NATIONAL HURRICANE CENTER FORECAST VERIFICATION REPORT

2017 HURRICANE SEASON

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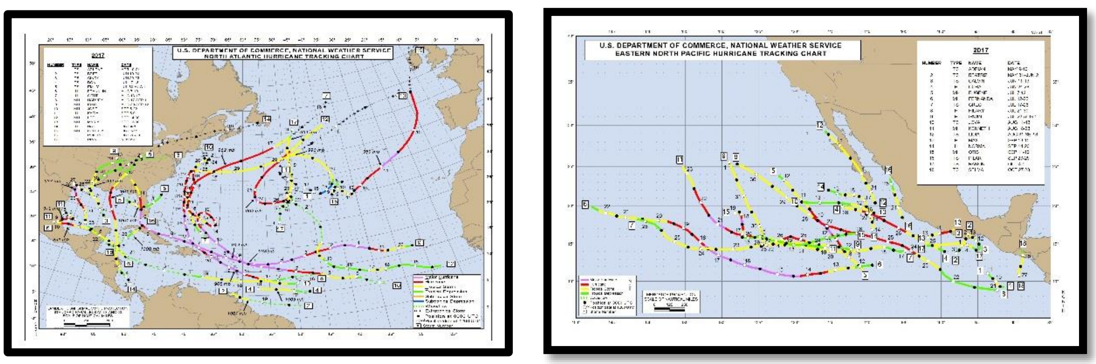

2017 HURRICANE SEASON TRACK MAP OF THE ATLANTIC BASIN (LEFT) AND THE EASTERN NORTH PACIFIC BASIN (RIGHT).[1]

ABSTRACT

The 2017 Atlantic hurricane season had above-normal activity, with 407 official forecasts issued. The mean NHC official track forecast errors in the Atlantic basin were smaller than the previous 5-yr means at all forecast times. The official track forecasts were quite successful in 2017, with records for track accuracy set at all forecast times. However, these track forecasts were slightly beaten by the consensus models. EMXI was the best-performing individual model, followed by EGRI and UEMI. GFSI, AEMI, HWFI, and CMCI were fair performers while CTCI and NVGI performed less well. The Government Performance and Results Act of 1993 (GPRA) track goal was met.

Mean official intensity errors for the Atlantic basin in 2017 were above the 5-yr means from 12 to 48 h, but near the means at the longer lead times. Decay-SHIFOR errors in 2017 were notably higher than their 5-yr means at most forecast times. The official forecasts were quite skillful, but they were slightly beaten by some of the consensus aids. No records for intensity accuracy were set in 2017. Among the guidance, FSSE, IVCN, and HCCA were the best performers. HWFI was the best individual model, and CTCI showed increased skill with forecast time. LGEM, HMNI, and

[1] Orginal report date 9 May. This update corrected a typo in Table 1.

DSHP were fair performers while the global models lagged behind. The GPRA intensity goal was just missed.

There were 334 official forecasts issued in the eastern North Pacific basin in 2017, although only 86 of these verified at 120 h. This level of forecast activity was near average. No records for track accuracy were set in this basin in 2017. The official track forecasts were very skillful, but they were outperformed by HCCA and TVCE at some forecast times. EMXI and AEMI were the next best models, followed by HWFI, GFSI, EGRI, and UEMI.

For intensity, the official forecast errors in the eastern North Pacific basin were lower than the 5-yr means at all forecast times, and they were significantly lower than the 5-yr means at the longer lead times. Decay-SHIFOR errors in 2017 were also notably lower than their 5-yr means, indicating the season's storms were easier than average to predict. Records for intensity accuracy were set at 96 and 120 h. The official forecasts were more skillful than the models at 12 h and 120 h, but were beaten by HCCA, HWFI, and IVCN at some of the other forecast times. DSHP and LGEM were fair performers, while GFSI and EMXI were not skillful.

An evaluation of track performance during the 2015-17 period in the Atlantic basin indicates that HCCA was the best-performing model at all forecast times. FSSE and TVCA were close to HCCA early, and EMXI was one of the best-performing models from 72 to 120 h. The official track forecasts for the 3-yr sample had skill that was quite close to the best aids throughout the forecast period. For intensity in the Atlantic basin, the official track forecasts have performed well, but they were beaten by FSSE, HCCA, and IVCN at several time periods.

A three-year evaluation from 2015-17 in the eastern North Pacific indicates that the official track forecasts were very skillful, and they had skill levels close to the consensus models. Regarding intensity, the official forecasts during the 3-yr sample performed as good as or better than the consensus models in that basin.

Quantitative probabilistic forecasts of tropical cyclogenesis are expressed in 48 and 120 h time frames in 10% increments and in terms of categories ("low", "medium", or "high"). In the Atlantic basin, results from 2017 indicate that the 48-h probabilistic forecasts were quite reliable and well calibrated at most probabilities. The 120-h probabilities had a slight low bias (under-forecast) at the low probabilities. In the eastern North Pacific basin, the 48-h probabilistic forecasts were well calibrated at probabilities higher than 50 percent, but had a low bias at probabilities of 50 percent and lower. A low bias was present at most 120-h probabilities.

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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 48 h in the Atlantic and eastern North 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, 72, 96, and 120 h after the forecast's nominal initial time (0000, 0600, 1200, or 1800 UTC)[2]. 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[3]) 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[4]. 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[5]. 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)[6]. 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[7]. 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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[2] 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.

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

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

[5] 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.

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

[7] 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.[8]

Forecast intensity 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 and 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're probably less useful for interpreting forecast performance with smaller samples (e.g., for a single storm).

The trajectory-CLIPER (TCLP) model is an alternative to the CLIPER and SHIFOR models for providing baseline track and intensity forecasts (DeMaria, personal communication). The input to TCLP [Julian Day, initial latitude, longitude, maximum wind, and the time tendencies of position and intensity] is the same as for CLIPER/SHIFOR, but rather than using linear regression to predict the future latitude, longitude and maximum wind, a trajectory approach is used. For track, a monthly climatology of observed storm motion vectors was developed from a 1982-2011 sample. The TCLP storm track is determined from a trajectory of the climatological motion vectors starting at the initial date and position of the storm. The climatological motion vector is modified

[8] 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.

by the current storm motion vector, where the influence of the current motion vector decreases with time during the forecast. A similar approach is taken for intensity, except that the intensity tendency is estimated from the logistic growth equation model (LGEM) with climatological input. Similar to track, the climatological intensity tendency is modified by the observed tendency, where the influence decreases with forecast time. The track used for the TCLP intensity forecast is the TCLP track forecast. When the storm track crosses land, the intensity is decreased at a climatological decay rate. A comparison of a 10-yr sample of TCLP errors with those from CLIPER5 and DSHIFOR5 shows that the average track and intensity errors of the two baselines are within 10% of each other at all forecast times out to five days for the Atlantic and eastern North Pacific. One advantage of TCLP over CLIPER5/DSHIFOR5 is that TCLP can be run to any desired forecast time.

NHC also issues forecasts of the size of tropical cyclones; these "wind radii" forecasts are estimates of the maximum extent of winds of various thresholds (34, 50, and 64 kt) expected in each of four quadrants surrounding the cyclone. Unfortunately, there is insufficient surface wind information to allow the forecaster to accurately analyze the size of a tropical cyclone's wind field. As a result, post-storm best track wind radii are likely to have errors so large as to render a verification of official radii forecasts unreliable and potentially misleading; consequently, no verifications of NHC wind radii are included in this report. In time, as our ability to measure the surface wind field in tropical cyclones improves, it may be possible to perform a meaningful verification of NHC wind radii forecasts.

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[9]. 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

9 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 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.[10]

A list of models is given in Table 1. 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 other 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 FSU "super-ensemble", for example, combines its individual components on the basis of past performance and attempts to correct for biases in those components (Williford et al. 2003). A consensus model that considers past error characteristics can be described as a "weighted" or "corrected" consensus. Additional 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. Note that this verification does not include forecasts made for potential tropical cyclones, which NHC began issuing forecasts for in 2018. These statistics are based on forecast and best track data sets taken from the Automated Tropical Cyclone Forecast (ATCF) System[11] on 9 April 2018 for the Atlantic basin, and on 3 April 2018 for the eastern North Pacific basin. Verifications for the Atlantic and eastern North Pacific basins are given in Sections 2 and 3 below, respectively. Section 4 discusses NHC's probabilistic genesis forecasts. Section 5 summarizes the key findings of the 2017 verification and previews anticipated changes for 2018.

2. Atlantic Basin

a. 2017 season overview – Track

Figure 1 and Table 2 present the results of the NHC official track forecast verification for the 2017 season, along with results averaged for the previous 5-yr period, 2012-2016. In 2017, the NHC issued 407 Atlantic basin tropical cyclone forecasts[12], a number well above the long-term average of 319 (Fig. 2). This was the highest number of forecasts issued for the Atlantic

[10] The UKM and EMX models are only available through 120 h twice a day (at 0000 and 1200 UTC). Consequently, roughly half the interpolated forecasts from these models are 12 h old.
[11] In ATCF lingo, these are known as the "a decks" and "b decks", respectively.
[12] This count does not include forecasts issued for systems later classified to have been something other than a tropical cyclone at the forecast time.

basin since 2012. Mean track errors ranged from 21 n mi at 12 h to 156 n mi at 120 h. The mean official track forecast errors in 2017 were smaller than the previous 5-yr means at all forecast times, by up to 24%. The CLIPER errors for 2017 were slightly lower than average, indicating that the season's storms were a little easier to forecast than normal. Records for accuracy were set at all time periods, and in fact, the errors were about 15% lower than the previous records at some forecast periods. The official track forecast vector biases were east-southeasterly (i.e., the official forecast tended to fall to the east or southeast of the verifying position) at all forecast periods, and the biases increased with time. Track forecast skill ranged from 49% at 12 h to 73% at 48 h (Table 2). The track errors in 2017 decreased from the 2016 values, and over the past 25 years or so, the 24−72-h track forecast errors have been reduced by 70 to 75% (Fig. 3). Track forecast error reductions of about 60% have occurred over the past 15 years or so for the 96- and 120-h forecast periods. Figure 4 indicates that on average the NHC track errors decrease as the initial intensity of a cyclone increases. This trend is most notable between tropical depressions/weak tropical storms and strong tropical storms.

Note that the mean official error in Fig. 1 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 "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 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 Fig. 1 contain both true analysis error and representativeness error.

Table 3a presents a homogeneous[13] verification for the official forecast along with a selection of early models for 2017. In order to maximize the sample size, a guidance model had to be available at least two-thirds of the time at both 48 and 120 h to be included in this comparison. The performance of the official forecast and the early track models in terms of skill are presented in Fig. 5. The figure shows that the official forecasts were highly skillful, but they were slightly bested by the consensus model HCCA at all forecast times. TVCA and FSSE also had slightly lower errors than the official forecasts at several time periods. Among the individual models, EMXI was the best-performing model, and it had only slightly lower skill than the official forecasts and the consensus aids at all time periods. EGRI and UEMI were the next best models, and these aids were very competitive with EMXI through 36 h. However, their skill trailed slightly beyond that forecast time. GFSI, AEMI, and HWFI were fair performers, and CMCI had similar skill levels with this group of models for a few forecast time periods. CTCI, HMNI, and NVGI were the poorest-performing dynamical models in 2017. In fact, these models were outperformed by the simple TABM and TABS models from 72 to 120 h. An evaluation over the three years 2015-17 (Fig. 6) indicates that HCCA was the best-performing model at all forecast times. FSSE and TVCA performed close to HCCA in the short term, and EMXI had skill values very near HCCA from 48 to 120 h. The official forecast had skill that was quite close to the best aids throughout

[13] 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.

the forecast period. EGRI, GFSI, AEMI, and HWFI were strong performers and made up the next best models. CMCI and NVGI performed less well.

Vector biases of the guidance models for 2017 are given in Table 3b. The table shows that the official forecast had similar biases to the consensus aids. Much of the guidance, like the official forecast, had an east or southeast bias at most forecast time periods.

A separate homogeneous verification of the primary consensus models for 2017 is shown in Fig. 7. The figure shows that the skill of HCCA, FSSE, and TVCX were similar to one another. TVCA and GFEX were not quite as good, as they had skill values a few percent lower than the best consensus models. UEMI had less skill, but it was competitive with the consensus aids in the short term while AEMI was not competitive.

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 2017, the GPRA goal was 68 n mi and the verification for this measure was 56.4 n mi.

b. 2017 season overview – Intensity

Figure 8 and Table 4 present the results of the NHC official intensity forecast verification for the 2017 season, along with results averaged for the preceding 5-yr period. Mean forecast errors in 2017 ranged from 6 kt at 12 h to 14 kt at 96 and 120 h. These errors were 10 to 15% higher than the 5-yr means from 12 to 48 h, but close to the 5-yr means from 72 to 120 h. No records for accuracy were set in 2017. The official forecasts had a slight low bias (under-forecast) that became more pronounced with forecast time. Decay-SHIFOR5 errors were well above their 5-yr means, by up to 30%, at all times, implying that the season's storms were challenging to predict. Figure 9 shows that the NHC official errors increased from the 2016 values from 24 to 72 h, but decreased at the 96- and 120-h forecast times. Despite the year-to-year variability, there has been a notable decrease in error that began at the start of the decade. Over the long term, the intensity predictions are gradually improving as the forecasts are generally more skillful in the current decade than they were in the previous one.

Table 5a presents a homogeneous verification for the official forecasts and the primary early intensity models for 2017. Intensity biases are given in Table 5b, and forecast skill is presented in Fig. 10. The official forecasts were quite skillful, but they were beaten by FSSE at all forecast time periods and by TVCA and HCCA at most forecast time periods. Among the individual models, HWFI was the strongest performer and it had skill close to the official forecasts and some of the consensus models from 24 to 96 h. CTCI showed increased skill with forecast time and was competitive with the best guidance from 72 to 120 h. LGEM and HMNI were fair performers with DSHP closely following. GFSI was skillful from 24 to 120 h, but it was not competitive with the guidance. EMXI was not skillful for this sample.

An inspection of the intensity biases (Table 5b) indicates that a majority of the models had a low bias in 2017, which is not surprising given the strong hurricanes that occurred. LGEM, DSHP, and CTCI had fairly notable low biases. Despite its only fair performance, HMNI had the smallest biases overall, and it had smaller biases than the official forecasts at a few time periods.

An evaluation over the three years 2015-17 (Fig. 11) indicates that the official forecasts have been consistently performing quite well, but they were outperformed by FSSE from 12 to 72 h and by HCCA from 48 to 120 h. Similar to 2017, HWFI was the best individual model, followed by LGEM and DSHP.

The 48-h official intensity error, evaluated for all tropical cyclones, is another GPRA measure for the NHC. In 2017, the GPRA goal was 12 kt and the verification for this measure was slightly higher, 12.6 kt.

c. Verifications for individual storms

Forecast verifications for individual storms are given in Table 6. Of note are the large track errors for Tropical Storm Lee at most forecast lead times. The large errors for that storm were associated with the regeneration of the system and its unusual path, which led to a difficult set of track forecasts. Conversely, the official track forecast errors were quite low for many of the tropical cyclones that affected the United States in 2017, including Hurricanes Harvey, Irma, Maria, and Jose. Figure 12 shows an illustration of the official track errors stratified by storm.

With regards to intensity, Hurricane Irma was one of the more challenging cyclones to predict in 2017. The official intensity forecast errors were higher than the 5-yr averages at all forecast times. The NHC forecasts during the early stages of Irma's lifecycle were too low because the extended period of rapid intensification was under-forecast. Conversely, the NHC forecasts did not expect Irma to interact with Cuba as much as it did, and consequently, Irma weakened more than expected when it was near that island. Figure 13 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=2017&basin=atl**

3. Eastern North Pacific Basin

a. 2017 season overview – Track

The NHC track forecast verification for the 2017 season in the eastern North Pacific, along with results averaged for the previous 5-yr period, are presented in Figure 14 and Table 7. There were 334 forecasts issued for the eastern Pacific basin in 2017, although only 86 of these verified at 120 h. This level of forecast activity is very near the long-term average of 331 (Fig. 15). Mean track errors ranged from 21 n mi at 12 h to 136 n mi at 120 h. These errors were slightly lower than the 5-yr means from 12 to 36 h and 96 and 120 h, but slightly higher than the 5-yr means at the other forecast times. The CLIPER5 errors were 10 to 15% lower than its 5-yr means, indicating that the season's storms were a little easier to forecast than average, likely due to relatively few recurving storms in 2017. No records for accuracy were set in this basin in 2017. The official track forecast vector biases were small at all lead times and mainly north-northeastward.

Figure 16 shows recent trends in track forecast accuracy and skill for the eastern North Pacific. Errors have been reduced by 60-70% for the 24 to 72 h forecasts since 1990, though there has been little change in the errors during the past few years. Similar improvements have been made for the 96 and 120 h forecasts since 2001. Forecast skill in 2017 decreased slightly from 2016, and there has been little trend during the past few years. However, the longer term trend shows a significant increase in skill over the past couple of decades.

Table 8a presents a homogeneous verification for the official forecast and the early track models for 2017, with vector biases of the guidance models given in Table 8b. Skill comparisons of selected models are shown in Fig. 17. The official forecasts were very skillful and were near the best models, the consensus aids. HCCA and TVCE were the only models that beat the official forecasts, and even these models had errors that were only slightly lower than the official forecast at some time periods. EMXI and AEMI were the next best models and had skill values about 5 to 10% lower than official forecast and the consensus models. HWFI, GFSI, EGRI, and UEMI were fair performers while NVGI and CMCI lagged behind. In fact, NVGI and CMCI had less skill than the simple TAB models beyond 48 h. An evaluation of the three years 2015-17 (Fig. 18) indicates that the official forecasts were very skillful, and they were near or better than the consensus models. Among the individual models, EMXI was the best performer, closely followed by AEMI, GFSI, and HWFI. The official forecasts had similar biases to TVCE and HCCA. Most of the global models, including GFSI, EGRI, NVGI, and CMCI had larger track biases than the official forecasts.

A separate verification of the primary consensus aids is given in Figure 19. The skill of the consensus models was tightly clustered with HCCA, edging out the other models from 12 to 36 h, and also at 96 and 120 h. AEMI was competitive with the consensus models from 72 to 120 h, but UEMI had considerably less skill.

b. 2017 season overview – Intensity

Figure 20 and Table 9 present the results of the NHC eastern North Pacific intensity forecast verification for the 2017 season, along with results averaged for the preceding 5-yr period. Mean forecast errors were 5 kt at 12 h and increased to 12 kt at 72 and 120 h. The errors were about 5 to 10% lower than the 5-yr means from 12 to 48 h, and around 20 to 30% lower than the 5-yr means from 72 to 120 h. The DSHIFOR5 forecast errors were also significantly lower than its 5-yr means, indicative that the season's storms were easier than normal to predict. Records for accuracy were set at 96 and 120 h in 2017. A review of error and skill trends (Fig. 21) indicates that although there is considerable year-to-year variability in intensity errors, there has been a slight decrease in error over the past couple of decades at 48 h and beyond. No trend, however, is apparent for 24 h. Forecast skill has changed little during the past 6 or 7 years. Intensity forecast biases were slightly high (over-forecast) and increased with forecast lead time.

Figure 22 and Table 10a present a homogeneous verification for the primary early intensity models for 2017. Forecast biases are given in Table 10b. The official forecasts outperformed the models at 12 h, but were beaten by the best-performing models IVCN and HCCA from 24 to 48 h, and IVCN also beat the official forecasts at 72 and 96 h. Among the individual models, HWFI was a strong performer early, and it had lower errors than the official forecasts at 24 and 36 h, but its skill dropped sharply beyond that time. DSHP and LGEM were fair performers and although they had notably less skill than the consensus aids early, these models were among the better-performing models at the longer lead times. GFSI and EMXI were not skillful for this sample. Most of the models had little bias for the 2017 storms with the exception of LGEM, which had a notable low bias at most forecast times. An evaluation over the three years 2015-17 (Fig. 23) indicates that the official forecast had skill levels close to or slightly better than the consensus aids. HCCA was the best-performing model through 48 h, and IVCN was the best model at the longer lead times. HWFI, DSHP, and LGEM were fair performers, and they had skill values close to one another. GFSI had little skill and EMXI was not skillful.

c. Verifications for individual storms

Forecast verifications for individual storms are given for reference in Table 11. 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=2017&basin=epac.

4. Genesis Forecasts

The NHC routinely issues Tropical Weather Outlooks (TWOs) 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. Since 2007, forecasters subjectively assigned a probability of genesis (0 to 100%, in 10% increments) to each area of disturbed weather described in the TWO, where the assigned probabilities represented the forecaster's determination of the chance of tropical cyclone formation during the 48-h period following the nominal TWO issuance time. In 2009, the NHC began producing in-house (non-public) experimental probabilistic tropical cyclone forecasts through 120 h, which became public in August of 2013. 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 outlook for the Atlantic and eastern North Pacific basins for 2017 are given in Table 12 and illustrated in Fig. 24. In the Atlantic basin, a total of 624 genesis forecasts were made. These 48-h forecasts were quite reliable and generally well calibrated at most probabilities. In the eastern Pacific, a total of 574 genesis forecasts were made. The forecasts had a low bias at probabilities of 50 percent and lower, but were fairly well calibrated at probabilities higher than 50 percent.

Verification of the 120-h outlook for the Atlantic and eastern North Pacific basins for 2017 are given in Table 13 and illustrated in Fig. 25. In the Atlantic basin, the 120-h forecasts were generally well calibrated, but there was a slight low bias at the low probabilities. In the eastern North Pacific, a slight low bias was noted at most probabilities. The diagrams also show the refinement distribution, which indicates how often the forecasts deviated from (a perceived) climatology. Sharp peaks at climatology indicate low forecaster confidence, while maxima at the extremes indicate high confidence; the refinement distributions shown here suggest an intermediate level of forecaster confidence.

5. Looking Ahead to 2018

a. Track Forecast Cone Sizes

The National Hurricane Center 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 2018 for the Atlantic and eastern North Pacific basins (based on error distributions for 2013-17) are given in Table 14. In the Atlantic basin, the cone circles will be smaller (by up to 11%) at all forecast time periods. In the eastern Pacific basin, the cone circles will change little through 72 h, but will be slightly larger (by up to 8%) at 96 and 120 h.

b. Consensus Models

In 2008, NHC changed the nomenclature for many of its consensus models. The new system defines a set of consensus model identifiers that remain fixed from year to year. The specific members of these consensus models, however, will be determined at the beginning of each season and may vary from year to year.

Some consensus models require all of their member models to be available in order to compute the consensus (e.g., TCOA), while others are less restrictive, requiring only two or more members to be present (e.g., TVCA). The terms “fixed” and “variable” can be used to describe these two approaches, respectively. In a variable consensus model, it is often the case that the 120-h forecast is based on a different set of members than the 12-h forecast. While this approach greatly increases availability, it does pose consistency issues for the forecaster.

The consensus model composition for 2018 is given in Table 15. An analysis of HMNI’s performance suggests that adding that model to the IVCN and ICON consensus aids should improve those models, and therefore, HMNI is being included in the intensity consensus models for 2018. In addition, for 2018 EMNI and HMNI are being added to the multi-model track consensus for the east Pacific (TVCE).

Two new consensus aids are being created for 2018. A track consensus model (TVDG) that includes a double-weight of GFSI, EMXI, and EGRI and normal weight for regional models CTCI and HWFI is new for 2018. Similarly, a new intensity consensus model (IVDR) that includes a double-weight for CTCI, HWFI, HMNI, and normal weight for GFSI, DSHP, and LGEM will be available in 2018.

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List of Tables

Table 1. National Hurricane Center forecasts and models.

ID	Name/Description	Type	Timeliness (E/L)	Parameters forecast
OFCL	Official NHC forecast			Trk, Int
HWRF	Hurricane Weather and Research Forecasting Model	Multi-layer regional dynamical	L	Trk, Int
HMON	Hurricanes in a Multi-scale Ocean-coupled Non-hydrostatic model	Multi-layer regional dynamical	L	Trk, Int
GFSO	NWS/Global Forecast System (formerly Aviation)	Multi-layer global dynamical	L	Trk, Int
AEMN	GFS ensemble mean	Consensus	L	Trk, Int
UKM	United Kingdom Met Office model, automated tracker	Multi-layer global dynamical	L	Trk, Int
EGRR	United Kingdom Met Office model with subjective quality control applied to the tracker	Multi-layer global dynamical	L	Trk, Int
UEMN	UKMET ensemble mean	Consensus	L	Trk, Int
NVGM	Navy Global Environmental Model	Multi-layer global dynamical	L	Trk, Int
CMC	Environment Canada global model	Multi-level global dynamical	L	Trk, Int
NAM	NWS/NAM	Multi-level regional dynamical	L	Trk, Int
CTCX	COAMPS-TC using GFS initial and boundary conditions	Multi-layer regional dynamical	L	Trk, Int
EMX	ECMWF global model	Multi-layer global dynamical	L	Trk, Int
EEMN	ECMWF ensemble mean	Consensus	L	Trk

ID	Name/Description	Type	Timeliness (E/L)	Parameters forecast
TABS	Beta and advection model (shallow layer)	Single-layer trajectory	E	Trk
TABM	Beta and advection model (medium layer)	Single-layer trajectory	E	Trk
TABD	Beta and advection model (deep layer)	Single-layer trajectory	E	Trk
CLP5	CLIPER5 (Climatology and Persistence model)	Statistical (baseline)	E	Trk
SHF5	SHIFOR5 (Climatology and Persistence model)	Statistical (baseline)	E	Int
DSF5	DSHIFOR5 (Climatology and Persistence model)	Statistical (baseline)	E	Int
OCD5	CLP5 (track) and DSF5 (intensity) models merged	Statistical (baseline)	E	Trk, Int
TCLP	Trajectory-CLIPER model	Statistical (baseline)	E	Trk, Int
SHIP	Statistical Hurricane Intensity Prediction Scheme (SHIPS)	Statistical-dynamical	E	Int
DSHP	SHIPS with inland decay	Statistical-dynamical	E	Int
OFCI	Previous cycle OFCL, adjusted	Interpolated	E	Trk, Int
HWFI	Previous cycle HWRF, adjusted	Interpolated-dynamical	E	Trk, Int
HMNI	Previous cycle HMON, adjusted	Interpolated-dynamical	E	Trk, Int
CTCI	Previous cycle CTCX, adjusted	Interpolated-dynamical	E	Trk, Int
GFSI	Previous cycle GFS, adjusted	Interpolated-dynamical	E	Trk, Int
UKMI	Previous cycle UKM, adjusted	Interpolated-dynamical	E	Trk, Int

ID	Name/Description	Type	Timeliness (E/L)	Parameters forecast
EGRI	Previous cycle EGRR, adjusted	Interpolated-dynamical	E	Trk, Int
NVGI	Previous cycle NVGM, adjusted	Interpolated-dynamical	E	Trk, Int
EMXI	Previous cycle EMX, adjusted	Interpolated-dynamical	E	Trk, Int
CMCI	Previous cycle CMC, adjusted	Interpolated-dynamical	E	Trk, Int
AEMI	Previous cycle AEMN, adjusted	Consensus	E	Trk, Int
UEMI	Previous cycle UEMN, adjusted	Consensus	E	Trk, Int
FSSE	FSU Super-ensemble	Corrected consensus	E	Trk, Int
GFEX	Average of GFSI and EMXI	Consensus	E	Trk
TCON	Average of EGRI, GFSI, and HWFI	Consensus	E	Trk
TCCN	Version of TCON corrected for model biases	Corrected consensus	E	Trk
TVCN	Average of at least two of GFSI EGRI HWFI EMXI CTCI	Consensus	E	Trk
TVCA	Average of at least two of GFSI EGRI HWFI EMXI CTCI	Consensus	E	Trk
TVCE	Average of at least two of GFSI EGRI HWFI EMXI CTCI HMNI EMNI	Consensus	E	Trk
TVCX	Average of at least two of EMXI (double weight) GFSI EGRI HWFI CTCI	Consensus	E	Trk
TVDG	Average of at least two of GFSI (double weight) EMXI (double weight) EGRI (double weight) CTCI HWFI	Consensus	E	Trk

ID	Name/Description	Type	Timeliness (E/L)	Parameters forecast
TVCC	Version of TVCN corrected for model biases	Corrected consensus	E	Trk
HCCA	Weighted average of AEMI, GFSI, CTCI, DSHP, EGRI, EMNI, EMXI,HWFI, LGEM	Corrected consensus	E	Trk, Int
ICON	Average of DSHP, LGEM, CTCI, HWFI, HMNI	Consensus	E	Int
IVCN	Average of at least two of DSHP LGEM HWFI CTCI HNMI	Consensus	E	Int
IVDR	Average of at least two of DSHP LGEM GFSI HWFI (double weight) CTCI (double weight) HMNI (double weight)	Consensus	E	Int

Table 2. Homogenous comparison of official and CLIPER5 track forecast errors in the Atlantic basin for the 2017 season for all tropical cyclones. Averages for the previous 5-yr period are shown for comparison.

	Forecast Period (h)						
	12	24	36	48	72	96	120
2017 mean OFCL error (n mi)	21.1	32.0	43.0	56.4	87.7	113.5	155.7
2017 mean CLIPER5 error (n mi)	41.6	92.7	150.5	206.2	299.7	387.0	453.1
2017 mean OFCL skill relative to CLIPER5 (%)	49.3	65.5	71.4	72.6	70.7	70.7	65.6
2017 mean OFCL bias vector (°/n mi)	091/003	096/007	095/012	099/019	107/037	115/045	140/050
2017 number of cases	376	341	309	280	227	185	156
2012-2016 mean OFCL error (n mi)	25.2	39.8	53.9	70.8	103.0	148.7	196.3
2012-2016 mean CLIPER5 error (n mi)	47.0	101.0	162.2	223.2	334.9	435.1	516.9
2012-2016 mean OFCL skill relative to CLIPER5 (%)	46.4	60.6	66.8	68.3	69.2	65.8	62.0
2012-2016 mean OFCL bias vector (°/n mi)	333/03	309/005	300/008	301/012	308/017	327/028	330/044
2012-2016 number of cases	1248	1108	975	848	635	484	379
2017 OFCL error relative to 2012-2016 mean (%)	-16.3	-19.6	-20.2	-20.3	-14.9	-23.7	-20.7
2017 CLIPER5 error relative to 2012-2016 mean (%)	-11.5	-8.2	-7.2	-7.6	-10.5	-11.1	-12.3

Table 3a. Homogenous comparison of Atlantic basin early track guidance model errors (n mi) for 2017. Errors smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	17.4	27.7	38.3	51.3	81.3	98.3	140.8
OCD5	37.5	87.7	140.4	191.8	290.6	385.2	452.8
GFSI	20.0	33.2	48.3	66.0	102.3	133.2	182.5
HMNI	23.2	39.6	57.8	81.8	134.6	150.7	167.9
HWFI	21.5	36.2	49.9	64.3	99.2	130.9	167.7
EMXI	17.7	29.9	40.7	53.0	84.5	114.7	160.5
CMCI	23.4	39.6	53.2	69.8	96.7	147.1	219.9
EGRI	18.2	29.9	41.1	54.9	91.5	130.6	177.9
NVGI	25.7	44.9	62.5	85.9	142.5	182.9	208.3
CTCI	20.9	37.2	54.8	74.2	117.3	156.3	203.7
AEMI	21.3	36.3	52.0	67.3	102.2	138.6	181.9
UEMI	18.3	30.8	43.2	58.3	92.8	132.6	179.3
FSSE	18.0	28.6	39.0	**49.5**	**77.0**	**92.5**	**138.2**
TVCA	**17.2**	**27.1**	**38.2**	**51.2**	**80.5**	103.3	**135.5**
HCCA	**16.7**	**27.2**	**37.6**	**49.8**	**79.9**	**94.2**	**135.8**
TABD	25.9	47.8	67.3	81.6	120.4	170.1	209.9
TABM	24.4	43.9	61.6	76.7	109.5	137.8	191.0
TABS	39.9	73.7	88.8	94.6	112.8	143.5	194.0
TCLP	38.9	89.5	144.7	197.9	297.3	362.6	408.0
# Cases	201	185	170	157	132	111	86

Table 3b. Homogenous comparison of Atlantic basin early track guidance model bias vectors (º/n mi) for 2017.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	063/003	082/006	097/010	101/016	112/026	107/038	130/046
OCD5	000/003	000/010	010/024	015/048	022/111	036/208	044/301
GFSI	033/004	058/005	081/009	087/012	085/031	081/066	089/065
HMNI	008/006	004/009	016/008	036/009	051/014	065/047	062/069
HWFI	031/007	032/011	044/011	056/008	099/011	086/038	070/062
EMXI	331/000	151/002	142/005	124/010	145/020	154/031	151/056
CMCI	291/002	011/004	030/012	039/021	037/037	039/077	047/132
EGRI	348/001	308/000	123/002	158/006	193/016	168/017	152/041
NVGI	328/006	326/006	020/004	078/013	096/040	081/068	050/060
CTCI	038/008	052/017	060/027	066/037	076/058	081/068	078/079
AEMI	021/002	051/004	073/008	080/012	084/031	074/074	076/088
UEMI	211/004	192/003	166/006	165/011	181/025	173/031	162/048
FSSE	106/005	123/009	136/015	148/021	153/030	125/049	117/067
TVCA	031/004	048/007	069/010	081/013	098/022	096/038	100/051
HCCA	117/004	121/009	127/014	131/018	141/028	131/043	126/047
TABD	050/003	061/009	052/010	049/009	083/028	062/073	077/061
TABM	322/005	327/004	322/004	175/004	083/026	082/062	096/058
TABS	283/019	248/024	227/024	192/025	167/020	115/049	114/055
TCLP	255/007	263/019	274/031	289/042	304/062	347/058	019/070
# Cases	201	185	170	157	132	111	86

Table 4. Homogenous comparison of official and Decay-SHIFOR5 intensity forecast errors in the Atlantic basin for the 2017 season for all tropical cyclones. Averages for the previous 5-yr period are shown for comparison.

	Forecast Period (h)						
	12	24	36	48	72	96	120
2017 mean OFCL error (kt)	6.1	8.7	11.0	12.6	13.3	14.0	14.4
2017 mean Decay-SHIFOR5 error (kt)	7.7	12.3	16.0	19.2	22.2	22.1	21.0
2017 mean OFCL skill relative to Decay-SHIFOR5 (%)	20.8	29.3	31.3	34.4	40.1	36.9	31.4
2017 OFCL bias (kt)	-0.1	-0.6	-1.4	-2.1	-3.1	-2.2	-2.4
2017 number of cases	376	341	309	280	227	185	156
2012-16 mean OFCL error (kt)	5.3	7.8	9.8	11.3	12.6	13.7	14.3
2012-16 mean Decay-SHIFOR5 error (kt)	6.8	10.2	12.7	14.8	17.3	18.4	20.3
2012-16 mean OFCL skill relative to Decay-SHIFOR5 (%)	22.1	21.6	22.8	23.6	27.2	25.5	29.6
2012-16 OFCL bias (kt)	-1.2	-1.3	-1.1	-0.8	-0.7	-0.4	0.5
2012-16 number of cases	1248	1108	975	848	635	484	379
2017 OFCL error relative to 2012-16 mean (%)	15.1	11.5	12.2	11.5	5.6	2.2	0.7
2017 Decay-SHIFOR5 error relative to 2012-16 mean (%)	13.2	20.6	26.0	29.7	28.3	20.7	3.4

Table 5a. Homogenous comparison of selected Atlantic basin early intensity guidance model errors (kt) for 2017. Errors smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	6.2	9.0	11.3	12.4	12.6	13.8	14.6
OCD5	7.9	12.9	16.7	19.0	21.1	22.1	20.9
HWFI	7.1	9.6	11.5	12.6	12.7	14.1	16.8
HMNI	7.6	10.5	12.5	12.9	13.9	15.7	17.0
DSHP	7.1	11.0	13.4	14.0	15.0	16.9	17.5
LGEM	7.0	10.5	13.1	13.6	13.9	15.2	15.6
IVCN	6.3	9.1	**11.1**	**11.7**	**11.7**	**12.8**	**14.1**
FSSE	**6.0**	**8.1**	**9.5**	**9.8**	**11.5**	**13.6**	**13.8**
HCCA	6.3	9.0	**11.1**	**11.5**	**12.2**	**12.8**	15.0
GFSI	8.6	12.2	14.9	17.0	18.8	20.8	19.8
EMXI	9.6	14.4	18.4	21.2	24.3	26.1	26.4
CTCI	8.0	10.9	13.8	14.7	13.8	**12.7**	16.0
TCLP	7.6	13.4	17.8	20.5	22.9	23.6	25.0
# Cases	280	261	242	224	188	147	128

Table 5b. Homogenous comparison of selected Atlantic basin early intensity guidance model biases (kt) for 2017. Biases smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	0.3	0.4	-0.4	-1.1	-2.2	-1.0	-0.7
OCD5	-0.7	-1.2	-2.5	-3.5	-5.4	-6.3	-10.1
HWFI	-1.8	-2.2	-2.9	-3.6	-2.4	**0.1**	2.0
HMNI	1.8	1.7	0.6	**-0.5**	**-0.6**	**0.4**	2.8
DSHP	-1.1	-1.9	-3.4	-5.2	-7.0	-5.8	-4.0
LGEM	-1.6	-3.4	-5.0	-6.1	-7.4	-7.7	-8.4
IVCN	-1.5	-2.9	-4.1	-5.1	-5.6	-4.5	-3.3
FSSE	**-0.2**	-0.7	-1.5	-2.3	-2.9	-2.3	-3.1
HCCA	-1.5	-3.2	-5.0	-5.1	-6.7	-5.9	-6.8
GFSI	-0.9	-1.1	-2.0	-2.8	-2.5	-1.3	-3.0
EMXI	**-0.2**	0.4	1.1	2.6	6.7	10.3	11.9
CTCI	-2.6	-4.9	-6.2	-6.6	-6.6	-5.6	-3.1
TCLP	-3.0	-6.7	-9.1	-10.4	-12.3	-14.7	-13.7
# Cases	280	261	242	224	188	147	128

Table 6. Official Atlantic track and intensity forecast verifications (OFCL) for 2017 by storm. CLIPER5 (CLP5) and SHIFOR5 (SHF5) forecast errors are given for comparison and indicated collectively as OCD5. The number of track and intensity forecasts are given by NT and NI, respectively. Units for track and intensity errors are n mi and kt, respectively.

Verification statistics for: AL012017 ARLENE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	8	4.7	6.7	8	1.3	1.3
012	6	52.1	138.1	6	7.5	11.0
024	2	85.3	301.8	2	10.0	24.5
036	0	-999.0	-999.0	0	-999.0	-999.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL022017 BRET

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	3	9.6	21.0	3	6.7	6.7
012	1	18.0	67.1	1	10.0	14.0
024	0	-999.0	-999.0	0	-999.0	-999.0
036	0	-999.0	-999.0	0	-999.0	-999.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL032017 CINDY

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	8	7.7	9.2	8	2.5	4.4
012	8	17.2	46.0	8	2.5	4.5
024	8	28.5	109.1	8	1.3	4.4
036	6	46.5	190.3	6	2.5	4.5
048	4	68.8	222.3	4	2.5	7.3
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL042017 FOUR

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	7	42.1	43.5	7	0.0	0.0
012	5	76.4	115.5	5	3.0	2.2
024	3	85.6	209.2	3	5.0	6.0
036	1	127.9	329.9	1	5.0	10.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL052017 DON

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	4	4.4	4.4	4	3.8	5.0
012	2	13.4	17.6	2	5.0	8.5
024	0	-999.0	-999.0	0	-999.0	-999.0
036	0	-999.0	-999.0	0	-999.0	-999.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL062017 EMILY

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	7	10.7	10.3	7	4.3	4.3
012	5	21.5	48.3	5	2.0	4.6
024	3	23.0	62.2	3	3.3	3.7
036	1	6.0	130.7	1	0.0	2.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL072017 FRANKLIN

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	14	4.7	5.1	14	0.7	0.7
012	13	19.4	31.0	13	5.8	8.6
024	11	19.3	63.7	11	7.3	14.5
036	9	25.5	125.6	9	7.2	17.3
048	7	23.7	178.7	7	6.4	19.6
072	3	56.7	271.9	3	18.3	25.7
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL082017 GERT

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	19	6.9	6.7	19	3.4	3.4
012	17	25.1	50.0	17	4.7	6.6
024	15	53.1	127.4	15	7.3	9.3
036	13	83.6	204.0	13	9.6	11.5
048	11	116.9	246.4	11	12.3	12.8
072	7	231.5	288.8	7	25.7	21.7
096	3	231.6	552.2	3	30.0	19.7
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL092017 HARVEY

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	40	8.9	9.0	40	2.5	2.6
012	38	18.8	35.6	38	5.8	6.7
024	36	28.8	68.8	36	8.9	11.5
036	32	38.9	112.1	32	12.0	14.9
048	28	49.7	157.1	28	15.0	16.9
072	23	81.2	239.5	23	6.5	11.5
096	20	124.5	305.3	20	3.5	10.2
120	20	168.7	350.8	20	6.3	13.8

Verification statistics for: AL112017 IRMA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	51	3.2	3.3	51	4.4	4.5
012	49	14.8	31.2	49	9.0	11.0
024	47	25.5	74.3	47	12.4	17.1
036	45	37.6	122.2	45	15.8	22.3
048	43	50.5	175.8	43	17.4	27.0
072	39	73.9	291.7	39	18.7	33.5
096	35	101.8	463.2	35	24.9	39.8
120	31	135.0	677.1	31	29.7	39.5

Verification statistics for: AL122017 JOSE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	68	7.9	8.3	68	2.4	2.3
012	66	19.3	37.1	66	5.1	6.9
024	64	25.6	88.6	64	6.6	10.9
036	62	32.0	147.0	62	7.8	13.9
048	61	41.5	199.2	61	8.9	16.3
072	57	66.0	285.9	57	10.5	19.9
096	53	86.0	381.5	53	11.6	19.7
120	49	125.6	458.3	49	10.8	14.1

Verification statistics for: AL132017 KATIA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	15	3.4	3.4	15	0.7	1.0
012	14	18.1	32.8	14	11.8	13.8
024	12	29.1	77.9	12	17.1	19.3
036	10	29.9	132.1	10	18.0	17.9
048	8	25.0	195.6	8	19.4	21.6
072	4	46.3	345.8	4	18.8	25.8
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL142017 LEE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	47	7.1	6.9	47	0.7	0.7
012	45	28.2	45.9	45	4.3	5.4
024	42	52.0	104.5	42	6.8	9.5
036	40	75.5	171.6	40	10.0	13.9
048	36	103.5	238.3	36	11.4	17.3
072	28	176.2	388.6	28	11.3	23.5
096	20	256.8	519.2	20	13.5	27.3
120	12	359.0	631.7	12	14.6	22.0

Verification statistics for: AL152017 MARIA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	57	2.9	2.9	57	1.0	1.1
012	55	12.9	29.3	55	6.6	8.5
024	53	20.4	70.0	53	10.6	13.7
036	51	26.7	112.3	51	13.0	17.3
048	49	35.6	149.3	49	14.5	18.7
072	45	58.3	191.9	45	12.2	15.5
096	41	84.9	214.2	41	8.8	12.2
120	37	122.3	225.4	37	8.1	14.6

Verification statistics for: AL162017 NATE

000	17	4.3	4.3	17	0.9	1.2
012	16	24.6	62.2	16	7.5	7.0
024	14	35.5	153.6	14	10.7	12.1
036	12	53.4	277.1	12	10.8	18.3
048	10	79.6	434.2	10	12.0	25.7
072	6	177.4	704.5	6	15.8	31.2
096	2	220.6	892.7	2	37.5	2.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL172017 OPHELIA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	27	3.3	3.3	27	2.4	2.4
012	25	19.8	44.6	25	6.0	7.6
024	23	28.9	115.0	23	7.8	12.8
036	21	35.7	193.7	21	10.5	19.3
048	19	44.7	280.6	19	11.6	23.9
072	15	52.8	458.4	15	18.0	31.4
096	11	57.1	586.4	11	21.8	30.8
120	7	247.9	613.9	7	28.6	39.7

Verification statistics for: AL182017 PHILIPPE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	3	47.9	52.4	3	1.7	1.7
012	1	37.7	126.9	1	5.0	4.0
024	0	-999.0	-999.0	0	-999.0	-999.0
036	0	-999.0	-999.0	0	-999.0	-999.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL192017 RINA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	12	8.2	8.2	12	1.3	1.3
012	10	39.2	58.3	10	3.5	5.0
024	8	64.9	154.6	8	1.9	4.5
036	6	95.1	270.4	6	1.7	5.0
048	4	159.4	408.5	4	3.8	4.5
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Table 7. Homogenous comparison of official and CLIPER5 track forecast errors in the eastern North Pacific basin in 2017 for all tropical cyclones. Averages for the previous 5-yr period are shown for comparison.

	Forecast Period (h)						
	12	24	36	48	72	96	120
2017 mean OFCL error (n mi)	20.7	31.9	43.1	55.7	84.5	108.0	136.0
2017 mean CLIPER5 error (n mi)	30.8	63.3	98.8	133.9	194.5	242.9	306.6
2017 mean OFCL skill relative to CLIPER5 (%)	32.8	49.6	56.4	58.4	56.6	55.5	55.6
2017 mean OFCL bias vector (°/n mi)	023/002	038/005	022/008	012/013	013/015	018/014	268/029
2017 number of cases	297	260	226	199	159	120	86
2012-2016 mean OFCL error (n mi)	22.2	33.9	44.0	55.2	81.1	111.3	148.9
2012-2016 mean CLIPER5 error (n mi)	35.7	72.2	112.7	151.2	219.1	273.3	340.1
2012-2016 mean OFCL skill relative to CLIPER5 (%)	37.8	53.0	61.0	63.5	63.0	59.3	56.2
2012-2016 mean OFCL bias vector (°/n mi)	319/003	305/006	297/006	298/006	003/003	062/010	028/019
2012-2016 number of cases	1607	1433	1261	1106	834	615	431
2017 OFCL error relative to 2012-2016 mean (%)	-6.8	-5.9	-2.0	0.9	4.2	-3.0	-8.7
2017 CLIPER5 error relative to 2012-2016 mean (%)	-13.7	-12.3	-12.3	-11.4	-11.2	-11.1	-9.9

Table 8a. Homogenous comparison of eastern North Pacific basin early track guidance model errors (n mi) for 2017. Errors smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	19.7	31.2	42.0	55.7	89.3	114.3	141.6
OCD5	28.5	59.0	92.2	127.5	176.6	223.0	285.1
GFSI	23.7	38.2	51.7	70.1	113.5	151.9	182.0
HWFI	23.9	37.7	51.0	65.9	103.6	155.1	220.0
EMXI	20.2	34.0	47.9	61.7	92.0	128.6	178.7
CMCI	27.3	47.5	66.5	91.1	149.5	188.8	238.0
EGRI	22.2	37.4	53.9	73.2	115.9	177.3	256.9
NVGI	29.2	52.4	75.1	101.2	158.9	210.3	279.4
AEMI	23.2	36.7	48.4	62.8	98.7	130.2	158.9
UEMI	21.4	37.2	53.4	69.8	110.1	156.0	217.7
TVCE	**19.5**	**30.5**	**41.3**	**54.9**	**88.3**	119.7	152.8
HCCA	**18.9**	**30.3**	**41.3**	56.4	90.9	116.4	**131.9**
TABD	28.2	53.1	74.1	90.8	127.9	169.0	215.4
TABM	27.2	49.1	68.0	84.2	121.6	155.7	180.9
TABS	31.0	62.5	90.7	106.8	126.9	167.1	176.4
TCLP	28.2	58.6	91.4	125.4	175.8	223.3	286.5
# Cases	199	178	162	149	112	81	58

Table 8b. Homogenous comparison of eastern North Pacific basin early track guidance model bias vectors (º/n mi) for 2017.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	007/004	022/007	004/011	001/013	014/013	037/010	256/032
OCD5	341/002	281/002	258/011	256/023	284/048	301/095	298/116
GFSI	045/006	050/013	045/020	050/027	066/046	072/080	070/070
HWFI	003/005	359/008	340/013	342/015	004/014	032/002	217/046
EMXI	325/006	333/008	326/013	325/015	302/019	278/012	264/057
CMCI	022/006	027/011	017/016	017/023	358/032	320/055	292/115
EGRI	328/003	302/007	292/015	281/019	278/041	280/070	269/155
NVGI	003/010	004/020	356/030	353/040	349/064	343/109	325/181
AEMI	060/004	055/009	044/013	045/017	071/029	074/049	077/031
UEMI	307/004	288/008	278/018	269/026	267/049	277/080	270/147
TVCE	011/004	016/007	000/012	002/014	002/016	007/016	267/044
HCCA	052/003	049/007	029/010	026/014	031/015	071/022	205/014
TABD	359/008	017/015	024/022	037/027	050/044	073/078	070/104
TABM	331/012	321/014	336/009	057/015	049/044	069/076	063/063
TABS	317/011	293/012	294/003	071/018	048/044	078/058	062/035
TCLP	287/002	238/007	242/020	243/033	265/058	283/102	278/144
# Cases	199	178	162	149	112	81	58

Table 9. Homogenous comparison of official and Decay-SHIFOR5 intensity forecast errors in the eastern North Pacific basin for the 2017 season for all tropical cyclones. Averages for the previous 5-yr period are shown for comparison.

	Forecast Period (h)						
	12	24	36	48	72	96	120
2017 mean OFCL error (kt)	5.4	8.9	10.7	11.8	12.3	11.1	12.2
2017 mean Decay-SHIFOR5 error (kt)	6.9	11.4	13.9	14.9	15.6	14.6	13.0
2017 mean OFCL skill relative to Decay-SHIFOR5 (%)	21.7	21.9	23.0	20.8	21.2	24.0	6.2
2017 OFCL bias (kt)	-0.1	0.3	0.3	0.6	1.4	1.4	1.5
2017 number of cases	297	260	226	199	159	120	86
2012-16 mean OFCL error (kt)	5.8	9.4	11.8	13.2	14.9	15.7	15.0
2012-16 mean Decay-SHIFOR5 error (kt)	7.6	12.3	15.7	18.1	20.3	21.7	20.4
2012-16 mean OFCL skill relative to Decay-SHIFOR5 (%)	23.7	23.6	24.8	27.1	26.6	27.6	26.5
2012-16 OFCL bias (kt)	-0.9	-1.4	-2.4	-3.5	-3.7	-3.4	-2.9
2012-16 number of cases	1607	1433	1261	1106	834	615	431
2017 OFCL error relative to 2012-16 mean (%)	-6.9	-5.3	-9.3	-9.8	-17.4	-29.3	-18.7
2017 Decay-SHIFOR5 error relative to 2012-16 mean (%)	-9.2	-7.3	-11.5	-17.7	-23.2	-32.7	-36.3

Table 10a. Homogenous comparison of eastern North Pacific basin early intensity guidance model errors (kt) for 2017. Errors smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	5.2	8.6	10.5	11.7	12.4	11.0	11.6
OCD5	6.8	11.3	13.7	14.8	15.7	14.4	12.6
HWFI	6.2	**8.5**	**10.0**	11.8	15.8	15.3	16.4
DSHP	6.2	9.7	11.7	13.1	12.9	11.9	11.8
LGEM	6.1	9.5	11.8	13.3	14.4	12.4	12.5
IVCN	5.7	**8.3**	**9.8**	**10.9**	**11.7**	**10.9**	11.8
HCCA	5.7	**8.0**	**9.6**	**11.0**	12.5	12.7	13.8
GFSI	7.3	11.2	14.1	16.8	17.9	17.3	16.4
EMXI	8.0	12.8	16.3	18.9	21.9	22.7	23.3
TCLP	6.6	11.1	14.2	16.0	17.3	15.4	12.7
# Cases	281	249	221	196	157	118	82

Table 10b. Homogenous comparison of eastern North Pacific basin early intensity guidance model biases (kt) for 2017. Biases smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	-0.1	0.6	0.3	0.5	1.4	1.7	2.4
OCD5	-0.6	-0.6	-1.5	-2.1	**0.1**	2.0	**1.1**
HWFI	-2.3	-1.9	-1.4	**0.0**	3.0	5.6	7.0
DSHP	-0.8	**-0.4**	-0.4	**-0.2**	2.3	4.3	4.3
LGEM	-1.8	-3.7	-5.9	-7.3	-7.2	-5.2	-5.2
IVCN	-1.5	-2.0	-2.2	-1.7	**0.7**	2.3	**2.3**
HCCA	-0.5	**0.0**	0.3	1.7	2.1	3.1	2.3
GFSI	-1.7	-1.1	-1.0	-0.6	**0.1**	1.9	**0.9**
EMXI	-1.2	-0.8	-0.6	**-0.1**	3.0	6.8	11.9
TCLP	-1.3	-2.8	-4.3	-5.4	-4.9	-3.5	-3.0
# Cases	281	249	221	196	157	118	82

Table 11. Official eastern North Pacific track and intensity forecast verifications (OFCL) for 2017 by storm. CLIPER5 (CLP5) and SHIFOR5 (SHF5) forecast errors are given for comparison and indicated collectively as OCD5. The number of track and intensity forecasts are given by NT and NI, respectively. Units for track and intensity errors are n mi and kt, respectively.

Verification statistics for: EP012017 ADRIAN

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	5	18.4	18.4	5	2.0	2.0
012	3	37.3	56.5	3	5.0	7.0
024	1	24.4	46.4	1	5.0	19.0
036	0	-999.0	-999.0	0	-999.0	-999.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP022017 BEATRIZ

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	8	10.4	10.4	8	1.9	1.9
012	6	21.6	28.7	6	6.7	5.5
024	4	33.5	55.1	4	6.3	3.0
036	2	63.7	117.0	2	5.0	9.5
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP032017 CALVIN

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	7	6.8	7.4	7	0.7	0.7
012	5	21.5	28.3	5	3.0	6.6
024	3	20.5	39.3	3	3.3	7.3
036	1	42.8	62.5	1	10.0	22.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP042017 DORA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	13	5.7	5.7	13	2.7	2.7
012	11	12.6	19.3	11	6.4	10.6
024	9	22.6	34.8	9	11.7	20.8
036	7	32.0	55.3	7	13.6	24.3
048	5	39.5	85.7	5	10.0	15.2
072	1	67.9	200.2	1	0.0	1.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP052017 EUGENE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	20	4.7	5.6	20	0.8	0.8
012	18	15.9	18.9	18	6.9	7.8
024	16	29.1	34.6	16	10.6	14.7
036	14	39.6	62.7	14	13.2	19.2
048	12	42.9	106.3	12	10.4	21.7
072	8	38.0	218.7	8	5.0	19.4
096	4	36.5	335.5	4	6.3	18.5
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP062017 FERNANDA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	36	5.4	5.4	36	1.3	1.3
012	36	14.5	24.3	36	5.6	7.4
024	36	26.7	51.6	36	7.8	11.7
036	36	39.5	82.3	36	8.9	14.3
048	35	50.9	110.5	35	9.7	16.9
072	31	72.1	158.8	31	11.1	19.9
096	27	91.3	192.1	27	8.1	20.5
120	23	124.7	228.5	23	6.7	22.6

Verification statistics for: EP072017 GREG

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	36	9.8	9.8	36	1.1	1.1
012	35	26.3	28.4	35	3.3	4.1
024	33	43.5	54.2	33	5.9	6.4
036	31	60.2	84.8	31	7.9	8.1
048	29	79.9	113.2	29	9.3	9.3
072	25	132.9	172.6	25	10.6	12.7
096	21	154.6	232.1	21	11.9	14.8
120	17	150.7	327.7	17	14.7	14.5

Verification statistics for: EP082017 EIGHT

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	7	4.6	3.4	7	0.7	0.7
012	5	20.2	32.3	5	4.0	6.4
024	3	41.6	84.9	3	5.0	10.0
036	1	49.9	139.9	1	10.0	16.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP082017 EIGHT

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	7	4.6	3.4	7	0.7	0.7
012	5	20.2	32.3	5	4.0	6.4
024	3	41.6	84.9	3	5.0	10.0
036	1	49.9	139.9	1	10.0	16.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP092017 HILARY

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	38	11.7	12.0	38	2.0	2.0
012	36	23.4	31.3	36	4.6	4.5
024	34	31.1	60.6	34	8.8	7.7
036	32	41.3	91.2	32	13.1	11.3
048	30	52.8	117.4	30	14.5	13.0
072	26	72.0	145.2	26	14.0	14.0
096	22	77.7	145.2	22	14.1	13.7
120	18	108.0	158.2	18	18.1	6.8

Verification statistics for: EP102017 IRWIN

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	41	8.7	8.8	41	2.2	2.4
012	39	20.4	37.7	39	5.0	6.3
024	37	31.8	84.5	37	7.2	8.9
036	35	42.8	139.0	35	7.9	10.2
048	33	55.6	196.6	33	9.4	11.3
072	29	72.6	305.0	29	10.2	10.2
096	21	93.1	385.6	21	8.3	4.5
120	20	120.3	481.1	20	6.5	4.2

Verification statistics for: EP112017 ELEVEN-E

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	5	3.3	3.3	5	1.0	1.0
012	3	27.4	41.8	3	1.7	3.7
024	1	41.4	85.8	1	5.0	1.0
036	0	-999.0	-999.0	0	-999.0	-999.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP122017 JOVA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	7	13.9	13.9	7	1.4	1.4
012	5	25.6	45.2	5	5.0	4.8
024	3	40.9	90.8	3	11.7	11.7
036	1	28.8	43.3	1	10.0	18.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP132017 KENNETH

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	20	10.8	11.3	20	0.8	0.8
012	18	17.3	32.0	18	6.7	10.3
024	16	26.0	75.4	16	11.6	20.7
036	14	38.9	127.2	14	16.1	29.5
048	12	49.3	168.8	12	19.6	35.0
072	8	57.9	191.6	8	16.9	27.4
096	4	54.9	176.5	4	2.5	10.3
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP142017 LIDIA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	14	3.7	3.7	14	0.4	0.4
012	12	13.9	23.7	12	1.7	4.8
024	10	15.5	62.7	10	1.5	5.9
036	8	18.2	108.6	8	3.1	8.0
048	6	32.9	153.4	6	2.5	6.8
072	2	99.3	226.0	2	5.0	4.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP152017 OTIS

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	31	6.7	7.1	31	1.9	2.3
012	29	20.0	32.9	29	8.4	10.1
024	27	32.4	67.6	27	14.3	16.7
036	25	41.6	99.8	25	14.0	17.1
048	23	53.8	147.0	23	14.8	18.4
072	19	90.8	221.7	19	14.5	19.8
096	15	128.3	331.8	15	15.0	20.4
120	6	195.1	468.4	6	24.2	19.8

Verification statistics for: EP162017 MAX

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	8	5.7	5.7	8	1.3	1.9
012	6	24.4	50.3	6	16.7	19.3
024	4	35.2	137.8	4	31.3	25.0
036	2	33.0	258.1	2	17.5	20.5
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP172017 NORMA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	22	7.0	6.9	22	1.4	1.6
012	20	14.4	24.0	20	5.0	5.9
024	18	25.0	55.0	18	8.6	10.1
036	16	42.7	87.8	16	11.9	11.2
048	14	59.1	104.1	14	16.1	8.4
072	10	113.6	92.8	10	23.0	13.0
096	6	215.8	128.0	6	19.2	10.8
120	2	372.5	131.1	2	20.0	12.5

Verification statistics for: EP182017 PILAR

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	7	19.5	19.5	7	3.6	3.6
012	5	62.0	54.2	5	0.0	2.8
024	3	112.6	112.1	3	8.3	8.3
036	1	133.7	150.4	1	15.0	6.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP192017 RAMON

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	3	11.5	11.5	3	1.7	1.7
012	1	48.0	73.6	1	5.0	17.0
024	0	-999.0	-999.0	0	-999.0	-999.0
036	0	-999.0	-999.0	0	-999.0	-999.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP202017 SELMA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	6	6.3	7.3	6	0.0	0.0
012	4	33.7	45.8	4	3.8	7.3
024	2	62.7	116.6	2	10.0	27.5
036	0	-999.0	-999.0	0	-999.0	-999.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0

Table 12a. Verification of 48-h probabilistic genesis forecasts for the Atlantic basin in 2017.

Atlantic Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	**Verifying Genesis Occurrence Rate (%)**	**Number of Forecasts**
0	5	268
10	13	120
20	27	62
30	23	60
40	34	44
50	56	18
60	60	10
70	81	21
80	92	13
90	62	8
100	-	-

Table 12b. Verification of 48-h probabilistic genesis forecasts for the eastern North Pacific basin in 2017.

Eastern North Pacific Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	**Verifying Genesis Occurrence Rate (%)**	**Number of Forecasts**
0	6	321
10	22	74
20	58	40
30	35	34
40	86	14
50	61	23
60	60	15
70	68	28
80	63	19
90	100	3
100	100	3

Table 13a. Verification of 120-h probabilistic genesis forecasts for the Atlantic basin in 2017.

Atlantic Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	**Verifying Genesis Occurrence Rate (%)**	**Number of Forecasts**
0	3	32
10	21	140
20	30	106
30	27	63
40	42	99
50	43	60
60	80	41
70	81	32
80	78	32
90	83	18
100	-	-

Table 13b. Verification of 120-h probabilistic genesis forecasts for the eastern North Pacific basin in 2017.

Eastern North Pacific Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	**Verifying Genesis Occurrence Rate (%)**	**Number of Forecasts**
0	9	11
10	25	154
20	43	96
30	52	60
40	54	56
50	81	43
60	79	42
70	72	39
80	79	43
90	100	27
100	100	3

Table 14. NHC forecast cone circle radii (n mi) for 2018. Change from 2017 values expressed in n mi and percent are given in parentheses.

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	26 (-3: -10%)	25 (0: 0%)
24	43 (-2: -4%)	39 (-1: -3%)
36	56 (-7: -11%)	50 (-1: -2%)
48	74 (-4: -5%)	66 (0: 0%)
72	103 (-4: -4%)	94 (1: 1%)
96	151 (-8: -5%)	125 (9: 8%)
120	198 (-13: -6%)	162 (11: 7%)

Table 15. Composition of NHC consensus models for 2018. It is intended that TCOA/TVCA would be the primary consensus aids for the Atlantic basin and TCOE/TVCE would be primary for the eastern Pacific.

NHC Consensus Model Definitions For 2018			
Model ID	**Parameter**	**Type**	**Members**
GFEX	Track	Fixed	GFSI EMXI
TCOA*	Track	Fixed	GFSI EGRI HWFI
TCOE	Track	Fixed	GFSI EGRI HWFI
ICON	Intensity	Fixed	DSHP LGEM HWFI CTCI HMNI
TVCA**	Track	Variable	GFSI EGRI HWFI EMXI CTCI
TVCE	Track	Variable	GFSI EGRI HWFI EMXI CTCI EMNI HMNI
TVCX	Track	Variable	EMXI (double weight) GFSI EGRI HWFI
TVDG	Track	Variable	GFSI (double weight) EMXI (double weight) EGRI (double weight) CTCI HWFI
IVCN	Intensity	Variable	DSHP LGEM HWFI CTCI HMNI
IVDR	Intensity	Variable	CTCI (double weight) HWFI (double weight) HMNI (double weight) GFSI DSHP LGEM

* TCON will continue to be computed and will have the same composition as TCOA.
** TVCN will continue to be computed and will have the same composition as TVCA. GPCE circles will continue to be based on TVCN.

LIST OF FIGURES

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22. Homogenous comparison for selected eastern North Pacific basin early intensity guidance models for 2017. This verification includes only those models that were available at least 2/3 of the time (see text).

23. Homogenous comparison for selected eastern North Pacific basin early intensity guidance models for 2015-17.

24. Reliability diagram for Atlantic (top) and eastern North Pacific (bottom) probabilistic tropical cyclogenesis 48-h forecasts for 2017. The solid lines indicate the relationship between the forecasts and verifying genesis percentages, with perfect reliability indicated by the thin diagonal black line. The dashed lines indicate how the forecasts were distributed among the possible forecast values.

25. As described for Fig. 24, but for 120-h forecasts.

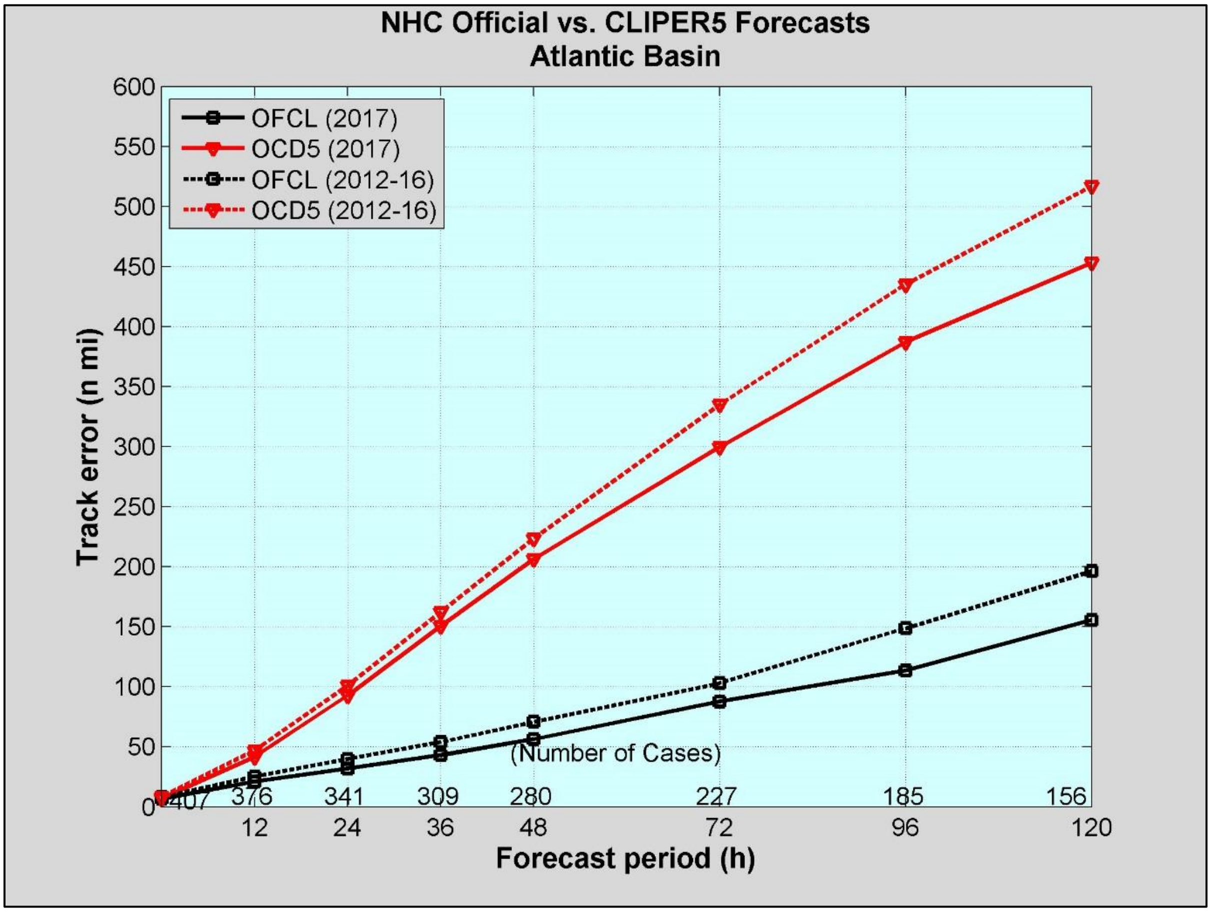


Figure 1. NHC official and CLIPER5 (OCD5) Atlantic basin average track errors for 2017 (solid lines) and 2012-2016 (dashed lines).

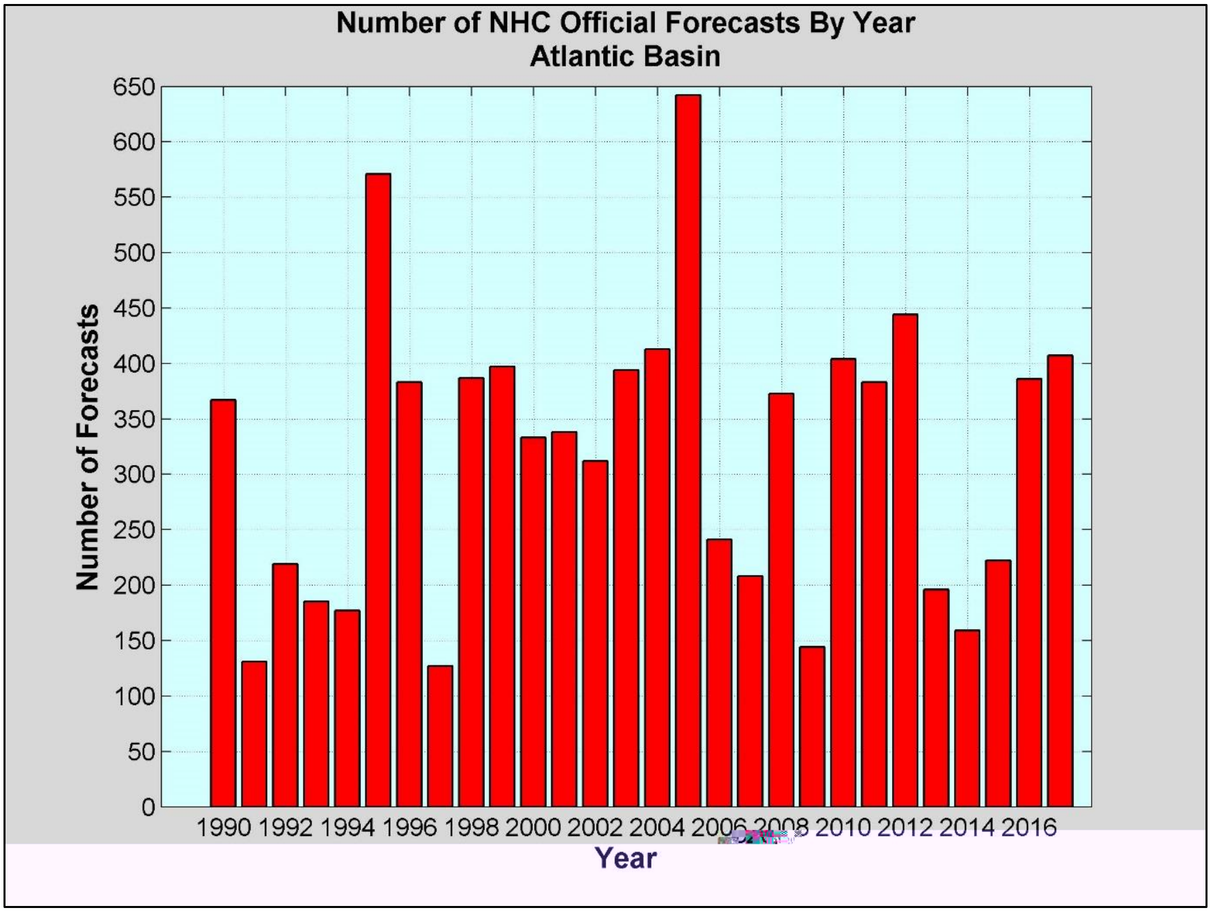
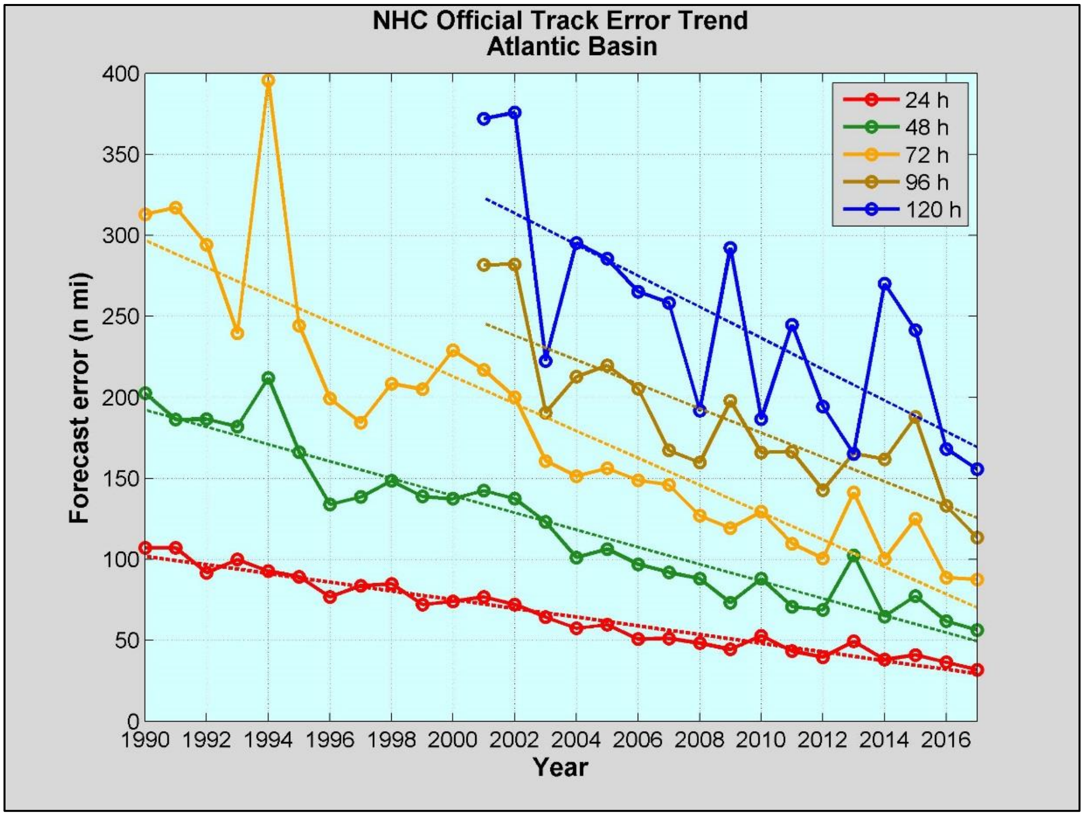


Figure 2. Number of NHC official forecasts for the Atlantic basin stratified by year.



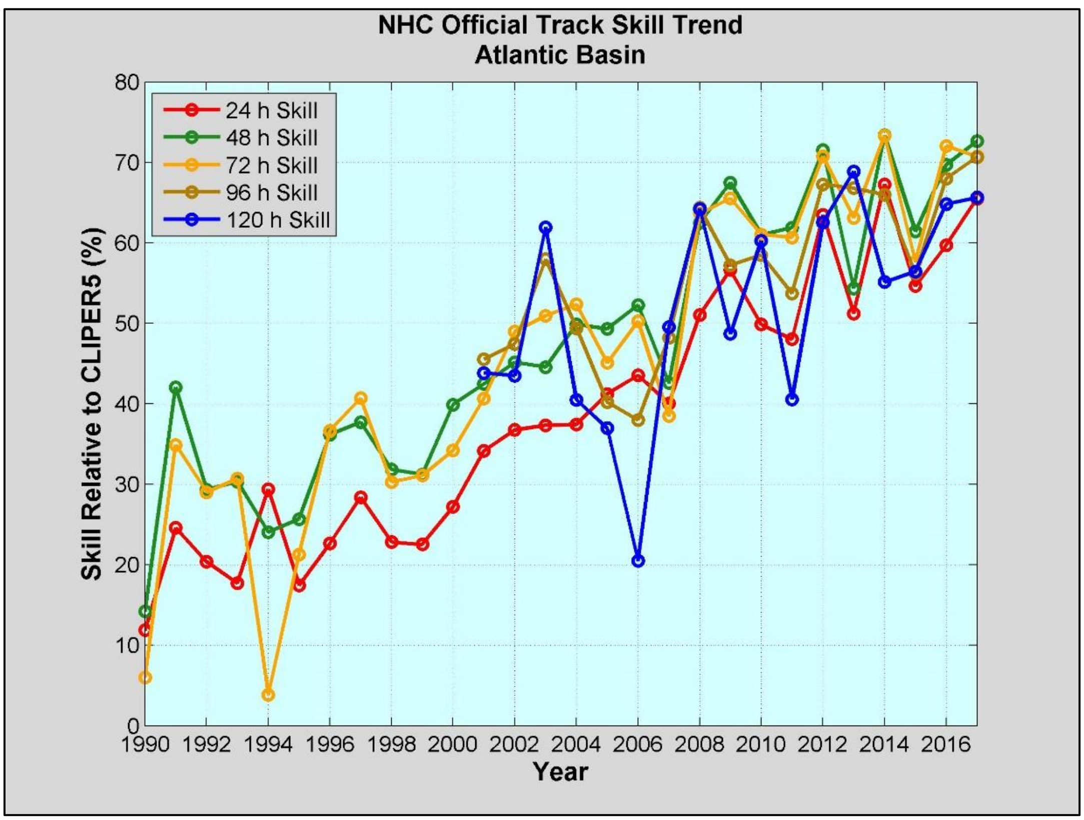


Figure 3. Recent trends in NHC official track forecast error (top) and skill (bottom) for the Atlantic basin.

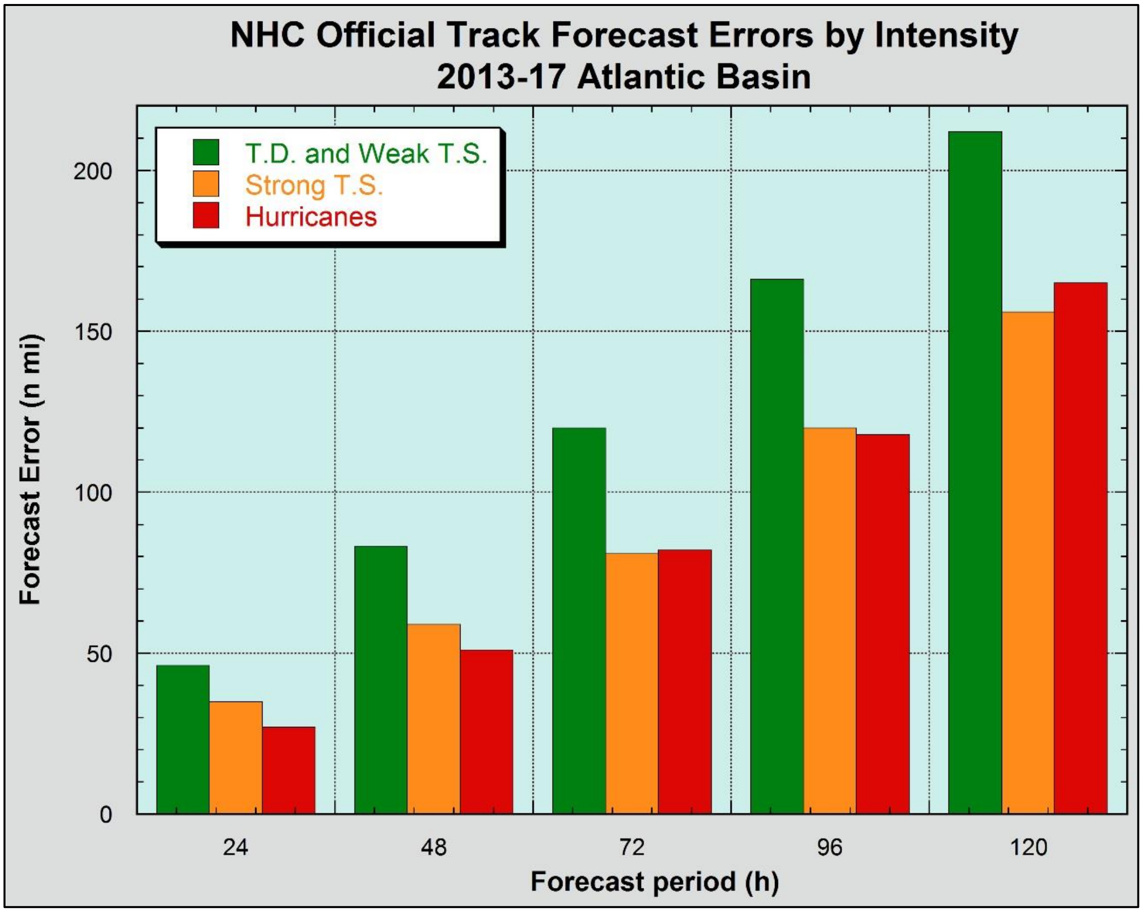


Figure 4. 2013-17 NHC official track forecast error binned by initial intensity for the Atlantic basin. Weak tropical storms are in the 35-45 kt range and strong tropical storms are in the 50-60 kt range.

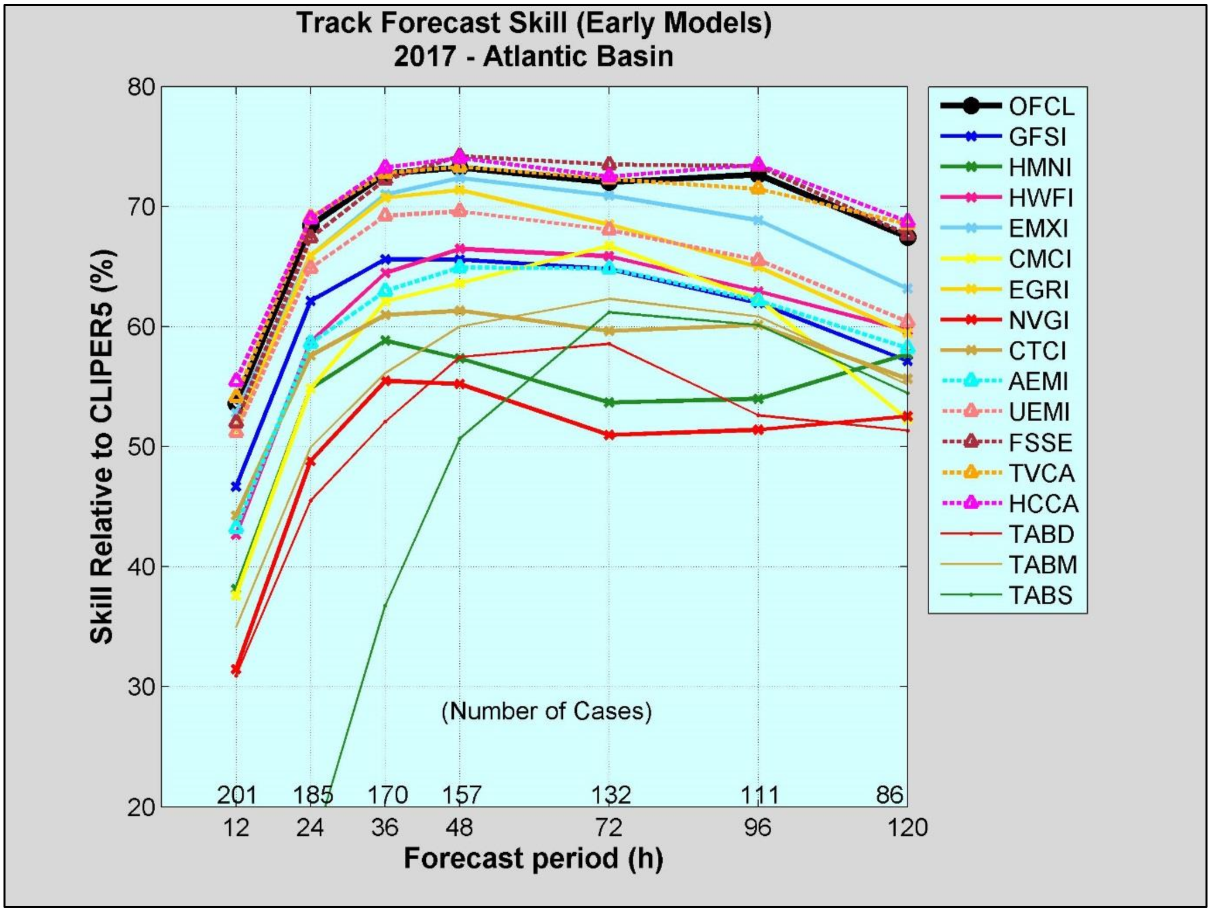


Figure 5. Homogenous comparison for selected Atlantic basin early track models for 2017. This verification includes only those models that were available at least 2/3 of the time (see text).

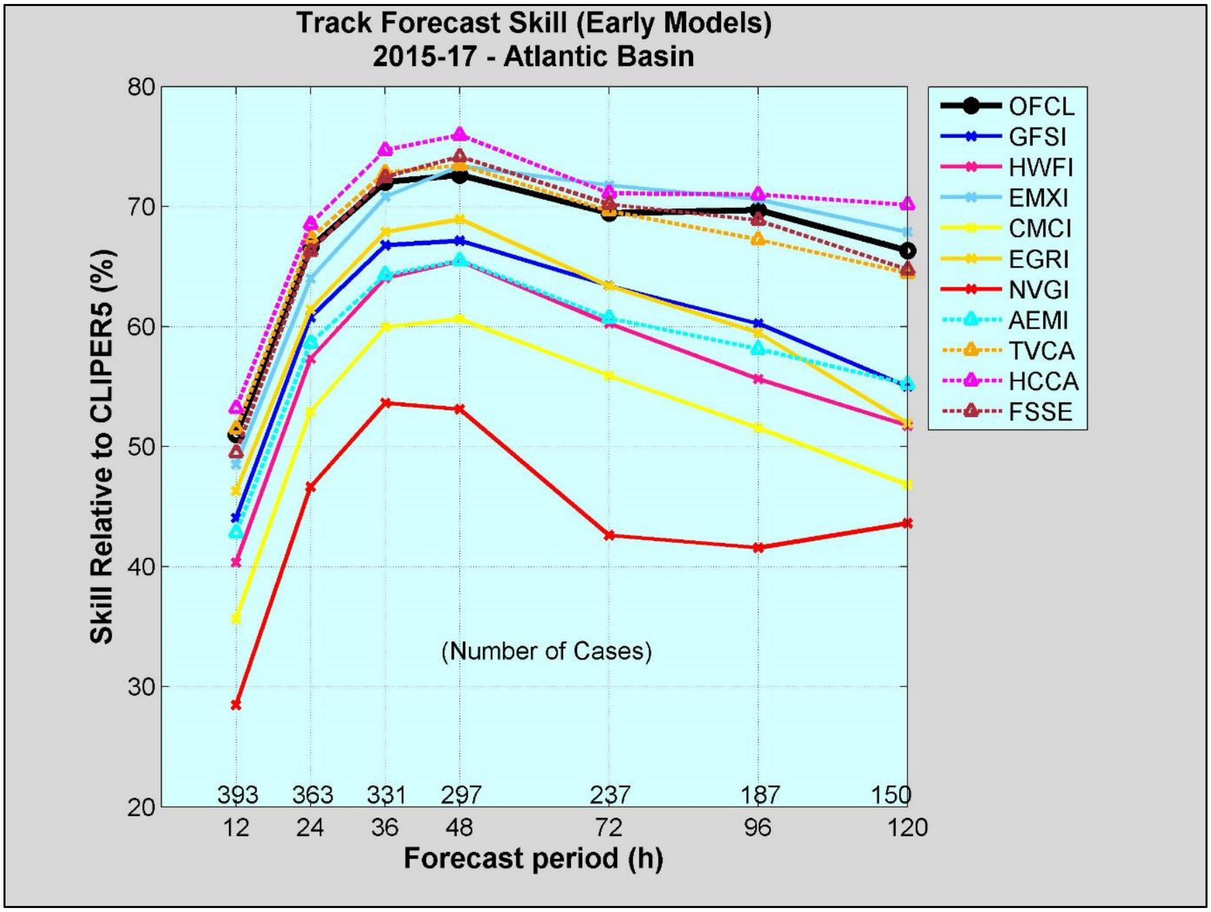


Figure 6. Homogenous comparison for selected Atlantic basin early track models for 2015-2017.

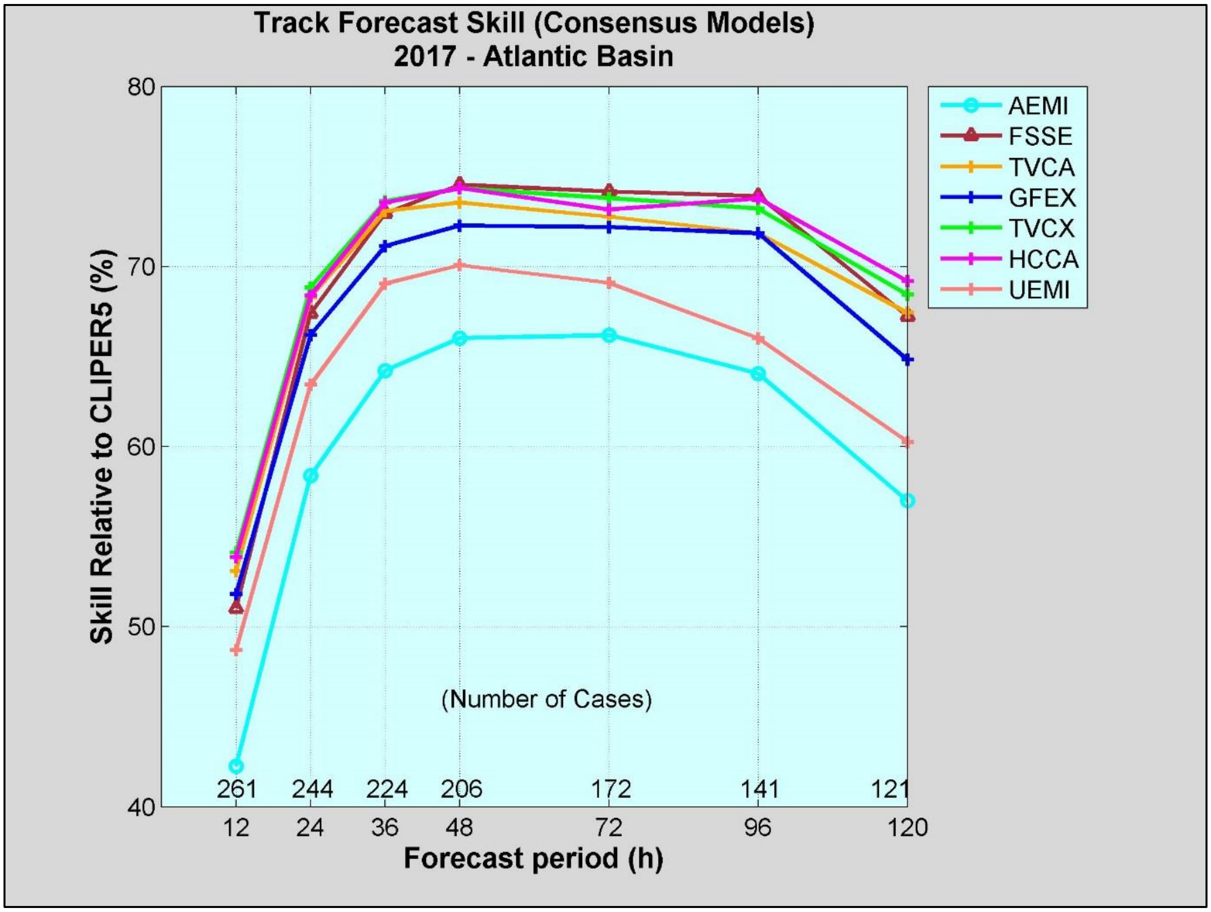


Figure 7. Homogenous comparison of the primary Atlantic basin track consensus models for 2017.

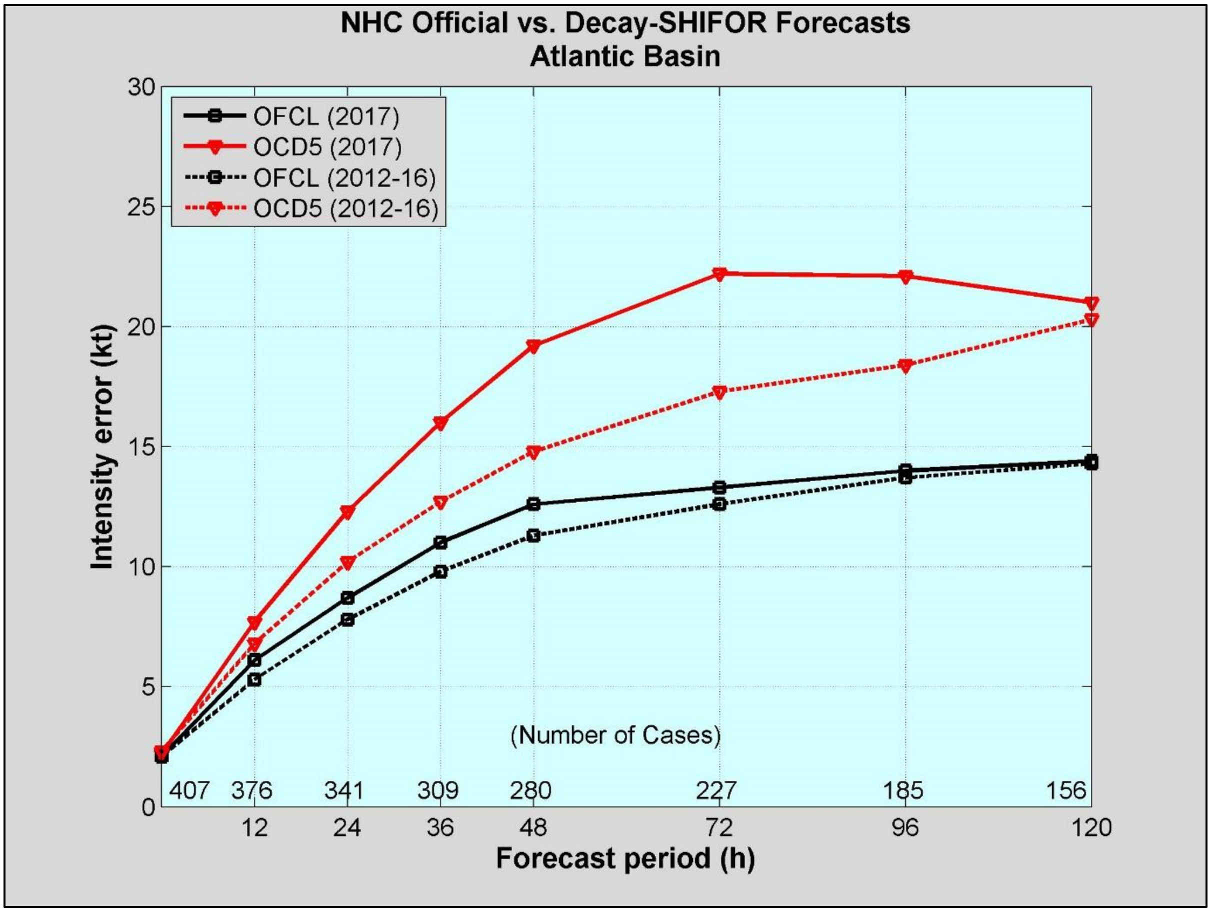


Figure 8. NHC official and Decay-SHIFOR5 (OCD5) Atlantic basin average intensity errors for 2017 (solid lines) and 2012-2016 (dashed lines).

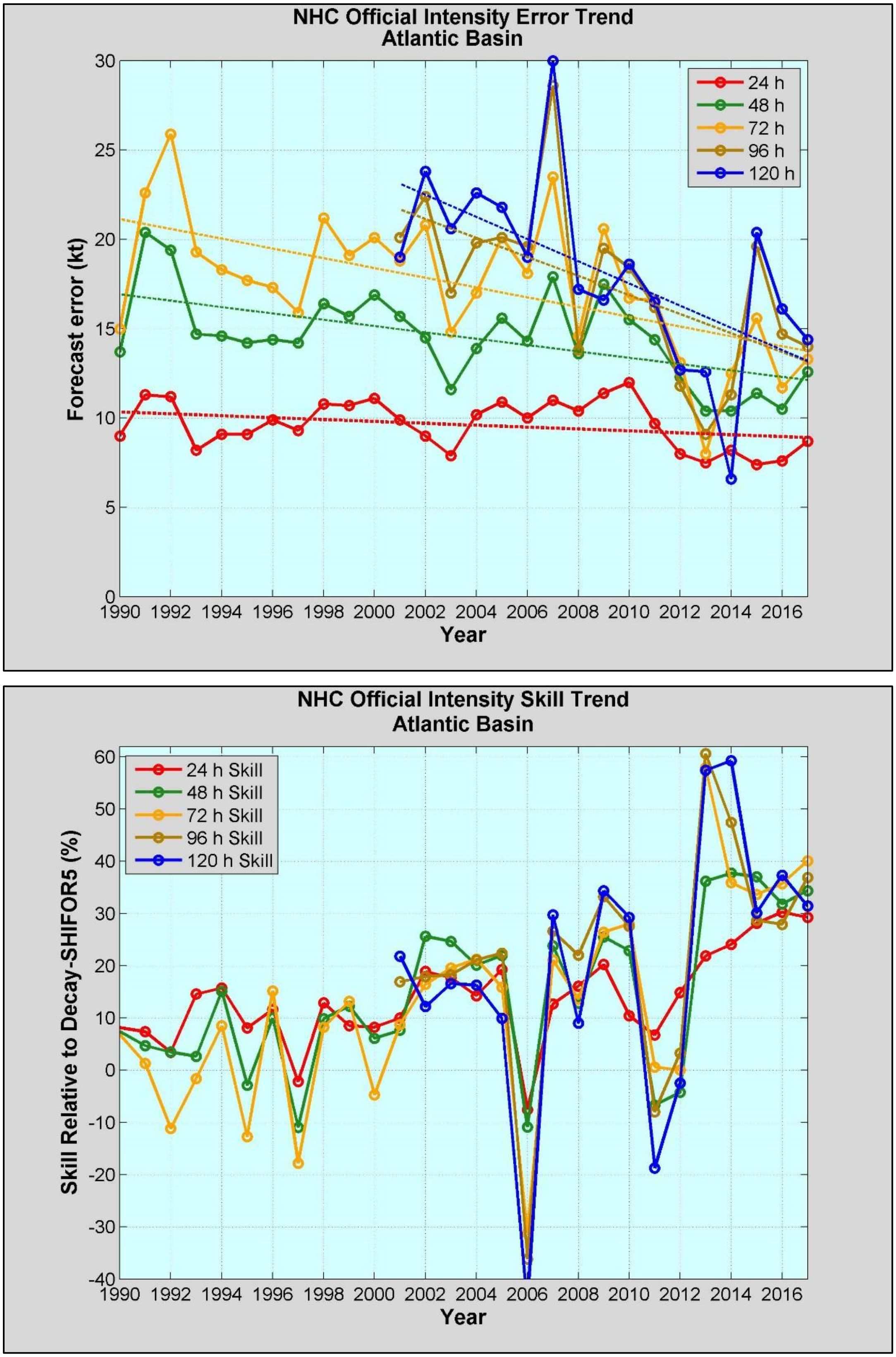


Figure 9. Recent trends in NHC official intensity forecast error (top) and skill (bottom) for the Atlantic basin.

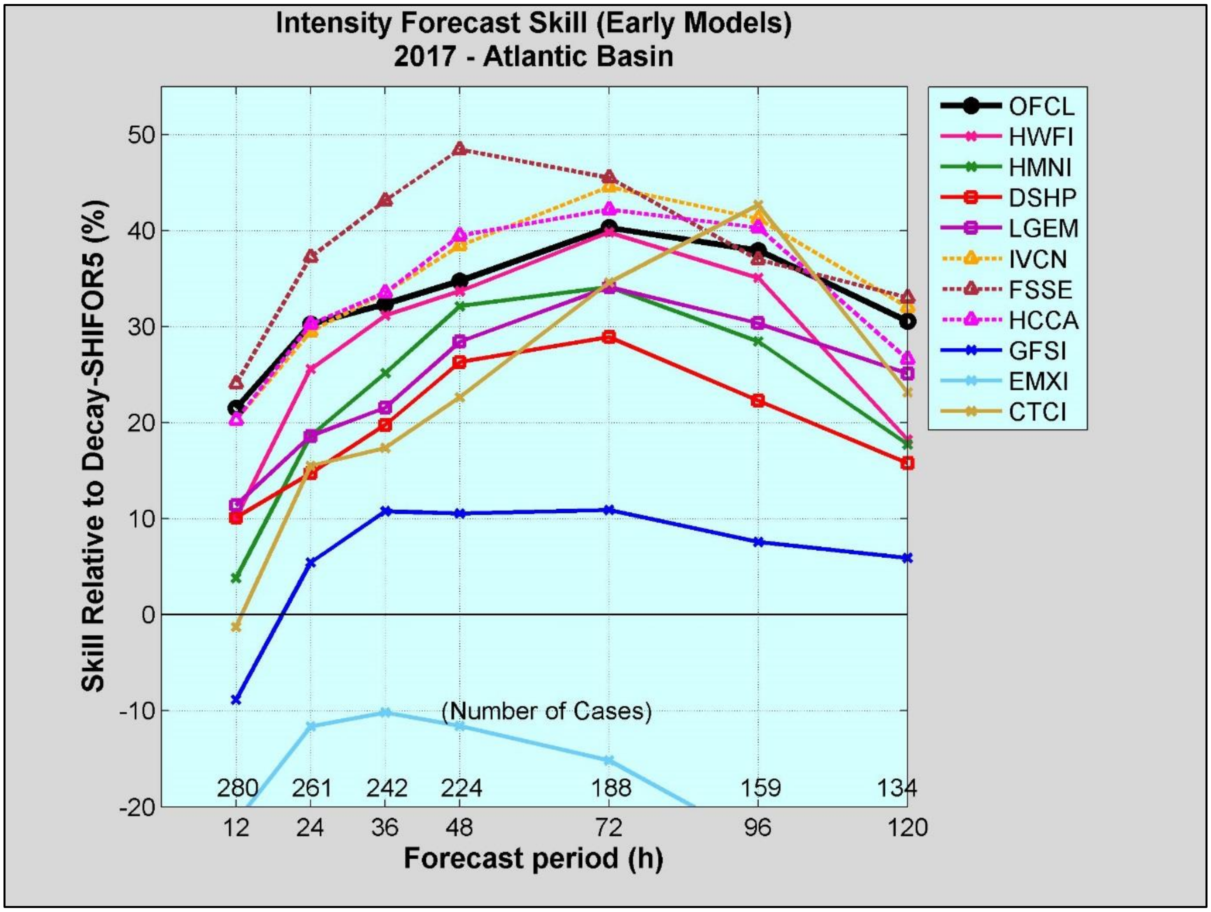


Figure 10. Homogenous comparison for selected Atlantic basin early intensity guidance models for 2017.

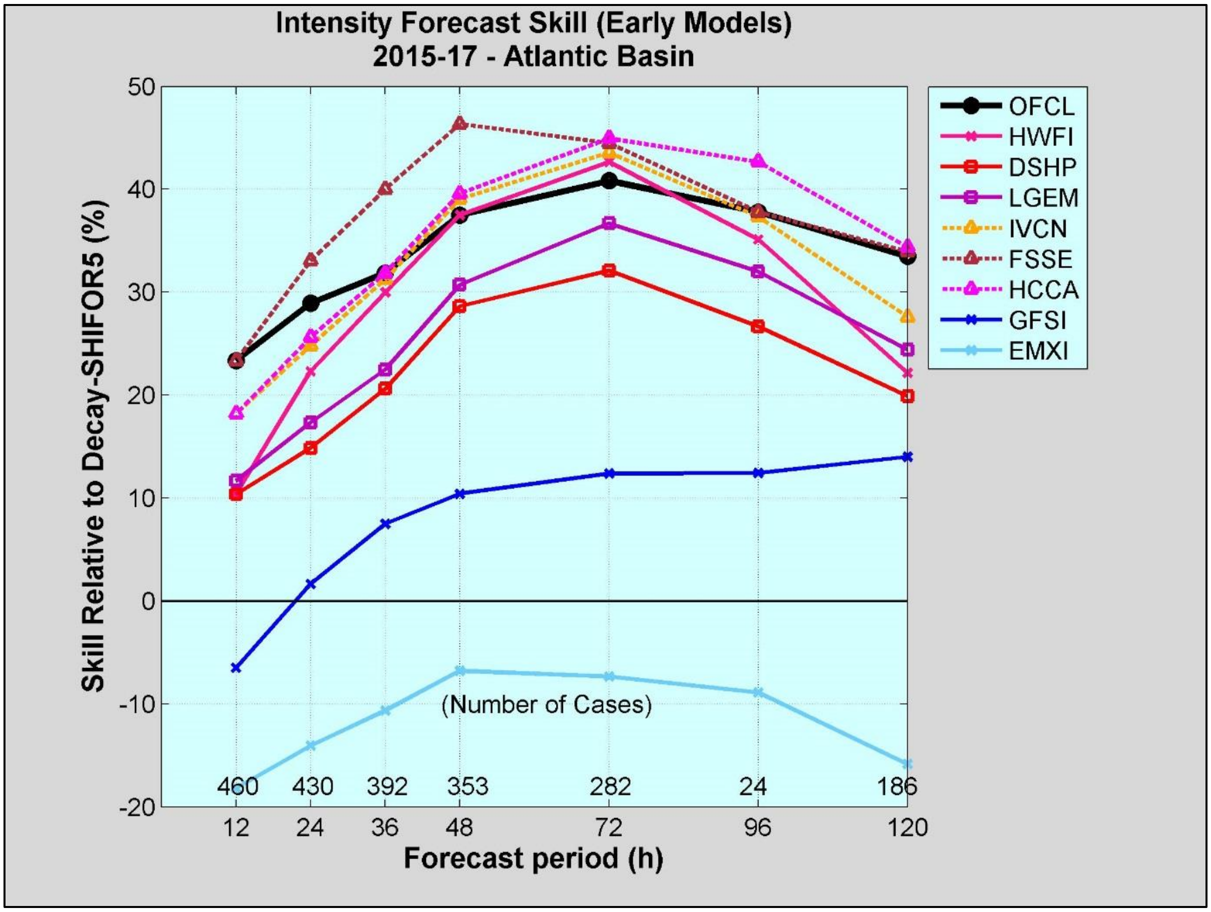


Figure 11. Homogenous comparison for selected Atlantic basin early intensity guidance models for 2015-2017.

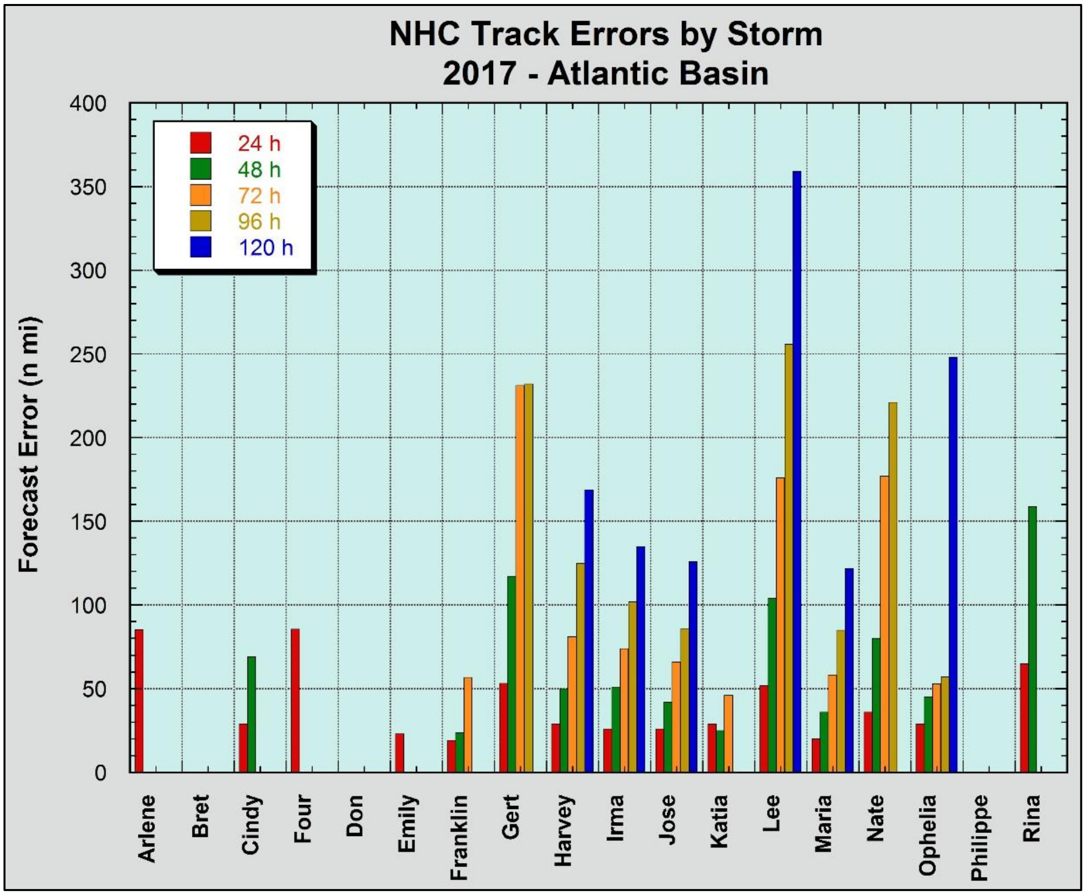


Figure 12. 2017 NHC official track errors by tropical cyclone.

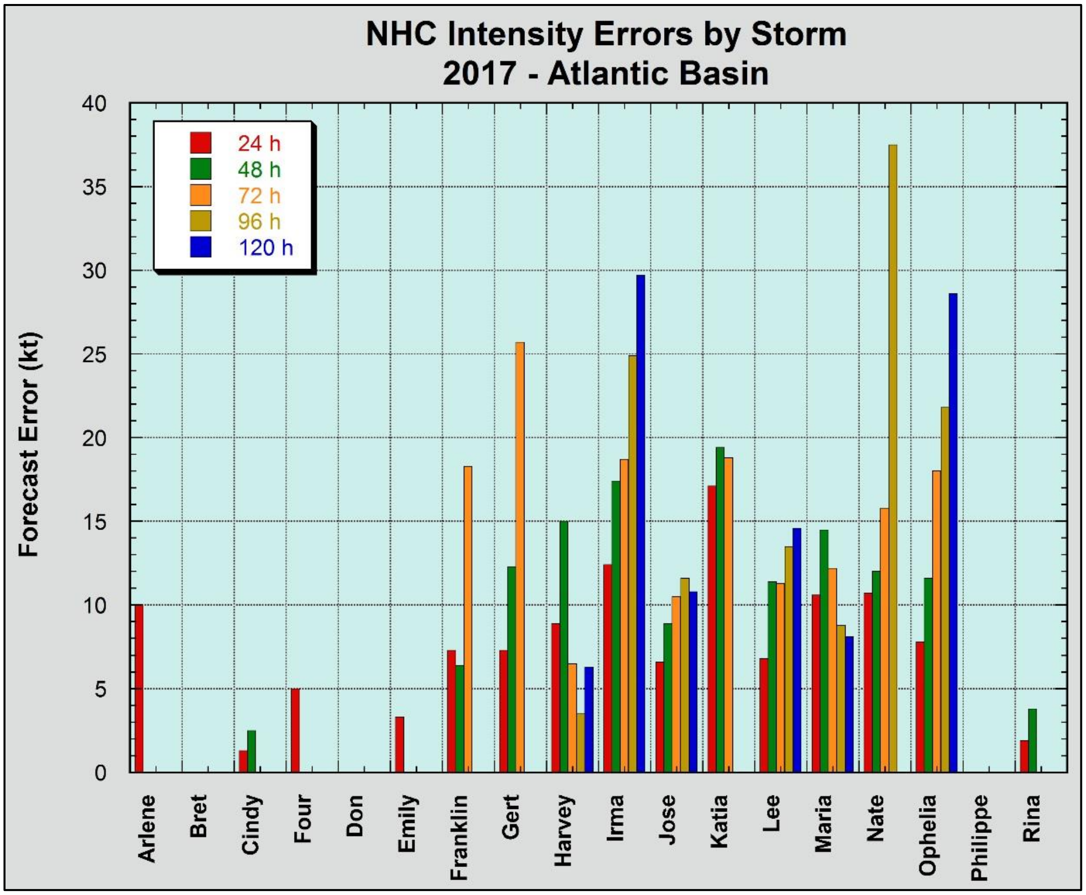


Figure 13. 2017 NHC official intensity errors by tropical cyclone.

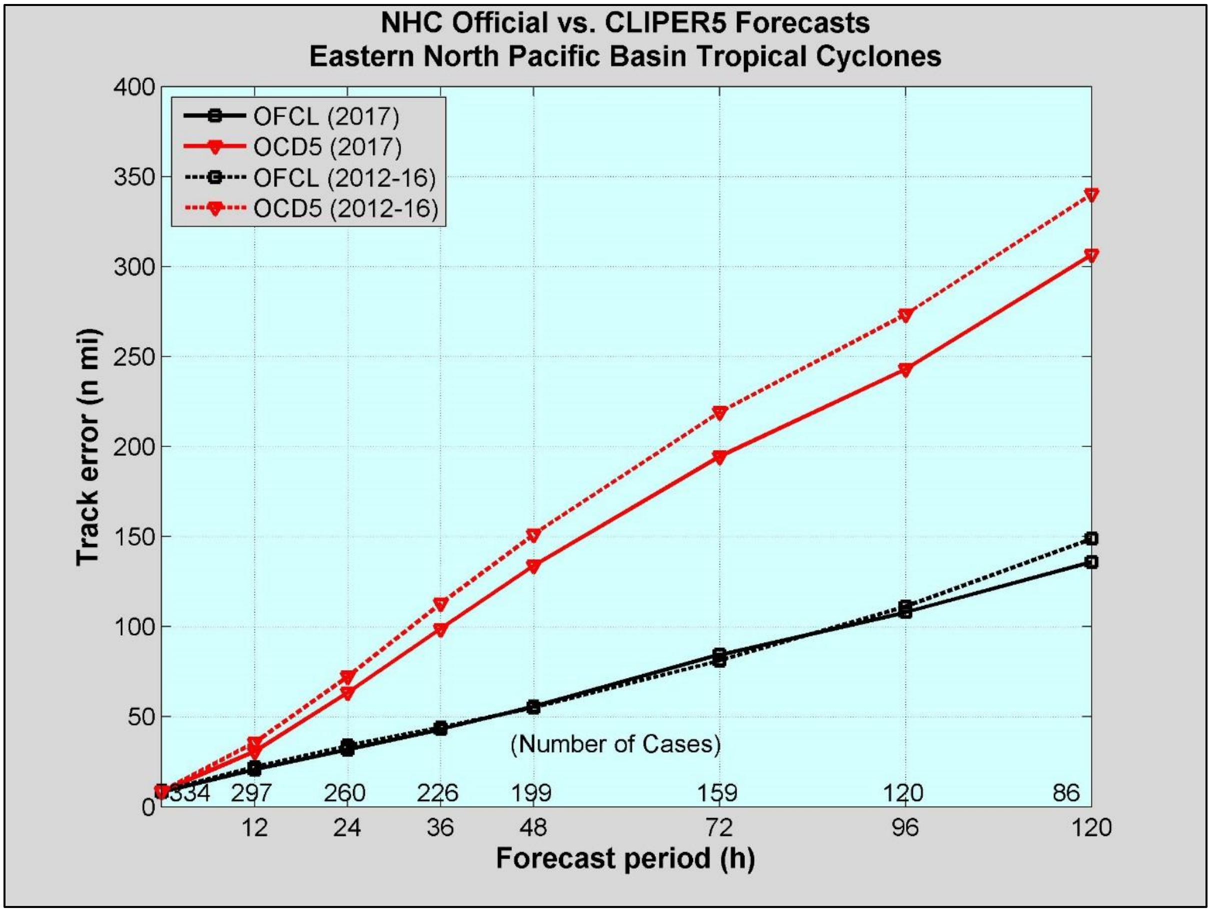


Figure 14. NHC official and CLIPER5 (OCD5) eastern North Pacific basin average track errors for 2017 (solid lines) and 2012-2016 (dashed lines).

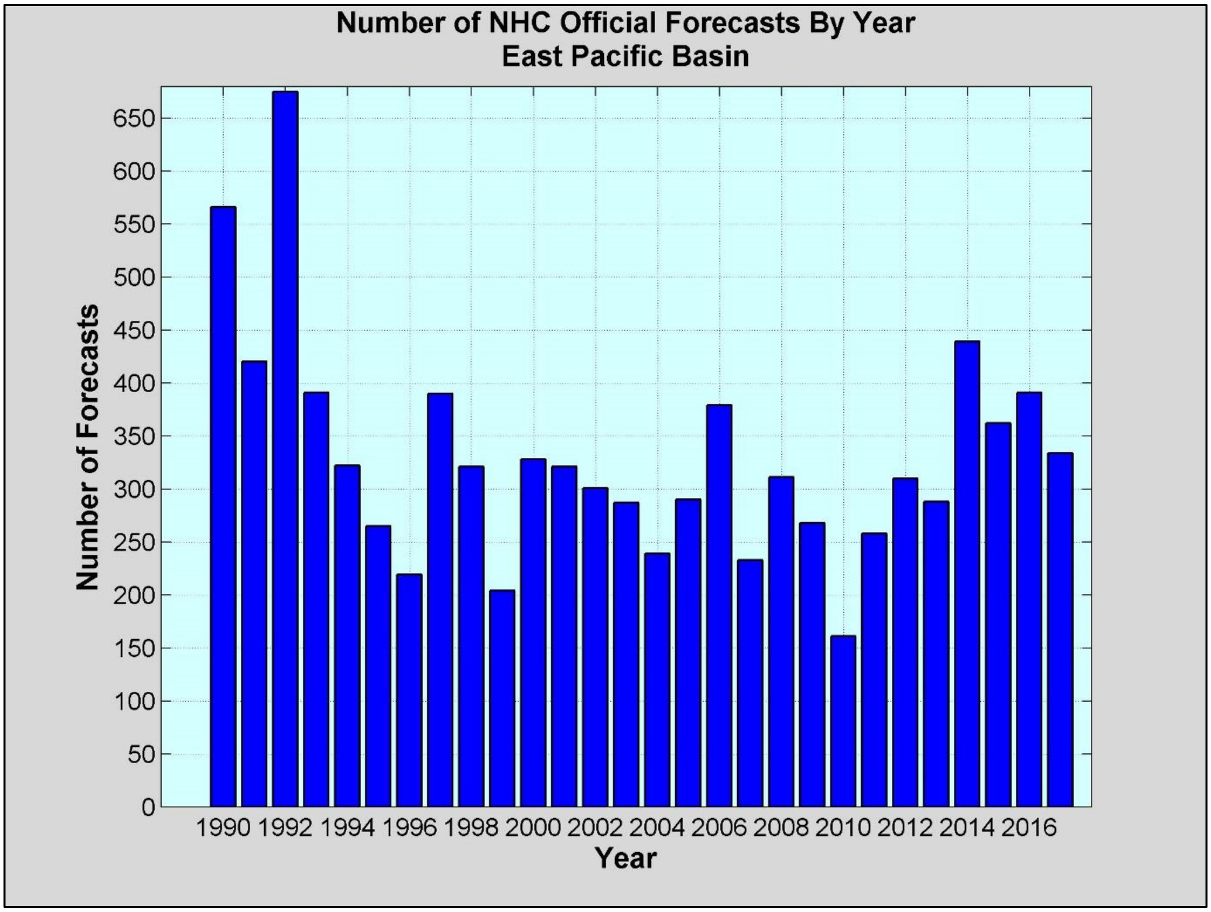


Figure 15. Number of NHC official forecasts for the eastern North Pacific basin stratified by year.

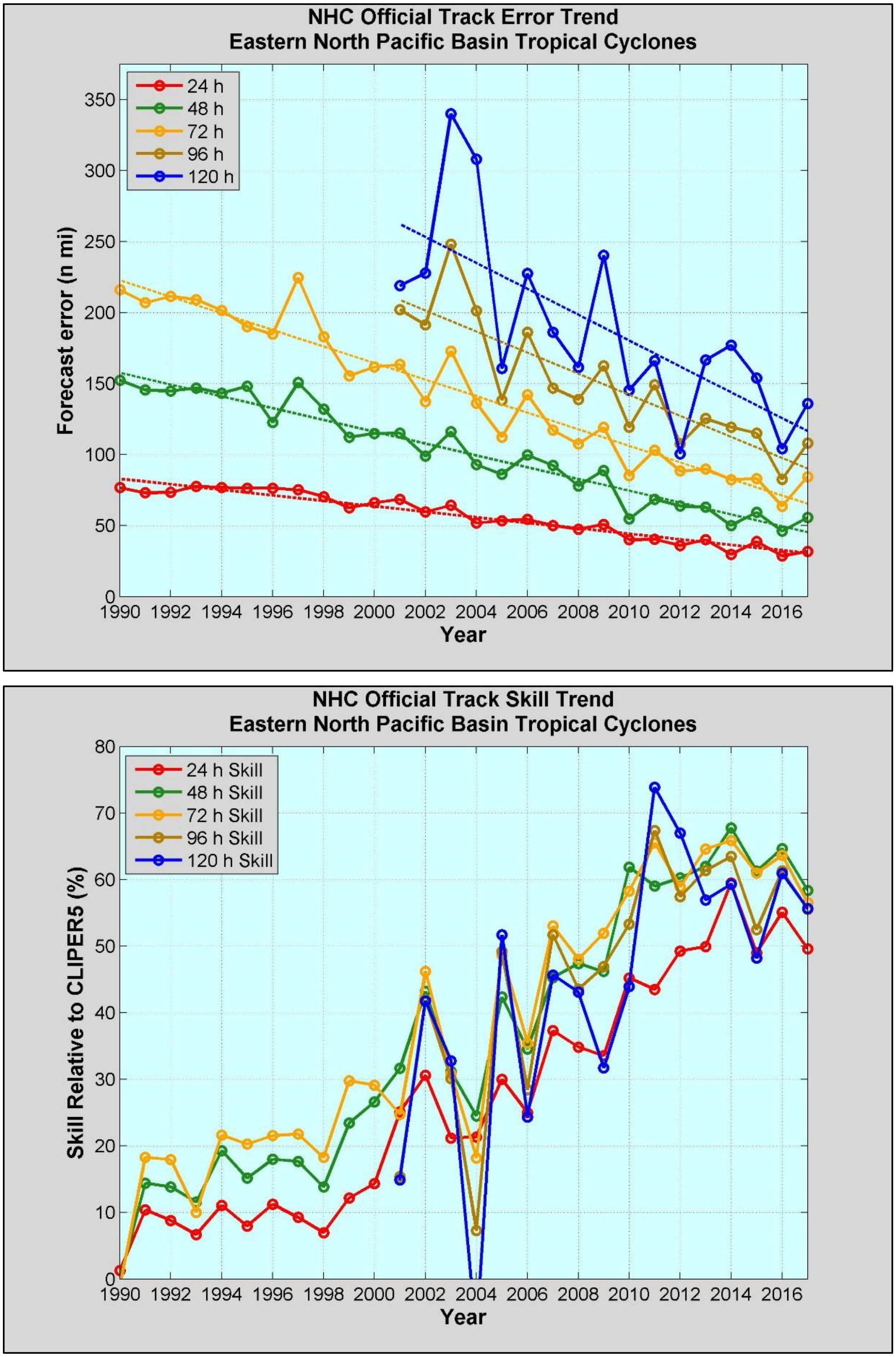


Figure 16. Recent trends in NHC official track forecast error (top) and skill (bottom) for the eastern North Pacific basin.

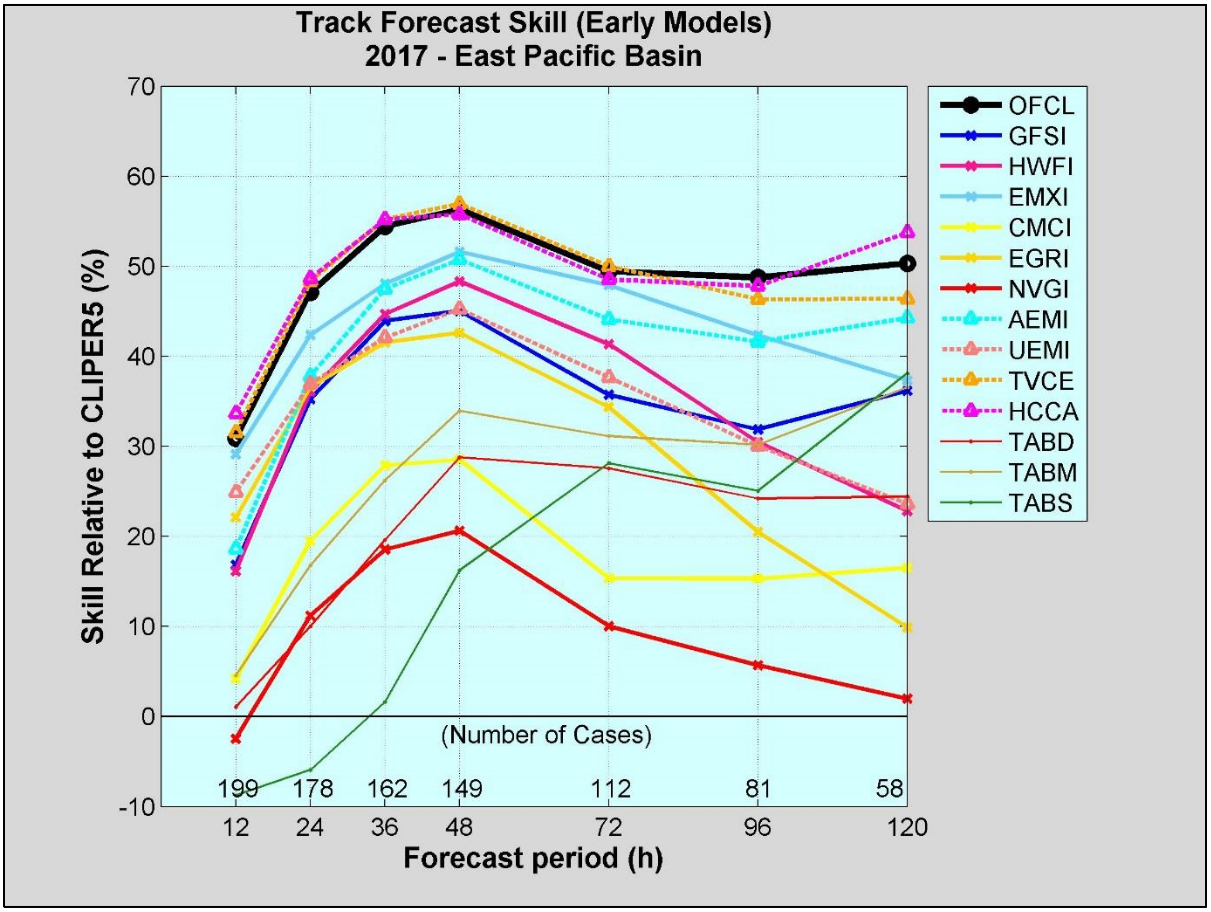


Figure 17. Homogenous comparison for selected eastern North Pacific early track models for 2017. This verification includes only those models that were available at least 2/3 of the time (see text).

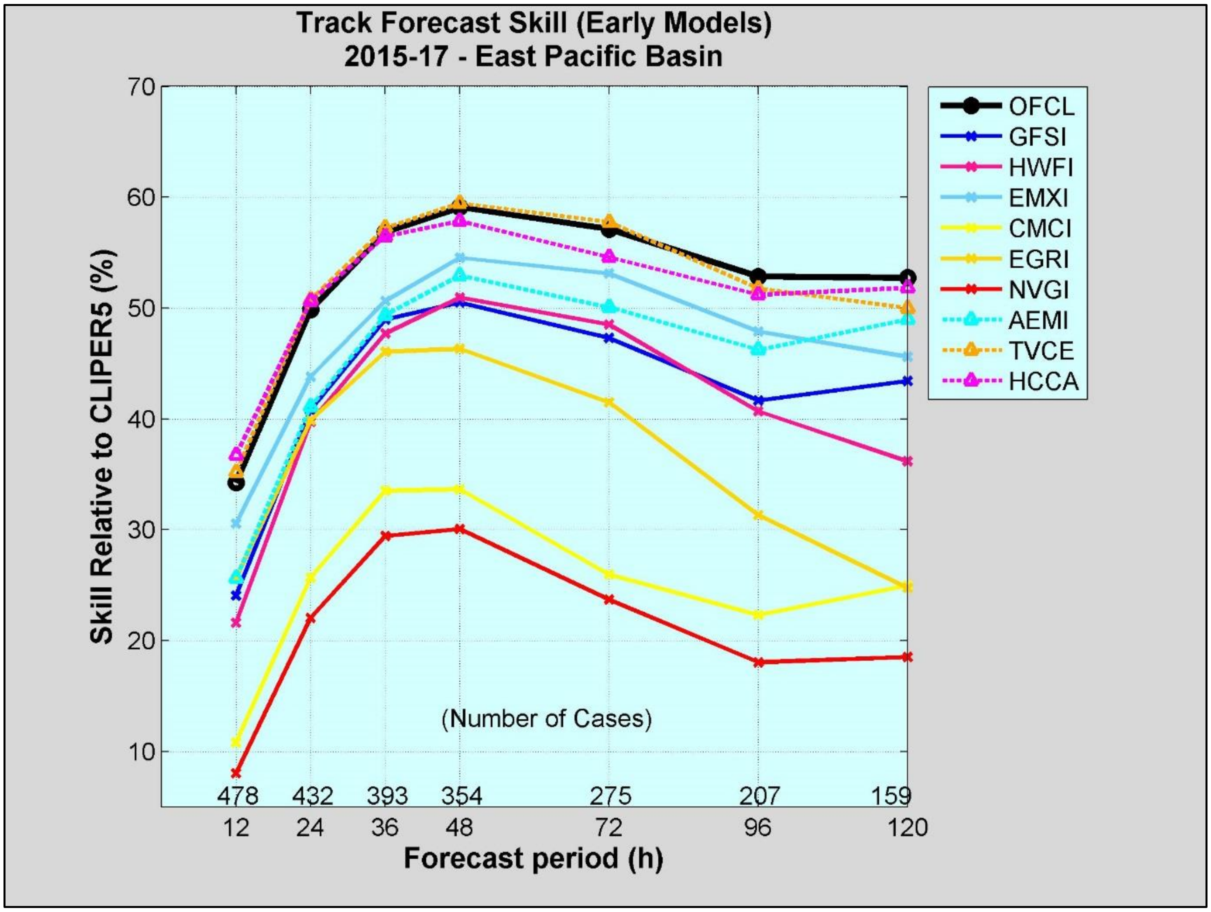


Figure 18. Homogenous comparison for selected eastern North Pacific basin early track models for 2015-2017.

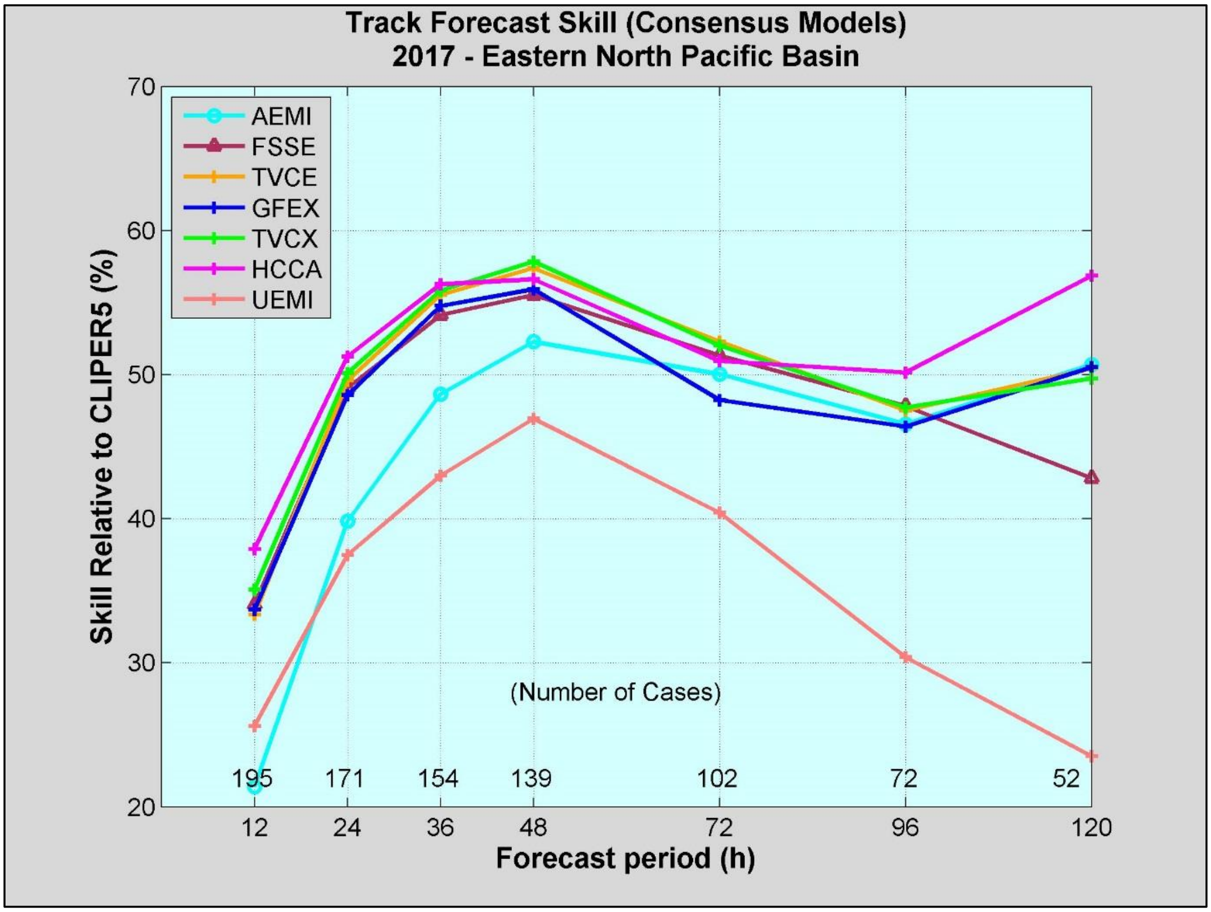


Figure 19. Homogenous comparison of the primary eastern North Pacific basin track consensus models for 2017.

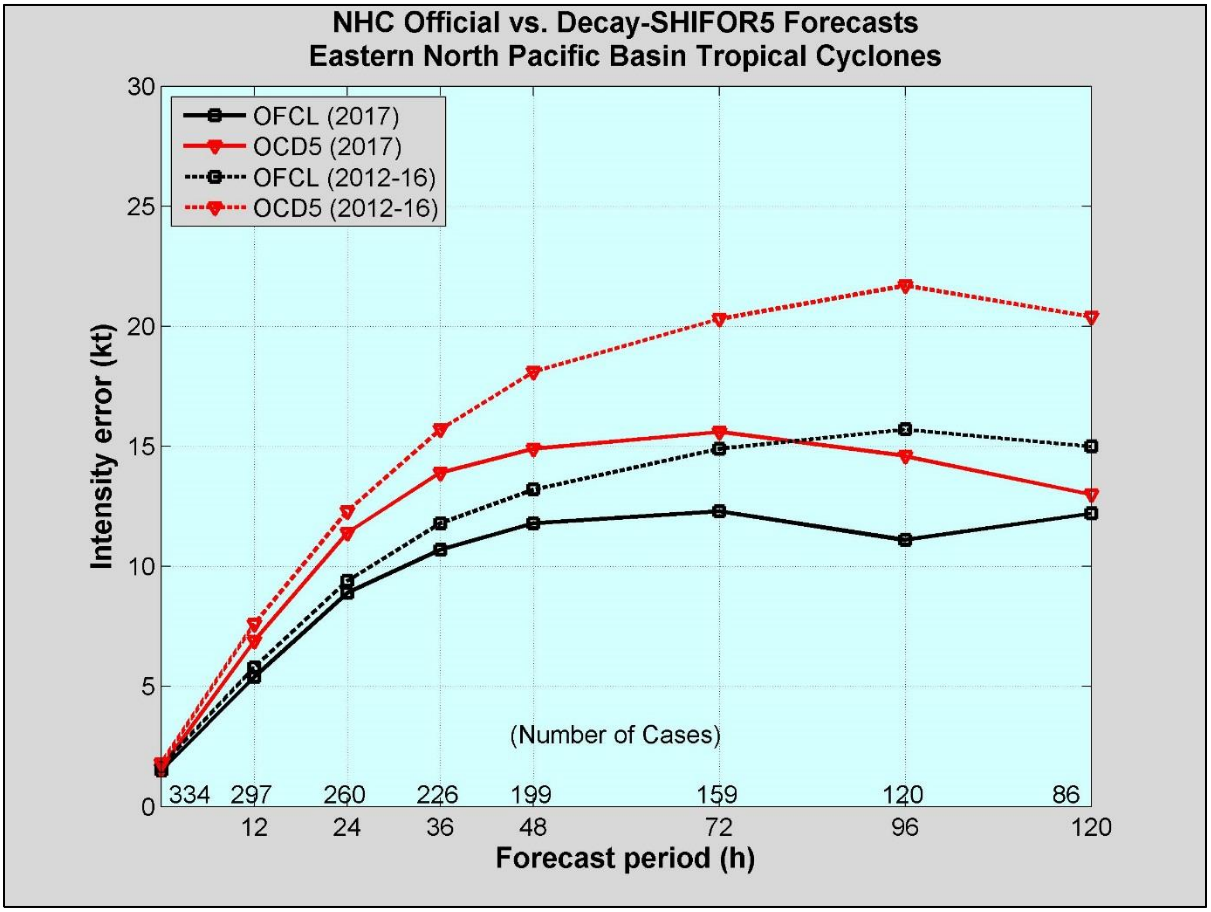
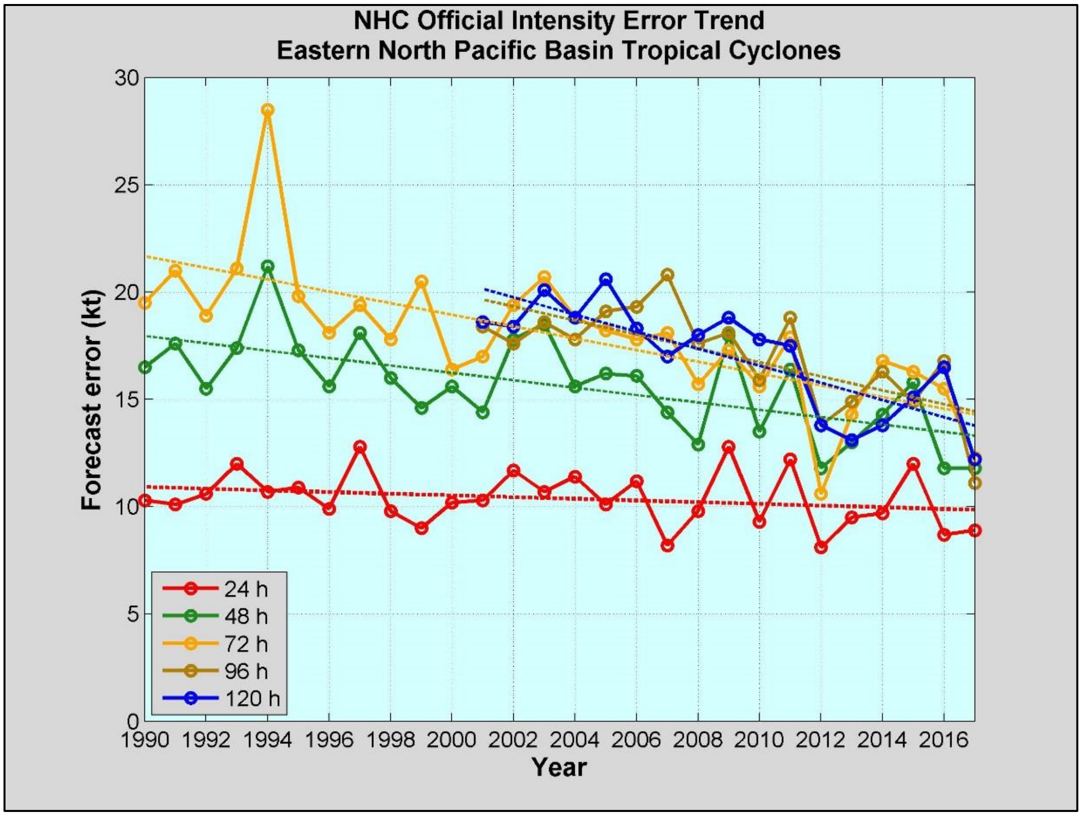


Figure 20. NHC official and Decay-SHIFOR5 (OCD5) eastern North Pacific basin average intensity errors for 2017 (solid lines) and 2012-2016 (dashed lines).



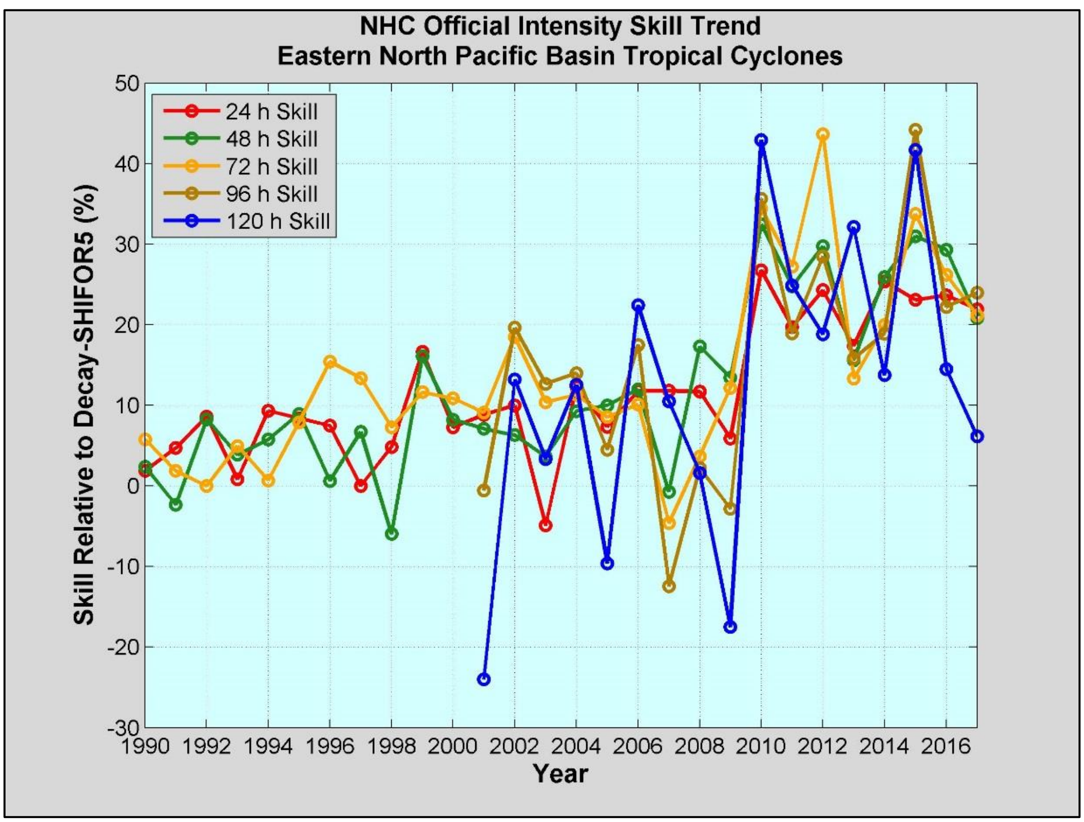


Figure 21. Recent trends in NHC official intensity forecast error (top) and skill (bottom) for the eastern North Pacific basin.

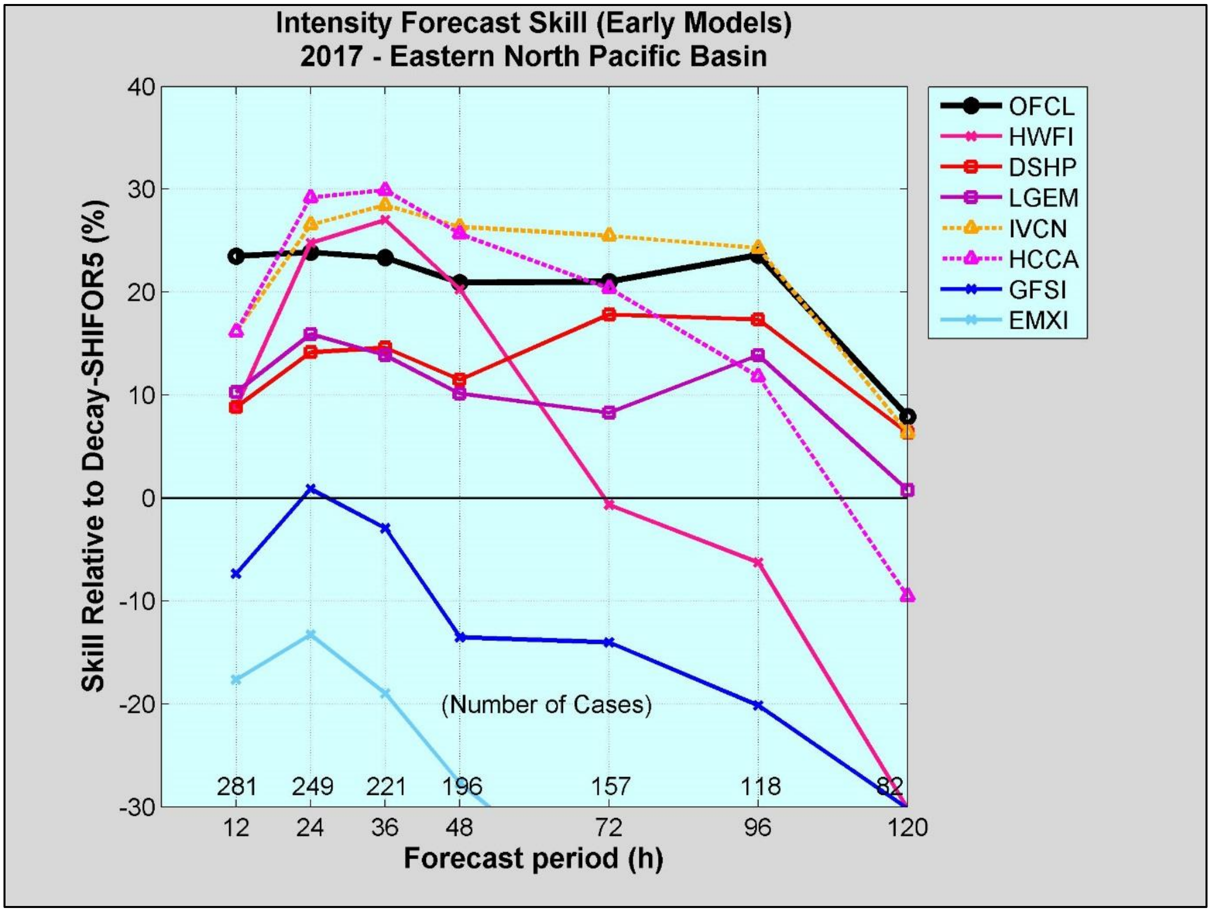


Figure 22. Homogenous comparison for selected eastern North Pacific basin early intensity guidance models for 2017.

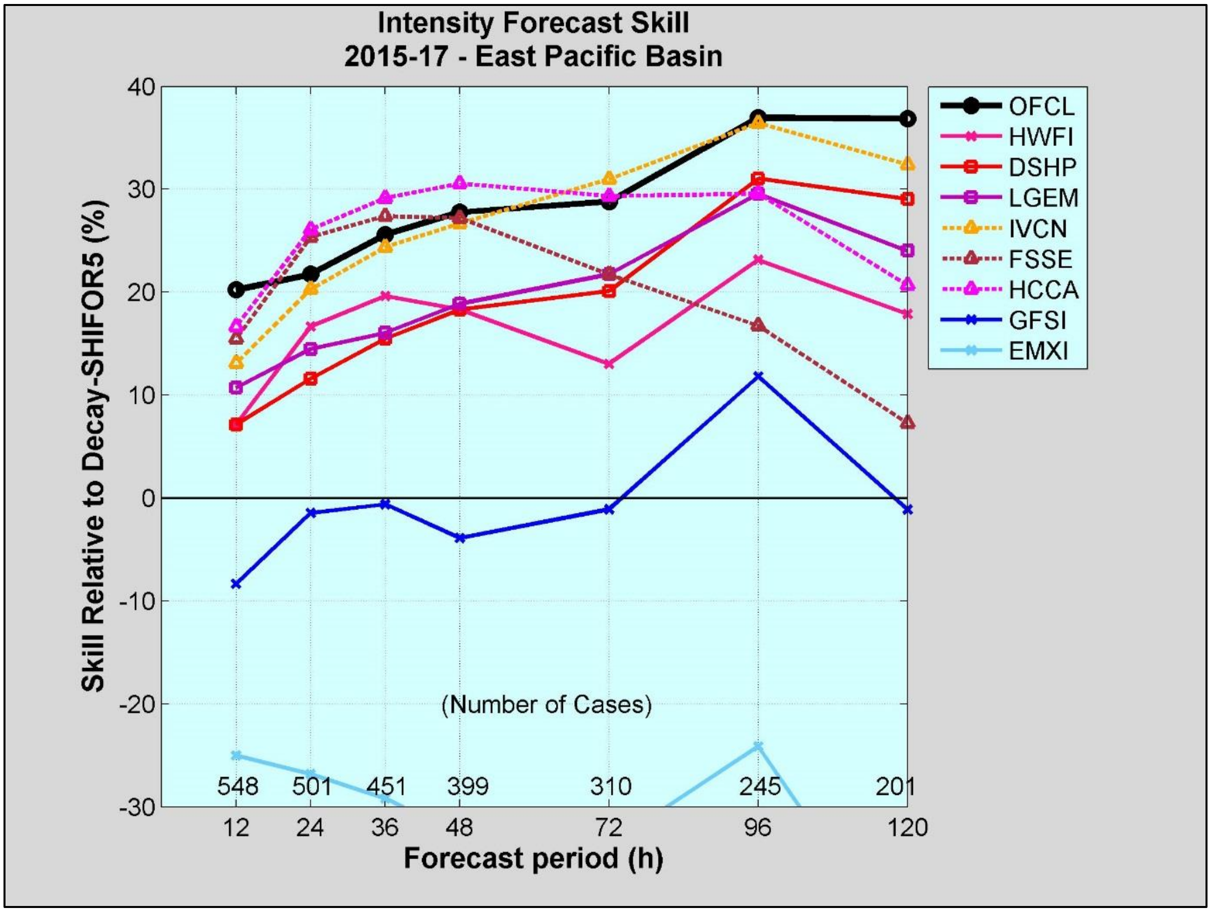


Figure 23. Homogenous comparison for selected eastern North Pacific basin early intensity guidance models for 2015 to 2017.

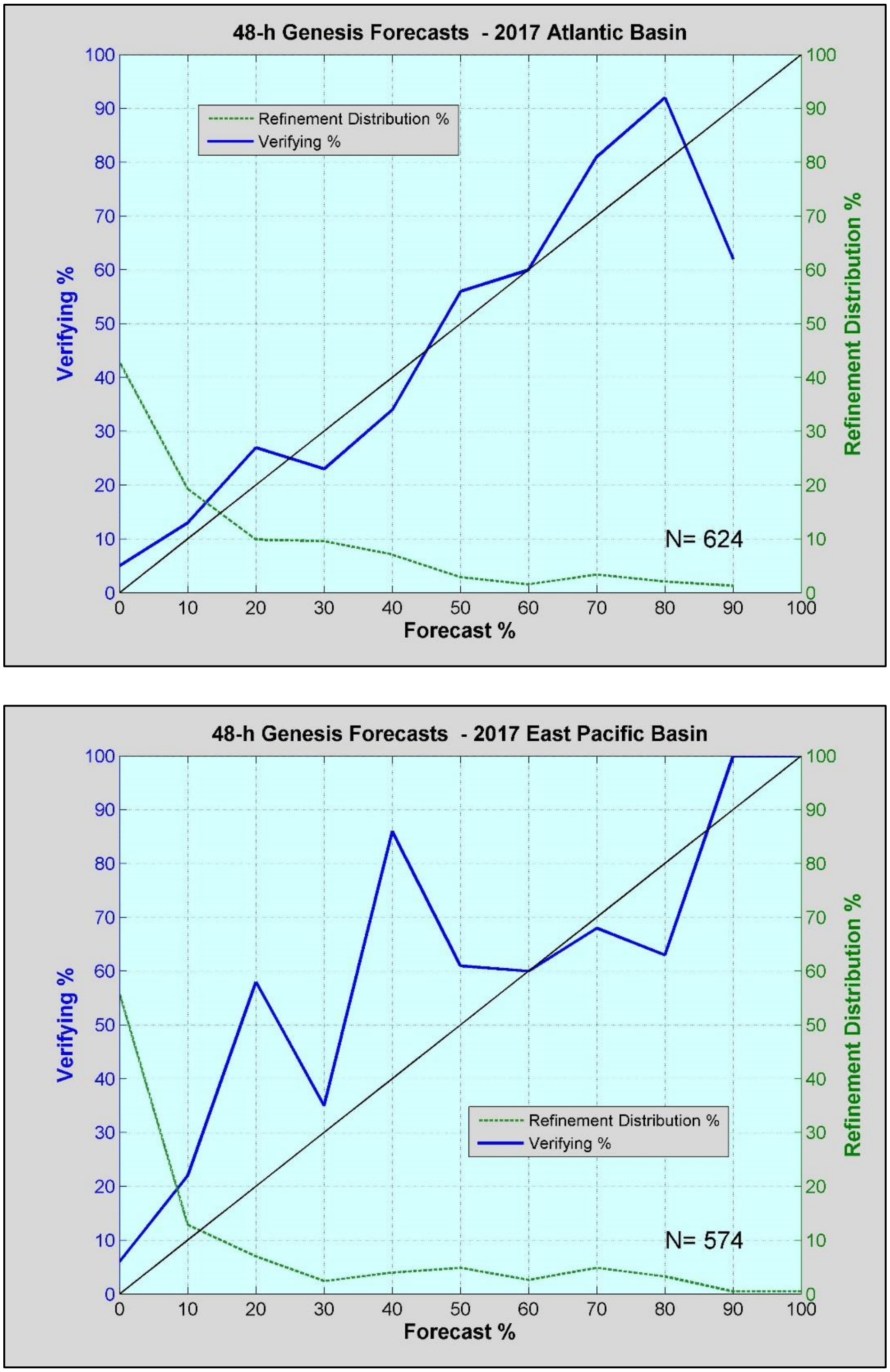


Figure 24. Reliability diagram for Atlantic (top) and eastern North Pacific (bottom) probabilistic tropical cyclogenesis 48-h forecasts for 2017. The solid lines indicate the relationship between the forecasts and verifying genesis percentages, with perfect reliability indicated by the thin diagonal black line. The dashed lines indicate how the forecasts were distributed among the possible forecast values.

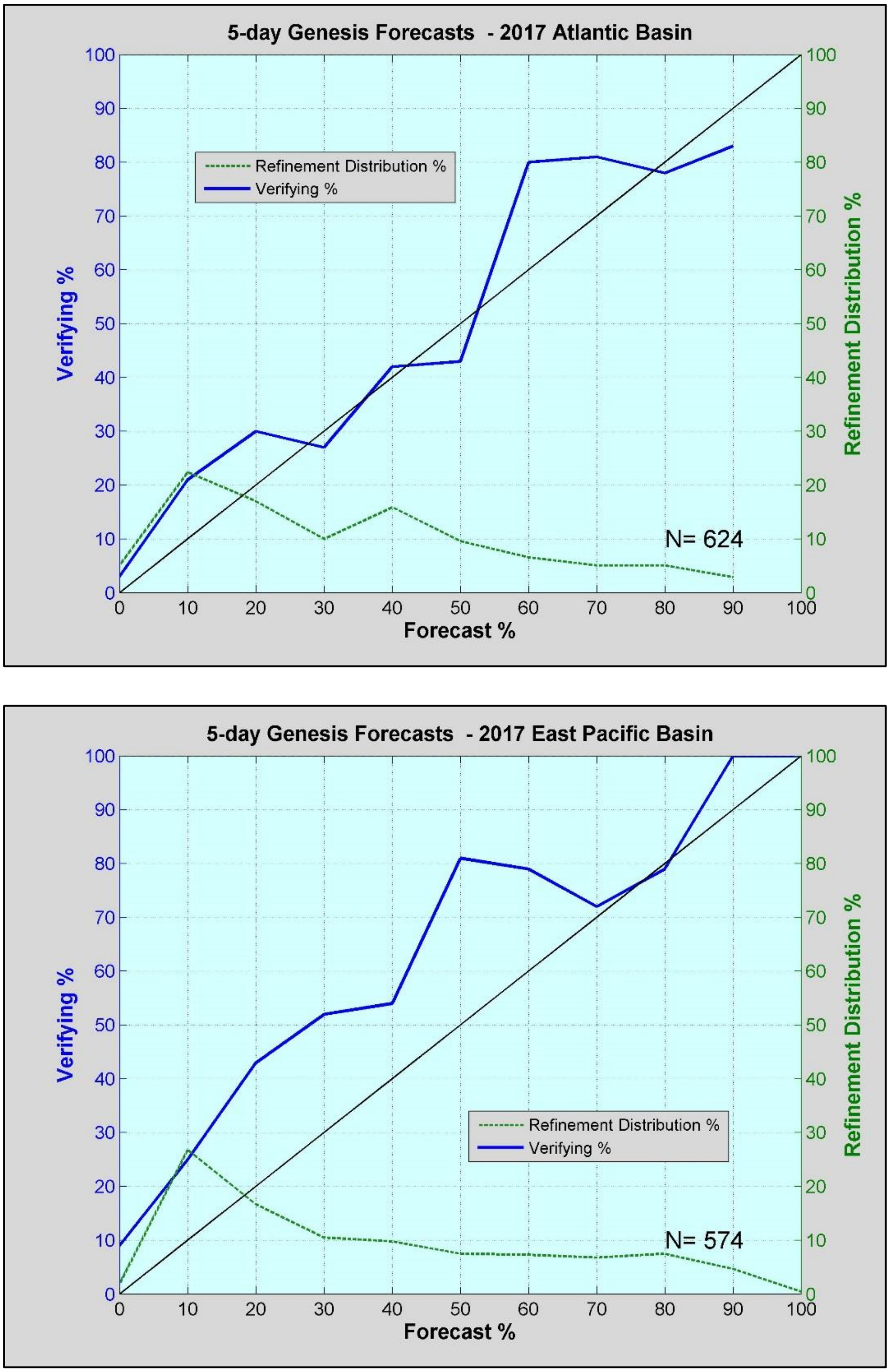


Figure 25. As described for Fig. 24, except for 120-h forecasts.