Air-Sea Interactions in Tropical Cyclones Workshop at NCEP: What Lies Beneath

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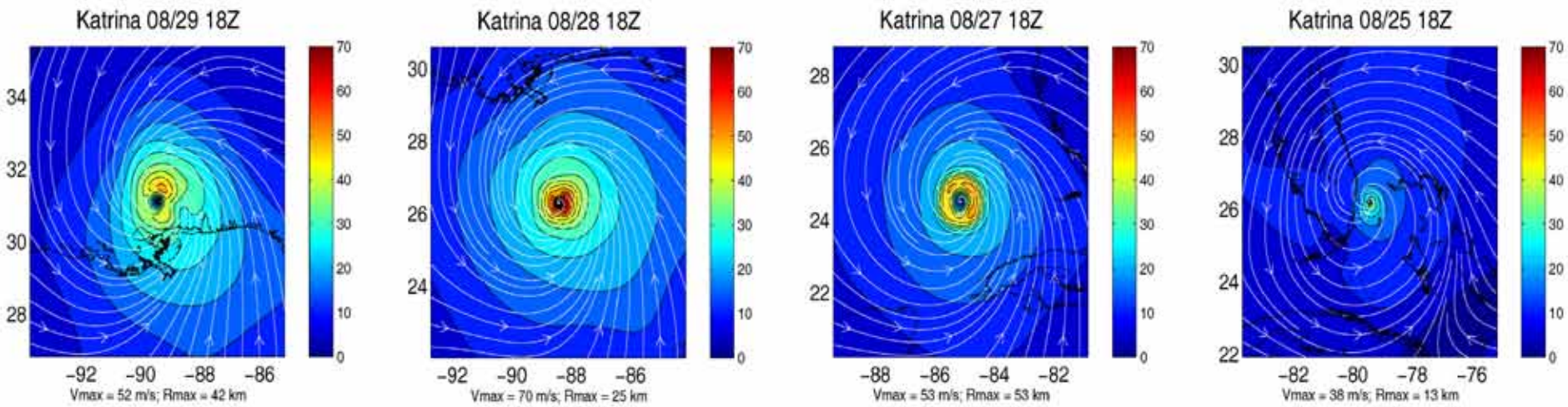
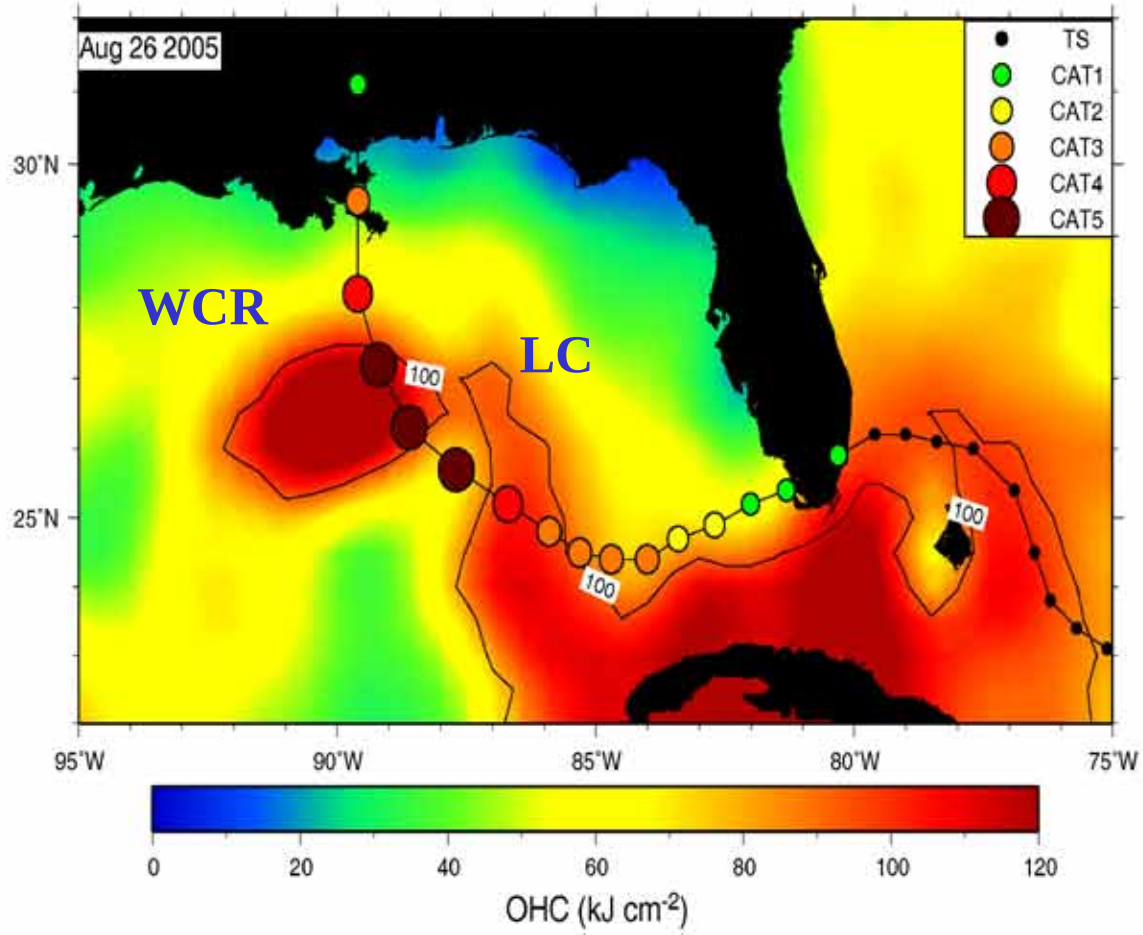
Charge: Assess progress in air-sea interactions during tropical cyclone passage from experimental, empirical, and numerical perspectives aimed at improving intensity forecasting at NCEP.

Acknowledgment and Preface:

- Dr. Steve Lord of EMC/NCEP and colleagues provided support for the workshop.
- Broad participation ~35 to 40 researchers and operational forecasters involved in experimental, empirical, and numerical studies.
- Several presentations provided the framework for breakout group discussions on both atmospheric and oceanographic processes wrt HWRF.
- Web site with report available shortly.





Katrina's Path and Strength Relative to Pre-Storm OHC and 10 m surface winds from HRD's HWIND Product (Mark Powell and colleagues)

Background:

A recurrent theme in workshop discussions from both breakout groups build on recent field programs such as ONR-CBLAST experiments in multiple years and NSF/NOAA HFP in Isidore and Lili as well as other efforts.

Breakout Group Questions:

1. What relevant time-space scales need to be resolved to improve intensity predictions and what are the needed observations to evaluate them with regard to vertical mixing, wave coupling, and air-sea parameterizations?
2. What metrics are needed to evaluate model-generated fields, and how do we implement them in near-real time for forecasting?
3. What is the design of an optimal field program for the evaluation of these models fields for *in situ* and satellite-based support? How can the community maximize the Integrated Ocean Observing System data?
4. What is the current *state-of-the-art* in observations and models for the tropical cyclone problem, and how can we maximize recently acquired data sets?

Recommendation 1:

Given the range of uncertainty in the surface drag (e.g., wave effects), heat fluxes (e.g., sea spray), and initial conditions (e.g., wind field) beyond 30 m s^{-1} using CBLAST data, assess how these uncertainties propagate through the coupled Models (i.e. GFDL/HWRF).

Recommendation 2:

Develop an archive of air-sea data sets and model outputs and make these archives available for research and operational purposes. Investigate the potential use of these data sets in assimilation, evaluation, and verification of models and parameterization schemes (e.g., Hybrid Coordinate Ocean Model).-**Not just a comparison between best track data and observed intensity.**

Experiments: High Winds

Few Experiments where U,V, T, and S have been measured….

•ONR CBLAST (Frances 04)

•NSF/NOAA HFP (Isidore, Lili 02)

•ORTAH Group (Norbert 84, Gloria 85, Josephine 84)

•ONR/NOAA (Gilbert 88)

•NSF/NOAA Post Katrina/Pre-Rita, Rita and Post-Rita (05)

Recent fortuitous encounters with moorings.

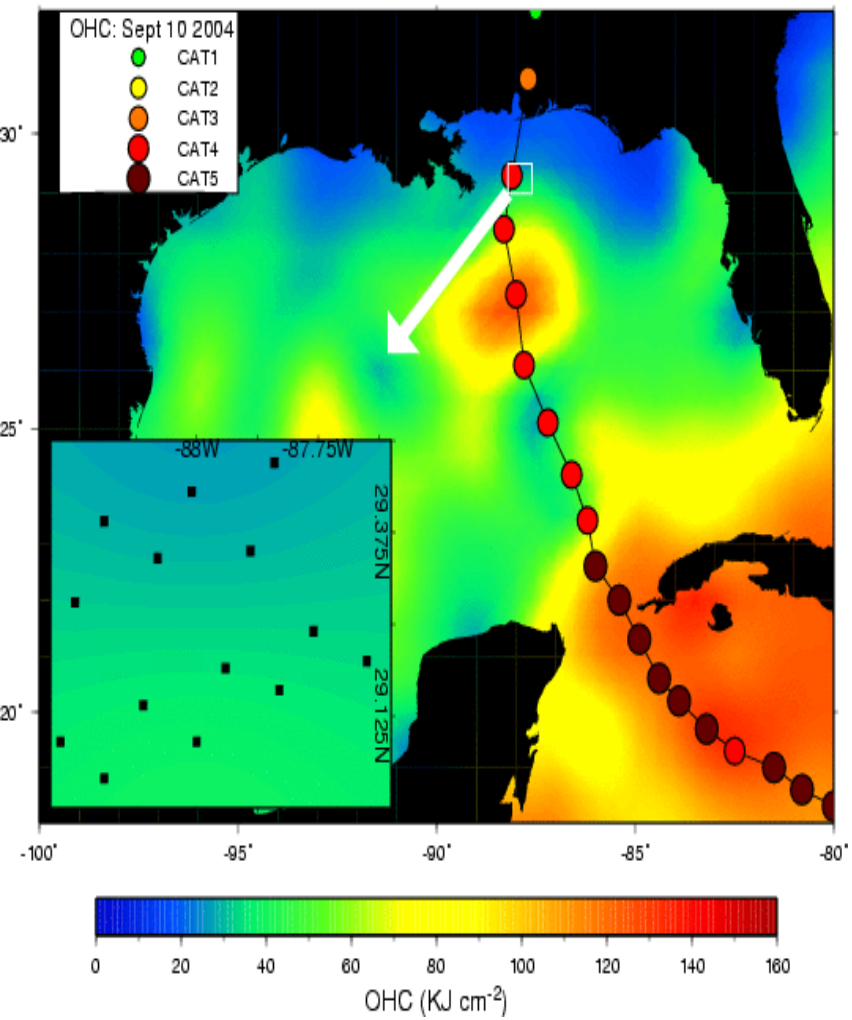
• MMS (Georges 99)

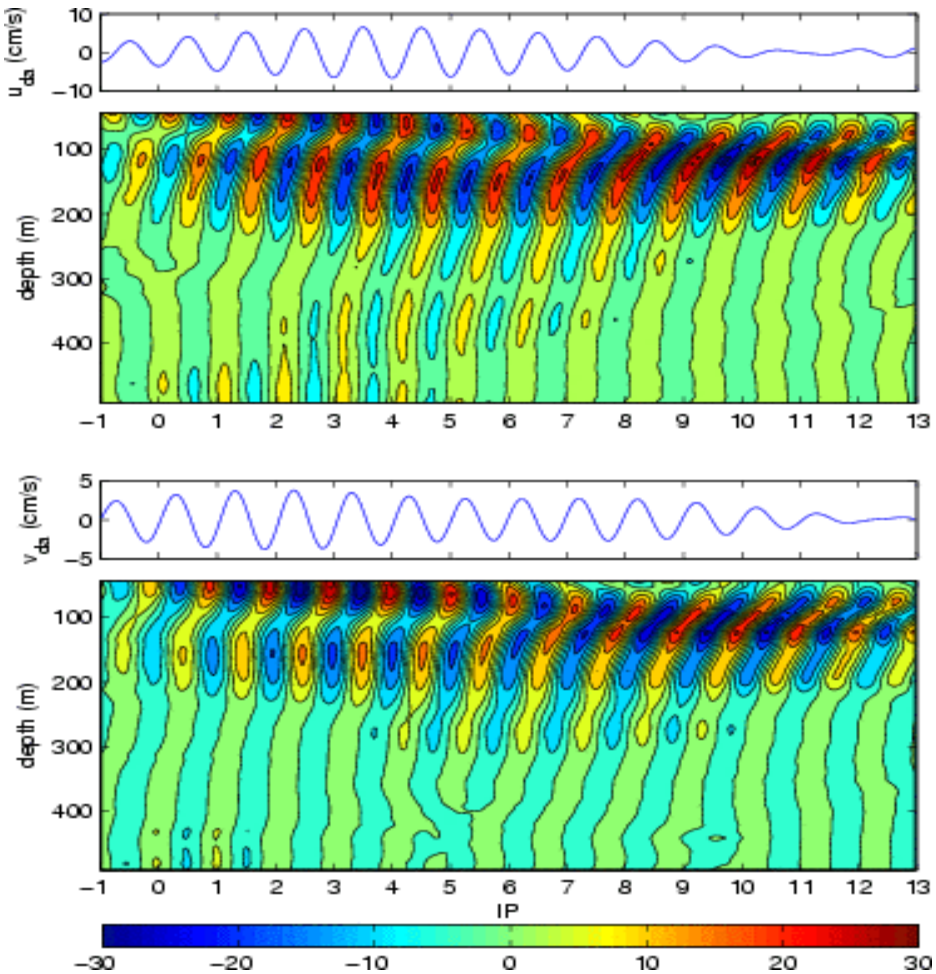
• NRL (Ivan 04)

Coastal HF Radar-SEA-COOS and GMOOS programs

•ONR Hurricane Jeanne (04)

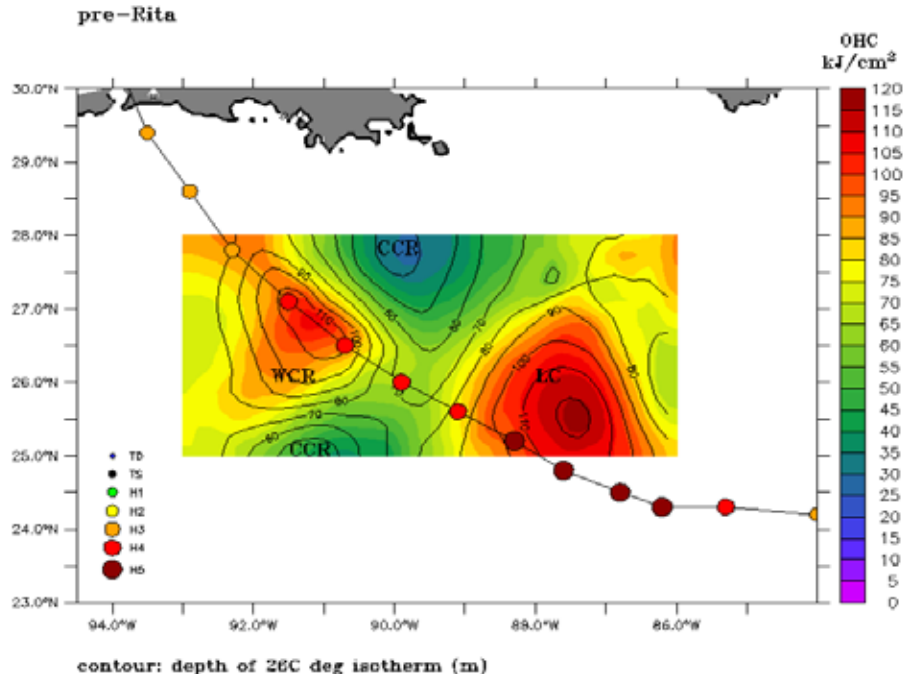
IVAN NRL ADCP Data:

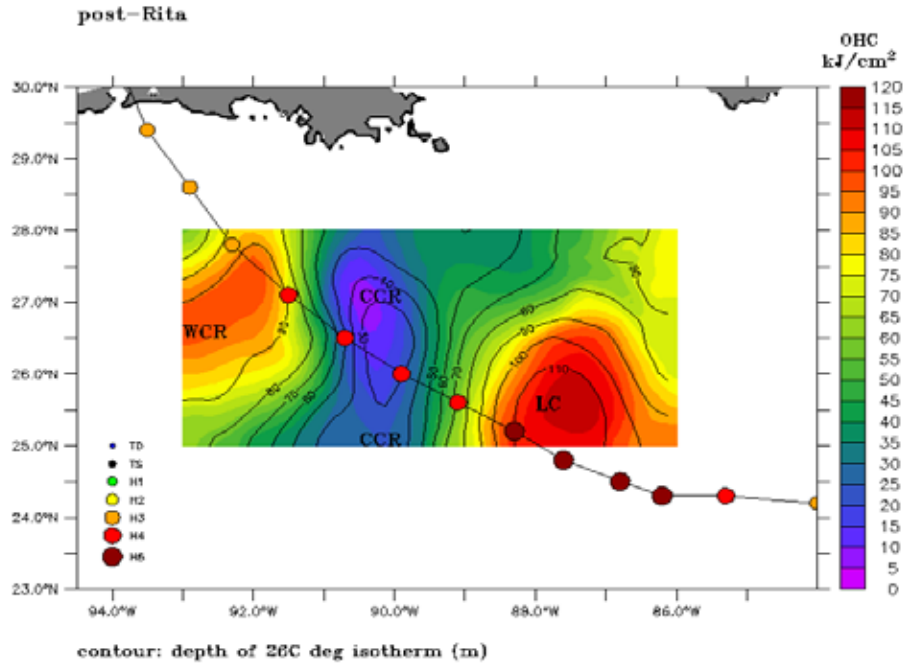


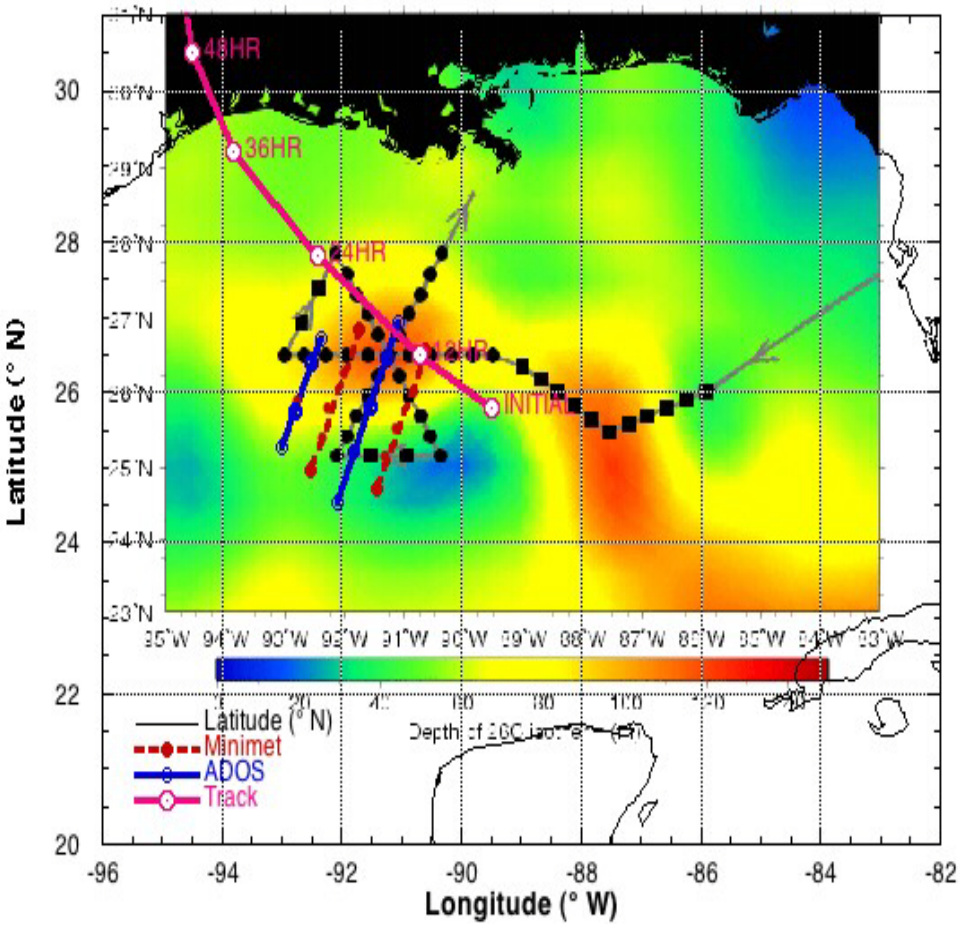


Recommendation 3:

Develop *in-situ* tropical cyclone coupled observing program for pre-storm, storm, and post-storm environments that optimizes sampling strategies and observational mix for spatial evolution of upper ocean current, temperature and salinity, interface processes such as surface waves and winds, and air-sea fluxes and atmospheric boundary layer fields (including secondary circulations such as roll vortices);





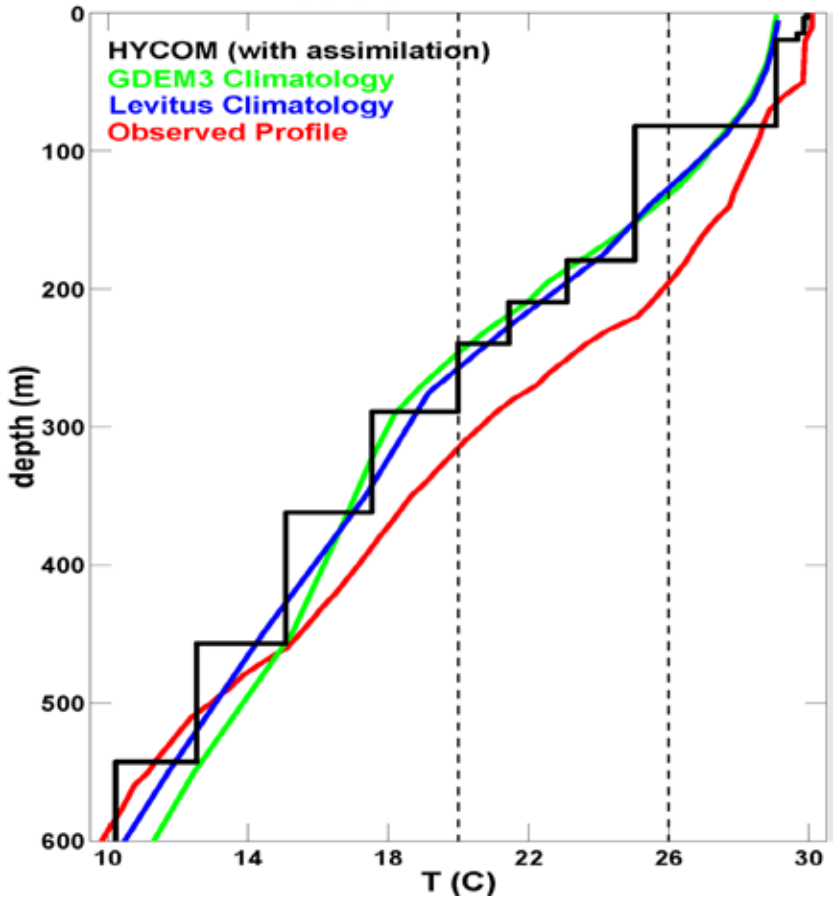


Pre/Post Rita Research Flight on 15 and 26 Sept 2005 from the NOAA WP-3D and SIO drifters (mini-met and ADOS) from the C-130.

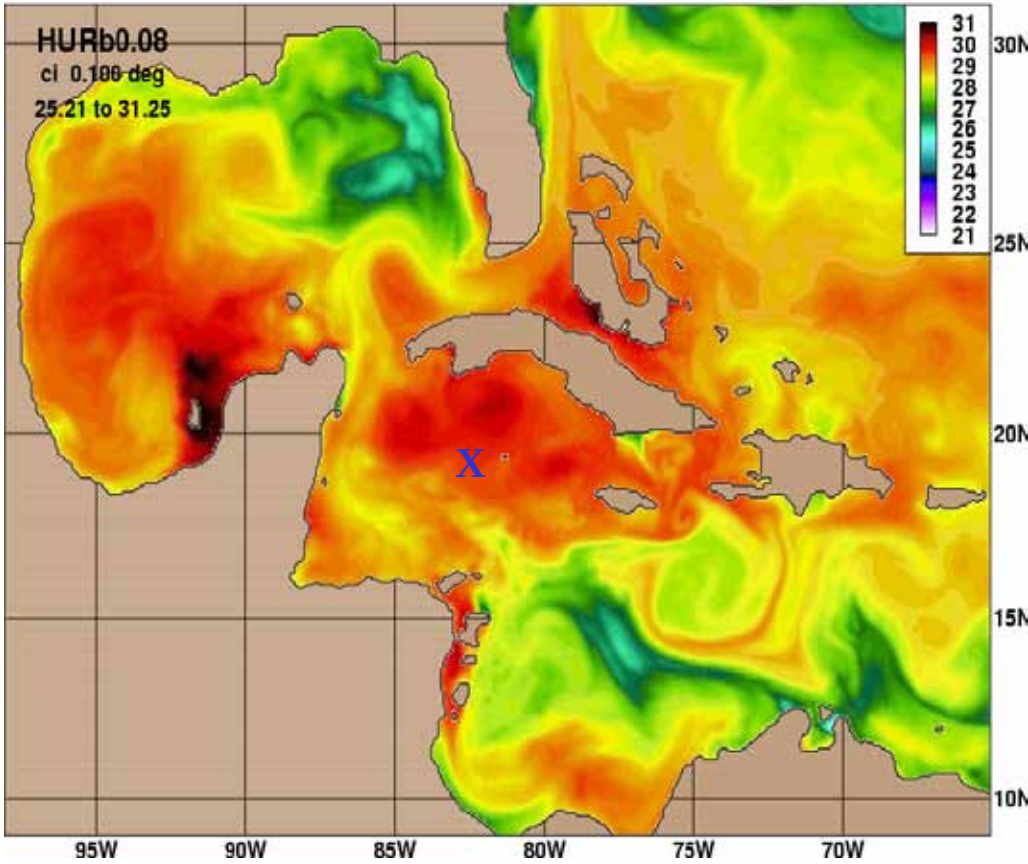
Recommendation 4:

Develop improved ocean model initialization schemes through data assimilation of satellite and *in situ* measurements, and test oceanic mixing parameterizations for a spectrum of ocean, wave and atmospheric conditions including the impact of waves on the surface heat, moisture and momentum fluxes and thus on the evolving ocean mixed layer and the entrainment zone.

Observed and Simulated Pre-Isidore Ocean Conditions in HYCOM:



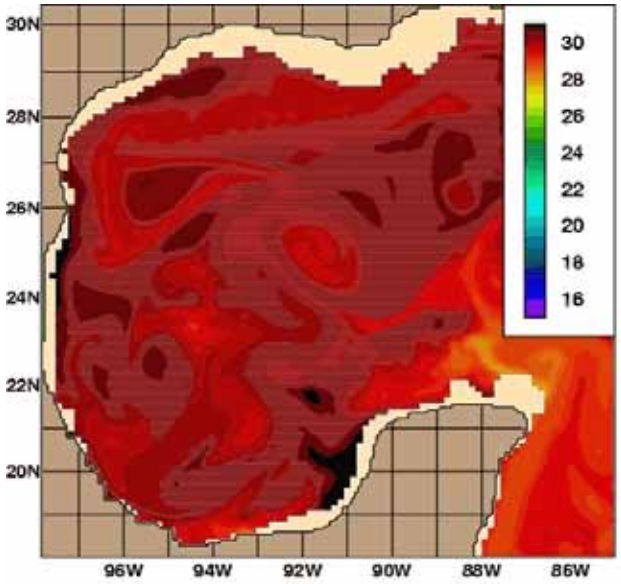
Vertical Structure (left)



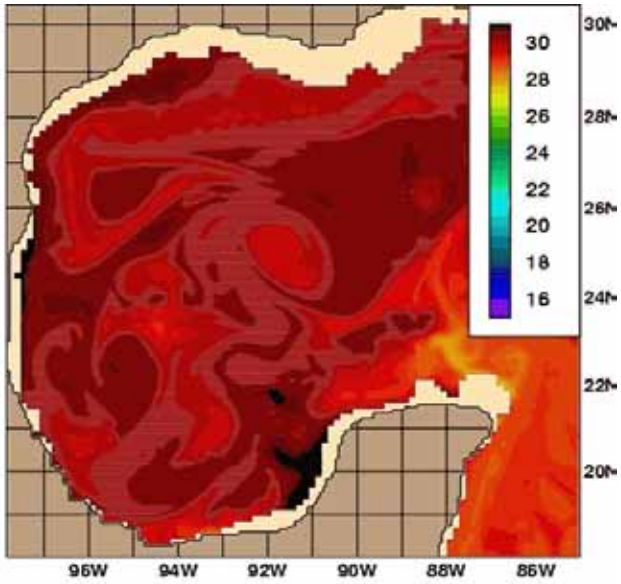
SST Simulation (with assimilation)

HYCOM SST Response to Gilbert (88) with WCR
Courtesy of S. D. Jacob

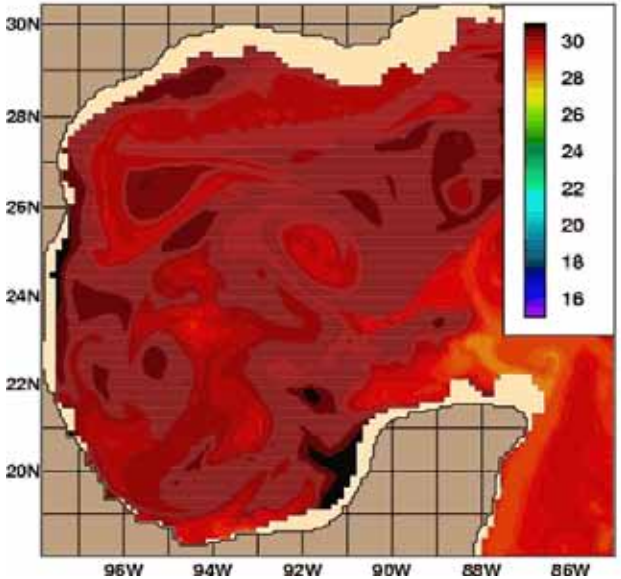
KPP



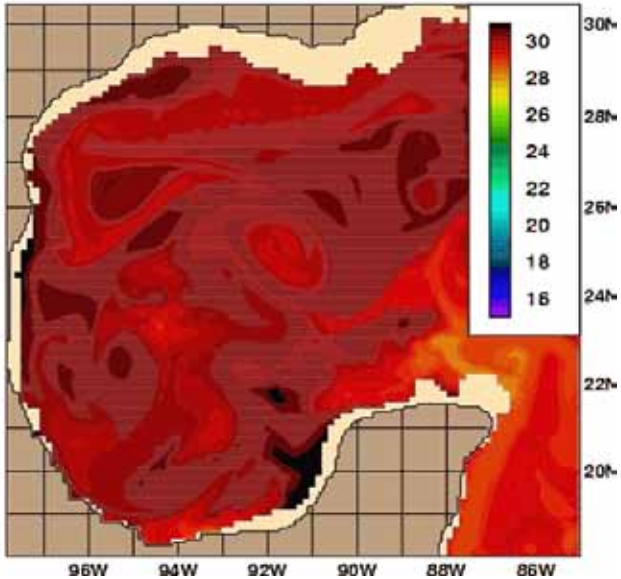
PWP



MY



GISS



NCEP Workshop Summary

Building on previous experimental and numerical studies, broad consensus is that the next generation coupled models (HWRF) must:

1. **Extend the range of bulk transfer coefficients** beyond 30 m s^{-1} and examine how uncertainties propagate into the models;
2. **Develop a data archive** for ocean and air-sea interaction fields for the research and forecasting communities;
3. **Develop optimal sampling schemes** for the upper ocean and atmospheric boundary layer that includes pre, during and post hurricanes to *evaluate* model fields;
4. **Initialize ocean models** by assimilating observations from Argo floats, satellite fields and carefully evaluate numerical schemes such as vertical mixing and air-sea parameterizations.

What lies beneath (The Ocean) has important effects on coupled ocean-atmosphere interactions and hurricane intensity.