9.3 EMPLOYING TROPICAL CYCLONE WIND PROBABILITIES TO ENHANCE LOCAL FORECASTS AND IMPROVE GUIDANCE FOR DECISION-MAKERS

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1. INTRODUCTION

During the 2005 hurricane season, the Tropical Prediction Center (TPC) produced experimental tropical cyclone wind speed probabilities for 34-, 50-, and 64-knot winds through 120 hours during operational forecast cycles for active systems in the Atlantic Basin. The probabilities were based on the official TPC track, intensity, and wind radii forecast, and incorporates average error statistics for those forecast variables from recent years (Gross et al., 2004). Development work was part of the Joint Hurricane Testbed (JHT) under the United States Weather Research Program (USWRP) to advance new research and technology into operational hurricane prediction. Considerable development was accomplished during the very active 2004 hurricane season which culminated with the experimental availability of these data for the record 2005 season in tabular, graphic, and gridded formats. The probabilities were produced in interval-form (Fig. 1) and cumulative-form (Fig. 2) for each successive 12-hour forecast increment. The motive for providing probabilistic wind speed information is to deliver coherent expressions of forecast uncertainty to complement official deterministic wind speed forecasts during tropical cyclone events. In short, it represents an initial attempt to equip sophisticated users with the necessary information for critical decision-making during (potential) hurricane events. For users, focus is clearly shifted away from the forecast center track and toward the depiction of numeric probability fields for exceeding certain prescribed intensity thresholds (34-, 50-, and 64-knot). For more information about the tropical cyclone wind speed probabilities please refer to the JHT Final Report by Knaff and DeMaria (2005).

Functioning in the role of sophisticated first-users, and also as advocates for less sophisticated users, the Weather Forecast Offices (WFOs) at Miami (MFL) and Melbourne (MLB) collaboratively developed and tested several unique applications to enhance local forecast products and improve guidance information for local decision-makers. So far, preliminary results have been promising and are being shared with the community for evaluation. As such, this paper will focus on aspects which enable MFL and MLB forecasters to offer expressions of uncertainty for tropical cyclone winds as conveyed within alpha-numeric and graphic forecast products. As the primary initiative, gridded interval-based probabilities were used to trigger enhanced wording via automated text formatters which can then responsibly convey forecast uncertainty within particular text products, namely the Zone Forecast Product and the Coastal Waters Forecast. The authors wish to note that enhanced wording has only been inserted within offline versions of these official products. Importantly, automated text formatters were able to express when hurricane (or tropical storm) conditions were *EXPECTED*, *LIKELY*, or *POSSIBLE* according to the temporal period of the forecast. With successful completion and subsequent agency support, it will help alleviate sensitivities surrounding the current deterministic-only approach for depicting forecast weather elements during high impact weather events. More so, it would foster greater forecast consistency with TPC and adjacent WFOs during tropical cyclones, while reducing the workload for manual text editing. Additions and improvements to tabular products such as forecast matrices can be similarly achieved.

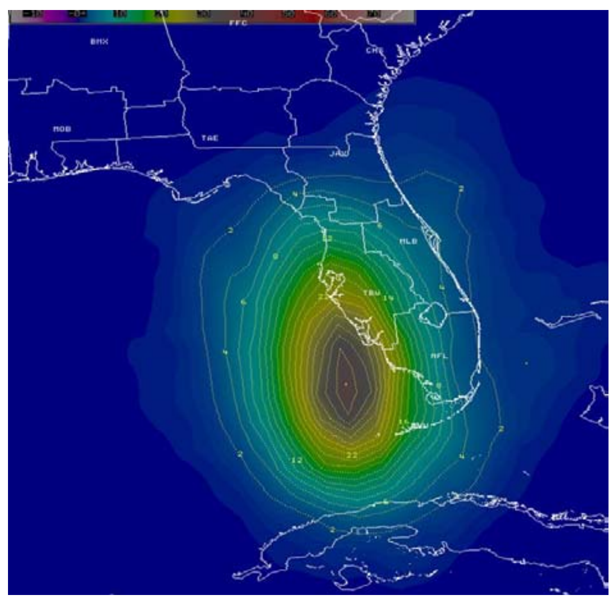

Figure 1. An example of the interval-form 64-knot tropical cyclone wind probabilities (graphic output; 36-hour interval shown here) for Hurricane Charley issued 1200 UTC, 12 August 2004.

In a parallel initiative, certain experimental web graphics which are currently available to Florida decision-makers (e.g., The Florida Emergency Management) were identified as candidates for possible

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improvement by utilizing the tropical cyclone wind probabilities. Here, the cumulative-based probabilities are considered for deriving first-guess depictions of the local wind threat. In tropical cyclone watch and/or warning situations, both MFL and MLB issue experimental wind threat graphics to benefit various web users who are seeking preparedness recommendations to support resource management decisions (Sharp et al., 2000). In practice, the first-guess depictions were manually created by compositing the 34-, 50-, and 64-knot probability fields using predetermined probability thresholds within each set. Utilizing the cumulative-based probabilities promoted increased efficiency during product preparation and allowed forecasters to spend more time adding value to the final product. Efforts are being undertaken to automate the process for creating the first-guess fields to realize even greater efficiency.

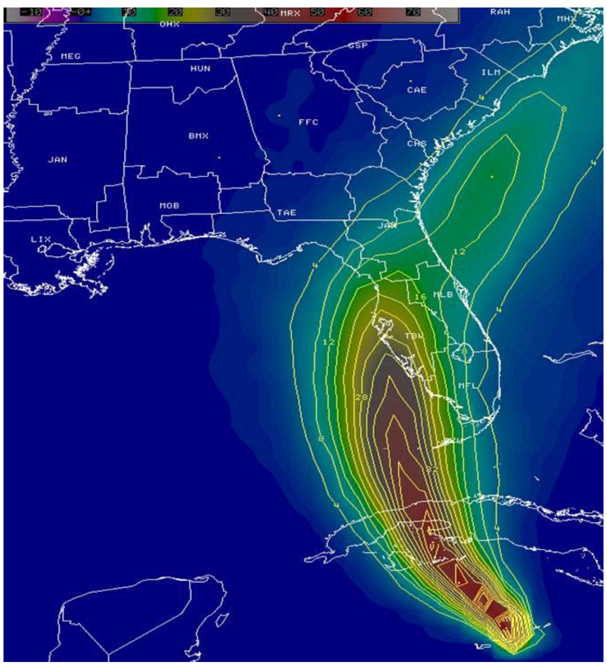

Figure 2. An example of the cumulative-form 64-knot tropical cyclone wind probabilities (graphic output; 0-120 hours) for Hurricane Charley issued 1200 UTC, 12 August 2004.

2. BACKGROUND

As a significant finding indicated within the Hurricane Charley Service Assessment (NOAA, 2006), post-event interviews revealed that many people tended to focus on the specific forecast track which showed the center of major Hurricane Charley making landfall near Tampa, FL, and not Punta Gorda, FL. Even though both cities were located within the Hurricane Warning area, residents in the vicinity of Punta Gorda stated that they had heard that Charley was going to hit Tampa and did not fully appreciate the associated uncertainty of the forecast. This readily indicates a breakdown in communications when conveying the situational wind threat. Recent efforts to profile the average error cone have helped somewhat, especially within graphic depictions. However, confused or mixed messages are inevitable since the error cone does not take into account important parameters such as cyclone size, inherent uncertainties in the intensity forecast, or ill-behavior according to the projected track beyond that which is average. So, providing wind speed probabilities (for exceeding critical thresholds) seems the next logical step in the quest for a satisfactory solution. For sophisticated resource managers, direct users of the wind speed probabilities will be able to make responsible decisions by considering a reasonable tolerance according to their specific risk and vulnerability. This requires a genuine appreciation for the significance of probability values relative to rare but high impact events, even with each increasing temporal period of the forecast. However, for the benefit of the general public, the authors feel that it is useful for WFOs (especially until a comprehensive public education effort is performed) to operate as sophisticated first-users in order to harness the probabilities for improvements to current products:

a.) By inserting expressions of uncertainty within certain (official) text products,

b.) And by providing easy-to-understand (experimental) graphics which convey a component of uncertainty.

Each is intended to complement the corresponding deterministic wind speed forecast (either textual or graphical). Fortunately, recent technological advances in forecast preparation procedures have created the ability for meteorologists to interface directly with gridded data fields. This is accomplished through the use of the Graphical Forecast Editor (GFE) software. The GFE offers WFO forecasters the efficient and effective means to interact with guidance data, to make essential value-added adjustments, to create derived fields through software tools (e.g., smart tools), and to automatically produce a plethora of products from its database. These can be created in text, tabular, graphical, and gridded forms according to local input/output configurations within each respective product formatter. Therefore, the GFE provides the context for which the tropical cyclone wind probabilities will be used to enhance particular products.

3. ENHANCED TEXT PRODUCTS

Among the most used text forecast products are the Zone Forecast Product (ZFP) and the Coastal Waters Forecast (CWF). Traditionally, these have been flagship products for WFOs within the National Weather Service (NWS), serving as primary supply vehicles for delivering valuable forecast information to a variety of users. For WFOs MFL and MLB, the CWF has scheduled issuance times by 4:30 AM, 10:30 AM, 4:30 PM, and 10:30 PM (local time) each day. The ZFP is scheduled for issuance by 4:00 AM and 4:00 PM (local time) each day. Amendments are issued as necessary any time throughout the day, which can be frequent during tropical cyclone situations. Importantly, wind speed information is of numeric form and rounded to the nearest 5 knots (CWF) or 5 mph (ZFP). The expression of wind speed continues to be deterministic in nature and is represented by either a single value or narrow range of values (e.g., 15 knots or 15-20 knots). Wind information is typically provided through 120 hours within the CWF and through 60 hours within the ZFP. A current shortcoming is that contingents do not exist for expressing uncertainty whenever high magnitude wind events threaten the forecast area.

To explore mitigating techniques, the 34-knot (tropical storm) and 64-knot (hurricane) incremental wind probabilities were obtained for tropical cyclones during the 2004-05 seasons which threatened Central and South Florida. Gridded versions were loaded into the GFE to be teamed with other wind-related data sets so that automated text formatters could then derive and express when hurricane or tropical storm conditions were *EXPECTED*, *LIKELY*, or *POSSIBLE* according to the temporal period of the forecast. This required the formulation of detailed and prioritized logic for proper coding of the text formatter. The purpose was to establish a set of rules for triggering enhanced wording by utilizing available hazards grids, wind grids, wind gust grids, 64 knot probability grids, and 34 knot probability grids. The hazard grids include hurricane (tropical storm) warning/watch grids as issued for coastal counties by the TPC, for inland counties by the WFO, and for marine zones by the WFO. The wind grids represent the official TPC wind forecast with WFO value-added mesoscale adjustments for local effects (e.g., friction over land, exposure over lakes, terrain altitude (including windward, leeward, and valley effects), gap winds, etc.). Wind gust grids were also utilized, with these being uniquely created by the WFO forecaster. Finally, the incremental 34-knot and 64-knot probabilities were used; the 50-knot probabilities were not needed. A hierarchy of priorities (Table 1) was established to account for official warning/watch sensitivity, official forecast sensitivity, and forecast error sensitivity. This hierarchy serves as the overarching governor, thereby ensuring a consistent and non-conflicting message within related NOAA/NWS products.

Hierarchy of Priorities for Sensitivity

Priority	Sensitivity	Grid Sets
1	Official Warnings, Official Watches	Hazard Grids
2	Official Forecasts	Wind Grids, Wind Gust Grids
3	Forecast Error	64-knot Probability Grids, 34-knot Probability Grids

Table 1. The hierarchy of priorities for sensitivity as used by the experimental ZFP and CWF formatters (within GFE). Its intent is to ensure a consistent and non-conflicting message within related NOAA/NWS products.

In determining the specific phraseology to be used as expressions of uncertainty, two particular notions regarding forecast accuracy were considered. The first notion was that deterministic wind speed information has decreasing value with increasing time, and the second was that probabilistic wind speed information has increasing value with increasing time. Thus, phrases were devised to accommodate three separate temporal categories with a separate set of phrases needed for the 00- to 24-hour period (e.g., situations involving the approximate warning period), for the 25- to 48-hour period (e.g., situations involving the approximate watch period), and for the 49- to 120-hour period (e.g., situations involving the approximate balance of the 5-day forecast for which wind information is depicted within the ZFP and CWF). For our purposes, the phrase *'HURRICANE CONDITIONS'* was defined as sustained winds greater than or equal to 64 knots, or sustained winds greater than or equal to 50 knots but gusting to 64 knots or greater. Similarly, the phrase *'TROPICAL STORM CONDITIONS'* was defined as sustained winds greater than or equal to 34 knots, or sustained winds greater than or equal to 25 knots but gusting to 34 knots or greater. Of course, the indicated wind speeds must be directly associated with a tropical cyclone and not with some other weather feature. Qualifications were then placed upon certain words such that *'EXPECTED'* would be reserved for the 00- to 24-hour period only (as warranted), and likewise the word *'LIKELY'* would be used only during the 25- to 48-hour period (as warranted). The word *'POSSIBLE'* would be used during the 49- to 120-hour period as warranted, but may be judiciously invoked during the 00- to 24-hour and 25- to 48-hour periods as well. In times when a tropical storm warning and hurricane watch co-exists for the same area, a compound phrase is invoked. A compound phrase may also be invoked when the hazard grids are not yet in sync with the wind and wind gust grids, or when the probabilities are increasing but do not yet outweigh the other grid sets. Table 2 offers a simplified overview of baseline phraseology invoked by the experimental ZFP and CWF formatters. Methodically, situations were addressed and tested within the code according to temporal category rules.

Baseline Phraseology for Text Formatters

HURRICANE CONDITIONS…	***…EXPECTED.***
	…LIKELY.
	…POSSIBLE.
TROPICAL STORM CONDITIONS…	***…EXPECTED.***
	…LIKELY.
	…POSSIBLE.

Table 2. The baseline phraseology invoked by the experimental ZFP and CWF text formatters (within GFE). The word *'EXPECTED'* may be used during the 00- to 24-hour period only; *'LIKELY'* may be used during the 25- to 48-hour period only; *'POSSIBLE'* may be used during the 49- to 120-hour period but may also be used during earlier periods. Certain situations may require that compound phrases be invoked.

Central to this initiative was determining the correct probability thresholds to trigger *POSSIBLE* hurricane or tropical storm conditions. Empirically-determined, a series of preliminary values were used so that logic and code development could mature. During early testing these threshold values (Table 3) have worked well. However, in order to obtain confidence in these values, or to identify any needed adjustments, a comprehensive distribution analysis is being performed.

Probability Thresholds Table – Preliminary

Period	Time	H-Prob	TS-Prob
Warning	00-24 hours	$\geq$ 30%	$\geq$ 50%
Watch	25-48 hours	20%	40%
Extended	49-72 hours	15%	35%
	73-96 hours	8%	25%
	97-120 hours	4%	15%

Table 3. The empirically-determined probability thresholds used during preliminary testing of the experimental ZFP and CWF text formatters (within GFE). Values were determined for successive temporal periods which trigger wording that indicates potential hurricane conditions (H-Prob) and/or tropical storm conditions (TS-Prob). Refinements to the preliminary values are likely.

During development, many cases were tested. As examples, Figures 3 and Figures 4a-c show test output from Hurricane Wilma (2005) from the perspective of South Florida for the ZFP. Of significant note was the ability of the experimental formatter to trigger on the 34-knot and 64-knot probability thresholds in the later periods to indicate the potential for tropical storm and hurricane conditions. In difficult extended forecast situations such as Wilma (which was slow-moving, but accelerating to fast-moving), the probabilities can offer responsible indications of a developing tropical cyclone wind threat, especially for strategic planning. Powerfully, it is noteworthy, too, that the formatter was able to successfully add increasing weight and importance to the wind and wind gust grids, and eventually the hazard grids, as Wilma approached (e.g. moved forward through the defined temporal categories). All the while, the probabilities operated as a safety net to minimize potential inconsistencies and negate the overemphasis of exact wind speeds forecast for exact time periods. Again, it is necessary to test the experimental formatters on many different cases from various WFO perspectives. Initial test cases from the 2004 season include Charley and Frances, and from the 2005 season Dennis, Katrina, Rita, and Wilma are used. Perspectives thus far have been limited to South Florida (the WFO MFL perspective) and East Central Florida (the WFO MLB perspective). These will be expanded to other geographic areas and include other cyclones as the applied research continues. Refinements to the thresholds table will likely occur as a result. However, required coding changes will be minor and only entail numeric value changes to respective threshold trigger variables.

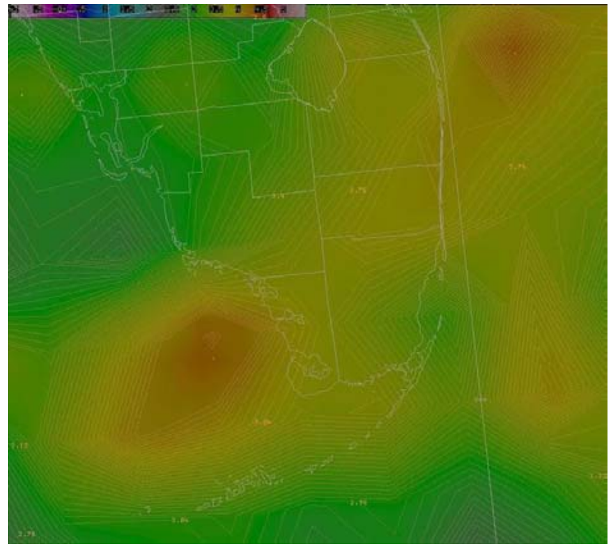

Figure 3. An interval-form 64-knot tropical cyclone wind probability depiction associated with Hurricane Wilma (2005) used to trigger the phrase *'HURRICANE CONDITIONS POSSIBLE'* in a later period of the ZFP and CWF. Valid time is at 96 hours on 24 October 2005, 0000 UTC (from a start time on 20 October 2005, 0000 UTC). Values shown range from 0 to 5%.

WESTERN COLLIER-EASTERN COLLIER-MAINLAND MONROE-
INCLUDING THE CITIES OF…NAPLES…IMMOKALEE…FLAMINGO
1130 PM EDT WED OCT 19 2005

.TONIGHT…
.THURSDAY…
.THURSDAY NIGHT…
.FRIDAY…
.FRIDAY NIGHT…BREEZY.
.SATURDAY…WINDY. SOUTHEAST WINDS 20 TO 25 MPH.
.SATURDAY NIGHT…TROPICAL STORM CONDITIONS POSSIBLE.
.SUNDAY…HURRICANE CONDITIONS POSSIBLE.
.SUNDAY NIGHT…TROPICAL STORM CONDITIONS POSSIBLE.
.MONDAY…BREEZY.

Figure 4a. From the Hurricane Wilma (2005) test case, the experimental formatter output for the ZFP indicated *POSSIBLE* tropical cyclone conditions in the extended periods of the forecast. Only the wind elements are shown.

WESTERN COLLIER-EASTERN COLLIER-WESTERN DADE-MAINLAND MONROE-
INCLUDING THE CITIES OF…NAPLES…IMMOKALEE…SHARK VALLEY…FLAMINGO
600 PM EDT SAT OCT 22 2005

…HURRICANE WATCH IN EFFECT…

.SUNDAY…WINDY. SOUTHEAST WINDS 10 TO 15 MPH BECOMING SOUTH 20 TO 25 MPH IN THE AFTERNOON. SOUTHEAST WINDS 20 TO 25 MPH NEAR THE COAST.
.SUNDAY NIGHT…TROPICAL STORM CONDITIONS LIKELY WITH HURRICANE CONDITIONS POSSIBLE. SOUTHEAST WINDS 35 TO 40 MPH BECOMING 65 TO 70 MPH WITH GUSTS TO AROUND 80 MPH AFTER MIDNIGHT.
.MONDAY…HURRICANE CONDITIONS LIKELY. SOUTHWEST TO WEST WINDS 65 TO 70 MPH WITH GUSTS TO AROUND 100 MPH DECREASING TO AROUND 30 MPH IN THE AFTERNOON.
.MONDAY NIGHT…WINDY. NORTHWEST WINDS 25 TO 30 MPH DECREASING TO 20 TO 25 MPH AFTER MIDNIGHT.

Figure 4b. Same as 4a, except for indicated *LIKELY* tropical cyclone conditions during the watch periods of the forecast.

WESTERN DADE-MAINLAND MONROE-
INCLUDING THE CITIES OF…SHARK VALLEY…FLAMINGO
600 PM EDT SUN OCT 23 2005

…HURRICANE WARNING IN EFFECT...

.TONIGHT…HURRICANE CONDITIONS EXPECTED. SOUTHEAST WINDS 25 MPH WITH GUSTS TO AROUND 35 MPH THEN BECOMING 65 TO 70 MPH WITH GUSTS TO AROUND 80 MPH AFTER MIDNIGHT. NEAR THE COAST…SOUTHEAST WINDS 45 TO 50 MPH WITH GUSTS TO AROUND 65 MPH THEN BECOMING SOUTH AND INCREASING TO 75 TO 80 MPH WITH GUSTS TO AROUND 110 MPH AFTER MIDNIGHT.
.MONDAY…HURRICANE CONDITIONS EXPECTED. WEST WINDS 75 TO 80 MPH WITH GUSTS TO AROUND 110 MPH IN THE MORNING BECOMING NORTHWEST AND DECREASING TO AROUND 30 MPH IN THE AFTERNOON.
.MONDAY NIGHT…WINDY. WEST WINDS 25 TO 30 MPH BECOMING NORTHWEST 20 TO 25 MPH AFTER MIDNIGHT.

Figure 4c. Same as 4a, except for indicated *EXPECTED* tropical cyclone conditions during the warning periods of the forecast.

As previously mentioned, future considerations for employing this method operationally will require a thorough objective examination in order to determine the best thresholds for triggering the *POSSIBLE* phraseology within public and marine text forecasts. That is, full appreciation must be given to the diversity of tropical cyclone situations. The initial values as presented in Table 3 were empirically established for use during the development phase and were used to trigger the wording contained in the examples provided in Figures 4a-c. However, a rigorous distribution (histogram) analysis is currently being conducted. The distribution analysis is first being done using four storms from the 2005 season, namely, Hurricanes Dennis, Katrina, Rita, and Wilma as they impacted South Florida. The analysis is being conducted for each cyclone for both the 34-knot and 64-knot probabilities (separately) for specific individual regions/zones across South Florida. This approach is more revealing given that the probability sets already account for inland decay; separate information is yielded independently for marine, coastal, and inland areas. Ultimately, individual analyses (as carried out by zone, intensity threshold, and cyclone) will be merged to create combined analyses. These will eventually be expanded to include more events across different coastal regions to gain confidence for choosing the final threshold values. At this time, it is unknown whether different probability thresholds will be needed for different geographic regions. Figures 5a-e illustrate raw histogram plots of the 34-knot interval-form wind speed probabilities for Hurricane Wilma for the warning, watch, Day-3, Day-4, and Day-5 periods (respectively). At first glance, and as expected, it is apparent that during the warning period the histogram is skewed toward the high end; in the watch period the distribution is spread out over a mid-range of values; and in the extended periods the distribution becomes more skewed toward the low end. It is evident, then, that the probability thresholds for triggering the mention of *POSSIBLE* hurricane or tropical storm conditions are subject to a function of time, with lower values gaining more significance in the extended range of the forecast and vice versa.

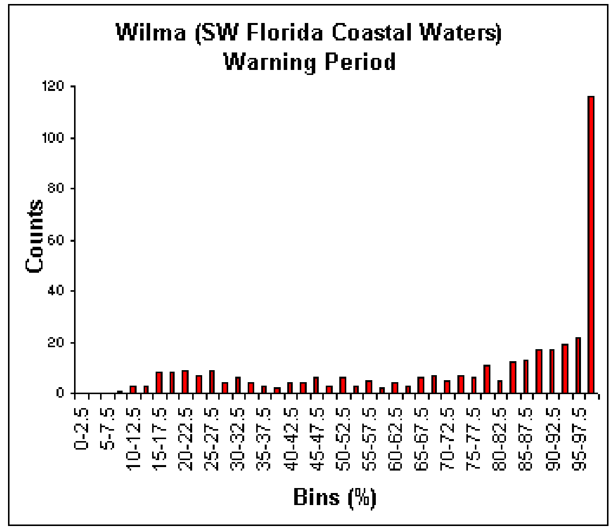

Figure 5a. A raw histogram plot of the 34-knot wind speed probabilities for the SW Florida Coastal Waters (out 60 nautical miles from Naples, Florida) for Hurricane Wilma. It refers to the probability that the wind speed will be equal to or greater than 34-knots at any given grid point within the defined area for the 12-hour intervals which fall within the approximate warning period (or 00- to 24-hours). Percentages are in bins of 2.5% plotted in the x axis with the raw counts plotted in the y axis.

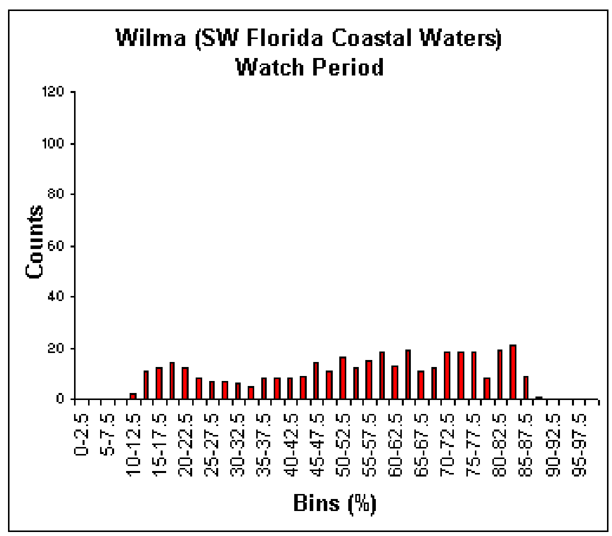

Figure 5b. The same as Figure 5a, except for the approximate watch period (25- to 48-hours).

4. ENHANCED GRAPHIC PRODUCTS

Over the past five years, WFOs MLB and MFL have successfully generated experimental wind threat index graphics during tropical cyclone situations affecting East Central Florida and South Florida. These index graphics are manually created, in the real-time, for the purpose of accompanying the official Hurricane Local Statement text product. It has been a tremendous but

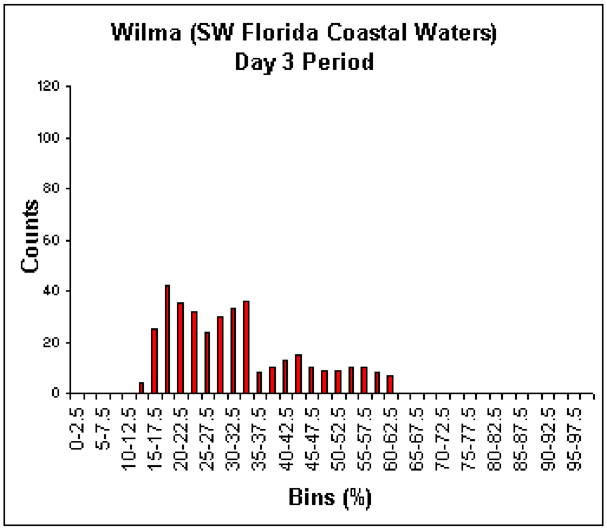

Figure 5c. The same as Figure 5a, except for the approximate Day-3 period (49- to 72-hours).

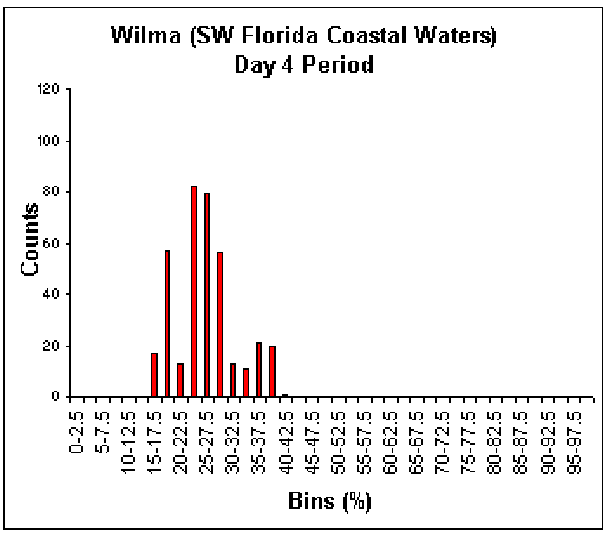

Figure 5d. The same as Figure 5a, except for the approximate Day-4 period (73- to 96-hours).

worthy commitment, especially considering the combined aspects of the 2004-05 hurricane seasons. The intent of the Wind Threat Index map (Figure 6) is to more effectively communicate event-specific recommendations to residents and decision-makers regarding adequate preparations when tropical cyclones threaten their area.

Typically, the manual threat assessment process begins by first using the official wind forecast (radii/wind swath) to determine the maximum forecast event winds (intensity) across the forecast area, including any mesoscale adjustments. Next, the forecaster subjectively considers the uncertainty of the wind speed

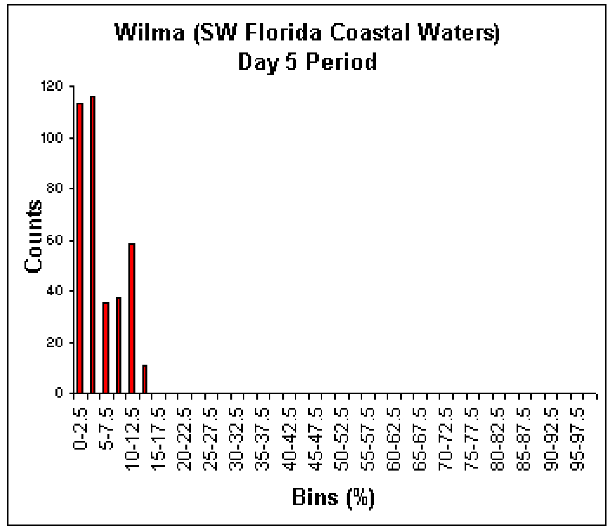

Figure 5e. The same as Figure 5a, except for the approximate Day-5 period (97- to 120-hours).

forecast (utilizing the average error cone for track, and also accounting for storm size and possible errors in intensity). These considerations broaden the initial threat area to account for the situational spectrum of reasonable possibilities. The closer in time to landfall, the more the threat index map tends toward the deterministic solution. On the other hand, the farther out in time (e.g., at the issuance time of a tropical cyclone watch) the more significant the role of forecast uncertainty. This method for locally assessing wind threat has worked well for years, relying heavily upon forecaster expertise. The assessments are then converted to indices and depicted on a plan-view map (Figure 7) using the GFE software. Stratifications in forecast wind speed (Table 4) govern the level of threat (6-levels; None to Extreme), while uncertainty governs the spatial distribution. For more background information about the experimental Tropical Cyclone Wind Threat Index, please refer to its associated Product Description Document.

http://products.weather.gov/PDD/Localstatement.pdf

Despite the success and positive user-feedback, there have been two main challenges to this scheme from operational peers:

1. How can workload be reduced since the threat index map is manually created?

2. How can differences in subjectivity be minimized among forecasters?

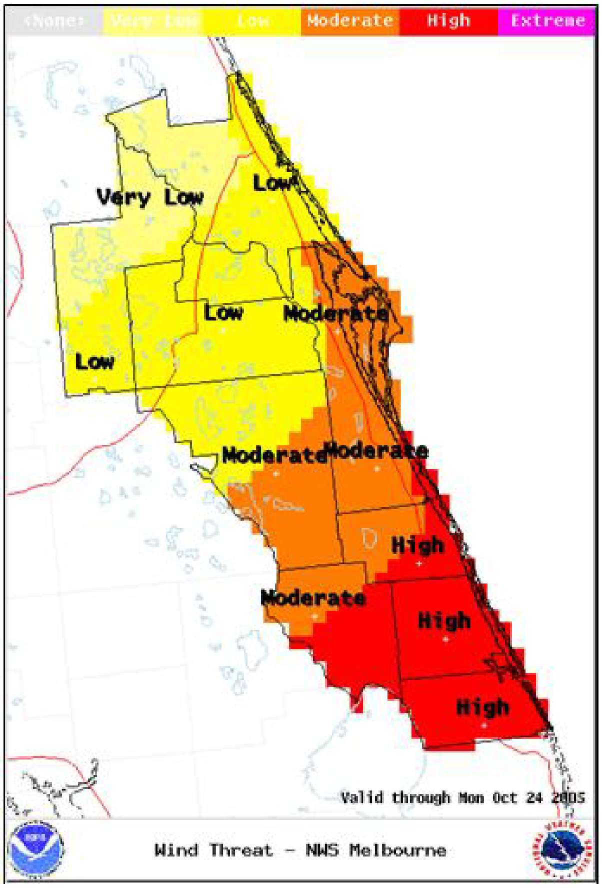

Figure 6. An example of the experimental Tropical Cyclone Wind Threat Index graphic as generated for East Central Florida during Hurricane Wilma (2005). This product is designed to become available to users whenever a tropical cyclone warning or watch is issued for the local area.

To meet these challenges, investigations involving the creative use of the cumulative-form probabilities have taken place. The idea was to use a composite of the 34-, 50-, and 64-knot probabilities to generate a first-guess field on GFE for which the forecaster could then focus on value-added aspects. In so doing, manual workload would be reduced while, at the same time, a degree of consistency would be achieved through the use of a common set of input guidance. So far, the compositing has been performed by hand to support the search for appropriate probability thresholds which reasonably approximate each of the defined threat levels. Particular difficulty was experienced regarding the *HIGH* and *EXTREME* threat levels since there is no differentiation in the strength of hurricane-force winds (Saffir-Simpson Hurricane Scale) in the probability sets. Importantly, early results from the 2004-05 seasons indicate the positive feasibility of creating a compositing tool for automatically creating the first-guess field according to identified preliminary thresholds (Table 5). It is hoped that this GFE tool will soon be created, and will be flexible enough to easily adjust the thresholds. More testing of the compositing technique is needed.

THREAT INDEX	RECCOMMENDED ACTIONS
Extreme Wind Threat	Preparations should be made for the likelihood of major hurricane-force winds; the chance of Category 3, 4, or 5 hurricane-force winds (winds greater than 110 mph) typically resulting in extensive wind damage.
High Wind Threat	Preparations should be made for the likelihood of strong hurricane-force winds; the chance of Category 2 hurricane force winds (96 to 110 mph) typically resulting in major wind damage.
Moderate Wind Threat	Preparations should be made for the likelihood of hurricane-force winds; the chance of Category 1 hurricane force winds (74 to 95 mph) typically resulting in moderate wind damage.
Low Wind Threat	Preparations should be made for the likelihood of strong tropical storm-force winds; the chance of strong tropical storm force winds (58 to 73 mph) typically resulting in minor to locally moderate wind damage.
Very Low Wind Threat	Preparations should be made for the likelihood of tropical storm-force winds; the chance of tropical storm force winds (39 to 57 mph) typically resulting in minor wind damage.
Non-Threatening	Tropical storm-force winds are non-threatening; "windy" conditions may still be present.

Table 4. The table shows the definition of each threat level for the experimental Tropical Cyclone Wind Threat Index graphic. The Index is color-coded and depicted on a plan-view map. This product is experimental.

5. SUMMARY

It has been shown that critical decision-making during tropical cyclone events stands to realize significant gains through the availability of interval-form and cumulative-form wind speed probabilities. Yet, it will still take some time before user-skill is acquired with these data sets. Serving as sophisticated first-users, and advocates of less-sophisticated users, WFOs can now offer information regarding the uncertainty of the wind speed forecast. During events of high impact, requirements for this type of information can be as important as the deterministic forecast. Here, WFOs MFL and MLB have shown creative application of the interval-form probability sets to enhance the wording of public and marine text products by introducing expressions of uncertainty via automated formatters that are coded to trigger on pre-selected probability thresholds. Rigorous testing will occur during the 2006 season and will be facilitated by the NOAA Tropical Cyclone Wind Team (as appointed by the NOAA Hurricane Conference attendees). Upon revealing the trigger thresholds which can consistently offer the most

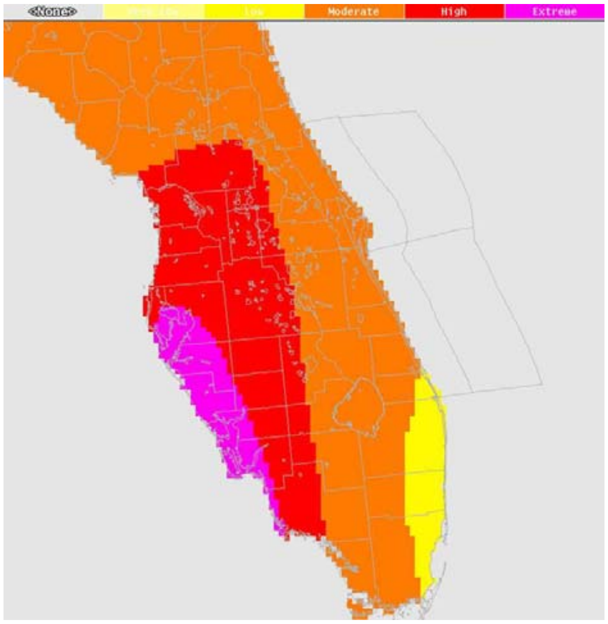

Figure 7. Through compositing techniques using the cumulative-form tropical cyclone wind probabilities, a first-guess map can be generated depicting the Tropical Cyclone Wind Threat Index. Shown is an example of a first-guess map for Hurricane Charley (2004).

Probability Thresholds Table - Preliminary

Wind Threat	Probability Threshold
Very Low	≥15% for 34-knot wind
Low	≥10% for 50-knot wind
Moderate	≥ 05% for 64-knot wind
High	≥ 15% for 64-knot wind (if Cat. 2)
Extreme	≥ 25% for 64-knot wind (if Cat. 3+)

Table 5. The table shows the preliminary threshold values of the cumulative-form probabilities for approximating each of Tropical Cyclone Wind Threat Index levels. By incorporating these values within the outlined compositing techniques, reasonable first-guess fields can be generated and provided to forecasters. Refinements to the preliminary values are likely with further testing.

responsible text wording, proper considerations will be made for operational implementation. This will take more hours of applied research, testing a variety of diverse situations. Too, it is hoped that other textual forecast products might be improved through a similar approach (e.g., fire weather forecast, tabular forecast products, etc.).

Opportunity has also been shown to exist for improving (experimental) graphic products by employing the cumulative-form probabilities. Workload and subjectivity can be reduced when performing tropical cyclone wind threat assessments. Graphics which distill an abundance of sophisticated decision-making information into an easy-to-understand depiction is the lofty desire of less-sophisticated users. Undoubtedly, probabilities for exceeding certain critical thresholds are main ingredients for such graphics. This would also have value for sophisticated users if related information was additionally available in gridded format. With an advanced geographic information system (GIS), a user would be able to answer questions (with more detail) regarding potential impact whenever tropical cyclones threaten.

6. ACKNOWLEDGEMENTS

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