NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT

HURRICANE AGATHA

(EP012022)

28–31 May 2022

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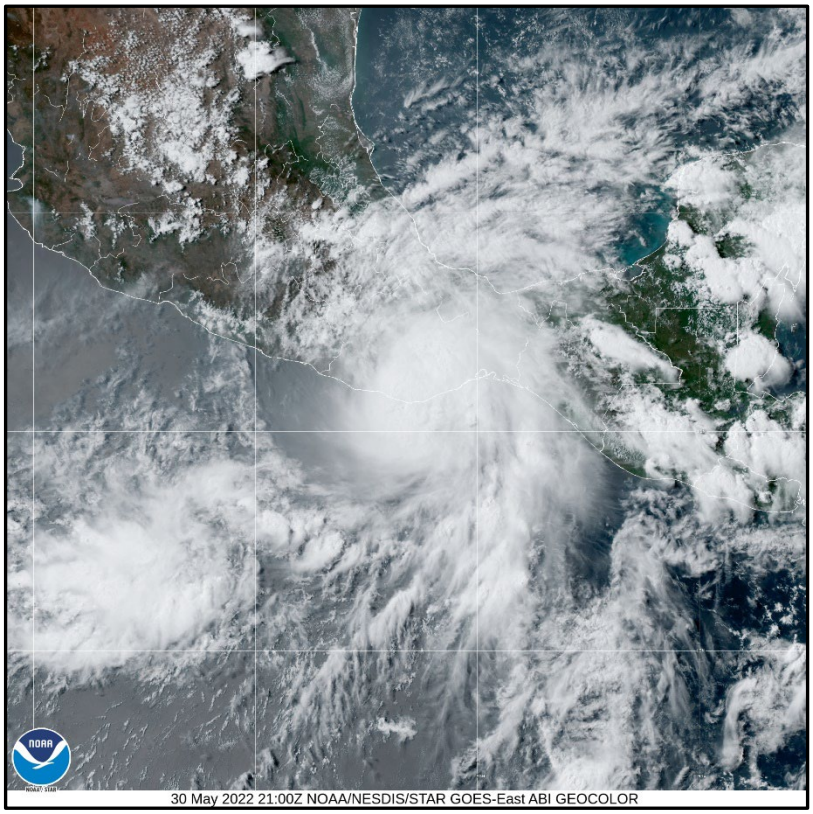
National Hurricane Center
6 December 2022



GOES-16 GEOCOLOR IMAGE OF AGATHA MAKING LANDFALL IN MEXICO AT 2100 UTC 30 MAY 2022. IMAGE COURTESY OF NOAA/NESDIS/STAR.

Agatha was a category 2 hurricane (on the Saffir-Simpson Hurricane Wind Scale) that made landfall in the Mexican state of Oaxaca and caused nine deaths.

Hurricane Agatha

28–31 MAY 2022

SYNOPTIC HISTORY

Agatha developed from a slowly organizing area of disturbed weather along the Intertropical Convergence Zone (ITCZ). Beginning on 17 May, satellite imagery showed an increase in convection along the portion of the ITCZ extending from the southwestern Caribbean Sea across Central America and into the extreme eastern Pacific. This area drifted westward with little change in organization until 22 May, when a more concentrated area of convection formed to the southeast of the Gulf of Tehuantepec. This area was nearly stationary and showed little additional development for the next couple of days. On 25 May, the convection began showing signs of banding, and a weak low pressure area formed the next day south of the Gulf of Tehuantepec. The low drifted westward on 27 May as the circulation became better defined and the convection increased in organization. A tropical depression is estimated to have formed at 0000 UTC 28 May about 200 n mi south-southwest of Bahia de Huatulco, 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 1[1].

At the time of genesis, the cyclone was located in weak steering currents between a mid-level ridge to the east and northeast over Central America and a mid-level ridge to the northwest over Mexico. Due to this steering pattern, the initial motion was a north-northwestward drift. An erratic west-northwestward motion began later that day and continued into 29 May as the ridge over Central America built a little westward. During this time, the system rapidly strengthened into a tropical storm and then a hurricane. A slow motion toward the northeast began later on 29 May as Agatha became embedded in southwesterly flow between a mid- to upper-level trough over the Gulf of Mexico and the ridge to the east. Continued rapid intensification led to Agatha reaching a peak intensity of 95 kt near 1800 UTC that day while it was centered about 190 n mi southwest of Bahia de Huatulco. Shortly after this peak, some weakening occurred due to westerly shear and a possible eyewall replacement cycle. While continuing northeastward on 30 May, Agatha re-intensified as it approached the coast of Mexico, and the maximum winds were estimated to be 90 kt (category 2 on the Saffir-Simpson Hurricane Wind Scale) when the eye made landfall around 2100 UTC that day near La Redonda, Mexico.

After landfall, Agatha rapidly weakened while it moved slowly northeastward across the mountains of southeastern Mexico. The cyclone decayed to a remnant low late on 31 May over the northern portion of the Isthmus of Tehuantepec, and the low dissipated on 1 June as it was

[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.

absorbed into the large and complex area of disturbed weather that eventually became Atlantic Tropical Storm Alex.

It should be noted that early-morning visible imagery on 1 June showed a low-level circulation over the Bay of Campeche in the general area where the remnant low of Agatha had been heading. Detailed examination of nighttime satellite imagery and surface observations suggests that this was not the remnants of Agatha, but part of the larger pre-Alex disturbance, and that the remnant low of Agatha dissipated near the northern coast of the Isthmus of Tehuantepec between 0600-1200 UTC that day.

METEOROLOGICAL STATISTICS

Observations in Agatha (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), objective Advanced Dvorak Technique (ADT) estimates and Satellite Consensus (SATCON) 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 two flights 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 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 Agatha.

Selected surface observations from land stations are given in Table 2.

Winds and Pressure

The Air Force Reserve Hurricane Hunter aircraft reported 700-mb flight-level winds of 107 kt and a 95-kt surface wind estimate from the SFMR near 2000 UTC 29 May. In addition, an eyewall dropsonde at 2012 UTC that day had surface and lower-layer average winds that support surface winds of 85-95 kt. Based on these data, the peak intensity of Agatha is set at 95 kt.

The estimated minimum pressure is more problematic. The dropsonde in the eye during the penetration near 2000 UTC 29 May failed, and the aircraft officially reported an extrapolated pressure of 968 mb during this fix. However, pressures on the high-density observations were as low as 964 mb, and the winds were not calm where the lowest pressure was measured. Also, the aforementioned eyewall dropsonde had a surface pressure of 974 mb, which combined with the estimated surface winds supports a pressure on the mid- to lower 960 mb range. Based on this data, the minimum pressure is set at 964 mb, with a larger-than-normal uncertainty in that value for a hurricane sampled by an aircraft.

Operationally, Agatha was assessed to have an intensity of 90-95 kt for much of 29-30 May leading up to landfall. A re-assessment of the available aircraft data, along with microwave satellite imagery (Fig. 4), suggests that the convective structure of the hurricane decayed between

1800 UTC 29 May and 1200 UTC 30 May and that the storm weakened during some of this time. This is supported by the aircraft on 29 May not reporting an eyewall, and the next aircraft penetration on 30 May showing a 10-15 mb pressure rise since the previous day. Subsequently, the cyclone became better organized and strengthened, as shown by the falling central pressure and reported eyewall during the aircraft mission on 30 May, along with the improved convective structure seen just before landfall in Fig. 4d. It should be noted while there is no conclusive evidence of an eyewall replacement between the two aircraft missions, the mission on 29 May reported a radius of maximum winds (RMW) of 5-7 n mi, while the mission on 30 May reported an RMW of about 12 n mi – an expansion that is consistent with an eyewall replacement.

No observing stations near the landfall area reported hurricane-force winds, with the highest reported gust being 47 kt at a private weather station in Huatulco. The landfall pressure of 971 mb is based on a combination of a 978.9 mb pressure measured by storm chaser Josh Morgerman of ICyclone in Mazunte, Mexico (just outside the eye) and extrapolation of the falling pressures from the 976 mb pressure measured during the last aircraft penetration 4.5 h before landfall.

Shipping generally avoided Agatha, and there are no reliable observations of tropical-storm or hurricane-force winds from ships during the cyclone.

Storm Surge

Agatha caused a storm surge near where the eye came ashore that resulted in some damage, as well as beach erosion (Fig. 5). However, there are no quantitative reports of its height.

Rainfall and Flooding

Agatha caused heavy rains over portions of southeastern Mexico (Fig. 6). The heaviest rains occurred in the state of Oaxaca, where Tonameca reported a storm total of 17.84 inches (453.1 mm) and Huatulco reported a storm total of 15.27 inches (387.9 mm). These rains caused deadly and damaging flooding and mudslides.

Tornadoes

There were no known tornadoes associated with Agatha.

CASUALTY AND DAMAGE STATISTICS

Agatha brought hurricane conditions to portions of the Mexican state of Oaxaca. Reports from officials in the state indicate that the hurricane caused nine deaths[2], along with six other

[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.

people missing. These deaths were due to freshwater flooding and mudslides caused by the heavy rains associated with Agatha. Media reports indicate there was damage to structures and infrastructure in Oaxaca. However, no monetary damage figures are currently available.

FORECAST AND WARNING CRITIQUE

The genesis of Agatha was well forecast both temporally and spatially. The disturbance from which Agatha developed was introduced in the 5-day Tropical Weather Outlook with a low (<40%) chance of development 114 h before genesis occurred (Table 3). The 5-day probabilities were raised to the medium (40-60% chance) category 102 h before genesis, and to the high (>60% chance) category 78 h before genesis. In the 2-day Tropical Weather Outlook, the system was introduced with a low chance of development 78 h before genesis. The probabilities were raised to the medium category 54 h before genesis and to the high category 30 h before genesis. The genesis location was also forecast well in the depictions of the genesis threat area on the NHC Graphical Tropical Weather Outlooks (Fig. 7).

A verification of NHC official track forecasts for Agatha is given in Table 4a. The official track forecast errors were excellent overall. First, they were smaller than the mean official errors for the previous 5-yr period at all forecast times, except 12 h. Second, although the number of forecasts was relatively small, none of the average track forecast errors exceeded 30 n mi. A homogeneous comparison of the official track errors with selected guidance models is given in Table 4b. The official forecasts had lower mean track forecast errors than all of the guidance, except at 72 h (1 forecast).

Table 4a shows that the average OCD5 (climatology-persistence) track forecast errors for Agatha were very large – indeed much larger than normal. Examination of the individual OCD5 forecasts (Fig. 8) shows that Agatha moved in an unclimatological northeasterly direction, while the OCD5 forecasts were calling for a west-northwestward to northwestward motion.

A verification of NHC official intensity forecasts for Agatha is given in Table 5a. Official intensity forecast errors were greater than the mean official errors for the previous 5-yr period for the 12-36 h forecast times, and smaller than the mean errors for the previous 5-yr period for the 48-72 h forecast times. An examination of the individual forecasts (not shown) revealed that a few forecasts showed a higher peak intensity than what actually occurred, and a few others forecasts did not capture Agatha's short-lived weakening on 29-30 May. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 5b. Some of the intensity guidance had lower errors than the official forecast during the 12-36 h forecast times, with the HFIP Corrected Consensus model (HCCA) having the best overall performance relative to the official forecasts.

Watches and warnings associated with Agatha are given in Table 6. A hurricane watch was issued for the landfall area at 0900 UTC 28 May, which was about 59 h before the eye reached the coast and roughly 48 h before the estimated arrival of tropical-storm-force winds. A hurricane warning was issued for the landfall area at 2100 UTC 28 May, which was about 47 h before landfall and about 36 h before the estimated time of arrival of tropical-storm-force winds.

ACKNOWLEDGEMENTS

CONAGUA and the Servicio Meteorológico Nacional of Mexico provided the rainfall data and Figure 6. The Mesowest web site and Josh Morgerman of iCyclone provided surface observation data, while Josh Morgerman provided Figure 5.

Table 1. Best track for Hurricane Agatha, 28 – 31 May 2022.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage*
27 / 1800	12.9	97.3	1008	25	low
28 / 0000	12.8	97.7	1006	30	tropical depression
28 / 0600	12.9	97.9	1004	35	tropical storm
28 / 1200	13.2	97.9	1002	40	"
28 / 1800	13.6	98.2	998	50	"
29 / 0000	13.8	98.8	996	55	"
29 / 0600	13.9	99.1	992	65	hurricane
29 / 1200	14.0	99.1	981	75	"
29 / 1800	14.0	98.9	964	95	"
30 / 0000	14.3	98.5	964	95	"
30 / 0600	14.6	98.0	968	90	"
30 / 1200	15.0	97.4	979	85	"
30 / 1800	15.4	96.9	974	90	"
31 / 0000	15.9	96.4	983	70	"
31 / 0600	16.5	95.8	998	50	tropical storm
31 / 1200	17.0	95.3	1004	30	tropical depression
31 / 1800	17.7	94.9	1005	20	remnant low
01 / 0000	18.0	94.7	1006	20	"
01 / 0600	18.3	94.6	1007	20	"
01 / 1200					dissipated
30 / 2100	15.7	96.6	971	90	landfall near La Redonda, Mexico
29 / 1800	14.0	98.9	964	95	minimum pressure and maximum winds

Table 2. Selected surface observations for Hurricane Agatha, 28 – 31 May 2022.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)[c]	Storm tide (ft)[d]	Estimated Inundation (ft)[e]	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
International Civil Aviation Organization (ICAO) Sites									
Bahias de Huatulco (MMBT) (15.78N 96.27W)			30/1550	20	35[i]				
Puerto Escondido (MMPS) (15.87N 97.08W)	30/2147	1001.0	30/2249		31				
Secretaria de Marina-Armada de Mexico (SEMAR) Sites									
Huatulco (15.75N 96.13W)			30/1830		32				
Salina Cruz (16.17N 95.19W)			31/0030		30				
Public/Other									
Huatulco (E7099) (15.75N 96.13W)			31/0101		47				
Mazunte (Morgerman/ ICyclone) (15.67N 96.55W)	30/2106	978.9							

[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 reports are 2 min; buoy averaging periods are 8 min.
[c] Storm surge is water height above normal astronomical tide level.
[d] For most locations, storm tide is water height above the North American Vertical Datum of 1988 (NAVD88). Storm tide is water height above Mean Lower Low Water (MLLW) for NOS stations in Puerto Rico, the U.S. Virgin Islands, and Barbados.
[e] Estimated inundation is the maximum height of water above ground.
[i] Incomplete record.

Table 3. 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%)	78	114
Medium (40%-60%)	54	102
High (>60%)	30	78

Table 4a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Hurricane Agatha, 28 – 31 May 2022. 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	60	72	96	120
OFCL	22.2	**28.5**	**22.4**	**17.6**	**24.6**	**28.8**		
OCD5	42.0	98.2	193.5	291.9	394.2	549.5		
Forecasts	13	11	9	7	5	3		
OFCL (2017-21)	21.9	33.8	45.6	56.9	74.8	79.9	99.5	121.3
OCD5 (2017-21)	35.8	72.3	112.7	155.0	198.7	239.0	309.2	372.2

Table 4b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Hurricane Agatha, 28 – 31 May 2022. 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	60	72	96	120
OFCL	18.2	26.5	23.2	20.9	18.3	25.9		
OCD5	37.2	100.9	206.9	307.4	390.3	553.4		
GFSI	26.5	35.1	35.9	43.3	41.8	48.3		
HWFI	23.4	41.2	47.8	51.2	62.4	108.2		
HMNI	23.4	33.9	48.4	57.1	56.0	56.7		
EMXI	21.1	32.9	31.6	39.3	44.1	42.7		
NVGI	31.0	48.7	74.6	85.4	118.9	191.5		
CMCI	27.1	34.5	37.9	68.8	82.2	91.0		
CTCI	24.6	31.9	39.2	58.7	65.1	96.3		
TVCE	20.4	27.7	27.3	23.4	24.2	**23.7**		
HCCA	22.3	31.7	31.4	32.4	32.5	37.8		
FSSE	21.0	30.3	25.4	23.8	29.6	**16.6**		
AEMI	24.3	27.0	31.9	42.8	45.5	**13.3**		
UEMI	27.2	36.2	60.4	80.6	89.0	136.4		
TABS	19.9	31.2	41.7	57.7	73.5	79.1		
TABM	22.2	32.1	39.5	53.0	55.7	58.6		
TABD	21.4	38.4	51.0	57.0	67.0	50.8		
Forecasts	11	9	7	5	3	1		

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Hurricane Agatha, 28 – 31 May 2022. 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	60	72	96	120
OFCL	8.5	14.1	15.0	**11.4**	**4.0**	**10.0**		
OCD5	12.1	21.4	32.6	26.9	25.6	16.7		
Forecasts	13	11	9	7	5	3		
OFCL (2017-21)	5.5	9.1	11.1	12.9	15.3	15.6	16.4	17.0
OCD5 (2017-21)	7.0	12.2	15.8	18.6	20.4	21.2	22.3	21.8

Table 5b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Hurricane Agatha, 28 – 31 May 2022. 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	60	72	96	120
OFCL	9.5	16.1	13.6	9.0	3.3	5.0		
OCD5	12.6	22.7	32.4	23.6	19.3	30.0		
HWFI	13.7	16.8	20.4	18.4	8.7	56.0		
HMNI	11.3	17.9	17.4	13.4	**0.3**	8.0		
DSHP	11.2	18.1	18.7	12.4	7.7	8.0		
LGEM	11.3	18.9	23.6	19.4	10.3	6.0		
ICON	10.8	**15.8**	19.0	13.4	5.0	20.0		
IVCN	10.3	**13.3**	17.1	13.4	6.0	16.0		
CTCI	11.8	**15.2**	**10.0**	19.2	17.7	**0.0**		
GFSI	11.2	16.2	19.7	20.2	11.7	**3.0**		
EMXI	18.4	27.4	28.1	22.4	11.7	**2.0**		
HCCA	**8.5**	**9.0**	**13.1**	10.0	4.3	20.0		
FSSE	**8.4**	**10.8**	16.6	11.4	4.7	14.0		
Forecasts	11	9	7	5	3	1		

Table 6. Watch and warning summary for Hurricane Agatha, 28 – 31 May 2022.

Date/Time (UTC)	Action	Location
28 / 0900	Hurricane Watch issued	Coast of Mexico from Salina Cruz to Punta Maldonado
28 / 2100	Hurricane Warning issued	Coast of Mexico from Salina Cruz to Lagunas de Chacahua
28 / 2100	Hurricane Watch extended eastward	Coast of Mexico from Salina Cruz to Barra de Tonala
28 / 2100	Tropical Storm Warning issued	Coast of Mexico from Boca de Pijijiapan to Salina Cruz
28 / 2100	Tropical Storm Warning issued	Coast of Mexico from Lagunas de Chacahua to Punta Maldonado
31 / 0300	Hurricane Warning changed to Tropical Storm Warning	Coast of Mexico from Salina Cruz to Lagunas de Chacahua
31 / 0300	Hurricane Watch discontinued	Coast of Mexico
31 / 0300	Tropical Storm Warning discontinued	Coast of Mexico west of Puerto Escondido
31 / 0900	Tropical Storm Warning discontinued	Coast of Mexico west of Bahias de Huatulco
31 / 1200	All warnings discontinued	Coast of Mexico

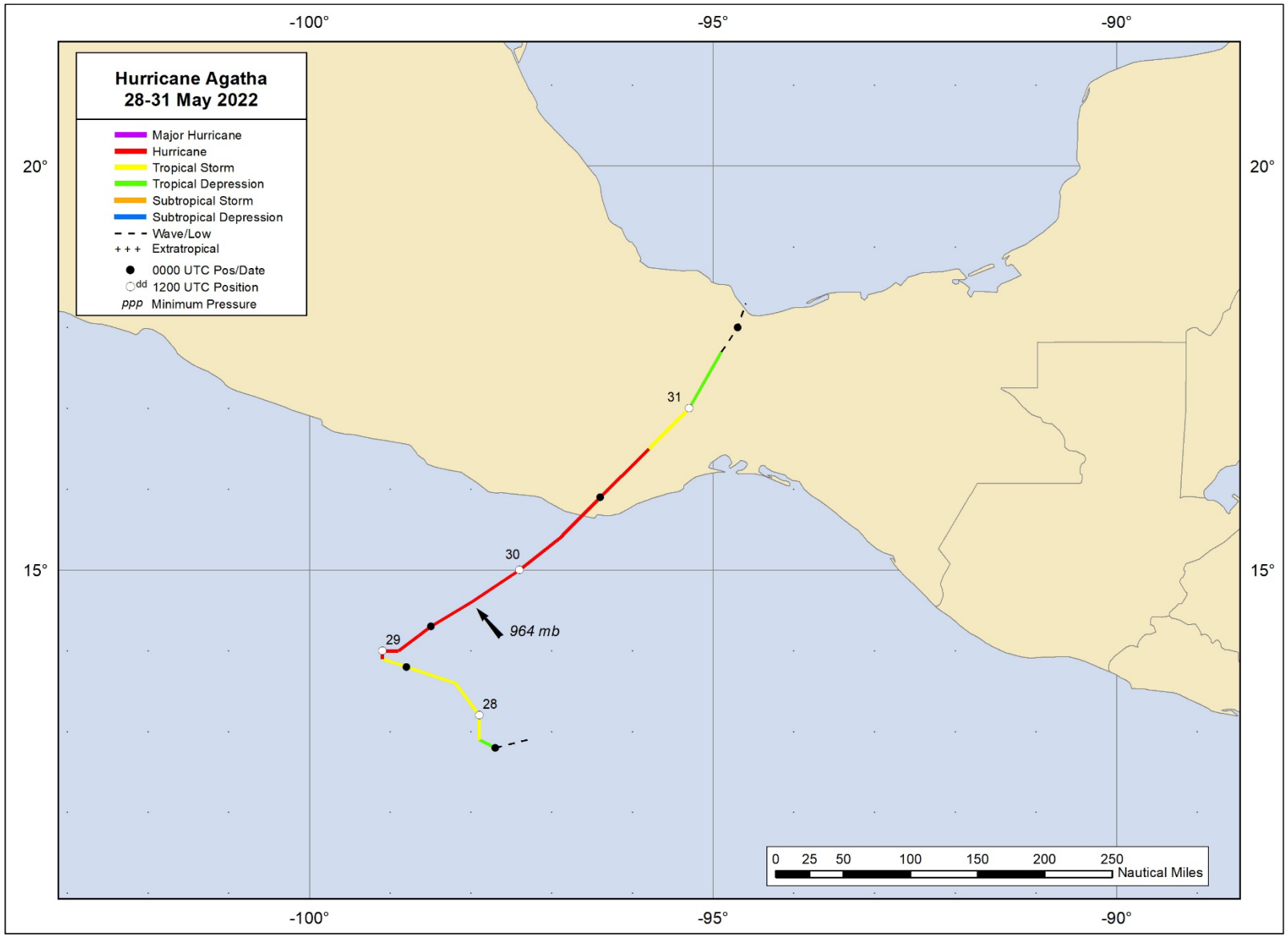


Figure 1. Best track positions for Hurricane Agatha, 28 – 31 May 2022.

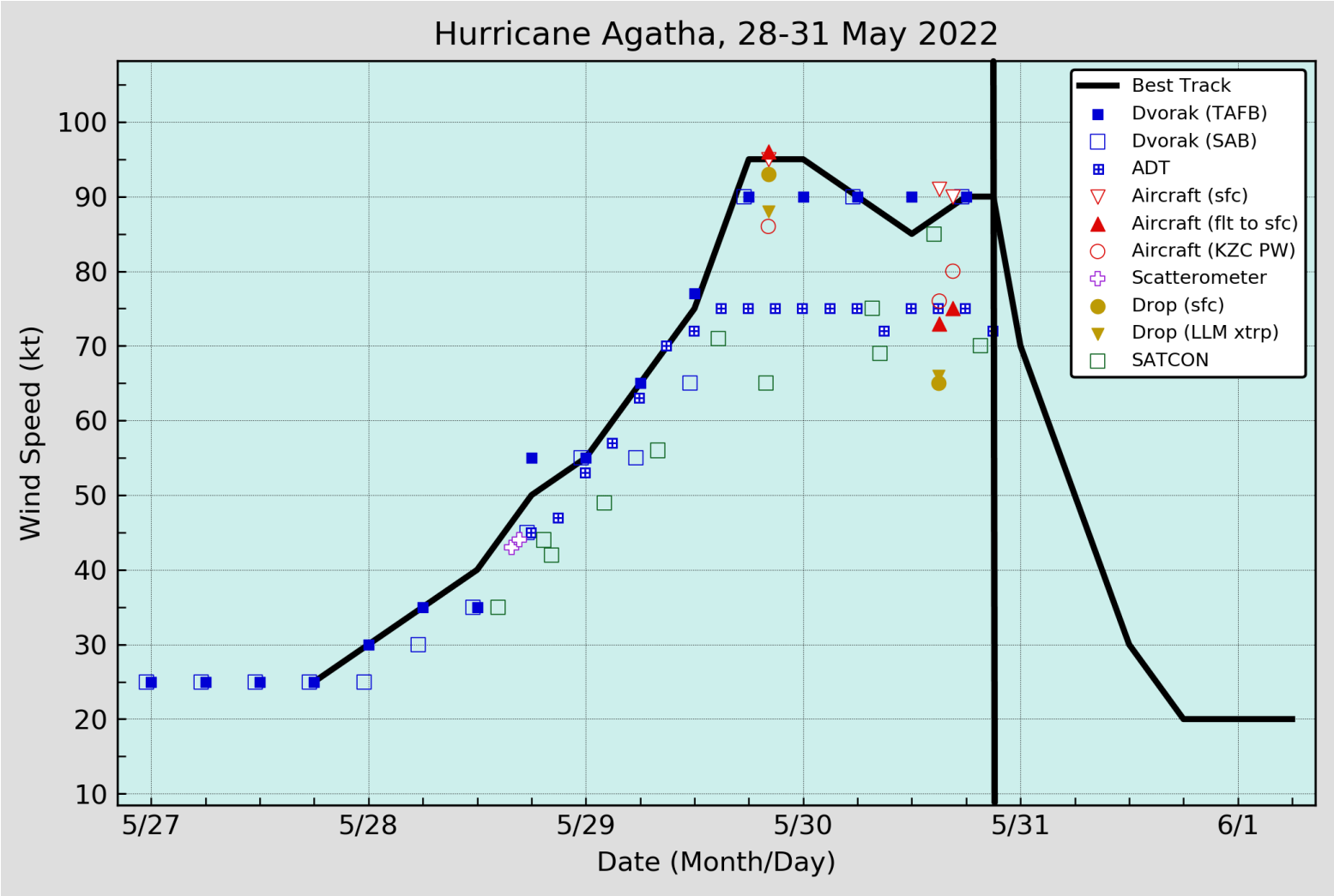


Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Hurricane Agatha, May 28 – 31, 2022. Aircraft observations have been adjusted for elevation using a 90% adjustment factor for observations from 700 mb. Dropwindsonde observations include actual 10 m winds (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. SATCON intensity estimates are from the Cooperative Institute for Meteorological Satellite Studies. Dashed vertical lines correspond to 0000 UTC, and solid vertical lines correspond to landfalls.

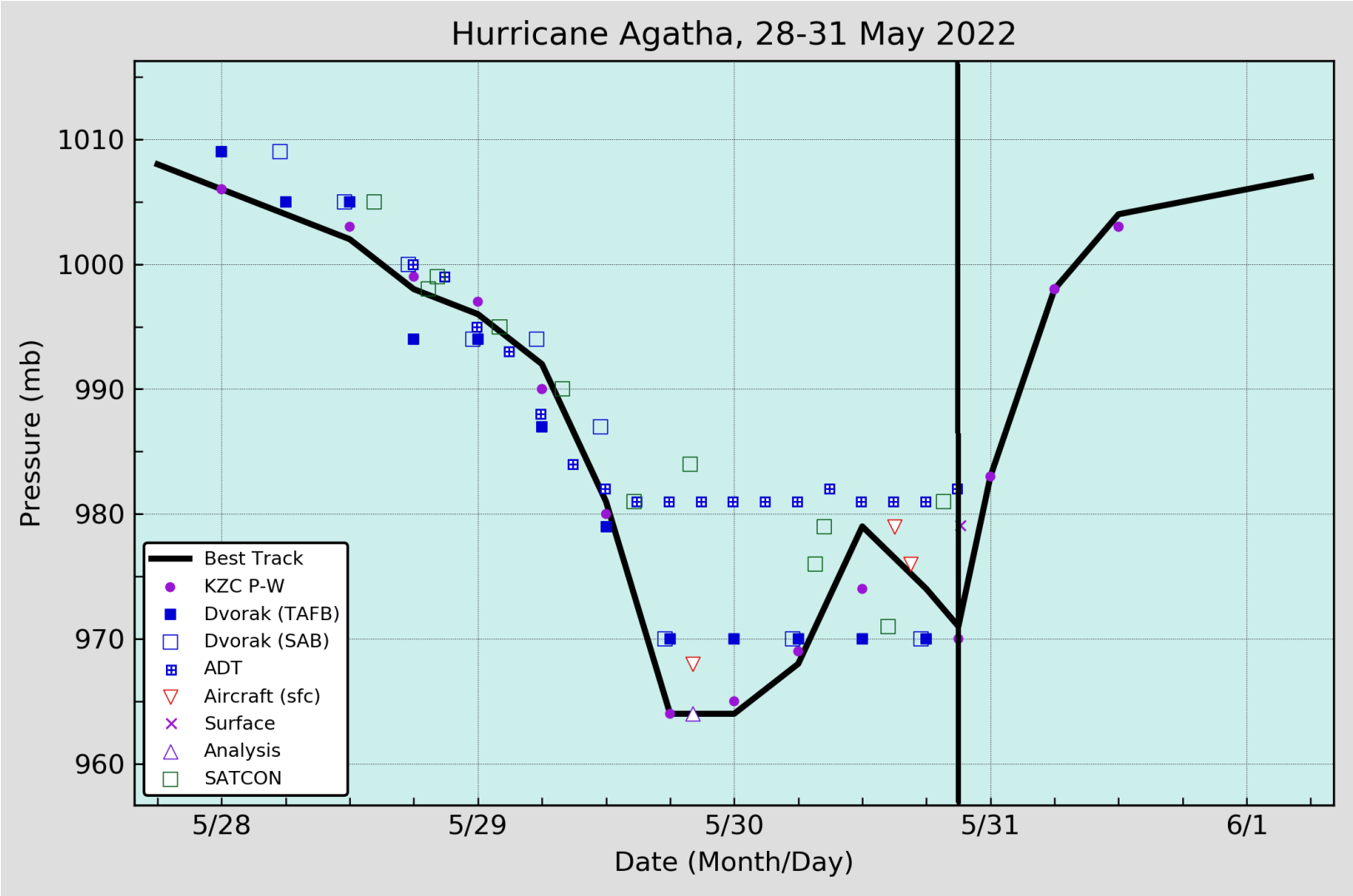


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Agatha, 28 – 31 May 2022. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute for Meteorological 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, and solid vertical lines correspond to landfalls.

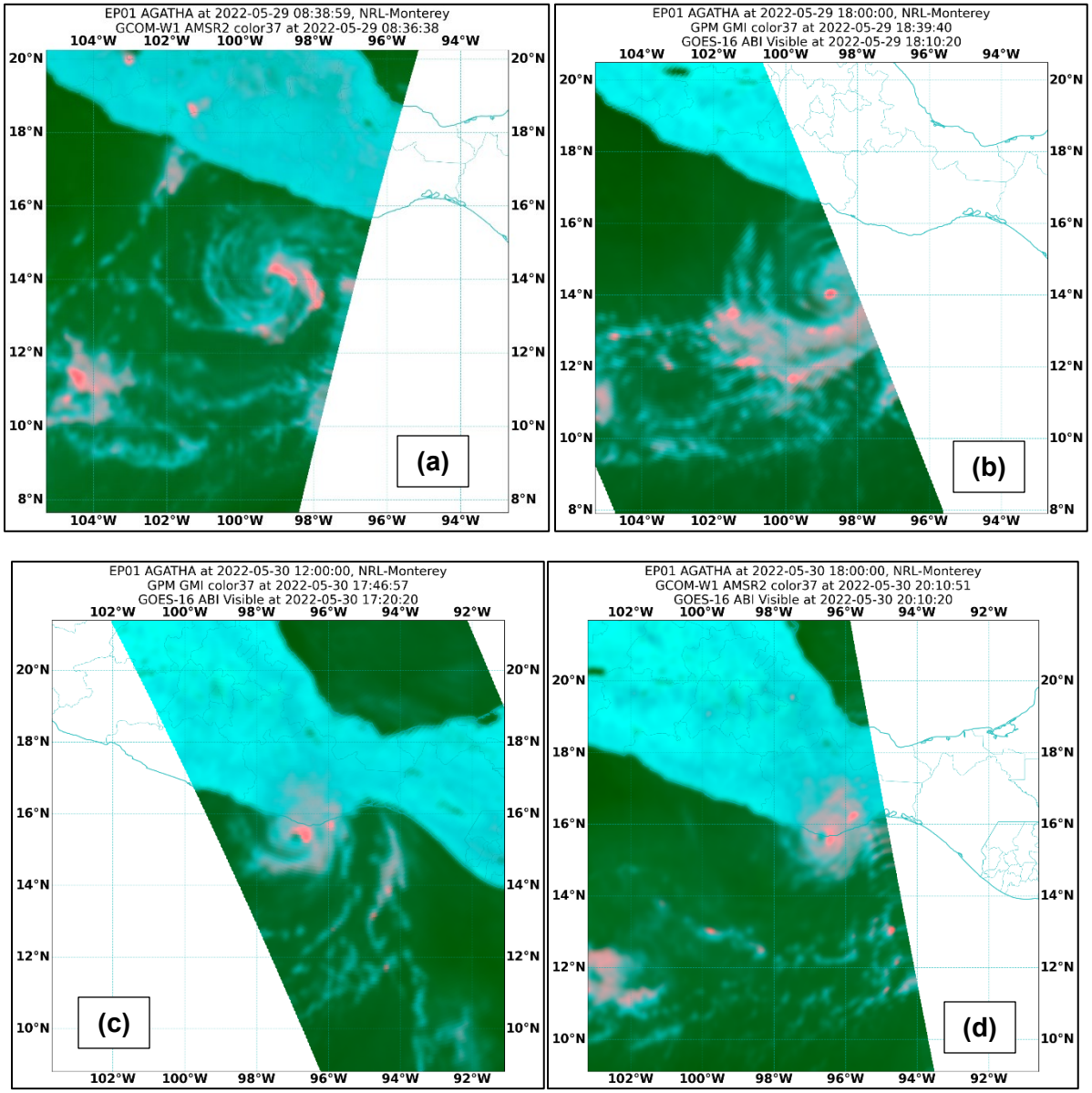


Figure 4. 37 Ghz color composite imagery of Agatha from the GCOM and GPM satellites at (a) 0837 UTC 29 May 2022, (b) 1840 UTC 29 May 2022, (c) 1747 UTC 30 May 2022, and (d) 2011 UTC 30 May 2022. Imagery courtesy of NRL Monterey.

Figure 5. Coastal area of Mazunte, Mexico, showing the impacts of the storm surge from Hurricane Agatha. Image courtesy of Josh Morgerman/iCyclone.

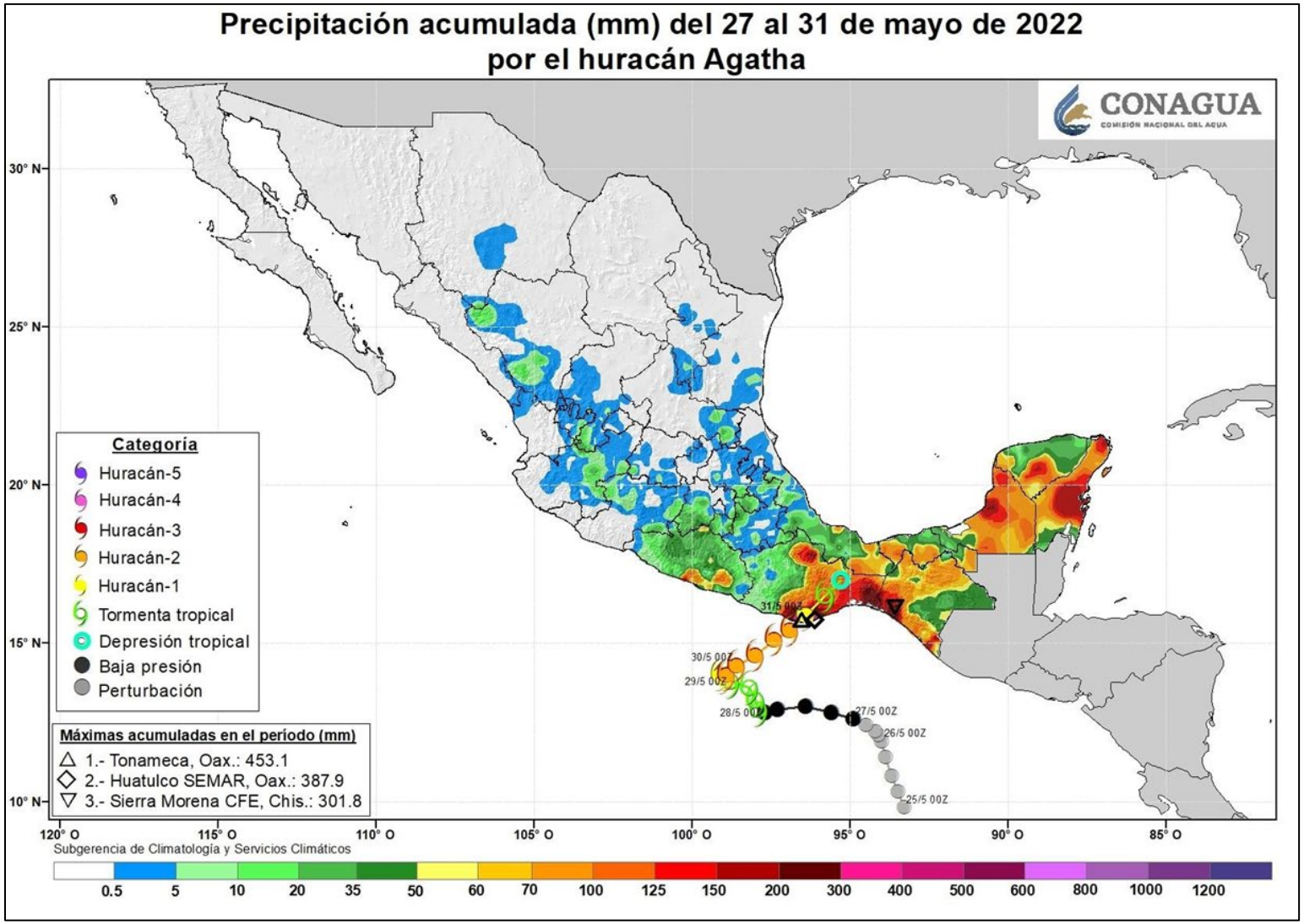


Figure 6. Accumulated rainfall totals over Mexico during the period 27 – 31 May, courtesy of CONAGUA and the Servicio Meteorológico Nacional of Mexico. Rainfalls in southeastern Mexico are due primarily to Hurricane Agatha. Note that the track is the operational track and not the best track shown in Fig. 1.

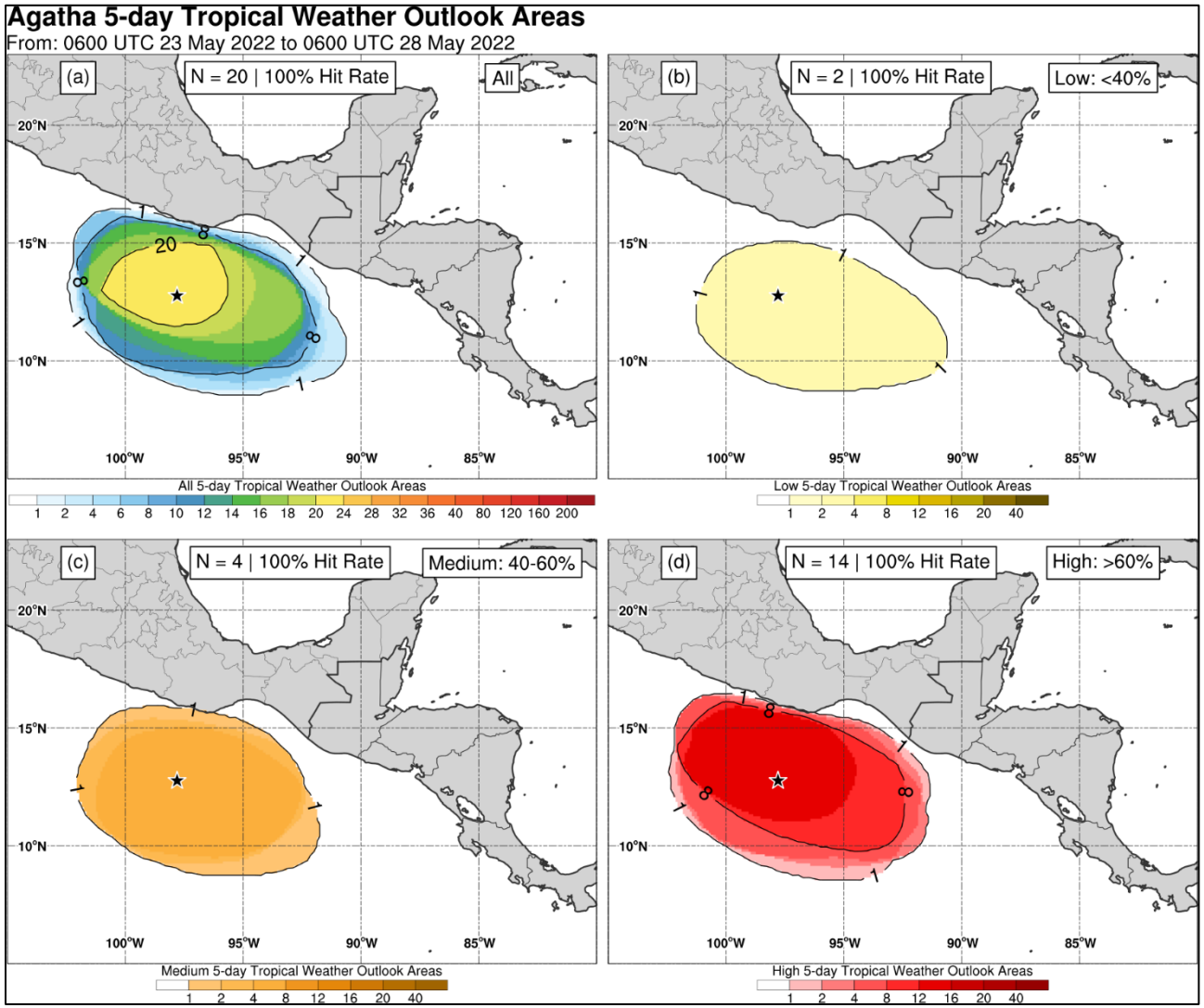


Figure 7. 5-day Tropical Weather Outlook genesis areas associated with the disturbance that developed into Hurricane Agatha for (a) all probability areas (10–100%, multi-color shading), (b) low probability areas (< 40%, yellow shading), (c) medium probability areas (40–60%, orange shading), and (d) high probability areas (> 60%, red shading). The black star in each panel indicates the genesis location of Agatha. Hit rate indicates the percentage of outlook areas where the genesis location was captured within.

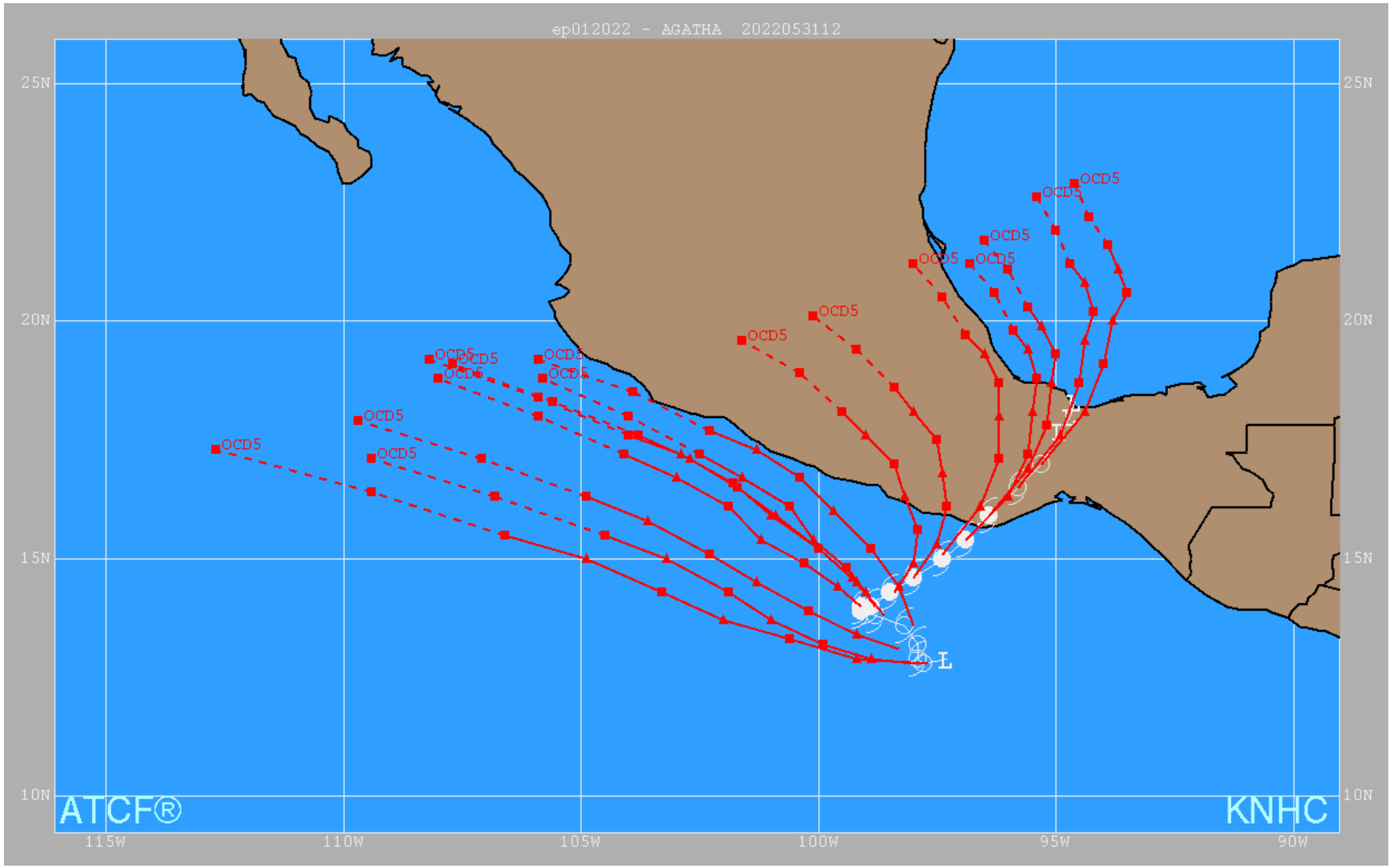


Figure 8. Selected OCD5 track forecasts (red lines, with 0, 12, 24, 36, 48, 60, 72, 96, and 120 h positions indicated) for Hurricane Agatha, 28 – 31 May 2022. The best track is given by the thick solid line with positions given at 6 h intervals.