Evolving dominant charge structures during upscale storm growth in West Texas on 4 June 2012

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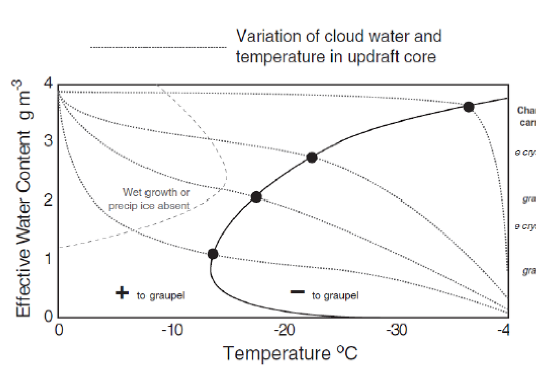
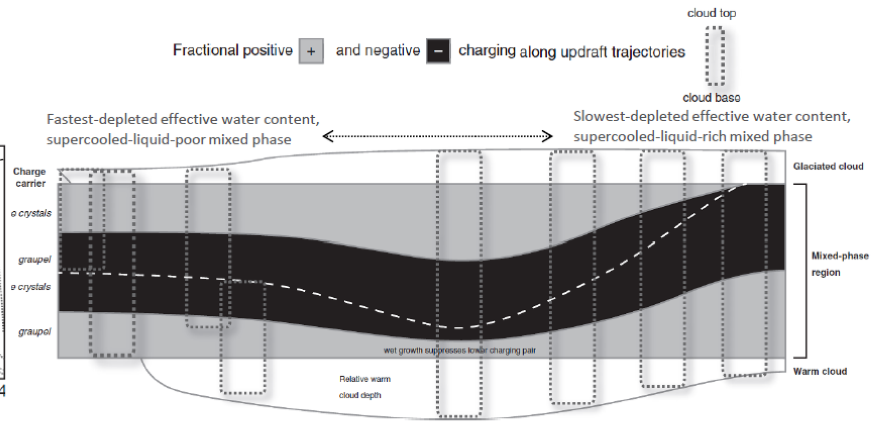
Goal

The Deep Convective Clouds and Chemistry Experiment (DC3) field campaign took place from 15 May to 30 June 2012. Among its goals were better understanding 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.

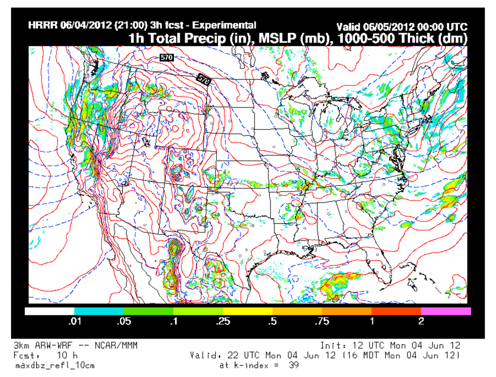
Below: From Bruning et al. (2012). Left: (Fig. 3) Idealized relationship between available cloud water and temperature in an updraft trajectory and the charge gained by graupel. Right: (Fig. 4) Shows how the charge structure varies with available water, with the lower precipitation storms (further right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





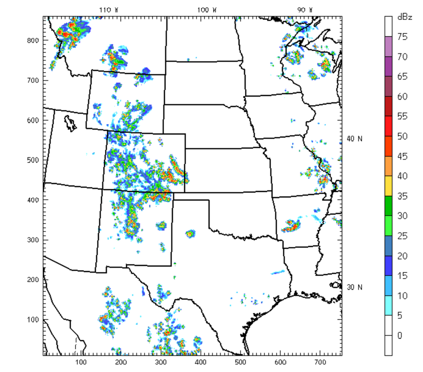
Method

This project focuses on a system which passed through the DC3 OK-TX domain overnight on 4 June 2012. The environment was analyzed using archived SPC analysis, model data, satellite, and environmental soundings, and West Texas Mesonet observations. The storms were analyzed using radar observations and flash-by-flash analysis of the LMA observations (Mazur, 2002; Weins et al., 2005).

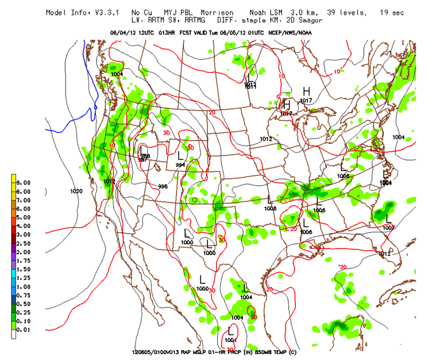


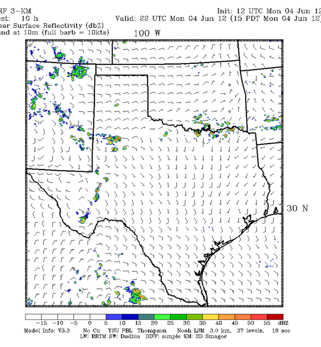
Model Data

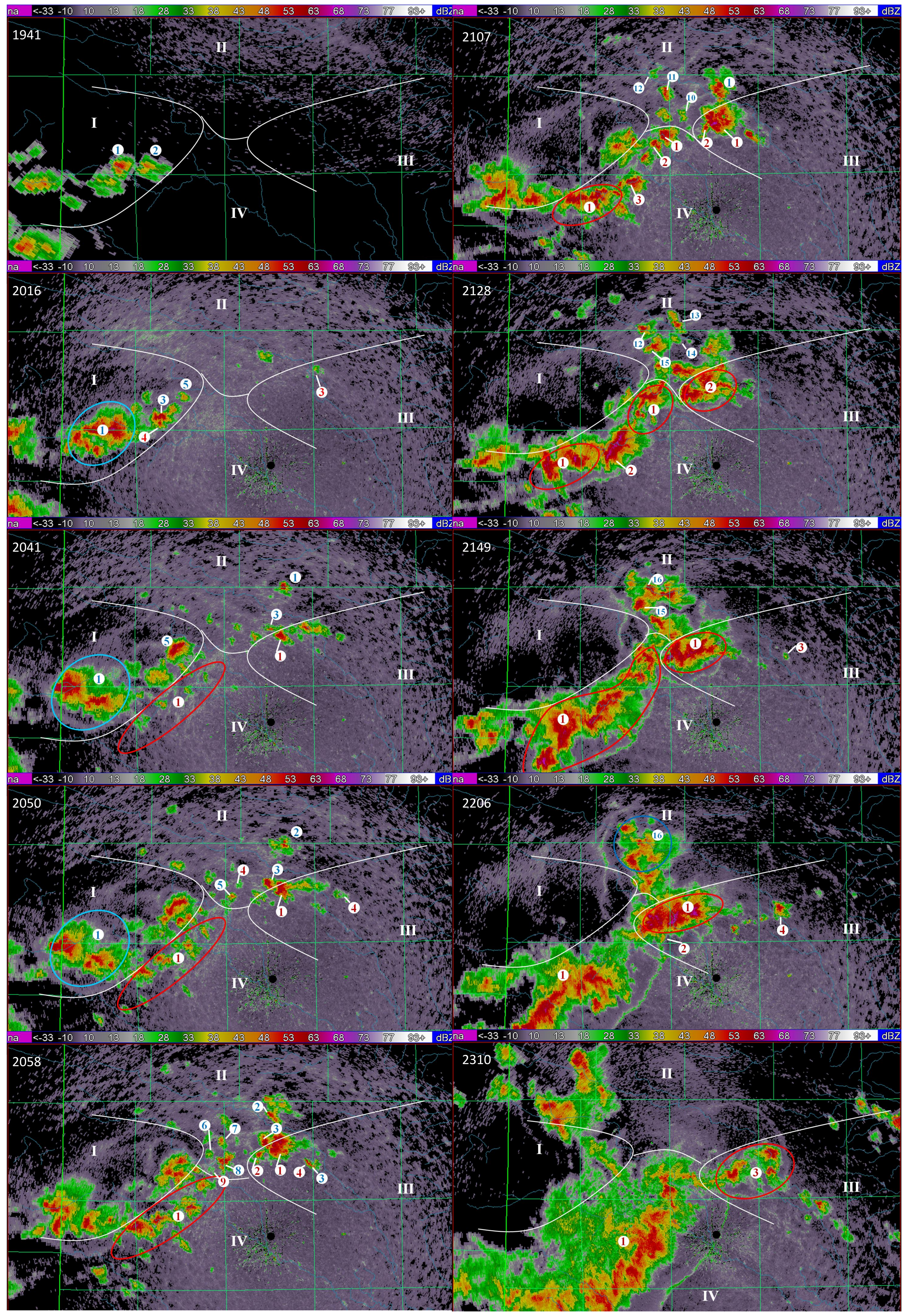
There was a large disparity among the handling of the convection for the different models, none of which well captured this event. The models most likely had difficulty resolving the location of the surface features which initiated convection.



The best performers: The precipitation field for the **(top left)** 2100Z HRRR forecast for 0000Z came close to capturing the location of initiation, but not the mode or the time. The **(middle left)** 1200Z NCAR WRF forecast for 2200Z well captured the location and time of initiation in region III, but not any of the other convection in the region. The **(bottom left)** 1200Z RUC forecast for 0100Z misplaced the time and location of convection. The **(bottom right)** 1200Z TTU WRF forecast for 2200Z well captured the time of initiation but misplaced the axis of convection.

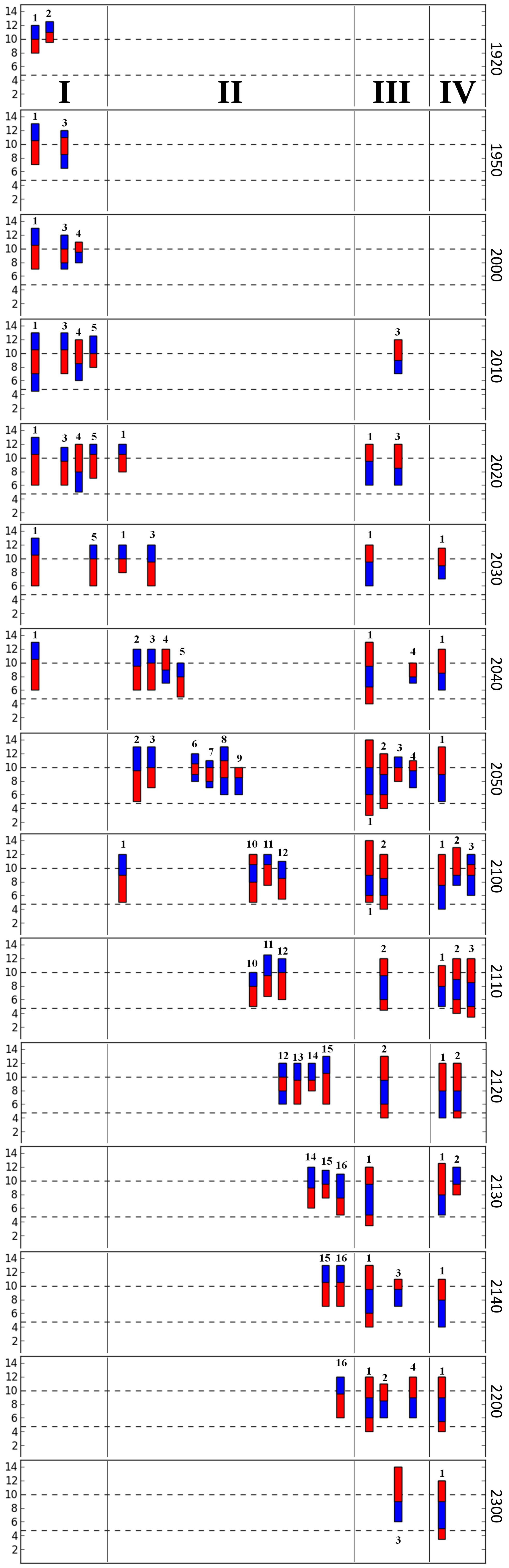






Above: Lowest-tilt reflectivity images from the KLBB/KAMA WSR-88D radars at select times (UTC) taken from WDSS-II (Lakshamanan et al., 2007). Regions of charge structures (I-IV) on right are marked, and the cells (or regions) with analyzed charge structures shown at right are numbered in red (blue) for dominant uppermost positive (negative) intracloud flashes.

Right: Analyzed charge regions by height (in km MSL) for different initiating/mature cells (or regions) near the updrafts at select times (UTC). The analysis is separated by the bulk regions (I-IV) shown above and numbered by the identifier used above in the radar images. The dashed lines represent the 0°C and -40°C levels at 00Z. The red (blue) regions represent heights dominated by positive (negative) charge based on flash-by-flash analysis of the WTLMA observations



Citations

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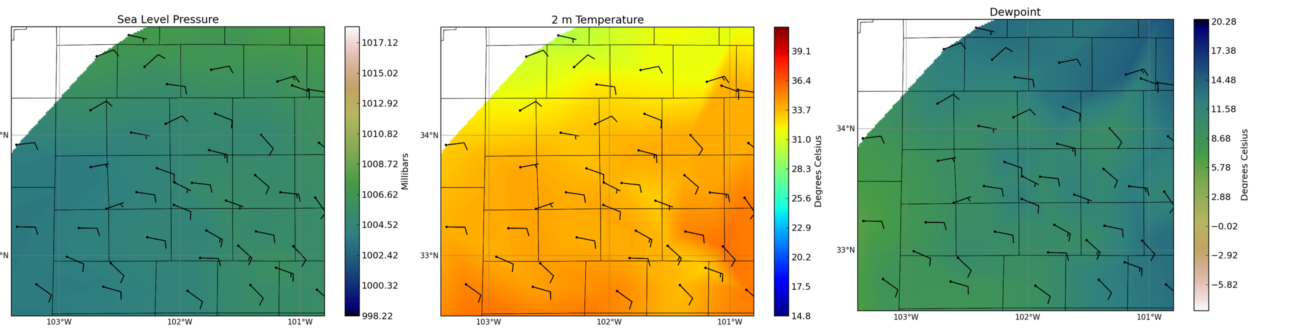
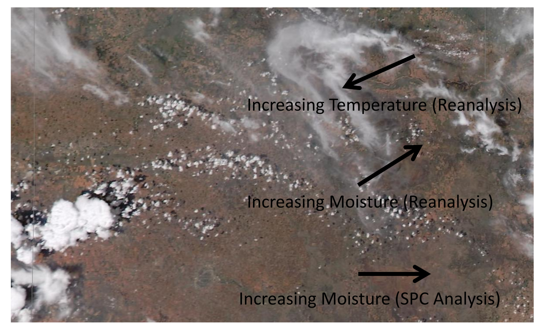
Environment





Top: Surface observations from the West Texas Mesonet at 1920Z: sea level pressure (**left**), temperature (**middle**) and dew point (**right**). **Left**: Aqua (MODIS) true-color image (Modis Today) from 1925Z with summary of analyzed gradients at 700 mb from SPC (0000z) and NCEP Reanalysis (1800Z).

Summary of Observations

Convective initiation occurred along a decaying stationary front and surface trough associated with a slight gradient in temperature and humidity along the New Mexico – Texas border. There was a low to mid-level moisture gradient (6°C) and temperature gradient (3°C) between New Mexico and Oklahoma, with drier air and warmer temperatures to the west. Generally, the storms could be grouped into four primary regions:

I. The storms which initiated on the western side of the domain were initially isolated in nature and dominated by a mid-level positive charge and –IC flashes at upper levels. The western-most storms were relatively long-lived and maintained the mid-level positive charge.

II. The storms which initiated on the northern side of the domain were also relatively isolated in nature, but contained a mixture of charge structures. Most of these cells were short-lived, but those further north were more long-lived and dominated by mid-level positive charge

III. The storms which initiated on the eastern side of the domain with more moist mid-levels contained more multi-cell clusters and were dominated by a mid-level negative charge and +IC flashes at upper levels.

IV. The storms which initiated on the southern and eastern outflows of the initial convection were dominated by mid-level negative charge and +IC flashes at upper levels.

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. However, some cells showed interaction effects in their charge structures. Future work includes more detailed investigation of the environment (or ranges of) and the impacts on charging mechanisms.

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