

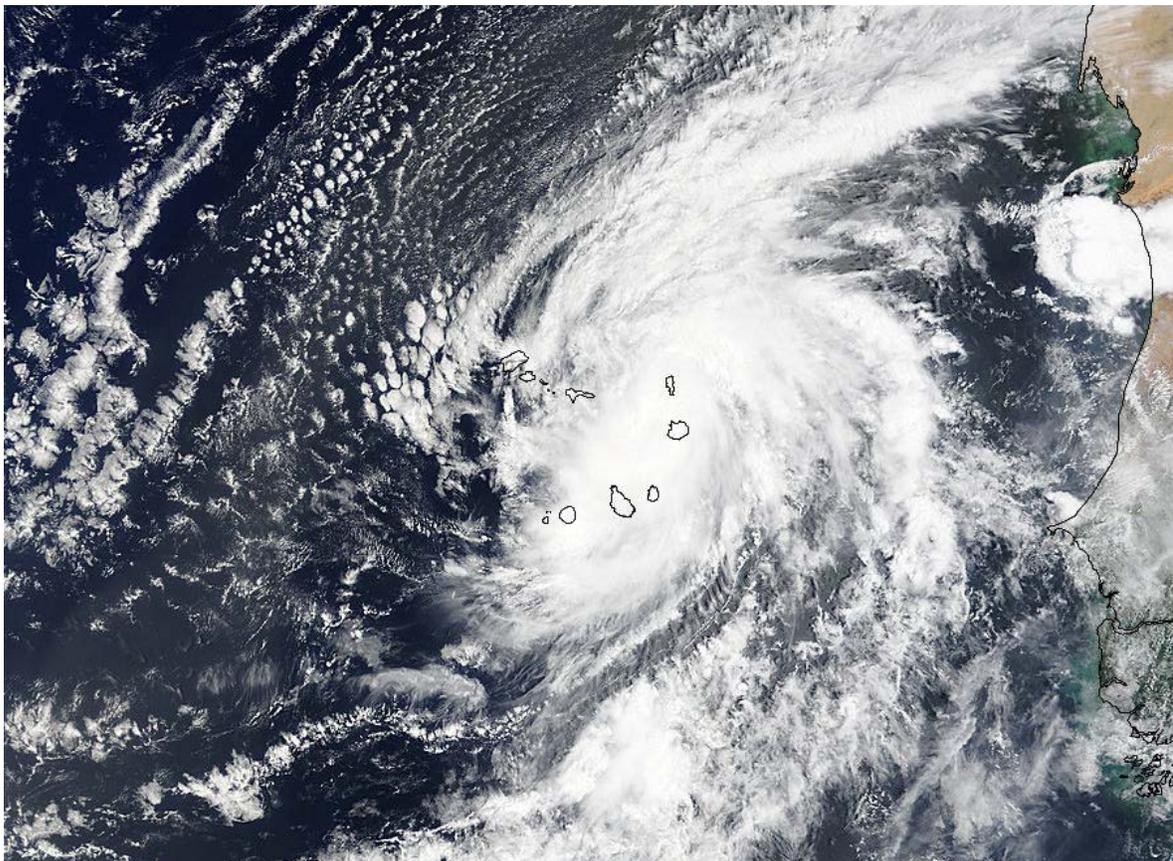


NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE FRED (AL062015)

30 August – 6 September 2015

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National Hurricane Center
20 January 2016



MODIS IMAGE OF HURRICANE FRED OVER CABO VERDE AT 1215 UTC 31 AUGUST 2015. IMAGE COURTESY OF NASA

Fred was a cyclone with many unclimatological aspects, including, the first hurricane passage through Cabo Verde since 1892. The cyclone was blamed for nine deaths.

Hurricane Fred

30 AUGUST – 6 SEPTEMBER 2015

SYNOPTIC HISTORY

Fred formed from a tropical wave that emerged from the west coast of Africa on 29 August. Unlike most tropical waves, Fred's precursor began to develop almost immediately upon reaching the Atlantic, and a low pressure area formed just west of the coast of Guinea later that day. The center of the low re-formed northward late on 29 August, and it is estimated that a tropical depression developed near 0000 UTC 30 August about 260 n mi west-northwest of Conakry, Guinea. The "best track" chart of the tropical cyclone'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 1¹.

The depression moved quickly on an climatological northwestward track after genesis, steered by a weakness in the subtropical ridge north of Cabo Verde. Microwave data showed that the system developed a well-defined inner core during or just after genesis (Fig. 4), and this, in combination with warm sea surface temperatures and light vertical wind shear, allowed a rapid strengthening that was also not normal for this area. The cyclone reached tropical storm strength 6 h after genesis, and it became a hurricane around 0000 UTC 31 August about 145 n mi south-southeast of Sal, Cabo Verde. Fred moved through the islands later that day as it reached an estimated peak intensity of 75 kt. After that, a combination of decreasing sea surface temperatures and increasing southwesterly shear caused weakening, and Fred fell below hurricane strength early on 1 September as it moved away from Cabo Verde.

Fred turned west-northwestward later on 1 September as the subtropical ridge strengthened to the north, and this general motion would continue for the next two days. During this time, the associated convection occurred in episodic sheared bursts, with the result that Fred gradually weakened. The cyclone moved westward on 4 September while it weakened to a tropical depression. Later that day, however, a new burst of convection caused the cyclone to strengthen back to a tropical storm for about 12 h as it turned back toward the west-northwest. A deep-layer trough and associated surface frontal system caused a break in the subtropical ridge, and Fred moved northward on 6 September. The cyclone remained in a strong shear environment, which caused it to degenerate to a trough later that day about 1050 n mi southwest of the Azores. Shortly thereafter, the remnants of Fred were absorbed by the front.

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 *bt* directory, while previous years' data are located in the *archive* directory.

METEOROLOGICAL STATISTICS

Observations in Fred (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 from the Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin-Madison. Observations also include dropwindsonde observations from one flight of the NOAA Global Hawk 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 Fred.

As best as can be determined, Fred is the first hurricane to move through Cabo Verde since 1892. Hurricane Debby of 1961 reached hurricane strength just after passing through the islands.

Winds and Pressure

The estimated peak intensity of Fred is based on satellite imagery. While hurricane and tropical storm conditions affected several of the eastern and northern islands of Cabo Verde, there are no meteorological observations currently available from the area.

There was one marine observation of tropical-storm-force winds from Fred. The ship **Laura Maersk** (call sign OWK12) reported 39-kt winds at 0000 UTC 31 August.

Storm Surge²

Media reports indicate that storm surge, accompanied by high surf, occurred in several islands of Cabo Verde. However, quantitative reports are not available. In addition, swells generated by the hurricane caused above normal tides on the western coast of Africa from Guinea-Bissau northward to Senegal.

Rainfall and Flooding

² Several terms are used to describe water levels due to a storm. **Storm surge** is defined as the abnormal rise of water generated by a storm, over and above the predicted astronomical tide, and is expressed in terms of height above normal tide levels. Because storm surge represents the deviation from normal water levels, it is not referenced to a vertical datum. **Storm tide** is defined as the water level due to the combination of storm surge and the astronomical tide, and is expressed in terms of height above a vertical datum, i.e. the North American Vertical Datum of 1988 (NAVD88) or Mean Lower Low Water (MLLW). **Inundation** is the total water level that occurs on normally dry ground as a result of the storm tide, and is expressed in terms of height above ground level. At the coast, normally dry land is roughly defined as areas higher than the normal high tide line, or Mean Higher High Water (MHHW).

No detailed rainfall observations are available from Cabo Verde. Media reports suggest that 6-8 inches of rain occurred on several of the islands. These rains caused some flooding, but also filled reservoirs that were low due to drought.

CASUALTY AND DAMAGE STATISTICS

Media reports indicate there were nine deaths³ directly associated with Fred. The Greek-registered fishing boat **Dimitrios** sank off the coast of Guinea-Bissau due to the high waves generated by Fred, and 7 members of its crew of 19 were not found. In addition, two fishermen from Cabo Verde were reported missing and presumed dead when their fishing boat failed to return to the island of Boa Vista.

Media reports also indicate that Fred caused damage on several islands of Cabo Verde, with Boa Vista being the hardest hit. These reports suggest that about \$1 US million of damage occurred on the islands. Additional damage from surf and above normal tides occurred along the coast of Africa, with damage to crops reported in Guinea-Bissau due to salt water inundation.

FORECAST AND WARNING CRITIQUE

The genesis of Fred was not well forecast. The system was first mentioned in the Tropical Weather Outlook 48 h before genesis occurred (Table 2). However, at that time, it was given a low chance (30% or less) for genesis within five days, with a near 0% chance shown within two days. The short-range genesis probability was increased above 0% 24 h before genesis, which is also the time that the medium-range probability was raised to a medium chance (40%-60%). Subsequently, the medium-range probability was raised to a high chance (70% or greater) 12 h before genesis, at which time the short-range genesis probability was raised to a medium chance. Finally, the short-range probability was raised to the high category 6 h before genesis. The poor genesis forecasts are partly attributable to the very climatological genesis location near the coast of Africa and the fact that genesis occurred less than 24 h after the wave moved offshore. In addition, the National Hurricane Center is typically conservative with its genesis forecasts for systems still over Africa.

A verification of NHC official track forecasts for Fred is given in Table 3a. Official forecast track errors were significantly lower than the mean official errors for the previous 5-yr period. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The track guidance and the official forecasts correctly assessed the various aspects of Fred's track, including the climatological northwestward track through Cabo Verde. The deep

³ Deaths occurring as a direct result of the forces of the tropical cyclone are referred to as "direct" deaths. These would include those persons who drowned in storm surge, rough seas, rip currents, and freshwater floods. Direct deaths also include casualties resulting from lightning and wind-related events (e.g., collapsing structures). Deaths occurring from such factors as heart attacks, house fires, electrocutions from downed power lines, vehicle accidents on wet roads, etc., are considered "indirect" deaths.



version of the Beta and Advection Model (BAMD) had the best overall performance of the track guidance with lower errors than the official forecast at 12-72 h.

A verification of NHC official intensity forecasts for Fred is given in Table 4a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period at all forecast times. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. Generally the official forecasts were better than the intensity guidance. However, they had higher errors than the intensity consensus models ICON and IVCN at 24-48 h.

Watches and warnings associated with Fred are given in Table 5. A hurricane watch was issued for Cabo Verde on the first advisory, which was about 36 h before the center of Fred started to pass through the islands. A subsequent hurricane warning was issued about 27 h before the center reached the islands.



Table 1. Best track for Hurricane Fred, 30 August – 6 September 2015.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
30 / 0000	11.6	17.5	1007	30	tropical depression
30 / 0600	12.2	18.4	1005	35	tropical storm
30 / 1200	13.1	19.5	1004	45	"
30 / 1800	14.0	20.7	998	55	"
31 / 0000	14.6	21.7	992	65	hurricane
31 / 0600	15.3	22.5	989	70	"
31 / 1200	16.1	23.3	986	75	"
31 / 1800	16.8	24.1	988	70	"
01 / 0000	17.4	24.9	991	65	"
01 / 0600	17.8	25.7	994	60	tropical storm
01 / 1200	18.2	26.7	1000	50	"
01 / 1800	18.7	27.6	1003	45	"
02 / 0000	19.1	28.7	1003	45	"
02 / 0600	19.3	29.7	1004	40	"
02 / 1200	19.6	30.5	1005	40	"
02 / 1800	20.0	31.4	1006	35	"
03 / 0000	20.4	32.2	1006	35	"
03 / 0600	20.7	32.9	1005	40	"
03 / 1200	21.3	33.7	1005	40	"
03 / 1800	21.8	34.9	1005	35	"
04 / 0000	21.9	36.0	1005	35	"
04 / 0600	22.0	36.9	1005	35	"
04 / 1200	22.2	37.9	1005	30	tropical depression
04 / 1800	22.4	38.7	1006	30	"
05 / 0000	22.7	39.6	1006	35	tropical storm
05 / 0600	23.0	40.6	1007	35	"
05 / 1200	23.3	41.5	1008	30	tropical depression
05 / 1800	23.5	42.2	1008	30	"
06 / 0000	23.8	42.9	1009	30	"
06 / 0600	24.5	43.3	1010	30	"



06 / 1200	25.3	43.2	1010	25	"
06 / 1800					dissipated
31 / 1200	16.1	23.3	986	75	minimum pressure and maximum winds



Table 2. Number of hours in advance of formation associated with the first NHC Tropical Weather Outlook forecast for Hurricane Fred 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%)	24	48
Medium (40%-60%)	12	24
High (>60%)	6	12



Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Fred, 30 August – 6 September 2015. 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	19.0	30.6	39.5	45.9	68.3	87.9	104.1
OCD5	29.4	50.0	80.4	112.8	196.1	297.4	411.6
Forecasts	29	27	25	23	19	15	11
OFCL (2010-14)	28.4	45.0	60.4	77.1	113.1	157.8	210.0
OCD5 (2010-14)	48.3	101.5	161.5	222.6	329.8	412.6	483.9

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Fred, 30 August – 6 September 2015. 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	19.0	29.8	40.6	47.9	71.3	83.3	87.4
OCD5	29.3	55.3	87.4	127.3	210.6	330.4	488.0
GFSI	19.8	31.6	42.8	56.1	84.5	128.3	187.0
GHMI	25.2	47.0	66.9	95.1	179.3	334.6	532.8
HWFI	25.6	45.4	65.9	84.6	139.0	234.1	407.2
EGRI	23.1	38.6	53.1	72.0	115.3	161.6	256.4
EMXI	19.0	35.4	43.9	47.4	78.2	97.7	96.1
NVGI	25.2	43.3	69.7	104.9	173.2	240.2	288.5
CMCI	17.6	28.8	48.5	76.0	117.4	179.8	237.2
GFEX	18.5	31.7	41.2	47.8	72.2	99.6	117.6
TCON	20.4	37.2	52.5	73.5	123.5	205.4	335.2
TVCA	20.6	33.8	48.3	65.4	108.4	176.4	275.4
FSSE	18.0	30.9	46.9	61.2	90.6	123.1	177.7
AEMI	19.6	32.5	50.1	73.5	128.6	193.4	254.5
LBAR	48.3	95.5	150.2	224.4	432.3	733.0	1062.5
BAMS	62.3	121.2	180.0	240.7	375.4	515.9	700.1
BAMM	31.3	57.0	78.0	99.1	145.6	195.3	287.4
BAMD	18.8	28.0	27.6	33.2	61.4	125.2	252.7
Forecasts	21	21	19	17	16	12	8

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Fred, 30 August – 6 September 2015. 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	3.4	6.7	8.6	7.6	7.9	6.3	6.4
OCD5	6.4	10.0	13.6	17.1	23.6	33.8	29.0
Forecasts	29	27	25	23	19	15	11
OFCL (2010-14)	6.2	9.4	11.5	13.3	14.6	14.6	15.8
OCD5 (2010-14)	7.3	10.8	13.3	15.3	17.7	17.8	17.6

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Fred, 30 August – 6 September 2015. 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	2.7	5.6	8.4	7.8	6.0	4.5	3.8
OCD5	6.1	8.6	13.1	17.6	25.7	37.4	35.8
HWFI	3.5	6.0	8.2	9.5	11.0	9.5	15.0
GHMI	4.5	8.3	9.6	9.9	15.6	22.8	28.3
DSHP	5.1	7.4	9.6	10.8	9.5	6.1	5.5
LGEM	4.9	6.8	8.4	8.8	6.7	6.3	10.1
ICON	3.8	5.2	6.8	7.5	7.3	8.2	12.9
IVCN	3.8	5.2	6.8	7.5	7.3	8.2	12.9
EMXI	5.7	8.0	10.4	11.4	13.8	16.4	20.8
GFSI	4.4	6.3	8.5	9.1	8.6	8.4	7.5
FSSE	3.4	4.8	6.8	7.9	9.0	9.8	13.1
Forecasts	24	24	22	20	15	11	8



Table 5. Watch and warning summary for Hurricane Fred, 30 August – 6 September 2015.

Date/Time (UTC)	Action	Location
30 / 0530	Tropical Storm Warning and Hurricane Watch issued	Cabo Verde
30 / 1500	Tropical Storm Warning and Hurricane Watch changed to Hurricane Warning	Cabo Verde
1 / 0300	Tropical Storm Warning issued	Northwest islands of Cabo Verde
1 / 0300	Hurricane Warning discontinued	All islands of Cabo Verde
1 / 1200	Tropical Storm Warning discontinued	All

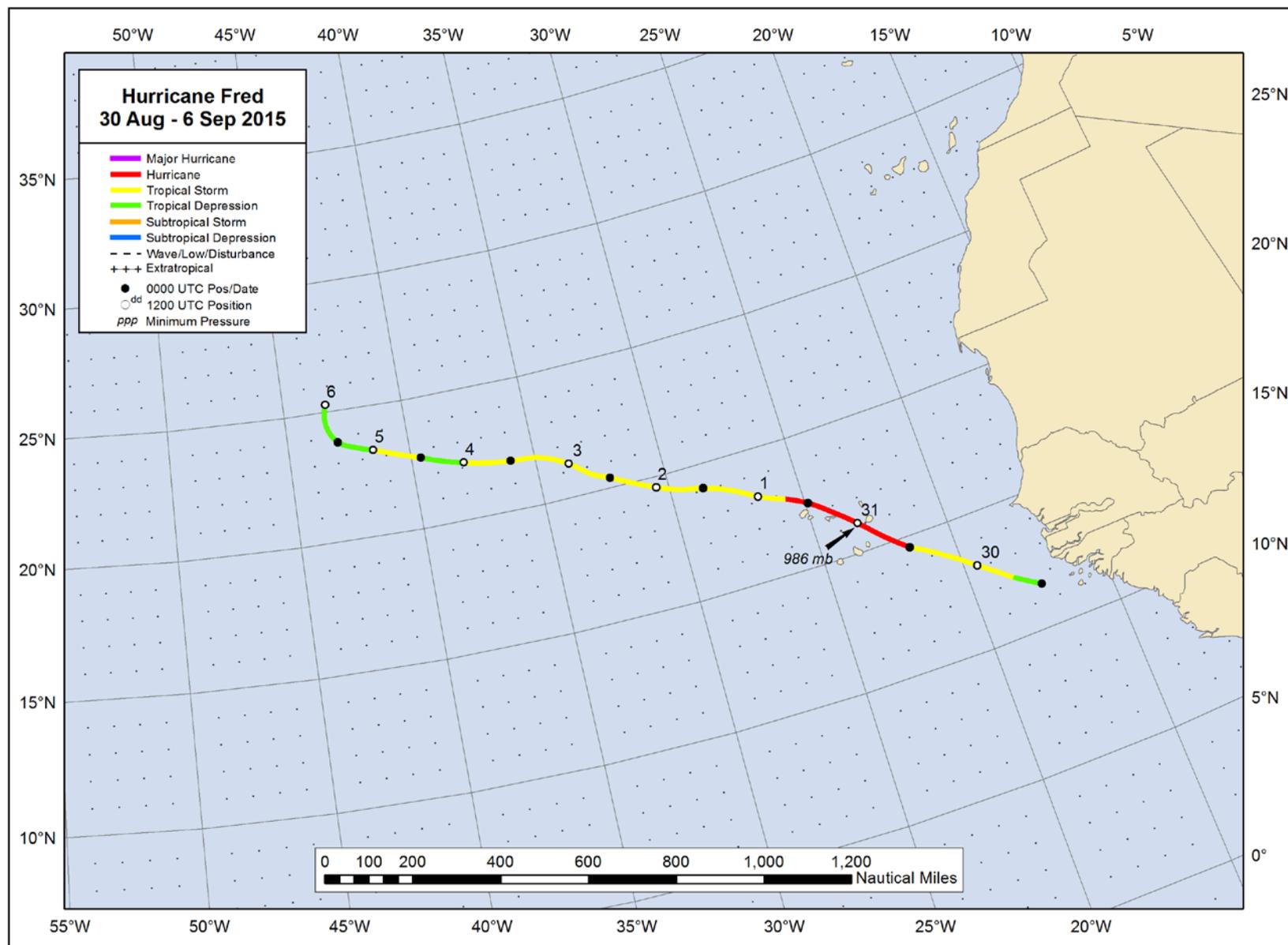


Figure 1. Best track positions for Hurricane Fred, 30 August – 6 September 2015.

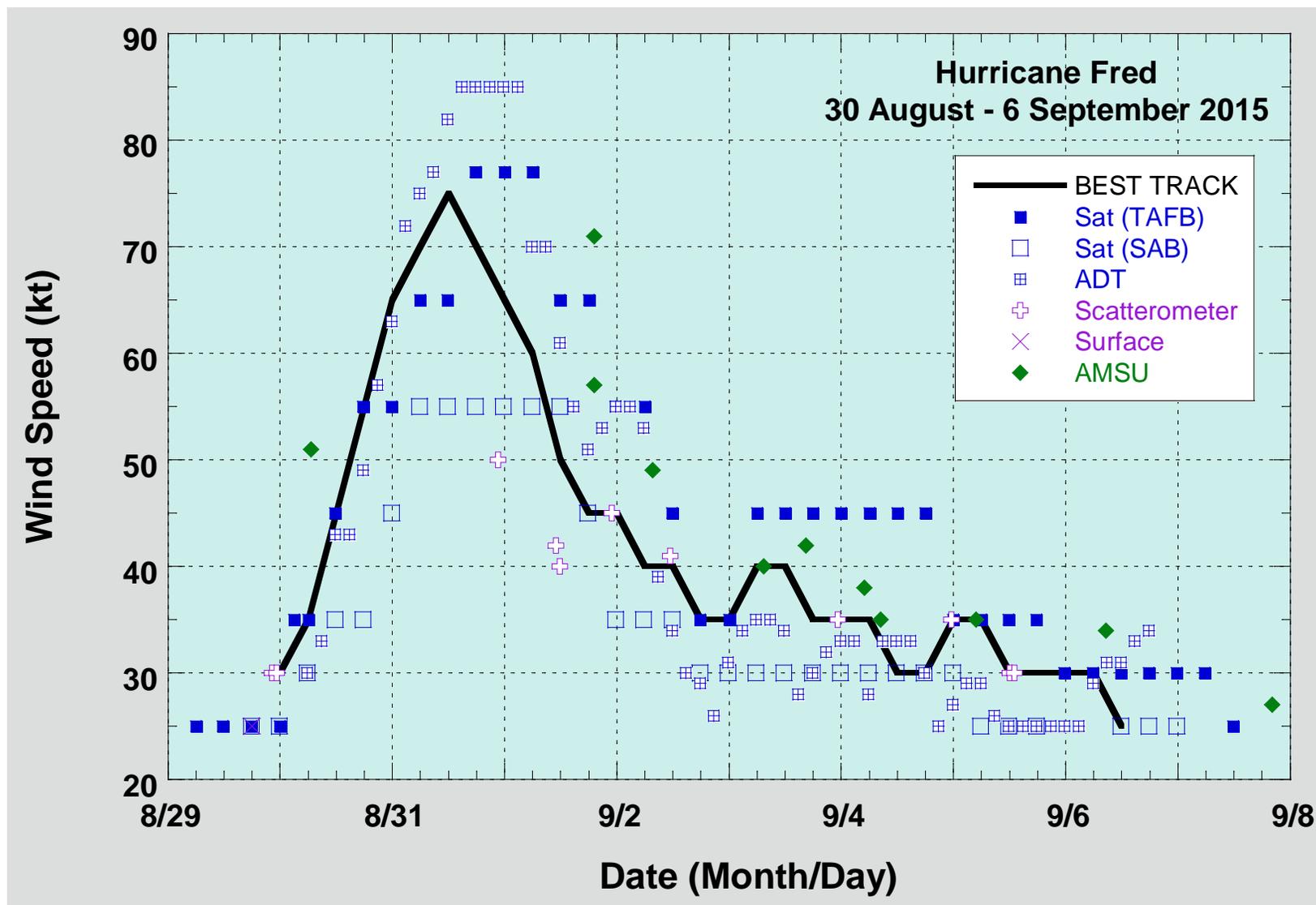


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Fred, 30 August – 6 September 2015. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

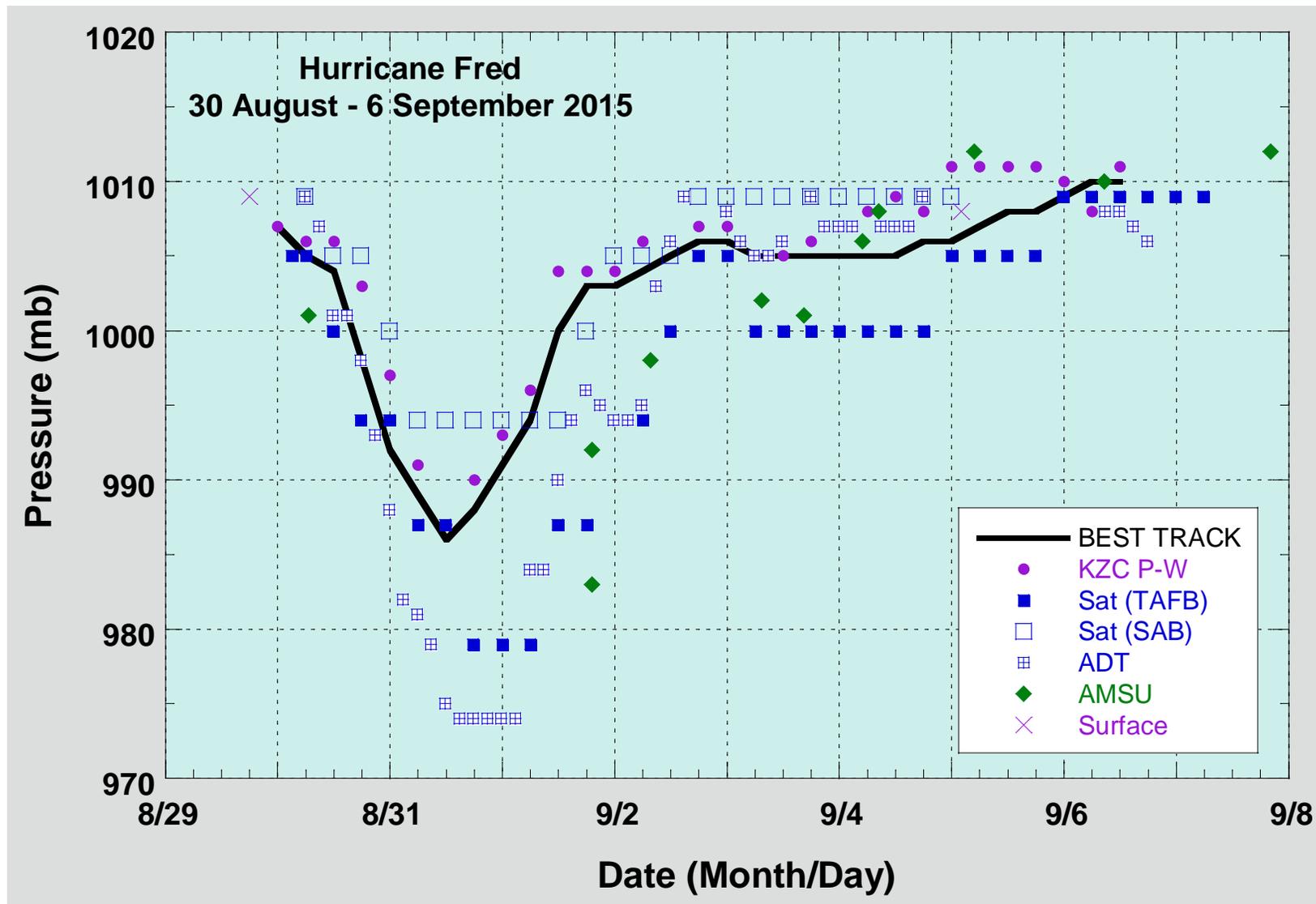


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Fred, 30 August – 6 September 2015. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. KZC P-W refers to pressure estimates derived using the Knaff-Zehr-Courtney pressure-wind relationship. Dashed vertical lines correspond to 0000 UTC.

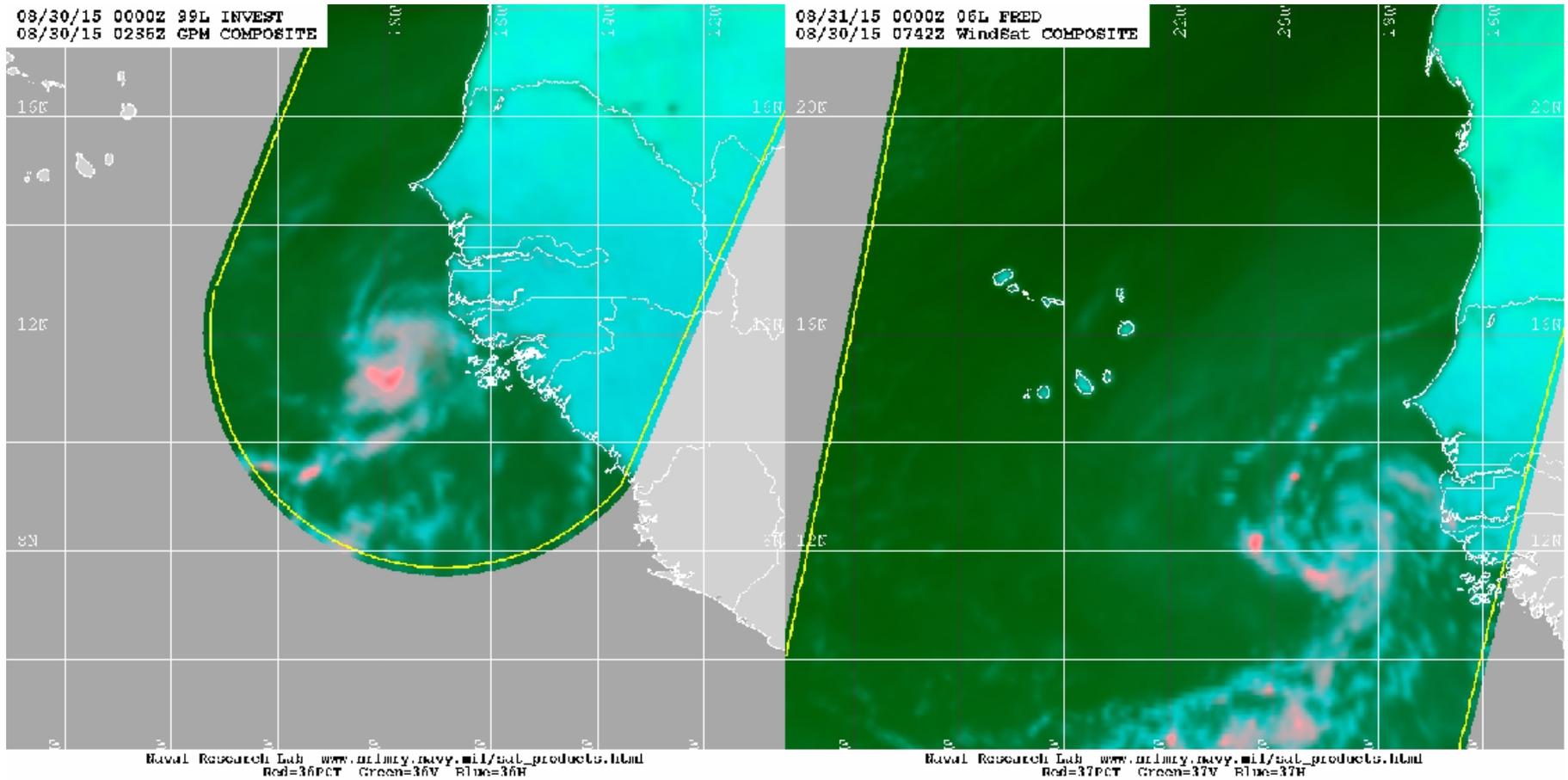


Figure 4. 36 Ghz composite imagery from the NASA GPM satellite at 0236 UTC 30 August (left) and 37 Ghz composite imagery from the Department of Defense Windsat satellite at 0742 UTC 30 August. Imagery courtesy of the Naval Research Laboratory.