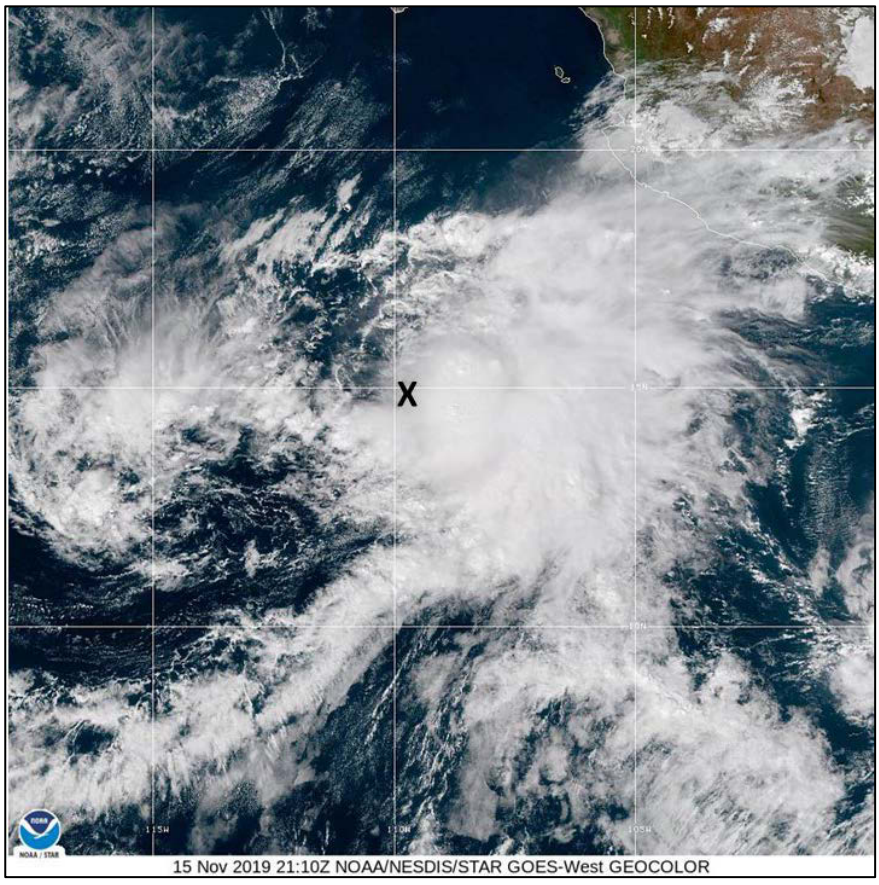
NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

TROPICAL STORM RAYMOND

(EP202019)

14–17 November 2019

Daniel P. Brown
National Hurricane Center
13 January 2020



GOES-17 GEOCOLOR IMAGE OF TROPICAL STORM RAYMOND AT 2110 UTC 15 NOVEMBER AROUND THE TIME THE STORM REACHED ITS PEAK INTENSITY. THE "X" DENONTES THE APPROXIMATE CENTER OF RAYMOND. IMAGE COURTESY OF NOAA/NESDIS/STAR.

Raymond was a late-season tropical storm that passed near Socorro Island after it had weakened to a tropical depression.

Tropical Storm Raymond

14–17 NOVEMBER 2019

SYNOPTIC HISTORY

The complex origin of Raymond can be traced back to a tropical wave that departed the west coast of Africa on 27 October. The wave moved westward across the tropical Atlantic with limited convective activity. When the wave crossed the southwestern Caribbean Sea and Central America, the associated shower and thunderstorm activity briefly increased. The shower activity, however, decreased when the system moved over the far eastern Pacific on 6 November. While the wave passed south of the coast of southern Mexico a few days later, the associated low-level vorticity was enhanced due to an ongoing Gulf of Tehuantepec gap wind event. An eastward-moving convectively coupled Kelvin wave (Fig. 1) passed the longitude of the wave around 12–13 November, aiding in the formation of a low pressure area and an increase in the associated deep convection. The tropical wave continued westward, while the low pressure area, located about 700 n mi south of the southern tip of the Baja California peninsula, began to move east-northeastward to the southeast of a mid- to upper-level low and associated trough that extended southwestward from the central portion of the Baja California peninsula. Early on 14 November, the associated deep convection markedly increased, and by 1200 UTC that day the convection became sufficiently well-organized to result in the formation of a tropical depression about 650 n mi south of the southern tip of the Baja California peninsula. The "best track" chart of the tropical cyclone's path is given in Fig. 2, with the wind and pressure histories shown in Figs. 3 and 4, respectively. The best track positions and intensities are listed in Table 1[1].

After genesis, the mid- to upper-level trough that had been steering the system east-northeastward lifted out. The depression then turned north-northeastward, followed by a north-northwestward turn when a mid-level ridge built westward from the northwestern Caribbean Sea across the eastern Pacific. Moderate northwesterly shear initially prevented strengthening; however, deep convection increased over the eastern portion of the circulation by 0000 UTC 15 November, and the depression strengthened into a tropical storm 6 h later. Raymond continued to gradually strengthen and it reached its peak intensity of 45 kt by 1800 UTC 15 November (cover photo) when it was located about 510 n mi south of the southern tip of the Baja California peninsula. The tropical storm maintained that intensity for the next 18 h while it moved northwestward around the southwestern portion of the aforementioned ridge. Shortly after 1200 UTC 16 November, Raymond began to encounter increasing southwesterly vertical wind shear from a mid- to upper-level trough that was approaching the central portion of the Baja California peninsula. This shear caused the tropical storm to weaken, and Raymond became a tropical depression by 0600 UTC 17 November. Around that time, the cyclone began to recurve north-northeastward around the southeastern portion of the mid- to upper-level trough. Raymond's

[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.

forward speed increased over the next 12 h, and the center of the cyclone passed just west of Socorro Island around 1330 UTC 17 November. Later that day, strong southwesterly shear caused the remaining thunderstorm activity to become separated from the low-level center, and visible satellite imagery indicated that the circulation became increasingly elongated after 1800 UTC. Shortly thereafter, the tropical depression degenerated into a trough of low pressure when it was located about 170 n mi south of the southern tip of the Baja California peninsula.

METEOROLOGICAL STATISTICS

Observations in Raymond (Figs. 3 and 4) 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. 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 Raymond.

Raymond's estimated peak intensity of 45 kt is based on a blend of scatterometer data and Dvorak classifications of T3.0 (45 kt) from TAFB beginning at 0000 UTC 16 November. ASCAT data from 1624 UTC 15 November revealed peak winds of nearly 40 kt. Shortly thereafter, Raymond's convective structure became better organized, which, along with the subjective Dvorak intensity estimates, support the 45-kt peak intensity.

There were no ship reports of winds of tropical storm force in association with Raymond. Although the center of Raymond passed near Socorro Island on 17 November, tropical-storm-force winds were not observed at the automated weather station on the island. A distinct wind shift was noted when the center moved nearby, and a minimum pressure of 1000.8 mb was reported at 1315 UTC 17 November; however, the pressure from that observing site is typically several millibars too low.

CASUALTY AND DAMAGE STATISTICS

There were no reports of damage or casualties associated with Raymond.

FORECAST AND WARNING CRITIQUE

The genesis of Raymond was adequately forecast, but it occurred somewhat earlier than expected. The disturbance from which Raymond formed was first mentioned in the Tropical Weather Outlook at 1800 UTC 10 November, about 90 h before genesis. At that time, the system

was assigned a low (<40%) chance of formation during the next 5 days (Table 2). The 5-day genesis probabilities reached the medium (40–60%) and high (>60%) categories 42 h and 24 h before formation, respectively. Although the disturbance was given a low chance of formation during the next 2 days beginning 84 h before development, the short-range chances were later removed, and not re-introduced into the Tropical Weather Outlook until 42 h before the tropical cyclone formed. The 2-day probabilities were increased to the medium category 24 h before development and did not reach the high category until 6 h before formation occurred. The upper-level environment was expected to be only marginally favorable for development, and this led to the relatively low probabilities in the 2-day genesis forecasts until shortly before the depression formed. In addition, the global models were mixed as to whether genesis would occur with the ECMWF and its ensembles being somewhat more bullish than the GFS.

A verification of NHC official track forecasts for Raymond is given in Table 3a. Due to Raymond's short existence as a tropical cyclone there were only 10, 8, 6, and 4 verifying forecasts at 12, 24, 36, and 48 h, respectively. Official forecast track errors were much larger than the long-term means, albeit for the small sample size. The average track errors at 24, 36, and 48 h were more than double the 5-year means. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The numerical track model guidance also performed poorly for Raymond. Although the EMXI had the lowest track model errors through 36 h, that model's mean errors were also much higher than usual. The OCD5 mean errors were lower than the NHC forecast and all of the guidance at 36 and 48 h, indicating that neither the NHC forecast nor the track models were skillful at those lead times. The NHC forecasts and much of the model guidance exhibited a right-of-track bias and also predicted a faster northward motion than what occurred (Fig. 5).

A verification of NHC official intensity forecasts for Raymond is given in Table 4a. Official forecast intensity errors were lower than the mean official errors for the previous 5-yr period at all times. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. NHC forecasts correctly anticipated that little overall intensification would occur due to unfavorable upper-level winds; however, the statistical guidance and multi-model consensus aids (ICON and IVCN) had lower mean errors than the official forecast at almost every verifying lead time.

There were no coastal watches or warnings issued in association with Raymond.

Table 1. Best track for Tropical Storm Raymond, 14–17 November 2019.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
13 / 0600	11.2	111.8	1008	25	low
13 / 1200	11.3	111.0	1008	25	"
13 / 1800	11.5	110.2	1008	25	"
14 / 0000	11.9	109.6	1008	25	"
14 / 0600	12.1	108.8	1008	25	"
14 / 1200	12.2	108.3	1008	25	tropical depression
14 / 1800	12.5	108.2	1008	25	"
15 / 0000	12.8	108.3	1007	30	"
15 / 0600	13.2	108.4	1006	35	tropical storm
15 / 1200	13.8	108.7	1004	40	"
15 / 1800	14.4	109.1	1001	45	"
16 / 0000	15.0	109.8	1001	45	"
16 / 0600	15.6	110.6	1001	45	"
16 / 1200	16.0	111.3	1001	45	"
16 / 1800	16.3	111.8	1003	40	"
17 / 0000	16.6	112.0	1004	35	"
17 / 0600	17.2	111.8	1005	30	tropical depression
17 / 1200	18.4	111.3	1005	30	"
17 / 1800	20.1	110.7	1005	30	"
18 / 0000					dissipated
15 / 1800	14.4	109.1	1001	45	maximum wind and minimum pressure

Table 2. Number of hours in advance of formation 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%)	84	90
Medium (40%-60%)	24	42
High (>60%)	6	24

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Raymond, 14–17 November 2019. 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	41.8	75.7	100.9	107.9			
OCD5	58.4	107.9	97.3	92.8			
Forecasts	10	8	6	4			
OFCL (2014-18)	21.1	32.2	41.8	51.8	75.7	101.1	133.7
OCD5 (2014-18)	34.0	69.7	109.0	148.4	223.5	285.5	356.7

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Raymond, 14–17 November 2019. 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	45.1	82.3	109.6	112.7			
OCD5	63.9	118.4	**98.8**	**87.2**			
GFSI	58.4	107.0	137.6	135.2			
HMNI	49.7	87.0	118.9	**108.6**			
HWFI	47.5	94.3	129.4	**101.2**			
EMXI	**36.2**	**67.2**	**102.3**	140.7			
NVGI	50.6	85.9	115.5	126.5			
AEMI	51.4	92.5	116.0	**111.9**			
HCCA	**41.7**	**78.3**	113.5	122.6			
TVCX	**41.0**	**75.8**	**107.2**	114.1			
GFEX	**43.2**	**81.8**	114.0	128.3			
TVCE	**42.9**	**79.1**	111.1	**111.4**			
TVDG	**42.3**	**76.0**	**106.2**	**110.2**			
TABD	63.3	181.2	294.8	388.2			
TABM	**44.7**	106.3	170.9	204.4			
TABS	50.0	83.5	116.2	118.5			
Forecasts	9	7	5	3			

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Raymond, 14–17 November 2019. 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	**6.0**	**7.5**	**7.5**	**7.5**			
OCD5	5.2	9.9	13.2	19.5			
Forecasts	10	8	6	4			
OFCL (2014-18)	6.1	10.0	12.2	13.7	15.5	15.4	15.7
OCD5 (2014-18)	7.9	13.1	16.7	19.2	21.8	22.9	22.1

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Raymond, 14–17 November 2019. 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	5.6	7.1	8.0	8.3			
OCD5	**5.3**	10.7	15.6	22.3			
GFSI	**4.0**	**5.4**	8.4	**8.0**			
HMNI	5.8	**6.0**	9.4	12.7			
HWFI	5.7	7.6	10.4	13.3			
EMXI	6.6	12.3	13.8	13.7			
HCCA	**5.3**	7.4	8.6	11.3			
LGEM	**4.9**	**6.4**	**6.4**	**4.0**			
DSHP	**4.2**	**6.3**	**6.4**	**3.7**			
ICON	**4.8**	**6.0**	**7.0**	**6.0**			
IVCN	**4.9**	**6.4**	**7.4**	8.7			
IVDR	**5.0**	**6.9**	8.0	11.0			
Forecasts	9	7	5	3			

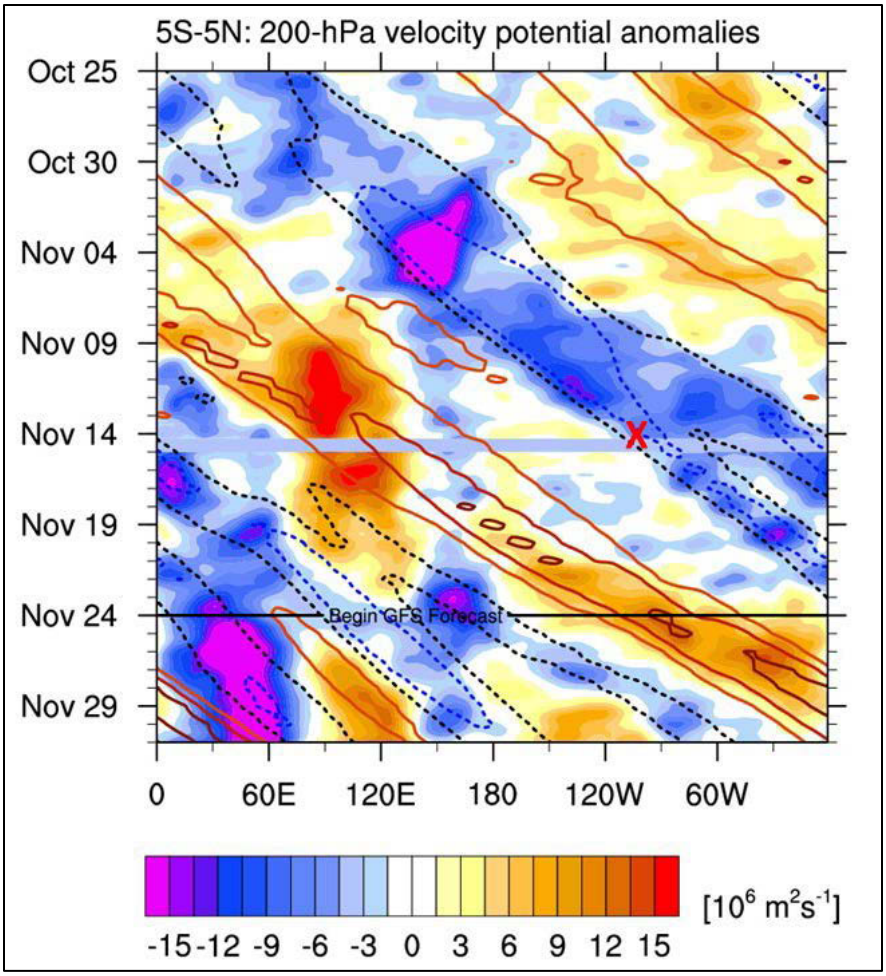


Figure 1. Hovmöller diagram of 200-mb velocity potential anomalies from 5°S to 5°N from the GFS analysis and forecast. Note the passage of a convectively coupled Kelvin wave (CCKW) just east of 120°W (blue shading) around November 12–13. This CCKW aided in the formation of Raymond, which is marked by the red "X" on the figure. Image courtesy of Michael Ventrice, IBM/The Weather Channel, in collaboration with the University of Albany, Albany NY.

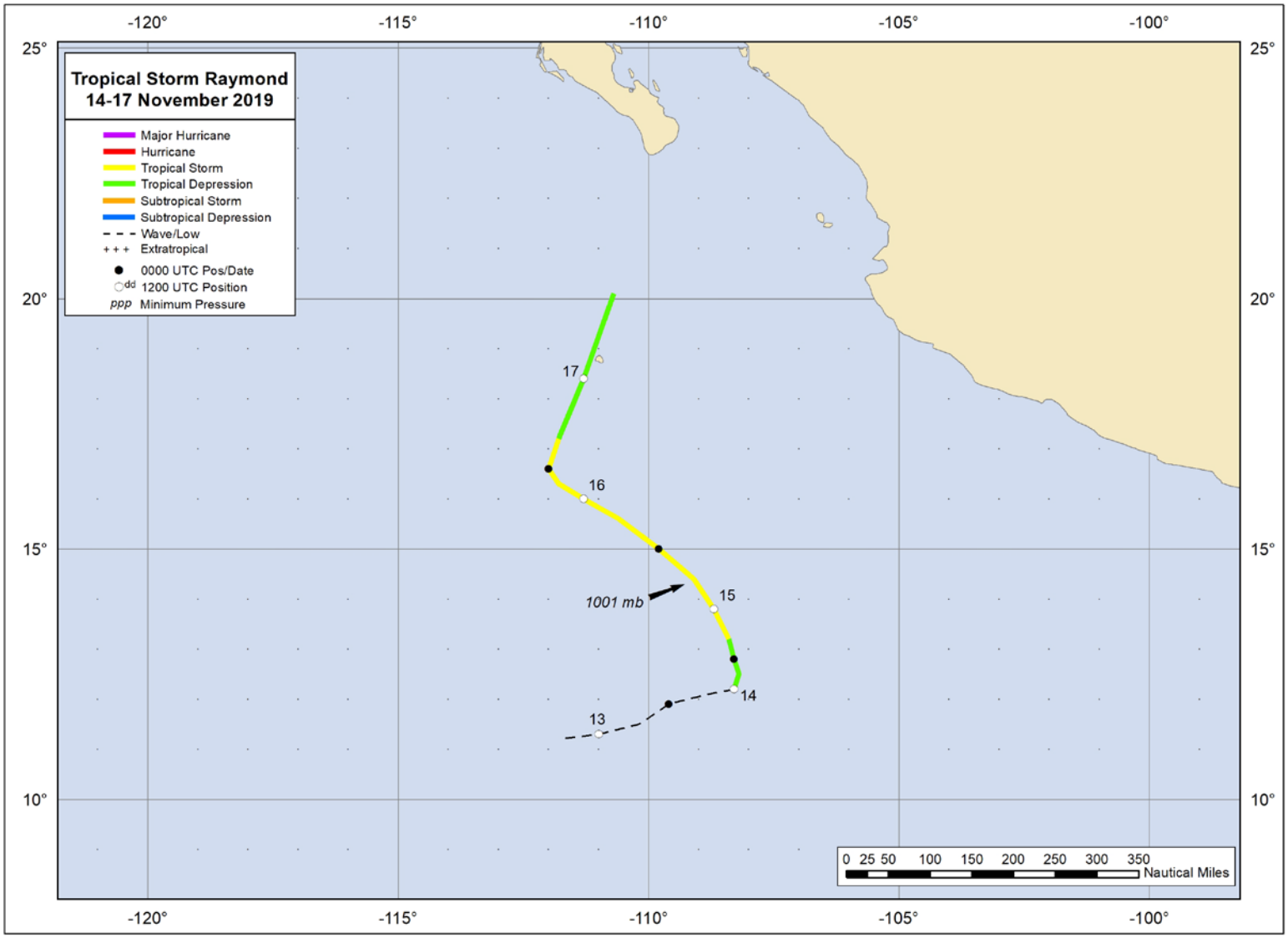


Figure 2. Best track positions for Tropical Storm Raymond, 14–17 November 2019.

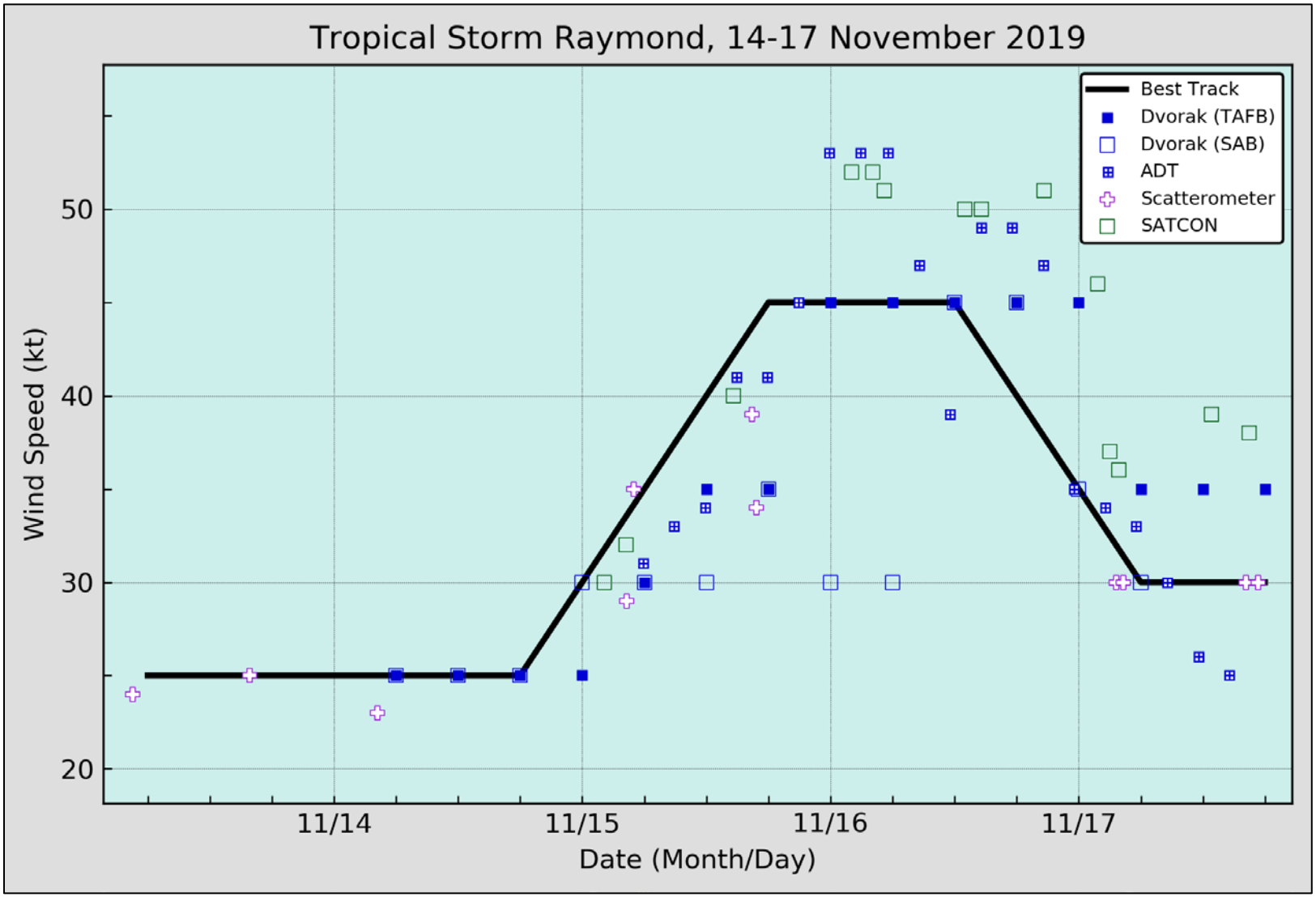


Figure 3. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Raymond, 14–17 November 2019. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC.

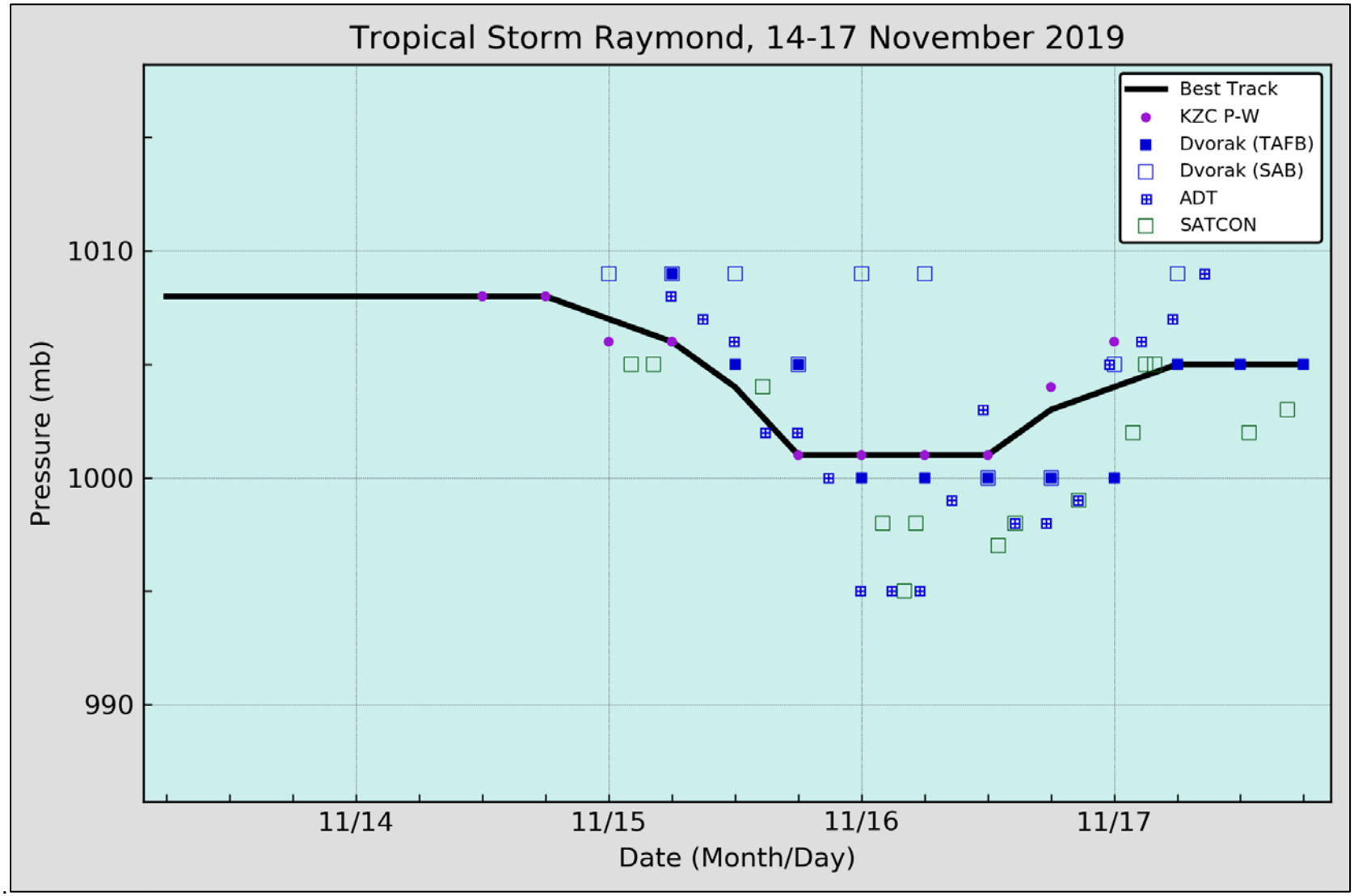


Figure 4. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Raymond, 14–17 November 2019. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for 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.

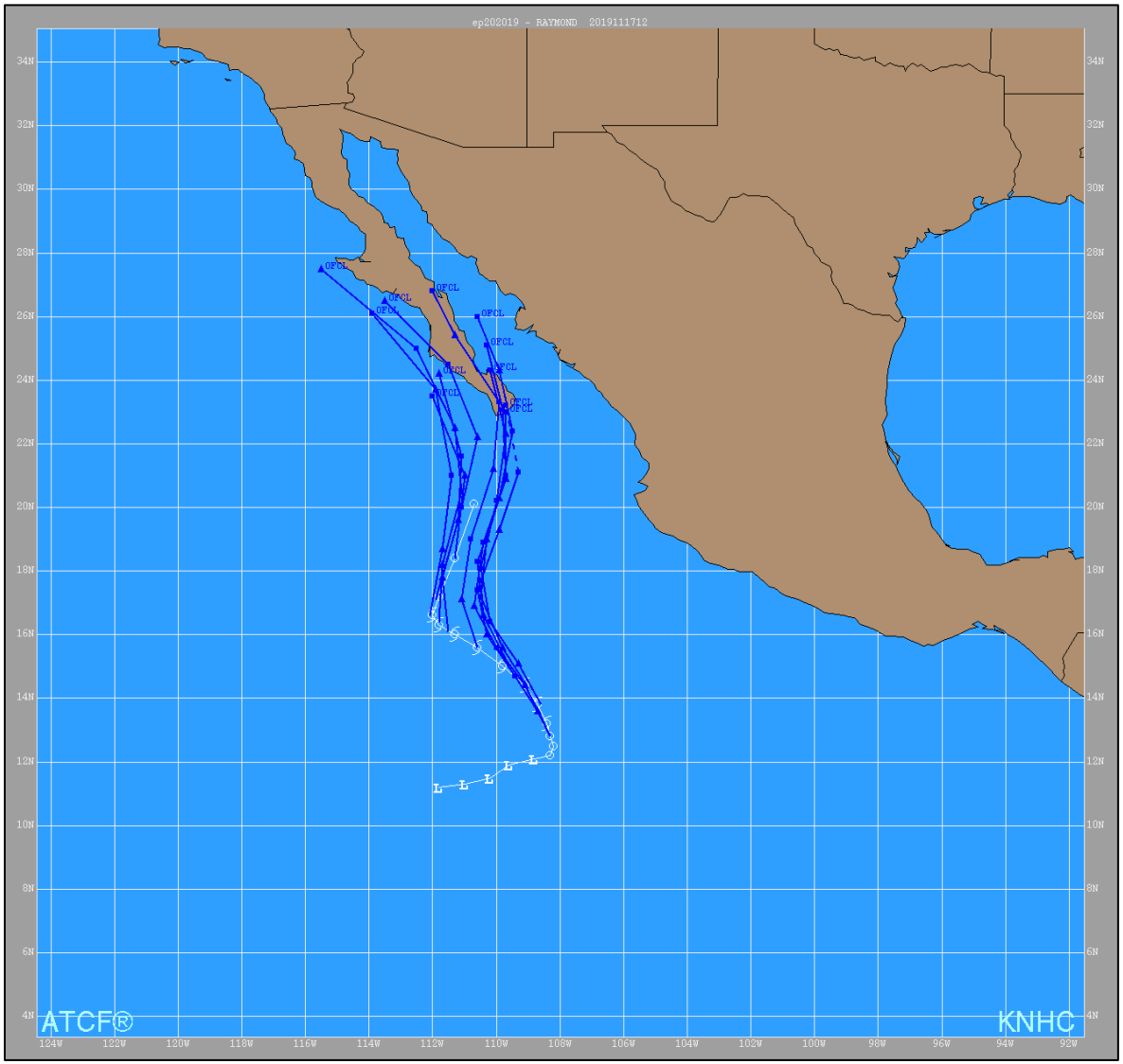


Figure 5. Official track forecasts (solid blue lines, with 0, 12, 24, 36, 48, 72, 96, and 120 h positions indicated) for Tropical Storm Raymond. The best track is given by the solid white line with positions given at 6-h intervals. Note the right-of-track bias of the official forecasts, especially early in Raymond's lifecycle. The official forecasts showed the cyclone reaching the Baja California peninsula, but they correctly predicted that Raymond would not be a tropical cyclone when it reached that area.