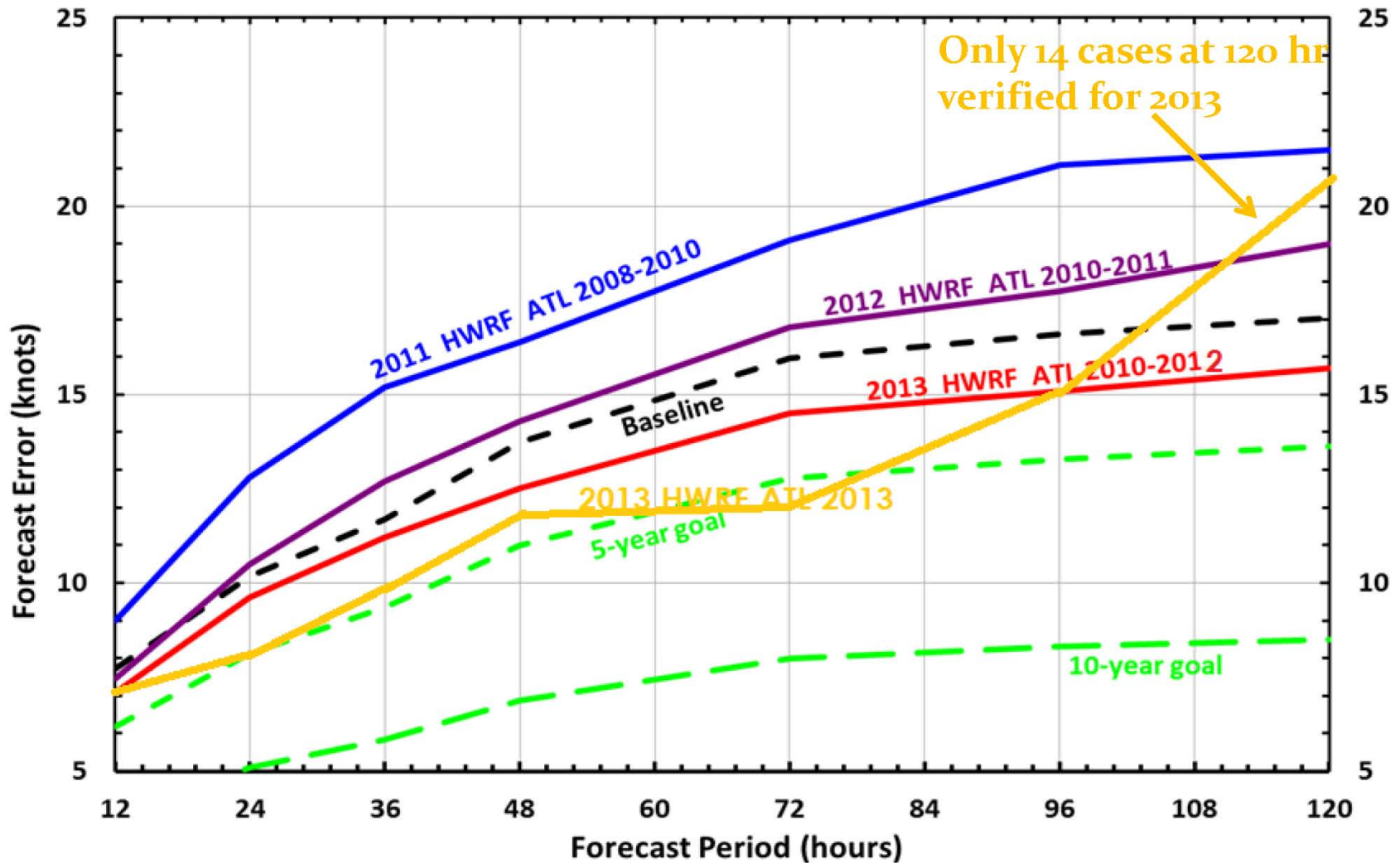


# **HWRF Initialization with APSU ARW-EnKF analysis**

Fuqing Zhang & Yonghui Weng

July 31, 2014

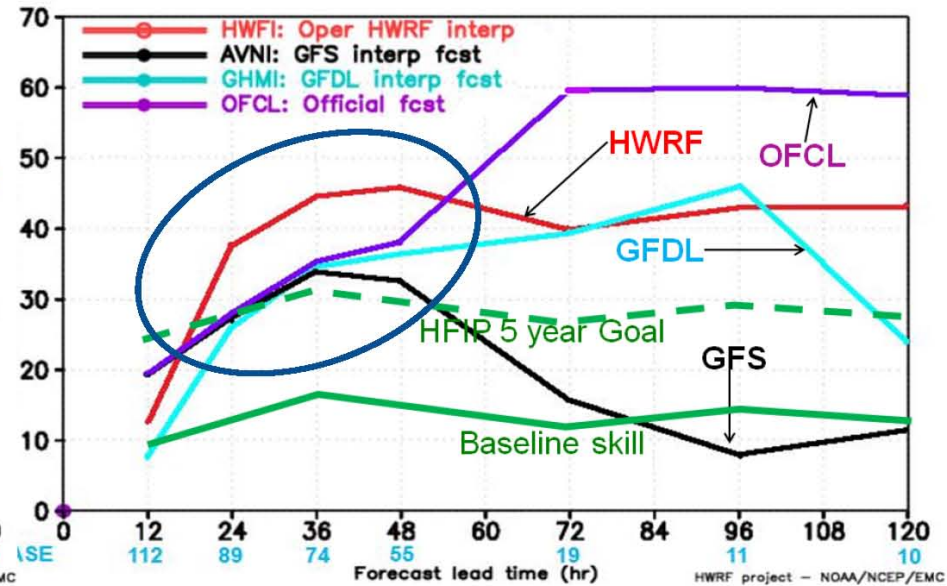
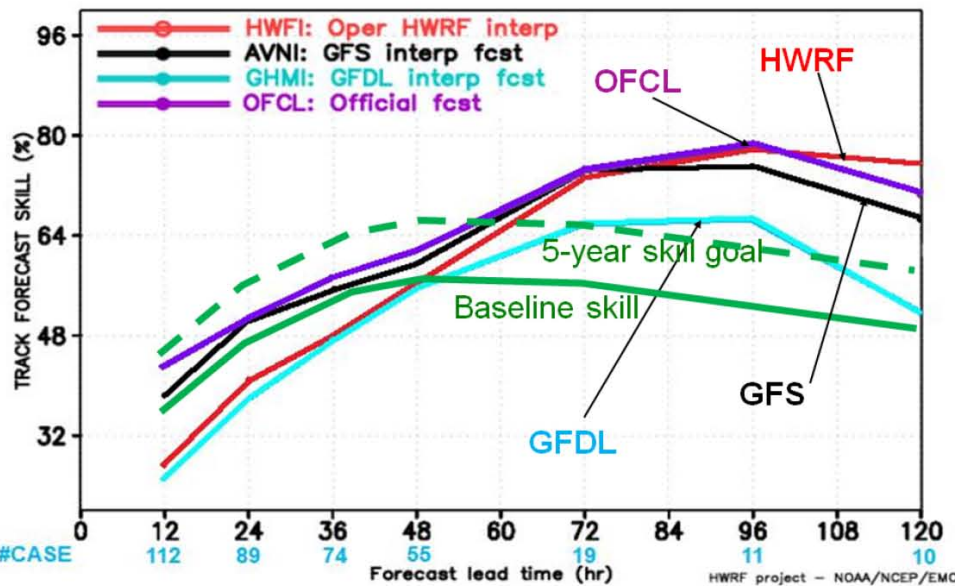
# HWRF Intensity ATL Basin: Cumulative Forecast Improvements (Retrospective and Real-Time Performance)



# Performance of NCEP Models for 2013 North Atlantic Basin

Comparison of 2013 NCEP Operational Models to the 5 Year HFIP Goal: Track (Early Models)

Comparison of 2013 NCEP Operational Models to the 5 Year HFIP Goal: Intensity (Early Models)



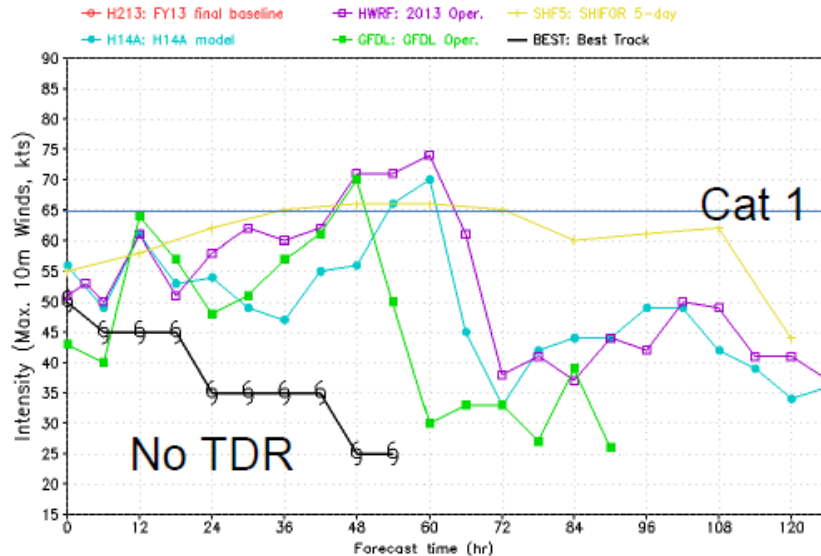
HWRF Model Real-Time Performance for 2013 Atlantic intensity forecasts match the expectations from the pre-implementation T&E



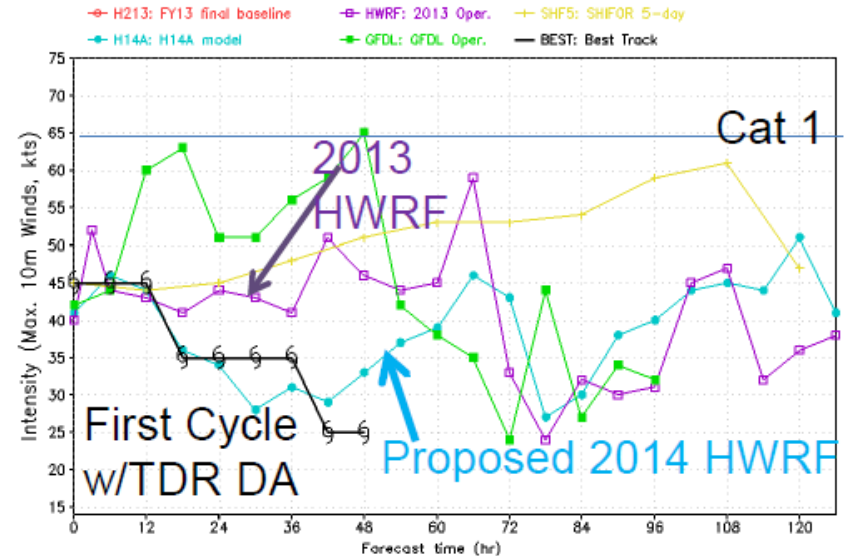
# Impact of TDR DA on operational HWRF for TS Karen:



H14A 2013 Real time: TC Intensity Vmax  
Storm: KAREN (12L) valid 2013100406



H14A 2013 Real time: TC Intensity Vmax  
Storm: KAREN (12L) valid 2013100412



Real-time assimilation of NOAA P3 TDR DA for operational HWRF – A First in many years of flying.

- Conduct experiments to maximize the effective utilization of inner core data for 2014 HWRF implementation

## Impact of HWRF forecasts with TDR DA on NHC Operational Forecasts

NHC Forecast Discussion on October 4, 5 PM:

- **THE 12Z HWRF RUN SHOWED CONSIDERABLY LESS INTENSIFICATION WITH KAREN COMPARED TO PREVIOUS RUNS AFTER ASSIMILATING DATA FROM THE FROM THE NOAA P-3 TAIL DOPPLER RADAR. THIS MARKS THE FIRST TIME DOPPLER RADAR DATA HAVE BEEN ASSIMILATED INTO AN OPERATIONAL HURRICANE MODEL IN REAL TIME.**

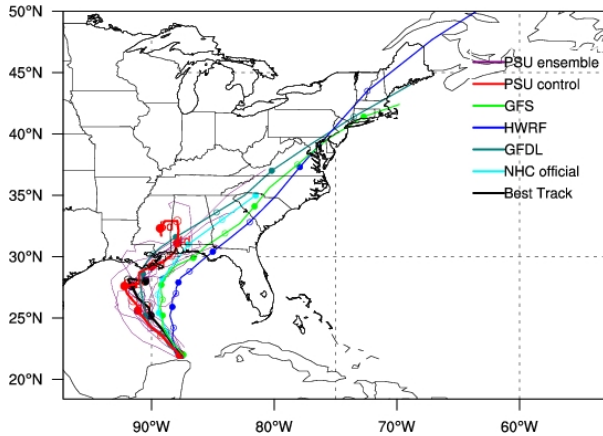
-- Forecaster Brennan

**Vijay, Banglin, Mingjing and Emily, NOAA, March 11, 2014**

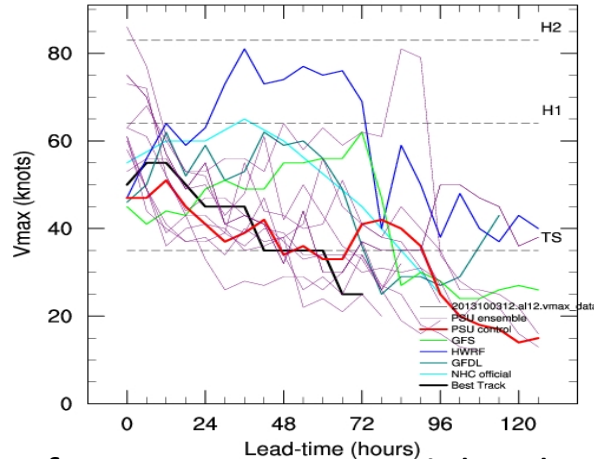
# Case Review:

## Storm Karen (2013 a12) & Storm Gabrielle (2013a107)

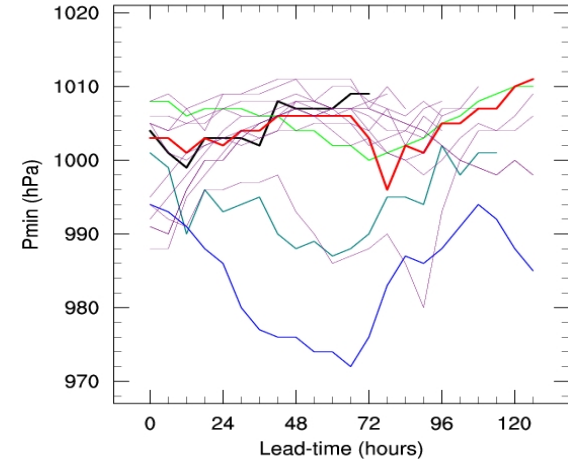
Track Forecasts: a12@2013100312



Vmax Forecasts: a12@2013100312

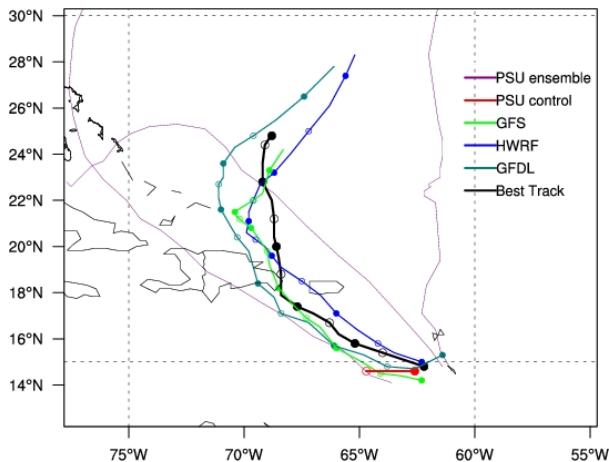


Pmin Forecasts: a12@2013100312

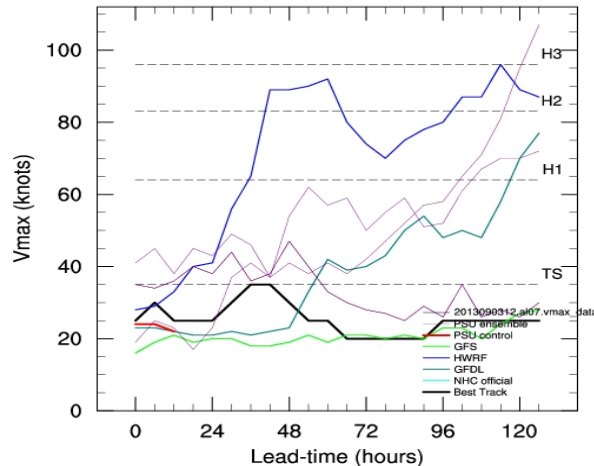


Real-time forecasts for storm Karen initialized at 12Z 03 Oct 2013.

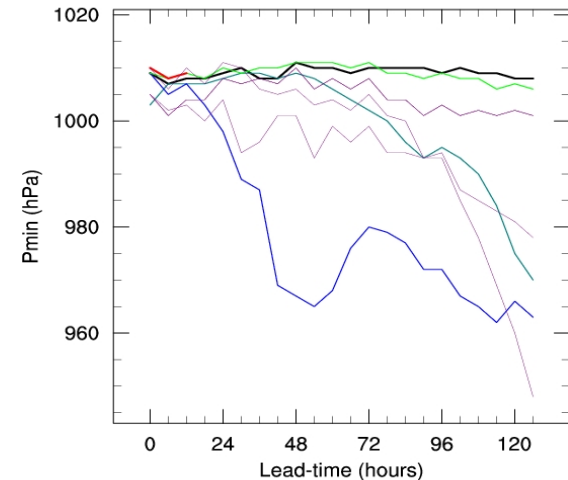
Track Forecasts: a107@2013090312



Vmax Forecasts: a107@2013090312



Pmin Forecasts: a107@2013090312

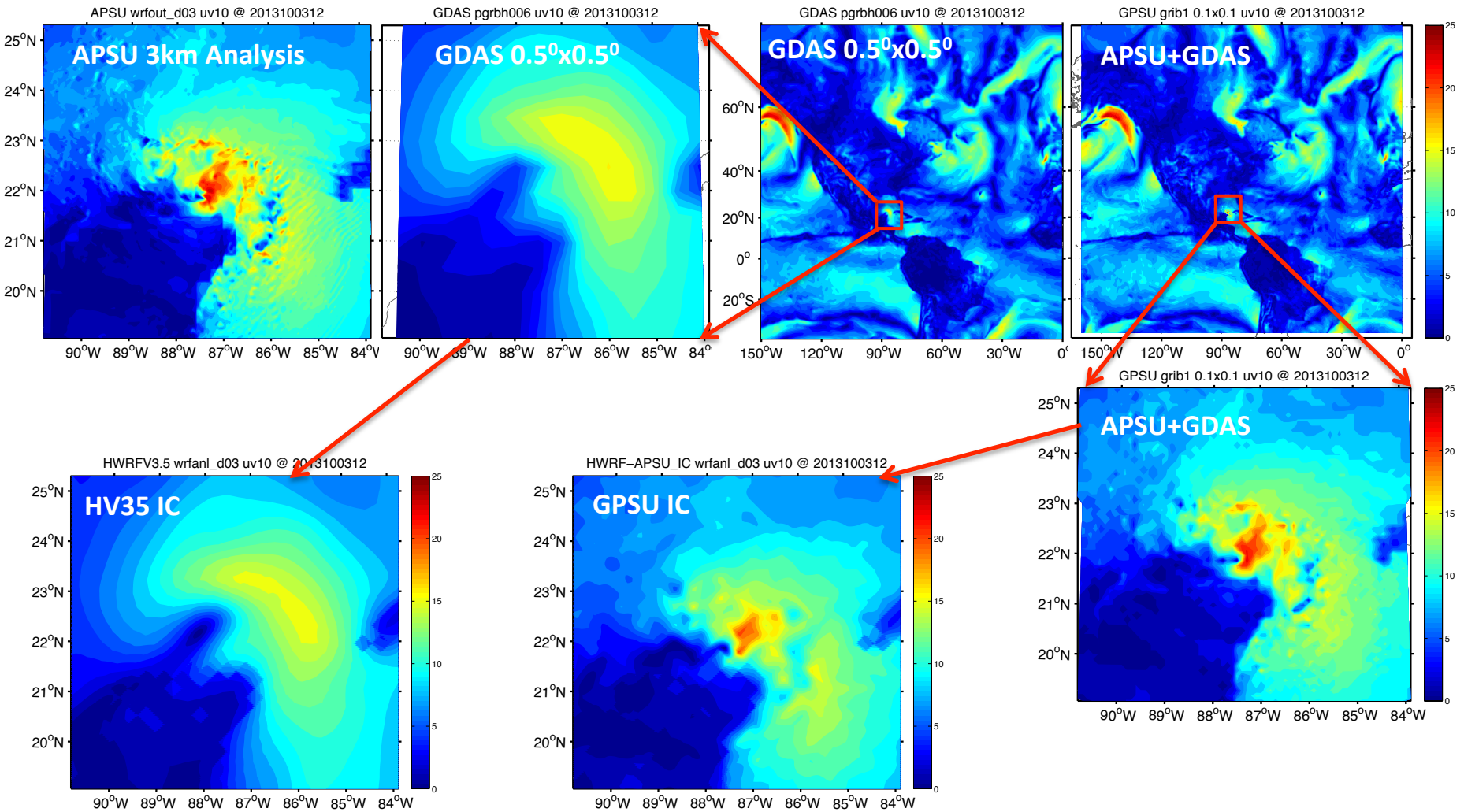


Real-time forecasts for storm Gabrielle initialized at 12Z 03 Sep 2013.

# Experiment Design

- HV35:
  - HWRF V3.5a (downloaded from DTC) exactly following the use guider including relocater, GSI DA with all obs except TDR;
- GPSU:
  - HV35 initialized with the combination of APSU and GDAS, no relocater, no GSI DA.
  - Merging the ARW-EnKF analysis (nc) and GDAS 6h forecast (grib1) to 0.1X0.1, 27 levels grib1 files;
  - Produce the HWRF wrfinput\_d01 with WPS;
  - Produce the HWRF wrfana\_d0[2-3] with hwrf gost;
  - Run HWRF V3.5a with wrfinput\_d01, wrfana\_d0[2-3] and the boundary wrfbdy\_d01 produced with previous time GFS forecasts.
- APSU: APSU 2013 realtime;
- HWRF: HWRF operational forecast;

# Combining APSU and GDAS: uv10m

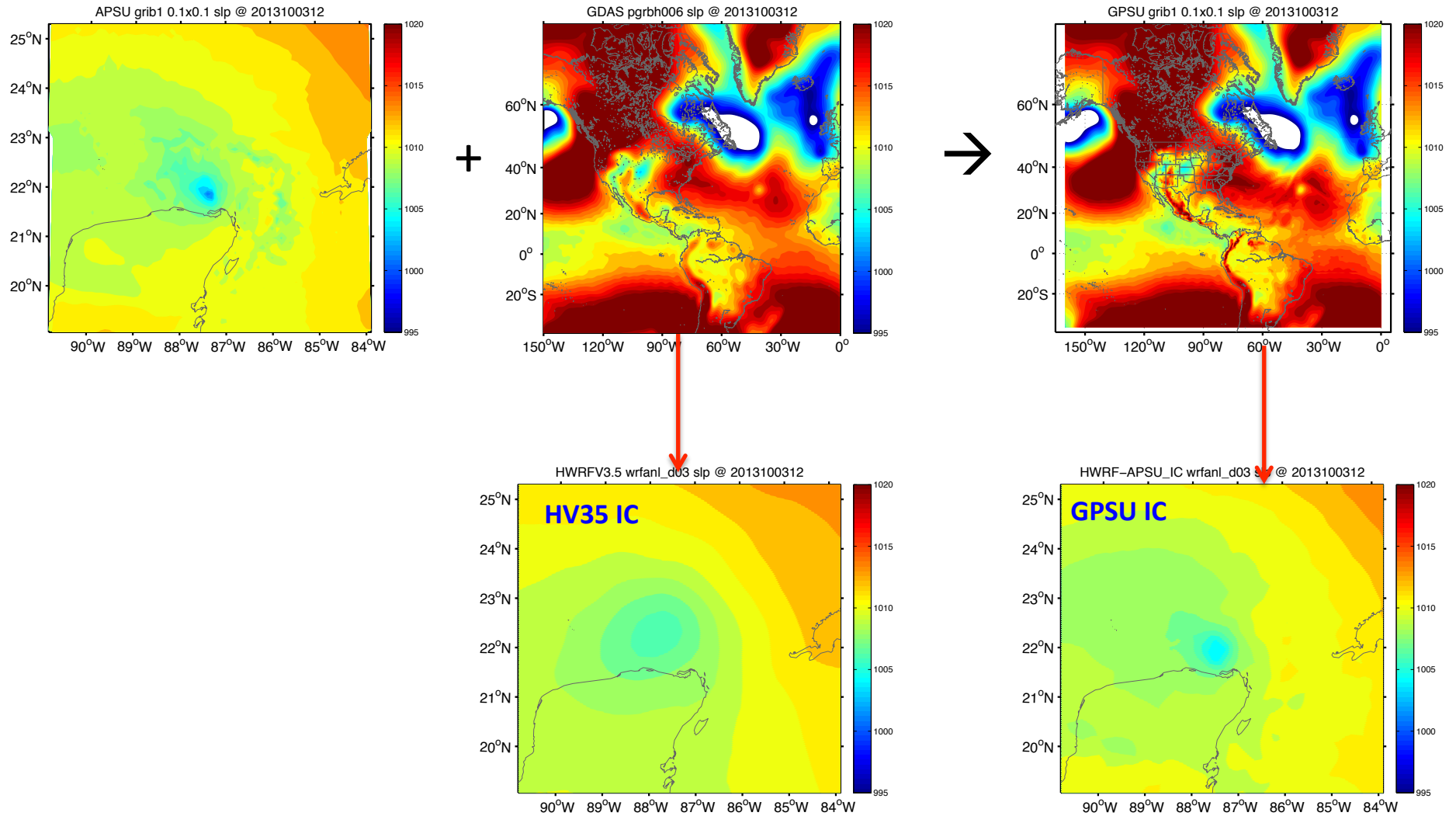


**HWRF d03 initialized with GDAS and TC-relocalization**

**HWRF d03 initialized with GDAS +APSU, no TC-relocalization**

**Note: this is ghosted from wrfinput\_d01**

# Combining APSU and GDAS: MSLP



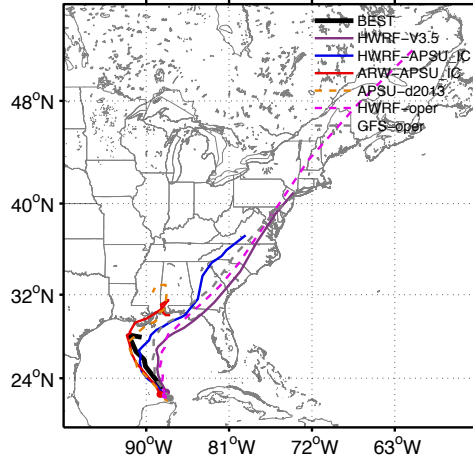
**HWRF d03 initialized with GDAS and TC-relocalization**

**HWRF d03 initialized with GDAS +APSU, no TC-relocalization**  
**Note: this is ghosted from wrfinput\_d01**

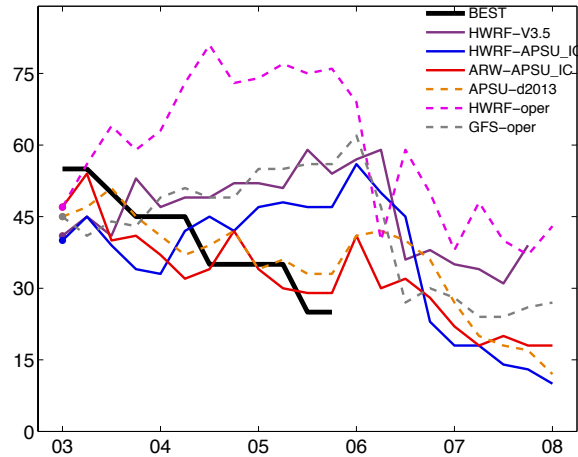


# Forecast for Storm Karen initialized @ 2013100312

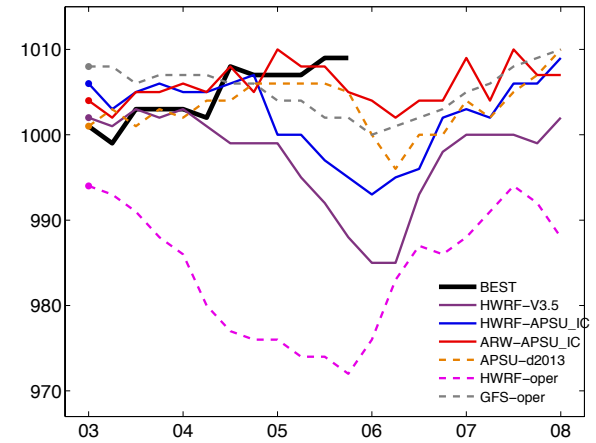
2013a12 Karen APSU Track



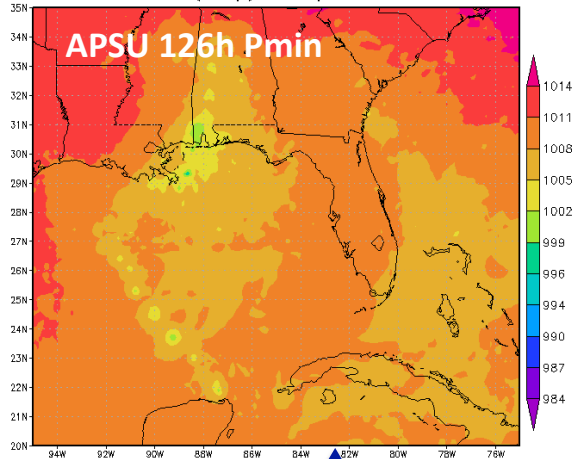
2013a12 Karen APSU Vmax



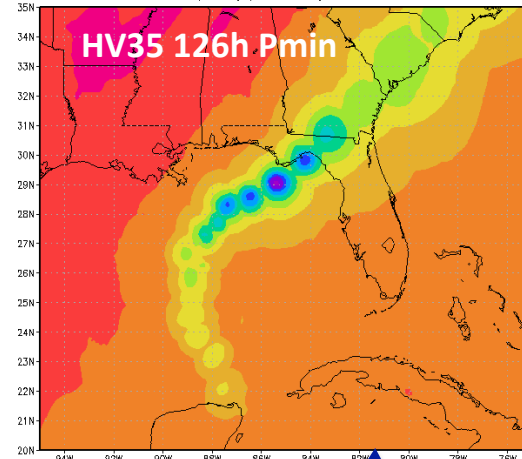
2013a12 Karen APSU Pmin



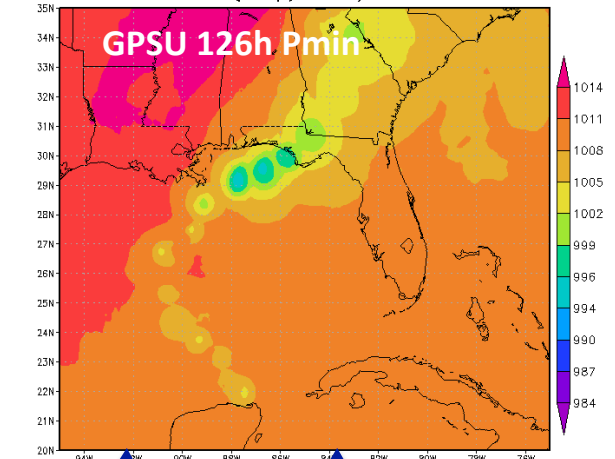
APSUd2013 min(mslp) 126h/6h @ 2013100312



HWRFV3.5 min(mslp) 126h/6h @ 2013100312



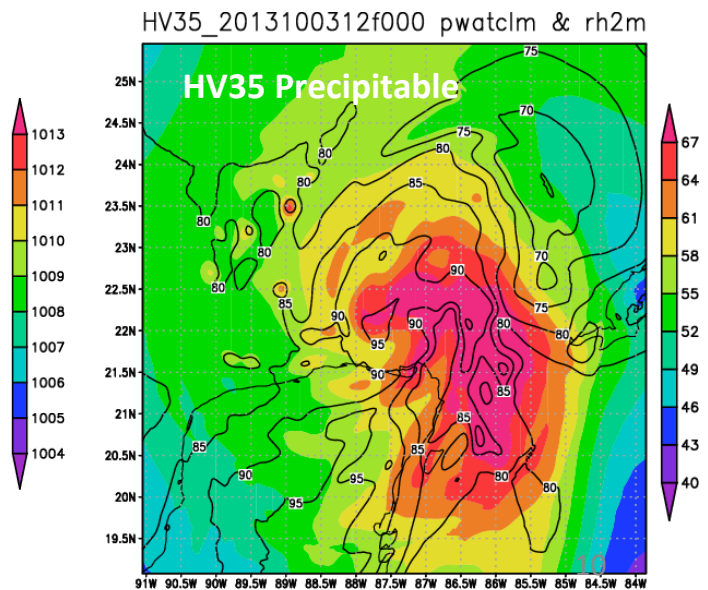
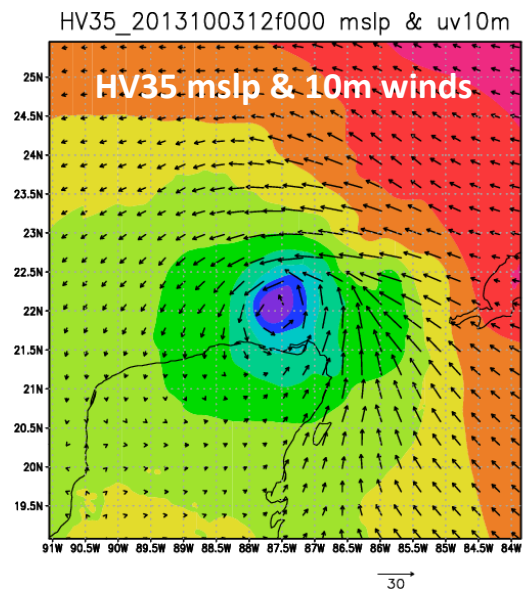
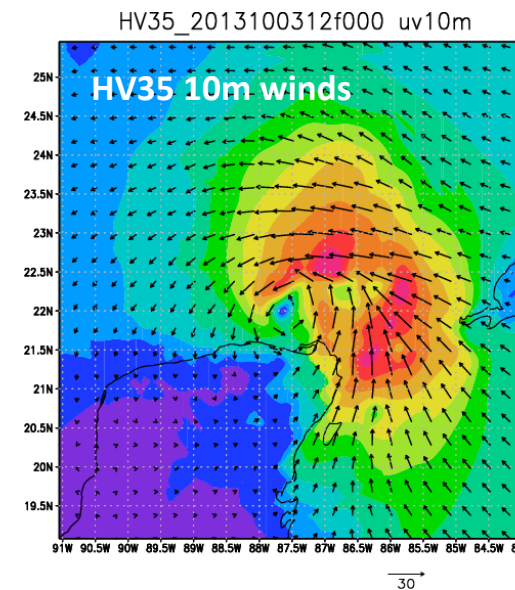
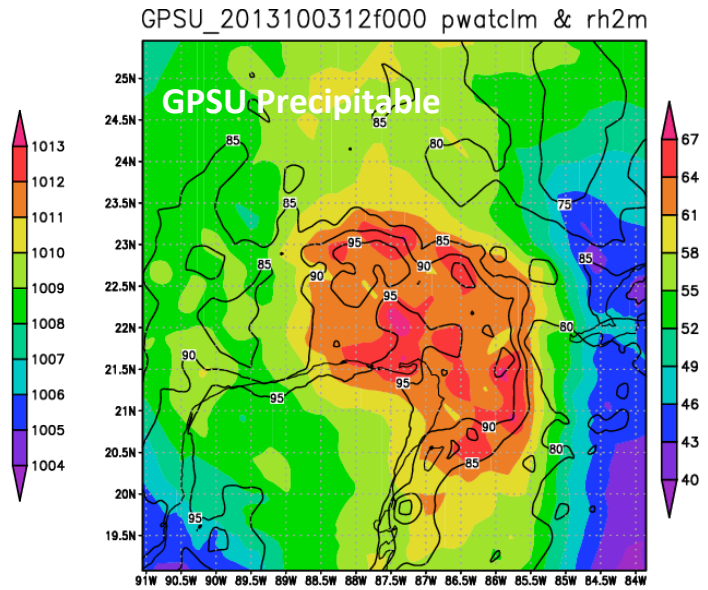
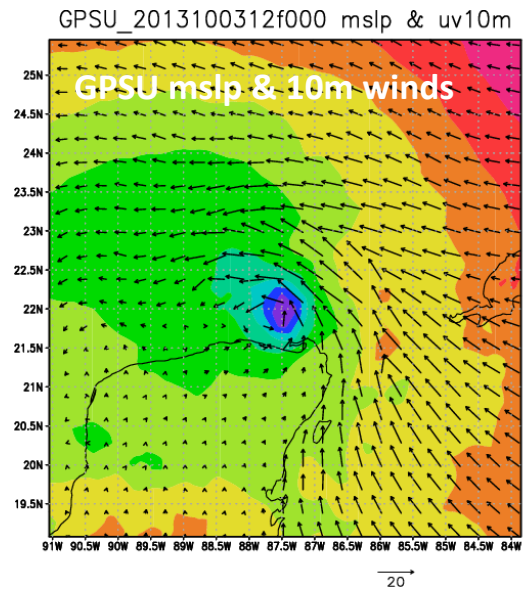
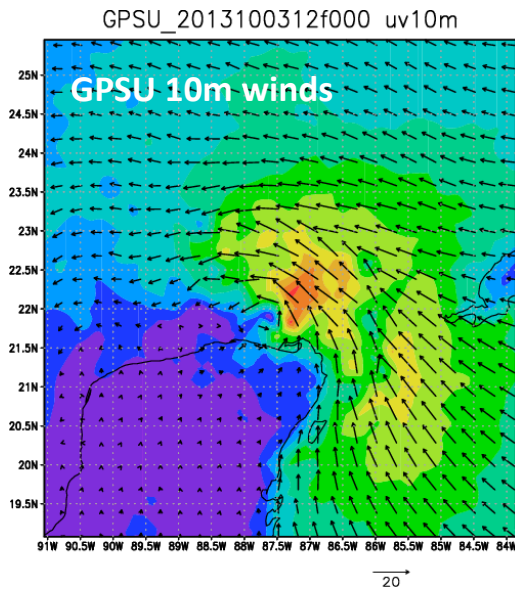
HWRF-APSUic min(mslp) 126h/6h @ 2013100312



Same HWRF model + same BC + different IC

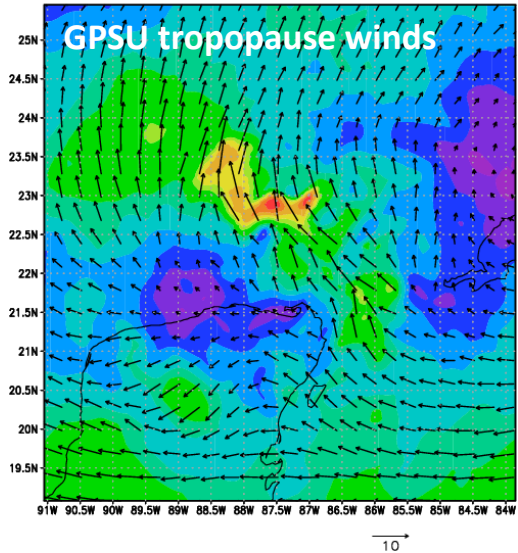
Same IC (different H and V resolutions) + different model + different BC

# GPSU vs HV35: Surface

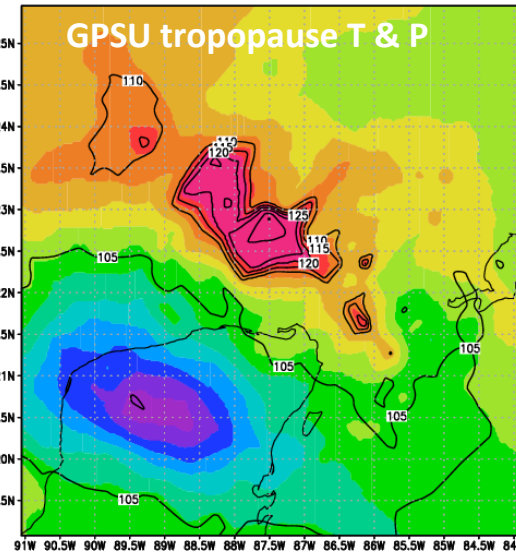


# GPSU vs HV35: Tropopause

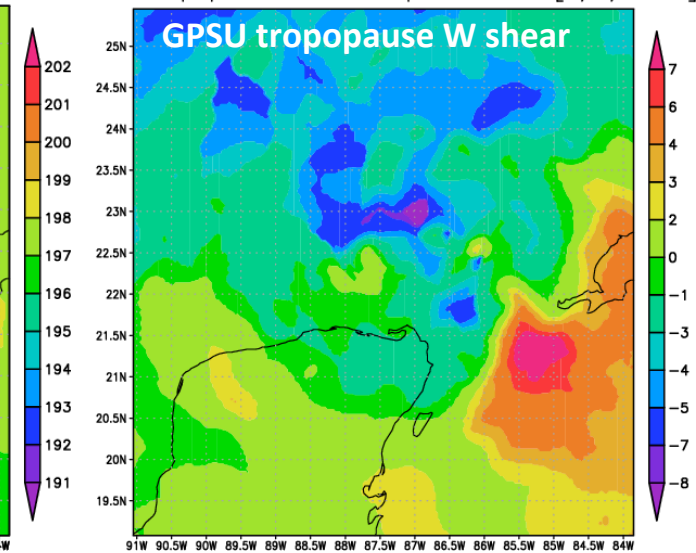
GPSU\_2013100312f000 tropopause winds



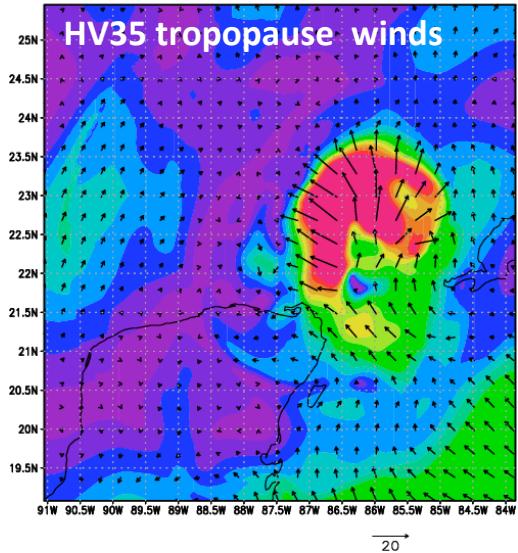
GPSU\_2013100312f000 tropopause T & P



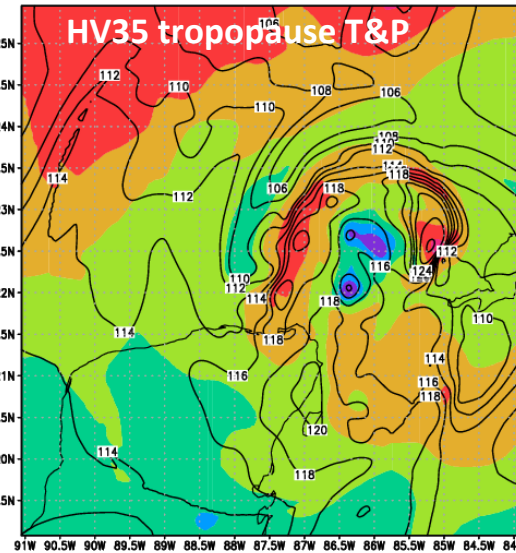
GPSU tropopause Vertical speed shear [1/s/1000]



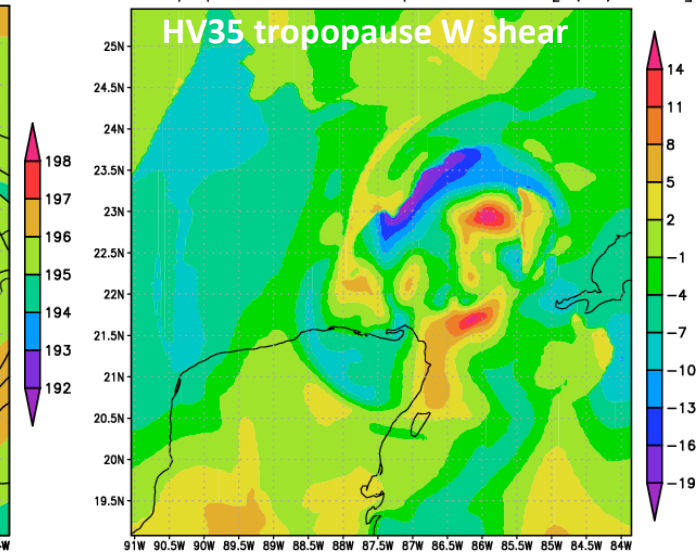
HV35\_2013100312f000 tropopause winds



HV35\_2013100312f000 tropopause T & P

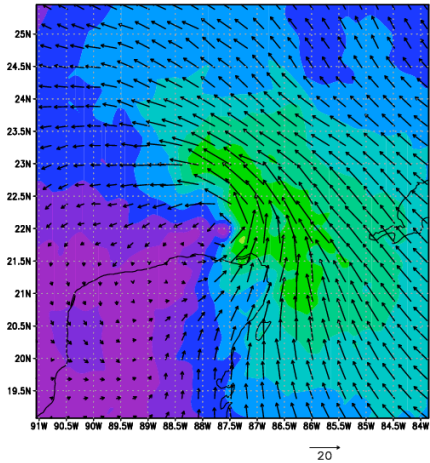


HV35 tropopause Vertical speed shear [1/s/1000]

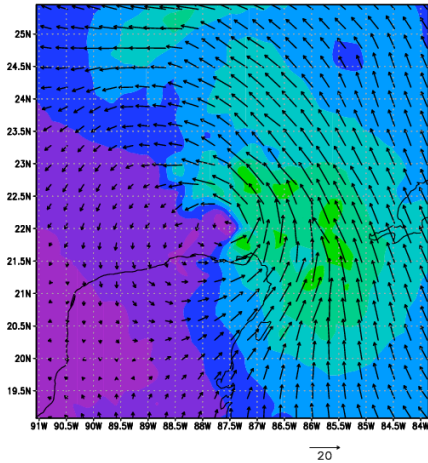


# GPSU vs HV35: Horizontal Winds

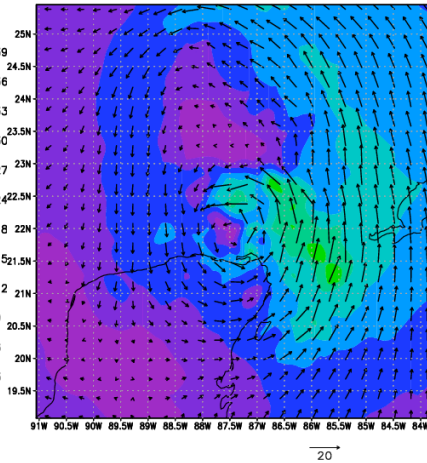
GPSU\_2013100312f000 850mb winds



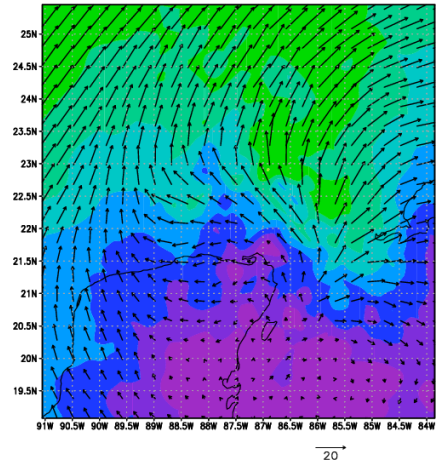
GPSU\_2013100312f000 700mb winds



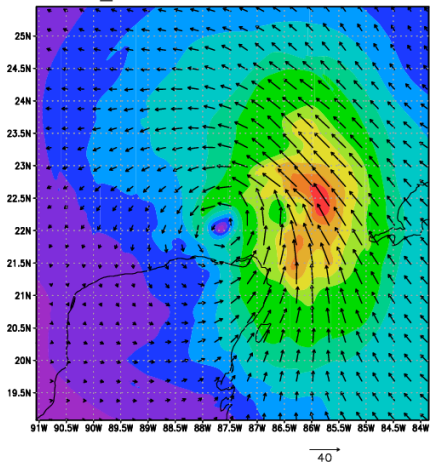
GPSU\_2013100312f000 500mb winds



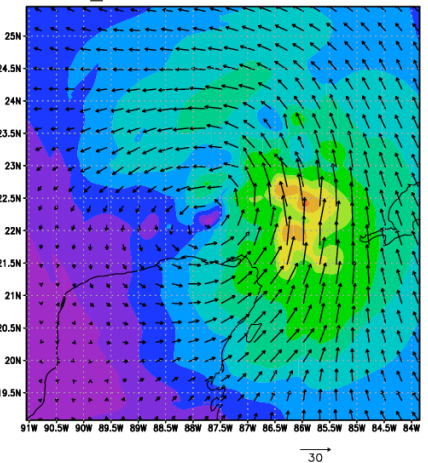
GPSU\_2013100312f000 200mb winds



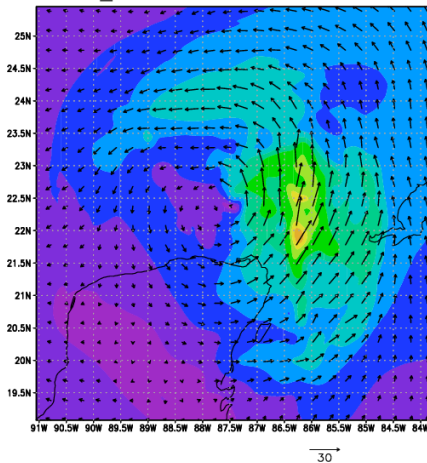
HV35\_2013100312f000 850mb winds



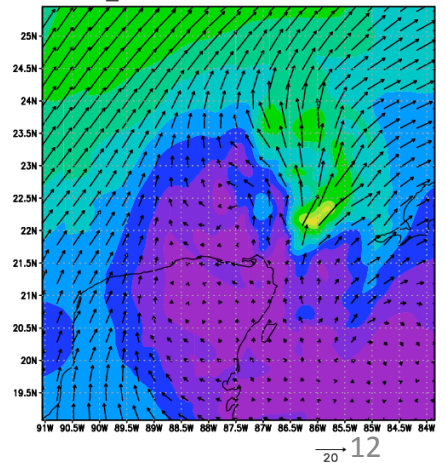
HV35\_2013100312f000 700mb winds



HV35\_2013100312f000 500mb winds

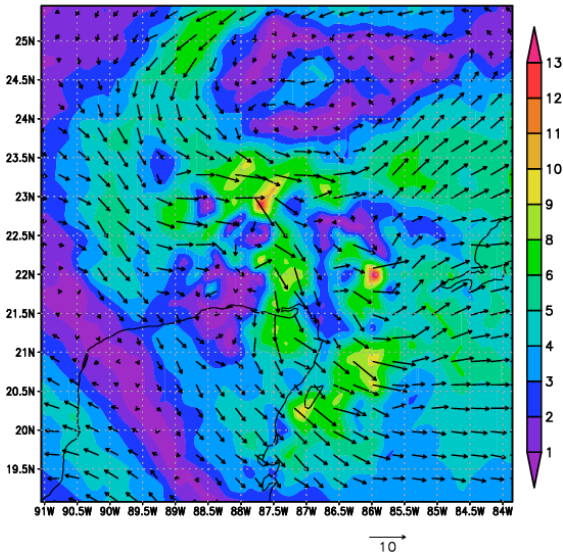


HV35\_2013100312f000 200mb winds

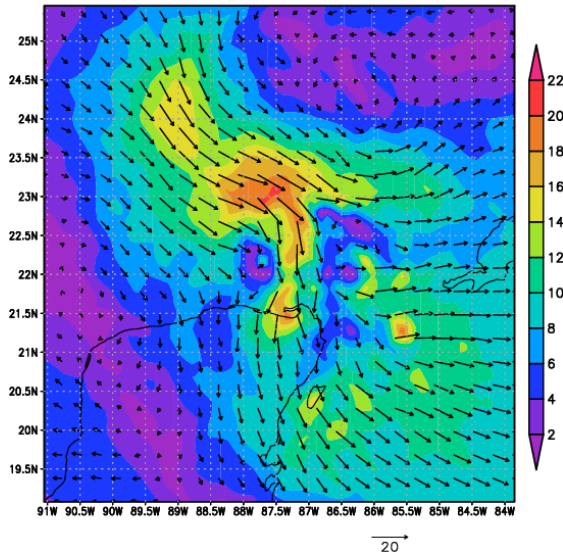


# GPSU vs HV35: Wind Shear & Steer

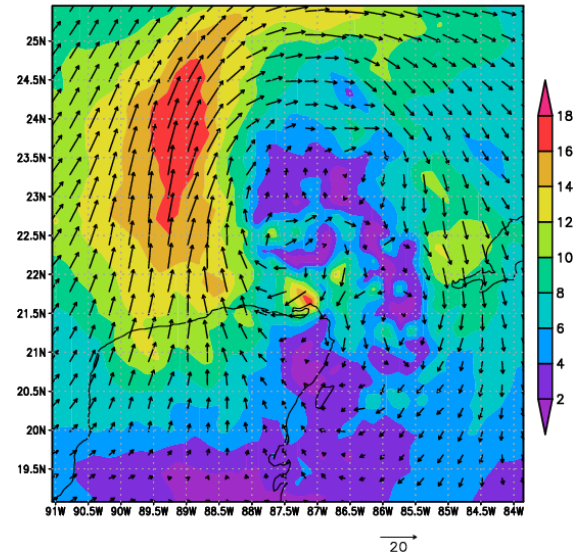
GPSU\_2013100312f000 700-850mb winds



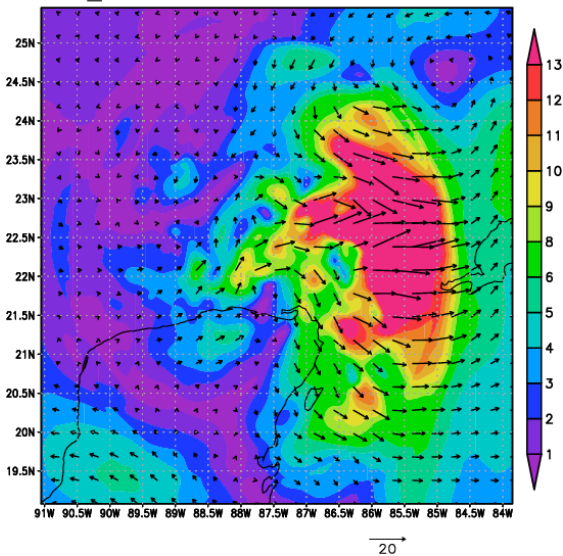
GPSU\_2013100312f000 500-850mb winds



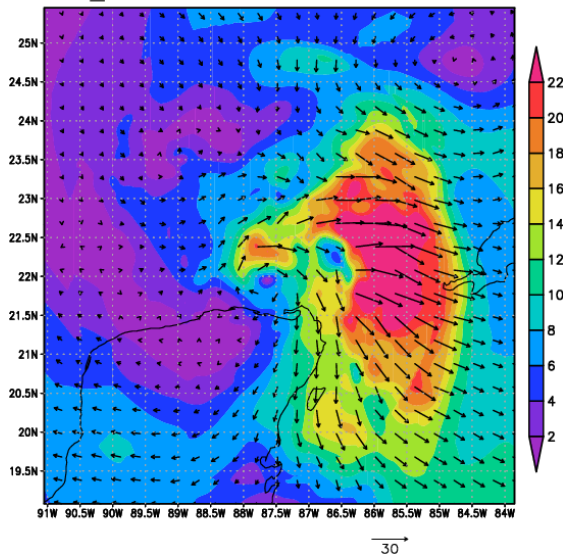
GPSU\_2013100312f000 300-500mb winds



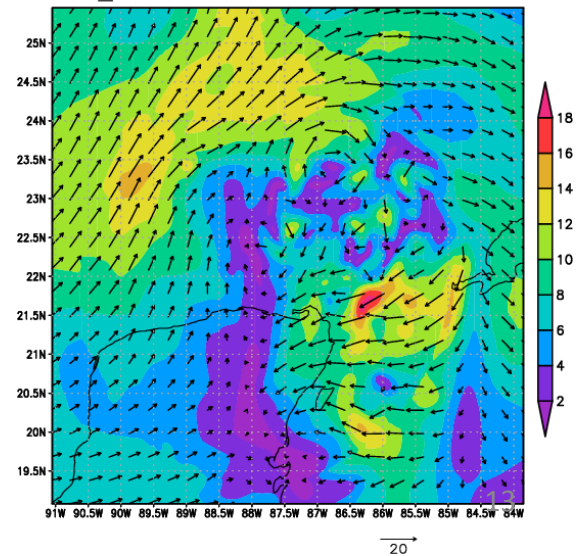
HV35\_2013100312f000 700-850mb winds



HV35\_2013100312f000 500-850mb winds

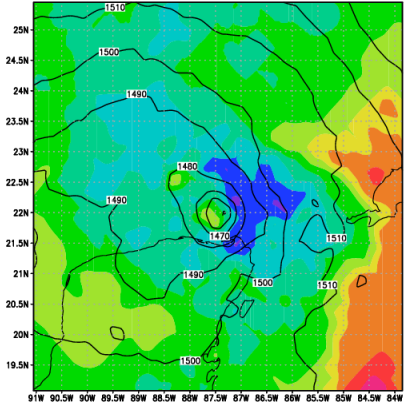


HV35\_2013100312f000 300-500mb winds

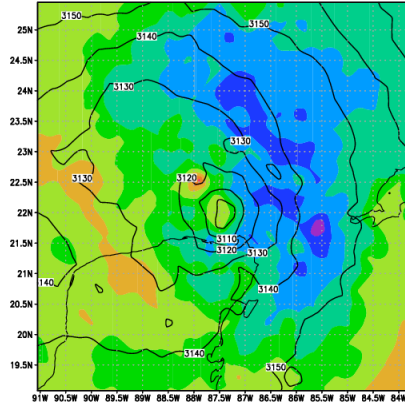


# GPSU vs HV35: T & GH

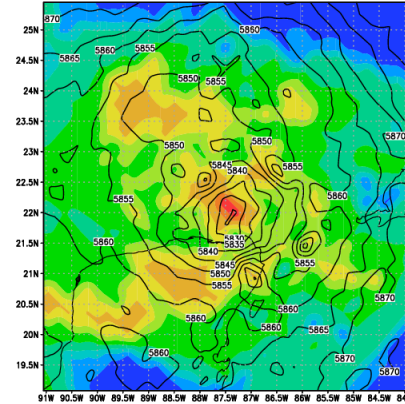
GPSU\_2013100312f000 850mb T&gh



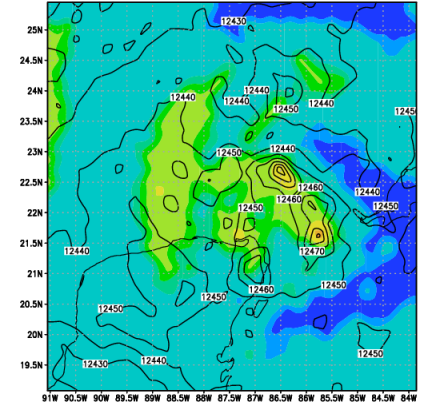
GPSU\_2013100312f000 700mb T&gh



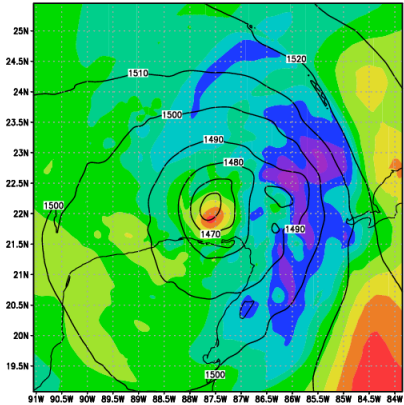
GPSU\_2013100312f000 500mb T&gh



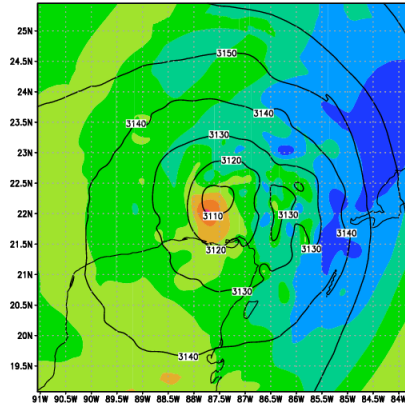
GPSU\_2013100312f000 200mb T&gh



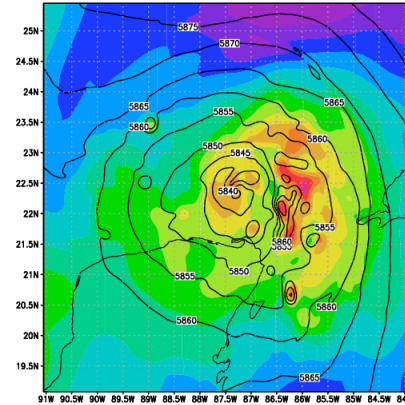
HV35\_2013100312f000 850mb T&gh



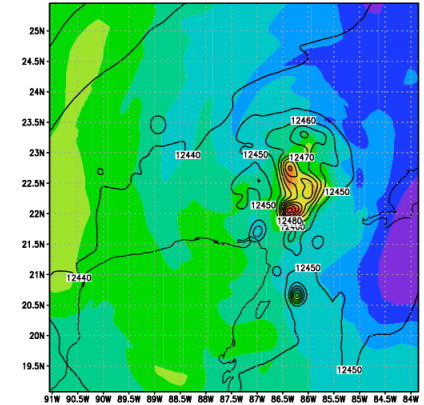
HV35\_2013100312f000 700mb T&gh



HV35\_2013100312f000 500mb T&gh

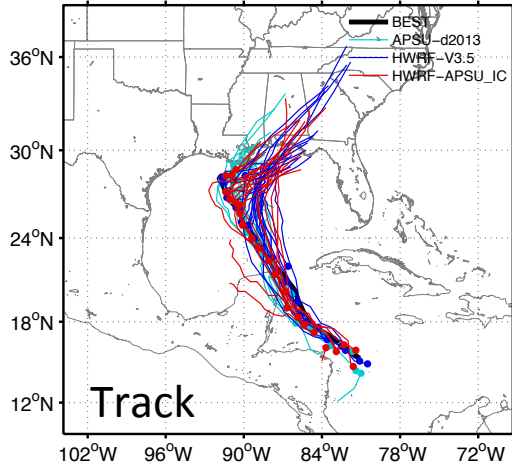


HV35\_2013100312f000 200mb T&gh

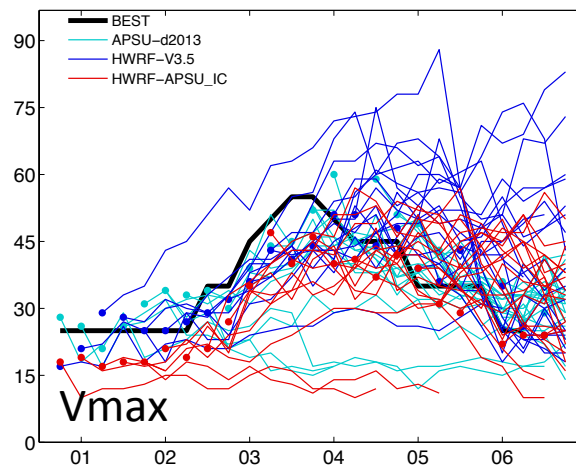


# Forecast for Weak Storm: Karen-2013a12

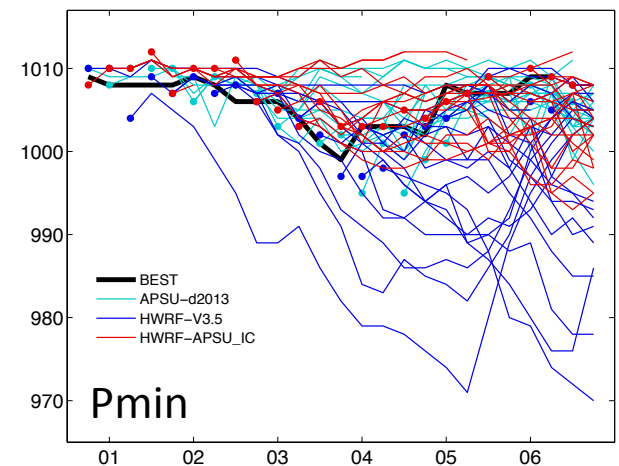
2013a12 Karen APSU Track



2013a12 Karen APSU Vmax



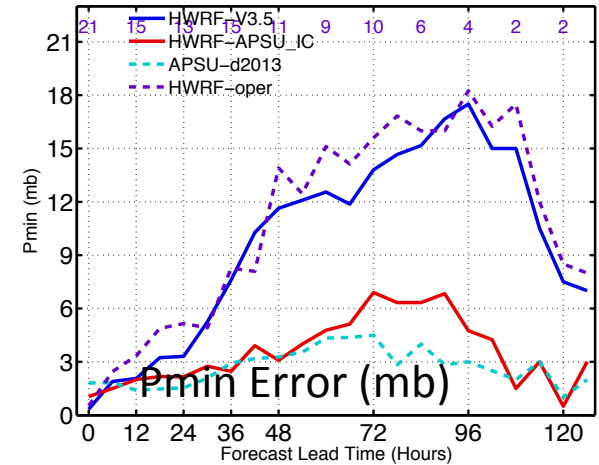
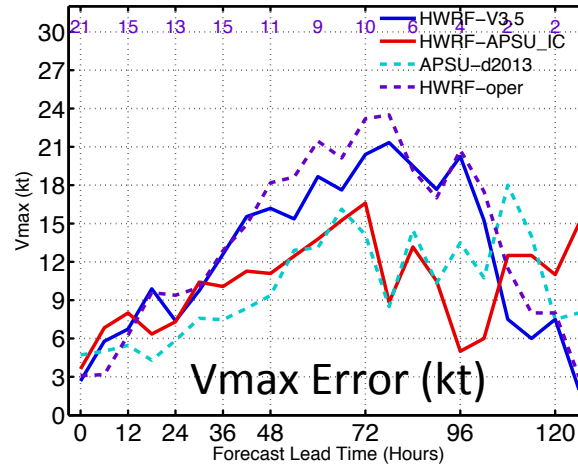
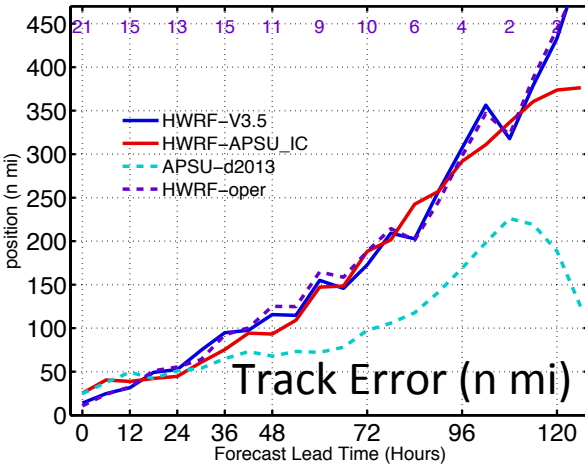
2013a12 Karen APSU Pmin



Abs Error of position (n mi) for al122013-HV35GPSUAPSUHWRf

Abs Error of Vmax (kt) for al122013-HV35GPSUAPSUHWRf

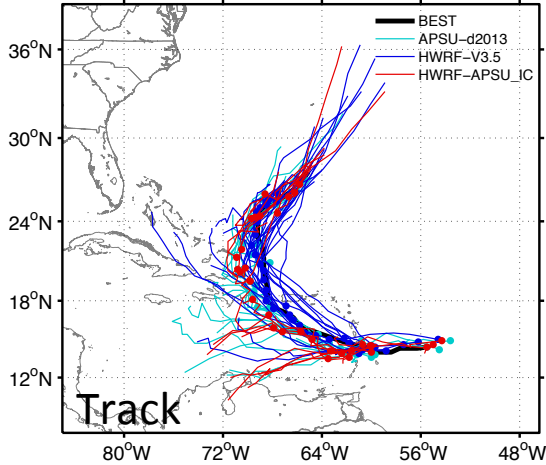
Abs Error of Pmin (mb) for al122013-HV35GPSUAPSUHWRf



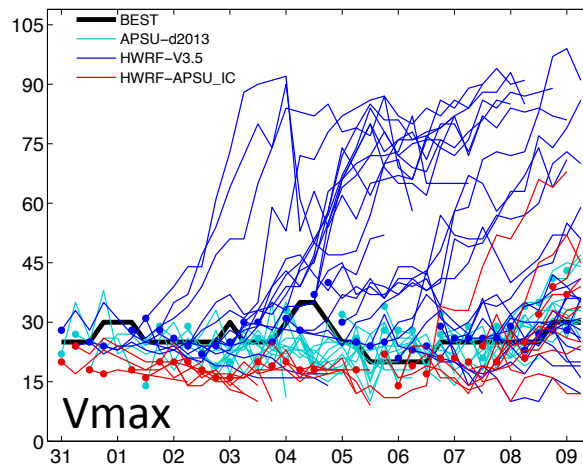
Note: Bug of 9 samples at 60h, while 10 at 72h: GPSU missed some trackers.

# Forecast for Weak Storm: Gabrielle-2013aI07

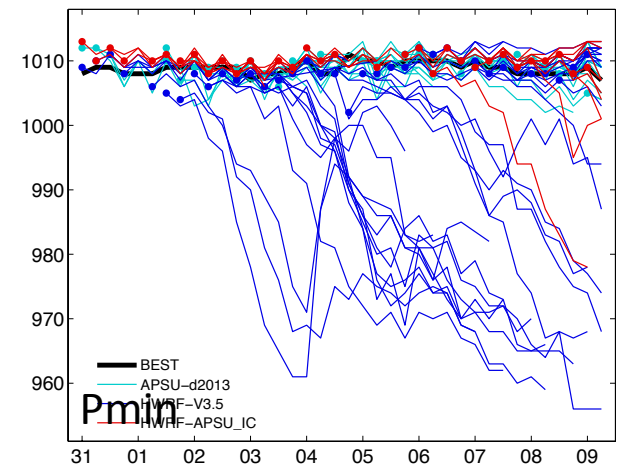
2013aI07 Gabrielle APSU Track



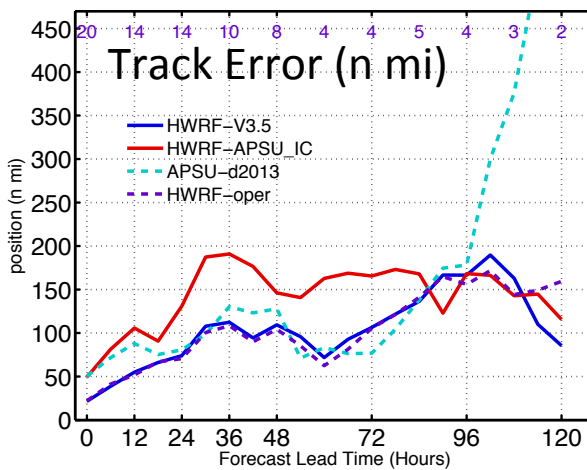
2013aI07 Gabrielle APSU Vmax



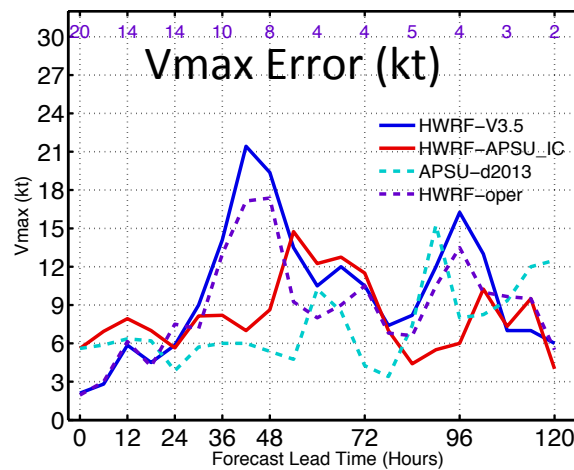
2013aI07 Gabrielle APSU Pmin



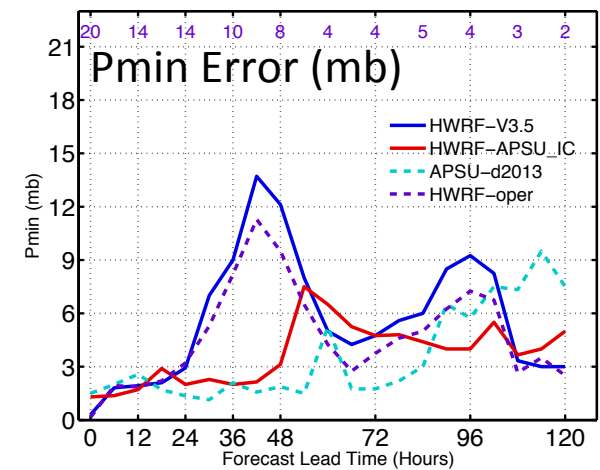
Abs Error of position (n mi) for aI072013--HV35GPSUAPSUHWRf



Abs Error of Vmax (kt) for aI072013--HV35GPSUAPSUHWRf



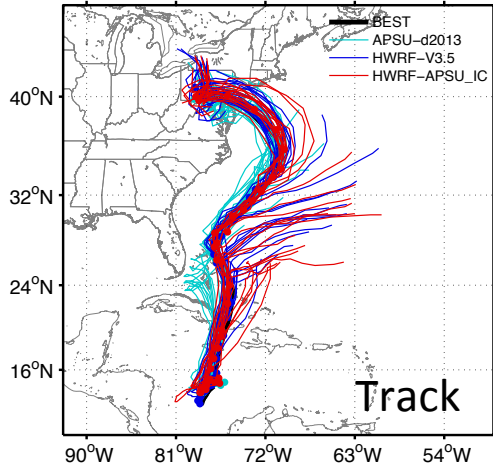
Abs Error of Pmin (mb) for aI072013--HV35GPSUAPSUHWRf



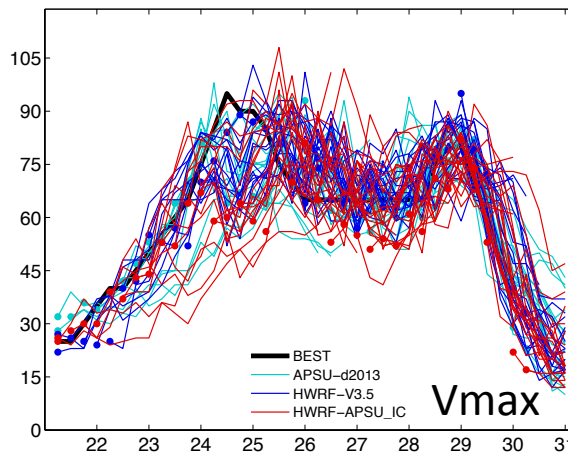


# Forecast for Strong Storm: Sandy-2012a18

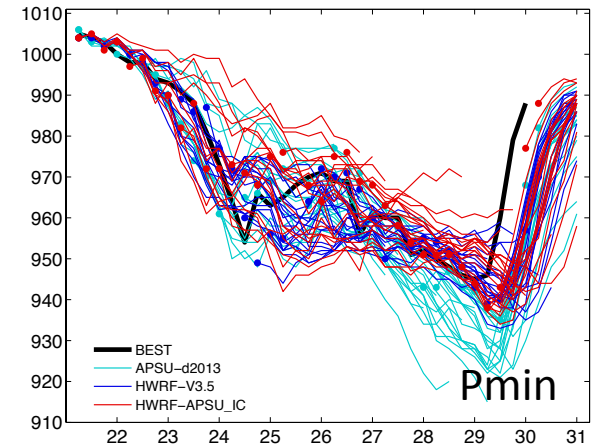
2012a18 Sandy APSU Track



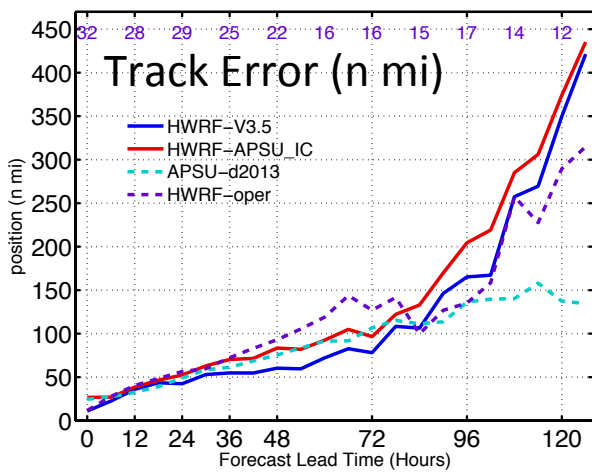
2012a18 Sandy APSU Vmax



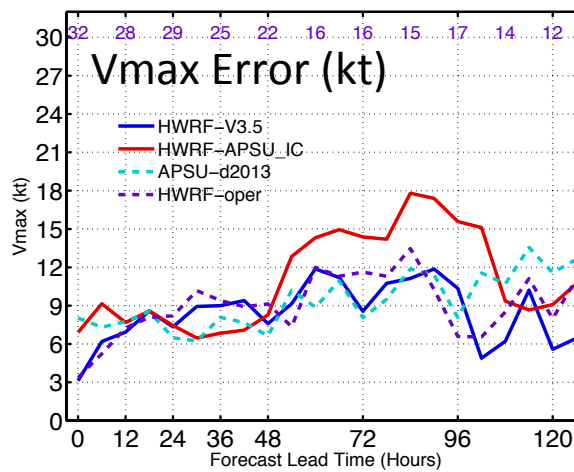
2012a18 Sandy APSU Pmin



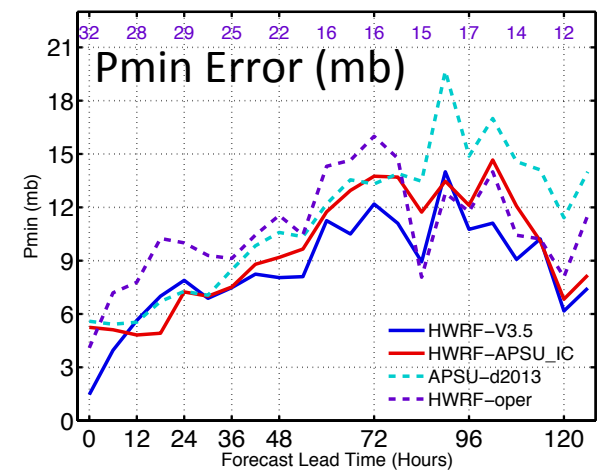
Abs Error of position (n mi) for al182012-HV35GPSUAPSUHWRF



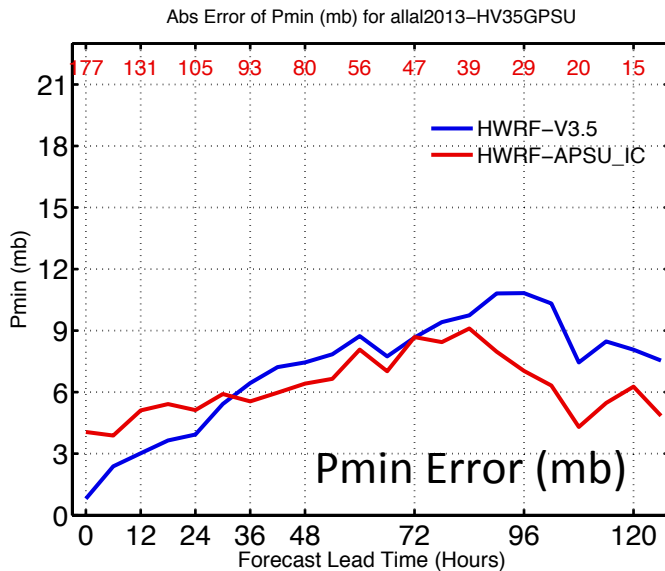
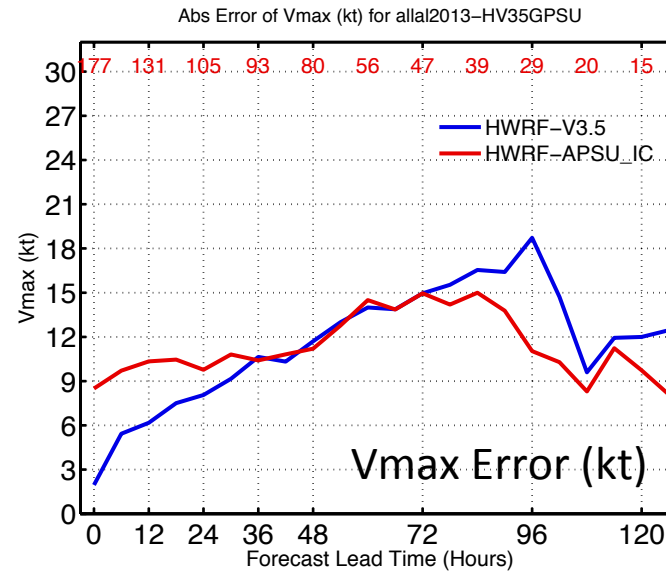
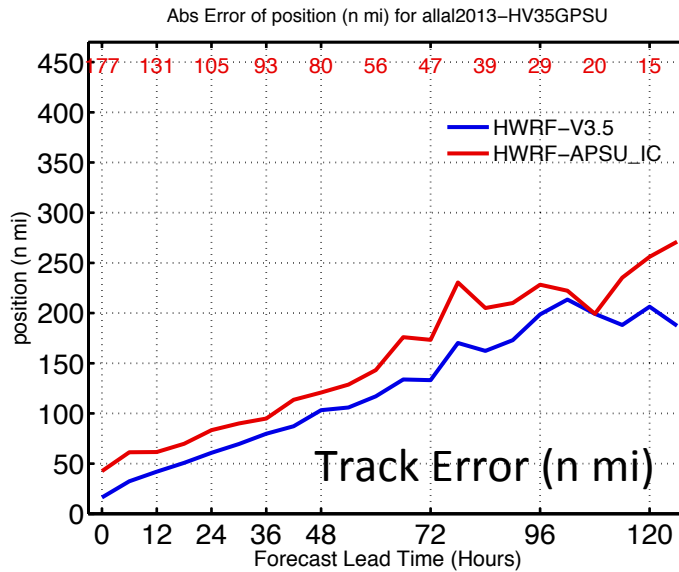
Abs Error of Vmax (kt) for al182012-HV35GPSUAPSUHWRF



Abs Error of Pmin (mb) for al182012-HV35GPSUAPSUHWRF

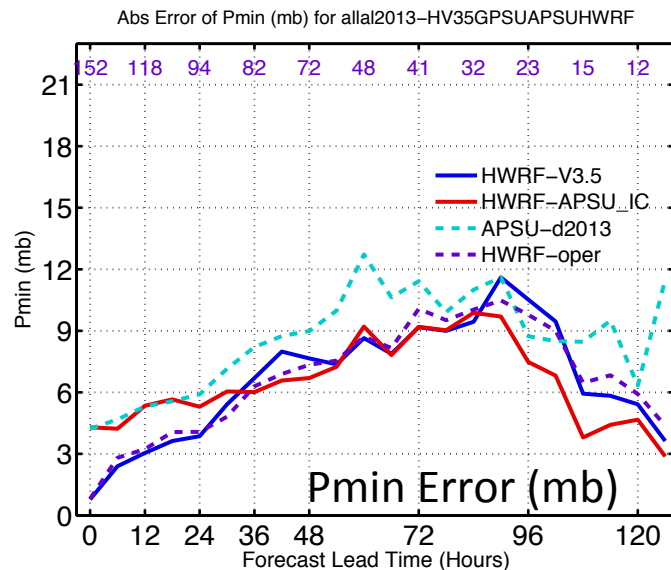
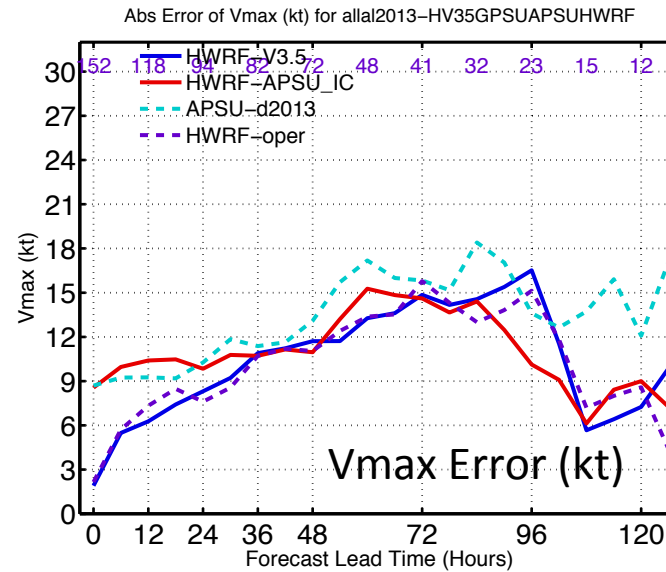
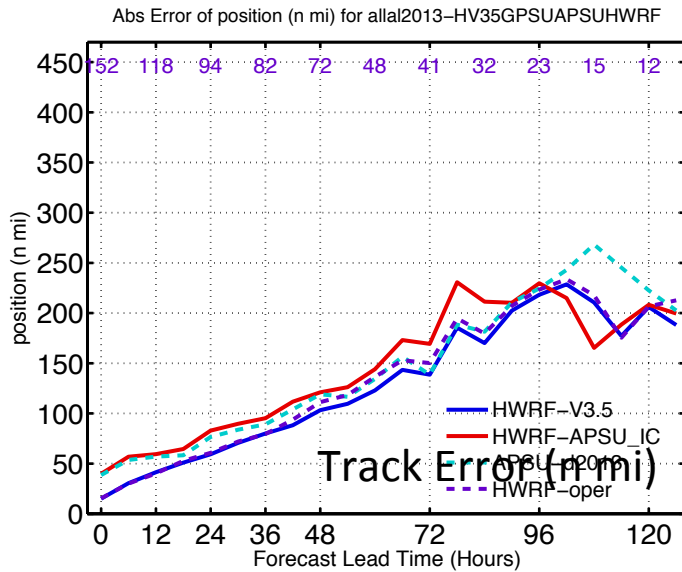


# Forecast Errors: all 2013 storms



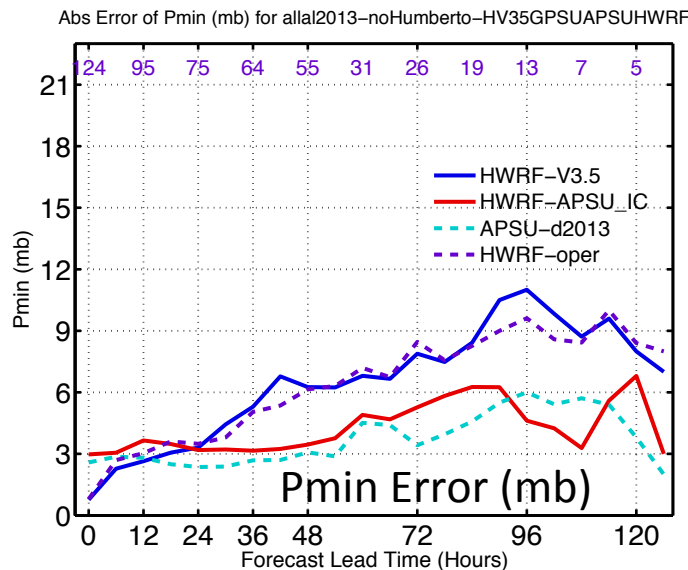
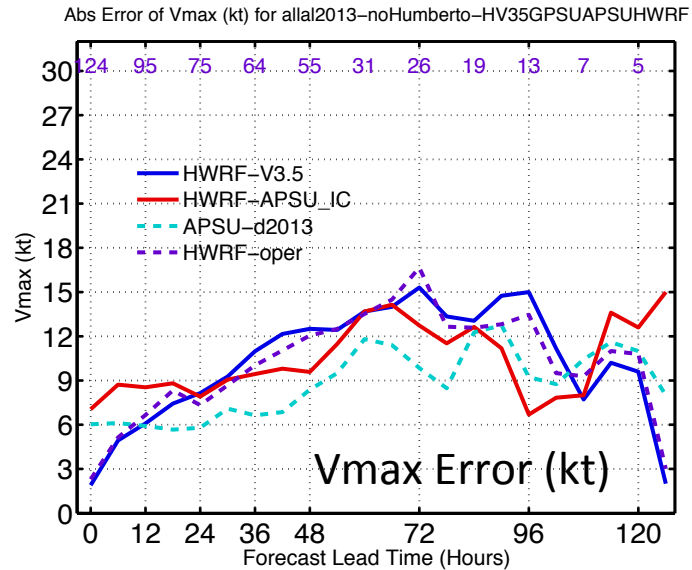
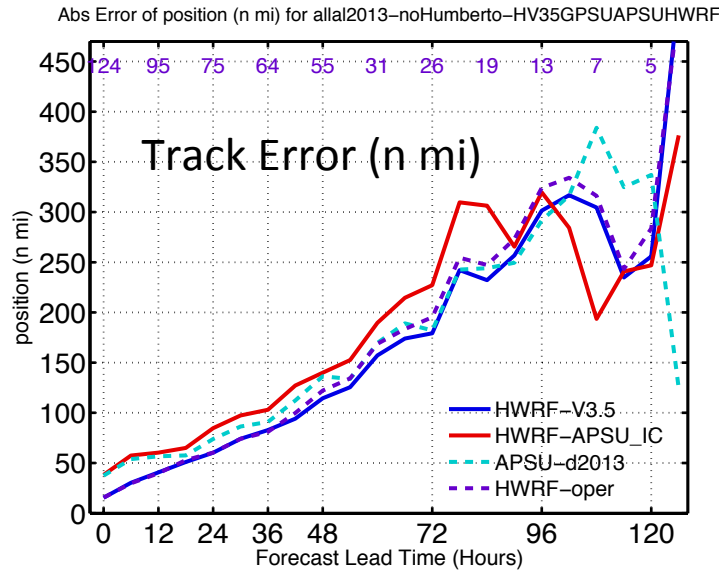
- Total 260+ cases in 2013;
- GPSU has larger tracker errors;
- GPSU has smaller intensity errors after 36h lead time.

# Forecast Errors: all 2013 storms



- Total 260+ cases in 2013;
- HV35 is very close to operational HWRF;
- GPSU has smaller intensity errors than APSU in both Vmax and Pmin:
  - does this mean HWRF has smaller model error than ARW?
  - Or means the impact of BC or ocean model?

# Forecast Errors: all 2013 storms except Humberto

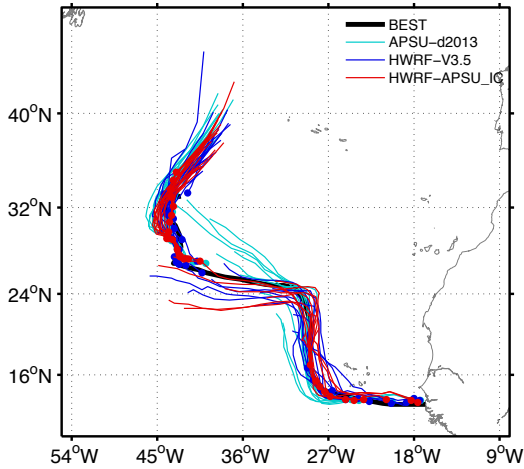


**Humberto was too far away from American, and few observations were assimilated in APSU.**

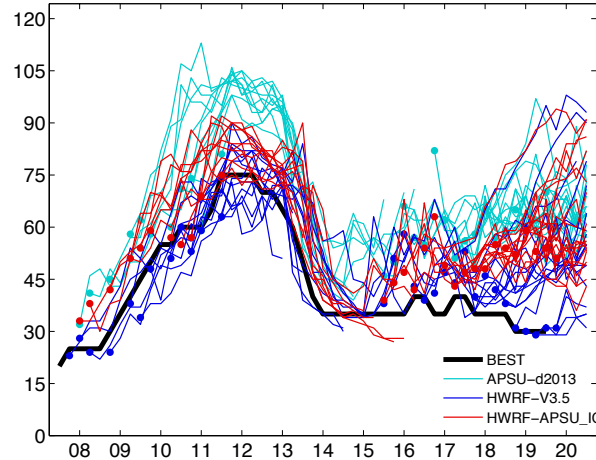
- Total 168 cases in 2013;
- HV35 is very close to operational HWRF;
- GPSU is a little bit of worse than APSU;
- GPSU has smaller intensity error than HWRF.

# Forecast for Storm: Humberto-2013a109

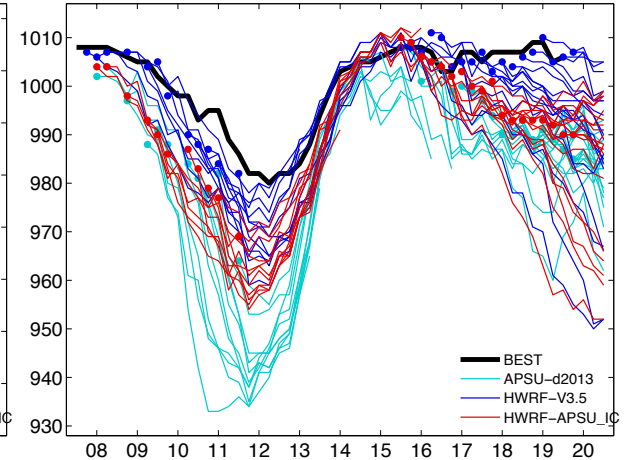
2013a109 Humberto APSU Track



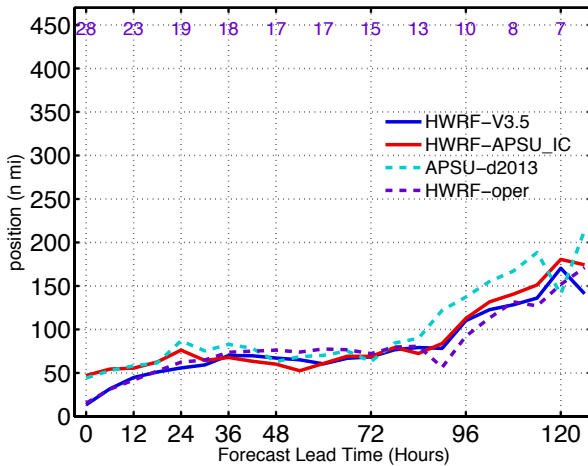
2013a109 Humberto APSU Vmax



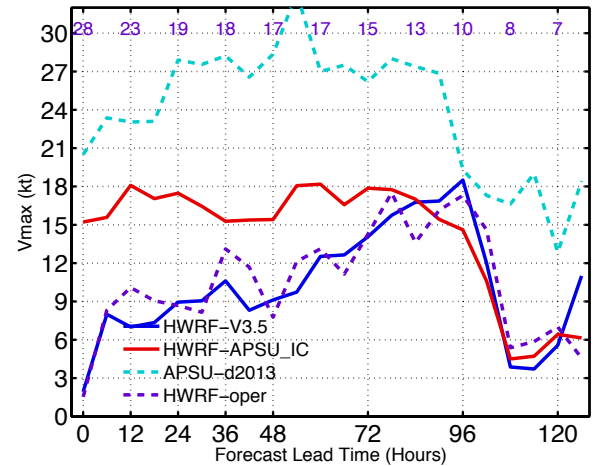
2013a109 Humberto APSU Pmin



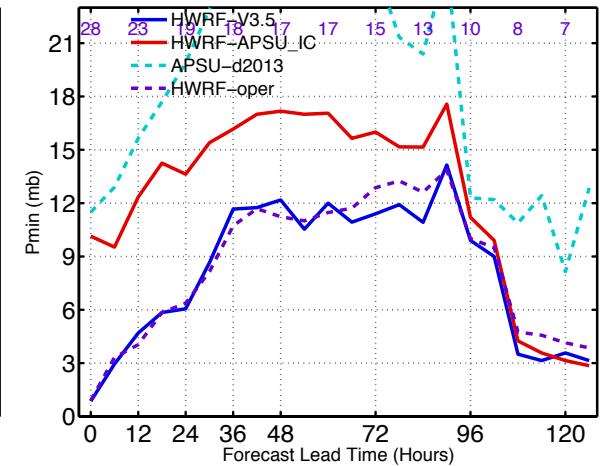
Abs Error of position (n mi) for a1092013-HV35GPSUAPSUHWRf



Abs Error of Vmax (kt) for a1092013-HV35GPSUAPSUHWRf



Abs Error of Pmin (mb) for a1092013-HV35GPSUAPSUHWRf



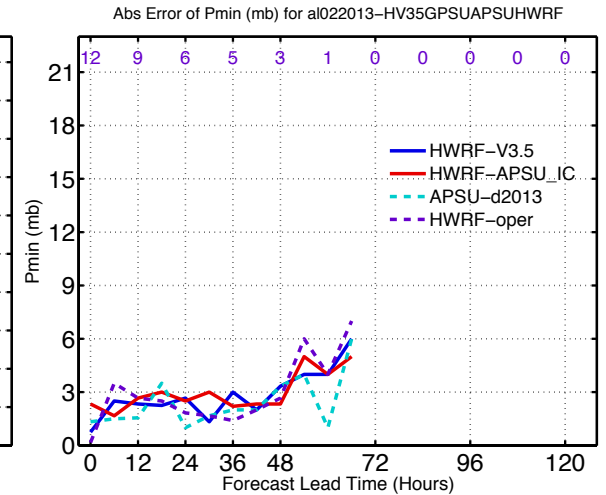
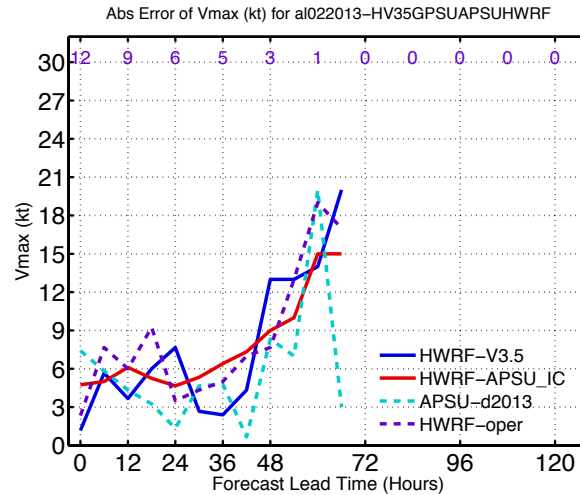
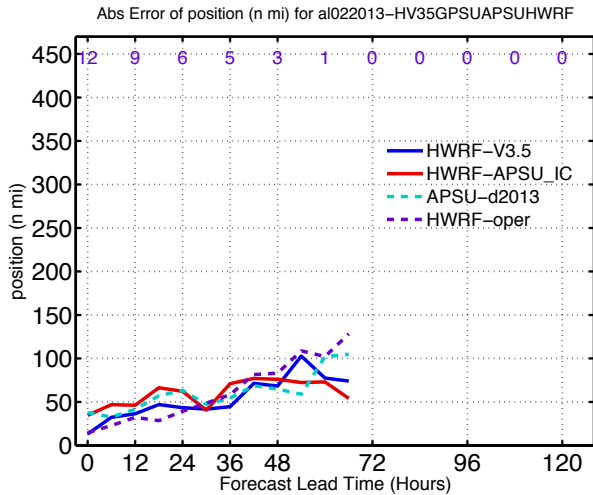
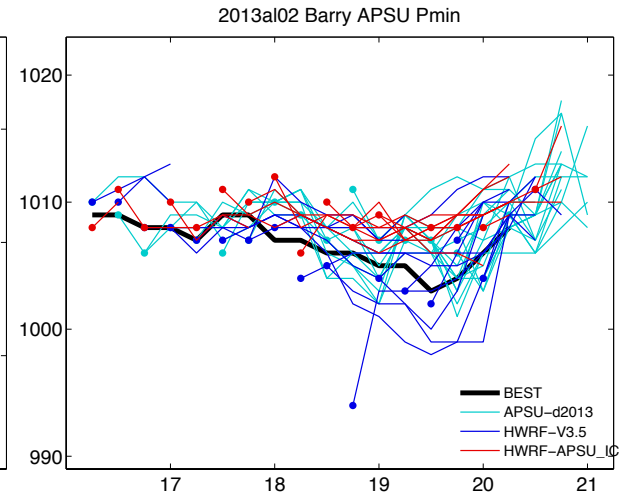
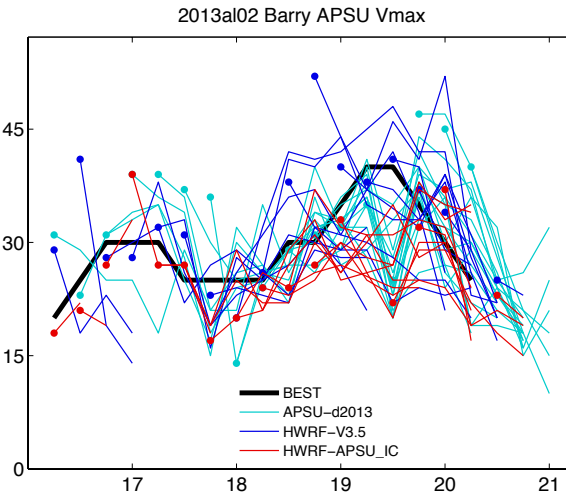
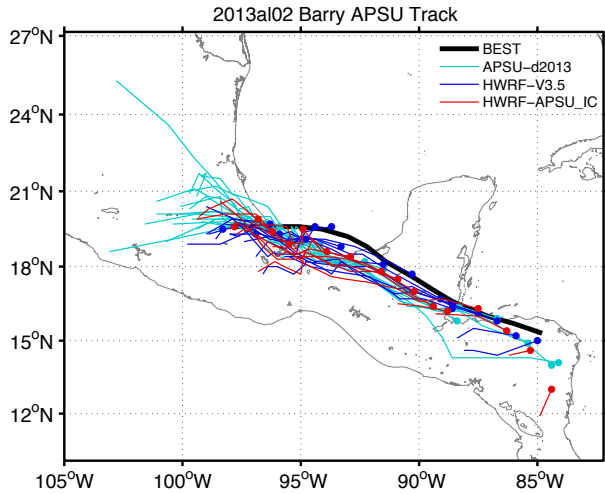
# Findings

- HV35 is very close to 2013 operational HWRF;
- When obs are available in the storm, APSU produces more realistic storm structures;
- After 24h, GPSU reduces intensity forecast errors, especially on Pmin;
- HWRF model can rival ARW, and HWRF cost much less computing resources.

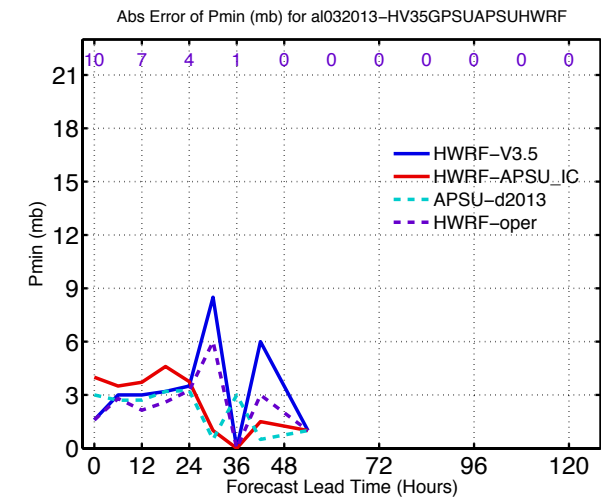
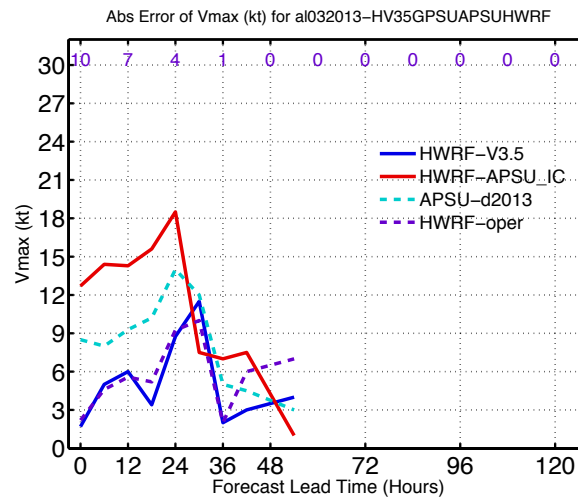
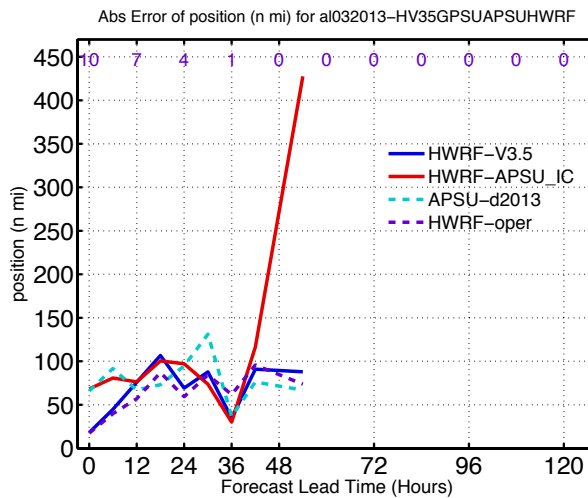
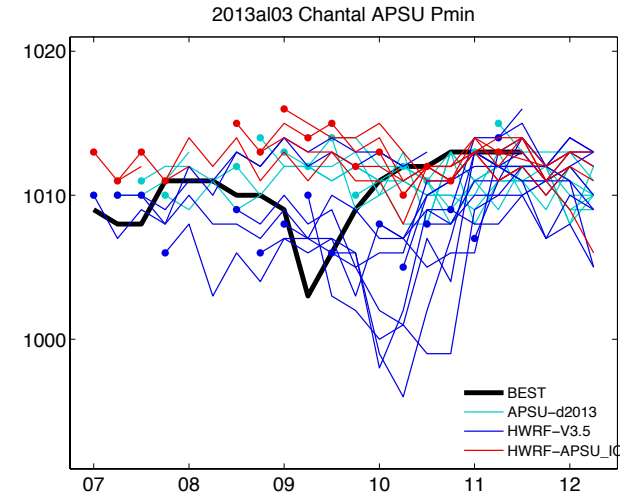
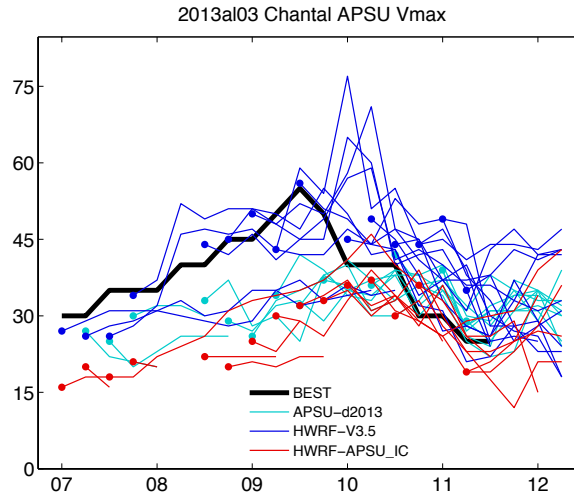
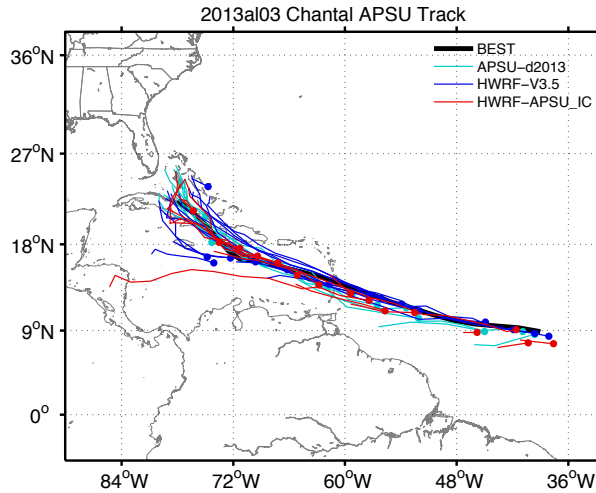
## May go to...

- HWRF without relocater, without GSI, directly initialized with the previous cycle GFS;
- GSI with the above HWRF;
- ...

# Forecast for Storm: Barry-2013aI02

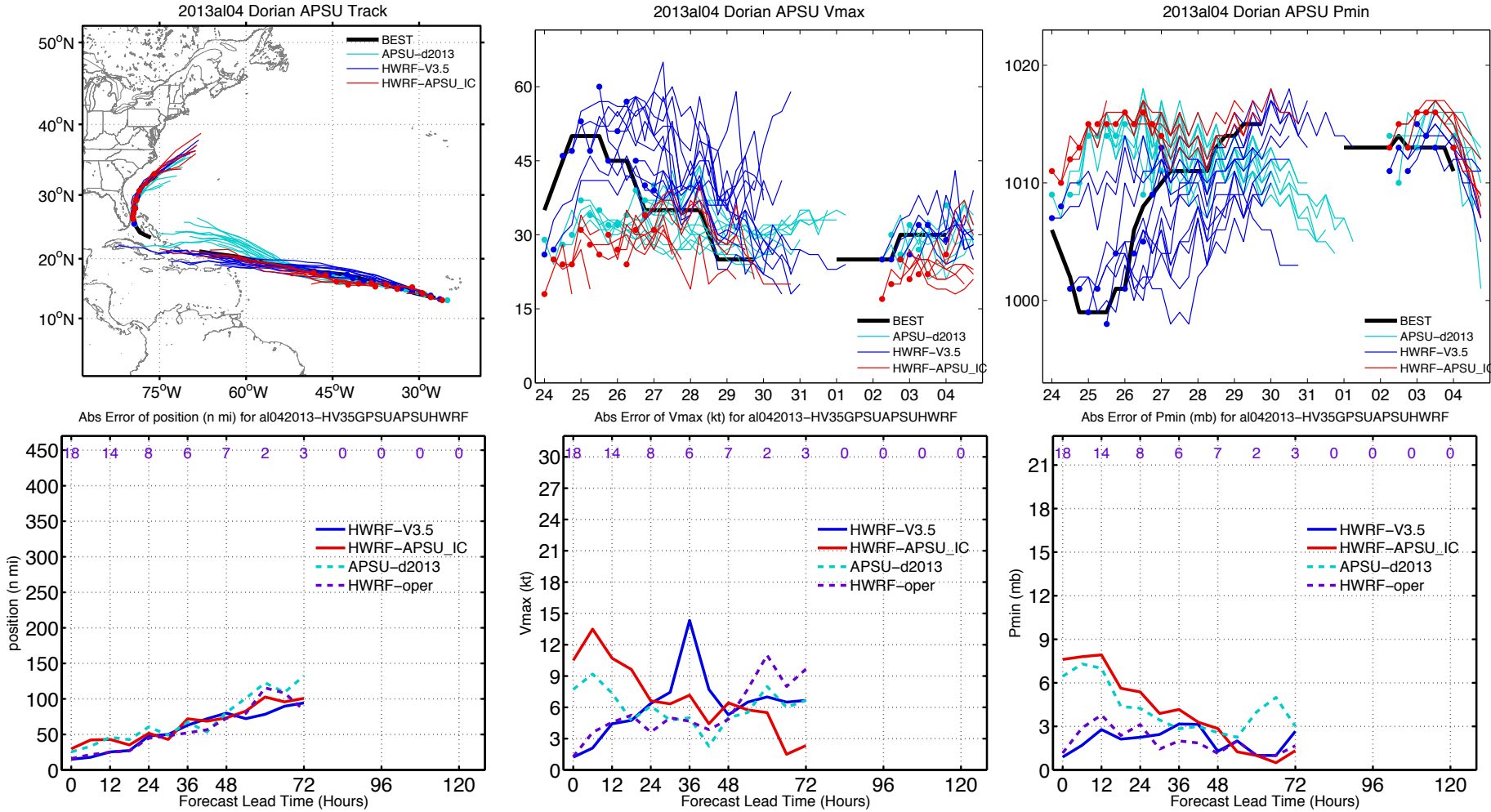


# Forecast for Storm: CHANTAL-2013aI03



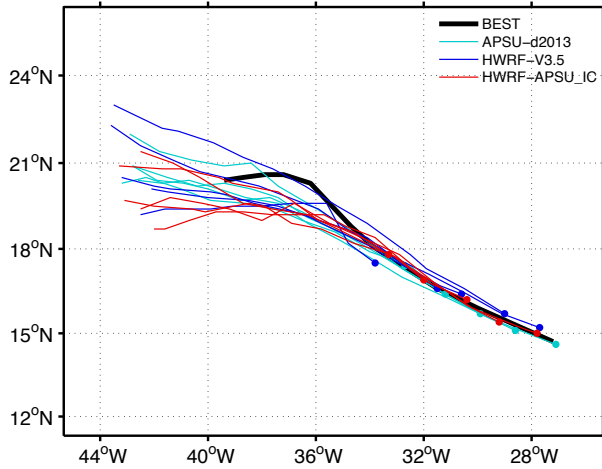


# Forecast for Storm: Dorian-2013aI04

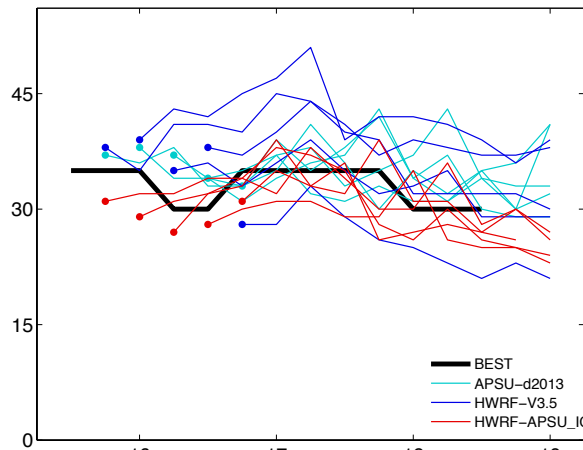


# Forecast for Storm: Erin-2013a105

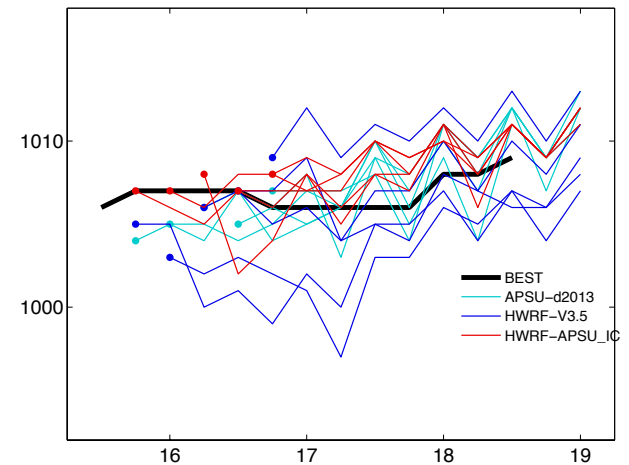
2013a105 Erin APSU Track



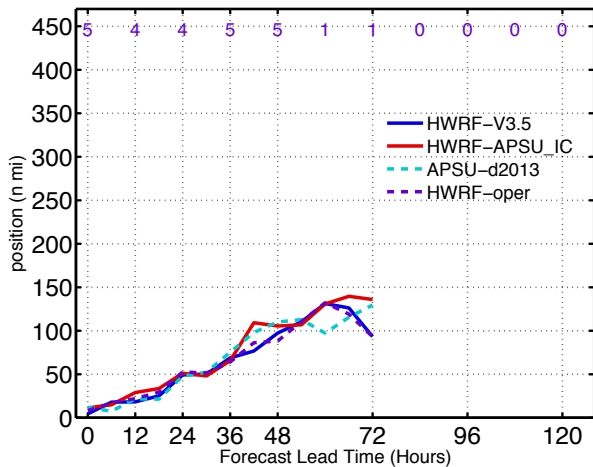
2013a105 Erin APSU Vmax



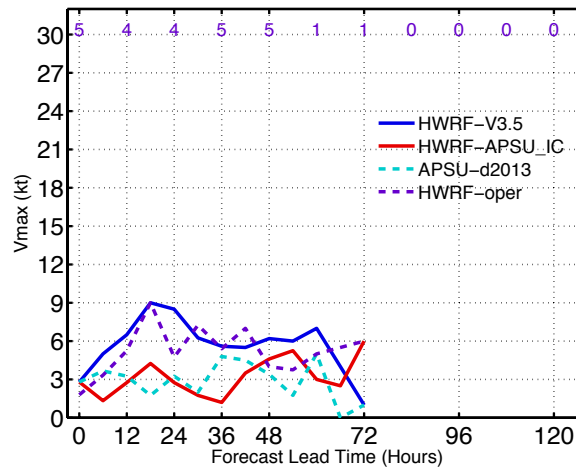
2013a105 Erin APSU Pmin



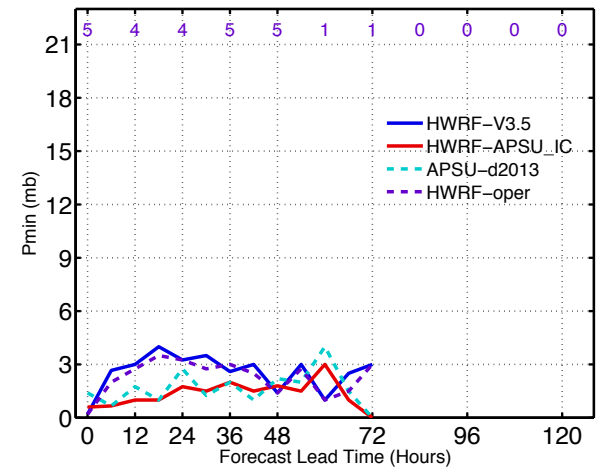
Abs Error of position (n mi) for a1052013-HV35GPSUAPSUHWRf



Abs Error of Vmax (kt) for a1052013-HV35GPSUAPSUHWRf

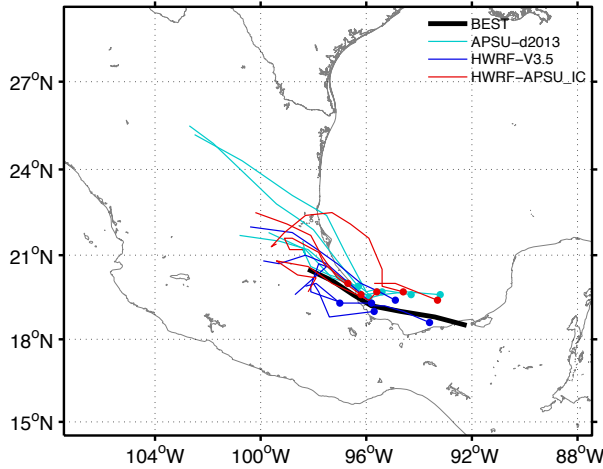


Abs Error of Pmin (mb) for a1052013-HV35GPSUAPSUHWRf

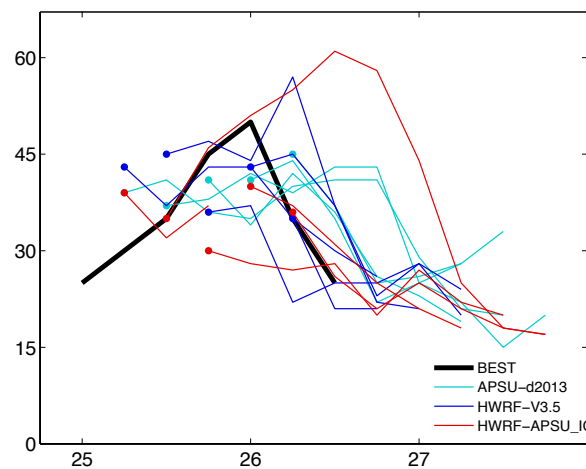


# Forecast for Storm: Fernand-2013a106

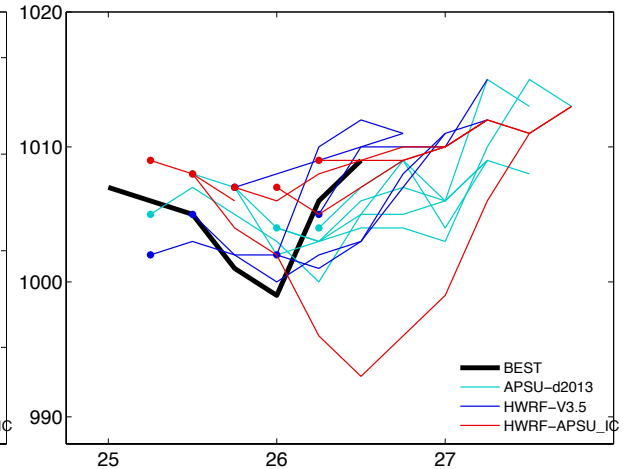
2013a106 Fernand APSU Track



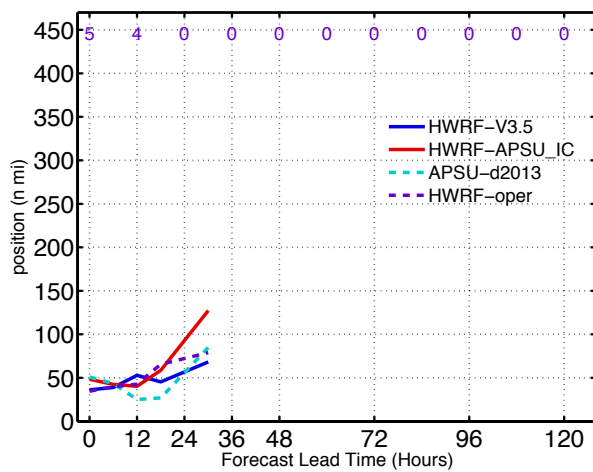
2013a106 Fernand APSU Vmax



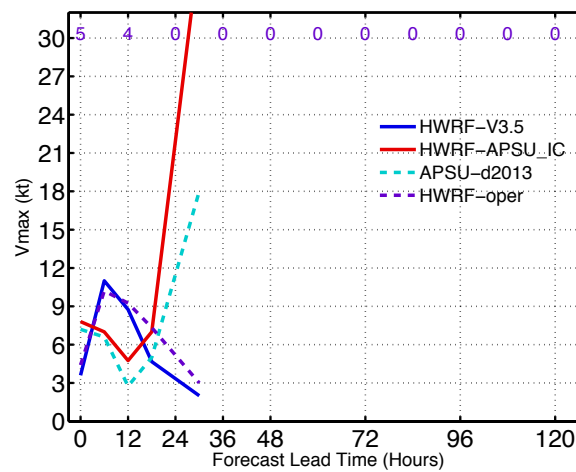
2013a106 Fernand APSU Pmin



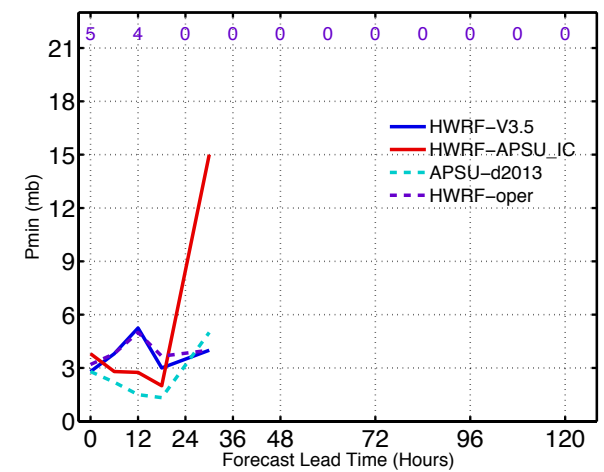
Abs Error of position (n mi) for a1062013-HV35GPSUAPSUHWRf



Abs Error of Vmax (kt) for a1062013-HV35GPSUAPSUHWRf

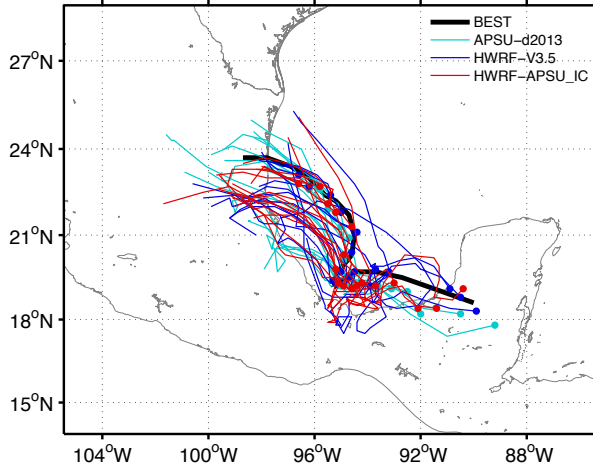


Abs Error of Pmin (mb) for a1062013-HV35GPSUAPSUHWRf

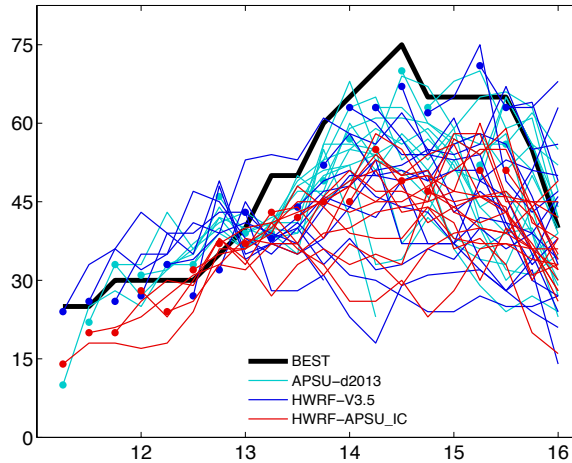


# Forecast for Storm: Ingrid-2013a10

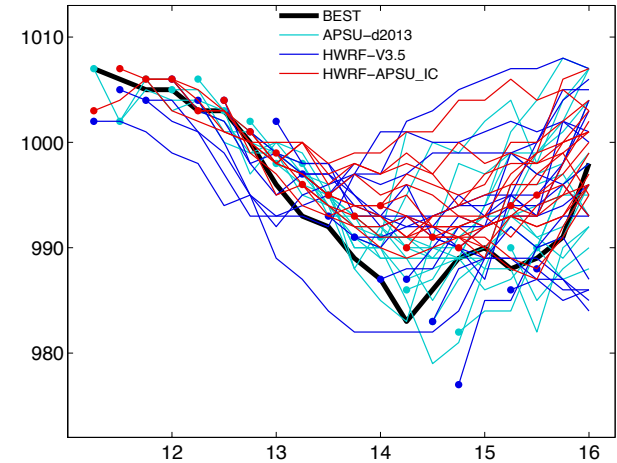
2013a10 Ingrid APSU Track



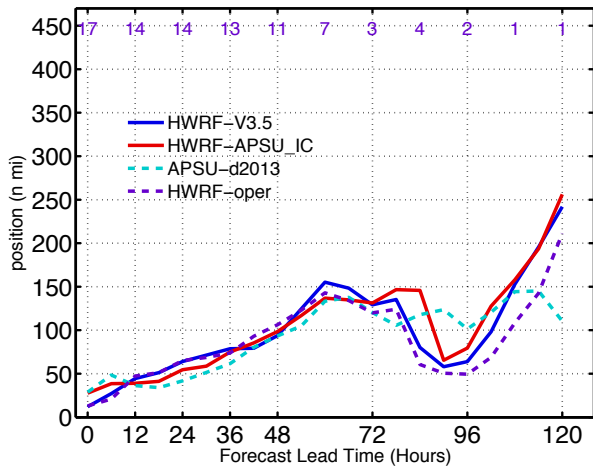
2013a10 Ingrid APSU Vmax



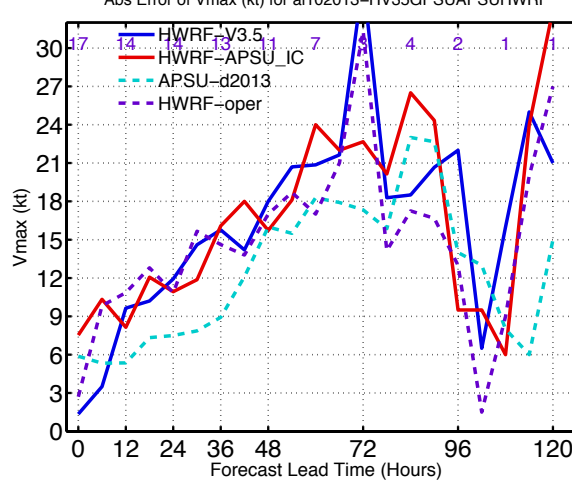
2013a10 Ingrid APSU Pmin



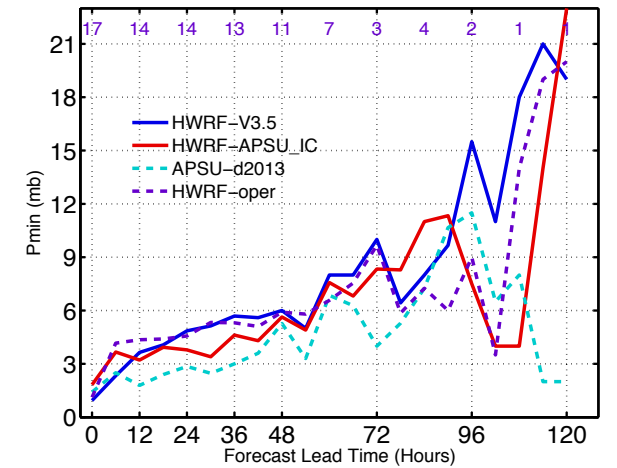
Abs Error of position (n mi) for al102013-HV35GPSUAPSUHWRf



Abs Error of Vmax (kt) for al102013-HV35GPSUAPSUHWRf

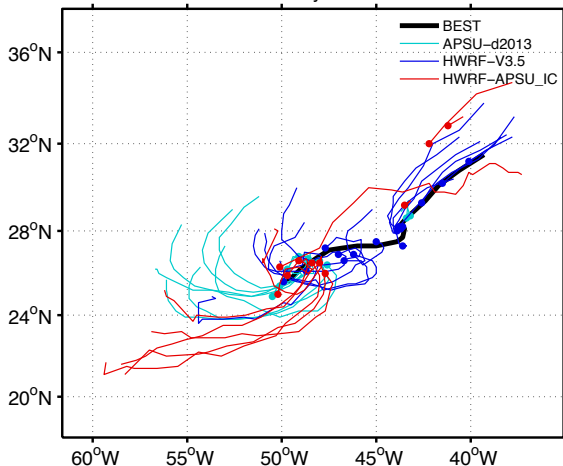


Abs Error of Pmin (mb) for al102013-HV35GPSUAPSUHWRf

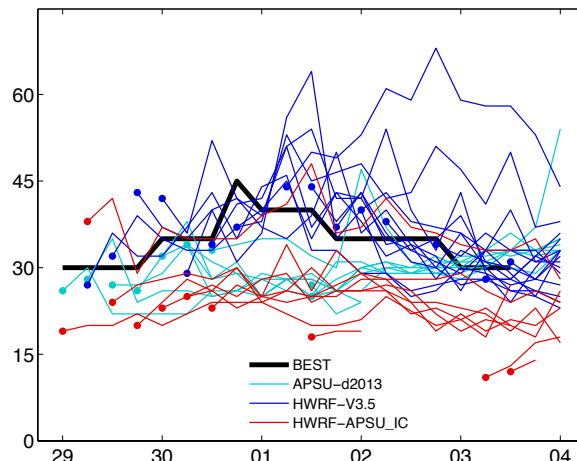


# Forecast for Storm: Jerry-2013a11

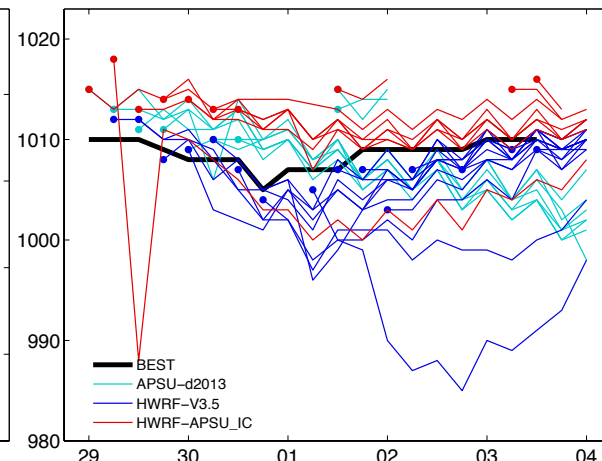
2013a11 Jerry APSU Track



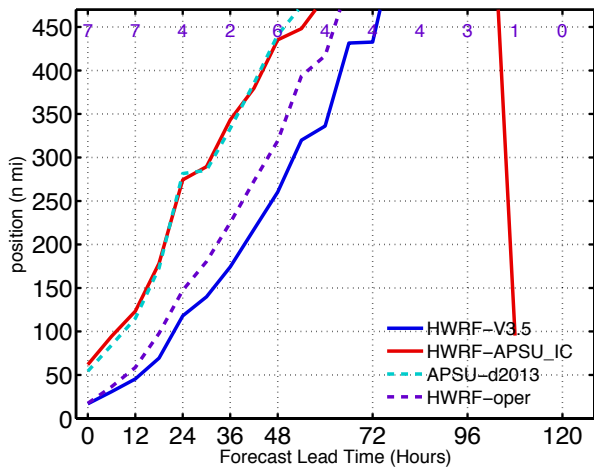
2013a11 Jerry APSU Vmax



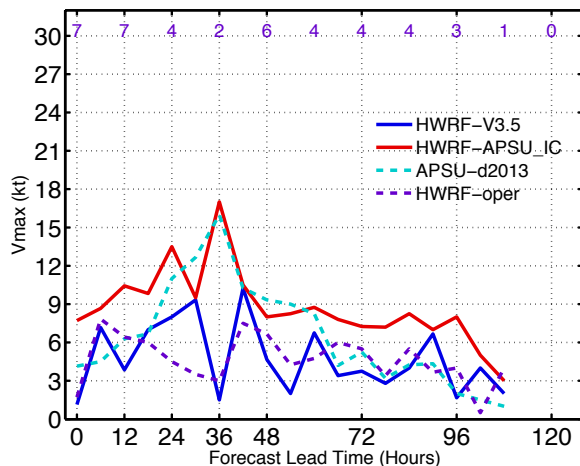
2013a11 Jerry APSU Pmin



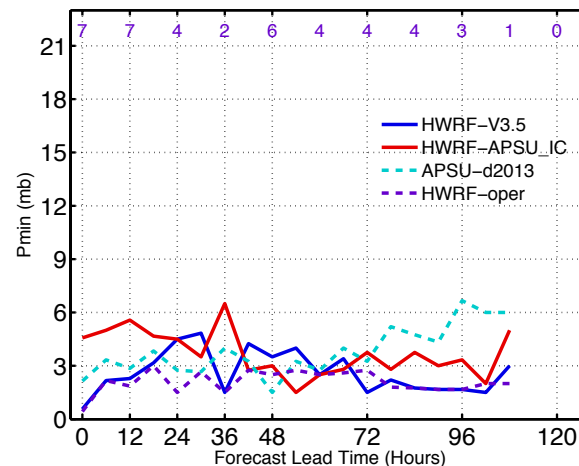
Abs Error of position (n mi) for all12013-HV35GPSUAPSUHWRf



Abs Error of Vmax (kt) for all12013-HV35GPSUAPSUHWRf

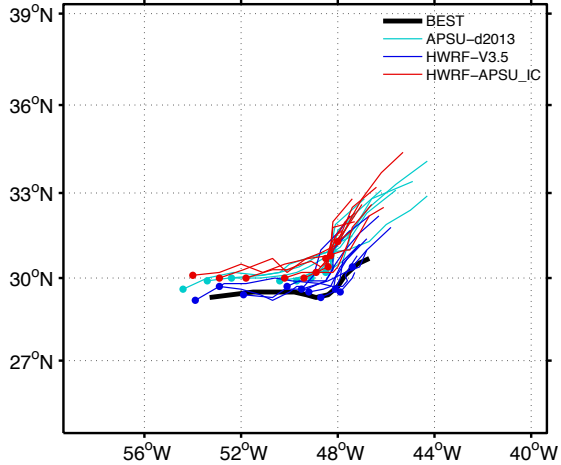


Abs Error of Pmin (mb) for all12013-HV35GPSUAPSUHWRf

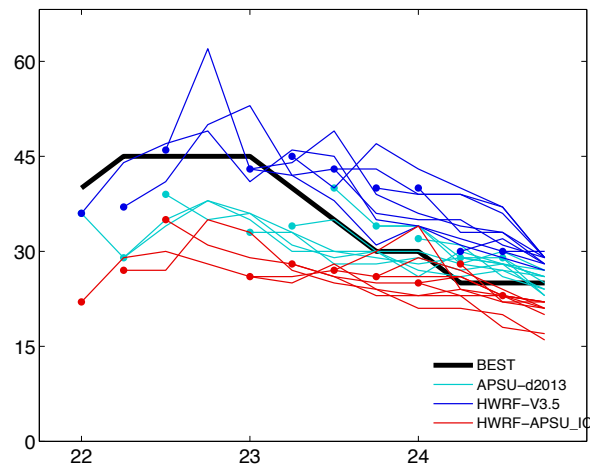


# Forecast for Storm: Lorenzo-2013a113

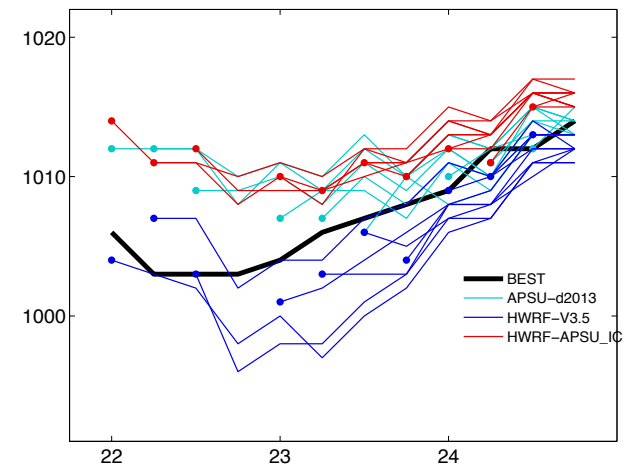
2013a113 Lorenzo APSU Track



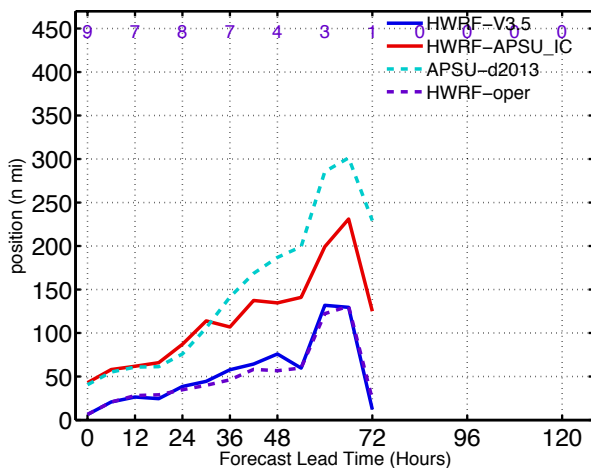
2013a113 Lorenzo APSU Vmax



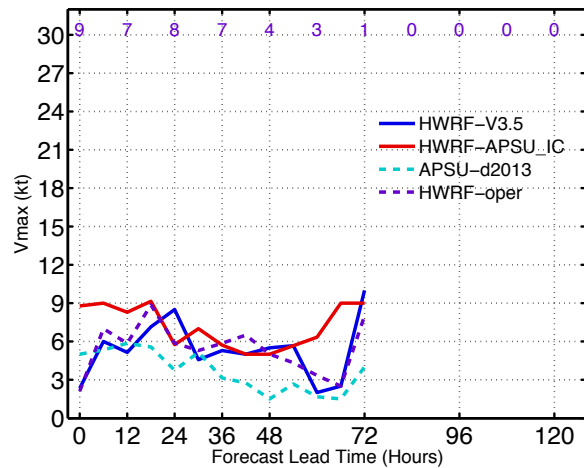
2013a113 Lorenzo APSU Pmin



Abs Error of position (n mi) for a1132013-HV35GPSUAPSUHWRf



Abs Error of Vmax (kt) for a1132013-HV35GPSUAPSUHWRf



Abs Error of Pmin (mb) for a1132013-HV35GPSUAPSUHWRf

