HFIP RESULTS FOR HURRICANE FORECASTS USING THE MULTIMODEL SUPERENSEMBLE FOR THE 2012 SEASON AND PROPOSED WORK FOR THE 2013 SEASON

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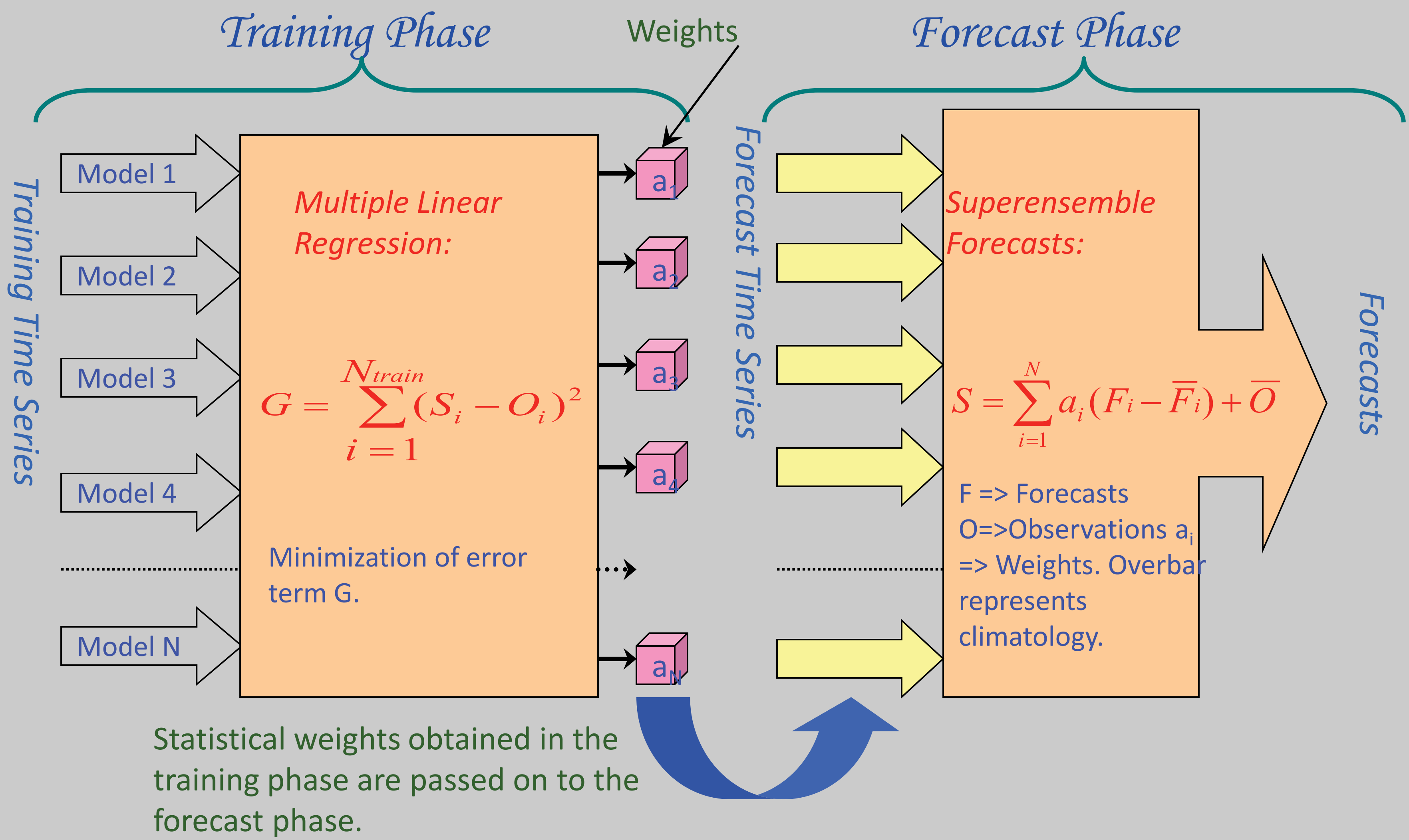
FSU Meteorology

One dimensional Multimodel Superensemble Methodology for Hurricane tracks and intensity



- In addition to removing the bias, the superensemble scales the individual model forecasts contributions according to their relative performance in the training period in a way that, mathematically, is equivalent to weighting them.
- We had noted that roughly 60 forecasts per storm per map time is desirable for stabilizing the weights of the multimodel superensemble. That is always not possible in operations.

Number of Weights

1. Ensemble Mean : A single weight 1/N (where N is the number of member models) is used

Here models with good skill carry same weight as a poor model.

2. Bias removed ensemble mean : The bias removal for x-position, y-position and intensity (from poor forecasts) utilize the equation

$$Q' = Q_F - \overline{Q_F} + \overline{Q_O}$$

This is done for each member model and the ensemble mean of these bias removed model utilizes a weight 1/N. The assumption that a poor model becomes equivalent to a good model after bias removal is weak.

3. In the Multimodel superensemble weights can be positive, negative or fractional as in any statistical regression problem.

The maximum number of weights we utilize are:

Number of models= 11 *times* Number of forecast hours = 7 *times* number of variables (x-position, y-position, intensity) 3 = Total weight 231

WE CARRIED OUT REAL TIME FORECASTS WITH TWO VERSIONS OF THE MULTIMODEL ENSEMBLES

1. CORRELATION BASED CONCENSUS
2. MULTIMODEL SUPERENSEMBLE

CONSISTENTLY SUPERIOR PERFORMANCE OF THE MULTIMODEL SUPERENSEMBLE FOR THE 2009, 2010 AND 2011 LEAD TO US TO DROP THE CORRELATION BASED CONSENSUS. THE WEAKNESS OF THE FORMER PROCEDURE WAS THE LACK OF SENSITIVITY TO THE REMOVAL OF OUTLIERS. WHERE AS THE LATTER METHOD SHOWED A MAJOR IMPROVEMENT FROM THE DESIGN FOR THE REJECTION OF OUTLIERS, THESE RESULTS WILL BE SHOWN TODAY.

- TWO VERSIONS OF THE MULTIMODEL SUPEREMBLE BASED RESULTS FOR THE HURRICANE SEASON OF 2012 WERE SENT TO TCMT.

- THE FIRST OF THESE UTILIZED A SIMPLE OUTLIER REMOVAL BASED ON A STANDARD DEVIATION CHECK FOR MEMBER MODEL FORECASTS. THESE WERE SENT ON REAL TIME.

- THE SECOND METHOD APPEARED MORE PROMISING THIS UTILIZED THE FOLLOWING METHOD:

Robust line fitting in Model using IDL routine by removing Outliers

Chi-Square statistics is typically employed as a goodness of fit metric for iterative removal of outliers of Model forecast data (Press et al., 1986)

where

$$x^2 = \sum \left(\frac{d_i - y_i}{\sigma_i} \right)^2$$

chi-squared = the sum of the distances between observation and model, squared, but weighted down by the uncertainties .

The procedure involves finding the slope and intercept using linear regression of the forecast error for each forecast hour. We next perturb the slope and determine the chi-square of that data set . An iteration procedure finds the best perturbed slope that provides the minimum chi-square.

Steps involved in the numerical method of finding the best model are:

(1) Perform a linear regression of the forecast against the observed estimate and thus obtain the first estimate of the slope and intercept.
(2) Generate the model y.
(3) Calculate chi-square
(4) Perturb the slope and intercept and evaluate chi-square.
(5) Repeat until small changes of the parameters no longer reduce the value of chi-square.
(6) From this procedure, determine which parameters provides the smallest value for the chi-square.
(7) With the best estimates of the slope and intercepts generate a new string of model variables.

Reference

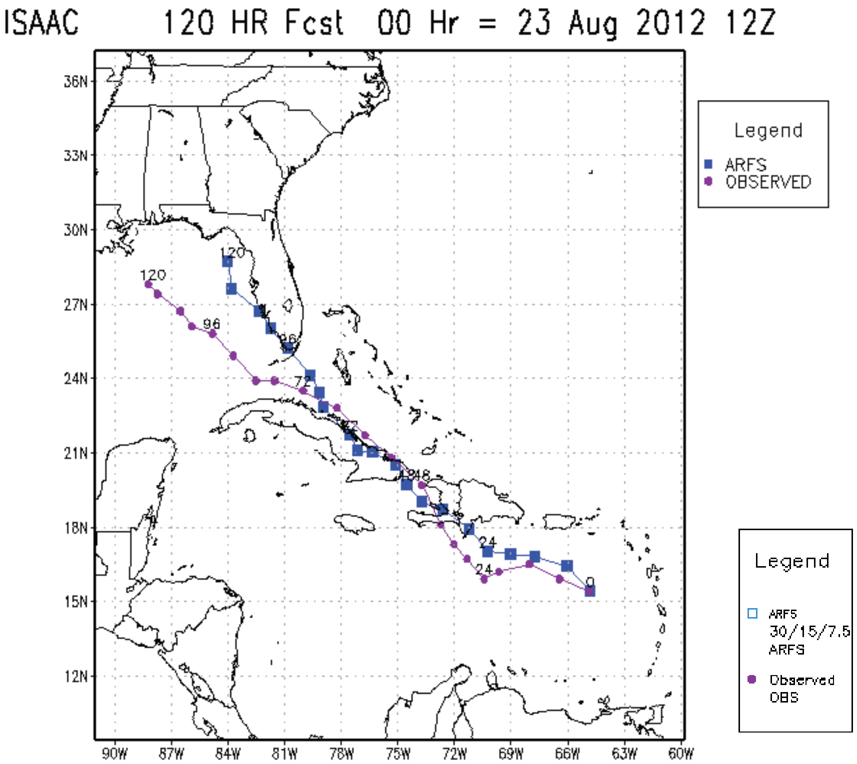
Press W H, Flannery B P, Teukolsky S A, Vetterling W T 1986 Numerical Recipes: The Art of Scientific Computing. Cambridge University Press: Cambridge, 818.

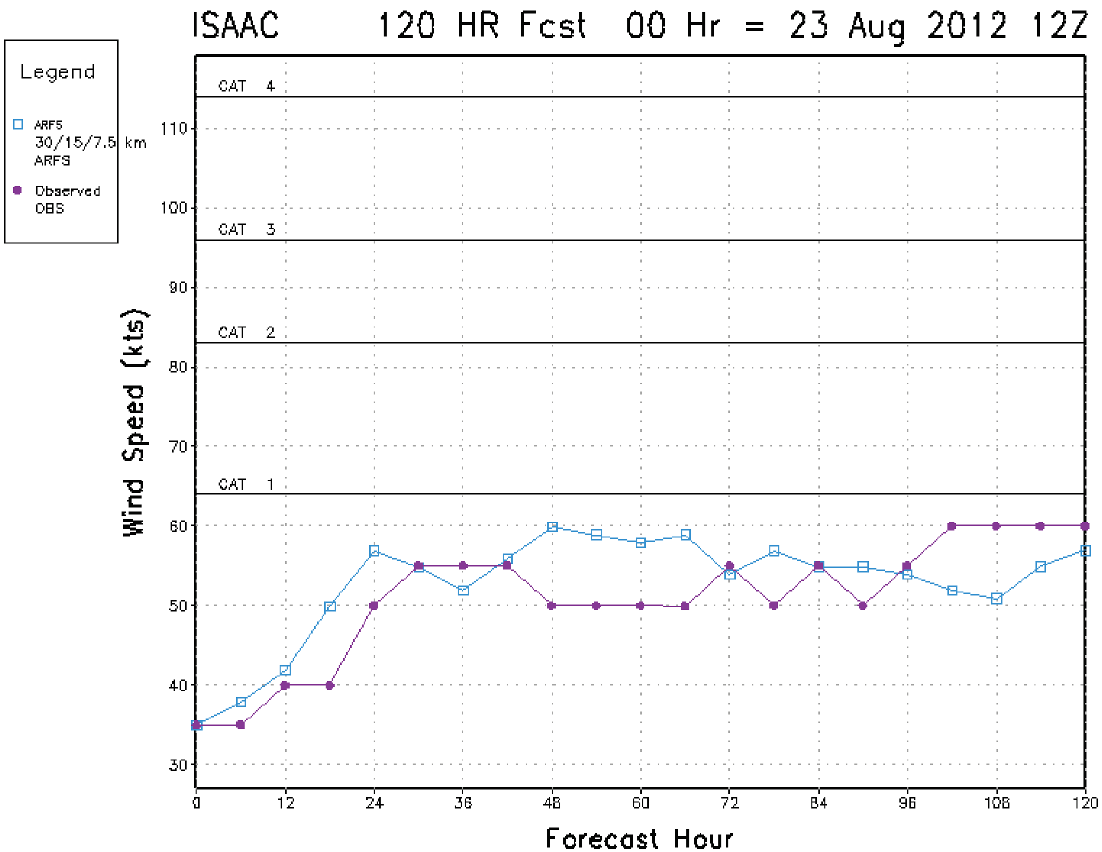
The contribution from our new approach for the removal of outliers contributed the most to the improvements of skills for the 2012 season. That far outweighed the advantage gained from having a large sample of member model forecasts. In the two forecasts submissions to TCMT during 2012 season the major improvements of the second submission came from the better handling of the outliers.

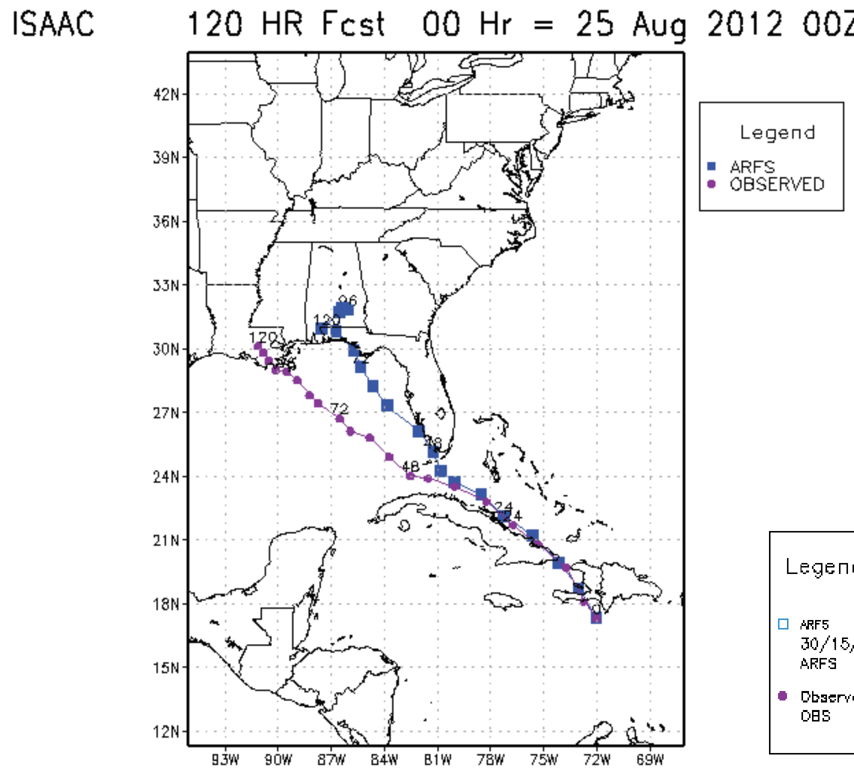
List of Real time forecast models

	Model (Track)	Model (Intensity)
1.	HWRF (H212) (M)	HWRF (H212) (M)
2.	COTC (M)	COTC (M)
3.	AHW4 (M)	AHW4 (M)
4.	ARFS (M)	ARFS (M)
5..	SPC3 (S)	SHIPS (S)
6.	FIM9 (L)	SPC3 (S)
7.	UWN8 (M)	UWN8 (M)
8.	GFDL (M)	GFDL (M)
9.	NGPS (L)	FIM9 (L)
10.	ECMF (only for training data from 2011) (L)	NGPS (L)
11.	AVNI (L)	AVNI (L)

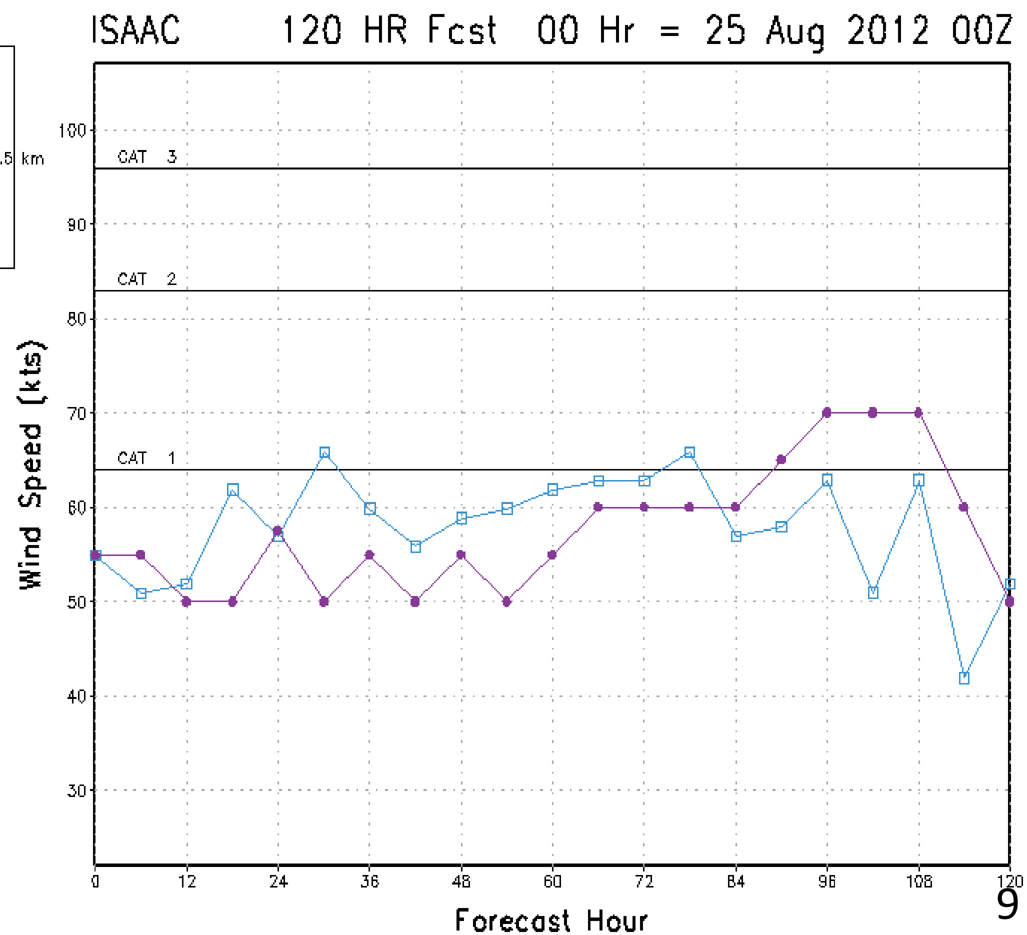
WE INCLUDE A VERIOSN OF FSU/WRF (ARFS) IN OUR SUITE OF MODELS.



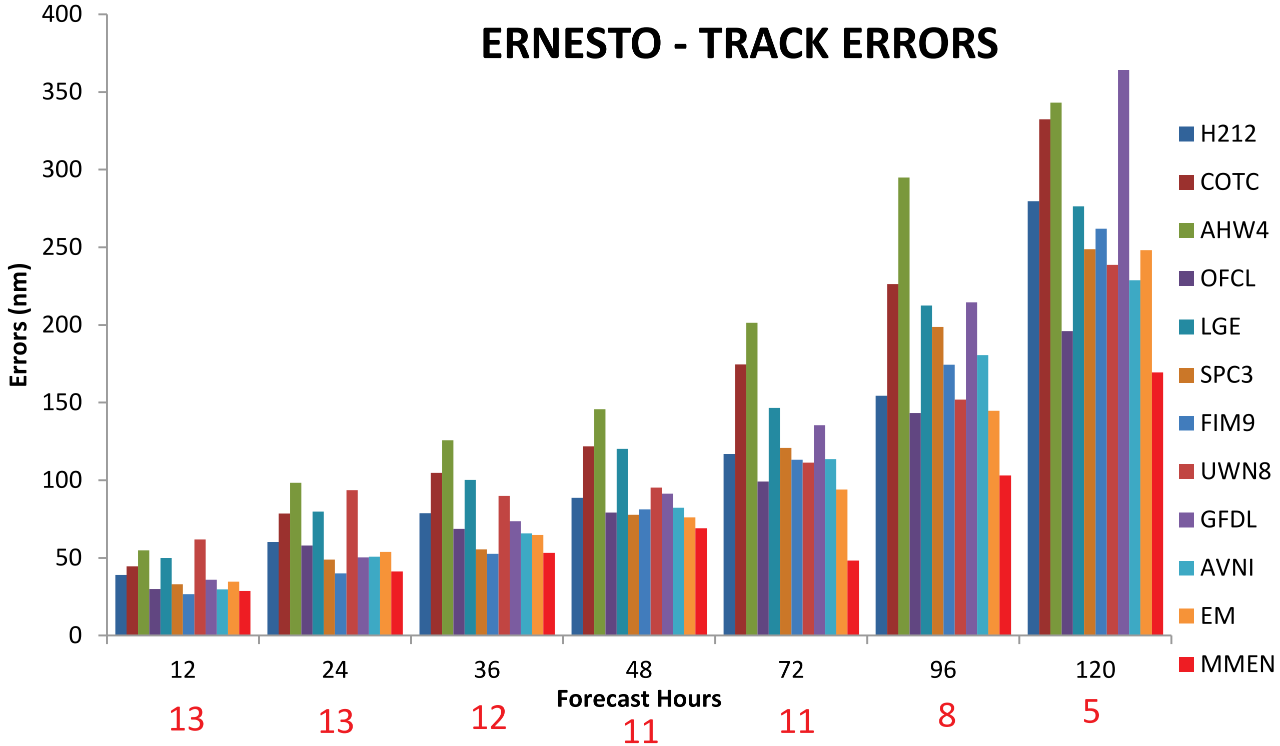


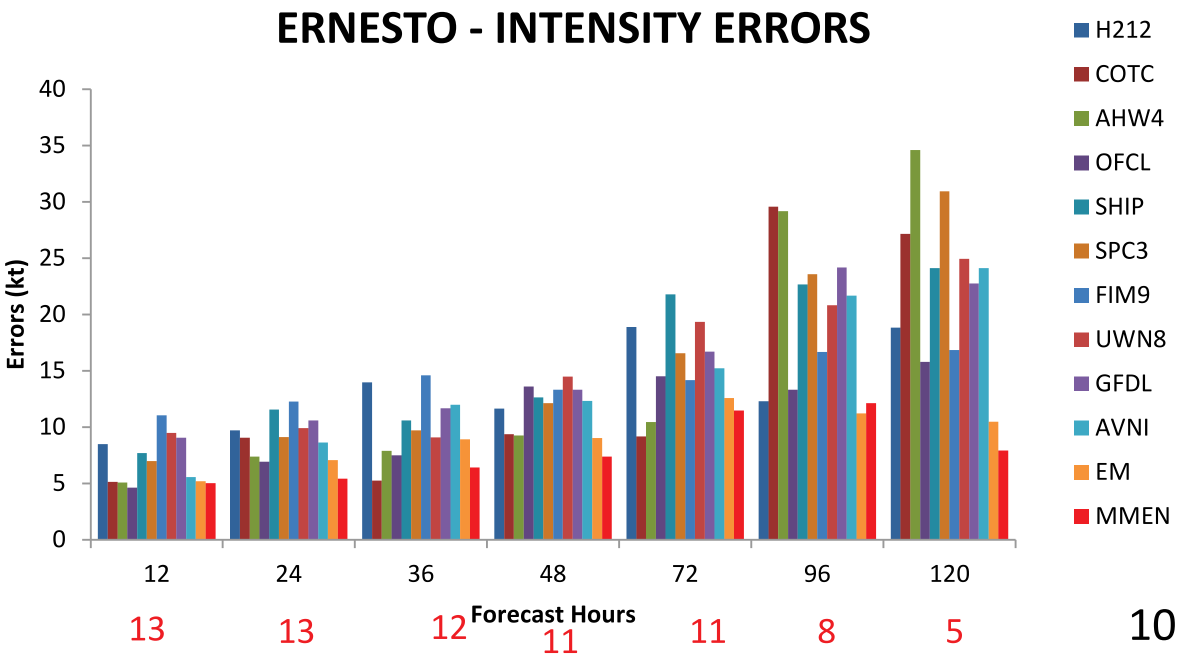


ISAAC 120 HR Fcst 00 Hr = 25 Aug 2012 00Z
Legend
ARFS
OBSERVED
42N
39N
36N
33N
30N
27N
24N
21N
18N
15N
12N
93W
90W
87W
84W
81W
78W
75W
72W
69W

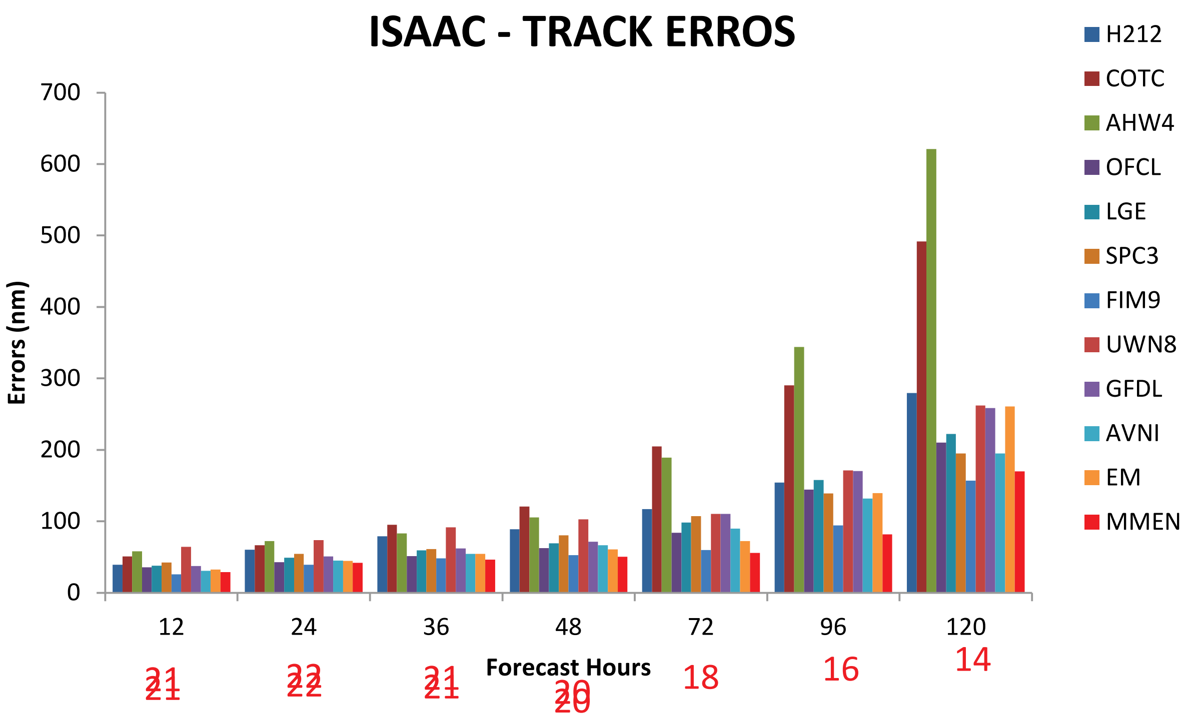


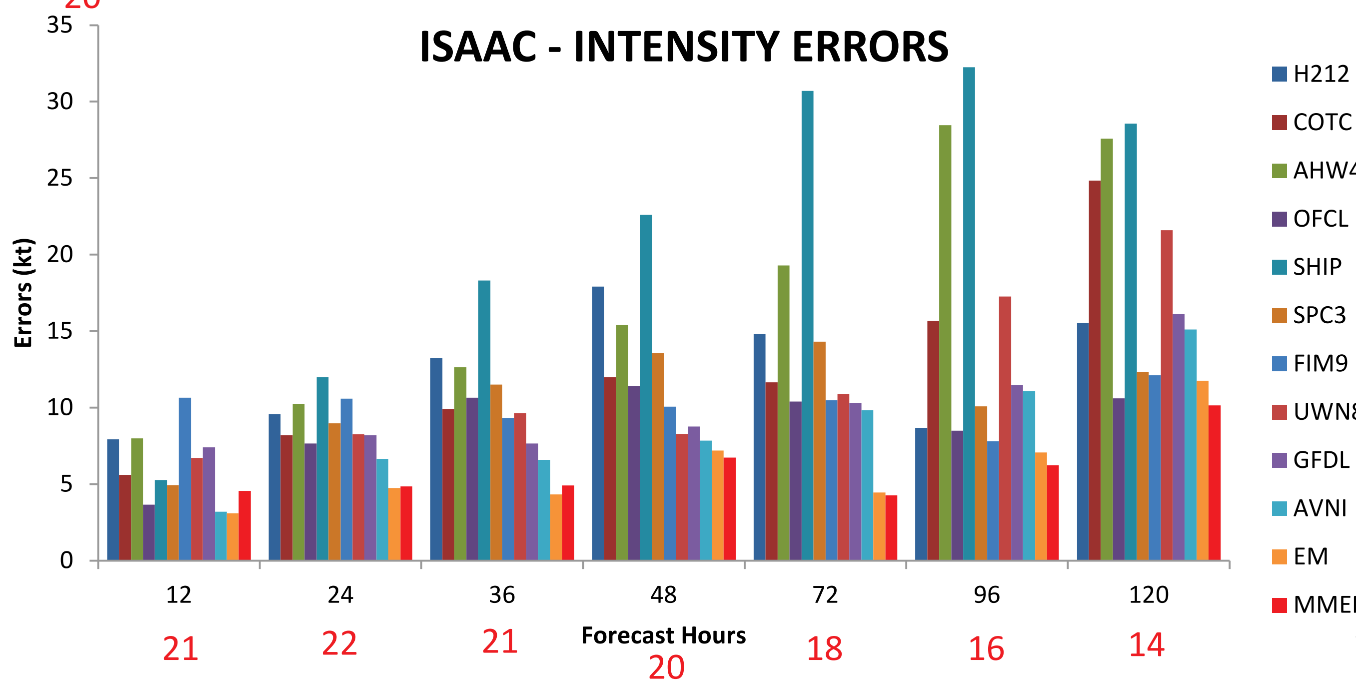
ISAAC 120 HR Fcst 00 Hr = 25 Aug 2012 00Z
Legend
ARFS 30/15/7.5 km ARFS
Observed OBS
CAT 3
CAT 2
CAT 1
Wind Speed (kts)
Forecast Hour





No. of Cases in red





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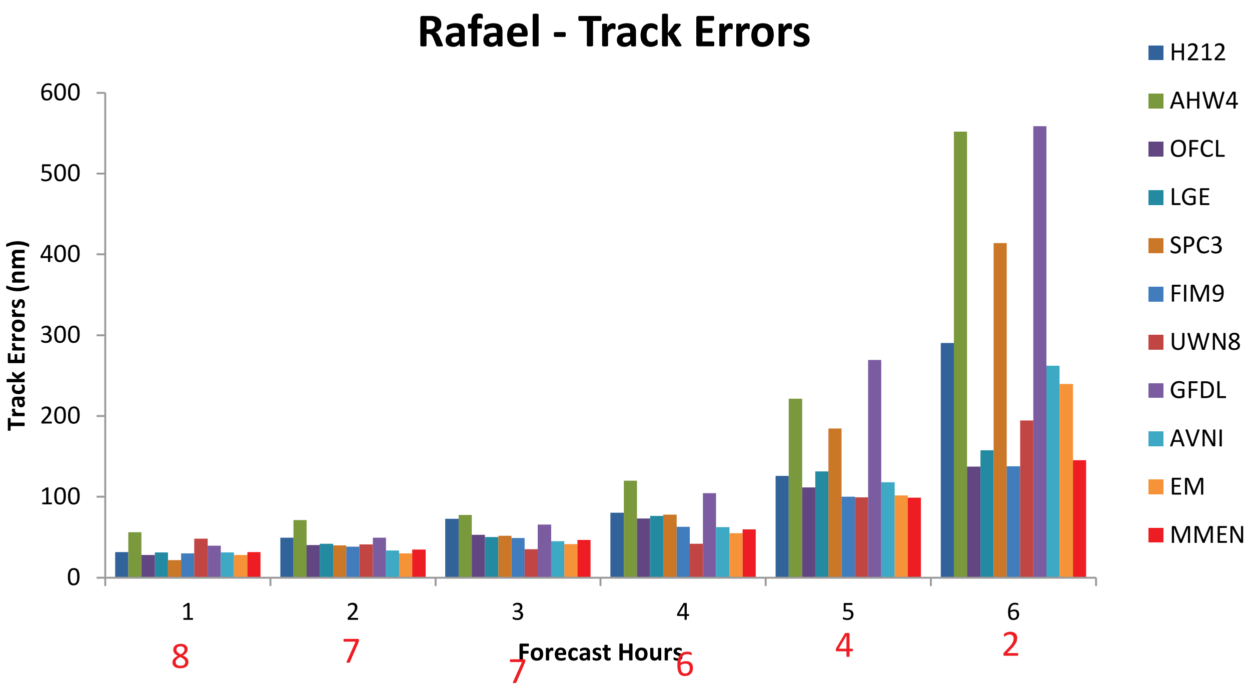
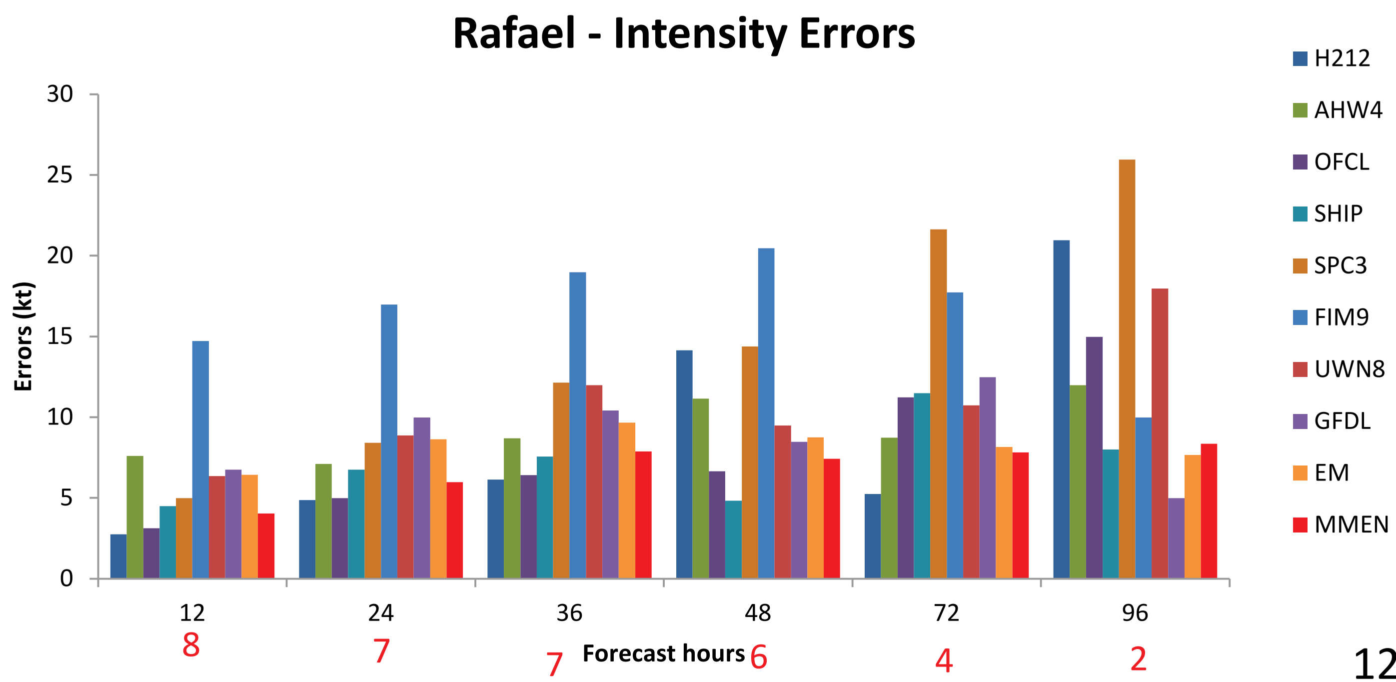
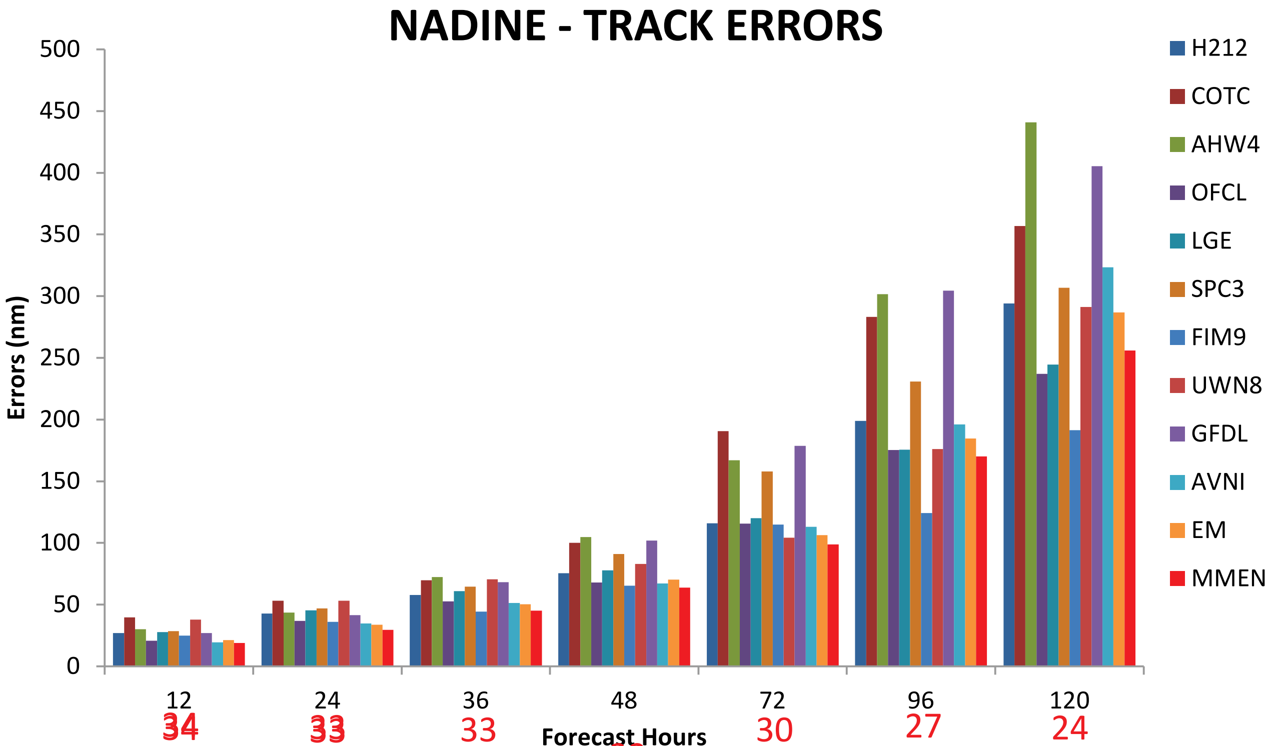
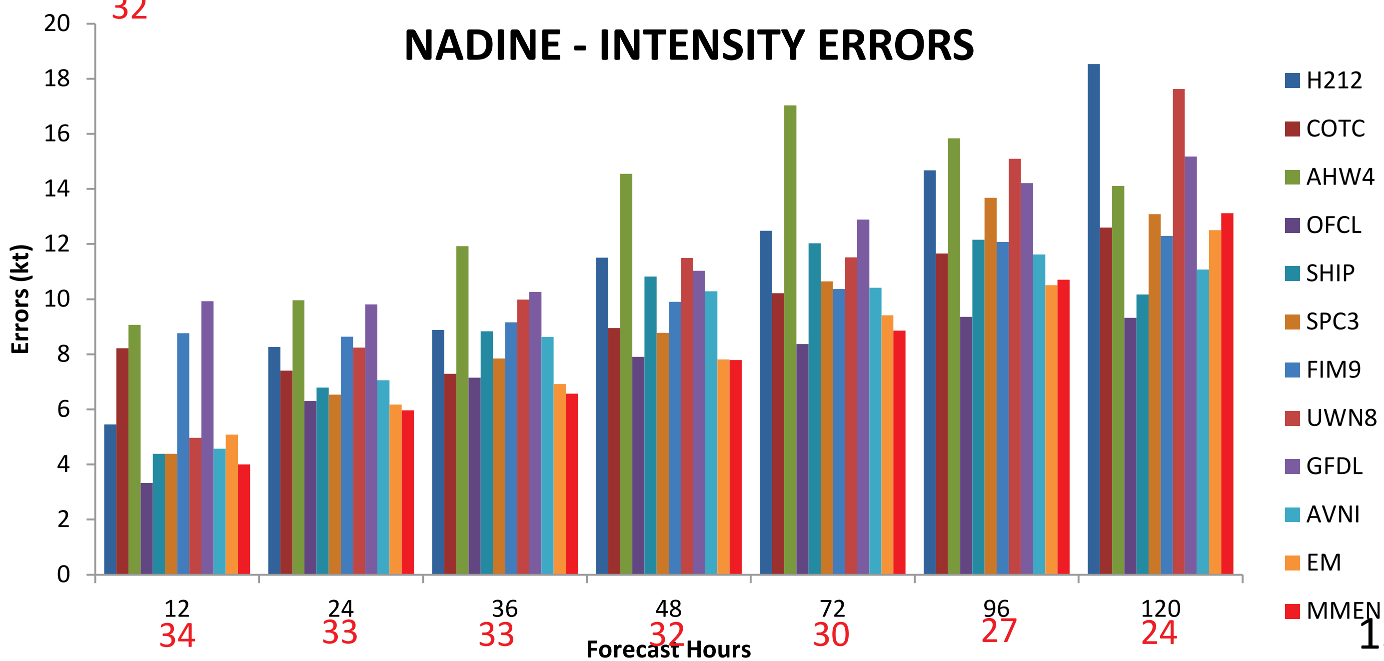




No. of Cases in red





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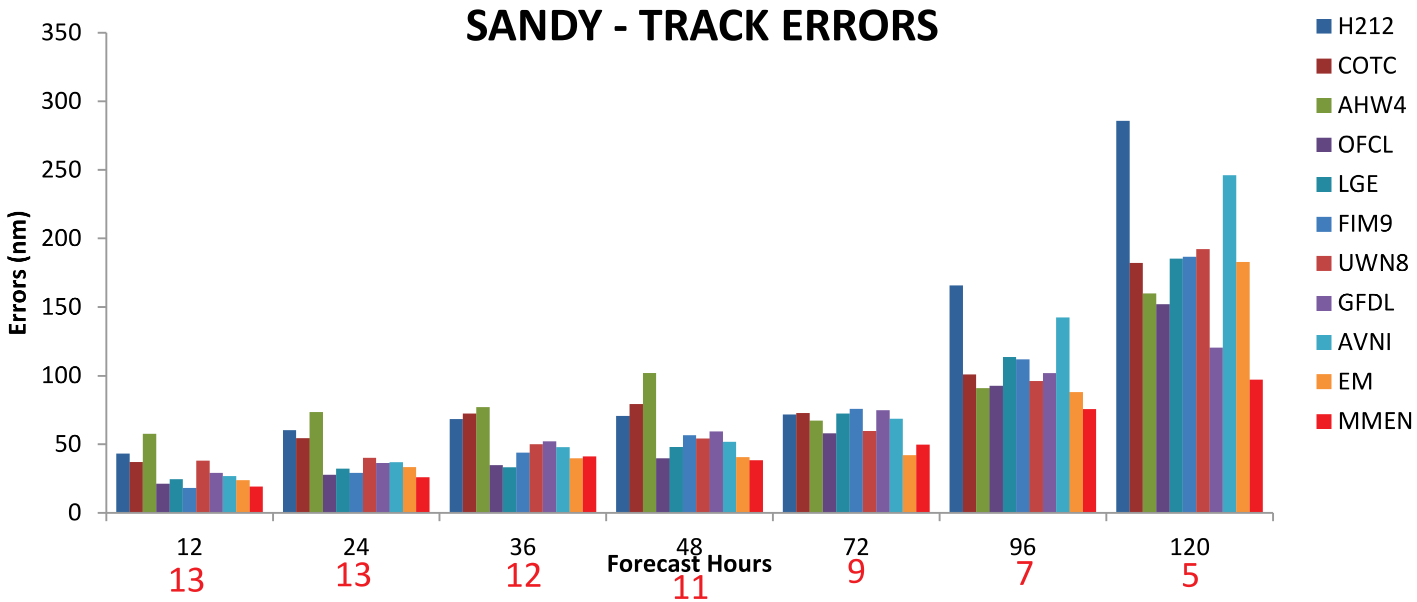
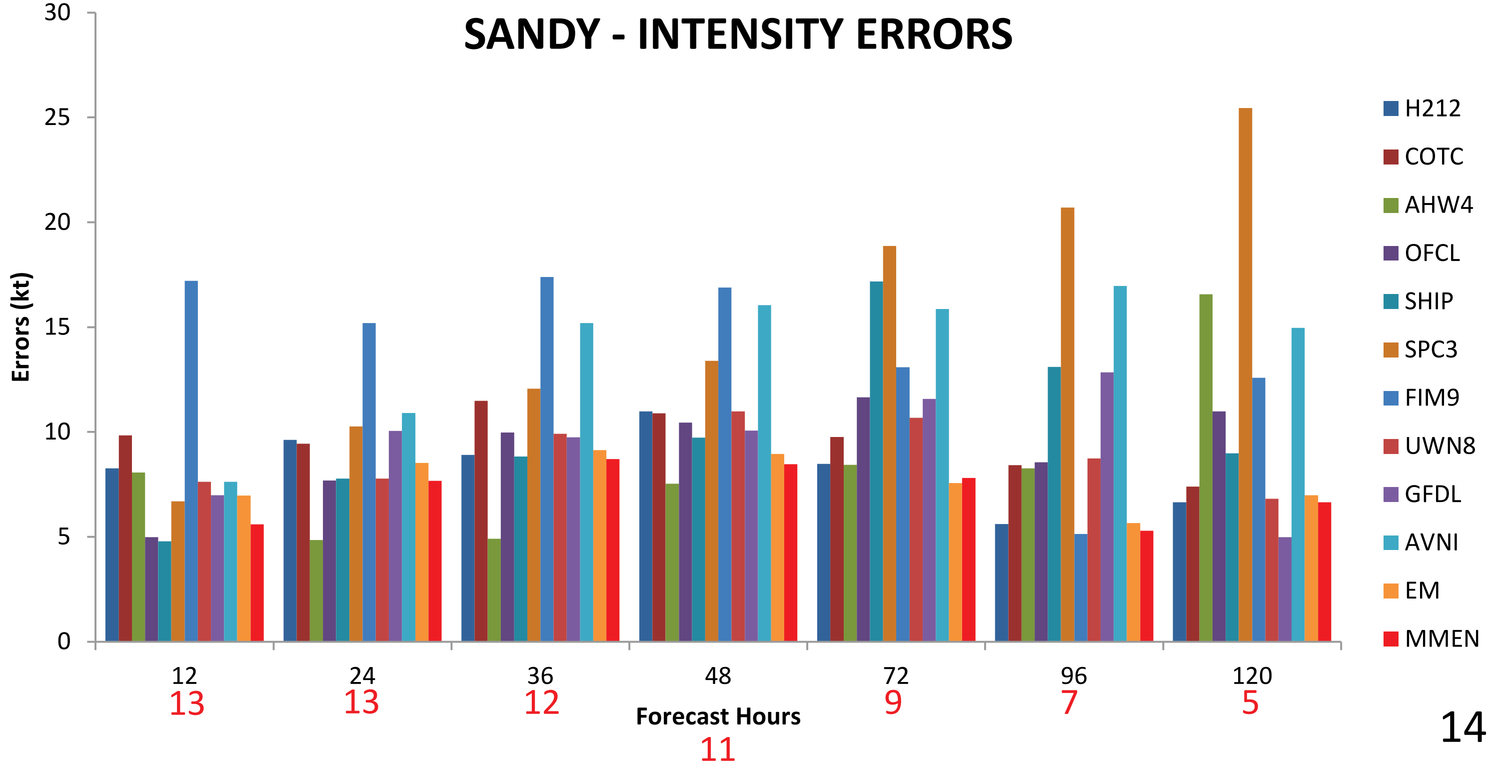
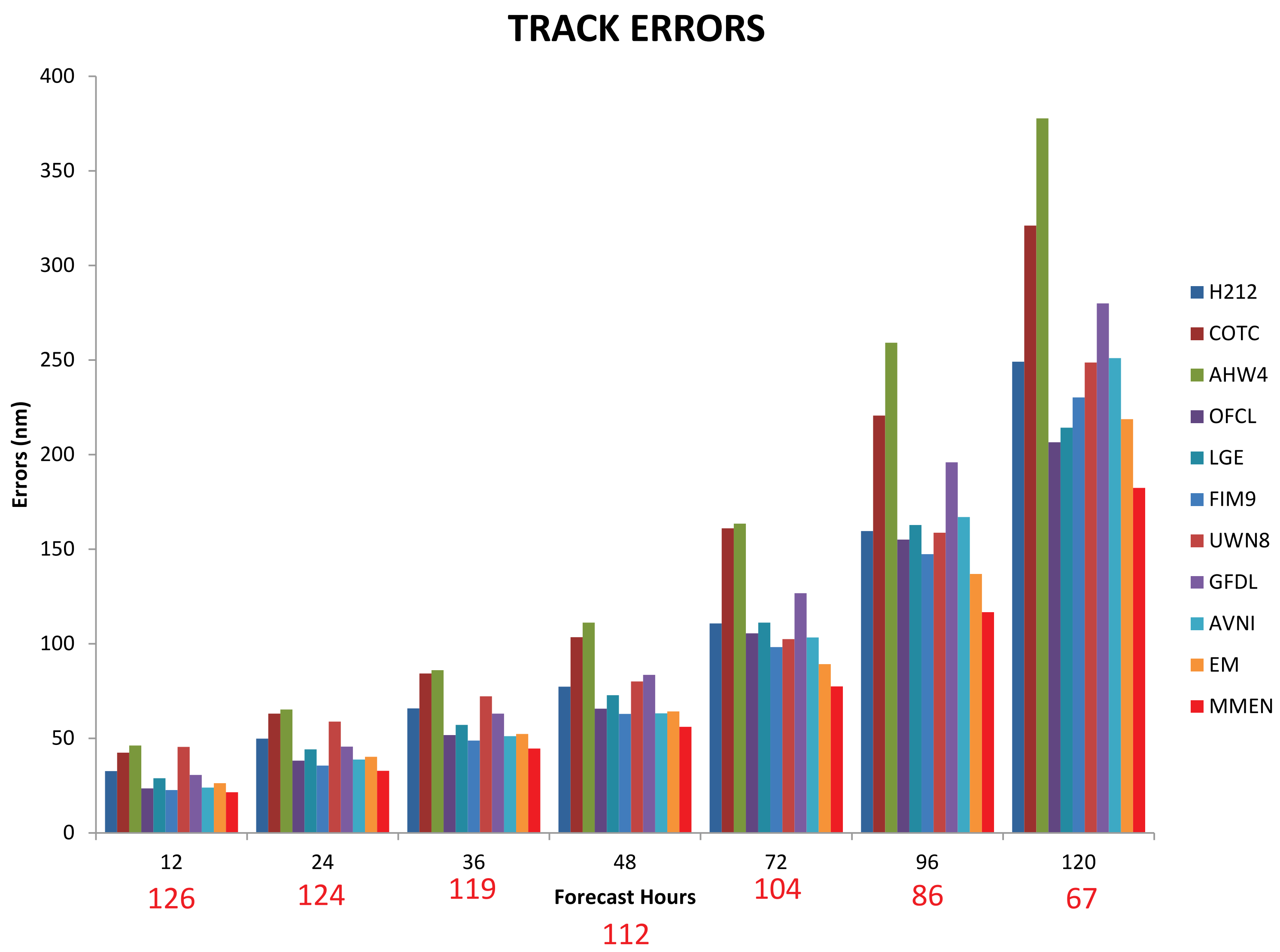




No. of Cases in red



No. of Cases in red

Examining the consistency of MMEN Track forecast (FSU)

ERNESTO

Id	H212	COTC	AHW4	OFCL	LGE	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Case
12	39.05	44.52	54.86	29.88	49.95	33.06	**26.59**	61.83	35.87	29.72	34.68	**28.82**	14
24	60.34	78.61	98.29	58.02	79.83	48.96	**40.11**	93.71	50.35	50.77	53.88	**41.39**	14
36	78.88	104.78	125.82	68.66	100.3	55.59	**52.61**	90	73.58	65.88	64.73	**53.18**	13
48	88.64	121.94	145.66	79.18	120.2	77.69	81.27	95.29	91.45	82.21	**76.14**	**69.01**	12
72	116.89	174.63	201.35	99.22	146.66	120.79	113.11	111.27	135.4	113.66	**94.1**	**48.35**	11
96	154.4	226.22	294.92	**143.2**	212.43	198.67	174.35	152.03	214.47	180.53	144.75	**103.13**	10
120	279.58	332.31	343.2	**196**	276.29	248.77	261.85	238.63	364.2	228.75	248.08	**169.54**	7

SANDY

Id	H212	COTC	AHW4	OFCL	LGE	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Case
12	44.45	50.98	57.77	35.5	37.67	42.31	**25.94**	64.17	37.47	30.48	32.53	**28.75**	21
24	63.98	66.53	72.08	42.9	49.12	54.62	**39.08**	73.82	50.63	44.94	44.49	**41.76**	21
36	72.45	95.17	82.82	51.22	59.29	61.21	**48.34**	91.53	61.84	54.29	54.53	**46.24**	21
48	71.1	120.69	105.41	62.5	69.21	80.52	**52.5**	102.62	71.56	66.7	60.6	**50.28**	20
72	88.81	204.79	189.07	83.76	98.09	107.09	**59.96**	110.43	110.26	89.7	72.52	**55.56**	18
96	128.62	290.08	344.12	144.21	157.71	138.92	**94.19**	171.14	170.25	132.03	139.57	**81.63**	16
120	215.69	491.5	620.93	210.36	222.2	194.99	**157.01**	262.28	258.58	195.14	260.93	**170**	13

KIRK

Id	H212	COTC	AHW4	OFCL	LGE	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Case
12	28.53	58.11	71.35	**23.26**	31.68	43.6	29.92	59.32	34.76	30.99	30.14	**21.85**	7
24	**48.5**	107.35	112.77	51.13	55.63	261.69	57.05	94.74	69.1	58.06	59.7	**42.76**	7
36	**67.77**	141.33	146.92	74.19	82.71	260.52	82.06	121.98	102.99	72.8	81.33	**63.95**	6
48	77.06	122.31	182.92	96.44	109.27	261.9	90.06	124.85	112.63	68.68	82.75	**68.49**	5
72	**153.39**	210.12	335.23	204.19	236.2	296.14	180.29	203.47	164.28	158.41	155.83	**133**	4
96	**154.44**	402.45	576.09	473.78	539.26	504.8	210.52	217.68	226.76	287.84	196.89	**147**	2

NADINE

Id	H212	COTC	AHW4	OFCL	LGE	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Case
12	26.84	39.55	30.02	20.66	27.82	28.45	19.79	37.77	27.01	**19.57**	21.32	**19**	40
24	42.82	53.04	43.57	36.87	45.46	46.91	**30.11**	53.21	41.6	34.64	33.74	**29.63**	39
36	57.84	69.74	72.37	52.55	60.87	64.67	**48.88**	70.56	68.21	51.29	50.27	**45.03**	38
48	75.54	100	104.88	67.93	77.69	90.95	67.44	83.07	101.85	**67.28**	70.26	**63.9**	37
72	115.93	190.49	167.1	115.73	120	157.91	115.65	**104.21**	178.75	113.14	106.37	**98.84**	35
96	198.92	283.32	301.48	**175.39**	175.59	230.8	190.01	176.21	304.55	195.95	184.64	**170**	33
120	294.2	356.83	440.97	**237.1**	**244.46**	306.84	291.77	291.25	405.31	323.32	286.92	256	32

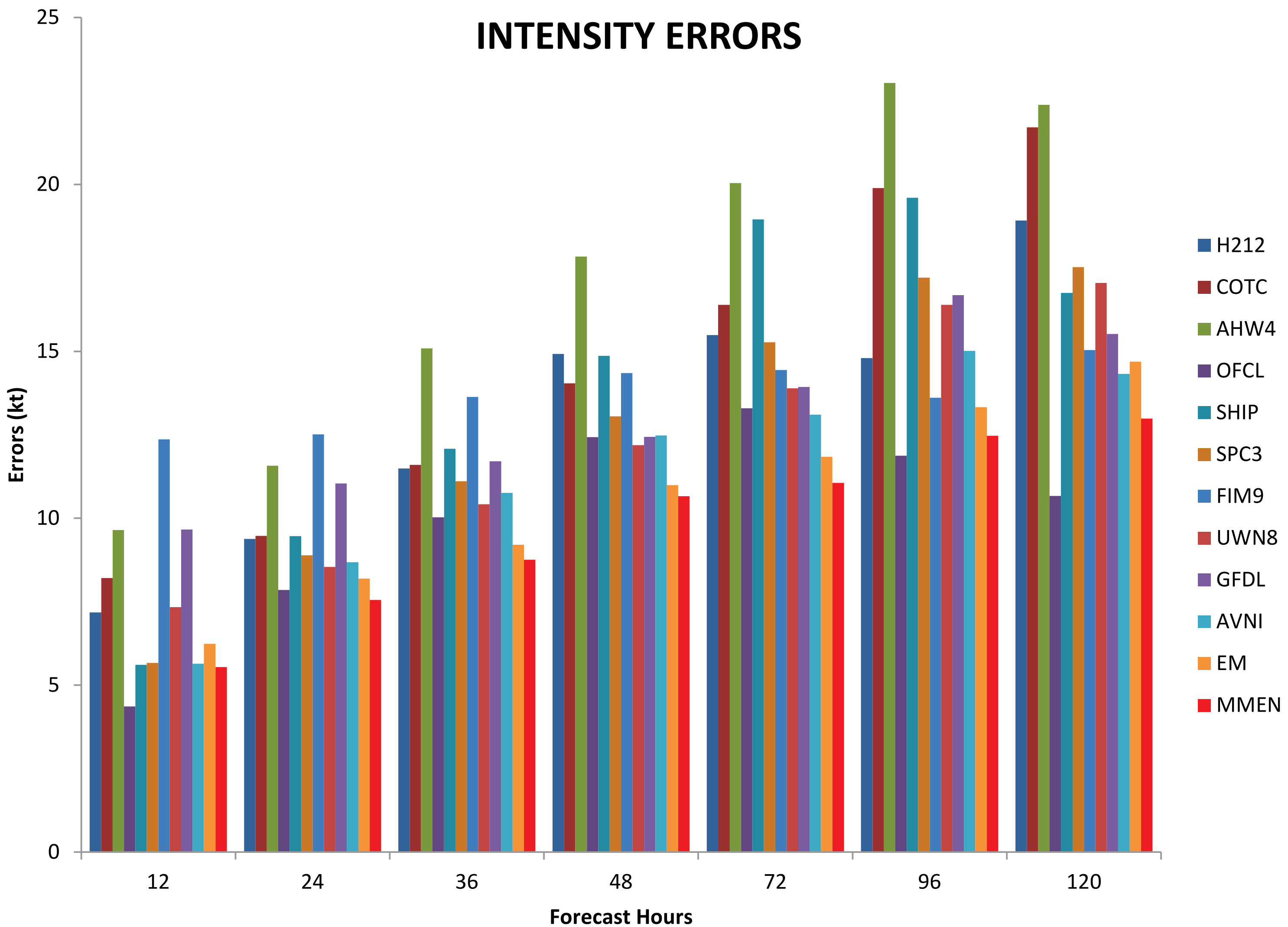
SANDY

Id	H212	COTC	AHW4	OFCL	LGE	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Case
12	43.22	37	57.74	21.26	24.4	235.94	**18.3**	38.06	29.05	26.89	23.77	**19.04**	13
24	60.16	54.37	73.63	**27.86**	32.24	238.21	29.28	40.03	36.35	36.83	33.43	**25.96**	13
36	68.44	72.27	77.01	**34.69**	**33.06**	251.6	43.98	49.91	52.15	47.85	**39.71**	41.07	12
48	70.7	79.39	102.09	**39.57**	48.07	270.02	56.4	54.25	59.36	51.86	40.58	**38.32**	11
72	71.55	72.93	67.12	57.83	72.28	337.01	75.82	59.74	74.8	68.7	**42.11**	49.81	9
96	165.67	100.94	90.82	92.63	113.75	466.35	111.92	96.07	101.72	142.4	**88.08**	**75.6**	7
120	285.88	182.25	159.81	151.96	185.48	690.49	186.78	192.04	**120.43**	246.07	182.71	**97.23**	5

OVERALL

Id	H212	COTC	AHW4	OFCL	LGE	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Case
12	32.65	42.43	46.24	23.48	28.84	53.83	**22.6**	45.46	30.6	23.86	26.31	**21.45**	137
24	49.76	63.01	65.21	38.13	44.12	80.08	**35.49**	58.76	45.64	38.83	40.15	**32.8**	136
36	65.74	84.29	86.06	51.76	57.03	91.79	**48.78**	72.21	62.97	51.18	52.28	**44.63**	129
48	77.22	103.49	111.15	65.68	72.71	112.25	**62.96**	79.99	83.55	63.13	64.21	**56.06**	121
72	110.76	161.08	163.44	105.44	111.16	155.32	98.26	102.5	126.71	103.36	**89.27**	**77.46**	108
96	159.54	220.57	259.15	155.08	162.74	213.36	147.29	158.65	195.88	167.05	**136.96**	**116.72**	91
120	249.08	321.09	377.76	**206.49**	214.25	281.9	230.28	248.72	279.94	251.09	218.76	**182.35**	73

2012 all storms



No. of cases 136 135 129 122 113 97 79

Examining the consistency of MMEN Intensity forecast errors (kts)(FSU)

ERNESTO

Id	H212	COTC	AHW4	OFCL	ICON	LGE	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Cases
12	8.48	5.14	5.07	**4.61**	**4.91**	6.35	7.7	6.99	11.05	9.48	9.06	5.56	5.18	**5.03**	14
24	9.7	9.06	7.37	**6.91**	**6.68**	8.56	11.55	9.11	12.26	9.9	10.6	8.63	7.07	**5.4**	14
36	13.97	**5.24**	7.9	7.49	**6.74**	10.21	10.6	9.7	14.59	9.09	11.67	11.98	8.91	**6.41**	13
48	11.65	9.35	9.26	13.61	**8.89**	13.48	12.64	12.12	13.31	14.47	13.31	12.31	**9.02**	**7.37**	12
72	18.88	**9.17**	**10.44**	14.52	**9.07**	17.8	21.79	16.54	14.16	19.34	16.7	15.22	12.58	11.48	11
96	**12.28**	29.57	29.17	13.31	14.26	23.56	22.66	23.56	16.67	20.82	24.18	21.66	**11.2**	**12.11**	10
120	18.82	27.15	34.6	15.8	**10.23**	27.66	24.1	30.94	16.83	24.95	22.76	24.12	**10.48**	**7.92**	7

ISSAC

Id	H212	COTC	AHW4	OFCL	ICON	LGEM	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Cases
12	7.92	5.59	7.99	**3.66**	4.86	5.59	5.26	4.92	10.65	6.72	7.39	**3.19**	**3.08**	4.56	15
24	9.58	8.19	10.25	7.65	7.19	9.18	11.98	8.98	10.58	8.25	8.19	**6.65**	**4.74**	**4.84**	15
36	13.24	9.92	12.64	10.65	7.12	11.45	18.3	11.51	9.32	9.65	7.65	**6.59**	**4.33**	**4.9**	15
48	17.9	11.98	15.4	11.41	9.63	14.83	22.6	13.55	10.05	8.27	8.77	**7.84**	**7.2**	**6.74**	14
72	14.81	11.65	19.3	10.4	**9.4**	16.14	30.69	14.31	10.48	10.9	10.31	9.82	**4.44**	**4.27**	12
96	8.68	15.67	28.45	8.48	**6.77**	9.88	32.24	10.08	7.79	17.27	11.48	11.08	**7.07**	**6.23**	10
120	15.53	24.83	27.58	**10.61**	**10.69**	11.35	28.57	12.35	12.1	21.59	16.1	15.1	11.76	**10.15**	8

NADINE

Id	H212	COTC	AHW4	OFCL	ICON	LGEM	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Cases
12	5.45	8.22	9.06	**3.33**	**3.79**	4.31	4.38	4.39	8.76	4.97	9.93	4.57	5.08	**4**	41
24	8.26	7.41	9.96	**6.3**	6.35	6.86	6.79	6.53	8.63	8.24	9.81	7.06	**6.17**	**5.97**	40
36	8.88	7.29	11.92	**7.15**	7.85	8.88	8.83	7.85	9.16	9.98	10.26	8.62	**6.92**	**6.57**	39
48	11.51	8.95	14.55	**7.9**	8.07	9.88	10.82	8.78	9.9	11.49	11.03	10.28	**7.81**	**7.79**	38
72	12.48	10.21	17.03	**8.37**	**9.19**	10.76	12.03	10.65	10.37	11.52	12.89	10.41	9.41	**8.86**	36
96	14.68	11.65	15.84	**9.36**	12.34	12.33	12.15	13.68	12.07	15.09	14.21	11.62	**10.5**	**10.7**	34
120	18.53	12.6	14.11	**9.32**	11.65	11.32	**10.17**	13.08	12.29	17.62	15.18	**11.08**	12.5	13.12	32

SANDY

Id	H212	COTC	AHW4	OFCL	ICON	LGEM	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Cases
12	8.27	9.83	8.06	**4.99**	5.78	6.7	**4.78**	6.7	17.2	7.63	6.99	7.63	6.97	**5.6**	13
24	9.63	9.44	**4.84**	**7.68**	8.56	11.05	7.77	10.27	15.2	7.77	10.05	10.91	8.53	**7.67**	13
36	8.91	11.48	**4.91**	9.98	9.52	13.51	**8.83**	12.06	17.39	9.91	9.75	15.2	9.14	**8.7**	12
48	10.98	10.89	**7.53**	10.44	11.23	15.8	9.73	13.39	16.88	10.98	10.07	16.05	**8.95**	**8.46**	11
72	8.48	9.76	**8.43**	11.65	12.08	23.26	17.17	18.87	13.09	10.68	11.58	15.87	**7.57**	**7.8**	9
96	**5.61**	8.41	8.27	8.56	10.61	24.21	13.1	20.71	**5.13**	8.73	12.85	16.97	5.65	**5.29**	7
120	**6.65**	7.39	16.57	10.98	15.64	28.95	8.98	25.45	12.58	**6.82**	**4.99**	14.97	6.99	**6.65**	5

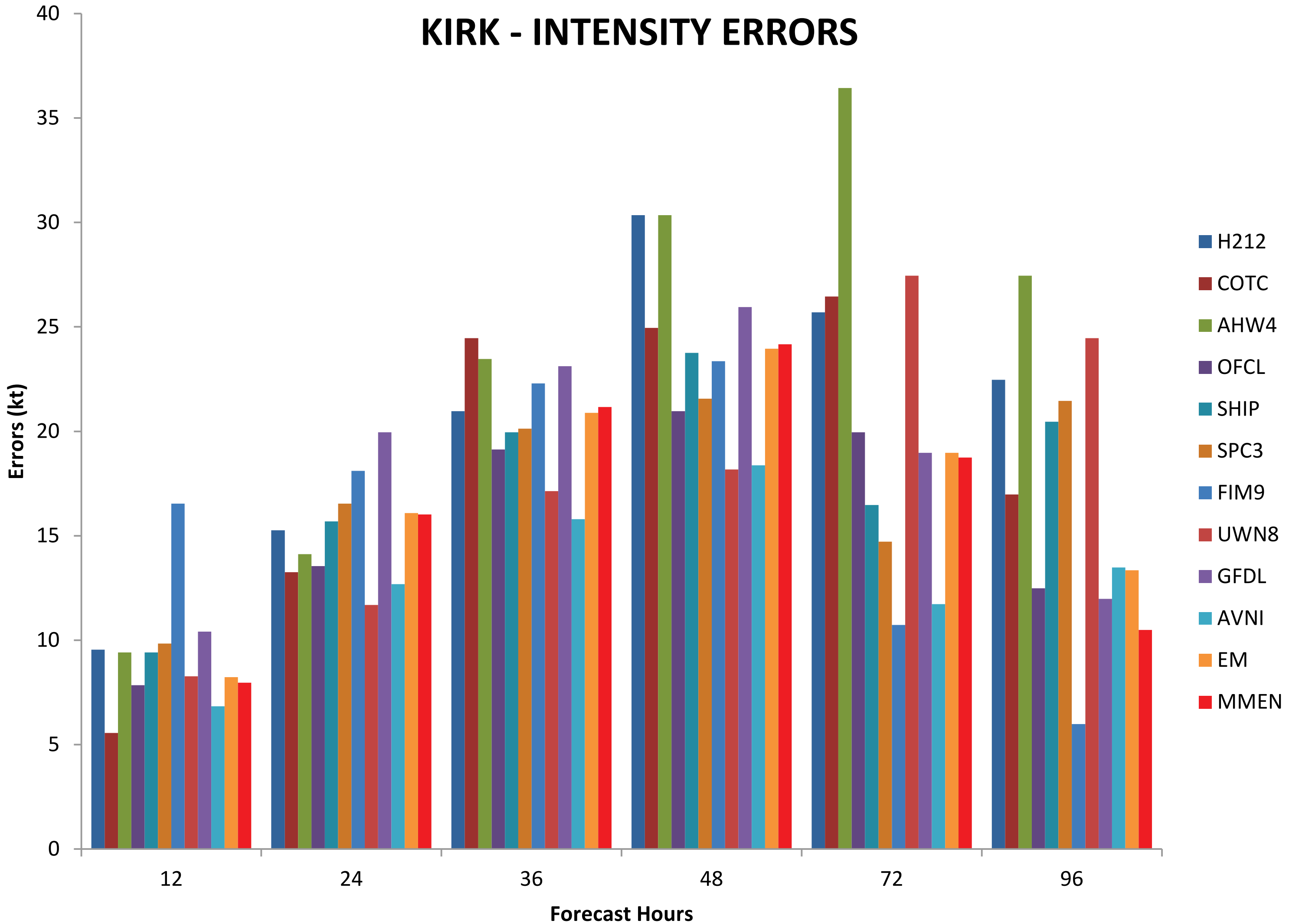
KIRK

Id	H212	COTC	AHW4	OFCL	ICON	LGEM	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Cases
12	9.55	**5.56**	9.41	**7.84**	10.27	7.84	9.41	9.84	16.54	8.27	10.41	**6.84**	8.23	**7.84**	7
24	15.26	**13.26**	14.12	13.55	18.97	13.69	15.69	16.54	18.11	**11.69**	19.96	**12.69**	16.08	16.02	7
36	20.96	24.46	23.46	19.13	22.76	**18.13**	19.96	20.13	22.29	**17.14**	23.12	**15.8**	20.88	21.16	6
48	30.35	24.95	30.35	20.96	**20.71**	21.16	23.76	21.56	23.36	**18.17**	25.95	**18.37**	23.96	24.17	5
72	25.7	26.45	36.43	19.96	19.96	13.48	16.47	**14.72**	**10.73**	27.45	18.97	**11.73**	18.97	18.74	4
96	22.46	16.97	27.45	12.48	18.97	23.96	20.46	21.46	**5.99**	24.46	**11.98**	13.48	13.35	**10.49**	2

OVERALL

Id	H212	COTC	AHW4	OFCL	ICON	LGEM	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN	Cases
12	7.18	8.21	9.65	**4.36**	**5.5**	**5.57**	5.61	5.67	12.36	7.34	9.66	5.64	6.24	**5.54**	136
24	9.38	9.47	11.57	**7.85**	**8.11**	8.81	9.46	8.89	12.51	8.54	11.04	8.68	8.19	**7.55**	135
36	11.49	11.6	15.09	10.03	**9.47**	11.31	12.08	11.11	13.63	10.42	11.71	10.76	**9.21**	**8.76**	129
48	14.92	14.04	17.84	12.43	**10.97**	13.92	14.86	13.05	14.35	12.19	12.44	12.48	**10.99**	**10.66**	122
72	15.49	16.39	20.04	13.29	**11.9**	16.36	18.95	15.27	14.44	13.89	13.93	13.1	**11.84**	**11.06**	113
96	14.8	19.89	23.04	**11.87**	**12.7**	18.08	19.6	17.21	13.61	16.39	16.68	15.01	13.33	**12.47**	97
120	18.92	21.71	22.38	**10.67**	**11.77**	16.54	16.75	17.52	15.04	17.05	15.52	14.32	14.69	**12.99**	79

KIRK WAS A DIFFICULT STORM TO PREDICT



KIRK (absolute intensity errors in kts) all intensity forecasts for all models

Id	H212	COTC	AHW4	OFCL	ICON	LGE	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN
12	3.99	8.98	21.96	4.99	3.99	**2**	3.99	4.99	7.99	15.97	**1.5**	3.99	**1.2**	3.25
24	**2**	25.95	28.95	14.97	11.98	9.98	13.97	13.97	**2.99**	28.95	5.99	13.97	7.73	11.72
36	4.99	37.93	33.94	14.97	14.97	13.97	17.97	17.97	5.99	29.95	17.97	12.98	16.72	18.63

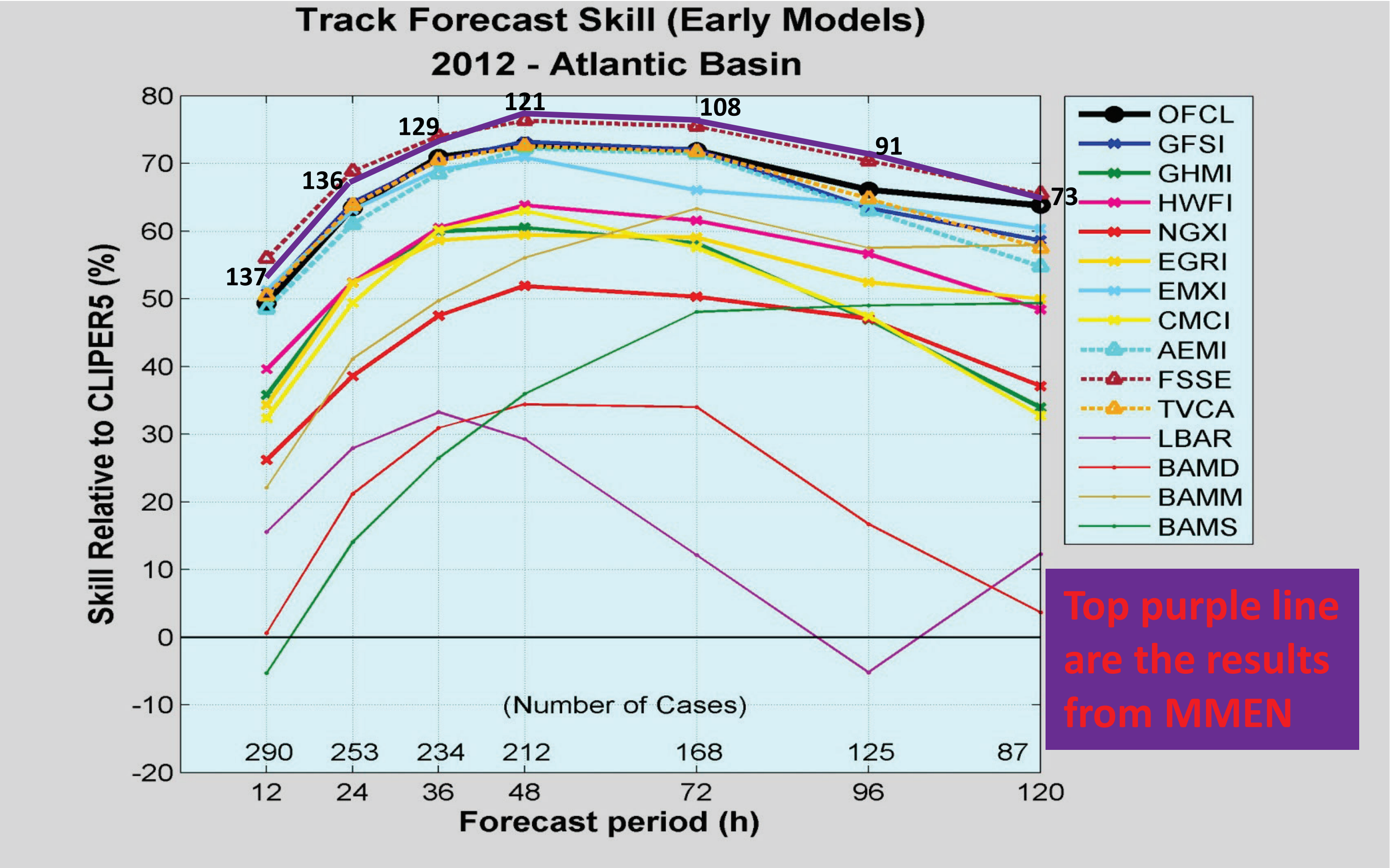
Id	H212	COTC	AHW4	OFCL	ICON	LGE	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN
12	17.97	**0**	**2**	19.96	19.96	20.96	21.96	20.96	22.96	18.97	**2**	12.98	2.75	3.5
24	34.94	21.96	21.96	24.95	25.95	25.95	28.95	28.95	**4.99**	24.95	**12.98**	18.97	**16.22**	20.2
36	37.93	27.95	28.95	29.95	31.94	29.95	38.93	34.94	**3.99**	31.94	27.95	27.95	**24.46**	**26.36**
48	35.94	40.93	38.93	29.95	32.94	28.95	40.93	34.94	**11.98**	34.94	**24.95**	33.94	**28.45**	29.1

Id	H212	COTC	AHW4	OFCL	ICON	LGE	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN
12	**3.99**	13.97	**2**	9.98	13.97	12.98	13.97	15.97	37.93	**3.99**	18.97	15.97	18.71	14.47
24	4.99	**3.99**	**2.99**	9.98	12.98	12.98	12.98	16.97	31.94	**1.25**	15.97	17.97	14.23	10.24
36	17.97	16.97	20.96	9.98	4.99	**3.99**	**3.99**	**3.99**	19.96	16.97	**3.2**	4.2	3.25	5.15
48	28.95	23.96	29.95	19.96	15.97	12.98	15.97	11.98	**4.99**	24.95	**7.99**	**9.98**	13.97	14.63
72	36.93	22.96	41.92	29.95	28.95	22.96	31.94	24.95	**8.98**	38.93	27.95	**18.97**	24.21	**22.59**

Id	H212	COTC	AHW4	OFCL	ICON	LGE	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN
12	10.98	**2**	**4.99**	**4.99**	9.98	8.98	9.98	8.98	14.97	**5.99**	20.96	**5.99**	12.23	7.98
24	18.97	23.96	**8.98**	19.96	24.95	22.96	20.96	19.96	25.95	**4.99**	36.93	**12.98**	26.45	22.47
36	32.94	27.95	**20.96**	29.95	37.93	34.94	32.94	32.94	41.92	**8.98**	47.91	**23.96**	37.68	35.78
48	25.95	**11.98**	**4.99**	29.95	32.94	35.94	33.94	32.94	39.93	**1**	41.92	26.95	29.95	29.3
72	23.96	16.97	39.93	4.99	4.99	**0**	**1**	**2**	4.99	21.96	6.99	3.99	7.24	5.62
96	37.93	33.94	47.91	19.96	18.97	23.96	22.96	21.96	**7.99**	24.95	**12.98**	**11.98**	23.21	19.94

Id	H212	COTC	AHW4	OFCL	ICON	LGE	SHIP	SPC3	FIM9	UWN8	GFDL	AVNI	EM	MMEN
12	9.98	2	3.99	**0**	2.99	2	**1**	2	8.98	2.99	16.97	**0**	9.48	5.23
24	12.98	6.99	5.99	**0**	-99.9	**0**	1	2.99	17.97	2	23.96	**0**	15.48	11.49
36	20.96	27.95	30.94	**9.98**	-99.9	11.98	10.98	14.97	28.95	13.97	23.96	**8.98**	25.46	23.55
48	40.93	39.93	51.91	24.95	-99.9	23.96	23.96	26.95	42.92	**9.98**	47.91	**18.97**	42.92	42.28
72	**2.99**	32.94	24.95	14.97	-99.9	**5.99**	**5.99**	8.98	23.96	12.98	**5.99**	**2.99**	16.47	18.08
96	6.99	**0**	6.99	4.99	-99.9	23.96	17.97	20.96	3.99	23.96	10.98	14.97	**3.5**	**0.23**

2012 Preliminary Verifications

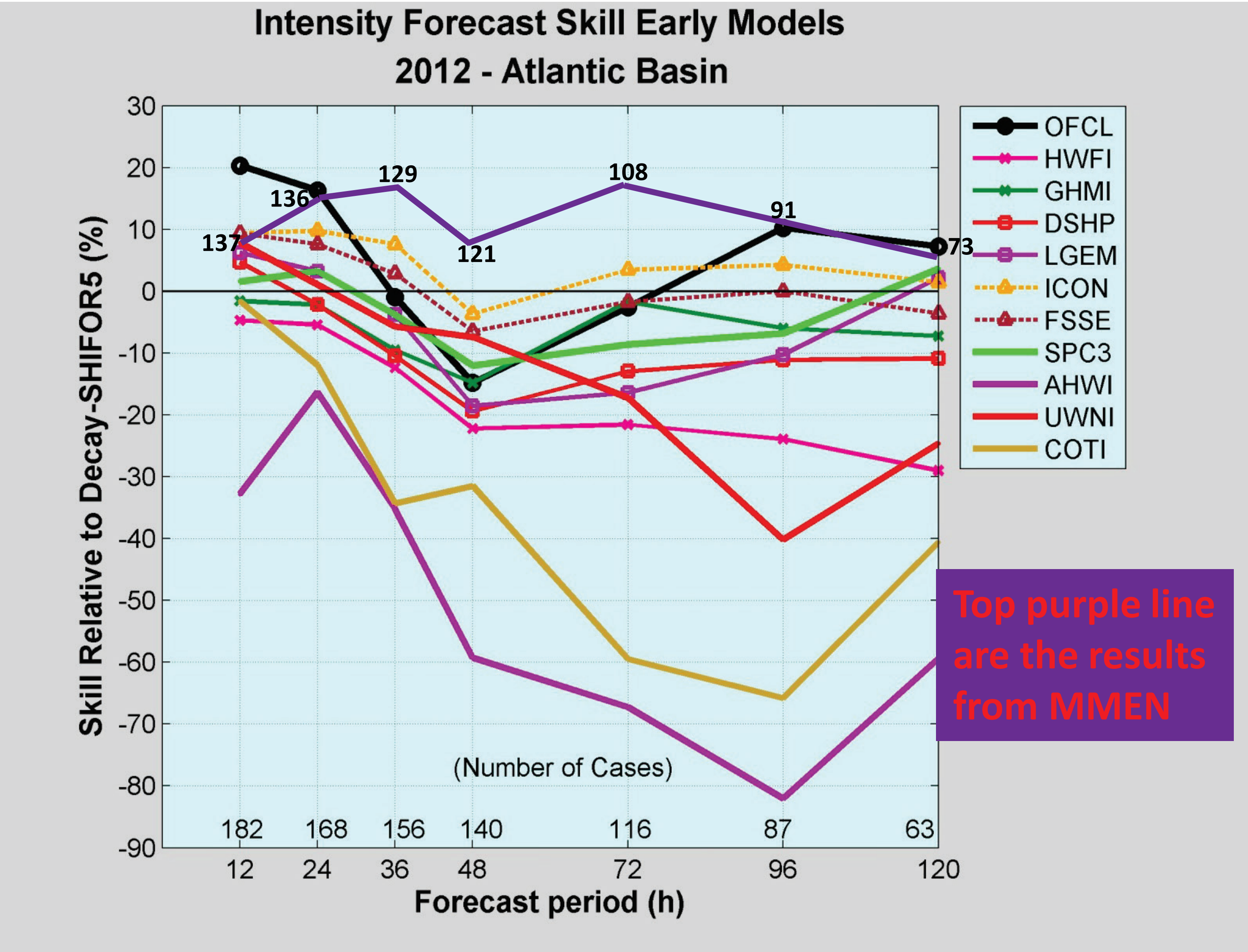


Among the operational dynamical models, GFS was the best performer, with ECMWF close behind.

Second tier comprises the regional models, CMC and UKMET. NOGAPS trails. BAMM beat the more sophisticated members of this group at longer ranges.

FSU Superensemble best consensus model.

2012 Preliminary Verifications



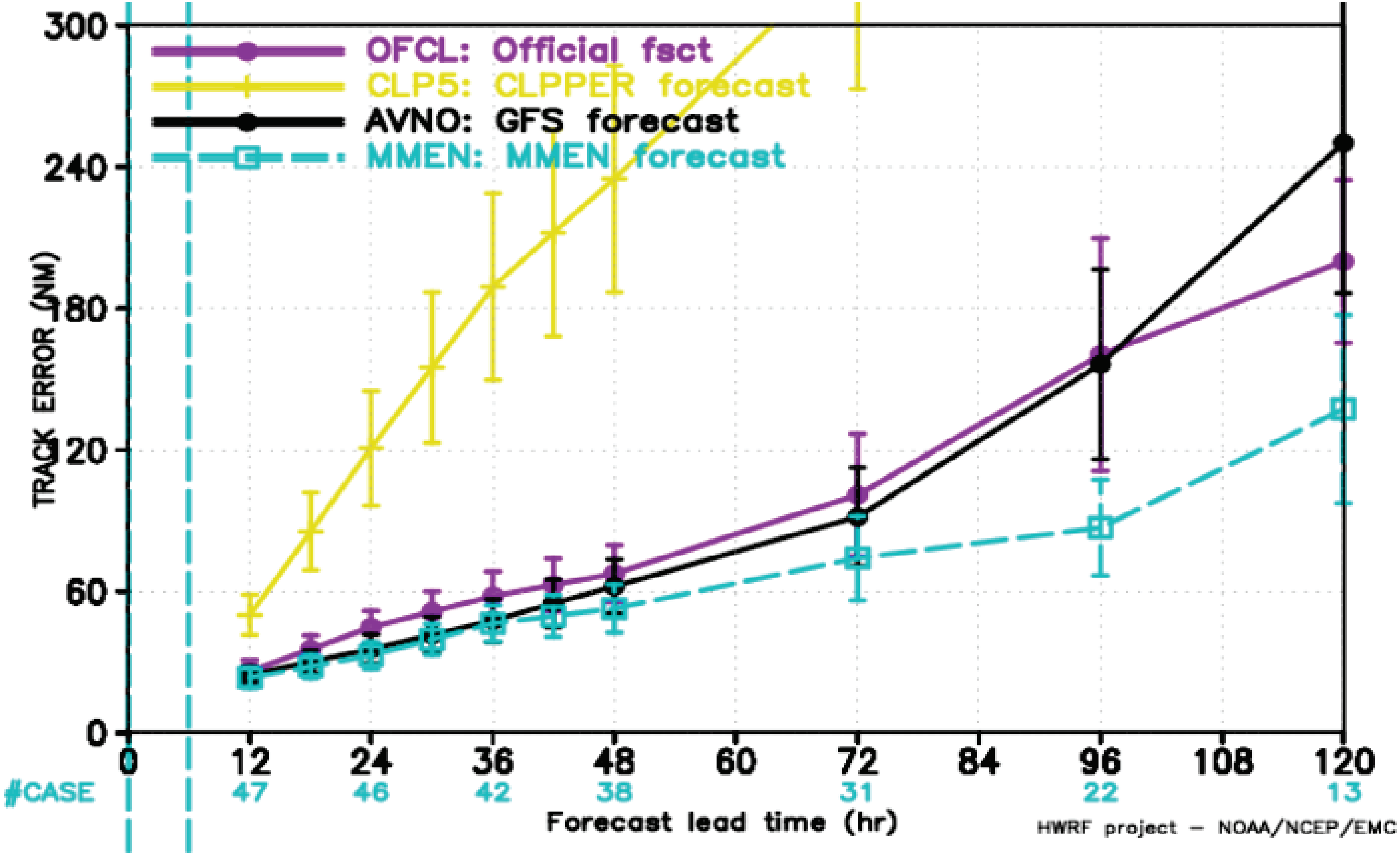
A4PI (radar) omitted due to sample size.

UWNI, COTI were poor performers and much worse than all of the operational models.

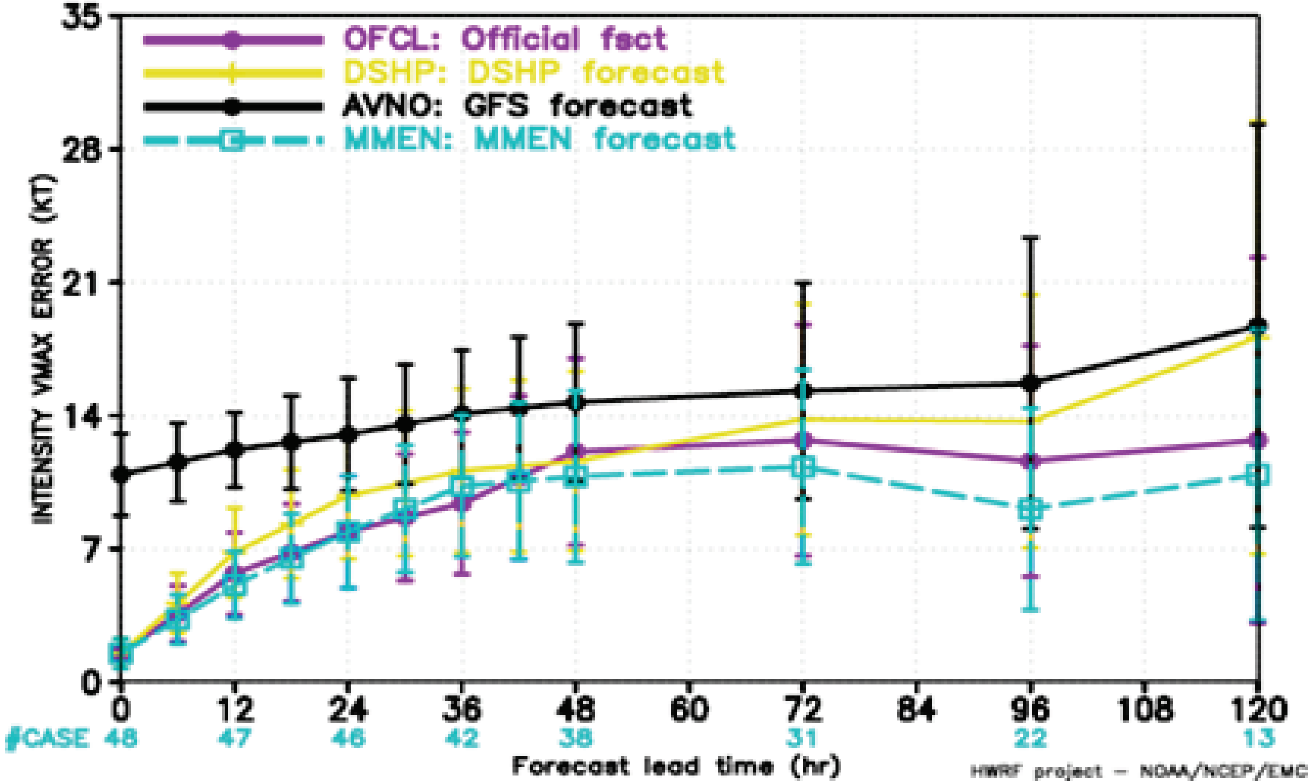
SPC3 beat DSHP and LGEM but still had little skill.

1

Comparison of MMEN to GFS Track



Comparison of MMEN to GFS Intensity



SUMMARY REMARKS

The FSU multimodel superensemble provided some of the best results for the 2012 season. The model carried least errors for track and intensity for most forecast hours.

We used 10 models for hurricane intensity and 11 models for hurricane tracks

The conventional FSU MULTIMODEL SUPERENSEMBLE utilizes a TRAINING PHASE and a FORECAST PHASE. We started with the named storms of the 2011 for the training phase and started including more and more 2012 named storms (after their life cycle was completed). In all we use 231 number of weights for track and intensity. We use fractional positive and negative weights, and differs from the ensemble mean in a major way.

The most important feature for the improvement of forecasts was the new algorithm for the removal of outliers from member model forecasts.

In our suite of models we do use one FSU forecast model a version of WRF/ARW (ARFS).

In 2013 the FSU modified ships (that includes DYNAMICAL PREDICTANDS) will be used as an additional model.

In 2012 we were a stream 2 modeling group, we expect to complete all the required retro runs by April 2013 and hopefully might qualify for the stream 1.5.

The contribution from our new approach for the removal of outliers contributed the most to the improvements of skills for the 2012 season. That far outweighed the advantage gained from having a large sample of member model forecasts. In the two forecasts submissions to TCMT during 2012 season the major improvements of the second submission came from the better handling of the outliers.

Inclusion of ECMWF model in our ensemble suite

It has now become possible to include ECMWF model's hurricane forecast results in our real time multimodel superensemble. During 2012 we had access to the 2011 data sets, those helped the training for the 2012 training phase of the MULTIMODEL SUPERENSEMBLE, but we could not update those weights during the course of the 2012 season . This year we will be able to use the 2013 results by updating the weights after each storm's forecast is validated.

PROPOSED WORK FOR THE 2014 SEASON WILL INCLUDE :

• We will address issues on resolution, optimal number of ensemble members needed to increase forecast accuracy and the research methods on post processing techniques needed for such improvements.

• Continue forecasts using the multimodel superensemble using a suite of mesoscale plus large scale models for hurricane intensity forecasts

• We shall critically analyze the training phase weights and their distribution in time to find ways to better relate relative model performances to these weights

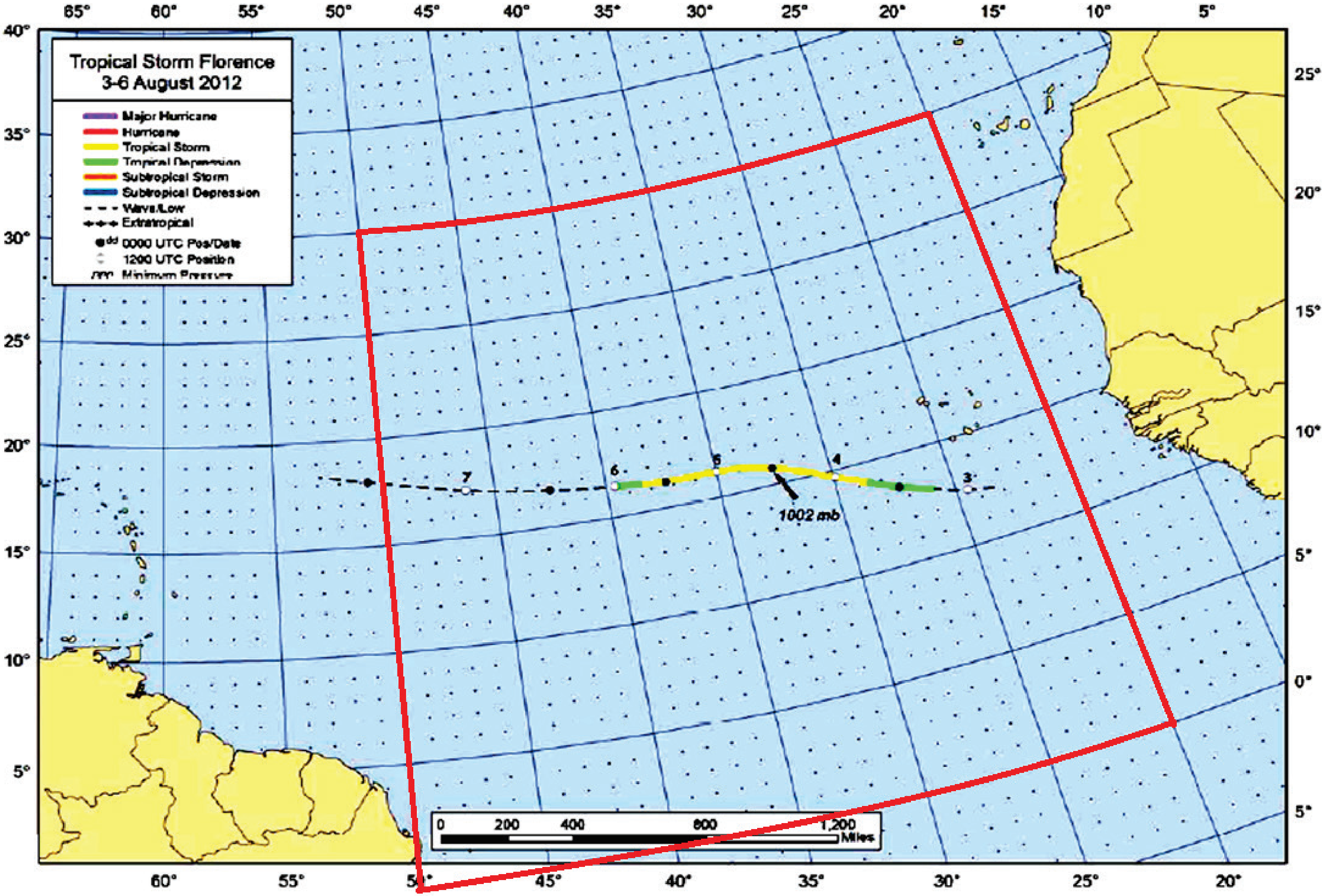
• We continually improve our results by improving the methodology for the construction of the superensemble especially during the training phase. Combination of various high performance models (as was previously done with GUNA) to generate new member models for the superensemble is an avenue we propose to explore. In the same light the exclusion of poorly performing models (during the training phase) will also be systematically explored for the construction of the multimodel superensemble

•From scatter plots of systematic and random error growth during forecasts hours (12 to 120) we shall explore the mature growth in track and intensity forecasts of the member models and relate those to the performance weights

HURRICANE FLORENCE

- **Tropical Storm Florence of 2012 developed from a tropical wave that departed the West African coast early on 2 August**
- **The disturbance became a tropical depression around 1800 UTC 3 August**
- **The system became a tropical storm near 0600 UTC 4 August and reached peak intensity of 50 knots at 0000 UTC 5 August with a central dense overcast and curved banding features.**
- **Florence weakened to a depression by 0600 UTC 6 August, about 30 hours after its peak intensity, as deep convection diminished. The system became a remnant low 6 hours later at 1200 UTC 6 August**
- **Weakening was evidently associated with the influx of Saharan air into the storm's circulation**

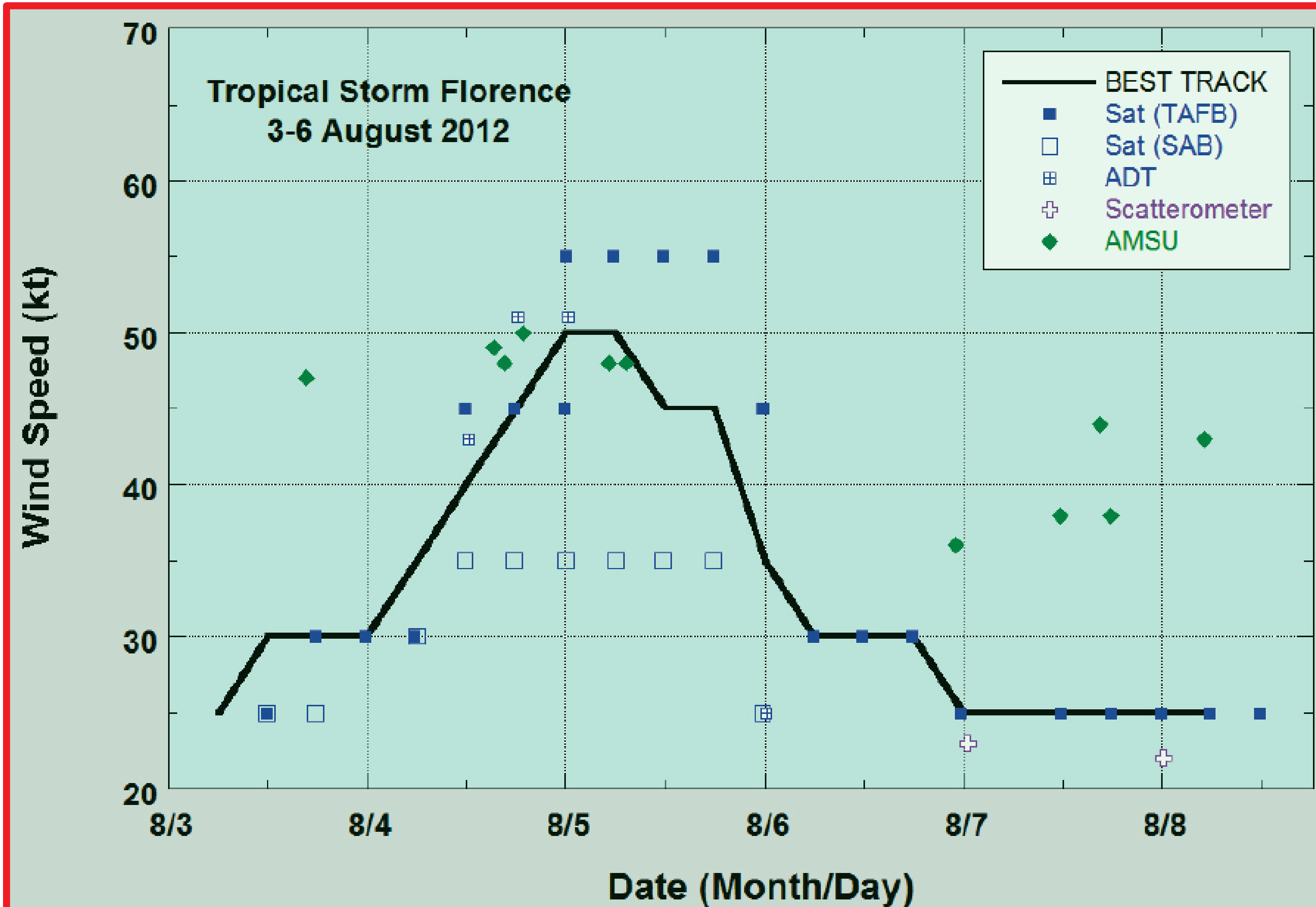
Track for Florence and the domains used in the WRF control and the WRF-CHEM runs



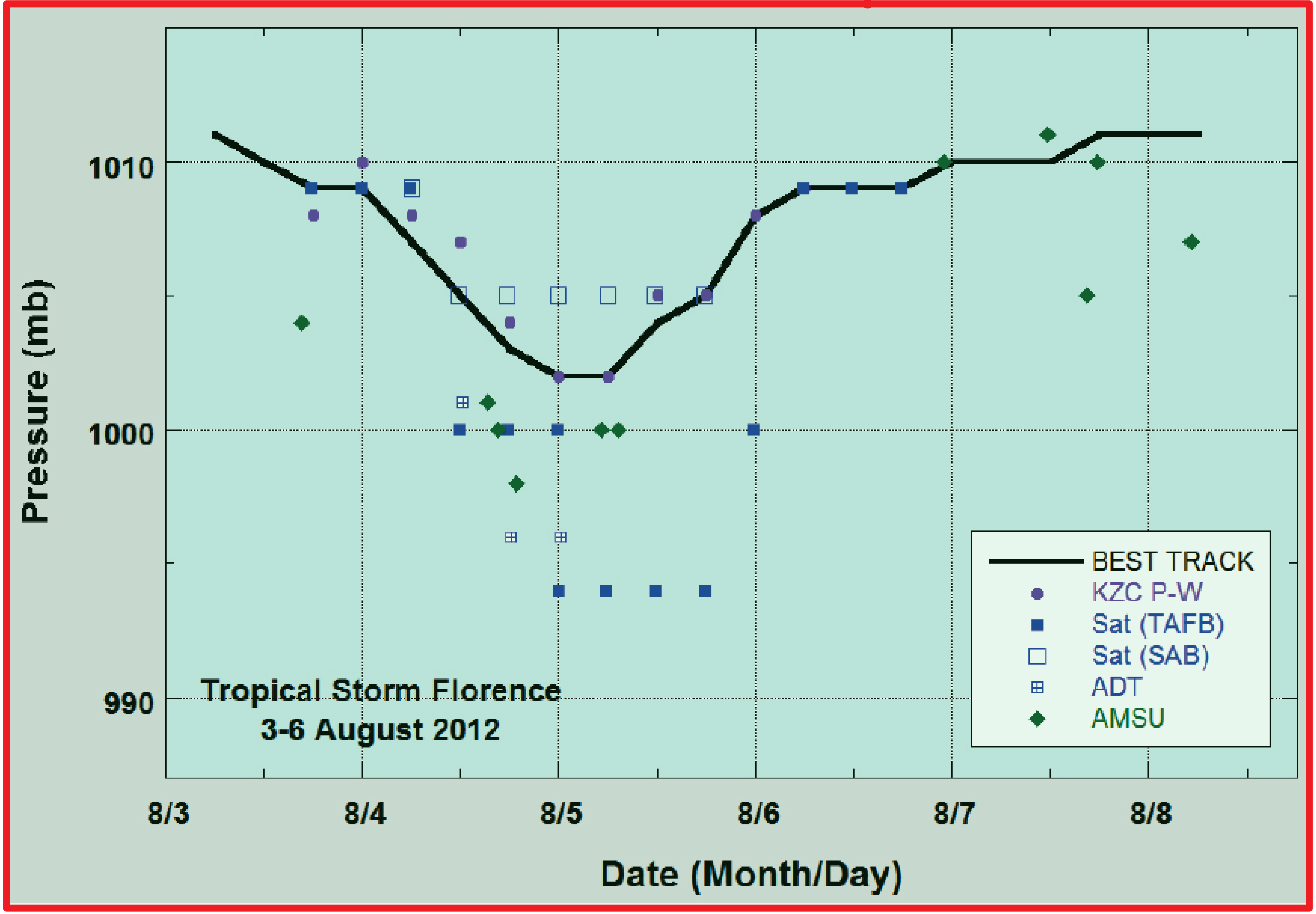
BEST TRACK OF TROPICAL STORM FLORENCE

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
03 / 0600	12.2	23.1	1011	25	low
03 / 1200	12.5	24.5	1010	30	"
03 / 1800	13.0	25.9	1009	30	tropical depression
04 / 0000	13.5	27.3	1009	30	"
04 / 0600	14.1	28.6	1007	35	tropical storm
04 / 1200	14.7	29.9	1005	40	"
04 / 1800	15.3	31.2	1003	45	"
05 / 0000	15.8	32.5	1002	50	"
05 / 0600	16.1	33.8	1002	50	"
05 / 1200	16.2	35.0	1004	45	"
05 / 1800	16.2	36.2	1005	45	"
06 / 0000	16.2	37.3	1008	35	"
06 / 0600	16.3	38.4	1009	30	tropical depression
06 / 1200	16.4	39.6	1009	30	low
06 / 1800	16.5	40.9	1009	30	"
07 / 0000	16.7	42.5	1010	25	"
07 / 0600	16.9	44.3	1010	25	"
07 / 1200	17.2	46.3	1010	25	"
07 / 1800	17.6	48.5	1011	25	"
08 / 0000	18.0	50.7	1011	25	"
08 / 0600	18.4	52.9	1011	25	"
08 / 1200					dissipated
05 / 0000	15.8	32.5	1002	50	maximum wind and minimum pressure

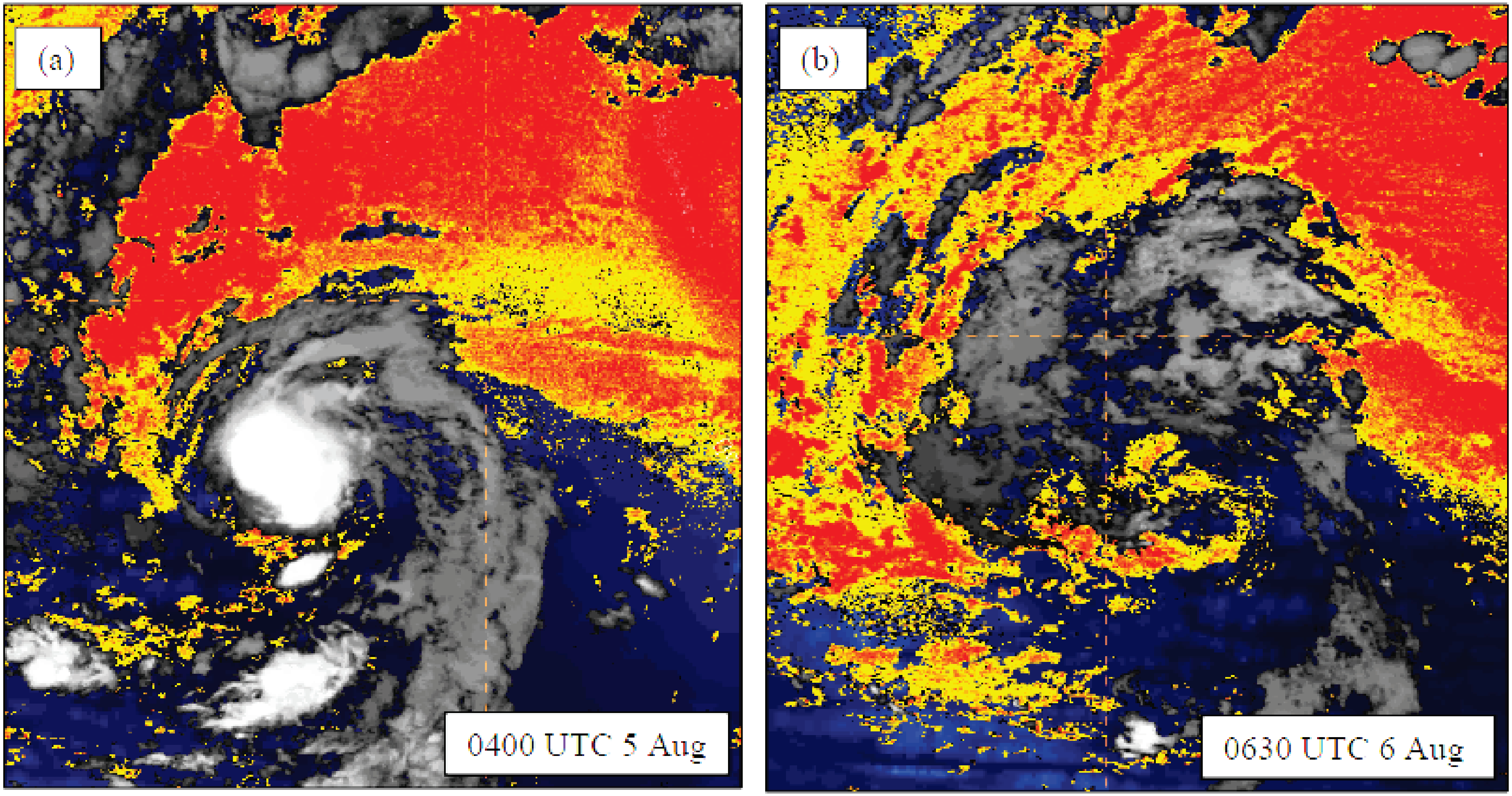
Selected wind observations and best track maximum sustained surface wind speed curve



Selected pressure observations and best track minimum central pressure curve



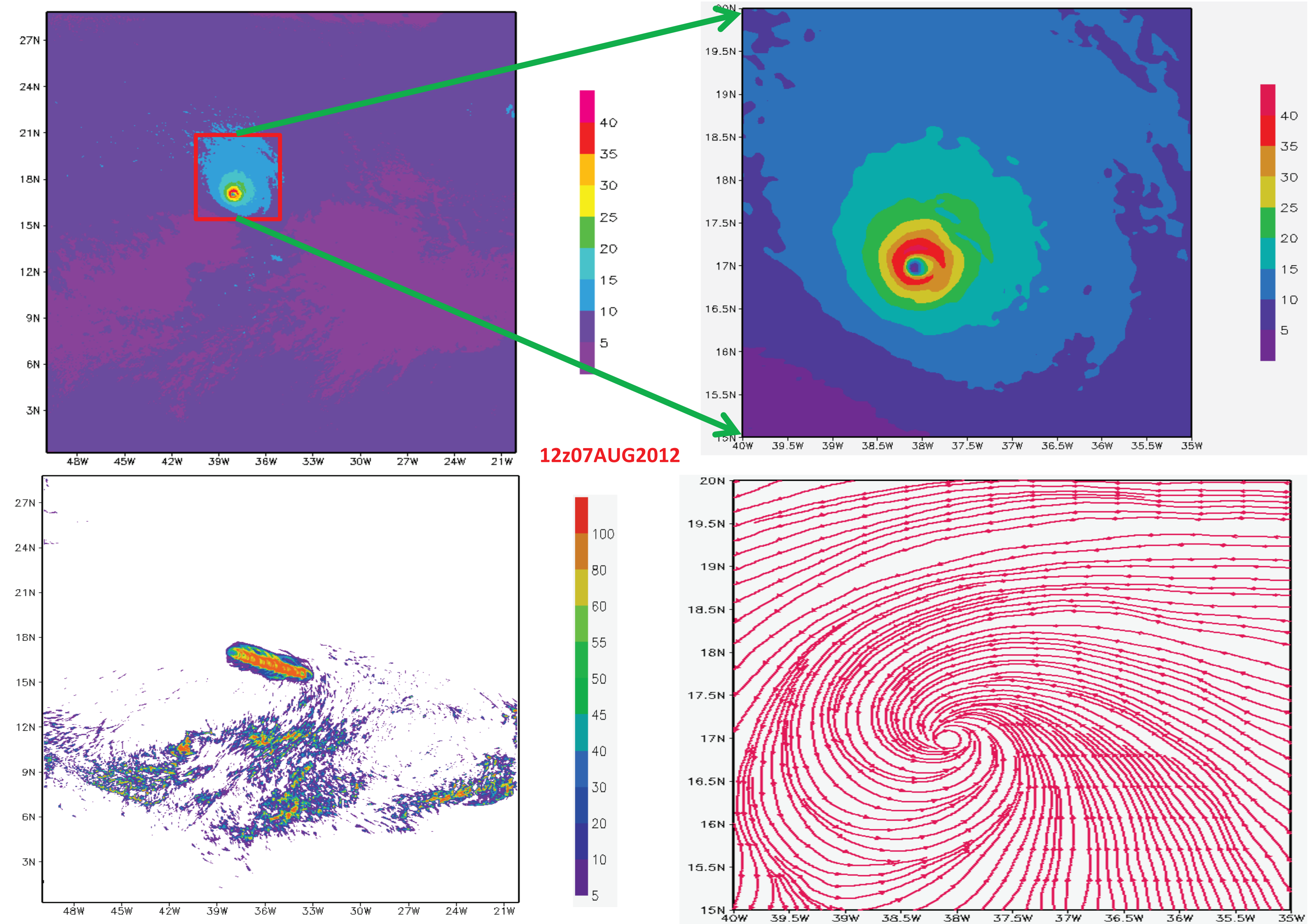
GOES-R proving ground Saharan Air Layer product from Meteosat-9 of Florence



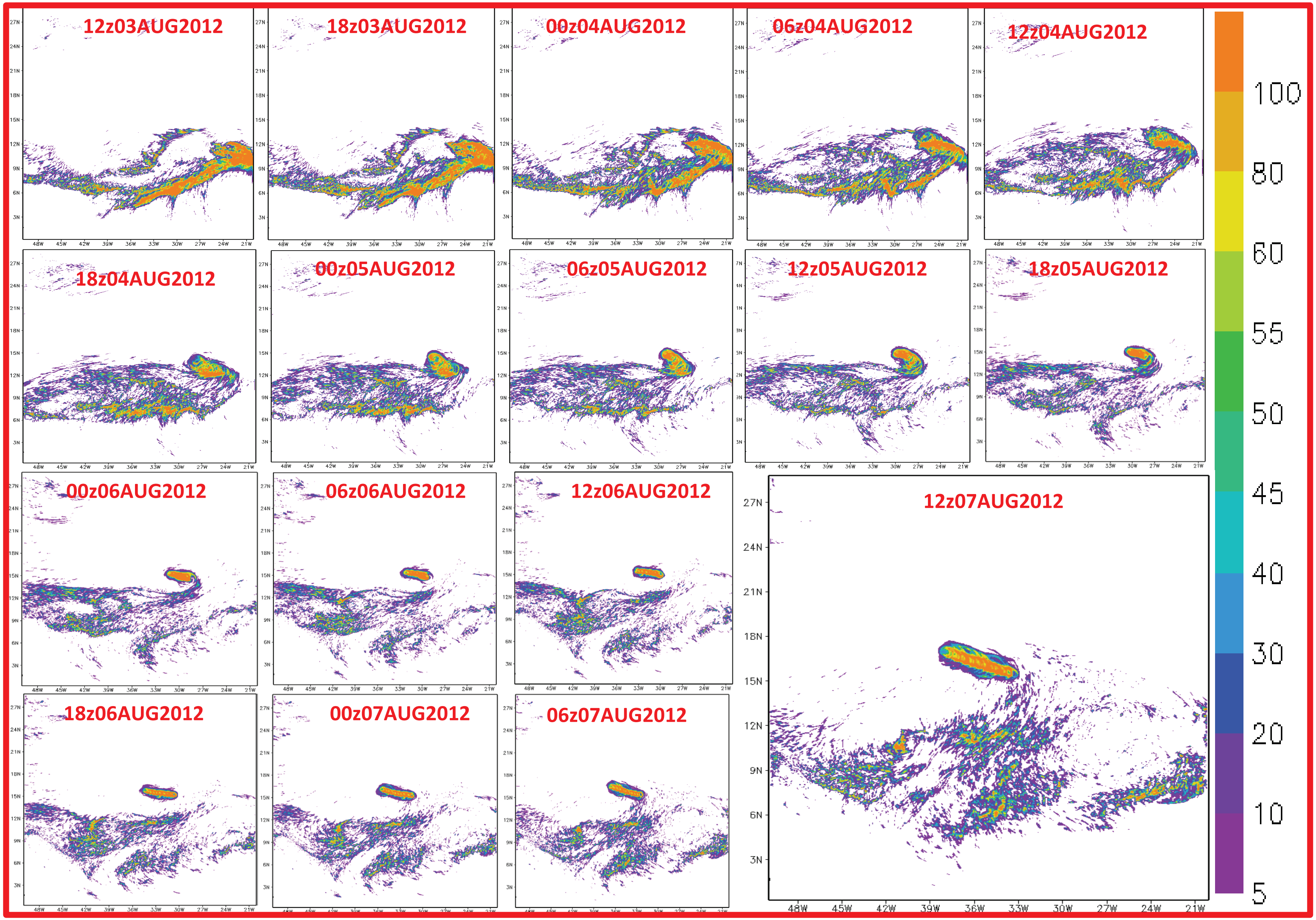
(a) near peak intensity

(b)around the time it degenerated to a remnant low

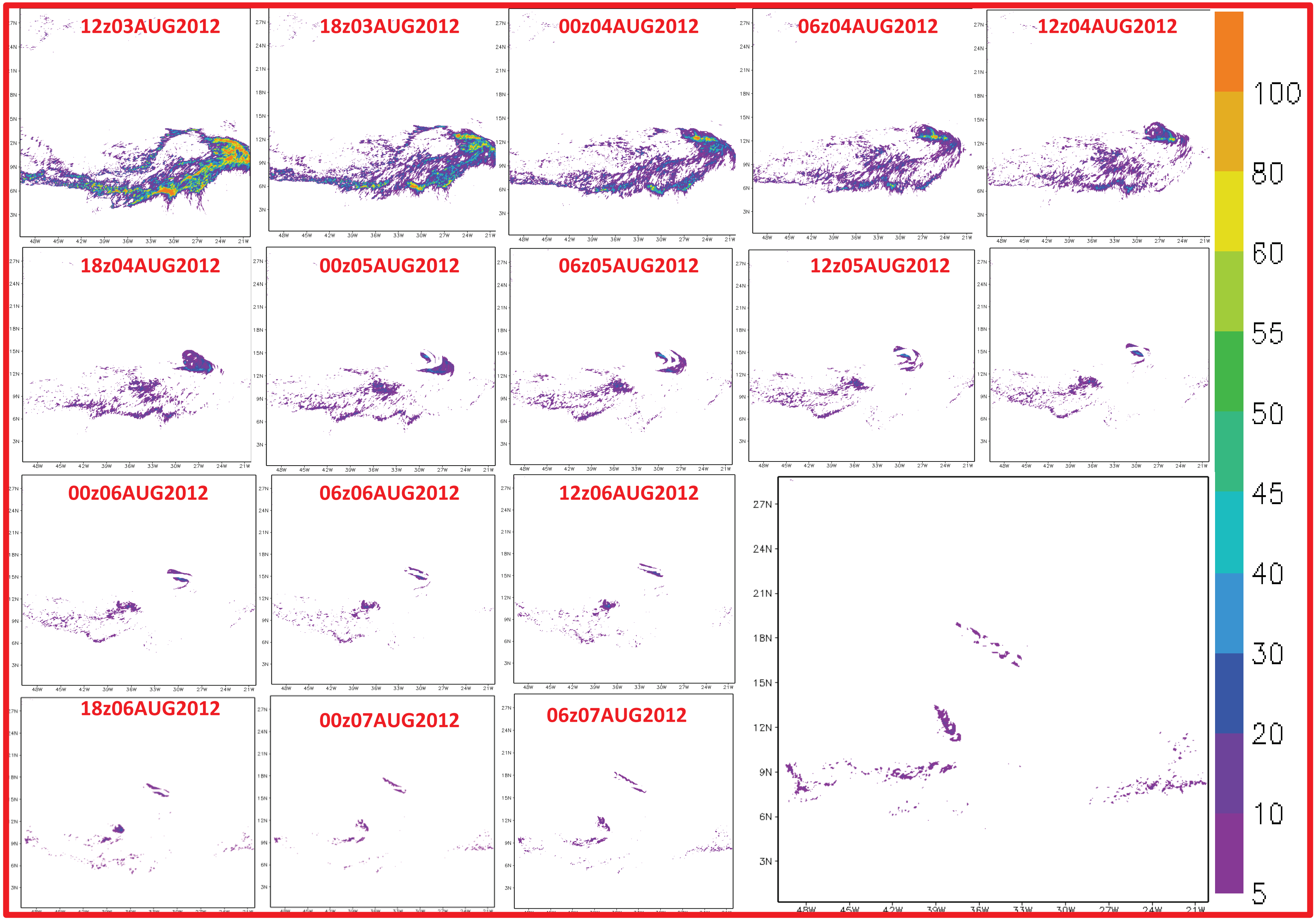
LOW AEROSOL EXPERIMENT SHOWING day-6 forecast of 10m winds, precipitation , and streamlines.



A 6-hourly sequence of precipitation for the low aerosol experiment

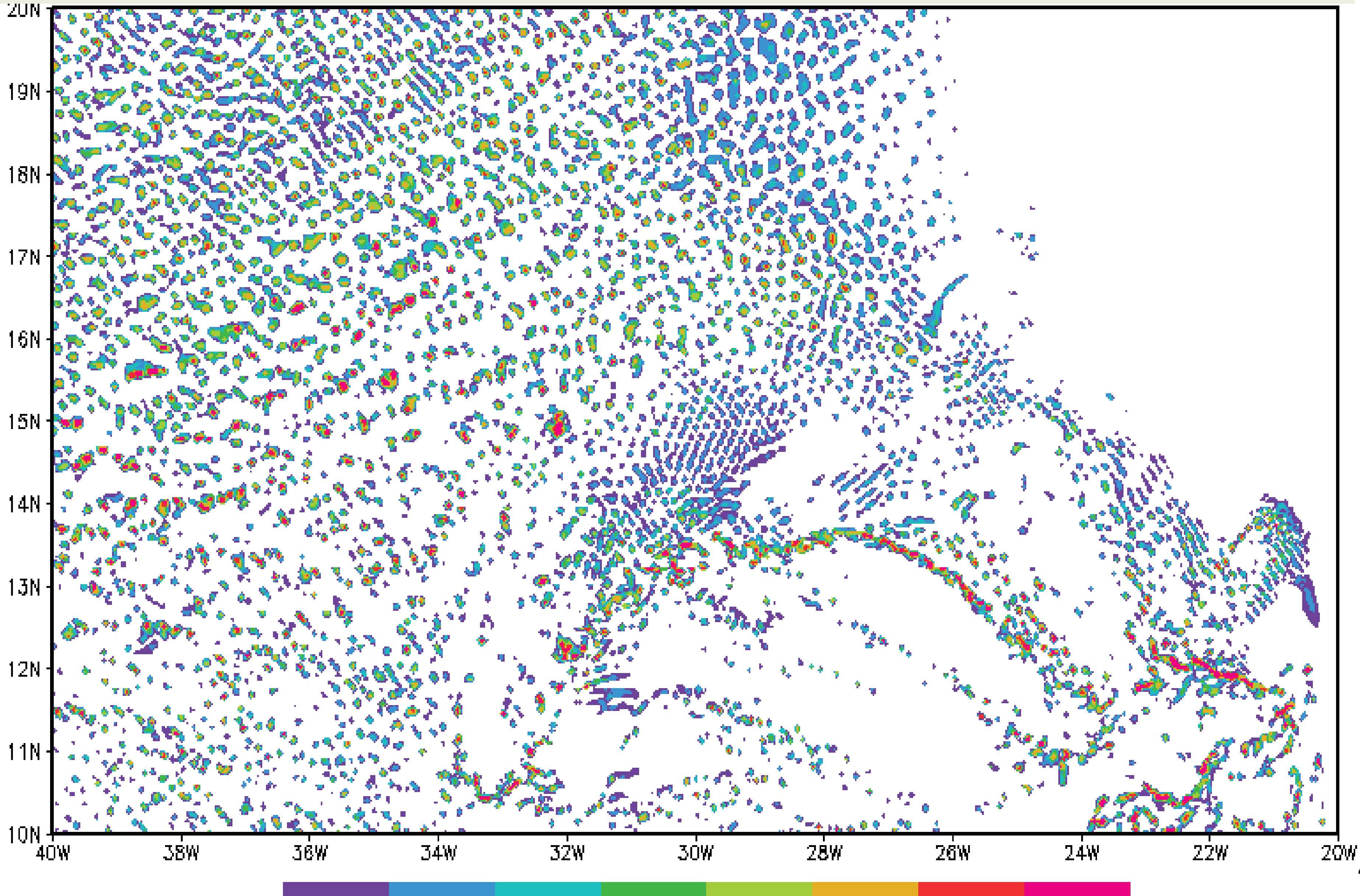


A 6-hourly sequence of precipitation for the high aerosol experiment

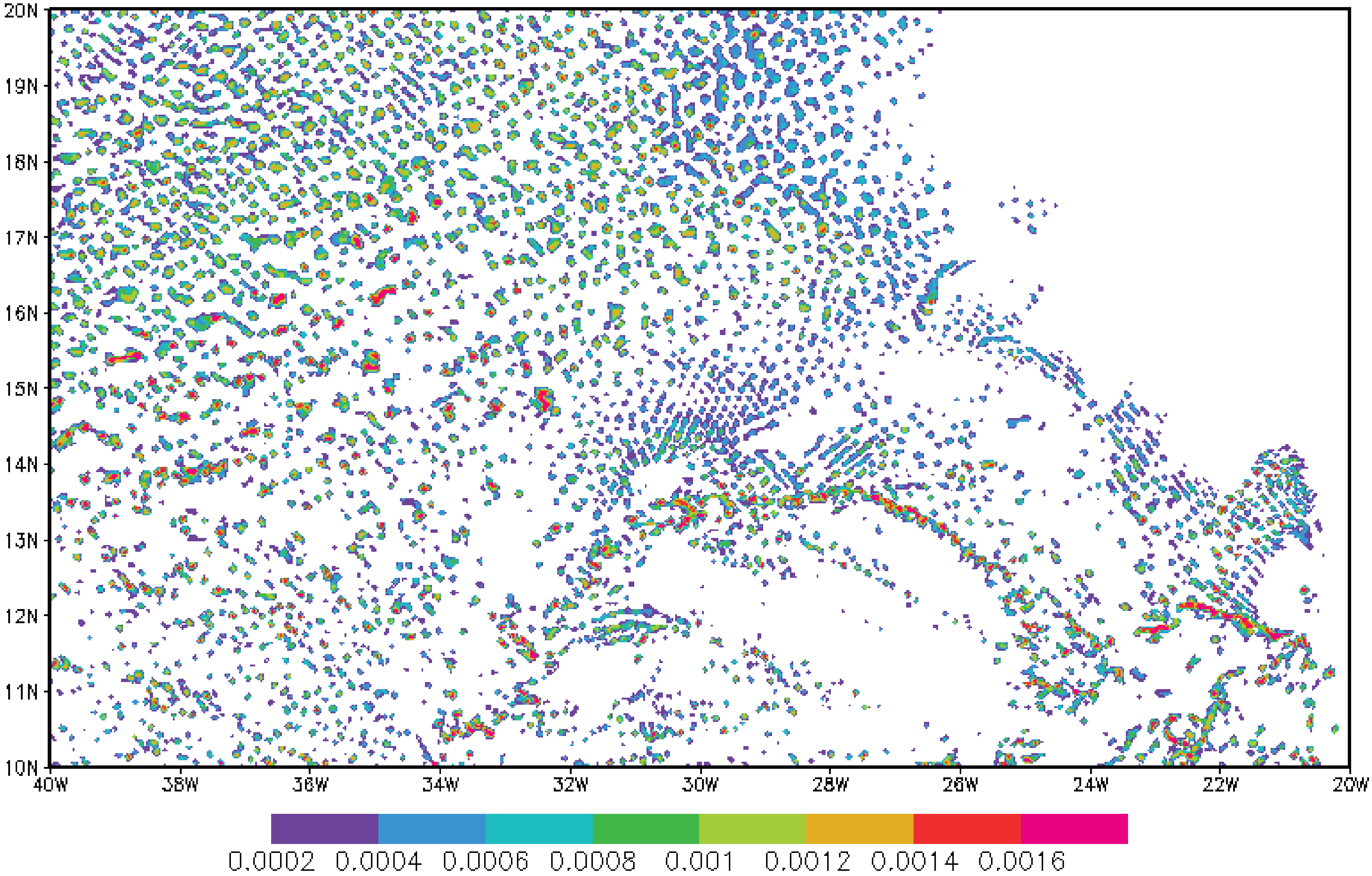


Hourly frames of vertically integrated Liquid water mixing ratio (650-750hPa) for the low aerosol experiment starting on 12 UTC 02 August, 2012, Florence.

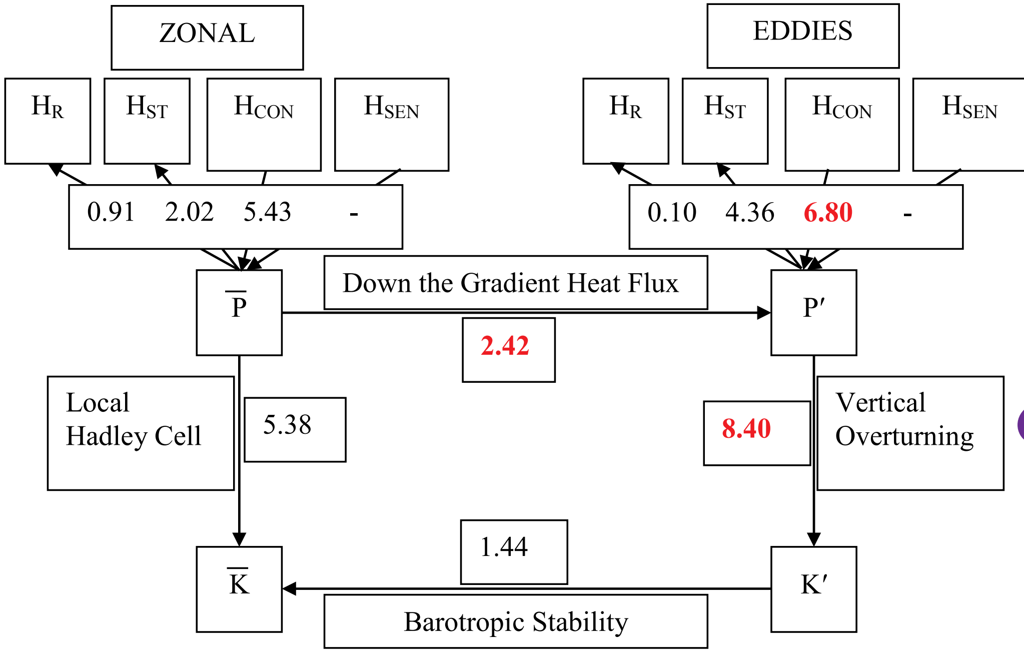
A 6 day forecast.



Hourly frames of vertically integrated Liquid water mixing ratio (650-750hPa) for the high aerosol experiment staring on 12 UTC 02 August, 2012, Florence. A 6 day forecast.



A case of Hurricane FLORENCE



Control Run on 5th Day

Heavy Aerosols Run on 5th Day