Impact of Satellite Data and Aircraft Reconnaissance Data in 2013 HWRF

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Assimilation of Satellite Data in HWRF

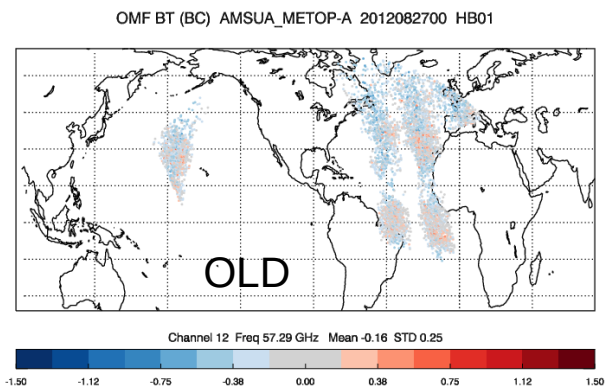
Radiances

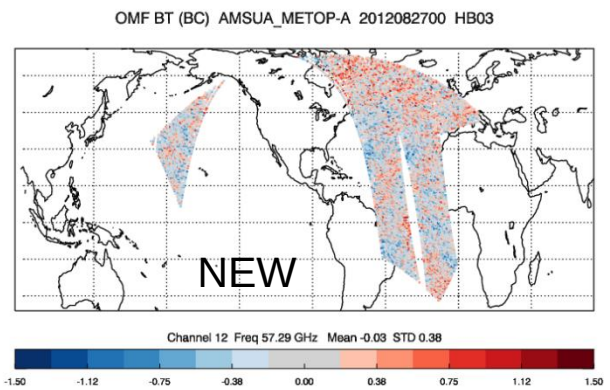
GPSRO bending angles

Cloud track winds

Assimilation of Satellite Radiances in Basin-scale HWRF

- **Current Issues**
  - Short cycling period and variable sample size make the spin up of bias correction problematic
  - Lower model top (2 hPa) makes the use of high peaking channels difficult
  - No ozone profiles in HWRF background and this may lead to biases in the simulated brightness temperature, especially for IR instruments
- **Solutions**
  - Use global-regional blended vertical coordinate to obtain better vertical resolution in stratosphere and extend the model top up to 0.3 hPa
  - Use bias correction estimation from GFS
  - Use ozone profiles from GFS in HWRF
- **Improvements**
  - More data assimilated in the upper troposphere and stratosphere
  - Cost function for minimization greatly reduced for IR instruments





Penalty **Used Obs. Count**

	IASI	AIRS
OLD	0.62 307743	0.60 176881
NEW	0.23 382407	0.26 218753

Assimilation of Satellite Data in 2013 HWRF

- 61 model levels with model top at 2 hPa
- Background with FGAT (for both D1 and ghost domains)
- Use global-regional blended vertical coordinate (76 levels)
- Use GFS ozone guess field
- Satellite data assimilated in D1 domain (27 km)
  - Calibrated radiances (AMSU-A, ATMS, MHS, AIRS, IASI, HIRS4, GOES Sounders)
  - GPSRO blending angles
  - Satellite derived winds (IR/VIS cloud drift winds, water vapor winds)
- Satellite data assimilation in ghost domain failed (experiment crashed during analysis step), need more investigation
  - No satellite data in ghost domain (3km)
- Conventional data and TDR data only in ghost domain (3km)

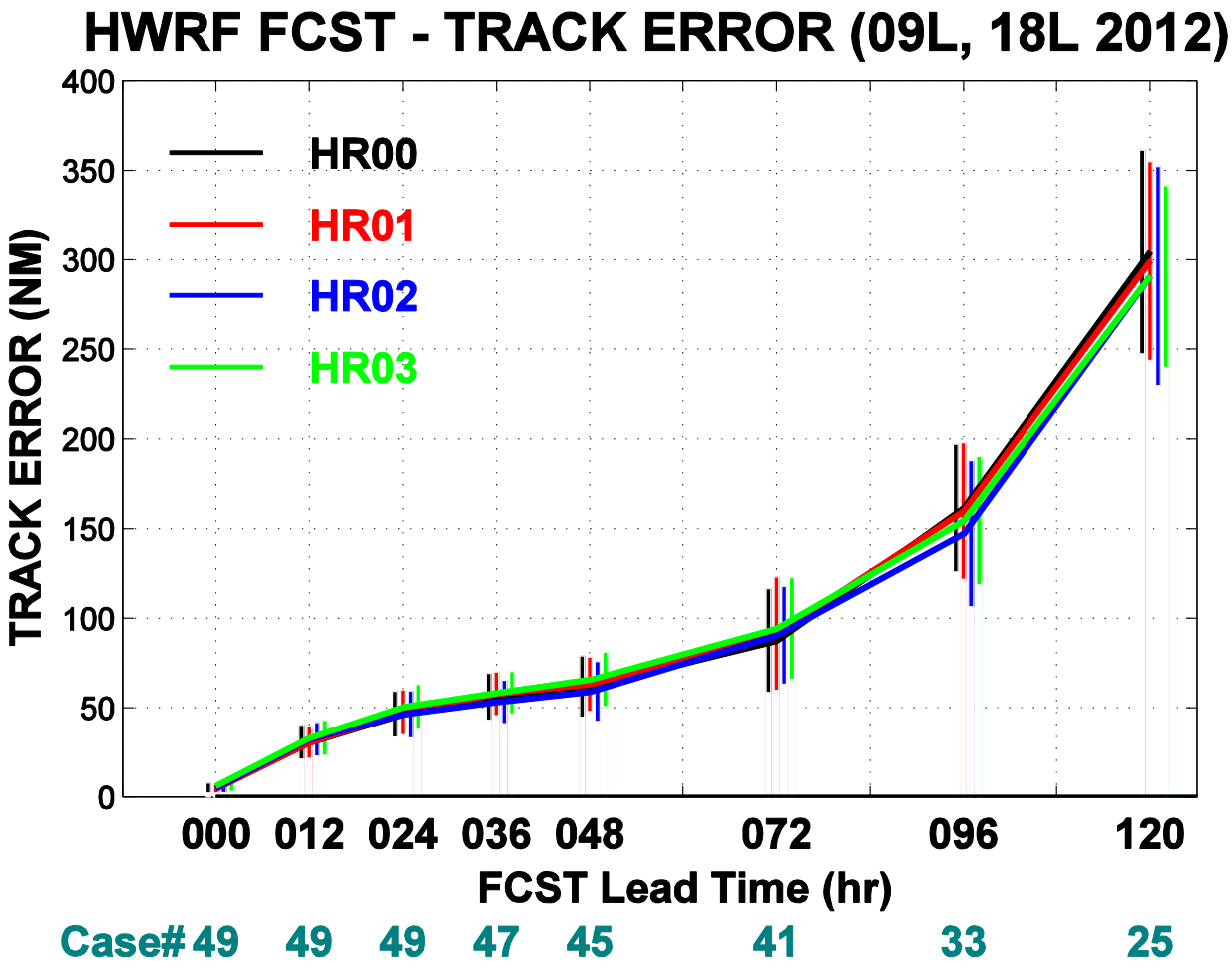
Sanity check on blending

	EXP1	EXP2	EXP3
D01	FGAT on Blending **on** Radiances assimilated	FGAT on Blending **on** Radiances assimilated	FGAT on Blending **off** Radiances assimilated
D02	FGAT on Blending **on** Radiances assimilated Blew up with NaN	FGAT on Blending **off** Radiances assimilated Blew up with NaN	FGAT on Blending **off** Radiances assimilated Blew up with NaN

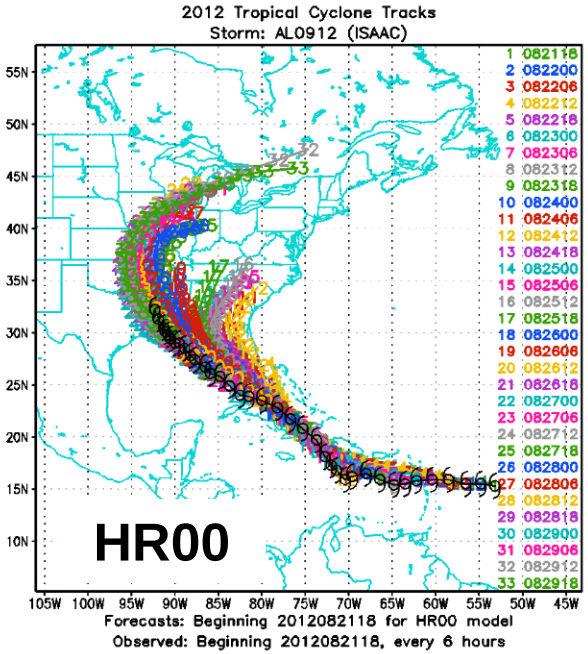
GFS-HWRF blended vertical coordinate is not the cause of the blow up in ghost domain

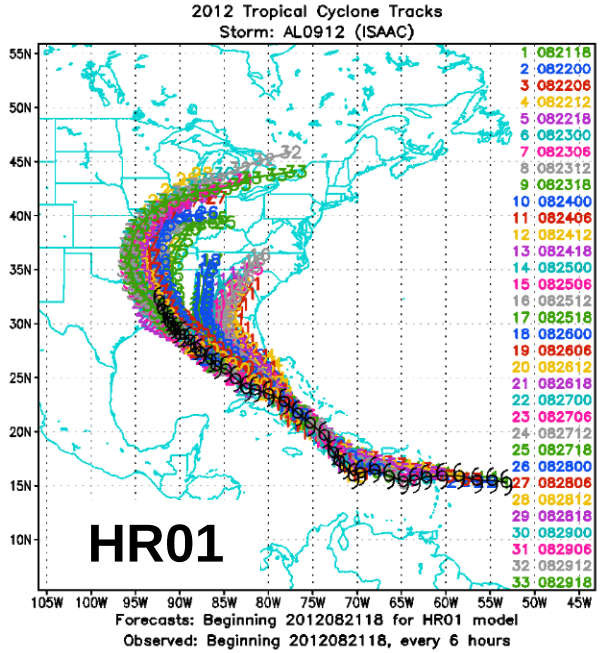
Experiments with satellite data

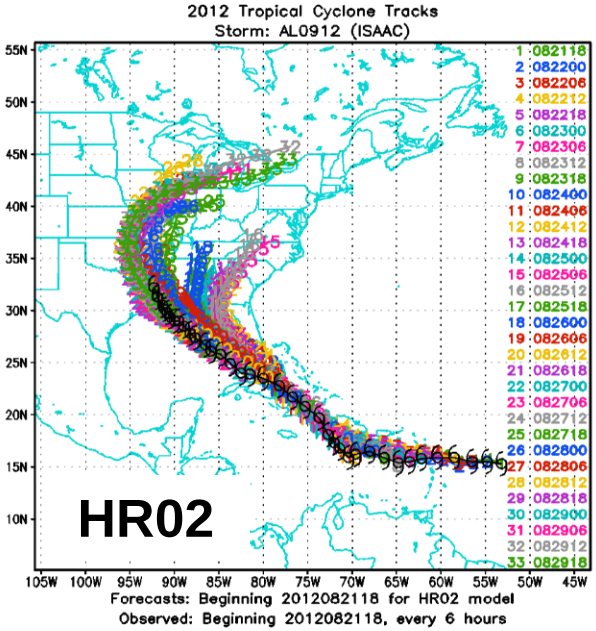
EXPID	Description
HR00	Control Conventional Data in both D1 and ghost domain Ghost domain activated when TDR is available
HR01	Conventional and satellite data in D1 domain Thinning box size: 145 km for both MW and IR instruments Conventional and TDR data in ghost domain Ghost domain is activated when TDR is available
HR02	Same as HR01; thinning box size: 120 km for IR; 60 km for MW
HR03	Same as HR01; thinning box size: 90 km for IR; 45 km for MW

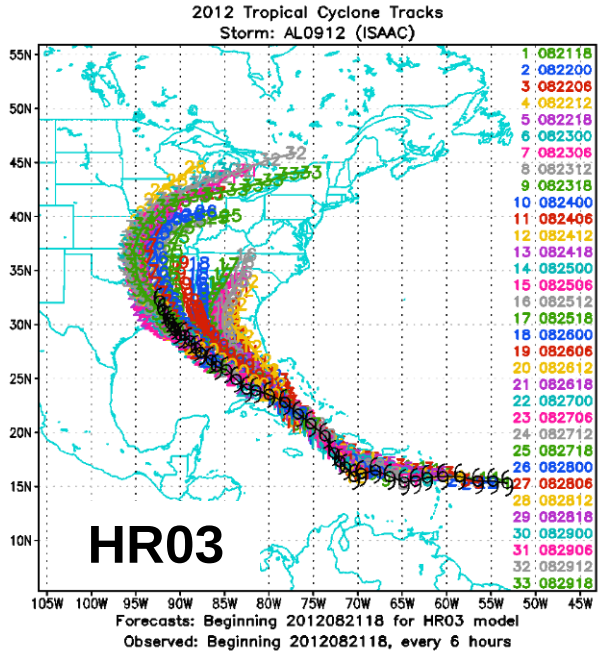

HWRF FCST - TRACK ERROR (09L, 18L 2012)
TRACK ERROR (NM)
400
350
300
250
200
150
100
50
0
HR00
HR01
HR02
HR03
000 012 024 036 048 072 096 120
FCST Lead Time (hr)
Case# 49 49 49 47 45 41 33 25

ISAAC TRACK FORECASTS

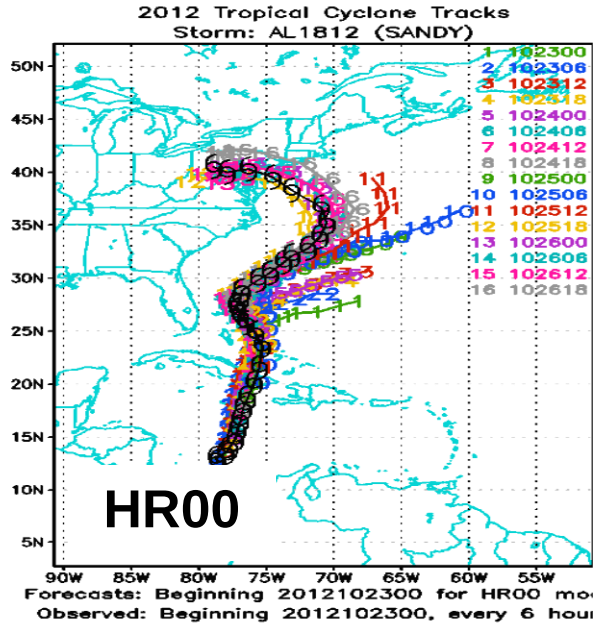


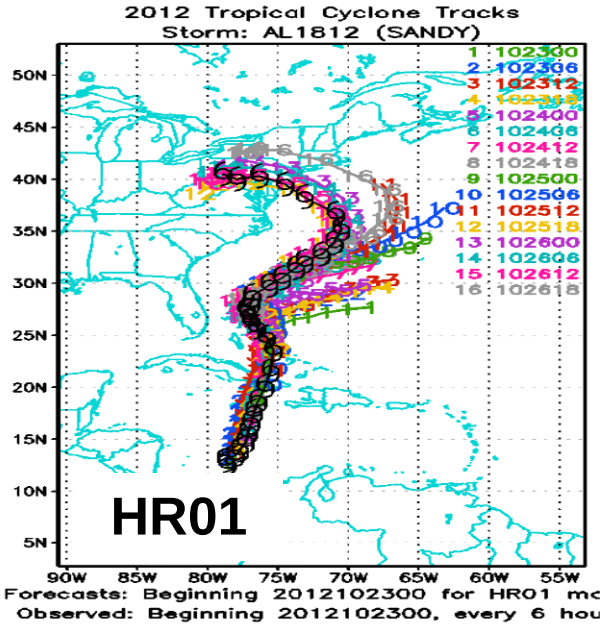


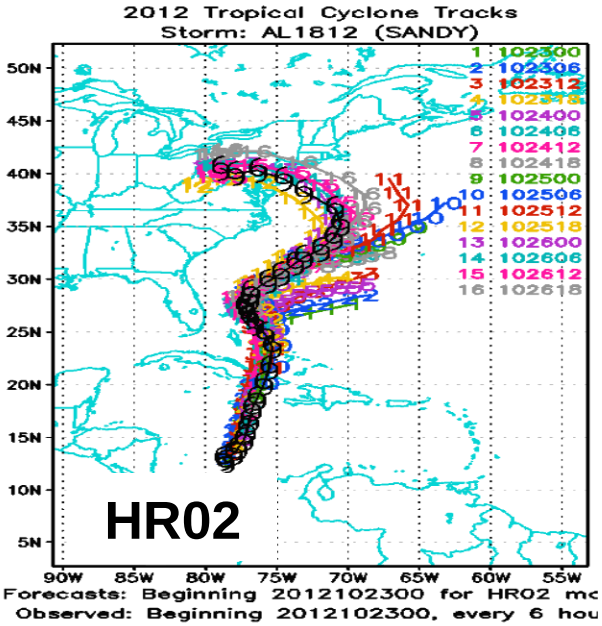


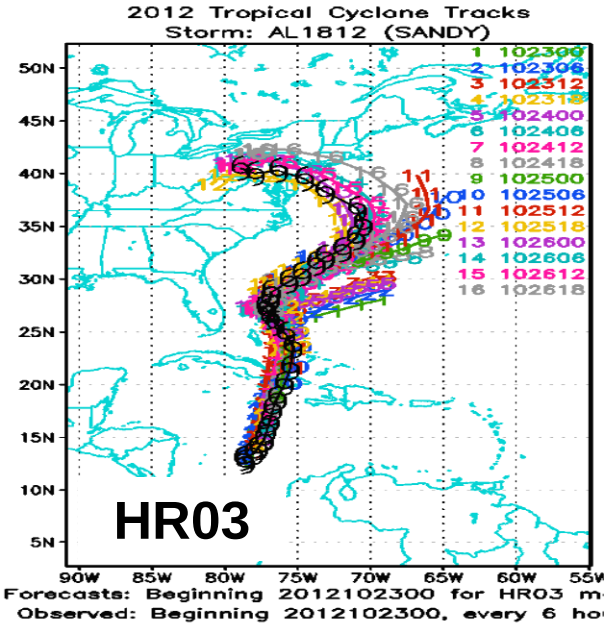


SANDY TRACK FORECASTS

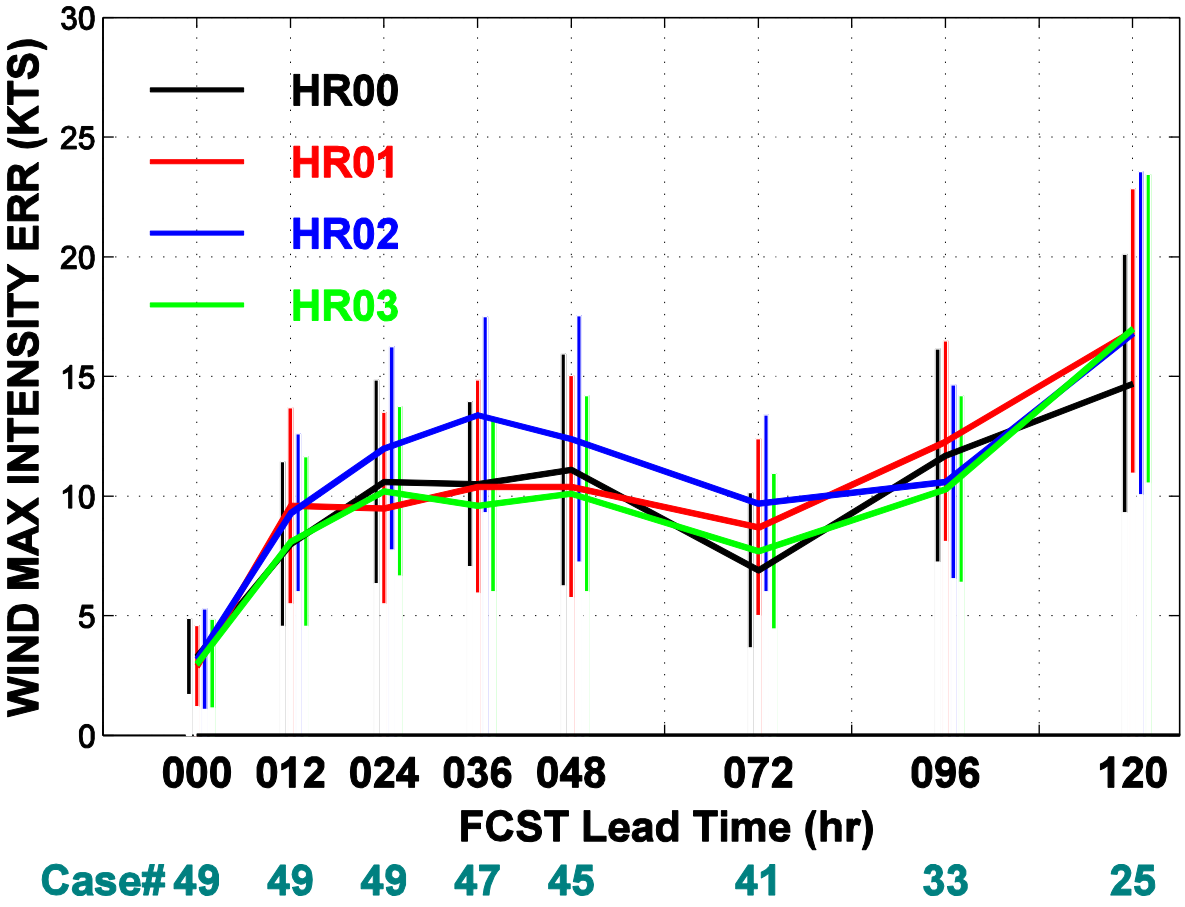




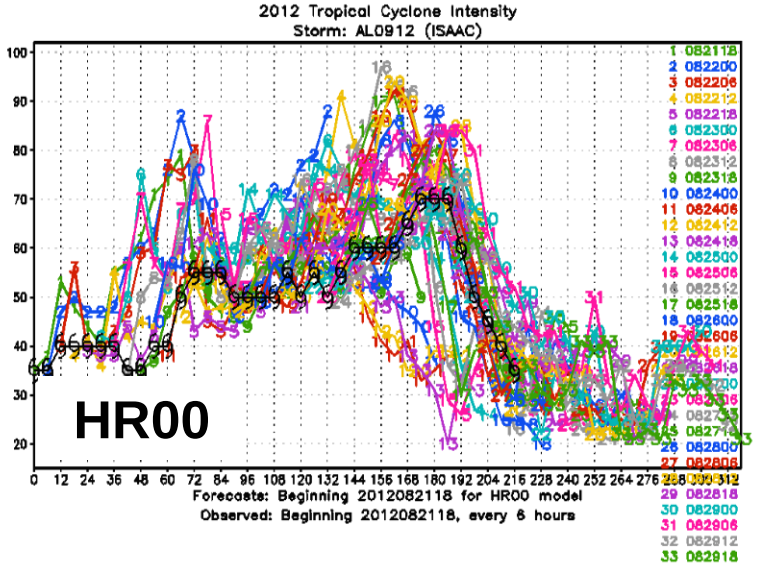


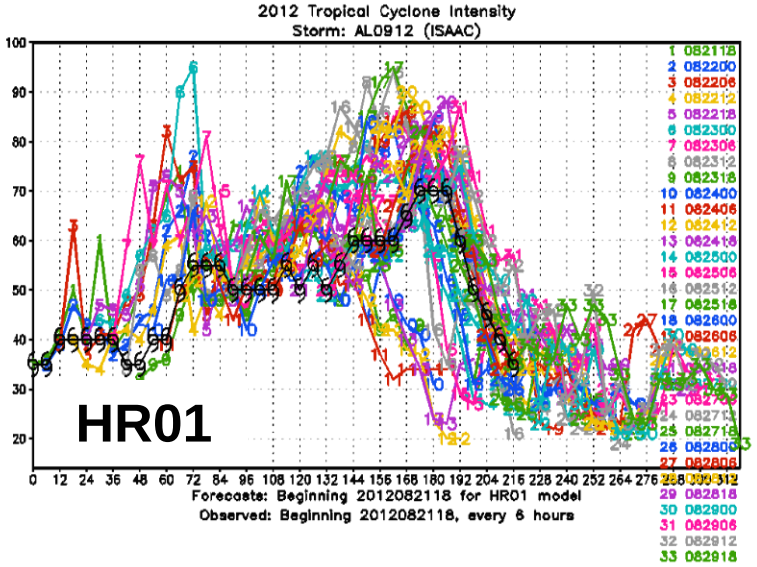


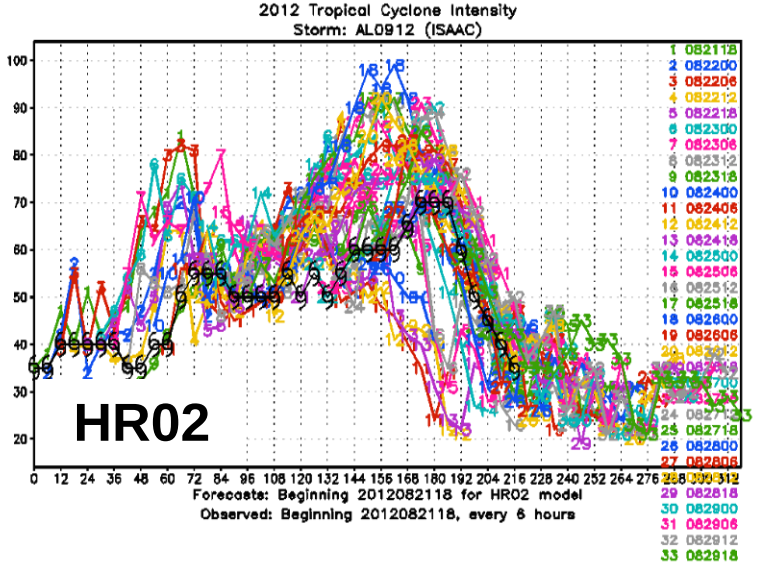
HWRF FCST - WIND MAX INTENSITY ERROR (09L, 18L 201

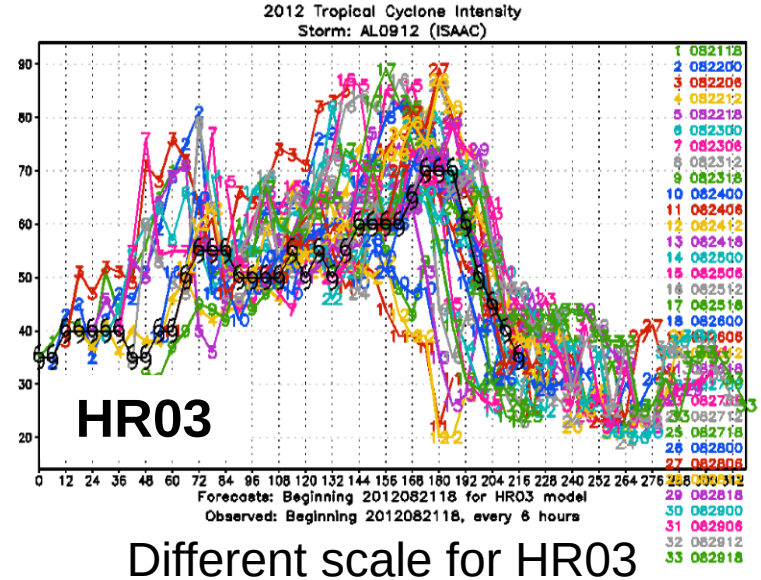


ISAAC VMAX FORECASTS



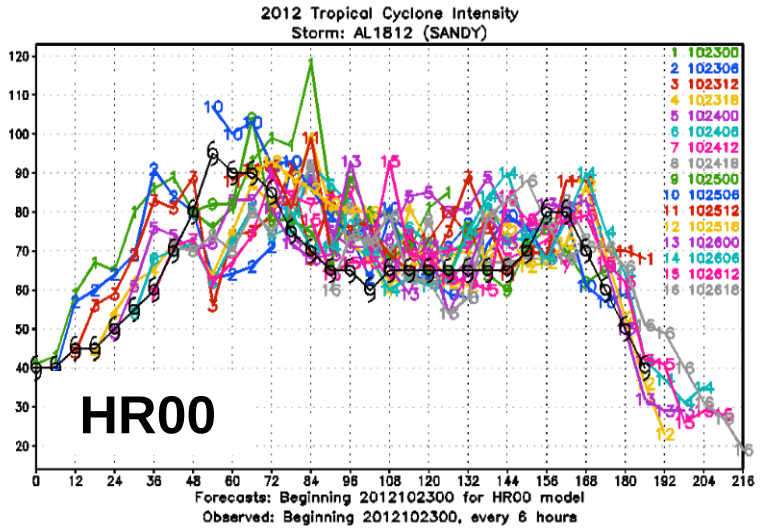


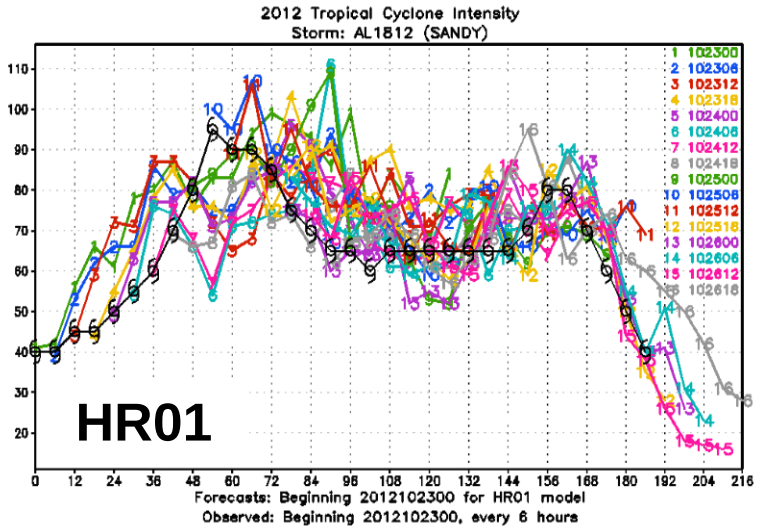


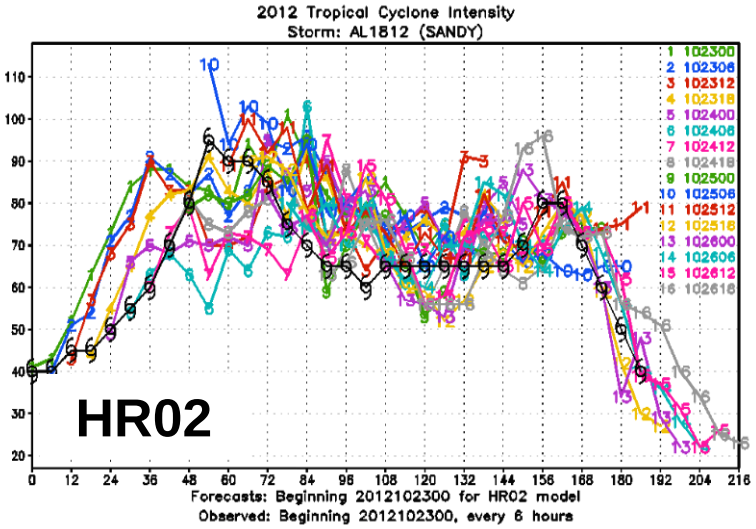


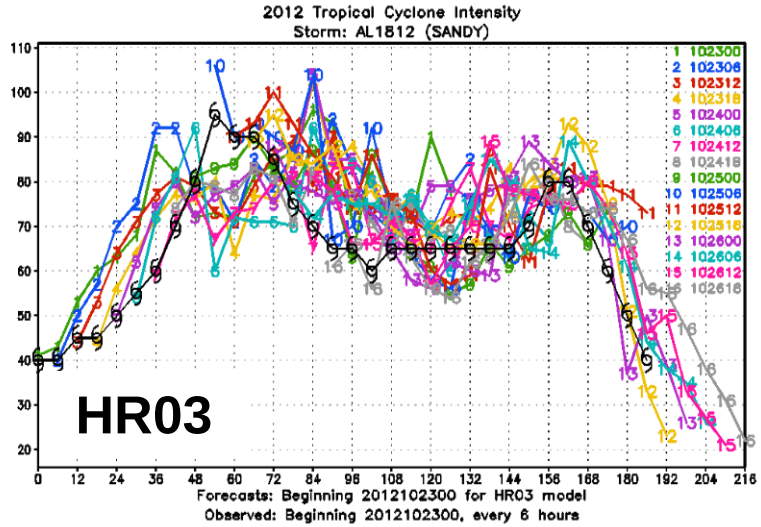
Different scale for HR03

SANDY VMAX FORECASTS



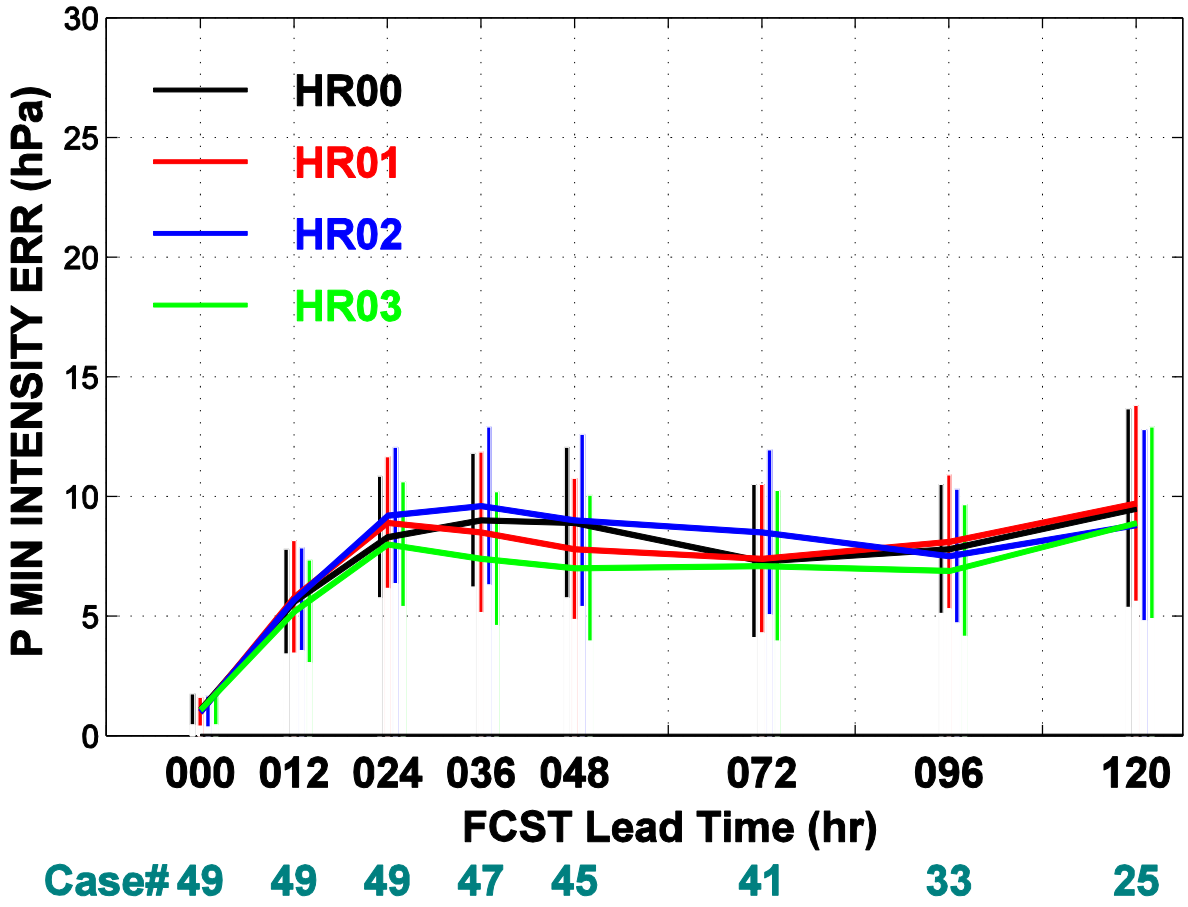




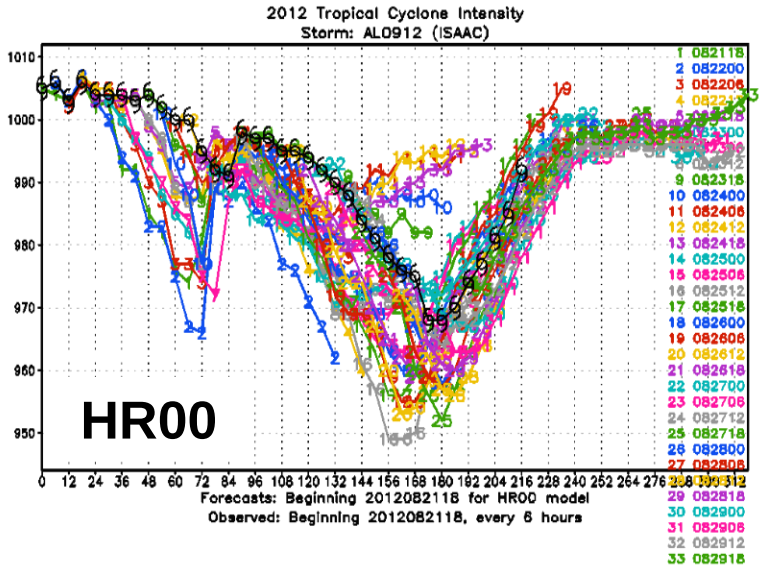


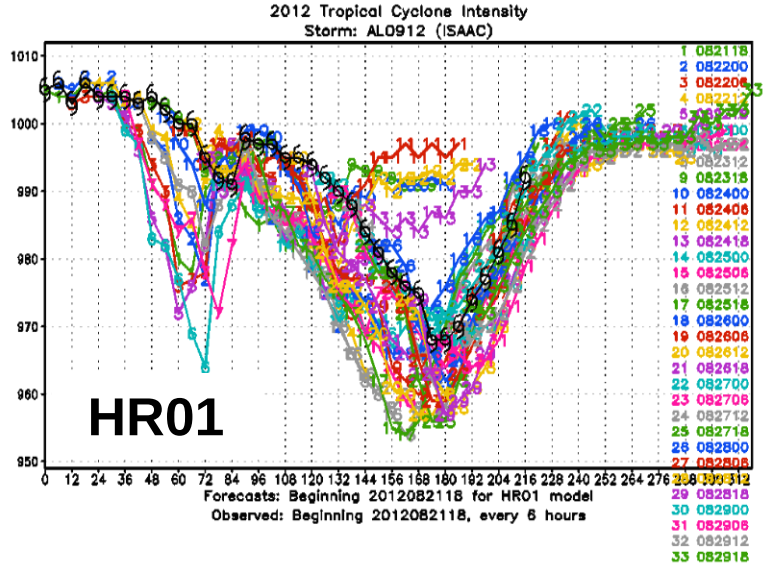
Different scale for HR03

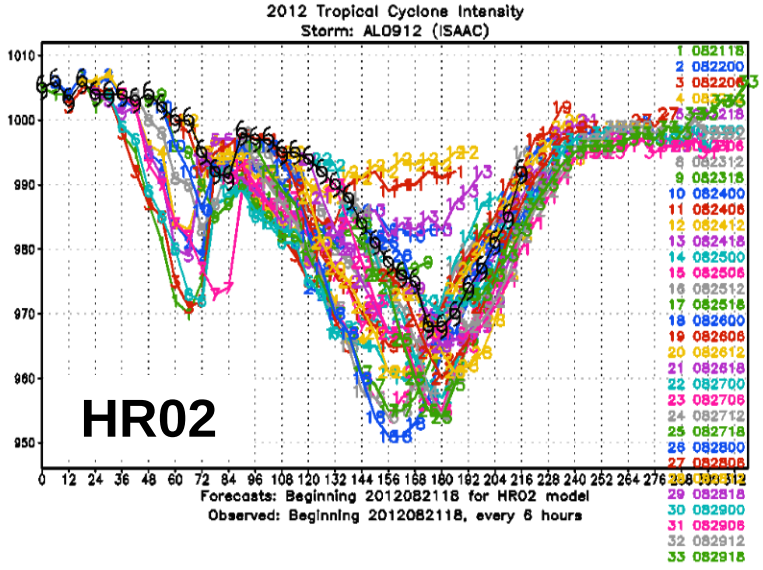
HWRF FCST - P MIN INTENSITY ERROR (09L, 18L 2012)

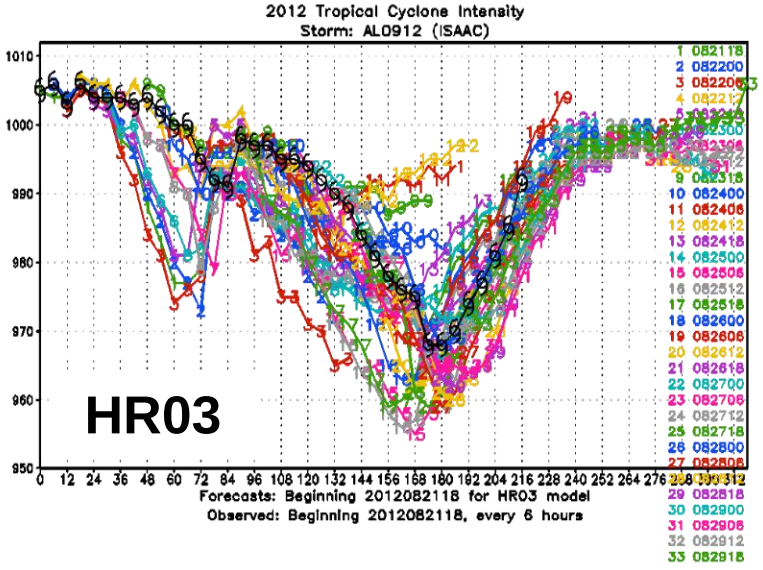


ISAAC PMIN FORECASTS

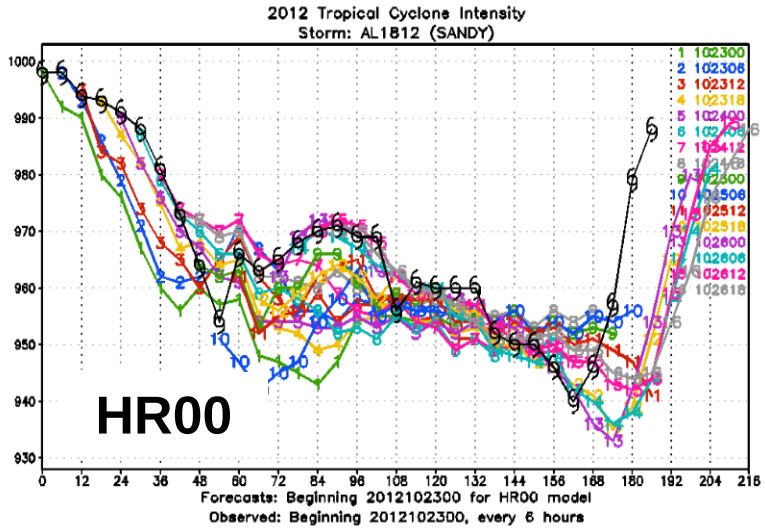


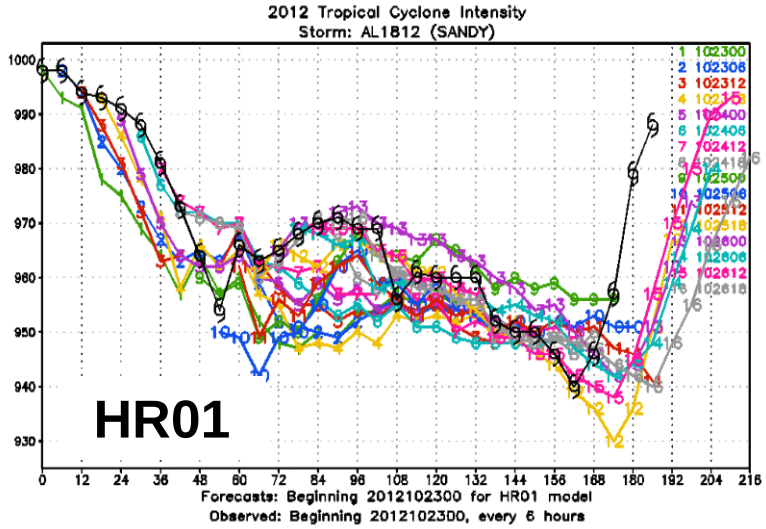


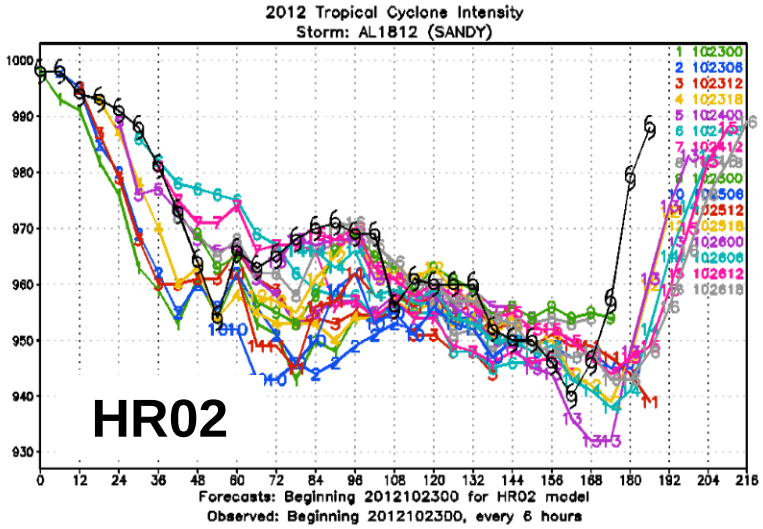


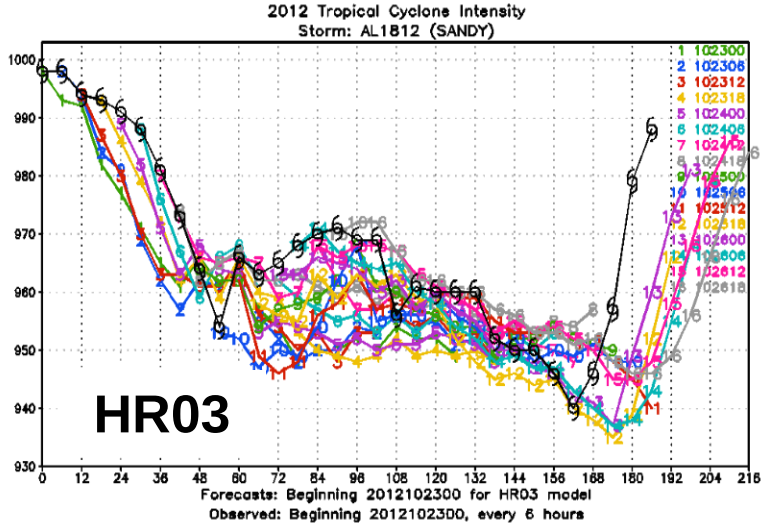


SANDY PMIN FORECASTS







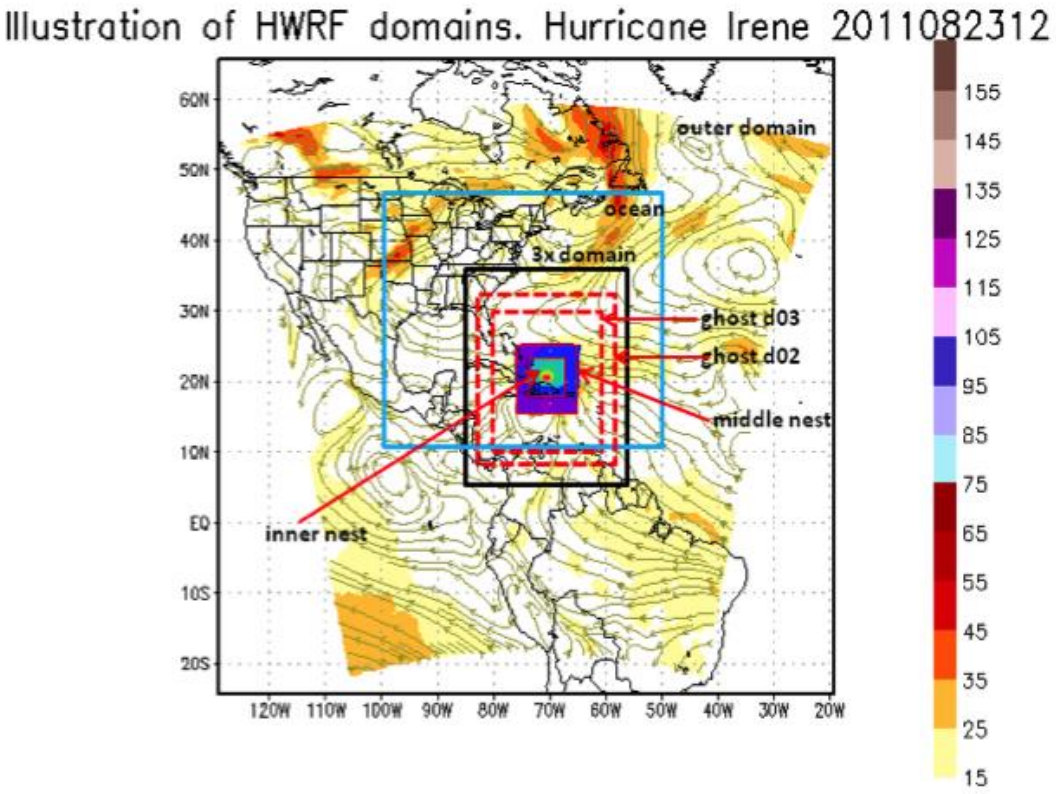


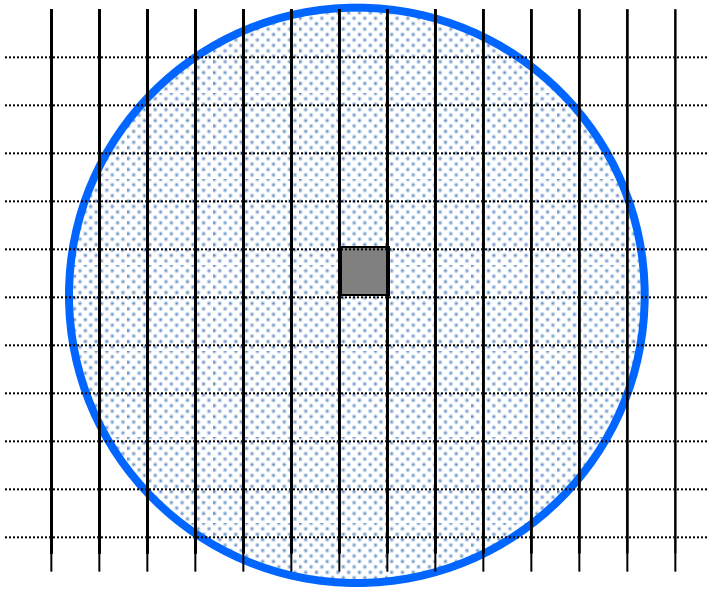
Summary

- 2013 HWRF/GSI is re-configured with:
  - 61 vertical layer with higher model top at 2 hPa
  - GFS-HWRF blended vertical coordinate is used (for appropriate use of satellite bias correction from GFS)
  - GFS ozone profiles are used (for better use of IR data)
- Better improvement of track forecast is achieved in HR02 while best improvement of intensity forecast is achieved in HR03
- Configuration for HR03 is probably the best configuration for 2013 stream 2.0 real-time demo
- The use of satellite data in ghost domain (3km) needs more investigates

Consideration for using radiance data in ghost domain

- Using the radiance data twice (First in D1 domain, and in D2 later) ?
- Problem with representiveness



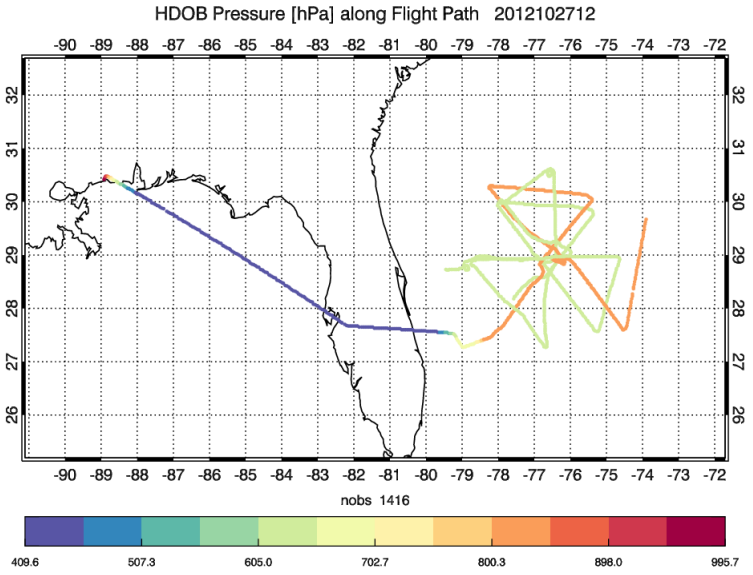


Assimilation of Aircraft Reconnaissance Data in HWRF

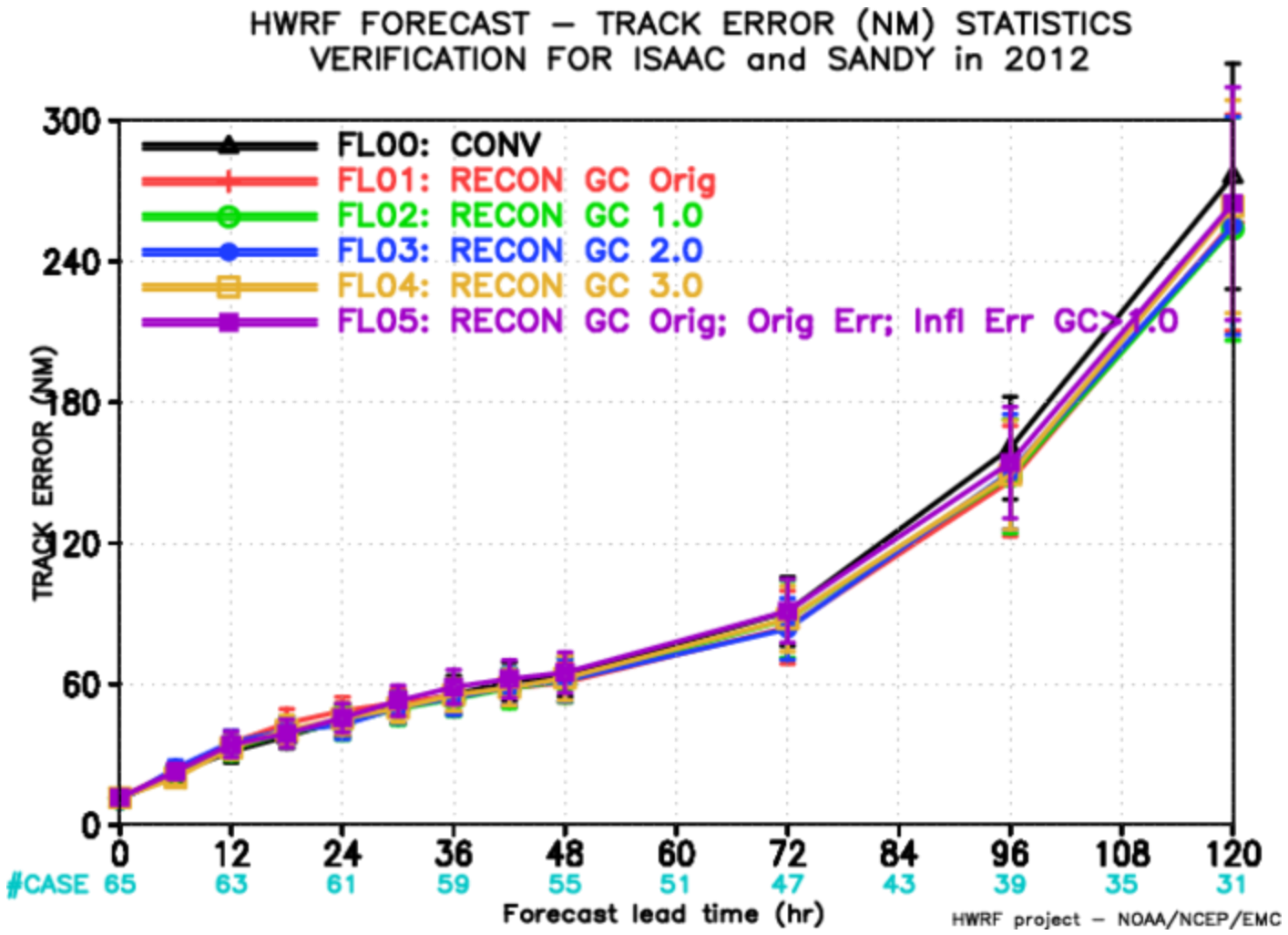
Aircraft Reconnaissance (Recon)

- Mission is tasked on tropical and subtropical cyclones.
- Coverage: Atlantic, Eastern and Central Pacific, and West Pacific
- Flight pattern in cyclone: x, box, or delta pattern.
- Processed 2008-2012 aircraft reconnaissance data into 6-hourly data files in BUFR format
- Information content for data assimilation (DA):

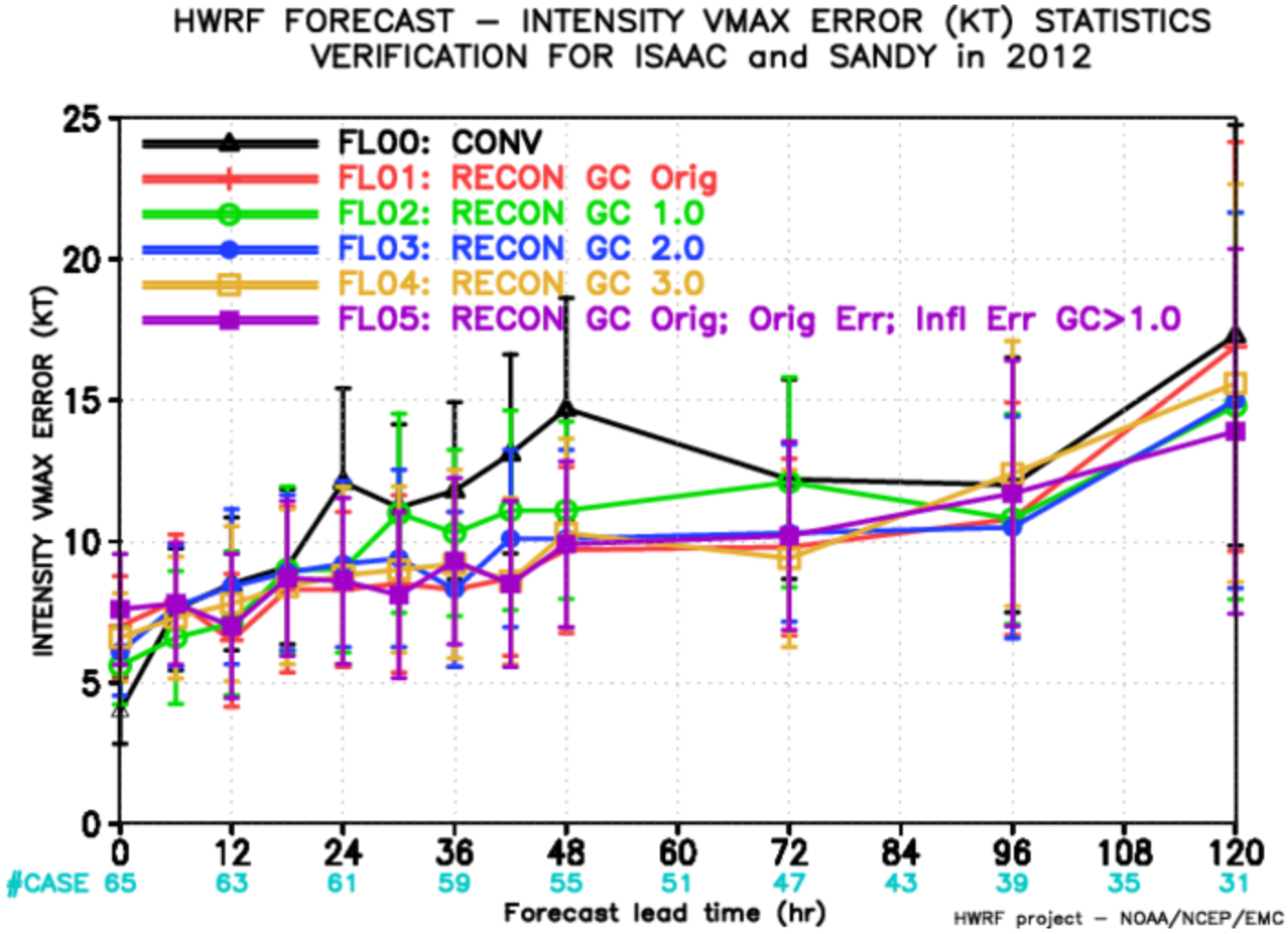
Observation	Conversion for DA
Time, latitude/longitude	
Air temperature	Virtual temperature
Dew point temperature	Specific humidity
Wind direction/speed	U- & v-component winds
SFMR derived surface wind speed (10m wind)	



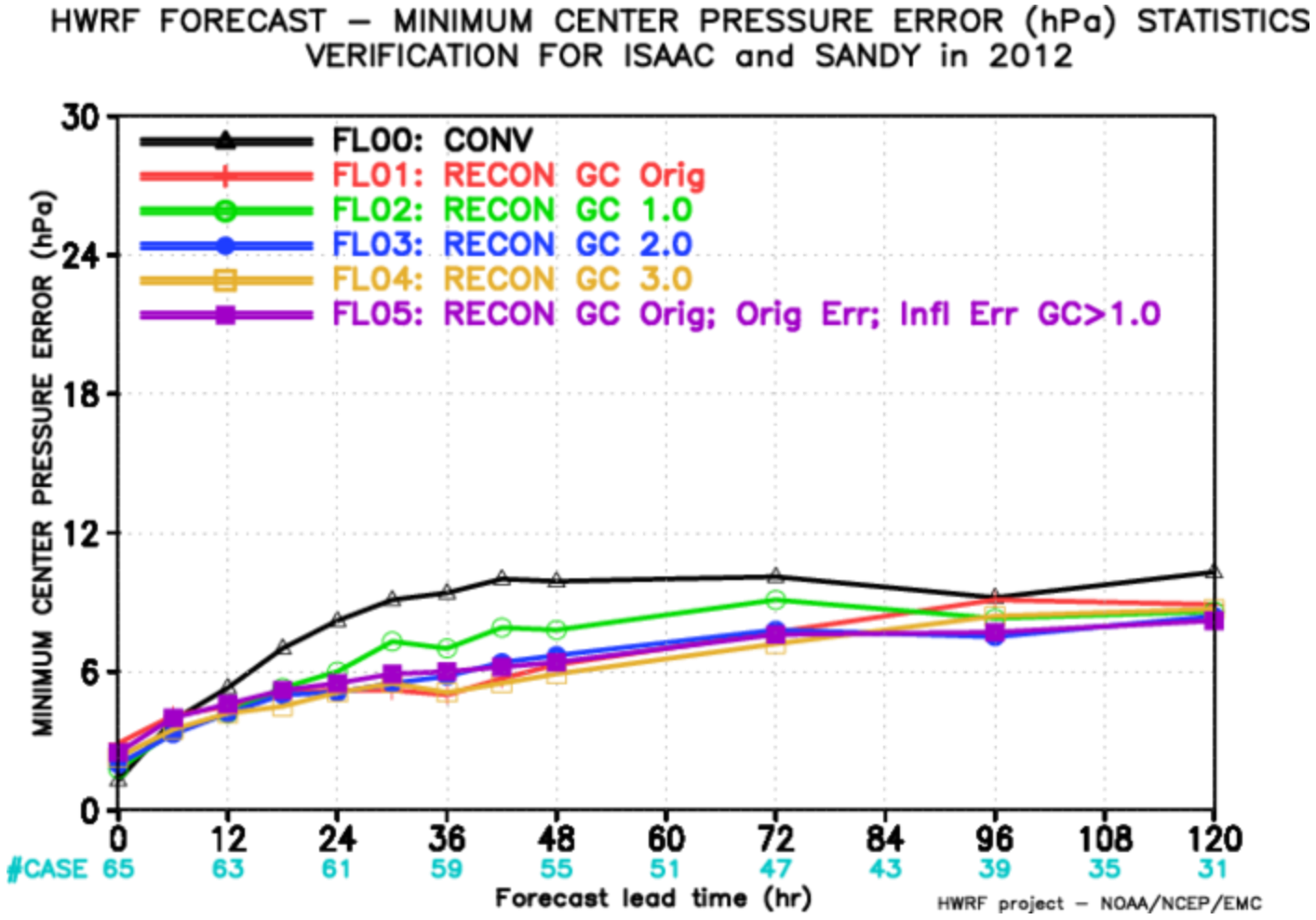
Track Error


HWRF FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR ISAAC and SANDY in 2012
FL00: CONV
FL01: RECON GC Orig
FL02: RECON GC 1.0
FL03: RECON GC 2.0
FL04: RECON GC 3.0
FL05: RECON GC Orig; Orig Err; Infl Err GC>1.0
TRACK ERROR (NM)
300
240
180
120
60
0
0 12 24 36 48 60 72 84 96 108 120
#CASE 65 63 61 59 55 51 47 43 39 35 31
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

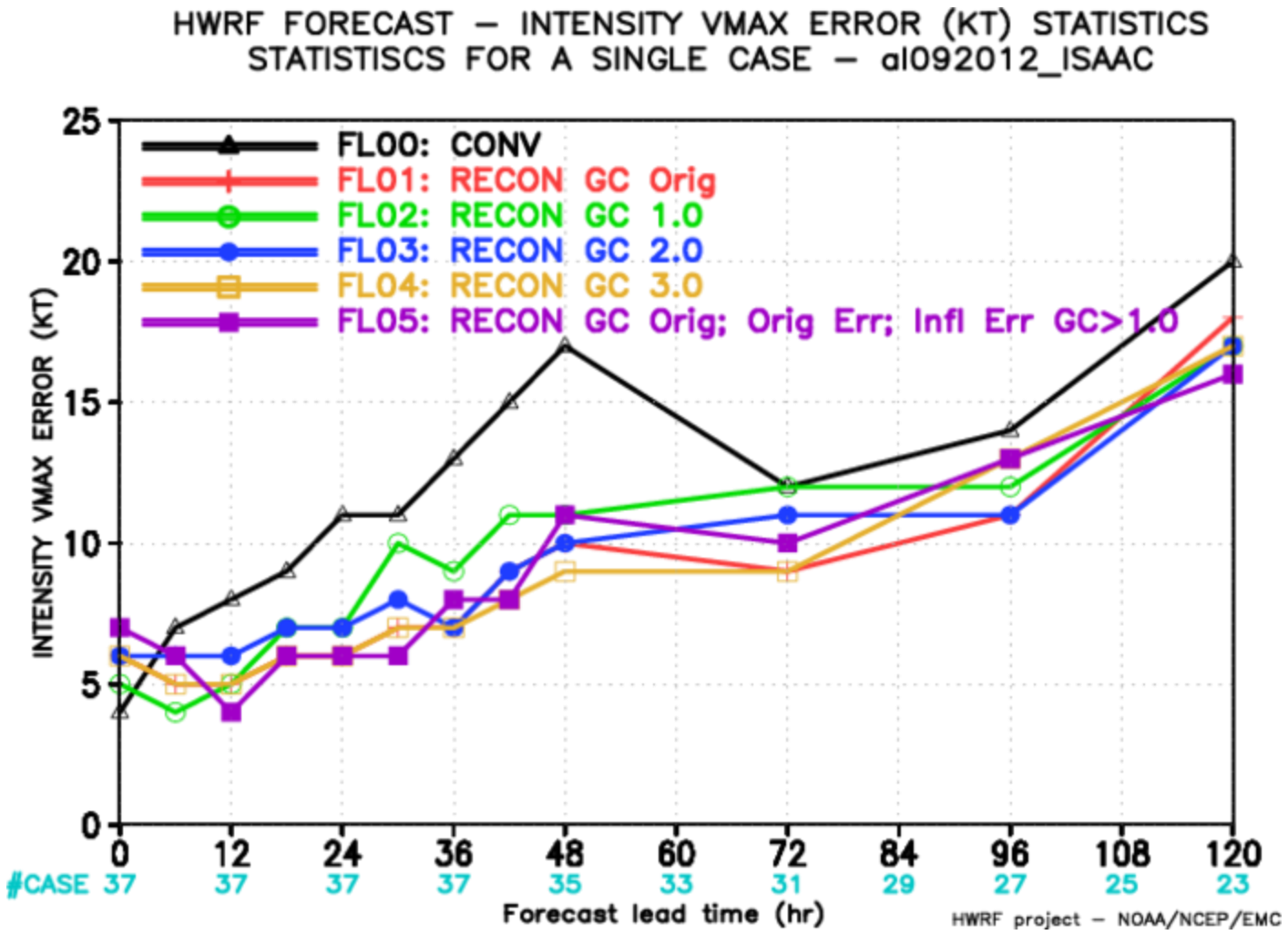
Intensity Error – Max Wind

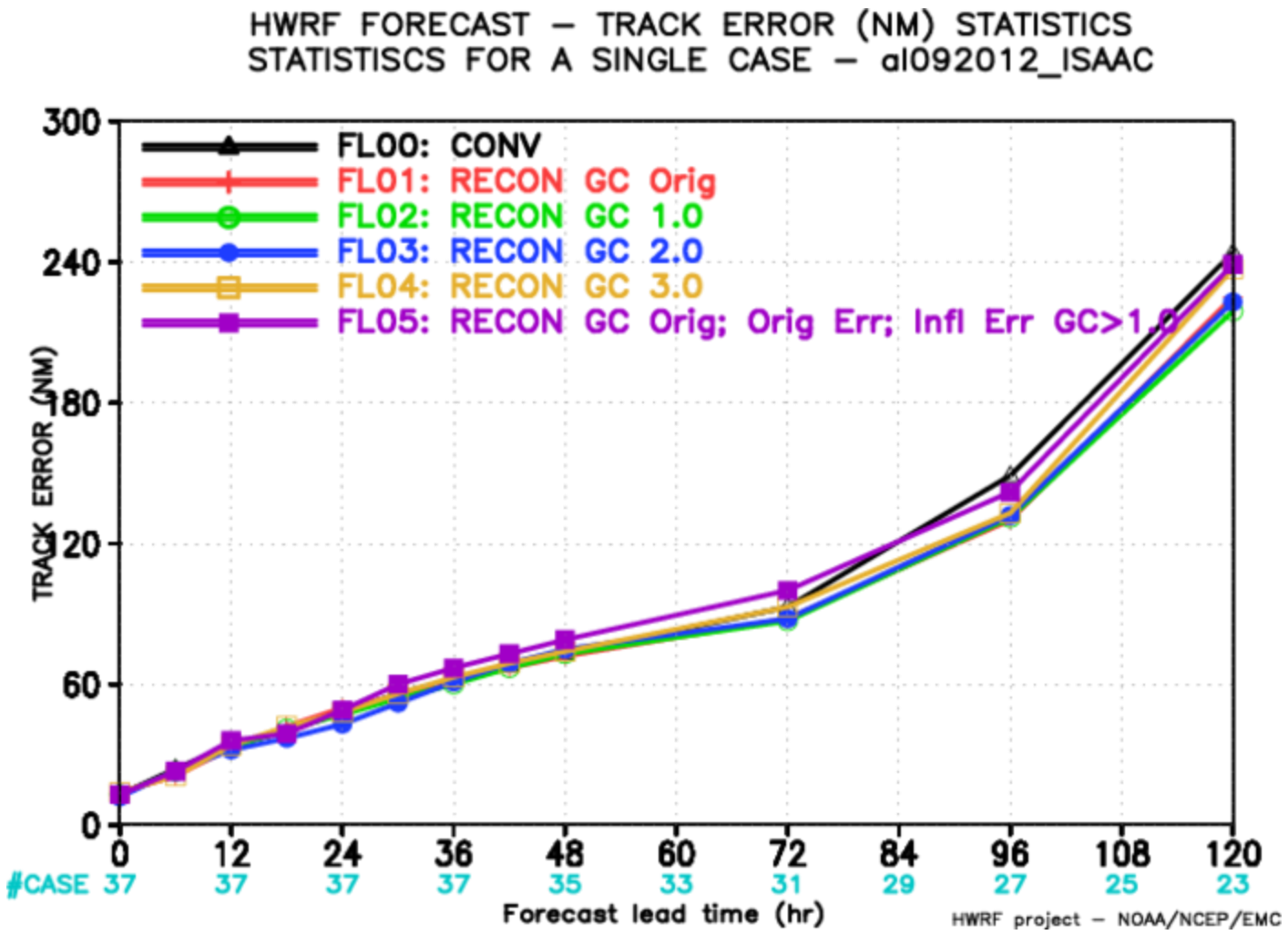


Intensity Error – Min Pressure

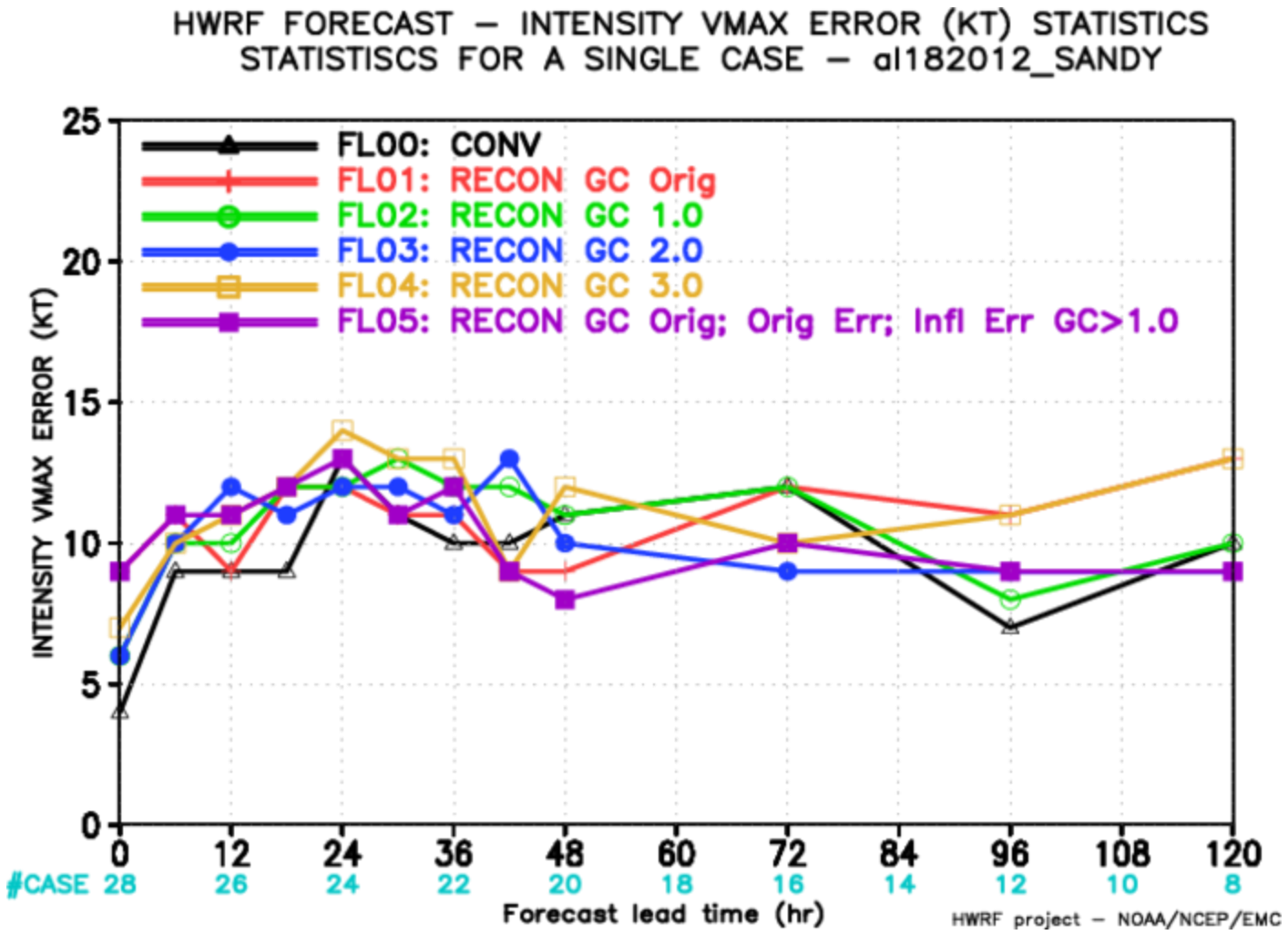


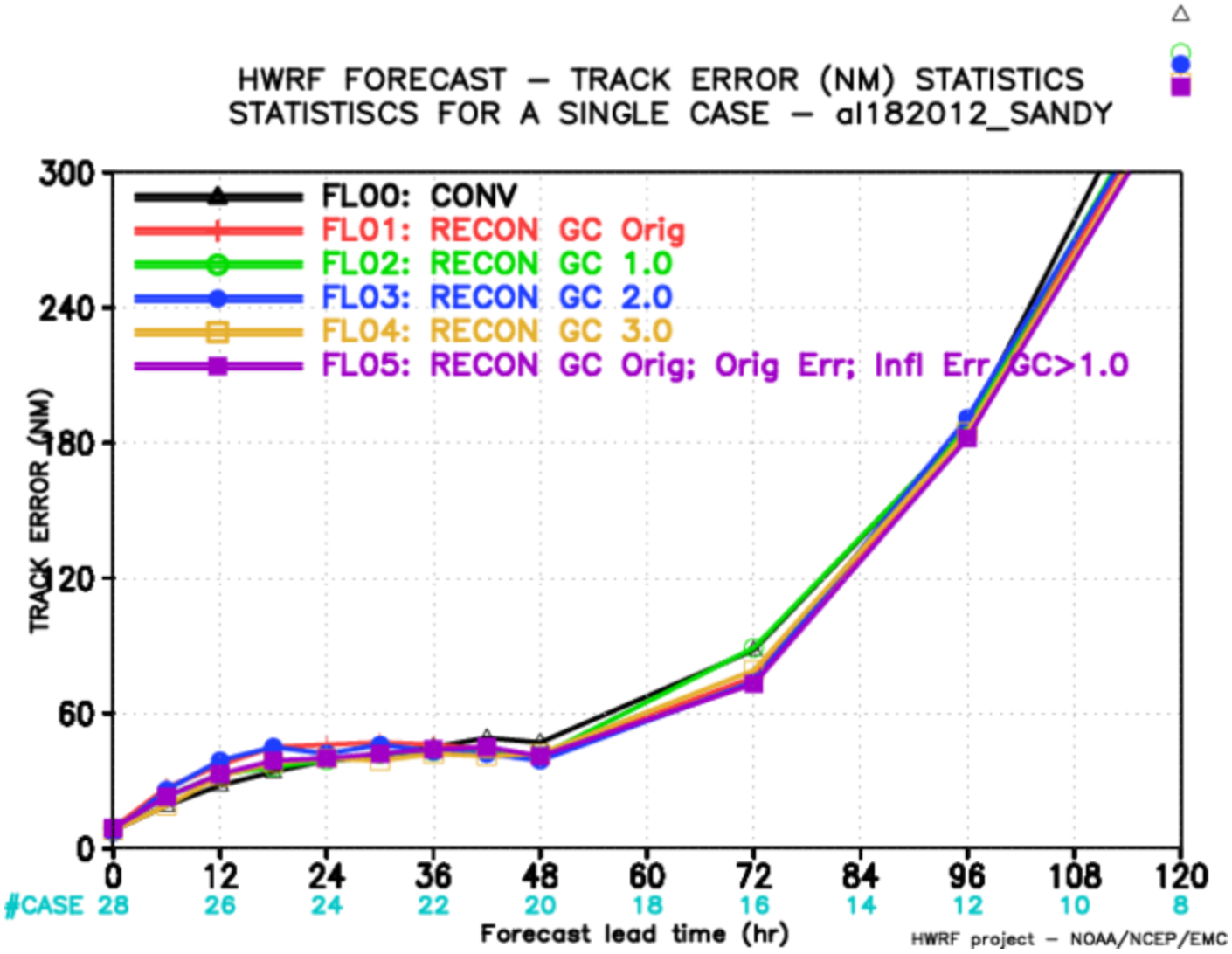
Isaac


HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
STATISTISCS FOR A SINGLE CASE – al092012_ISAAC
FL00: CONV
FL01: RECON GC Orig
FL02: RECON GC 1.0
FL03: RECON GC 2.0
FL04: RECON GC 3.0
FL05: RECON GC Orig; Orig Err; Infl Err GC>1.0
INTENSITY VMAX ERROR (KT)
0
5
10
15
20
25
0 12 24 36 48 60 72 84 96 108 120
#CASE 37 37 37 37 35 33 31 29 27 25 23
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

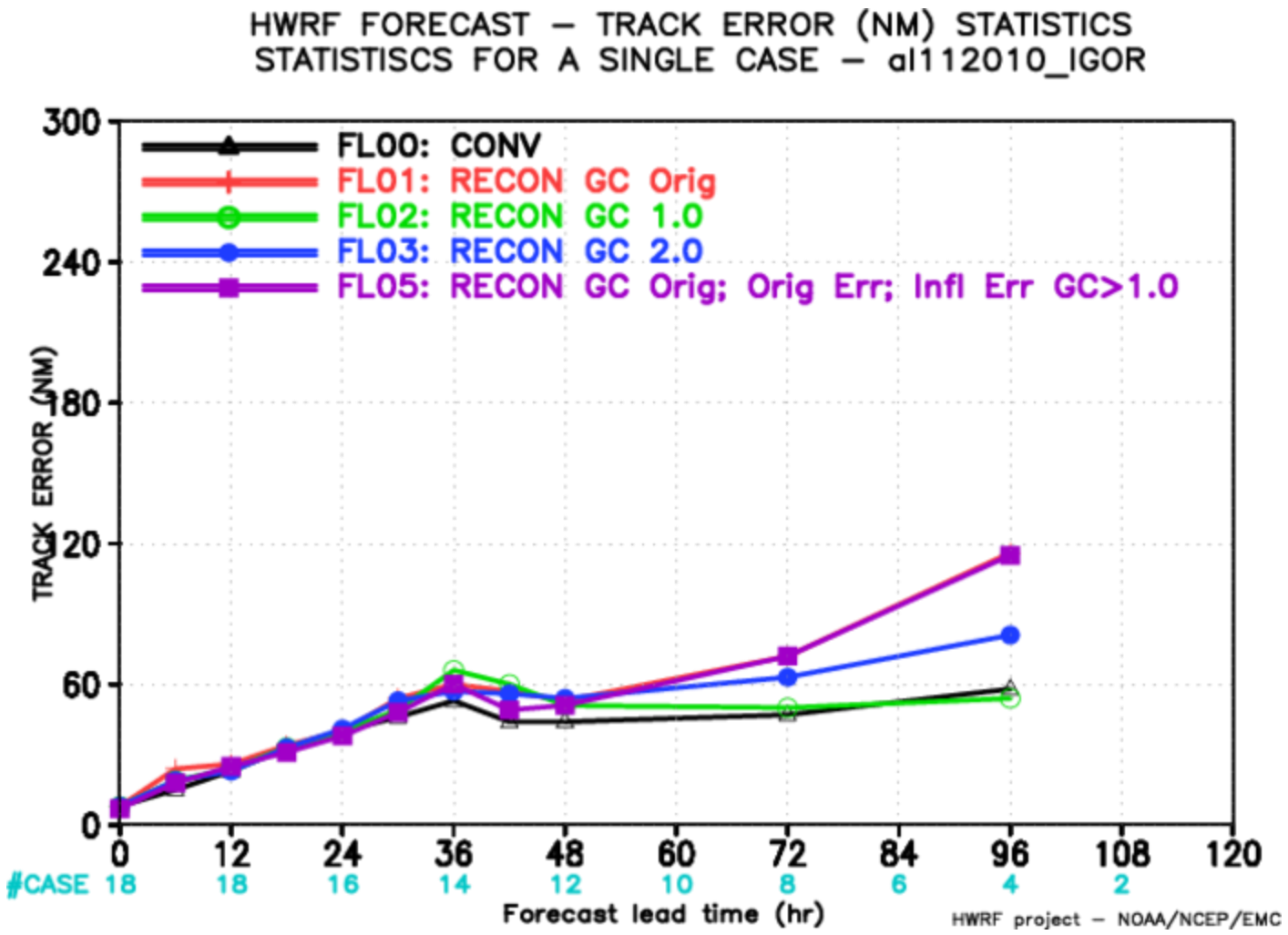

HWRF FORECAST – TRACK ERROR (NM) STATISTICS
STATISTISCS FOR A SINGLE CASE – al092012_ISAAC
FL00: CONV
FL01: RECON GC Orig
FL02: RECON GC 1.0
FL03: RECON GC 2.0
FL04: RECON GC 3.0
FL05: RECON GC Orig; Orig Err; Infl Err GC>1.0
TRACK ERROR (NM)
300
240
180
120
60
0
0 12 24 36 48 60 72 84 96 108 120
#CASE 37 37 37 37 35 33 31 29 27 25 23
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

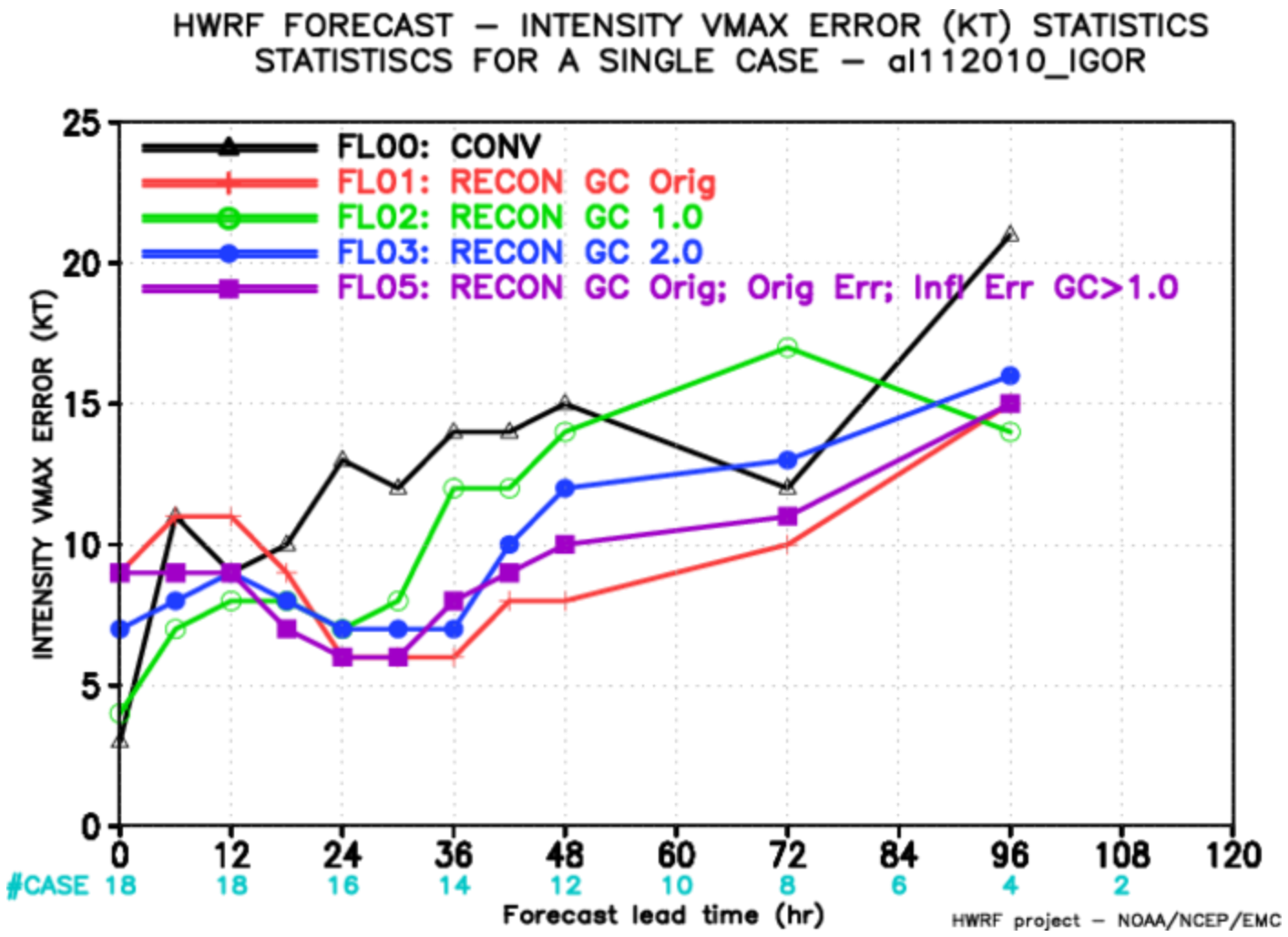
Sandy


HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
STATISTISCS FOR A SINGLE CASE – al182012_SANDY
FL00: CONV
FL01: RECON GC Orig
FL02: RECON GC 1.0
FL03: RECON GC 2.0
FL04: RECON GC 3.0
FL05: RECON GC Orig; Orig Err; Infl Err GC>1.0
INTENSITY VMAX ERROR (KT)
25
20
15
10
5
0
0 12 24 36 48 60 72 84 96 108 120
#CASE 28 26 24 22 20 18 16 14 12 10 8
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC


HWRF FORECAST – TRACK ERROR (NM) STATISTICS
STATISTISCS FOR A SINGLE CASE – al182012_SANDY
FL00: CONV
FL01: RECON GC Orig
FL02: RECON GC 1.0
FL03: RECON GC 2.0
FL04: RECON GC 3.0
FL05: RECON GC Orig; Orig Err; Infl Err GC>1.0
TRACK ERROR (NM)
300
240
180
120
60
0
0 12 24 36 48 60 72 84 96 108 120
#CASE 28 26 24 22 20 18 16 14 12 10 8
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

Igor


HWRF FORECAST – TRACK ERROR (NM) STATISTICS
STATISTISCS FOR A SINGLE CASE – al112010_IGOR
FL00: CONV
FL01: RECON GC Orig
FL02: RECON GC 1.0
FL03: RECON GC 2.0
FL05: RECON GC Orig; Orig Err; Infl Err GC>1.0
TRACK ERROR (NM)
300
240
180
120
60
0
0 12 24 36 48 60 72 84 96 108 120
#CASE 18 18 16 14 12 10 8 6 4 2
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC


HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
STATISTISCS FOR A SINGLE CASE – al112010_IGOR
FL00: CONV
FL01: RECON GC Orig
FL02: RECON GC 1.0
FL03: RECON GC 2.0
FL05: RECON GC Orig; Orig Err; Infl Err GC>1.0
INTENSITY VMAX ERROR (KT)
0
5
10
15
20
25
0 12 24 36 48 60 72 84 96 108 120
#CASE 18 18 16 14 12 10 8 6 4 2
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

Summary

- The large intensity error at the initial time seems to be associated with the large discrepancies between the background and the observation (OMFs)
  - Conclusion is made based on results from limited samples
  - The tightened gross check helps to reduce the initial error in intensity
  - The configuration for FL03 is used for the RECON experiment
- Need to look at a few more cases
  - Isaac, Sandy in 2012 (Completed)
  - Irene in 2011 (in progress)
  - Igore in 2010 (in progress)
- Two ways to inflate errors for large OMFs
  - Variational QC
  - Empirical tuning