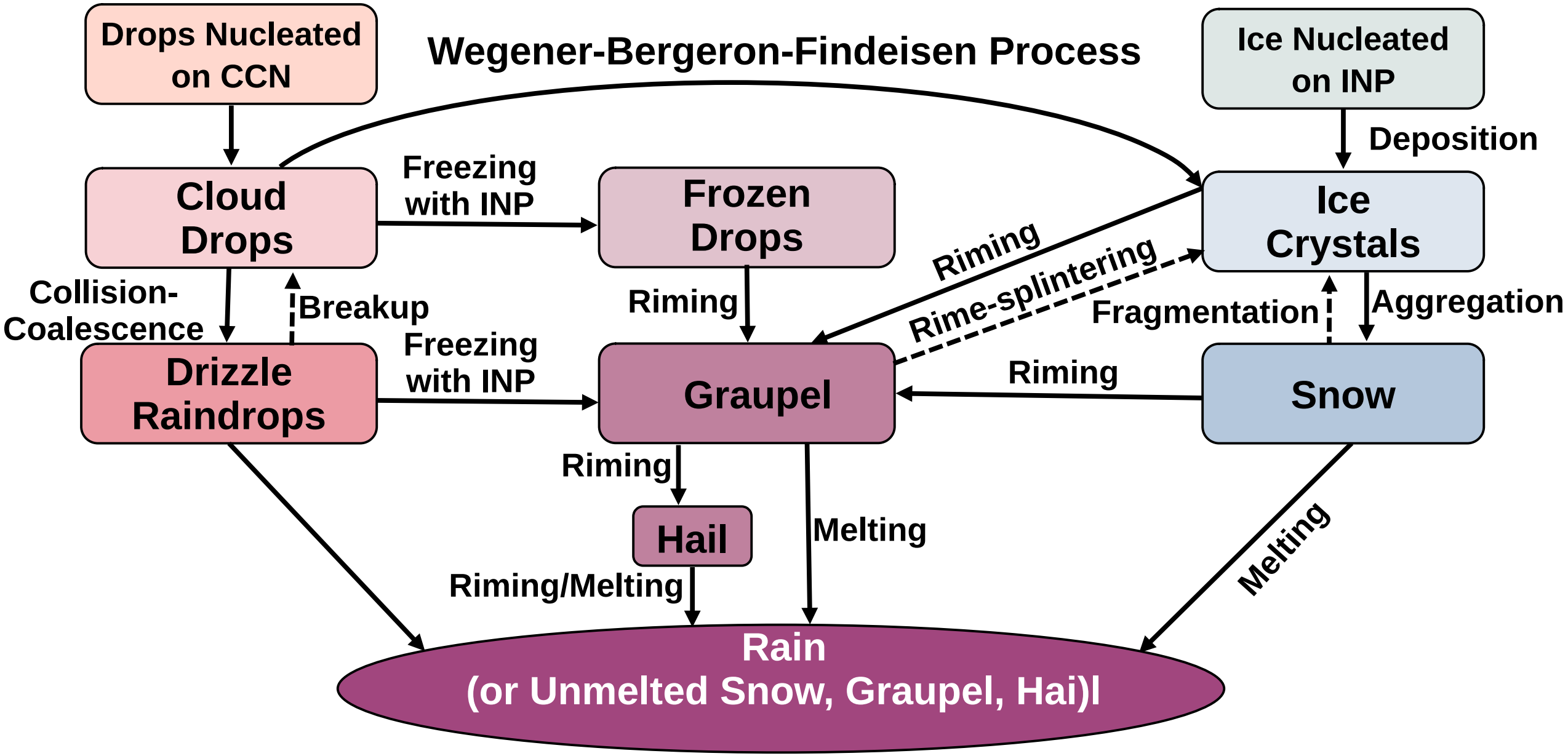
Cloud Aggregation

David Delene

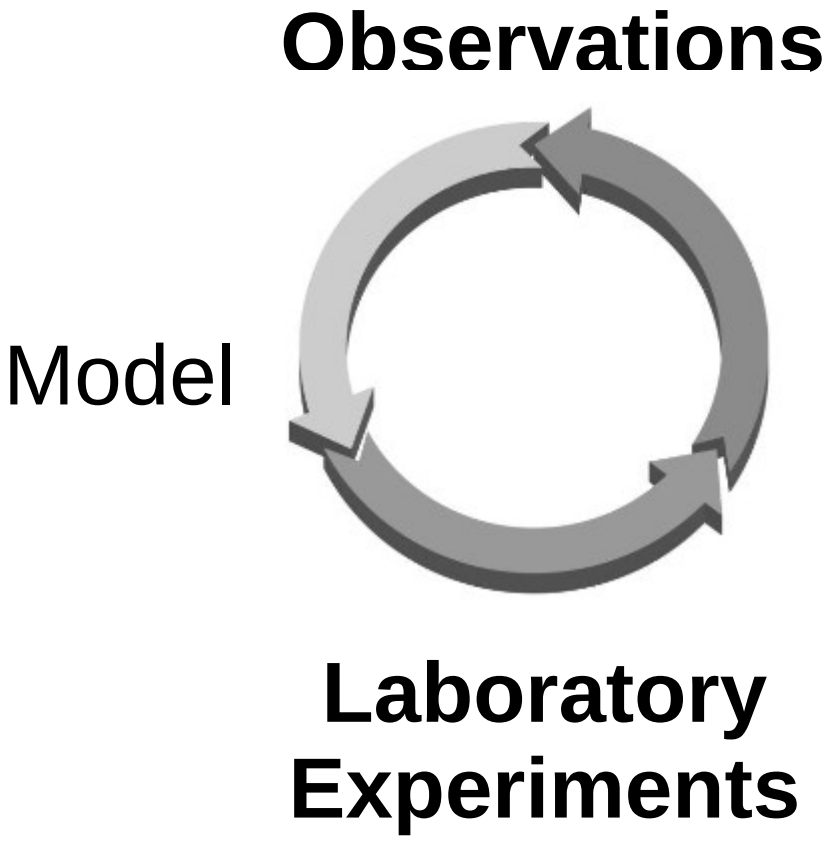
Thank All Team Members and Students
Christian Nairy, Ph.D Student

Microphysical Processes that Produce Precipitation



The Scientific Method

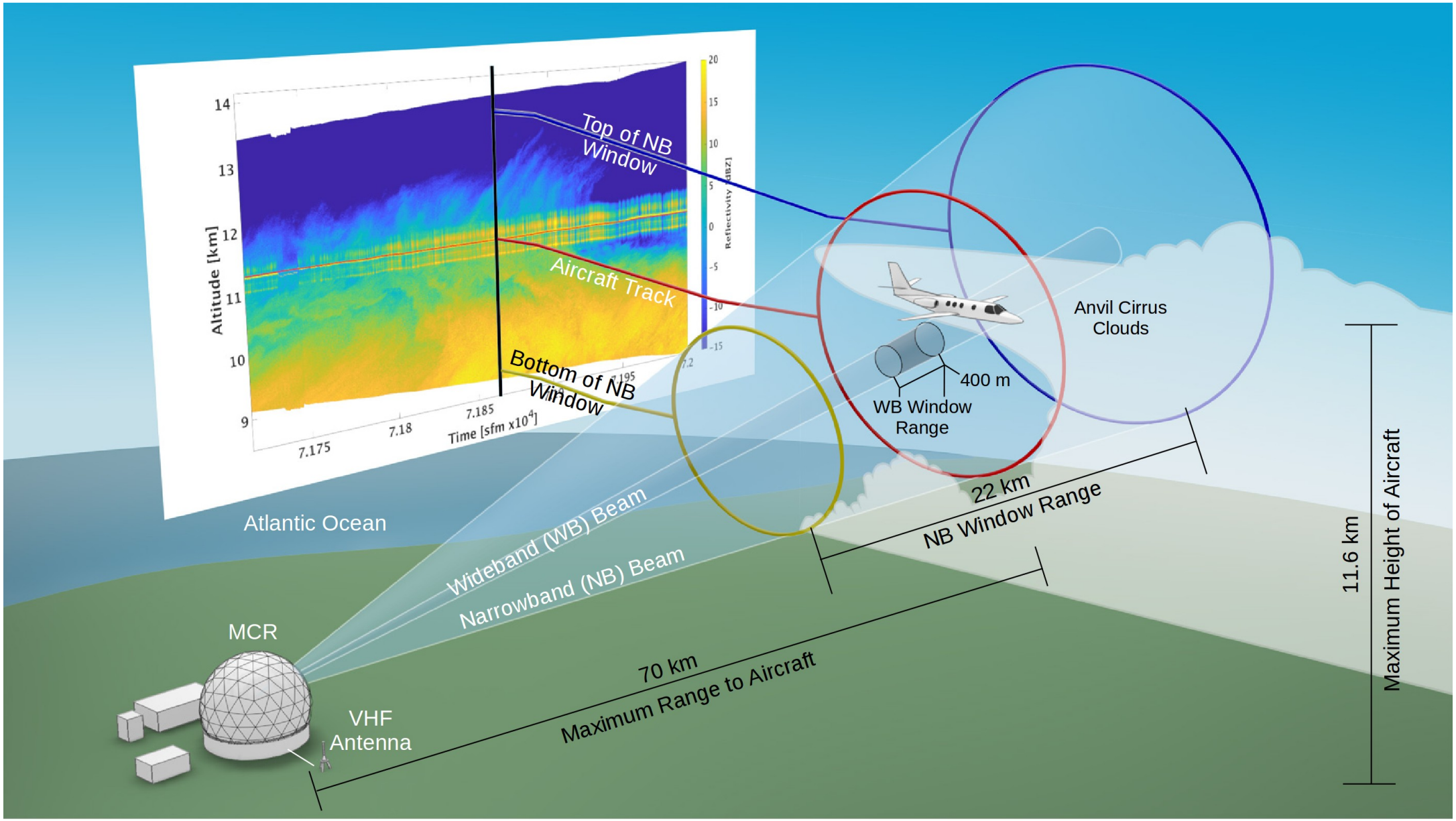
- **Observations**
  - The starting point of the scientific method.
- Questions
  - Why do we observe it?
- **Hypothesis**
  - What is a possible answer?
- **Laboratory Experiments**
  - Control variables during observations.
- Conclusion
  - Does the evidence supports or does not support the hypothesis.



Observations and Objectives

During the CAPE2015 and CapeEx19 field projects, cloud microphysical observations were obtained concurrent with CPR-HD radar observations to improve the understanding of radar operations and cirrus cloud models.

Cloud and Precipitation Radar with Discrete Hydrometeor Detection (CPR-HD)

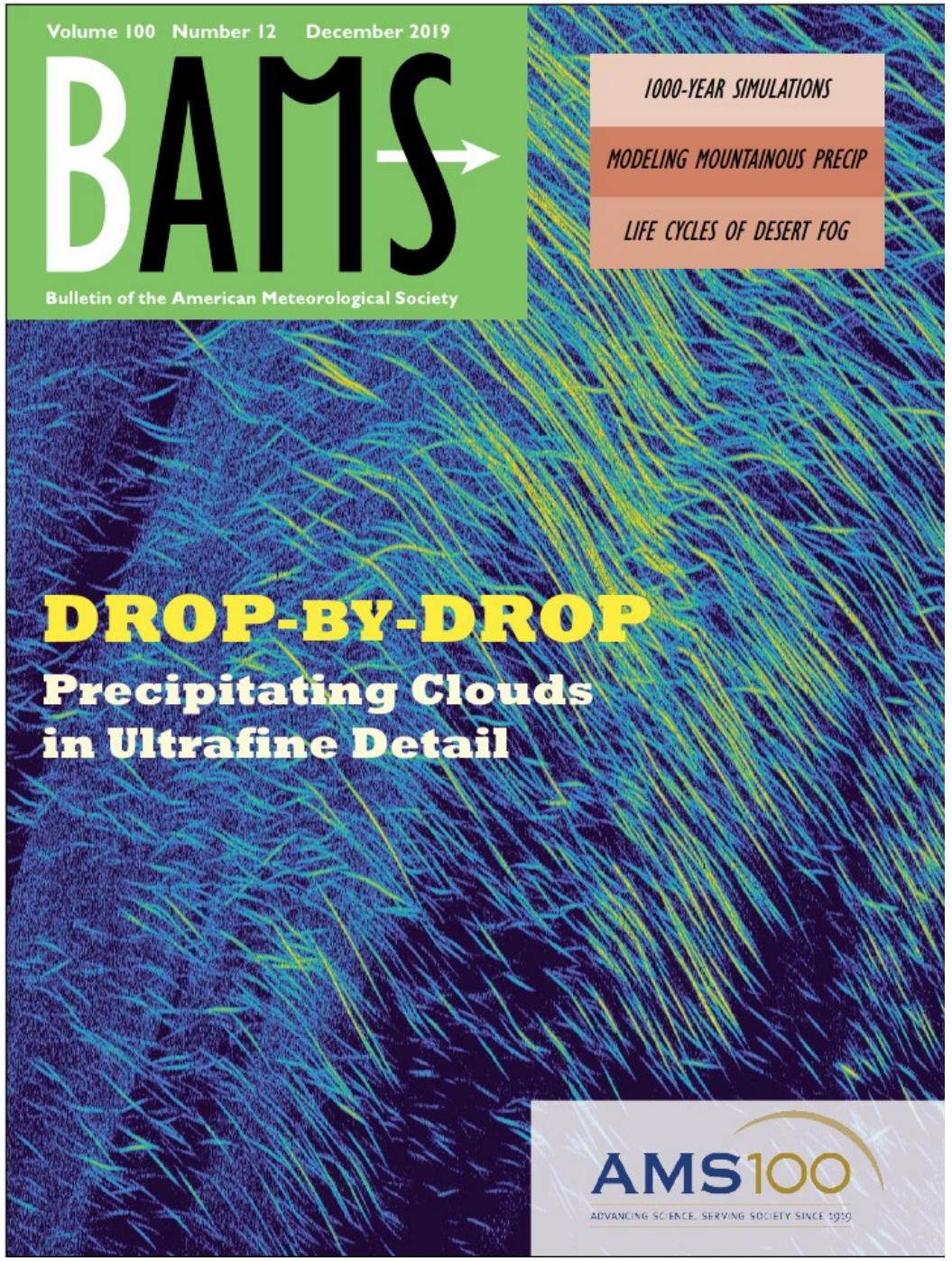


Gapp, Nicholas, David J. Delene, Jerome Schmidt, and Paul Harasti, 2025: Comparison of Concurrent Radar and Aircraft Measurements of Cirrus Clouds, Journal of Atmospheric Sciences, 82, 15-176, https://doi.org/10.1175/JAS-D-24-0014.1.

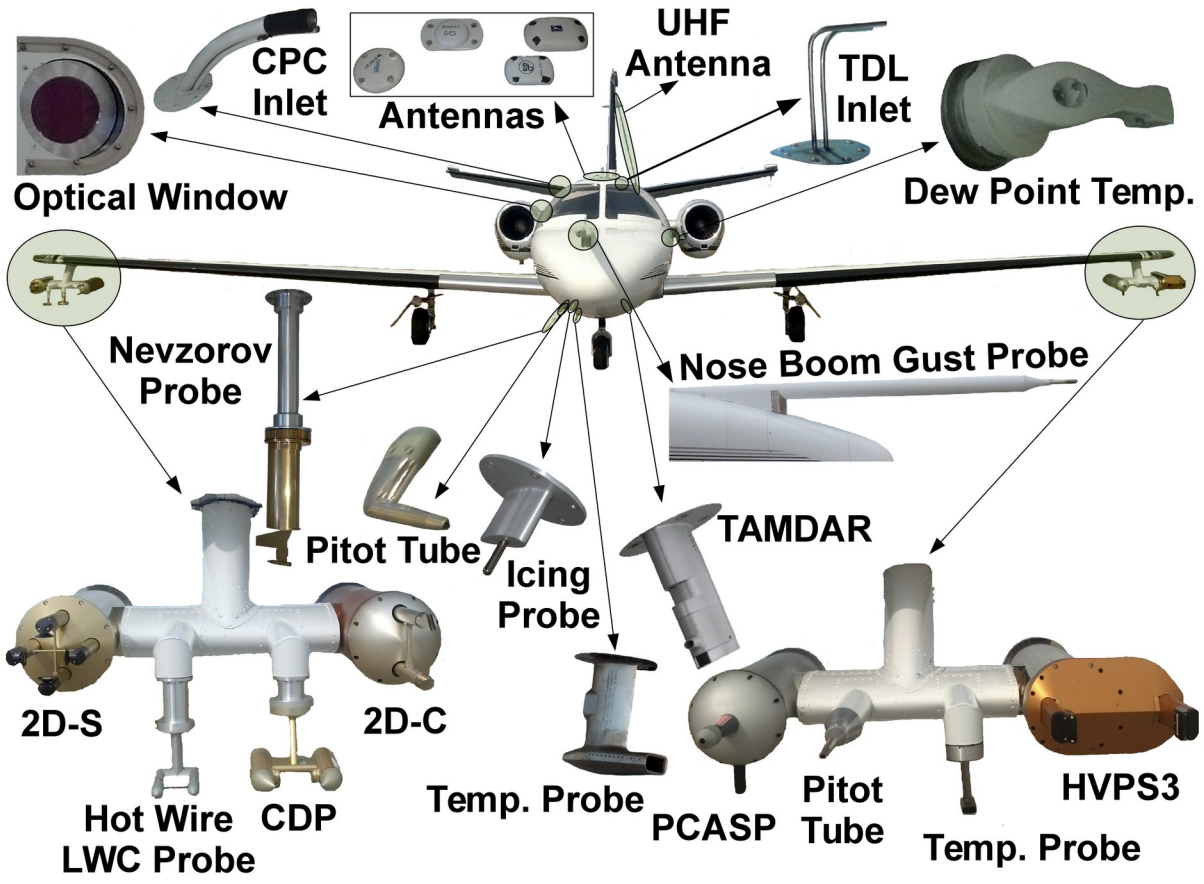
Detection of Individual Drops

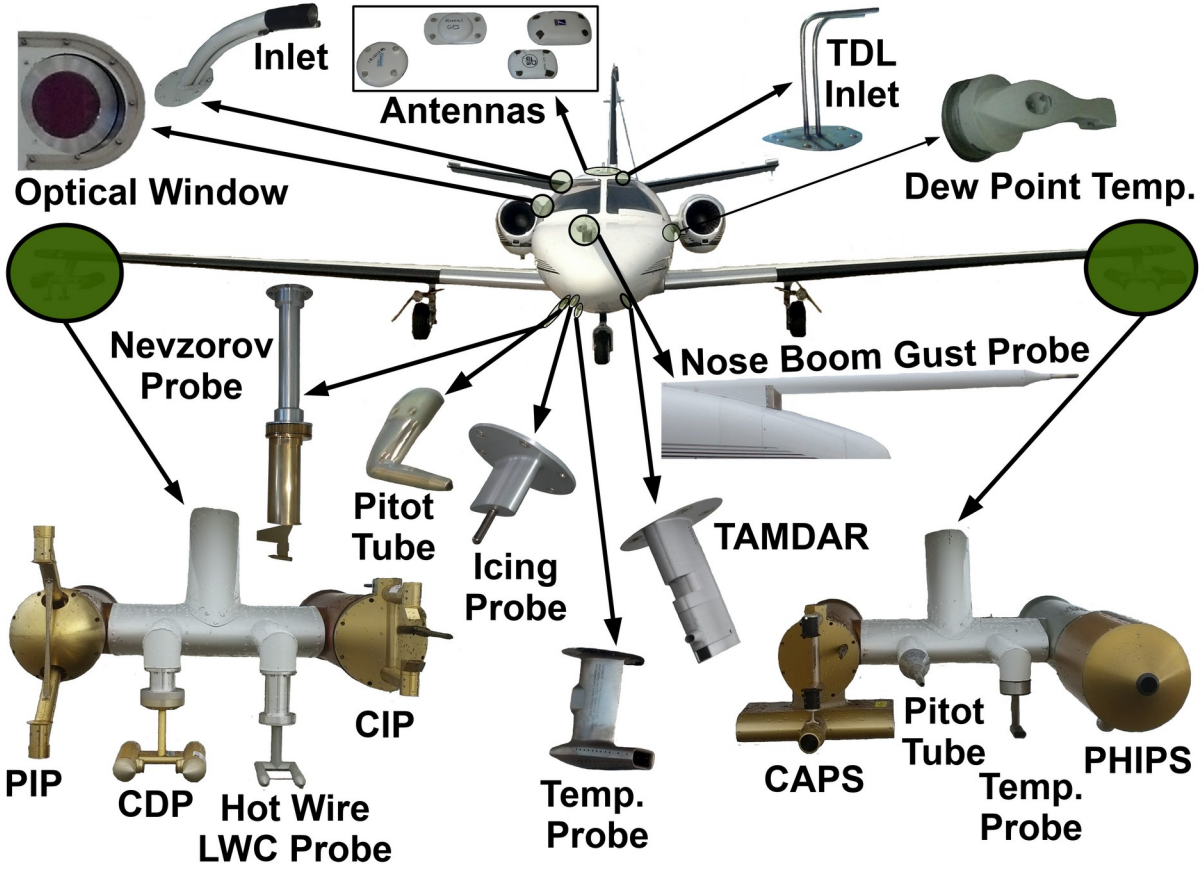
Parameter	MCR	UND North Pol	CSU CHILL	NCAR S-Pol	WSR-88D	KAZR
Frequency (GHz)	5.4–5.9	5.6	2.725	2.7–2.9	2.7–3.0	34.86
Transmit polarization	Right circular	Linear H, V	Linear H, V, slant 45/135, right and left circular	Linear H, V	Linear H, V	Linear H
Receive polarization	Right and left circular	Linear H, V	Linear H, V, slant 45/135, right and left circular	Linear H, V	Linear H, V	Co-/cross polar
Antenna dish diameter (m)	15.24	3.66	8.5	8.5	8.5	2 to 3
Beamwidth (degrees)	0.22	0.99	1.1	0.91	0.925 at 2,850 MHz	0.31 to 0.19
Peak power (MW)	3	0.25	0.8 to 1.0	1.0	0.7	0.002
Maximum pulse rate (Hz)	320	1,000	1,250	1,300	1,304	10,000
Pulse width (*ms*)	12.5 (LFM)	0.6 to 2.0	0.2 to 1.6 (Gaussian)	0.3 to 1.4 (tapered)	1.57 to 4.71	0.03 to 12 (NLFM)
Maximum/ minimum range resolution (m)	0.543/34.0	90/300	30/150	38/1,000	250/1,000	30
Sensitivity at 5 km range [*Z* (dBZ)]	–57 (NB) –38 (WB)	-28	–24	–29	–28 to –37	–31
Sensitivity at 150 km range [*Z* (dBZ)]	–26 (NB) –8 (WB)	2	6	1	2 to –7	–1 (150 km range not attainable) –21 (at 15 km)
Typical scan range interval (km)	75 (NB) 0.3 (WB)	150	150	150	300 (Doppler) 460 (dBZ, dual-Pol)	15

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, 2019: Radar Detection of Individual Raindrops, Bulletin of the American Meteorological Society, 100, 2433-2450, https://doi.org/10.1175/BAMS-D-18-0130.1.



North Dakota Citation Research Aircraft

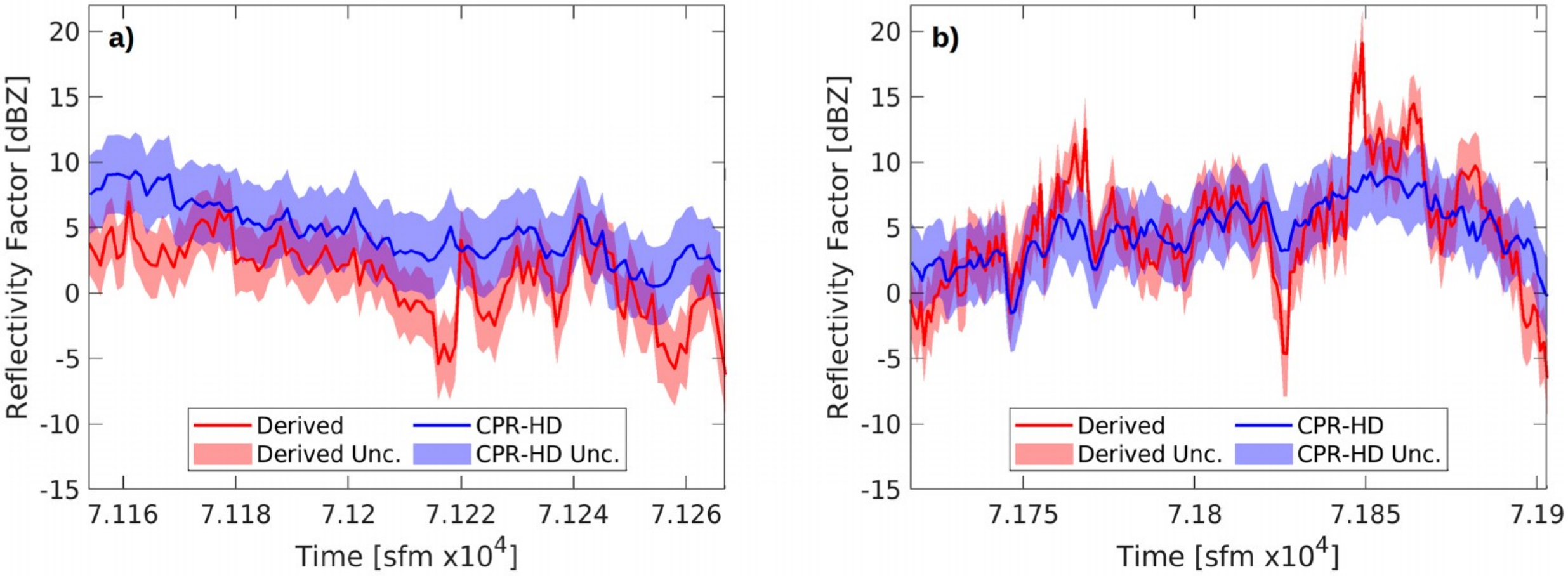




CAPE2015 – Summer 2015

CapeEx19 – Summer 2019

CPR-HD Measured and In-situ Cloud Probe Derived Reflectivity



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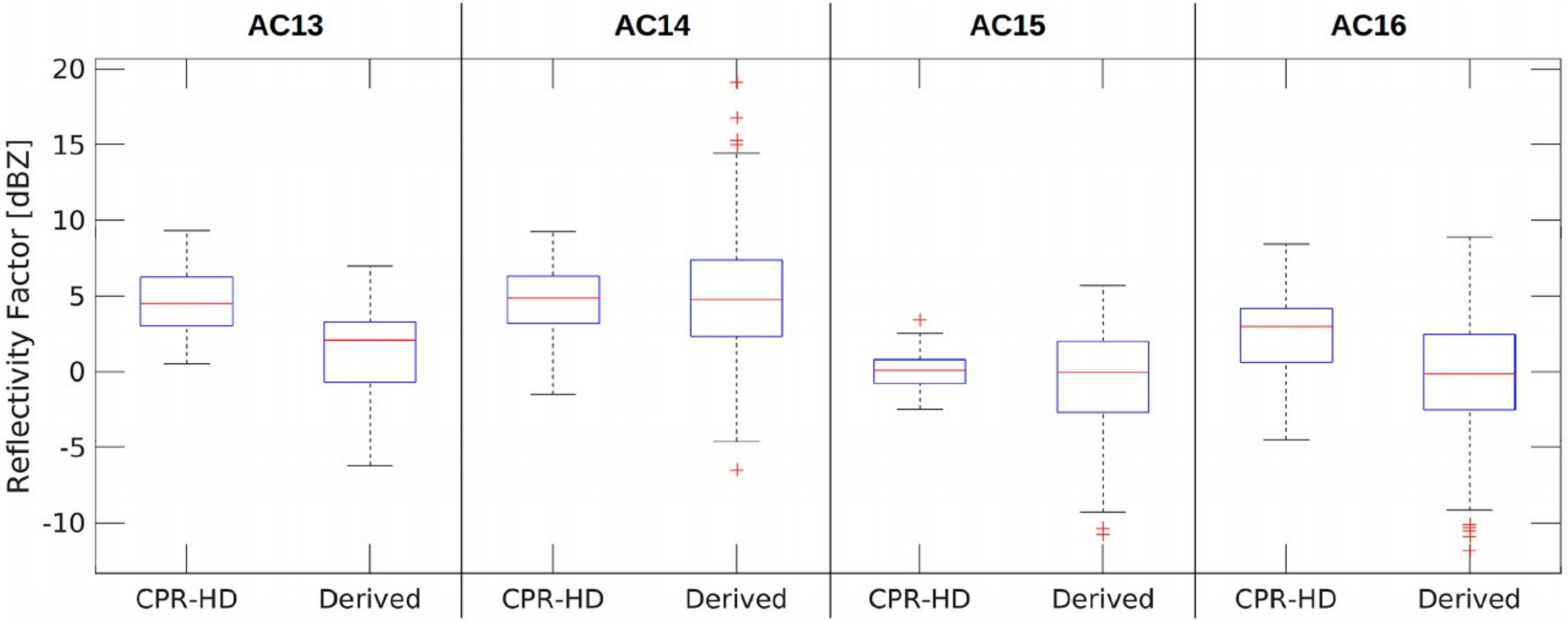

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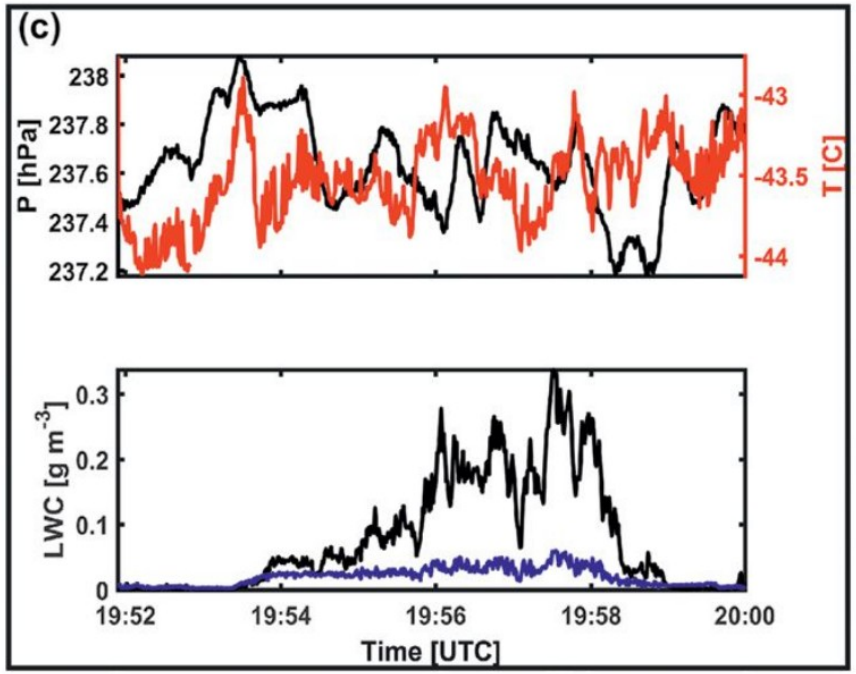
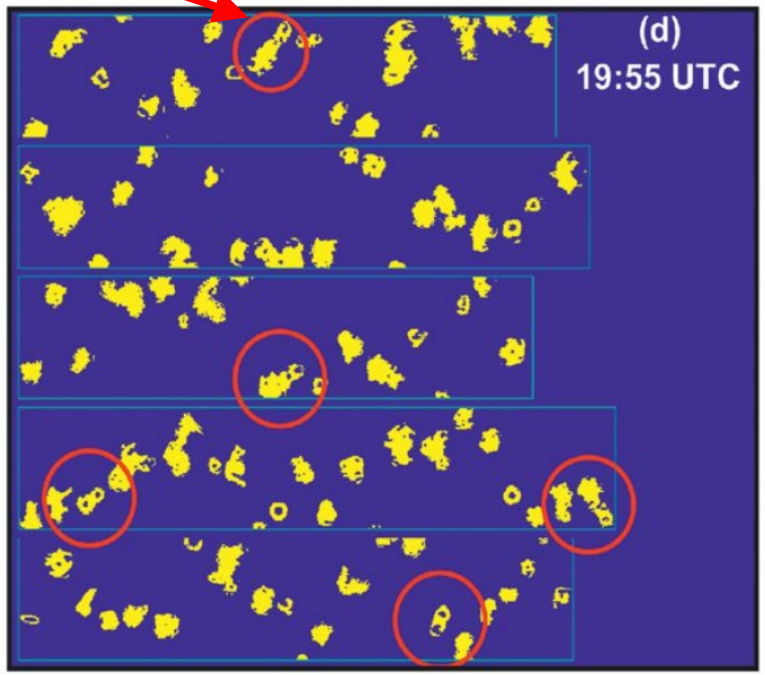
Chain-like Aggregates





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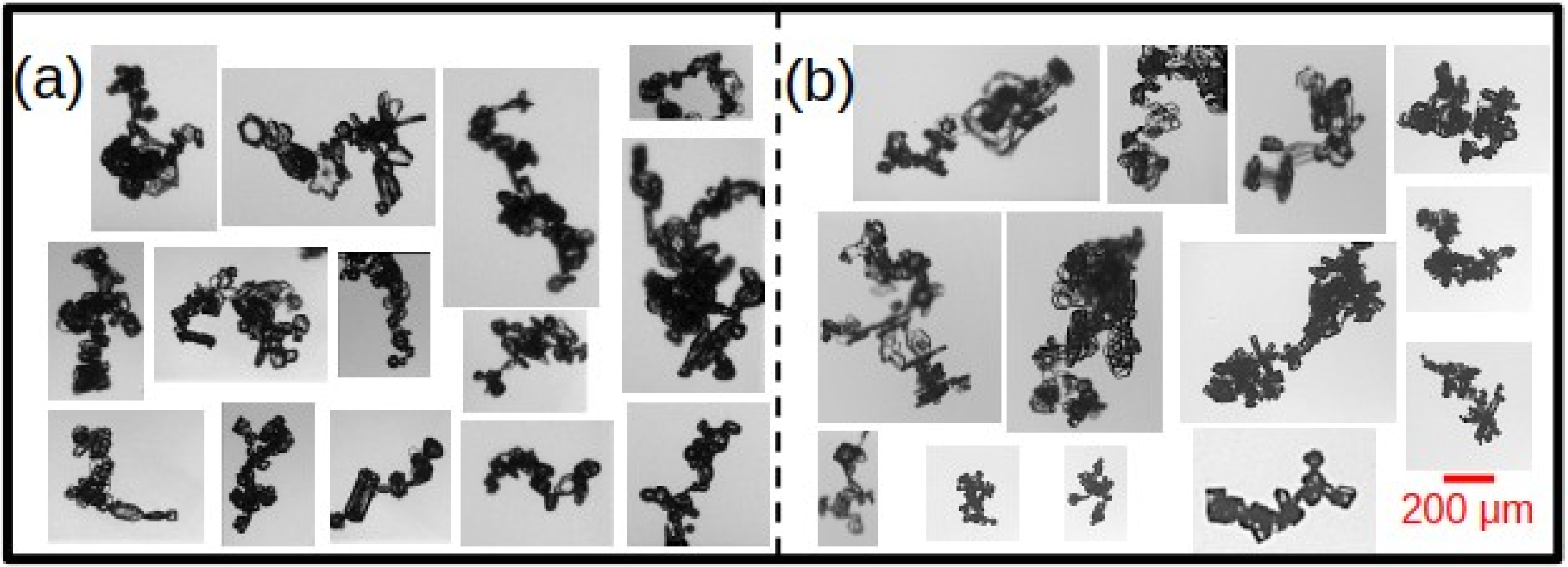
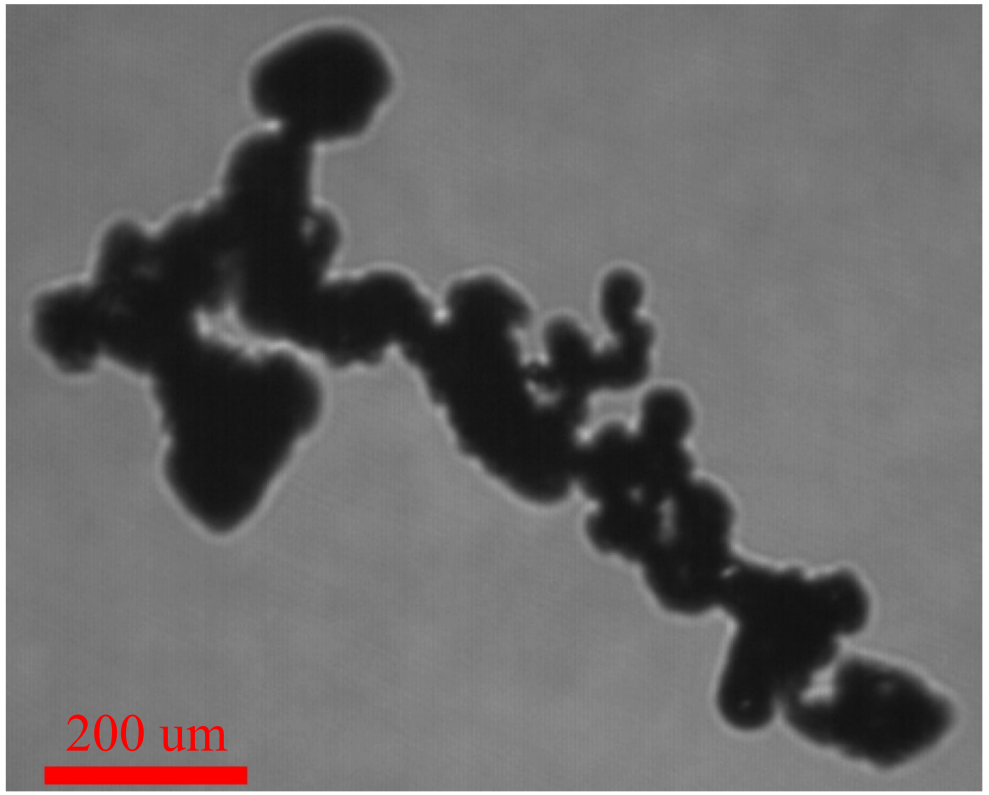


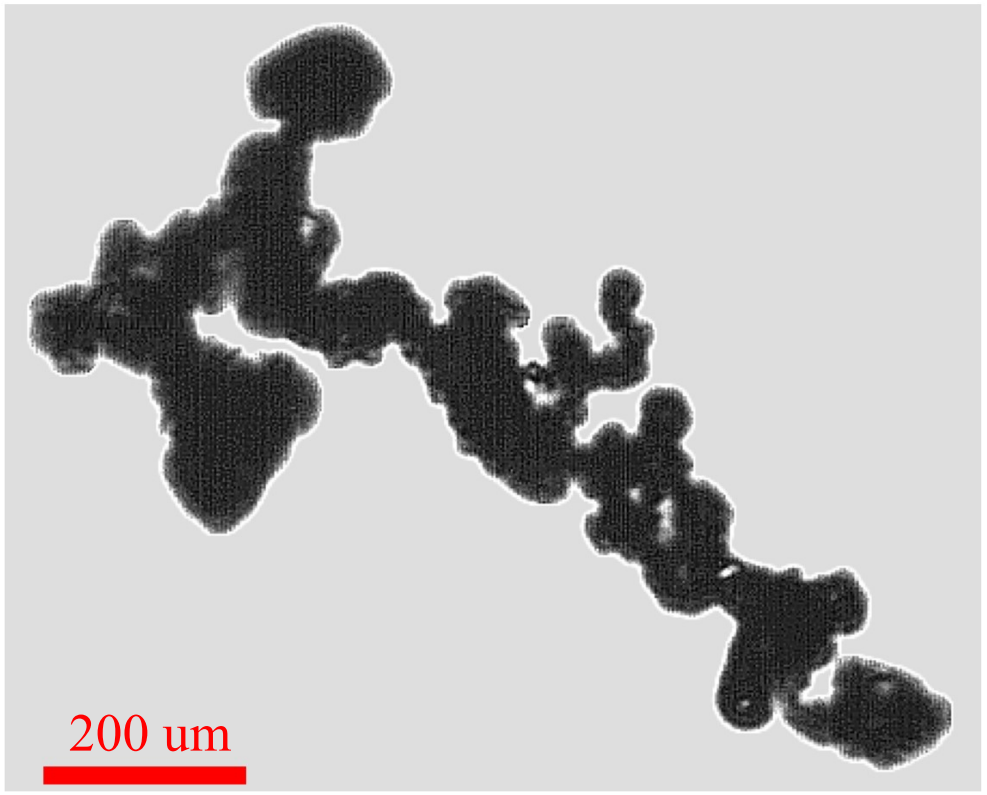
A collage of Particle Habit Imaging and Polar Scattering (PHIPS) probe images of chain like aggregates observed during (a) CapeEx19 and (b) IMPACTS field projects. Images are courtesy of Dr. Emma Järvinen of University of Wuppertal.

IMPACTS Chain-like Aggregate

Original Image
IMPACTS_HawkeyeCPI_20220117143115143607328_003617_C1.png



Enhanced Image



Courtesy of Christian Nairy, Ph.D Student, University of North Dakota.

IMPACTS Chain-like Aggregate

Original Image

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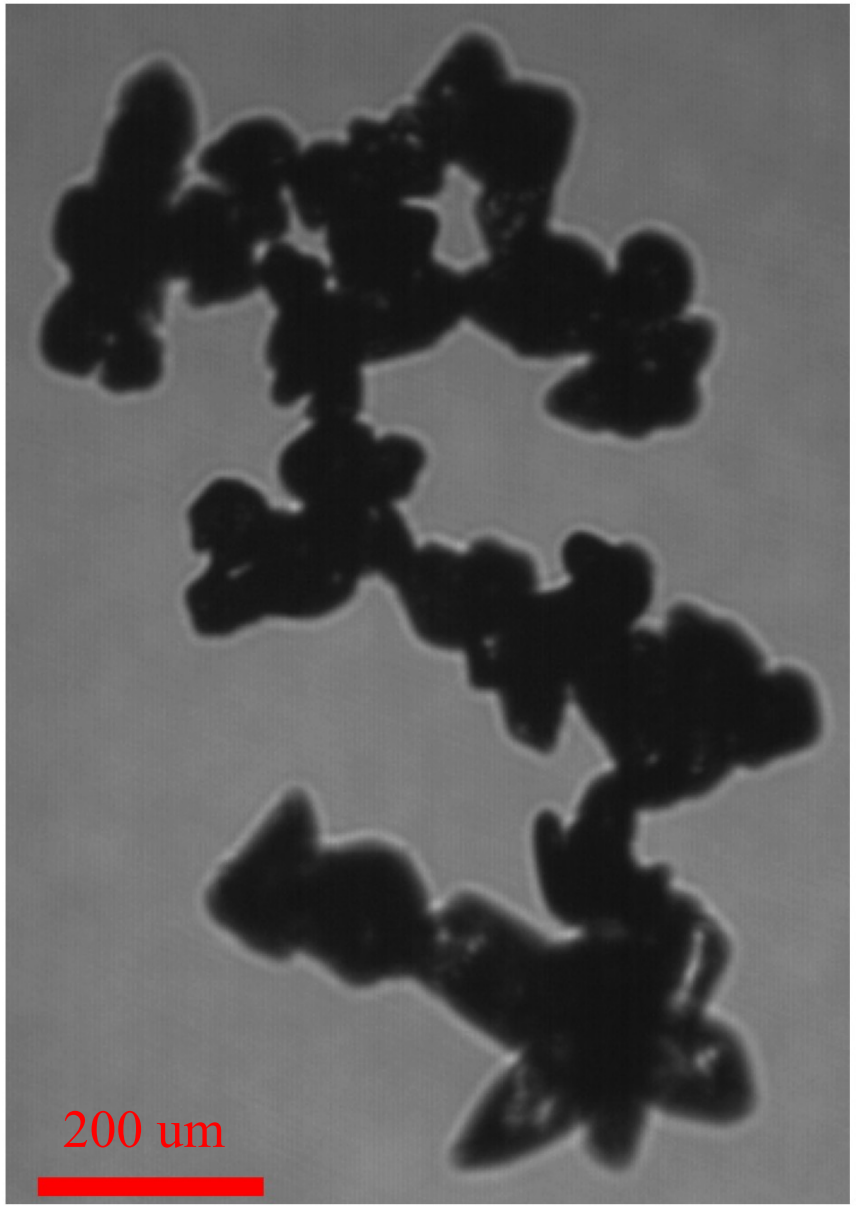

Enhanced Image

Courtesy of Christian Nairy, Ph.D Student, University of North Dakota.

IMPACTS Chain-like Aggregate

Original Image

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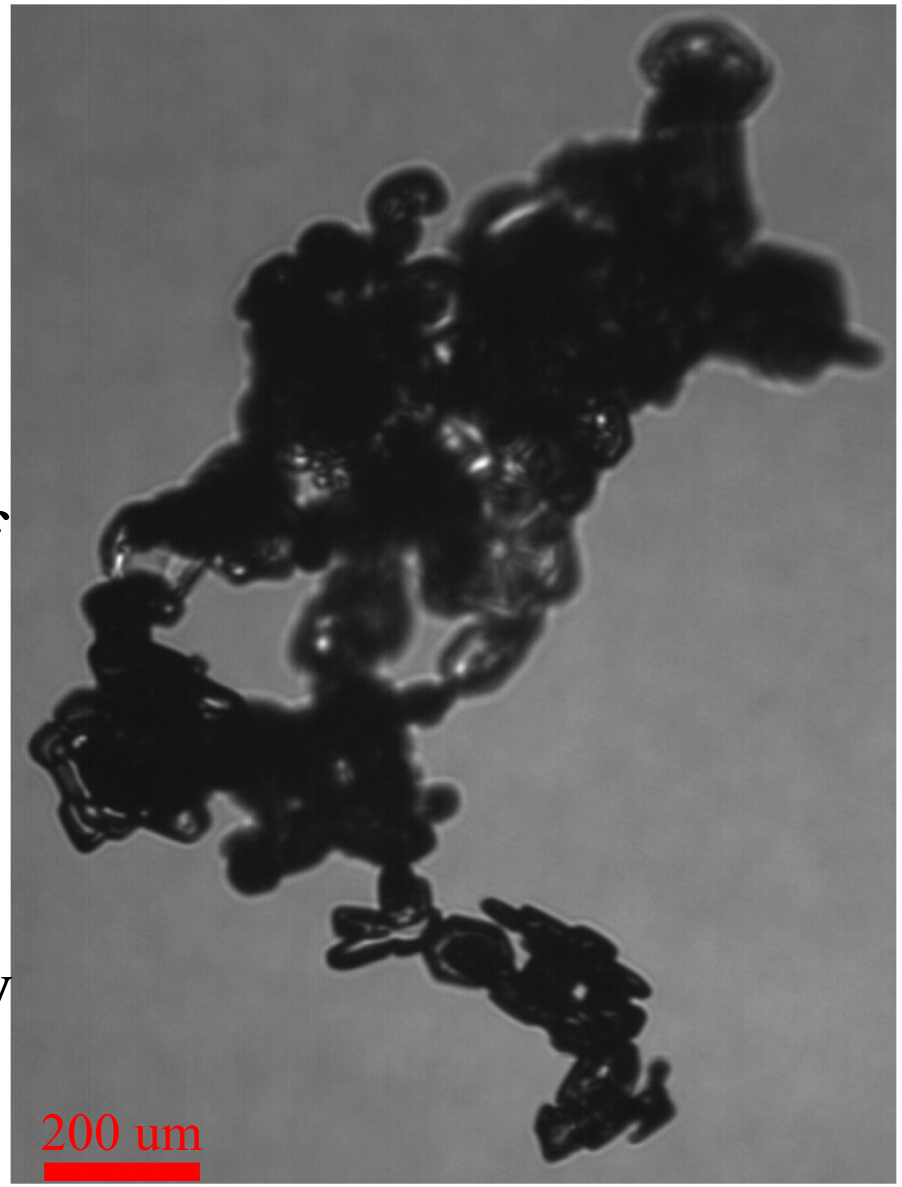

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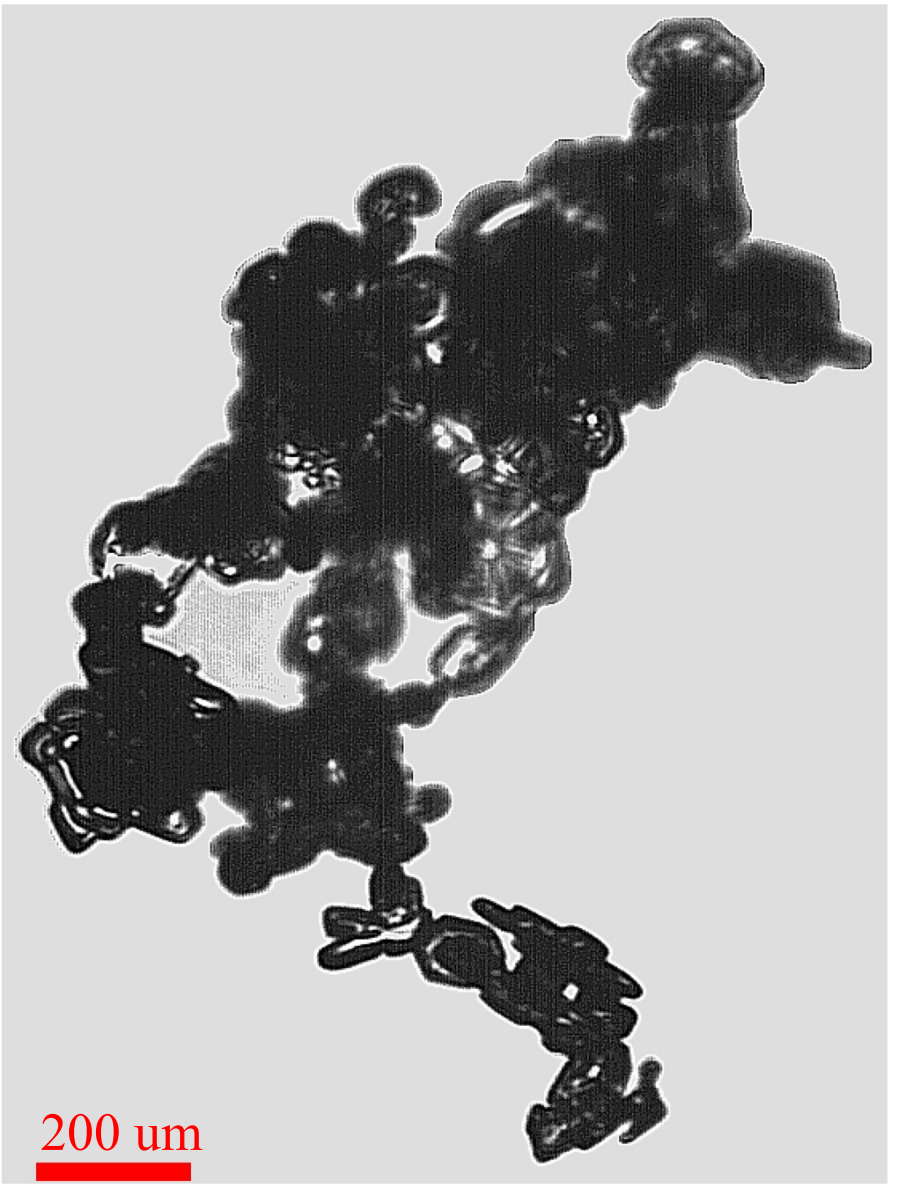

Courtesy of Christian Nairy, Ph.D Student, University of North Dakota.

IMPACTS Chain-like Aggregate

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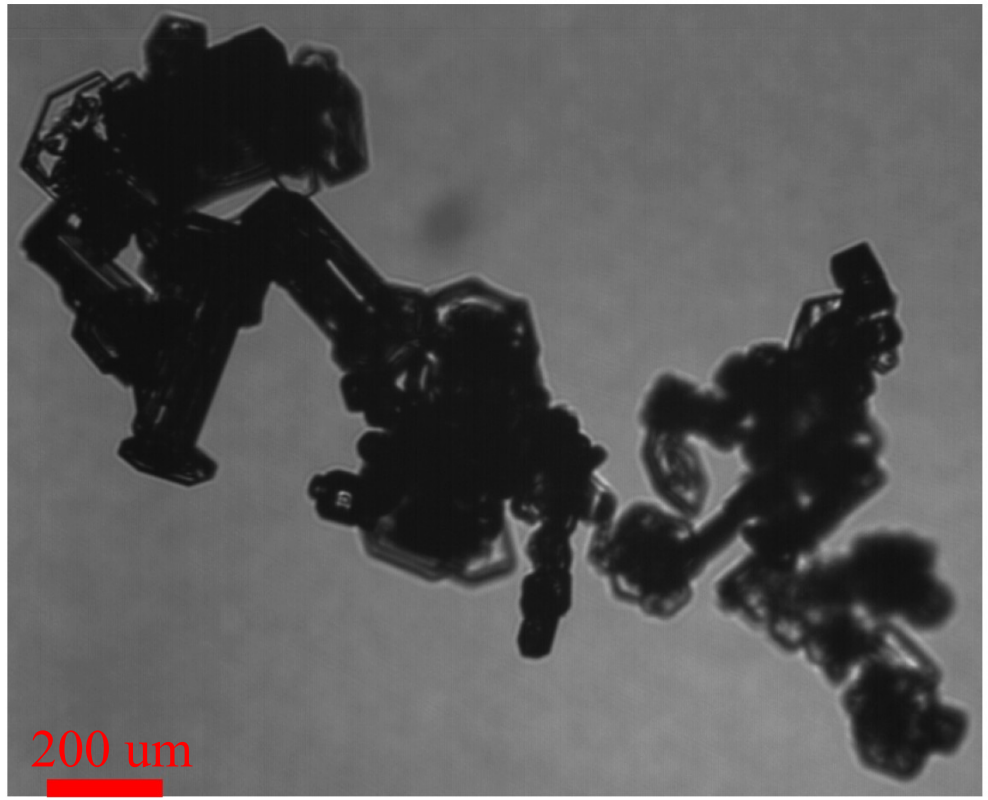

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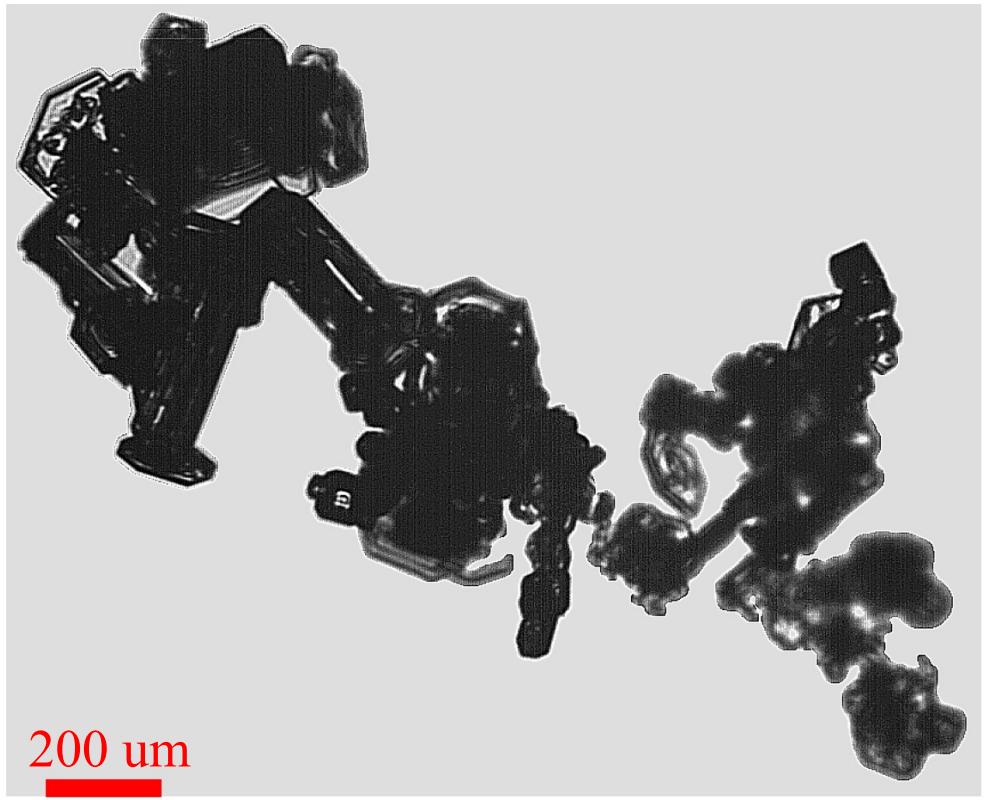

Courtesy of Christian Nairy, Ph.D Student, University of North Dakota.

IMPACTS Chain-like Aggregate

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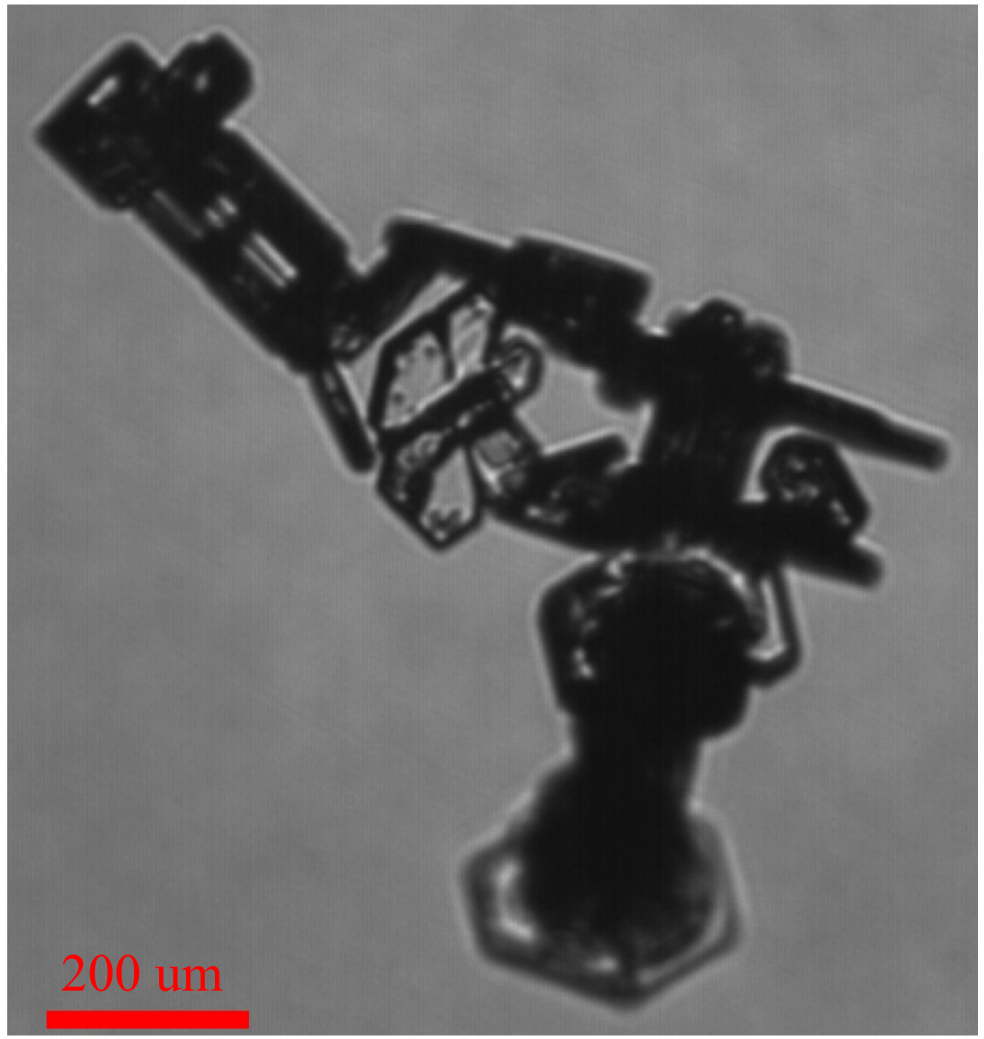

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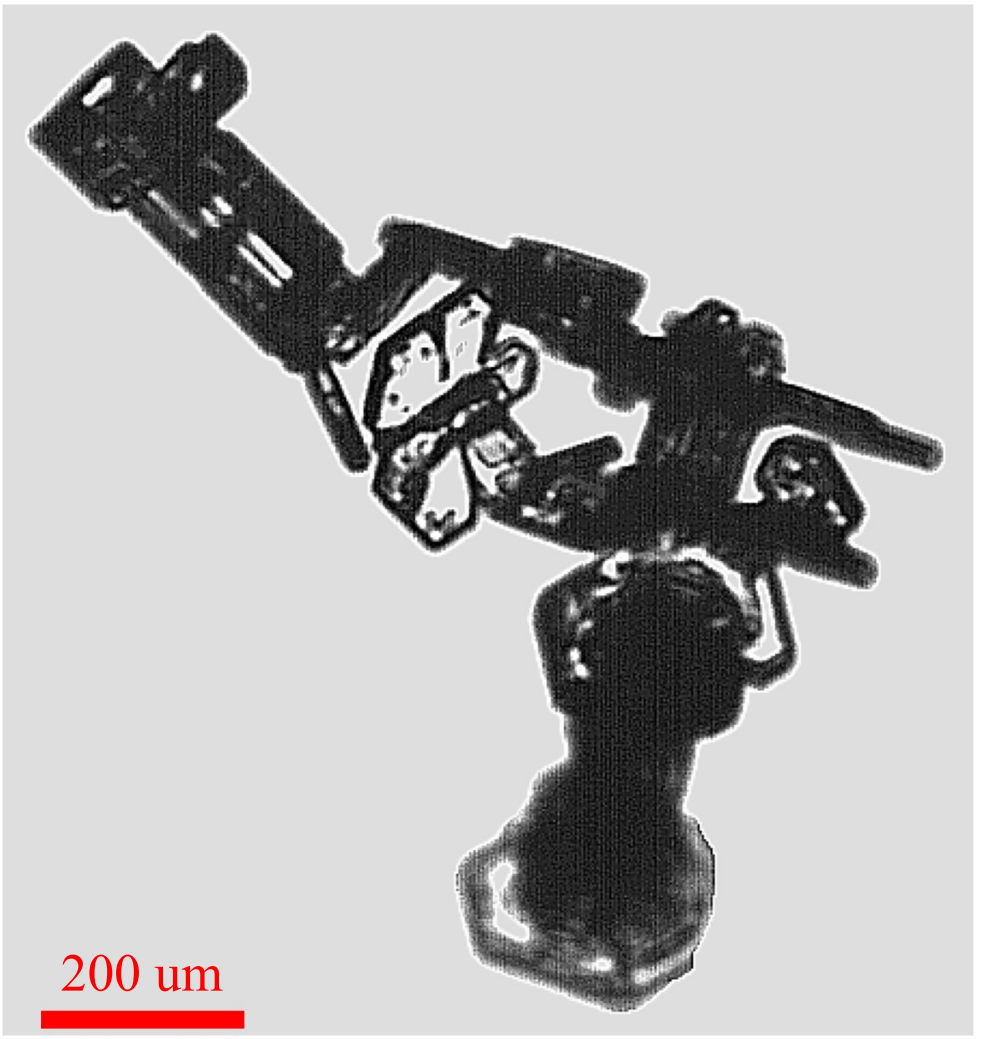

Courtesy of Christian Nairy, Ph.D Student, University of North Dakota.

IMPACTS Chain-like Aggregate

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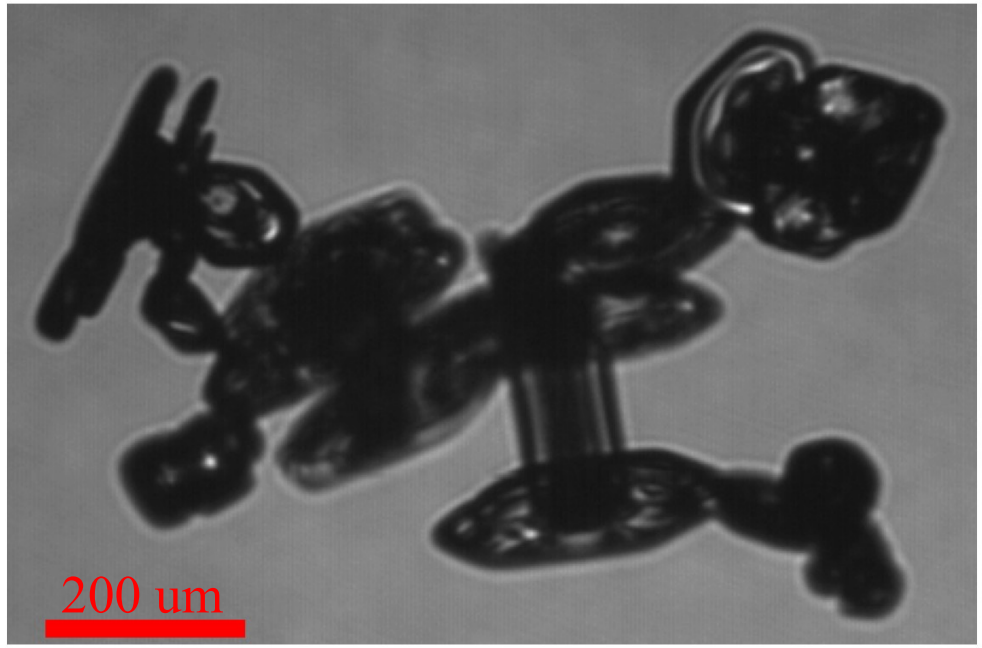

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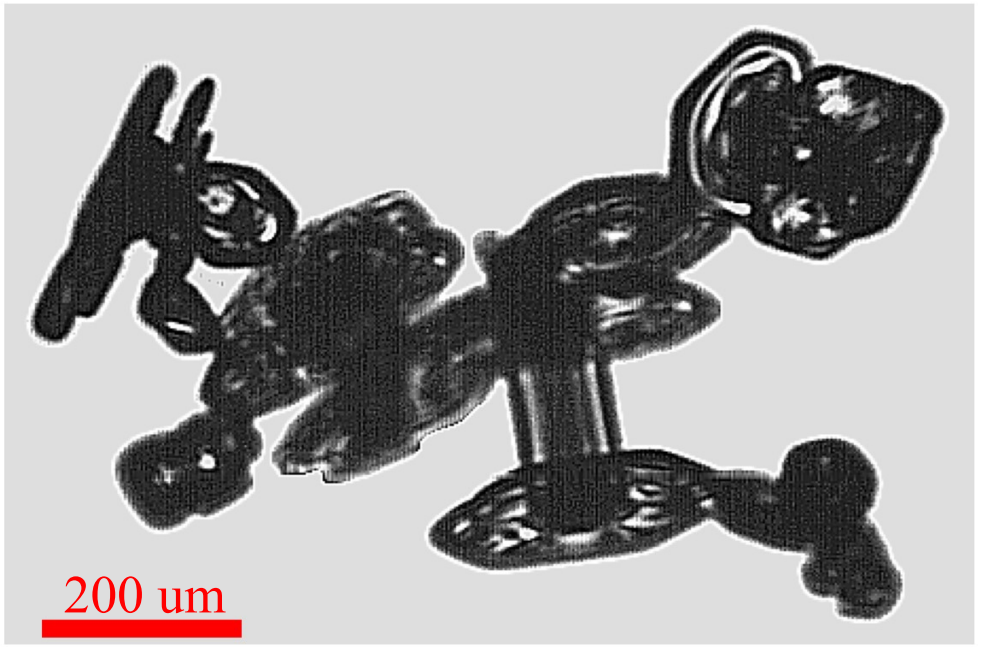

Courtesy of Christian Nairy, Ph.D Student, University of North Dakota.

Conclusions

- Observations are fun!
  - Agreement between remote sensing and in-situ observations.
- Observation generate questions and new discoveries.
  - Chain-like aggregates are everywhere.

Current PI Research Projects

- Atmospheric Methane Observations and Analysis in Western North Dakota (Anna Hodshire, Colorado State University)
  - DOE EPA-MERP; $714,703; 01/01/2025 - 09/30/2027
- Summer and Fall 2023 Saudi Arabia Field Project and Analysis
  - WMI; $449,930; 07/01/2023 - 06/30/2025
- Collaborative Research: Comparison between In-situ and Polarimetric Radar Hail Observations in Convective Storms
  - NSF; $277,610; 08/01/2022 - 07/31/2025
- IMPACTS (Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms)
  - NASA; $1,152,905; 11/01/2021-12/31/2025

Current Co-I Research Projects

- Improving North Dakota Thunderstorm Forecasting using Machine Learning Neural Network (PI - Marwa Majdi
  - ND-ARB; $131,892; 08/16/2024 - 06/30/2025
- Investigating the Formation and Impacts of Ice Crystal Aggregates on Hypersonic Vehicles
  - DOD ONR; $750,000; 02/01/2023 - 01/31/2026
- Interdisciplinary Renewable and Environmental Chemistry Research Experience for Undergraduates (PI – Guodong Du)
  - NSF; $330,000; 04/01/2024 - 03/31/2027

Pending PI Research Projects

- Utilizing WISPER Cloud Water Content from NASA IMPACTS 2023 Datasets to Quantify Mass Dimensional Relationships across Precipitation Habits
  - NASA FINESST; $148,262; 01/01/2026 - 12/31/2028
- INSPYRE Cloud Probes Research and Observations
  - NASA INSPYRE Team; $2,511,430; 07/01/2023 - 06/30/2025
- Unveiling Ice Crystal Chain Aggregates in Winter Storms: Contextualization using In-situ and Remote-sensing Observations
  - NASA ROSES F.20-MOSAICS, $399,905, 03/01/2025-02/28/2028

Pending Co-I Research Projects

- Research Infrastructure: MRI: Track 1 Acquisition of Pyrolysis-Gas Chromatograph with a High-Resolution Mass Spectrometer (Pyr-GC-HR-MS) (PI - Alena Kubatova
  - NSF MRI; $804,139; 07/01/2025 - 06/31/2028
- Markov-Chain Radiative Transfer Formalism for Investigating Cloud Microstructure with LIDAR (PI - Markus Allgaier)
  - NASA; $579,225; 05/01/2025 - 04/30/2028

Student Support

- With new position, funding would allow an additional 10 students over next 15 years!
  - Postdoctoral Researchers
    - Currently - 1
    - Position – 2: Apply for UND VPR Program in Spring 2026)
  - Ph.D Students
    - Currently – 1:
    - Position – 2: (*NASA INSPYRE/MOSAICS Proposals*)
  - Master Students
    - Currently - 1
    - Position - 2 (**DOE Methane**)