The extratropical transition of Tropical Storm Cindy from a GLM, ISS LIS, and GPM perspective

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Introduction

Background

The distribution of lightning with respect to tropical convective precipitation systems has been well established in previous studies and more recently by the successful Tropical Rainfall Measuring Mission (TRMM). However, TRMM did not provide information about precipitation features poleward of ±38° latitude. Hence we focus on the evolution of lightning within extra-tropical cyclones traversing the mid-latitudes, especially its oceans. To facilitate such studies, lightning data from the Geostationary Lightning Mapper (GLM) onboard GOES-16 was combined with precipitation features obtained from the Global Precipitation Measurement (GPM) mission constellation of satellites.

Objectives

- Compare lightning (e.g., flash density) to precipitation characteristics (e.g., precipitation amount, reflectivity, etc.) throughout the lifetime of Tropical Storm Cindy (20 June – 24 June 2017)
- Examine trends in lightning characteristics as Tropical Storm Cindy transitions from tropical to extra-tropical (~June 23 21Z), as well as when it made landfall (~June 22 09Z)

Data

- Lightning
  - GOES-16 Geostationary Lightning Mapper (GLM; temporal resolution: 2 ms; spatial resolution (at nadir): 8 km)[1] – GLM data are non-operational data still undergoing testing prior to official release
  - Flashes: temporal constraint of 330 ms and 16.5 km
  - No distinction between intra-cloud, cloud-cloud, cloud-ground flashes
- Precipitation
  - NASA-JAXA Global Precipitation Measurement (GPM) mission
    - Core Observatory carries Dual-frequency Precipitation Radar (DPR; operates at Ku- and Ka-bands) and multi-channel microwave radiometer (GMI)[2, 3]
    - GPM International constellation satellites also carry microwave radiometers
  - IMERG 30-minute
    - Precipitation estimates at 0.1° by the Integrated Multi-satellitE Retrievals for GPM
    - Intercalibrates, merges, and interpolates GPM microwave precipitation estimates and combines them with IR satellite estimates and precipitation gauge analyses
- Radar
  - Weather Surveillance Radar 1988 Doppler (WSR-88D)
  - Reflectivity (Z_H) from KLCH (Lake Charles, LA) and KJKL (Jackson, KY)[4]

Results

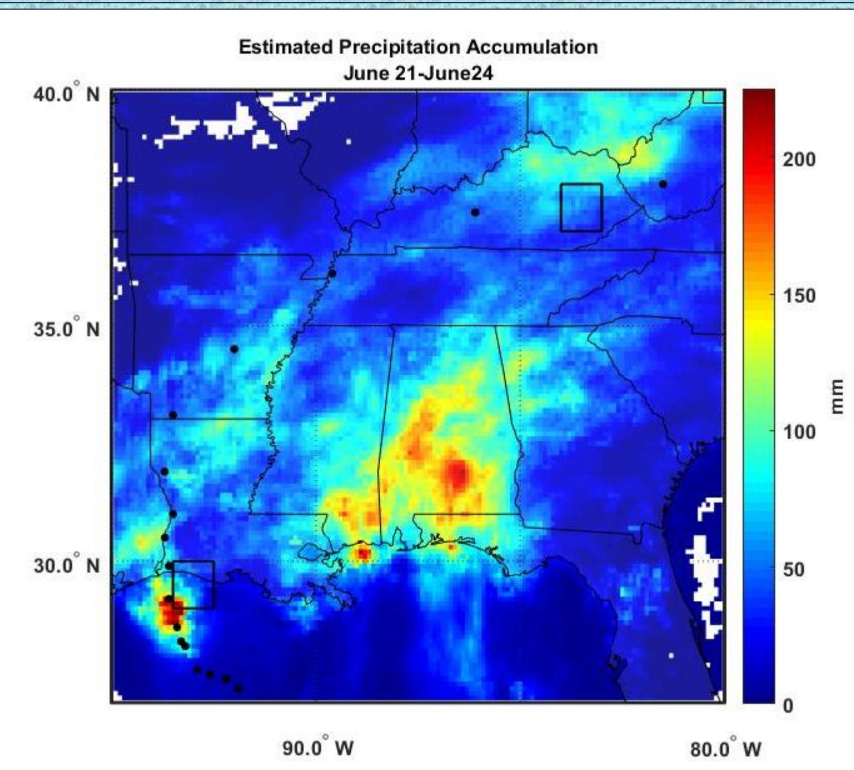


Fig. 1: IMERG total estimated precipitation accumulation (mm) June 21-June 24, 2017. The track of Tropical Storm Cindy is overlaid (black dots; obtained from the NHC), and the boxes refer to regions of analysis focus. Box 1 is in southern Louisiana (in the KLCH radar domain; [29°-30°N; 93.5°-92.5°W]) and Box 2 is in east-central Kentucky (in the KJKL radar domain; [37°-38°N; 84°-83°W]).

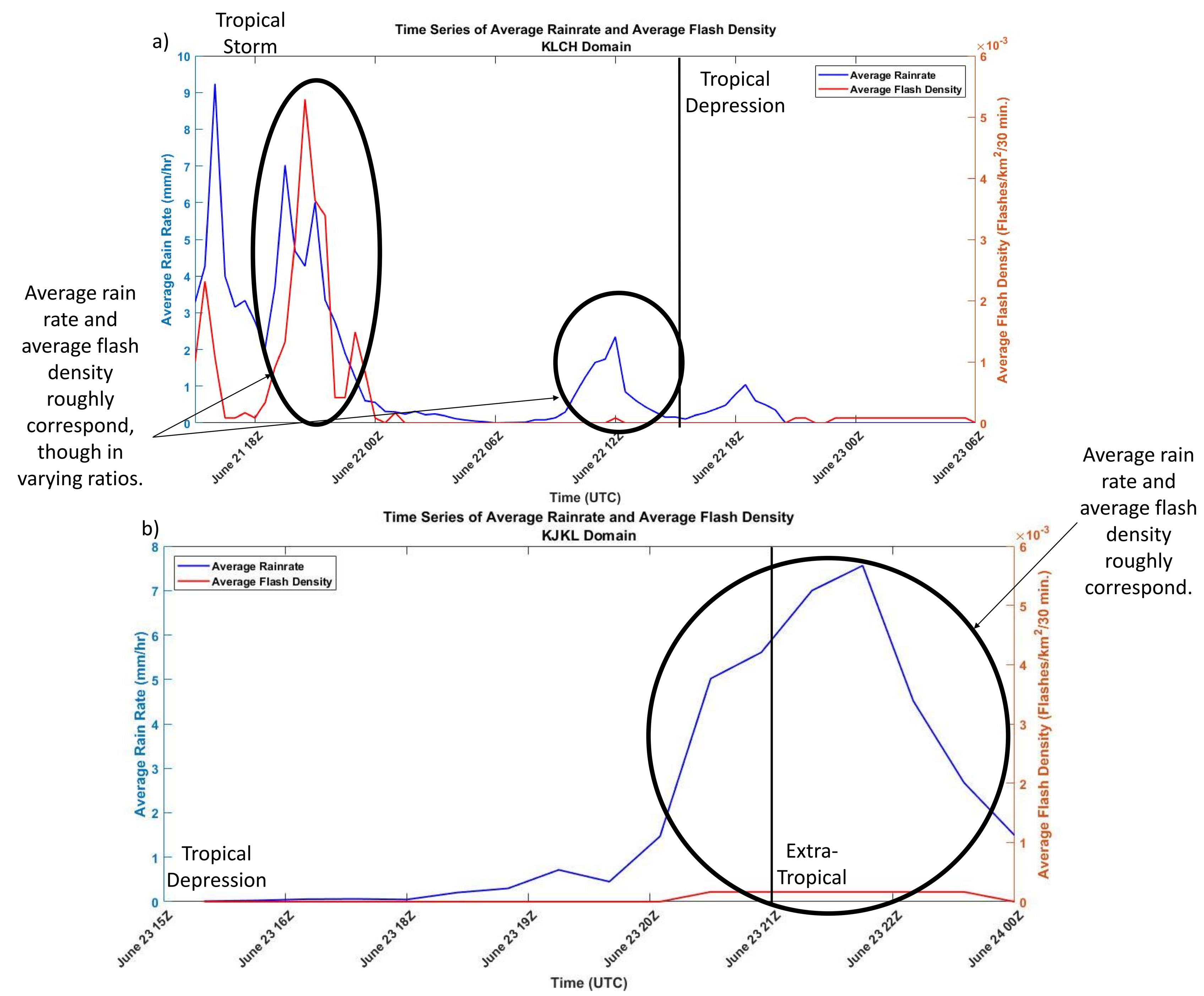


Fig. 2: Time series of average rain rate (blue line; mm/hr) and average flash density (red line; flashes/km²/30 min.) within each box for a) Box 1 (KLCH domain) and b) Box 2 (KJKL domain).

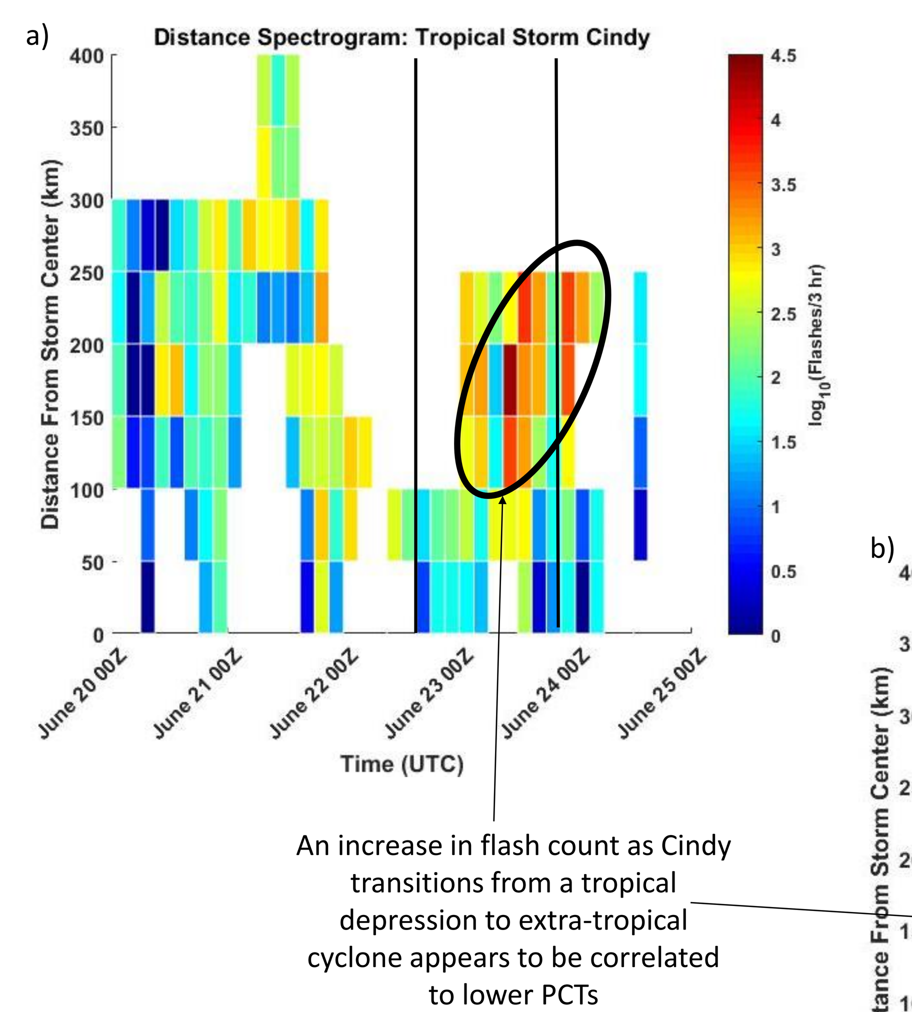
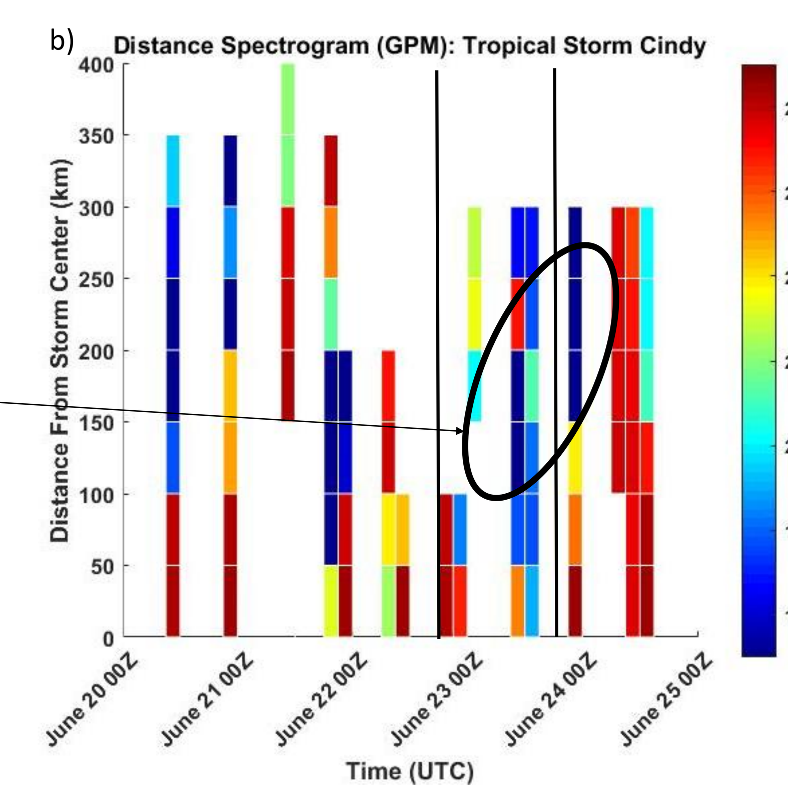


Fig. 3: Distance Spectrogram for Tropical Storm Cindy looking at a time series of a) flash count from GLM and b) polarization corrected brightness temperature (PCT) at 89 GHz from passive microwave imagers on board the GPM constellation of satellites. Satellites used include the GPM satellite (NASA-JAXA), F16-F18 satellites (DoD), and the GCOMW1 satellite (JAXA). Both spectrographs are presented as a function of distance (km) from the storm center.



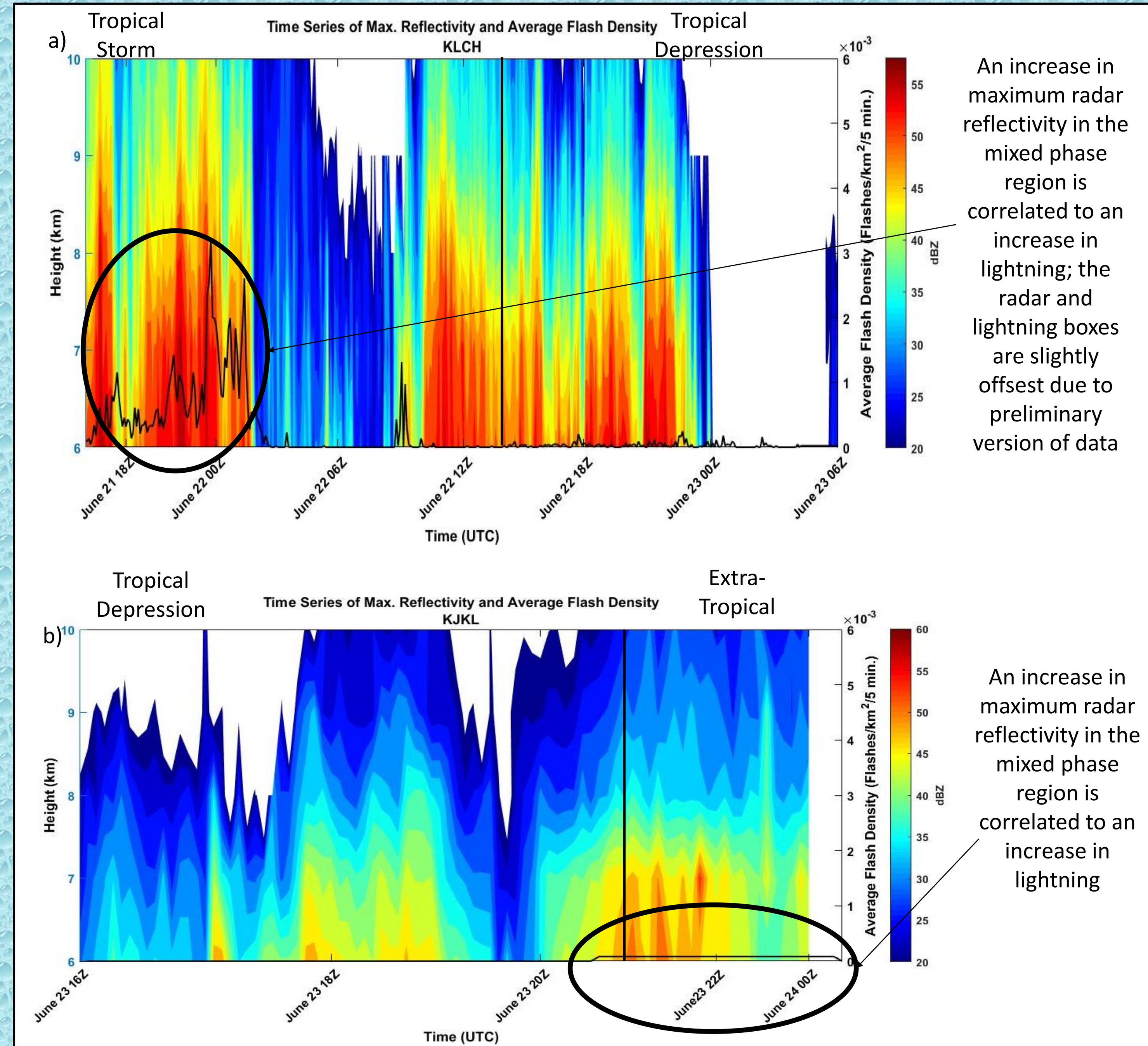


Fig. 4: Time series of maximum radar reflectivity (dBZ) at each level in the mixed phase zone between -10°C and -25°C and average flash density (black line; flashes/km²/5 min.) within each box for a) Box 1 (KLCH domain) and b) Box 2 (KJKL domain). In a) the maximum radar reflectivity is constrained to Box 1, while the GLM data is from 28.5°-30.5°N; 94°-92°W due to location errors in preliminary data.

Conclusions and Future Work

Conclusions

- A correlation between the increase in maximum radar reflectivity and flash density appeared while Cindy was transitioning from a tropical storm to a tropical depression; however, during this time, there appeared to be a correlation between the average rain rate and the average flash density.
- After Cindy became extra-tropical, there appeared to be a correlation between maximum radar reflectivity and average flash density, as well as average rain rate and average flash density.
- As Cindy transitioned from a tropical depression to an extra-tropical system, maximum radar reflectivity increased as well as lightning occurrence; no such correlation was observed when Cindy transitioned between a tropical storm and tropical depression.

Future Work

- Extend this analysis to other tropical systems during the 2017 Hurricane Season to investigate lightning and storm transitions in more detail and with new and improved releases of GLM data.
- Investigate lightning characteristics in different quadrants and/or eyewall/rainbands of the considered storms

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References

[1]Goodman , S., and Coauthors, 2013: The GOES-R geostationary lightning mapper (GLM). *Atmos. Res.*, **125-126**, 34-49, doi: 10.1016/j.atmosres.2013.01.006.
[2]Hou, A. Y., and Coauthors, 2014: The global precipitation measurement mission. *Bull. Am. Meteorol. Soc.*, **95**, 701–722, doi: 10.1175/BAMS-D-13-00164.1.
[3]GPM, cited 2017: Precipitation measurement missions. Global Precipitation Measurement Program, NASA. [Available online at http://gpm.nasa.gov/.]
[4]National Centers for Environmental Information (NCEI), 2017: NEXRAD Data Archive, Inventory and Access. Accessed 26 November 2017. [Available online at https://www.ncdc.noaa.gov/nexradinv/.]