Investigating the relationship between turbulence and lightning

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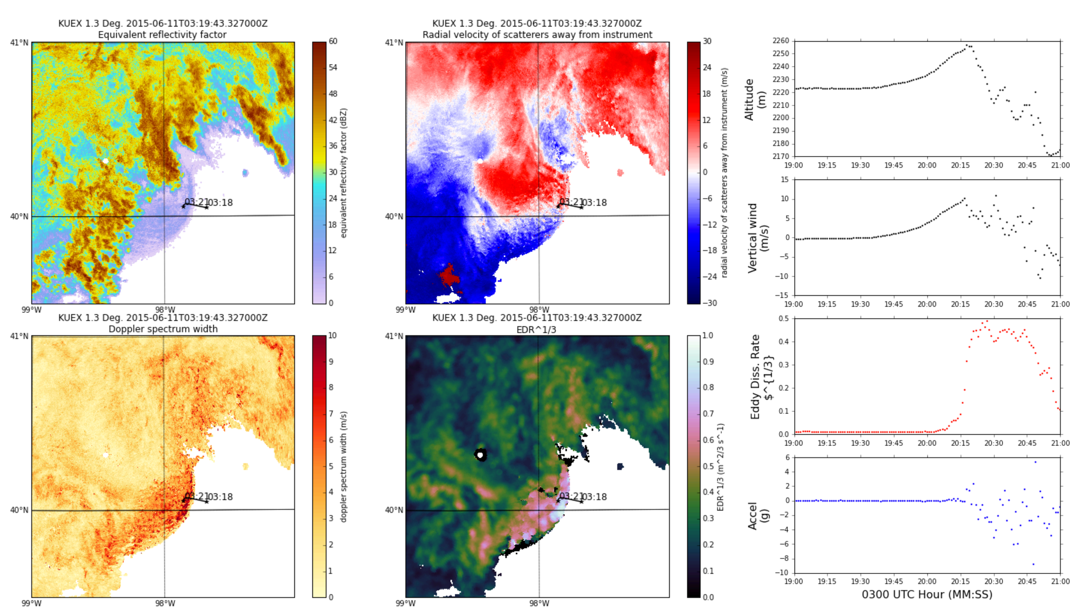
AGU Fall Meeting AE31C-0451

1. Introduction

Recent studies have indicated that turbulence may control lightning characteristics, such as flash rate and size. Moreover, there are indications that the onset of lightning may be related to rapid intensification of turbulence within a growing convective storm. We explore these relationships using open source research tools:

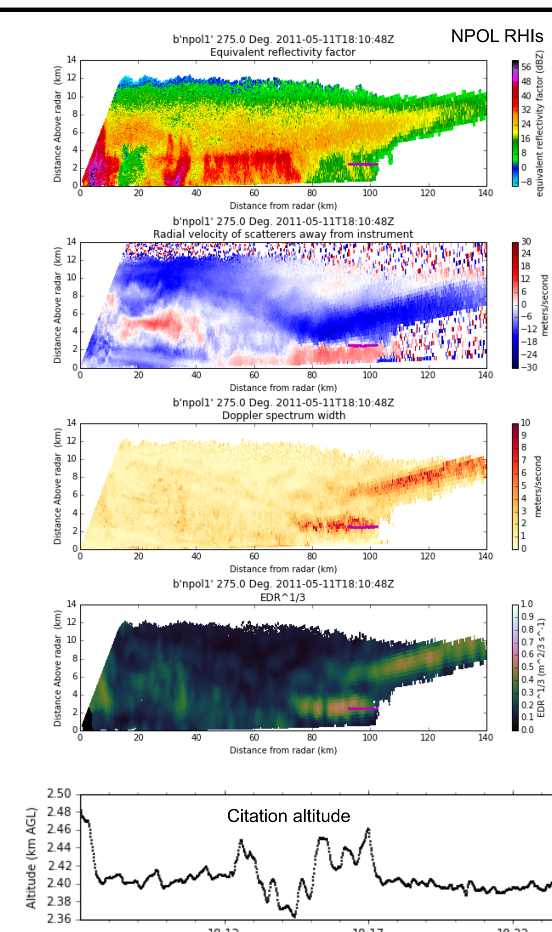
- DOE Python Atmospheric Radiation Measurement (ARM) Radar Toolkit (Py-ART)
- NASA Python Turbulence Detection Algorithm (PyTDA)
- Airborne Weather Observations Toolkit (AWOT)
- CSU_RadarTools
- NASA Python Interface to Dual-Pol Radar Algorithms (DualPol)
- lmatools

2. Validation of Turbulence Products

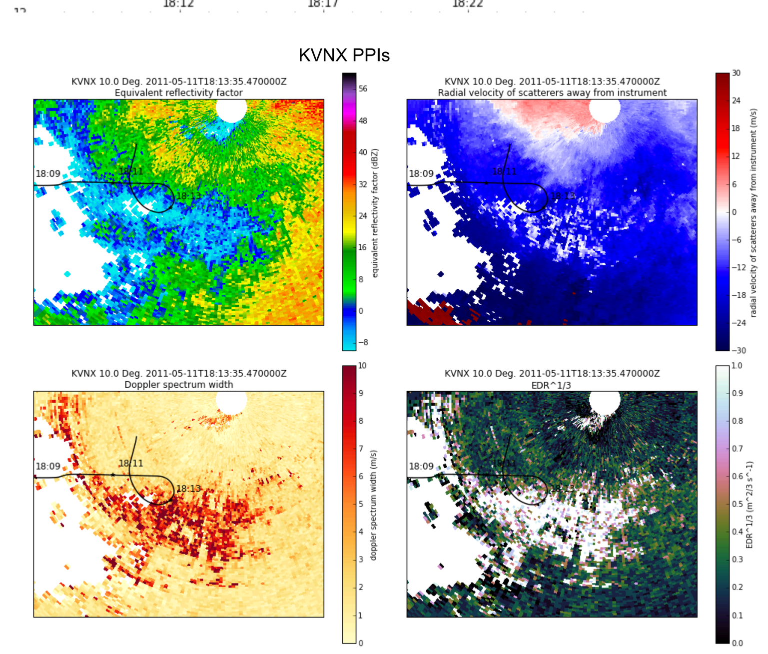


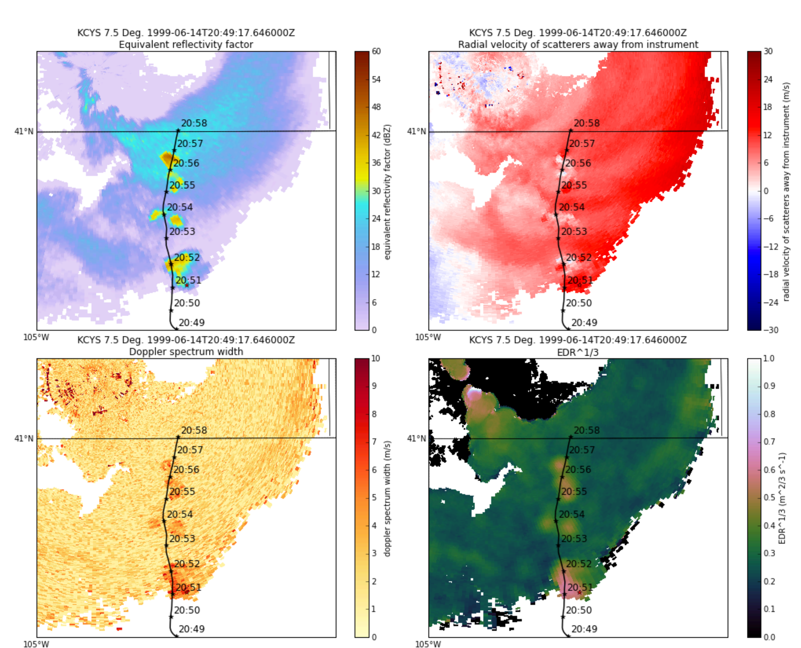
PECAN 06/11/2015 Turbulence in bore forced emergency landing

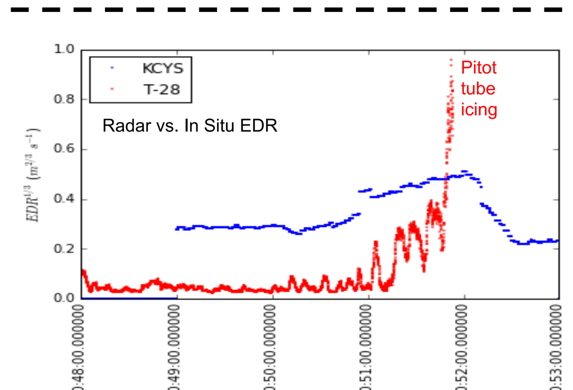
University of Wyoming King Air Severe+ Turbulence Encounter

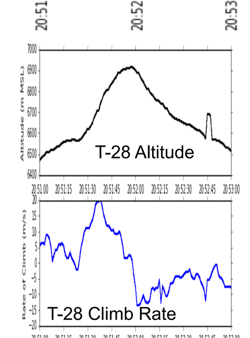


MC3E 05/11/2011 Turbulence in embedded convection led to rapid UND Citation altitude fluctuations and course alteration



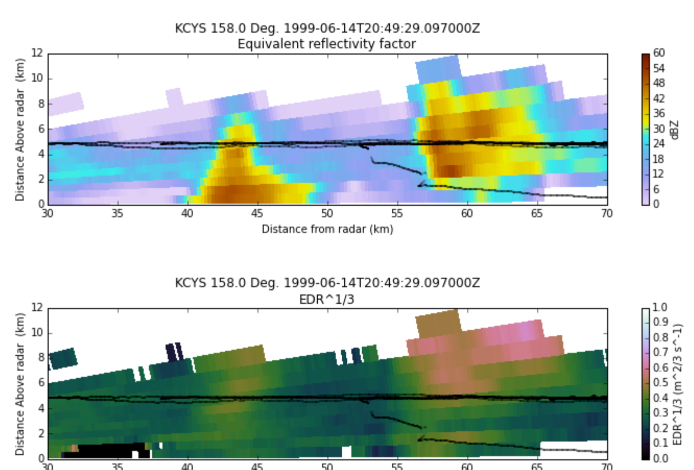




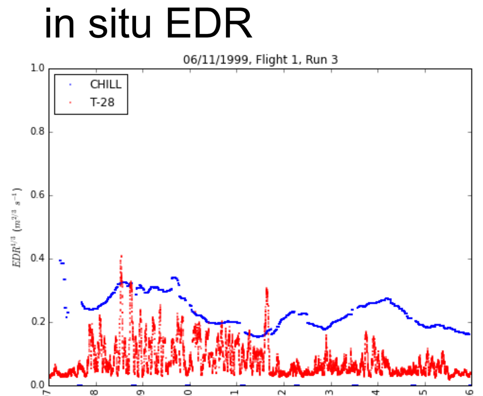


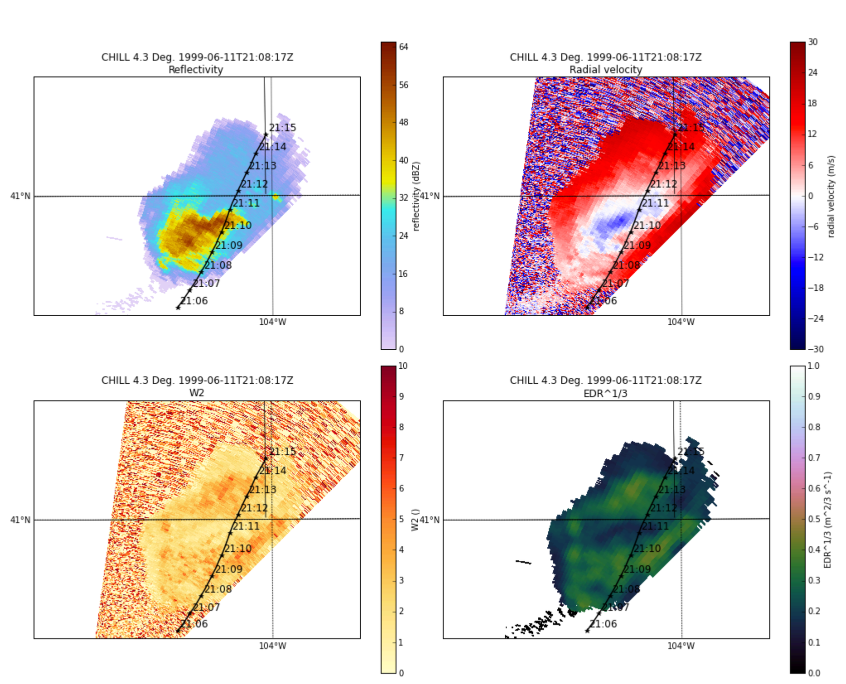
TCAD 06/14/1999 Strong updraft in high radar EDR (> 0.5)

SDSM&T T-28 20+ m/s Updraft Encounter



TCAD 06/11/1999 Correlating CHILL and in situ EDR





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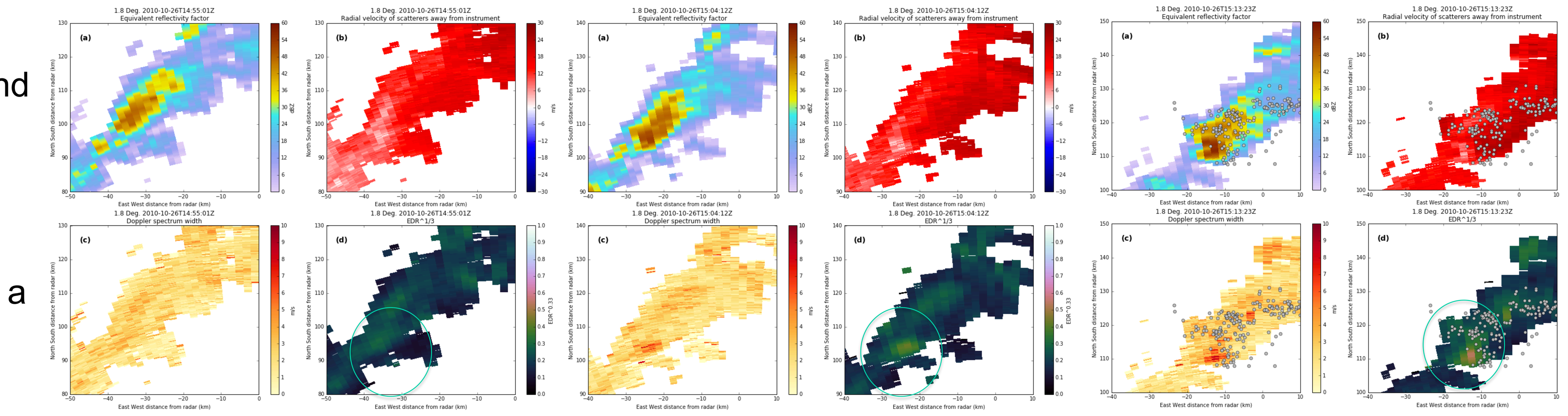
Funding for this work has come from NASA and USDOJ

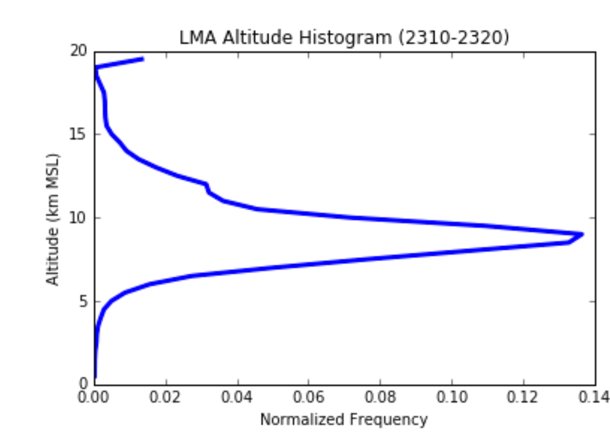
3. Lightning Analysis

26 October 2010

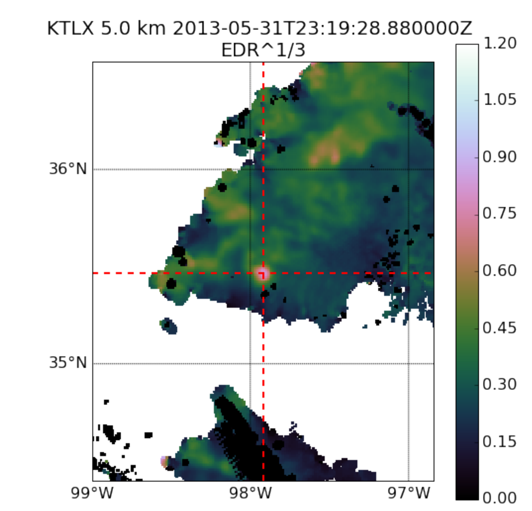
Weak cell electrified and produced 16 flashes during 1510-1537. PyTDA indicated increasing turbulence after 1455, suggesting a strengthening updraft.

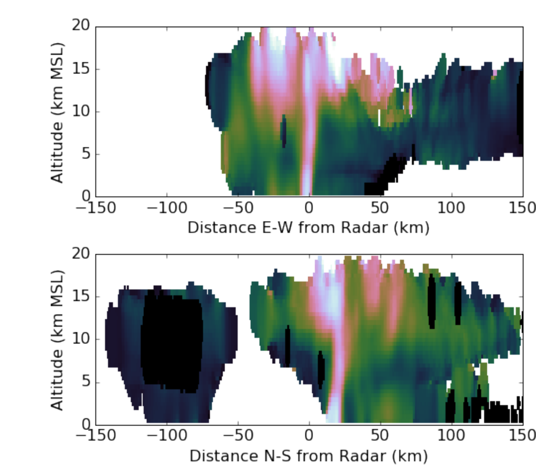


El Reno (2013)

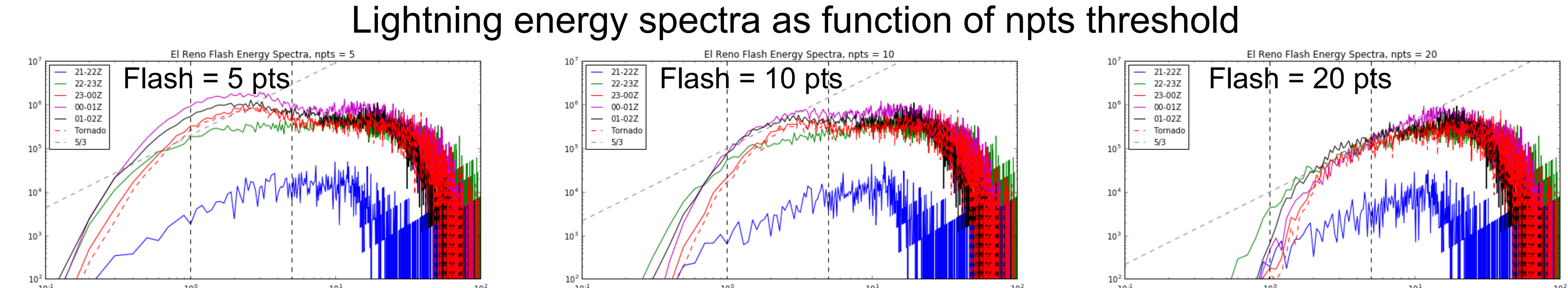


Without correction for shear contribution to spectrum width, PyTDA detects strong mesocyclonic circulation throughout depth of storm. Strongest turbulence is above 10 km, while most lightning is below this altitude.

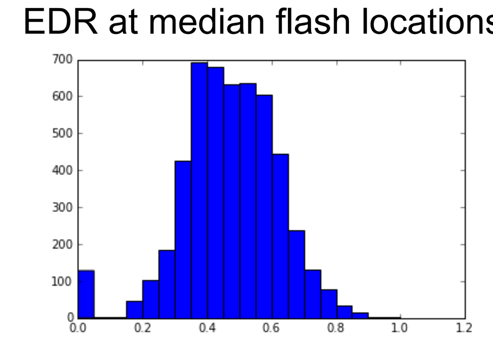




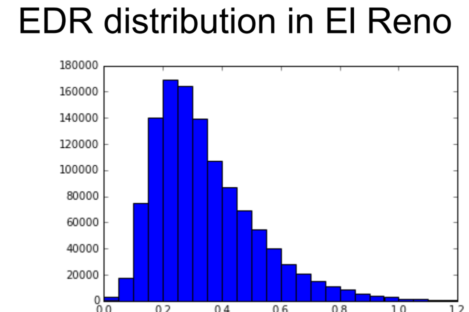
Lightning energy spectra as function of npts threshold



EDR at median flash locations



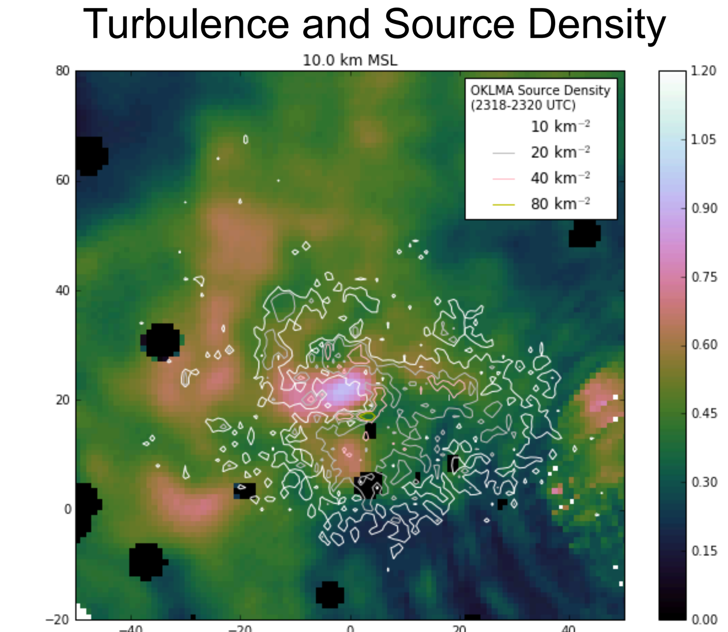
EDR distribution in El Reno



El Reno Flash Count Correlation

Volume	Pearson	Spearman
EDR > 0.7	0.704	0.607
EDR 0.5-0.7	0.858	0.573
EDR 0.3-0.5	0.888	0.726
HID = Graupel/Hail	0.921	0.868
> 10 dBZ	0.919	0.827
> 20 dBZ	0.874	0.477
> 30 dBZ	0.913	0.800
> 40 dBZ	0.942	0.890
> 50 dBZ	0.916	0.855

Turbulence and Source Density



4. Summary and Conclusions

- PyTDA implemented across several different radar (research, operational) and scanning types (PPI, RHI, sectors)
- Radar-inferred EDR enhanced in regions of in situ updrafts and turbulence; high bias, essentially constrains the envelope of in situ EDR
- First lightning in 26 October 2010 storm followed intensification in turbulence
- Lightning less common in the most turbulent regions of El Reno storm
- El Reno lightning energy spectra shift during tornadic stage – relatively less energy in smaller flashes, but energy spectra vary based on npts threshold
- Lightning less correlated to turbulence than to traditional metrics (e.g., 40 dBZ, graupel)
- Future work – Correct for shear contribution to spectrum width