CapeEx19 Field Project (CapeEx19 현장 프로젝트)

3 August 2019 Case Study (2019 년 8 월 3 일 사례 연구)

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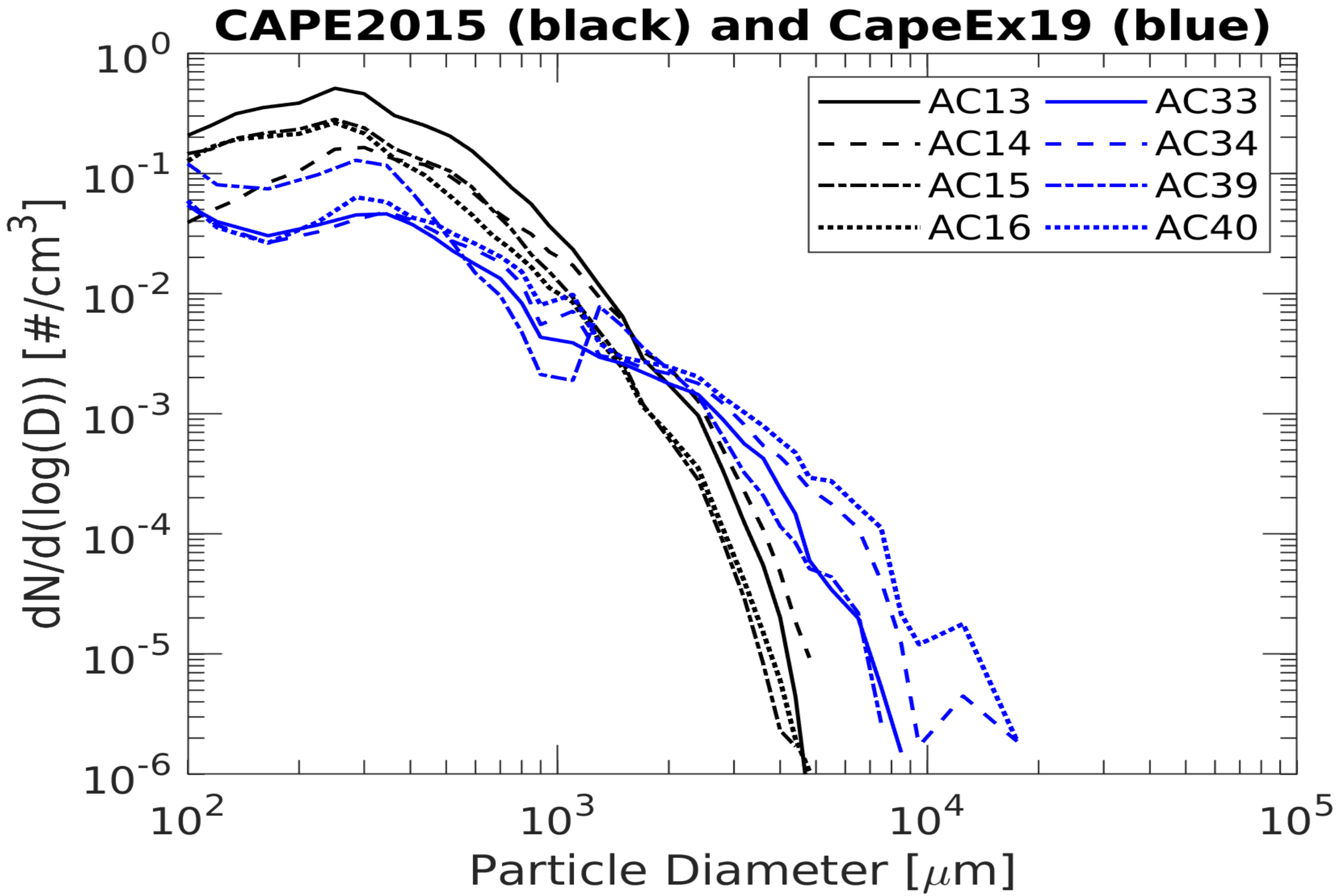
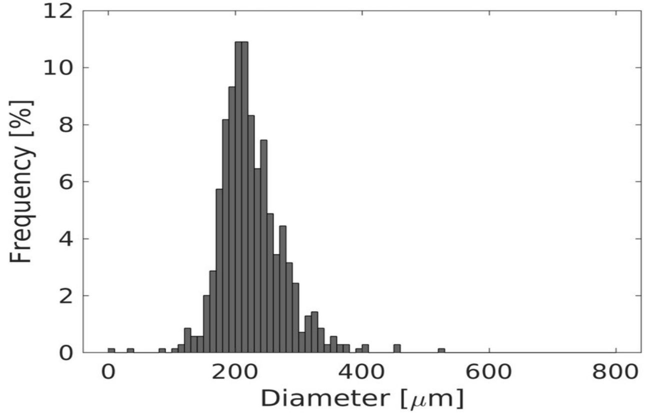
Objective #1: Improving Radar (목표 #1: 레이더 개선)

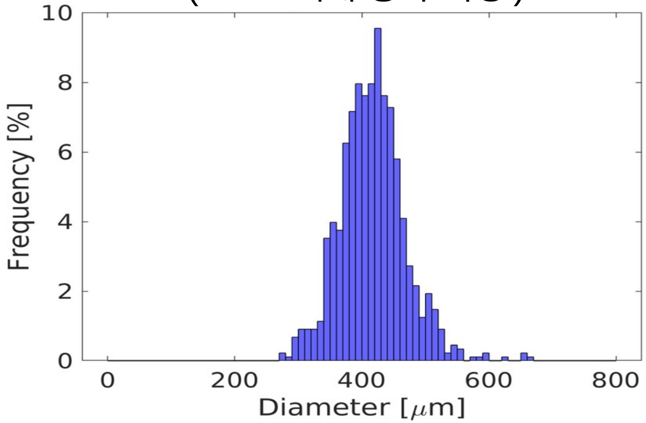
Concurrent Radar and Aircraft Observations
(동시 레이더 및 항공기 관측)



2015 Liquid Equivalent Diameter
(2015 액체 등가 직경)



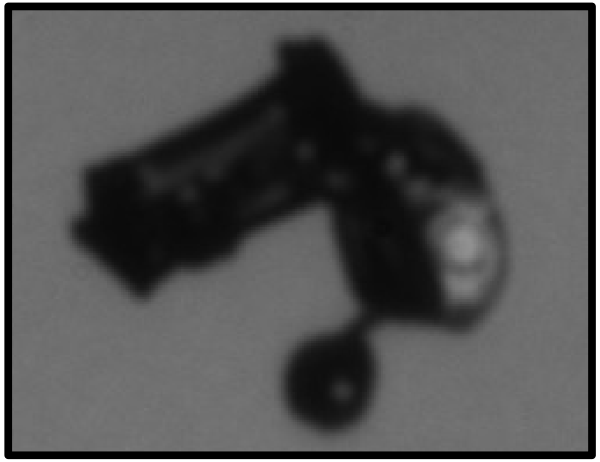
2015 Liquid Equivalent Diameter
(2015 액체 등가 직경)



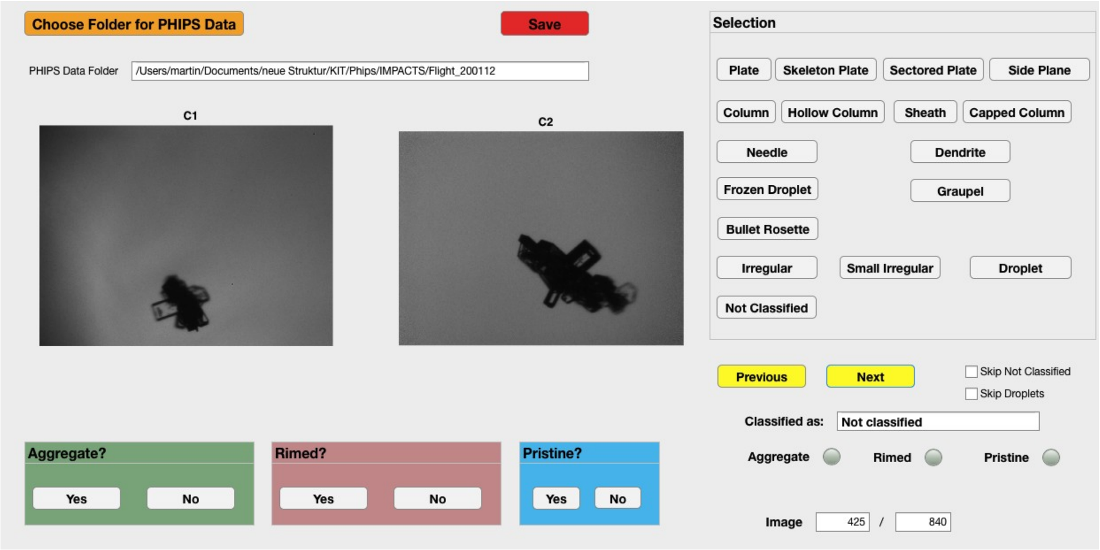
Objective #2: Improving Modeling (목표 #2: 모델링 개선)

Understanding chain aggregate formation process.
(체인 집합체 형성 과정을 이해합니다 .)

- Determine the location of chain aggregates. (체인 집합체의 위치를 결정합니다 .)
- Relate to cloud microphysical and electrical properties. (구름의 미세물리적 , 전기적 특성과 관련됩니다 .)

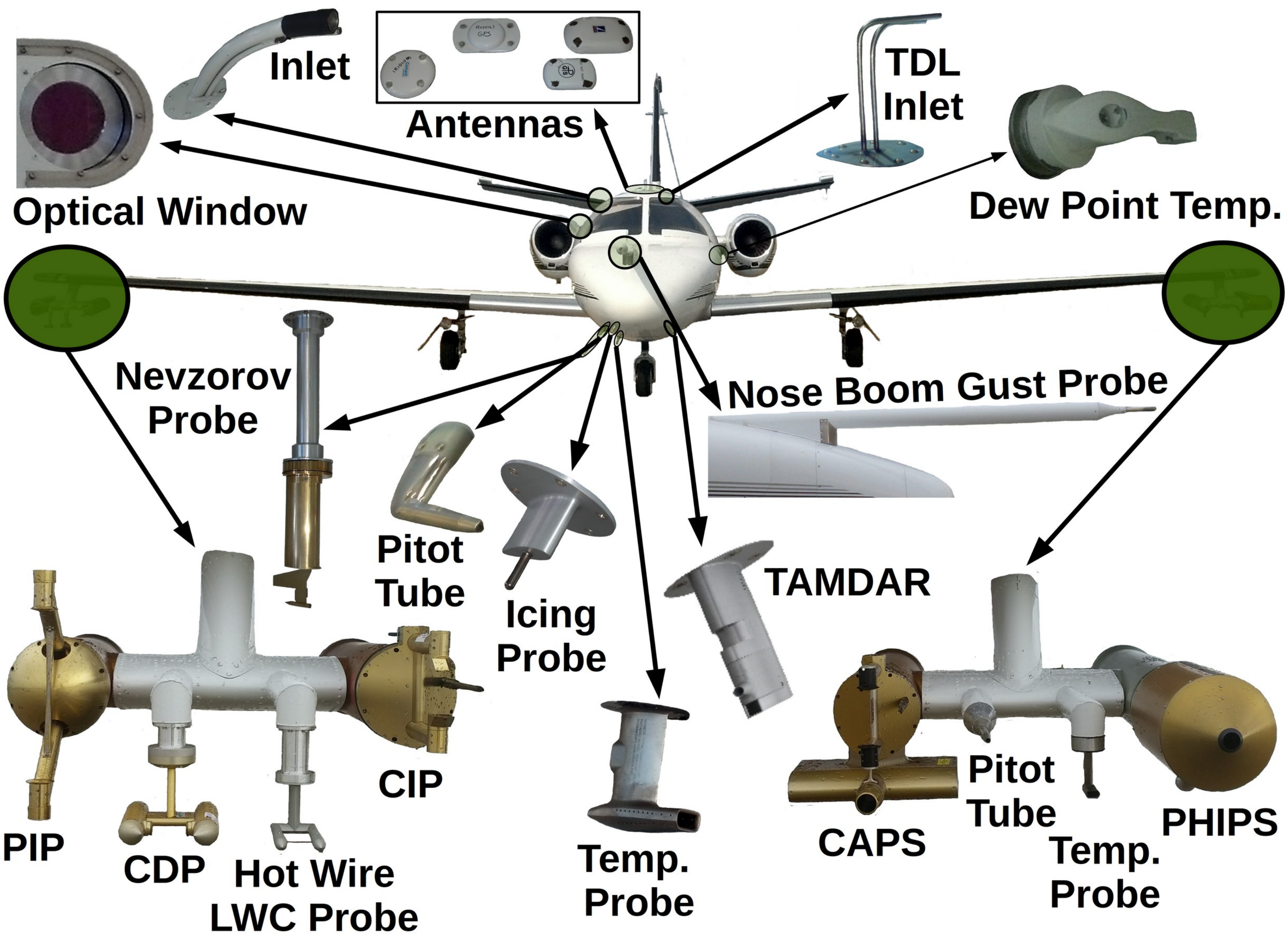


20190803 (016341)



2019
12 Flights

2019/7/22
2019/7/24
2019/7/25
2019/7/26
2019/7/29
2019/7/30
2019/7/31
2019/8/01
2019/8/2a
2019/8/2b
2019/8/3a
2019/8/3b



Project Related Publications (프로젝트 관련 출판물)

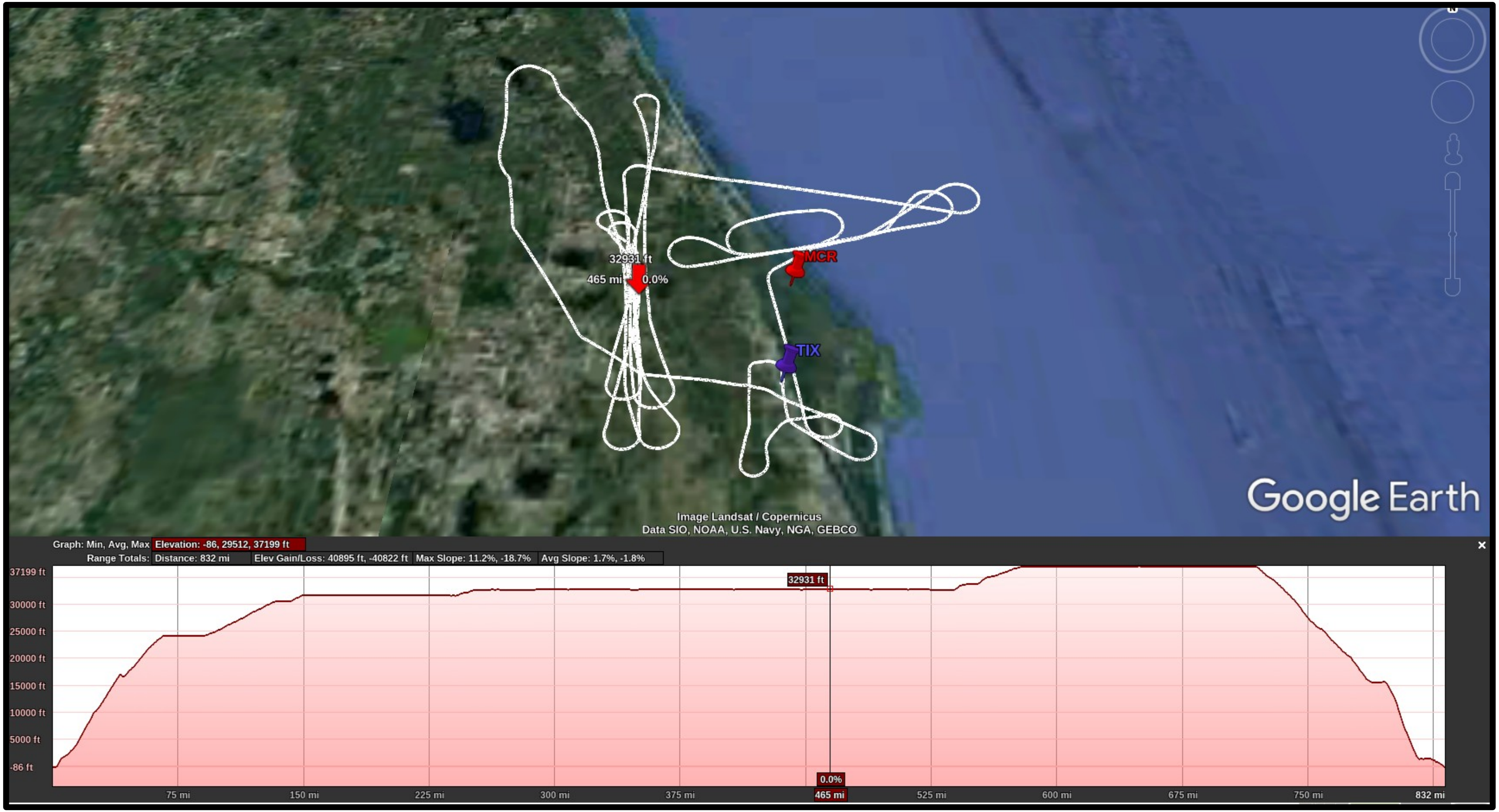
Schmidt, Jerome M., Piotr J. Flatau, Paul R. Harasti, Robert D. Yates, David J. Delene, Nicholas J. Gapp, William J. Kohri, Jerome R. Vetter, Jason E. Nachamkin, Mark G. Parent, Joshua D. Hoover, Mark J. Anderson, Seth Green, and James E. Bennett, Radar Detection of Individual Raindrops, Bulletin of the American Meteorological Society, 100, 2433-2450, 2019, https://doi.org/10.1175/BAMS-D-18-0130.1.

Wagner, S. W. and Delene, D. J., Technique for comparison of backscatter coefficients derived from in-situ cloud probe measurements with concurrent airborne Lidar, Atmos. Meas. Tech., 15, 6447-6466, https://doi.org/10.5194/amt-15-6447-2022, 2022.

Gapp, Nicholas, David J. Delene, Jerome Schmidt, and Paul Harasti, Comparison of Concurrent Radar and Aircraft Measurements of Cirrus Clouds, Journal of Atmospheric Sciences, in review (JAS-D-24-0014), 2024.

Nairy, Christian M., David J. Delene, Jerome M. Schmidt, Paul R. Harasti, Emma Järvinen, Case Study of Chain Aggregates in Florida Cirrus Cloud Anvils from Electrified Thunderstorms. Journal of Geophysical Research: Atmospheres. In Preparation 2024.

August 3, 2019 Flight Path (2019 년 8 월 3 일 비행경로)



Research Flight Video (2019 년 8 월 3 일 비행경로)

http://aerosol.atmos.und.edu/CapeEx19_HarrisonRademacher.mp4

Airborne Data Processing (항공 데이터 처리)

- Data Quality Control (데이터 품질 관리)
  - Performance Checks (성능 점검)
- Data Missing Values Codes (데이터 결측값 코드)
- Levels of Data Processing (데이터 처리 수준)
  - Raw Recorded Data (원시 기록 데이터)
  - Engineering to Physical Units (엔지니어링을 물리적 단위로)
  - Single Instrument Data Files (단일 기기 데이터 파일)
  - Combined Data Files (결합된 데이터 파일)
- Data Quality Assurance (데이터 품질 보증)
  - Scientific Data Review (과학적 데이터 검토)
  - Automated Checks (자동화된 점검)

```
delene@ice:/nas/und/NorthDakota/2014/Aircraft/CitationII_N555DS/Fl
[delene@ice 20140306_174537]$ process_all_ophir
Processing the 14_03_06_17_45_37.sea file ........................ Done
Creating 14_03_06_17_45_37.applanix.1Hz .......................... Done
Creating 14_03_06_17_45_37.analog.1Hz ............................ Done
Processing the 14_03_06_17_45_37.analog.??? file ................. Done
Processing the 14_03_06_17_45_37.2dc file ........................ Done
Processing the 14_03_06_17_45_37.serial.GPS.raw .................. Done
Creating 14_03_06_17_45_37.physical.clean ........................ Done
Creating 14_03_06_17_45_37.physical.filtered ..................... Done
Creating the 14_03_06_17_45_37.physical.10Hz file ................ Done
Creating the 14_03_06_17_45_37.physical.1Hz file ................. Done
Processing the 14_03_06_17_45_37.physical.? file ................. Done
Creating 14_03_06_17_45_37.basicP1T1.1Hz ......................... Done
Creating 14_03_06_17_45_37.basicP1T2.1Hz ......................... Done
Creating 14_03_06_17_45_37.basicP2T1.1Hz ......................... Done
Creating 14_03_06_17_45_37.basicP2T2.1Hz ......................... Done
Creating 14_03_06_17_45_37.basic.10Hz ............................ Done
Creating 14_03_06_17_45_37.basic.1Hz ............................. Done
Processing the 14_03_06_17_45_37.counts.pcasp.raw ................ Done
Creating 14_03_06_17_45_37.basic.8Hz ............................. Done
Processing the 14_03_06_17_45_37.counts.cdp.raw .................. Done
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Processing the 14_03_06_17_45_37.applanix.raw .................... Done
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Creating 14_03_06_17_45_37.conc.cdp.1Hz .......................... Done
Creating 14_03_06_17_45_37.egg.raw ............................... Done
Creating 14_03_06_17_45_37.wind.raw .............................. Done
Creating 14_03_06_17_45_37.nevwc.raw file ........................ Done
Creating 14_03_06_17_45_37.nevwc.1Hz ............................. Done
Creating 14_03_06_17_45_37.serial.GPS.10sec ...................... Done
Creating 14_03_06_17_45_37.REAL.winds.1Hz ........................ Done
Creating 14_03_06_17_45_37.550nm.scat.raw ........................ Done
Creating 14_03_06_17_45_37.conc_stp.pcasp.raw .................... Done
Creating 14_03_06_17_45_37.oph file .............................. Done
Creating 14_03_06_17_45_37.air file .............................. Done
Using 14_03_06_17_45_37.2dc to create 2DC images ................. Done
[delene@ice 20140306_174537]$
```

Additional Software Information (추가 소프트웨어 정보)

Gateway - http://aerosol.atmos.und.edu/ADPAA/index.html

Web Site - https://sourceforge.net/projects/adpaa/

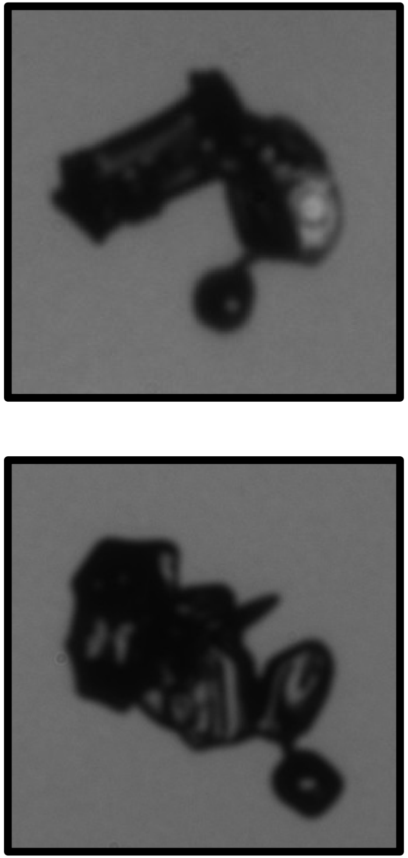
Wiki - http://adpaa.sourceforge.net/wiki/index.php/Main_Page

Delene, D., Andrea, S., Hibert, K., Nairy, C., Moore, J., Twohey, L., Kim, M.-S., Gapp, N., O'Brien, J., & Klinman, J. Airborne Data Processing and Analysis Software Package (Version 4632). Zenodo, January 16, 2024. https://doi.org/10.5281/zenodo.10519255.

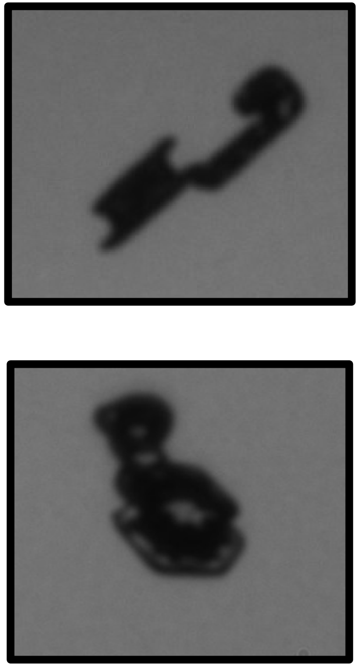
Delene, D. J., Airborne Data Processing and Analysis Software Package, Earth Science Informatics, 4(1), 29-44, 2011, URL: http://dx.doi.org/10.1007/s12145-010-0061-4, DOI: 10.1007/s12145-010-0061-4

Chain Aggregates (체인 집합체)
(20190803_142455)

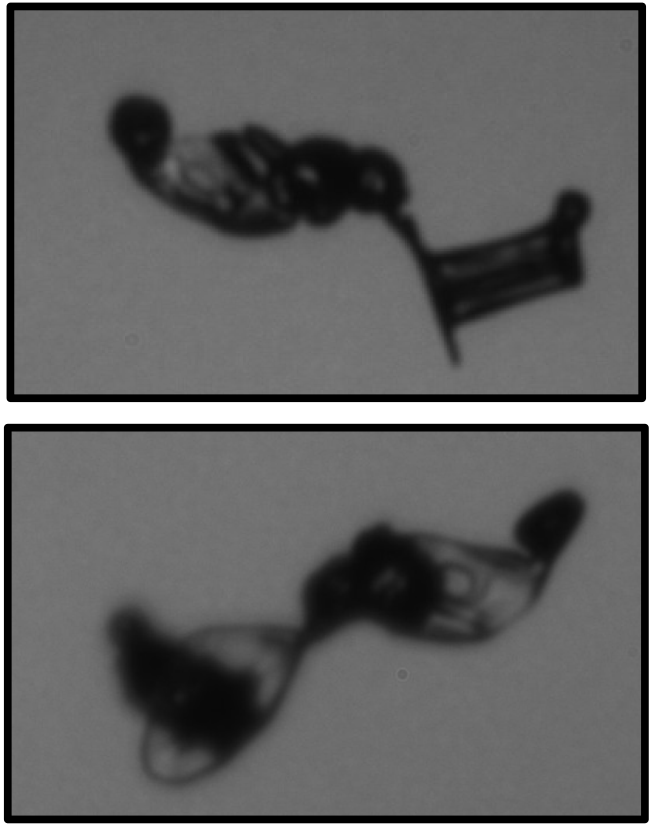
016341



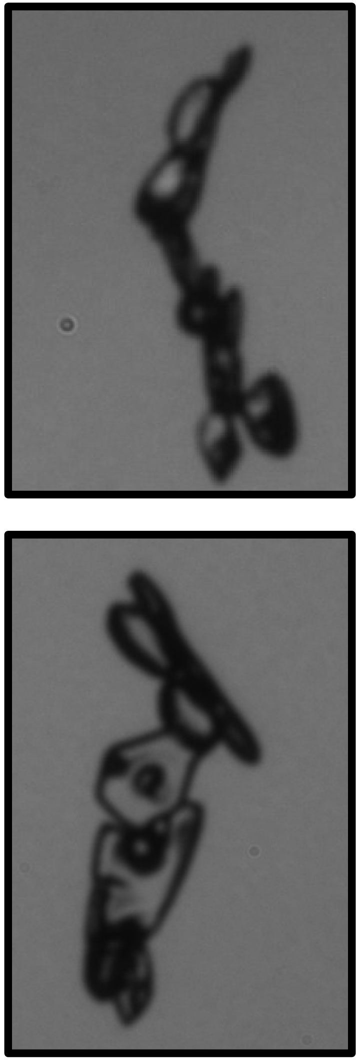
016358



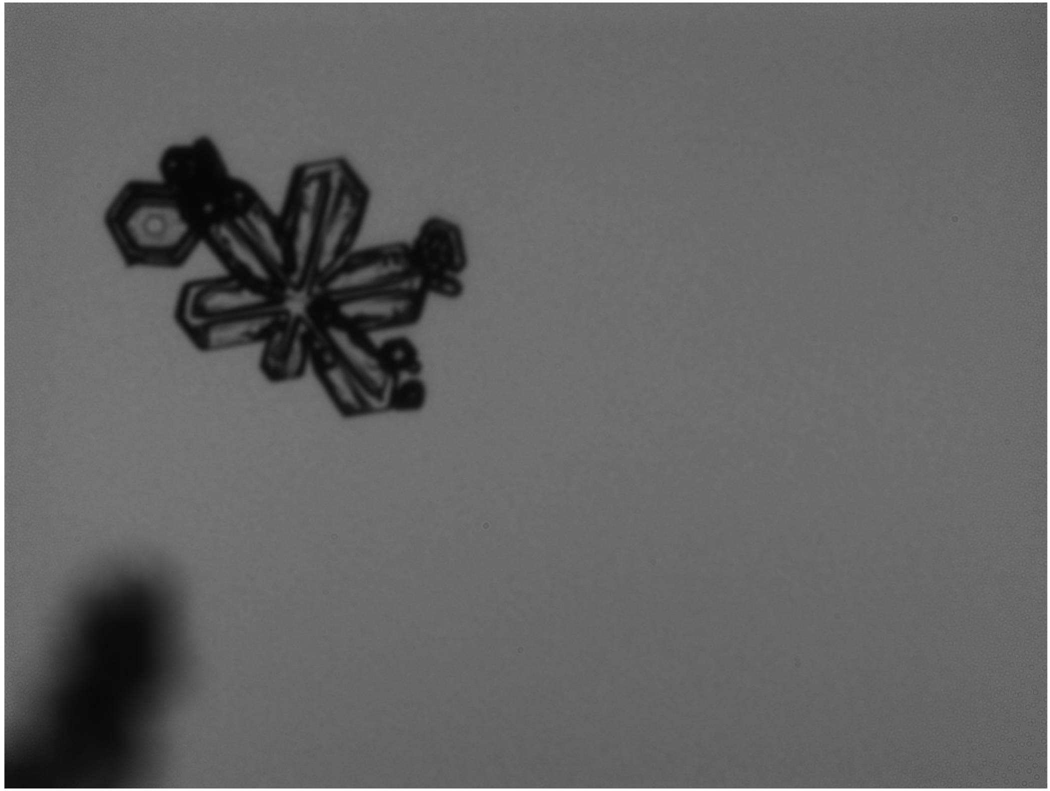
016370



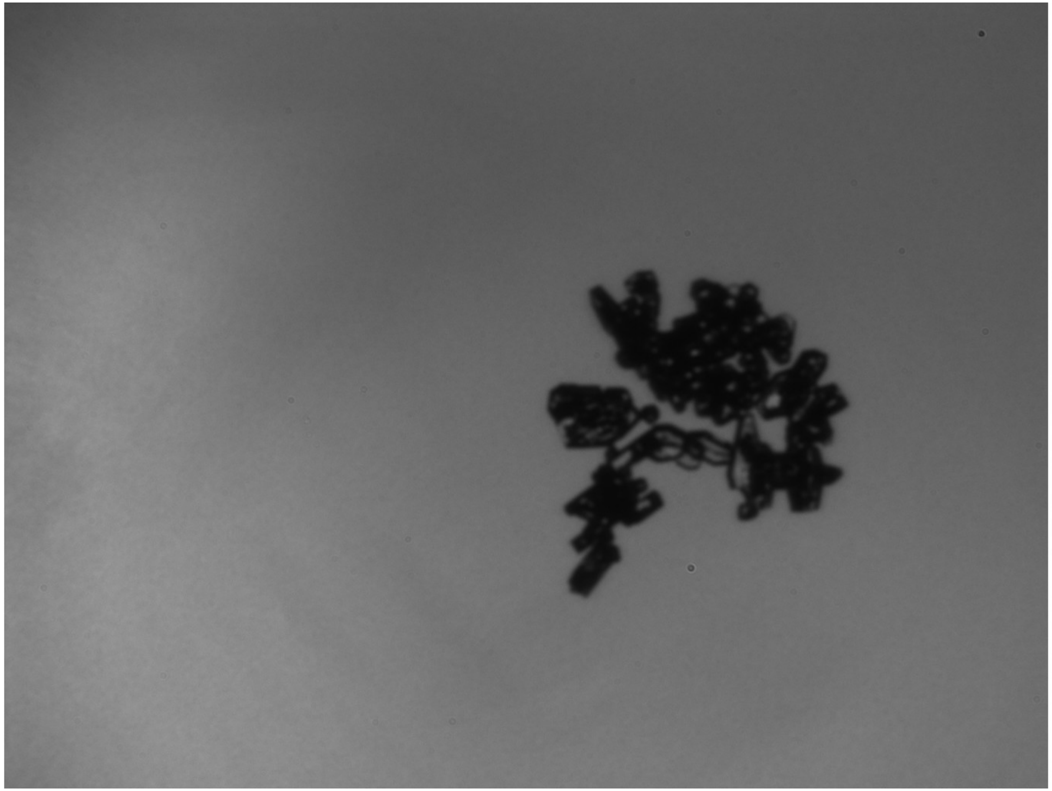
016385

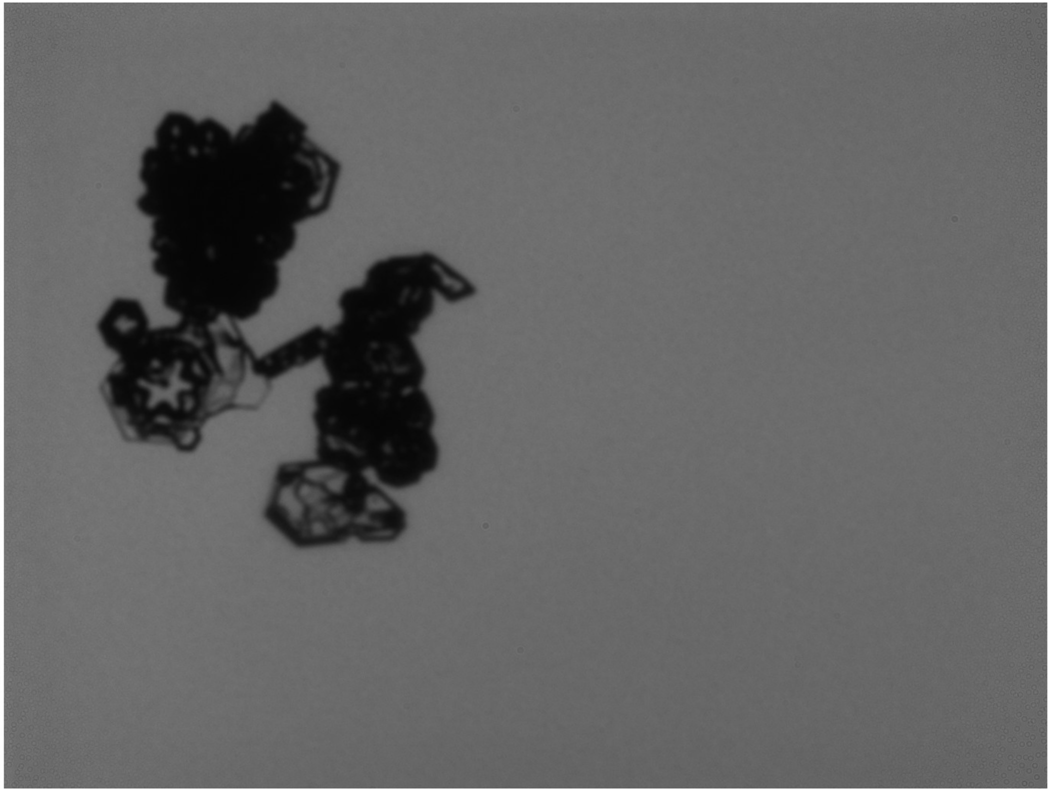


Chain Plate Aggregates (체인 플레이트 집합체) (20190803_142455 ID 016076)



Chain Plate Aggregates (체인 플레이트 집합체)
(20190803_142455 ID 016136)

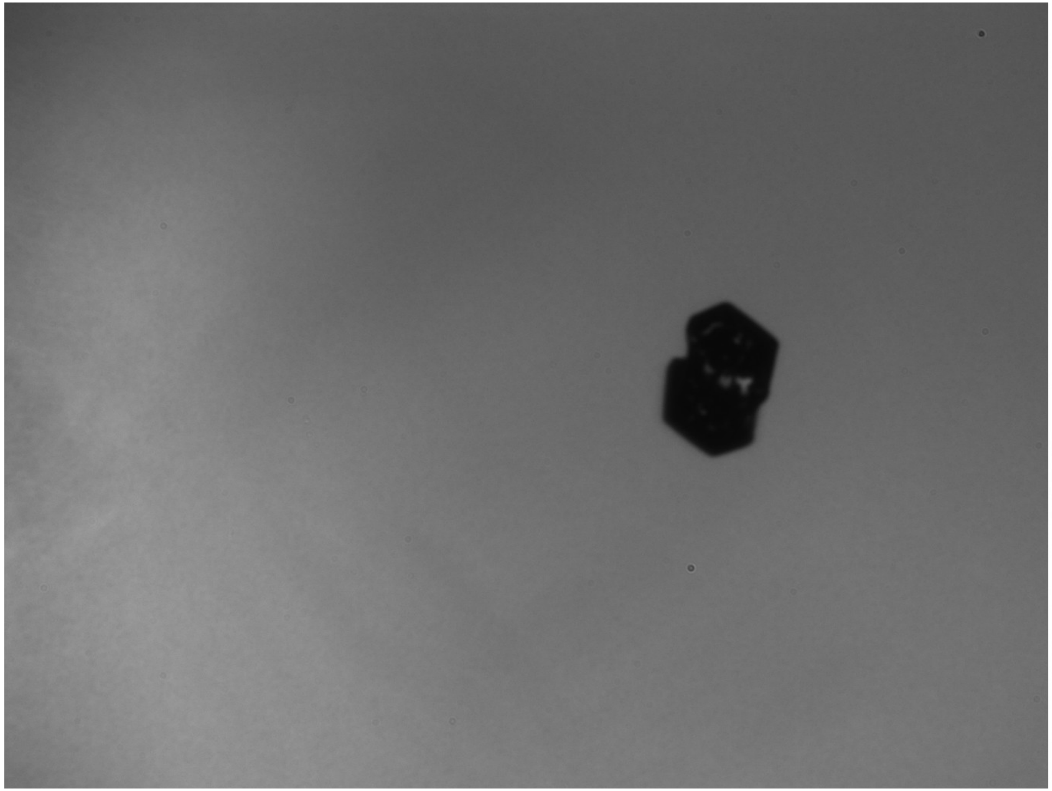




Chain Plate Aggregates (체인 플레이트 집합체)
(20190803_142455 ID 016146)

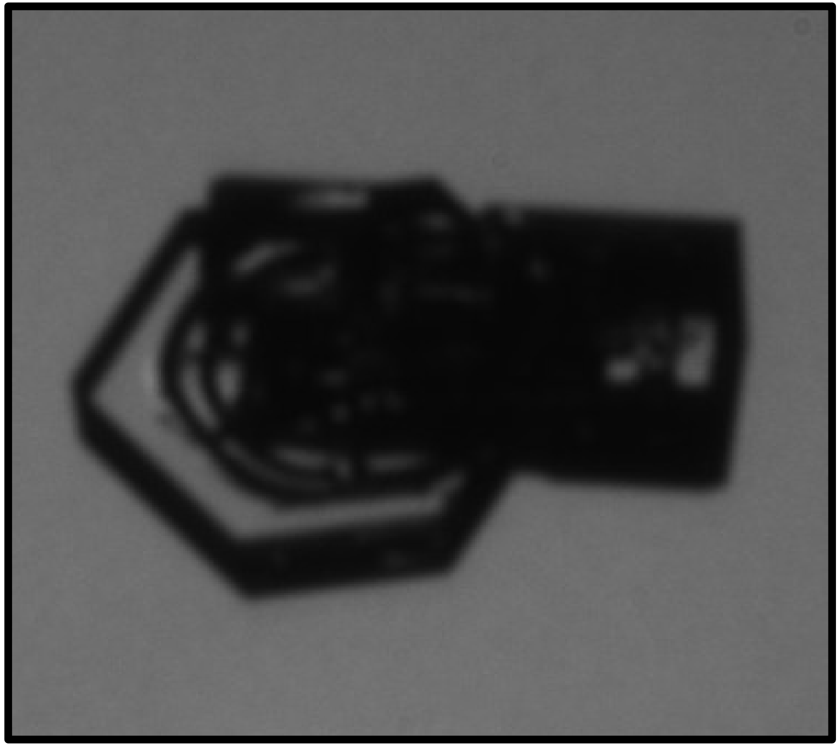
Chain Plate Aggregates (체인 플레이트 집합체)
(20190803_142455 ID 016146)

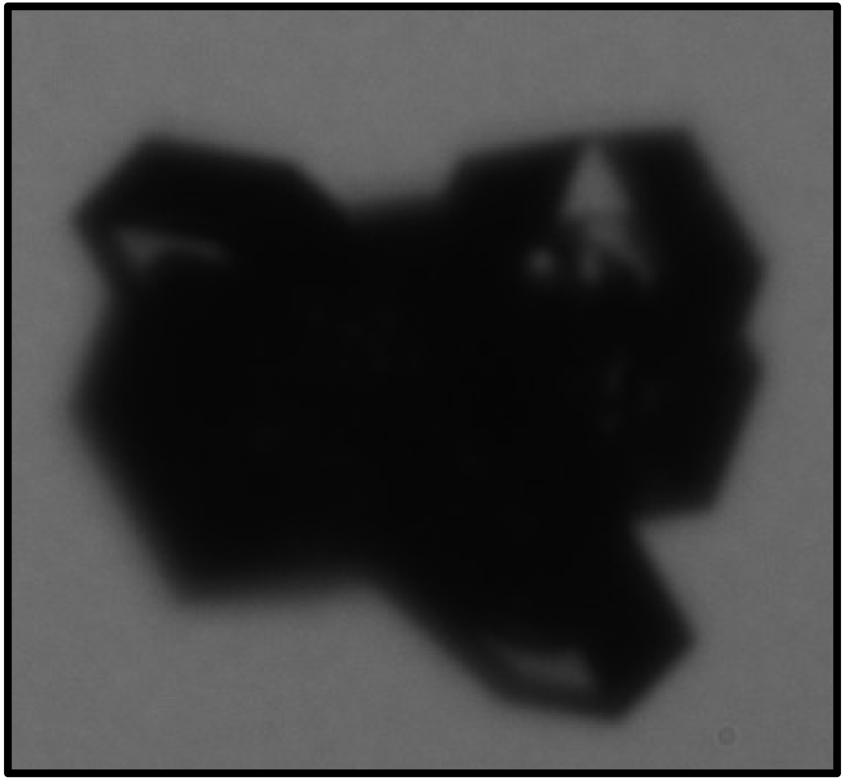
Chain Plate Aggregates (체인 플레이트 집합체)
(20190803_142455 ID 017033)



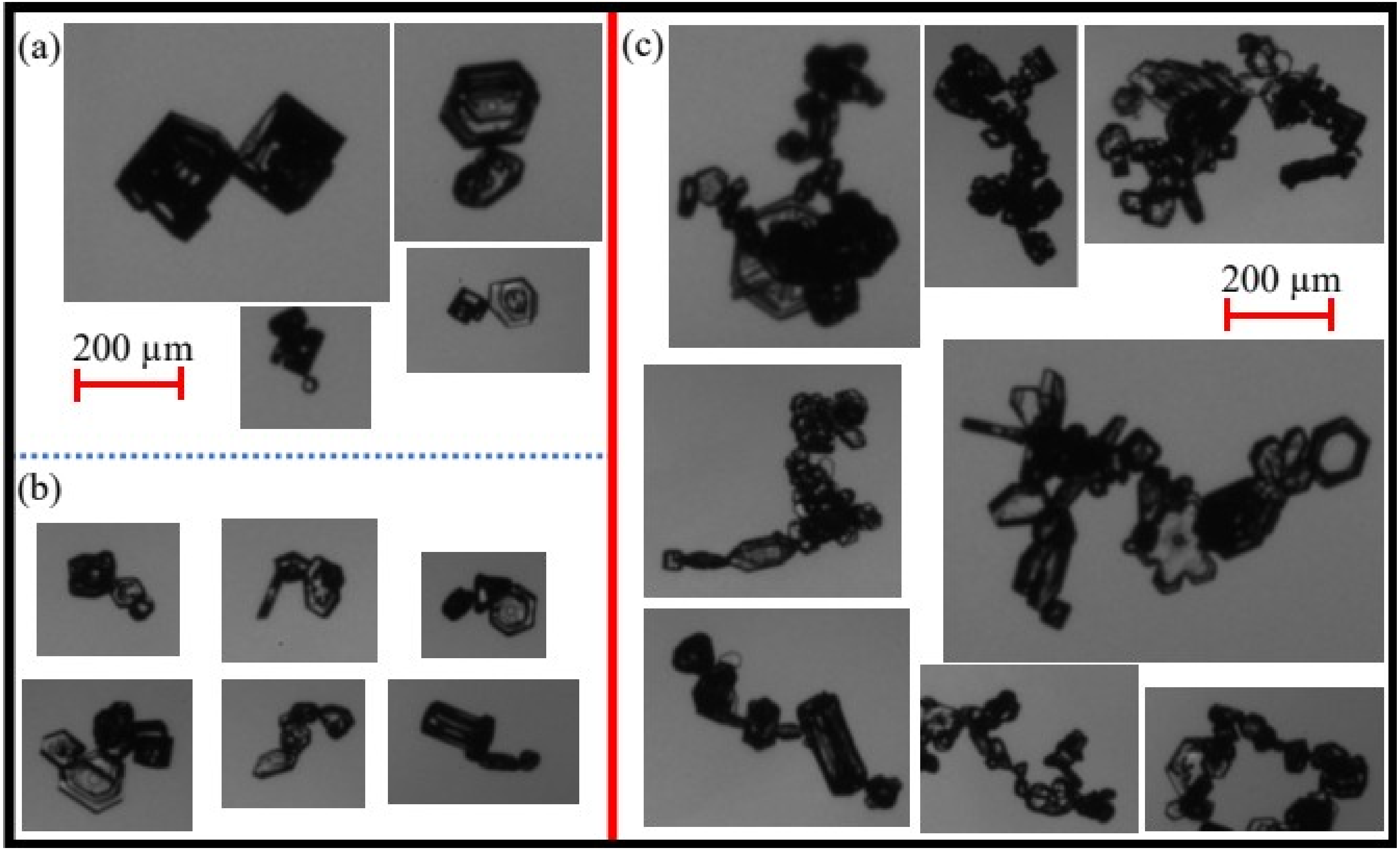
Aggregates 1-Plate, 1-Column (1- 플레이트 , 1- 컬럼 집계) (20190803_142455)

016052



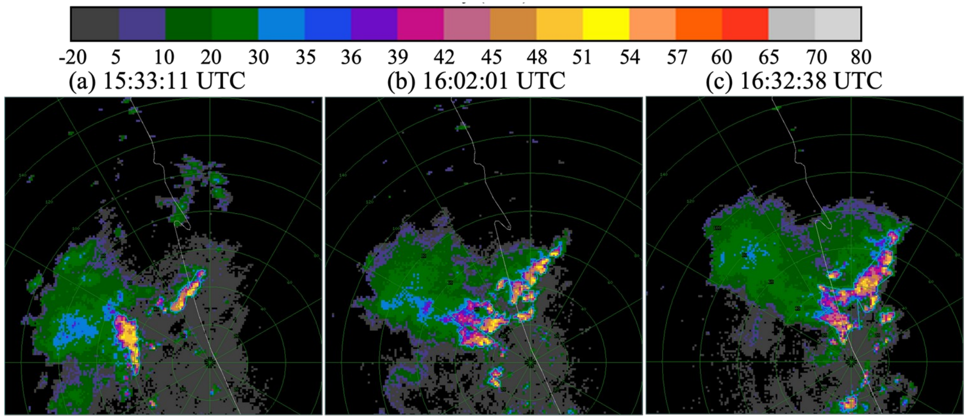


Types of Chain Aggregates (체인 집합체의 유형)

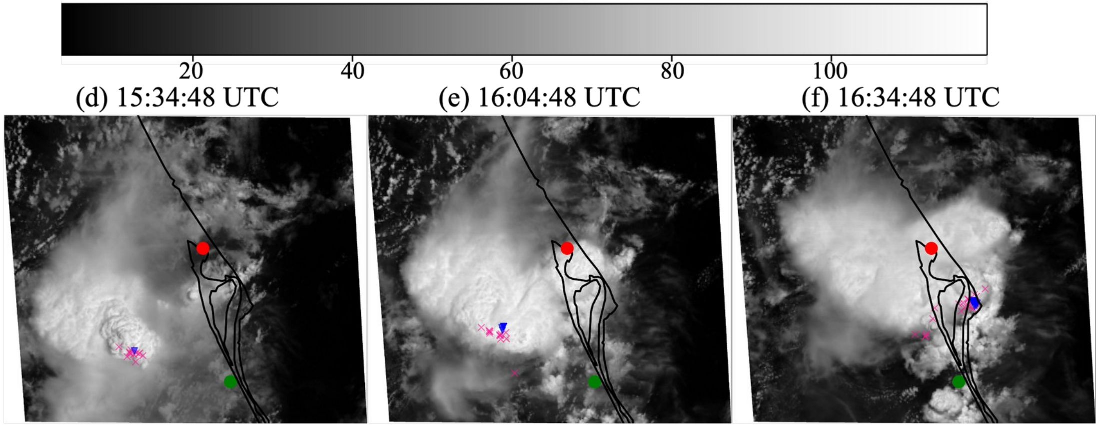


3 August 2019 Radar, Satellite, and Lightning Observations
(2019 년 8 월 3 일 레이더 , 위성 및 번개 관측)

Reflectivity (dBZ)
반사율 (dBZ)



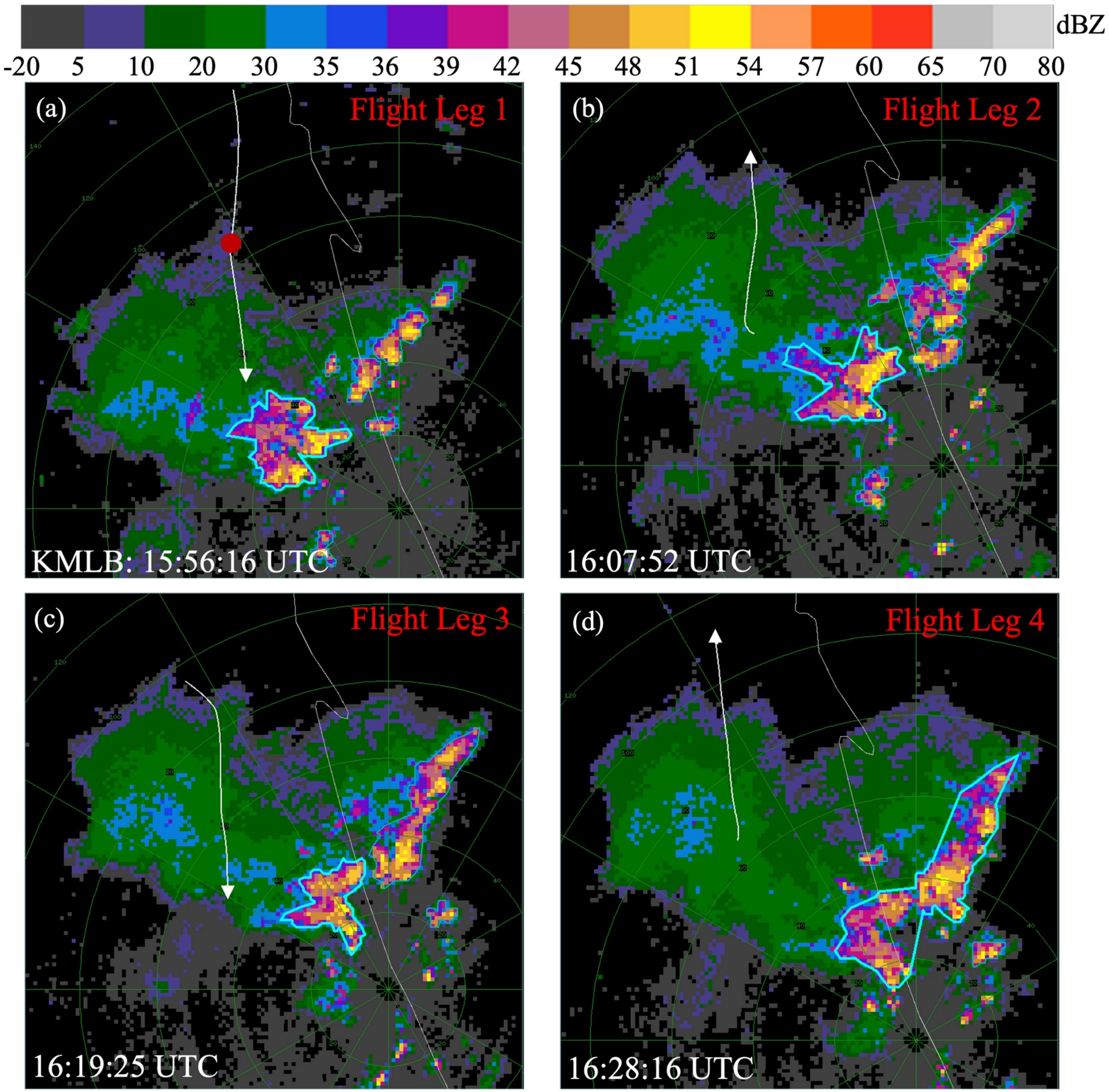
Reflectance (%)
(반사율 (%))



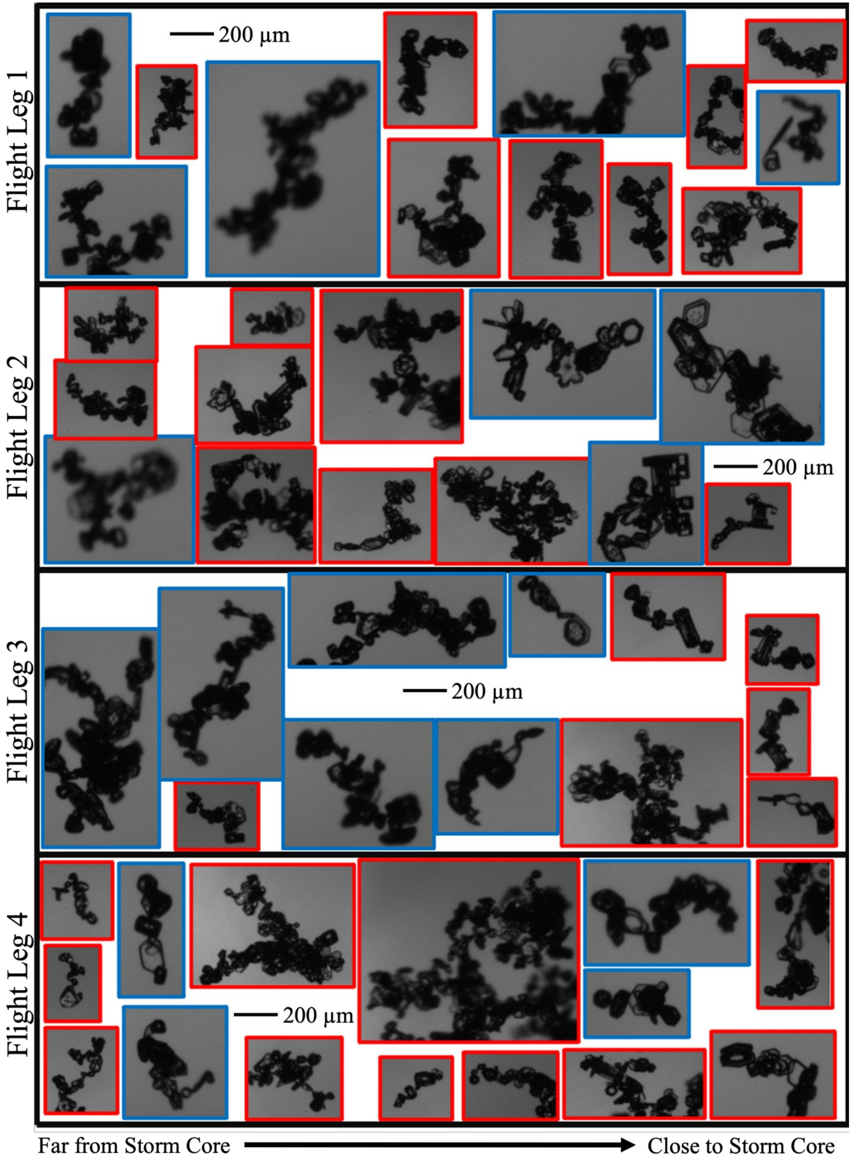
Panels a through c show the composite radar reflectivity with 35 dBZ convective storm cores (blue outlines) from the Melbourne, Florida (KMLB) National Weather Service (NWS) Next-Generation Radar (NEXRAD). Range rings (thin green lines) are 20 km apart. In panel (a), the TITAN cell is the left most cell, 40-60 km northwest of the KMLB radar. Panels (d) through (f) show the visible (0.64 μm wavelength) satellite imagery from the Geostationary Operational Environmental Satellite (GOES-16). The satellite imagery (panels d-f) is at the closest time and shows an area similar to the radar observations (panels a-c). Overlaid on satellite imagery is the National Lightning Detection Network (NLDN) cloud-to-ground (CG) lightning strokes (blue upside-down triangles), NLDN cloud-to-cloud/intra-cloud (CC/IC) lightning strokes (pink ‘x’), and the KMLB (green circle) and the Cloud and Precipitation Radar with Discrete Hydrometeor Detection (CPR-HD) radar locations (red circle). The lightning data displayed is for 15 minutes before and after the satellite image start time.

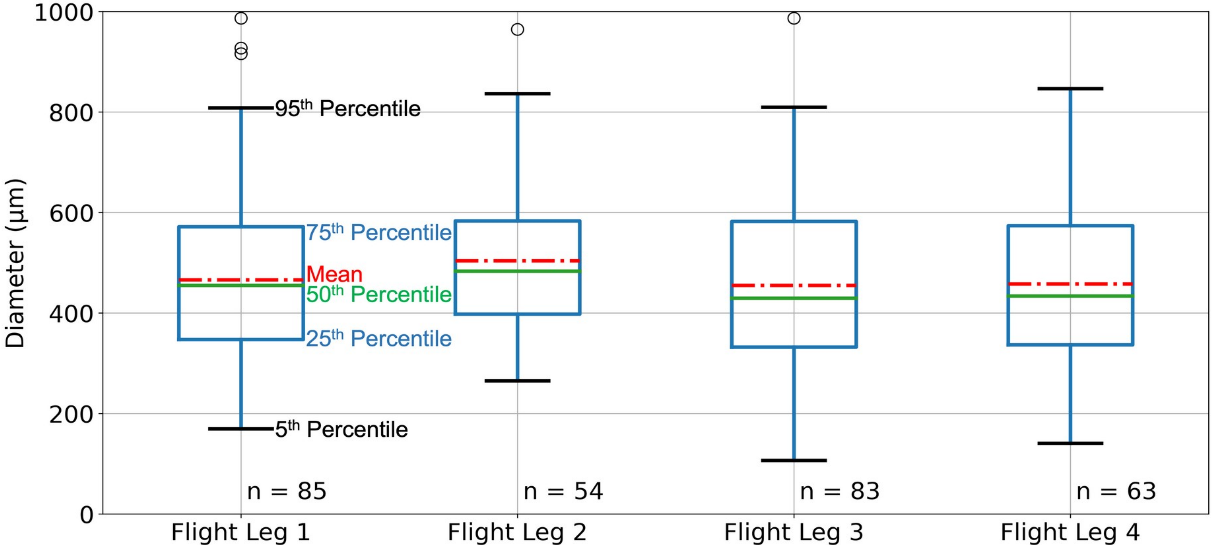
3 August 2019 Flight Legs
(2019 년 8 월 3 일 비행 다리)

Images showing flight legs (white line with arrow) for the 3 August 2019 storm overlaid on the closest (timestamp in white text) Melbourne, Florida (KMLB) National Weather Service (NWS) Next-Generation Radar (NEXRAD) composite radar reflectivity (dBZ). The flight leg arrow is at the flight leg end and shows the flight direction. The red circle gives the aircraft position at the radar timestamp, and images without a red circle have the radar scan finished after the flight leg ends.



PHIPS Images and Size Distribution (PHIPS 이미지 및 크기 분포)

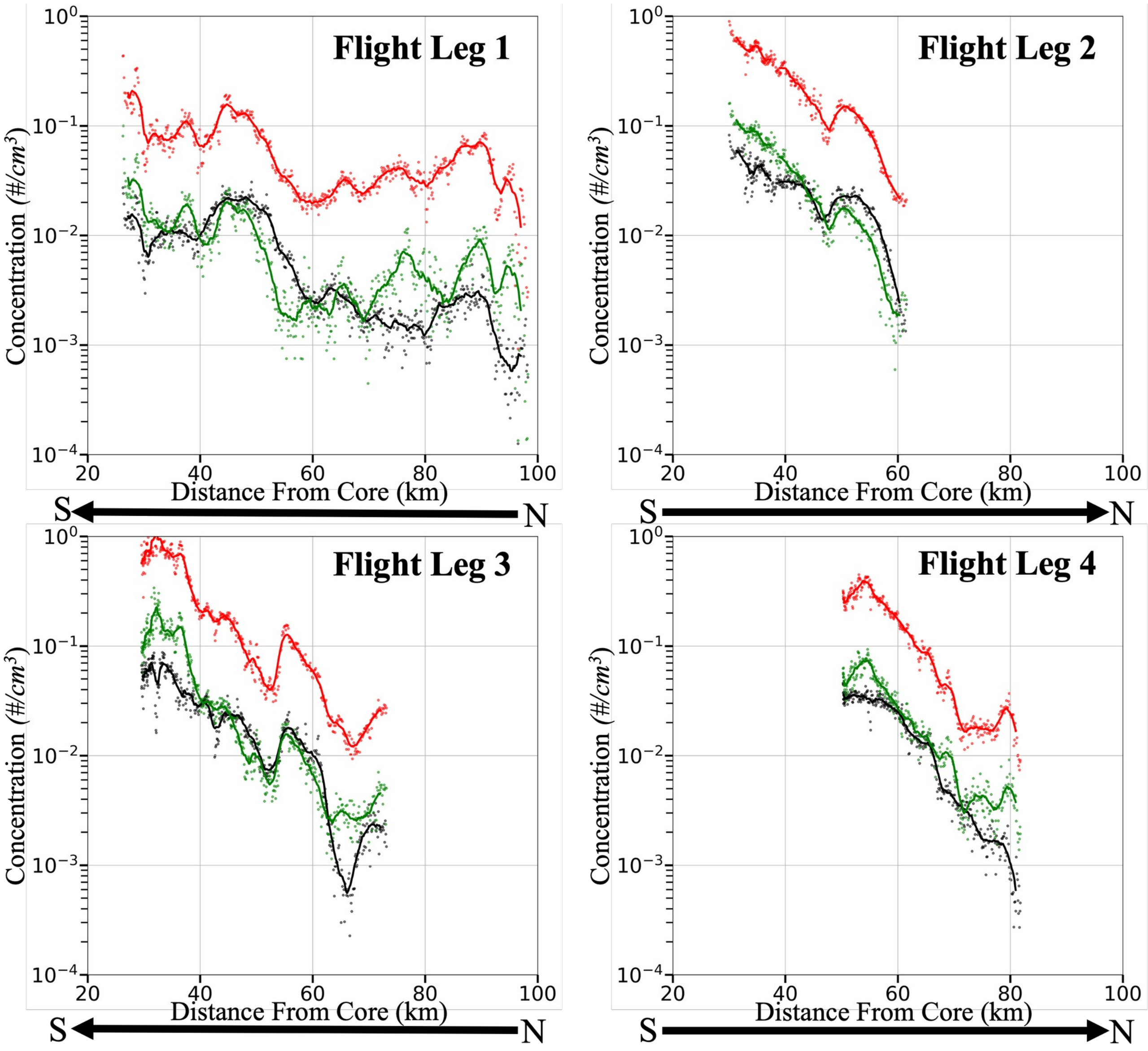




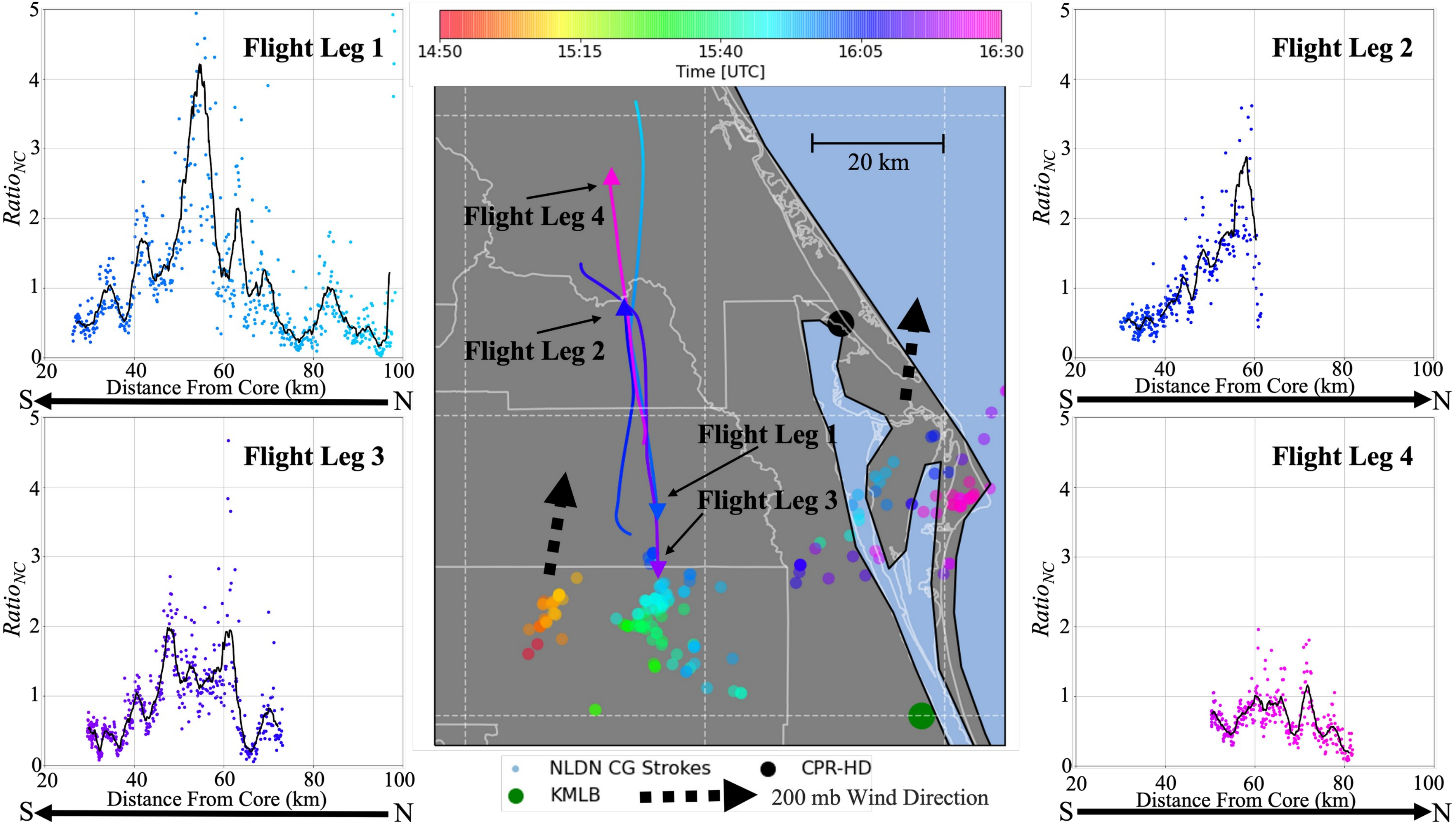
Type II chain aggregates with respect to distance from the storm core reflectivity centroid. Shown are the best chain aggregate view, with camera one denoted by the red boxes and camera two denoted by the blue boxes. Box-and-whisker plots showing the diameter ("fast-circle" method) distribution of the of Particle Habit Imaging and Polar Scattering (PHIPS) classified, type II chain aggregates. The diameter is only determined for chain aggregates that are completely ("all-in" method) within the image frame. The overall average diameters for the 25^{th}, 50^{th}, 75^{th} percentiles are 354, 450, and 578 μm, respectively.

CIP Concentrations (CIP 농도)

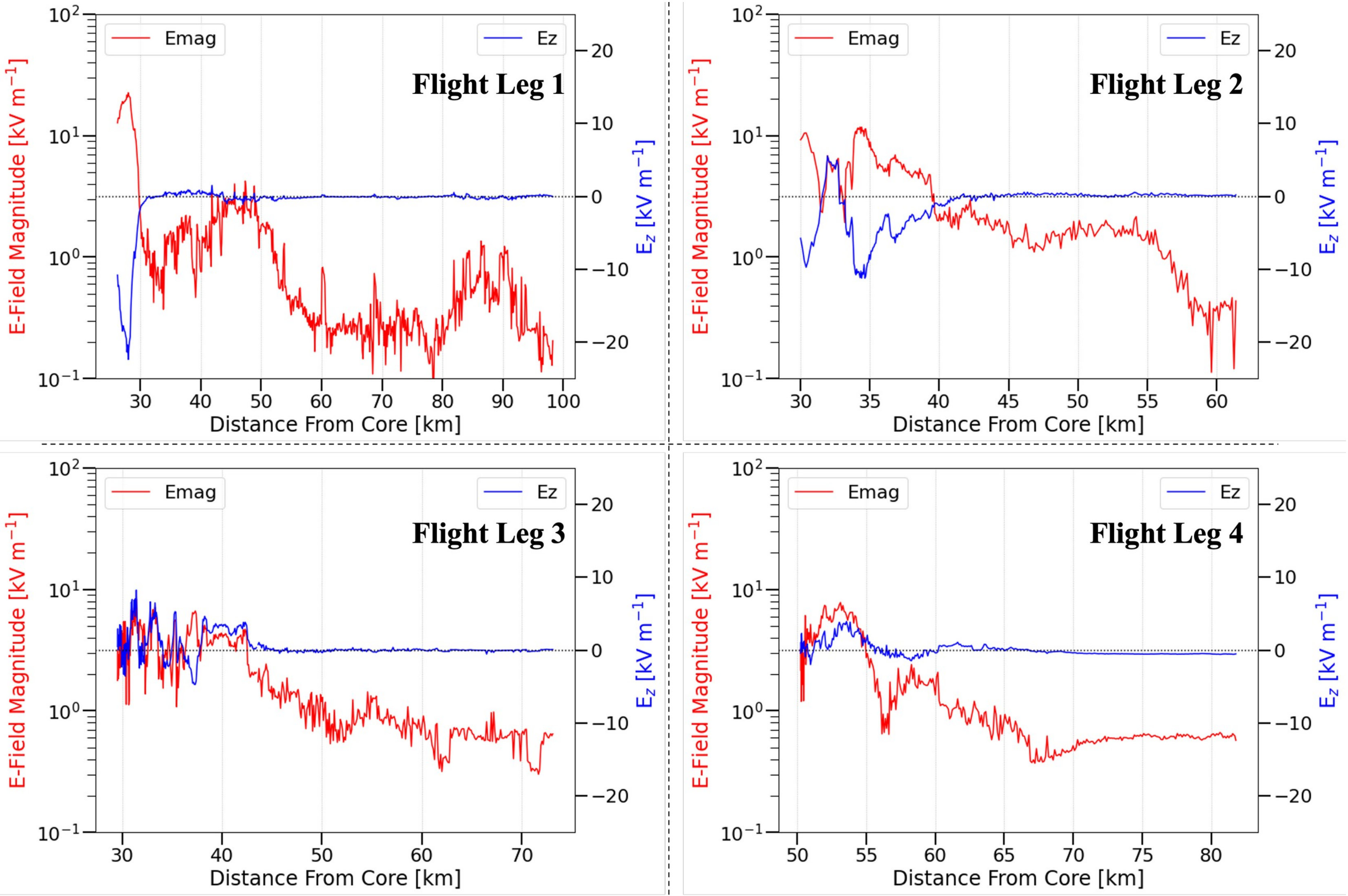
Plots showing the 1 Hz (points) and 20-point moving averages (solid lines) of Cloud Imaging Probe (CIP) derived **chain aggregate concentration (black)**, non-chain aggregate concentration (green), and total (red) particle number concentrations for each flight leg versus distance from the cell's reflectivity core centroid. The black arrow depicts the aircraft heading direction.

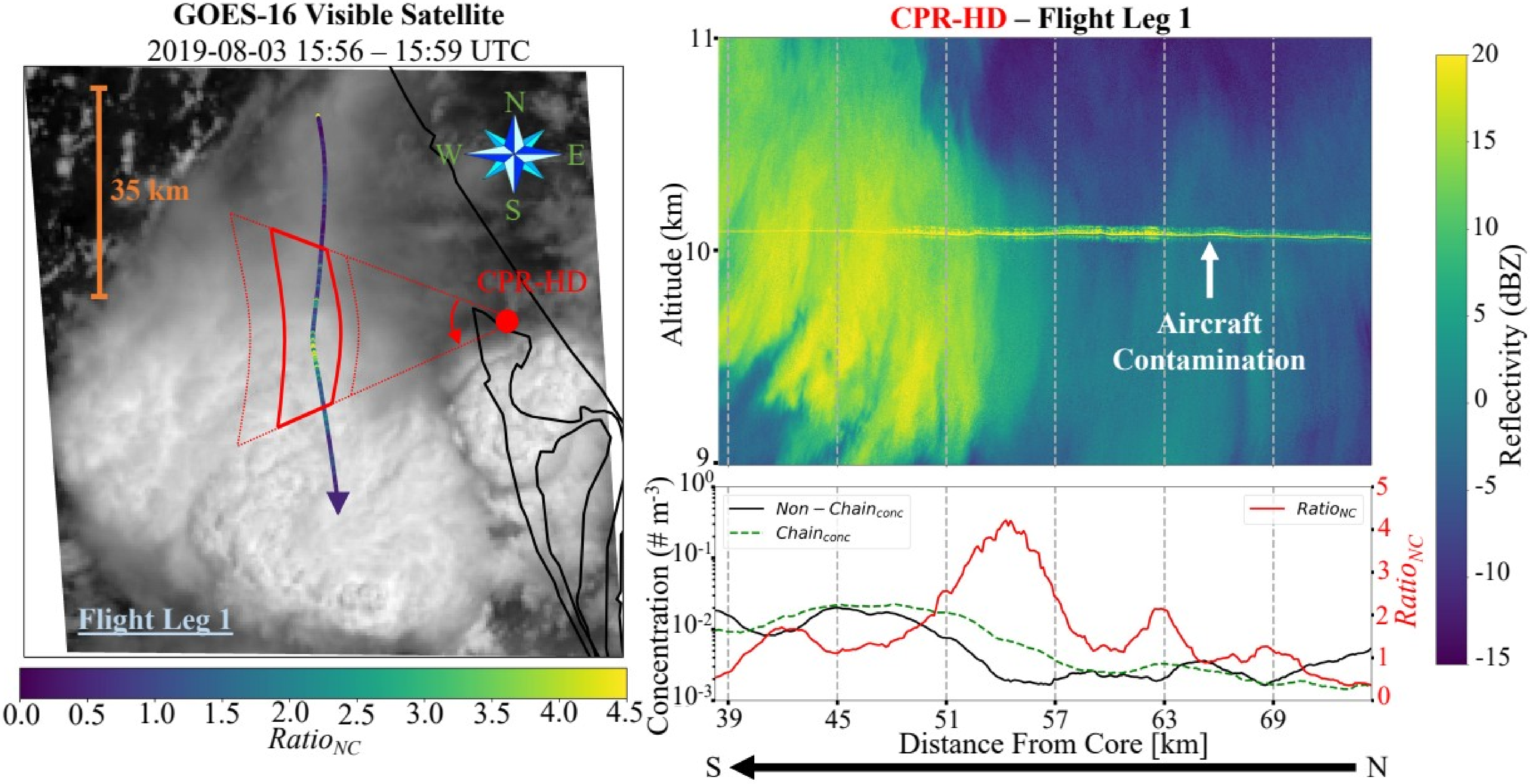


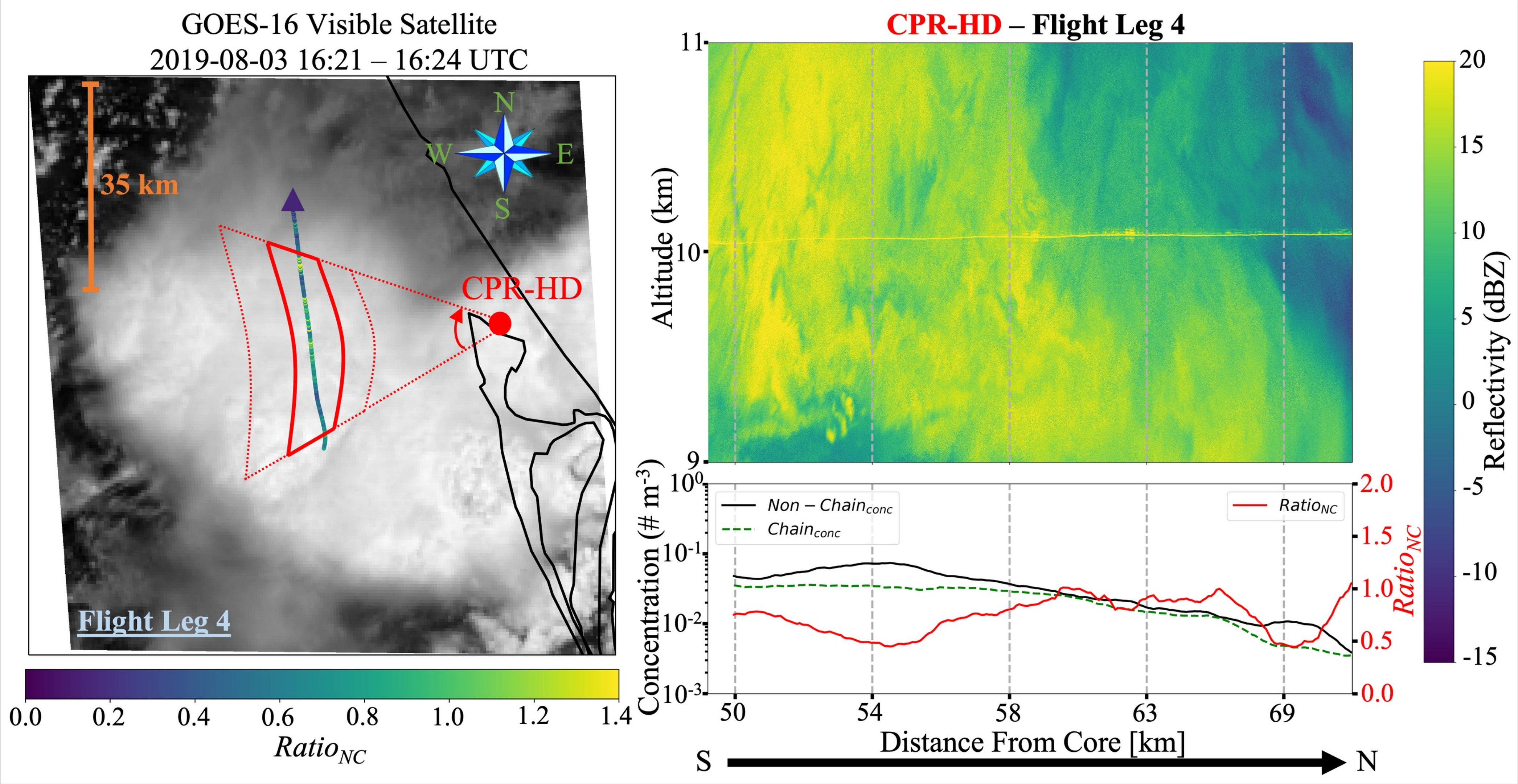
Chain Aggregate Ratio (체인 집합 비율)



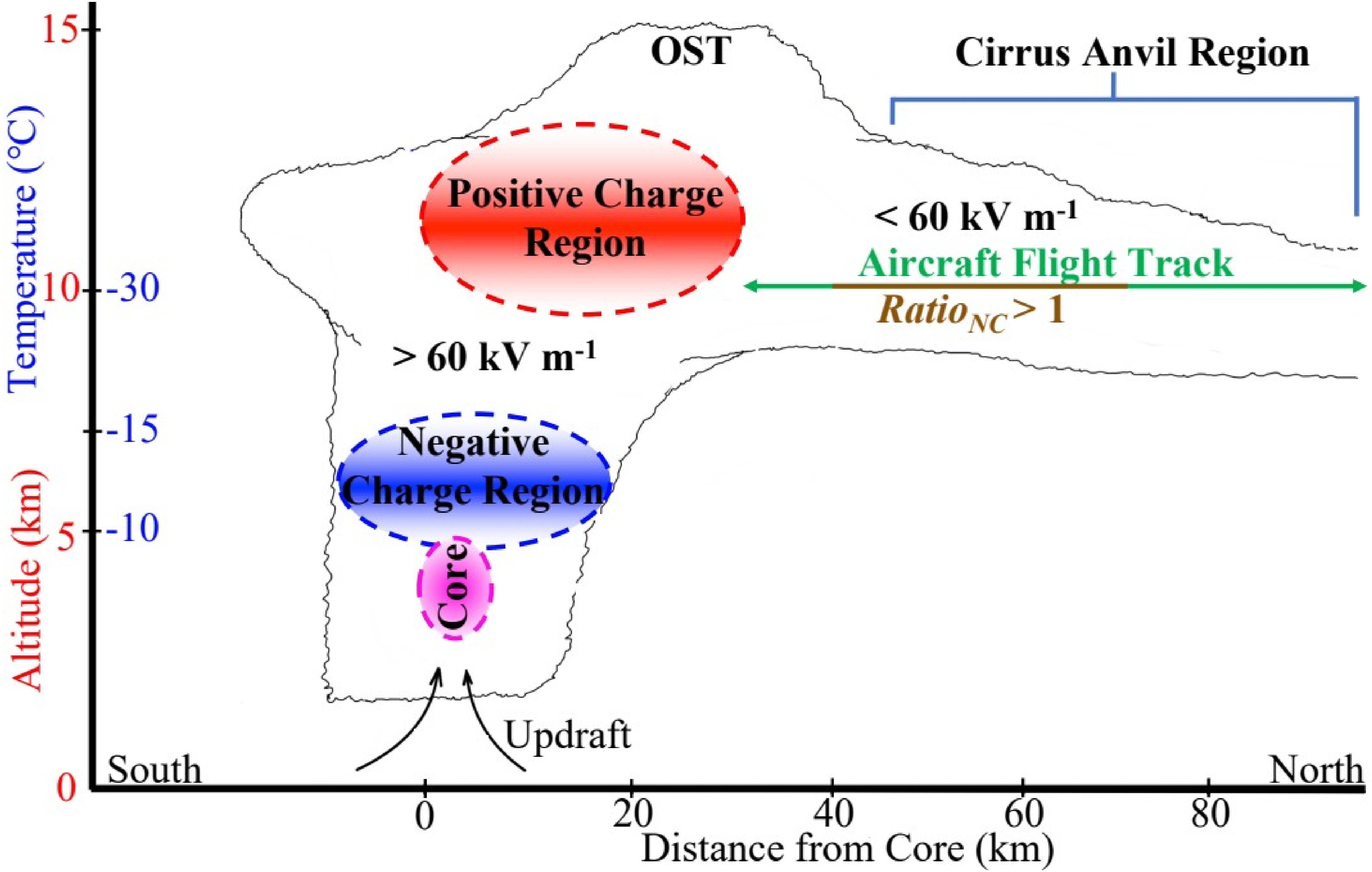
Aircraft-based Electric Field Measurements (항공기 기반 전기장 측정)




GOES-16 Visible Satellite
2019-08-03 15:56 – 15:59 UTC
35 km
N
W
E
S
CPR-HD
Flight Leg 1
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
$Ratio_{NC}$
CPR-HD – Flight Leg 1
Altitude (km)
Aircraft Contamination
Reflectivity (dBZ)
$Non-Chain_{conc}$
$Chain_{conc}$
$Ratio_{NC}$
Concentration (# m^{-3})
Distance From Core [km]
39 45 51 57 63 69
S
N



GOES-16 Visible Satellite
2019-08-03 16:21 – 16:24 UTC
35 km
N
W
E
S
CPR-HD
Flight Leg 4
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4
Ratio_NC
CPR-HD – Flight Leg 4
Altitude (km)
11
10
9
Reflectivity (dBZ)
20 15 10 5 0 -5 -10 -15
Concentration (# m^-3)
10^0
10^-1
10^-2
10^-3
Non – Chain_conc
Chain_conc
Ratio_NC
2.0 1.5 1.0 0.5 0.0
50 54 58 63 69
Distance From Core [km]
S
N


OST
Cirrus Anvil Region
Positive Charge Region
< 60 kV m-1
Aircraft Flight Track
Ratio$_{NC}$ > 1
> 60 kV m-1
Negative Charge Region
Core
Updraft
South
North
Temperature (°C)
Altitude (km)
15
10
5
0
-30
-15
-10
0
20
40
60
80
Distance from Core (km)

Conclusions (결론)

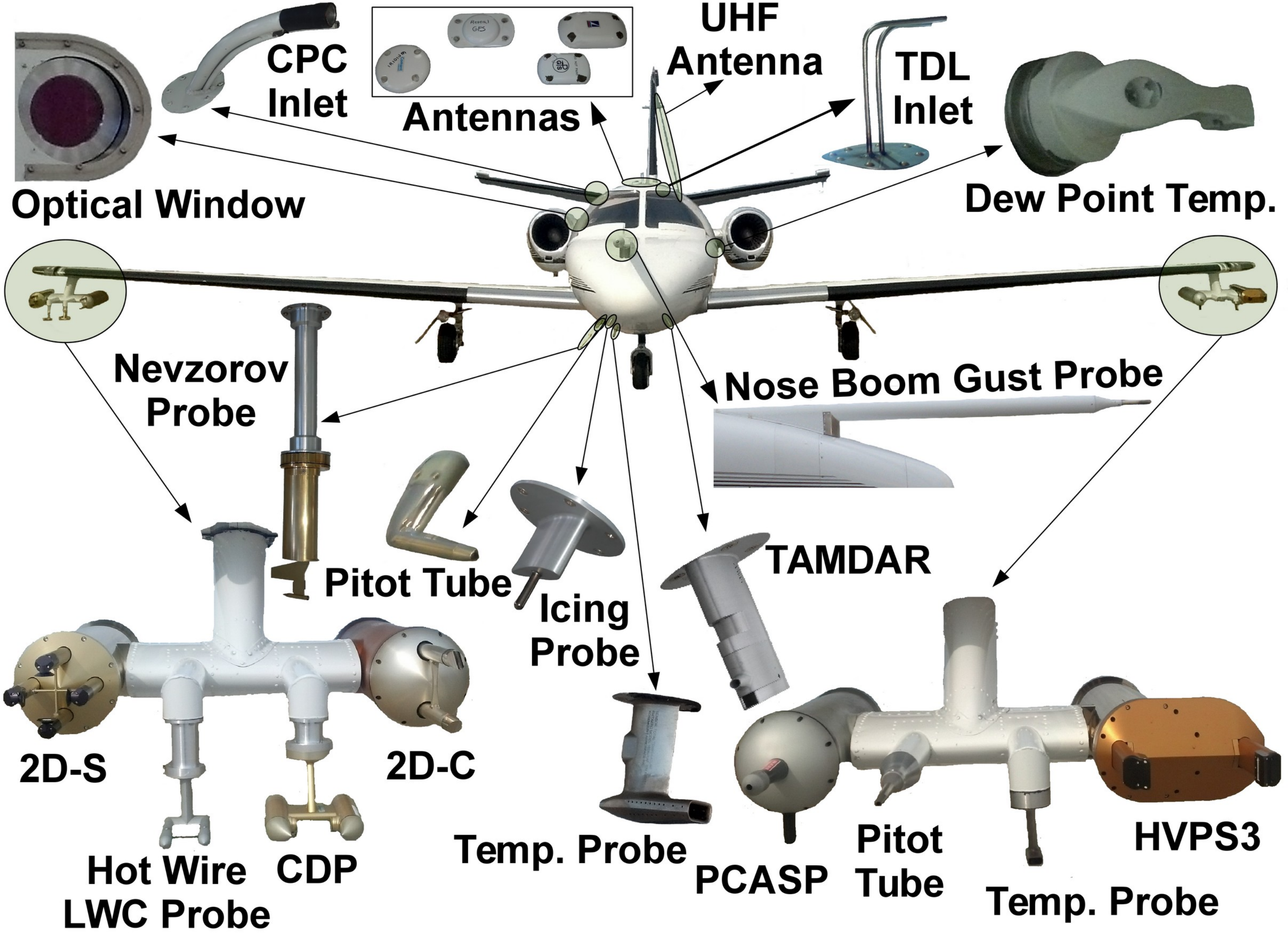
- The relative concentration of chain aggregates increase away for the convective core as the cloud becomes more diffuse.
  (구름이 더 확산됨에 따라 대류 코어에 대한 사슬 집합체의 상대적 농도 가 증가합니다.)
- The electric field magnitudes do not surpass ~60 kV m^{-1} magnitude threshold for enhance chain aggregation.
  (전기장 크기는 체인 집합 강화를 위해 ~60kV m^{-1} 크기 임계값을 초과하지 않습니다.
    - However, we conclude that chain aggregation is occurring in the cirrus cloud anvil region.
      (그러나 우리는 권운 모루 지역에서 사슬 응집이 일어나고 있다고 결론을 내립니다.)

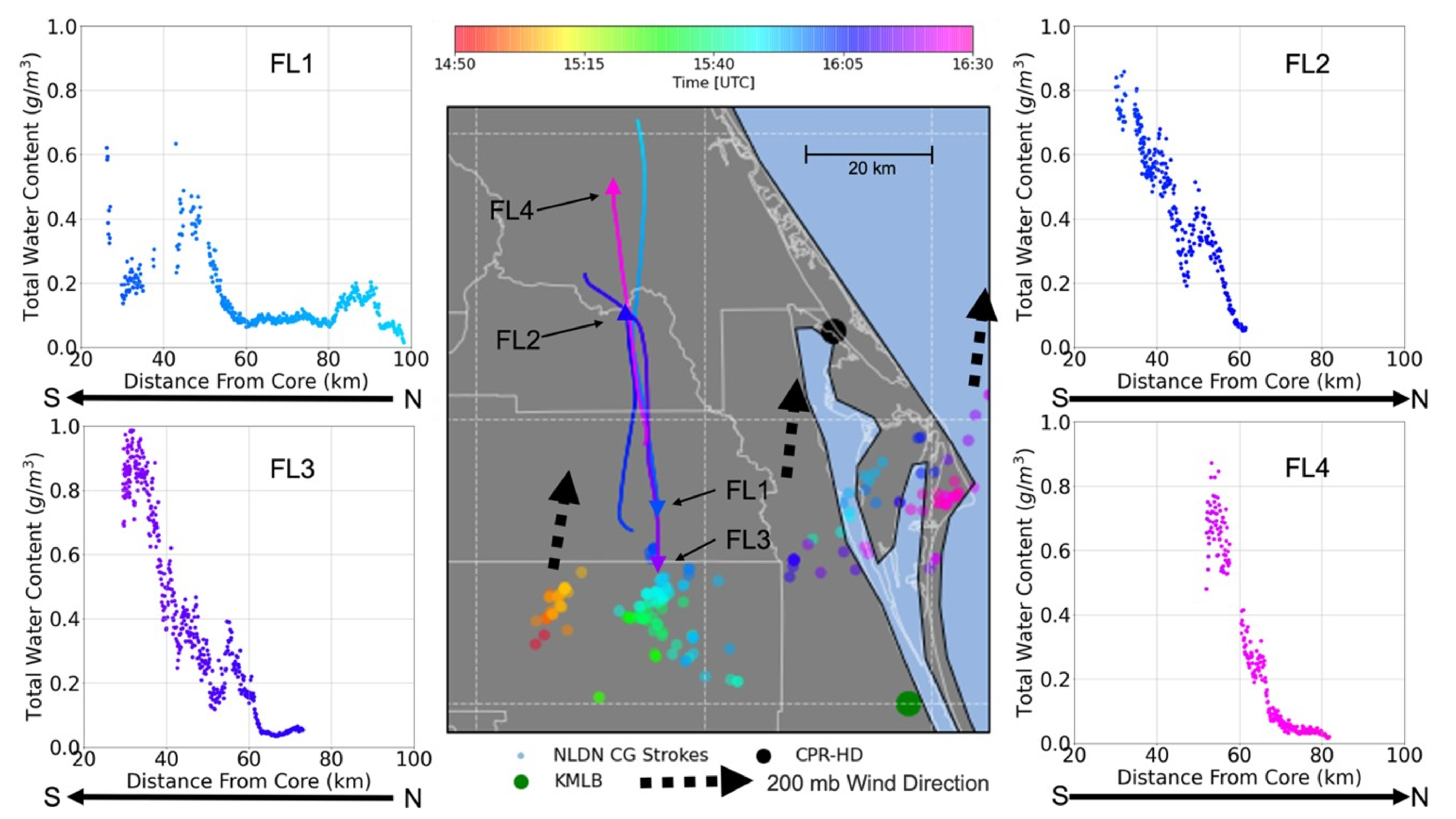
Thank You, Team Effort（감사합니다，팀 노력）

Nairy, Christian M., David J. Delene, Jerome M. Schmidt, Paul R. Harasti, Emma Järvinen, Case Study of Chain Aggregates in Florida Cirrus Cloud Anvils from Electrified Thunderstorms. Journal of Geophysical Research: Atmospheres. In Preparation 2024.

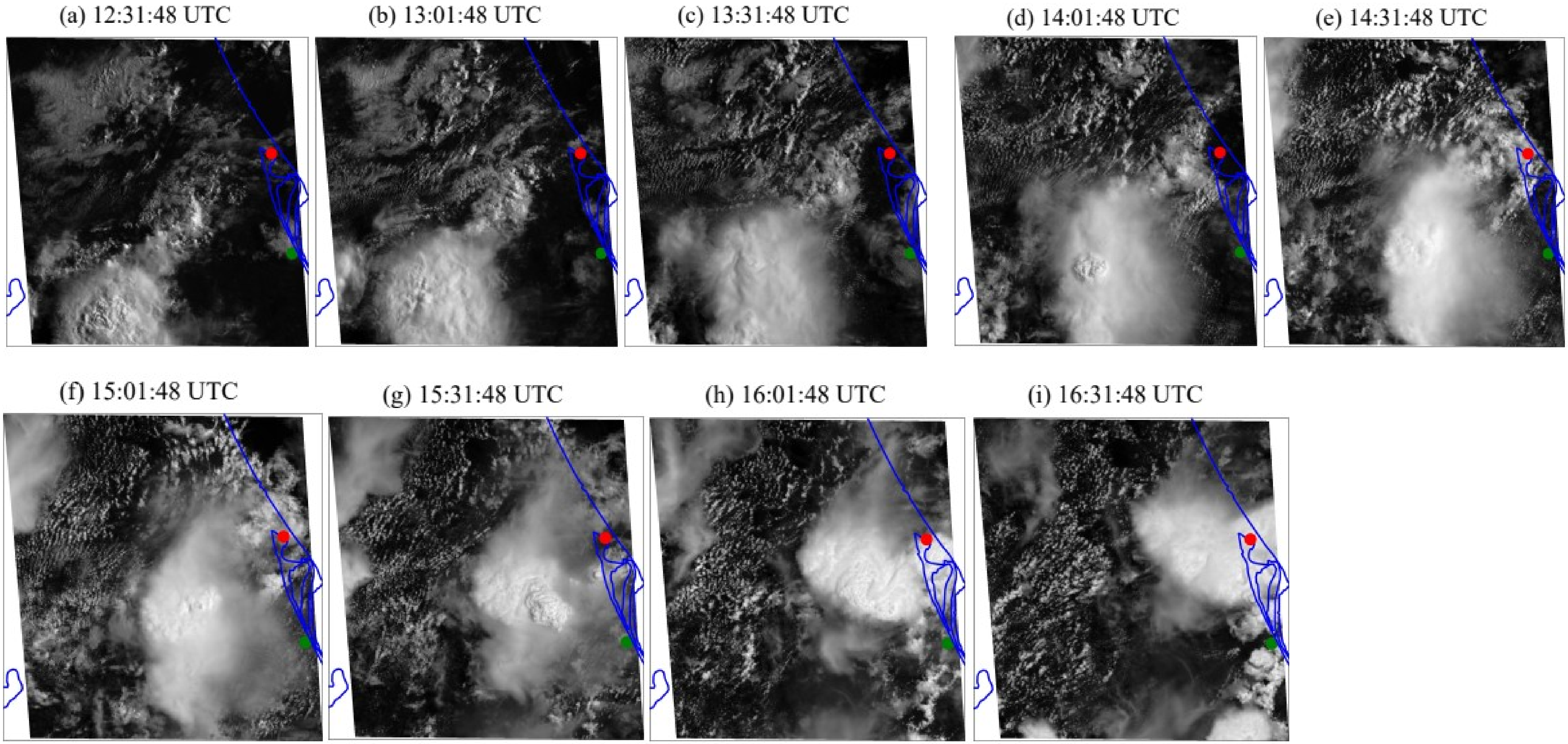
2015
7 Flights

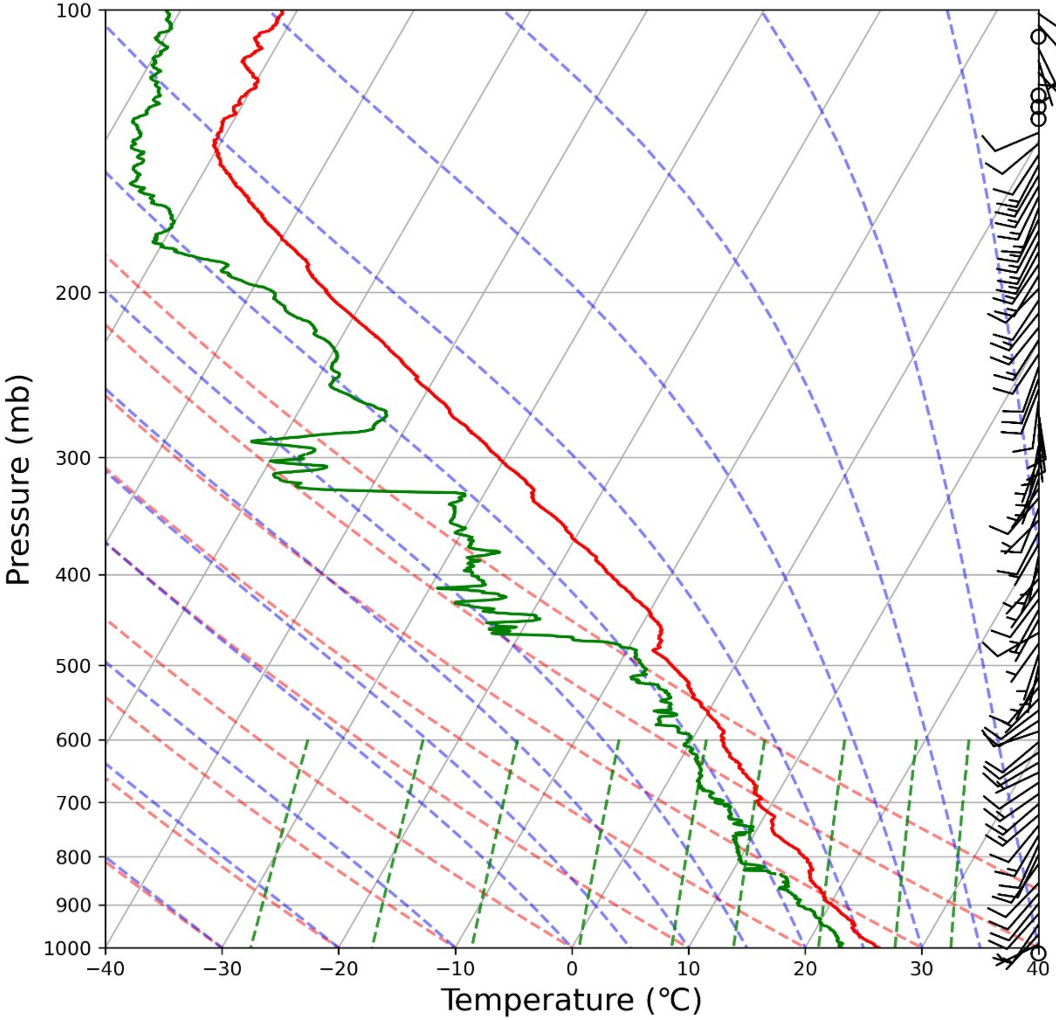
July 29
July 30
July 31
August 1-a
August 1-b
August 2
August 8

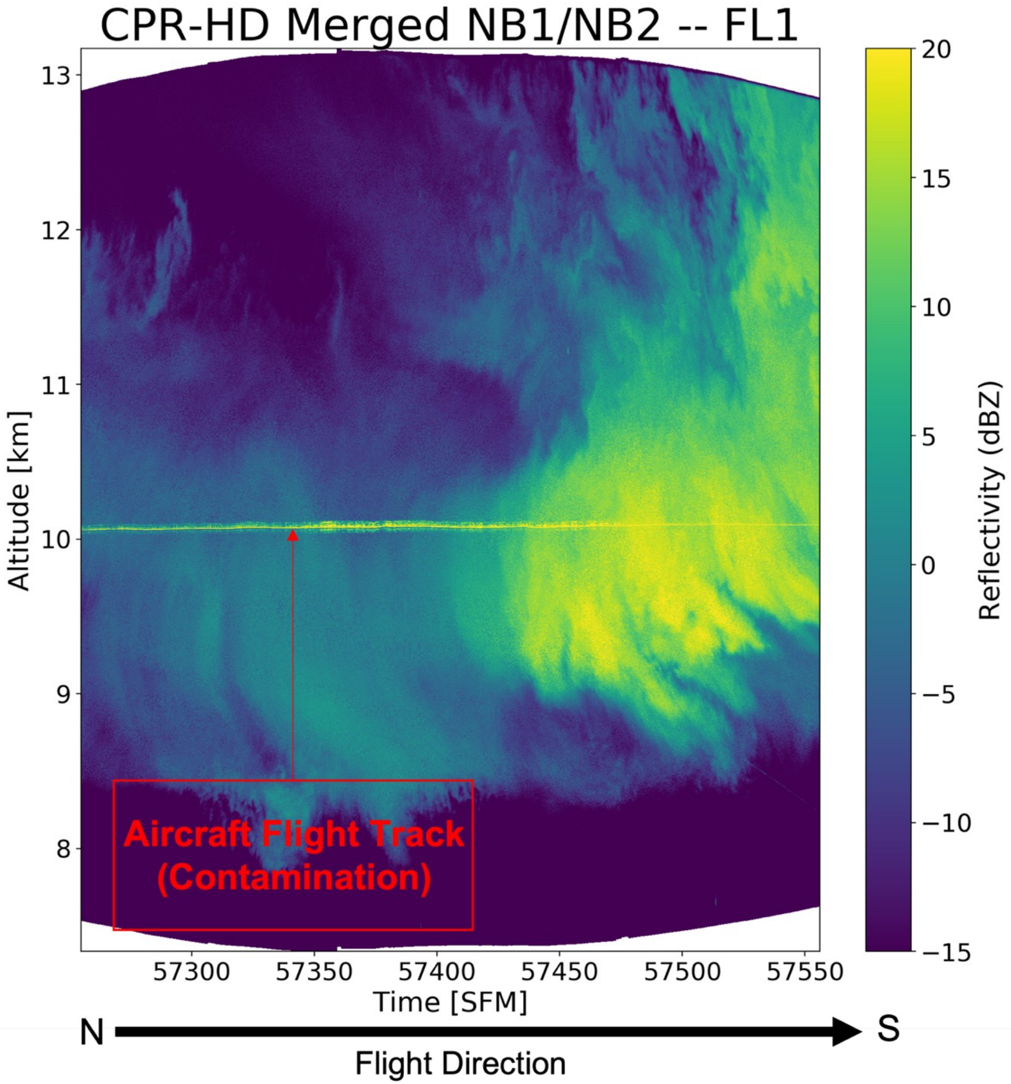


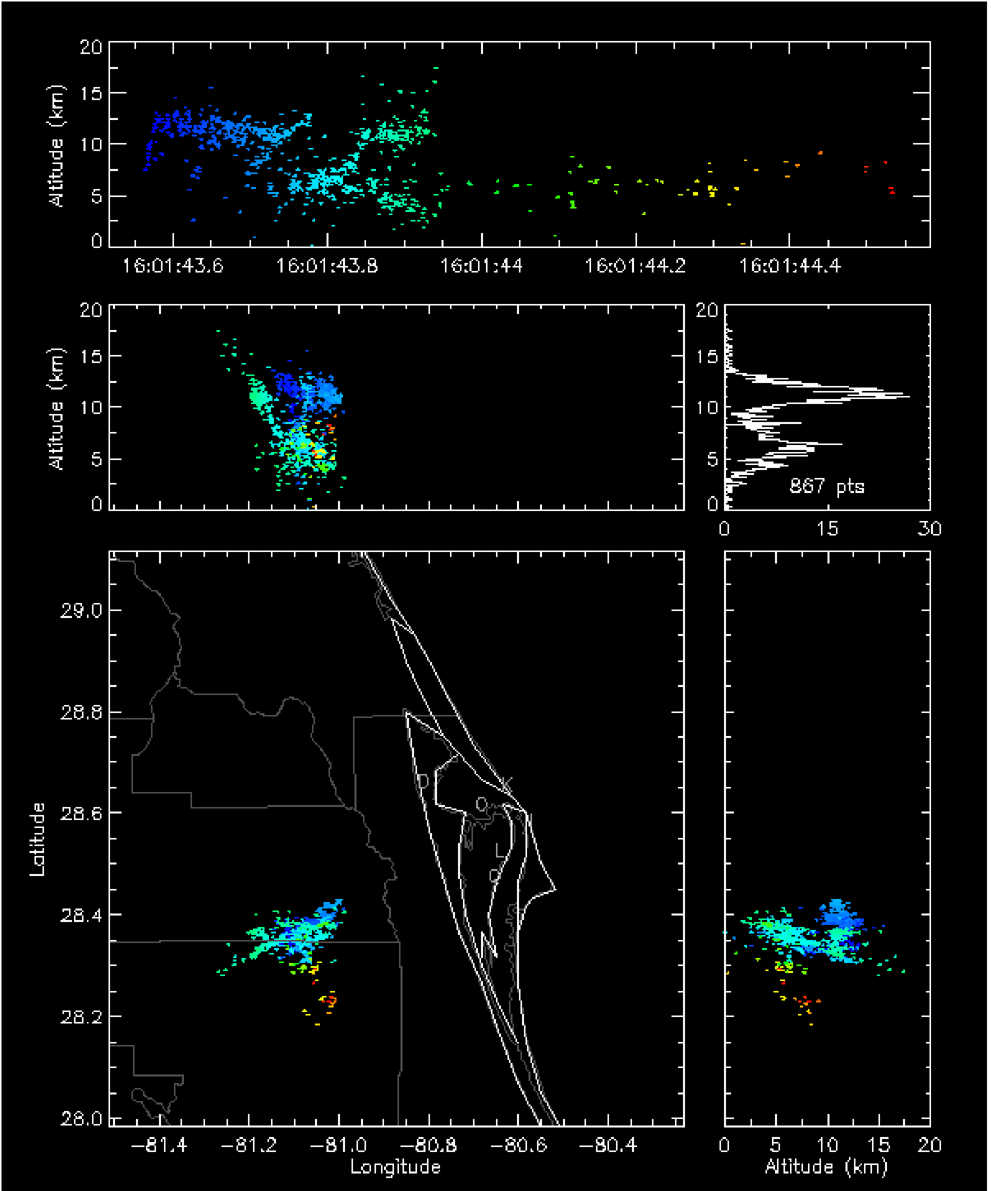

FL1
FL2
FL3
FL4
Total Water Content (g/m^3)
Distance From Core (km)
S
N
14:50
15:15
15:40
16:05
16:30
Time [UTC]
20 km
NLDN CG Strokes
CPR-HD
KMLB
200 mb Wind Direction

Visible (Red – CO2) GOES-16 Satellite Image, 3 August 2019

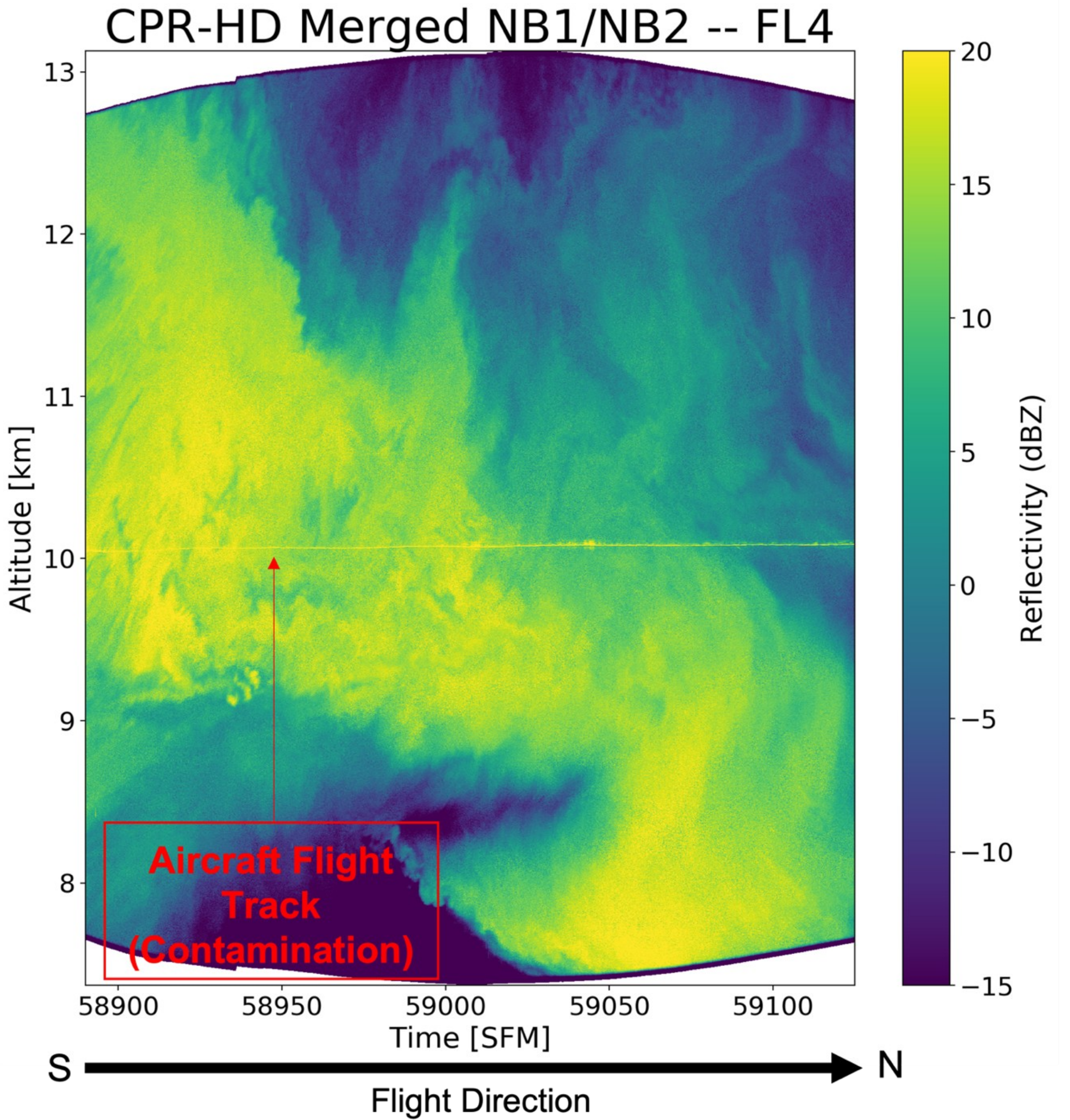



Pressure (mb)
Temperature (°C)
100
200
300
400
500
600
700
800
900
1000
−40
−30
−20
−10
0
10
20
30
40


CPR-HD Merged NB1/NB2 -- FL1
Altitude [km]
Time [SFM]
Reflectivity (dBZ)
Aircraft Flight Track
(Contamination)
N
S
Flight Direction
8
9
10
11
12
13
57300
57350
57400
57450
57500
57550
20
15
10
5
0
−5
−10
−15



Altitude (km)
16:01:43.6
16:01:43.8
16:01:44
16:01:44.2
16:01:44.4
867 pts
Latitude
Longitude
Altitude (km)



CPR-HD Merged NB1/NB2 -- FL4
Altitude [km]
Aircraft Flight Track (Contamination)
Time [SFM]
Reflectivity (dBZ)
S
N
Flight Direction

2019/08/03 Tracking Along-Track Narrow Band Reflectivity