Unified Air-Sea Interface in Fully Coupled Atmosphere-Wave-Ocean Models for Storm Predictions

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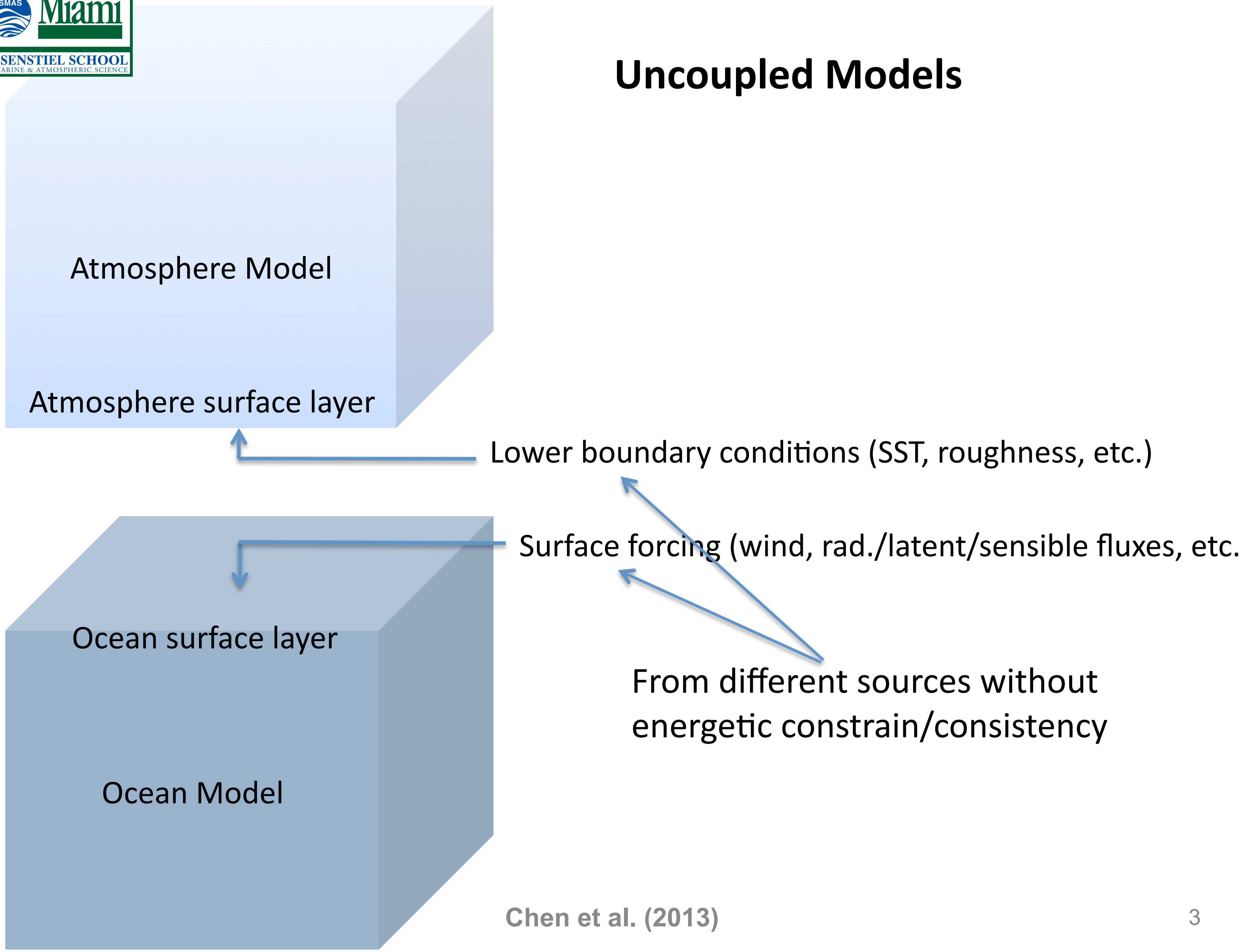
National Oceanographic Partnership Program

Chen et al. (2013)

Goals:

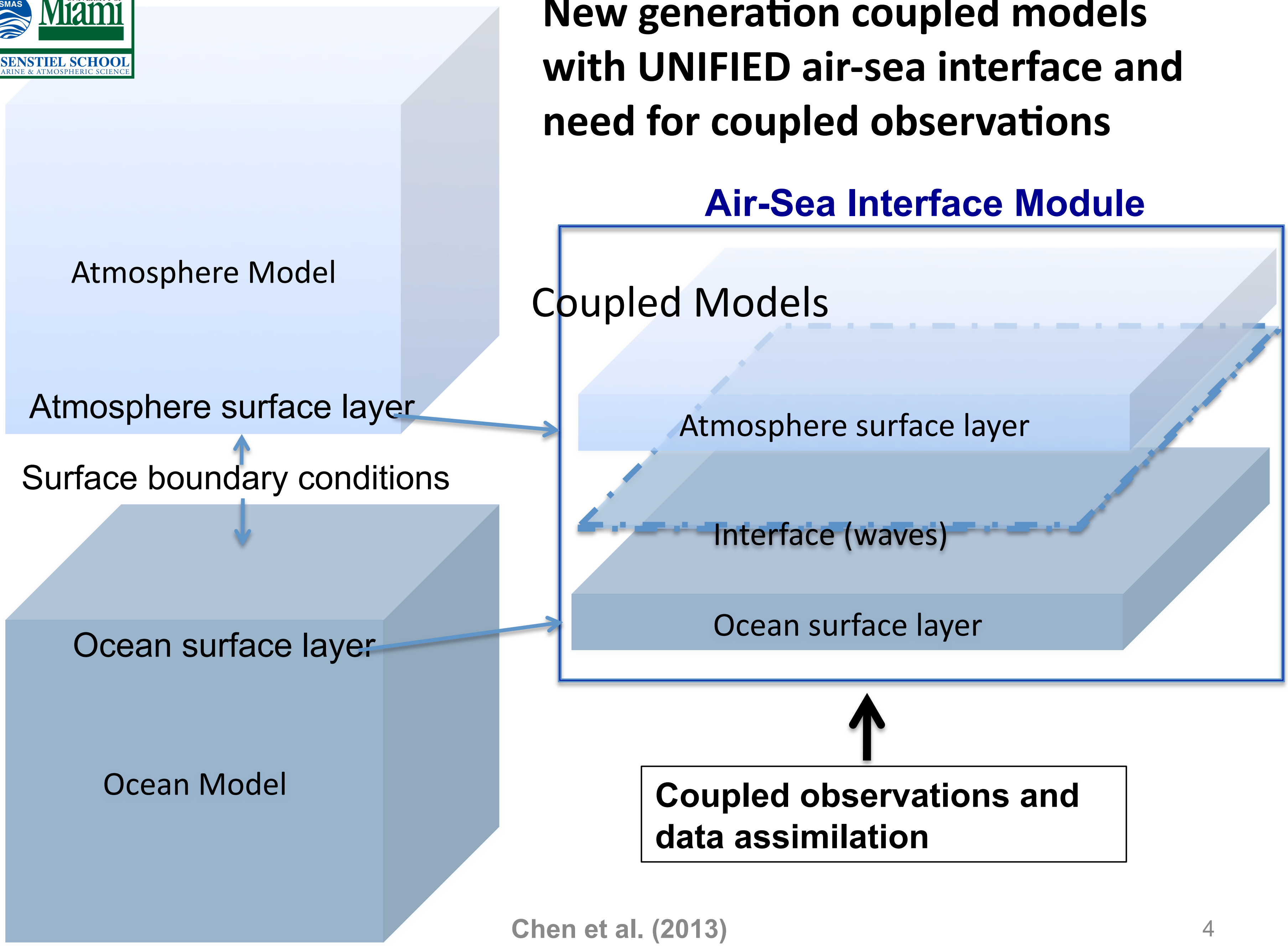
- ❑ Understand the physical processes that control the air-sea interaction and their impacts on storm prediction
- ❑ Develop a physically based and computationally efficient coupling at the air-sea interface for use in a multi-model system that can transition to the next generation of research and operational coupled atmosphere-wave-ocean-land models

Uncoupled Models



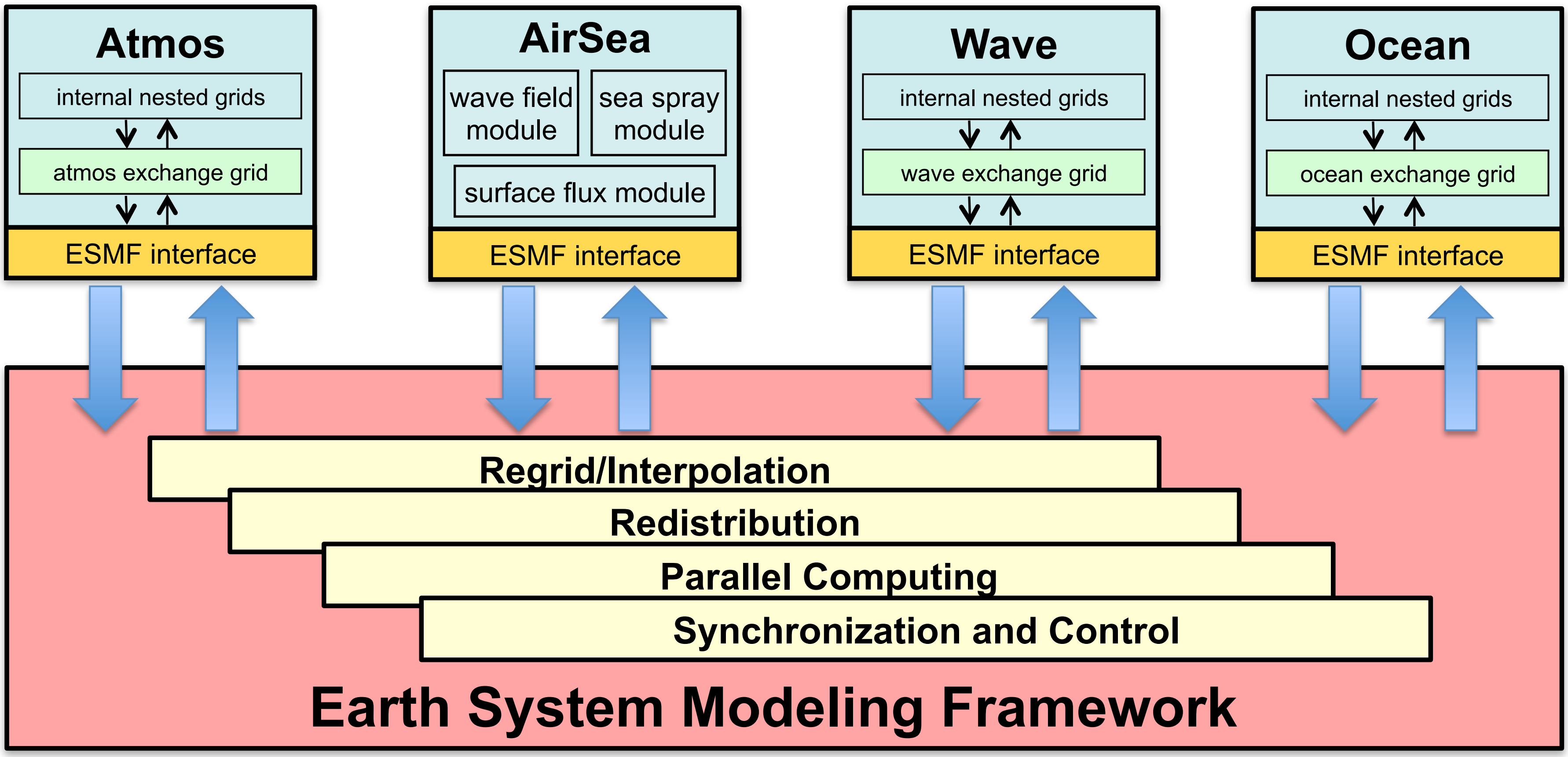
Chen et al. (2013)

New generation coupled models with UNIFIED air-sea interface and need for coupled observations



Chen et al. (2013)

ESMF Based Software Architecture



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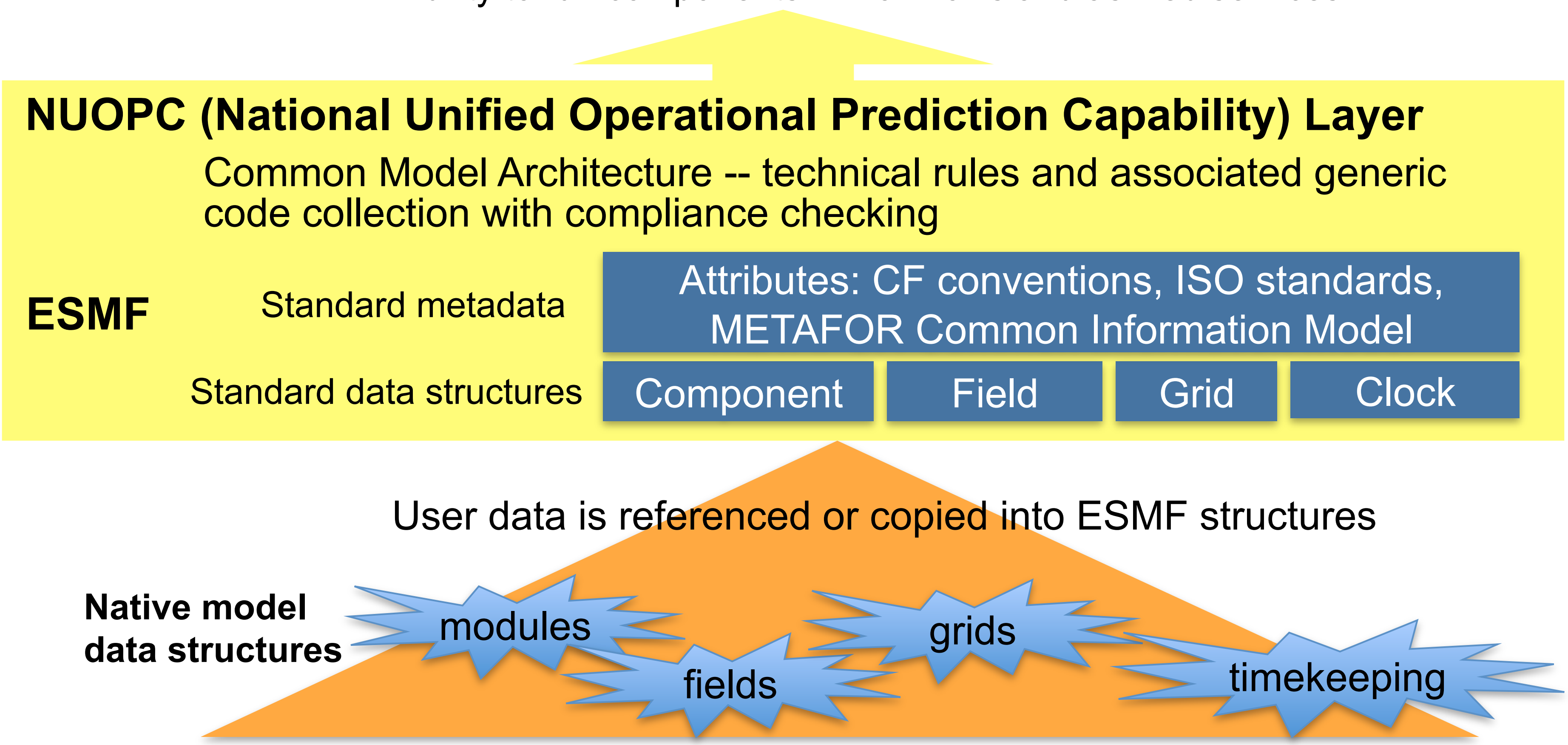
Building an Information & Interoperability Software Layer

Applications of information layer

- Parallel generation and application of interpolation weights
- Run-time compliance checking of metadata and time behavior
- Fast parallel I/O
- Redistribution and other parallel communications
- Automated documentation of models and simulations
- Ability to run components in workflows and as web services



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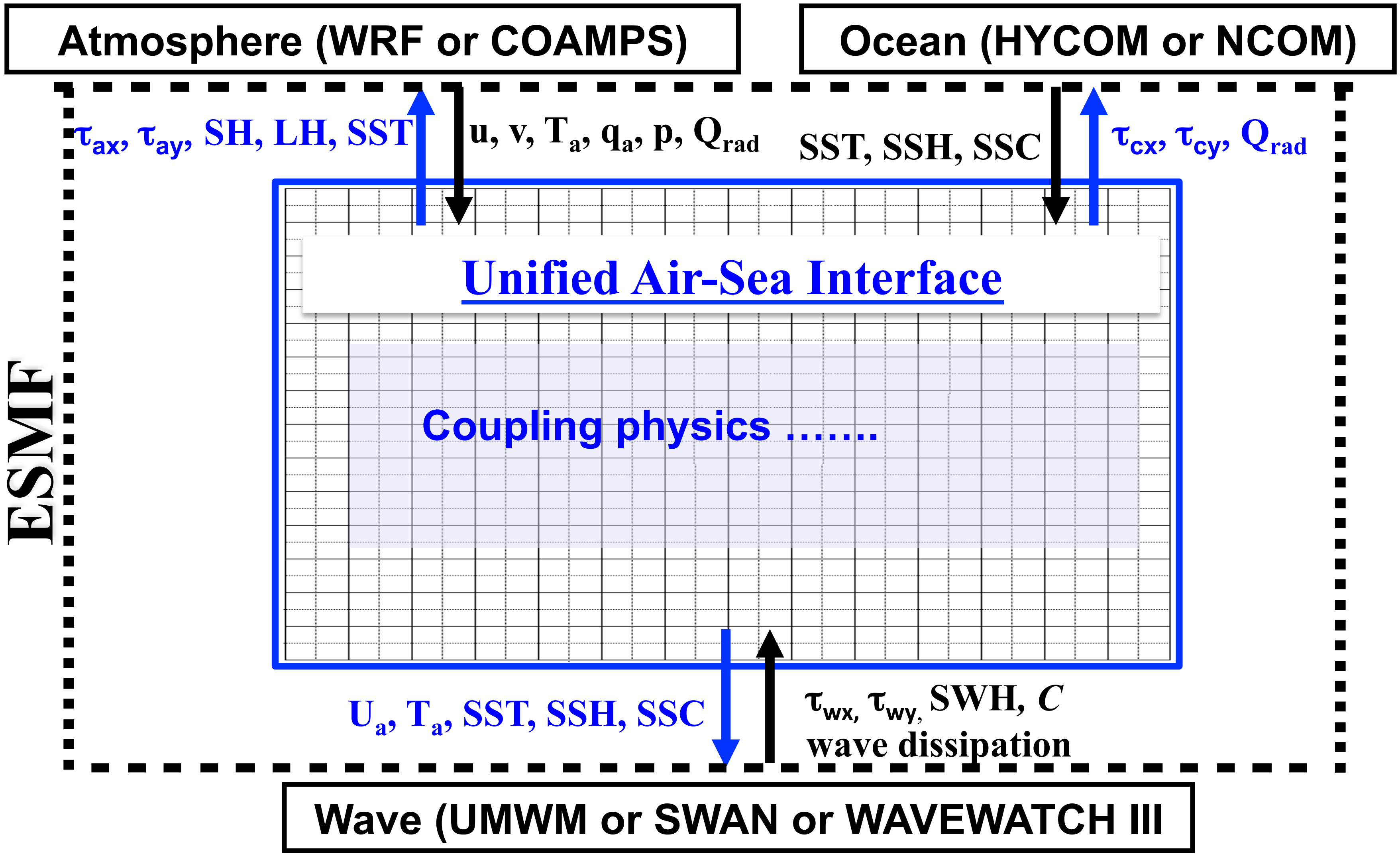
Coupled Modeling System



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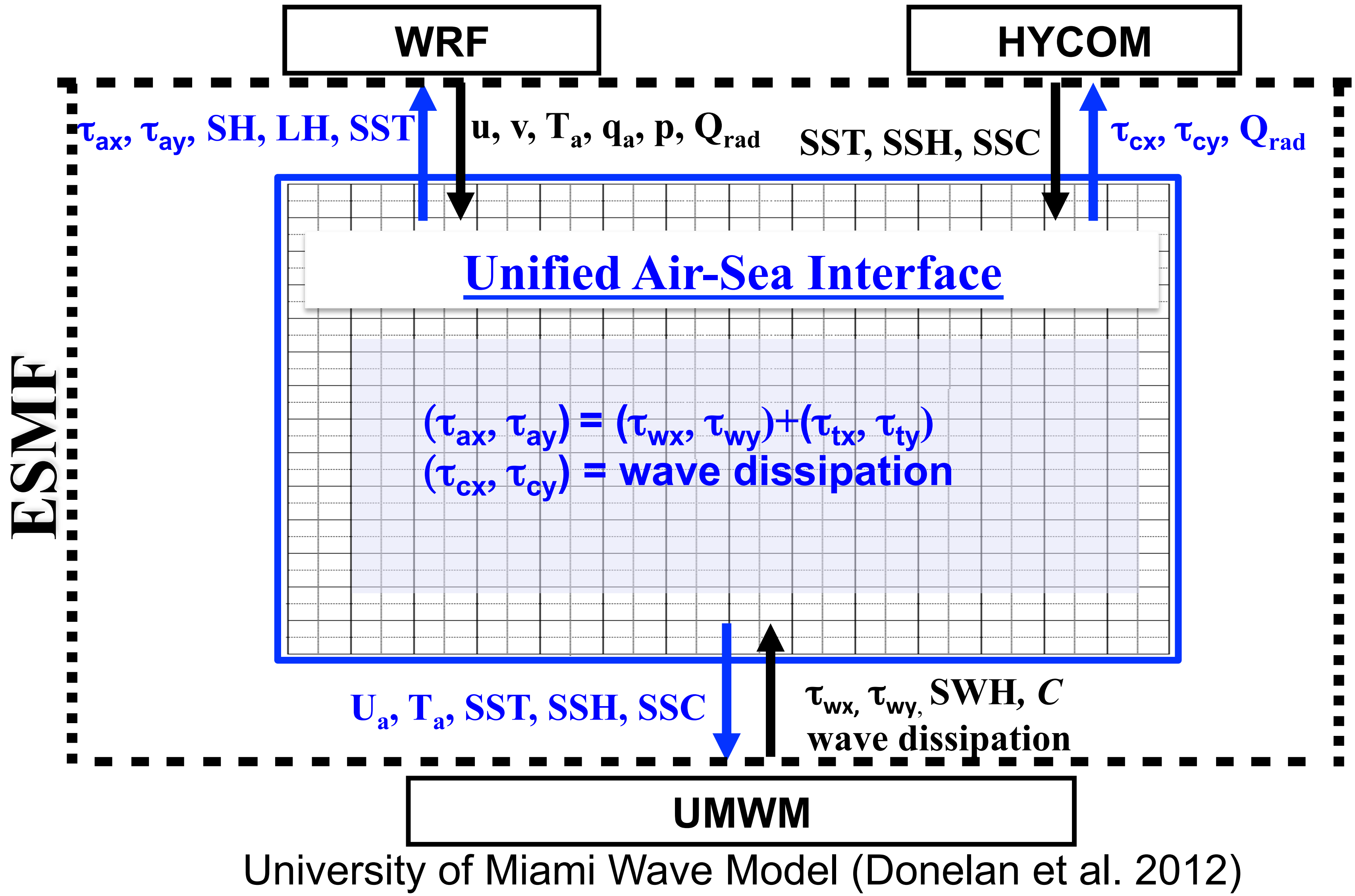
University of Miami Coupled Model (UMCM)



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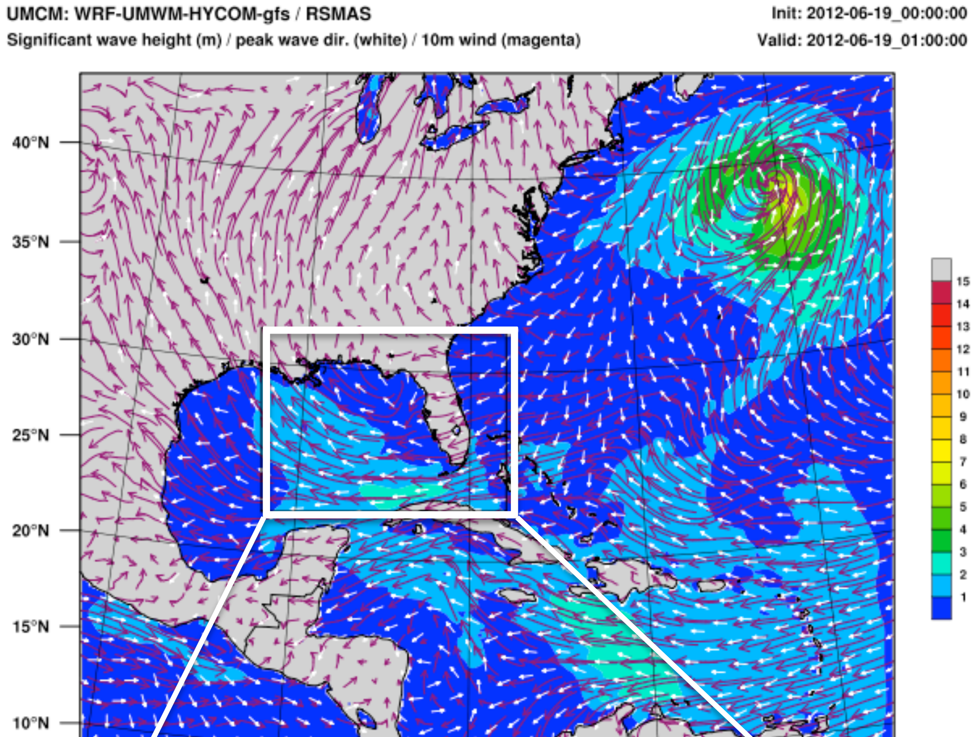
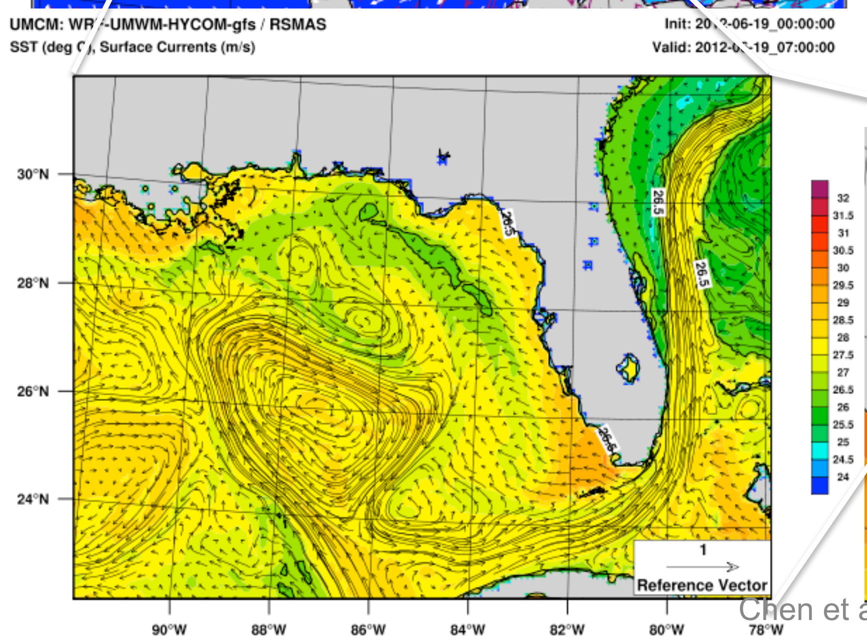
Real-time Experiment: **GLAD/CARTHE**

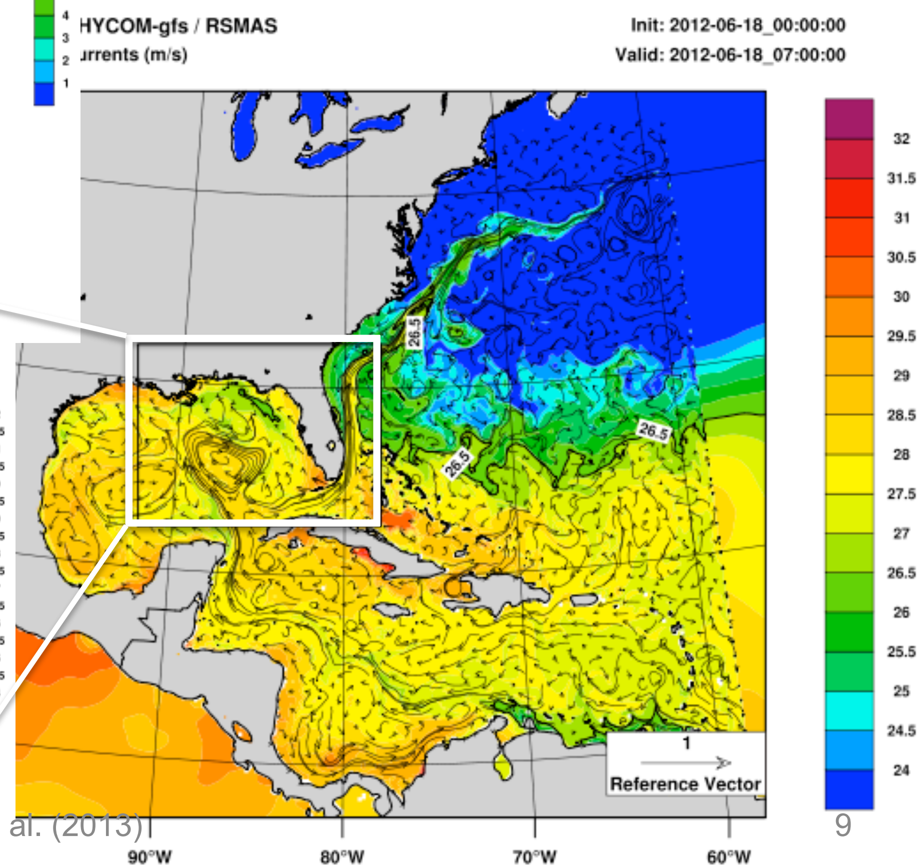
UMCM (WRF-UMWM-HYCOM)

Initialized daily at 0000 UTC daily

- Atmosphere (1.3km) initial/LB: GFS
- Wave (4km) initial/LB: WW3 or none
- Ocean (4km) initial/LB: HYCOM global







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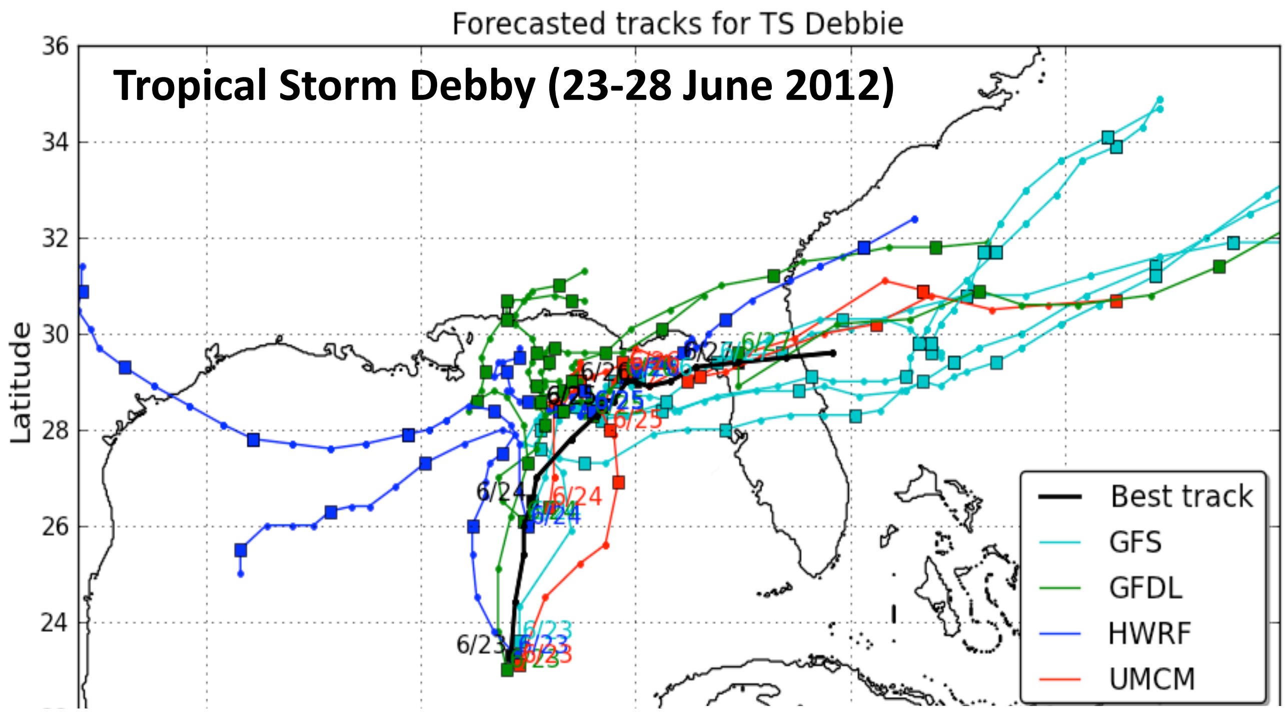
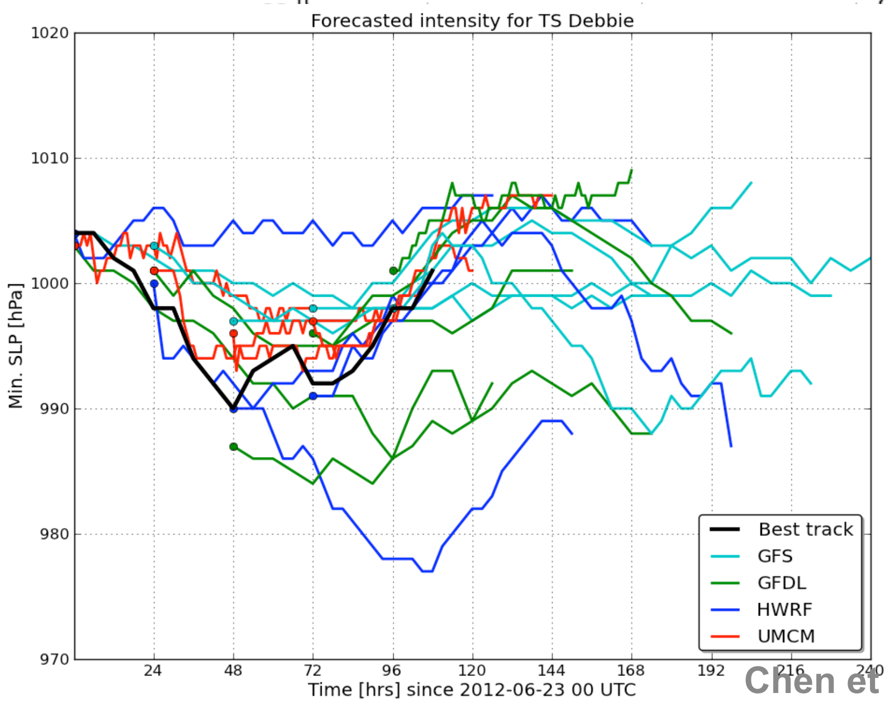
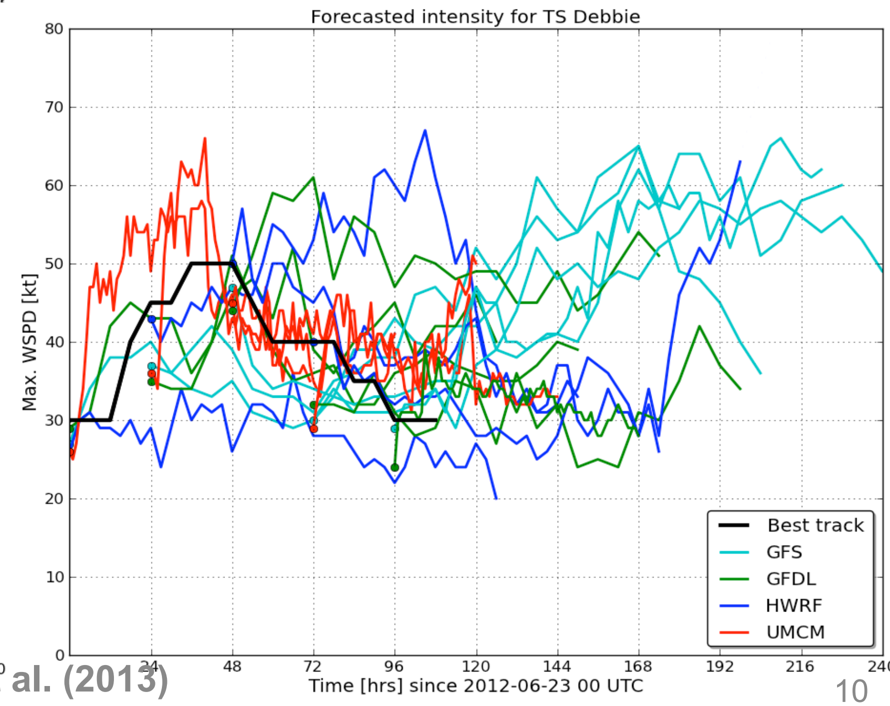
Tropical Storm Debby (23-28 June 2012)

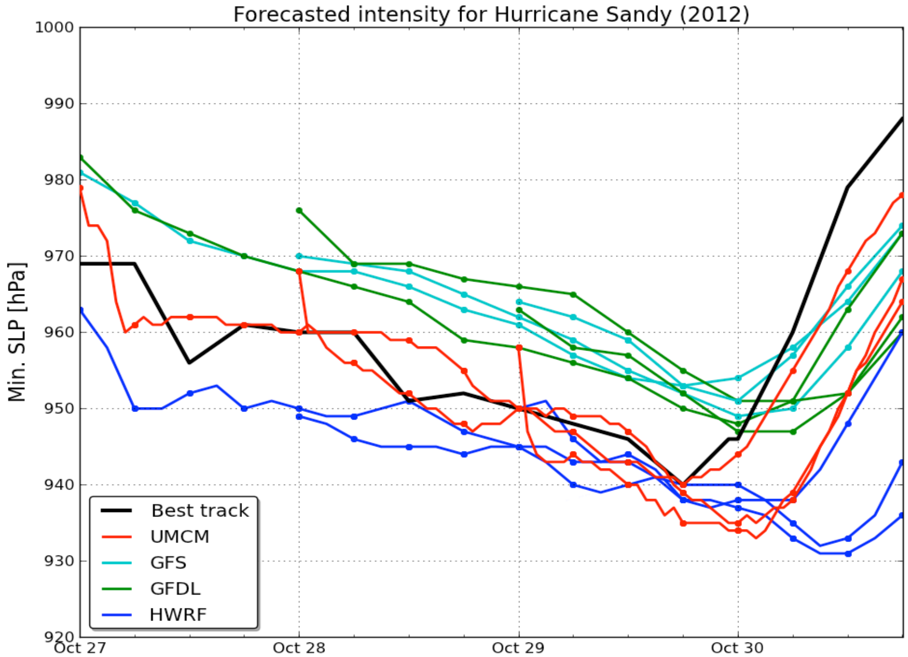


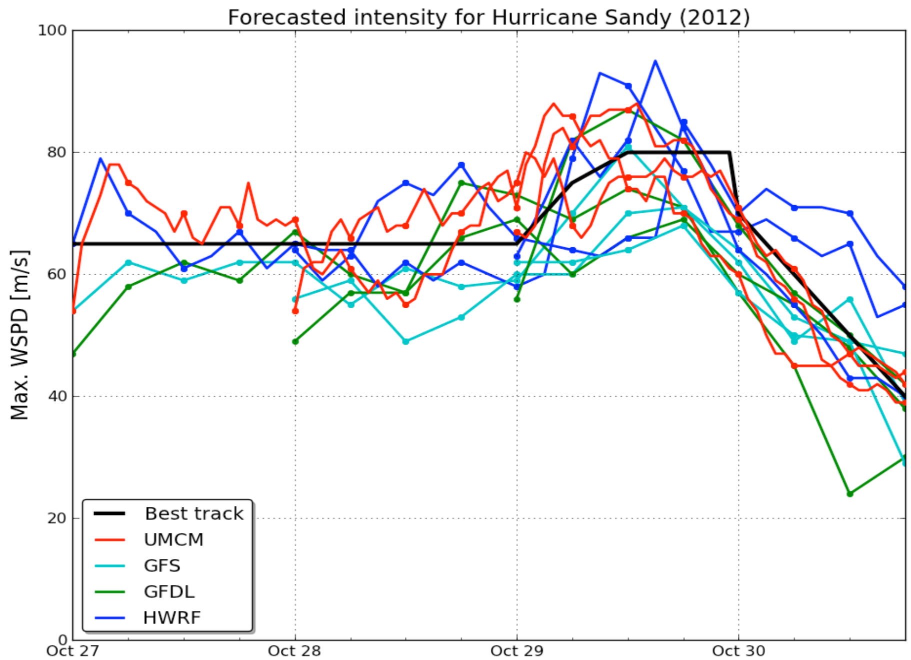


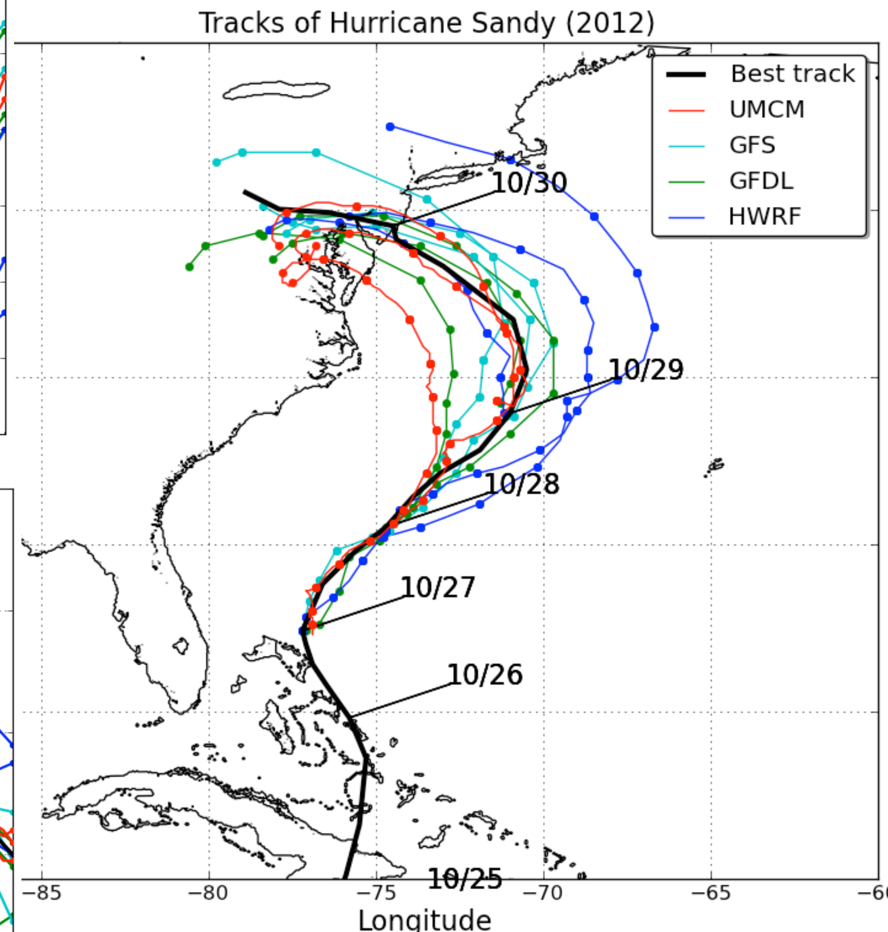


Chen et al. (2013)

Hurricane Sandy (27-30 Oct 2012)

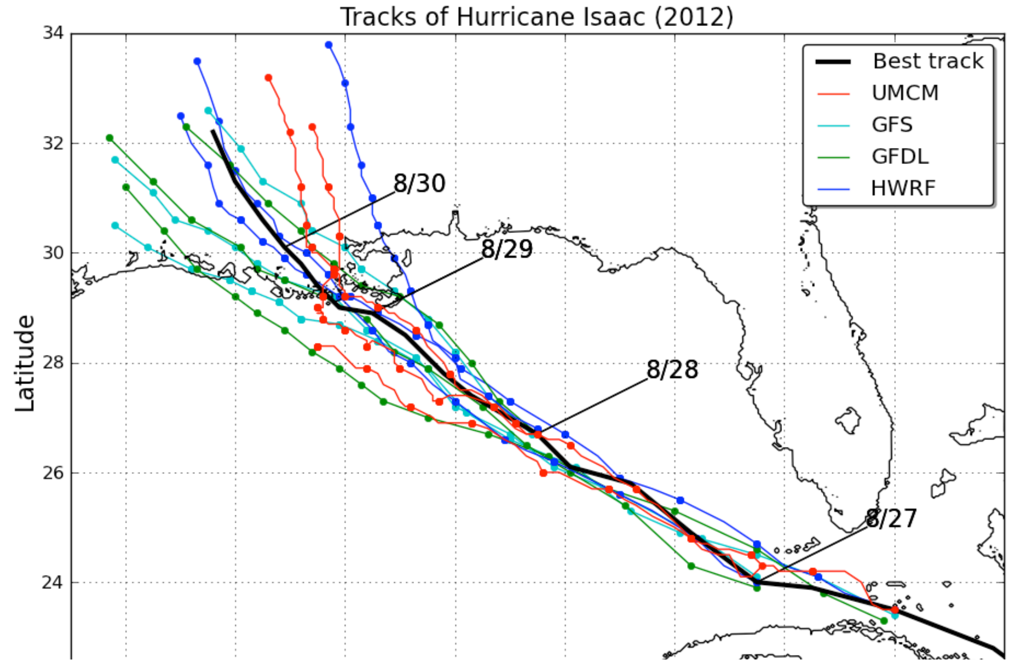


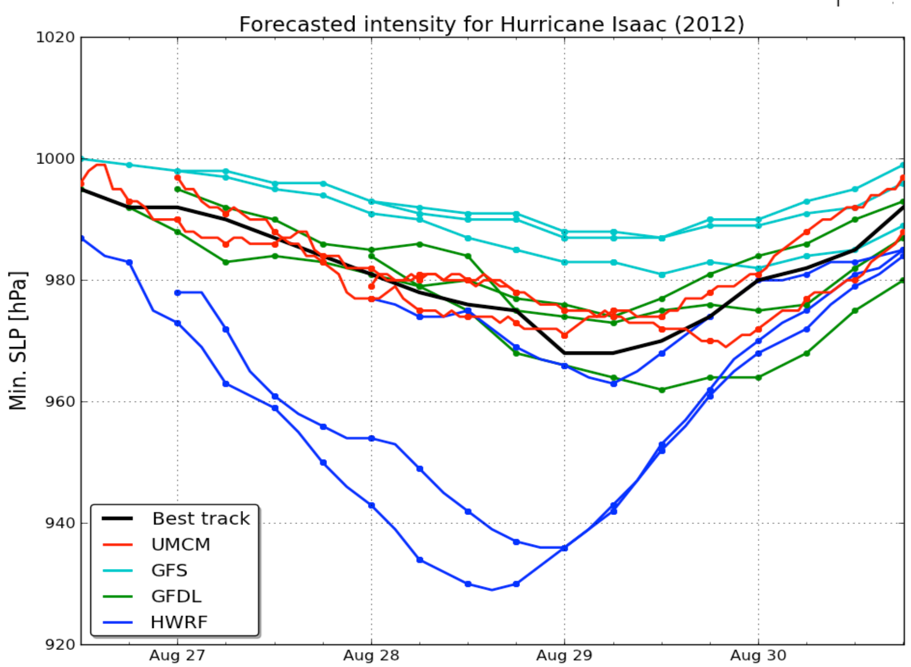


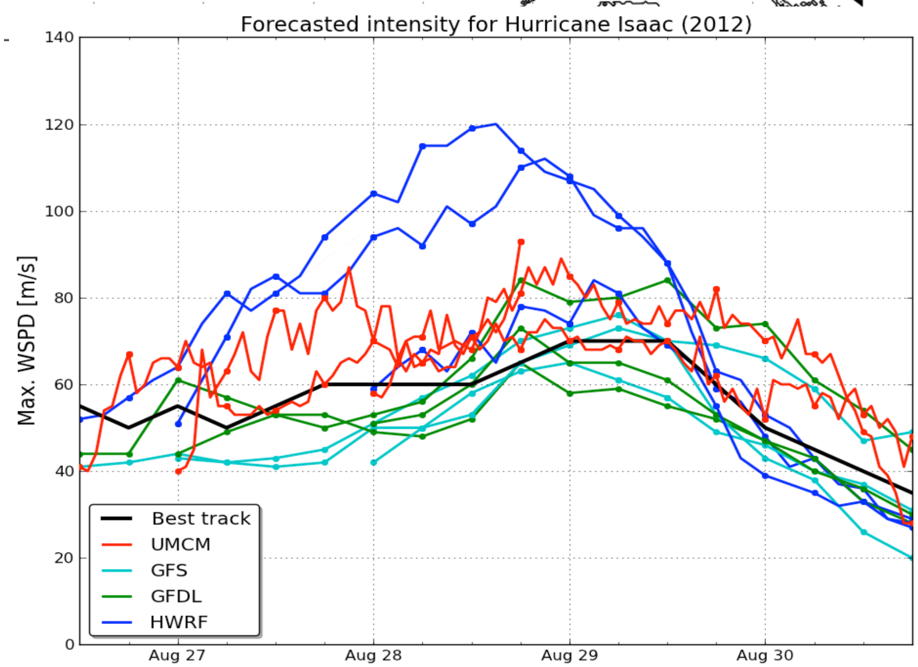


Chen et al. (2013)

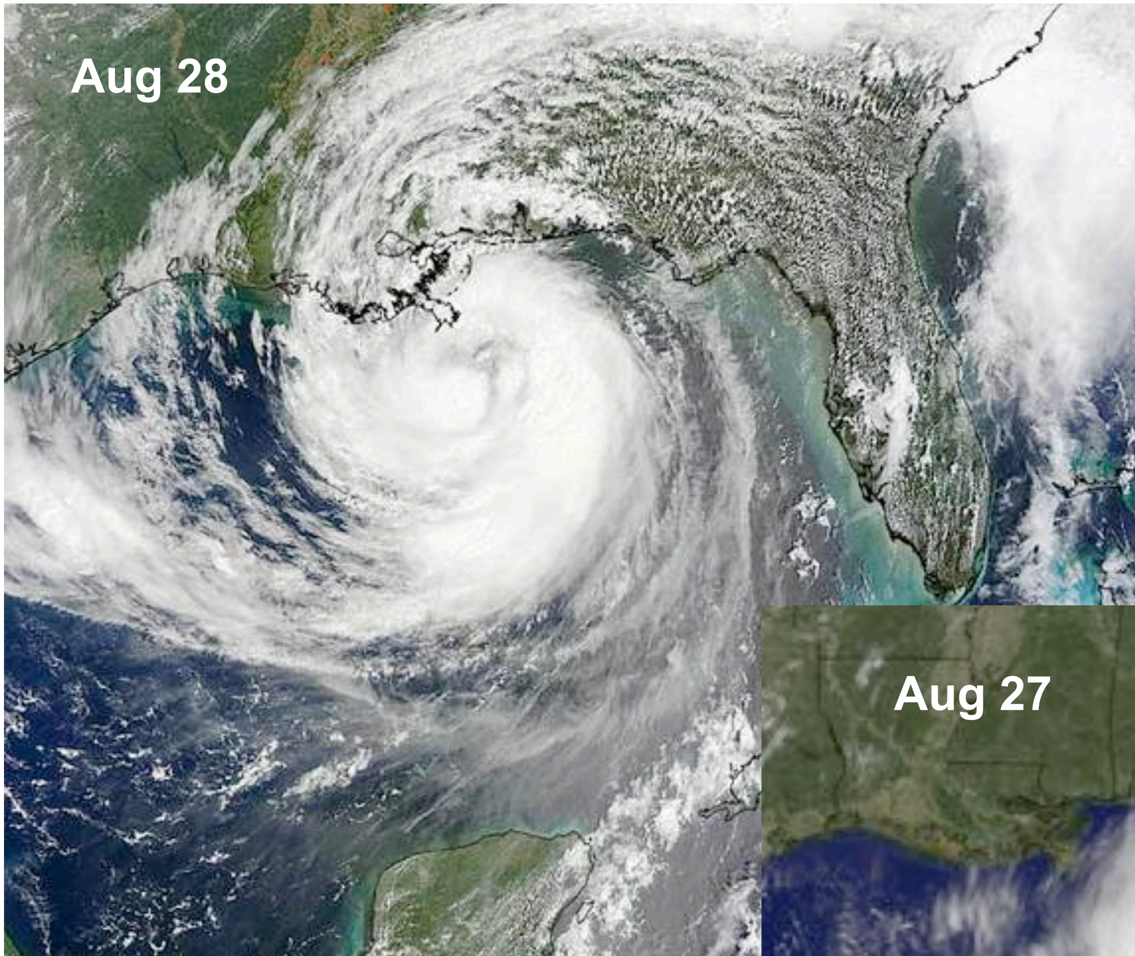
Hurricane Isaac (26-30 Aug 2012)







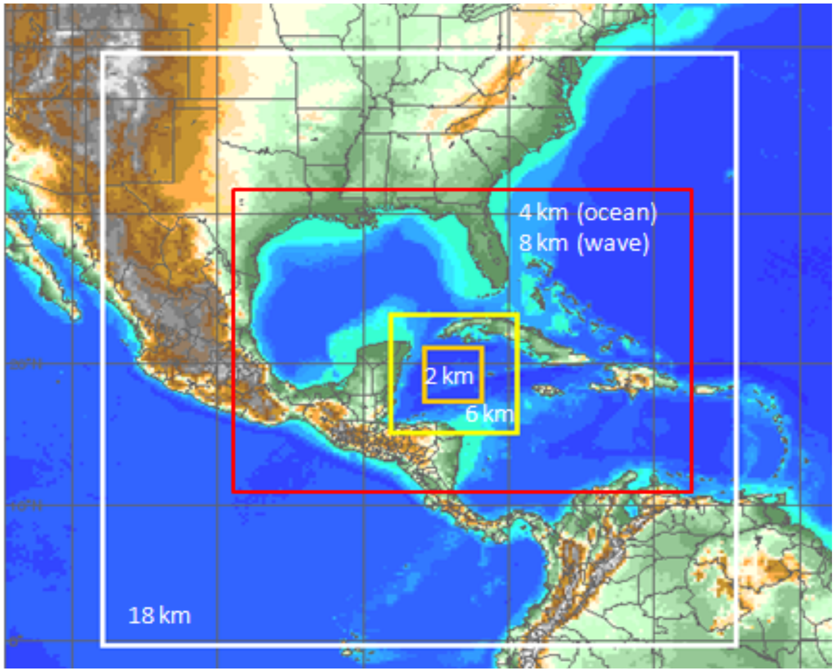
Chen et al. (2013)



Hurricane Isaac (Aug 2012)

Chen et al. (2013)

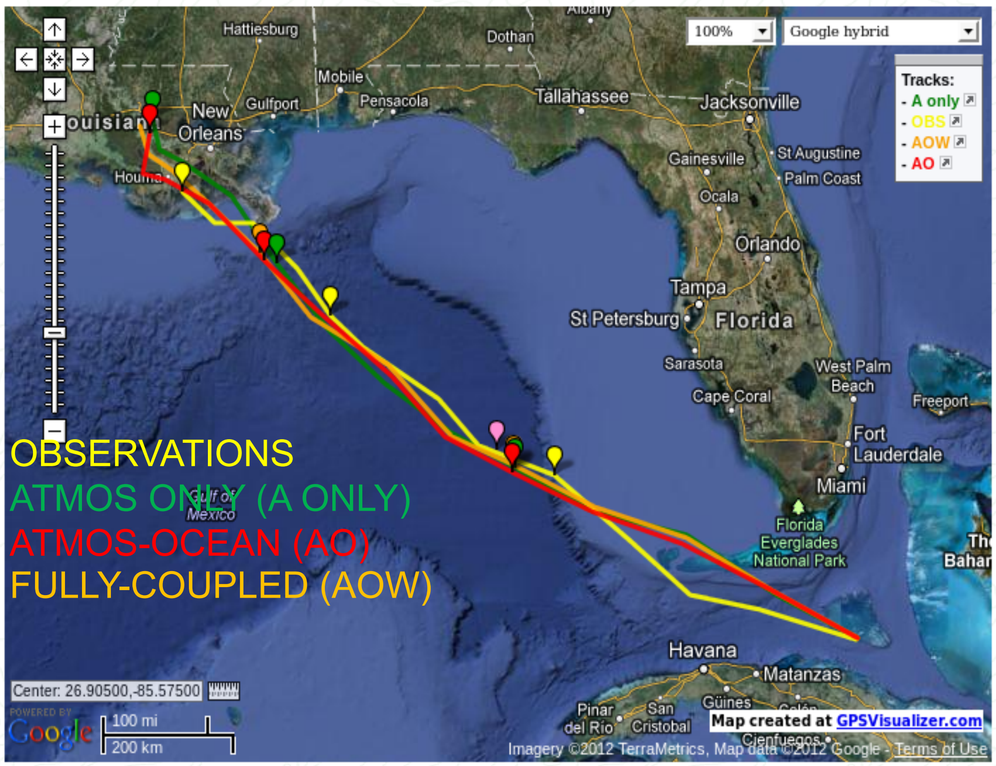
COAMPS SETUP



- **Isaac – Gulf of Mexico (AUG 2012)**
- **Horizontal Resolution**:
  Atmos: 18, 6, and 2 km (child moving)
  Ocean: 4 km
  Wave: 8 km
- **Vertical Resolution**:
  - 60 atmospheric levels
  - 50 ocean levels
- **Boundary Conditions:**
  Atmos: 0.5^{o} NOGAPS
  Ocean: Global NCOM
- **Data Assimilation**:
  Atmos: NAVDAS (3DVAR)
  Ocean: NCODA (3DVAR)
  12 hour update cycle for spinup
- **Observation Data**:
  AXBT (E. Sanabia, USNA)
  ADOS Drifters (Scripps)
  Wave Buoy Data (NOAA)

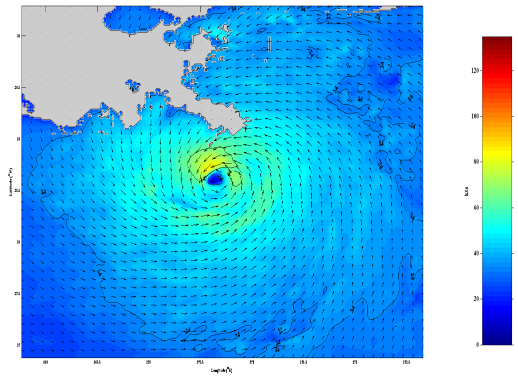
HURRICANE ISAAC

Hurricane Isaac Track
2012082612 72-Hour Forecast

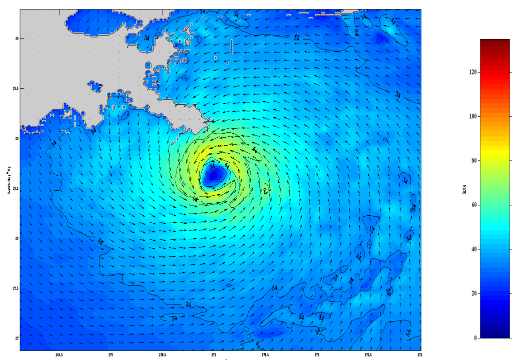


Differing coupling configurations can produce different inner-core convective structures in COAMPS-TC and alter the cyclone’s intensity.

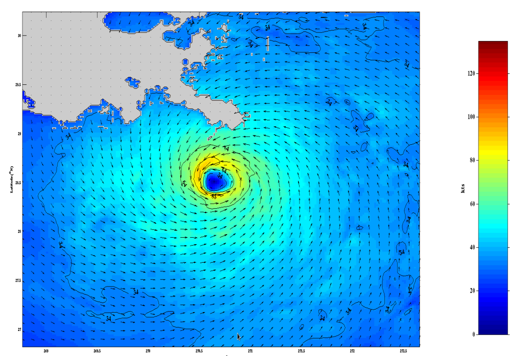
A

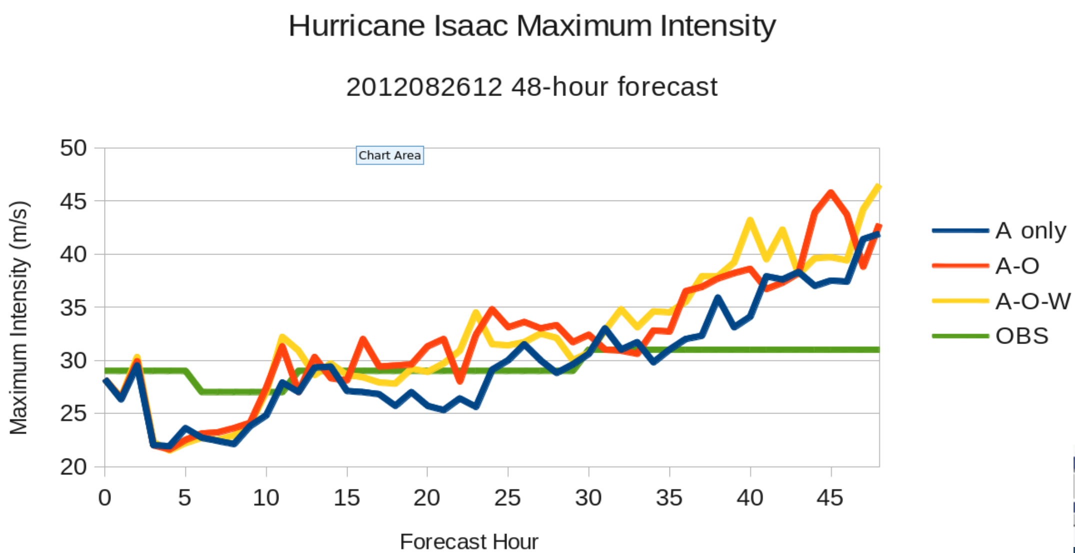


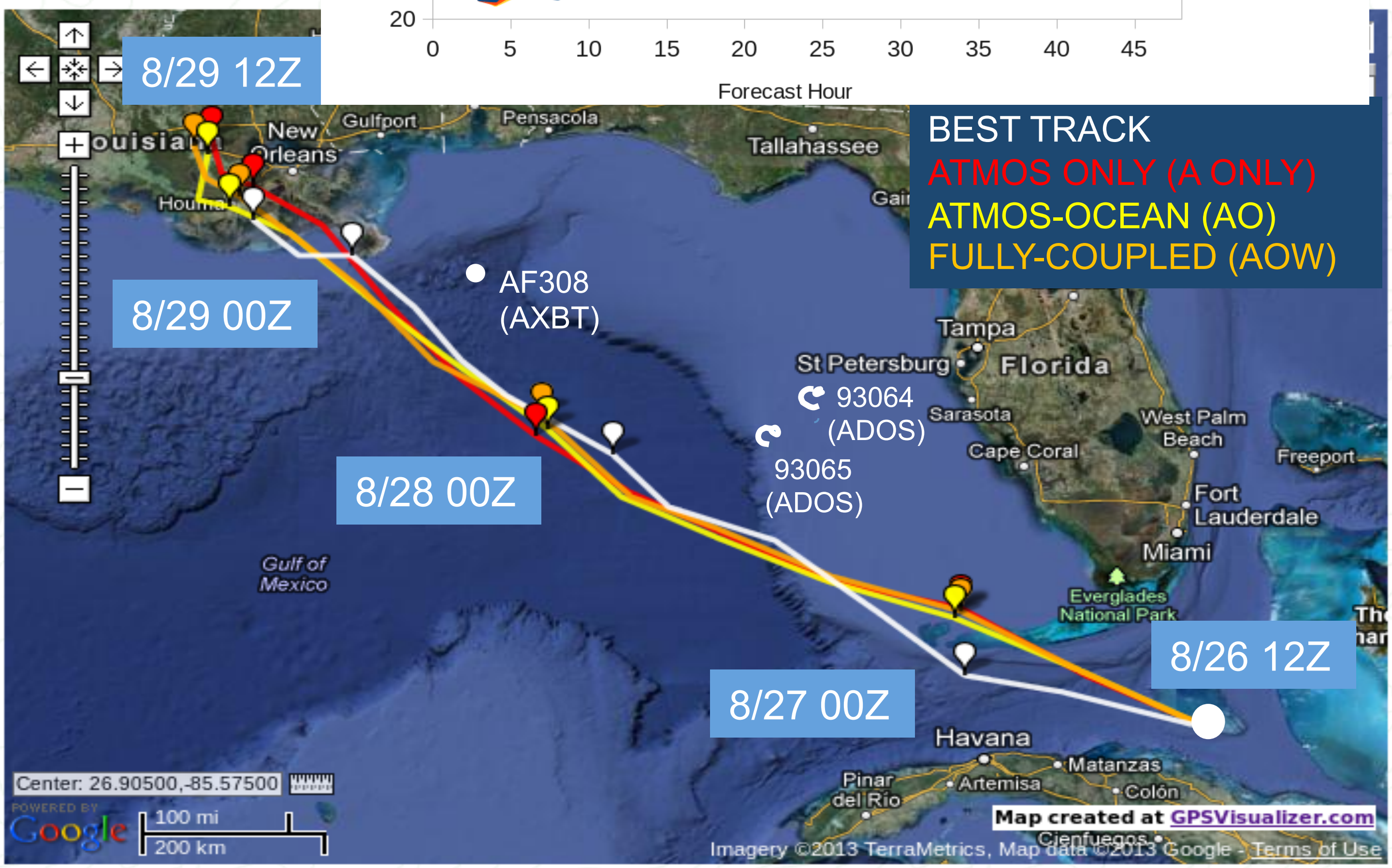
AO



AOW

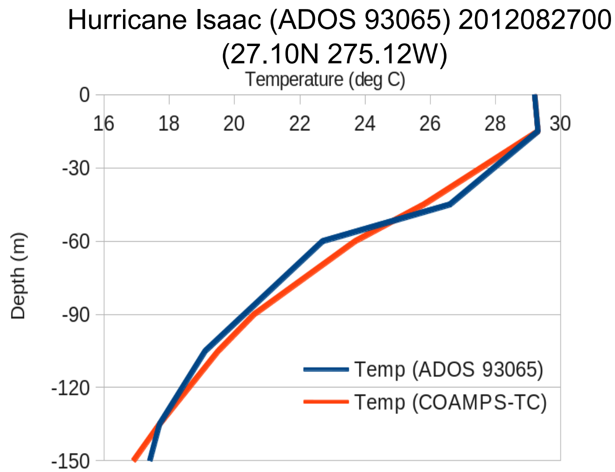



Hurricane Isaac Maximum Intensity
2012082612 48-hour forecast
Chart Area
Maximum Intensity (m/s)
50
45
40
35
30
25
20
0
5
10
15
20
25
30
35
40
45
Forecast Hour
A only
A-O
A-O-W
OBS

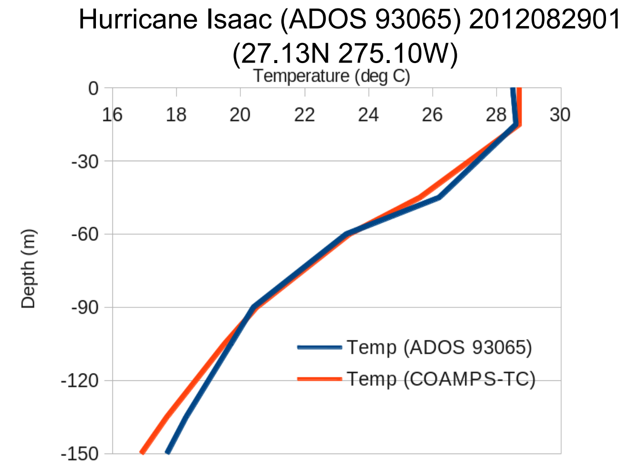

8/29 12Z
8/29 00Z
8/28 00Z
8/27 00Z
8/26 12Z
BEST TRACK
ATMOS ONLY (A ONLY)
ATMOS-OCEAN (AO)
FULLY-COUPLED (AOW)
AF308
(AXBT)
93064
(ADOS)
93065
(ADOS)
New
Orleans
Gulfport
Pensacola
Tallahassee
Houma
Tampa
St Petersburg
Florida
Sarasota
Cape Coral
West Palm
Beach
Freeport
Fort
Lauderdale
Miami
Everglades
National Park
Gulf of
Mexico
Havana
Matanzas
Pinar
del Rio
Artemisa
Colón
Cienfuegos
Center: 26.90500,-85.57500
POWERED BY
Google
100 mi
200 km
Map created at GPSVisualizer.com
Imagery ©2013 TerraMetrics, Map data ©2013 Google - Terms of Use

HURRICANE ISAAC

BEFORE ISAAC PASSAGE

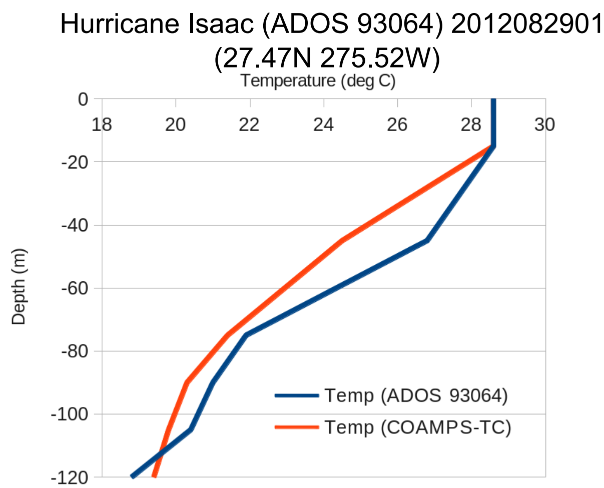


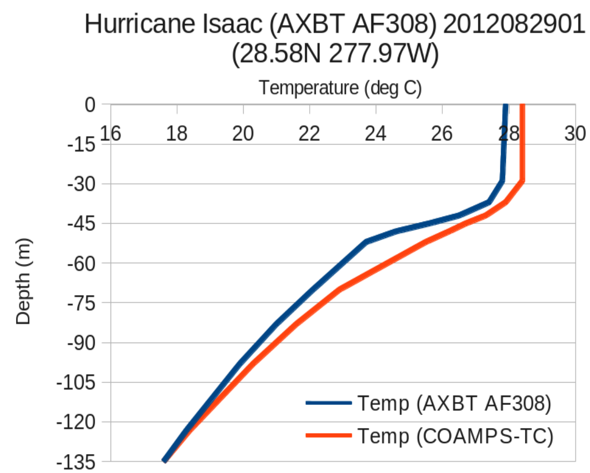
AFTER ISAAC PASSAGE



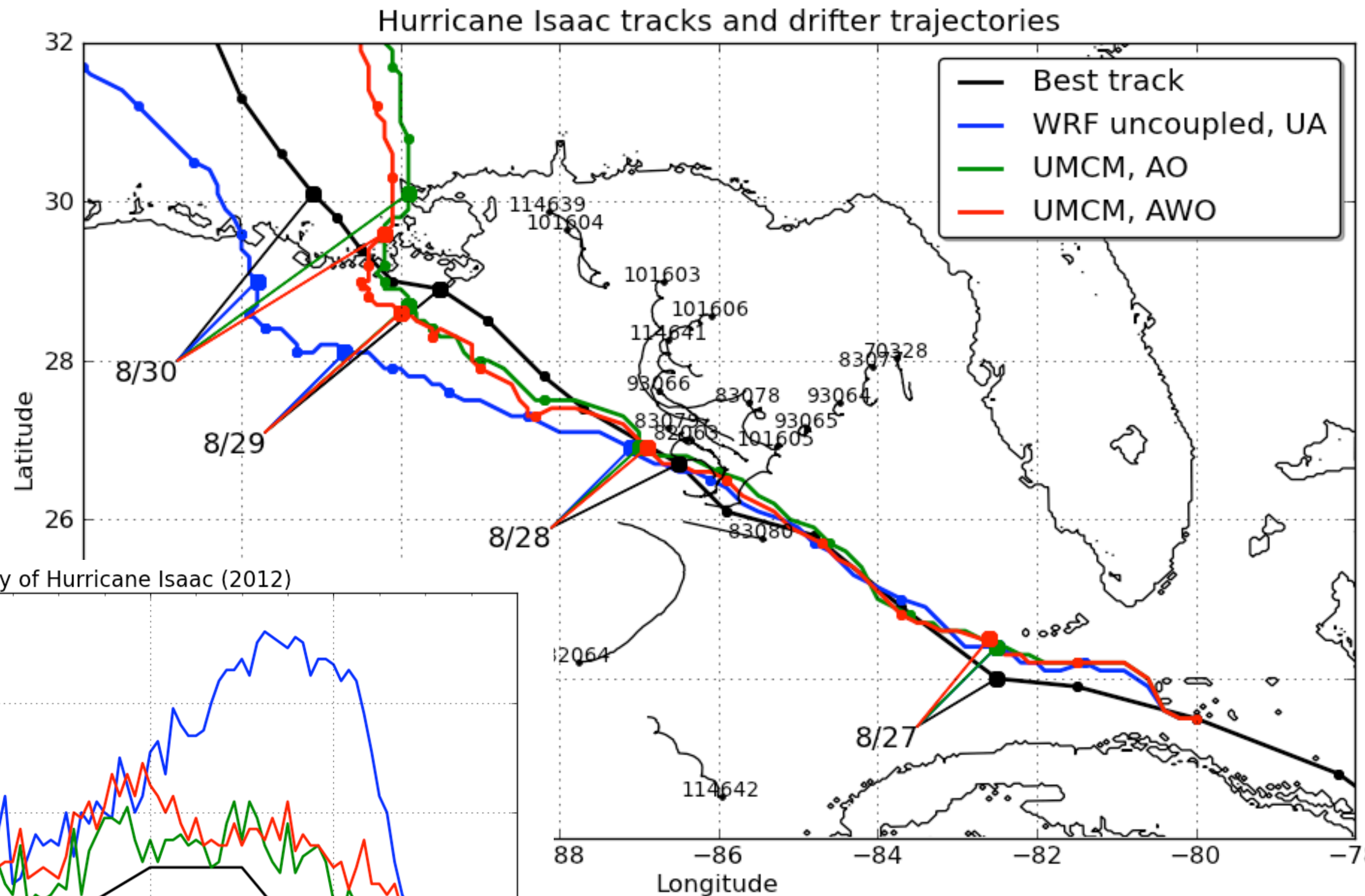
ADOS DRIFTER 93065

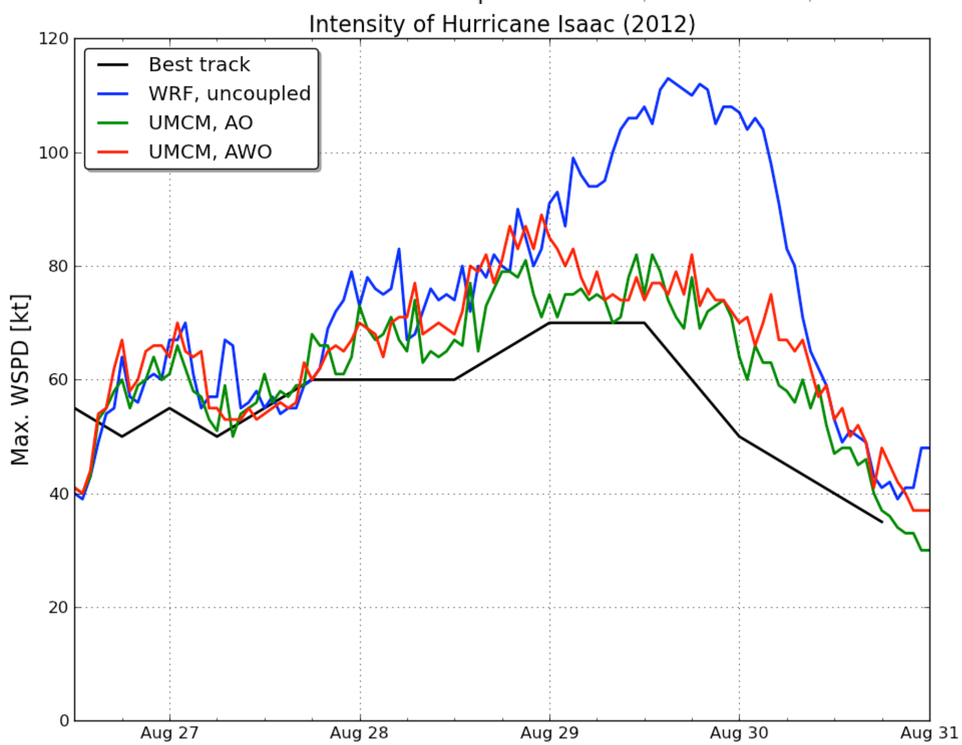
ADOS DRIFTER 93064 (after Isaac)





AXBT AF308 (after Isaac)

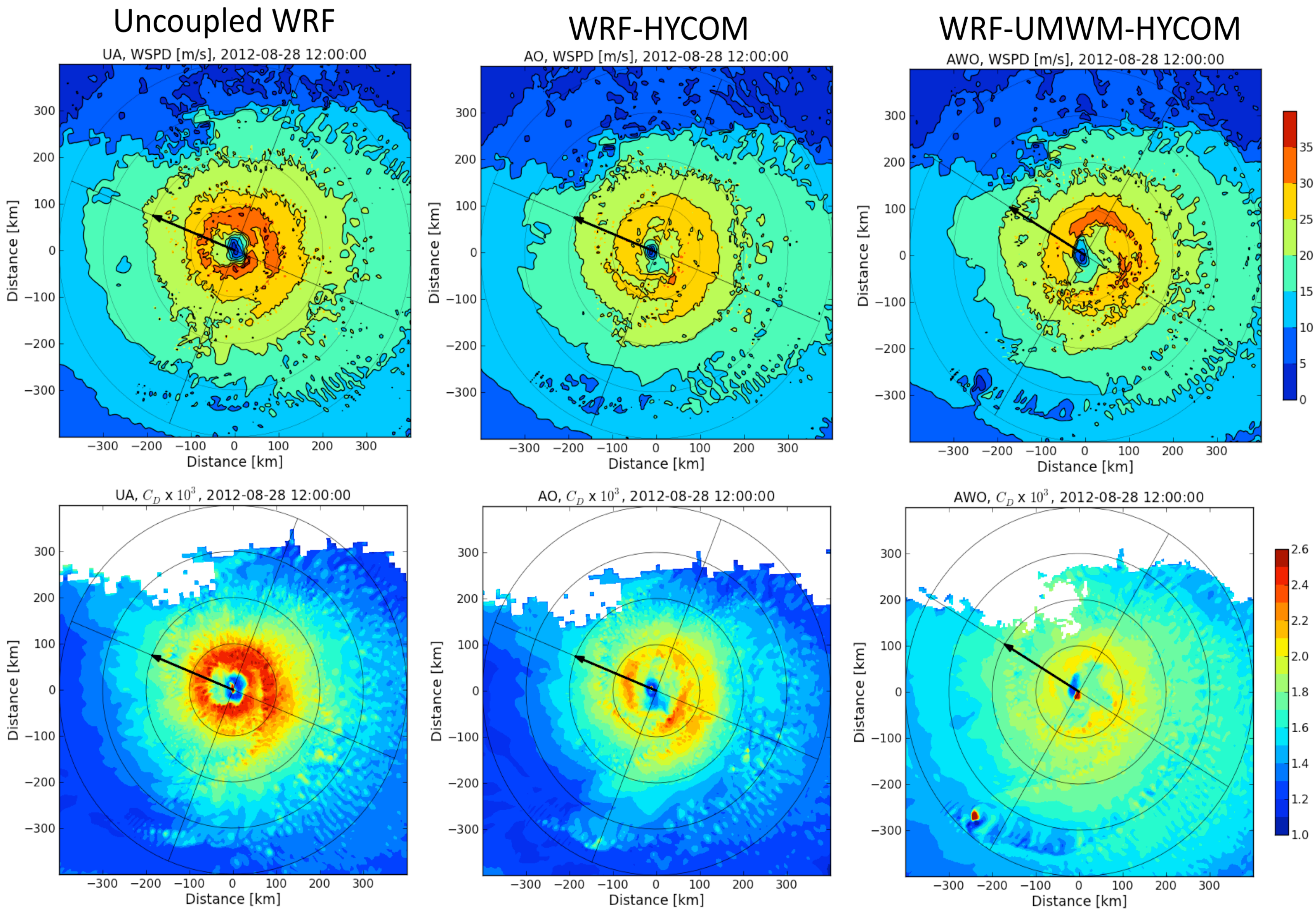




UMCM 5-day Forecast of Hurricane Isaac (initialized at 1200 26 Aug 12): Track and Intensity

Chen et al. (2013)

UMCM Forecasts of Surface Wind Speed and C_D in TS Issac (1200 28 Aug 2012)



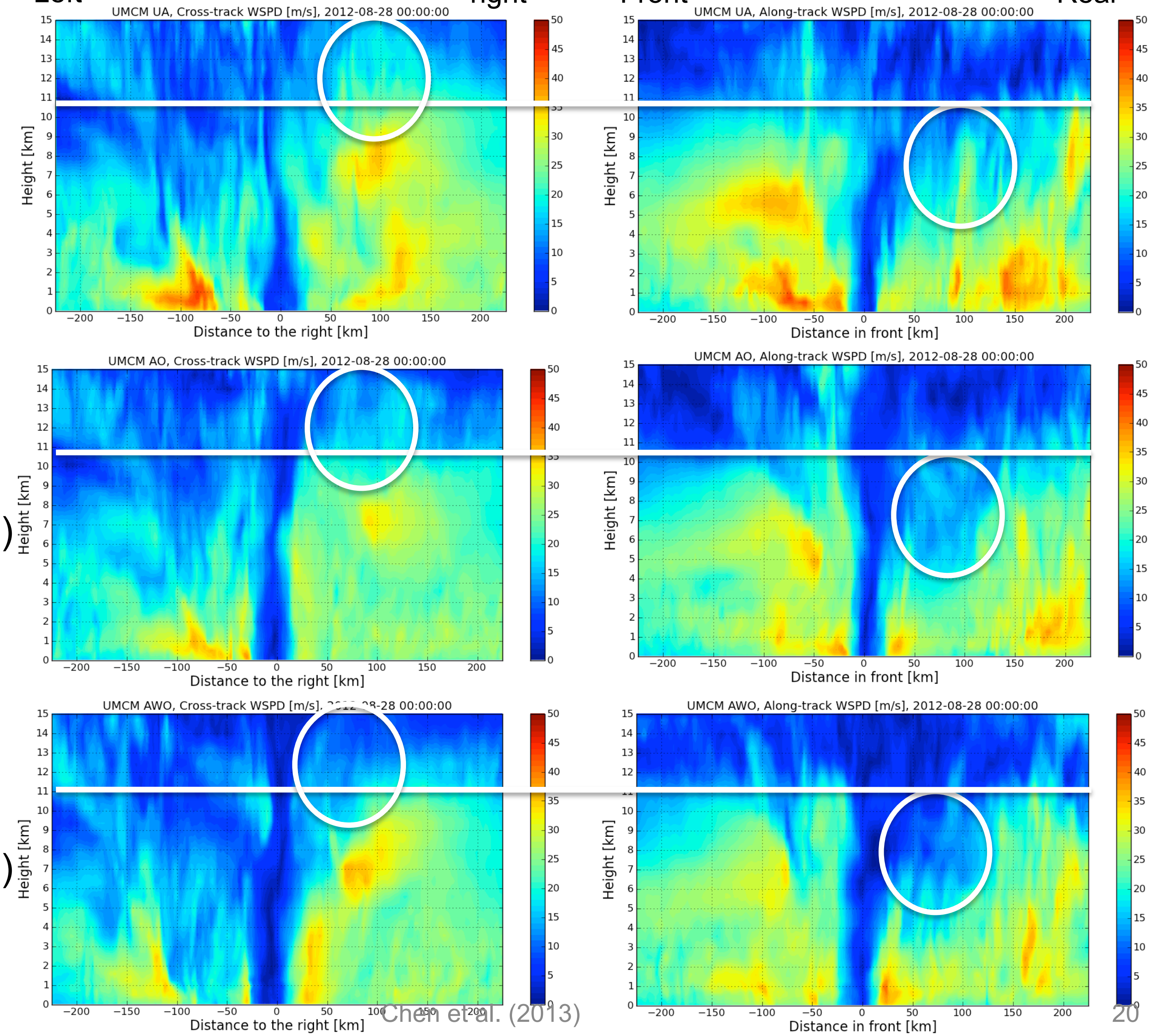
Chen et al. (2013)

Left | Cross-track wind | right — Front | Along-track wind | Rear

Uncoupled (deep/sym)

AO (shallow/asym)

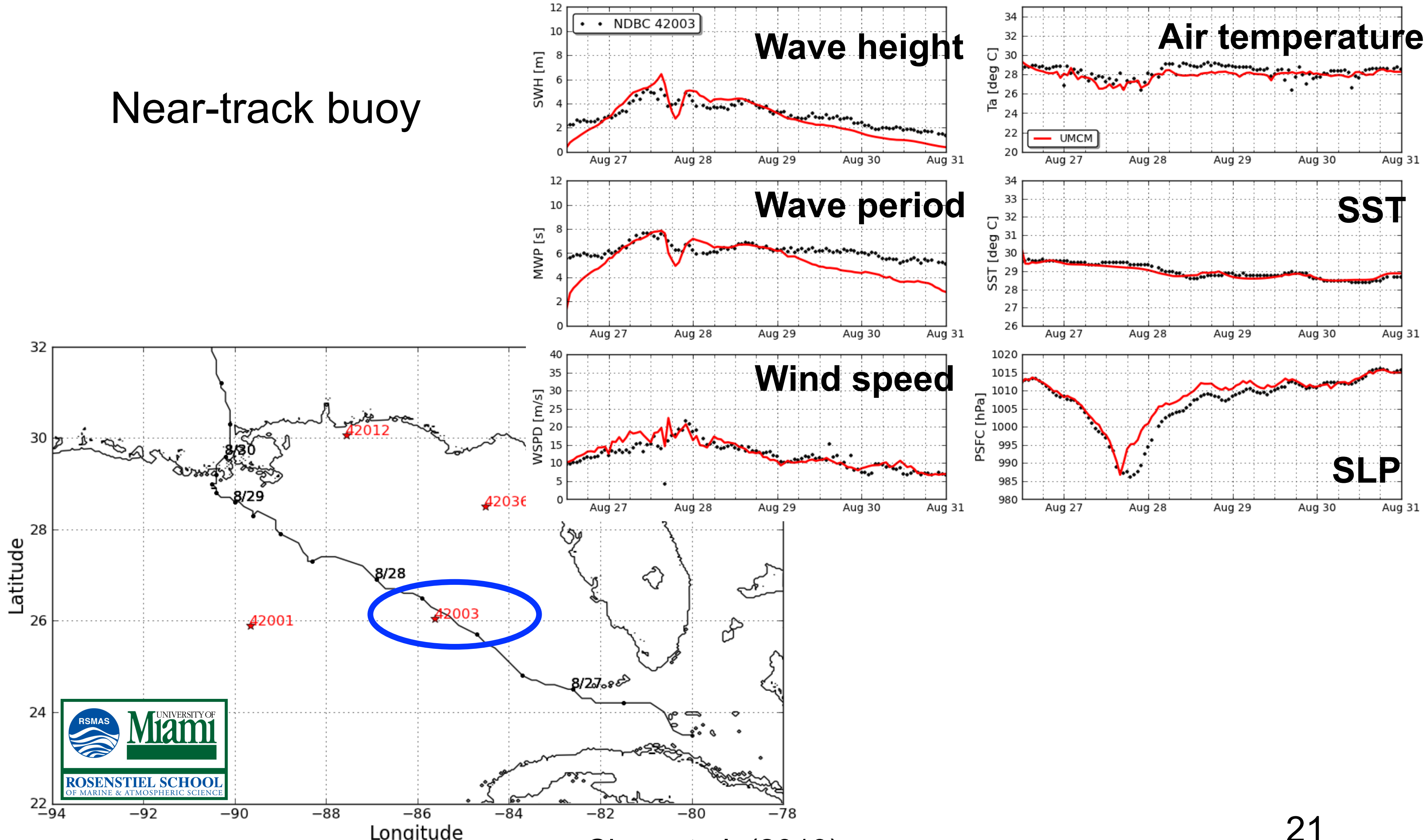
AWO (shallow/asym)



Chen et al. (2013)

UMCM verification against NDBC buoy measurements

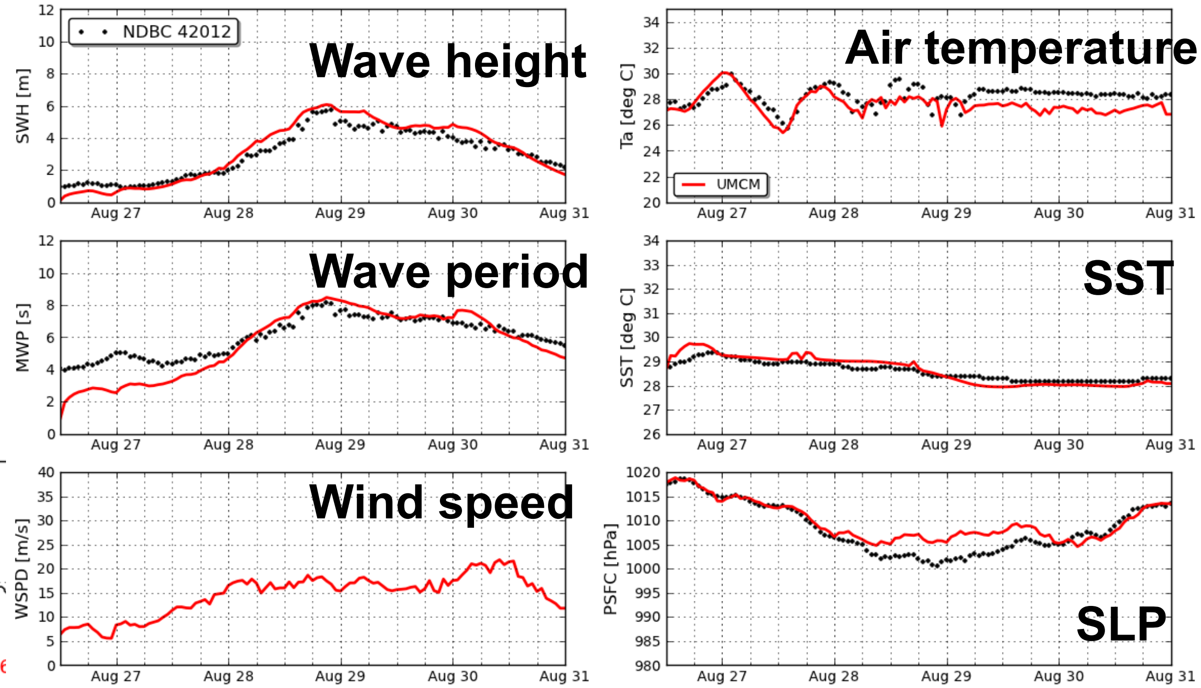
Near-track buoy

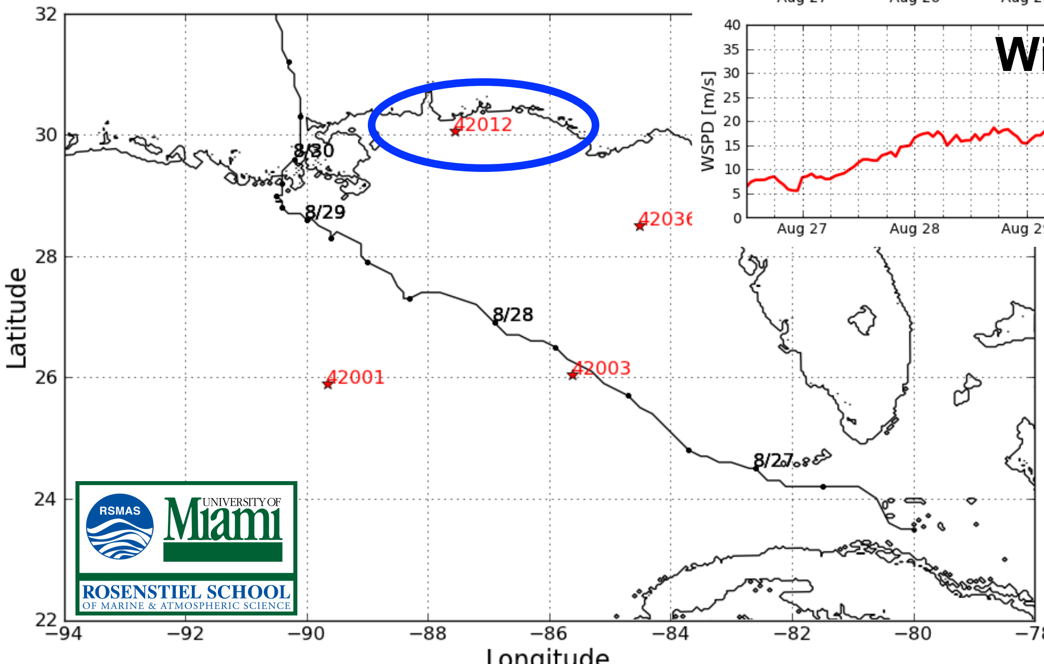


Chen et al. (2013)

UMCM verification against NDBC buoy measurements

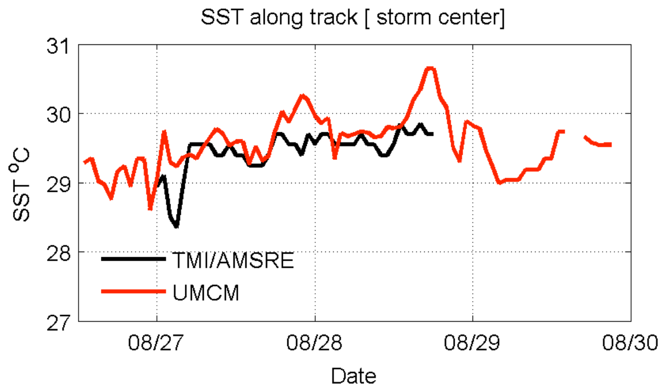
Coastal buoy

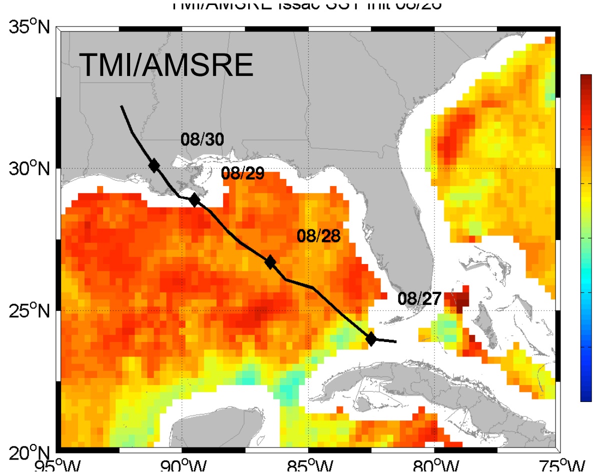


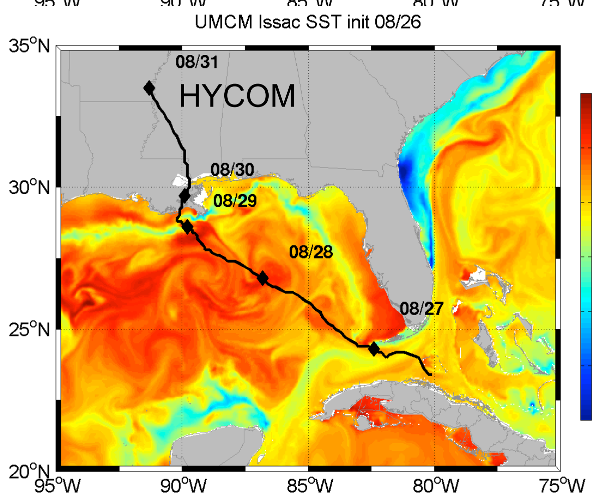


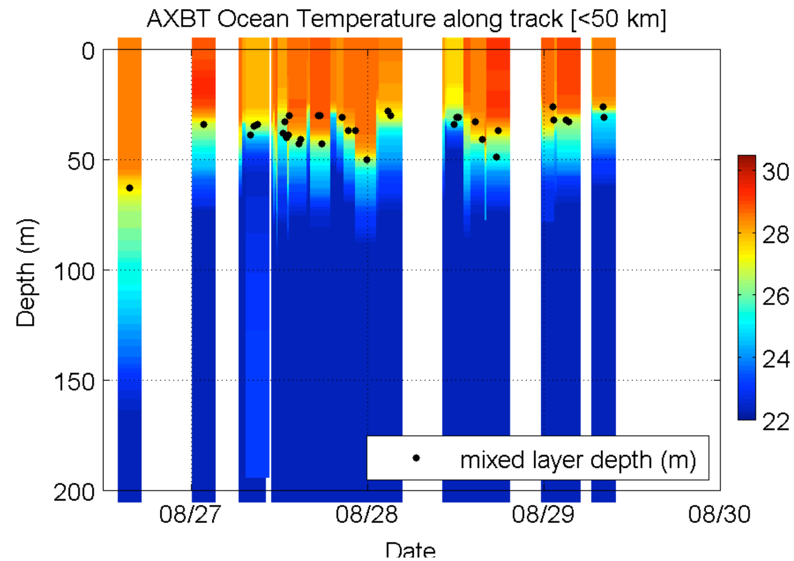
Chen et al. (2013)

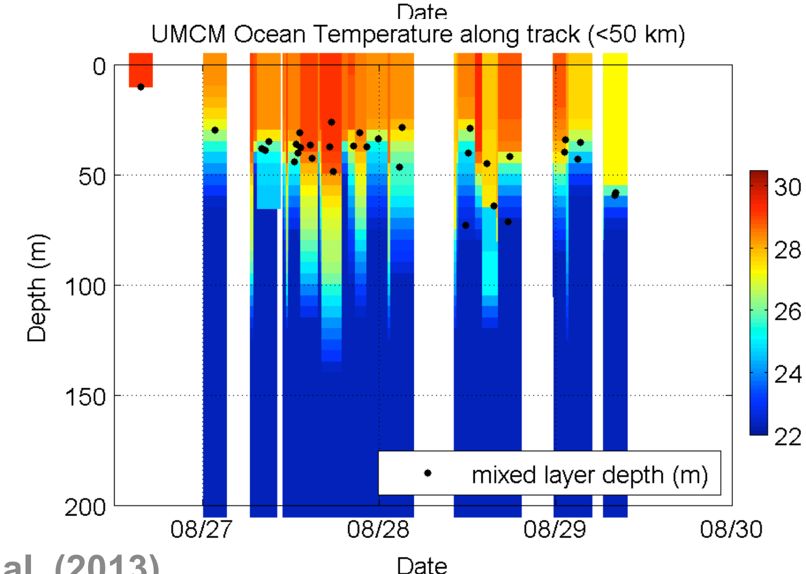
Model verification against sat SST and AXBT data (Sanabia et al. 2013)





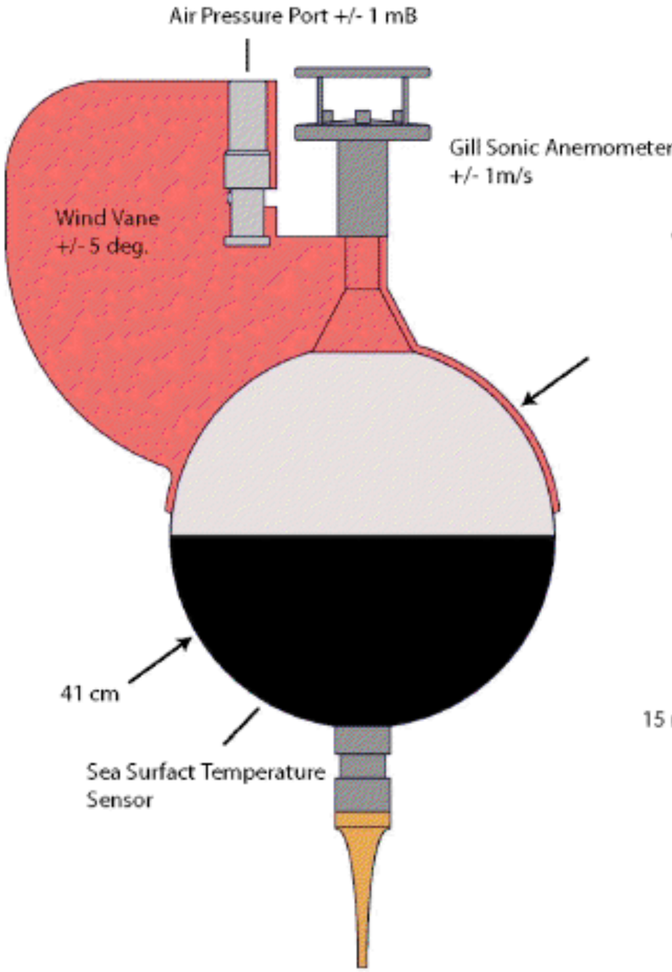


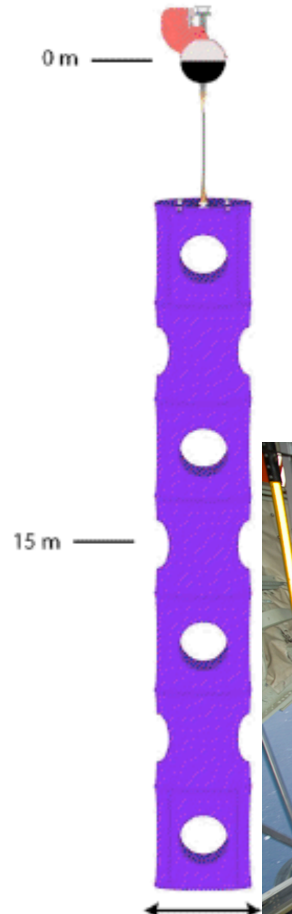


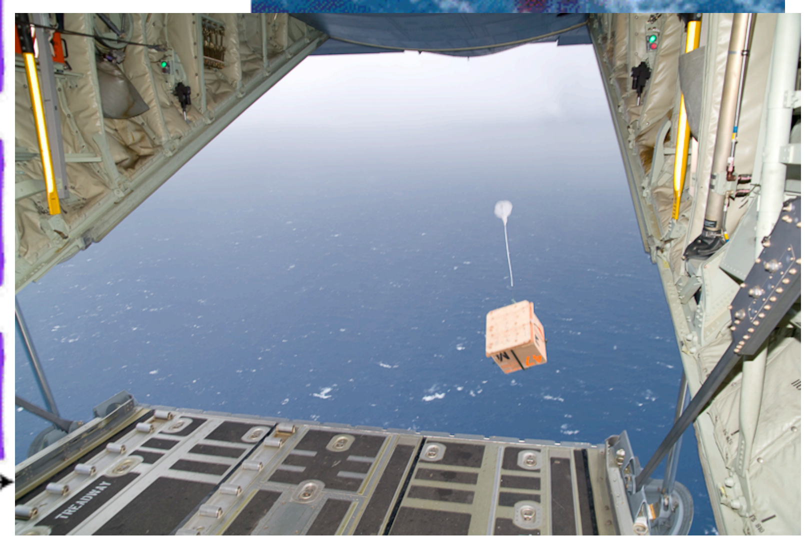


Chen et al. (2013)

Sonic Minimet Drifters





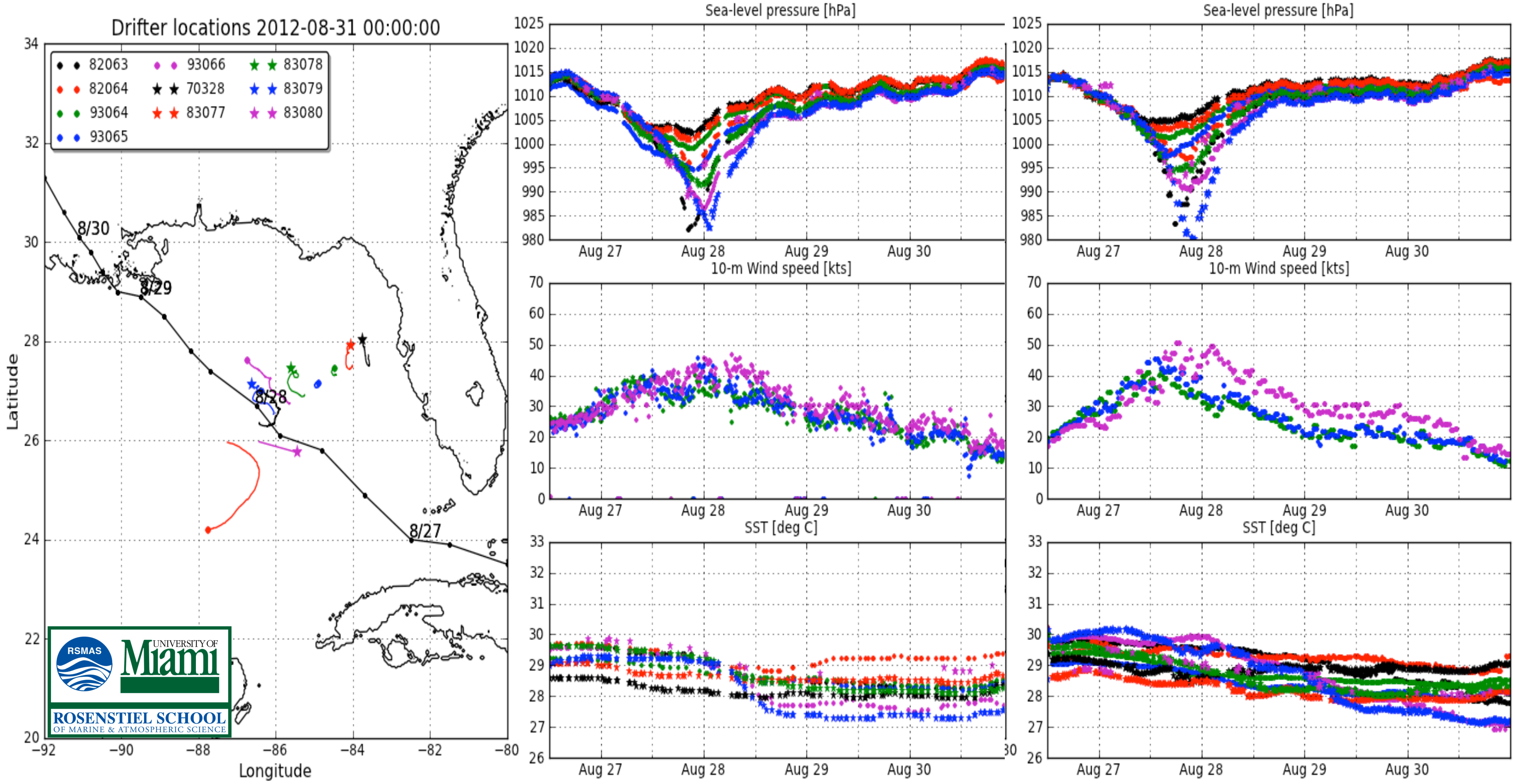


L. Centurioni and J. Morzel

Chen et al. (2013)

Model Verification against Drifter Data

SIO drifters UMCM forecast



Chen et al. (2013)

SUMMARY

- Fully coupled models are a key for building a physically consistent and energetic balanced prediction systems

- Progress toward development of the unified air-sea interface module using ESMF/NUOPC with interoperability layer that can be transitioned to operations

- Important to use coupled observations to evaluate/verify coupled model forecasts (e.g., winds, SLP, rain, surface waves, ocean temperature and current, etc.)

- Working toward a data assimilation system using coupled observations in coupled models

Chen et al. (2013)