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# AP-26 Tornadoes Associated with an Absence of Cloud-to-Ground Lightning

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ABSTRACT

Thunderstorm forecasts and observed lightning occurrence are important situational awareness factors for the issuance of severe thunderstorm and tornado-related convective outlooks, watches, and warnings. However, tornadoes are occasionally associated with convection that has an observed absence of cloud-to-ground (CG) lightning. At least 2% of tornadoes during 2005-2014 were found to be associated with an absence of CG lightning. This preliminary study examines the climatology and environmental conditions of nearly 300 United States tornado events that were not associated with observed CG lightning.

## 1. Introduction

Thunderstorm forecasts and observed lightning occurrence are important situational awareness factors for the issuance of severe thunderstorm and tornado-related convective outlooks, watches, and warnings. Lightning often relates to storm intensity through stronger and deeper convective updrafts. However, tornadoes are occasionally associated with convection that has an observed absence of observed cloud-to-ground (CG) lightning. A recent example is an EF2 tornado that struck parts of Valdosta, Georgia, on 29 December 2014. There was no CG lightning detected with this event or with any of the convection that occurred before or after the tornado in that general region. This preliminary study examines the climatology and environmental conditions of United States tornado events that were not associated with CG lightning from 2005-2014.

## 2. Methodology

Tornado statistics for the contiguous United States (CONUS) were derived from the Storm Prediction Center (SPC) "ONETOR" tornado database, which is based upon official StormData tornado reports. These tornado reports were compared to observed CG lightning data from the Vaisala National Lightning Detection Network (NLDN) to determine the number of CG strikes in a 40-km grid box containing the tornado report. A three-hour temporal window (1 hour prior to the analysis hour to 2 hours after the analysis hour) surrounding the tornado report was used in addition to a 3x3 neighborhood grid (120 km x 120 km) to ensure that no CG lightning strikes occurred in a broad spatiotemporal proximity to the tornado-producing storm. Given the very broad spatiotemporal constraints of this methodology, it is important to note that this preliminary study likely underestimates the number of actual tornadoes that occurred with an absence of CG lightning (hereafter no-CG tornadoes). For comparisons between no-CG tornadoes and all other tornadoes, environment information for tornado-related parameters was examined from a SPC database as described by Dean et al. (2006). This database contains information from the hourly SPC Mesoanalysis 40-km grids, which are generated by blending objectively

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analyzed surface METAR observations with RAP/RUC analysis fields above the surface (Bothwell et al. 2002).

## 3. No-CG Lightning Tornado Climatology

Preliminary findings are that at least 2% of tornadoes (293 total) were associated with an absence of CG lightning during 2005-2014. No-CG tornadoes were found to be most common across the Gulf Coast region, Southeast U.S. and Middle-Atlantic States (Fig. 1), but almost every state had at least one no-CG tornado during the 10-year period. The proportion of no-CG tornadoes from August to January exceeds that of the full tornado climatology, associated with late summer/early autumn tropical cyclones and during the cool season when buoyancy tends to be more limited (Fig. 2). As compared to the climatology for all tornadoes, no-CG tornadoes were found to be slightly more common earlier in the day during the morning and early afternoon hours (1200-2100 UTC; Fig. 3). No-CG tornadoes also tended to be comparatively weaker than other tornadoes (Fig. 4), but significant tornadoes did occur (~3% or 9 EF2+ tornadoes), and a small number of fatalities have also been documented (e.g., two fatalities on 4 January 2007 in Louisiana).

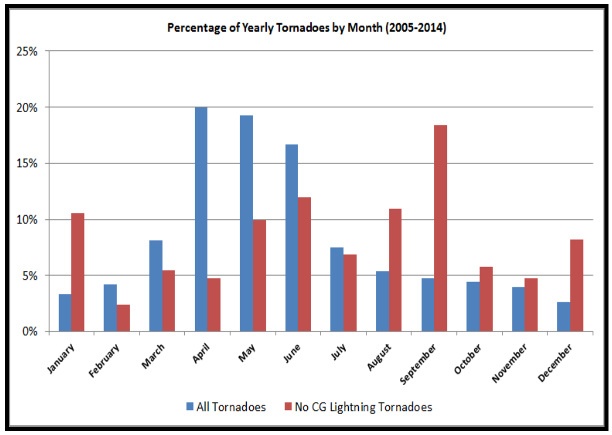


**Figure 2.** Percentage of yearly tornadoes by month for 2005-2014 for no cloud-to-ground lightning tornadoes (red) as compared to all tornadoes (blue).

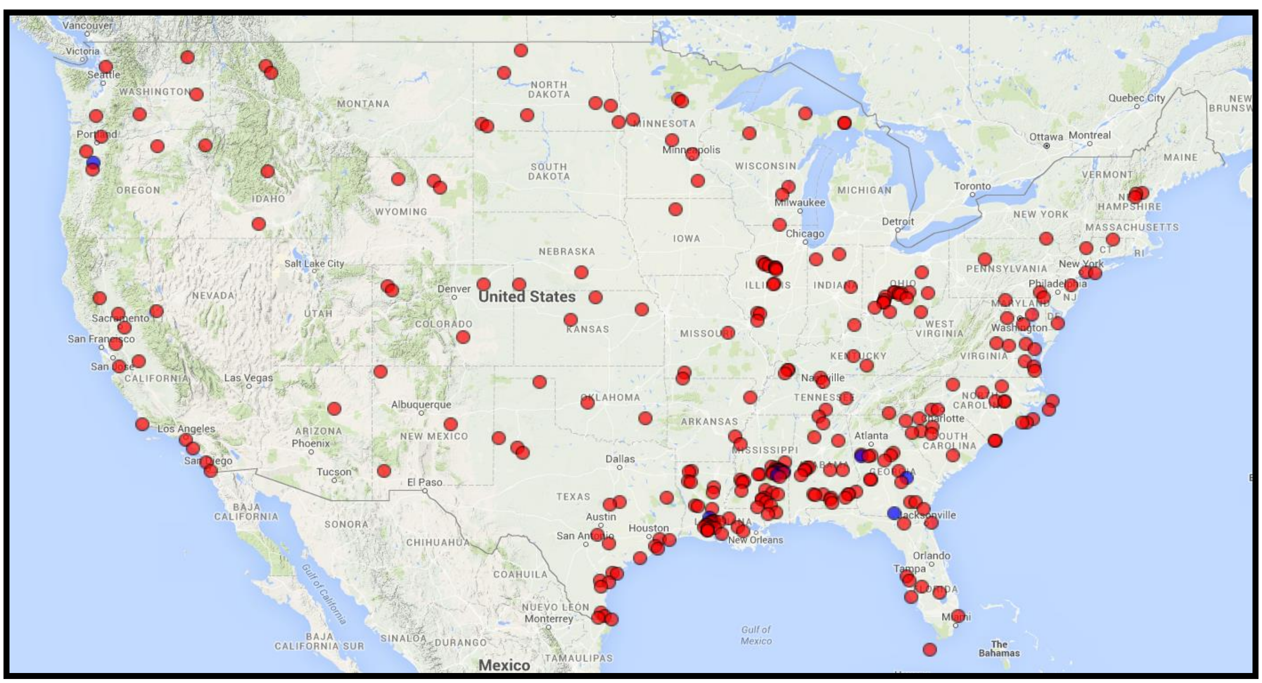


**Figure 1.** Map of tornadoes associated with no cloud-to-ground (CG) lightning for 2005-2014. EF0 and EF1 tornadoes (284) shown as red dots with EF2+ tornadoes (9) as blue dots.

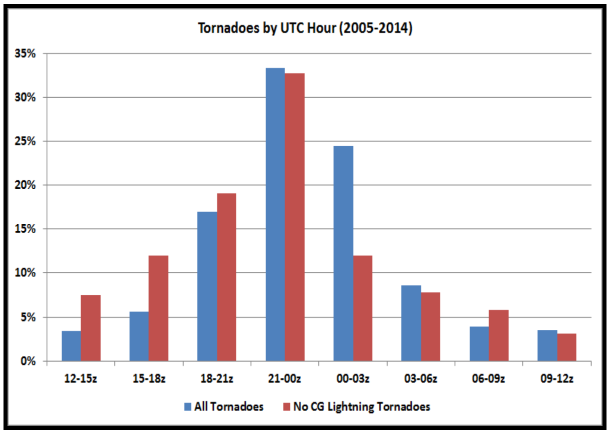


**Figure 3.** Same as Fig. 2, except for tornadoes by UTC hour.

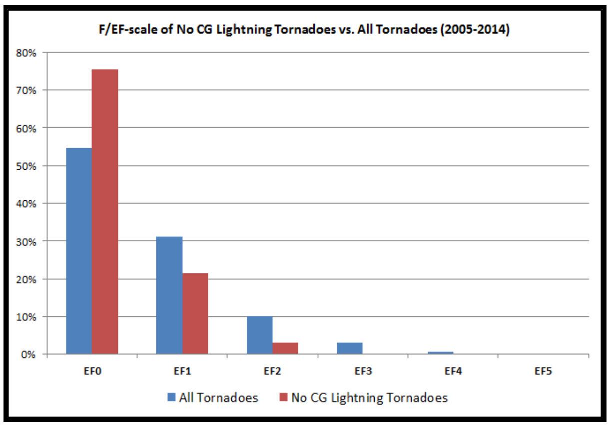


**Figure 4.** Same as Fig. 2, except for tornado F/EF-Scale rating.

## 4. Tornado Environments

Based on SPC Mesoanalysis-estimated storm environments, these relatively rare no-CG tornadoes tend to occur in thermodynamic environments characterized by relatively weak mid-level lapse rates and weak buoyancy. Mixed-layer CAPE (MLCAPE) values are commonly less than 500 J $kg^{-1}$ (82% of all cases; Fig. 5). However, 0-3 km MLCAPE (Fig. 6) and precipitable water (Fig. 7) values were similar for both no-CG tornadoes and the environments of all other tornadoes. Vertical shear tended to be slightly weaker for no-CG tornadoes, but magnitudes of 0-1 km Storm Relative Helicity (SRH; Fig. 8) were comparable for both no-CG tornadoes and the environments of all other tornadoes. The vast majority of no-CG tornadoes were associated with Significant Tornado Parameter (STP – Thompson et al. 2004; 2012) values of less than 1.0 (Fig. 9), which is not surprising given dependency on CAPE in the STP calculation and the low frequency of no-CG significant tornadoes (only 3% were EF2+).

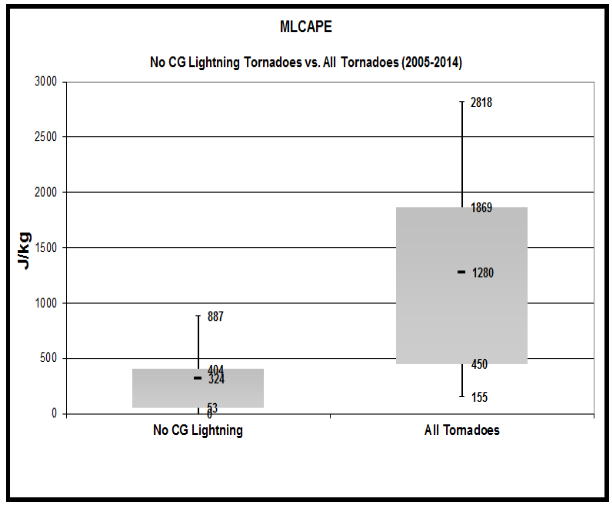


**Figure 5.** Comparison of MLCAPE (J $kg^{-1}$) associated with no-CG tornadoes versus all tornadoes. Each box is representative of the 25th to 75th percentiles of values, with the outer whiskers representing the 10th and 90th percentiles.

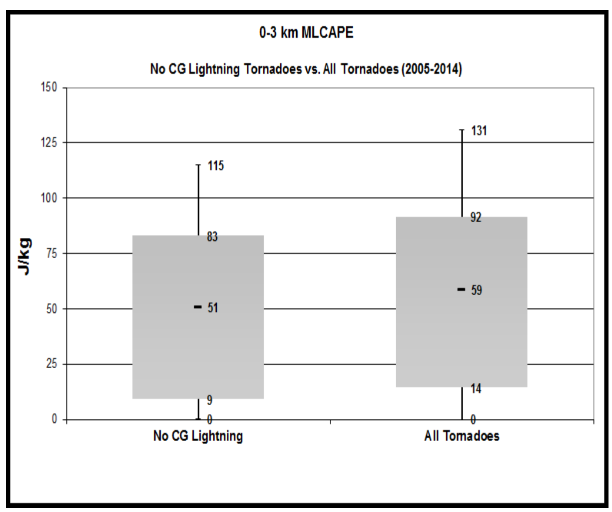


**Figure 6.** Same as Fig. 5, except for 0-3 km MLCAPE (J $kg^{-1}$).

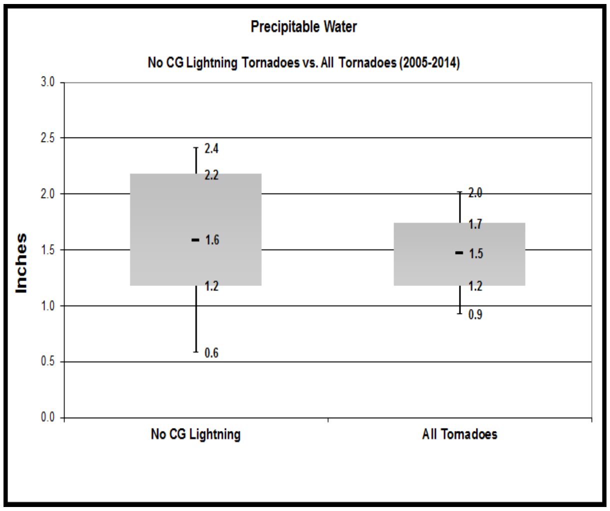


**Figure 7.** Same as Fig. 5, except for precipitable water (inches).

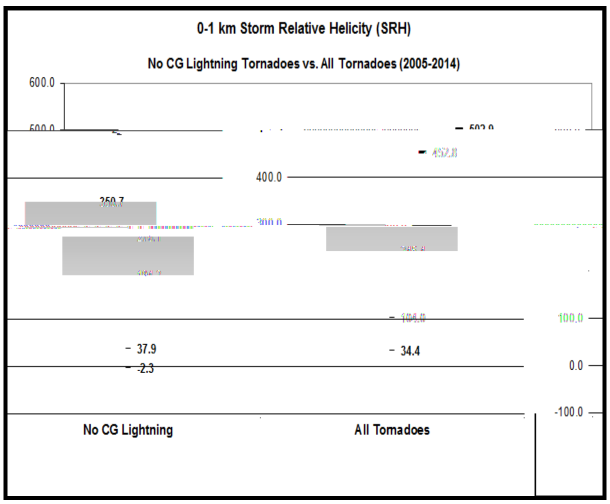


**Figure 8.** Same as Fig. 5, except for 0-1 km Storm Relative Helicity ($m^2 s^{-2}$).

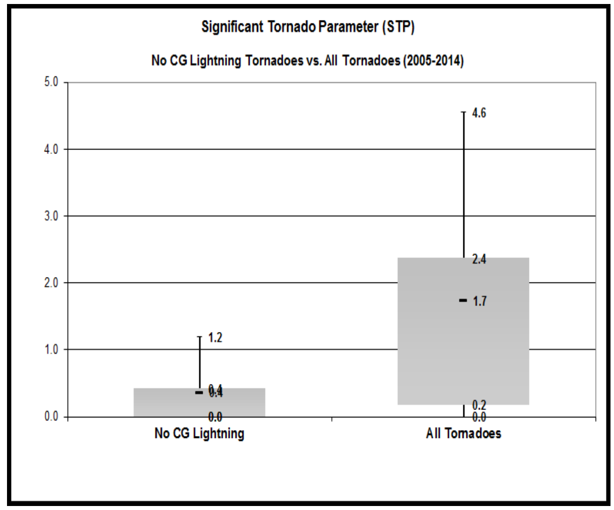


**Figure 9.** Same as Fig. 5, except for STP.

## 5. Case Example – 29 December 2014

An EF2 tornado struck parts of Valdosta, Georgia, during the late morning hours (around 1626 UTC) of 29 December 2014 (Fig. 10). This storm notably occurred without any observed CG lightning across the region. Regional early morning (1200 UTC) observed soundings sampled very weak low/mid-level lapse rates and little, if any, buoyancy although winds were relatively strong through a deep layer (Figs. 11 and 12). Aided by some heating and a modest influx of low-level moisture, subsequent SPC Mesoanalysis data from 1600 UTC suggests there may have been as much as 250 J $kg^{-1}$ of surface-based CAPE in proximity to the Valdosta, Georgia, EF2 tornado (Fig. 13). Figure 14 features Doppler radar imagery from nearby Moody Air Force Base, Georgia, (KVAX) around the time of the short-lived EF2 tornado.

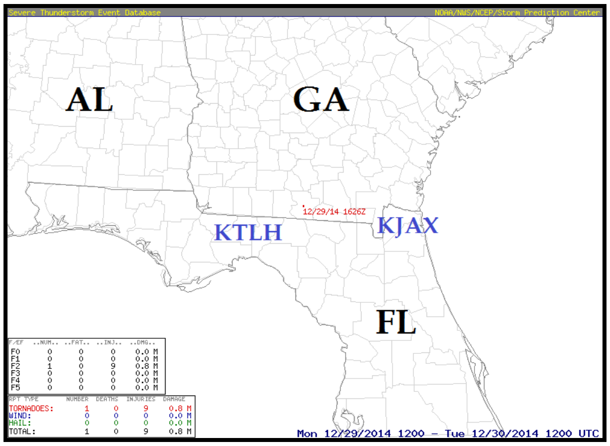


**Figure 10.** Valdosta, Georgia, EF2 tornado noted by red dot and related date/time. KTLH and KJAX denote the locations of the 1200 UTC observed soundings at Tallahassee and Jacksonville, Florida, respectively.

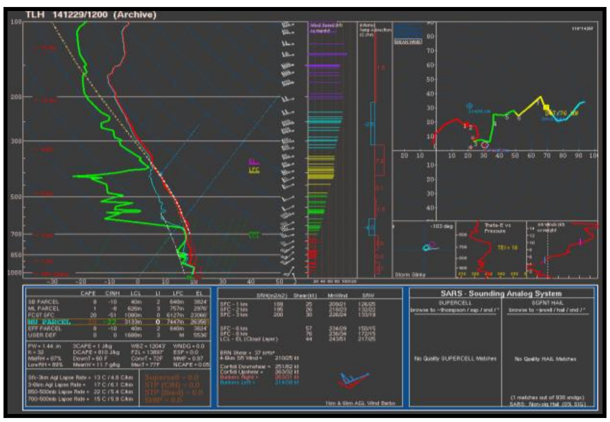

**Figure 11.** Observed sounding from Tallahassee, Florida (KTLH) on 12 UTC 29 December 2014.

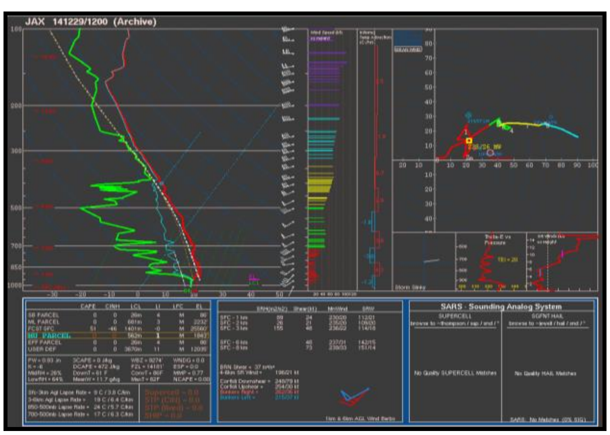

**Figure 12.** Observed sounding from Jacksonville, Florida (KJAX) on 12 UTC 29 December 2014.

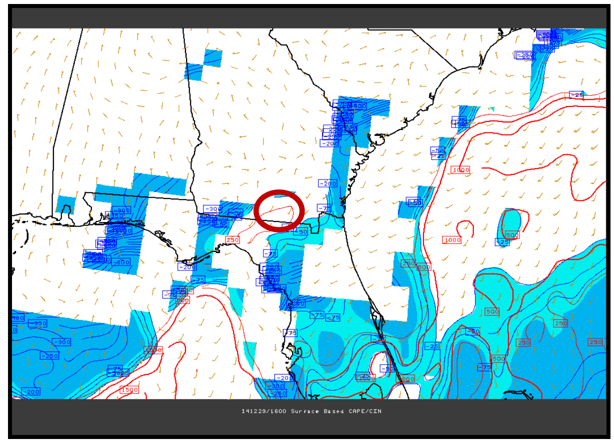

**Figure 13.** 1600 UTC 29 December 2014 SPC Mesoscale Analysis of surface-based CAPE/CIN.

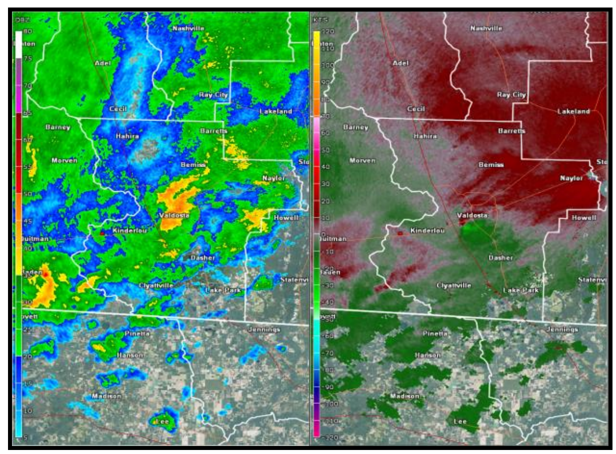

**Figure 14.** 1.4 degree reflectivity (left) and storm-relative velocity (right) WSR-88D radar imagery from Moody Air Force Base, Georgia, (KVAX) at 1621 UTC 29 December 2014.

## 6. Summary

At least 2% of tornadoes (293 total) during 2005-2014 were found to be associated with an absence of CG lightning. While these relatively rare no-CG tornadoes tend to be weak and short-lived tornadoes, significant tornadoes (EF2+) and tornado-related fatalities have occurred. While overall buoyancy tends to be very weak (e.g., MLCAPE less than 500 J $kg^{-1}$), preliminary analysis of the near-storm environment suggests that low-level profiles of moisture (e.g., precipitable water; dew point), buoyancy (e.g., 0-3 km CAPE), and vertical shear (e.g., storm-relative helicity) are relatively similar for no-CG tornadoes and all other tornadoes.

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