Coupled Air-Sea Interaction Team Report

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Daniel Melendez (NOAA/OAR)

HFIP Telecon, 14 November 2012

Outline

1. Team reorganization
2. NCEP: operational development
3. URI: Coupled modeling
4. NRL-Monterey: COAMPS-TC
5. ESRL and URI: NOAA/ESRL sea spray flux parameterizations
6. AOML: idealized HWRF v.3.2 ocean response study
7. Team workshop summary (19-20 Sept. 2012)

1. Team 8 Reorganization

- Name changed to "coupled air-sea interaction" team
- New members
  - Hyun-Sook Kim (EMC)
  - Joe Cione (HRD)
  - Eric Uhlhorn (HRD)
- Hyun-Sook Kim replaced Hendrik Tolman as co-lead

2. NCEP: Operational Development

RTOFS Global HYCOM

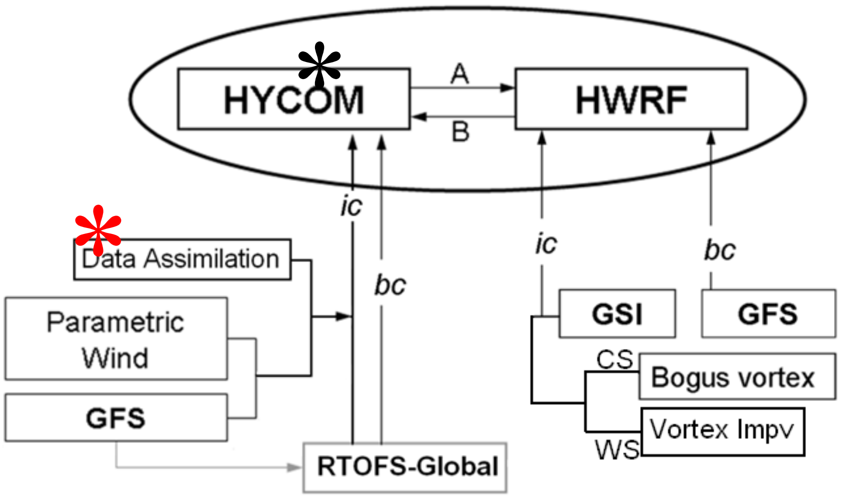
- KPar update using monthly Ocean Color Observation
- Implementing latest ESMF version in progress

Wave Watch III

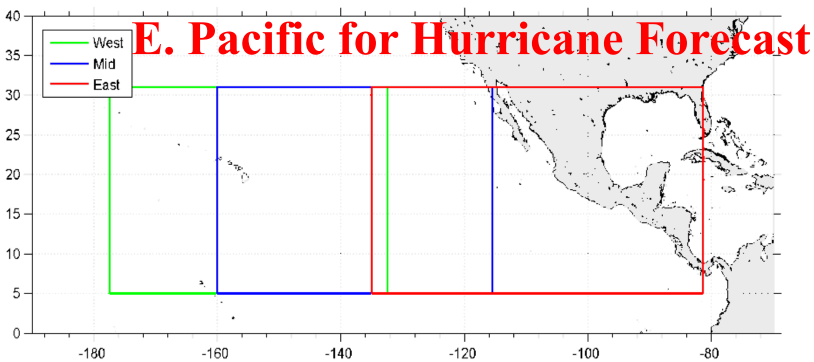
- 3-way coupling in progress
- ESMF compliance and WWIII modularization will be completed in next 6 months.

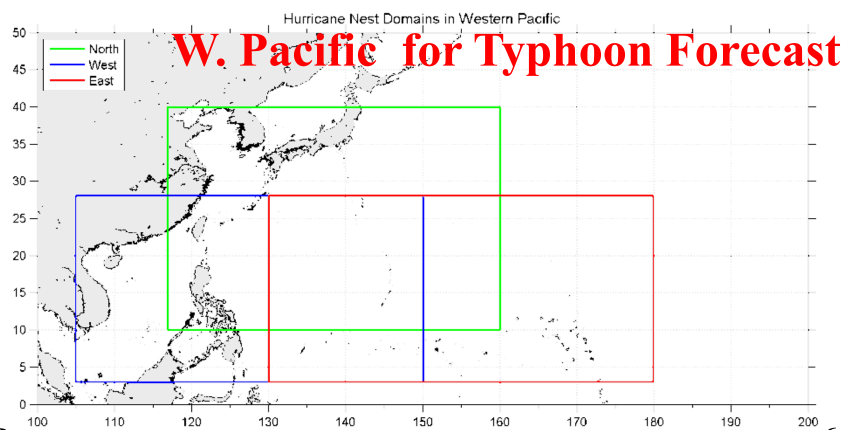
Version 2012 – HyHWRF2

1. Eddy-resolving, 1/12-degree and 32-layers (better res. in the mixed layer) HYCOM
2. IC/BC from RTOFS Global
3. Provide uniform ocean to E. Pac, W.Pac and Atlantic – easier to configure
4. Data Assimilation – Global
5. Data Assimilation – Regional (in progress)
6. Re-locatable, practically anywhere in the *world
7. ESMF compliant – advantage for 3-way coupling



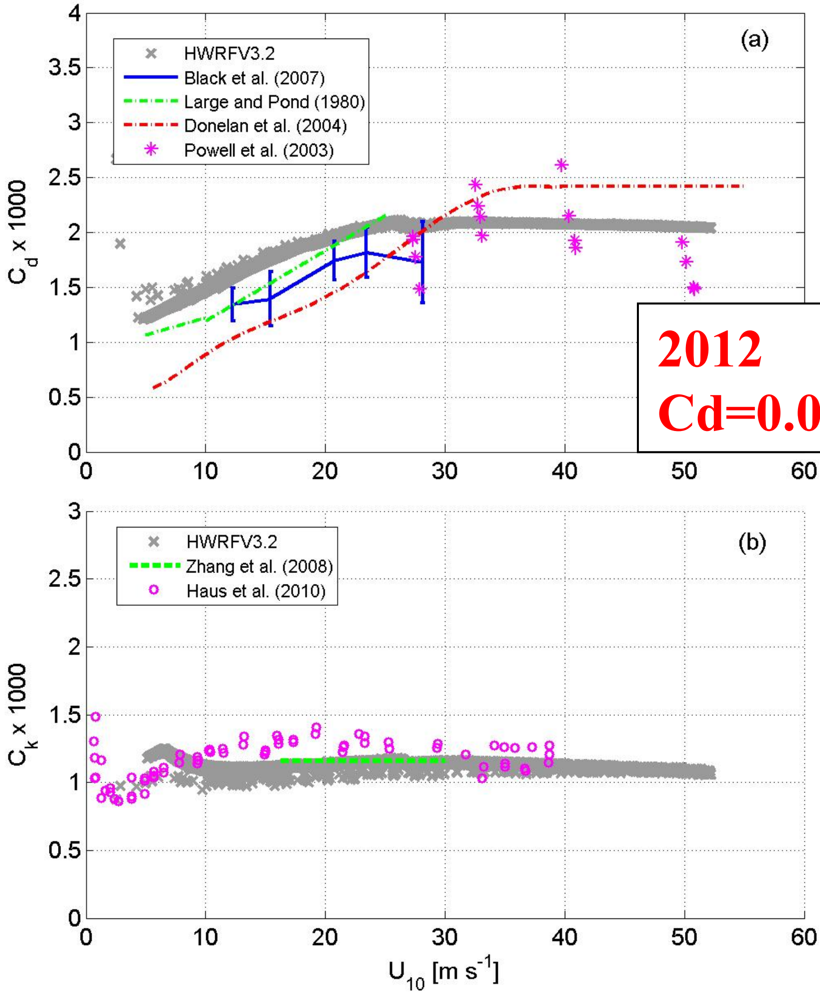
* Same config. as the Global





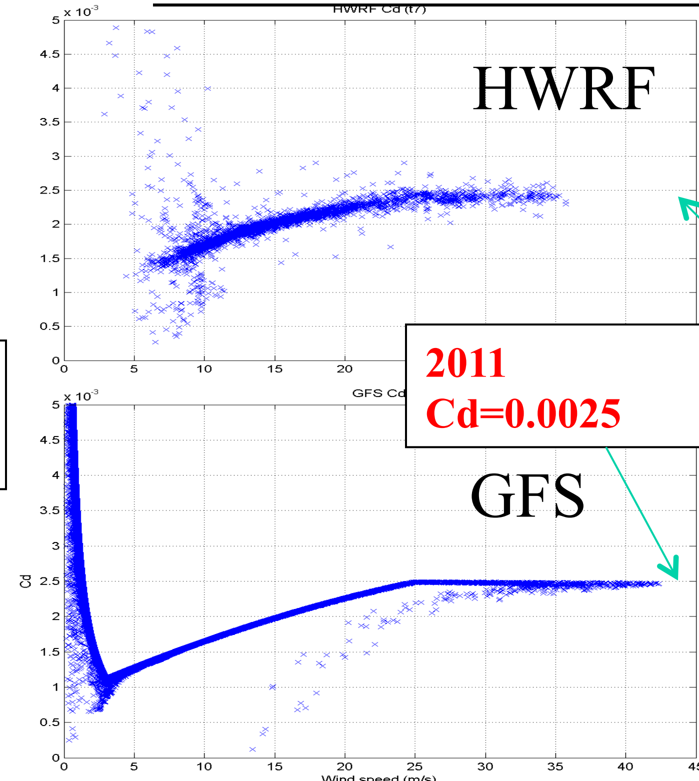
Air-Sea Exchange Parameters – Cd and Ck

2012 HWRF Cd & Ck



2012
Cd=0.0020

Cd for 2011 HWRF and GFS



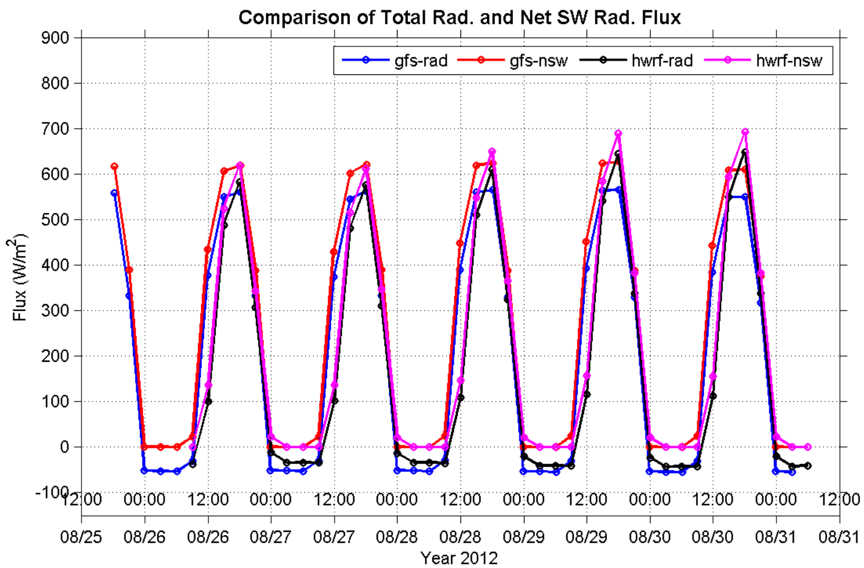
2011
Cd=0.0025

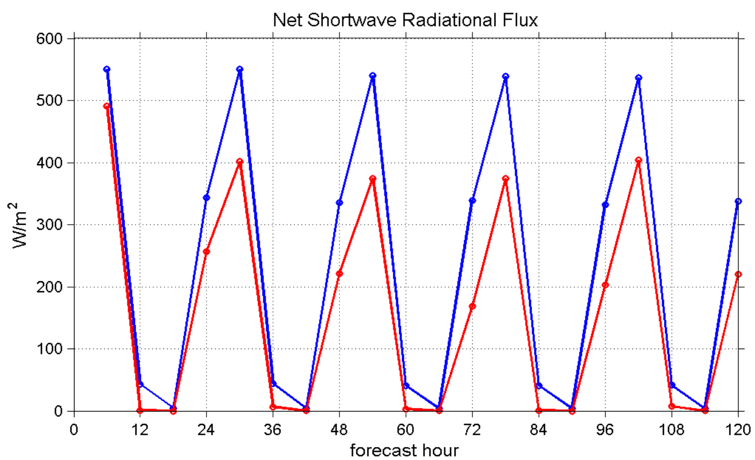
GFS 2012
Cd=0.0025

1. **2012 Cd** ~2.5E-3 (GFS) vs. 2E-3 (HWRF)
2. **The inflection point:**
   5 – 10 m/s for HWRF ;
   ~2.5m/s for GFS.

Heat Flux Comparison between HWRF and GFS

Total and Net SW Rad.





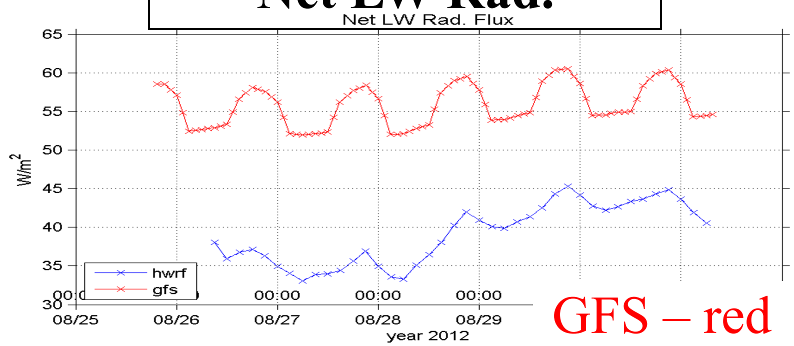
GFS – blue
HWRF – red

Year 2012

Improvement of radiational heat flux (little difference between them)
But,

1. Daily max. increases with time (both for total and HWRF for net SWRad).
2. HWRF Net LW Rad. is ~30% smaller than the GFS.

Net LW Rad.

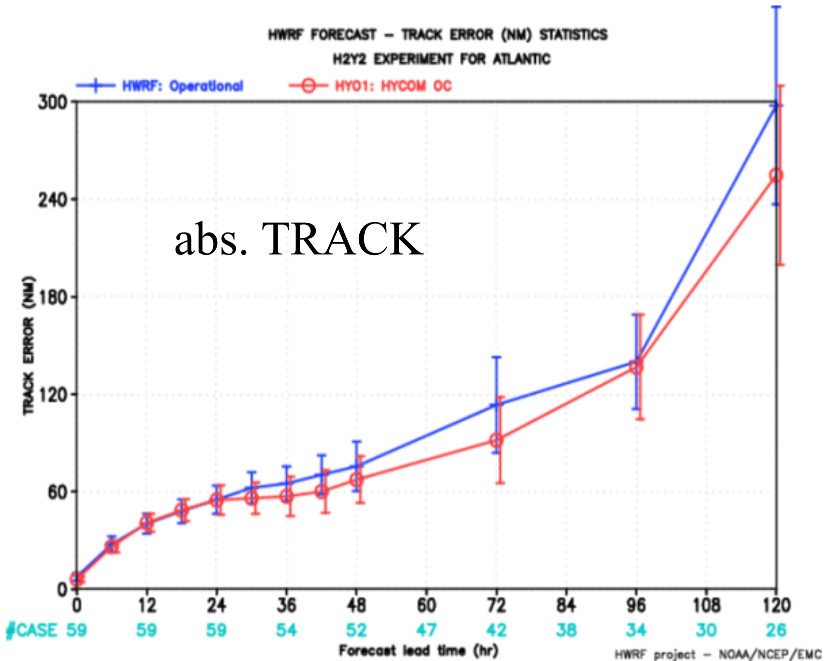


GFS – red
HWRF – blue

Before Year 2012

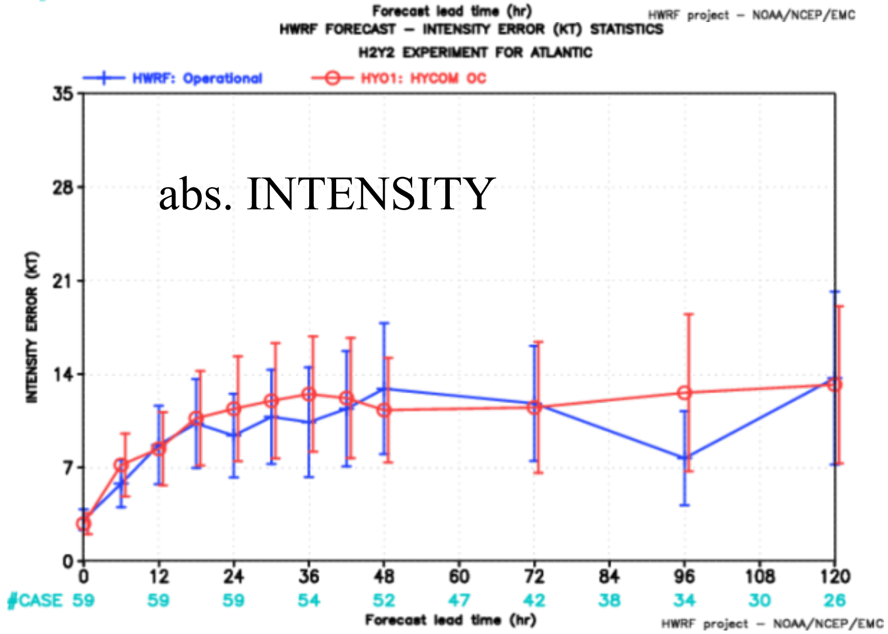
An ad hoc correction was implemented in the coupled system.

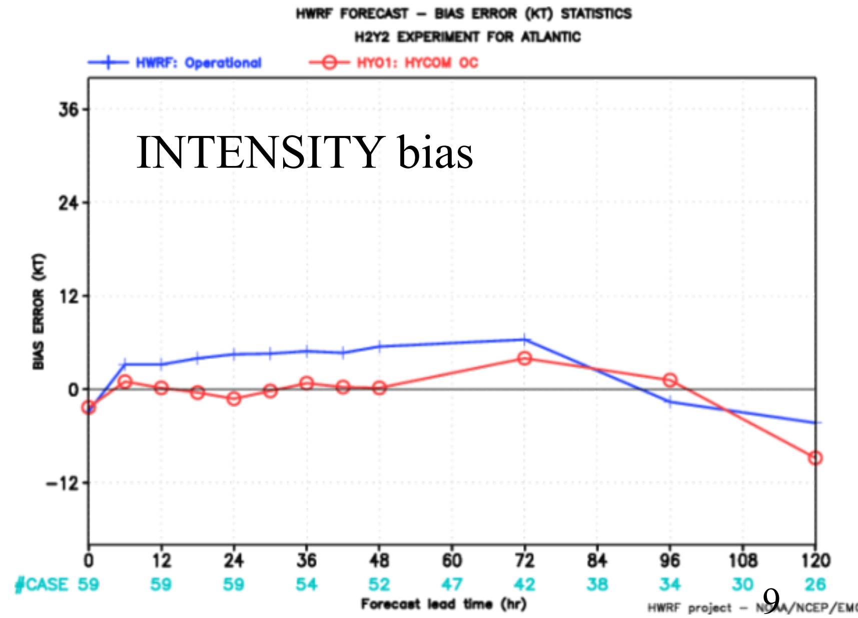
Parallel run for three basins – Atlantic, East Pac. (West Pac. In progress)



Results shown for two Atlantic hurricanes"
<u>Issac (09L)</u> <u>and</u> **<u>Sandy (18L) (59 cases)</u>**

HWRF – blue
HyHWRF - red

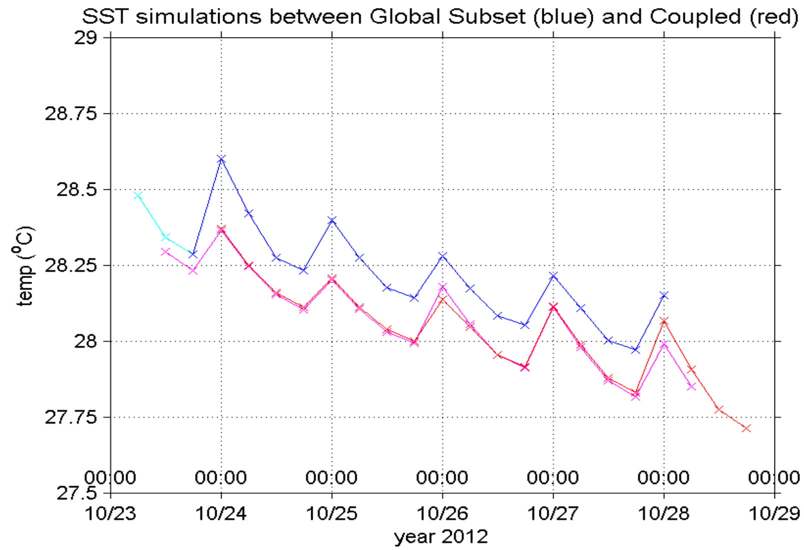




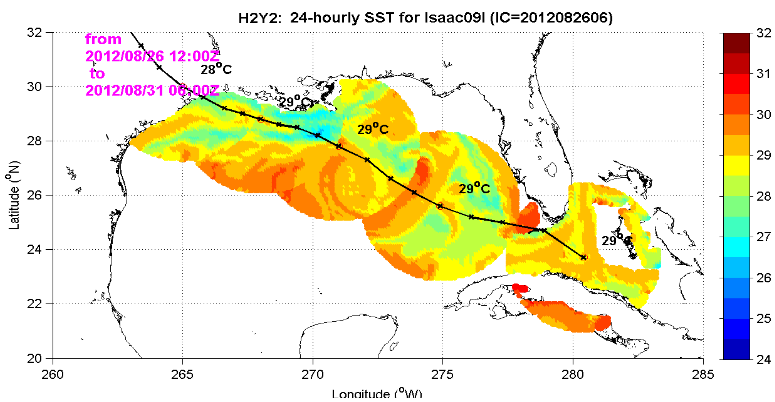
SST Evaluation

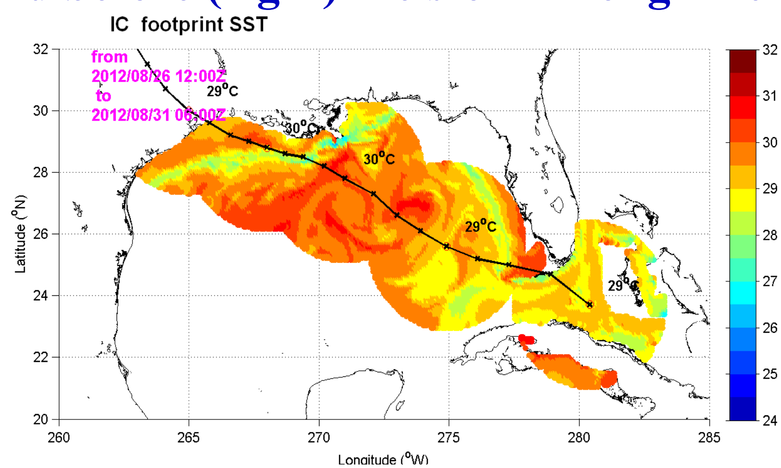
SST simulation comparison between subset Global HYCOM (blue) and coupled simulations (red)

- coupled shows lower SST by ~0.20°C on average. ➔ may be related to FLUX (later)



a) Footprint SST - cooling during (left) and before (right) the storm along track





SST Cooling:

- 0.5°C footprint average
- but, peak as large as 3.5°C

Initial Condition for 06Z 2012/08/26 cycle

The cooling verification is still in progress

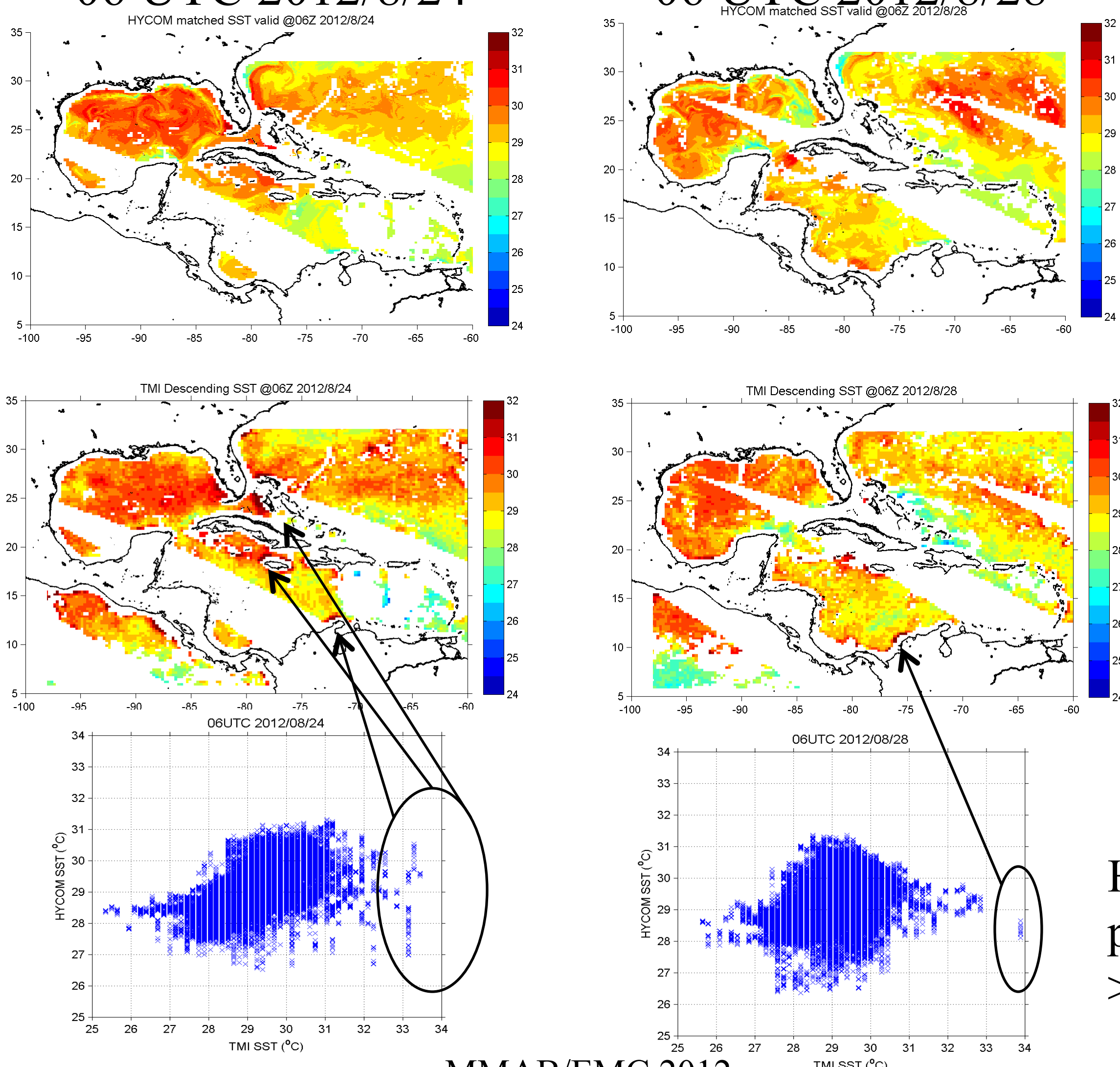
b) Domain-wide SST: Comparison to Remote Sensing Satellite Obs.

Example – w/ TMI SST

06 UTC 2012/8/24 | 06 UTC 2012/8/28

HyHWRF SST

TMI SST



In terms of large scale comparison – good agreement;

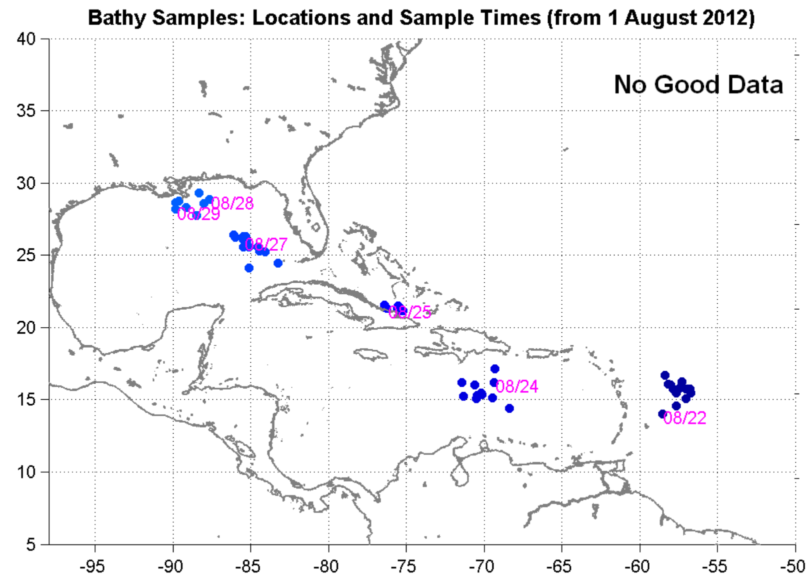
TMI SST in shallow waters trustworthy??

However, point-point comparison >???

Ongoing HY-HWRF Evaluation

- Target for operational implementation: 2015
- Ocean model evaluation
  - Is the ocean model correctly reproducing the relevant physical processes that control SST cooling?
  - Will focus on subsurface dynamical and thermodynamical balances
- Evaluation of air-sea fluxes
  - Must also be physics-based
- Hurricane Isaac will be an important test case

Real-Time Transmitted Data as of Sep. 2012

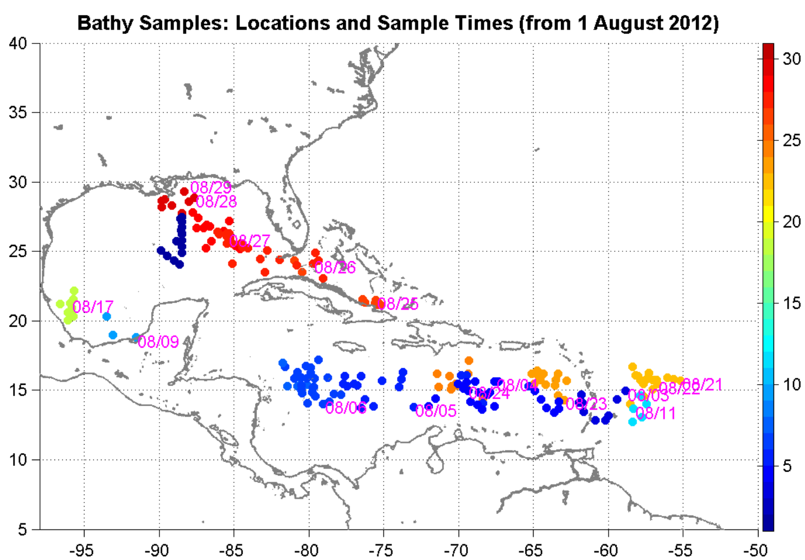


I. Types

A. <u>AXBTs</u> from WC-130J and P3
B. <u>SeaGlider</u> from NDBC
C. Argo <u>Drifters</u> from SIO
D. NDBC <u>buoys</u>

II. Quality check

1.A. AXBTs

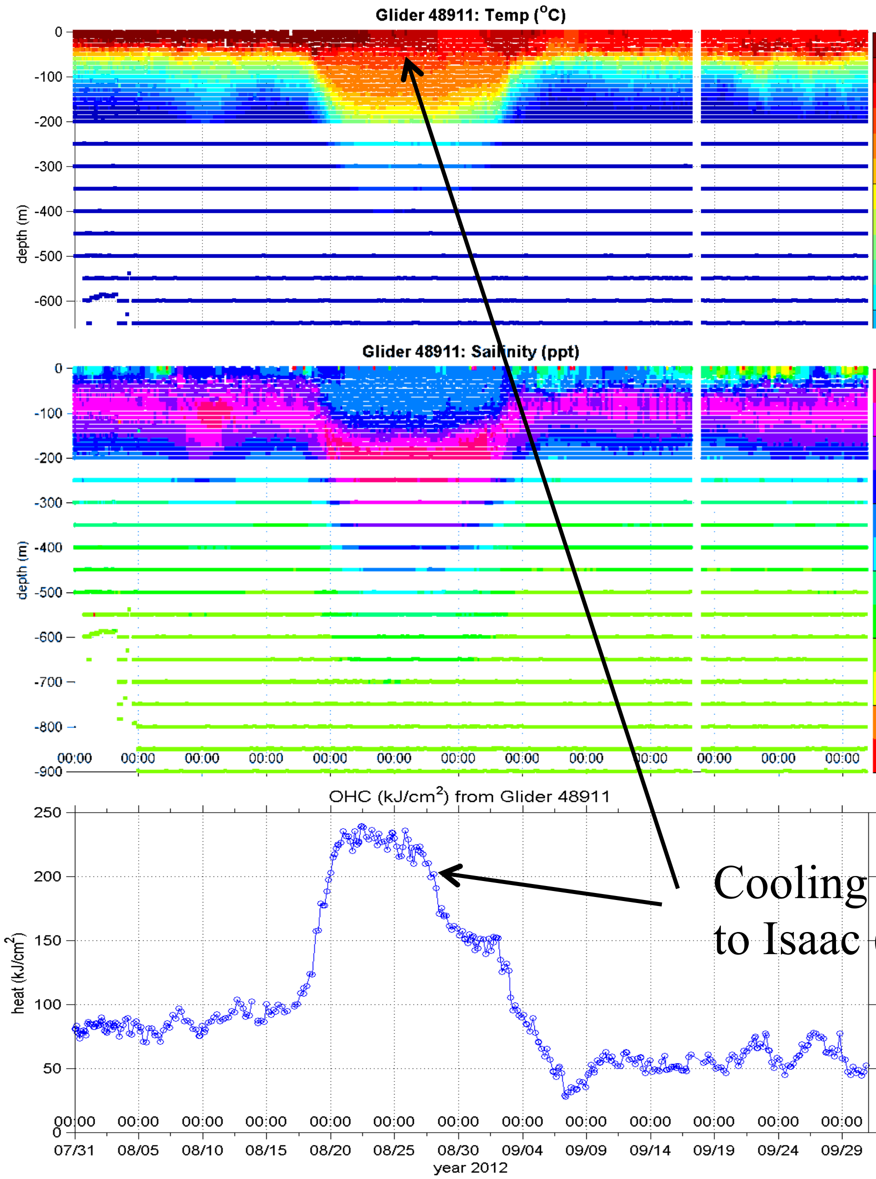


~35% bad data

Due to Message Format Error ??? – still in investigation lead by Beth Sanabia.

13

Real-Time Transmitted Data



Cooling due to Isaac (09L)

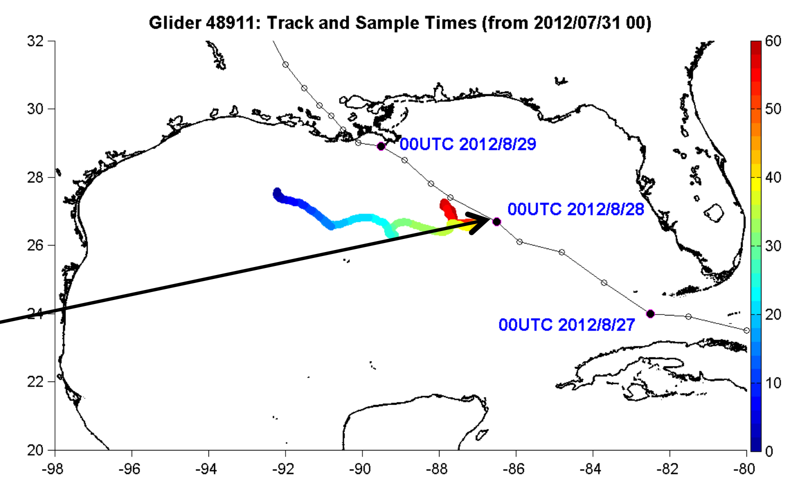
SeaGlider from NDBC

(POC: Walt McCall)

The first time in the GOM !!!

NDBC is in the process of acquiring QC package from NAVOCEANO. ➔ Help to remove some noise.

Web site for Wpac and Epac
http://www.ndbc.noaa.gov/gliders.php



3. URI: Coupled Modeling

URI Contribution to Ocean/Wave Models Team Report for the HFIP Telecon

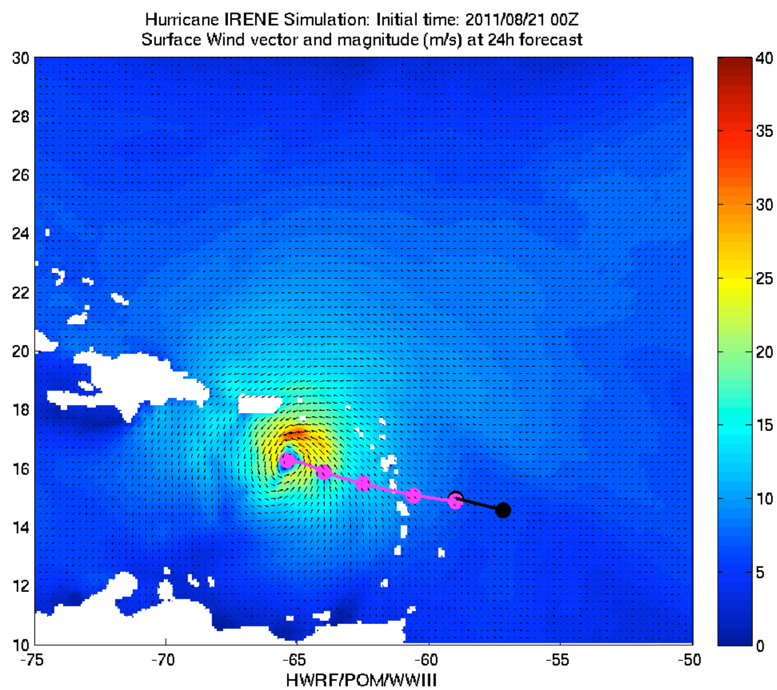
Isaac Ginis, Richard Yablonsky, Biju Thomas, and Melissa Kaufman

University of Rhode Island, Graduate School of Oceanography
Narragansett, Rhode Island, United States

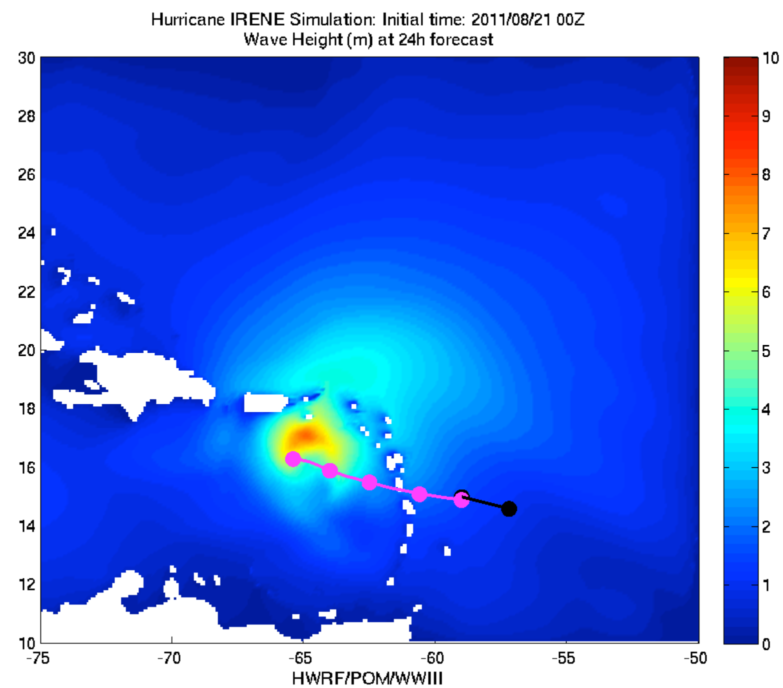
HFIP Telecon
14 November 2012

Incorporating URI's air-sea interface module into a coupled HWRF-wave-ocean model

Surface wind



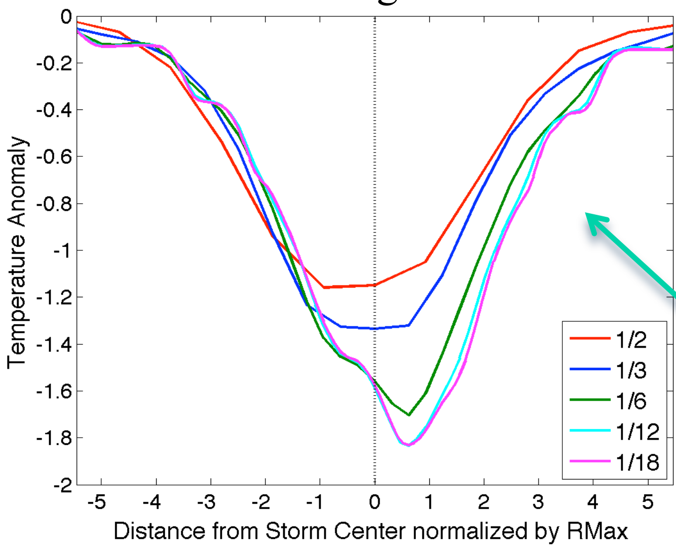
Significant wave height



HWRF-WAVEWATCH: Hurricane Irene (2011) 24-h forecast

Determining optimal ocean model resolution for HWRF coupling

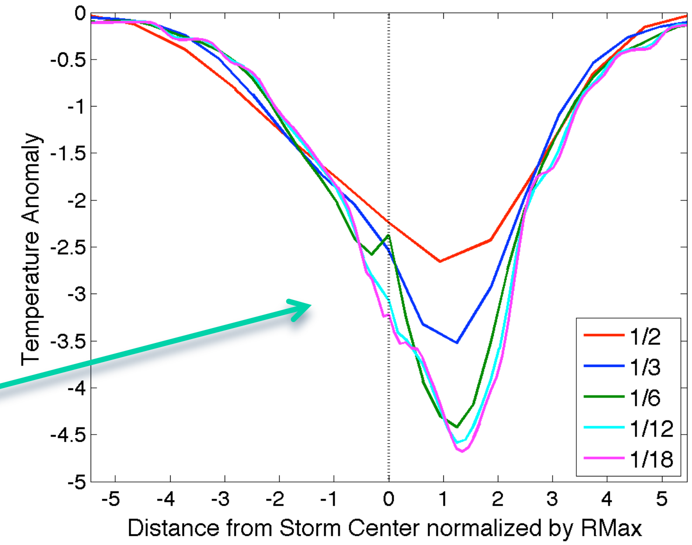
Cross-section through storm center



Idealized POM-TC simulations with prescribed hurricane wind and 1/2°, 1/3°, 1/6°, 1/12°, or 1/18° horizontal grid spacing

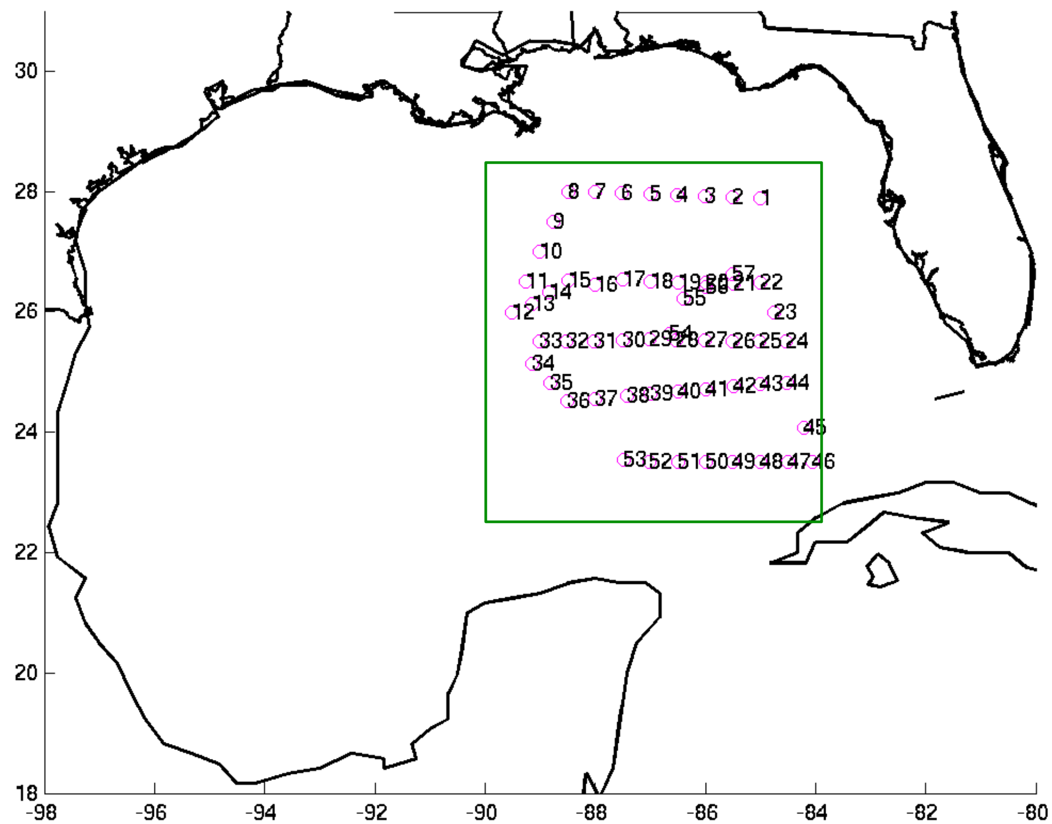
Cross-track SST anomaly from pre-storm conditions

Cross-section 100-km behind storm



- 1/2° and 1/3° grid spacing produce unrealistically weak cooling
- 1/6° is reasonable, but still underestimates cooling relative to 1/12° and 1/18°
- 1/12° and 1/18° are very similar, so little value is added by using 1/18°

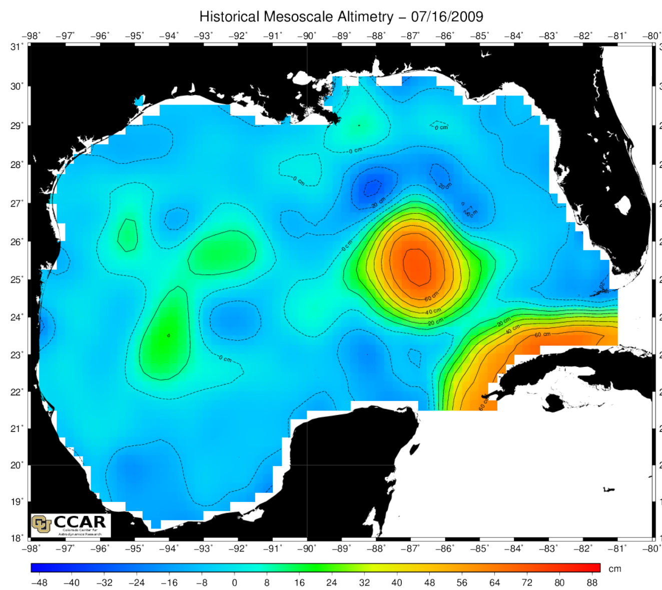
Evaluating Global HYCOM & feature-based ocean initialization for HWRF using NOAA/AOML/HRD's 16 July 2009 AXBTs



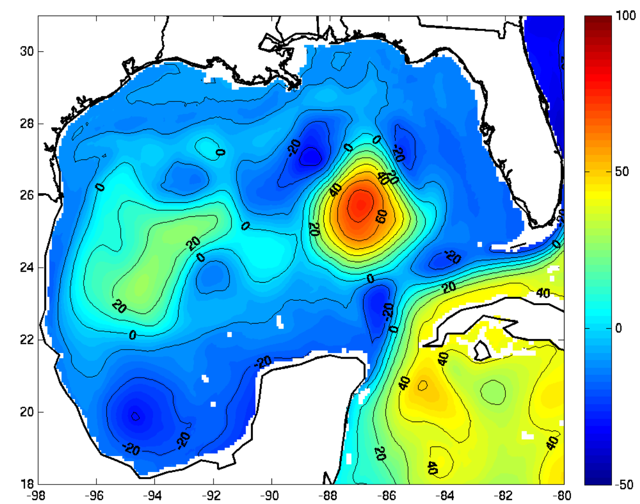
*http://eddy.colorado.edu/ccar/ssh/hist_gom_grid_viewer

16 July 2009: Sea surface height comparison

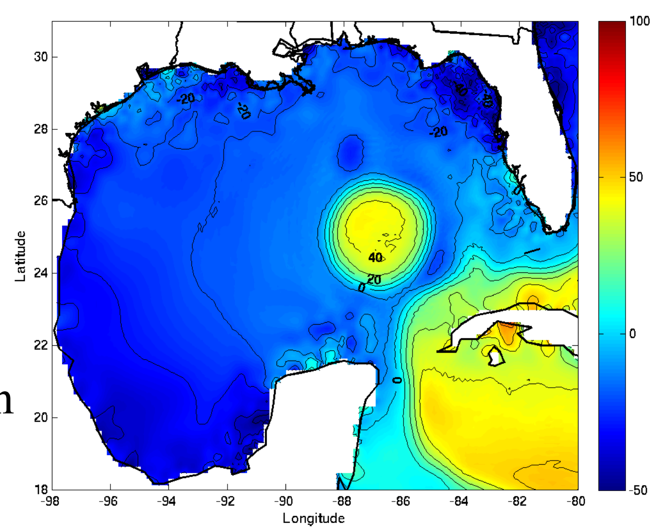
CCAR historical gridded SSH*



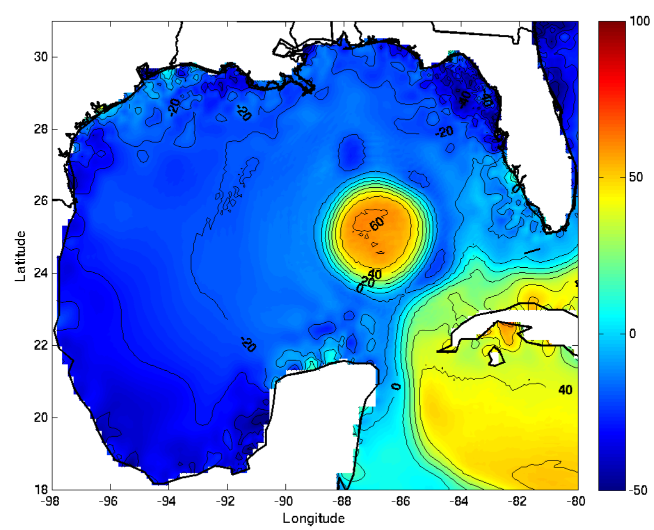
Global HYCOM



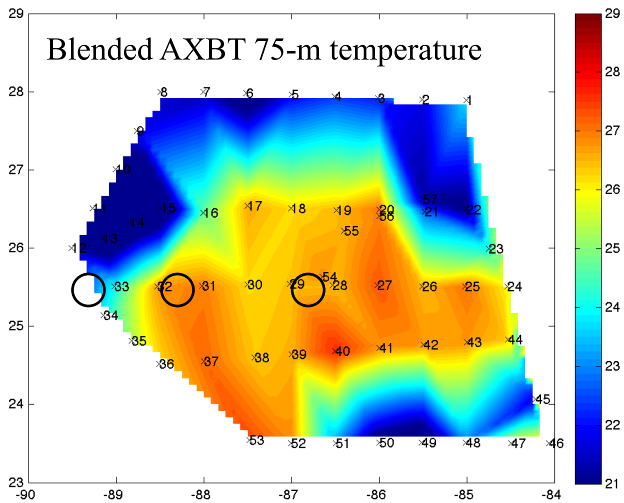
Feature Based: No AXBT assimilation

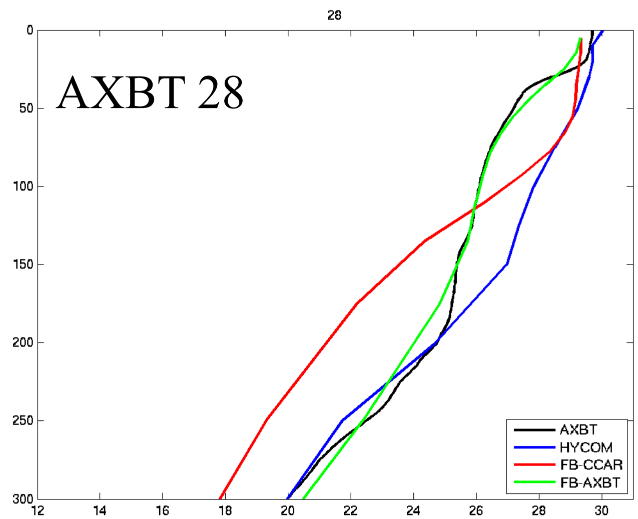


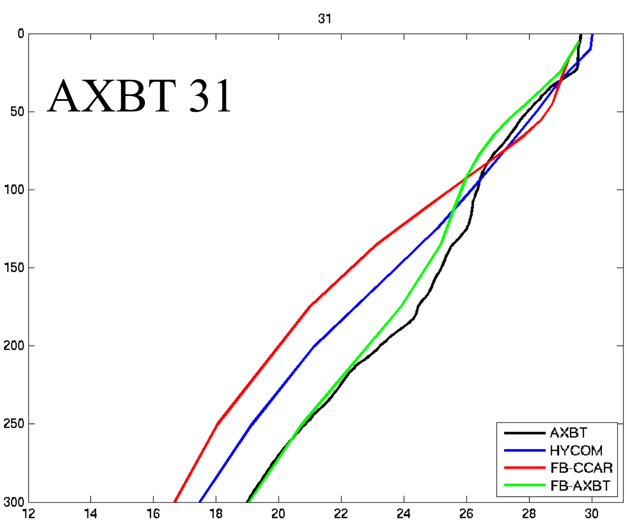
Feature Based: With AXBT assimilation

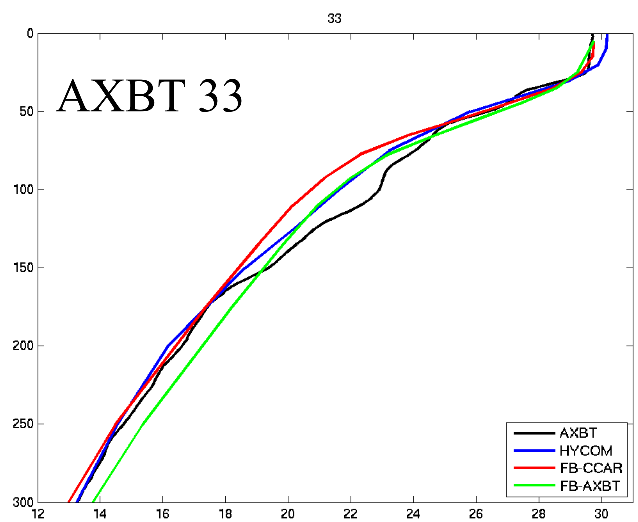


16 July 2009: AXBT temperature profiles



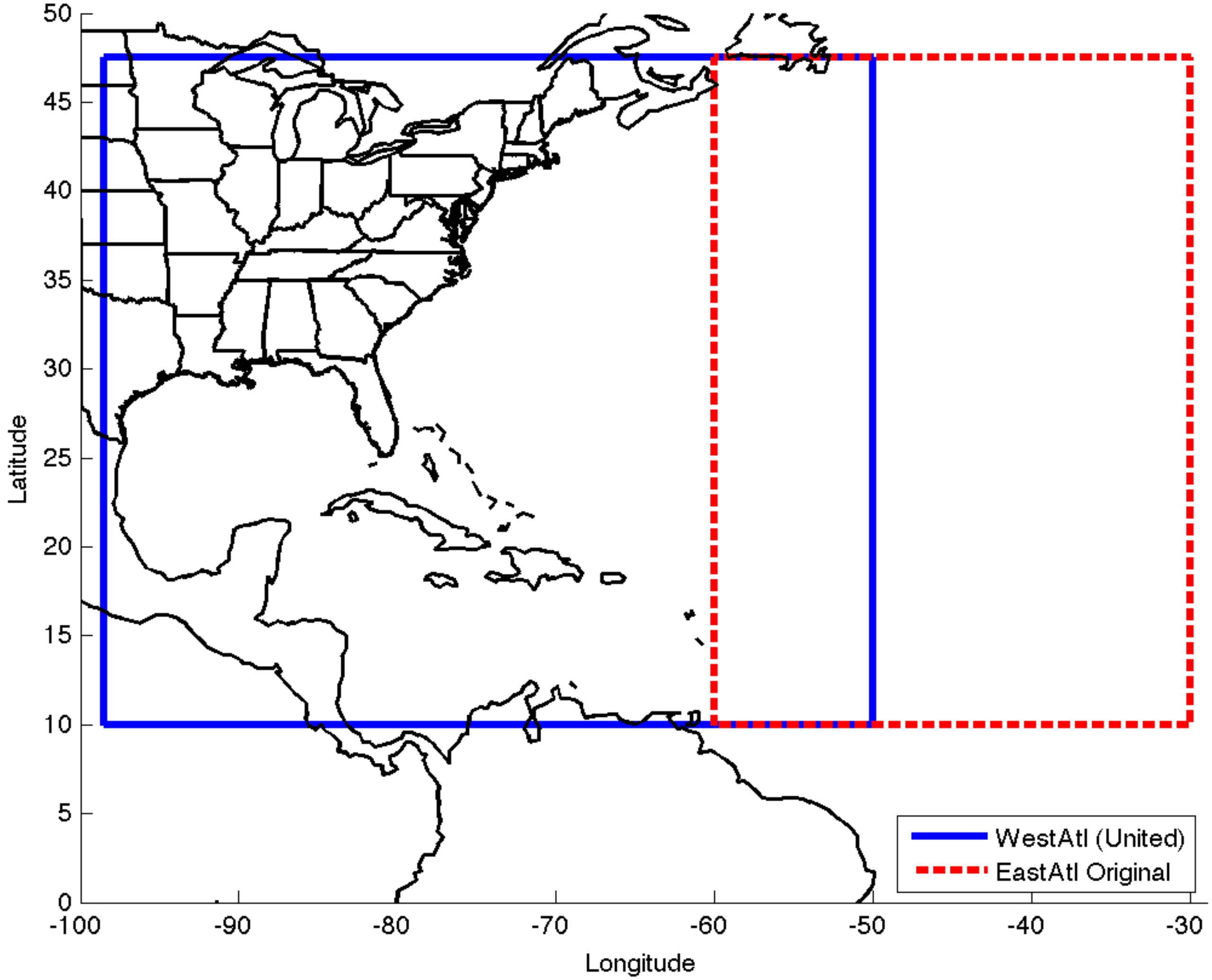






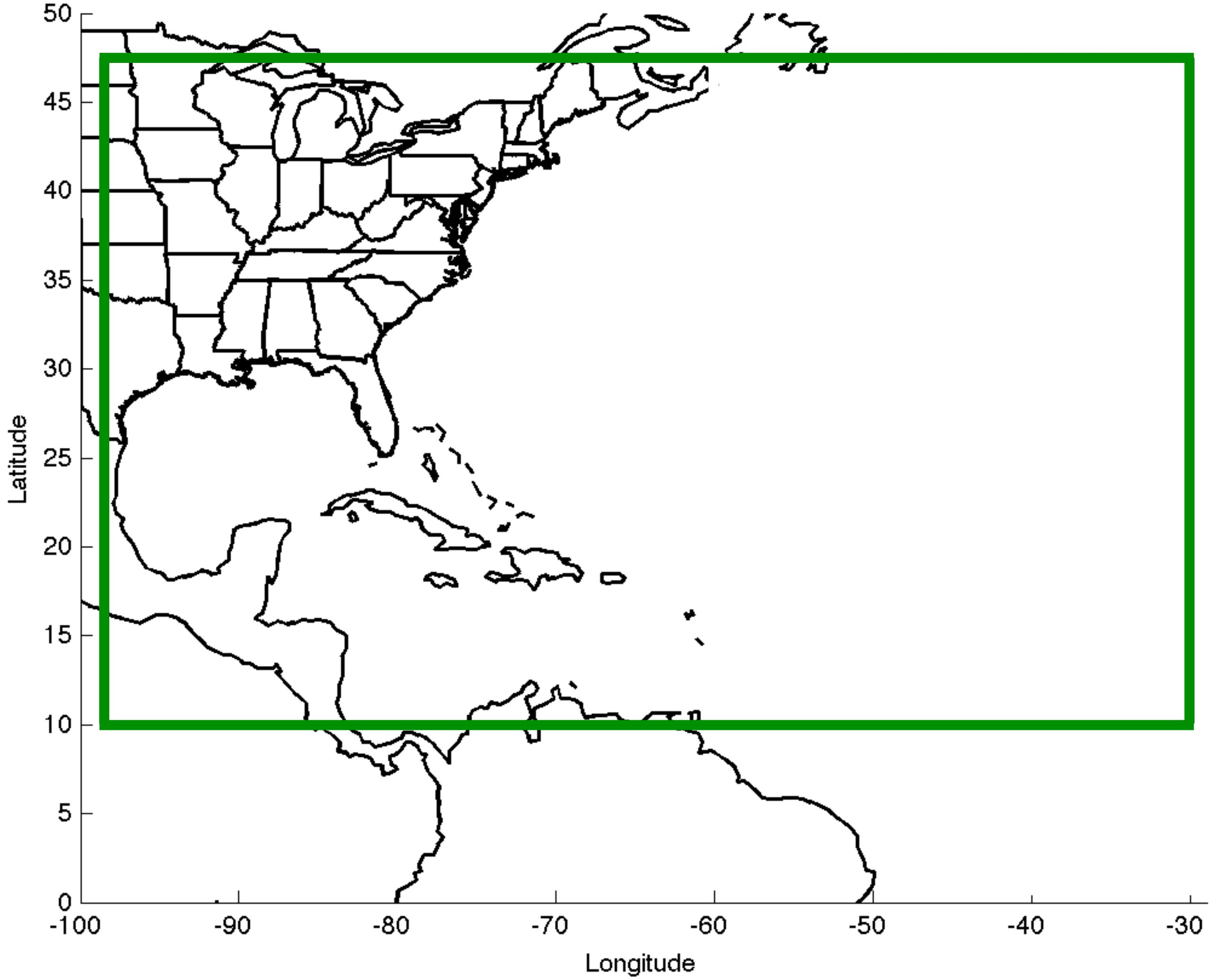
Temperature profiles (upper 300 m) are from Global HYCOM (blue), feature-based model without AXBT assimilation (red), feature-based model with AXBT assimilation (green), and AXBT observation (black)

HWRF's 2012 operational POM-TC United and East Atlantic domains



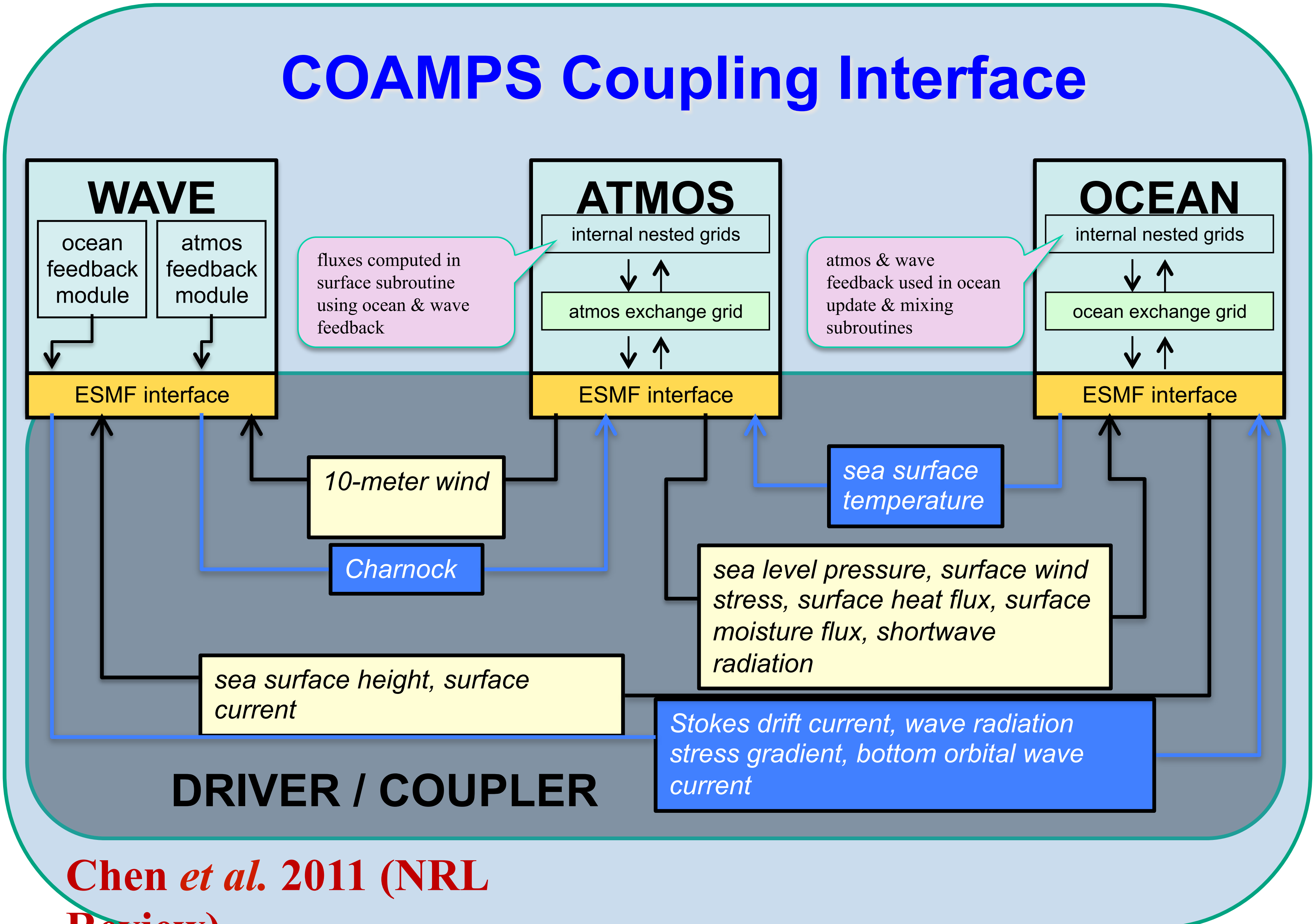
~1/6° horizontal grid spacing

URI's new MPIPOM-TC transatlantic domain



~1/12°
horizontal
grid spacing

4. NRL Monterey: COAMPS-TC



Chen *et al.* 2011 (NRL Review)

Wind-Wave Coupling

Three different methods of wind-wave coupling have been tested in COAMPS-TC

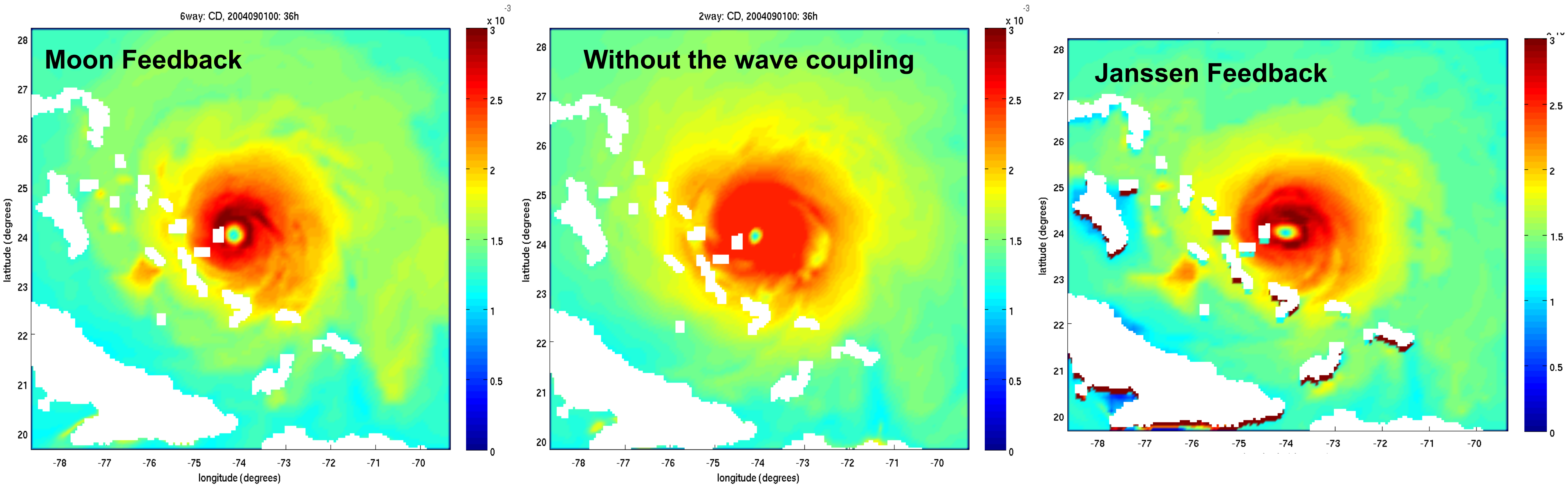
- Janssen (1991) and Doyle(2001) – scalar wave stress
- Moon *et al.* (2004) – wave age and wind speed
- URI (Ginis) – similar to Moon

Currently is implemented a fourth UM wind-wave scheme

- Donlean *et al.* (2012) – vector wave stress

Frances Wind-Wave Coupling

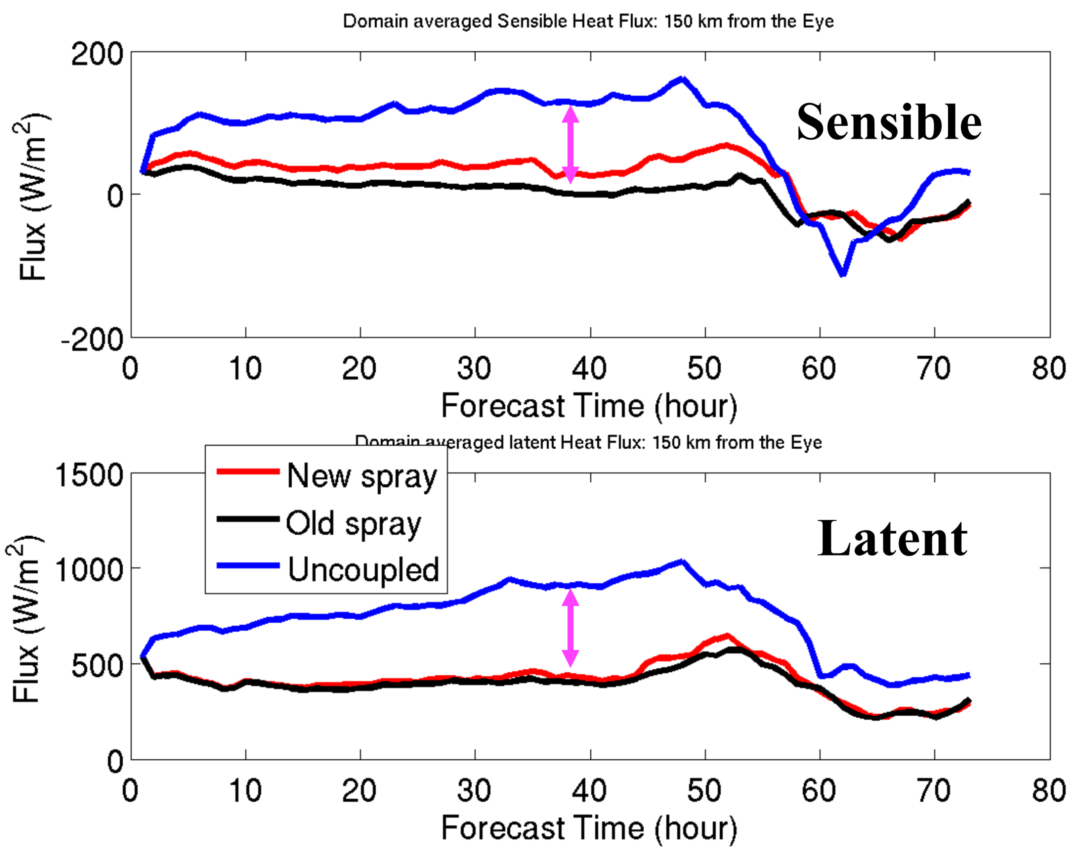
COAMPS atmospheric momentum drag



Including the wave feedback to the atmosphere produced a much higher value of momentum drag near the eyewall region.

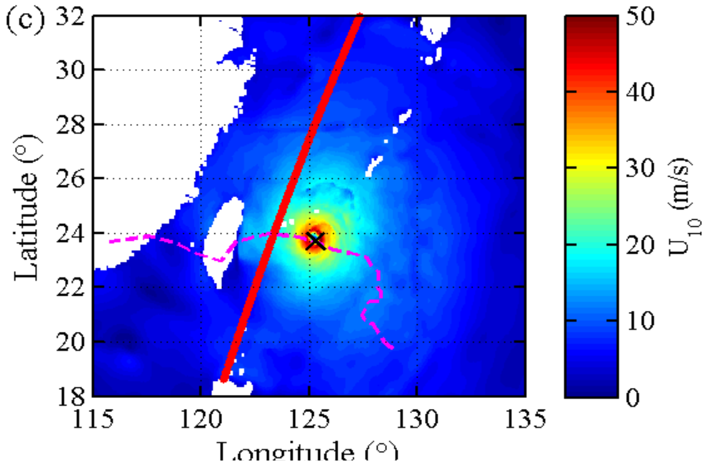
Effect of Sea Spray on Fanapi Simulations

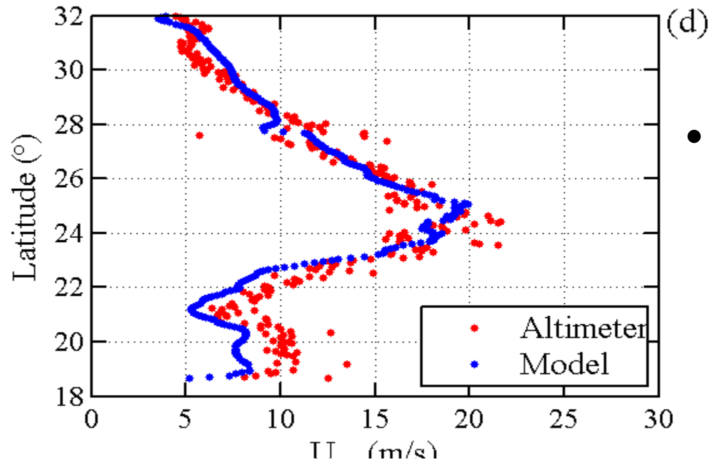
Averaged fluxes within 150 km radius of eye

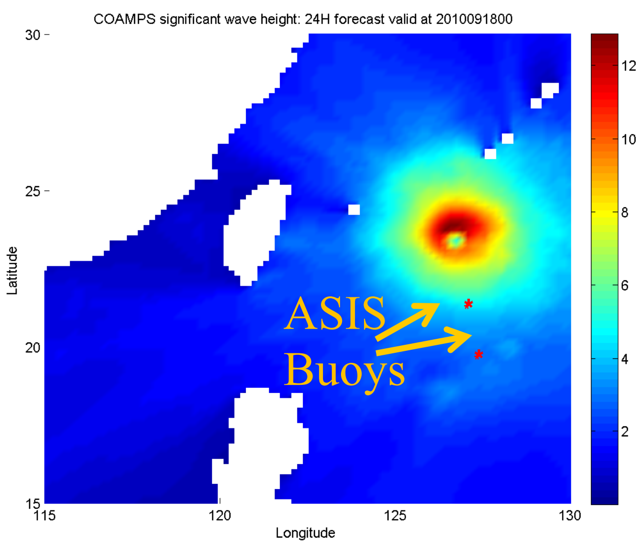


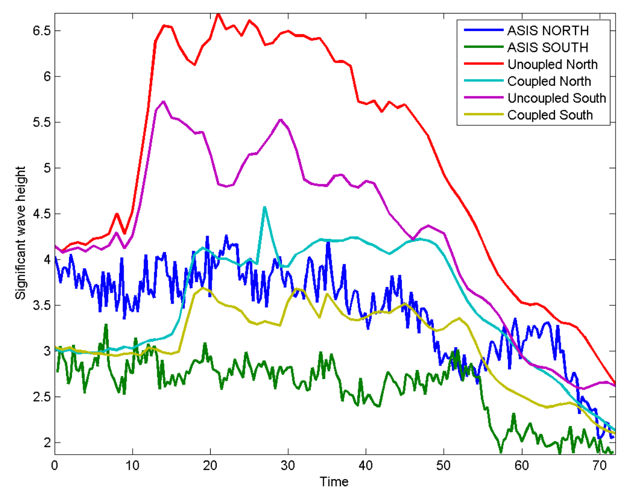
- **New sea spray increases more sensible flux**
- **Smaller increase in latent heat flux**
- **Fully coupled run has a 32% less total flux over the ocean compared to the uncoupled run**
- **New sea spray provides about 5% flux increase**
- **With new sea spray, there is still a large flux difference between coupled and uncoupled runs**

Fanapi Altimeter Wave/Wind Comparisons (model adjusted +6 hours)









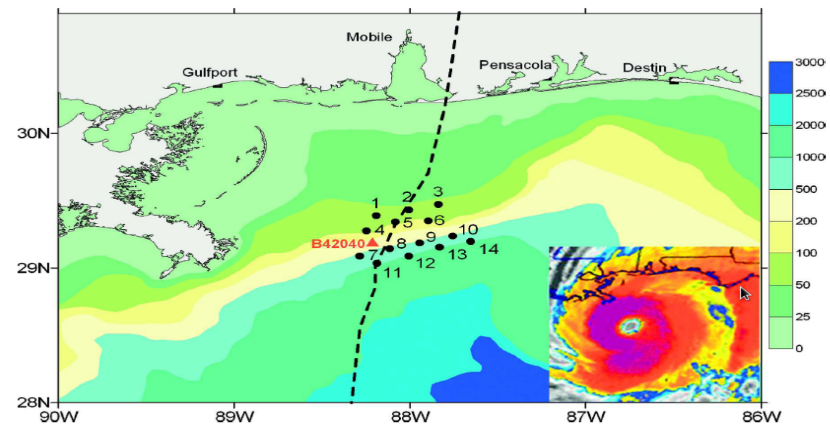
- **COAMPS significant wave height and wind forecast compare well with altimeter near Fanapi after adjusting the track bias Max of 6 m significant wave height west of Fanapi**

Ivan Current Evaluation

Coupled (w and w/o Stokes' drift)

SHALLOW ADCPs	# COMP. BINS	TOP BIN DEPTH	BOTTOM BIN DEPTH	CCC	MDE with SDC (deg)	MDE w/o SDC (deg)	% improvement
M1	13	6	52	0.86	6.21	6.72	**7.59**
M2	14	4	54	0.87	10.35	11.31	**8.49**
M3	13	6	54	0.78	10.93	11.52	**5.12**
M4	13	10	82	0.80	11.10	11.38	**2.46**
M5	13	11	83	0.81	14.24	14.53	**2.00**
M6	14	9	81	0.82	15.60	16.22	**3.82**
ALL SHALLOW AVG.				0.82	11.41	11.95	**4.53**
DEEP ADCPs							
M7	13	52	492	0.73	4.68	N/A	N/A
M8	13	52	492	0.88	10.65	N/A	N/A
M9	13	50	492	0.80	7.65	N/A	N/A
M10	13	50	500	0.87	15.87	N/A	N/A
M11	13	53	493	0.86	15.26	N/A	N/A
M12	13	53	513	0.73	17.92	N/A	N/A
M13	13	50	500	0.76	12.53	N/A	N/A
M14	13	52	502	0.81	11.38	N/A	N/A
ALL DEEP AVG.				0.81	11.99	N/A	N/A

The passing of Stokes' Drift Current from SWAN to NCOM shows improvement in both the Mean Directional Error (MDE) and current velocity. In an extreme event such as Hurricane Ivan, the SDC can be as much as 10-20% of the total current velocity near the surface.



Lesson learned

- Validation of TC structure in the atmosphere, ocean, and wave help to guide the parameterization improvements

- Validation statistics can be used to obtain information about the coupled model error covariance

Challenge

- Diagnostic of culprit parameterizations in the coupled model require in-depth analysis of model physics interaction and atmosphere, ocean, and wave observations in different ocean basins

Outstanding issues

- Lack of correction in the data assimilation cycle to account for the displacement of background ocean cold wake due to track error
- Coupled model took about 6h to adjust to the bogus vortex

5. ESRL and URI: Sea Spray Flux Parameterization

Summary of the Improved ESRL Sea-Spray Parameterization Work

Jian-Wen Bao, Chris Fariall

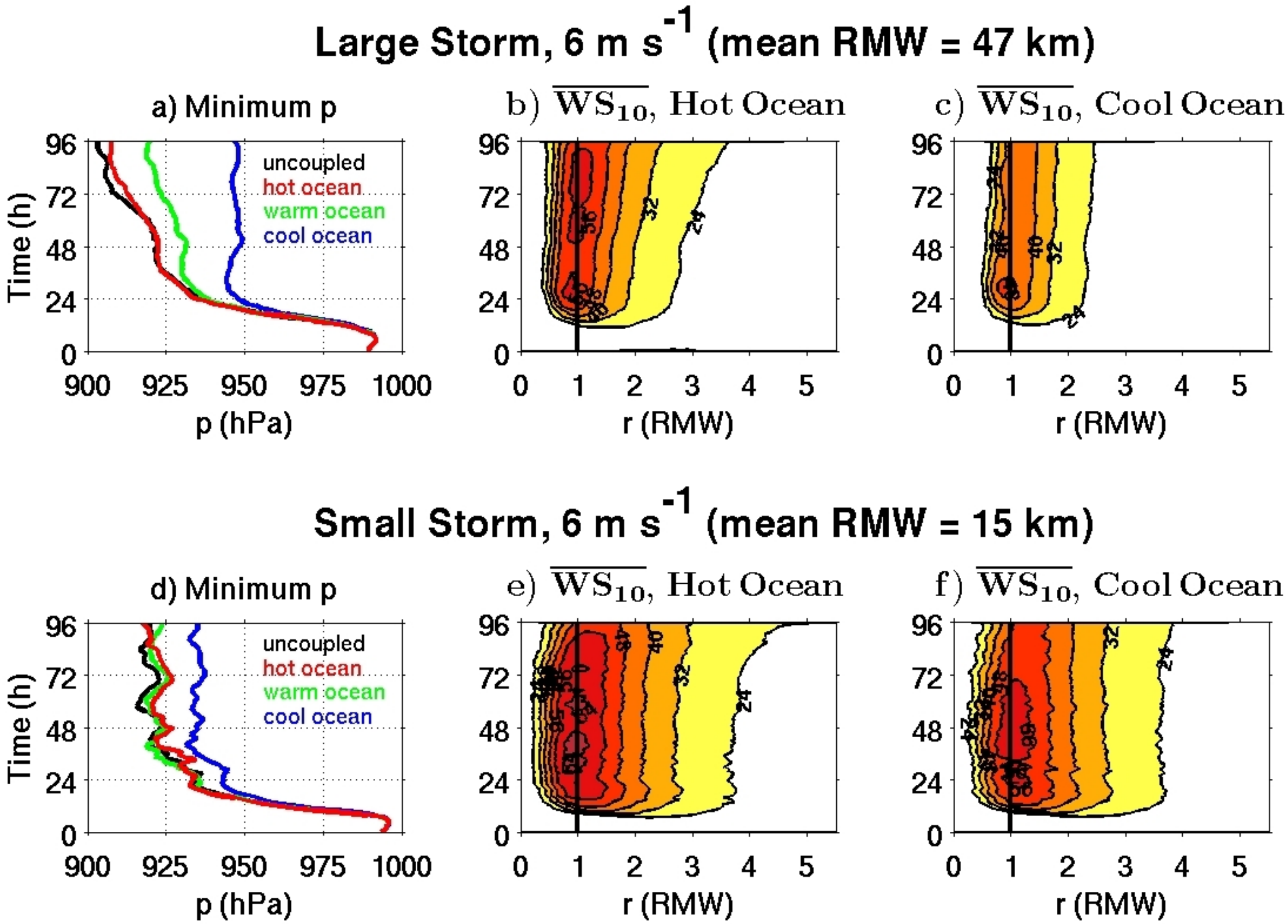
- Implemented the scheme in the fully coupled GFDL hurricane in collaboration with the URI team
- Conducted both idealized and real-case simulation experiments for parametric adjustment
- Shared the program module with HFIP partners, the NOPP partners and other research groups over the world
- Made plans to test out the module in the fully coupled HWRF model

6. AOML: Idealized HWRF v.3.2 Ocean Response Study

Sensitivity of HWRF V3.2 to the Ocean

- Problem: poor quantitative understanding of the sensitivity of forecast intensity to changing ocean conditions in coupled forecast models (when/where can the ocean be important?)
- Approach: Perform idealized HWRF V3.2 study minimizing impact of atmospheric processes that affect intensity
  - Idealized atmosphere
    - Idealized initial vortex embedded in stationary atmosphere
  - Idealized ocean
    - 1-D ocean model coupled to HWRF v.3.2
  - Ocean fields advected to east to mimic westward storm speed
- Parameter study:
  - Storm size (small vs. large)
  - Storm translation speed (2, 4, 6, 8, 10 m s^{-1})
  - TCHP or OHC (25, 85, 148 kJ cm^{-2})

Intensity Evolution

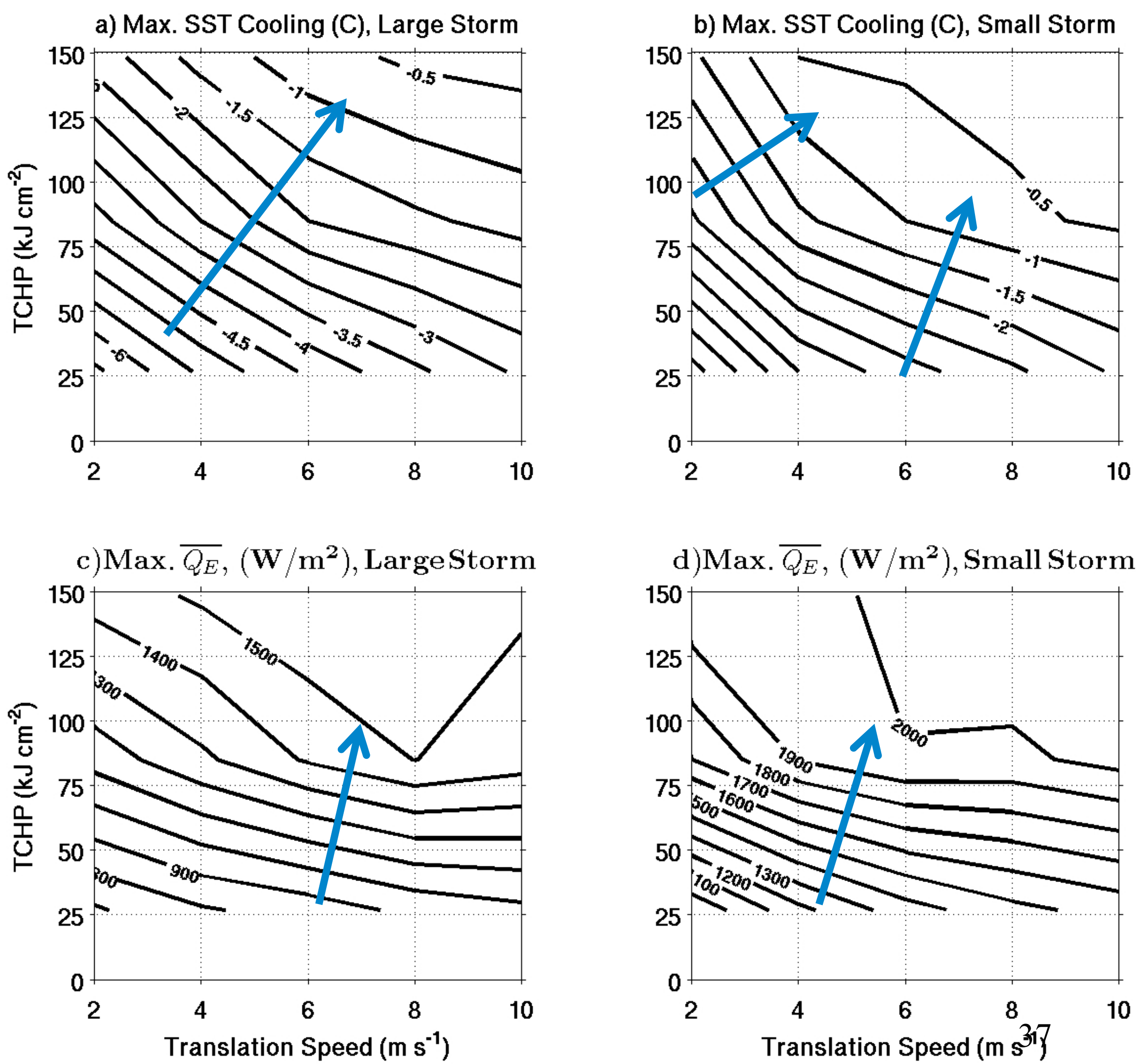


- RI completed by forecast hour 30 for all uniform ocean experiments
- Slow decrease in minimum p after hour 60 for both warm and hot ocean cases
- Cool ocean (low TCHP) significantly limits intensity

Parameter Dependence of SST Cooling and Enthalpy Flux

Minimum SST in cold wake →

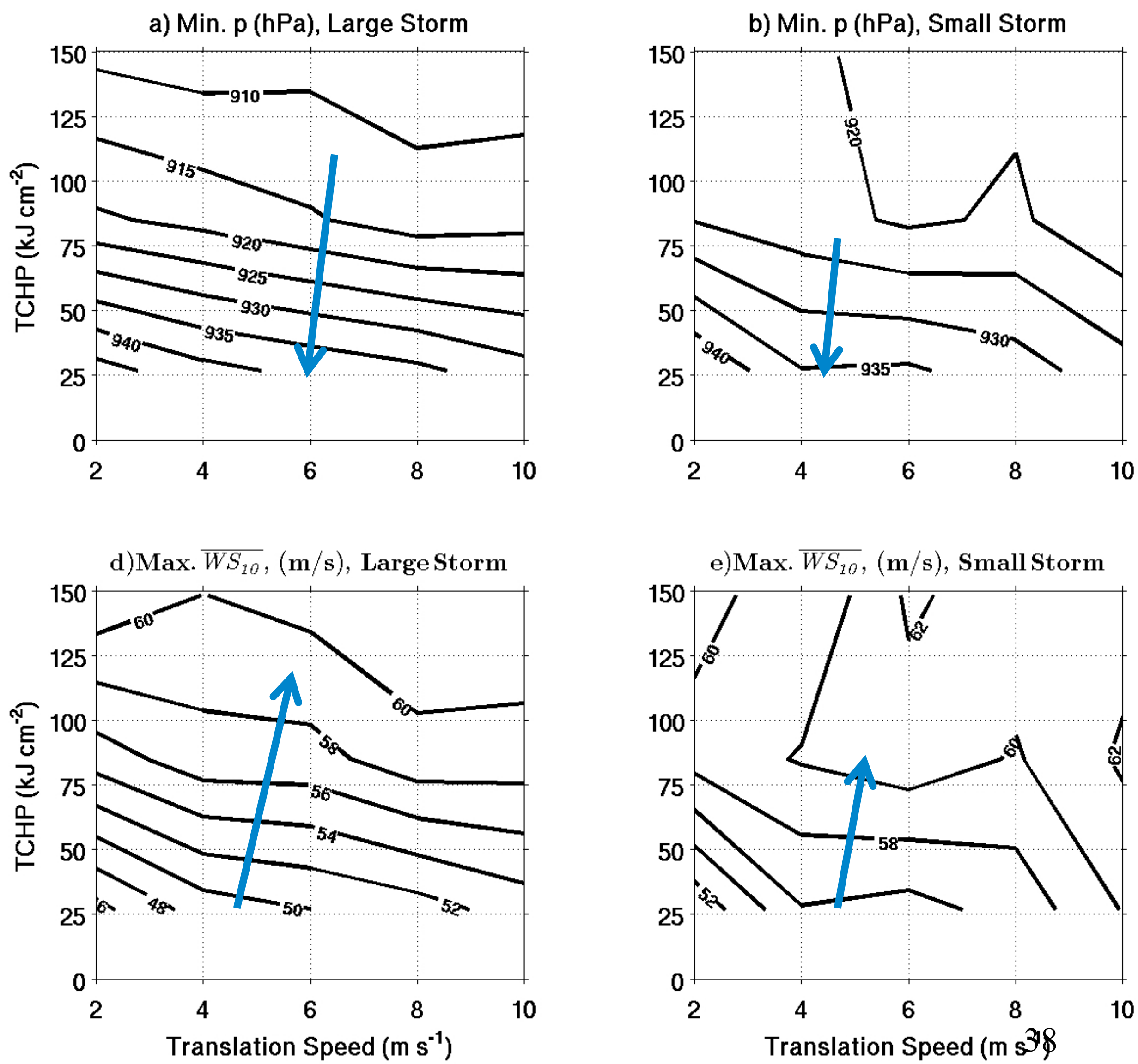
Maximum enthalpy flux →



Parameter Dependence of Intensity

Minimum central pressure →

Maximum $(WS)_{10}$ →



7. Workshop Summary

- Strategies for evaluating and improving model performance
  - Diagnostic requirements
    - Metrics
      - Determine if model components are correctly reproducing the relevant physical processes
      - Do not rely solely on the accuracy of track and intensity forecasts
  - Observational requirements
    - Evaluate the accuracy with which model components reproduce the selected metrics
    - Are additional observations (operational and targeted) required?
    - Can we obtain co-located observations of ocean, atmosphere, waves, and fluxes?
      - Existing datasets versus new field programs
  - Collaborations required
    - Among people evaluating the atmospheric, oceanic, and wave models plus the flux parameterizations
    - Among different modeling groups (HWRF, COAMPS-TC, etc.)
    - HFIP Team 8 needs to provide this coordination
  - Target a study of hurricane Isaac due to extensive observations
  - Workshop report will be released shortly