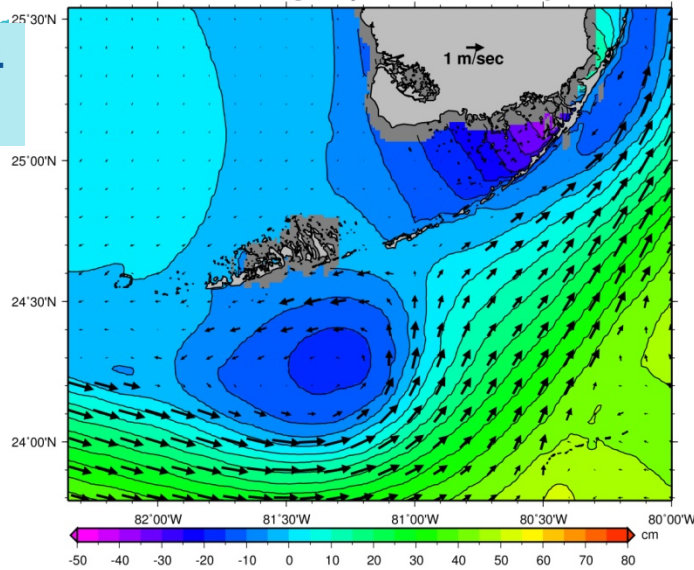
Sea Surface Height Jan 21 2005 00Z GOMh0.04



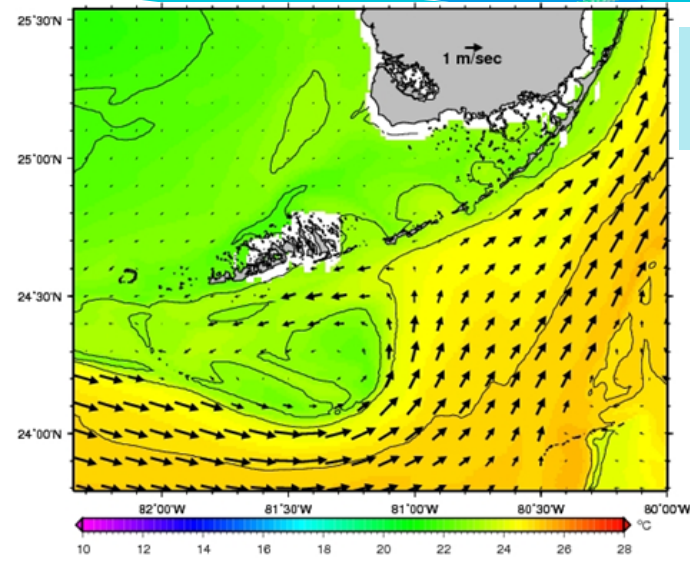
High Frequency Radar WERA data (N. Shay, RSMAS):
<http://iwave.rsmas.miami.edu/wera/>

Influence of eddies on upwelling along the Keys

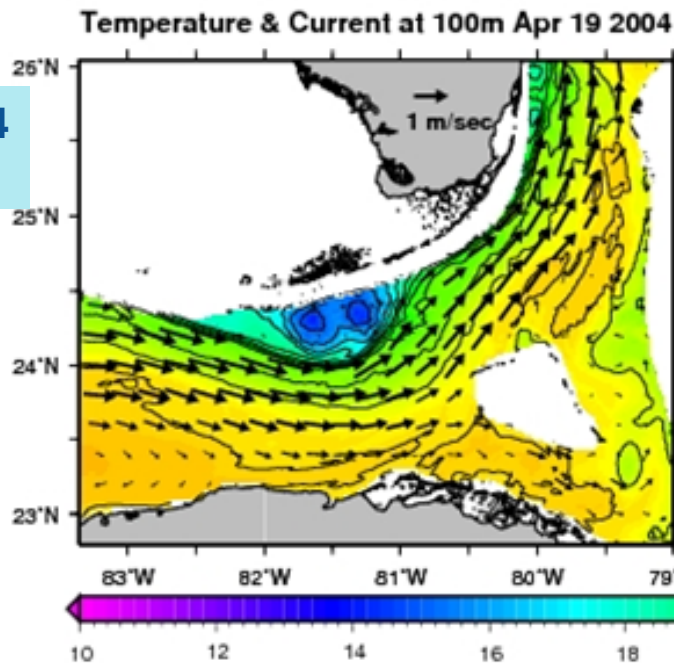
Apr 21 2004
SSH



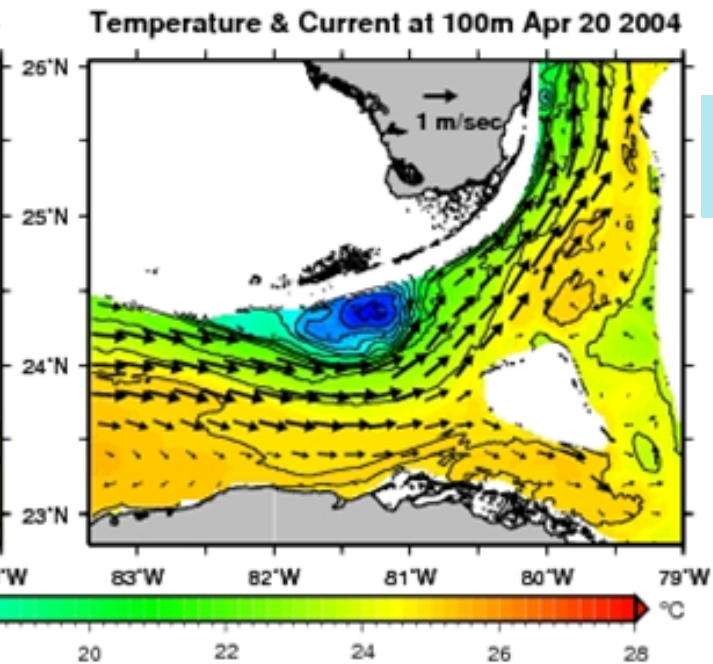
Apr 21 2004
SST



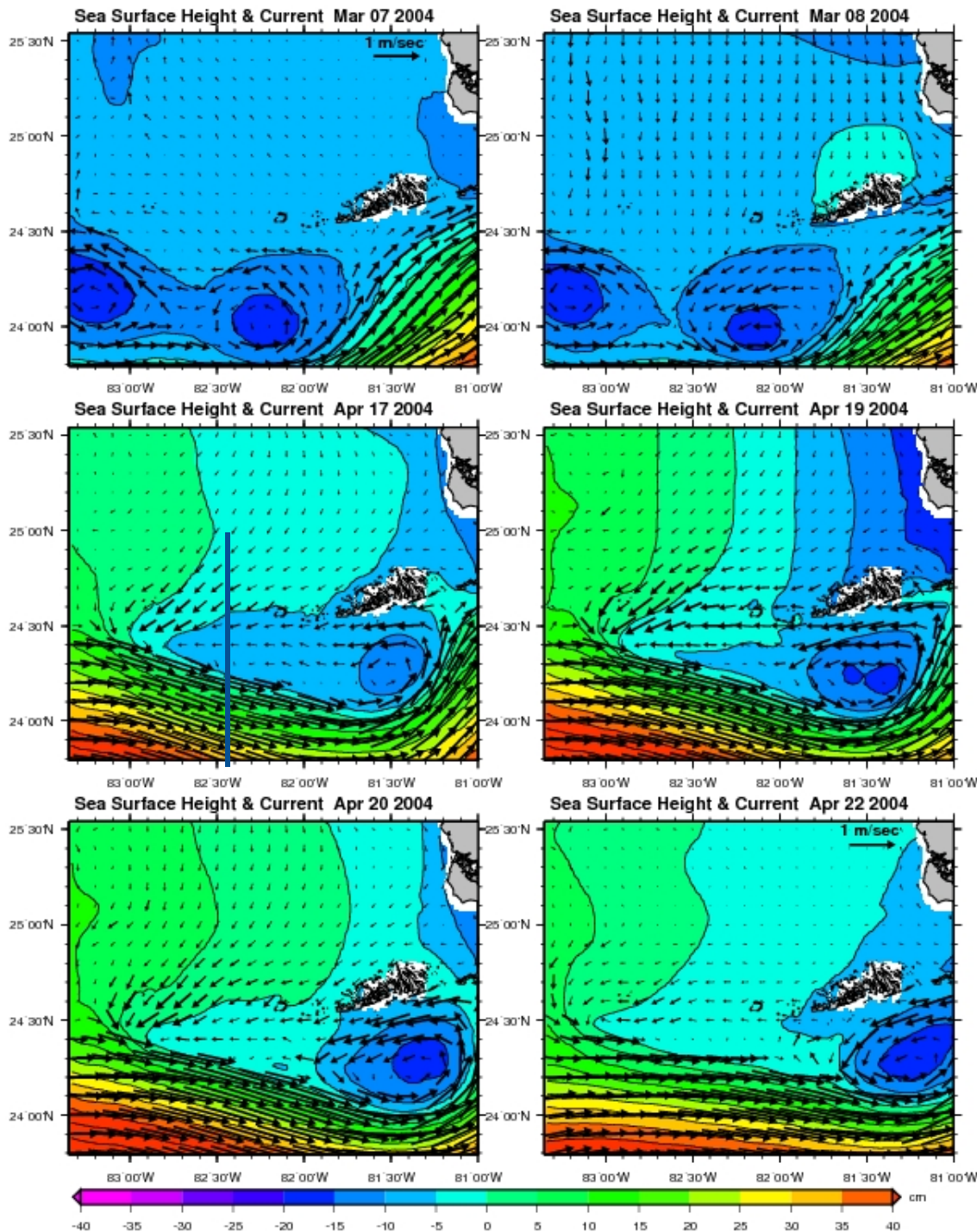
Apr 19 2004
T,V 175m



Apr 20 2004
T,V 175m



Kourafalou and Kang (2010)



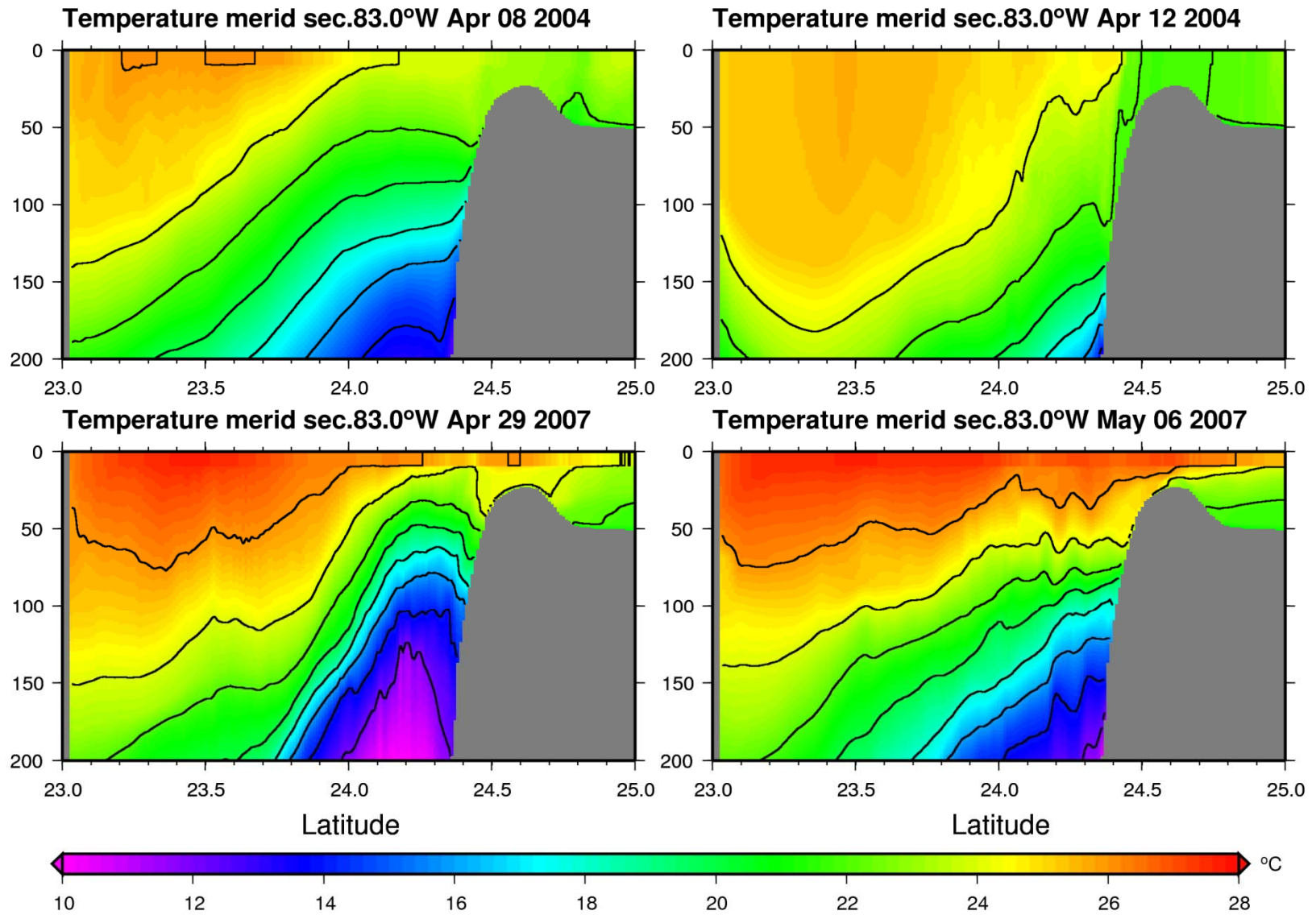
➤ **New findings:**

Merging/splitting of eddies along the Keys

➤ Implications on connectivity between the Keys and upstream sources of larvae, nutrients, pollutants...

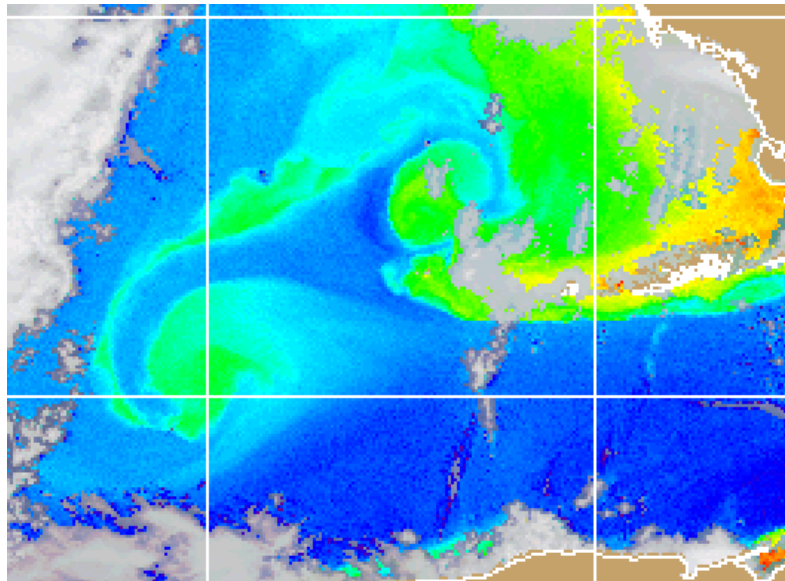
Kourafalou and Kang (2010)

Influence of Florida Current on upwelling along the Keys

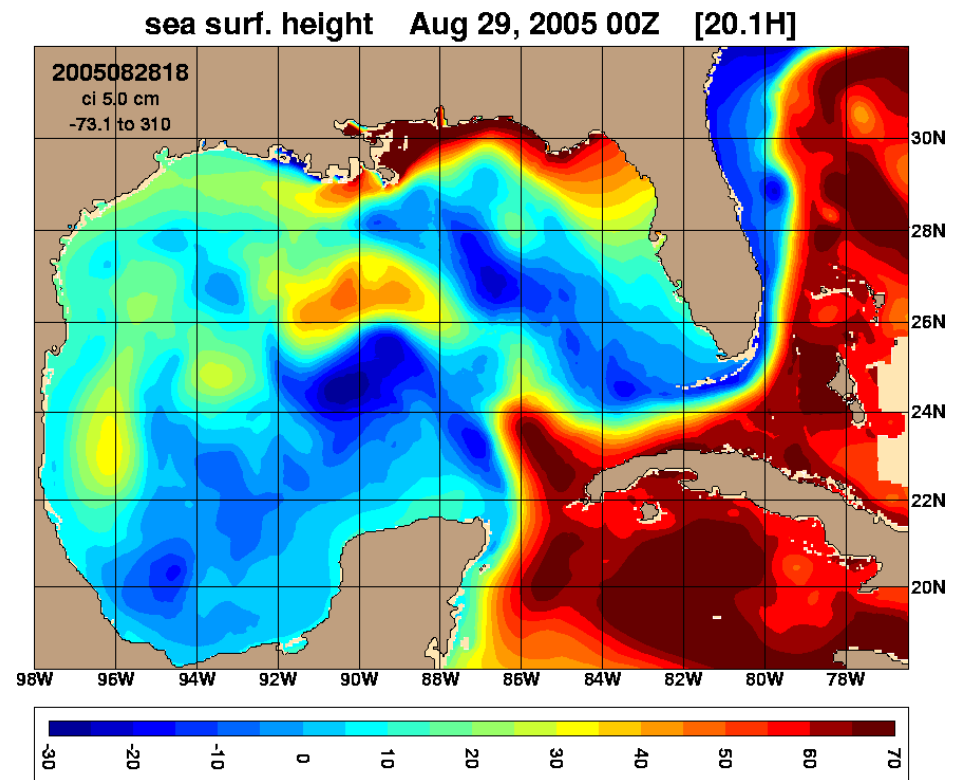


Kourafalou and Kang (2010)

Hurricane effects: enhanced interaction of shelf and offshore flows



NOAA HAB bulletin (08/30/2005)

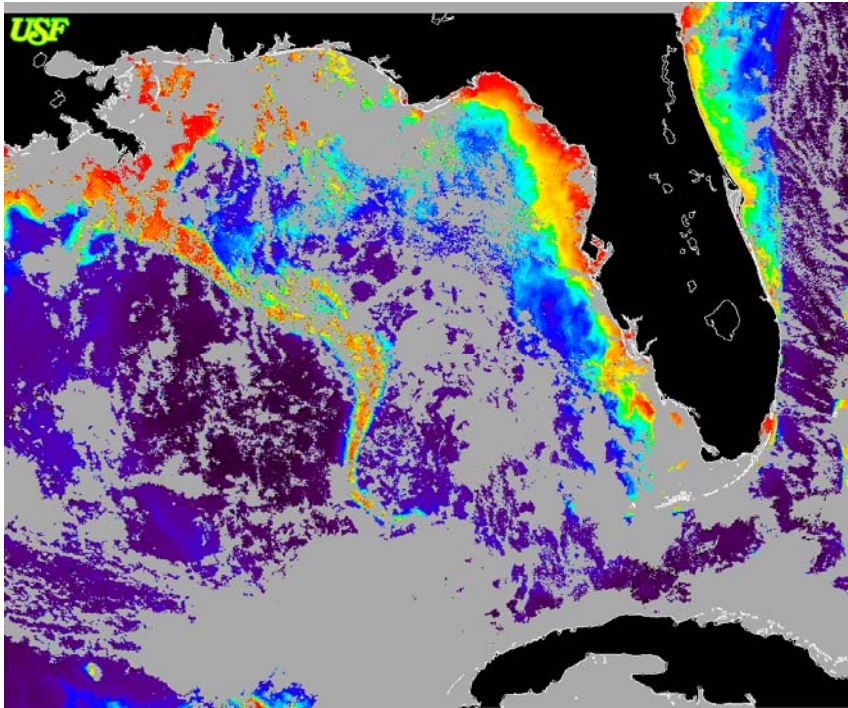


Hurricane Katrina

➤ Offshore advection of high chlorophyll waters from the SW Florida shelf and entrainment in Tortugas eddy

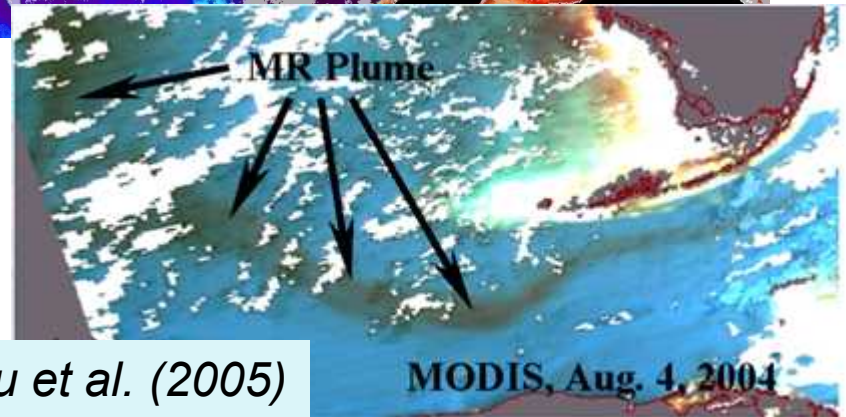
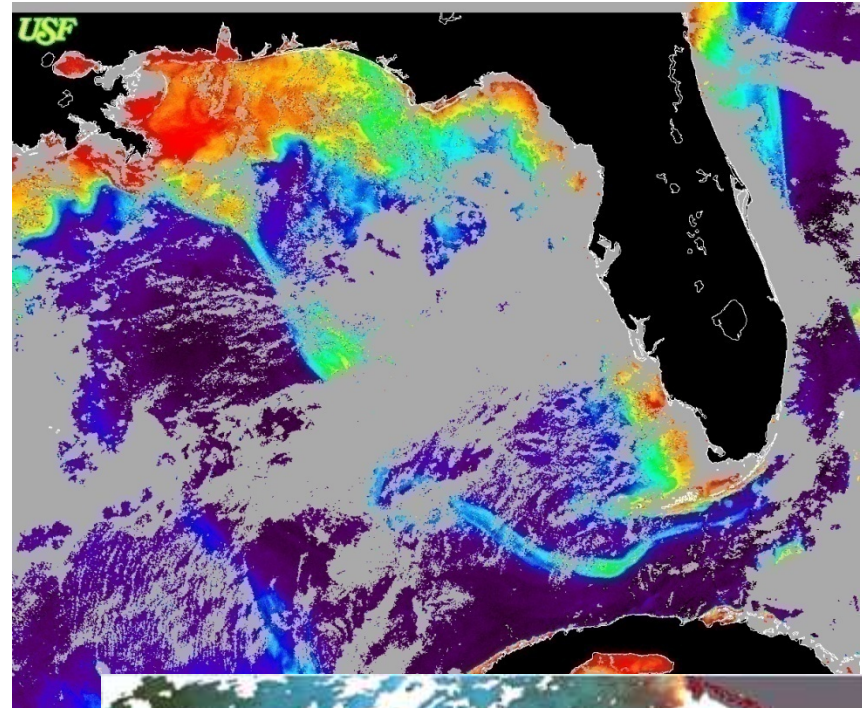
Remote effects: Mississippi waters reaching the Florida Keys

07/30/2004



SeaWiFS chl-a images

08/04/2004

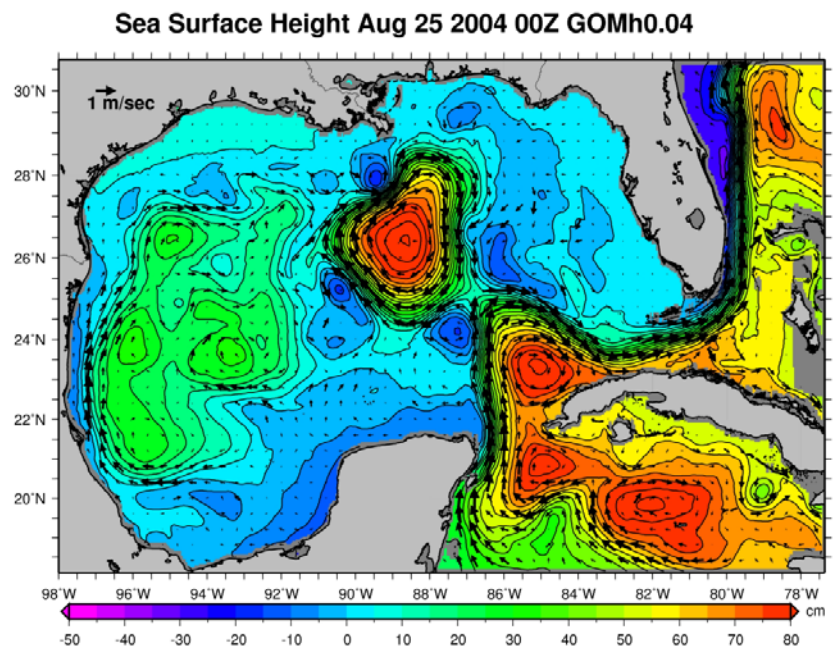
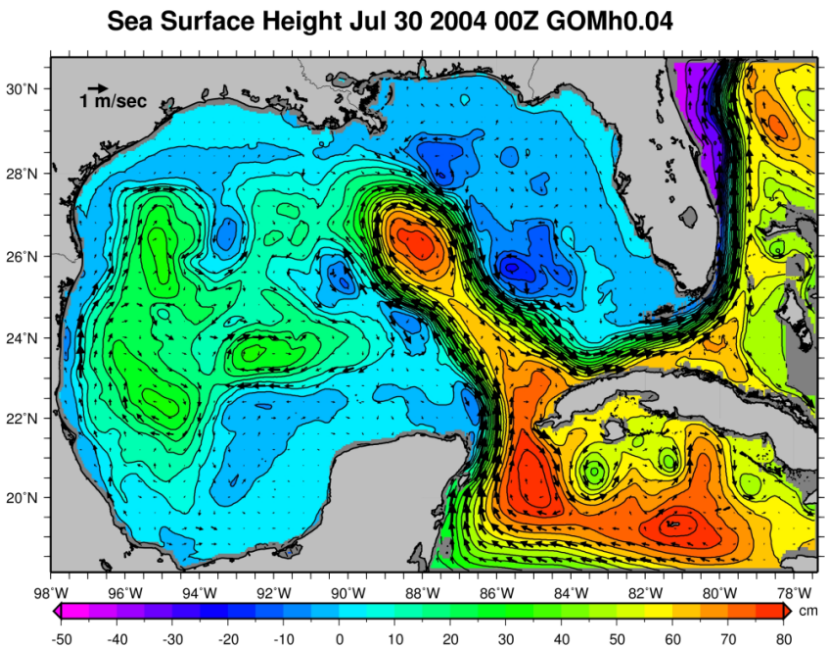
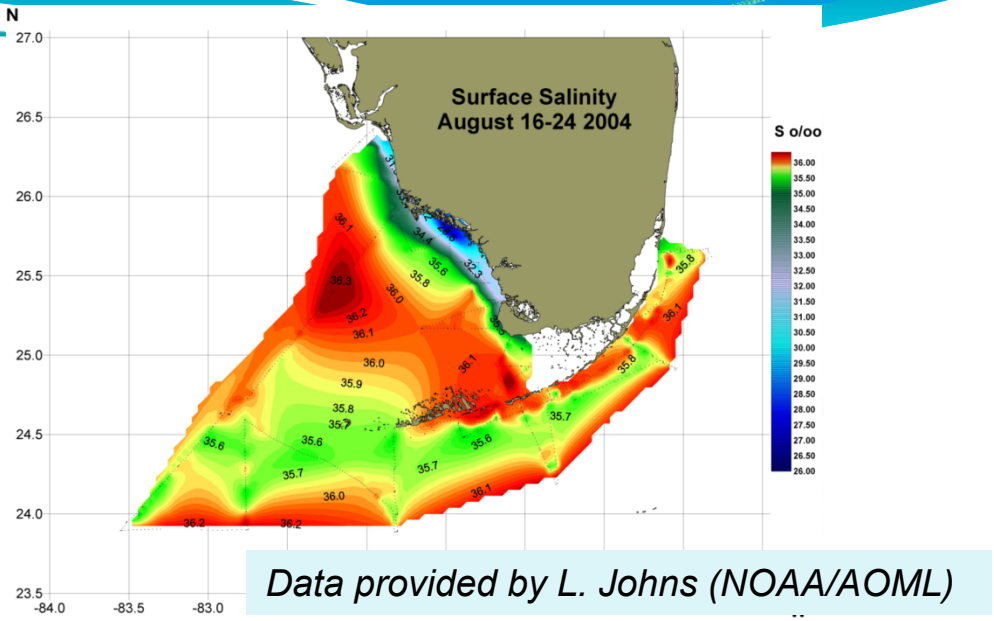
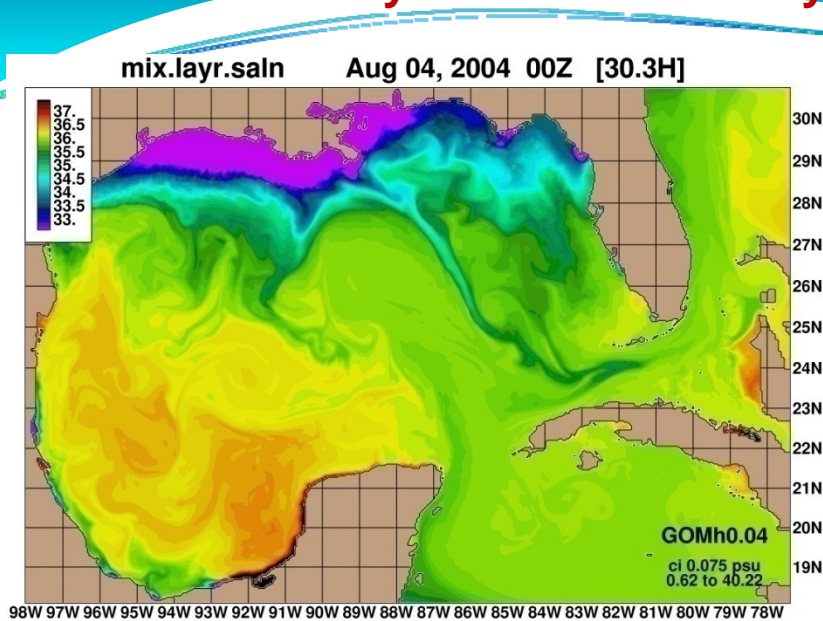


Hu et al. (2005)

MODIS, Aug. 4, 2004

First documented event: Aug-Sep 1993 (Ortner et al., 1995)

Connectivity of the Florida Keys to the Northern Gulf shelf: evidence

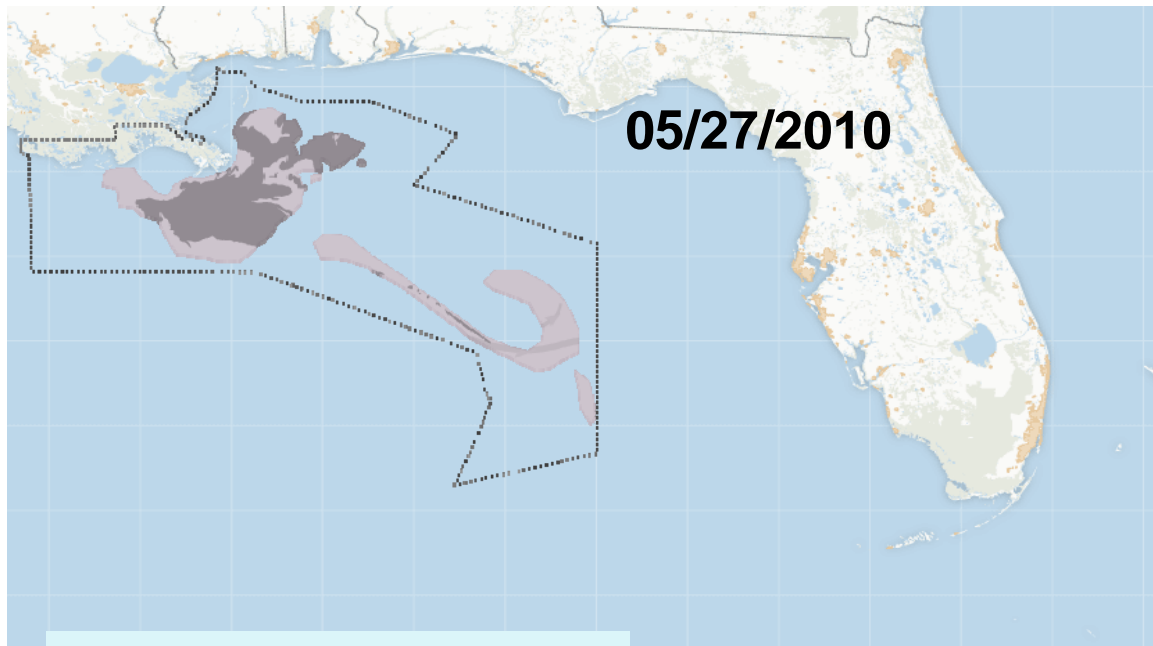


Connectivity of the Florida Keys to the Northern Gulf: the Deepwater Horizon oil spill

➤ A challenge of historical proportions for the management of the Florida Keys

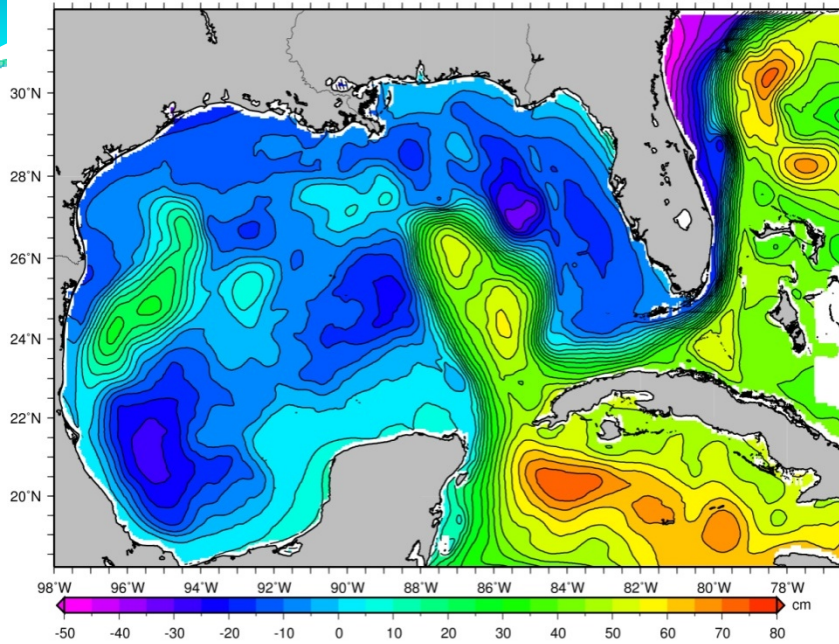


➤ Accurate predictions of oil pathways:
need an **integrated, real time
regional modeling and observing system**

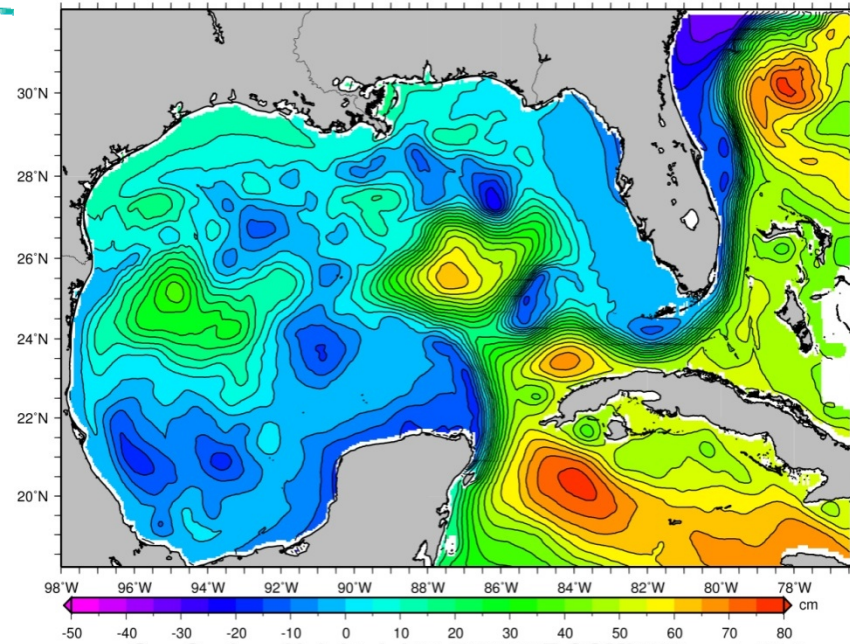


Source: the New York Times

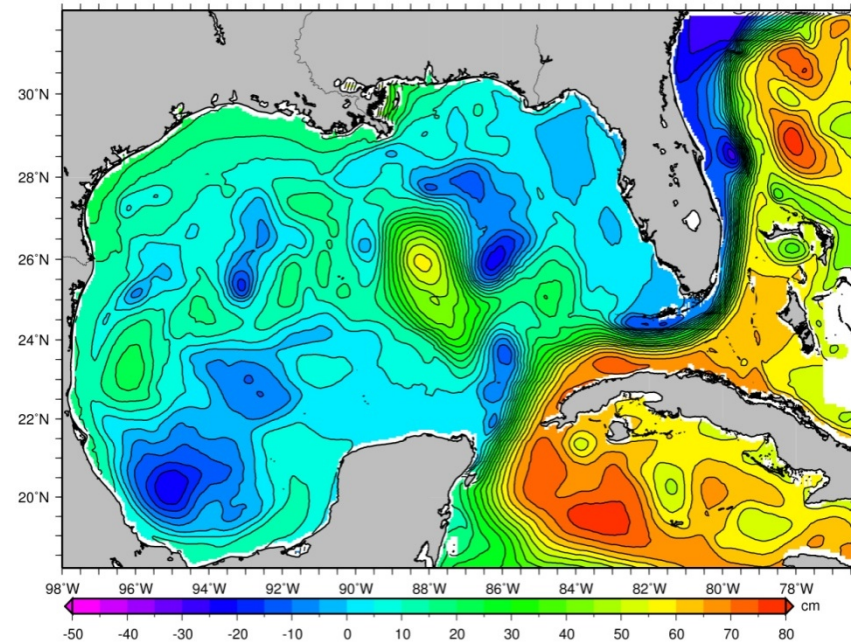
Sea Surface Height Apr 26 2010 00Z GOMI0.04 expt_20.1



Sea Surface Height May 26 2010 00Z GOMI0.04 expt_20.1



Sea Surface Height Jul 04 2010 00Z GOMI0.04 expt_20.1



➤ The influence of the DH oil spill on South Florida

was controlled by:

the evolution of the GoM eddy field, especially the detachment of the **Loop Current Eddy Franklin**

■ Main points

- The circulation around the Florida Keys is controlled by **local and regional forcing mechanisms**.
- The narrow Atlantic Florida Keys shelf is **wind and tidally driven**, while waters of Southwest Florida Shelf and Florida Bay origin enter through the Keys passages. Shelf break processes are dominated by **exchanges with offshore waters** coming to the Florida Straits from the Gulf of Mexico and the Wider Caribbean.
- The **variability of the Loop Current/Florida Current system** is a major factor in the characteristics of the oceanographic regime around the Florida Keys and the connectivity to upstream ecosystems (*examples: Mississippi River plume waters; 2010 Deepwater Horizon oil spill accident*)
- **Cyclonic eddies** between the Florida Current and the Florida Keys island chain (extending to the Dry Tortugas) are of primary importance, entering at diameter sizes of ~ 100 km and elongating downstream, influenced by the topography, possibly colliding with other eddies and/or breaking into smaller eddy cells (~a few km to tens of km) – there is a **synergy between eddy evolution and Florida Current meandering**
- **Management** of the socioeconomically important, environmentally fragile ecosystems extending along the Florida Keys and the Dry Tortugas requires **the understanding of both local and regional circulation driving mechanisms and their variability**.

Thank you!

