NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE ISAAC

(AL092018)

7–15 September 2018

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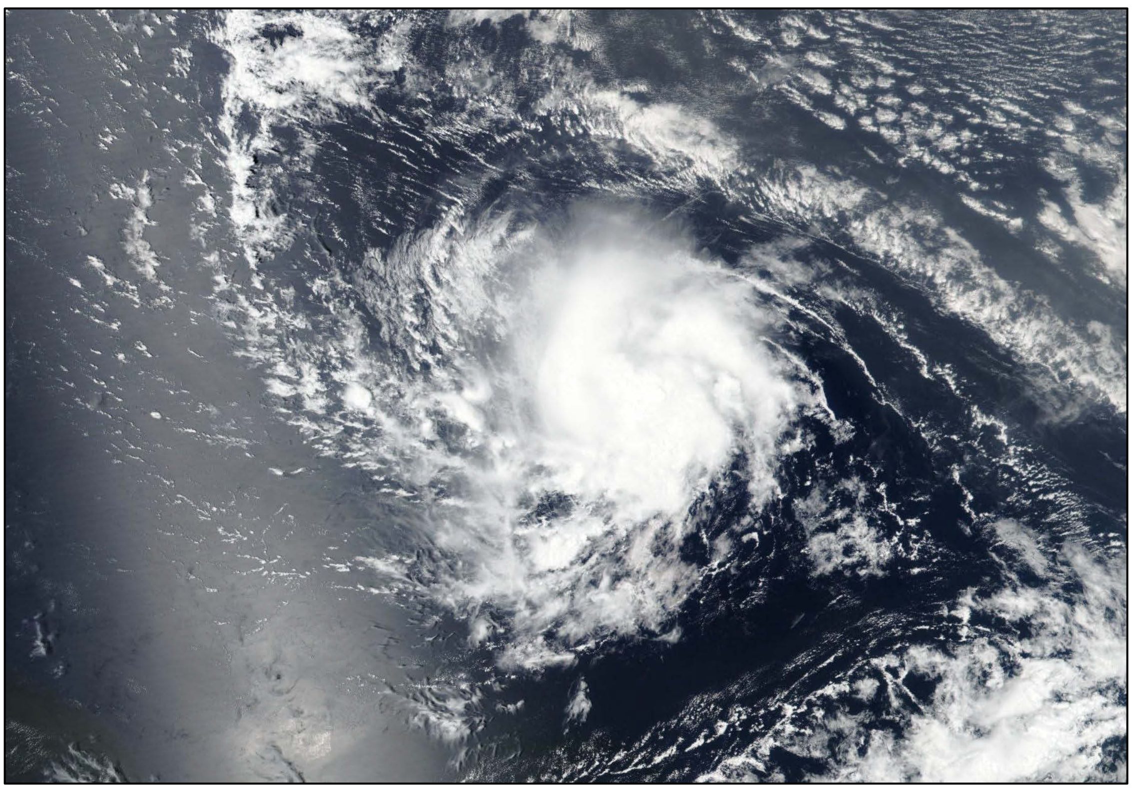

SUOMI-NPP/VIIRS 1625 UTC 10 SEPTEMBER 2018 TRUE COLOR IMAGE OF ISAAC WHILE IT WAS A HURRICANE. IMAGE COURTESY OF NASA WORLDVIEW.

Isaac was a category 1 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that formed over the east-central tropical Atlantic and moved westward. The cyclone weakened and passed through the Lesser Antilles as a tropical storm, causing locally heavy rain and flooding.

Hurricane Isaac

7–15 SEPTEMBER 2018

SYNOPTIC HISTORY

Isaac developed from a tropical wave that moved off the west coast of Africa on 2 September. A broad area of low pressure was already present when the convectively active wave moved over the eastern Atlantic, and the low gradually consolidated over the next several days while the wave moved steadily westward. A concentrated burst of deep convection initiated late on 6 September and led to the formation of a well-defined center, marking the development of a tropical depression by 1200 UTC 7 September a little more than 600 n mi west of the Cabo Verde Islands. Weak steering flow caused the depression to move very little while moderate easterly wind shear prevented it from strengthening for the first 24 h following formation. The shear decreased the next morning, and the cyclone reached tropical-storm strength by 1200 UTC 8 September. The "best track" chart of Isaac's path is given in Fig. 1, with the wind and pressure histories shown in Figs. 2 and 3, respectively. The best track positions and intensities are listed in Table 1[1].

A subtropical ridge to the north of Isaac became better established on 8 September, and the tropical cyclone began to move westward at 10 to 15 kt. At the same time, Isaac was located over warm sea surface temperatures exceeding 27°C and was embedded within a moist, low-shear environment. Strengthening ensued, and Isaac became a hurricane by 0000 UTC 10 September when it was located about 1100 n mi east of the Windward Islands. A tongue of dry air that was previously isolated to the north began to wrap around Isaac's small circulation as it reached hurricane strength. The dry air likely suppressed convection within the developing eyewall and outer rain bands of the hurricane, ending Isaac's strengthening (Fig. 4). Beginning on 11 September, the cyclone gradually weakened as an upper-level trough to the north caused an increase in westerly wind shear. This trough was amplified by outflow from two larger and stronger hurricanes, Florence over the northwest Atlantic and Helene over the northeast Atlantic. The shear persisted for several more days, and it caused the surface center of Isaac to be exposed on 12 and 13 September.

Faster low-level trade wind flow caused Isaac to accelerate westward while it weakened and became vertically shallow. Although the cyclone was weakening, its faster motion likely contributed to an expansion of its tropical-storm-force wind field to the north of the center as Isaac approached the Lesser Antilles. The center of the tropical storm crossed the Windward Islands between Martinique and Dominica just after 1200 UTC 13 September (Fig. 5a). At the time of its passage through the islands, Issac's remaining tropical-storm-force winds were located about

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[1] A digital record of the complete best track, including wind radii, can be found on line at ftp://ftp.nhc.noaa.gov/atcf. Data for the current year's storms are located in the *btk* directory, while previous years' data are located in the *archive* directory.

100 n mi to the north and east of its surface center, and the associated rainfall occurred in the Lesser Antilles after the cyclone's center had already moved into the eastern Caribbean Sea.

Around the time that Isaac reached the eastern Caribbean Sea, interaction with the high terrain of Martinique and a lack of deep convection nearly caused the cyclone to dissipate, but convection redeveloped near the center of Isaac early on 14 September. This allowed Isaac to maintain a small well-defined center that was embedded within a southwest-to-northeast oriented surface trough (Fig. 5b). The convective resurgence was short-lived, however, and Isaac weakened to a tropical depression by 0000 UTC 15 September. The system opened up into a tropical wave 6 h later while it was located about 200 n mi south-southwest of the southwestern coast of Puerto Rico.

METEOROLOGICAL STATISTICS

Observations in Isaac (Figs. 2 and 3) include subjective satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), and objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) estimates from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Observations also include flight-level, stepped frequency microwave radiometer (SFMR), Tail Doppler Radar (TDR), and dropwindsonde observations from five flights of a NOAA P-3 Hurricane Hunter aircraft. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Global Precipitation Mission (GPM), the European Space Agency's Advanced Scatterometer (ASCAT), and Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Isaac.

Isaac's estimated maximum intensity of 65 kt was based on consensus Dvorak Final-T and Current Intensity estimates of 4.0/4.0 from TAFB and SAB. The estimated minimum pressure of 995 mb was based on the Knaff-Zehr-Courtney pressure-wind relationship.

The cruise ship *Carnival Fascination* (C6FM9) reported sustained winds of 37 kt at 0300 UTC 14 September. This observation was taken at a height of 42 m (138 ft), and is more representative of 10-m winds of 30 to 35 kt. There were no land-based observations of sustained tropical-storm-force winds associated with Isaac. Pointe-á-Pitre International Airport (TFFR) on Guadeloupe reported a gust of 36 kt at 1500 UTC 13 September.

An automated station on Guadeloupe measured 0.46 inches of rain from 1200 UTC 13 September to 1200 UTC 14 September. Heavier rains likely occurred on islands to the south, however, no rainfall observations were available at those locations.

CASUALTY AND DAMAGE STATISTICS

There were no reports of deaths associated with Isaac. Locally heavy rain and high surf caused some impacts in the Lesser Antilles, particularly on the island of St. Lucia where local media reported flooding in parts of Anse La Raye and Castries and trees down in the Barre de L´isle area. Minor landslides and flooding were also noted in media reports from the island of Dominica.

FORECAST AND WARNING CRITIQUE

The genesis of Isaac was well forecast. Table 2 provides the number of hours in advance of formation associated with the first NHC Tropical Weather Outlook (TWO) forecast in each likelihood category. The wave from which Isaac developed was first included in the TWO 108 h prior to formation, just as it moved off the west coast of Africa, and was given a low probability (<40%) of becoming a tropical cyclone with 5 days (120 h). The 120-h probability was increased to the medium (40–60%) and high (>60%) categories 90 h and 72 h prior to the formation of a tropical depression, respectively. The wave was first given a low chance of becoming a tropical cyclone in the 48-h (2-day) forecast 90 h before genesis occurred. The probability of development in the 2-day forecast was increased to the medium category 60 h before formation, and was increased to the high category 42 h prior to the formation of Isaac.

A verification of NHC official track forecasts for Isaac is given in Table 3a. Official forecast track errors were very low, besting the mean official errors for the previous 5-yr period at all forecast times. The official track forecast errors for Isaac were at least 50% lower than the previous 5-yr mean from 48 h onward, and were nearly one third of the previous 5-yr mean at 120 h. In fact, the average NHC track forecast errors were lower for Isaac than for any Atlantic tropical cyclone since 1970 with a minimum of 10 verifying forecasts from 48–120 h. It is also noteworthy that OCD5 track errors were not substantially lower than the previous 5-yr mean of that model, and in fact were nearly double the 5-yr mean at 120 h, suggesting that Isaac's track was not necessarily easier-than-normal to forecast. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The GFSI had lower error than the NHC official track forecast at 12 h, but no other individual model performed better than the NHC forecast at any forecast hour. Several of the models, most notably the UKMET (EGRI), had very large errors for Isaac. The track consensus aids had smaller errors, but none were better than the official forecast from 24 h through 72 h. Only the HFIP Corrected Consensus (HCCA) consistently had errors close to or lower than the NHC forecast.

A verification of NHC official intensity forecasts for Isaac is given in Table 4a. Official forecast intensity errors were generally higher than the mean official errors for the previous 5-yr period, significantly so at 72–120 h. The NHC intensity forecasts suffered from a pronounced high bias (Figs. 6, 7a) and generally missed the sudden halt to Isaac's intensification that occurred on 10 September, as well as its subsequent gradual weakening. Although the intensity forecast errors were high, Isaac's evolution was not entirely unexpected. Soon after formation, NHC's public advisory products repeatedly stressed that the intensity forecast was more uncertain than usual and that Isaac could be weaker (or stronger) than explicitly shown in the forecast when it approached the Lesser Antilles. The small size of Isaac and low confidence regarding the future strength of the shear were the primary factors contributing to the difficulty of the intensity forecast.

A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. All of the regional and statistical intensity guidance exhibited the same high bias as the NHC forecast (Fig. 7a), however, nearly all of those models caught on to the weakening of Isaac faster than the NHC forecast and consequently had lower errors at 24–72 h. The GFS and ECMWF models never forecasted that Isaac would strengthen significantly and had very low errors at all verifying times. The HWRF model had an extreme high bias for Isaac and repeatedly forecasted the cyclone to become a major hurricane. Remarkably, the mean intensity errors of the HWRF at 96 h and 120 h were higher during Isaac than for any other Atlantic tropical cyclone since that model became operational in 2007 (with a minimum of 5 verifying forecasts). At least part of the high error can be attributed to the HWRF not properly forecasting the amplification of an upper-level trough between Hurricane Florence and Hurricane Helene that contributed to the high shear across Isaac. An experimental version of the HWRF run by NOAA's Hurricane Research Division with high resolution applied to the other two hurricanes corrected for some of high bias (Fig. 7b), however that version of the model still had an extreme high bias at 96 h and 120 h, indicating that other sources of error also contributed to the poor forecasts.

Coastal watches and warnings associated with Isaac are given in Table 5.

ACKNOWLEDGMENTS

TDR data and experimental HWRF output was provided by the Hurricane Research Division of NOAA. Christopher Mello and Stephanie Stevenson of the NHC Technology and Science Branch assisted with the processing and display of TDR data used for this report.

Table 1. Best track for Hurricane Isaac, 7–15 September 2018.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
07 / 1200	13.5	35.0	1007	30	tropical depression
07 / 1800	13.7	34.9	1007	30	"
08 / 0000	13.9	34.9	1007	30	"
08 / 0600	14.2	35.2	1007	30	"
08 / 1200	14.4	35.8	1006	35	tropical storm
08 / 1800	14.5	36.3	1005	40	"
09 / 0000	14.4	37.0	1002	45	"
09 / 0600	14.3	37.7	1001	50	"
09 / 1200	14.3	38.7	999	55	"
09 / 1800	14.4	39.8	997	60	"
10 / 0000	14.5	41.0	995	65	hurricane
10 / 0600	14.5	42.2	995	65	"
10 / 1200	14.4	43.5	995	65	"
10 / 1800	14.4	44.8	995	65	"
11 / 0000	14.5	46.2	997	60	tropical storm
11 / 0600	14.6	47.6	997	60	"
11 / 1200	14.6	49.1	997	60	"
11 / 1800	14.6	50.5	997	60	"
12 / 0000	14.5	51.7	998	55	"
12 / 0600	14.6	52.9	999	55	"
12 / 1200	14.9	54.2	1001	55	"
12 / 1800	15.2	55.7	1003	50	"
13 / 0000	15.3	57.2	1004	45	"
13 / 0600	15.1	58.9	1004	40	"
13 / 1200	14.9	60.7	1004	40	"
13 / 1800	14.9	62.3	1004	35	"
14 / 0000	14.9	63.6	1004	35	"
14 / 0600	15.0	64.8	1004	35	"
14 / 1200	15.2	66.2	1004	35	"
14 / 1800	15.3	67.6	1004	35	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
15 / 0000	15.4	69.0	1006	30	tropical depression
15 / 0600					dissipated
10 / 0000	14.5	41.0	995	65	maximum winds and minimum pressure

Table 2. Number of hours in advance of formation of Hurricane Isaac associated with the first NHC Tropical Weather Outlook forecast in the indicated likelihood category. Note that the timings for the "Low" category do not include forecasts of a 0% chance of genesis.

	Hours Before Genesis	
	48-Hour Outlook	**120-Hour Outlook**
Low (<40%)	90	108
Medium (40%-60%)	60	90
High (>60%)	42	72

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Isaac, 7–15 September 2018. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**23.1**	**30.0**	**28.3**	**29.2**	**49.8**	**57.2**	**62.2**
OCD5	35.4	67.1	111.3	167.8	328.3	536.1	774.4
Forecasts	28	26	24	22	18	14	10
OFCL (2013-17)	24.1	37.4	50.5	66.6	98.4	137.4	180.7
OCD5 (2013-17)	44.7	95.8	153.2	211.2	318.7	416.2	490.6

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Isaac, 7–15 September 2018. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 3a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	20.5	26.0	28.7	31.3	55.3	58.8	62.1
OCD5	33.4	61.3	104.0	162.3	327.0	537.1	805.4
GFSI	**19.4**	33.3	43.4	52.9	88.4	96.4	116.0
EGRI	31.6	60.1	103.9	159.6	294.9	441.5	558.9
EMXI	21.8	31.4	36.3	37.3	65.4	80.3	105.2
CMCI	30.2	48.1	66.7	100.5	156.0	280.9	575.6
NVGI	28.2	35.0	54.5	90.6	176.2	295.7	459.5
HWFI	22.3	29.6	37.6	55.6	110.9	196.6	327.4
HMNI	23.9	33.2	37.2	50.1	62.4	94.7	157.5
CTCI	25.7	37.2	52.4	70.5	103.1	104.9	102.2
AEMI	**18.9**	29.2	43.6	66.7	109.9	127.8	83.6
HCCA	**18.8**	26.5	30.9	32.4	65.7	**56.1**	**52.0**
FSSE	**18.1**	30.3	35.7	47.1	87.7	89.3	**59.6**
TVCA	**19.9**	29.0	39.2	55.0	92.4	132.8	142.6
TVCX	**20.2**	26.9	34.3	45.5	75.3	104.6	116.3
GFEX	**19.2**	29.7	33.3	38.0	65.1	66.4	102.3
TCON	**19.5**	31.8	47.6	73.1	137.3	214.2	265.3
TABS	35.8	78.2	122.4	162.5	194.7	204.0	161.0
TABM	30.1	53.2	71.7	87.8	100.8	118.6	103.6
TABD	38.7	88.1	139.7	205.8	370.3	506.4	553.8
Forecasts	15	15	13	12	11	8	5

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Isaac, 7–15 September 2018. Mean errors for the previous 5-yr period are shown for comparison. Official errors that are smaller than the 5-yr means are shown in boldface type.

	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	**4.1**	8.8	12.7	15.0	21.4	26.1	31.0
OCD5	4.7	9.9	16.2	21.3	27.6	26.1	27.3
Forecasts	28	26	24	22	18	14	10
OFCL (2013-17)	5.5	8.0	10.1	11.4	12.7	14.5	15.0
OCD5 (2013-17)	7.1	11.1	14.4	17.4	20.6	22.3	23.7

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Isaac, 7–15 September 2018. Errors smaller than the NHC official forecast are shown in boldface type. The number of official forecasts shown here will generally be smaller than that shown in Table 4a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	4.3	9.0	13.8	18.3	24.5	28.1	29.0
OCD5	4.3	9.2	15.5	20.8	30.5	33.4	37.6
GFSI	4.5	**7.8**	**10.0**	**10.0**	**8.1**	**4.4**	**5.0**
EMXI	4.9	**7.7**	**9.8**	**10.2**	**8.7**	**5.9**	**1.0**
HWFI	4.9	**5.1**	**6.2**	**14.7**	32.5	70.2	79.4
HMNI	4.6	**7.9**	**8.5**	**7.9**	**6.9**	**5.1**	**3.6**
CTCI	4.4	**4.3**	**4.7**	**8.2**	**15.7**	**19.9**	**9.0**
HCCA	**3.8**	**4.2**	**7.1**	**13.0**	**23.8**	35.4	**28.4**
FSSE	**4.1**	**5.7**	**10.9**	**16.1**	24.5	32.5	35.6
ICON	**3.9**	**4.6**	**7.5**	**12.1**	**20.4**	33.6	36.4
IVCN	**3.8**	**4.3**	**6.7**	**10.9**	**19.2**	30.9	31.2
DSHP	4.7	**6.8**	**11.5**	**14.8**	**22.7**	32.6	38.8
LGEM	4.7	**6.7**	**12.2**	**16.7**	**23.0**	**27.8**	**27.0**
Forecasts	15	15	13	12	11	8	5

Table 5. Watch and warning summary for Hurricane Isaac, 7–15 September 2018.

Date/Time (UTC)	Action	Location
11 / 1500	Tropical Storm Watch issued	Antigua, Montserrat
11 / 1500	Hurricane Watch issued	Guadeloupe, Dominica, Martinique
11 / 1800	Tropical Storm Watch issued	St. Kitts and Nevis
12 / 0300	Hurricane Watch changed to Tropical Storm Warning	Guadeloupe, Dominica, Martinique
12 / 0300	Tropical Storm Watch issued	Saba, St. Eustatius
12 / 1800	Tropical Storm Watch issued	St. Martin, St. Maarten
13 / 0900	Tropical Storm Watch issued	Barbuda
13 / 1800	Tropical Storm Watch discontinued	St. Martin, St. Maarten, St. Eustatius, Saba
13 / 2100	All watches and warnings discontinued	All

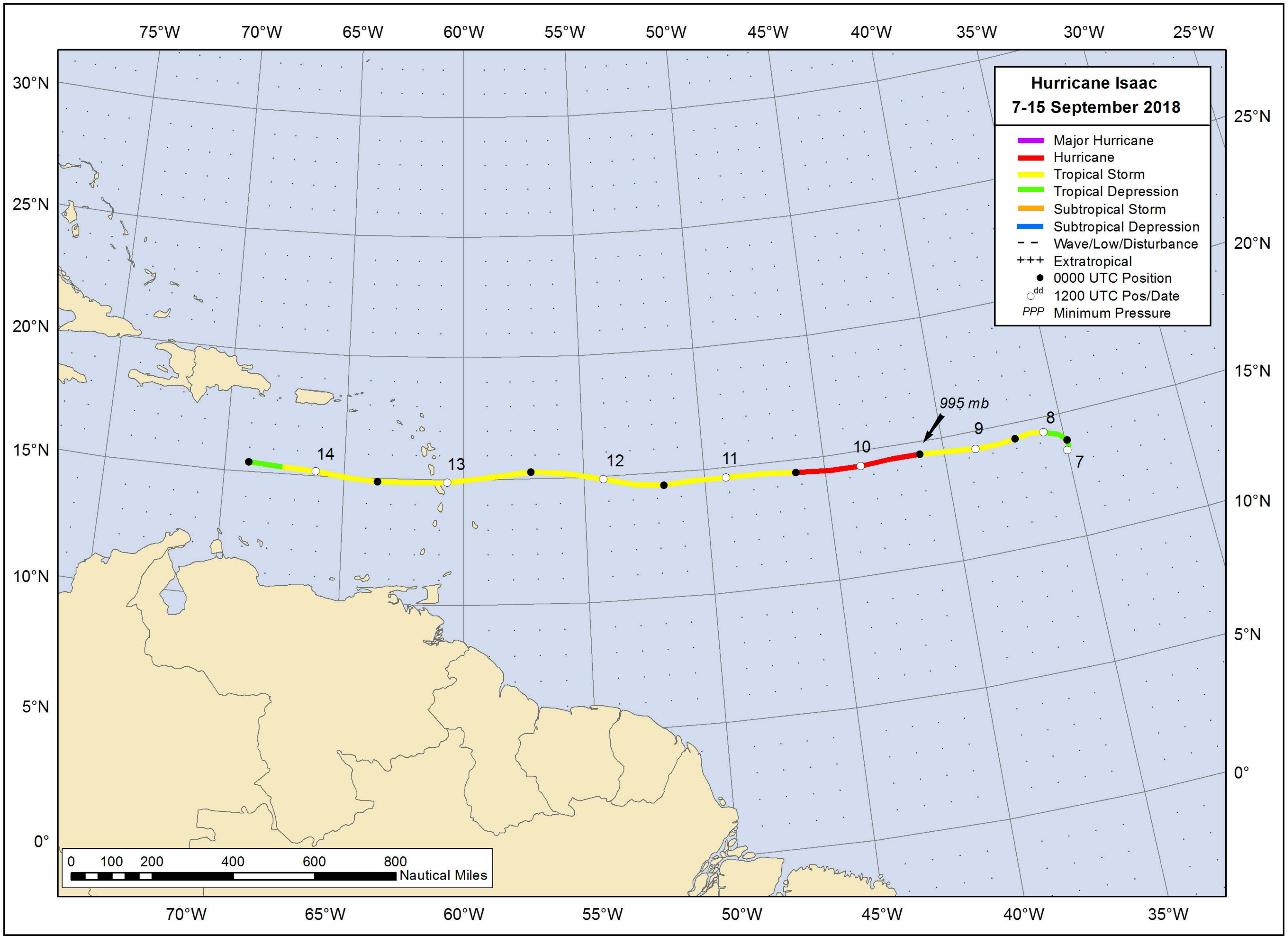

Figure 1. Best track positions for Hurricane Isaac, 7–15 September 2018.

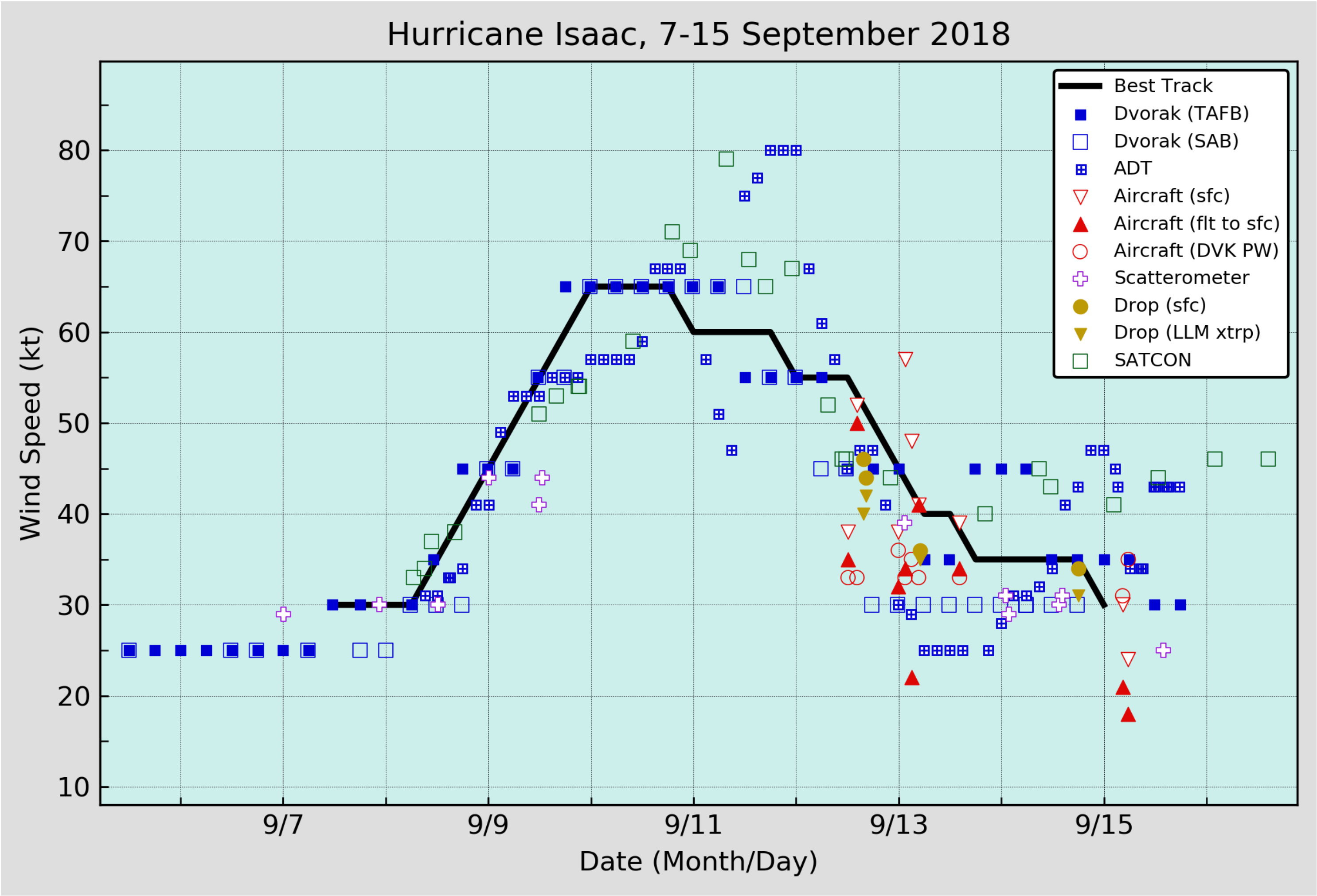

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Isaac, 7–15 September 2018. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% adjustment factors for observations from 700 mb, 850 mb, and 1500 ft, respectively. Dropwindsonde observations include actual 10 m winds (sfc), as well as surface estimates derived from the mean wind over the lowest 150 m of the wind sounding (LLM). Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC.

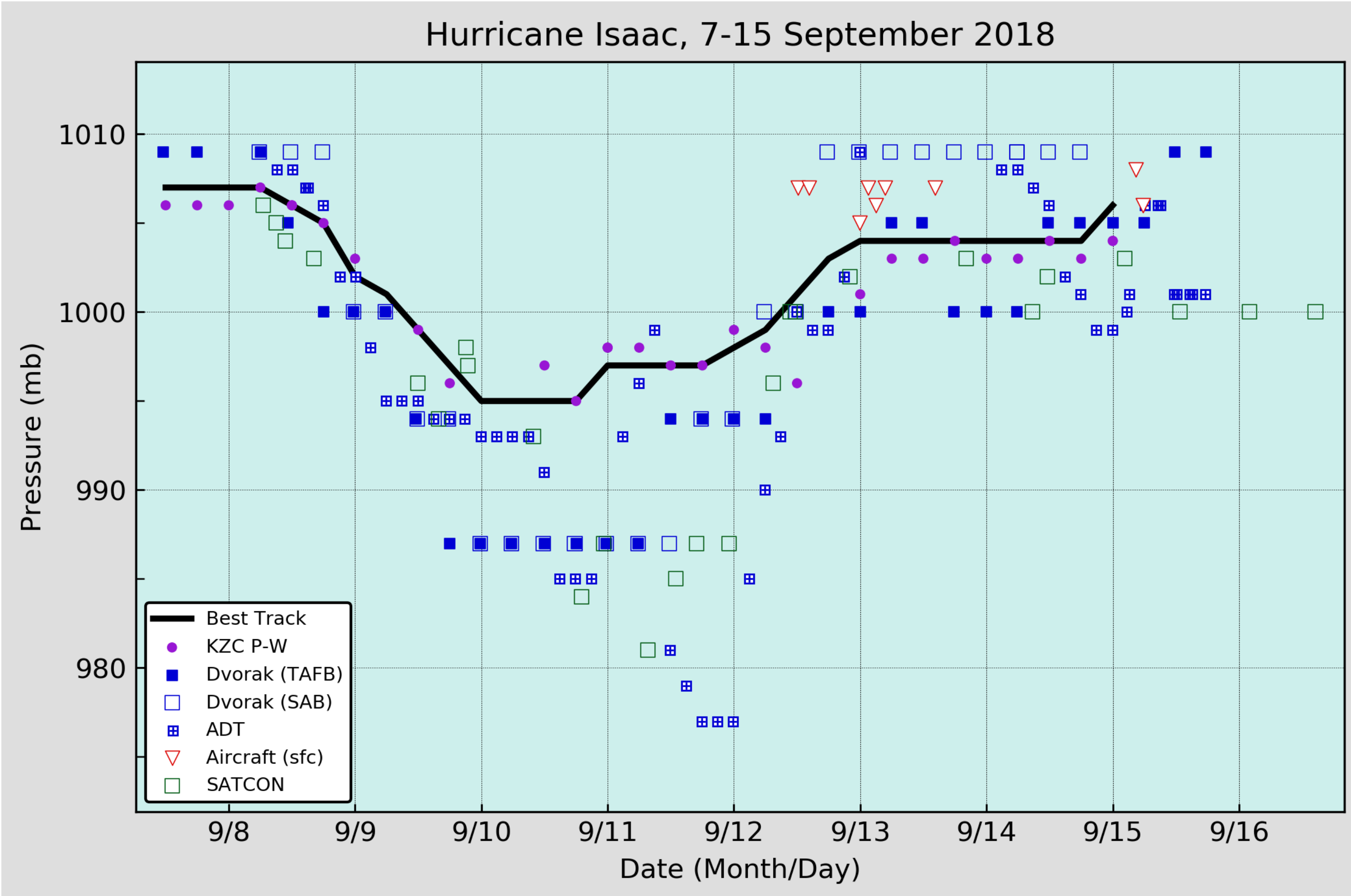

Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Isaac, 7–15 September 2018. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

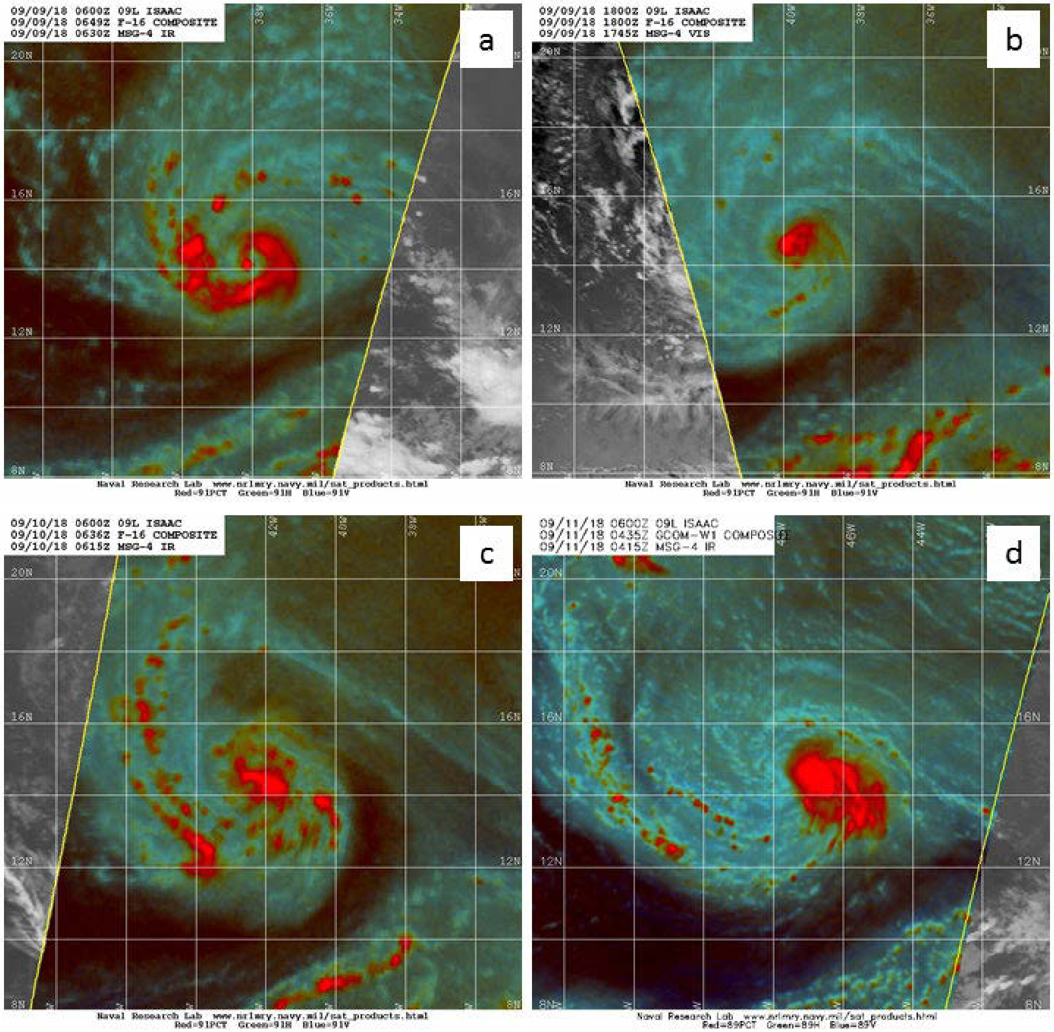

Figure 4. 91/89-GHz color composite microwave imagery showing the convective evolution of Hurricane Isaac, 9–11 September. A mid-level eye developed on 9 September while banding convection decreased, likely due to dry air entrainment (a,b). Convection was limited to the eastern half of the cyclone by 11 September due to an increase in westerly wind shear across the cyclone (c,d). Images courtesy of the Naval Research Laboratory.

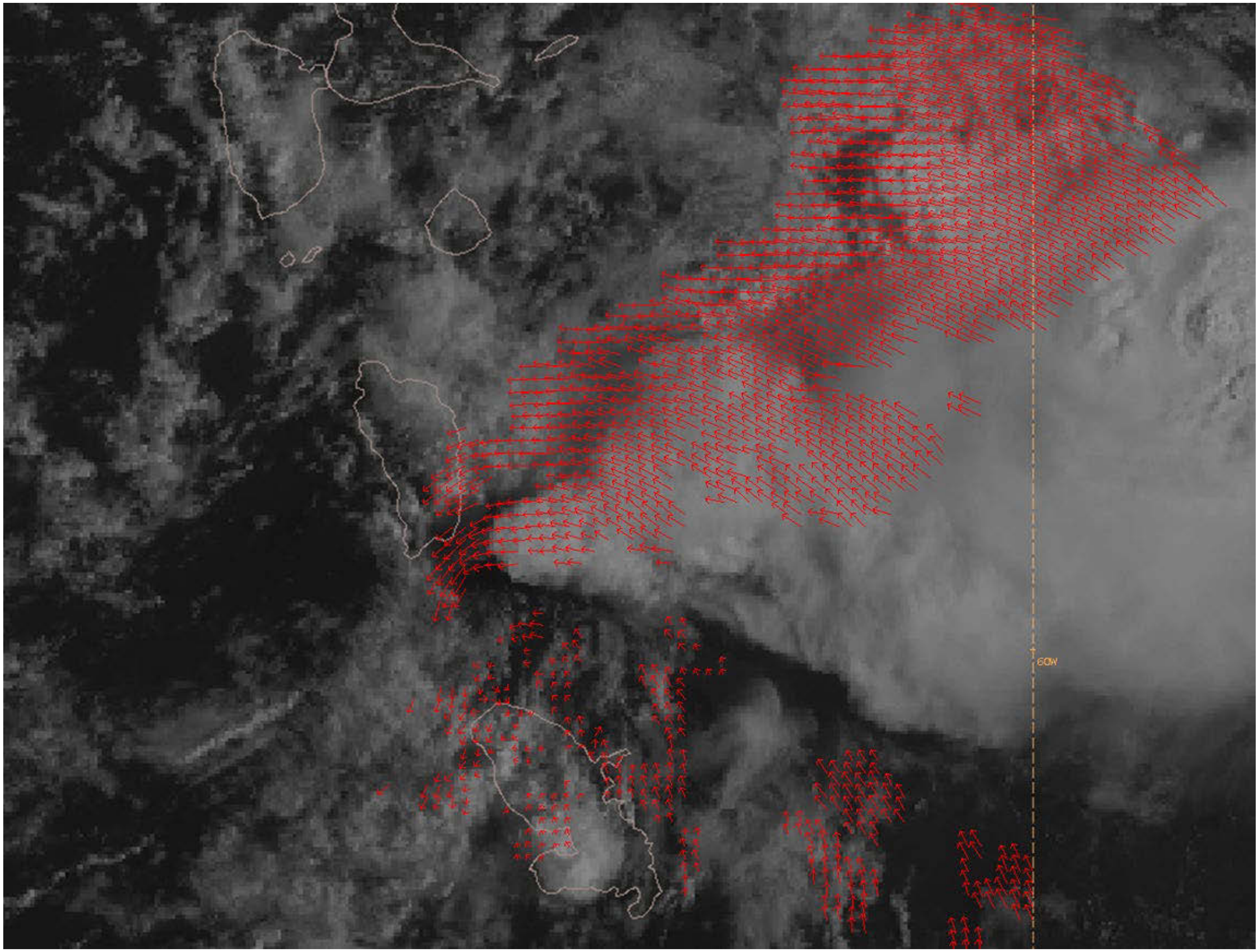

Figure 5a. 1300 UTC 13 September GOES-E visible (Ch2) image of Isaac with NOAA-P3 Tail Doppler Radar wind data 1 km above ground level (red arrow vectors with a peak magnitude of 38 kt, valid 1252 UTC) showing the exposed center of Isaac passing between the islands of Guadeloupe and Martinique.

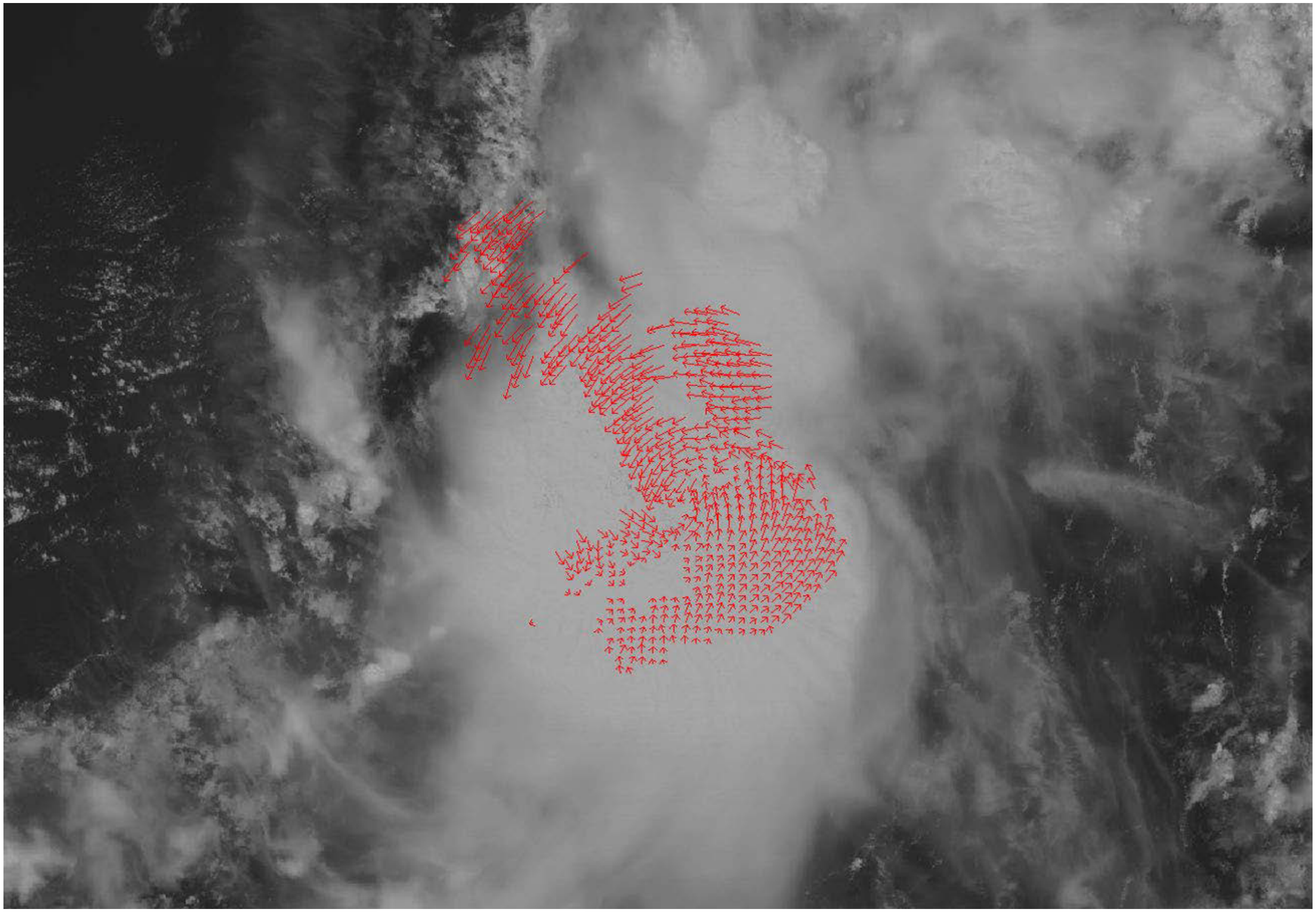

Figure 5b. 1700 UTC 14 September GOES-E visible (Ch2) image of Isaac with NOAA-P3 TDR wind data 1 km above ground level (red arrow vectors with a peak magnitude of 35 kt, valid 1700 UTC), showing Isaac maintaining a small well-defined center.

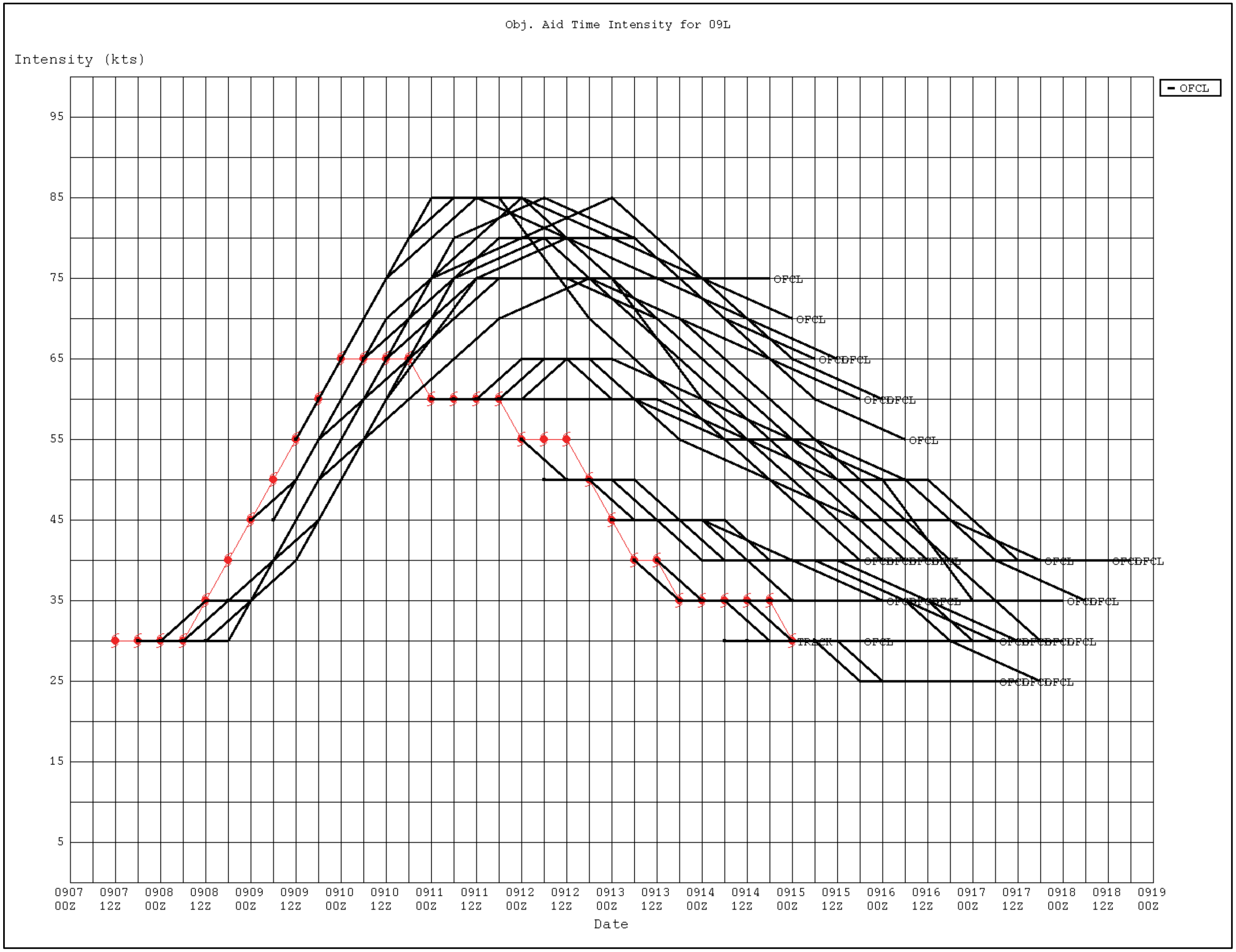

Figure 6. Selected official intensity forecasts (kt, black lines) for Hurricane Isaac. The best track is shown by the solid red line and tropical cyclone symbols with intensity plotted at 6 h intervals.

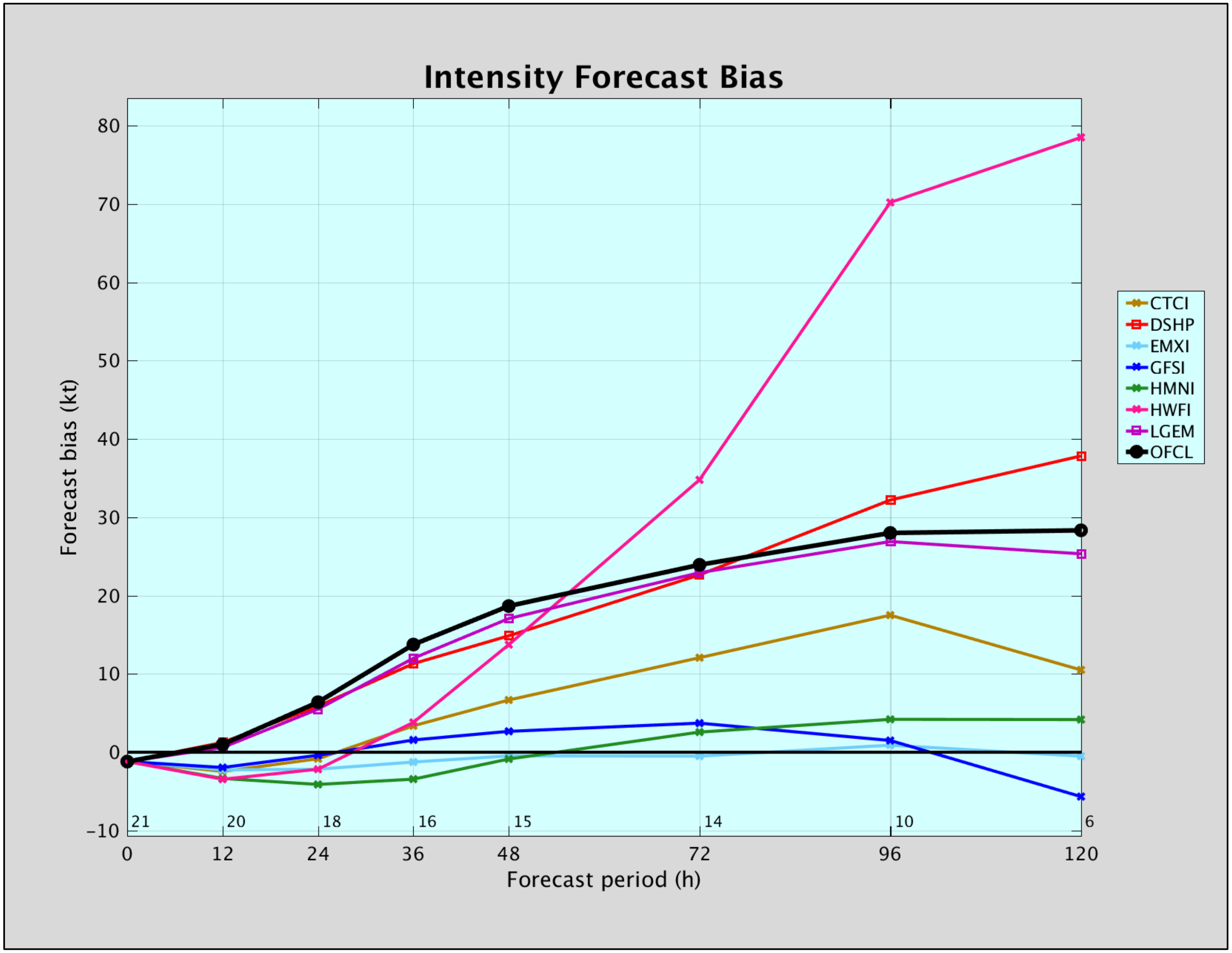

Figure 7a. Forecast intensity bias (kt) of the NHC official forecast and selected models for Hurricane Isaac. The number of forecasts in the homogenous sample is given by the small numbers just above the x-axis at each forecast period.

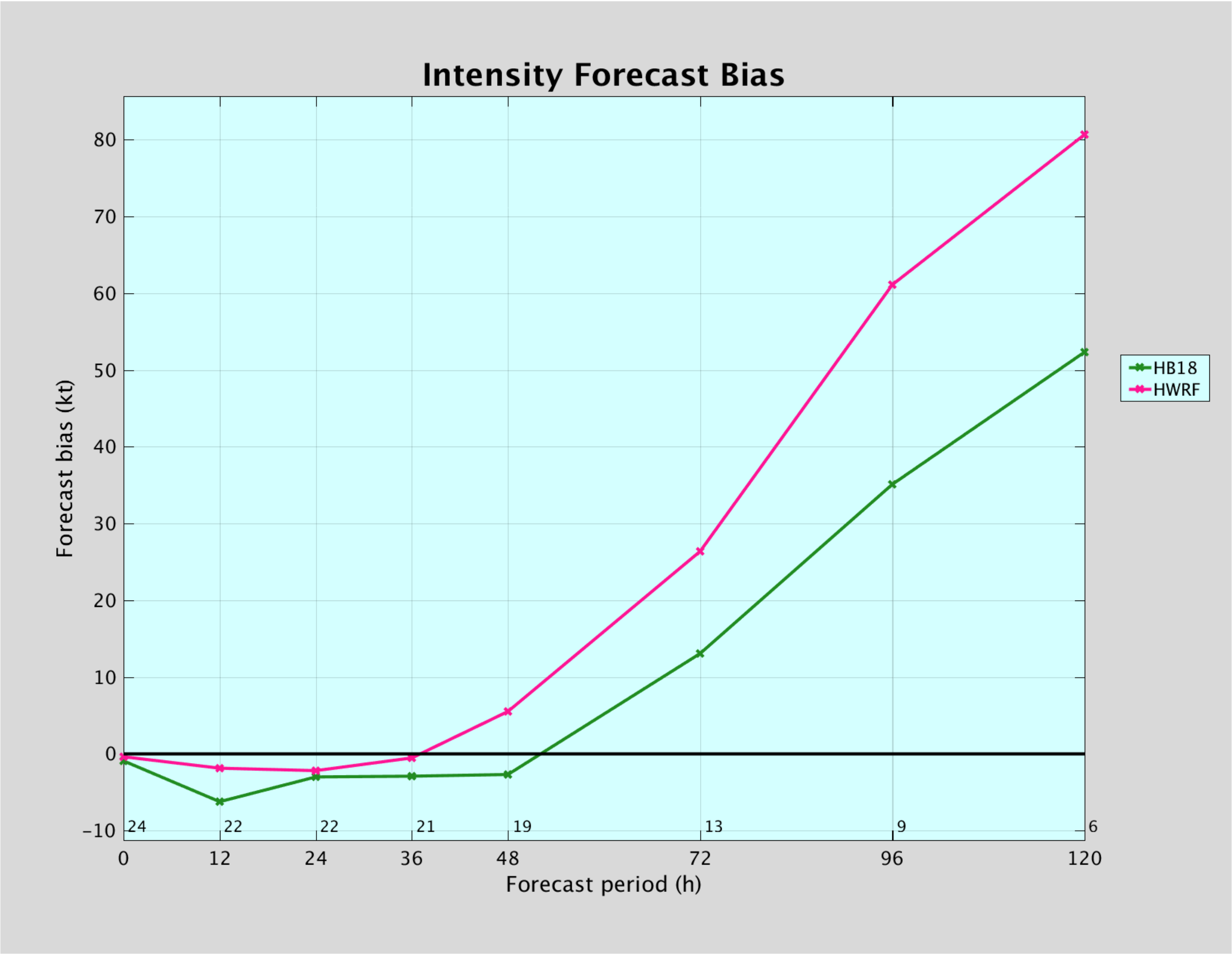

Figure 7b. Forecast intensity bias (kt) for Hurricane Isaac for the HWRF (pink) and experimental "basin-scale" HWRF (HB18, green). The basin-scale HWRF differs from the operational model primarily in that high resolution is applied to other simultaneous tropical cyclones, which contributed to a better forecast of the wind shear affecting Isaac. The number of forecasts in the homogenous sample is given by the small numbers just above the x-axis at each forecast period.