Observations of stratiform lightning flashes and their microphysical and kinematic environments

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1. Introduction

During the Midlatitude Continental Convective Clouds Experiment (MC3E), combined observations of clouds and precipitation were made from airborne and ground-based in situ and remote sensing platforms. These observations were coordinated for multiple mesoscale convective systems (MCSs) that passed over the MC3E domain in northern Oklahoma. Notably, during a storm on 20 May 2011 in situ and remote sensing airborne observations were made near the times and locations of stratiform positive cloud-to-ground (+CG) lightning flashes. These +CGs resulted from extremely large stratiform lightning flashes that were hundreds of km in length and lasted several seconds. This dataset provides an unprecedented look at kinematic and microphysical environments in the vicinity of large, powerful, and long-lived stratiform lightning flashes.

We will use this dataset to understand the influence of low liquid water contents (LWCs) in the electrical charging of MCS stratiform regions.

2. Datasets

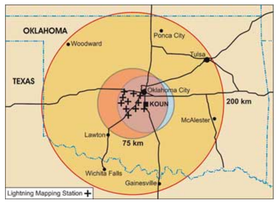
UND Citation
- In situ microphysics

NASA ER-2
- AMPR
- HIWRAP
- CoSMIR

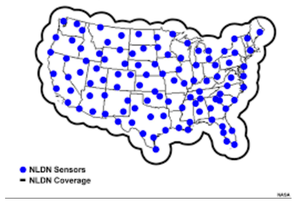
Oklahoma LMA

NLDN

NEXRAD Radars
- KVNX (Dual-Pol)
- KTLX



NLDN Sensor Map



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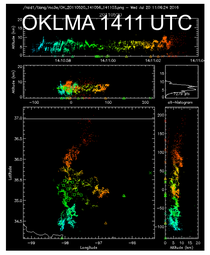
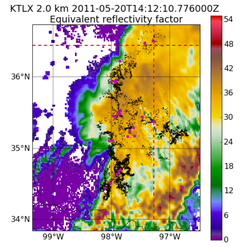
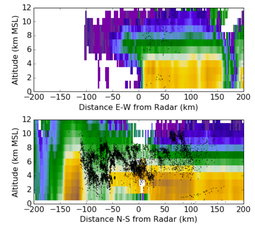
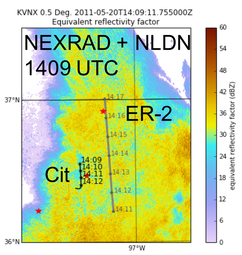
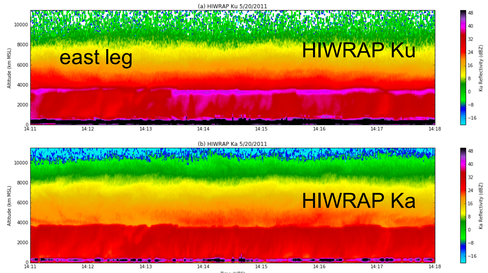
3. Lightning Flashes on 20 May 2011

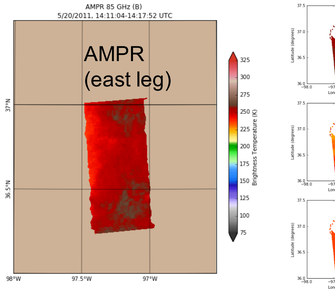


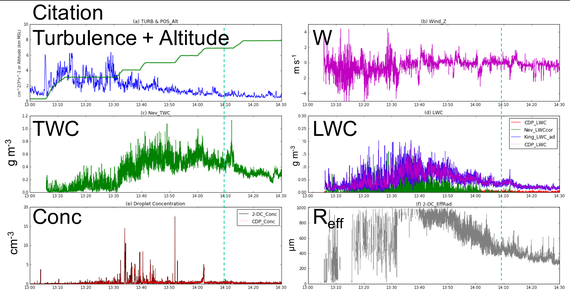


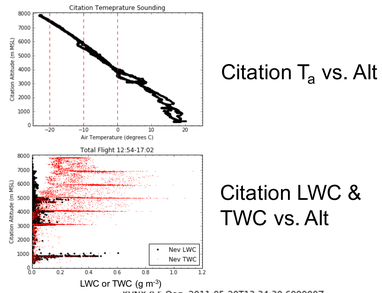






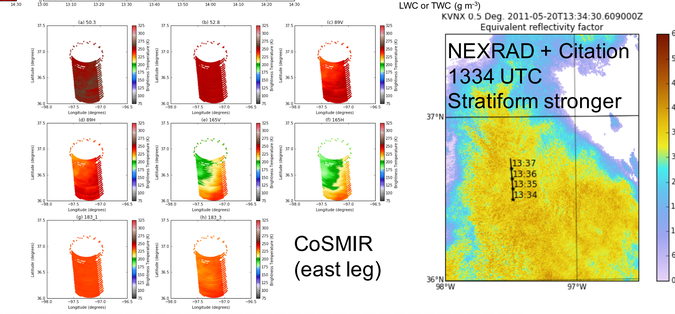




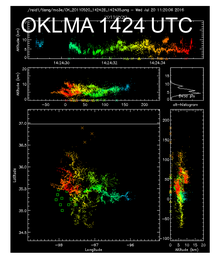


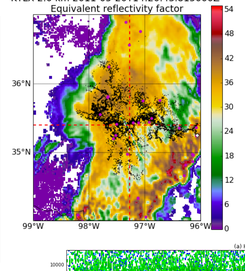
Citation T_a vs. Alt

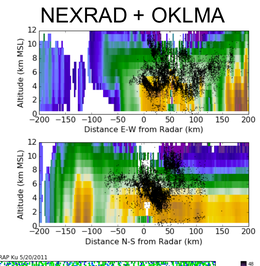
Citation LWC & TWC vs. Alt

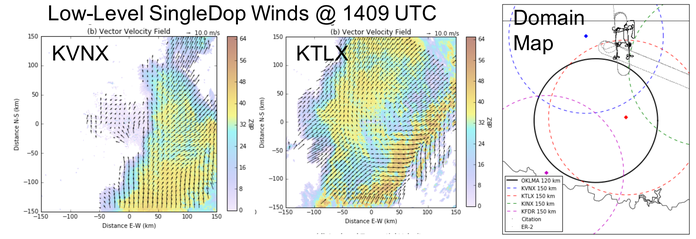


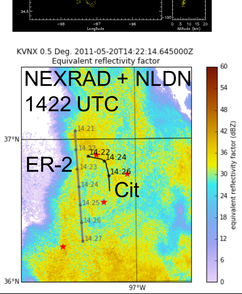
CoSMIR (east leg)

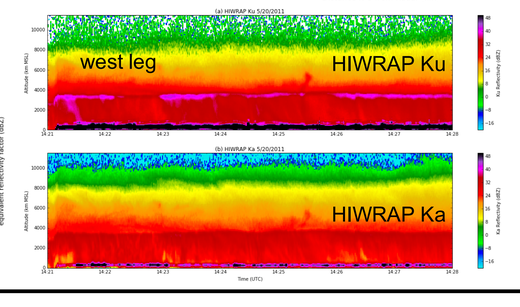


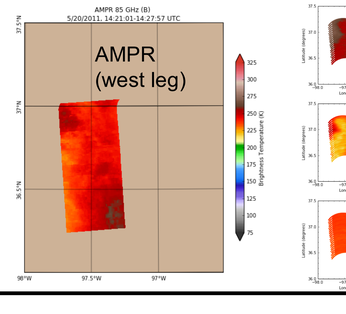


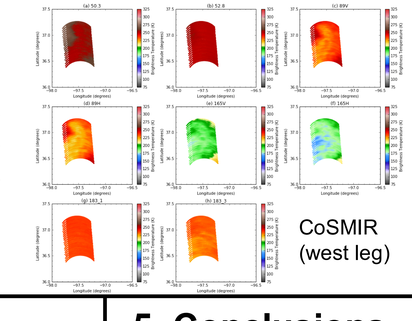




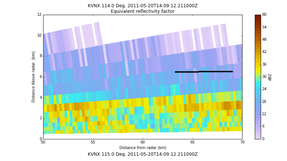




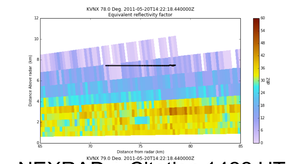




CoSMIR (west leg)



NEXRAD + Citation 1409 UTC



NEXRAD + Citation 1422 UTC

4. Discussion

- Stratiform lightning flashes at 1411 and 1424 UTC occurred in decaying stratiform region sampled by NASA ER-2 and UND Citation
- Flashes lasted several seconds, traveled hundreds of km from convective line, and produced multiple +CG strikes near sampled region
- 1411 UTC flash came within 2.8 km (LMA) and 4.8 km (NLDN) of Citation
- 1424 UTC flash came within 26.4 km (LMA) and 10.9 km (NLDN) of Citation
- Lightning propagated into region above freezing altitude, where Citation indicated low LWC (≤ 0.25 g m^{-3})
- Citation observed little supercooled liquid water above 5000 m MSL (-5 ºC)
- OKLMA indicated little negative leader activity near Citation and +CGs in 1424 UTC flash
- Microwave radiometers indicated colder TBs near western edge of stratiform, where flash propagation appeared to be favored
- Citation also indicated more ice/liquid in this region, but was undergoing altitude change
- Evidence for small convective pockets with enhanced ice/liquid, as well as increased vertical motions
- Animations and single-Doppler retrievals indicate advection of stratiform toward NNE

5. Conclusions

- In situ evidence for lightning propagating in stratiform regions with low LWC (≤ 0.25 g m^{-3})
- Besides advection, charge separation may also have occurred in situ from early stronger stratiform microphysics, plus isolated pockets of local convection
- MC3E underrated as an electrification field campaign

Data provided by https://ghrc.nsstc.nasa.gov/home/ and Don MacGorman/NOAA NSSL

Open Source Tools Used in this Analysis:
https://github.com/ARM-DOE/pyart, https://github.com/nasa/SingleDop, https://github.com/nguy/AWOT, https://github.com/nasa/PyAMPR, https://github.com/deeplycloudy/lmatools, https://github.com/nasa/DualPol