FY2011 HFIP Stream 1 Advancements at NCEP/EMC - Performance of Operational Models

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Outline

- **Performance of operational models in FY2011**

- **Status of activities in support of HFIP**

- **Ongoing developments and proposed changes in FY2012**

- **Prioritized Stream 1.0 activities for FY2012**

Changes to GSI/GFS in 2011 implemented on May 9, 2011

- **Analysis Changes:**
- Improved Ozone measurement QC and observational errors
- Relax AMSU-A Channel 5 quality control, Update Community Radiative Transfer Model(CRTM) to version 2.0.2 , Include field of view size/shape/power for radiative transfer
- Remove down weighting of collocated radiances , Limit moisture >= 1.e-10 in each outer iteration and at end of analysis, Include uniform (higher resolution) thinning for satellite radiances
- Improve location of buoys in vertical (move from 20m to 10m)
- Improved GSI and recomputed background errors
- Include SBUV from NOAA-19 , Ambiguous vector quality control for ASCAT (type 290) data

- **Model Changes:**
- Set new thermal roughness length
- Set minimum moisture value in Stratosphere to 1.0×10^{-7}
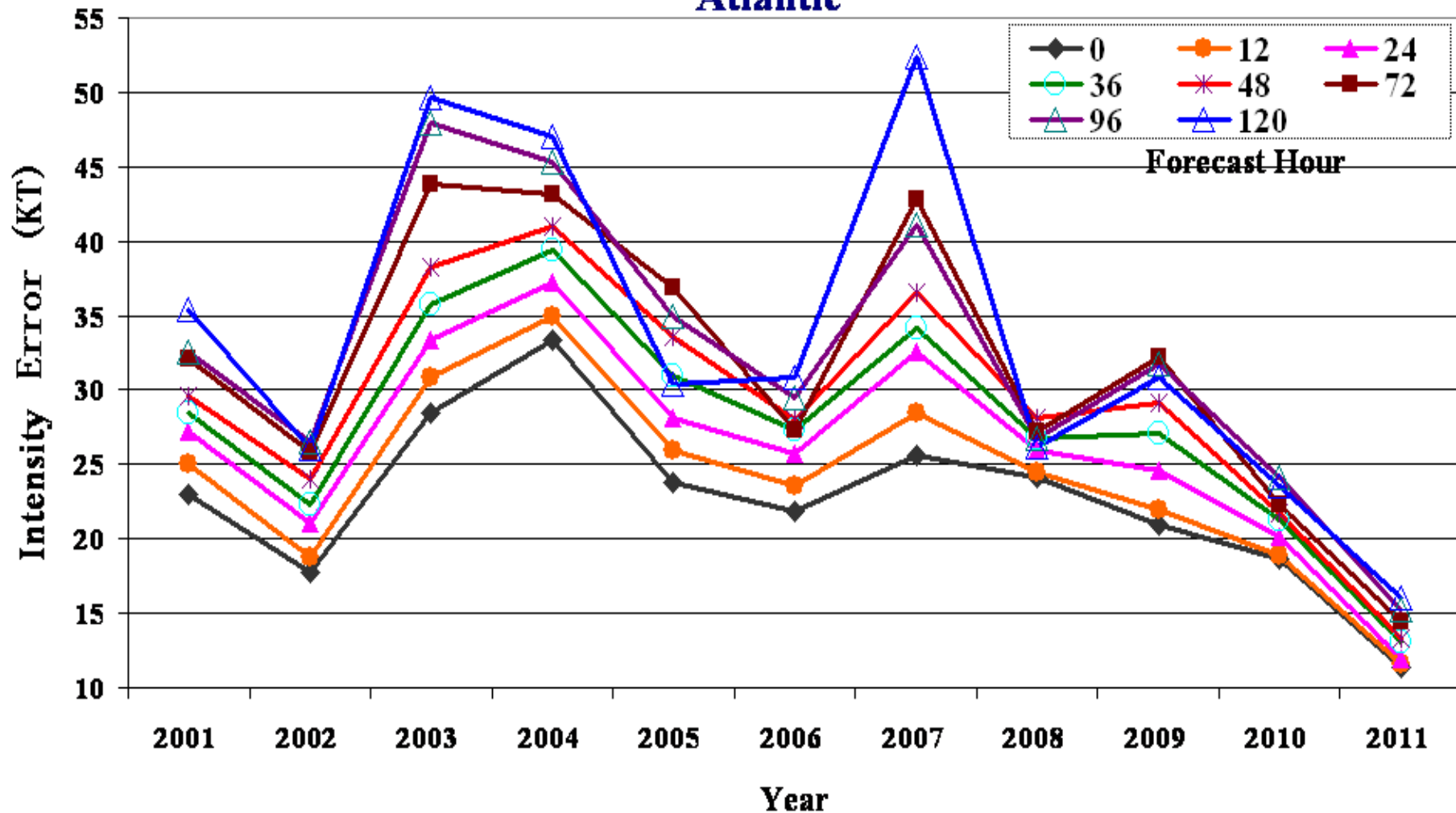- Reduce background diffusion in the Stratosphere

GFS Forecasts: Hurricane Track Error (NM) in the Atlantic
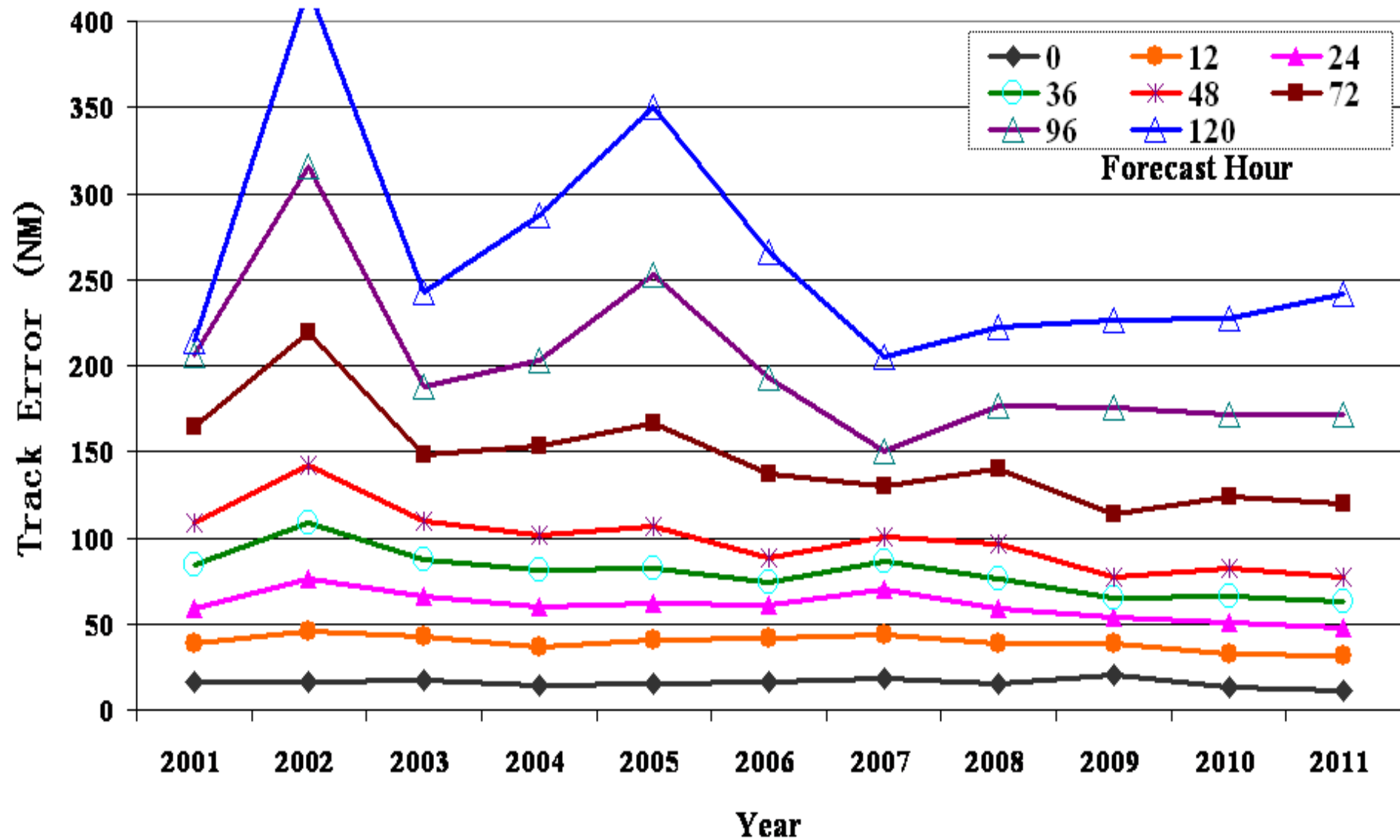
GFS Forecasts: Hurricane Track Error (NM) in the Eastern Pacific
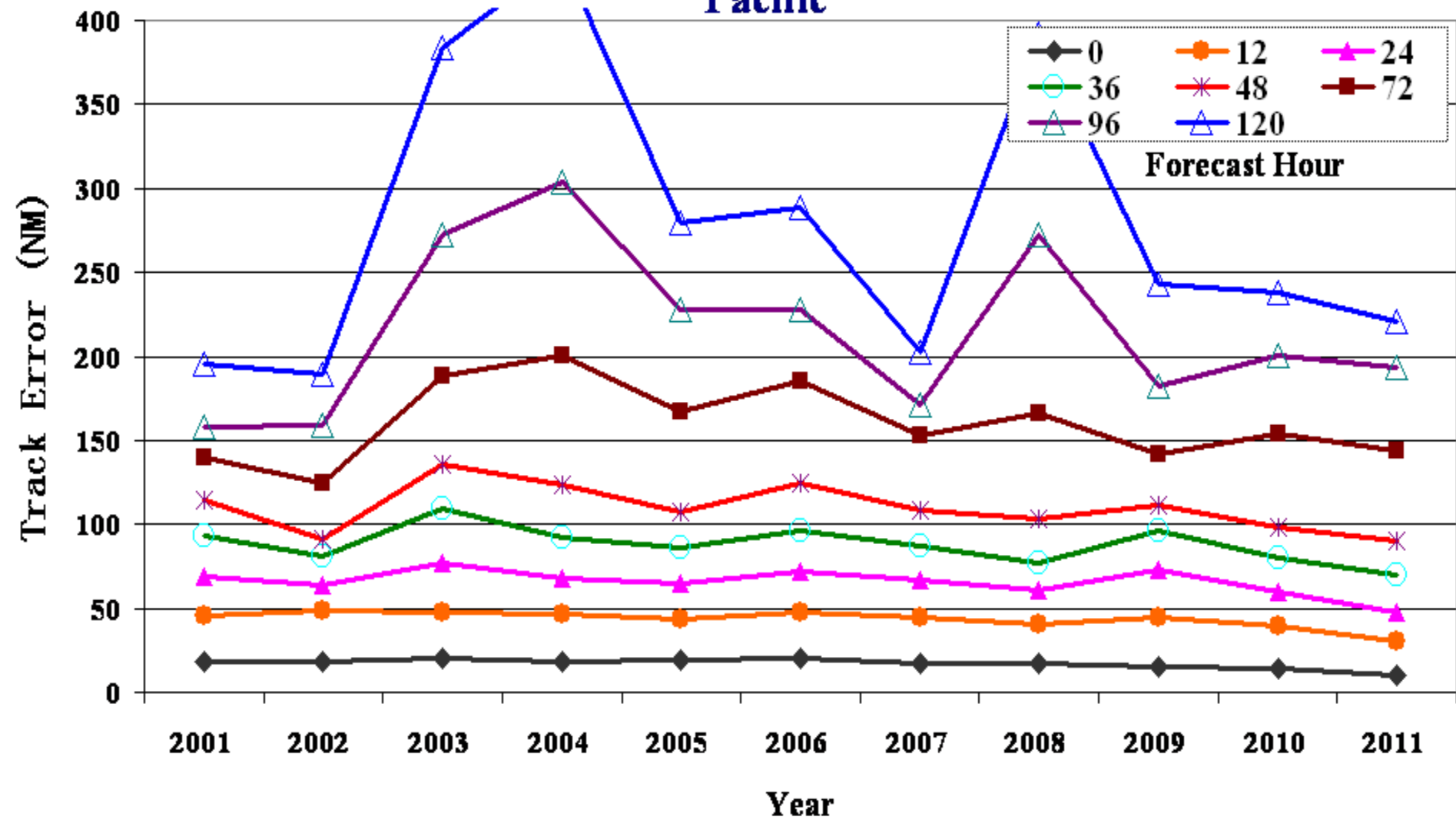
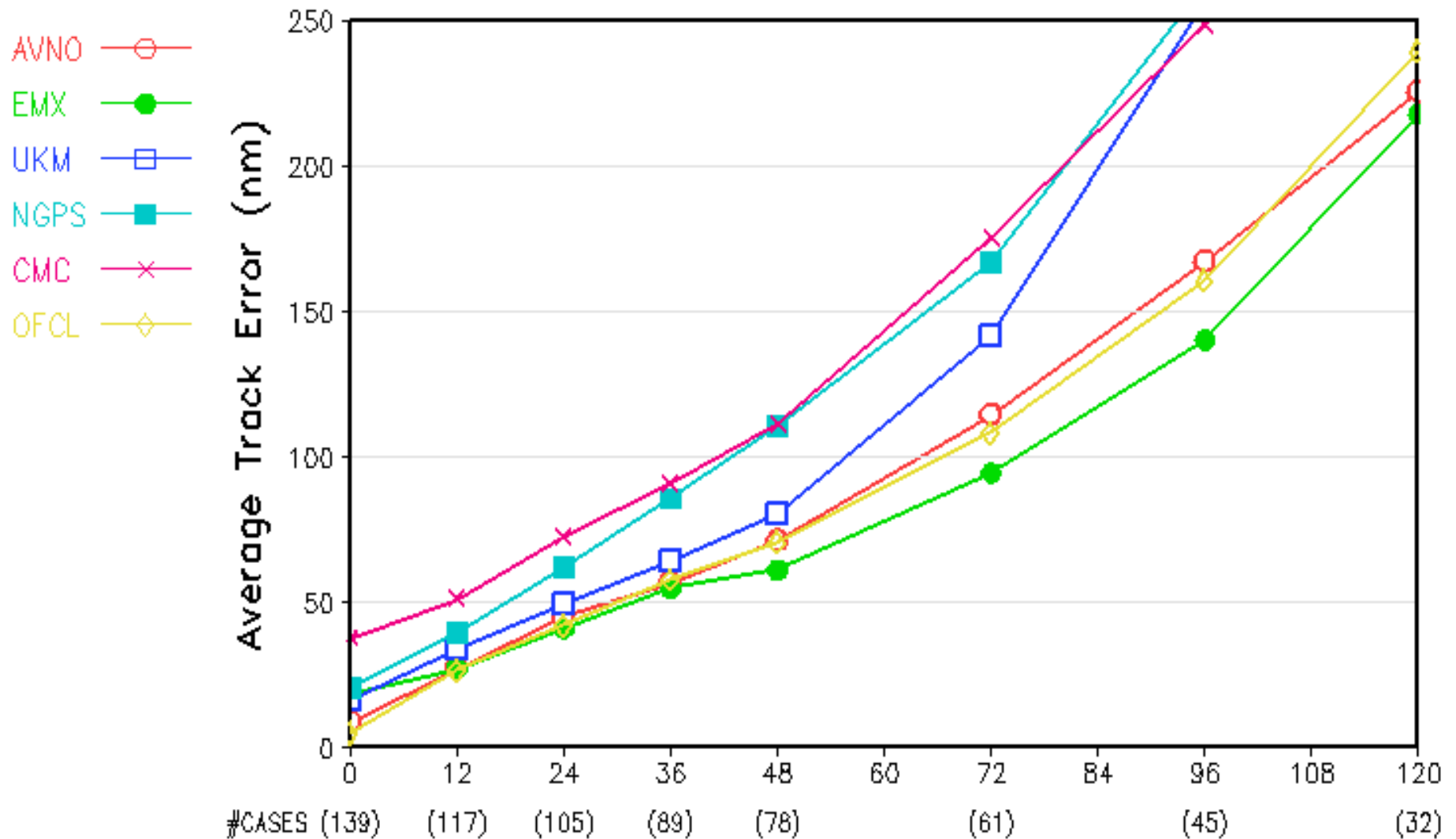GFS Forecasts: Hurricane Intensity Error (Knots) in the Atlantic

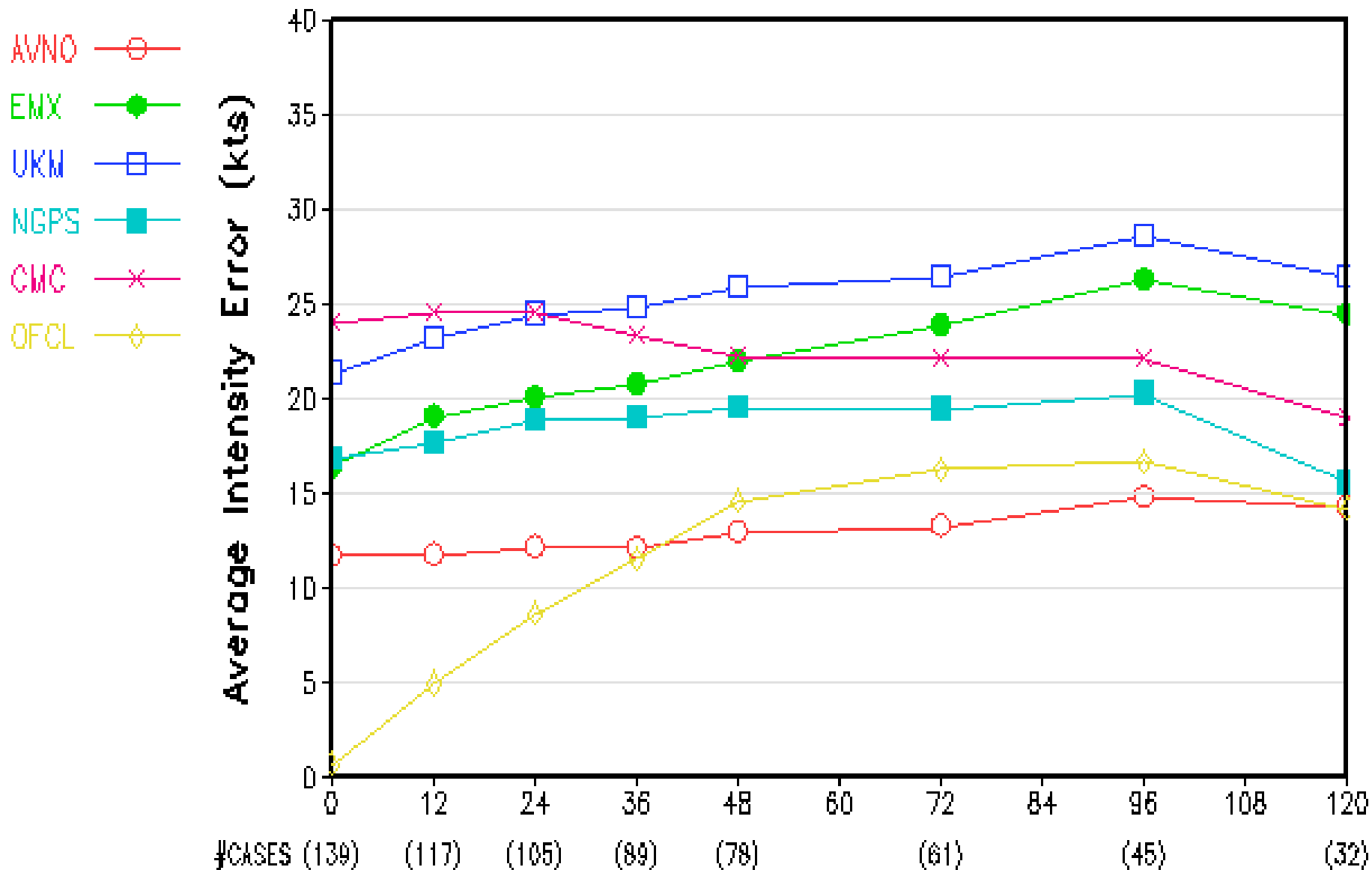Note: GFS July-2010 Implementation (T382 to T574)

2011 Atlantic

Hurricane Track Errors — Atlantic 2011
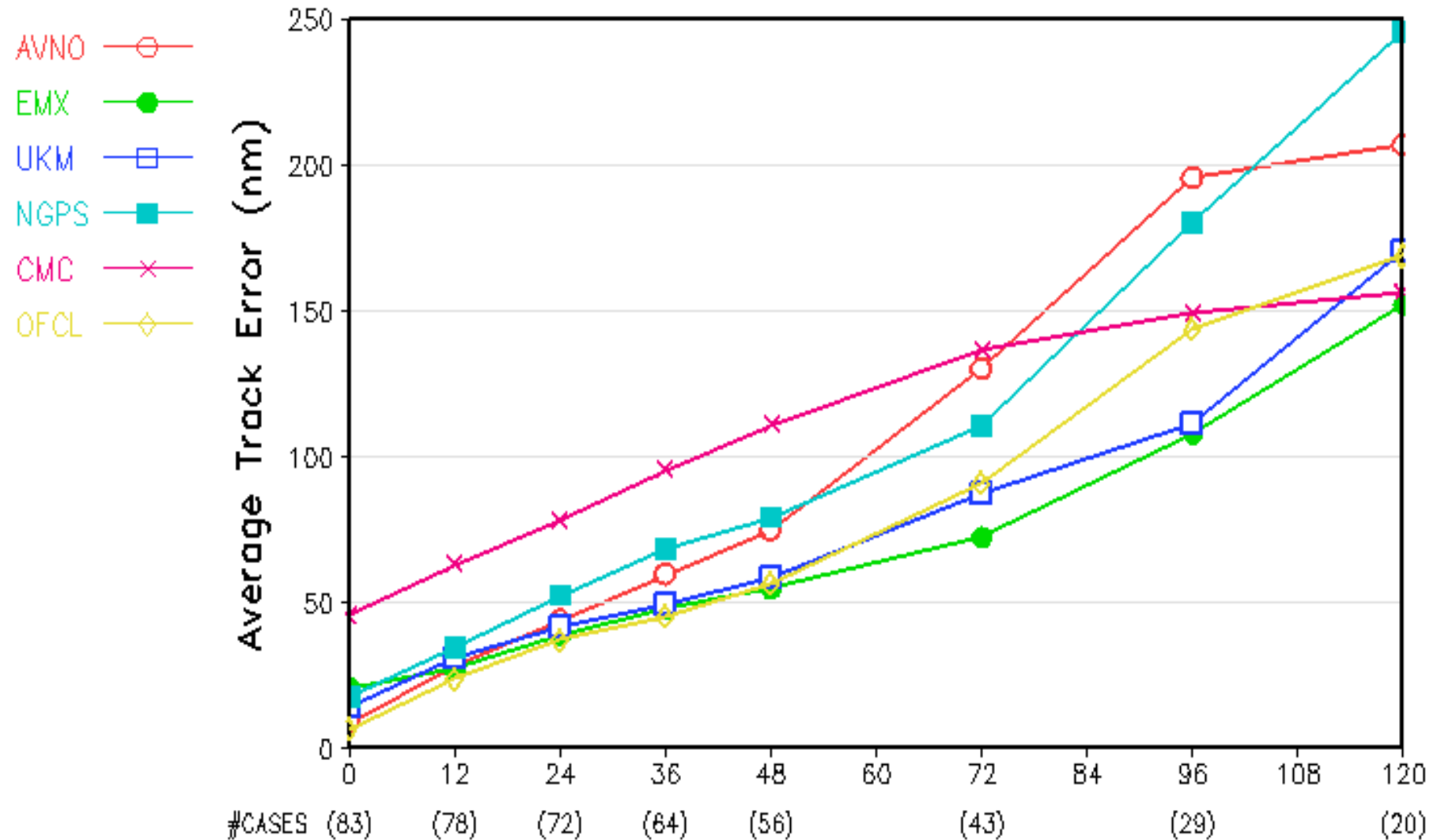20110601__20111025__2cyc

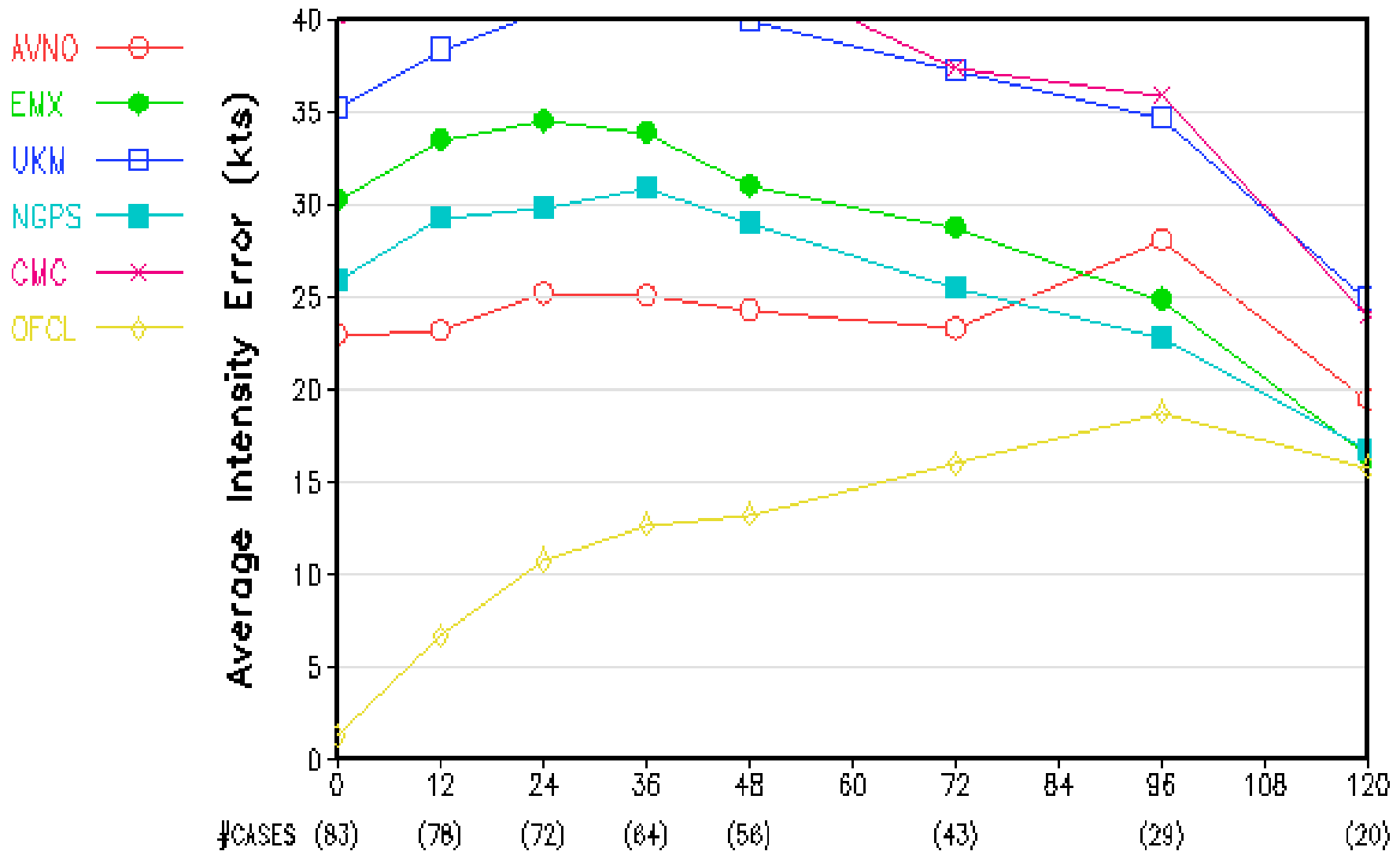Hurricane Intensity Errors — Atlantic 2011
20110601__20111025__2cyc

2011 Eastern Pacific

Hurricane Track Errors — East-Pacific 2011
20110601__20111025__2cyc

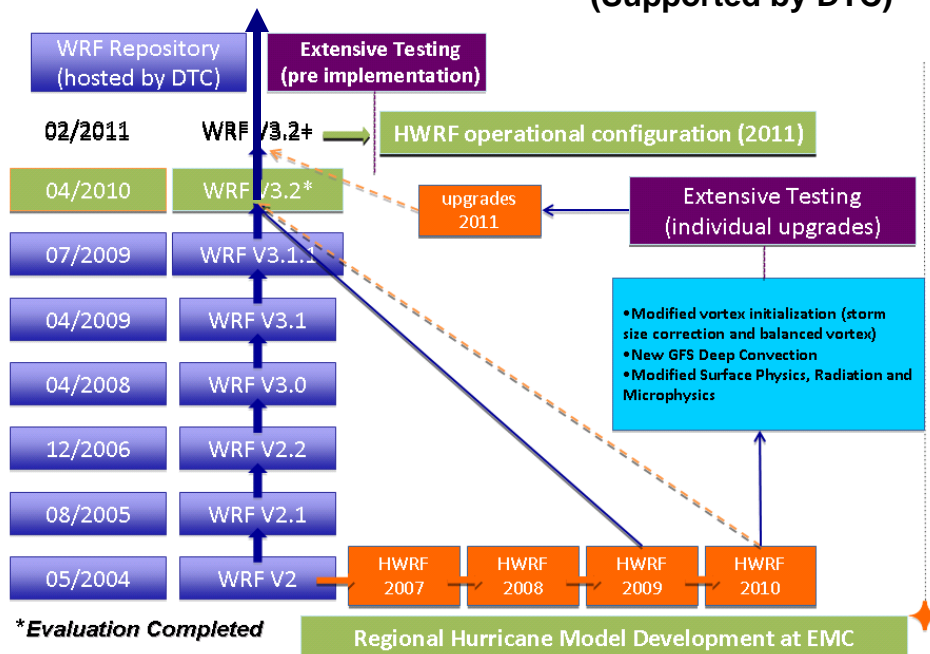Hurricane Intensity Errors — East-Pacific 2011
20110601__20111025__2cyc

HWRF Upgrades FY2011 (implemented on May 17, 2011)

- **Model Upgrades (Atmosphere)**

  – **Upgrade dynamical core to NMM community version V3.2 (EMC-DTC Collaboration)**

  – **New GFS Deep Convection, Improved surface physics, and new FY2011 GSI/GFS IC/BC (EMC- GFDL Collaboration)**
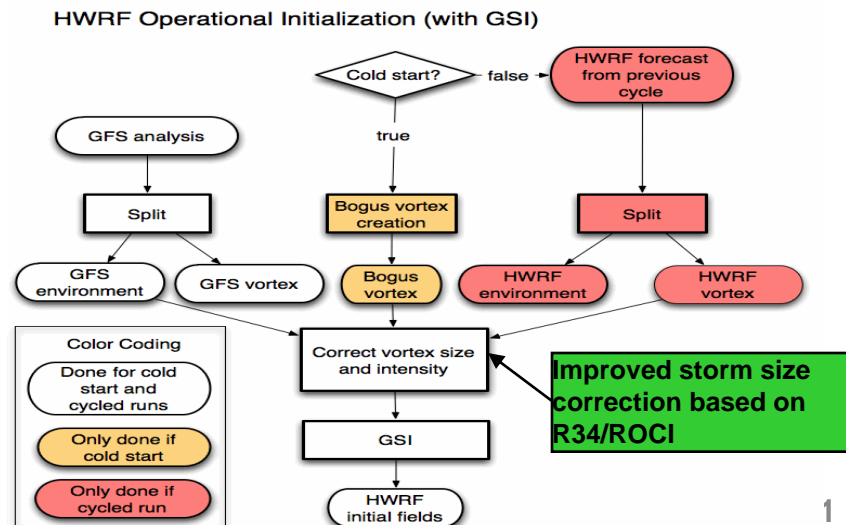
- **Vortex initialization upgrades**

  – **Improved storm size correction based on radius of 34 kt winds or ROCI and dynamical mass-wind consistency of the initial vortex (EMC-HRD collaboration)**

  – **Modification of synthetic storm and its application in the initialization (vortex cycling)**

  – **Upgrade HWRF GSI to V2.5 (community code)**

- **Operational HWRF product enhancements**

  – **Satellite angle corrections for simulated GOES WV and IR imagery, additional simulated microwave products**

  – **New enhanced HWRF website for product display and navigation**

  – **High-frequency output (3 hourly) and additional derived variables for diagnostics (EMC-NHC-CIRA Collaboration)**
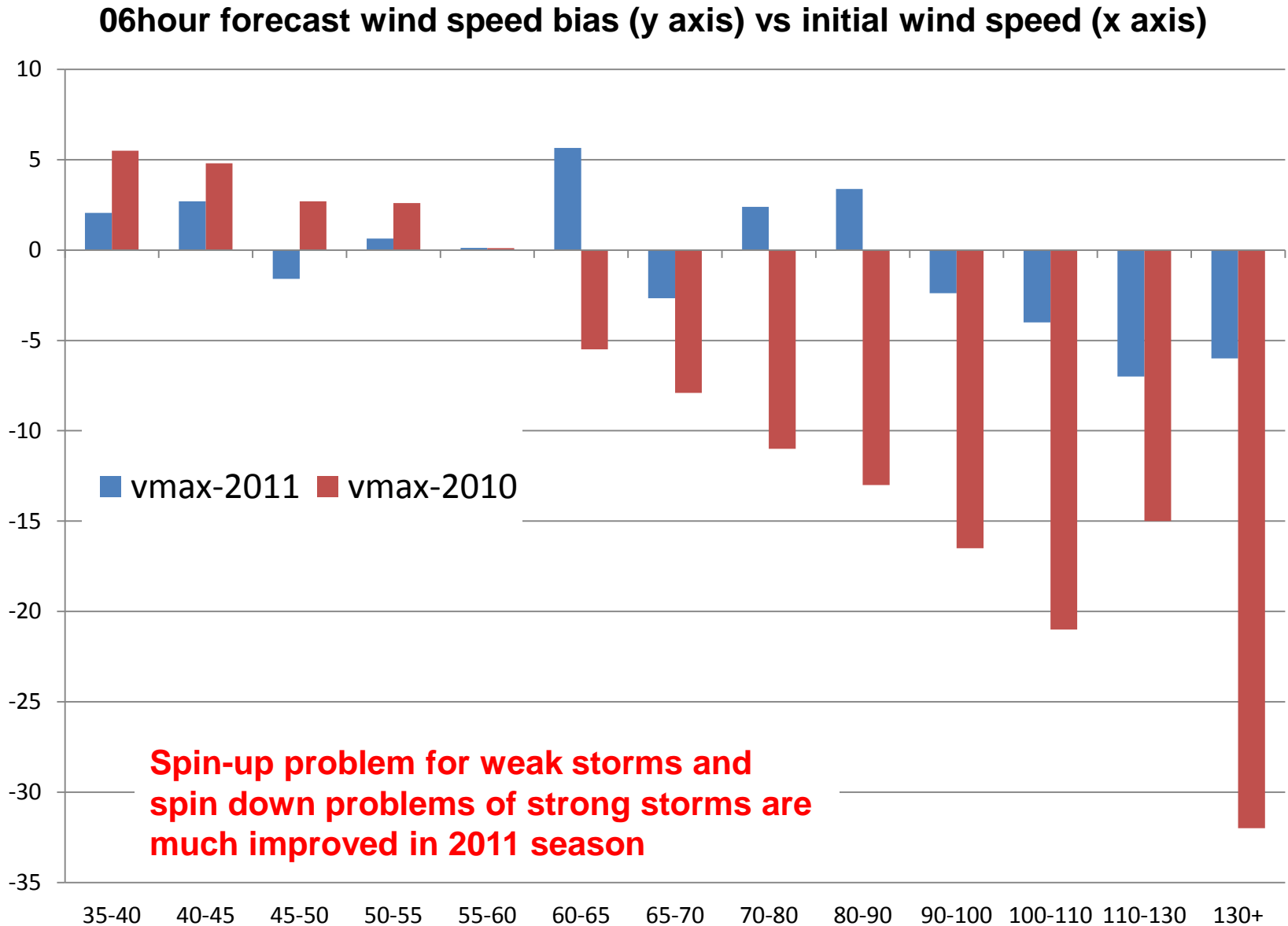
- **Mid-Season major bug fix in SAS deep convection (array out of bounds)**

FY2011 Operational HWRF Baseline Configuration
(Supported by DTC)

WRF Repository (hosted by DTC)	Extensive Testing (pre implementation)

02/2011 — WRF V3.2+ → HWRF operational configuration (2011)

04/2010	WRF V3.2*	→ upgrades 2011 ← Extensive Testing (individual upgrades)
07/2009	WRF V3.1.1	
04/2009	WRF V3.1	•Modified vortex initialization (storm size correction and balanced vortex) •New GFS Deep Convection •Modified Surface Physics, Radiation and Microphysics
04/2008	WRF V3.0	
12/2006	WRF V2.2	
08/2005	WRF V2.1	
05/2004	WRF V2	HWRF 2007 — HWRF 2008 — HWRF 2009 — HWRF 2010

*Evaluation Completed

Regional Hurricane Model Development at EMC

HWRF Operational Initialization (with GSI)

Improved storm size correction based on R34/ROCI

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# GFDL FY2011 Upgrades Implemented on May 17, 2011

- Upgrade Simplified Arakawa-Schubert (SAS) deep convection parameterization to new version implemented in the NCEP Global Forecast System (GFS)

- Modify the surface enthalpy exchange coefficient and dissipative heating effect

- Expand coupled region in the Eastern Atlantic domain to prevent storms from losing coupling effect with the ocean due to insufficient overlap with the Western Atlantic region. The new overlap will be 25 degrees.

- Correct several bugs in the model.

Impact of upgraded vortex initialization scheme in 2011 HWRF (EMC-HRD)

06hour forecast wind speed bias (y axis) vs initial wind speed (x axis)

Spin-up problem for weak storms and spin down problems of strong storms are much improved in 2011 season

Legend: ■ vmax-2011 ■ vmax-2010

X-axis categories: 35-40, 40-45, 45-50, 50-55, 55-60, 60-65, 65-70, 70-80, 80-90, 90-100, 100-110, 110-130, 130+

* Modified initialization significantly improve the intensity skill of HWRF model (especially 0-48hr)

Initial observations from Mike Brennan (NHC): 18 to 24 hours into the HWRF model run the low-level vortex associated with the invest appears to break down. The model shows a patchwork pattern of low-level vorticity maxima and minima in association with the invest, along the ITCZ, and in the high terrain of Mexico. This appears to be due to very large amounts of grid-scale precipitation, in some areas exceeding 5 or even 10 inches in a 6-h period across much of the domain. Interestingly, the precip amounts produced by the convective scheme are quite small (generally < 1 inch in a 6-h period).

850 hPa Vorticity
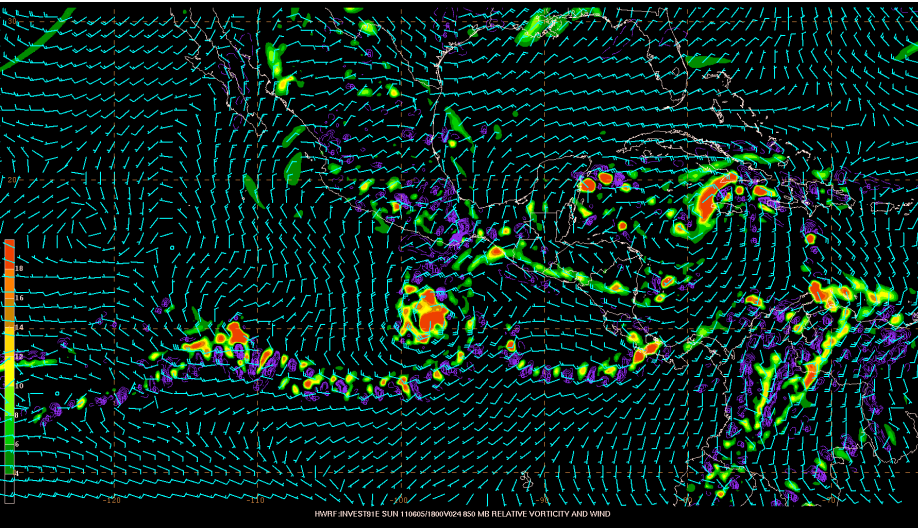
Grid-Scale Precipitation

Analysis led to mid-Season Array out-of-bound bug fix for GFS SAS Deep Convection in HWRF
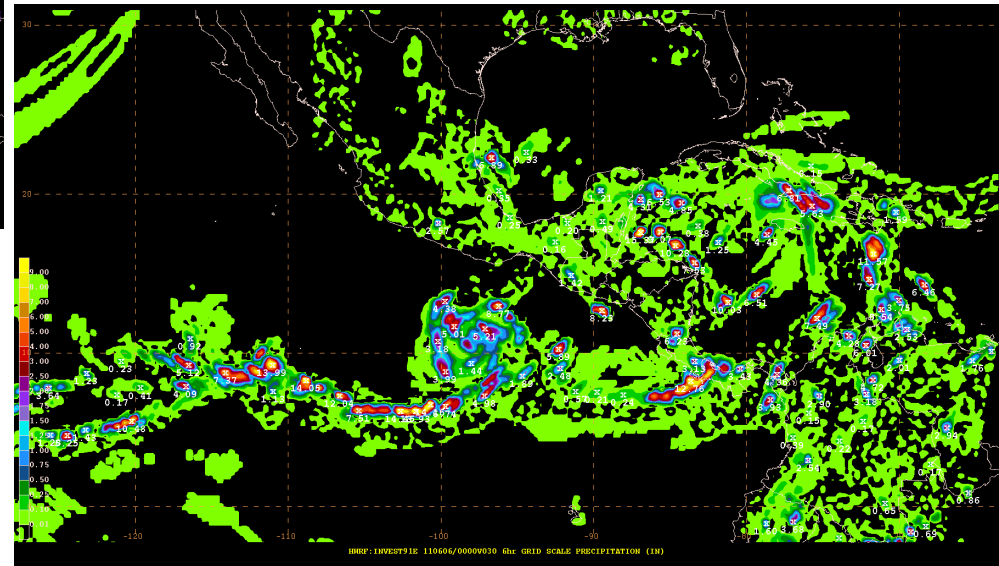
Operational HWRF: 2011 TC Tracks
Storm: FIVE (05E) valid 2011073112

Operational HWRF: 2011 TC Tracks
Storm: EUGENE (05E) valid 2011080106

Operational HWRF: 2011 TC Tracks
Storm: EUGENE (05E) valid 2011080118

Operational HWRF: 2011 TC Tracks
Storm: EUGENE (05E) valid 2011080200
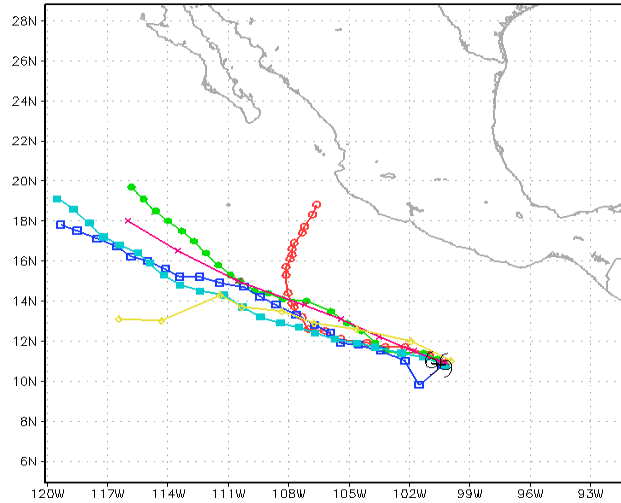
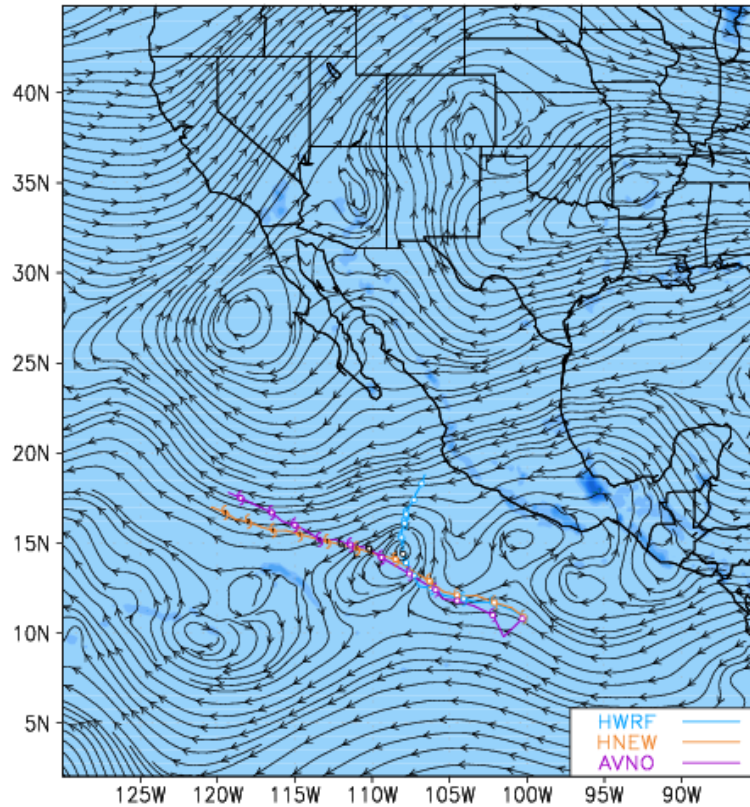Unpredictable nature of the track forecasts – traced to an out-of-bound array problem in SAS scheme
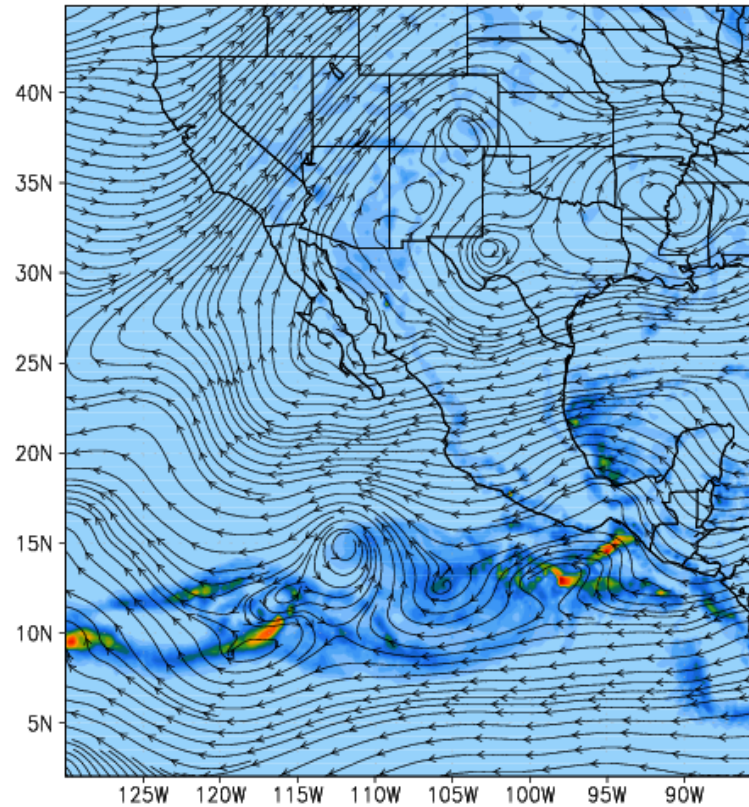
Data Set #1 : HWRF PARENT GRID – FIVE05e
Data Set #2 : HNEW PARENT GRID – FIVE05e
it: 2011073112   vt: 2011080306 (66h)

surface convective precip (shaded, kg/m^2)
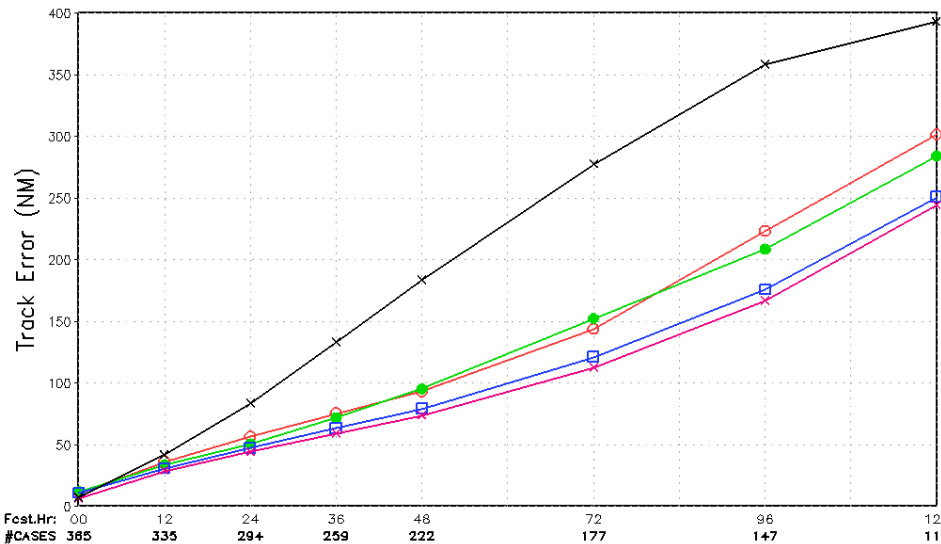850–200 mb mean wind (streamlines,)

HWRF

HNEW

HWRF
HNEW
AVNO

15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285

2011 Atlantic Season so far

HWRF and GFDL have comparable track errors. GFS has better track skill at all forecast times.

HWRF has less intensity errors compared to GFDL, with less positive bias.

GFS has better intensity skill compared to HWRF/GFDL for 2011 ATL
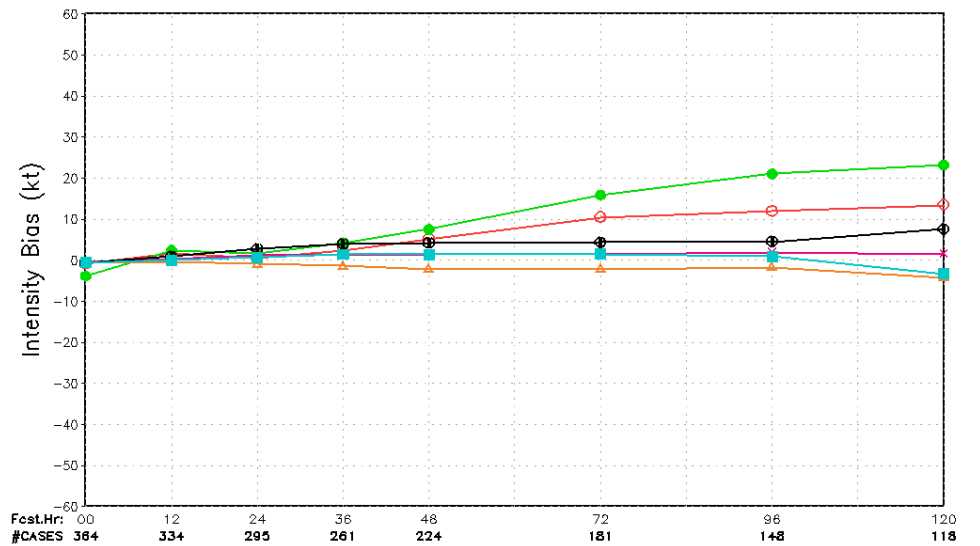
Average Track Errors (NM)
Operational Statistics Plots — ALL 2011 EASTPAC through IRWIN11E

Average Intensity Errors (kt)
Operational Statistics Plots — ALL 2011 EASTPAC through IRWIN11E

Intensity Bias (kt)
Operational Statistics Plots — ALL 2011 EASTPAC through IRWIN11E

2011 Eastern Pacific Season so far

HWRF and GFDL have comparable track errors. GFS has better track skill at days 4&5

Intensity errors from HWRF and GFDL are comparable, with slight positive bias at days 4&5

Average Track Errors (NM)
Operational Statistics Plots – 2011 IRENE09L

Legend: HWRF, OFCL, CLP5, GFDL, AVNO

Track Forecast errors for Hurricane Irene

GFDL Track errors traced to convective detrainment and microphysics issues

Y-axis: Track Error (NM), 0 to 500

Fcst.Hr: 00 12 24 36 48 72 96 120
#CASES: 32 31 29 27 25 22 18 14

Average Intensity Errors (kt)
Operational Statistics Plots – 2011 IRENE09L

Legend: HWRF, OFCL, SHIP, SHF5, GFDL, LGEM, DSHP

Intensity Forecast errors for Hurricane Irene

Improved skill from HWRF through 72hrs

Y-axis: Intensity Error (kt), 0 to 60
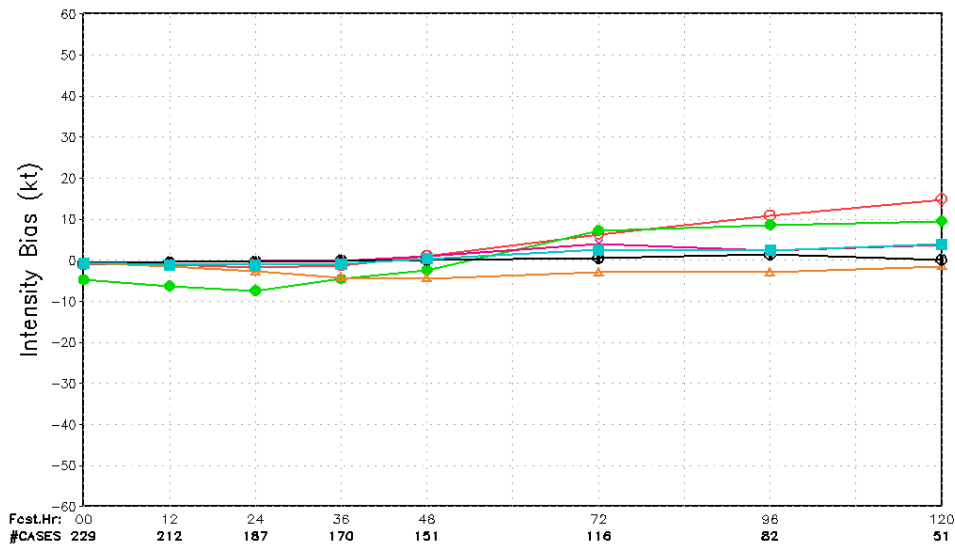
Fcst.Hr: 00 12 24 36 48 72 96 120
#CASES: 32 31 29 27 25 22 18 14
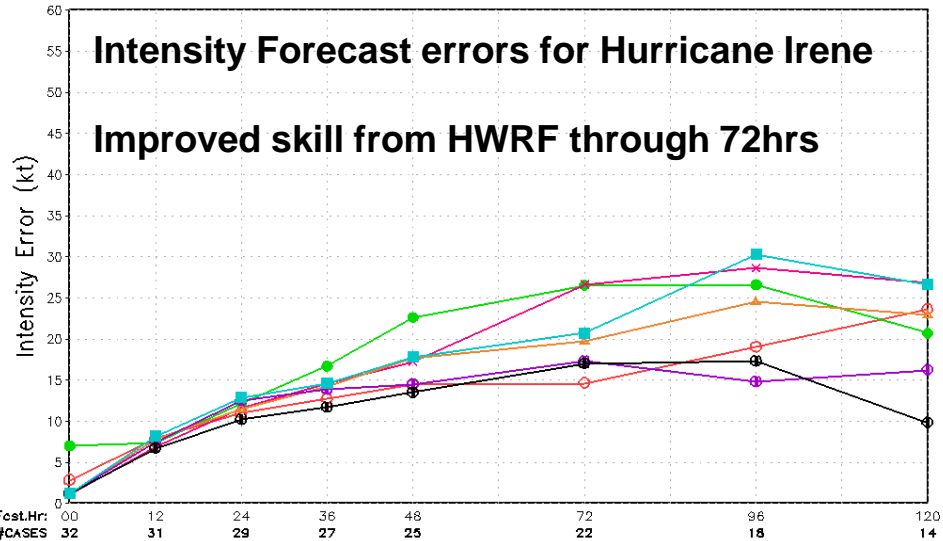
NCEP Hurricane Forecast Project

Average Track Errors (NM)
Operational Statistics Plots – 2011 KATIA12L
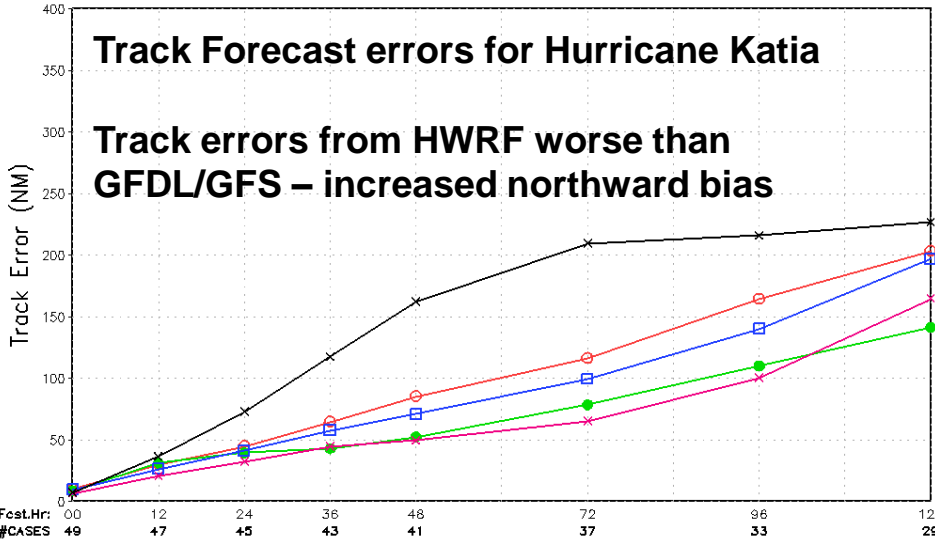
Legend: HWRF, OFCL, CLP5, GFDL, AVNO

Track Forecast errors for Hurricane Katia

Track errors from HWRF worse than GFDL/GFS – increased northward bias

Y-axis: Track Error (NM), 0 to 400

Fcst.Hr: 00 12 24 36 48 72 96 120
#CASES: 49 47 45 43 41 37 33 29

Forecast Errors (NM) For MARIA 14L 2011
Operational Statistics Plots – ALL 2011 ATLANTIC through PHILIPPE17L

Legend: HWRF, OFCL, CLP5, GFDL, AVNO

Track Forecast errors for Hurricane Maria

A difficult storm for regional models

Y-axis: Track Error (NM), 0 to 600

Fcst.Hr: 00 12 24 36 48 72 96 120
#CASES: 40 39 37 35 33 29 25 20
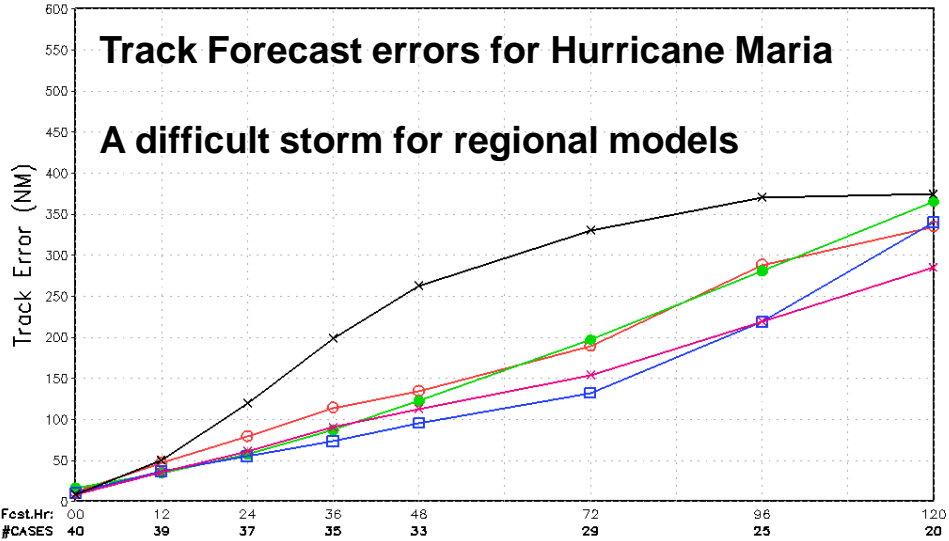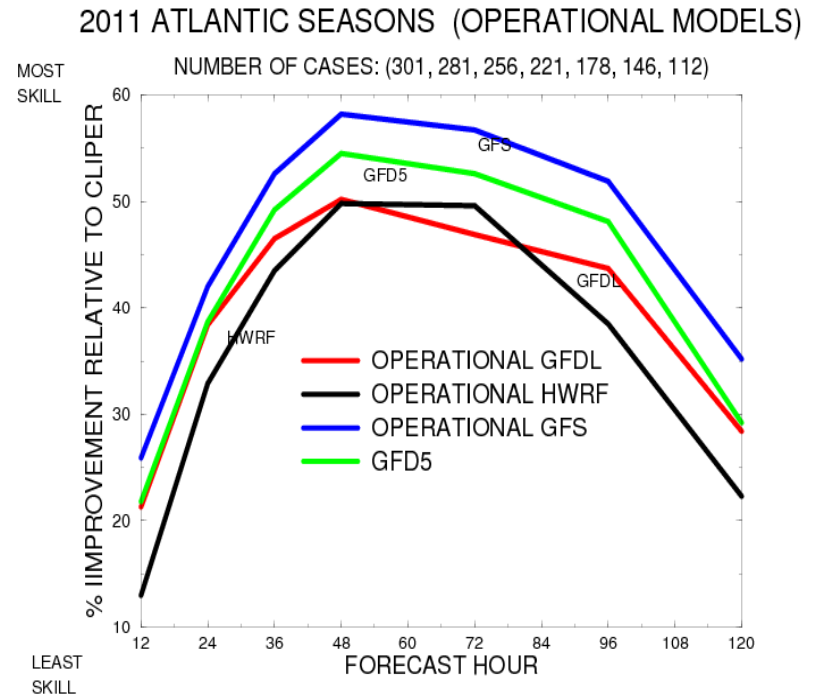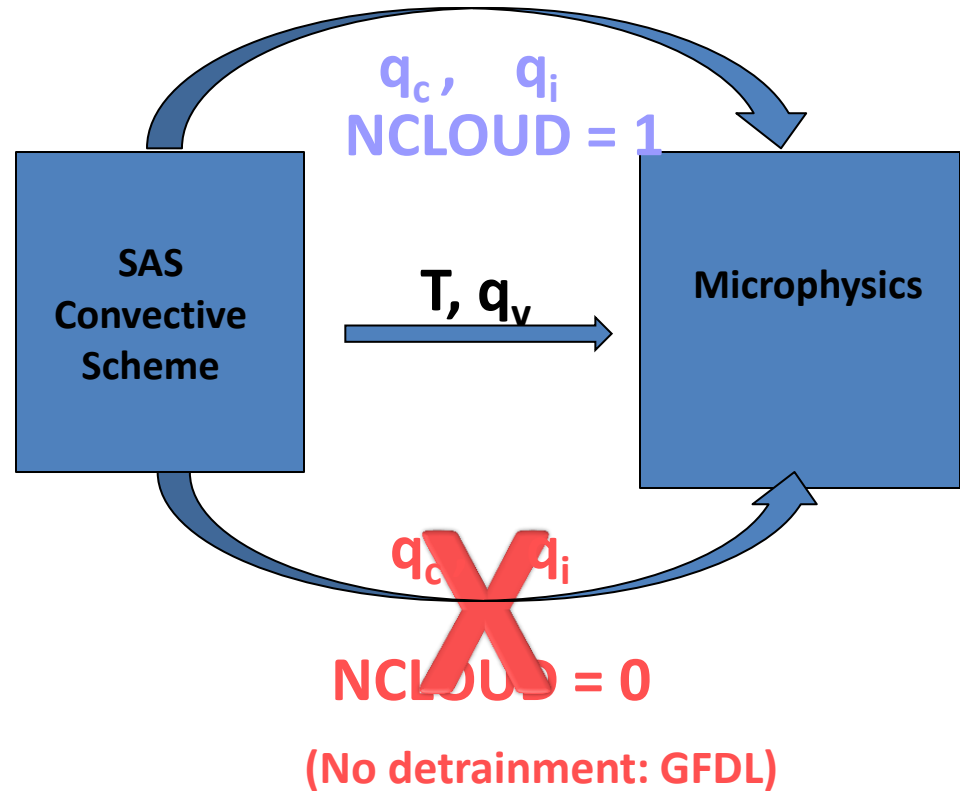
NCEP Hurricane Forecast Project

Physics Sensitivities: Importance of Microphysics and Microphysics-Cumulus interactions (GFDL)

(Detrainment allowed: GFD5, run in parallel during the season)

q_c , q_i

NCLOUD = 1

SAS Convective Scheme

T, q_v

Microphysics

q_c , q_i

NCLOUD = 0

(No detrainment: GFDL)

2011 ATLANTIC SEASONS (OPERATIONAL MODELS)

NUMBER OF CASES: (301, 281, 256, 221, 178, 146, 112)

MOST SKILL

LEAST SKILL

% IMPROVEMENT RELATIVE TO CLIPER

FORECAST HOUR

GFS

GFD5

HWRF

GFDL

— OPERATIONAL GFDL
— OPERATIONAL HWRF
— OPERATIONAL GFS
— GFD5

Towards High-Resolution HWRF implementation for FY2012

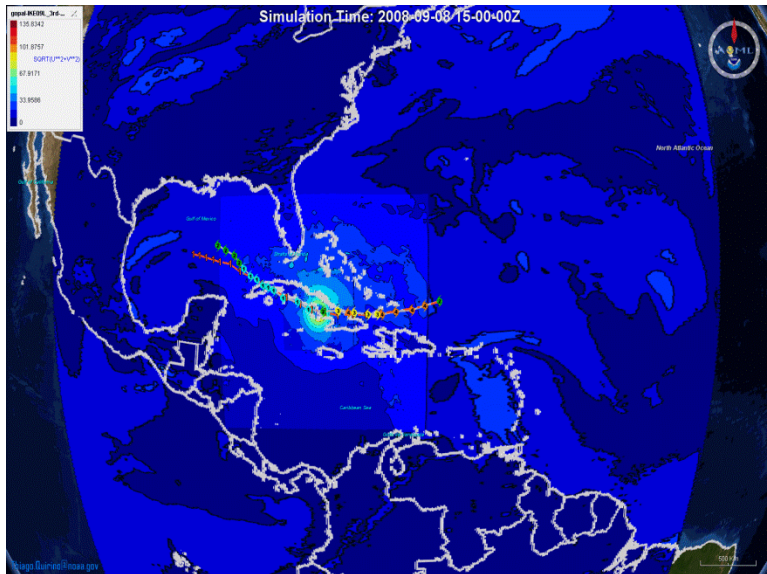- **Further advancements to the HWRF coupled modeling system (EMC & HRD)**

- **Code management and community support (EMC, DTC)**

- **Advanced vortex initialization (EMC & HRD)**

- **Improved physics (EMC & HRD)**
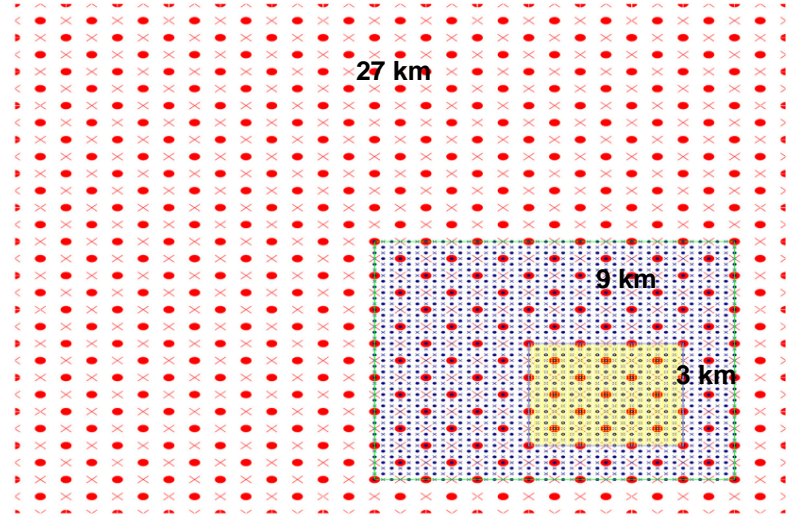
HWRF real-time demo simulations (https://storm.aoml.noaa.gov/realtime/)

Planned 2012 Operational HWRF System (EMC-HRD)

- Three atmospheric telescoping nested domains:
  - 27km resolution 75x75 degree domain
  - 9km resolution ~11x10 degree storm-following
  - 3km resolution ~6x5 degree storm-following
- Include new nest motion algorithm and other dynamics improvements tested in real-time during 2011 season in collaboration with HRD
- Coupled with POM ocean model.
- New coupler and modified HWRF vortex initialization for third nest
- Changes to HWRF physics appropriate for 3 km resolution
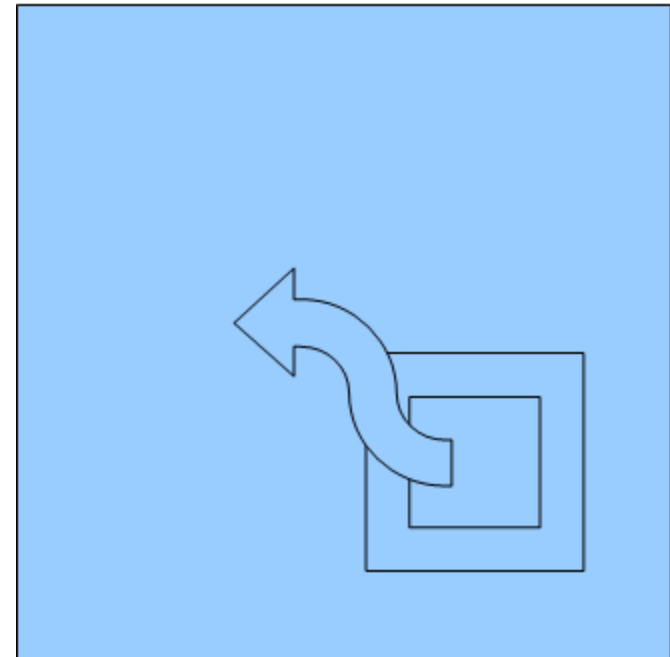
Code Optimization of Triple Nested HWRF System

➢ **Triple nested HWRF system (27-9-3) has been running parallel for 2011 hurricane season ;**

➢ **The system is stable and produces comparable or better track/intensity forecasts with current operational HWRF;**

➢ **The bottleneck for the system to be implemented into operation is the run time: it costs about 2 hours and 20 minutes for 126 hours forecast;**

➢ **Several possible ways to further reduce the model run time, including:**
   - IO Servers configuration (identical results);
   - Reducing HALO width (identical results);
   - Increasing model time steps and physics calling frequencies;
   - Adding one more node; Reducing model print statements;
   - Reducing model domain; Loadleveler environment configuration;

➢ **3 dedicated nodes – thanks to vapor helpdesk.**

➢ **End Result: Triple Nested HWRF system can run in 75 minutes with four nodes**

HWRF T&E for 2012 Implementation

HR12	H061	H062	H063	HWRFV6.0.0
New Baseline (Control)	GFS Shallow convection and new PBL	Tuning of Microphysics parameters (NCW, NLImax, fall speed and so on)	Q3FY12 GFS (Hybrid GSI, prd12q3k)	H061+ H062+H063
Triple nested HWRF (27-9-3km)	Uses GFS shallow convection and PBL scheme implemented in July 2010	Tune some microphysics parameters suggested by Eric and Brad	Create another baseline with proposed Q3FY12 Hybrid GSI/GFS	Combination of shallow convection, PBL and Microphysics and Q3FY12 GSI/GFS
Test cases: All 2011 cases in ALT and EP (about 600 cases)	Priority cases	Priority cases	All 2011 cases in ALT and EP (about 600 cases)	All 2011 cases in ALT and EP (about 600 cases)
Dec. 15, 2011	Jan. 31, 2012	Jan. 31, 2012	Feb. 28, 2012	Feb. 28, 2012

Real-time and pre-implementation T&E HWRF products:

http://www.emc.ncep.noaa.gov/gc_wmb/vxt/index.html

Thanks for your attention

Questions?

Acknowledgements:

HWRF team at EMC

EMC and HFIP Management

Collaborations with NHC, DTC, HRD, GFDL, URI, CIRA and other HFIP partners