

MPIPOM-TC: A new ocean modeling system with flexible initialization for improved coupled hurricane-ocean model forecasts

Richard M. Yablonsky, Isaac Ginis, and Biju Thomas

University of Rhode Island, Graduate School of Oceanography
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Special thanks to HFIP, JHT, and our collaborators at EMC, GFDL, and the DTC



Early history of Princeton Ocean Model

- Three-dimensional, primitive equation, numerical ocean model (commonly known as POM)
- Originally developed by Alan Blumberg and George Mellor in the late 1970's
- Uses Mellor-Yamada Level 2.5 turbulence closure model
- Initially used for coastal ocean circulation applications
- Open to the community during the 1990's and 2000's
- Many user-generated changes incorporated into “official” code version housed at Princeton University

Developing POM for Tropical Cyclones

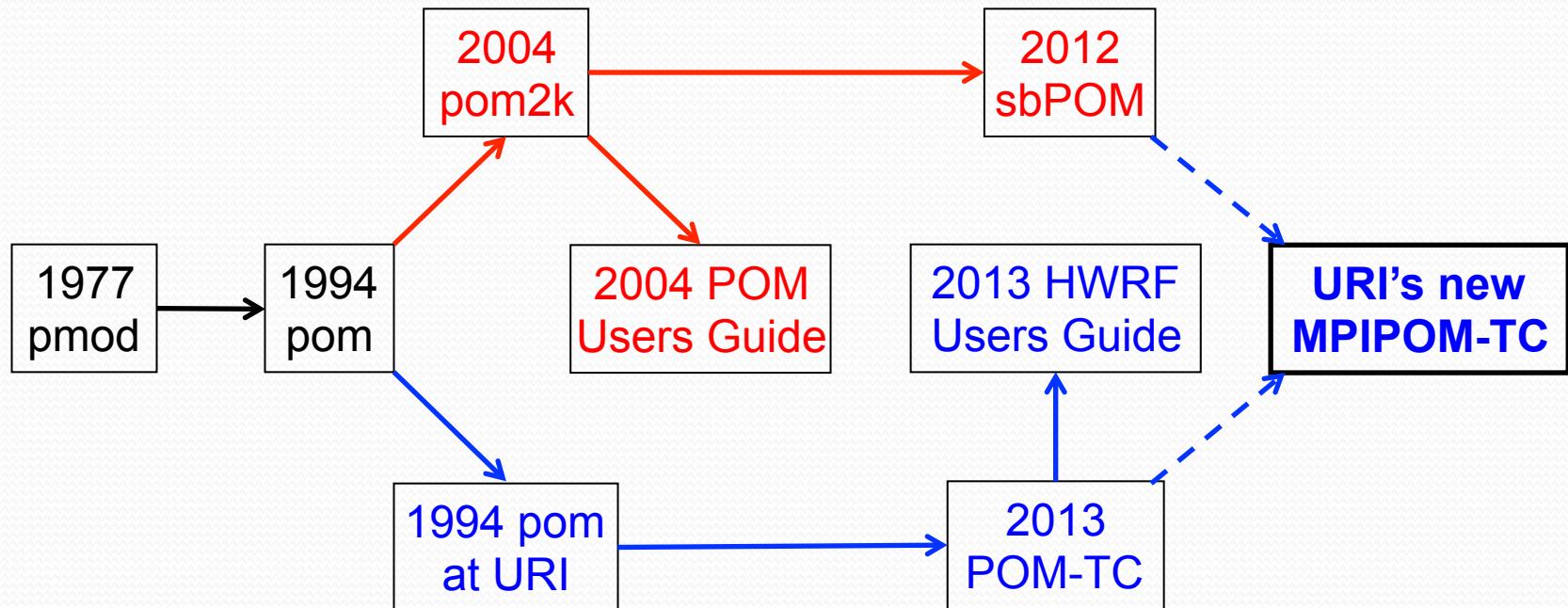
- Available POM code version transferred to University of Rhode Island (URI) in 1994
- POM code changes made at URI specifically to address ocean response to hurricane wind forcing
- This POM version coupled to GFDL hurricane model at URI
- Coupled GFDL/POM model operational at NCEP in 2001
- Additional POM upgrades made at URI during 2000's (e.g. initialization) and implemented in operational GFDL/POM
- Same version of POM coupled to operational HWRF in 2007
- This POM version is now designated “POM-TC”
- Some further POM-TC upgrades made at URI since 2007

Why Couple a Fully 3-D Ocean Model to a Hurricane Model?

- To create accurate SST during hurricane model integration
- Evaporation (moisture flux) from sea surface provides heat energy to drive a hurricane
- Available energy decreases if storm-core SST decreases
- Uncoupled hurricane models with static SST neglect SST cooling during integration → high intensity bias
- One-dimensional (vertical-only) ocean models neglect upwelling and horizontal advection, both of which can impact SST during integration

Developing a new MPIPOM-TC at URI

POM community code development

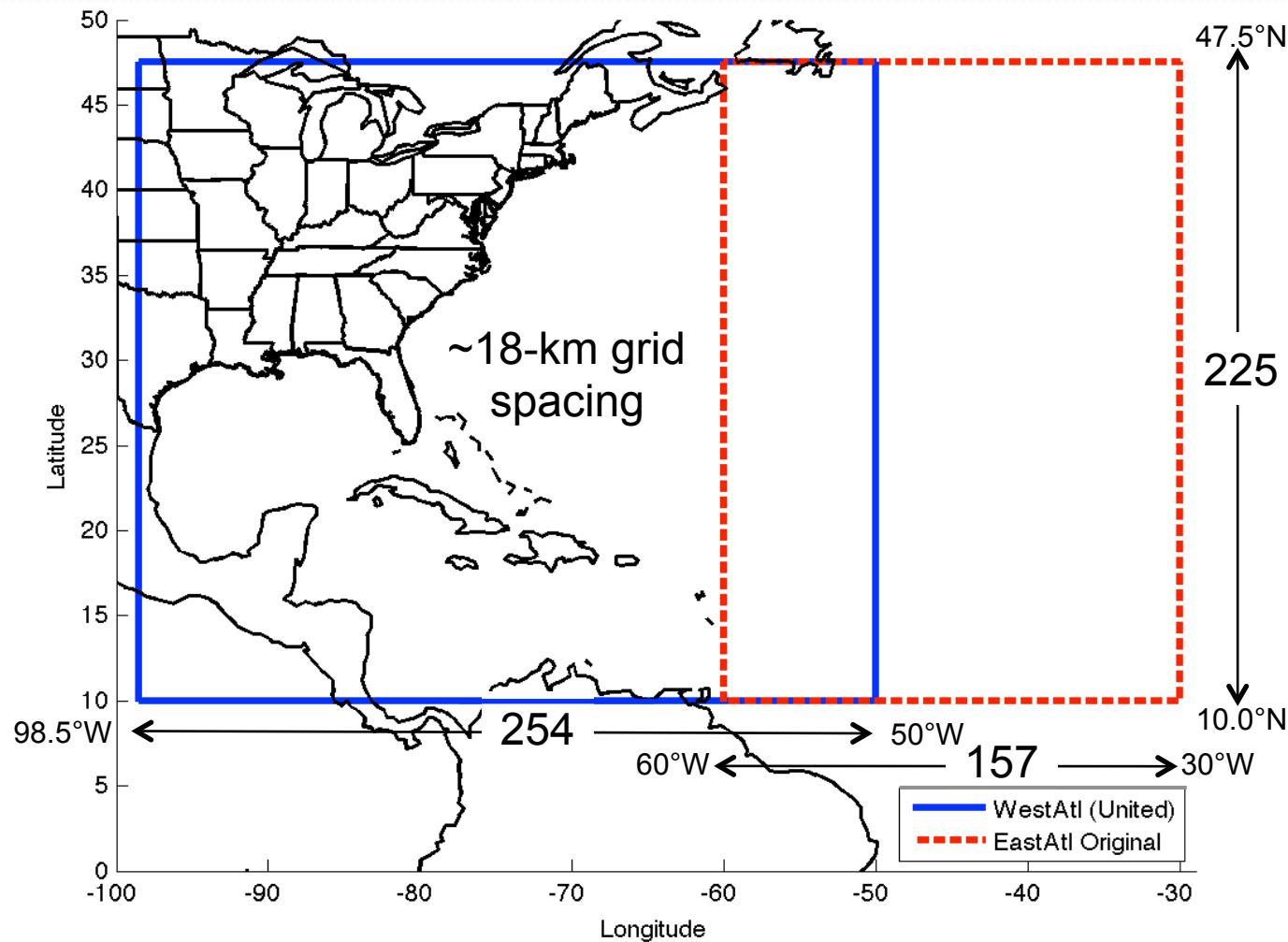


URI-based code development

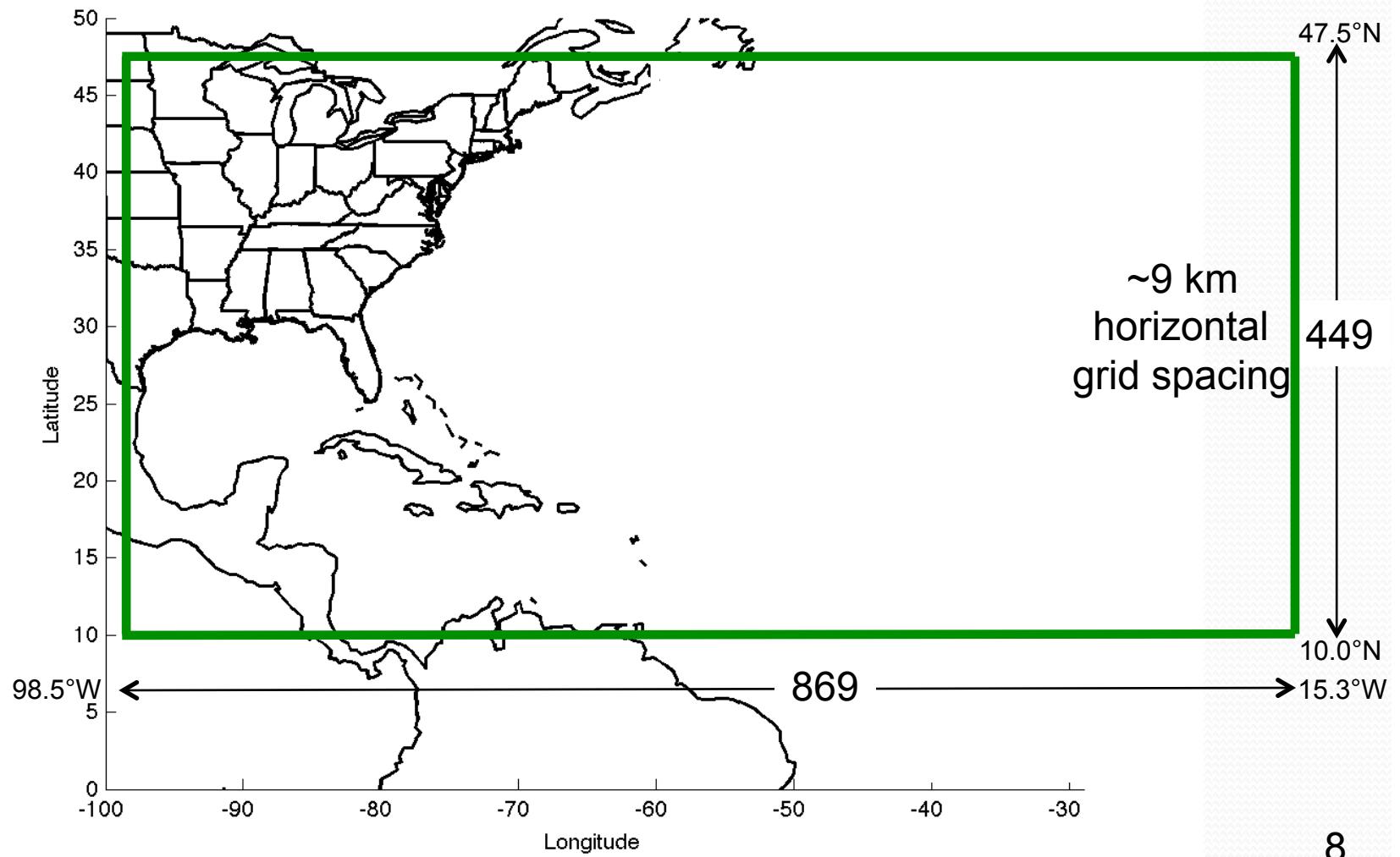
Why create a new MPIPOM-TC?

- MPIPOM-TC uses MPI software to run efficiently on multiple processors, allowing for both **higher grid resolution** and a **larger ocean domain** than POM-TC
- MPIPOM-TC accepts **flexible initialization options**
- MPIPOM-TC is an adaptation of sbPOM, which has **community support** and includes 18 years of **physics updates and bug fixes**
- MPIPOM-TC is a modernized code with **NetCDF I/O**
- MPIPOM-TC uses a **single prognostic code** in all **worldwide GFDL, GFDN, and HWRF ocean basins**

POM-TC Atlantic Domains: “United” and “East Atlantic”

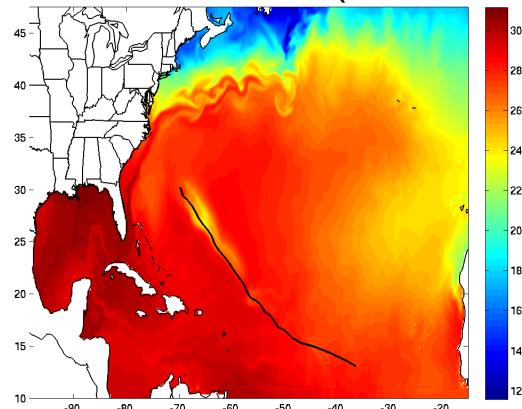


URI's MPIPOM-TC Transatlantic domain

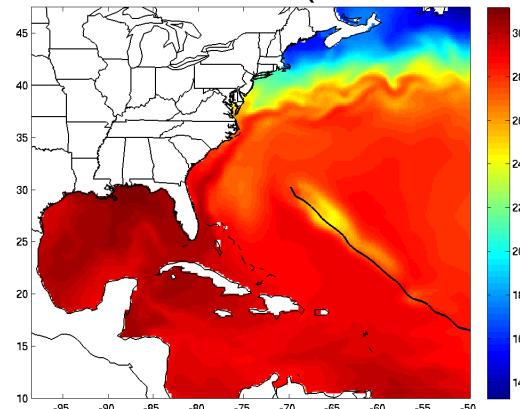


MPIPOM-TC vs. POM-TC: Ocean response to Hurricane Katia (through 2011090800)

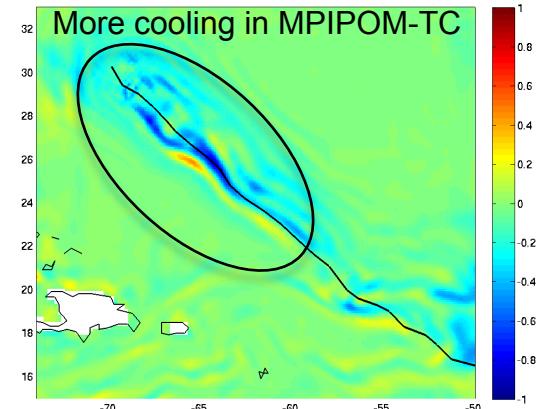
MPIPOM-TC SST (full domain)



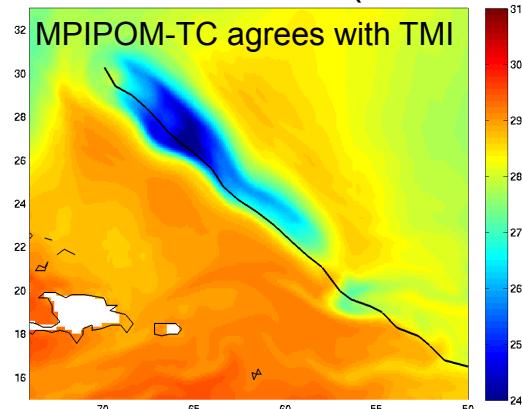
POM-TC SST (full domain)



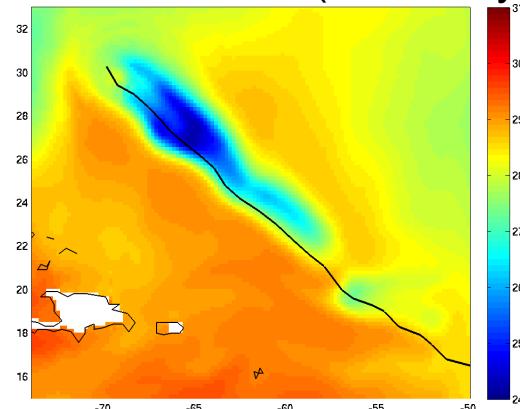
MPIPOM-TC – POM-TC SST



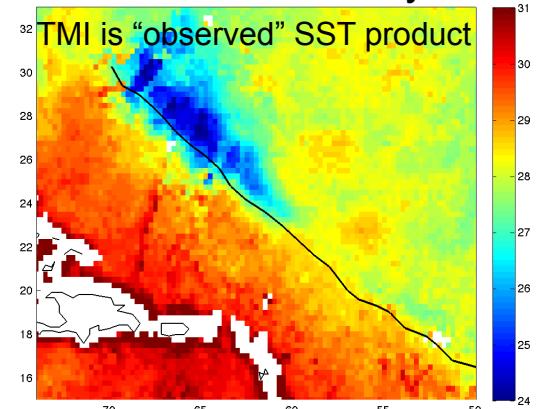
MPIPOM-TC SST (wake only)



POM-TC SST (wake only)

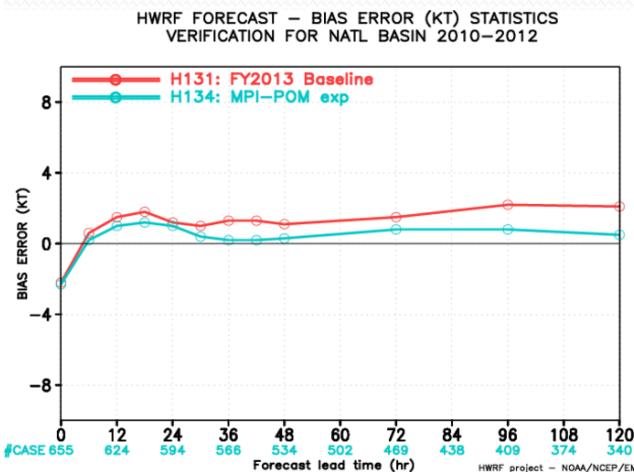


20110908 TMI 3-day SST

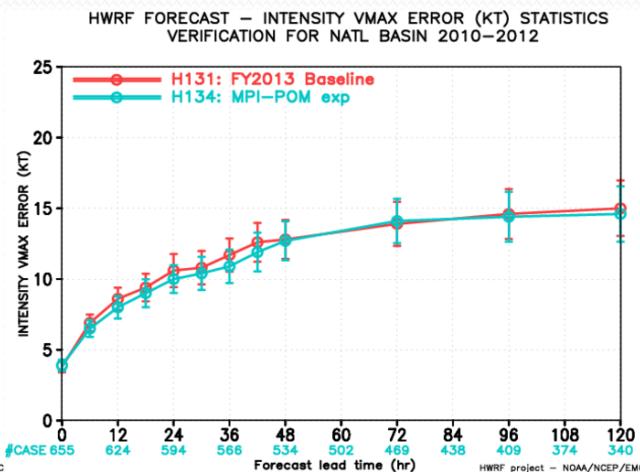




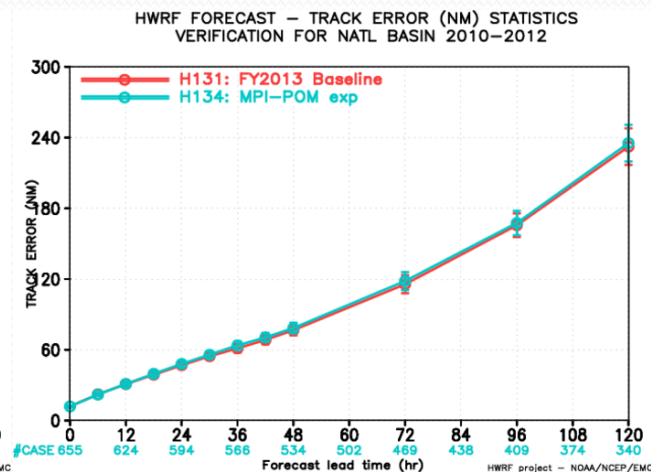
MPIPOM-TC vs. POM-TC: 2013 HWRF statistics from 655 Atlantic cases (2010-12)



Intensity Bias*



Intensity Error*

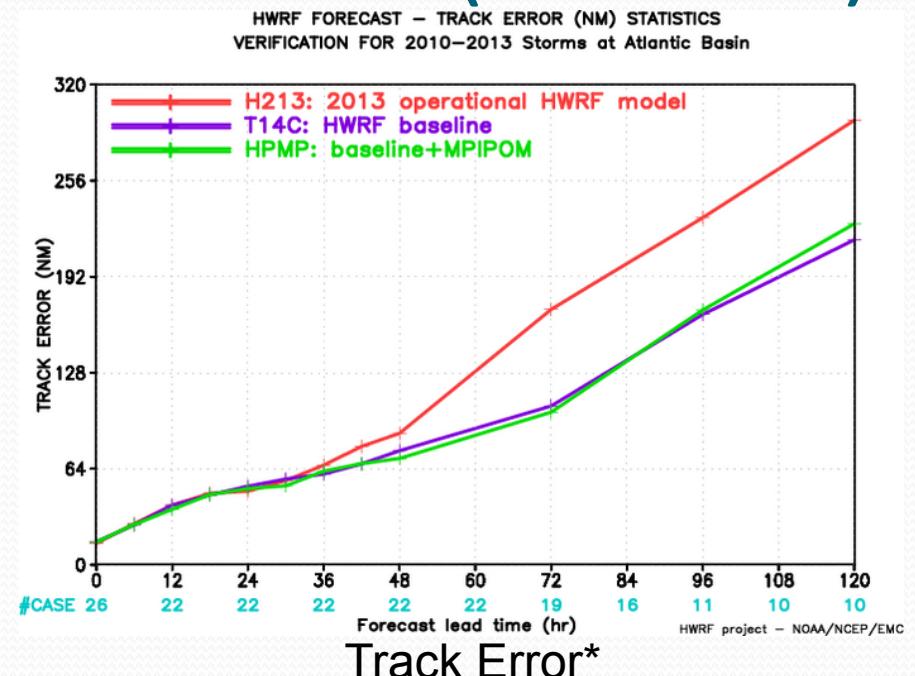
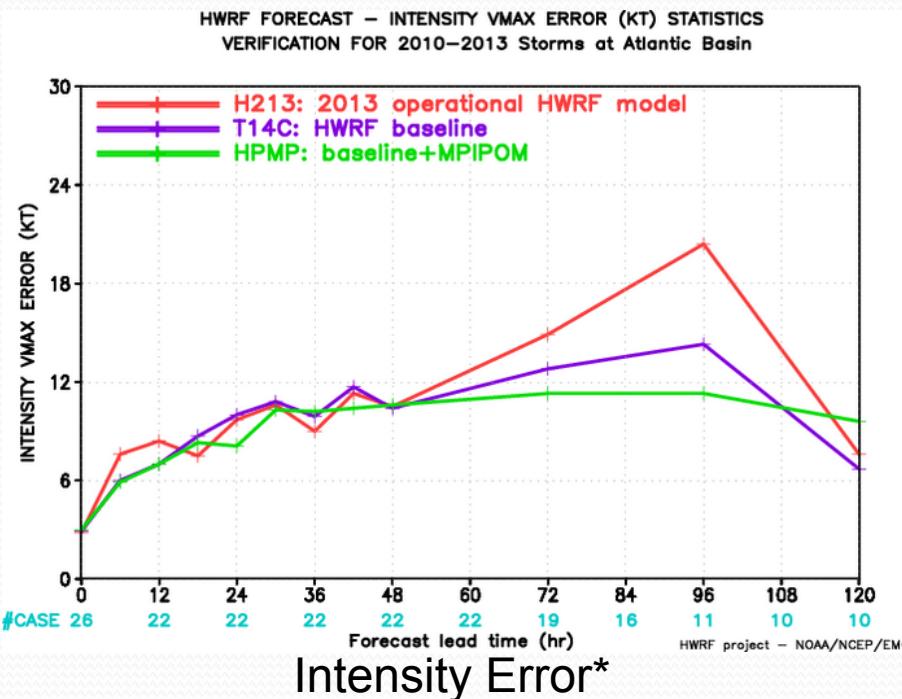


Track Error*

- HWRF positive intensity bias is reduced with MPIPOM-TC (H134) compared to POM-TC (H131)
- HWRF intensity error is slightly reduced with MPIPOM-TC (H134) compared to POM-TC (H131)
- HWRF track error is virtually unaffected with MPIPOM-TC (H134) compared to POM-TC (H131)

* Courtesy of EMC

MPIPOM-TC vs. POM-TC: 2014 HWRF statistics from 26 Atlantic cases (2010-13)

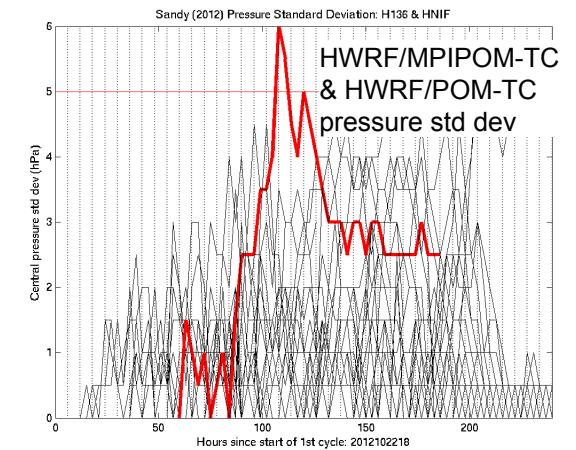
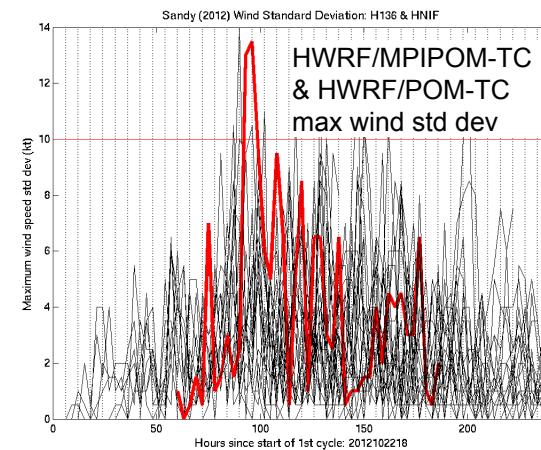
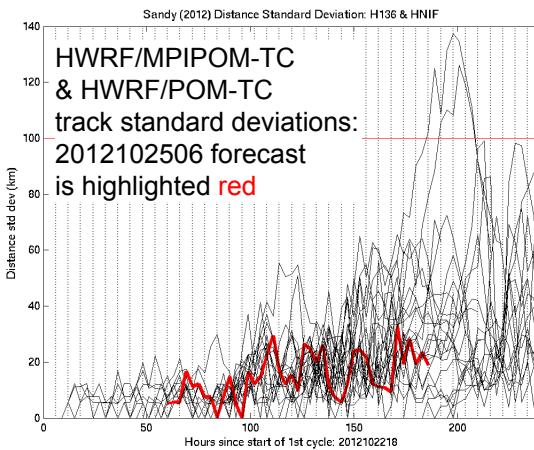
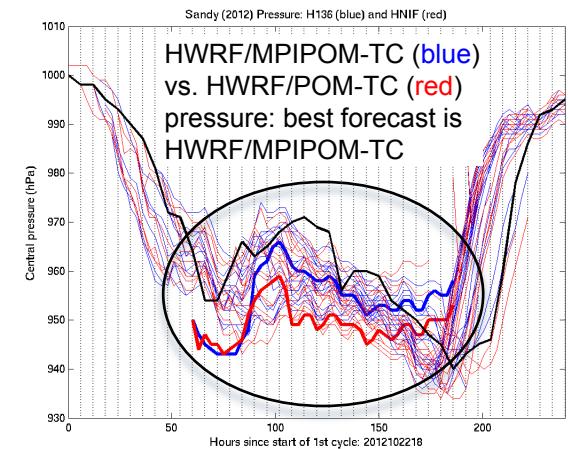
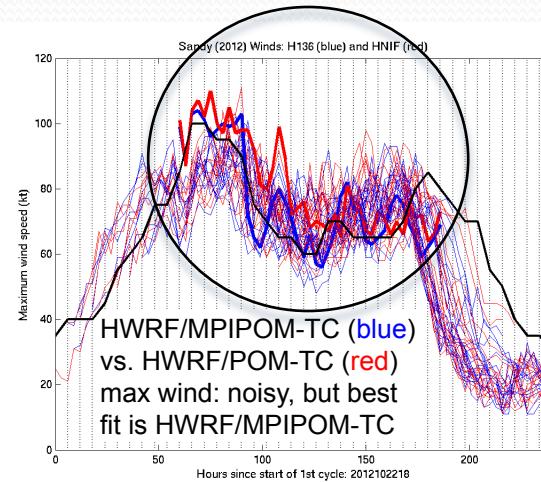
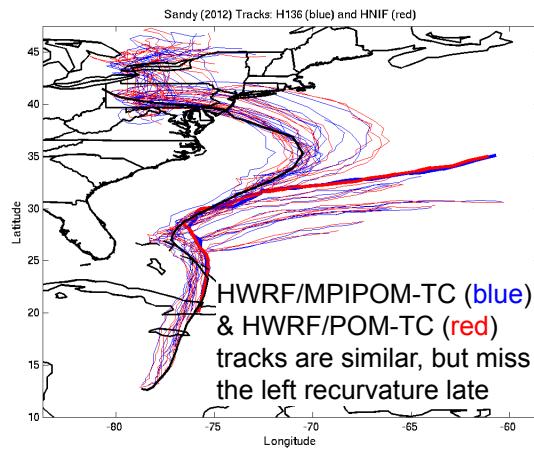


- HWRF intensity error is generally less with MPIPOM-TC (HPMP) compared to POM-TC (T14C)
- HWRF track error is virtually unaffected with MPIPOM-TC (HPMP) compared to POM-TC (T14C)

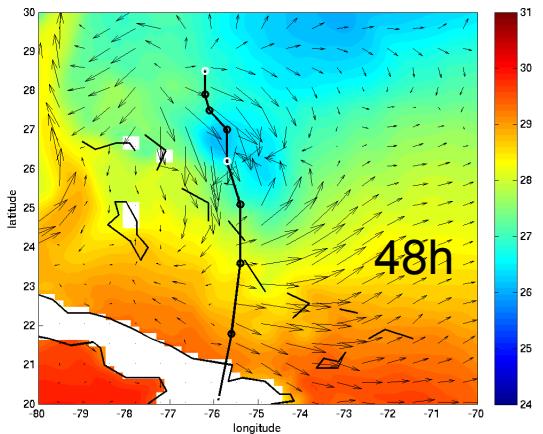
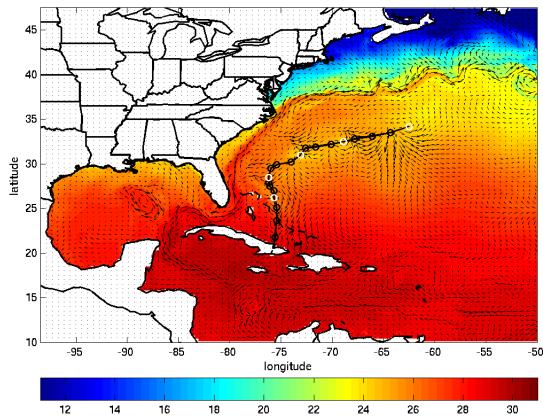
* Courtesy of EMC



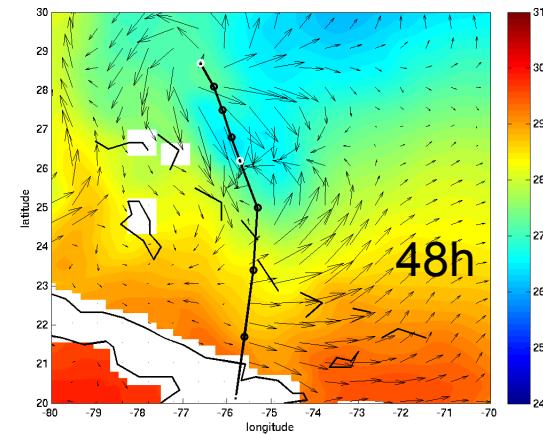
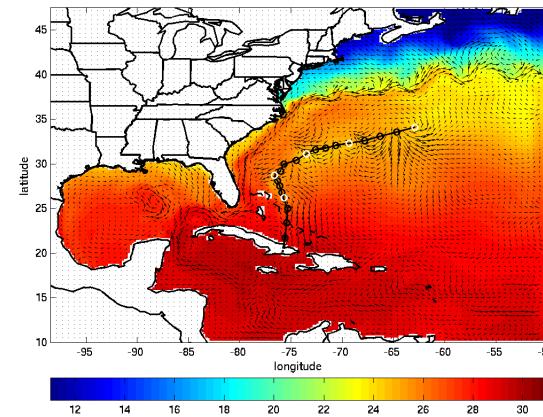
Hurricane Sandy 18L: 2012102506



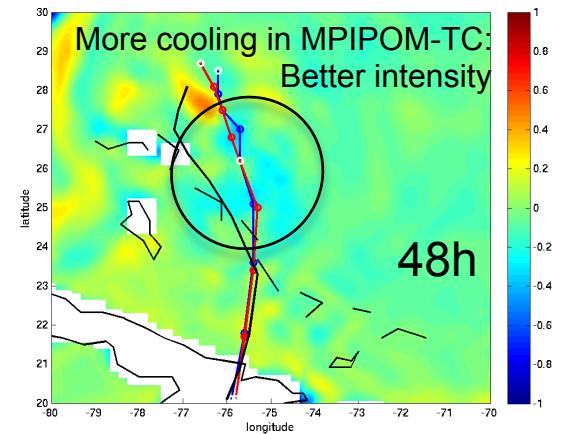
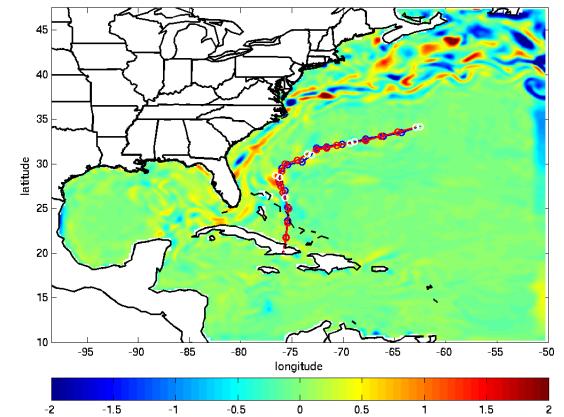
Hurricane Sandy 18L: 2012102506



MIPOMTC SST + Currents

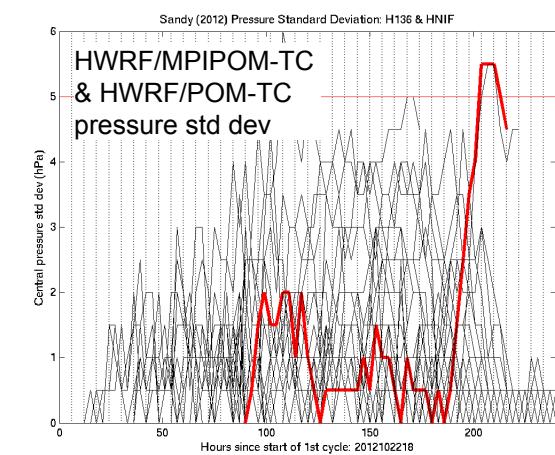
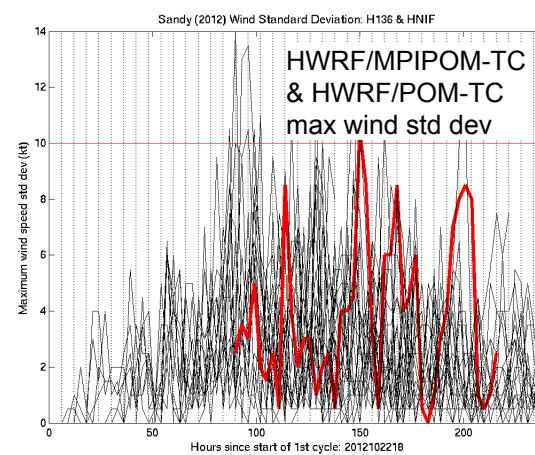
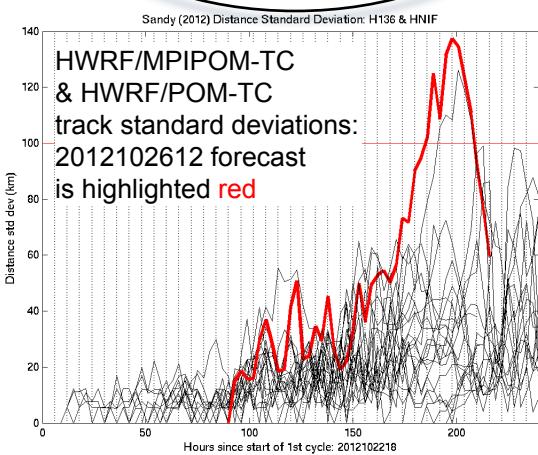
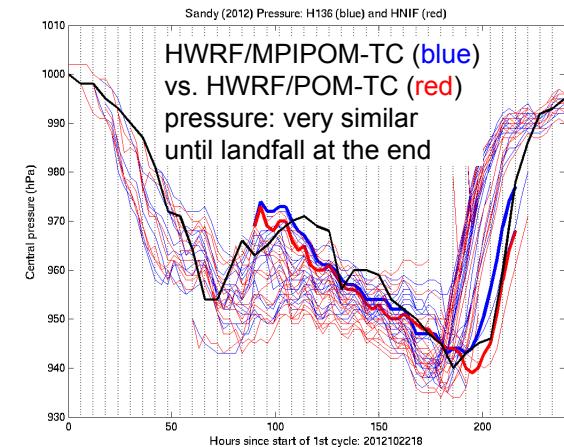
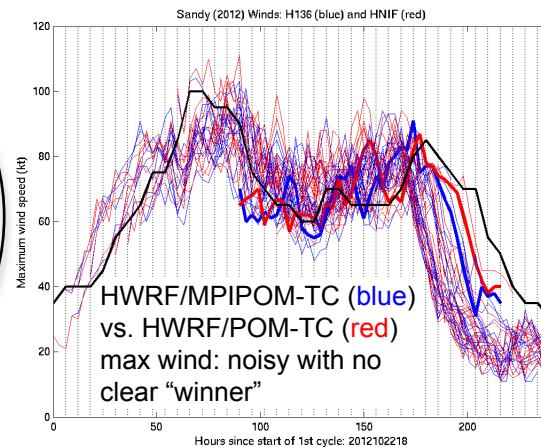
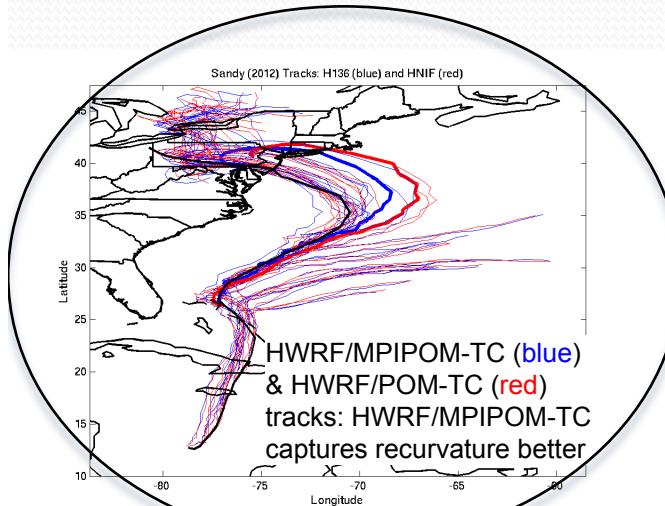


POM-TC SST + Currents

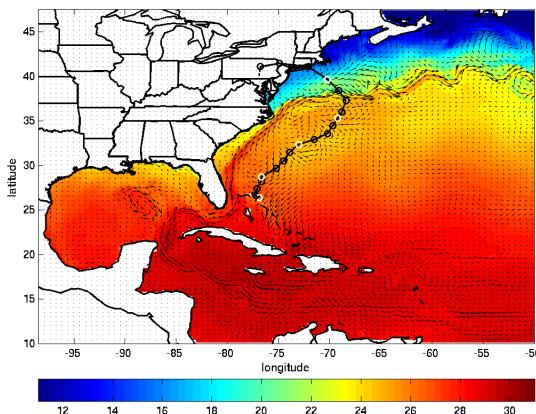


MIPOMTC - POM-TC SST

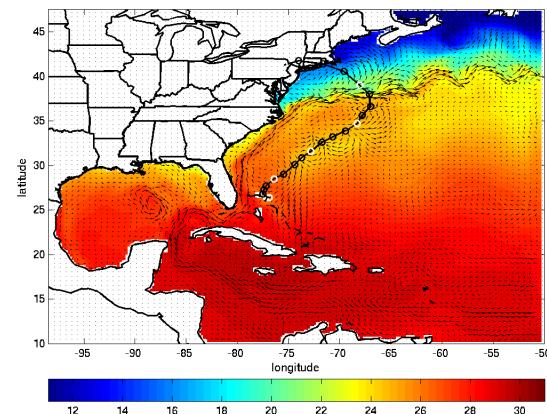
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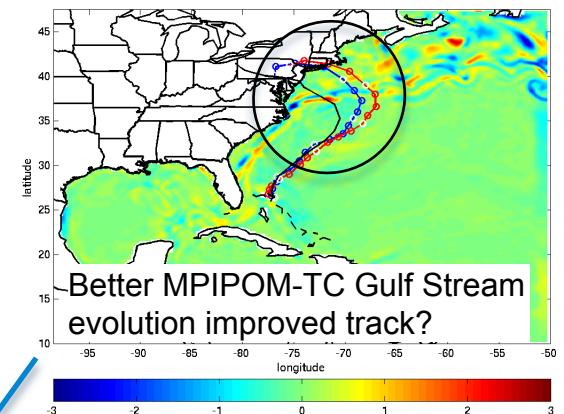
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MPIPOMTC SST + Currents



POM-TC SST + Currents

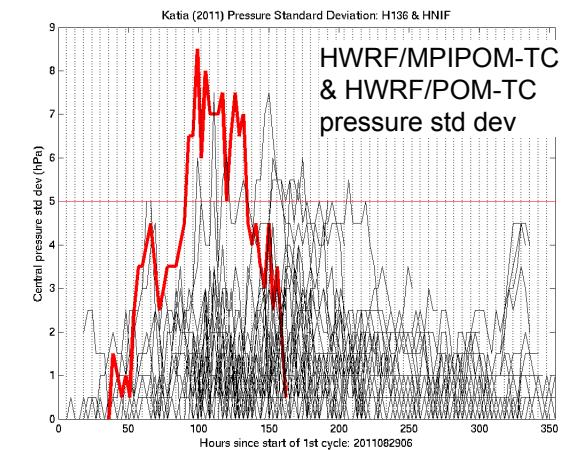
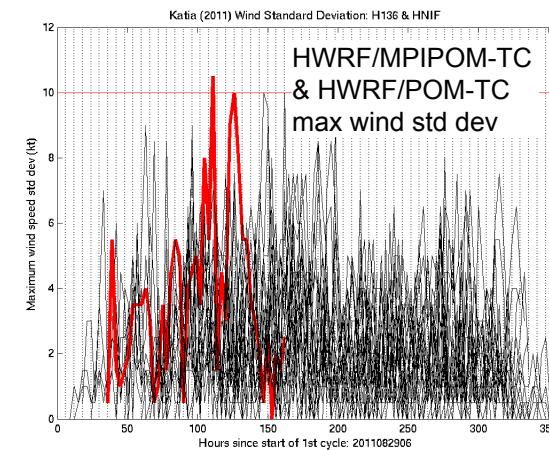
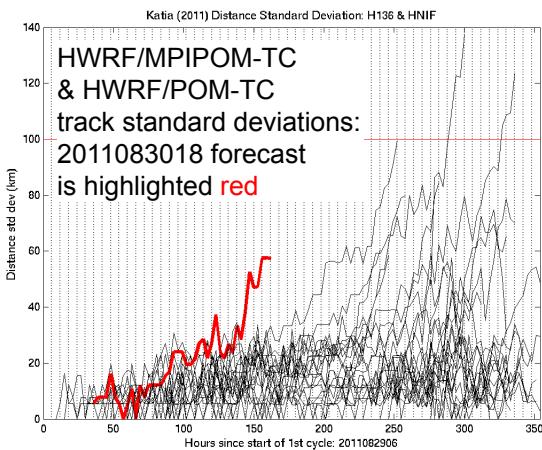
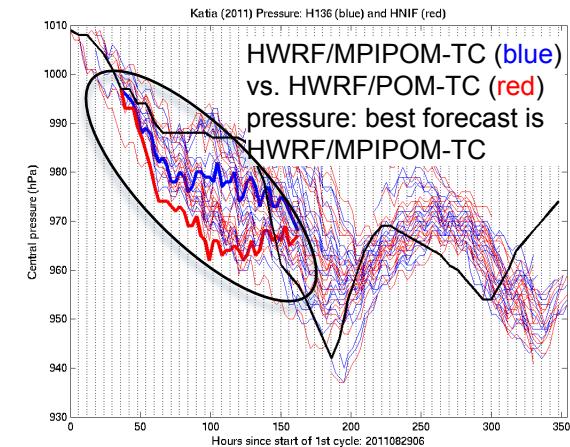
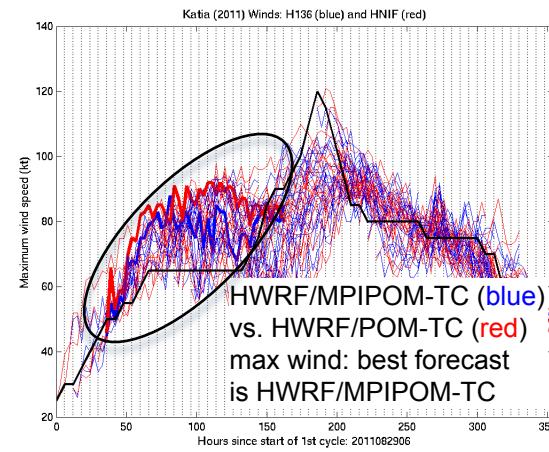
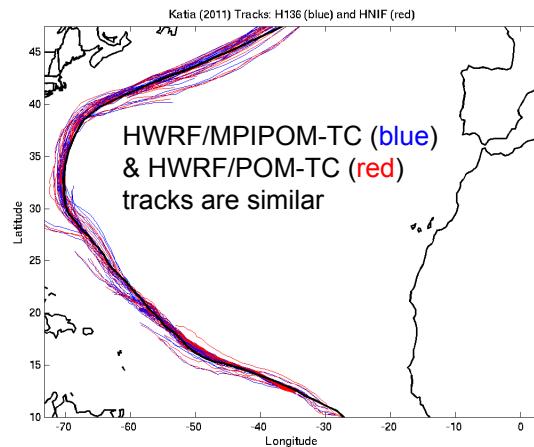


MPIPOMTC – POM-TC SST

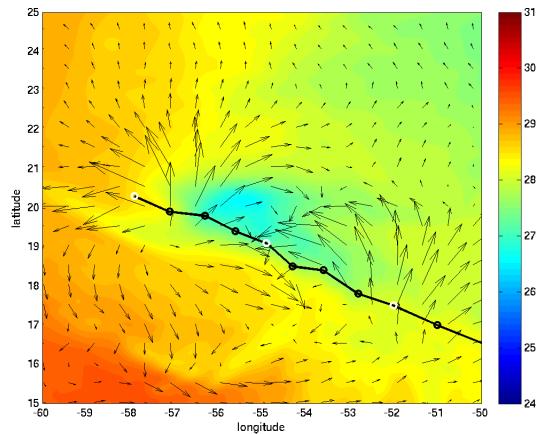
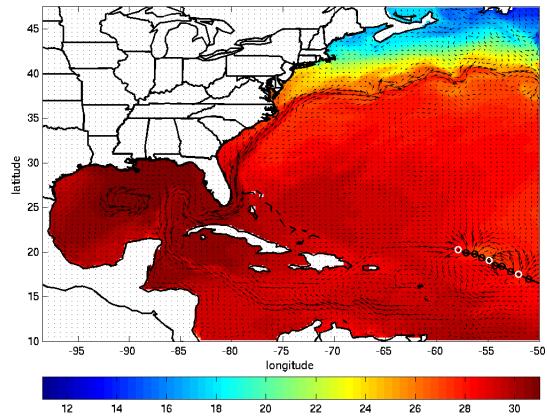
... Or maybe track difference is due to subtle differences in SST cooling/storm intensity/storm structure interactions when Sandy was near Bahamas?
Further investigation is needed...



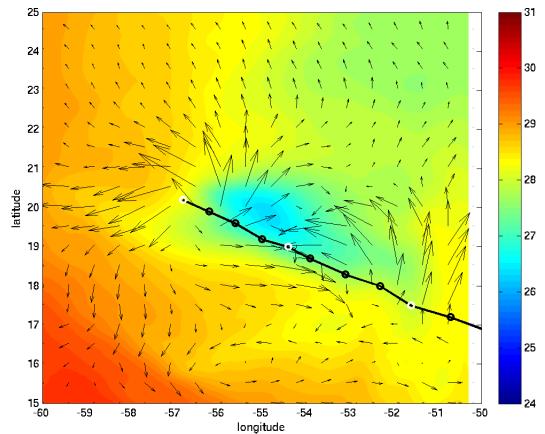
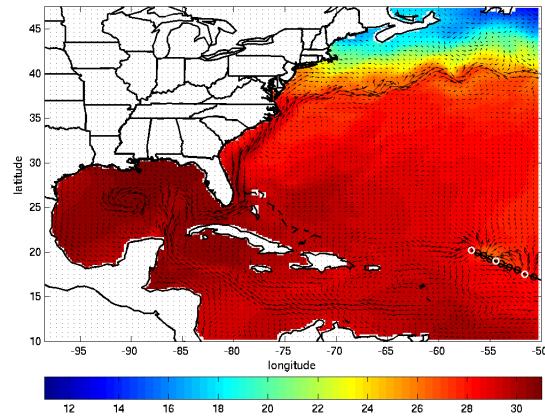
Hurricane Katia 12L: 2011083018



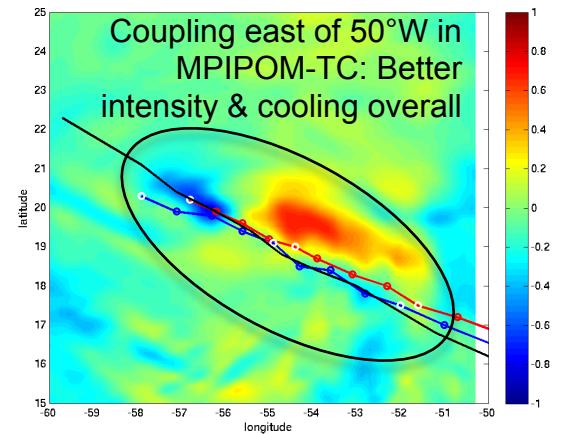
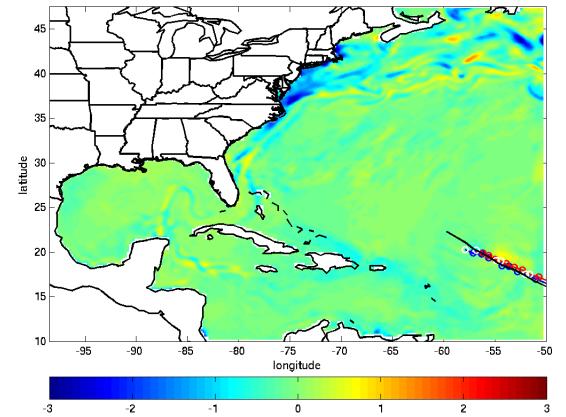
Hurricane Katia 12L: 2011083018



MIPOMTC SST + Currents



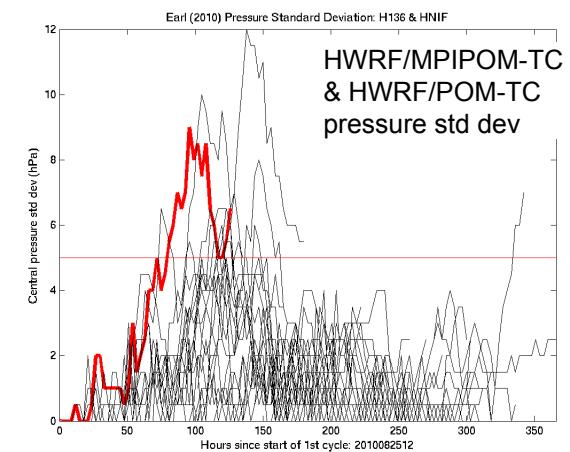
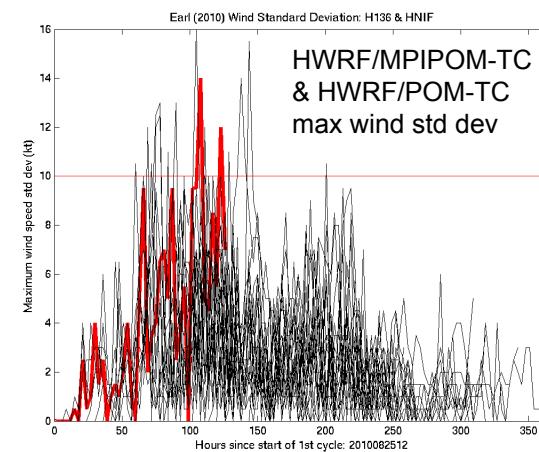
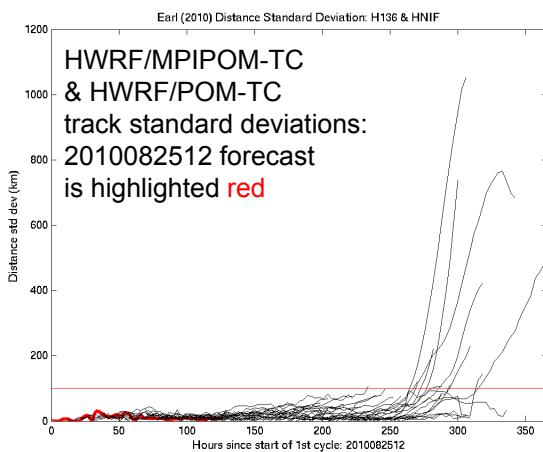
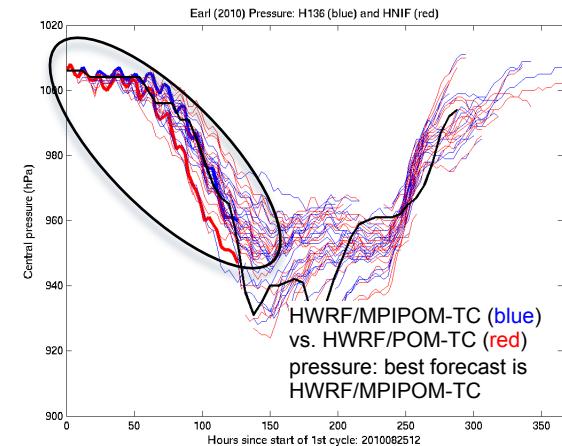
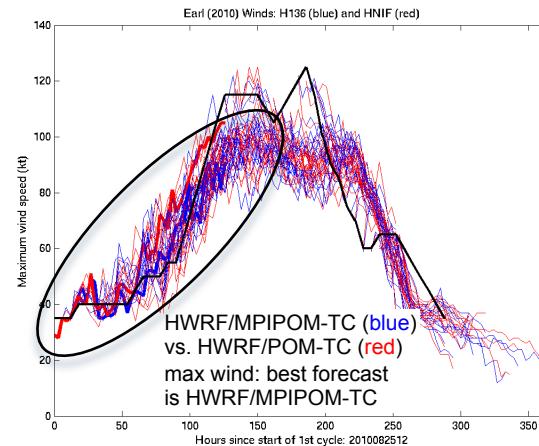
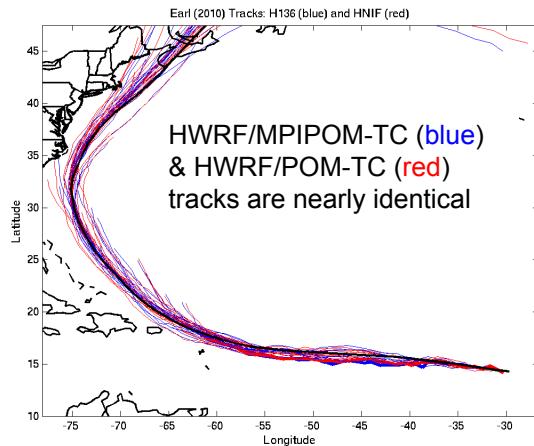
POM-TC SST + Currents



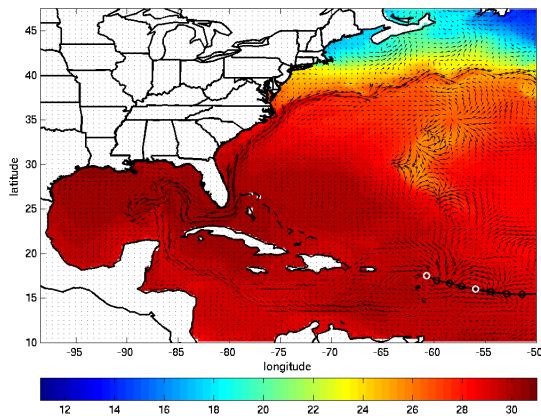
MIPOMTC – POM-TC SST



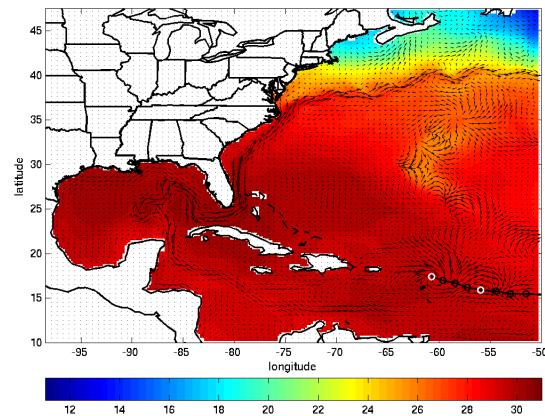
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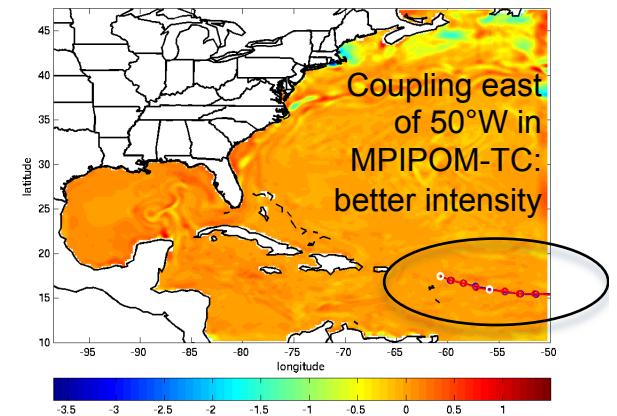
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MPIPOMTC SST + Currents

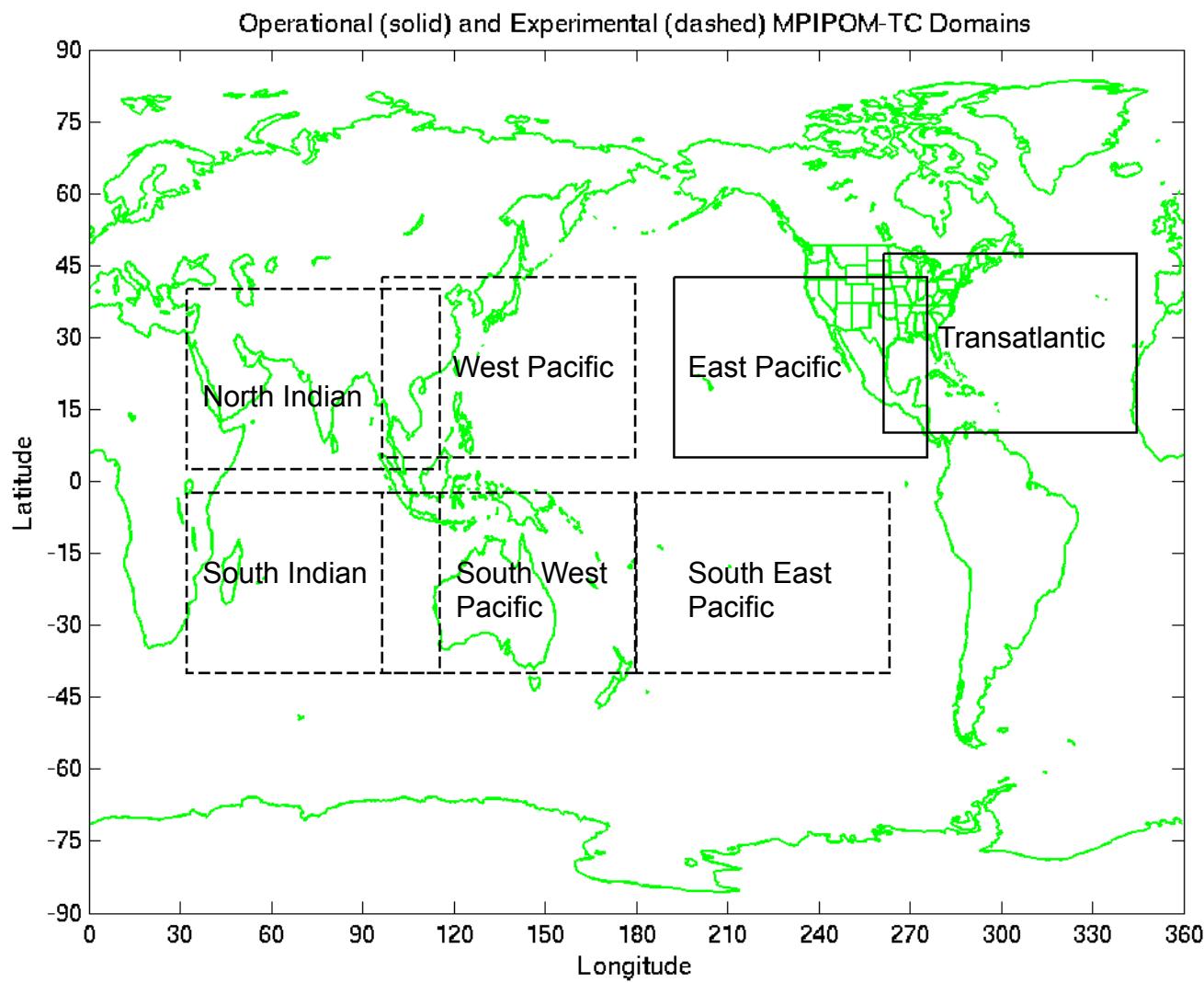


POM-TC SST + Currents

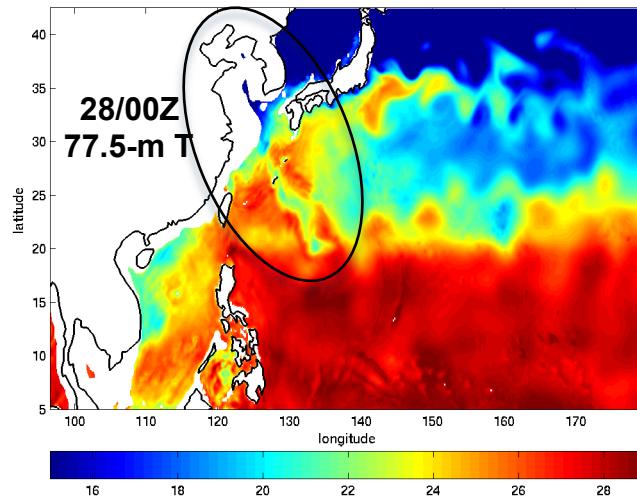
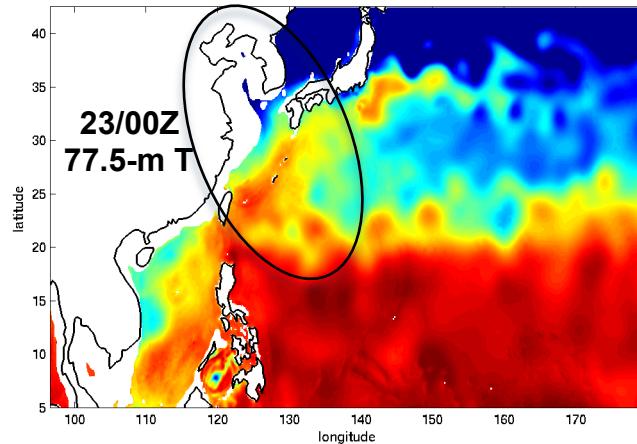
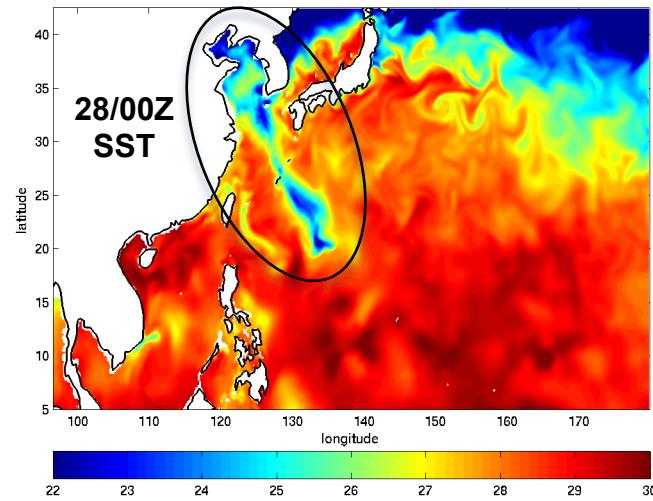
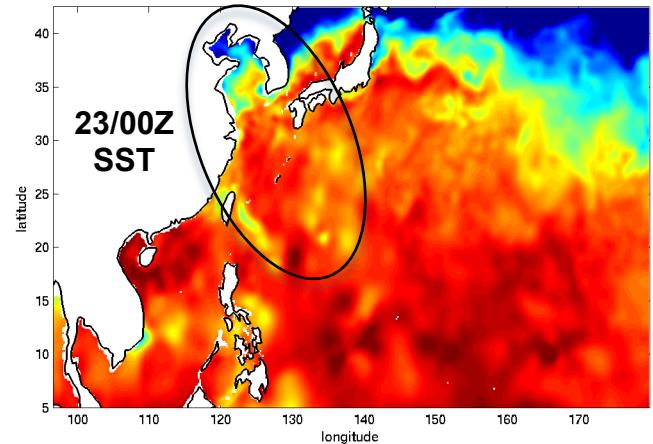


MPIPOMTC – POM-TC SST

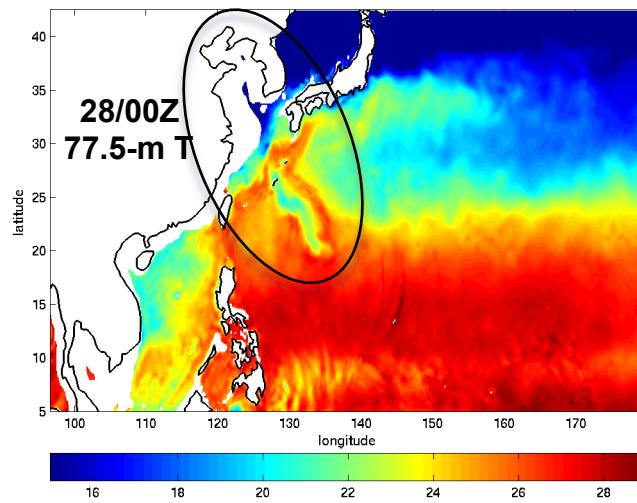
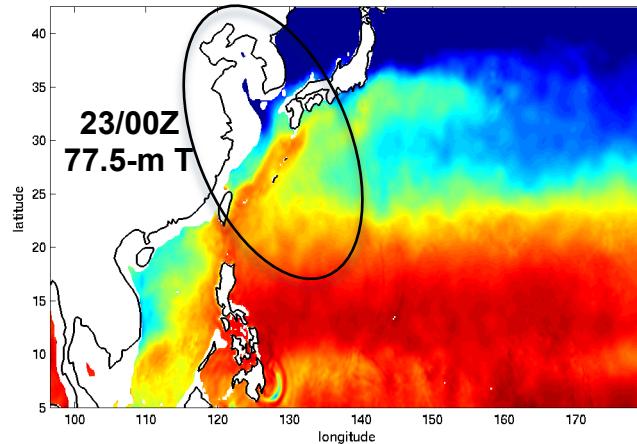
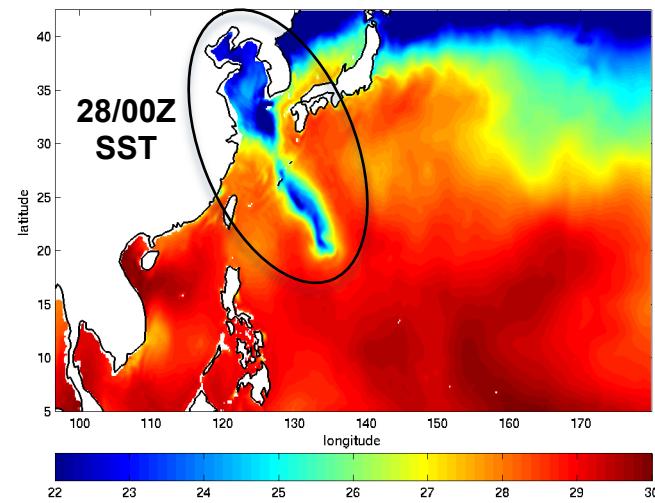
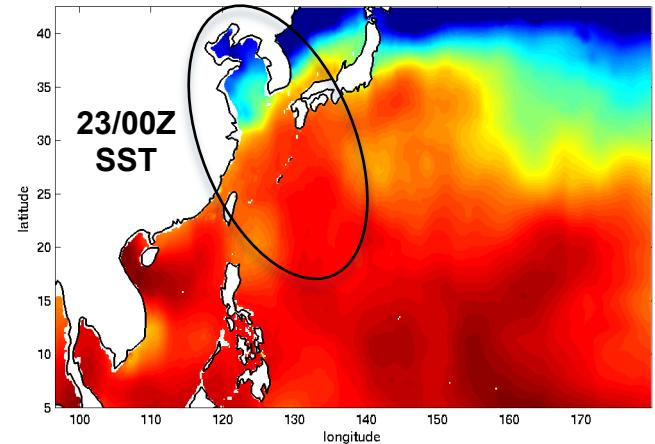
Proposed Worldwide MPIPOM-TC domains



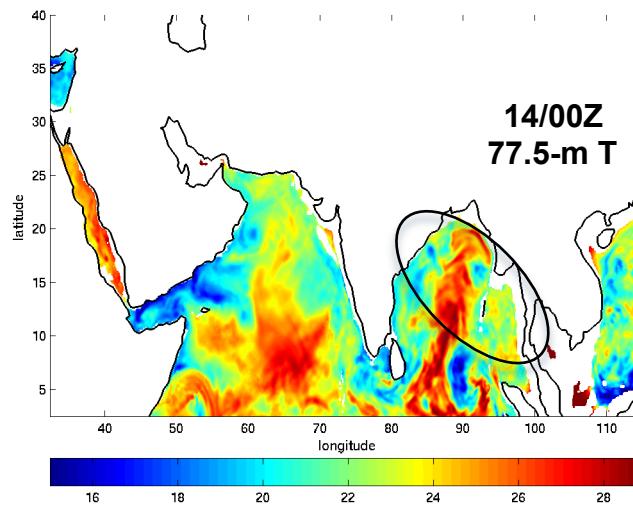
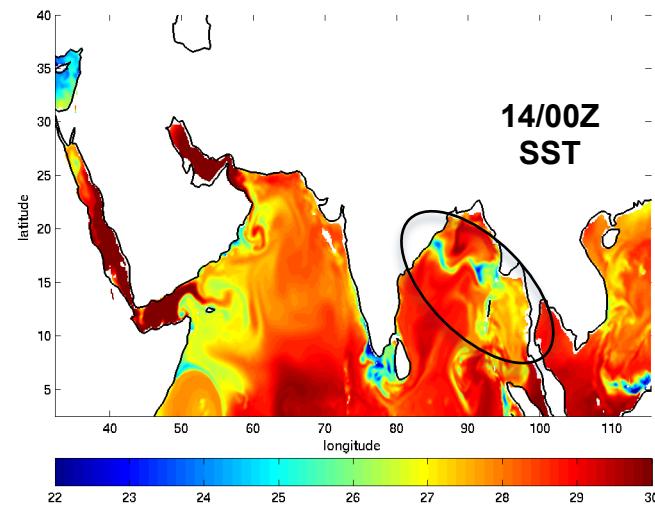
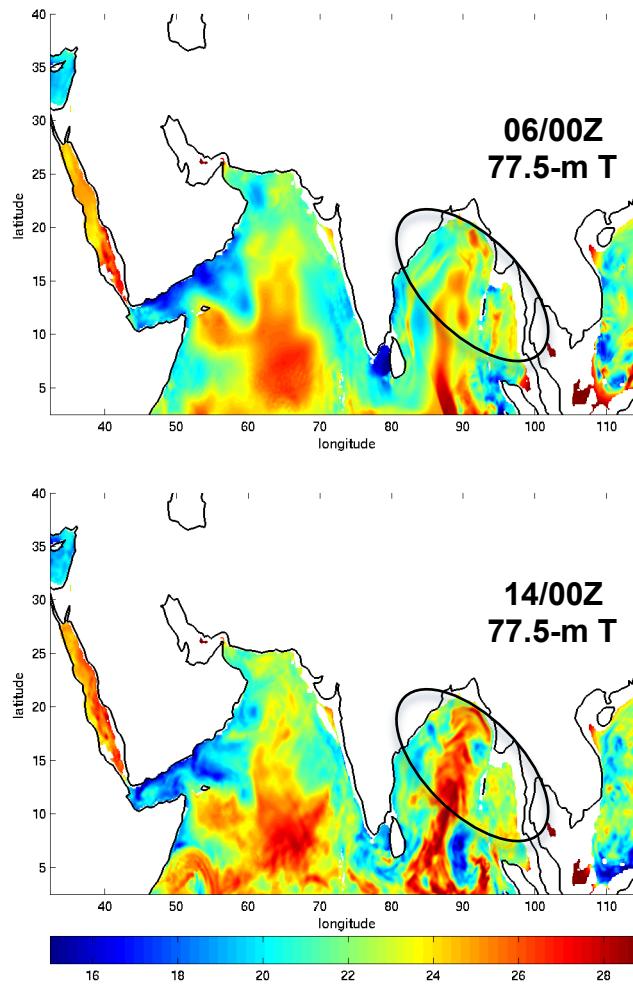
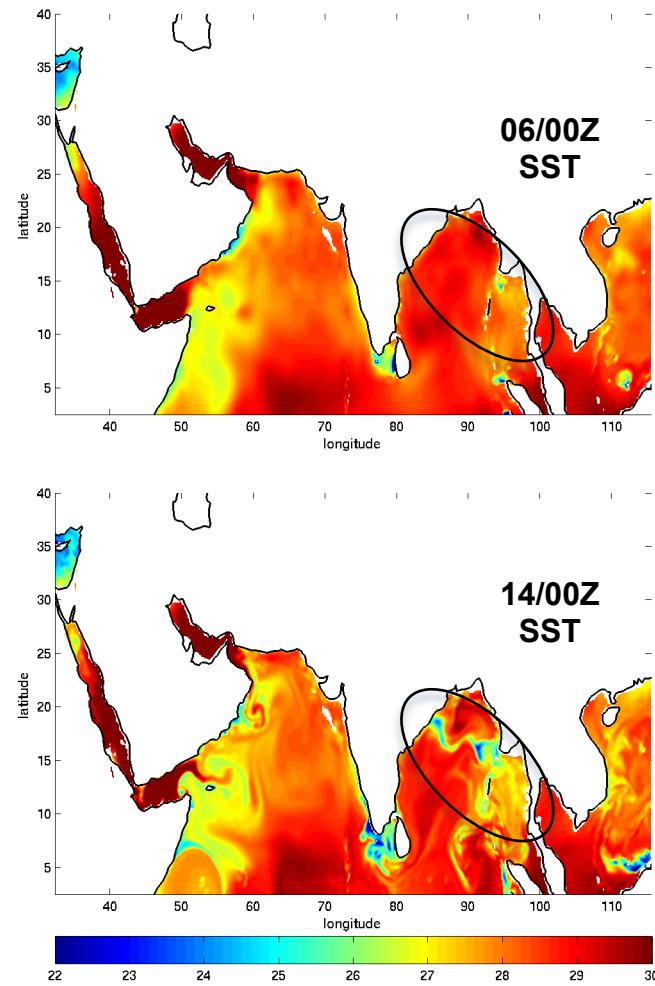
URI's MPIPOM-TC West Pacific Domain: Ocean Response to Supertyphoon Bolaven with NCODA initialization: 2012082300-2800



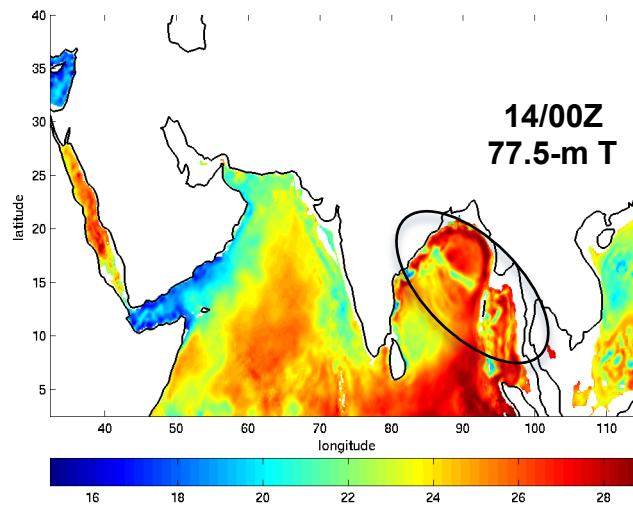
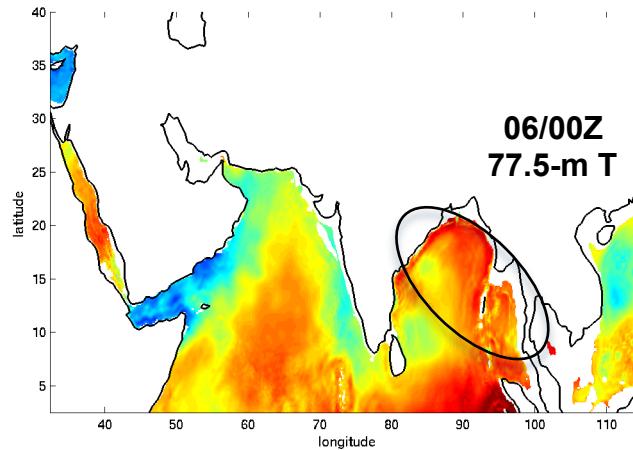
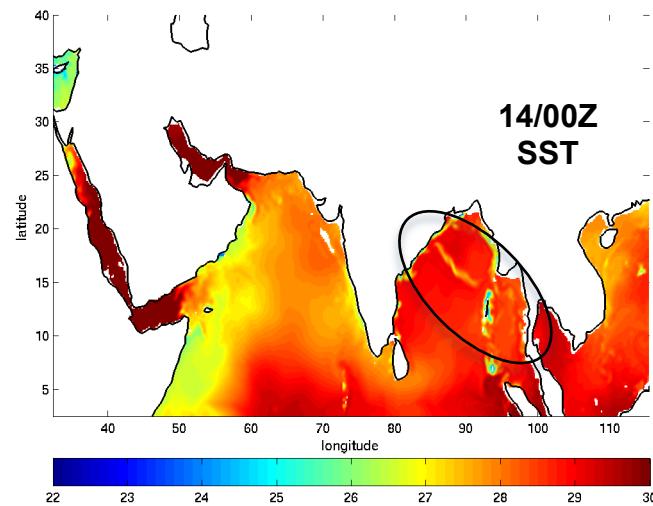
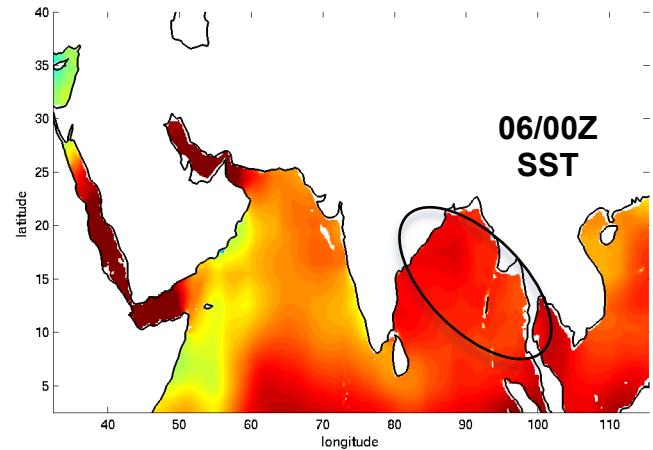
URI's MPIPOM-TC West Pacific Domain: Ocean Response to Supertyphoon Bolaven with GDEMv3 + GFS SST initialization: 2012082300-2800



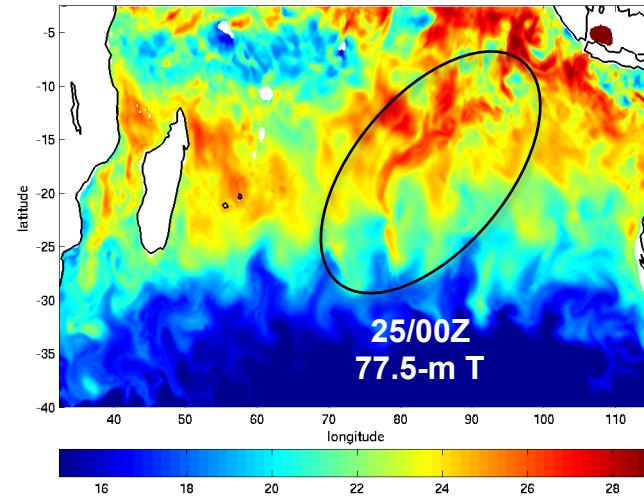
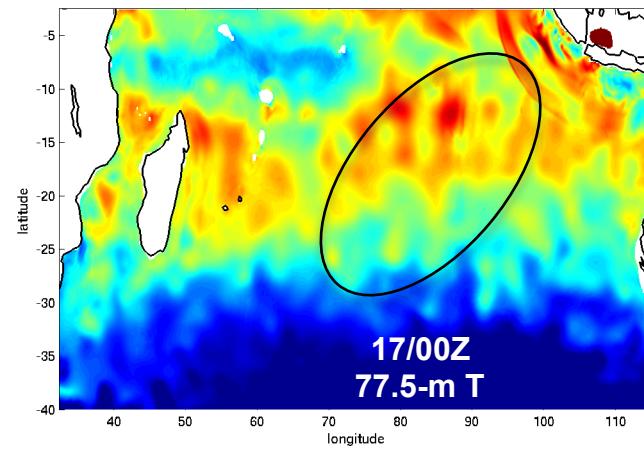
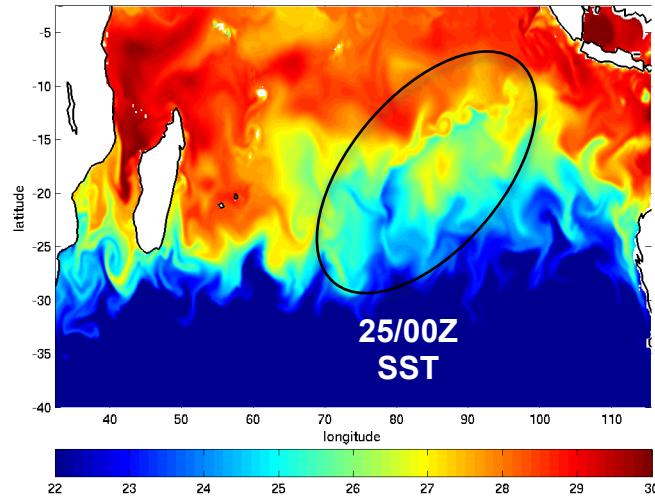
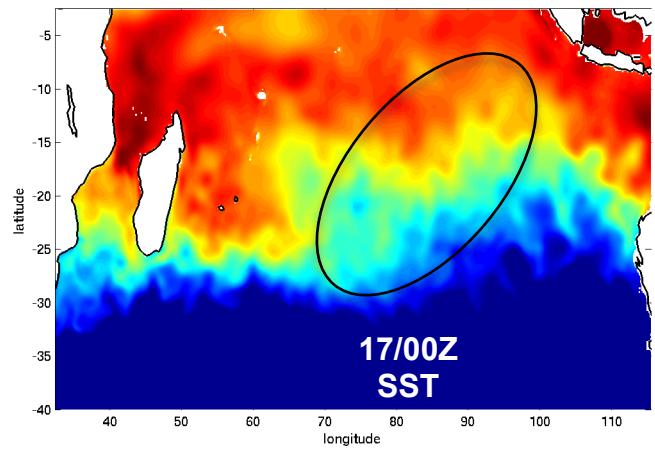
URI's MPIPOM-TC North Indian Domain: Ocean Response to Cyclone Phailin with NCODA initialization: 2013100600-1400



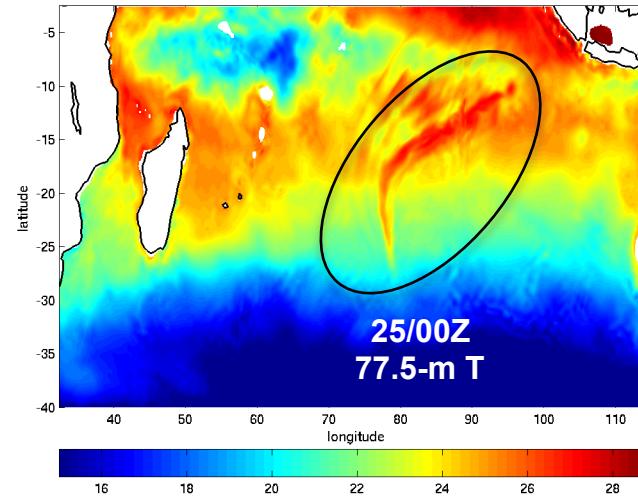
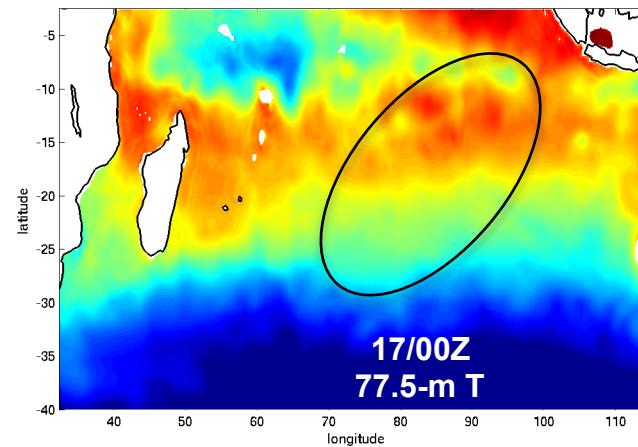
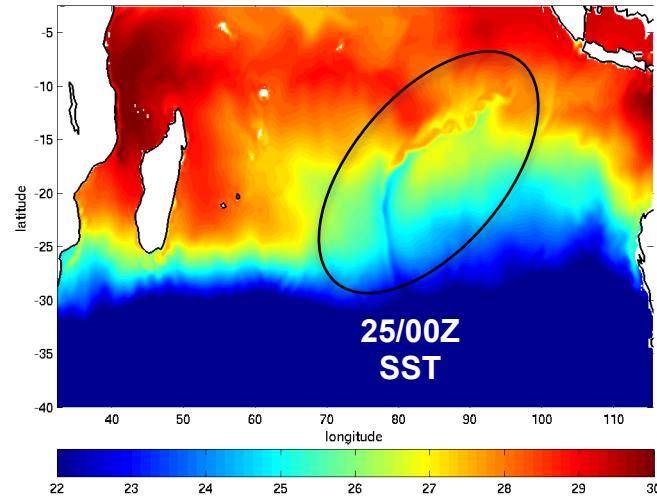
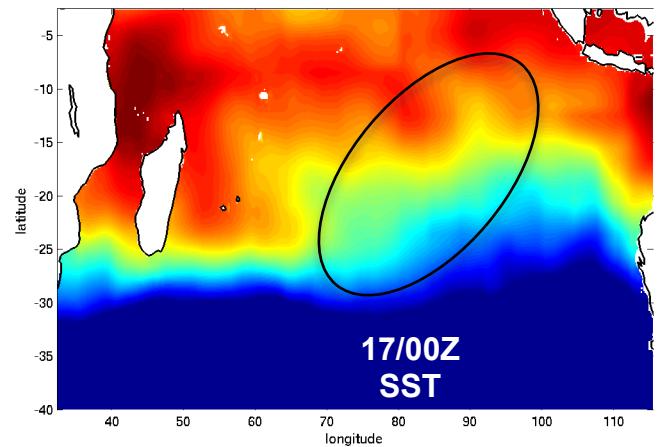
URI's MPIPOM-TC North Indian Domain: Ocean Response to Cyclone Phailin with GDEMv3 + GFS SST initialization: 2013100600-1400



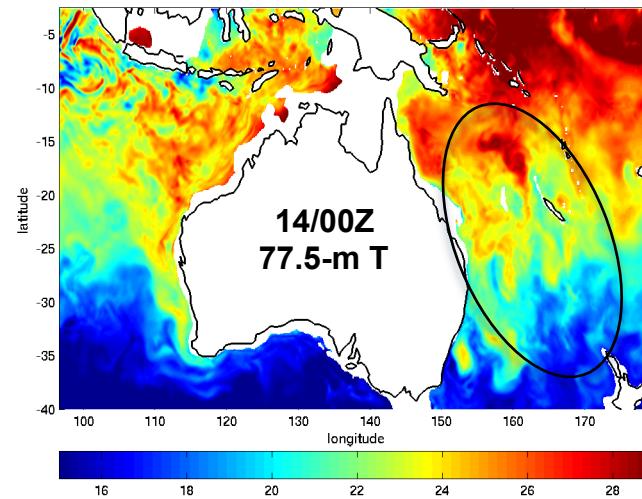
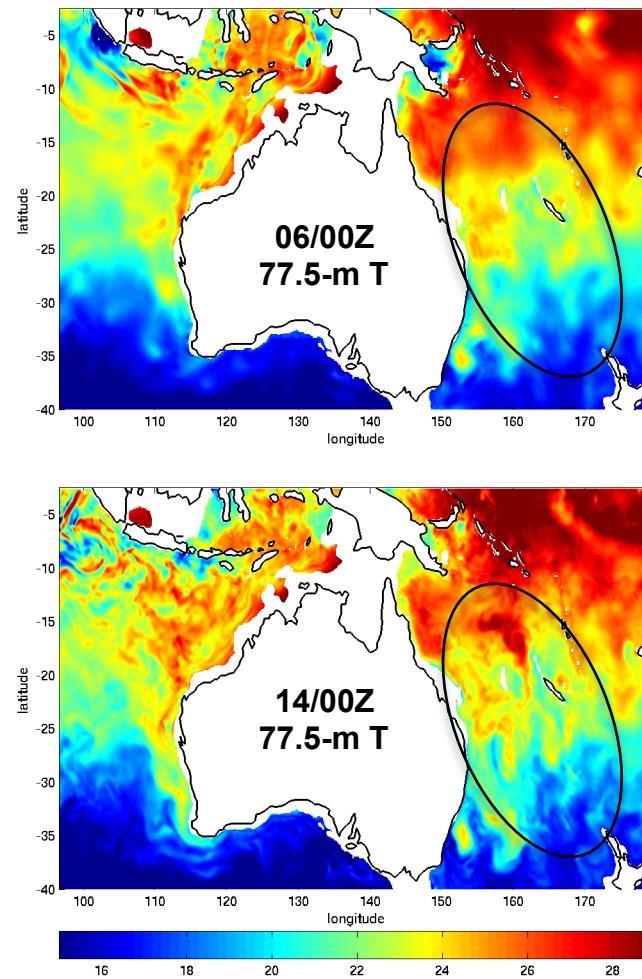
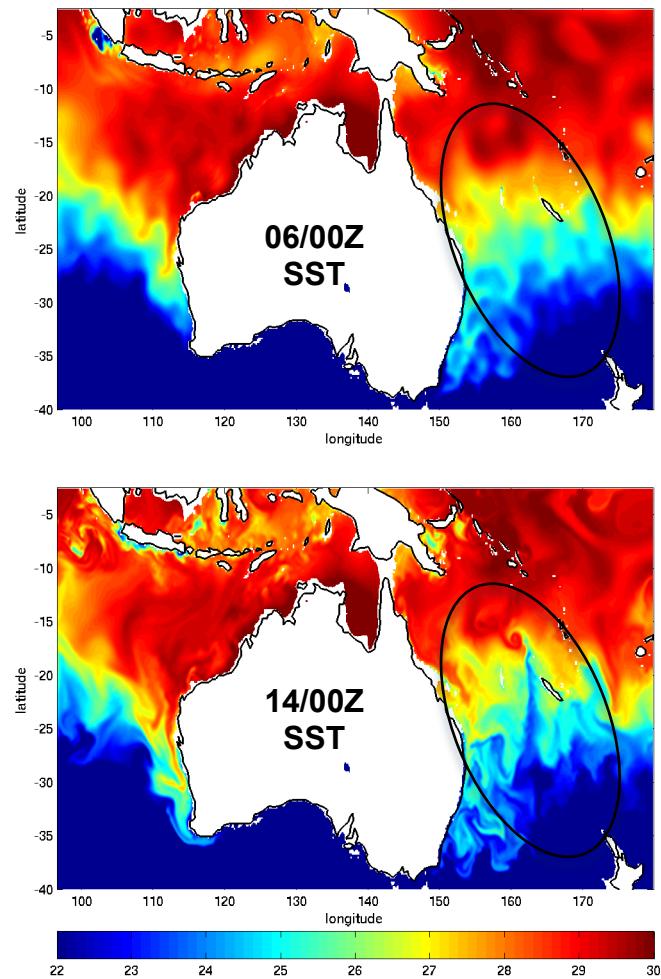
URI's MPIPOM-TC South Indian Domain: Ocean Response to Cyclone Bruce with NCODA initialization: 2013121700-2500



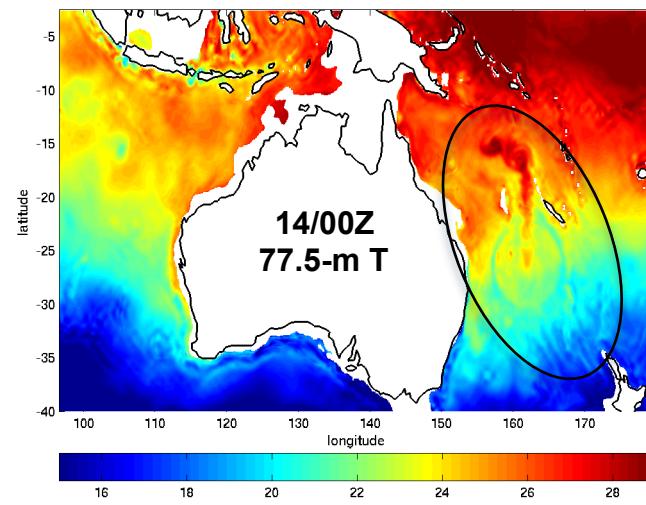
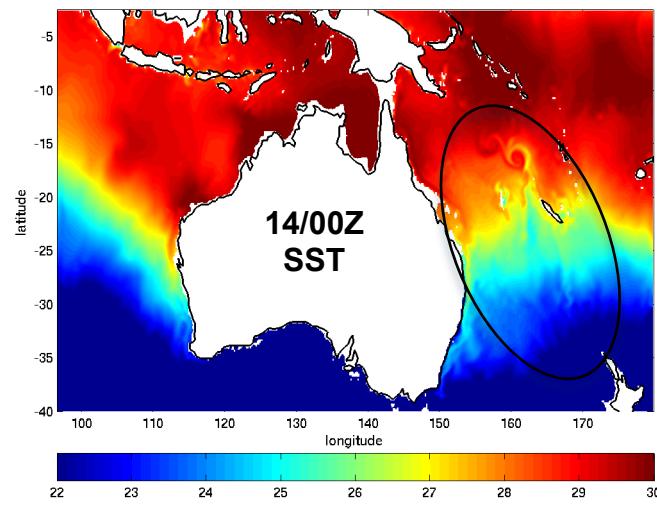
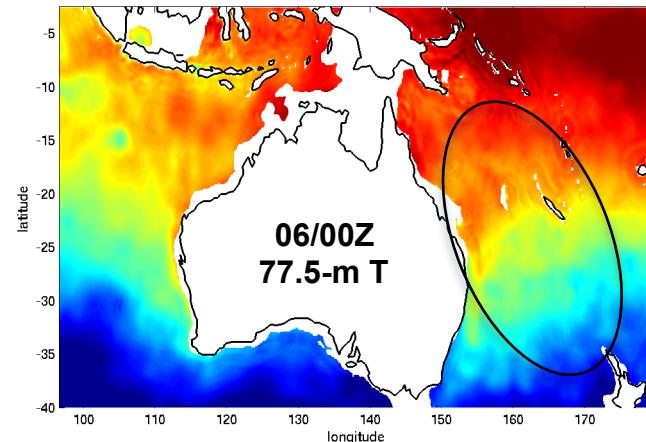
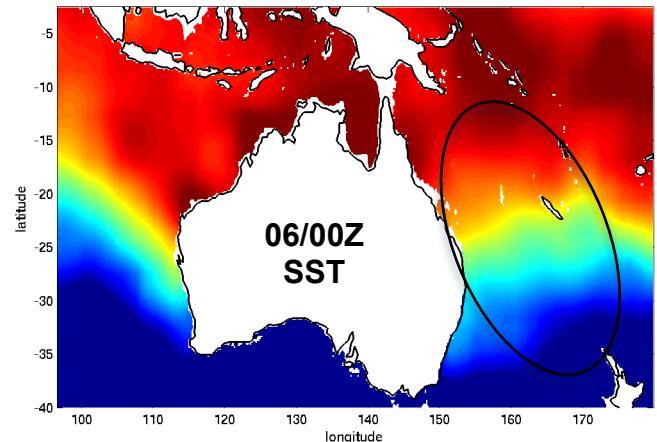
URI's MPIPOM-TC South Indian Domain: Ocean Response to Cyclone Bruce with GDEMv3 + GFS SST initialization: 2013121700-2500



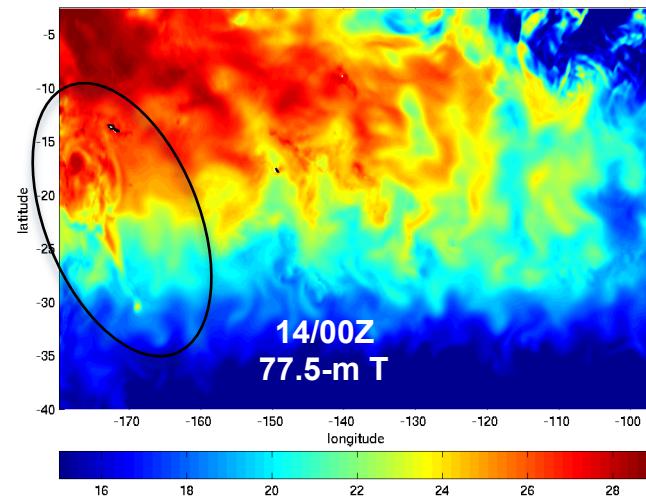
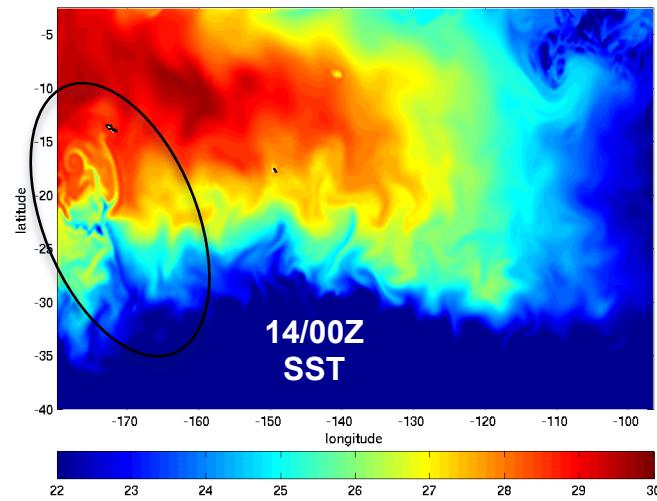
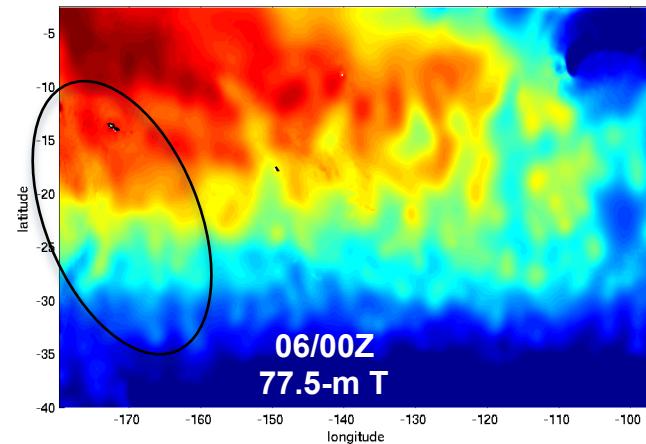
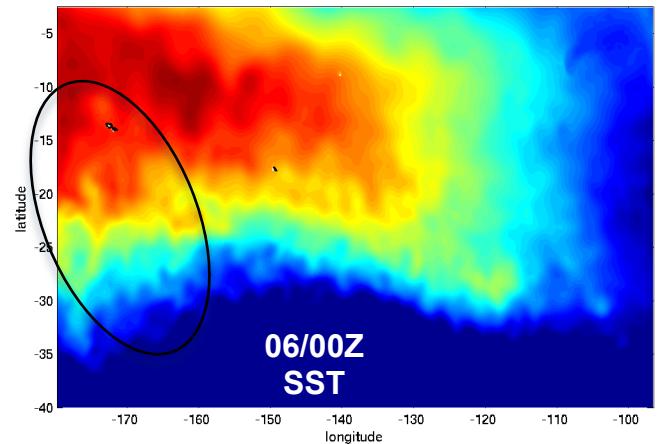
URI's MPIPOM-TC South West Pacific Domain: Ocean Response to Cyclone Sandra with NCODA initialization: 2013030600-1400



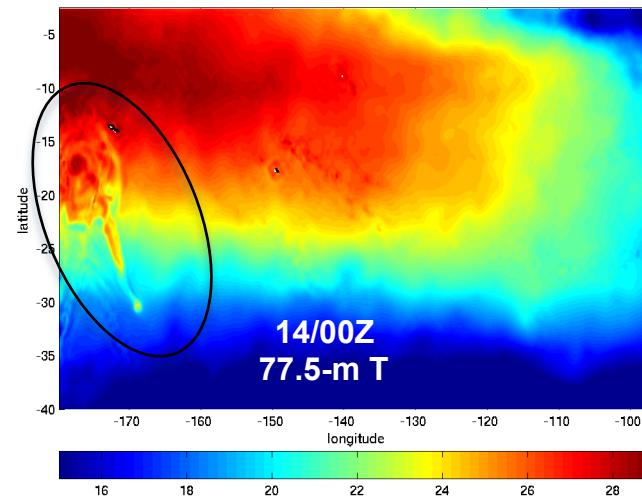
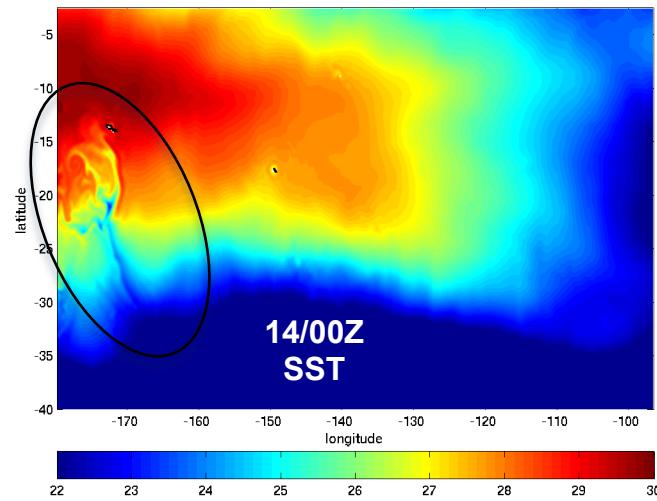
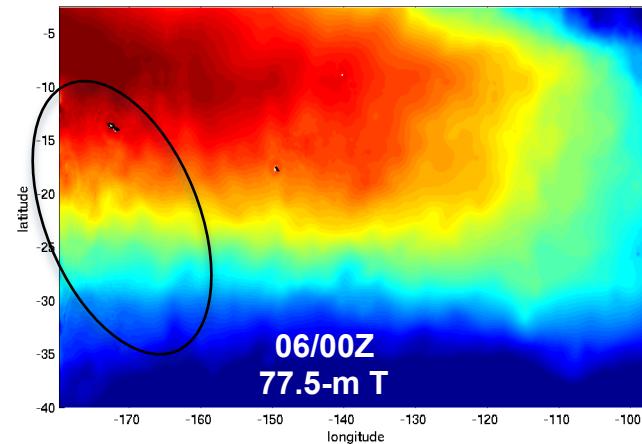
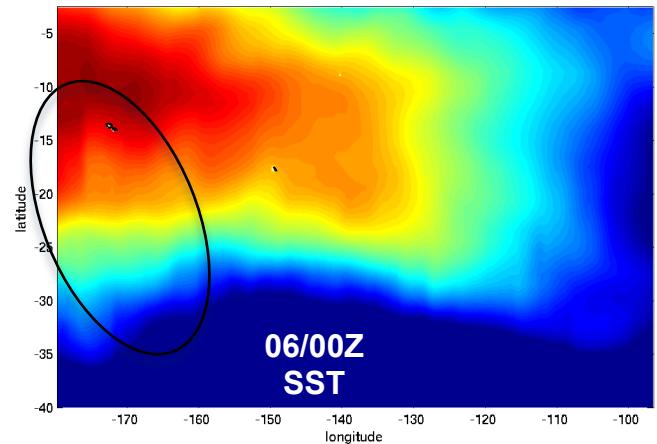
URI's MPIPOM-TC South West Pacific Domain: Ocean Response to Cyclone Sandra with GDEMv3 + GFS SST initialization: 2013030600-1400



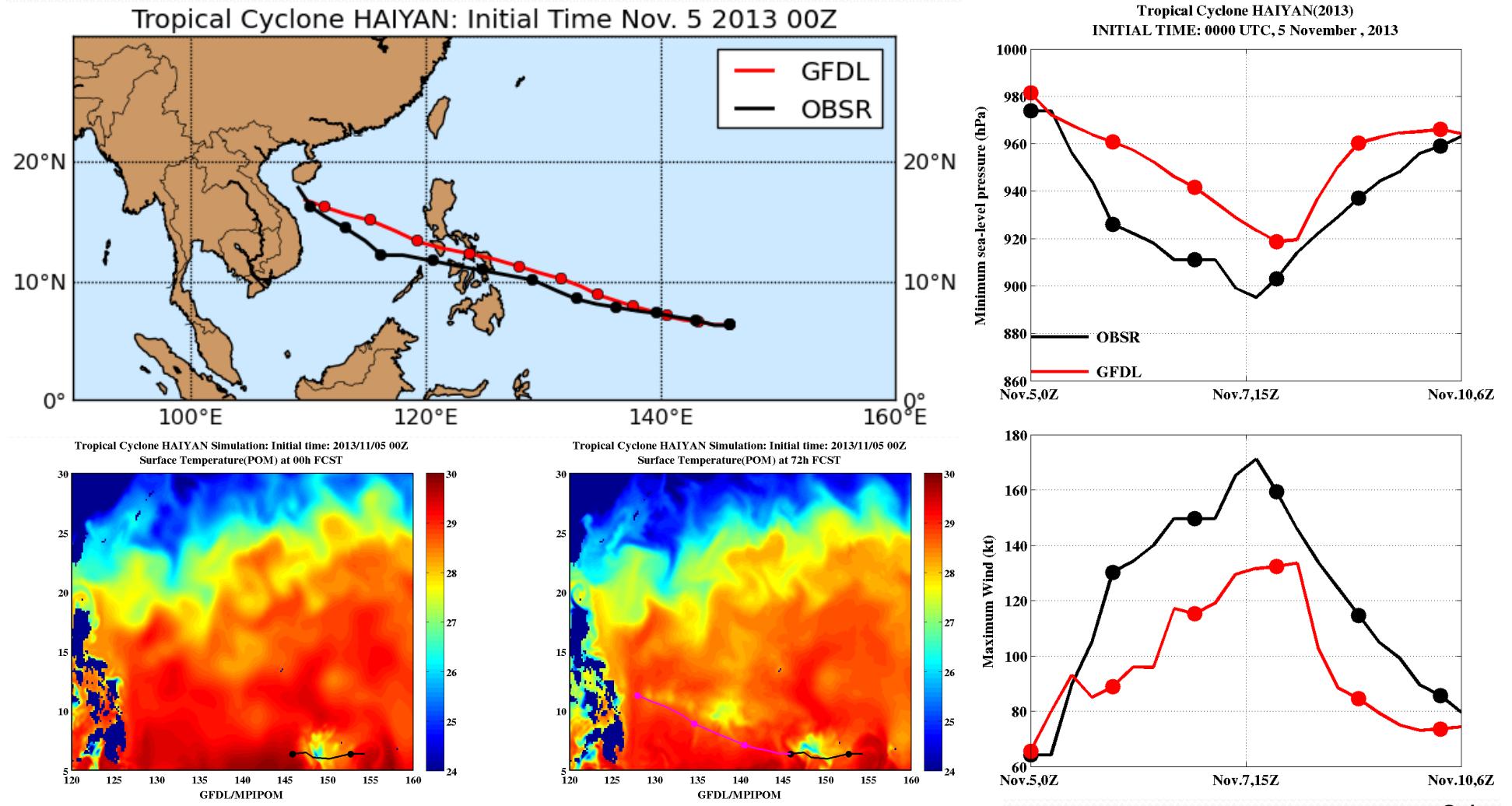
URI's MPIPOM-TC South East Pacific Domain: Ocean Response to Cyclone Ian with NCODA initialization: 2014010600-1400



URI's MPIPOM-TC South East Pacific Domain: Ocean Response to Cyclone Ian with GDEMv3 + GFS SST initialization: 2014010600-1400



GFDL/MPIPOM-TC retrospective forecast of Supertyphoon Haiyan, initialized 2013110500 (NCODA)



Summary

- POM-TC was the Princeton Ocean Model-based component of the GFDL, GFDN, and HWRF operational hurricane models until 2014
- Major 2014 upgrade of the GFDL/N and HWRF ocean model components: Replacing POM-TC with MPIPOM-TC
- Multiple MPIPOM-TC ocean initialization options are being evaluated and tested for future implementation
- A new collaborative coupled hurricane-ocean model inter-comparison and evaluation effort is planned to improve MPIPOM-TC, as well as HYCOM-TC and NCOM-TC
 - Collaborators: EMC, NRL, URI, USNA, AOML, UM, MSU, WHOI, Rutgers, U Maine, UMD, others?

