

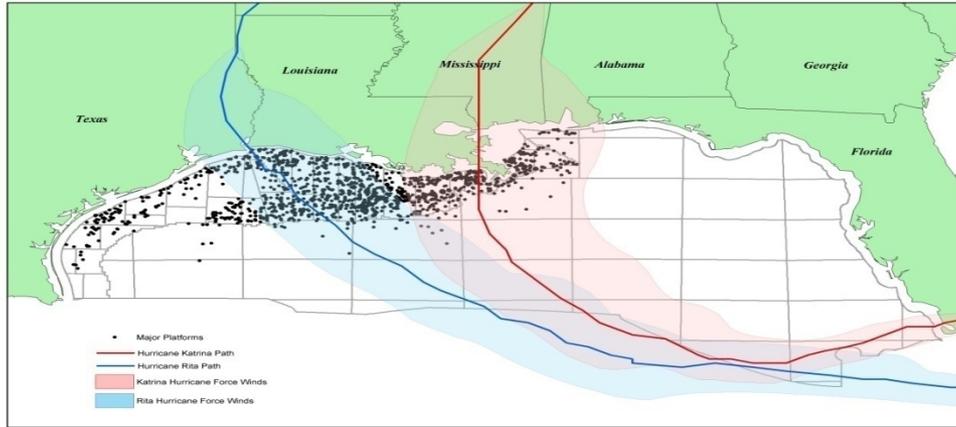
*Oceanic Heat Content Index For Tropical Cyclone Intensity Forecasting: **What Lies Beneath!***



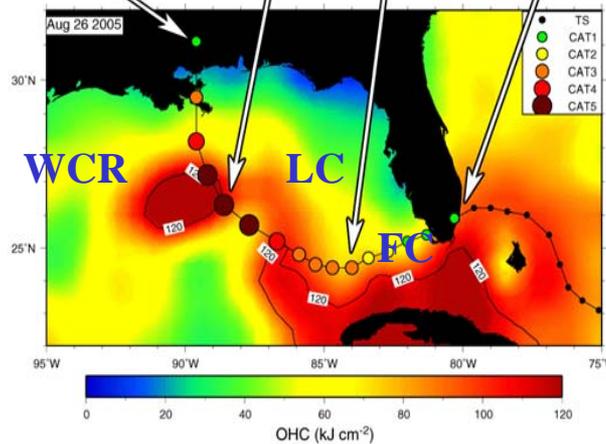
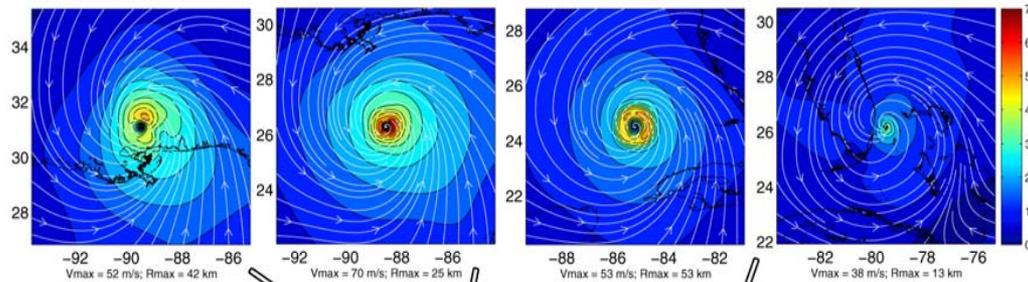
L. K. (Nick) Shay, J. Brewster, E. Uhlhorn, R. Lumpkin, J. Zhang, G. Halliwell, J. Kaplan, M. DeMaria, B. Jaimes, P. Myers, J. Zuczek
MPO, RSMAS, Univ. of Miami, NOAA HRD/PhOD, CIRA

<http://isotherm.rsmas.miami.edu/~nick>





Why study the GOM?



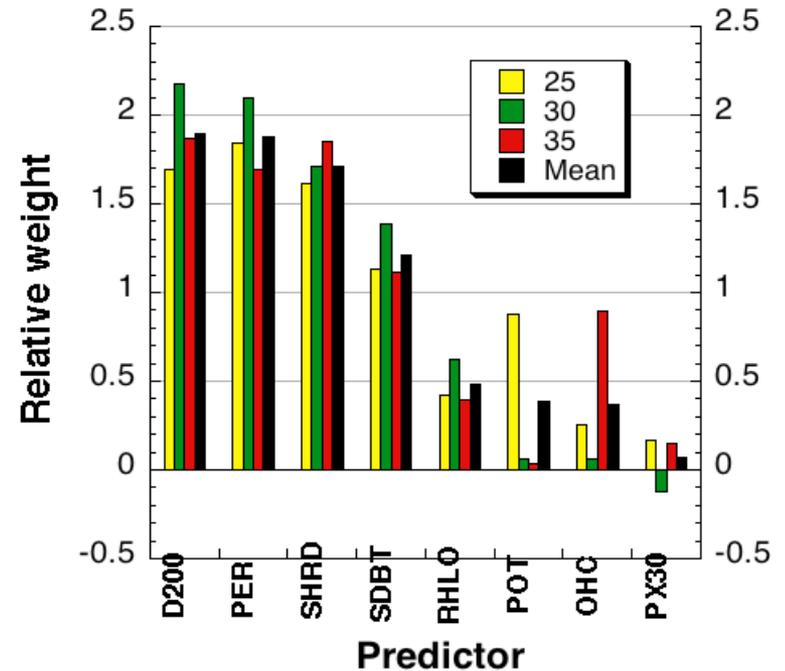
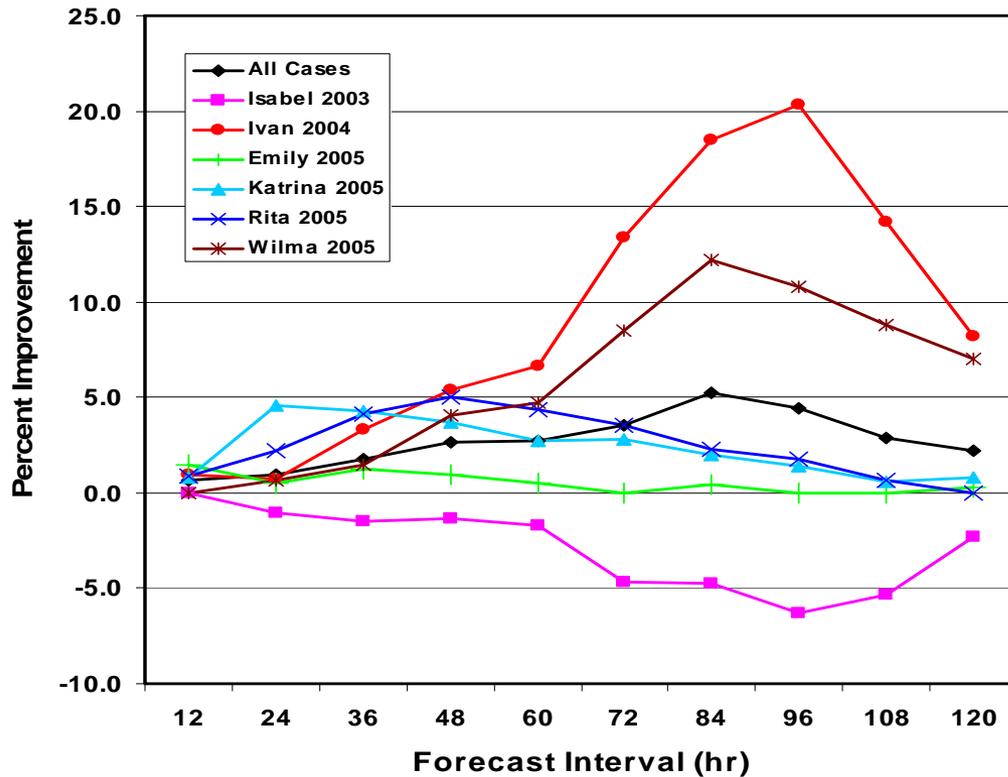
Not much upper ocean cooling in the LC/WCR complex (Jaimes and Shay 2009).

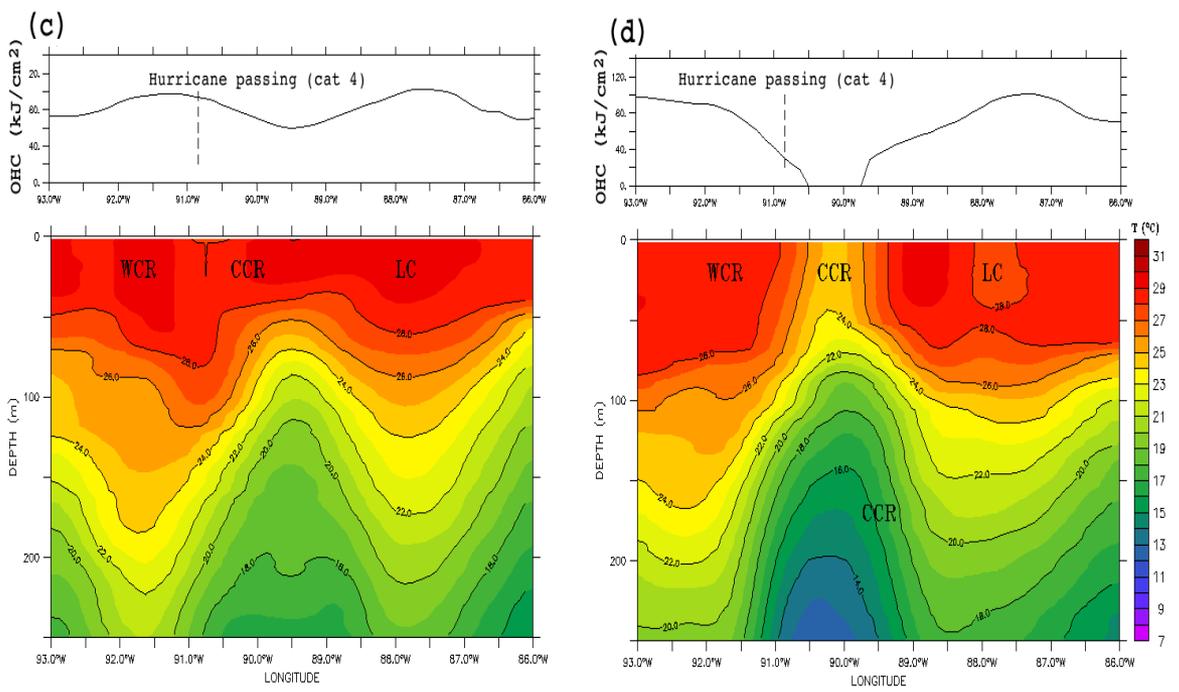
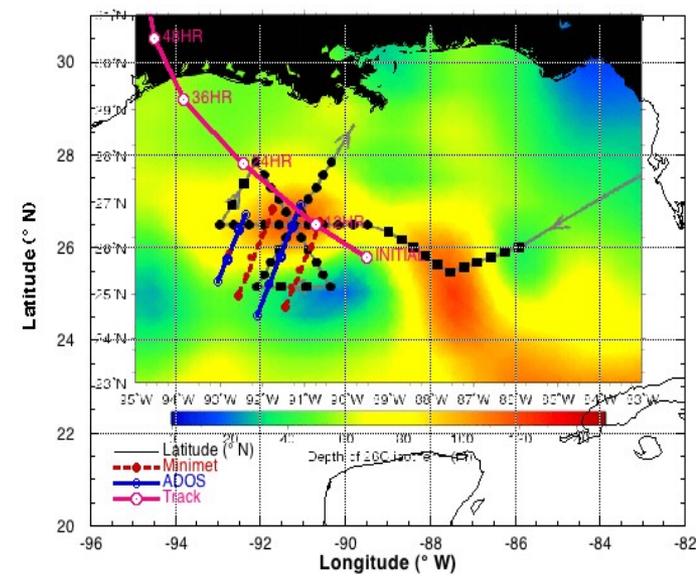
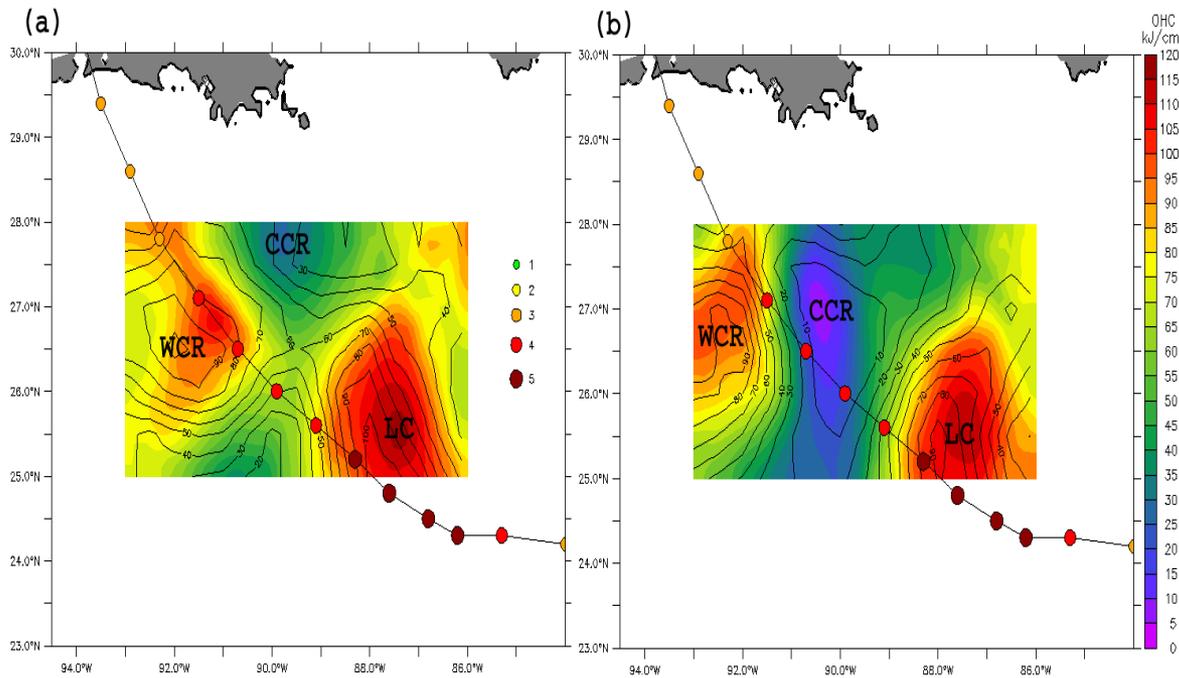
A Tipping Point (Gladwell 2000).

Intensity Forecasting From SHIPS with OHC (left) and RI (right)

(DeMaria et al. 2005; Mainelli et al. 2008; Kaplan et al. 2009)

see: <http://isotherm.rsmas.miami.edu/heat>





Sampling Pattern: AXCTDs and Drifters relative to OHC and Rita's track.

Pre (15 Sep) and Post Rita (26 Sep) WCR/CCR/ LC OHC and 26°C isotherm depth.

Vertical structure from AXCTDs

(Jaimes and Shay, MWR, 2009)

Goal and Objectives:



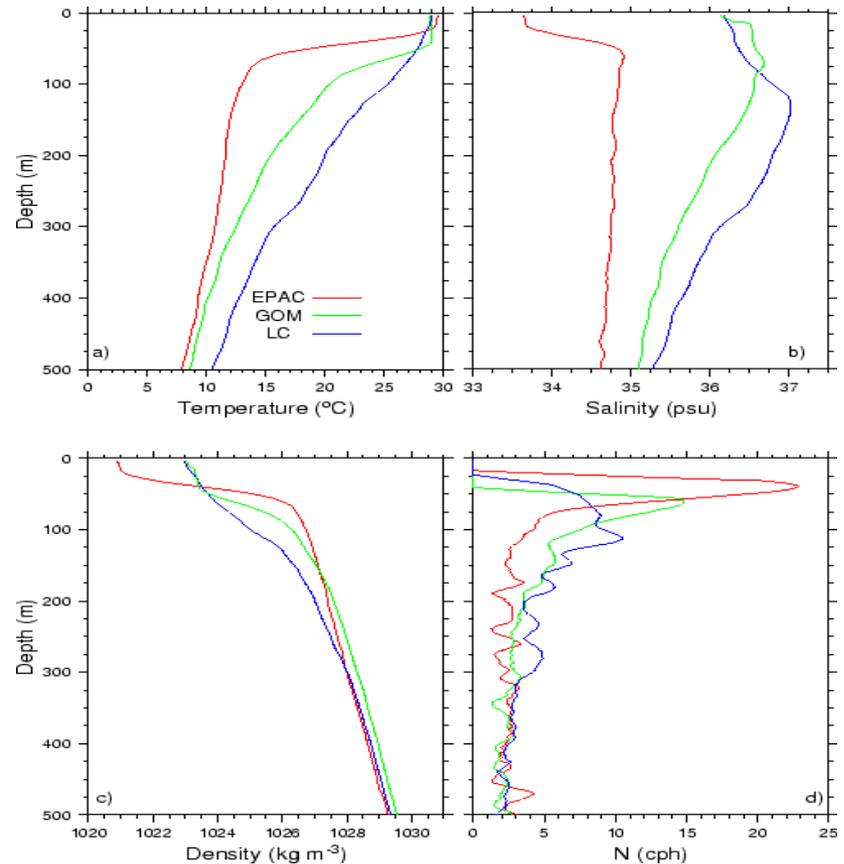
Goal of the research optimizes the use of satellite altimetry (SHA) and SST data to improve TC intensity evolution using in situ data from recent field campaigns such as *NASA CAMEX and NSF/NOAA* programs. Objectives are:

- *Evaluate and improve satellite-derived ocean heat content (OHC) estimates through calibration by in situ measurements;*
- *Improve the representation of upper ocean stratification and OHC in the ocean models that assimilate satellite data that will be used in coupled prediction models; and*
- Understand oceanic thermal and momentum responses (i.e. 1-D/3-D mixing and advection) and their relationship to air-sea fluxes during TC passage.

Water Masses T/S Important



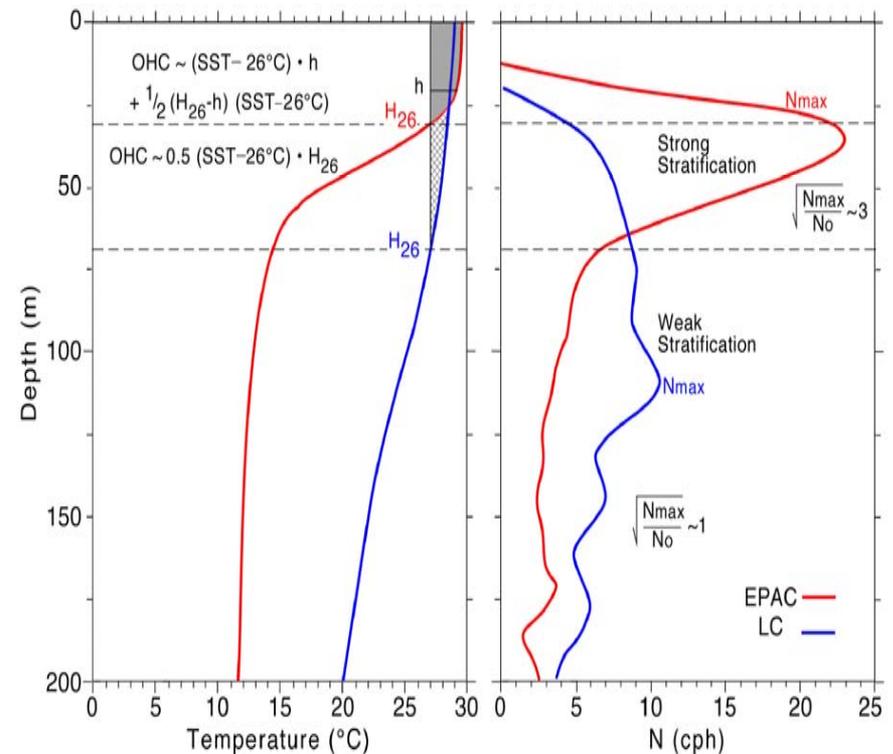
- Strong vertical temperature, salinity and density gradients at base of OML in EPAC.
- $N > 20$ cycles per hour –implications for vertical mixing.
- Subsurface salinity maximum in Loop Current-weaker stratification
- Cooling of SST and deepening of the OML.
- Precip decreases salinity in the OML which tends to stabilize the layer decreasing vertical mixing rate.



Empirical Model



- Reduced gravity (g'), H_{20} , h (ocean mixed layer depth)
GDEM V2.1 mapped to 0.25
- Blend and objectively map SHA from Jason-1, GFO, and Envisat (9.9, 17 and 35-d repeat track).
- Infer H_{20} using mapped SHA and seasonal climatology.
- Estimate H_{26} relative to H_{20} (via ratio).
- Estimate OHC relative to 26°C using H_{26} , h , and SST.

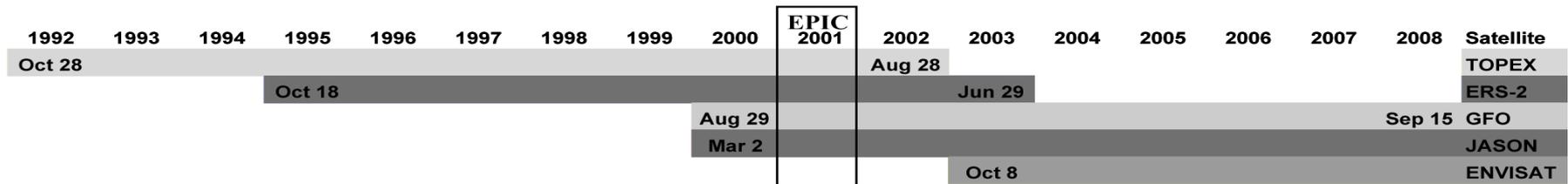




Progress To Date

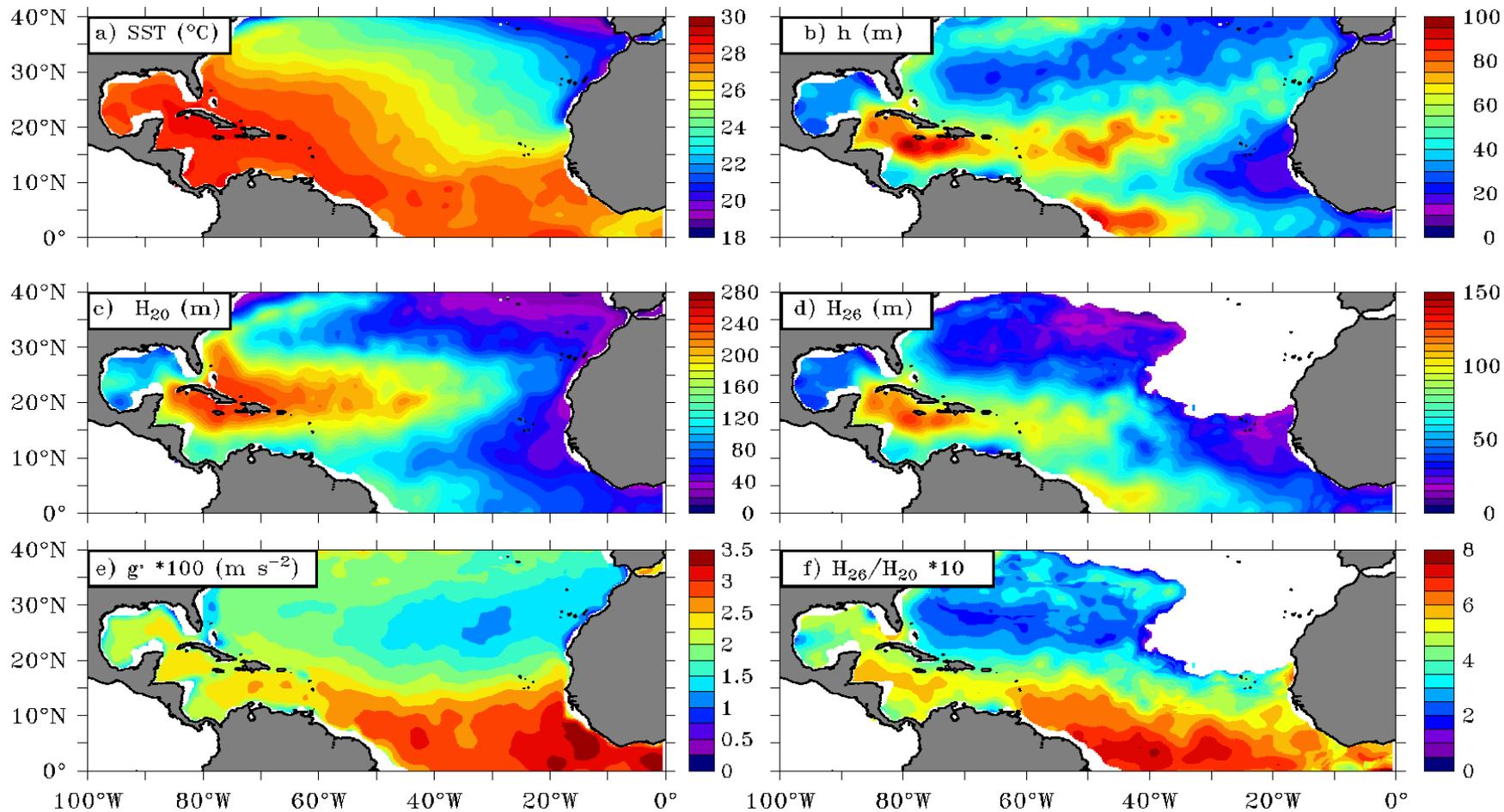
Ocean Heat Content (OHC) has been found to improve intensity forecasting in Atlantic Ocean Basin in SHIPS (DeMaria *et al.* 2005; Mainelli *et al.* 2008) and an important parameter in RI (Kaplan *et al.* 2009).

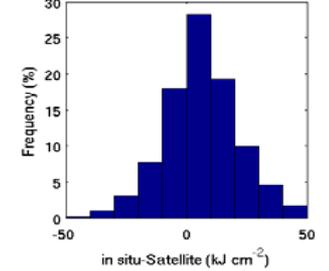
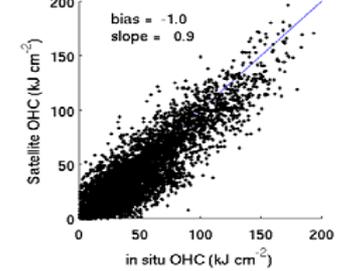
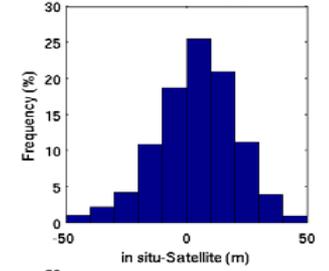
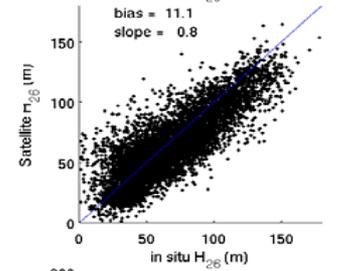
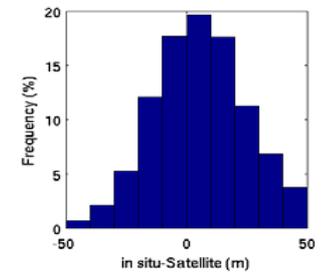
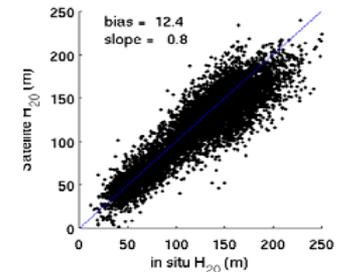
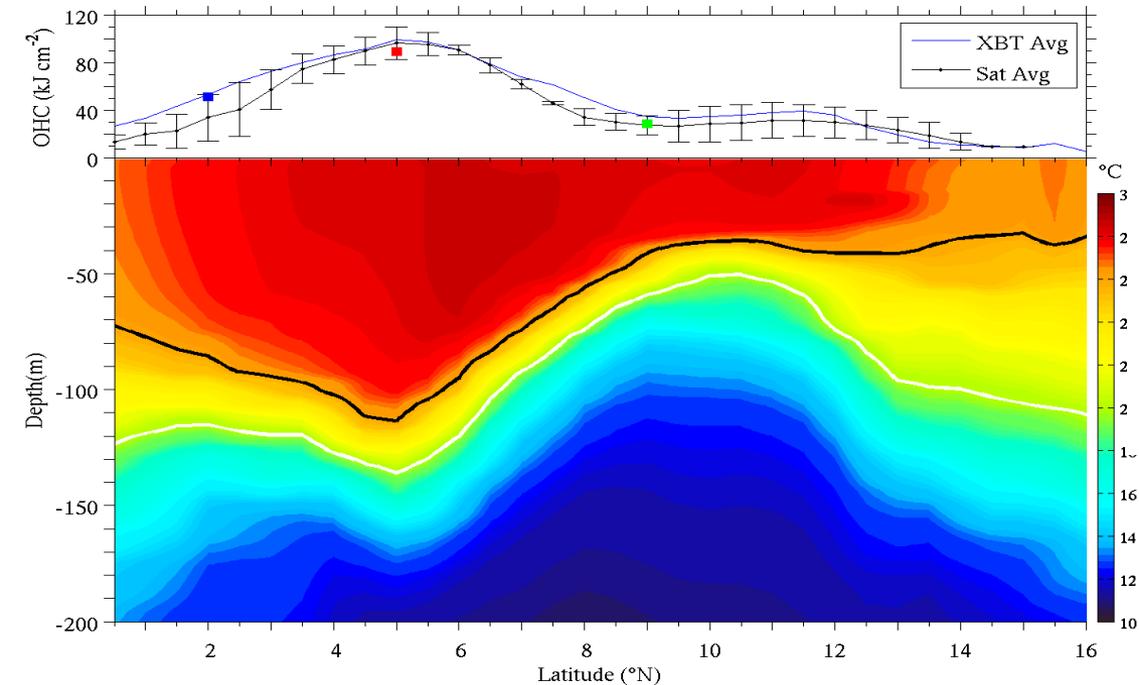
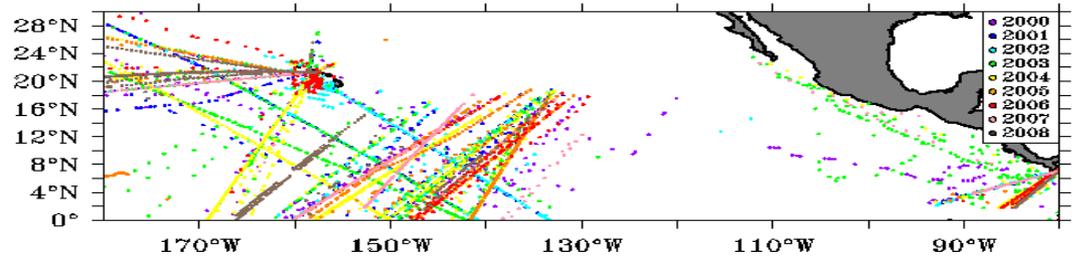
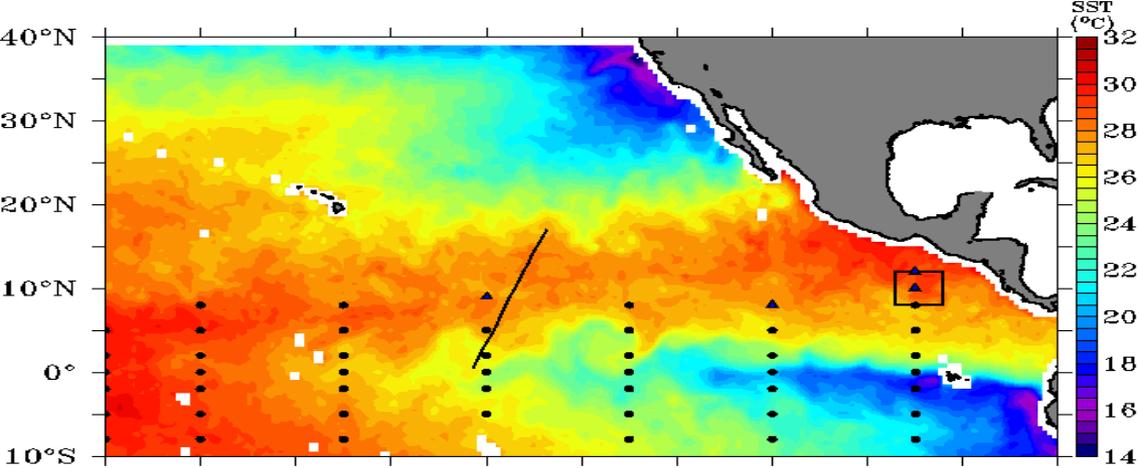
1. Mapped GDEM 2.1 Climatology to 0.25 grid for mean depths of the isotherms (20 and 26C water, OML depth, reduced gravity, mean ratio between 20 and 26C water (and errors).
2. **Generating isotherm depths and OHC from 96 to 08 from multi-platform**



3. Synthesizing data from XBT transects, ARGO floats, equatorial moorings, data from aircraft field programs such as NASA, NOAA, NSF, ONR etc.
4. Data Comparisons.
5. Monitoring Phase (Equivalent OHC_E).
6. Estimates for SHIPS.

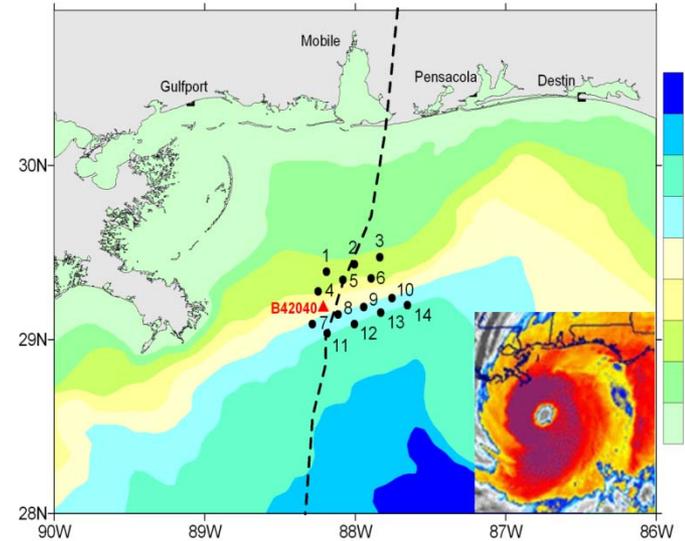
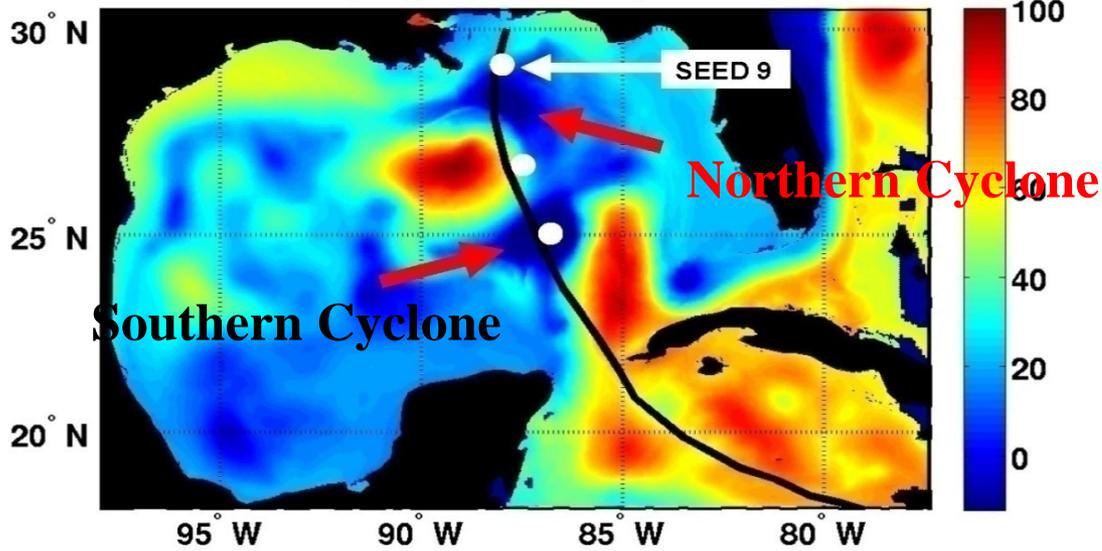
Atlantic Ocean Basin: Hurricane Season





From Shay and Brewster (2009).

SSH (cm), GOM1, 17 Sept. 2004

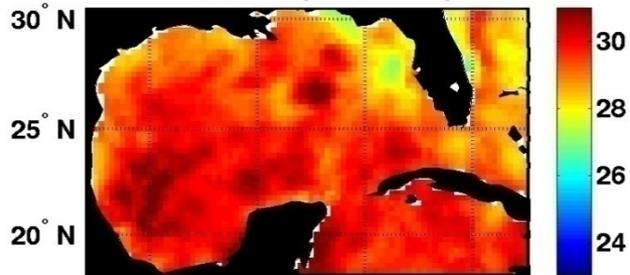


MOTIVATION:

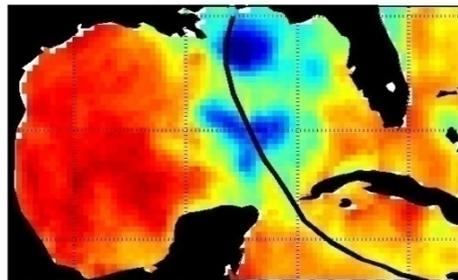
Ivan (2004) over the GOM
SSH (cm) from HYCOM
(from Halliwell et al.,
MWR, 2008).

SST Analyses

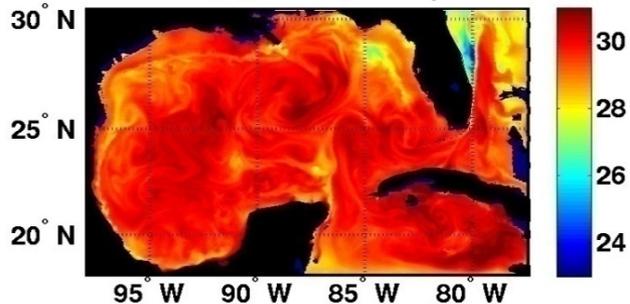
SST (C) Analysis, 10 Sept.



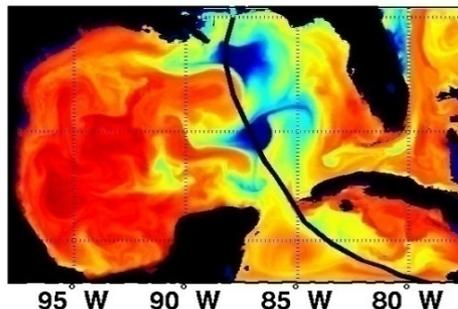
SST (C) Analysis, 17 Sept.



SST (C), GOM1, 10 Sept.



SST (C), GOM1, 17 Sept.



HYbrid Coordinate Ocean Model (HYCOM) Hurricane Ivan Simulations 10 Sept-6 Oct 04



Configuration:

- 0.04° Mercator grid, Gulf of Mexico domain
- No data assimilation performed

Initial and boundary conditions from U.S. Navy HYCOM ocean nowcast-forecast system:

- Data assimilative ocean nowcast
- Navy Coupled Ocean Data Assimilation (NCODA) assimilation

Atmospheric Forcing:

- Navy 27 km COAMPS atmospheric model
- Vector wind blended with higher resolution fields from HWIND
- Wind stress for HWIND calculated using Donelan cd

NOAA WP-3D profiling over MMS Moorings

(In collaboration with AOML HRD, AOC, TPC, NCEP)

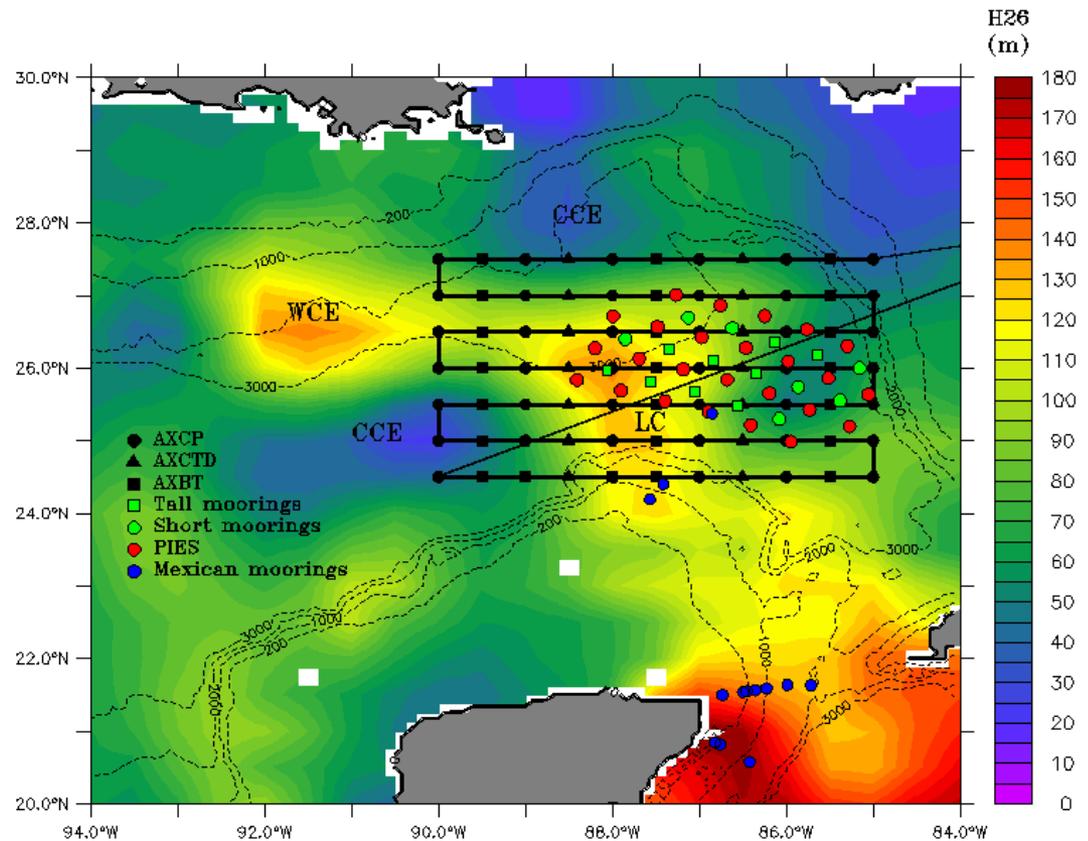


Deliverables include:

**V, T, S profiles to 1000 m @
2-m resolution.**

**Surface winds (SFMR, GPS)
provided by HRD.**

**Atmospheric profiles of V, T
and RH @ 5-m resolution.**



Goal: To observe and improve our understanding of the LC response to the near-surface wind structure during TC passages. Specific objectives are:

- 1. Determine the oceanic response of the LC to TC forcing; and,**
- 2. Influence of the LC response on the TC's boundary layer and intensity.**

Progress Summary



Higher spatial resolution OHC product (0.25) available this hurricane season. Need to accurately determine threshold value for TC's to intensify in both SHIPS and RI (Not 60 kJ cm^{-2})

Negative feedback (wake cooling/mixing induced by strong winds and Cold Core Ring) and **positive feedback** (over the Loop Current and Warm Core Rings) are central to the intensity puzzle (how much heat and moisture is available?)

SST reflect forced upper ocean response-data assimilation of satellite fields both SHA and SST (and upper ocean thermal structure) - critical to getting the pre-TC ocean correct.

Temperatures and currents needed to assess model mixing schemes and evaluate initialization schemes. Both Eulerian (AXCP, AXCTD, moorings) and Lagrangian (drifters, floats) needed – Targeted Obs in storm coordinates! Working with *MMS on 5-year Loop Current Dynamical Study, NOAA HFIP and NSF.*