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USING CLOUD-TO-GROUND LIGHTNING CLIMATOLOGIES TO INITIALIZE GRIDDED LIGHTNING THREAT FORECASTS FOR EAST CENTRAL FLORIDA

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1. INTRODUCTION

The forecasters at the National Weather Service in Melbourne, FL (NWS MLB) produce an experimental cloud-to-ground (CG) lightning threat index map for their county warning area (CWA) that is posted to the URL http://www.srh.weather.gov/mlb/ghwo/lightning.shtml. The lightning threat index map is issued for the 24-hour period beginning at 1200 UTC (0800 AM EDT) each day at a grid resolution of 5 x 5 km. The map from 3 July 2004 is shown in Figure 1 as an example.

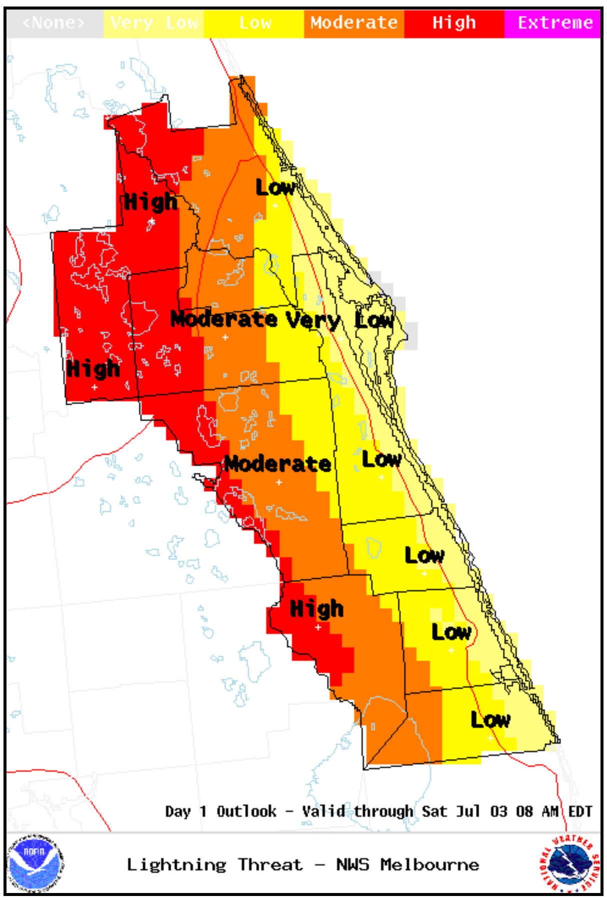

Figure 1. An example of the lightning threat index map as issued daily by NWS MLB. The color legend for each threat level is shown at the top of the image.

Given the hazardous nature of lightning in East Central Florida, especially during the warm season months of May–September, these maps help users factor the threat of CG lightning, relative to their geographic location, into their daily plans (Sharp 2005). The maps are color-coded in five levels from Very Low to Extreme, with threat level definitions based on two parameters:

- The likelihood of CG lightning occurrence and
- The expected amount of CG activity.

On a day in which thunderstorms are expected, there are typically two or more threat levels depicted spatially across the CWA, as seen in Figure 1. The locations of relative lightning threat maxima and minima often depend on the position and orientation of the low-level ridge axis, forecast propagation and interaction of sea/lake/outflow boundaries, expected evolution of moisture and stability fields, and other factors that can influence the spatial distribution of thunderstorms over the CWA.

The map preparation is performed on the Advanced Weather Interactive Processing System (AWIPS) Graphical Forecast Editor (GFE), which is the standard NWS platform for graphical editing. The forecasters create each map manually from a blank map, determining the locations of the threat levels through a subjective analysis of all parameters related to thunderstorm formation over the CWA. To provide a climatological first-guess background when creating the map, NWS MLB requested that the Applied Meteorology Unit (AMU) (Bauman et al. 2004) create gridded warm season CG flash densities and frequencies of occurrence in 6-hour increments based on the situational large-scale flow regime (Lericos et al., 2000) over the Florida Peninsula. The frequency would be used as a proxy for the likelihood of lightning occurrence and the density would be a proxy for the expected amount of CG activity. Having climatologies in 6-hour increments will allow forecasters to provide greater temporal resolution by depicting the lightning threat for the morning, afternoon, evening, and overnight periods of the Day-1 forecast. This climatological approach will help increase the efficiency of the forecast process during the warm season, improve consistency between forecasters, and enable the MLB forecasters to focus on the mesoscale detail of the forecast, ultimately benefiting the end-users of the product.

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2. BACKGROUND

Several studies have taken place whose results have direct relevance to this work. The framework of this task was built upon these results.

2.1 Previous Related Work

Lericos et al. (2000) identified major synoptic-scale flow regimes over the Florida peninsula and found a strong relationship between the regimes and the distribution of CG lightning over Florida. The flow regimes were determined from the Florida soundings and the lightning distributions were determined using gridded CG lightning data from the National Lightning Detection Network (NLDN) (Cummins et al. 1998). In a recent AMU task, Lambert and Wheeler (2005) used these flow regimes as predictors of CG lightning over Kennedy Space Center / Cape Canaveral Air Force Station (KSC/CCAFS). The flow regimes were shown to have a large influence on the probability of lightning occurrence in the local KSC/CCAFS area.

Flash densities and frequencies of occurrence for each flow regime in the years 1989-2002 were created on a 2.5 x 2.5 km grid by Stroupe (2003). Figure 2 shows the distribution of daily (24 hour) lightning occurrence frequency for southwesterly to westerly flow over the peninsula, calculated by dividing the number of days with lightning occurrence by the number of flow regime days. Note the clear distinction of high values along the east coast and lower values along the west coast. This is due to the influence of the larger scale flow pattern on the inland propagation and interaction of peninsular-Florida's two sea breezes: the east coast sea breeze from the Atlantic Ocean, and the west coast sea breeze from the Gulf of Mexico. In this case, the west coast sea breeze will propagate across the state while the east coast sea breeze propagates very little, setting up a zone of convergence along the east coast.

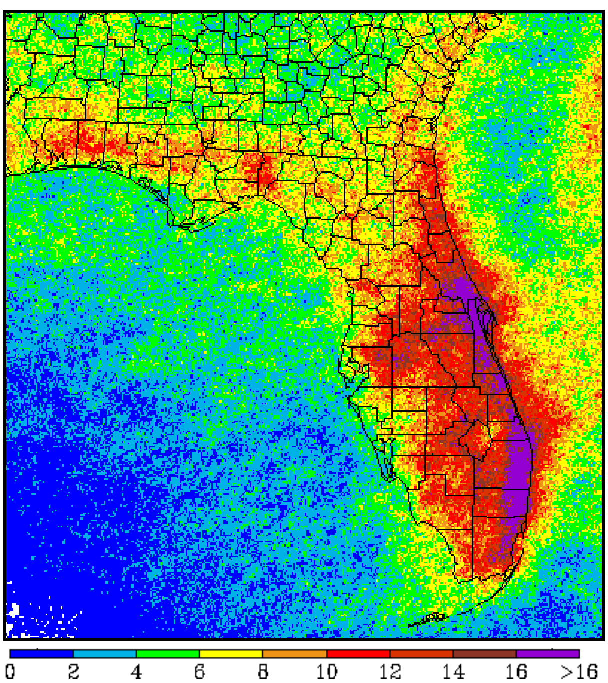

Figure 2. The distribution of daily CG frequencies of occurrence (percent) over Florida for southwest flow in the years 1989-2002 (Stroupe 2003).

Winarchick and Fuelberg (2005) used local sounding parameters and NLDN data in the creation of equations that forecast the probability of lightning occurrence in Southeast Florida for the Florida Power and Light Corporation (FP&L). Shafer and Fuelberg (2005) used similar data sets to develop a set of equations that provide guidance on the amount of lightning activity to be expected conditional on the occurrence of at least one flash. The results from both studies were very favorable.

2.2 Current Work

The successes of the aforementioned projects led to the decision by NWS MLB forecasters that lightning distribution climatologies based on the flow regimes would provide a good first-guess when creating the lightning threat index map.

The specific products created were the gridded warm season climatological lightning frequencies of occurrence and flash densities for each flow regime, similar to that done in Stroupe (2003). The frequencies and densities were updated with additional data from 2003–2004, and calculated for the four 6-hour periods 00–06, 06–12, 12–18, and 18–00 UTC. Also, 12-hour climatologies were calculated for 15–03 UTC to depict the diurnal situational lightning event. The climatological frequency of occurrence for each grid box is the number of times lightning occurred during a specific flow regime divided by the number of days on which that flow regime occurred. It does not account for the number of flashes, only whether or not lightning occurred. The climatological flash densities are calculated by using the total number of CG strikes in a grid box during a specific flow regime divided by the number of days in that flow regime.

3. DATA

All data needed for this work was provided by personnel at the NWS office in Tallahassee, FL (TAE) and Florida State University (FSU). They are the same data used by Stroupe (2003), Winarchik and Fuelberg (2005), and Shafer and Fuelberg (2005). The CG lightning data were provided as hourly flash densities on a 2.5 x 2.5 km grid for all warm season days in the years 1989–2004, created from NLDN data. The grids encompass the area from 24°–32.5° North latitude and 78°–88° West longitude, which covers the entire state of Florida, adjacent Atlantic and Gulf of Mexico waters, and southern Georgia and Alabama, just slightly larger than the area shown in Figure 2. The NWS TAE and FSU personnel also provided the individual dates of occurrence for each of the flow regimes, eliminating the need to collect sounding data to determine the flow regime days.

4. CLIMATOLOGIES

Examples of the 6-hour climatologies for the time period 18–00 UTC are shown in Figures 3 and 4. In this case, a low-level ridge extends westward across the peninsula from a high pressure center over the Atlantic Ocean and is positioned north of Miami and south of Tampa. This results in southwesterly to westerly flow over the central to northern part of the CWA resulting in a higher probability of CG lightning occurrence and higher flash densities in that location.

The 2.5 x 2.5 km gridded hourly densities were first stratified by flow regime, then by time in the previously mentioned 6-hour increments. Again, the frequency of occurrence was calculated for each regime/time stratification and grid box by summing the number of days with lightning over the entire warm season and dividing the sum by the number of flow regime days. An example of the CG frequency as available to forecasters on the AWIPS/GFE is shown in Figure 3.

Similarly, the CG flash densities were calculated by summing the raw strike counts per grid box over all warm seasons, and normalized by dividing the summed values by the number of flow regime days. This provides a more realistic value of the expected number of strikes on any given day for that particular flow regime and time period. An example of the ground flash densities as available to forecasters on the AWIPS/GFE is shown in Figure 4.

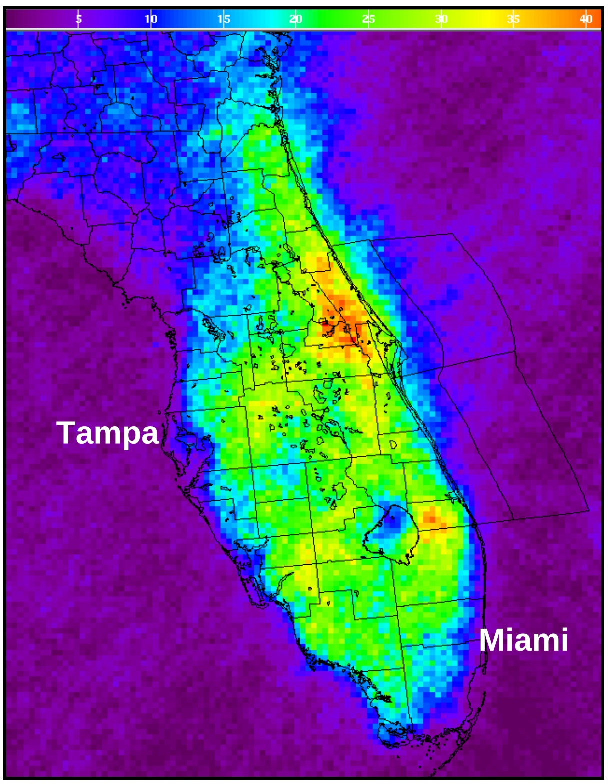

Figure 3. The climatology of CG lightning frequency of occurrence for 18-00 UTC with the ridge axis between Miami and Tampa for the years 1989-2004.

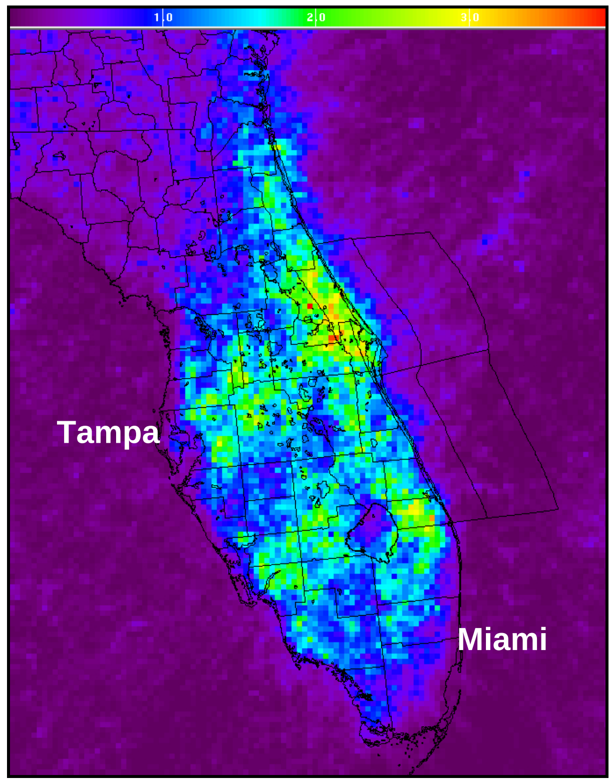

Figure 4. Same as Figure 3 except for CG flash density.

5. SUMMARY AND FUTURE WORK

Climatologies of CG lightning frequency and density were created by the AMU to be used by NWS MLB forecasters as first guess fields in creating their daily lightning threat index map for the warm season. An example is shown in Figure 5 where the two fields shown in Figures 3 and 4 are multiplied together using a utility called SmartTool in the GFE. The new image is then empirically tuned to the threat index scale (see Figure 1) using observational and forecast data.

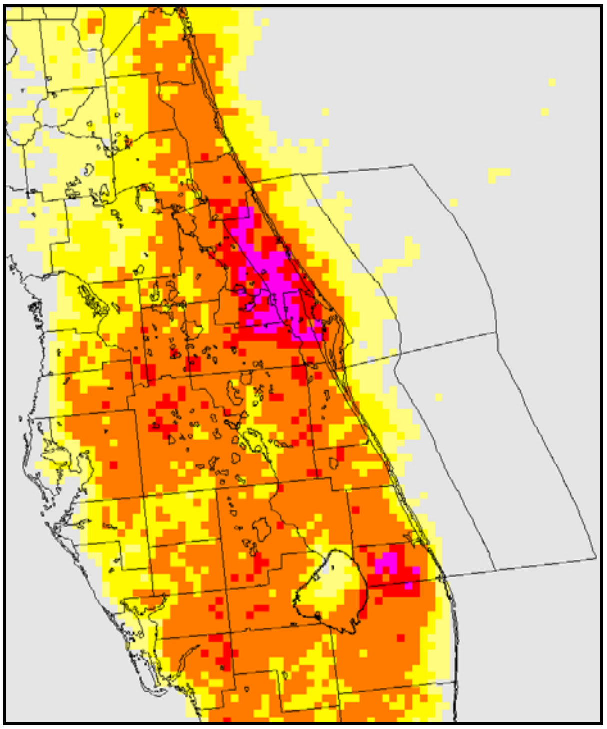

Figure 5. An initial first-guess lightning threat index map based on the climatological CG density and frequency from 18-00 UTC with the ridge axis located between Miami and Tampa.

The climatologies will provide improved temporal and spatial resolution for the daily threat index maps, expand the lightning threat area to include adjacent coastal waters, improve efficiency in creating the maps, increase consistency between forecasters by removing part of the subjective component, and provide the potential to extend the forecast into the Day-2 period based on forecast soundings from which the forecast flow regime can be derived. Both forecasters and users will benefit greatly from this work.

Routinely, value-added enhancements to the first-guess threat map will be accomplished by assessing dynamic and thermodynamic parameters (observed and forecast) that signal potential changes to the location and/or magnitude of CG lightning maxima and minima. Future work will focus on creating average soundings for each regime that forecasters can use to compare against the current sounding(s). Additional climatologies are being planned that will focus on intra-seasonal differences, as well as the strength of the steering flow.

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