Committee Meeting #2

Christian Nairy

2020/11/13

Overview

1. Work done since last meeting.
   - Review of possible thesis topics.
   - PHIPS Particle Classifications
   - LROSE-TITAN Analysis
   - Electric Field & NLDN Lightning Analysis
2. Latest Results (Poster and Presentation)
3. Thesis Topic Proposal
4. Plan of Study

Work Done Since Last Meeting
- Possible Thesis Topics (discussed last meeting)

1. Electric Fields & chain-like particles from CapeEx19 (2019 flights).
2. Working with Cloud Imaging Probe/PHIPS Probe & classifying particles from 2015 and 2019 flights.
3. Extension to Nick Gapp's research but looking at different flights.

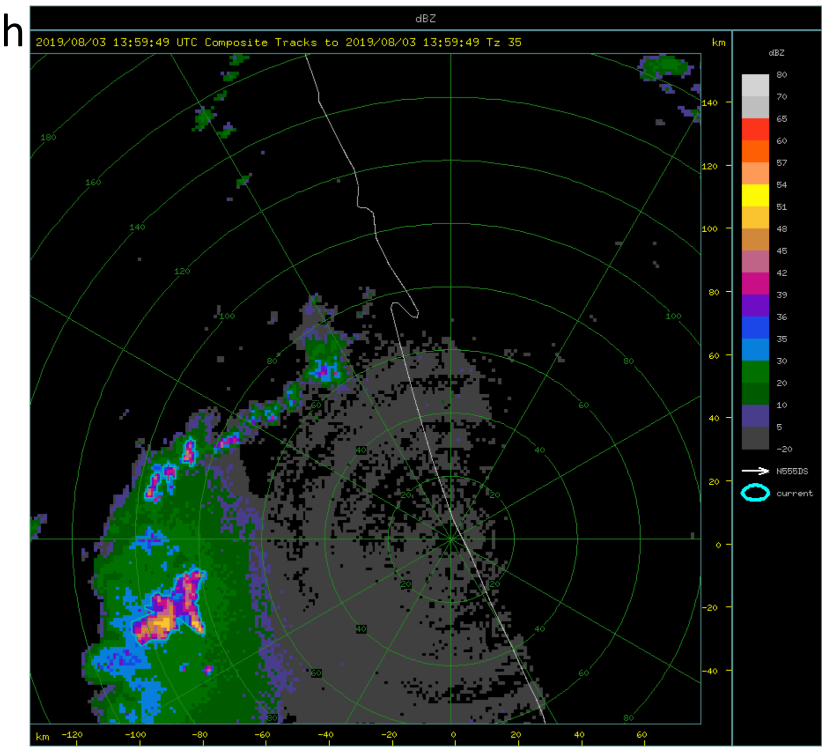
Work Done Since Last Meeting
- PHIPS Particle Classifications

- Classified CapeEx19 PHIPS particles from flights:
  - 2019/07/25
  - 2019/08/02b – Take off: 19:29:15 UTC
  - 2019/08/03a – Take off: 14:24:55 UTC
  - 2019/08/03b – Take off: 20:38:40 UTC
- Used MATLAB software provided by Emma Järvinen, Martin Schnaiter, and Waltz Fritz [Karlsruhe Institute of Technology].
- Wrote Python code to organize and filter the chain aggregates.

Work Done Since Last Meeting

- LROSE-TITAN Analysis

- Rview was used to visualize NWS composite radar with the Citation II flight track overlaid.
  - Animations were created for ALL 2019 flights.
  - CAPPI plots were also generated.
- LROSE-TITAN was able to depict storm core info.
  - Found that 35 dBZ worked best for the 20190803a flight.
- Code was generated to calculate aircraft distance from storm core reflectivity centroid.



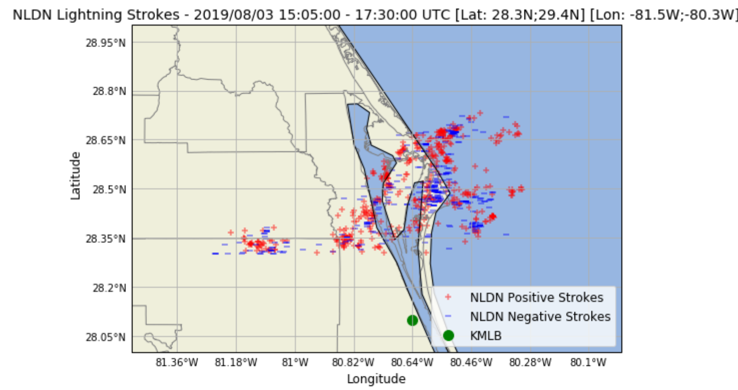
Rview animation using NWS KMLB composite reflectivity for the 2019/08/03a flight. Overlaid is the Citation II flight track (5 min of flight data per scan). LROSE-TITAN storm core is depicted by the blue outline – 35 dBZ threshold.

Work Done Since Last Meeting

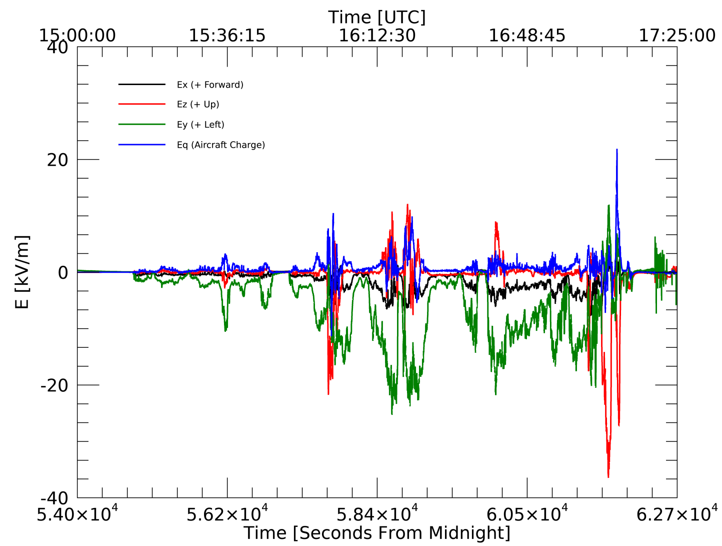
- Electric Field & NLDN Lightning Analysis

- More focused on 20190803a
- Aircraft sampling of continental and maritime convection shows possible evidence of electrical effects on hydrometeor aggregation (Connolly et al., 2005).
- Aircraft sampling from Florida cirrus anvils (Connolly et al., 2005, Dye et al., 2007) mostly agree with past lab experiments (Saunde & Wahab 1975) where electric fields can alter microphysical processes.
- NLDN data (provided by Dr. Ron Holle [Vaisala]) was gathered foı all flight days in 2019.

- Electric Field data was gathered by the Citation II during all flights.



Total # of Negative Strokes = 354
Total # of Positive Strokes = 446
Total # of Cloud-to-Ground Strokes = 195
Total # of Cloud-to-Cloud Strokes = 605



Electric Field Mill data from the 20190803_142455 flight.

Latest Results
- Introduction

- Chain aggregates were observed during research flights over Florida in 2019 (CapeEx19). The airborne Particle Habit Imaging and Polar Scattering (PHIPS) probe was implemented on the Weather Modification International (WMI) Citation II Research Aircraft to obtained higher resolution stereographic images.
- Surface radar and aircraft instrumentation are utilized to determine the location and characteristics of the chain aggregates.
- An analysis of the CapeEx19 flight on August 3, 2019 showed that of a total of 17,146 PHIPS images, 7,151 where classified as chain aggregates.

Latest Results Introduction/Background

- Multiple airborne field projects have been performed to obtain in-situ measurements within Florida thunderstorms (Bringi et al., 1997, Schmidt et al., 2012).
- Aircraft/balloon sampling of continental and maritime convection show differences in electrical structure (Connolly et al., 2005).
  - As well as microphysical properties.
- Aircraft sampling from Florida cirrus anvils (Connolly et al., 2005) mostly agree with past lab experiments (Saunders & Wahab, 1975) where electric fields can alter microphysical processes.

Motivation

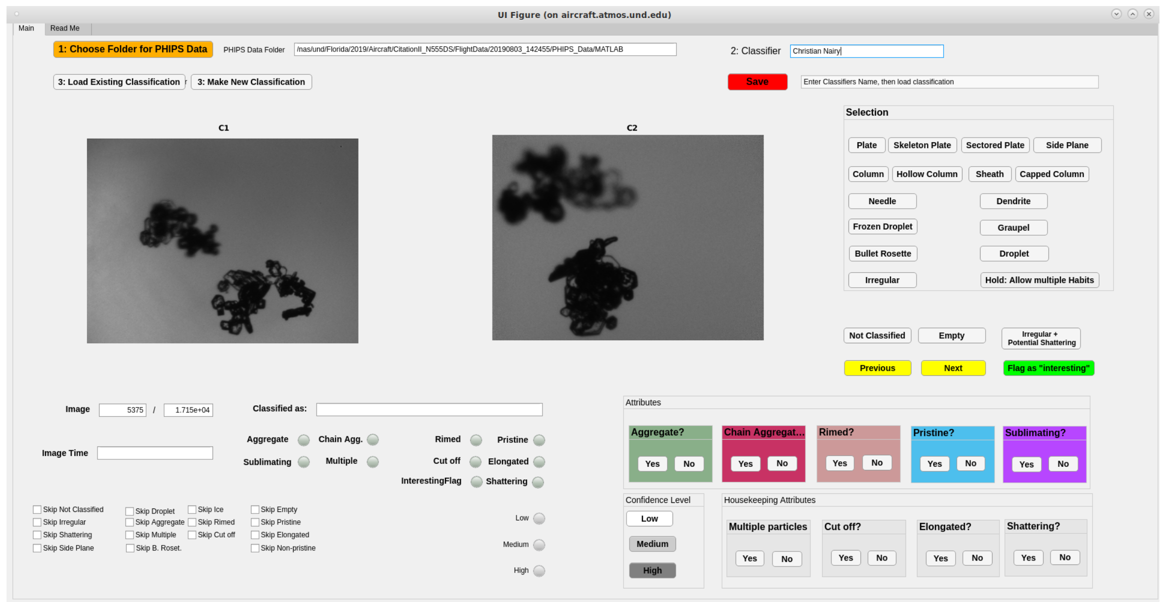
- State-of-the-art in-situ observations of electric fields, radar, particle, microphysical, and environmental observations by aircraft through Florida cirrus anvils were obtained during the CapeEx19 Field Campaign.
- Newly obtained data may provide further insight in the electrical structure and microphysical characteristics in the upper-levels of Florida Thunderstorms.
- Determining the process which generate these large chain aggregates in cirrus cloud anvils should enable models to predict their occurrence.
- implementing chain aggregates in models should provide increased knowledge for the radiative impacts of cirrus anvils as well as for militaristic applications such as projectile re-entry impacts.

Latest Results
- Methodology & Data

- **1.)** Collect in-situ environmental and microphysical observations as well as photographic (PHIPS probe) imagery within the Florida cirrus anvils through the use of aircraft sampling.
- **2.)** Classify particles and pick out the chain aggregates observed in the cirrus anvil.

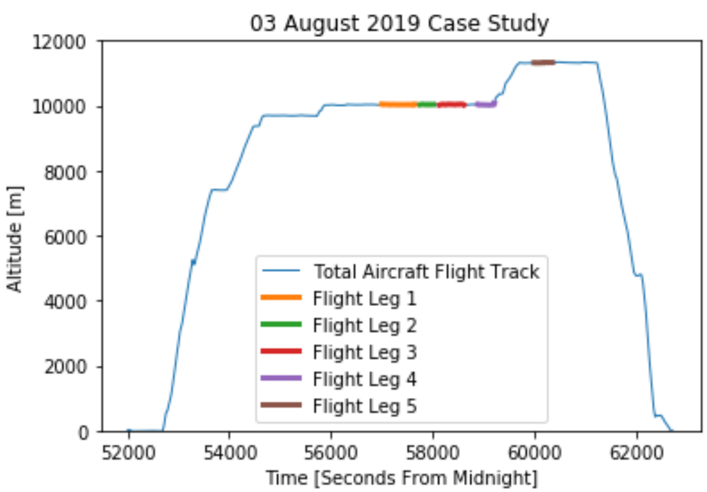
- Chain aggregates were defined by:
  - 3 or more particles oriented in a linear fashion and/or…
  - Multiple particles joined by small joints and/or…
  - Elongated
- Confidence was determined by the classifier:
  - Lowest Confidence (1): One of the three definitions observed.
  - Moderate Confidence (2): Two of the three definitions observed.
  - Highest Confidence (3): All three definitions observed.

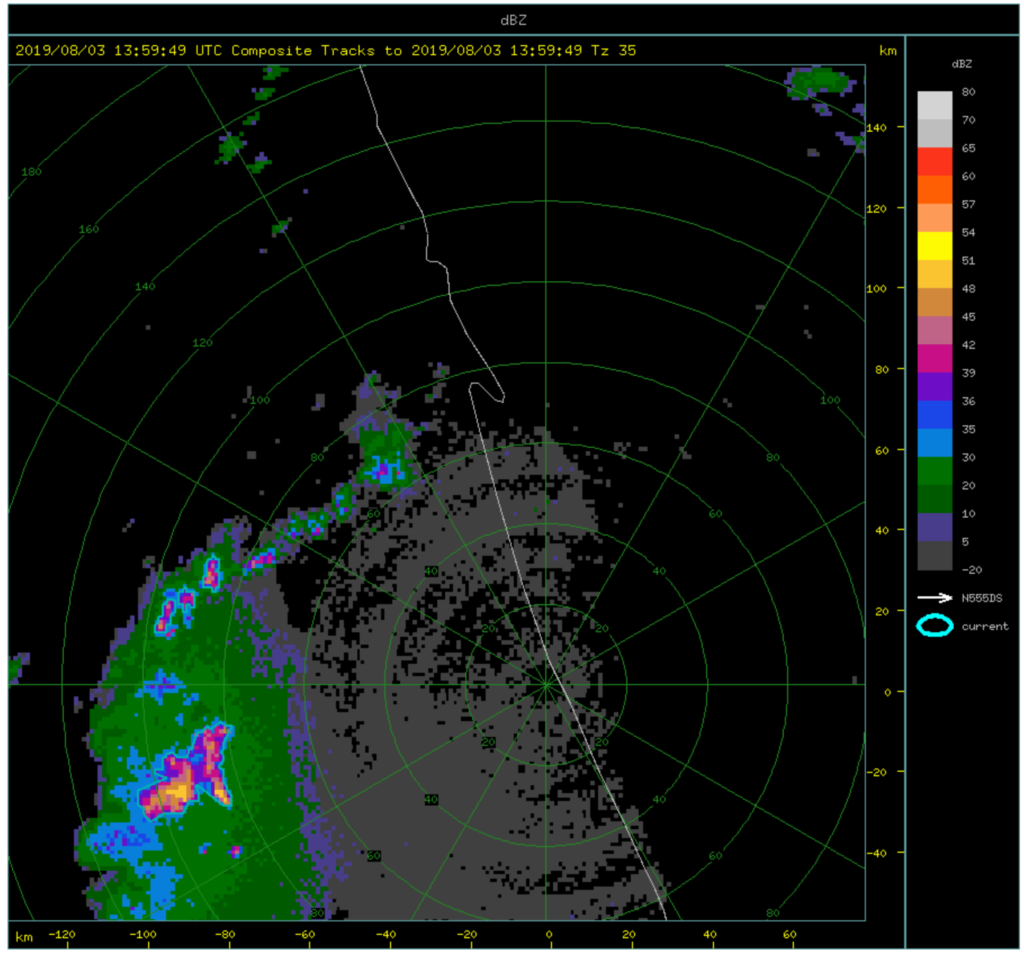
- **3.)** Using flight-leg intervals (where the aircraft was level at a constant altitude) shown in the figure above, calculate the amount of the chain aggregates per flight-leg, location (distance from storm core), and compare to in-situ environmental conditions.



Latest Results
- Methodology & Data

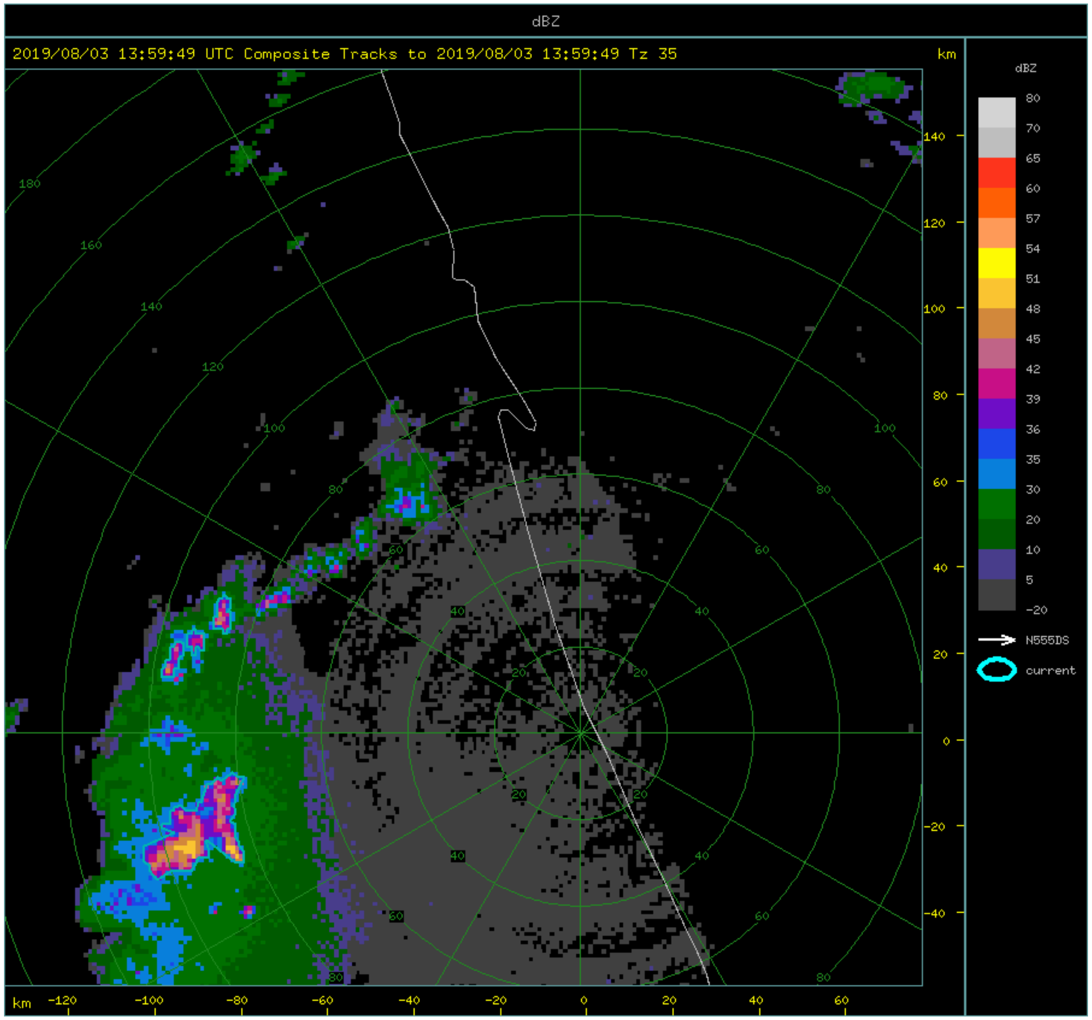
- TITAN-Rview Radar Animation (figure above) using data from the NWS KMLB WSR-88D. Aircraft track is depicted as the white line where the slightly apparent buldge in the line is the current aircraft postion with the line being 5 minutes of past flight track with repect to the time stamp. Blue circles represent the TITAN storm tracking algorithm (35 dBZ threshold).



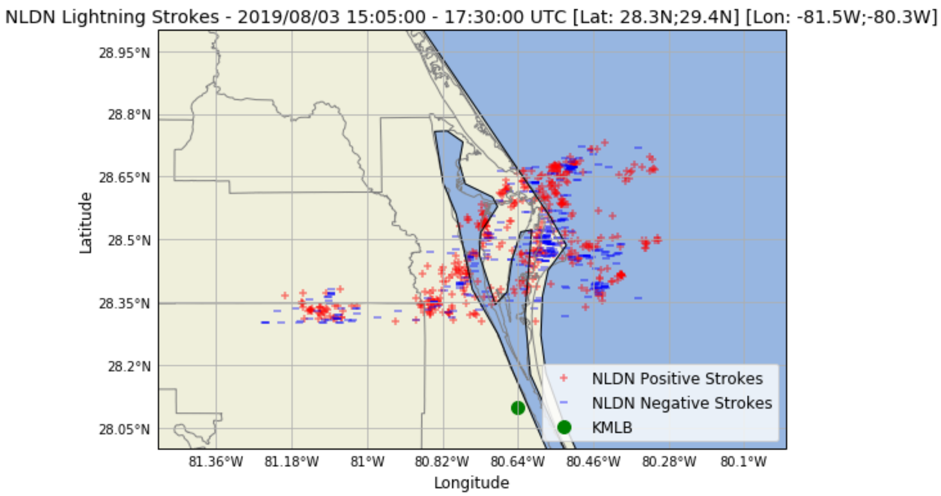


2019/08/03

- Weak upper-level low pressure to the NW of Florida (FL)
- Storms initiate on the west side of the FL peninsula (sea-breeze circulation)
- Then storms are enhanced by the sea-breeze circulation of the east side of the FL peninsula.



NLDN Data[5]



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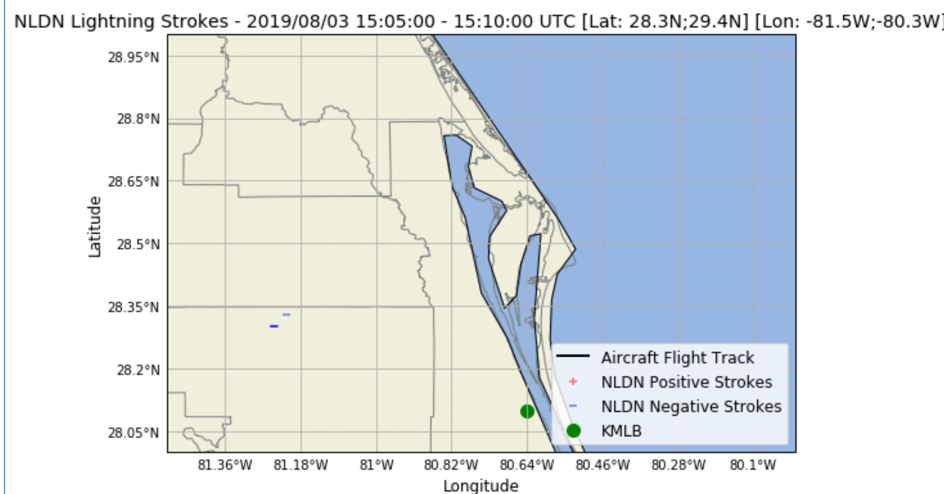
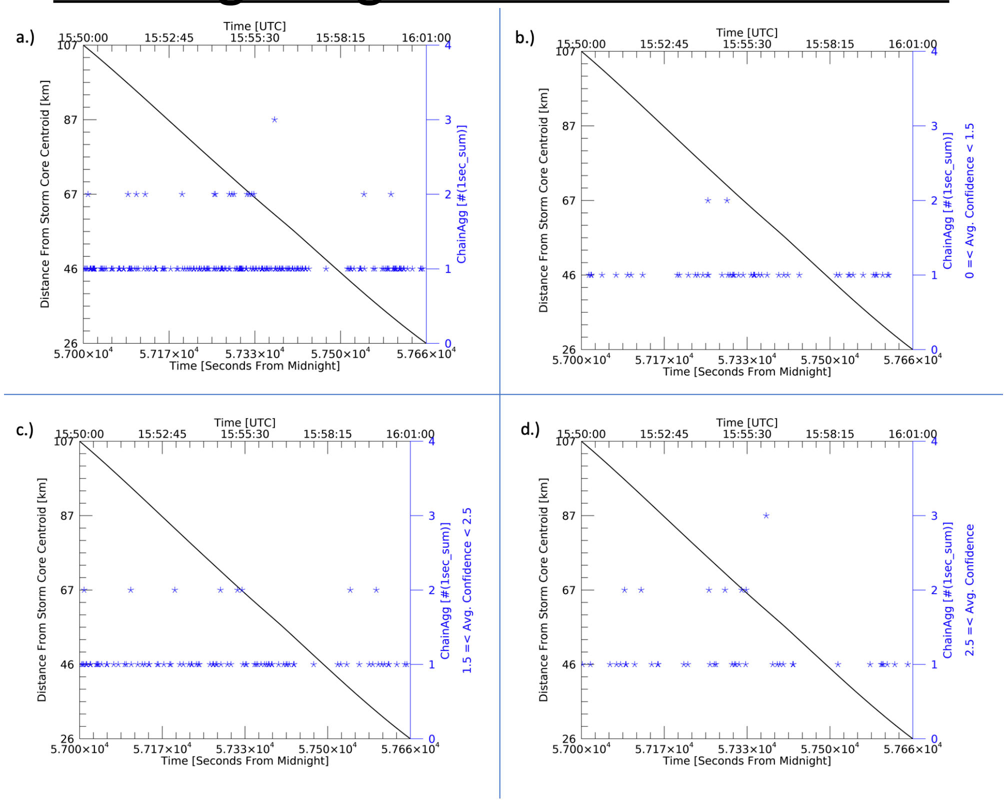
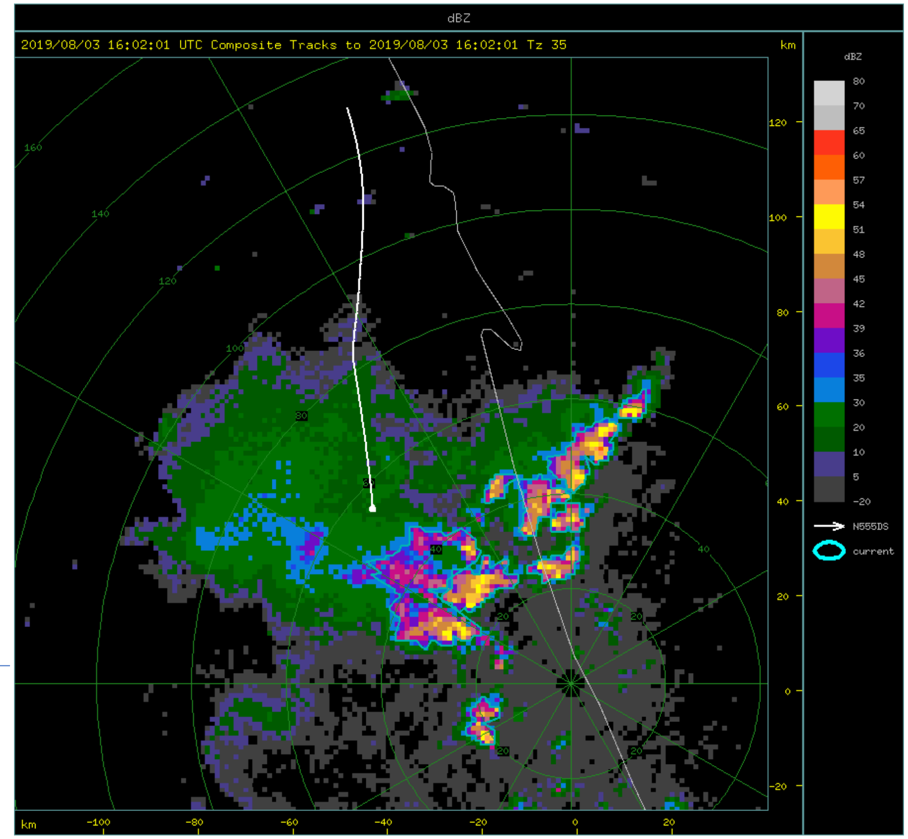


Total # of Negative Strokes = 4
Total # of Positive Strokes = 0
Total # of Cloud-to-Ground Strokes = 4
Total # of Cloud-to-Cloud Strokes = 0

Latest Results

- **First Flight Leg: 15:50:00 - 16:01:00 UTC**





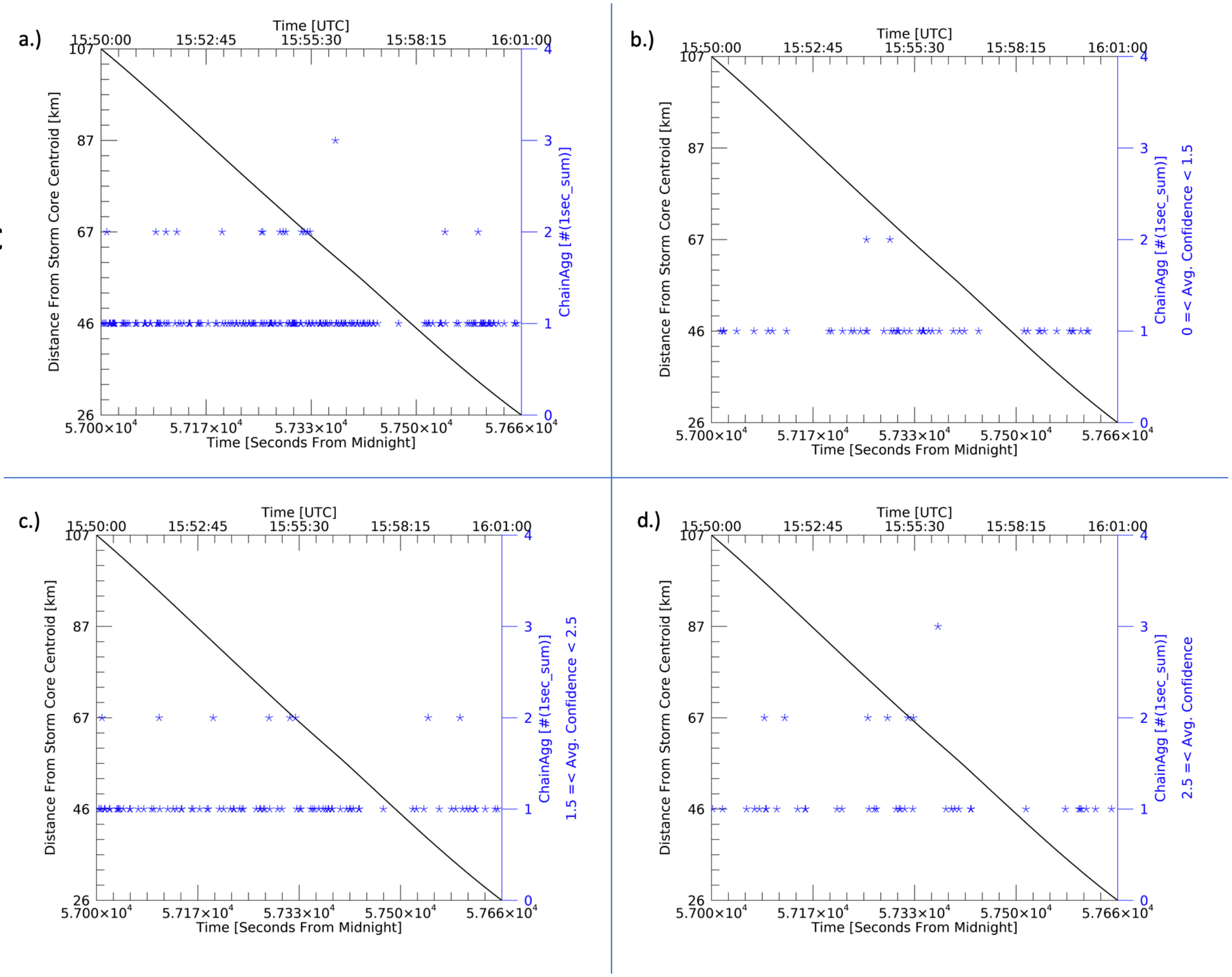
Rview image (figure above) depiciting NEXRAD KMLB WSR-88D Level II composite refelctivity (dBZ) as well as airfcraft flight track data (white line) and TITAN storm tracking data (blue outlines - 35 dBZ threshold [Tz]). White aircraft line showing 11 minutes of previous aircraft track. White buldge at the bottom point of the white line is the aircraft's position at 16:01:00 UTC.

Latest Results

First Flight Leg: 15:50:00 - 16:01:00 UTC

Figure to the right showing total amount of chain aggregates in flight leg 1 (a), while (b-d) show chain aggregates in varying average confidence intervals.

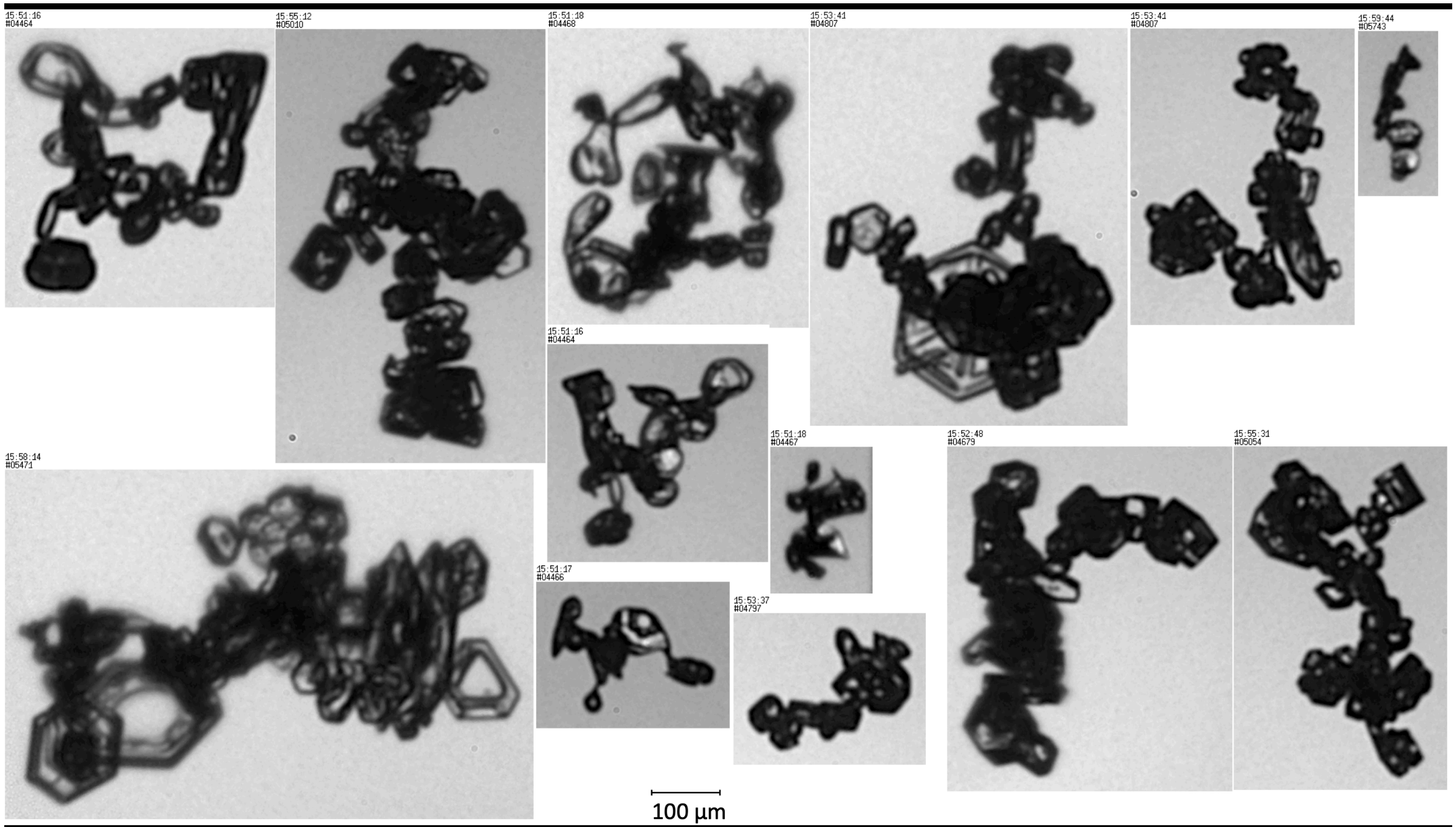
- (a) Total Chain Aggregates = 198
- (b) 0 ≤ Avg. Confidence < 1.5 = 52
- (c) 1.5 ≤ Avg. Confidence < 2.5 = 96
- (d) 2.5 ≤ Avg. Confidence = 50



Latest Results

PHIPS Images

First Flight Leg:
15:50:00 - 16:01:00 UTC

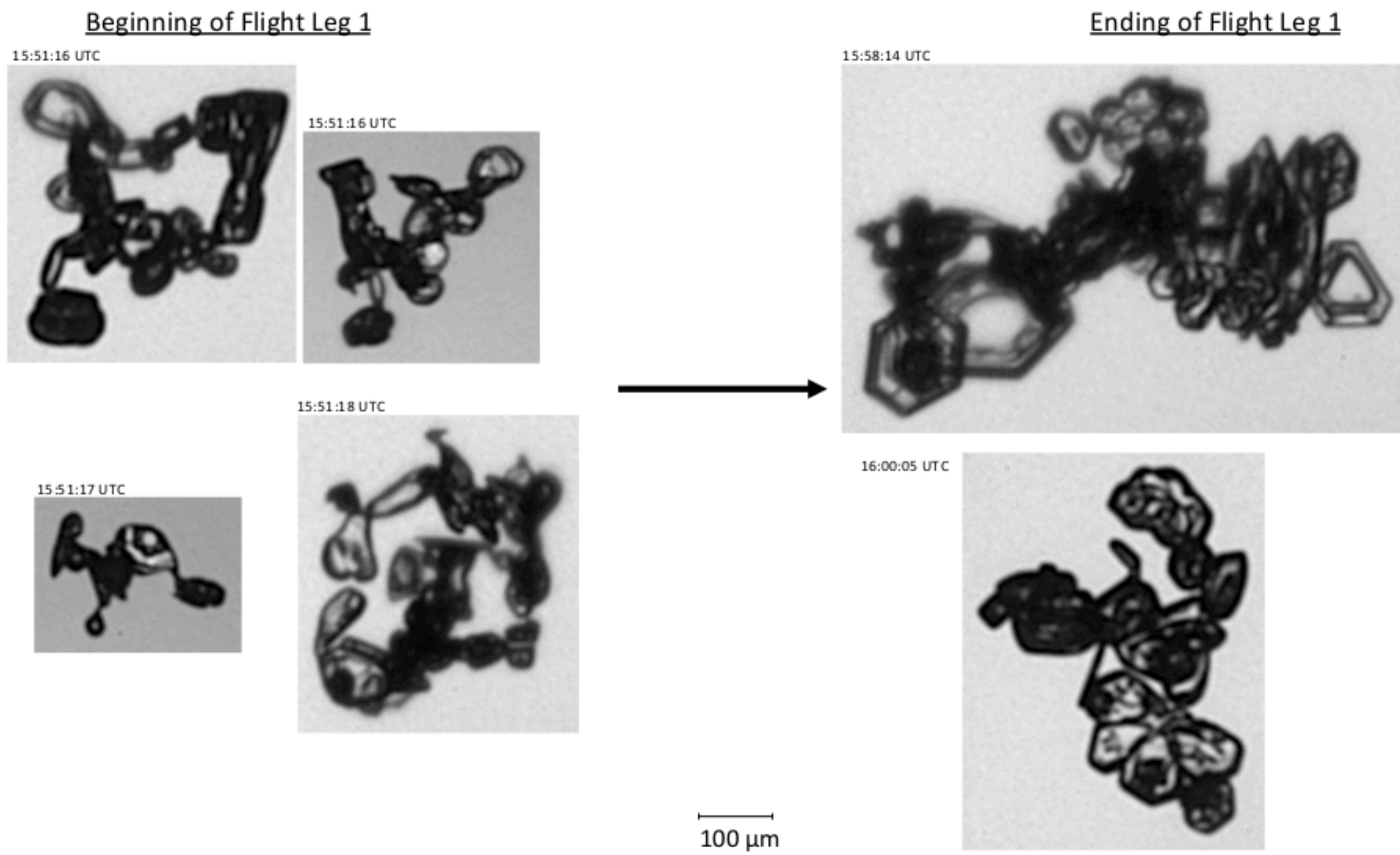


Latest Results

PHIPS Images

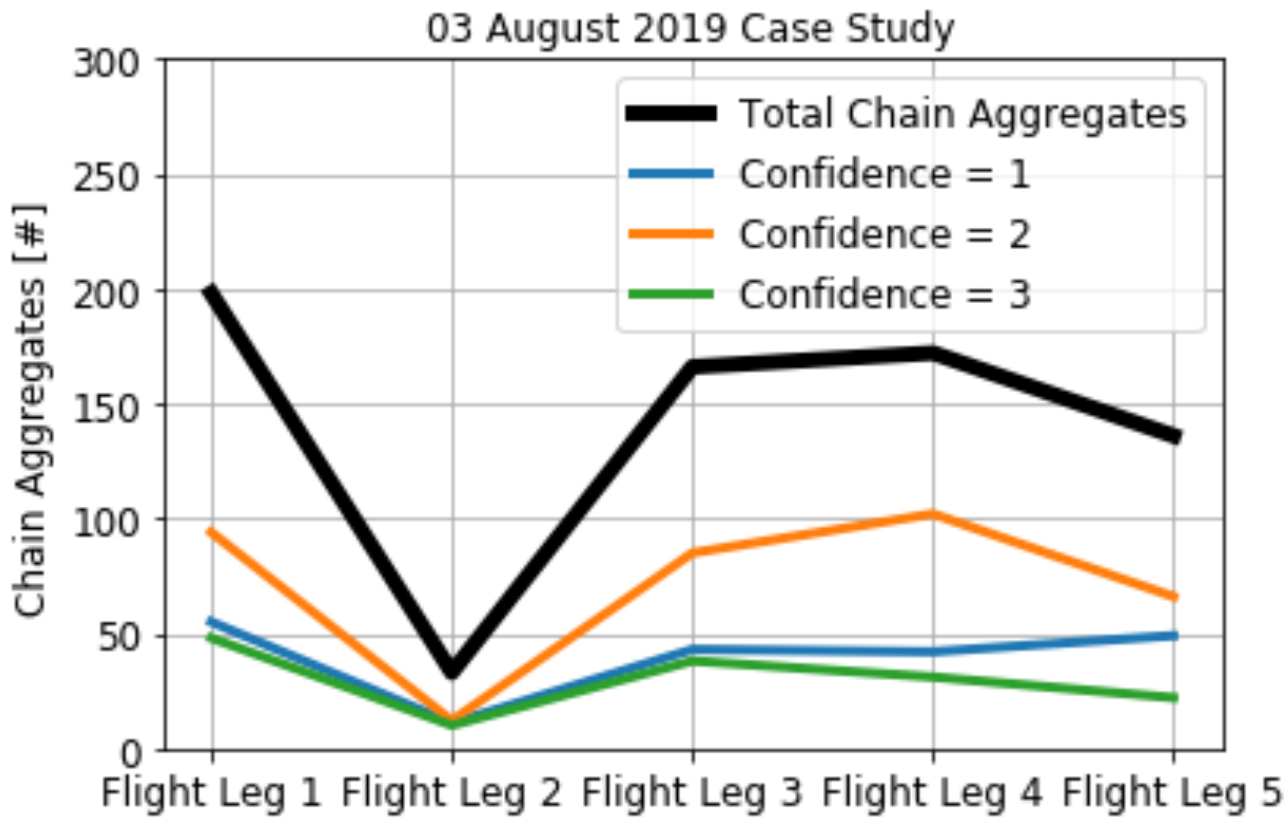
First Flight Leg:
15:50:00 - 16:01:00 UTC

Figure showing a few particles images taken in the early stage verses the later stage of the first flight leg.



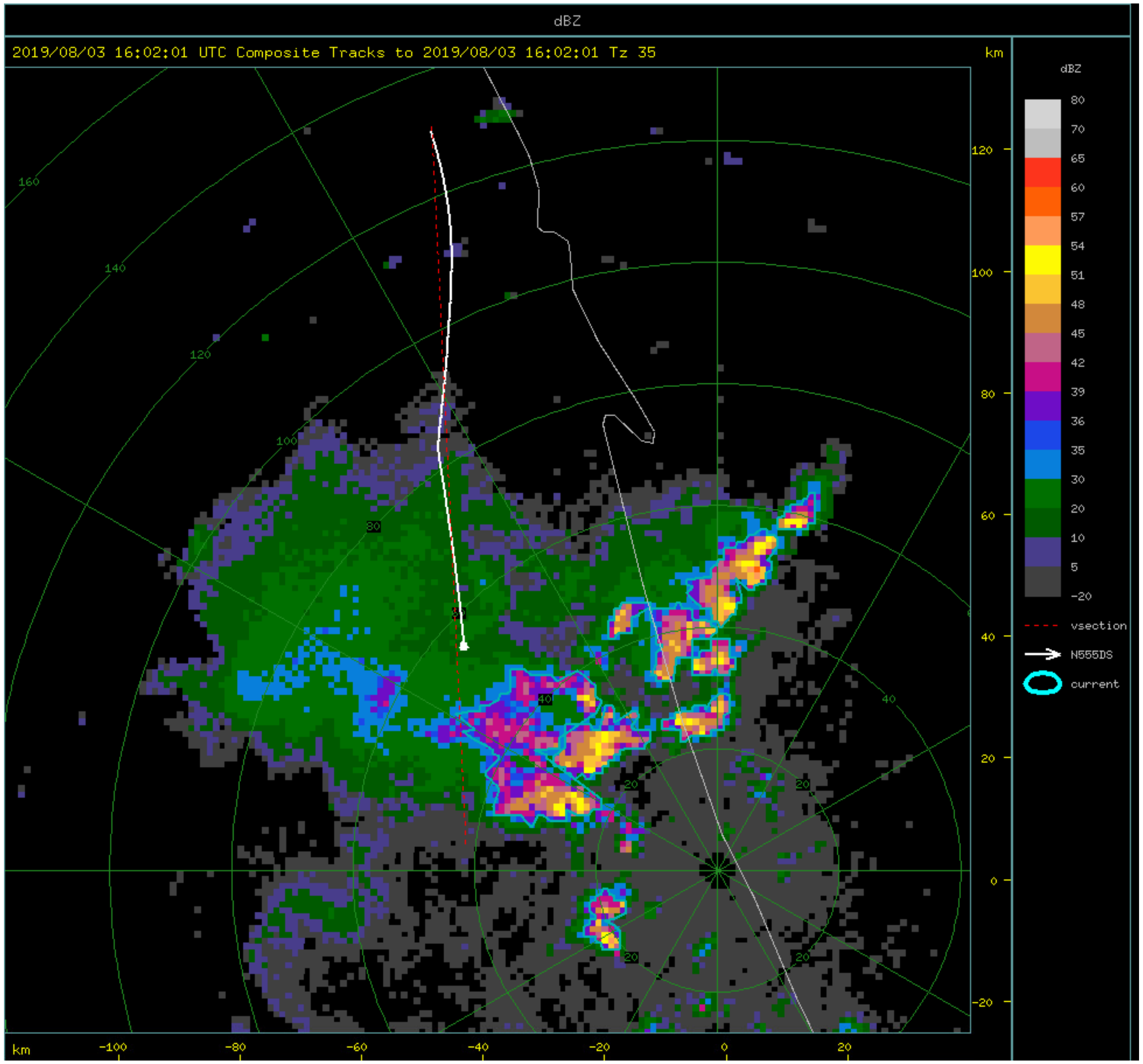
Latest Results

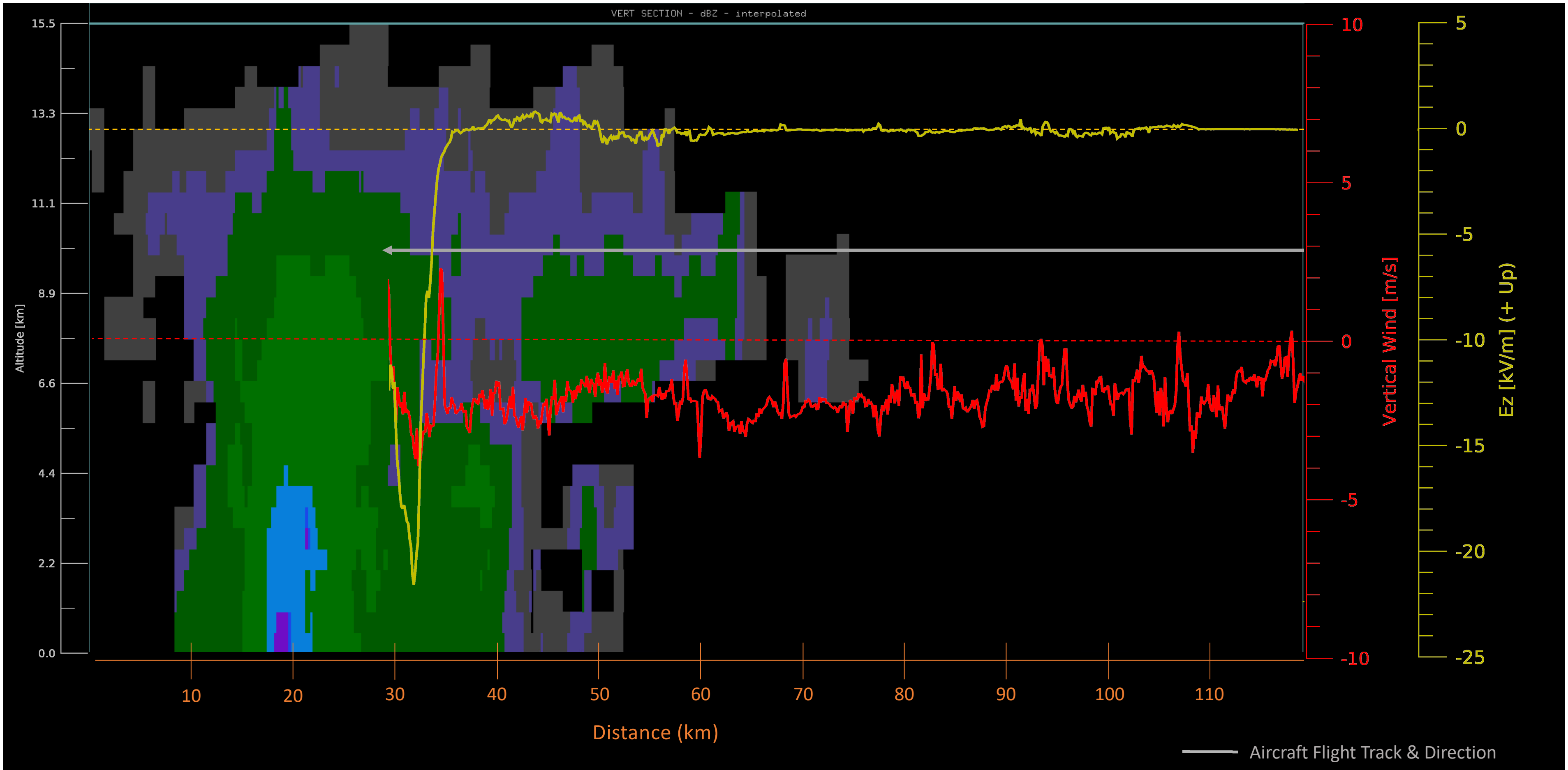
All Flight Legs Summary



Flight Leg 1 (FL1)

15:50:00 – 16:01:00

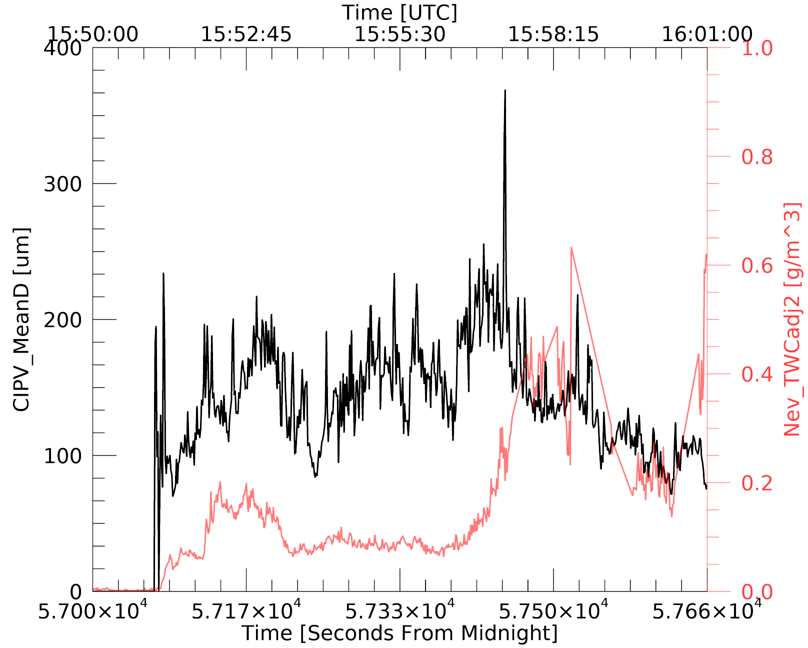




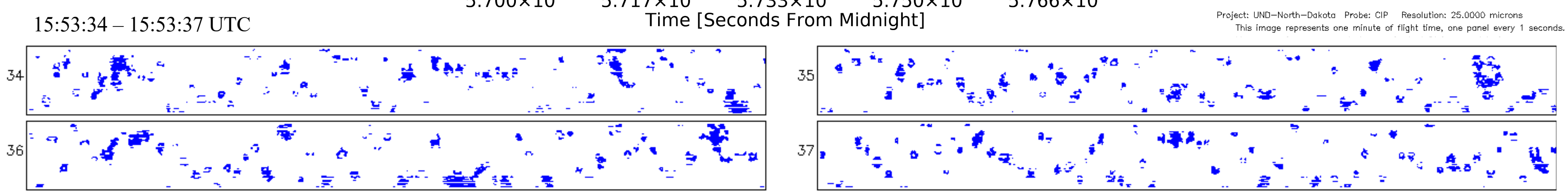
Flight Legs	Time Span (hh:mm:ss) UTC	Time Span (SFM)	Average Altitude (m)	Average Temperature (degrees C)
Flight Leg 1	15:50:00-16:01:00	57000-57659	10032 (+/- 10)	-33.65 (+/- 1)

Microphysical Data

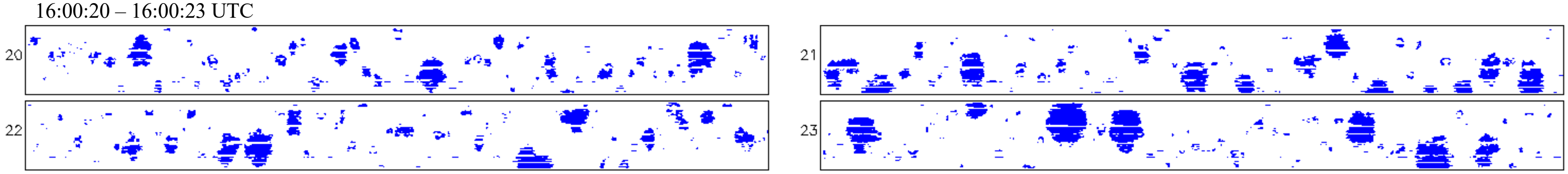
Flight Leg 1
15:50:00 – 16:01:00



15:53:34 – 15:53:37 UTC



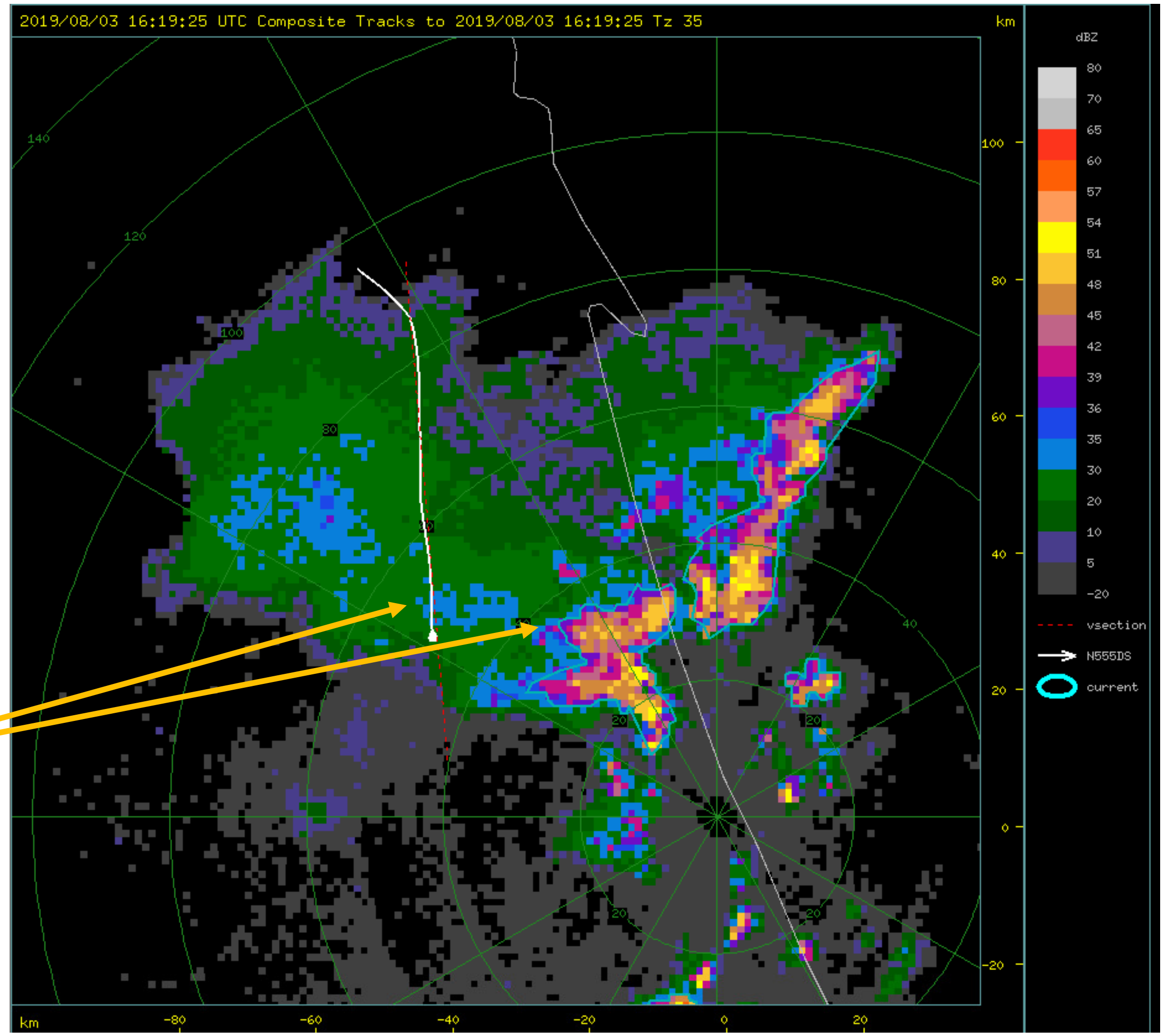
16:00:20 – 16:00:23 UTC

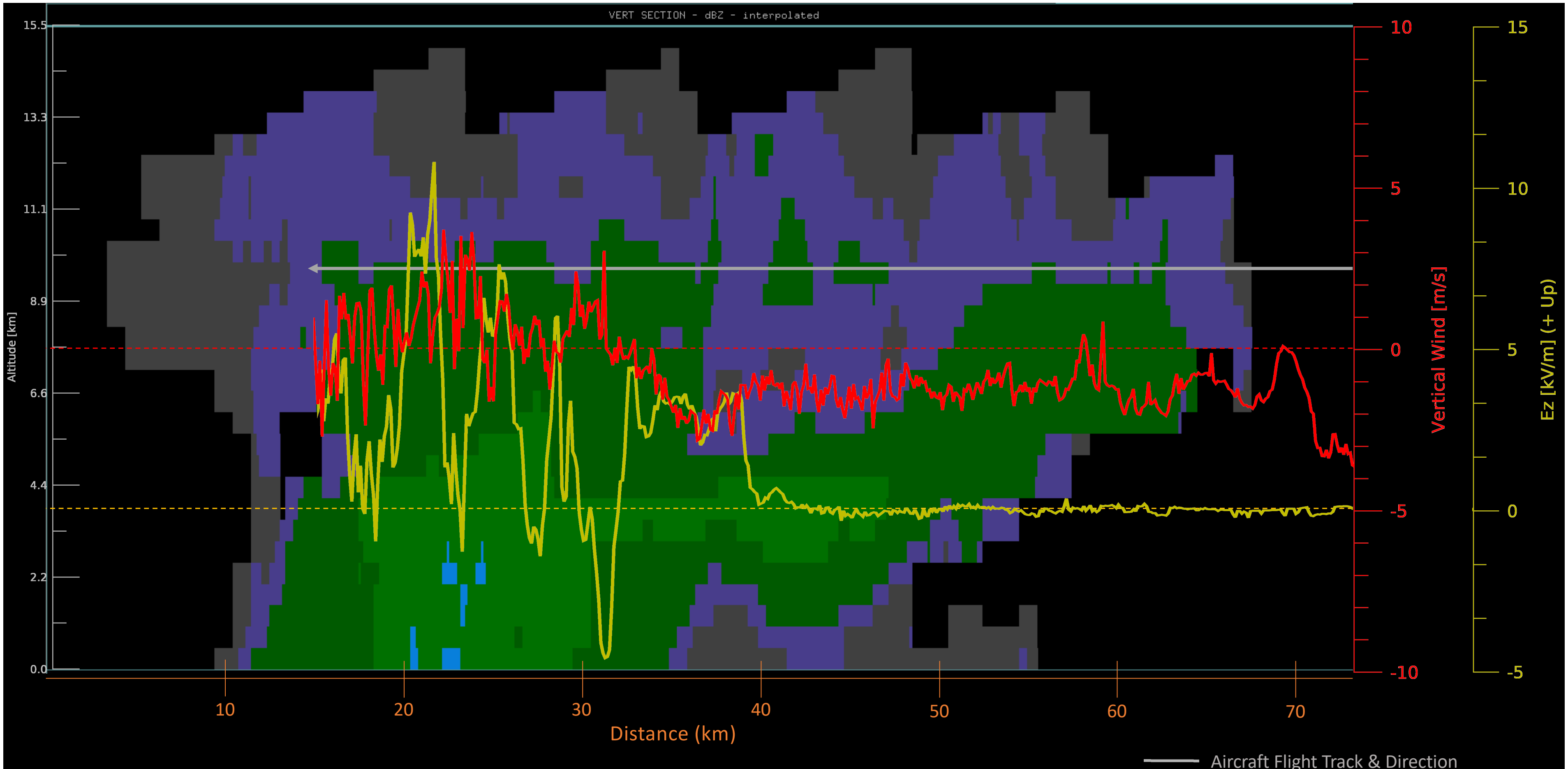


Flight Leg 3 (FL3)

16:09:00 – 16:17:00

Aircraft sampling farther away from storm core but in the same relative sampling locations as Flight Leg 1.

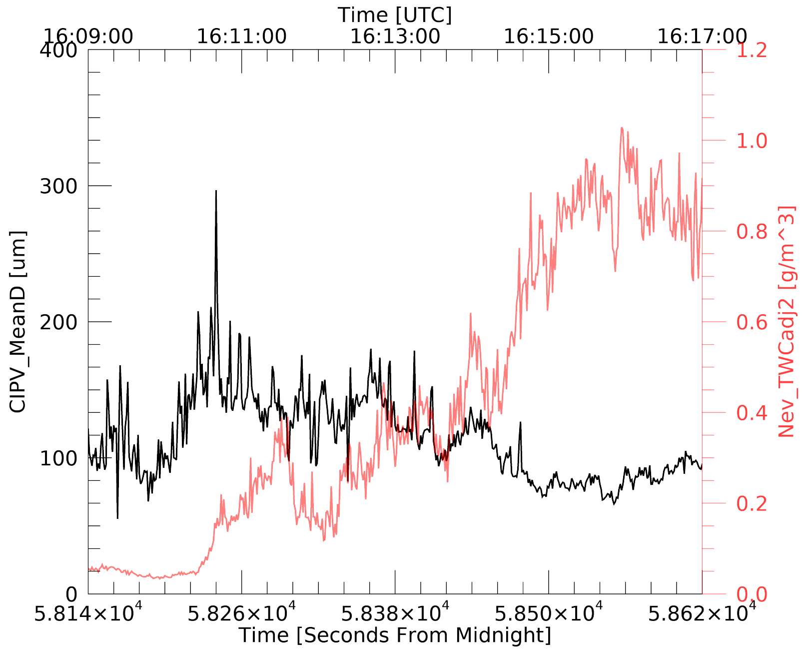




Flight Legs	Time Span (hh:mm:ss) UTC	Time Span (SFM)	Average Altitude (m)	Average Temperature (degrees C)
Flight Leg 3	16:09:00-16:17:00	58140-58619	10032 (+/- 10)	-32.62 (+/- 1.5)

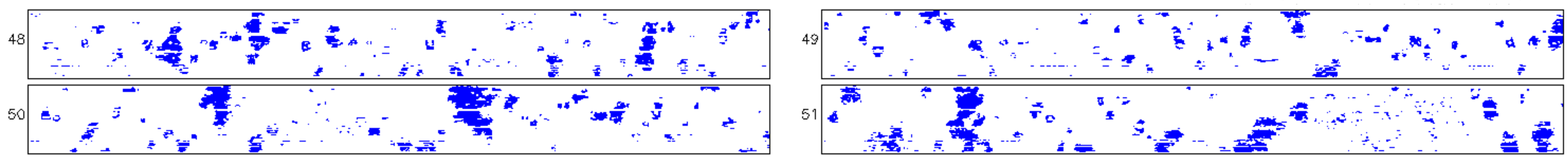
Microphysical Data

Flight Leg 3
16:09:00 – 16:17:00

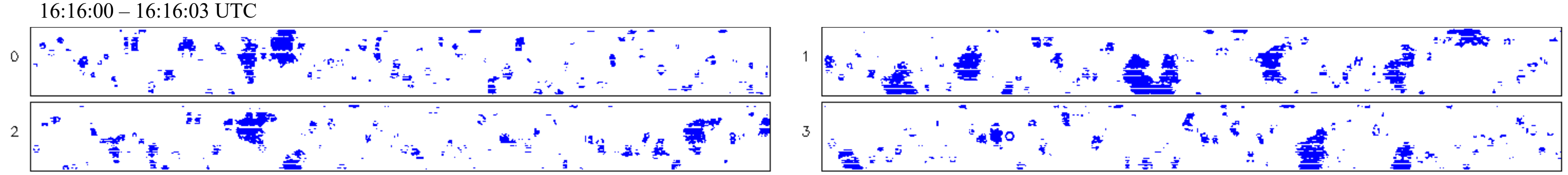


Project: UND−North−Dakota Probe: CIP Resolution: 25.0000 microns
This image represents one minute of flight time, one panel every 1 seconds.

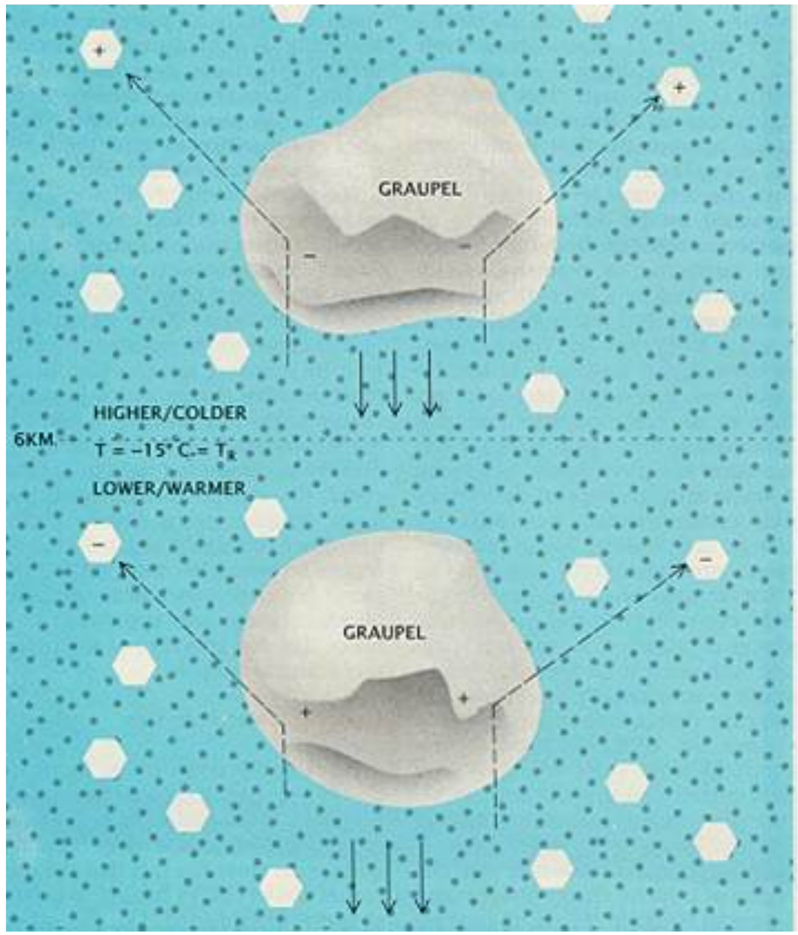
16:10:48 – 16:10:51 UTC

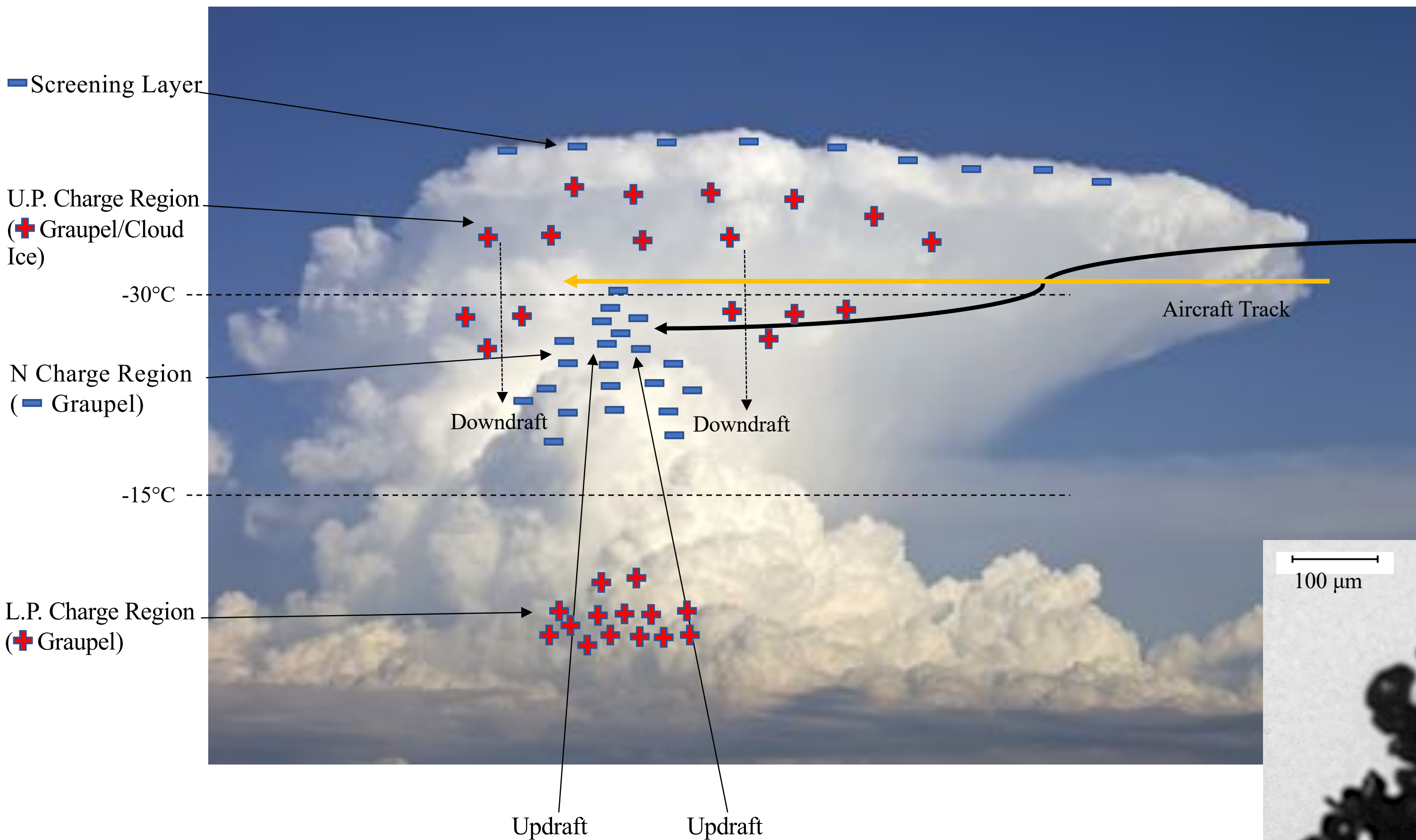


16:16:00 – 16:16:03 UTC

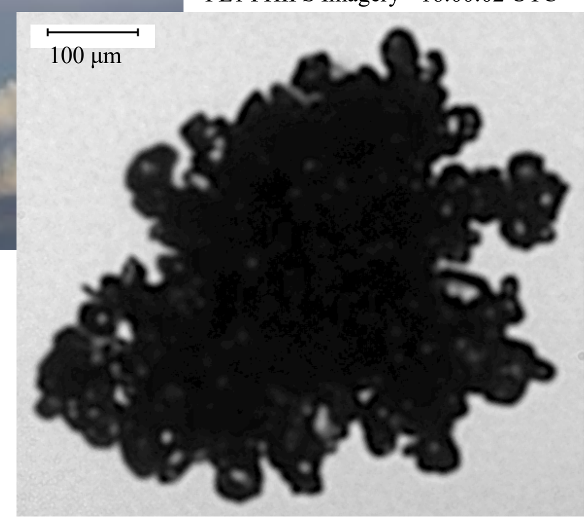


Graupel-Ice Collision Mechanism[6]





FL1 PHIPS Imagery - 16:00:02 UTC



Remarks

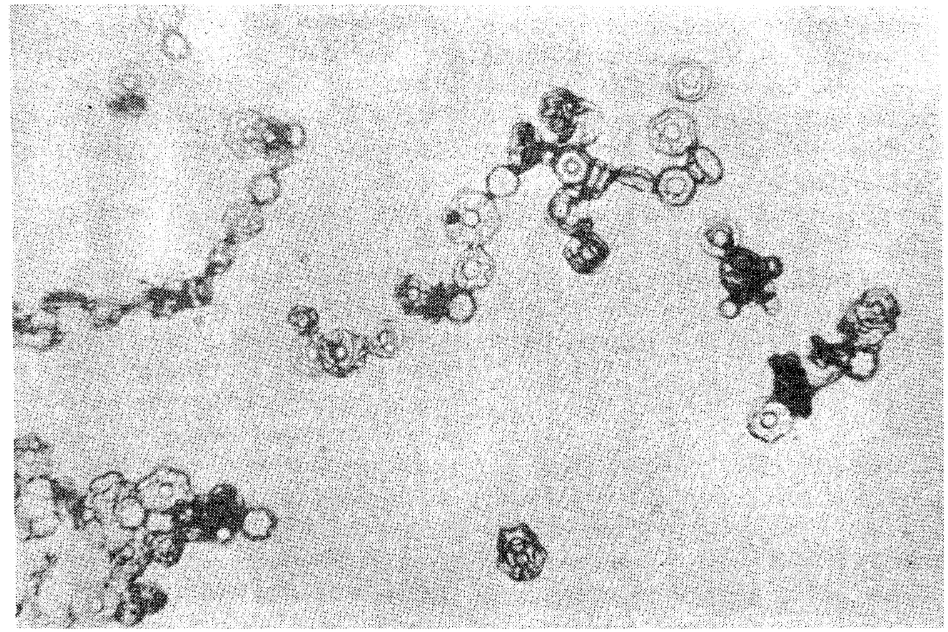
- We theorize that negatively charged graupel is being lofted higher in Florida thunderstorms by updrafts (~10 km // < -30°C).
    - While positively charged particles may be descending lower into the storm by downdrafts.

- CIP and PHIPS imagery add confidence to our hypothesis.

- More investigating needs to be performed on other flights from the CapeEx19 Campaign.

Future Work

- Compare locations of chain aggregates verses electric fields observed during sampling.
  - Literature suggest high crystal concentrations and E-fields necessary for chain aggregates[4,5].
- Compare results from this case study to other flights during the CapeEx19 field campaign.
- Origin of chain aggregates are still unknown.
  - Additional aircraft flights through and around the vicinity of the storm core may provide further insight.
- More microphysical analyzation of chain aggregates needed before implementation into cloud microphysical aggregation models.



[4]Saunders & Wahab (1975) laboratory image.

References

- Bringi, V. N., K. Knupp, A. Detwiler, L. Liu, I. Caylor, and R. Black, 1997: Evolution of a Florida Thunderstorm during the Convection and Precipitation/Electrification Experiment: The Case of 9 August 1991. *Monthly Weather Review - MON WEATHER REV*, **125**, https://doi.org/10.1175/1520-0493(1997)125<2131:EOAFTD>2.0.CO;2.
- Schmidt, J. M., and Coauthors, 2012: Radar observations of individual rain drops in the free atmosphere. *PNAS*, **109**, 9293–9298, https://doi.org/10.1073/pnas.1117776109.
- Connolly, P. J., C. P. R. Saunders, M. W. Gallagher, K. N. Bower, M. J. Flynn, T. W. Choularton, J. Whiteway, and R. P. Lawson, 2005: Aircraft observations of the influence of electric fields on the aggregation of ice crystals. *Quarterly Journal of the Royal Meteorological Society*, **131**, 1695–1712, https://doi.org/10.1256/qj.03.217.
- Saunders, C. P. R., and N. M. A. Wahab, 1975: The Influence of Electric Fields on the Aggregation of Ice Crystals. *Journal of the Meteorological Society of Japan*, **53**, 121–126, https://doi.org/10.2151/jmsj1965.53.2_121.
- NLDN lightning data was provided by Dr. Ron Holle (Viasala), 3 August 2019. https://www.vaisala.com/en/products/national-lightning-detection-network-nldn
- Williams, E. R., 1988: The Electrification of Thunderstorms. *Scientific American*, **259**, 88–99.

Thesis Topic Proposal

- Case study on 2019/08/03
  - FOCUS: Chain aggregates & Electric Fields

Plan of study

- Need 8 more credits
- Plan on taking NWP and Thesis credits to finish out.

Dept.	Course Number	UND Credits	Grade (leave blank)	Title of Course (If substituting a required course, list the UND course it is being substituted for after the title of the course.	Transfer Course	
					Credit	University Name
ATSC	515	3		Advanced Climatology		
ATSC	505	4		Advanced Atmospheric Dynamics		
ATSC	500	1		Introduction to Atmospheric Research		
ATSC	552	3		Satellite Meteorology		
ATSC	548	3		Advanced Mesoscale Dynamics		
ATSC	998	4		Thesis		
ATSC	570	1		Seminar		
ATSC	525	3		Atmospheric Radiation		
ATSC	530	3		Numerical Weather Prediction (spring '21)		
ATSC	998	5		Thesis (spring '21)		