NASA Contractor Report NASA/CR-2007-214736

Situational Lightning Climatologies for Central Florida, Phase II, Part 3

William H. Bauman III
Applied Meteorology Unit
Kennedy Space Center, Florida

August 2007

NASA STI Program ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA scientific and technical information (STI) program plays a key part in helping NASA maintain this important role.

The NASA STI program operates under the auspices of the Agency Chief Information Officer. It collects, organizes, provides for archiving, and disseminates NASA's STI. The NASA STI program provides access to the NASA Aeronautics and Space Database and its public interface, the NASA Technical Report Server, thus providing one of the largest collections of aeronautical and space science STI in the world. Results are published in both non-NASA channels and by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA Programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA counterpart of peer-reviewed formal professional papers but has less stringent limitations on manuscript length and extent of graphic presentations.

- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.

- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.

- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or co-sponsored by NASA.

- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial public interest.

- TECHNICAL TRANSLATION. English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services also include creating custom thesauri, building customized databases, and organizing and publishing research results.

For more information about the NASA STI program, see the following:

- Access the NASA STI program home page at *http://www.sti.nasa.gov*

- E-mail your question via the Internet to help@sti.nasa.gov

- Fax your question to the NASA STI Help Desk at (301) 621-0134

- Phone the NASA STI Help Desk at (301) 621-0390

- Write to:
  NASA STI Help Desk
  NASA Center for AeroSpace Information
  7121 Standard Drive
  Hanover, MD 21076-1320

NASA Contractor Report NASA/CR-2007-214736

Situational Lightning Climatologies for Central Florida, Phase II, Part 3

William H. Bauman III
Applied Meteorology Unit
Kennedy Space Center, Florida

August 2007

Acknowledgements

The author would like to thank Ms. Winnie Lambert of the Applied Meteorology Unit for her help and guidance in deciphering the FORTRAN code so the programs could be applied to this work and Mr. Bill Roeder of the 45th Weather Squadron for his analysis that helped determine scaling the lightning probabilities by the ratio of the areas between the squares and circles was not a valid methodology using gridded lightning data.

Available from:

NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076-1320
(301) 621-0390

This report is also available in electronic form at

http://science.ksc.nasa.gov/amu/

Executive Summary

The threat of lightning is a daily concern during the warm season in Florida. The forecasters at the Spaceflight Meteorology Group (SMG) at Johnson Spaceflight Center in Houston, TX consider lightning in their landing forecasts for space shuttles at the Kennedy Space Center (KSC), FL Shuttle Landing Facility (SLF). The forecasters at the National Weather Service in Melbourne, FL (NWS MLB) do the same in their routine Terminal Aerodrome Forecasts (TAFs) for seven airports in the NWS MLB County Warning Area (CWA).

In Phase I of this work, the Applied Meteorology Unit (AMU) created 6- and 24-hour gridded lightning density and frequency climatologies based on the flow regime that the forecasters at the National Weather Service in Melbourne, FL (NWS MLB) use to issue daily lightning threat maps for their county warning area (Lambert et al. 2006). Phase II of this work consisted of three parts. In the first part, the AMU created climatological soundings of wind speed, wind direction, temperature, and dew point at Jacksonville, Tampa, Miami, and Cape Canaveral Air Force Station for each of eight flow regimes from a 16 year database of soundings (Short 2006). In the second part, the AMU calculated the same climatologies as in Phase I for the two 12-hour periods 0000–1200 UTC and 1200–2400 UTC. This report describes the third part of the Phase II work in which the AMU created flow regime climatologies of lightning probability in the 5-, 10-, 20-, and 30-n mi circles surrounding the Shuttle Landing Facility (SLF) and all airports in the NWS MLB county warning area in 1-, 3-, and 6-hour increments.

All data and code used in this work were provided to the AMU by the NWS in Tallahassee (TAE) and the Florida State University (FSU). NWS TAE and FSU provided a gridded dataset of cloud-to-ground lightning strikes from the National Lightning Detection Network (NLDN). The NLDN gridded data covered a large area that included all of Florida. The AMU modified the code to apply the gridded NLDN data only to the 5-, 10-, 20- and 30-n mi circles centered at each site for the 1-, 3- and 6-hour time intervals. Because the data were provided in gridded format, each circle size had to be approximated by squares that encompassed each of the circles. This approximation likely resulted in lower-than-actual lightning probability values for the 5-n mi circle and higher-than-actual lightning probabilities for the 10-, 20- and 30- n mi circles.

Once the code was setup and tested for the SLF, it was modified and run for the NWS airport locations. The 5- and 10-n mi circles are consistent with the TAF requirements at NWS MLB. The 20- and 30-n mi circles at the SLF were chosen to create the climatologies that will assist the SMG in making forecasts for Flight Rule violations of lightning occurrence during a shuttle landing.

The results were presented in tabular and graphical format and incorporated into a web-based graphical user interface (GUI) so forecasters could easily navigate through the resulting 432 tables and corresponding graphs. The GUI's Hypertext Markup Language format makes it usable in any web browser on computers with different operating systems.

Table of Contents

List of Figures

List of Tables

1. Introduction

Lightning occurrence is a concern for both the Space Program and commercial/general aviation. The forecasters at the Spaceflight Meteorology Group (SMG) at Johnson Spaceflight Center in Houston, TX consider lightning in their landing forecasts for space shuttles at the Kennedy Space Center (KSC), FL Shuttle Landing Facility (SLF). The forecasters at the National Weather Service in Melbourne, FL (NWS MLB) do the same in their routine Terminal Aerodrome Forecasts (TAFs) for seven[1] airports in the NWS MLB County Warning Area (CWA). Figure 1 shows the location of the SLF and the NWS MLB TAF locations within the NWS MLB CWA in east-central Florida.

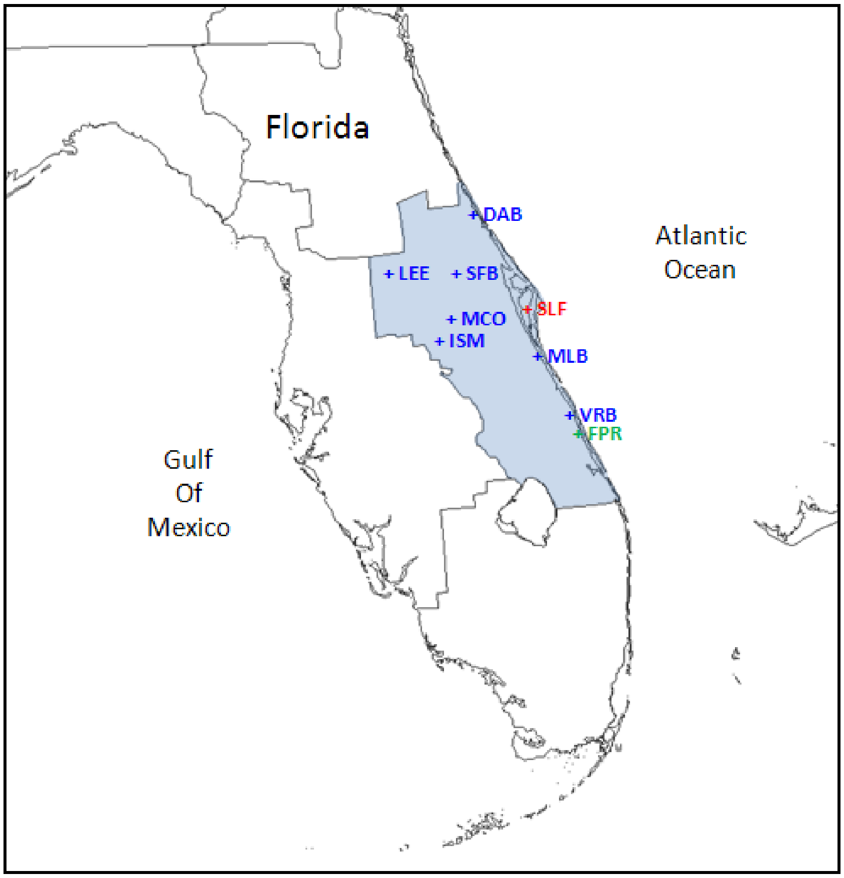


Figure 1. Map of the Florida peninsula showing the location of the SLF (red text), the seven current NWS MLB TAF sites (blue text), possible future NWS MLB TAF site (green text) and the NWS MLB CWA (light blue shaded area). The other areas (not shaded) represent CWA's of other NWS forecast offices in Florida.

The threat of lightning is always a consideration for SMG forecasters during shuttle landing operations as it may violate Flight Rules (FR). The NWS MLB creates a daily cloud-to-ground (CG) lightning threat index map for their CWA that encompasses all of their TAF locations. These daily maps are available on the NWS MLB web site at the URL http://www.srh.weather.gov/mlb/ghwo/lightning.shtml. The 45th Weather Squadron (45 WS) forecasters include a probability of lightning occurrence in their daily 24-Hour and Weekly Planning forecasts, which are briefed in the morning at 1100 UTC (0700 EDT). The probability of lightning occurrence is used by personnel involved in determining the possibility of violating launch commit criteria, evaluating shuttle FR, and planning for daily ground operation activities on KSC and Cape Canaveral Air Force Station (CCAFS).

[1] At the request of NWS MLB, the AMU added an eighth airport, St. Lucie County International Airport (FPR), to this task because it may be added to their TAF responsibility in the future.

The work described in this report is Part 3 in Phase II of this project. In Phase I, the Applied Meteorology Unit (AMU) created 6- and 24-hour gridded lightning density and frequency climatologies (Lambert et al. 2006) based on synoptic-scale flow regimes over the Florida peninsula (Lericos et al., 2002). In Phase II, Part 1 the AMU created climatological soundings of wind speed, wind direction, temperature, and dew point at Jacksonville (JAX), Tampa (TBW), Miami (MFL), and CCAFS (XMR) for the flow regimes from a 16 year database of soundings (Short 2006). In Part 2, the AMU calculated the same climatologies as in Phase I but for the two 12-hour periods 0000–1200 UTC and 1200–2400 UTC. In Part 3, the AMU created climatologies of lightning probabilities based on the flow regimes for 5-, 10-, 20-, and 30-n mi circles around the SLF and the seven current TAF locations as shown in Figure 2, in 1-, 3-, and 6-hour increments. The 20- and 30-n mi circles at the SLF were chosen to create the climatologies that will assist SMG in making forecasts for FR violations of lightning occurrence during a shuttle landing. The 5- and 10-n mi circles are consistent with the aviation forecast requirements at NWS MLB. The 20-and 30-n mi circles were included for the NWS MLB TAF sites at their request.

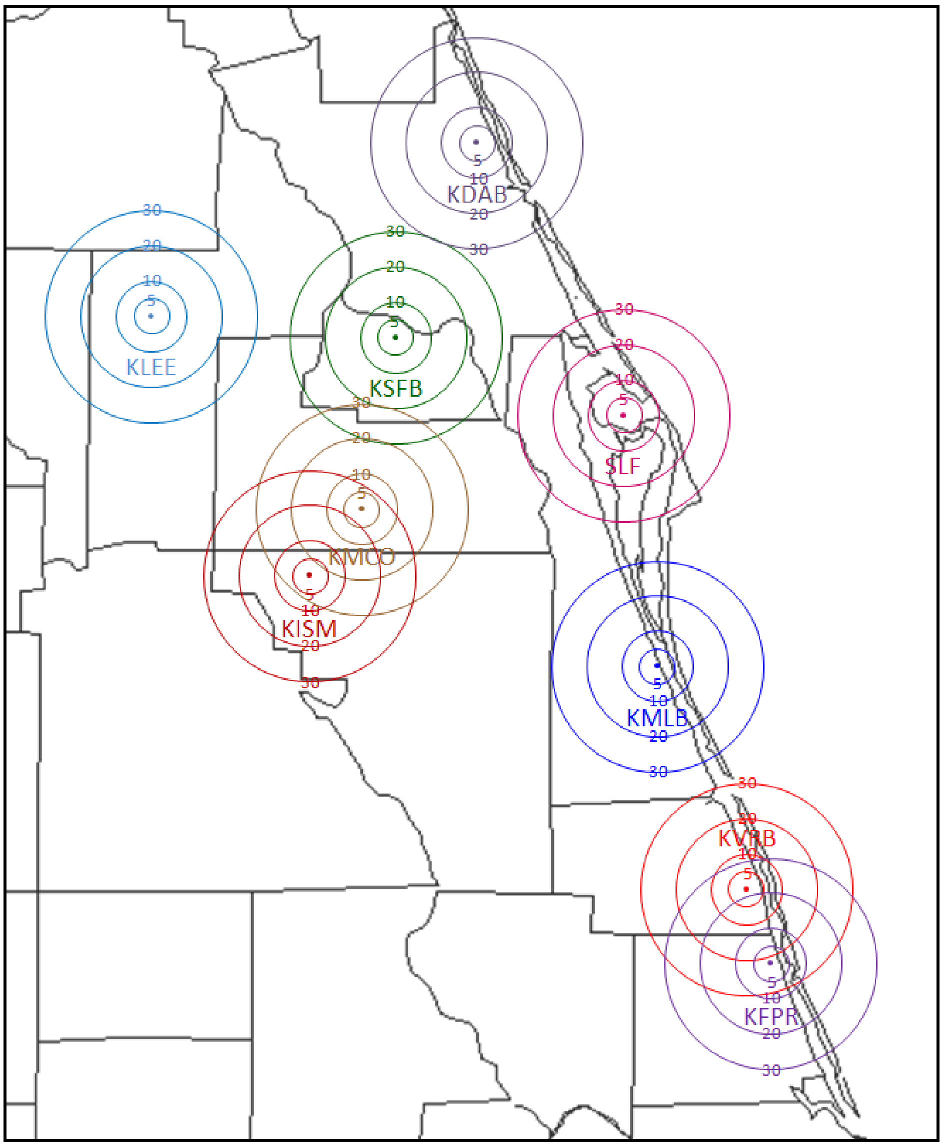


Figure 2. Depiction of the 5-, 10-, 20- and 30- n mi range rings around the SLF and seven current TAF locations.

2. Data and Programs

All data and code used in this work were provided to the AMU by Mr. Irv Watson of the NWS in Tallahassee (TAE) and Mr. Phil Shafer of the Florida State University (FSU). This allowed the AMU to create the climatologies desired by NWS MLB much sooner than creating the gridded data files and code independently. It also allowed NWS MLB to have values and calculations consistent with those of NWS TAE and FSU. This will facilitate future collaboration between the groups.

2.1 Data

The data for this task were the same as used in Lambert (2006). The period of record (POR) for the data is the warm season months of May through September in the 16-year period 1989–2004. The data files included all the information on flow regime and CG lightning occurrence needed to create the climatologies

2.1.1 Flow Regime Information

The AMU was given 10 files that contained low-level wind direction information extracted from the 1200 UTC soundings at MFL, TBW and JAX. The low-level directions were calculated using the wind observations in the 1000–700 mb layer at each of the three stations. These average winds were not used directly in the climatology calculations. There were two types of flow regime files:

- Three files containing the information from each of the three stations, and
- Seven files that contained the information for each of the flow regimes.

The information in the three station files included the month, day, year, day-of-year number, and the average wind speed and direction in the 1000–700 mb layer. The seven flow regime files contained the month, day year, day-of-year number, and the average wind direction in the 1000–700 mb layer at all three stations.

Table 1 shows the names of each flow regime as designated by FSU and the AMU, a short definition of each flow regime, and the number of days on which each flow regime occurred in the period. The AMU names are shown to provide a consistent reference to the naming convention in previous AMU reports and articles. Note that there are eight flow regimes in Table 1, but that only seven flow regime files were provided. FSU/NWS TAE did not have a flow regime file containing dates for which the flow regime could not be defined. Lambert et al. (2005) found that the number of days for these 'undefined' flow regimes comprised ~45% of the days in their POR. They decided that these days should be included in the analysis and created a regime named 'Other'. The AMU and NWS MLB also decided that CG climatologies should be calculated for the 'Other' regime. Therefore, the AMU determined the dates for this regime by extracting dates in the three station files that were not also found in the seven flow regime files, while accounting for days with missing data. Possibly due to a longer POR and one more flow regime than in Lambert et al (2005), the number of days in the 'Other' regime make up ~37% of the days in this study. More information on the flow regimes can be found in Lericos et al. (2002), Stroupe (2003), Lambert et al. (2005), and Lambert et al. (2006).

Table 1. This table contains the names of each flow regime as designated by FSU and the AMU, the definition of each flow regime, and the number of days in each regime during the warm seasons in 1989–2004.

FSU Naming Convection	***AMU Naming Convection***	***Flow Regime Definition***	***# Days in Regime***
r1	SE-2	Ridge north of Florida	225
r2	SW-1	Ridge south of Florida	271
r3	SE-1	Ridge btwn TBW and JAX	309
r4	SW-2	Ridge btwn TBW and MIA	241
r5	PAN	Possible ridge over Panhandle	109
f1	NW	Peninsular NW flow	94
f2	NE	Peninsular NE flow	174
ot	Other	Undefined Regime	827

2.1.2 Lightning Data

The CG data, from National Lightning Detection Network (NLDN) observations collected during the POR, were in the form of grids. These grids have a spatial resolution of 2.5 X 2.5 km and a temporal resolution of 1 hour. Therefore, there is one grid for every hour of every day in the period. Each grid box contains the number of CG strikes that occurred within that area in one hour. The entire grid encompasses the area from 24°–32.5° North latitude and 78°–88° West longitude and contains 405 x 377 grid boxes. This domain covers the entire state of Florida, adjacent Atlantic and Gulf of Mexico waters, and southern Georgia and Alabama as shown in Figure 3.

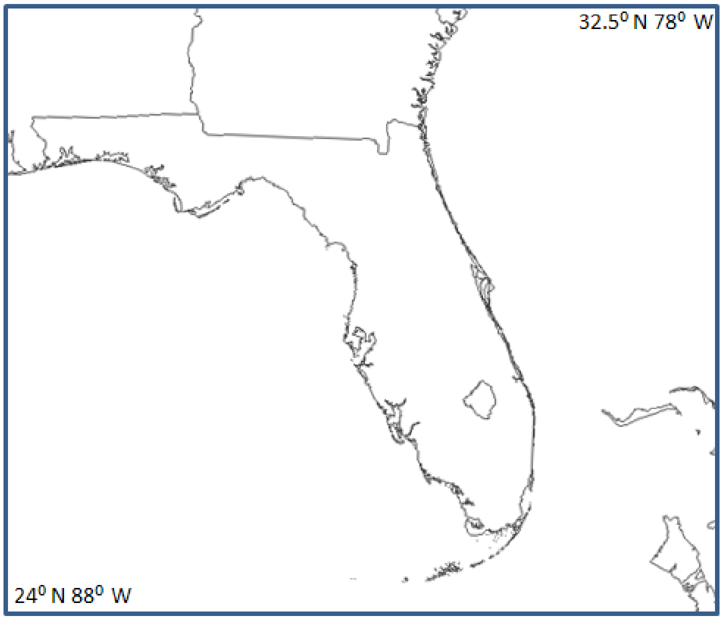


Figure 3. The coverage area of NLDN data provided by NWS TAE and FSU. There are 405 x 377 grid boxes which are 2.5 x 2.5 km each in size.

2.2 FORTRAN Programs

The AMU modified the Phase I FORTRAN code to create the SLF and TAF location climatologies. In order to approximate the 5-, 10-, 20- and 30-n mi circles with the gridded NLDN data, the location of each site needed to be determined to the nearest grid box within the code. The latitudes and longitudes of the runway centers (from http://www.airnav.com) and their associated nearest grid boxes are shown in Table 2.

Table 2. This table contains the latitude and longitude of the center of the runway for each location and corresponding grid box from the NLDN domain.

Site	***Lat/Lon***	***Nearest Grid Box (x, y)***
SLF	28.6150N/80.6945W	284,205
Daytona Beach (DAB)	29.1799N/81.0580W	270,240
Sanford (SFB)	28.7776N/81.2375W	264,213
Leesburg (LEE)	28.8231N/81.8087W	242,215
Orlando (MCO)	28.4294N/81.3090W	262,197
Kissimmee (ISM)	28.2898N/81.4371W	257,191
Melbourne (MLB)	28.1028N/80.6453W	289,183
Vero Beach (VRB)	27.6556N/80.4179W	299,163
St. Lucie (FPR)	27.4951N/80.3683W	302,156

The three FORTRAN programs provided by FSU to read and process the flow regime and CG grid files are discussed in detail in Lambert (2006). For this part of the work, the AMU modified two of the three programs for each location. The first program modified reads information from a parameter file that tells the program which grid files to open and process. The AMU modified this program and then created three separate programs, one for each time interval of 1-, 3-, and 6-hours, which output 1-, 3-, and 6-hourly grids for each day of each flow regime in the POR. The second program modified reads in the output from the first one and creates files containing twenty-four 1-, eight 3- and four 6-hourly climatological lightning probabilities at 5-, 10-, 20- and 30- n mi circles for each site and flow regime. This resulted in 36 new programs to handle the various combinations of time interval and site location.

The AMU made the modifications for the SLF first to test the code and make sure the conversion from the 405 x 377 grid domain (Figure 3) to the latitude/longitude (lat/lon) of the SLF was working properly. After determining the location of the SLF within the grid domain (see Table 2), the two programs were modified to create the probabilities for the SLF. The output was exported to Microsoft® Excel© (hereafter Excel) and then into ArcGIS software to plot the grid over a map with the SLF. The resulting map is shown in Figure 4. The domain approximating a 30 n mi circle from the center of the SLF is 22 x 22 grid squares. As Figure 4 shows, within the 22 x 22 grid squares, the nearest grid square to the center of the SLF runway at 28.6150N, 80.6945W is x=284,y=205. After the location procedure was verified to be accurate, the AMU carried out the same procedure for the seven current and one future TAF sites to verify the grid domain was properly placed relative to the lat/lon of each location before running the code to calculate the probabilities for each site.

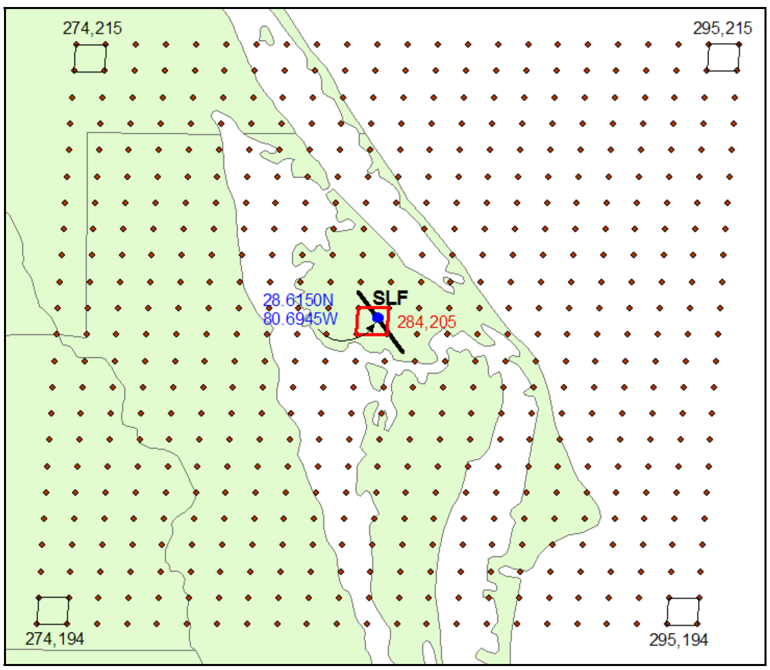


Figure 4. Graphical representation of the 30 n mi grid domain overlaid on a map with the SLF runway at the center. The four corners of the grid show the number of each grid box (x, y) in the domain. The red square at the SLF is the closest grid box to the center of the 30 n mi grid domain and the SLF. The lat/lon of the center of the SLF runway is depicted by the blue dot.

2.3 Approximating Circles with a Square Grid

Because the CG lightning data was provided in 2.5 x 2.5 km grids, the center point of each runway was not always in the center of a grid box or at an apex of a grid box. Because the data was in the form of grid boxes, each of the circles was approximated by a square area around each circle. Figure 5 shows the size of the four circles used in this work overlaid on a grid of 2.5 x 2.5 km grid boxes. This figure represents an idealized case where the center of a runway is at the middle of the range rings. This was not the case for each of the nine locations as they were all offset somewhat from the center of the grid square closest to the center of the circle.

The 5 n mi circle in Figure 5 (blue) is represented by nine grid boxes (blue square). The area of the circle is 67 km^2 while the area of the square is 56.25 km^2. Thus, the area of the square is 16% smaller than the area of the 5 n mi circle. This likely resulted in lower-than-actual values for the probabilities, although the difference is probably small. The 10 n mi circle (red) is approximated by 49 grid boxes (red square) about its center. Only four grid boxes (shaded in red) at the corners of the square are outside of this circle. The area of the square is 306 km^2. This is about 13% larger than the area of the circle, which is 269 km^2. This likely resulted in higher-than-actual values for the probabilities, but, as for the 5 n mi circle, the difference is probably small as well.

The 20 n mi circle (green) is represented by 225 grid boxes (green square). There are 48 grid boxes (shaded in green) outside of the circle at the four corners of the square. The area of the circle is 1078 km^2 and the area of the square is 1406 km^2, or 23% larger than the circle. As with the 10 n mi circle, this likely resulted in higher-than-actual values for the probabilities, possibly significantly higher since the area of the square outside the circle is larger than for the 10 n mi circle. The 30 n mi circle (purple) is represented by 529 grid boxes (purple square). There are 144 grid boxes (shaded in purple) outside the circle at the corners of the square. The area of the circle is 2425 km^2 and the area of the square is 3306 km^2, or 27% larger than the area of the circle. As with the 10 and 20 n mi circles, this likely resulted in higher-than-actual values for the probabilities, probably significantly higher since the area of the square outside the circle is larger than for the 10 and 20 n mi circles.

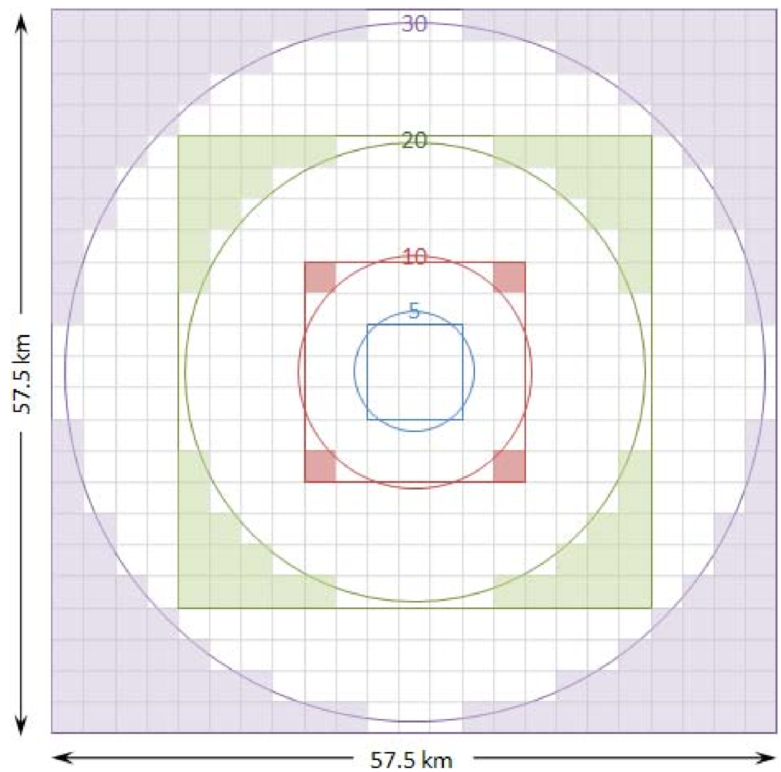


Figure 5. Depiction of the 5-, 10-, 20-, and 30- n mi circles and their idealized relationship to the 2.5 x 2.5 km grid squares containing the lightning data. The 5 n mi circle is blue, the 10 n mi circle is red, the 20 n mi circle is green, and the 30 n mi circle is purple. The shaded grid boxes show the areas outside of the circles that were included in the computation of lightning probabilities.

In summary, using grid boxes to approximate the area of the circles likely resulted in climatological probability values that were too low for the 5 n mi circle and too high for the 10-, 20- and 30- n mi circles. Although the magnitude of the uncertainty is unknown for all four circles, one can assume that an over-estimate for the outer three circles would provide a more conservative estimate of lightning probability. The AMU considered approximating the area of each square to the corresponding circle to normalize the probabilities by taking the ratio of the area of square to that of the circle and multiplying it by the probability obtained for the square. After further consideration and consultation with AMU customers, this methodology was not adopted because taking a ratio of the probabilities would not create more accurate probabilities for the area of the circle. For example, if the probability of lightning for a given area was 100% and the area was doubled, the probability could not then be 200%. An accurate way to create these probabilities would be to use raw lightning data containing the lat/lon of each strike. Data in that form were not available for this work.

3. Results and Graphical User Interface

The output from the FORTRAN code for all sites, time intervals and circles was imported into Excel to create data tables and graphics for incorporation into the graphical user interface (GUI). The GUI was written in Hypertext Markup Language (HTML) to help make the tool more portable among different computer operating systems.

3.1 Data Tables and Graphics

A total of 864 spreadsheets were generated in Excel from the FORTRAN output. These spreadsheets contained the climatological probabilities of lightning for nine sites at three time intervals, four different size circles and eight flow regimes. An example of a spreadsheet with 1-hour probabilities in the 5 n mi circle for the Southwest-2 flow regime at the SLF is shown in Table 3. The climatological probability of lightning for each hour of the day rounded to the nearest integer is displayed in the first column, the corresponding UTC time is shown in the second column, the number of CG strikes for each hour is shown in the third column and the number of flow regime days in the POR is shown in the fourth column.

Table 3. This table shows an example of one of the 864 spreadsheets generated from the FORTRAN output. This data shows the climatological probability of lightning within 5 n mi of the SLF for every hour of the day for the Southwest-2 flow regime. The number of CG strikes and number of flow regime days are also shown.

Probability (%)	UTC Time	# Strikes	# Flow Regime Days
4	0	368476	271
4	1	292974	271
4	2	233788	271
3	3	175805	271
1	4	140630	271
0	5	118449	271
0	6	100309	271
0	7	86359	271
0	8	85585	271
0	9	92138	271
0	10	97960	271
0	11	103508	271
0	12	112800	271
0	13	125424	271
0	14	139956	271
0	15	149935	271
0	16	175178	271
1	17	217121	271
4	18	282131	271
8	19	348460	271
7	20	430364	271
12	21	487357	271
12	22	475868	271
10	23	429330	271

To put the data in a more presentable format for the forecasters, the AMU first merged the data from multiple spreadsheets into data tables grouped by either time interval or flow regime. An example of one data table in the time interval format is shown in Table 4. This table shows data for 1-hour intervals for all four circles at the SLF for the Southwest-2 flow regime. The AMU then created graphs from the tables to provide a "quick look" tool for the forecasters. The graphs make it easier for the forecaster to see the lightning probability trends throughout the day in a graphical presentation. An example of one graph that corresponds to the data from Table 4 is shown in Figure 6.

Table 4. This table shows an example of one of the combined data tables developed for the forecaster's use. It combines the climatological probability of lightning during the Southwest-2 flow regime from all four circles at the SLF for every hour of the day.

Time	**5 n mi**	**10 n mi**	**20 n mi**	**30 n mi**
00-01 UTC	4%	11%	23%	31%
01-02 UTC	4%	8%	18%	24%
02-03 UTC	4%	8%	13%	18%
03-04 UTC	3%	5%	8%	13%
04-05 UTC	1%	3%	5%	7%
05-06 UTC	0%	1%	3%	4%
06-07 UTC	0%	0%	1%	3%
07-08 UTC	0%	0%	1%	2%
08-09 UTC	0%	0%	1%	1%
09-10 UTC	0%	0%	1%	1%
10-11 UTC	0%	0%	0%	1%
11-12 UTC	0%	0%	0%	1%
12-13 UTC	0%	0%	0%	1%
13-14 UTC	0%	0%	1%	1%
14-15 UTC	0%	1%	1%	1%
15-16 UTC	0%	1%	2%	3%
16-17 UTC	0%	1%	4%	5%
17-18 UTC	1%	3%	7%	8%
18-19 UTC	4%	7%	14%	19%
19-20 UTC	8%	14%	20%	27%
20-21 UTC	7%	14%	26%	34%
21-22 UTC	12%	23%	35%	42%
22-23 UTC	12%	23%	35%	45%
23-00 UTC	10%	18%	28%	39%

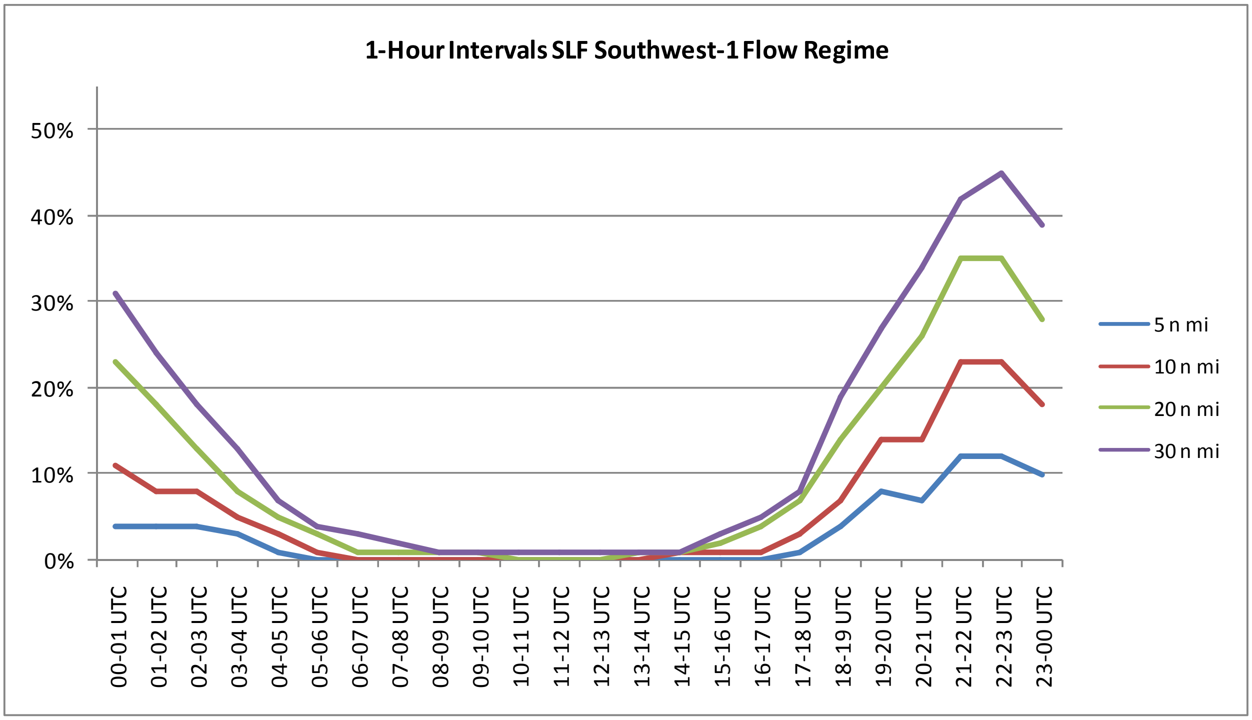


Figure 6. Graphical representation of climatological lightning probabilities shown in Table 4.

3.1 GUI and HTML Tool

Combining the data from the 864 original spreadsheets still left 432 spreadsheets and the same number of corresponding graphs. Searching through this many tables and graphs to find the desired data in Excel would be difficult for the forecasters to use in a timely manner. Therefore, the AMU built a GUI using HTML in the form of an easily navigable web site[2] to display the Excel tables and graphs.

The main page of the GUI (Figure 7) is the starting point for the forecasters. From the navigation menu at the top of the page, they can click the **Data and Definitions** button to view helpful information regarding the data, methodology and flow regime definitions or they can click a button for a specific site either on the navigation menu or directly on the interactive map. Once they have chosen a site, they are presented with the main page for that site as shown for the SLF in Figure 8. The forecasters are presented with two additional navigation menus on this page allowing them to view the lightning probabilities based on time interval or by flow regime. The main navigation menu remains visible so they can easily switch to another site or access the Data and Definitions page.

An example of the data for the 3-hour time interval for the SLF is shown in Figure 9. The data table for each flow regime is presented on the left of the page and the corresponding graph is shown to the right of each table. The forecaster can use the vertical scroll bar to navigate down and up on the page to view all 8 flow regimes. An example of the data for the Southwest-2 flow regime for the SLF is shown in Figure 10. The data table for each of the 3 time intervals is presented on the left of the page and the corresponding graph is shown to the right of each table. The forecaster can use the vertical scroll bar to navigate down and up on the page to view the three time intervals.

[2] The web site files and GUI are available by request from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL 32931, or via e-mail request to amu@ensco.com.

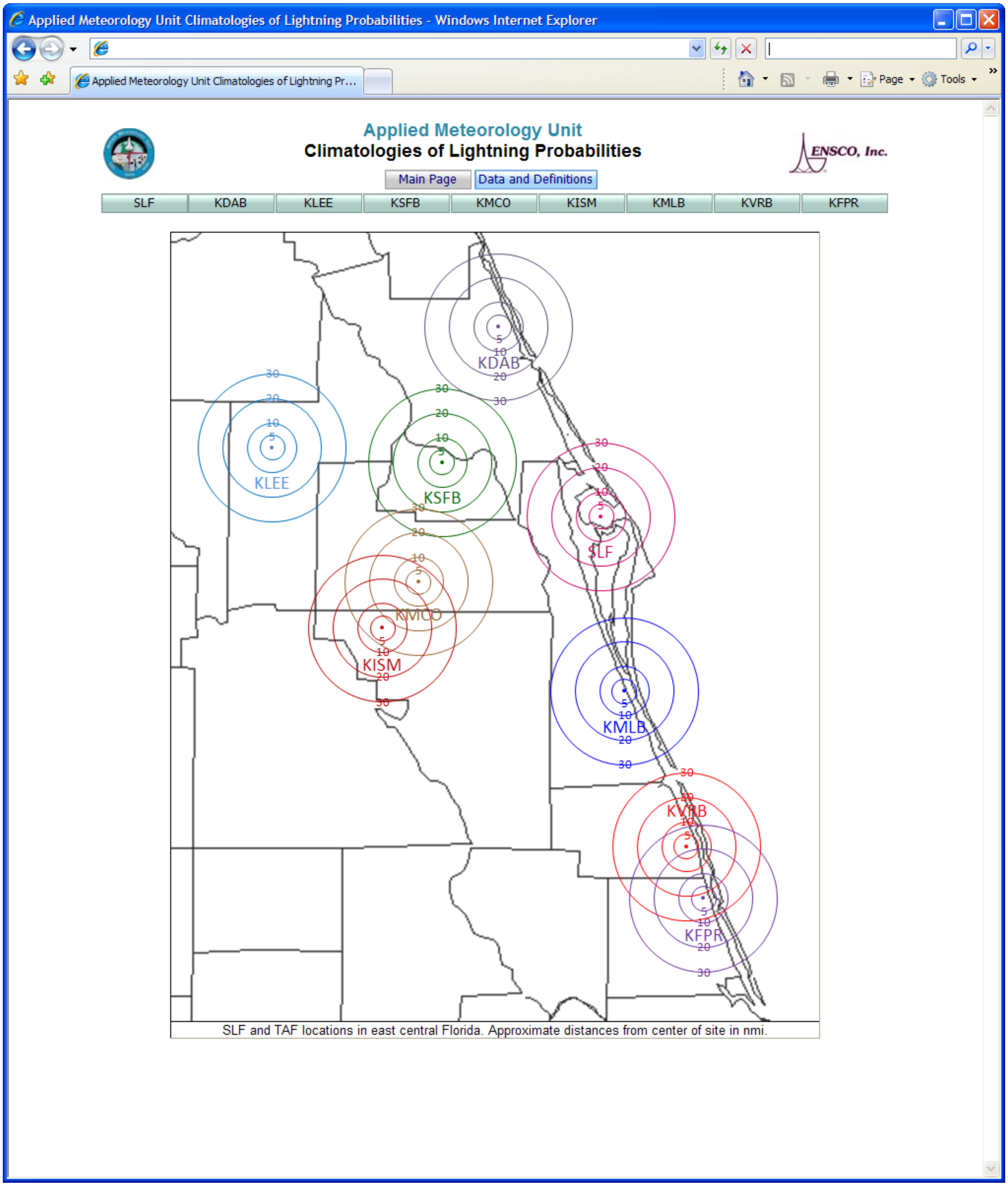


Figure 7. Main page of the GUI. Forecasters can access any of the nine sites by clicking on the site identifier in the top-level navigation menu or by clicking on the site on the interactive map.

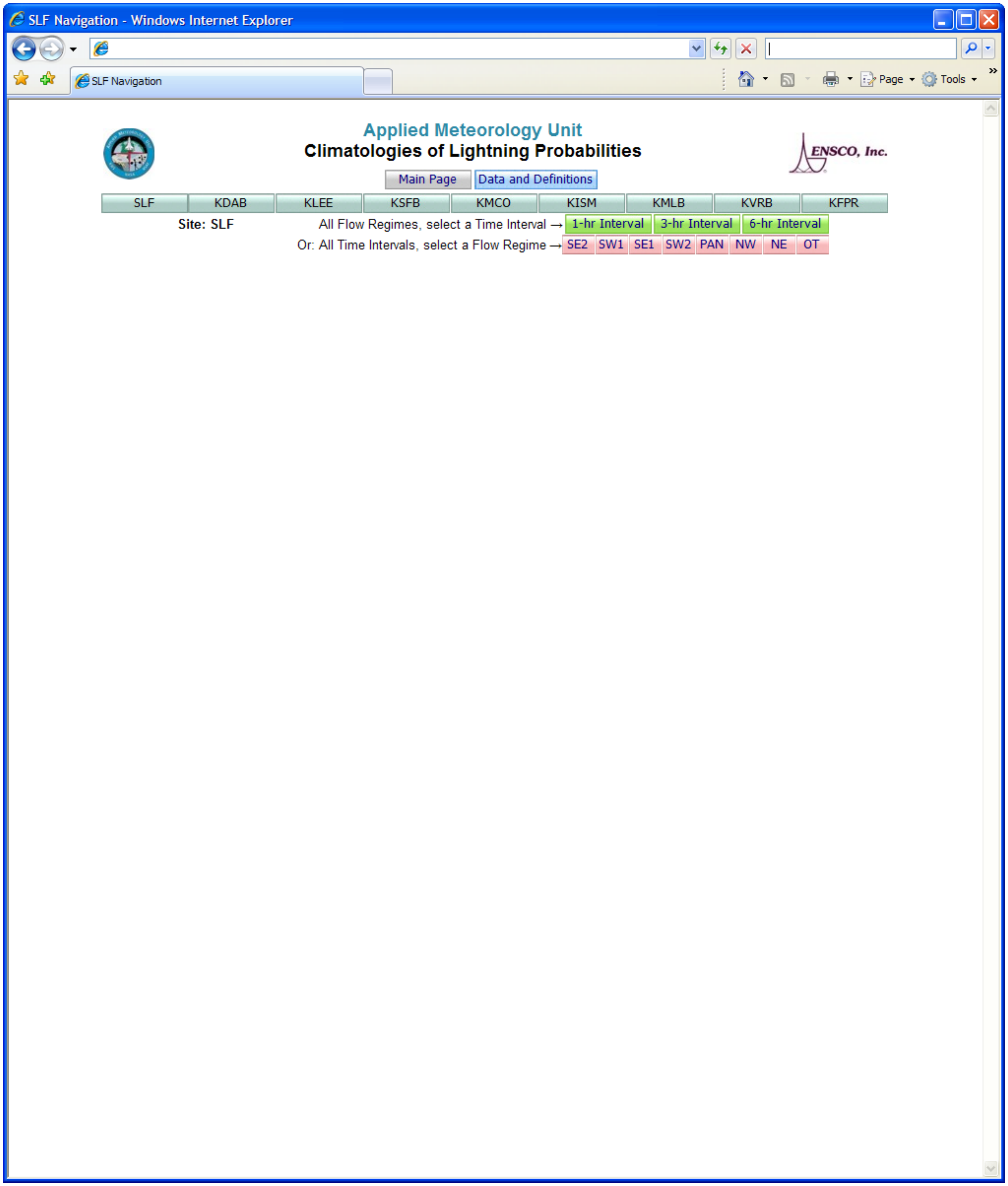


Figure 8. SLF page of the GUI. Forecasters can access the SLF data by time interval or by flow regime by clicking on the appropriate button on either of the two sub-navigation menus. The other sites are still accessible from this page from the top-level navigation menu.

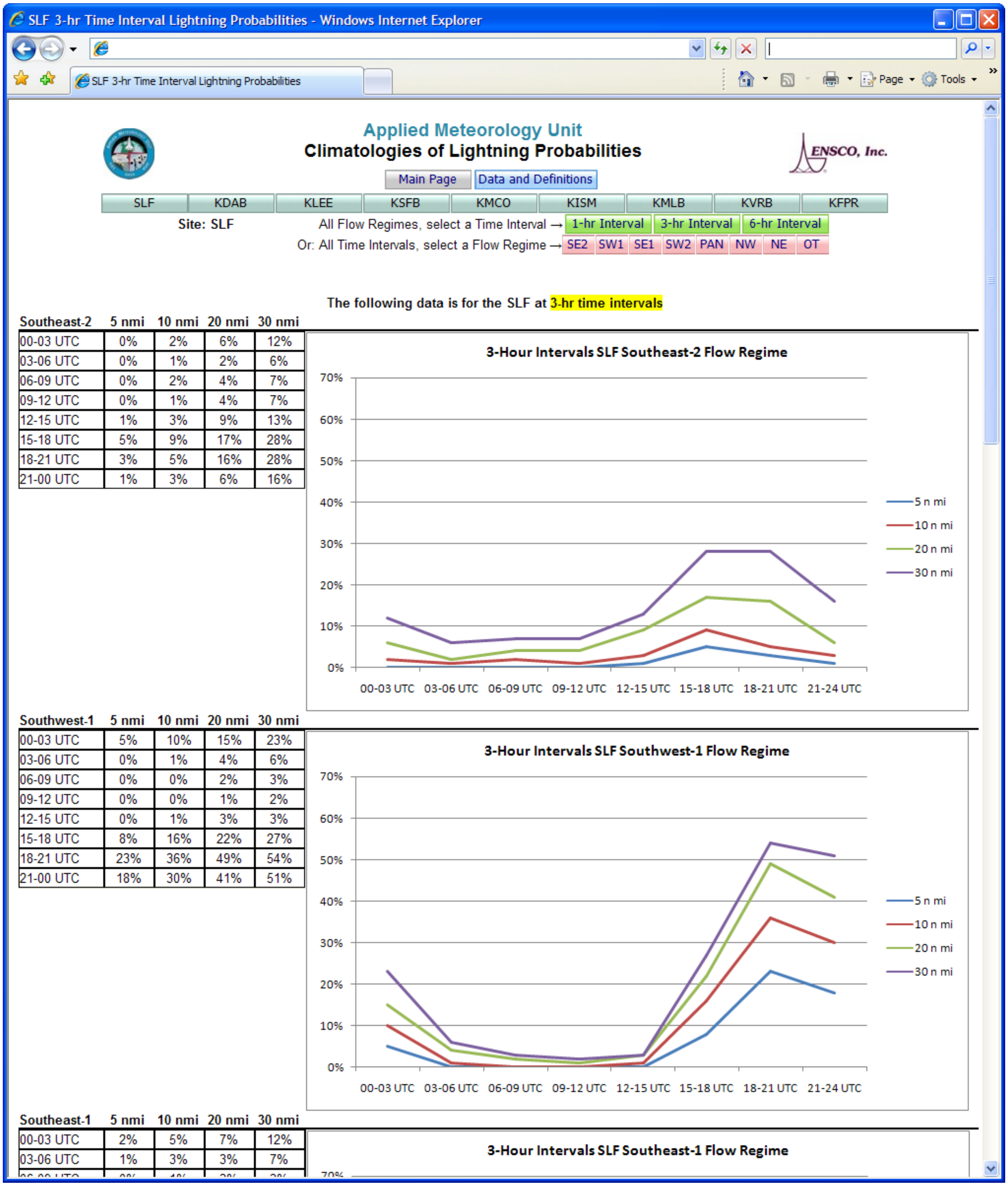


Figure 9. SLF data for the 3-hour time interval and all flow regimes. The data is in tabular form on the left side of the page with corresponding graphs to the right of the tables. The user can use the scroll bar on the right to view other flow regimes not shown in this figure. Forecasters can access the other two time intervals or any of the flow regime-based data by clicking on the appropriate button on either of the two sub-navigation menus. The other sites are still accessible from this page from the top-level navigation menu.

SLF Southwest-2 Flow Regime Lightning Probabilities - Windows Internet Explorer

Applied Meteorology Unit

Climatologies of Lightning Probabilities

ENSCO, Inc.

Main Page | Data and Definitions

SLF | KDAB | KLEE | KSFB | KMCO | KISM | KMLB | KVRB | KFPR

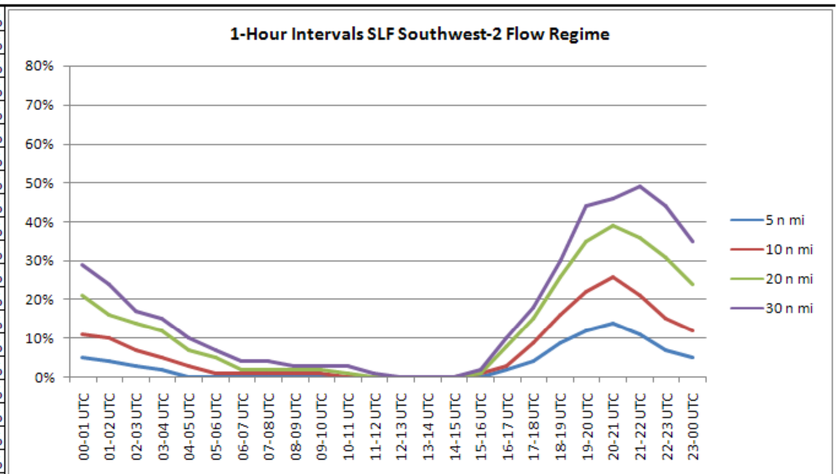
Site: SLF

All Flow Regimes, select a Time Interval → 1-hr Interval | 3-hr Interval | 6-hr Interval

Or: All Time Intervals, select a Flow Regime → SE2 | SW1 | SE1 | SW2 | PAN | NW | NE | OT

The following data is for the SLF Southwest-2 Flow Regime

1-hour Intervals	5 nmi	10 nmi	20 nmi	30 nmi
00-01 UTC	5%	11%	21%	29%
01-02 UTC	4%	10%	16%	24%
02-03 UTC	3%	7%	14%	17%
03-04 UTC	2%	5%	12%	15%
04-05 UTC	0%	3%	7%	10%
05-06 UTC	0%	1%	5%	7%
06-07 UTC	0%	1%	2%	4%
07-08 UTC	0%	1%	2%	4%
08-09 UTC	0%	1%	2%	3%
09-10 UTC	0%	1%	2%	3%
10-11 UTC	0%	0%	1%	3%
11-12 UTC	0%	0%	0%	1%
12-13 UTC	0%	0%	0%	0%
13-14 UTC	0%	0%	0%	0%
14-15 UTC	0%	0%	0%	0%
15-16 UTC	0%	1%	1%	2%
16-17 UTC	2%	3%	8%	10%
17-18 UTC	4%	9%	15%	18%
18-19 UTC	9%	16%	26%	30%
19-20 UTC	12%	22%	35%	44%
20-21 UTC	14%	26%	39%	46%
21-22 UTC	11%	21%	36%	49%
22-23 UTC	7%	15%	31%	44%
23-00 UTC	5%	12%	24%	35%



3-hour Intervals	5 nmi	10 nmi	20 nmi	30 nmi
00-03 UTC	6%	13%	24%	30%
03-06 UTC	2%	5%	11%	16%
06-09 UTC	0%	2%	5%	7%
09-12 UTC	0%	0%	1%	3%
12-15 UTC	0%	0%	0%	0%
15-18 UTC	7%	14%	24%	27%
18-21 UTC	27%	40%	52%	58%
21-24 UTC	15%	29%	46%	61%

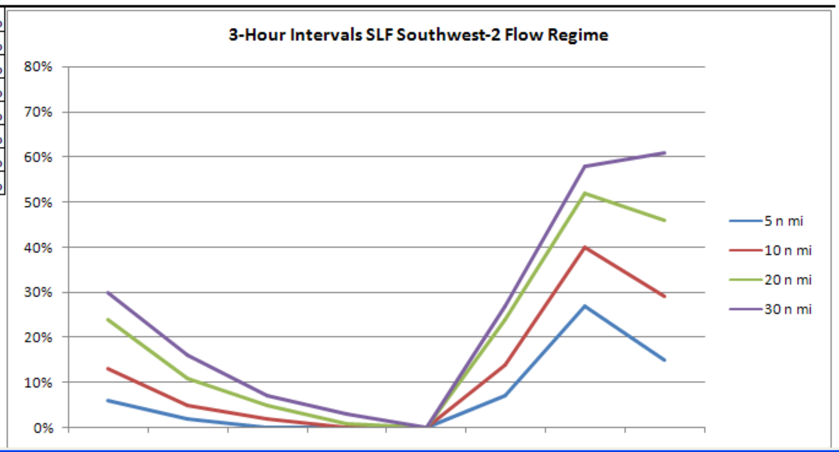


Figure 10. SLF data displayed for the Southwest-2 flow regime and all time intervals. The data is presented in tabular form on the left side of the page with corresponding graphs to the right of the tables. The user can use the scroll bar on the right to view the 6-hour time interval not shown in this figure. Forecasters can access the other seven flow regimes or any of the time interval-based data by clicking on the appropriate button on either of the two sub-navigation menus. The other sites are still accessible from this page from the top-level navigation menu.

4. Summary and Future work

The AMU created climatologies of CG lightning probability for nine sites in east-central Florida using gridded NLDN data. The AMU modified the FORTRAN programs provided by NWS TAE and FSU to create climatologies for four different circle sizes (5-, 10-, 20- and 30- n mi) centered at each site and three time intervals (1-, 3-, and 6-hours) and stratified by eight flow regimes. The NLDN gridded data provided to the AMU covered a large area including the eastern Gulf of Mexico, all of Florida and the western Atlantic Ocean from offshore southern Georgia to the western Bahamas. The AMU modified the FORTRAN programs to apply the gridded NLDN data only to the four circle sizes and three time intervals for each site. Because the data were provided in gridded format, each circle size had to be approximated by squares resulting in likely lower-than-actual lightning probabilities for the 5-n mi circle and higher-than-actual lightning probabilities for the 10-, 20- and 30- n mi circles. The results were presented in tabular and graphical format and incorporated into a web-based GUI so the forecasters could easily navigate through the large amount of data and to make the GUI usable in any web browser on computers with different operating systems.

More accurate climatological lightning probabilities could be obtained by re-writing the FORTRAN code to exclude extraneous grid boxes or by using non-gridded CG lightning data to determine a single probability for a specific radius from the center of each site. Re-writing the FORTRAN code to exclude the area in the squares that are not within the circles would be a major effort. If the time and lat/lon data were provided for each CG strike in the POR, code could be written to determine whether a strike was within a circle.

The NWS MLB and SMG forecasters both use the Advanced Weather Interactive Processing System (AWIPS) as their primary weather analysis and display system in their operations. While the GUI developed in this task can be displayed on an AWIPS workstation via the web browser, it might be useful to write the GUI in a language other than HTML so it could be displayed directly on AWIPS without a web browser and possibly plot data directly on the AWIPS Two-Dimensional-Display (D2D). This would let the forecasters plot climatological lightning probabilities in D2D and overlay other pertinent data on the same display.

References

Lambert, W., 2006: User's Guide for the Programs and Data Used to Create the Florida Lightning Frequency and Density Climatologies. NASA Applied Meteorology Unit Memorandum, 13 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL 32931, or via e-mail request to amu@ensco.com].

Lambert, W. and M. Wheeler, 2005: Objective lightning probability forecasting for Kennedy Space Center and Cape Canaveral Air Force Station. NASA Contractor Report CR-2005-212564, Kennedy Space Center, FL, 54 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL, 32931, and at http://science.ksc.nasa.gov/amu/final.html]

Lambert, W., M. Wheeler, and W. Roeder, 2005: Objective lightning forecasting at Kennedy Space Center and Cape Canaveral Air Force Station using Cloud-to-Ground Lightning Surveillance System data. Preprints, *Conf. on Meteorological Applications of Lightning Data*. San Diego, CA, Amer. Meteor. Soc., 9 pp.

Lambert, W., D. Sharp, S. Spratt, and M. Volkmer, 2006: Using cloud-to-ground climatologies to initialize gridded lightning threat forecasts for East Central Florida. Preprints, *Second Conf. on Meteorological Applications of Lightning Data*. Atlanta, GA, Amer. Meteor. Soc., 4 pp.

Lericos, T. P., H. E. Fuelberg, A. I. Watson, and R. L. Holle, 2002: Warm season lightning distributions over the Florida Peninsula as related to synoptic patterns. *Wea. Forecasting*, **17**, 83 – 98.

Short, D., 2006: Situational Lightning Climatologies for Central Florida, Phase II. Applied Meteorology Unit Memorandum, 8 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL 32931]

Stroupe, J. R., 2003: *1989-2002 Florida Lightning Climatology*. Available on the Florida State University website at: http://bertha.met.fsu.edu/~jstroupe/flclimo.html.

List of Acronyms

45 WS	45th Weather Squadron
AMU	Applied Meteorology Unit
AWIPS	Advanced Weather Interactive Processing System
CCAFS	Cape Canaveral Air Force Station
CG	Cloud-to-Ground
D2D	AWIPS Two-Dimensional-Display
DAB	Daytona Beach International Airport
FPR	St. Lucie County International Airport
FR	Flight Rules
FSU	Florida State University
GUI	Graphical User Interface
HTML	Hypertext Markup Language
ISM	Kissimmee Gateway Airport
JAX	Jacksonville, FL rawinsonde 3-letter identifier
KSC	Kennedy Space Center
LEE	Leesburg Regional Airport
MCO	Orlando International Airport
MIA	Miami, FL rawinsonde 3-letter identifier
MLB	Melbourne International Airport
NE	Northeast flow regime
NLDN	National Lightning Detection Network
NW	Northwest flow regime
NWS MLB	National Weather Service Melbourne, FL
NWS TAE	National Weather Service Tallahassee, FL
POR	Period of Record
SE	Southeast flow regime
SFB	Orlando Sanford International Airport
SLF	Shuttle Landing Facility
SMG	Spaceflight Meteorology Group
SW	Southwest flow regime
TAF	Terminal Aerodrome Forecast
TBW	Tampa, FL rawinsonde 3-letter identifier
VRB	Vero Beach Municipal Airport
XMR	CCAFS rawinsonde 3-letter identifier

NOTICE