

Coupling, diagnosing, and improving the POM-TC ocean model component of NOAA's HWRF and GFDL coupled hurricane forecast models

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Melissa Kaufman (URI/GSO)**

HFIP Teleconference, 6 June 2012, 2pm EDT

Acknowledgements

Hurricane Forecast Improvement Project (HFIP)

Joint Hurricane Testbed (JHT)

V. Tallapragada & NOAA/EMC HWRF Group

A. Mehra & NOAA/EMC/MMAB Group

L. Bernardet & DTC HWRF Group

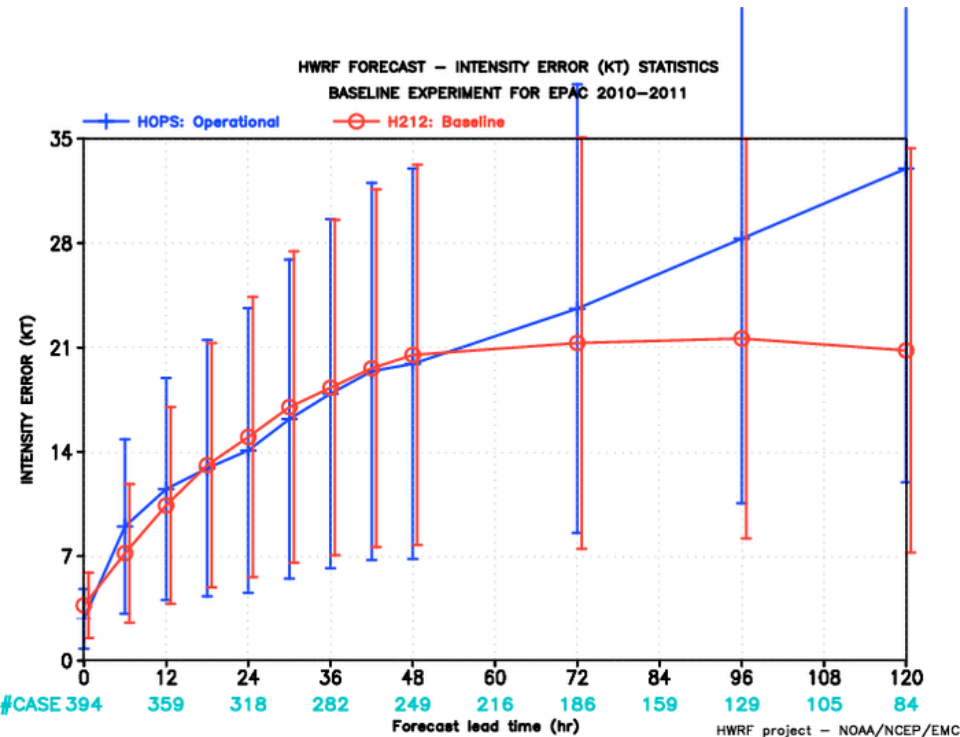
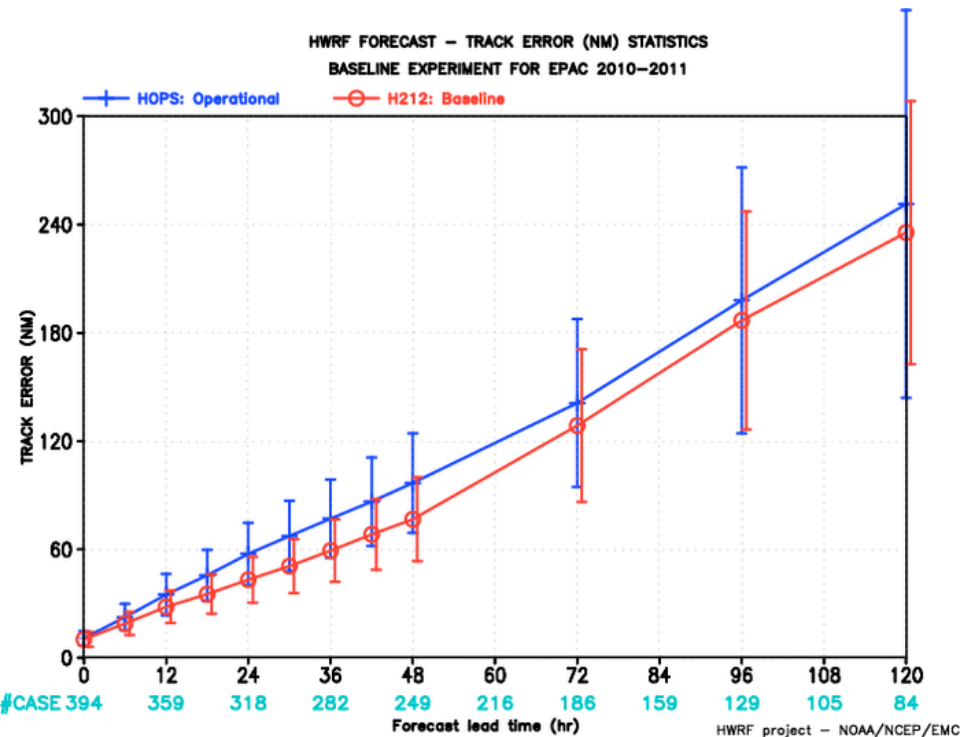
M. Bender & NOAA/GFDL Hurricane Group

URI/GSO Numerical Modeling Lab Group

Outline

- Coupling HWRF to POM-TC in the East Pacific
- Diagnosing operational POM-TC in HWRF
- Determining optimal POM-TC resolution
- Initializing POM-TC with Global HYCOM RTOFS
- Creating a new MPIPOM-TC

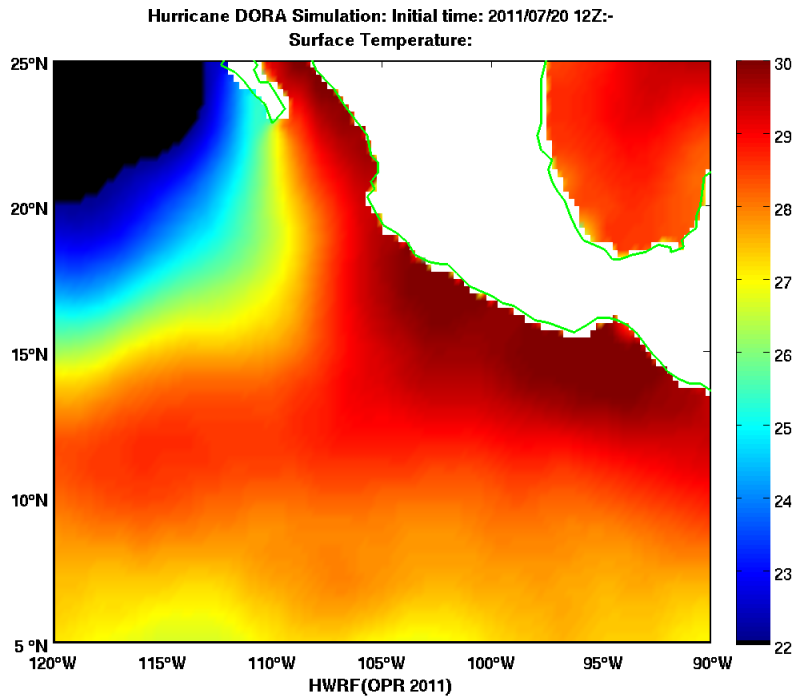
Impact of East Pac ocean coupling



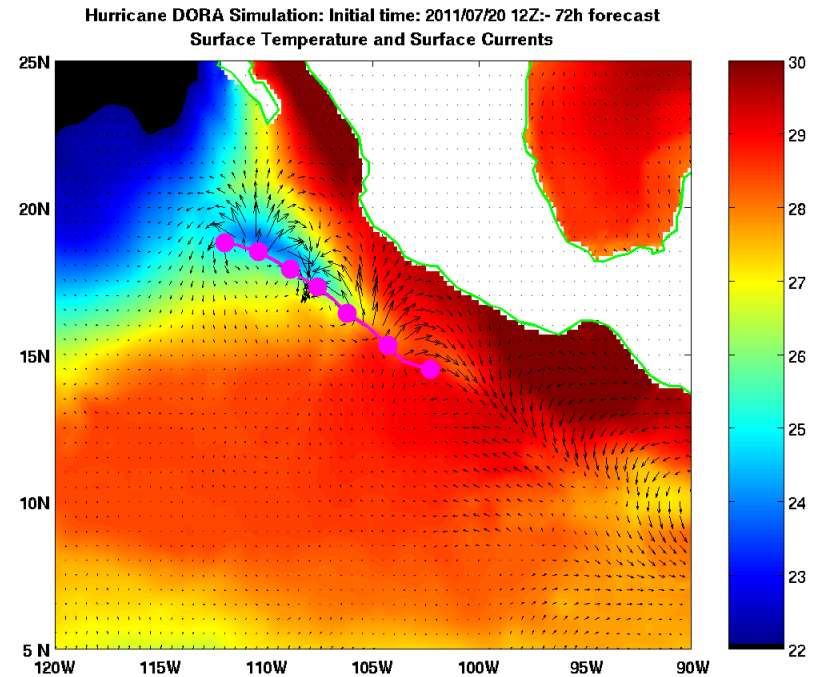
H211 (uncoupled) and H212 (coupled)
HWRf **track** forecast errors for the 2010
and 2011 East Pacific hurricane seasons

H211 (uncoupled) and H212 (coupled)
HWRf **intensity** forecast errors for the 2010
and 2011 East Pacific hurricane seasons

Impact of East Pac ocean coupling

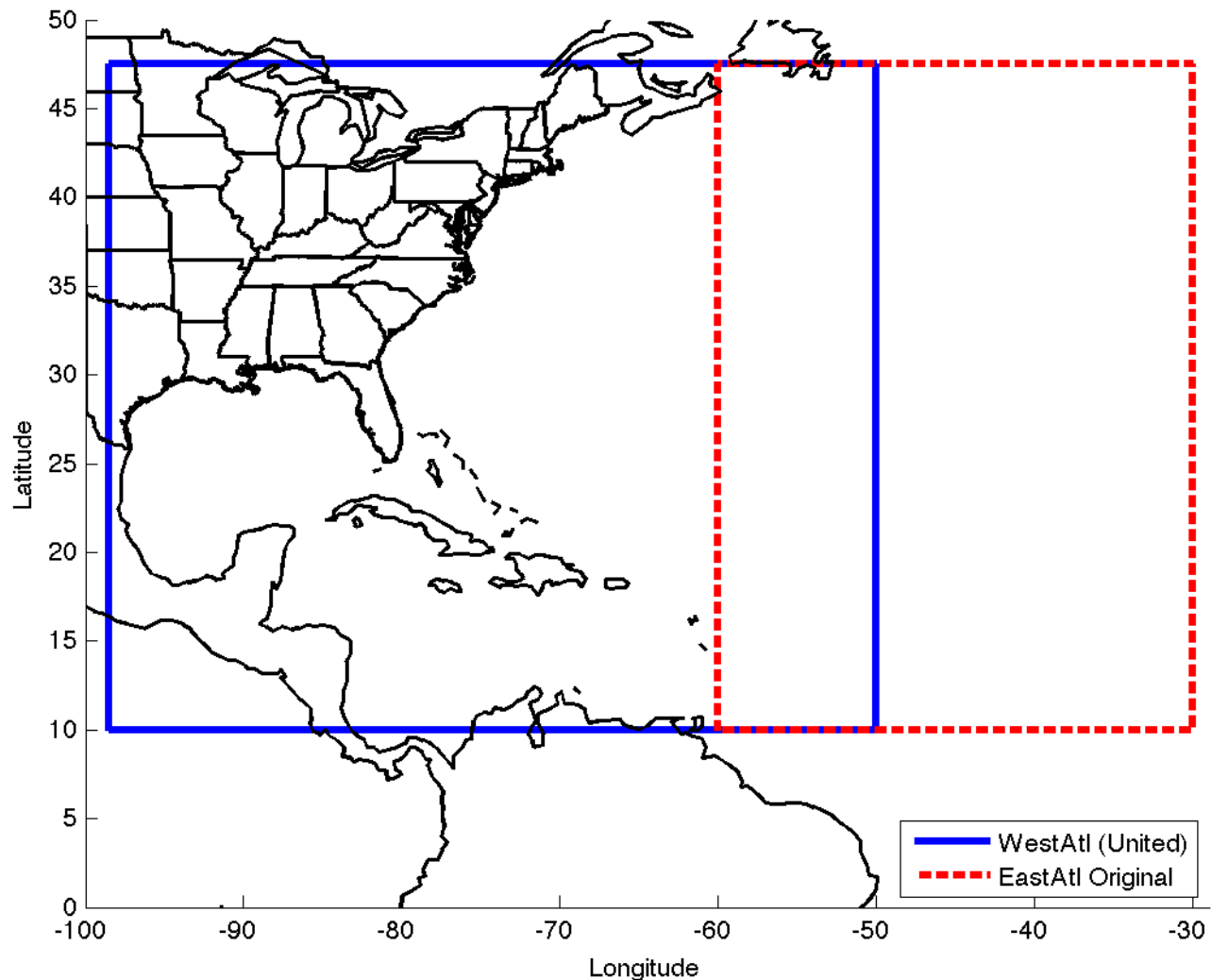


SST at 72-h into the H211 (uncoupled)
HWRf forecast of Hurricane Dora,
initialized 2011072012

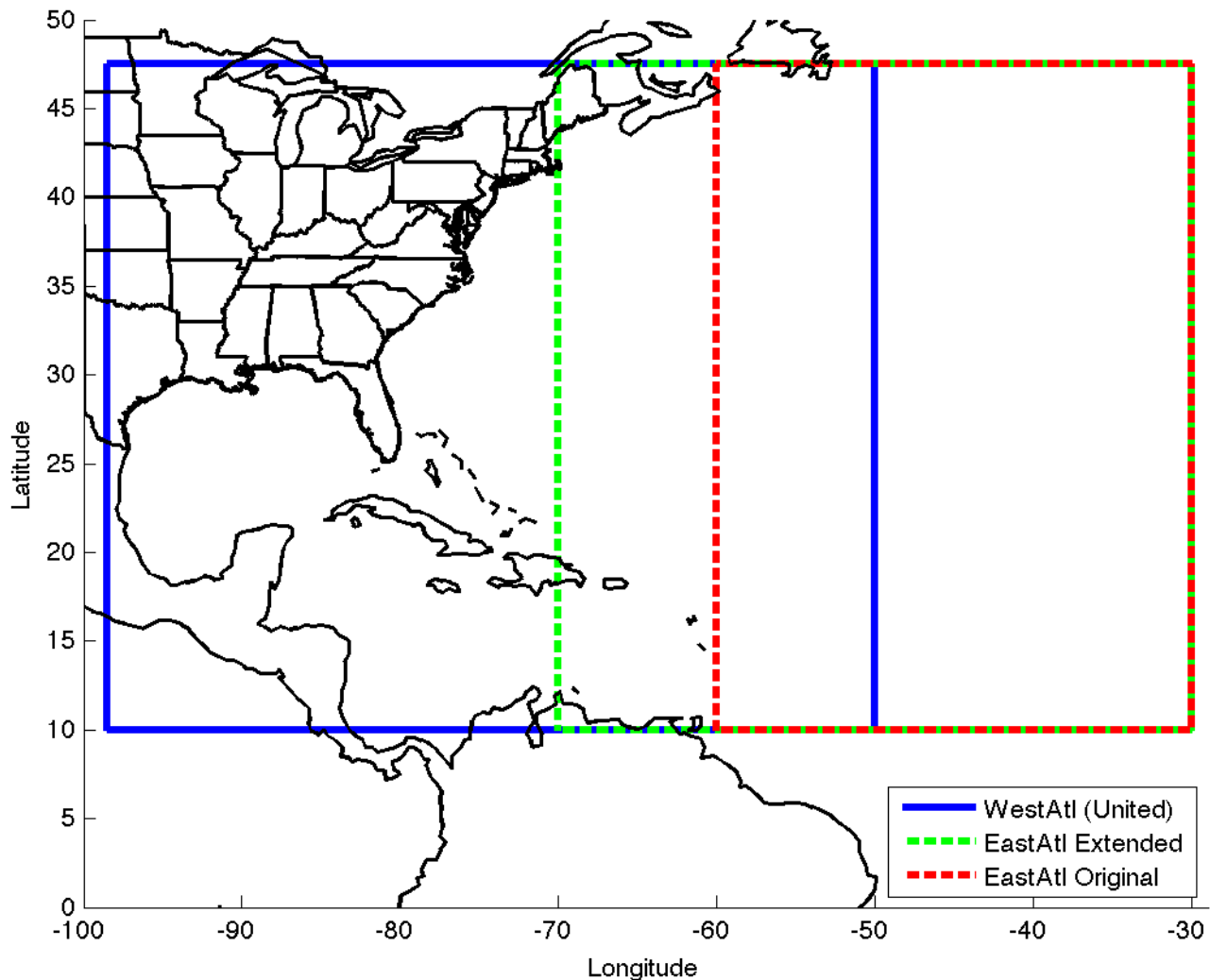


SST at 72-h into the H212 (coupled)
HWRf forecast of Hurricane Dora,
initialized 2011072012

HWRF's and GFDL's pre-2011 POM-TC ocean domains: United & East Atlantic

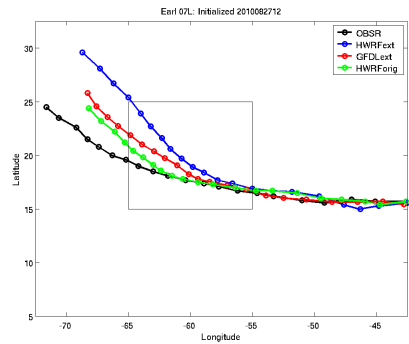


HWRF's and GFDL's new extended East Atlantic POM-TC ocean domain

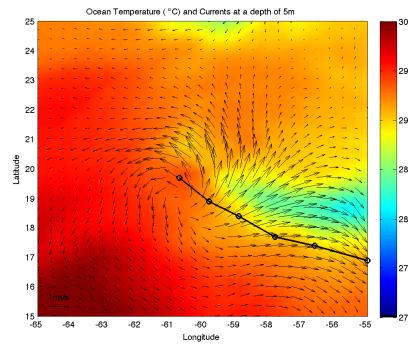


Hurricane Earl (20100827/12Z): HWRF ocean, intensity, and RMW

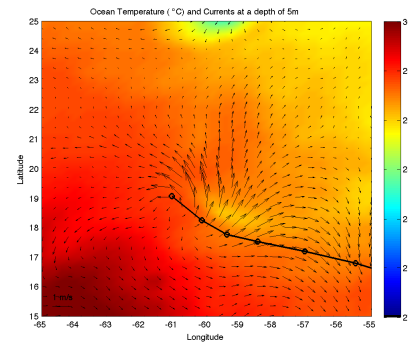
0 to 120-h Tracks



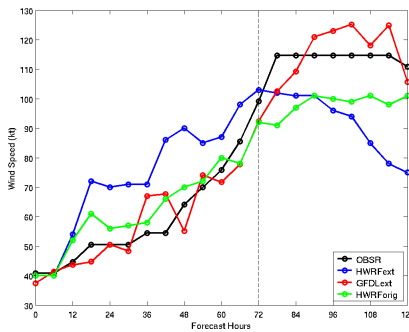
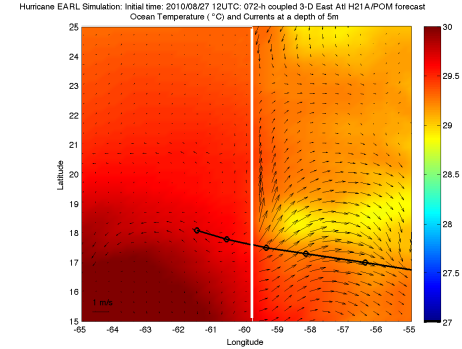
72-h SST: HWRF ext



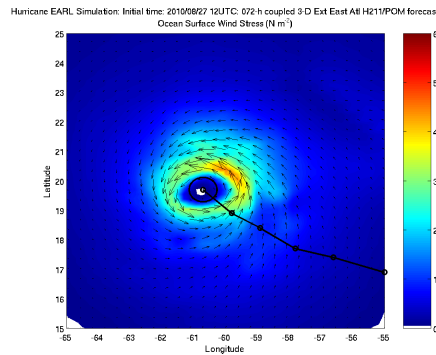
72-h SST: GFDL ext



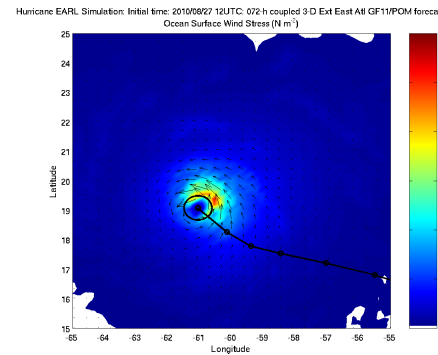
72-h SST: HWRF orig



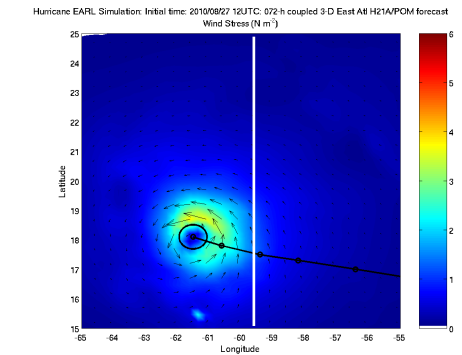
0 to 120-h Intensities



72-h Tau: HWRF ext



72-h Tau: GFDL ext

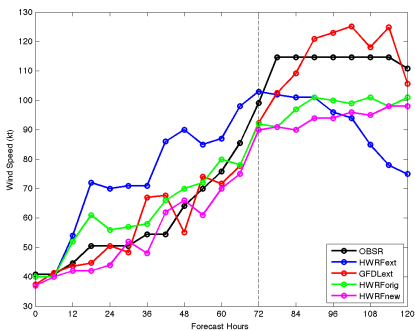
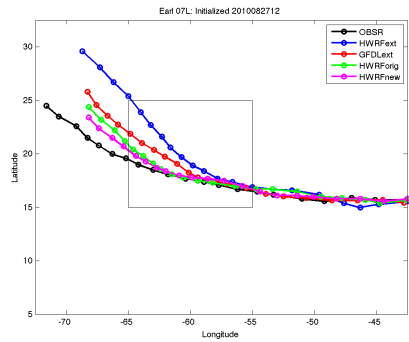


72-h Tau: HWRF orig

- Ext domain prevents loss of ocean coupling but degrades HWRF intensity forecast
- Anomalously large HWRF RMW \rightarrow excessive ocean cooling \rightarrow erroneous weakening?
- Ext domain in GFDL, which has accurate storm size, produces better intensity forecast

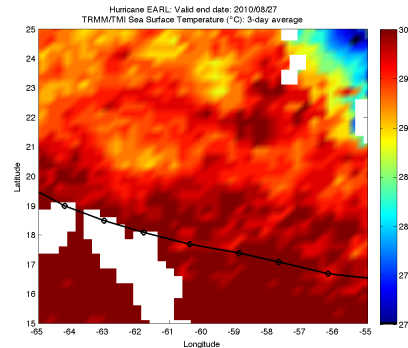
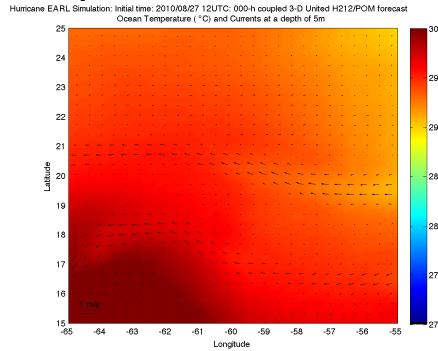
Hurricane Earl (20100827/12Z): New HWRF (H212) ocean and intensity

0 to 120-h Tracks



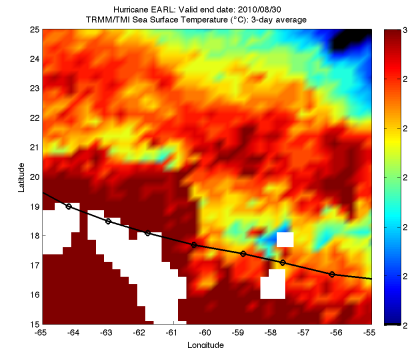
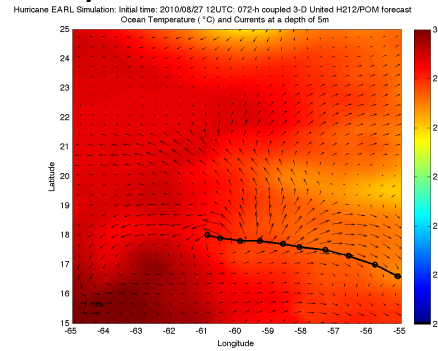
0 to 120-h Intensities

8/27 H212 00-h SST



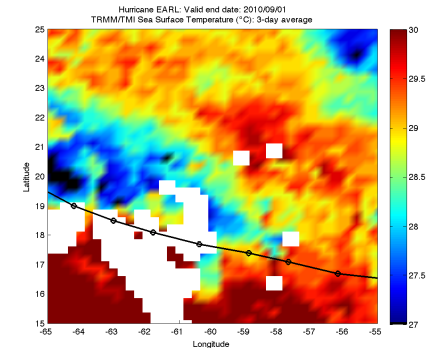
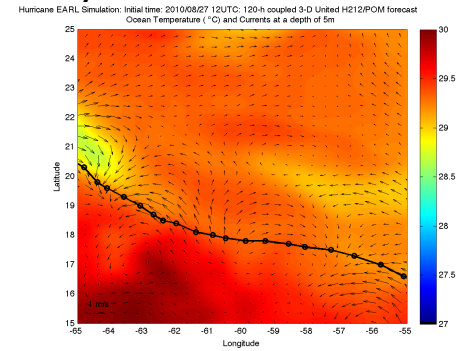
8/27 TMI 3-day SST

8/30 H212 72-h SST



8/30 TMI 3-day SST

9/01 H212 120-h SST

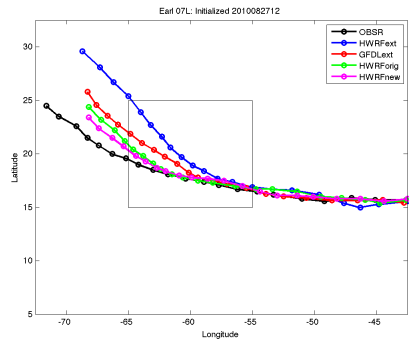


9/01 TMI 3-day SST

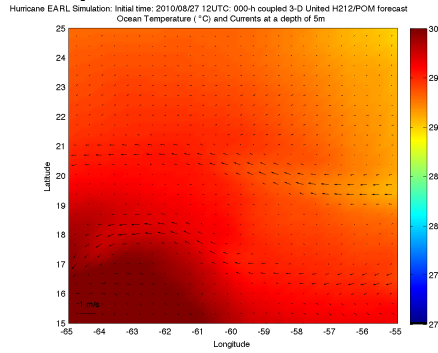
- New HWRF (H212) ocean cooling is under predicted...
- Likely explanation: low H212 intensity bias, especially after 72 hours

Hurricane Earl (20100827/12Z): New HWRf ocean, intensity, and RMW

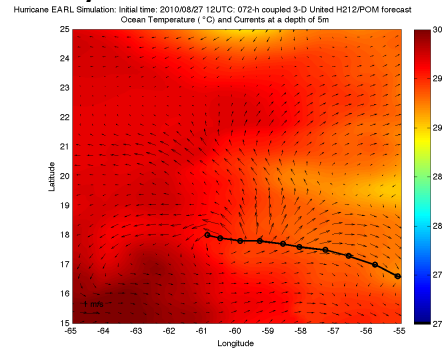
0 to 120-h Tracks



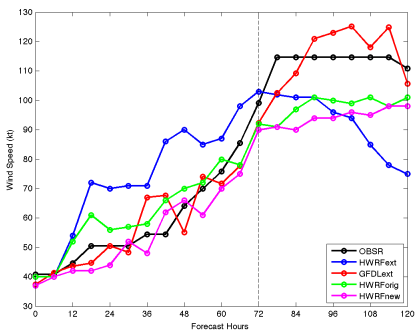
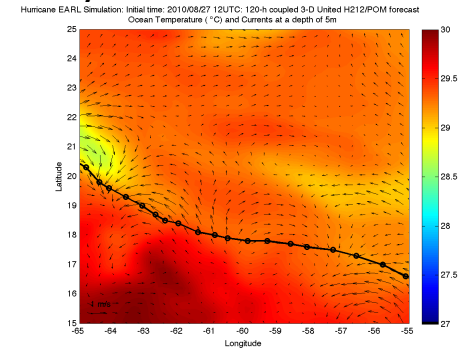
8/27 H212 00-h SST



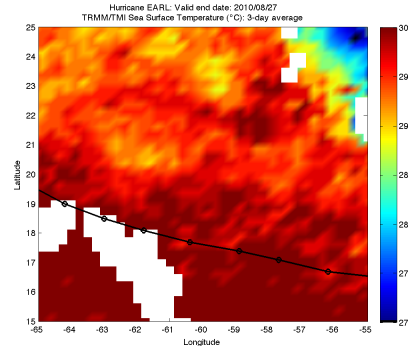
8/30 H212 72-h SST



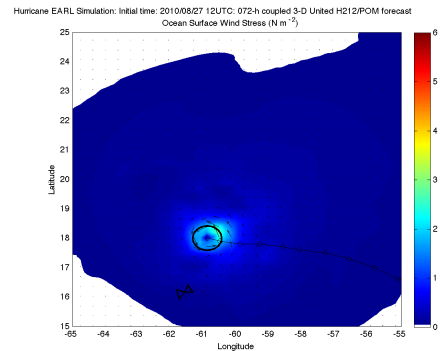
9/01 H212 120-h SST



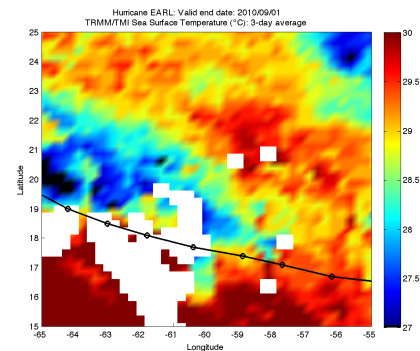
0 to 120-h Intensities



8/27 TMI 3-day SST



8/30 H212 72-h Tau

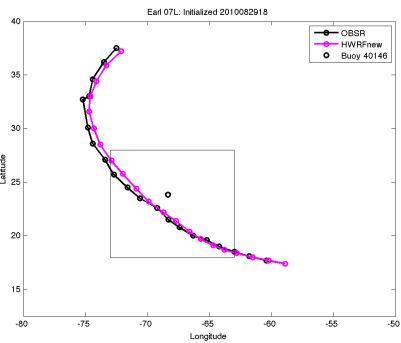


9/01 TMI 3-day SST

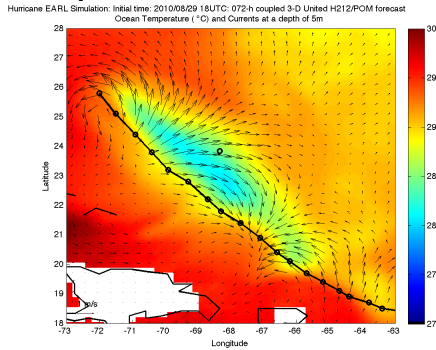
- New HWRf (H212) ocean cooling is under predicted...
- Likely explanation: low H212 intensity bias, especially after 72 hours
- But new HWRf storm size is much improved (vs. old HWRf storm size)

Hurricane Earl (20100829/18Z): New HWRF (H212) ocean and intensity

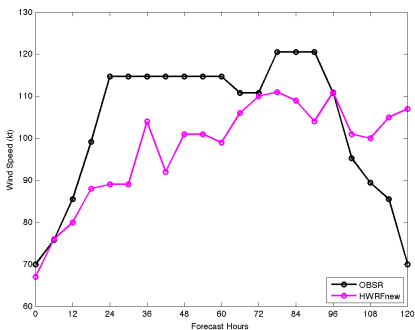
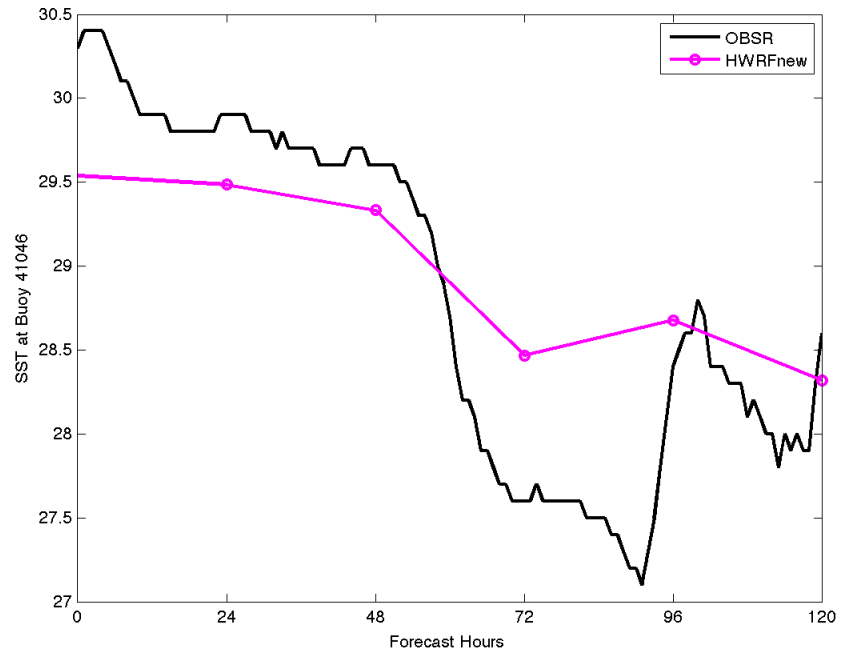
0 to 120-h Tracks



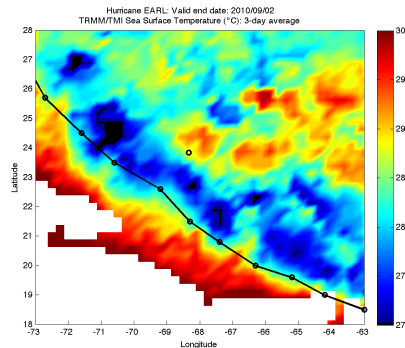
9/01 H212 72-h SST



SST Time Series at Buoy 41046 Location



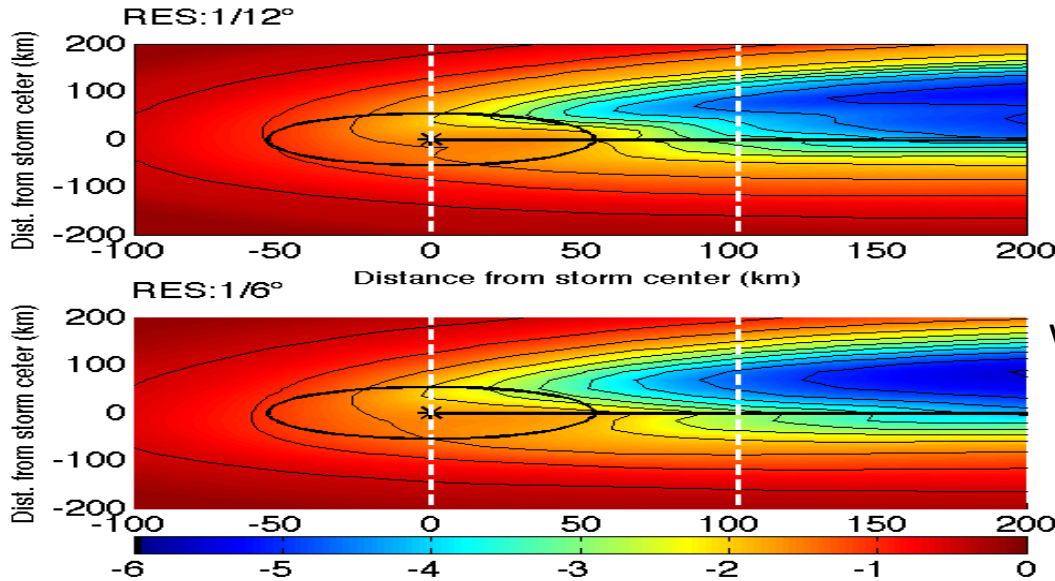
0 to 120-h Intensities



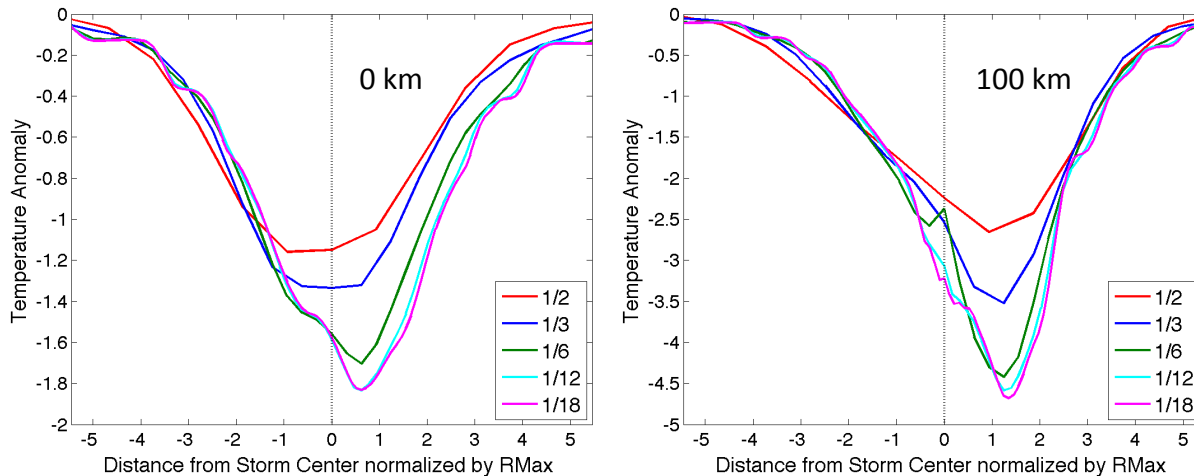
9/02 TMI 3-day SST

- At ~72-h, new HWRF ocean cooling is under predicted for the 29/18Z case too...
- Likely explanation again is the low intensity bias (in spite of very accurate track)
- But low HWRF intensity bias may be (partially?) due to cold pre-storm SST bias (see buoy)

Resolution impact in POM-TC



SST anomaly from pre-storm conditions 72-h into POM-TC forecast with prescribed hurricane wind field moving westward at 5 m/s: 1/12° (top) and 1/6° (bottom) horizontal grid spacing



Cross-track SST anomalies through storm center (left) and 100 km behind storm (right) for 1/2°, 1/3°, 1/6°, 1/12°, and 1/18° horizontal grid spacing

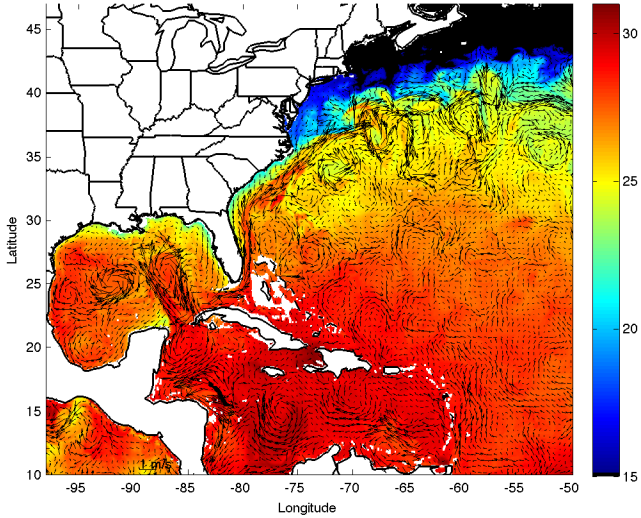
RTOFS-Global*

- Global 1/12 degree HYCOM model implemented operationally 10/25/2011.
 - Brand new model the size of the GFS implemented within two years, after 2 years of planning and developing partnership with Navy. NCODA initialization provided daily by Navy.
- Application for hurricane modeling (HFIP)
 - Base of unified HWRF-HYCOM regionally coupled model for anywhere in the world.
 - Possible downstream use:
 - Simplified POM initialization (HWRF-POM). ← **URI Effort**
 - Possibly OHC products.

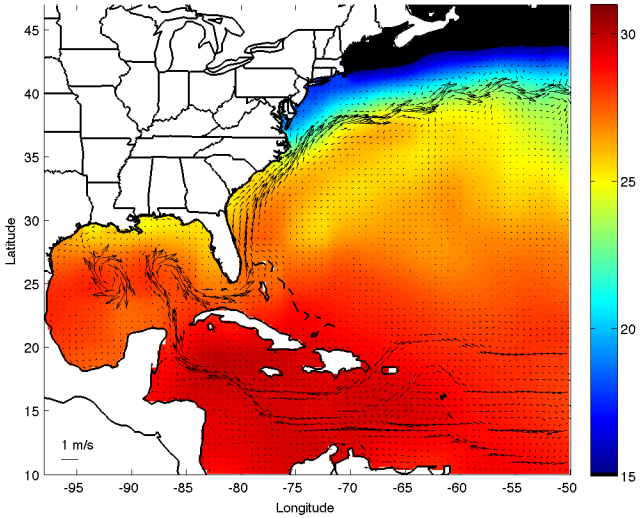
* Slide courtesy of H. Tolman (EMC)

20111025: RTOFS-Global vs. Feature-based

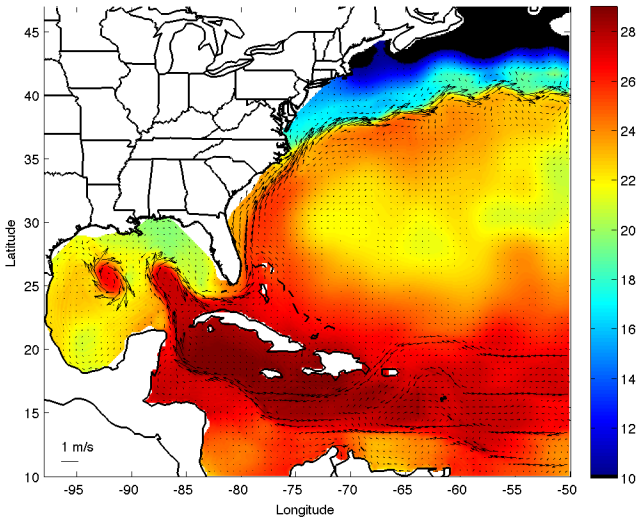
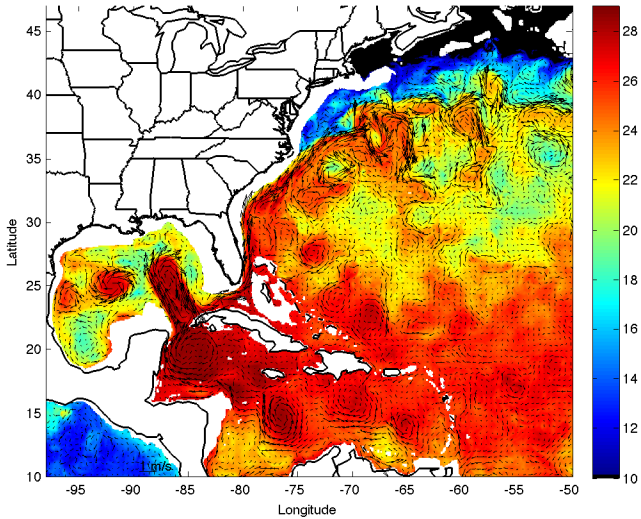
RTOFS-Global



Feature-based w/ GFS SST



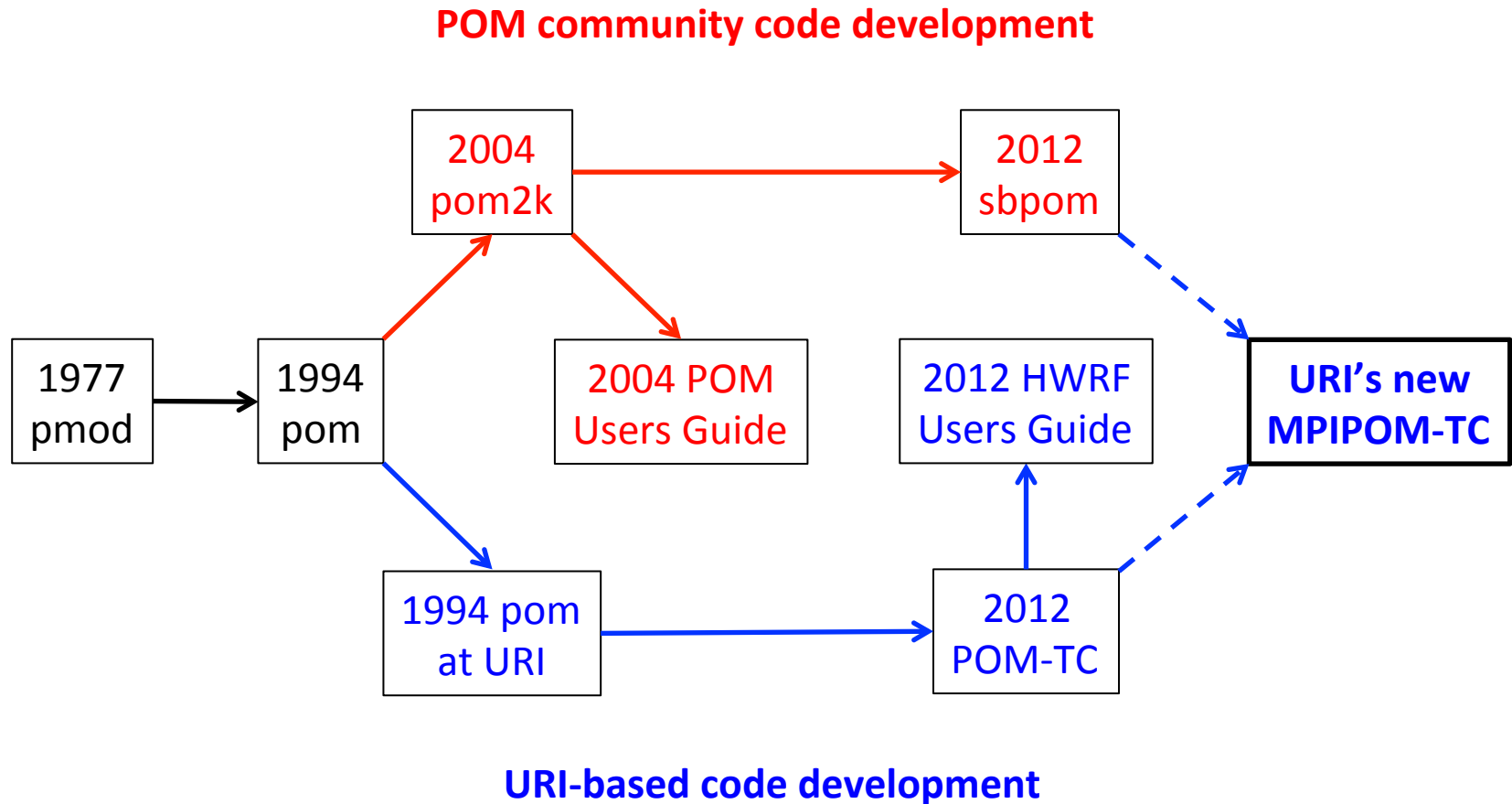
SST



75-m T

20111025 RTOFS-Global used for Rina hindcast; will run in parallel in 2012

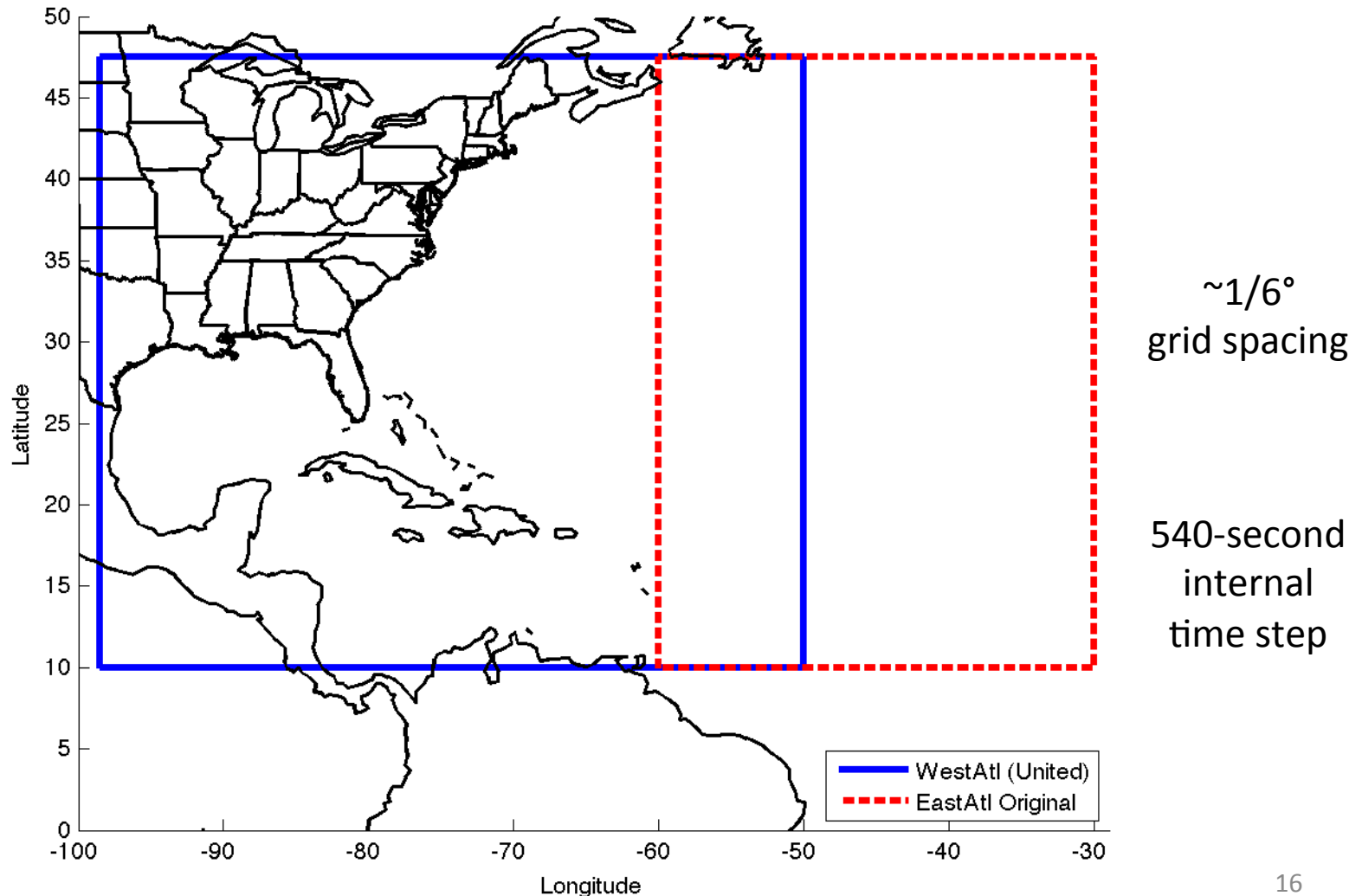
Developing a new MPIPOM-TC at URI



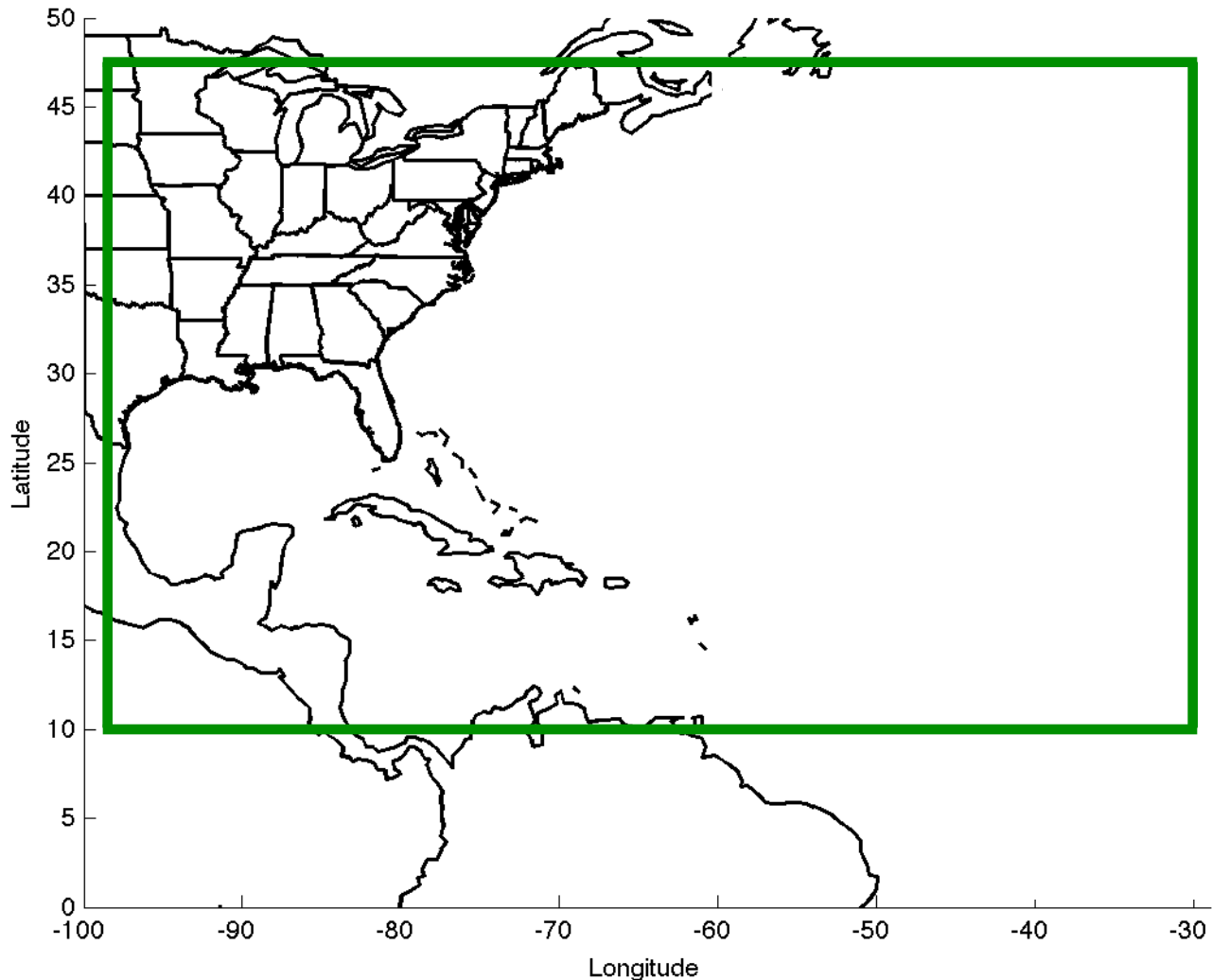
Why create a new MPIPOM-TC?

- MPIPOM-TC uses MPI, allowing for higher resolution and/or a larger domain in POM-TC
- MPIPOM-TC is very scalable (to > 1000 CPUs)
- MPIPOM-TC includes 18 years of community-based updates and bug fixes
- MPIPOM-TC is a modernized code with netCDF input and output
- MPIPOM-TC is an adaptation of sbPOM, which has community support

2012 HWRF's POM-TC Atlantic Ocean domains: United & East Atlantic



New proposed MPIPOM-TC Transatlantic ocean domain



~1/12°
grid spacing
(subset of
Global HYCOM)

360-second
internal
time step

5-day MPIPOM-TC benchmarking

- Benchmark results on URI linux cluster:

1 CPU = 146 min

2 CPU = 82 min

4 CPU = 58 min ← fast enough?

8 CPU = 29 min

16 CPU = 15 min

32 CPU = 9 min

64 CPU = 7 min

128 CPU = 5 min

Summary

- **Coupling HWRF to POM-TC in the East Pacific**
 - East Pac coupling combined with other HWRF upgrades yields improved track and intensity forecasts
- **Diagnosing operational POM-TC in HWRF**
 - Intensity biases affect and are affected by SST cooling biases
 - Storm size biases affect intensity biases via SST cooling biases
 - Pre-storm ocean temperature biases affect intensity biases
- **Determining optimal POM-TC resolution**
 - Wider than $1/6^\circ$ grid spacing (e.g. $1/3^\circ$ or $1/2^\circ$) is unacceptable
 - $1/12^\circ$ is marginally better than $1/6^\circ$, but finer than $1/12^\circ$ is overkill

Summary (cont'd)

- **Initializing POM-TC with Global HYCOM RTOFS**
 - RTOFS-Global initialization is an alternative to feature-based initialization
 - Whether RTOFS-Global is better for POM-TC initialization is being explored
 - A potential issue is differences between RTOFS-Global SST and GFS SST
- **Creating a new MPIPOM-TC**
 - Having an MPI version of POM-TC would facilitate future developments, such as increased resolution, larger ocean domains, better plug-and-play initialization options, and wider community support