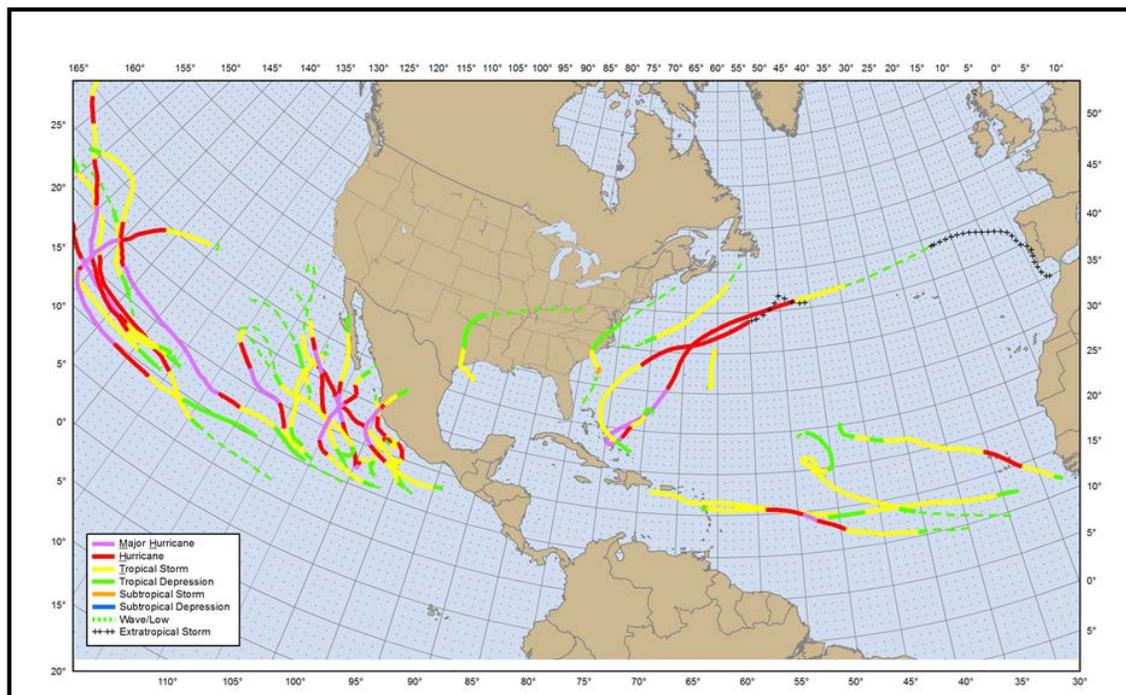# NATIONAL HURRICANE CENTER FORECAST VERIFICATION REPORT

2015 HURRICANE SEASON

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TRACKS OF THE 2015 ATLANTIC AND EAST PACIFIC TROPICAL CYCLONES.

ABSTRACT

The 2015 Atlantic hurricane season had below-normal activity, with 222 official forecasts issued. The mean NHC official track forecast errors in the Atlantic basin were slightly smaller than the previous 5-yr means from 12 to 36 h, but higher than the 5-yr means from 72 to 120 h. No records for track accuracy were set. The official track forecasts were highly skillful and performed close to or better than the consensus models. EMXI was the best-performing model and the only aid to consistently beat the official forecasts at 36 h and beyond. GFSI was a strong performer and the second best individual model. AEMI, EGRI, and HWFI were fair performers while GHMI, CMCI, NVGI, and GFNI performed less well. The Government Performance and Results Act of 1993 (GPRA) track goal was just missed.

Mean official intensity errors for the Atlantic basin in 2015 were below the 5-yr means from 12 to 48 h, but above the means at the longer lead times. Decay-SHIFOR errors in 2015 were close to their 5-yr means from 12 to 36 h, but considerably larger than average at the other forecast times. The official forecasts were quite skillful and near or better than the top models. Records for intensity accuracy were set at 12 and 24 h. Among the guidance, FSSE, HWFI, DSHP, and LGEM were the best performers, followed by IVCN. GHMI was the poorest-performing model, and GFNI was not competitive. The GPRA intensity goal was met.

There were 362 official forecasts issued in the eastern North Pacific basin in 2015, although only 127 of these verified at 120 h. This level of forecast activity was considerably above average. No records for track accuracy were set in 2015. The official forecasts were very skillful, but they were outperformed by TVCE and occasionally by FSSE. EMXI was the best individual model, but it had a little less skill than the consensus aids and the official forecasts. GFSI, AEMI, and HWFI performed fairly well and made up the second tier of models.

For intensity, the official forecast errors in the eastern North Pacific basin were slightly higher than the 5-yr means at most times. Decay-SHIFOR errors in 2015 were also higher than their 5-yr means, indicating the season's storms were more difficult than average to predict. No records for intensity accuracy were set. The official forecasts were as good as or better than all of the guidance, and they were only outperformed by FSSE at 24 and 36 h. IVCN was a strong perfomer, but it had less skill than the official forecasts. HWFI, DSHP, and LGEM were about equally skillful and made up the second tier of models. GHMI, GFNI, GFSI, and EMXI were not competitive. Nearly all of the guidance and the official forecasts had a low bias in 2015.

Quantitative probabilistic forecasts of tropical cyclogenesis were publically expanded from 48 to 120 h in August of 2013. Forecasts were expressed in 10% increments and in terms of categories ("low", "medium", or "high"). In the Atlantic basin, results from 2015 indicate that the 48-h probabilistic forecasts were quite reliable at the low probabilities, but had a low (under-forecast) bias at medium probabilities. The 120-h probabilities also had a low bias at probabilities higher than 40%. In the eastern North Pacific basin, the 48-h probabilistic forecasts were well calibrated, but the 120-h probabilities had a low bias at most ranges.

TABLE OF CONTENTS

1.   Introduction

For all operationally designated tropical or subtropical cyclones 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)[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.

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

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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.

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]

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 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 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

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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.

estimated from the logistic growth equation model 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[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

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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 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.[9]

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 based on forecast and best track data sets taken from the Automated Tropical Cyclone Forecast (ATCF) System[10] on 4 February 2016 for the Atlantic basin, and on 17 February 2016 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 2015 verification and previews anticipated changes for 2016.

2.   Atlantic Basin

a.   2015 season overview – Track

Figure 1 and Table 2 present the results of the NHC official track forecast verification for the 2015 season, along with results averaged for the previous 5-yr period, 2010-2014. In 2015, the NHC issued 222 Atlantic basin tropical cyclone forecasts[11], a number well below the previous 5-yr average of 317 (Fig. 2)   Mean track errors ranged from 25 n mi at 12 h to 241 n mi at 120 h. It is seen that the mean official track forecast errors in 2015 were slightly smaller than the previous 5-yr means from 12 to 36 h, near the 5-yr mean at 48 h, and higher than the 5-yr means from 72

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[9] 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.

[10]   In ATCF lingo, these are known as the "a decks" and "b decks", respectively.

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

to 120 h. The season's storms were about of average difficulty to forecast from 12 to 48 h, but were a little more difficult to forecast than average from 72 to 120 h. No records for accuracy were set in 2015. The official track forecast vector biases were small through 48 h, but increased beyond that time and were generally northwestward at 96 and 120 h (i.e., the official forecast tended to fall to the northwest of the verifying position). These biases at the longer range forecast times were largely dominated by forecasts made for Hurricane Joaquin, which accounted for a little more than one-third of the total sample at 96 and 120 h. Track forecast skill ranged from 41% at 12 h to 61% at 48 h (Table 2). The track errors in 2015 increased from the 2014 values (except at 120 h), but over the past 20-25 yr, 24−72-h track forecast errors have been reduced by about 70% (Fig. 3). Track forecast error reductions of about 50% have occurred over the past 10-15 yr for the 96- and 120-h forecast periods. On average, the NHC track errors steadily decrease as the initial intensity of a cyclone increases (Fig. 4).

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[12] verification for the official forecast along with a selection of early models for 2015. 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. Note that the sample becomes small (around 50 cases or less) at 96 h and beyond. The figure shows that the official forecasts were highly skillful, and near or slightly better than the accuracy of the consensus aids TVCA and FSSE. EMXI was the most skillful model, and the only aid that consistently beat the official forecasts. The strong performance of EMXI was boosted by its correct predictions of Hurricane Joaquin's moving southwestward near the Bahamas and then away from the United States. GFSI was a good performer (second best individual model) and had skill values just below the official forecast and consensus aids. AEMI, EGRI, and HWFI were not quite as skillful and made up the the next tier of models. GHMI, CMCI, NVGI, and GFNI were the poorest-preforming dynamical models. An evaluation over the three years 2013-15 (Fig. 6) indicates that FSSE and TVCA are the best-performing models through 48 h, however, EMXI is the most skillful model from 72 to 120 h. The official forecast has skill that is quite close to the best aids throughout the forecast perod. GFSI, AEMI, EGRI, and HWFI were strong performers and were the next best models. GHMI and CMCI performed less well.

Vector biases of the guidance models for 2015 are given in Table 3b. The table shows that the official forecast had similar biases to TVCA, FSSE, and GFSI. Most of the guidance, like

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[12] 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 official forecast, had a large northwest bias at 96 and 120 h primarily due to the poor predictions of Hurricane Joaquin when it was located near the Bahamas.

A separate homogeneous verification of the primary consensus models for 2015 is shown in Fig. 7. The figure shows that the skill of the consensus aids were similar to one another for the short lead times, but GFEX (consensus of GFSI and EMXI) was the most skillful model at 48 h and beyond. The second best performer was TVCX, which uses the members of TVCA but gives EMXI double weight. AEMI had less skill than the other consensus aids. An examination of AEMI over the past few years (not shown) indicates that the ensemble mean has become increasingly skillful in the Atlantic basin, and it is even more skillful than the GFS deterministic run at 96 and 120 h.

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 2015, the GPRA goal was 77 n mi and the verification for this measure was 77.4 n mi.

b.   2015 season overview – Intensity

Figure 8 and Table 4 present the results of the NHC official intensity forecast verification for the 2015 season, along with results averaged for the preceding 5-yr period.   Mean forecast errors in 2015 ranged from 5 kt at 12 h to about 20 kt at 120 h. These errors were below the 5-yr means from 12 to 48 h, but above the 5-yr means beyond 48 h. Records for accuracy were set at 12 and 24 h. The official forecasts had a slight low bias from 12 to 72 h, and a slight high bias at 96 and 120 h. Decay-SHIFOR5 errors were close to their 5-yr means from 12 to 36 h, but much larger than average at the other forecast times.   Although larger-than-average Decay-SHIFOR5 errors can sometimes imply that the season's storms were challengeing, in this case that model's large high biases at the latter forecast times suggest that the tropical cyclones in 2015 strengthened at a rate far less than climatology. This implies that the season's storms were actually not more difficult than average to forecast since environmental conditions were generally hostile (and known to be so), and forecasters were more confident than normal in their intensity predictions. Figure 9 shows that the errors increased at all forecast times (except 12 h) in 2015, disrupting the decreasing error trend that began at the start of the decade. Over the long term there has been a slight decrease in error, and forecasts in this decade, on average, have been more skillful than those from the previous one. In 2015, skill was at or near an all time high at 24 and 48 h. Skill values beyond 48 h, however, have decreased from record levels set a couple of years ago.

Table 5a presents a homogeneous verification for the official forecasts and the primary early intensity models for 2015. Intensity biases are given in Table 5b, and forecast skill is presented in Fig. 10. The official forecasts were quite skillful at all times, and were near or better than the top models. The most accurate intensity models in 2015 were FSSE, DSHP, LGEM, and HWFI. The performances of these models were quite similar to one another, and they occasionally outperformed the official forecasts from 36 to 96 h. IVCN was competitive with the top models from 12 to 72 h, but it trailed at the longer lead times likely due to the poor performance of GHMI, which is one of its members. GHMI had no skill at 96 and 120 h, with errors near 32 and 40 kt, respectively. GFNI was better than GHMI, but it was not competitive with the best models. The top-performing global models, GFSI and EMXI, were included in the intensity

verification for completeness, although they are typically not considered by forecasters. GFSI and EMXI showed little skill through 72 h, but had skill values close to the better-performing models at the longer lead times. An inspection of the intensity biases (Table 5b) indicates that most of the models had a small low bias at the shorter lead times, but a more notable high bias at the longer lead times. HWFI had the smallest bias overall (less than 3 kt), while GHMI had a very large (21 kt) high bias at 120 h. An evaluation over the three years 2013-15 (Fig. 11) indicates that the official forecasts have been performing better than all of the guidance. Similar to 2015, the top models for the 3-yr sample are FSSE, IVCN, HWFI, DSHP, and LGEM, which all have similar skill levels.

The 48-h official intensity error, evaluated for all tropical cyclones, is another GPRA measure for the NHC. In 2015, the GPRA goal was 12 kt and the verification for this measure was 11.4 kt. This was the fifth time in eight years that the intensity goal was met.

c.   Verifications for individual storms

Forecast verifications for individual storms are given in Table 6. Of note are the large track errors for Hurricane Joaquin, which were more than double the long-term mean at 96 and 120 h. The primary reason for the higher than average errors for this storm was that the official forecasts did not anticipate the southwestward motion of the cyclone over the Bahamas and some forecasts incorrectly showed a track too far west near the United States. Conversely, the official track forecast errors were quite low for Hurricane Danny and Tropical Storm Ida. The track errors for those storms where about 20-30% lower than the long-term mean at all forecast times. Figure 12 shows an illustration of the official track errors stratified by storm.

Regarding intensity forecast errors, Hurricane Danny was one of the more challenging cyclones to predict in 2015. The official intensity forecasts were greater than the long-term mean at all forecast times and more than twice the 5-yr averages at 96 and 120 h. The primary reason for the higher than average errors for Danny was because the official forecasts failed to predict the rapid intensification, peak intensity, and rapid weakening that ensued shortly after Danny had reached its peak intensity. Conversely, official intensity errors were very low for Tropical Depression Nine as forecasts correctly anticipated that the cyclone would not strengthen due to hostile environmental conditions. 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=2015&basin=atl**

3.   Eastern North Pacific Basin

a.   2015 season overview – Track

The NHC track forecast verification for the 2015 season in the eastern North Pacific, along with results averaged for the previous 5-yr period is presented in Figure 14 and Table 7. There were 362 forecasts issued for the eastern Pacific basin in 2015, although only 127 of these verified at 120 h. This level of forecast activity is slightly above average (Fig. 15). Mean track errors

ranged from 26 n mi at 12 h to 154 n mi at 120 h. These errors were higher than the 5-yr means from 12 to 36 h, but lower than the 5-yr means from 72 to 120 h.   No records for accuracy were set in 2015. CLIPER5 errors were a little higher than their long-term means for the short lead times, but much lower than the means from 72 to 120 h.   The official track forecast vector biases were small through 36 h, but increased beyond that time and were generally northeastward or east-northeastward from 48 to120 h.

Figure 16 shows recent trends in track forecast accuracy and skill for the eastern North Pacific. Although the 2015 errors changed little from the 2014 values, the long-term trend is quite pronounced. Errors have been reduced by roughly 60% for the 24 to 72 h forecasts since 1990. Similar improvements have been made for the 96 and 120 h forecasts since 2001. Forecast skill in 2015 decreased from record values in 2014, but the overall trend shows a significant increase in skill.

Table 8a presents a homogeneous verification for the official forecast and the early track models for 2015, 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 only slightly beat by TVCE and by FSSE at 12 and 24 h. EMXI was the best individual model, but it had less skill than TVCE/FSSE and the official forecasts.   GSFI, HWFI, and AEMI made up the second tier of models, and EGRI and GHMI had similar skill levels except for the longer leads where they trailed. GFNI, NVGI, and CMCI were the poorest-performing dynamical models and were beat by the simple BAMM model beyond 48 h.

A separate verification of the primary consensus aids is given in Figure 18. The skill of the consensus models was tightly clustered with TVCX slightly outperforming TVCE. GFEX had a little less skill than TVCE/TVCX, except for the longer leads where it was superior. FSSE was not far behind, and AEMI was the least skillful of the consensus aids shown.

b.   2015 season overview – Intensity

Figure 19 and Table 9 present the results of the NHC eastern North Pacific intensity forecast verification for the 2015 season, along with results averaged for the preceding 5-yr period. Mean forecast errors were 7 kt at 12 h and increased to 16 kt at 72 h. The errors were a little higher than the 5-yr means at most forecast time periods. The Decay-SHIFOR5 forecast errors were also higher than their 5-yr means, indicative that the season's storms were more difficult than normal to predict. A review of error and skill trends (Fig. 20) indicates that although there is considerable year-to-year variability in intensity errors, there has been a slight decrease in error over the past 20-25 yr at 48 h and beyond. No trend is apparent for 24 h. Forecast skill increased in 2015, and it was at or near all time highs at 48 h and beyond. Intensity forecast biases were low for all lead times.

Figure 21 and Table 10a present a homogeneous verification for the primary early intensity models for 2015. Forecast biases are given in Table 10b. The official forecasts performed as good as or better than all of the guidance. In fact, the only model that had lower errors was FSSE at 24 and 36 h, but that model trailed at longer lead times. IVCN was a strong performer for all forecast periods, but it had slightly less skill than the official forecasts. HWFI, DSHP, and LGEM made up the next tier of models and were about equally skillful. GHMI, GFNI, and GFSI had little

skill and were not competitive, and EMXI was not skillful at any forecast time. Nearly all of the models suffered from a low bias in 2015, with GHMI and GFNI having the most significant bias of about 20 kt at 36 and 48 h. It should be noted that the official forecast bias was lower than the guidance.

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=2015&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 out to 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 2015 are given in Table 12 and illustrated in Fig. 22. In the Atlantic basin, a total of 542 genesis forecasts were made. These 48-h forecasts were quite reliable for the low probabilities but exhibited a slight under-forecast (low) bias in the medium probabilities. The sample is too small at the high probabilities to draw meaningful conclusions. In the eastern Pacific, a total of 765 genesis forecasts were made. The forecasts were well calibrated and much improved from previous years.

Verification of the 120-h outlook for the Atlantic and eastern North Pacific basins for 2015 are given in Table 13 and illustrated in Fig. 23. In the Atlantic basin, the 120-h forecasts were well calibrated from 0 to 40%, but, in general, a low bias existed at probabilities greater than 40%. In the eastern North Pacific, a slight low bias exists 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 2016

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 2016 for the Atlantic and eastern North Pacific basins (based on error distributions for 2011-15) are given in Table 14. In the Atlantic basin, the cone circles will be slightly smaller (by up to 7 %) at all forecast time periods except 120 h, where the cone circle will be 5 % larger. In the eastern Pacific basin, the cone circles will change little except at 96 and 120 h where they will be slightly smaller .

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 2016 is given in Table 15. The 2016 consensus model composition for TVCA, TVCE, and IVCN have been modified to include the regional model COAMPS-TC using the GFS initial and lateral boundary conditions (CTCI).   CTCI has been a strong performer for track and intensity of tropical cyclones for both the Atlantic and east Pacific basins during the past few years, and it has had similar skill levels to the best performing track and intensity models during that time (not shown).

Acknowledgments

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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
GFDL	NWS/Geophysical Fluid Dynamics Laboratory model	Multi-layer regional dynamical	L	Trk, Int
HWRF	Hurricane Weather and Research Forecasting 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
NVGM	Navy Global Environmental Model	Multi-layer global dynamical	L	Trk, Int
GFDN	Navy version of GFDL	Multi-layer regional 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
CTX	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

ID	Name/Description	Type	Timeliness (E/L)	Parameters forecast
EEMN	ECMWF ensemble mean	Consensus	L	Trk
BAMS	Beta and advection model (shallow layer)	Single-layer trajectory	E	Trk
BAMM	Beta and advection model (medium layer)	Single-layer trajectory	E	Trk
BAMD	Beta and advection model (deep layer)	Single-layer trajectory	E	Trk
LBAR	Limited area barotropic model	Single-layer regional dynamical	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
GFDI	Previous cycle GFDL, adjusted	Interpolated-dynamical	E	Trk, Int

ID	Name/Description	Type	Timeliness (E/L)	Parameters forecast
GHMI	Previous cycle GFDL, adjusted using a variable intensity offset correction that is a function of forecast time. Note that for track, GHMI and GFDI are identical.	Interpolated-dynamical	E	Trk, Int
HWFI	Previous cycle HWRF, 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
EGRI	Previous cycle EGRR, adjusted	Interpolated-dynamical	E	Trk, Int
NVGI	Previous cycle NVGM, adjusted	Interpolated-dynamical	E	Trk, Int
GFNI	Previous cycle GFDN, 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
GUNA	Average of GFDI, EGRI, and GFSI	Consensus	E	Trk
CGUN	Version of GUNA corrected for model biases	Corrected consensus	E	Trk

ID	Name/Description	Type	Timeliness (E/L)	Parameters forecast
AEMI	Previous cycle AEMN, 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 GHMI, 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 GHMI HWFI EMXI	Consensus	E	Trk
TVCA	Average of at least two of GFSI EGRI GHMI HWFI EMXI	Consensus	E	Trk
TVCE	Average of at least two of GFSI EGRI GHMI HWFI EMXI	Consensus	E	Trk
TVCX	EMXI and average of at least two of GFSI EGRI GHMI HWFI EMXI	Consensus	E	Trk
TVCC	Version of TVCN corrected for model biases	Corrected consensus	E	Trk
ICON	Average of DSHP, LGEM, GHMI, and HWFI	Consensus	E	Int
IVCN	Average of at least two of DSHP LGEM GHMI HWFI GFNI	Consensus	E	Int

Table 2.   Homogenous comparison of official and CLIPER5 track forecast errors in the Atlantic basin for the 2015 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
2015 mean OFCL error (n mi)	25.4	41.1	57.1	77.4	125.2	188.0	241.4
2015 mean CLIPER5 error (n mi)	43.2	90.6	146.1	200.6	295.5	429.2	554.4
2015 mean OFCL skill relative to CLIPER5 (%)	41.2	54.6	60.9	61.4	57.6	56.2	56.5
2015 mean OFCL bias vector (°/n mi)	359/006	358/013	003/019	001/028	358/053	332/101	304/165
2015 number of cases	202	182	159	136	96	67	49
2010-2014 mean OFCL error (n mi)	28.4	45.0	60.4	77.1	113.1	157.8	210.0
2010-2014 mean CLIPER5 error (n mi)	48.3	101.5	161.5	222.6	329.8	412.6	483.9
2010-2014 mean OFCL skill relative to CLIPER5 (%)	41.2	55.7	62.6	65.4	65.7	61.8	56.6
2010-2014 mean OFCL bias vector (°/n mi)	355/002	329/004	312/006	313/008	293/009	344/007	015/022
2010-2014 number of cases	1407	1235	1082	942	712	545	427
2015 OFCL error relative to 2010-2014 mean (%)	-10.6	-8.7	-5.5	0.4	10.7	19.1	15.0
2015 CLIPER5 error relative to 2010-2014 mean (%)	-10.6	-10.7	-9.5	-9.9	-10.4	4.0	14.6

Table 3a.   Homogenous comparison of Atlantic basin early track guidance model errors (n mi) for 2015. Errors smaller than the NHC official forecast are shown in bold-face.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	25.6	40.4	56.6	74.1	114.7	154.9	220.2
OCD5	45.1	96.8	163.0	216.6	309.4	456.1	641.5
GFSI	28.9	45.1	63.0	82.8	126.9	185.6	288.4
GHMI	32.3	55.2	78.0	104.3	184.5	313.9	419.6
HWFI	30.8	51.8	76.2	98.8	165.3	255.4	389.9
EMXI	26.5	**40.2**	**53.1**	**59.9**	**81.9**	**113.8**	**142.9**
CMCI	32.4	55.6	85.8	115.6	210.4	297.8	369.5
EGRI	28.2	46.5	66.1	87.0	146.0	215.1	361.8
NVGI	35.8	59.9	88.7	121.0	226.2	335.9	433.5
GFNI	34.1	58.2	87.7	117.0	211.6	347.0	447.6
AEMI	28.4	45.9	67.5	89.3	149.5	210.7	291.3
FSSE	25.6	**39.1**	**54.9**	**71.5**	**119.8**	172.1	247.6
TVCA	25.7	**39.4**	**54.5**	**71.0**	**115.1**	174.0	256.8
LBAR	40.9	76.8	120.9	163.0	268.0	384.0	468.1
BAMD	43.5	85.2	130.0	177.2	267.1	372.0	512.8
BAMM	37.1	69.7	104.4	135.7	210.8	311.8	469.9
BAMS	48.2	92.5	140.1	180.5	280.1	440.5	693.7
TCLP	46.3	100.4	170.7	221.5	309.2	462.3	670.0
# Cases	130	118	106	91	70	51	36

Table 3b.   Homogenous comparison of Atlantic basin early track guidance model bias vectors (º/n mi) for 2015.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	004/006	005/014	358/019	358/031	339/056	310/097	296/179
OCD5	301/011	299/027	304/056	313/081	314/174	303/300	301/421
GFSI	002/008	004/014	360/019	002/028	346/050	310/085	297/157
GHMI	049/012	031/024	020/041	015/066	005/135	356/204	355/261
HWFI	029/008	028/014	016/022	016/031	349/055	300/114	295/197
EMXI	337/010	332/014	323/017	323/021	329/025	336/029	329/050
CMCI	330/011	326/022	324/036	325/055	308/100	288/152	286/241
EGRI	011/005	021/009	014/015	009/021	345/037	303/078	287/200
NVGI	343/016	350/023	351/024	358/032	311/067	275/149	268/252
GFNI	051/007	036/017	015/026	005/046	322/105	293/200	284/333
AEMI	000/008	005/014	000/019	356/025	333/057	306/101	298/176
FSSE	003/008	002/014	359/020	000/030	341/059	312/094	298/162
TVCA	016/008	013/014	008/021	007/032	354/059	326/092	313/151
LBAR	032/011	012/027	005/045	013/070	033/131	056/244	070/362
BAMD	065/022	063/046	059/067	054/089	046/118	043/100	079/060
BAMM	351/007	346/011	328/017	333/028	305/057	269/152	260/292
BAMS	308/026	2911.7/054	288/088	284/117	273/189	260/339	259/563
TCLP	269/014	270/035	274/067	282/084	282/166	275/334	276/503
# Cases	130	118	106	91	70	51	36

Table 4.   Homogenous comparison of official and Decay-SHIFOR5 intensity forecast errors in the Atlantic basin for the 2015 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
2015 mean OFCL error (kt)	5.0	7.4	9.9	11.4	15.6	19.6	20.4
2015 mean Decay-SHIFOR5 error (kt)	6.7	10.3	13.8	18.1	23.5	27.5	29.2
2015 mean OFCL skill relative to Decay-SHIFOR5 (%)	25.4	28.2	28.3	37.0	33.6	28.7	30.1
2015 OFCL bias (kt)	-1.6	-1.6	-1.6	-1.8	-1.1	0.9	4.7
2015 number of cases	202	182	159	136	96	67	49
2010-14 mean OFCL error (kt)	6.2	9.4	11.5	13.3	14.6	14.6	14.8
2010-14 mean Decay-SHIFOR5 error (kt)	7.3	10.8	13.3	15.3	17.7	17.8	17.6
2010-14 mean OFCL skill relative to Decay-SHIFOR5 (%)	15.1	13.0	13.5	13.1	17.5	18.0	15.9
2010-14 OFCL bias (kt)	-0.6	0.0	0.6	1.3	1.3	1.3	1.7
2010-14 number of cases	1407	1235	1082	942	712	545	427
2015 OFCL error relative to 2010-14 mean (%)	-19.4	-21.3	-13.9	-14.3	6.8	34.2	37.8
2015 Decay-SHIFOR5 error relative to 2010-14 mean (%)	-8.2	-4.6	3.8	18.3	32.8	54.5	65.9

Table 5a.   Homogenous comparison of selected Atlantic basin early intensity guidance model errors (kt) for 2015. Errors smaller than the NHC official forecast are shown in boldface.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	5.8	8.3	11.3	12.2	13.9	16.8	16.8
OCD5	7.5	11.0	15.4	19.7	22.7	25.7	29.7
HWFI	6.8	9.4	11.7	**11.9**	**12.6**	17.1	20.5
GHMI	7.8	11.8	15.3	16.6	20.7	31.6	40.2
GFNI	8.6	11.6	15.2	16.9	18.8	22.2	19.9
DSHP	7.0	9.6	12.2	13.6	**13.4**	**16.2**	20.7
LGEM	6.8	9.4	11.9	13.2	**12.9**	16.9	22.2
IVCN	6.6	9.2	11.6	12.5	**13.5**	18.9	24.9
FSSE	6.3	8.7	**11.0**	12.4	14.2	**16.7**	18.3
GFSI	8.0	11.8	16.0	18.8	20.6	20.4	19.4
EMXI	8.5	12.6	16.5	19.7	22.1	20.8	21.7
TCLP	7.3	11.2	15.5	19.5	22.9	25.3	27.0
# Cases	135	125	111	96	72	55	38

Table 5b.   Homogenous comparison of selected Atlantic basin early intensity guidance model biases (kt) for 2015. Biases smaller than the NHC official forecast are shown in boldface.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	-1.4	-0.4	-0.1	-0.1	1.7	5.5	6.8
OCD5	**-1.2**	1.6	3.4	5.3	6.9	13.2	15.9
HWFI	-1.8	-1.0	-0.3	**0.0**	2.7	**1.9**	**-0.9**
GHMI	-1.8	-0.9	0.3	1.4	6.6	13.2	20.8
GFNI	-4.2	-4.7	-4.7	-5.1	-5.3	-7.7	**-6.0**
DSHP	-1.9	-0.6	-0.1	0.4	**0.9**	**4.2**	**4.8**
LGEM	-1.8	-0.4	0.5	1.7	3.1	6.5	6.8
IVCN	-1.6	-0.4	0.4	1.1	3.6	6.7	8.3
FSSE	-1.7	-0.5	-0.1	0.5	3.4	6.1	8.9
GFSI	-2.8	-0.9	-0.1	0.3	2.3	6.7	**5.5**
EMXI	-2.5	-1.2	**0.0**	0.7	4.4	10.9	19.7
TCLP	-1.5	**0.1**	1.5	3.5	8.2	16.8	24.3
# Cases	135	125	111	96	72	55	38

Table 6.   Official Atlantic track and intensity forecast verifications (OFCL) for 2015 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:     AL012015                  ANA

    VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
    000         12       4.5       4.5      12       1.3       1.3
    012         12      11.6      25.3      12       3.3       5.6
    024         12      13.5      50.9      12       2.5       7.5
    036         10      22.7      77.0      10       3.0       8.3
    048          8      31.2     115.8       8       3.8       7.4
    072          4      85.3     215.2       4       0.0       4.3
    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:     AL022015                  BILL

    VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
    000          6       6.6       7.6       6       0.8       0.8
    012          6      32.6      64.6       6       3.3       4.3
    024          6      25.5     114.2       6       0.8       2.3
    036          5      19.6     195.8       5       3.0       3.2
    048          2      15.6     238.9       2       5.0       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

Verification statistics for:     AL032015                  CLAUDETTE

    VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
    000          6       4.9       4.9       6       3.3       2.5
    012          4      45.4      36.3       4       0.0       5.0
    024          2      94.2     103.5       2       2.5      18.0
    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:     AL042015                  DANNY

    VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
    000         25       5.5       6.0      25       5.4       5.6
    012         23      20.4      27.4      23      10.4      13.5
    024         21      34.6      52.7      21      14.8      20.8
    036         19      47.9      89.6      19      17.4      28.2
    048         17      54.4     132.8      17      17.4      34.2
    072         13      78.1     187.2      13      16.9      29.6
    096          9     109.7     228.6       9      27.8      21.9
    120          5     158.9     294.5       5      43.0      31.0
```

```
Verification statistics for:    AL052015                    ERIKA

    VT (h)       NT      OFCL      OCD5      NI      OFCL      OCD5
    000          15       7.9       8.1      15       0.7       0.7
    012          13      29.0      33.1      13       4.6       4.5
    024          11      57.8      43.7      11       6.4       7.0
    036           9      81.0      70.6       9       7.2       8.8
    048           7      91.2      98.2       7       7.9       9.3
    072           3     118.5     166.0       3      15.0      21.7
    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:    AL062015                    FRED

    VT (h)       NT      OFCL      OCD5      NI      OFCL      OCD5
    000          31       4.1       4.1      31       1.0       1.1
    012          29      19.0      29.4      29       3.4       6.4
    024          27      30.6      50.0      27       6.7      10.0
    036          25      39.5      80.4      25       8.6      13.7
    048          23      45.9     112.8      23       7.6      17.1
    072          19      68.3     196.1      19       7.9      23.6
    096          15      87.9     297.4      15       6.3      33.8
    120          11     104.1     411.6      11       6.4      29.0

Verification statistics for:    AL072015                    GRACE

    VT (h)       NT      OFCL      OCD5      NI      OFCL      OCD5
    000          16      11.5      11.5      16       1.6       1.9
    012          14      21.4      33.9      14       4.6       5.3
    024          12      31.2      72.6      12       7.9      10.0
    036          10      40.9     123.7      10      13.0      16.0
    048           8      55.5     176.3       8      14.4      23.4
    072           4      87.7     260.2       4      20.0      32.0
    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:    AL082015                    HENRI

    VT (h)       NT      OFCL      OCD5      NI      OFCL      OCD5
    000          10      13.0      13.2      10       7.5       7.5
    012           8      24.3      47.0       8       4.4       4.9
    024           6      48.5     101.2       6       3.3       3.5
    036           4      84.9     147.2       4       5.0       6.5
    048           2     129.5     156.7       2      10.0      15.0
    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: AL092015   NINE

```
    VT (h)      NT     OFCL      OCD5      NI     OFCL      OCD5
    000         13     14.6      14.6      13      0.0       0.0
    012         11     36.5      52.3      11      1.8       3.7
    024          9     57.5      95.5       9      2.2       8.1
    036          7     72.4     126.1       7      1.4      11.1
    048          5     99.2     128.3       5      0.0      17.8
    072          1    228.5     198.6       1      0.0      17.0
    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: AL102015   IDA

```
    VT (h)      NT     OFCL      OCD5      NI     OFCL      OCD5
    000         36     15.4      15.3      36      0.8       1.1
    012         34     28.6      46.1      34      3.1       4.0
    024         32     39.6      94.9      32      4.5       6.8
    036         30     50.1     155.3      30      6.2       8.3
    048         28     63.2     218.5      28      7.9      12.3
    072         24     80.8     334.3      24     12.9      17.8
    096         20     99.5     438.1      20     18.5      25.5
    120         16    139.6     597.5      16     21.9      32.3
```

Verification statistics for: AL112015   JOAQUIN

```
    VT (h)      NT     OFCL      OCD5      NI     OFCL      OCD5
    000         40      9.1       9.3      40      2.1       2.4
    012         38     26.3      52.5      38      7.2       8.5
    024         36     50.6     127.0      36     11.0      12.4
    036         34     79.7     203.7      34     15.0      16.5
    048         32    121.0     276.6      32     17.3      20.3
    072         28    231.7     413.9      28     24.8      27.5
    096         23    360.9     586.0      23     25.9      27.3
    120         17    450.4     682.7      17     21.5      25.8
```

Verification statistics for: AL122015   KATE

```
    000         12      4.1       4.1      12      4.2       4.2
    012         10     34.8      98.7      10      5.5       7.4
    024          8     65.6     263.1       8      8.8       9.4
    036          6    110.9     474.0       6     11.7      11.7
    048          4    197.4     750.6       4     18.8      14.3
    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
```

Table 7.   Homogenous comparison of official and CLIPER5 track forecast errors in the eastern North Pacific basin in 2015 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
2015 mean OFCL error (n mi)	26.2	38.8	49.3	59.4	83.1	115.1	153.8
2015 mean CLIPER5 error (n mi)	38.8	76.1	117.6	153.4	213.2	242.3	297.0
2015 mean OFCL skill relative to CLIPER5 (%)	32.5	49.0	58.1	61.3	61.0	52.5	48.2
2015 mean OFCL bias vector (°/n mi)	344/004	360/007	021/011	035/017	050/032	055/045	062/064
2015 number of cases	331	300	272	246	200	158	127
2010-2014 mean OFCL error (n mi)	23.4	36.1	46.8	59.2	89.1	124.2	160.8
2010-2014 mean CLIPER5 error (n mi)	36.6	74.2	116.4	159.7	246.8	334.1	431.2
2010-2014 mean OFCL skill relative to CLIPER5 (%)	36.1	51.3	59.8	62.9	63.9	62.8	62.7
2010-2014 mean OFCL bias vector (°/n mi)	321/001	312/001	090/001	091/005	089/015	074/031	048/040
2010-2014 number of cases	1310	1163	1020	889	665	478	318
2015 OFCL error relative to 2010-2014 mean (%)	12.0	7.5	5.3	0.3	-6.7	-7.3	-4.3
2015 CLIPER5 error relative to 2010-2014 mean (%)	6.0	2.6	1.0	-3.9	-13.6	-27.5	-31.1

Table 8a.   Homogenous comparison of eastern North Pacific basin early track guidance model errors (n mi) for 2015. Errors smaller than the NHC official forecast are shown in boldface.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	23.3	36.9	47.3	55.9	73.4	103.7	136.8
OCD5	36.4	73.4	113.6	144.7	192.1	213.1	291.5
GFSI	26.1	41.5	52.8	64.8	88.2	124.7	163.1
GHMI	29.1	46.5	62.1	74.8	105.9	173.5	250.8
HWFI	27.7	43.7	57.1	69.2	93.0	121.5	167.1
EMXI	24.1	40.7	54.2	62.5	86.1	113.7	140.7
CMCI	30.6	50.4	66.9	85.5	125.7	151.4	189.5
EGRI	24.7	40.6	53.3	68.8	99.7	133.4	188.7
NVGI	30.4	51.1	70.4	89.7	125.5	163.8	205.5
GFNI	31.4	54.6	74.4	91.5	136.2	195.3	262.2
AEMI	25.9	42.8	55.5	65.8	90.8	117.7	144.2
FSSE	**22.8**	**36.5**	47.8	58.1	78.3	111.6	151.3
TVCE	**23.1**	**36.2**	46.6	**55.2**	**71.1**	**103.6**	141.4
LBAR	33.4	64.3	97.4	131.9	186.5	236.4	303.9
BAMD	37.3	65.0	91.7	110.8	125.7	177.9	248.9
BAMM	33.2	55.7	75.2	90.7	106.4	126.3	166.2
BAMS	43.3	77.4	107.7	128	136.3	148.7	196.2
TCLP	36.7	74.1	116	155.8	218.6	262.7	362.1
# Cases	222	203	186	165	127	93	75

Table 8b.   Homogenous comparison of eastern North Pacific basin early track guidance model bias vectors (º/n mi) for 2015.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	007/005	014/009	018/012	025/015	050/024	063/047	075/052
OCD5	301/004	279/012	260/026	250/039	242/087	250/117	248/218
GFSI	013/007	010/011	015/013	026/014	050/026	060/057	068/066
GHMI	036/009	028/018	021/024	015/033	037/064	040/126	040/203
HWFI	352/010	350/015	341/016	336/017	001/009	075/028	093/024
EMXI	344/004	010/006	033/007	047/013	065/023	075/031	105/033
CMCI	021/006	030/011	045/015	051/025	055/048	061/092	070/103
EGRI	322/001	329/004	327/006	304/010	270/013	209/008	235/053
NVGI	334/011	323/020	315/026	314/037	318/054	334/069	352/101
GFNI	026/004	029/011	017/017	007/027	013/049	021/098	029/179
AEMI	340/007	344/012	353/014	004/015	038/027	058/064	067/080
FSSE	014/006	018/012	021/016	022/022	035/036	050/059	060/068
TVCE	005/005	009/010	007/013	007/015	037/022	053/045	056/049
LBAR	031/015	357/034	340/056	334/079	333/103	010/131	035/187
BAMD	003/017	001/030	357/038	356/042	355/041	032/085	045/136
BAMM	336/017	330/027	322/031	316/032	323/021	031/041	036/053
BAMS	337/021	329/033	321/041	316/043	305/031	350/019	245/013
TCLP	254/003	233/013	224/030	219/050	218/100	224/140	229/263
# Cases	222	203	186	165	127	93	75

Table 9.   Homogenous comparison of official and Decay-SHIFOR5 intensity forecast errors in the eastern North Pacific basin for the 2015 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
2015 mean OFCL error (kt)	7.4	11.9	14.7	15.7	16.2	14.9	15.1
2015 mean Decay-SHIFOR5 error (kt)	9.4	15.6	20.2	22.9	24.6	26.7	25.9
2015 mean OFCL skill relative to Decay-SHIFOR5 (%)	20.2	23.1	27.2	31.0	33.7	44.2	41.7
2015 OFCL bias (kt)	-1.6	-2.9	-4.0	-5.3	-4.6	-4.3	-4.8
2015 number of cases	331	300	272	246	200	158	127
2010-14 mean OFCL error (kt)	5.9	9.7	12.4	13.9	15.4	16.2	14.7
2010-14 mean Decay-SHIFOR5 error (kt)	7.6	12.6	16.2	18.6	20.8	20.7	19.5
2010-14 mean OFCL skill relative to Decay-SHIFOR5 (%)	22.4	23.0	25.9	25.3	26.0	21.7	24.6
2010-14 OFCL bias (kt)	-0.5	-0.7	-1.5	-2.2	-2.2	-1.7	-0.7
2010-14 number of cases	1310	1163	1020	889	665	478	318
2015 OFCL error relative to 2010-14 mean (%)	25.4	22.7	18.5	12.9	5.2	-8.0	2.7
2015 Decay-SHIFOR5 error relative to 2010-14 mean (%)	23.7	23.8	24.7	23.2	18.3	29.0	32.8

Table 10a.   Homogenous comparison of eastern North Pacific basin early intensity guidance model errors (kt) for 2015. Errors smaller than the NHC official forecast are shown in boldface.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	8.7	14.0	16.2	15.7	13.1	12.5	11.6
OCD5	10.9	18.0	22.6	23.4	21.3	25.5	21.1
HWFI	10.4	15.4	18.8	19.4	15.7	15.1	13.2
GHMI	11.7	18.8	24.0	24.2	20.1	21.1	17.3
GFNI	12.4	20.1	25.1	25.7	23.0	22.4	21.5
DSHP	9.6	15.7	18.5	18.3	15.1	13.7	13.5
LGEM	9.4	15.0	18.0	18.0	14.6	14.8	14.1
IVCN	9.6	14.7	17.2	16.9	13.3	13.4	11.8
FSSE	9.1	**13.3**	**15.8**	15.8	13.9	15.9	16.0
GFSI	12.0	18.3	22.1	22.7	19.7	18.4	21.3
EMXI	14.3	23.4	29.0	30.1	27.2	26.9	27.4
TCLP	11.3	20.3	26.7	28.9	27.8	29.7	25.8
# Cases	237	210	186	169	129	95	81

Table 10b.   Homogenous comparison of eastern North Pacific basin early intensity guidance model biases (kt) for 2015. Biases smaller than the NHC official forecast are shown in boldface.

Model ID	Forecast Period (h)						
	12	24	36	48	72	96	120
OFCL	-2.3	-3.7	-4.0	-3.6	1.0	-1.2	-0.7
OCD5	-3.4	-7.3	-11.0	-13.6	-13.2	-20.5	-14.9
HWFI	-6.1	-9.9	-12.6	-13.5	-9.9	-9.4	-4.7
GHMI	-7.3	-14.9	-20.3	-19.3	-12.9	-8.5	-2.4
GFNI	-8.3	-16.3	-21.9	-22.8	-17.5	-16.3	-11.5
DSHP	-2.8	-4.6	-6.0	-6.7	-3.6	-3.7	-1.0
LGEM	-2.8	-5.2	-7.0	-6.6	-3.4	-6.2	-7.6
IVCN	-4.5	-8.4	-11.2	-11.3	-7.2	-6.8	-3.9
FSSE	-3.4	-5.2	-6.4	-6.1	-2.4	-5.9	-5.4
GFSI	-3.8	-4.0	-4.6	-4.4	2.4	5.2	11.8
EMXI	-3.9	-7.0	-8.6	-7.8	-1.5	2.3	10.9
TCLP	-5.5	-13.5	-19.7	-22.6	-22.5	-26.7	-21.6
# Cases	237	210	186	169	129	95	81

Table 11.   Official eastern North Pacific track and intensity forecast verifications (OFCL) for 2015 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:     EP012015              ANDRES

       VT (h)      NT     OFCL     OCD5      NI     OFCL     OCD5
       000         29      5.4      5.4      29      1.7      1.9
       012         27     20.3     33.0      27      8.7      9.9
       024         25     32.1     74.4      25     13.8     16.3
       036         23     41.2    116.2      23     17.8     21.5
       048         21     51.2    141.8      21     20.7     26.0
       072         17     85.5    192.7      17     26.8     30.9
       096         13    127.3    235.4      13     28.1     28.8
       120          9    173.4    401.4       9     18.9     15.6

Verification statistics for:     EP022015              BLANCA

       VT (h)      NT     OFCL     OCD5      NI     OFCL     OCD5
       000         34      8.4      8.6      34      0.9      1.3
       012         32     22.9     37.9      32      8.9     11.4
       024         30     34.9     78.0      30     15.5     20.5
       036         28     40.0    127.9      28     20.2     27.9
       048         26     47.3    177.9      26     21.3     29.3
       072         22     61.6    268.7      22     16.6     24.6
       096         18     81.1    318.3      18     13.1     31.7
       120         14     88.0    351.2      14     10.0     34.6

Verification statistics for:     EP032015              CARLOS

       VT (h)      NT     OFCL     OCD5      NI     OFCL     OCD5
       000         28      9.0      9.7      28      1.4      1.6
       012         26     24.9     34.1      26      7.5      9.0
       024         24     37.3     67.8      24     10.6     11.4
       036         22     47.9    107.2      22     11.4     12.4
       048         20     55.8    140.4      20      8.0     11.6
       072         16     84.5    197.2      16      8.4     12.8
       096         12    108.1    276.9      12     11.3     15.0
       120          8    138.7    426.2       8      8.8     20.9
```

```
Verification statistics for:     EP042015                        ELA

       VT (h)        NT      OFCL      OCD5        NI      OFCL      OCD5
       000           1       12.0      12.0         1       0.0       0.0
       012           1       23.8      26.6         1       0.0       4.0
       024           1       29.1      58.7         1       0.0      11.0
       036           1       83.4     135.3         1      10.0      11.0
       048           1      107.0     194.4         1      10.0      14.0
       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:     EP052015                        DOLORES

       VT (h)        NT      OFCL      OCD5        NI      OFCL      OCD5
       000          29       12.2      12.3        29       5.2       5.3
       012          27       18.3      30.9        27       9.6      11.9
       024          25       23.3      48.1        25      13.8      16.7
       036          23       29.8      71.3        23      14.1      21.0
       048          21       33.8      87.6        21      16.2      24.8
       072          17       41.3      98.5        17      21.2      29.1
       096          13       35.7     118.8        13      23.1      27.5
       120           9       53.6     139.3         9      26.7      15.3

Verification statistics for:     EP062015                        ENRIQUE

       VT (h)        NT      OFCL      OCD5        NI      OFCL      OCD5
       000          23        6.8       6.6        23       1.1       1.1
       012          22       21.6      32.6        22       3.6       4.3
       024          20       31.9      61.8        20       6.0       6.1
       036          18       37.1      83.6        18       4.4       7.3
       048          16       40.1      98.5        16       5.6       6.1
       072          12       50.1     136.2        12       5.0       4.7
       096           8       70.3     153.3         8       2.5       5.3
       120           4      116.1     179.1         4       5.0      15.0

Verification statistics for:     EP072015                        FELICIA

       VT (h)        NT      OFCL      OCD5        NI      OFCL      OCD5
       000           6       10.7      10.7         6       0.0       0.0
       012           4       19.1      30.5         4       3.8       5.3
       024           2       39.2      88.3         2       2.5       4.5
       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:      EP082015                    EIGHT

        VT (h)        NT       OFCL       OCD5         NI       OFCL       OCD5
        000            9        8.4        9.4          9        0.0        0.0
        012            7       21.1       32.3          7        1.4        1.4
        024            5       22.3       51.7          5        4.0        1.2
        036            3       37.2       90.1          3        5.0        1.3
        048            1       37.8       91.6          1        5.0        1.0
        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:      EP092015                    GUILLERMO

        VT (h)        NT       OFCL       OCD5         NI       OFCL       OCD5
        000           12        5.8        6.9         12        1.3        1.3
        012           12       36.8       52.6         12        5.0        6.0
        024           12       53.9      107.6         12        9.2       11.4
        036           12       47.5      152.1         12       10.0       12.7
        048           12       43.2      188.8         12        7.9       12.6
        072           12       53.5      249.5         12        9.2       10.3
        096           12       81.5      292.9         12        5.0        4.9
        120           12       98.6      354.4         12        4.2        8.0

Verification statistics for:      EP102015                    HILDA

        VT (h)        NT       OFCL       OCD5         NI       OFCL       OCD5
        000            9        5.7        5.7          9        4.4        4.4
        012            9       20.8       21.9          9       12.2       14.2
        024            9       41.5       40.4          9       23.9       27.2
        036            9       70.9       59.9          9       32.8       40.6
        048            9       97.7       76.2          9       35.6       46.9
        072            9      127.0      104.4          9       25.6       31.4
        096            9      158.6      152.7          9       18.3       19.9
        120            9      195.0      250.6          9       13.9       15.0

Verification statistics for:      EP112015                    ELEVEN

        VT (h)        NT       OFCL       OCD5         NI       OFCL       OCD5
        000            8       11.8       11.8          8        0.6        0.6
        012            6       29.8       62.5          6        2.5        2.7
        024            4       26.7      114.9          4        2.5        4.8
        036            2       33.4      219.6          2        0.0        8.5
        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:     EP122015                IGNACIO

    VT (h)      NT     OFCL     OCD5      NI     OFCL     OCD5
    000         11     12.7     12.7      11      0.0      0.0
    012         11     32.2     43.8      11      3.6      5.2
    024         11     51.5     77.7      11      6.8      9.7
    036         11     68.6    116.8      11     11.4     13.4
    048         11     79.3    147.7      11     10.9     16.6
    072         11     82.4    204.5      11     15.9     26.6
    096         11     74.7    238.4      11     25.9     39.0
    120         11    117.2    287.7      11     29.1     36.1

Verification statistics for:     EP132015                JIMENA

    VT (h)      NT     OFCL     OCD5      NI     OFCL     OCD5
    000         24      2.7      2.9      24      1.9      2.1
    012         24     17.1     29.6      24      8.1     10.1
    024         24     26.6     65.6      24     12.9     18.6
    036         24     37.2    104.4      24     14.0     24.0
    048         24     44.4    139.1      24     12.7     28.4
    072         24     58.8    196.6      24      8.8     31.6
    096         24     81.8    232.3      24      6.7     33.4
    120         24    107.7    253.8      24      6.0     24.3

Verification statistics for:     EP142015                KEVIN

    VT (h)      NT     OFCL     OCD5      NI     OFCL     OCD5
    000         19     13.0     13.0      19      5.0      5.0
    012         17     35.1     41.3      17      5.3      7.5
    024         15     54.0     81.7      15      7.3      9.8
    036         13     64.8    126.6      13      9.6     11.2
    048         11     72.8    186.9      11      8.2      9.0
    072          7     78.7    383.5       7     11.4     18.0
    096          3     65.2    587.2       3      6.7     28.3
    120          0   -999.0   -999.0       0   -999.0   -999.0

Verification statistics for:     EP152015                LINDA

    VT (h)      NT     OFCL     OCD5      NI     OFCL     OCD5
    000         18      8.2      8.2      18      2.5      2.5
    012         16     25.7     38.7      16     10.9     12.5
    024         14     33.0     68.6      14     16.8     21.3
    036         12     38.4    104.4      12     14.6     21.0
    048         10     31.4    139.8      10     16.0     20.8
    072          6     59.1    247.3       6     16.7     21.2
    096          2    161.4    353.3       2      7.5      9.0
    120          0   -999.0   -999.0       0   -999.0   -999.0
```

```
Verification statistics for:    EP162015                SIXTEEN

        VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
        000          4      10.5      10.5       4       0.0       0.0
        012          2      36.0      70.7       2       0.0       2.5
        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:    EP172015                MARTY

        VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
        000         14       9.8       9.9      14       1.4       1.4
        012         12      29.7      40.0      12       6.3       7.6
        024         10      39.5      78.0      10       7.0       5.4
        036          8      42.2     123.6       8       5.0      11.8
        048          6      42.4     189.9       6       5.0      13.3
        072          2      37.0     327.7       2       7.5      22.5
        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:    EP182015                NORA

        VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
        000          7      13.8      13.8       7       0.0       0.0
        012          7      30.2      30.7       7       0.7       2.4
        024          7      34.7      41.0       7       3.6       3.7
        036          7      42.4      54.2       7       3.6       4.6
        048          7      66.8      68.2       7       9.3       9.4
        072          7     152.2      84.8       7      28.6      14.6
        096          7     290.2     110.3       7      33.6      21.6
        120          5     485.3     161.5       5      37.0      28.0

Verification statistics for:    EP192015                OLAF

        VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
        000         25      10.3      10.8      25       1.8       2.0
        012         23      25.0      35.8      23       5.9       8.8
        024         22      35.9      62.5      22       9.3      14.6
        036         22      53.6      91.2      22      13.6      19.7
        048         22      77.8     113.2      22      13.4      24.2
        072         22     136.3     166.0      22      15.0      28.9
        096         22     196.3     236.5      22      15.0      42.5
        120         22     247.4     331.2      22      20.7      43.4
```

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Verification statistics for:     EP202015              PATRICIA

     VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
     000         16       8.3       9.3      16       7.8       8.1
     012         15      34.8      66.3      15      22.7      29.5
     024         13      55.9     162.5      13      35.0      55.5
     036         11      86.9     267.6      11      47.7      64.3
     048          9     105.7     345.6       9      57.8      72.1
     072          5     105.4     413.1       5      55.0      74.6
     096          1     199.8     346.6       1      25.0       2.0
     120          0    -999.0    -999.0       0    -999.0    -999.0

Verification statistics for:     EP212015                 RICK

     VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
     000         17      10.8      13.8      17       0.0       0.0
     012         15      43.7      56.8      15       3.3       2.3
     024         13      71.9     110.1      13       4.6       2.8
     036         11      83.1     179.9      11       8.2       4.9
     048          9     116.2     283.5       9       9.4       6.3
     072          5     176.1     463.5       5      11.0      11.8
     096          1     232.4     396.8       1       0.0      12.0
     120          0    -999.0    -999.0       0    -999.0    -999.0

Verification statistics for:     EP222015               SANDRA

     VT (h)      NT      OFCL      OCD5      NI      OFCL      OCD5
     000         18       7.9       8.2      18       2.5       2.5
     012         16      34.7      44.6      16       6.3       9.9
     024         14      54.9      96.2      14      11.8      18.9
     036         12      70.1     168.0      12      16.7      28.3
     048         10      81.1     245.9      10      21.5      32.4
     072          6     104.2     434.0       6      17.5      28.3
     096          2     124.6     571.5       2       5.0       8.0
     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 2015.

Atlantic Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	Verifying Genesis Occurrence Rate (%)	Number of Forecasts
0	2	271
10	10	115
20	19	57
30	30	20
40	33	12
50	65	20
60	75	16
70	84	19
80	60	10
90	100	2
100	-	0

Table 12b.   Verification of 48-h probabilistic genesis forecasts for the eastern North Pacific basin in 2015.

Eastern North Pacific Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	Verifying Genesis Occurrence Rate (%)	Number of Forecasts
0	3	333
10	14	133
20	24	78
30	23	47
40	54	35
50	50	40
60	64	25
70	82	33
80	88	24
90	82	17
100	-	0

Table 13a.   Verification of 120-h probabilistic genesis forecasts for the Atlantic basin in 2015.

Atlantic Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	Verifying Genesis Occurrence Rate (%)	Number of Forecasts
0	0	45
10	14	203
20	17	103
30	30	56
40	45	33
50	78	18
60	72	29
70	89	19
80	70	27
90	100	8
100	-	0

Table 13b.   Verification of 120-h probabilistic genesis forecasts for the eastern North Pacific basin in 2015.

Eastern North Pacific Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	Verifying Genesis Occurrence Rate (%)	Number of Forecasts
0	0	16
10	15	163
20	31	137
30	50	76
40	53	47
50	46	48
60	70	33
70	87	60
80	88	78
90	93	107
100	-	0

Table 14.   NHC forecast cone circle radii (n mi) for 2016. Change from 2015 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	30 (-2: -6%)	27 (1: 4%)
24	49 (-3: -6%)	42 (0: 0%)
36	66 (-5: -7%)	55 (1: 2%)
48	84 (-6: -7%)	70 (1: 1%)
72	115 (-7: -6%)	100 (0: 0%)
96	165 (-5: -3%)	137 (-6: -4%)
120	237 (12: 5%)	172 (-10: -5%)

Table 15.   Composition of NHC consensus models for 2016. 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 2016			
Model ID	**Parameter**	**Type**	**Members**
GFEX	Track	Fixed	GFSI EMXI
TCOA	Track	Fixed	GFSI EGRI GHMI HWFI
TCOE*	Track	Fixed	GFSI EGRI GHMI HWFI
ICON	Intensity	Fixed	DSHP LGEM GHMI HWFI
TVCA**	Track	Variable	GFSI EGRI GHMI HWFI EMXI CTCI
TVCE**	Track	Variable	GFSI EGRI GHMI HWFI EMXI CTCI
TVCX	Track	Variable	EMXI (double weight) GFSI EGRI GHMI HWFI
IVCN	Intensity	Variable	DSHP LGEM GHMI HWFI CTCI

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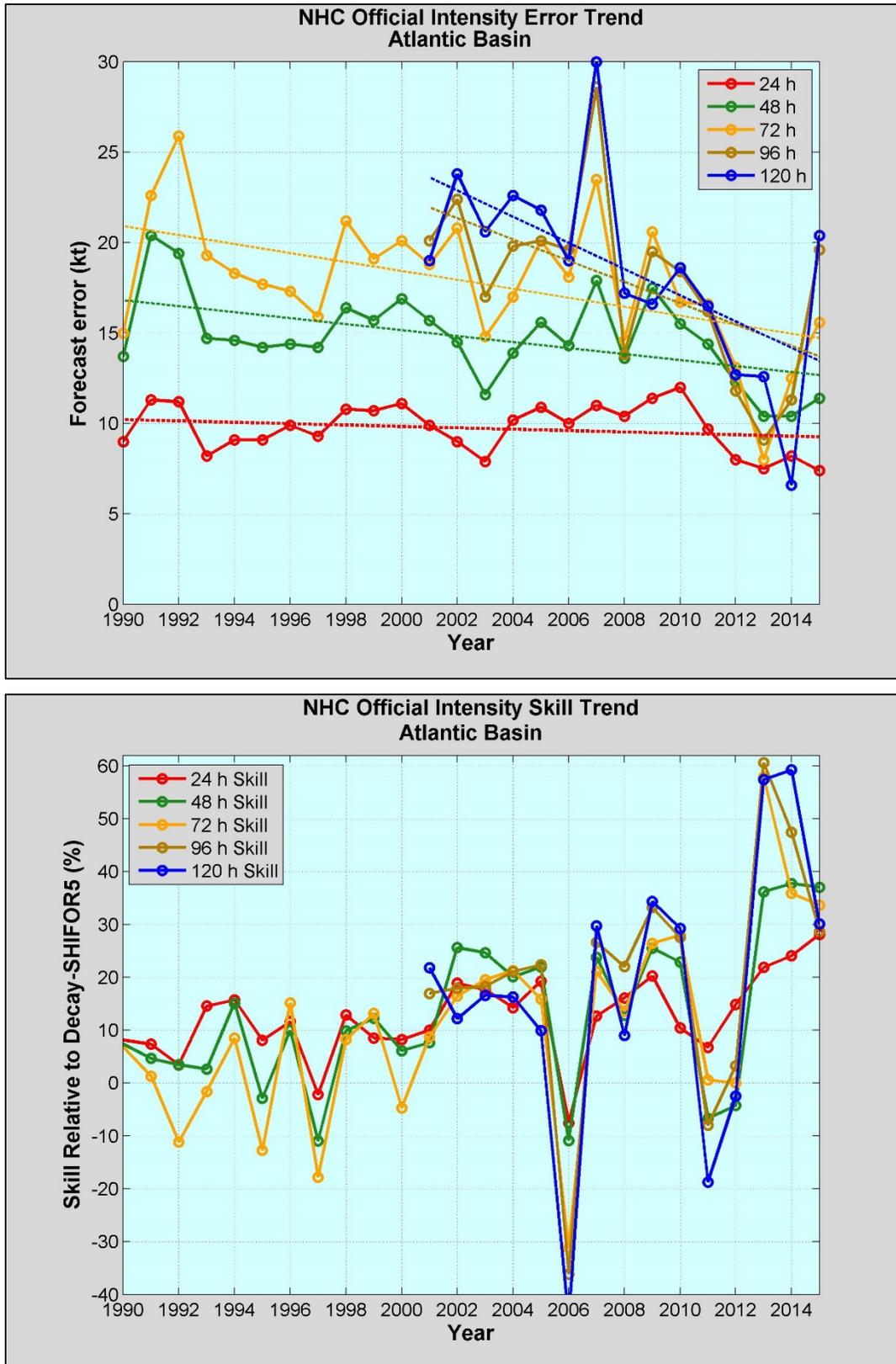GPCE circles will continue to be based on TVCN.

LIST OF FIGURES

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

21.   Homogenous comparison for selected eastern North Pacific basin early intensity guidance models for 2015. This verification includes only those models that were available at least 2/3 of the time (see text).

22.   Reliability diagram for Atlantic (top) and eastern North Pacific (bottom) probabilistic tropical cyclogenesis 48-h forecasts for 2015. 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.
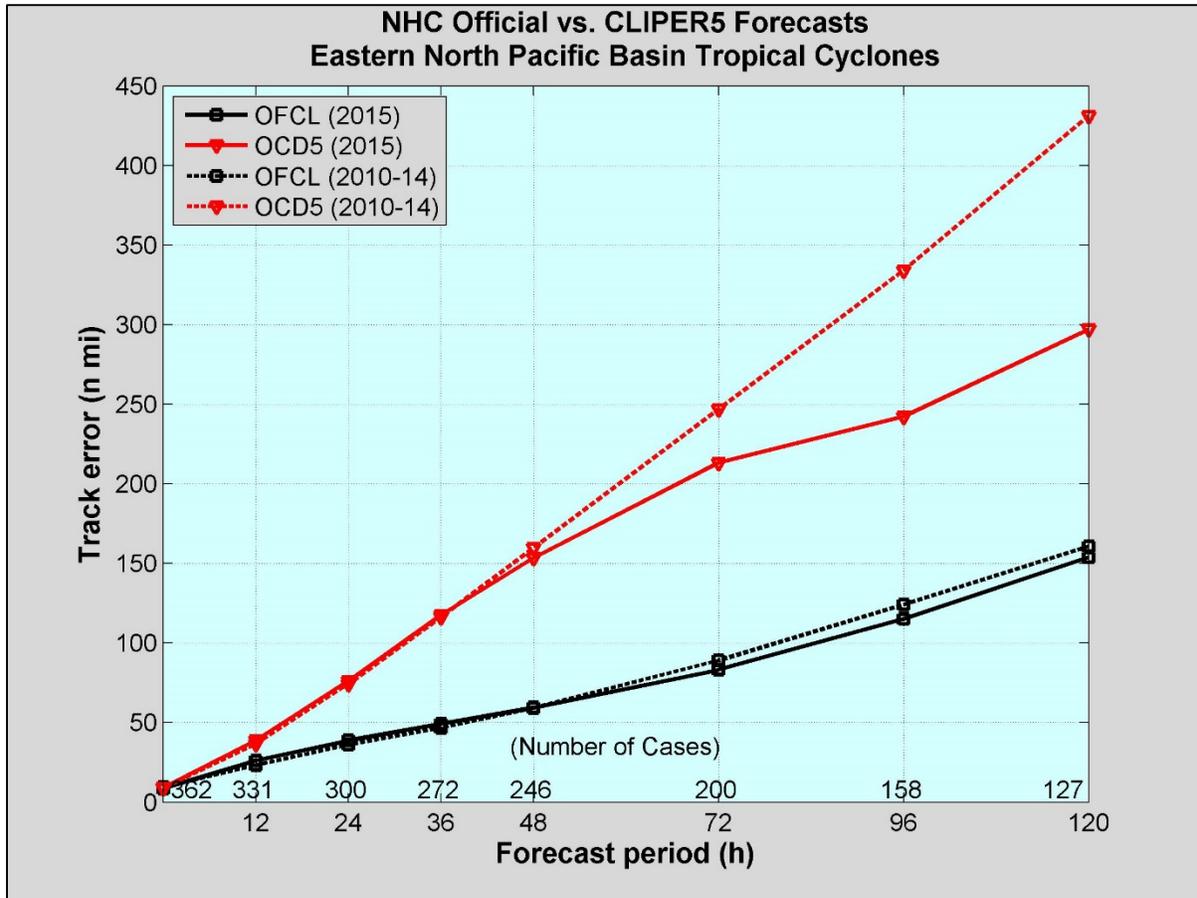
23.   As described for Fig. 22, but for 120-h forecasts.
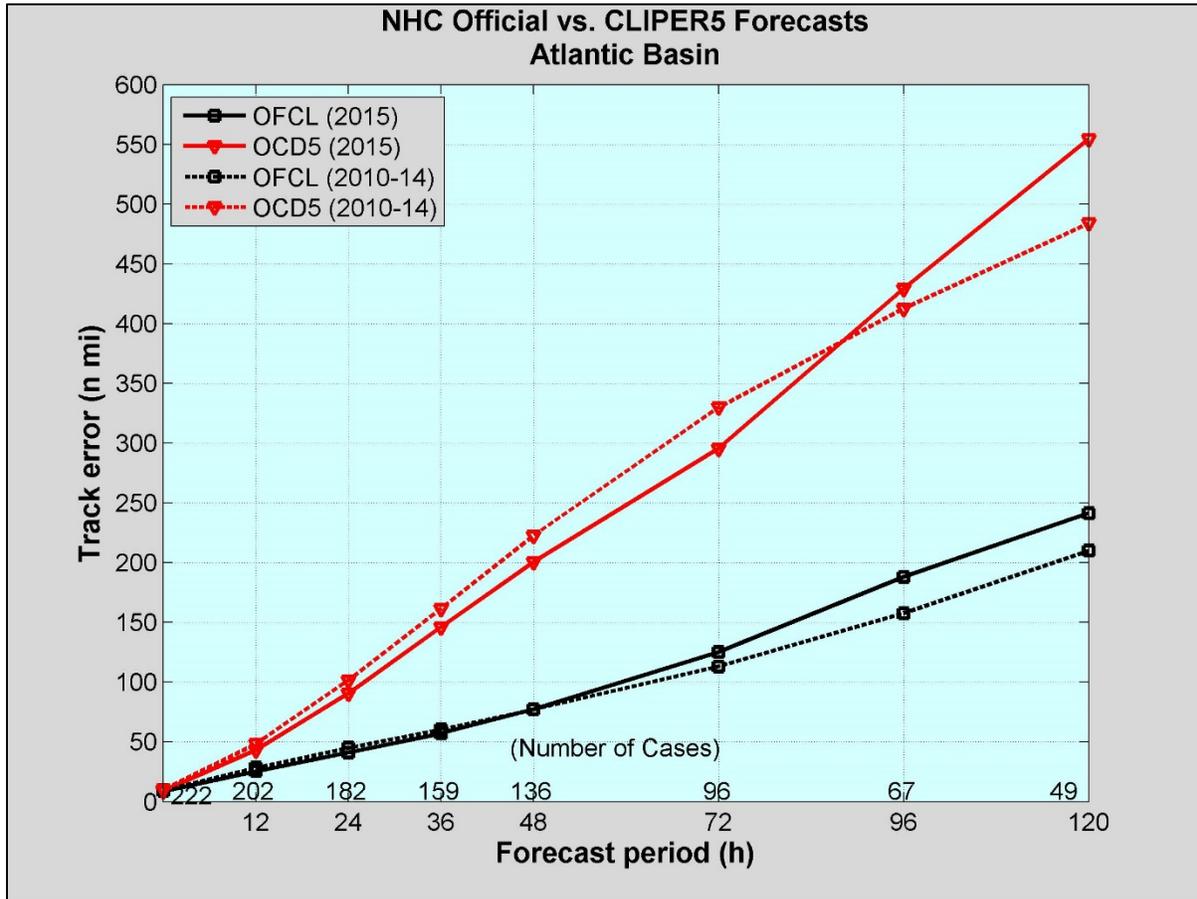
Figure 1.   NHC official and CLIPER5 (OCD5) Atlantic basin average track errors for 2015 (solid lines) and 2010-2014 (dashed lines).
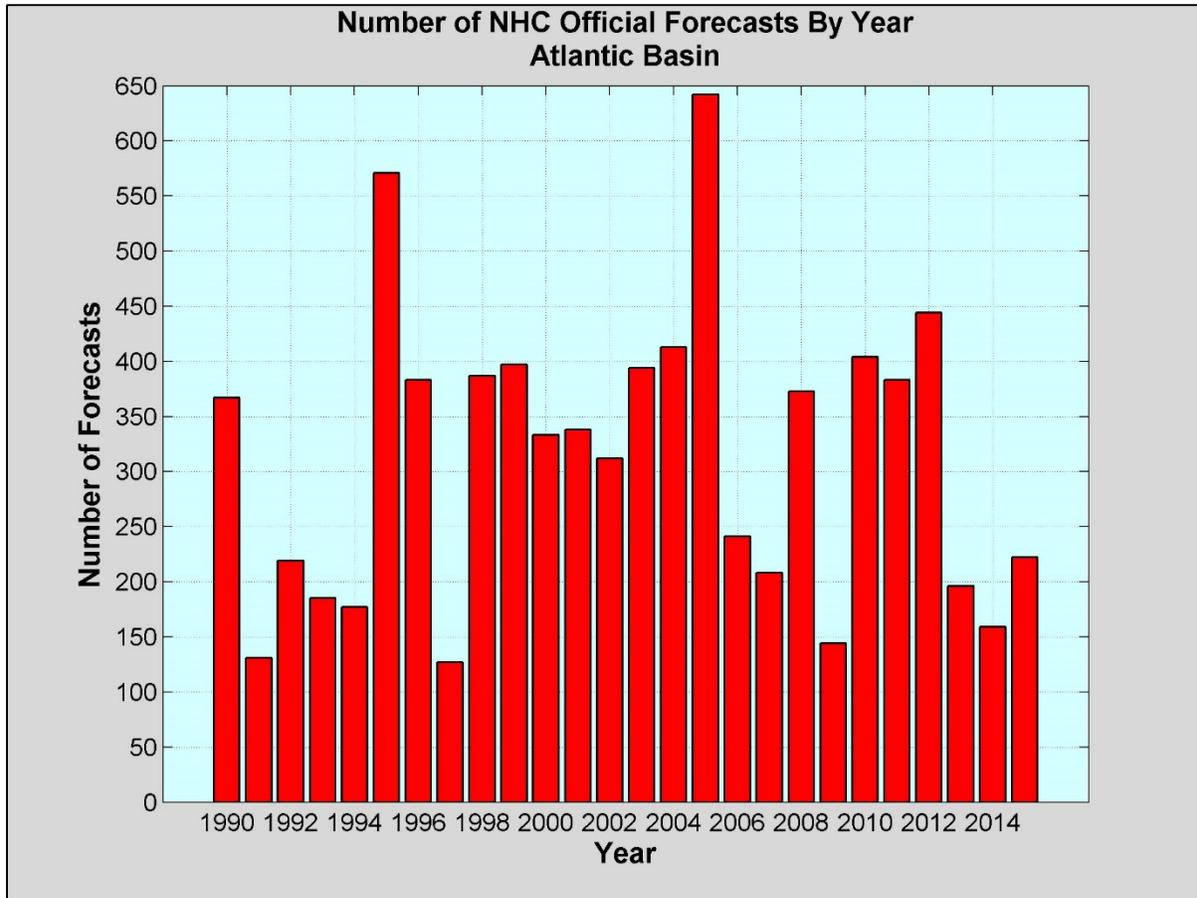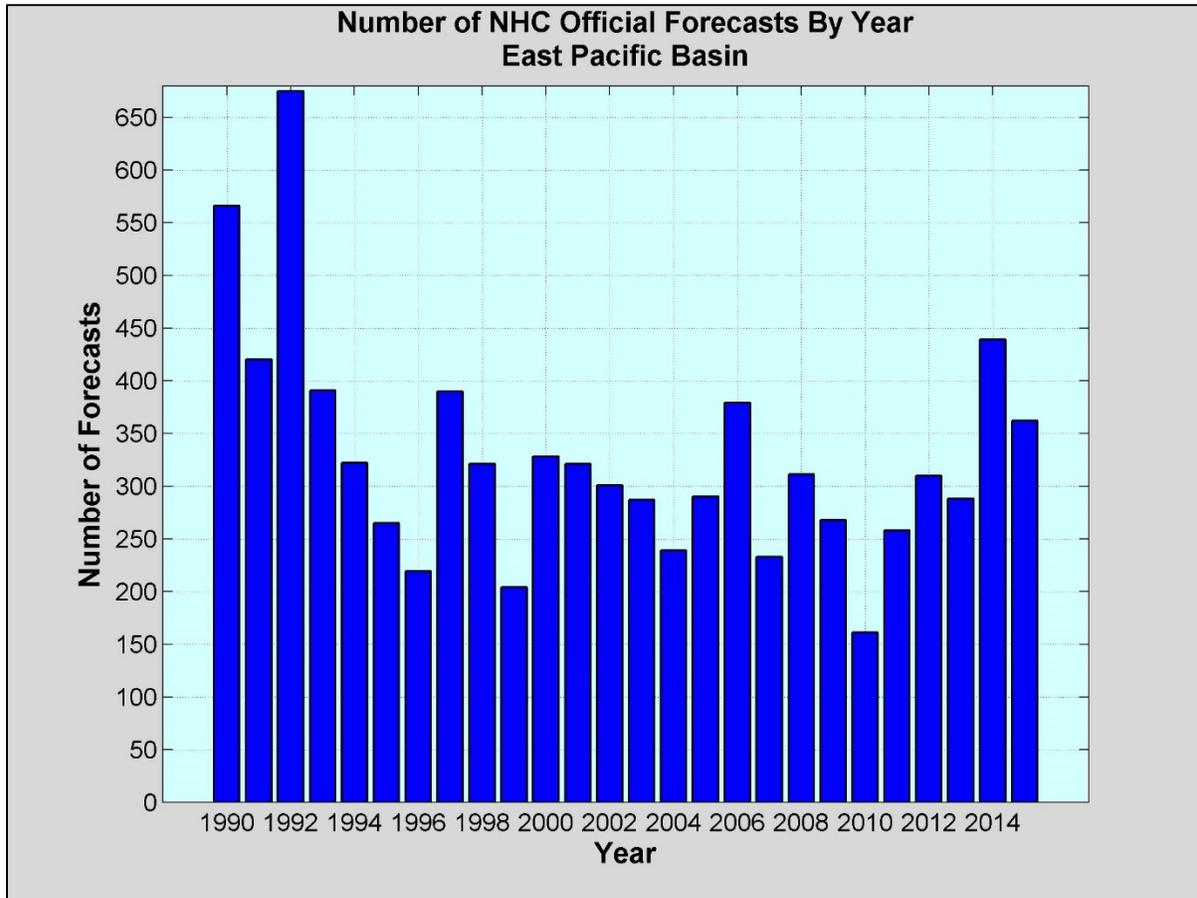
Figure 2.   Number of NHC official forecasts for the Atlantic basin stratified by year.
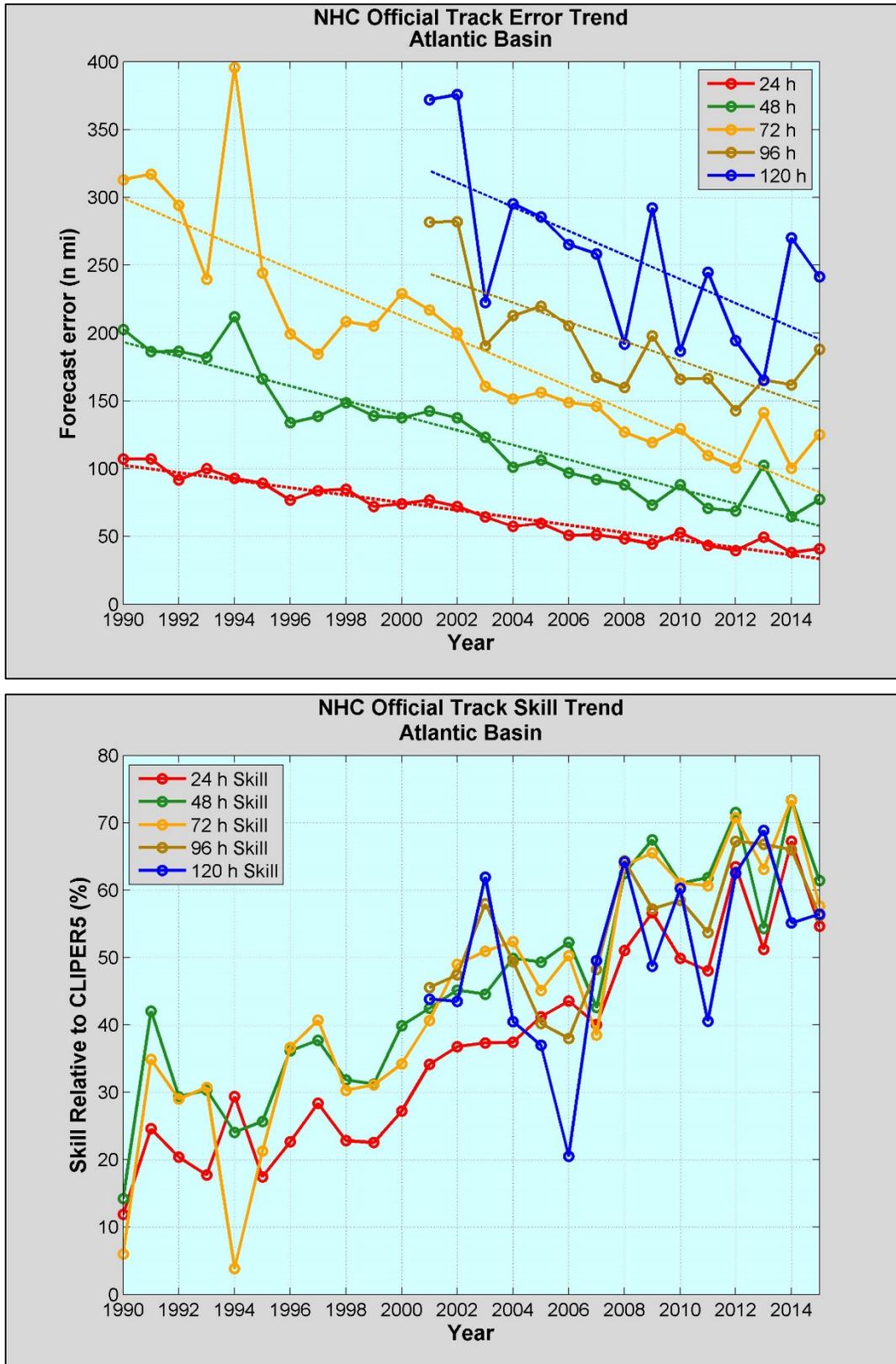
Figure 3.   Recent trends in NHC official track forecast error (top) and skill (bottom) for the Atlantic basin.
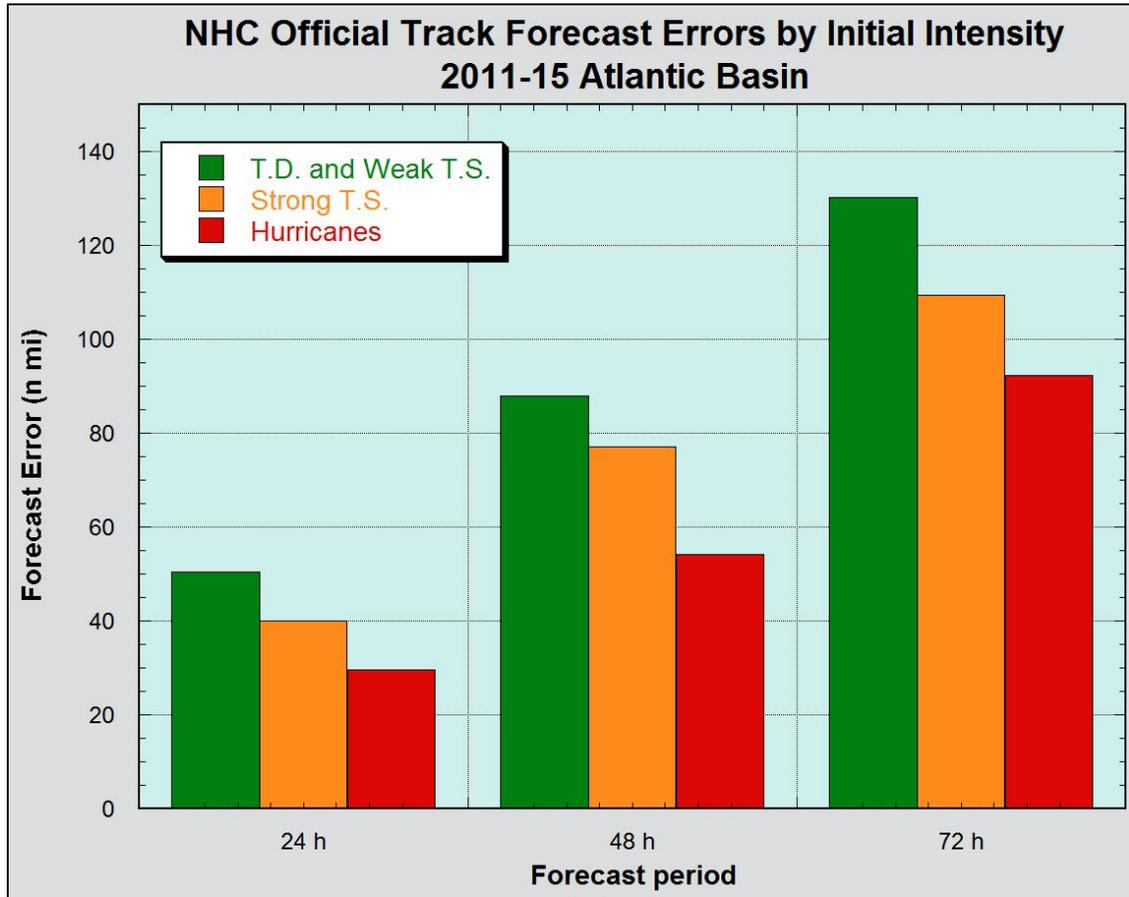
Figure 4.   2011-15 NHC official track forecast error binned by initial intensity for the Atlantic basin. Weak tropical storms are in the 35-45 kt range and strong tropical storms are in the 50-60 kt range.
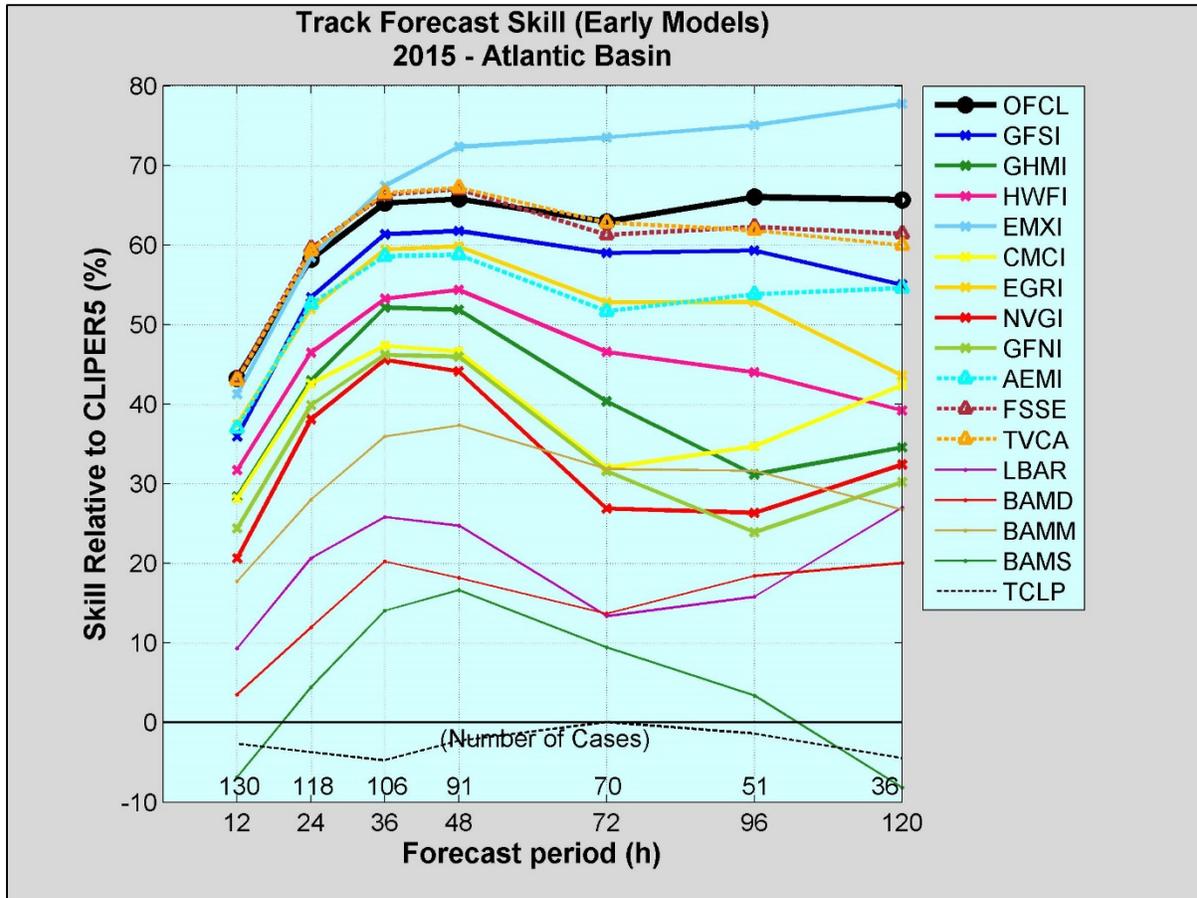
Figure 5.   Homogenous comparison for selected Atlantic basin early track models for 2015. This verification includes only those models that were available at least 2/3 of the time (see text).
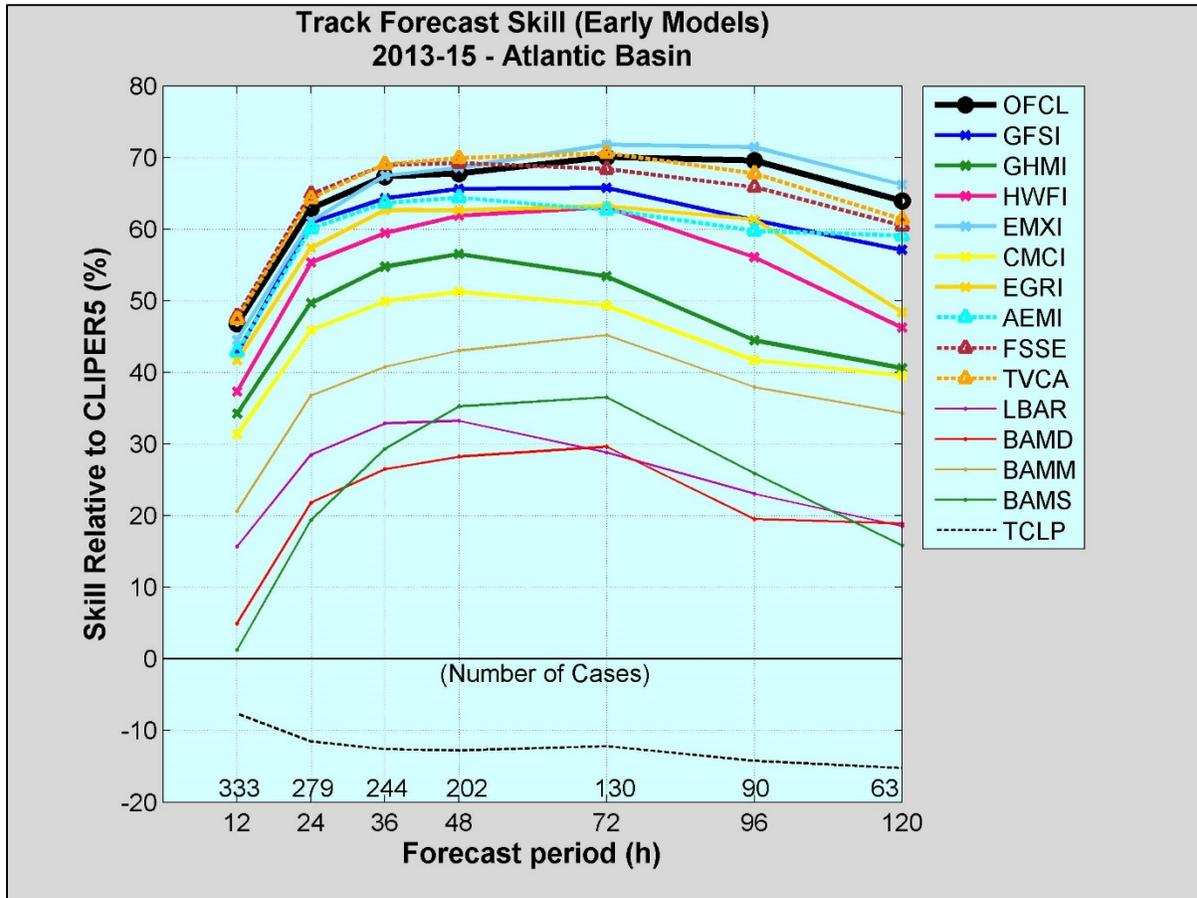
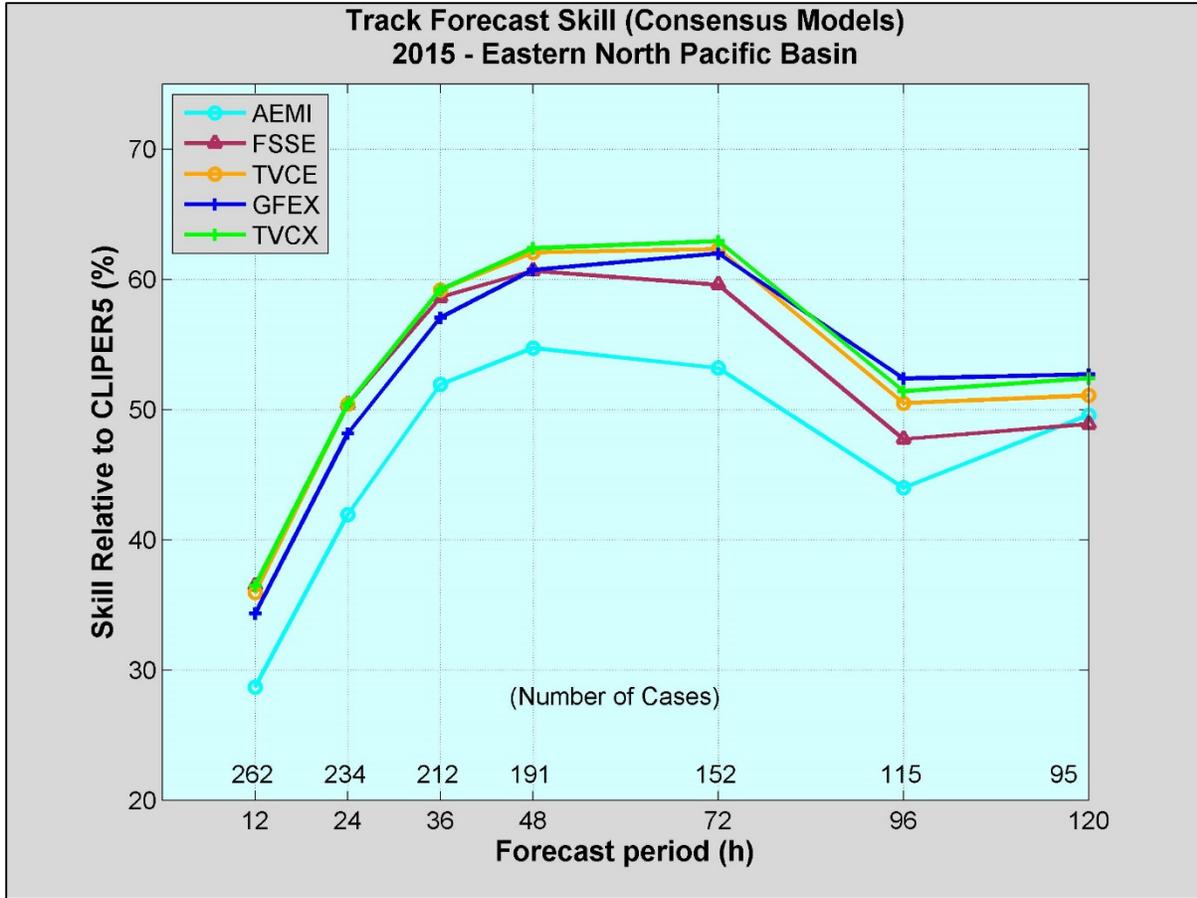Figure 6.   Homogenous comparison for selected Atlantic basin early track models for 2013-2015.
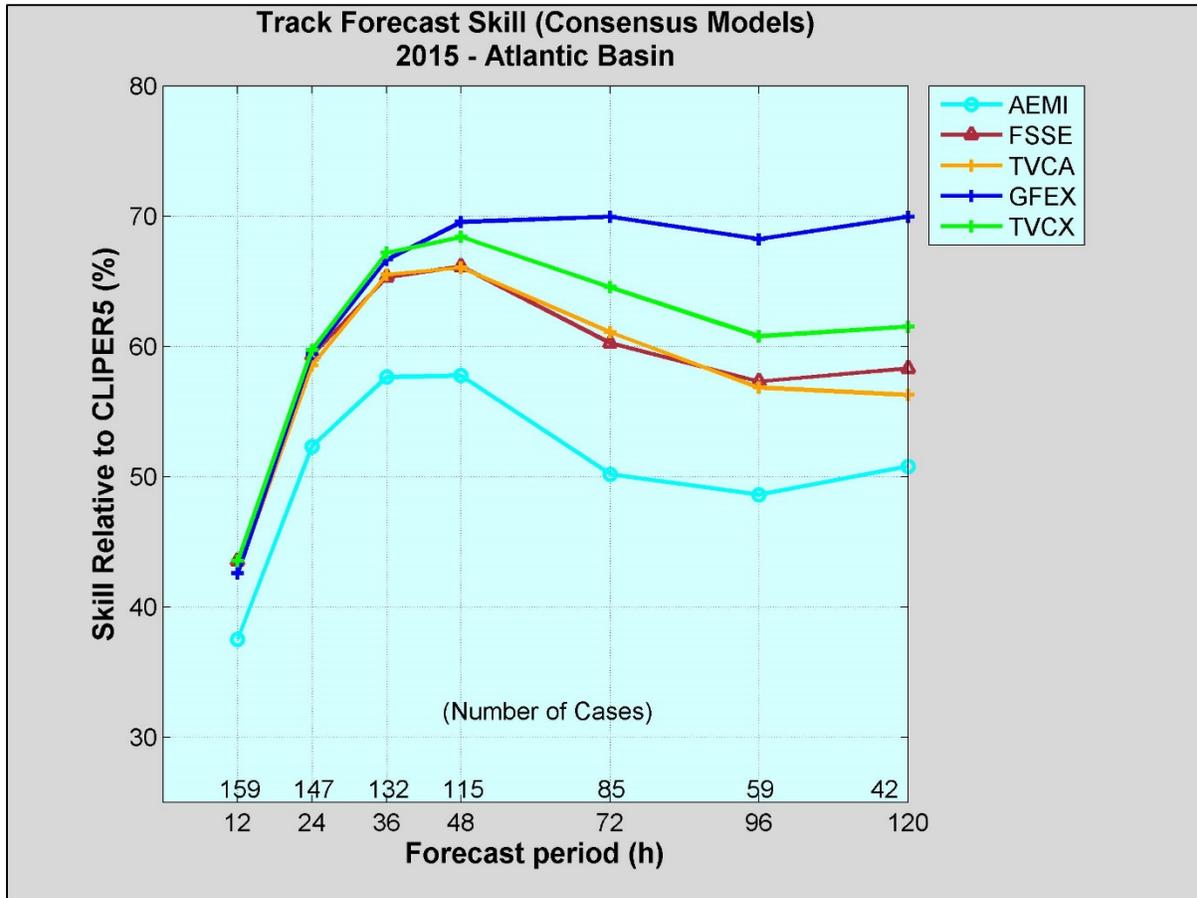
Figure 7.   Homogenous comparison of the primary Atlantic basin track consensus models for 2015.
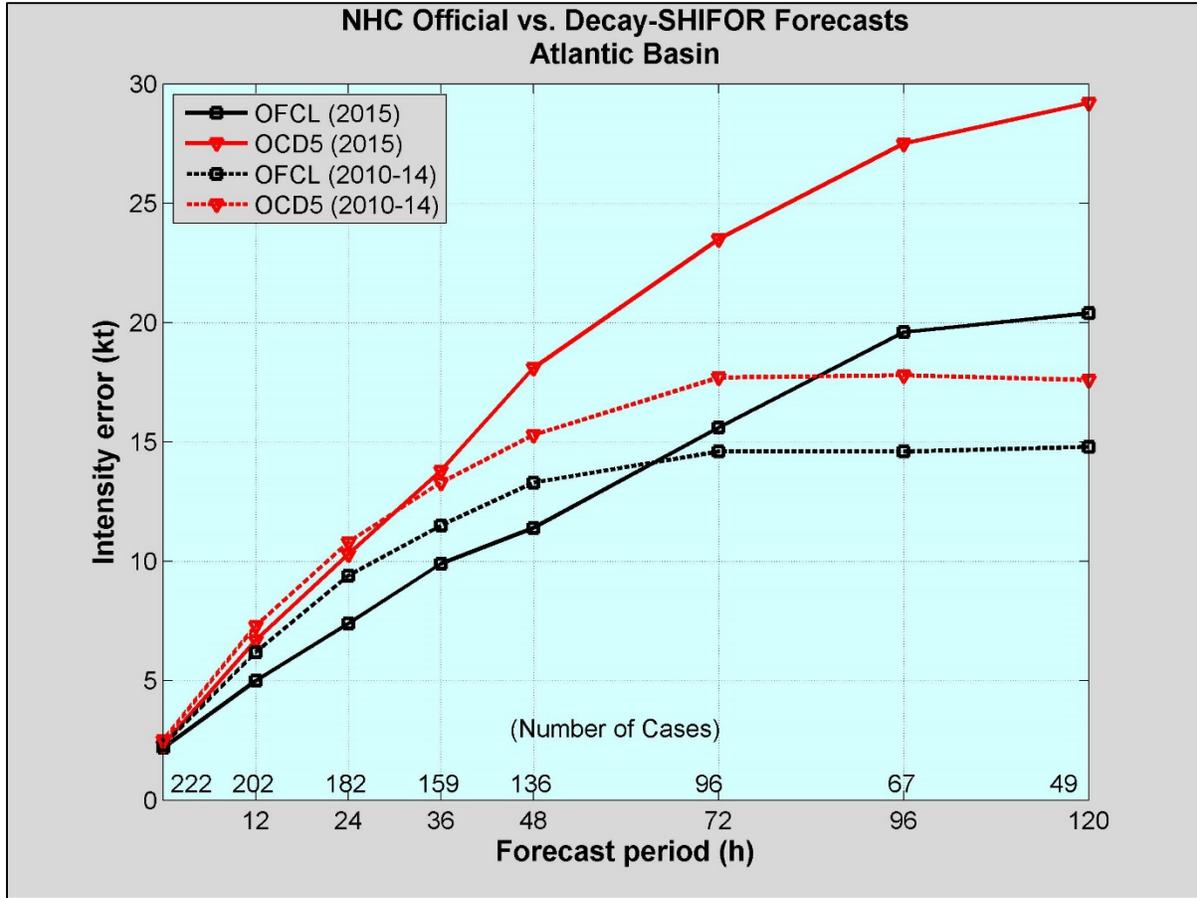
Figure 8.   NHC official and Decay-SHIFOR5 (OCD5) Atlantic basin average intensity errors for 2015 (solid lines) and 2010-2014 (dashed lines).

Figure 9.   Recent trends in NHC official intensity forecast error (top) and skill (bottom) for the Atlantic basin.
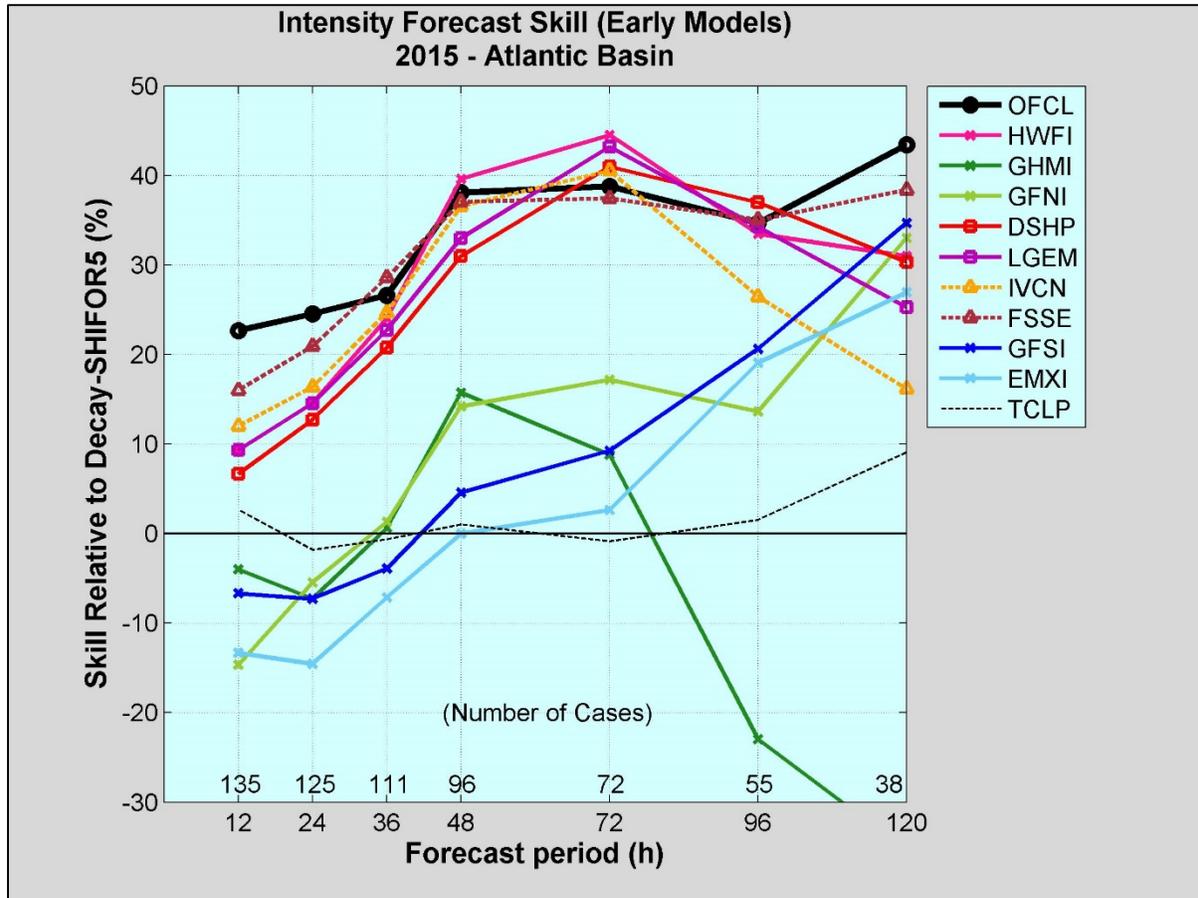
Figure 10.   Homogenous comparison for selected Atlantic basin early intensity guidance models for 2015.
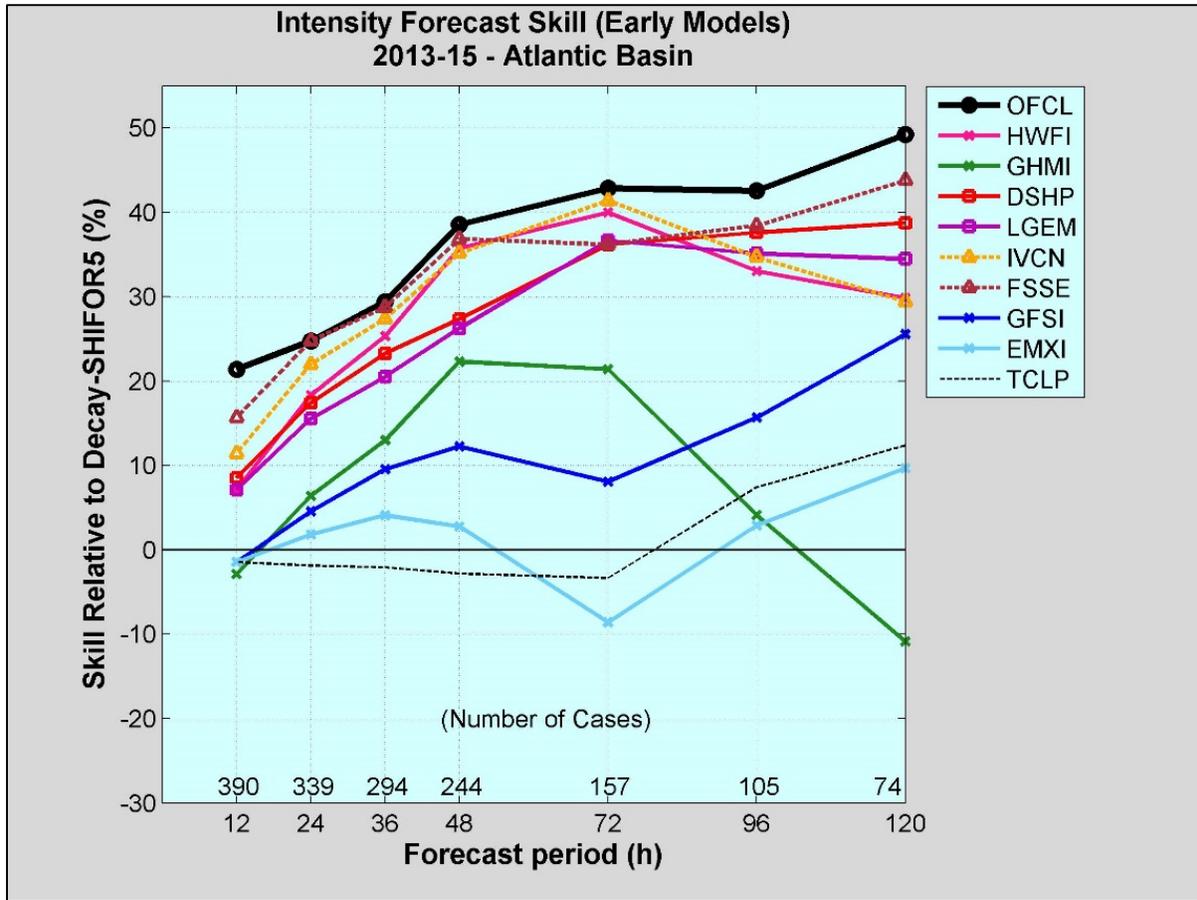
Figure 11.   Homogenous comparison for selected Atlantic basin early intensity guidance models for 2013-2015.
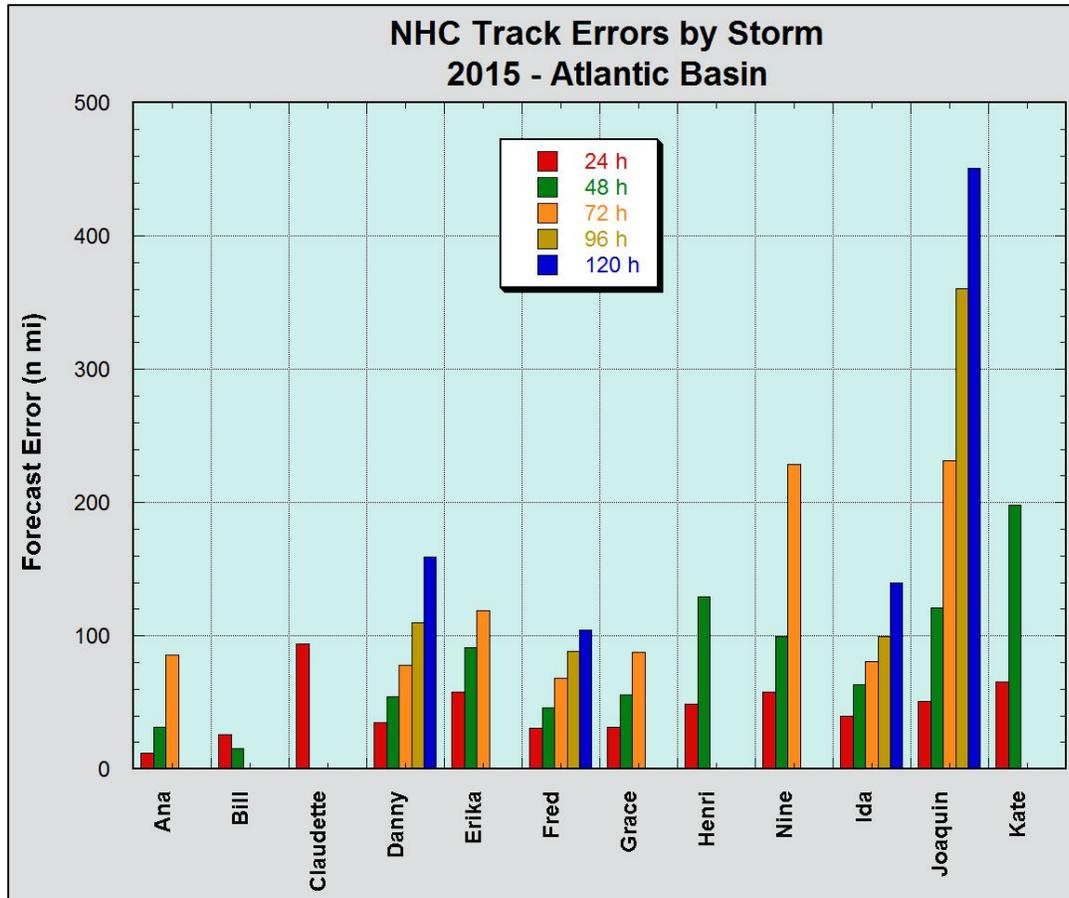
Figure 12.   2015 NHC official track errors by tropical cyclone.
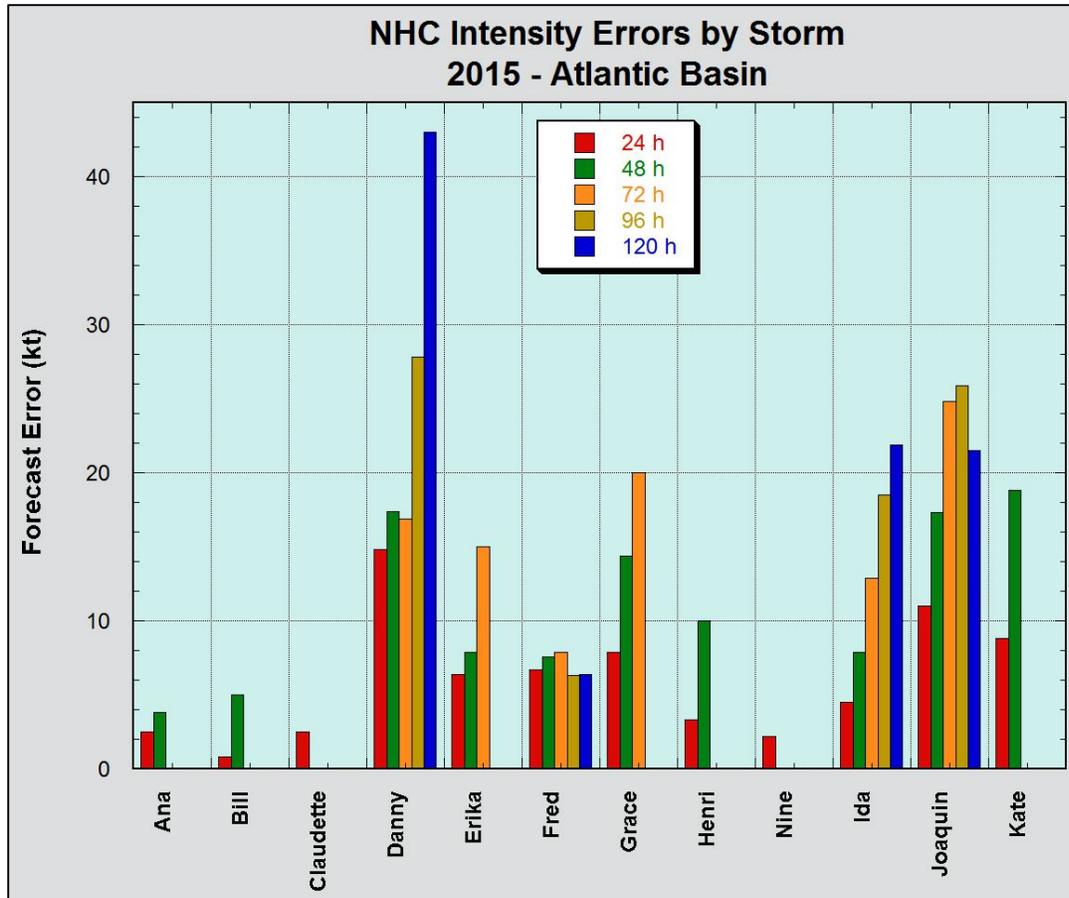
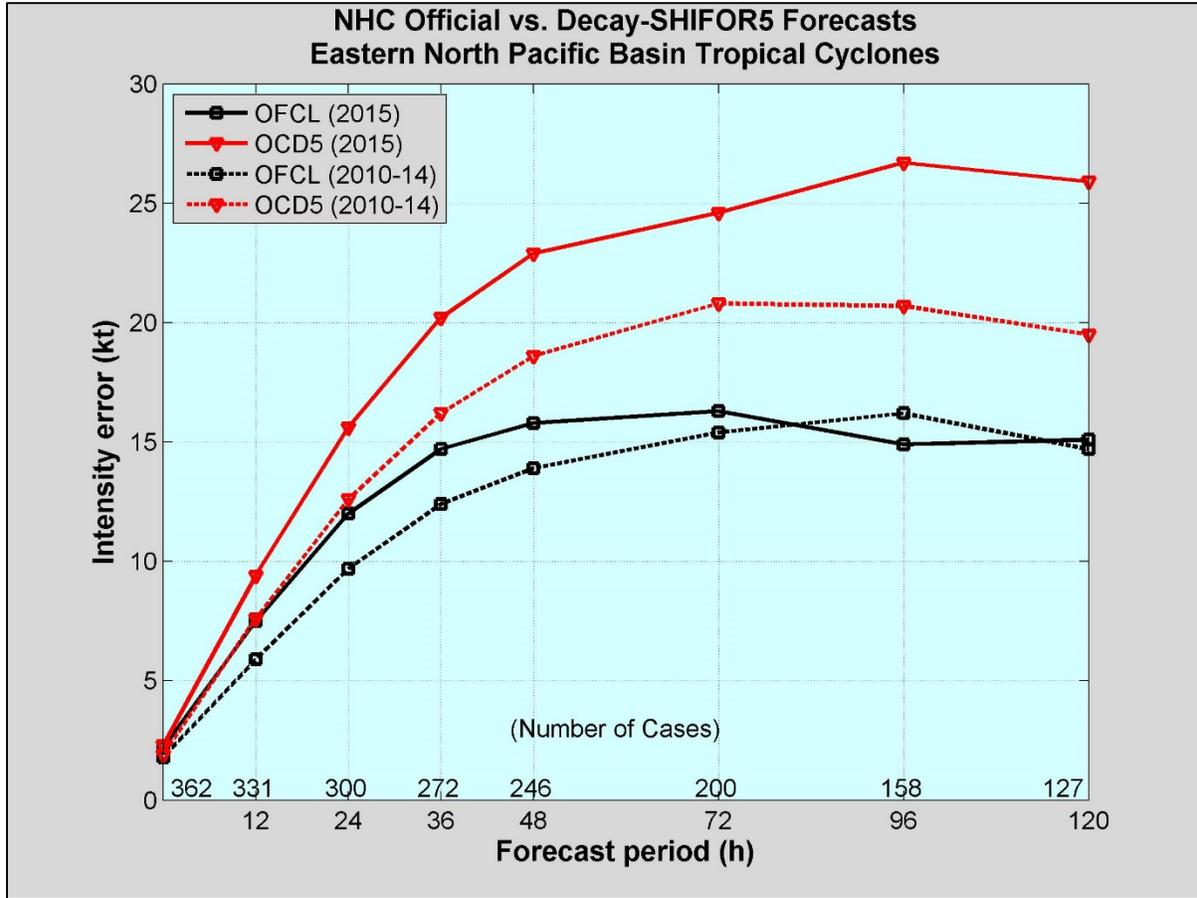Figure 13.   2015 NHC official intensity errors by tropical cyclone.

Figure 14.   NHC official and CLIPER5 (OCD5) eastern North Pacific basin average track errors for 2015 (solid lines) and 2010-2014 (dashed lines).

Figure 15.   Number of NHC official forecasts for the Atlantic basin stratified by year.
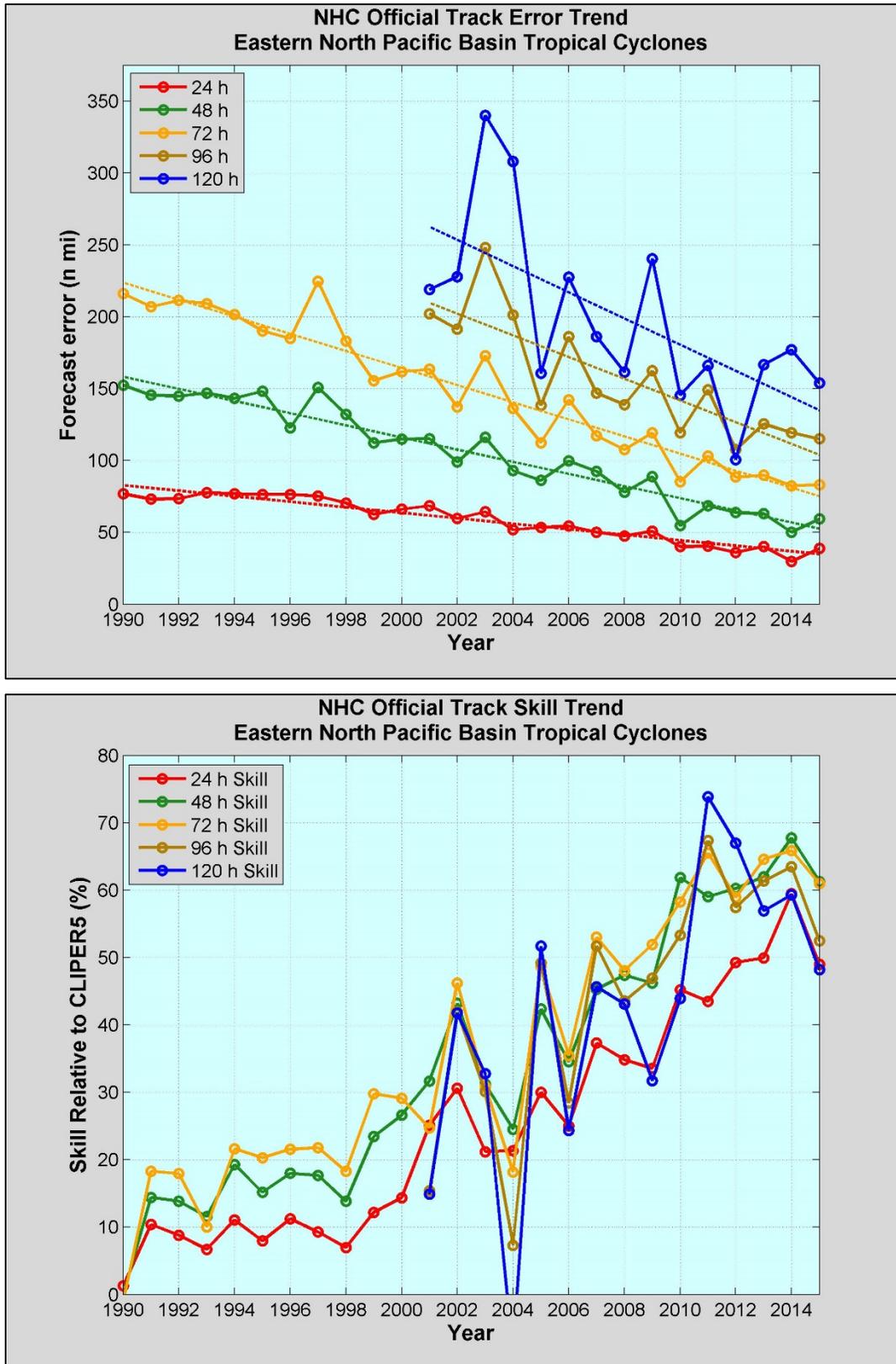
Figure 16.   Recent trends in NHC official track forecast error (top) and skill (bottom) for the eastern North Pacific basin.
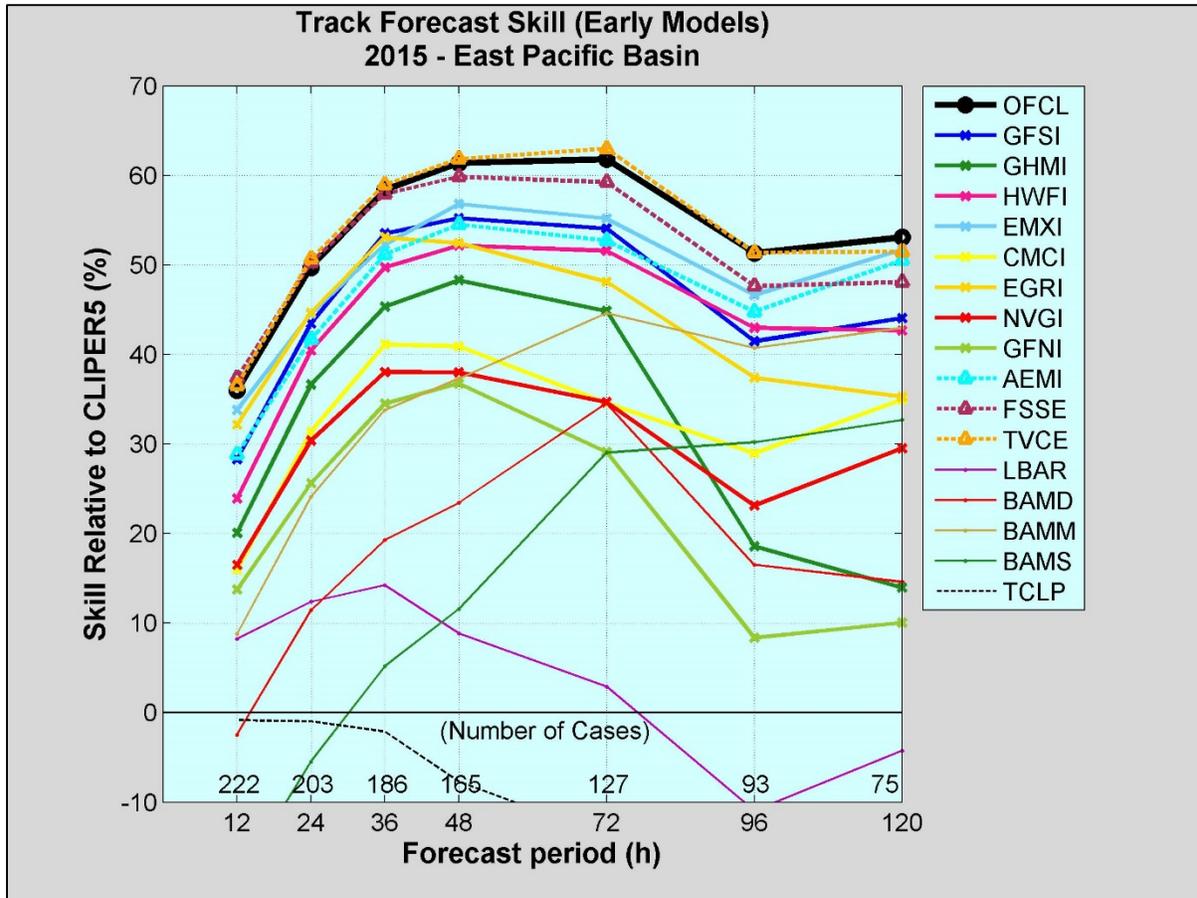
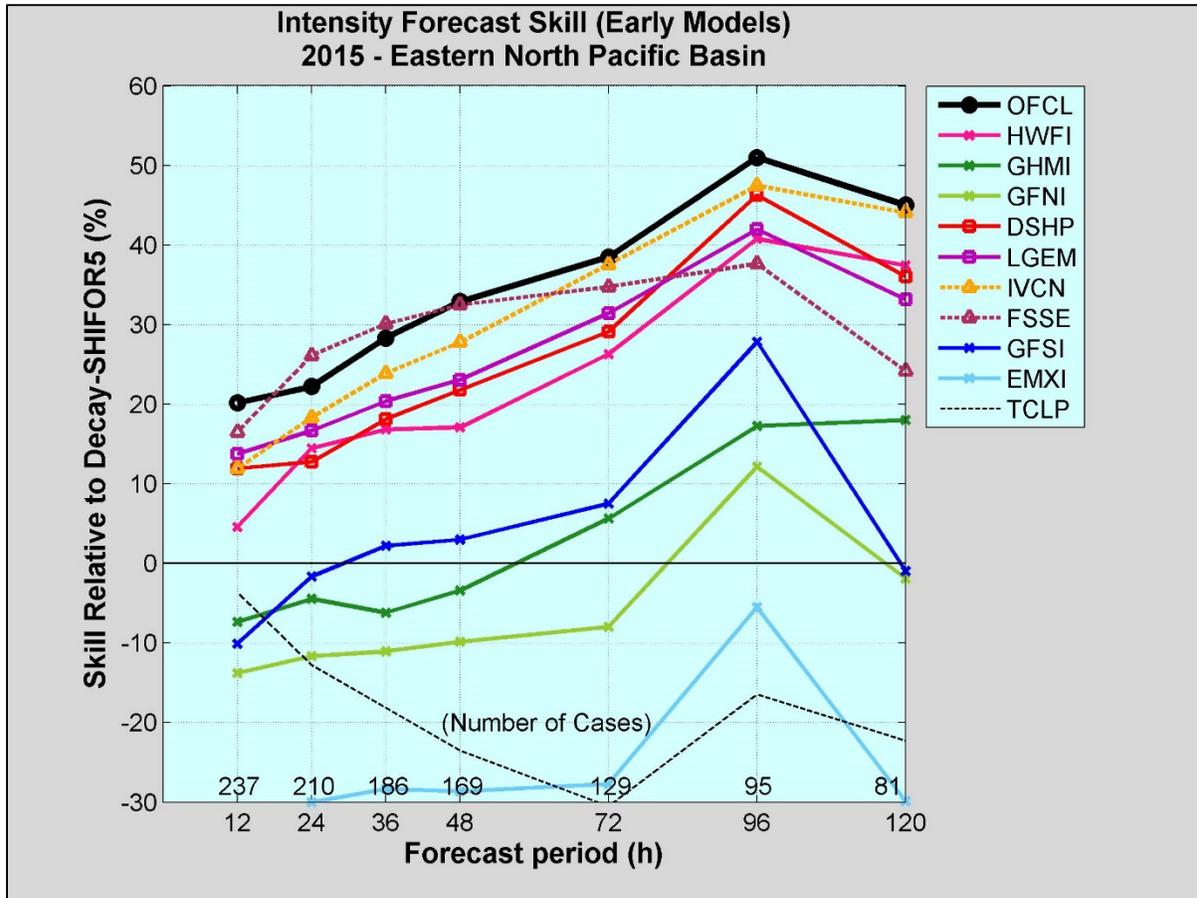Figure 17.   Homogenous comparison for selected eastern North Pacific early track models for 2015. This verification includes only those models that were available at least 2/3 of the time (see text).

Figure 18.   Homogenous comparison of the primary eastern North Pacific basin track consensus models for 2015.

Figure 19.   NHC official and Decay-SHIFOR5 (OCD5) eastern North Pacific basin average intensity errors for 2015 (solid lines) and 2010-2014 (dashed lines).
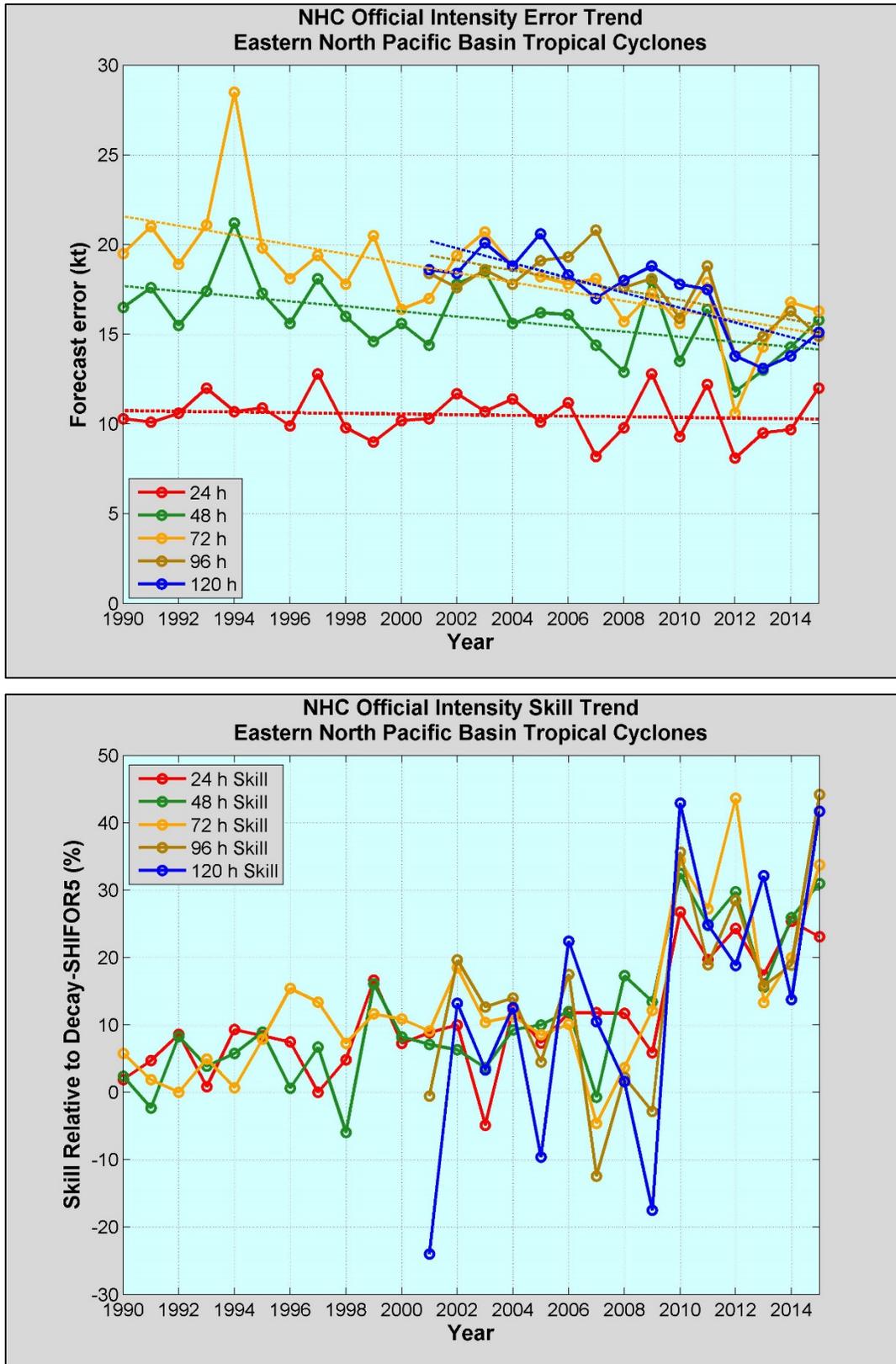
Figure 20.   Recent trends in NHC official intensity forecast error (top) and skill (bottom) for the eastern North Pacific basin.

Figure 21.   Homogenous comparison for selected eastern North Pacific basin early intensity guidance models for 2015.
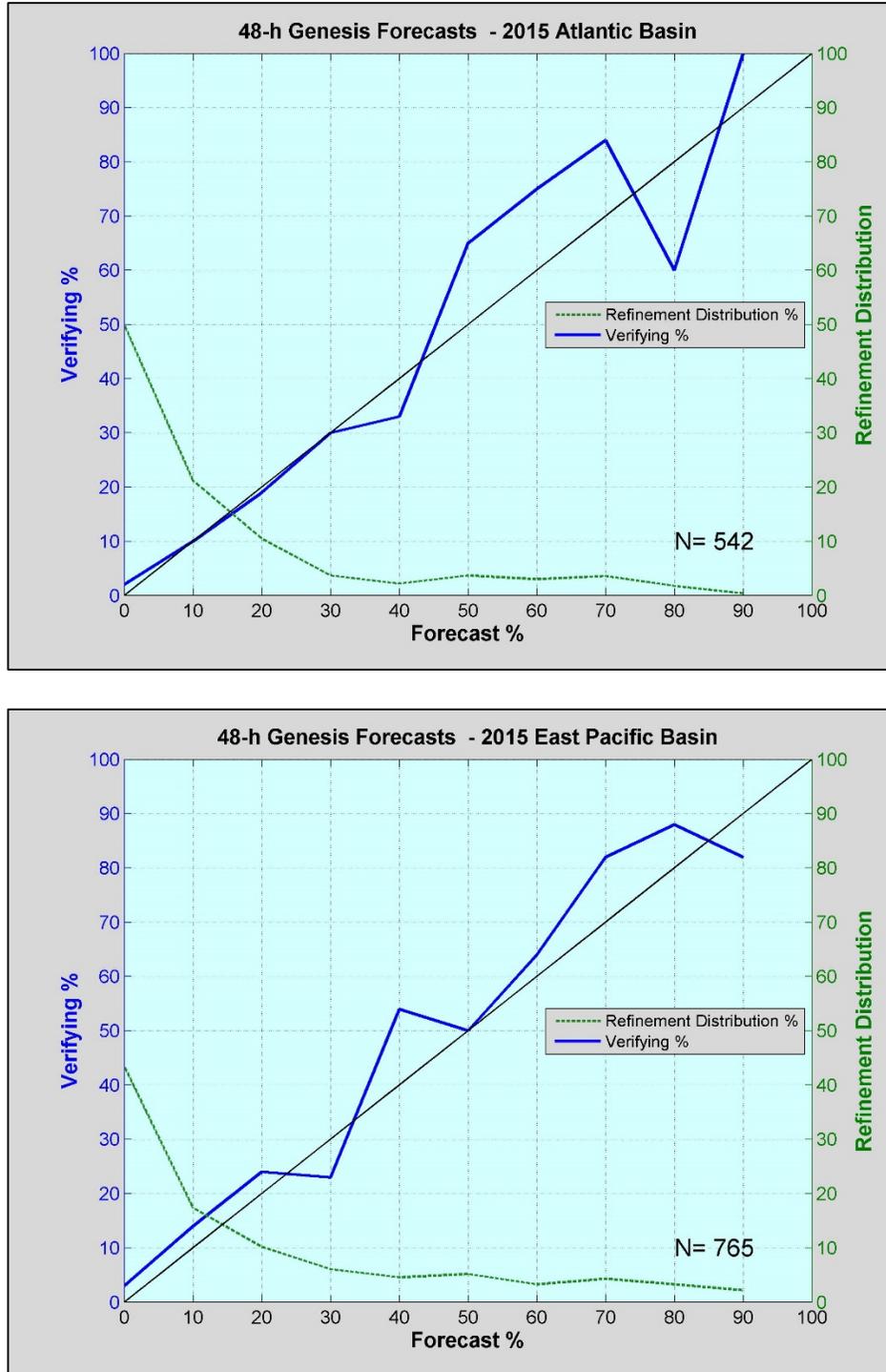
Figure 22.   Reliability diagram for Atlantic (top) and eastern North Pacific (bottom) probabilistic tropical cyclogenesis 48-h forecasts for 2015. The solid lines indicate the relationship between the forecasts and verifying genesis percentages, with perfect reliability indicated by the thin diagonal black line. The dashed lines indicate how the forecasts were distributed among the possible forecast values.
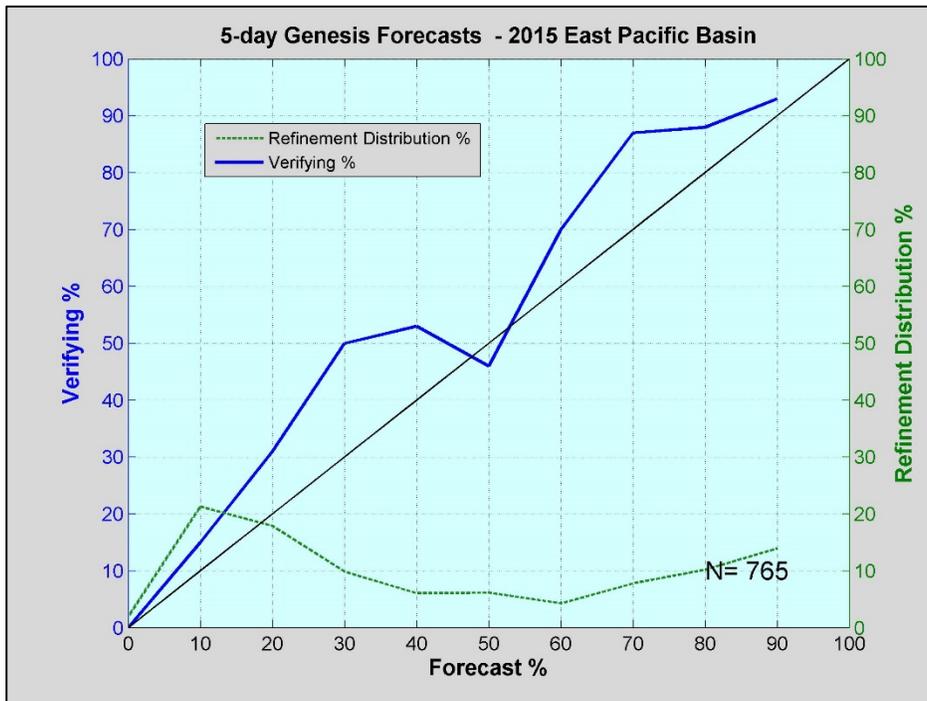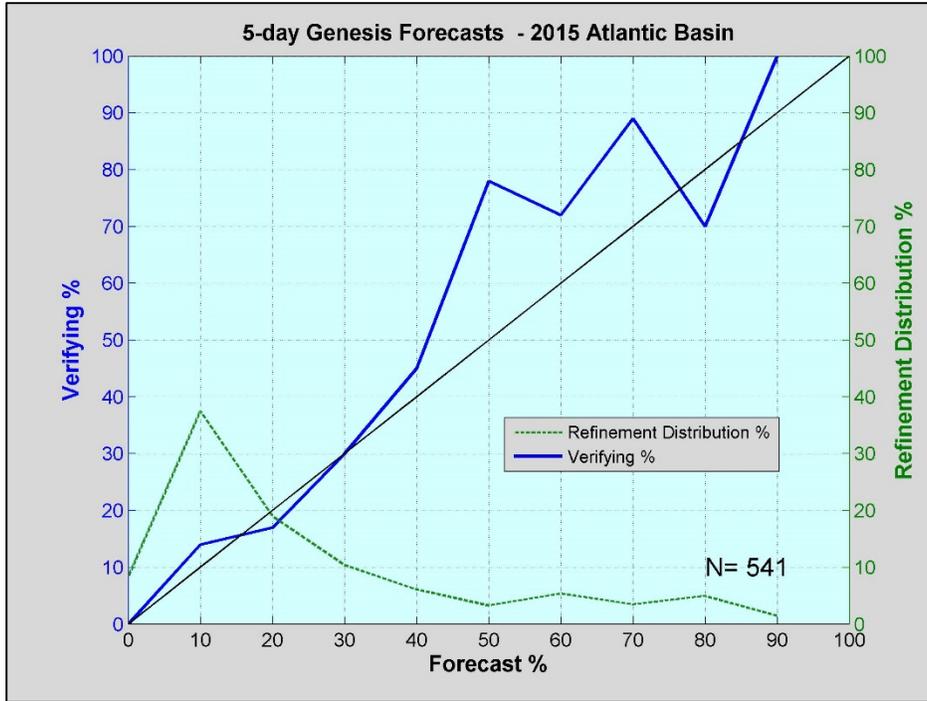
Figure 23.   As described for Fig. 22, except for 120-h forecasts.