

NCEP ensemble status and the development of TC forecasts

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Acknowledgements:

Bill Lapenta, Geoff DiMego, John Ward
Jun Du, Richard Wobus, Jiayi Peng, Vijay Tallapragada, Zhan Zhang,
George Vandenberghe and Tim Marchok

Highlight

- SREF implementation
- GEFS implementation
- High resolution GEFS experiments
- HWRF ensembles
- Next GFS implementation
- Others

SREF Implementation (October 27th 2009)

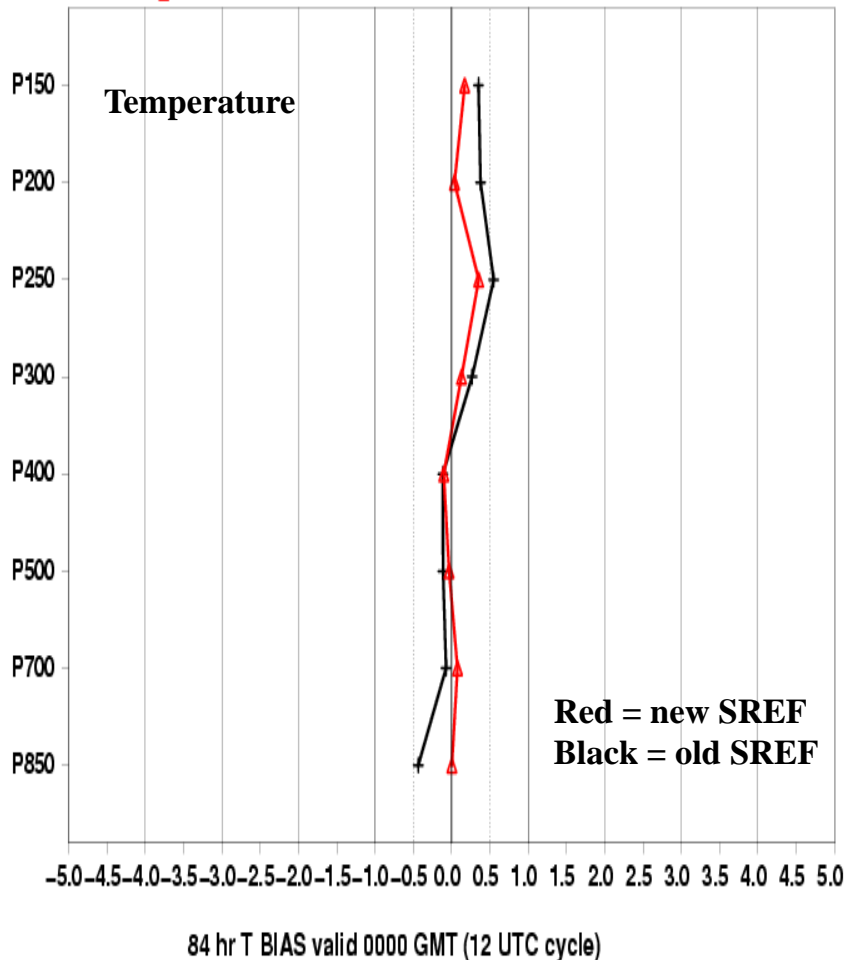
- Geoff DiMego, Jun Du and etc...

- Upgrade model versions
 - WRF-NMM from v2.0+ to v2.2+
 - WRF-ARW from v2.0+ to v2.2+
 - RSM from v2007 to v2009
- Increase horizontal resolution
 - WRF NMM from 40 km to 32 km
 - WRF ARW from 45 km to 35 km
 - RSM from 45 km to 30 km
- Adjust membership
 - Replace 2 Eta (BMJ-sat) members with 2 WRF-NMM members
 - Replace 2 Eta (KF-det) members with 2 WRF-ARW members
- Enhancement physics diversity of RSM: replace Zhao cloud scheme with Ferrier cloud scheme for 3 SAS members
- Enhance initial perturbation diversity: Replace regional bred perturbations with global ET perturbations for 10 WRF members

Smaller Mean errors of temperature and wind over entire atmosphere

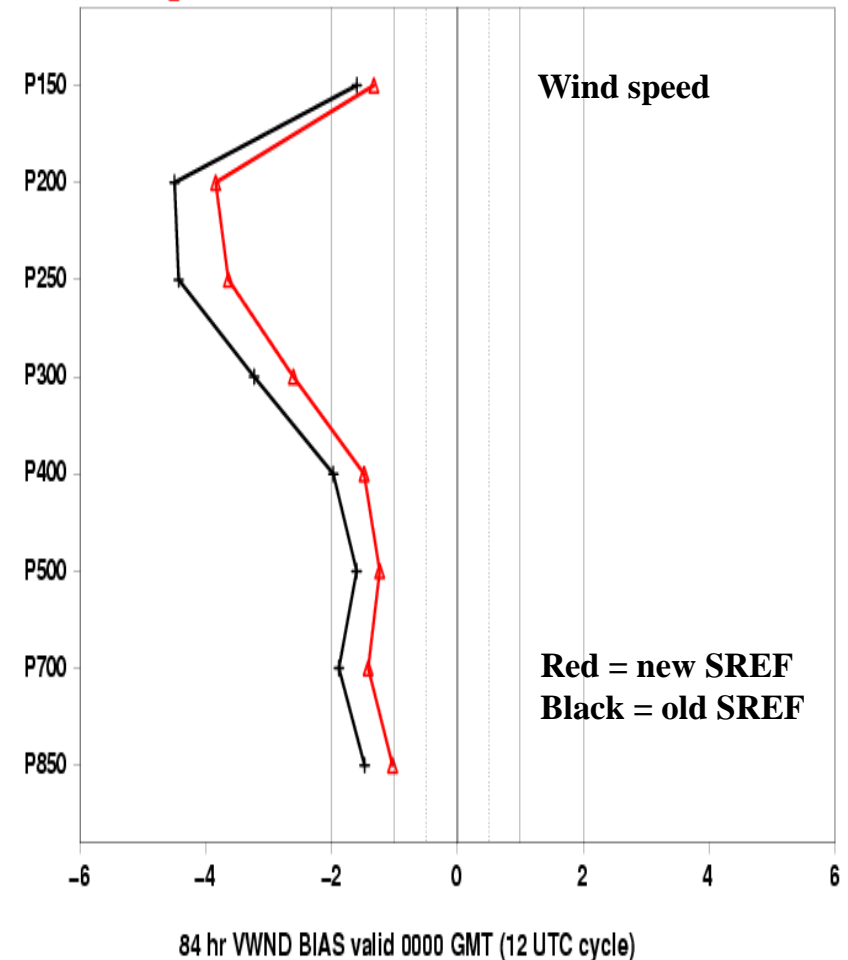
T BIAS by pressure from 20090622 to 20090810
for all 84 HR forecasts valid 0000 GMT

SRMEAN VARB: T RGN: CONUS FHR: 84 STAT: bias
SRMEANP VARB: T RGN: CONUS FHR: 84 STAT: bias

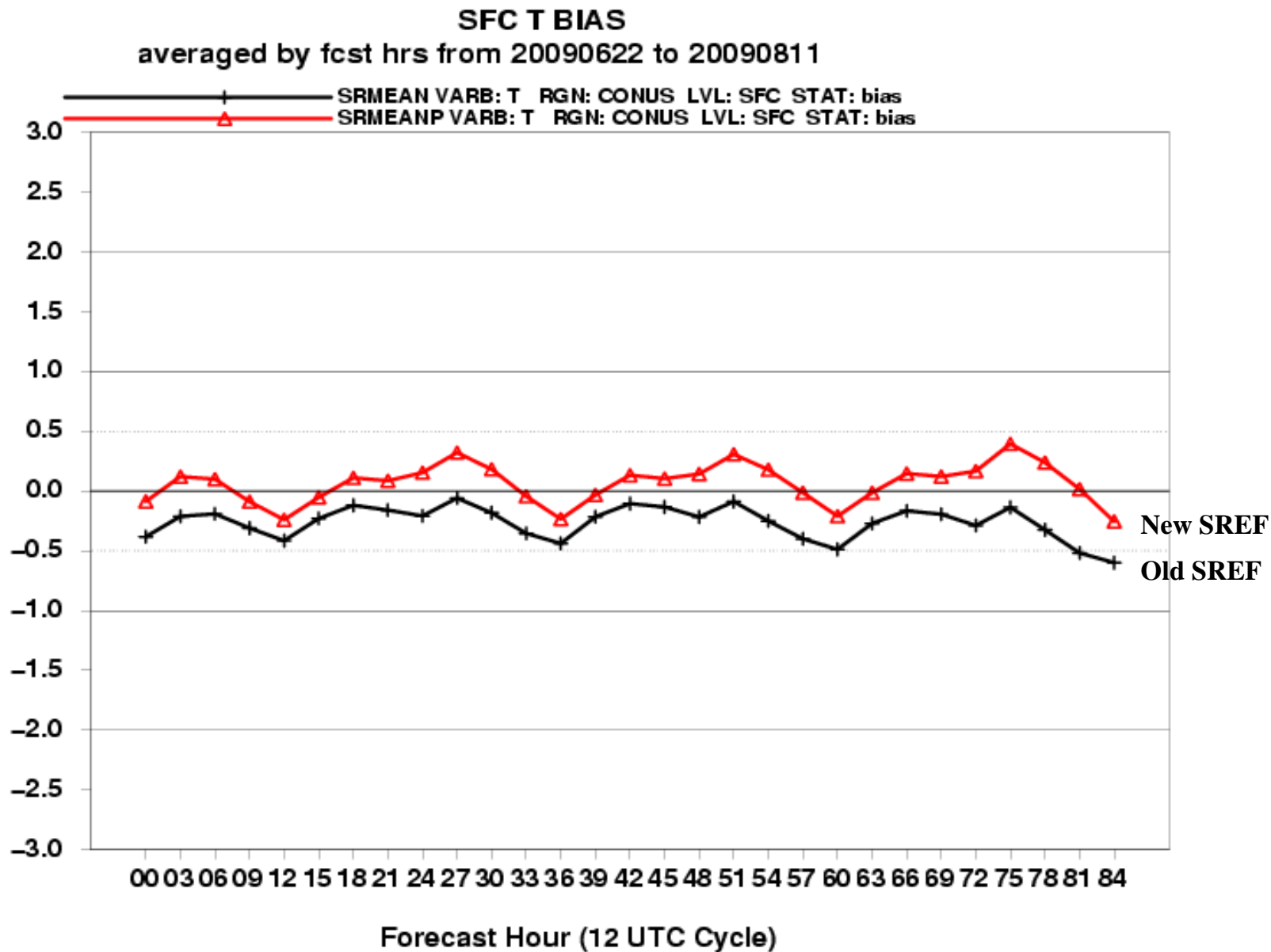


VWND BIAS by pressure from 20090622 to 20090810
for all 84 HR forecasts valid 0000 GMT

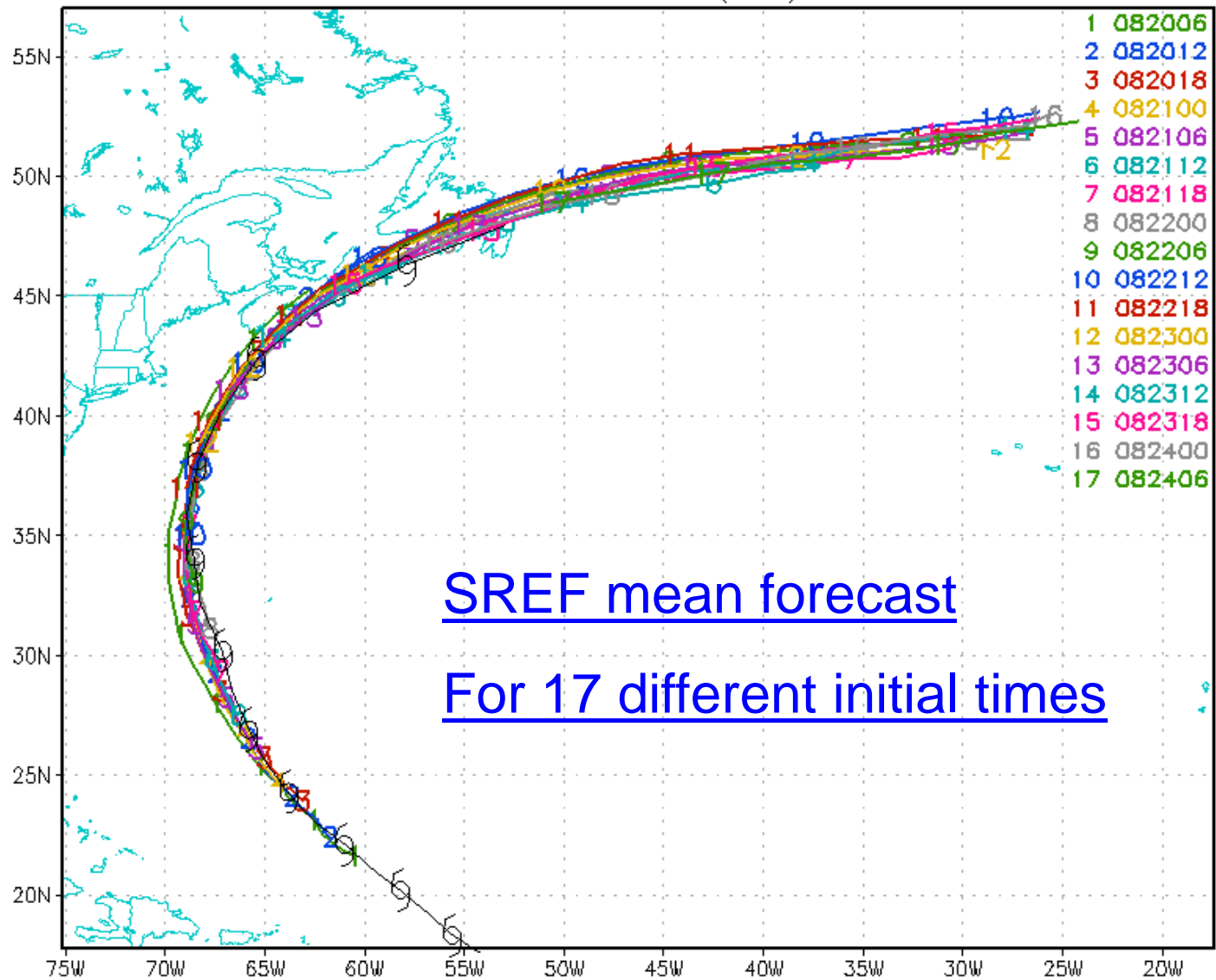
SRMEAN VARB: VWND RGN: CONUS FHR: 84 STAT: bias
SRMEANP VARB: VWND RGN: CONUS FHR: 84 STAT: bias



T2m bias



2009 Tropical Cyclone Tracks
Storm: AL0309 (BILL)



SREF mean forecast

For 17 different initial times

Forecasts: Beginning 2009082006 for SRMN model
Observed: Beginning 2009081400, every 12 hours

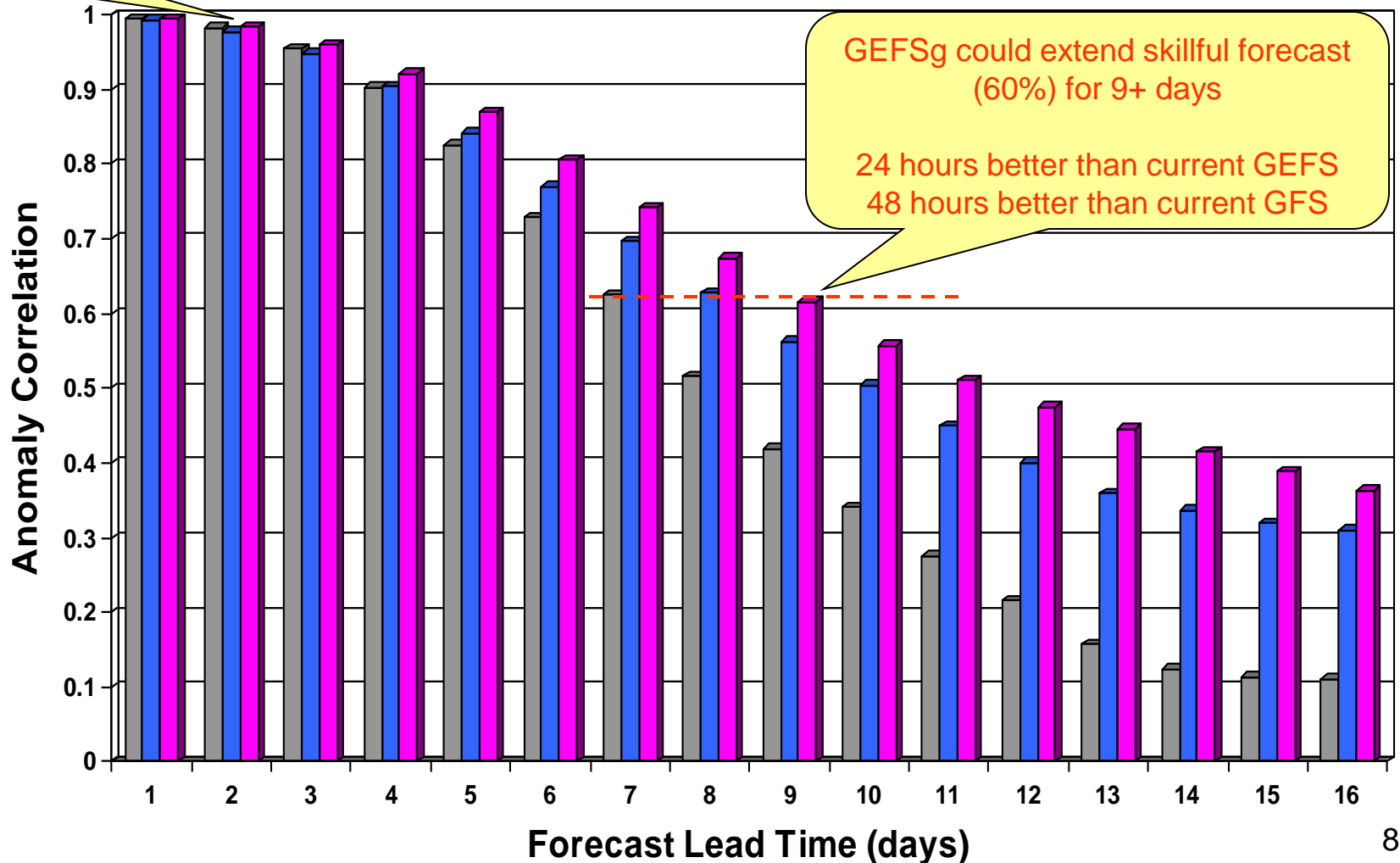
GEFS Implementation (February 23rd 2010)

- Use operational GFS (version 6.0???)
- Upgrade horizontal resolution from T126 to T190
 - 4 cycles per day, 20+1 members per cycle
 - Up to 384 hours (16 days)
- Use 8th order horizontal diffusion for all resolutions
 - Improved forecast skills and ensemble spread
- Introduce ESMF (Earth System Modeling Framework) for GEFS
 - Version 3.1.0rp2
 - Allows concurrent generation of all ensemble members
 - Needed for efficiency of stochastic perturbation scheme
- Add stochastic perturbation scheme to account for random model errors
 - Increased ensemble spread and forecast skill (reliability)
- Add new variables (28 more) to pgrba files
 - Based on user request
 - Supports NAEFS ensemble data exchange
 - From current 52 (variables) to future 80 (variables)

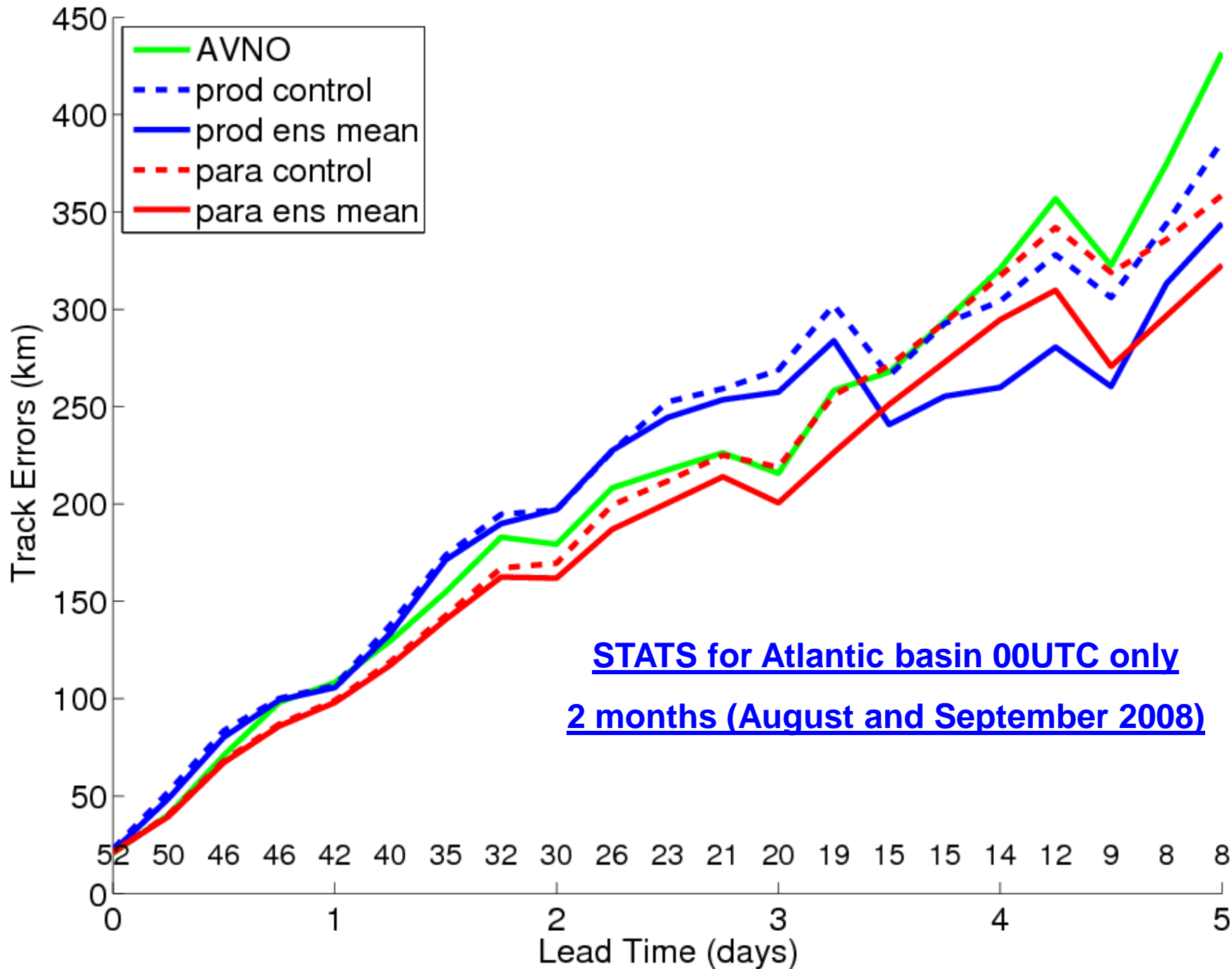
NH Anomaly Correlation for 500hPa Height

Period: August 1st – September 30th 2007

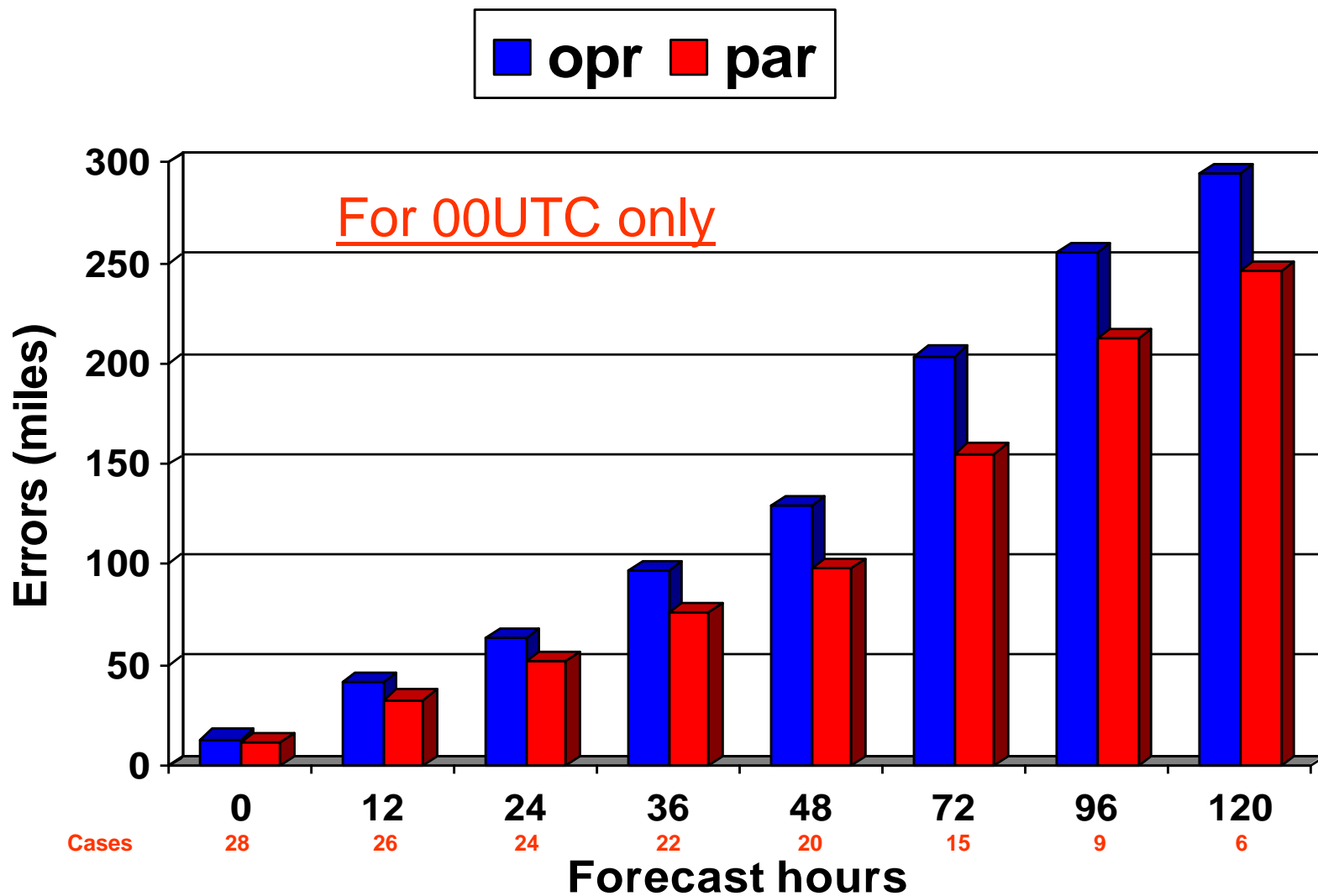
GEFSg is better than GFS at 48 hours



Tropical Cyclone Track Error vs. Fhr – NCEP Ensemble



TS track errors (2009)



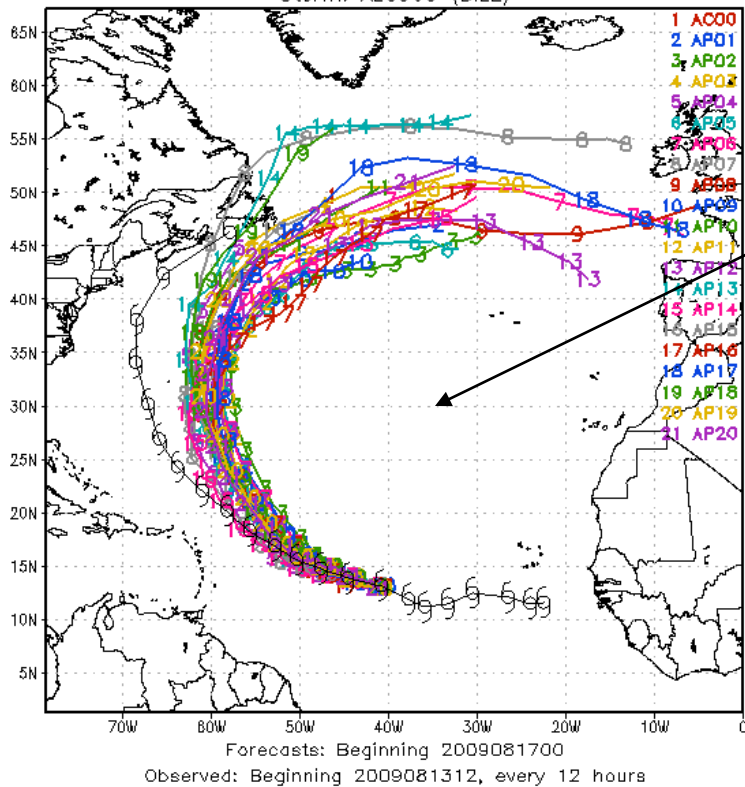
TPC's evaluation



- Tropical Cyclones

- TC Track errors for the new ensemble mean are smaller compared to the operational ensemble mean at most lead times
 - Results varied from case to case
 - Evaluation based on a relatively small sample of cases (1 August-30 September 2008, and selected runs from Bill, Ida, Jimena and Rick in 2009)
- In some cases, the observed TC track now lies within the parallel ensemble envelope where it was outside the operational ensemble envelope
- With the increase in resolution, the vortex tracker is able to follow the TC in more ensemble members at longer time ranges.
- This will help to improve the availability of the ensemble mean, particularly at longer lead times
- **The overall ensemble mean forecast skill and probabilistic forecast skill of the GFS are improved**

IN NEST DOMAIN M1.0:MM=1.0
 2009 Tropical Cyclone Tracks
 Storm: AL0309 (BILL)



Forecasts: Beginning 2009081700
 Observed: Beginning 2009081312, every 12 hours

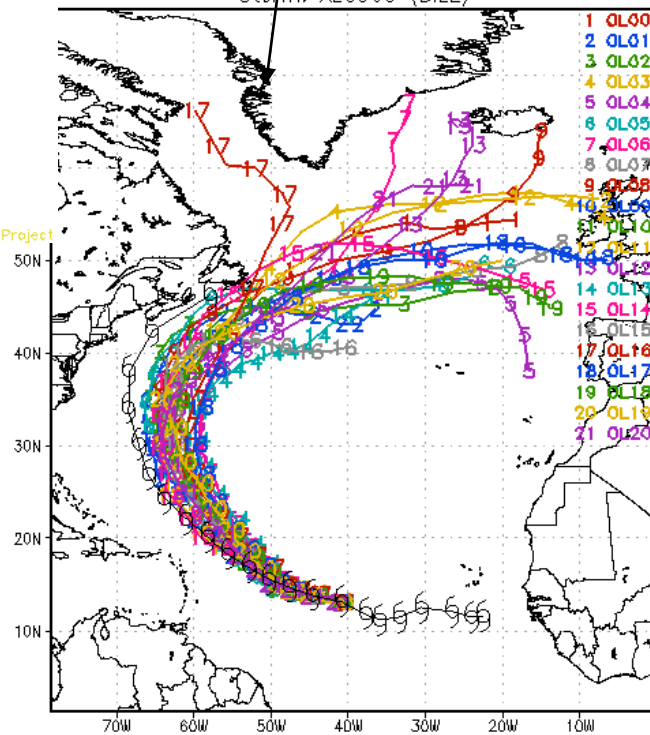
NCEP Hurricane Forecast Project

Hurricane Bill

Operational
(T126L28)

Parallel
(T190L28)

IN NEST DOMAIN M1.0:MM=1.0
 2009 Tropical Cyclone Tracks
 Storm: AL0309 (BILL)



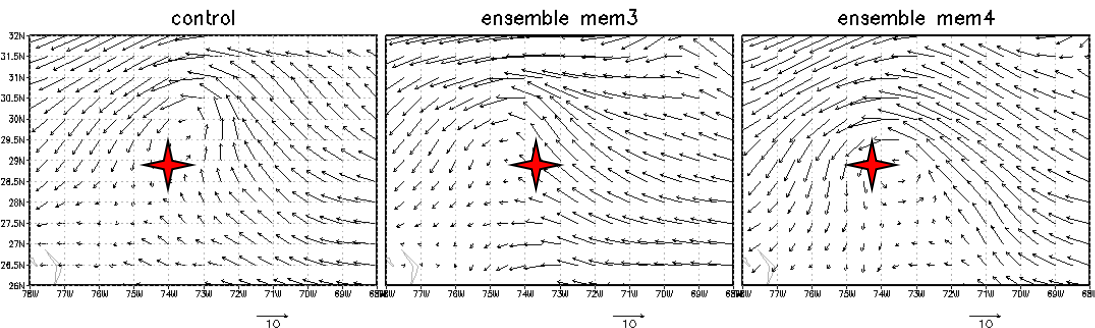
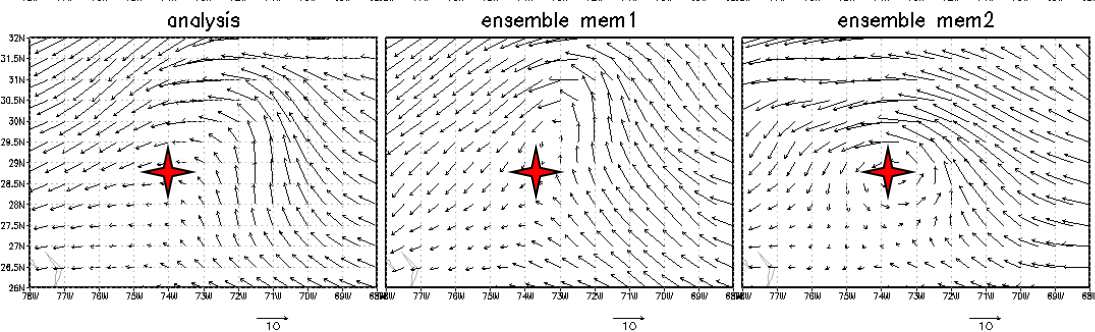
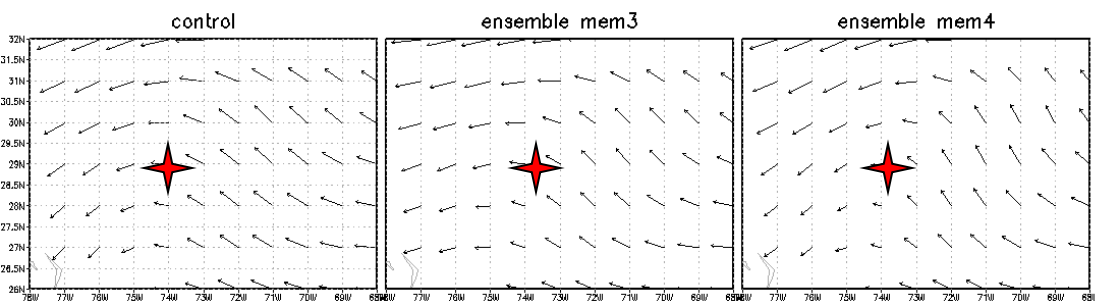
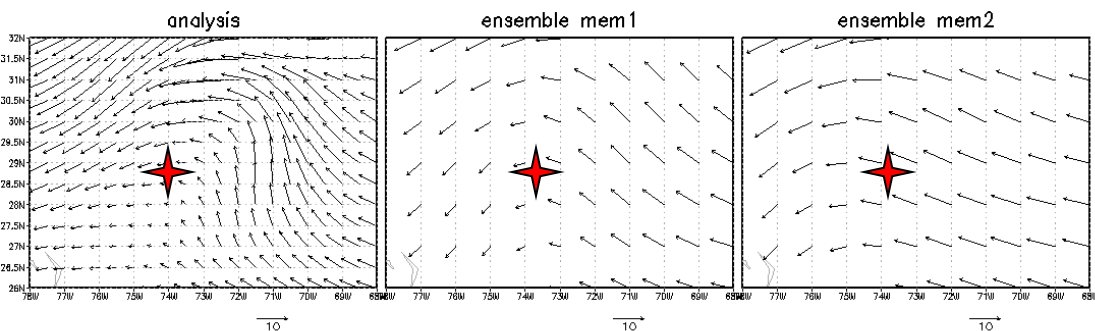
Forecasts: Beginning 2009081700
 Observed: Beginning 2009081312, every 12 hours

NCEP Hurricane Forecast Project

High resolution GEFS T574L64 setting up

- High resolution global ensembles (NCEP/GEFS)
 - T574L64 (~23km horizontal resolution)
 - Initial analysis
 - GSI T382L64 analysis
 - ETR (ensemble transform with rescaling)
 - Every 24 hours (T126L28 and T190L28: every 6 hours)
 - Cycling at T382L64 resolution
 - NCEP/CCS
 - No tuning for rescaling (using T126's tuning parameters)
 - Upgrade to T574L64
 - Integrations
 - At Texas Advanced Computing Center (TACC)
 - Use GFS model at T574L64 resolution
 - 5 members (include control)
 - Out to 168 hours
 - No stochastic perturbations
 - Experiments
 - Once per day for period of Sept. 1st – 20th 2009
 - Output
 - Tracks for each members, ensemble mean

1000mb Wind for 24hr from 2009092000



Hurricane Fred (07L)

Fred (07L) was reduced to Tropical depression after 2009092100

24-hr 1000hPa winds forecast from 2009092000

Top 6 panels (left):
GSI verify analysis with operational GEFS (T126 -90km)

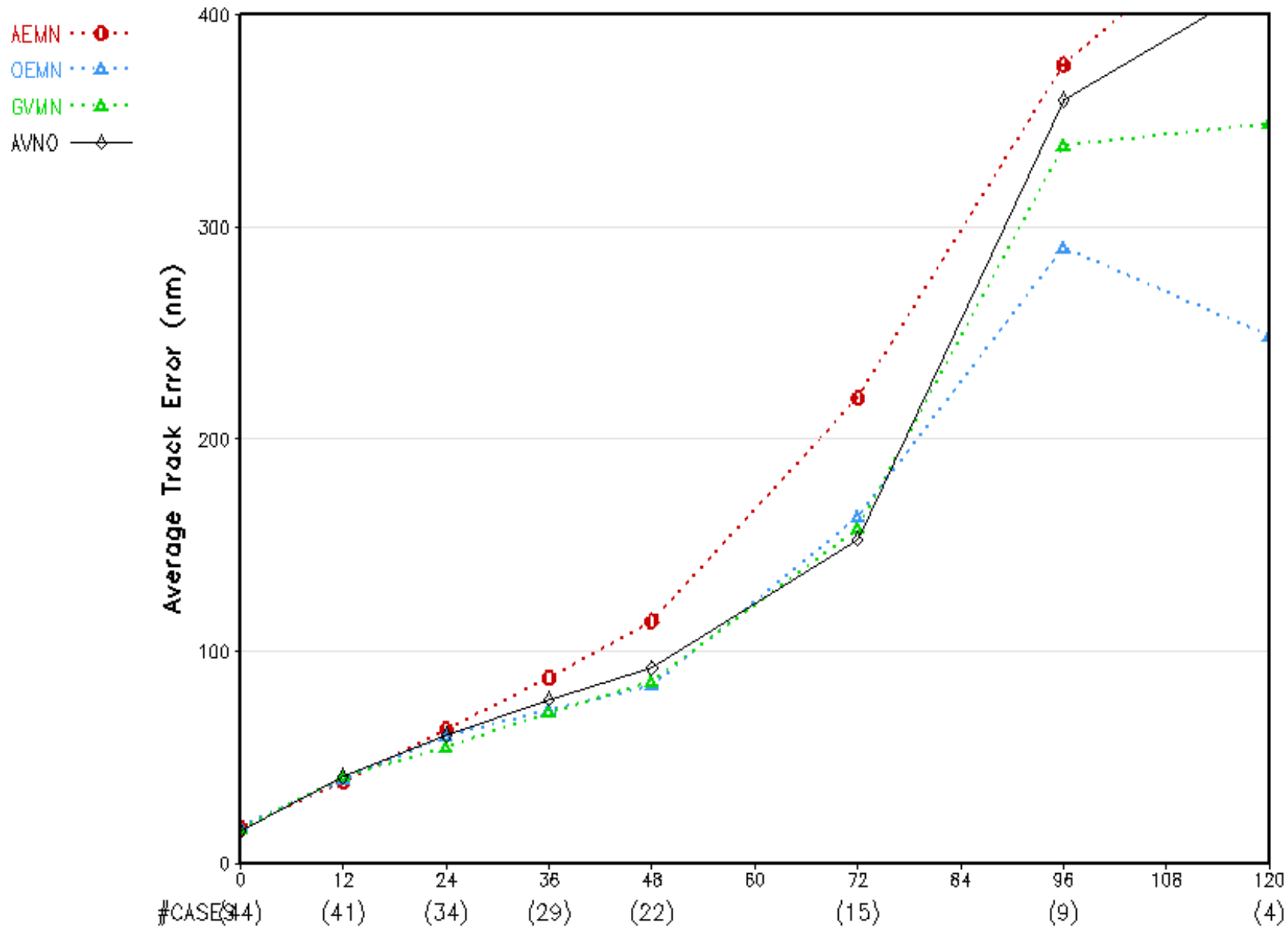
Bottom 6 panels (left):
GSI verify analysis with high resolution GEFS (T574 - 23km)

Results:

High resolution ensemble with high resolution initial perturbations recycling (at T382) could catch up a storm development very well

[Plots from Jessie Ma](#)

Track Forecast Error for 2009 AL/EP/WP Storms
 GEFS operational(AEMN):Parallel(OEMN):T574L64(GVMN)



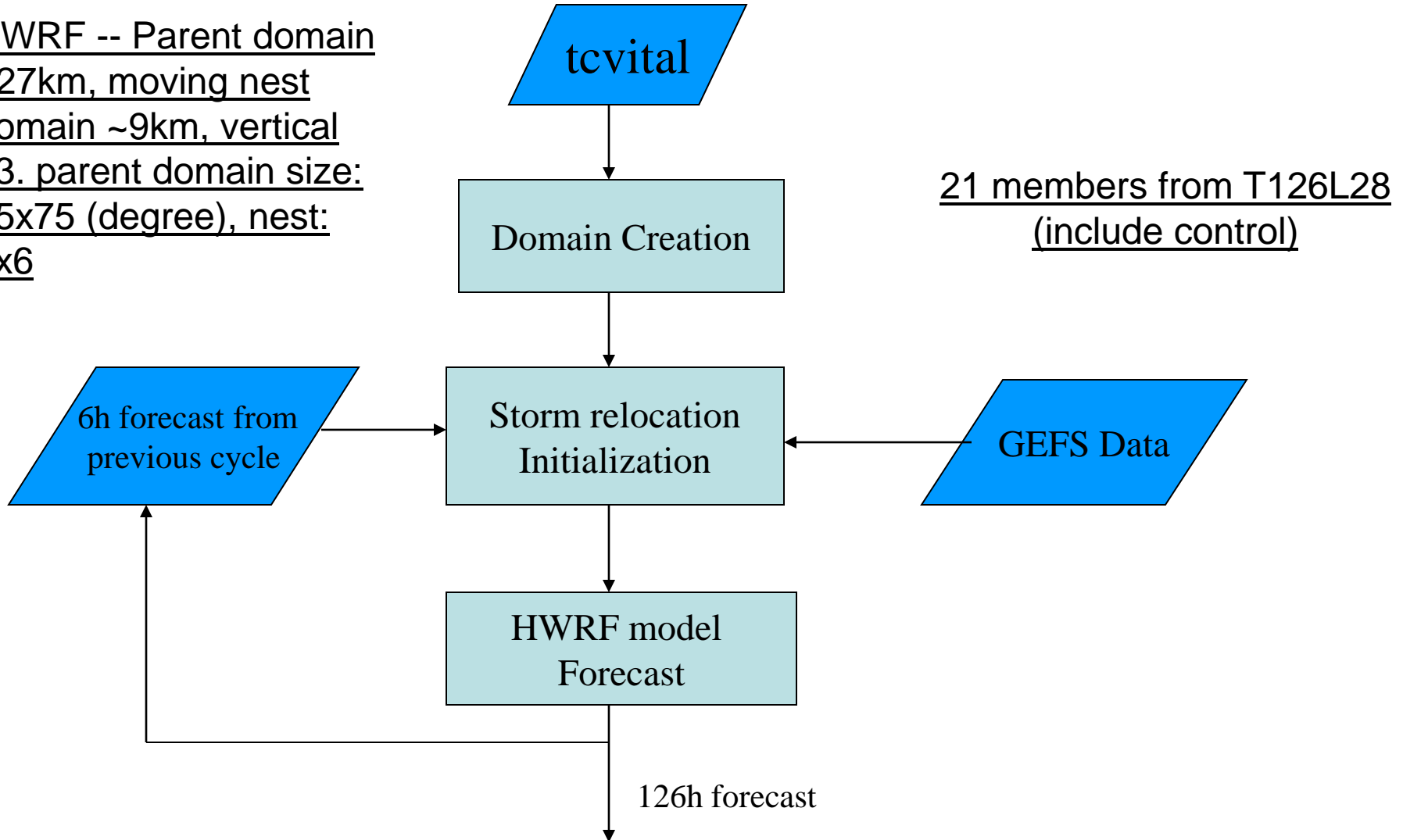
Conclusions and Plans

- Overall: GEFS T190L28 package is excellent
 - It has been implemented (February 23rd 2010)
- T574L64 is not that good comparing to T190L28 (because)
 - No tuning for rescaling parameters
 - 24hr cycling instead of 6hr cycling
 - Without stochastic perturbations
 - 64 levels (against 28 levels)
 - Horizontal diffusion (already 8th order)
- Resolution is important
 - Higher is better if we have tuned system for
 - Don't know which resolution is good for ensemble for current GFS
- Membership is important
 - Large membership is good for probabilistic forecast (optimum: 40-50?)
 - Less contribute to ensemble mean
 - Multi-model ensembles (need to work on)
- Set up T574L64 by using new ensemble, new GFS (v8.0)
 - 6-hr cycling instead 24-hr cycling
 - Stochastic perturbations
 - Parameters tuned (may need tune again, costs??)

HWRF Ensemble Flow Chart for Each Member

- Zhan Zhang

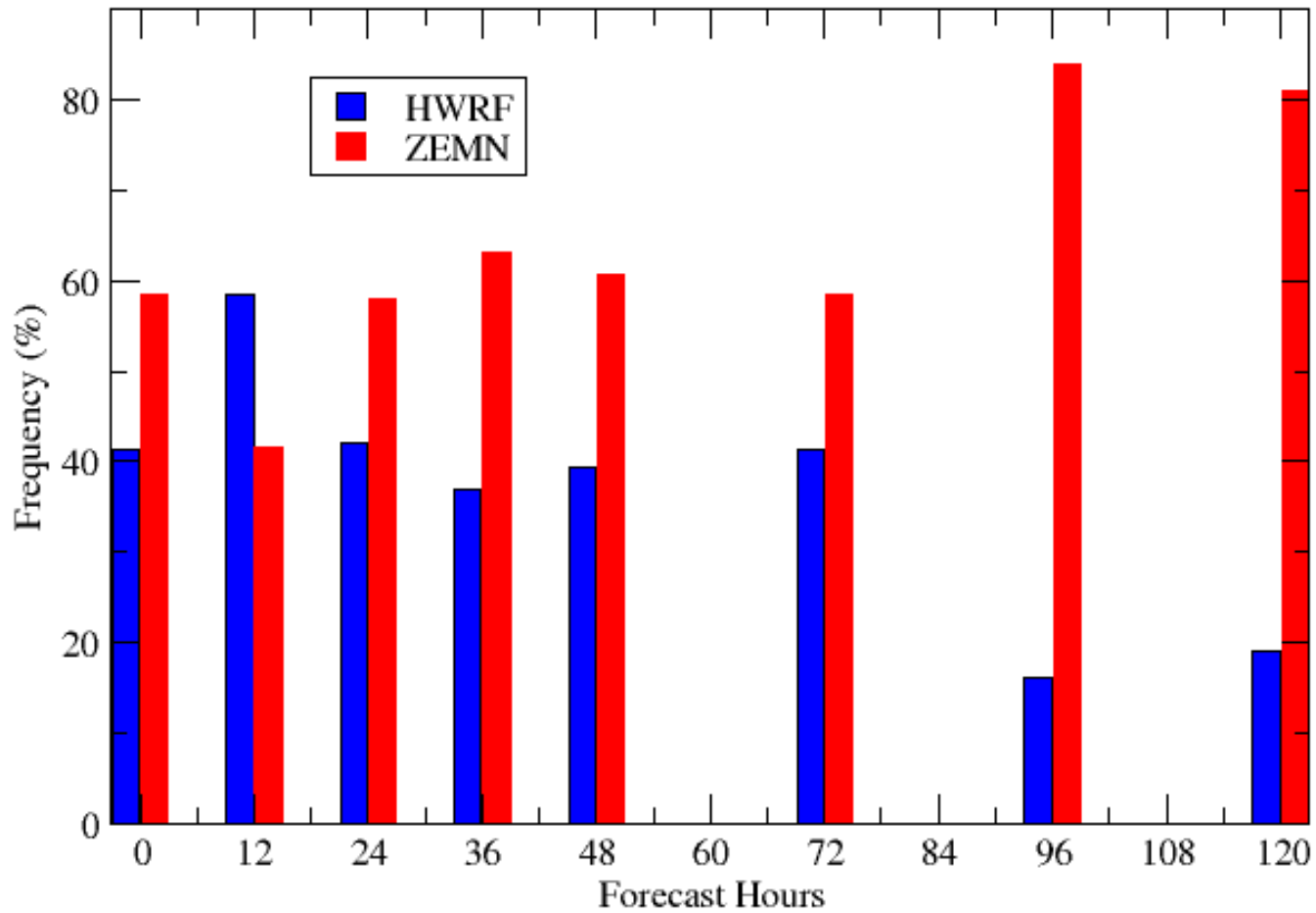
HWRF -- Parent domain
~27km, moving nest
domain ~9km, vertical
43. parent domain size:
75x75 (degree), nest:
6x6



21 members from T126L28
(include control)

Track Error -- Frequency of Superior Performance (%)

Hurricane Hanna 2008



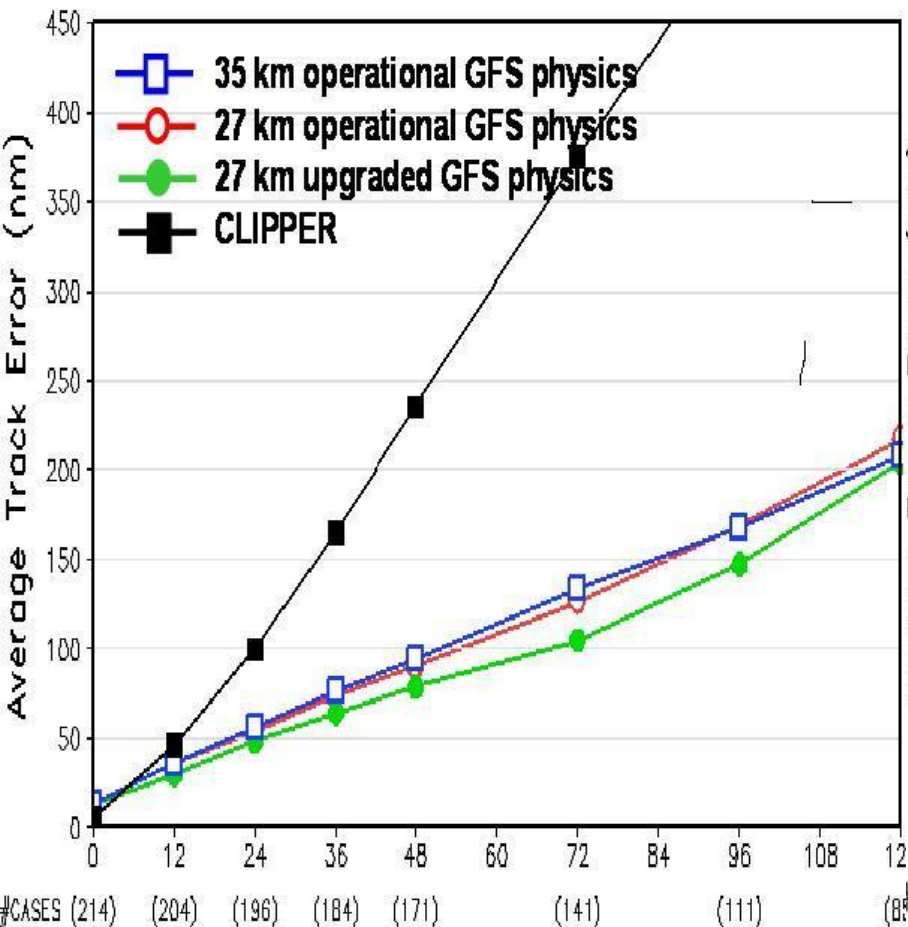
NEXT GFS implementation

- John Ward

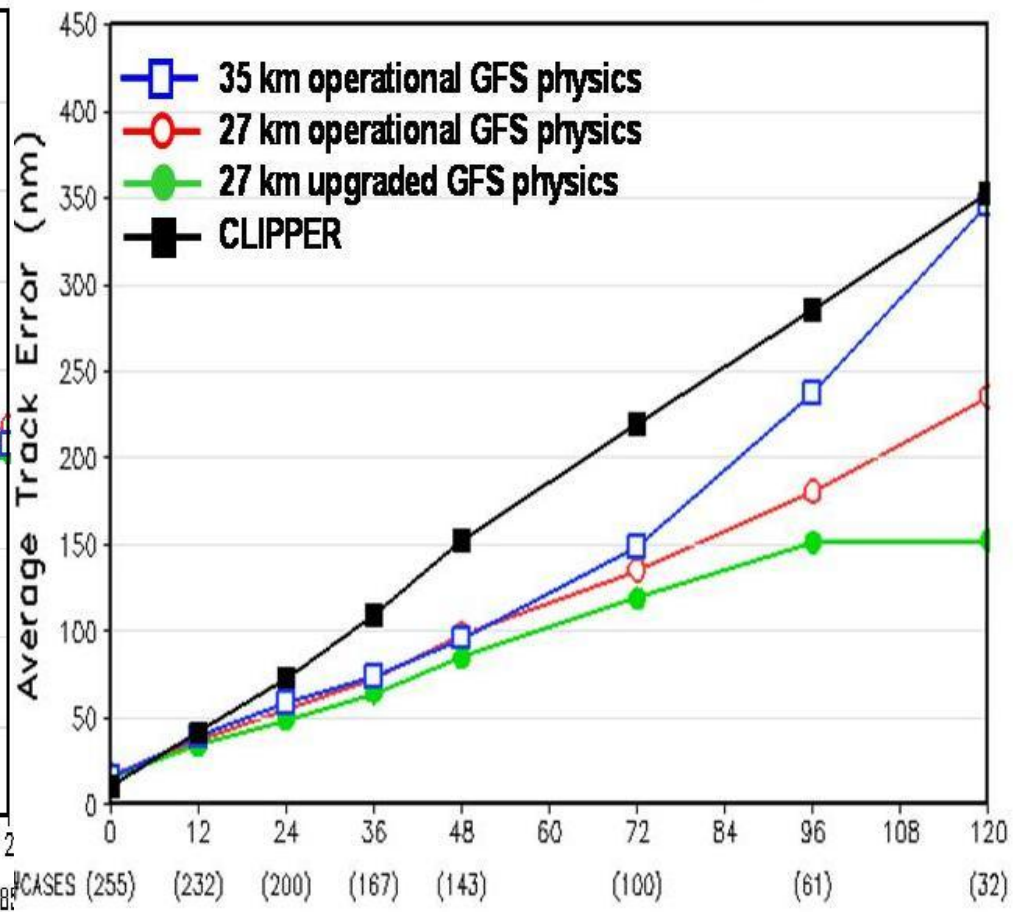
- GFS upgrades (Planned for June **2010**)
 - Resolution increase (27 km from 35 km)
 - Upgrade radiation to AER RRTM2
 - Revised Gravity Wave Drag and Mountain Blocking
 - Removal of negative water vapor with a positive-definite tracer transport scheme (enhances impact of satellite radiance data)
 - Higher resolution hurricane relocation
 - Major upgrades to shallow convection, PBL, deep convection with overshooting cloud tops (minimizes grid point storms)

TC scores for 2008 hurricane season (NCEP GFS)

Hurricane Track Error Comparison - Atlantic 2008
Cristobal_Dolly_Fay_Gustav_Hanna_Ike_Omar_4cyc

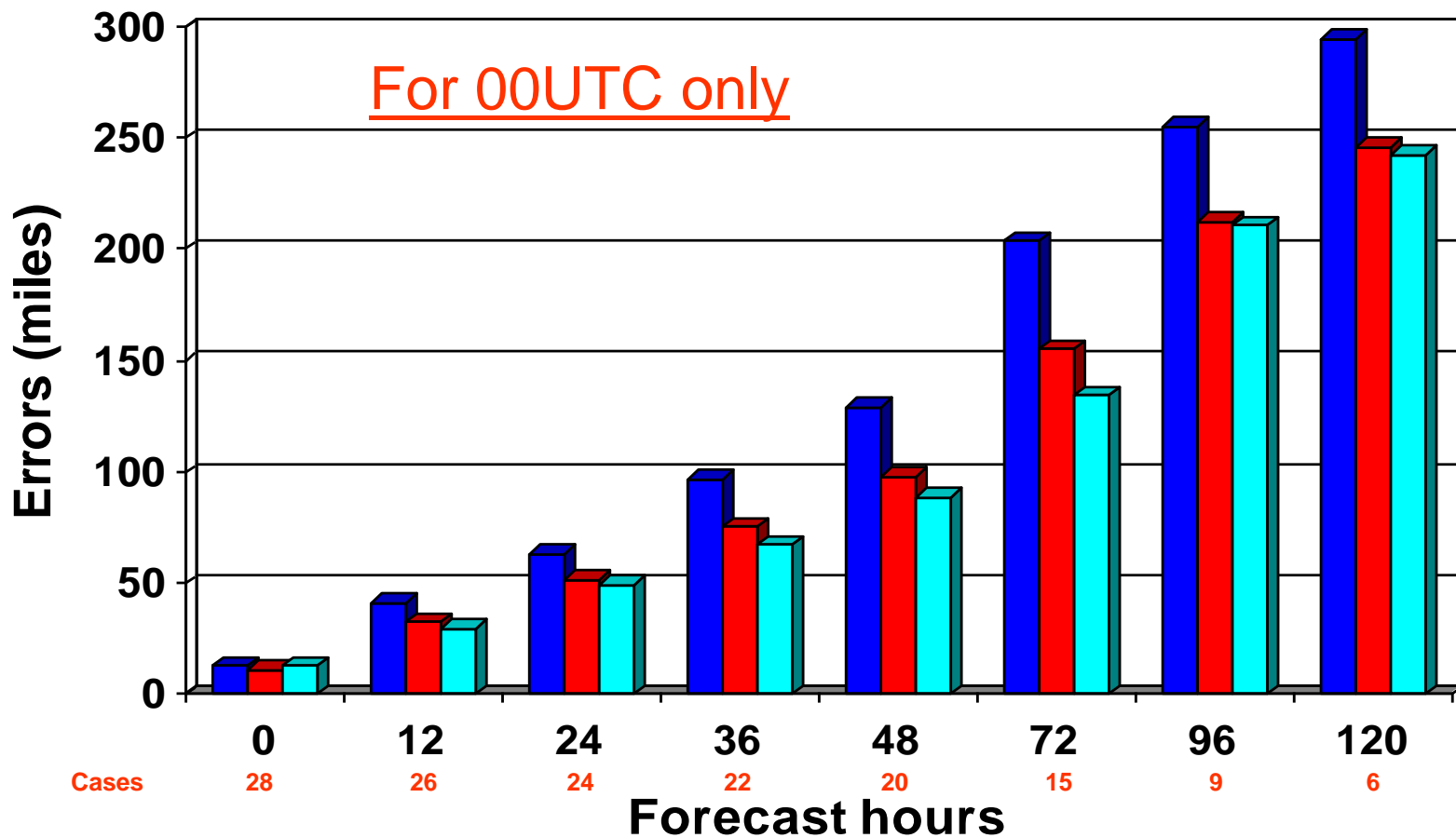


Hurricane Track Error Comparison - East-Pacific 2008
20080602_20081110_4cyc



Background!!!

TS track errors (2009)



HWRF FY2010 Test Plan and Results

- Vijay Tallapragada and etc..

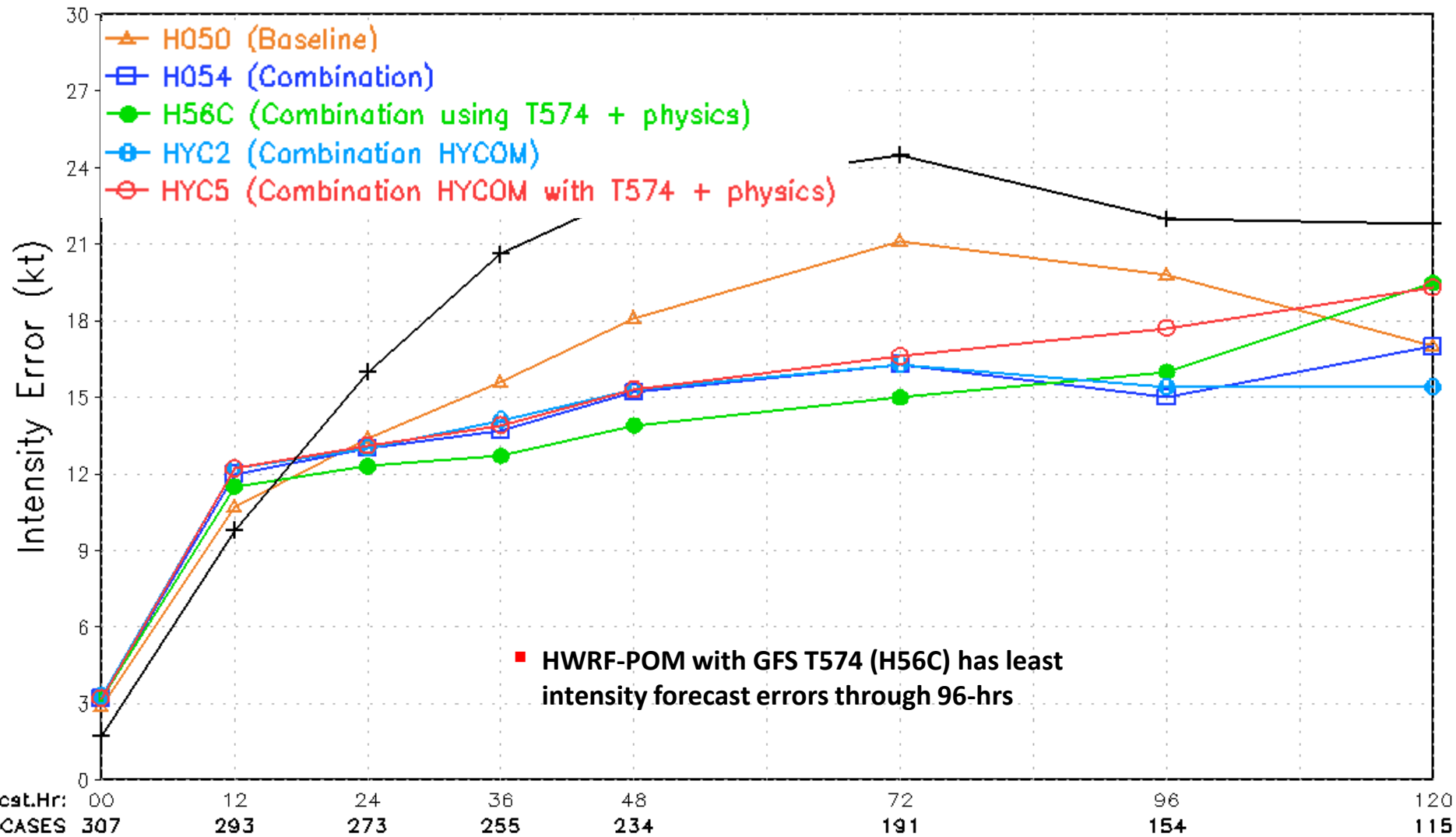
- **Define new baseline (benchmark) based on 2009 operational HWRF (H050)**
 - Include bug fixes for land surface temperature, radiation, advection of vertical velocity.
- **Proposed upgrades for 2010 HWRF implementation**
 1. Include changes to initialization (use of satellite data in 9km nest) (H051)
 2. Include new surface physics specification for Cd/Ch (H052)
 3. Gravity wave drag parameterization (H053)
- **Evaluated each of the above individual upgrades against the benchmark configuration (H054)**
- **Combine (1), (2), (3) for final pre-implementation testing using current operational GFS as well as proposed upgrades to GFS (T574 + physics) (H56C)**
- **Comprehensive testing and evaluation plan designed and executed in close collaboration with NHC forecasters , and included about 315 Atlantic and 295 East Pac individual 5-day forecasts**
- **Test results positive for both the current operational GDAS/GFS and the planned T574 with upgraded physics, for both Atlantic and Eastern Pacific basins**
- **Results in the Atlantic and East Pacific suggest that NCEP can deliver an improved operational configuration of HWRF-POM in terms of track and intensity error/bias.**
 - H56C (GFS Phase 2) generally has higher percent of superior performance for track and intensity forecasts for both Atlantic and East-Pac basins
- **HWRF FY2010 test plan also included evaluating HWRF coupled to HYCOM in the Atlantic basin. Results from these experiments indicated loss of intensity forecast skill compared to H56C.**

Average Intensity Errors (kt)

Statistics Plots – FY2010 HWRF Expts. 2008–09 ATL

▲ H050 (Baseline)
 ● H56C (Combination using T574 + physics)
 ◆ HYC2 (Combination HYCOM)

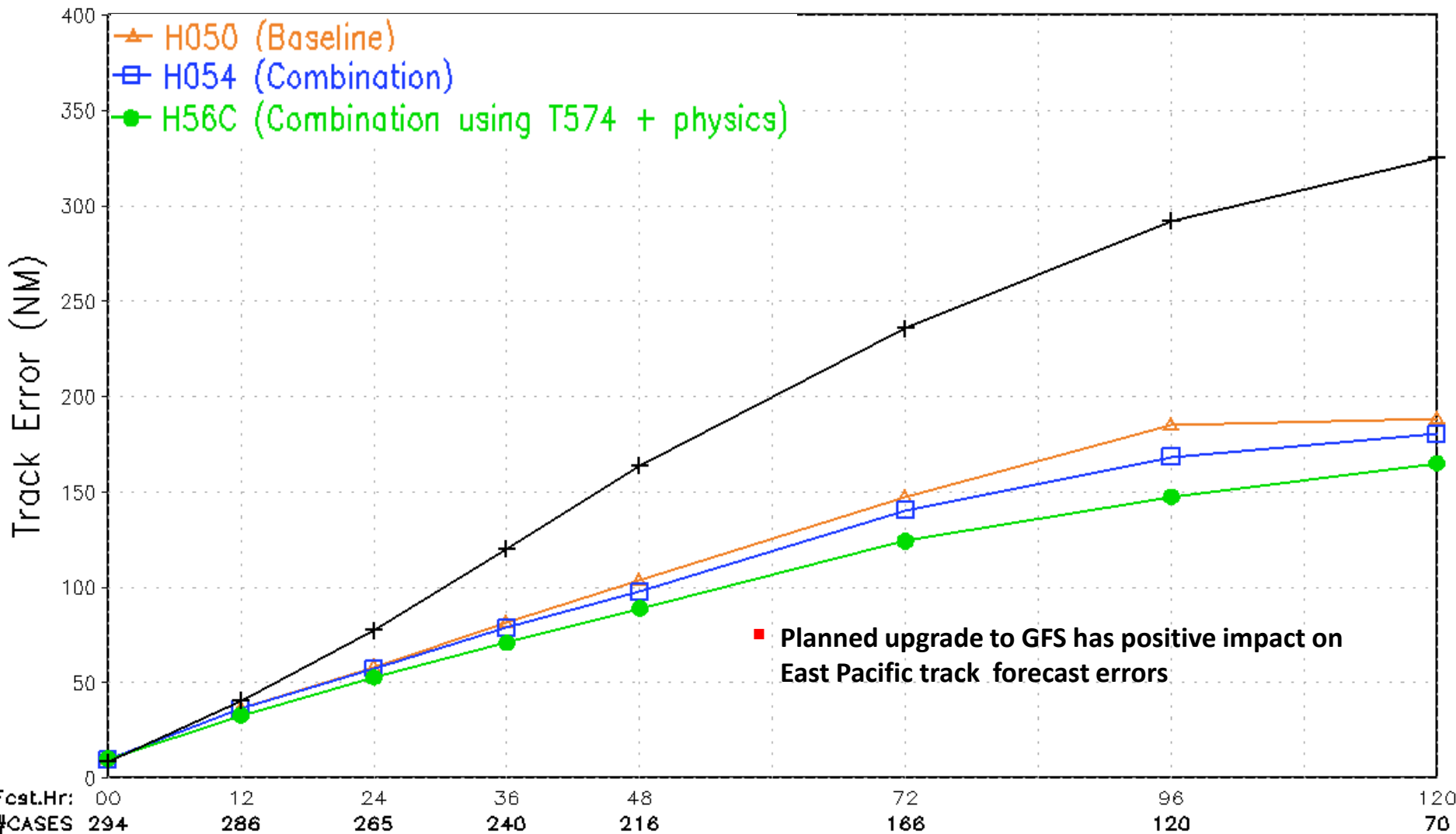
■ H054 (Combination)
 ○ HYC5 (Combination HYCOM with T574 + physics)
 + SHF5



Average Track Errors (NM)

Statistics Plots – FY2010 HWRF Expts. 2008–09 EAST–PAC

- ▲ H050 (Baseline)
- H56C (Combination using T574 + physics)
- H054 (Combination)
- + CLIPER

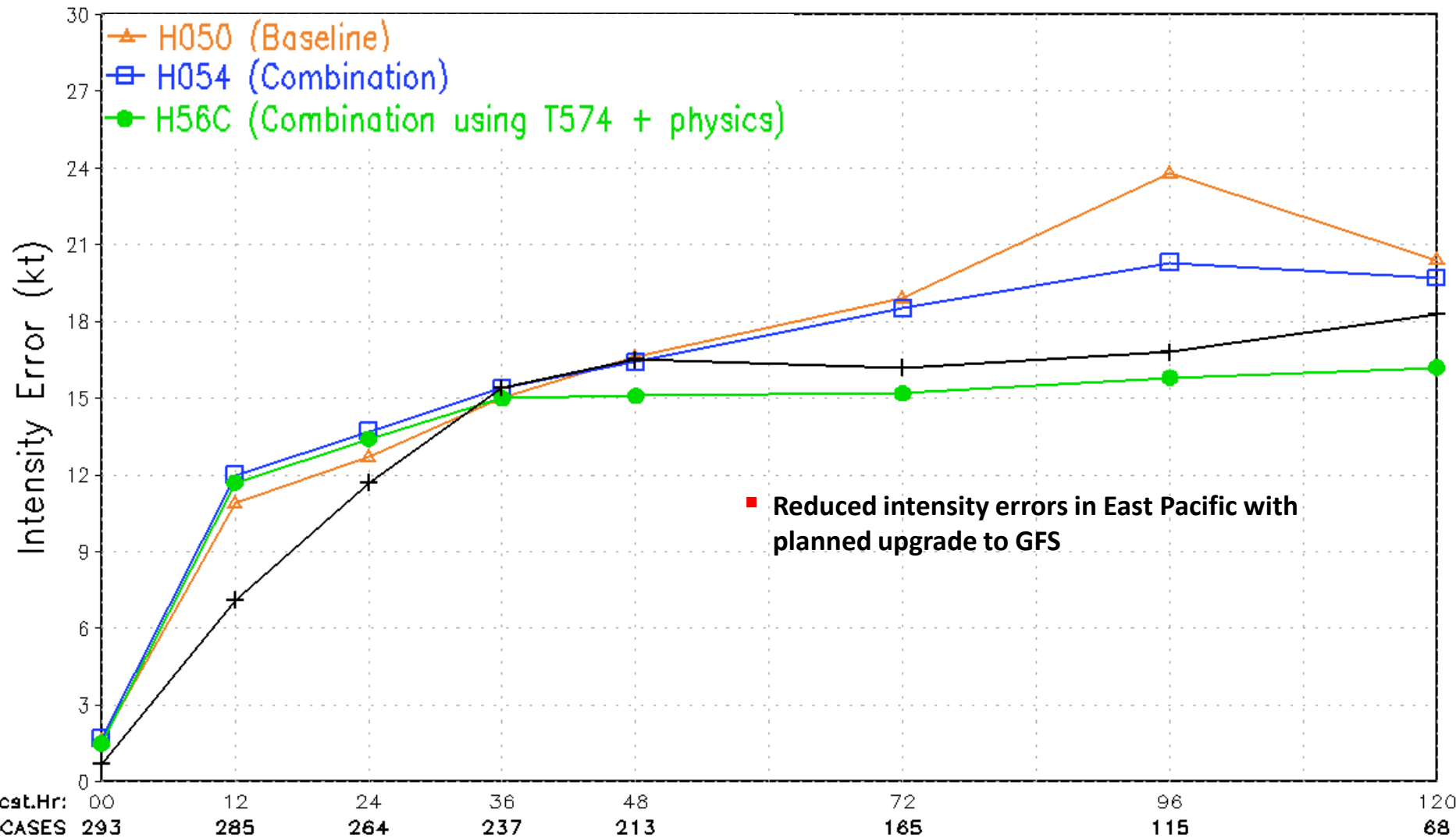


■ Planned upgrade to GFS has positive impact on East Pacific track forecast errors

Average Intensity Errors (kt)

Statistics Plots – FY2010 HWRF Expts. 2008–09 EAST–PAC

▲ H050 (Baseline) ● H56C (Combination using T574 + physics)
■ H054 (Combination) + DSHP

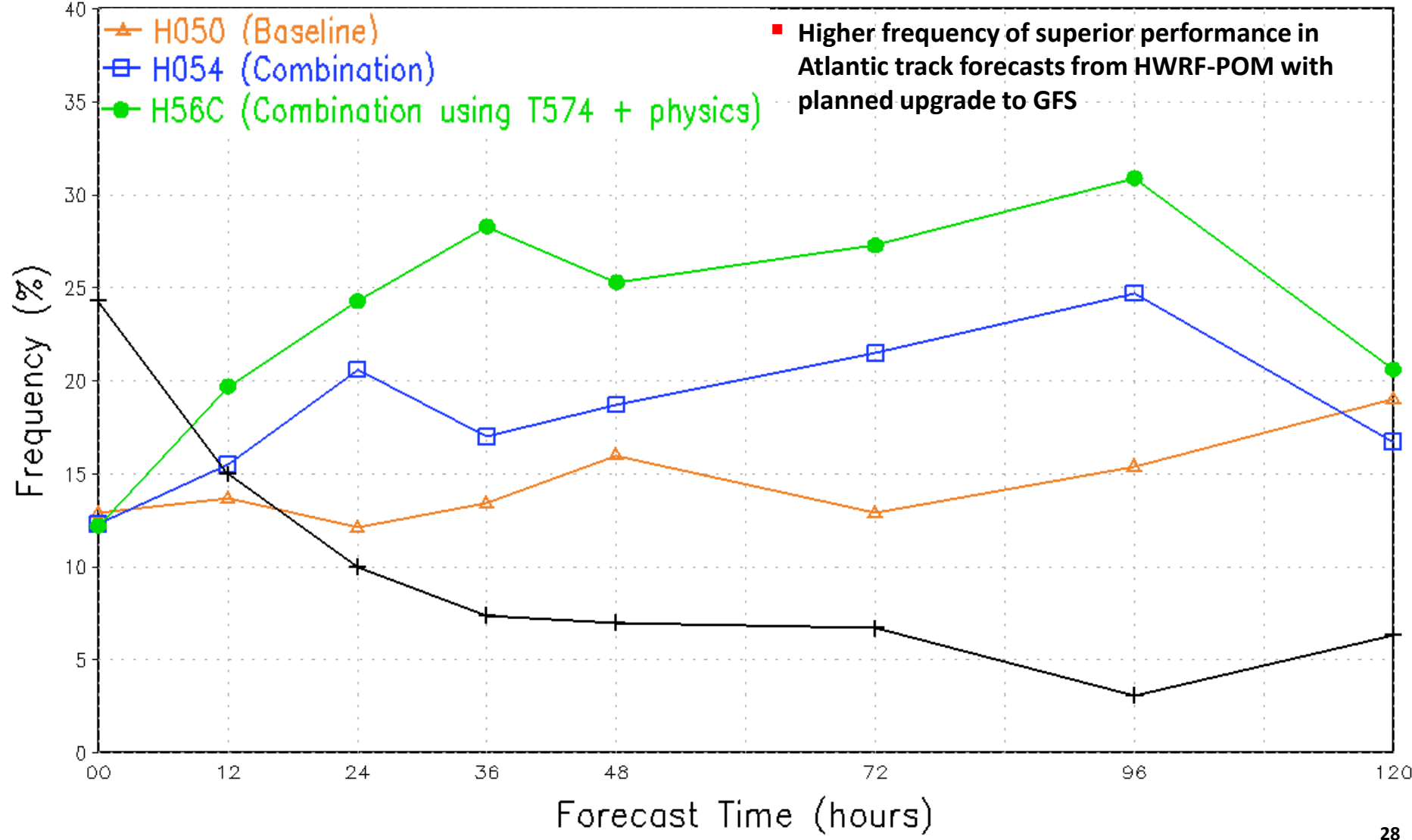


Fcast.Hr: 00 12 24 36 48 72 96 120
#CASES 293 285 264 237 213 165 115 68

Track Errors – Frequency of Superior Performance (%)

Statistics Plots – FY2010 HWRF Expts. 2008–09 ATL

- ▲ H050 (Baseline)
- H56C (Combination using T574 + physics)
- H054 (Combination)
- ✦ CLIPER



Track Errors – Frequency of Superior Performance (%)

Statistics Plots – FY2010 HWRF Expts. 2008–09 EAST–PAC

- ▲ H050 (Baseline)
- H054 (Combination)
- H56C (Combination using T574 + physics)
- + CLIPER

