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Flow Regime Based Climatologies of Lightning Probabilities for Spaceports and Airports



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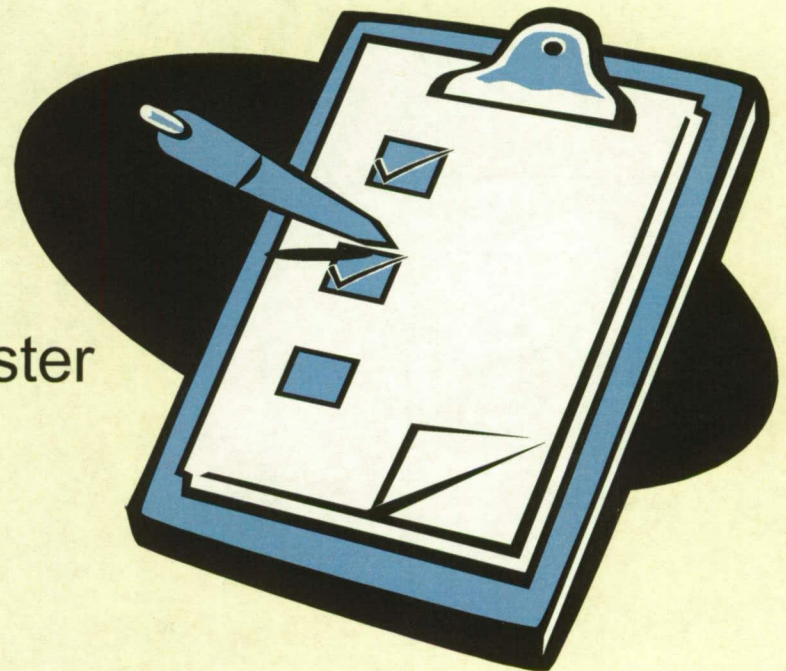
Reno, Nevada



Outline



- Project objectives
- Data and period of record
- Flow regime definitions
- Methodology
- Taming the data for the forecaster
- Summary

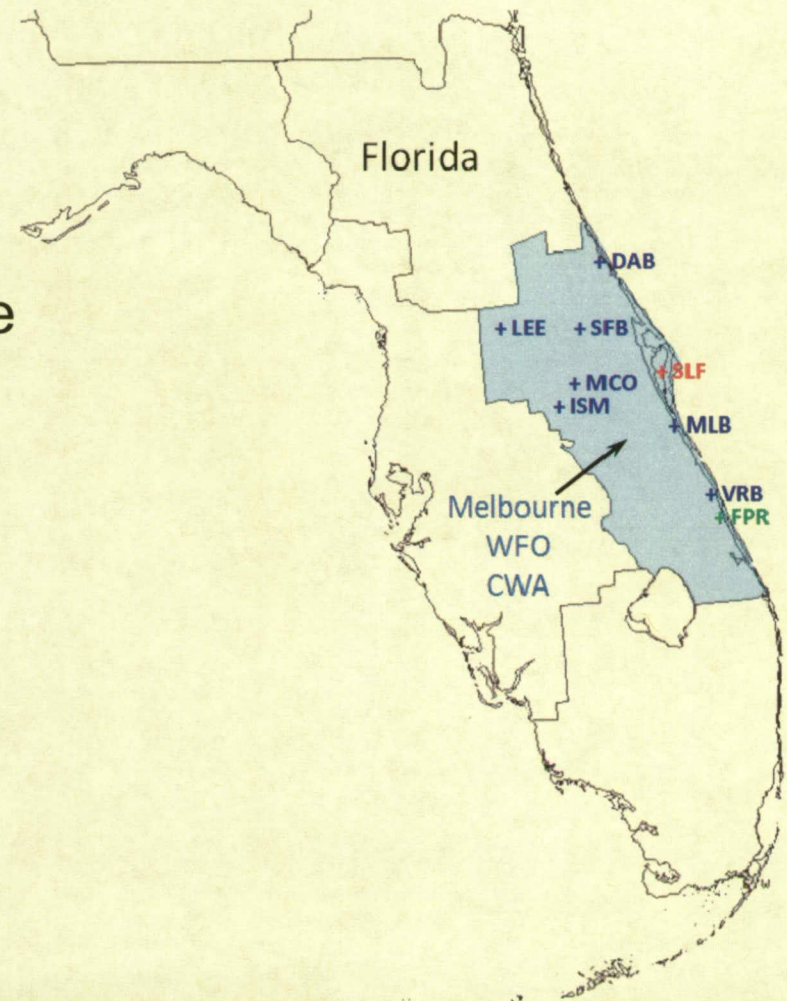




Project Objectives



- Provide forecasters with “first guess” warm season climatological lightning tool
- Create climatologies of lightning probabilities based on flow regime
 - 5-, 10-, 20-, and 30-n mi circles around the Shuttle Landing Facility and seven airports within Melbourne National Weather Service (NWS) Forecast Office CWA for TAF support
 - 1-, 3-, and 6-hour increments
- Develop a forecaster tool to display the data with an easy to use GUI

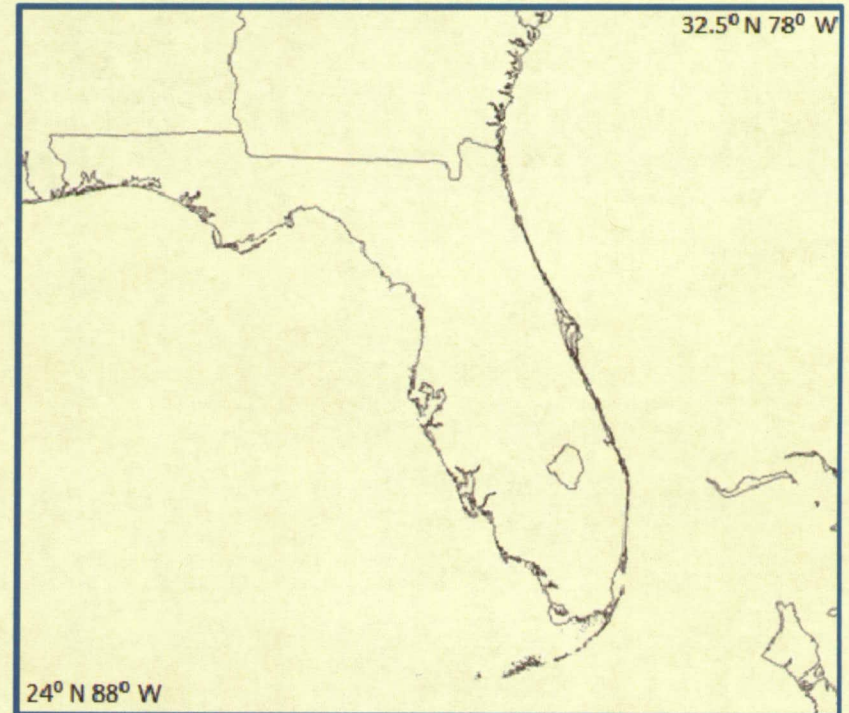




Data and Period of Record (POR)



- NWS in Tallahassee provided National Lightning Detection Network (NLDN) gridded data of cloud-to-ground (CG) lightning strikes
 - Spatial resolution: 2.5 X 2.5 km
 - 24°–32.5° N and 78°–88° W
 - 405 x 377 grid boxes
 - Temporal resolution: 1 hour
- Warm season months of May through September in the 16-year period 1989–2004





Flow Regime Definitions

- Florida State University (FSU) identified large-scale flow regimes over Florida
 - Found strong relationship between regimes and spatial distribution of CG lightning
 - Average wind directions in 1000 – 700 mb layer from the 1200 UTC soundings Miami (MFL), Tampa (TBW), and Jacksonville (JAX)
 - Studies yielded 7 distinct flow regimes

Flow Regime Name	Definition	Days in Regime
SW-1	Ridge from Atlantic High South of MFL	271
SW-2	Ridge from Atlantic High North of MFL and South of TBW	241
SE-1	Ridge from Atlantic High North of TBW and South of JAX	309
SE-2	Ridge from Atlantic High North of JAX	225
NE	Overall Northeast Flow	174
PAN	Ridge from Central Gulf Coast High over Panhandle	109
NW	Overall Northwest Flow	94
Other	Undefined Regime	827



Methodology



- FSU provided code which AMU modified to:
 - Output 1-, 3-, and 6-hourly grids for each day of each flow regime in the POR
 - Read the output from the first program to create files with 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
- Resulting 36 new programs handled various combinations of time interval and site location

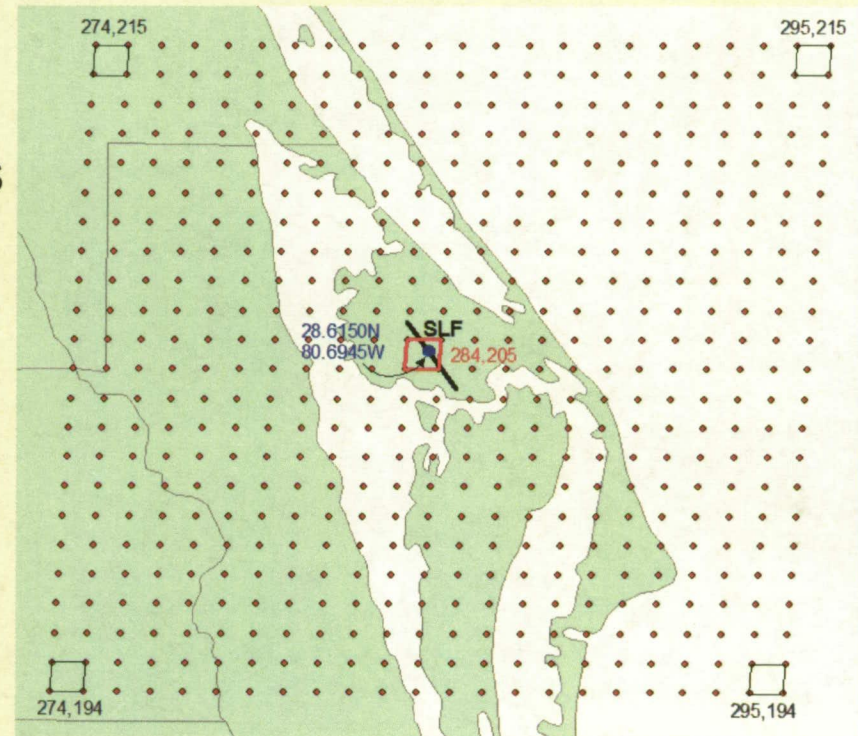




Methodology



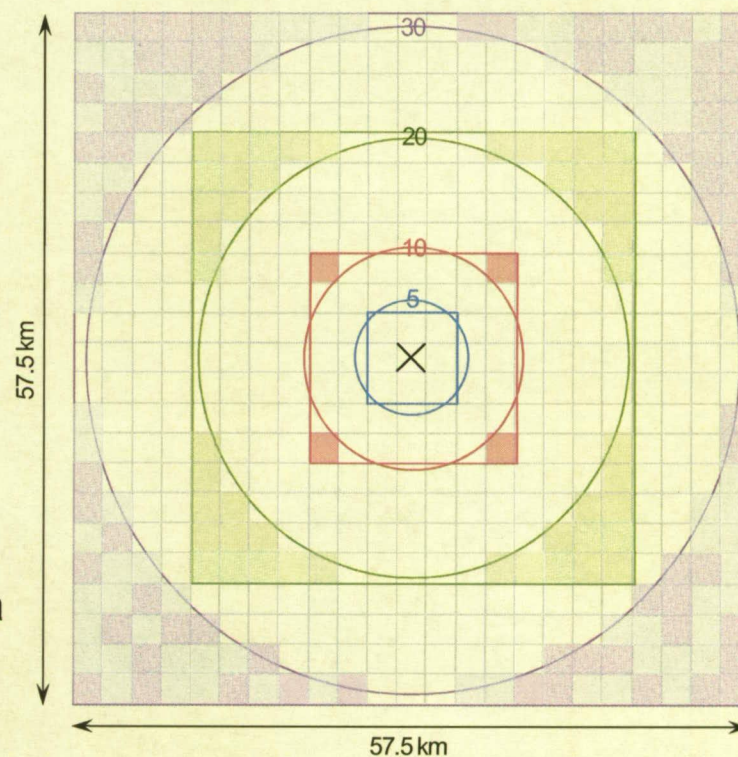
- AMU modified code to convert the gridded data to latitude/longitude for each site
- Center point of each runway was not always in the center of a grid box or at an apex of a grid box
 - Picked closest 2.5 km X 2.5 km grid box to runway center
 - Determined corner grid boxes at 5-, 10-, 20-, and 30-n mi from center square
 - Had to use area of square instead of area of circle due to design of code

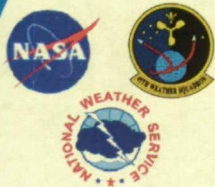




Methodology

- 529 grid boxes instead of 30-n mi circle
 - Area of purple square is 27% larger than area of purple circle
- 225 grid boxes instead of 20-n mi circle
 - Area of green square is 23% larger than area of green circle
- 49 grid boxes instead of 10-n mi circle
 - Area of red square is 13% larger than area of the red circle
- 9 grid boxes instead of 5-n mi circle
 - Area of blue square is 16% smaller than area of the blue circle





Taming the Data

- Generated 864 spreadsheets in Excel from the FORTRAN output which contained the climatological probabilities of lightning for:
 - 9 sites
 - 3 time intervals
 - 4 different size circles
 - 8 flow regimes
- Contained climatological probability of lightning for:
 - each hour of the day rounded to the nearest integer
 - corresponding UTC time
 - number of CG strikes for each hour
 - number of flow regime days in the POR

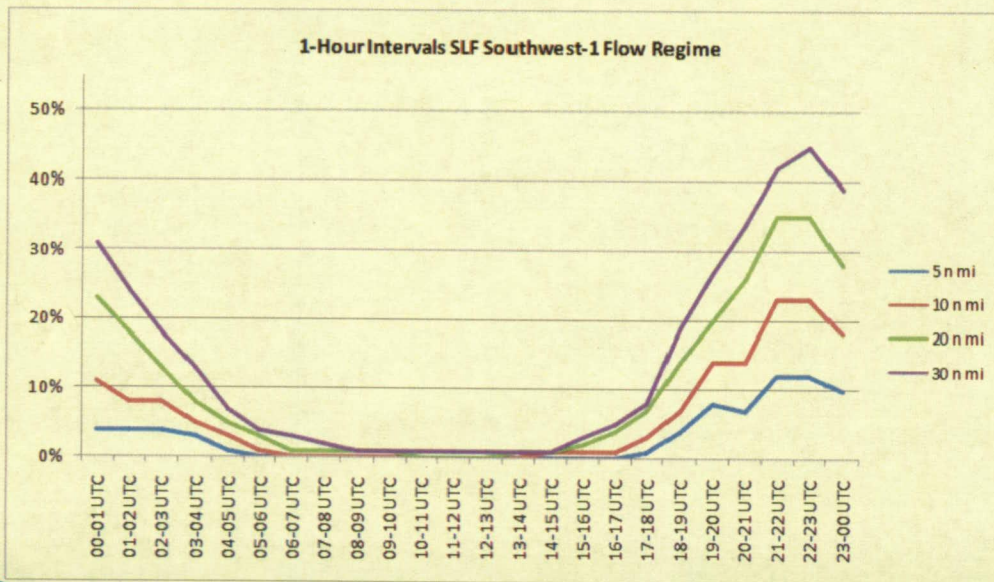
SLF. hourly. Southwest-2 flow regime. 5 n mi circle			
Probability (%)	UTC Time	# Strikes	# Flow Regime Days
4	0	268476	271
4	1	292974	271
4	2	253788	271
3	3	175805	271
1	4	140630	271
0	5	118449	271
0	6	100309	271
0	7	86359	271
0	8	85585	271
0	9	92138	271
0	10	97960	271
0	11	103508	271
0	12	112800	271
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



User Friendly Format



- Merged the data from multiple spreadsheets into data tables grouped by time interval and flow regime
- Created graphs from the tables to provide a “quick look” tool for the forecasters



Southwest-1	5 nmi	10 nmi	20 nmi	30 nmi
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%	35%

Twenty-four
1-hr periods

Southwest-1	5 nmi	10 nmi	20 nmi	30 nmi
00-03 UTC	5%	10%	15%	25%
03-06 UTC	0%	1%	4%	6%
06-09 UTC	0%	0%	2%	3%
09-12 UTC	0%	0%	1%	2%
12-15 UTC	0%	1%	3%	3%
15-18 UTC	8%	16%	22%	27%
18-21 UTC	23%	36%	49%	54%
21-00 UTC	18%	30%	41%	51%

Eight
3-hr periods

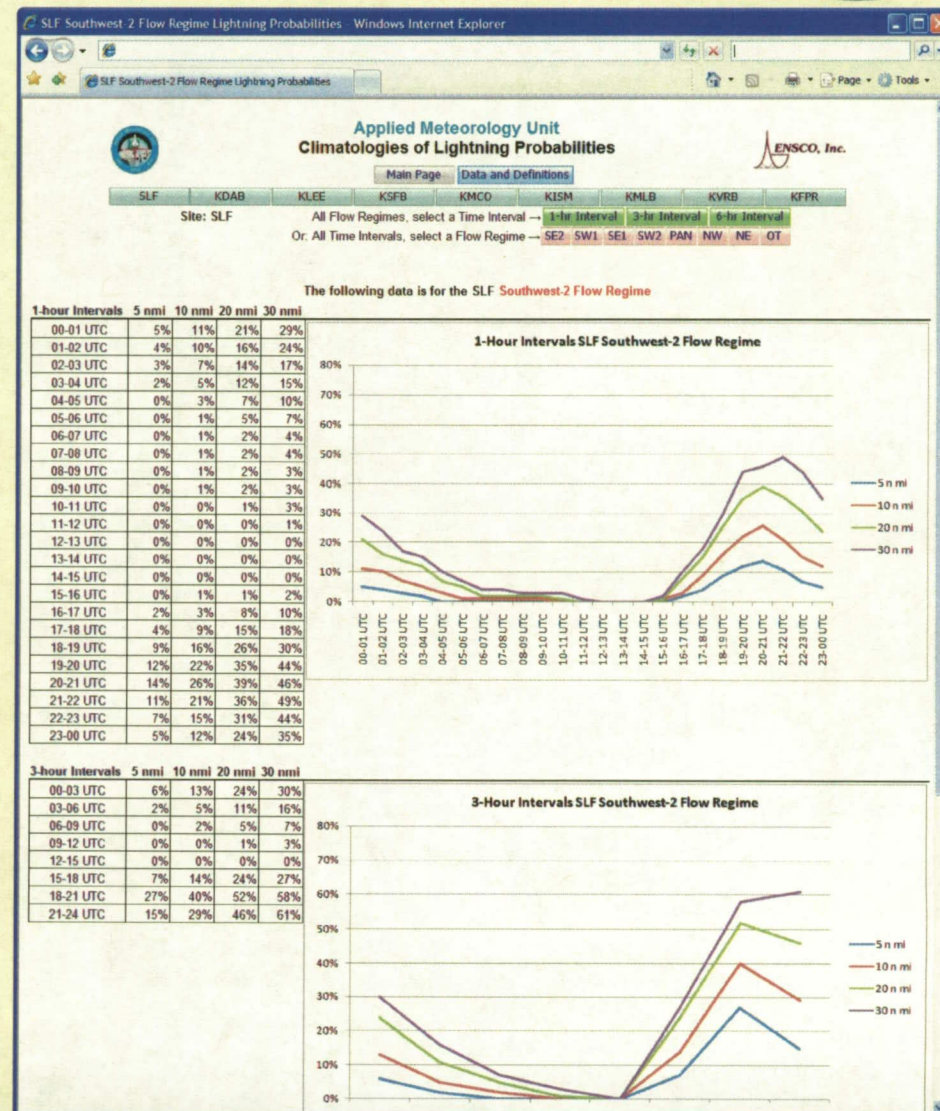
Southwest-1	5 nmi	10 nmi	20 nmi	30 nmi
00-06 UTC	5%	10%	17%	24%
06-12 UTC	0%	1%	3%	4%
12-18 UTC	9%	16%	23%	27%
18-00 UTC	35%	50%	51%	66%

Four
6-hr periods



Tying it all together for the Forecaster





- Built a GUI using HTML
 - Easily navigable web site
 - Platform independent
- Navigation
 - Data and Definitions
 - View helpful information about data, methodology and flow regime definitions
 - Nine sites
 - By flow regime or time interval
- Displays both tables and corresponding graphs






Summary


- Objective: provide forecasters with a “first guess” climatological lightning probability tool
 - Focus on Space Shuttle landings and NWS TAFs
 - Four circles around sites: 5-, 10-, 20- and 30 n mi
 - Three time intervals: hourly, every 3 hr and every 6 hr
- Based on:
 - NLDN gridded data
 - Flow regime
 - Warm season months of May-Sep for years 1989-2004
- Gridded data and available code → squares, not circles
- Over 850 spreadsheets converted into manageable user-friendly web-based GUI


   





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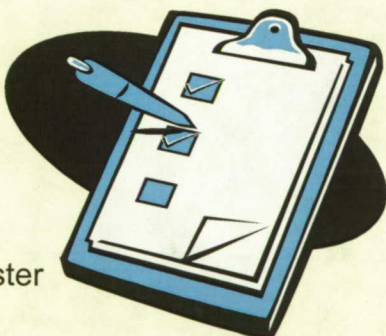
 Reno, Nevada


Applied Meteorology Unit <http://science.ksc.nasa.gov/amu> 1 



   

Outline


- Project objectives
- Data and period of record
- Flow regime definitions
- Issues
- Problems
- Solutions
- Taming the data for the forecaster
- Summary



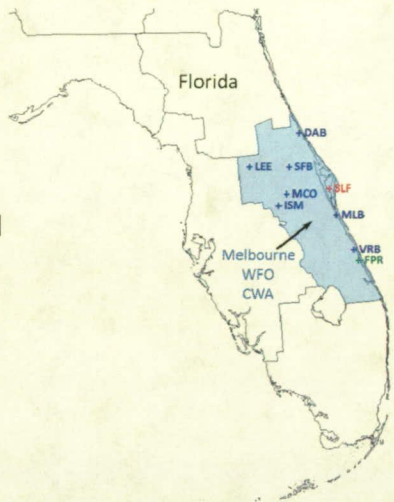
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Project Objectives





- Provide forecasters with a warm season climatological probability of one or more lightning strikes within a circle at a site within a specified time interval
- Create climatologies based on Florida flow regimes for TAFs and shuttle landings for:
 - 9 sites
 - 5-, 10-, 20-, and 30-n mi circles around the sites
 - 1-, 3-, and 6-hour increments
- Develop an easy to use GUI to display data




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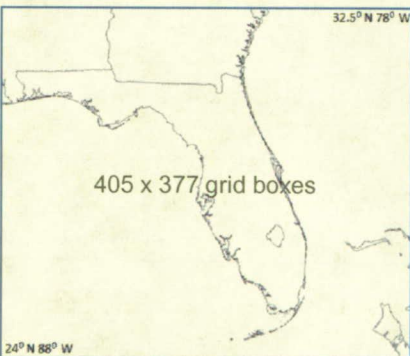



Data and Period of Record (POR)






- NWS in Tallahassee provided NLDN **gridded data** of cloud-to-ground (CG) lightning strikes
 - Spatial resolution: 2.5 X 2.5 km
 - Temporal resolution: 1 hour
- Warm season months:
 - May – Sep
 - 16-year period
 - 1989–2004




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Flow Regime Definitions






- Florida State University (FSU) identified large-scale flow regimes over Florida
 - Found strong relationship between regimes and spatial distribution of CG lightning
 - Average wind directions in 1000 – 700 mb layer from the 1200 UTC soundings Miami (MFL), Tampa (TBW), and Jacksonville (JAX)
 - Studies yielded 7 distinct flow regimes


Flow Regime Name	Definition	Days in Regime
SW-1	Ridge from Atlantic High South of MFL	271
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Other	Undefined Regime	827

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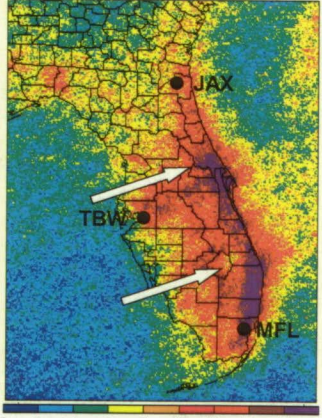


Flow Regime Definitions - Example






- Southwest (SW-1)
 - Atlantic high pressure ridge south of MFL
 - 1000-700 mb layer average wind direction is from the southwest across peninsula
 - CG lightning maximum along the east coast of Florida




24-hour CG Probability for Southwest Flow (Stroupe 2003)

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Issues





- Needed to know:
 - Number of CG strikes in given period of time and distance from site
- Had to work with:
 - Code provided by FSU to read NLDN data in gridded format
- Needed to generate:
 - 1-, 3-, and 6-hourly grids for each day and each flow regime
 - 5-, 10-, 20- and 30- n mi circles for each site and each flow regime




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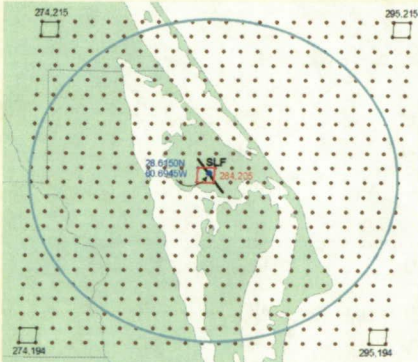



Problems






- Data
 - Gridded format not individual CG's
- Code designed for:
 - 24 hr intervals
 - Entire (rectangular) domain (343,000 n mi²)
 - Not lat/lon based



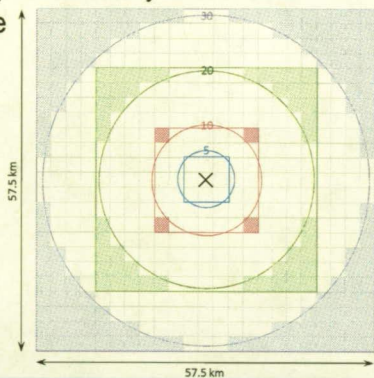
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Solutions

- Data
 - No change
- Changed code
 - Multiple time intervals and smaller, multiple domains by lat/lon
- Used area of square instead of circle
 - 30-n mi circle:
 - 529 grid boxes: area of square is 27% larger than area of circle
 - 20-n mi circle
 - 225 grid boxes: area of square is 23% larger than area of circle
 - 10-n mi circle
 - 49 grid boxes: area of square is 13% larger than area of the circle
 - 5-n mi circle
 - 9 grid boxes: area of square is 16% smaller than area of the circle




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Taming the Data

- Generated 864 spreadsheets in Excel[®] containing climatological probabilities of lightning for:
 - 9 sites
 - 3 time intervals
 - 4 different size circles
 - 8 flow regimes
- Tables contained:
 - Climatological probability of lightning
 - UTC time
 - Number of CG strikes for each hour
 - Number of flow regime days in the POR

SLF, hourly, Southwest-2 flow regime, 5 n mi circle			
Probability (%)	UTC Time	# Strikes	# Flow Regime Days
4	0	268476	271
4	1	292974	271
4	2	253788	271
3	3	175805	271
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0	5	118449	271
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User Friendly Format

- Merged the data from multiple spreadsheets into data tables grouped by time interval and flow regime
- Created graphs from the tables to provide a "quick look" tool for the forecasters

1-Hour Intervals SLF Southwest-1 Flow Regime

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00-01 UTC	4%	11%	22%	31%
01-02 UTC	4%	8%	16%	24%
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11-12 UTC	0%	0%	0%	1%
12-13 UTC	0%	0%	0%	1%
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Southwest-1 5 nmi 10 nmi 20 nmi 30 nmi


Southwest-1	5 nmi	10 nmi	20 nmi	30 nmi
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15-20 UTC	35%	50%	61%	66%

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Twenty-four 1-hr periods

Eight 3-hr periods

Four 6-hr periods




Tying It All Together for the Forecaster







- Built a GUI using HTML
 - Easily navigable web site
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- Navigation
 - Data and Definitions
 - Nine sites
 - Flow regime or time interval
- Displays both tables and corresponding graphs

Demo

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Summary

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 - Three time intervals: 1 hr, 3 hr and 6 hr
- Based on:
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