

Physical Connectivity between Pulley Ridge and the Florida Keys

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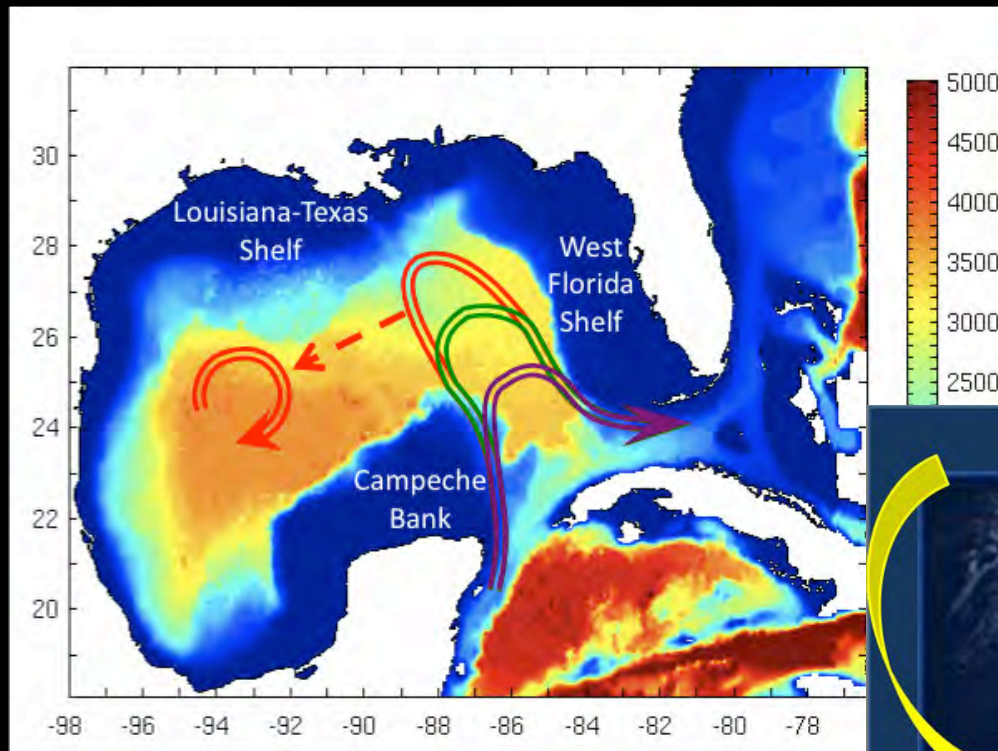
HeeSook Kang, Yannis Androulidakis
(*Univ. of Miami/RSMAS*)

Matthieu Le Hénaff (*Univ. of Miami/CIMAS*)

George Halliwell, Ryan Smith
(*NOAA/AOML*)

Arnoldo Valle-Levinson
(*Univ. of Florida*)

Gulf of Mexico: the Loop Current / Florida Current system

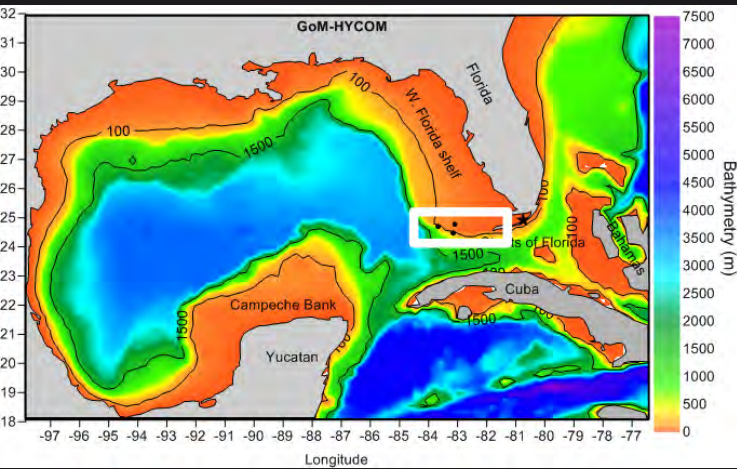


Le Hénaff et al., 2012

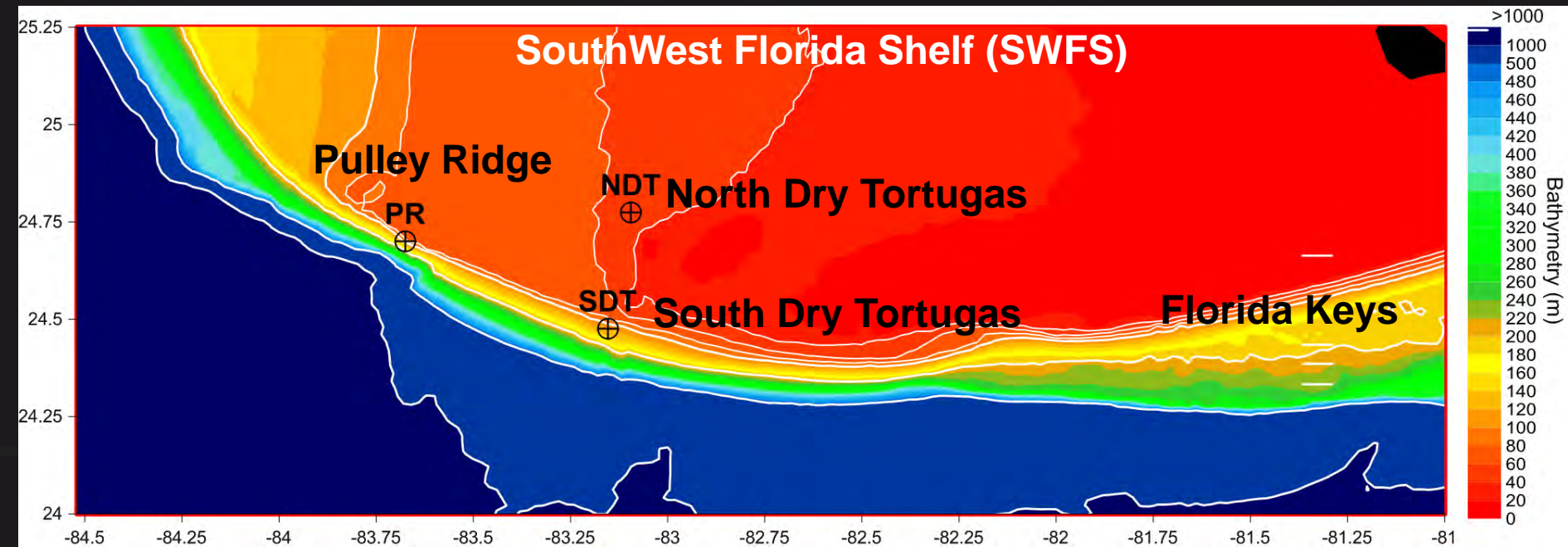
Kourafalou et al., 2017



South Florida coral reefs



- Pulley Ridge (PR): ~60-90, mesophotic
- Dry Tortugas (DT): ~20-50m, deep patch and fringing reefs (North DT and South DT)
- Florida Keys: <~20 m (shallow reefs)



OBJECTIVES

➤ Describe and quantify:

- The **physical connectivity** pathways between Pulley Ridge, Dry Tortugas and Florida Keys

➤ Determine the impact of:

- The **Loop Current** on the area surrounding Pulley Ridge reefs
- The **Florida Current** on the area surrounding Dry Tortugas and Florida Keys reefs
- **Cyclonic Eddies** on the Loop/Florida Current system & how that influences physical connectivity among South Florida reefs
- **Circulation** on the shelf (eg. currents driven by winds)
- **Remote influences** on water quality around reefs

METHODS

Field Observations (*multi-platform*)

- Currents and Temperature (3 Moorings)
- Altimetry and sea surface temperature (Satellite)
- Currents (Deep and surface drifters)

Models (*high resolution, ie. high level of detail in space/time*)

Gulf of Mexico, GoM-HYCOM ($1/50^\circ$, ~ 2 km)

Florida Keys, FKEYS-HYCOM ($1/100^\circ$, ~ 1 km)

Field observations

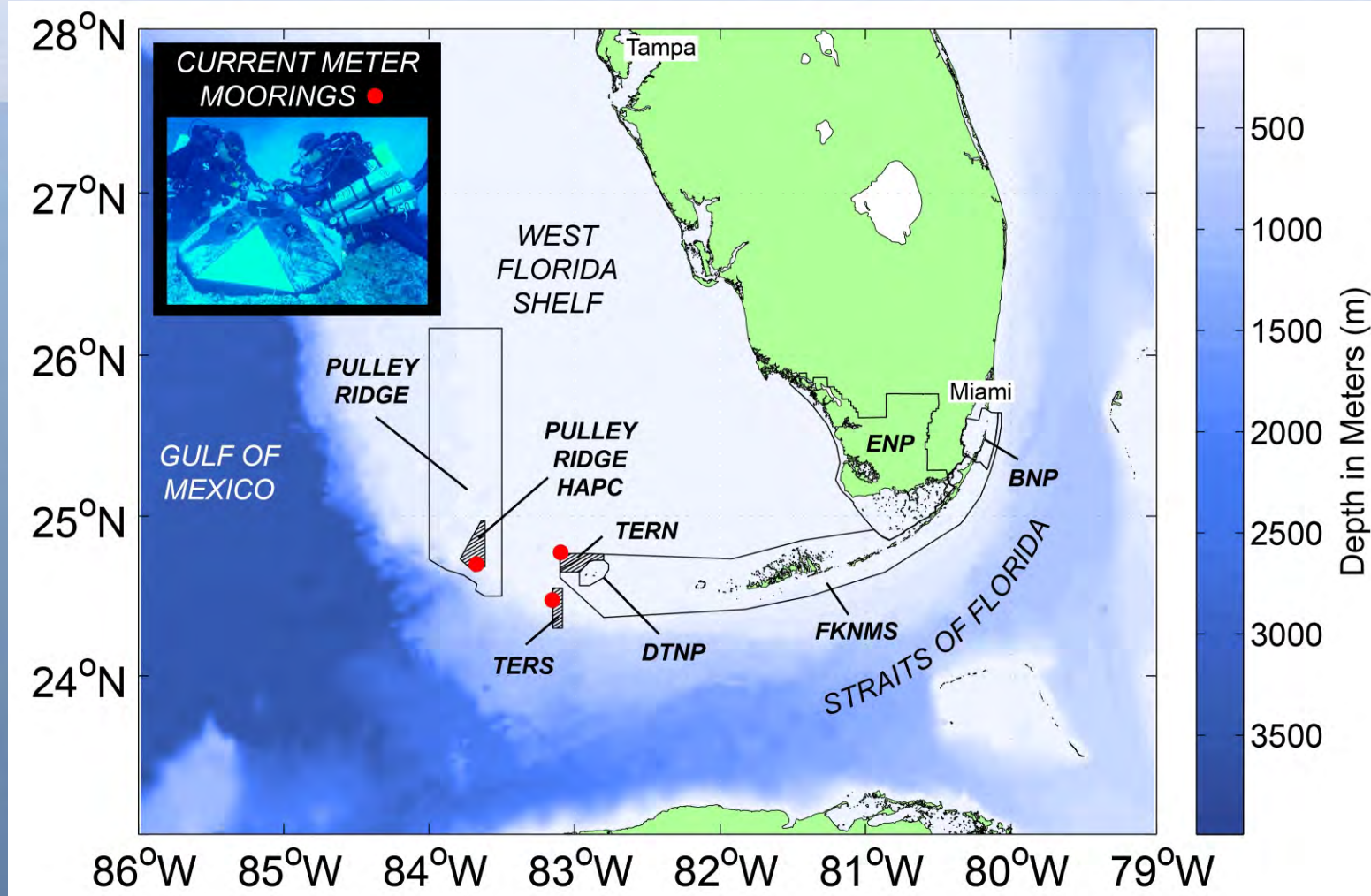
Moorings

NOAA/AOML



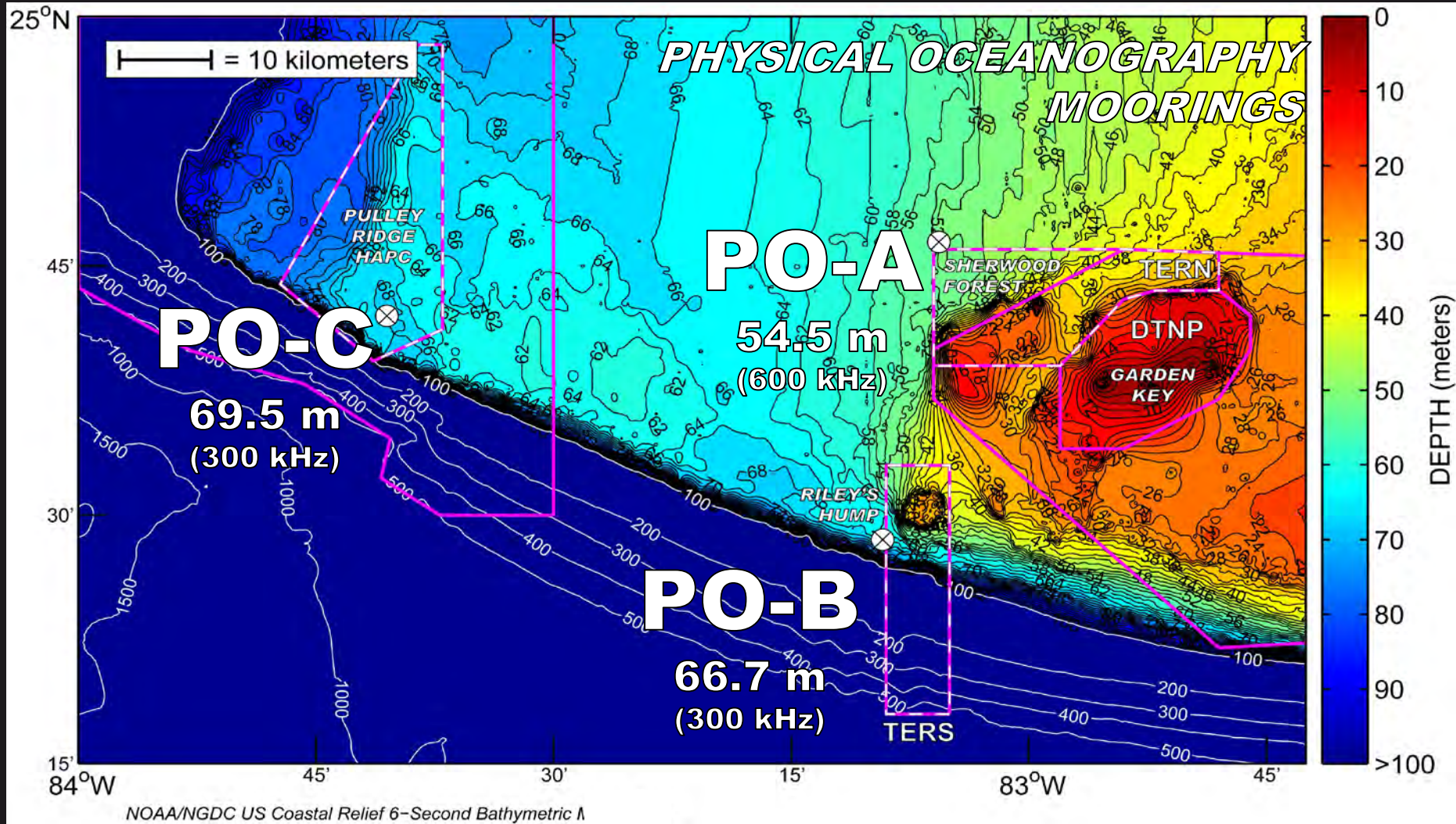
➤ Purpose:

- measure currents (*bottom-mounted acoustic Doppler current profiler or ADCP*)
 - measure temperature, salinity, and pressure (*bottom-mounted CTD*)
- (Hourly measurements)



Trawl-resistant moorings, located on the sea floor, each housed an upward-looking Acoustic Doppler Current Profiler (ADCP). Unlike mechanical current meters, ADCPs can provide a water velocity profile for the entire water column using acoustics and the Doppler effect to determine which direction the water is moving.





- PO-A = Dry Tortugas North; PO-B = Dry Tortugas South; PO-C = Pulley Ridge
- PO-A and C – Deployed Aug 2012-Jun 2015 (34 Months)
- PO-B – Deployed Mar 2013-Jun 2015 (27 Months)
- Instruments switched out annually for downloading and equipment maintenance

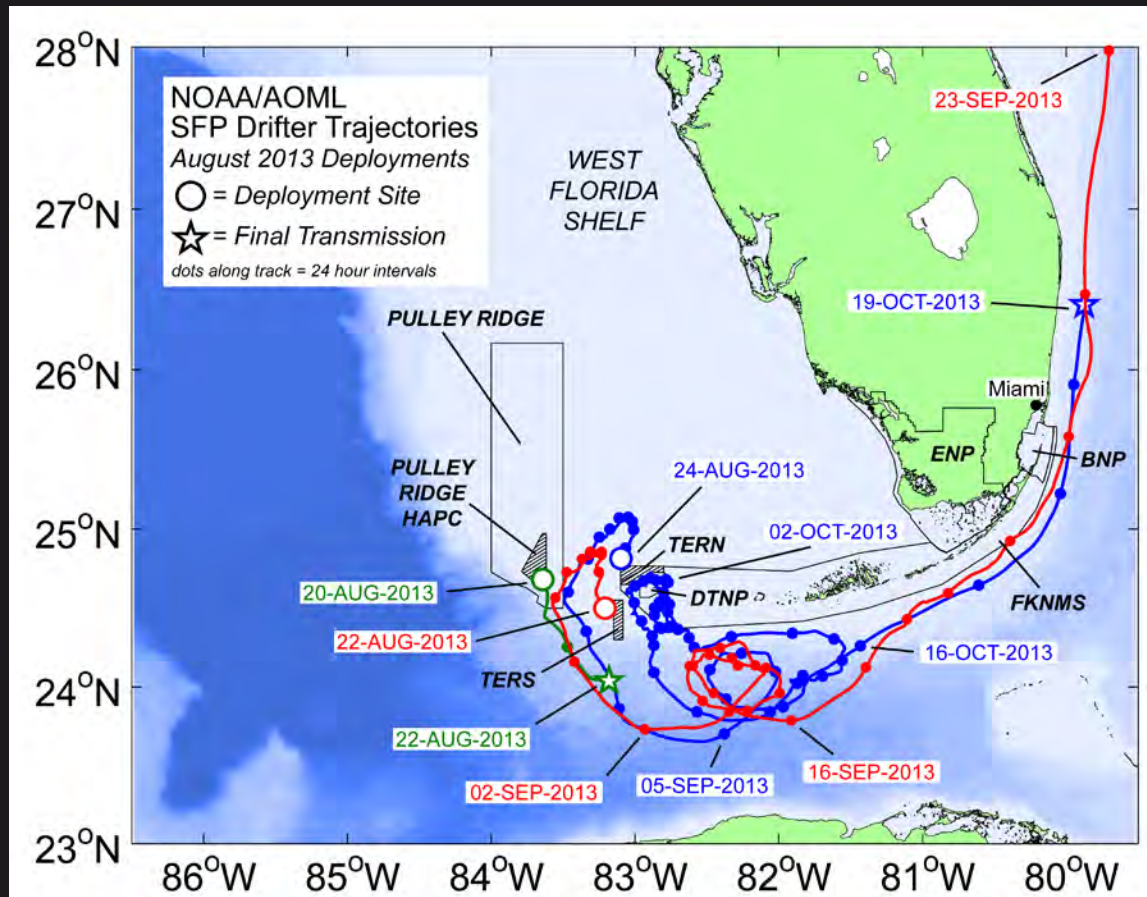
Field Observations - Drifters



➤ **Purpose: Investigate the Loop/Florida Current and cyclonic eddy formation**

- Satellite-tracked drifters have their drogues centered at 15 m depth

Field Observations - Drifters

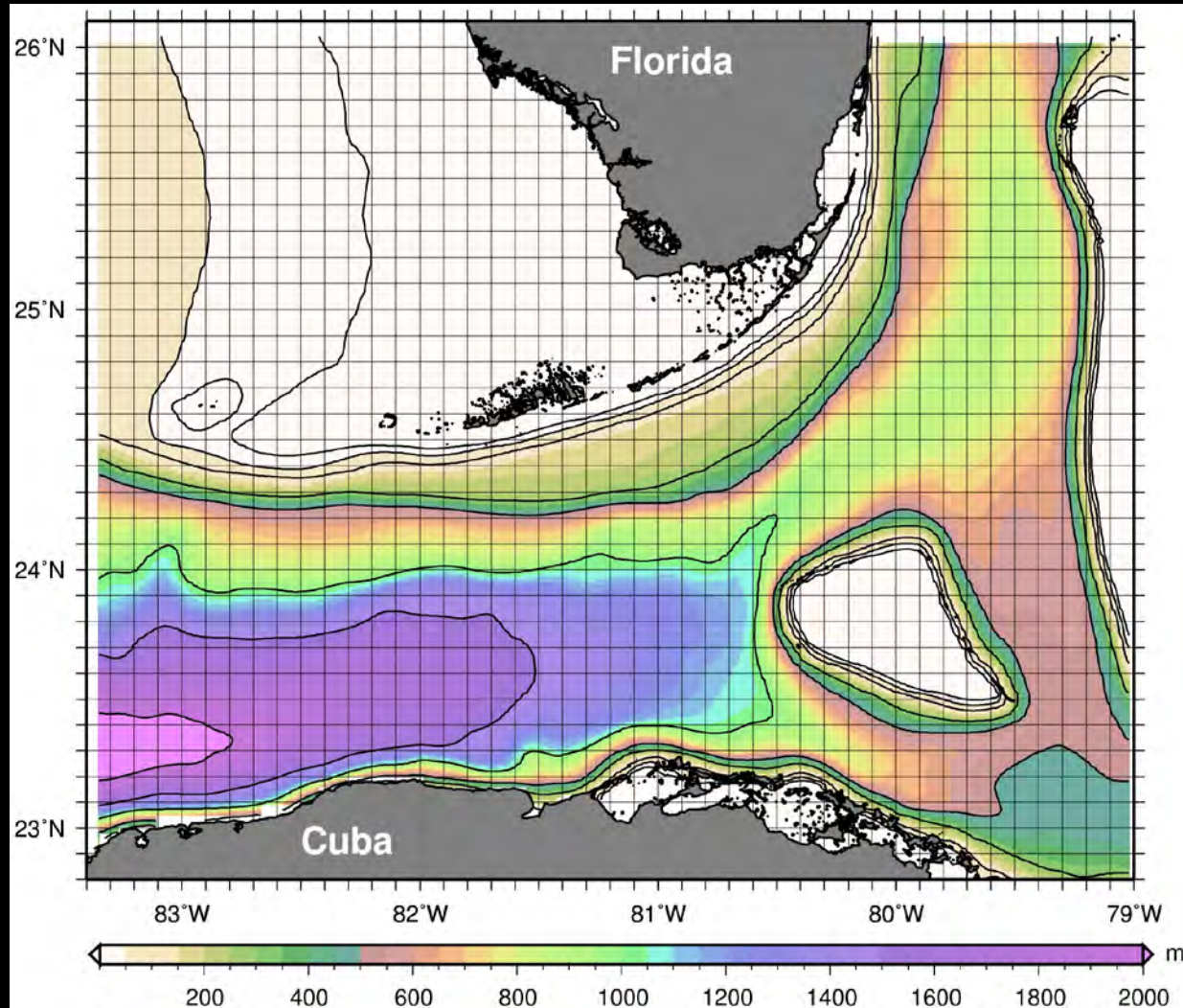


- Red = South Dry Tortugas (22 Aug – 23 Sep 2013)
- Blue = North Dry Tortugas (24 Aug – 19 Oct 2013)
- Green = Pulley Ridge (20 Aug – 22 Aug 2013)

- Purpose: Investigate the FC meandering and respective cyclonic eddies formation and evolution over the coral reef regions

Modeling

Univ. of Miami
RSMAS & CIMAS

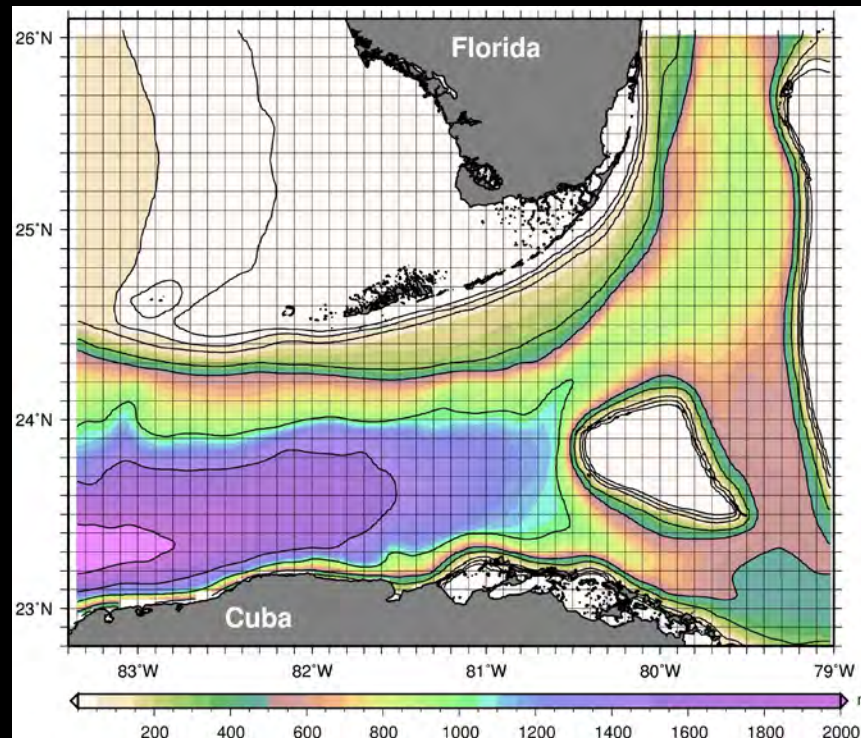


Modeling

Hydrodynamic: (“physical”) deals with the ocean physics (e.g., water motions, circulation)

Numerical: solves equations that describe these phenomena through computer coding

Model: a series of equations and coding methods are used to describe (i.e., model) the physical system



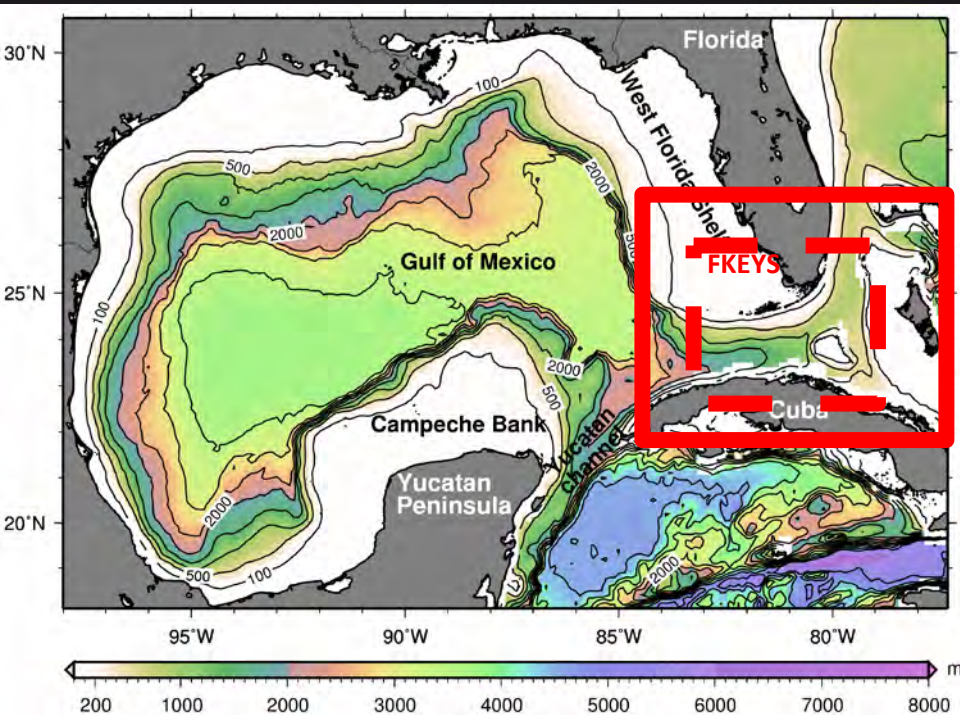
Modeling

How to model hydrodynamics?

- Select the model to be used (HYCOM)
 - Develop method to bring the data into the model
 - Determine the scale (global/regional/coastal)
 - Select the model domain (Gulf of Mexico and Florida Keys)
 - Divide the domain into small gridded blocks
 - Implement forcing (winds, tides, rivers, solar radiation)
 - Run the model
 - Evaluate the simulations
 - Analyze the results
 - Develop products
- **Added Value :** How a model can help managers?
- fill data gaps
 - understand natural phenomena
 - perform scenarios and predict outcomes

MODEL DOMAINS (simulations and forecasts)

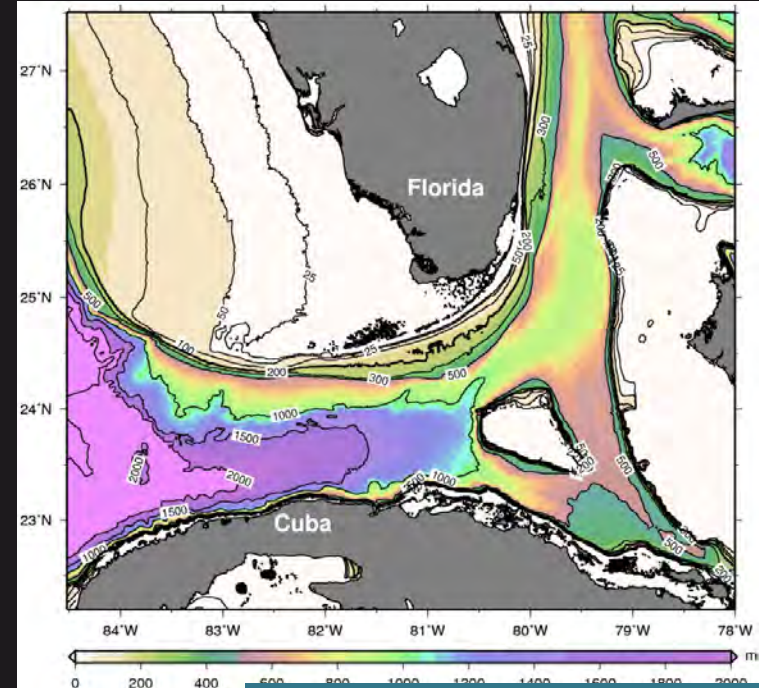
Gulf of Mexico HYCOM



ANCILLARY PRODUCTS (full Gulf of Mexico domain):

- Real time 7-day forecasts of circulation, sea elevation, temperature, salinity
- High resolution model archives (~1.8 km)

FKEYS - HYCOM



Kourafalou and Kang, 2012

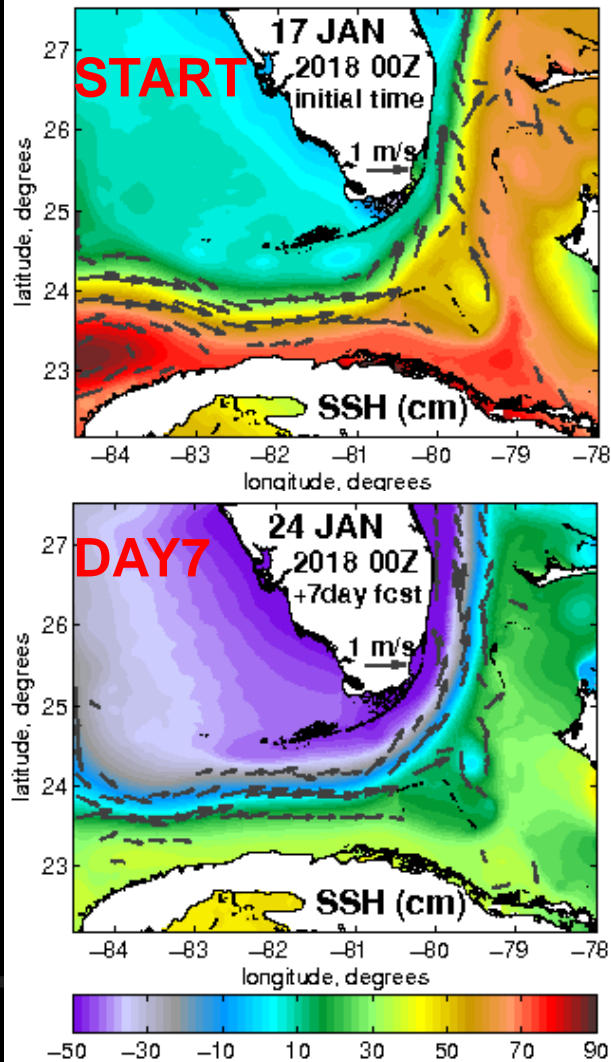
MAIN PRODUCTS (extended FKEYS domain):

- Real time 7-day forecasts of circulation, sea elevation, temperature, salinity
- High resolution model archives (~900 m)

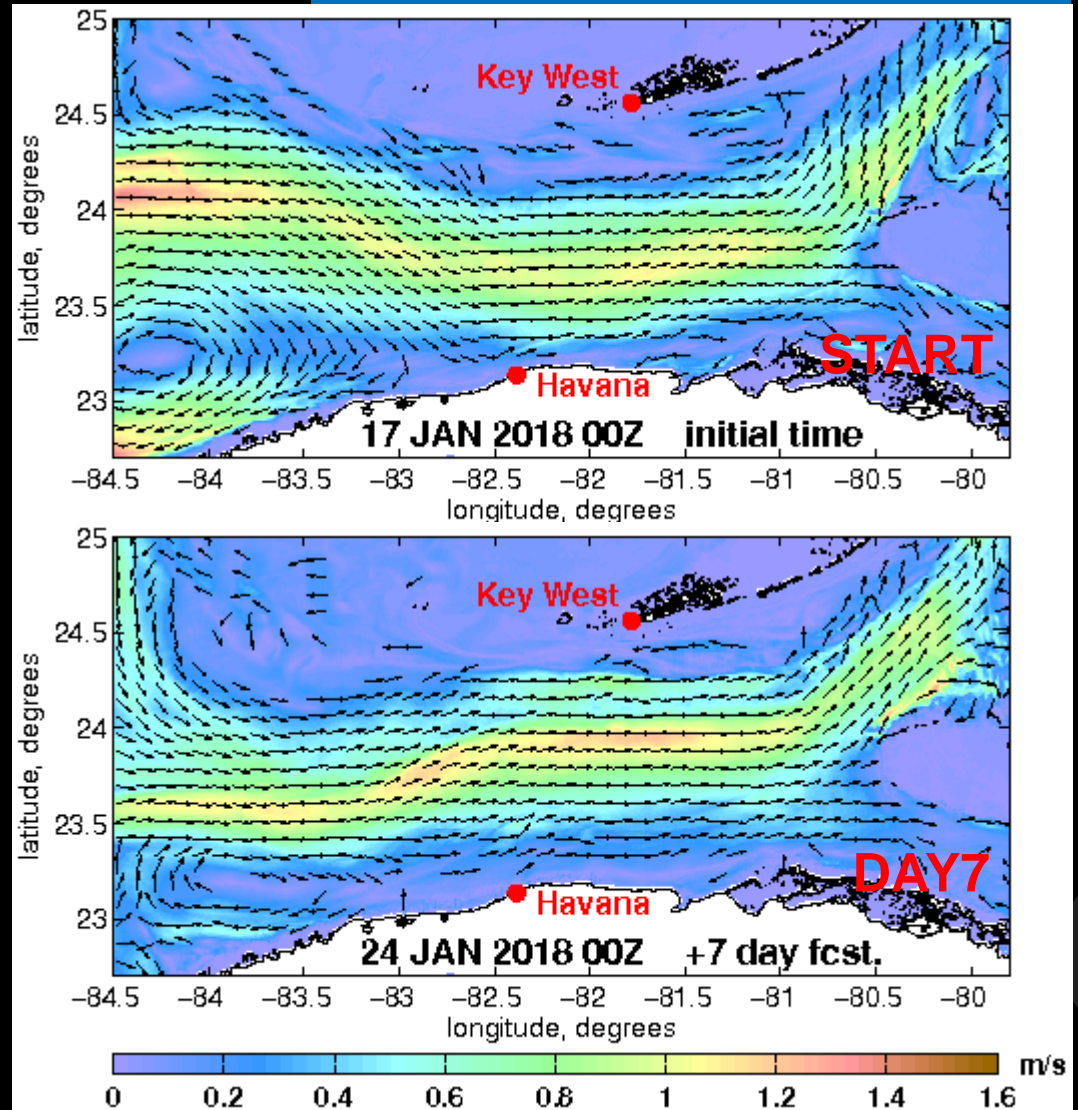
FKEYS-HYCOM 7-day forecast from Jan 17 (initial) to Jan 24, 2018

http://coastalmodeling.rsmas.miami.edu/Models/View/FORECAST_SOUTH_FLORIDA_AND_FLORIDA_STRAITS

Sea Surface Height & Currents

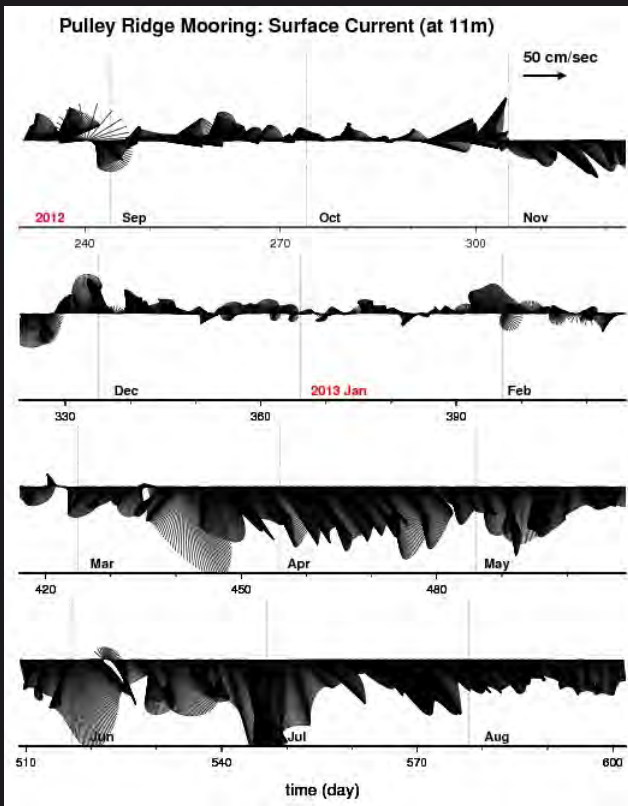


Surface Currents (zoom)

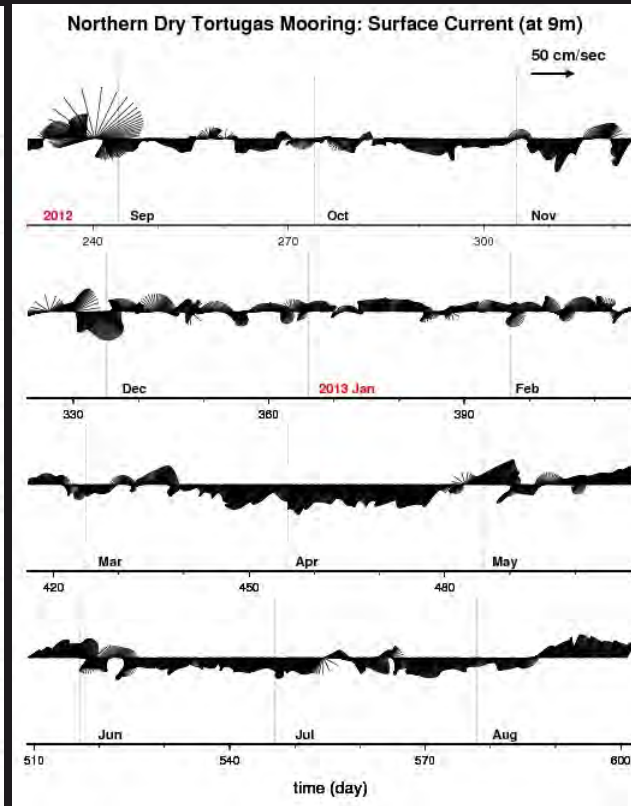


1st Major finding: Local circulation over the Southwest Florida Shelf is influenced by winds AND regional, GoM-wide currents (Loop Current and Florida Current system)

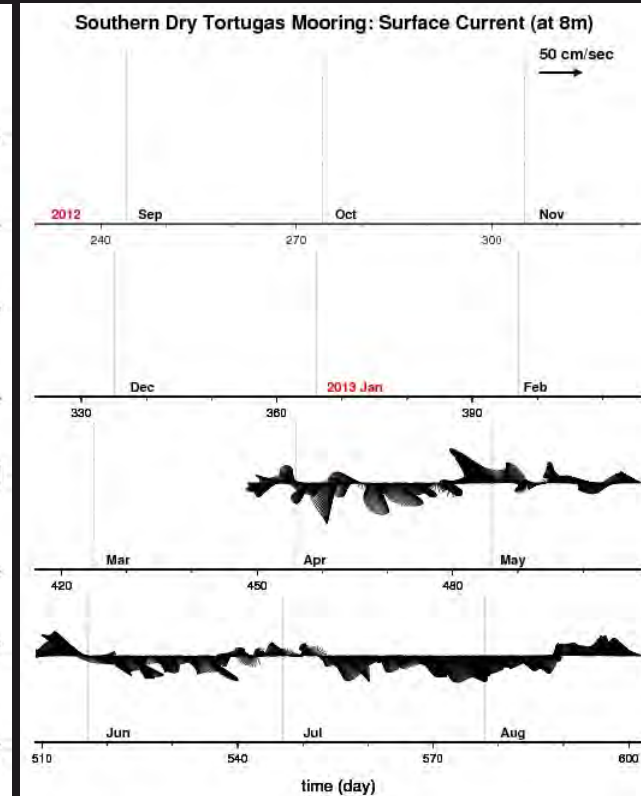
**Pulley Ridge
(sfc)**



**North Dry Tortugas
(sfc)**

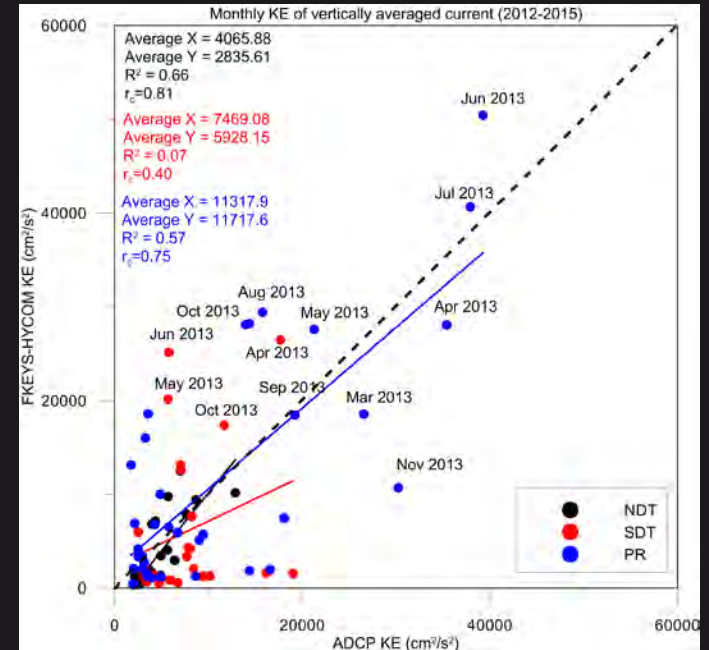
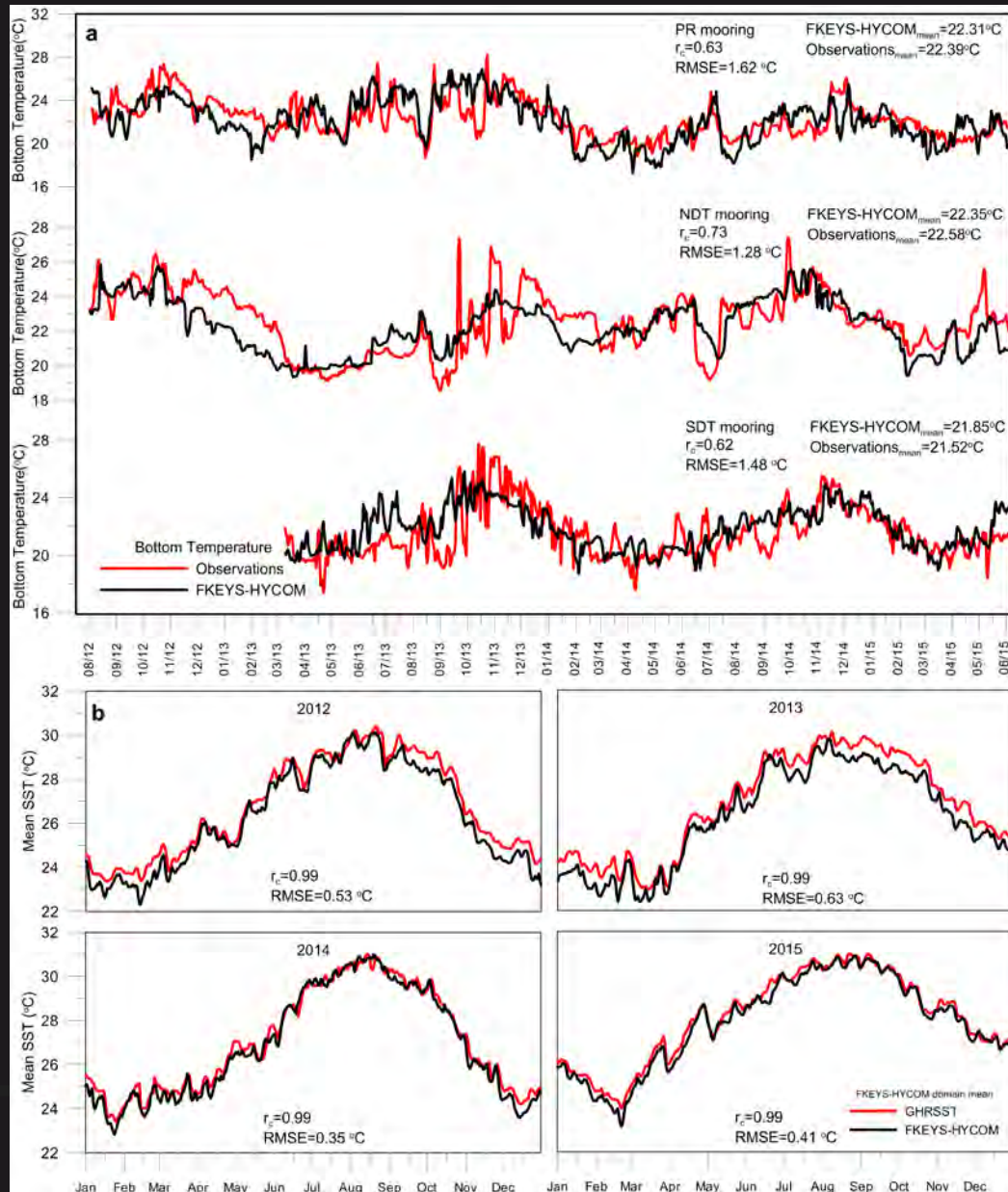


**South Dry Tortugas
(sfc)**



- Strong influence of regional oceanic currents at PR and SDT locations
- Wind-driven currents at NDT
- PR and SDT prevailing direction → South-eastward
- NDT prevailing direction → South-westward

Model Evaluation

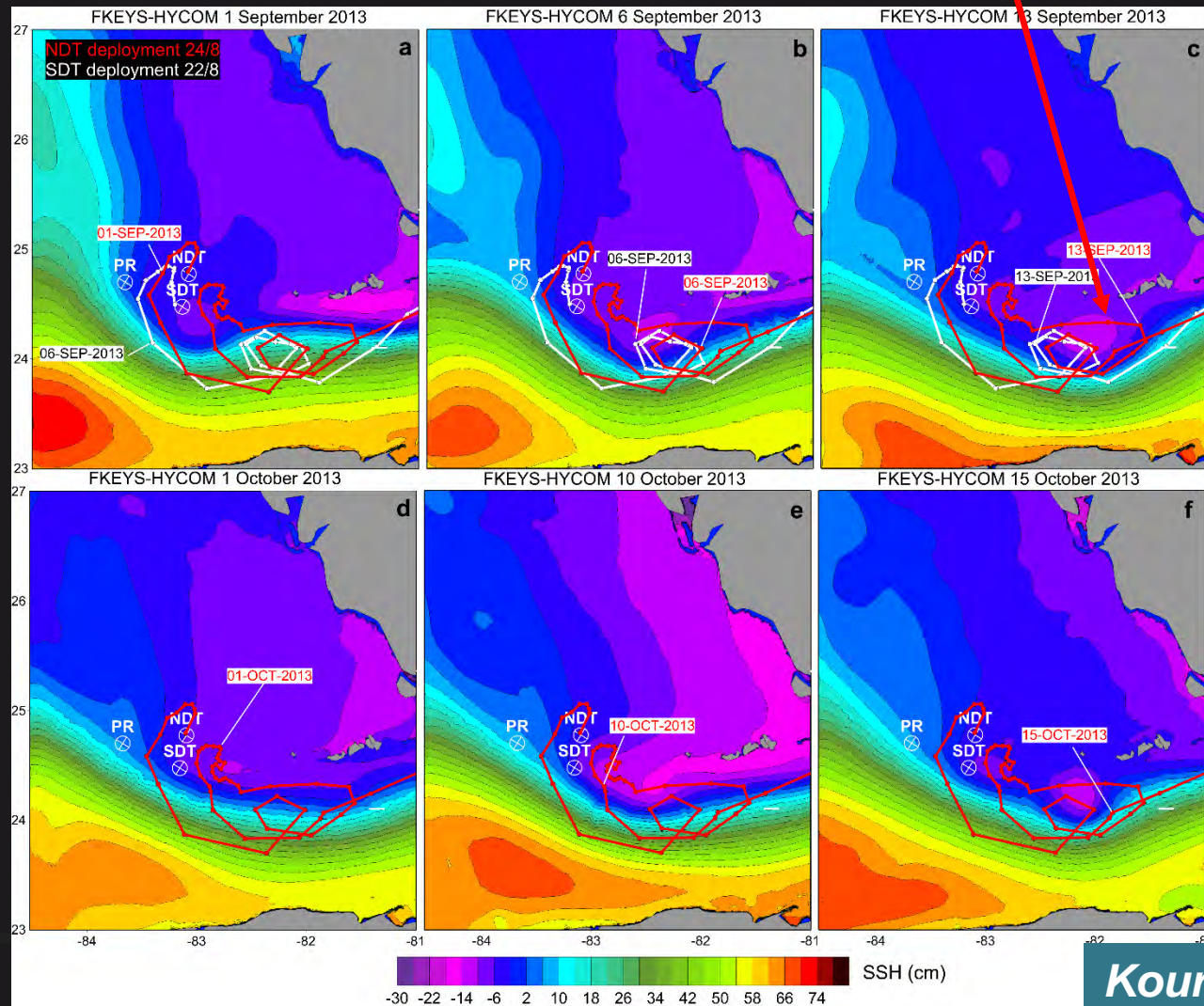


- Good model performance
- FKEYS-HYCOM efficiently simulated the **local circulation** (magnitude-direction currents)
- Both **seasonal and non-seasonal** (regional oceanic dynamics) variability is captured by the model

Kourafalou et al., 2018

2nd Major finding: Cyclonic Eddies play an important role in the connectivity patterns

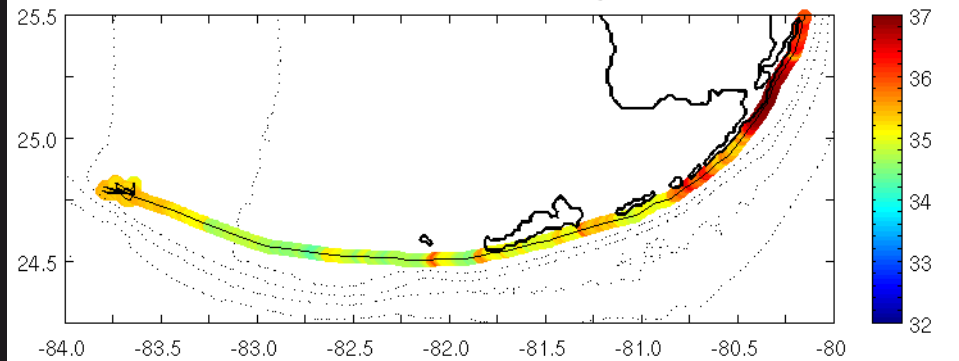
Two drifters deployed at Dry Tortugas were trapped in the cyclonic eddy north of the Florida Current



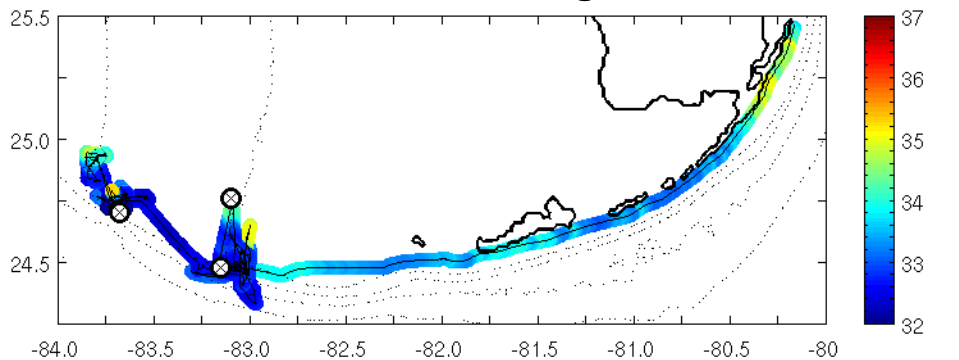
Kourafalou et al., 2018

3rd Major finding: Quantify impact of Mississippi export events around South Florida reefs (summer 2014 & 2015)

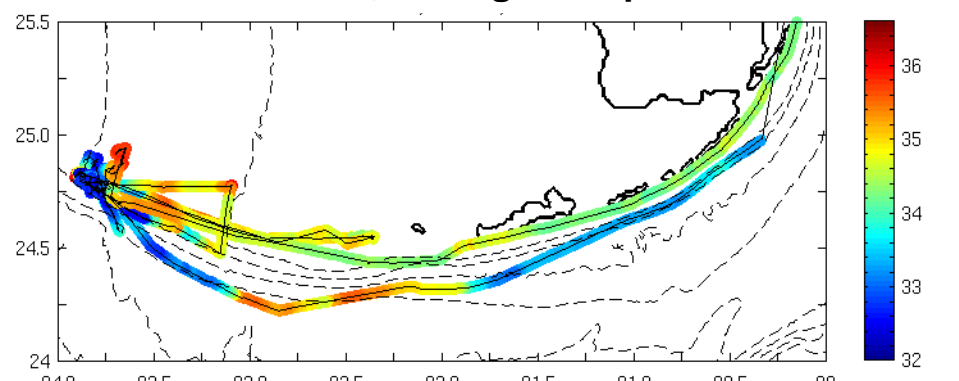
In situ SSS, 13-18 Aug. 2014



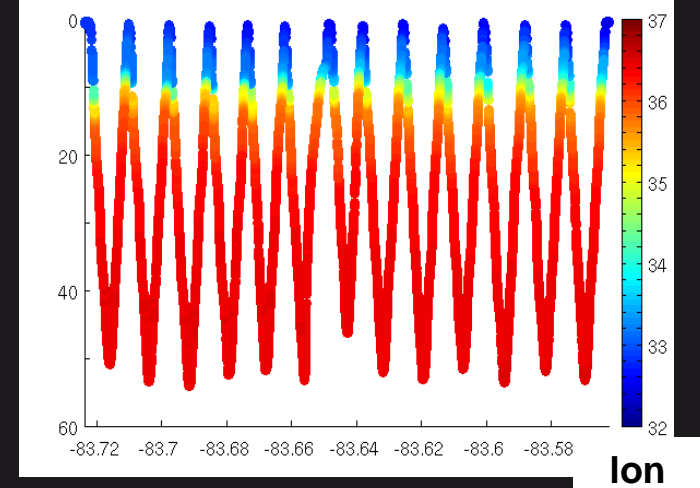
In situ SSS, 18-28 Aug. 2014



In situ SSS, 22 Aug.- 4 Sept. 2015



S vertical section

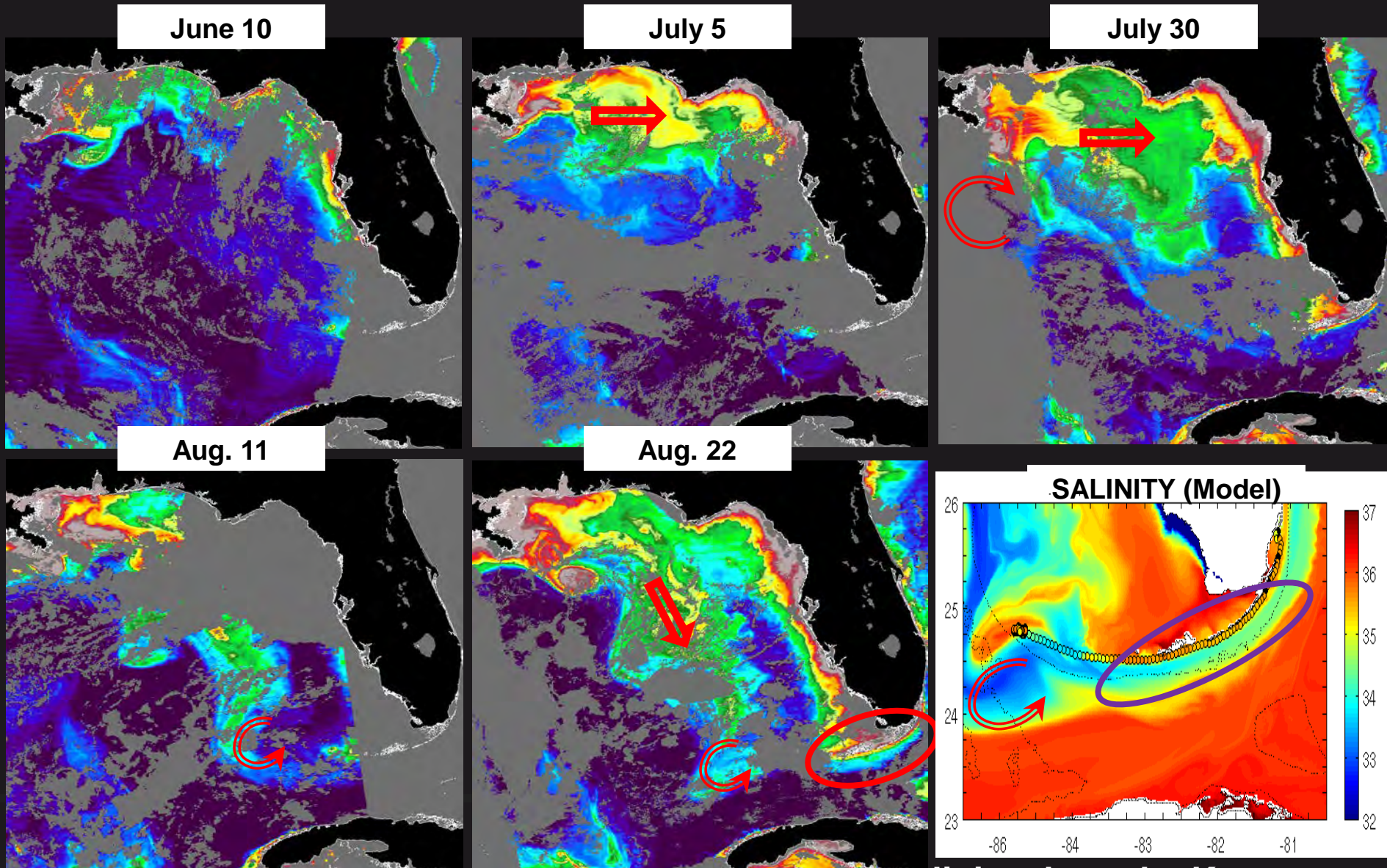


- 3 ISIS deployments: T and S profiles
- Low salinity: **10 to 15 m deep, varies in space and time**

Le Hénaff and Kourafalou, 2016

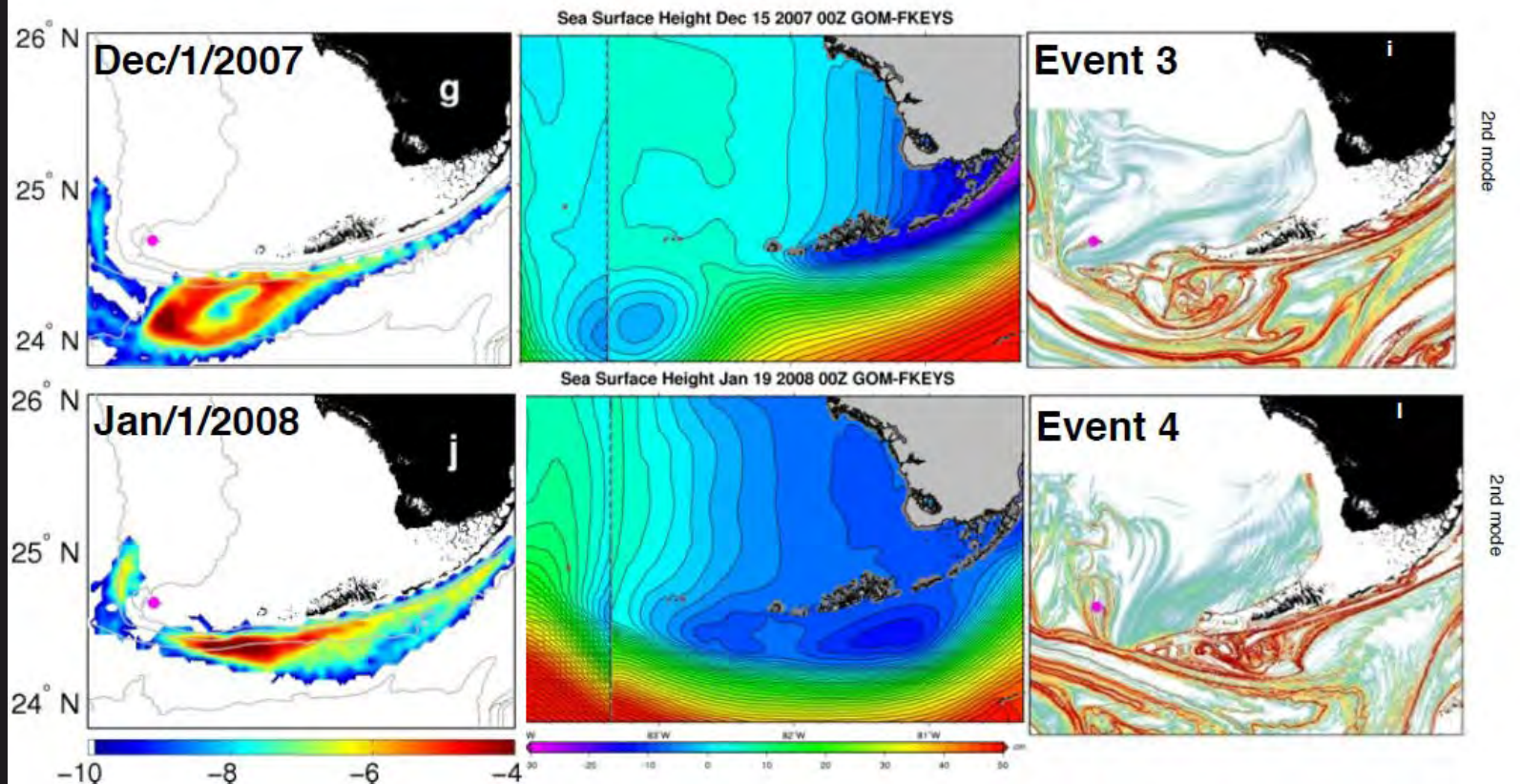
Mississippi influence around south Florida reefs – summer 2014

- Satellite (Chlorophyll) images (from C. Hu/USF): trace Mississippi waters



4th Major finding: Mesophotic coral reef ecosystems can serve as refugia for coral reef fish (*a critical role in the resilience of shallow reef communities*)

Settlement conditions: 2nd mode



- Connection from Pulley Ridge to Dry Tortugas occurs via two main pathways
- Larvae spawned at Pulley Ridge can be entrapped by remotely generated eddies and transported over the shallower bathymetry of the Florida Keys

SUMMARY

- ❑ **Physical connectivity** and circulation processes around the Pulley Ridge, Dry Tortugas and Florida Keys reefs were examined and **quantitatively assessed for the first time**, with a combination of **multi-platform observations and high resolution numerical models**.
- ❑ Local circulation over the Southwest Florida Shelf is influenced by both **shelf processes** (*ie. winds*) and regional, **GoM-wide currents** (Loop Current and Florida Current system).
- ❑ **Cyclonic Eddies** play an important role in the connectivity patterns.
- ❑ The impact of **Mississippi export events** around South Florida reefs was quantified (summer 2014 & 2015).
- ❑ Combining biophysical observations and models we found that mesophotic coral reef ecosystems (*ie. Pulley Ridge*) can serve as **refugia for coral reef fish** and thus play a critical role in the **resilience of shallow reef communities** (*ie. Dry Tortugas and Florida Keys*).