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Severe Weather Forecast Decision Aid

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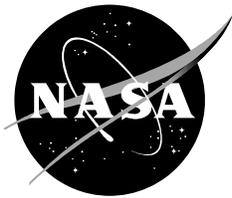
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Executive Summary

This report presents a 15-year climatological study of severe weather events and related severe weather atmospheric parameters. Data sources included local forecast rules, archived sounding data, Cloud-to-Ground Lightning Surveillance System (CGLSS) data, surface and upper air maps, and two severe weather event databases covering east-central Florida. The local forecast rules were used to set threat assessment thresholds for stability parameters that were derived from the sounding data. The severe weather events databases were used to identify days with reported severe weather and the CGLSS data was used to differentiate between lightning and non-lightning days. These data sets provided the foundation for analyzing the stability parameters and synoptic patterns that were used to develop an objective tool to aid in forecasting severe weather events. The period of record for the analysis was May – September, 1989 – 2003.

The results indicate that there are certain synoptic patterns more prevalent on days with severe weather and some of the stability parameters are better predictors of severe weather days based on locally tuned threat values. The results also revealed the stability parameters that did not display any skill related to severe weather days.

An interactive web-based Severe Weather Decision Aid was developed to assist the duty forecaster by providing a level of objective guidance based on the analysis of the stability parameters, CGLSS data, and synoptic-scale dynamics. The tool will be tested and evaluated during the 2005 warm season.

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1. Introduction

The 45th Weather Squadron (45 WS) Commander's morning weather briefing includes an assessment of the likelihood of local convective severe weather for the day in order to enhance protection of personnel and material assets of the 45th Space Wing, Cape Canaveral Air Force Station (CCAFS), and Kennedy Space Center (KSC). The severe weather elements produced by thunderstorms include tornadoes, convective surface winds $\geq$ 50 knots, and/or hail with a diameter $\geq$ 0.75 inches. Forecasting the occurrence and timing of these phenomena is challenging for 45 WS operational personnel. The AMU has been tasked with the creation of a new severe weather forecast decision aid, such as a flow chart or nomogram, to improve the various 45 WS severe weather watches and warnings. The tool will provide severe weather guidance for the day by 1100 UTC (0700 EDT).

An Internet, journal article and periodical search was conducted to find and review work done in the area of forecasting severe weather. Very little current information was discovered or valid for the central Florida region. Most research has been done on storms in the Midwest or on weather events several decades ago.

The AMU developed databases for reported severe weather events, synoptic weather patterns associated with severe and non-severe weather events, and Cloud-to-Ground Lightning Surveillance System (CGLSS) lightning data. Current severe weather forecast indices, procedures and/or signatures in east-central Florida (KSC/CCAFS) and other similar locales were investigated. Guidelines for stability index thresholds and other severe weather thresholds that are locally applicable were explored. Based on the results of the analyses, an interactive web-based Severe Weather Decision Aid was developed to assist the duty forecaster by providing a level of objective guidance based on the analysis of the morning CCAFS sounding stability parameters, CGLSS data, and synoptic-scale dynamics. This tool improves upon the original 45 WS Severe Weather Checklist (4.Appendix A) because it is based on a statistical climatology of 15 year's worth of data tuned to east-central Florida, it is more objective and it is presented in a user-friendly interactive web-based GUI.

2.   Data Methodology

It is important to determine how experienced Florida forecasters have tackled severe weather forecasts – to understand what data and rules-of-thumb they use, what triggers are believed important, what parameters are specific to Florida severe weather and how all the information is pulled together. Armed with this knowledge, five distinct data sets were developed and then merged together. The data sets included local forecast rules, severe weather events, cloud-to-ground lightning, synoptic weather patterns, and sounding stability parameters. All five types of "data" were important to tackle this difficult forecast problem. Each data type has some relevance to forecasting the threat of convection in Florida and if evaluated properly could help forecast the threat of severe weather at KSC/CCAFS.

2.1   Local Forecast Rules

The 45 WS provided the AMU with their Severe Weather Worksheet (Appendix A) and numerous forecasters discussed their procedures for developing a severe weather forecast. With the exception of the launch weather officers, most of the 45 WS forecasters have limited experience forecasting at KSC/CCAFS due to the transitory nature of military assignments. Forecasters typically stay in one place for about three years which hampers their ability to develop their own personal experience in forecasting for the local area.

Members of the AMU staff visited with three Florida NWS forecast offices to further develop the forecaster experience database for this task. They visited Melbourne, Jacksonville, and Tampa NWS offices to discuss how their forecasters evaluate the probability of severe weather on any particular day. NWS forecasters tend to stay at one forecast office for many years and develop a keen sense for the local nuances that play a role in severe weather forecasting. Of the three offices visited, only Jacksonville had a severe weather checklist (Appendix B) that is used occasionally by the forecasters. In general, the three NWS forecast offices relied on the knowledge and expertise of each individual forecaster. They do not have or utilize any decision aids or checklist. Each forecaster is well trained in the local environment and relies on NWS national, regional and local training programs.

2.2   Severe Weather Events

Severe weather events included tornadoes, convective surface winds ≥ 50 knots (≥ 26 m s^{-1}), and/or hail with a diameter ≥ 0.75 inches (≥ 1.9 cm). Severe weather occurrence reports were found in the National Climatic Data Center (NCDC) *U. S. Storm Events Database* (NCDC 2004), and from the Storm Prediction Center (SPC) database (Hart and Janish 2003). Severe weather events from six east central Florida counties were extracted from the NCDC and SPC databases. Reports from the six counties were needed to make sure the database had enough events to derive meaningful statistical relationships since so few events occur in the KSC/CCAFS area. Figure 1 shows a map of Florida with the six counties highlighted in yellow. There are three coastal counties (Volusia, Brevard, Indian River) and three inland counties (Seminole, Orange, Osceola), all of which are typically in the same large-scale air mass as KSC/CCAFS on most warm season days. The main triggers of convection in the warm season are the location, movement, and strength of the local sea breeze front and storm outflow boundary collisions. Two sources of reported severe weather were used to create the severe weather events database for this task.

The NCDC database was the primary data source used and contains data from the following:
- Severe weather events from 1993 – 1995 (except 6/93 – 7/93) with no latitude/longitude, and
- Severe weather events from 1996 – Current including latitude/longitude.

Additional data from the SPC database include:
- Tornadoes from 1950 – 1992,
- Thunderstorm winds ≥ 50 knots from 1955 – 1992, and
- Hail ≥ 0.75 inches from 1955 – 1992.

The NCDC data were cross-checked with the SPC data. The SPC data are available through a graphical database developed by SPC called *SeverePlot* (Hart and Janish 2003). *SeverePlot* contains data files available from 1950 – current, updated every July, and allows users to create custom maps showing the locations of tornadoes and severe hail and wind events (Figure 2). Tabular data can be saved in ASCII format for use in other programs.
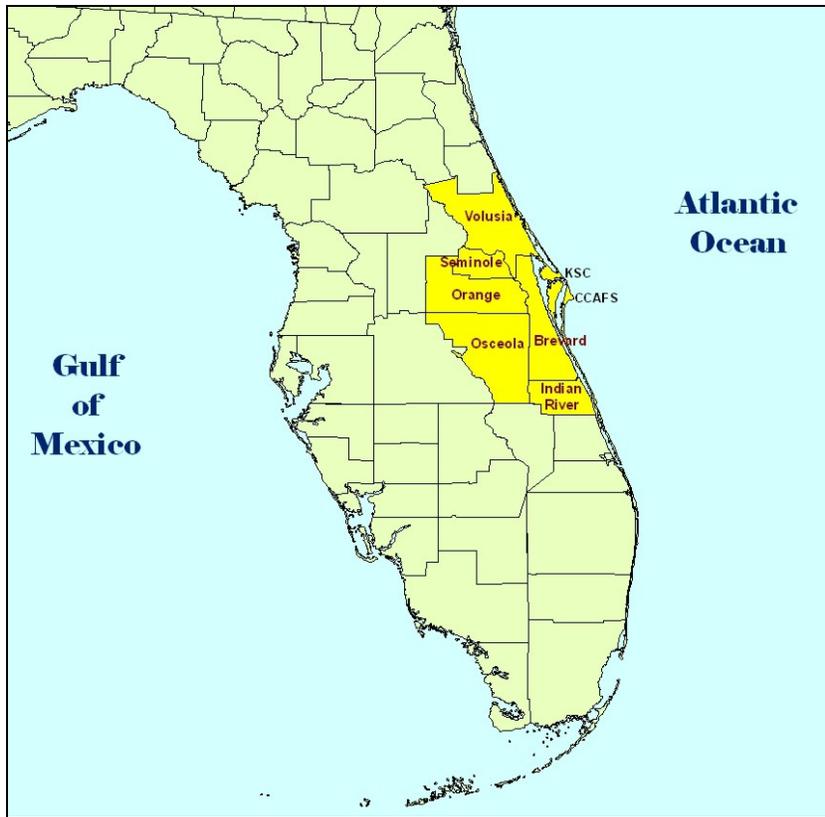
Figure 1. Map of Florida showing the six counties (shaded in yellow) included in the severe weather events database. The location of KSC and CCAFS are shown on the map and both reside in Brevard County.
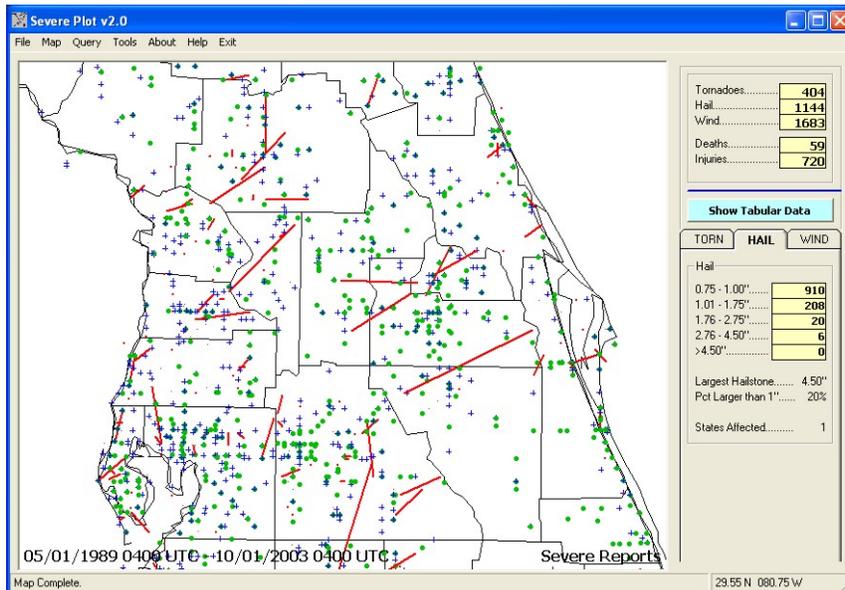
Figure 2.   Screen capture from the SPC *SeverePlot* graphical database program. All reports of tornadoes, hail ≥ 0.75 inches and convective surface winds ≥ 50 knots from 5/1/89 – 10/1/03 over central Florida are shown. Tornadoes are represented by the red dots, tornado tracks by the red lines, hail by the green dots, and convective wind events by the blue plus signs.

The SPC and NCDC databases were merged into one database for this task since both contained some severe weather events the other did not have. The final database included only severe weather events in the six east central Florida counties for 1989 – 2003 and only during the warm season (May – September). The commercial-off-the-shelf graphical information system software package ESRI® ArcMap™ was used to display all tornado, hail and wind events included in the database used for this task (Figure 3).
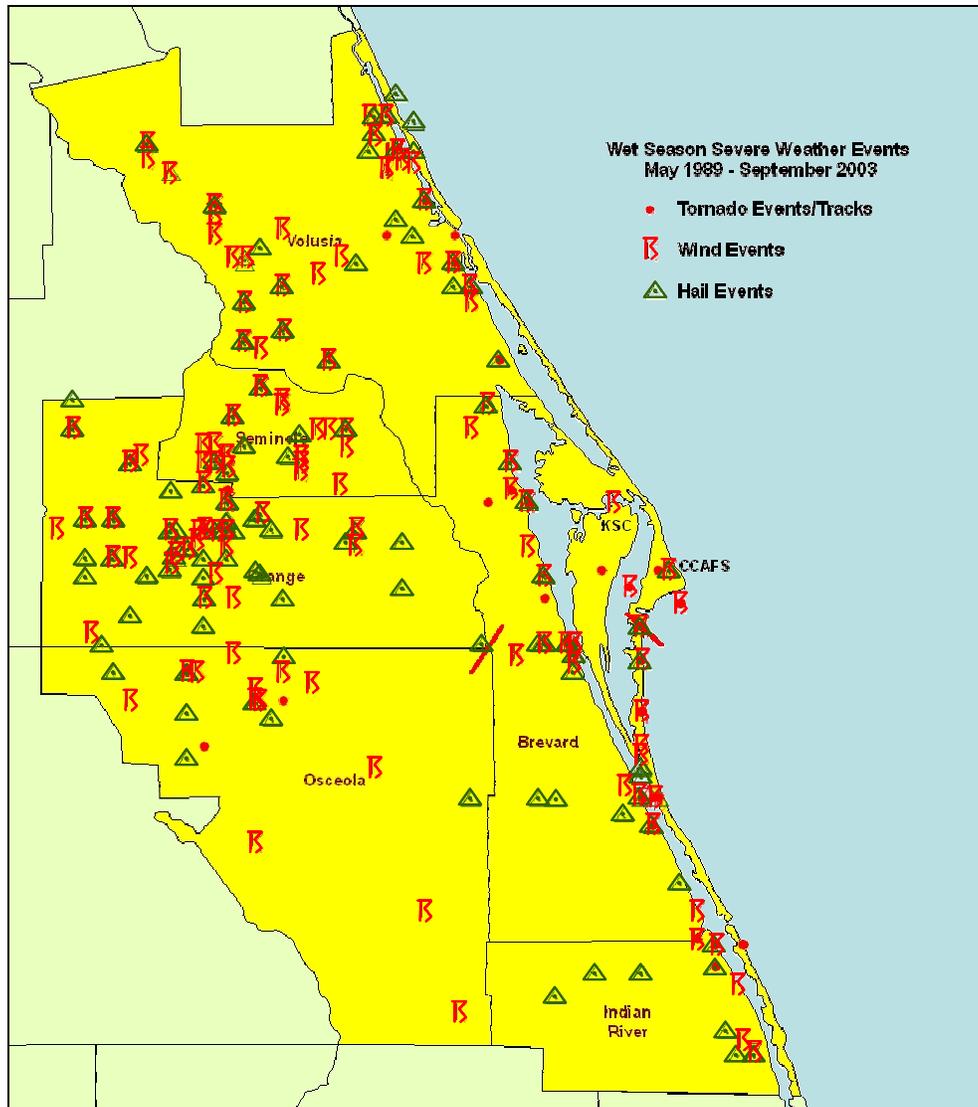
Figure 3. Locations of all tornado, wind, and hail events in the database used for this task. Tornadoes are represented by the red dots, tornado tracks by the red lines, hail by the green triangles, and wind events by the red severe thunderstorm symbols.

The database contained a total of 635 reported severe weather events of which 40 were tornadoes, 270 hail, and 325 wind gust. Many of the reports in the database are recorded at the same latitude and longitude resulting in fewer than 635 plots in Figure 3. The reason they are recorded at the same latitude and longitude is because the storm data is entered into the NCDC and SPC databases as a distance in miles and a direction on 16-point compass scale from a known location, usually a town or city. For example: 4.5 miles ESE Orlando. The NWS uses a database of over 106,000 cities and towns including their latitudes and longitudes. Using an algorithm, the location 4.5 miles ESE of Orlando can be derived from the known latitude and longitude of Orlando. These latitude and longitude pairs are generated by the NWS and populated into the database (NCDC 2004).

Of the 635 reported severe weather events, rawinsonde data from the morning (~1000 UTC) sounding at CCAFS was available for 364 days (some of the days had multiple severe events). The rawinsonde data were

available for 27 tornadoes, 137 hail events, and 200 wind events. It is important to note that the database contains only those severe weather events that were reported by human observers (general public, law enforcement, NWS spotters, etc.). Severe weather events can only be recorded when observed by people in the vicinity, and then only if the proper authorities are notified. Results from a study by the KSC Weather Office (Ward 2004) indicated that many severe weather events likely go unreported in east central Florida due to low population densities in many areas of the six-county region. For the 15 year period, for days with a morning CCAFS rawinsonde that could be used to compute stability indices, about 82% of all days had lightning observed by the CGLSS in at least one of the six counties considered while only 13% of these days had reported severe weather. This does not mean severe weather did not occur on the other 87% of the days with lightning, it just was not reported. When interstate highways and major roads are superimposed on the map from Figure 3 as shown in Figure 4, there is a clear correlation between severe weather reports and population/popular roadways. This fact makes the unambiguous separation of severe weather days from non-severe weather days in the database impossible. Severe weather days are more accurately described as "reported" severe weather days. However, in order to determine relationships between the data and severe weather occurrence, an assumption had to be made that severe weather only occurred on reported severe weather days. In this work, days with reported severe weather were classified as severe days, days with CGLSS-observed lightning were classified as lightning days, and days with no CGLSS-observed lightning or reported severe weather were classified as non-lightning days.
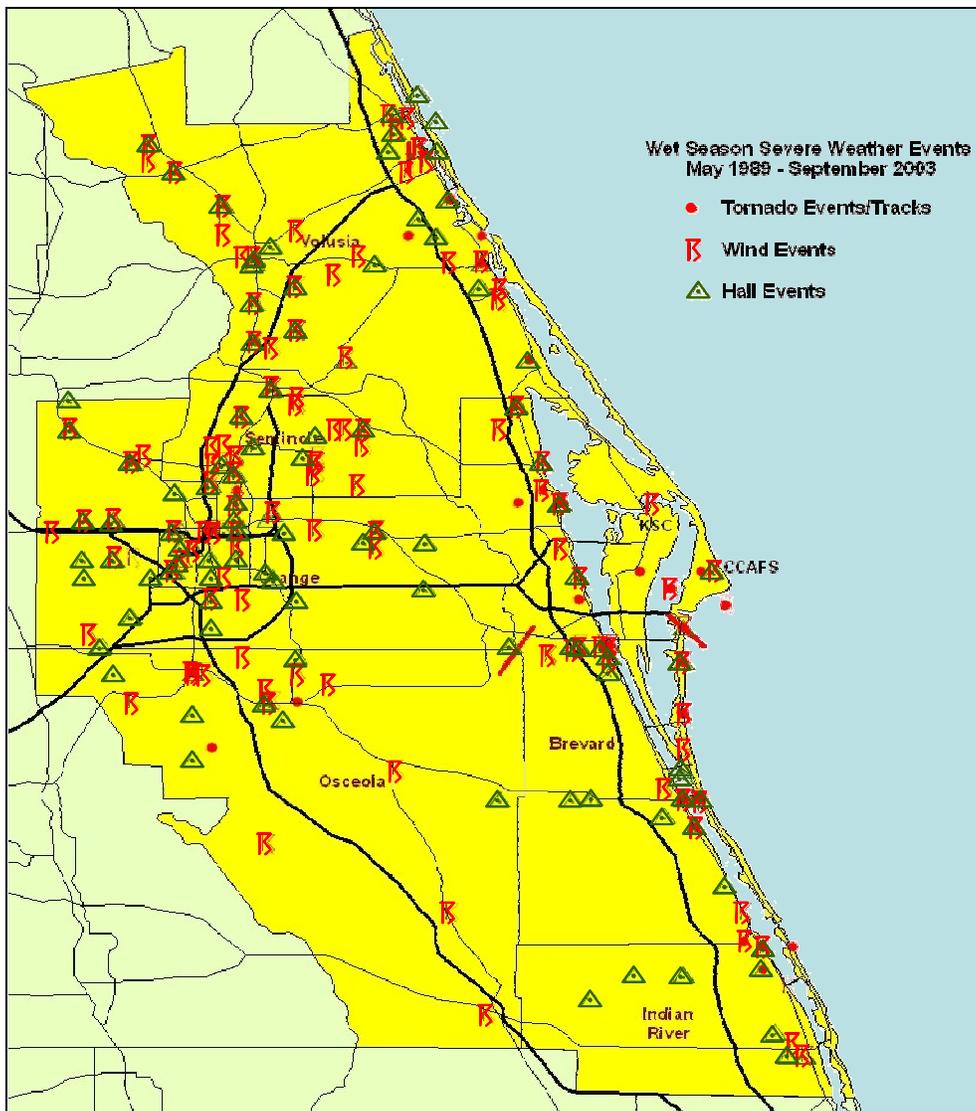
Figure 4. Interstate highways (thick black lines) and major roads (thin black lines) superimposed on the severe weather events map.

2.3 CGLSS

The CGLSS is a lightning detection network of six sensors (Figure 5) that collects date/time, latitude/longitude, strength, and polarity information of cloud-to-ground strikes in the local area. The CGLSS data provided to the AMU covered a 2° x 2° latitude/longitude area approximately centered at KSC as shown in Figure 5. The CGLSS data were required to segregate the days with lightning from days without lightning. Even though the goal of this task was to increase the objectivity of and improve severe weather forecasts, it became obvious during the synoptic pattern and atmospheric stability analyses that it would be difficult to distinguish severe weather days from all other days with significant objectivity. It was decided to first determine if there was an objective way to forecast days without lightning versus days with lightning, regardless of whether or not a severe weather event was reported. This was accomplished by first converting the CGLSS data from ASCII format files into dBase IV format files for input into the commercial-off-the-shelf graphical information system software package ESRI® ArcMap™. Using this software, the lightning strikes were plotted on a central Florida map to determine the days that lightning occurred. The CGLSS data were plotted for each warm season day. As stated in Section 2.2, if a CG lightning strike occurred within one of the six counties, the day was considered a lightning day. An example of a CGLSS plot from 6 August 1994 is shown in Figure 6.
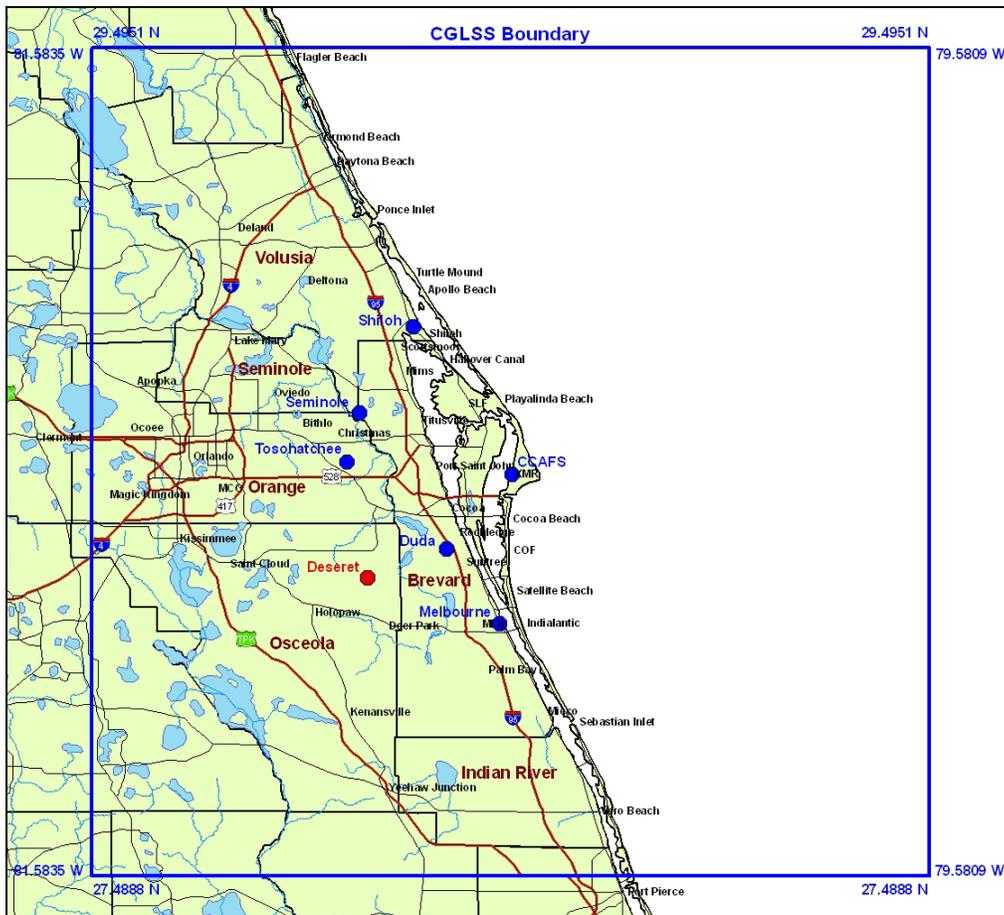
Figure 5.   The locations of the six CGLSS sensors in the network during the period of record for the data in this task (1989 – 2003) are indicated by the blue octagons. The names of each location are next to the octagon. In early 2004, the Duda site was moved to Deseret which is shown as a red octagon. The blue box represents the boundary of the coverage of CGLSS data and is about 2° x 2° latitude/longitude centered on KSC.
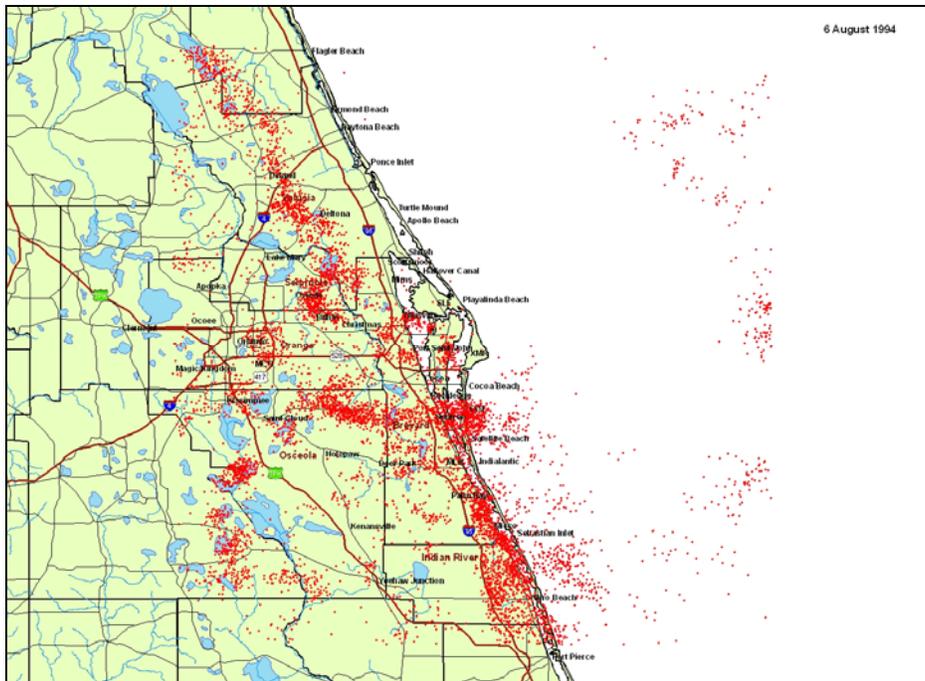
Figure 6. Example of a CGLSS plot from 6 August 1994. Each red dot represents one lightning strike as observed by the CGLSS.

Although not directly part of this task, the CGLSS data were tabulated to produce statistics to include the number of lightning days per county and the KSC/CCAFS area, percent of lightning days per county and KSC/CCAFS area, and daily lightning strikes for all six counties. Examples of the data charts are shown in Figure 7 and Figure 8. The data are available in Excel format on CD-ROM. Additionally, an interactive web-based tool was produced for easy interrogation of the CGLSS maps and provided on CD-ROM. A screen shot of the web-based CGLSS tool is shown in Figure 9.
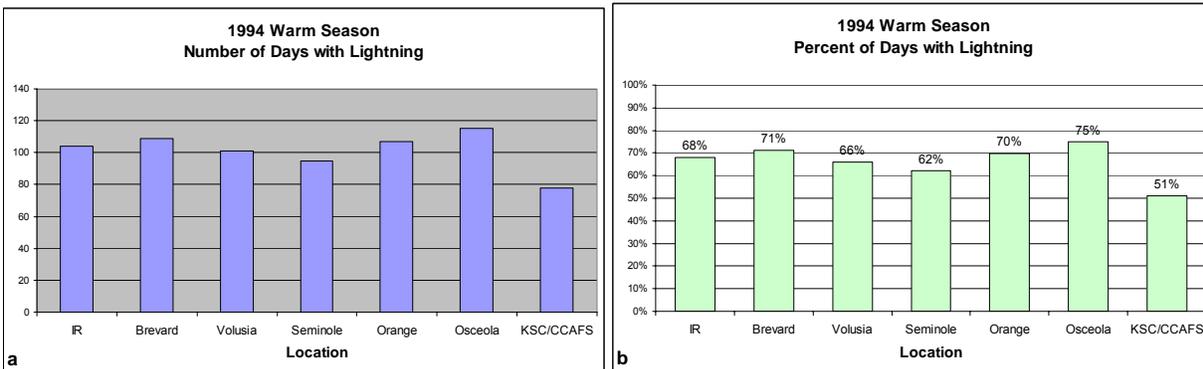
Figure 7. Examples of CGLSS data showing (a) number and (b) percent of CG lightning strikes by county and KSC/CCAFS for the 1994 warm season.
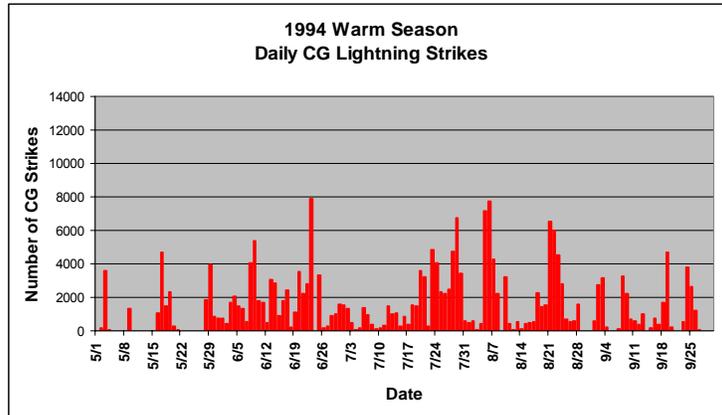
Figure 8. Example of CGLSS number of daily CG lightning strikes for the six counties in east central Florida for the 1994 warm season.
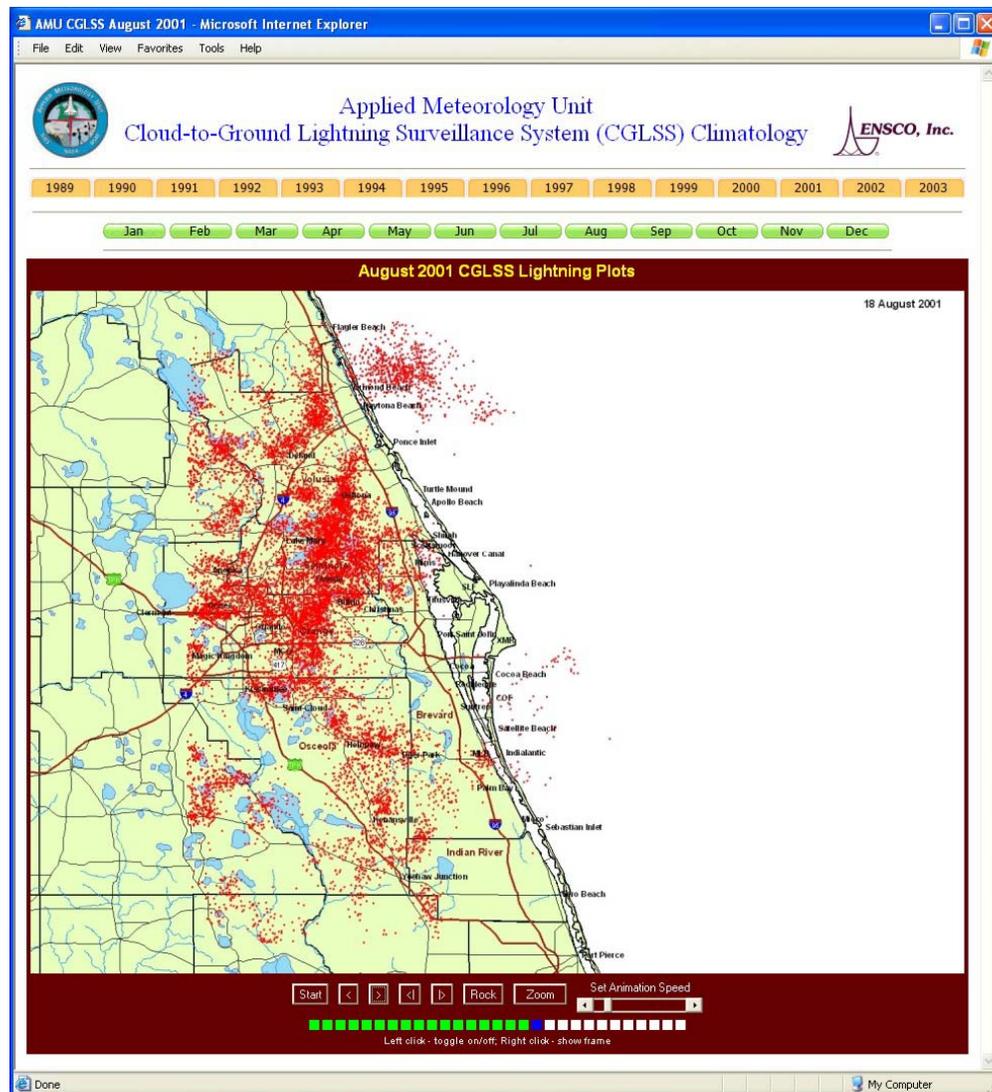
Figure 9. Screen shot of the interactive web based tool used to view CGLSS maps.

2.4 Synoptic Weather Patterns

The synoptic weather patterns investigated included the position of the upper level jet streak (if any) and position of the surface high pressure ridge axis over east central Florida. It is commonly known that upper level divergence and/or a jet streak exit region in the vicinity of convective systems can help produce severe weather. Historical upper air charts similar to the example in Figure 10 were evaluated for each day in the 15-year period and one of five criteria were entered into the database. The upper level criteria under consideration were:

- Jet streak not present,

- Jet streak overhead,

- Jet exit region overhead,

- Upper level divergence overhead, or

- Jet position undetermined.
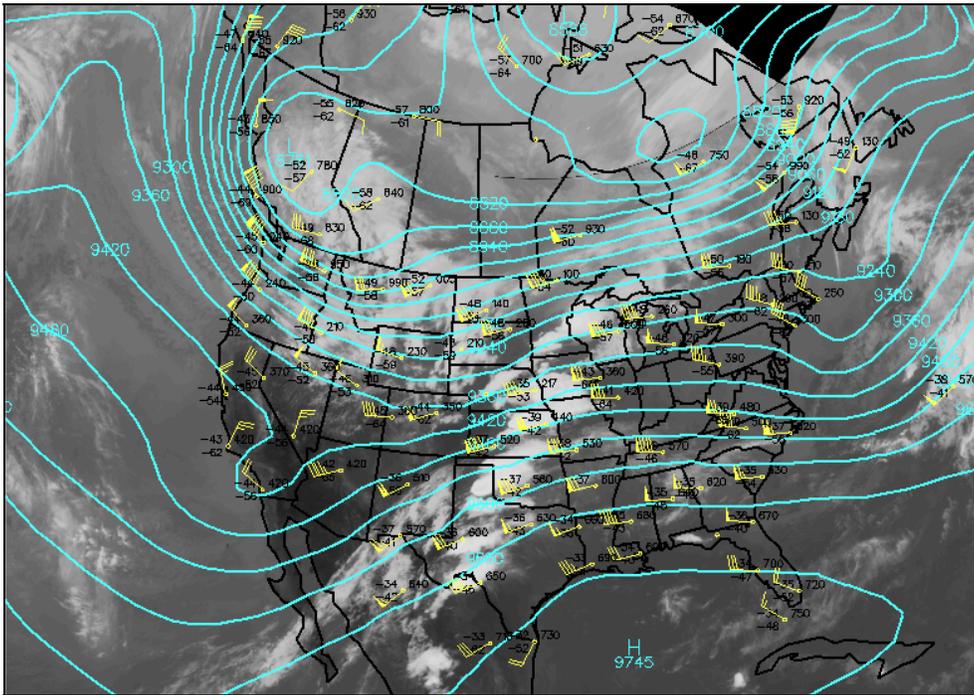
Figure 10.   Example of a 300 mb upper air chart used to determine flow aloft over east central Florida.

The 45 WS forecasters often analyze the position of the surface high pressure ridge axis protruding westward form the Bermuda high pressure center as an indicator for convection occurrence. It is generally accepted that if the surface ridge is south of the KSC/CCAFS area the chance for convection is increased. Historical surface maps similar to that shown in Figure 11 were evaluated for each day in the 15-year period and the position of the surface high pressure ridge was characterized as

- No surface high pressure ridge,

- High pressure ridge north of KSC/CCAFS, or

- High pressure ridge south of KSC/CCAFS.
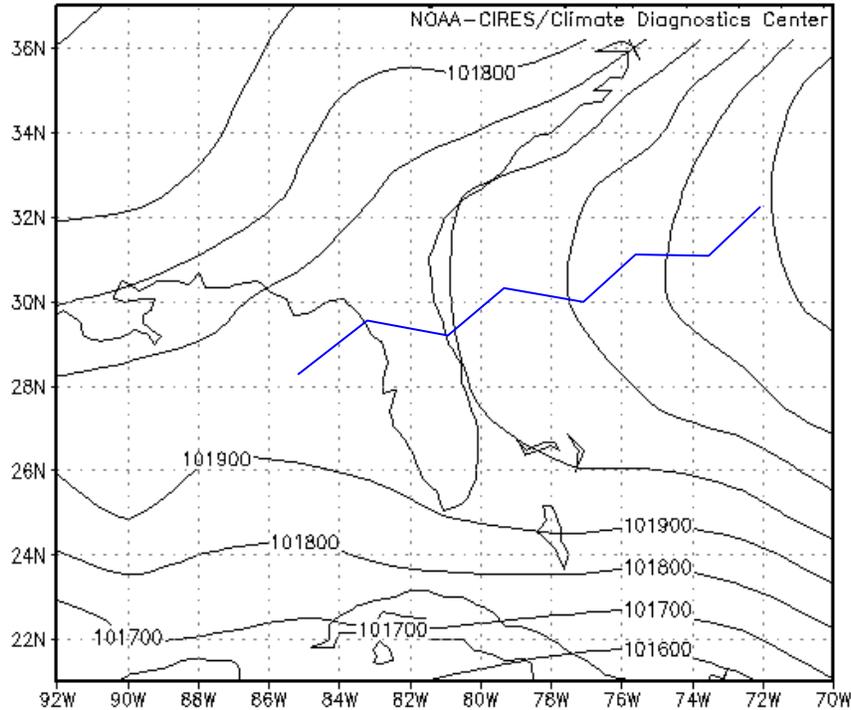
Figure 11.   Example of a surface map used to determine the position of the surface ridge over east central Florida. The high pressure ridge axis is highlighted by the jagged blue line.

2.5   Sounding Stability Parameters

A thorough analysis of atmospheric stability based on a local upper air sounding is needed for any convective forecast. The 45 WS Severe Weather Worksheet (Appendix A) analyzes four stability indices.

- Lifted Index (LI),
- K-Index (KI),
- Total Totals (TT), and
- Showalter Stability Index (SSI).

These indices are calculated from the 1000 UTC CCAFS rawinsonde via the Meteorological Interactive Data Display System (MIDDS). These four indices and nine others that are readily available via MIDDS from the CCAFS rawinsonde were evaluated for each day in the database. They include the

- Severe Weather Threat Index (SWEAT),
- Cross Totals (CT),
- Thompson Index (TI),
- Convective Available Potential Energy (CAPE),
- Precipitable Water (PW),
- Convective Inhibition (CIN),
- Helicity,
- CAPE based on Maximum Equivalent Potential Temperature (CAPE Maxθ_e), and
- CAPE based on Maximum Forecast Temperature (CAPE FMaxT).

A summary of how each stability index was calculated is shown in Table 1.

Table 1. Stability parameters and the equations used in their calculation.		
Index	**Units**	**Calculation**
LI		$(T_{500} - T^*)$
		T* = Temperature of a parcel characterized by the mean T_d in the lowest 3000ft and the forecast maximum surface temperature if it were lifted dry adiabatically to saturation and then moist adiabatically to 500 mb.
KI		$(T_{850} - T_{500}) + T_{d850} - (T_{700} - T_{d700})$
TI		$KI - LI$ *or* $[(T_{850} - T_{500}) + T_{d850} - (T_{700} - T_{d700})] - [(T_{500} - T^*)]$
TT		$(T_{850} - T_{500}) + (T_{d850} - T_{500})$
SSI		$(T_{500} - T^*)$
		T* = Temperature a parcel characterized by the T_{850} and T_{d850} would have if it were lifted dry-adiabatically to the LCL and then moist-adiabatically to 500 mb.
SWEAT		$12D + 20(T-49) + 2F8 + F5 + 125(S + 0.2)$
		D = T_{d850} (if D is negative, then 12D = 0) *F8 = 850 mb wind speed in knots* *F5 = 500 mb wind speed in knots* *S = sin(500 mb – 850 mb wind direction)* *T = Total Totals (If T is less than 49, the term [20 (T-49)] is set to zero)*
CT		$(T_{d850} - T_{500})$
CAPE	J/kg	$-R\int_{p_{LFC}}^{p_{EL}} (T - \overline{T}) \, d\ln p$
		R = Universal gas constant *p_{EL} = Pressure at the equilibrium level* *p_{LFC} = Pressure at the level of free convection* *T = Temperature of the lifted air parcel* *$\overline{T}$ = Temperature of the environment*
CAPE Max θ_e	J/kg	CAPE calculated using the layer with the maximum equivalent potential temperature (θ_e)
CAPE FMaxT	J/kg	CAPE calculated using the forecast maximum temperature for the day instead of the surface temperature in the morning
PW	mm	Precipitable water in the layer from the surface to 500 mb
CIN	J/kg	$-R\int_{p_o}^{p_{LFC}} (T - \overline{T}) \, d\ln p$
		R = Universal gas constant *p_{LFC} = Pressure at the level of free convection* *p_o = Pressure at the surface* *T = Temperature of the lifted air parcel* *$\overline{T}$ = Temperature of the environment*
Helicity	m² s⁻²	$\int_0^{3km} (\vec{V} - \vec{C}) \cdot \left(\hat{k} \times \frac{\partial \vec{V}}{\partial z} \right)$
		$\vec{V}$ = Environmental wind vector *$\vec{C}$ = Storm motion vector* *$\hat{k}$ = Unit vector in the vertical*

3.   Data Analysis Results

The local forecast rules were used to set threat assessment thresholds for the stability parameters, the severe weather events were used to identify days with reported severe weather and the CGLSS data was used to differentiate between lightning and non-lightning days. These three data sets provided the foundation for analyzing the stability parameters and synoptic patterns which are discussed in detail in this section.

3.1   Stability Parameters

The relationship between each stability parameter and threshold criteria for the severe weather threat was calculated for each day-type based on the 1000 UTC CCAFS sounding. The threshold values were provided by one of the following sources in order:

- 45 WS Severe Weather Worksheet,

- Jacksonville NWS Severe Weather Checklist,

- Forecaster experience, or

- Other nationally accepted criteria

The intent was to evaluate if a threshold level could be used as a predictor of severe weather and, if so, if the threshold value needed to be adjusted for the local KSC/CCAFS area. Stacked column graphs were created and statistics calculated to show the relationship between each stability index threshold values and the type of weather day. All of the stability parameters and their potential to forecast severe weather are summarized in Table 3 at the end of Section 3.1.14.

3.1.1   Total Totals

The TT thresholds were derived from the 45 WS Severe Weather Worksheet which specifies that there is a low threat for severe weather when TT < 45, a medium threat when TT is between 46 and 48, and a high threat when TT > 48. These thresholds do not account for TT = 45, so, for this report, it was assumed the low threat would include TT ≤ 45. Referring to Figure 12, there were 118 days out of 1355 with reported severe weather when the severe weather threat was low, 107 days out of 591 with reported severe weather when the severe weather threat was medium and 46 days out of 160 with reported severe weather when the severe weather threat was high. The TT values were in the low range 64% of the days during the warm season. When there was a low threat, lightning without severe weather occurred on 67% of the days and severe weather occurred on 9% of the days, leaving 24% of the days as non-lightning days. Only 8% of warm season days had a TT in the high threat range. But when TT was in the high range, severe days occurred 29% of the time and non-severe lightning days occurred 68% of the time. When the severe weather threat was medium, severe weather days accounted for 18% and non-severe lightning days 75% of the total.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 9% chance of severe weather, 67% chance of lightning without severe weather,

- Medium threat: 18% chance of severe weather, 75% chance of lightning without severe weather, and

- High threat: 29% chance of severe weather, 68% chance of lightning without severe weather.

Figure 12. Stacked column graph of TT value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The 45 WS threat criteria and thresholds are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.2   K-Index

The KI thresholds derived from the 45 WS Severe Weather Worksheet indicate that there is a low threat for severe weather when KI < 26, a medium threat when KI is between 26 and 28, and a high threat when KI > 28. Referring to Figure 13, there were 58 days out of 763 with severe weather when the threat was low, 36 days out of 204 with severe weather when the threat was medium, and 177 days out of 1139 with severe weather when the threat was high. The KI values were in the low range 36% of the days during the warm season. When there was a low threat, lightning without severe weather occurred on 53% of the days and severe weather on 8% of the days. Therefore, 39% of the days were non-lightning days. When the severe weather threat was medium, severe weather days accounted for 18% and lightning without severe weather days for 72% of the total. When the severe weather threat was high, severe days occurred 16% of the time and lightning without severe weather days occurred 80% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 8% chance of severe weather, 53% chance of lightning without severe weather,

- Medium threat: 18% chance of severe weather, 72% chance of lightning without severe weather, and

- High threat: 16% chance of severe weather, 80% chance of lightning without severe weather.

K-Index

Figure 13.   Stacked column graph of KI value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The 45 WS threat criteria and thresholds are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.3   Lifted Index

The LI thresholds derived from the 45 WS Severe Weather Worksheet indicate that there is a low threat for severe weather when LI > -2, a medium threat when LI is between -3 and -5, and a high threat when LI < -5. These thresholds do not account for LI = -2, so it was assumed the low threat would be LI ≥ -2. Referring to Figure 14, there were 122 days out of 1190 with severe weather when the threat was low, 133 days out of 853 with severe weather when the threat was medium and 16 days out of 63 with severe weather when the threat was high. The LI values were in the low range (LI ≥ -2) 57% of the days during the warm season. When there was a low threat, lightning without severe weather occurred on 62% of the days and severe weather occurred on 10% of the days. Therefore, 28% of the days were non-lightning days. When the severe weather threat was medium, severe weather days accounted for 16% and lightning days without severe weather for 80% of the total. The LI value was in the high threshold range on only 3% of warm season days. When the LI value indicated a high threat, severe days occurred 25% of the time and lightning days without severe weather occurred 71% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 10% chance of severe weather, 62% chance of lightning without severe weather,

- Medium threat: 16% chance of severe weather, 80% chance of lightning without severe weather, and

- High threat: 25% chance of severe weather, 71% chance of lightning without severe weather.

Lifted Index

Figure 14.   Stacked column graph of LI value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The 45 WS threat criteria and thresholds are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.4   Thompson Index

The TI thresholds were derived from the 88th Weather Squadron's *Guide to Thunderstorm Stability Indices* (88th Weather Squadron 2004) which specifies no thunderstorms when TI < 25, possible thunderstorm occurrence when TI is between 25 and 34, strong thunderstorms when TI is between 35 and 39, and potentially severe thunderstorms when TI ≥ 40. Referring to Figure 15, there were 37 days out of 637 with reported severe weather when the threat was low, 125 days out of 758 with reported severe weather when the threat was medium, 84 days out of 539 with reported severe weather when the threat was high and 25 out of 119 with reported severe weather when the threat was very high. The TI values were in the low range 31% of the days during the warm season. When there was a low threat, lightning without severe weather occurred on 48% of the days and severe weather occurred on 6% of the days. Therefore, 46% of the days were non-lightning days. When the severe weather threat was medium, severe weather days accounted for 16% and lightning days without severe weather for 75% of the total. When the severe weather threat was high, severe weather days accounted for 16% and lightning days without severe weather for 82% of the total. The TI values were at the very high end of the threat range on 6% of warm season days. When there was a very high threat, severe days occurred 21% and lightning days without severe weather occurred 79% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 6% chance of severe weather, 48% chance of lightning without severe weather,

- Medium threat: 16% chance of severe weather, 75% chance of lightning without severe weather,

- High threat: 16% chance of severe weather, 82% chance of lightning without severe weather, and

- Very high threat: 21% chance of severe weather, 79% chance of lightning without severe weather.

Figure 15.   Stacked column graph of LI value thresholds. Stacked column graph of LI value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The 88th Weather Squadron threat criteria are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.5 SWEAT

The SWEAT thresholds were derived from the Jacksonville NWS Severe Weather Checklist which specifies a low threat when SWEAT < 200, moderate when SWEAT is between 200 and 300, high when SWEAT is between 301 and 400, very high when SWEAT is between 401 and 500, and extreme when SWEAT > 500. There were no SWEAT values above 400 in the database so the Jacksonville NWS severe weather threat criteria for very high and extreme were not used, and their moderate threat was named medium here for consistency. Referring to Figure 16, there were 165 days out of 633 with severe weather when the threat was low, 91 days out of 1441 with severe weather when the threat was "medium", 15 days out of 32 with severe weather when the threat was high. When there was a low threat, lightning without severe weather occurred on 42% of the days and severe weather occurred on 26% of the days. Therefore, 32% of the days were non-lightning days. When the severe weather threat was medium, severe weather days accounted for 6% and lightning days without severe weather for 82% of the total. The SWEAT values were in the high range on only 2% of warm season days. When the SWEAT values were in the high range, severe days occurred 47% and lightning days without severe weather occurred 47% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 26% chance of severe weather, 42% chance of lightning without severe weather,

- Medium threat: 6% chance of severe weather, 82% chance of lightning without severe weather, and

- High threat: 47% chance of severe weather, 47% chance of lightning without severe weather.
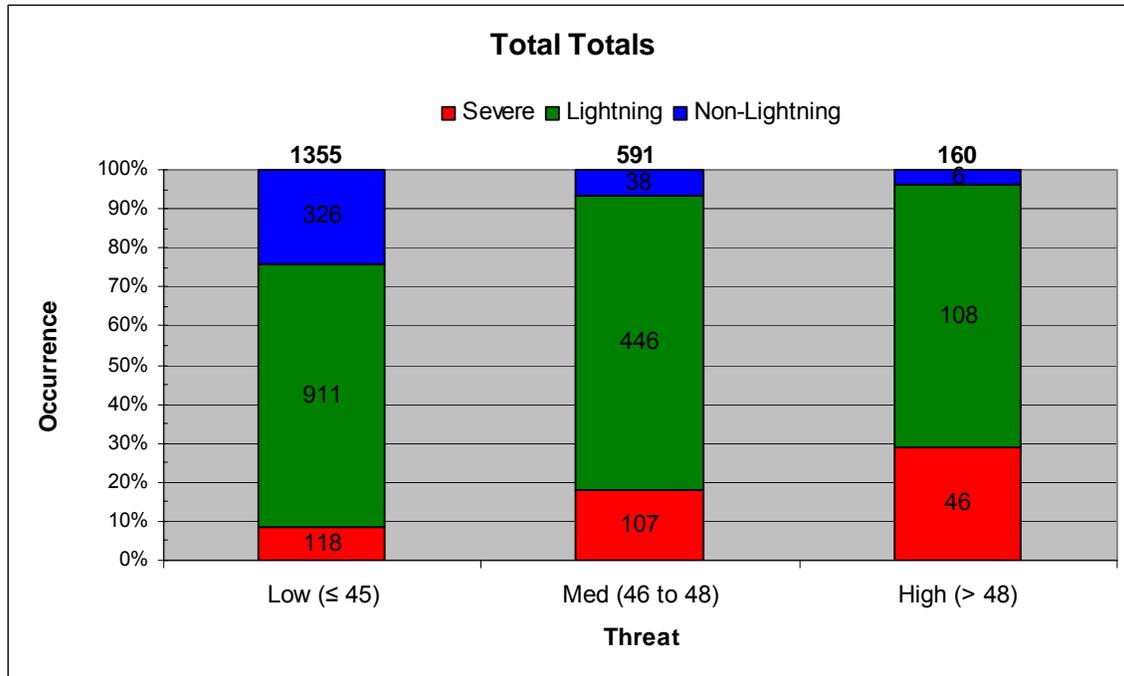
Figure 16.   Stacked column graph of SWEAT value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The modified Jacksonville NWS threat criteria are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.6 Precipitable Water

The PW thresholds were derived from discussions with the 45 WS. A low threat is generally assumed when PW < 1.00 in, medium when PW is between 1.00 in and 1.50 in, and high when PW > 1.50 in. Referring to Figure 17, there were 3 days out of 90 with severe weather when the threat was low, 54 days out of 585 with severe weather when the threat was medium and 215 days out of 1431 with severe weather when the threat was high. The PW values were in the low range 4% of the days during the warm season. When there was a low threat, lightning without severe weather occurred on 20% of the days and severe weather occurred on 3% of the days. Therefore, 77% of the days were non-lightning days. When the severe weather threat was medium, severe weather days accounted for 9% and lightning days without severe weather for 53% of the total. The PW values were in the high range on 68% of warm season days. When PW was high, severe days occurred 15% of the time and lightning days without severe weather occurred 79% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 3% chance of severe weather, 20% chance of lightning without severe weather,

- Medium threat: 9% chance of severe weather, 53% chance of lightning without severe weather, and

- High threat: 15% chance of severe weather, 79% chance of lightning without severe weather.
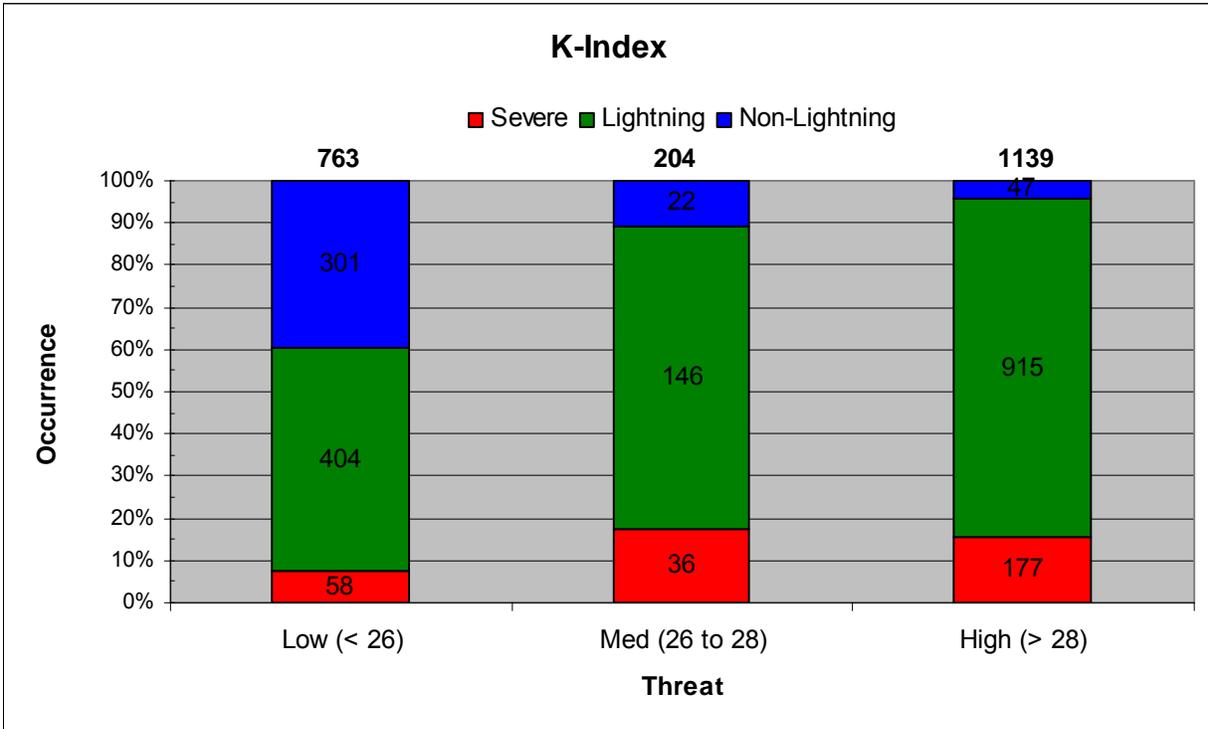
Figure 17.   Stacked column graph of PW value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The local forecast rules threat criteria are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.7   Showalter Stability Index

The SSI thresholds derived from the 45 WS Severe Weather Worksheet indicate that there is a low threat when SSI $\geq$ 3, a medium threat when SSI is between 2 and -2, and a high threat when SSI < -2. Referring to Figure 18, there were 61 days out of 842 with severe weather when the threat was low, 198 days out of 1226 with severe weather when the threat was medium, 12 days out of 38 with severe weather when threat was high. When there was a low threat, lightning without severe weather occurred on 58% of the days and severe weather occurred on 7% of the days. Therefore, 35% of the days were non-lightning days. When the severe weather threat was medium, severe weather days accounted for 16% and lightning days without severe weather for 78% of the total. The SSI values were in the high range on only 2% of warm season days. When SSI was in the high range, severe days occurred 32% of the time and lightning days without severe weather occurred 68% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 7% chance of severe weather, 58% chance of lightning without severe weather,

- Medium threat: 16% chance of severe weather, 78% chance of lightning without severe weather, and

- High threat: 32% chance of severe weather, 68% chance of lightning without severe weather.
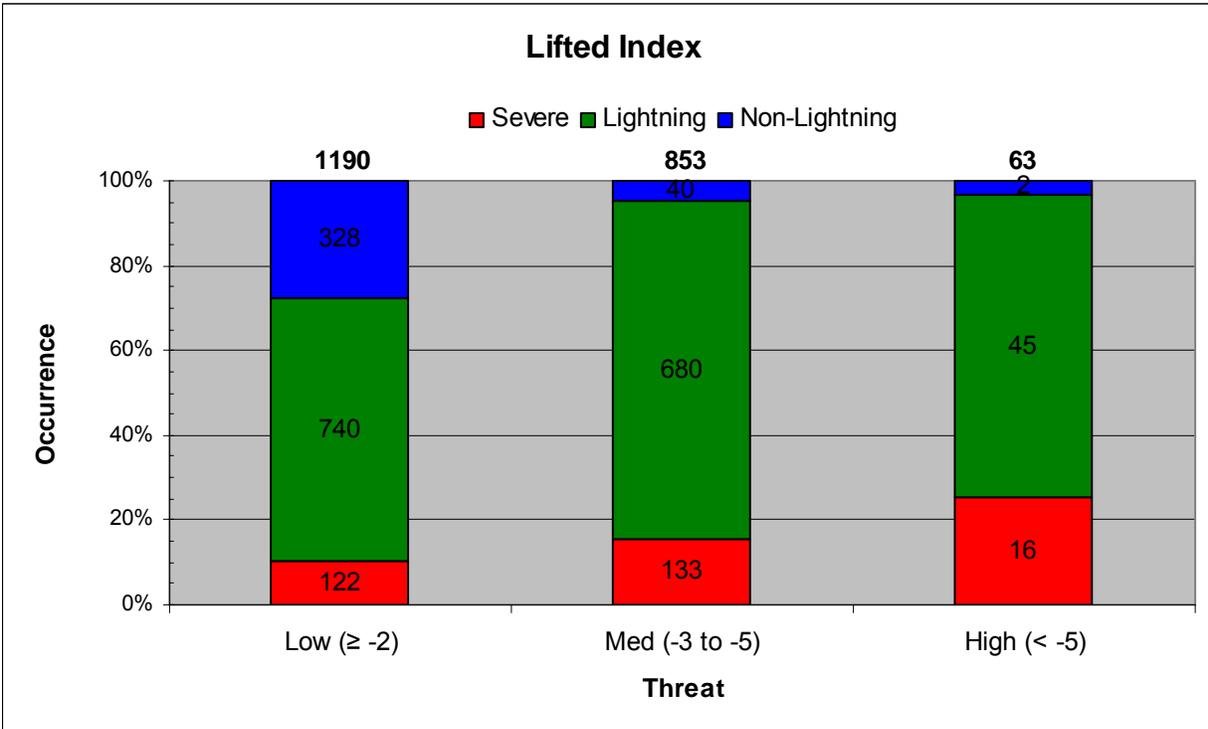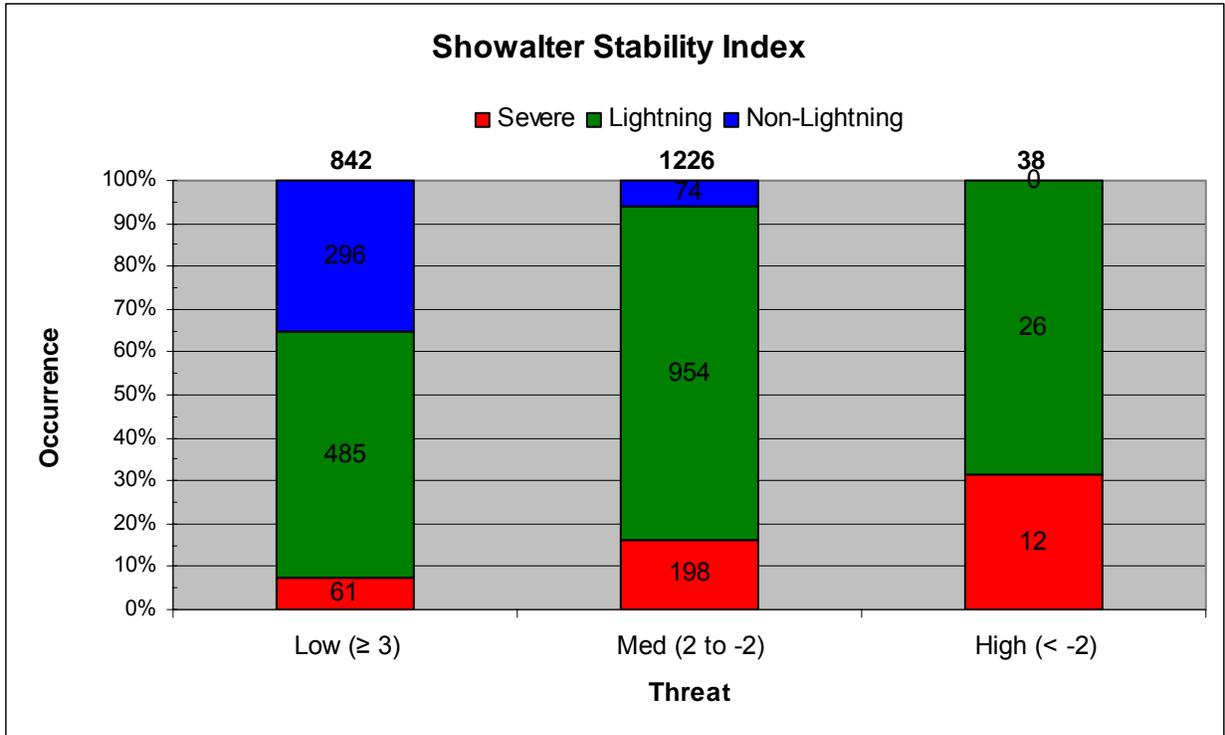
Figure 18.   Stacked column graph of SSI value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The 45 WS threat criteria are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.8 Cross Totals

The CT thresholds were derived from the threat criteria in the NWS Southern Region Headquarters (SRH) online glossary (NWS SRH 2005). Table 2 is from the glossary and shows the criteria for CT east of the Rockies. Based on the range of CT values in the stability database compared with those in Table 2, the severe threat levels were defined as low, medium, high, and very high. The threat level was defined as low when CT ≤ 19, medium when CT was between 20 and 21, high CT was between 22 and 23, and very high when CT ≥ 24.

Table 2.   NWS Southern Region Headquarters criteria for Cross Totals east of the Rockies from their online glossary.

Cross Totals (CT)	Forecast
18-19	Isolated or few thunderstorms
20-21	Scattered thunderstorms
22-23	Scattered thunderstorms, isolated severe
24-25	Scattered thunderstorms, few severe, isolated tornadoes
26-29	Scattered to numerous thunderstorms, few to scattered severe, few tornadoes
30	Numerous thunderstorms, scattered severe, scattered tornadoes

Referring to Figure 19, there were 88 days out of 905 with severe weather when the threat was low, 89 days out of 622 with severe weather when the threat was medium, 61 days out of 457 with severe weather when the threat was high, and 33 days out of 122 with severe weather when the threat was very high. When there was a low threat, lightning without severe weather occurred on 61% and severe weather on 10% of the days. When the severe weather threat was medium, severe weather days accounted for 14% and lightning days without severe weather for 75% of the total. When the severe weather threat was high, severe weather days accounted for 13% and lightning days without severe weather 79% of the total. The CT values were in the very high threat range on only 6% of warm season days. When CT was very high, severe days occurred 27% and lightning days without severe weather 70% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 10% chance of severe weather, 61% chance of lightning without severe weather,

- Medium threat: 14% chance of severe weather, 75% chance of lightning without severe weather,

- High threat: 13% chance of severe weather, 79% chance of lightning without severe weather, and

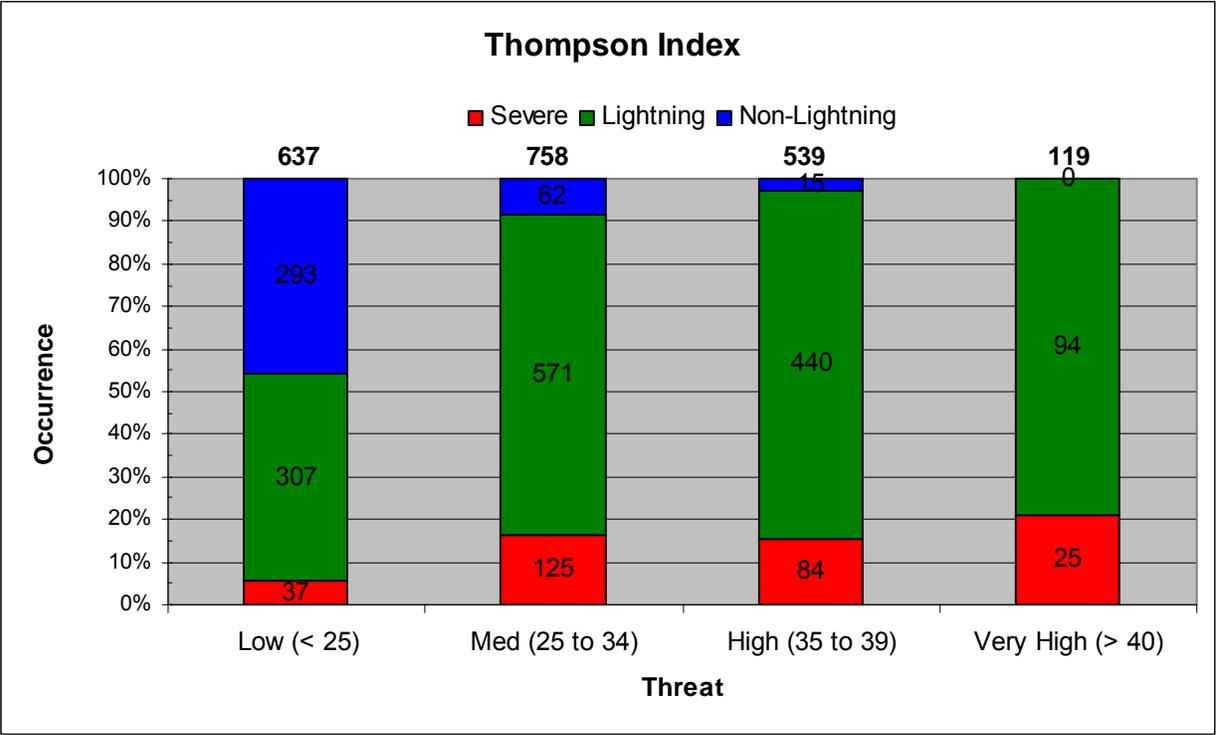- Very high threat: 27% chance of severe weather, 70% chance of lightning without severe weather.

Figure 19.   Stacked column graph of CT value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The threat criteria are based on a modified version of the NWS SRH online glossary (NWS SRH 2005) and are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.9   CAPE

The CAPE thresholds were derived from the Jacksonville NWS Severe Weather Checklist which specifies that the threat is low when CAPE < 500 (units in J/kg), moderate when CAPE is between 501 and 1000, high when CAPE is between 1001 and 2500, very high when CAPE is between 2501 and 3500, and extreme when CAPE > 3500. There were no CAPE values above 3000 in the stability indices database for this task so the extreme threat category was not used. Referring to Figure 20, there were 75 days out of 588 with severe weather when the threat

was low, 69 days out of 562 with severe weather when the threat was medium, 107 days out of 684 with severe weather when the threat was high and 5 days out of 26 with severe weather when the threat was very high. When there was a low threat, lightning without severe weather occurred on 68% and severe weather on 13% of the days. Therefore, 20% of the days were non-lightning days. When the severe weather threat was medium, severe weather days accounted for 12% and lightning days without severe weather for 75% of the total. When the severe weather threat was high, severe weather days accounted for 16% and lightning days without severe weather for 80% of the total. The CAPE values were in the very high threat range on only 1% of warm season days. When the CAPE values were in the very high range, severe days occurred 19% and lightning days without severe weather 81% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 13% chance of severe weather, 68% chance of lightning without severe weather,

- Medium threat: 12% chance of severe weather, 75% chance of lightning without severe weather,

- High threat: 16% chance of severe weather, 80% chance of lightning without severe weather, and

- Very high threat: 19% chance of severe weather, 81% chance of lightning without severe weather.
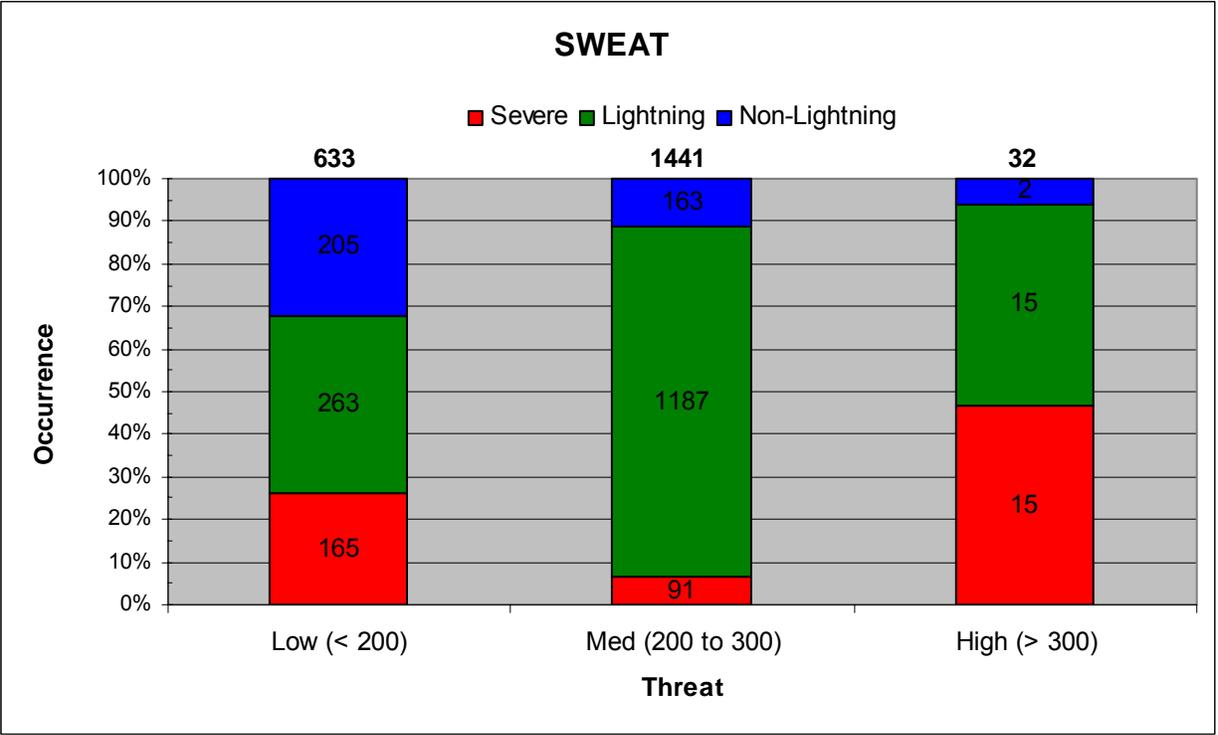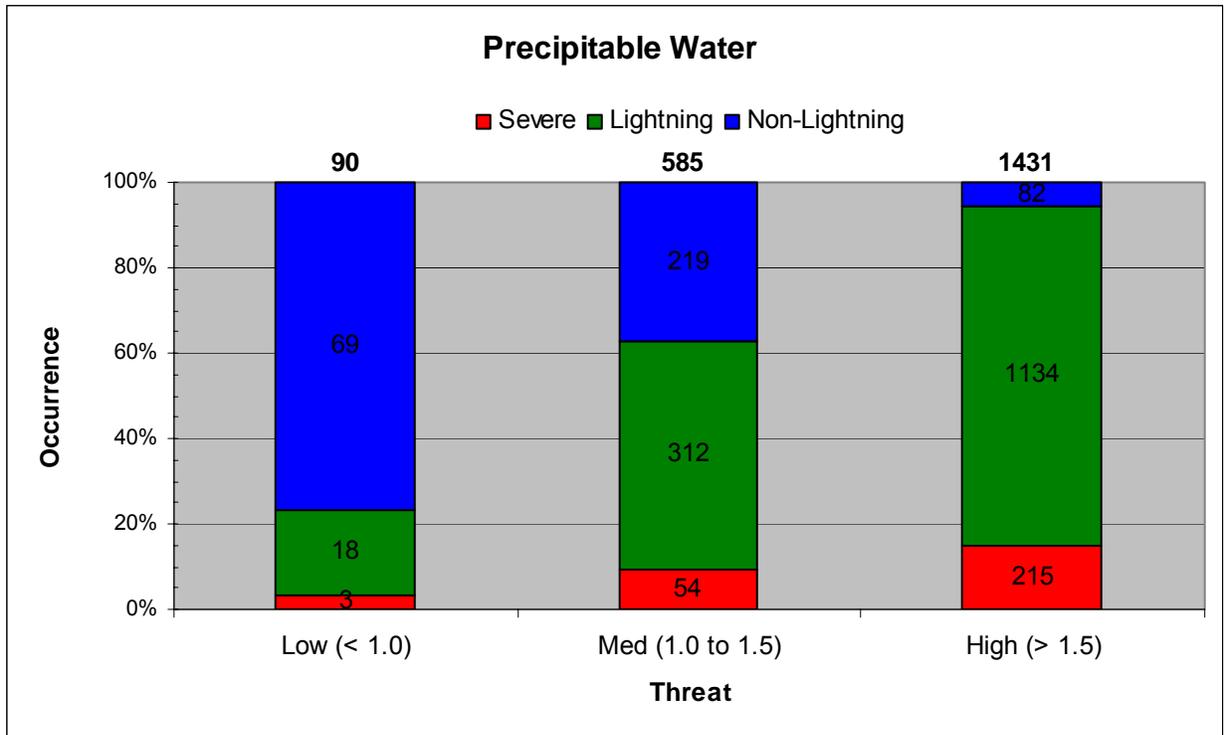

Figure 20.   Stacked column graph of CAPE value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The Jacksonville NWS threat criteria are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.10 CAPE Max θ_e

The CAPE Max θ_e thresholds were derived from the Jacksonville NWS Severe Weather Checklist for CAPE, which are defined in Section 3.1.9. Referring to Figure 21, there were 11 days out of 108 with severe weather when the threat was low, 22 days out of 256 with severe weather when the threat was medium, 131 days out of 918 with severe weather when the threat was high, 68 days out of 476 with severe weather when the threat was very high and 32 days out of 186 with severe weather when the threat was extreme. When there was a low threat, lightning without severe weather occurred on 54% and severe weather on 10% of the days. The CAPE Max θ_e values were in the

extreme range on 10% of warm season days. When the severe weather threat was medium, severe weather days accounted for 9% and lightning days without severe weather for 65% of the total. When the severe weather threat was high, severe weather days accounted for 15% and lightning days without severe weather for 74% of the total. When the severe weather threat was very high, severe weather days accounted for 14% and lightning days without severe weather for 76% of the total. When the CAPE Max θ_e values were in the extreme range, severe days occurred 17% and lightning days without severe weather 78% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 10% chance of severe weather, 54% chance of lightning without severe weather,

- Medium threat: 9% chance of severe weather, 65% chance of lightning without severe weather,

- High threat: 15% chance of severe weather, 74% chance of lightning without severe weather,

- Very high threat: 14% chance of severe weather, 76% chance of lightning without severe weather, and

- Extreme threat: 17% chance of severe weather, 78% chance of lightning without severe weather.
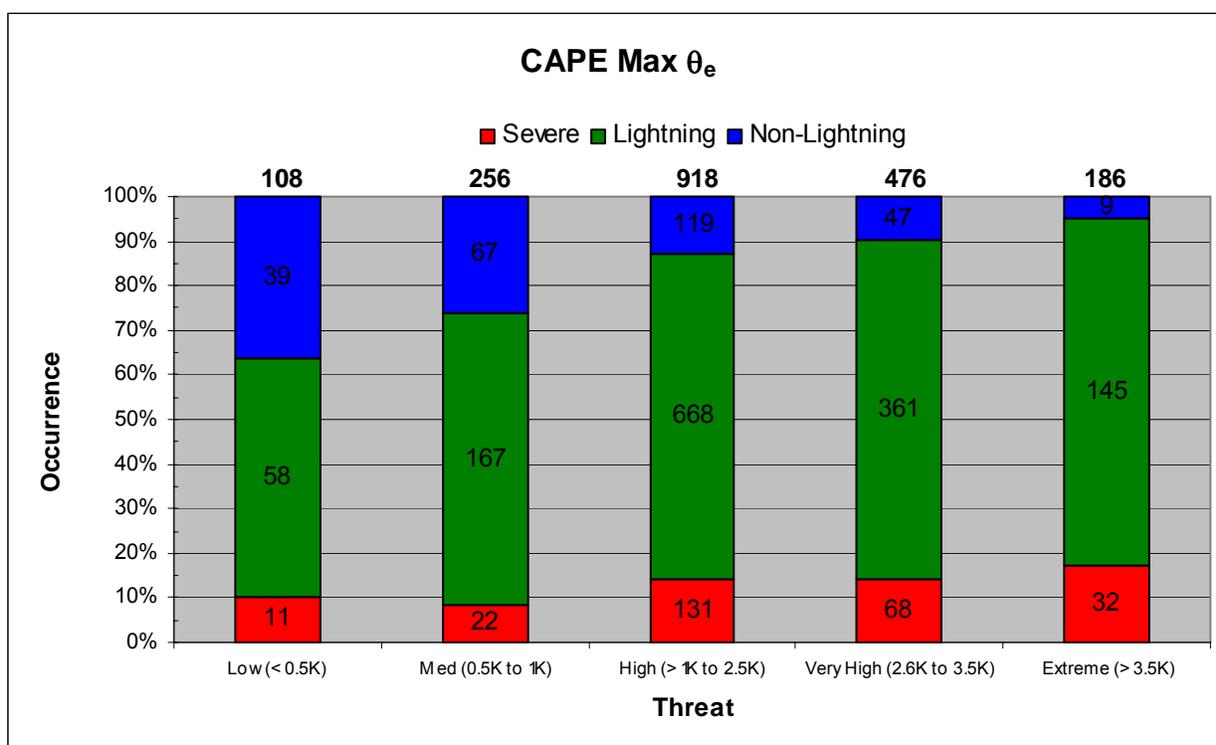
Figure 21. Stacked column graph of CAPE Max θ_e value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The Jacksonville NWS threat criteria are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.11 CAPE FMaxT

The CAPE FMaxT thresholds were derived from the Jacksonville NWS Severe Weather Checklist for CAPE, which are defined in Section 3.1.9. Referring to Figure 22, there were 18 days out of 252 with severe weather when the threat was low, 462 days out of 379 with severe weather when the threat was medium, 169 days out of 1172 with severe weather when the threat was high, 26 days out of 162 with severe weather when the threat was very high and 6 days out of 9 with severe weather when the threat was extreme. When there was a low threat, lightning without severe weather occurred on 54% and severe weather on 7% of the days. When the severe weather threat was medium, severe weather days accounted for 12% and lightning days without severe weather for 69% of the total.

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When the severe weather threat was high, severe weather days accounted for 14% and lightning days without severe weather for 76% of the total. When the severe weather threat was very high, severe weather days accounted for 16% and lightning days without severe weather for 81% of the total. The CAPE FMaxT values were in the extreme range on only 0.5% of warm season days. When the CAPE FMaxT values were extreme, severe days occurred 67% and lightning days without severe weather 33% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 7% chance of severe weather, 54% chance of lightning without severe weather,

- Medium threat: 12% chance of severe weather, 69% chance of lightning without severe weather,

- High threat: 14% chance of severe weather, 76% chance of lightning without severe weather,

- Very high threat: 16% chance of severe weather, 81% chance of lightning without severe weather, and
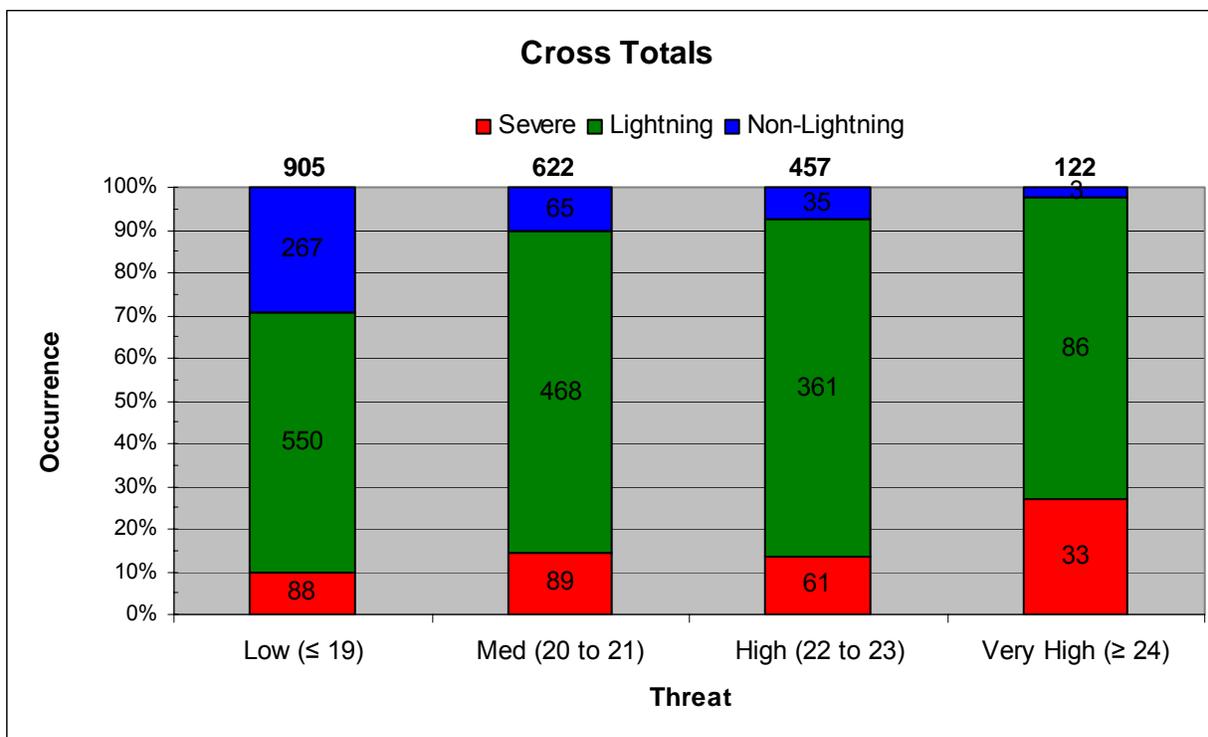
- Extreme threat: 67% chance of severe weather, 33% chance of lightning without severe weather.
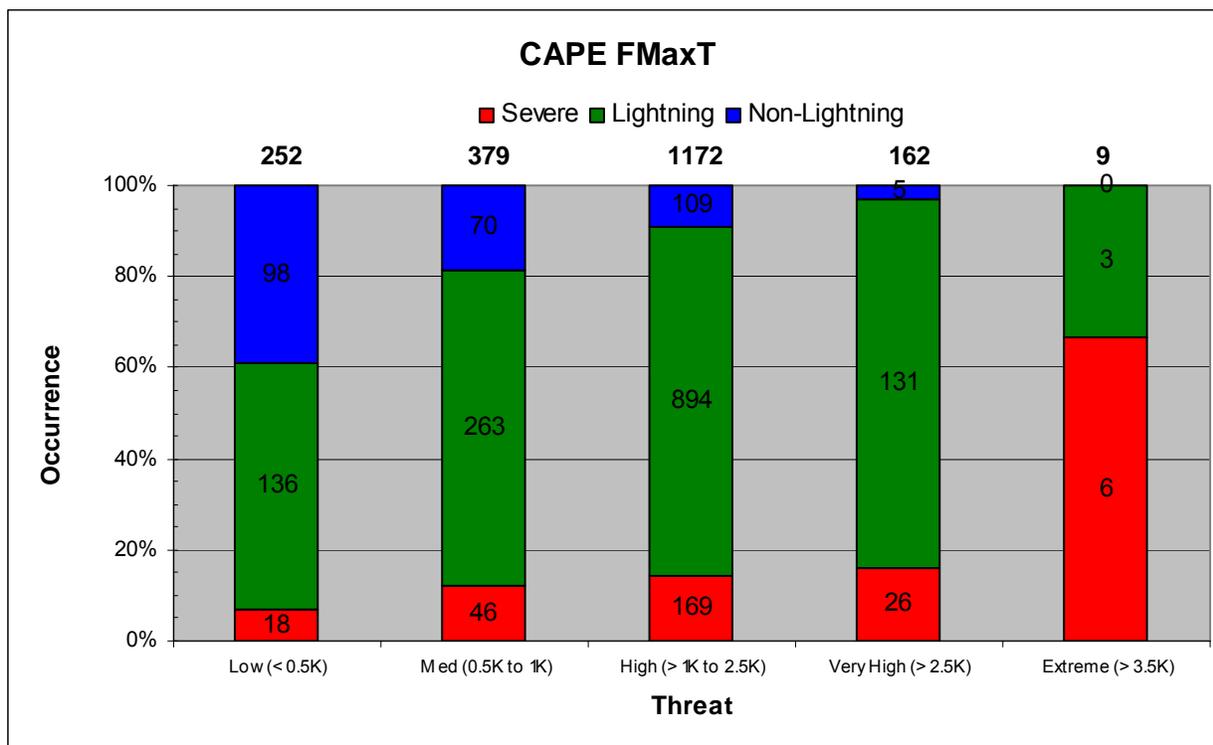
Figure 22. Stacked column graph of CAPE FMaxT value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The Jacksonville NWS threat criteria are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.12 500 mb Temperature

The T_{500} thresholds were derived from the 45 WS based on forecaster experience. The forecasters stated that, as a rule-of-thumb, there is a low threat of severe weather when $T_{500} > -10°C$ and a high threat when $T_{500} \leq -10°C$. Referring to Figure 23, there were 245 days out of 1890 with severe weather when the threat was low and 26 days out of 232 with severe weather when the threat was high. The T_{500} values were in the low range 89% of the days during the warm season. When there was a low threat, lightning without severe weather occurred on 72% and severe weather on 13% of the days. Therefore, 15% of the days were non-lightning days. The T_{500} values were in the high threat range on only 11% of warm season days. When T_{500} values were in the high threat range, severe days

occurred 11% and lightning days without severe weather 47% of the time. Therefore, 42% of the days were non-lightning days when $T_{500} \leq -10°$.

This climatological data suggests the following implications based on the severe weather threat:

- Low threat: 13% chance of severe weather, 72% chance of lightning without severe weather, and

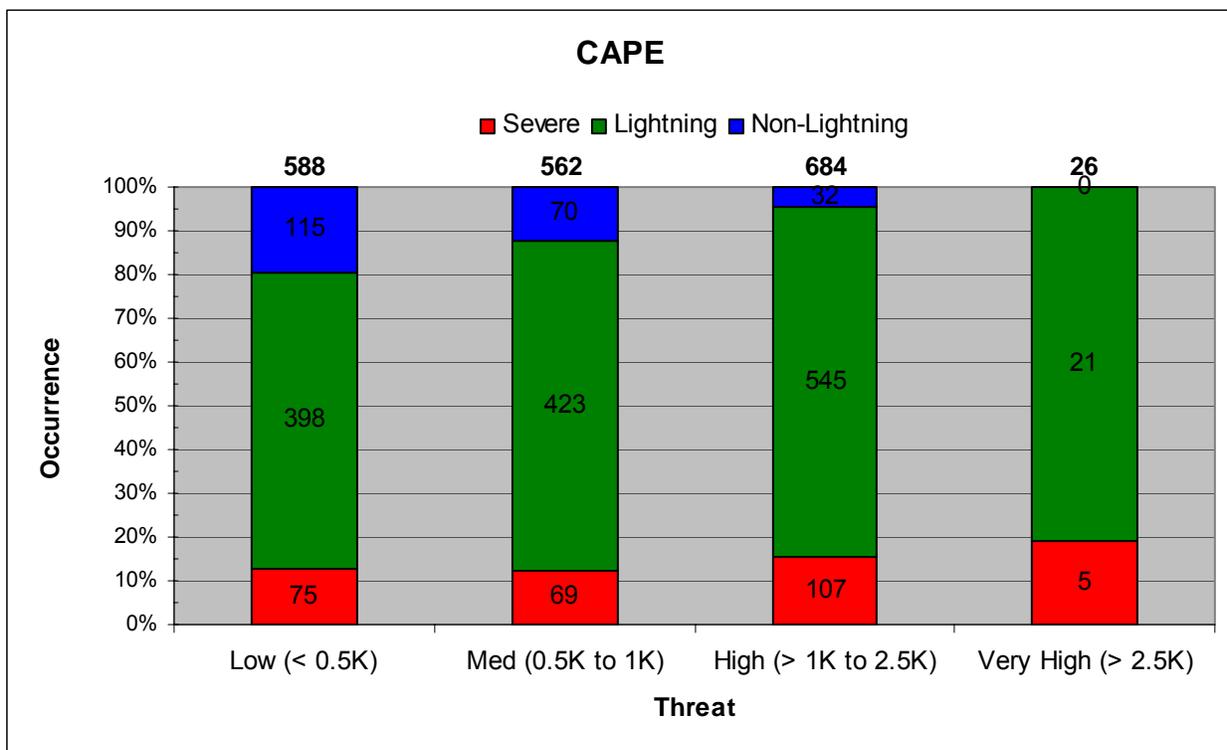- High threat: 11% chance of severe weather, 47% chance of lightning without severe weather.

Figure 23. Stacked column graph of T_{500} value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The 45 WS threat criteria are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.13 Helicity

Helicity thresholds were derived from the NWS Melbourne, Florida description of ADAS Graphics (NWS Melbourne 2003). If the wind veers with height helicity will be positive, if the wind backs with height helicity will be negative. In the northern hemisphere, tornadoes associated with negative helicity are rare but they do occur, so negative helicity is included in this section. Helicity values are conditional – i.e. high values can occur without the necessary conditions to produce deep convection. Therefore, if helicity values are high, favorable atmospheric instability and lift must also be present in order to produce a threat for rotating storms. The NWS states that this condition is more common along or ahead of winter or spring cold fronts, or within tropical cyclone outer rainbands. This condition is uncommon during the warm season that is typified by prevailing weak winds and little vertical shear. The exception is the local vertical shear created by the sea breeze front, outflow boundaries and the interaction of boundaries. These highly localized conditions are not evident in the soundings because the sea breeze front and other boundaries are not normally in the vicinity of the CCAFS rawinsonde during the morning sounding times.

The NWS definitions state that helicity values from 150 - 299 m^2/s^2 imply the possible formation of weak tornadoes of F0 - F1 on the Fujita Scale, values from 300 - 499 m^2/s^2 imply the possible formation of strong tornadoes (F2 - F3) and values > 450 m^2/s^2 imply the possible formation of violent tornadoes (F4 - F5). There were

no observed helicity values greater than +260 m^2/s^2 or less than -120 m^2/s^2 in the database and there were only 27 reported tornadoes. In addition to forecasting tornado intensity, helicity is also an indicator of mid-level rotation which can lead to non-tornadic severe wind events. Therefore, helicity is presented as a parameter for evaluating the possibility of a severe wind event, not just tornado formation and intensity. For the 207 severe weather events associated with positive helicity, there were 21 tornadoes (10%) with an average helicity of 33 m^2/s^2 and a range of 0 to 170 m^2/s^2. For the 112 severe weather events with negative helicity, there were 6 tornadoes (5%) with an average helicity of -22 m^2/s^2 and a range of -10 to -50 m^2/s^2.

Referring to Figure 24, there were 207 days out of 1380 with severe weather when the positive helicity values indicated the tornado threat was below the criteria for possible formation of weak tornadoes and 2 days out of 21 with severe weather when the positive helicity values indicated the possible formation of weak tornadoes. The helicity values were below the criteria for possible formation of weak tornadoes 99% of the days during the warm season. When the threat of possible formation of weak tornadoes was below the weak criteria, lightning without severe weather occurred on 72% and severe weather on 15% of the days. When the threat was for possible formation of weak tornadoes, severe days occurred 9% and lightning days without severe weather 48% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Below weak tornado threat: 15% chance of severe weather, 72% chance of lightning without severe weather, and

- Weak tornado threat: 9% chance of severe weather, 48% chance of lightning without severe weather.
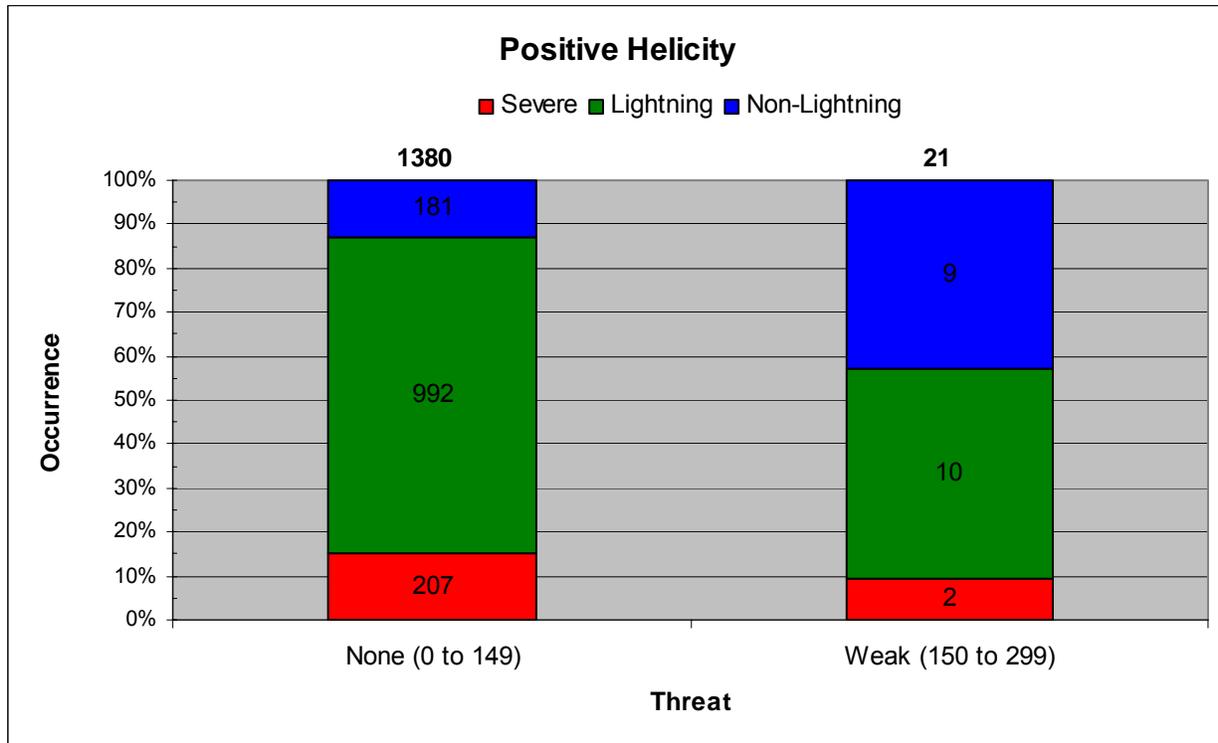
Figure 24.   Stacked column graph of positive helicity value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The Melbourne NWS threat criteria are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

Referring to Figure 25 for negative helicity values, there were 112 days out of 978 with severe weather when negative helicity indicated the tornado threat was below the criteria for possible formation of weak tornadoes and 2 days out of 2 with severe weather when negative helicity indicated the tornado threat was weak. The helicity values were below the criteria for possible formation of weak tornadoes on almost 100% of the days during the warm

season. When the threat of possible formation of weak tornadoes was below the weak criteria, lightning without severe weather occurred on 70% and severe weather on 11% of the days. When threat was for the formation of weak tornadoes, severe days occurred 0.2% and lightning days 0% of the time.

This climatological data suggests the following implications based on the severe weather threat:

- Below weak tornado threat t: 11% chance of severe weather, 70% chance of lightning without severe weather, and

- Weak tornado threat: 0% chance of severe weather, 0% chance of lightning without severe weather.
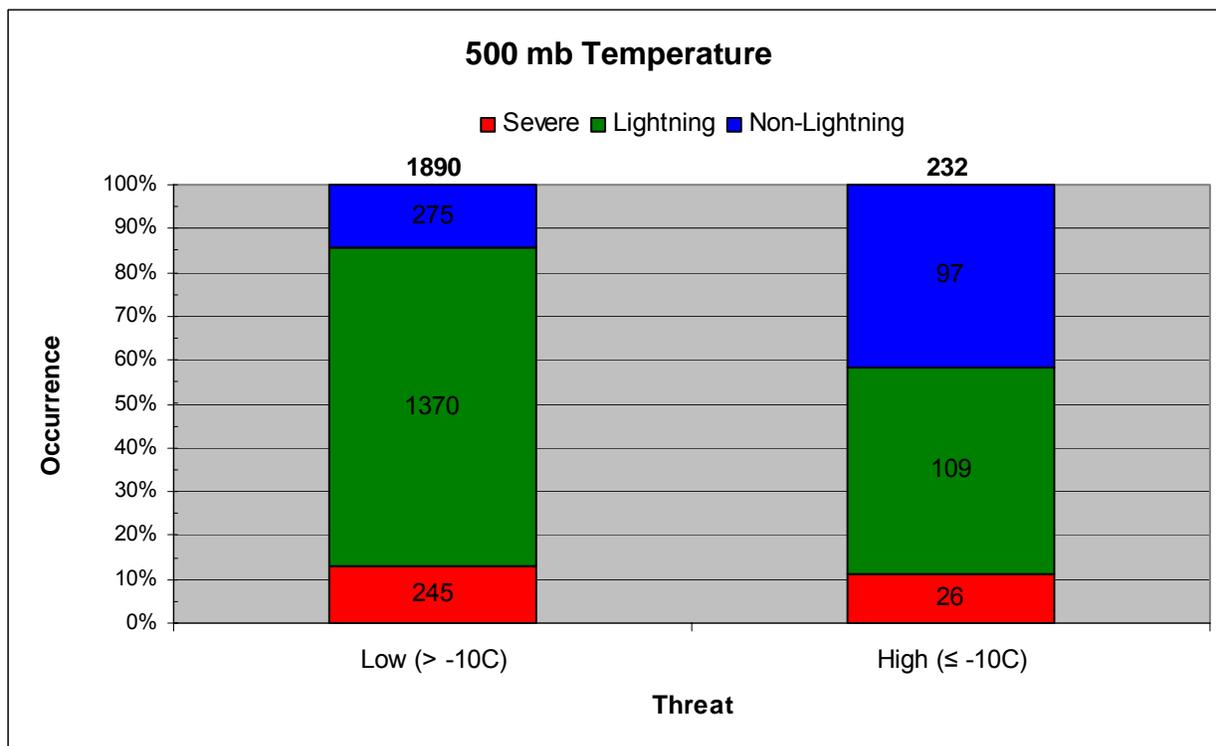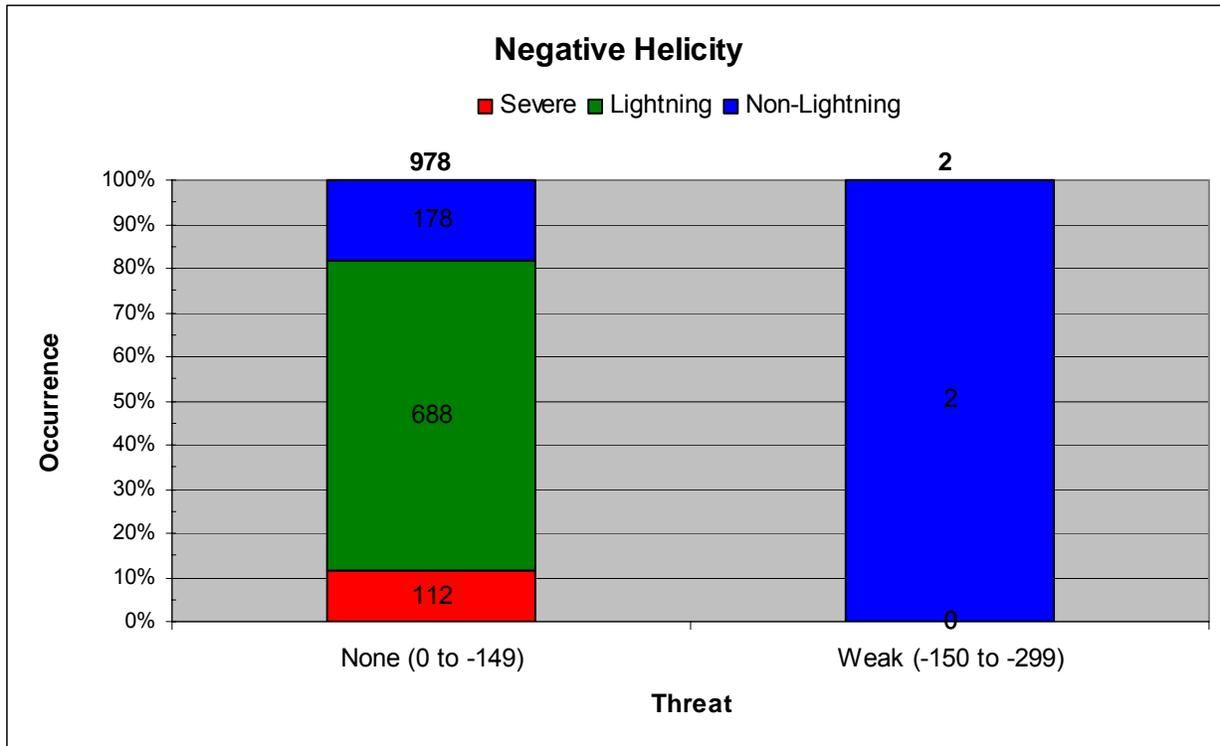

Figure 25. Stacked column graph of negative helicity value thresholds. The numbers of severe days are in red, lightning days without severe weather in green, and non-lightning days in blue. The Melbourne NWS threat criteria are on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.1.14 Summary of Stability Parameters

Of the 14 stability parameters analyzed, only TT, LI, TI, SSI, CT, CAPE FMaxT and showed the possibility of providing guidance in forecasting the occurrence of severe weather. Also, KI and PW showed the possibility of providing guidance in forecasting the occurrence of non-severe and non-lightning weather days. These 8 are the only stability parameters included in the Severe Weather Decision Aid, shown in Section 3.3. In general, the severe weather threat was less than 18% for TT, LI, TI, SSI, and CT when their values were in the low-medium threat ranges. But when the values were in the high, very high, or extreme threat ranges the chance of severe weather was generally 25% or higher. However, the occurrence of values in the high, very high, or extreme threat ranges was rare for each parameter. Table 3 provides a summary of the severe weather threat analyses for each of the stability parameters that are used in the Severe Weather Decision Aid and a brief discussion of each follows.

The TT was a significant factor only when there was a high threat when TT > 48. The high threat occurred 8% of the time and when it did, severe weather occurred 28% of the time. It is also interesting to note that TT was in the low threat range (TT ≤ 45) on 64% of all warm season days.

The LI was a significant factor when there was a high threat when TI < -5. The high threat only occurred 3% of the time but when it did, severe weather occurred 25% of the time. It is also interesting to note that LI was in the low threat range (LI ≥ -2) on 57% of all warm season days.

The TI was a significant factor when there was a very high threat when TI > 40. The very high threat occurred 6% of the time and when it did, severe weather occurred 21% of the time. It is also interesting to note that when TI was in the low threat range (TI < 25) there was a 46% occurrence of non-lightning days.

The SSI was a significant factor when there was a high threat when SSI < -2. The high threat only occurred 2% of the time but when it did, severe weather occurred 32% of the time. It is also interesting to note that when SSI was in the low threat range (LI ≥ 3) there was a 35% occurrence of non-lightning days.

The CT was a significant factor when only there was a very high threat when CT ≥ 24. The very high threat occurred 6% of the time and when it did, severe weather occurred 27% of the time.

The CAPE FMaxT severe chance was almost uniformly spread among the threat categories except for the extreme threat when CAPE FMaxT > 3500 which only occurred 0.04% of the time. When CAPE FMaxT was in the extreme threat category, severe weather occurred 67% of the time.

The KI was not a good predictor of severe weather but is included here because it was a good predictor of non-severe and non-lightning days. When KI was in the low threat category (KI < 26) on 36% of the warm season days, there was a 39% occurrence of non-lightning days.

The PW is similar to KI in that it was not a good predictor of severe weather occurrence, but during the rare 4% of the time PW was in the low threat category severe weather only occurred 3% of the time and 77% of the days were non-lightning days.

Table 3. Summary of the 8 stability parameters that showed some potential to indicate the severe weather chance. The most significant threat category and combined occurrence/severe occurrence are shaded in light yellow.

Stability Parameter	Low Threat	Medium Threat	High Threat	Very High Threat	Extreme Threat
Total Totals					
Threat Level Frequency	64%	28%	8%		
Severe Weather Frequency	9%	18%	29%		
Lifted Index					
Threat Level Frequency	57%	40%	3%		
Severe Weather Frequency	10%	16%	25%		
Thompson Index					
Threat Level Frequency	31%	37%	26%	6%	
Severe Weather Frequency	6%	16%	16%	21%	
SSI					
Threat Level Frequency	40%	58%	2%		
Severe Weather Frequency	7%	16%	32%		
Cross Totals					
Threat Level Frequency	43%	30%	21%	6%	
Severe Weather Frequency	10%	14%	13%	27%	
CAPE FMaxT					
Threat Level Frequency	13%	19%	59%	8%	.04%
Severe Weather Frequency	7%	12%	14%	16%	67%
K-Index					
Threat Level Frequency	36%	10%	54%		
Severe Weather Frequency	8%	18%	16%		
Precip. Water					
Threat Level Frequency	4%	28%	68%		
Severe Weather Frequency	3%	9%	15%		

Table 4 provides a summary of the severe weather threat analyses for each of the stability parameters that did not show potential to indicate the severe weather chance and a brief discussion of each follows.

The SWEAT was not a good predictor of severe weather because the low threat had a higher occurrence of severe weather than the medium threat. The SWEAT was in the medium threat range 68% of the warm season days but severe weather only occurred 6% of the time while severe weather occurred 26% of the time when the threat was in the low range.

The CAPE was not a good predictor because the threat occurrence was almost uniformly spread among the threat categories except for the very high threat which occurred 1% of the time. Severe weather occurred only slightly more frequently as the threat increased but there was only a 6% spread between the low threat and very high threat. Additionally, the severe occurrence with a low threat was slightly higher than with a medium threat.

The CAPE Maxθ_e was not a good predictor because the severe occurrence was somewhat uniformly spread among the threat categories and the severe occurrence did not consistently increase as the threat category increased.

The T_{500} was not a good predictor because severe occurrence was almost equal for temperatures above and below -10°C.

The helicity (+) and helicity (-) are not good predictors because the occurrence of severe weather was higher for a lower threat for both parameters. Also helicity was in the low threat category over 99% of the time during the warm season.

Table 4. Summary of the 6 stability parameters that did not show potential to indicate the severe weather chance.					
Stability Parameter	Low Threat	Medium Threat	High Threat	Very High Threat	Extreme Threat
SWEAT					
Threat Level Frequency	30%	68%	2%		
Severe Weather Frequency	26%	6%	47%		
CAPE					
Threat Level Frequency	32%	30%	37%	1%	
Severe Weather Frequency	13%	12%	16%	19%	
CAPE Maxθ_e					
Threat Level Frequency	6%	13%	47%	24%	10%
Severe Weather Frequency	10%	9%	15%	14%	17%
T_{500}	> -10°C		≤ -10°C		
Threat Level Frequency	89%		11%		
Severe Weather Frequency	13%		11%		
Helicity (+)					
Threat Level Frequency	99%		1%		
Severe Weather Frequency	15%		9%		
Helicity (-)					
Threat Level Frequency	99.8%		0.2%		
Severe Weather Frequency	11%		0%		

3.2 Synoptic Weather Patterns

As part of an AMU study by Lambert et. al. (2005) to create an objective lightning forecast tool, lightning occurrence climatologies in the KSC/CCAFS vicinity for 7 flow regimes were developed based on work by Lericos et. al. (2000). These climatologies yielded improvements in the forecast when using individual flow regimes probabilities over the seasonal climatological probability and 1-day persistence. This showed that the larger scale synoptic patterns should be considered as possible predictors of severe weather. In this study, the prevailing surface and upper level synoptic patterns were analyzed to determine if they could provide guidance to differentiate among severe, lightning and non-lightning days.

The synoptic weather patterns identified for each day were assigned to the upper-level jet streak positions and high pressure ridge as defined in Section 2.4. The pie charts in Figure 24 show the percent occurrence of the

synoptic patterns on the severe days. On days with severe weather, the prevailing upper level features indicated there was no upper level jet streak 54% of the time and divergence 34% of the time. The prevailing surface ridge position was south of KSC/CCAFS 60% of the time.
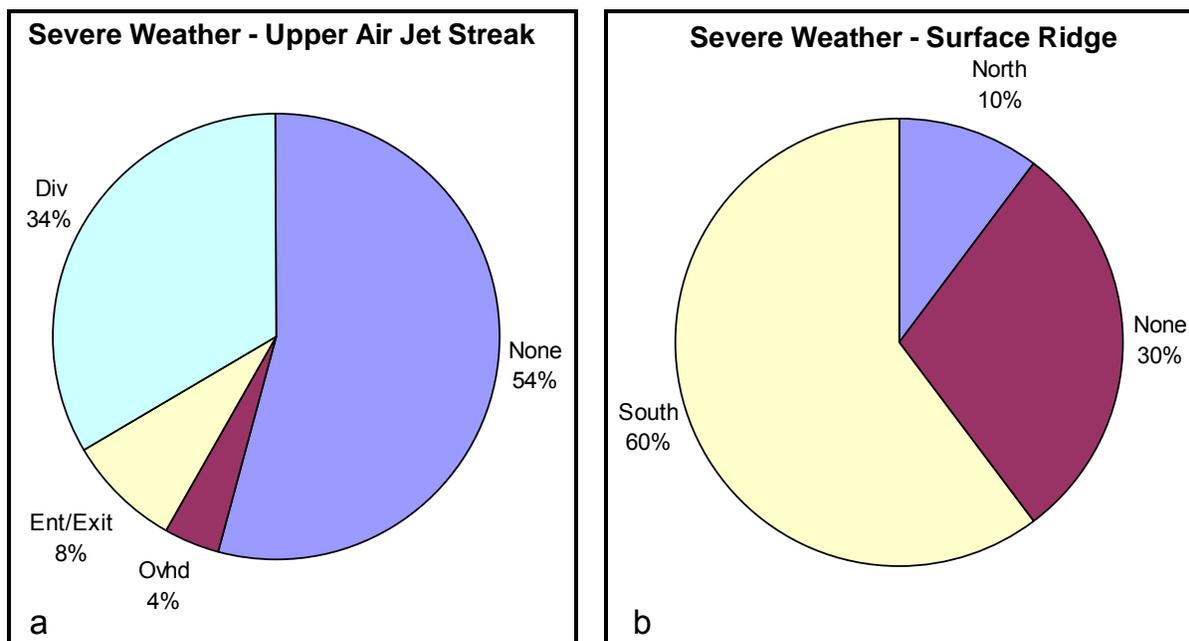
Figure 26. Pie charts showing the relationship between severe days and (a) the upper level jet streak position and (b) surface ridge position.

3.2.1 250 mb Jet Position

As stated in Section 2.4, historical upper air charts similar to the example in Figure 10 were evaluated for each day in the 15-year period. There were no cases when the jet streak position could not be determined. Referring to Figure 27 for the 250 mb jet streak position, there were 147 days out of 1360 with severe weather when there was no jet streak present, 10 days out of 132 with severe weather when the jet streak was overhead, 23 days out of 119 with severe weather when a jet streak exit region was overhead and 91 days out of 494 with severe weather when upper level divergence was present. There was no jet streak present 65% of the days during the warm season. When there was no jet streak present, lightning without severe weather occurred on 72% and severe weather on 11% of the days. When a jet streak was overhead, severe days occurred 8% and lightning without severe weather days 67% of the time. When a jet streak exit region was overhead, severe days occurred 19% and lightning without severe weather days 66% of the time. When upper level divergence was present, severe days occurred 18% and lightning without severe weather days 64% of the time.

This climatological data suggests the following implications for the forecaster:

- No jet streak present: 11% chance of severe weather, 72% chance of lightning without severe weather,

- Jet streak overhead: 8% chance of severe weather, 67% chance of lightning without severe weather,

- Jet streak exit region overhead: 19% chance of severe weather, 66% chance of lightning without severe weather, and

- Upper level divergence present: 18% chance of severe weather, 64% chance of lightning without severe weather.
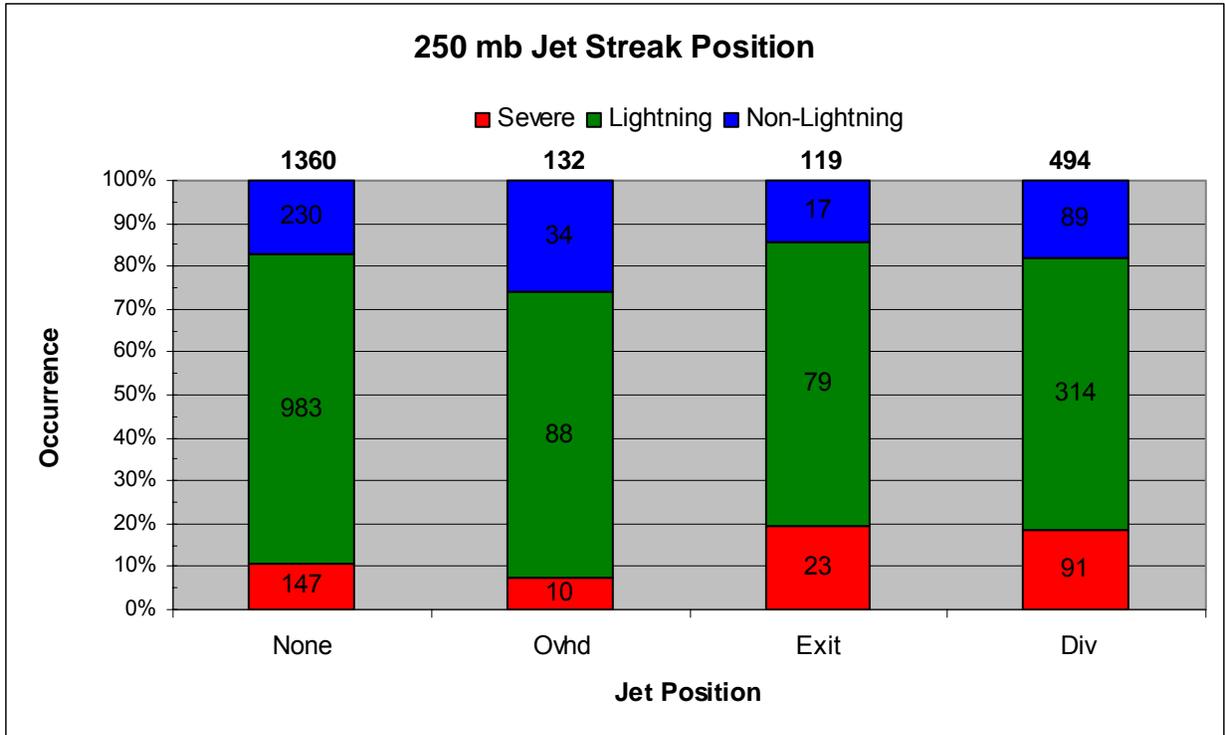
Figure 27. Stacked column graph of 250 mb jet streak position categories. The numbers of severe days are in red, lightning without severe weather days in green, and non-lightning days in blue. The position of the jet streak is on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.2.2 Surface High Pressure Ridge Position

As stated in Section 2.4, surface maps similar to that shown in Figure 11 were evaluated for each day in the 15 year period. Referring to Figure 28 for the surface high pressure ridge position, there were 28 days out of 594 with severe weather when the surface ridge was north of KSC/CCAFS, 80 days out of 781 with severe weather when there was no ridge present and 163 days out of 731 with severe weather when the surface ridge was south of KSC/CCAFS. When the surface ridge was north of the area, lightning without severe weather occurred on 73% and severe weather on 5% of the days. Therefore, 22% of the days were non-lightning days. When there was no ridge present, severe days occurred 10% and lightning without severe weather days 69% of the time. When the ridge was south of the area, severe days occurred 22% and lightning without severe weather days 67% of the time.

This climatological data suggests the following implications for the forecaster:

- Surface ridge north of KSC/CCAFS: 5% chance of severe weather, 73% chance of lightning without severe weather,

- No surface ridge present: 10% chance of severe weather, 69% chance of lightning without severe weather, and

- Surface ridge south of KSC/CCAFS: 22% chance of severe weather, 67% chance of lightning without severe weather.
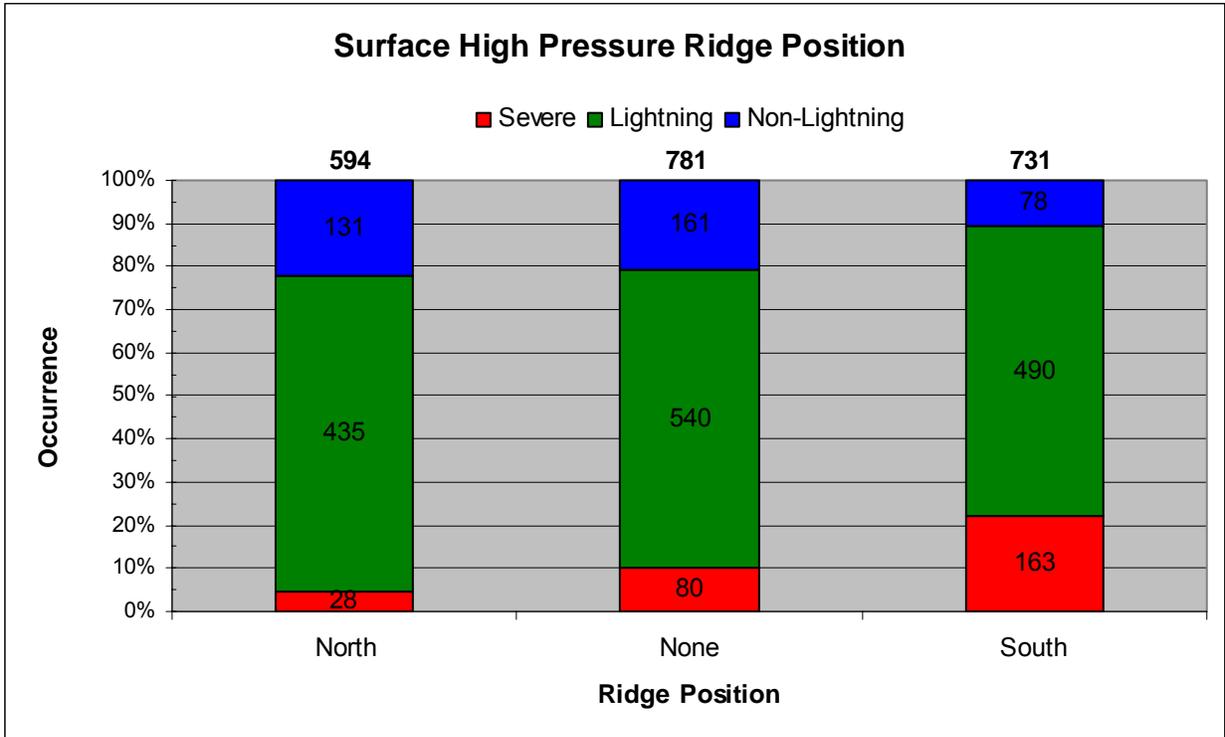
Figure 28. Stacked column graph of surface high pressure ridge position. The numbers of severe days are in red, lightning without severe weather days in green, and non-lightning days in blue. The position of the surface ridge is on the x-axis. The cumulative frequency of occurrence of each type of day is shown on the y-axis. The bold numbers at the top of each column indicate the total number of days in that threat range and the numbers within each colored portion of a column indicate the number of days of that type.

3.3 Development of a Severe Weather Decision Aid

This section describes the methodology used in developing a Severe Weather Decision Aid worksheet. The tool was developed from the results of the technical interchange meetings held with the NWS offices and members of the 45 WS. Further discussions were held with the 45 WS Launch Weather Officers (LWO) and forecasters to determine appropriate values for the forecasters to assign to the questions and atmospheric stability parameters when completing the worksheet.

Figure 29 shows the proposed Severe Weather Decision Aid worksheet graphical user interface (GUI). The worksheet is a JavaScript-based tool that the forecaster can access from any computer with a Java-enabled web browser. The forecaster will check the appropriate box for each question or parameter. Each question or parameter has a value based on discussions with experienced forecasters and/or the occurrence of severe weather related to the stability parameters. The values assigned to the stability parameters are more objective than those values assigned to the other questions because they are based on the climatology of severe weather events. The other questions are more subjective but are based on discussion with forecasters who have many years of experience forecasting in east-central Florida. An unchecked item or an answer of "Not Sure" will retain the default value of zero. The values range from a low of -2 to a high of +3. The question or stability parameter received a higher value if there was a higher occurrence of severe weather. The worksheet will automatically algebraically add the values based on the responses and provide a Total Threat Score. The higher the Total Threat Score, the more likely severe weather will occur. As of the writing of this report, it is not known what the occurrence of severe weather was related to particular Total Threat Scores. The values and Total Threat Score can be refined over time as the worksheet is used by the forecasters. Each question or parameter has a help link that will give the forecaster more information about the question and brief rationale for the value assigned to a particular question or parameter.

The first two questions provide the forecaster with the big picture beyond the local area. The guidance generated by the 28th Operational Weather Squadron at Shaw Air Force Base, SC and at the Melbourne, FL NWS

office is focused on a much larger area than KSC/CCAFS, which provides a good first guess for the region. The rest of the questions in the tool require the forecasters to think about the local causes of severe weather during the warm season regarding persistence, squall line activity, moisture boundaries, stability parameters, jet streak dynamics, synoptic flow regime, and sea breeze and boundary collisions. Points are subtracted if there is an easterly steering flow, low level inversion, non-veering winds and a low-level temperature cap. Local forecaster experience indicates that these are typically negative in severe weather development. There are three key ingredients for thunderstorm development; moisture, instability and lift. For a thunderstorm to become severe, a fourth ingredient, shear, is needed to give the storm rotation. This shear may be from an upper or low level jet streak, veering of the steering flow winds or a sea-breeze and/or boundary collision.

The question or parameter (bold faced) and corresponding text plus assigned value from the help links in the GUI are shown below:

1. **28 OWS Southeast CONUS Hazard Discussion:** Access the 28 OWS discussion at https://28ows.shaw.af.mil for a high-level overview of the southeastern US weather situation.

   Is there a mention of a severe weather threat? The 28 OWS has forecast, watch, and warning responsibility for the entire southeast US. This discussion should be used as a guide for your severe weather forecast. Yes = 3, No = -1.

   Was there a severe weather threat mentioned in the previous discussion? Mention of severe weather in the previous discussion that indicates a persistent pattern. Yes = 1, No = -1.

2. **KMLB Area Forecast Discussion (FXUS62):** Access the NWS discussion at http://www.srh.noaa.gov/mlb/forecast.html. The Melbourne NWS Forecast Office forecasters have many years of local expertise. This discussion is coordinated with multiple NWS offices prior to dissemination and should be used as a guide for your severe weather forecast.

   Is there a mention of a severe weather threat? The Melbourne NWS Forecast Office forecasters have many years of local expertise. This discussion is coordinated with multiple NWS offices prior to dissemination and should be used as a guide for your severe weather forecast. Yes = 3, No = -1.

   Was there a severe weather threat mentioned in the previous discussion? Mention of severe weather in the previous discussion indicates a persistent pattern. Yes = 1, No = -1.

3. **Persistence:**

   Has severe weather occurred in east-central Florida in the last 24 hours? If severe weather has occurred in east-central Florida within the last 24 hours, it is likely to occur again today if the air mass and triggers are the same. Yes = 1, No = -1.

4. **Front or squall line activity:**

   Has severe weather occurred in northwest Florida in the last 24 hours? Look for a front or squall line that triggered severe weather over northwest Florida – if the feature is moving into the local area it could increase instability, lift and rotation. Yes = 1, No = -1.

   Is there a front or squall line in northwest Florida moving ESE (morning only)? Look for a front or squall line that triggered severe weather over northwest Florida – if the feature is moving into the local area it could increase instability, lift and rotation. Yes = 2, No = -1.

5. **Water vapor satellite image:**

   Is there a distinct moisture/dry boundary across central Florida? Look for a dry zone boundaries in the water vapor imagery – these include axes of jet streams, thermal and upper-level ridges, and upper-level anticyclones. Yes = 1, No = -1.

6. **Sounding/stability parameters:**

   MDPI: MDPI values over 1.0 indicate a strong microburst potential with additional energy in the downdraft. MDPI > 1 = 2, MDPI $\leq$ 1 = -1.

   K-Index: Climatology shows that when K-Index was in the moderate to high threat categories, 26 to 28 and greater than 28, the occurrence of severe weather was 18% and 16%, respectively. But when KI < 26, 39%

of all days were non-lightning while severe weather occurred only 8% of the time. KI > 28 = 0, 26 to 28 = 0, KI < 26 = -2.

Total Totals: Climatology shows that when Total Totals was over 48, severe weather occurred 29% of the time. Values over 48 only occurred 8% of the time. With TT values between 46 and 48, severe weather occurred 18% of the time and when TT values less than or equal to 45, severe weather occurred 9% of the time. Also, when TT was less that or equal to 45, 24% of all days were non-lightning days. TT > 48 = 2, 46 to 48 = 0, TT ≤ 45 = -1.

Cross Totals: Climatology shows that when Cross Totals were in the very high threat category, greater than or equal to 24, there was a 27% occurrence of severe weather. However, CT equal to or greater than 24 only occurred on 6% of the warm season days. When CT was less than or equal to 23, the occurrence of severe weather was nearly uniform at 10-14% among the low, moderate, and high threat categories. CT ≥ 24 = 2, 22 to 23 = 0, 20 to 21 = 0, CT ≤ 19 = 0.

Lifted Index: Climatology shows that when the Lifted Index was less than -5, there was a 25% occurrence of severe weather. But LI was less than -5 on only 3% of the warm season days. When LI was -3 to -5, severe weather occurrence was 16% and when LI was greater than -3, severe weather occurrence was 10%. LI < -5 = 3, -3 to -5 = 0, LI > -3 = 0.

Showalter Stability Index: Climatology shows that when the Showalter Stability Index was less than -2, there was a 32% occurrence of severe weather. But SSI was only less than -2 on 2% of the warm season days. When SSI was -2 to 2, severe weather occurred 16% of the time and when SSI was greater than or equal to 3, severe weather occurred 7% of the time. Also, when SSI was greater than or equal to 3, non-lightning days occurred 35% of the time. SSI < -2 = 3, -2 to 2 = 0, SSI ≥ 3 = -1.

Thompson Index: Climatology shows that when the Thompson Index was greater than 40, severe weather occurred 21% of the time. TI greater than 40 occurred 6% of the time. When TI was between 35 and 39, severe weather occurred 16% of the time. When TI was between 25 and 34, severe weather occurred 16% of the time and when TI was less than 25, severe weather occurred 6% of the time. Also, when TI was less than 25, 46% of all days were non-lightning days. TI > 40 = 2, 35 to 39 = 1, 25 to 34 = 0, TI < 25 = -1.

Precipitable Water: Climatology shows that when Precipitable Water was equal to or greater than 1.5, there was a 15% occurrence of severe weather. When PW was between 1 and 1.5, severe weather occurred 9% of the time and when PW was less than 1 severe weather occurred 3% of the time. PW is greater than 1.5 68% of the time so it is not a good indicator of severe weather but it is a good indicator of non-severe weather days. PW > 1.5 = 0, 1 to 1.5 = -1, PW < 1 = -2.

Is CAPE FMaxT > 3500 J/kg? CAPE FMaxT was not able to differentiate among severe and non-severe days except when it was over 3500 J/kg. CAPE FMaxT was only this high 0.04% of the time but when it was, severe weather occurred 67% of the time. Yes = 3, No = 0.

Are the winds veering with height from surface to 10,000 ft? A veering wind with height in the lower part of the atmosphere is a type of directional shear often considered important for development of a rotating updraft. The rotating updraft of a supercell, called a mesocyclone, helps the supercell to produce extreme severe weather events such as large hail, strong downbursts of 80 miles per hour or more and strong to violent tornadoes. Yes = 2, No = -1.

Is there an inversion below 8,000 ft? This could indicate low level dry air moving in and increased subsidence. Lack of moisture in the lower troposphere reduces the severe storm threat. Note that this inversion is not part of a morning surface inversion. Yes = -2, No = 1.

Is the forecast max temp minus sounding conv temp equal to or greater than 5 °C? This difference will indicate the lower atmosphere lift potential, turn over of the boundary layer. Warm/moist rising air will increase the lower atmosphere instability. Yes = 1, No = -1.

Is there an 850 mb cap (is the 850 mb temp < 20 °C)? This indicates that the lower atmosphere is to too warm to allow strong thermals to develop – the atmosphere is capped. The 850 MB temperature needs to be colder than the air at the surface for storms to develop. Yes = -2, No = 1.

Is the mean RH from 1000 mb to 700 mb equal to or greater than 70%? Moisture is critical for storm development and severity. 70-90% RH is a good range, the lower atmosphere should not be too dry or moist for severe storm development. Yes = 1, No = -1.

Does it look hazy outside? Normally in the warm season it is not hazy outside. Haze indicates subsidence and trapped particulates in the low levels. Yes = -2, No = 0.

7. **Jet Dynamics:**

Upper-level speed max exit region or divergence over KSC/CCAFS? When an upper level speed max entrance/exit region or upper level divergence is present over KSC/CCAFS, severe weather occurs 19% of the time. These conditions account for 29% of all warm season days. Yes = 2, No = 0.

Low-level jet with a south to west component from surface to 5,000 ft > 25 kts? A low level jet with a south to west component transports moisture and warm air advection into a developing thunderstorm updraft. The high-speed wind and directional shear helps generate large values of helicity that can lead to tornadogenesis or strong gusts of wind at the surface. Yes = 2, No = 0.

8. **Flow Regime Lightning Climatology:**

SW-1: Southwest flow (SW-1) over KSC/CCAFS occurs when the layer-averaged wind direction at all 3 stations is 180°-270°, indicating the Atlantic ridge is south of the Florida Peninsula. The probability of lightning is 66%. SW-1 = 2.

SW-2: Southwest flow (SW-2) also occurred when the ridge was between MIA and TBW, with layer-averaged wind directions of 180°-270° at JAX and TBW and 90°-180° at MIA. The probability of lightning is 72%. SW-2 = 3.

SE-1: Southeast flow (SE-1) occurred when the ridge moved north of KSC/CCAFS with the layer-averaged wind directions 180°-270° at JAX and 90°-180° at MIA and TBW. The probability of lightning is 51%. SE-1 = 1.

SE-2: Southeast flow (SE-2) also occurred when the ridge was north of the Florida Peninsula and the layer-averaged wind direction at all three stations was 90°-180°. The probability of lightning is 39%. SE-2 = -1.

NW: Northwest flow regime (NW) occurred when the layer-averaged wind direction at all three stations was 270°-360°. The probability of lightning is 43%. NW = 0.

NE: Northeast flow regime (NE) occurred when the layer-averaged wind direction at all three stations was 0°-90°. The probability of lightning is 18%. NE = -2.

Other: When the layer-averaged wind directions at the three stations did not fit any of the above criteria, it was designated as Other. The probability of lightning is 44%. Other = 0.

9. **Sea Breeze and Boundary Collisions:** Boundary collisions will increase lift and rotation.

If a sea breeze forms, will it stay east of I-95? If so, this leaves a strong line of discontinuity (Temp, RH & Helicity) in the forecast area. Yes = 1, No = -1.

Are you forecasting a late developing sea breeze? If so, you are adding additional lower atmosphere heating (lift), which will increase the instability. Yes = 1, No = -1.

Are you forecasting or observing multiple boundary collisions? Multiple boundary collisions are often the single most important trigger for severe weather. Yes = 2, No = -1.

Warm Season Severe Weather Worksheet - Microsoft Internet Explorer

File   Edit   View   Favorites   Tools   Help

45th Weather Squadron
Warm Season Severe Weather Forecast Tool
ENSCO, Inc.

Wed, 29 Jun 2005 15:09:14 UTC   Check one box per row!

1. 28 OWS Southeast CONUS Hazard Discussion (AWUS12): Help

   Is there a mention of a severe weather threat? Help   Yes ☐ No ☐ Not Sure ☐
   Was there a severe weather threat mentioned in the previous discussion? Help Yes ☐ No ☐ Not Sure ☐

2. KMLB Area Forecast Discussion (FXUS62): Help

   Is there a mention of a severe weather threat? Help   Yes ☐ No ☐ Not Sure ☐
   Was there a severe weather threat mentioned in the previous discussion? Help Yes ☐ No ☐ Not Sure ☐

3. Persistence:

   Has severe weather occurred in east-central Florida in the last 24 hours? Help   Yes ☐ No ☐ Not Sure ☐

4. Front or squall line activity:

   Has severe weather occurred in northwest Florida in the last 24 hours? Help   Yes ☐ No ☐ Not Sure ☐
   Is there a front or squall line in northwest Florida moving ESE (morning only)? Help Yes ☐ No ☐ Not Sure ☐

5. Water vapor satellite image:

   Is there a distinct moisture/dry boundary across central Florida? Help   Yes ☐ No ☐ Not Sure ☐

6. Sounding/stability parameters:

   a. MDPI: ⩽ 1.0 ☐ > 1.0 ☐   Help
   b. K-Index: < 26 ☐   26 to 28 ☐   > 28 ☐   Help
   c. Total Totals: ⩽ 45 ☐   46 to 48 ☐   > 48 ☐   Help
   d. Cross Totals: ⩽ 19 ☐   20 to 21 ☐   22 to 23 ☐   ⩾ 24 ☐   Help
   e. Lifted Index: < -5 ☐   -3 to -5 ☐   > -3 ☐   Help
   f. Showalter Stability Index: < -2 ☐   -2 to 2 ☐   ⩾ 3 ☐   Help
   g. Thompson Index: < 25 ☐   25 to 34 ☐   35 to 39 ☐   ⩾ 40 ☐   Help
   h. Precipitable Water: < 1.0" ☐   1" to 1.5" ☐   > 1.5" ☐   Help
   i. Is CAPE FMaxT > 3500 J/kg? Help   Yes ☐ No ☐ Not Sure ☐
   j. Are the winds veering with height from surface to 10,000 ft? Help   Yes ☐ No ☐ Not Sure ☐
   k. Is there an inversion below 8,000 ft? Help   Yes ☐ No ☐ Not Sure ☐
   l. Is the forecast max temp minus sounding conv temp equal to or greater than 5°C? Help Yes ☐ No ☐ Not Sure ☐
   m. Is there an 850 mb cap (is the 850 mb temp < 20°C)? Help   Yes ☐ No ☐ Not Sure ☐
   n. Is the mean RH from 1000 mb to 700 mb equal to or greater than 70%? Help   Yes ☐ No ☐ Not Sure ☐
   o. Does it look hazy outside? Help   Yes ☐ No ☐ Not Sure ☐

7. Jet Dynamics

   a. Upper-level speed max exit region or divergence over KSC/CCAFS? Help   Yes ☐ No ☐ Not Sure ☐
   b. Low-level jet with a south to west component from surface to 5,000 ft > 25 kts? Help Yes ☐ No ☐ Not Sure ☐

8. Flow Regime Lightning Climatology - See Objective Lightning Tool Flow Regimes

   a. ☐ SW-1 Help   ☐ SW-2 Help   ☐ SE-1 Help   ☐ SE-2 Help   ☐ NW Help   ☐ NE Help   ☐ Other Help

9. Sea Breeze and Boundary Collisions Help

   a. If a sea breeze forms, will it stay east of I-95? Help   Yes ☐ No ☐ Not Sure ☐
   b. Are you forecasting a late developing sea breeze? Help   Yes ☐ No ☐ Not Sure ☐
   c. Are you forecasting or observing multiple boundary collisions? Help   Yes ☐ No ☐ Not Sure ☐

Click here to reset all values to zero   Total Threat Score: 0   Print this page

Local intranet

Figure 29.   Proposed 45 WS Severe Weather Decision Aid worksheet GUI. Forecasters will answer each item by checking the appropriate boxes. The "Total Threat Score" will be automatically calculated and displayed at the bottom of the worksheet as the forecaster checks boxes.

4. Summary

This report presented a 15-year climatological study of severe weather events and related severe weather atmospheric parameters. Data sources included local forecast rules, archived sounding data, CGLSS, surface and upper air maps, and two severe weather event databases covering east-central Florida. The local forecast rules were used to set threat assessment thresholds for stability parameters that were derived from the sounding data. The severe weather events databases were used to identify days with reported severe weather and the CGLSS data was used to differentiate between lightning and non-lightning days. These data sets provided the foundation for analyzing the stability parameters and synoptic patterns that were used to develop an objective tool to aid in forecasting severe weather events. The period of record for the analysis was May – September, 1989 – 2003.

The two severe weather event databases were compared and combined to form one severe weather events database. The days in the period were stratified into severe/non-severe event days by east-central Florida county and type of severe event. The CCAFS rawinsonde data were used to calculate stability indices to determine if they could be used to discern between the severe/non-severe days. The results showed that severe/non-severe event days were indistinguishable based on stability index values. Therefore, the data were re-stratified into severe, lightning with no severe weather, and non-lightning days in an attempt to better discern among them using the stability indices. This re-stratification required evaluating the CGLSS data to distinguish between lightning and non-lightning days. The CGLSS data were displayed on a map of east-central Florida to determine which counties had lightning strikes on each individual day. The lightning strike maps were saved as image files and then incorporated into a web-based lightning strike climatology tool that was delivered to the 45 WS.

The stability indices were then used to evaluate the data with the new stratification. The results were presented in stacked column graphs that depicted the percent occurrence of each type of day with respect to a severe weather threat index for each stability parameter. By displaying the data in this format, it was evident some stability parameters provided objective guidance for the frequency of occurrence of severe weather and others provided no guidance. This analysis also indicated that some of the stability parameters were better predictors of non-lightning/non-severe days based on certain threat values which will provide key objective information to the duty forecaster. The upper level and surface synoptic-scale dynamics were also investigated for each day of the 15-year period. While jet streak interaction appears to have some influence on convective development, the location of the surface high pressure ridge and prevailing surface synoptic flow was a clear discriminator among the three types of days evaluated.

Based on the results of the analyses, an interactive web-based Severe Weather Decision Aid was developed to assist the duty forecaster by providing a level of objective guidance based on the analysis of the stability parameters, CGLSS data, and synoptic-scale dynamics. This tool improves upon the original 45 WS Severe Weather Checklist (Appendix A) because it is based on a statistical climatology of 15 year's worth of data tuned to east-central Florida, it is more objective and it is presented in a user-friendly interactive web-based GUI. The tool will be tested and evaluated during the 2005 warm season.

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List of Abbreviations and Acronyms

Term	Description
45 WS	45th Weather Squadron
AMU	Applied Meteorology Unit
CAPE	Convective Available Potential Energy
CCAFS	Cape Canaveral Air Force Station
CGLSS	Cloud-to-Ground Lightning Surveillance System
CIN	Convective Inhibition
CT	Cross Totals
EDT	Eastern Daylight Time
GUI	Graphical User Interface
HTML	HyperText Markup Language
KSC	Kennedy Space Center
KI	K-Index
LI	Lifted Index
LWO	Launch Weather Officer
MIDDS	Meteorological Interactive Data Display System
NCDC	National Climatic Data Center
PW	Precipitable Water
SPC	Storm Prediction Center
SSI	Showalter Stability Index
SWEAT	Severe Weather ThrEAT
T_{500}	Temperature at 500 mb
TI	Thompson Index
TT	Total Totals Index
UTC	Coordinated Universal Time

Appendix A – 45 WS Severe Weather Worksheet

SEVERE WEATHER WORKSHEET

DATE:	TAF TIME: (CIRCLE ONE)	11-11/12-12	17-17/18-18	23-23/24-00	FORECASTER'S INITIALS:

HEMISPHERIC ANALYSIS (IDENTIFY THE SUB-REGIME IMPACTING YOUR TAF)

GRADIENT WIND FLOW (1-5KFT)	SOUTHEAST (111 – 156)	SOUTH (156 – 201)	SOUTHWEST 201 – 270)	NORTHWEST (270 – 336)	NORTH NORTHEAST (336-020)/(021 – 065)	EAST (066 – 110)
THUNDERSTORM ONSET TIME	NOCTURNAL (0500 – 0900L)	0900 – 1200L	1400 – 2000L	1500 – 1900L	NOCTURNAL (0500 – 0900L)	NOCTURNAL (0500 – 0900L)
SEA BREEZE MIGRATION	CENTRAL TO WEST FLORIDA	I-95 TO ST. JOHNS RIVER	ECSB MERGES WITH WCSB OVER ORLANDO AND MOVES BACK TO THE EAST COAST	ECSB MERGES WITH WCSB NEAR ORLANDO AND MOVES BACK TO THE EAST COAST	I-95 TO CENTRAL FLORIDA	I-95 TO CENTRAL FLORIDA
REMARKS	EXPECT BRIEF PERIODS WITH HEAVY PRECIP. AS SHOWERS MOVE ONSHORE NO AFTN COASTAL THUNDERSTORMS	T-STORMS WILL MOVE OVER COASTAL AREAS AT SEA BREEZE COLLAPSE WITH SW-W STEERING FLOW	WATCH FOR INITIAL THUNDERSTORM DEVELOPMENT WITH S/B INITIATION. EXPECT GUSTS ≥ 40 KNOTS W/ LATE AFTN MERGED BOUNDARY & MONITOR CLOSELY FOR SEVERE WX.	WATCH FOR INITIAL THUNDERSTORM DEVELOPMENT WITH SEA BREEZE INITIATION. IF MERGE IS WEST OF ORLANDO EXPECT < 35 KNOTS, EAST MERGER BRINGS POSSIBLE GUSTS > 50 KNOTS.	NORMALLY DRY (RH 800 –600MB < 40%), AND CONVECTION DOES NOT OCCUR, OR IT OCCURS FARTHER INLAND.	COMPLETE SOUTHEAST GRADIENT FLOW. MID-LEVEL MOISTURE IS NORMALLY HIGHER WITH CONVECTIVE POTENTIAL GREATER. MODERATE TO HEAVY RAINSHOWERS.

THUNDERSTORM FORMATION RULES OF THUMB

RELATIVE HUMIDITY 800 TO 600 MB		K-INDEX	AVERAGE WIND DIRECTION AND VELOCITY FROM 2-20KFT			
RH ≥ 60% THERE IS ≥ 70% PROBABLITY OF THUNDERSTORMS	RH < 40% THERE IS ≤ 10% PROBABILITY OF THUNDERSTORMS	K-INDEX ≥ 28 THERE IS ≥ 85% PROBABLITY OF T-STORM W/IN 10NM OF KSC/CCAFS	DIRECTION		VELOCITY	
			S/SW/W > 75% PROBABILTY OF T-STORMS	NW/N/NE/E ≤ 25% PROBABILITY OF T-STORMS	≤ 12KT THERE IS 75% PROBABLITY OF T-STORMS	>18KT THERE IS < 5% PROBABILTY OF T-STORMS

SKEW-T AND SEVERE WEATHER DATA

	LOW THREAT	MEDIUM THREAT	HIGH THREAT
LIFTED INDEX	>-2	-3 TO –5	<-5
K-INDEX	<26	26 TO 28	>28
TOTAL TOTALS	<45	46 TO 48	>48
SHOWALTER STABILITY INDEX	>3	2 TO –2	<-2

CYA MISC THUNDER DATA

T-STORMS PROBABILITY: Y / N ONSET TIME:		GUST SPEED (KNOTS) MAX:		MIN.: MEAN:
MEAN WIND 2-20K FT: DEG KTS		MEAN RH 800 – 600 MB:		
FREEZING LEVEL:	WET BULB ZERO:		TROPOPAUSE:	
-10C LEVEL:	-20C LEVEL:	STEERING FLOW (100-180): DEG KTS		
MDPI:	WINDEX:	CONVECTIVE TEMPERATURE:		

PROBABILITY OF T-STORMS FOR CAPE CANAVERAL:

CLIMATOLOGICAL:	850MB WINDS ONLY:	500MB WINDS:
PREVIOUS SSI PROBABILITY:		

MISCELLANIOUS SEVERE WEATHER PARAMETERS

WWUS35 KMLB OR ACUS1 KMKC SEVERE WEATHER POTENTIAL FORECASTED FOR OUR AREA: YES / NO

ARE THERE ANY CONVECTIVE SIGNETS OR OUTLOOKS FOR THE FORECAST AREA: YES / NO

ARE WE IN A MWA RED OR BLUE AREA: YES / NO

DOES AFWA HAVE A POINT WARNING OUT FOR OUR AREA: YES / NO

AMIS FORECASTED SEVERE PARAMETERS

MAX GUST:	MAX HAIL SIZE:

TODAY'S FORECAST FOR THUNDERSTORMS

T-STORMS TODAY: YES / NO	ONSET TIME: Z	MAX GUST: KT	MAX HAIL SIZE IN

45 WS Form 7, 3 May 00 (EF)

Appendix B – Jacksonville, Florida NWS Severe Weather Checklist

Severe Weather Checklist   (version 2003)

	None	General	Slight	Moderate	High
Does...SWODY1 indicate a risk for any part of our CWA?	None	General	Slight	Moderate	High
SWODY2 indicate a risk for any part of our CWA?	None	General	Slight	Moderate	High

Does a Tropical System pose a hazard to the CWA?   Yes   No

Synoptic Situation...Are there any low level jets (40 kts + at 850 mb)?   Yes   No

Are there low level forcing boundaries present/anticipated?   Yes   No
Fronts, outflows, sea breezes

Is there QG forcing present/anticipated?   Yes   No
PVA, Cold Pool Aloft, RRQ/LEQ upper jet, Divergence

	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
SWEAT Index____	< 200	200 - 300	301-400	401-500	>500
Total Totals_____	< 44	44 - 47	48-52	53-56	>56
K Index_____	< 15	15 - 23	24 - 32	33 - 40	> 40
Showalter_____	> 4	1- 4	0 to -3	- 4 to -6	< - 6
Lifted Index_____	> 0	0 to -2	-3 to -5	-6 to - 9	< - 9
CAPE_____	< 500	501-1000	1001-2500	2501-3500	> 3500
SRH (0-3 km)_____	< 50	51-150	151-250	251-350	> 350
Energy Helicity____	< 1	1-2	2-3	3-4	> 4
Wet Bulb Zero_____	below 5 kft above 11 kft	5 - 7 kft 10 - 11 kft	7-8 kft	8-9 kt	9-10 kft
Microburst DPI____	> 0.6	0.6 - 0.9	1.0 - 1.4	1.4 - 1.8	> 1.8

VIL of the day_____

Storm Motion_____

Precip Water_____

Color Code (if necessary)

SITE	COLOR
JAX	Red
TLH	Blue
____	____
____	____

Forecaster's Evaluation of Severe Weather Potential

_____
_____
_____
_____
_____

NOTICE