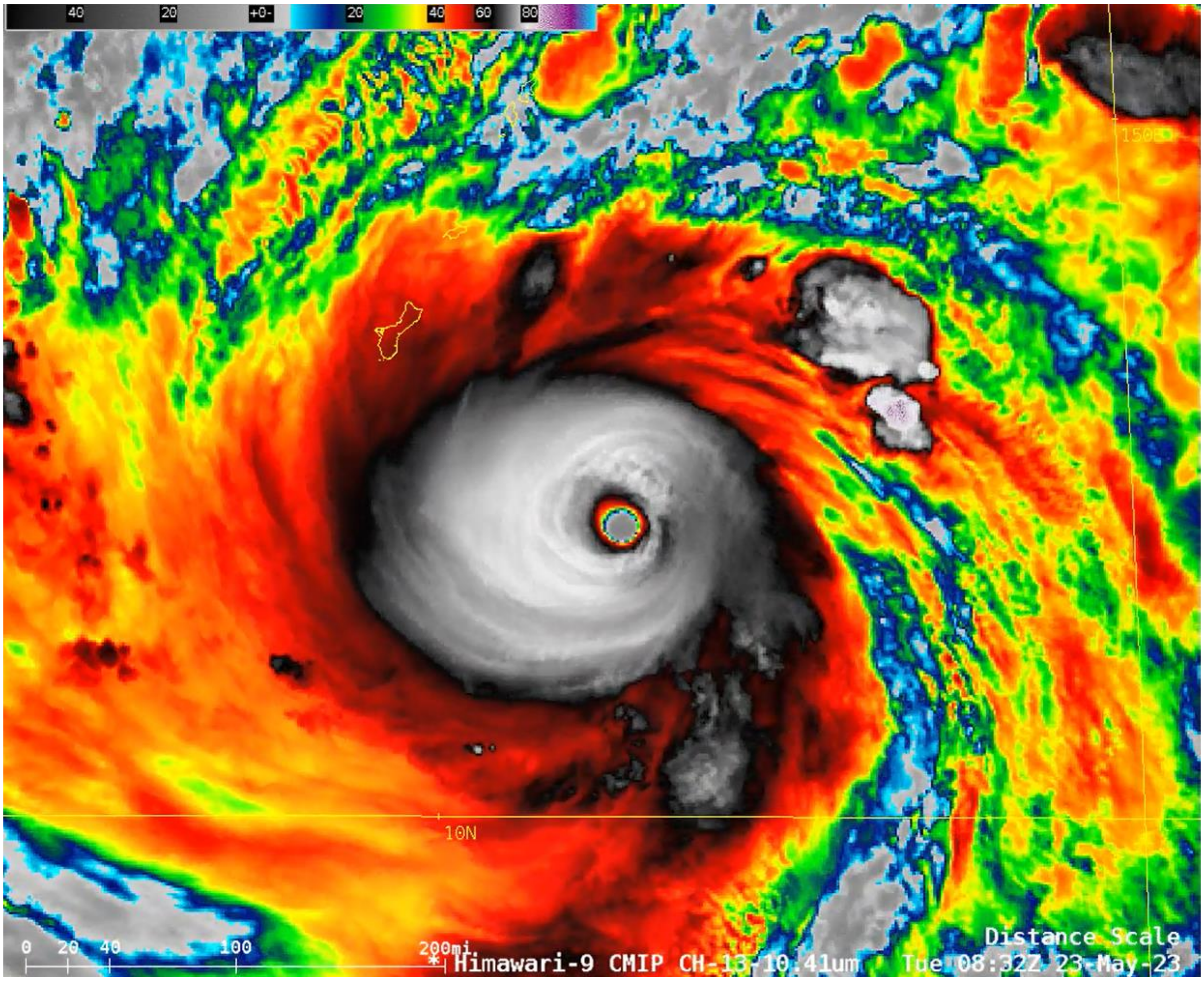


NWS Guam

Meteorological Report on the Effects of Super Typhoon Mawar (02W) in Micronesia and the Marianas
20-28 May 2023

Notable Changes in Status in the Evolution of STY Mawar while in close proximity of Micronesia and the Marianas:

Invest 97W Opened:	17 May/0200Z	6.3N/146.6E		
Low:	17 May/0300Z	5.7N/146.1E		
Medium:	18 May/0330Z	5.7N/146.3E		
TCFA:	18 May/2000Z	5.4N/148.7E		
Trop Depression:	20 May/0300Z	5.6N/149.0E	Advy	1
Trop Storm:	20 May/1500Z	5.9N/149.2E	Advy	3
Typhoon:	21 May/1500Z	8.3N/148.1E	Advy	7
Super Typhoon:	23 May/0900Z	12.1N/146.3E	Advy	14
Typhoon:	23 May/2100Z	12.7N/145.4E	Advy	16
Approx Guam CPA:	24 May/0900Z	13.7N/144.9E	Advy	18
Super Typhoon:	24 May/2100Z	14.2N/143.6E	Advy	20

Approximate closest points of approach for islands that had TC Watches or Warnings issued, based on JTWC bulletins and satellite imagery:

ISLAND	DATE/TIME (UTC)	DISTANCE	BEARING	STORM INTENSITY
Polowat	21May/0400	20 MI	SW	TS 60 MPH
Ulul	21May/1000	95 MI	SW	TS 70 MPH
Satawal	21May/1100	105 MI	NE	TS 70 MPH
Guam (WFO)	24May/0800	15 MI	NE	TY 140 MPH
Rota	24May/0900	35 MI	SSW	TY 140 MPH
Tinian	24May/0900	105 MI	SSW	TY 140 MPH
Saipan	24May/0900	115 MI	SSW	TY 140 MPH

TC Watch and Warning Issuances and Cancellations:

20 May/0300 UTC	TS Warning	Polowat, Satawal, Ulul
	TY Watch	Guam, Rota, Tinian, Saipan
21 May/2200 UTC	TS Warning Canc	Polowat, Ulul
22 May/0100 UTC	TY Warning (upg)	Guam, Rota
	TS Warning	Tinian, Saipan
	TS Warning Canc	Satawal
24 May/1900 UTC	TS Warning Canc	Tinian, Saipan
25 May/0700 UTC	TY Warning Canc	Guam, Rota

Acknowledgements: *NWS Guam would like to extend thanks to the Joint Typhoon Warning Center (JTWC) for their tireless efforts in the provision of tropical cyclone forecasts and analyses, while also engaging WFO Guam in frequent communications before, during and after Super Typhoon Mawar. Also, NWS Guam would like to thank Chip Guard, retired NWS Guam Warning Coordination Meteorologist, for his many hours spent leading the NWS Guam ground assessment team in surveying the impacts from Mawar. Finally, NWS Guam would like to thank the many members of the UOG Drone Corps for devoting many long days in the immediate aftermath of Mawar's passage to the aerial reconnaissance of some of Guam's most hard-hit areas. Their high-resolution orthomosaic footage of Guam's post-typhoon landscape will inform future decisions regarding tropical cyclone impacts and mitigation.*

Super Typhoon Mawar first developed well southwest of Chuuk on 20 May after having been a persistent feature in the global model surface wind fields for more than a week. The GFS had long depicted (starting around 9 May) a developing tropical cyclone somewhere in the region with substantial run-to-run variability in potential tracks, sending this modeled TC as far west as Palau to as far northeast as just east of the Marianas. By around 15 May, the GFS began to show increased consistency in the eventual TC lifting north, eventually passing through or very near the Marianas as it made an eventual turn to the west. The initial circulation, JTWC Invest 97W, formed southwest of Chuuk in the vicinity of 6N147E, within the eastern end of the monsoon trough, which extended eastward from near Mindanao across Palau, to another circulation south of Yap, JTWC Invest 96W near 7N138E, before ending at 97W (Figure 1).

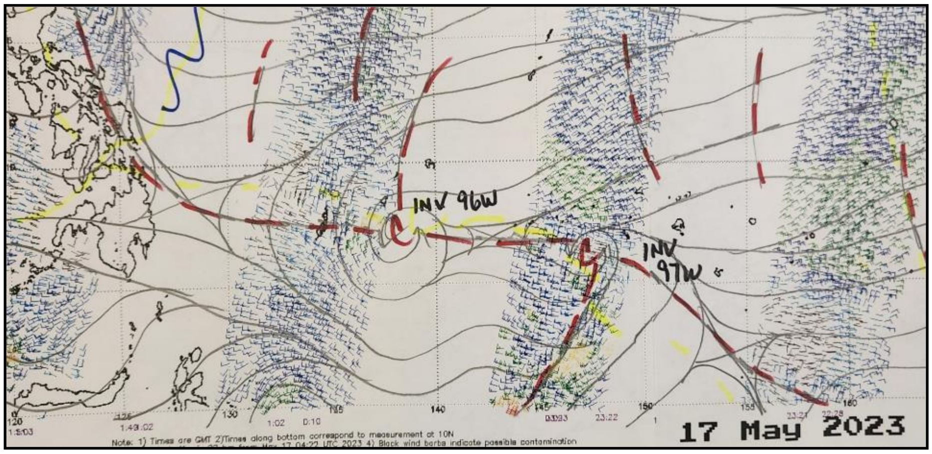


Figure 1: NWS Guam's midday scatterometer analysis indicating JTWC Invests 96W (east of Palau) and 97W (west-southwest of Chuuk), 17 May 2023.

Forecasters continued to monitor this area, looking specifically for a significant westerly wind burst that the GFS had been indicating for several days would be the precursor to gradual consolidation. A 17May/11Z Metop-B scatterometer pass (Figure 2) highlighted a robust westerly wind burst between the EQ and 5N from 144E to 149E with maximum sustained winds around 30 kt. By this time, the JTWC had already assigned 97W a LOW status for development, meaning that TC development was unlikely in the ensuing 24 hours. For the next couple of days, the circulation remained loosely-organized with flaring deep convection while the center dropped southward to just south of 6N.

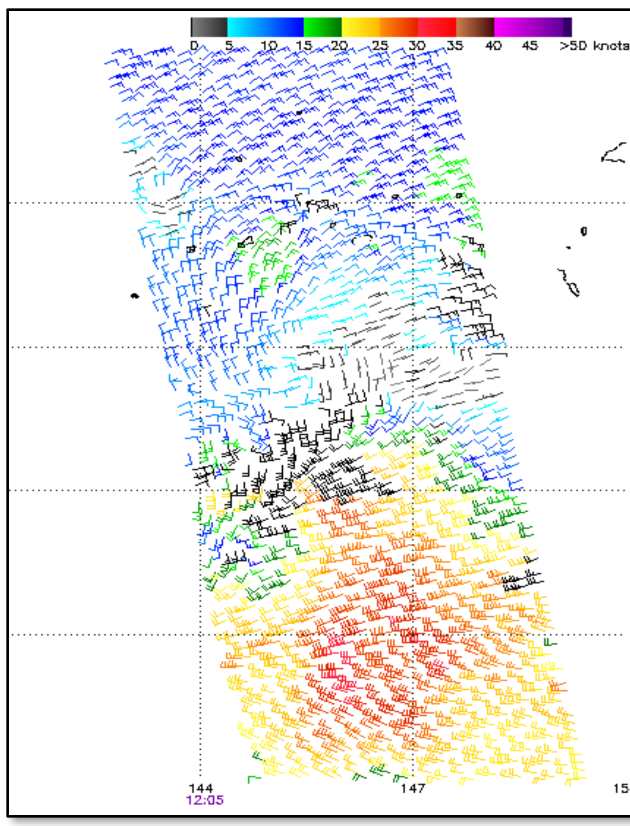


Figure 2: Overnight ASCAT-B pass indicating a strong equatorial westerly wind burst south of JTWC Invest 97W.

Between 19 and 20 May, subsequent Metop-B/C passes confirmed a developing wind field, with the 20May/00Z scatterometry data indicating 20-25 kt winds all around a consolidating low-level circulation (Figure 3).

Soon after, at 03Z, the JTWC issued its first warning on newly-formed TD 02W. For much of 20 May, Himawari-9 IR satellite imagery showed flaring deep convection, but by around 15Z, about the time the JTWC upgraded 02W (Mawar) to a tropical storm (TS), a deep plume of convection developed and did not cease. With no inhibiting environmental factors to intensification, TS Mawar steadily intensified as it continued a slow north to north-northwest heading toward the Marianas. A 21May/0813Z Synthetic Aperture Radar (SAR) pass (Figure 4) depicted an east-west elongated eye with near-typhoon force winds surrounding this feature.

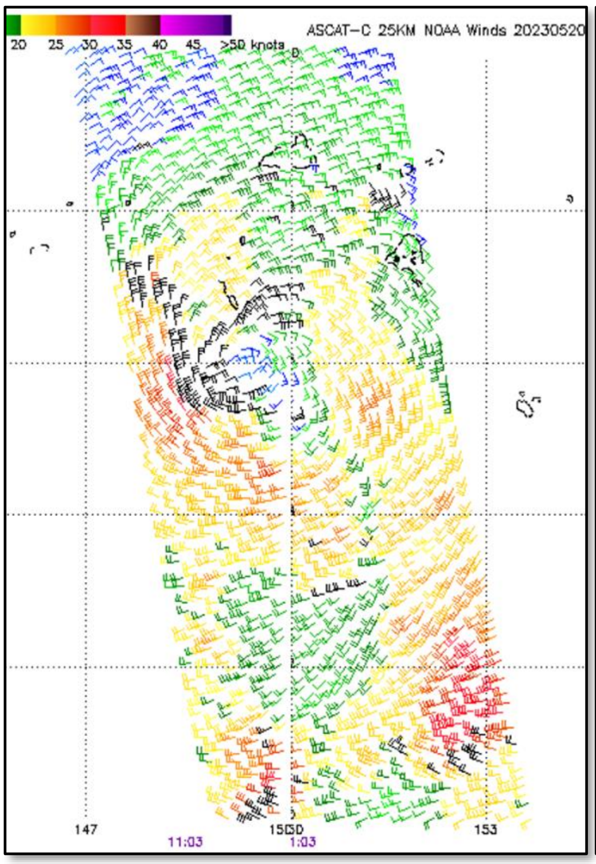


Figure 3: Midday ASCAT-C pass indicating the consolidating low-level circulation center of JTWC Invest 97W. The LLCC is nearly wrapped by 20-25 KT winds.

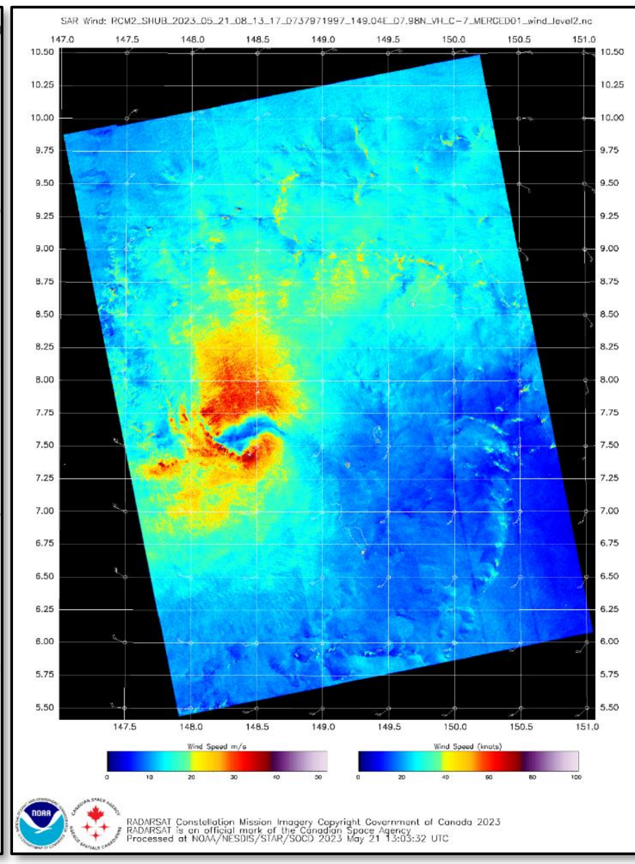
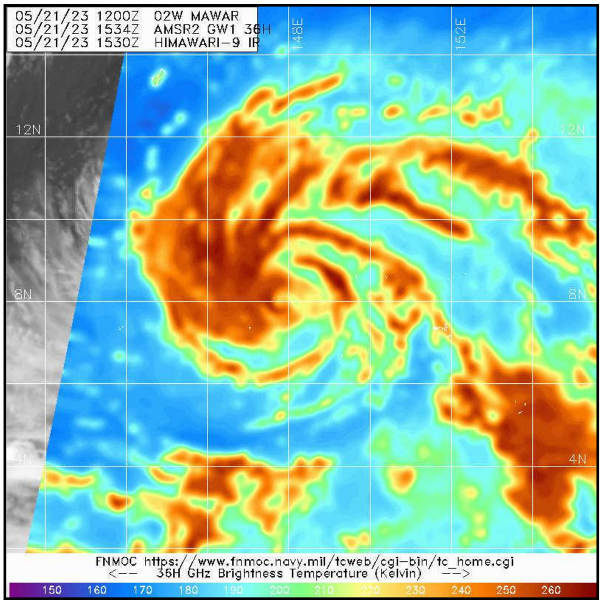


Figure 4: SAR pass over TS Mawar from 21May/0813Z. SAR data indicated near-typhoon force winds around the developing east-west elongated eye.

Several hours later, 1534Z 36GHz and 89GHz AMSR2 imagery (Figures 5 and 6) both highlighted this eye feature embedded within peripheral bands of convection.



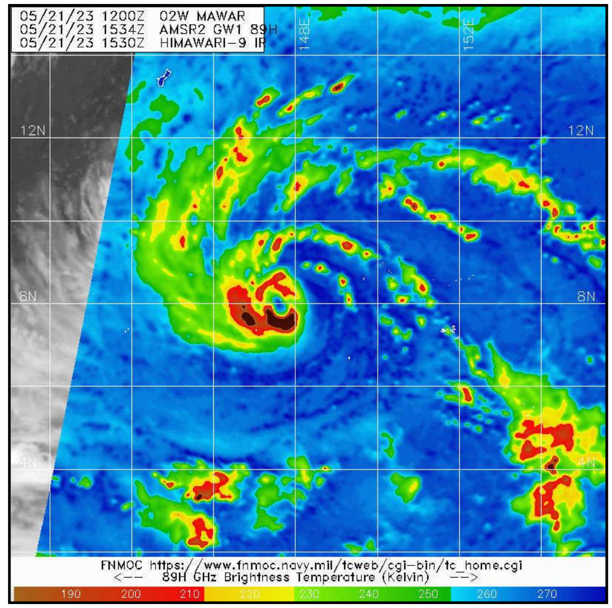


Figure 5 (left) and Figure 6 (right): 1534Z AMSR2 36GHz (left) and 89GHz (right) imagery highlighting the spiraling bands of deep convection around a developing eye feature.

Around this time (21May/15Z) the JTWC upgraded Mawar to a typhoon. Although steadily intensifying, it wasn't until about 36 hours later (between 00Z and 06Z 23 May) that TY Mawar took on the appearance of a mature typhoon with a symmetric cirrus cloud canopy and a cloud-free eye in IR satellite imagery (Figure 7).

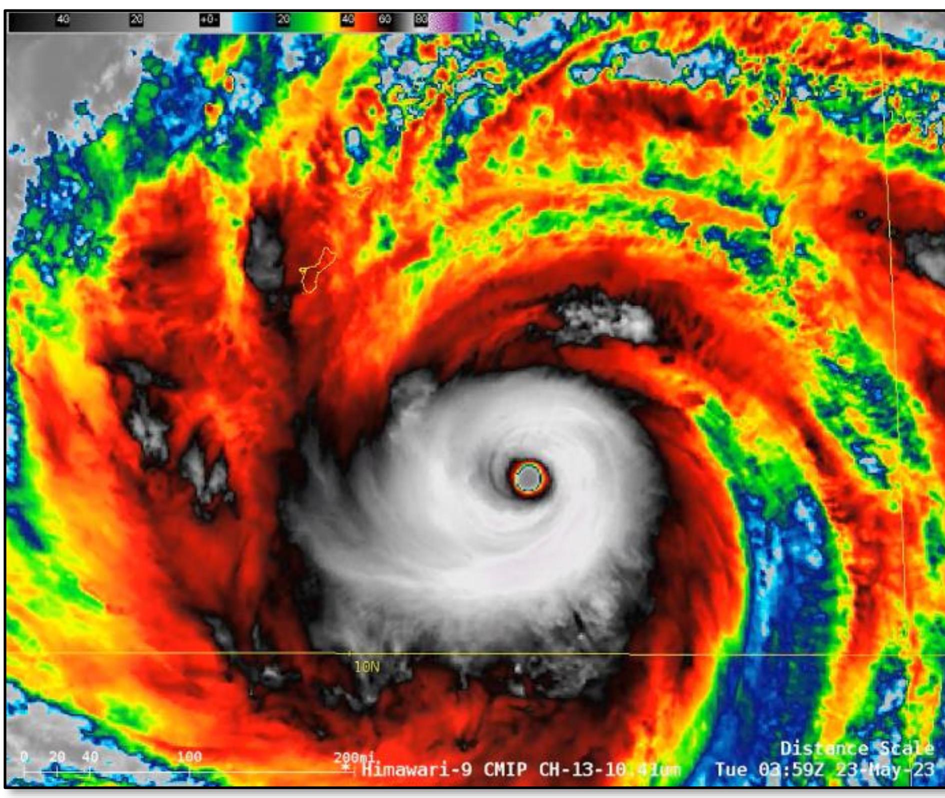


Figure 7: 23May/0359Z Himawari-9 10.41um "Clean IR" image of TY Mawar. Guam is just northwest of Mawar.

An 0830Z SAR pass (Figure 8) showed a symmetric typhoon wind field, though the 100+ kt wind shading revealed a wide band of such winds north of the center; while to the south, two distinct narrow bands were identifiable about 7nm and 14nm from the center.

At 23May/0900Z, the JTWC upgraded Mawar to a super typhoon. It was about this time that deep convection began to wane along the eastern and northern periphery of Mawar as an eyewall replacement cycle (ERC) commenced. The asymmetric convection was particularly notable in the subsequent SSMIS 91GHz images at 23May/1756Z and 1952Z (Figures 9 and 10).

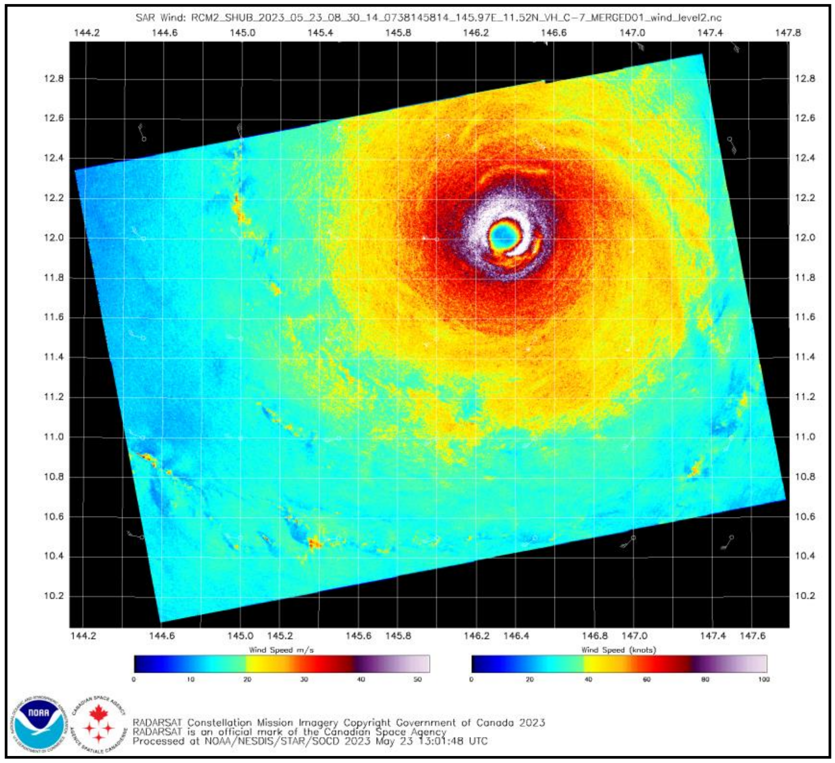


Figure 8: 23May/0830Z SAR pass over TY Mawar. The white shading indicates winds in excess of 100 kt. Two wind maxima in the southern semi-circle hint at the eventual eyewall replacement cycle.

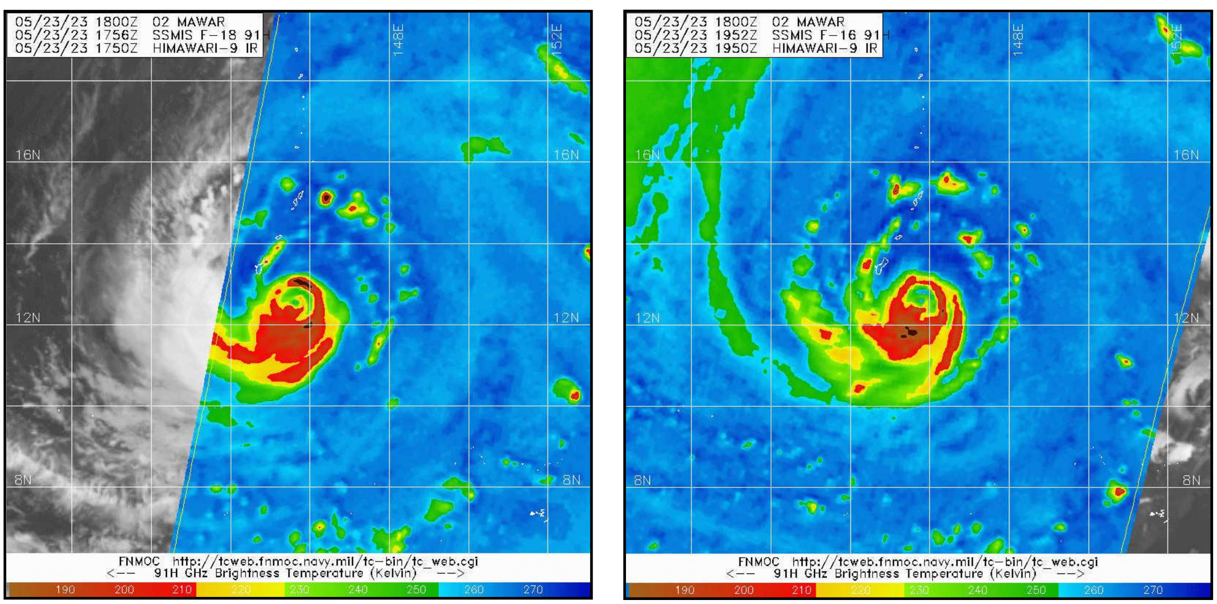


Figure 9 (left) and Figure 10 (right): SSMIS 91GHz images from 1756Z (left) and 1952Z (right) on 23 May. Microwave imagery reflected asymmetric convection within TY Mawar as it approached Guam.

With the exception of a narrow band of deep convection along the inner edge of the northern semi-circle of the eyewall, all deep convection was found to the south of the eye of Mawar.

With the subsequent deterioration of Mawar's structure evident in both satellite and radar imagery, and decreasing trends in TC intensity guidance (Figure 11), JTWC dropped Mawar from a 155 mph category 4 super typhoon to a 140 mph category 4 typhoon at 23May/21Z.

As Mawar slowly approached Guam, forecast tracks, closely following model guidance, continued to point to a passage just south of or over the southern half of Guam. However, soon after 23May/21Z, 3-hourly satellite position estimates and Guam-radar-based hourly fixes, issued by NWS Guam, began showing the center of Mawar shifting to the right (north) of forecast tracks. As a result, subsequent forecast tracks accordingly showed a northward trend, keeping within the cluster of satellite and radar fixes (Figure 12).

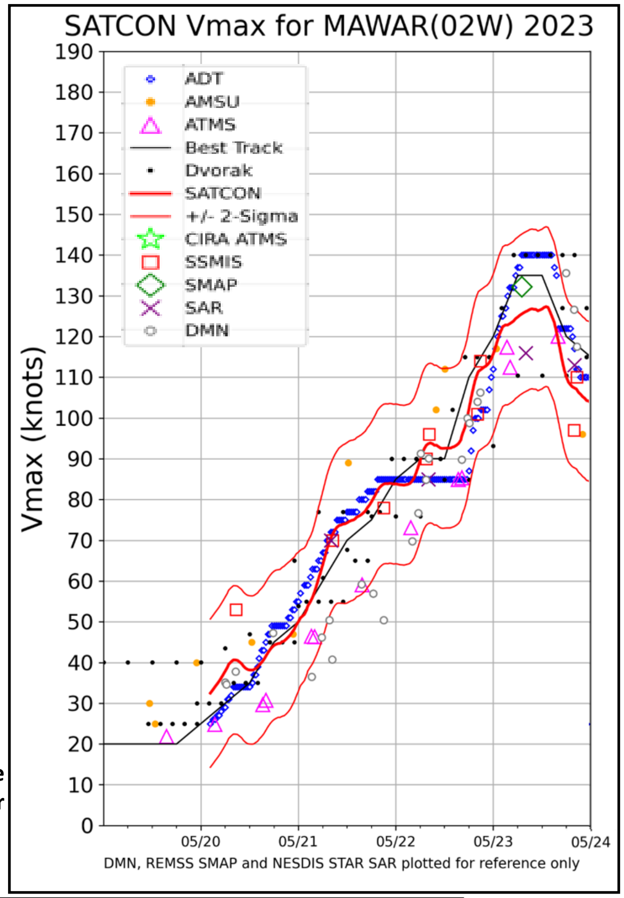


Figure 11 (right): SATCON intensity guidance leading up to the 23May/21Z lowering of Mawar from a "super" typhoon to a typhoon by JTWC.

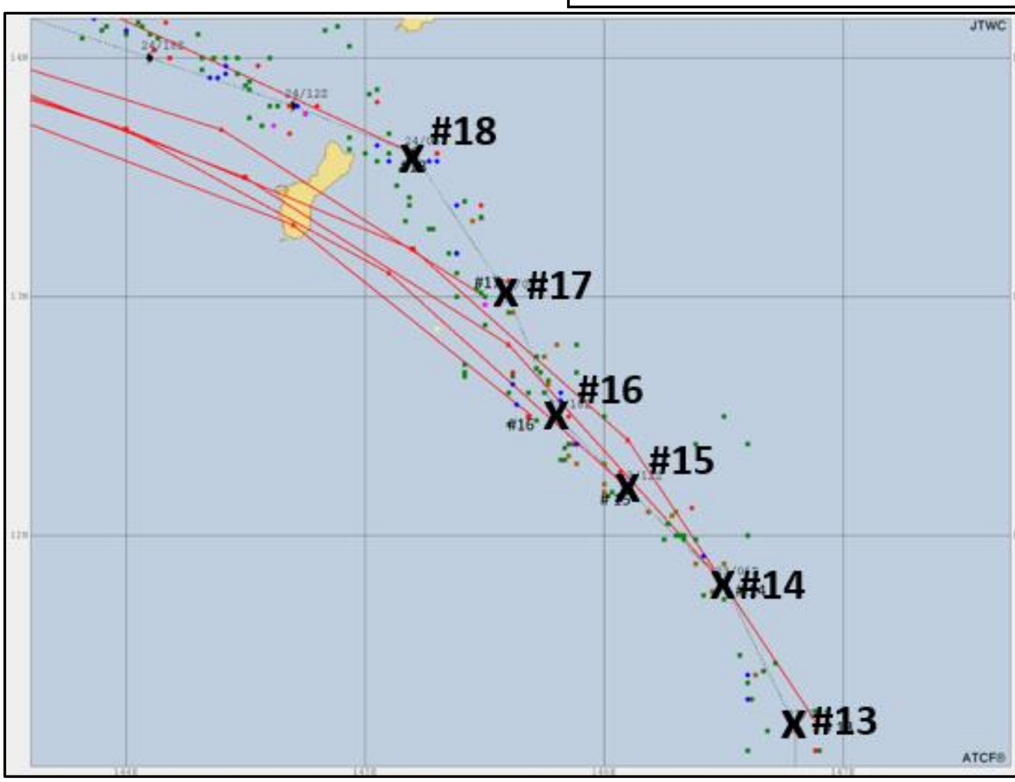


Figure 12: A composite of 6-hourly JTWC warning positions and forecast tracks, satellite fixes, and hourly radar position estimates. Courtesy, JTWC.

For the nearly 30 hours that the center of Mawar had been within range of the Guam radar, Mawar's motion displayed the typical trochoidal bobble that TCs often make (Figure 13).

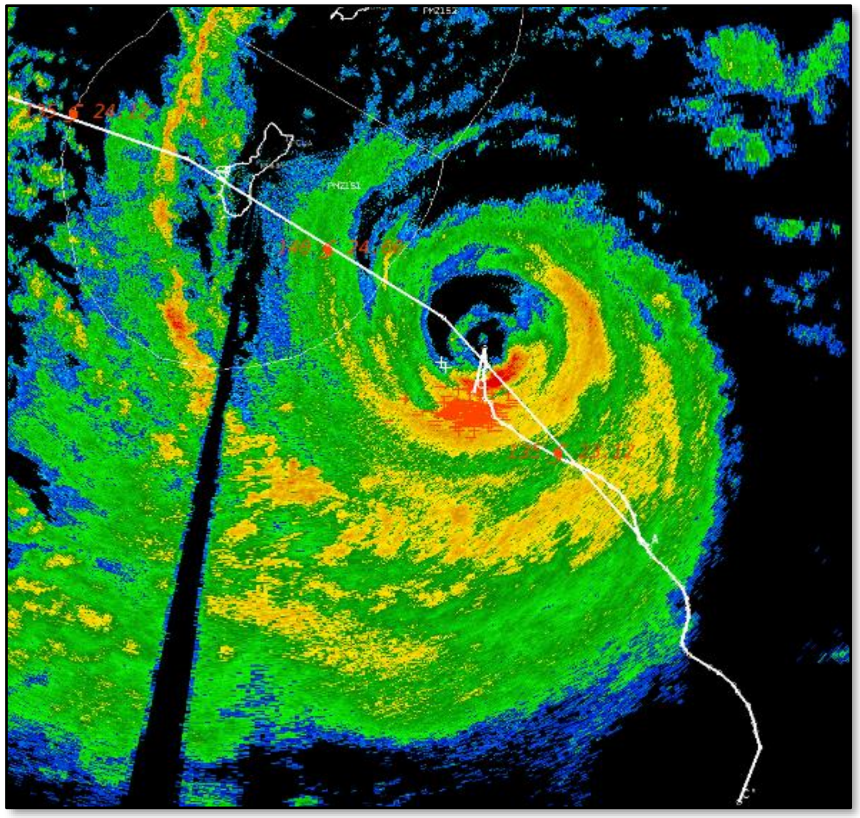


Figure 13: Andersen AFB WSR-88D image of TY Mawar as it approached Guam. The slightly-arcing white line shows JTWC's latest forecast track; the curvy white line shows the actual path of Mawar's eye.

Mawar's 6-hourly averaged motion closely followed subsequent JTWC forecast tracks until that prolonged northward bobble on Wednesday, 24 May. This spared Guam's low-lying southeast coastline from potentially significant coastal inundation, but also brought the heaviest rains and strongest winds of the southern eyewall over much of Guam. Around 24May/06Z, satellite position estimates based on AMSR2 and GPMI microwave imagery (Figures 14 and 15) indicated Mawar was making its anticipated westerly turn with the eye likely to pass very near, or over, the northern tip of Guam.

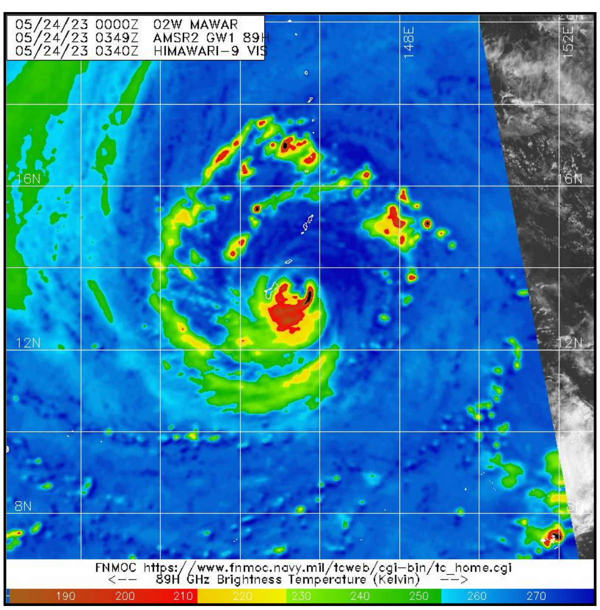


Figure 14: 0349Z 24 May AMSR2 89GHz image showing the southern eyewall of Mawar approaching Guam.

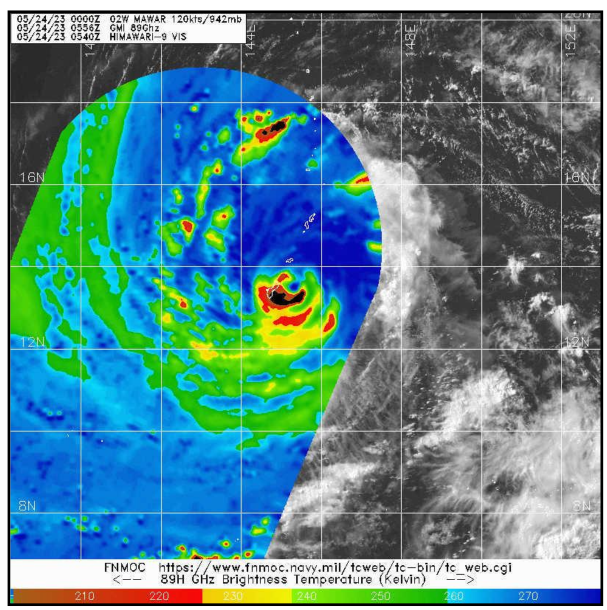


Figure 15: 0556Z 24 May GPMI 89GHz image showing the southern eyewall of Mawar moving over Guam.

It is worth noting the inherent difficulty with center fixing via both satellite imagery (Figure 16) and radar imagery (Figure 17) due to the double eyewall structure with the inner eyewall moving within the secondary eyewall.

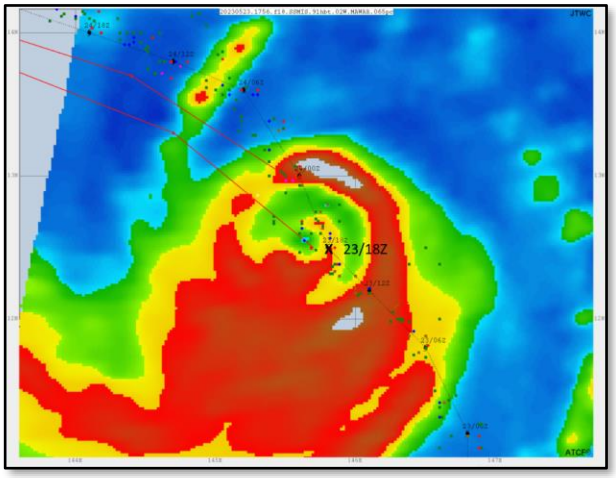


Figure 16: JTWC's 23/18Z warning position atop the 1756Z SSMIS 91GHz image. Courtesy, JTWC.

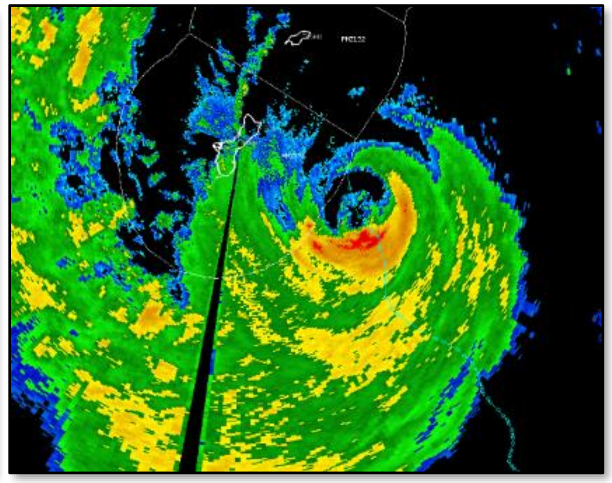


Figure 17: 0016Z 24 May PGUA radar reflectivity showing the double eyewall structure. The blue line is a radar-based tracking of the center of the eye.

However, a quick look at the forecast track cones from Advisories 14-17 (Figure 18) shows that Mawar's poleward motion on the 24th and subsequent movement, while deviating from consistent model guidance, still fell within the error envelope. (Keep in mind, the forecast cone (white shaded area) indicates the probable (60-70%) area in which the center of a tropical cyclone will move based on the prior 5 years of official forecast errors.)

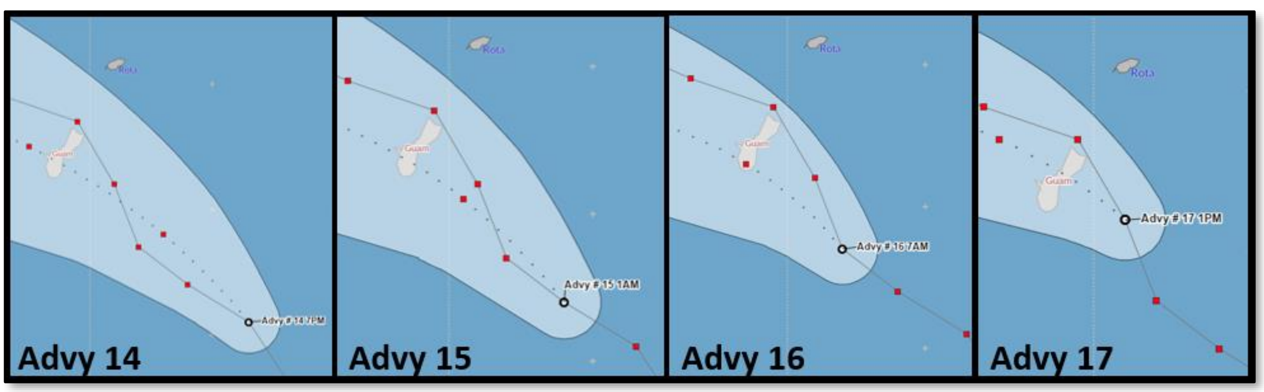


Figure 18: Error cone forecast tracks from JTWC's Advy 14, 23/09Z; Advy 15, 23/15Z; Advy 16, 23/21Z; Advy 17, 24/03Z;

Between 05Z and 18Z of 24 May (3pm 24 May and 4am 25 May), much of Guam felt the brunt of the southern eyewall. Destructive northwest winds became typhoon force west winds soon after sunset, then increased further while turning southwest before midnight (24May/14Z) (Figures 19, 20, and 21).

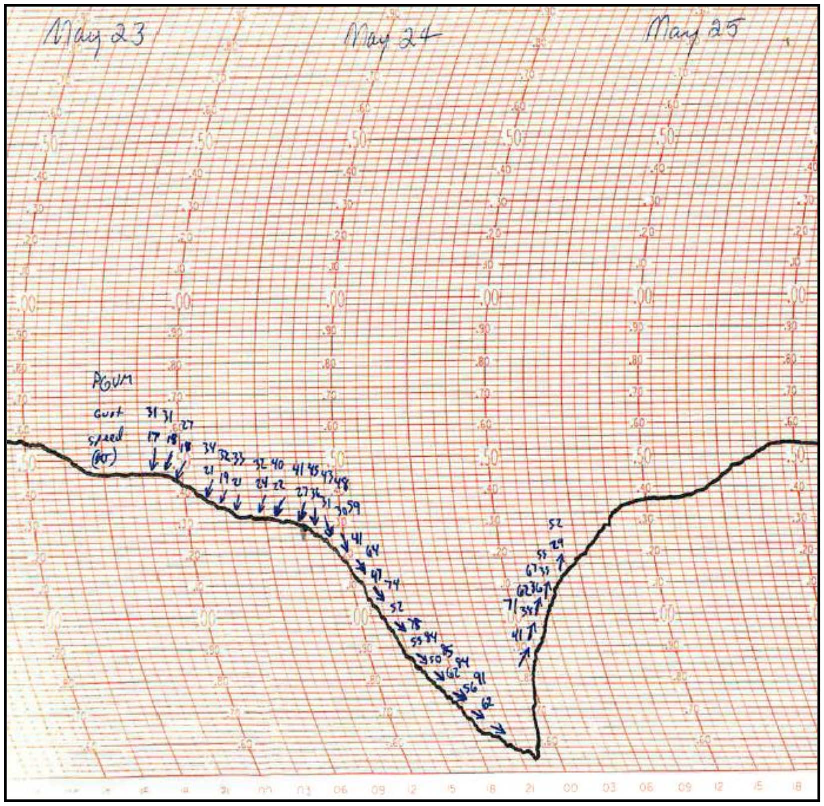


Figure 19: NWS WFO Guam microbarograph chart of Mawar's passage. Guam International Airport (PGUM) wind observations, going up from the pressure trace: wind direction (arrow), 2-min wind (kt) gusts/peak wind (kt). Wind reports are indicated along the vertical hour (ChST) line in which they were recorded (or for gusts, at the end of the hour of sampling). Wind observations failed at the peak of Mawar's passage.

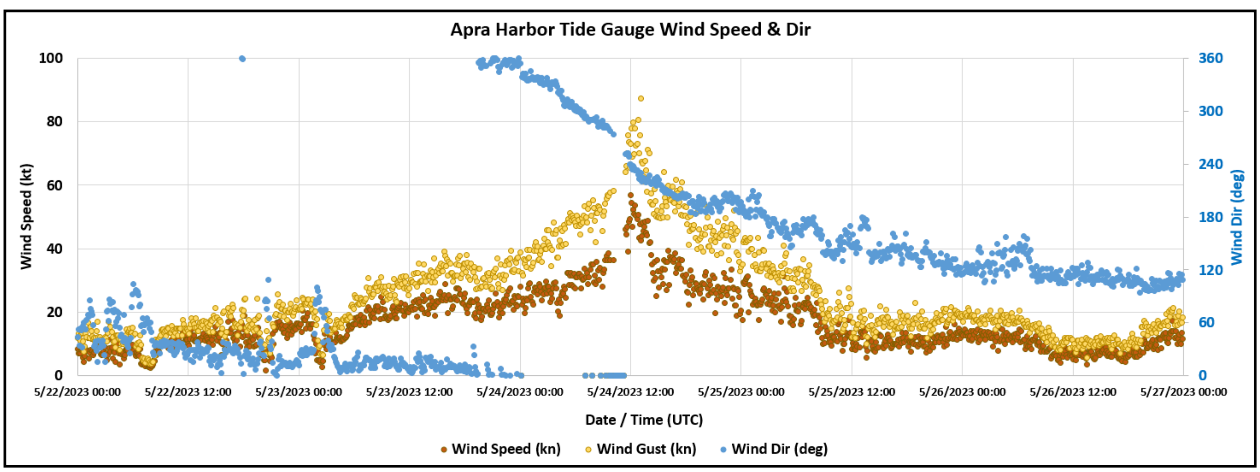


Figure 20: Apra Harbor Tide Gauge plot of wind speed and gusts (kt) and wind direction (in blue). Peak winds came out of the southwest. The tide gauge, placed on the southern shore of Apra Harbor, was sheltered from the full brunt of the southwesterly winds.

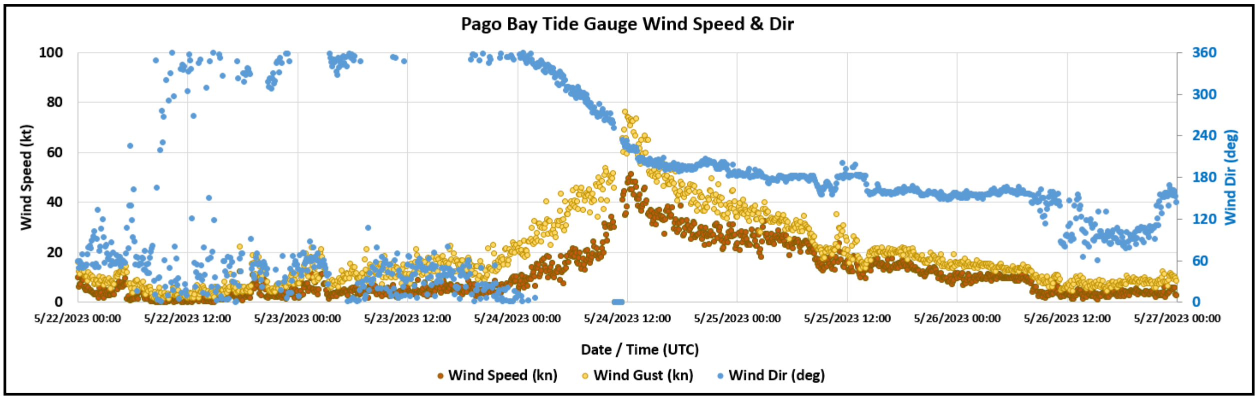


Figure 21: Pago Bay Tide Gauge plot of wind speed and gusts (kt) and wind direction (in blue). Similar to Apra Harbor, peak winds also came out of the southwest. The tide gauge, situated in the north end of Pago Bay, is protected by surrounding higher terrain to the north-through-northeast (initial destructive winds) and the west-through-northwest (later winds).

A close look at satellite imagery (Figures 22 and 23) shows the closest point of approach to Guam having been 08Z-10Z 24 May, as the center of Mawar's eye passed just north of Andersen AFB and Ritidian. The southern eye may likely have come on shore, based on some accounts from AAFB.

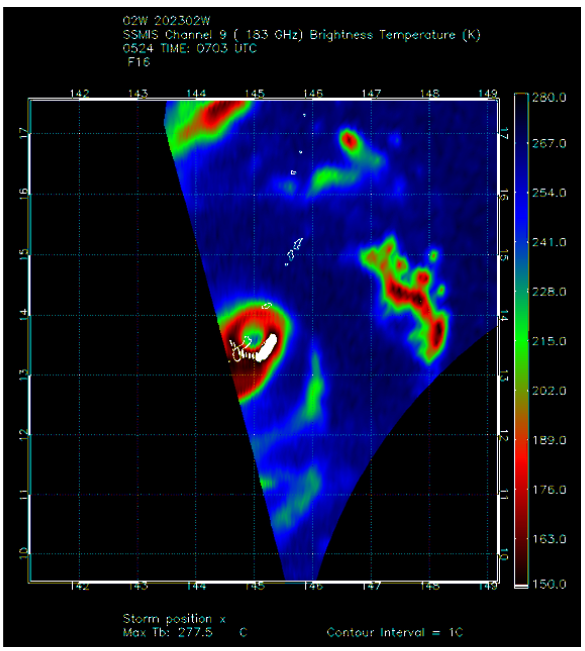


Figure 22: 24May/0524Z SSMIS 183GHz imagery showing the center of TY Mawar passing Guam's northern coast with the southern eyewall passing over Guam.

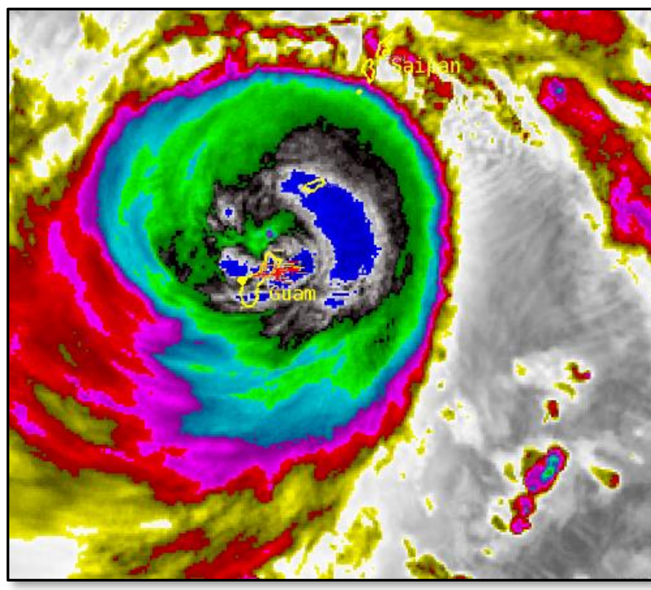


Figure 23: Himawari-9 10.41um "Clean IR" imagery from 24May/0959Z (7:59 PM ChST) depicting the cloud-filled eye of Mawar passing near Ritidian, Guam, while intense eyewall convection envelops the island. Red crosses indicate lightning detected by Vaisala's GLD360.

Cellphone-based pressure traces (Figure 24), via the RedVox App, show the lowest pressures as having occurred between 11Z and 13Z 24 May (9 PM and 11 PM ChST). The second pressure minimum is thought to have occurred as Mawar began its rapid intensification while pulling away from Guam. Coincidentally, this is when the strongest winds were observed by the various observational platforms and noted by many folks across Guam.

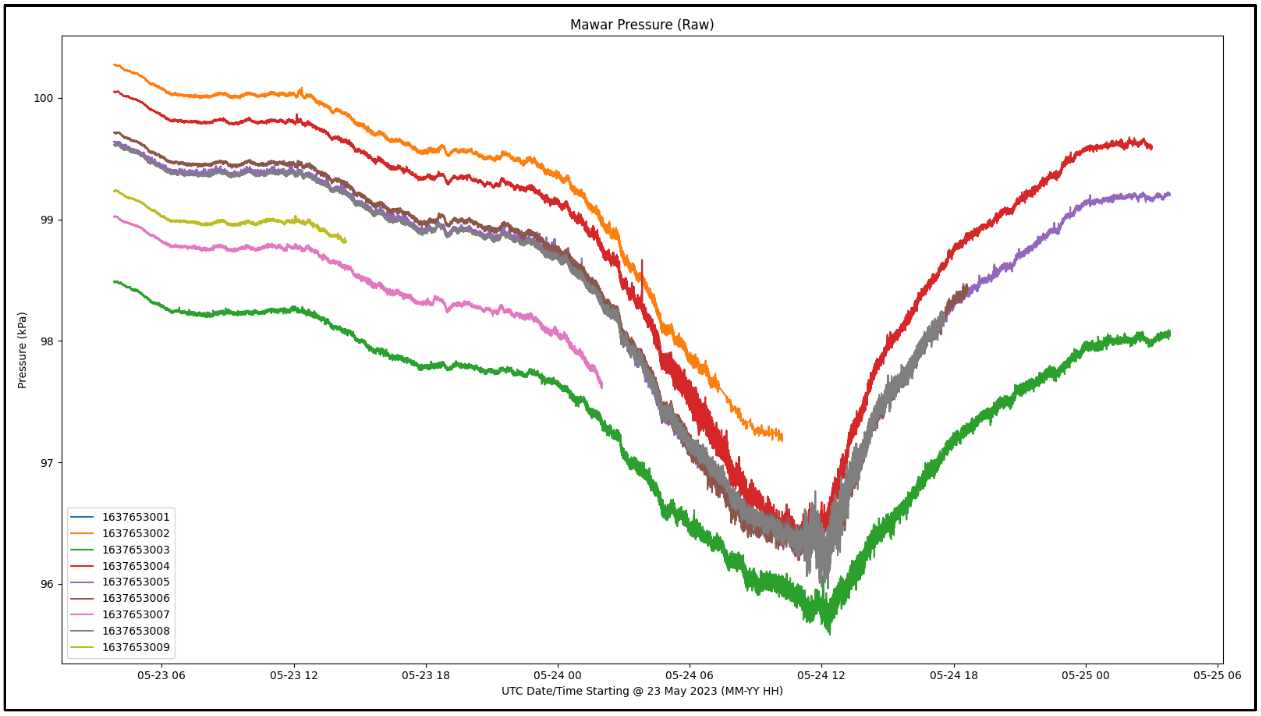


Figure 24: Pressure (kPa) from 7 cell phones that were actively collecting and sending data via the RedVox App. The number of active phones decreased during and after Mawar due to the loss of power, and the ability to charge the phones. Similar to the microbarograph at the NWS Guam office, several phones showed a rapid rise in pressure soon after 12Z (10 PM ChST).

Ground assessments by NWS staff and unmanned aerial drone assessments by the University of Guam Drone Corps show that most damage came from the west-northwest (early winds, as Mawar's center approached north Guam) to southwest (after closest-point-of-approach, as Mawar's center moved away from Guam) (Figures 25 and 26).

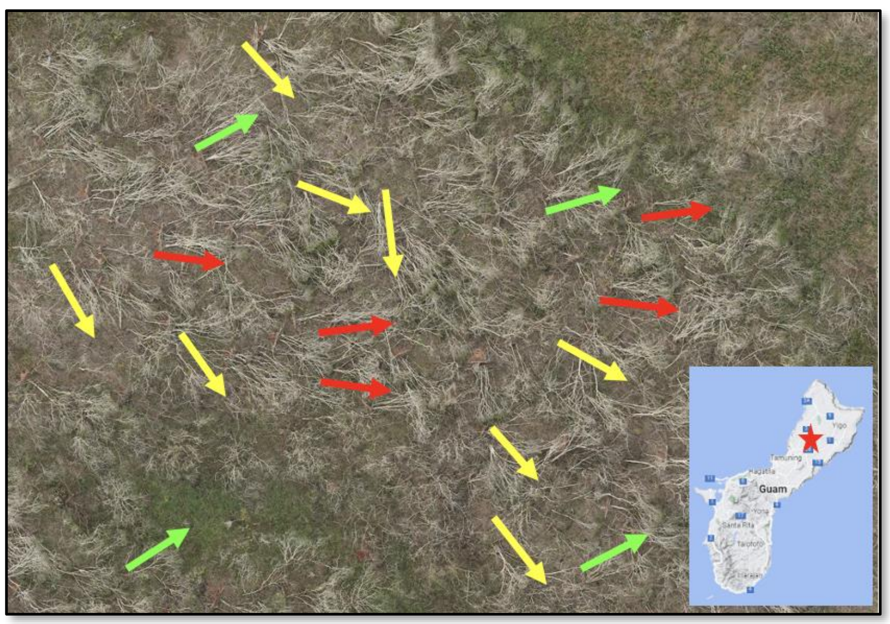


Figure 25: Aerial drone imagery from the Dededo/Astumbo area of north-central Guam shows numerous downed trees. Snapped and uprooted trees falling to the south/southeast (yellow arrows) are related to the initial destructive north/northwest winds as Mawar approached the eastern side of Guam; trees fallen toward the east (red arrows) are a result of the west winds as Mawar passed the northern tip of Guam; trees fallen to the northeast (green arrows) resulted from the southwesterly winds as Mawar moved away from Guam.

While many trees snapped from winds of these directions, stronger trees were snapped or blown down by west and southwest winds.

Additionally, the number of uprooted trees falling from west to southwest could also be partly related to the saturation of the ground from the torrential rains.

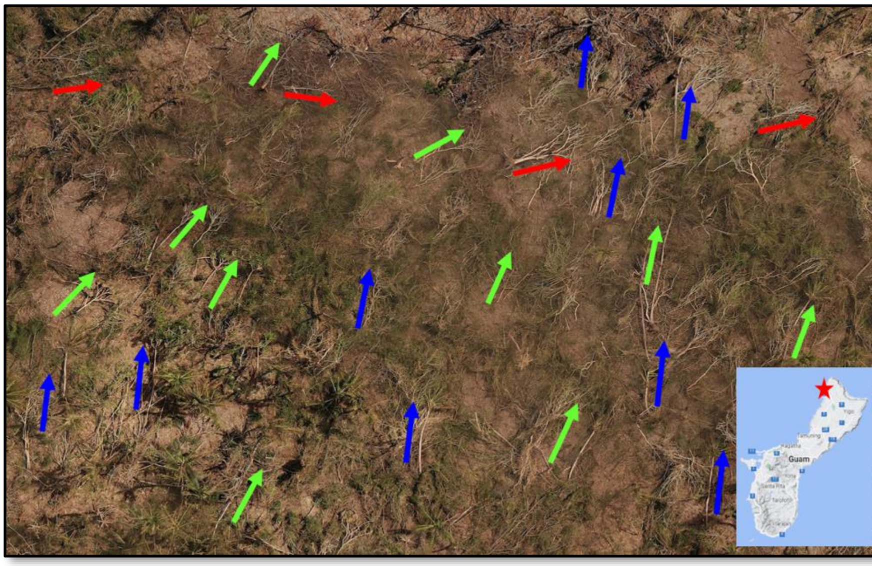


Figure 26: Aerial drone imagery from the Ritidian, Guam, area. A significant majority of tree falls, here, were the result of southwesterly winds (green arrows) with some notable tree falls coming from nearly due-south (blue arrows) as Mawar began rapidly intensifying in its departure from Guam.

A close look at Himawari-9 IR imagery (Figure 27) showed persistent, flaring deep convection in the south-southeastern eyewall that affected Guam for much of the time between 09Z-15Z, Guam’s evening and overnight hours, even though Mawar was moving away.

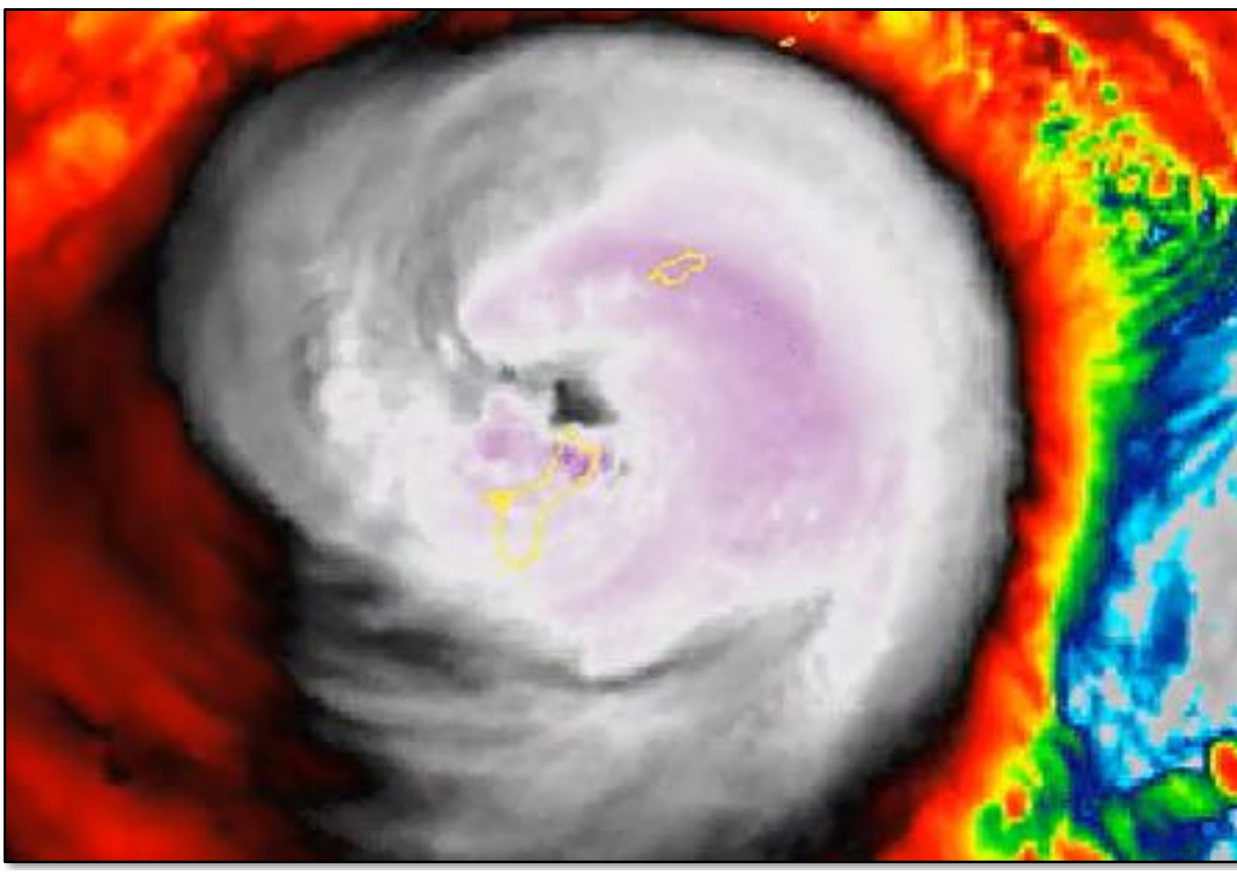


Figure 27: Himawari-9 10.41um “Clean IR” imagery from 24May/0947Z (7:47 PM ChST) depicting the cloud-filled eye of Mawar passing near Ritidian, Guam, while intense eyewall convection (light to darker purple) envelops the island.

Surface observations from a University of Guam Soil Lab weather monitoring station in Yigo also reflected this notion, with the strongest winds having come from the southwest AFTER pressures had already started to rise (Figure 28).

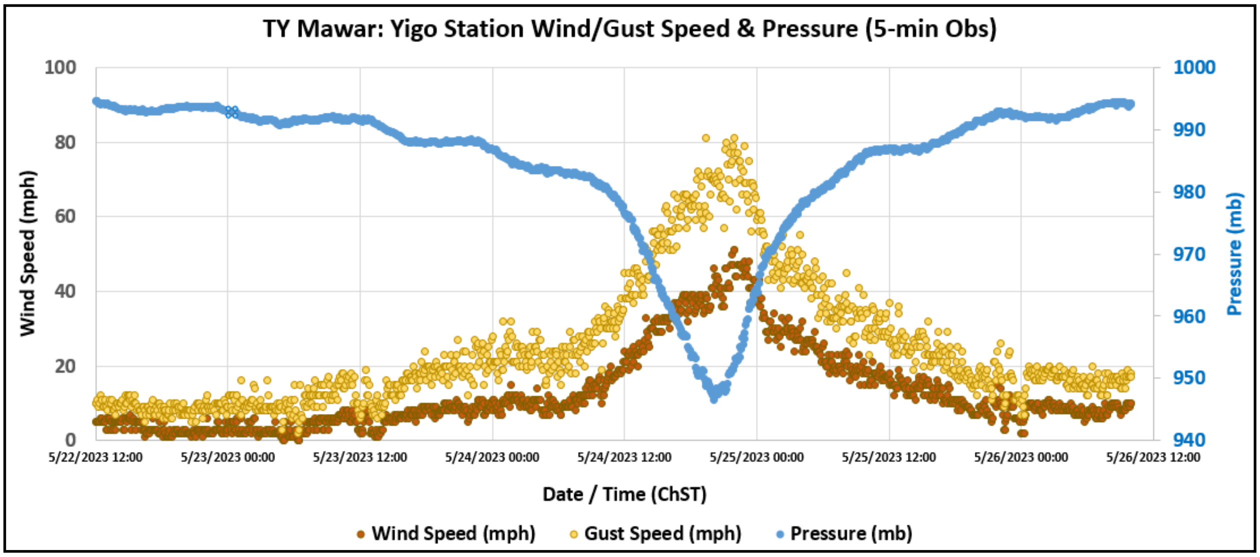
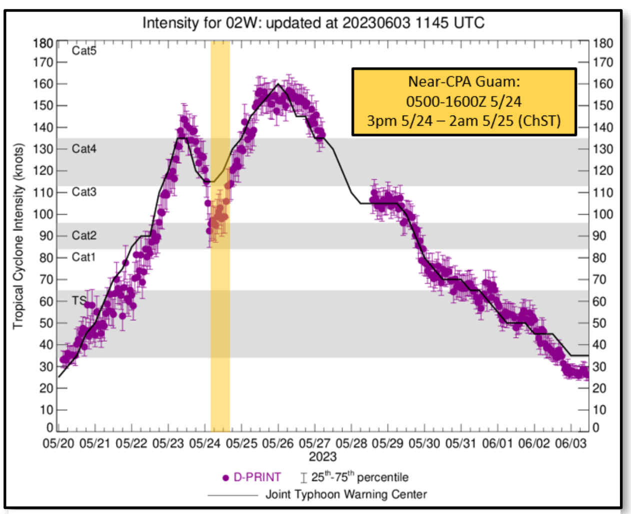


Figure 28: Sustained wind (brown) and gust (yellow) in mph, and pressure (blue, mb) 5-min observations from a University of Guam Soil Lab weather monitoring station in Yigo Guam. Strongest winds were observed in the 3-5 hours after the lowest-observed station pressure.

TC intensity guidance pointed to an onset of rapid intensification around 12Z following the completion of the ERC (Figures 29, 30, and 31).



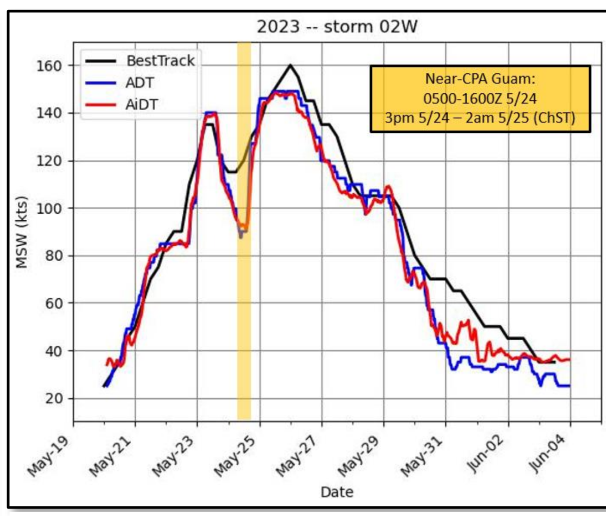


Figure 29: DeeP IR Intensity of TCs (D-PRINT) intensity guidance for TY Mawar, courtesy Cooperative Institute for Meteorological Satellite Studies / University of Wisconsin-Madison (CIMSS/UWisc) https://tropic.ssec.wisc.edu/real-time/open-aiir/2023_02W_history_IR.html

Figure 30: AI-enhanced Advanced Dvorak Technique (AiDT) guidance for TY Mawar, courtesy CIMSS/UWisc https://tropic.ssec.wisc.edu/real-time/adt/AiDT/archive2023/02W.AiDTplot.jpg

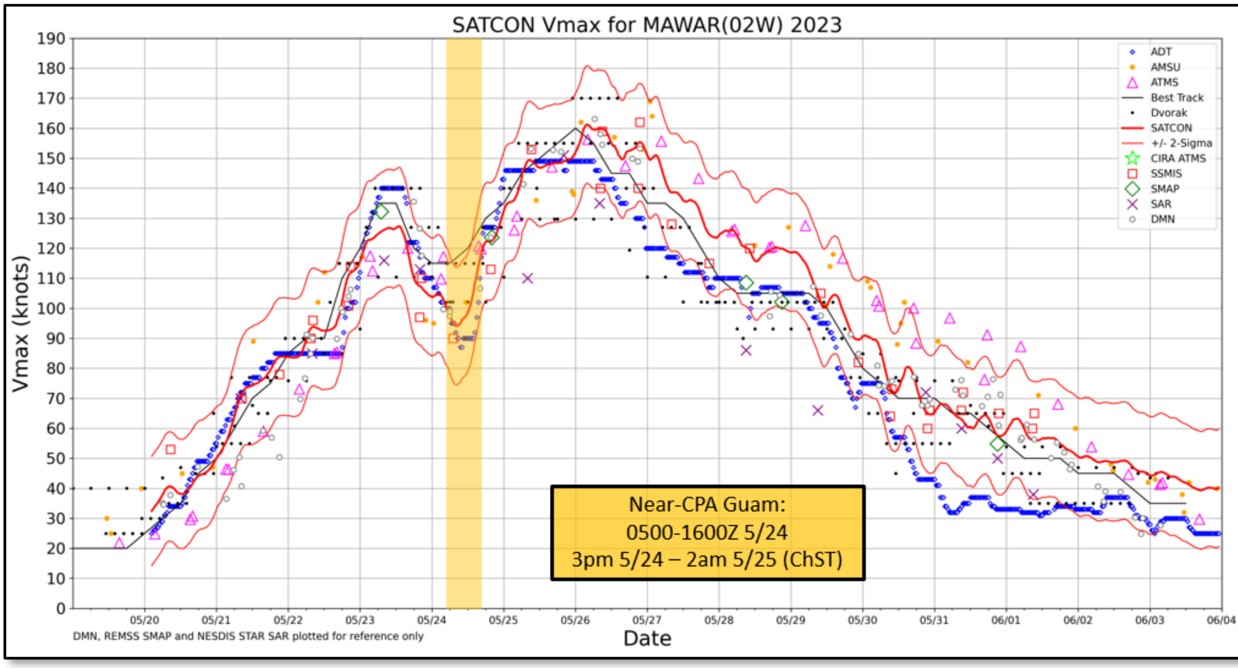


Figure 31: CIMSS Satellite Consensus (SATCON) intensity guidance for TY Mawar, https://tropic.ssec.wisc.edu/real-time/satcon/202302W_wind.png

As noted earlier, Vaisala's GLD360 lightning data showed several impressive bursts of lightning overhead northern Guam between 10Z and 12Z (Figure 32).

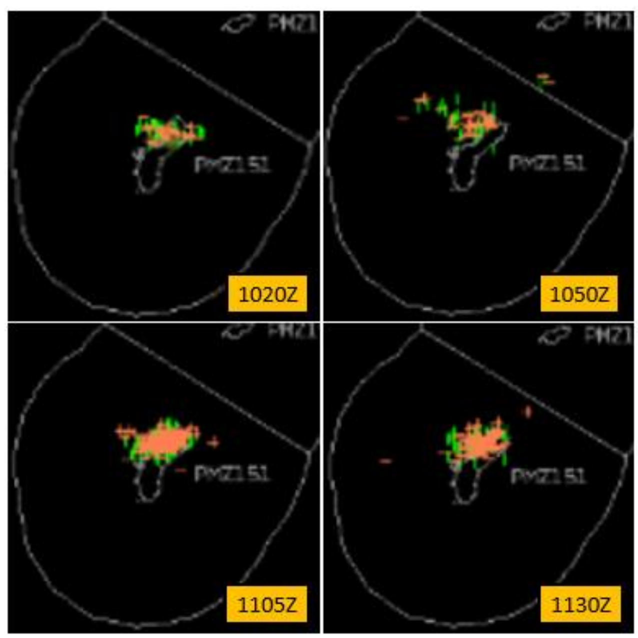


Figure 32: GLD360 5-min lightning data, as observed on NWS Guam AWIPS displays during Mawar's intensification while departing from Guam.

Despite all of the lightning, only a few rumbles of thunder were heard at the NWS Guam office over the din of the typhoon. This all happened as Mawar was pulling away to the west-northwest from Ritidian, Guam. A review of the Guam International Airport observations (PGUM) shows that the duration of tropical storm force winds, and greater (39+ mph), was nearly 14 hours—approximately from 03Z to 17Z 24 May (1 PM 24 May to 3 AM 25 May).

During its slow passage over Guam, the southern eyewall of Mawar brought long-duration torrential rains with much of Guam receiving around 2 feet of rain in the 72 hours of 23-25 May. At the Guam International Airport (WFO Guam), 24.71 inches of rain was recorded during a 24-hour period from 24May/00Z to 25May/00Z (10am Wednesday 5/24 to 10am Thursday 5/25 ChST), with the bulk of this rain occurring in a 16-hour period from 04Z to 20Z 24 May (2pm 24 May to 6am 25 May ChST). A USGS rain gauge in Dededo (northern limestone plateau of Guam) recorded a rainfall rate of 6.92 inches per hour from 1145Z to 1245Z (945pm to 1045pm ChST) Wednesday evening, 24 May, as the southern eyewall pivoted overhead. While Mawar led to remarkable rainfall across Guam, it was not unprecedented: 33 inches of rain was measured during the slow passage of Typhoon Pamela in 1976. The JTWC 1976 annual report also notes 27 inches of rain occurred during a 24-hour period during Pamela's passage. Although there is no rainfall data during the passage of Karen (1962), historical records suggest that Mawar's 24-hour and storm total rainfall are possibly the second greatest on record for Guam (daily data from 1945 to present).

Once to the west of Guam, Mawar steadily intensified to a peak satellite-based estimated intensity of 185 mph at 26May/03Z as noted in JTWC's Bulletin #25. A 26May/0855Z SAR pass (Figure 33) shows the mature Super Typhoon Mawar as it continued to the west-northwest from the Marianas. Mawar finally exited the western boundary of Guam's AOR, crossing 130E near 17N around 27May/17Z.

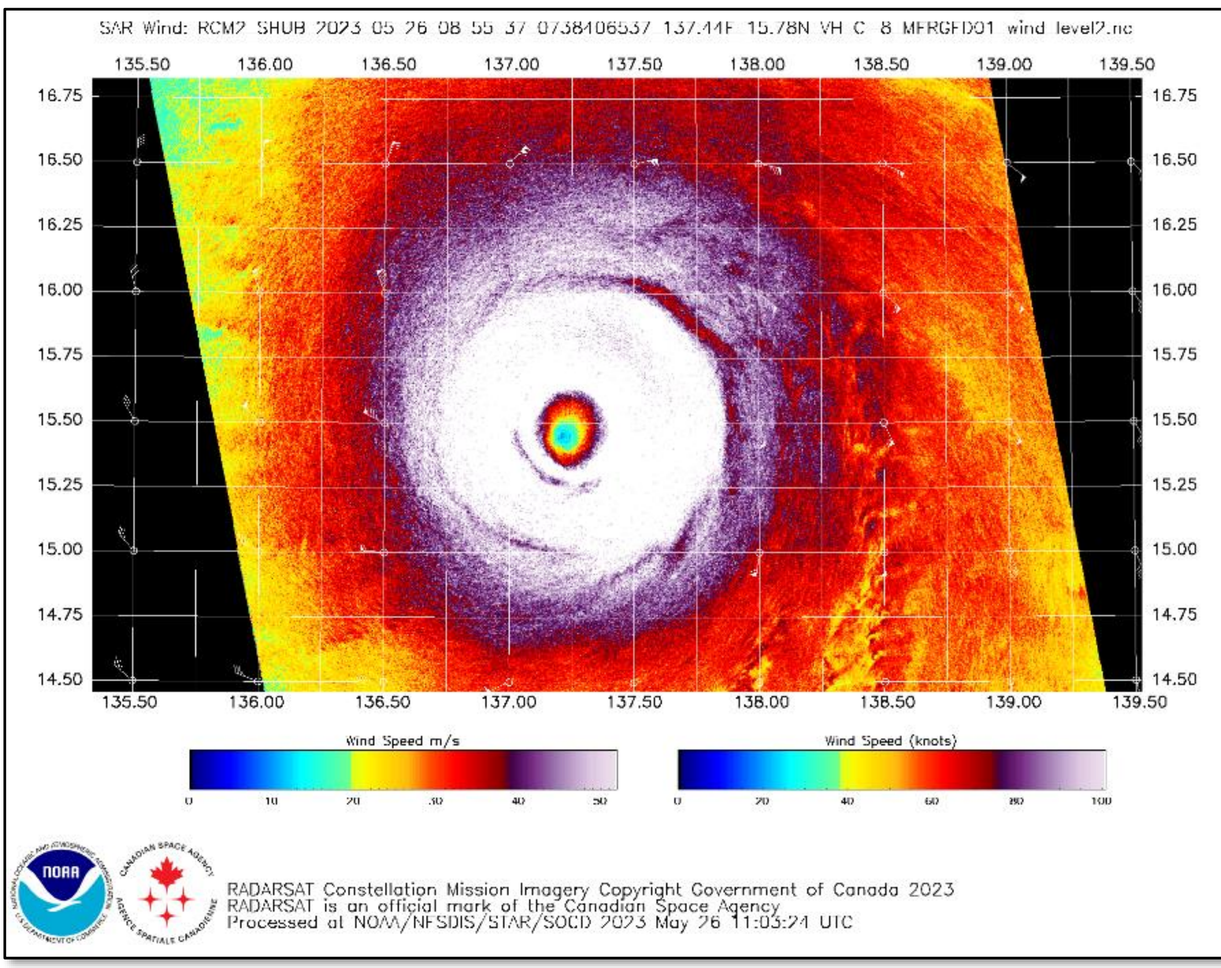


Figure 33: 26May/0856Z SAR pass over STY Mawar in the Philippine Sea west, west of the Marianas. The white shading indicates winds well in excess of 100 kt. The JTWC intensity of Mawar, at this time, was 155 KT (JTWC Bulletin #26).

Notable Marine and Oceanographic Details

Marine-based observations showed that Typhoon Mawar had notable oceanic effects on the waters around Guam as it moved through the area.

A 23May/00Z s3a altimetry pass (Figure 34) recorded significant wave heights just under 30 feet as Mawar strengthened into a super typhoon well southeast of Guam. A Pacific Islands Ocean Observing System (PacIOOS) Waverider buoy, moored roughly 1 mile east of Ipan, Talofofo, Guam, measured a peak significant wave height of 20.05 feet at 16Z on 23 May, with wave energy exclusively confined to wind wave energy from 70-80 degrees and E-SE swell from 100-120 degrees. Observed sea heights were notably lower at Ipan buoy compared to model data (Figure 35). This was likely due to the right-of-track movement with Mawar, which ultimately brought the center of the storm over the northern tip of Guam instead of the southern part of the island.

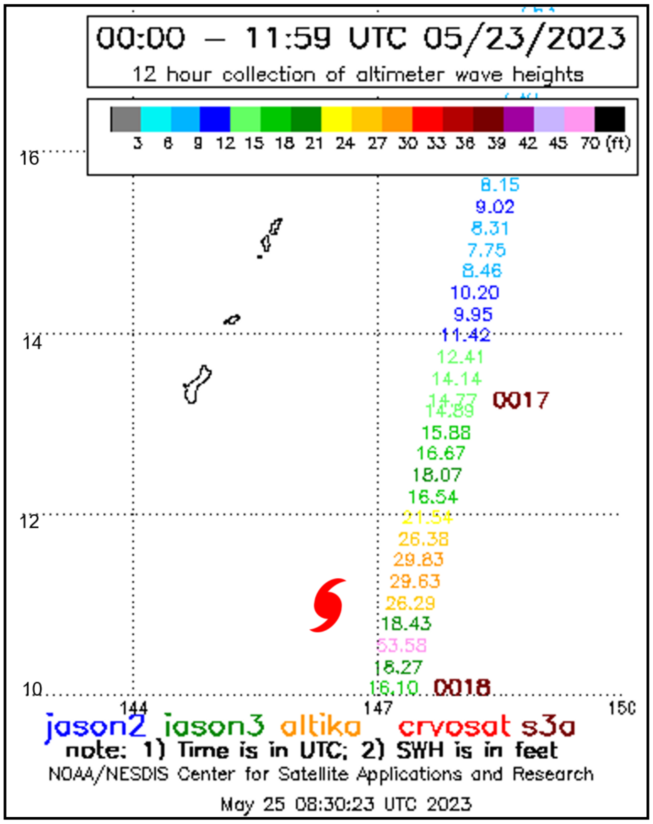


Figure 34: 23May/0017Z s3a altimetry pass over TY Mawar southeast of Guam indicating large seas reaching nearly 30 ft.

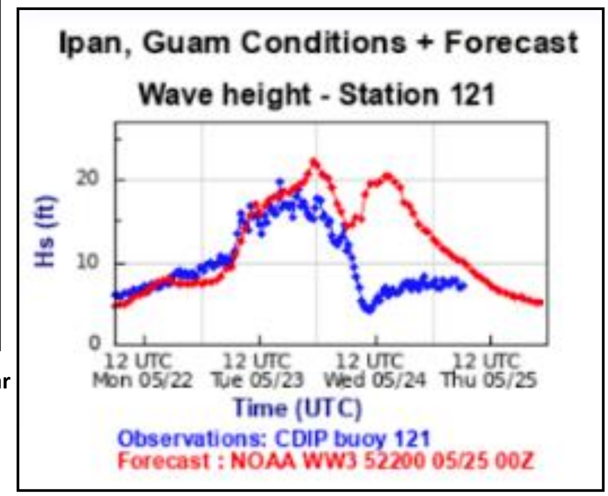


Figure 35: 23-25 May Ipan Buoy observations (blue) and Wave Watch 3 (red) wave height model guidance. Wave heights rapidly dropped at the buoy as winds became northerly and westerly.

This northward shift in the track brought the center of Mawar very close or directly over the PacIOOS wave buoy located roughly 3 miles off of northern Guam's Ritidian Point. The buoy measured a significant wave height of 28.97 feet at 0930Z, 24 May, (Figure 36, left) with a maximum wave height of 47 feet. Between 0930Z and 1130Z, the Ritidian buoy showed a steady drop in significant wave heights as the center of Mawar passed nearby. At 1130Z, the buoy reported a significant wave height minimum of 17.13 feet (Figure 36, middle) before seas steadily rose. Sometime soon after 1430Z, the buoy stopped reporting as it broke from its mooring. Mawar's slow westward crawl, combined with its rapid intensification, led to an abrupt shift and rise in west-southwest swell. The Ritidian buoy showed a steady "backing" of swell energy from the north prior to 24May/11Z to large west-southwest swell after 12Z as shown in the 9-band plot sequence (Figure 36). This ramp up in WSW swell energy led to significant coastal erosion along the western side of Guam, particularly northern Guam. The most dramatic coastal effects were noted along the northwestern Guam coastline north of Tanguisson to the western side of Ritidian Point. This is where high water marks were observed up to nearly 15 feet above the normal water level along with an erosional step 3-5 feet tall in some locations. (Images included at the end of this report.)

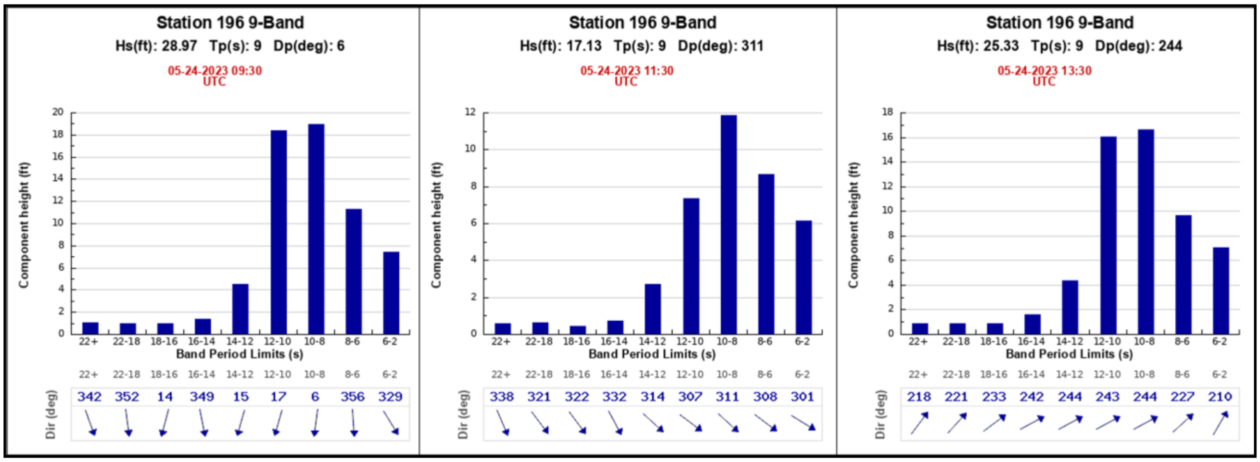


Figure 36: Ritidian Buoy 9-Band Plots from 24 May at 0930Z (left), 1130Z (middle) and 1330Z (right). Significant wave height (Hs) dropped from 28.97ft to 17.13ft by 1130Z before steadily climbing to more than 25ft. During this time, swell directions shifted from north to northwest, then quickly out of west-southwest.

The passage of Mawar produced a unique signature in the Apra Harbor tide gauge data with nearly ten days of lower water levels following Mawar's passage (Figure 37). Lower water levels were similarly observed following the passage of Typhoons Keith (1996), Paka (1997) and Pongsona (2002) over Guam, and Typhoon Sudal (2004) at Yap. Water levels gradually moderated back to pre-typhoon levels 1-2 weeks later.

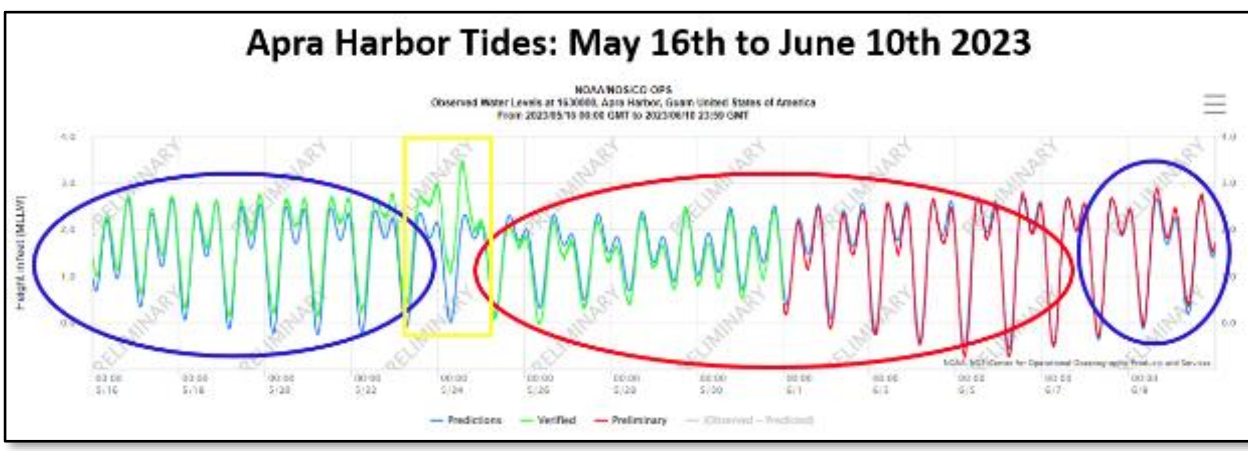


Figure 37: Apra Harbor tide gauge data from May 16th through June 10th. The blue circles indicate observed tides (verified data in green, preliminary data in red) prior to and well after the passage of Mawar, which were/are above the predicted tide levels (blue). The spike in water levels directly tied to Mawar is shown with a yellow box. The red circle highlights a 10 day period following Mawar in which the tide data indicates lower water levels.

Mawar’s timing just prior to the early June King Tide event resulted in very low low tides in early June. Vast swaths of Guam’s reef flats were above water during the afternoon low tides of June 3-6. While the reef flats would have been exposed without Mawar’s influence, tide gauge data indicates the low tides were 3 inches lower due to Mawar’s “low-tide wake”. This unique convergence of events, alongside a gradual lowering of sea levels tied to a developing El Nino, led to coral bleaching for parts of Guam.

NWS Guam Tropical Cyclone Watches and Warnings:

With the expectation of quick and steady intensification of newly-developed TD 02W, TS warnings were issued for several islands (Satawal, Polowat, Ulul) within eastern Yap State and western Chuuk State, with the first National Weather Service (NWS) Guam Public Advisory on 02W at 20May/03Z. Additionally, TY watches were issued for Guam, Rota, Tinian, and Saipan, as the forecast track showed an eventual passage of a category 2 typhoon near Rota on the morning of 24 May (ChST). This TY watch issuance provided more lead time than is routine (nearly 70 hours rather than the prescribed 48 hours) for a few reasons: model guidance, including ensemble model plumes, consistently showed a powerful tropical cyclone passing overhead or very near (glancing blow) the Marianas; it was a weekend, one with fair weather across the Marianas in which tropical cyclone preparations would otherwise be considered less important unless backed by increasingly urgent communications of an increasing threat; and a watch issued mid-evening at 8 PM (ChST) would've been impractical as key decision makers and residents would have no benefit in having a watch issued at nighttime. By 21May/2200Z, the TS Warnings were canceled for Ulul and Polowat as TS Mawar continued NNW, maintaining the period of damaging winds at Satawal until its TS Warning cancelation by 22May/0100Z. At this time, NWS Guam issued a TY Warning for Guam and Rota and a TS Warning for Tinian and Saipan, giving about 30-36 hours of lead time before the onset of damaging winds. With the eventual slowing of Mawar as it approached the Marianas from the southeast, residents ended up with additional time to complete preparations and seek shelter. On the morning of the 25th (ChST) conditions steadily improved following the passage of Mawar, beginning farther north at Tinian and Saipan, and the TS Warning was canceled for the 2 islands around 24May/1900Z. Later that day, with ATMS and SSMIS microwave imagery showing the core of Mawar well to the west of Guam with only peripheral bands of showers nearer Guam (Figures 38, 39, and 40), NWS Guam canceled the TY Warnings for Guam and Rota at 25May/0700Z.

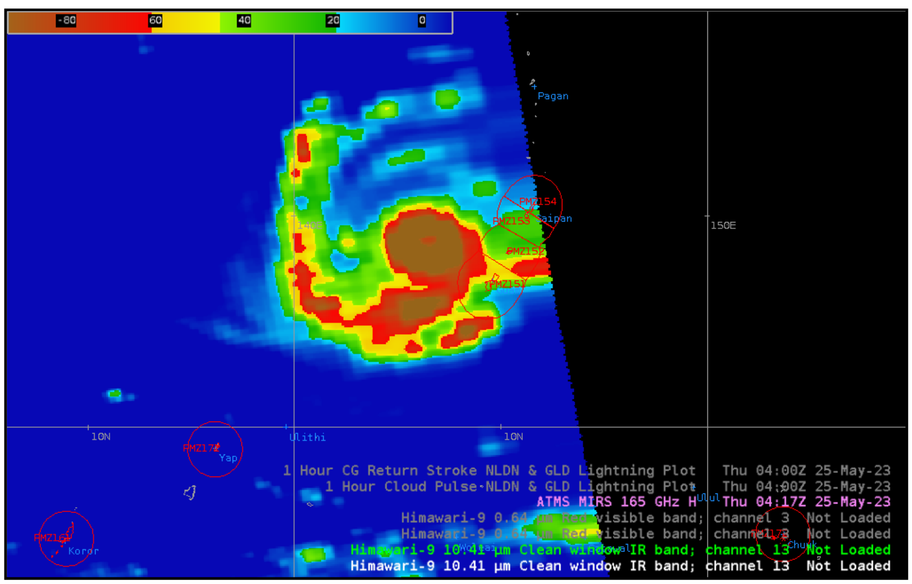
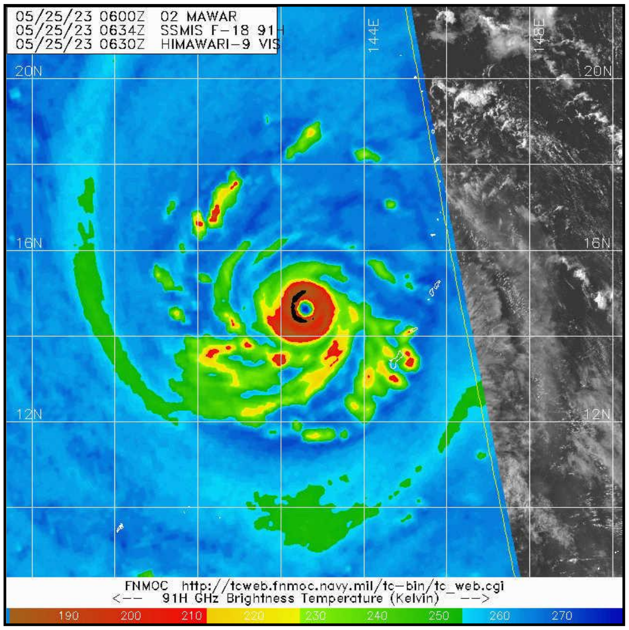


Figure 38: 25May/0417Z (Thursday 2:17pm ChST) ATMS 165GHz imagery depicting the convective core of Mawar pulling away to the west of the Marianas. via NWS Guam AWIPS during Mawar's intensification while departing from Guam.



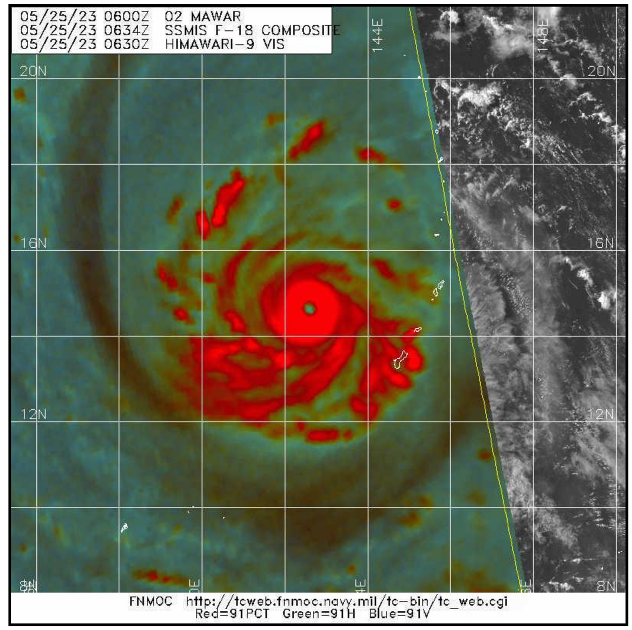


Figure 39 (left) and Figure 40 (right): 25May/0634Z (Thursday 4:34pm ChST) SSMIS 91GHz imagery (left) and composite (right) showing the convective core of Mawar well west of the Marianas. Heavy showers associated with peripheral convective bands are still in line to pass over the Mariana Islands.

Although there have been no reports of injuries or deaths directly resulting from Mawar, 2 males drowned in separate swimming incidents: one having swam out to an island on the reef's edge of central west Guam as Mawar approached and was subsequently pulled into the powerful currents; and a 2nd having entered the waters near a SW Guam marina within hours of Mawar having moved to the west of Guam and subsequently was pulled out to sea in the strong currents.

Across Ulul, Satawal, and Polowat, few reports have been received, but damage was generally light from the low-end to moderate tropical storm Mawar as it passed by. Impacts were largely limited to fleshier vegetation with a number of banana trees downed, as well as some breadfruit trees and coconut palms. While no significant structural damage was reported, the sea wall in Satawal had damage in a few areas, as well as 2 main dwelling houses.

Mawar impacts across the CNMI were generally wind-related with the more-widespread impacts across Rota, where category 1 typhoon conditions were felt. Tinian and Saipan impacts were consistent with tropical storm wind conditions. For the two northern islands, many banana trees were felled, along with many large branches and some uprooted trees that blocked some secondary roads. Lighter-constructed buildings saw some damage with some tin roofs being peeled up. On Saipan, a few non-residential wood and tin structures were blown apart. Rota saw partial defoliation of trees with a number of larger downed trees. Primary utilities (power and water) were lost for much of the island during the peak of Mawar's passage. While concrete structure fared well, some wood and tin extensions suffered some wind damage, with some tin roofs having blown off and through neighborhoods. Additionally, some wooden power poles were downed.

Guam, having experienced the totality of the southern eyewall for a significant portion of the overnight hours Wednesday night into Thursday morning (24-25 May ChST), saw extensive, and in some locations, devastating damage. Nearly 100% of Guam was left without power, water and most cellular communications. One mandatory evacuation was issued for folks in low-lying coastal areas of southeast Guam with the concern of potentially devastating coastal inundation as the (then) Super Typhoon Mawar was forecast to pass just south of Guam (Figure 41).

Impacts ranged from moderate in the south to devastating in the north, closest to the eye of Mawar, where the full brunt of the category 4 typhoon winds were felt. While concrete structures received little damage, significant impacts were noted to wooden and tin structures, particularly in northern Guam. Defoliation of trees was near 100% in parts of central and northern Guam (Figures 42-45), except for areas that had some topographical shielding from the winds.

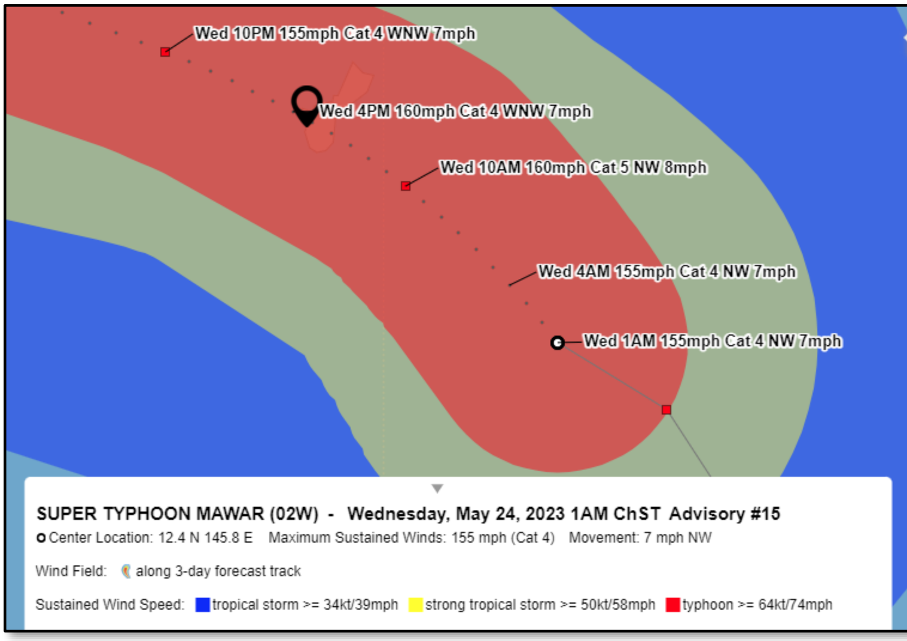


Figure 41: JTWC Bulletin #15 depicting a 160mph super typhoon approaching and passing over southern Guam. Such an approach could have brought potentially devastating coastal inundation to Guam's low-lying southeastern shores.

Figure 42: The ravaged forest of the northwestern extent of the Ritidian Wildlife Refuge reflects the destructive winds that were experienced for multiple hours as the eye of Mawar passed nearby.

Figure 43: What used to be thick and lush jungle vegetation in the Jonestown area of Tamuning was laid bare by the vicious winds of Mawar. All trees in this area of the cliff line were fully defoliated.

Figure 44: The road above the descent into the Ritidian Wildlife Refuge shows a complete defoliation of the jungle.

Figure 45: Despite the eye of Mawar having passed very near Ritidian, quite a bit of tree foliage survived in the northernmost extent of Ritidian and farther east toward Tarague where the terrain served as a buffer from the thrashing winds.

Some structures, including high-rise hotels, exhibited damage to facades (Figure 46). Across northern Guam, numerous wood and tin structures were destroyed. Houses with concrete walls but wood or tin roofing, saw extensive or complete roof failure (Figure 47).

Figure 46 (right): One of the towers of the Pacific Islands Club resort lost some of its façade from the battering winds of Mawar.

Figure 47 (below): A house in Tamuning had significant tin and wooden roof damage as typhoon winds became more westerly late Wednesday night (24 May). The concrete walls held firm.

Even for concrete structures suffering no damage, many had water intrusion from torrential wind-blown rains exploiting every little crack/opening in window sills or doorways.

While concrete power poles held firm, a number of wooden power poles were snapped or tilted (Figures 48, 49, and 50). Throughout the island, and particularly in central and northern Guam, numerous power and communications lines were also downed.

Figure 48: Concrete power poles, as seen along Marine Corps Drive in Yigo, withstood the destructive typhoon force winds.

Figure 49: Wooden poles around the island fared worse with a number either tilted, like these along Route 18 toward the Marianas Yacht Club, or snapped.

Many road signs were tilted, crimped, snapped or blown over still attached to their concrete anchors (Figure 51). Numerous roads were impassable due to large downed trees or other wind-blown debris, while a number of low-lying roads and those with poor drainage, were impassable due to severe rain-related floodwaters. Guam's coastlines saw extensive erosion along all shores with salt water running up well above normal water levels due to the combination of storm surge, ocean surface wind stress, and wave action. These shore-line effects were most noted along Guam's northwest coastline, where erosion left 'steps' in the beach along the tree line 3-5 feet tall and pushed debris as high as 10-14 feet above the normal water level while powerful winds stripped jungles and cliff sides of their lush vegetation (Figures 52-56).

Figure 50: A downed wooden utility pole along East Sunset Blvd.

Figure 51: A speed limit sign along the road to Ritidian Wildlife Refuge completely bowed over.

Figure 52: The beach area between the Santa Fe Hotel and Onward Resort contained debris lines that showed sea water ran well up into normally dry ground. This area faces west, and consequently, the full brunt of the strongest winds as Mawar began moving away from Guam.

Figure 53: Shark's Cove Beach, north of Tanguisson. Salt water intruded deep into the beach-jungle interface, eroding 10-20 feet of beachfront vegetation. Beaches along much of western and northwestern Guam were left much wider as a result.

Figure 54: The beach between Tanguisson and Shark's Cove: what used to be a lush, shade-providing jungle is now a defoliated and ravaged collection of nearly-bared trees.

Figure 55: Many of Guam's west-facing beaches exhibited significant erosion that ate into the beach-jungle interface, leaving large steps at the jungle's edge, as shown here. This step was about 5 feet tall. The base of the step was yet another 8-10 ft above the water level at the time of observation. Above the step was a wall of debris pushed into the jungle.

Figure 56: What used to be a lush, green forest and clifftop was left nearly barren from Mawar's winds. The forest canopy was significantly thinned with remaining palm fronds gnarled in the tree tops.