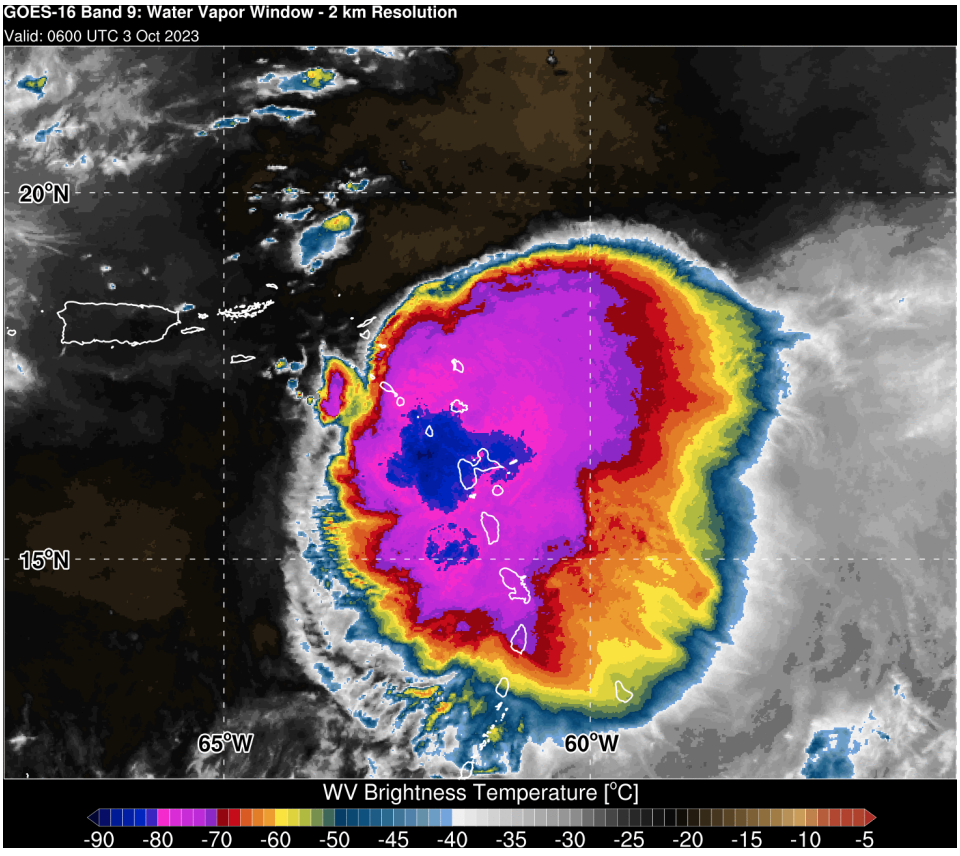
NATIONAL HURRICANE CENTER
TROPICAL CYCLONE REPORT

TROPICAL STORM PHILIPPE

(AL172023)

23 September–6 October 2023

Philippe P. Papin
National Hurricane Center
3 April 2024



GOES-16 WATER VAPOR IMAGE AT 0600 UTC 3 OCTOBER, SHOWING TROPICAL STORM PHILIPPE AFFECTING THE LEEWARD ISLANDS. DATA USED TO CREATE THIS SATELLITE IMAGE COURTESY OF THE NOAA BIG DATA PROJECT.

Philippe was a long-lived tropical storm that formed in the eastern Atlantic. The storm meandered generally westward, and eventually affected the Leeward Islands with heavy rainfall before the system turned northward and was ultimately absorbed by a larger non-tropical low.

Tropical Storm Philippe

23 SEPTEMBER–6 OCTOBER 2023

SYNOPTIC HISTORY

Philippe originated from a tropical wave that emerged off the west coast of Africa on 20 September. The wave was accompanied by a broad area of showers and thunderstorms that fluctuated diurnally in intensity during the first day or so after leaving the coast of Africa. The following day, convective activity started to show signs of organization, and a broad area of low pressure developed as the entire system moved steadily westward to the south of a subtropical ridge located north of the Cabo Verde Islands. While convection continued to show signs of organization, scatterometer data on 22 September did not yet provide sufficient evidence that a well-defined circulation had formed. However, an additional convective burst overnight likely started this process, and a tropical depression is estimated to have formed by 0600 UTC 23 September, about 1350 n mi east of Barbados. The depression became Tropical Storm Philippe 12 h later. The "best track" chart of Philippe'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].

While Philippe initially moved steadily westward to west-northwestward, the steering mid-level ridge north of the tropical cyclone became eroded by a mid-latitude trough moving across the central Atlantic. As a result, the mid-level ridge axis shifted westward, and Philippe's forward motion slowed during its first couple of days after genesis. Environmental conditions were initially favorable for intensification with light-to-moderate vertical wind shear, warm sea-surface temperatures, and sufficient mid-level moisture. Philippe reached its first peak intensity of 50 kt between 0600–1200 UTC 25 September when it was located about 1000 n mi to the east of Barbuda in the Leeward Islands. Not long thereafter, westerly mid-level vertical wind shear increased markedly, and Philippe's low-level circulation became exposed. The center decoupling from its deep convection, in addition to a slightly stronger mid-level ridge, contributed to an acceleration in the tropical cyclone's westward motion between 25–26 September as Philippe weakened to a 40-kt tropical storm.

The moderate-to-strong westerly vertical wind shear affecting Philippe proved unrelenting, but the storm also remained over anomalously warm 29–30°C sea-surface temperatures, enabling deep convective bursts to continue primarily east of Philippe's center. The storm remained nearly steady in a 40–45 kt intensity from 27–28 September, but its radius of maximum winds broadened as the center remained detached from the deepest convection. During this period, the tropical cyclone decelerated and began to move erratically, first turning north-northwest, and then stalling as it eventually began a slow southwestward drift. The reasons for

[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.

these track undulations were twofold. First, the mid-level ridging that was Philippe's primary steering influence had weakened again due to another mid-latitude trough creating a weakness north of Philippe. At the same time, Tropical Storm Rina[2] developed just to the east of Philippe by 0600 UTC 28 September. Rina was in close enough proximity to Philippe to induce binary interaction between the two cyclones, and some of Philippe's southwestward motion beginning on 28 September is likely in response to the cyclonic flow created by the interaction of the two systems.

Philippe continued a slow south-southwestward drift between 29–30 September as Rina moved faster to the northwest, with both cyclones making their closest approach to each other during the afternoon of 29 September (Fig. 4). While both tropical storms were similar in intensity, the larger circulation of Philippe was slightly dominant over the smaller Rina. The slower motion of Philippe also allowed deep convection associated with its mid-level vortex to form closer to the low-level circulation, enabling some modest re-intensification despite continued moderate-to-strong mid-level vertical wind shear. An Air Force reconnaissance aircraft sampled Philippe for the first time after 1800 UTC 29 September, confirming its broad radius of maximum winds with the highest winds located about 80 n mi to the southwest of the low-level circulation.

Philippe would continue to produce numerous diurnal convective bursts that attempted to re-align the low-level and mid-level circulation centers. One such occurrence happened between 30 September–1 October and contributed to a second intensity peak of 50 kt from 1800 UTC 30 September–0600 UTC 1 October, while Philippe was located a few hundred miles east-southeast of Barbuda. After these convective bursts, the vertical wind shear, which had shifted out of the northwest, continued to strip away convection near the center, leaving the low-level circulation exposed again during the day. By this time, Rina's influence on Philippe's motion had waned as Rina weakened and moved farther poleward. Meanwhile, Philippe resumed a slow west-northwest motion on 1 October, though the forward speed remained somewhat erratic, likely due to the frequent convective bursts east of the center.

On this general track, Philippe approached the Leeward Islands between 1–2 October and passed directly over Barbuda at 2245 UTC 2 October with estimated maximum sustained winds of 45 kt, though these winds were mostly observed over water, away from the storm center. The storm's main impact for the Leeward Islands was torrential rainfall, primarily after the center moved through due to deep convection southeast of the center (cover photo). With northwesterly vertical wind shear now above 30 kt, Philippe's structure degraded further, and the cyclone weakened to 35 kt between 3–4 October. Its motion also curved northward as a mid- to upper-level trough provided a weakness in ridging, allowing the storm to move more poleward. Philippe barely maintained a closed circulation during this period with the associated shower and thunderstorm activity also losing organization.

The same trough then began to interact with Philippe, aiding a brief period of re-intensification on 5 October. However, the larger trough also initiated another non-tropical area of low pressure that formed to the west of Philippe early on 6 October. The tropical cyclone ultimately became attached to the non-tropical low's warm front extending to the east. By 1200 UTC 6

[2] Tropical Storm Rina's report is available at https://www.nhc.noaa.gov/data/tcr/AL182023_Rina.pdf

October, this merger resulted in Philippe's remaining circulation being absorbed by the larger non-tropical low, about 150 n mi to the south of Bermuda.

METEOROLOGICAL STATISTICS

Observations in Philippe (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 12 flights of the 53rd Weather Reconnaissance Squadron of the U.S. Air Force Reserve Command (flight paths and center fixes shown in Fig. 5). 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 Philippe.

Ship reports of winds of tropical storm force associated with Philippe are given in Table 2, and selected surface observations from land stations and data buoys are given in Table 3.

Winds and Pressure

Philippe's first peak intensity of 50 kt between 0600–1200 UTC 25 September is based on a blend of subjective and objective satellite estimates. Both TAFB and SAB provided Dvorak classifications of T3.0/45 kt during this period, while the peak UW-CIMSS SATCON estimates were as high as 53 kt and hovered near 50 kt from 0000–1200 UTC 25 September. The peak ADT measurement during this time was T3.2/49 kt at 1210 UTC 25 September. The final best-track peak intensity slightly favors the higher ADT and SATCON values during this period. While not shown here, this period roughly matches Philippe's best structure on microwave imagery. The highest mean intensity estimate provided by UW-CIMSS Deep Multispectral Intensity of TCs (D-MINT)[3] over the storm's lifespan was 49 kt, based on a 0455 UTC AMSR-2 pass, which exhibited pronounced curved banding.

Philippe's second peak intensity of 50 kt between 1800 UTC 30 September and 0600 UTC 1 October is based on a combination of aircraft and scatterometer observations. Air Force reconnaissance aircraft measured a peak unflagged SFMR wind observation of 60 kt at 1710 UTC 30 September with more prevalent values of greater than 50 kt while the aircraft was sampling convection in the southeastern portion of Philippe's circulation near 1800 UTC that day. Later that evening, an ASCAT-B scatterometer pass at 0032 UTC 1 October had a peak wind value of 48 kt, with Ultra-High Resolution (UHR) ASCAT data (Fig. 6) from that same pass

[3] For more information about how D-MINT intensity estimates are produced, please refer to Griffin, S. M., A. Wimmers, and C. S. Velden, 2024: Predicting Short-Term Intensity Change in Tropical Cyclones Using a Convolutional Neural Network. *Wea. Forecasting*, **39**, 177–202, https://doi.org/10.1175/WAF-D-23-0085.1.

suggesting peak wind values as high as 55–60 kt. It should be noted that UHR ASCAT data are still being evaluated for their utility in estimating the peak winds of a tropical cyclone. A blend of subjective Dvorak classifications from SAB (T3.0/45 kt) and TAFB (T3.5/55 kt) also supports an intensity of around 50 kt. However, it is worth noting the large spread in intensity estimates among both the satellite and in-situ based data sources during this period (Fig. 2). Users are reminded that NHC best track intensities typically have an uncertainty of around ±10% from the assigned value, and this estimate has more uncertainty than usual.

Philippe's first estimated minimum central pressure of 998 mb is based on a blend of the Knaff-Zehr-Courtney pressure-wind relationship with lower pressure estimates provided by SATCON and ADT on 0600–1200 UTC 25 September. The second 998 mb estimate between 1800 UTC 30 September–0000 UTC 1 October is a blend of lower satellite estimates with dropsonde data from an Air Force reconnaissance mission that measured 999 mb with 5 kt of wind at 1827 UTC 30 September.

Philippe's landfall in Barbuda as a 45-kt tropical storm at 2245 UTC 2 October is supported by Air Force reconnaissance aircraft observations after Philippe's center moved over the island. The plane reported peak 850-mb flight-level winds of 50 kt at 0218 UTC 3 October and peak SFMR winds of 43 kt at 0118 UTC that day. The highest surface wind observation in Barbuda, reported at the Hannah Thomas Hospital, was 31 kt gusting to 42 kt at 2332 UTC 2 October.

Philippe also brought tropical-storm-force wind gusts to several Leeward Island locations. A wind gust of 50 kt was reported at 1954 UTC 3 October in Gustavia, the capital of St. Barthelemy. The highest wind gust in Martinique was 47 kt at La Trinité-Caravel at 0426 UTC 3 October, while in Guadeloupe the peak gust was 44 kt at 0647 UTC 3 October in Capesterre Beau Neufchateau. Finally, in Montserrat there was a wind gust of 50 kt reported at the John Osbourne Airport at 1400 UTC 3 October.

Rainfall and Flooding

Philippe produced substantial rainfall leading to mudslides and flooding over the Leeward Islands, including Anguilla, Antigua, Barbuda, Dominica, Guadeloupe, and Martinique. Rainfall totals exceeding 6 inches (150 mm) were common across several of the Leeward Islands, especially in Martinique and Guadeloupe (Table 3, Fig. 7). The highest rainfall total from Philippe was observed in Guadeloupe, with a station in Vieux-Fort reporting 16.41 inches of rainfall (416 mm). The highest rainfall total in Martinique was reported at St. Maria Morn Esse with 6.43 inches (163 mm). In Antigua and Barbuda, 6–8 inches (150–200 mm) of rainfall were reported by media, though official observations were not available.

CASUALTY AND DAMAGE STATISTICS

There were no reports of casualties associated with Philippe, although heavy rainfall led to significant flooding and mudslides, especially across Guadeloupe, Martinique, and Antigua. In Guadeloupe, four people were swept away by floodwaters after attempting to drive across water-covered roads, but emergency personnel were able to rescue them. Mudslides were observed in Vieux-Fort, Guadeloupe (Fig. 8, top right), with additional washed-out roads due to floodwaters also found further inland (Fig. 8, left). In Antigua, people were found stranded in vehicles, and

several homes were inundated by floodwaters, prompting the government to open a shelter for those affected.

While overall wind damage was minor, some scattered power outages affected 2,500 households. In Antigua, a lightning strike initiated a fire that burned down several buildings at the Yacht Club Marina in English Harbor (Fig. 8 bottom right), though fortunately there were no injuries. Government offices and schools were closed in Antigua, Barbuda, Guadeloupe, St. Martin, and St. Barthelemy as the storm passed by.

Towards the end of Philippe's lifespan, Bermuda was affected with strong winds and rain, but the overall impacts for the island were minor. Philippe's remnant moisture was later absorbed into an extratropical low that produced gale-force winds and significant rainfall in Maine and several provinces in Atlantic Canada.

FORECAST AND WARNING CRITIQUE

Genesis

The genesis of Philippe was well anticipated with extended lead time in the 7-day outlook (Table 4). The wave from which Philippe developed was introduced in the Tropical Weather Outlook 192 h prior to genesis. The probabilities were increased to the medium (40–60%) category 138 h and then high (>60%) 120 h before the system became a tropical cyclone. The 2-day formation probabilities were also well calibrated, with the system given a low chance of development 72 h before formation, with probabilities increased to the medium and high categories 36 h and 18 h before genesis, respectively. The location of Philippe's genesis was also well forecast (Fig. 9) with 97% (32/33) of outlooks capturing the correct location of formation.

Track

A verification of NHC official track forecasts for Philippe is given in Table 5a. Official track forecast errors were much greater than the mean official errors for the previous 5-yr period at all forecast times, especially so after 48 h, with some track errors more than double the 5-yr means. These poor track forecasts are also notable given the large number of forecasts issued for Philippe, which contributed to a degradation of NHC's mean track stats for the 2023 season. One reason for these high track errors was that the majority of NHC official predictions (OFCL) forecasted Philippe too far north and/or too fast relative to the ultimate track (Fig. 10). A homogeneous comparison of the official track errors with selected guidance models is given in Table 5b and Figure 11. Of the deterministic model guidance, the ECMWF (EMXI), HAFS-A/B (HFAI/HFBI), and the Canadian (CMCI) outperformed the official track forecast starting at forecast times 36–48 h and beyond. Many of the consensus aids also outperformed the NHC track forecast during this time, though it should be noted that all the guidance exhibited mean errors well above the average 5-yr track means. This track difficulty was highlighted early on in discussions by the NHC forecasters[4], and Philippe's final best-track over the first five days even fell outside of any of the available global ensemble guidance, with almost all individual track forecasts being too fast and too far north (Fig. 12).

[4] Philippe Forecast Discussion, 24 September: https://www.nhc.noaa.gov/archive/2023/al17/al172023.discus.007.shtml

Of all the guidance aids, HFBI had the lowest track errors from 60–120 h, especially compared to the other hurricane-regional guidance. Its better performing track forecast with Philippe could be related to a more realistic storm structure forecast, as shown in Figure 13. The HAFS-B forecast on 30 September (Fig. 13a) stood out against other hurricane regional models (Fig. 13b–d), keeping the low-level and mid-level centers misaligned over the forecast period. Philippe's misaligned vertical structure, in addition to limiting its intensity, likely also contributed to its slower and more equatorward track through the Leeward Islands (Fig. 13e). Ultimately, the tropical cyclone never became vertically aligned, with the HAFS-B forecast in better agreement with the final best track than the other model forecasts.

Intensity

A verification of NHC official intensity forecasts for Philippe is given in Table 6a. In contrast to official track forecasts, official intensity forecast errors were lower than the mean official errors for the previous 5-yr period from 12–60 h, but then a little higher than the mean from 72–120 h. A homogeneous comparison of the official intensity errors with selected guidance models is given in Table 6b and Figure 14. The intensity guidance did not perform much better than the NHC intensity forecast, though HFBI and EMXI were once again notable standouts that outperformed the NHC intensity forecast from 60–120 h.

A look into the individual NHC intensity forecasts (Fig. 15) reveals that, despite reasonable mean intensity errors, there were large forecast intensity changes over Philippe's lifespan. For instance, the intensity forecast oscillated quite a bit, with initial forecasts on 23–24 September showing a max storm intensity of 60 kt. However, as the tropical storm's structure became degraded due to increased shear, the intensity guidance shifted to a weaker system succumbing to the shear, and the official forecast from 26–28 September also indicated Philippe becoming a post-tropical remnant low in the 3–5-day forecast. Yet, the tropical cyclone did not dissipate, and anomalously warm sea-surface temperatures helped maintain repeated convective bursts east of the low-level center. By 30 September, the GFS and most of the regional hurricane guidance (Fig. 13) showed significant intensification, and the official forecast from 30 September–2 October predicted Philippe to become a hurricane in the 4–5-day forecast. While the persistent shear did not deal a fatal blow to the tropical storm, it still prevented realignment of Philippe's vertical circulation. The continued misaligned structure prevented much intensification until Philippe was absorbed by a larger non-tropical low on 6 October.

Indeed, the intensity forecasts that performed the best with Philippe over its two-week lifespan were those that showed little intensity change over the forecast period, which was explicitly forecasted on 1500 UTC 25 September, and again on 1500 UTC 28 September (except for 120 h). Cases like Philippe exemplify the difficulty of forecasting intensity changes (both up and down) in moderate environmental wind shear (15–25 kt). Philippe was also notable for its unusual longevity while remaining at tropical storm intensity. In the satellite era (since 1970), Philippe currently holds the record for most tropical storm days for a tropical cyclone that never reached hurricane intensity.

Watches and warnings associated with Philippe are given in Table 7. It should be noted that Philippe's poor track forecasts contributed to less lead time than optimal for both Tropical Storm Watches and Warnings prior to Philippe affecting the Leeward Islands.

ACKNOWLEDGEMENTS

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Table 1. Best track for Tropical Storm Philippe, 23 September–6 October 2023.

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
23 / 0600	15.5	36.6	1007	30	tropical depression
23 / 1200	15.6	38.0	1007	30	"
23 / 1800	15.7	39.1	1005	35	tropical storm
24 / 0000	15.8	39.8	1003	40	"
24 / 0600	16.0	40.5	1001	45	"
24 / 1200	16.3	41.3	1000	45	"
24 / 1800	16.6	42.0	1000	45	"
25 / 0000	16.9	42.9	1000	45	"
25 / 0600	17.1	43.8	998	50	"
25 / 1200	17.1	44.8	998	50	"
25 / 1800	17.1	46.2	1000	45	"
26 / 0000	17.4	47.3	1001	45	"
26 / 0600	17.5	48.5	1001	45	"
26 / 1200	17.4	49.7	1003	40	"
26 / 1800	17.1	50.8	1003	40	"
27 / 0000	17.2	51.6	1003	40	"
27 / 0600	17.4	52.3	1003	40	"
27 / 1200	17.5	53.0	1000	45	"
27 / 1800	17.8	53.7	1000	45	"
28 / 0000	18.1	54.3	1002	40	"
28 / 0600	18.5	54.5	1002	40	"
28 / 1200	18.7	54.7	1002	40	"
28 / 1800	18.6	54.8	1002	40	"
29 / 0000	18.5	54.9	1002	40	"
29 / 0600	18.4	55.0	1002	40	"
29 / 1200	18.2	55.3	1002	45	"
29 / 1800	18.0	55.6	1002	45	"
30 / 0000	17.6	55.7	1001	45	"
30 / 0600	17.2	55.8	999	45	"
30 / 1200	16.8	56.0	999	45	"

Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
30 / 1800	16.4	56.3	998	50	"
01 / 0000	16.1	56.7	998	50	"
01 / 0600	16.0	57.5	999	50	"
01 / 1200	16.0	58.4	1001	45	"
01 / 1800	16.2	58.8	1001	45	"
02 / 0000	16.5	59.0	999	45	"
02 / 0600	16.8	59.7	999	45	"
02 / 1200	16.9	60.5	1000	45	"
02 / 1800	17.3	61.2	1001	45	"
02 / 2245	17.6	61.8	1001	45	"
03 / 0000	17.6	61.9	1001	45	"
03 / 0600	18.1	62.7	1001	45	"
03 / 1200	18.6	63.6	1003	40	"
03 / 1800	19.1	64.5	1004	40	"
04 / 0000	19.5	65.2	1004	40	"
04 / 0600	20.2	65.4	1004	40	"
04 / 1200	21.2	65.6	1004	40	"
04 / 1800	22.2	65.8	1004	35	"
05 / 0000	23.1	66.0	1004	35	"
05 / 0600	24.0	66.2	1004	40	"
05 / 1200	25.1	66.3	1004	45	"
05 / 1800	26.4	66.1	1004	45	"
06 / 0000	27.6	66.0	1004	45	"
06 / 0600	28.7	65.5	1003	45	"
06 / 1200					absorbed by non-tropical low
25 / 0600	17.1	43.8	998	50	minimum pressure and maximum winds
02 / 2245	17.6	61.8	1001	45	landfall on Barbuda

Table 2. Selected ship reports with winds of at least 34 kt for Tropical Storm Philippe, 23 September–6 October 2023.

Date/Time (UTC)	Ship call sign	Latitude (°N)	Longitude (°W)	Wind dir/ speed (kt)	Pressure (mb)
30 / 1800	7JDP	10.2	58.3	280 / 47	1008.7
01 / 1800	MERFR0	14.4	61.1	310 / 39	1006.3

Table 3. Selected surface observations for Tropical Storm Philippe, 23 September–6 October 2023.

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)	Storm tide (ft)	Estimated Inundation (ft)	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Offshore									
Buoys									
Caribbean Valley (42060) (16.43°N, 63.33°W)	03/0700	1003.6	03/1530	35	43				
Antigua									
V.C. Bird International Airport (TAPA) (17.14°N, 61.79°W)	02/2000	1002	03/0540	19	41 (8 m)				6.26
Barbuda									
Hannah Thomas Hospital (17.63°N, 61.83°W)	02/1830	1007	02/2332	31	42				1.98
St. Barthelemy									
Gustavia (97123001) (17.90°N, 62.85°W)			03/1954		50 (44 m)				
St. Martin									
St. Martin Grand Case (18.10°N, 63.04°W)			03/1110		41 (5 m)				
Guadeloupe									
Capesterre-Beau Neufchateau (16.08°N, 61.60°W)			03/0647		44 (243 m)				4.70
Goyave Christophe (16.11°N, 61.59°W)			03/0648		41 (115 m)				4.49
Le Raizet Aero (TFFR) (16.26°N, 61.52°W)	02/2100	1003	03/0144	20	36 (11 m)				
Pointe-Noire Bellevue (16.23°N, 61.78°W)			03/1036		36 (213 m)				4.83
Saint Francois Aerodrome (16.26°N, 61.26°W)			03/0050		34 (1 m)				3.29
Vieux-Fort Bourg (15.95°N, 61.70°W)									16.41
Baillif Aero (16.01°N, 61.74°W)									9.79
Gourbeyre Gros-Morne Dole (16.00°N, 61.67°W)									9.09
St. Calude Matouba SAPC (16.05°N, 61.69°W)									8.71
St. Claude Maison-Volcan SAPC (16.05°N, 61.67°W)									8.55
Vieux-Habitants Gend SAPC (16.05°N, 61.76°W)									8.28
St. Claude Citerne (16.03°N, 61.66°W)									7.90
Vieux Habitants Laurichesse (16.08°N, 61.75°W)									6.86

Location	Minimum Sea Level Pressure		Maximum Surface Wind Speed			Storm surge (ft)	Storm tide (ft)	Estimated Inundation (ft)	Total rain (in)
	Date/ time (UTC)	Press. (mb)	Date/ time (UTC)[a]	Sustained (kt)[b]	Gust (kt)				
Capesterre M-Galante Bellevue (15.93°N, 61.24°W)									6.28
Pointe-Noire Col Des Mamelles (16.18°N, 61.73°W)									6.20
Petit-Bourg Providence SAPC (16.18°N, 61.69°W)									6.03
Capesterre Beau Carbet SAPC (16.04°N, 61.64°W)									5.70
Bouillante Gend Pigeon SAPC (16.15°N, 61.77°W)									5.38
St. Louis Presbytere (165.96°N, 61.32W)									5.30
Grand-Bourg Les Basses Aero (15.87°N, 61.27°W)									5.29
Capesterre-Be Bois Debout SAPC (16.02°N, 61.59°W)									5.26
Port-Louis Gendarmeirie (16.42°N, 61.53°W)									5.24
Petit-Bourg Roujol (16.26°N, 61.59°W)									5.18
Martinique									
La Trinité-Caravel (14.77°N, 60.88°W)			03/0426		47 (26 m)				3.76
Vauclin (14.55°N, 60.84°W)			03/0424		43 (12 m)				1.92
St. Marie Morn Esse (14.74°N, 61.02°W)									6.43
St. Marie Gend (14.77°N, 60.99°W)									5.63
Trinite-Reseer Voir (14.74°N, 60.98°W)									5.60
Gros-Morne Boislez (14.73°N, 61.04°W)									5.19
Gros-Morne Bellevue SAPC (14.74°N, 61.06°W)									5.04
Montserrat									
John Osbourne Airport (TRPG) (16.79°N, 62.19°W)			03/1400	25	52 (168 m)				

[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.

Table 4. 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	**168-Hour Outlook**
Low (<40%)	72	192
Medium (40%-60%)	36	138
High (>60%)	18	120

Table 5a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) track forecast errors (n mi) for Tropical Storm Philippe. 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	36.5	66.3	94.6	126.9	163.8	206.9	308.7	411.3
OCD5	42.0	80.4	127.8	172.8	221.4	275.2	380.6	502.0
Forecasts	50	48	46	44	42	40	36	32
OFCL (2018-22)	23.8	35.7	47.8	61.4	76.1	90.5	125.7	172.1
OCD5 (2018-22)	46.4	99.2	157.4	215.0	254.9	321.2	405.1	486.6

Table 5b. Homogeneous comparison of selected track forecast guidance models (in n mi) for Tropical Storm Philippe. 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	35.8	64.7	92.3	128.3	167.3	211.8	309.4	416.4
OCD5	41.8	79.9	127.4	172.4	216.5	271.5	371.7	466.8
GFSI	46.4	89.3	128.2	167.3	212.9	267.1	400.7	574.1
HWFI	42.1	75.9	112.2	157.9	216.1	280.2	444.6	638.2
HMNI	43.6	72.8	102.8	137.4	186.1	252.7	418.6	601.6
HFAI	45.6	77.9	104.8	**110.1**	**145.5**	**188.0**	**291.7**	424.6
HFBI	46.2	76.1	97.3	**122.6**	**136.1**	**166.2**	**209.1**	**235.7**
EMXI	42.0	67.2	**89.5**	**116.7**	**141.1**	**172.8**	**254.0**	**323.7**
NVGI	50.2	89.3	126.3	172.6	228.9	299.5	477.9	732.6
CMCI	46.2	74.0	93.6	**119.6**	**147.1**	**186.2**	**294.0**	**413.6**
TVCA	37.4	65.5	**88.7**	**118.7**	**155.7**	**199.3**	**304.6**	416.6
TVCX	36.7	64.7	**87.7**	**117.6**	**154.1**	**195.3**	**297.7**	**405.0**
GFEX	40.0	70.0	98.1	**127.0**	**163.0**	**206.2**	**305.6**	**411.0**
TVDG	36.9	65.7	**90.9**	**120.7**	**156.1**	**195.8**	**297.8**	**406.7**
HCCA	36.4	**62.4**	**88.9**	**117.4**	**155.1**	**202.7**	314.5	428.2
FSSE	38.5	71.1	96.6	**126.7**	**165.3**	212.1	323.3	437.2
AEMI	44.4	79.2	110.9	148.4	192.0	236.4	339.9	474.2
TABS	48.0	93.9	131.0	159.0	169.3	**181.7**	**275.7**	468.2
TABM	**34.1**	**64.0**	97.0	141.1	200.3	258.4	394.1	596.1
TABD	42.4	93.3	151.7	221.4	305.9	383.7	566.4	852.7
Forecasts	49	47	45	41	38	37	31	25

Table 6a. NHC official (OFCL) and climatology-persistence skill baseline (OCD5) intensity forecast errors (kt) for Tropical Storm Philippe. 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	**2.9**	**3.6**	**4.8**	**6.4**	**9.0**	12.2	17.4	17.7
OCD5	4.2	5.9	8.2	11.2	12.3	13.5	15.9	24.9
Forecasts	50	48	46	44	42	40	36	32
OFCL (2018-22)	5.1	7.6	8.9	10.1	10.7	11.5	13.3	15.5
OCD5 (2018-22)	6.8	10.7	13.9	16.5	18.3	20.2	22.9	23.4

Table 6b. Homogeneous comparison of selected intensity forecast guidance models (in kt) for Tropical Storm Philippe. 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 6a due to the homogeneity requirement.

Model ID	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	2.9	3.5	4.7	6.5	9.6	12.6	17.6	17.6
OCD5	4.2	5.9	8.4	11.4	12.5	13.6	**16.3**	24.4
HWFI	4.4	5.7	7.9	10.2	12.9	17.9	31.5	41.9
HMNI	4.6	6.8	9.5	10.6	12.2	14.9	23.1	26.9
HFAI	4.1	5.7	7.8	9.9	12.5	14.6	22.3	28.7
HFBI	4.7	5.7	7.1	8.5	**7.3**	**9.6**	**13.3**	**14.7**
DSHP	3.8	4.3	6.0	9.4	12.6	17.4	25.4	32.6
LGEM	4.1	4.0	5.2	7.1	**8.9**	**12.2**	20.8	26.5
ICON	3.5	3.8	5.0	7.1	9.9	14.2	23.8	30.4
IVCN	3.2	3.8	**4.6**	6.9	**8.7**	**12.1**	20.4	25.2
IVDR	3.4	4.2	5.2	7.2	**9.2**	**12.4**	20.5	24.6
GFSI	5.3	7.0	8.4	11.4	14.9	20.2	26.5	28.2
EMXI	3.5	4.8	6.1	7.6	**9.2**	**11.0**	**12.6**	**14.9**
HCCA	3.1	3.5	4.9	7.1	**8.3**	**12.3**	22.1	25.0
FSSE	3.3	3.8	5.2	7.9	10.8	14.9	26.2	31.3
Forecasts	49	47	45	41	38	37	31	25

Table 7. Watch and warning summary for Tropical Storm Philippe, 23 September–6 October 2023.

Date/Time (UTC)	Action	Location
1 / 1500	Tropical Storm Watch issued	Antigua/Barbuda
2 / 1500	Tropical Storm Watch changed to Tropical Storm Warning	Barbuda
2 / 2100	Tropical Storm Watch changed to Tropical Storm Warning	Antigua
3 / 0600	Tropical Storm Warning issued	Anguilla
3 / 1200	Tropical Storm Watch issued	British Virgin Islands
3 / 1200	Tropical Storm Warning discontinued	Antigua
3 / 1500	Tropical Storm Warning discontinued	Barbuda
3 / 1800	Tropical Storm Warning discontinued	Anguilla
3 / 2100	Tropical Storm Watch discontinued	British Virgin Islands
4 / 1500	Tropical Storm Watch issued	Bermuda
4 / 2100	Tropical Storm Watch changed to Tropical Storm Warning	Bermuda
6 / 1500	Tropical Storm Warning discontinued	Bermuda

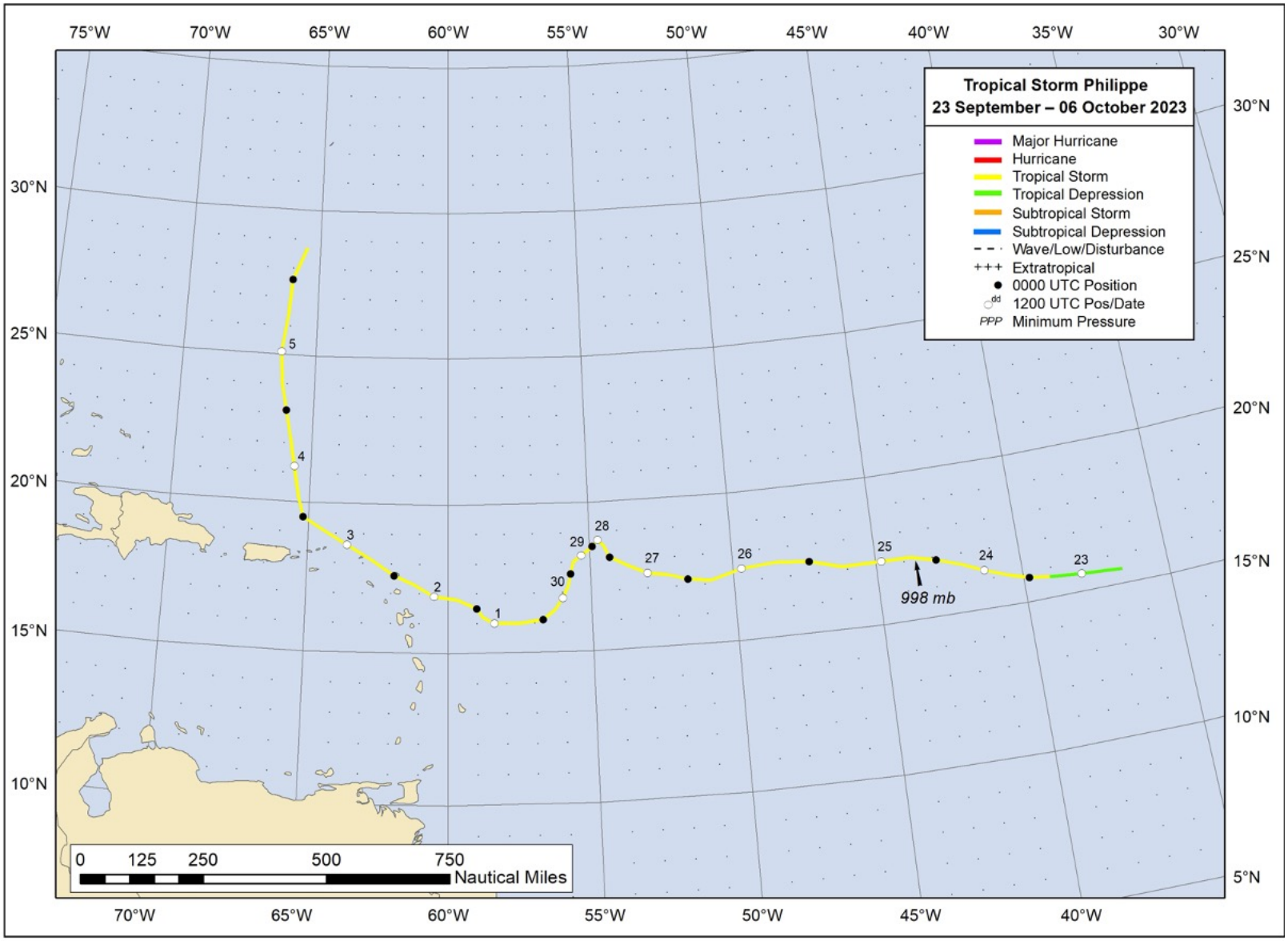

Figure 1. Best track positions for Tropical Storm Philippe, 23 September–6 October 2023.

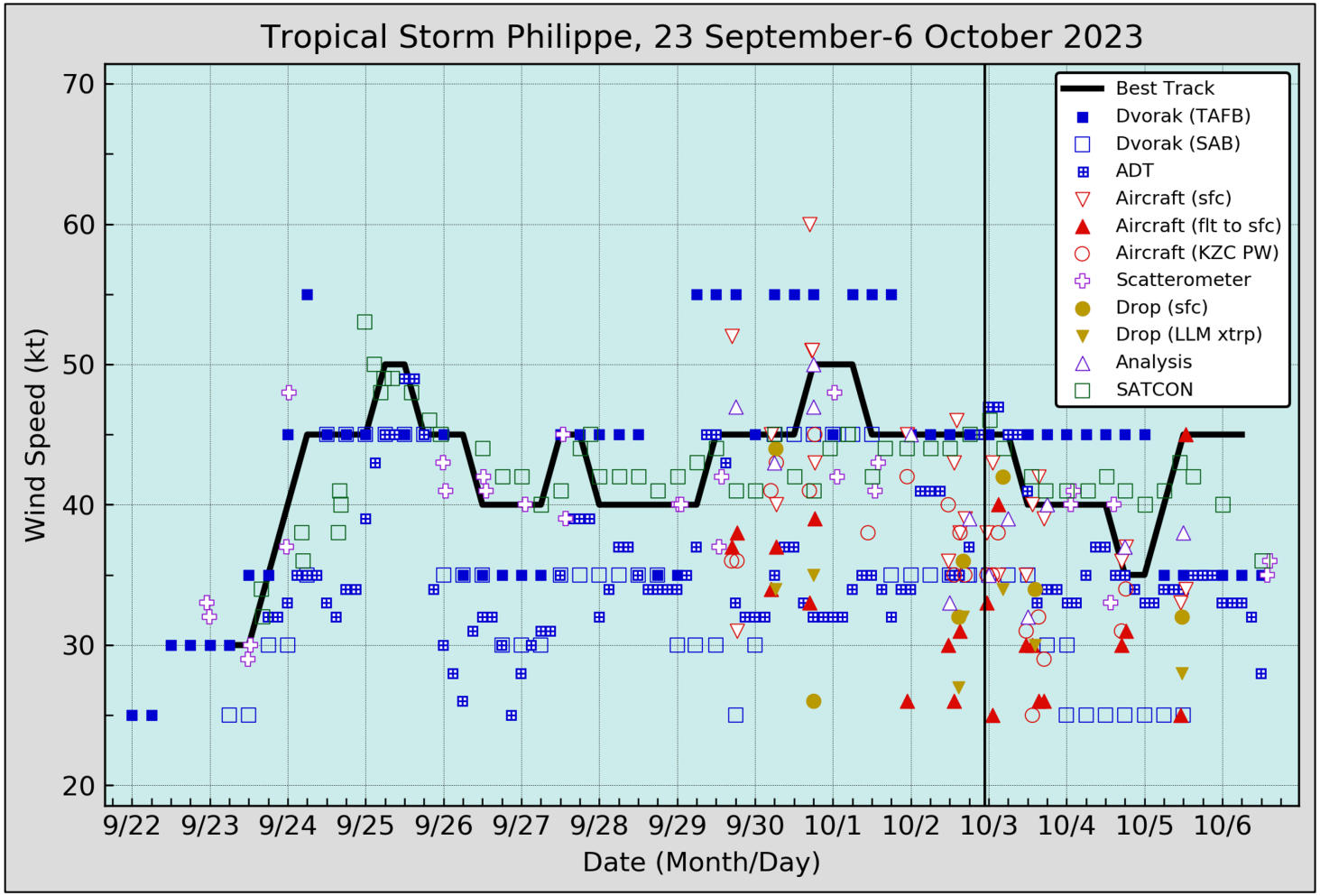

Figure 2. Selected wind observations and best track maximum sustained surface wind speed curve for Tropical Storm Philippe, 23 September–6 October 2023. Aircraft observations have been adjusted for elevation using 90%, 80%, and 75% adjustment factors for observations from 700 mb, 850 mb, and 925 mb, respectively. 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.

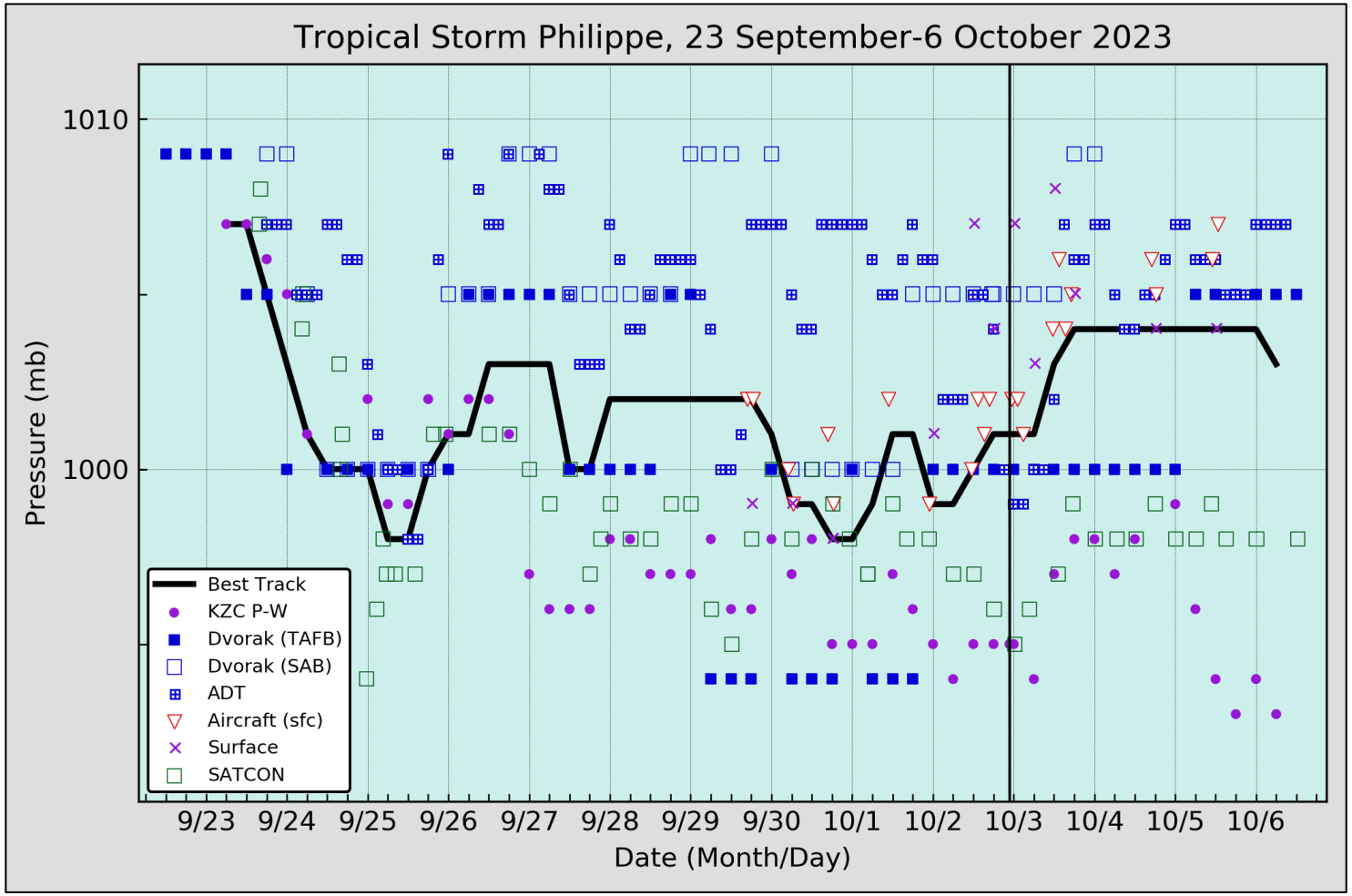

Figure 3. Selected pressure observations and best track minimum central pressure curve for Tropical Storm Philippe, 23 September–6 October 2023. Advanced Dvorak Technique estimates represent the Current Intensity at the nominal observation time. SATCON intensity estimates are from the Cooperative Institute 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.

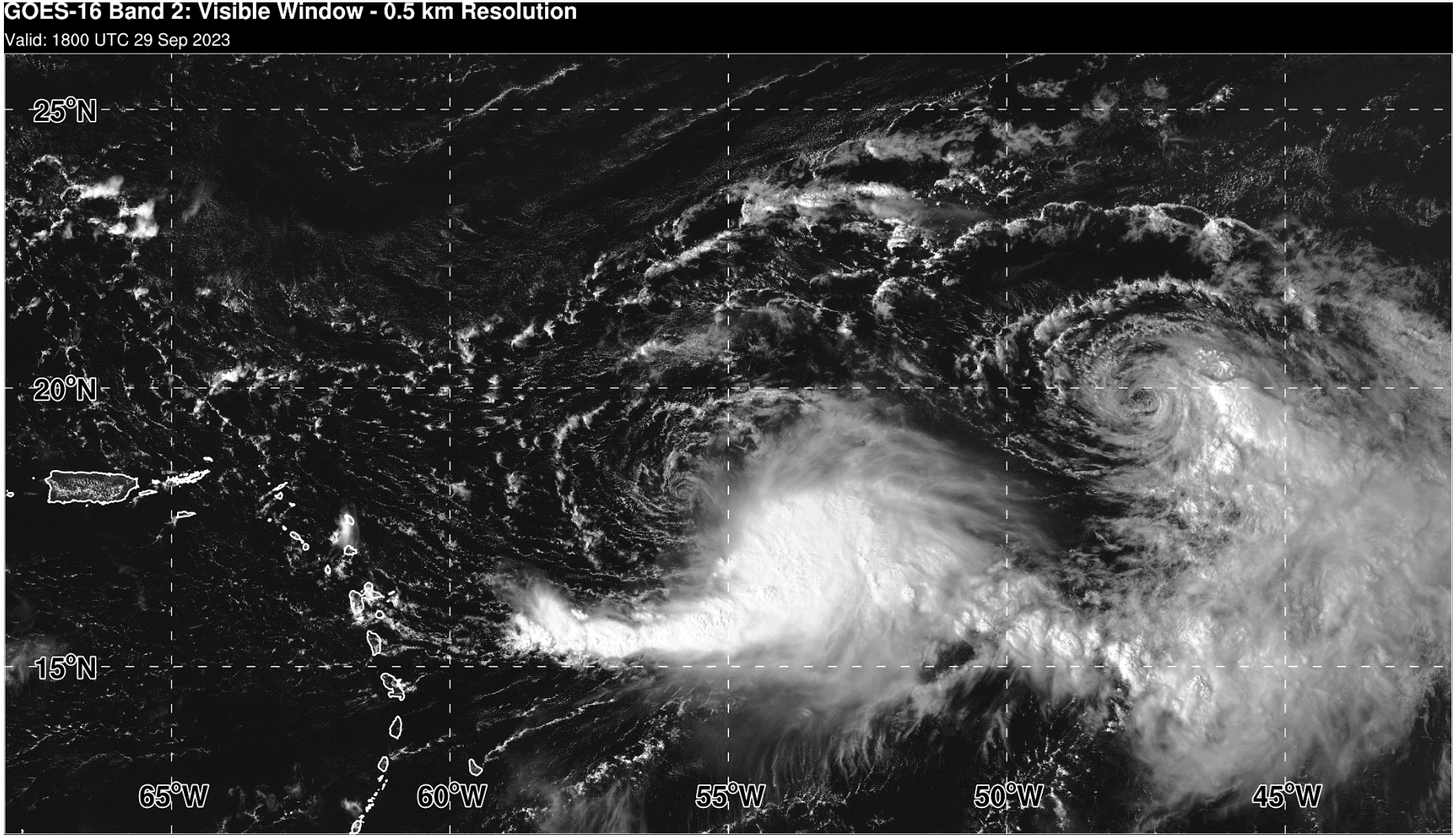

Figure 4. GOES-16 visible satellite image at 1800 UTC 29 September, depicting both Philippe (left) and Rina (right) at approximately their closest approach to each other.

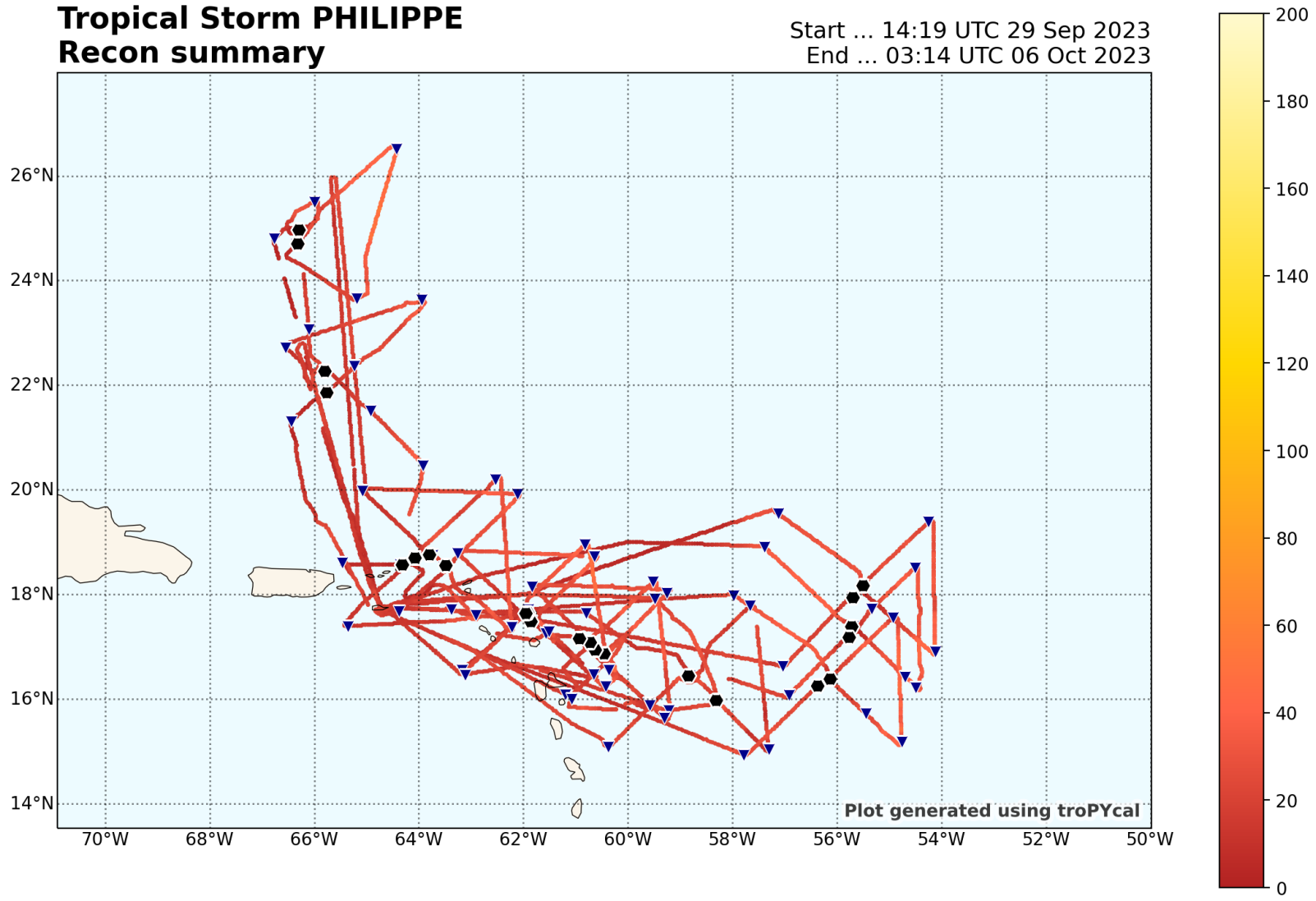

Figure 5. Air Force Reserve aircraft flight tracks (red) from reconnaissance missions into Tropical Storm Philippe from 29 September–6 October 2023. The black markers denote center fixes, and the blue triangles indicate dropsonde locations. The color coding of the flight tracks is based on the observed flight-level wind speed with the color legend to the right of the map representing the color associated with the various wind speeds in knots.

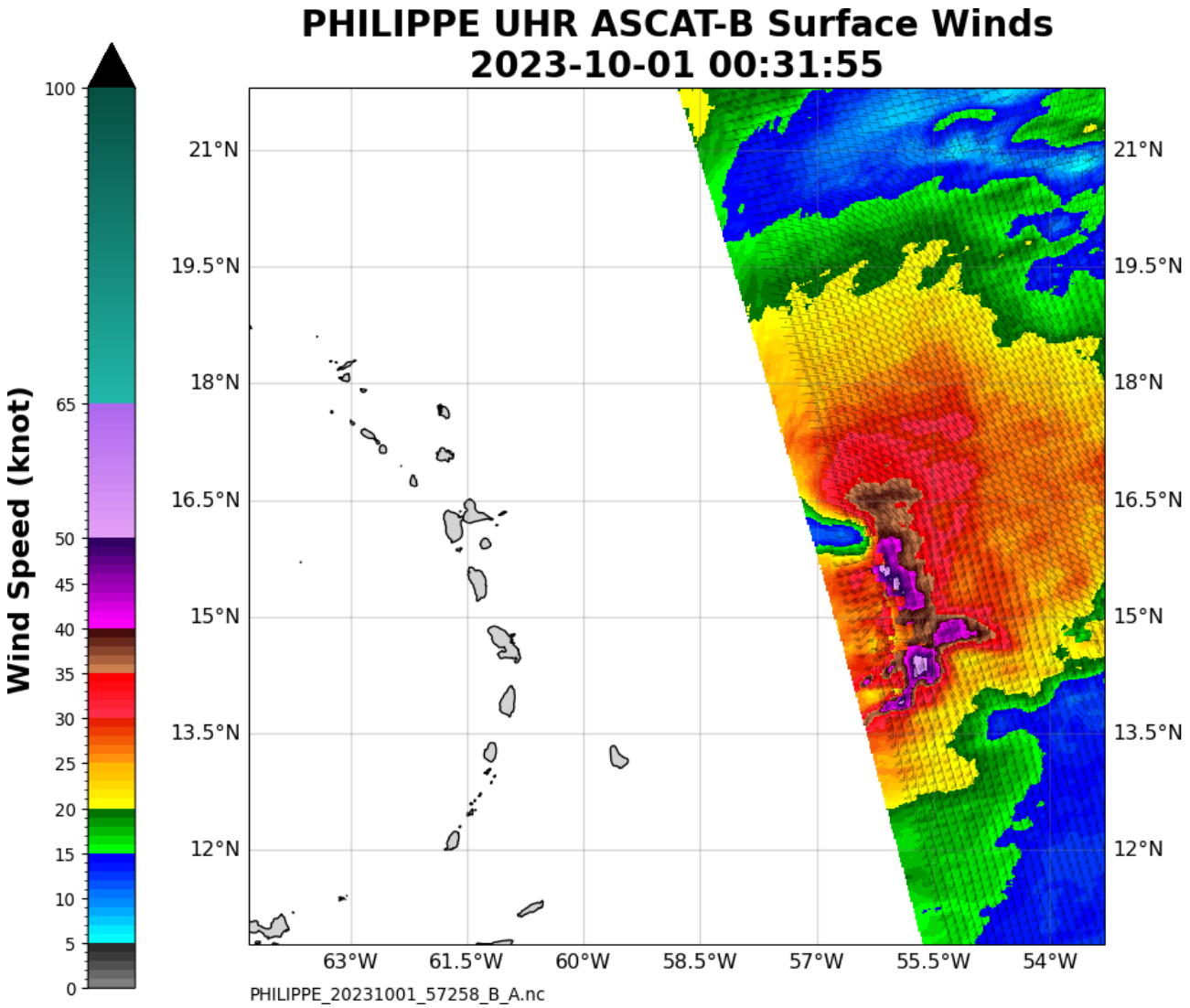

Figure 6. UHR ASCAT-B pass at 0032 UTC 1 October 2023. Note the area of greater than 50 kt values located in the southeast quadrant of Philippe's circulation.

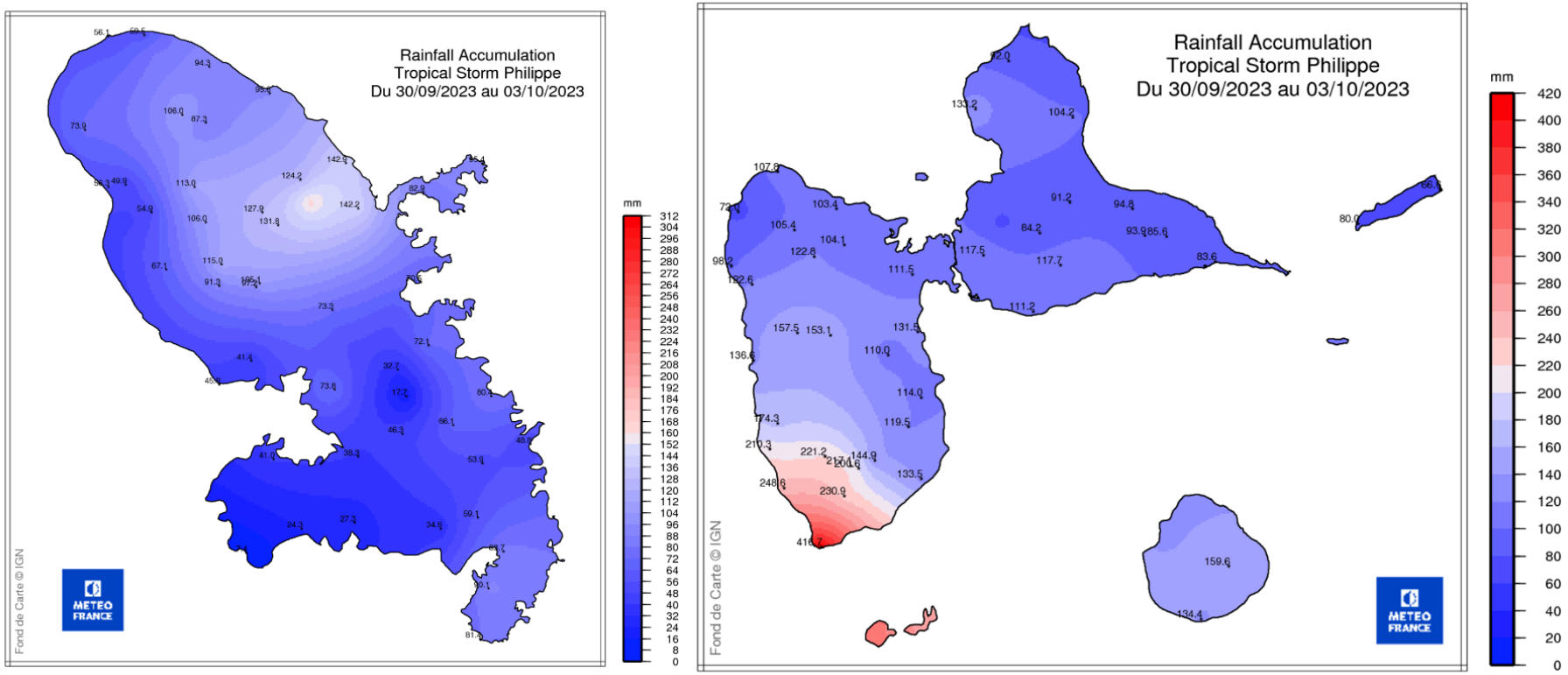

Figure 7. Rainfall totals for Martinique (left) and Guadeloupe (right) for Tropical Storm Philippe between 30 September–3 October, courtesy of Météo France.

Figure 8. Select images illustrating damage associated with Tropical Storm Philippe in the Leeward Islands. Images are courtesy of media outlets Antigua Breaking News (bottom right) and France Info (left and top right).

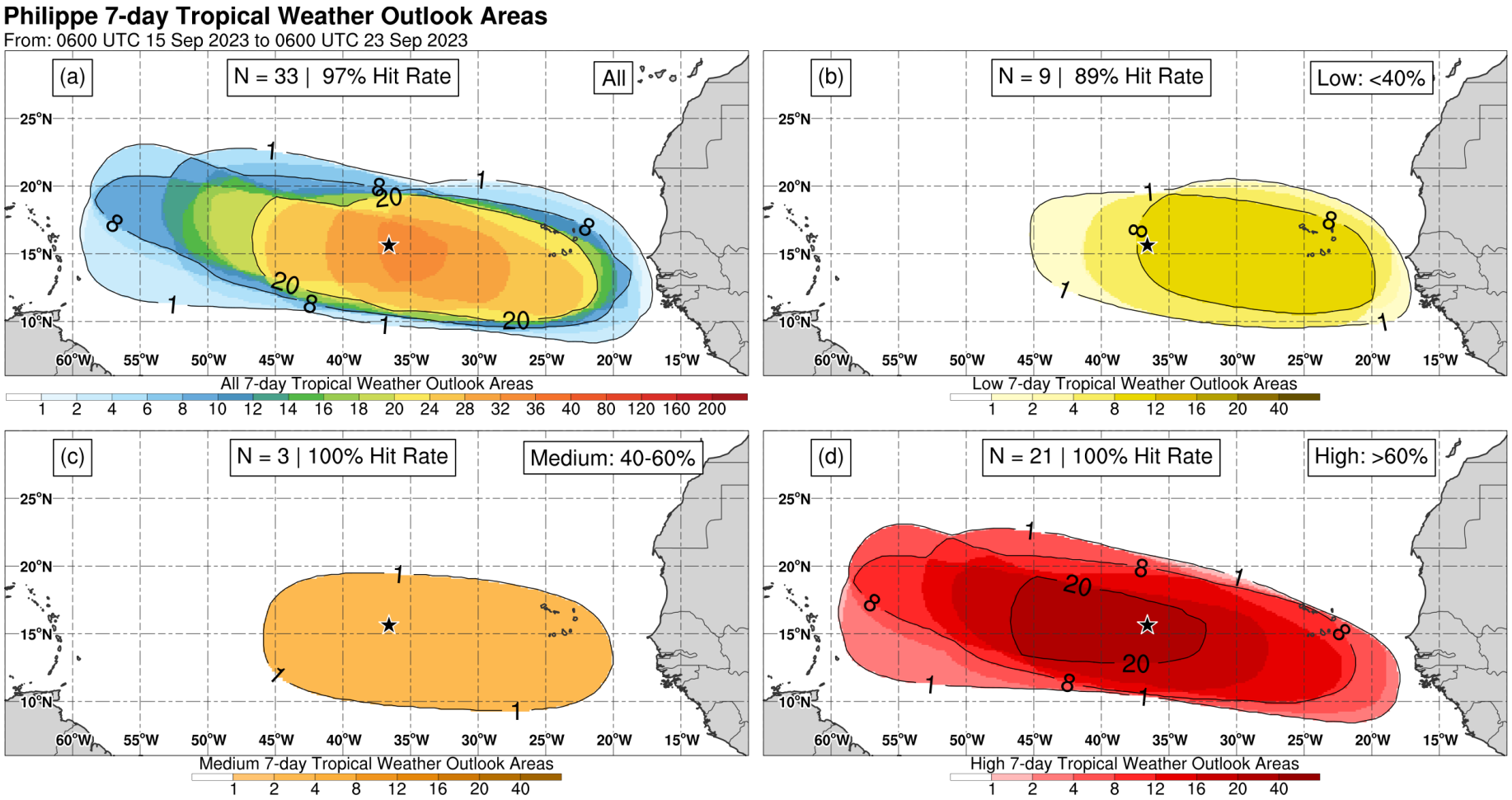

Figure 9. Composites of 7-day tropical cyclone genesis areas depicted in NHC's Tropical Weather Outlooks prior to the formation of Philippe for (a) all probabilistic genesis categories, (b) the low (<40%) category, (c) medium (40–60%) category, and (d) high (>60%) category. The location of genesis is indicated by the black star.

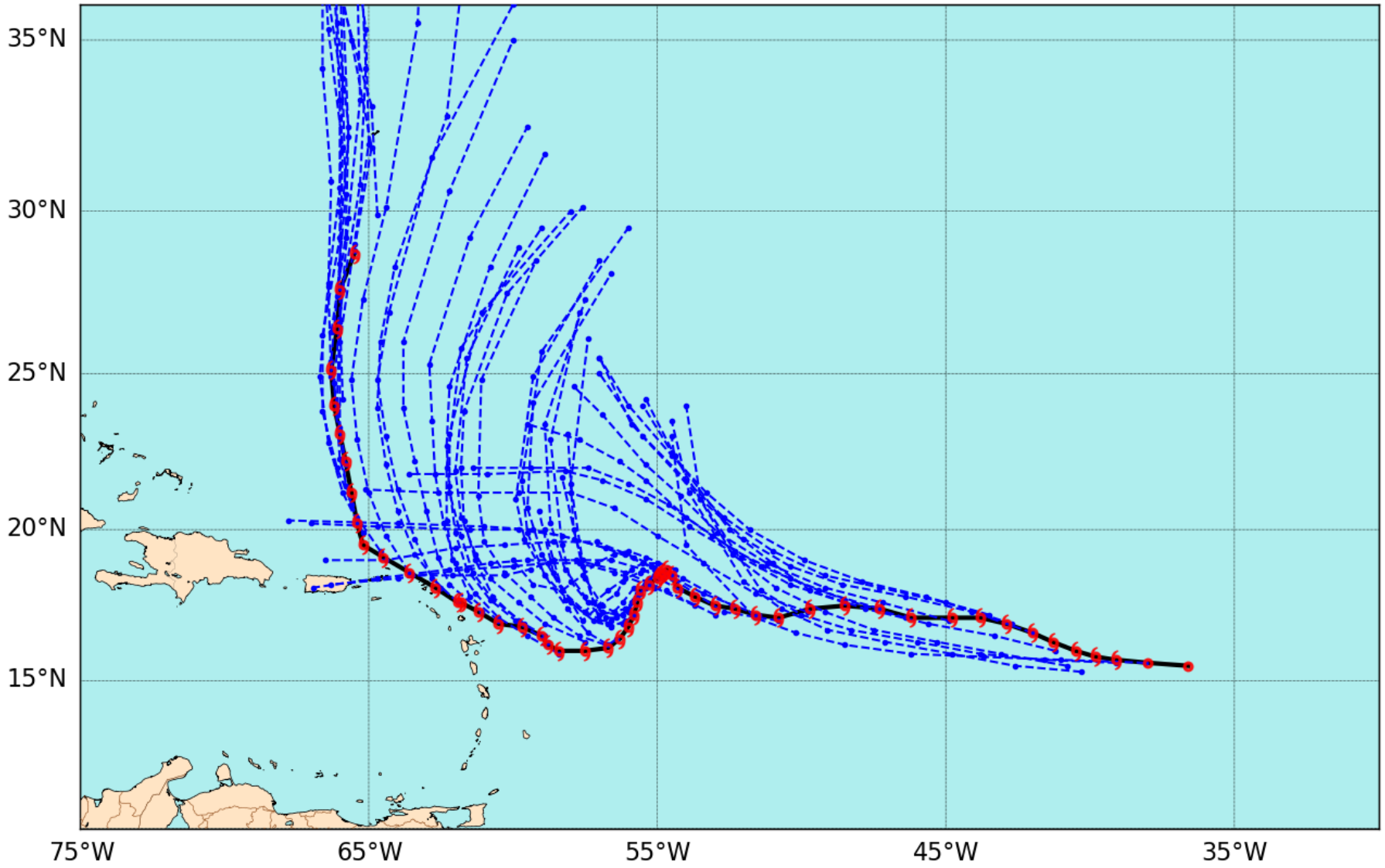

Figure 10. Selected official track forecasts (dashed lines, with 0, 12, 24, 36, 48, 60, 72, 96, and 120 h positions indicated) for Tropical Storm Philippe, 23 September–6 October 2023. The best track is given by the thick solid line with positions given at 6-h intervals.

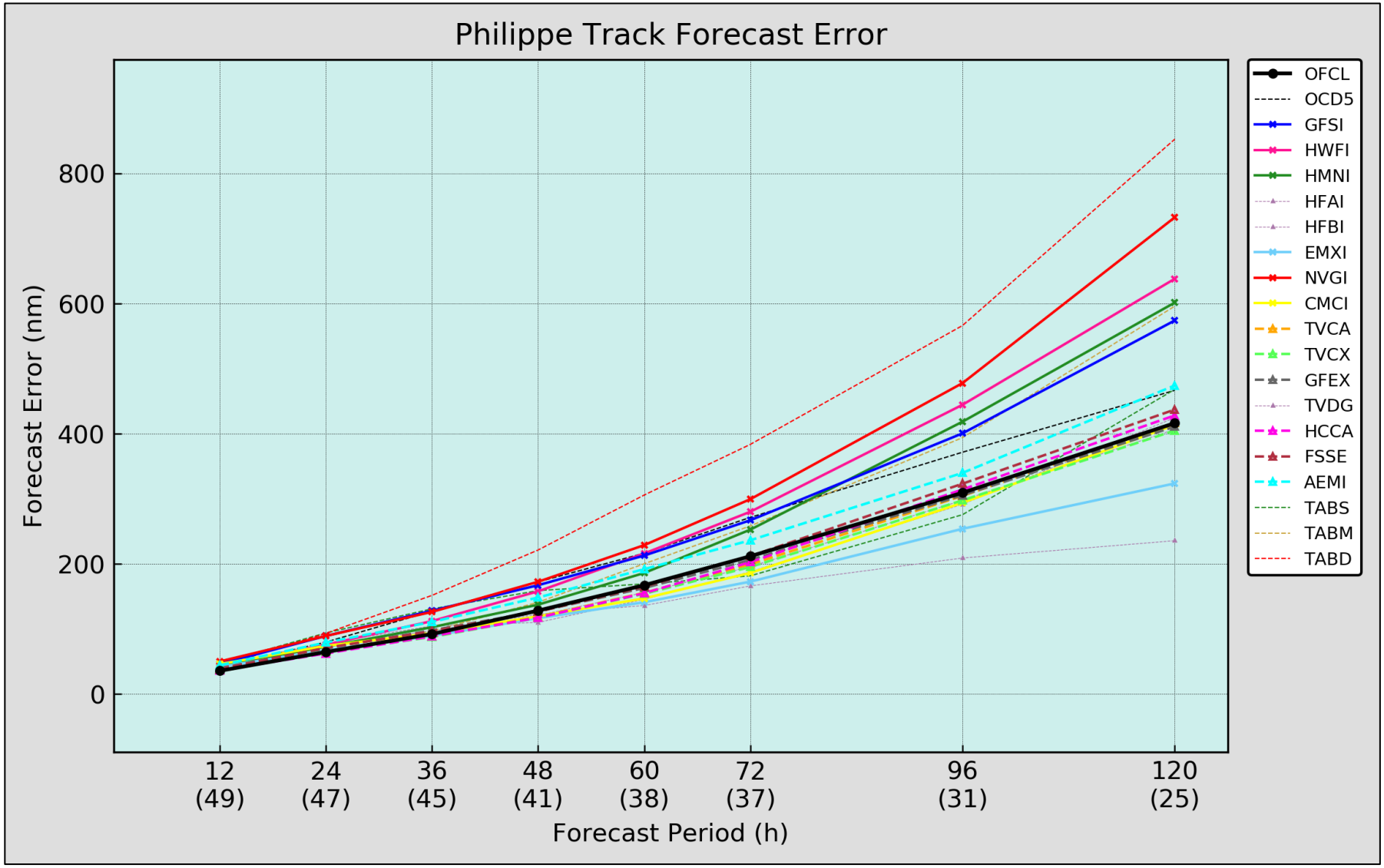

Figure 11. Official forecast and selected model forecast track errors for Tropical Storm Philippe, 23 September–6 October 2023. Note the guidance members that stand with the lowest track errors from 60–120 h (EMXI, HFBI).

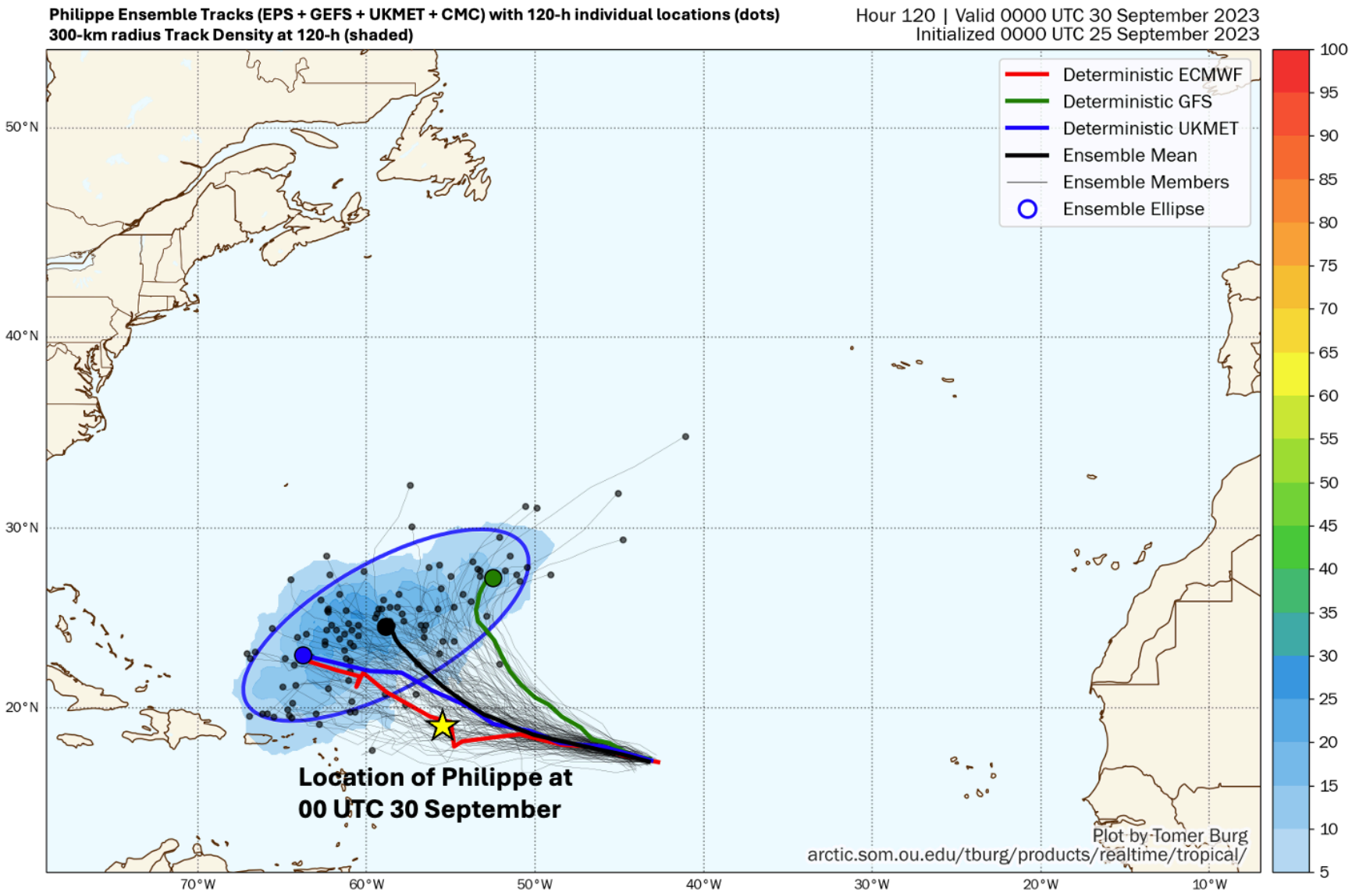

Figure 12. 120-h forecast track plot of each ensemble member (combining EPS, GEFS, UKMET, CMC) of Tropical Storm Philippe initialized at 0000 UTC 25 September valid at 0000 UTC 30 September. Philippe's location at the verifying time is given in the yellow star. Image adapted from Tomer Burg's Tropical Cyclone Archive: arctic.som.ou.edu/tburg/products/archive/tropical/

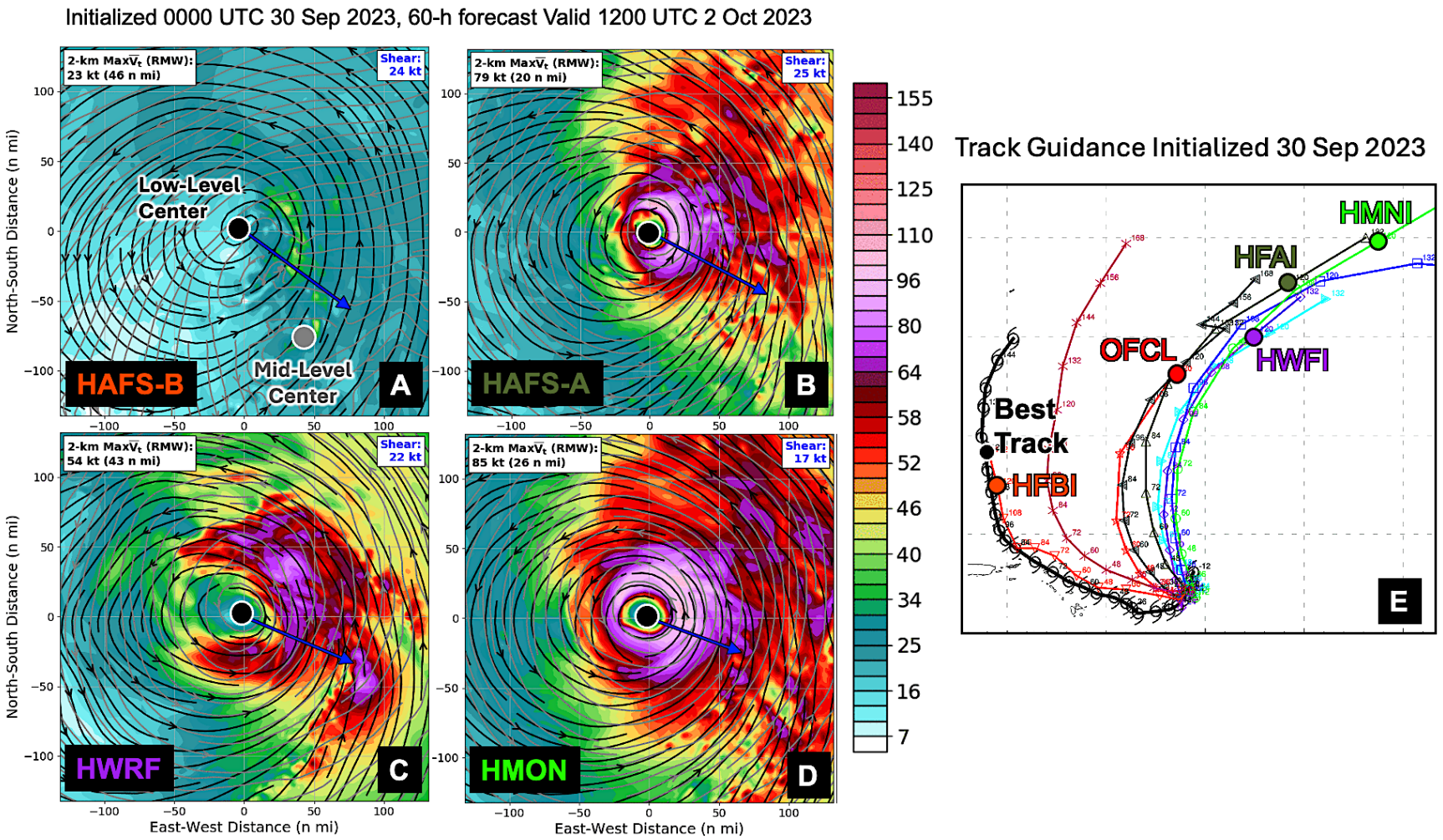

Figure 13. Comparison of hurricane-regional model guidance initialized at 0000 UTC 30 September. Left panels depict low-level 2-km wind speed (color shading, kt) and direction (black streamlines), with mid-level 5-km wind direction (gray streamlines) overlaid for HAFS-B (a), HAFS-A (b), HWRF (c), and HMON (d). Black and gray circles denote the location of the low-level and mid-level centers, respectively, and blue arrow indicates shear direction. Right panel (e) depicts the track guidance of each model with the 120-h position denoted by colorized circles (HFBI in orange, HFAI in dark green, HWRF in purple, and HMNI in light green) compared to the official track forecast (OFCL in red). Imagery adapted from AOMLs Hurricane Model Viewer: https://storm.aoml.noaa.gov/

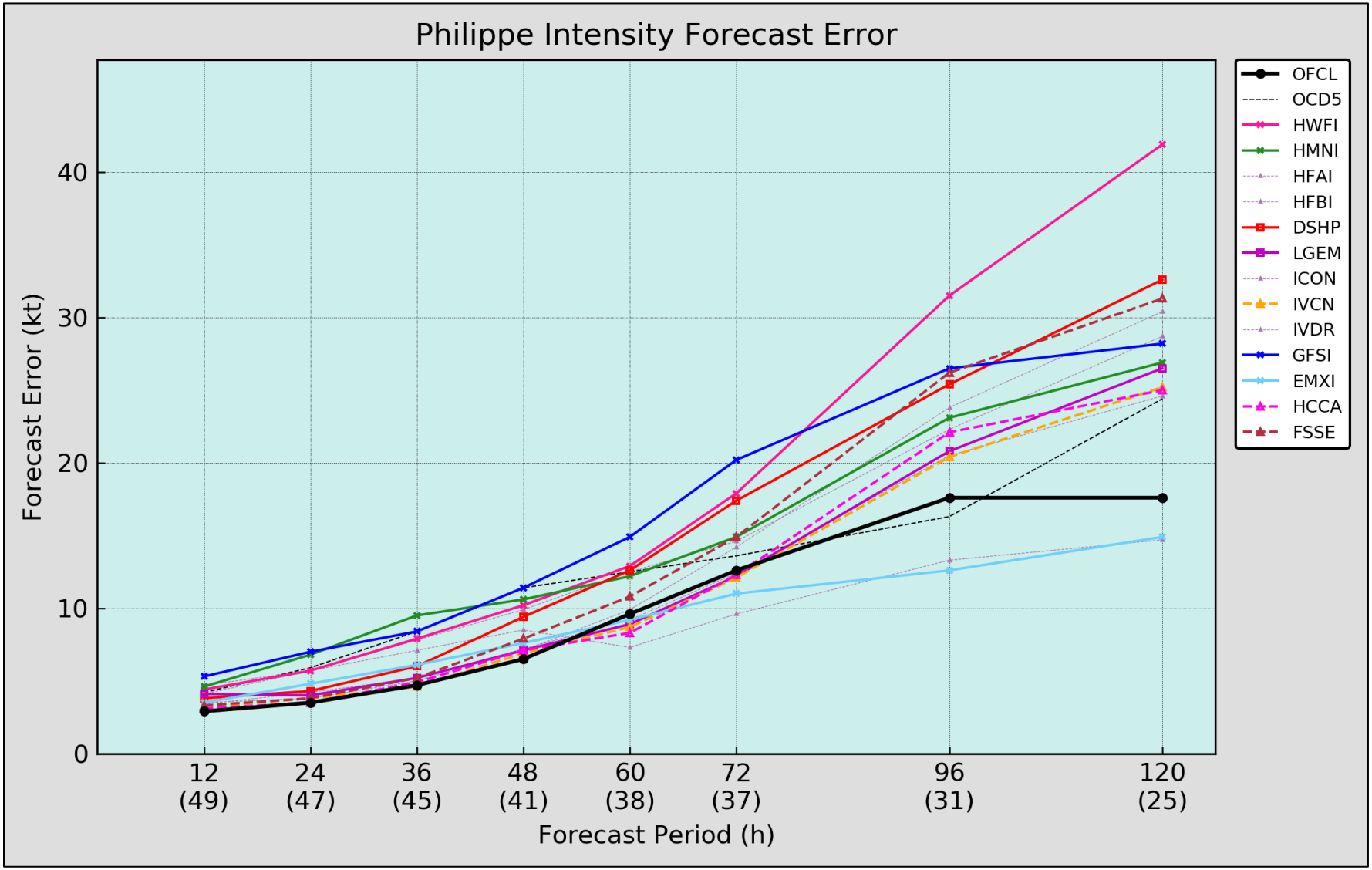

Figure 14. Official forecast and selected model forecast intensity errors for Tropical Storm Philippe, 23 September–6 October 2023.

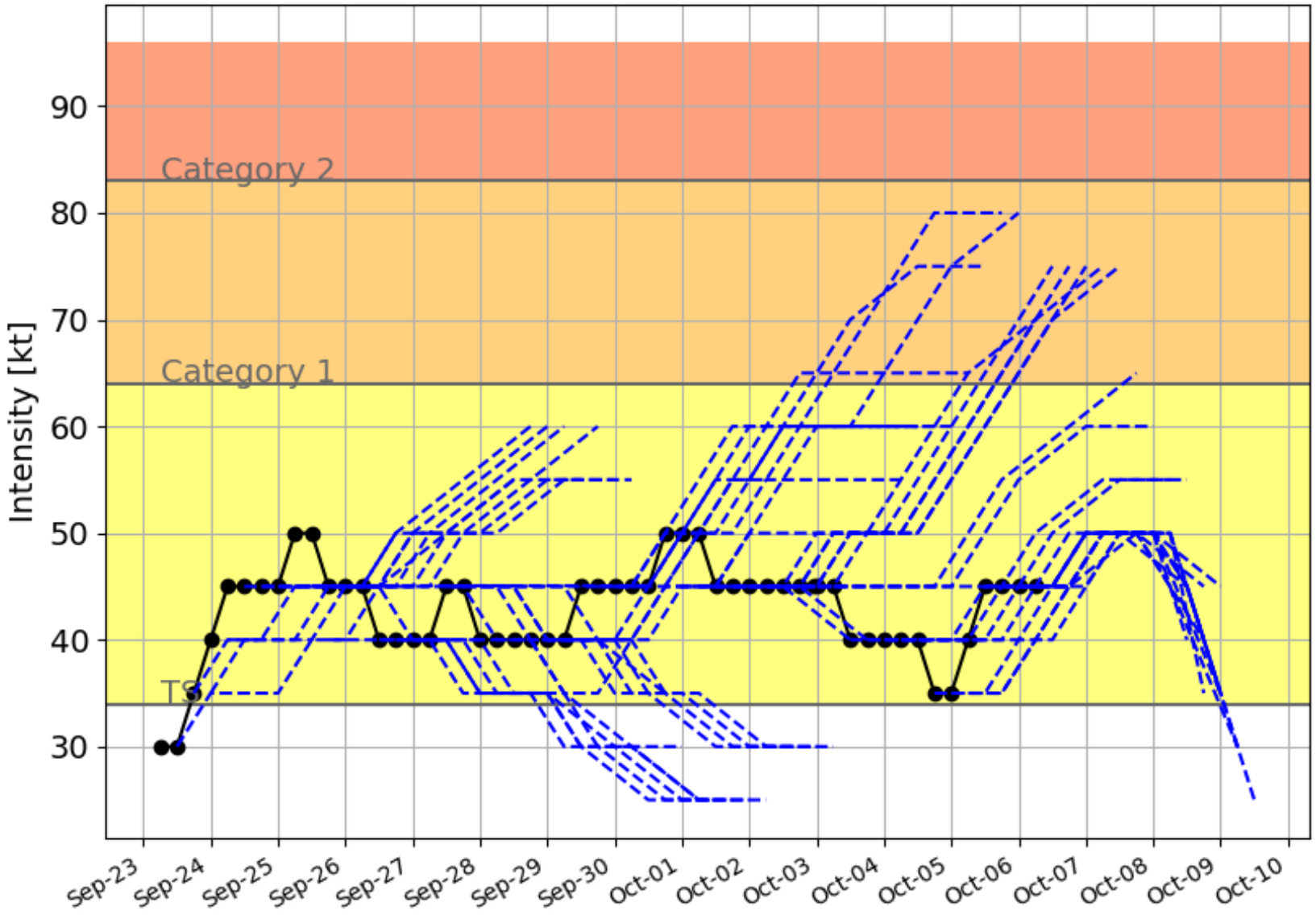

Figure 15. Selected official intensity forecasts (dashed lines, with 0, 12, 24, 36, 48, 60, 72, 96, and 120 h positions indicated) for Tropical Storm Philippe, 23 September–6 October 2023. The best track is given by the solid black line with the intensity at 6-h intervals denoted as black dots.