2025 NHC Verification Report Preview

Atlantic Basin

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The 2025 hurricane season is winding down, and the National Hurricane Center (NHC) is shifting focus from forecasting tropical cyclones to reflecting on the season's activity and identifying ways to improve future predictions. As part of this annual process, NHC prepares detailed Tropical Cyclone Reports for each system and produces a comprehensive Verification Report that examines the accuracy and potential biases of NHC forecasts and real-time model guidance. While the full 2025 Verification Report will be released in the spring, this brief summary highlights some of the preliminary findings on NHC's forecast performance for the Atlantic basin, based on both post-analysis and real-time best track data. For verification details on individual storms, visit the completed Tropical Cyclone Reports at https://www.nhc.noaa.gov/data/tcr/index.php

Atlantic Basin Season Activity and Track, Intensity, and Genesis Forecast Statistics

While the total numbers of tropical storms (13) and hurricanes (5) were slightly below the 30-year averages of 14 and 7, respectively, the season was notable for its three category 5 hurricanes. The number of major hurricanes (4) and the Accumulated Cyclone Energy (ACE) were above the 30-year seasonal average with about 70% of the activity occurring after the typical peak of the hurricane season (September 10). Perhaps most remarkable, the three Category 5 hurricanes is the second-highest total on record, surpassed only by the 2005 season.

NHC thus far has issued a total of 246 forecasts in the Atlantic basin in 2025, which is well below the long-term average of about 325 forecasts. A map of the 2025 Atlantic basin tropical storms and hurricanes is shown in Figure 1. As seen in the figure, the southwest portion of the basin was less active, with one notable exception (Melissa).

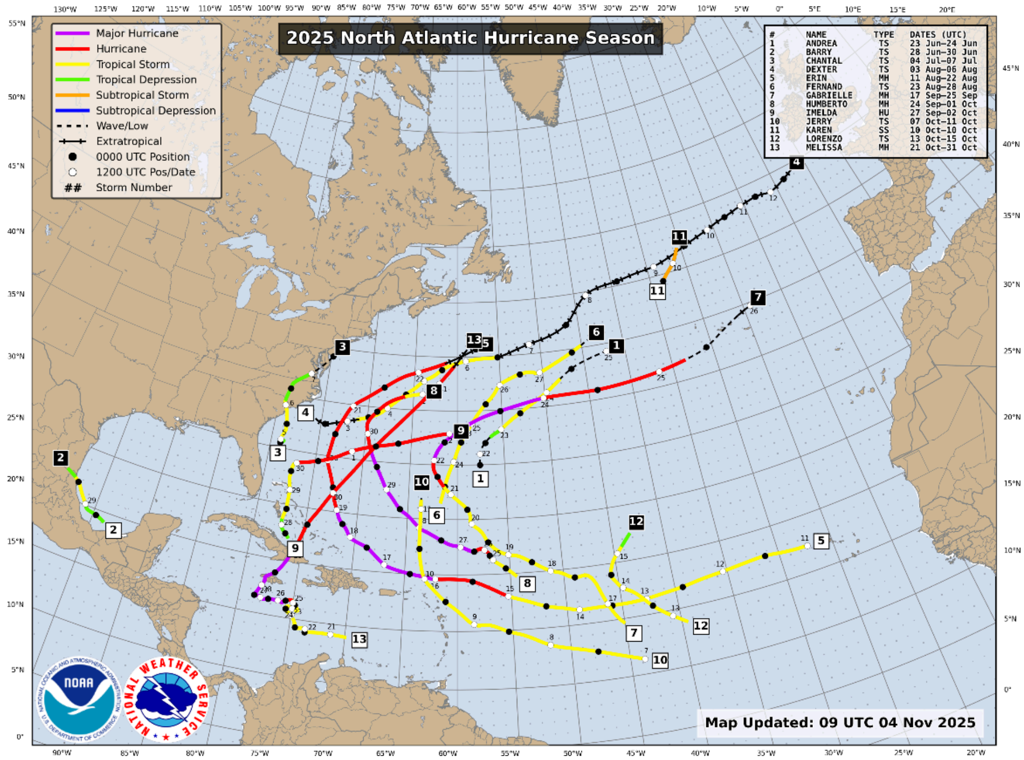

Figure 1 – Preliminary map of the 2025 Atlantic basin tropical storms and hurricanes .

Figure 2 shows the NHC's annual average track errors at different forecast times from 1990 through 2025. Track errors in 2025 were slightly higher than in 2024, but generally close to the average of the past few years. While there is considerable year-to-year variability, the long-term trend is clear—steady and substantial improvement in reducing track errors over the past three decades. It's also worth noting that NHC's forecasts were more consistent from one advisory cycle to the next compared to most models, although a few experimental models did have lower error than NHC at some forecast periods. For a deeper look at NHC's progress in track forecasting, check out this video: https://youtu.be/RB1mTkgkI5E?si=sTjYMBZCohMRgQAn

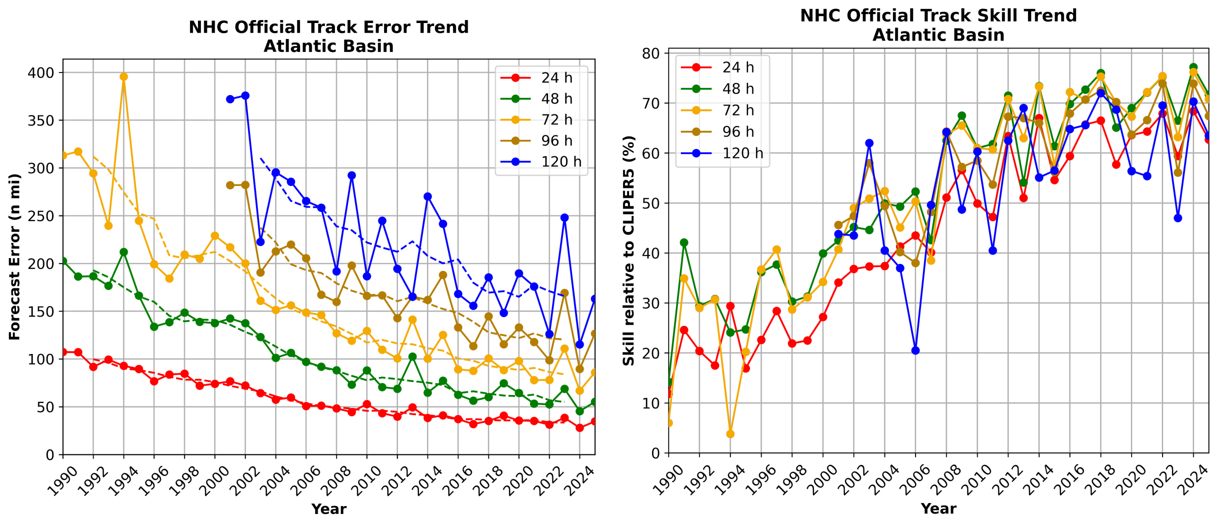

Figure 2 – Trends in NHC official track errors (n mi, left) and skill (right) from 1990-2025.

Intensity forecasting in 2025 was especially challenging in the Atlantic. Many of the season's long-lived storms were powerful and went through rapid intensification (RI)—a jump in maximum winds of at least 30 kt (35 mph) in just 24 hours. More on that topic in the next section below. NHC's average intensity errors were higher than the past couple of years, but the long-term trend of improvement remains strong. However, a closer inspection of the data explains the higher error. Results from a climatology and persistence model show that 2025's storms were about 50% harder to predict than average, underscoring how challenging the year was in predicting the strength of the storms. In fact using that metric, **2025 was the one of the most skillful years of intensity forecasting for NHC.** Figure 3 below shows an illustration of the annual trends of intensity error and skill.

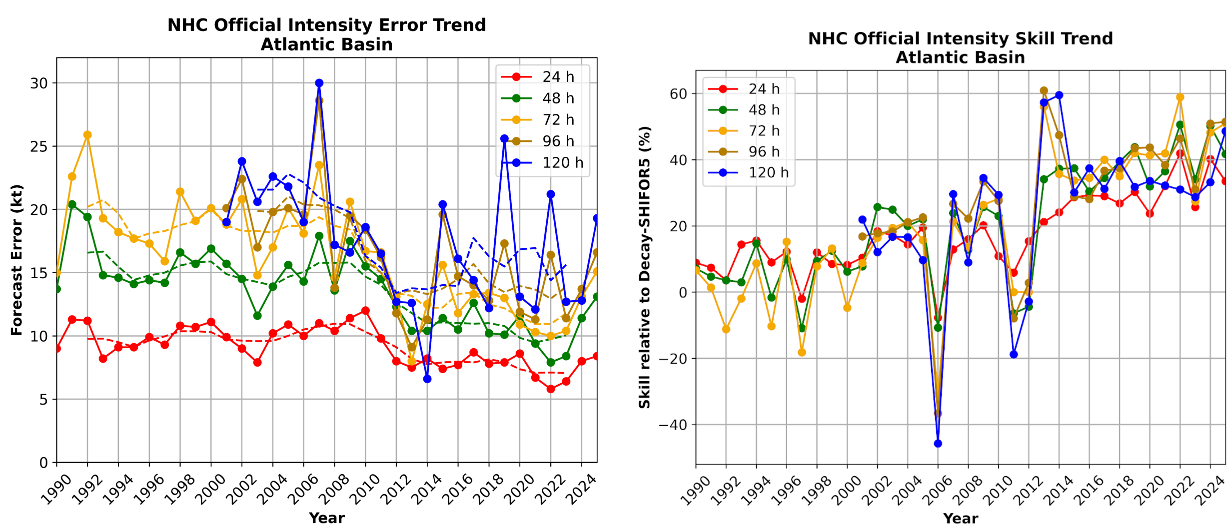

Figure 3 – Trends in NHC official intensity errors (kt, left) and skill (right) from 1990-2025.

When it came to tropical cyclone formation, NHC's genesis probabilities were well calibrated in both the 2-day and 7-day outlooks for 2025. In most probability ranges, forecast probabilities closely matched the actual probability of disturbances that became tropical cyclones, though there are a few spots (high outlooks in 2-day, low outlooks in in 7-day) where a low bias in the yearly stats is observed. Figure 4 shows this information in a reliability diagram for both 2-day and 7-day tropical weather outlooks issued over the 2025 season.

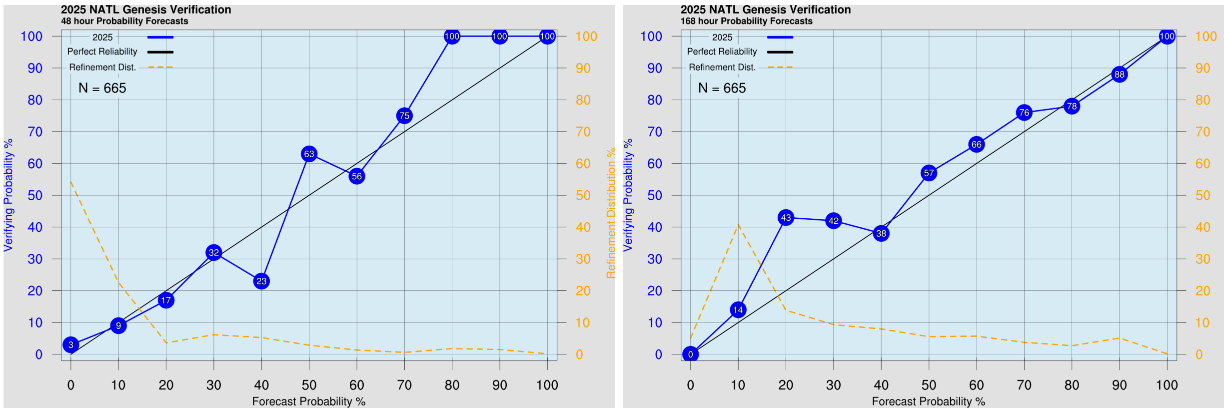

Figure 4 – 2025 Reliability diagram of NHC forecast TC genesis % (black line) vs verification (blue line). A perfect forecast would be when the blue line matches the black line. Sample size of each probability bin is shown as an orange dotted line as the refinement distribution (%) relative to total sample size (N) in top left.

Rapid Intensification

Although 2025 presented significant challenges for intensity forecasting, NHC performed particularly well in the most difficult cases. Figure 5 shows the critical success index of official and model forecasts for storms in 2025 that went through RI. Critical success index is a metric used to evaluate how well a forecast aligns with actual outcomes and ranges from 0 to 1, where 1 represents perfect accuracy. It can be seen that NHC intensity forecasts (OFCL/black dot) had a higher probability of detection (vertical axis) and higher critical success index (curved/shaded lines) for the subset of RI systems compared to all of the real time model guidance (other colored symbols).

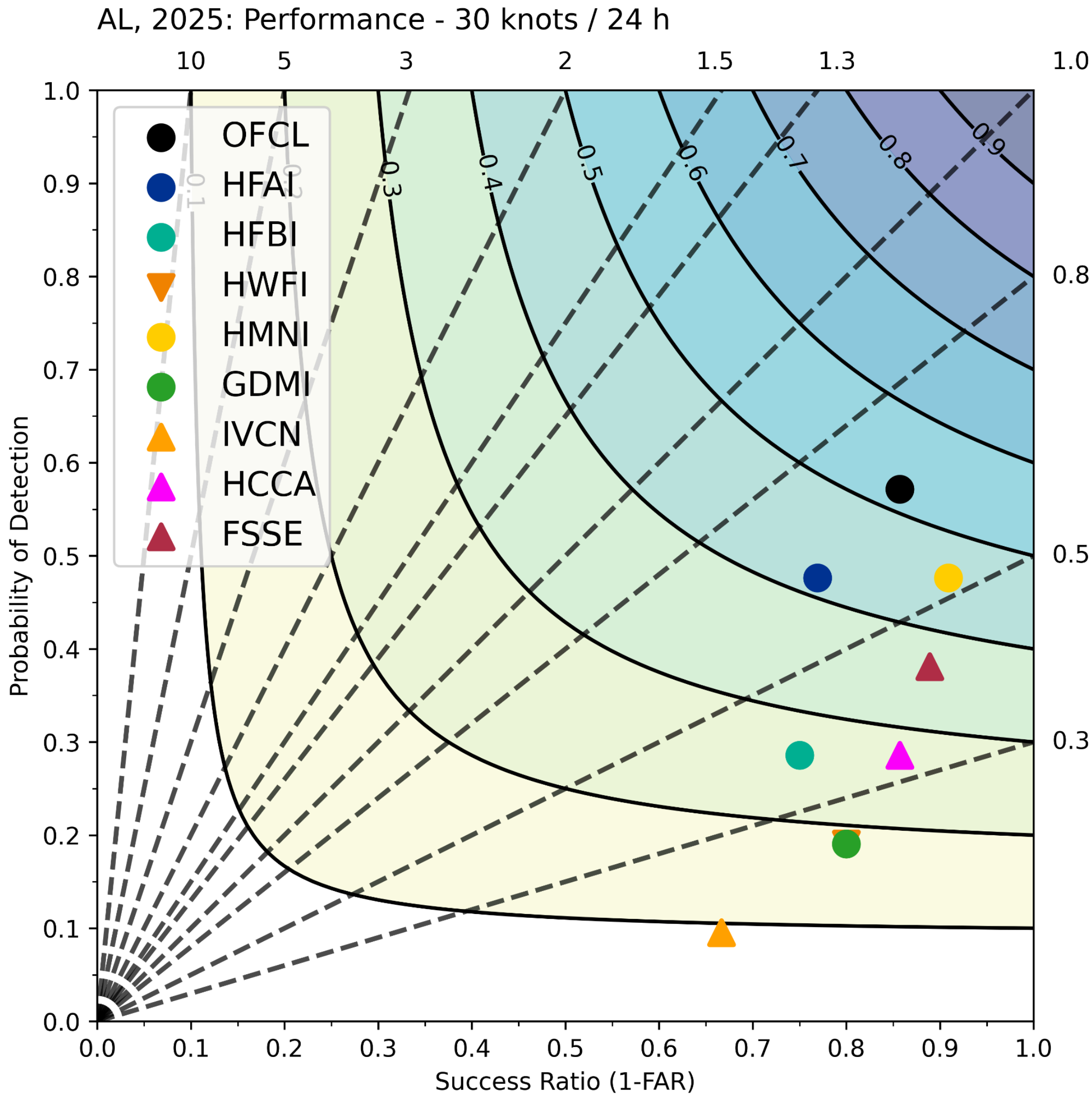

Figure 5 – Roebber performance diagram of NHC official forecast (OFCL) and intensity models of rapidly strengthening storms (30 kt/35 mph within a 24-hour period). Probability of detection is given by the ratio of hits to the total number of times the events occurred. False Alarm Ratio (FAR) is given by the ratio of false alarms to the total number of forecast events. Note: HWFI and GDMI showed similar results and overlap in the image.

Although RI remains one of the greatest challenges in hurricane forecasting, continued advancements in hurricane modeling and scientific understanding are making a noticeable difference—even in the most difficult cases. While there is still work to be done, significant progress is clearly underway. Recent improvements in NWS regional hurricane models and the emergence of AI ensembles, have increased forecasters' confidence to issue more aggressive intensity forecasts. Hurricane Melissa serves as a strong example of this progress.

Hurricane Melissa

Hurricane Melissa was undoubtedly the most significant storm of the 2025 season, especially given its devastating impact on Jamaica. A first look at NHC's forecasts shows that NHC performed exceptionally well in predicting both Melissa's track and intensity (Fig 6). For the storm's path, NHC's forecasts were as accurate as—or even better than—the leading numerical weather prediction models, with an average 5-day track error of around 100 nautical miles (115 miles). That's about 50% smaller than the typical NHC error from the past five years. Impressively, four days before landfall, NHC projected a path right over western Jamaica, and that forecast ended up being off by only about 11 nautical miles (13 miles).

When it came to intensity, NHC's forecasts outperformed every model at nearly every time range and provided almost three days of advance notice that Melissa would make landfall in Jamaica as a powerful Category 5 hurricane. This lead time was remarkable, since it was the first time NHC forecasted a hurricane to reach category 5 intensity from such a low initial intensity when the forecast was made (category 1). Compared to the last three hurricanes to make landfall at Category 5 intensity in NHC's area of responsibility (Michael 2018, Dorian 2019, Otis 2023), Melissa's forecast stands out, better capturing the peak intensity at landfall, illustrating the progress NHC has made in forecasting rapid intensification events in the past decade (Fig 7).

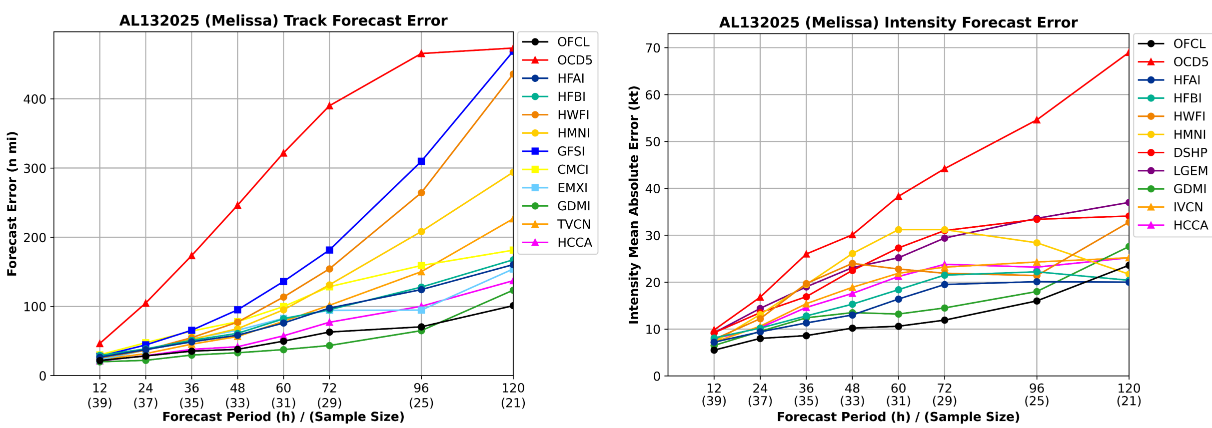

Figure 6 – Verification of Melissa track forecasts (left) and intensity forecasts (right).

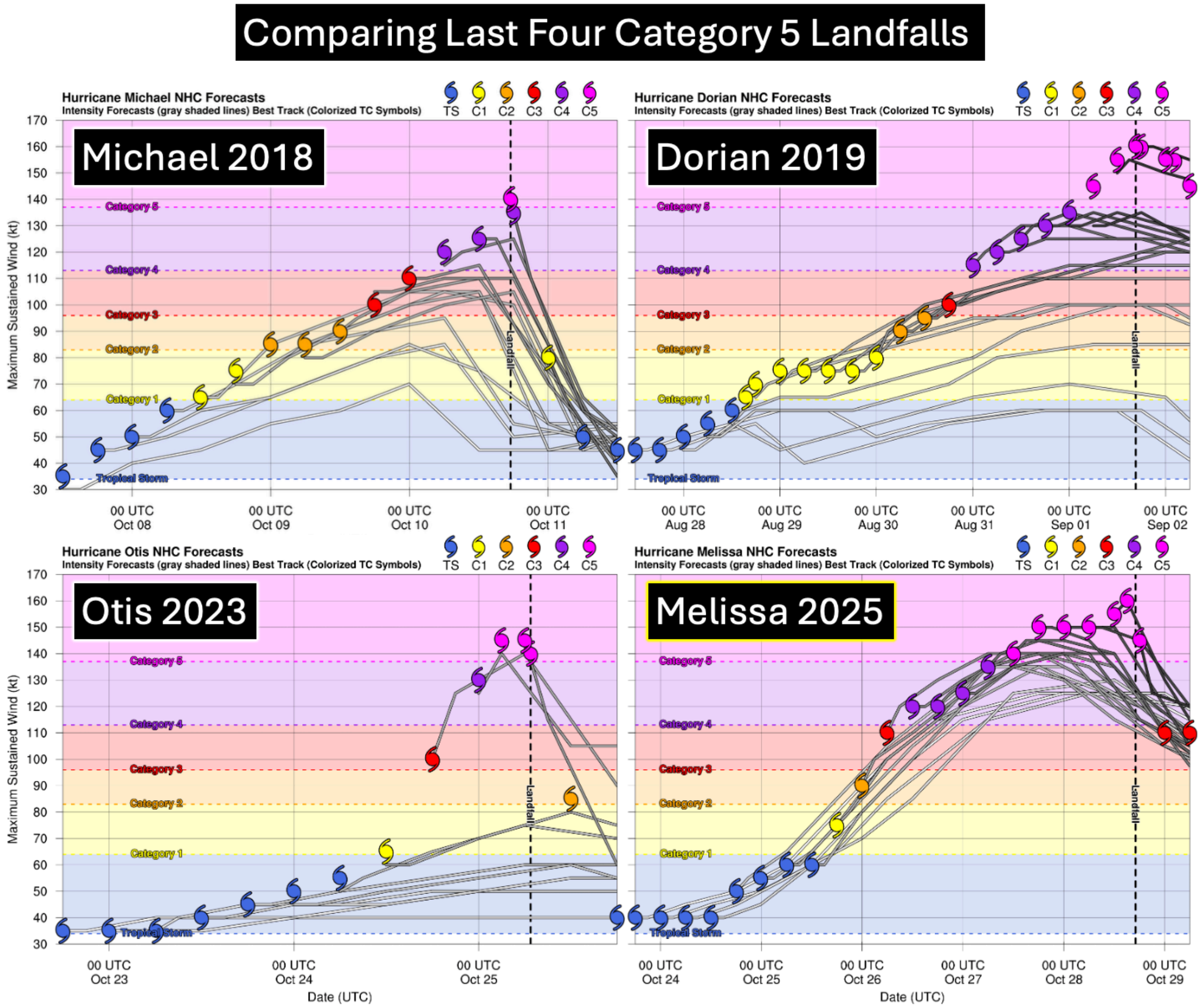

Figure 7 – Comparison of NHC intensity forecasts for recent Category 5 hurricane landfalls.

Artificial Intelligence

Artificial intelligence (AI) is becoming an integral part of many scientific disciplines, and hurricane forecasting is no exception. The 2025 season marked the first time that NHC incorporated AI-based models into real-time operations, and early results indicate considerable promise. In particular, the Google DeepMind (shown as GDMI in figures 5 and 6) was very useful. However, many of these systems remain under active development, and some were not consistently available on a timely basis for routine use by forecasters. Despite these limitations, AI models are expected to become increasingly reliable, efficient, and influential components of the hurricane forecasting process in the coming years.

What's coming

NHC is working toward finalizing Tropical Cyclone Reports for each system from the season. Once those are complete, the focus will shift to producing the NHC Verification Report. This comprehensive report will analyze the accuracy and biases of NHC and model forecasts, assess genesis predictions, and evaluate forecasts for systems that prompted U.S. watches and warnings. It will also include data from the eastern North Pacific basin. For details and past reports, visit nhc.noaa.gov/verification.