USING FLOW REGIME LIGHTNING AND SOUNDING CLIMATOLOGIES TO INITIALIZE GRIDDED LIGHTNING THREAT FORECASTS FOR EAST-CENTRAL FLORIDA

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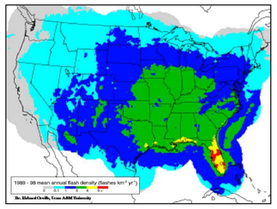
OBJECTIVE:

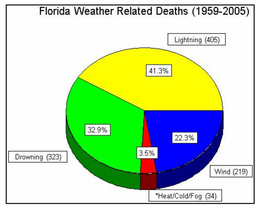
Create two types of climatologies based on the large-scale flow regime to assist forecasters when creating the daily Lightning Threat Index map:

1) Spatial gridded lightning frequency and density climatologies, and
2) Florida soundings.

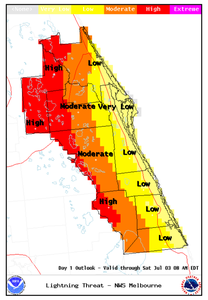
LIGHTNING THREAT INDEX MAP

- Florida is the Lightning Capital of the United States. More deaths occur from cloud-to-ground (CG) lightning in the state than any other weather phenomenon.





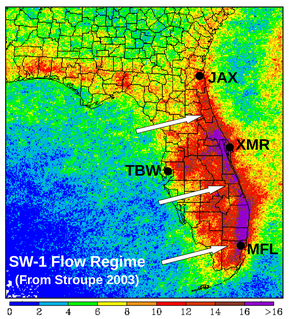
- The NWS in Melbourne, Florida (MLB) posts a lightning threat index map (right) for their county warning area (CWA) to their website by 1200 UTC (8:00 am EDT)
- This maps helps users determine the threat of lightning to their outdoor activities.
- They are color-coded in five threat levels from Very Low to Extreme.
- The threat levels are based on 2 parameters:
  1) Likelihood of CG lightning occurrence
  2) Expected amount of CG activity
- The spatial distribution of the threat levels depends on the large-scale low-level flow, distribution of moisture and stability fields, timing/intensity/inland penetration of the sea breeze, boundary interactions, and other factors that affect the formation and spatial distribution of thunderstorms over the CWA.



- Prior to creation of the climatologies, forecasters created this map from a blank field.

FLOW REGIMES

- Studies at Florida State University (FSU) identified large-scale flow regimes over Florida, and found a strong relationship between the regimes and the spatial distribution of CG lightning across the peninsula (Lericos et al. 2002; Stroupe 2003).
- The FSU studies yielded 7 distinct flow regimes.
- The average wind directions in the 1000 – 700 mb layer from the 1200 UTC soundings taken at Miami (MFL), Tampa (TBW), and Jacksonville (JAX) were used in combination to determine the flow regime of the day.



Flow Regime Name	*Definition*
SW-1	Ridge from Atlantic High South of MFL
SW-2	Ridge from Atlantic High North of MFL and South of TBW
SE-1	Ridge from Atlantic High North of TBW and South of JAX
SE-2	Ridge from Atlantic High North of JAX
PAN	Ridge from Central Gulf Coast High over Panhandle
NW	Overall Northwest Flow
NE	Overall Northeast Flow
Other	Undefined Regime

- The first four flow regimes in the table are associated with the latitudinal position of a ridge extending westward from a high pressure center over the Atlantic Ocean, the fifth accounts for a ridge extending eastward from a Gulf Coast high over the Florida Panhandle.
- The sixth and seventh regimes account for general northwest and northeast flow across the peninsula.
- A flow regime could not be defined for a large percentage of the days in the study period, close to 40%. The AMU created an eighth category named 'Other' to account for these days.

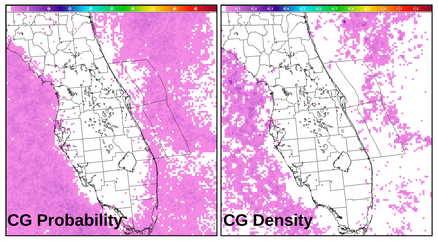
DATA

- The period of record (POR) was the warm season months of May – September in the years 1989 – 2004.
- All the data and code needed for development of the gridded climatologies was provided by FSU and NWS Tallahassee. The data included:
  - Lightning data grids created from National Lightning Detection Network (NLDN) data that contained hourly CG strike counts in 2.5 x 2.5 km grid boxes. The grids encompass the entire state of Florida and adjacent waters.
  - Flow regime dates of occurrence for the POR.
- 1200 UTC soundings in the POR from MFL, TBW, and JAX; and 1000 UTC soundings from Cape Canaveral Air Force Station (XMR) for the sounding climatologies.
- The grids and soundings were stratified by flow regime prior to the creation of the climatologies.

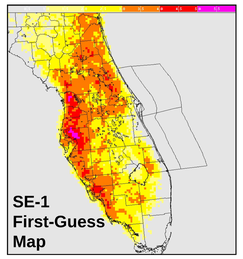
GRIDDED CLIMATOLOGIES

- Two types of gridded climatologies were created: the probability of CG occurrence and CG strike density for each flow regime (Lambert et al. 2006).
  - The probability was calculated by dividing the number of days on which lightning occurred in each grid box during each flow regime by the number of days in the flow regime
  - The density was calculated by dividing the cumulative number of strikes in each grid box during each flow regime by the number of days in the flow regime
- The grids were also stratified into four six-hour periods: 0000–0600, 0600–1200, 1200–1800, and 1800–2400 UTC. The relationship between CG occurrence and time of day is demonstrated in the images below for the SE-1 regime.

0600–1200 UTC (2:00–8:00 am EDT) | **1800–2400 UTC (2:00–8:00 pm EDT)**

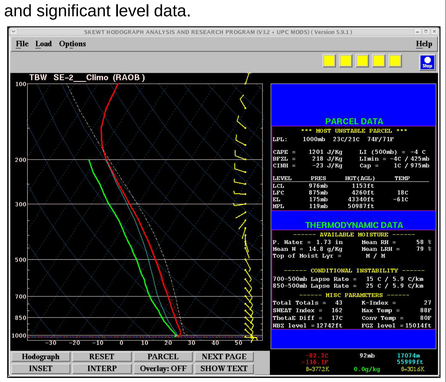


- The forecasters multiplied the probability and density fields for each flow regime using the SmartTool utility in their GFE, and then thresholded the resulting gridded values according to the threat index levels.
- They considered the probability grids as a proxy for the likelihood of CG occurrence, and the density grids as a proxy for the expected amount of CG activity. The result is a climatological first-guess lightning threat index map for each flow regime.
- The first-guess threat index map at right is for the SE-1 regime during the 1800–2400 UTC time period. The probability and density fields used to create it are shown in the two panels above on the right.
- Forecasters identify the flow regime of the day, then use the first-guess map for that flow regime as a starting point to create the lightning threat index map.



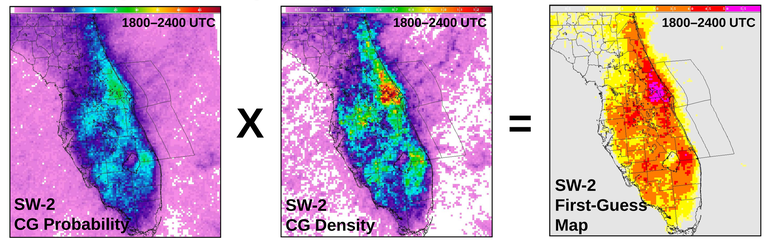
SOUNDING CLIMATOLOGIES

- Forecasters modify the first-guess map described above through a subjective analysis of the observed and forecast parameters related to thunderstorm formation for the day.
- To assist in this process, climatological soundings were created at each station for each flow regime (Short 2006). The forecasters can compare observed and forecast soundings to the climatology and refine the lightning threat areas bases on their differences.
- The soundings in the POR were comprised of mandatory and significant level data.
- Since the number of levels in each sounding varied due to the significant level data, the levels in the soundings were interpolated to 25 mb intervals to create consistent levels for mathematical averaging.
- Four sounding sites and eight flow regimes resulted in 32 composite soundings containing vertical profiles of wind speed and direction, temperature, and dewpoint.
- The soundings were formatted for display in the Skew-T Hodograph Analysis and Research Program (NSHARP, Hart and Karotky 1991) software, a package already in use by the NWS MLB forecasters.
- NSHARP displays the sounding in Skew-T format, and calculates and displays several stability parameters.
- The sounding at right is for the SE-2 regime at Tampa displayed in NSHARP.

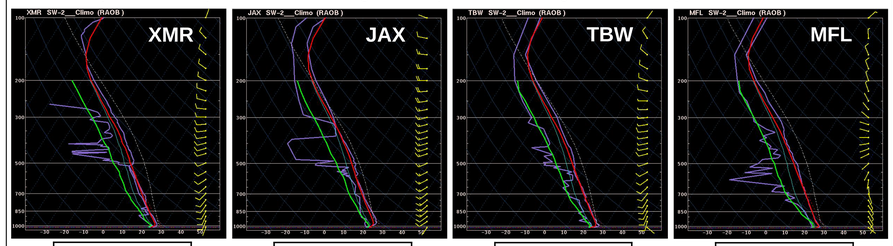


17 JULY 2006 CASE EXAMPLE

- The gridded and sounding climatologies were delivered to NWS MLB in time for the 2006 warm season, at which time the forecasters began using them to create the daily lightning threat index map.
- On 17 July 2006, the low-level ridge axis from the high over the Atlantic Ocean was north of Miami, but south of Tampa, consistent with the SW-2 flow regime. This regime brings low-level southwest flow across much of East-Central Florida and MLB's CWA.
- The gridded climatologies and climatological first guess lightning threat index map for this regime are shown below:



- The forecasters developed the daily lightning threat index map by modifying the first-guess field on the right, above.
- The 1200 UTC observed and climatological soundings are shown below, along with stability parameters calculated from the soundings. The climatological temperature and dew point profiles are in red and green, respectively, the observed profiles are in purple. The climatological wind profile is at the right in each image.



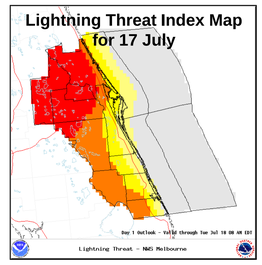
XMR	*Climo*	*Obs*
PW	1.83	2.23
KI	31	37
TT	46	45
LI	-7	-7

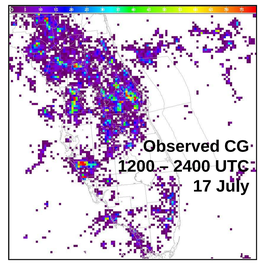
JAX	*Climo*	*Obs*
PW	1.76	1.87
KI	30	32
TT	44	42
LI	-4	-2

TBW	*Climo*	*Obs*
PW	1.73	1.87
KI	29	30
TT	45	45
LI	-5	-6

MFL	*Climo*	*Obs*
PW	1.73	1.71
KI	26	28
TT	44	43
LI	-7	-4

- XMR is the only sounding in NWS MLB's CWA (left-most). It shows higher precipitable water (PW) and K-Index values than climatology. The Total Totals (TT) and Lifted Index (LI) are very close to climatology, yet indicative of probable thunderstorm formation.
- The final lightning threat index map issued on 17 July and the CG strikes as observed by NLDN in the 1200 – 2400 UTC period in a 5 km grid are shown at right.
- The threat index map verified well, depicting the area of 'High' threat (red area) in the northwest CWA.
- Just as important, the map identified the area of Low threat along the coast, most likely from the early inland penetration of the sea breeze.





CONCLUSIONS

- The first-guess lightning threat maps were created to help reduce the amount of time spent by forecasters in creating the daily map, and to increase consistency between forecasters, and the soundings were created to assist forecasters in modifying the first-guess map by studying the differences between the climatological sounding for each flow regime and the observed and model forecast soundings.
- Both climatologies were used with success by the NWS MLB forecasters in the 2006 warm season.

WEBSITES AND REFERENCES

MLB Daily Lightning Threat Index Map: http://www.srh.noaa.gov/mlb/ghwo/lightning.shtml
MLB IMPACT Meteorology Unit: http://www.srh.noaa.gov/mlb/amu_mlb/IMU2.html
Lightning Threat Graphic Descriptions: http://www.srh.noaa.gov/mlb/amu_mlb/LTG/ltgclimothreat.htm and http://www.srh.noaa.gov/mlb/ghwo/lightning_levels.html
Applied Meteorology Unit: http://science.ksc.nasa.gov/amu/

Hart, J. A., and W. Korotky, 1991: The SHARP workstation v1.50 users guide. NOAA/National Weather Service. 30 pp. [Available from NWS Eastern Region Headquarters, 630 Johnson Ave., Bohemia, NY 11716.]

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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. AMU Memorandum, 8 pp. [Available by calling 321-853-8203 or from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL, 32931]

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