# Forecasts of Hurricanes using a suite of mesoscale models

T. N. Krishnamurti
and
Anu Simon

*Earth Oceanic and Atmospheric Sciences, Florida State University,*

*Tallahassee, FL 32306, USA*.

2011 HFIP Annual Meeting, Miami, 8-9 November

# HFIP BASELINE

HFIP **Track** Performance Baseline (units are nautical miles)

| VT (h) | N | OFCL | OCD5 | CONS |
|---|---|---|---|---|
| 0 | 818 | 7.4 | 7.7 | 7.8 |
| 12 | 741 | 29.4 | 44.5 | 30.0 |
| 24 | 663 | 49.6 | 93.3 | 49.8 |
| 36 | 586 | 69.9 | 150.9 | 69.5 |
| 48 | 518 | 91.2 | 212.2 | 89.6 |
| 72 | 411 | 135.0 | 317.2 | 132.0 |
| 96 | 313 | 173.0 | 396.5 | 175.2 |
| 120 | 247 | 218.6 | 473.0 | 221.9 |

HFIP **Intensity** Performance Baseline (Units are knots)

| VT (h) | N | OFCL | OCD5 | CONS |
|---|---|---|---|---|
| 0 | 820 | 1.9 | 2.2 | 2.2 |
| 12 | 745 | 7.2 | 8.3 | 7.7 |
| 24 | 667 | 10.4 | 11.5 | 10.1 |
| 36 | 590 | 12.6 | 14.2 | 11.7 |
| 48 | 522 | 14.6 | 16.1 | 13.7 |
| 72 | 415 | 17.0 | 17.8 | 16.0 |
| 96 | 316 | 17.5 | 19.3 | 16.6 |
| 120 | 250 | 19.0 | 19.3 | 17.0 |

The CONS Baseline is plotted on the plots

| ATCF ID | |
|---|---|
| FIMY | Flow-Following Finite-Volume Icosahedral Model |
| AHW4 | NCAR AHW |
| COTC | Coupled Ocean/Atmosphere Mesoscale Prediction System – Tropical Cyclone (COAMPS-TC) |
| GFDL | GEOPHYSICAL FLUID DYNAMICS LABORATORY (NOAA/GFDL) |
| H3GP | 3 Nest HWRF 27/9/3 |
| HWRF | Hurricane WRF 27/9 |
| MMEN | Mesoscale Ensemble |
| ENSM | Ensemble Mean of Member Models |
| NGPS | NOGAPS |
| ECMW | ECMWF Global Model |
| AVNI | GFS |
| | |
| | |

**All are late models except GFS, which is interpolated**

# Early and Late models

Guidance models are characterized as either *early* or *late*, depending on whether or not they are available to the forecaster during the forecast cycle.

The Verification reports mainly focus on the early models also known as interpolated models.

Example 12Z forecast cycle:
Forecast data for hours 6-126 from the previous run (06Z) of a model would be smoothed and then adjusted, or shifted, so that the 6-h forecast (valid at 12Z) would match the observed 12Z position and intensity of the tropical cyclone. The adjustment process creates an “early” version of the model for the 12Z forecast cycle that is based on the most current available guidance.

The adjusted versions of the late models are known, mostly for historical reasons, as *interpolated* models. The adjustment algorithm is invoked as long as the most recent available late model is not more than 12 h old, e.g., a 00Z late model could be used to form an interpolated model for the subsequent 06Z or 12Z forecast cycles, but not for the subsequent 18Z cycle.

# Hurricane Irene, August 20 – August 29

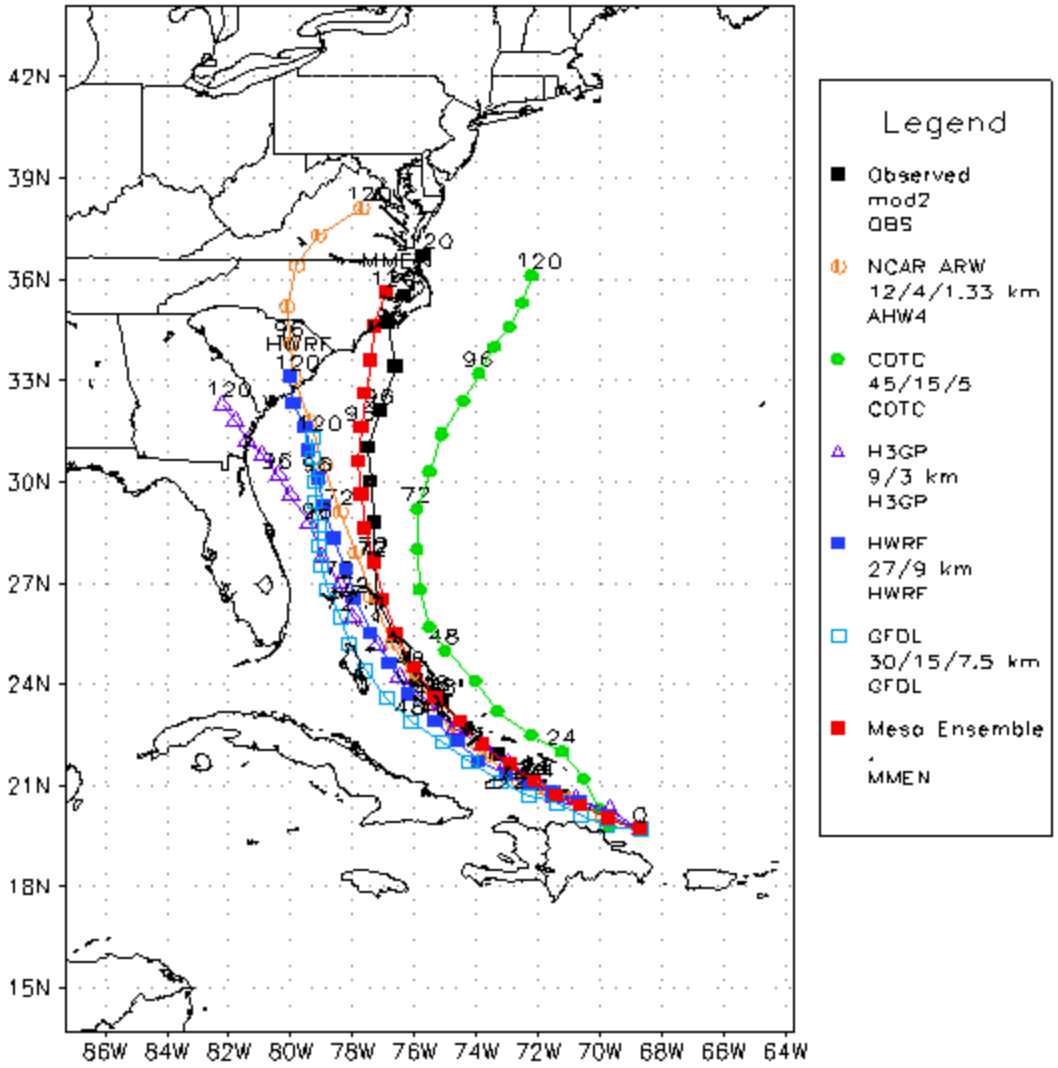
**Saffir-Simpson Hurricane Scale**

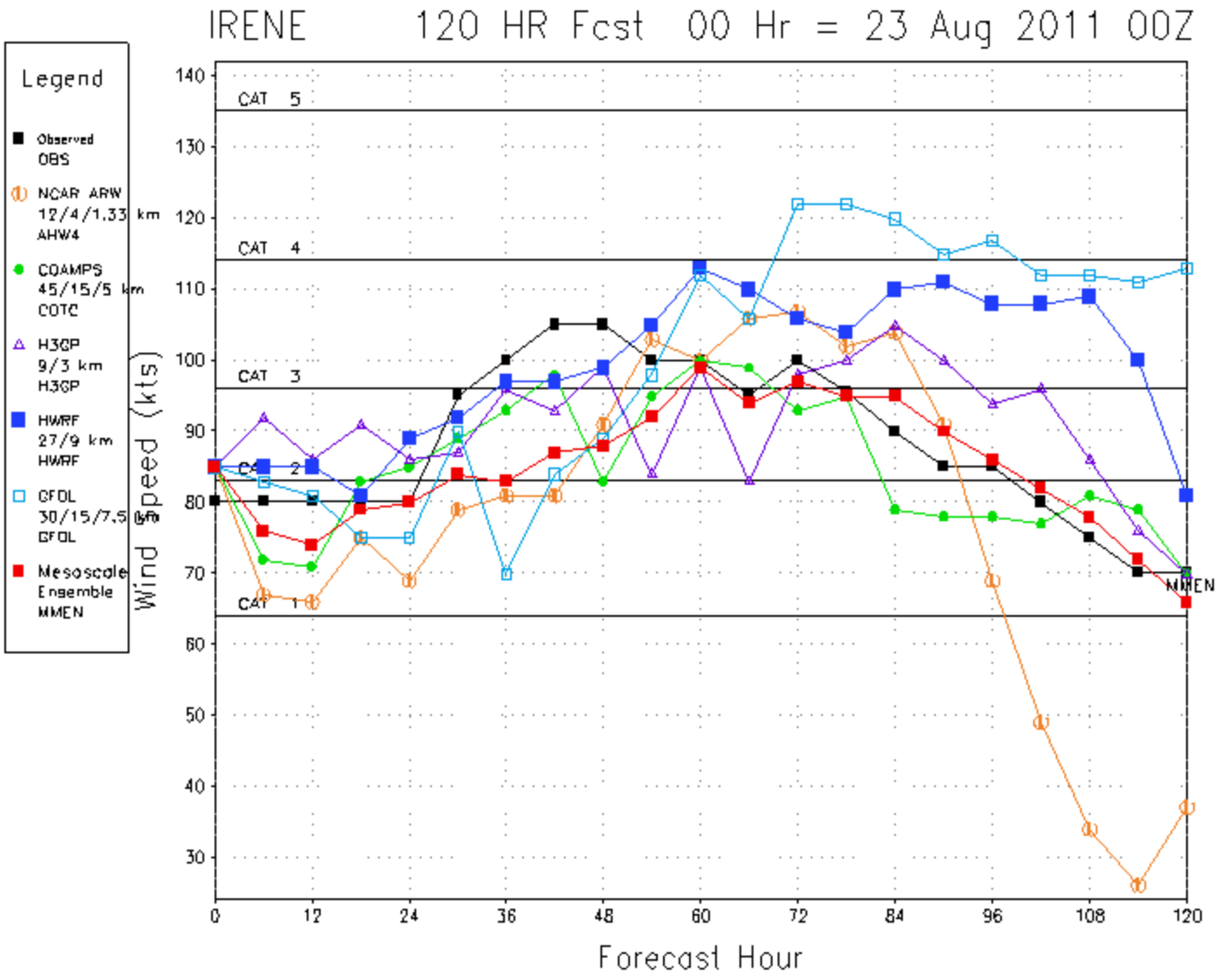
| | | | | | |
|---|---|---|---|---|---|
| Tropical depression | 0–39 mph | 0–62 km/h | Category 3 | 111–130 mph | 178–209 km/h |
| Tropical storm | 39–73 mph | 63–117 km/h | Category 4 | 131–155 mph | 210–249 km/h |
| Category 1 | 74–95 mph | 119–153 km/h | Category 5 | ≥156 mph | ≥250 km/h |
| Category 2 | 96–110 mph | 154–177 km/h | Unknown | | |

**Storm type**

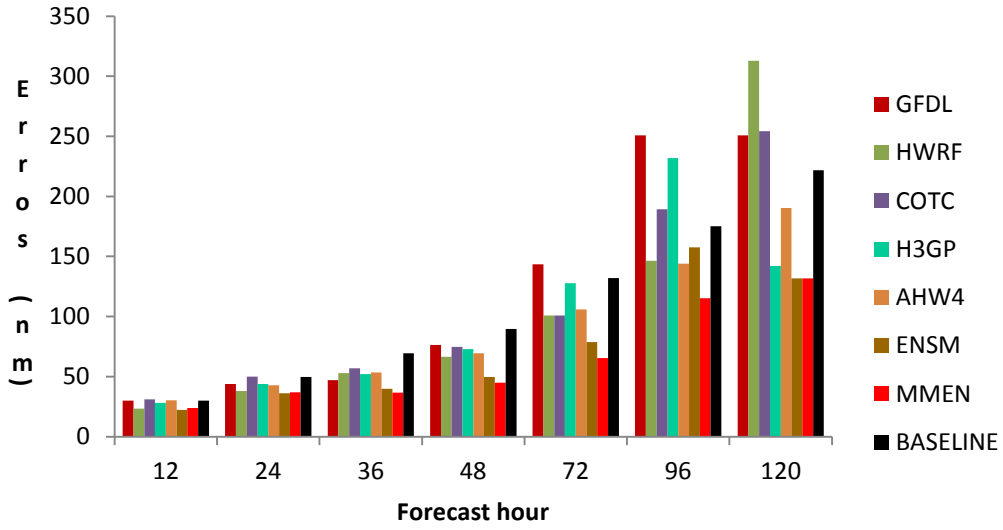
- Tropical cyclone
- Subtropical cyclone
- Extratropical cyclone / Remnant low / Tropical disturbance

IRENE 120 HR Fcst 00 Hr = 23 Aug 2011 00Z

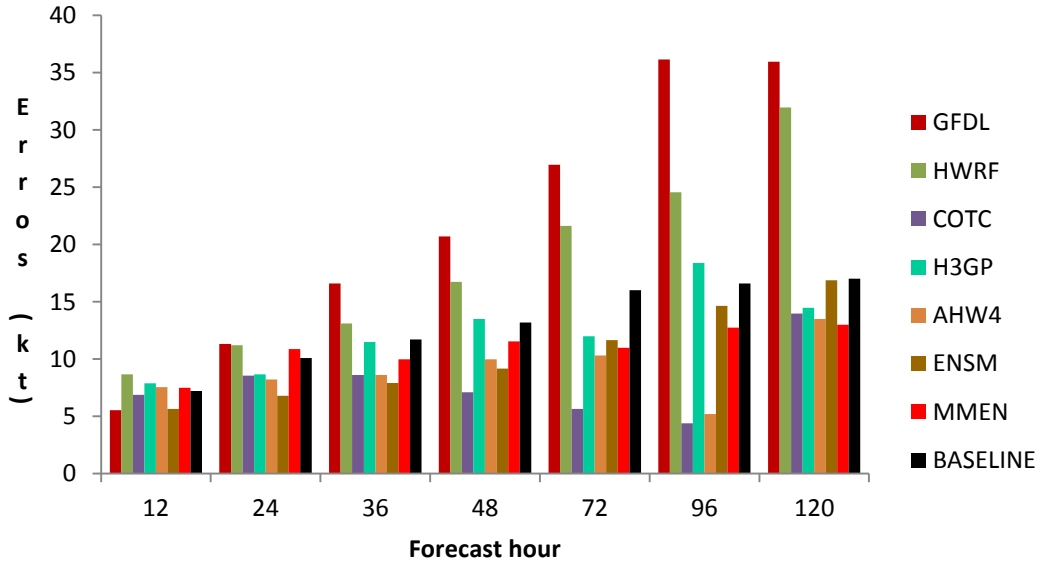



IRENE 120 HR Fcst 00 Hr = 23 Aug 2011 00Z
Legend
Observed
OBS
NCAR ARW
12/4/1.33 km
AHW4
COAMPS
45/15/5 km
COTC
H3GP
9/3 km
H3GP
HWRF
27/9 km
HWRF
GFDL
30/15/7.5 km
GFDL
Mesoscale
Ensemble
MMEN
Wind Speed (kts)
CAT 5
CAT 4
CAT 3
CAT 2
CAT 1
MMEN
140
130
120
110
100
90
80
70
60
50
40
30
0
12
24
36
48
60
72
84
96
108
120
Forecast Hour

## Irene (2011) Track Errors

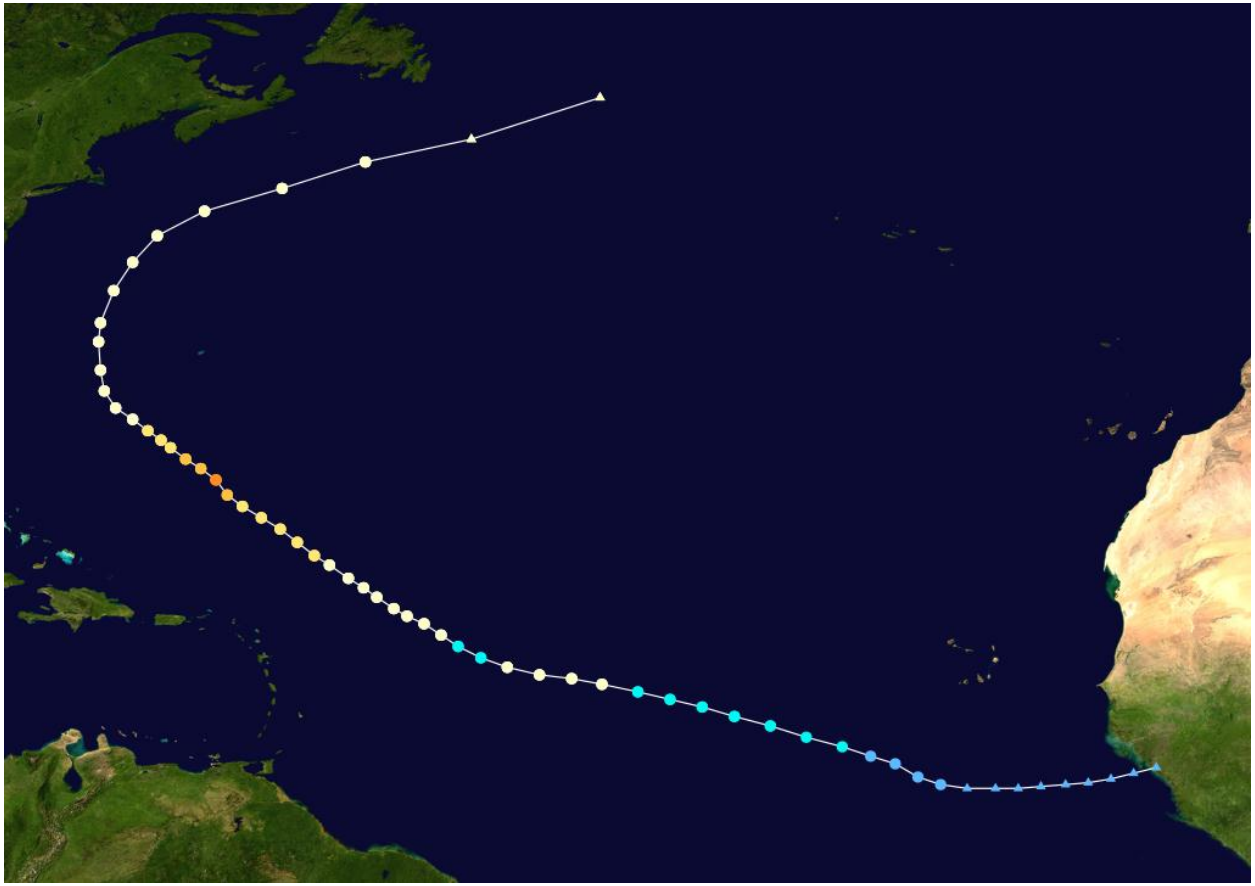



## Irene(2011) Intensity Errors




Cases: 9, 9, 8, 8, 6, 5, 2

# Hurricane Katia, August 29 – September 10

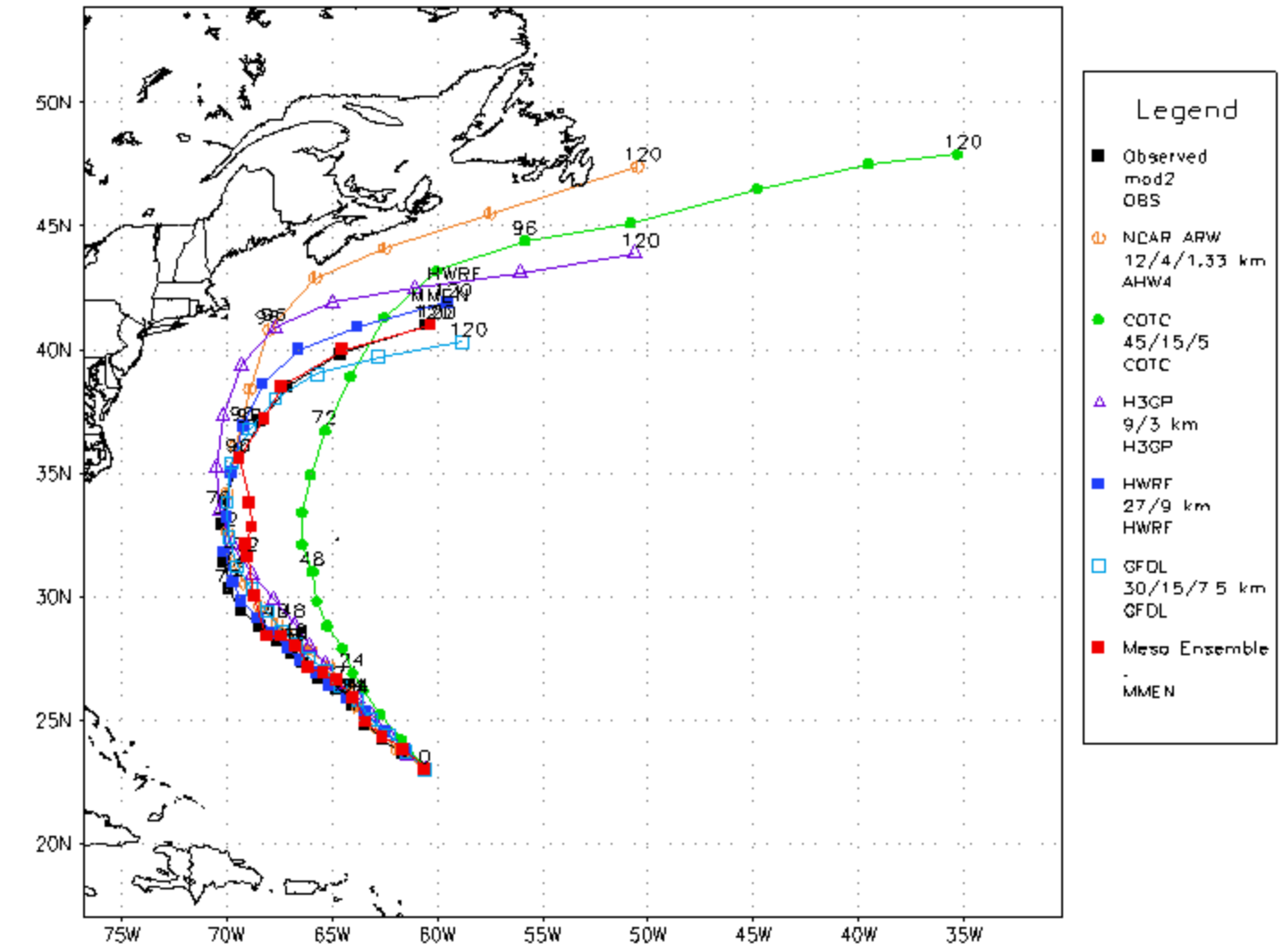


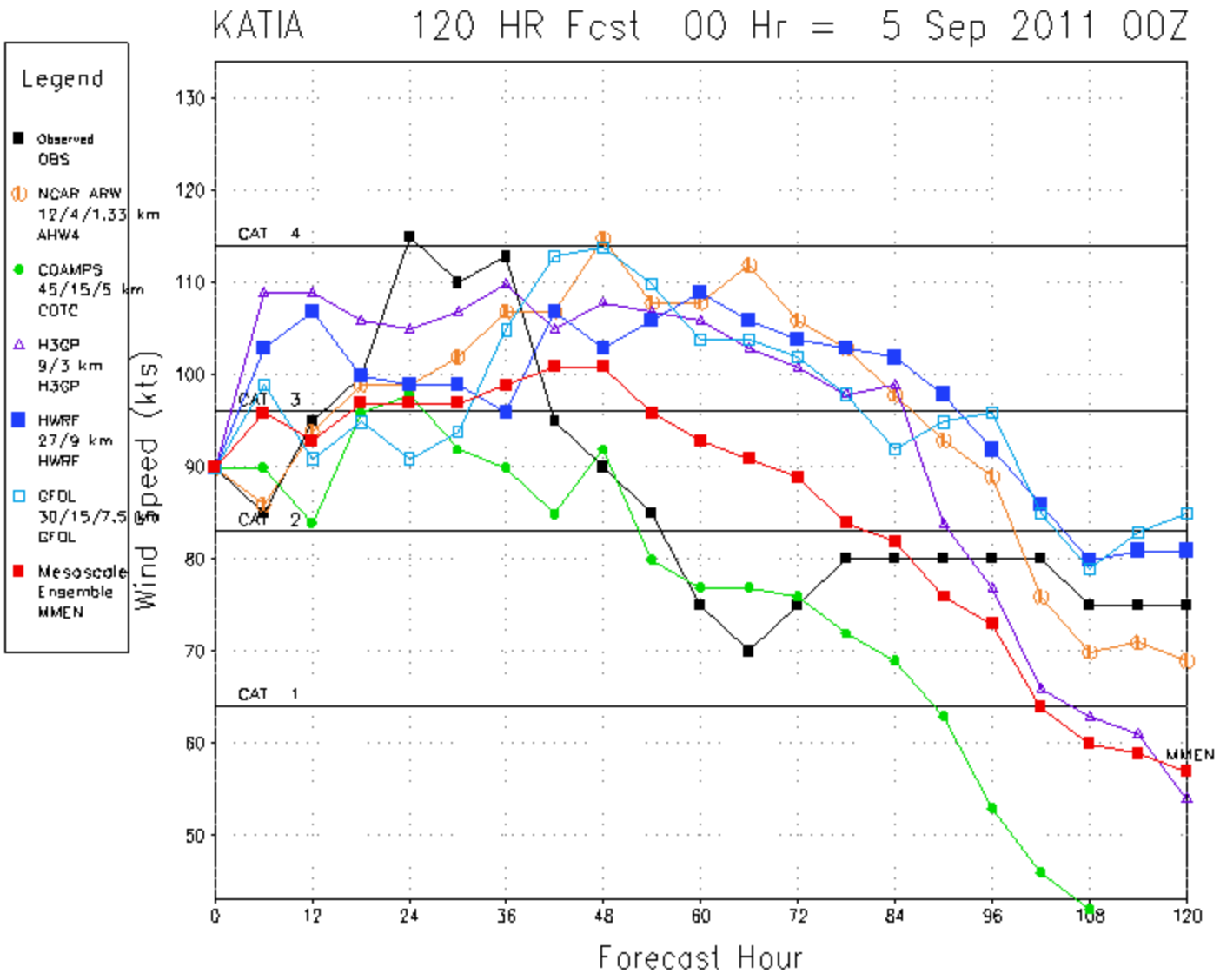
**Saffir-Simpson Hurricane Scale**

| | | | | | |
|---|---|---|---|---|---|
| Tropical depression | 0–39 mph | 0–62 km/h | Category 3 | 111–130 mph | 178–209 km/h |
| Tropical storm | 39–73 mph | 63–117 km/h | Category 4 | 131–155 mph | 210–249 km/h |
| Category 1 | 74–95 mph | 119–153 km/h | Category 5 | ≥156 mph | ≥250 km/h |
| Category 2 | 96–110 mph | 154–177 km/h | Unknown | | |

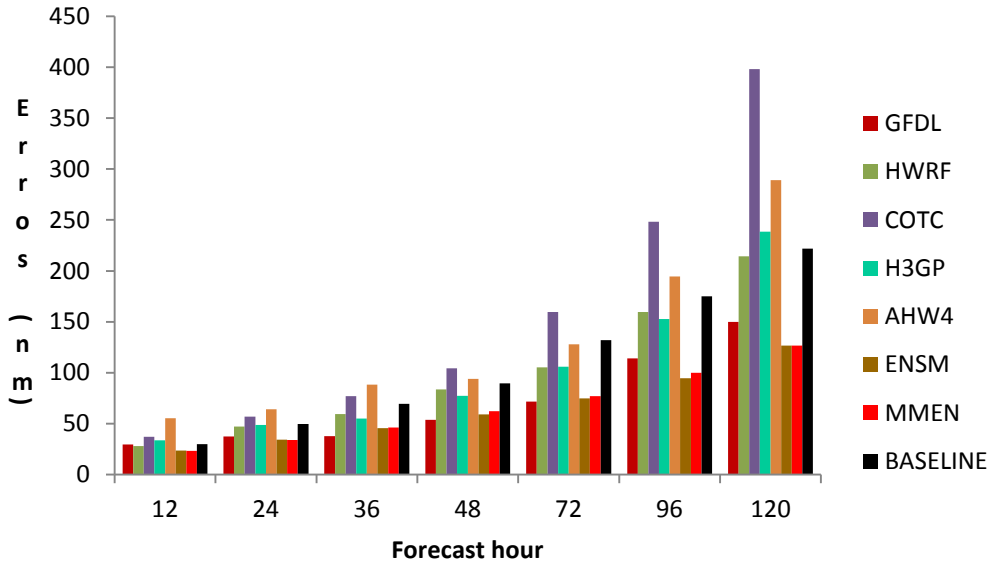
**Storm type**

- Tropical cyclone
- Subtropical cyclone
- Extratropical cyclone / Remnant low / Tropical disturbance

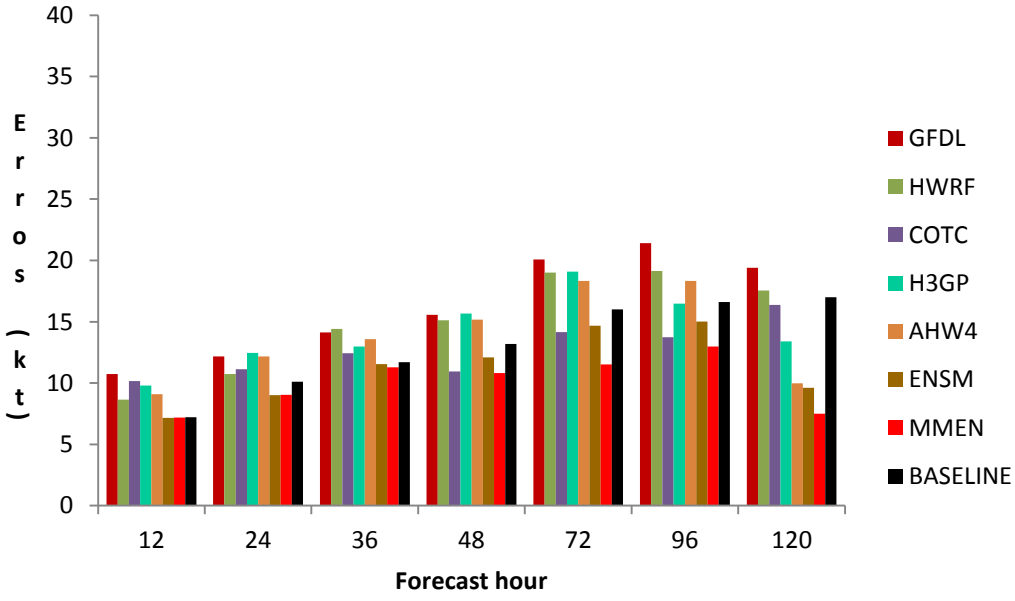

KATIA 120 HR Fcst 00 Hr = 5 Sep 2011 00Z
50N
45N
40N
35N
30N
25N
20N
75W
70W
65W
60W
55W
50W
45W
40W
35W
120
96
72
48
24
0
HWRF
Legend
Observed
mod2
OBS
NCAR ARW
12/4/1.33 km
AHW4
COTC
45/15/5
COTC
H3GP
9/3 km
H3GP
HWRF
27/9 km
HWRF
GFDL
30/15/7.5 km
GFDL
Meso Ensemble
-
MMEN


KATIA 120 HR Fcst 00 Hr = 5 Sep 2011 00Z
Legend
Observed
OBS
NCAR ARW
12/4/1.33 km
AHW4
COAMPS
45/15/5 km
COTC
H3GP
9/3 km
H3GP
HWRF
27/9 km
HWRF
GFDL
30/15/7.5 km
GFDL
Mesoscale
Ensemble
MMEN
Wind Speed (kts)
Forecast Hour
CAT 4
CAT 3
CAT 2
CAT 1
MMEN
130
120
110
100
90
80
70
60
50
0
12
24
36
48
60
72
84
96
108
120

## Katia (2011) Track Errors




## Katia(2011) Intensity Errors




Cases: 20, 20, 19, 18, 16, 15, 13

# Tropical Storm Nate, September 7 – September 12

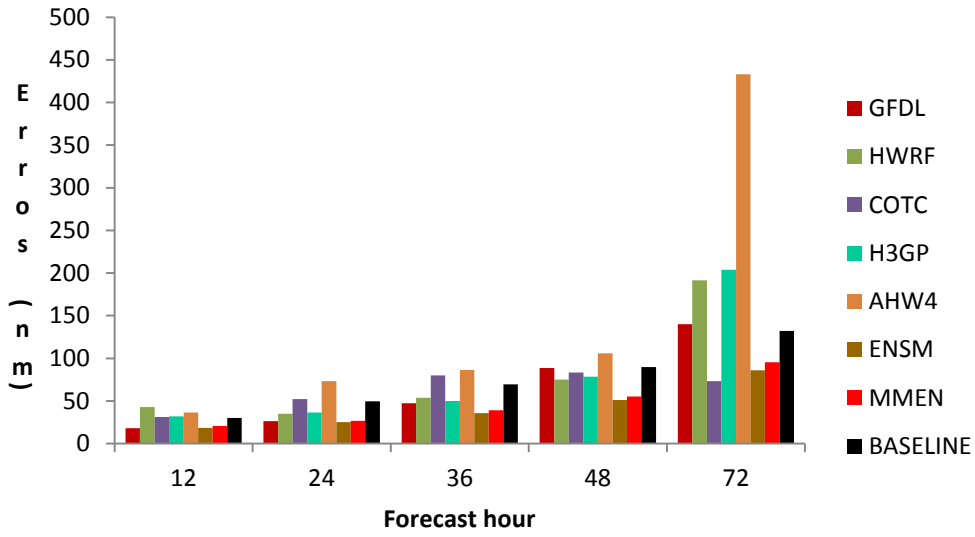
**Saffir-Simpson Hurricane Scale**

| | | | | | |
|---|---|---|---|---|---|
| Tropical depression | 0–39 mph | 0–62 km/h | Category 3 | 111–130 mph | 178–209 km/h |
| Tropical storm | 39–73 mph | 63–117 km/h | Category 4 | 131–155 mph | 210–249 km/h |
| Category 1 | 74–95 mph | 119–153 km/h | Category 5 | ≥156 mph | ≥250 km/h |
| Category 2 | 96–110 mph | 154–177 km/h | Unknown | | |

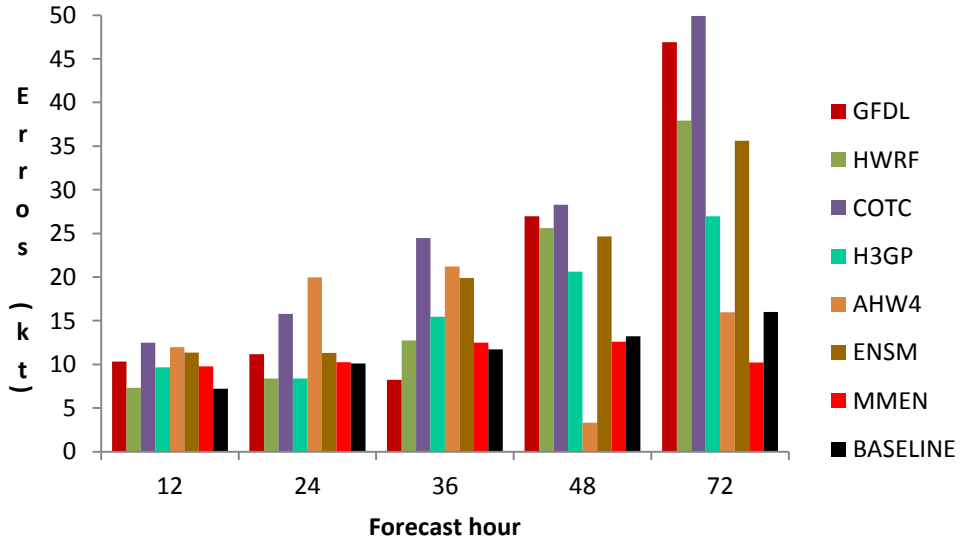
**Storm type**

- Tropical cyclone
- Subtropical cyclone
- Extratropical cyclone / Remnant low / Tropical disturbance

## Nate (2011) Track Errors

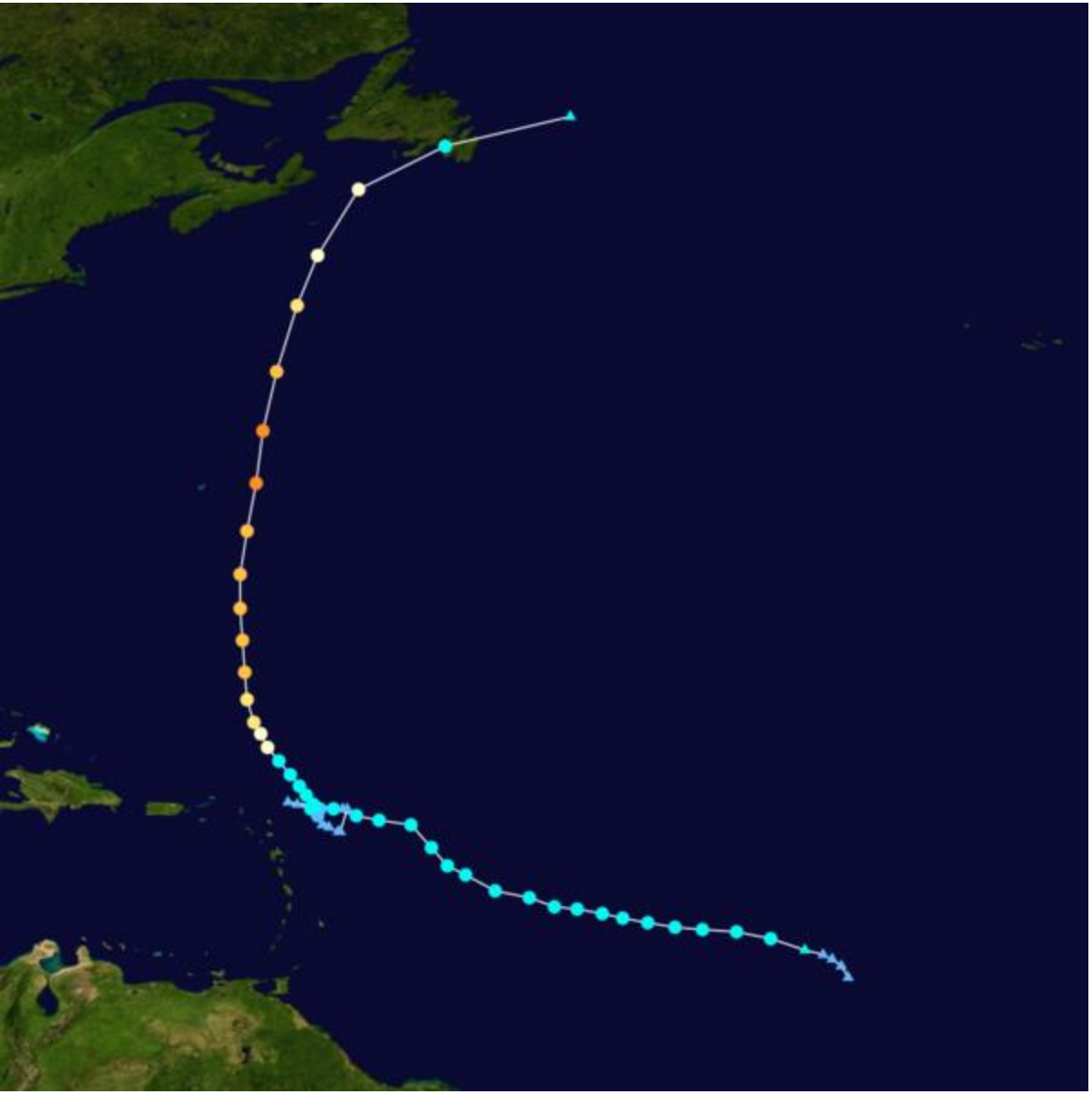



## Nate(2011) Intensity Errors




Cases: 6, 5, 4, 3, 1

# Hurricane Ophelia, September 21 – October 3



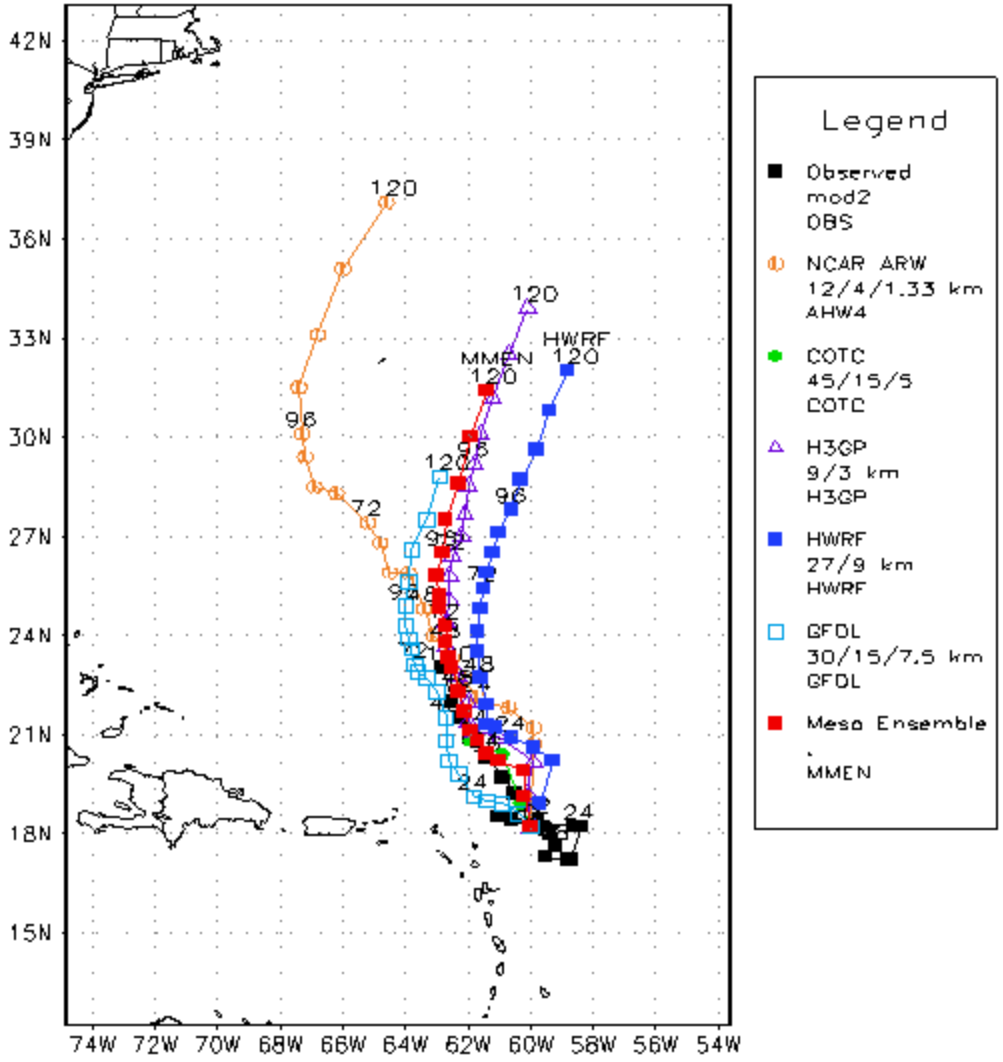
**Saffir-Simpson Hurricane Scale**

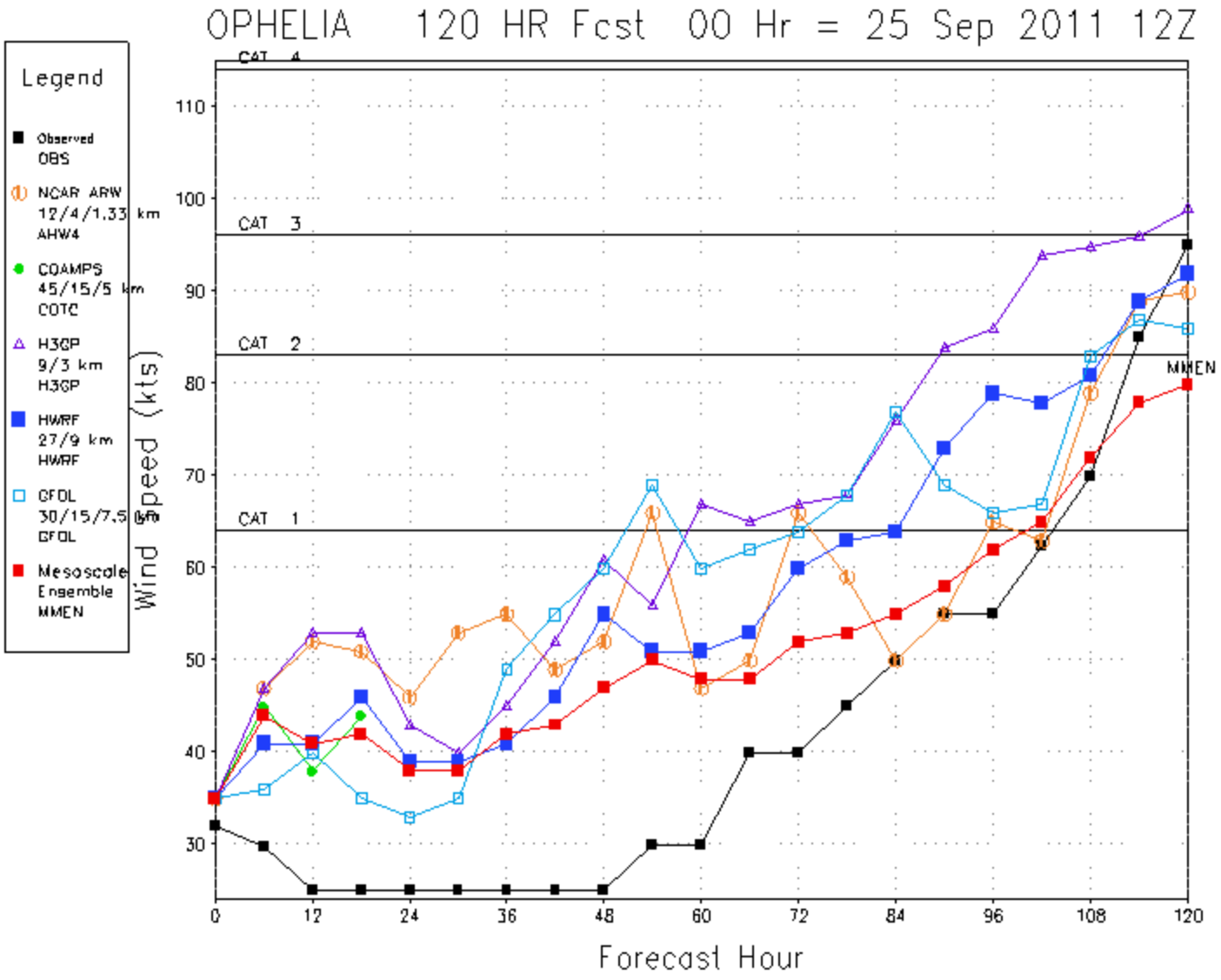
| | | | | | |
|---|---|---|---|---|---|
| Tropical depression | 0–39 mph | 0–62 km/h | Category 3 | 111–130 mph | 178–209 km/h |
| Tropical storm | 39–73 mph | 63–117 km/h | Category 4 | 131–155 mph | 210–249 km/h |
| Category 1 | 74–95 mph | 119–153 km/h | Category 5 | ≥156 mph | ≥250 km/h |
| Category 2 | 96–110 mph | 154–177 km/h | Unknown | | |

**Storm type**

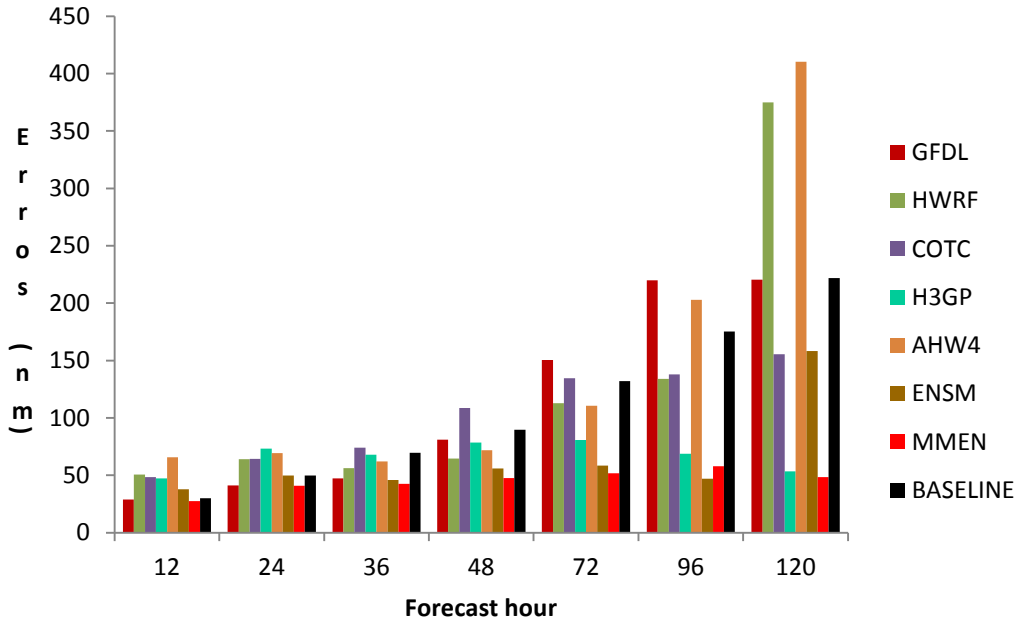
- Tropical cyclone
- Subtropical cyclone
- Extratropical cyclone / Remnant low / Tropical disturbance

# OPHELIA 120 HR Fcst 00 Hr = 25 Sep 2011 12Z

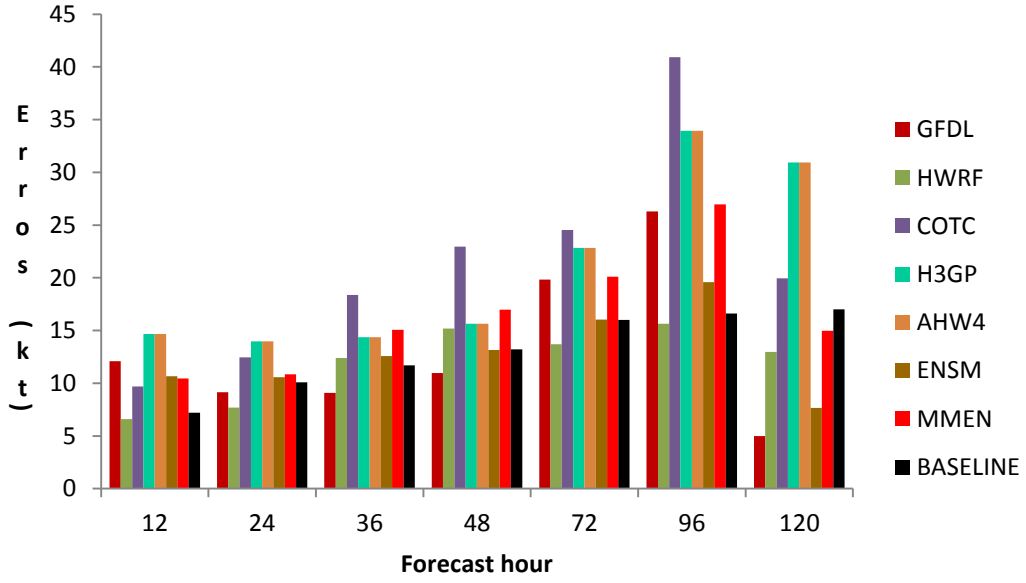



OPHELIA 120 HR Fcst 00 Hr = 25 Sep 2011 12Z
Legend
Observed
OBS
NCAR ARW
12/4/1.33 km
AHW4
COAMPS
45/15/5 km
COTC
H3GP
9/3 km
H3GP
HWRF
27/9 km
HWRF
GFDL
30/15/7.5 km
GFDL
Mesoscale
Ensemble
MMEN
CAT 4
CAT 3
CAT 2
CAT 1
MMEN
Wind Speed (kts)
Forecast Hour
30
40
50
60
70
80
90
100
110
0
12
24
36
48
60
72
84
96
108
120

## Ophelia (2011) Track Errors




## Ophelia(2011) Intensity Errors




Cases: 17, 13, 10, 9, 7, 3, 1

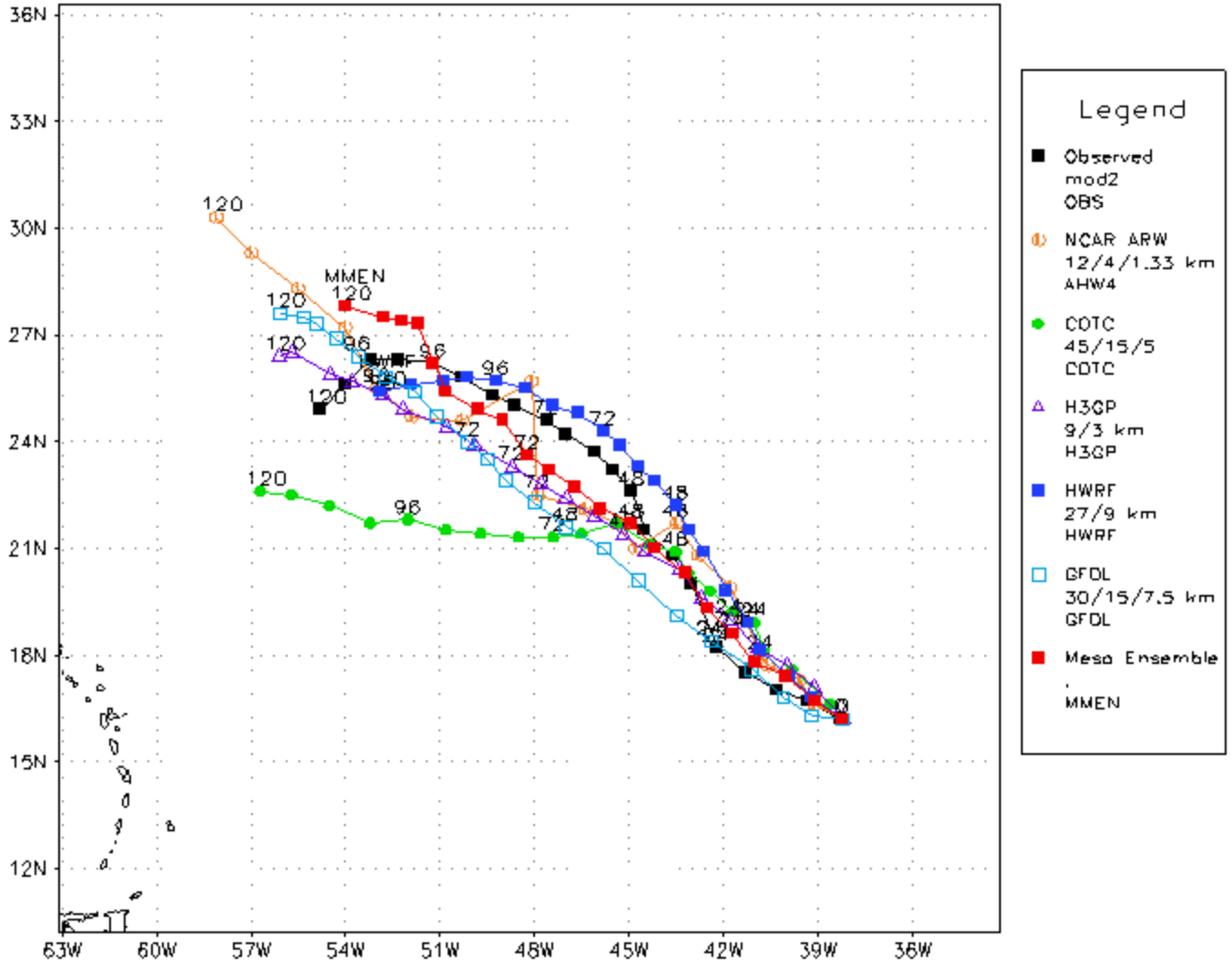
**Hurricane Philippe,** September 24 – October 9

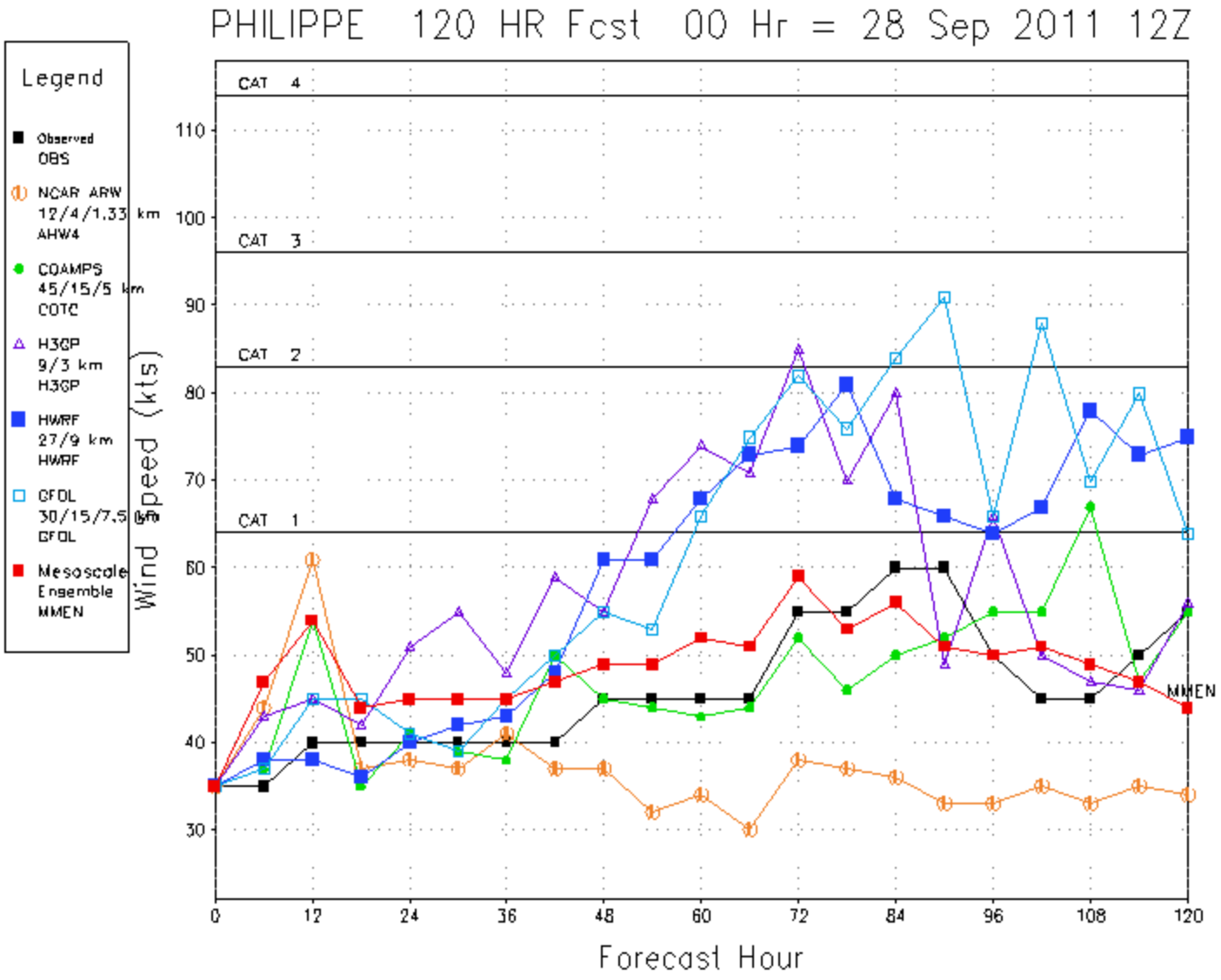
| Saffir-Simpson Hurricane Scale | | | | | |
|---|---|---|---|---|---|
| Tropical depression | 0–39 mph | 0–62 km/h | Category 3 | 111–130 mph | 178–209 km/h |
| Tropical storm | 39–73 mph | 63–117 km/h | Category 4 | 131–155 mph | 210–249 km/h |
| Category 1 | 74–95 mph | 119–153 km/h | Category 5 | ≥156 mph | ≥250 km/h |
| Category 2 | 96–110 mph | 154–177 km/h | Unknown | | |

**Storm type**

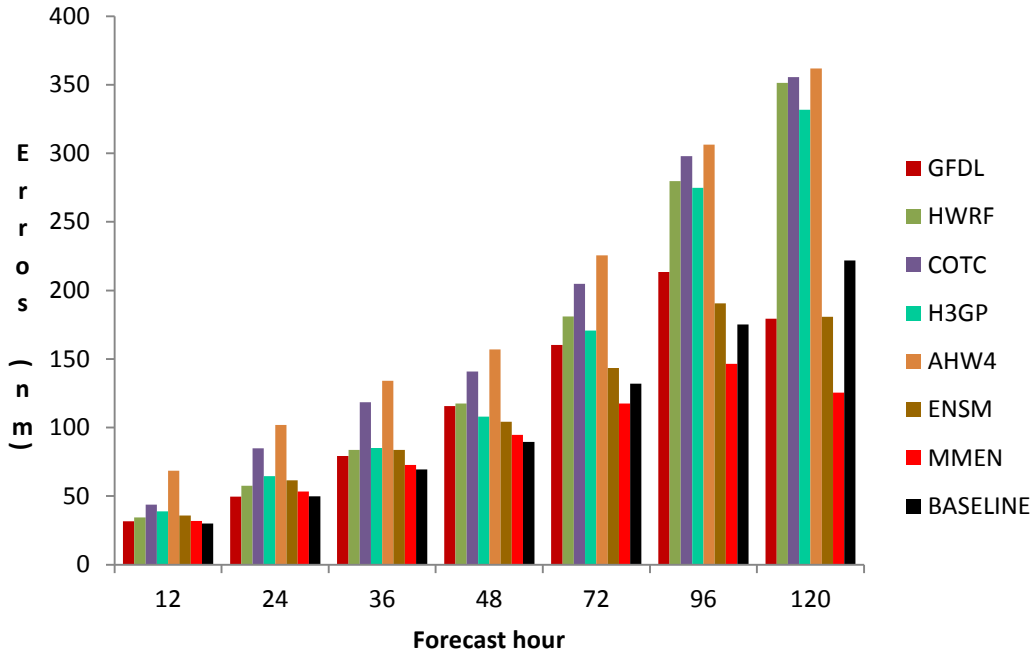
- Tropical cyclone
- Subtropical cyclone
- Extratropical cyclone / Remnant low / Tropical disturbance

# PHILIPPE 120 HR Fcst 00 Hr = 28 Sep 2011 12Z



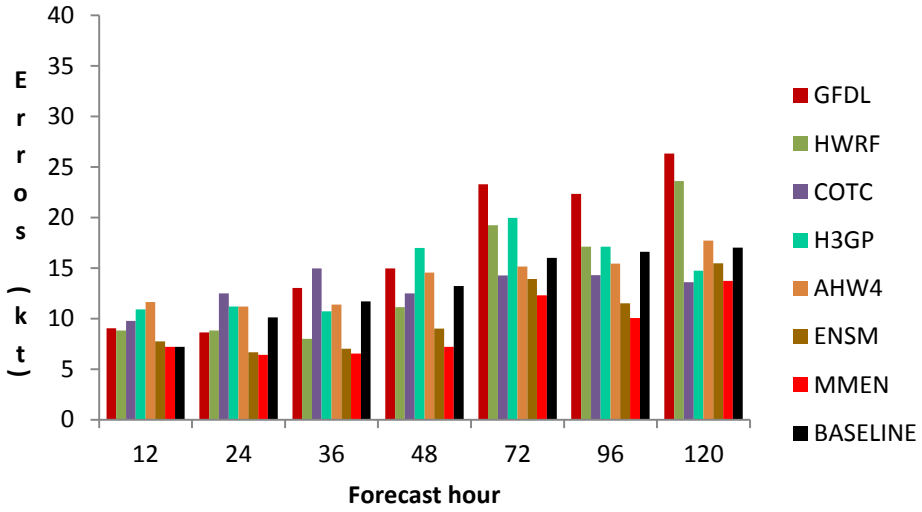

PHILIPPE 120 HR Fcst 00 Hr = 28 Sep 2011 12Z
Legend
Observed
OBS
NCAR ARW
12/4/1.33 km
AHW4
COAMPS
45/15/5 km
COTC
H3GP
9/3 km
H3GP
HWRF
27/9 km
HWRF
GFDL
30/15/7.5 km
GFDL
Mesoscale
Ensemble
MMEN
CAT 4
CAT 3
CAT 2
CAT 1
Wind Speed (kts)
Forecast Hour
MMEN
110
100
90
80
70
60
50
40
30
0
12
24
36
48
60
72
84
96
108
120

## Philippe (2011) Track Errors

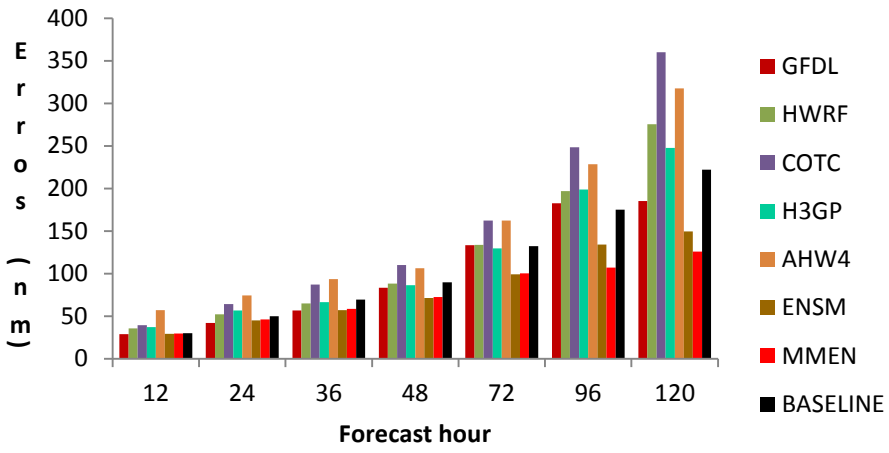



Cases: 23, 23, 22, 19, 18, 13, 8

## Philippe(2011) Intensity Errors

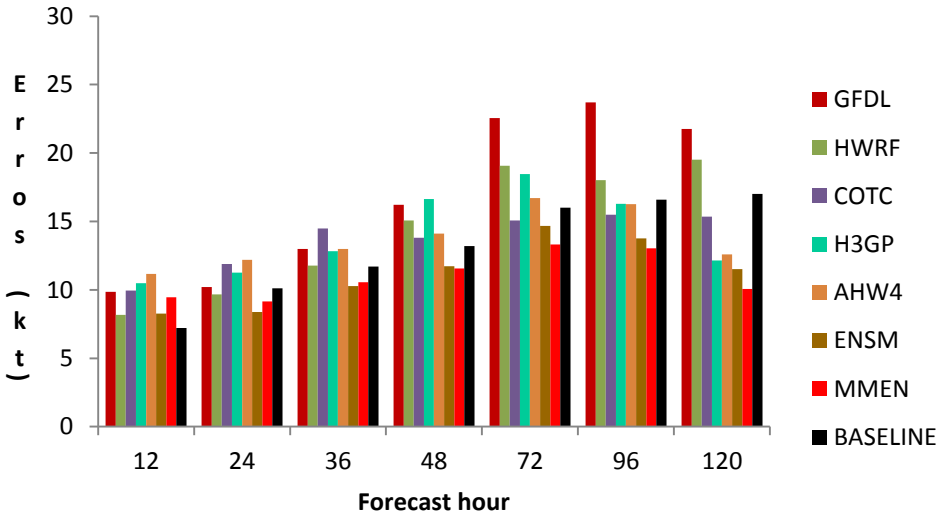


## 2011 Track Errors



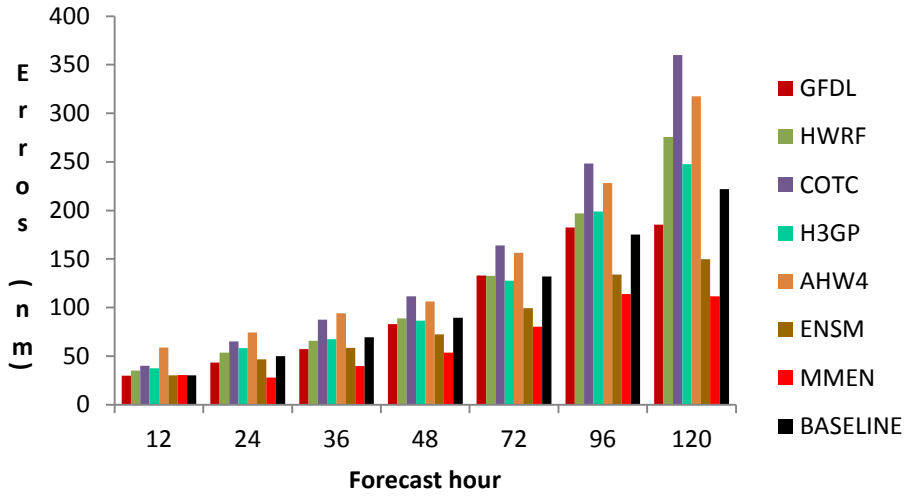

Seasonal Summary as of October 21, 2011

## 2011 Intensity Errors




Cases: 74, 69, 63, 56, 48, 35, 24

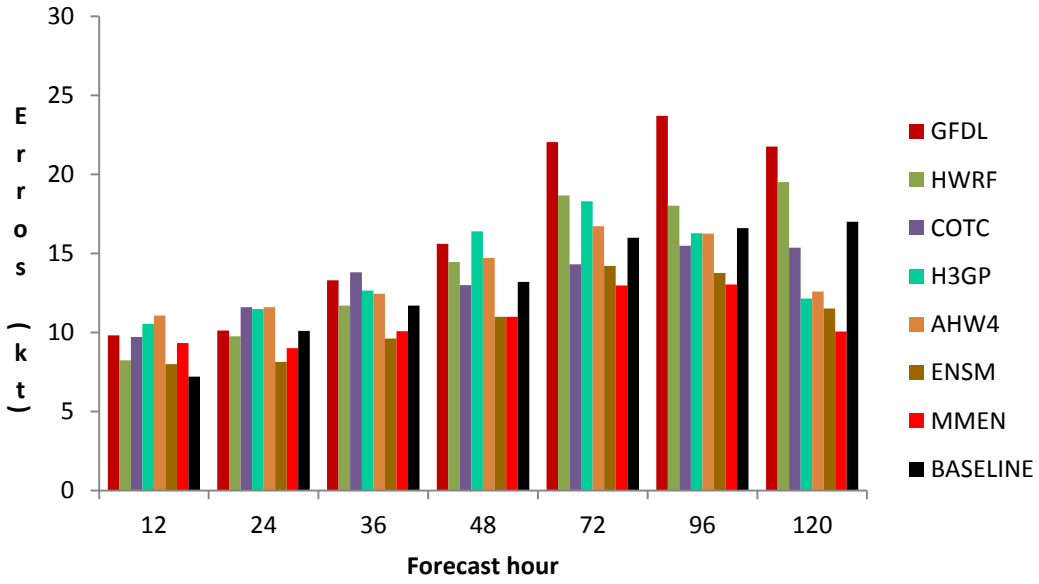
## 2011 Track Errors Strong Storms



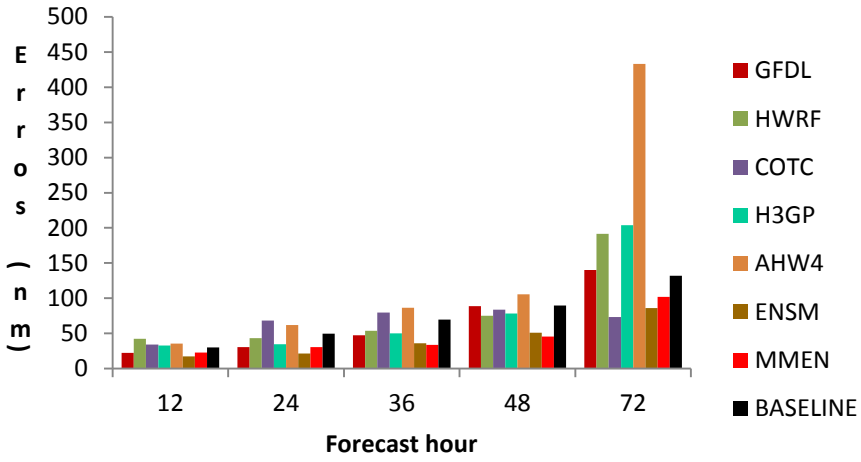

Hurricane Irene
Hurricane Katia
Hurricane Ophelia
Hurricane Philippe

Cases: 68,64,59,53,47,35,24

## 2011 Intensity Errors Strong Storms



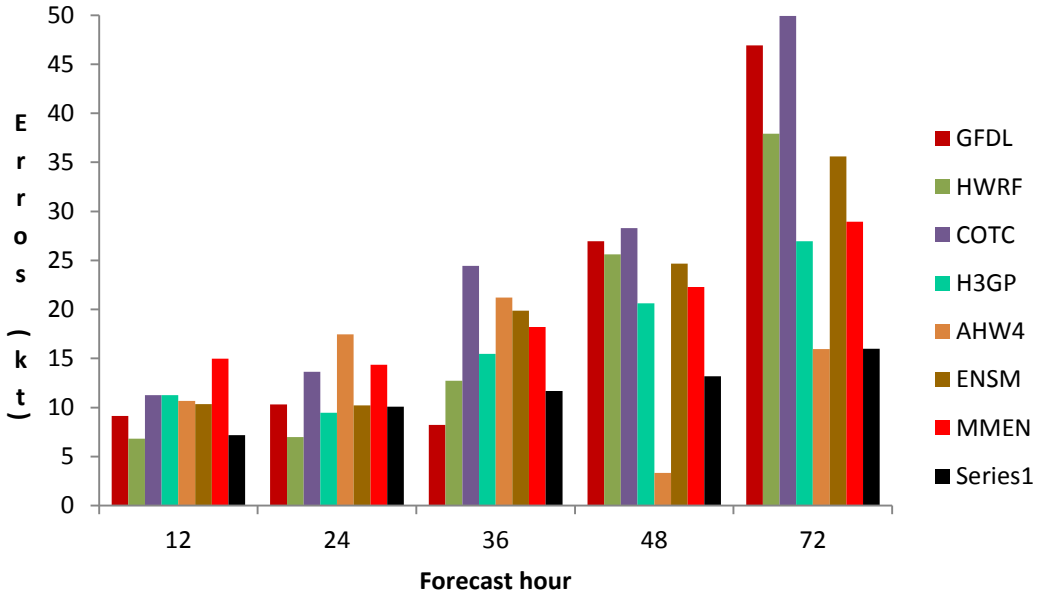
## 2011 Track Errors for WEAK STORMS



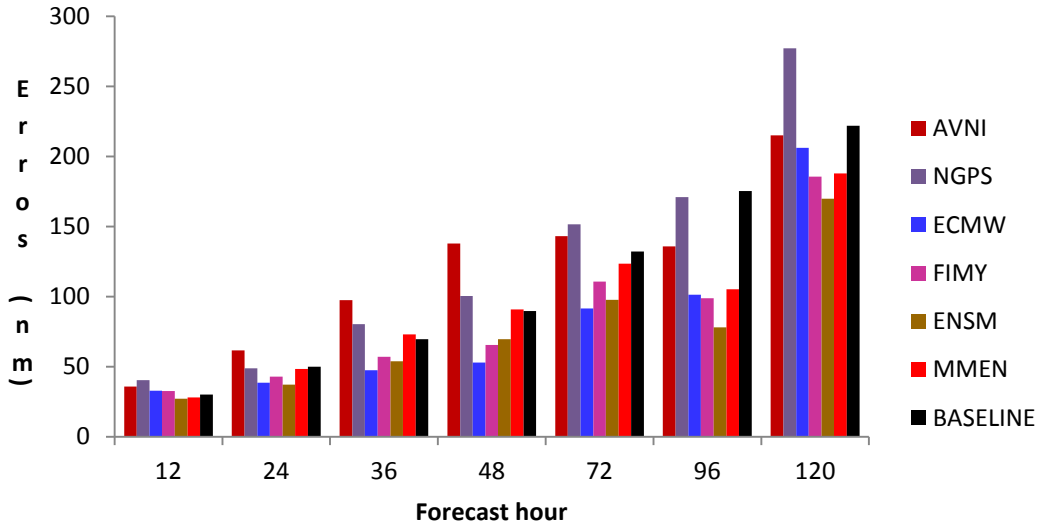

Tropical Storm Emily
Tropical Storm Franklin
Tropical Storm Harvey
Tropical Storm Lee
Tropical Storm Nate

Cases: 7, 6, 4, 3, 1

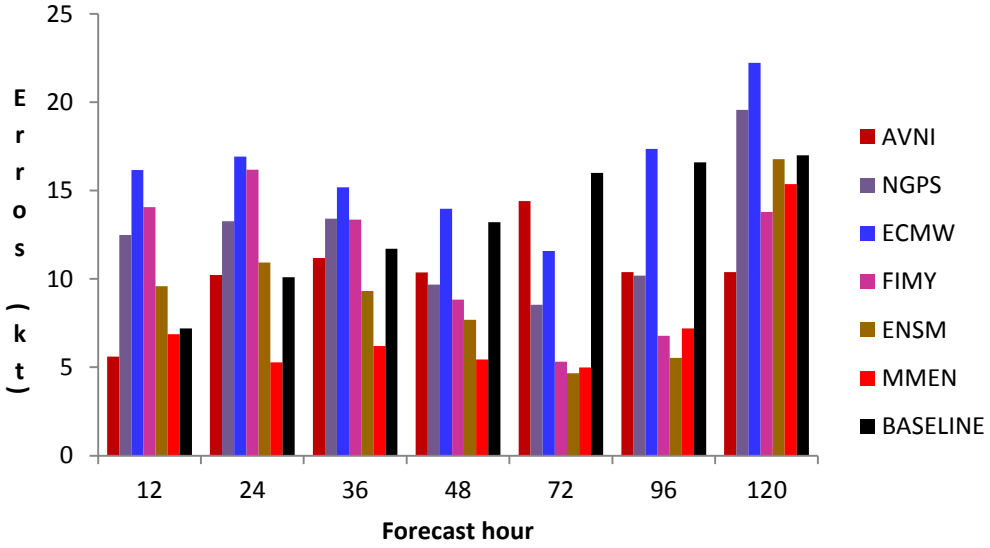
## 2011 Intensity Errors WEAK STORMS



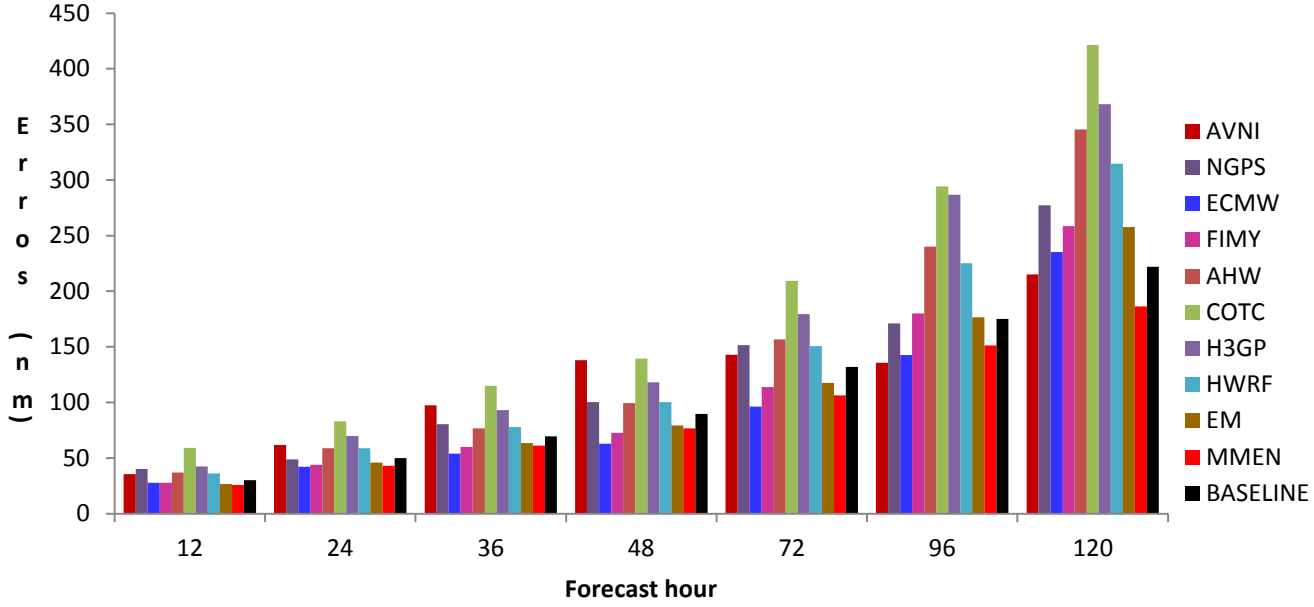
## 2011 Track Errors (Large scale models)



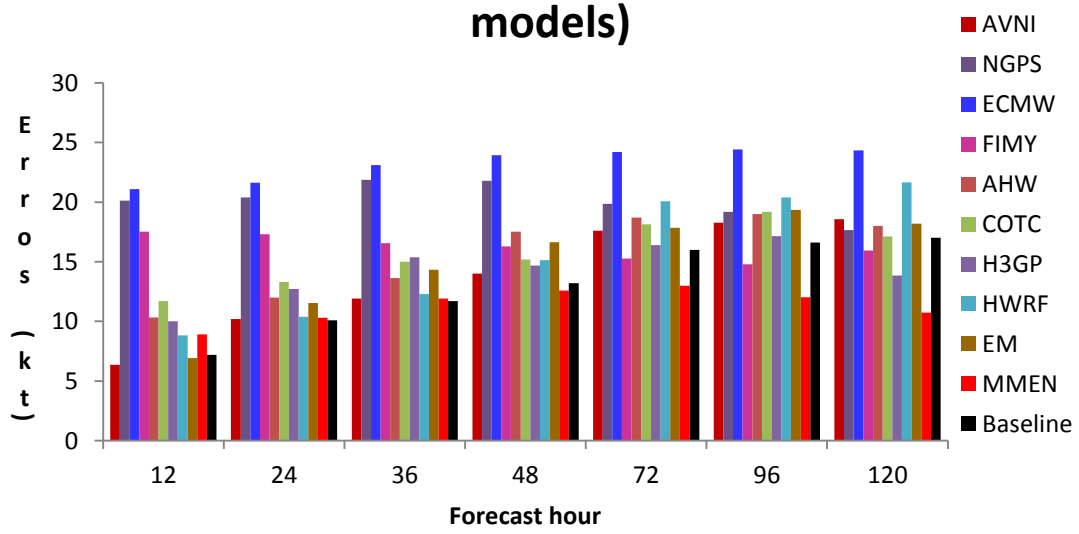

## 2011 Intensity Errors (Large scale models)



## 2011 Track Errors (Large scale + meso models)




## 2011 Intensity Errors (Large scale + meso models)



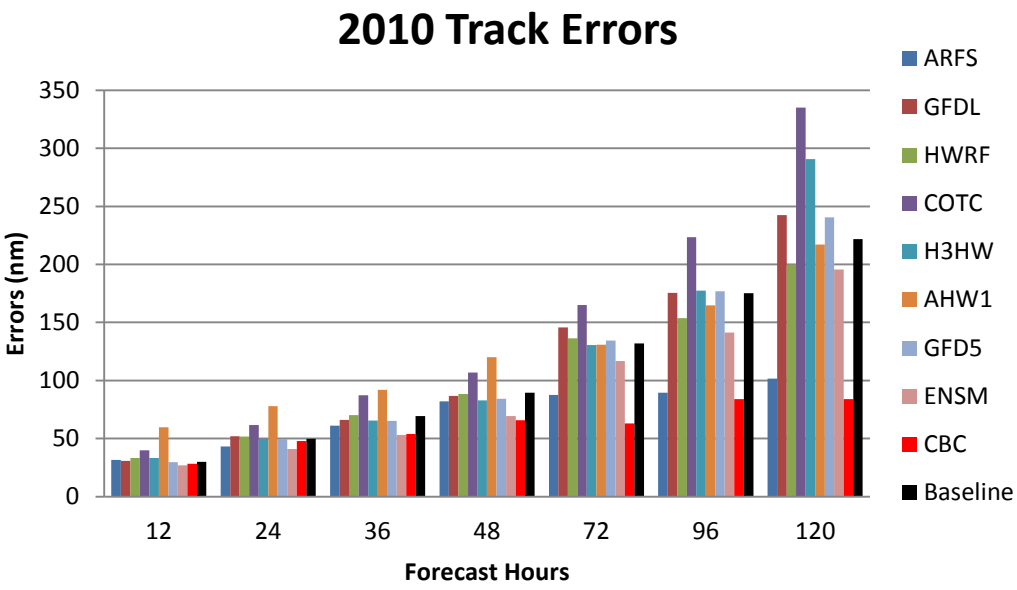
2011 season

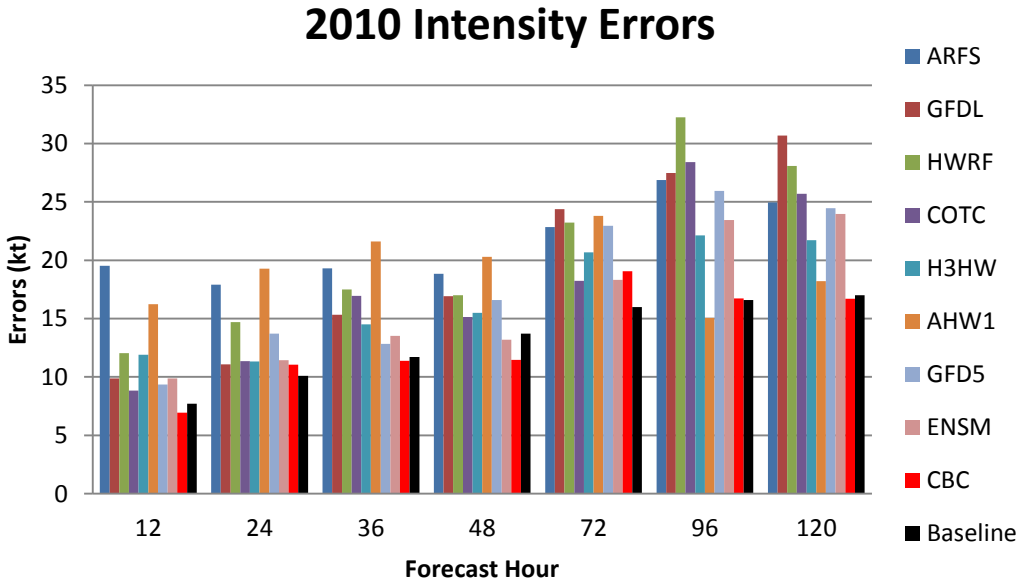
Track Errors (nm)

| | 12 | 24 | 36 | 48 | 72 | 96 | 120 |
|---|---|---|---|---|---|---|---|
| Meso | 30 | 46 | **59** | **73** | **100** | 107 | **126** |
| Large | 28 | 48 | 73 | 91 | 123 | **105** | 188 |
| Combined | **26** | **43** | 61 | 77 | 106 | 151 | 186 |

Intensity Errors (kt)

| | 12 | 24 | 36 | 48 | 72 | 96 | 120 |
|---|---|---|---|---|---|---|---|
| Meso | 10 | 9 | 11 | 12 | 13 | 13 | **10** |
| Large | **7** | **5** | **6** | **5** | **5** | **7** | 15 |
| Combined | 9 | 10 | 12 | 13 | 13 | 12 | 11 |




Cases: 41, 39, 36, 33, 19, 13, 8

## Summary Remarks

The results from the FSU multimodel ensemble, from the suite of mesoscale models, were equally encouraging for 2011 as were for the 2010 season for hurricane intensity forecasts

For large intensity storms, Cat 2 or higher the errors from the mesoscale multimodel ensemble were the smallest. Larger errors arise when we examined the superensemble based on tropical storms

The intensity forecasts from the multimodel ensemble were consistently lower at all forecast hours compared to the HFIP Baseline

The multimodel ensemble for intensity forecasts, based on large scale models, appeared to show rather consistent systematic errors. When the multimodel superensemble removed those errors the final results from the multimodel ensemble were very impressive, whereas, the spread of systematic errors for mesoscale models was rather inconsistent and as a results were somewhat larger compared to the multimodel ensemble of large scale models.