2013 Upgrades to the Operational GFDL/GFDN Hurricane Model

Morris A. Bender, Timothy Marchok

Geophysical Fluid Dynamics Laboratory, NOAA

Isaac Ginis, BijuThomas, Richard M. Yablonsky

Graduate School of Oceanography, University of Rhode Island

Robert E. Tuleya

NOAA Visiting Scientist, CCPO/ODU, Norfolk, Va.

This NOAA Joint Hurricane Testbed project was funded by the US Weather Research Program in NOAA/OAR's Office of Weather and Air Quality

GFDL 2012 UPGRADES

Model Physics Upgrades

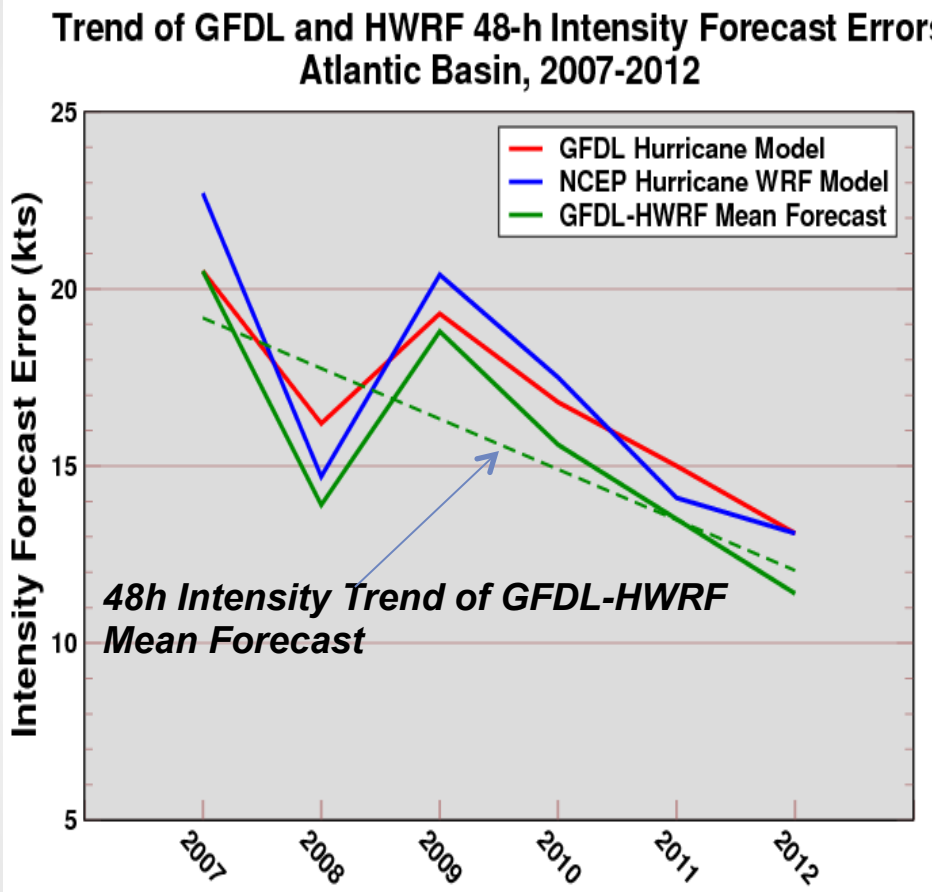
1. Detrained Microphysics passed from SAS to micro-physics
2. Bugs Fixed in PBL and SAS convective schemes
3. Retuning of momentum mixing
4. Improved formulation of surface exchange coefficients (ch, cd)
5. Implementation of GFS Shallow Convection
6. Improved PBL structure (.25 Critical Richardson number; reduced vertical mixing coefficient by 40% in storm region)

Initialization

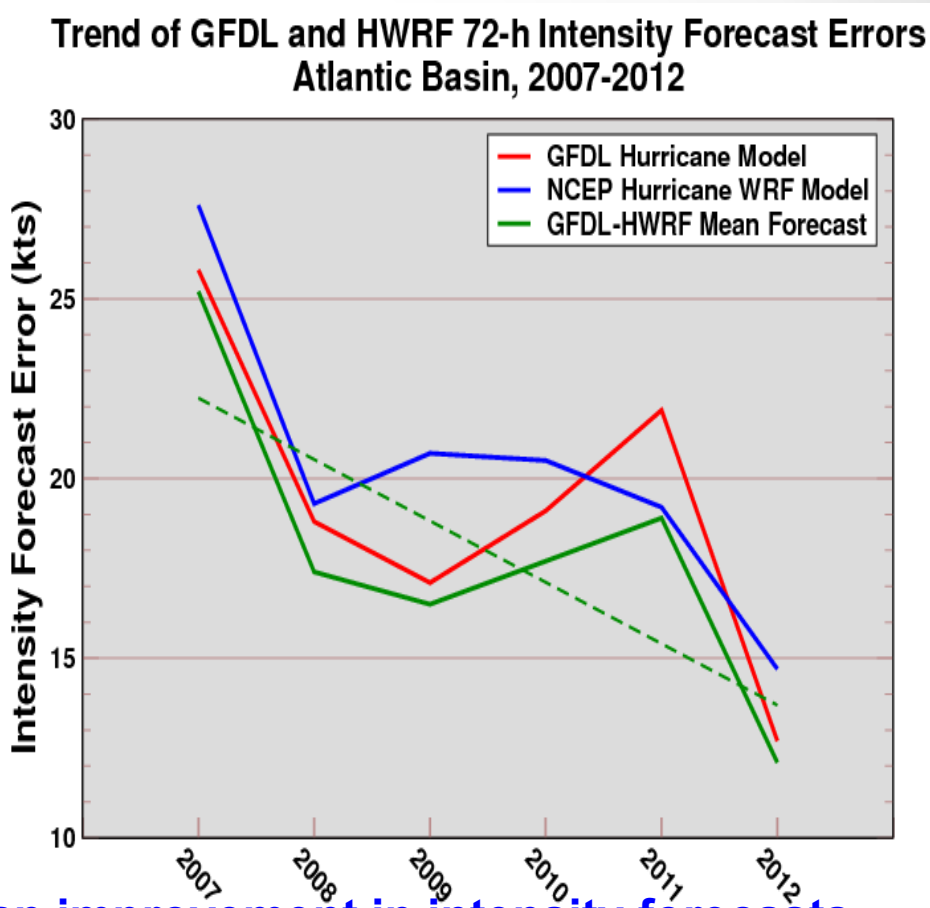
1. Reduction in storm size for larger storms
2. Removal of asymmetries (impact was neutral)

GFDL/HWRF Six Year Intensity Trend

48h Intensity Error (knots)



72h Intensity Error (knots)



Trends over the past 6 seasons indicate an improvement in intensity forecasts with operational NWS regional hurricane models

GFDL and HWRF exhibit comparable improvements, with their mean showing further improvements

Proposed GFDL 2013 UPGRADES

Model Resolution and Dynamics

1. **Increase of inner nest model resolution from 1/12th to 1/18th degree.**
2. **Reduction of gravity wave damping term in time differencing scheme (Kurihara, Tripoli, Bender, *MWR, 1976*)**

Model Physics

1. **Initiation of large-scale condensation at 100% humidity for inner nests**
2. **Implementation of meso-SAS (to be evaluated)**
3. **Implementation of new version of Princeton Ocean Model (MPIPOM-TC) for ocean coupling (to be evaluated)**

Initialization

1. **Improved specification of maximum wind in vortex initialization (*significant reduction in initial negative wind bias*)**

- Proposed Upgraded model to be extensively tested on 2010, 2011 and 2012 seasons using current version of the GFS.

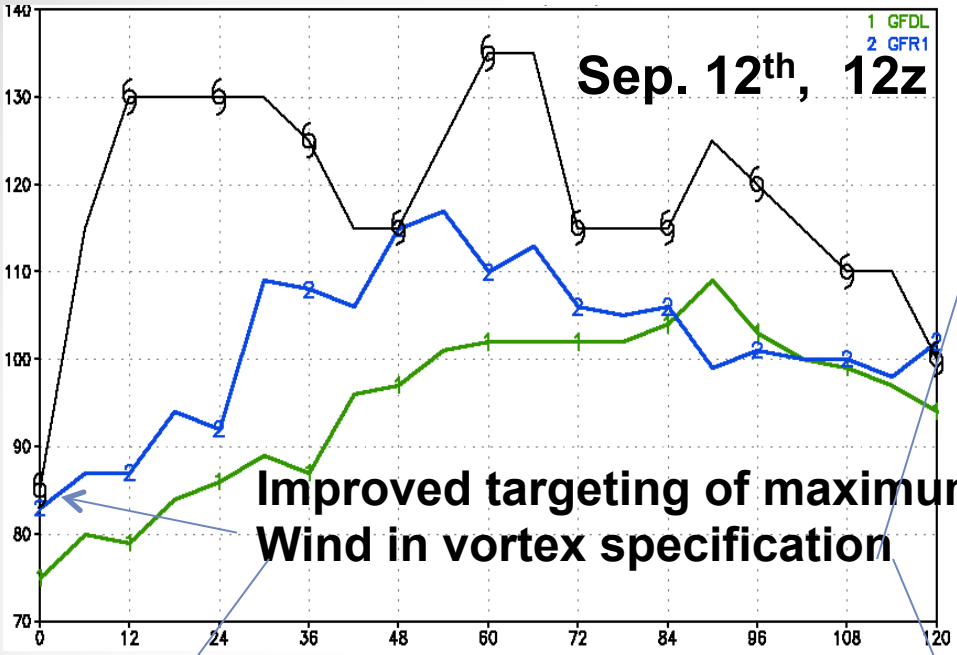
- Results to be summarized in presentation for Atlantic basin only.

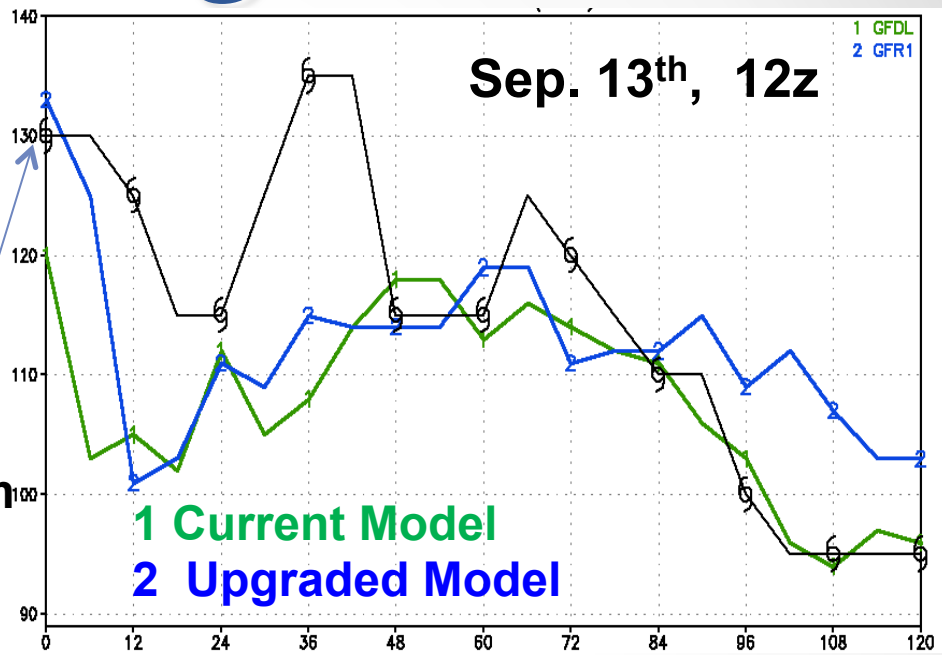
- Results presented without new meso-SAS and MPIPOM-TC (Preliminary results !)

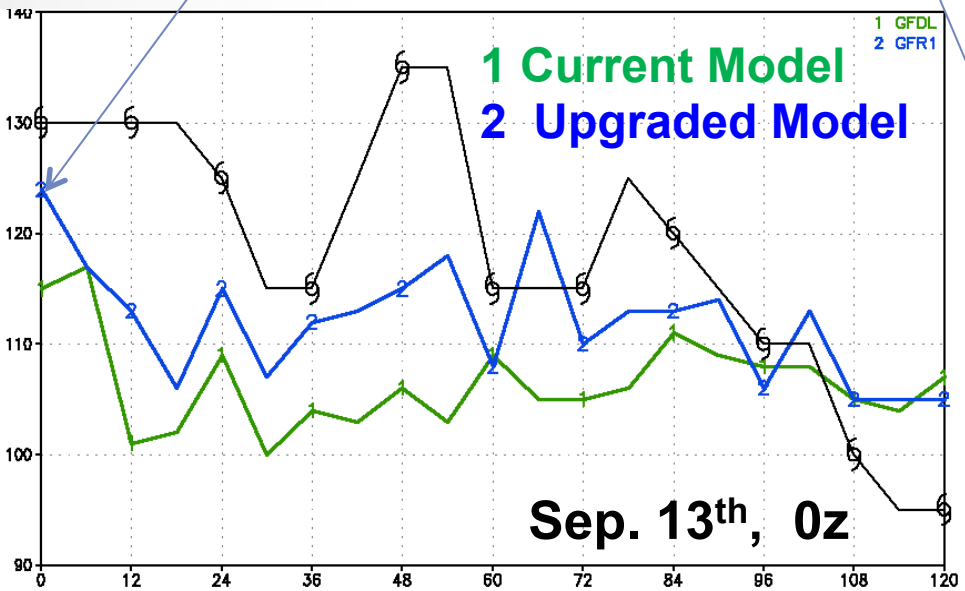
- Version will serve as benchmark for evaluation of new meso-SAS and MPIPOM-TC for final model configuration

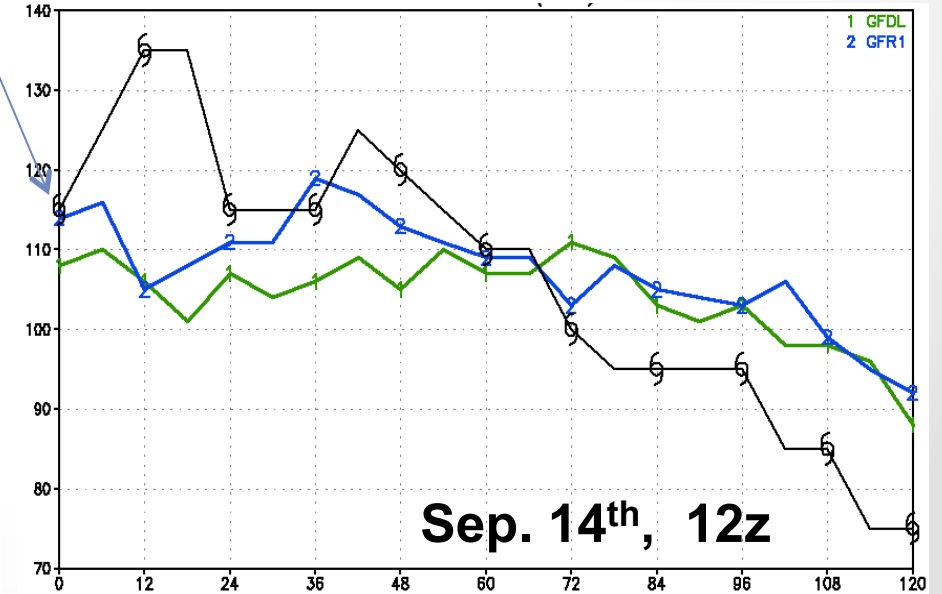
Impact of Improved Vortex Specification in Initialization

Hurricane Igor





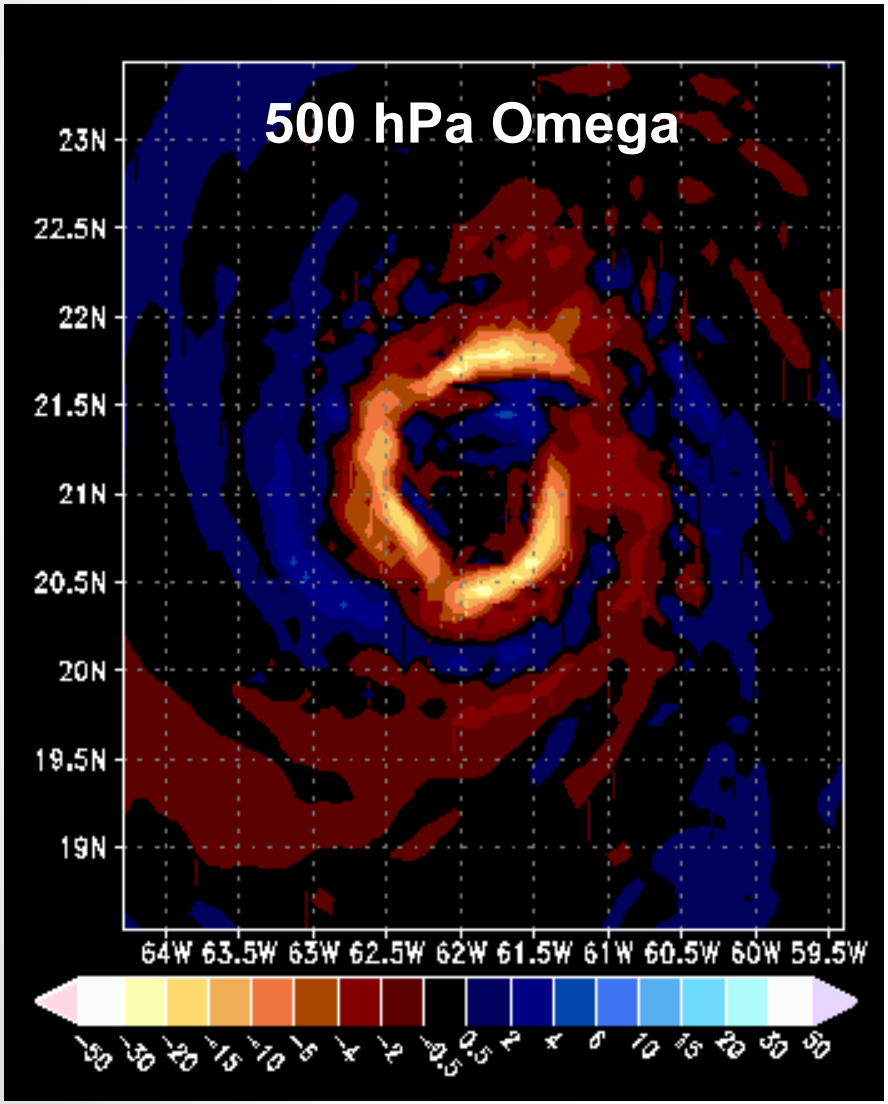




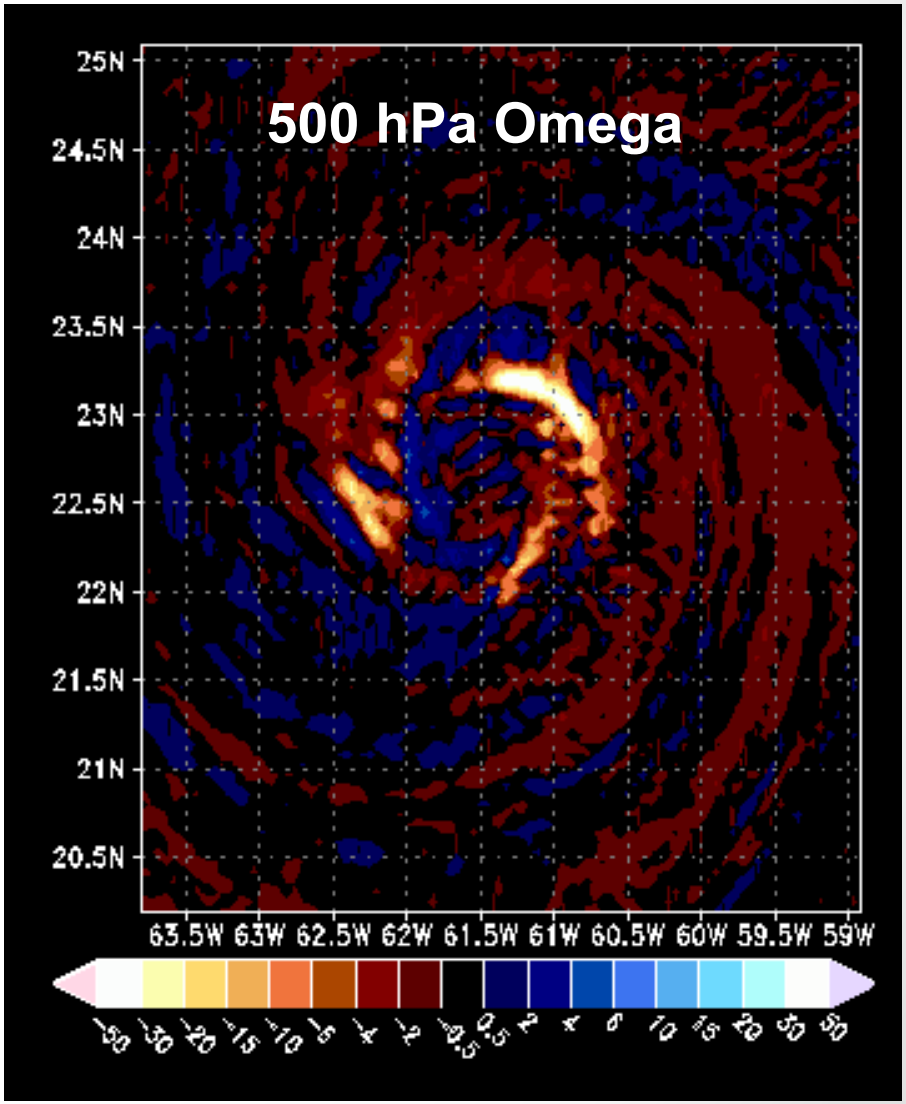
Impact of Higher Resolution and Reduced Gravity Wave Damping on Inner Core

Hurricane Katia (0000 UTC 1 September, 2011)

Current Model

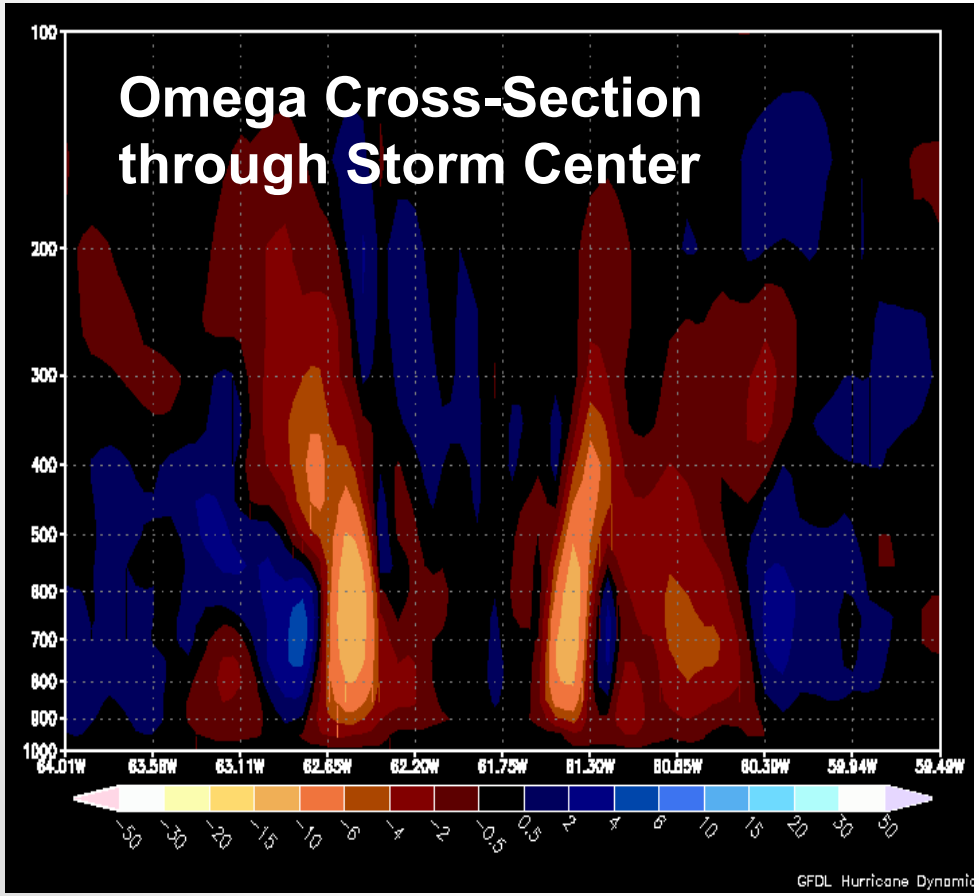


Upgraded Model

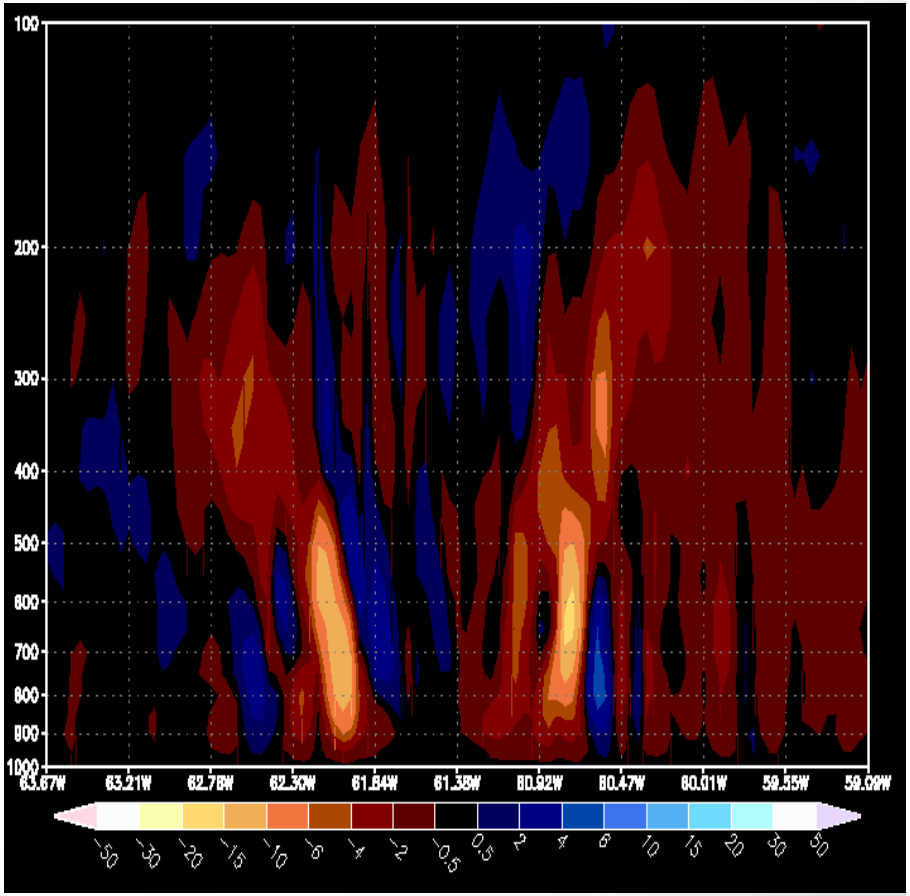


Hurricane Katia (0000 UTC 1 September, 2011)

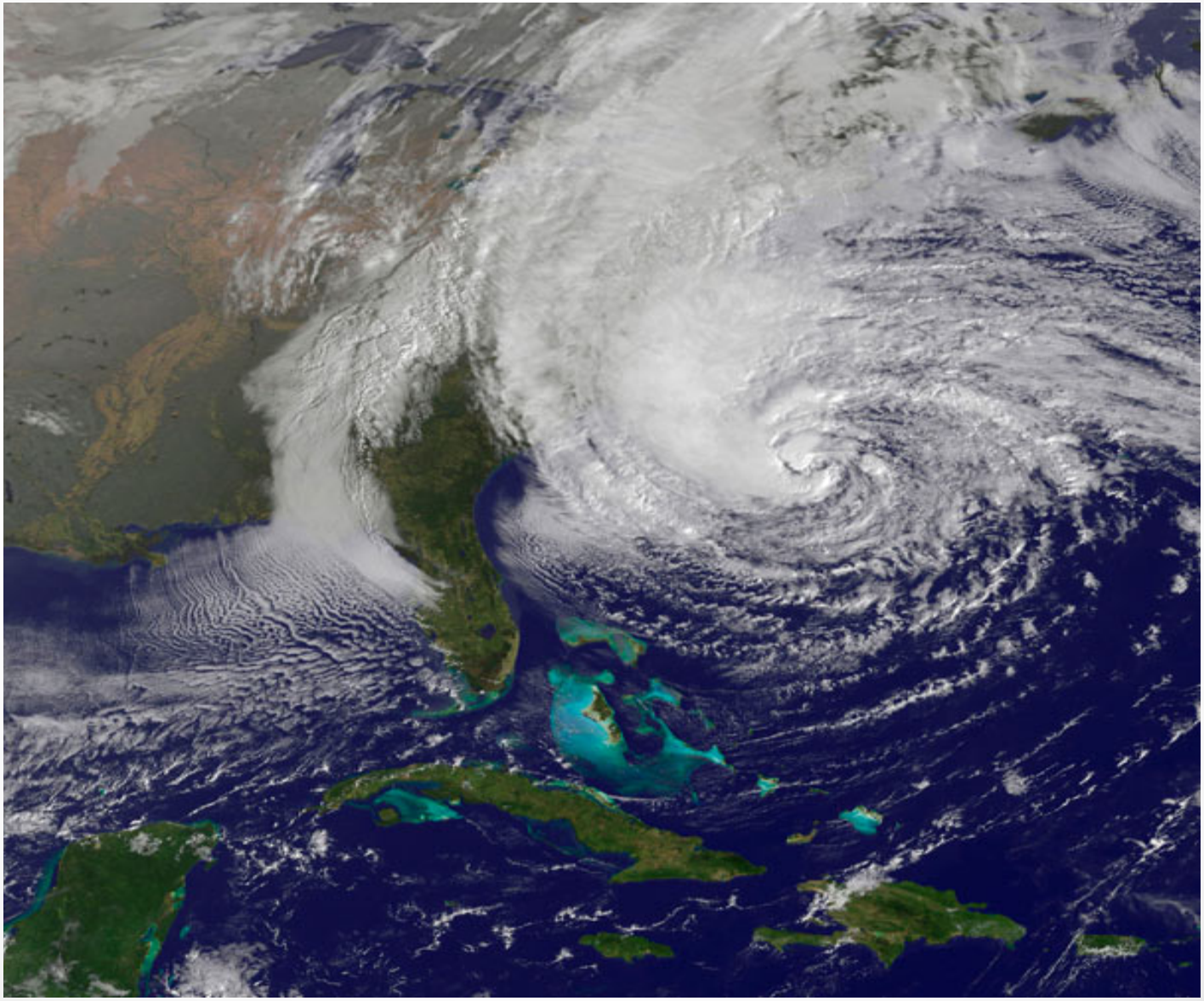
Current Model



Upgraded Model

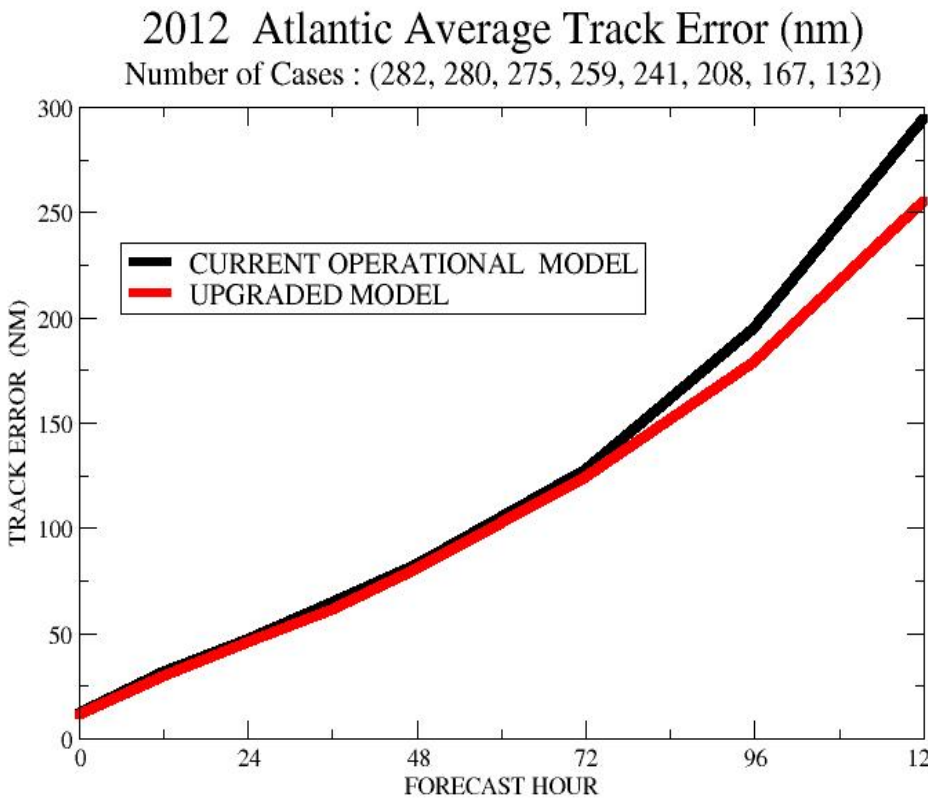


IMPACT ON TRACK AND INTENSITY

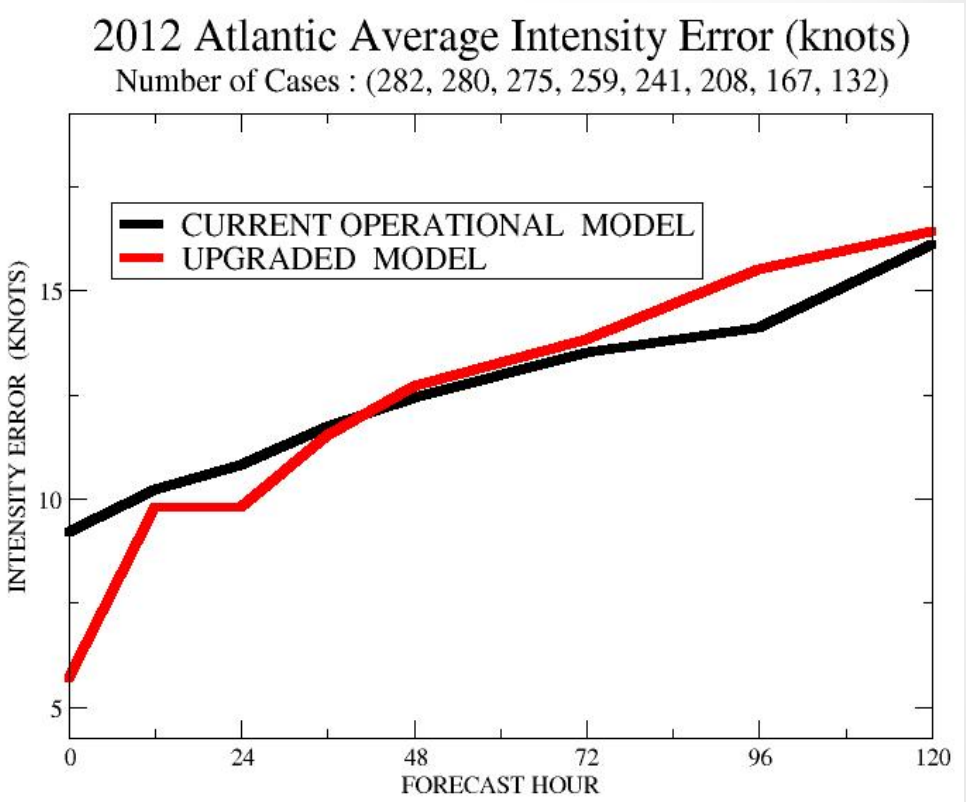


2012 Atlantic Track and Intensity Errors

TRACK ERROR



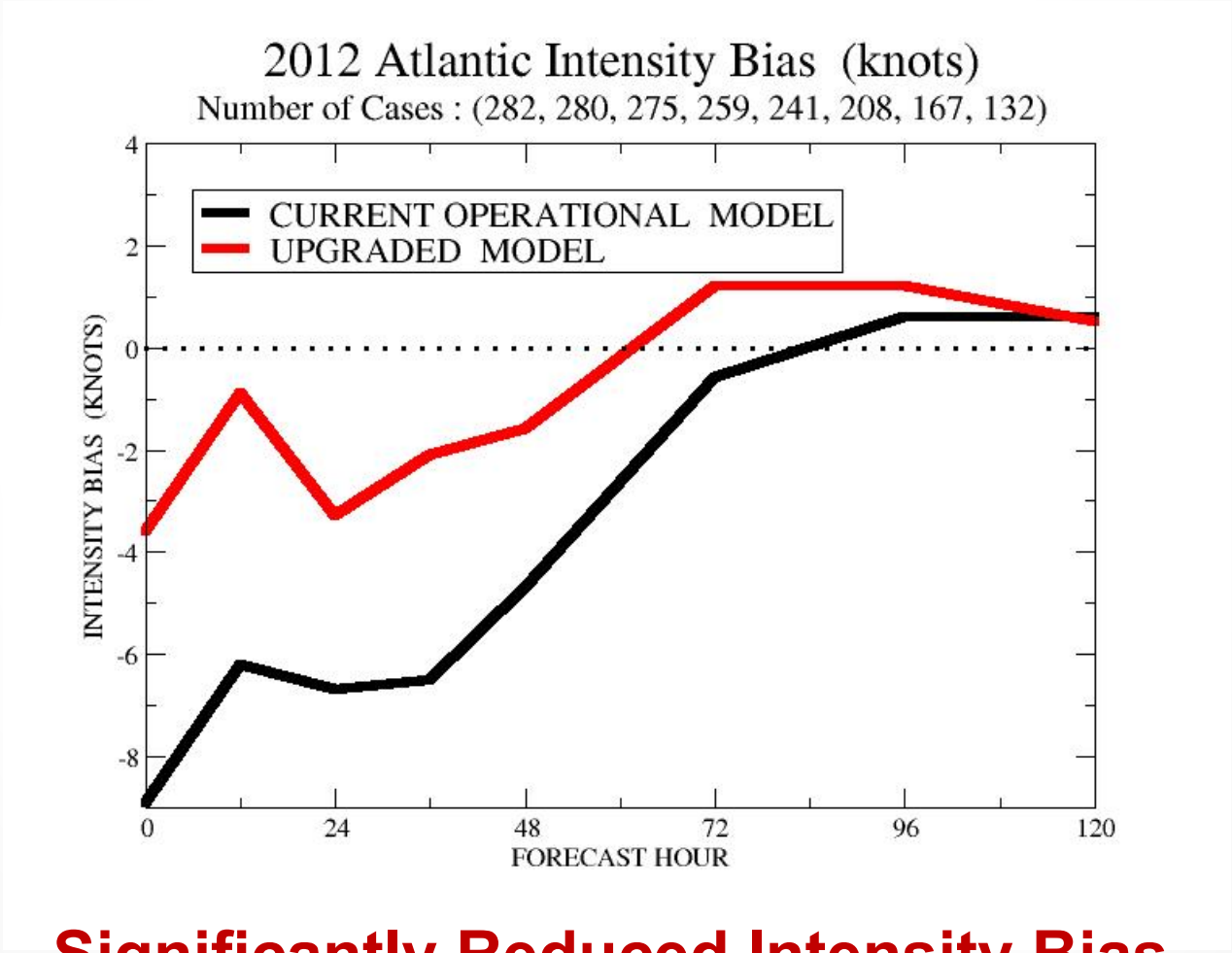
INTENSITY ERROR



12% Reduced track error days 4-5.
Track error reduced all time levels

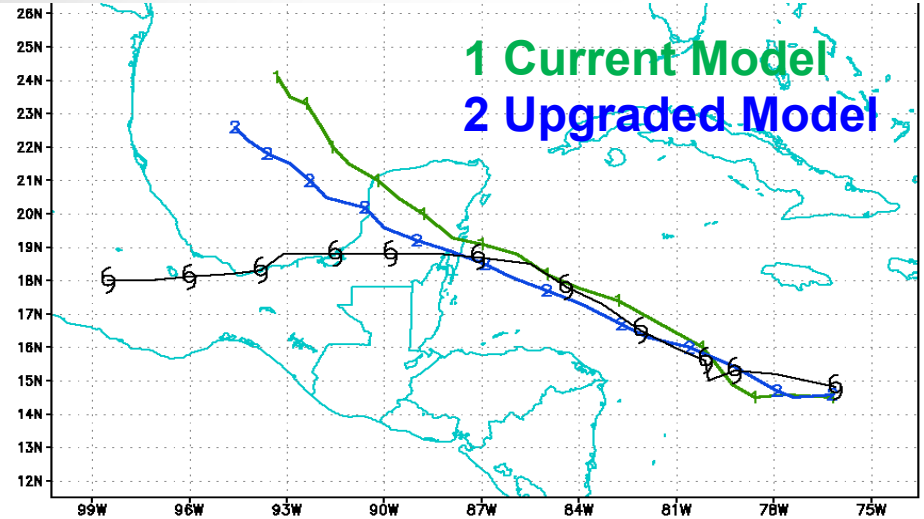
Significant reduction in early forecast periods due to improved initialization.
Neutral Impact Beyond hour 12.

2012 Intensity Bias



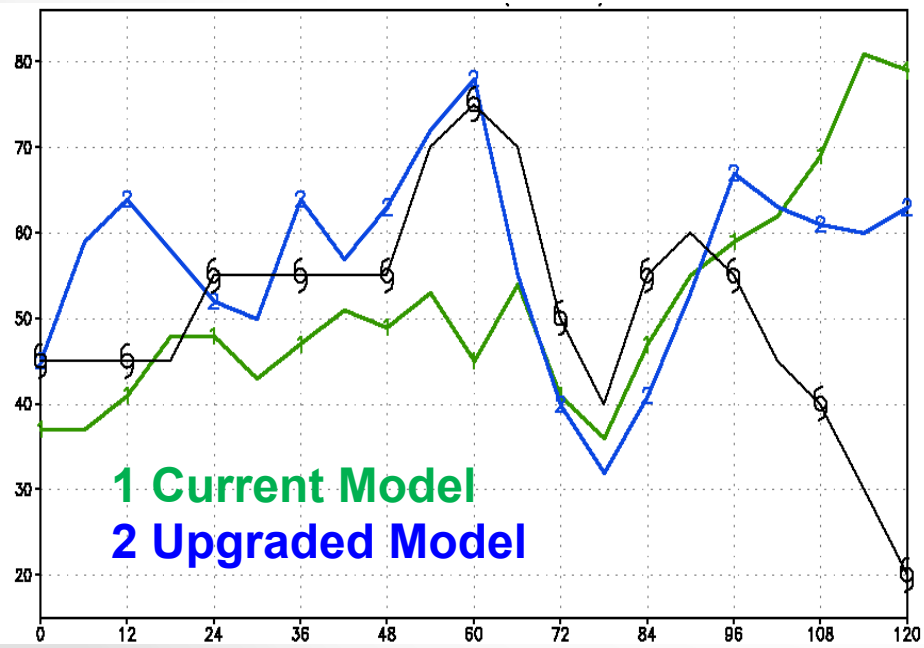
Significantly Reduced Intensity Bias.
Small Positive Bias at 3-5 days

Hurricane Ernesto

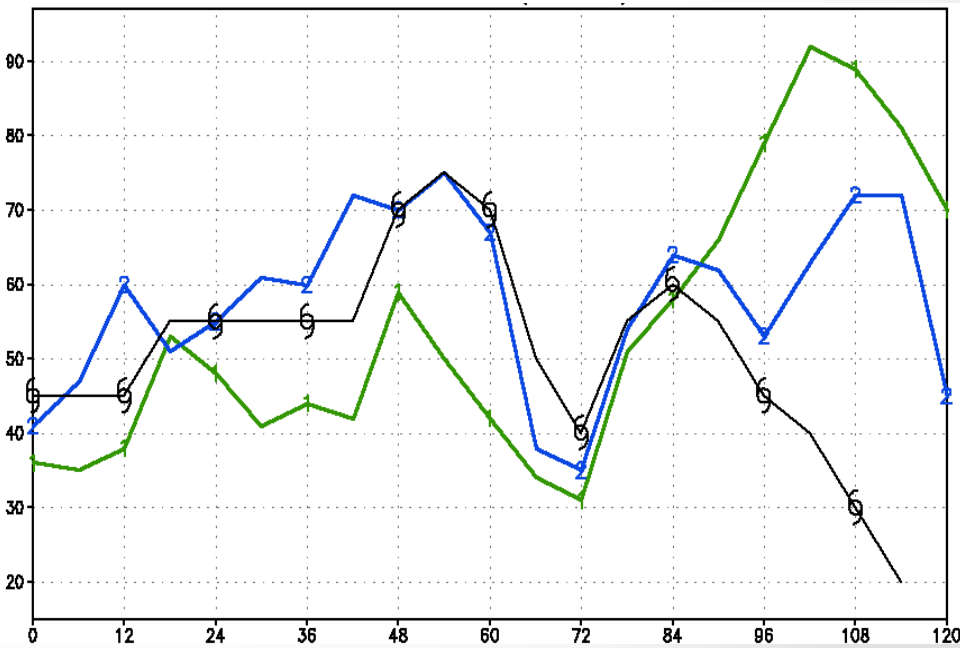


Improved Track and Intensity Forecasts for Hurricane Ernesto

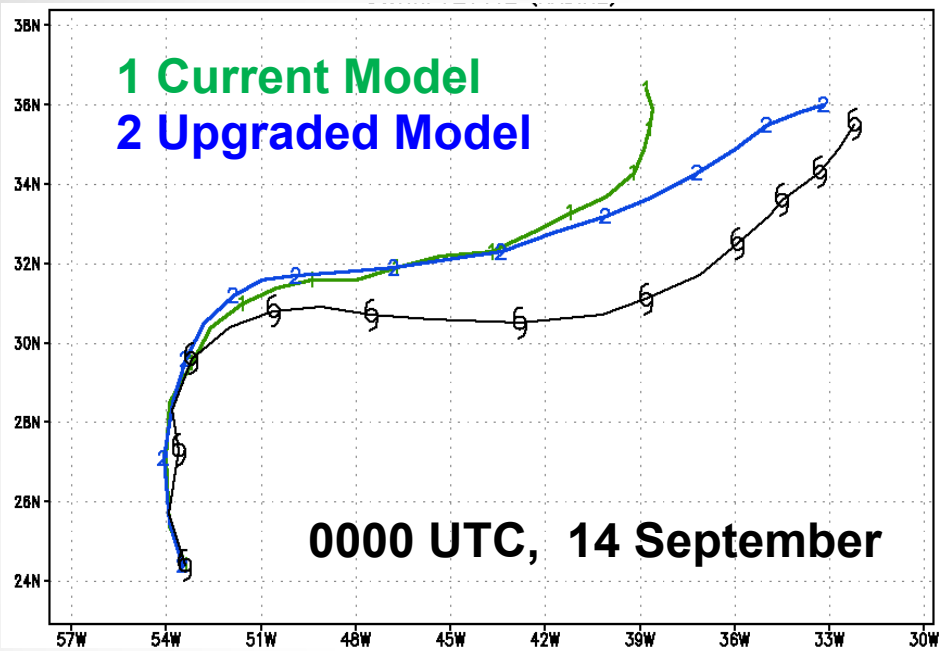
1200 UTC 5 August

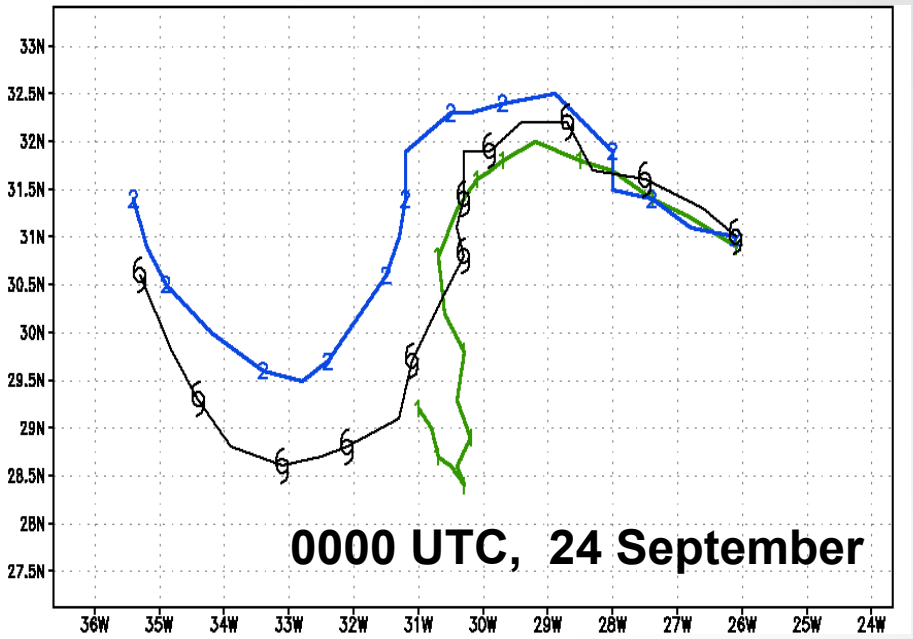


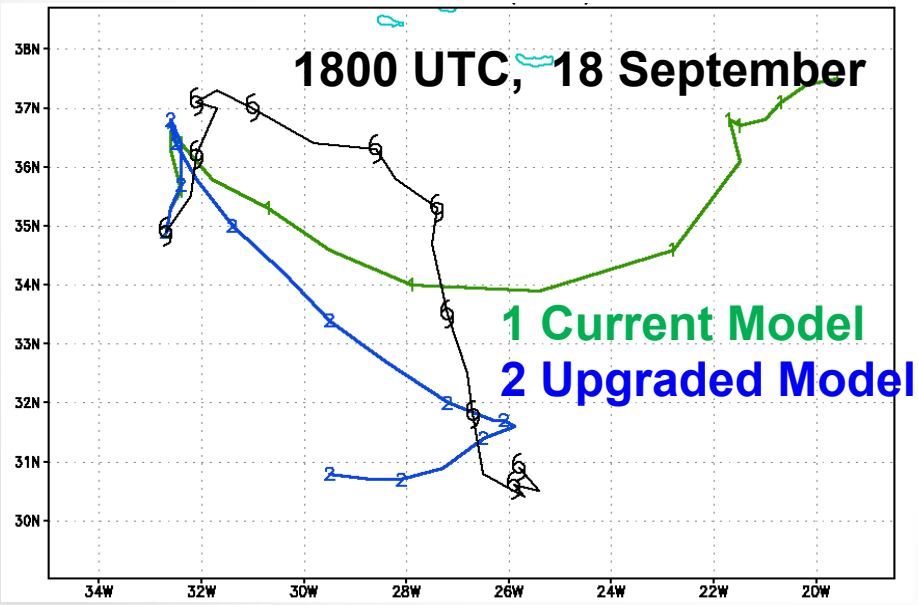
1800 UTC 5 August

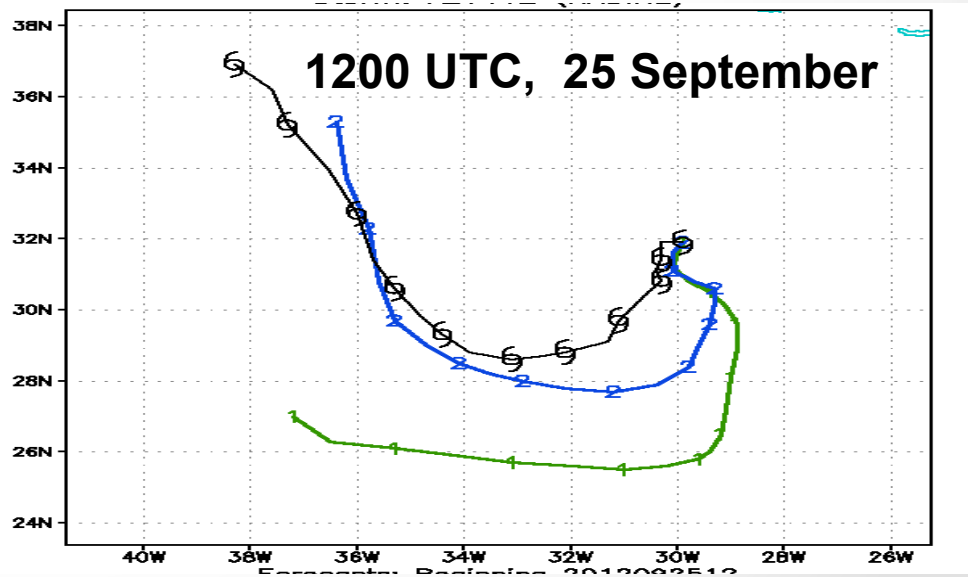


Much Improved Tracks for Nadine



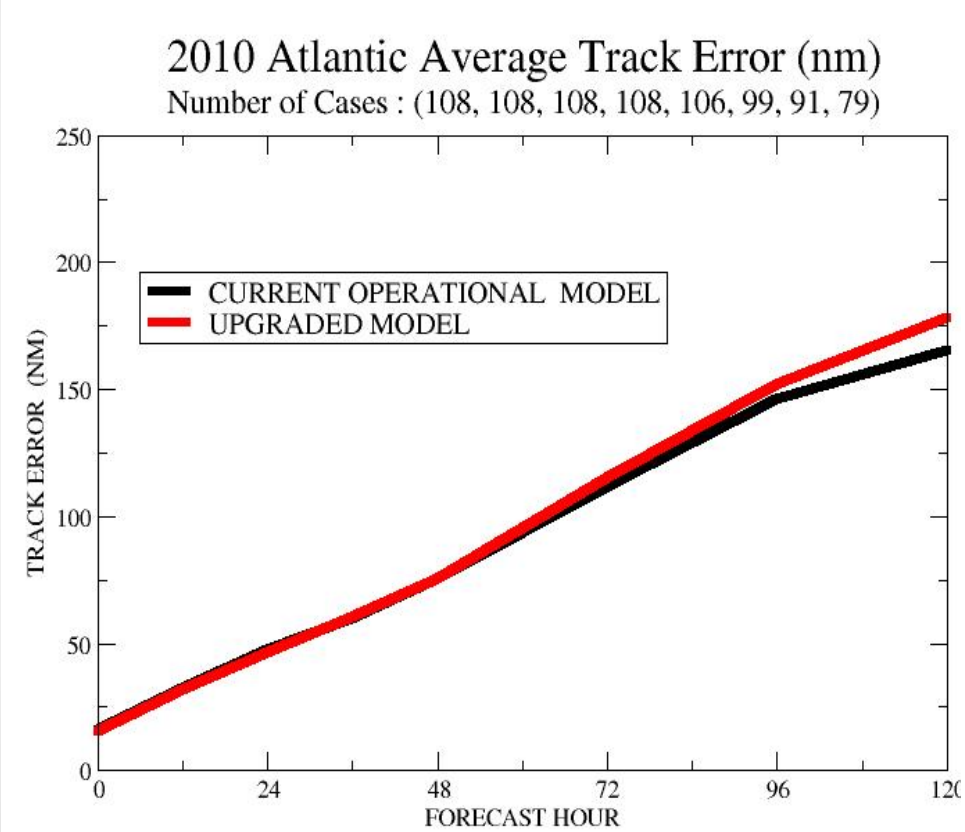




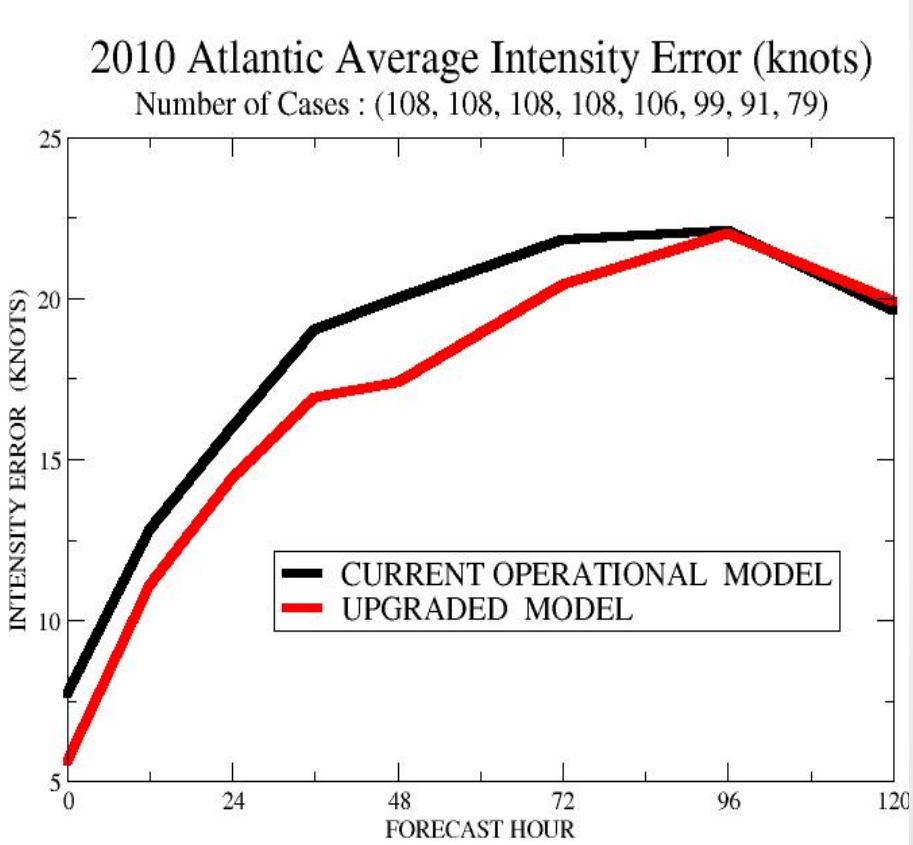


2010 Atlantic Track and Intensity Errors

TRACK ERROR



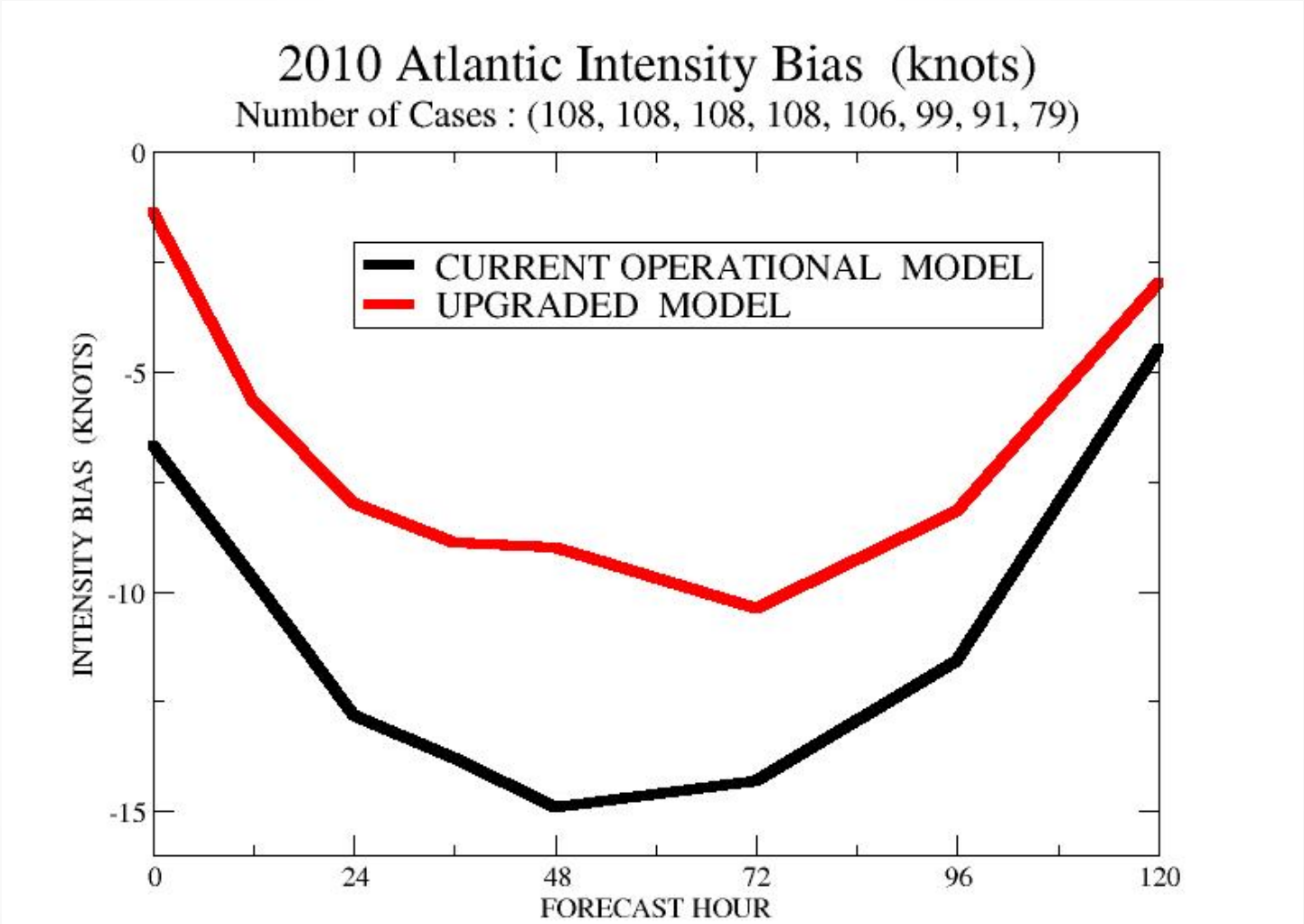
INTENSITY ERROR



Overall Neutral Impact on Track

11% Reduced Intensity Error Through Day 3
(Season Dominated by Strong Storms)

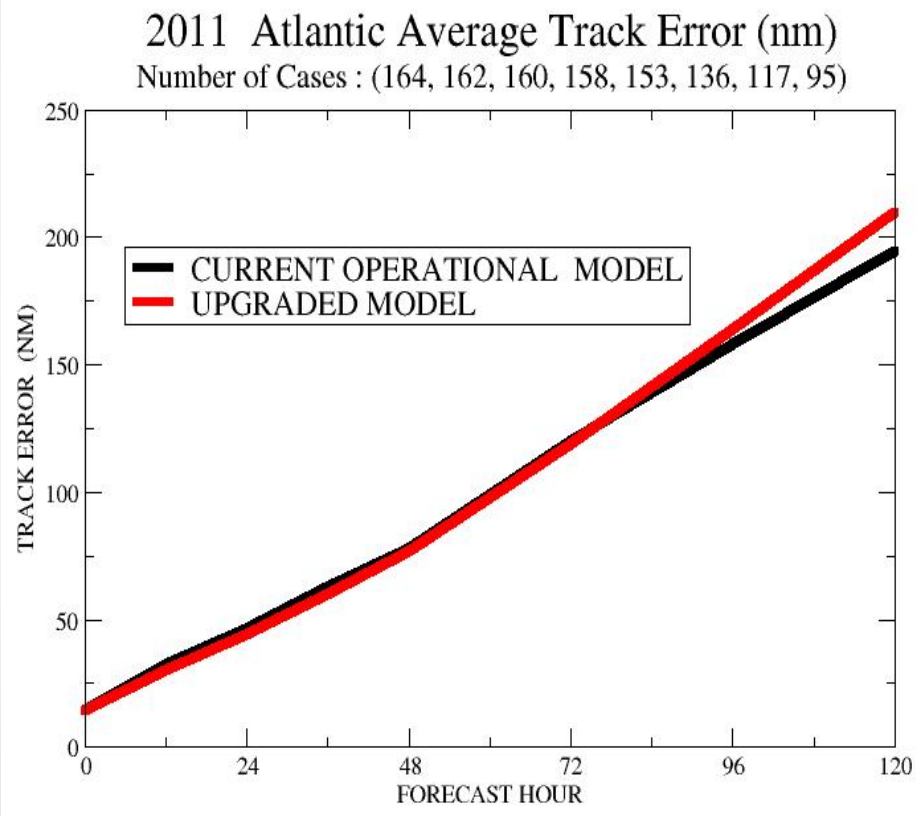
2010 Intensity Bias



Much Reduced Negative Bias in a Season Dominated by Intense Hurricanes (Danielle, Igor, Earl, Julia)

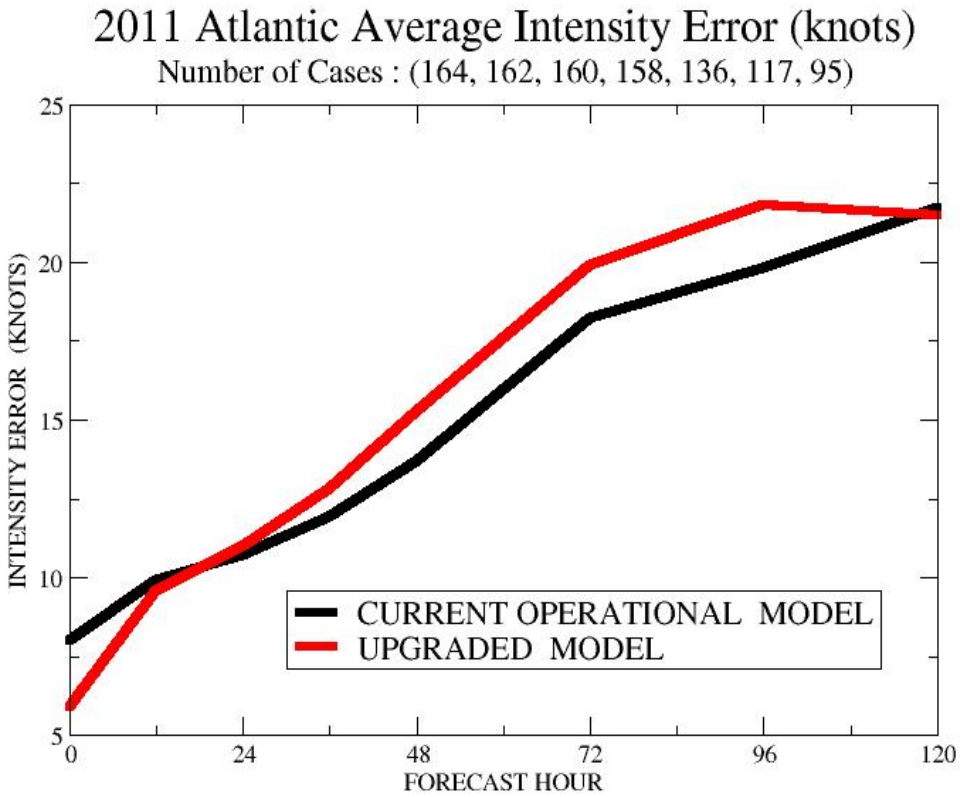
2011 Atlantic Track and Intensity Errors

TRACK ERROR



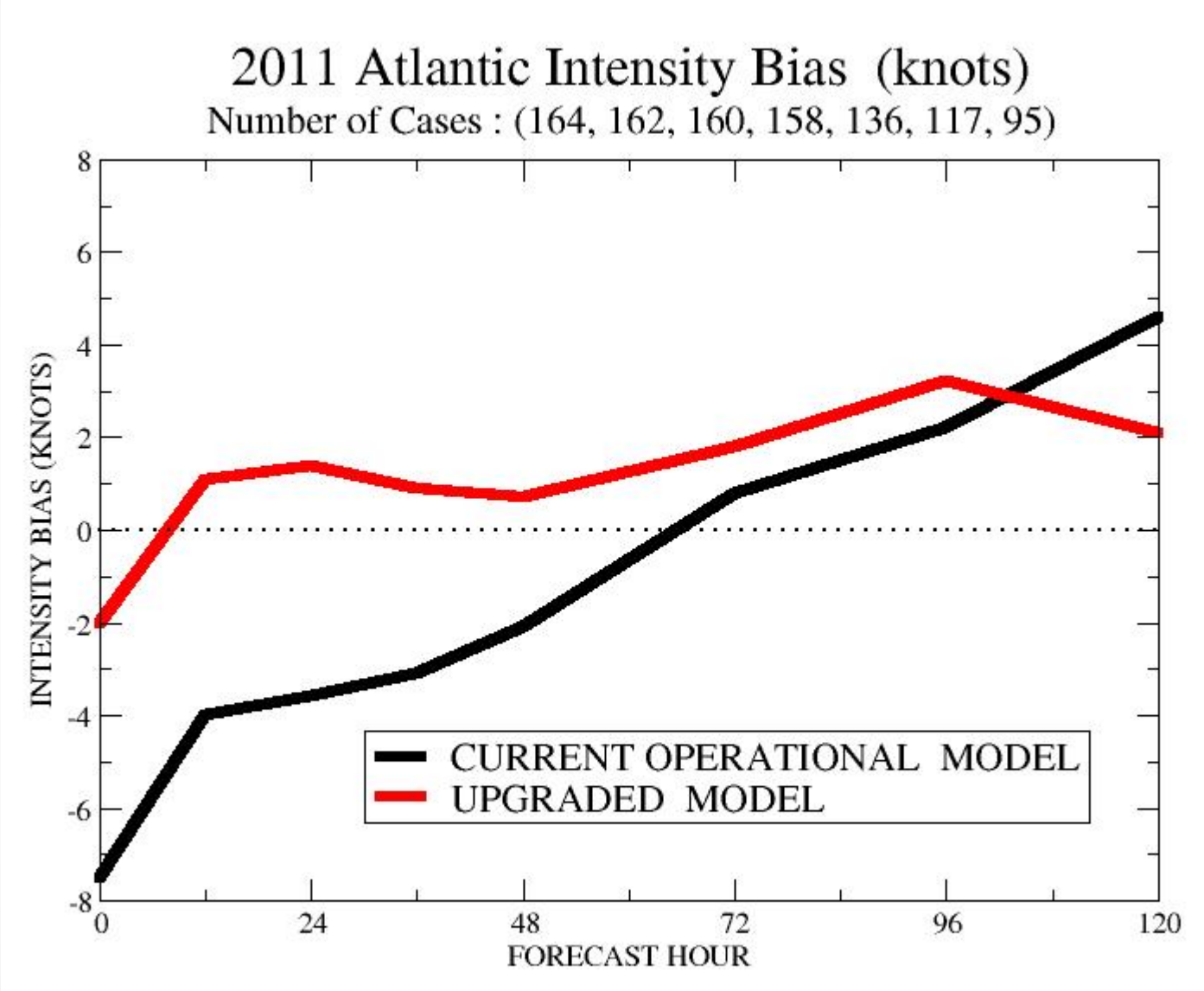
Slightly Improved Track Errors for early forecast periods.
4-5% Degraded Track Error Days 4-5

INTENSITY ERROR



Excessive Positive bias in Irene and Katia at Days 2-4 Contributed to Increased Intensity Error with Upgraded Model

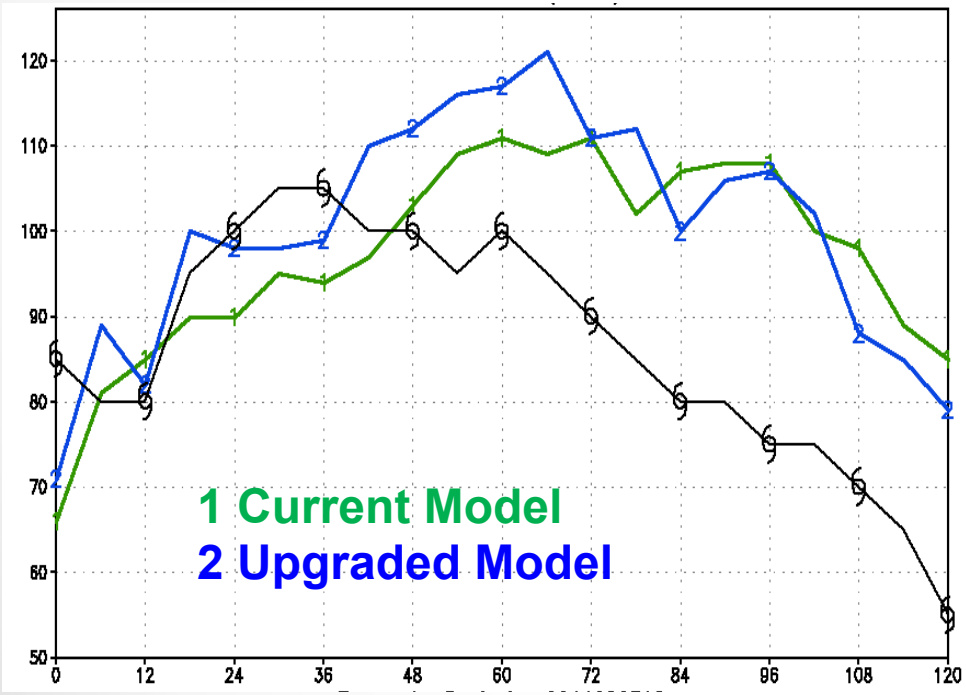
2011 Intensity Bias



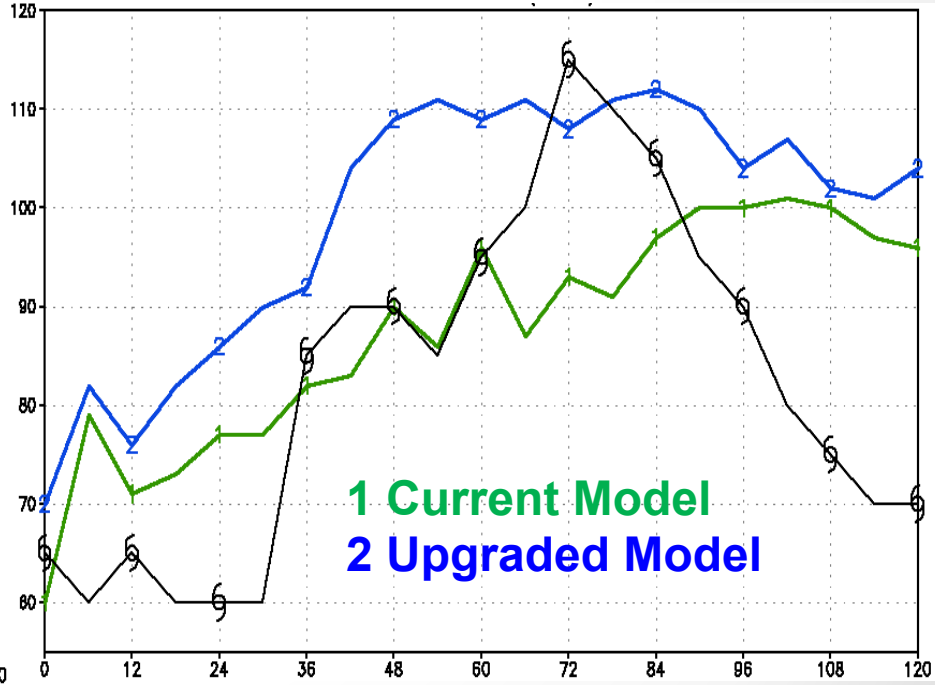
Significant Positive Bias at Days 3 through 5

Five Day Forecast of Maximum Surface Winds (knots)

Hurricane Irene
(1200 UTC 23rd August)



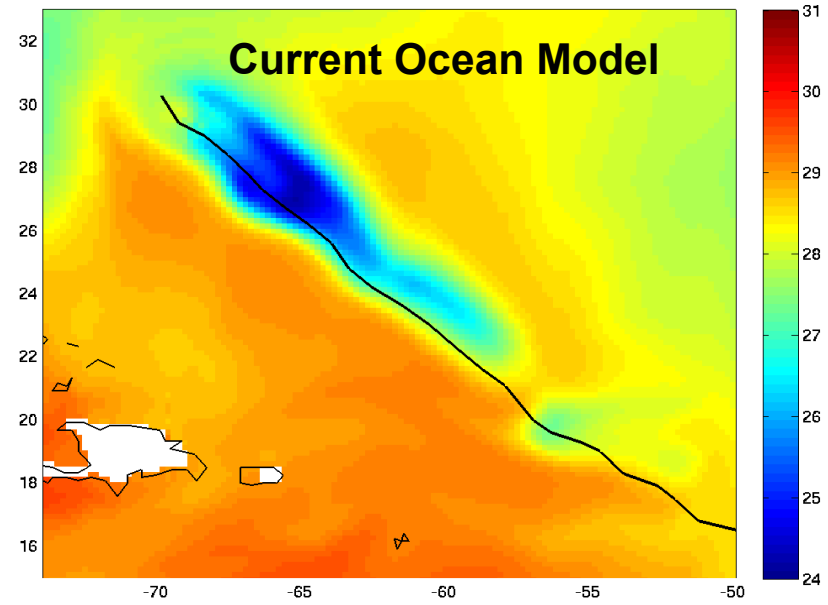
Hurricane Katia
(0000 UTC 3rd September)

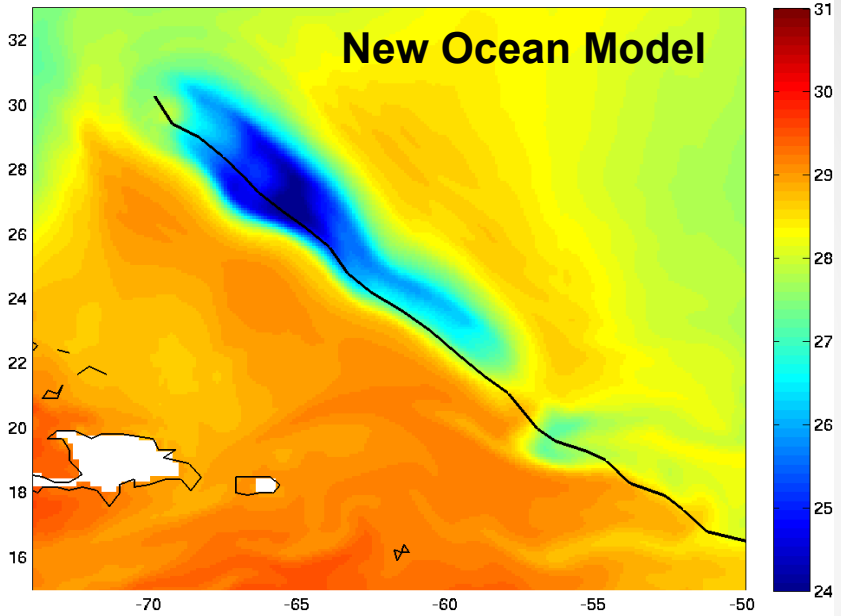


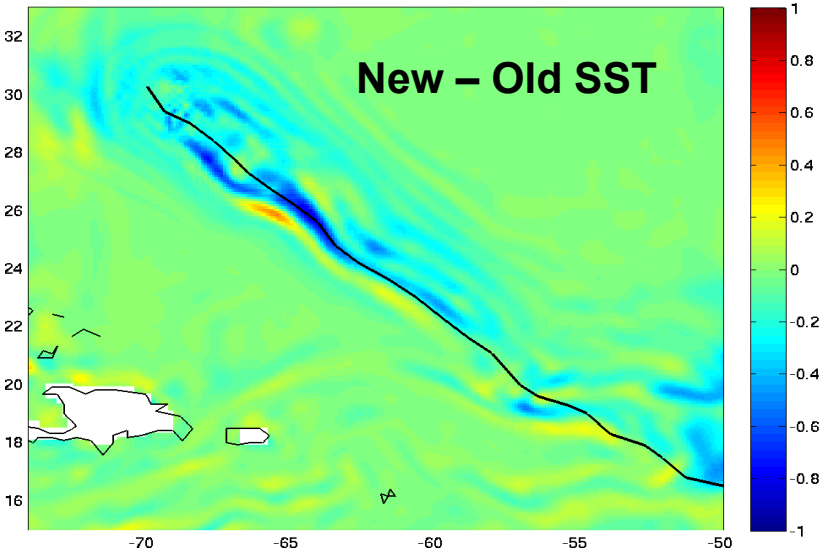
- Too Little Ocean Cooling Possibly Contributed to Excessive Intensification for these 2 Storms)

Impact of new Princeton Ocean Model on SSTs

Hurricane Katia (3rd September starting time)





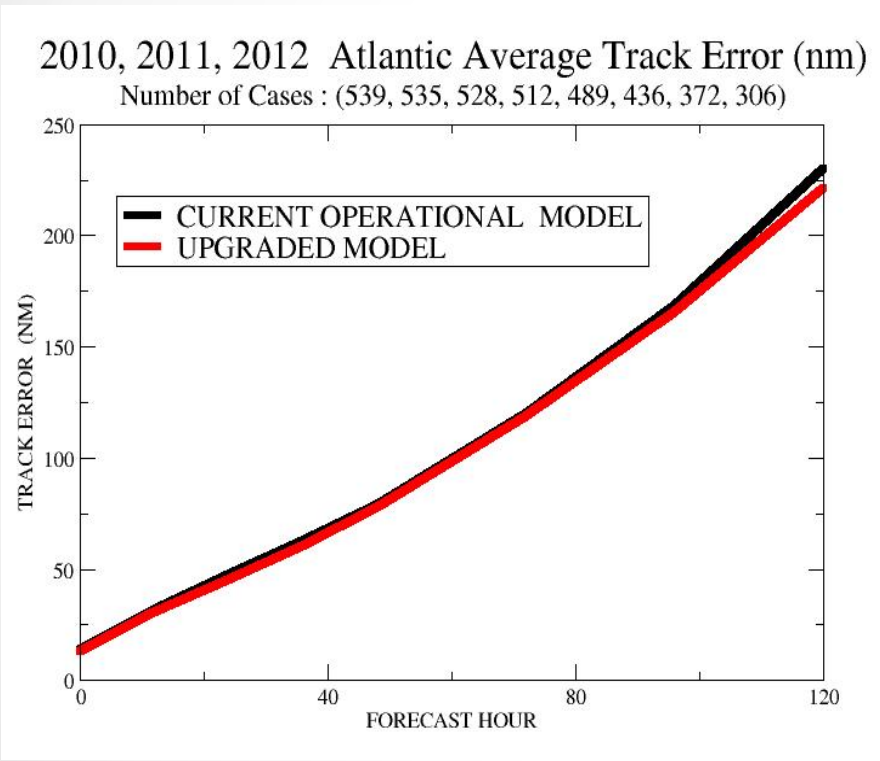


More realistic SST cold wake may significantly reduce positive bias

COMBINED 2010, 2011, AND 2012 SEASONS

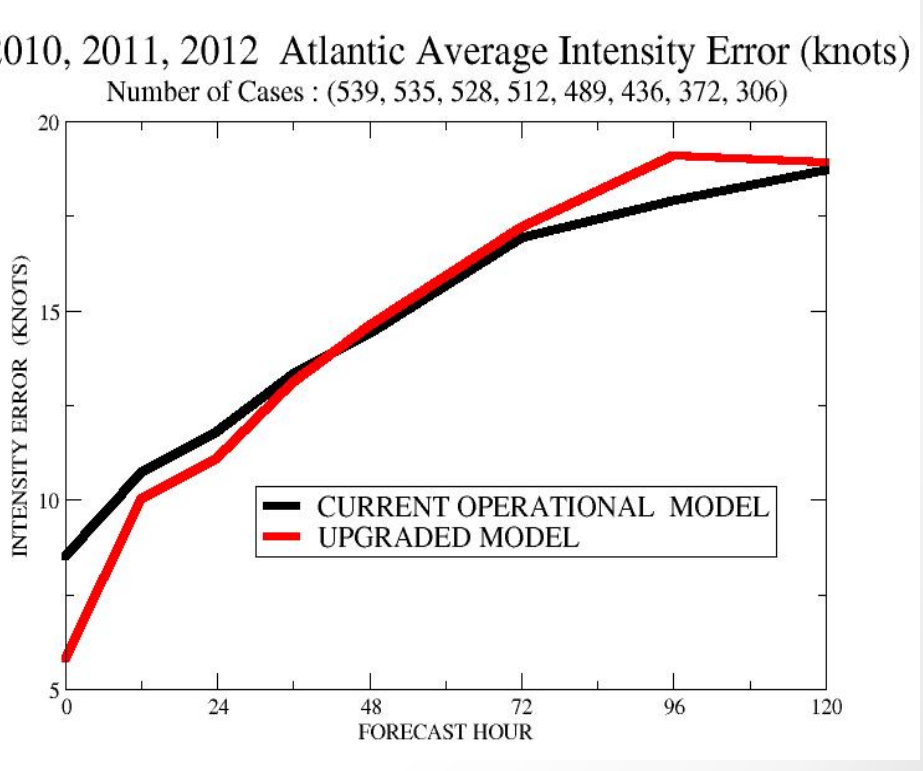
2010, 2011, 2012 Combined Seasons

Track



Small Reduction in Track Error (~4%)

Intensity



Overall Neutral Impact on Intensity Despite Large Reduction in Bias

SUMMARY

- PRELIMIARY TESTS OF GFDL/GFDN 2013 UPGRADES WERE CONDUCTED FOR 2010, 2011 AND 2012 HURRICANE SEASONS.
- THESE TESTS WILL SERVE AS BENCHMARK TO EVALUATE NEW MESO-SAS AND NEW PRINCETON OCEAN MODEL FOR FINAL UPGRADED MODEL CONFIGURATION
- NEW MODEL HAS MUCH REDUCED INTENSITY BIAS ALTHOUGH OVERALL IMPACT ON INTENSITY ERROR SO FAR WAS MOSTLY NEUTRAL EXCEPT AT EARLY FORECAST TIMES.
- PREDICTION OF INTENSE HURRICANES WAS SIGNIFICANTLY IMPROVED.
- IMPACT ON TRACK WAS SMALL (~4% REDUCTION IN TRACK ERROR)