2009 National Hurricane Center Forecast Verification Report

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14 March 2010

ABSTRACT

It was a relatively quiet Atlantic hurricane season, with only 144 official forecasts issued in 2009; only 22 of these forecasts verified at 120 h. The NHC official track forecasts in the Atlantic basin set records for accuracy at 24-72 h in 2009. Official forecast skill was also at record levels at those times. On average, the skill of the official forecasts was very close to that of the TCON/TVCN consensus models, as well as to the best performing of the dynamical models. The GFSI and EMXI exhibited the highest skill, and the GHMI also performed well. For the second year in a row, NGPI and EGRI were the poorer performing major dynamical models. Among the consensus models, FSSE (a corrected consensus model) performed the best overall. The corrected versions of TCON, TVCN, and GUNA, however, did not perform as well as their parent models.

Official intensity errors for the Atlantic basin in 2009 were mostly above the previous 5-yr means. Decay-SHIFOR errors in 2009 were unusually large, indicating the season's storms were more difficult to forecast than normal. However, intensity forecast skill was at or just above historical highs. Among the individual intensity guidance models, the LGEM performed best in 2009 (its second year in a row as the top model) and its third consecutive strong showing. The dynamical models GHMI and HWFI performed poorly – so poorly that the ICON consensus could not surpass LGEM. ICON, however, fared as well or better than the corrected consensus FSSE.

There were 268 official forecasts issued in the eastern North Pacific basin in 2008, although only 45 of these verified at 120 h. This level of forecast activity was near average. NHC official track forecast errors set a new record at 12 h. The official forecast skill was very close to the TVCN consensus and the best of the dynamical models. Among the guidance models with sufficient availability, EMXI stood out, with GFNI and HWFI faring least well. There was a large southwestward bias in both the guidance and the official forecast.

For intensity, the official forecast outperformed all the Pacific guidance at 12, 36 and 48 h. Official intensity biases turned sharply positive at 96-120 h, in contrast to the negative long-range biases in 2007-8. The positive bias is partly attributable to the southwestward official track bias. The best model at most forecast times was statistical in nature, with DSHP and LGEM sharing the honors for best model. The four-model intensity consensus ICON performed well.

Experimental quantitative probabilistic forecasts of tropical cyclogenesis (i.e., the likelihood of tropical cyclone formation from a particular disturbance within 48 h) continued in 2009. In-house forecasts were produced in 10% increments while the public forecasts were expressed in terms of categories ("low", "medium", or "high"). Results for the three-year experimental period 2007-9 show that the numerical probabilities have acquired sufficient reliability to issue public genesis forecasts in 10% increments.

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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 hours, 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]. Except where noted to the contrary, 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

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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.

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 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

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[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.

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.

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

[7] On very rare occasions, operational CLIPER or SHIFOR runs are missing from forecast databases. To ensure a complete 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.

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, so that the 6-h forecast (valid at 12Z) would match the observed 12Z position and intensity of the tropical cyclone. The adjustment process creates an "early" version of the GFS model for the 12Z forecast cycle that is based on the most current available guidance. The adjusted versions of the late models are known, mostly for historical reasons, as *interpolated* models[8]. The adjustment algorithm is invoked as long as the most recent available late model is not more than 12 h old, e.g., a 00Z late model could be used to form an interpolated model for the subsequent 06Z or 12Z forecast cycles, but not for the subsequent 18Z cycle. Verification procedures here make no distinction between 6 h 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

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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".

[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.

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 26 January 2010 for the Atlantic basin, and on 12 February 2010 for the eastern 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 in-house probabilistic genesis forecasts, an experimental program that began in 2007. Section 5 summarizes the key findings of the 2009 verification and previews anticipated changes for 2010.

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

2. Atlantic Basin

a. 2009 season overview – Track

Figure 1 and Table 2 present the results of the NHC official track forecast verification for the 2009 season, along with results averaged for the previous 5-yr period 2004-2008. In 2009, the NHC issued 144 Atlantic basin tropical cyclone forecasts[11], a number well below the average over the previous five years (375). Mean track errors ranged from 30 n mi at 12 h to 292 n mi at 120 h. It is seen that mean official track forecast errors were smaller in 2009 than during the previous 5-yr period except at 120 h, and the forecast projections established all-time lows from 24-72 h. Over the past 15 years or so, 24-72 h track forecast errors have been reduced by about 50% (Fig. 2). Vector biases were mostly southeastward (i.e., the official forecast tended to fall to the southeast of the verifying position) and were most pronounced at the longer lead times (e.g., the bias was about 70% of the mean error at 120 h). Examination of along- and cross-track errors shows that the biases at the longer leads were almost exclusively along-track and slow. Table 3b indicates that the official forecast biases closely tracked those of the TVCN consensus. Track forecast skill in 2008 ranged from 41% at 12 h to 68% at 48 h (Table 2), with records for skill being set at 24-72 h (Fig. 2).

Table 3a presents a homogeneous[12] verification for the official forecast along with a selection of early models for 2009. In order to maximize the sample size for comparison with the official forecast, a guidance model had to be available at least two-

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[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.

[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.

thirds of the time at both 48 h and 120 h. For the early track models, this requirement resulted in the exclusion of GFNI. Vector biases of the guidance models are given in Table 3b. Results in terms of skill are presented in Fig. 3. The figure shows that official forecast skill was very close to that of the consensus model TVCN, although below that of FSSE. In the Atlantic basin it is not uncommon for the best of the dynamical models to beat TVCN, and such was the case in 2009 beyond 48 h. The best-performing dynamical model in 2009 was GFSI, followed closely by EMXI. The GHMI and HWFI made up the "second tier" of three-dimensional dynamical models, with NGPI and EGRI performing less well, and not much better than the two-dimensional BAM collection. For the first time in 2009, an interpolated version of the Environment Canada global model (CMCI) was available to the forecasters; the model was competitive with the other dynamical guidance, and performed well at the longer lead times, albeit for a very small sample. The performance of BAMD was very poor, because of the strong shear present over much of the Atlantic basin in 2009.

A separate homogeneous verification of the primary consensus models is shown in Fig. 4. The best consensus model in 2009 was FSSE, a corrected-consensus model. The other corrected-consensus models (TCCN, TVCC, GCUN) did not perform as well as their respective parent models in 2009. In general, it has proven difficult to use the past performance of models to derive operational corrections: the sample of forecast cases is too small, the range of meteorological conditions is too varied, and model characteristics are insufficiently stable to produce a robust developmental data sample on which to base the corrections.

Although not shown here, the GFS and ECMWF ensemble means (AEMI, EEMN) trailed their respective deterministic runs (GFSI, EMX) at all time periods during 2009. While multi-model ensembles continue to provide consistently useful tropical cyclone guidance, the same cannot yet be said for single-model ensembles (although a three-year comparison of AEMI and GFSI shows roughly equivalent skill at 120 h).

Atlantic basin 48-h official track error, evaluated for tropical storms and hurricanes only, is a forecast measure tracked under the Government Performance and Results Act of 1993 (GPRA). In 2009, the GPRA goal was 108 n mi and the verification for this measure was 70.1 n mi.

b. 2009 season overview – Intensity

Figure 5 and Table 4 present the results of the NHC official intensity forecast verification for the 2009 season, along with results averaged for the preceding 5-yr period. Mean forecast errors in 2009 ranged from about 6 kt at 12 h to about 21 kt at 72 h. These errors were below the 5-yr means at 12 and 120 h but above the 5-yr means at the remaining lead times. The 120 h official intensity error set a record for accuracy, although the sample size (22) was exceedingly small, making its significance uncertain. Forecast biases did not exhibit any strong tendencies. Except at 12 h, Decay-SHIFOR5 errors were well above their 5-yr means, indicating the season's storms were unusually difficult to forecast. The Decay-SHIFOR5 errors were so high, in fact, that even though the official forecast errors were above the 5-yr means, record forecast skill was obtained at 24, 72, 96, and 120 h (Figure 6). Figure 6 also shows that there has been virtually no net change in error over the past 15-20 years, although forecasts during the current decade have been more skillful than those from the previous one.

Table 5a presents a homogeneous verification for the official forecast and the primary early intensity models for 2009. Intensity biases are given in Table 5b, and forecast skill is presented in Fig. 7. For the second year in a row, LGEM was the most skillful model (and in 2009 by a substantial margin). The official forecasts on average beat all the guidance only at 12 h, and were better than the ICON consensus through 48 h (and close to it thereafter). ICON fared significantly better than FSSE at 72-120 h. Neither the two dynamical models (GHMI and HWFI) nor DSHP performed well; this was likely due to the significant wind shear that prevailed over the basin during much of the season (LGEM handles changes in predictors over the forecast period more effectively than DSHP). Of particular note are the very large high forecast biases of HWFI (Table 5b), reaching 27 kt at 120 h.

LGEM was so superior to the other models in 2009 that it bested the ICON consensus, the latter being negatively influenced by the dynamical models. Still, an evaluation over the three years 2007-9 (not shown) indicates that ICON is slightly superior to LGEM. Surprisingly, over this same period HWFI contributed positively to the ICON consensus, and so will be retained as a component of ICON (and IVCN) in 2010.

The 48-h official intensity error, evaluated for all tropical cyclones, is another GPRA measure for the NHC. In 2009, the GPRA goal was 13 kt and the verification for this measure was 17.5 kt. Failure to reach the GPRA goal in 2009 can be attributed in part to high forecast difficulty in 2009; as noted above, Decay-SHIFOR5 errors were well above their 5-yr means. In fact, despite the poor intensity guidance provided by the GFDL and HWRF models, the NHC official forecast had its best year ever in terms of 48-h intensity skill. The primary problem, however, is the GPRA goal itself, which was established based on the assumption that the HWRF model would immediately lead to forecast improvements. This has not occurred, of course, and only once, in 2003, were seasonal mean errors as low as the current GPRA goal of 13 kt. (And as it happens, the forecast *skill* in 2003 was not particularly high.) It is reasonable to assume that until there is some modeling or conceptual breakthrough, annual official intensity errors are mostly going to rise and fall with forecast difficulty, and therefore routinely fail to meet GPRA goals.

c. Verifications for individual storms

Forecast verifications for individual storms are given in Table 6. Of note are the relatively large track errors at 72-120 h for Ida, which were associated with forecasts that were essentially on track but too slow. Intensity forecasts for Ida also had large errors, due primarily to missed timing of the interaction of the cyclone's track with land. Additional discussion on forecast performance for individual storms can be found in NHC Tropical Cyclone Reports available at http://www.nhc.noaa.gov/2009atlan.shtml.

3. Eastern North Pacific Basin

a. 2009 season overview – Track

Figure 8 and Table 7 present the NHC official track forecast verification for the 2009 season in the eastern North Pacific, along with results averaged for the previous 5-yr period 2004-8. There were 268 official forecasts issued in the eastern North Pacific basin in 2008, although only 45 of these verified at 120 h. This level of forecast activity was near average. Mean track errors ranged from 30 n mi at 12 h to 240 n mi at 120 h, and were very close to the 5-yr means, except at 120 h where they were about 20% higher than the 5-yr mean. The only new record for accuracy that was set was at 12 h. CLIPER5 errors, however, were somewhat above their long-term means, implying that forecast difficulty in 2009 was higher than normal. Forecast biases were smaller than average through 48 h, but significantly larger than average at 96 and 120 h; biases at the latter times were about 50% of the mean error magnitude, and directed toward the west-southwest. Guillermo was a major contributor to these biases.

Figure 9 shows recent trends in track forecast accuracy and skill for the eastern North Pacific. Errors have been reduced by roughly 30-50% for the 24-72 h forecasts since 1990, a somewhat smaller, but still substantial, improvement than what has occurred in the Atlantic. Forecast skill in 2009 was mixed compared with 2008, but a general upward trend that began near the end of the last decade is still evident.

Table 8a presents a homogeneous verification for the official forecast and the early track models for 2009, with vector biases of the guidance models given in Table 8b. Skill comparisons of selected models are shown in Fig. 10. Note that the sample becomes very small by 120 h. Several models (EGRI, CMCI, AEMI, FSSE, GUNA, and

TCON) were eliminated from this evaluation because they did not meet the two-thirds availability threshold. Among the surviving three-dimensional dynamical models, the EMXI performance stood out, with the GFNI and HWFI faring least well. The multi-model consensus TVCN provided value over the models it comprises; indeed, the power of a multi-model consensus traditionally is much stronger for the eastern North Pacific than for the Atlantic. The skill of the official forecasts was very close to that of TVCN and EMXI. Note that the large southwestward bias at 120 h in TVCN was reflected in OFCL. The GFSI had an even larger bias in that direction.

A separate verification of the primary consensus aids is given in Figure 11. TVCN performed best overall – better than either of the corrected consensus models (FSSE and TVCC), and significantly better than the GFS ensemble mean (AEMI). AEMI, interestingly enough, was superior to its deterministic run through 36 h but worse thereafter (not shown). Typically the value of AEMI (if it has any at all) is at the longer ranges.

b. 2009 season overview – Intensity

Figure 12 and Table 9 present the results of the NHC eastern North Pacific intensity forecast verification for the 2009 season, along with results averaged for the preceding 5-yr period. Mean forecast errors were 7 kt at 12 h and increased to 18 kt by 48 h, remaining relatively constant thereafter. The errors through 48 h were considerably above the 5-yr means, although decay-SHIFOR5 forecast errors in 2009 were above their 5-yr means by a comparable amount. A review of error and skill trends (Fig. 13) indicates little net change in intensity error since 1990, although there has been a slight increase in forecast skill. Intensity forecast biases in 2009 were small except at 96-120 h, where they were strongly positive. This is consistent with the pronounced southwestward bias of the track forecasts at these forecast leads (the storms were expected to remain over warmer waters longer than they actually did).

Figure 14 and Table 10a present a homogeneous verification for the primary early intensity models for 2009. Forecast biases are given in Table 10b. The official forecast beat all the individual guidance models at 12, 36, and 48 h, but was beaten by most of the guidance at the longer ranges, and in fact had negative skill at 96-120 h. The best individual model at each time period was one of the statistical models (either DSHP or LGEM). None of the guidance models had skill at 120 h. The ICON consensus performed well. Although neither the GHMI nor HWFI performed well in 2009, they still contributed positively to the ICON consensus (not shown).

The official forecast high bias at 96 and 120 h was higher than the bias in any of the guidance models. This suggests that the southwestward track bias noted above cannot completely explain the bias in the official forecast. Official intensity forecast skill at 120 h has been negative in each of the past three seasons, suggesting that Decay-SHIFOR5 might be worthy of a little more attention at the longer ranges.

The above sample excludes FSSE because it did not meet the two-thirds availability requirement. However, a homogeneous comparison of FSSE against the simple ICON consensus (not shown) reveals that ICON had lower average errors at all forecast times (as it did in 2008).

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/2009epac.shtml.

4. Experimental 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 during the following 48 hours. In 2007, the NHC began producing in-house (non-public) experimental probabilistic tropical cyclone genesis forecasts. 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 subjective determination of the chance of TC formation during the 48 h period following the nominal TWO issuance time. Verification was 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 for the Atlantic and eastern North Pacific basins for 2009 are given in Table 12. In both basins the experimental forecasts mostly exhibited a low bias (genesis occurred more often than forecast), with a larger bias for the eastern Pacific. Even so, the forecasters were clearly able to distinguish gradations in genesis likelihood (evidenced by the nearly monotonic increase of the verifying percentage with forecast percentage).

Combined results for the three-year period 2007-9 are given in Table 13 and illustrated in Fig. 15. For the three-year sample, there is virtually no bias for the Atlantic basin forecasts, and the verifying percentages increase nearly monotonically. Results for the eastern North Pacific are not quite as good, with an under-forecast bias but still reasonable separation among the 10% forecast bins. The diagrams also show the refinement distribution, which indicate 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.

Based on these results, NHC has decided to issue its public genesis forecasts in 2010 in 10% increments, rather than in the three bins (low/medium/high) that were used in 2009.

5. Looking Ahead to 2010

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-year sample fall within the circle. The circle radii defining the cones in 2010 for the Atlantic and eastern North Pacific basins (based on error distributions for 2005-9) are in Table 14. In both basins, the cone circles will be about 3%-5% smaller than they were last year.

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., GUNA), while others are less restrictive, requiring only two or more members to be present (e.g., TVCN). 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 2010 is unchanged from 2009 and is given in Table 18.

Acknowledgments:

The author gratefully acknowledges Chris Sisko of TPC, keeper of the NHC forecast databases, and Hurricane Specialist Dan Brown for maintaining the genesis forecast database.

6. References

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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
NGPS	Navy Operational Global Prediction System	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
AFW1	Air Force MM5	Multi-layer regional dynamical	L	Trk, Int
EMX	ECMWF global model	Multi-layer global dynamical	L	Trk, Int
EEMN	ECMWF ensemble mean	Consensus	L	Trk
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

ID	Name/Description	Type	Timeliness (E/L)	Parameters forecast
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
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
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
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
NGPI	Previous cycle NGPS, 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, NGPI, and GFSI	Consensus	E	Trk
CGUN	Version of GUNA corrected for model biases	Corrected consensus	E	Trk
AEMI	Previous cycle AEMN, adjusted	Consensus	E	Trk, Int

ID	Name/Description	Type	Timeliness (E/L)	Parameters forecast
FSSE	FSU Super-ensemble	Corrected consensus	E	Trk, Int
TCON	Average of GHMI, EGRI, NGPI, 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 NGPI GHMI HWFI GFNI 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 2009 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
2009 mean OFCL error (n mi)	30.1	44.5	61.8	73.2	119.2	197.9	292.3
2009 mean CLIPER5 error (n mi)	51.0	102.6	166.5	225.1	345.8	462.6	569.8
2009 mean OFCL skill relative to CLIPER5 (%)	41.0	56.6	62.9	67.5	65.5	57.2	48.7
2009 mean OFCL bias vector (°/n mi)	328/2	118/2	150/15	167/39	174/67	170/82	174/202
2009 number of cases	122	98	76	61	49	38	22
2004-2008 mean OFCL error (n mi)	32.1	54.9	77.1	99.0	147.0	200.3	263.6
2004-2008 mean CLIPER5 error (n mi)	45.8	95.7	152.8	208.6	306.2	393.6	472.9
2004-2008 mean OFCL skill relative to CLIPER5 (%)	29.9	42.6	49.5	52.5	52.0	49.1	44.3
2004-2008 mean OFCL bias vector (°/n mi)	303/6	306/14	311/22	315/30	313/31	334/27	010/49
2004-2008 number of cases	1726	1565	1404	1259	1020	808	651
2009 OFCL error relative to 2004-2008 mean (%)	-6	-19	-20	-26	-19	-1	11
2009 CLIPER5 error relative to 2004-2008 mean (%)	11	7	9	8	13	18	20

Table 3a. Homogenous comparison of Atlantic basin early track guidance model errors (n mi) for 2009. Errors smaller than the NHC official forecast are shown in bold-face.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	27.5	40.7	56.7	72.9	104.4	167.3	235.0
OCD5	51.5	103.0	169.3	235.7	368.4	482.0	638.4
GFSI	28.6	42.5	59.8	**72.7**	**93.0**	**143.6**	240.4
GHMI	32.8	46.6	64.3	81.0	117.9	**155.6**	**228.8**
HWFI	30.6	49.0	63.2	79.7	132.3	219.5	342.1
NGPI	32.4	52.8	77.4	103.7	165.2	234.3	305.1
EGRI	34.2	54.3	77.5	109.6	169.0	301.2	448.9
EMXI	28.2	42.4	62.9	74.1	112.8	**159.4**	**217.3**
CMCI	31.9	53.0	73.6	86.1	112.7	**106.1**	**130.3**
AEMI	33.4	53.2	72.3	92.0	137.9	191.2	277.8
FSSE	**26.7**	**37.2**	**47.0**	**60.3**	**81.2**	**128.0**	**198.2**
TCON	**27.0**	**38.5**	**54.3**	73.0	112.4	180.8	266.5
TCCN	29.3	45.5	68.1	91.5	130.6	231.8	425.6
TVCN	**25.8**	**38.0**	**54.8**	**72.2**	107.8	169.5	241.1
TVCC	28.3	45.0	67.5	89.9	127.9	218.1	355.3
LBAR	38.1	61.6	96.1	139.1	229.1	211.5	358.8
BAMS	45.1	76.6	108.5	143.0	224.5	274.0	341.5
BAMM	38.7	61.3	90.1	117.1	192.9	250.6	366.6
BAMD	43.3	70.9	93.4	119.4	192.5	241.5	362.9
# Cases	62	56	47	39	27	19	10

Table 3b. Homogenous comparison of Atlantic basin early track guidance model bias vectors (º/n mi) for 2009.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	180/008	152/015	153/030	159/046	174/061	179/117	179/203
OCD5	180/019	173/045	181/091	181/139	196/234	180/383	174/579
GFSI	163/004	115/009	119/019	134/030	136/040	137/083	122/196
GHMI	164/016	156/025	156/034	162/040	171/026	156/072	155/152
HWFI	105/007	086/016	118/021	136/031	174/055	180/149	185/270
NGPI	172/006	140/012	153/026	161/052	178/087	190/170	199/271
EGRI	197/017	194/031	194/054	198/087	205/153	205/285	201/434
EMXI	158/005	129/012	131/017	133/031	124/047	126/097	126/172
CMCI	255/012	277/024	282/031	264/030	179/022	204/061	182/098
AEMI	224/013	222/018	206/027	198/037	185/036	115/059	085/222
FSSE	127/008	109/017	116/026	120/028	123/014	177/078	188/173
TCON	169/009	151/015	159/027	168/044	184/067	185/140	182/234
TCCN	153/015	144/029	150/047	159/070	178/098	187/207	188/410
TVCN	165/009	150/015	157/027	164/042	178/060	180/122	177/202
TVCC	146/014	139/028	145/047	153/068	167/091	180/186	178/329
LBAR	142/008	185/012	206/044	209/091	222/167	191/166	165/320
BAMS	084/006	071/014	149/017	168/039	170/085	155/154	148/283
BAMM	215/014	206/027	197/057	188/089	178/144	168/205	153/318
BAMD	248/027	240/051	222/083	209/118	199/178	180/232	157/305
# Cases	62	56	47	39	27	19	10

Table 4. Homogenous comparison of official and Decay-SHIFOR5 intensity forecast errors in the Atlantic basin for the 2009 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
2009 mean OFCL error (kt)	6.4	11.4	14.9	17.5	20.6	19.5	16.6
2009 mean Decay-SHIFOR5 error (kt)	7.9	14.3	19.7	23.5	28.0	29.2	25.3
2009 mean OFCL skill relative to Decay-SHIFOR5 (%)	19.0	20.3	24.4	25.5	26.4	33.2	34.4
2009 OFCL bias (kt)	0.6	1.7	-0.1	-2.5	-4.3	-1.6	5.2
2009 number of cases	122	98	76	61	49	38	22
2004-8 mean OFCL error (kt)	7.1	10.5	12.8	14.7	18.1	19.0	20.9
2004-8 mean Decay-SHIFOR5 error (kt)	8.5	12.3	15.3	17.7	20.8	23.1	23.2
2004-8 mean OFCL skill relative to Decay-SHIFOR5 (%)	16.5	14.6	16.3	16.9	13.0	17.7	9.9
2004-8 OFCL bias (kt)	0.2	0.4	0.1	-0.3	-0.5	-2.1	-2.5
2004-8 number of cases	1726	1565	1404	1259	1020	808	651
2009 OFCL error relative to 2004-8 mean (%)	-10	9	16	19	14	3	-21
2009 Decay-SHIFOR5 error relative to 2004-8 mean (%)	-7	16	29	33	35	26	9

Table 5a. Homogenous comparison of selected Atlantic basin early intensity guidance model errors (kt) for 2009. Errors smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	6.8	11.7	13.8	14.3	17.9	18.0	16.6
OCD5	8.4	14.8	18.8	20.7	27.4	29.6	22.8
HWFI	8.5	13.9	16.4	17.2	18.8	23.9	31.0
GHMI	8.7	14.5	18.6	18.6	18.2	**17.9**	19.6
DSHP	7.9	12.5	15.5	15.9	18.0	20.5	18.8
LGEM	7.5	**10.8**	**12.8**	**12.6**	**13.6**	**13.0**	**9.8**
ICON	7.8	12.6	15.4	15.1	**15.9**	**17.2**	**15.9**
IVCN	8.0	12.8	15.6	15.1	**16.7**	**17.7**	16.9
FSSE	7.8	12.4	15.1	15.1	20.4	22.8	23.1
# Cases	90	75	58	47	33	23	16

Table 5b. Homogenous comparison of selected Atlantic basin early intensity guidance model biases (kt) for 2009. Biases smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	1.3	3.7	3.4	1.9	3.0	3.7	9.7
OCD5	1.5	4.3	4.2	3.8	**1.4**	-4.5	**-4.7**
HWFI	1.3	**3.3**	3.9	4.8	5.8	13.6	27.4
GHMI	**0.1**	**1.1**	**2.2**	2.9	**1.5**	5.8	15.8
DSHP	1.3	4.1	5.6	5.2	4.1	**3.0**	**5.6**
LGEM	**0.4**	**0.8**	**-0.1**	-1.9	-4.1	-5.0	**-3.4**
ICON	**1.0**	**2.5**	**3.3**	3.0	**2.1**	4.6	11.4
IVCN	**0.6**	**2.1**	**2.9**	2.8	**2.8**	5.8	12.9
FSSE	**0.5**	**1.2**	**1.2**	**0.3**	**-0.4**	**0.2**	**4.9**
# Cases	90	75	58	47	33	23	16

Table 6. Official Atlantic track and intensity forecast verifications (OFCL) for 2009 by storm. CLIPER5 and Decay-SHIFOR5 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: AL012009 ONE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	6	12.3	12.7	6	0.0	0.0
012	4	21.2	49.1	4	5.0	4.5
024	2	42.4	83.5	2	5.0	6.5
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
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL022009 ANA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	15	6.4	6.4	15	1.7	1.3
012	11	18.0	30.8	11	2.7	4.5
024	7	35.6	71.1	7	5.7	6.6
036	3	61.8	114.1	3	6.7	4.0
048	1	13.3	68.3	1	15.0	12.0
072	5	116.7	220.5	5	14.0	15.2
096	6	233.8	412.6	6	14.2	18.8
120	2	355.1	606.6	2	15.0	20.5
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL032009 BILL

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	36	6.2	6.5	36	1.3	1.4
012	34	26.5	48.2	34	5.7	5.9
024	32	40.8	100.1	32	10.8	11.2
036	30	55.5	153.5	30	13.3	15.3
048	28	72.7	209.2	28	14.3	19.2
072	24	113.2	323.9	24	18.8	25.6
096	20	164.6	434.8	20	18.0	27.4
120	16	237.7	576.2	16	16.6	22.4
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL042009 CLAUDETTE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	5	2.1	2.1	5	2.0	2.0
012	5	24.0	37.6	5	6.0	10.6
024	3	32.6	111.9	3	6.7	7.0
036	1	42.1	217.4	1	0.0	9.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL052009 DANNY

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	11	8.4	8.6	11	0.9	0.9
012	9	57.7	73.3	9	7.8	6.0
024	7	55.1	80.8	7	12.1	11.9
036	5	82.4	100.9	5	19.0	22.2
048	3	75.9	55.9	3	26.7	24.3
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
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL062009 ERIKA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	9	23.3	22.8	9	2.2	2.8
012	7	57.9	68.1	7	7.1	11.0
024	5	104.1	124.9	5	12.0	17.2
036	3	162.4	234.9	3	20.0	30.7
048	1	196.1	279.7	1	30.0	41.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL072009 FRED

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	20	16.0	16.0	20	2.3	2.5
012	18	26.9	58.1	18	8.1	12.1
024	16	38.1	125.8	16	12.8	22.4
036	14	42.6	213.4	14	16.1	29.1
048	12	45.7	304.4	12	16.3	30.7
072	8	50.8	504.6	8	15.6	30.0
096	4	97.5	728.9	4	10.0	24.8
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL082009 EIGHT

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	5	8.7	8.7	5	0.0	0.0
012	3	21.3	26.2	3	5.0	6.7
024	1	16.5	18.1	1	10.0	20.0
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
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL092009 GRACE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	5	3.8	3.8	5	1.0	1.0
012	3	56.7	125.7	3	3.3	4.0
024	1	83.0	377.0	1	0.0	9.0
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
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL102009 HENRI

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	8	12.1	12.1	8	0.6	0.6
012	6	26.1	31.4	6	4.2	8.2
024	4	58.5	58.7	4	6.3	17.8
036	2	116.1	108.9	2	5.0	22.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: AL112009 IDA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	24	7.9	8.5	24	2.5	2.5
012	22	26.2	46.8	22	8.6	10.0
024	20	39.0	101.0	20	15.8	16.7
036	18	59.7	170.9	18	17.8	20.3
048	16	90.3	231.7	16	21.6	25.1
072	12	178.0	336.1	12	30.4	36.8
096	8	304.6	436.4	8	31.9	44.0
120	4	479.0	526.1	4	17.5	39.3
144	0	-999.0	-999.0	0	-999.0	-999.0
168	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 for the 2009 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
2009 mean OFCL error (n mi)	29.5	50.9	71.9	89.0	119.2	162.5	240.4
2009 mean CLIPER5 error (n mi)	38.4	76.6	119.8	165.4	248.1	306.3	352.2
2009 mean OFCL skill relative to CLIPER5 (%)	23.2	33.6	40.0	46.2	52.0	46.9	31.7
2009 mean OFCL bias vector (°/n mi)	225/1	202/3	195/9	206/11	248/34	253/79	242/138
2009 number of cases	236	204	173	143	99	69	45
2004-8 mean OFCL error (n mi)	31.0	51.7	71.7	90.2	123.6	161.3	201.8
2004-8 mean CLIPER5 error (n mi)	38.4	73.6	111.9	149.1	214.2	261.1	311.5
2004-8 mean OFCL skill relative to CLIPER5 (%)	19.3	29.8	35.9	39.5	42.3	38.2	35.2
2004-8 mean OFCL bias vector (°/n mi)	314/3	298/5	289/9	288/15	272/16	271/7	006/7
2004-8 number of cases	1299	1140	986	855	626	451	310
2009 OFCL error relative to 2004-8 mean (%)	-5	-2	0	-1	-4	1	19
2009 CLIPER5 error relative to 2004-8 mean (%)	0	4	7	11	16	17	13

Table 8a. Homogenous comparison of eastern North Pacific basin early track guidance model errors (n mi) for 2009. Errors smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	26.0	44.5	65.1	79.3	98.0	155.1	248.4
OCD5	36.2	72.7	121.5	170.0	255.7	308.7	326.9
GFSI	39.1	64.7	91.0	107.3	134.2	187.4	292.2
GHMI	34.2	59.1	87.8	118.7	166.6	235.3	249.5
HWFI	35.4	62.8	93.7	125.5	179.5	213.1	250.8
GFNI	33.6	63.1	99.9	132.5	193.0	273.0	354.4
NGPI	33.9	60.6	90.5	118.1	157.4	218.7	296.1
EMXI	27.6	**44.1**	**64.2**	81.4	108.8	157.6	**209.3**
TVCN	26.1	**41.9**	**60.6**	**78.5**	100.0	**137.1**	**228.1**
TVCC	28.9	48.4	65.1	84.4	114.0	181.0	274.8
LBAR	33.4	67.9	106.3	157.3	251.0	319.0	452.9
BAMD	35.6	60.5	82.8	107.8	181.7	284.5	406.4
BAMM	33.2	55.7	78.2	106.0	155.8	206.3	261.5
BAMS	41.6	74.1	110.0	145.3	200.7	268.4	274.8
# Cases	137	114	100	81	58	39	19

Table 8b. Homogenous comparison of eastern North Pacific basin early track guidance model bias vectors (º/n mi) for 2009.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	282/002	285/005	254/009	262/014	254/038	249/089	225/155
OCD5	232/004	249/011	234/022	233/037	200/074	189/077	144/092
GFSI	287/013	282/022	274/032	266/037	253/085	245/155	232/228
GHMI	033/006	011/013	345/024	340/045	344/096	003/088	254/101
HWFI	342/014	343/028	330/042	330/066	334/110	329/112	275/099
GFNI	077/004	125/012	129/027	120/037	153/033	168/067	171/155
NGPI	063/004	090/015	098/027	113/034	179/033	211/049	198/117
EMXI	192/004	185/008	182/016	172/022	189/034	215/077	210/101
TVCN	303/003	291/003	252/005	256/009	266/035	248/067	223/122
TVCC	273/006	212/019	270/014	268/017	268/057	256/098	204/123
LBAR	012/007	339/033	326/054	317/083	318/118	330/118	051/092
BAMD	358/010	001/021	004/025	354/023	342/035	054/032	087/043
BAMM	310/011	303/020	287/027	274/037	266/060	249/076	250/045
BAMS	289/019	279/043	267/068	257/096	246/138	242/176	255/160
# Cases	137	114	100	81	58	39	19

Table 9. Homogenous comparison of official and Decay-SHIFOR5 intensity forecast errors in the eastern North Pacific basin for the 2009 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
2009 mean OFCL error (kt)	7.1	12.8	17.1	18.0	17.3	18.1	18.8
2009 mean Decay-SHIFOR5 error (kt)	8.0	13.6	17.9	20.8	19.7	17.6	16.0
2009 mean OFCL skill relative to Decay-SHIFOR5 (%)	11.3	5.9	4.5	13.5	12.2	-2.8	-17.5
2009 OFCL bias (kt)	-0.2	0.2	-0.4	-1.4	1.1	7.2	12.1
2009 number of cases	236	204	173	143	99	69	45
2004-8 mean OFCL error (kt)	6.2	10.2	13.3	15.1	17.7	19.0	18.8
2004-8 mean Decay-SHIFOR5 error (kt)	7.1	11.5	14.7	16.8	18.9	20.3	20.2
2004-8 mean OFCL skill relative to Decay-SHIFOR5 (%)	12.7	11.3	9.5	10.1	6.3	6.4	6.9
2004-8 OFCL bias (kt)	0.9	2.2	3.2	3.0	3.7	2.0	-1.2
2004-8 number of cases	1299	1140	986	855	626	451	310
2009 OFCL error relative to 2004-8 mean (%)	14.5	25.5	28.6	19.2	-2.3	-4.7	0.0
2009 Decay-SHIFOR5 error relative to 2004-8 mean (%)	12.7	18.3	21.8	23.8	4.2	-13.3	-20.8

Table 10a. Homogenous comparison of eastern North Pacific basin early intensity guidance model errors (kt) for 2009. Errors smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	7.3	13.0	17.2	18.3	17.3	18.3	21.5
OCD5	8.0	13.7	18.0	21.1	19.5	**17.7**	**15.1**
HWFI	8.7	14.0	18.9	21.5	22.2	22.8	22.0
GHMI	9.3	14.7	18.3	20.2	21.8	19.5	**19.6**
DSHP	7.8	**12.8**	**16.8**	18.9	17.5	**18.1**	**21.0**
LGEM	8.1	13.8	17.7	20.5	18.5	**16.0**	**17.6**
ICON	7.9	**12.9**	**16.6**	19.0	18.6	**17.4**	**17.8**
IVCN	8.0	**12.9**	**16.5**	18.8	18.7	**17.7**	**18.9**
# Cases	231	199	170	139	97	66	37

Table 10b. Homogenous comparison of eastern North Pacific basin early intensity guidance model biases (kt) for 2009. Biases smaller than the NHC official forecast are shown in boldface.

	Forecast Period (h)						
Model ID	12	24	36	48	72	96	120
OFCL	-0.2	0.2	-0.5	-1.5	0.8	7.1	13.6
OCD5	-0.5	-0.8	-0.9	**-0.7**	3.1	**6.1**	**9.7**
HWFI	-0.4	-1.2	-0.9	-1.5	-2.1	**3.4**	**12.8**
GHMI	-3.4	-6.4	-7.7	-6.3	-4.1	**1.1**	**10.1**
DSHP	-0.7	-0.4	**-0.1**	**-0.3**	**0.0**	**4.3**	**11.1**
LGEM	-1.5	-2.9	-4.3	-5.3	-4.0	**0.8**	**7.0**
ICON	-1.2	-2.4	-3.0	-3.1	-2.3	**2.7**	**10.6**
IVCN	-1.7	-3.1	-3.5	-3.1	-1.0	**3.9**	**11.6**
# Cases	231	199	170	139	97	66	37

Table 11. Official eastern North Pacific track and intensity forecast verifications (OFCL) for 2009 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: EP012009 ONE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	5	21.4	21.4	5	0.0	1.0
012	3	52.6	71.1	3	3.3	3.7
024	1	70.0	153.9	1	0.0	6.0
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
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP022009 ANDRES

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	12	9.5	9.5	12	5.4	6.3
012	10	25.7	40.1	10	8.5	11.6
024	8	39.8	89.9	8	12.5	15.0
036	6	55.5	141.0	6	15.8	16.0
048	4	76.1	177.2	4	15.0	17.5
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
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP032009 BLANCA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	12	4.4	4.4	12	1.3	1.3
012	10	27.4	29.7	10	3.5	3.9
024	8	50.5	61.7	8	5.6	5.1
036	6	75.6	107.1	6	7.5	8.8
048	4	92.9	143.9	4	6.3	10.5
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
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP042009 CARLOS

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	27	6.3	5.9	27	0.6	0.7
012	25	34.6	35.8	25	11.4	11.6
024	23	67.9	79.6	23	24.3	24.0
036	21	101.2	120.1	21	30.2	32.8
048	19	137.5	165.1	19	26.6	34.7
072	15	223.6	249.2	15	16.7	18.2
096	11	321.2	333.2	11	24.1	24.6
120	7	413.6	390.7	7	32.1	24.9
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP052009 DOLORES

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	7	19.4	19.4	7	0.7	0.7
012	5	41.5	72.5	5	5.0	5.2
024	3	63.2	150.5	3	6.7	5.7
036	1	61.8	198.5	1	0.0	5.0
048	0	-999.0	-999.0	0	-999.0	-999.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP062009 LANA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	1	13.2	32.2	1	0.0	0.0
012	1	38.1	51.1	1	10.0	8.0
024	1	74.8	82.8	1	10.0	9.0
036	1	93.4	96.1	1	0.0	4.0
048	1	85.5	99.0	1	0.0	2.0
072	1	84.9	130.2	1	0.0	22.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP072009 ENRIQUE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	17	8.3	9.3	17	1.5	1.8
012	15	41.4	41.0	15	5.7	5.1
024	13	99.2	97.1	13	6.9	6.3
036	11	171.7	148.4	11	6.8	7.5
048	8	245.4	233.6	8	10.0	13.6
072	5	375.3	374.3	5	19.0	31.6
096	1	476.5	463.7	1	25.0	35.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP082009 FELICIA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	18	4.6	4.6	18	3.9	3.9
012	18	21.6	26.2	18	8.3	10.4
024	18	38.2	47.0	18	13.9	15.1
036	18	51.2	75.1	18	18.1	19.6
048	18	63.1	106.6	18	18.9	18.7
072	18	75.0	170.4	18	11.7	9.1
096	15	90.5	213.9	15	9.3	10.5
120	11	150.4	207.7	11	10.0	13.5
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP092009 NINE

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	9	6.9	6.9	9	0.0	0.0
012	7	24.1	28.7	7	2.1	4.0
024	5	53.0	59.5	5	6.0	7.2
036	3	81.1	105.1	3	10.0	12.7
048	1	79.0	127.6	1	20.0	19.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP102009 GUILLERMO

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	18	4.4	3.7	18	1.4	0.8
012	18	15.8	17.8	18	8.6	8.4
024	18	24.6	39.4	18	14.4	15.2
036	18	31.7	73.4	18	18.6	20.9
048	18	45.7	124.2	18	22.5	25.1
072	17	83.5	248.3	17	19.1	18.3
096	13	144.2	358.5	13	12.7	11.2
120	9	276.2	495.7	9	8.3	4.4
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP112009 HILDA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	5	4.9	6.1	5	0.0	1.0
012	5	27.5	30.6	5	6.0	2.6
024	5	58.0	53.2	5	10.0	6.0
036	5	86.5	76.8	5	14.0	7.4
048	5	91.1	76.6	5	8.0	6.6
072	5	99.9	120.2	5	6.0	11.8
096	5	106.2	201.0	5	17.0	21.2
120	5	123.6	238.9	5	26.0	25.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP122009 IGNACIO

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	11	18.9	18.9	11	0.9	1.4
012	9	38.2	55.4	9	2.8	3.9
024	7	52.5	100.1	7	5.0	6.0
036	5	90.4	184.0	5	11.0	7.0
048	3	135.5	258.3	3	11.7	11.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP132009 JIMENA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	28	5.6	5.6	28	2.7	2.9
012	26	23.3	34.0	26	6.9	8.6
024	24	43.5	71.5	24	10.4	13.1
036	22	58.9	116.8	22	14.1	15.8
048	20	64.4	157.0	20	11.5	17.2
072	16	52.4	241.0	16	12.5	25.6
096	12	109.4	372.2	12	10.0	26.0
120	8	218.8	503.4	8	6.9	22.1
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP142009 KEVIN

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	13	11.6	11.6	13	0.8	0.8
012	11	30.6	39.8	11	5.5	5.5
024	9	52.5	85.6	9	8.3	12.4
036	7	78.5	159.7	7	11.4	20.4
048	5	84.8	261.9	5	12.0	29.8
072	1	72.3	458.4	1	10.0	30.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP152009 LINDA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	19	14.7	14.4	19	2.4	2.4
012	17	30.1	33.8	17	5.6	7.4
024	15	49.3	69.6	15	10.3	13.3
036	13	56.3	113.7	13	11.9	13.5
048	11	73.3	169.4	11	10.5	12.0
072	7	112.8	311.4	7	12.1	14.1
096	3	163.7	372.7	3	8.3	10.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP162009 MARTY

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	13	11.6	11.6	13	1.2	1.2
012	11	18.0	36.0	11	1.8	4.0
024	9	29.8	64.7	9	6.1	6.0
036	7	47.3	88.6	7	6.4	8.0
048	5	70.2	91.0	5	5.0	7.2
072	1	140.8	164.3	1	10.0	12.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP172009 NORA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	9	16.0	15.4	9	0.6	0.6
012	7	28.4	35.3	7	5.7	6.3
024	5	41.9	57.4	5	13.0	10.8
036	3	77.4	95.8	3	11.7	10.7
048	1	127.1	148.9	1	0.0	10.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP182009 OLAF

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	9	21.5	22.3	9	1.1	1.7
012	7	71.9	86.7	7	2.1	4.0
024	5	141.0	167.7	5	3.0	5.0
036	3	241.2	279.7	3	1.7	2.0
048	1	289.4	532.7	1	5.0	2.0
072	0	-999.0	-999.0	0	-999.0	-999.0
096	0	-999.0	-999.0	0	-999.0	-999.0
120	0	-999.0	-999.0	0	-999.0	-999.0
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP192009 PATRICIA

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	10	12.4	12.4	10	2.0	2.0
012	8	43.5	46.0	8	9.4	7.4
024	6	55.0	73.4	6	10.8	9.5
036	4	26.0	67.6	4	12.5	6.5
048	2	55.7	66.0	2	12.5	5.5
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
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Verification statistics for: EP202009 RICK

VT (h)	NT	OFCL	OCD5	NI	OFCL	OCD5
000	25	8.1	8.6	25	1.8	1.8
012	23	22.2	46.9	23	12.6	13.9
024	21	30.8	101.2	21	23.3	22.7
036	19	47.3	174.3	19	32.1	28.2
048	17	63.9	249.1	17	35.9	31.6
072	13	105.5	328.9	13	38.1	31.6
096	9	181.7	283.4	9	47.2	17.7
120	5	282.8	228.9	5	50.0	11.4
144	0	-999.0	-999.0	0	-999.0	-999.0
168	0	-999.0	-999.0	0	-999.0	-999.0

Table 12a. Verification of experimental in-house probabilistic genesis forecasts for the Atlantic basin in 2009.

Atlantic Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	**Verifying Genesis Occurrence Rate (%)**	**Number of Forecasts**
0	2	83
10	8	153
20	14	90
30	33	36
40	50	8
50	67	9
60	67	9
70	78	9
80	100	4
90	100	3
100	-	0

Table 12b. Verification of experimental in-house probabilistic genesis forecasts for the eastern North Pacific basin in 2009.

Eastern North Pacific Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	**Verifying Genesis Occurrence Rate (%)**	**Number of Forecasts**
0	3	29
10	17	115
20	34	71
30	44	27
40	68	31
50	74	23
60	89	19
70	88	17
80	79	14
90	100	1
100	-	0

Table 13a. Verification of experimental in-house probabilistic genesis forecasts for the Atlantic basin for the period 2007- 2009.

Atlantic Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	**Verifying Genesis Occurrence Rate (%)**	**Number of Forecasts**
0	2	404
10	6	581
20	13	275
30	30	162
40	42	77
50	43	60
60	58	57
70	71	35
80	67	24
90	75	16
100	100	1

Table 13b. Verification of experimental in-house probabilistic genesis forecasts for the eastern North Pacific basin for the period 2007-2009.

Eastern North Pacific Basin Genesis Forecast Reliability Table		
Forecast Likelihood (%)	**Verifying Genesis Occurrence Rate (%)**	**Number of Forecasts**
0	3	152
10	18	369
20	32	234
30	42	105
40	58	71
50	72	71
60	85	46
70	83	36
80	73	26
90	100	5
100	100	1

Table 14. NHC forecast cone circle radii (n mi) for 2010. Change from 2009 values (n mi) given in parentheses.

Track Forecast Cone Two-Thirds Probability Circles (n mi)		
Forecast Period (h)	**Atlantic Basin**	**Eastern North Pacific Basin**
12	36 (0)	36 (0)
24	62 (0)	59 (0)
36	85 (-4)	82 (-3)
48	108 (-3)	102 (-3)
72	161 (-6)	138 (-10)
96	220 (-10)	174 (-13)
120	285 (-17)	220 (-10)

Table 15. Composition of NHC consensus models for 2010.

NHC Consensus Model Definitions For 2010			
Model ID	**Parameter**	**Type**	**Members**
GUNA	Track	Fixed	GFSI EGRI NGPI GHMI
TCON	Track	Fixed	GFSI EGRI NGPI GHMI HWFI
ICON	Intensity	Fixed	DSHP LGEM GHMI HWFI
TVCN	Track	Variable	GFSI EGRI NGPI GHMI HWFI GFNI EMXI
IVCN	Intensity	Variable	DSHP LGEM GHMI HWFI GFNI
CGUN	Track	Fixed (corrected)	GFSI EGRI NGPI GHMI
TCCN	Track	Fixed (corrected)	GFSI EGRI NGPI GHMI HWFI
TVCC	Track	Variable (corrected)	GFSI EGRI NGPI GHMI HWFI GFNI EMXI

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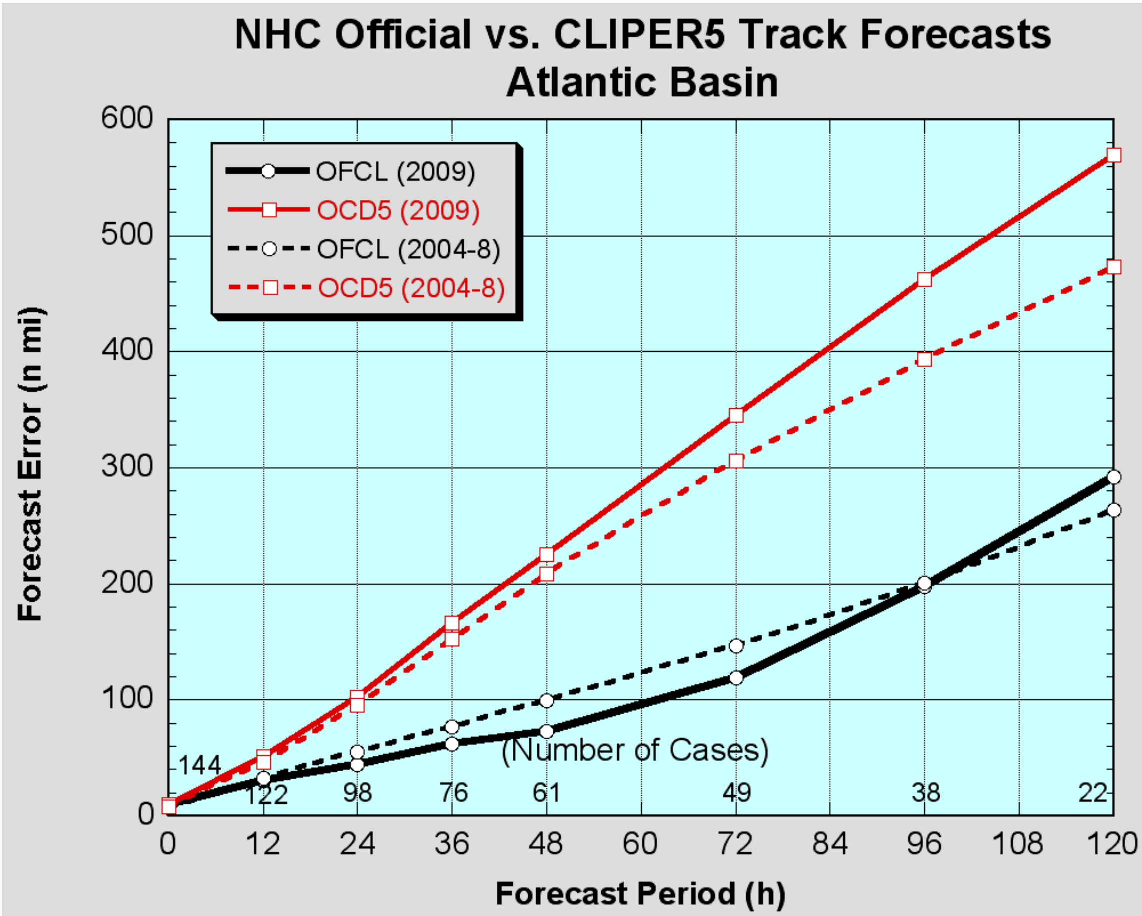


Figure 1. NHC official and CLIPER5 (OCD5) Atlantic basin average track errors for 2009 (solid lines) and 2004-2008 (dashed lines).

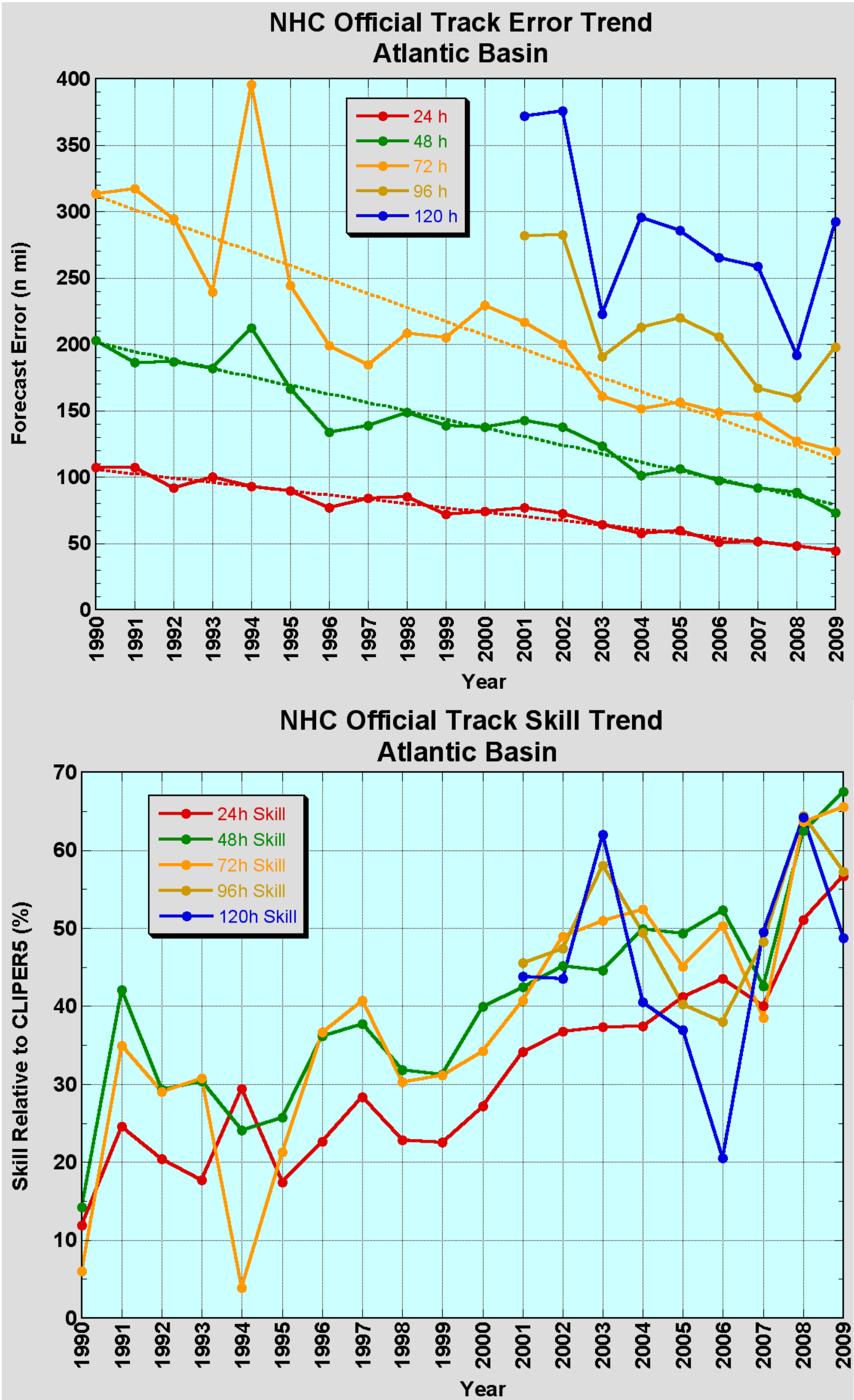


Figure 2. Recent trends in NHC official track forecast error (top) and skill (bottom) for the Atlantic basin.

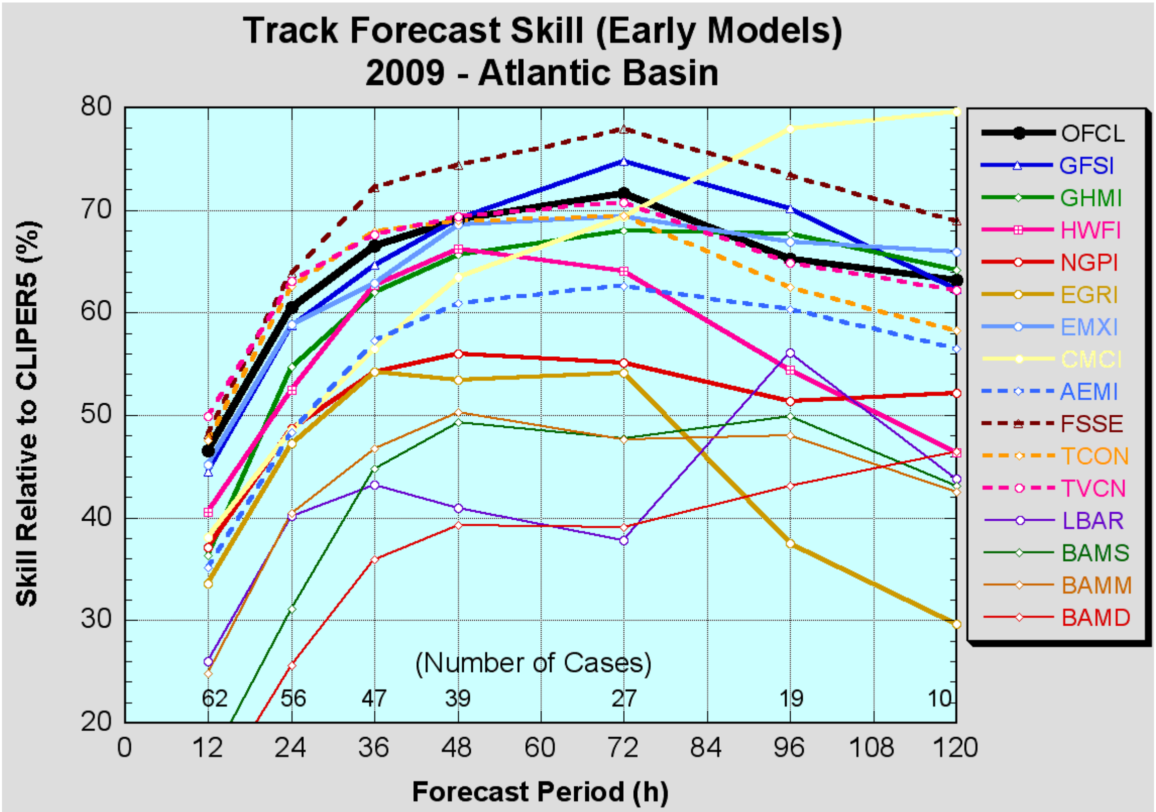


Figure 3. Homogenous comparison for selected Atlantic basin early track guidance models for 2009. This verification includes only those models that were available at least 2/3 of the time (see text).

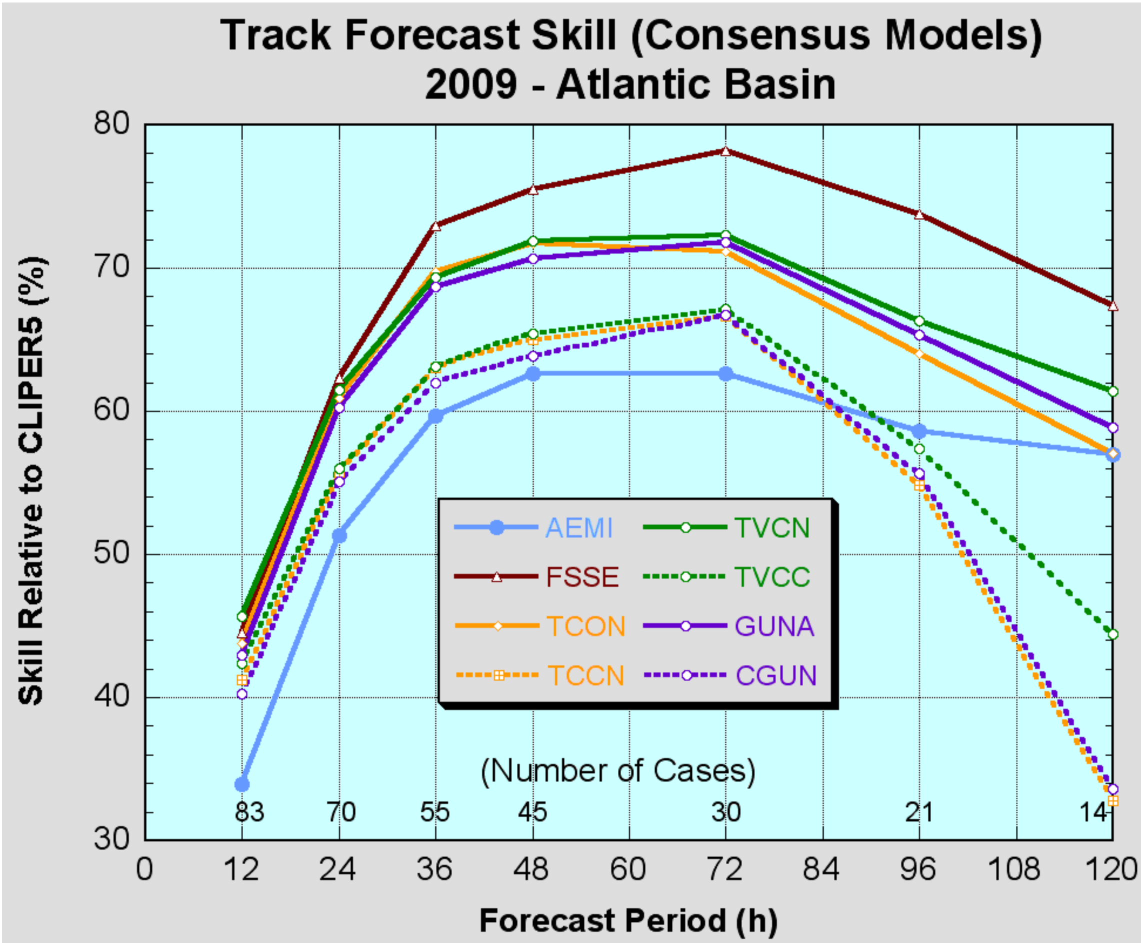


Figure 4. Homogenous comparison of the primary Atlantic basin track consensus models for 2009.

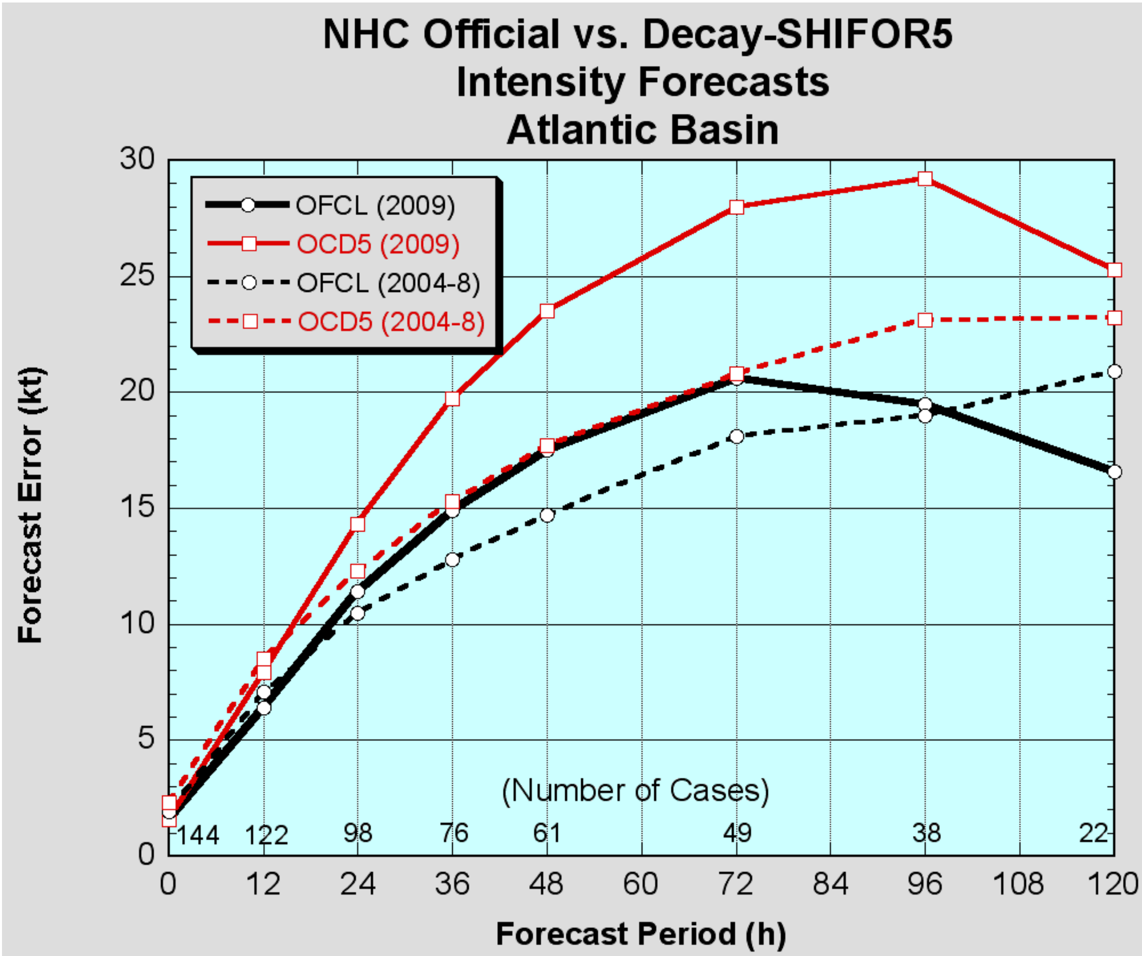


Figure 5. NHC official and Decay-SHIFOR5 (OCD5) Atlantic basin average intensity errors for 2009 (solid lines) and 2004-2008 (dashed lines).

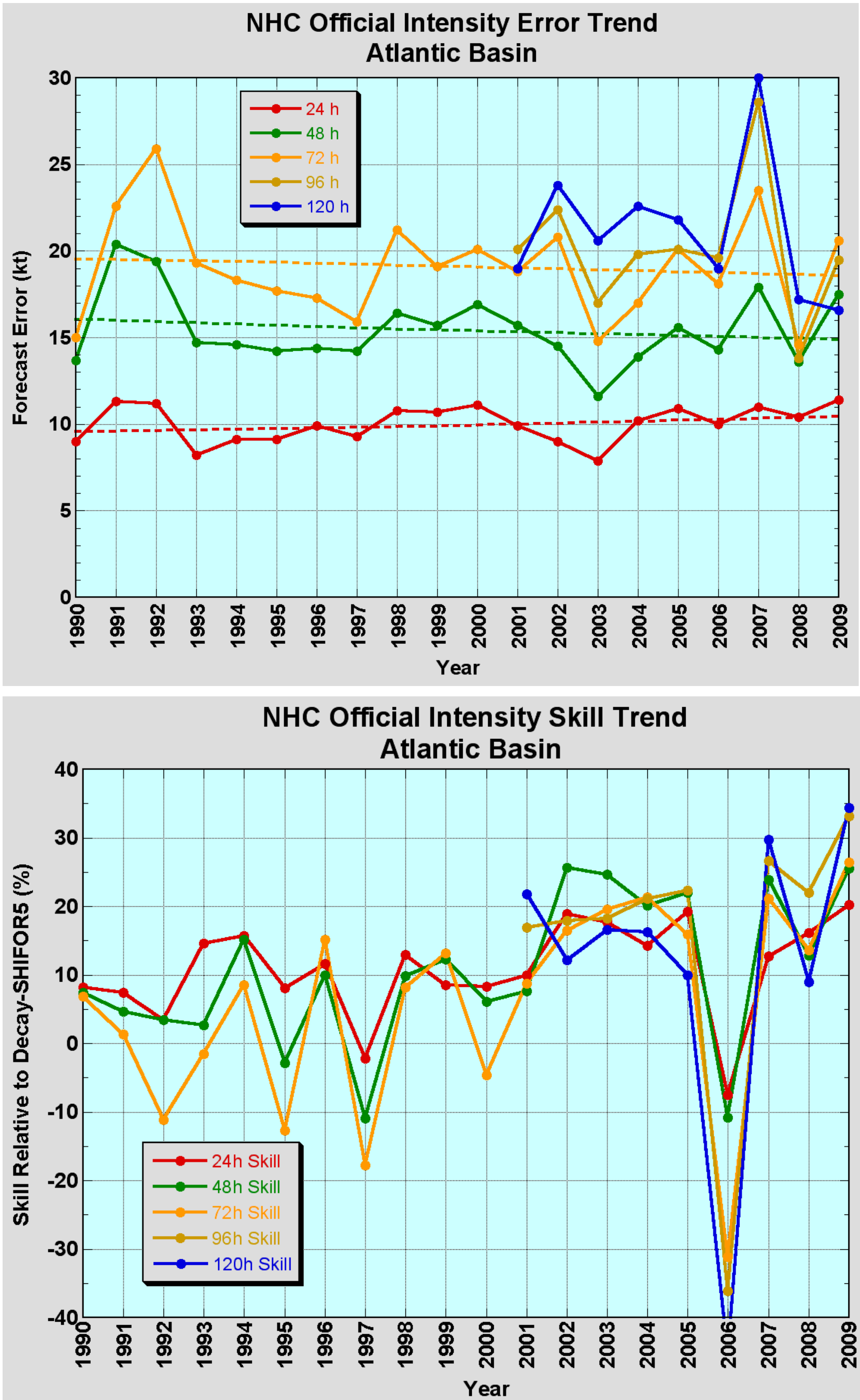


Figure 6. Recent trends in NHC official intensity forecast error (top) and skill (bottom) for the Atlantic basin.

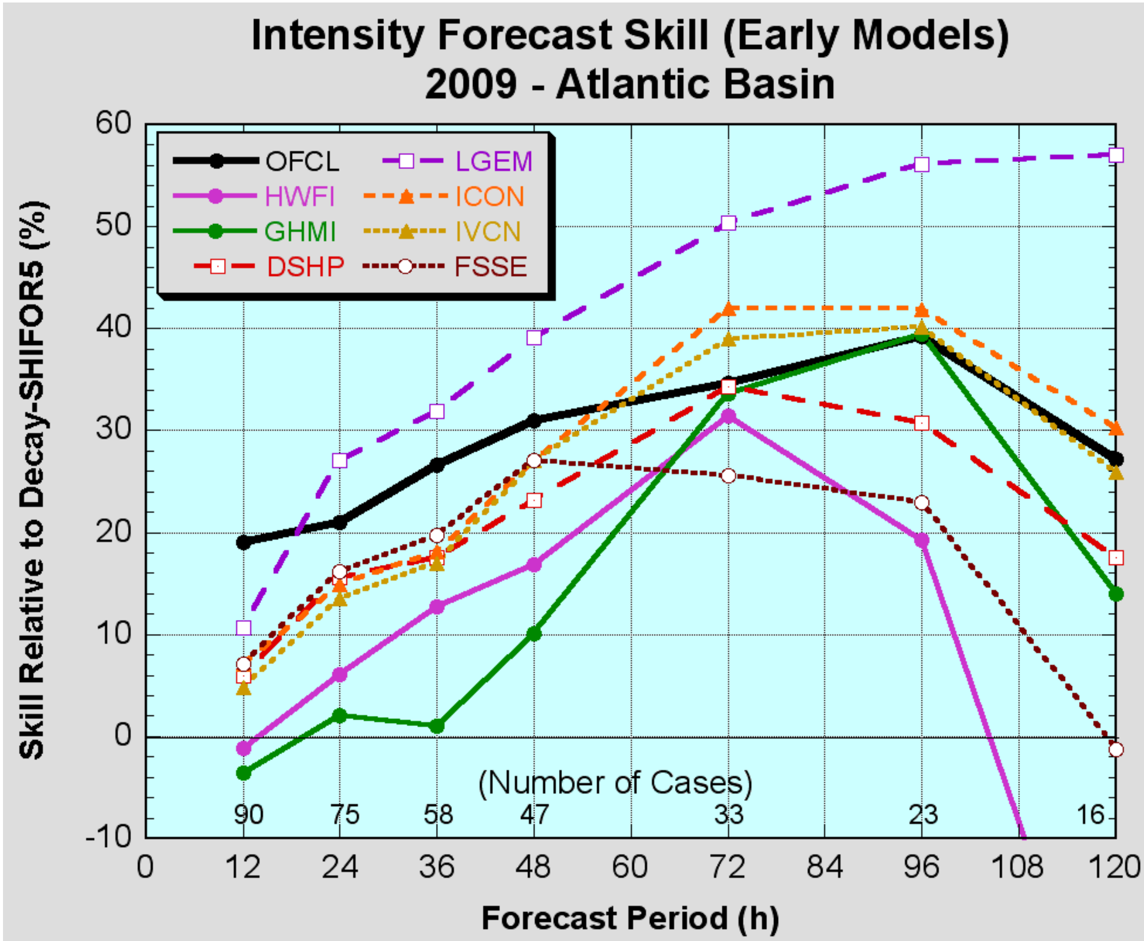


Figure. 7. Homogenous comparison for selected Atlantic basin early intensity guidance models for 2009.

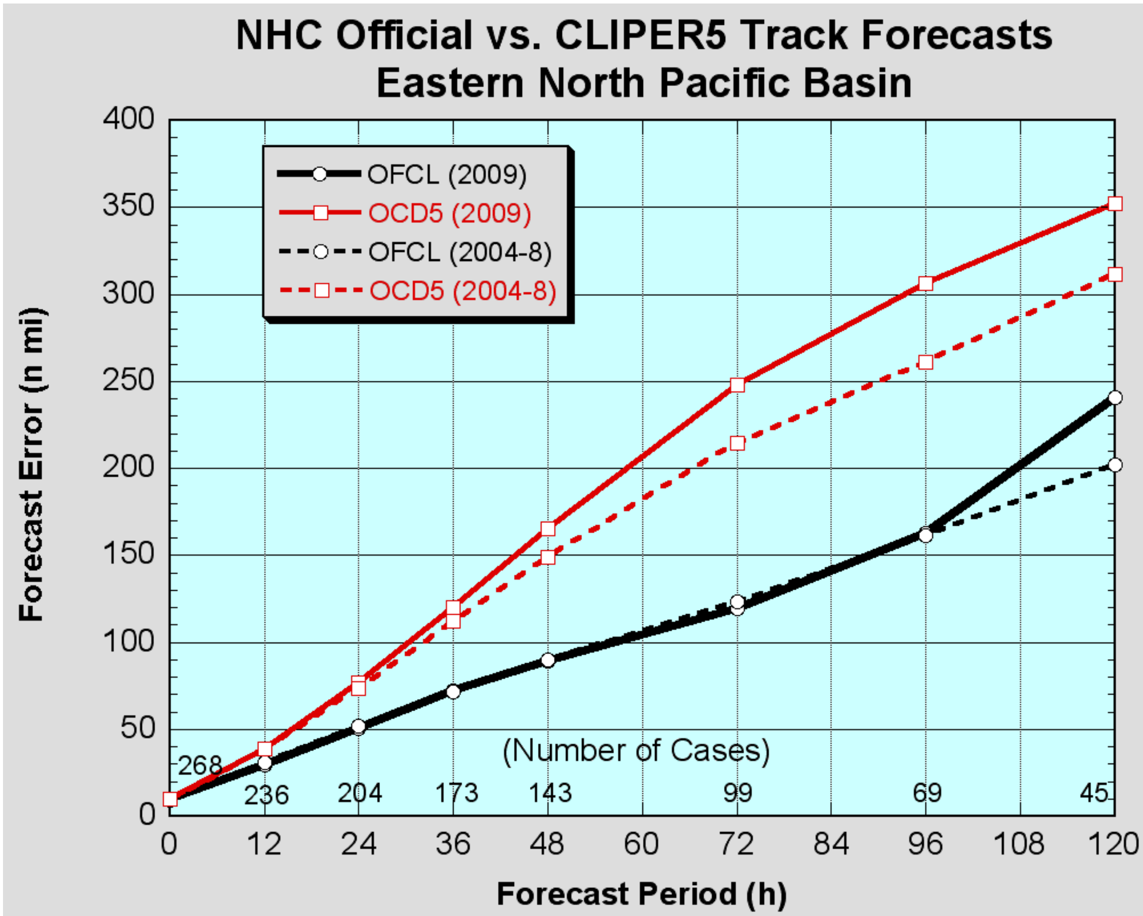


Figure 8. NHC official and CLIPER5 (OCD5) eastern North Pacific basin average track errors for 2009 (solid lines) and 2004-2008 (dashed lines).

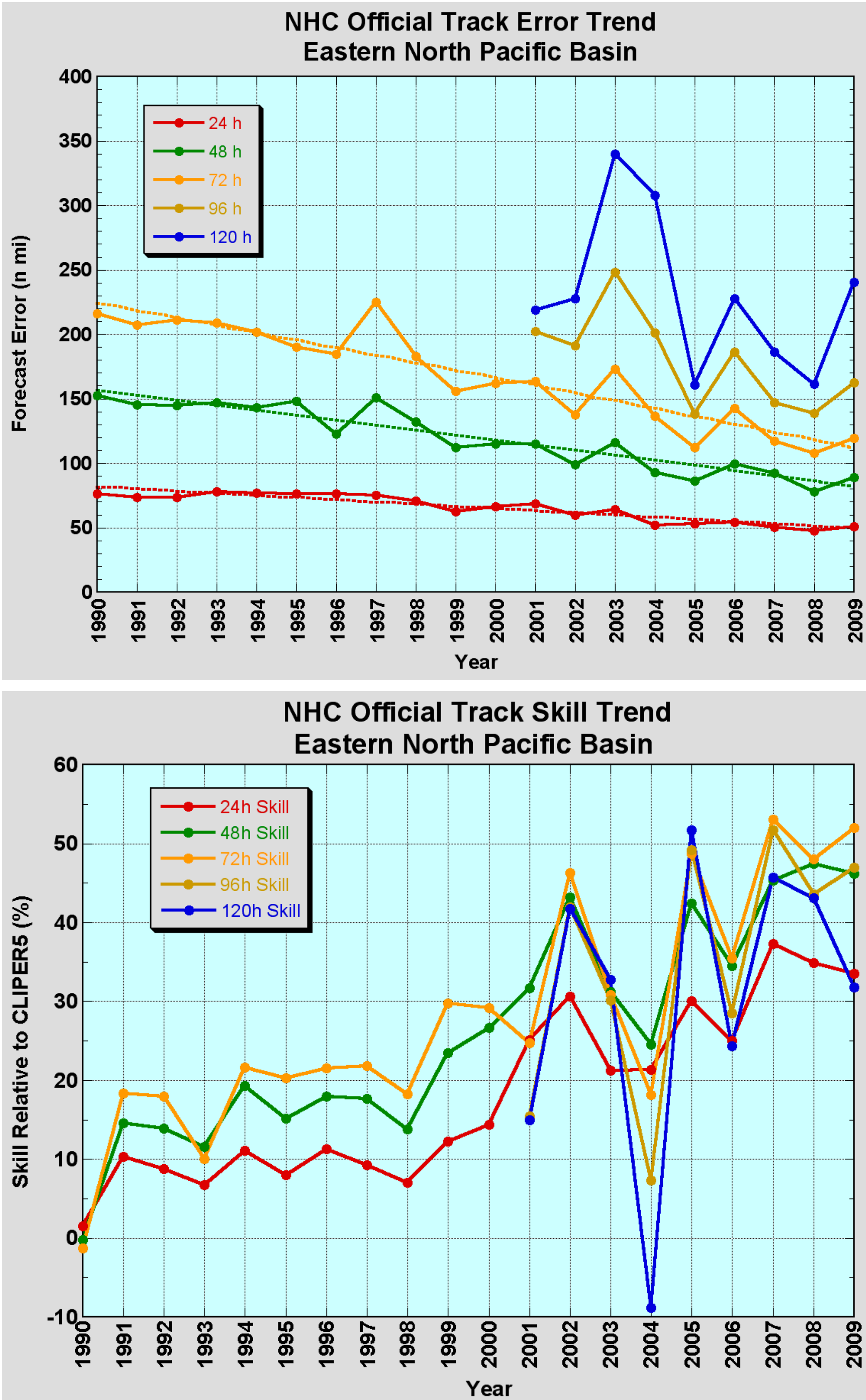


Figure 9. Recent trends in NHC official track forecast error (top) and skill (bottom) for the eastern North Pacific basin.

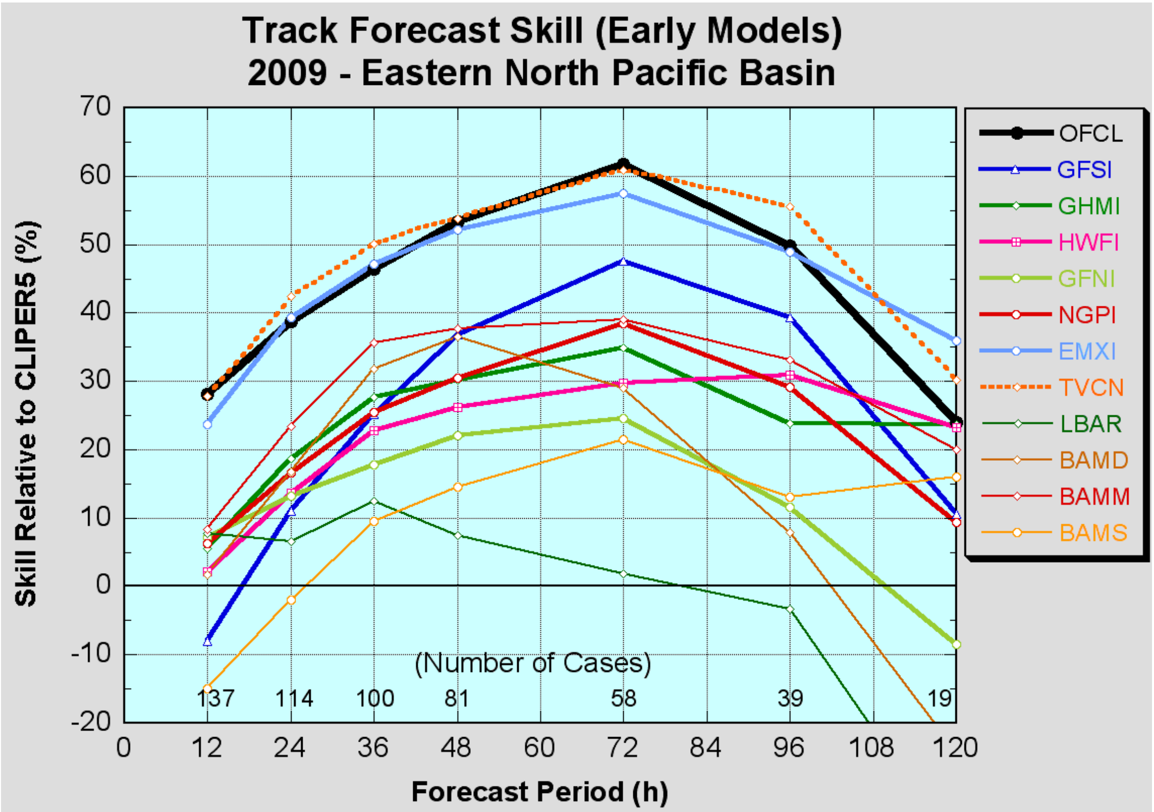


Figure. 10. Homogenous comparison for selected eastern North Pacific early track models for 2009. This verification includes only those models that were available at least 2/3 of the time (see text).

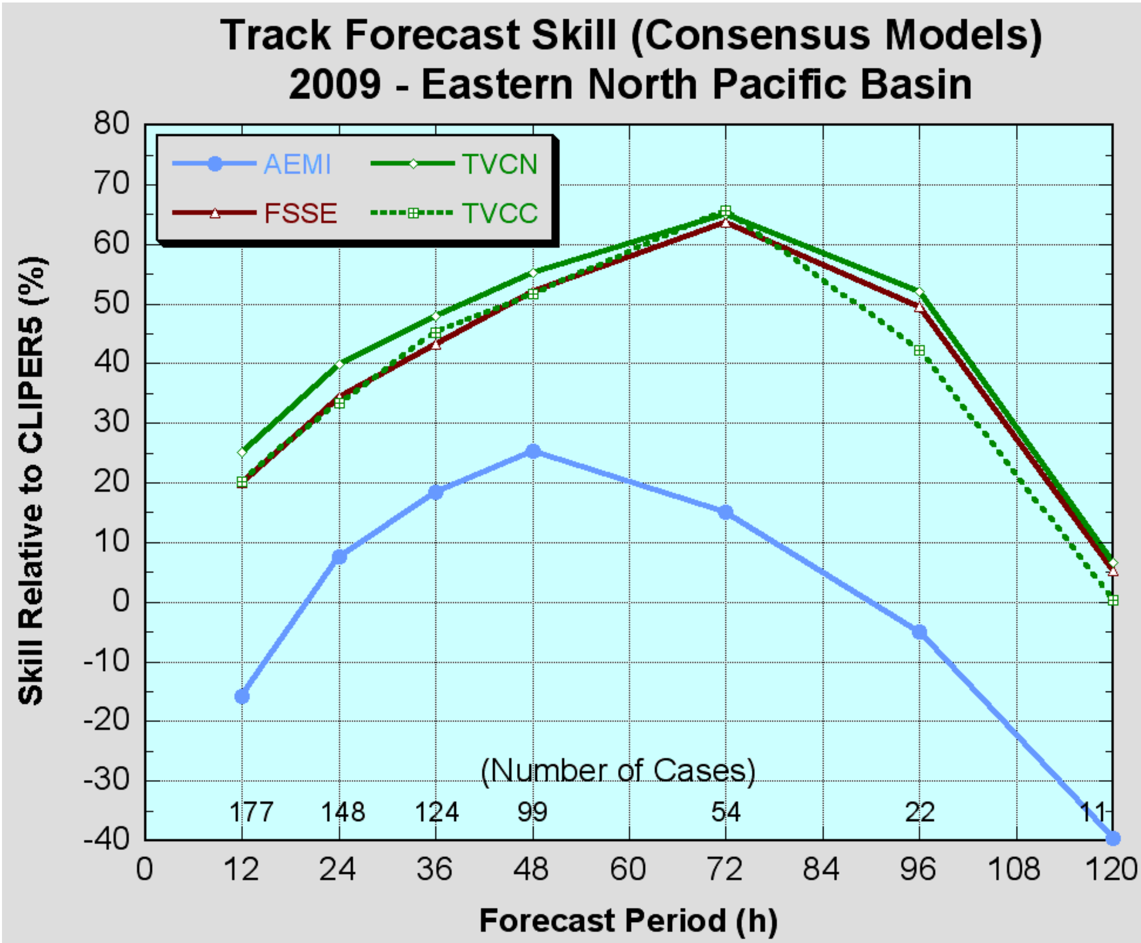


Figure 11. Homogenous comparison of the primary eastern North Pacific basin track consensus models for 2009.

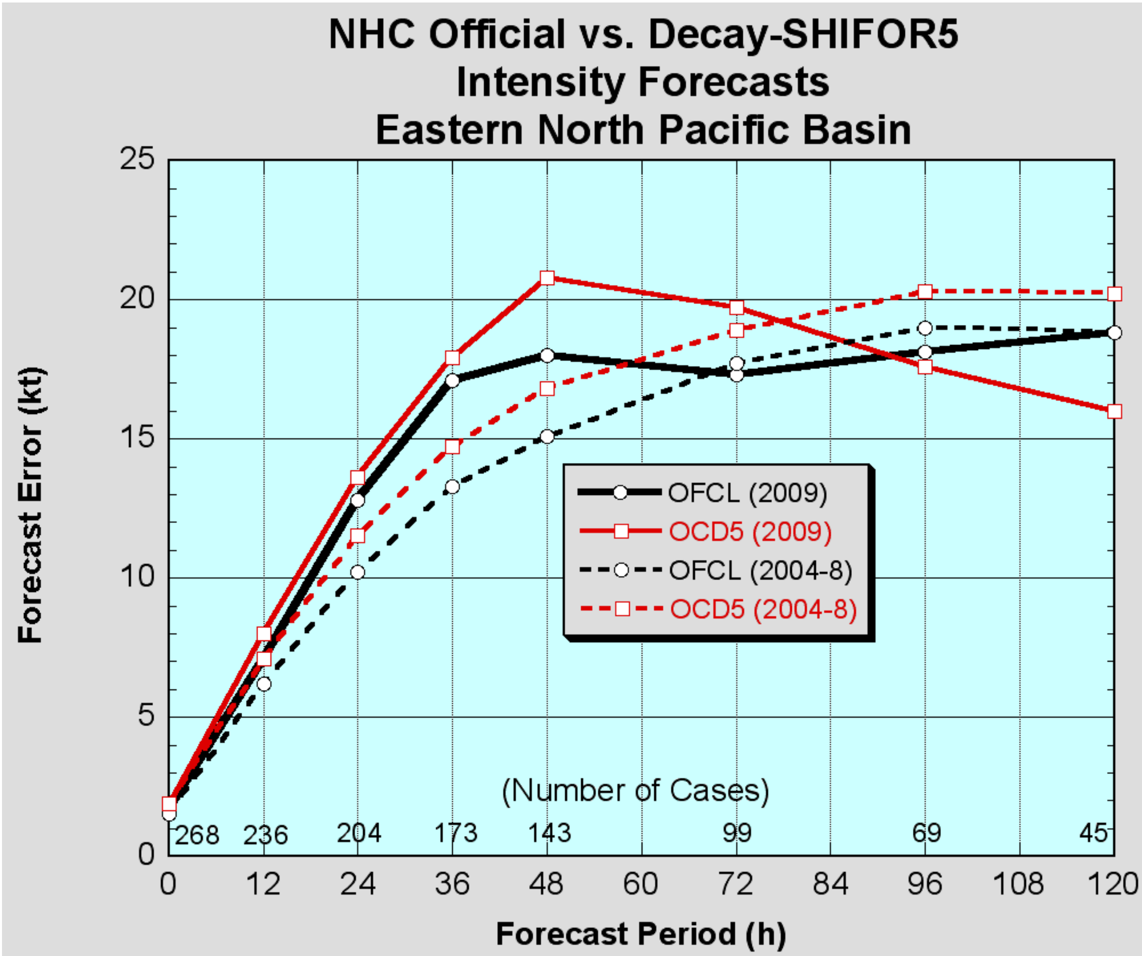
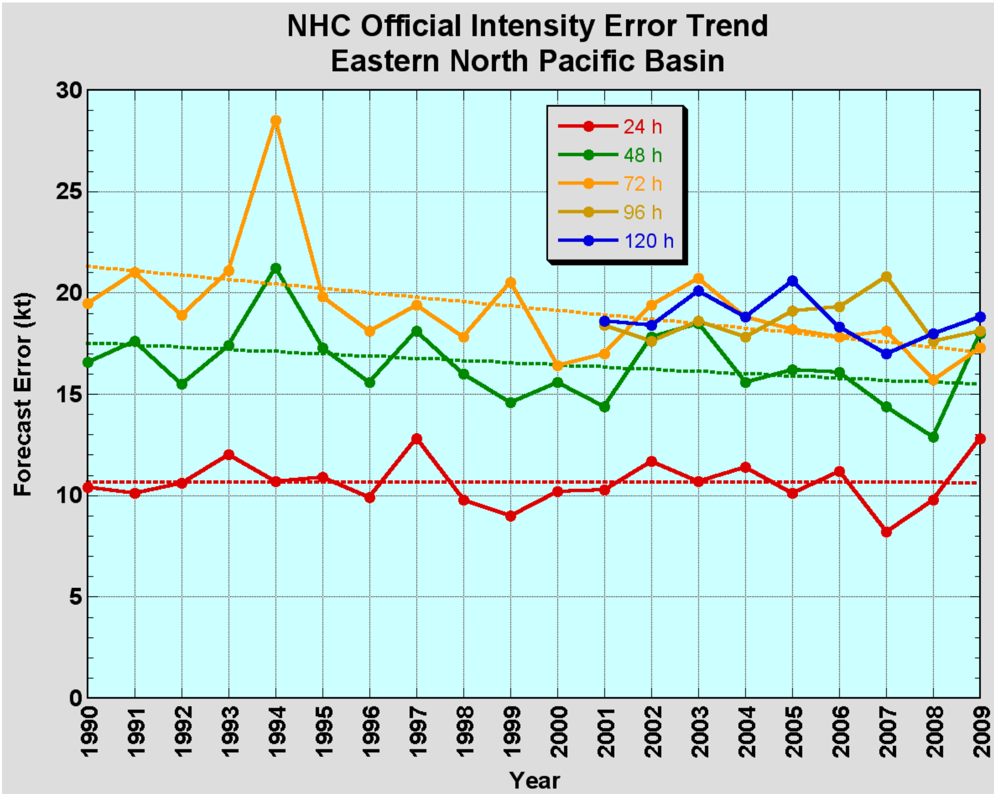


Figure 12. NHC official and Decay-SHIFOR5 (OCD5) eastern North Pacific basin average intensity errors for 2009 (solid lines) and 2004-2008 (dashed lines).



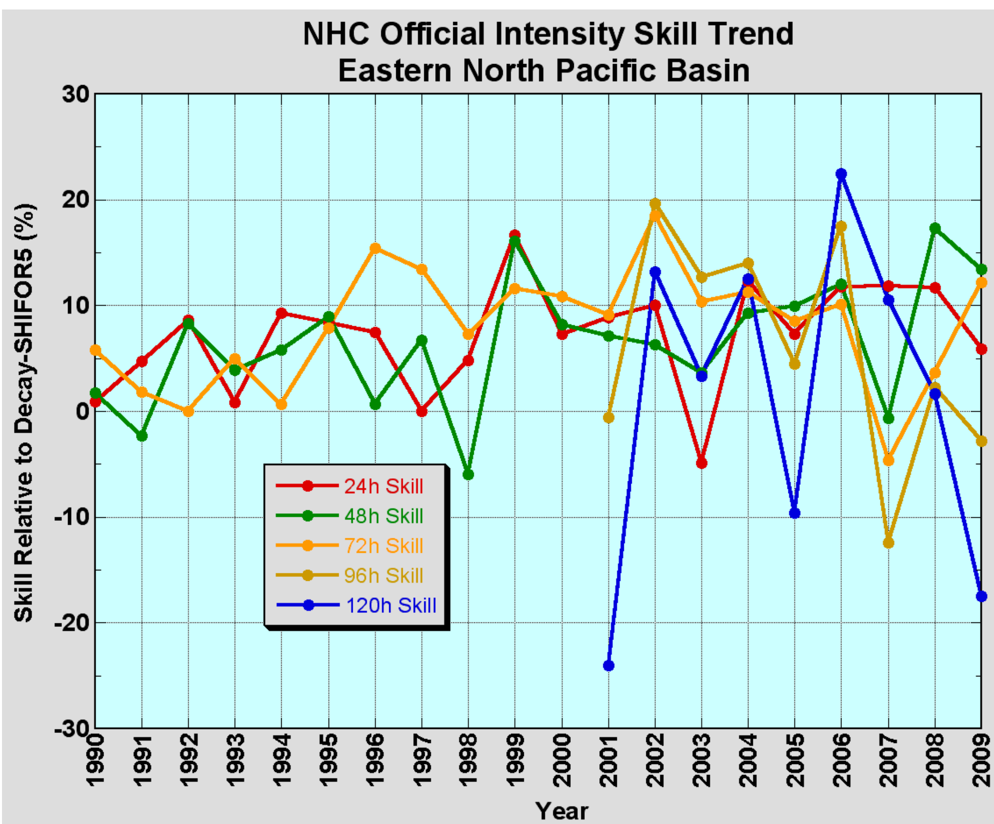


Figure 13. Recent trends in NHC official intensity forecast error (top) and skill (bottom) for the eastern North Pacific basin.

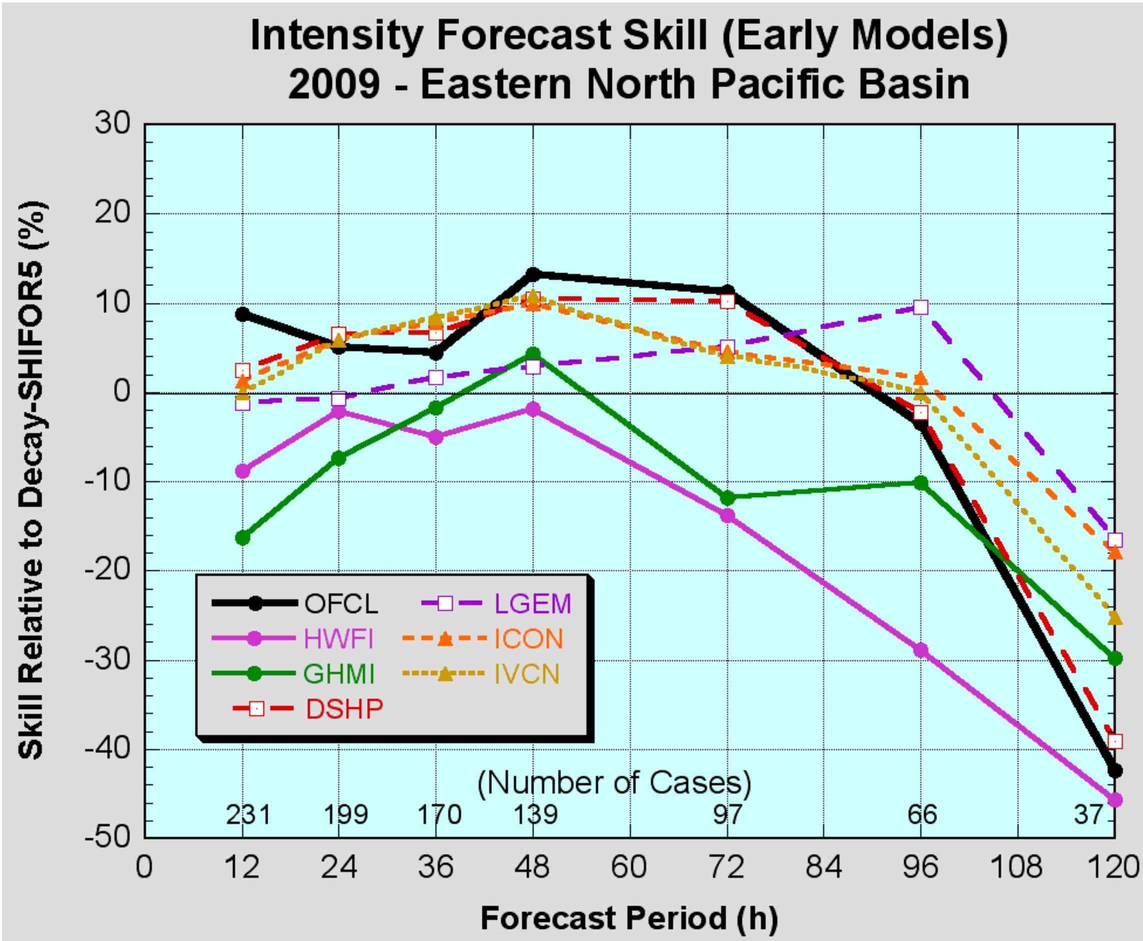


Figure 14. Homogenous comparison for selected eastern North Pacific basin early intensity guidance models for 2009.

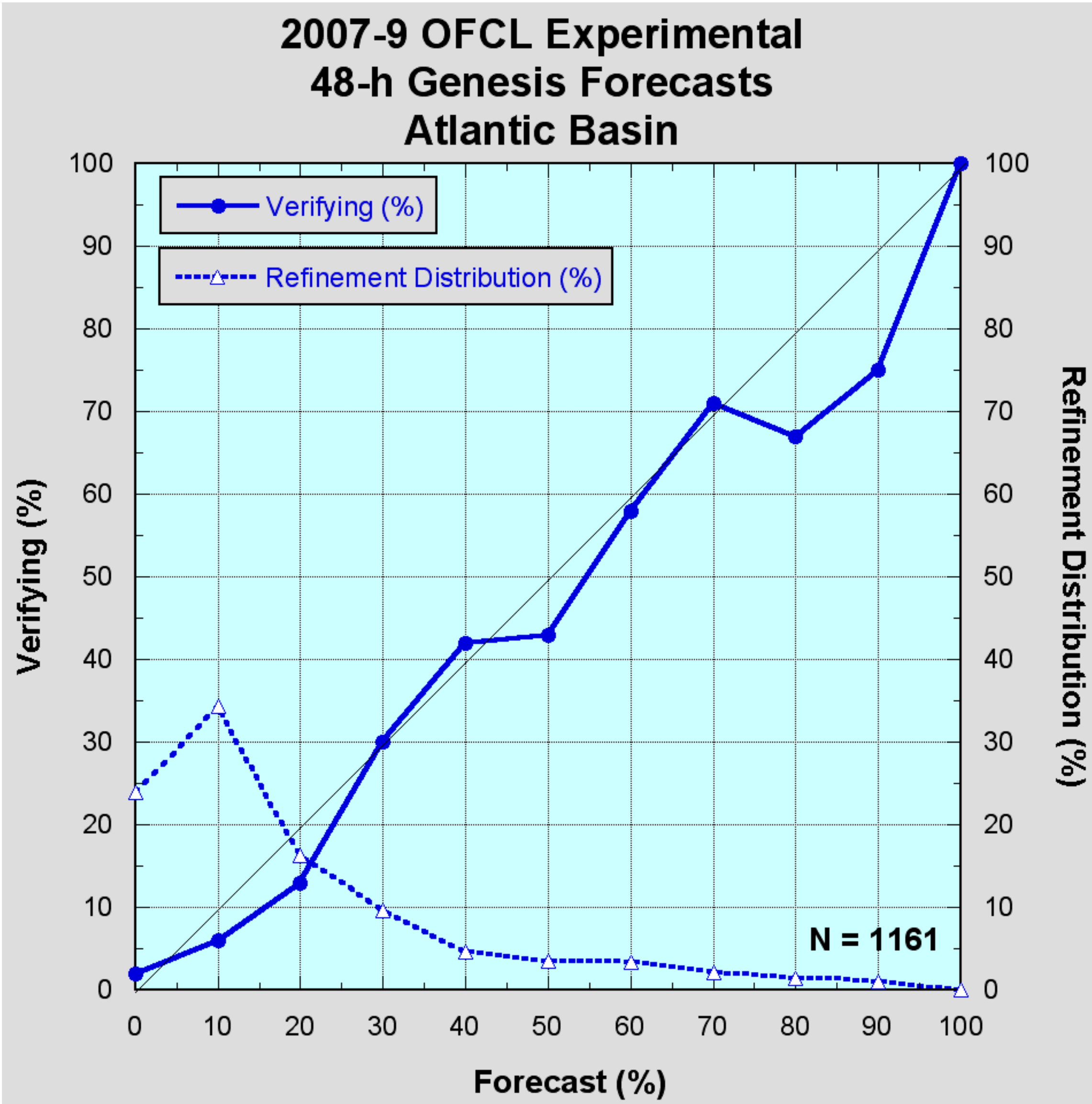


Figure 15a. Reliability diagram for experimental Atlantic probabilistic tropical cyclogenesis forecasts for the period 2007-9. The solid blue line indicates the relationship between the forecast and verifying genesis percentages, with perfect reliability indicated by the thin diagonal black line. The dashed blue line indicates how the forecasts were distributed among the possible forecast values.

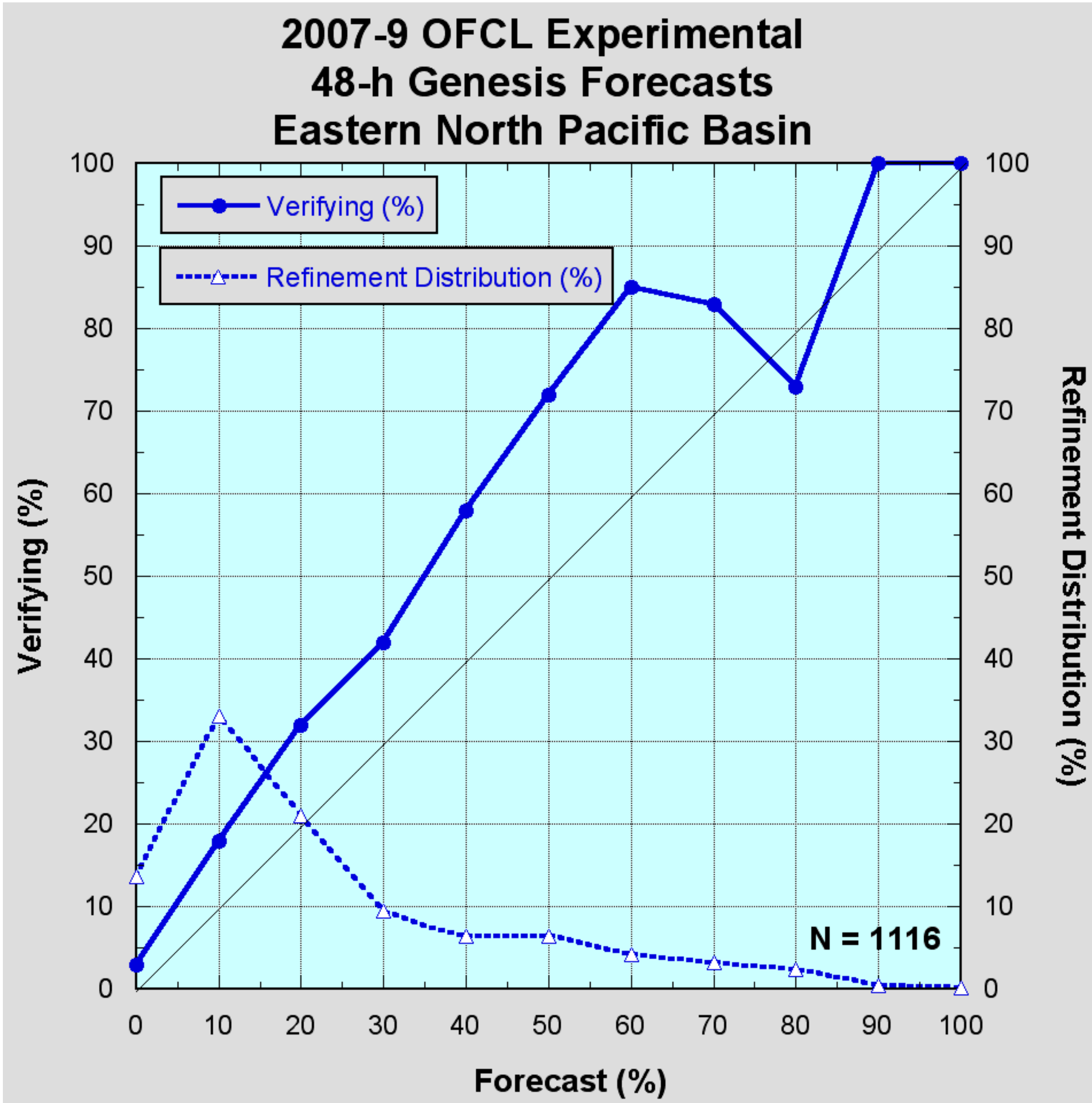


Figure 15b. As described for Fig. 15a, except for the eastern North Pacific basin.