HURRICANE MODELING AND FORECASTING AT GFDL

Presented by

Timothy Marchok
On behalf of the GFDL hurricane modeling team

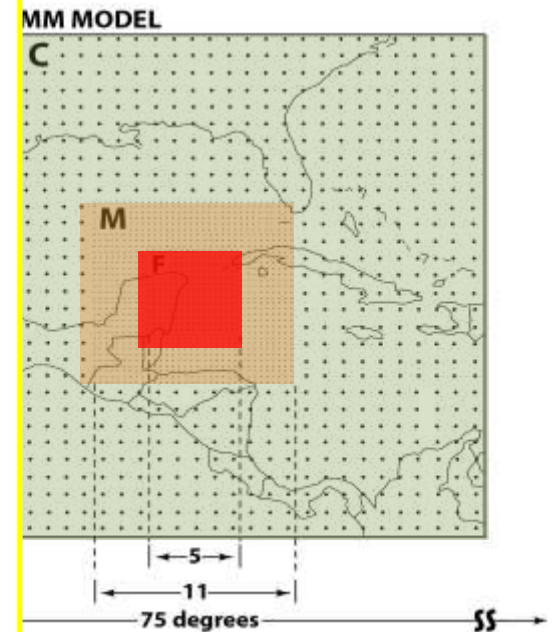Geophysical Fluid Dynamics Laboratory Review

May 20 – May 22, 2014

GFDL Hurricane Model: Timeline

1970: Kurihara starts hurricane research project at GFDL

1995: GFDL hurricane model becomes operational at NWS.

2014+: Continued model development, plus work on a hurricane ensemble.

Hurricane Katrina Coupled Model Forecast
Aug 27 02:30 UTC

Central Pressure / Category

Observed
Model

Sea Surface Temperature (°F)

71   75   79   83   88

MM MODEL

C

M

F

5
11
75 degrees

GFDL Hurricane Group: Key Collaborations

NOAA / HFIP Program: Interactions on a wide range of modeling topics

University of Rhode Island: Ocean coupling, surface physics

NWS / EMC: Cloud microphysics, convective and boundary layer parameterizations; Provide scientific upgrades for operational use

U.S. Navy: Feedback on performance of model in various global basins; Provide scientific upgrades for operational use

AOML / HRD: Boundary layer parameterizations; Development of advanced verification techniques

NWS / NHC: Comparison of forecasts with observations
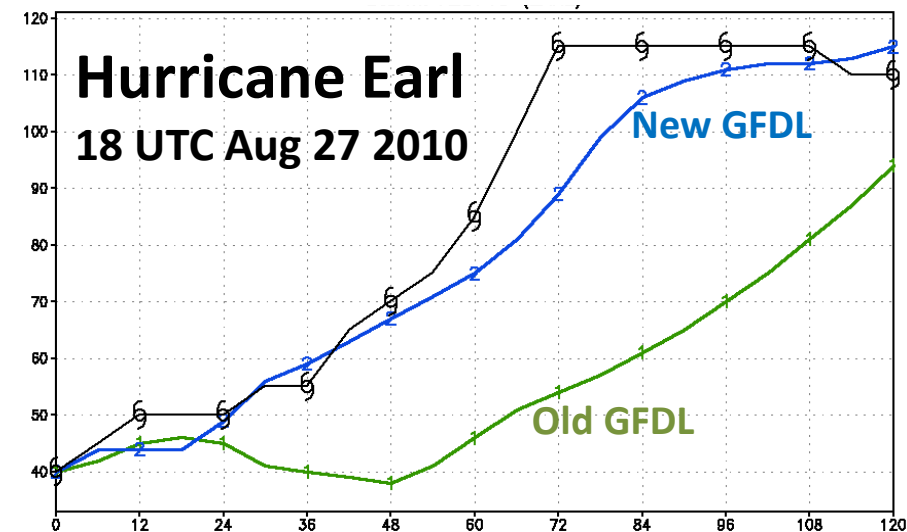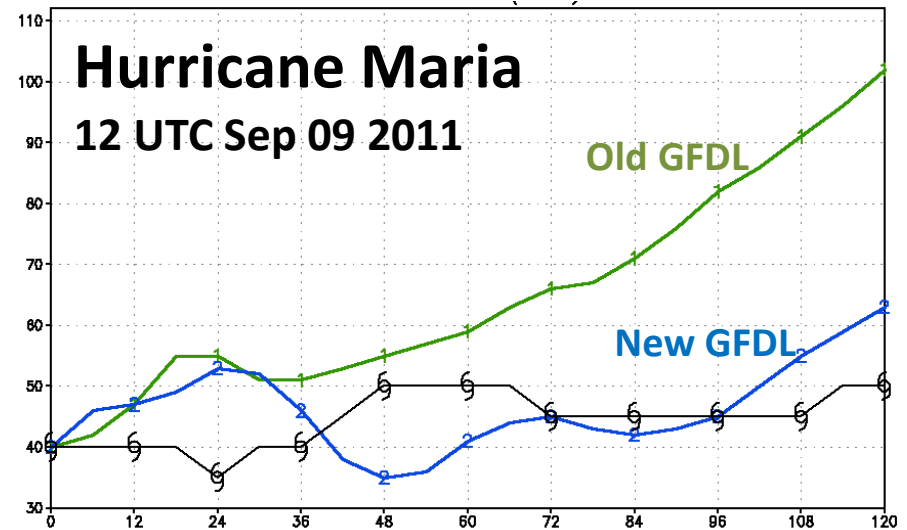
Major upgrades to hurricane model for 2014

- Increased horizontal resolution of inner nest from 9 km to 6 km.

- Improved formulation of surface exchange coefficients (*Ch, Cd*).

- Increased resolution of ocean model to ~9 km.

- Improved targeting of initial storm maximum wind speed and storm structure in initialization.
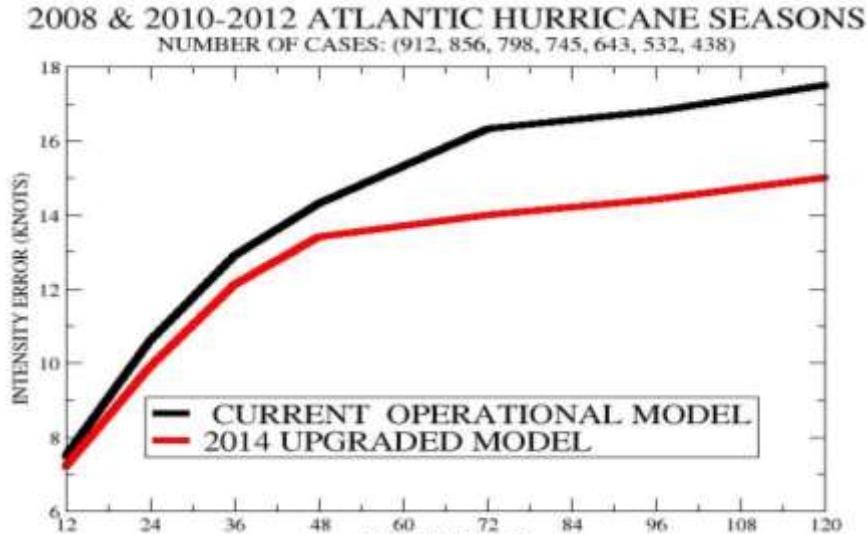

Cd
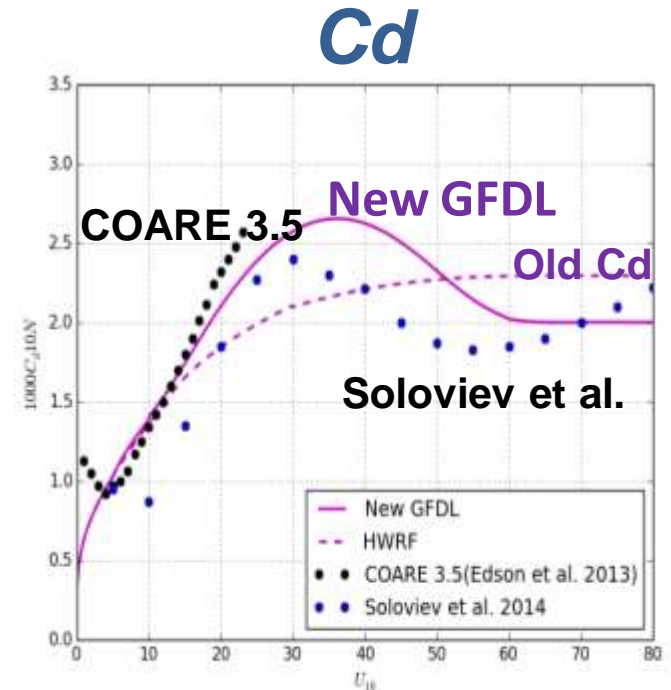
Selected intensity forecasts with 2014 model

Reduced over-intensification tendency

Improved prediction of rapid intensification

Hurricane Maria
12 UTC Sep 09 2011

Old GFDL

New GFDL

Hurricane Earl
18 UTC Aug 27 2010

New GFDL

Old GFDL

Significantly improved intensity skill at all lead times

Atlantic

2008 & 2010-2012 ATLANTIC HURRICANE SEASONS
NUMBER OF CASES: (912, 856, 798, 745, 643, 532, 438)

Error reduction:
Days 1-2:   6%
Days 3-5: 15%
Statistically significant for all lead times

Eastern Pacific

2011, 2012, 2013 EASTERN PACIFIC SEASONS
NUMBER OF CASES: (728, 635, 548, 467, 329, 217, 124)
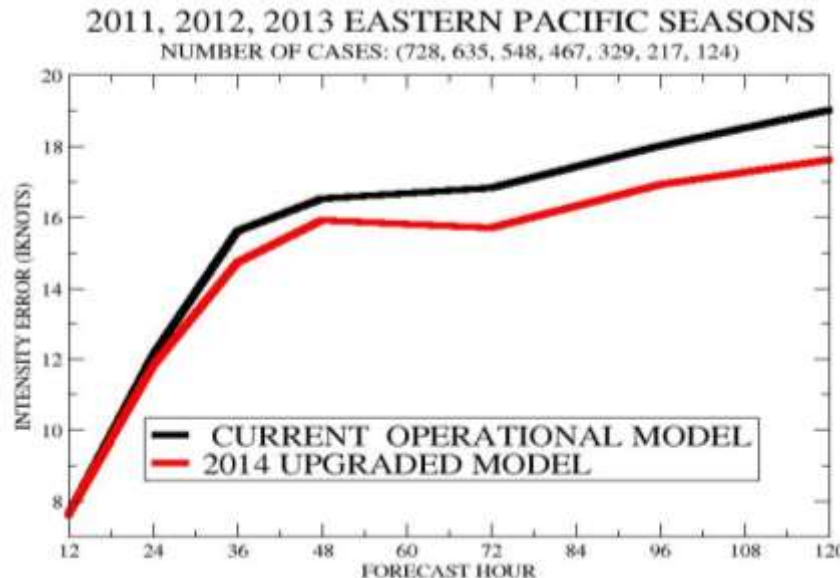
Error reduction:
Day 2:   5%
Days 3-5:   8%
Statistically Significant at 36h and 72h

2008 & 2010-2012 ATLANTIC HURRICANE SEASONS
NUMBER OF CASES: (934, 891, 839, 782, 731, 631, 519, 426)

CURRENT OPERATIONAL MODEL
2014 UPGRADED GFDL MODEL
GFDL (OPERATIONAL AT THE TIME)
HWRF (OPERATIONAL AT THE TIME)
LGEM (OPERATIONAL AT THE TIME)
DECAY SHIPS (OPERATIONAL AT THE TIME)
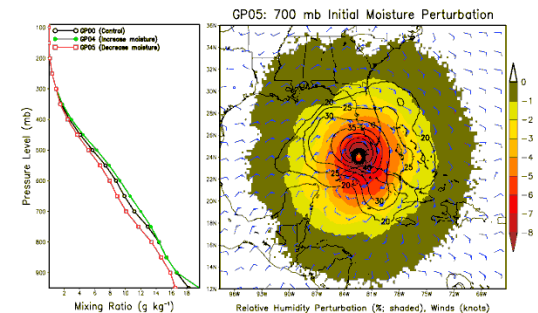OFFICIAL AT THE TIME
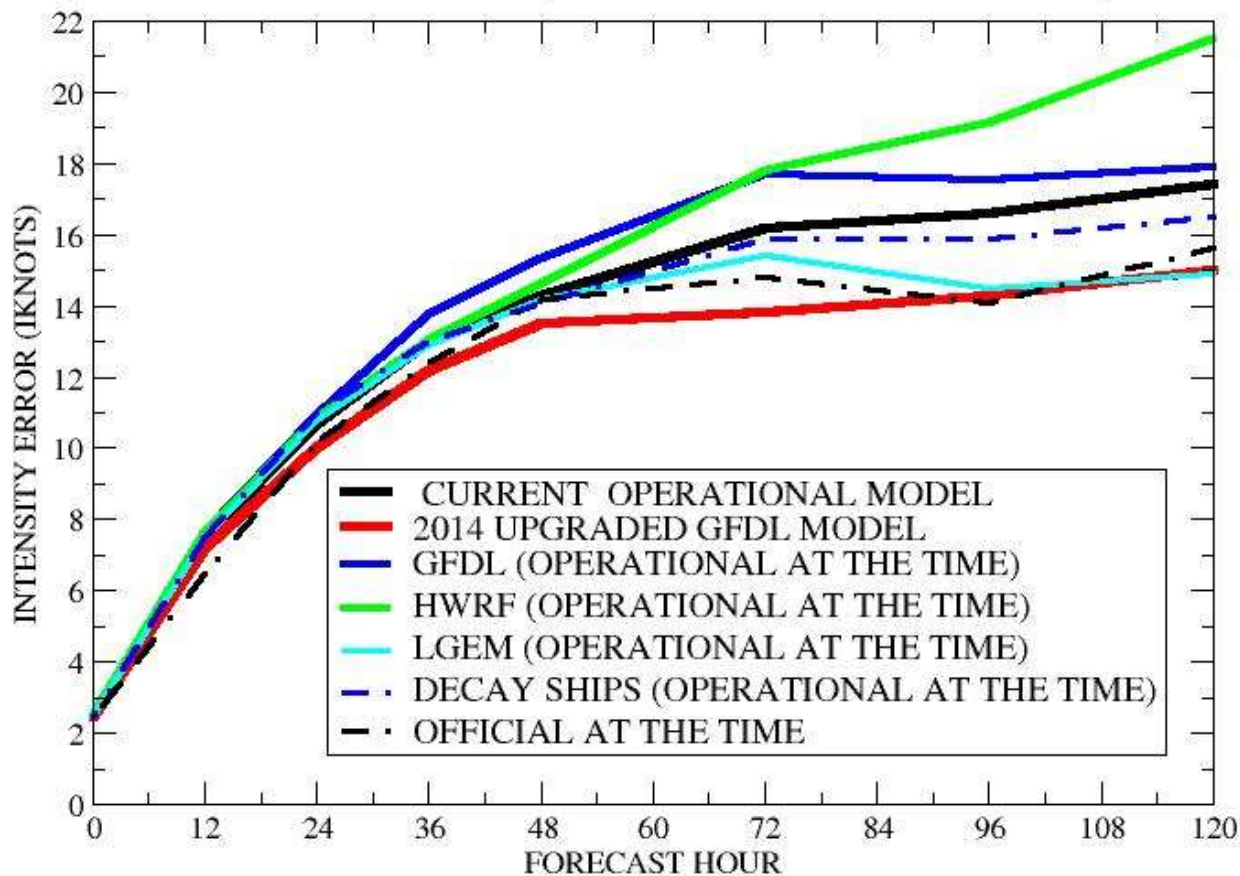
GFDL Hurricane Ensemble

- **Part of the regional modeling effort for the NOAA / Hurricane Forecast Improvement Program (HFIP).**

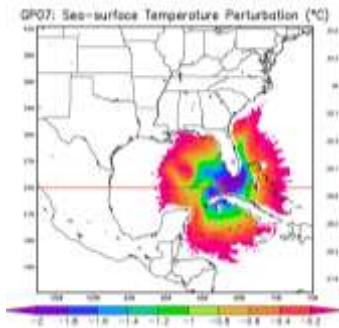**Modify observed max winds and storm size**
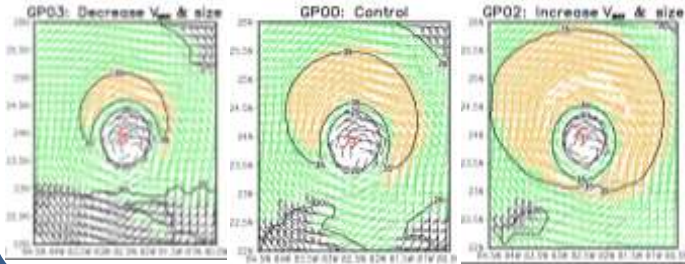
Unbogussed Member

Modify observed moisture
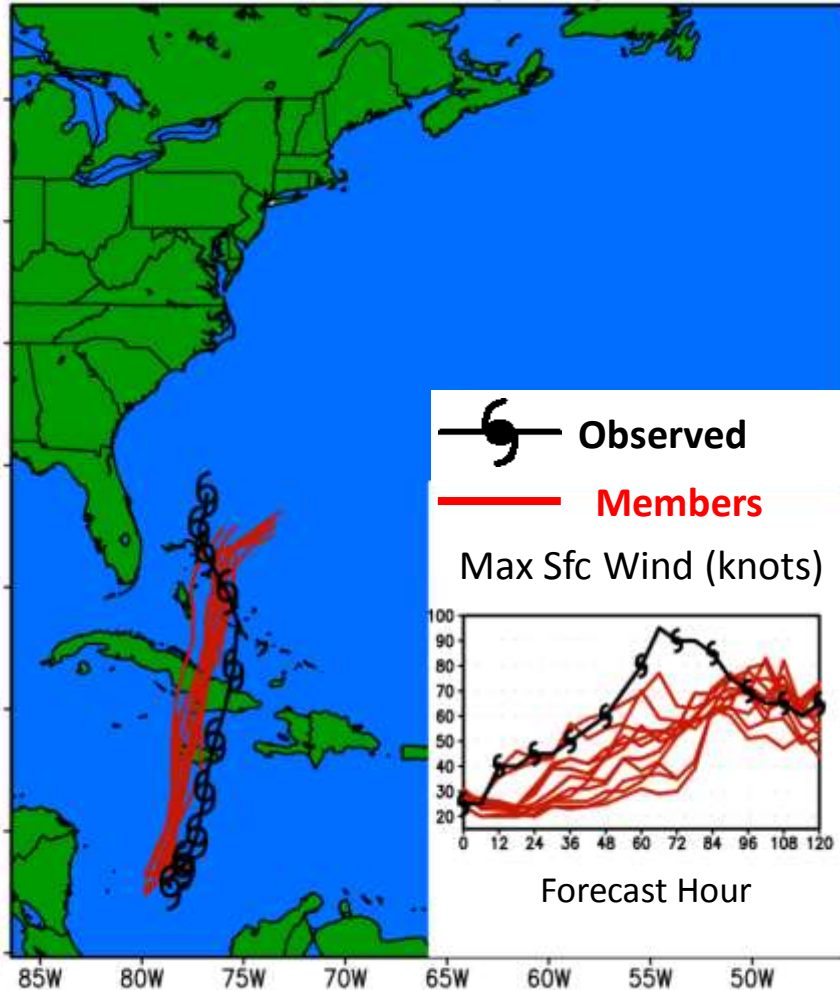
Control Member

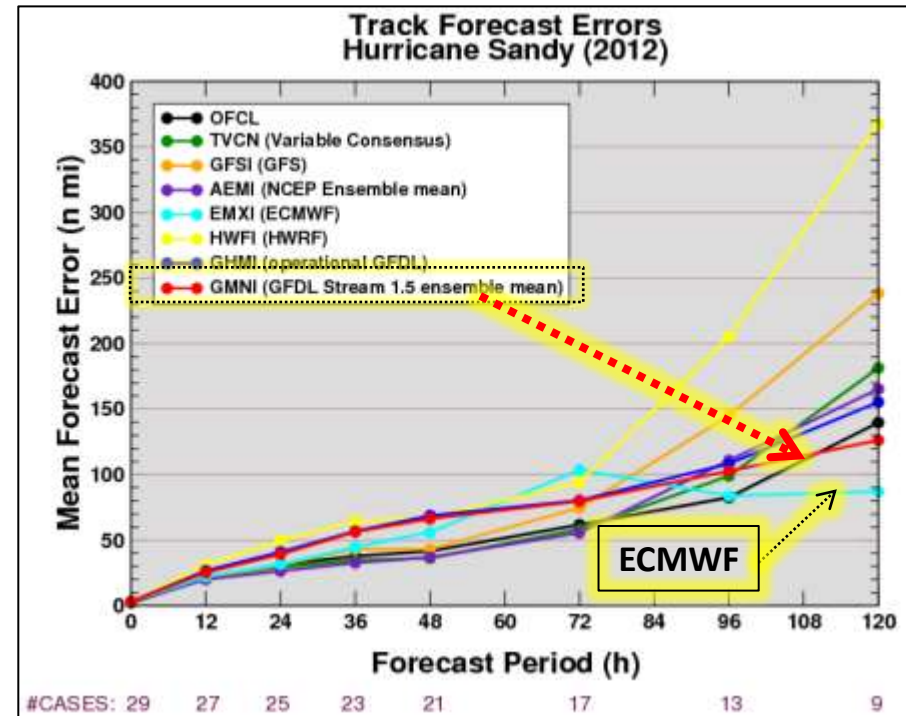**Modify observed SST**

Modify surface physics parameters
- **Cd**
- **Ch**

GFDL Hurricane Ensemble: Sandy

The GFDL ensemble outperformed the control for track on Sandy and was comparable with the ECMWF

Use of GFDL Hurricane Model in climate studies

2) Regional model projects change in hurricane counts from climate model output.

3) Hurricane model projects change in most intense hurricanes from regional model output.

1) Global climate model projects large-scale climate changes from changes in greenhouse gases and aerosols.

The GFDL Hurricane Model has been used to project tropical cyclone intensities under future climate scenarios.

Summary

- 40+ years of model development: Research   Operations

- Operational upgrades continue, including major improvements for 2014

- GFDL Hurricane Model has recently also been used as a tool for:
  - ➢ Creating an ensemble forecast system
  - ➢ Investigating projections of future hurricane intensities in climate studies