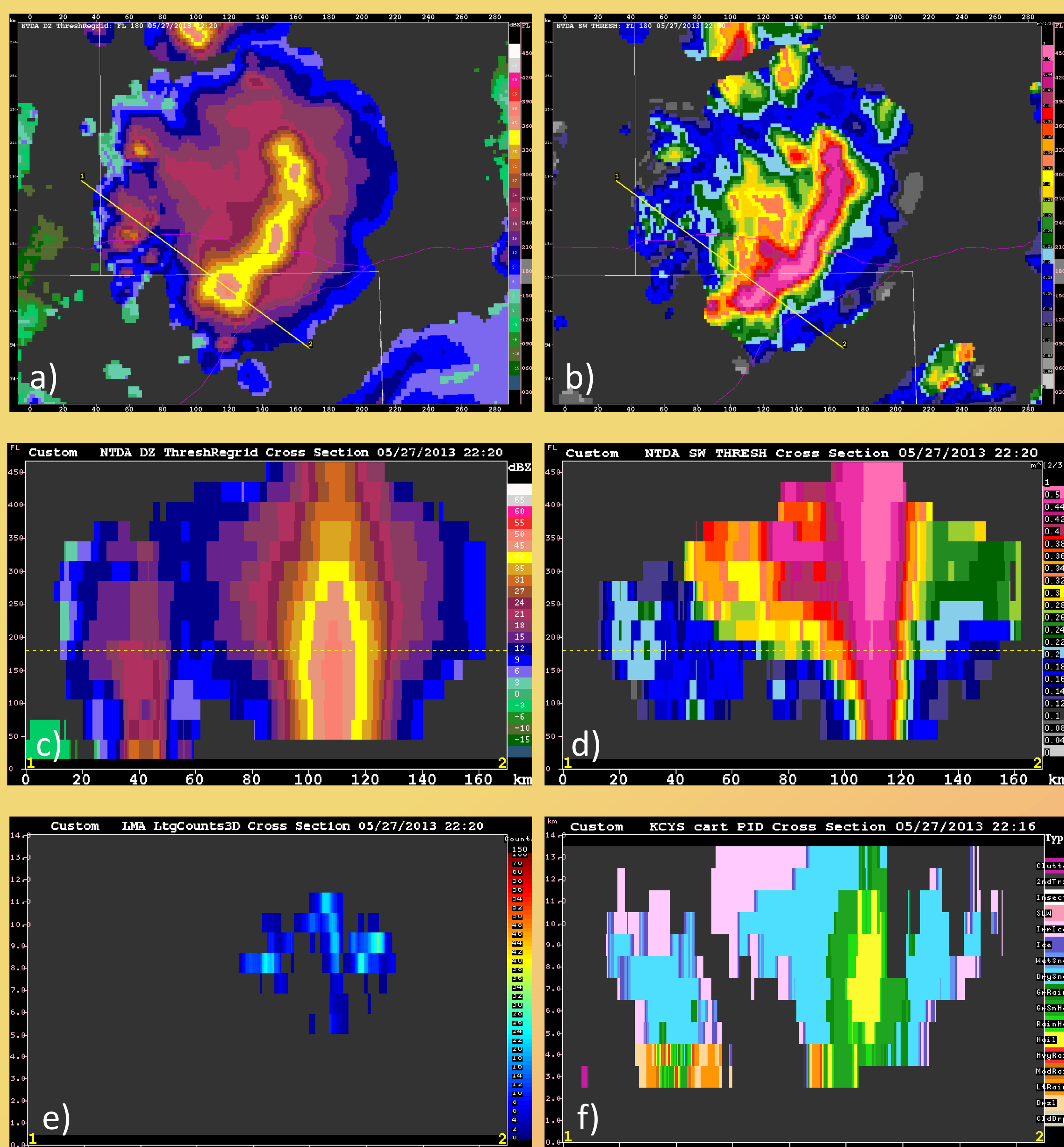
Relating Total Lightning and Storm Microphysics to In-Cloud Convective Turbulence

Sarah Al-Momar[1], Wiebke Deierling[2], John Williams[2], Dan Adriaansen[2], Marcia Politovich[2]

1) Significant Opportunities in Atmospheric Research and Science (SOARS), Plymouth State University 2) National Center for Atmospheric Research (NCAR)

Background and Methods

- Convectively induced turbulence (CIT) influences a large portion of weather-related commercial aviation accidents
- In-cloud CIT is created by dynamics within the cloud (i.e. the updraft)
- Lightning is also dependent on the updraft-it acts like a generator, creating charge through non-inductive charging
- Lightning may be an indicator of a robust updraft and the likelihood of CIT
- This relationship may enable the identification of CIT in otherwise data sparse locations
- Four case studies of severe storms from May-July 2013 in Colorado, Wyoming, and Nebraska were analyzed using NCAR Turbulence Detection Algorithm (NTDA), lightning mapping array (LMA), and dual-polarimetric radar products

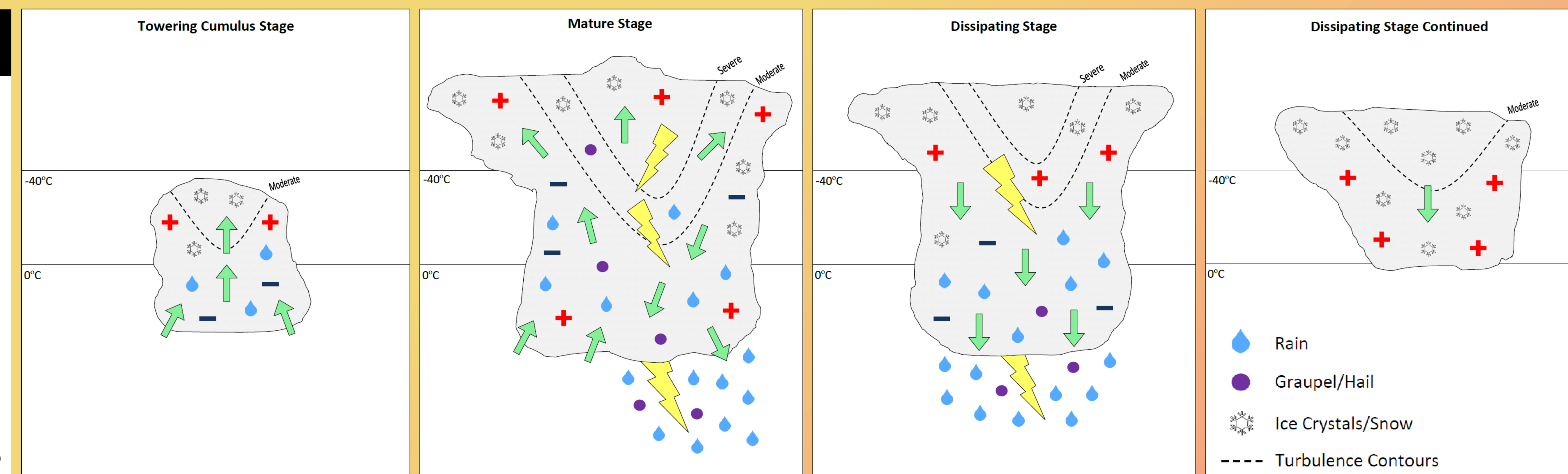


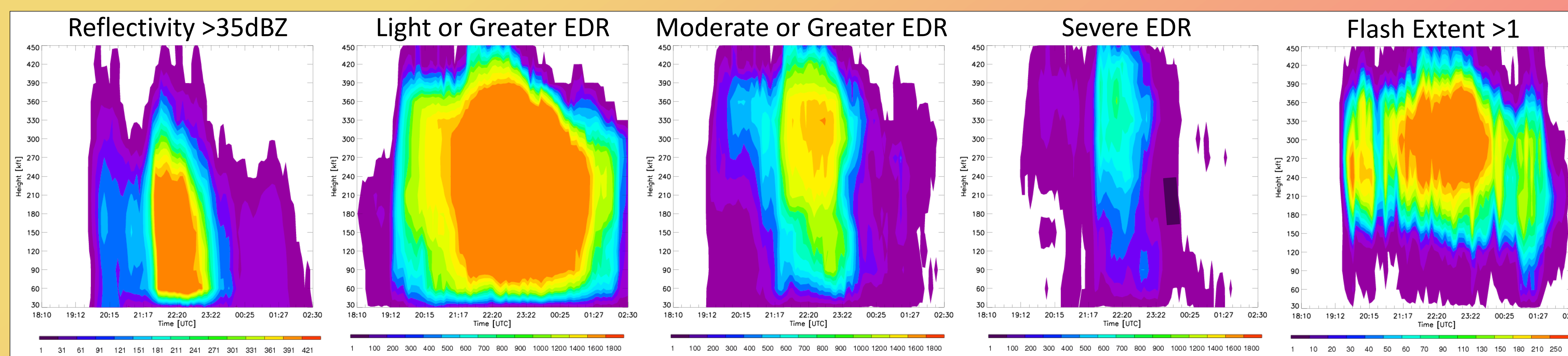
Above: 27 May 2013 North at 2220 UTC: a) reflectivity at 18000 ft, just above the freezing level in the mixed phase region; b) NTDA Eddy Dissipation Rate (EDR) at the same level; c) reflectivity cross-section; d) EDR cross-section; e) LMA 3D VHF sources cross-section; f) particle identification algorithm cross-section

Conceptual Model

Developed from the reoccurring patterns found in these cases, the conceptual model represents the microphysics, development of charge regions, and turbulent areas throughout a storm's lifecycle.

Adapted from Byers and Braham 1949





Results

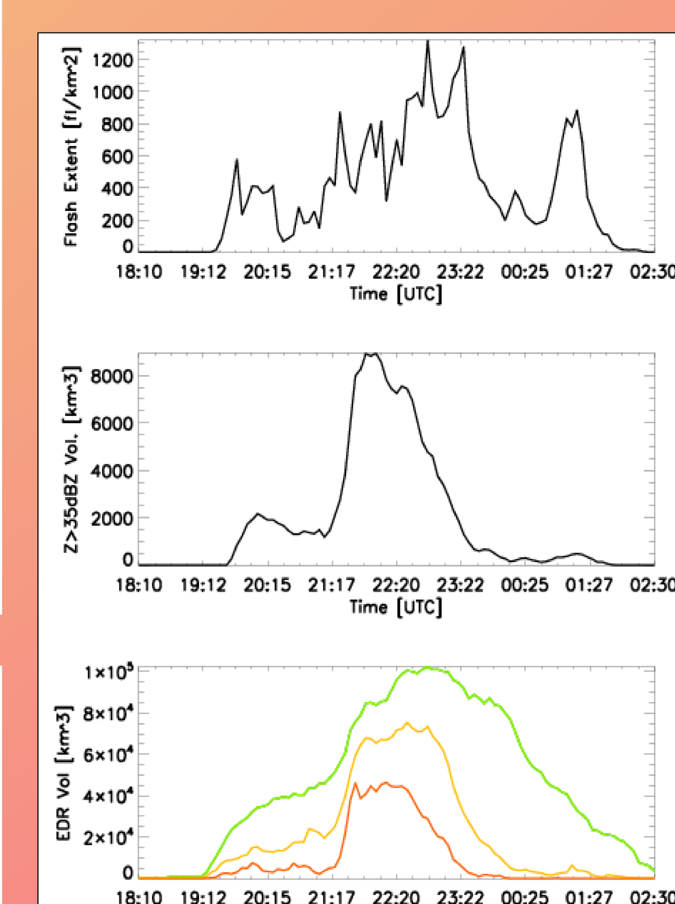
Above: Storm volume time-height plots describing the 27 May 2013 North storm through its lifecycle. The scale represents the maximum number of occurrence of each volume that correspond to the plot's title.

Right: Storm volume time series showing flash extent, reflectivity >35dBZ, and turbulence at three different intensities.

Green: Light or Greater (0.15+)
Orange: Moderate or Greater (0.3+)
Red: Severe (0.4+)

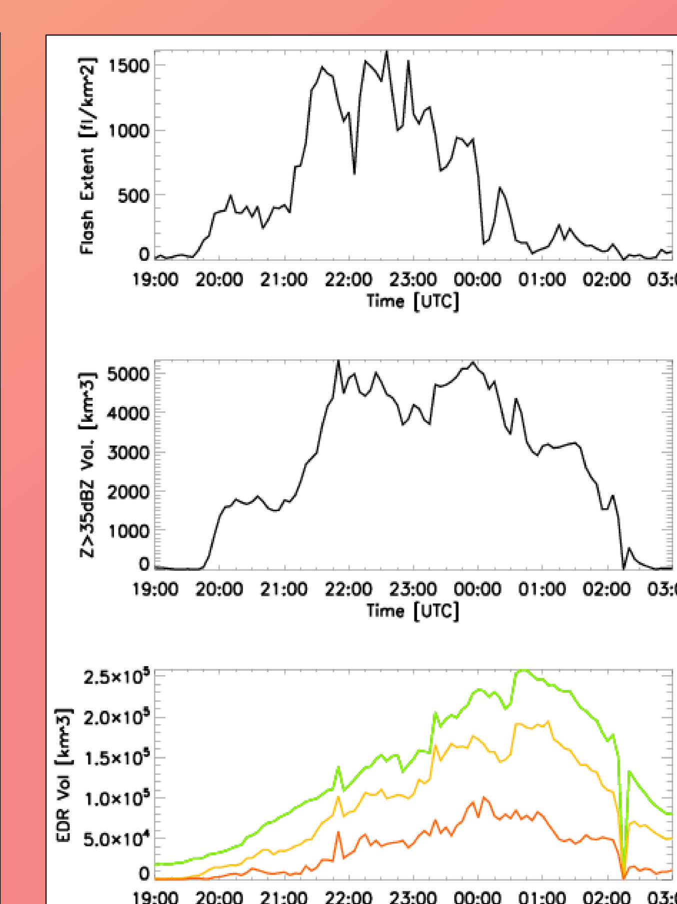
27 May 2013 North

MoG: increased by a factor of 1.5
Svr: increased by a factor of 2



18 June 2013

MoG: increased by a factor of 3
Svr: increased by a factor of 9



Conclusions

- Higher lightning frequencies relate to higher turbulence intensities
- High reflectivity does not necessarily correspond to high EDR
- Most storms exhibited charge centers in between the maximum reflectivity core and peak turbulence core during the mature stage
- Conceptual model developed, but does not always represent complex storms with many dynamical factors

Future Work:

- Examine more cases with different storm types/atmospheric setups
- Compare tropopause height with cloud top height to investigate turbulence increases
- Refine findings with numerical model simulations

Acknowledgements: Thank you to Joseph Wakefield (National Oceanic and Atmospheric Administration) for all of his grammatical insights and support.

Byers, H.R., and R.R. Braham, Jr., 1949: The Thunderstorm. U.S. Government Printing Office, Washington, D.C., 287. [out of print]

This work was performed under the auspices of the Significant Opportunities in Atmospheric Research and Science Program.
Photo above from Ian Livingston, voices.washingtonpost.com

To contact: sa1010@plymouth.edu