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MONTHLY LIGHTNING TRENDS OVER FLORIDA 1989-2004

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1. Background

Monthly National Lightning Detection Network (NLDN) cloud to ground lightning data over Florida land areas from 1989 to 2004 reveals interesting trends over the 16 year period. The first major system-wide upgrade was completed in 1995 and added IMPACT lightning sensors combining magnetic direction finding and time-of-arrival detection methods (Cummins et. al., 1998). Flash detection efficiency increased to 80-90% with a median stroke location accuracy of 500 meters. The second major upgrade was completed in 2003 with installation of Vaisala IMPACT ESP Lightning Sensors throughout the network (Grogan, 2004). This has increased overall flash detection efficiency to 90% and stroke detection efficiency to 60-80%. For this study, lightning totals do not account for system outages and system efficiency.

2. Monthly Data Trends

Annual lightning flash totals (Fig. 1) averaged 940,169 and ranged from a low of 538,779 during 1991 to 1,503,373 during 2004. During 2004, the annual total was 60% higher than the 16 year average and nearly three times that of 1991. This is likely a result of increased network efficiency. As expected, lightning totals increase greatly during June and taper off during September. June 2004 had the greatest number of recorded lightning flashes with 529,981 (Fig. 2) Considerable variability exists with June, July, and August monthly lightning totals varying by 200,000 flashes from year to year. June lightning totals were greatly affected by 2004 counts that were over twice the 16 year average. Although direct causes were difficult to attribute over monthly time scales, during June 2004 the 300 hPa relative humidity (RH) was 10% lower than the 16 year average and the 600 and 500 hPa RH were about 5% higher than the June average.

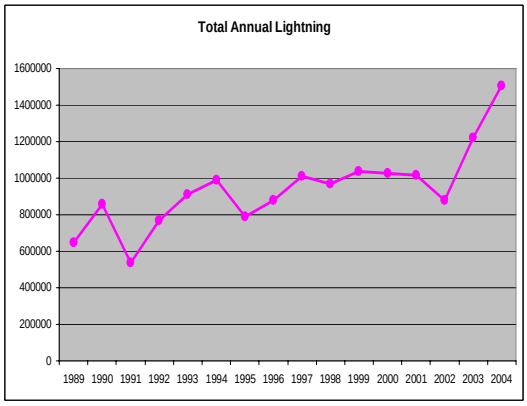

Figure 1. Cloud to ground lightning flashes per year over Florida (1989-2004).

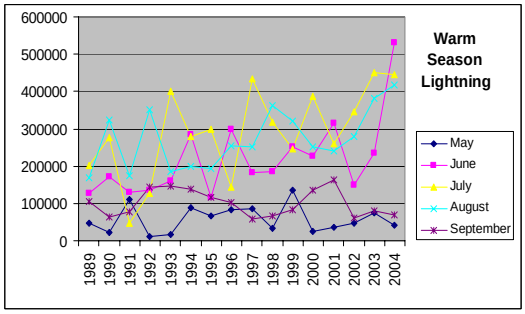

Figure 2. Warm season lightning flash totals by month.

The fewest monthly flashes (102) occurred during December 1990. Three warm season lightning peak patterns emerged: early occurring in June (4 years), mid peak in July (7 years) and a late peak in August (5 years). The 16 year average for warm season months peaks in July (291,245 flashes) followed by August and June (Fig. 3).

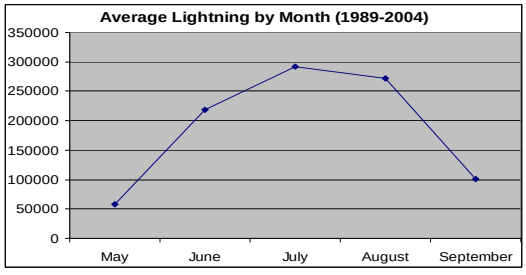

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Figure 3. Warm season lightning averages by month.

Florida lightning deaths and injuries have decreased over the 16 year period even though annual cloud to ground lightning flashes appears to have increased. As Florida's population grows, and apparent cloud to ground flashes increase (Fig. 4), the number of injuries and deaths has decreased. This is likely due to lightning awareness campaigns.

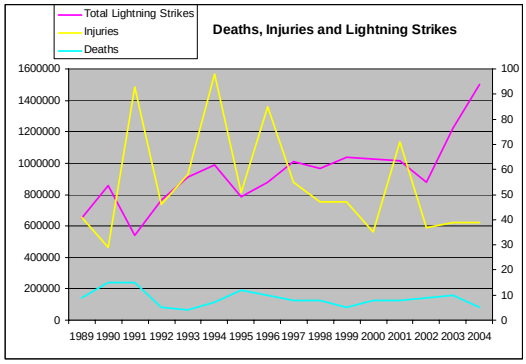

Figure 4. Lightning deaths and injuries compared to lightning flash totals (1989-2004)

Looking for longer term predictors of lightning activity, monthly flash data were compared to monthly temperature anomalies over Florida and to more than 30 longer term climate signals using the Climate Diagnostics Center web interface (CDC). No significant correlations were found as in the example in Figure 5.

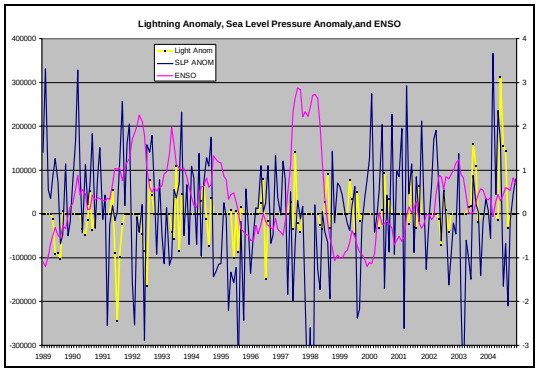

Figure 5. Lightning anomaly, sea level pressure anomaly, and ENSO.

3. Daily Data Trends

Seeking a method to improve forecasts of daily lightning activity levels for daily hazardous weather outlooks and fire weather forecasts, the lightning data were filtered into daily flash totals for May through September. The ten highest values ranged from 33000 to 43000 flashes. Out of those top ten days half were in 2004 and one was in 2003. To determine if increased network efficiency played a role in the 2003 and 2004 values, those years were then eliminated from the top ten grouping. An average ten group was made from the average of June, July, and August flashes excluding 2003 and 2004. Composite analyses of the two groups derived from the CDC using NCEP Reanalysis Data (Kalnay et.al., 1996) were then compared for pattern similarity.

The sea level pressure patterns (Fig. 6) show a broad sub-tropical ridge over Florida on average days. On the top ten days, the ridge is suppressed southward with a frontal trough just north of Florida. This pattern extends upward (Figs. 7-9) with a persistent trough just east of Florida. The top lightning days have warmer low level temperatures over a broad area (Fig. 10) and slightly cooler upper level temperatures resulting in Lifted Indices -1 to -2 lower than average days. Upward vertical velocity values are higher over Florida from the surface to 200 hPa (Figs 11 and 12) for the top lightning days. Relative humidity values are slightly lower through the atmosphere on the top ten days. Precipitable water estimates are higher by about 5mm on the top lightning days.

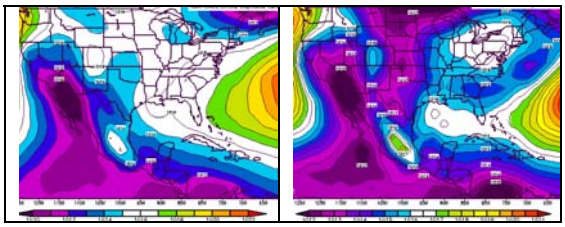

Figure 6. SLP composites for Average and Top 10 lightning days.

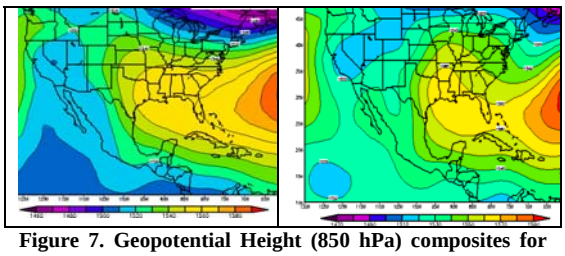

Figure 7. Geopotential Height (850 hPa) composites for Average and Top 10 lightning days.

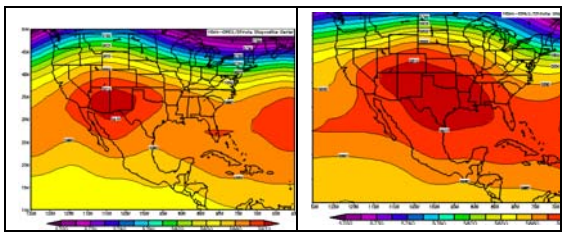

Figure 8. Geopotential Height (500 hPa) composites for Average and Top 10 lightning days.

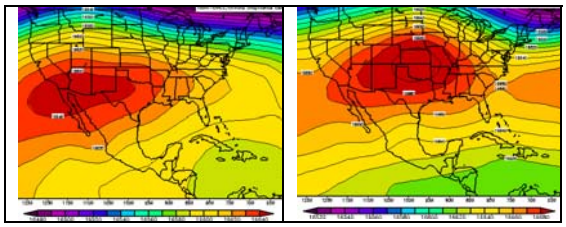

Figure 9. Geopotential Height (100 hPa) composites for Average and Top 10 lightning days.

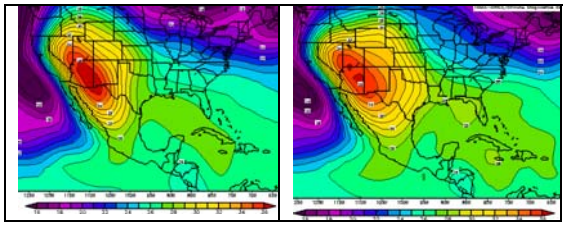

Figure 10. T (850 hPa) composites for Average and Top 10 lightning days.

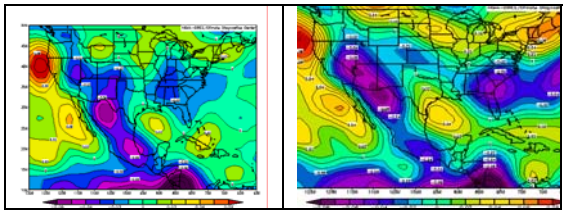

Figure 11. Omega (850 hPa) composites for Average and Top 10 lightning days.

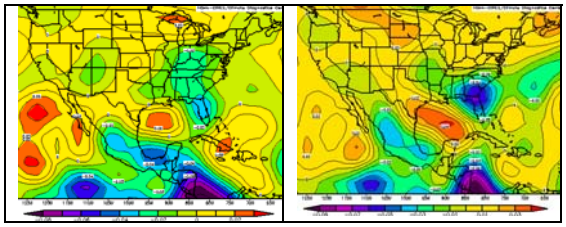

Figure 12. Omega (200 hPa) composites for Average and Top 10 lightning days.

Derived sounding variables from unmodified 1200 UTC Ruskin Florida soundings for the top ten days show average lifted indices (-5.6), CAPE (2363Jkg^{-1}), and precipitable water (49mm). A common factor in soundings for the top lightning days and also evident in the composite geopotential height fields is a northerly component to the wind in the mid and upper levels. Although the NCEP reanalysis data doesn't indicate moisture above 300 mb, soundings indicate top lightning days typically have drier air in the upper troposphere (Fig. 13).

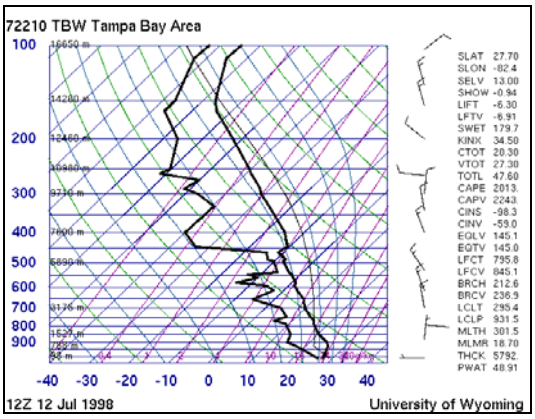

Figure 13. Representative 1200 UTC Ruskin, FL Skew T.

4. Conclusion

Monthly and daily cloud to ground lightning flash totals over Florida land areas were examined. Several interesting factors were revealed. The data reflect system upgrades to improve collection efficiency in 1995 and 2003 Despite efficiency upgrades, an upward trend in collected lightning is evident. As annual lightning totals increase lightning deaths and injuries have been in a downward trend. The monthly lightning totals and anomalies were also compared to monthly local atmospheric variables and monthly climate oscillations with no significant correlations found. The top ten daily lightning data totals from 1989 to 2002 were compared to the average ten days from June, July, and August using sounding and NCEP reanalysis data. Patterns for the top lightning days show the subtropical ridge typically over central Florida is suppressed southward with a frontal trough just north of the state. This trough persists through the troposphere to 100 hPa. In general more moisture and instability is present on the top lightning days with a mid and upper northerly component to the wind flow providing lower moisture levels in the upper troposphere.

5. References

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