A Comparison of the Electrical Characteristics of Three Different Storm Systems during DC3

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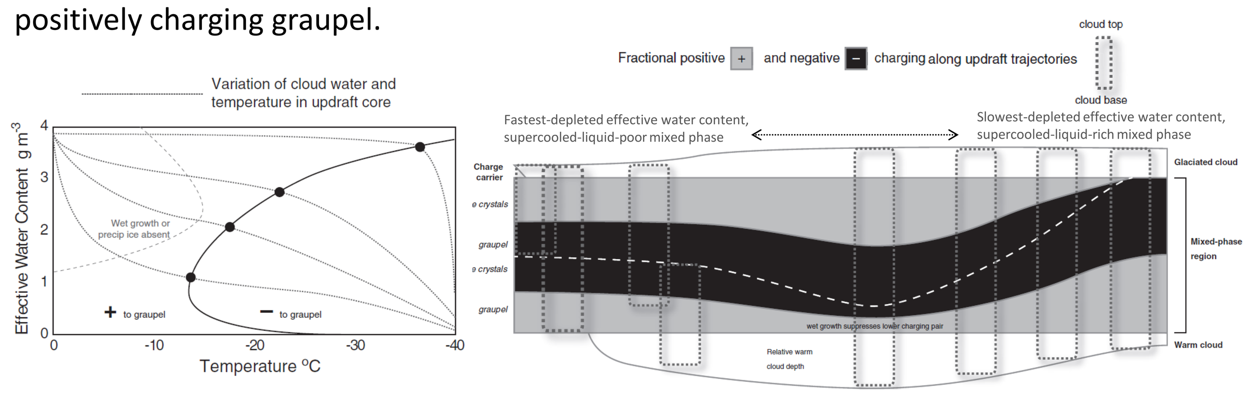
Goal

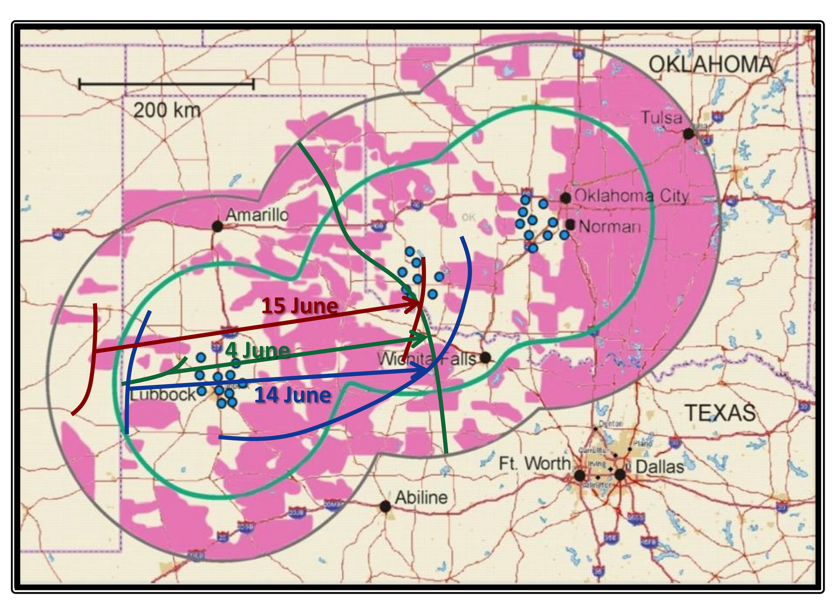
The Deep Convective Clouds and Chemistry Experiment (DC3) field campaign took place from 15 May to 30 June 2012. One of the goals is to better understand how lightning flash rates correlate to storm parameters such as precipitation-driven electrification mechanisms and how the local environment can impact the polarity of the lightning in a storm. If polarity changes are driven by changes in the electrification mechanism, then changes to the vertical distribution of lightning channels and NOx sources could result. It is expected that in a more moist environment with faster depletion of liquid water, more negative charging of graupel at midlevels in the troposphere will occur resulting in a midlevel negatively charged layer.

Below: From Bruning et al. (2012). **Left**: (Fig. 3) Idealized relationship between available cloud water and temperature in an updraft trajectory and the charge gained by graupel. **Right**: (Fig. 4) Shows how the charge structure varies with available water, with the lower precipitation storms (further right on the diagram) having a larger depth of positively charging graupel.



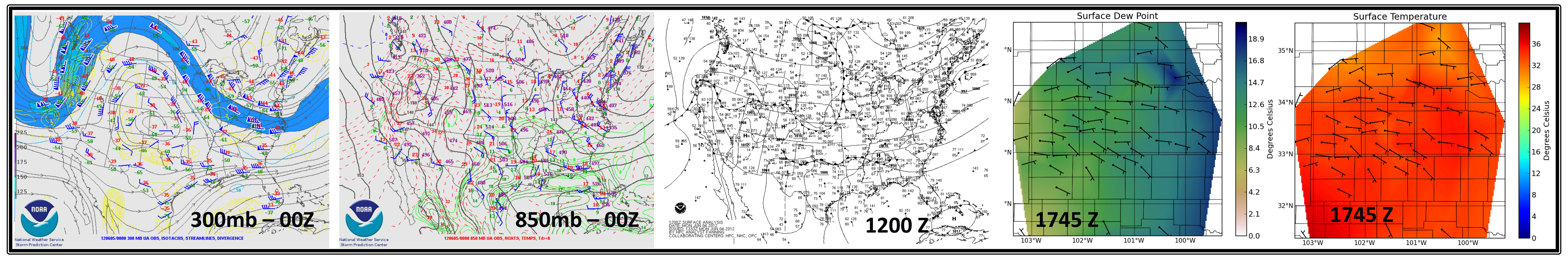
Method

This project focuses on the electrification of three storm systems which passed through the Oklahoma-Texas domain of the DC3 project during early June 2012. In this domain there are three Lightning Mapping Arrays (LMA) which allows for a relatively long-duration analysis of storm electrification as the storms move across the region and through different local environments. The environments are analyzed using archived SPC analysis, environmental soundings, and surface observations. The storms are analyzed using radar observations through WDSS-II (Lakshamanan et al., 2007) and flash-by-flash analysis of the LMA observations (Mazur, 2002; Wiens et al., 2005).



Left: The OK-TX DC3 domain. The green (grey) circles represent the extent of the 3-D (2-D) lightning mapping capabilities of the respective LMAs. The blue circles represent the individual station locations. The other curves the approximate initiation and decay locations of the main portions of interest of the respective systems, and the arrows the direction of motion.

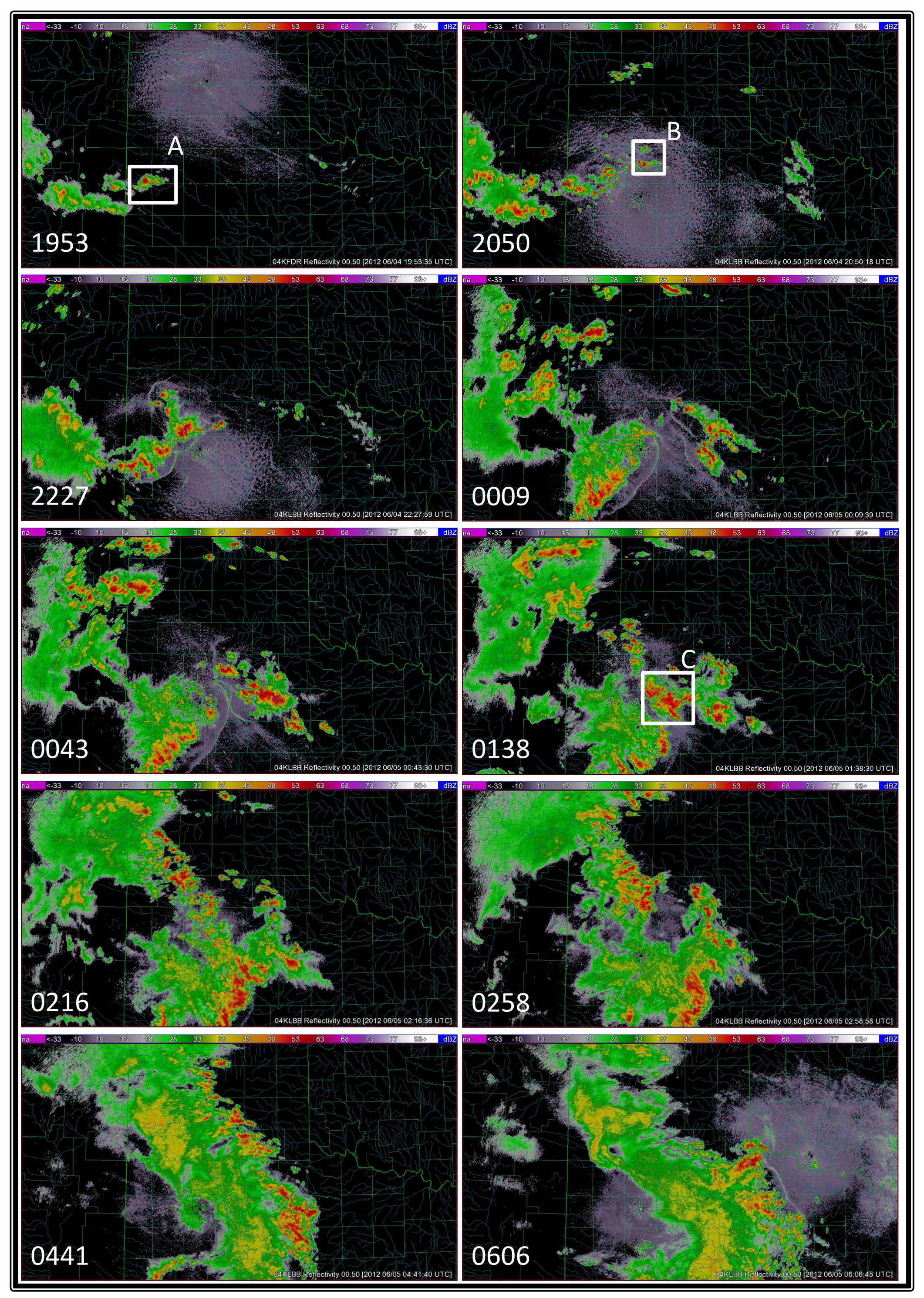
4-5 June 2012

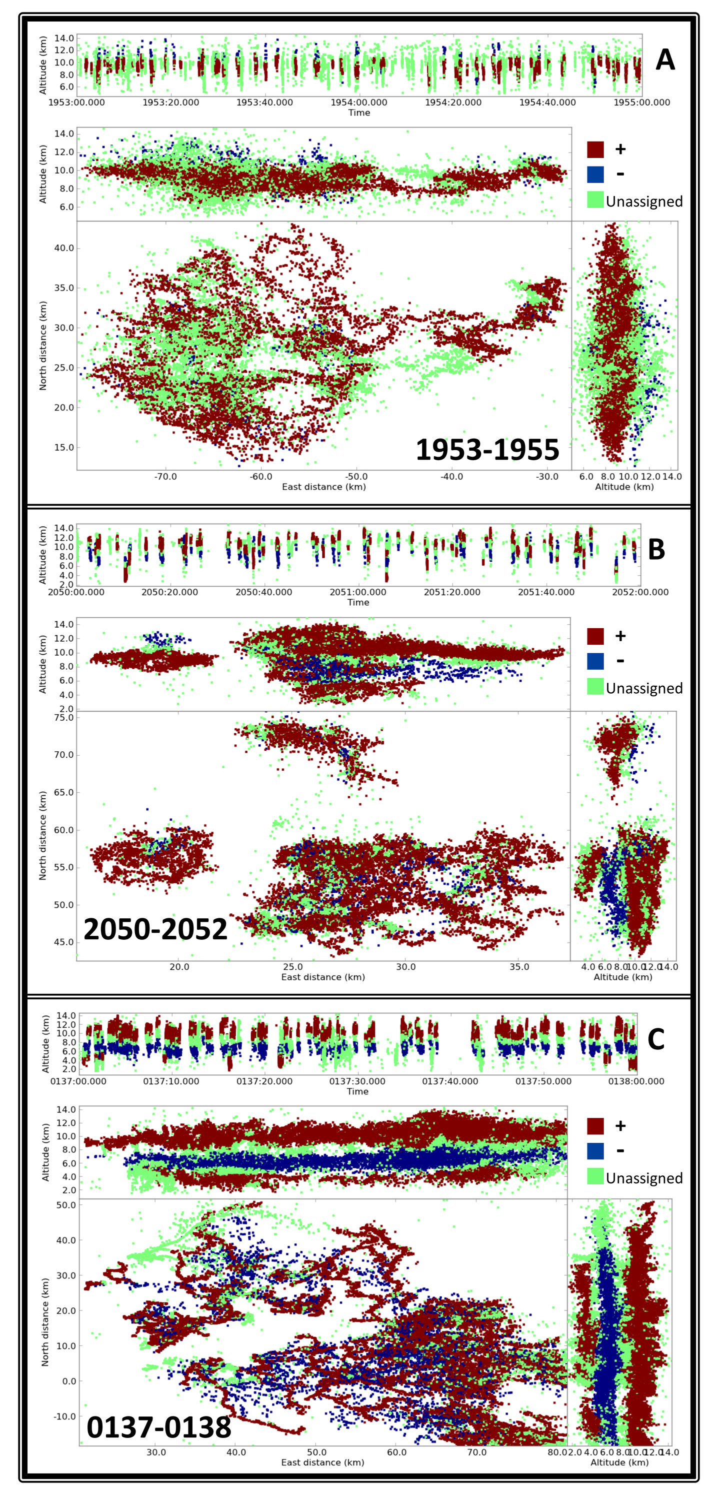


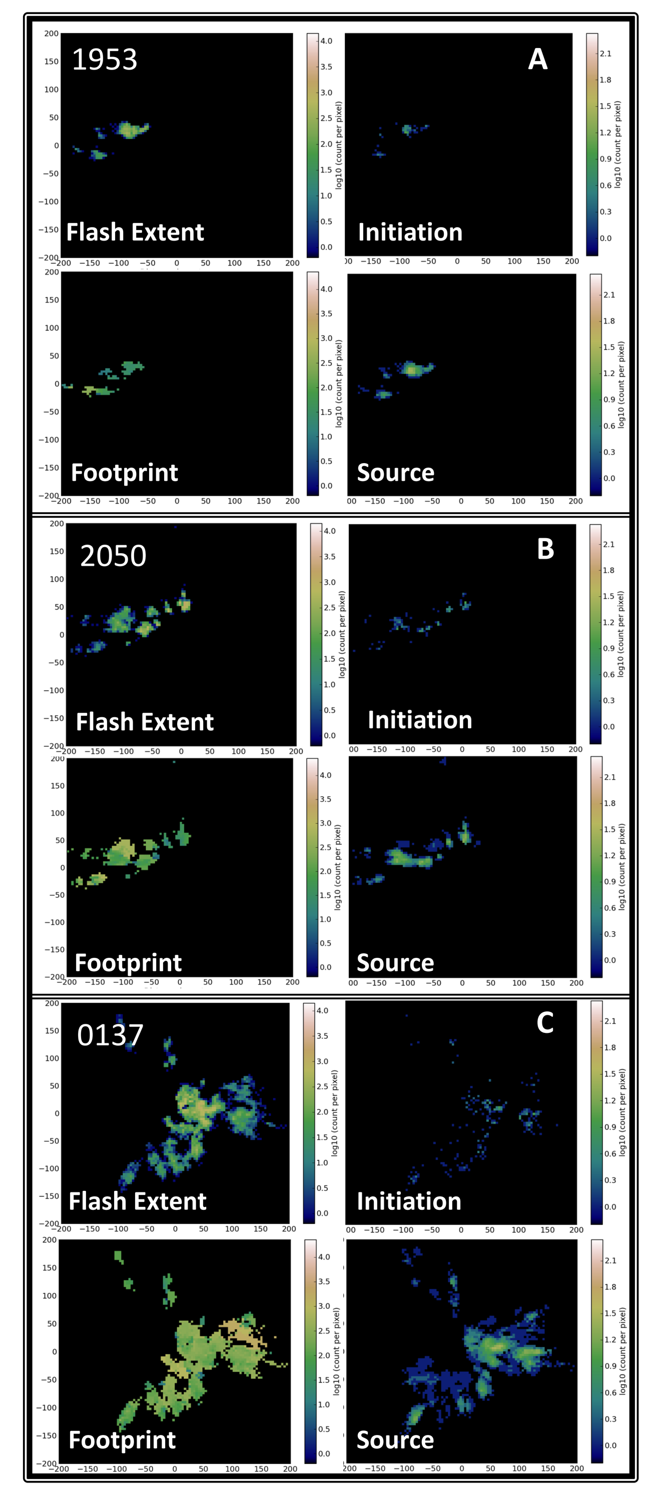
Left: Archived SCP CONUS analysis at 0000 UTC for 300mb and 850mb respectively. **Center**: HPC surface analysis from the morning before convection. **Right**: West Texas Mesonet surface analysis from the pre-convection environment of dew point and temperature respectively.

Convective initiation occurred along a decaying surface trough associated with a slight gradient in temperature and humidity along the New Mexico – Texas border. There was a significant low to mid-level moisture gradient between New Mexico and Oklahoma. Early convection was mostly cellular in nature, relatively stationary and analyzed portions contained three charged layers with a positively charged middle layer. Mature storms that initiated further east in a more moist environment or along the moist outflow, however, developed a negatively charged middle layer. While these storms slowly began to propagate eastwards along the outflow, convection began near Childress, TX and began to propagate westward. Several severe wind and hail reports were associated with this convection along with a brief tornado when the two convective boundaries collided. The largest flash rates were along the leading edges of these convective boundaries, especially in the storms along the collision of the boundaries. Lower rates were seen in the stratiform regions and in regions that had already been turned over by convection.

Left: WDSS-II Lowest-level reflectivity from KAMA, KLBB and/or KFDR (all times UTC). Circles highlight the storm associated with the analyses shown. **Center**: Charge assignment using the WTLMA showing [1]altitude vs. time, [2]altitude vs. east-west, [3]north-south vs. east-west, and [4]north-south vs. altitude. **Right**: Calculated flash statistics for 3x3km areas at the same times as the shown charge analyses, including: flash extent, flash initiation density, flash footprint (average flash area), and source density. Scale shows the distance (in km) from the center of the WTLMA.



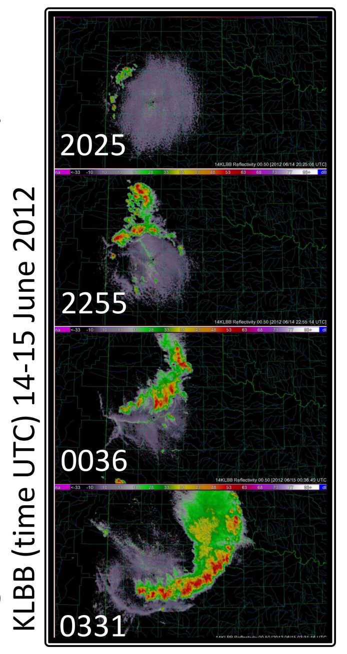




14-15 June 2012

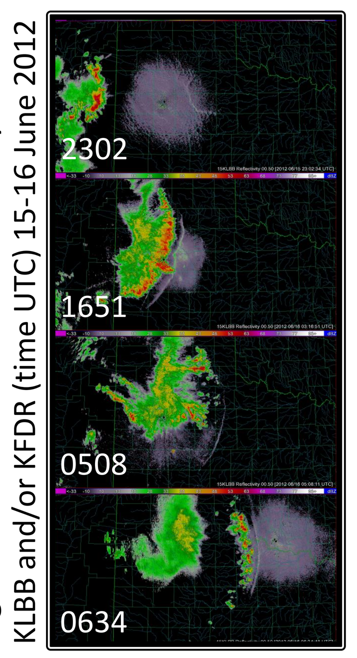
Convection associated with this system developed along the dryline near the Texas-New Mexico border under upper-level zonal flow and spread south and east along its outflow into western Oklahoma. This system was also associated with severe wind and hail reports in west Texas and crossed large, mid-level moisture gradient. As expected, the highest density of flashes occurred along the leading edge of convection.

Right: WDSS-II Lowest-level reflectivity from KLBB (time UTC) 14-15 June 2012



15-16 June 2012

Right: WDSS-II Lowest-level reflectivity from KLBB and/or KFDR (time UTC) 15-16 June 2012



Convective associated with this non-severe system initiated in eastern New Mexico ahead of an upper level trough. Unlike the other cases this system did not cross any large moisture gradients in the OK-TX region. The storms became somewhat linear in structure as they entered west Texas but began to lose intensity as they moved further east and were outrun by their outflow. However, as the outflow approached western Oklahoma, it began to support small, relatively short-lived cellular storms.

Preliminary Results

Variability of the mesoscale environment correlates to predicted variability in the charge structure, with the overall drier environment being associated with an enhanced positive charge region and a more moist or overturned environment being associated with an enhanced negative charge layer. Future work includes continuing to investigate the 14-15 June and 15-16 June cases and to possibly investigate other systems to further solidify the result.

Citations

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