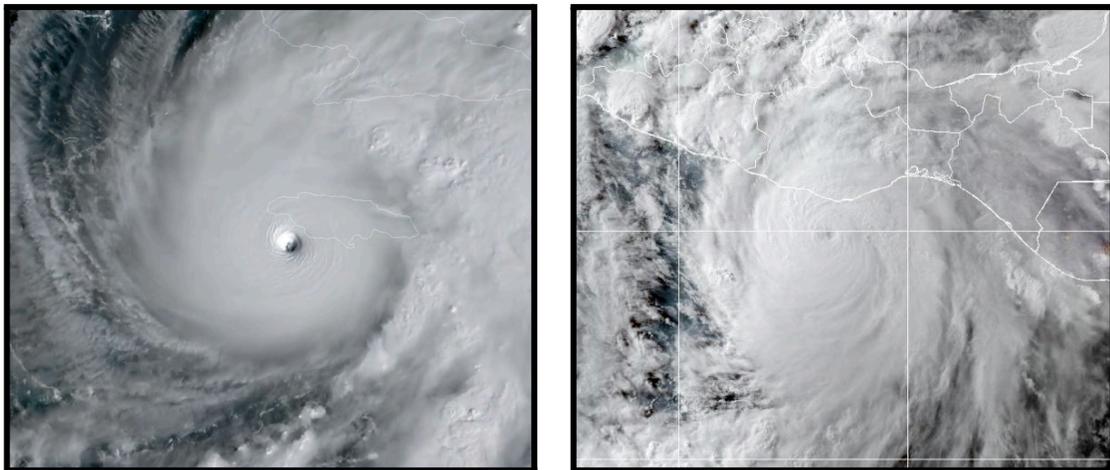# NATIONAL HURRICANE CENTER FORECAST VERIFICATION REPORT

2025 HURRICANE SEASON

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GOES-EAST VISIBLE IMAGE OF HURRICANE MELISSA JUST PRIOR TO LANDFALL IN JAMAICA AT 1400 UTC 28 OCTOBER 2025 (LEFT). GOES-WEST VISIBLE IMAGE OF HURRICANE ERICK AT 2350 UTC 18 JUNE 2025 (RIGHT).
IMAGES COURTESY OF NOAA/NESDIS/STAR.

ABSTRACT

The 2025 Atlantic hurricane season featured 13 tropical storms and 5 hurricanes, but was distinguished by three Category 5 hurricanes—the second-highest total on record behind 2005. While NHC issued fewer forecasts than average, official track forecasts were more accurate than the 5-year means at all lead times. In addition, track skill values are near historical highs and substantial long-term improvements continue across all forecast periods. Official forecasts generally outperformed most dynamical and consensus models, though the Google DeepMind ensemble mean (GDMI) showed slightly better short-range performance. In contrast, intensity forecasts were more challenging, with errors exceeding the 5-year means, particularly during numerous rapid intensification (RI) events. Despite increased difficulty, intensity skill remained near all-time highs, and

official forecasts demonstrated improved RI prediction relative to model guidance. Wind radii forecasts continued their gradual long-term improvement, and genesis outlooks were generally well calibrated at 48 h but exhibited some low bias at lower probabilities in the 168-h product. Overall, the 2025 Atlantic season highlighted continued gains in track forecasting, ongoing progress in intensity and wind radii prediction, and the operational challenges posed by an unusually high frequency of RI cases.

The 2025 eastern North Pacific hurricane season was close to average. NHC's track forecast performance was exceptional. The mean errors were 15–30% lower than the 5-year averages and set records for accuracy at numerous lead times (24–120 h), making 2025 one of the most accurate eastern North Pacific track forecast seasons in history. Official forecasts outperformed nearly all of the models, but GDMI excelled from 48–120 h. Intensity forecasts were likewise excellent in 2025, with mean errors lower than the 5-year averages at all lead times with record-setting accuracy at 48 and 72 h. Official forecasts were comparable to the best consensus aids (HCCA and NNIC) at most forecast intervals. While RI forecasting remains challenging, NHC showed higher detection rates and critical success indices than model guidance for those cases. Wind radii forecasts continued their gradual long-term improvement and outperformed the radii consensus model. Genesis forecasts were generally well calibrated, though the 168-h outlooks exhibited some low bias. Overall, 2025 represented one of the strongest years for eastern North Pacific forecast performance, particularly for track accuracy.

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1.   Introduction

For all operationally designated tropical or subtropical cyclones, or systems that could become tropical or subtropical cyclones and affect land within the next 72 h in the Atlantic and eastern North Pacific (commonly referred to as eastern Pacific) basins, the National Hurricane Center (NHC) issues an official forecast of the cyclone's center location and maximum 1-min surface wind speed. Forecasts are issued every 6 h, and contain projections valid 12, 24, 36, 48, 60, 72, 96, and 120 h after the forecast's nominal initial time (0000, 0600, 1200, or 1800 UTC)[1]. At the conclusion of the season, forecasts are evaluated by comparing the projected positions and intensities to the corresponding post-storm derived "best track" positions and intensities for each cyclone. A forecast is included in the verification only if the system is classified in the final best track as a tropical (or subtropical[2]) cyclone at both the forecast's initial time and at the projection's valid time. All other stages of development (e.g., tropical wave, [remnant] low, extratropical) are excluded[3]. For verification purposes, forecasts associated with special advisories do not supersede the original forecast issued for that synoptic time; rather, the original forecast is retained[4]. All verifications in this report include the depression stage.

It is important to distinguish between *forecast error* and *forecast skill*. Track forecast error, for example, is defined as the great-circle distance between a cyclone's forecast position and the best track position at the forecast verification time. Skill, on the other hand, represents a normalization of this forecast error against some standard or baseline. Expressed as a percentage improvement over the baseline, the skill of a forecast s_f is given by

$$s_f\,(\%) = 100 * (e_b - e_f)\,/\,e_b$$

where e_b is the error of the baseline model and e_f is the error of the forecast being evaluated. It is seen that skill is positive when the forecast error is smaller than the error from the baseline.

To assess the degree of skill in a set of track forecasts, the track forecast error can be compared with the error from CLIPER5, a climatology and persistence model that contains no information about the current state of the atmosphere (Neumann 1972, Aberson 1998)[5]. Errors from the CLIPER5 model are taken to represent a "no-skill" level of accuracy that is used as the baseline (e_b) for evaluating other forecasts[6]. If CLIPER5 errors are unusually low during a given season, for example, it indicates that the year's storms were inherently "easier" to forecast than normal or otherwise unusually well behaved. The current version of CLIPER5 is based on developmental data from 1931–2004 for the Atlantic and from 1949–2004 for the eastern Pacific.

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[1]   The nominal initial time represents the beginning of the forecast process. The actual advisory package is not released until 3 h after the nominal initial time, i.e., at 0300, 0900, 1500, and 2100 UTC.

[2]   For the remainder of this report, the term "tropical cyclone" shall be understood to also include subtropical cyclones.

[3]   Possible classifications in the best track are: Tropical Depression, Tropical Storm, Hurricane, Subtropical Depression, Subtropical Storm, Extratropical, Disturbance, Wave, and Low.

[4]   Special advisories are issued whenever an unexpected significant change has occurred or when watches or warnings are to be issued between regularly scheduled advisories. The treatment of special advisories in forecast databases changed in 2005 to the current practice of retaining and verifying the original advisory forecast.

[5]   CLIPER5 and SHIFOR5 are 5-day versions of the original 3-day CLIPER and SHIFOR models.

[6]   To be sure, some "skill", or expertise, is required to properly initialize the CLIPER model.

Particularly useful skill standards are those that do not require operational products or inputs, and can therefore be easily applied retrospectively to historical data. CLIPER5 satisfies this condition, since it can be run using persistence predictors (e.g., the storm's current motion) that are based on either operational or best track inputs. The best-track version of CLIPER5, which yields substantially lower errors than its operational counterpart, is generally used to analyze lengthy historical records for which operational inputs are unavailable. It is more instructive (and fairer) to evaluate operational forecasts against operational skill benchmarks, and therefore the operational versions are used for the verifications discussed below.[7]

Intensity forecast error is defined as the absolute value of the difference between the forecast and best track intensity at the forecast verifying time. Skill in a set of intensity forecasts is assessed using Decay-SHIFOR5 (DSHIFOR5) as the baseline. The DSHIFOR5 forecast is obtained by initially running SHIFOR5, the climatology and persistence model for intensity that is analogous to the CLIPER5 model for track (Jarvinen and Neumann 1979, Knaff et al. 2003). The output from SHIFOR5 is then adjusted for land interaction by applying the decay rate of DeMaria et al. (2006). The application of the decay component requires a forecast track, which here is given by CLIPER5. The use of DSHIFOR5 as the intensity skill benchmark was introduced in 2006. On average, DSHIFOR5 errors are about 5–15% lower than SHIFOR5 in the Atlantic basin from 12–72 h, and about the same as SHIFOR5 at 96 and 120 h.

It has been argued that CLIPER5 and DSHIFOR5 should not be used for skill benchmarks, primarily on the grounds that they were not good measures of forecast difficulty. Particularly in the context of evaluating forecaster performance, it was recommended that a model consensus (see discussion below) be used as the baseline. However, an unpublished study by NHC has shown that on the seasonal time scales at least, CLIPER5 and DSHIFOR5 are indeed good predictors of official forecast error. For the period 1990–2009, CLIPER5 errors explained 67% of the variance in annual-average NHC official track forecast errors at 24 h. At 72 h, the explained variance was 40% and at 120 h the explained variance was 23%. For intensity, the relationship was even stronger: DSHIFOR5 explained between 50–69% of the variance in annual-average NHC official errors at all time periods. Given this, CLIPER5 and DSHIFOR5 appear to remain suitable, if imperfect, baselines for skill, in the context of examining forecast performance over the course of a season (or longer). However, they are probably less useful for interpreting forecast performance with smaller samples (e.g., for a single storm).

NHC also issues forecasts of the size of tropical cyclones; these "wind radii" forecasts are estimates of the maximum extent of sustained winds of various thresholds (34, 50, and 64 kt) expected in each of four quadrants surrounding the cyclone (Cangialosi and Landsea 2016). Although there is more uncertainty in the best track for these values, this report does provide some baseline statistics on this parameter, and there continues to be more thorough internal efforts to assess the state of tropical cyclone structure forecasts. Some of the size statistics are

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[7] On very rare occasions, operational CLIPER or SHIFOR runs are missing from forecast databases. To ensure a completely homogeneous verification, post-season retrospective runs of the skill benchmarks are made using operational inputs. Furthermore, if a forecaster makes multiple estimates of the storm's initial motion, location, etc., over the course of a forecast cycle, then these retrospective skill benchmarks may differ slightly from the operational CLIPER/SHIFOR runs that appear in the forecast database.

given in skill space with wind-radii CLIPER model (DRCL) being the used baseline (Knaff et. al. 2007).

Numerous objective forecast aids (guidance models) are available to help the NHC in the preparation of official track and intensity forecasts. Guidance models are characterized as either *early* or *late*, depending on whether or not they are available to the forecaster during the forecast cycle. For example, consider the 1200 UTC (12Z) forecast cycle, which begins with the 12Z synoptic time and ends with the release of an official forecast at 15Z. The 12Z run of the National Weather Service Global Forecast System (GFS) model is not complete and available to the forecaster until about 16Z, or about an hour after the NHC forecast is released. Consequently, the 12Z GFS would be considered a late model since it could not be used to prepare the 12Z official forecast. This report focuses on the verification of early models.

Multi-layer dynamical models are generally, if not always, late models. Fortunately, a technique exists to take the most recent available run of a late model and adjust its forecast to apply to the current synoptic time and initial conditions. In the example above, forecast data for hours 6–126 from the previous (06Z) run of the GFS would be smoothed and then adjusted, or shifted, such that the 6-h forecast (valid at 12Z) would match the observed 12Z position and intensity of the tropical cyclone. The adjustment process creates an "early" version of the GFS model for the 12Z forecast cycle that is based on the most current available guidance. The adjusted versions of the late models are known, mostly for historical reasons, as *interpolated* models[8]. The adjustment algorithm is invoked as long as the most recent available late model is not more than 12 h old, e.g., a 00Z late model could be used to form an interpolated model for the subsequent 06Z or 12Z forecast cycles, but not for the subsequent 18Z cycle. Verification procedures here make no distinction between 6- and 12-h interpolated models.

In addition to their timeliness, models are characterized by their complexity or structure; this information is contained in the table for reference. Briefly, *dynamical* models forecast by solving the physical equations governing motions in the atmosphere. Dynamical models may treat the atmosphere either as a single layer (two-dimensional) or as having multiple layers (three-dimensional), and their domains may cover the entire globe or be limited to specific regions. The interpolated versions of dynamical model track and intensity forecasts are also sometimes referred to as dynamical models. *Statistical* models, in contrast, do not consider the characteristics of the current atmosphere explicitly but instead are based on historical relationships between storm behavior and various other parameters. *Statistical-dynamical* models are statistical in structure but use forecast parameters from dynamical models as predictors. *Consensus* models are not true forecast models *per se*, but are merely combinations of results from various models. One way to form a consensus is to simply average the results from a collection (or "ensemble") of models, but other, more complex techniques can also be used. The Hurricane Forecast Improvement Program Corrected Consensus Approach (HCCA), for example, combines its individual components on the basis of past performance and attempts to correct for biases in those components (Simon et al. 2018). A consensus model that considers past error characteristics can be described as a "weighted" or "corrected" consensus.

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[8]   When the technique to create an early model from a late model was first developed, forecast output from the late models was available only at 12 h (or longer) intervals. In order to shift the late model's forecasts forward by 6 hours, it was necessary to first interpolate between the 12 h forecast values of the late model – hence the designation "interpolated".

The 2025 season marked the first time that NHC incorporated AI-based models into real-time operations. 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.

More information on how NHC utilized AI models in 2025 can be found at https://www.weather.gov/news/261102-AI-Hurricane-Forecasting.

More detailed information about the guidance models used at the NHC can be found at http://www.nhc.noaa.gov/modelsummary.shtml.

The verifications described in this report are for all tropical cyclones in the Atlantic and eastern North Pacific basins. These statistics are based on forecast and best track data sets taken from the Automated Tropical Cyclone Forecast (ATCF) System on 11 February 2026 for both the Atlantic and eastern North Pacific basins. Verifications for the Atlantic and eastern North Pacific basins are given in Sections 2 and 3 below, respectively. Section 4 previews anticipated changes for 2026.

2.   Atlantic Basin

a.   2025 season overview – Track

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 averages 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. A map of the 2025 Atlantic basin tropical storms and hurricanes is shown in Figure 1. As seen in the figure, the area off the U.S. east coast was particularly active, with large gaps over the Gulf of America and Caribbean Sea. Figure 2 and Table 1 present the results of the NHC official track forecast verification for the 2025 season, along with results averaged for the previous 5-yr period, 2020–2024. In 2025, the NHC issued 240 Atlantic basin tropical cyclone forecasts[9], a number well below the long term mean of around 325 (Fig. 3). Mean track errors ranged from 20 n mi at 12 h to 162 n mi at 120 h. The mean official track forecast errors in 2025 were below the 5-yr means at all times, and up to 14% smaller at 96 h. Although NHC's forecast errors were lower than average, no records were set in 2025. The CLIPER errors for 2025 were slightly lower (up to 8%) than their 5-yr means for the short lead times, which typically indicates that the storms' tracks were a little less difficult to predict than average at those time periods, but their errors were up to 4% larger than the 5-yr means at 96 and 120 h.

The official track forecasts had a northeast to east-northeast bias (i.e., the official forecast tended to fall to the northeast/east-northeast of the verifying position) that became larger with forecast time. Track forecast skill ranged from 52% at 12 h to 72% at 48 and 60 h (Table 1). Over the past couple of decades, the 24−72-h track forecast errors have been drastically reduced by about 75% (Fig. 4a). Track forecast error reductions of about 60−70% have occurred over the past 20 years for the 96- and 120-h forecast periods. An evaluation of track skill indicates that there has been a considerable amount of year-to-year variability, but a gradual increase in skill has occurred over the long term (Fig. 4b), and skill values were near all-time highs in 2025. Figure 5 indicates that on average the NHC track errors decrease as the initial intensity of a cyclone increases, and that relationship holds true through the entire 120-h forecast period. It has been seen in multiple cases during the past few years that the NHC track errors are notably lower than average for major hurricanes, including Humberto and Melissa in 2025.

Note that the mean official error in Figure 2 is not precisely zero at 0 h (the analysis time). This non-zero difference between the operational analysis of storm location and best track location, however, is not properly interpreted as just "analysis error". The best track is a subjectively smoothed representation of the storm history over its lifetime, in which the short-term variations in position or intensity that cannot be resolved in a 6-hourly time series are deliberately removed. Thus, the location of a strong hurricane with a well-defined eye might be known with great accuracy at 1200 UTC, but the best track may indicate a location elsewhere

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[9] This count does not include forecasts issued for systems later classified to have been something other than a tropical cyclone at the forecast time.

by 5–10 miles or more if the precise location of the cyclone at 1200 UTC was unrepresentative. Operational analyses tend to follow the observed position of the storm more closely than the best track analyses, since it is more difficult to determine unrepresentative behavior in real time. Consequently, the t=0 "errors" shown in Figure 2 contain both true analysis error and representativeness error.

Table 2 presents a homogeneous[10] verification for the official forecasts along with a selection of early models for 2025. In order to maximize the sample size, a guidance model had to be available at least two-thirds of the time at all forecast times to be included in this comparison (Fig. 6). The performance of the official forecasts and the early track models in terms of skill are presented in Figure 7. The official forecasts were highly skillful, even outperforming the typically reliable consensus aids TVCA, HCCA, and FSSE. However, there was one model, the Google DeepMind ensemble mean (GDMI), that slightly outperformed NHC at the shorter lead times from 12 to 72 h. Among the individual models, EMXI performed near the middle of the pack from 12 to 72 h, but was a strong performer at 96 and 120 h, having skill levels close to HCCA and GDMI at those time periods. The hurricane regional models HFAI/HFBI and AEMI were fair performers, and CMCI was competitive with those aids at 96 and 120 h. However, GFSI, HMNI, and HWFI were less competitive, especially for the longer lead times, and were among the least skillful track models overall. Note that GDMI was not available during the early part of the season, so this homogeneous model comparison does not include the first two storms of the season.

An evaluation over the three years 2023–25 (Fig. 8) indicates that HCCA, FSSE, and TVCA were the best models for this sample, with TVCA being slightly superior at the longer lead times. The official forecasts had about the same skill levels as those models throughout the forecast period. EMXI was the best individual model, but it had about 5% lower skill than the official forecasts and consensus aids at most forecast times. HFBI and AEMI were next best, closely followed by GFSI, UKMI, and HMNI. HWFI was slightly less skillful than that group, while NVGI lagged at all forecast times. A separate homogeneous verification of the primary consensus models for 2025 is shown in Figure 9. The figure shows that HCCA was the best model, outperforming all of the other aids at every time period.

Figure 10 provides a comparison of track error and consistency, or how much the official forecast and models changed from cycle to cycle, around the 96- and 120-h forecast time periods. Greater forecast consistency is operationally important because it provides users with a more stable and reliable basis for planning and decision-making. It can be seen that for the 2023–25 sample the official forecasts had lower error and were notably more consistent than GFSI, EMXI, UKMI, and HCCA. Although the NHC's accuracy was similar to TVCA, the official forecasts were also more consistent than that consensus aid. A closer inspection of NHC's 2021–25 track error distribution is shown in Figure 11. This violin diagram shows the mean errors (colored dots) are higher than medians (horizontal lines) at all forecast times. The mean is being inflated by a small number of cases with significantly higher error, like for Philippe in 2023. Various percentiles (10, 25, 75, 90) can also be seen on the diagram along with kernel density estimates (KDEs) of the track forecast error probability density functions. These diagrams better illustrate the distribution of NHC's forecast errors.

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[10] Verifications comparing different forecast models are referred to as *homogeneous* if each model is verified over an identical set of forecast cycles. Only homogeneous model comparisons are presented in this report.

Atlantic basin 48-h official track error, evaluated for all tropical cyclones, is a forecast measure tracked under the Government Performance and Results Act of 1993 (GPRA). In 2025, the GPRA goal was 52 n mi, and the verification for this measure was narrowly missed at 53.4 n mi.

b.   2025 season overview – Intensity

Figure 12 and Table 3 present the NHC Atlantic intensity forecast verification for the 2025 season, along with results averaged for the preceding 5-yr period. The intensity errors were higher than the 5-yr means at all time periods, and 40−50% larger than the means from 60 to 120 h. The Decay-SHIFOR forecast errors were also significantly (up to 90%) larger than their 5-yr means, which suggests the season's storms' intensities were substantially more difficult to forecast than normal. The official forecasts exhibited little bias from 12 to 72 h, but a fairly significant low bias was present at 96 and 120 h. Figure 13 shows recent trends in intensity forecast accuracy and skill for the Atlantic basin. While there has been a modest decrease in error over the past couple of decades, there remains considerable year-to-year variability, and errors ticked up in 2025 compared to the all-time lows that were set a few years ago. On the other hand, intensity skill has been holding steady near all-time highs. Overall, it appears that the intensity predictions are gradually improving since the forecasts are generally more skillful in the past 10−15 years than they were in the 1990s and the first decade of the 2000s (Cangialosi et al. 2020). Progress has also been made in predicting Rapid Intensification (RI), which is defined as an increase in the storm's maximum winds of at least 30 kt over a 24-h period. A more detailed analysis on RI is shown below.

Table 4 presents a homogeneous verification for the official forecasts and the primary early intensity models for 2025, and forecast skill is presented in Figure 14. The official forecasts were quite skillful, beating all of the models at 12 and 96 h and having comparable skill with the best model, GDMI, at the other forecast time periods. FSSE was the next best model, closely followed by other consensus aids NNIC, IVCN, and HCCA. The hurricane regional models HFAI and HFBI were fair performers and generally bested HWFI and HMNI. The dynamical-statistical LGEM and DSHP were not as good as HFAI and HFBI, but still provided some value. GFSI was skillful but not competitive, and EMXI had little to no intensity skill.

An evaluation over the three years 2023–25 (Fig. 15) indicates that the official forecasts have been consistently performing quite well, and had skill values close to or higher than the best aids IVCN and HCCA. FSSE was a strong performer at the short lead times, but its skill trailed off sharply after 60 h. HWFI and HMNI were the best individual models at most forecast times, followed by HFAI, HFBI, and LGEM. DSHP and GFSI were slightly less good, while EMXI had little to no skill and was not competitive with the remainder of the guidance.

A closer inspection of NHC's 2021–25 intensity error distribution is shown in Figure 16. This diagram indicates that there is generally little bias in the official forecasts with the mean and median errors close to zero. However, it can also be seen that there is a fair amount of spread at all forecast times, indicating that there are cases that have both too high and too low predictions at each forecast time period. The distributions also become slightly left-skewed with forecast time, indicating an increasing negative (low) intensity forecast bias with time.

Although RI remains one of the biggest challenges at NHC, it is worth noting that advancements in hurricane modeling and understanding of the science are making a difference in improving forecasts for even the most challenging cases (DeMaria et al. 2021). In fact, the NHC intensity bias has been steadily decreasing over the past 10 to 15 years (not shown). One way to evaluate NHC's performance against the models for RI is to look only at cases when RI was occurring or forecast over the past few seasons (Figure 17). It can be seen that the official forecasts have lower errors than the models at just about every forecast time. Although there is still work to do, progress is clearly underway. Figure 18 shows the critical success index (CSI) of official and selected model forecasts for storms from 2023–25 that went through RI on a Roebber performance diagram (Roebber 2009). CSI is a skill score measuring the proportion of correct RI forecasts (hits) to the total number of times an RI event was forecast and/or observed. Therefore, CSI equally penalizes false alarms (RI was forecast but did not occur) and misses (RI occurred but was not forecast) while ignoring correct forecasts of non-RI occurrences. CSI values range from 0 to 1 with the best possible score being 1. It can be seen that NHC intensity forecasts (OFCL/black dot) had a higher probability of detection (vertical axis) and higher CSI (curved/shaded lines) for the subset of storms that underwent RI compared to the real time model guidance (other colored symbols).

The 48-h official intensity error, evaluated for all tropical cyclones, is another GPRA measure for NHC. In 2025, the GPRA goal was 10 kt, and the verification for this measure was missed at 13.7 kt. It should be noted that the primary reason the GPRA target was missed in 2025 was due to the high percentage of RI cases relative to the total sample. A total of 23 RI episodes occurred in 2025. This is slightly above the 10-year average, but notably higher when considered relative to the total number of forecasts, with RI cases accounting for about 10% of all forecasts.

c.   Wind Radii and Watch/Warning Verification

Even though the available data is often insufficient across much of the Atlantic basin to compose a comprehensive verification on tropical cyclone wind radii, this report provides an attempt to quantify some of NHC's errors and progress since wind radii forecasts were first post-analyzed and included in the best track dataset in 2004. Figure 19 shows recent trends in the 34- and 50-kt wind radii forecast accuracy averaged in all quadrants for the Atlantic basin. The trends in the 64-kt error are not shown due to relatively small sample sizes in some years. It can be seen that although there is notable year-to-year variability, the errors have been decreasing for both of these wind thresholds. Note, the 96- and 120-h wind radii predictions only began in 2024, so no trends are available for those lead times. An evaluation of NHC's prediction against the wind radii consensus model (RVCN) from 2023–25 indicates that NHC has more skill than that consensus model for all wind radii thresholds (Fig. 20).

Storm surge, hurricane, and tropical storm watches and warnings provide the public with actionable information when a tropical cyclone threatens land areas. Watches are issued about 48 hours before storm surge or tropical-storm-force winds are anticipated to arrive, and warnings are issued 36 hours in advance of those hazards.   Figure 21 shows a comparison of the official track and intensity errors when U.S. coastal watches and warnings were and were not in effect. To ensure a sufficient sample, this analysis includes the most recent 5-yr period,

2021–25. It can be seen that track forecasts were more accurate when U.S. watches and warnings were in effect at all forecast times. Intensity forecast errors were also lower from 72 to 120 h for cases when U.S. watches and warnings were in effect. It is believed that the better forecasts when U.S. watches and warnings are in effect are due to more available observational data (e.g. reconnaissance aircraft within a cyclone and the surrounding environment) in those events. These data help the forecaster assess the structure of the tropical cyclone in real time, and advance models through data assimilation for better predictions of the future track and intensity.

d.   Verifications for individual storms

As is the case most years, the errors vary significantly by storm. The official track forecast errors were generally low for the stronger storms in 2025 like Erin, Humberto, and Melissa. However, NHC's errors were much larger for Imelda and Fernand. Figure 22 shows an illustration of the official track errors stratified by storm.

With regards to intensity, large forecast errors occurred for Humberto during its rapid intensification phase, and for Jerry, which failed to strengthen as predicted. Conversely, excellent intensity forecasts were issued for Imelda. Figure 23 shows an illustration of the official intensity errors stratified by storm. Additional discussion on forecast performance for individual storms can be found in NHC Tropical Cyclone Reports available at http://www.nhc.noaa.gov/data/tcr/index.php?season=2025&basin=atl

e.   Genesis forecasts

The NHC routinely issues Tropical Weather Outlooks (TWOs) every 6 h for both the Atlantic and eastern North Pacific basins. The TWOs are text products that discuss areas of disturbed weather and their potential for tropical cyclone development. Forecasters subjectively assign a probability of genesis (0 to 100%, in 10% increments) to each area of disturbed weather described in the TWO, where the assigned probabilities represent the forecaster's determination of the chance of tropical cyclone formation during the 48-h and 168-h periods following the nominal TWO issuance time. Note that the TWO was extended from 5 to 7 days in 2023. Verification is based on NHC best-track data, with the time of genesis defined to be the first tropical cyclone point appearing in the best track.

Verifications of the 48-h and 168-h outlook for the Atlantic basin in 2025 are given in Figure 24. In the Atlantic basin, a total of 664 genesis forecasts were made. These 48-h forecasts were generally well calibrated, but had a slight low (under-forecast) bias for the 70–90% probabilities. In contrast, the 168-h forecasts showed a low bias in the 10–30% probabilities, with better calibration in the medium and high probabilities. Figure 25 shows composites of all 7-day tropical cyclone genesis areas depicted in the Graphical TWO during the 2025 season in the North Atlantic basin. The largest area of outlooks were issued in the eastern-central portion of the basin this year, primarily in the main development region between 10–25°N and 30–60°W. These outlook areas contained the correct location of genesis (black circles) 81% of the time, increasing to 99% hit rate accuracy for high outlooks issued before

tropical cyclone formation (Fig. 25d). Compared to the prior 10-year average (2015–2024), there were fewer outlook areas issued in the Caribbean Sea and southern Gulf of America, highlighting fewer tropical cyclone candidates observed in this region of the North Atlantic (Fig. 26). While there were more outlooks issued near the southeastern U.S. coastline and across the Florida Peninsula (Fig. 26a-c), these were primarily low and medium outlooks with only one tropical cyclone forming in this region making landfall in the U.S. (Chantal). A 3-yr verification of the 48-h and 168-h genesis forecasts from 2023–25 in the Atlantic basin is given in Fig. 27. Overall the forecasts over this time span remain well calibrated in the 48-h forecasts, though a more notable low bias appears over the majority of probability bins in the 168-h forecasts.

3.   Eastern North Pacific Basin

a.   2025 season overview – Track

The 2025 eastern North Pacific hurricane season was above average for tropical storm activity, with an average amount of hurricanes and major hurricanes. Figure 28 shows a map of the 2025 eastern North Pacific basin tropical storms and hurricanes. The NHC track forecast verification for the 2025 season in the eastern North Pacific, along with results averaged for the previous 5-yr period, is presented in Figure 29 and Table 5. There were 298 forecasts issued in 2025 (Fig. 30), which is about 8% below the long-term mean for the basin. The 2025 mean NHC track errors ranged from 19 n mi at 12 h to 100 n mi at 120 h. The NHC errors were roughly 15–20% lower than the 5-yr means from 12 to 48 h and 25–30% lower than the 5-yr means from 60 to 120 h. In fact, the mean NHC track errors broke records for accuracy at 24–120 h, making 2025 one of the best NHC track forecast performances in history for the eastern North Pacific basin. The 2025 CLIPER errors were also 5–15% smaller than their 5-yr means at most forecast times, which suggests that the track forecasts for the eastern North Pacific basin storms in 2025 were somewhat easier than normal. The official track forecast vector biases were small through 72 h, with a pronounced southward bias noted at 96 and 120 h.

Figure 31 shows recent trends in track forecast accuracy and skill for the eastern North Pacific. Over the long-term, 24- to 72-h track errors have been reduced by about 60–70% since 1990. However, the 5-yr running mean track errors have generally leveled off in recent years. At the 96- and 120-h forecast times, errors have dropped by 45–55% since 2001, but these decreasing error trends have also flattened out in recent years. Likewise, NHC's track forecast skill is notably higher than it was decades ago, currently about 60–75% better than climatology-persistence. The skill trends have also levelled off over the past few years. Figure 32 shows that on average, NHC track errors in the Pacific are lower for hurricanes and stronger tropical storms than for weaker tropical cyclones (< 50 kt).

Table 6 presents a homogeneous verification for the official forecasts along with a selection of early models for 2025. A guidance model had to be available at least two-thirds of the time at all forecast times to be included in this comparison (Fig. 33). A skill comparison of the official forecasts with the early track models is shown in Fig. 34. The official forecasts were among the most skillful guidance from 12–36 h and bested all of the consensus aids at 48–120

h. GDMI performed considerably better than all of the other individual models and beat the official forecast and all of the consensus aids at 48–120 h. GFSI and AEMI performed well at shorter lead times (12–48 h), while EMXI was more skillful at longer ranges (60–120 h). The regional hurricane models HFAI, HFBI, and HMNI were generally competitive with each other, although HFAI was slightly better at most forecast times. HWFI and CMCI were the least skillful models for track in 2025. Note that GDMI was not available during the early part of the season, so this homogeneous model comparison does not include the first five storms of the season. A separate model comparison that excluded GDMI (not shown) did not reveal any notable differences in the official forecast performance relative to the other models.

Figure 35 shows an analysis of forecast skill over the past three seasons (2023–2025). The official forecasts were among the most skillful consensus models during this period, but HCCA and FSSE slightly bested OFCL at a few forecast times. EMXI remains the most skillful individual model through 60 h, while AEMI (72–120 h) and GFSI (96–120 h) performed better at longer time ranges. HFAI was generally the best performing regional model through 60 h, and HWFI generally trailed the other leading models. HMNI was among the most skillful individual models from 72–120 h. CMCI was a poor performer overall, and EGRI and NVGI were the worst track models for this sample. Figure 36 provides a separate verification of the primary consensus aids for 2025. HCCA and FSSE were the best aids at a majority of forecast times, although the skill of the consensus models was tightly clustered overall. AEMI was notably less skillful than the multi-model consensus aids.

Figure 37 provides a comparison of track error and consistency, or how much the official forecast and models changed from cycle to cycle, at the 96-h and 120-h forecast time periods. Greater forecast consistency is operationally important because it provides users with a more stable and reliable basis for planning and decision-making. For the 2023–25 sample, the official forecasts had lower errors and were more consistent than GFSI, EMXI, UKMI, and HCCA. While TVCE has comparable or slightly lower errors than OFCL at 96 and 120 h, OFCL remains more consistent. A closer inspection of the 2021–25 NHC track error distribution in the eastern North Pacific basin is shown in Figure 38. This violin diagram shows the mean errors (colored dots) are higher than the medians (horizontal lines) at all forecast times. Thus, the mean is being inflated by a small number of cases with significantly higher error. Various percentiles (10, 25, 75, 90) can also be seen on the diagram along with kernel density estimates of the track forecast error probability density functions.

b.   2025 season overview – Intensity

Figure 39 and Table 7 present the NHC eastern North Pacific intensity forecast verification for the 2025 season, along with results averaged for the preceding 5-yr period. The mean intensity errors were lower than the 5-yr means at all forecast times. Notably, the official errors were 20–30% lower than the 5-yr means from 48–120 h. The Decay-SHIFOR forecast errors were lower than their 5-yr means at most lead times, which suggests the intensities of the season's storms were easier than normal to forecast. The official forecasts exhibited a slight high bias at 12–72 h, with an increasing low bias noted at 96 and 120 h. In 2025, NHC tied a record for intensity accuracy at 12 h and set new records at 48 and 72 h. Figure 40 shows recent trends in intensity forecast accuracy and skill for the eastern North Pacific. NHC intensity

errors decreased at all forecast times in 2025 and were generally 30–40% more skillful than climatology and persistence. While there remains considerable year-to-year variability, overall there has been a modest decrease in error over the past couple of decades.

Table 8 presents a homogeneous verification for the official intensity forecasts and the early intensity guidance for 2025. Skill comparisons of the official forecasts and selected models are shown in Fig. 41. The official forecasts were skillful at all lead times and among the top performing models for every forecast interval. The corrected consensus aids HCCA and NNIC were generally the most skillful models, with HCCA besting OFCL at 12 and 24 h and NNIC performing better at 48 and 96 h. IVCN and FSSE slightly trailed the other consensus aids but were also quite skillful. In terms of individual models, GDMI was the top performer from 12–48 h but was bested by the hurricane regional models at longer time ranges. HFBI was more skillful at 60 and 72 h, and HFAI was the most skillful model overall at 96 and 120 h. Although DSHP, LGEM, and GFSI exhibited some skill, these models were not competitive with the hurricane regional models or consensus aids. EMXI was the worst performing intensity model with no forecast skill in 2025.

A three-year (2023–2025) evaluation of forecast skill is shown in Fig. 42. The official forecasts were among the best-performing aids overall during this period and generally 25-40% more skillful than climatology-persistence. The consensus aids HCCA and NNIC were top performers, with NNIC besting OFCL from 36–96 h and HCCA besting OFCL at 24 h and 48–72 h. IVCN and FSSE were also quite skillful, although the latter showed a significant decline in skill at 96 and 120 h. HFAI and HFBI performed better at longer lead times (60–120 h) and bested HWFI and HMNI at most forecast intervals. DSHP, LGEM, and the global models (GFSI and EMXI) trailed the rest of the guidance.

Figure 43 shows an analysis of NHC's 2021–25 intensity error distribution. There is a fair amount of spread at each forecast time period, indicating that there are cases that have both too high and too low predictions. The mean errors (colored dots) and median errors (horizontal line) are close to zero at 24–72 h. The distributions become more left-skewed at 96 and 120 h, with an increased amount of larger negative intensity errors resulting in a mean that is lower than the median. Overall, the data indicate an increasing negative (low) bias with time.

RI remains a significant challenge and an area of focus to evaluate. Figure 44 evaluates NHC's RI forecast performance against the models by looking only at cases when RI was occurring or forecast over the past few seasons. The official forecasts are among the best performing models through 36 h but are bested by some of the consensus aids and hurricane regional models at longer-range forecast periods, albeit for small sample sizes particularly at 96–120 h. Figure 45 shows the critical success index (CSI) of official and selected model forecasts for storms in 2023–25 that underwent RI. The NHC intensity forecasts (OFCL/black dot) had a higher probability of detection (vertical axis) and higher CSI (curved/shaded lines) for the subset of rapidly strengthening storms compared to the real time model guidance (other colored symbols). While NHC still had a low bias, it provided more accuracy than the available models and consensus aids.

c.   Wind Radii Verification

Although there is a lack of sufficient data to perform a comprehensive analysis on wind radii, particularly in the eastern North Pacific basin, this is an attempt to provide some input on the performance trends of NHC since wind radii forecasts were first post-analyzed and included in the best track dataset in 2004. Figure 46 shows recent trends in the 34- and 50-kt wind radii forecast accuracy averaged in all quadrants for the eastern North Pacific. Trends in the 64-kt error are not shown due to small sample sizes in some years. Although there is notable year-to-year variability, the running 5-yr means (dashed lines) indicate that 34- and 50-kt wind radii errors have been decreasing over time. Note that the 96- and 120-h wind radii predictions only began in 2024, so no meaningful trends are available for those lead times. An evaluation of NHC's wind radii predictions against the wind radii consensus model (RVCN) from 2023–2025 (Fig. 47) indicates that NHC is more skillful for all wind radii thresholds compared to the multi-model consensus.

d.   Verifications for individual storms

Figure 48 illustrates the official track error at different time intervals stratified by storm in the eastern North Pacific basin. The NHC track errors for Flossie, Henriette, and Priscilla were well below NHC's 5-yr means at all lead times. The larger track errors for Kiko and Octave at 96 and 120 h were still comparable to or slightly below the 5-yr averages. On the other hand, the 24–72-h track forecasts for Ivo had larger errors than the 5-yr means.

Figure 49 shows the official intensity errors stratified by storm. The large NHC intensity errors for Erick were the result of underforecasting the magnitude of its rapid intensification before the hurricane made landfall in southern Mexico. The intensity of Kiko was also challenging to predict, particularly its rapid intensification and subsequent rapid weakening. Conversely, NHC issued excellent intensity forecasts for Flossie and Priscilla, which were the other two major hurricanes of the 2025 season.

Additional discussion on forecast performance for individual storms can be found in NHC Tropical Cyclone Reports, available at:
http://www.nhc.noaa.gov/data/tcr/index.php?season=2025&basin=epac.

e.   Genesis forecasts

Verifications of the 48-h and 168-h outlooks for the eastern North Pacific basin in 2025 are given in Figure 50. In the Pacific basin, a total of 721 genesis forecasts were made. These 48-h forecasts were generally well calibrated, but the 168-h forecasts showed a low (underforecast) bias over a large portion of the forecast probability range (10–80%). Figure 51 shows composites of all 7-day tropical cyclone genesis areas depicted in the Graphical TWO during the 2025 season in the North Pacific along with genesis locations and seasonal hit rate of their associated outlooks. The highest concentration of outlooks was just south of the coast of Mexico centered near 13°N, 100°W, which also closely captured the majority of genesis events in the East Pacific in 2025, with an overall hit rate of 95%. Compared to the prior 10-year

average (2015–2024, Fig. 52), there were more outlooks issued closer to the coast of Mexico between 90–110°W, with a distinct shift eastward in the overall quantity of low, medium, and high outlook areas relative to the prior 10-yr average. However, there was also a slight increase in outlook areas approaching the 140°W boundary at 10°N, associated with increased Central Pacific activity that is beyond the scope of this report. The 3-yr verification of the 48-h and 168-h genesis forecasts from 2023–25 is given in Figure 53. The 48-h forecasts are fairly well calibrated, though with a subtle low forecast bias from the 30–80% probability bins. This underforecast bias becomes more noticeable in the 168-h forecasts, especially from the 10–70% probability bins.

4.   Looking Ahead to 2026

The NHC track forecast cone depicts the probable track of the center of a tropical cyclone, and is formed by enclosing the area swept out by a set of circles along the forecast track (at 12, 24, 36 h, etc.). The size of each circle is set so that two-thirds of historical official forecast errors over the most-recent 5-yr sample fall within the circle. The circle radii defining the cones in 2026 for the Atlantic and eastern North Pacific basins (based on error distributions for 2021–25) are given in Table 9. In the Atlantic and East Pacific basins, the cone circles will be smaller (up to 8%) at most forecast times.

Prior to the start of hurricane season, NHC will evaluate the consensus aid composition for 2026. For more information, visit http://www.nhc.noaa.gov/modelsummary.shtml.

Acknowledgments

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List of Tables

Table 1.   Homogenous comparison of official and CLIPER5 track forecast errors in the Atlantic basin in 2025 for all tropical cyclones. Averages for the previous 5-yr period are shown for comparison.

	Forecast Period (h)							
	12	24	36	48	60	72	96	120
2025 mean OFCL error (n mi)	20.1	32.6	43.0	53.4	67.5	85.2	110.5	162.0
2025 mean CLIPER5 error (n mi)	41.5	89.2	140.7	190.6	239.7	293.6	381.4	438.5
2025 mean OFCL skill relative to CLIPER5 (%)	51.6	63.5	69.4	72.0	71.8	71.0	71.0	63.1
2025 mean OFCL bias vector (°/n mi)	047/005	047/010	045/017	043/023	046/028	048/035	066/057	064/120
2025 number of cases	215	191	169	148	128	111	83	64
2020-2024 mean OFCL error (n mi)	23.0	34.3	45.8	58.7	73.5	89.8	128.7	185.4
2020-2024 mean CLIPER5 error (n mi)	45.1	95.7	150.9	203.1	252.7	295.4	366.2	426.6
2020-2024 mean OFCL skill relative to CLIPER5 (%)	49.0	64.2	69.6	71.1	70.9	69.6	64.9	56.5
2020-2024 mean OFCL bias vector (°/n mi)	359/003	341/003	335/003	335/004	348/004	010/008	028/007	069/011
2020-2024 number of cases	1824	1619	1432	1270	1114	969	722	531
2025 OFCL error relative to 2020-2024 mean (%)	-12.6	-5.0	-6.1	-9.0	-8.2	-5.1	-14.4	-12.6
2025 CLIPER5 error relative to 2020-2024 mean (%)	-8.0	-6.8	-6.8	-6.2	-5.1	-0.6	4.2	2.8

Table 2.   Homogenous comparison of Atlantic basin early track guidance model errors (n mi) for 2025. Errors smaller than the NHC official forecast are shown in boldface.

Model ID	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	20.4	31.1	41.9	49.2	62.2	81.4	113.9	168.5
OCD5	41.0	88.8	141.5	191.0	241.9	293.5	377.2	428.8
HFAI	27.4	45.1	60.7	71.9	87.2	107.1	145.3	180.2
HFBI	28.1	45.9	63.7	73.6	86.8	107.7	155.2	203.6
HWFI	27.1	44.1	62.0	79.5	103.9	134.8	208.4	311.1
HMNI	26.0	42.8	61.3	76.8	96.6	123.6	173.6	247.0
GDMI	**19.6**	**26.4**	**34.8**	**41.4**	**50.8**	**66.5**	**111.7**	173.1
GFSI	26.8	46.0	64.3	78.9	96.7	128.6	221.3	362.3
EMXI	22.4	37.8	53.0	65.2	83.6	102.7	126.2	174.5
CMCI	28.0	48.6	72.8	91.7	109.7	126.1	150.4	179.9
AEMI	24.5	40.1	57.0	68.4	81.2	100.4	146.4	192.3
HCCA	20.5	31.3	43.2	52.5	66.3	87.4	118.4	**162.4**
FSSE	22.1	35.0	47.9	58.5	73.2	95.7	145.9	229.3
TVCA	23.0	36.2	51.0	60.1	76.0	98.8	139.6	189.7
Forecasts	193	170	155	135	117	103	78	59

Table 3.   Homogenous comparison of official and Decay-SHIFOR5 intensity forecast errors in the Atlantic basin for the 2025 season for all tropical cyclones. Averages for the previous 5-yr period are shown for comparison.

	Forecast Period (h)							
	12	24	36	48	60	72	96	120
2025 mean OFCL error (kt)	5.9	9.2	11.8	13.7	15.1	15.8	17.5	20.4
2025 mean Decay-SHIFOR5 error (kt)	8.1	13.3	18.7	23.1	28.2	31.6	35.4	37.8
2025 mean OFCL skill relative to Decay-SHIFOR5 (%)	27.2	30.8	36.9	40.7	46.5	50.0	50.6	46.0
2025 OFCL bias (kt)	1.3	2.0	2.0	1.2	-0.1	-1.5	-5.1	-8.8
2025 number of cases	215	191	169	148	128	111	83	64
2020-24 mean OFCL error (kt)	5.1	7.3	8.6	10.0	10.5	10.9	12.4	13.6
2020-24 mean Decay-SHIFOR5 error (kt)	6.8	10.6	13.8	16.5	17.9	19.2	21.4	19.9
2020-24 mean OFCL skill relative to Decay-SHIFOR5 (%)	25.0	31.1	37.7	39.4	41.3	43.2	42.1	31.7
2020-24 OFCL bias (kt)	0.5	0.5	0.3	0.3	0.3	0.5	0.1	-1.6
2020-24 number of cases	1824	1619	1432	1270	1114	969	722	531
2025 OFCL error relative to 2020-24 mean (%)	15.7	26.0	37.2	37.0	43.8	45.0	41.1	50.0
2025 Decay-SHIFOR5 error relative to 2020-24 mean (%)	19.1	25.4	35.5	40.0	57.5	64.6	65.4	89.9

Table 4.   Homogenous comparison of selected Atlantic basin early intensity guidance model errors (kt) for 2025. Errors smaller than the NHC official forecast are shown in boldface.

Model ID	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	6.1	9.3	11.7	13.1	14.1	14.6	17.2	20.4
OCD5	8.4	13.7	18.9	22.9	27.8	31.0	35.0	37.3
HFAI	7.2	10.7	13.9	15.5	16.3	16.2	20.6	21.8
HFBI	7.4	10.3	13.2	15.6	16.7	17.5	21.2	20.9
HWFI	8.2	12.5	17.3	18.8	19.6	18.9	19.1	25.9
HMNI	7.6	11.6	14.8	16.7	19.2	19.5	20.1	**20.0**
DSHP	7.7	11.1	13.7	17.0	19.8	23.0	26.6	25.8
LGEM	8.1	11.8	14.6	17.2	19.2	22.4	25.7	26.8
GDMI	7.1	9.4	**11.2**	**12.3**	**13.5**	14.6	17.3	21.9
GFSI	8.2	12.8	16.8	20.2	23.1	25.8	30.5	32.2
EMXI	9.2	14.8	19.6	24.3	28.1	29.6	32.2	35.3
FSSE	6.7	**9.0**	11.9	14.2	15.4	16.5	18.3	21.6
HCCA	7.0	**9.2**	12.4	14.9	16.7	17.7	19.5	21.3
NNIC	7.1	**9.2**	12.3	14.5	15.2	15.9	22.4	21.6
IVCN	6.8	9.6	12.7	15.0	16.5	17.5	20.2	21.2
Forecasts	195	174	156	137	119	104	78	59

Table 5.   Homogenous comparison of official and CLIPER5 track forecast errors in the eastern North Pacific basin in 2025 for all tropical cyclones. Averages for the previous 5-yr period are shown for comparison.

	Forecast Period (h)							
	12	24	36	48	60	72	96	120
2025 mean OFCL error (n mi)	18.6	27.7	36.2	42.4	47.6	54.3	76.6	100.2
2025 mean CLIPER5 error (n mi)	32.4	69.3	106.1	143.5	182.4	222.7	323.3	419.0
2025 mean OFCL skill relative to CLIPER5 (%)	42.6	60.0	65.9	70.4	73.9	75.6	76.3	76.1
2025 mean OFCL bias vector (°/n mi)	251/002	221/003	232/004	264/004	286/004	265/003	178/013	187/033
2025 number of cases	262	226	194	164	137	116	86	67
2020-2024 mean OFCL error (n mi)	22.4	33.6	43.5	53.2	65.1	79.4	108.6	135.2
2020-2024 mean CLIPER5 error (n mi)	38.2	75.3	117.2	160.9	206.0	251.9	340.7	422.7
2020-2024 mean OFCL skill relative to CLIPER5 (%)	41.4	55.4	62.9	66.9	68.4	68.5	68.1	68.0
2020-2024 mean OFCL bias vector (°/n mi)	264/000	163/002	161/004	148/008	141/013	135/020	124/028	118/026
2020-2024 number of cases	1236	1064	908	768	645	541	363	237
2025 OFCL error relative to 2020-2024 mean (%)	-17.0	-17.6	-16.8	-20.3	-26.9	-31.6	-29.5	-25.9
2025 CLIPER5 error relative to 2020-2024 mean (%)	-15.2	-8.0	-9.5	-10.8	-11.5	-11.6	-5.1	-0.9

Table 6.   Homogenous comparison of eastern North Pacific basin early track guidance model errors (n mi) for 2025. Errors smaller than the NHC official forecast are shown in boldface.

Model ID	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	18.0	27.3	35.2	41.1	46.7	52.6	77.8	111.9
OCD5	32.4	71.6	110.0	149.0	187.1	230.9	323.2	403.7
GFSI	19.1	30.0	41.4	54.5	66.3	78.2	119.0	159.1
EMXI	21.1	35.1	47.6	54.0	60.2	71.0	99.8	136.1
CMCI	22.8	38.2	50.9	63.9	80.0	102.6	150.0	213.4
HWFI	22.2	36.4	49.4	63.7	84.4	102.6	132.8	187.3
HMNI	20.8	34.1	46.4	61.0	76.6	91.1	123.3	168.6
HFAI	20.9	32.7	43.7	57.1	71.6	85.4	119.6	163.1
HFBI	22.0	35.0	45.9	58.2	71.4	86.4	125.9	175.0
AEMI	19.7	30.9	40.4	51.4	64.1	77.3	120.5	165.2
HCCA	**17.9**	**26.3**	**34.8**	43.2	49.7	57.3	81.5	121.3
FSSE	**17.9**	**26.9**	**33.5**	**41.0**	48.9	56.7	83.8	128.6
TVCE	**17.5**	**26.8**	35.3	45.0	55.2	64.7	91.4	128.3
GDMI	18.3	27.5	**34.5**	**38.7**	**42.0**	**45.3**	**56.7**	**87.3**
Forecasts	180	157	135	116	99	87	66	49

Table 7.   Homogenous comparison of official and Decay-SHIFOR5 intensity forecast errors in the eastern North Pacific basin for the 2025 season for all tropical cyclones. Averages for the previous 5-yr period are shown for comparison.

	Forecast Period (h)							
	12	24	36	48	60	72	96	120
2025 mean OFCL error (kt)	5.0	7.4	9.0	10.1	10.2	10.5	13.1	13.8
2025 mean Decay-SHIFOR5 error (kt)	7.1	11.3	14.1	15.5	17.6	18.5	20.7	22.3
2025 mean OFCL skill relative to Decay-SHIFOR5 (%)	29.6	34.5	36.2	34.8	42.0	43.2	36.7	38.1
2025 OFCL bias (kt)	0.6	0.8	1.5	1.6	1.3	0.9	-1.4	-5.7
2025 number of cases	262	226	194	164	137	116	86	67
2020-24 mean OFCL error (kt)	5.7	8.9	10.8	12.9	14.4	15.5	17.0	18.6
2020-24 mean Decay-SHIFOR5 error (kt)	7.4	12.4	16.2	19.2	21.0	21.3	21.5	21.6
2020-24 mean OFCL skill relative to Decay-SHIFOR5 (%)	23.0	28.2	33.3	32.8	31.4	27.2	20.9	13.9
2020-24 OFCL bias (kt)	0.6	0.6	0.4	0.0	-0.2	-0.3	-1.8	-5.6
2020-24 number of cases	1236	1064	908	768	645	540	363	237
2025 OFCL error relative to 2020-24 mean (%)	-12.3	-16.9	-16.7	-21.7	-29.2	-32.3	-22.9	-25.8
2025 Decay-SHIFOR5 error relative to 2020-24 mean (%)	-4.1	-8.9	-13.0	-19.3	-16.2	-13.1	-3.7	3.2

Table 8.   Homogenous comparison of eastern North Pacific basin early intensity guidance model errors (kt) for 2025. Errors smaller than the NHC official forecast are shown in boldface.

Model ID	Forecast Period (h)							
	12	24	36	48	60	72	96	120
OFCL	5.4	7.9	9.3	10.3	10.1	10.5	14.5	14.2
OCD5	7.3	11.7	15.1	16.8	19.1	19.3	22.8	24.3
HWFI	7.7	10.2	12.4	13.2	14.0	13.7	17.0	14.2
HMNI	6.9	11.4	13.7	13.9	14.9	14.8	**13.8**	18.3
HFAI	7.0	10.6	12.3	12.6	13.6	13.8	**13.1**	**12.0**
HFBI	6.4	9.7	11.3	12.4	12.6	12.0	14.8	15.7
DSHP	6.4	9.9	13.0	15.0	15.6	16.8	20.4	19.9
LGEM	6.5	10.3	13.1	14.8	15.3	16.5	20.0	19.8
HCCA	**5.1**	**7.2**	9.8	10.6	10.8	11.3	14.6	**14.1**
IVCN	5.7	8.6	10.5	11.5	12.1	12.0	15.2	14.3
FSSE	5.4	7.9	10.4	11.3	12.0	11.8	16.1	20.2
NNIC	5.6	8.3	9.6	**9.9**	10.1	10.9	**13.7**	19.0
GFSI	7.5	11.4	14.1	15.3	16.6	17.1	19.3	18.5
EMXI	7.8	12.6	16.2	18.6	19.9	20.3	24.9	26.0
GDMI	6.3	8.6	10.0	11.5	12.8	12.9	15.9	16.7
Forecasts	180	157	135	116	99	87	66	49

Table 9.   NHC forecast cone circle radii (n mi) for 2026. Change from 2025 values expressed in n mi and percent are given in parentheses.

2026 Track Forecast Cone Two-Thirds Probability Circles (n mi)		
Forecast Period (h)	**Atlantic Basin**	**Eastern North Pacific Basin**
3	16 (0: 0%)	16 (0: 0%)
12	25 (-1: -4%)	25 (-1: -4%)
24	39 (0: 0%)	37 (-1: -3%)
36	49 (-3: -6%)	48 (-2: -4%)
48	62 (-5: -8%)	56 (-3: -5%)
60	77 (-5: -8%)	66 (-5: -8%)
72	95 (-5: -5%)	78 (-5: -6%)
96	134 (-8: -6%)	106 (-7: -7%)
120	200 (-13: -7%)	138 (-8: -6%)

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18.   Roebber performance diagram of NHC official forecast and selected early intensity models of rapidly strengthening storms from 2023-2025 in the Atlantic basin. 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. Critical success index is shown in shading/solid contours

19.   Recent trends in NHC 34- (top) and 50-kt (bottom) wind radii official forecast error for the Atlantic basin. The results represent a quadrant average. Dashed lines represent 5-yr means.

20.   Quadrant-mean skill of NHC and RVCN for the 34-kt (top), 50-kt (middle), and 64-kt (bottom) wind radii forecasts for the Atlantic basin from 2023-2025.

21.   A comparison of NHC official track and intensity errors when U.S. watches and warnings were in effect and when they weren't in the Atlantic basin from 2021–2025.

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25.   Composites of 7-day tropical cyclone genesis areas depicted in NHC's Tropical Weather Outlooks for the Atlantic during the 2025 season for (a) all probabilistic genesis categories, (b) low (<40% category), (c) medium (40–60%) category, and (d) high (> 60% category).

26.   Difference of 7-day tropical cyclone genesis areas in the Atlantic 2025 season vs the 2015-2024 mean for (a) all probabilistic genesis categories, (b) low (<40% category), (c) medium (40–60%) category, and (d) high (> 60% category).

27.   As in Fig. 24 except for the 2023–2025 period.

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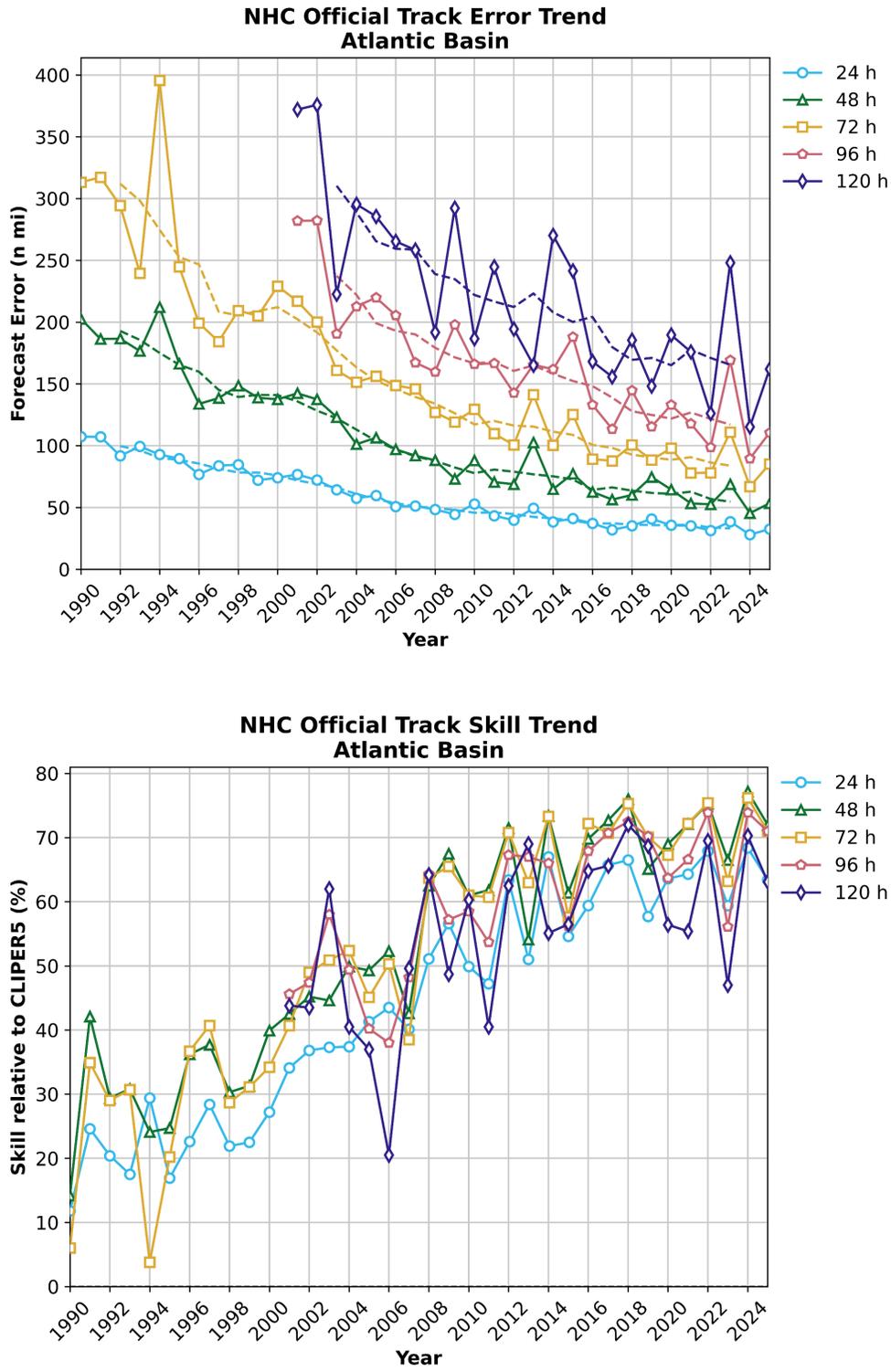
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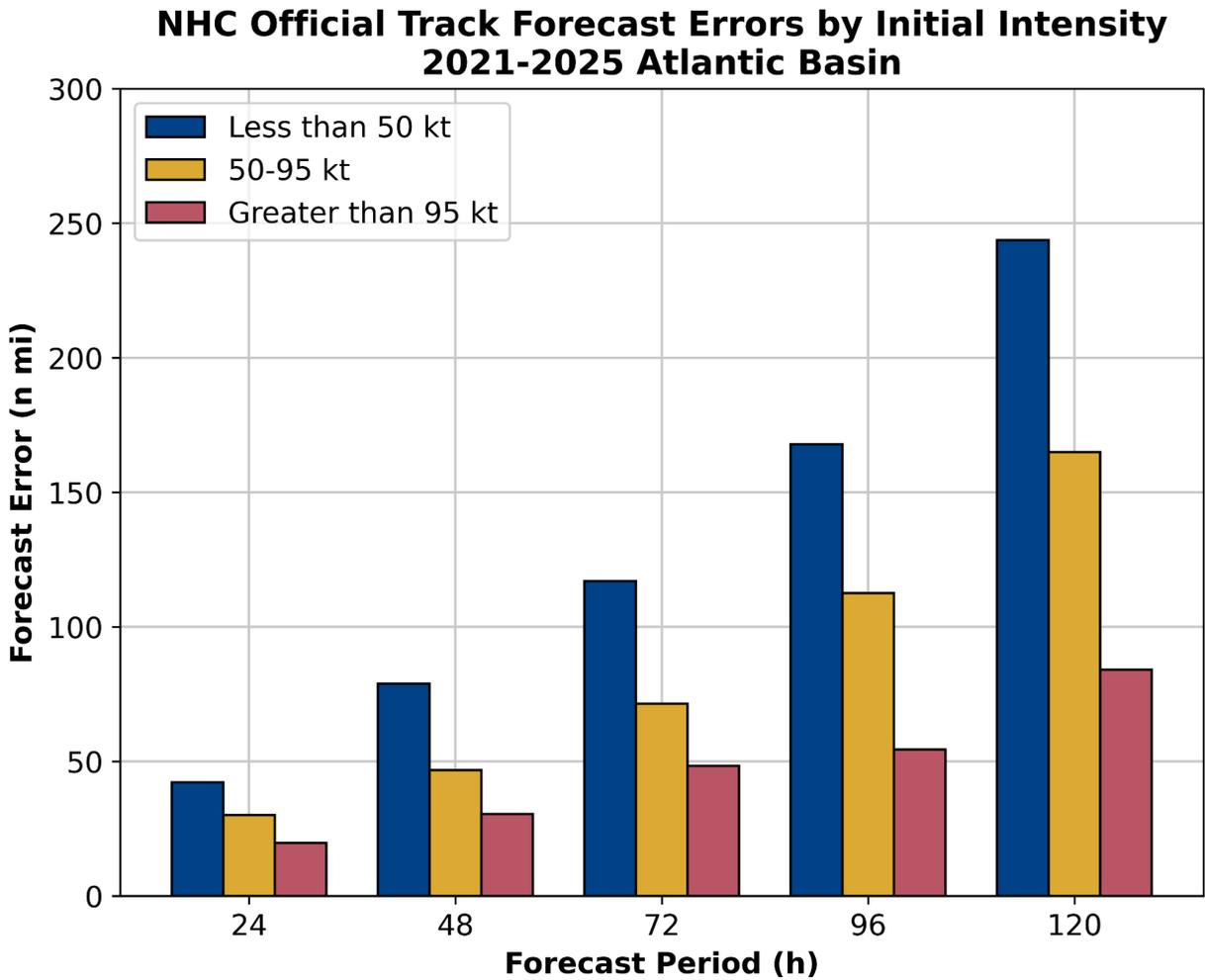
32.   2021–25 NHC official track forecast error binned by initial intensity for the eastern North Pacific basin.

33.   Number of forecasts by each model in 2025 in the eastern North Pacific basin. The dotted line shows the 67th percentile of the official forecasts, the metric needed to be met for verification inclusion.

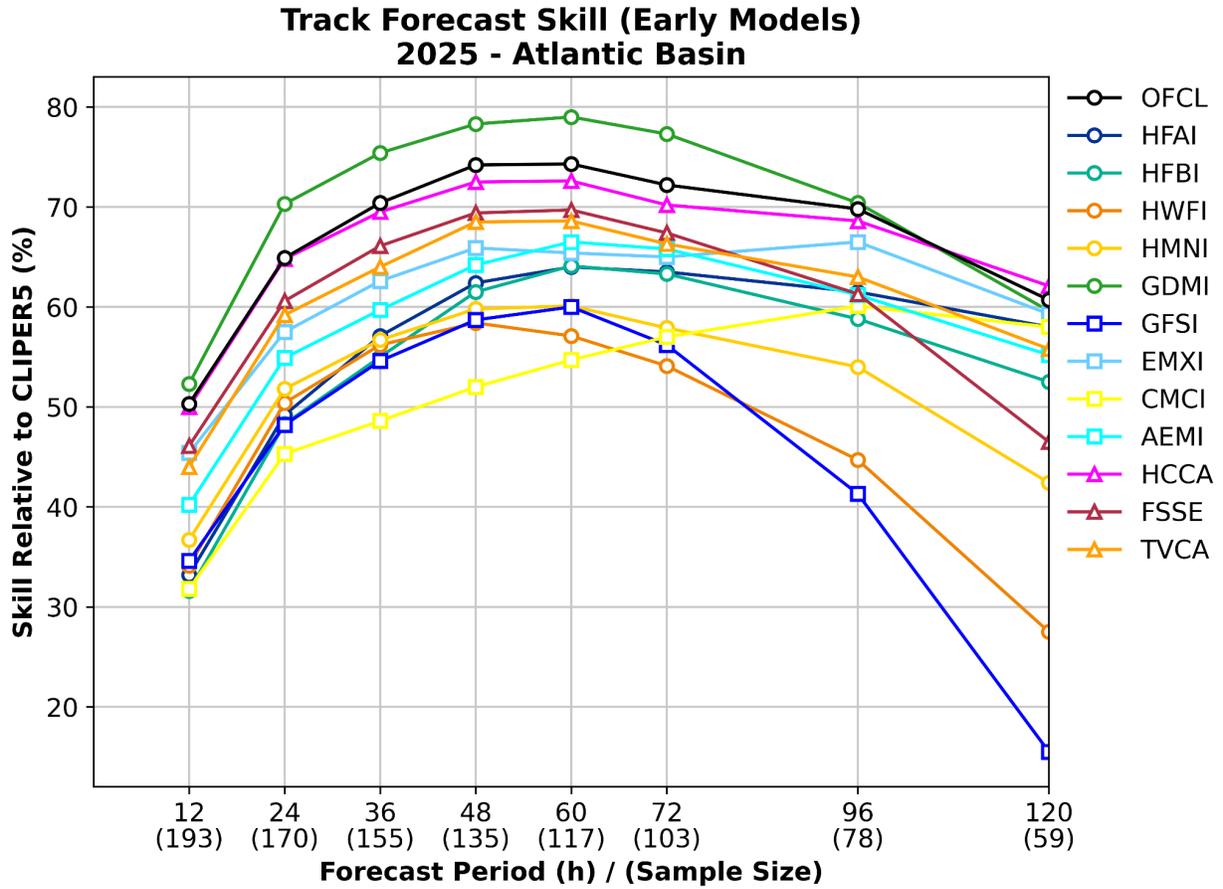34.   Homogenous comparison for selected eastern North Pacific early track models for 2025. This verification includes only those models that were available at least 2/3 of the time (see text).

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38.   Violin diagram of NHC official track forecasts for the eastern North Pacific basin for 2021–2025. The mean is shown by the colored dot, median by the horizontal line, 25-75th percentiles by the box edges, and 10-90th percentiles by whiskers.
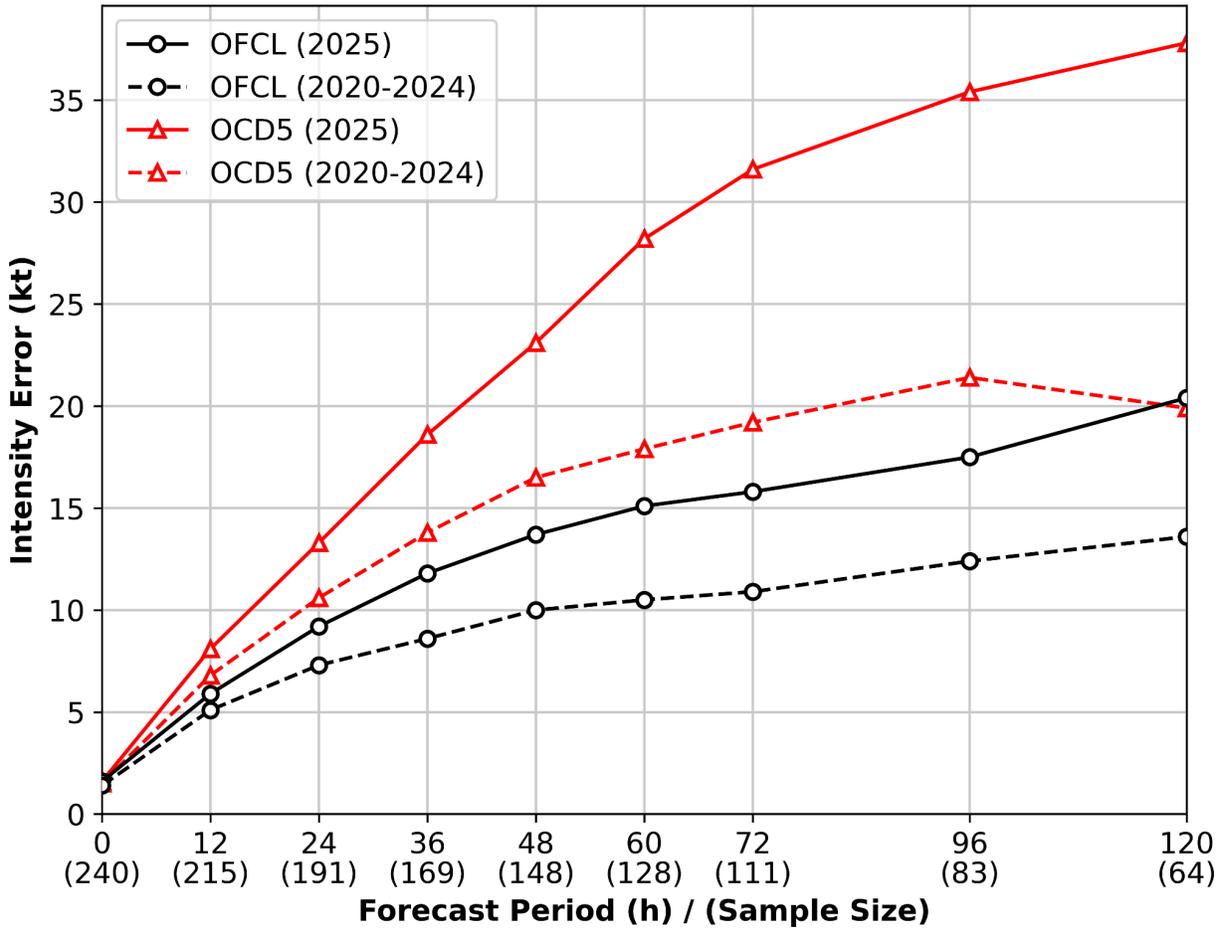
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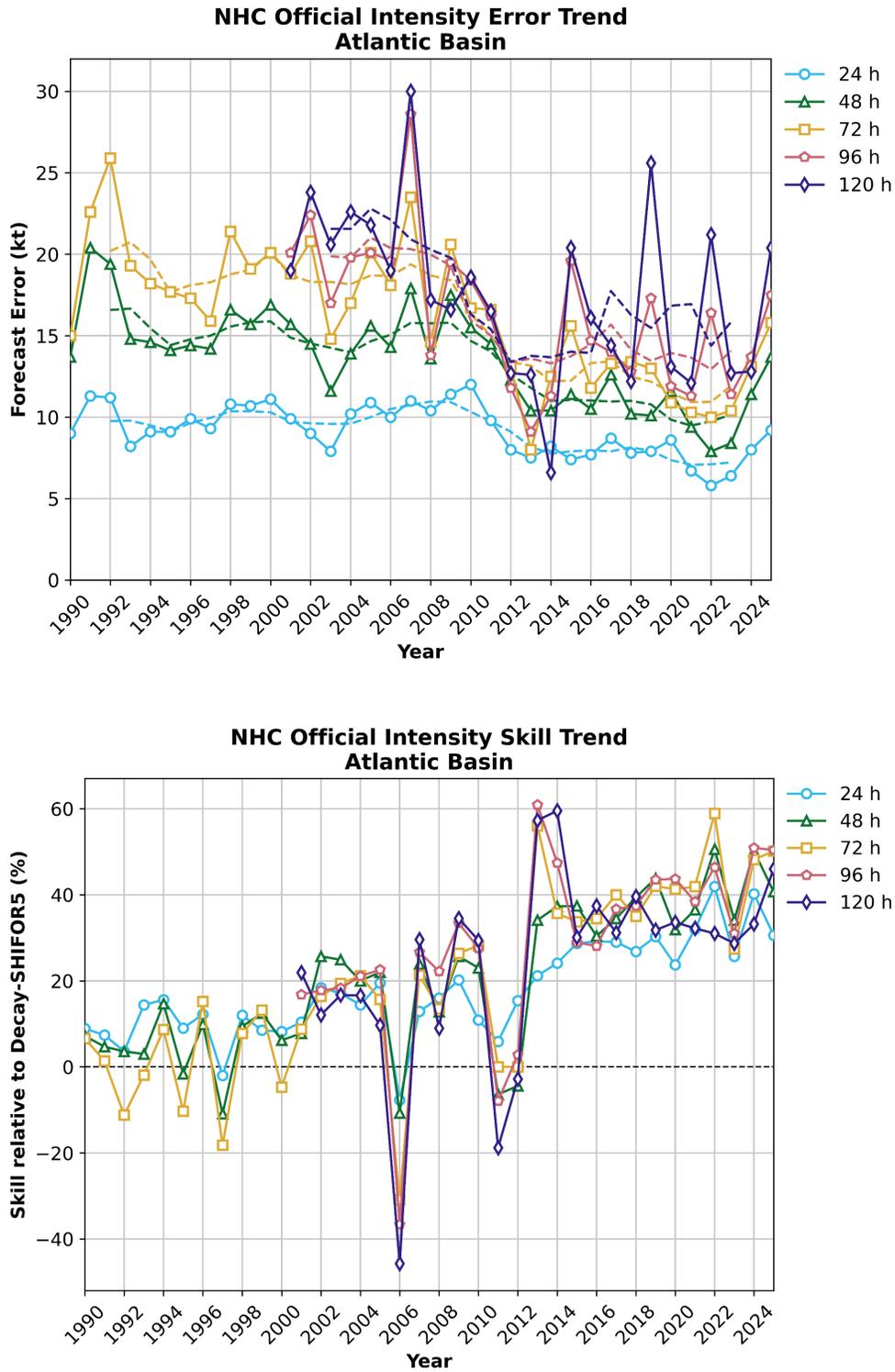
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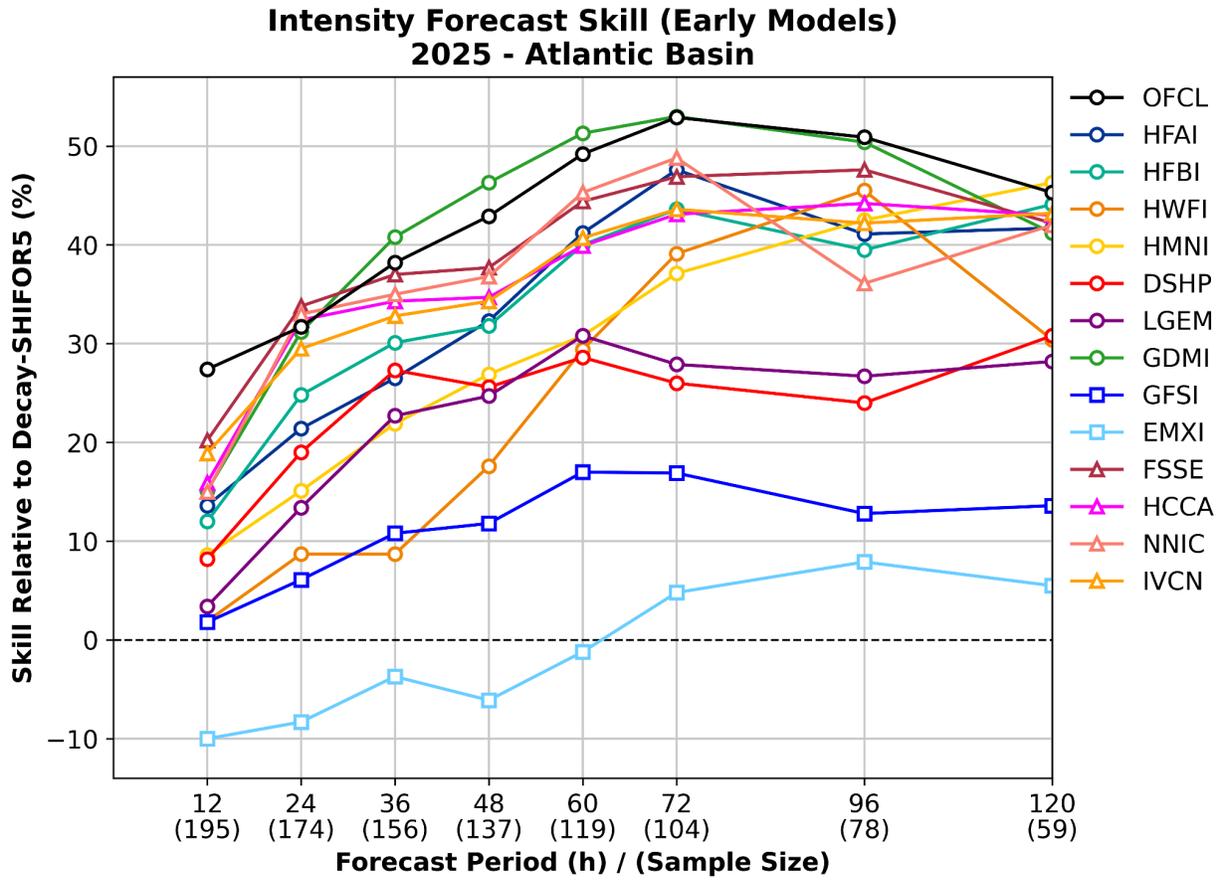
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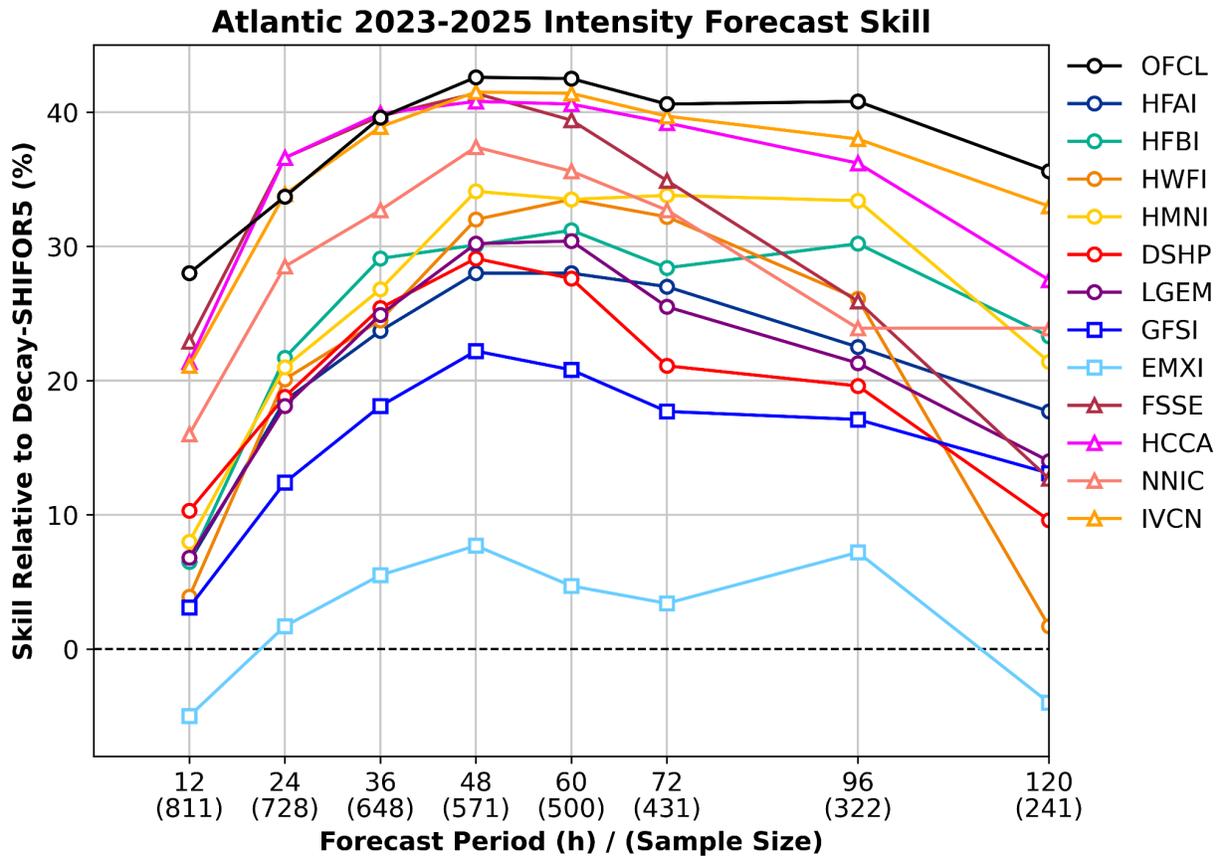
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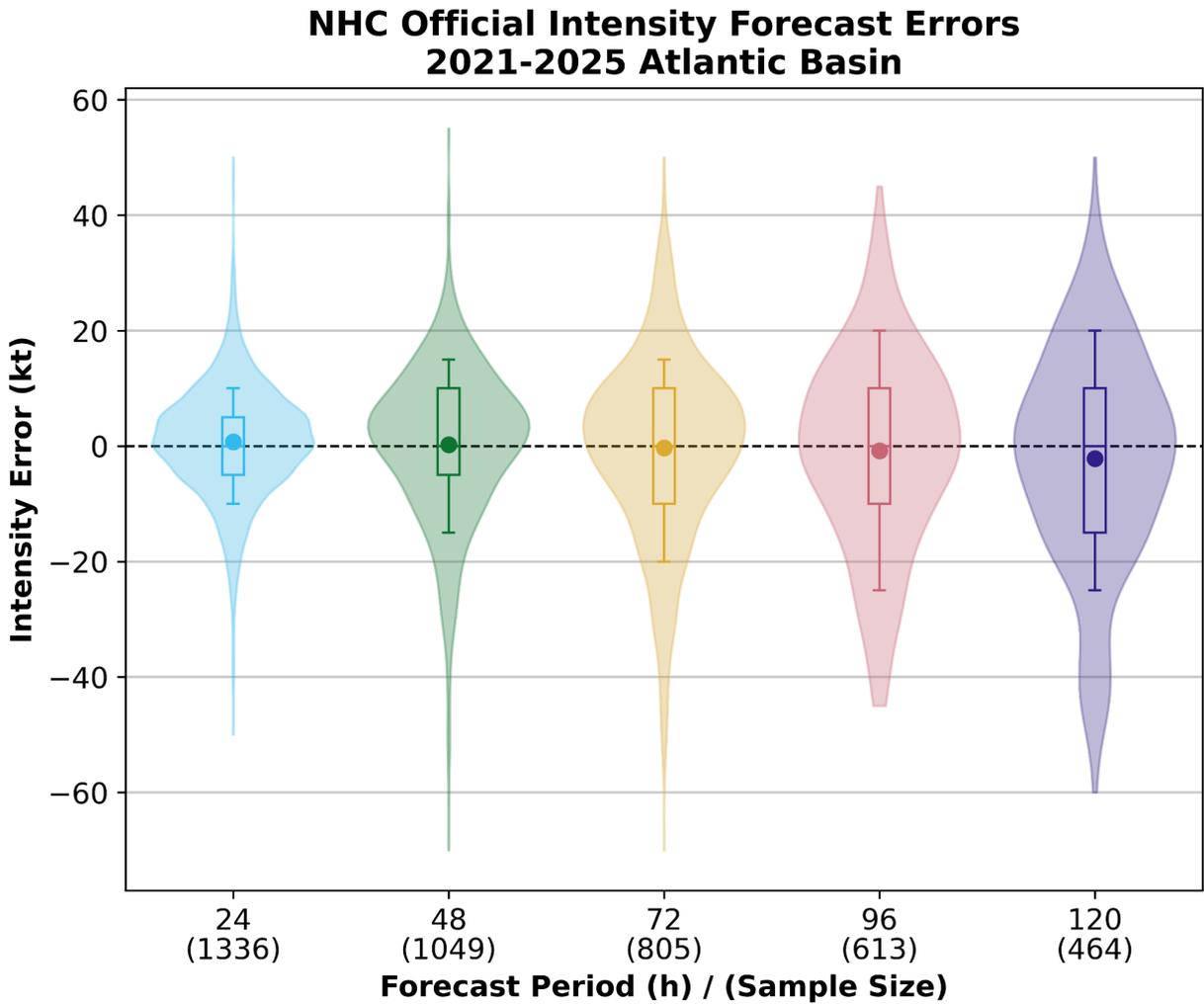
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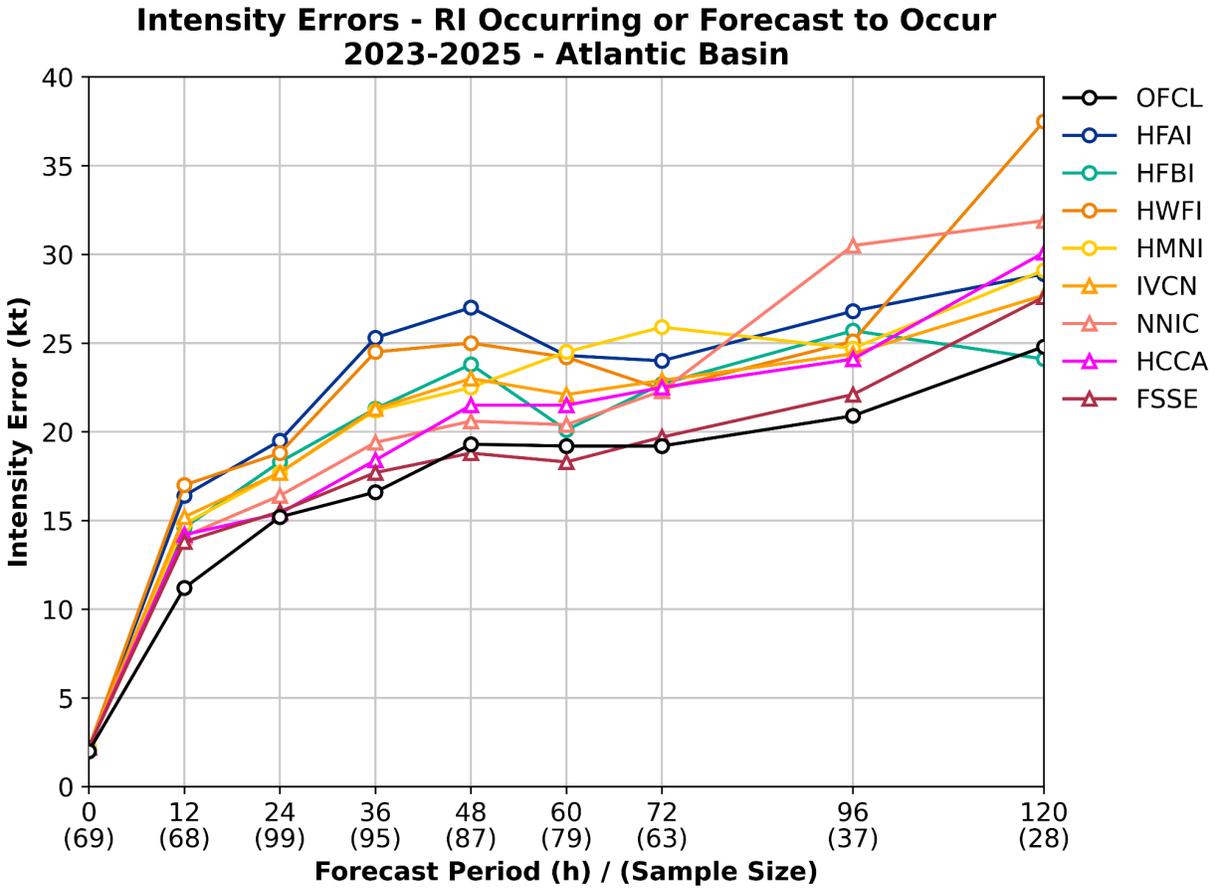
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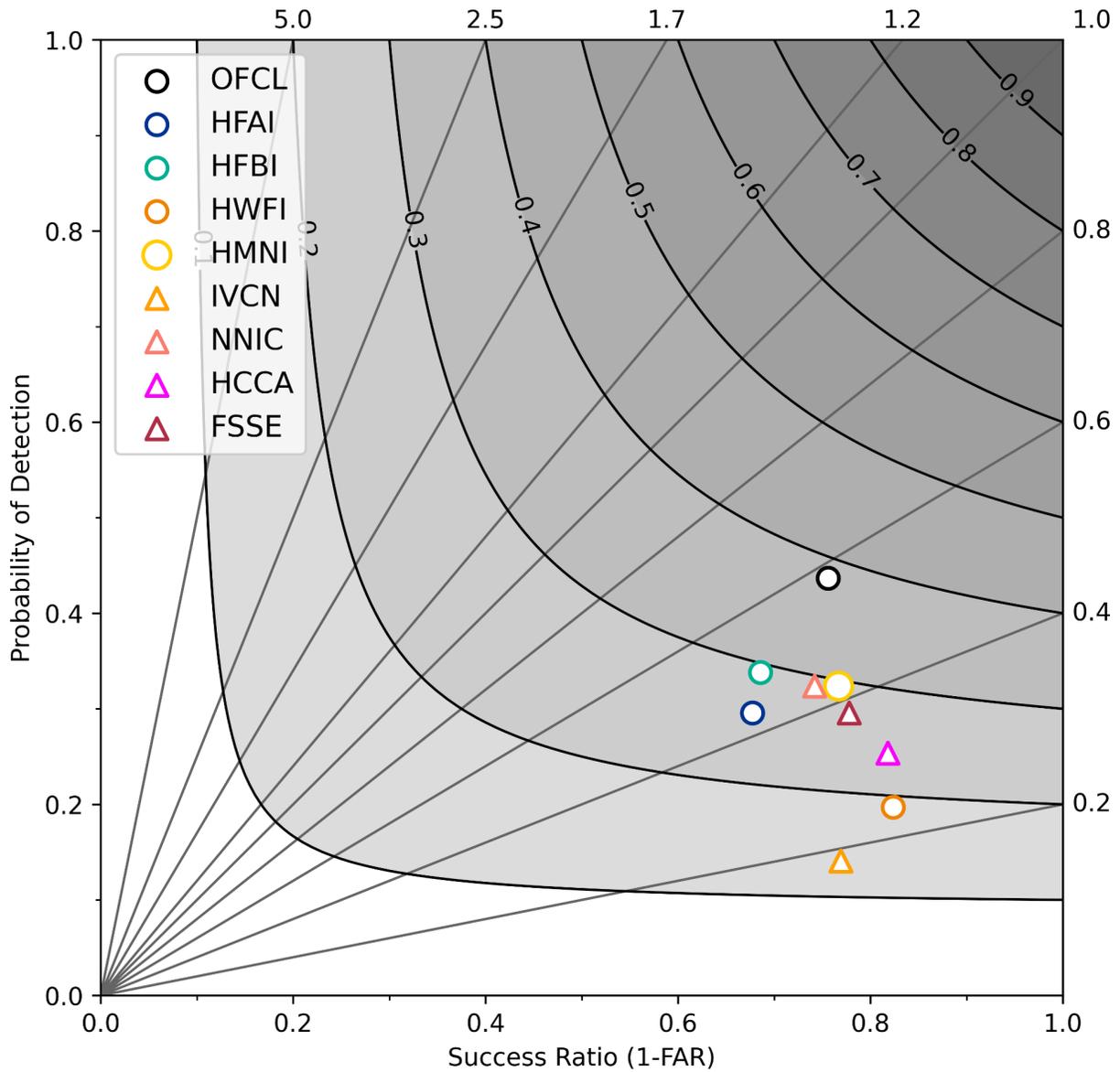45.   Roebber performance diagram of NHC official forecast and selected early intensity models of rapidly strengthening storms in 2023-2025 in the eastern Pacific basin. Probability of detection is given by the ratio of hits to the total number of times the events occurred. False Alarm Ratio (FAR) is given by the ratio of false alarms to the total number of forecast events. Critical success index is shown in shading/solid contours.
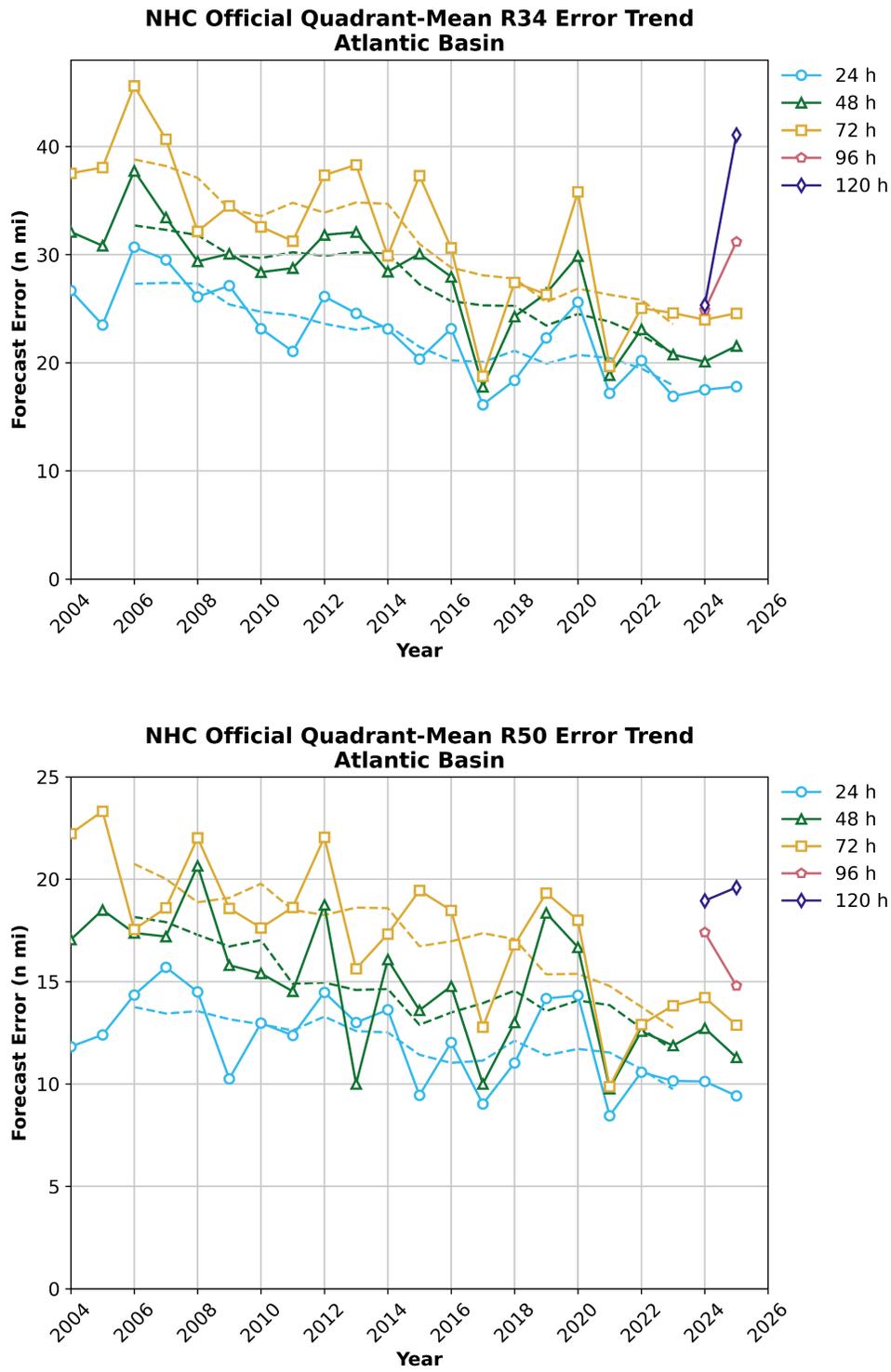
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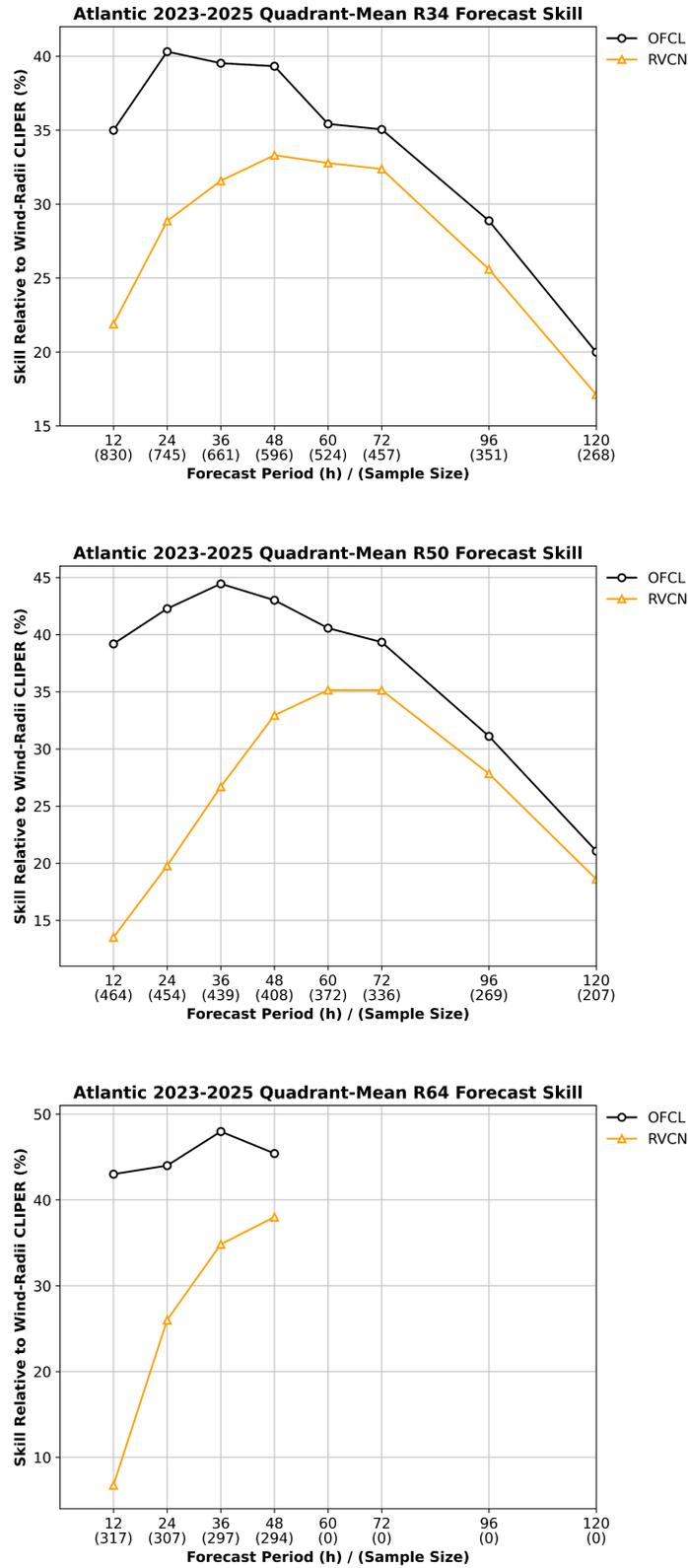
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50.   Reliability diagram for East Pacific probabilistic tropical cyclogenesis 48-h (top) and 168-h (bottom) forecasts for 2025. The lines indicate the relationship between the forecasts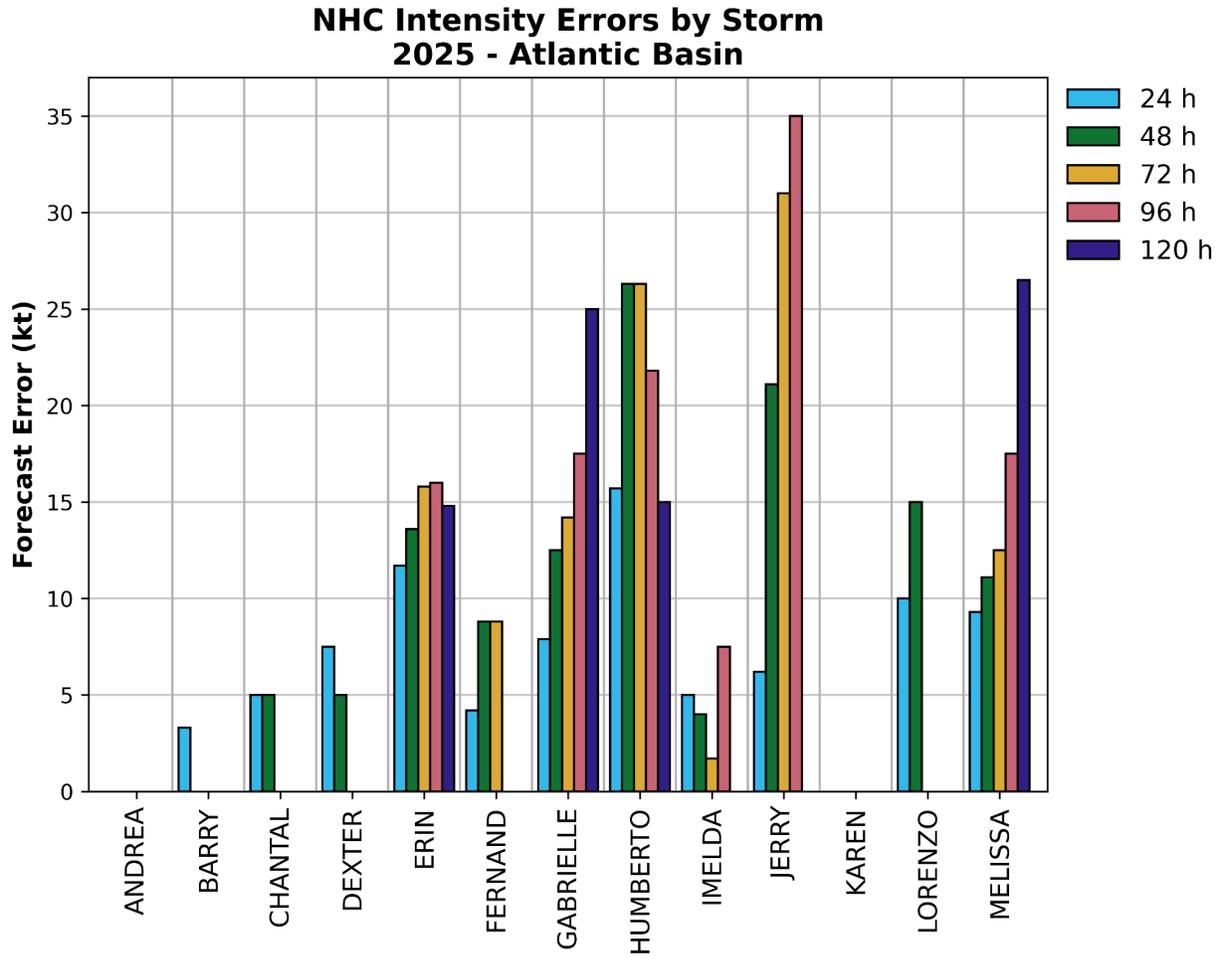 and verifying genesis percentages, with perfect reliability indicated by the thin diagonal black line. The dashed line represents how the forecasts were distributed among the possible forecast values.

51.   Composites of 7-day tropical cyclone genesis areas depicted in NHC's Tropical Weather Outlooks for the East Pacific basin during the 2025 season for (a) all probabilistic genesis categories, (b) low (<40% category), (c) medium (40–60%) category, and (d) high (> 60% category).

52.   Difference of 7-day tropical cyclone genesis areas in the East Pacific 2025 season vs the 2015-2024 mean for (a) all probabilistic genesis categories, (b) low (<40% category), (c) medium (40–60%) category, and (d) high (> 60% category).

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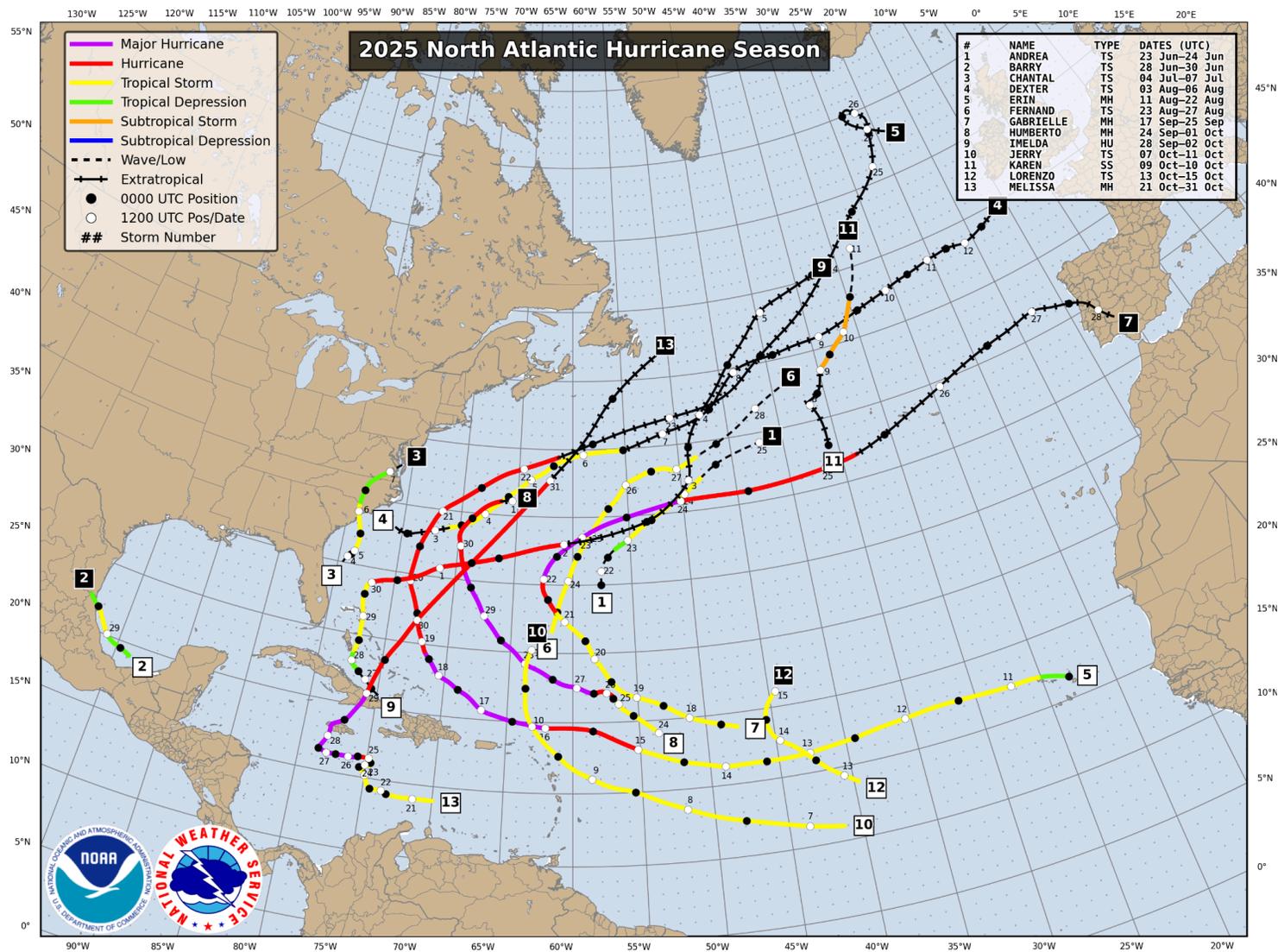
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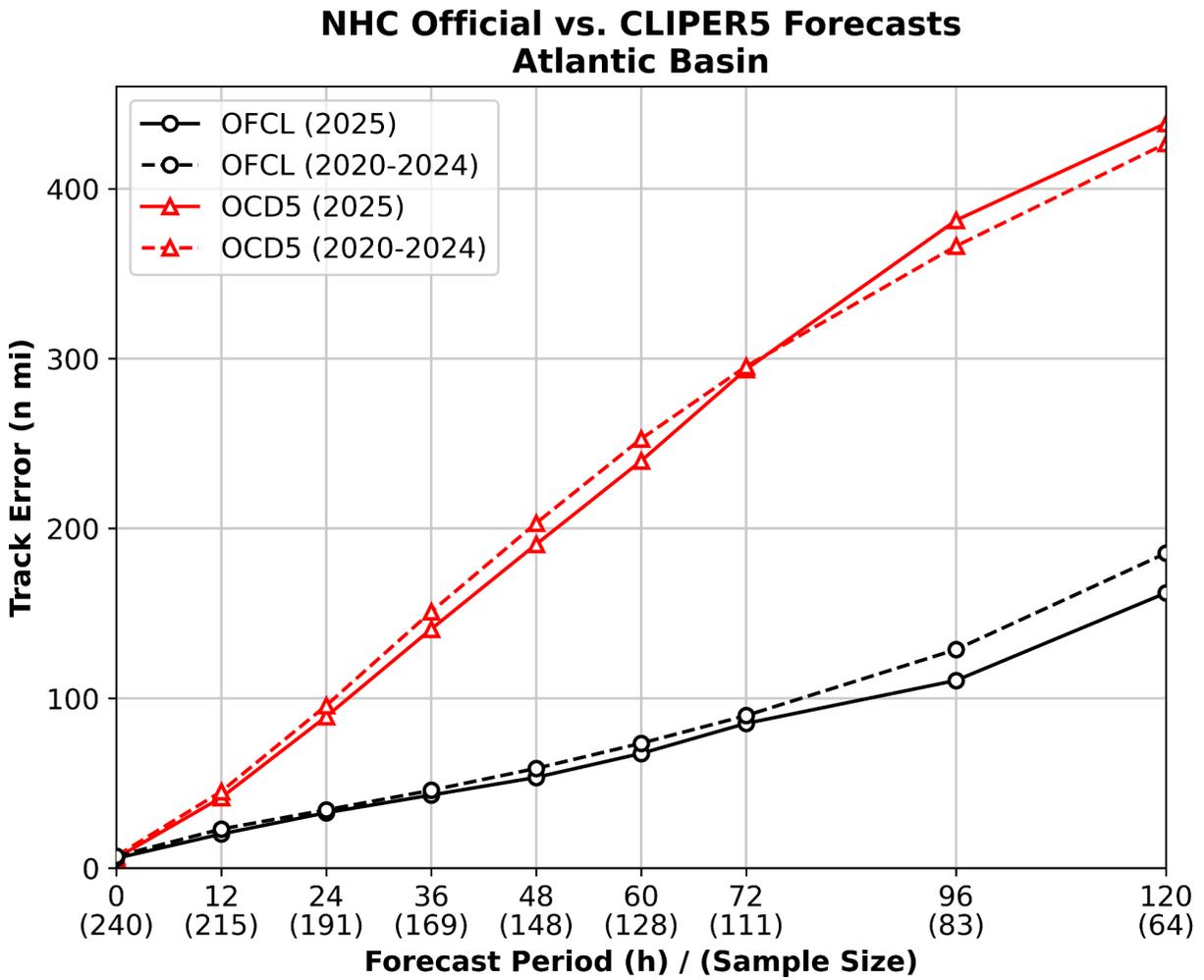
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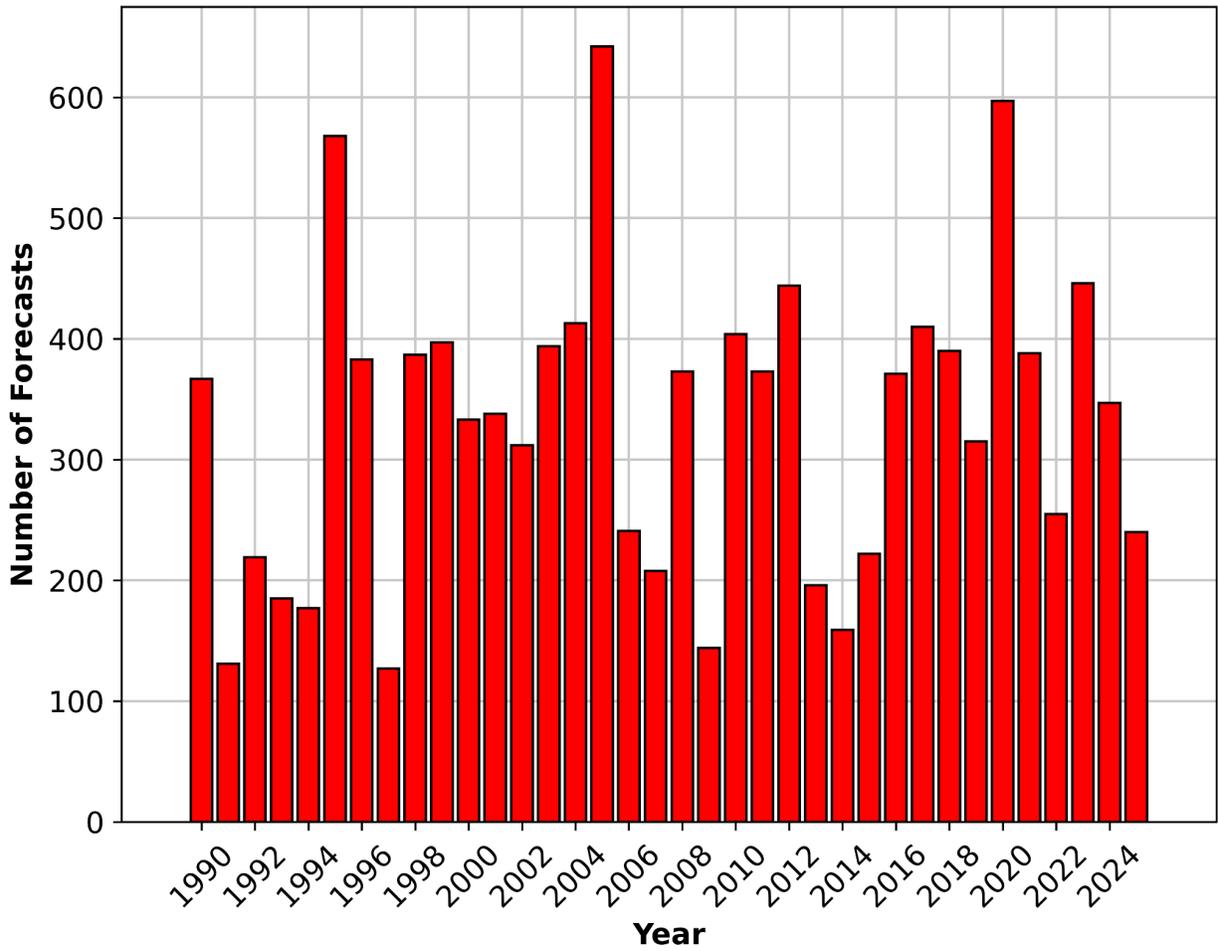
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NHC Official Track Forecast Errors by Initial Intensity 2021-2025 Atlantic Basin

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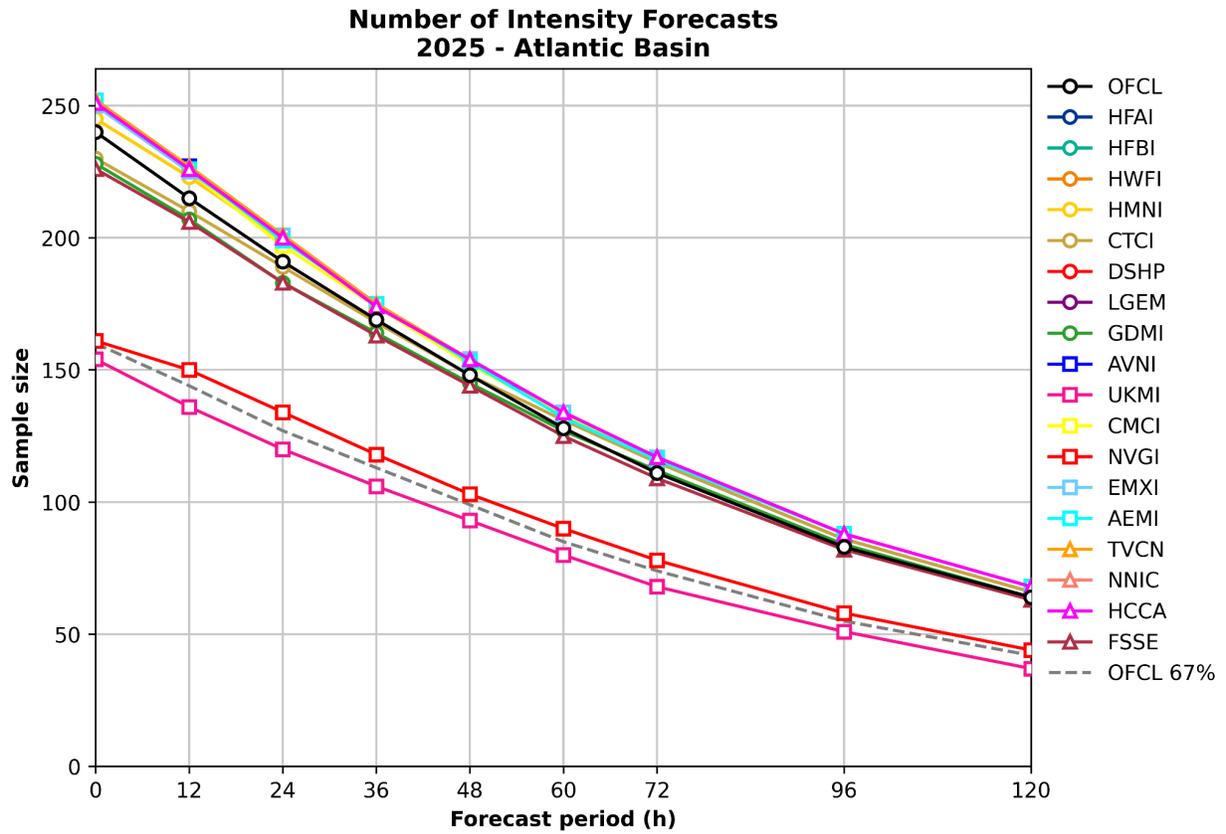
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Figure 7.   Homogenous comparison for selected Atlantic basin early track models for 2025. This verification includes only those models that were available at least 2/3 of the time (see text).
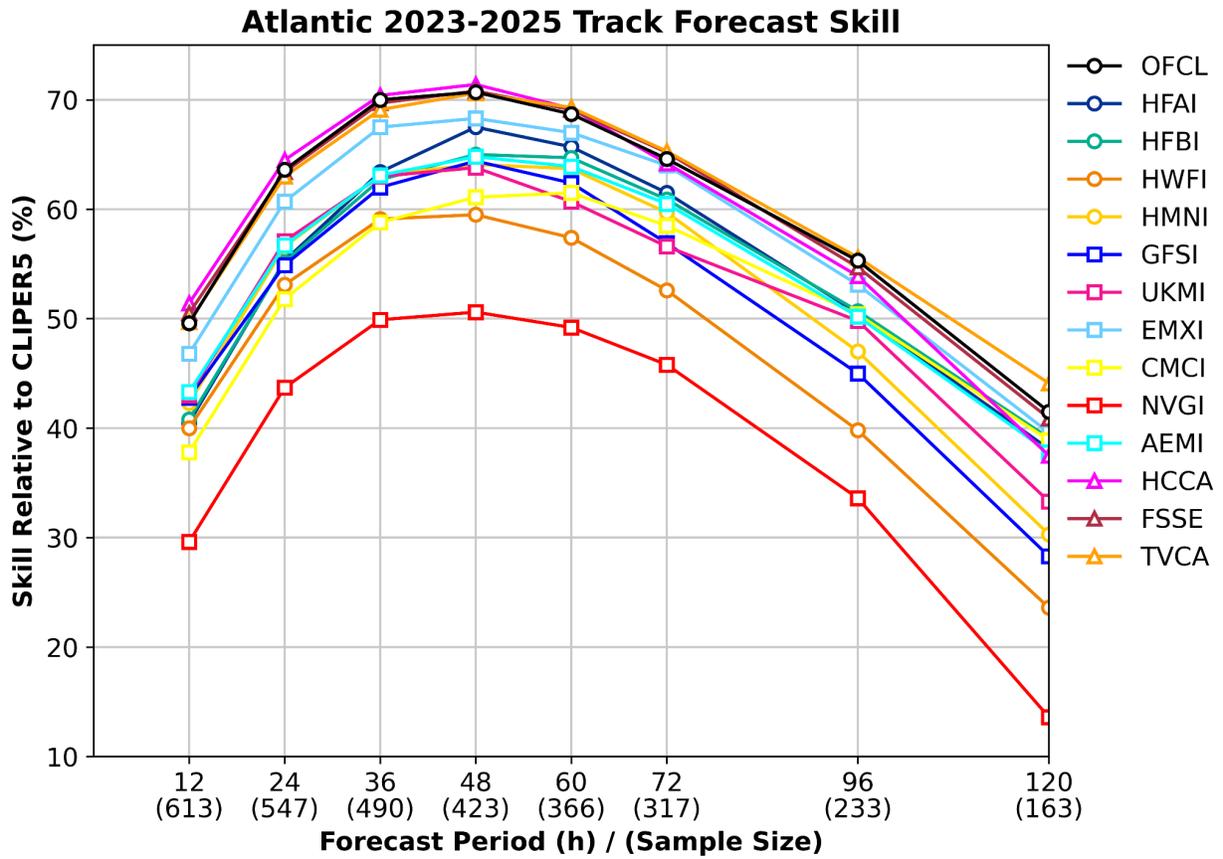
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Track Forecast Skill (Consensus Models)
2025 - Atlantic Basin
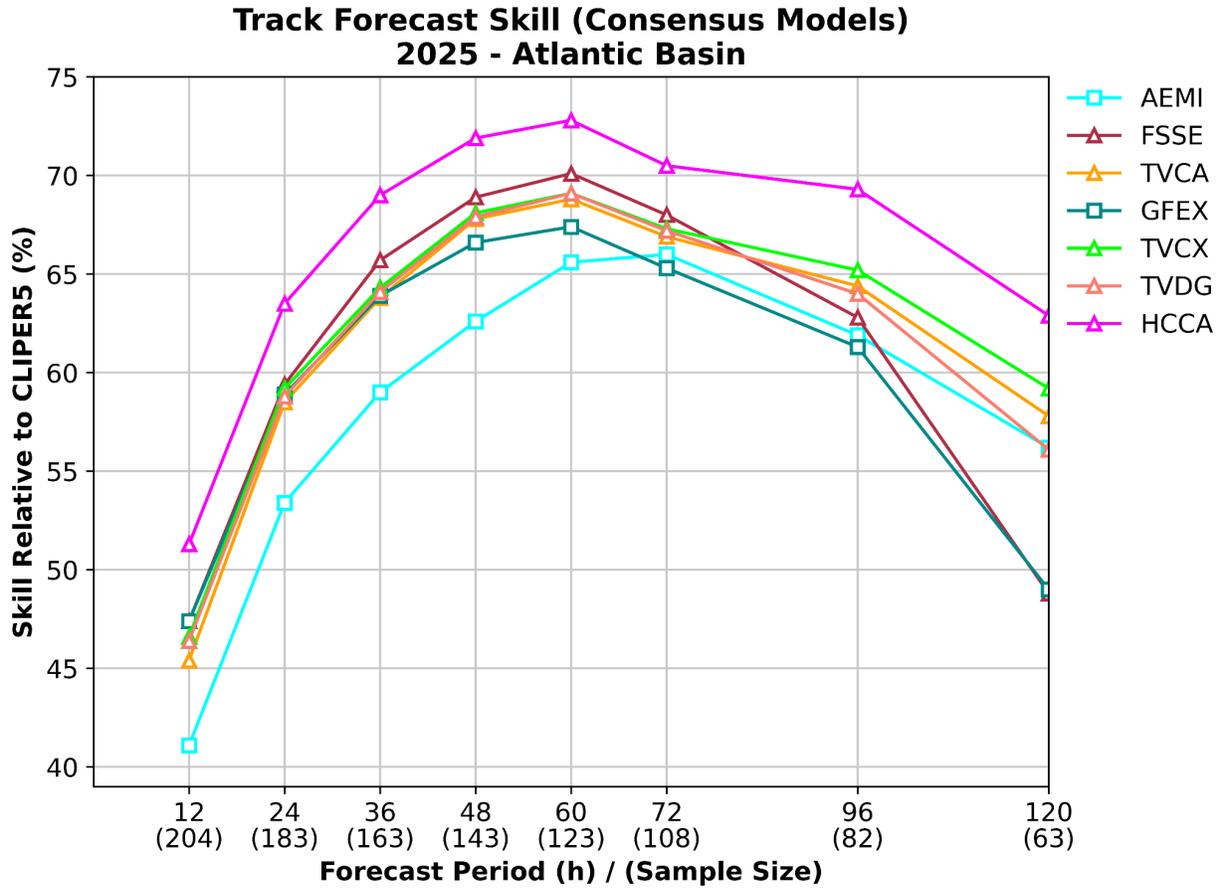
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96 h Track Error vs. Consistency - 2023-2025 Atlantic Basin

120 h Track Error vs. Consistency - 2023-2025 Atlantic Basin
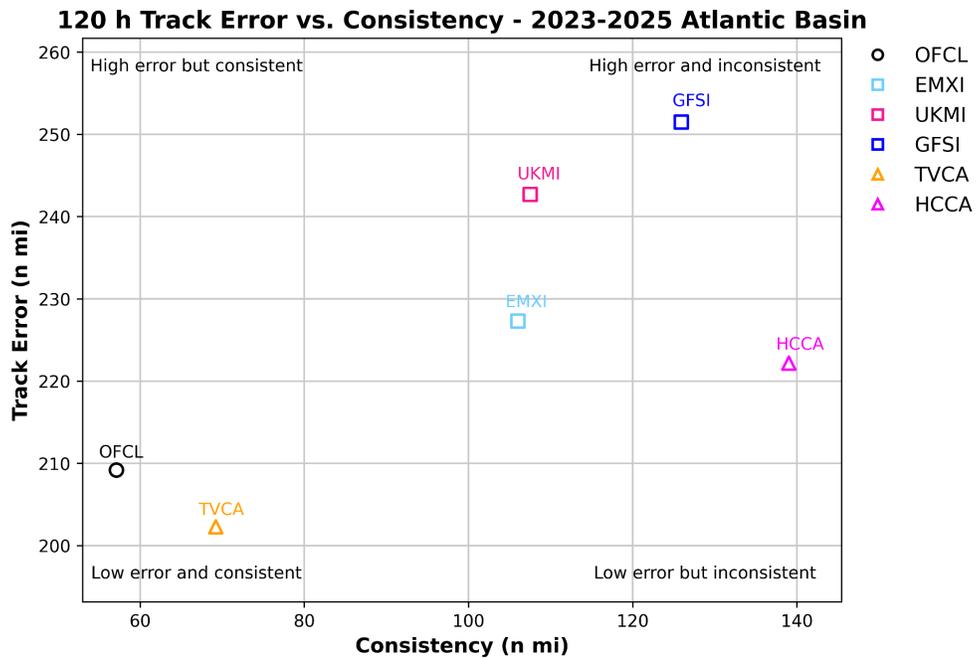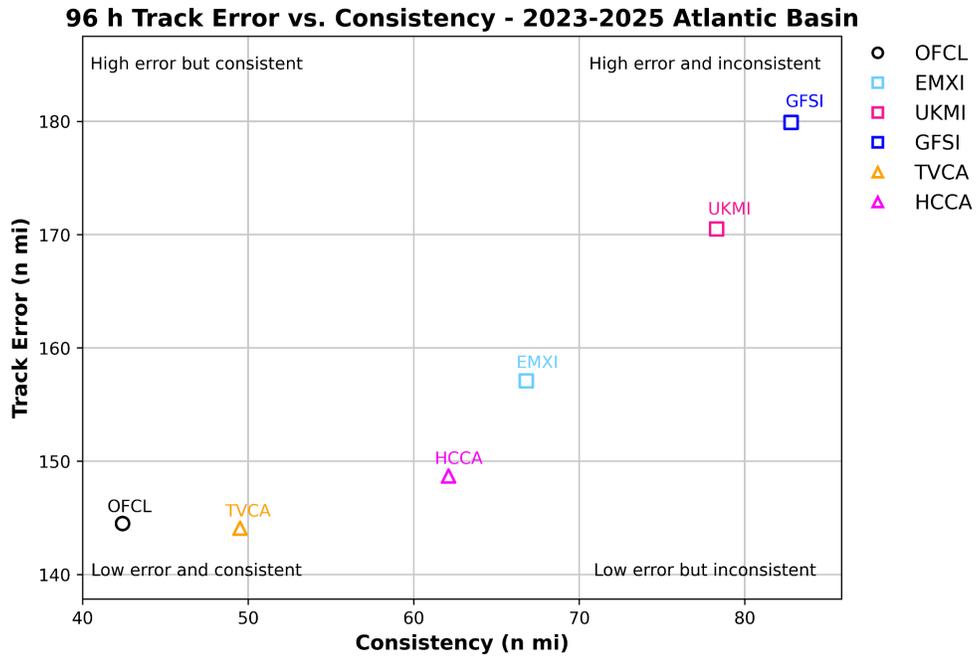
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NHC Official Track Forecast Errors
2021-2025 Atlantic Basin
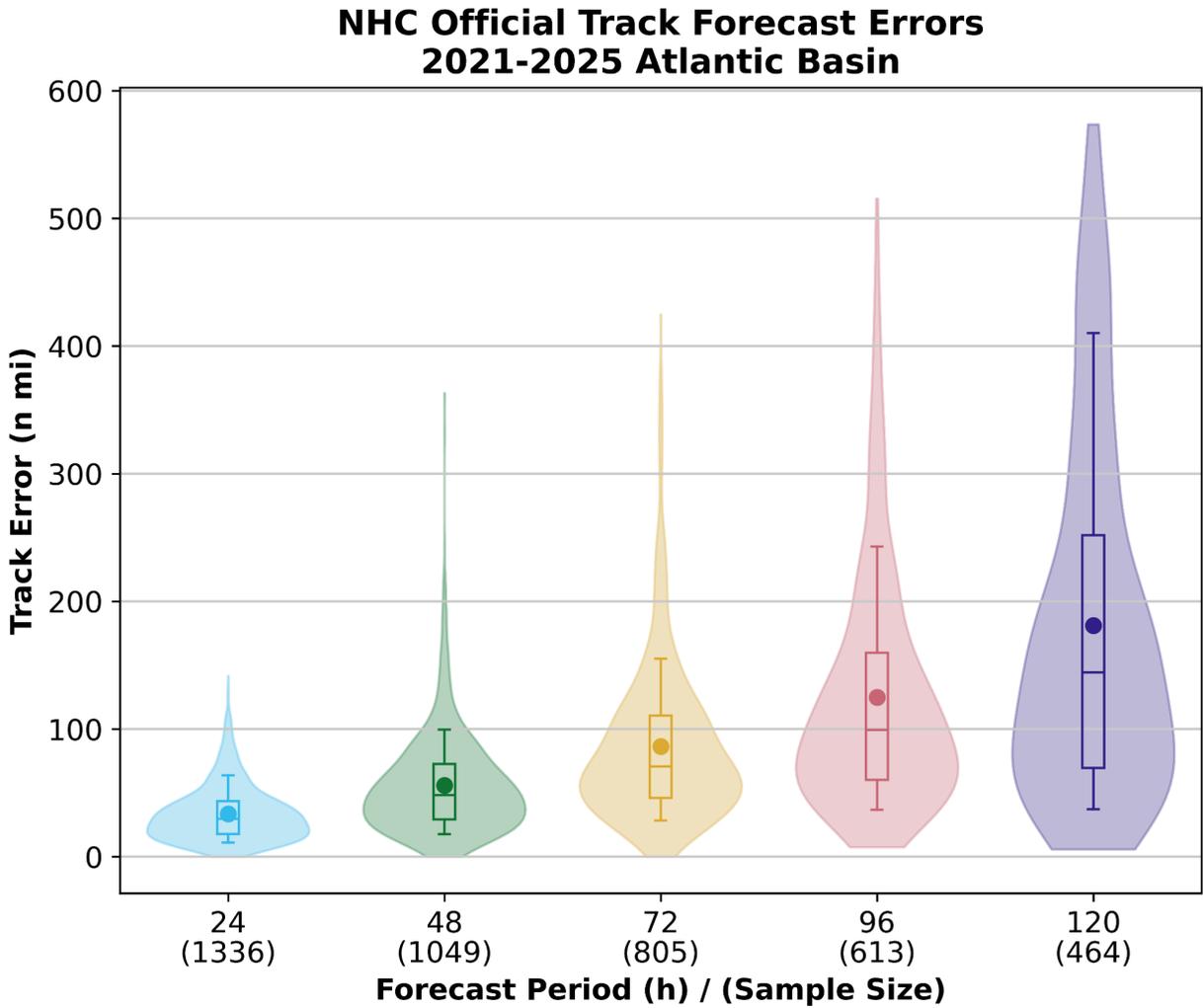
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**NHC Official vs. Decay-SHIFOR5 Forecasts
Atlantic Basin**

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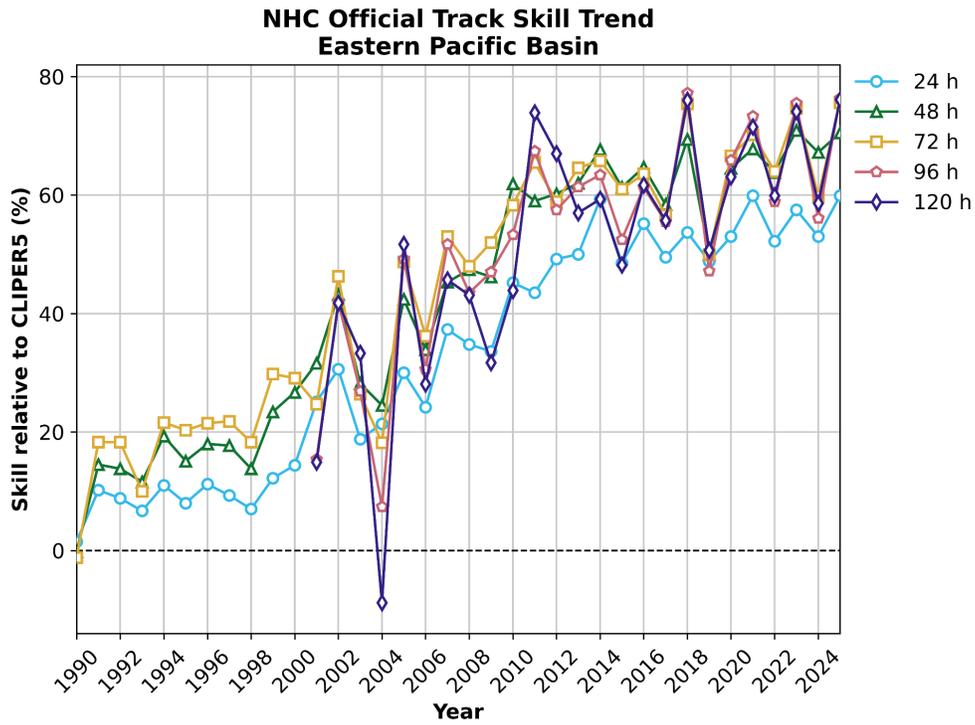for 2025 (solid lines) and 2020–2024 (dashed lines).
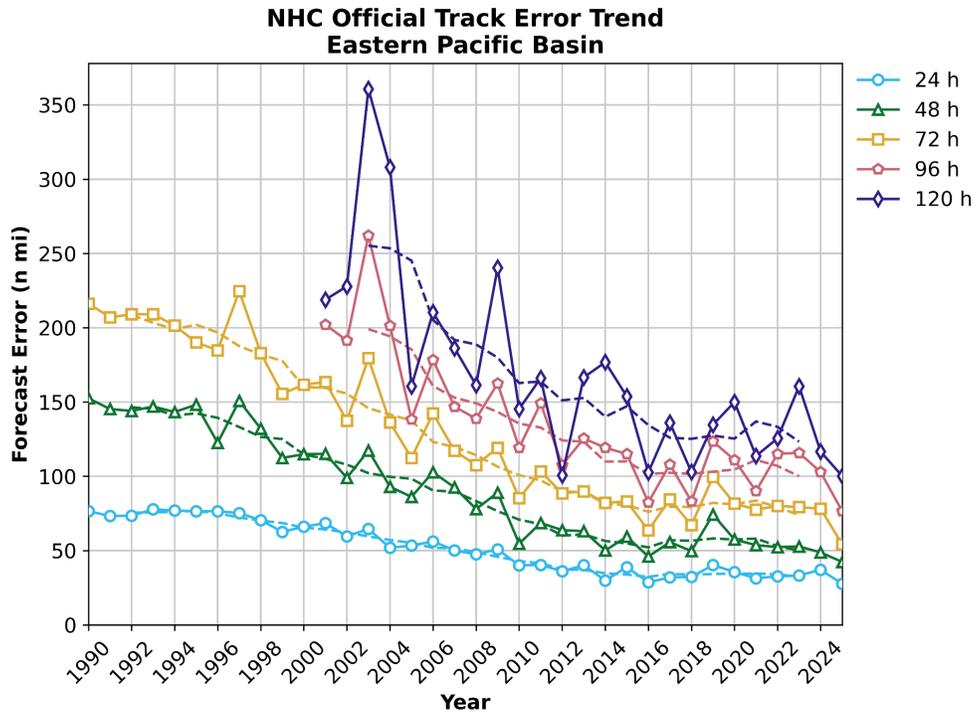
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Atlantic 2023-2025 Performance - 30 knots / 24 h

Figure 18.   Roebber performance diagram of NHC official forecast and selected early intensity models of rapidly strengthening storms from 2023-2025 in the Atlantic basin. 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. Critical success index is shown in shading/solid contours.

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**NHC Official Forecasts Verifying with/without U.S. W/Ws
2021-2025 Atlantic Basin**
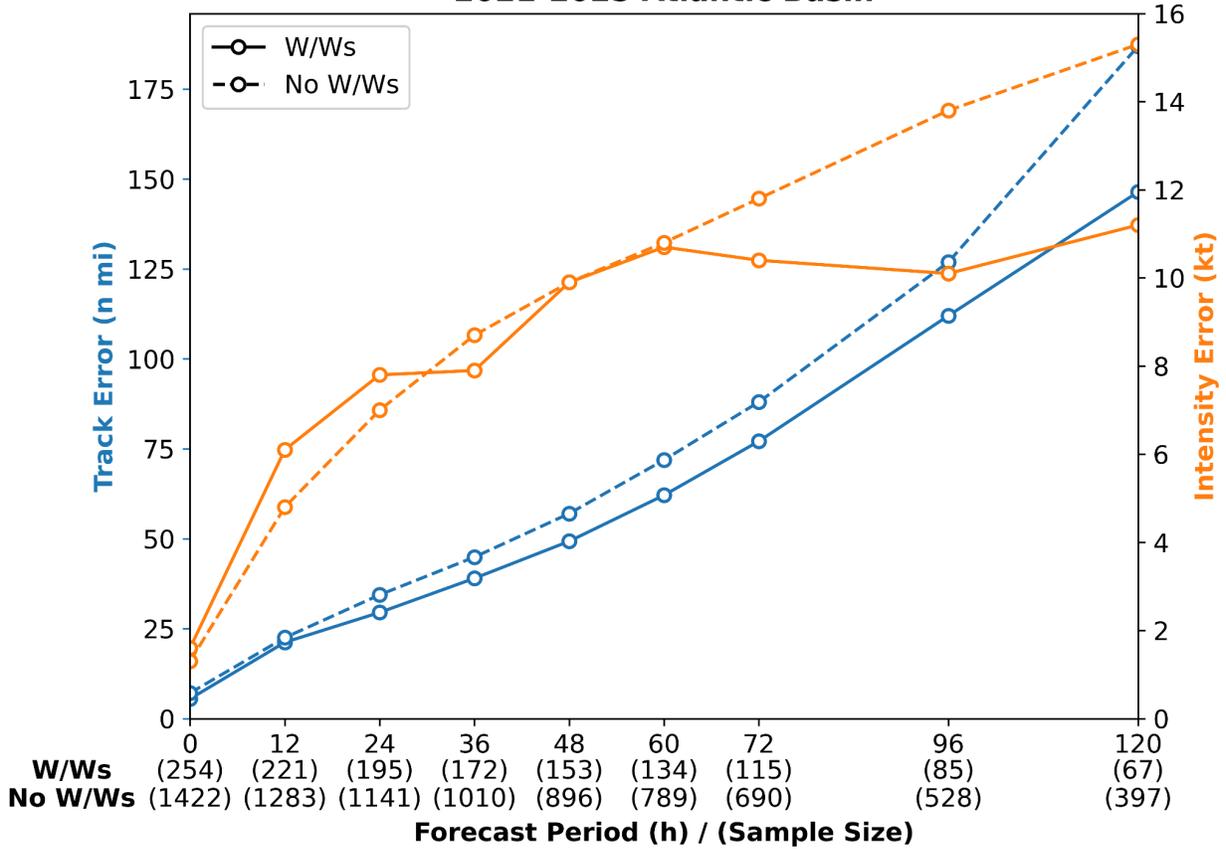
Figure 21.   A comparison of NHC official track (blue) and intensity (orange) errors when U.S. watches and warnings were in effect and when they weren't in the Atlantic basin from 2021–2025.
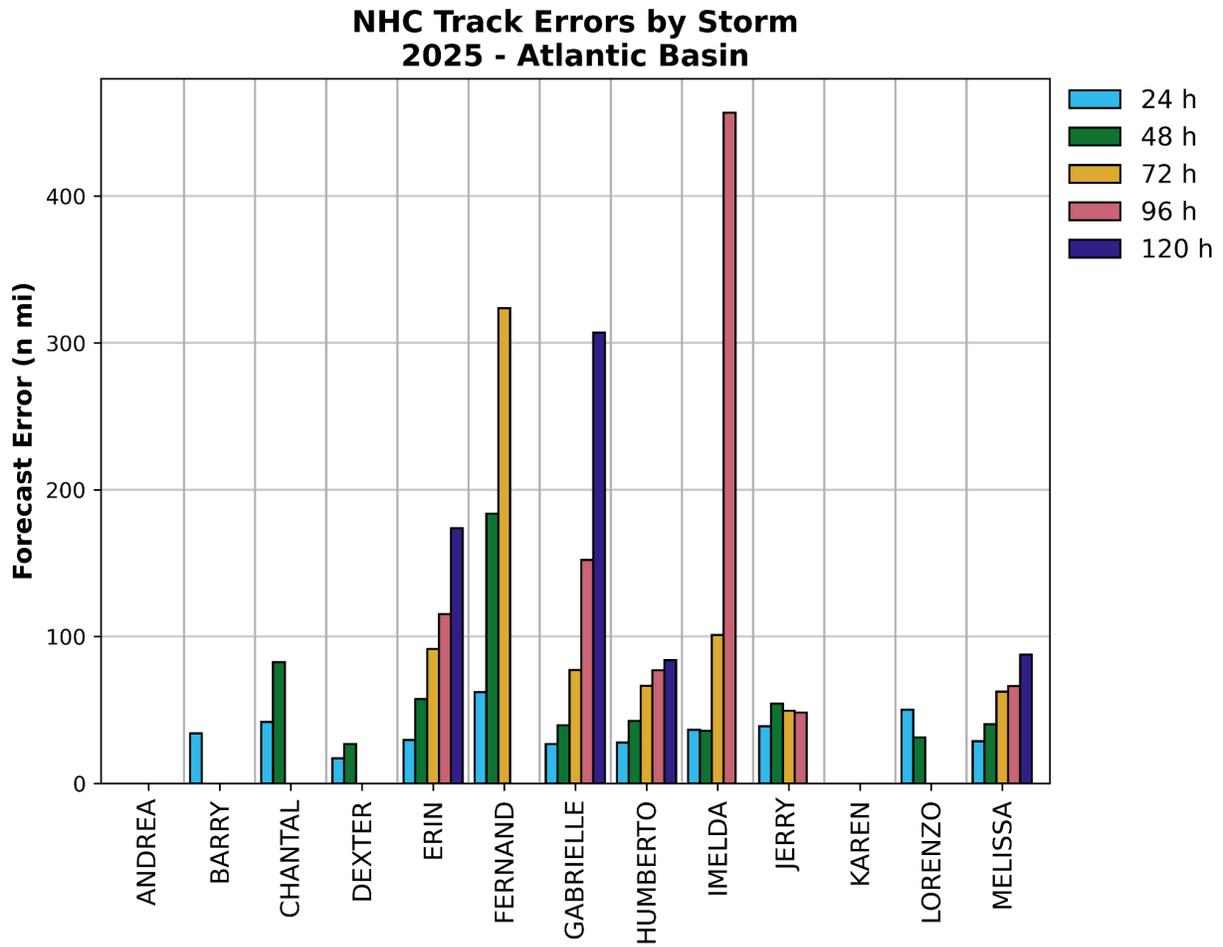
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NHC Intensity Errors by Storm
2025 - Atlantic Basin

Figure 23.   2025 NHC official intensity errors by tropical cyclone at 24, 48, 72, 96 and 120 h.
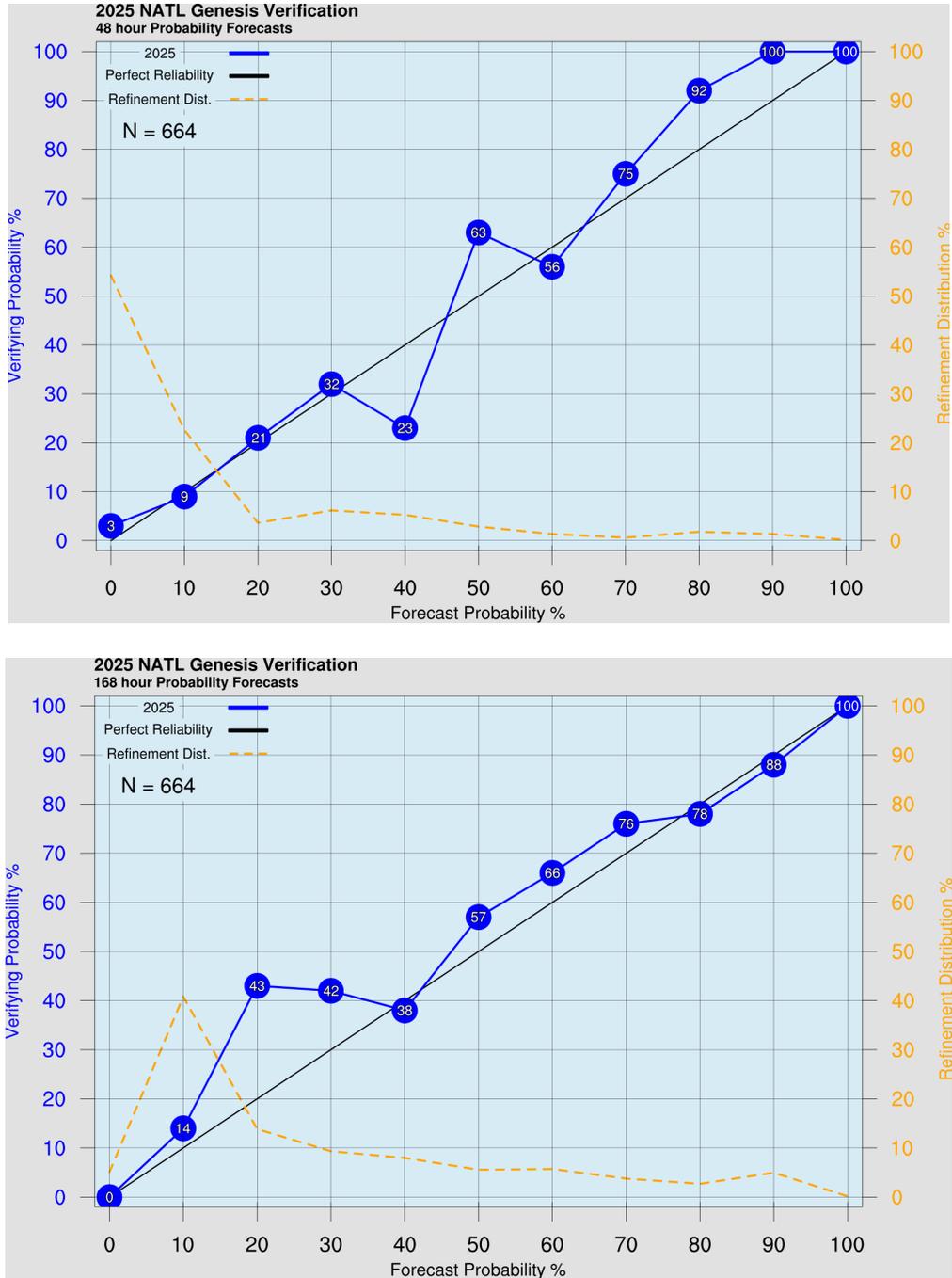
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2025 North Atlantic All 7-day Tropical Weather Outlook Areas and TC Genesis Locations (black circles)
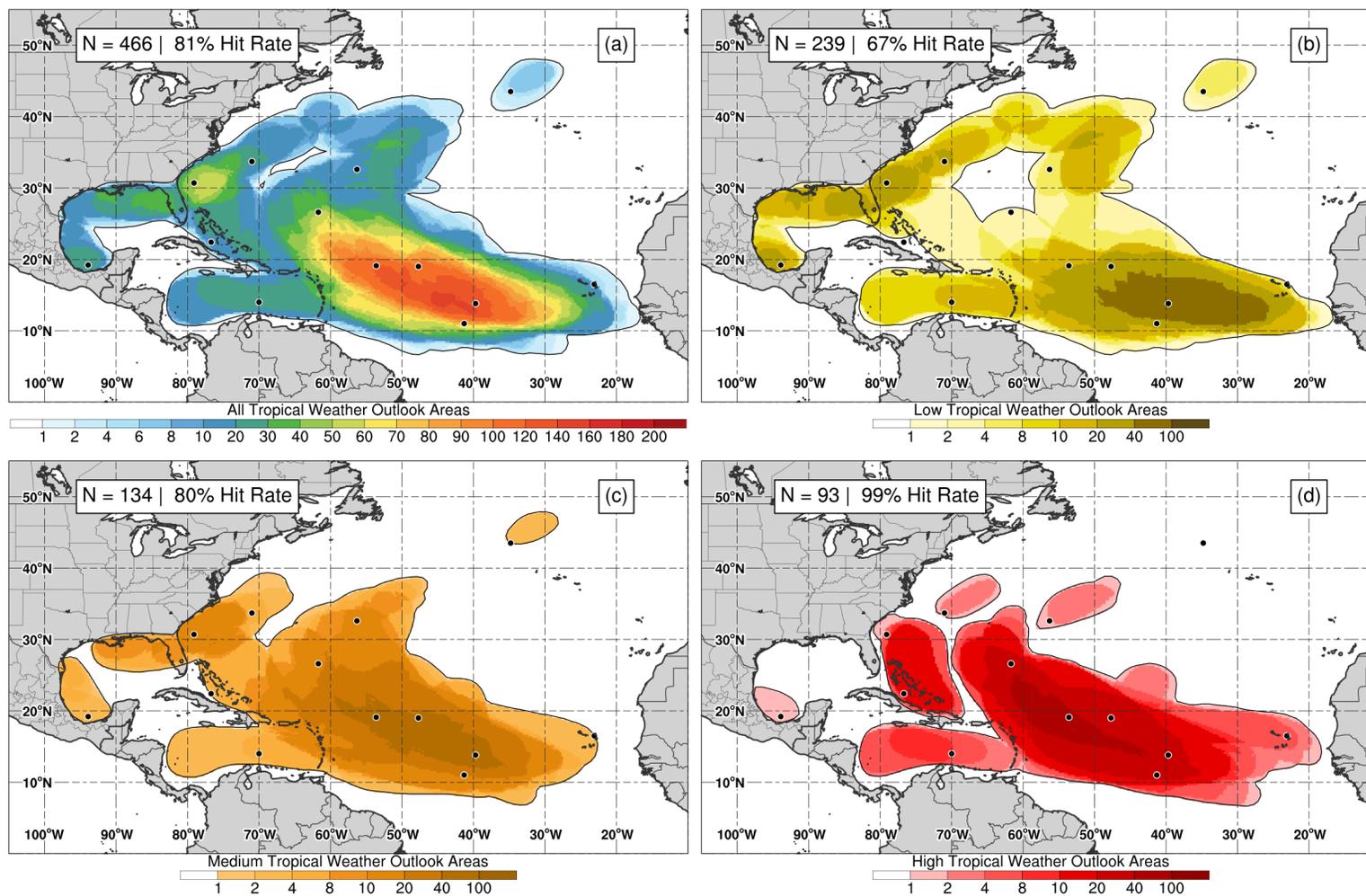
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2025 North Atlantic Tropical Weather Outlook Area Difference Vs. (2015-2024 avg)
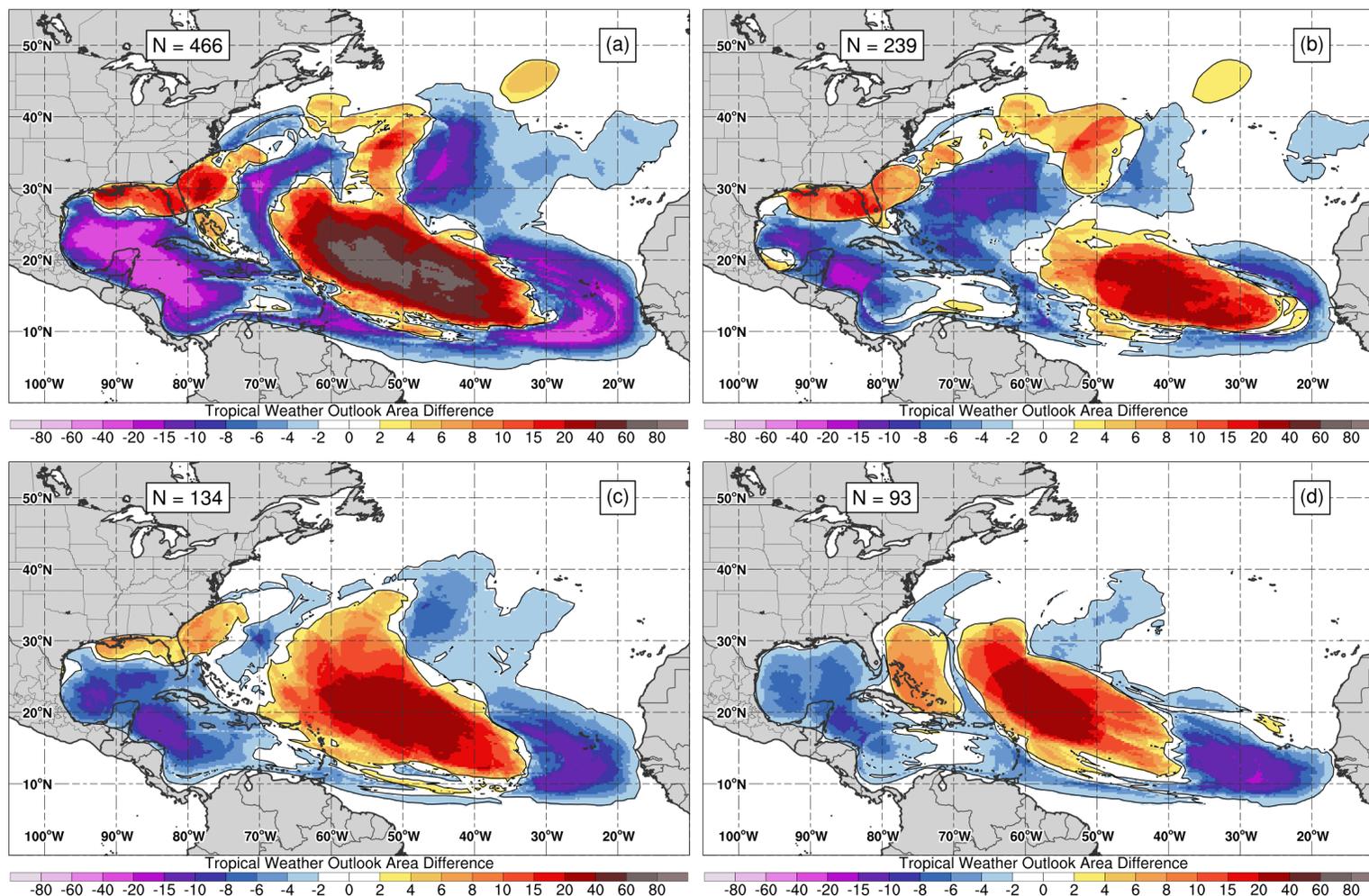
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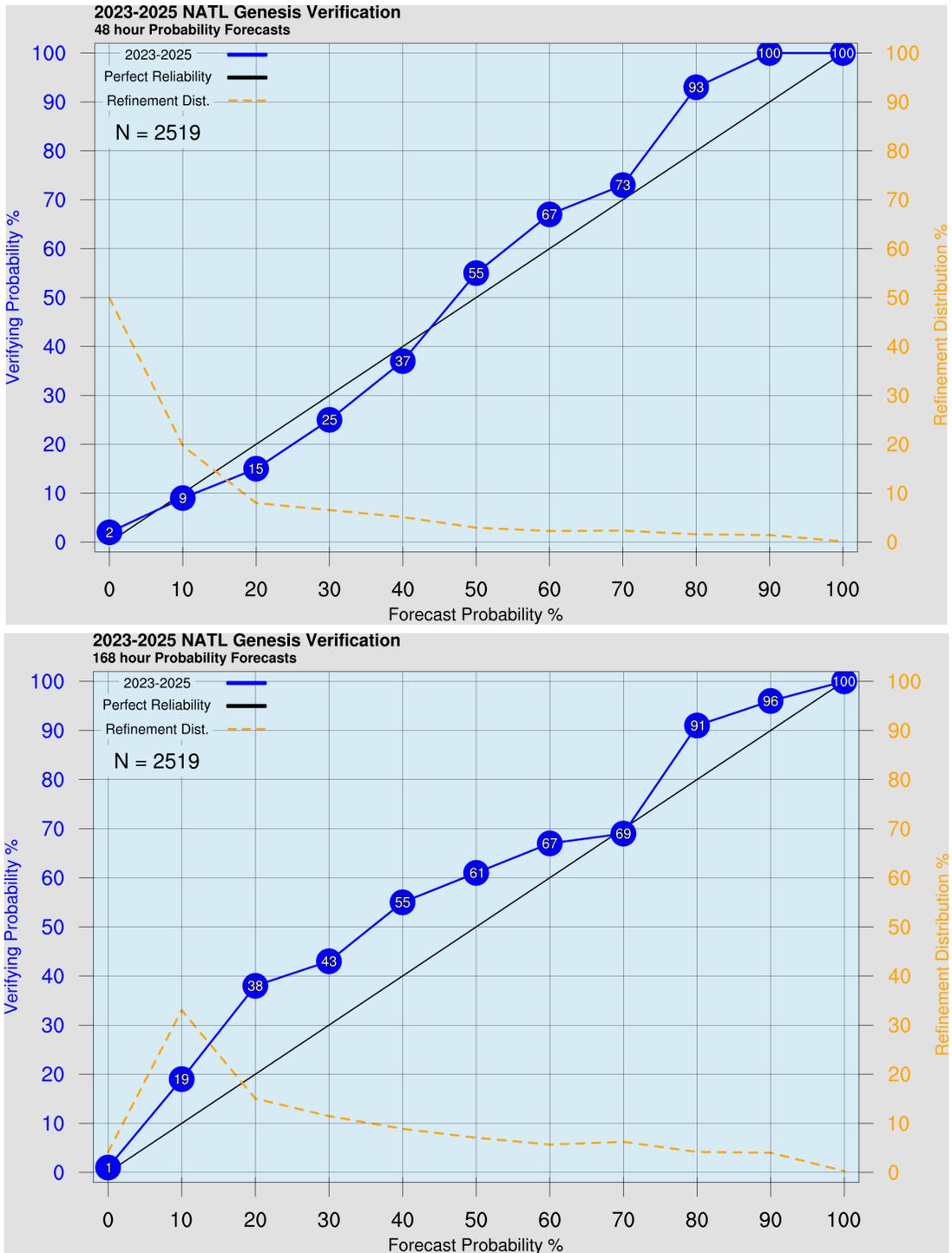
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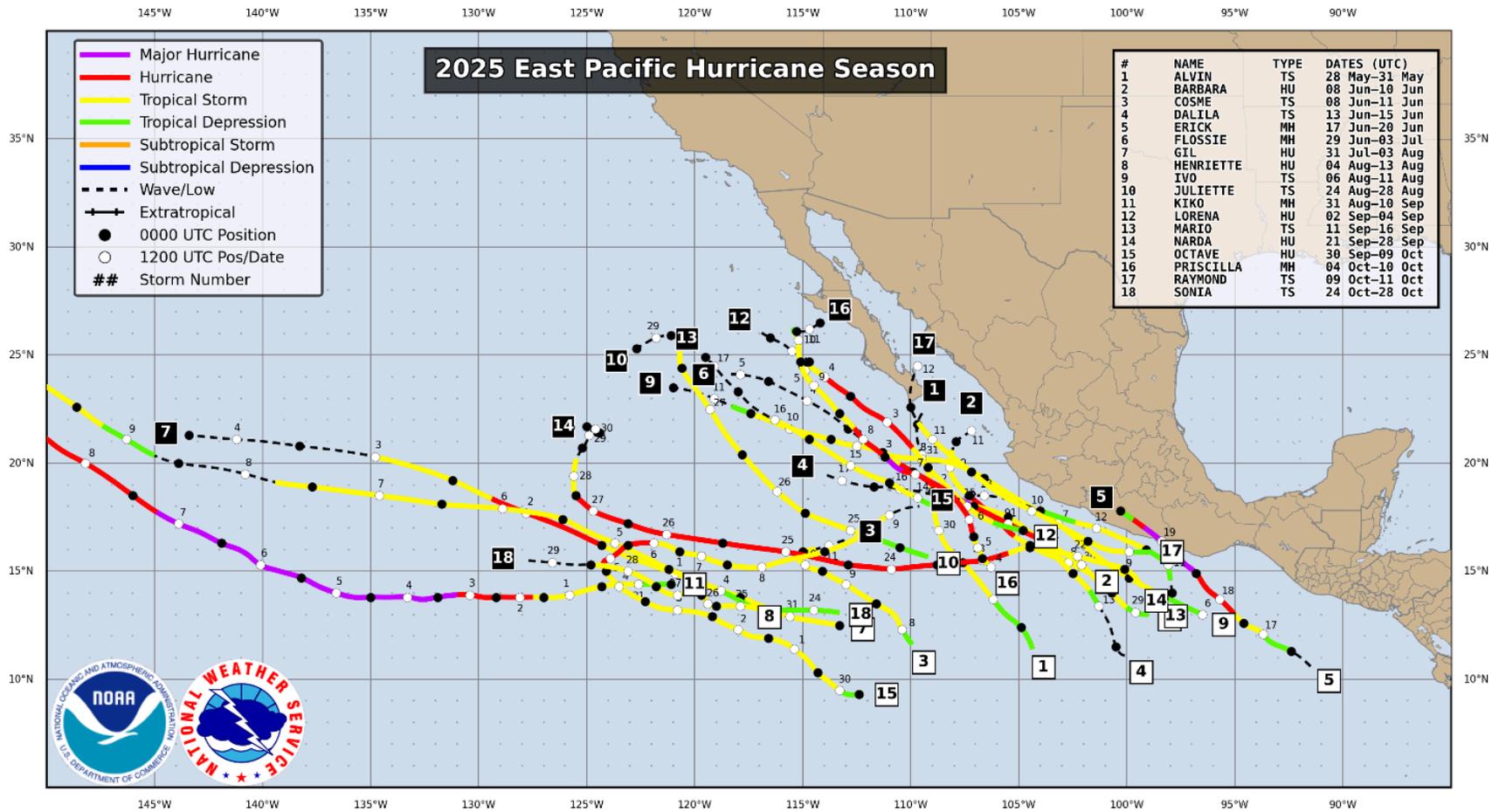
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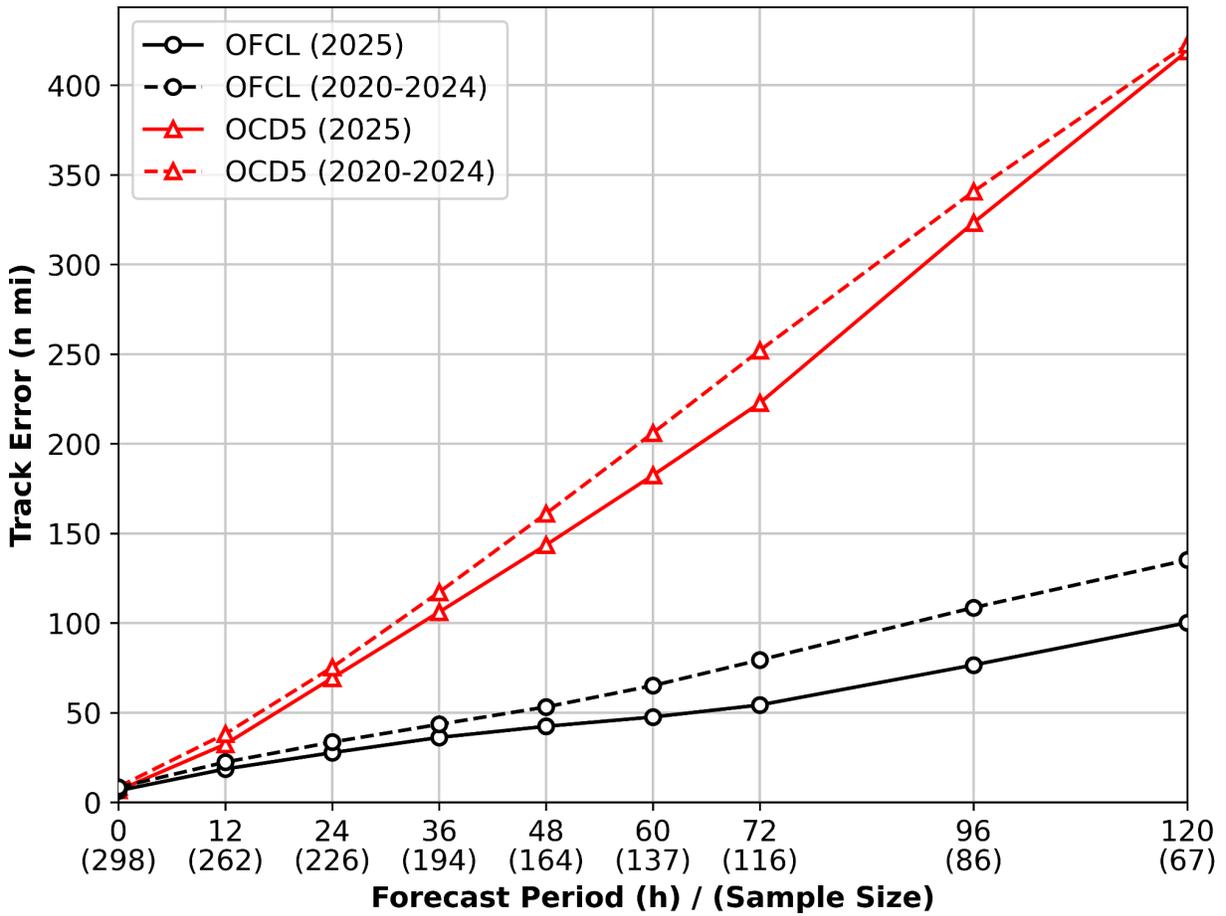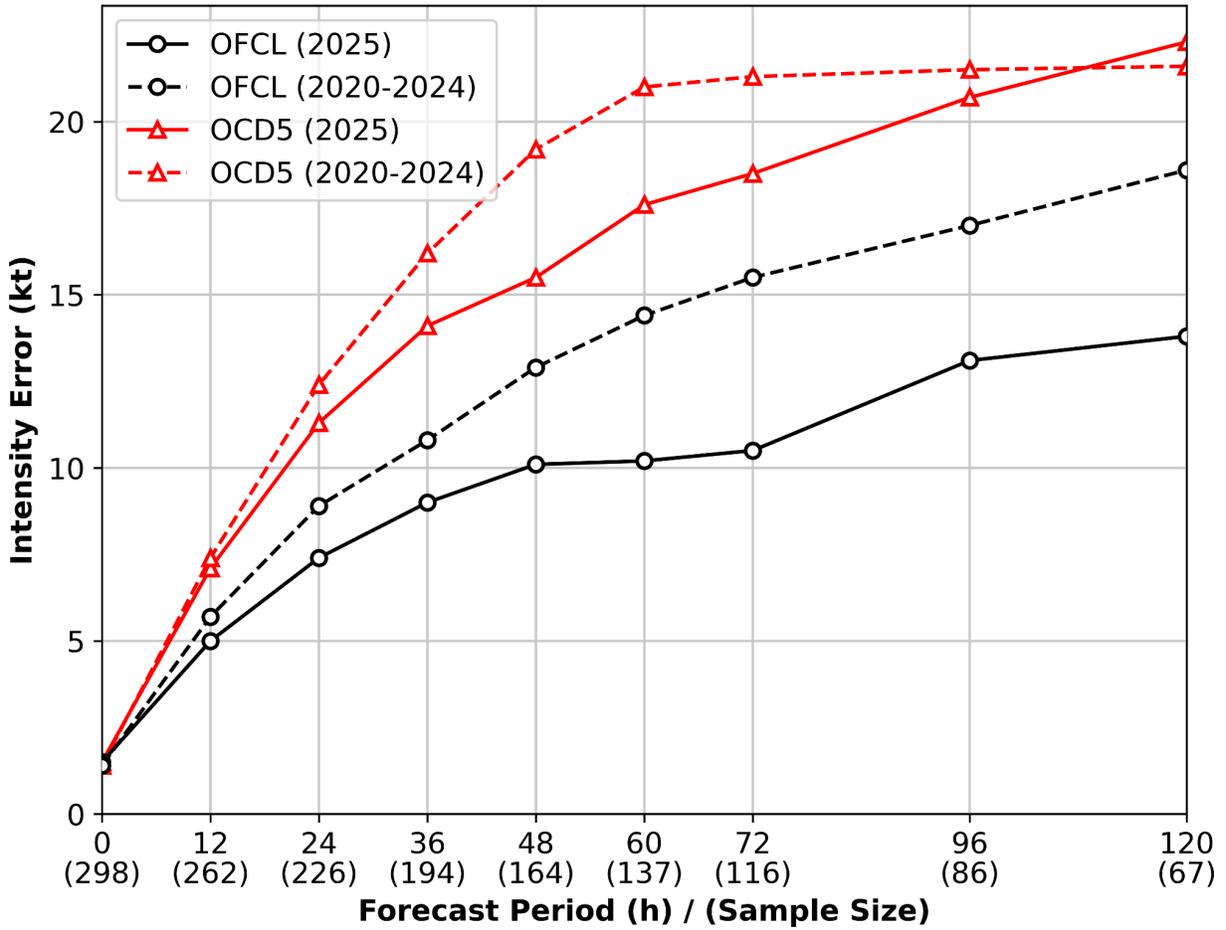
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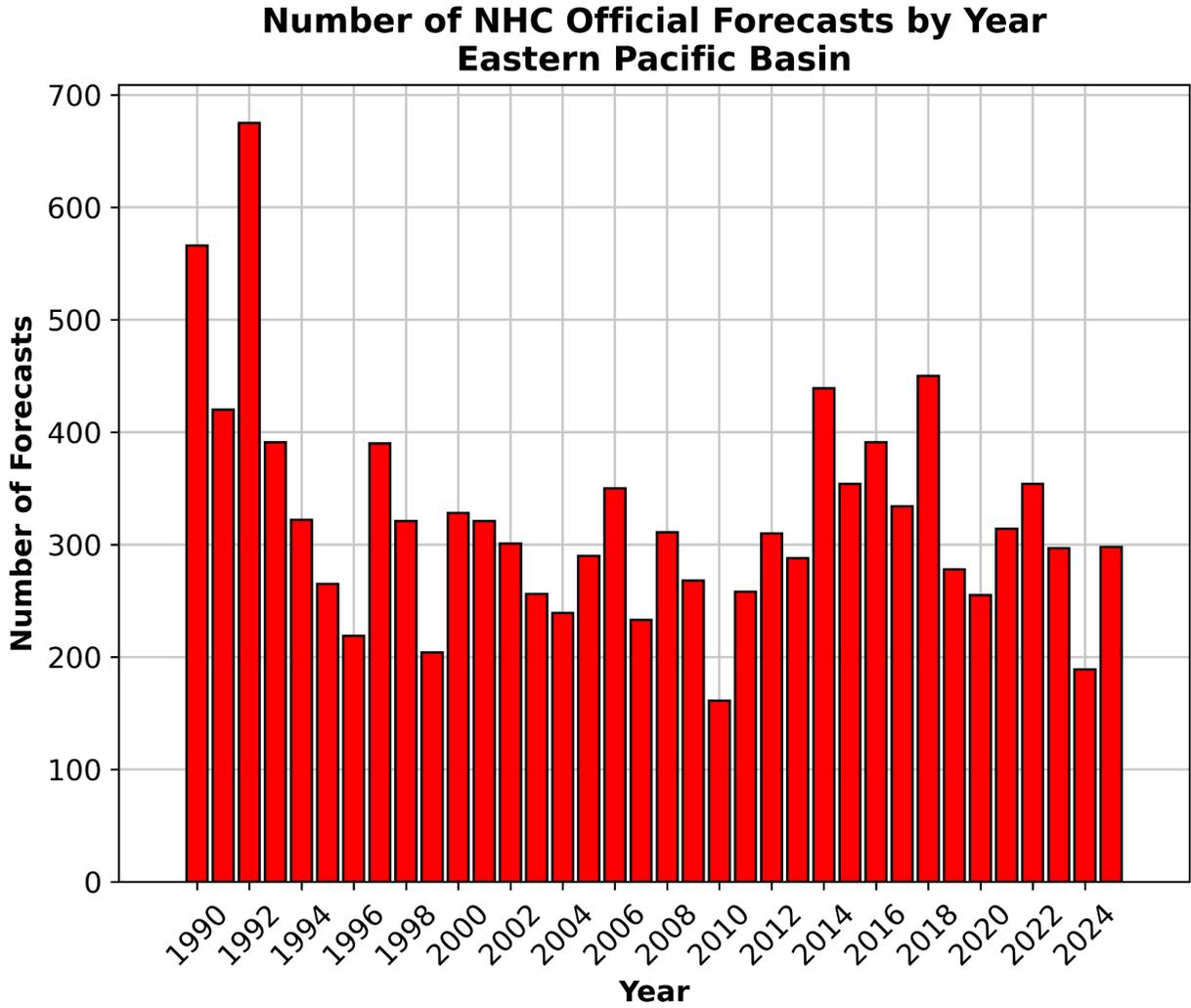
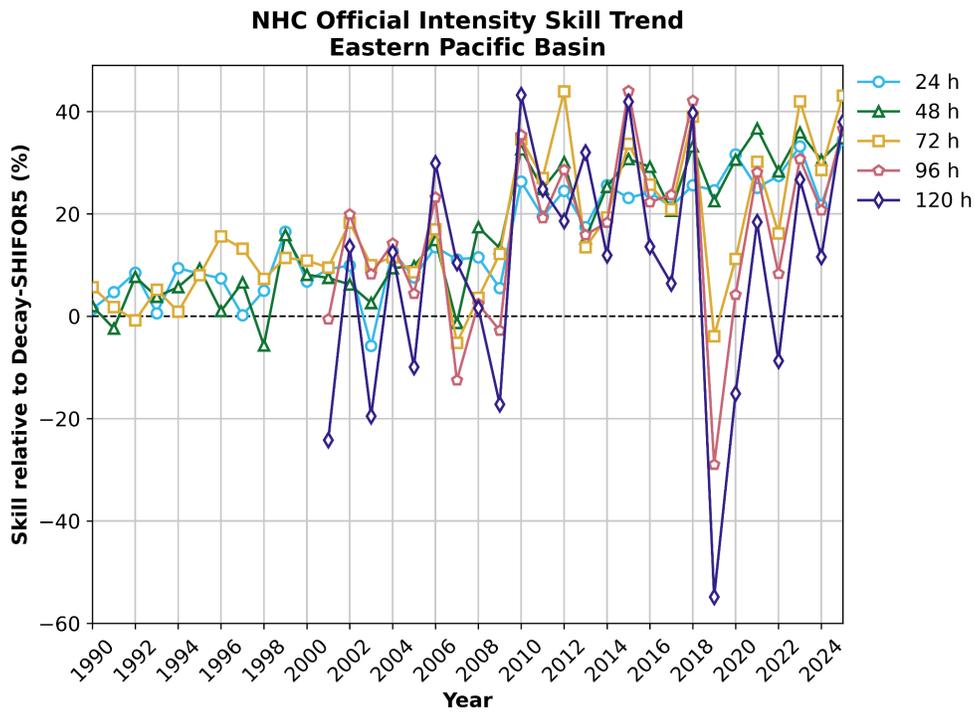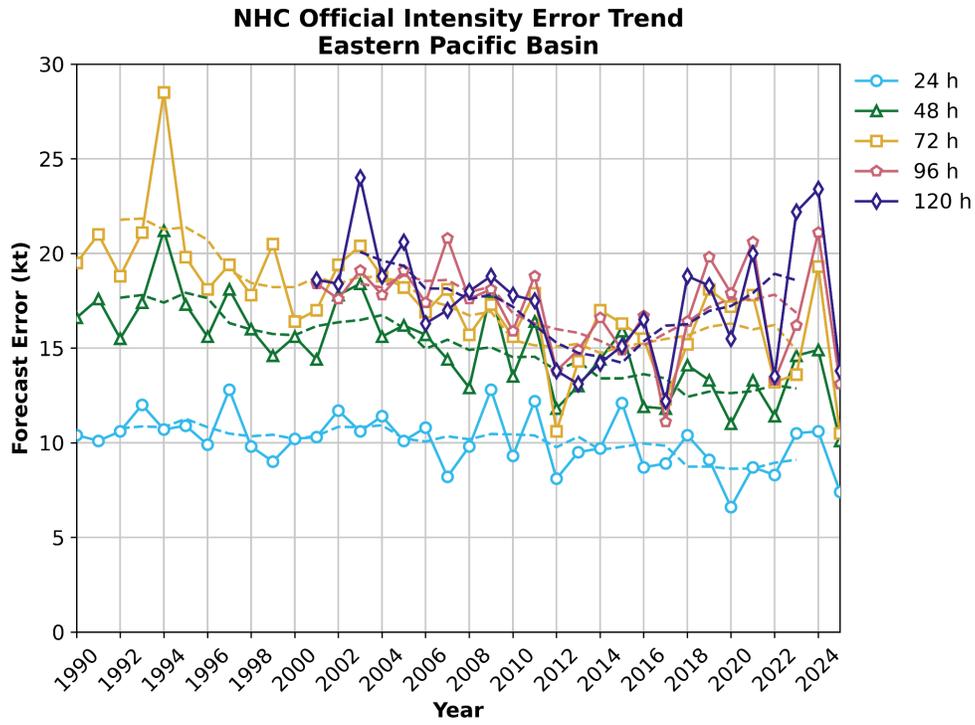Figure 30.   Number of NHC official forecasts for the eastern North Pacific basin stratified by year from 1990–2025.

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NHC Official Track Forecast Errors by Initial Intensity 2021-2025 Eastern Pacific Basin
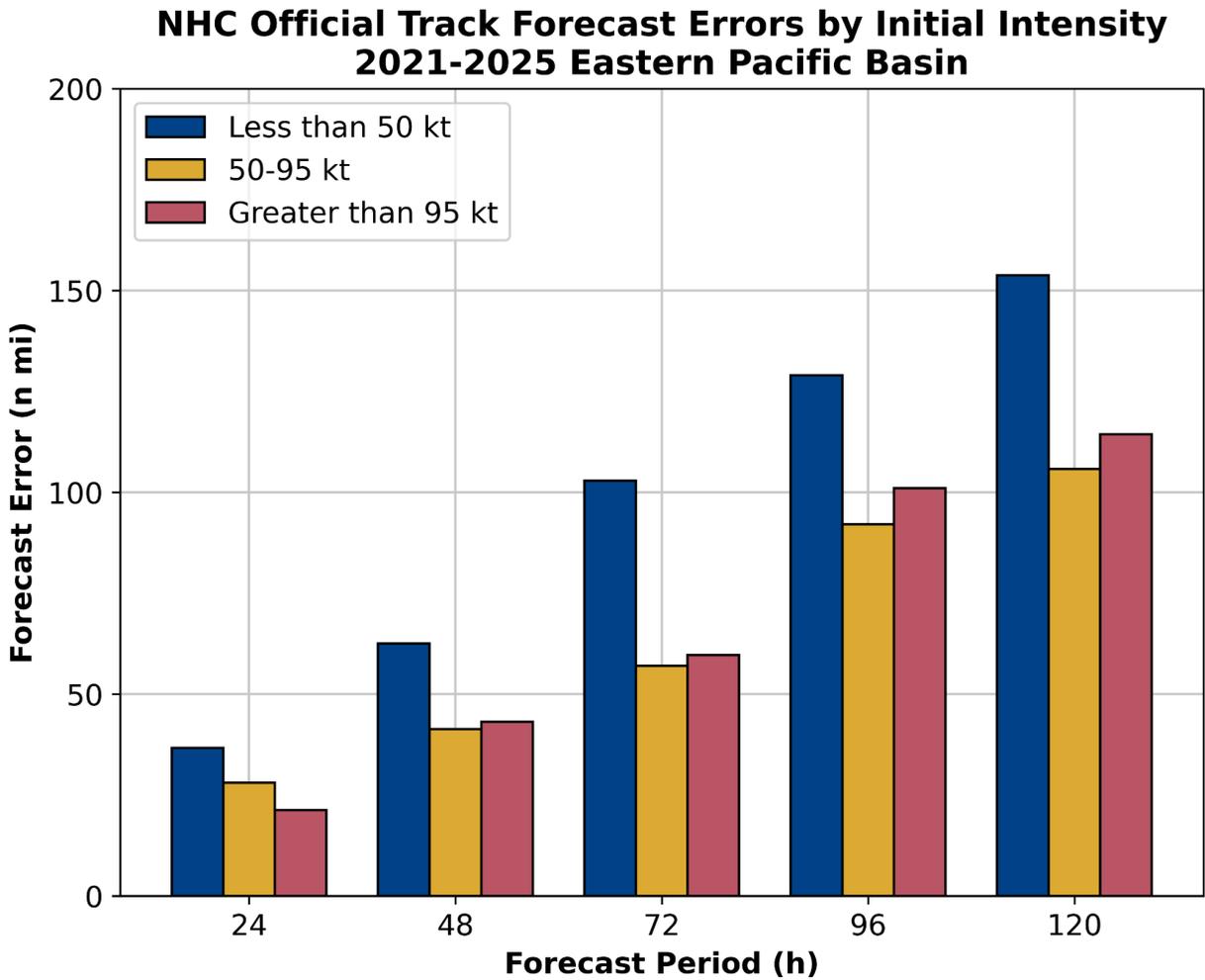
Figure 32.   2021–25 NHC official track forecast error binned by initial intensity for the eastern North Pacific basin.
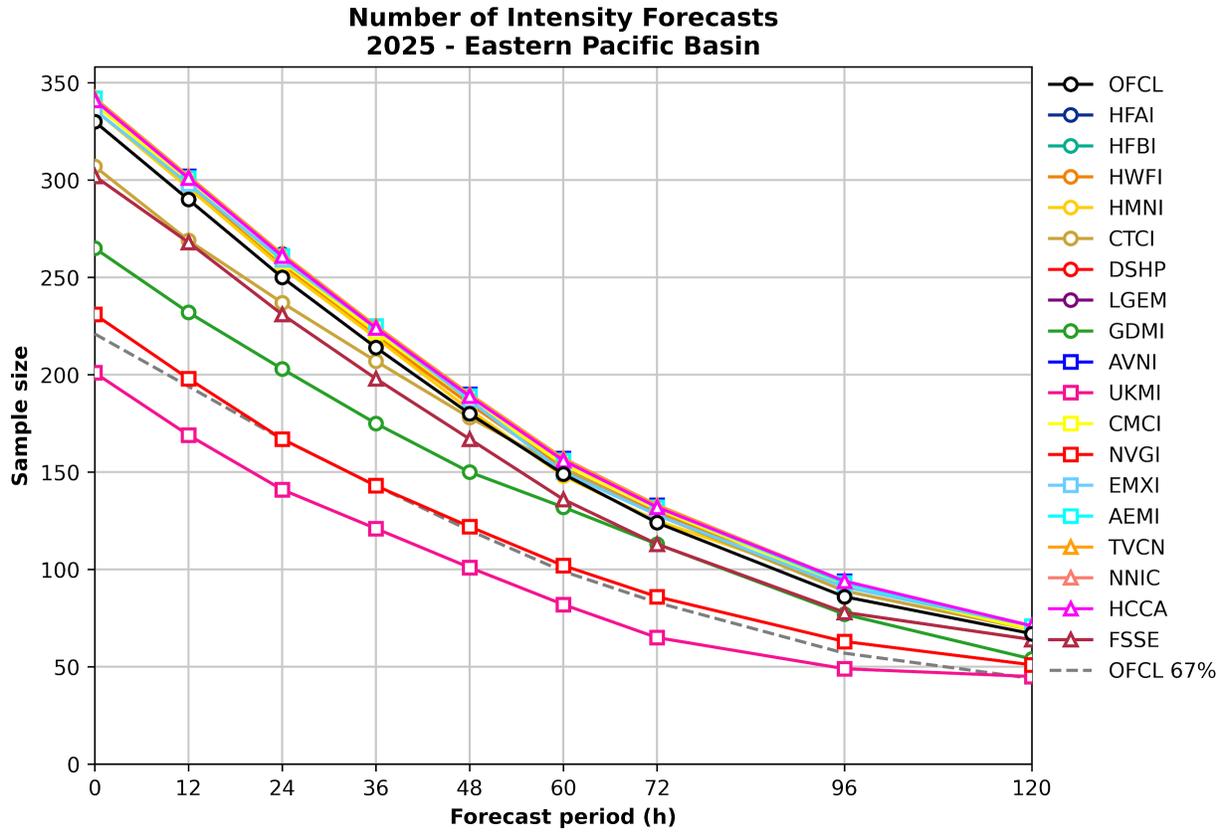
Figure 33.   Number of forecasts by each model in 2025 in the eastern North Pacific basin. The dotted line shows the 67th percentile of the official forecasts, the metric needed to be met for verification inclusion.
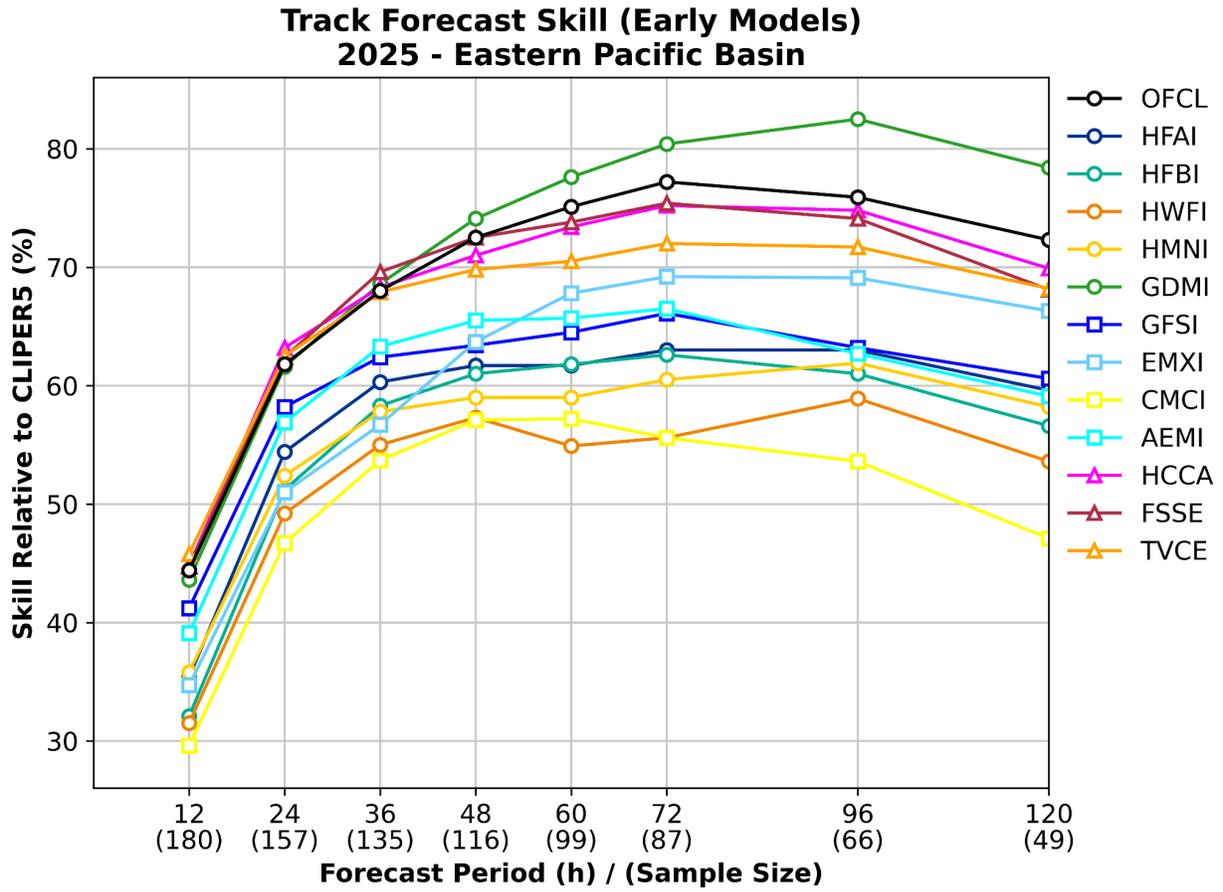
Figure 34.   Homogenous comparison for selected eastern North Pacific early track models for 2025. This verification includes only those models that were available at least 2/3 of the time (see text).
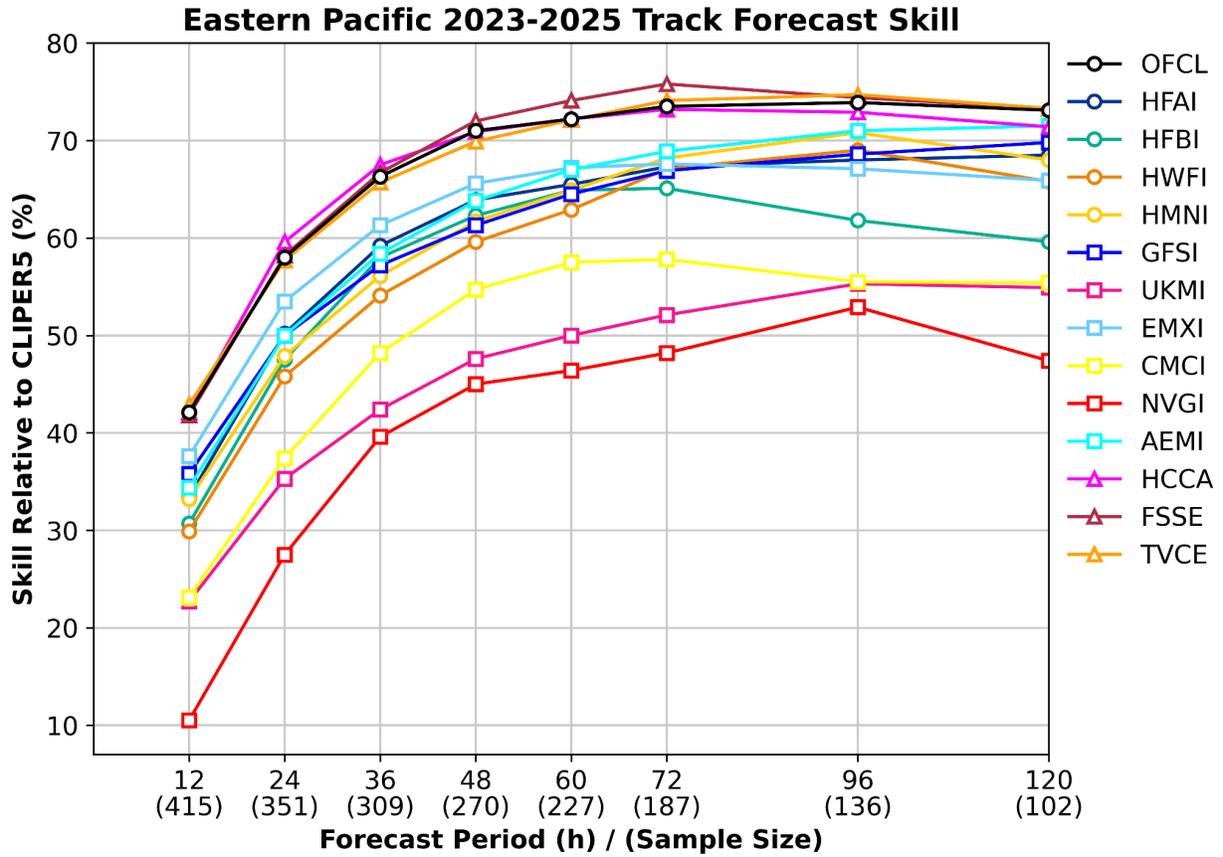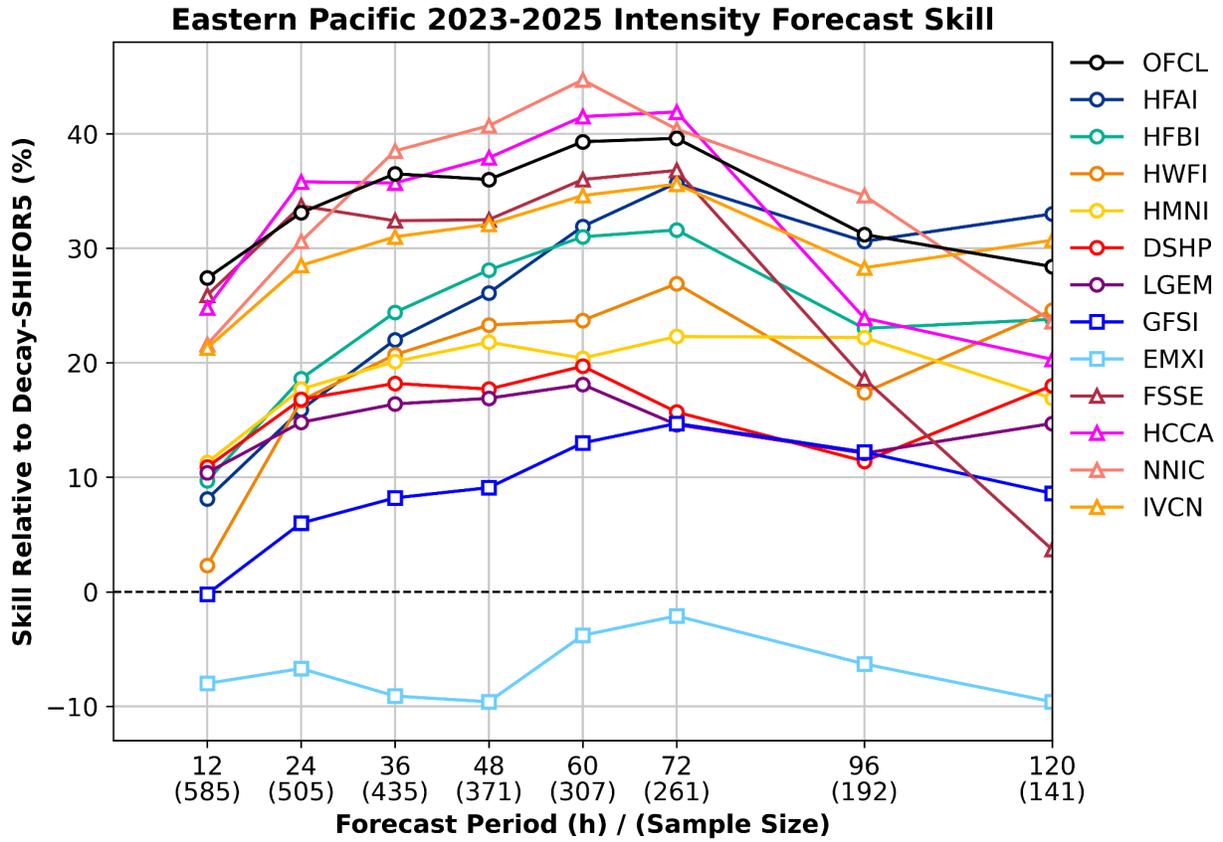
Figure 35.   Homogenous comparison of track forecast skill for selected eastern North Pacific basin early models for 2023–2025.

Figure 36.   Homogenous comparison of the primary eastern North Pacific basin track consensus models for 2025.

96 h Track Error vs. Consistency - 2023-2025 Eastern Pacific Basin

120 h Track Error vs. Consistency - 2023-2025 Eastern Pacific Basin

Figure 37.   Track error vs. consistency around the 96-h (top) and 120-h (bottom) forecast periods in the East Pacific basin of GFSI, EMXI, UKMI, TVCE, HCCA, and OFCL (NHC) from 2023–25.

NHC Official Track Forecast Errors
2021-2025 Eastern Pacific Basin
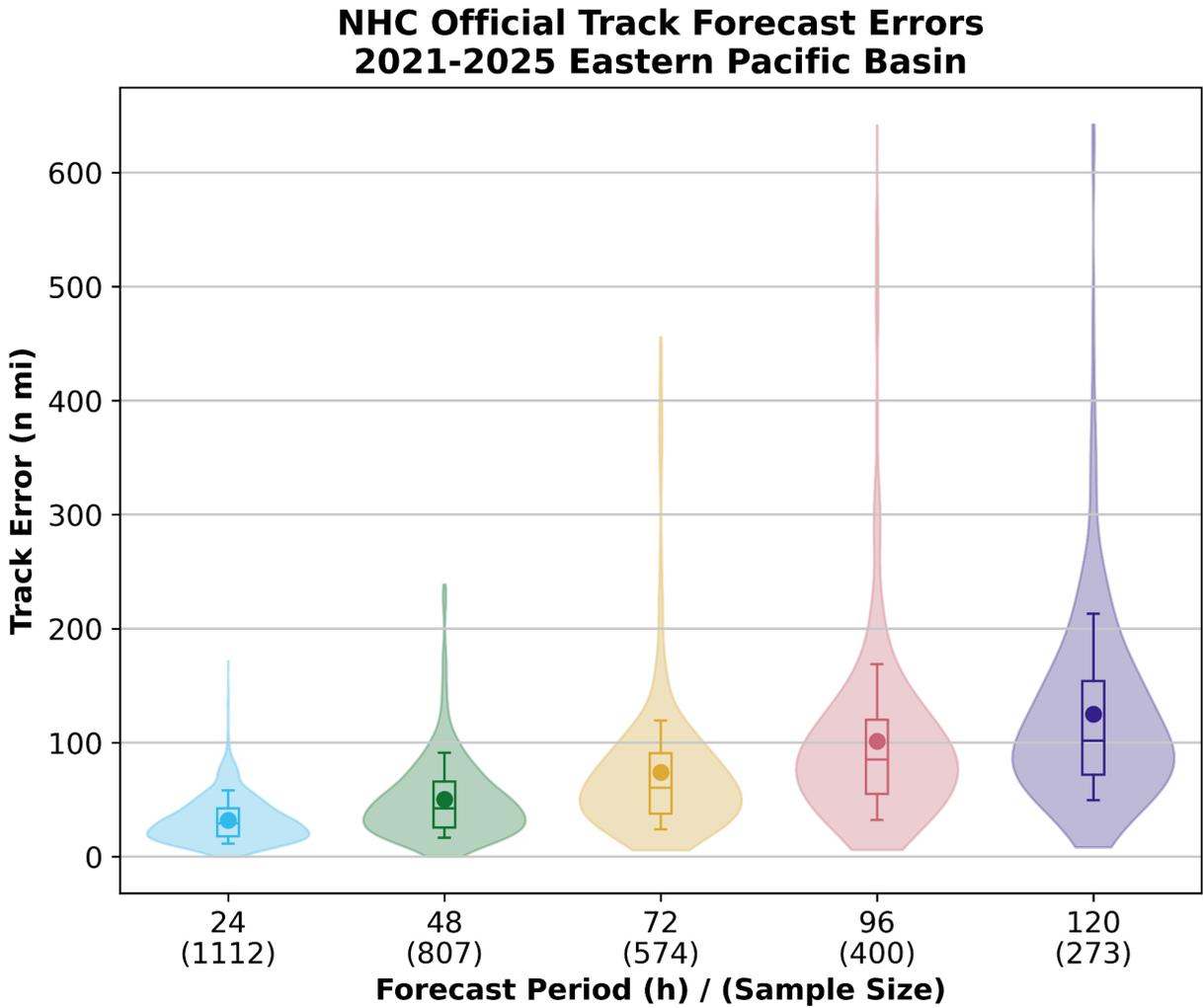
Figure 38.   Violin diagram of NHC official track forecasts for the eastern North Pacific basin for 2021–2025. The mean is shown by the colored dot, median by the horizontal line, 25-75th percentiles by the box edges, and 10-90th percentiles by whiskers.

Figure 39.   NHC official and Decay-SHIFOR5 (OCD5) eastern North Pacific basin average intensity errors for 2025 (solid lines) and 2020–2024 (dashed lines).

Figure 40.   Recent trends in NHC official intensity forecast error (top) and skill (bottom) for the eastern North Pacific basin. Dashed lines in error trend represent a 5-yr running mean.
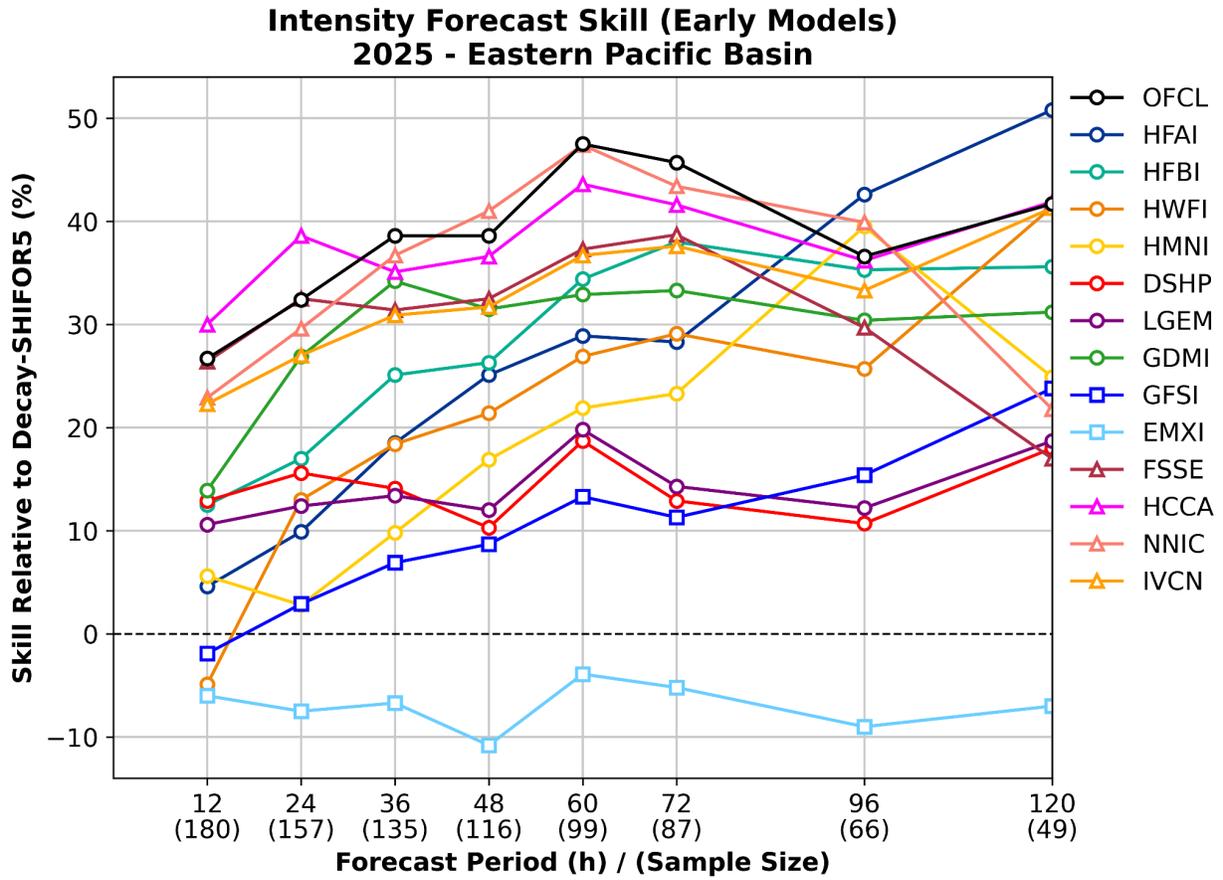
Figure 41.   Homogenous comparison for selected eastern North Pacific basin early intensity guidance models for 2025.

Figure 42.   Homogenous comparison of forecast intensity skill for selected eastern North Pacific basin early guidance models for 2023–2025.
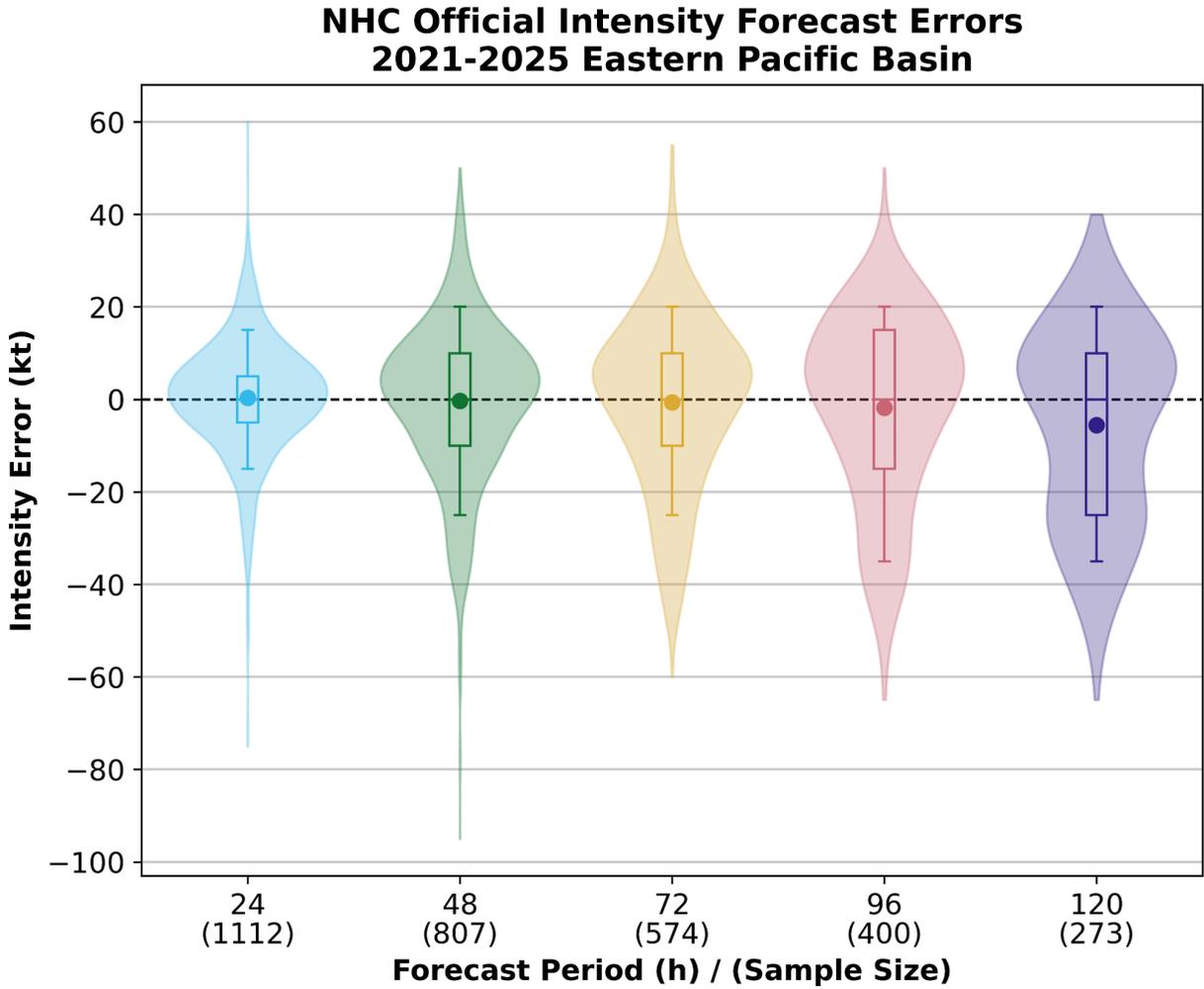
Figure 43.   Violin diagram of NHC official intensity forecasts for the eastern North Pacific basin for 2021–2025. The mean is shown by the colored dot, median, 25-75th percentiles by the box edges, and 10-90th percentiles by whiskers.
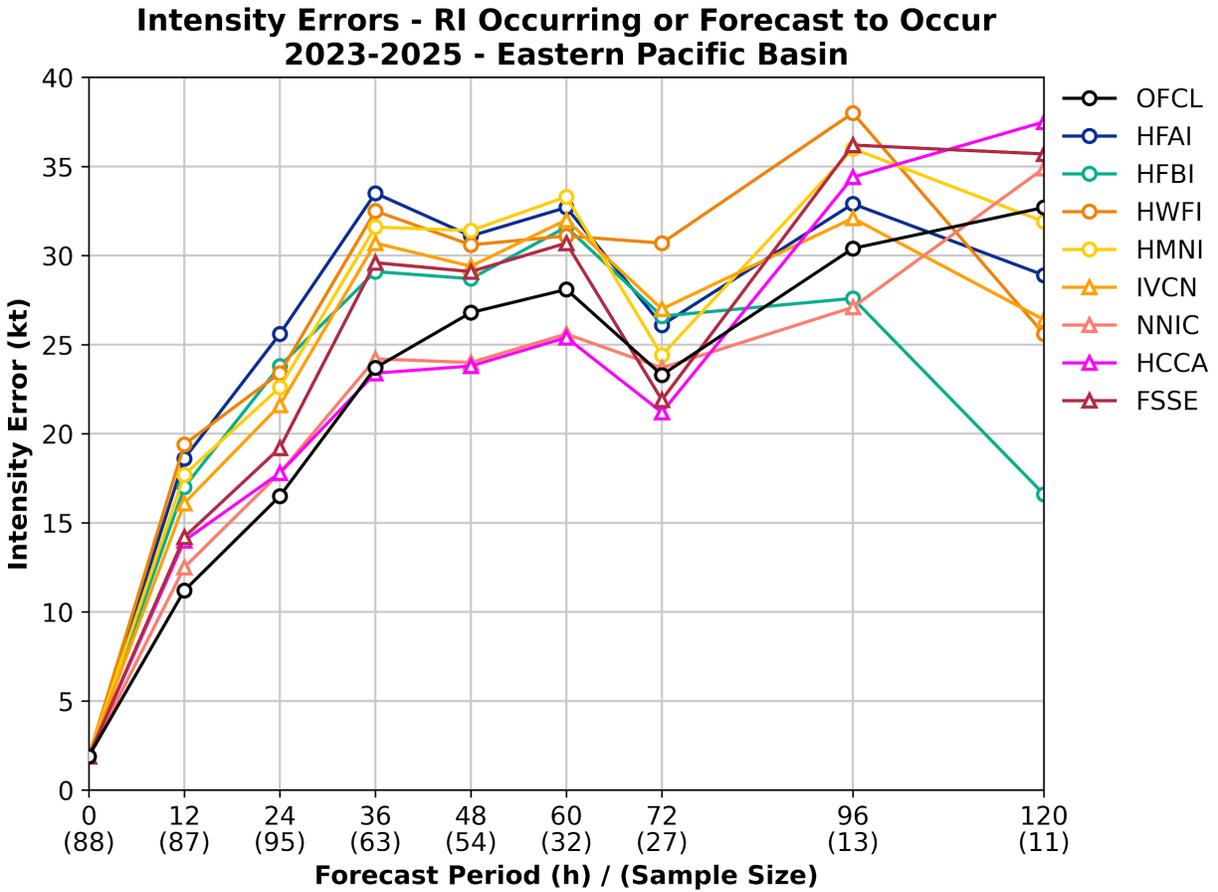
Figure 44.   Homogeneous comparison for selected eastern North Pacific basin early intensity guidance models for cases where rapid intensification was occurring or forecast from 2023–2025.

Eastern Pacific 2023-2025 Performance - 30 knots / 24 h
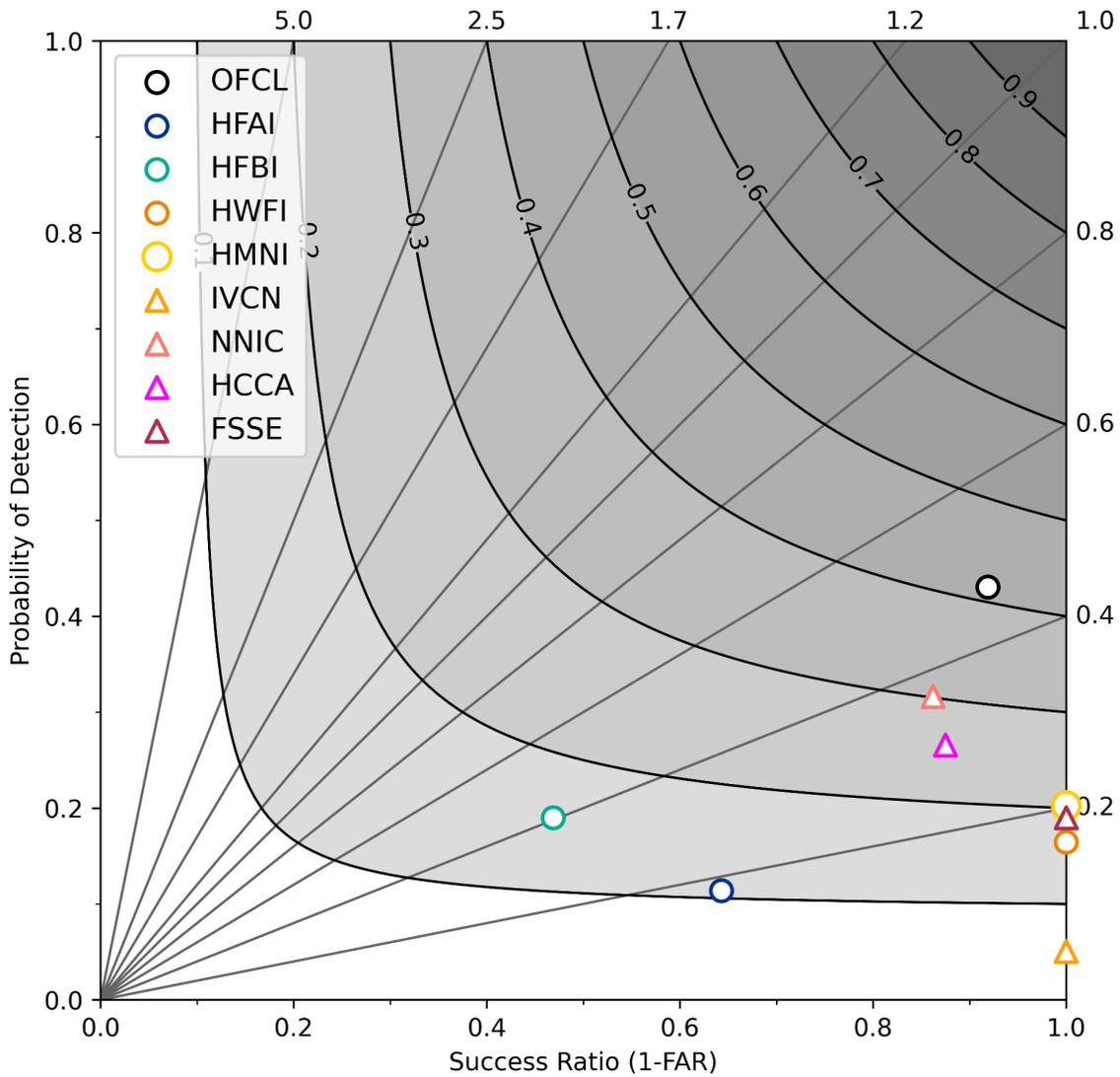
Figure 45.   Roebber performance diagram of NHC official forecast and selected early intensity models of rapidly strengthening storms in 2023-2025 in the eastern Pacific basin. Probability of detection is given by the ratio of hits to the total number of times the events occurred. False Alarm Ratio (FAR) is given by the ratio of false alarms to the total number of forecast events. Critical success index is shown in shading/solid contours.
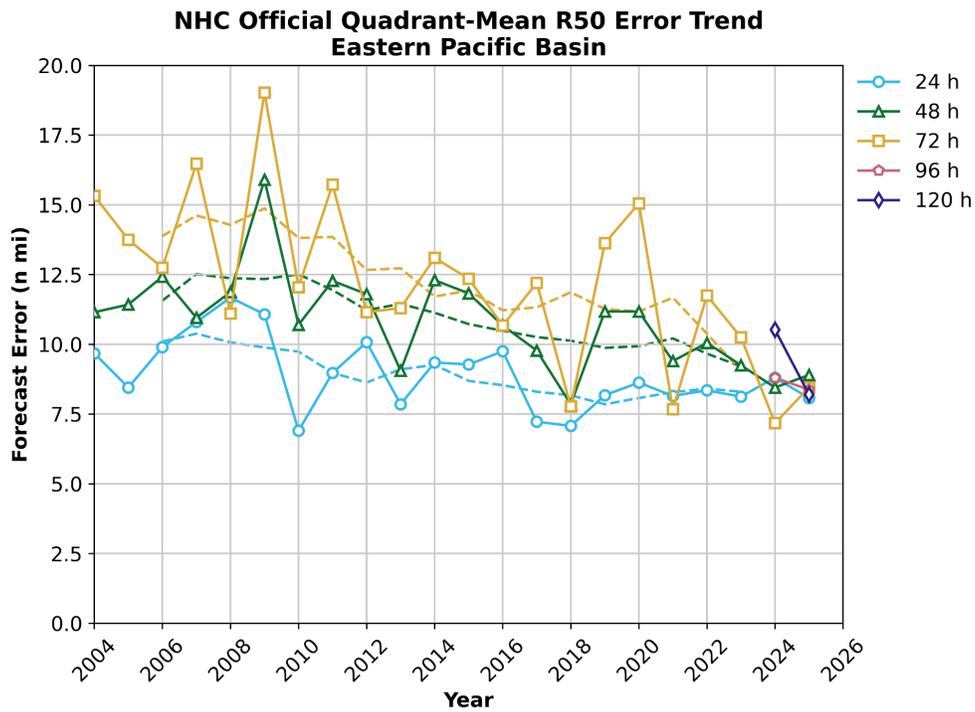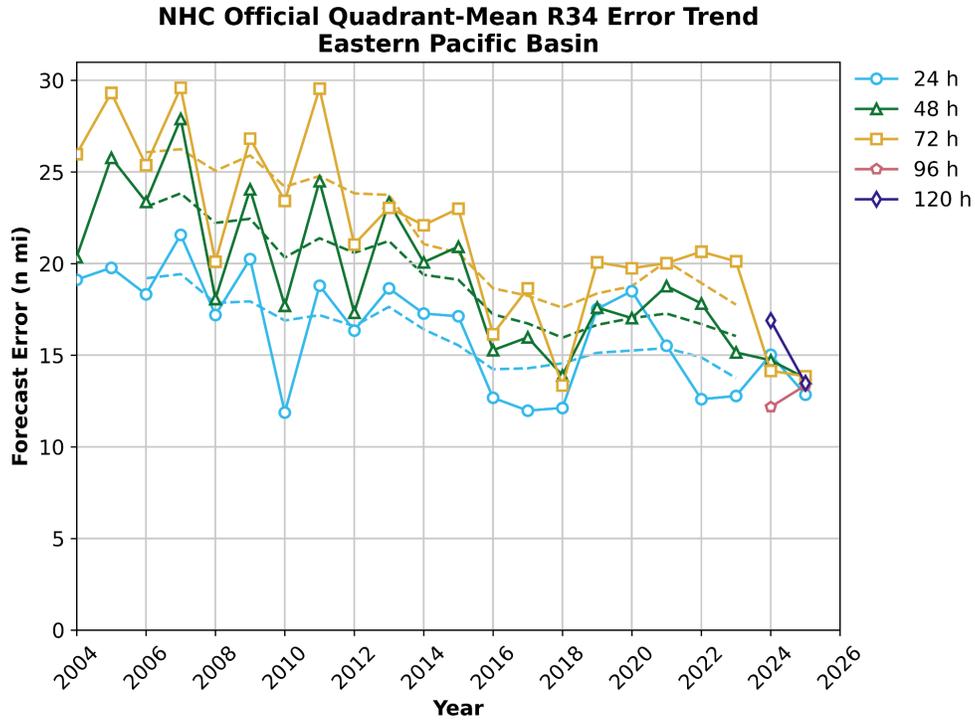
Figure 46.   Recent trends in NHC 34- (top) and 50-kt (bottom) wind radii official forecast error for the eastern North Pacific basin. The results represent a quadrant average. Dashed lines represent 5-yr running means.
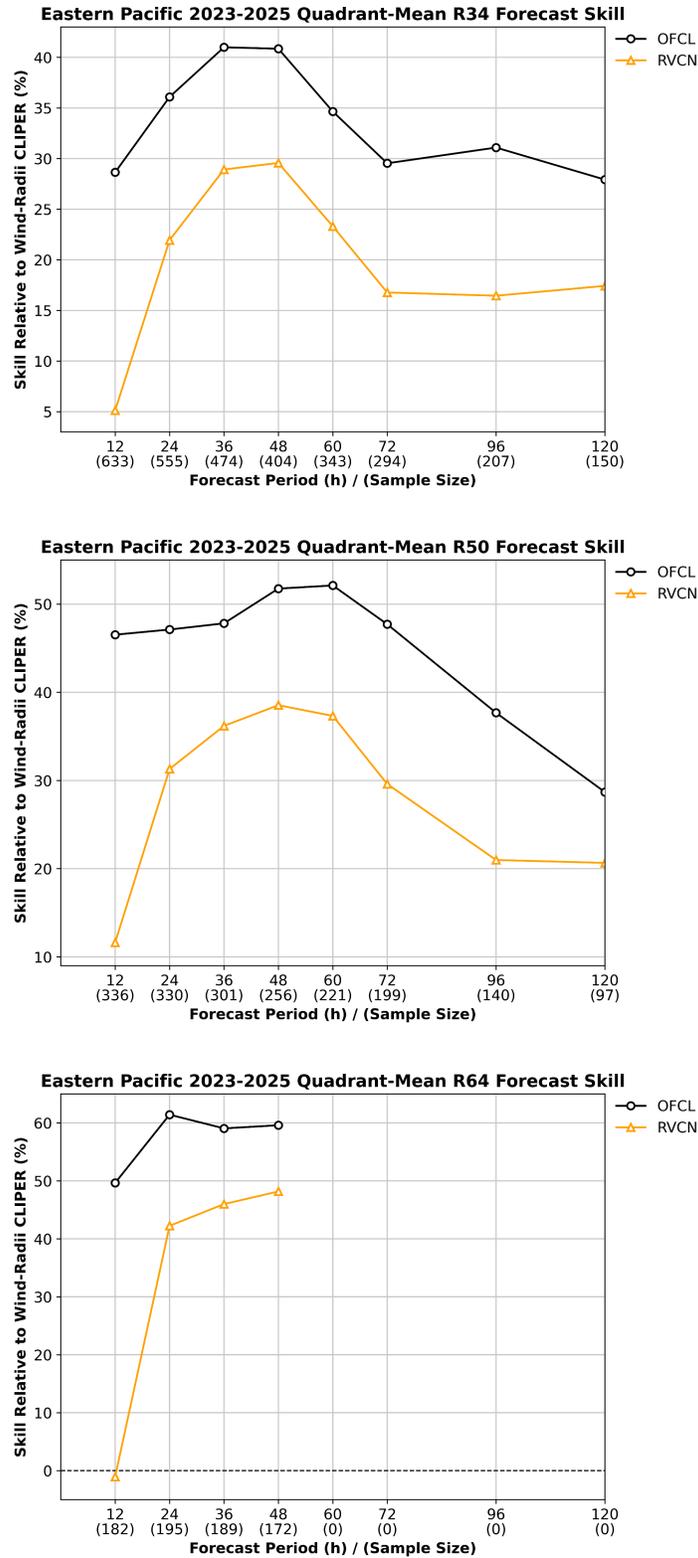
Figure 47.   Quadrant-mean skill of NHC and RVCN for the 34-kt (top), 50-kt (middle), and 64-kt (bottom) wind radii forecasts for the eastern North Pacific basin from 2023-2025.
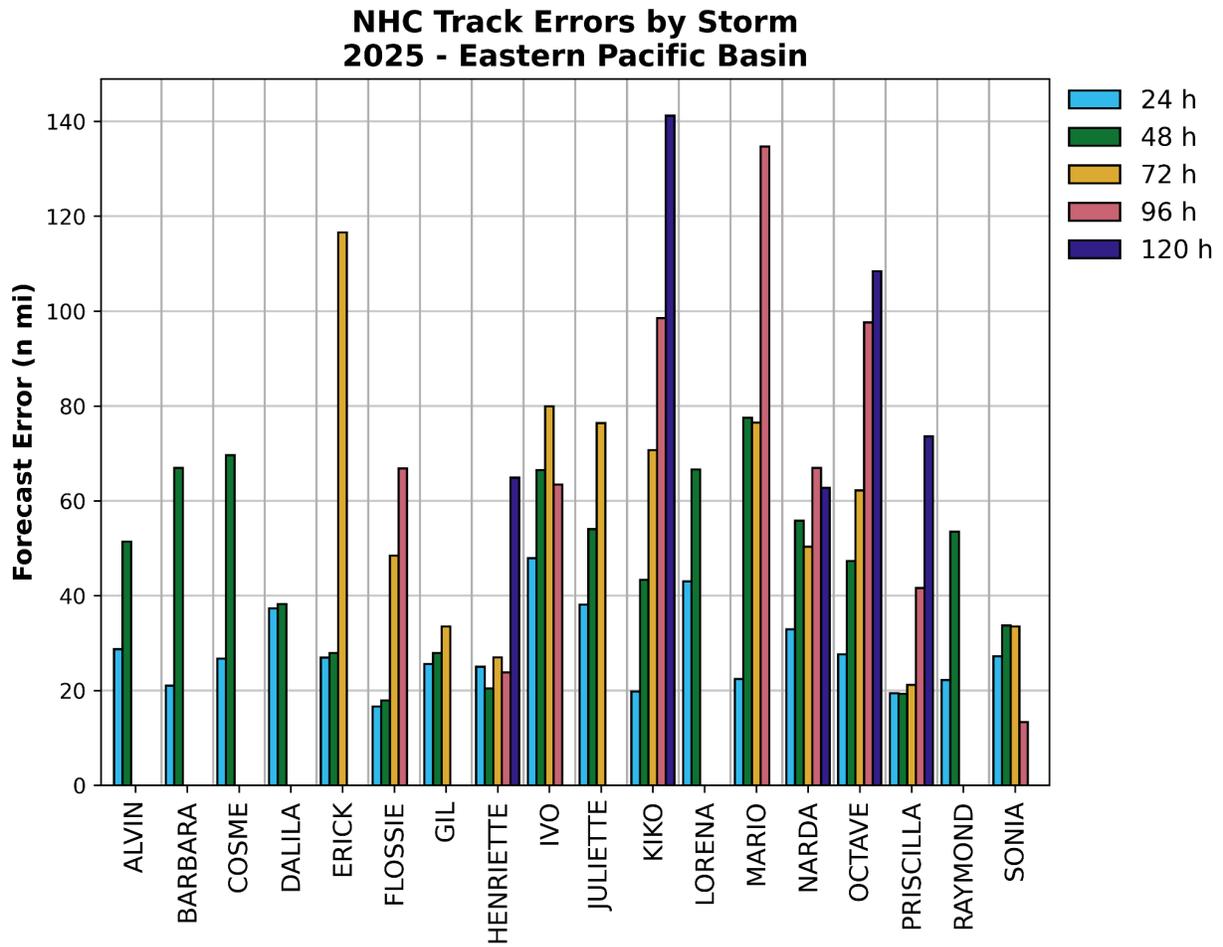
NHC Track Errors by Storm
2025 - Eastern Pacific Basin

Figure 48.   2025 NHC eastern North Pacific official track errors by tropical cyclone at 24, 48, 72, 96, and 120 h.
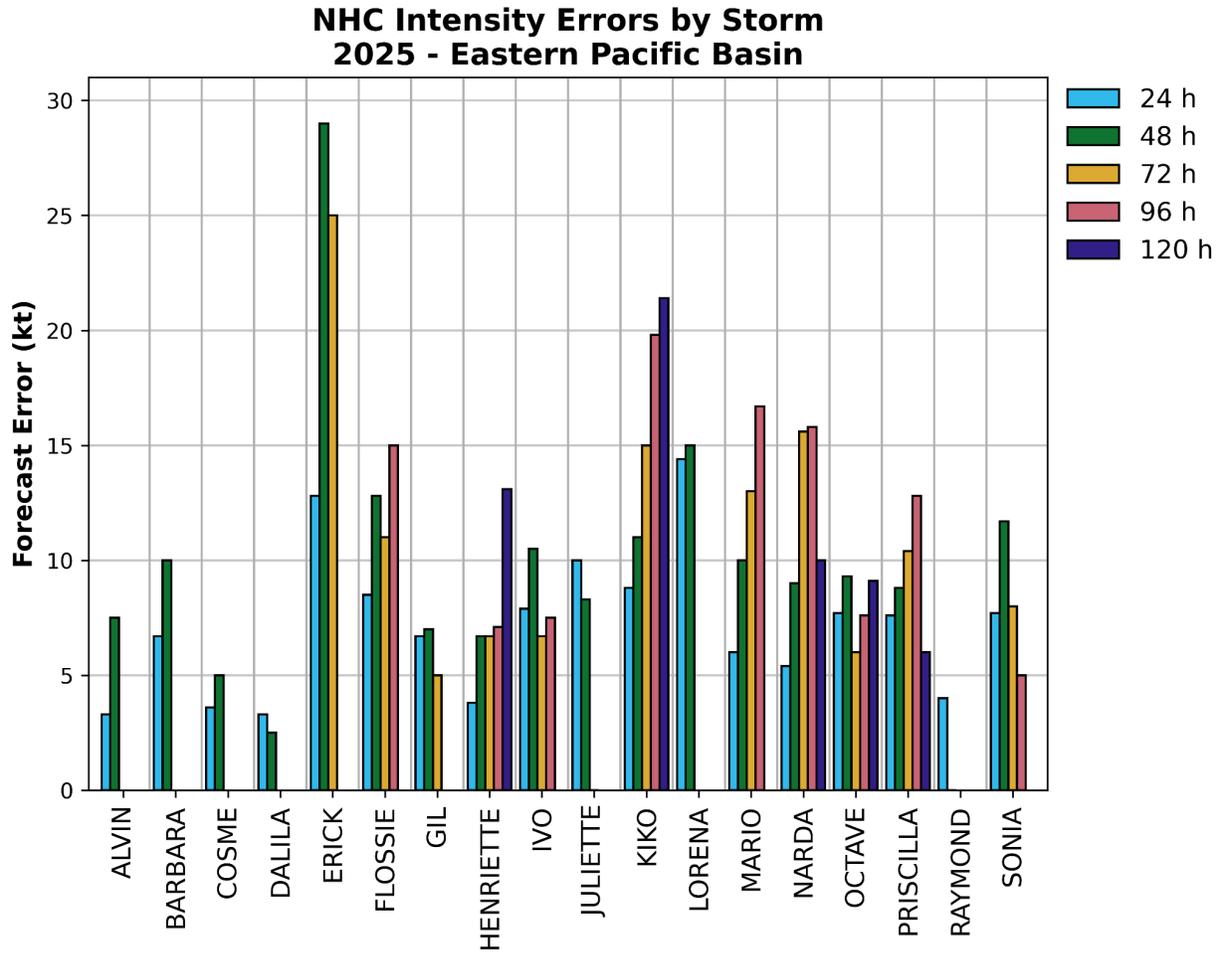
Figure 49.   2025 NHC eastern North Pacific official intensity errors by tropical cyclone at 24, 48, 72, 96, and 120 h.
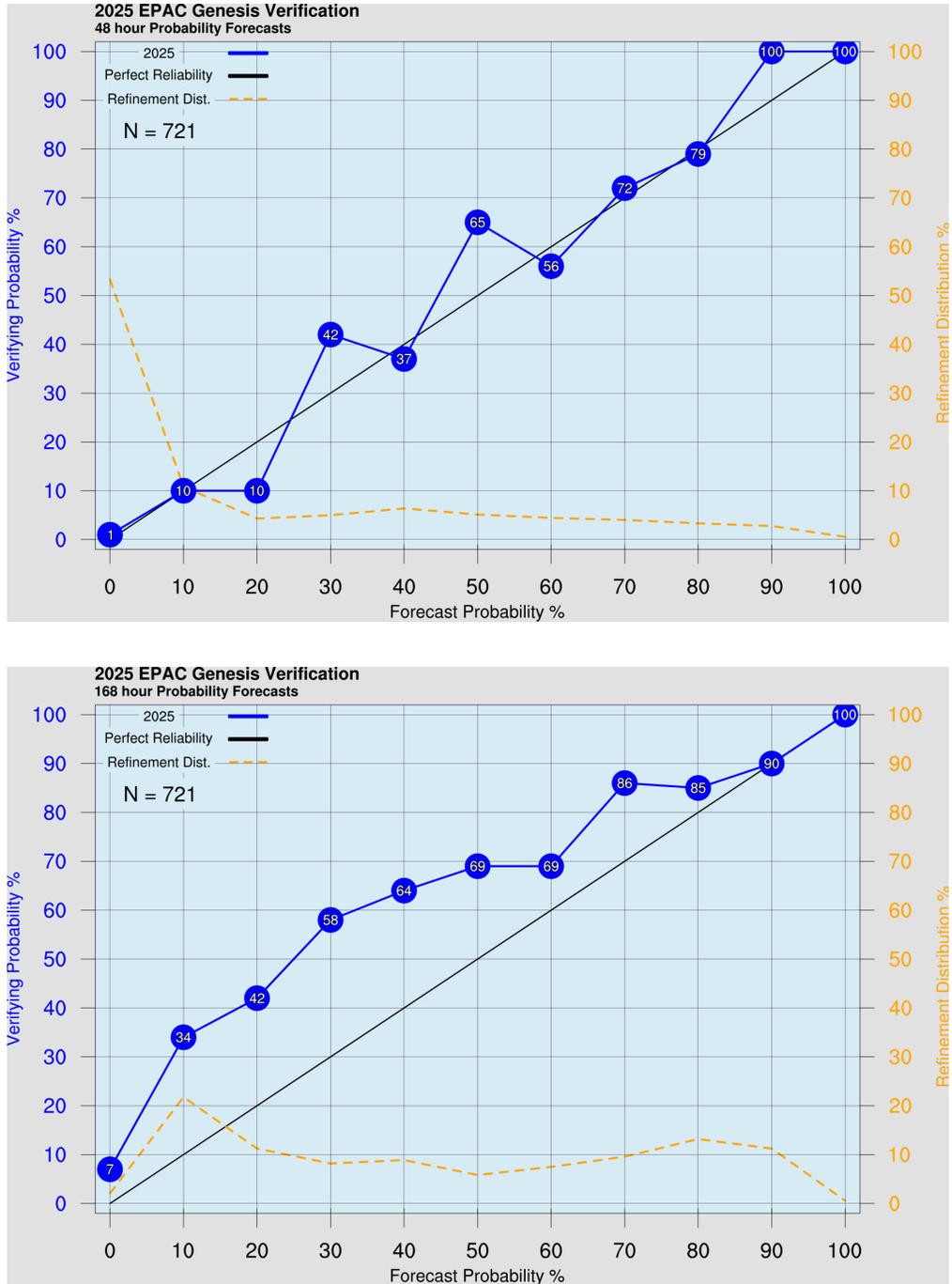
Figure 50.   Reliability diagram for East Pacific probabilistic tropical cyclogenesis 48-h (top) and 168-h (bottom) forecasts for 2025. The lines indicate the relationship between the forecasts and verifying genesis percentages, with perfect reliability indicated by the thin diagonal black line. The dashed line represents how the forecasts were distributed among the possible forecast values.

2025 East Pacific All 7-day Tropical Weather Outlook Areas and TC Genesis Locations (black circles)
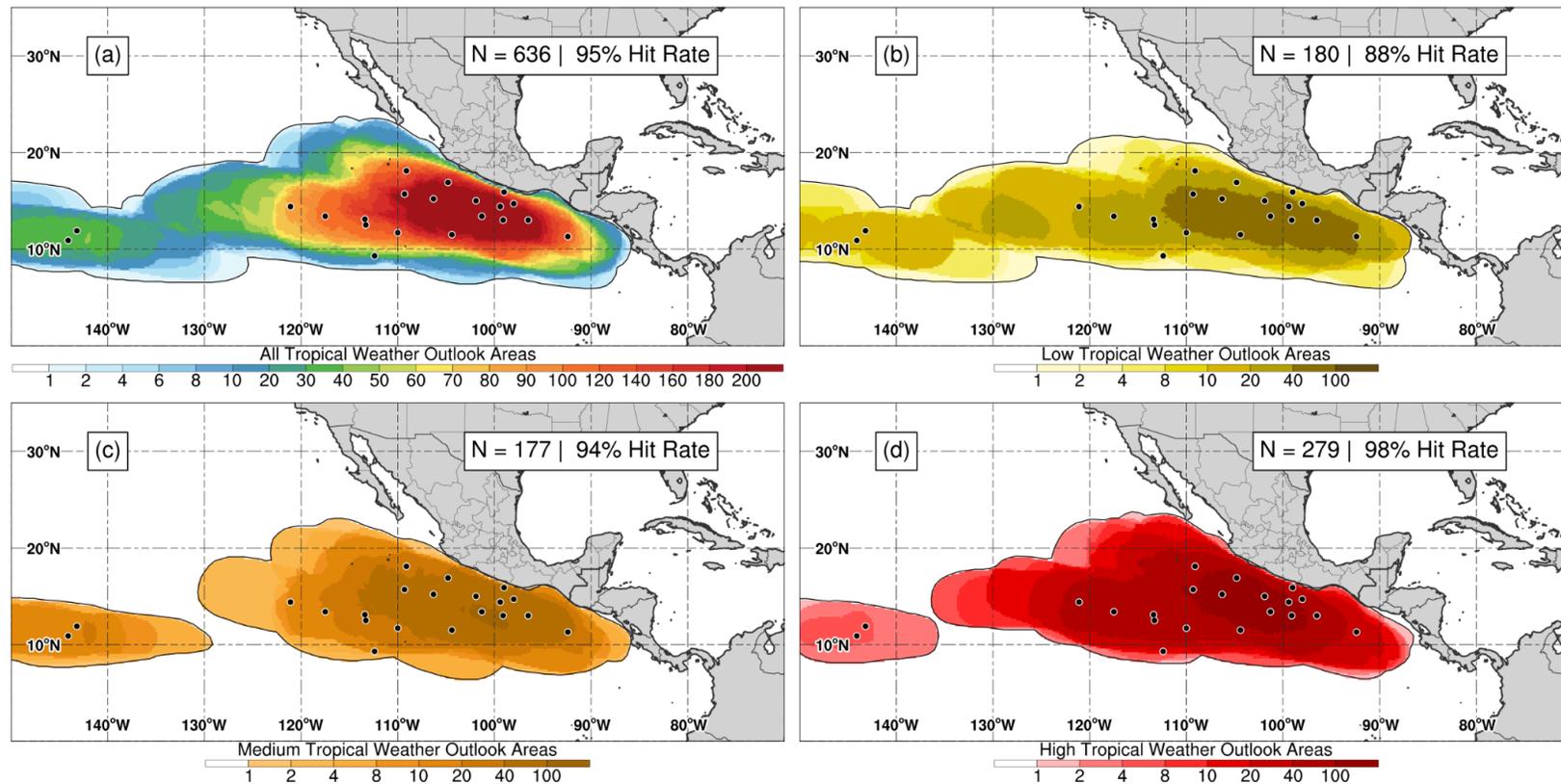

Figure 51.   Composites of 7-day tropical cyclone genesis areas depicted in NHC's Tropical Weather Outlooks for the East Pacific basin during the 2025 season for (a) all probabilistic genesis categories, (b) low (<40% category), (c) medium (40–60%) category, and (d) high (> 60% category).

2025 East Pacific Tropical Weather Outlook Area Difference Vs. (2015-2024 avg)
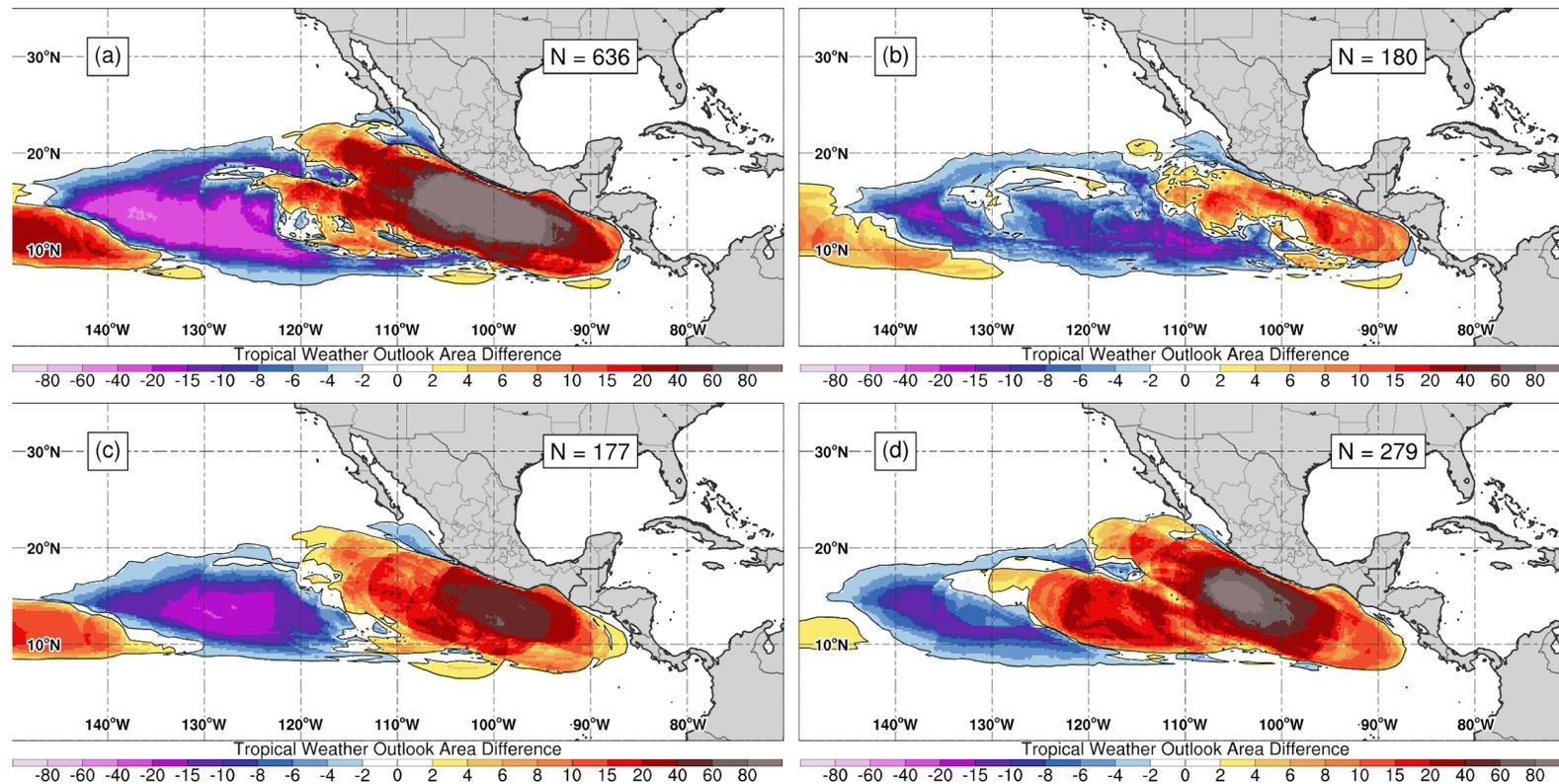

Figure 52.   Difference of 7-day tropical cyclone genesis areas in the East Pacific 2025 season vs the 2015-2024 mean for (a) all probabilistic genesis categories, (b) low (<40% category), (c) medium (40–60%) category, and (d) high (> 60% category).
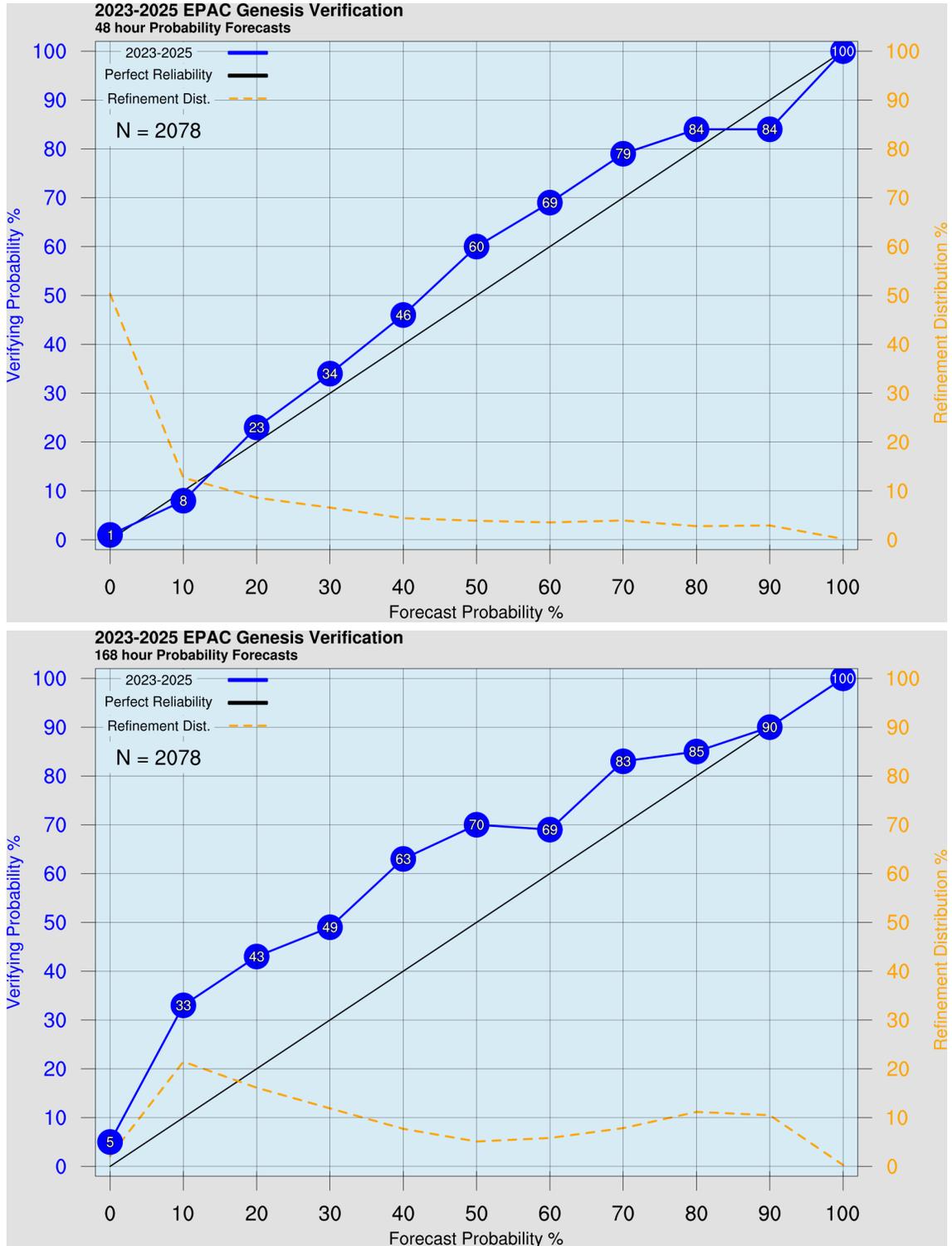
Figure 53.   As described for Fig. 50, except for the 2023–2025 period.