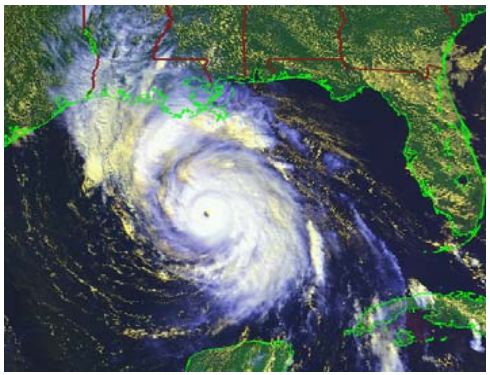
Evaluation and Improvement of Ocean Model Parameterizations for NCEP Operations



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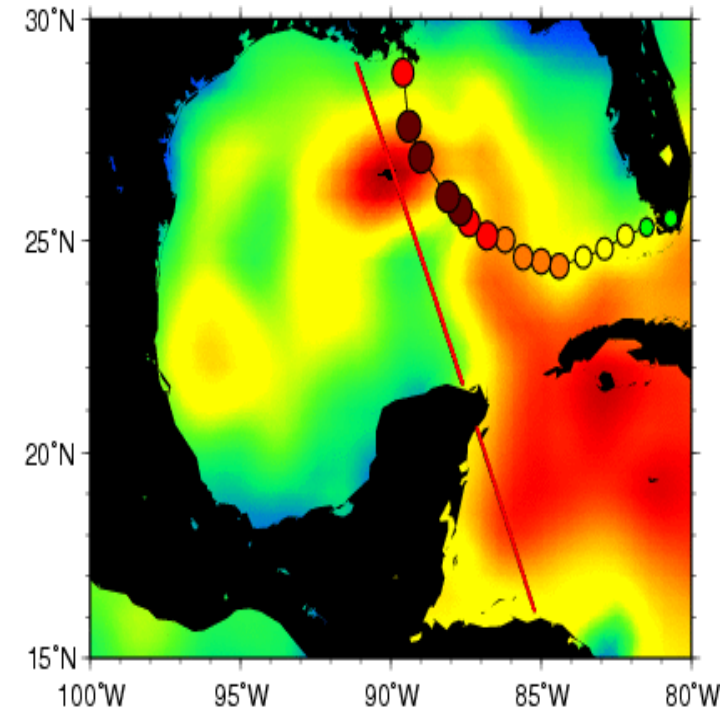
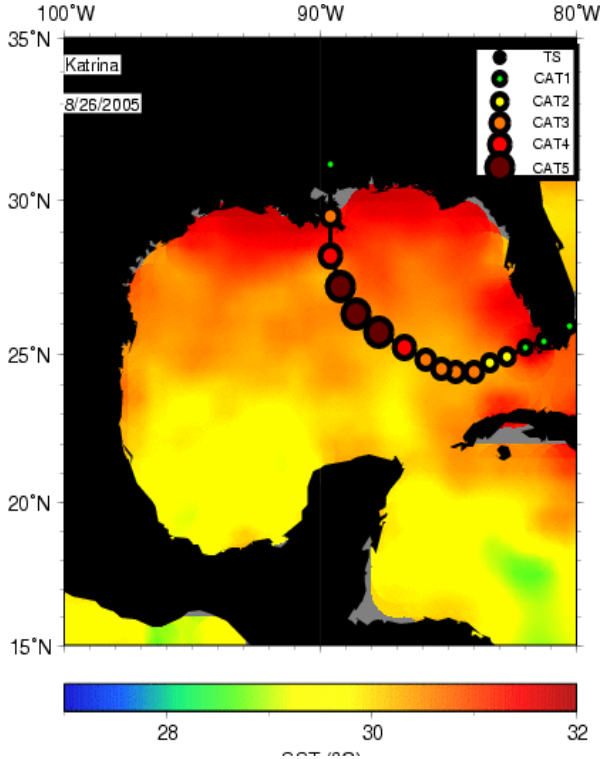
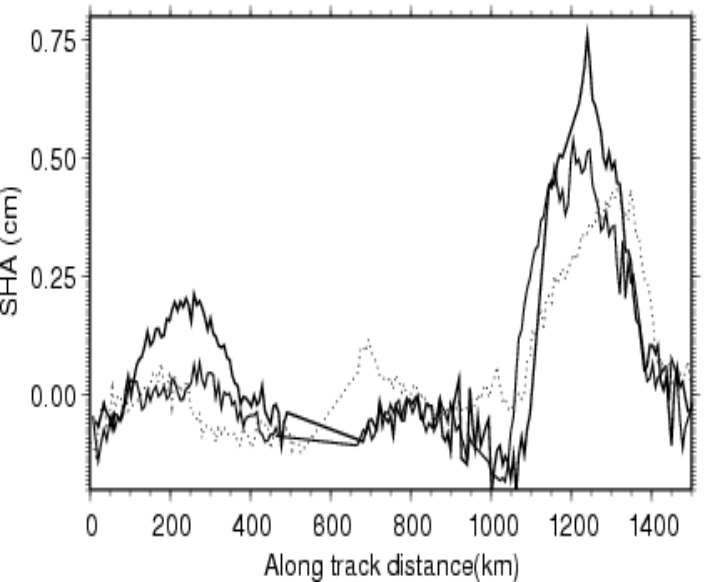
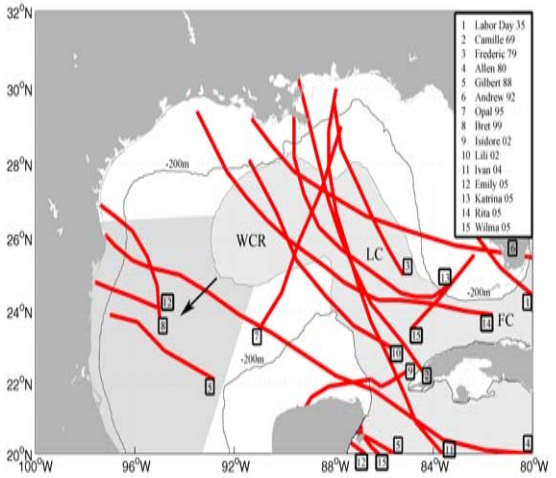
http://isotherm.rsmas.miami.edu/~nick







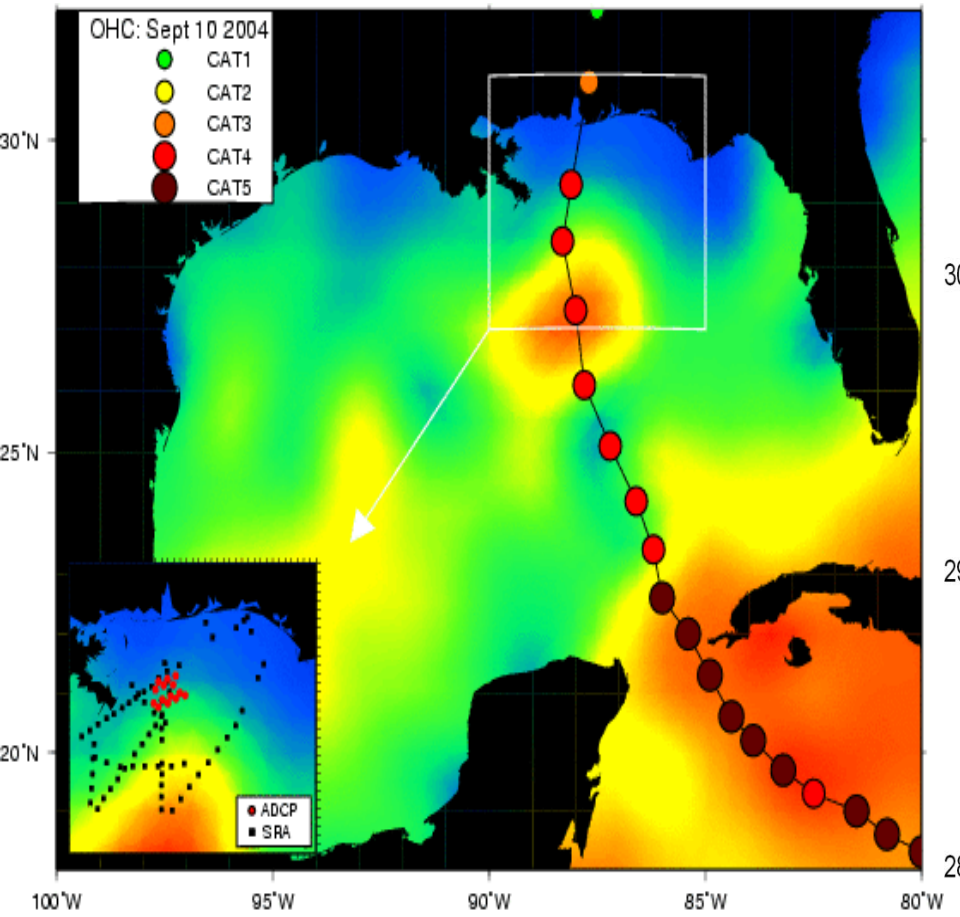


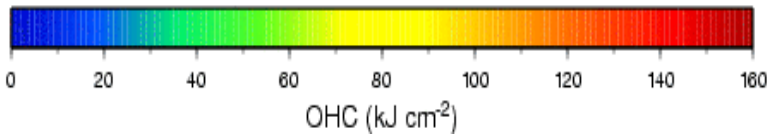
MOTIVATION:

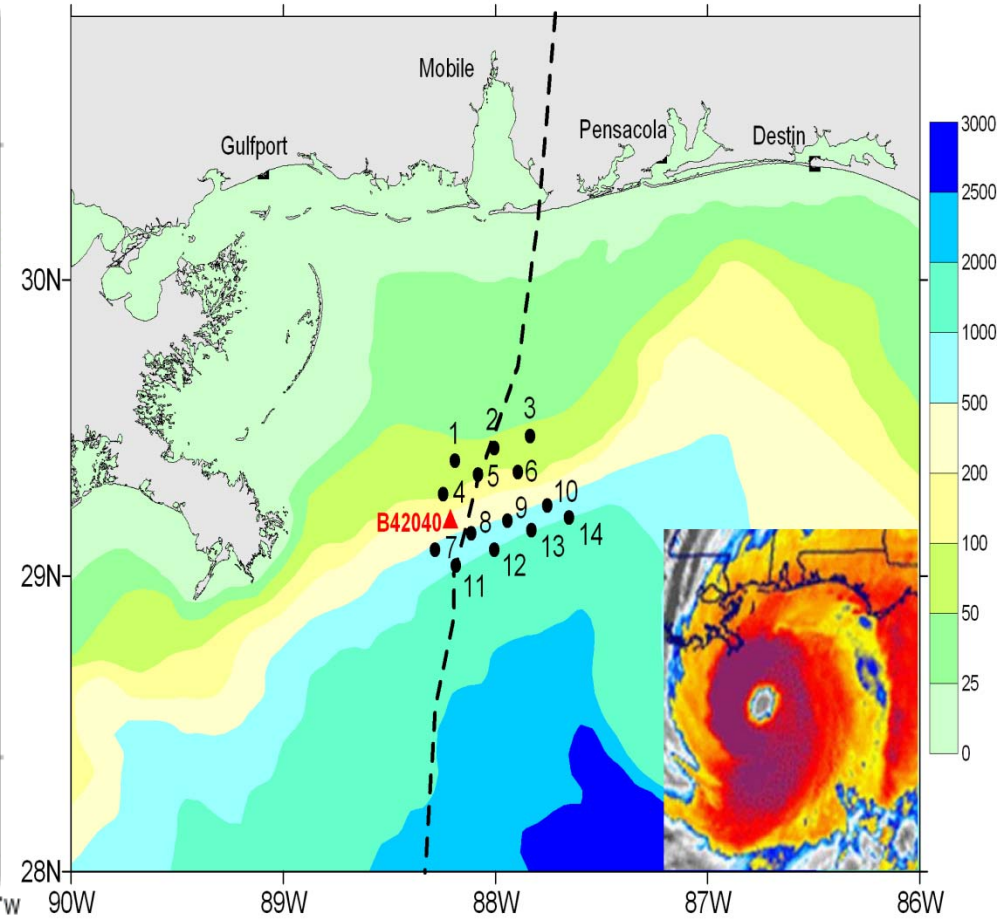
SHA field from GFO altimeter (left panels) and SST Image from TMI (right) Relative to Katrina's track & intensity.

Severe Storm (Cat 3 or above) Tracks (red) relative to the posit of the LC and WCR complex based on satellite data in Aug 05.

Ivan's Track and Intensity Relative to OHC (left) NRL SEED Mooring Locations in Northern Gulf of Mexico Relative to Bottom Depth (Right) (*Teague et al., JPO, 2007*).







14 ADCP moorings- Focus here in Array 9.

Objectives:

Ivan an example of **negative feedback** (cooling and Cold Core Ring) as opposed to less negative **feedback** (**Loop Current/Warm Core Rings)**

By building on a previous JHT (Jacob et al.), specific objectives of this grant are:

- optimizing spatial resolution that will permit the ocean model to run efficiently as possible without degrading the simulated response;
- *improving* the initial background state provided to the ocean model;
- ***improving*** the representation of vertical and horizontal friction and mixing;
- **generating** realistic high-resolution atmospheric forcing fields necessary to achieve these objectives; and
- Testing differing formulations of the drag coefficient (cd).

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

U.S. Navy HYCOM ocean nowcast-forecast system:

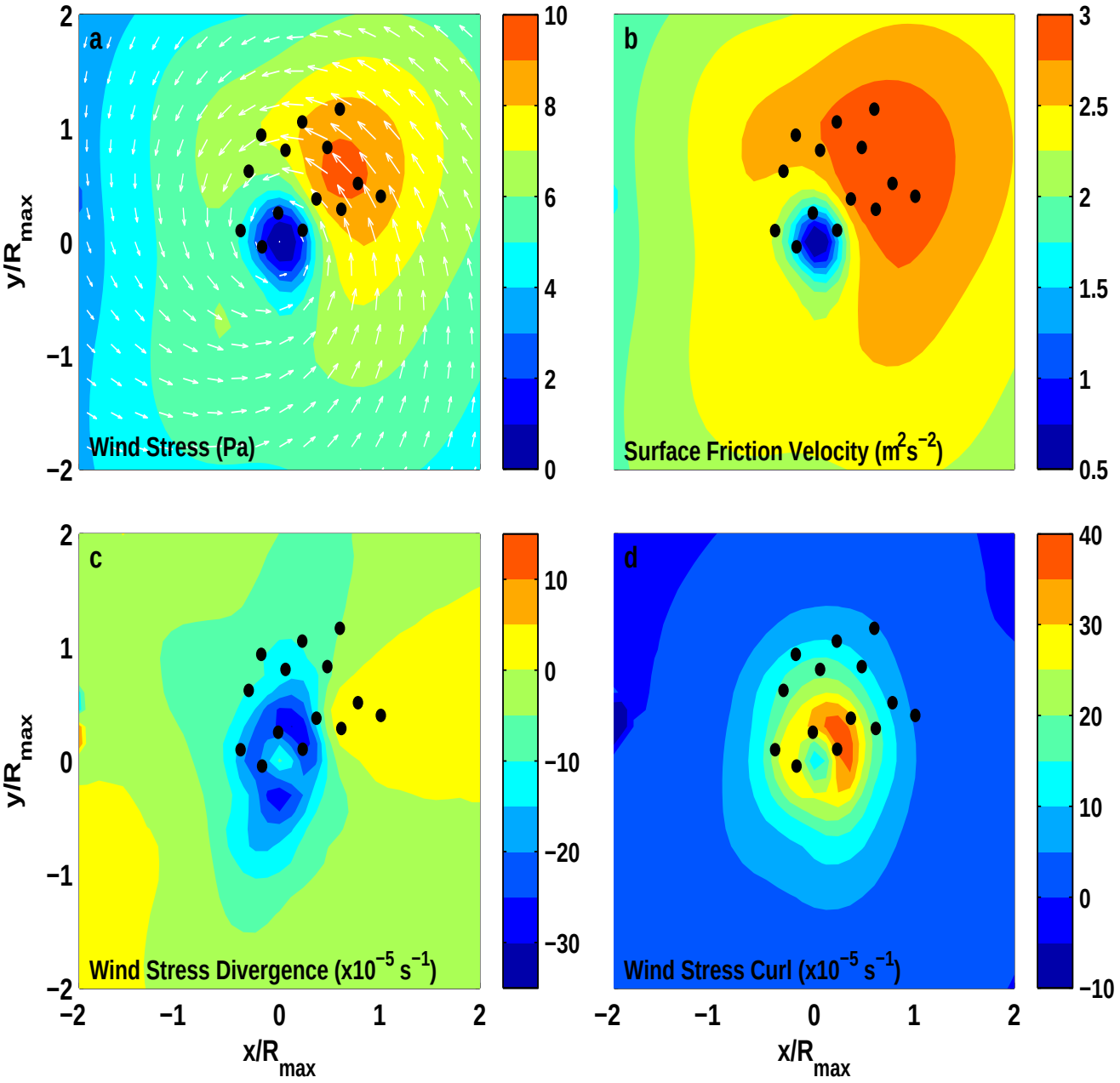
- Data assimilative ocean nowcast
- Navy Coupled Ocean Data Assimilation (NCODA) assimilation

Atmospheric Forcing:

- Navy 0.5^{o} NOGAPS atmospheric model
- Vector wind blended with higher resolution fields from HWIND
- Wind stress for HWIND calculated using Donelan cd

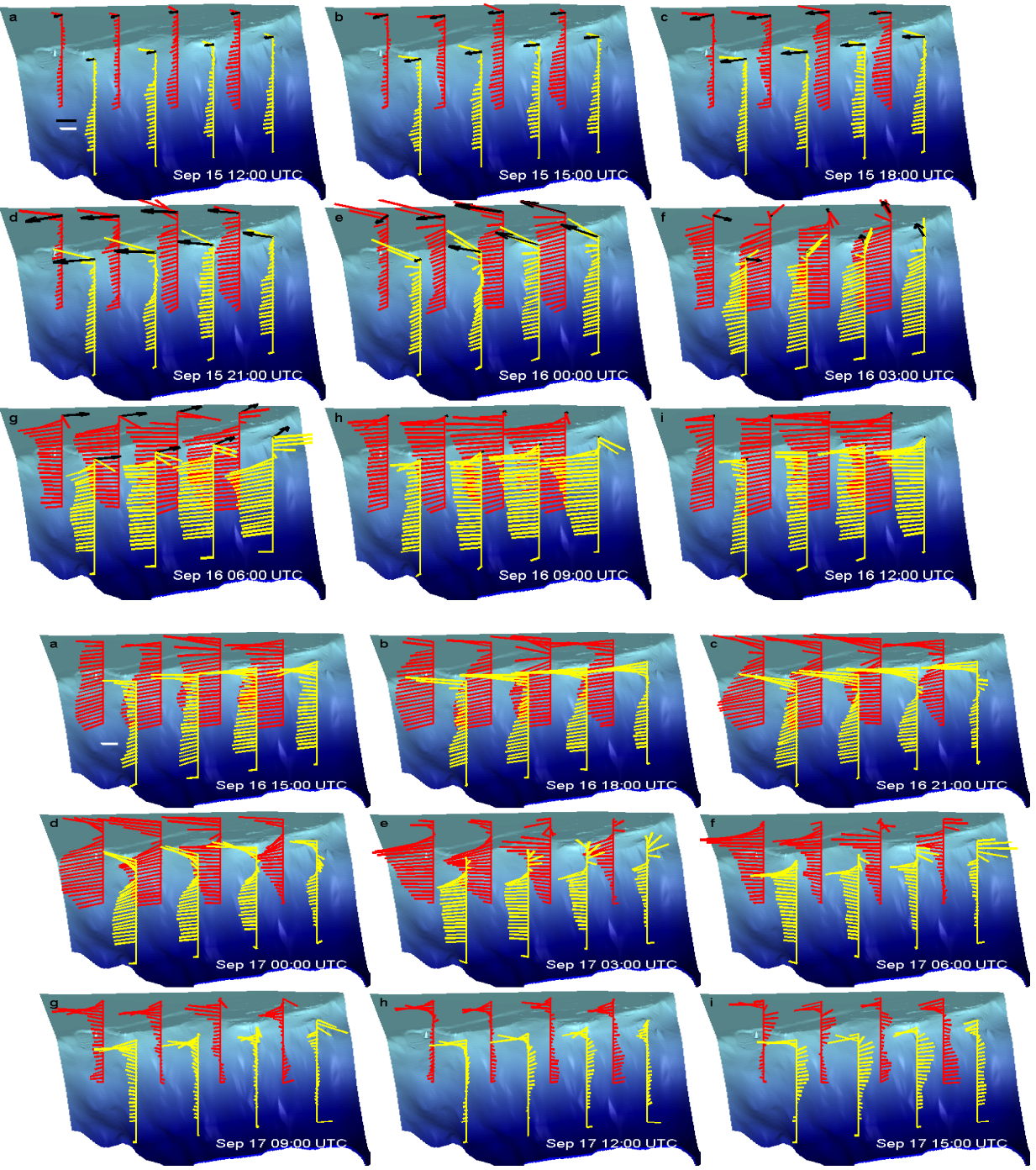
Hurricane Ivan Modeling Experiment Summary

Exp	Vertical Layers	Nearsurface Layer Thickness Range (m)	Vertical Mixing	Surface Forcing	Outer Nesting Model
EXP1 (base)	26	4-8	KPP	NOGAPS+ HWIND	NCODA
EXP2	21	3-5	KPP	NOGAPS+ HWIND	NCODA
EXP3	31	7.5-15	KPP	NOGAPS+ HWIND	NCODA
EXP4	26	4-8	MY	NOGAPS+ HWIND	NCODA
EXP5	26	4-8	GISS	NOGAPS + HWIND	NCODA
EXP6	26	4-8	KPP	° NOGAPS	NCODA
EXP7	26	4-8	KPP	NOGAPS +HWIND	NONE



Ivan's eye of over the moorings (dots) at 00 UTC on 16 Sept 04.

(a) Wind stress (Pa) with winds, (b) frictional wind velocity (m s^{-1}), (c) wind stress divergence (s^{-1}) (d) wind stress curl (s^{-1}). Based on HWIND fields.



Intense Forcing (upper) and

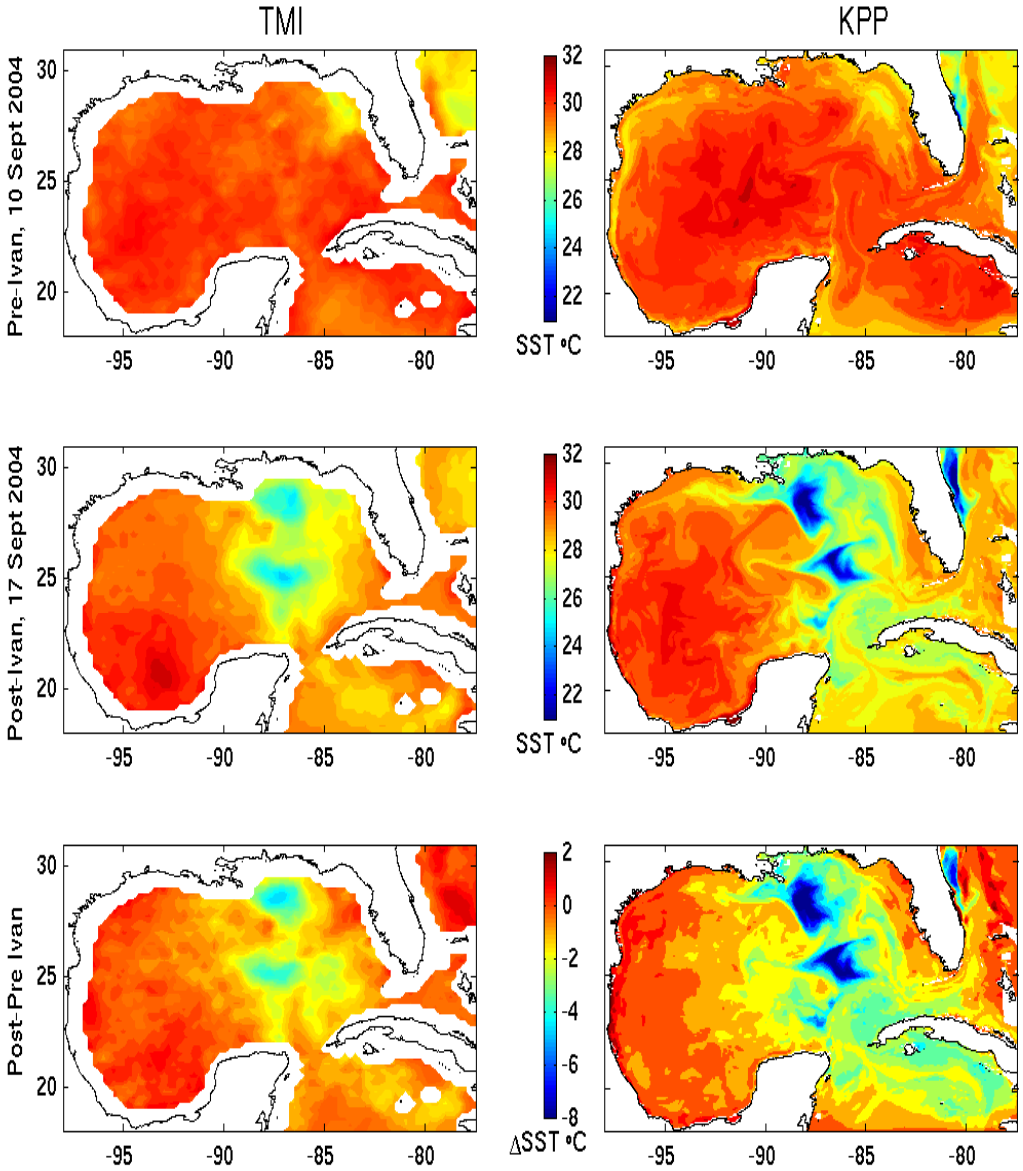
Relaxation Stages (lower) for NRL SEED moorings 7-14

7-10 Red ~500 m

11-14 Yellow~1000 m

(Teague et al. JPO, 2007).

TMI and KPP SST Comparisons



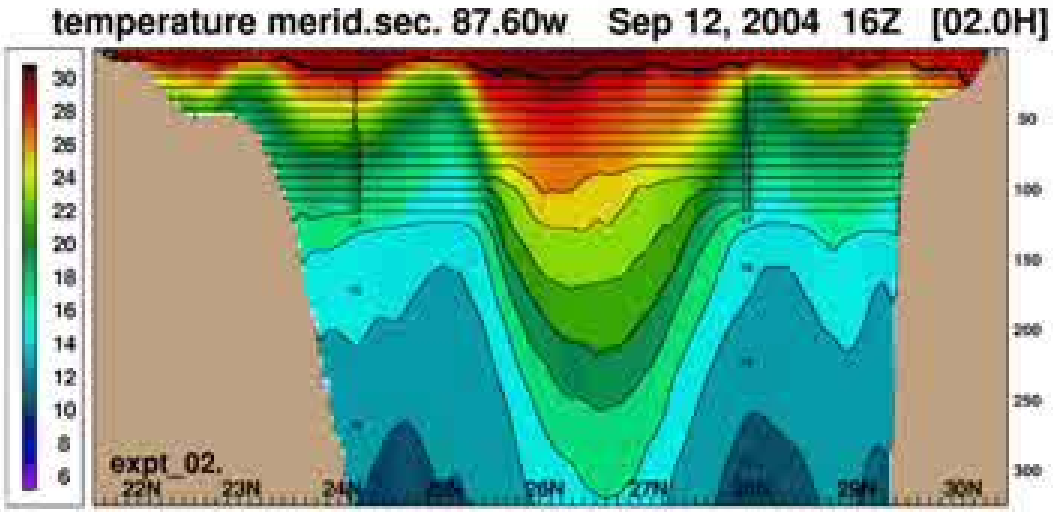
Pre Ivan SST

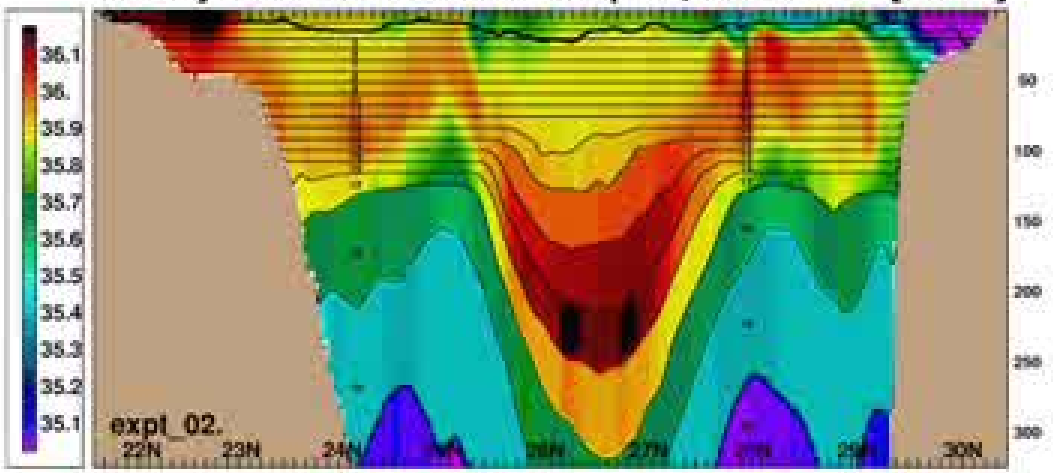
Post-Ivan SST

Pre-Post Ivan ΔSST

Summary of Major Differences Relative to Base State with KPP Mixing.

Experiments	Difference Factor from Base Experiment	ΔSST (°C)	ΔOHC (kJ cm^{-2})
EXP2 minus EXP1	Lower vert. res.	0.20	2.85
EXP3 minus EXP1	Higher vert. res.	0.10	1.63
EXP4 minus EXP1	MY mixing	0.38	5.87
EXP5 minus EXP1	GISS mixing	0.34	4.52
EXP6 minus EXP1	No HWIND	0.41	9.99
EXP7 minus EXP1	**No assimilation**	**1.04**	**24.40**
EXP5 minus EXP4		0.28	3.45


temperature merid.sec. 87.60w Sep 12, 2004 16Z [02.0H]
30
28
26
24
22
20
18
16
14
12
10
8
6
expt_02.
22N
23N
24N
29N
27N
30N
50
100
150
200
250
300

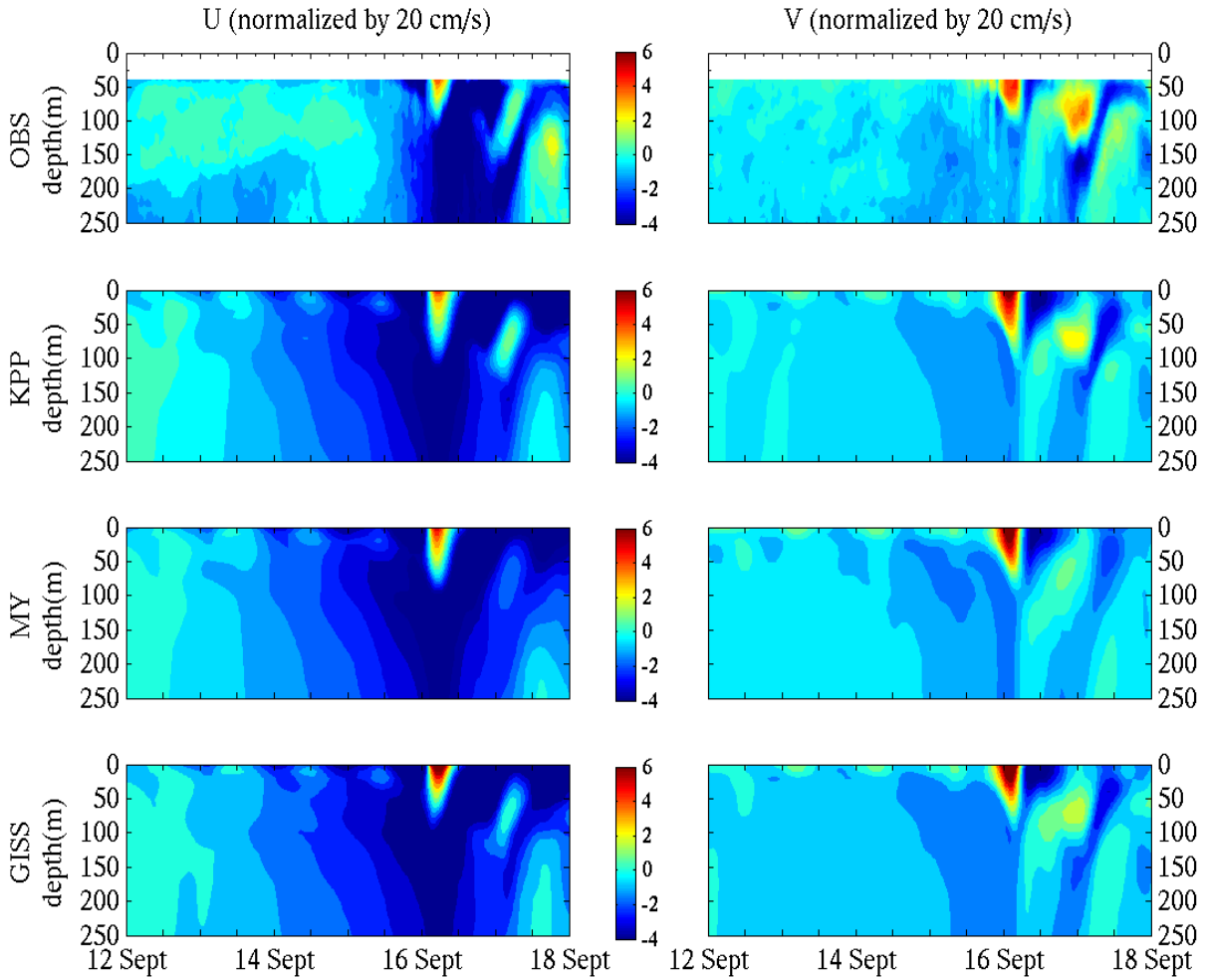

salinity merid.sec. 87.60w Sep 12, 2004 16Z [02.0H]
36.1
36.
35.9
35.8
35.7
35.6
35.5
35.4
35.3
35.2
35.1
expt_02.
22N
23N
24N
29N
27N
30N
50
100
150
200
250
300

SST Comparisons (°C) in Cold (Cyclone) and Warm (Anticyclones) for Each Mixing Scheme

	TMI	AVHRR	GISS Sim.	MY Sim.	KPP Sim.
Northern Cyclone (coldest T)	24.9	~23	22.9	22.8	21.3
Southern Cyclone (coldest T)	24.6	~22	21.1	22.2	18.8
Anticyclone (26-28°N, 88-89.5°W)	28.0	~28	29.4	29.4	29.2

Current Time Series Comparisons @ 1.5 R_{max}

U (east-west) V (north-south)



Observed

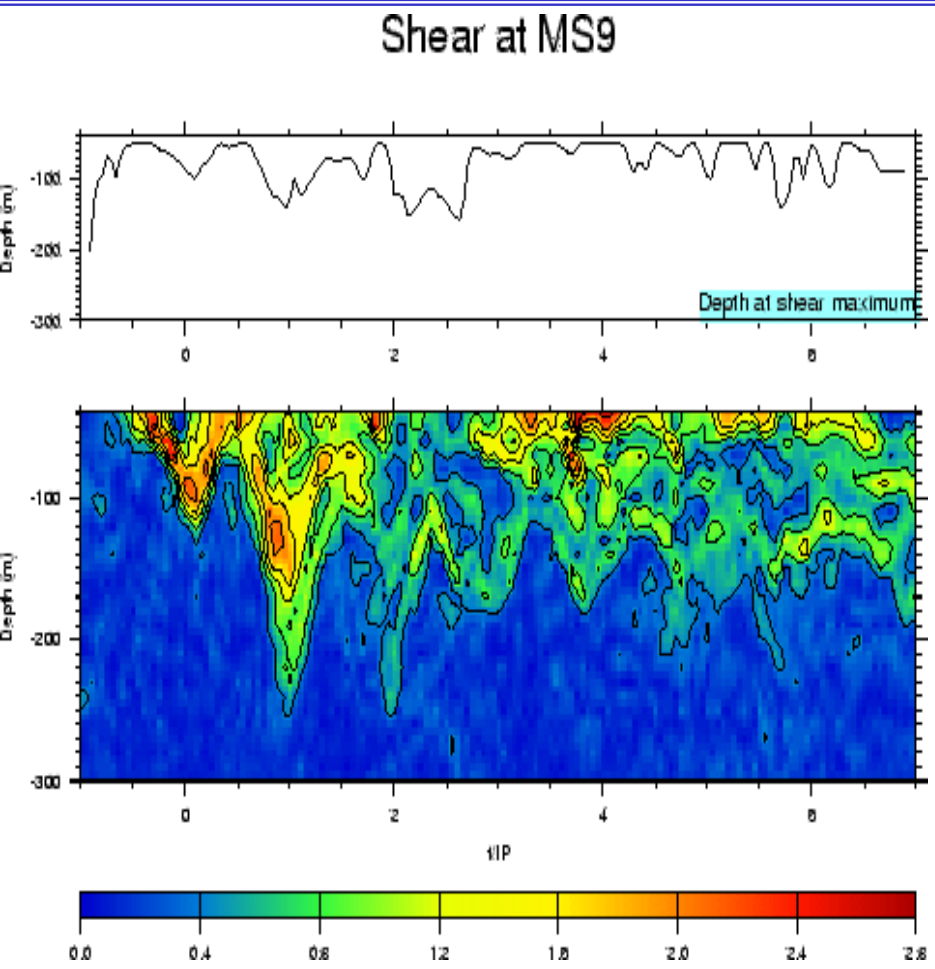
KPP

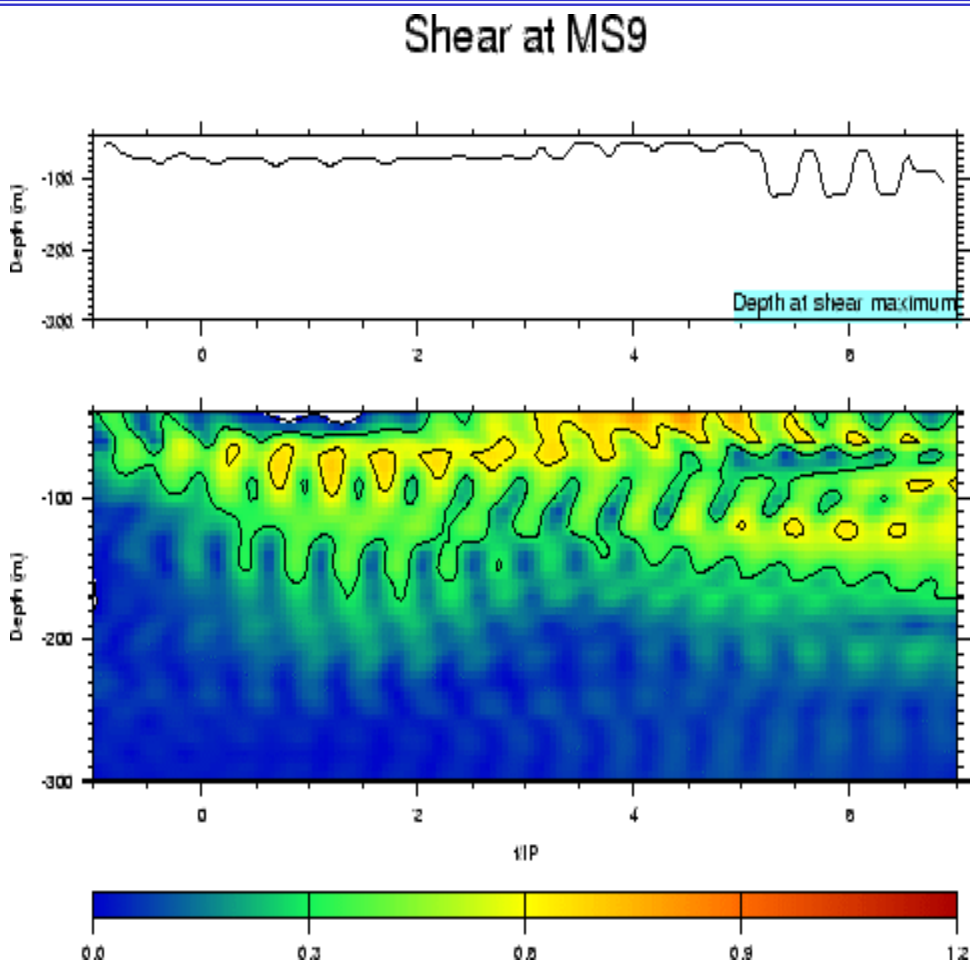
MY

GISS

Normalization $(\tau_{max}\, R_{max})/(\rho_0 b U_h) = 20$ cm s^{-1}

M9 (1.5 Rmax) Observed and Near-Inertial Current Shear Response (R_{max}= *32 km*)





Normalized shear by 10^{-2} s^{-1} based on Lili Data.

Progress and Blueprint For Future

Ivan a clear example of **negative feedback** (cooling/mixing induced by strong winds and Cold Core Ring) as opposed to **positive feedback** **over the Loop Current and Warm Core Rings.**

SST modulated by warm and cold ocean features that have to be properly initialized in ocean models and mixing. Data Assimilation essential!

Trifecta Katrina, Rita and Wilma is next.

Observed and simulated momentum response from deep ocean to the shelf. ***Potential for a student dissertation.*** Fields need to be made available to TC community.

Temperatures and currents needed to assess mixing schemes and evaluate initialization schemes. Expendables (AXCP, AXCTD, drifters) needed – Targeted Obs!

Working with MMS on their 5-year Loop Current Dynamical Study, NOAA HFIP and NSF