Multi-Sensor Observations of TLEs and Lightning from an Asymmetric MCS over Oklahoma (9 May 2007)

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On 9 May 2007, an asymmetric mesoscale convective system (MCS) passed through central Oklahoma. The MCS was monitored for transient luminous events (TLEs) using low-light video imagers from Yucca Ridge in north central Colorado, with storm structure detailed by regional NEXRAD radars and GOES IR satellite. Electrical characteristics were determined by the 3-D Oklahoma Lightning Mapping Array (LMA), the National Lightning Detection Network (NDLN), and the experimental National Charge Moment Change Network (CMCN) which produced real-time estimates of impulse (first 2 ms) charge moment changes from the more powerful cloud-to-ground (CG) strikes. There were 26 TLEs observed during the observation period (03-05 UTC).

This MCS differed substantially from the large leading line/trailing stratiform system of 20 June 2007 previously reported upon. Smaller in area, it consisted of a short NW-SE-oriented convective line with a stratiform region to its north. This stratiform region also contained intense embedded convection, and rotated cyclonically as a mesoscale convective vortex. The MCS was dominated by negative cloud-to-ground (CG) lightning, with 95% of the 3037 detected NLDN CG strokes being negative. The total flash rate sometimes exceeded 100 flashes per minute.

Of the 26 TLE-parent positive CG strokes, 24 were detected by the NLDN and 18 of these had impulse charge moment change (iCMC) retrievals by the CMCN. Thirteen of these had iCMC values in excess of 100 C km, roughly consistent with past studies that suggest that CGs with iCMC values ~100 C km or greater are favorable for generating TLEs. Fifty-eight percent of the TLE-producing positive CG strokes were detected by the World Wide Lightning Location Network (WWLLN), which suggests that this global network may have promising utility in TLE research studies. No negative CGs were associated with TLEs. The largest negative iCMC recorded during the two hour period was -101 C km (compared to the largest +CG event with +642 C km)

Both convective regions produced TLE parent flashes, although most TLE producers initiated in the stratiform embedded convection. TLE parent flashes initiated around 5.7 km MSL in the embedded convection, but slightly higher (7.5 km) in the southern convective line. Both sets of TLE parent flashes tended to propagate near 6 km MSL in the stratiform region while producing their TLEs. In general, TLE flash altitudes were lower (by ~2 km or more) and flash areas were smaller (by a factor of 2-3) than in the previously reported 20 June 2007 Oklahoma-Texas MCS. These differences were consistent with the observed differences in storm structures (radar, charge, etc.). The results suggest that, while a variety of flash scenarios can produce TLEs, some storm archetypes may be especially favorable for TLE production. In particular, a classic leading-line/trailing stratiform MCS, with advection of copious amounts of upper-level charge rearward from the convective line (e.g., 20 June 2007), may be a relatively good producer of TLEs compared to other MCS types. While earlier studies suggested sprite parent CGs tended to remove charge from near the melting layer (~4 km), other storm structures are now found to be conducive to charge removal from greater heights, thus systematically increasing CMC values in these storms. This may explain the large differences in the probabilities of +CGs producing TLEs between superficially similar storms.