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THE AUTOMATED GENERATION OF WIND PHRASES FOR THE INTERACTIVE COMPUTER WORDED FORECAST

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1. INTRODUCTION

The Techniques Development Laboratory (TDL) has been experimenting with the preparation of worded weather forecasts by computer for over 20 years (Glahn, 1970, 1979; Bermowitz, Heffernan, and Glahn, 1980; Bermowitz and Miller 1984). Interpretation of direct numerical model output by statistical techniques provides a database of Model Output Statistics (MOS) forecasts for those weather elements normally contained in the public weather forecast. The database is analyzed by computer and text forecasts are automatically produced. Similar experiments have been conducted in Sweeden (Lonnqvist, 1973) and Canada (Verret, 1990).

In support of the National Weather Service modernization, TDL has made extensive revisions and enhancements to an interactive version of the computer worded forecast known as the Interactive Computer Worded Forecast (ICWF). With the ICWF, forecasters are able to interact with the database and modify guidance as needed prior to submitting the database for text formatting.

For the current version of the ICWF, the forecast database has been redesigned to incorporate greater temporal and spatial resolution. In order to take advantage of this increased resolution, the text formatters have also been redesigned. This office note describes the new wind phrase formatting routines.

The ICWF database now contains wind speed and direction forecasts every 3 hours from an initial time (either 0000 UTC or 1200 UTC) through 60 hours. The previous version of the ICWF database provided wind forecasts only every 6 hours. The increased temporal resolution in the database is significant in that a wind forecast is now available at the mid/late afternoon time projection (all time zones) which is around the time of the normal diurnal maximum in wind speed.

Additional improvements to the wind formatting routines have been provided in response to suggestions from field forecasters at ICWF test sites. These improvements are intended to provide the user with more control over the formatting of wind shifts, wind gusts, and ranges in wind speed.

2. WIND PHRASES

Wind descriptors consist of up to two separate phrases depending on the desired level of detail and the wind speed forecast for the period. One phrase is an adjective phrase and is used to describe the wind speed (e.g., VERY WINDY) and the other is the speed/direction phrase which specifies the wind speed and direction (e.g., NORTH WIND 10 TO 15 MPH.).

Speed/direction phrases consist of two classes, change phrases and no change phrases. Change phrases are used when there is a significant wind shift or change in wind speed during the forecast period. In such cases, the

speed/direction phrase will contain references to wind speed and direction both before and after the wind shift or change in wind speed. In no change phrases, only one reference to wind speed and direction is needed to adequately describe the wind conditions during the forecast period.

The adjective phrase is usually merged into the body of the forecast describing the weather and temperature conditions (e.g., VERY COLD AND WINDY). The speed/direction phrase is always a stand alone sentence.

The new text formatter consists of two routines which can construct up to 10 types of speed/direction phrases and six adjective phrases. One routine handles situations where the wind speed and direction remains uniform during the forecast period (no change phrases), and the other handles situations in which there is a significant change in wind speed and/or direction during the forecast period (change phrases). For a detailed description of the wind phrases see Appendix I.

3. SELECTING THE WIND PHRASES

The first step in selecting the wind phrases is to analyze the wind speed and direction forecasts in the ICWF database by comparing them with a series of thresholds until a specific temporal pattern is identified. The thresholds are adjustable by the forecast office and relate to wind speed and direction, changes in wind speed and direction, and various wind event time durations. For a complete list of the wind thresholds see Appendix II.

The first, and most significant pattern searched for in the wind forecasts is a change of wind direction. A change of direction occurs when the direction shifts at least two points on an eight point compass (e.g., southwest to northwest) during the forecast period and does not shift back. The direction will be made variable when either:

a) the wind speed is less than a threshold value,

b) three wind shifts are detected with one shift of direction opposite to the other two,

c) a wind shift of at least three points on the compass and then a shift back to or near the original direction, or

d) a wind shift of 345 degrees or more.

If a change of direction is not found, then the wind speed forecasts are examined for a significant change of speed during the forecast period. A change of speed phrase is used when the wind speed increases or decreases enough during the forecast period to exceed a threshold value.

A significant change of speed also includes a change to or from a light wind. Periods of light wind will be determined by looking for wind speeds less than a threshold value for a minimum period of time, again determined by a threshold. If a light wind occurs during the forecast period and the maximum wind during the period exceeds a preset threshold, then a special change of speed phrase will be used specifically noting the change to or from a light wind.

If a change of direction or a change of speed has not been found, then a general speed/direction phrase will be selected. After the speed/direction phrase is selected, the adjective phrase is determined, if needed. Adjective phrase selection is based upon the maximum wind speed during the forecast period. If this wind speed falls within one of several wind speed ranges for a sufficient length of time (controlled by thresholds), an adjective phrase will be selected.

The thresholds which determine the selection of the adjective phrase are also adjustable by the user. For example, a user may choose to describe the wind speed as "WINDY" if the maximum speed exceeds 20 mph for 3 hours or call it "VERY WINDY" if the maximum speed exceeds 30 mph for 1 hour.

After the forecasts have been analyzed and the appropriate wind phrase determined, the necessary information is passed along to the text formatter and the phrase is constructed.

For a detailed description of the criteria necessary for the selection of each speed/direction and adjective phrase, see Appendix II.

4. CONSTRUCTING THE WIND PHRASES

The construction of phrases is accomplished by piecing together a series of phrase parts. A phrase part consists of one or more words describing a particular aspect of the wind conditions. For example, the time that a wind shift occurs would constitute a phrase part. The wind direction and wind speed would each be a phrase part. The number and order of phrase parts in the wind phrase, along with proper punctuation is controlled by information passed to the text formatting routines from the data analysis routines.

The descriptive content of the phrases is controlled by the detail level desired by the user. The highest level of detail (detail level 1) will produce the most descriptive phrase. Each lower detail level reduces the descriptive content. At lower detail levels, some phrases will not be produced at all.

There are five levels of detail the user may choose from in constructing the wind phrases. For detail levels 1-3, both a speed/direction phrase and an adjective phrase are constructed. For detail levels 4 and 5, only an adjective phrase is built (see Appendix I).

The wind direction for the period is arrived at by averaging. If a change of speed or direction occurs, then an averaged direction is used both before and after the change.

After the wind direction has been determined, a representative wind speed for the forecast period is determined. The wind speed forecast will usually include a range in speed (e.g., 10 TO 15 MPH). The range in wind speed is a function of the highest wind speed during the forecast period unless there is a change of speed in which case two ranges are determined based upon the highest speeds before and after the change of speed. Through the use of adjustable thresholds, the user is able to specify the desired range in wind speed for all possible maximum wind speed forecasts. Ranges of 5, 10, 15, and 20 mph can be selected. To determine the range in speed, the fastest speed during the period is located, then rounded up to the nearest speed divisible

by five. This value will then be the high end of the range. The low end of the range is then determined by subtracting the appropriate range from the high end.

The formatting of wind gusts is controlled by two speed thresholds and a gust factor. If the wind speed exceeds only the lower speed threshold, wind gusts will be formatted in general terms such as "AND GUSTY" or "WITH HIGHER GUSTS." If the higher speed threshold is exceeded, wind gusts will be directly specified in mph (e.g., WITH GUSTS TO 40 MPH).

The wind gust in mph is computed by multiplying the high end of the wind speed range by the gust factor and then rounding this number up to the nearest speed divisible by five. If the gust factor is set to 1.0, no mention of wind gusts will be made in the speed/direction phrase even though the speed thresholds have been exceeded. An additional constraint on the formatting of wind gusts is that the wind gust in mph must exceed the high range of the wind speed by a threshold specified mph in order for gusts to be mentioned.

An outline of the algorithm for the construction of wind phrases is presented in Appendix III.

References

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APPENDIX I

Wind Phrases

Detail levels 1 and 2:

Detail levels 1 and 2 provide fully descriptive speed/direction and adjective phrases. Detail level 1 gives specific times for wind shifts and significant changes in wind speed, while for detail level 2, time references are restricted to "MORNING/AFTERNOON" and "BEFORE MIDNIGHT (EARLY)/AFTER MIDNIGHT (LATE)". Definitions of D1, D2, S1, S2, Sg1, Sg2, items in ( ), and items in [ ] appear at the end of this Appendix.

Speed/direction phrases:

No change phrases:

1. CALM WINDS.
2. LIGHT WINDS. [or LIGHT AND VARIABLE]
3. LIGHT D1 WINDS.
4. D1 WINDS S1 MPH.
5. D1 WINDS S1 MPH AND GUSTY (time). [or WITH HIGHER GUSTS]
6. D1 WINDS S1 MPH, GUSTING TO Sg MPH (time).

Change phrases:

7. D1 WINDS S1 MPH (WITH GUSTS TO Sg1 MPH) SHIFTING TO D2 (time) (AND INCREASING/DECREASING TO S2 MPH (WITH GUSTS TO Sg2 MPH)) (AT S2 MPH (WITH GUSTS TO Sg2 MPH)).
8. D1 WINDS S1 MPH (WITH GUSTS TO Sg1 MPH) INCREASING/DECREASING (time) TO S2 MPH (WITH GUSTS TO Sg2 MPH).
9. LIGHT (D1) WINDS (BECOMING D2 (time) (AT S2 MPH (WITH GUSTS TO Sg2 MPH))) (INCREASING (time) TO S2 MPH (WITH GUSTS TO Sg2 MPH)).
10. D1 WINDS S1 MPH (WITH GUSTS TO Sg1 MPH) BECOMING LIGHT (D2) (time).

If two gust phrase parts are needed, use the higher gust. If the gust speeds are equal, use the first.

Adjective phrases:

1a. BREEZY (time).
2a. BLUSTERY (time). [or BRISK]
3a. WINDY (time). BECOMING WINDY (time). DIMINISHING WINDS (time).
WINDY (time), THEN DIMINISHING WINDS (time).
4a. VERY WINDY (time). BECOMING VERY WINDY (time).
VERY WINDY (time), THEN DIMINISHING WINDS (time).
5a. STRONG WINDS.
6a. HURRICANE FORCE WINDS. [or DAMAGING, DANGEROUS, EXTREME, etc.]

Detail level 3:

With detail level 3, no time references are given. Phrase 7 is slightly abbreviated so that no mention is made of increasing or decreasing wind speeds, and the adjective phrases using "BECOMING" and "DIMINISHING" are discontinued. All other speed/direction phrases and adjectives are formatted.

Speed/direction phrases:

No change phrases:

1. CALM WINDS.
2. LIGHT WINDS. [or LIGHT AND VARIABLE]
3. LIGHT D1 WINDS.
4. D1 WINDS S1 MPH.
5. D1 WINDS S1 MPH AND GUSTY. [or WITH HIGHER GUSTS]
6. D1 WINDS S1 MPH, GUSTING TO Sg MPH.

Change phrases:

7. D1 WINDS S1 MPH (WITH GUSTS TO Sg1 MPH) SHIFTING TO D2 AT (S2 MPH (WITH GUSTS TO Sg2 MPH)).
8. D1 WINDS S1 MPH (WITH GUSTS TO Sg1 MPH) INCREASING/DECREASING TO S2 MPH (WITH GUSTS TO Sg2 MPH).
9. LIGHT (D1) WINDS (BECOMING D2 AT S2 MPH (WITH GUSTS TO Sg2 MPH)) (INCREASING TO S2 MPH (WITH GUSTS TO Sg2 MPH)).
10. D1 WINDS S1 MPH (WITH GUSTS TO Sg1 MPH) BECOMING LIGHT (D2).

If two gust phrase parts are needed, use the higher gust. If the gust speeds are equal, use the first.

Adjective phrases:

1a. BREEZY.
2a. BLUSTERY. [or BRISK]
3a. WINDY.
4a. VERY WINDY.
5a. STRONG WINDS.
6a. HURRICANE FORCE WINDS. [or DAMAGING, DANGEROUS, EXTREME, etc.]

Detail levels 4 and 5:

With detail levels 4 and 5, there are no speed/direction phrases, no time references, and no high wind adjective phrases. All other adjectives are formatted. Detail level 4 can take on all adjective phrases listed below while detail level 5 can take on phrases 3a and 4a only.

Speed/direction phrases: none.

Adjective phrases:

1a.	BREEZY.	(detail level 4 only)
2a.	BLUSTERY. [or BRISK]	(detail level 4 only)
3a.	WINDY.	
4a.	VERY WINDY.	

Definitions

D1 (D2) - first (second) wind direction appearing in the phrase
S1 (S2) - first (second) wind speed appearing in the phrase
Sg1 (Sg2) - first (second) wind gust speed appearing in the phrase

Items in [ ] are alternative phrases.

Items in ( ) are phrase parts which may or may not be appropriate for a given situation. For example, in the phrase "WINDY (time)", if the windy conditions occur during the entire forecast period, the time descriptor would not be used. If the windy conditions occurred in the afternoon only, the time descriptor "IN THE AFTERNOON" would be used.

APPENDIX II

Control Constants (Thresholds) For Constructing The Wind Phrases

Control constants are thresholds which guide the generation of text phrases by the ICWF formatting routines. The thresholds are integer values which are read in from a file during the initialization of the ICWF. The threshold file is adjustable by the user so that each WFO may tailor the thresholds to best describe their local climatology.

The following thresholds make up the wind control constants:

LW(1) - Minimum wind speed required before a shift in wind direction, in order for the shift to be considered significant. Should not be less than LW(14) or LW(41).
Default value = 12.

LW(2) - Minimum speed required after a shift in wind direction in order for the shift to be considered significant. Should not be less than LW(14) or LW(41).
Default value = 12.

LW(3) - Required increase or decrease in wind speed during a forecast period in order for the increase or decrease to be formatted. Choose a value higher than the climatological variation in wind speed. Note that LW(4) also controls increasing/decreasing changes.
Default value = 15.

LW(4) - Required minimum difference between the high end of the range of the minimum wind speed during a forecast period to the low end of the range of the maximum wind speed during a forecast period in order for an increase or decrease in wind speed to be formatted (e.g., for a minimum wind speed of 5-10 mph and a maximum wind speed of 20-30 mph the difference is 20-10 = 10). A negative difference is allowed but not recommended.
Default value = 0.

LW(5) - Required minimum time period (in hours) that "light" winds must occur in order to format a "light wind" change phrase (e.g., LIGHT WINDS BECOMING... or ...WINDS BECOMING LIGHT). Values of 3-6 are recommended. Use -1 to allow any and all light wind change phrases.
Default value = 4.

LW(6) - Minimum wind speed that must occur before or after a period of "light" winds in order to format a "light wind" change phrase. Must be greater than LW(14). Values of 7-15 are recommended. Use -1 to disable.
Default value = 15.

LW(7) - Minimum wind speed required for a 5 mph range in wind speed to be formatted (e.g., 5 TO 10 MPH). Always use a value greater than or equal to 5. A value of 5 + LW(40) is recommended. Use 9999 to disable.
Default = 7.

LW(8) - Minimum wind speed required for a 10 mph range in wind speed to be formatted (e.g., 15 TO 25 MPH). Always use a value greater than or equal to 5. Use 9999 to disable.
Default value = 17.

LW(9) - Minimum wind speed required for a 15 mph range in wind speed to be formatted (e.g., 40 TO 55 MPH). Always use a value greater than or equal to 5. Use 9999 to disable.
Default value = 42.

LW(10)- Minimum wind speed required for a 20 mph range in wind speed to be formatted (e.g., 60 TO 80 MPH). Always use a value greater than or equal to 5. Use 9999 to disable.
Default value = 62.

LW(11)- First wind speed gust threshold. If exceeded and the second wind speed gust threshold, LW(12), is not exceeded, gusts will be mentioned but not explicitly forecast in mph (e.g., SOUTH WINDS 20 TO 30 MPH AND GUSTY). LW(19) is the minimum recommended first gust threshold. Use 9999 to disable. Will also be disabled if LW(11) = LW(12) or if the gust factor is set to 1.0.
Default value = 22.

LW(12)- Second wind speed gust threshold. If exceeded, gusts will be explicitly forecast in mph (e.g., ...WITH GUSTS TO 35 MPH). LW(19) is the minimum recommended second gust threshold. Use 9999 to disable. Will also be disabled if gust factor is set to 1.0.
Default value = 25.

LW(13)- Calm wind threshold. If the wind speed is at or below LW(13), then "calm" winds will be forecast. Use -1 to disable.
Default value = 3.

LW(14)- Light wind threshold. If the wind speed is at or below LW(14) and greater than LW(13) then "light" winds will be forecast. Use -1 to disable. Note that by disabling LW(14) the "light wind" change phrases will also not be generated.
Default value = 6.

LW(15)- First "breezy" wind threshold. If the wind speed is greater than or equal to LW(15) but less than LW(16), then the wind adjective will either be "BREEZY," "BRISK" or "BLUSTERY," or no adjective will be returned depending upon the temperature. If the temperature is below LW(18) no wind adjective will be returned. If the temperature is at or above LW(18) and below LW(17), the wind adjective will be "BLUSTERY" or "BRISK." If the temperature is at or above LW(17) the wind adjective will be "BREEZY." Use -1 to disable.
Default value = 16.

LW(16)- Second "breezy" wind threshold. If the wind speed is less than LW(16) but greater than or equal to LW(15), then the wind adjective will either be "BREEZY," "BRISK" or "BLUSTERY," or no adjective will be returned depending upon the temperature. If the temperature is below LW(18) no wind adjective will be returned. If the temperature is at or above LW(18) and below LW(17), the wind adjective will be "BLUSTERY" or "BRISK." If the temperature is at or above LW(17) the wind adjective will be "BREEZY." Use -1 to disable (with LW(15) also set to -1).
Default value = 27.

LW(17)- Used to discriminate between the phrases "BREEZY" and "BLUSTERY" or "BRISK." If the temperature is at or above LW(17) and the wind speed is greater than or equal to LW(15) and below LW(16), then "BREEZY" is used. Use -9999 to disable.
Default value = 41.

LW(18)- Used to discriminate between the phrases "BREEZY" and "BLUSTERY" or "BRISK." If the temperature is at or above LW(18) and below LW(17) and the wind speed is greater than or equal to LW(15) and below LW(16), then "BLUSTERY" or "BRISK" is used as an adjective phrase instead of "BREEZY." Use 9999 to disable.
Default value = 33.

LW(19)- The minimum wind speed needed to format "WINDY" as an adjective phrase. Use -1 to disable.
Default value = 22.

LW(20)- The minimum wind speed needed to format "VERY WINDY" as an adjective phrase. Use -1 to disable.
Default value = 32.

LW(21)- The minimum wind speed needed to format "STRONG WINDS" as an adjective phrase. Use -1 to disable.
Default value = 42.

LW(22)- The minimum wind speed needed to format an extreme wind descriptor (e.g., HURRICANE FORCE WINDS). Use -1 to disable.
Default value = 74.

LW(23)- Wind gust speed required in excess of the high end of the forecast wind speed range in order for wind gusts to be formatted. Use 9999 to disable.
Default value = 10.

LW(24)- The minimum number of hours the wind speed must be within a given range in wind speed after increasing or decreasing out of that range to be considered within that range for the entire forecast period. Used to allow for wind speeds that occur around threshold values. A value of 0 is recommended.
Default value = 0.

LW(25)- Number of hours the wind speed may be outside of a given range in wind speed, then return within that range and still be considered a continuous occurrence. Used to allow for wind speeds that occur around threshold values. Values of 1-3 are recommended.
Default value = 3.

LW(26)- Maximum number of hours at the beginning or end of a forecast period in which a particular wind episode can cease to occur but will still be considered to last for the entire forecast period. In such cases, a time of occurrence for that wind episode will not be mentioned. Values of 2-4 are recommended.
Default value = 3.

LW(27)- Minimum number of hours a wind speed in excess of LW(22) must occur in order for an extreme wind adjective phrase (e.g., HURRICANE FORCE WINDS) to be formatted. Use 0 to always mention an occurrence. Use 25 to disable.
Default value = 1.

LW(28)- Minimum number of hours a wind speed in excess of LW(21) must occur to use the adjective phrase "STRONG WINDS." Use 0 to always mention an occurrence.
Default value = 1.

LW(29)- Minimum number of hours a wind speed in excess of LW(20) must occur to use the adjective phrase "VERY WINDY". Use 0 to always mention an occurrence.
Default value = 2.

LW(30)- Minimum number of hours a wind speed in excess of LW(20) must occur to use the adjective phrase "VERY WINDY, THEN DIMINISHING WINDS." Use 0 to always mention an occurrence. Use 24 to disable.
Default value = 3.

LW(31)- Minimum number of hours a wind speed in excess of LW(19) must occur to use the adjective phrase "WINDY." Use 0 to always mention an occurrence.
Default value = 2.

LW(32)- Minimum number of hours a wind speed in excess of LW(19) must occur to use the adjective phrase "WINDY, THEN DIMINISHING WINDS." Use 0 to always mention an occurrence. Use 24 to disable.
Default value = 3.

LW(33)- Minimum number of hours a wind speed equal to or exceeding LW(15) and less than LW(16) must occur to use either "BREEZY, BRISK, or BLUSTERY" as an adjective phrase. Use 0 to always mention an occurrence. A value of at least 3 is recommended. Use 25 to disable.
Default value = 4.

LW(34)- LW(34) must be either a "0" or a "1." A value of "0" indicates that the time of occurrence in the speed/direction wind phrase will be the projection or point in time of the change (e.g., SOUTH WINDS BECOMING EAST LATE THIS MORNING where "LATE THIS MORNING" is the time phrase describing the time of the change). A value of "1" indicates the time of occurrence will include the entire time period from the time of change to the end of the wind event or forecast period whichever comes first (e.g., SOUTH WINDS BECOMING EAST LATE THIS MORNING AND THIS AFTERNOON).
Default value = 0.

LW(35)- Maximum number of hours the wind speed may fall below the gust threshold before returning above the gust threshold and still be considered a continuous occurrence of gusty winds. A value of 1-3 is recommended.
Default value = 3.

LW(36)- The minimum difference between the fastest and slowest forecast wind speed during the forecast period, below which a range in the wind speed will not be formatted. For example, If the wind speed is forecast to be south at 10 mph at each projection during the forecast period, the difference between the fastest and slowest wind speed is zero and the formatted wind phrase will read "SOUTH WINDS AT 10 MPH." Use -1 to disable.
Default value = 1.

LW(37)- The maximum forecast wind speed during the forecast period above which a range in the wind speed will always be formatted. Use 9999 to disable.
Default value = 24.

LW(38)- Maximum number of hours that a wind speed may be out of a given range in wind speed at the beginning of a forecast period for the formatter to ignore those speeds (unless they are too large or small). A value from 0 to 3 is recommended.
Default value = 3.

LW(39)- Maximum number of hours that a wind speed may be out of a given range in wind speed at the end of a forecast period for the formatter to ignore those speeds (unless they are too large or small). A value from 0 to 3 is recommended.
Default value = 3.

LW(40)- Number added to the wind speed before rounding to the nearest 5 mph. Integer division is used which truncates the quotient. LW(40) must be a value between and including 0 and 4. If LW(40) = 4, all speeds round up. If LW(40) = 3, speeds ending with 1's and 6's round down, all others round up. If LW(40) = 2, speeds ending in 1's, 2's, 6's, 7's round down, all others round up. If LW(40) = 1, only speeds ending in 4's and 9's round up. If LW(40) = 0, all values round down.
Default value = 3.

LW(41)- The wind speed below which the speed/direction phrase will be formatted as "LIGHT AND VARIABLE." Use -1 to disable.
Default value = 3.

LW(42)- Maximum number of hours during the forecast period that the wind speed may be above the "light" wind speed threshold LW(14) or the "light and variable" wind speed threshold LW(41) for the wind to still be considered "LIGHT" or "LIGHT AND VARIABLE." Note that if the wind speed exceeds LW(14) + 2 mph at any time during the forecast period, the entire period will not be considered "LIGHT" or "LIGHT AND VARIABLE."
Default value = 3.

APPENDIX III

Selecting The Wind Phrases

Speed/direction phrases:

Phrase	Criteria for selection
1. CALM WINDS.	S1 is greater than 0 but less than or equal to LW(13) mph.
2. LIGHT WINDS.	S1 greater than LW(13) mph and less than or equal to LW(14) mph with a shift in wind direction of two or more compass points on an eight point compass.
3. LIGHT D1 WINDS.	S1 greater than LW(13) mph and less than or equal to LW(14) mph with no wind shift. D1 will be set to "AND VARIABLE" if the wind speed is less than LW(41) mph.
4. D1 WINDS S1 MPH.	S1 greater than LW(14). No wind shift or gust thresholds are exceeded.
5. D1 WINDS S1 MPH AND GUSTY.	S1 greater than LW(14) mph. The first gust threshold, LW(11), is exceeded. The second gust threshold LW(12) is not exceeded. The gust factor is greater than 1.0, and the difference between the high end of the wind speed range for S1 and Sg is greater than LW(23) mph.
6. D1 WINDS S1 MPH, GUSTING TO Sg MPH.	S1 greater than LW(14) mph. The second gust threshold, LW(12), is exceeded. The gust factor is greater than 1.0, and the difference between Sg and the high end of the wind speed range for S1 is greater then LW(23) mph.
7. D1 WINDS S1 MPH SHIFTING TO D2 (time) (AND INCREASING/DECREASING TO S2 MPH) (AT S2 MPH).	Wind shift of at least 2 points on an eight point compass. Increasing (decreasing) phrase will be included when the difference from the high (low) end of S1 wind speed range to the low (high) end of S2 wind speed range is greater than or equal to LW(4).
8. D1 WINDS S1 MPH INCREASING/ DECREASING (time) TO S2 MPH.	No wind shift. Difference between the high end of S1 wind speed range and the low end of the S2 wind speed range must be greater than or equal to LW(4) mph and the difference between S1 and S2 must be at least LW(3) mph.

9. LIGHT (D1) WINDS BECOMING D2 (time) (AT S2 MPH) (AND) (INCREASING (time) TO S2 MPH)	S1 is greater than LW(13) mph and less than or equal to LW(14) mph for a minimum of LW(5) hours and then increases. Difference between LW(14) and low end of S2 wind speed range is greater than or equal to LW(6) mph. D1 is used if there is no wind shift. D2 will be formatted only if it differs from D1 by two points of the compass.
10. D1 WINDS S1 MPH BECOMING LIGHT (D2) (TIME).	S1 decreases to less than or equal to LW(14) mph but greater than LW(13) mph for at least LW(5) hours. The difference between the low end of the S1 wind speed range and LW(14) must equal or exceed LW(6) mph. D2 will be formatted only if it differs from D1 by two points of the compass.

Adjective phrases:

Adjective phrase selection is based upon the fastest wind speed during the forecast period. This wind speed must fall within various wind speed ranges (controlled by thresholds) for a specified number of hours (also controlled by thresholds) in order for an adjective phrase to be generated and inserted into the body of the forecast. The thresholds which control the formatting of adjective phrases are adjustable by the user. Thresholds can be set such that a particular adjective phrase will never be used. In addition, alternative phrases of similar meaning may be defined by the user.

In general, time descriptors for the adjective phrases describe the time of occurrence within the forecast period (e.g., VERY WINDY THIS AFTERNOON). Time descriptors describing the time of change are used in an adjective phrase containing the word "BECOMING" (e.g., BECOMING VERY WINDY LATE THIS MORNING).

Phrase	Criteria for selection
1a. BREEZY (time)	Wind speed greater than or equal to LW(15) mph and less than LW(16) mph for at least LW(33) hours. Temperature must equal or exceed LW(18).
2a. BRISK (time)	Wind speed greater than or equal to LW(15) mph and less than LW(16) mph for at least LW(33) hours. Temperature must exceed LW(17) and be less than LW(18).

3a. WINDY (time)	Wind speed greater than or equal to LW(19) mph and less than LW(20) mph for at least LW(31) hours.
BECOMING WINDY (time)	Wind speeds must increase to at least LW(19) but less than LW(20) mph from less than LW(16) mph.
WINDY (time1), THEN DIMINISHING WINDS (time2)	S1 must be greater than or equal to LW(19) mph and less than LW(20) mph for at least LW(32) hours, and S2 decreases to below LW(16) mph. The first time descriptor, time1, is used if the first half or less of the period meets the windy criteria. The second time descriptor, time2, is used if the windy sub-period lasts into the second half of the period.
DIMINISHING WINDS	S1 must be greater than or equal to LW(19) mph and less than LW(20) mph for less than LW(32) hours. S2 must fall below LW(16) mph.
4a. VERY WINDY (time)	Wind speed greater than or equal to LW(20) mph and less than LW(21) mph for at least LW(29) hours.
BECOMING VERY WINDY (time)	S1 is less than LW(19) mph and S2 must increase to at least LW(20) mph but less than LW(21) mph.
4a. VERY WINDY (time1), THEN DIMINISHING WINDS (time2)	S1 must be greater than or equal to LW(20) mph but less than LW(21) mph for at least LW(30) hours, then S2 must fall below LW(19) mph. The first time descriptor, time1, is used if the first half or less of the period meets the very wind criteria. The second time descriptor, time2, is used if the very windy sub-period lasts into the second half of the period.
5a. STRONG WINDS	Wind speed must be greater than or equal to LW(21) mph but less than LW(22) mph for at least LW(28) hours.
6a. HURRICANE FORCE WINDS	Wind speed must be greater than or equal to LW(22) mph for at least LW(27) hours.

APPENDIX IV

Methodology And Software Structure

The wind formatting routines consist of a set of data analysis routines and a set of phrase building routines. Once the forecasts have been analyzed, text formatting routines are chosen to build the phrases. The text formatting routines piece together words and phrase parts according to instructions determined from information passed to them by the data analysis routines.

The wind phrase selection and building takes place as follows:

```
IF (wind speed is light and variable for the period) THEN

   -Build speed/direction phrase.
   -Return.

ELSE IF (there is a significant shift of direction) THEN

   -Determine wind speed and direction before and after the shift.
   -Determine time of shift.
   -Determine if there is a significant increase or decrease in
    wind speed.
   -Compute wind gusts if needed.
   -Build speed/direction phrase.
   -Build adjective phrase.
   -Return.

ELSE IF (winds are "light" at beginning or end or period) THEN

   -Determine if wind speed increases (decreases) from (to) a
    light wind.  If not, build light or light and variable phrase.
   -Determine wind direction and speed before or after the period
    of light winds as appropriate.  Compute wind gusts if needed.
   -Build speed/direction phrase.
   -Build adjective phrase.
   -Return.

ELSE IF (there is a significant change in wind speed) THEN

   -Get wind speeds and directions before and after the change
    in wind speed.  Compute wind gusts if needed.
   -Determine time of change in wind speed
   -Build speed/direction phrase.
   -Build adjective phrase.
   -Return.

ELSE !  Standard wind speed and direction phrase.

   -Determine averaged wind speed and direction for the period.
   -Build speed/direction phrase.
   -Build adjective phrase.

ENDIF
RETURN
```