

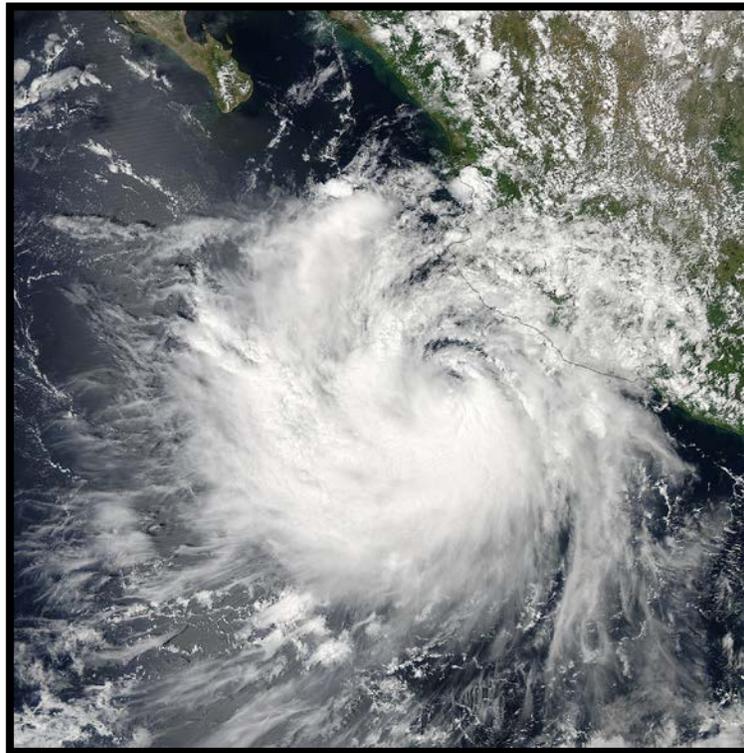


NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE POLO (EP172014)

16 – 22 September 2014

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National Hurricane Center
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AQUA/MODIS IMAGE OF POLO AT 2035 UTC 18 SEPTEMBER 2014 OFF THE COAST OF MEXICO, AFTER IT HAD WEAKENED FROM A HURRICANE TO A TROPICAL STORM. IMAGE COURTESY OF NASA.

Polo moved northwestward close to the west coast of Mexico, becoming a category 1 hurricane (on the Saffir-Simpson Hurricane Wind Scale) southwest of Manzanillo. Two lives were lost due to waves and rip currents caused by Polo, and the large waves also caused some damage along the coast.

Hurricane Polo

16 – 22 SEPTEMBER 2014

SYNOPTIC HISTORY

Polo's genesis appears to be associated with a surface trough over the far eastern North Pacific and a well-defined tropical wave that moved off the coast of Africa early on 4 September. The wave was convectively active and associated with a closed low pressure system when it moved over the far eastern Atlantic Ocean, but dry air and cool sea surface temperatures over the tropical Atlantic caused deep convection to decrease gradually and the low to dissipate by 8 September. The tropical wave continued westward, reaching the Lesser Antilles on 11 September and then Central America on 14 September. While the tropical wave was crossing Central America, an eastward-moving Kelvin wave was already enhancing the development of deep convection over the far eastern Pacific Ocean in the wake of Hurricane Odile. Scatterometer data indicate that an elongated surface trough developed within the deep convection, but the circulation does not appear to have closed off until the tropical wave reached the area late on 15 September. Subsequent scatterometer data showed that tropical-storm-force winds were already occurring on the southern side of the circulation at the time that a well-defined center formed, and it is estimated that the system became a tropical storm by 0000 UTC 16 September while located about 270 n mi south of Puerto Escondido, Mexico. 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.

With a mid-tropospheric high centered over southern Texas and northeastern Mexico, Polo moved generally northwestward and paralleled the Pacific coast of Mexico for several days. Although moderate northeasterly shear was affecting the cyclone when it first formed, the shear decreased later on 16 September and remained fairly low until early on 18 September. Meanwhile, sea surface temperatures were around 29°C, and the favorable conditions allowed Polo to gradually strengthen to a hurricane by 0000 UTC 18 September when it was located about 175 n mi west-southwest of Zihuatanejo, Mexico. Polo exhibited a tiny eye in 89-GHz microwave imagery when it became a hurricane (Fig. 4a), and it maintained that structure through 1500 UTC (Fig. 4b). Only a few hours later, microwave imagery showed that vertical shear had exposed the low-level center to the north of the cyclone's main area of deep convection (Fig. 4c). In addition, data from an Air Force Reserve Hurricane Hunter flight during the afternoon indicate that Polo had weakened to a tropical storm by 1800 UTC 18 September while centered about 115 n mi south-southwest of Manzanillo, Mexico.

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.

Polo remained a strong tropical storm for about a day but then began to weaken after 1800 UTC 19 September as vertical shear increased further. The storm continued to move northwestward, with deep convection decreasing in coverage significantly on 20-21 September. Polo moved within 75 n mi of the southern tip of the Baja California peninsula early on 21 September and then turned west-northwestward away from the peninsula due to the influence of lower-level flow. Moderate vertical shear caused additional weakening, and Polo became a tropical depression by 0600 UTC 22 September while centered about 200 n mi west of the southern tip of the Baja California peninsula. The depression degenerated into a remnant low about 6 h later when all of the associated deep convection had dissipated. The remnant low moved slowly southwestward for another four days and dissipated about 800 n mi west-southwest of the southern tip of the Baja California peninsula shortly after 1800 UTC 26 September.

METEOROLOGICAL STATISTICS

Observations in Polo (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 53rd 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 Polo.

Polo's estimated peak intensity of 65 kt beginning at 0000 UTC 18 September is based on satellite intensity estimates of T4.0 (65 kt) from TAFB, SAB, and the objective ADT. Polo's satellite signature degraded after 1200 UTC 18 September, and data from the one Air Force Reserve Hurricane Hunter mission indicated that Polo had weakened to a tropical storm by 1800 UTC. The highest SFMR measurement from the flight was 60 kt at 1941 UTC, while the highest 700-mb flight-level wind was 62 kt at 1809 UTC, consistent with a surface intensity estimate of about 55 kt. In addition, a dropwindsonde launched at 1942 UTC measured a mean wind of 71 kt in the lowest 150 m of the sounding, corresponding to a surface wind of about 60 kt.

One ship reported winds of tropical storm force in association with Polo. A container ship, the *UASC Jeddah* (call sign A8UL5), reported 40-kt sustained winds just to the northeast of Polo's center at 1800 UTC 21 September.

No reports of sustained tropical-storm-force winds have been received from Mexico, although gusts to tropical storm force were measured at a couple of locations. Manzanillo reported a sustained wind of 30 kt and a gust to 40 kt at 2240 UTC 18 September. Isla María Madre reported a wind gust to 35 kt at 0100 UTC 20 September.

CASUALTY AND DAMAGE STATISTICS

Two deaths² occurred in association with Polo. The Guerrero Civil Protection Agency reported that one man drowned in strong currents off an Acapulco beach (WTVY, 2014). Elsewhere, two fishermen set out from Acapulco on 14 September, and their vessel was overtaken by large waves from Polo. A Mexican pleasure boat found one of the men dehydrated and hypothermic in a giant foam cooler nearly a week later, while the other man was found deceased in the fishing boat (Storms, 2014).

Large breaking waves caused by swell from Polo damaged or destroyed numerous structures along the beach in several municipalities in Guerrero. Civil protection authorities in the state estimated that the waves caused over 100 million pesos (\$7.6 million US) in damage (Villagómez, 2014).

FORECAST AND WARNING CRITIQUE

The genesis of Polo was somewhat well forecast. The possibility of Polo's formation was first mentioned in the Tropical Weather Outlook (TWO) and given a medium (30-50%) chance during the next five days at 0600 UTC 11 September, which was 114 h (or almost five days) before genesis occurred. The five-day probability was raised to a high (>50%) chance 72 h before genesis. However, formation ultimately occurred sooner than expected, with the 48-h chance of formation only reaching the high category 6 h before genesis. Table 2 shows the number of hours in advance of formation in which the TWO first included a forecast in each likelihood category.

A verification of NHC official track forecasts for Polo is given in Table 3a. Official forecast track errors were significantly lower than the mean official errors for the previous 5-yr period at all forecast times. A homogeneous comparison of the official track errors with selected guidance models is given in Table 3b. The official track errors were lower than those from the individual global and regional models at nearly all forecast times. The best guidance, however, was the multi-model variable consensus TVCE, which had lower errors than the official forecasts at all forecast times. In addition, the TCON multi-model consensus had lower errors than the official forecast at all forecast times except 120 h, and the Florida State Superensemble had lower errors between 12-48 h.

A verification of NHC official intensity forecasts for Polo 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 except 96 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 4b. Despite the fairly good official intensity

² 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.

forecasts, many of the intensity models and model consensuses had even lower errors. The best guidance was the HWRF model and the ICON intensity consensus, which had lower errors than the official forecasts at all forecast times between 24-120 h. The dynamical GFS model and the SHIPS and LGEM statistical-dynamical models also performed respectably, especially between 36-96 h.

Watches and warnings associated with Polo are given in Table 5. Although no reports of sustained tropical-storm-force winds were received from Mexico, Polo's tropical storm wind field got very close to the coast within the tropical storm warning area, and it is possible that some exposed locations experienced sustained tropical-storm-force winds.

REFERENCES

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Table 1. Best track for Hurricane Polo, 16-22 September 2014.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
16 / 0000	11.4	97.6	1007	35	tropical storm
16 / 0600	11.6	98.3	1006	40	"
16 / 1200	12.1	99.1	1005	40	"
16 / 1800	12.8	100.0	1003	45	"
17 / 0000	13.6	100.8	1000	45	"
17 / 0600	14.4	101.5	998	45	"
17 / 1200	15.2	102.3	994	50	"
17 / 1800	15.7	103.1	986	60	"
18 / 0000	16.0	104.0	979	65	hurricane
18 / 0600	16.4	104.7	979	65	"
18 / 1200	16.9	105.2	980	65	"
18 / 1800	17.5	105.6	981	60	tropical storm
19 / 0000	18.1	106.1	982	60	"
19 / 0600	18.5	106.7	983	60	"
19 / 1200	18.9	107.2	985	60	"
19 / 1800	19.4	107.6	987	60	"
20 / 0000	19.8	107.9	990	55	"
20 / 0600	20.2	108.2	995	50	"
20 / 1200	20.7	108.6	1000	45	"
20 / 1800	21.1	109.1	1002	40	"
21 / 0000	21.4	109.6	1003	35	"
21 / 0600	21.6	110.2	1003	35	"
21 / 1200	22.0	111.0	1003	40	"
21 / 1800	22.4	111.8	1003	40	"
22 / 0000	22.6	112.7	1003	35	"
22 / 0600	22.5	113.5	1004	30	tropical depression
22 / 1200	22.3	114.2	1005	25	low
22 / 1800	22.1	114.8	1006	25	"
23 / 0000	21.9	115.1	1007	25	"
23 / 0600	21.6	115.4	1007	25	"



Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
23 / 1200	21.3	115.7	1007	25	"
23 / 1800	21.0	115.8	1007	20	"
24 / 0000	20.6	115.9	1007	20	"
24 / 0600	20.2	116.0	1007	20	"
24 / 1200	19.7	116.2	1007	20	"
24 / 1800	19.3	116.4	1007	20	"
25 / 0000	18.9	116.9	1007	20	"
25 / 0600	18.5	117.5	1007	20	"
25 / 1200	18.0	118.2	1007	20	"
25 / 1800	17.4	118.8	1007	20	"
26 / 0000	16.9	119.5	1007	20	"
26 / 0600	16.5	120.2	1007	20	"
26 / 1200	16.0	120.8	1007	20	"
26 / 1800	15.5	121.4	1007	20	"
27 / 0000					dissipated
18 / 0000	16.0	104.0	979	65	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 (<30%)	60	-
Medium (30%-50%)	36	114
High (>50%)	6	72

Table 3a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Polo, 16-22 September 2014. 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	20.3	27.2	31.5	40.0	53.2	67.4	56.7
OCD5	32.5	56.4	67.0	77.2	109.6	118.2	130.0
Forecasts	23	21	19	17	13	9	5
OFCL (2009-13)	25.7	41.4	55.0	68.6	97.8	134.2	167.1
OCD5 (2009-13)	37.2	74.8	118.0	162.5	249.4	332.6	413.3

Table 3b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Polo, 16-22 September 2014. 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	21.4	28.0	33.8	42.7	58.1	68.7	51.3
OCD5	31.0	50.4	49.4	68.8	99.3	101.9	83.0
GFSI	26.2	37.6	49.2	66.0	92.6	108.8	125.8
GHMI	26.3	40.9	48.8	48.6	66.6	116.1	191.5
HWFI	21.3	32.9	41.8	52.8	80.9	94.8	136.7
EGRI	24.2	45.2	77.1	95.8	91.0	67.9	53.0
EMXI	19.9	25.2	40.9	53.1	71.4	117.5	191.3
NVGI	39.9	75.9	120.3	152.1	185.8	210.6	243.6
GFNI	32.2	48.1	60.8	81.1	131.5	177.3	278.6
AEMI	25.7	37.4	45.5	58.1	89.4	92.5	113.0
FSSE	18.9	26.2	31.9	42.1	60.1	77.7	96.6
TCON	19.0	25.6	29.2	36.3	45.1	57.5	61.2
TVCE	18.8	24.3	27.6	34.8	43.8	48.6	40.9
BAMS	41.5	70.0	89.6	94.7	125.4	161.6	190.4
BAMM	29.2	48.2	66.0	84.6	137.3	167.0	203.9
BAMD	39.8	75.6	101.8	134.1	166.3	173.7	204.6
Forecasts	20	18	14	13	10	7	3

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Polo, 16-22 September 2014. 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	3.9	6.7	9.2	10.9	13.5	19.4	16.0
OCD5	4.6	7.7	10.4	13.8	19.4	23.1	21.6
Forecasts	23	21	19	17	13	9	5
OFCL (2009-13)	6.1	10.4	13.4	14.5	15.0	16.4	16.1
OCD5 (2009-13)	7.7	12.7	16.4	18.8	20.5	20.3	20.8

Table 4b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Polo, 16-22 September 2014. 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	6.9	9.6	12.7	16.5	20.7	15.0
OCD5	4.9	7.3	11.5	14.3	19.4	23.1	18.3
HWFI	4.6	5.9	6.2	6.8	10.6	8.7	8.7
GHMI	4.6	5.1	10.5	12.2	18.6	20.7	23.0
GFNI	4.4	6.8	10.9	13.4	15.5	11.3	10.3
GFSI	4.8	5.1	4.9	6.8	10.2	16.7	18.7
EMXI	4.8	9.3	12.8	15.5	18.4	15.6	7.0
DSHP	5.6	7.3	8.6	11.4	14.4	16.7	15.3
LGEM	5.6	7.5	7.8	10.1	13.7	18.3	17.0
ICON	4.9	5.6	7.3	9.6	13.2	15.9	14.7
IVCN	4.9	5.6	7.3	9.6	13.2	15.9	14.7
FSSE	5.8	8.7	12.6	15.0	17.7	17.0	16.3
Forecasts	20	18	14	13	10	7	3

Table 5. Watch and warning summary for Hurricane Polo, 16-22 September 2014.

Date/Time (UTC)	Action	Location
16 / 1500	Tropical Storm Watch issued	Zihuatanejo to Cabo Corrientes
17 / 1500	Tropical Storm Watch modified to	Zihuatanejo to Punta San Telmo
17 / 1500	Tropical Storm Warning issued	Punta San Telmo to Playa Perula
18 / 0300	Tropical Storm Watch discontinued	Zihuatanejo to Punta San Telmo
19 / 0300	Tropical Storm Watch issued	Santa Fe to La Paz
19 / 0900	Tropical Storm Watch discontinued	Playa Perula to Cabo Corrientes
19 / 0900	Tropical Storm Warning discontinued	All
21 / 0900	Tropical Storm Watch discontinued	All

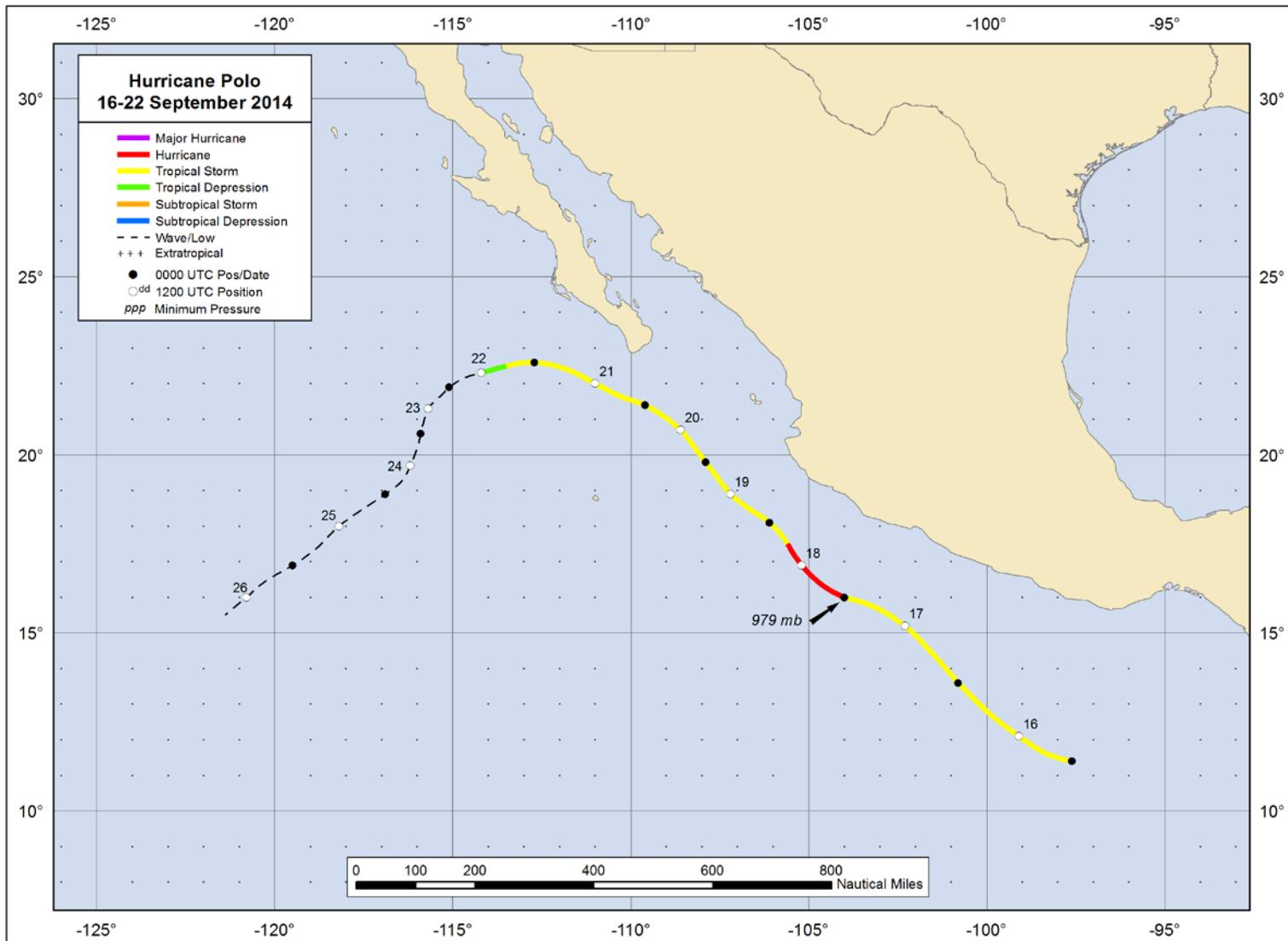


Figure 1. Best track positions for Hurricane Polo, 16-22 September 2014.

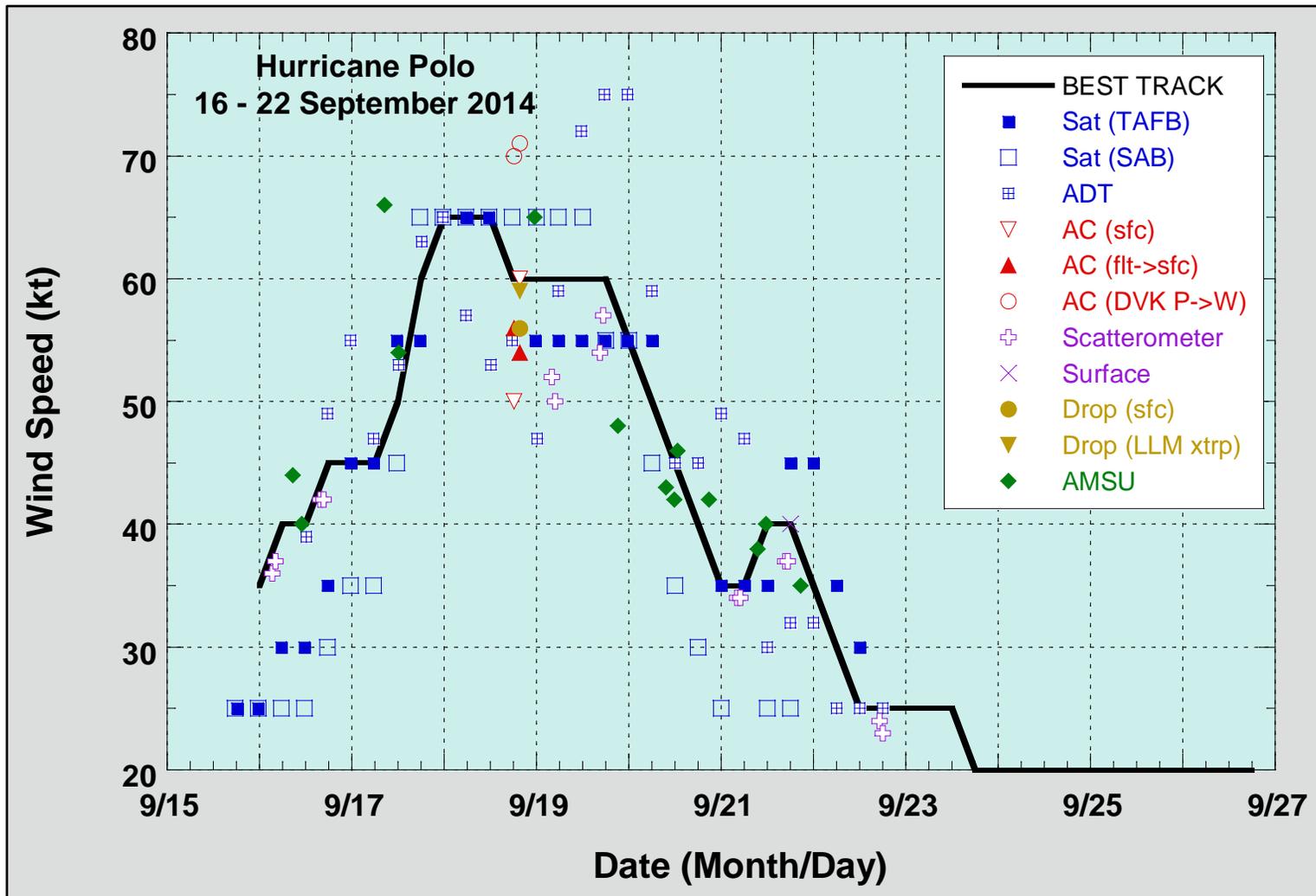


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Polo, 16-22 September 2014. Aircraft observations have been adjusted for elevation using 90% adjustment factors for observations from 700 mb. Dropwindsonde observations include actual 10 m winds (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.

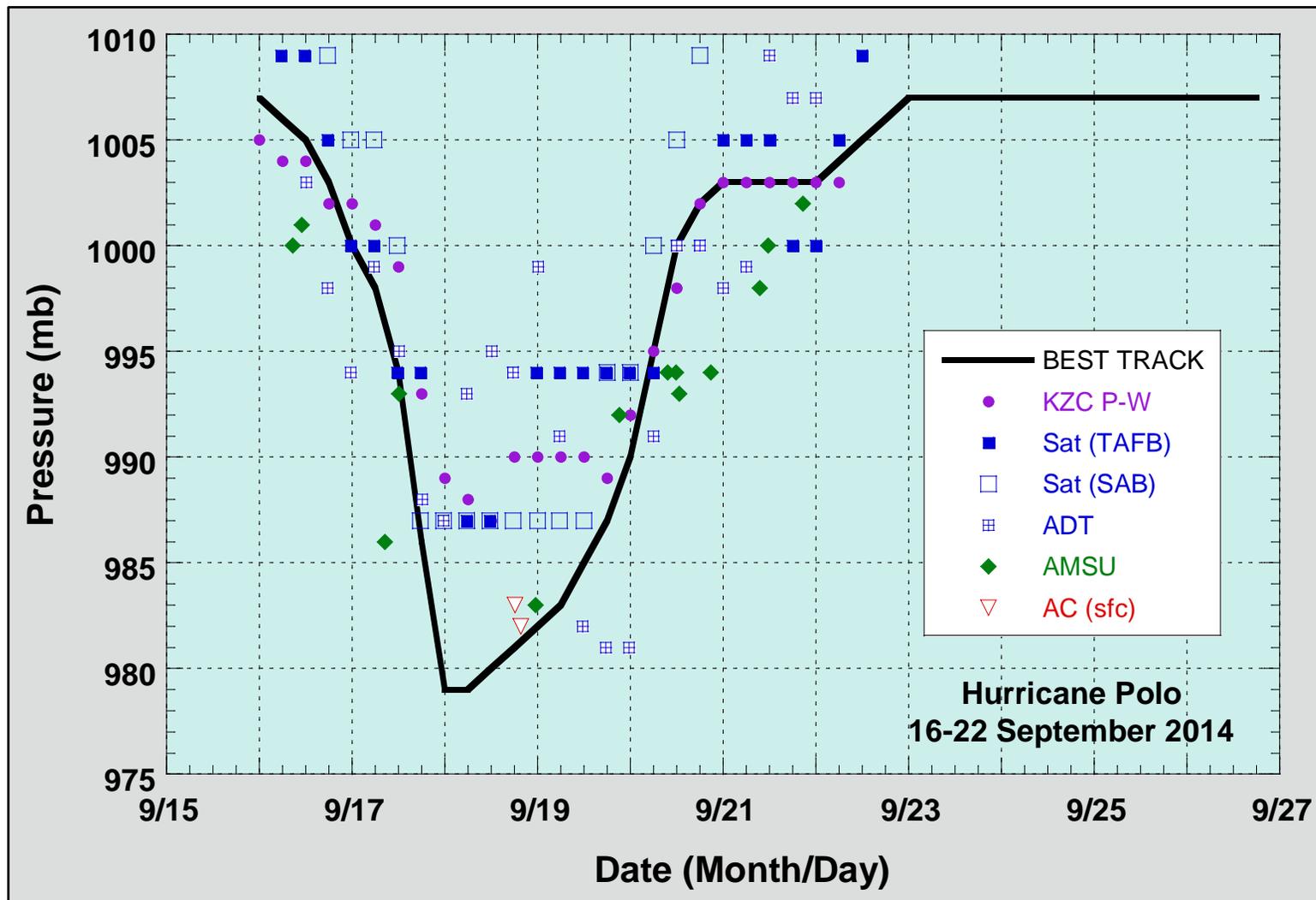


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Polo, 16-22 September 2014. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. AMSU intensity estimates are from the Cooperative Institute for Meteorological 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.

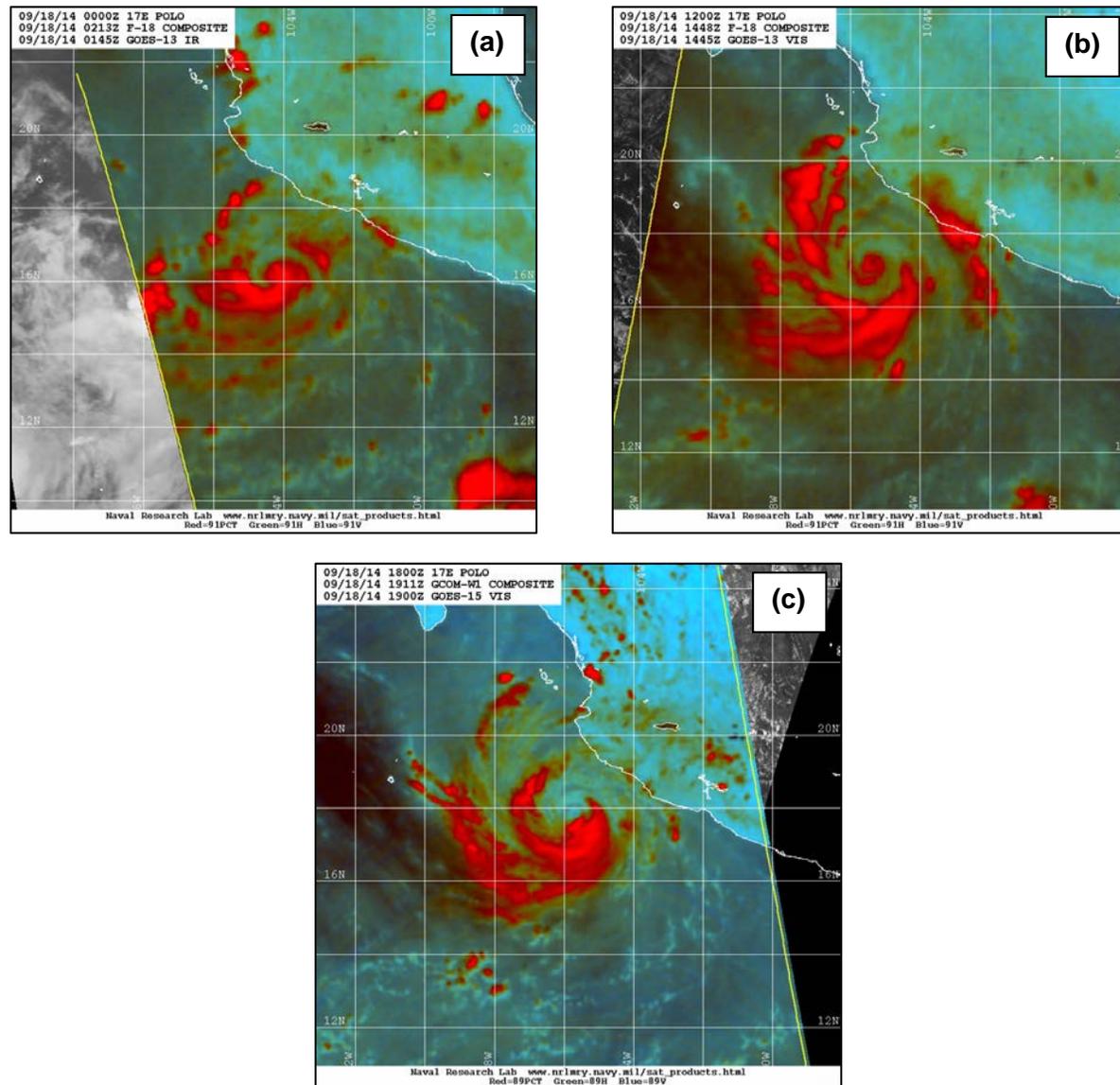


Figure 4. 89-GHz microwave images of Hurricane Polo at (a) 0213 UTC 18 September and (b) 1448 UTC 18 September. The low-level center of Polo became exposed to the north of the deep convection due to increasing vertical shear by (c) 1911 UTC 18 September, and Polo weakened to a tropical storm. Images courtesy of the Naval Research Laboratory.