# *2012 Upgrades to the Operational GFDL Hurricane Model*

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**HFIP PRESENTATION**

***(March 28th, 2012)***

# Summary of Final GFDL 2012 UPGRADE

**GFDL model Benchmark completed on January 1st, 2012**

**1.) Detrained Microphysics now passed from SAS to micro-physics**
**2.) Bug Fixed in current PBL scheme (from 2003 implementation)**
**3.) Bug Fixed in current SAS convective scheme (from 2010 implementation)**
**4.) Retuning of momentum mixing**

**Additional Physics**

1. **Improved formulation of Surface exchange coefficients (ch, cd)**
2. **Implementation of GFS Shallow Convection**
3. **New GFS PBL scheme evaluated and rejected for implementation**
4. **Improved PBL structure (.25 Critical Richardson number; reduced vertical mixing coefficient by 40% in storm region)**
5. **Advection of individual micro-physics species gave improved response to shear but not ready for 2012 implementation (To be run in parallel for 2013 implementation**

**Initialization**

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

- Proposed 2012 Upgraded model tested extensively on 2010 and 2011 Atlantic and East Pacific storms
- Results summarized and compared with new HWRF upgrade
- Upgraded GFDL model rerun using new GFS hybrid system to be implemented before start of hurricane season

Cases run during August 21st -October 15th test period :

**Irene, Katia, Maria, Nate Ophelia, Philippe: Atlantic**

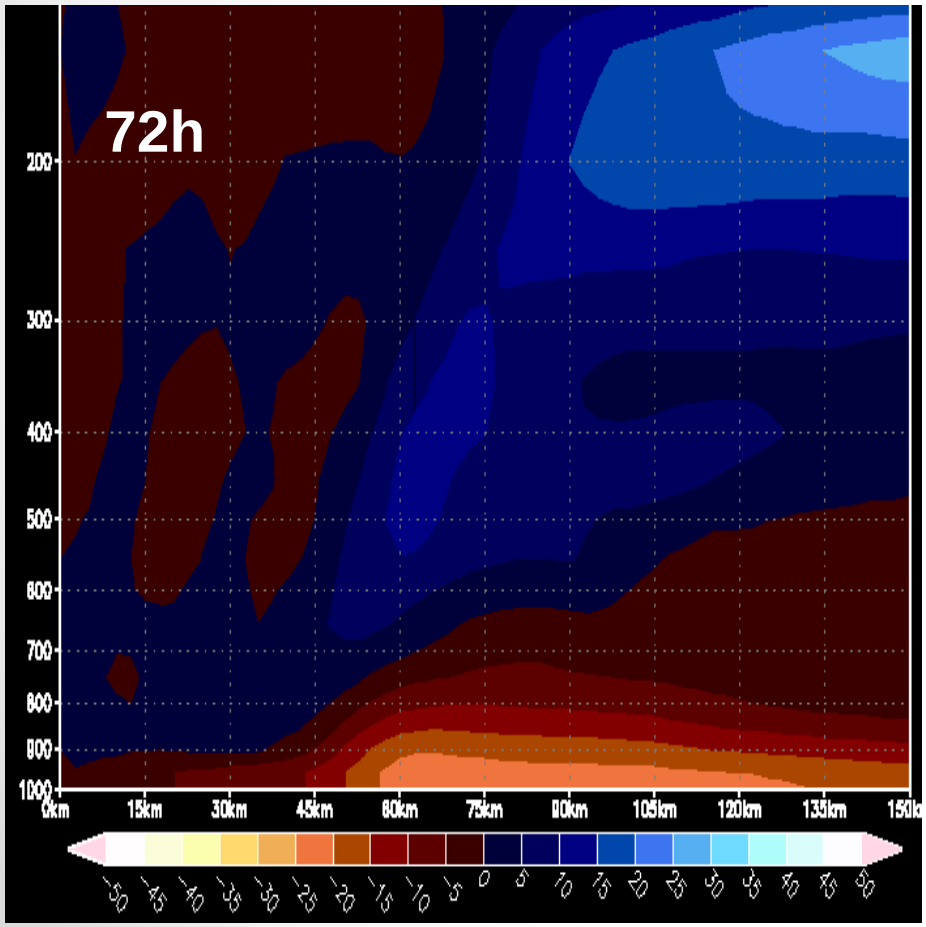
**Hillary, Irwin, and Jova : Eastern Pacific Basin**

- Outside GFS test period 2010 cases run with current GFS
- Remainder of 2011 season run with GFS hybrid bug

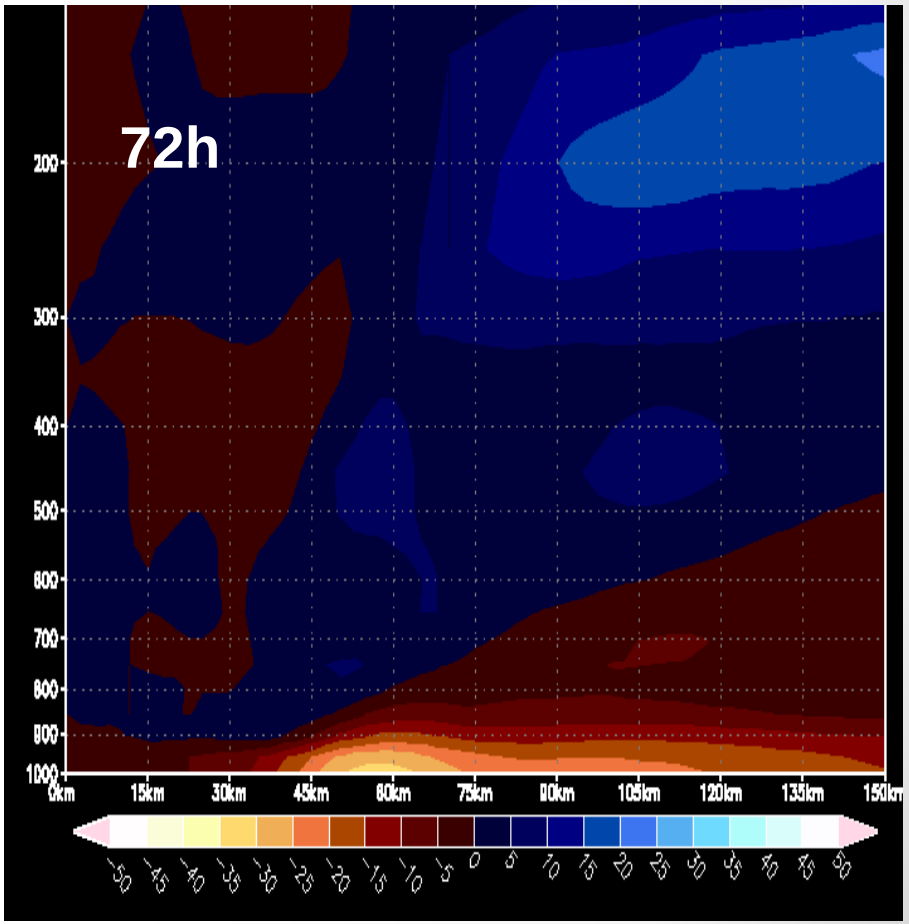
# Example of Improved Boundary Layer Structure

## Hurricane Katia (*0000 UTC 3 September, 2010*)

**CURRENT MODEL**




**UPGRADED MODEL**

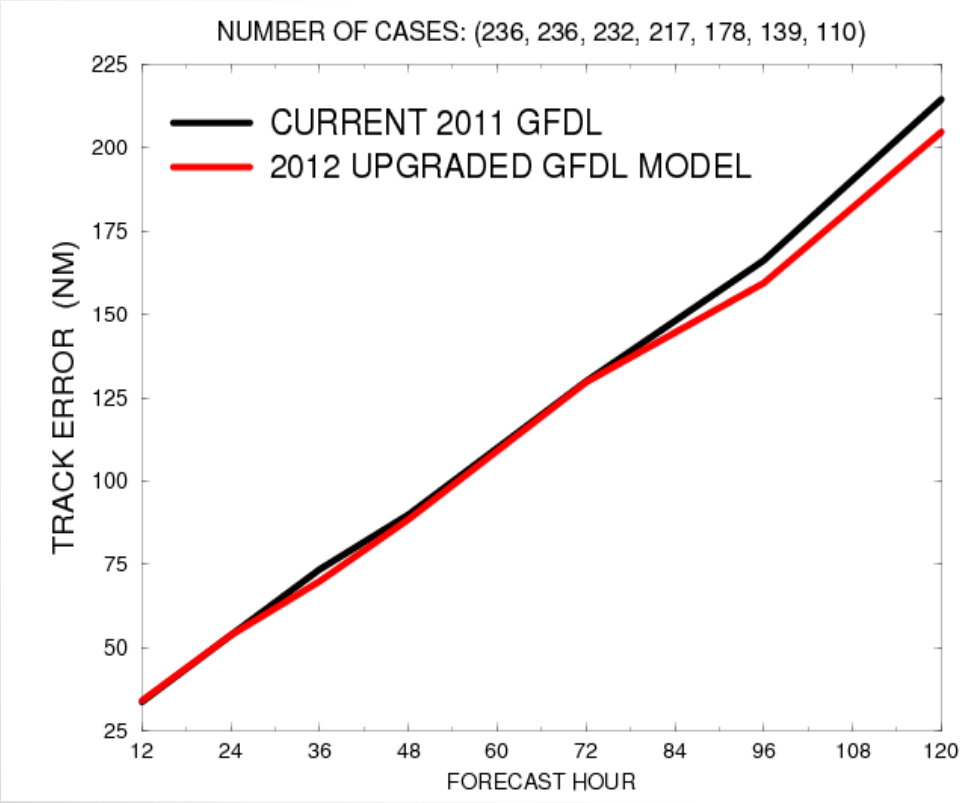



**CIRCULARLY AVERAGED RADIAL WIND**

# IMPACT ON TRACK PREDICTION

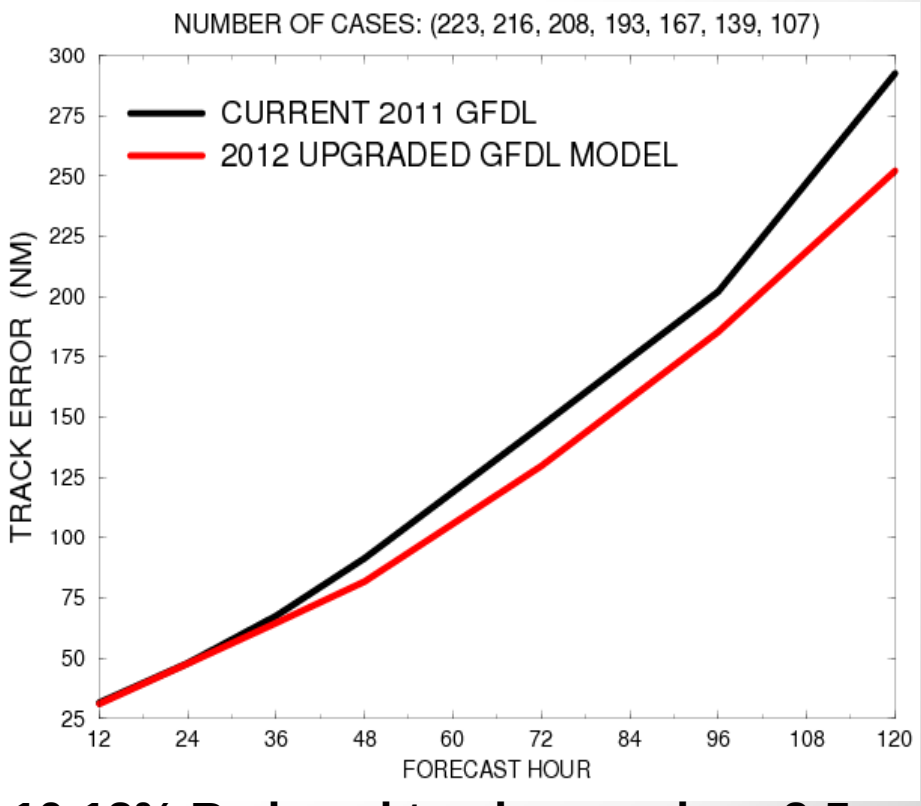
# Atlantic Average Track Error

## 2010 SEASON



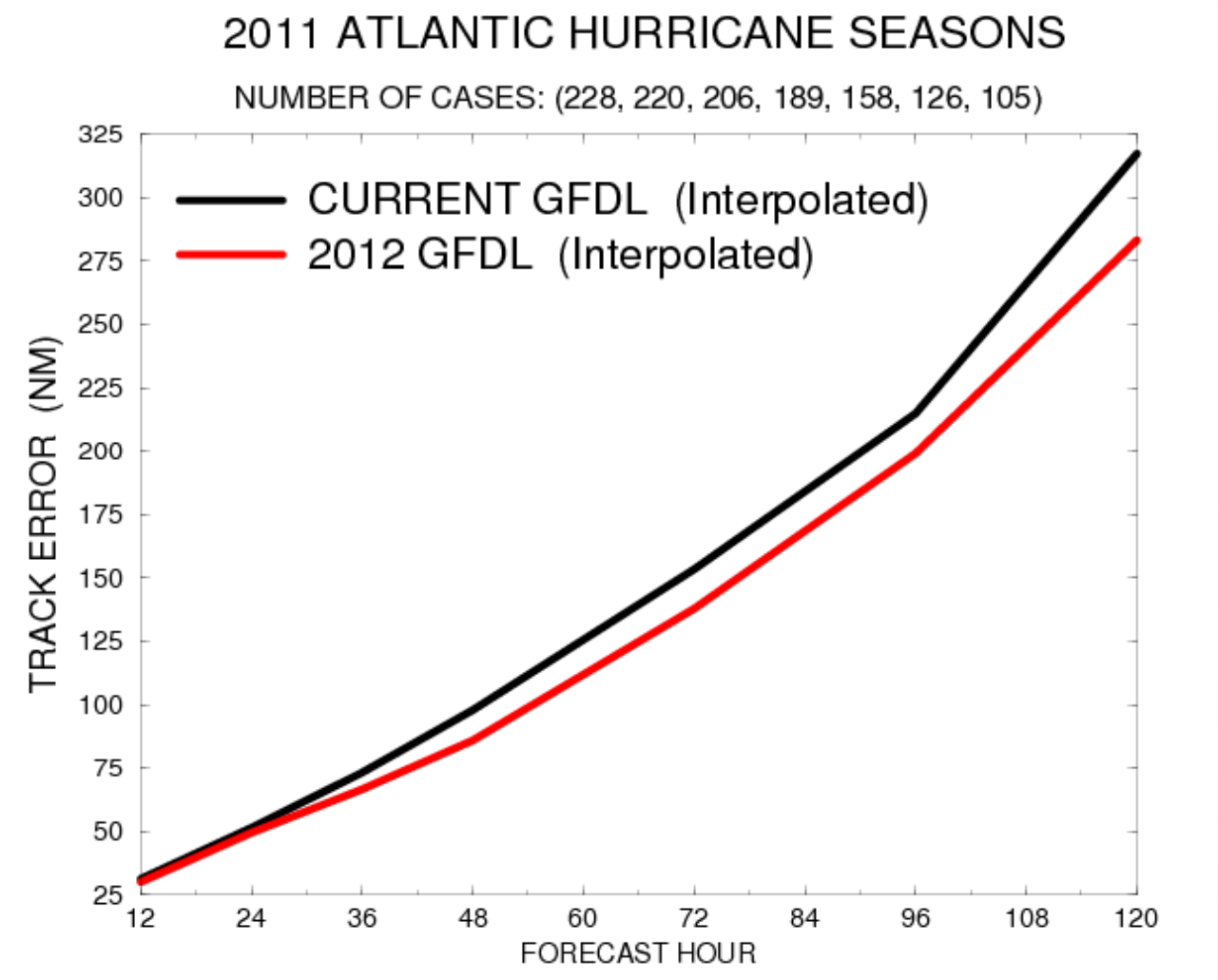

**5% Reduced track error days 4-5**

## 2011 SEASON




**10-12% Reduced track error days 3-5**

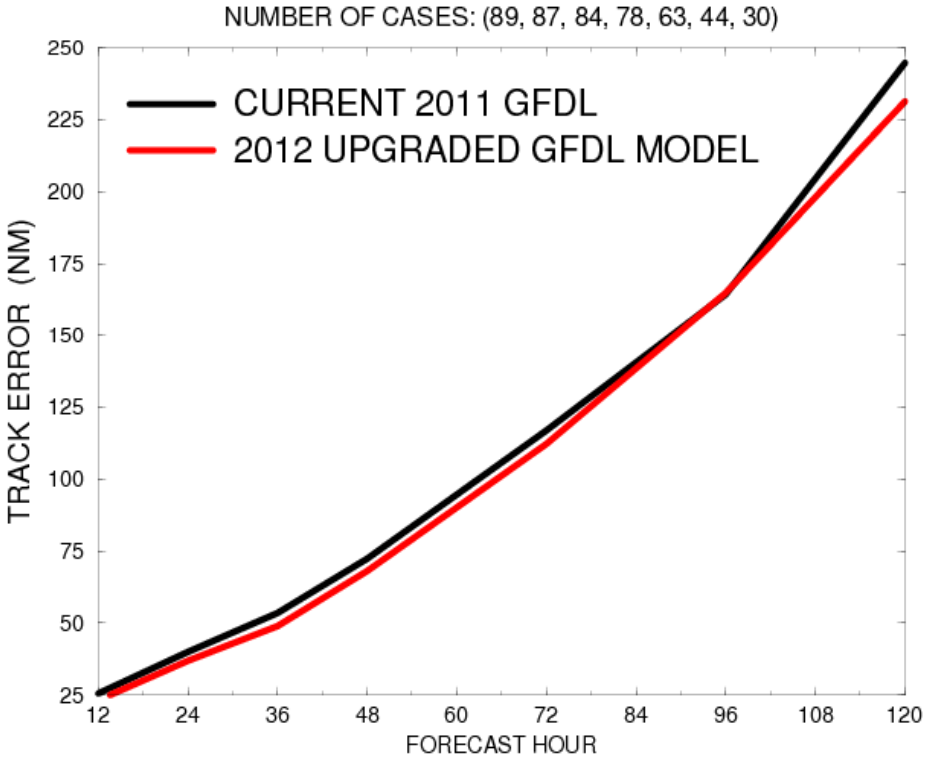
# Similar Improvement retained for Interpolated Model Track Forecast



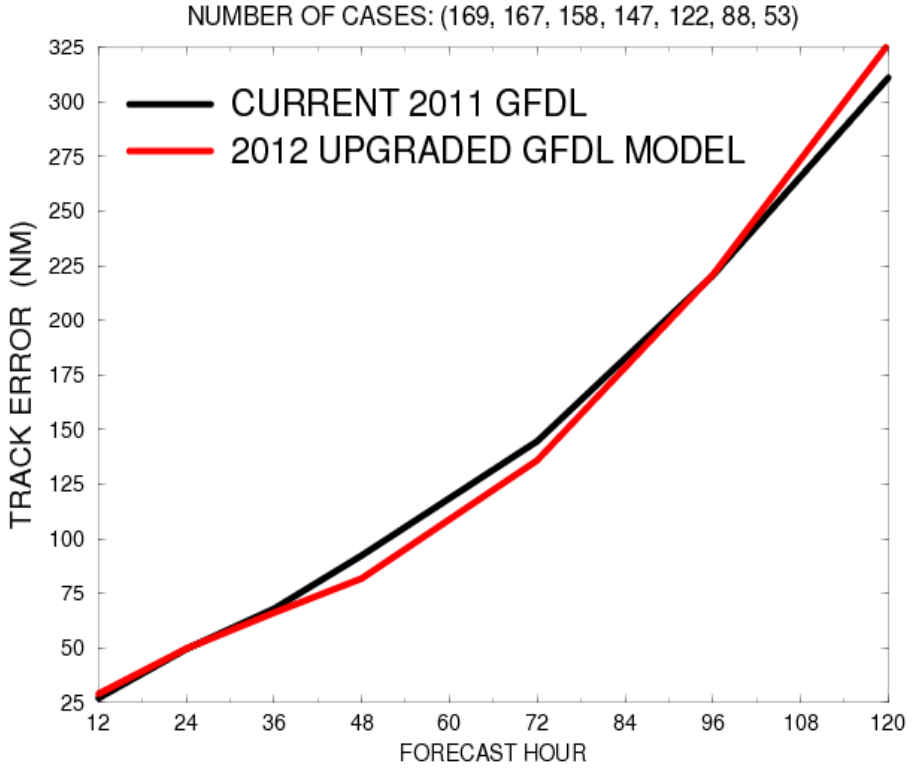

**12% Reduced track error days 2-5**

# Eastern Pacific Average Track Error

## 2010 SEASON



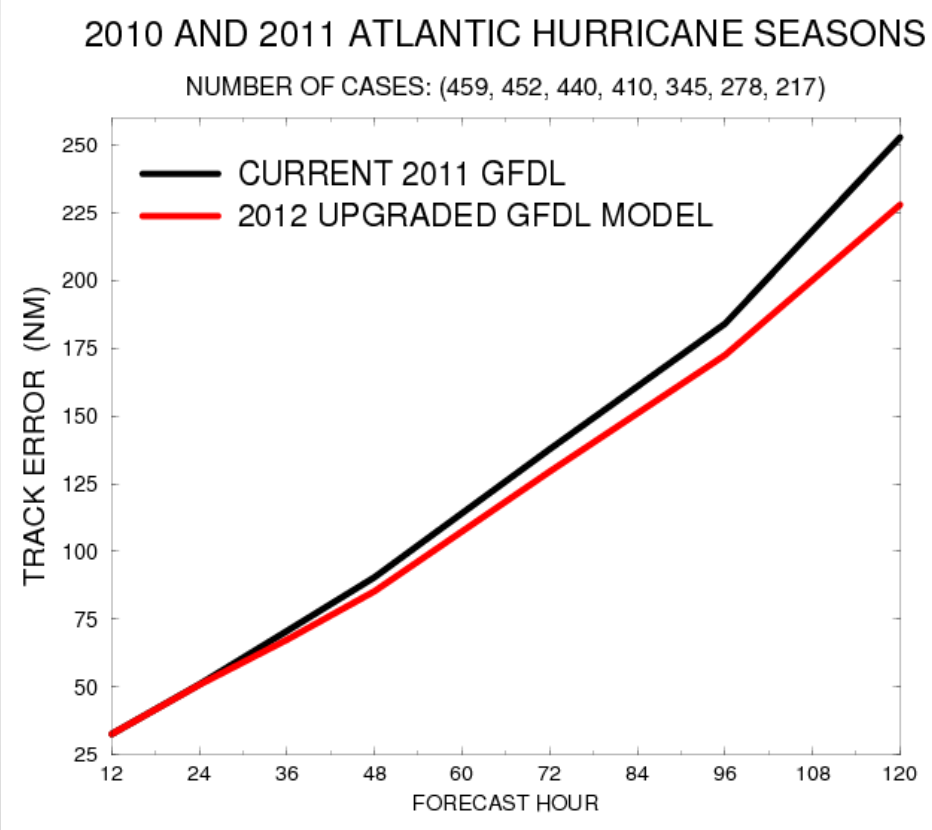

## 2011 SEASON




**Mostly Neutral Impact on track for both seasons**

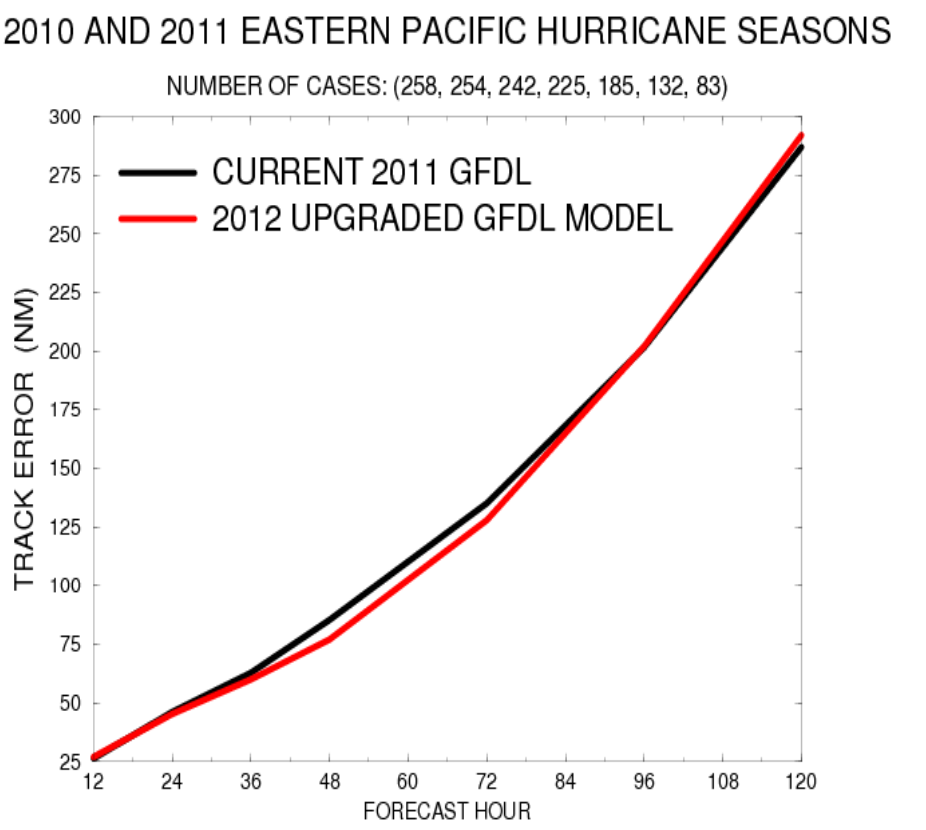
# 2010 and 2011 Combined Track Error

## Atlantic Basin



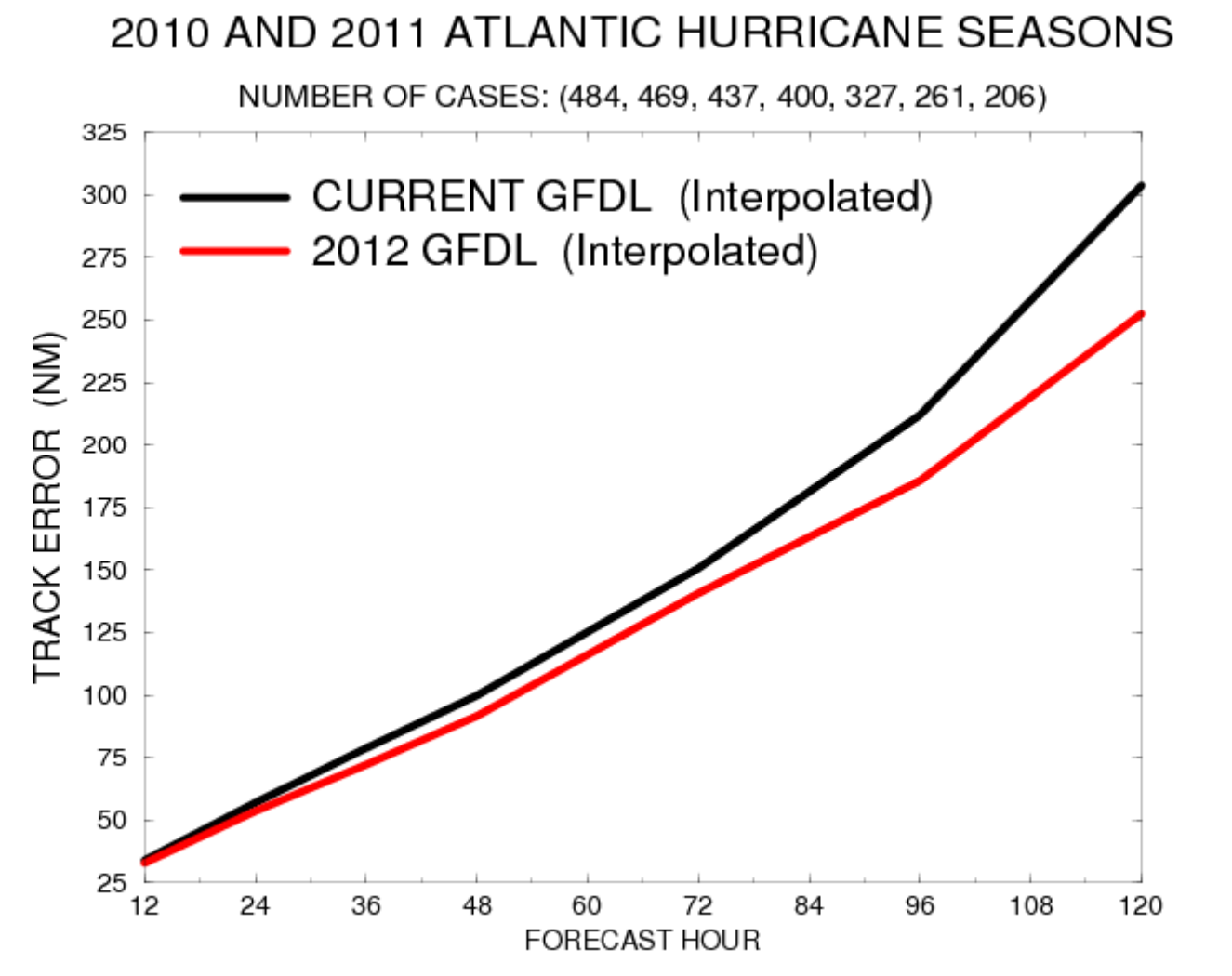

**8% Reduced Error 3-5 days**

## Eastern Pacific Basin

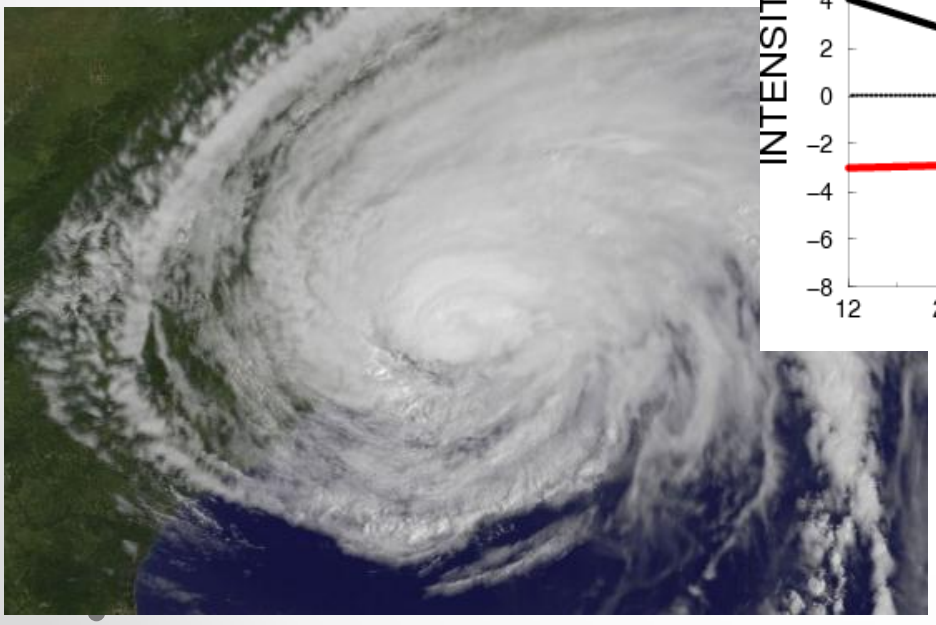


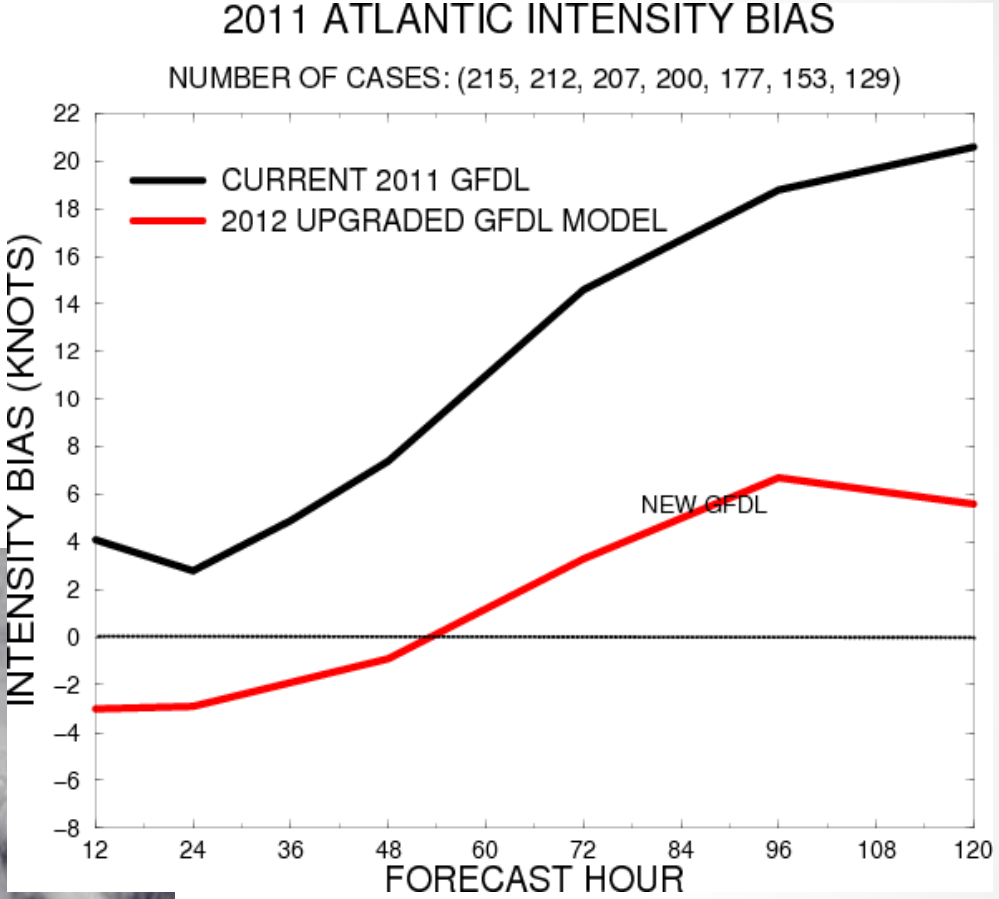

**Mostly neutral impact but improved cross track error**

# Combined Interpolated Model Track Forecast



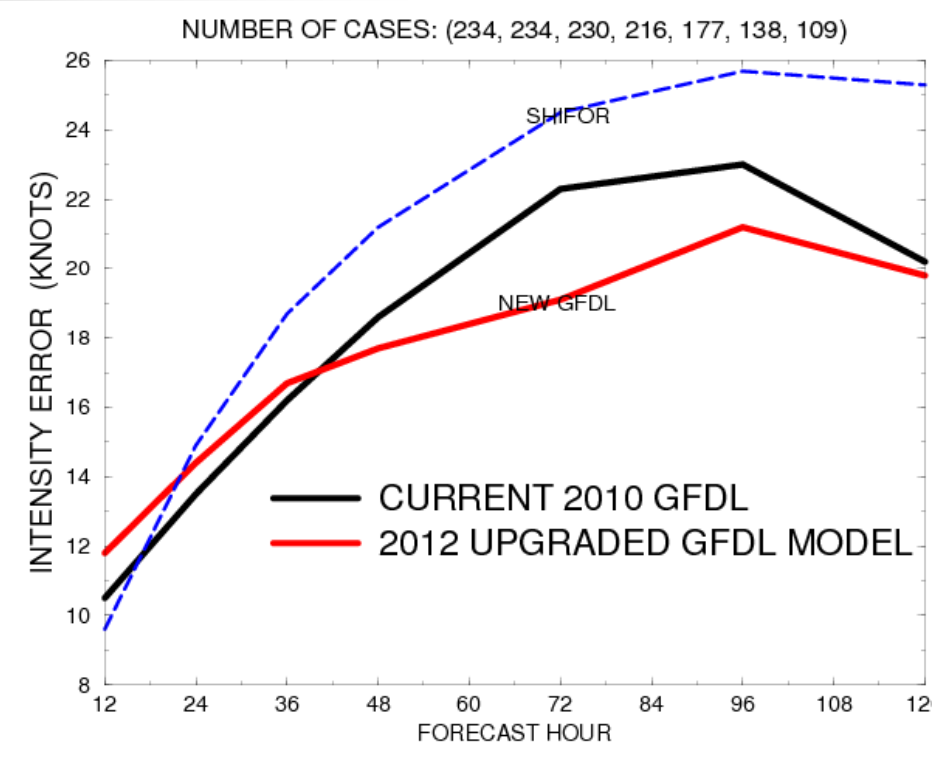
# IMPACT ON INTENSITY PREDICTION



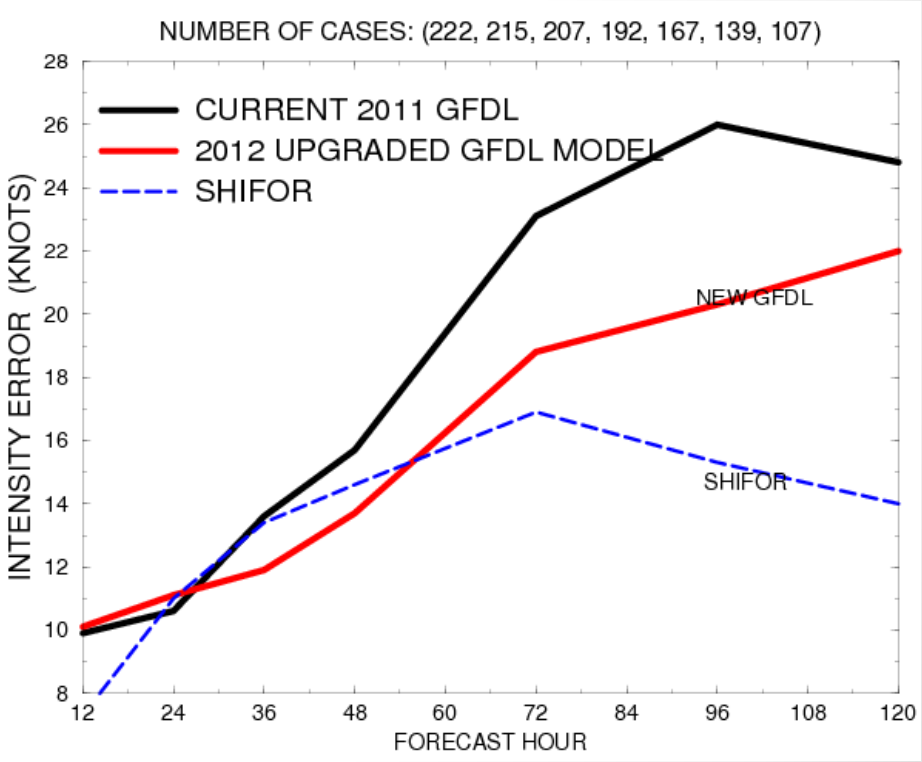


# Atlantic Average Intensity Error

## 2010 ATLANTIC SEASON



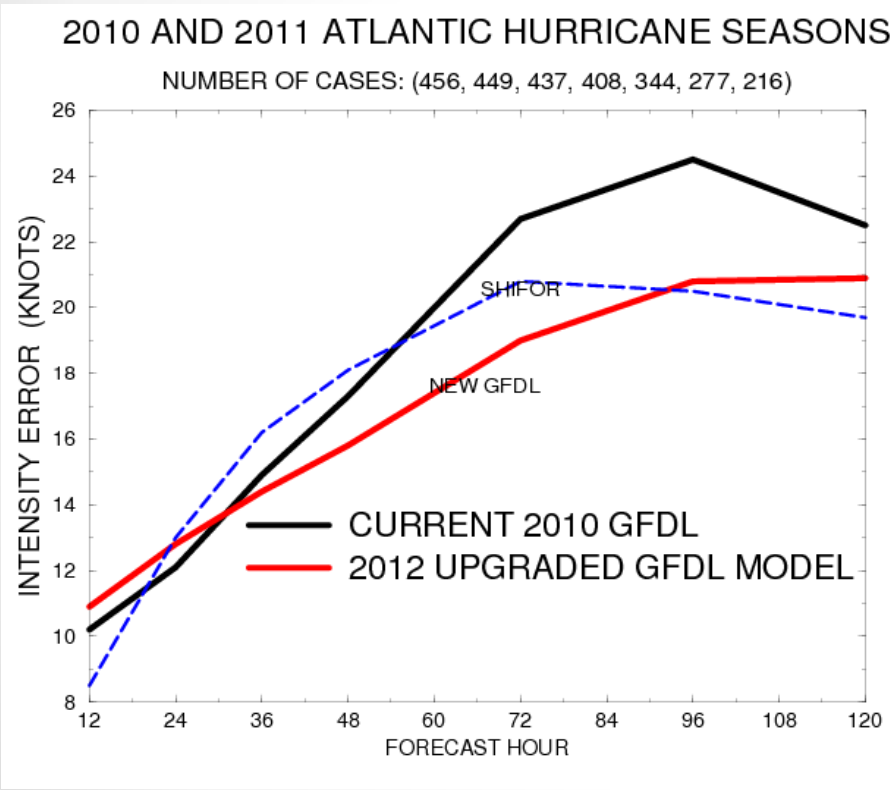

## 2011 ATLANTIC SEASON




**15-20% Reduction in error for days 2-5**

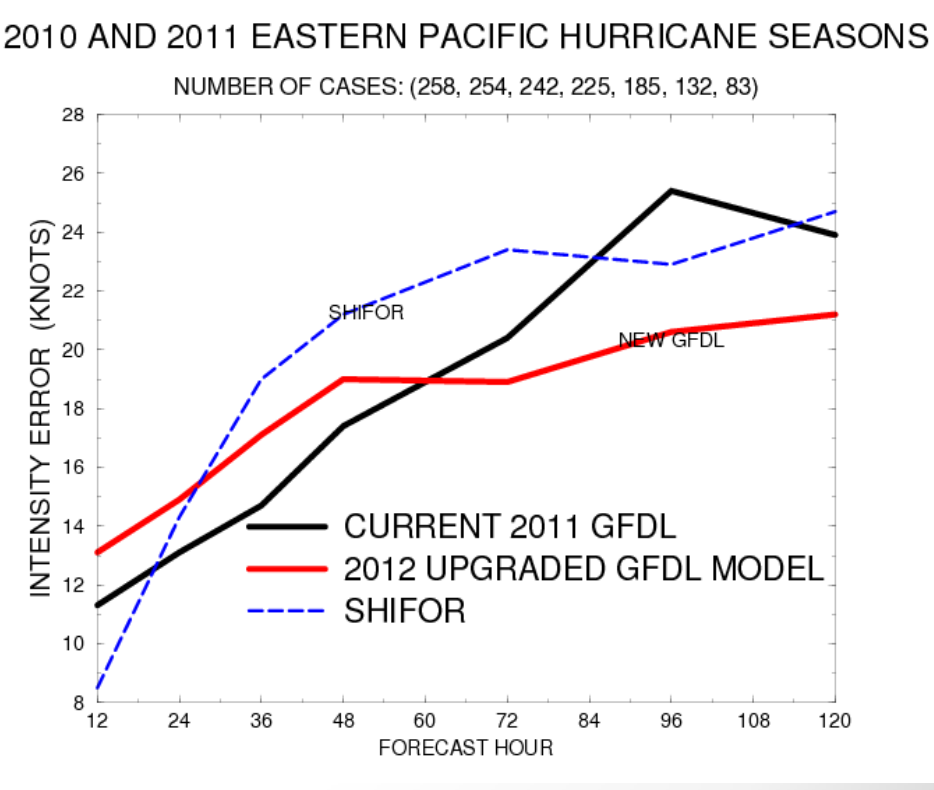
# 2010 and 2011 Combined Intensity Error

## Atlantic Basin




**10-15% reduction in error for days 2 through 5**

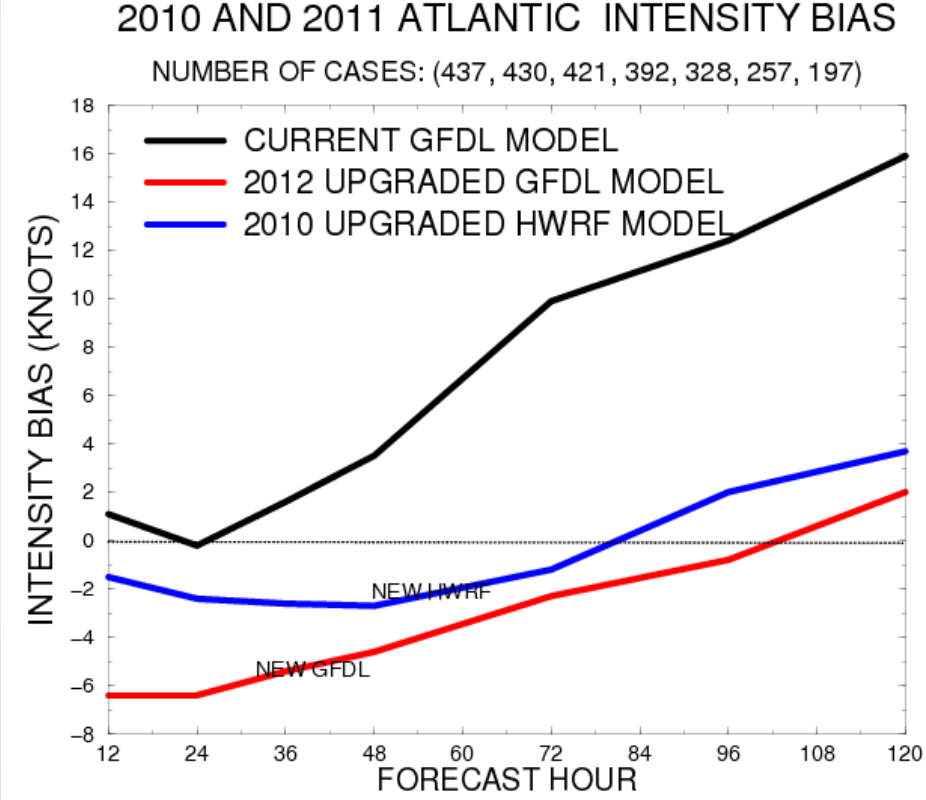
## Eastern Pacific Basin



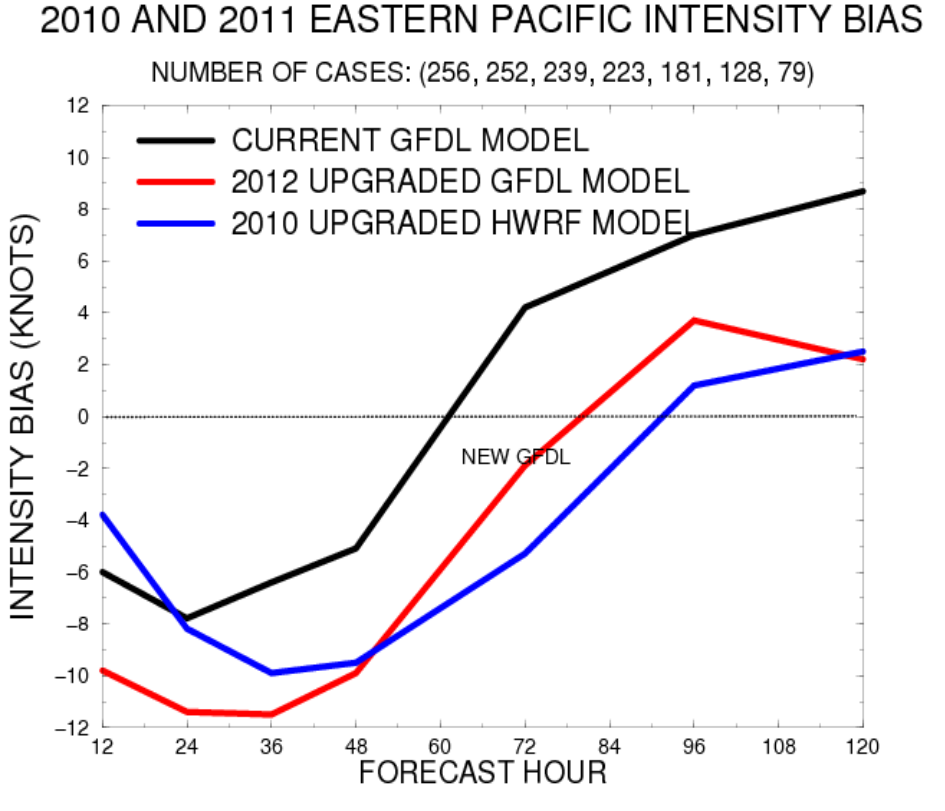

**Some degradation at early time periods, improved 3-5 days**

# 2010 and 2011 Combined Intensity Bias

## Atlantic Basin




## Eastern Basin




**GFDL: Increased negative bias days 1-2- much reduced positive bias days 3-5**

**Bias suggest new HWRF produces slightly stronger Atlantic storms**

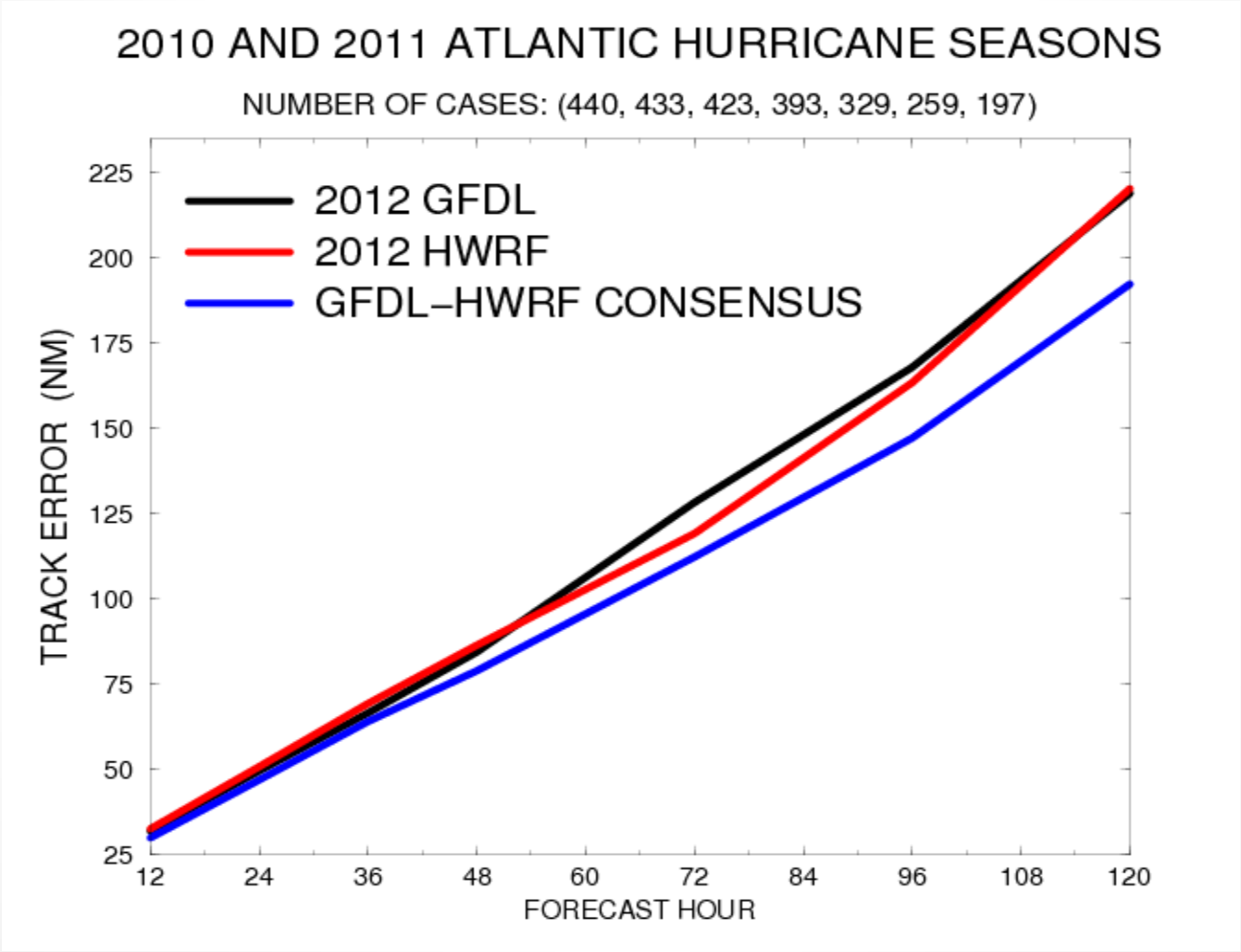
# GFDL/HWRF FORECAST COMPARISON

**Individual track comparison for Atlantic storms can be viewed at**

**ftp://ftp.gfdl.noaa.gov/pub/mb/newmodel/**

# CONSENSUS OF GFDL/HWRF GIVES SIGNIFICANTLY SUPERIOR

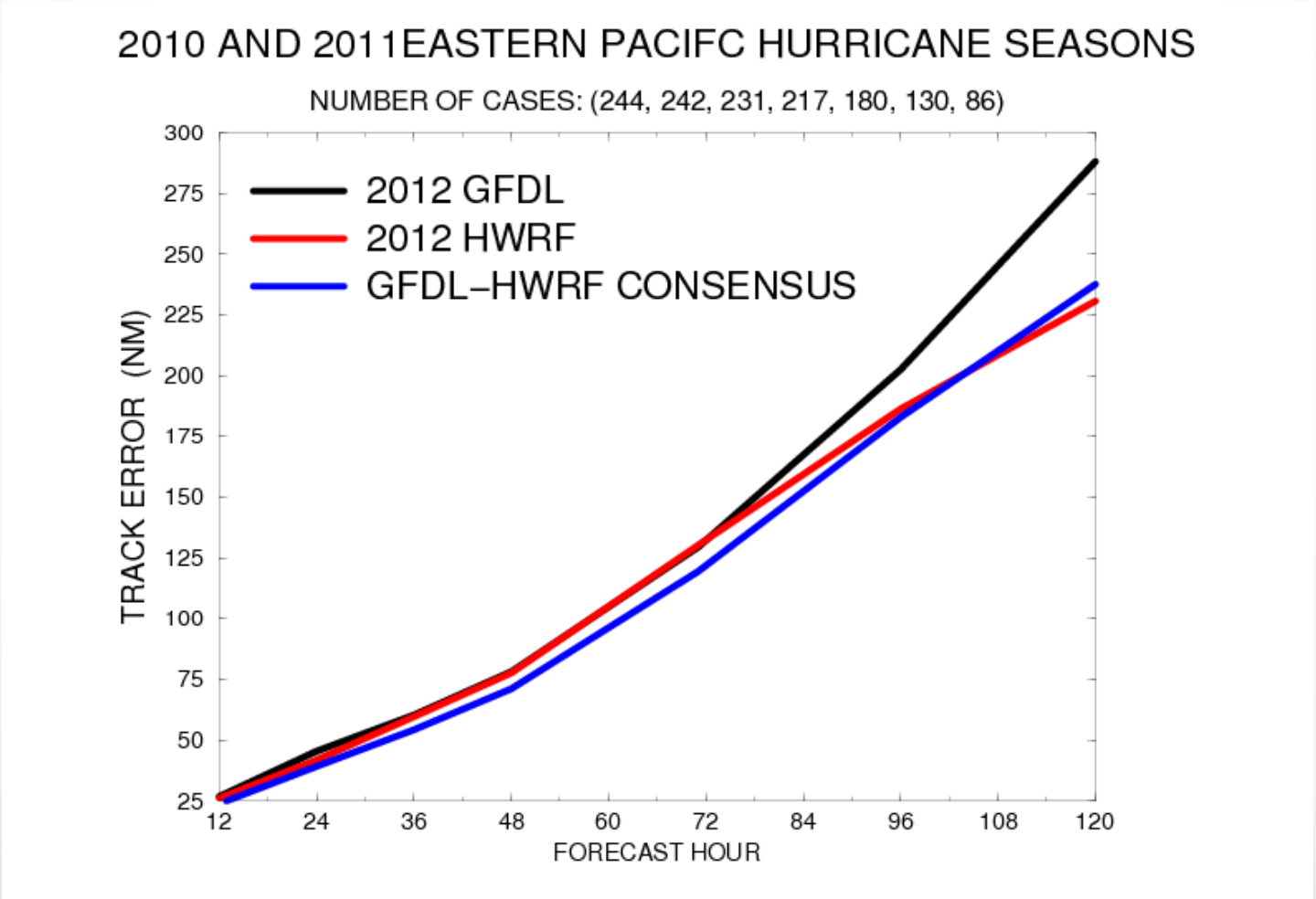
# TRACKS COMPARED TO EITHER INDIVIDUAL MODEL




**OVERALL COMPARABLE MODEL PERFORMANCE FOR ATLANTIC TRACKS**

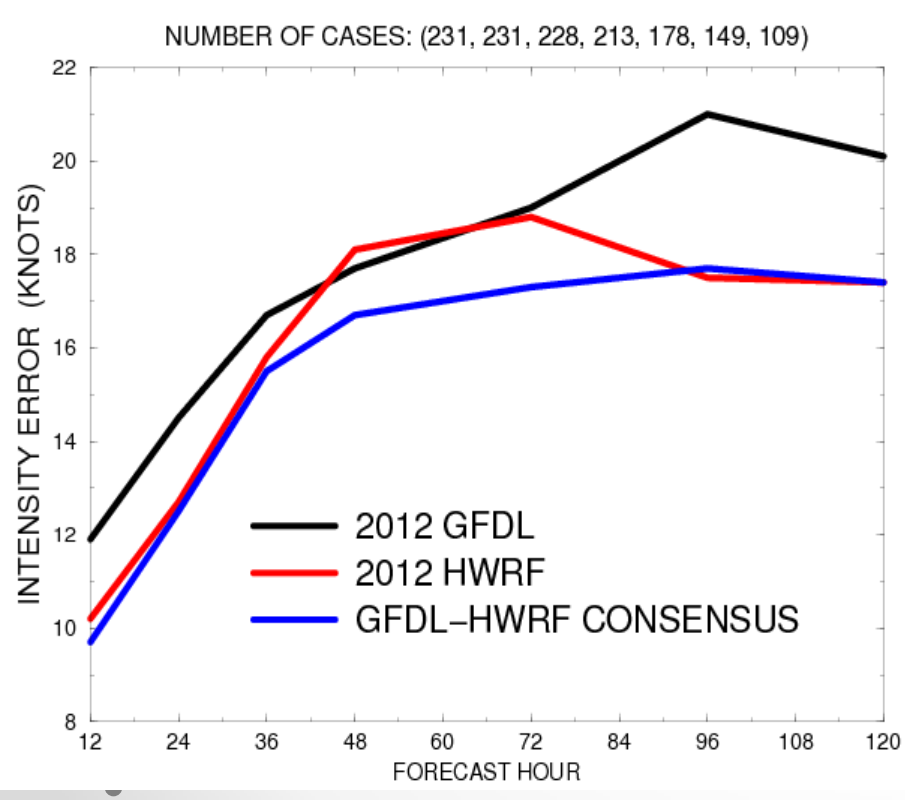
# In Eastern Pacific:

# Upgraded HWRF Performed Significantly better at 4-5 days but comparable to GFDL at days 1-3

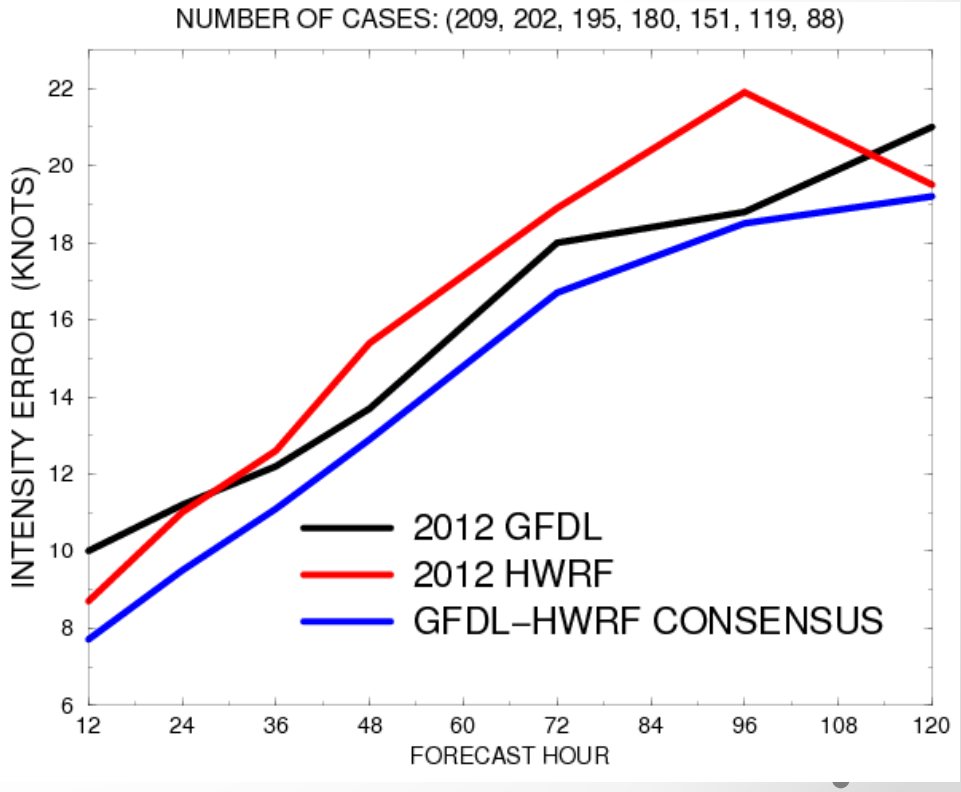


# IMPROVEMENT IN INTENSITY PREDICTION WITH GFDL/HWRF MODEL CONSENSUS

## 2010 Atlantic Season

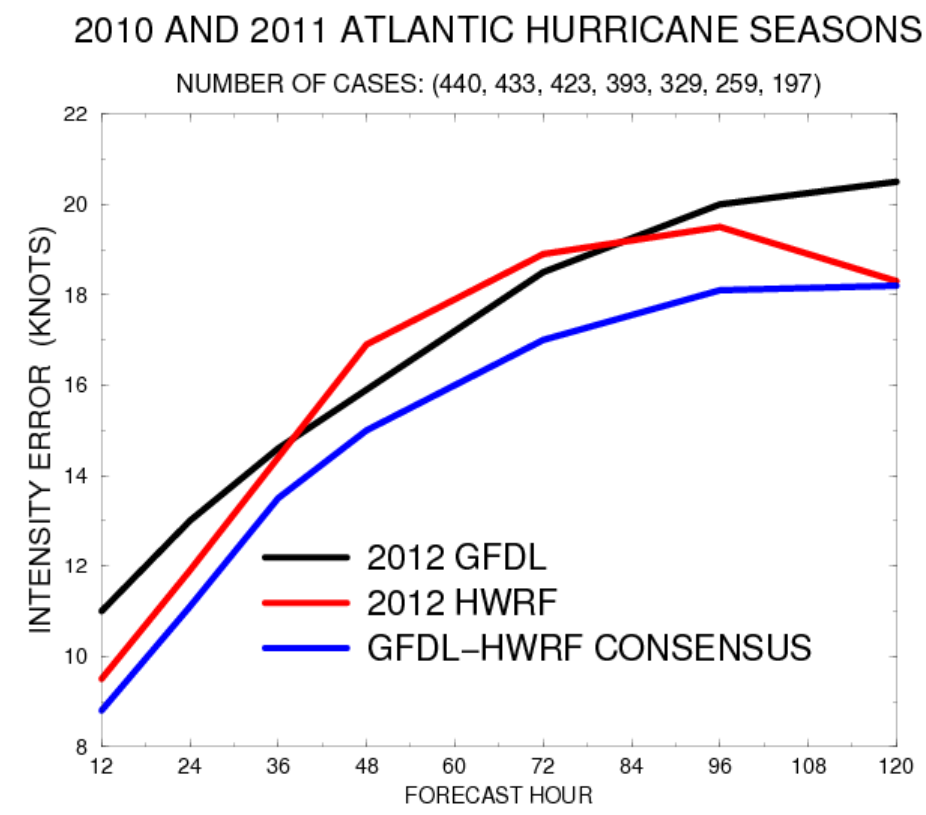



## 2011 Atlantic Season

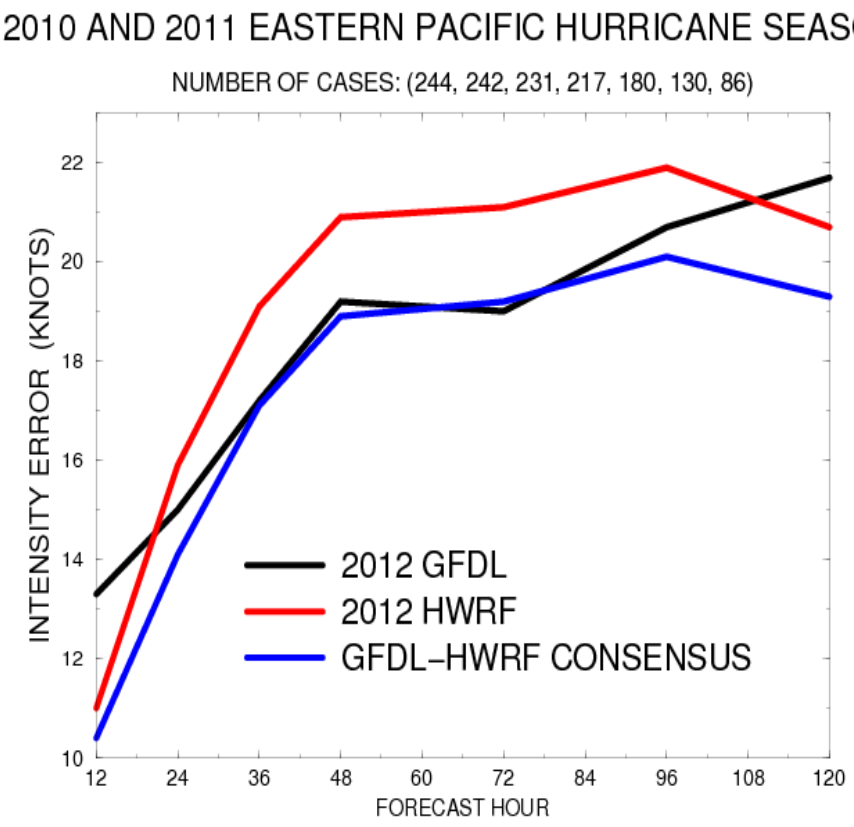


# 2010 AND 2011 COMBINED SEASONS

## ATLANTIC BASIN



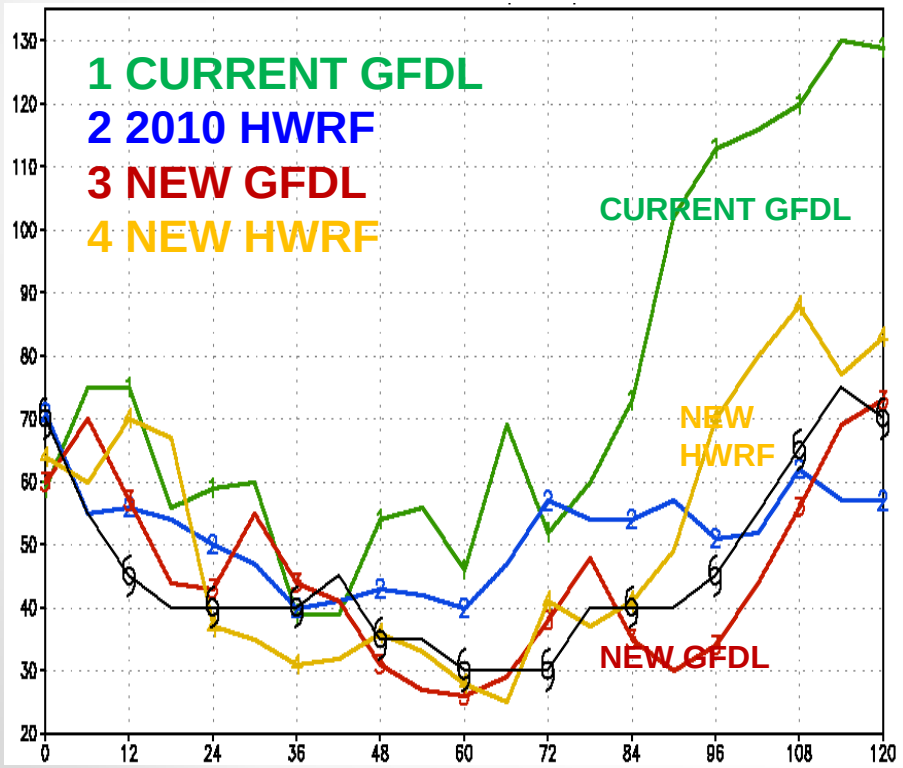

## EASTERN PACIFIC BASIN



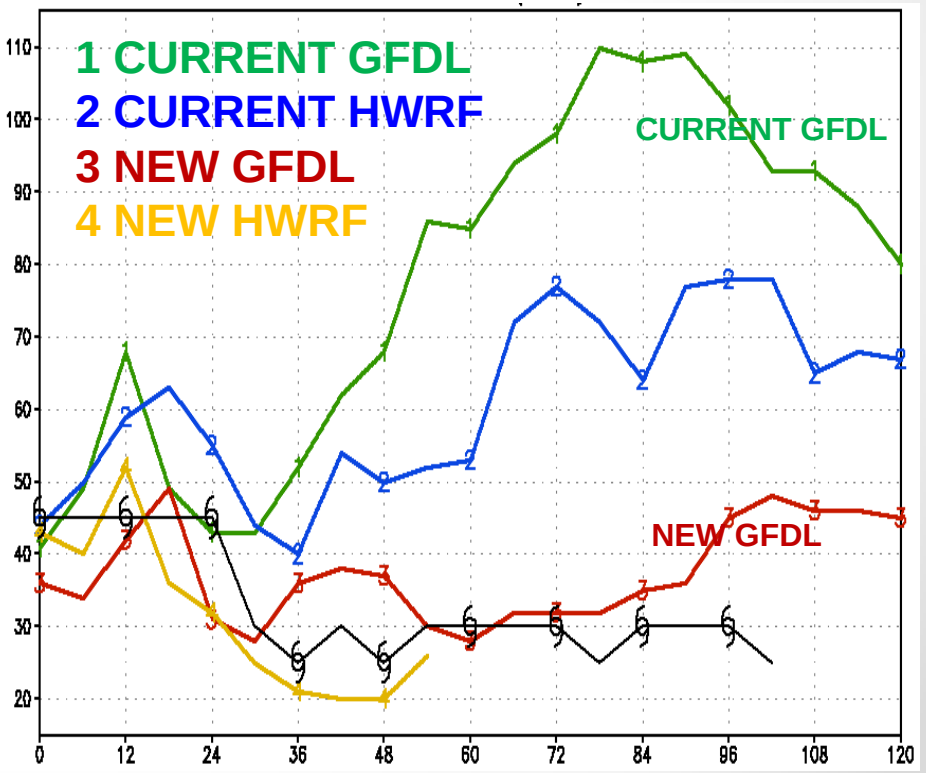

**GFDL GAVE SLIGHTLY BETTER INTENSITY GUIDANCE (except day 5)**

# Much Improved Intensity Prediction for sheared and non-developing systems for both upgraded models

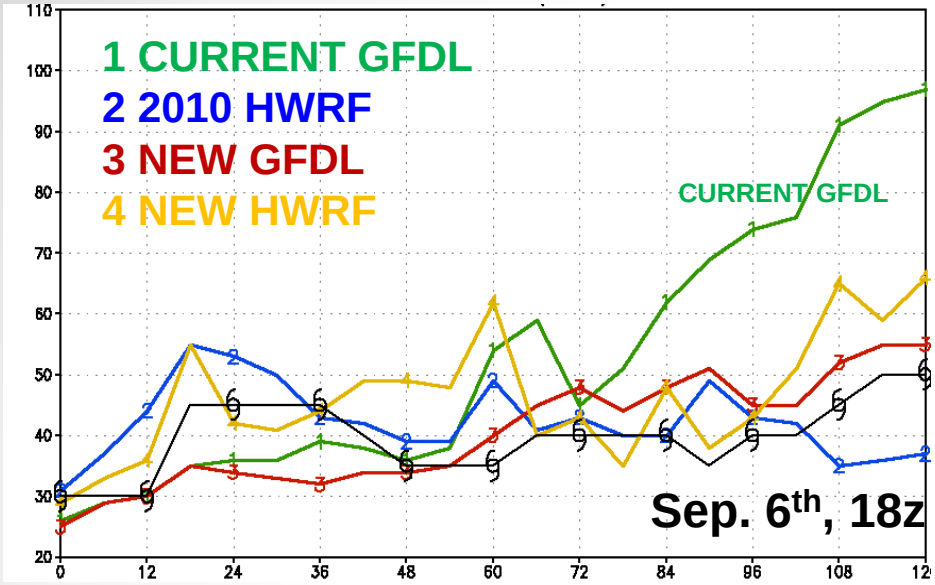
**HURRICANE TOMAS**
**(October 31st, 18z)**

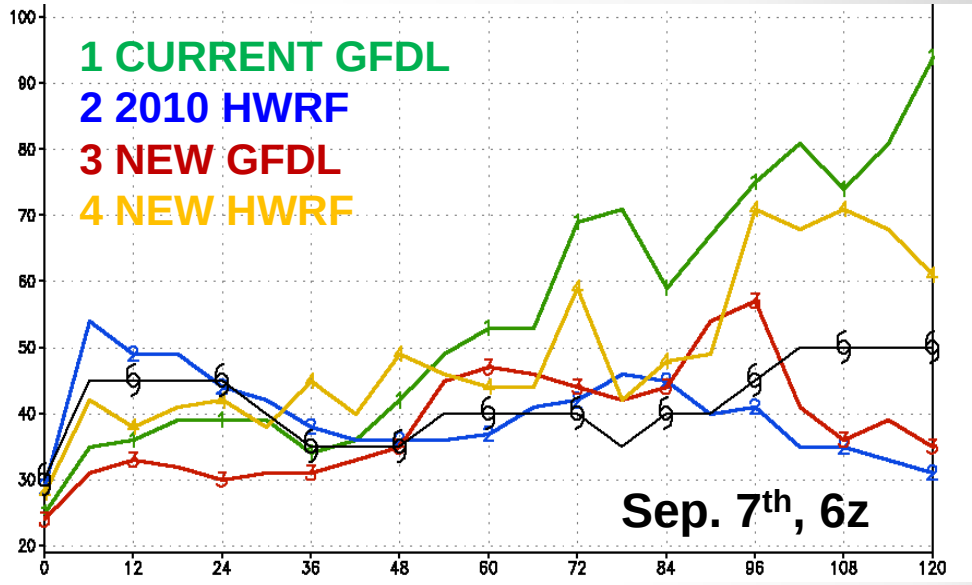


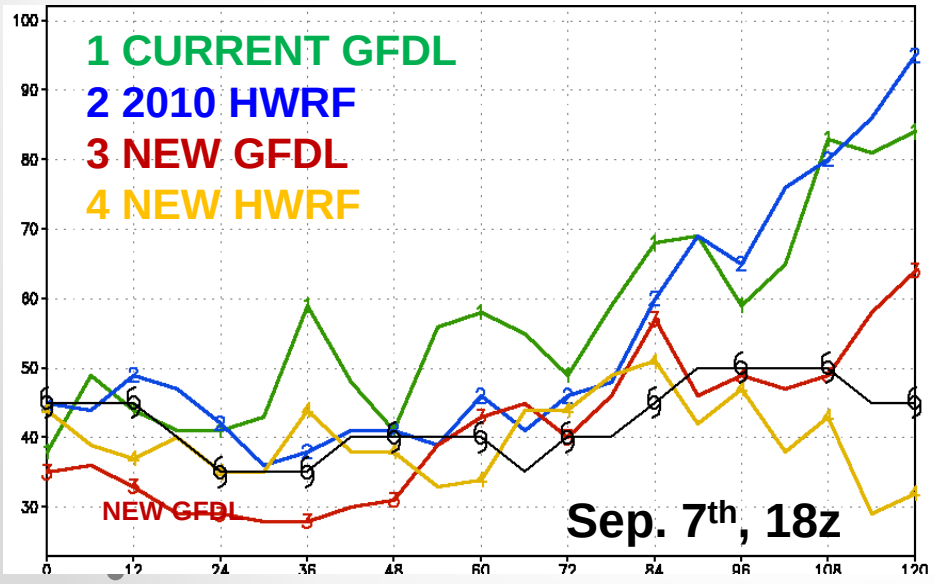

**HURRICANE EMILY**
**(August 3rd, 12z)**

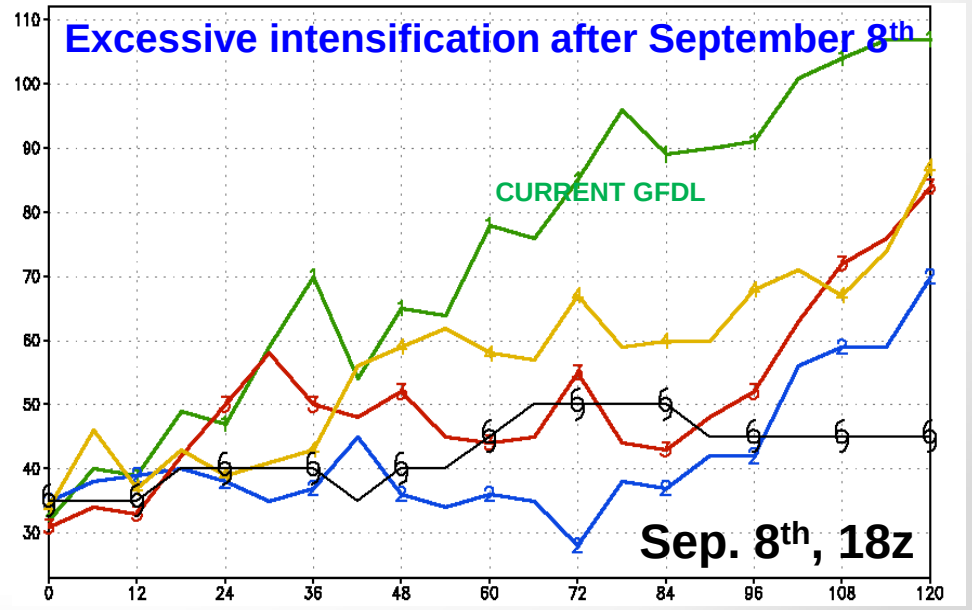


# Early Part of Maria much improved



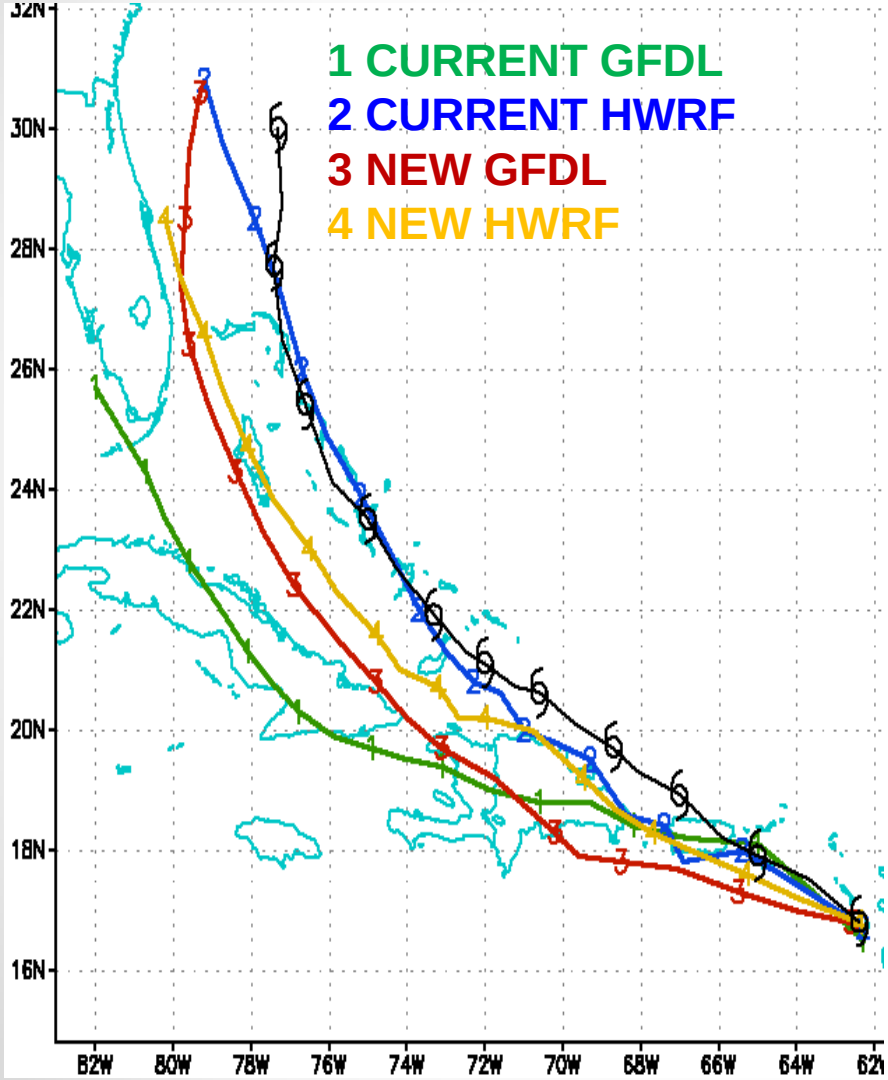



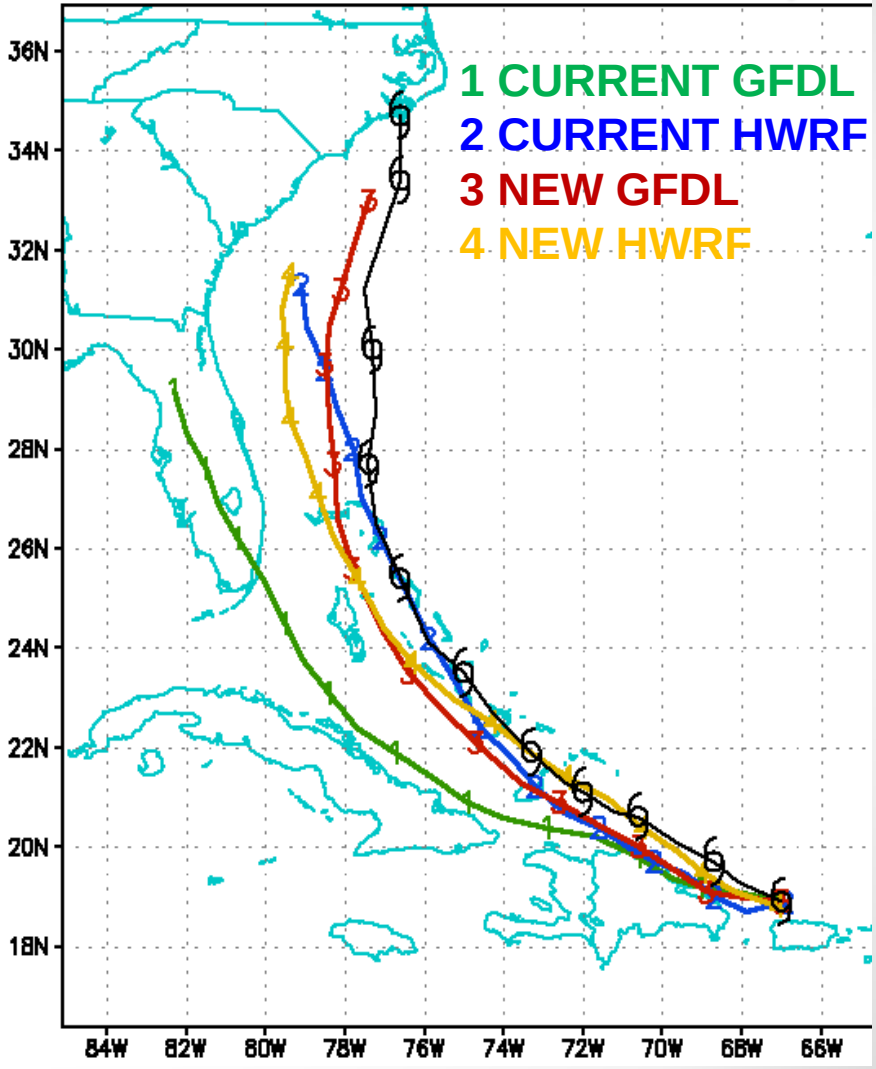



# Hurricane Irene

## (Impact quite different between the two models)



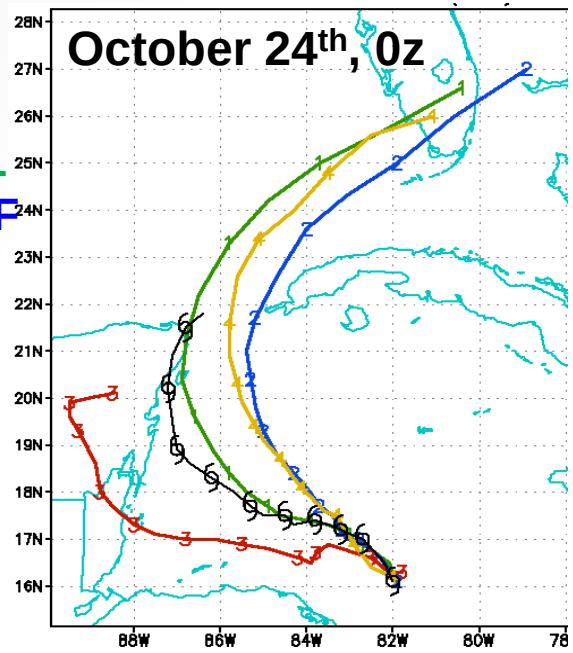

- August 21ST, 12Z

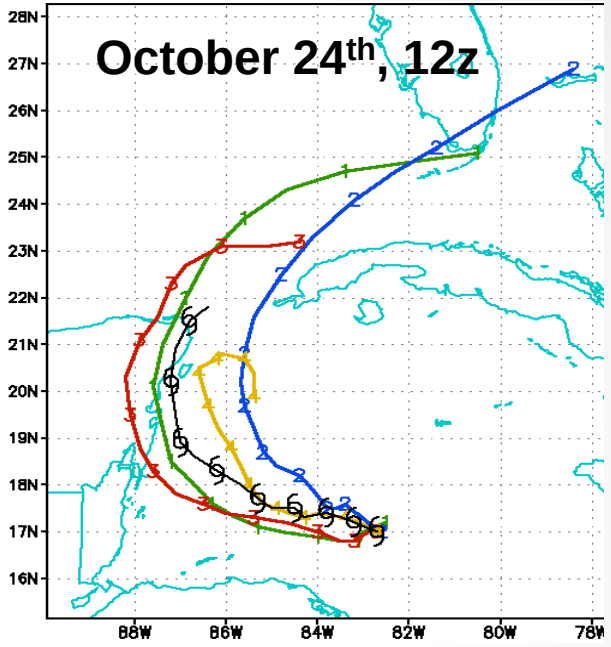


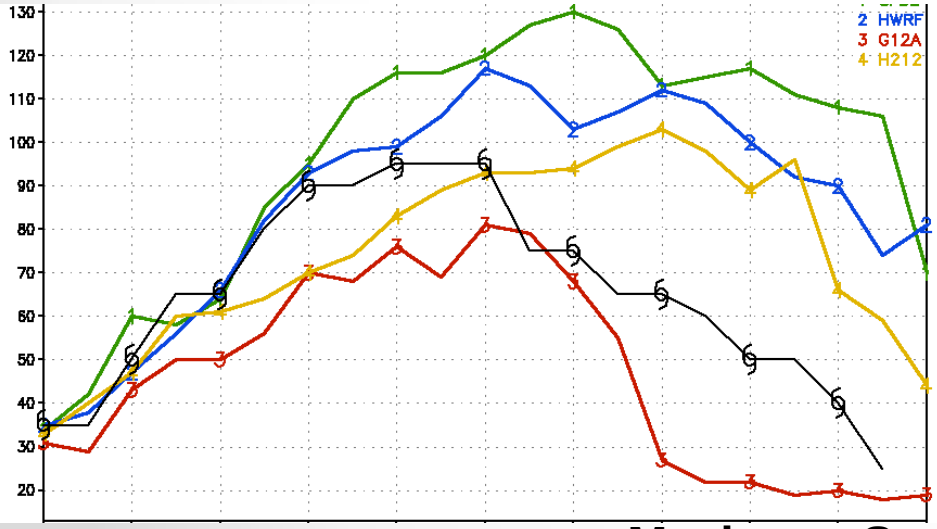

- August 22ND, 12Z

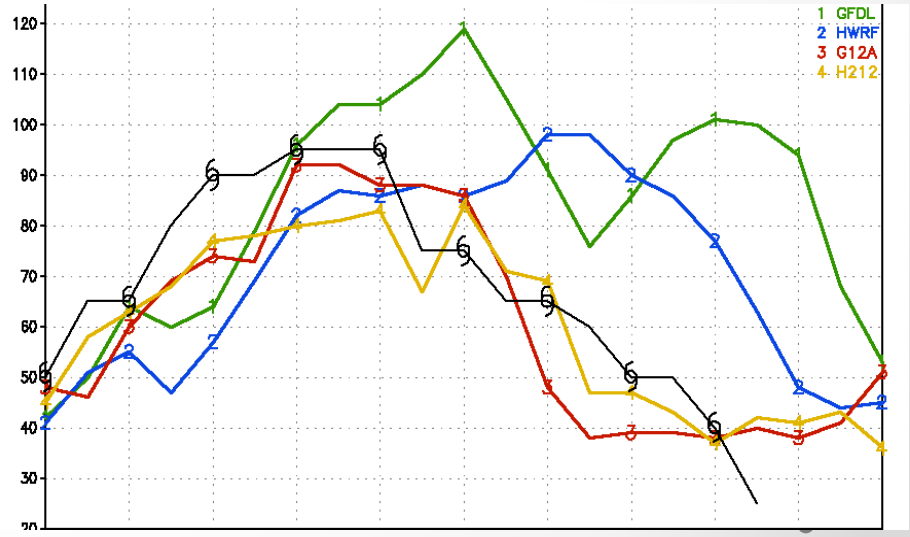
# Hurricane Rina (major track/intensity impact)

1 CURRENT GFDL
2 CURRENT HWRF
3 NEW GFDL
4 NEW HWRF




Maximum Surface Winds (knots)

# POSSIBLE FUTURE GFDL UPGRADES

- **Increase inner-nest resolution (1/12$^{th}$ to 1/18$^{th}$ degree).**

  **Address possible negative bias introduced with more realistic physics**

- **Full Coupling with Wave Model and incorporation of sea-spray effects.**

**(may be critical for improved intensity prediction)**

- **Improved Radiation Package**

**(possible reason regional model track skill now lagging behind global models !! )**

# NHC RECOMMENDATION FOR IMPLEMENTATION:

The National Hurricane Center endorses the upgrades to the GFDL Hurricane Model proposed for the 2012 hurricane season. Two bugs in the model code have been corrected and improvements to the model physics, including modification of the interaction between the parametrized deep convection and the microphysics along with several changes to the planetary boundary layer formulation, have been accomplished. Reruns of the model on a large number of tropical cyclone cases from the 2010 and 2011 Atlantic and east Pacific hurricane seasons show improvements to track and intensity forecasts in most cases. A significant high bias in the model forecasts of intensity beyond 48 hours has been removed in the modified model.

Based on these results, we recommend implementation of this new version of the GFDL model for the 2012 season.

*Richard Pasch – Senior NHC Forecaster*