

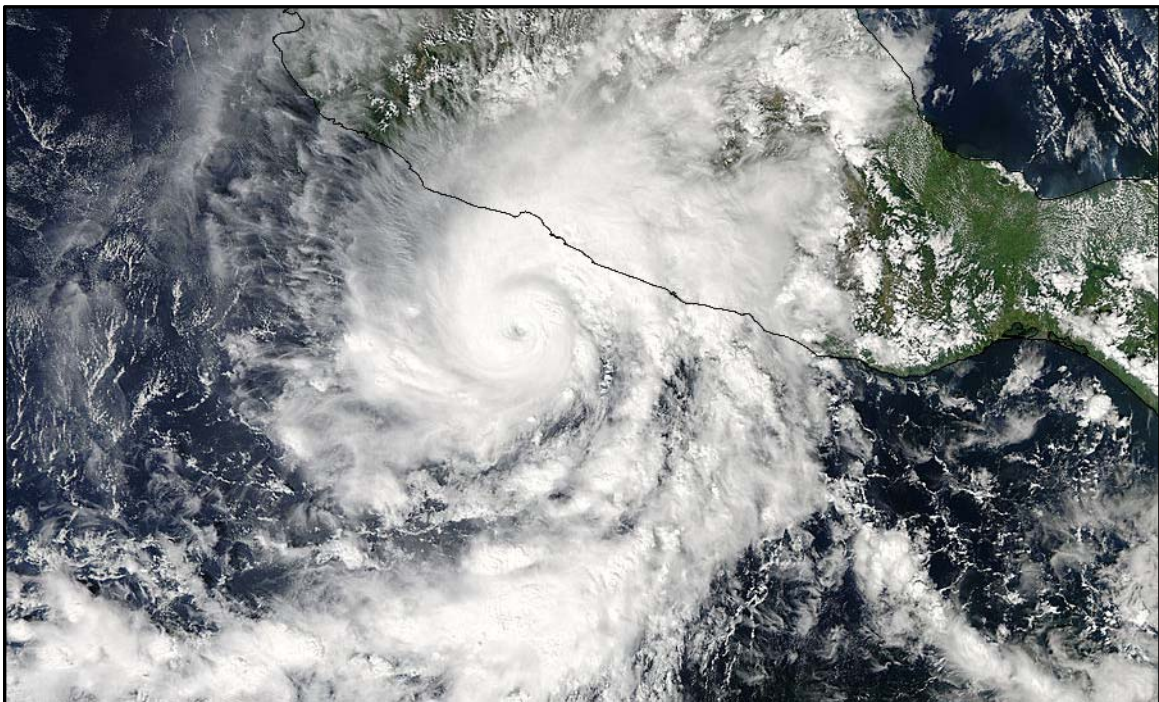


# NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

## HURRICANE RAYMOND (EP172013)

20 – 30 October 2013

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NASA AQUA VISIBLE IMAGE OF HURRICANE RAYMOND AT 2010 UTC 21 OCTOBER 2013 NEAR ITS PEAK INTENSITY

Raymond was a category 3 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that stalled off of the coast of southwestern Mexico for a few days and then weakened while it moved westward away from land. Raymond became a hurricane for a second time well off of the coast of Mexico and ultimately dissipated southwest of the Baja California peninsula. Raymond caused heavy rain and flooding in the state of Guerrero, where devastating flooding had occurred about a month earlier from Tropical Storm Manuel.

# Hurricane Raymond

20 – 30 OCTOBER 2013

## SYNOPTIC HISTORY

Raymond appears to have originated from a disturbance within the Intertropical Convergence Zone. The disturbance can be traced as far back as 13 October when it was located over the extreme southwestern Caribbean Sea, but there are no definitive data to suggest that it originated from an African easterly wave. The disturbance crossed Central America on 15 October and moved over the Pacific Ocean by 16 October with very little associated showers and thunderstorms. The disturbance continued moving westward to the south of the Gulf of Tehuantepec, and deep convection began to develop on 18 October. Shower activity consolidated quickly into curved bands on 19 October, and a low pressure center formed late in the day. The convection became sufficiently organized for the system to be designated as a tropical depression at 0000 UTC 20 October while centered about 190 n mi south-southwest of Acapulco, Mexico. The depression became a tropical storm 6 h later. 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 1<sup>1</sup>.

When Raymond became a tropical storm, it was located to the south of a deep-layer trough over the United States and northern Mexico, and between two mid-level anticyclones located over the northwestern Caribbean Sea and over the eastern Pacific centered near 130°W. As a result, the storm initially moved northwestward through the break in the ridge. Aided by sea surface temperatures near 30°C and low shear, Raymond rapidly intensified from a 30-kt tropical depression to a 110-kt category 3 hurricane over a period of 42 h, reaching its peak intensity while centered about 80 n mi south-southwest of Zihuatanejo, Mexico. At the same time, the trough over the United States moved eastward, leaving Raymond in an environment of light steering winds. The cyclone drifted erratically on 21 and 22 October, making a small clockwise loop off the Mexican coast. Since the ocean off of the coast of Mexico has a relatively shallow thermocline, Raymond upwelled colder water when it stalled, which likely contributed to its weakening on 22 October. Microwave and infrared SST data indicate that the water beneath Raymond cooled from about 30°C on 21 October to about 24°C on 24 October (Fig. 4).

Due to the colder water and increasing shear, Raymond weakened almost as rapidly as it had strengthened, becoming a tropical storm by 0600 UTC 23 October and weakening to 40 kt by 1800 UTC. That same day, a low- to mid-level ridge built to the north of the cyclone, accelerating it toward the west-southwest and west away from the Mexican coast through 26

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<sup>1</sup> 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.

October. Vertical shear decreased on 24 October, allowing Raymond to slowly re-strengthen during the next couple of days. The cyclone began a second (albeit less dramatic) period of rapid intensification on 26 October, becoming a hurricane again by 1200 UTC 27 October about 630 n mi south-southwest of the southern tip of the Baja California peninsula and reaching a secondary peak intensity of 90 kt at 0000 UTC 28 October.

The ridge to the north of Raymond weakened due to an amplifying deep-layer trough west of the Baja California peninsula, and Raymond turned abruptly toward the northwest and north on 28 October. Southwesterly shear near Raymond increased that day due to the trough's proximity, and Raymond weakened back to a tropical storm by 0000 UTC 29 October. Gradual weakening continued on 29 October, and Raymond turned toward the northeast on 30 October within the flow ahead of the trough. The cyclone weakened to a tropical depression early on 30 October, and degenerated to a remnant low at 1200 UTC about 320 n mi west-southwest of the southern tip of the Baja California peninsula when it lost all of its deep convection. Steered by the low-level flow, the remnant low turned toward the west and dissipated a little after 0000 UTC 1 November.

## METEOROLOGICAL STATISTICS

Observations in Raymond (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 flight-level, stepped frequency microwave radiometer (SFMR), and dropwindsonde observations from one flight of the 53<sup>rd</sup> Weather Reconnaissance Squadron of the U. S. Air Force Reserve Command. Data and imagery from NOAA polar-orbiting satellites including the Advanced Microwave Sounding Unit (AMSU), the NASA Tropical Rainfall Measuring Mission (TRMM), 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 Raymond.

Ship reports of winds of tropical storm force associated with Raymond are given in Table 2, and selected surface observations from land stations are given in Table 3. Tropical-storm-force winds likely affected a small portion of the coast of Guerrero on 21 and 22 October, but there were no reports of sustained tropical-storm-force winds. A gust to 35 kt was reported at Puerto Vicente on 22 October.

### *Winds*

Raymond's estimated peak intensity of 110 kt at 1800 UTC 21 October is based on a blend of subjective Dvorak satellite intensity estimates of T5.5 (102 kt) from TAFB and T6.0 (115 kt) from SAB, and an objective ADT satellite estimate of T5.6 (105 kt).

The Hurricane Hunters investigated Raymond about a day after it had reached its peak intensity. Satellite intensity estimates at the time suggested that maximum surface winds were between 75-85 kt, however observations from the aircraft were much lower. The maximum flight-level (700 mb) wind measured by the plane was 80 kt at 1854 UTC 22 October, which suggests a surface intensity of between 70-75 kt. The highest wind measured by the SFMR was 55 kt, which adjusted to about 47 kt when corrected for rain effects. In addition, a dropsonde released in the northwestern eyewall measured an average wind of 65 kt in the lowest 150 m of the sounding, corresponding to sustained surface winds near 55 kt. The intensity around the time of the flight is assumed to be near the high end of the various aircraft-based estimates (75 kt).

## Rainfall

Heavy rainfall occurred for several days over the state of Guerrero while Raymond was nearly stationary off of the coast of Mexico (Table 3). Most areas within the state received at least 4 inches of rain, with the greatest totals occurring near the coast. The highest available rainfall total was 14.20 inches from Ixtapa-Zihuatanejo, occurring over the three-day period from 20-22 October. Farther to the southeast, El Veladero reported a five-day rainfall total of 12.02 inches, and two separate stations in Acapulco reported five-day totals of about 10.4 inches.

## CASUALTY AND DAMAGE STATISTICS

There were no reported deaths associated with Raymond. Hundreds of people were evacuated in Guerrero, particularly from those areas that had been affected by severe flooding and landslides in Tropical Storm Manuel in mid-September. Heavy rains caused some flooding, including in Acapulco, but the damage from Raymond was significantly less than the damage caused by Manuel.

## FORECAST AND WARNING CRITIQUE

Raymond's genesis was not particularly well forecast. The possibility of Raymond's formation was first noted in the NHC Tropical Weather Outlook about three days beforehand, and genesis was not expected (given a high chance of formation) until within a day of its occurrence. The table below indicates how far in advance of genesis the NHC official genesis forecasts first reached the indicated likelihood categories.

	Hours Before Genesis	
	48-Hour Outlook	120-Hour Outlook
Low (<30%)	42	78
Medium (30%-50%)	30	72
High (>50%)	12	24

Part of the difficulty in forecasting Raymond’s formation arose from the forecasts from the Global Forecast System (GFS) model, which is one of the more reliable global models for tropical cyclogenesis. The GFS hinted at possible genesis 120 h before the time of actual genesis that was too far east (Fig. 5a) and then showed more definitive formation closer to the actual location of genesis 96 h beforehand (Fig. 5b). However, the model then backed off and did not depict a tropical cyclone 72 and 48 h prior to genesis (Figs. 5c and 5d). Genesis in the GFS was then shown again 24 h prior to formation (Fig. 5e). The trends seen in the GFS between 96 and 48 h before genesis likely contributed to NHC’s low confidence of Raymond’s formation in the days before genesis occurred.

A verification of NHC official track forecasts for Raymond is given in Table 4a. Official forecast track errors were lower than the mean official errors for the previous 5-yr period at every forecast period except 120 h. The low forecast errors occurred despite the fact that Raymond had an atypical track, according to OCD5 errors. A homogeneous comparison of the official track errors with selected guidance models is given in Table 4b. The official track forecasts were relatively skillful compared to most of the track models. Two exceptions were the European Centre for Medium-Range Forecasts model (EMXI) and the Florida State Superensemble (FSSE). EMXI had lower errors than the official forecast at 36, 48, 72, and 120 h, and FSSE had lower errors at 24, 36, 48, 96, and 120 h. The official forecasts were better than the multi-model variable consensus TVCE at all forecast periods except 96 and 120 h.

A verification of NHC official intensity forecasts for Raymond is given in Table 5a. Official forecast intensity errors were greater than the mean official errors for the previous 5-yr period at all forecast periods except 120 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 5b. Overall, the intensity consensus (ICON) had the lowest errors, beating the official intensity forecasts between 36 and 120 h. The individual intensity models beat the official forecasts at various forecast periods, but none had lower errors at a majority of the forecast times. Perhaps most notably, the official intensity forecasts beat all intensity models at 12 and 24 h, despite Raymond’s two periods of rapid intensification (when forecast skill tends to be low). Fig. 6 shows that once the first episode of rapid intensification began, the official forecast (Fig. 6a), as well as the FSSE (Fig. 6c), correctly forecast the remainder of the intensification trend and the ultimate peak intensity, while other models like the consensus (ICON, Fig. 6b) and the HWFI (Fig. 6d) showed no additional strengthening. Fig. 6d shows that the HWFI did do the best job in correctly anticipating the weakening rate after Raymond had reached its peak intensity, but this could have partially been a result of HWFI showing more interaction with land compared to the other models.





Watches and warnings associated with Raymond are given in Table 6. Tropical-storm-force winds likely affected a small portion of the warning area on 21 and 22 October, but Raymond stayed far enough offshore to prevent hurricane-force winds from affecting land.



Table 1. Best track for Hurricane Raymond, 20-30 October 2013.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
19 / 1800	13.2	99.8	1006	25	low
20 / 0000	13.7	100.5	1004	30	tropical depression
20 / 0600	14.2	101.0	1003	35	tropical storm
20 / 1200	14.7	101.4	1000	45	"
20 / 1800	15.2	101.7	993	60	"
21 / 0000	15.7	102.0	978	80	hurricane
21 / 0600	16.0	102.2	965	95	"
21 / 1200	16.2	102.2	956	105	"
21 / 1800	16.4	102.1	951	110	"
22 / 0000	16.4	101.9	955	105	"
22 / 0600	16.4	101.9	962	95	"
22 / 1200	16.4	101.9	969	85	"
22 / 1800	16.3	101.8	987	75	"
23 / 0000	16.0	101.8	988	65	"
23 / 0600	15.7	102.1	990	60	tropical storm
23 / 1200	15.4	102.8	995	55	"
23 / 1800	15.1	103.5	1000	45	"
24 / 0000	14.9	104.2	1002	40	"
24 / 0600	14.8	104.9	1002	40	"
24 / 1200	14.8	105.6	1002	40	"
24 / 1800	14.8	106.4	1002	40	"
25 / 0000	14.6	107.2	1000	45	"
25 / 0600	14.3	107.9	1000	45	"
25 / 1200	13.9	108.5	999	50	"
25 / 1800	13.4	109.3	999	50	"
26 / 0000	13.1	110.3	998	55	"



Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
26 / 0600	13.0	111.3	998	55	"
26 / 1200	13.0	112.2	998	55	"
26 / 1800	13.0	113.0	998	55	"
27 / 0000	13.2	113.9	998	55	"
27 / 0600	13.5	114.8	995	60	"
27 / 1200	13.8	115.6	983	75	hurricane
27 / 1800	14.2	116.3	979	80	"
28 / 0000	14.8	116.8	972	90	"
28 / 0600	15.4	117.0	971	90	"
28 / 1200	16.0	117.0	977	80	"
28 / 1800	16.4	117.0	990	65	"
29 / 0000	16.8	117.0	998	50	tropical storm
29 / 0600	17.4	117.0	1002	45	"
29 / 1200	18.0	116.9	1003	40	"
29 / 1800	18.6	116.5	1004	40	"
30 / 0000	19.0	115.9	1005	40	"
30 / 0600	19.4	115.3	1006	30	tropical depression
30 / 1200	19.9	114.7	1007	30	low
30 / 1800	20.4	114.4	1008	30	"
31 / 0000	20.7	114.4	1009	25	"
31 / 0600	20.9	114.6	1009	20	"
31 / 1200	21.0	114.8	1009	20	"
31 / 1800	21.0	115.0	1010	20	"
01 / 0000	21.0	115.2	1010	20	"
01 / 0600					dissipated
21 / 1800	16.4	102.1	951	110	maximum wind and minimum pressure



Table 2. Selected ship reports with winds of at least 34 kt for Hurricane Raymond, 20-30 October 2013.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/speed (kt)	Pressure (mb)
21 / 1800	VRGA6	16.8	100.9	080 / 35	1010.0
22 / 0000	JMVY	16.8	101.1	070 / 41	999.9
24 / 0000	3FJM9	17.4	102.0	360 / 44	1013.0

Table 3. Selected surface observations for Hurricane Raymond, 20-30 October 2013. Rainfall totals are for the five-day period from 19-23 October.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Total rain (in)
	Date/time (UTC)	Press. (mb)	Date/time (UTC) <sup>a</sup>	Sustained (kt) <sup>b</sup>	Gust (kt)	
<b>Mexico</b>						
<b>Guerrero</b>						
Ixtapa-Zihuatanejo (17.60N 101.46W)						14.20
El Veladero (16.88N 99.91W)						12.02
Acapulco (16.76N 99.75W)						10.43
Acapulco (16.76N 99.75W)						10.41
Copala (16.59N 98.91W)						9.04
Puerto Vicente (17.27N 101.06W)			22 Oct		35	7.82
Cuajinicuilapa (16.47N 98.40W)						5.05
Chilpancingo (16.91N 99.94W)						4.22
Petalcalco (17.98N 102.12W)						2.41

<sup>a</sup> Date/time is for sustained wind when both sustained and gust are listed.

<sup>b</sup> Except as noted, sustained wind averaging periods for C-MAN and land-based reports are 2 min; buoy averaging periods are 8 min.



Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Raymond, 20-30 October 2013. 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	<b>22.0</b>	<b>32.3</b>	<b>43.5</b>	<b>58.4</b>	<b>94.9</b>	<b>136.4</b>	185.1
OCD5	38.3	79.3	135.3	200.7	313.4	391.6	456.1
Forecasts	40	38	36	34	30	26	22
OFCL (2008-12)	27.0	43.1	57.8	71.9	101.7	137.2	165.9
OCD5 (2008-12)	37.4	73.0	114.9	158.3	238.4	313.5	389.1

Table 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Raymond, 20-30 October 2013. 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	22.1	32.4	43.7	58.9	95.6	133.9	185.3
OCD5	39.4	83.4	142.0	205.9	316.0	397.8	435.6
GFSI	28.2	40.8	48.0	64.1	100.9	<b>129.8</b>	188.5
GHMI	28.6	50.8	79.7	109.1	153.6	186.4	220.8
HWFI	27.6	44.5	60.1	75.0	112.4	163.9	272.5
EGRI	34.0	60.0	82.6	106.8	140.3	170.6	252.0
EMXI	23.6	32.7	<b>41.3</b>	<b>51.6</b>	<b>85.4</b>	137.5	<b>164.6</b>
CMCI	33.2	57.0	73.8	94.7	142.8	186.7	210.8
TCON	24.6	38.9	54.9	75.4	107.9	<b>132.3</b>	193.2
TVCE	23.3	33.8	47.3	64.7	96.4	<b>123.1</b>	<b>175.5</b>
FSSE	23.0	<b>32.2</b>	<b>41.9</b>	<b>57.9</b>	96.1	<b>133.2</b>	<b>183.8</b>
AEMI	32.2	50.6	60.0	79.8	125.0	154.5	204.4
BAMS	47.1	85.5	125.4	167.4	235.8	290.7	414.2
BAMM	34.3	60.1	77.6	98.3	122.6	164.0	216.6
BAMD	48.9	86.3	117.3	157.5	222.6	323.1	486.2
Forecasts	37	34	32	31	27	24	15

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Raymond, 20-30 October 2013. 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	7.1	15.0	19.0	18.4	16.7	18.3	<b>14.3</b>
OCD5	9.5	17.7	21.5	20.5	16.3	18.8	23.7
Forecasts	40	38	36	34	30	26	22
OFCL (2008-12)	6.3	10.5	13.4	14.5	15.3	17.0	17.3
OCD5 (2008-12)	7.6	12.5	16.5	18.8	20.4	20.3	20.6

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Raymond, 20-30 October 2013. 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 5a due to the homogeneity requirement.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	7.4	14.9	18.9	18.0	17.5	17.5	12.7
OCD5	9.7	17.7	21.3	19.2	<b>15.7</b>	18.6	25.5
HWFI	9.9	15.0	<b>14.4</b>	<b>14.0</b>	20.9	23.6	26.7
GHMI	11.2	19.2	20.8	20.3	21.6	24.6	21.8
DSHP	9.1	16.3	20.1	18.3	<b>17.0</b>	<b>15.4</b>	<b>11.5</b>
LGEM	9.0	15.7	20.1	20.8	19.5	20.1	15.9
ICON	9.5	15.4	<b>17.2</b>	<b>15.8</b>	<b>13.8</b>	<b>12.1</b>	<b>10.3</b>
IVCN	9.5	15.4	<b>17.2</b>	<b>15.8</b>	<b>13.8</b>	<b>12.1</b>	<b>10.3</b>
FSSE	8.1	<b>13.5</b>	<b>16.1</b>	<b>14.3</b>	18.0	17.9	20.5
Forecasts	38	35	33	32	28	24	15

Table 6. Watch and warning summary for Hurricane Raymond, 20-30 October 2013.

<b>Date/Time (UTC)</b>	<b>Action</b>	<b>Location</b>
20 / 0300	Tropical Storm Watch issued	Acapulco to Lázaro Cárdenas
20 / 2100	Tropical Storm Watch changed to Tropical Storm Warning	Acapulco to Lázaro Cárdenas
20 / 2100	Tropical Storm Watch changed to Hurricane Watch	Acapulco to Lázaro Cárdenas
21 / 0300	Tropical Storm Warning modified to	Acapulco to Tecpán de Galeana
21 / 0300	Hurricane Watch modified to	Acapulco to Tecpán de Galeana
21 / 0300	Hurricane Warning issued	Tecpán de Galeana to Lázaro Cárdenas
23 / 0300	Tropical Storm Warning modified to	Acapulco to Lázaro Cárdenas
23 / 0300	Hurricane Watch discontinued	All
23 / 0300	Hurricane Warning discontinued	All
23 / 1200	Tropical Storm Warning discontinued	All

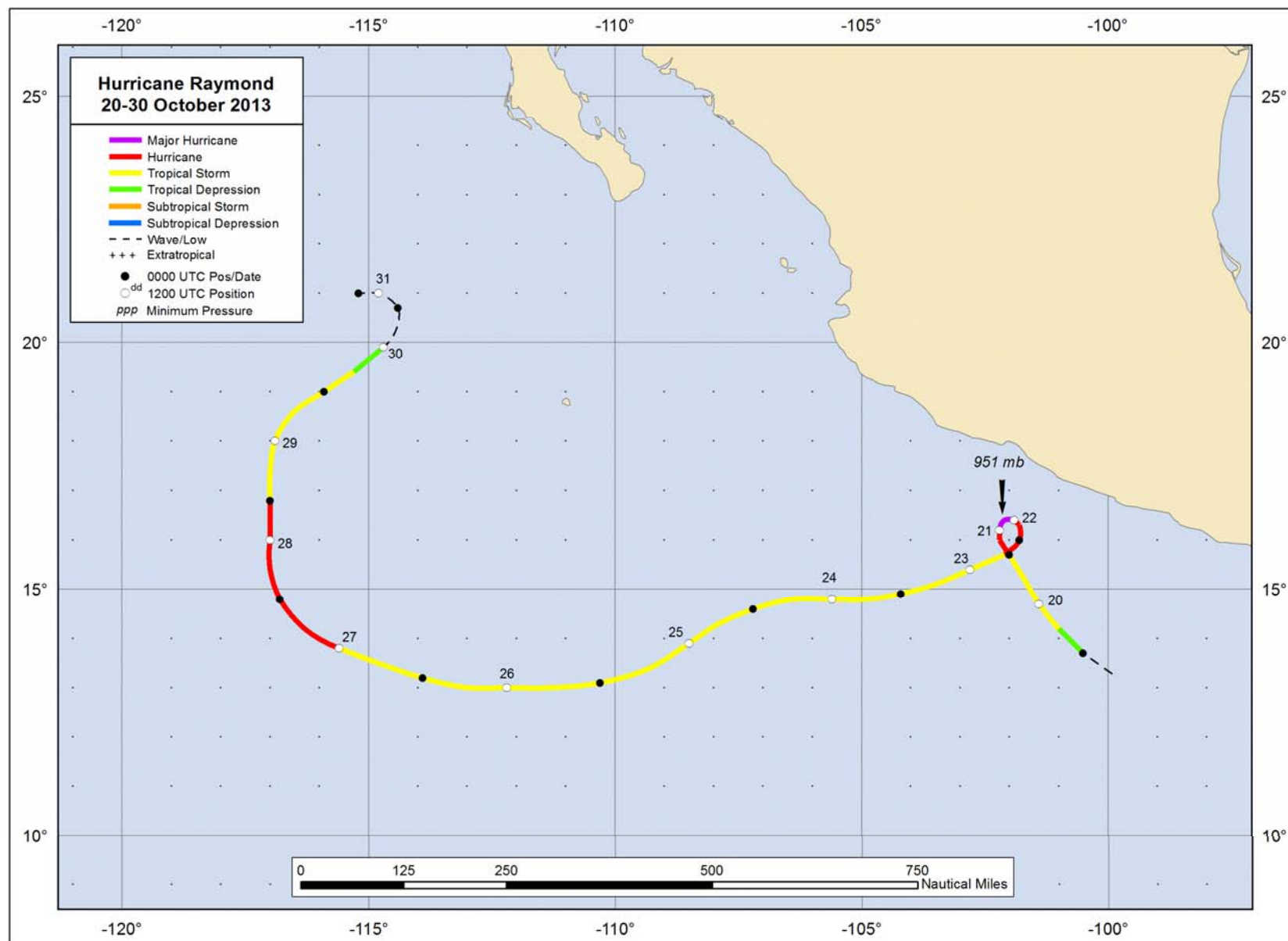


Figure 1. Best track positions for Hurricane Raymond, 20-30 October 2013.



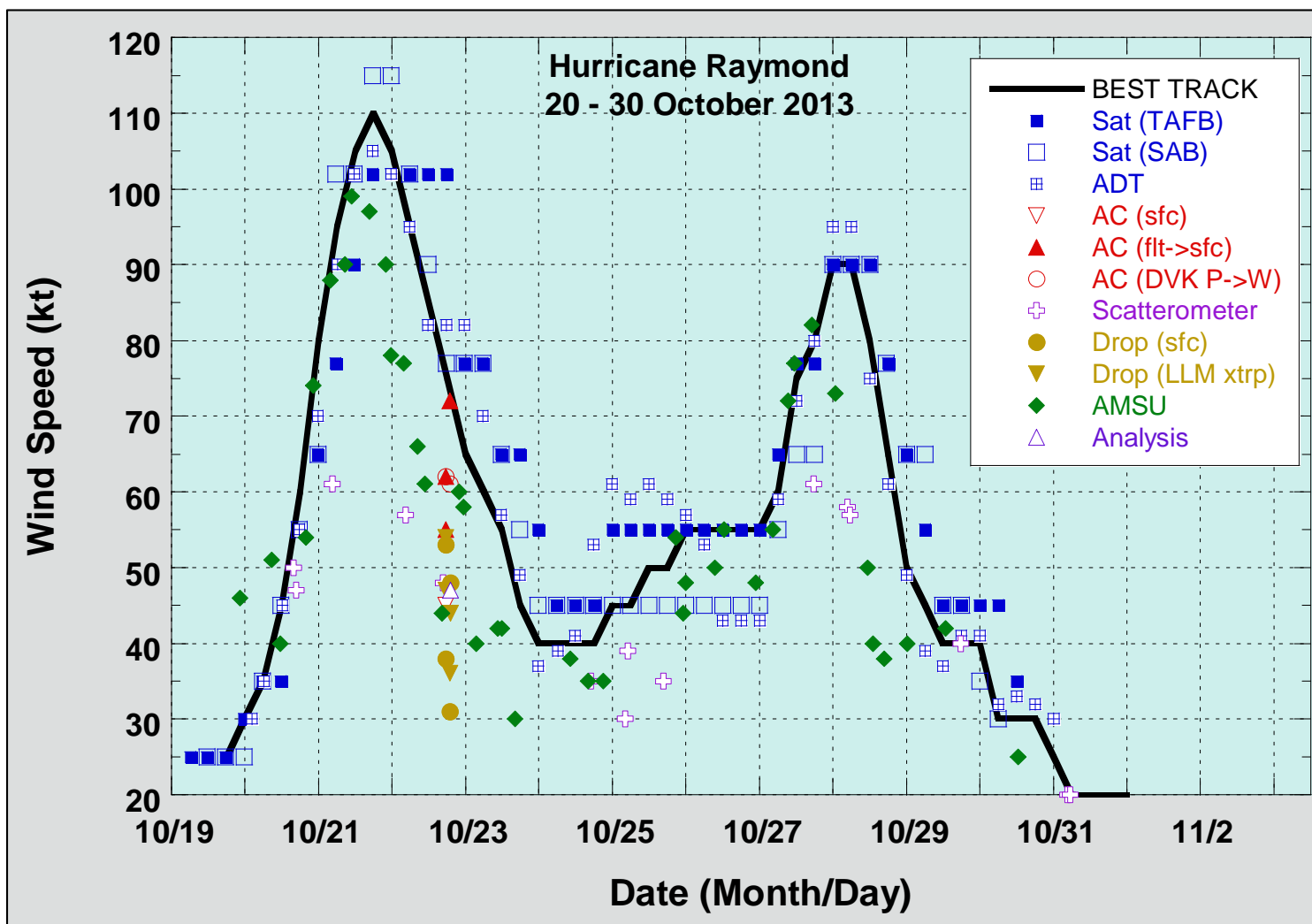


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Raymond, 20-30 October 2013. Aircraft observations have been adjusted for elevation using a 90% adjustment factor for observations from 700 mb. Dropwindsonde observations include actual 10 m winds (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. AMSU intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies technique. Dashed vertical lines correspond to 0000 UTC.

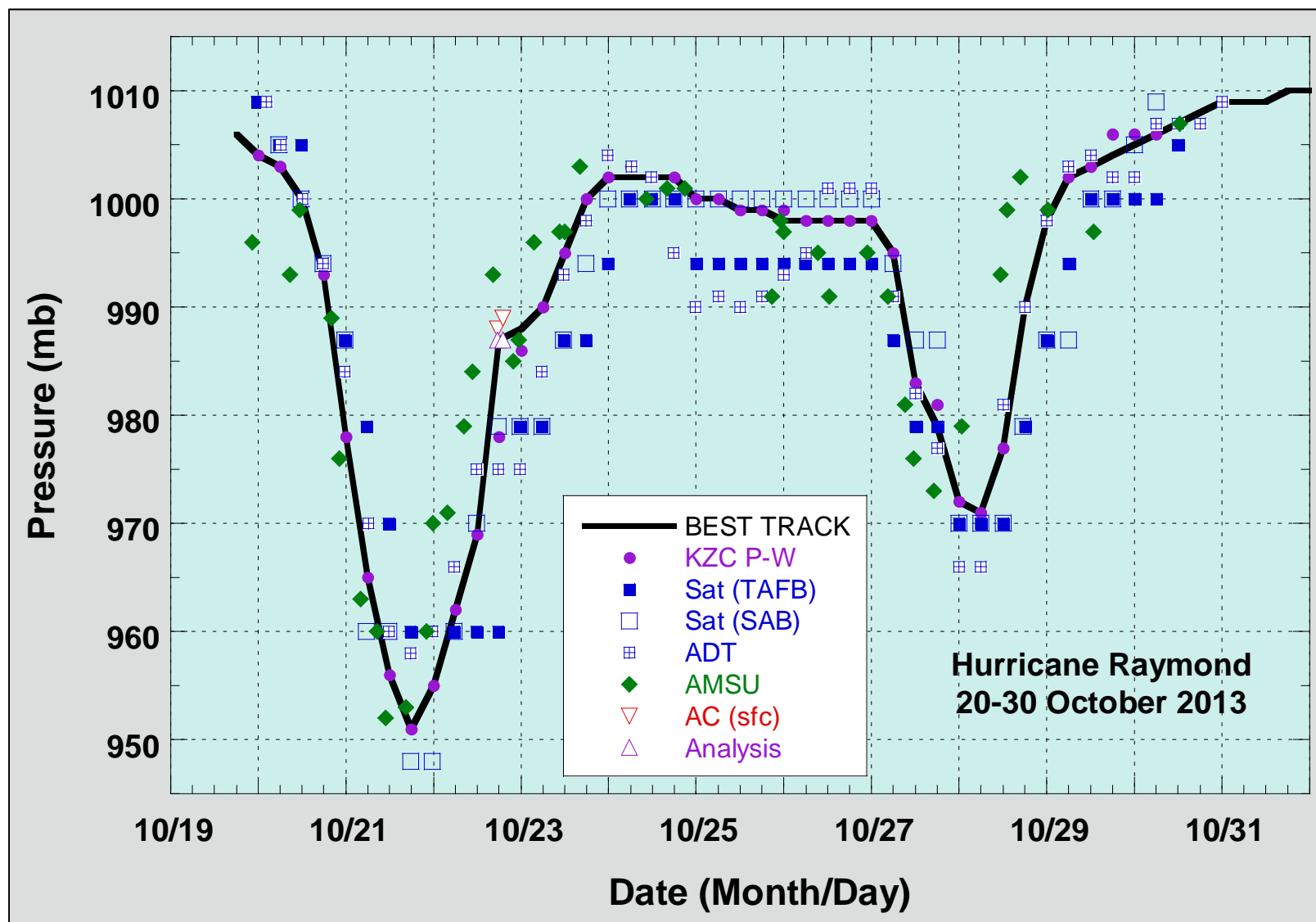


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Raymond, 20-30 October 2013. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological 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.

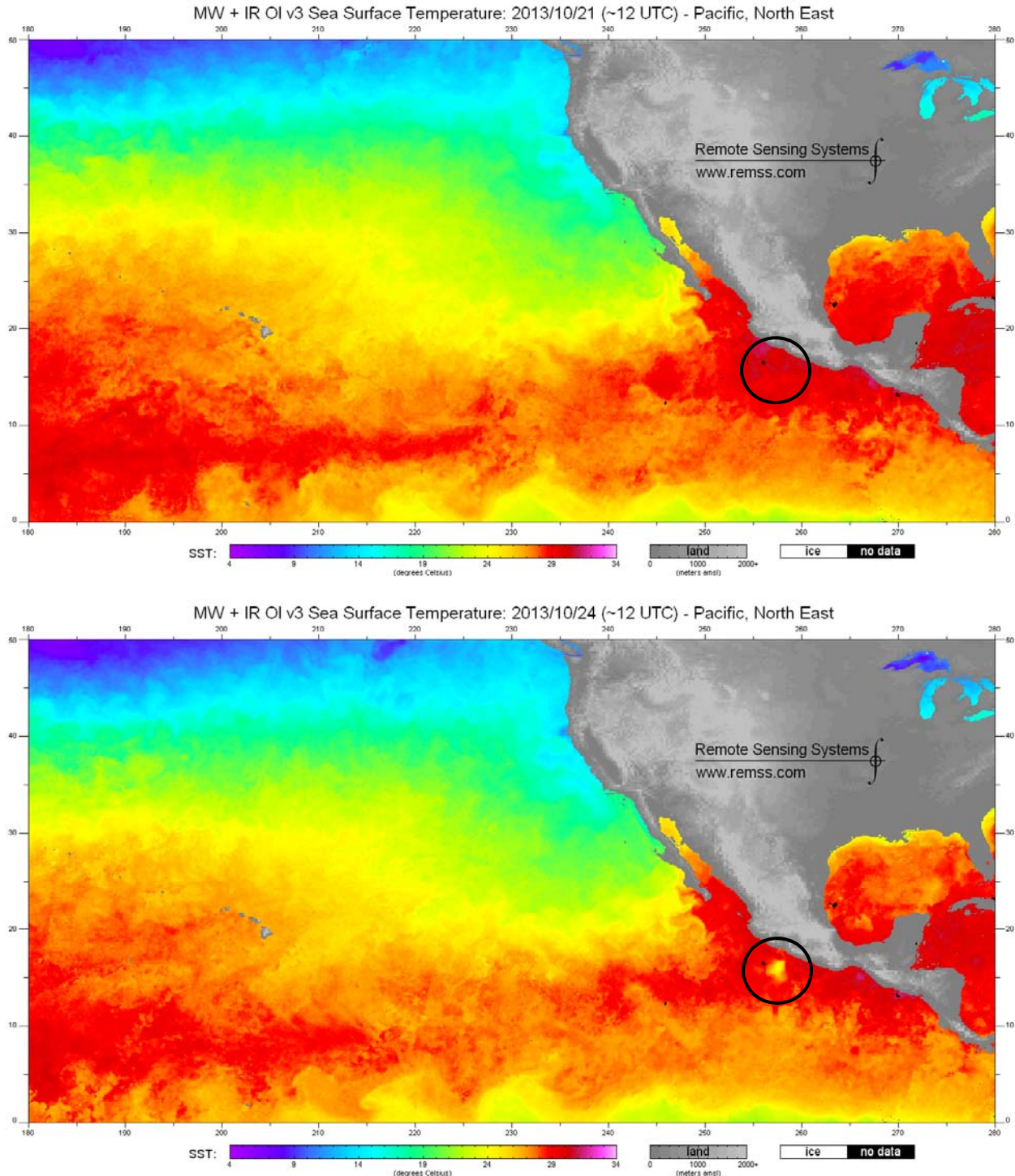


Figure 4. Combined microwave and infrared optimally interpolated (OI) sea surface temperature (SST) fields over the eastern North Pacific on (a) 21 October 2013 and (b) 24 October 2103. A small area of lower SSTs (location indicated by the black circle) developed off the coast of Mexico by 24 October due to upwelling caused by Raymond. Microwave OI SST data are produced by Remote Sensing Systems and sponsored by National Oceanographic Partnership Program (NOPP), the NASA Earth Science Physical Oceanography Program, and the NASA MEaSUREs DISCOVER Project. Data are available at [www.remss.com](http://www.remss.com).

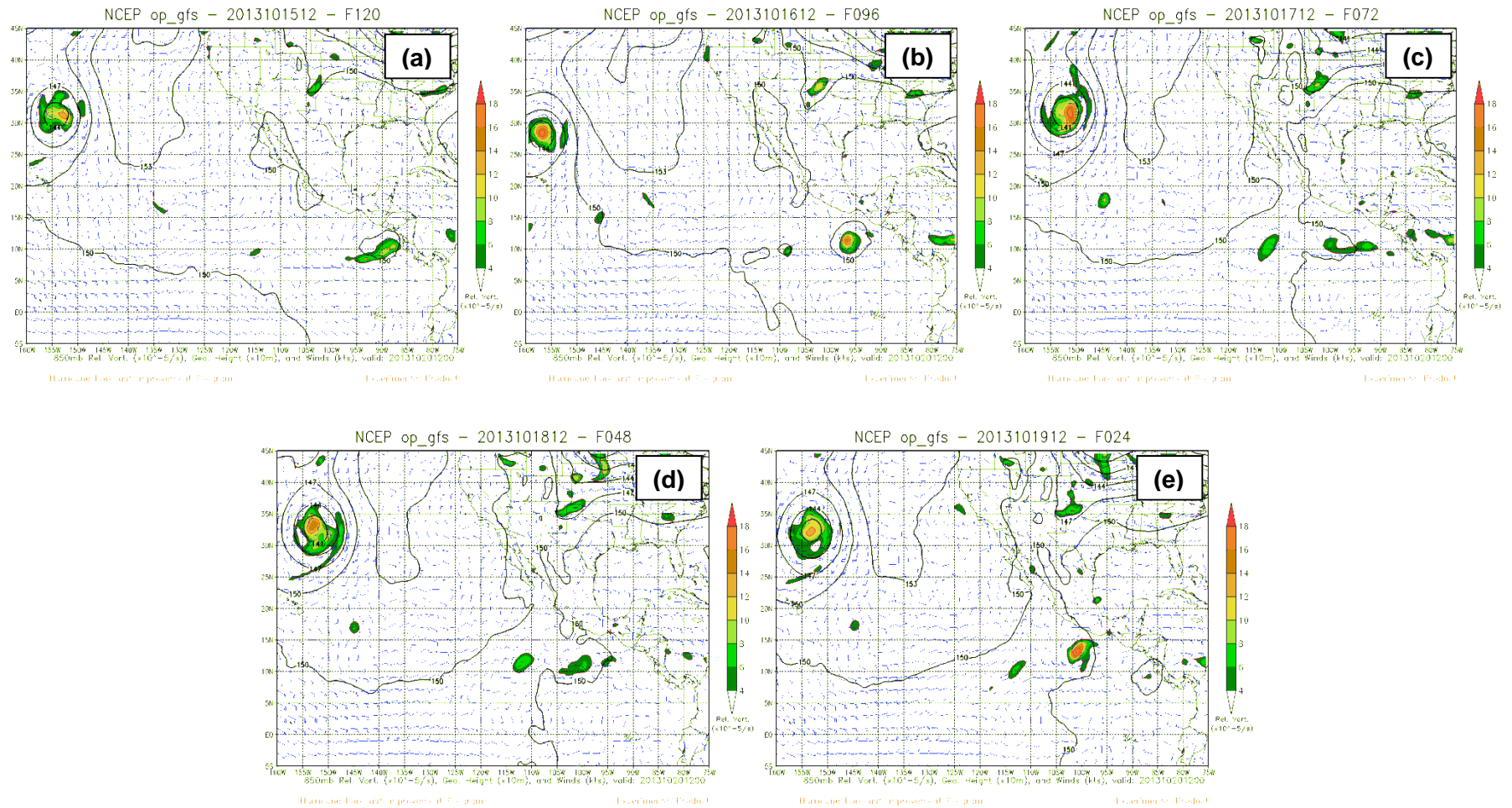


Figure 5. GFS 120- (a), 96- (b), 72- (c), 48- (d), and 24-h (e) forecasts of 850 mb relative vorticity (shaded areas,  $\times 10^{-5} \text{ s}^{-1}$ ), 850 mb geopotential height (black lines, dm), and 850 mb winds (barbs, kt) valid at 1200 UTC 20 October 2013. The figures show that the GFS suggested that Raymond would form 96 h before its actual genesis south of the Gulf of Tehuantepec (b), but the model then backed off and did not show a cyclone 72 h beforehand (c). More defined cyclogenesis was then indicated again 24 h before formation (e).



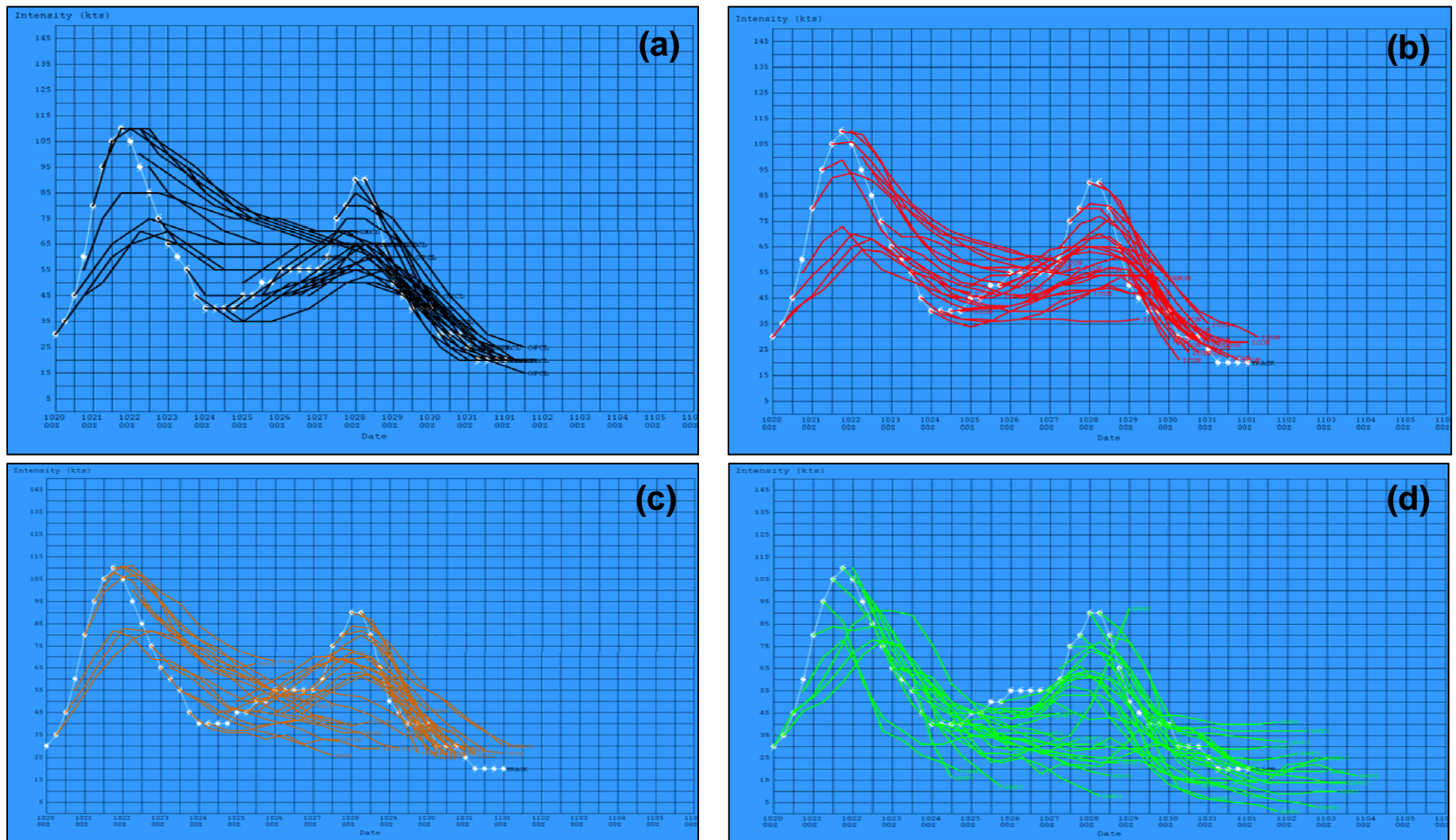


Figure 6. (a) Official intensity forecasts, (b) intensity consensus (ICON) forecasts, (c) FSSE forecasts, and (d) HWFI forecasts for Hurricane Raymond, 20-30 October 2013. The best track intensity is denoted by the white line in all figures.