Tropical Cyclone Report
Hurricane Rina
(AL182011)
23 – 28 October 2011

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(Updated to add acknowledgments)

Rina was a typical October major hurricane that formed in the western Caribbean Sea and moved toward the Yucatan Peninsula. However, it weakened significantly prior to landfall on the Yucatan Peninsula as a tropical storm and it dissipated near the Yucatan Channel.

a. Synoptic History

A relatively low-latitude tropical wave left the coast of west Africa on 9 October with little convection, but interacted with an upper-level trough on 12 October in the central Atlantic Ocean, which caused a brief increase in thunderstorms. Convection then diminished until the wave moved through the Windward Islands four days later, with thunderstorms regenerating at that time due to a diffluent upper-level environment. On 19 October, the wave showed some signs of organization, but easterly shear was too strong for development. A cold front entered the northwestern Caribbean Sea on that day, and although it might have contributed some low-level vorticity to the system over the next couple of days, the wave appears to have been the main focus for genesis. Convection intensified near the wave axis on 21 October, which resulted in the formation of a nearly stationary broad low in the western Caribbean. The next day, surface observations indicated falling pressures in the area and a better-defined low-level circulation. Thunderstorms increased markedly near and to the west of the center later that day, and a tropical depression formed by 0600 UTC 23 October about 55 n mi north of Providencia Island, east of Nicaragua. The "best track" chart of the 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 1[1].

A broad mid-level trough over the southeastern United States caused a weakness in a ridge near Florida, and as a result the depression moved northward. The system strengthened gradually at first, becoming a tropical storm 24 h after genesis. However, easterly wind shear then diminished and Rina rapidly intensified over the deep warm waters of the western Caribbean, becoming a hurricane by 1800 UTC 24 October and a major hurricane 24 h later. During that time, mid- to upper-level ridging rebuilt over the Gulf of Mexico, and the hurricane

[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.

slowed down, gradually turning toward the west. NOAA aircraft data indicate that Rina reached a peak intensity of 100 kt and a minimum pressure of 966 mb around 0000 UTC 26 October, when the tropical cyclone was 220 n mi east-southeast of Chetumal, Mexico. The conducive upper-level winds did not last very long, and Rina dropped below major hurricane strength 12 h later. Increasing southeasterly and southerly shear caused Rina to weaken further, although in an irregular fashion, for the next couple of days. The cyclone moved generally toward the west-northwest and northwest on 26 and 27 October as it was steered around the periphery of the ridge, becoming a tropical storm near 1200 UTC 27 October about 75 n mi south-southeast of Tulum, Mexico. A turn to the north commenced later that day, with strong southerly shear causing additional weakening. The tropical storm made landfall near Paamul, Mexico, about 10 n mi southwest of Playa del Carmen, with an intensity of 50 kt near 0200 UTC 28 October. The center of Rina remained over land for about 9 h before emerging into the Yucatan Channel. Strong southerly shear caused all convection near the center to dissipate, and Rina degenerated into a remnant low in the Yucatan Channel by 1800 UTC 28 October. The remnant low moved toward the east-northeast and east within the low-level flow ahead of a cold front, and dissipated early the next day just southeast of the western tip of Cuba.

b. Meteorological Statistics

Observations in Rina (Figs. 2 and 3) include satellite-based Dvorak technique intensity estimates from the Tropical Analysis and Forecast Branch (TAFB) and the Satellite Analysis Branch (SAB), as well as the Advanced Dvorak Technique from the University of Wisconsin-Madison/Cooperative Institute for Meteorological Satellite Studies (UW-CIMSS). Nine aircraft flights of the Air Force Reserve 53rd weather reconnaissance squadron and four flights of the NOAA WP-3 Orion provided flight-level and stepped frequency microwave radiometer (SFMR) surface wind and dropsonde data. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Tropical Rainfall Measuring Mission (TRMM), Defense Meteorological Satellite Program (DMSP) satellites, among others, were also useful in constructing the best track of Rina.

The 100-kt estimated peak intensity of Rina is primarily based on a NOAA SFMR measurement of 103 kt at 2240 UTC 25 October, with another SFMR reading of 98 kt also taken by the Air Force Reserve several hours later. Operationally, the peak SFMR reading was flagged as questionable, so a more conservative flight-level wind adjustment factor that supported 95 kt (actual flight-level measurement 106 kt) was used at that time. A post-analysis from the NOAA Hurricane Research Division, however, concluded that the SFMR data were not contaminated and are thus used to upgrade Rina to a major hurricane for the final best track. It is also noted that the surface-based data suggest that the typical flight-level wind adjustment factors were not applicable to Rina. Examples can be seen in Figure 2, where both the SFMR measurements (white triangles) and the surface winds from the dropsonde (yellow circles) are consistently higher than the flight-level adjustments (red triangles) and the layer-based averaging from the dropsondes (yellow triangles).

The analyzed lowest minimum pressure of 966 mb was based on extrapolation from the 700-mb flight-level from a NOAA center fix.

Selected surface observations from Rina are in Table 2. A public wind report of 46 kt with a gust to 62 kt is the basis for the estimated 50-kt landfall intensity in Mexico. A storm chaser at the landfall point reported a central pressure of 996.5 mb, which was very close to the final aircraft fix before landfall.

There were no reliable ship reports of tropical-storm-force winds in association with Rina.

c. Casualty and Damage Statistics

No significant damage or casualties were reported with Rina.

d. Forecast and Warning Critique

Rina's genesis was well forecast. The system was introduced in the Tropical Weather Outlook in the low category (10%) 60 h before genesis and reached a high chance (60%) of genesis 30 h before formation. One small critique is that 12 h before genesis, the estimated probability of formation had decreased slightly to 50%, perhaps weighing a short-term trend in convection too much. However, at the time of genesis, the probability had increased to 70%.

A verification of NHC official track forecasts for Rina is given in Table 3a. Official forecast track errors were far below the mean official errors for the previous 5-yr period. Although the OCD5 (CLIPER) errors for this system were also below their 5-yr averages, the official forecast errors were much lower than climatology alone explains. Most of the global models, as shown in Table 3b, provided excellent guidance for this hurricane and the official forecasts were generally near or somewhat better than the models. The GFDL and HWRF models, however, did not perform well due to a large track bias to the north and east.

A verification of NHC official intensity forecasts for Rina is given in Table 4a. In contrast to the track errors, the official forecast intensity errors were much worse than the average 5-yr errors through 72 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. The official intensity forecasts were rather poor compared to much of the guidance. An inspection of the NHC errors indicate that early forecasts were too conservative in forecasting intensification, and later forecasts held onto the high wind speeds for too long after the peak intensity. The Florida State Superensemble (FSSE) had a particularly good performance for Rina, especially considering the rapid changes in intensity. The GFDL and HWRF again struggled, showing too much intensification in a sheared environment at later time periods. The northeastward track bias of those models for this system also could have placed the storm in a more conducive environment for strengthening than what actually materialized.

Watches and warnings associated with Rina are in Table 5.

Acknowledgments:

Thanks are expressed to the Mexican Navy, Weather Underground and Josh Morgerman for providing data from near the landfall point in Mexico.

Table 1. Best track for Hurricane Rina, 23–28 October 2011.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
22 / 0000	12.7	81.0	1007	25	low
22 / 0600	12.7	81.2	1007	25	"
22 / 1200	12.9	81.4	1006	25	"
22 / 1800	13.2	81.4	1006	25	"
23 / 0000	13.6	81.4	1006	25	"
23 / 0600	14.2	81.4	1006	25	tropical depression
23 / 1200	14.8	81.5	1006	25	"
23 / 1800	15.5	81.7	1005	30	"
24 / 0000	16.0	81.9	1004	35	tropical storm
24 / 0600	16.5	82.2	1003	40	"
24 / 1200	16.9	82.6	1001	50	"
24 / 1800	17.1	83.0	991	65	hurricane
25 / 0000	17.2	83.2	982	75	"
25 / 0600	17.3	83.5	976	90	"
25 / 1200	17.3	83.8	972	95	"
25 / 1800	17.3	84.2	971	100	"
26 / 0000	17.4	84.6	966	100	"
26 / 0600	17.5	85.0	969	100	"
26 / 1200	17.7	85.4	973	85	"
26 / 1800	18.0	85.8	976	80	"
27 / 0000	18.3	86.3	978	80	"
27 / 0600	18.6	86.7	987	65	"
27 / 1200	19.0	86.9	988	60	tropical storm
27 / 1800	19.5	87.1	991	60	"
28 / 0000	20.2	87.2	996	55	"
28 / 0200	20.5	87.2	996	50	"
28 / 0600	20.9	87.1	998	50	"
28 / 1200	21.4	86.9	1002	40	"
28 / 1800	21.7	86.4	1007	25	low
29 / 0000	21.8	85.3	1008	20	"
29 / 0600	21.5	84.2	1008	20	"
29 / 1200					dissipated
26 / 0000	17.4	84.6	966	100	minimum pressure and maximum winds
28 / 0200	20.5	87.2	996	50	landfall near Paamul Mexico

Table 2. Selected surface observations for Rina, 23-28 October 2011.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)			
Mexico								
International Civil Aviation Organization (ICAO) Sites								
Cancun Airport (MMUN)	28/0946	1007.1	28/0248	25	36			
Navy Station								
Banco Chinchorro, Quintana Roo			27/1200	38	48			
Public/Other								
IQUINTAN5, Cancun 21.15°N 86.84°W			28/0358	37	46			
IQROOCAN5, Cancun 21.17°N 86.80°W			28/0417	46	62			
Paamul 20.52°N 87.19°W	28/0212	996.5						
IQROOCAN4, Puerto Aventuras 20.51°N 87.23°W			28/0118	26	38			
MD3338, Cozumel 20.50°N 86.96°W			28/0134	26	38			

[a] Date/time is for sustained wind when both sustained and gust are listed.
[b] Except as noted, sustained wind averaging periods for C-MAN and land-based ASOS reports are 2 min; buoy averaging periods are 8 min.
[c] Storm surge is water height above normal astronomical tide level.
[d] Storm tide is water height above National Geodetic Vertical Datum (1929 mean sea level).

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Rina. Mean errors for the 5-yr period 2006-10 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 (Rina)	**12.0**	**21.7**	**31.9**	**40.1**	**29.2**	**81.4**	
OCD5 (Rina)	22.6	52.7	80.3	111.5	172.5	295.3	
Forecasts	18	16	14	12	8	4	
OFCL (2006-10)	31.0	50.6	69.9	89.5	133.2	174.2	
OCD5 (2006-10)	47.7	98.3	156.4	218.1	323.3	402.2	

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Rina. 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	12.6	25.7	36.3	47.4	27.6	84.2	
OCD5	19.9	42.4	77.5	104.8	159.3	277.4	
GFSI	19.2	36.4	49.9	77.4	88.3	99.6	
GHMI	15.4	30.3	49.2	69.5	121.8	238.5	
HWFI	18.3	31.8	50.7	72.7	126.2	313.6	
GFNI	20.7	47.4	66.0	74.9	100.6	120.0	
NGPI	20.6	40.3	69.3	110.1	187.7	216.8	
EGRI	22.1	30.4	48.8	69.3	102.5	**56.5**	
EMXI	16.7	**21.1**	38.2	52.2	57.3	**66.7**	
CMCI	31.1	53.7	86.6	116.1	146.3	308.4	
AEMI	12.8	**15.2**	**29.3**	**37.4**	36.7	110.9	
FSSE	14.0	**20.7**	**24.4**	**35.9**	32.8	**41.3**	
TVCA	15.7	**24.0**	**36.1**	50.5	65.7	**79.7**	
TVCN	15.4	**23.3**	36.5	49.2	65.1	**37.7**	
TVCC	14.4	**18.6**	**29.1**	**43.5**	59.2	**12.7**	
LBAR	28.7	75.1	127.1	190.2	395.0	733.2	
BAMS	44.2	85.9	122.9	154.2	261.8	555.8	
BAMM	33.0	66.8	88.0	107.8	147.3	264.3	
BAMD	48.0	90.7	135.4	170.0	197.1	343.2	
Forecasts	12	10	10	8	4	1	

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Rina. Mean errors for the 5-yr period 2006-10 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 (Rina)	10.8	20.6	28.9	34.2	25.6	**15.0**	
OCD5 (Rina)	10.9	19.1	24.5	25.4	24.8	12.8	
Forecasts	18	16	14	12	8	4	
OFCL (2006-10)	7.2	11.0	13.2	15.1	17.2	17.9	
OCD5 (2006-10)	8.5	12.3	15.4	17.8	20.2	21.9	

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Rina. Errors smaller than the NHC 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	11.3	19.6	26.3	31.0	25.8	20.0	
OCD5	**11.2**	**18.1**	**21.2**	**20.3**	**23.3**	**9.5**	
HWFI	**9.1**	**14.5**	**14.0**	**13.7**	38.8	51.0	
GHMI	**10.8**	**18.4**	**20.3**	**26.6**	40.3	42.5	
GFNI	11.4	**18.6**	**17.3**	**18.7**	**19.3**	22.0	
DSHP	**10.9**	**19.2**	**22.7**	**23.0**	**15.0**	**10.5**	
LGEM	**10.1**	**18.4**	**23.0**	**26.8**	**21.0**	**18.0**	
ICON	**9.6**	**17.0**	**19.8**	**21.1**	28.7	30.5	
IVCN	**9.8**	**16.7**	**18.4**	**15.8**	**18.8**	20.0	
FSSE	**10.5**	**13.7**	**11.6**	**10.3**	**14.0**	25.0	
Forecasts	16	14	12	10	6	2	

Table 5. Watches and warnings issued for Rina, 23 – 28 October 2011.

Date/Time (UTC)	Action	Location
23 / 2100	Tropical Storm Watch issued	Punta Castilla, Nicaragua to Honduras/Nicaragua border
24 / 1500	Tropical Storm Watch discontinued	All
25 / 0900	Tropical Storm Watch issued	Chetumal to Punta Gruesa, Mexico
25 / 0900	Hurricane Watch issued	Punta Gruesa to Cancun
25 / 1500	Tropical Storm Watch changed to Tropical Storm Warning	Chetumal to Punta Gruesa
25 / 1500	Hurricane Watch changed to Hurricane Warning	Punta Gruesa to Cancun
25 / 1800	Tropical Storm Watch issued	Belize City to Belize/Mexico border
25 / 2100	Tropical Storm Watch issued	Roatan to Guanaja, Honduras
26 / 1500	Tropical Storm Warning issued	San Felipe to Progreso, Mexico
26 / 1500	Hurricane Warning modified to	Punta Gruesa to San Felipe
26 / 2100	Tropical Storm Watch discontinued	Roatan to Guanaja
27 / 0000	Tropical Storm Watch discontinued	All
27 / 1500	Tropical Storm Warning modified to	Chetumal to Progreso
27 / 1500	Tropical Storm Warning modified to	Chetumal to Progreso
27 / 1500	Hurricane Warning discontinued	All
27 / 2100	Tropical Storm Warning modified to	Punta Gruesa to Progreso
28 / 0300	Tropical Storm Warning discontinued	Punta Gruesa to Progreso
28 / 0300	Tropical Storm Warning issued	Punta Allen to San Felipe
28 / 1500	Tropical Storm Warning discontinued	All

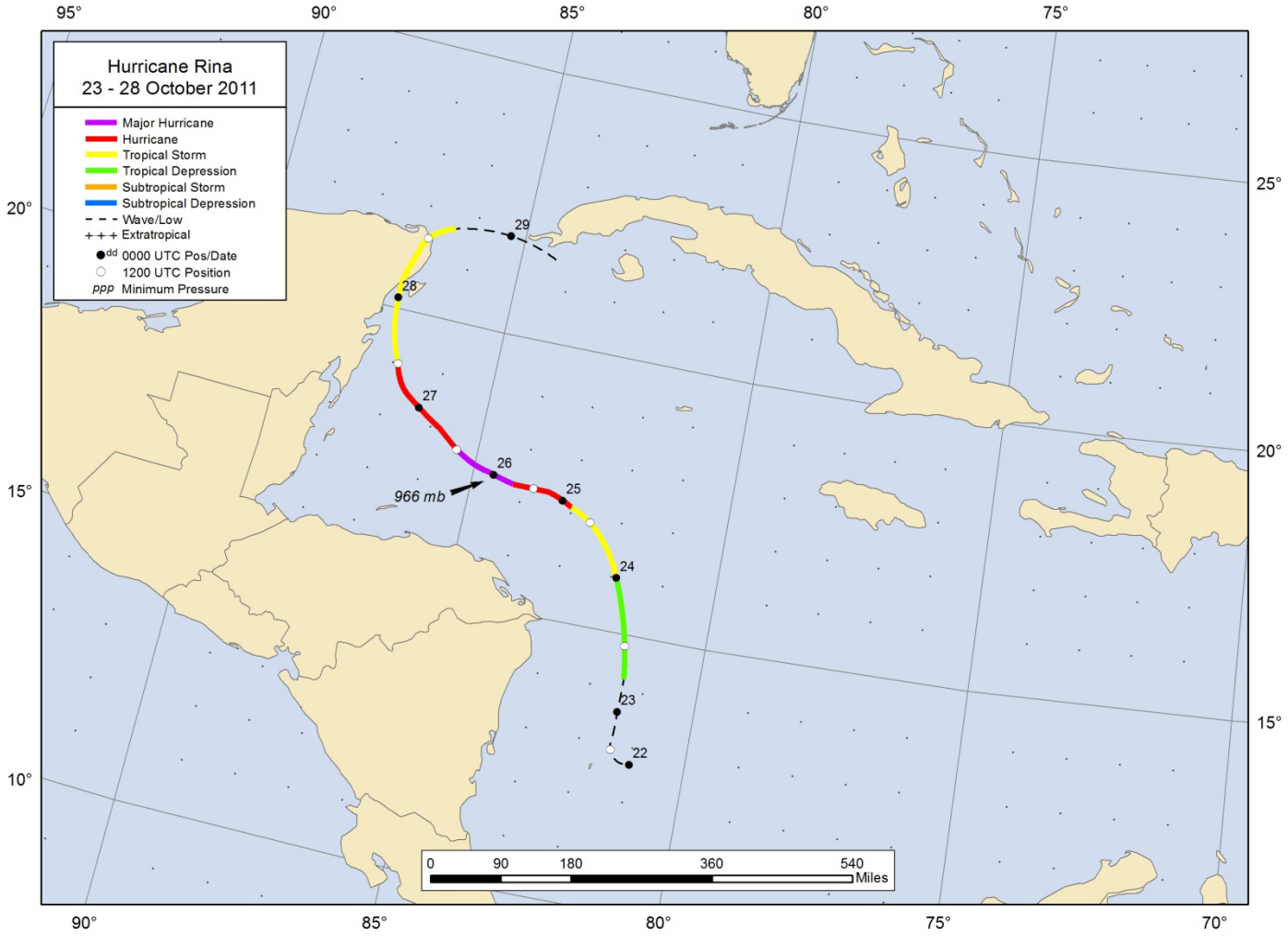

Figure 1. Best track positions for Hurricane Rina, 23 – 28 October 2011.

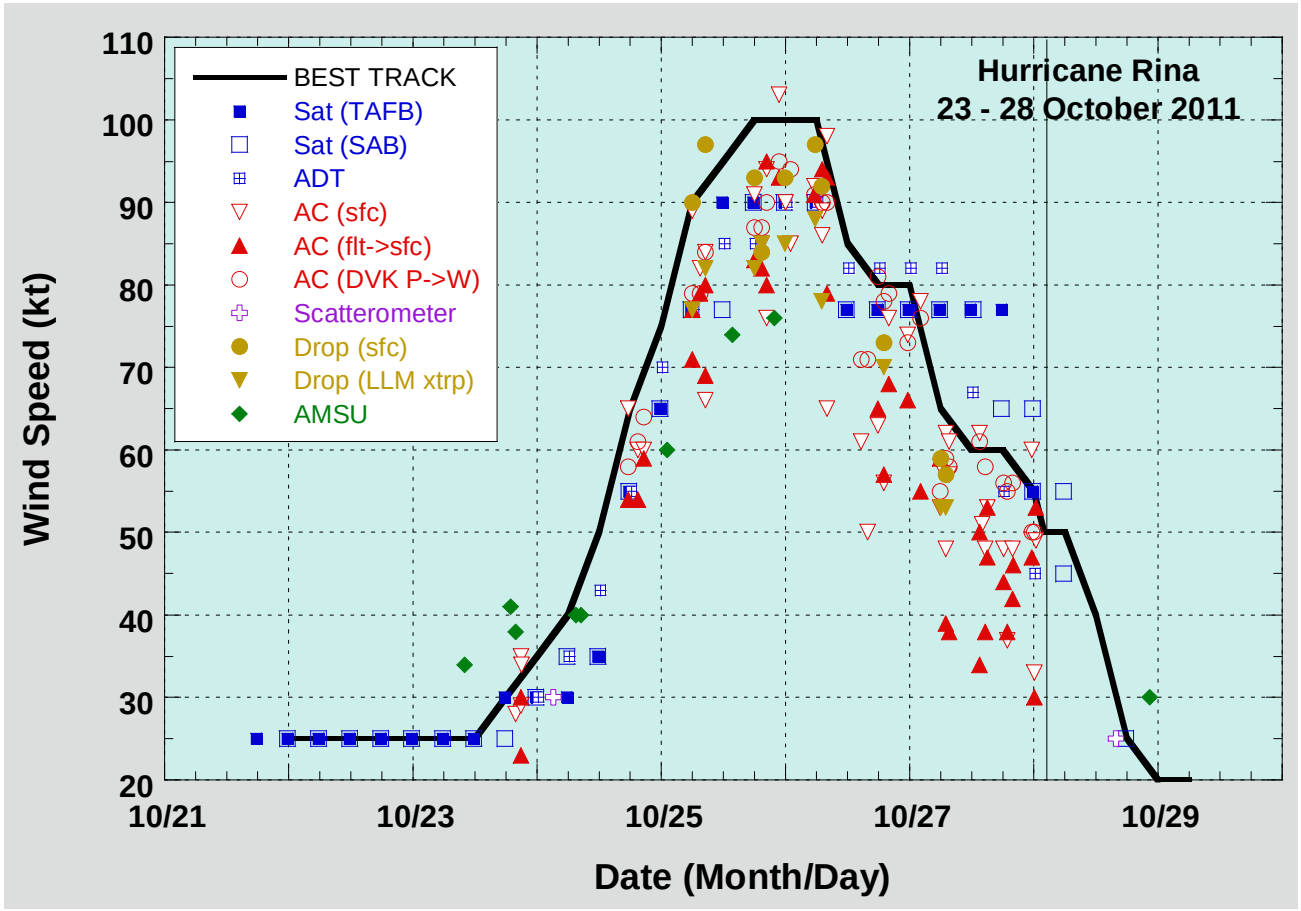

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Rina. Advanced Dvorak Technique (ADT) and AMSU estimates courtesy of UW-CIMSS. Aircraft observations have been adjusted for elevation using 90%, 80%, and 80% reduction factors for observations from 700 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), and from the sounding boundary layer mean (MBL). Solid vertical line represents when the cyclone made landfall in Mexico. Dashed vertical lines correspond to 0000 UTC.

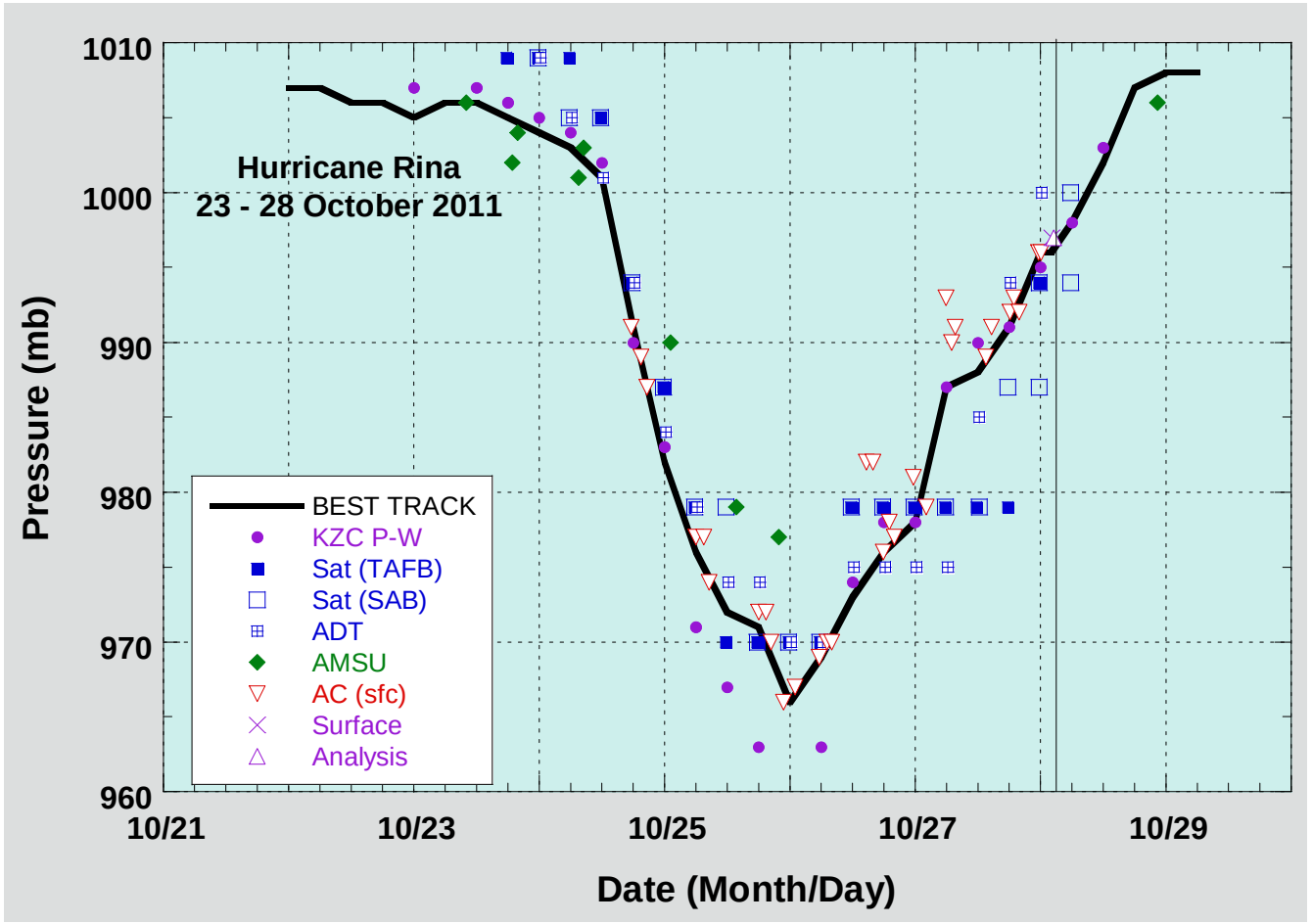

Figure 3. Selected pressure observations and best track minimum central pressure curve for Rina. Advanced Dvorak Technique (ADT) and AMSU estimates courtesy of UW-CIMSS. Dashed vertical lines correspond to 0000 UTC. Solid vertical line represents when the cyclone made landfall. KZC P-W refers to pressure estimates derived by applying the Knaff-Zehr-Courtney pressure-wind relationship to the best track wind speeds.