# Clustering of Cloud Particles Observed with In-situ Probes


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# Objectives

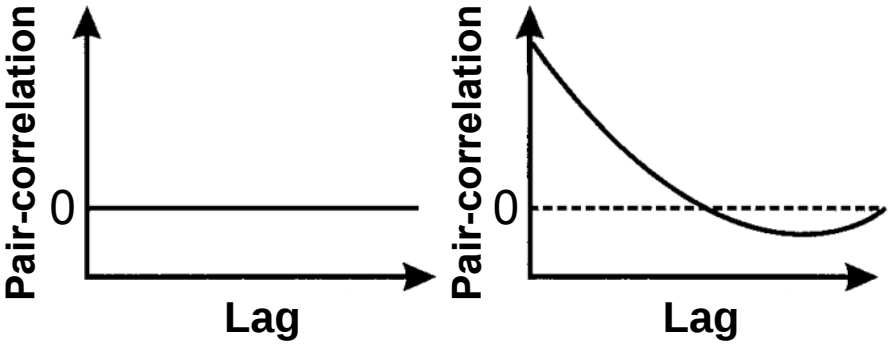
- Compare in-situ measurements with the Mid-Course Radar (MCR) observations.
- Improvements of MCR retrieval algorithms.
- **Model improvement of ice clouds (anvils).**

# Spatial Distribution of Cloud Particles

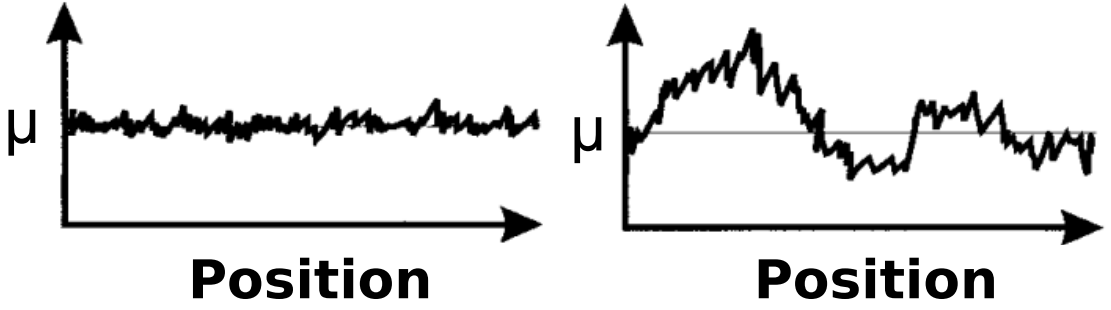
**POISSON** **PATCHY**

**Clouds**

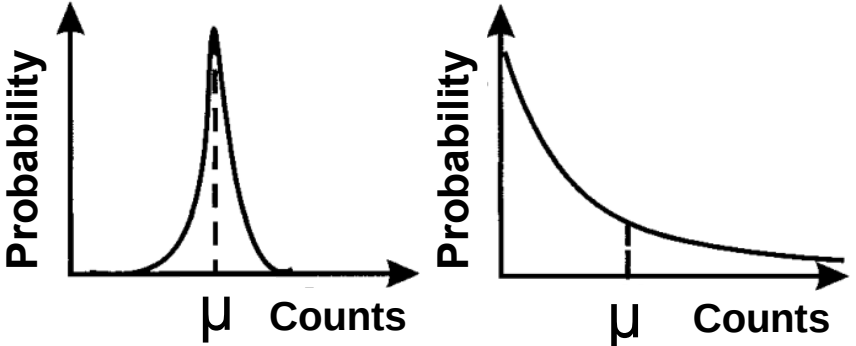
**Pair-correlation Function**




**Counts**



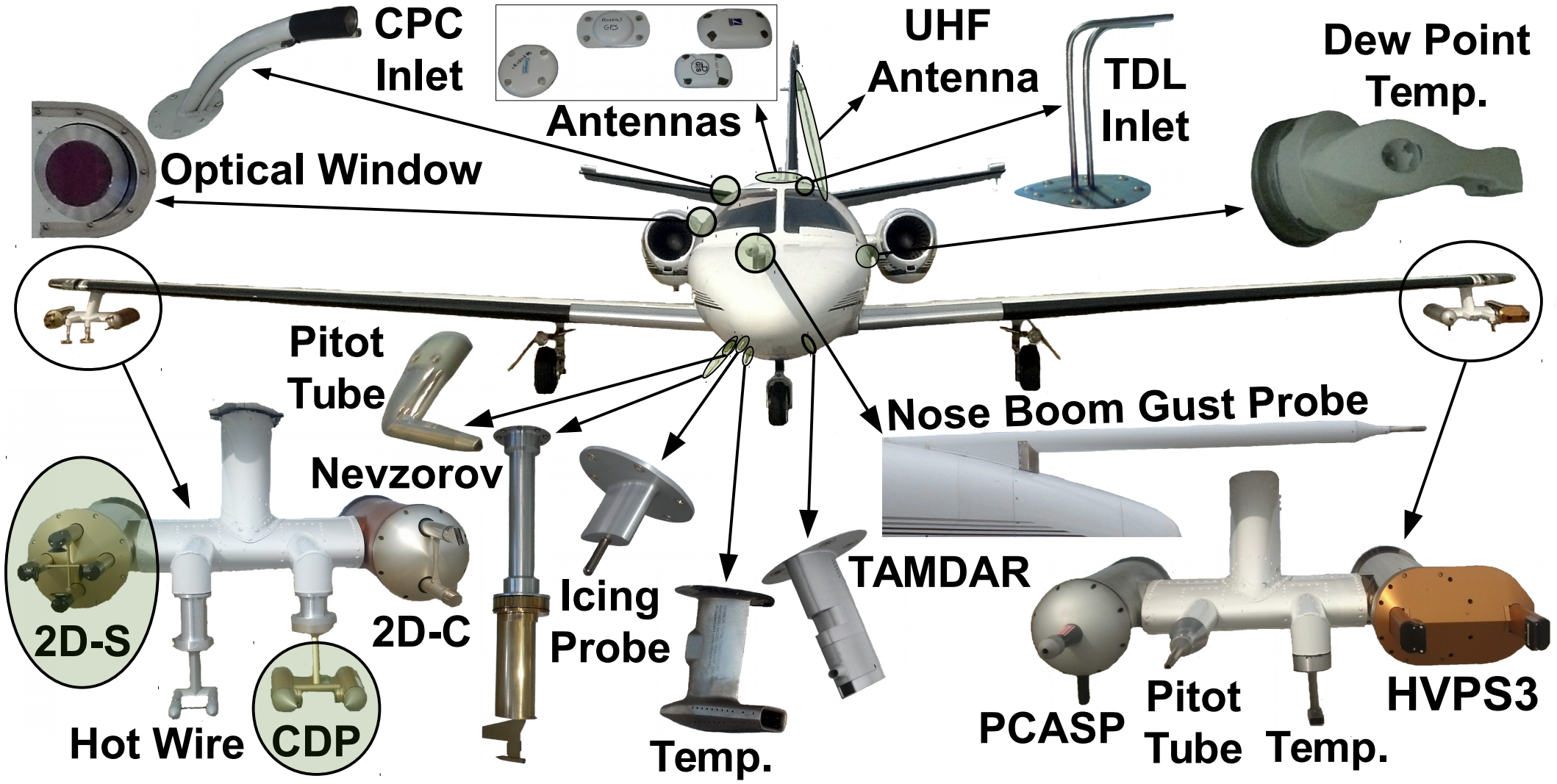

**Probability Densities**




$\sigma^2=\mu$ $\sigma^2=\mu+\mu^2$

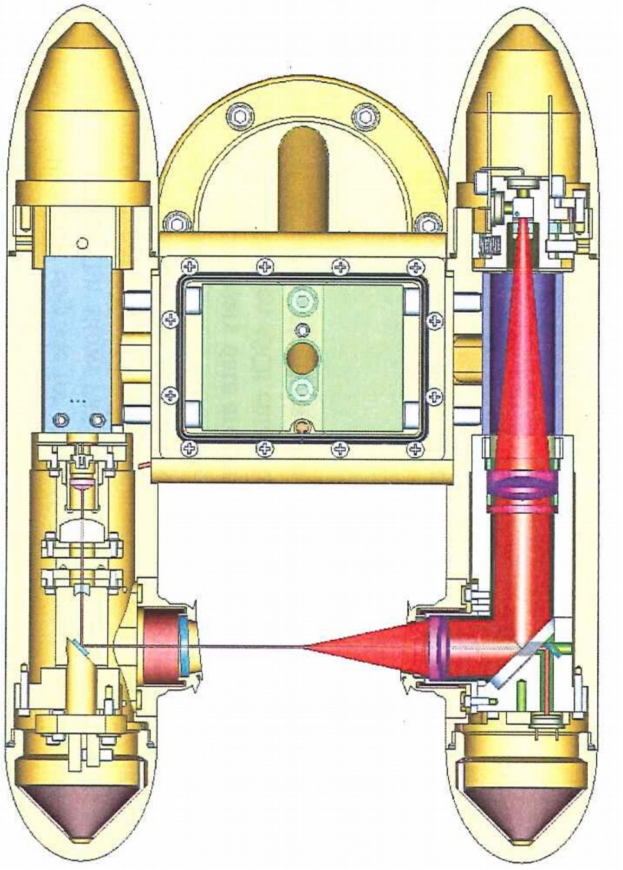
Adapted from Figure 1 of Kostinski and Jameson, 2000

# CAPE2015: Cirrus Anvils, Florida, 8 Flights



# Cloud Droplet Probe

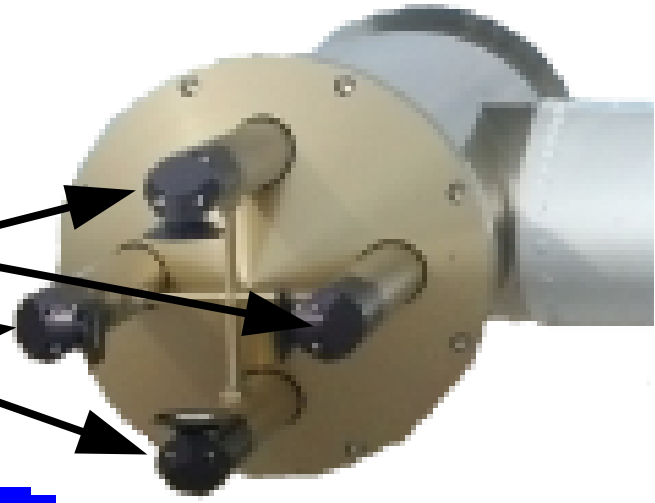
- Measurement of the cloud droplet spectrum in 30 channels between 2 and 50 µm diameter.
- Forward scattering between 3 - $12^0$
- Uses Mie scattering to determine particle diameter by assuming Spherical water droplets.

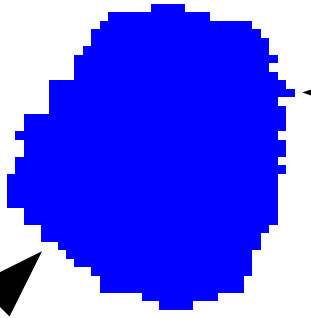


- 10 Hz sampling frequency with particle-by-particle information on first 256 particles per sampling interval.
- 24 $cm^3$ sample Volume (0.024 $cm^2$ * 100 m/s * 0.1 s)

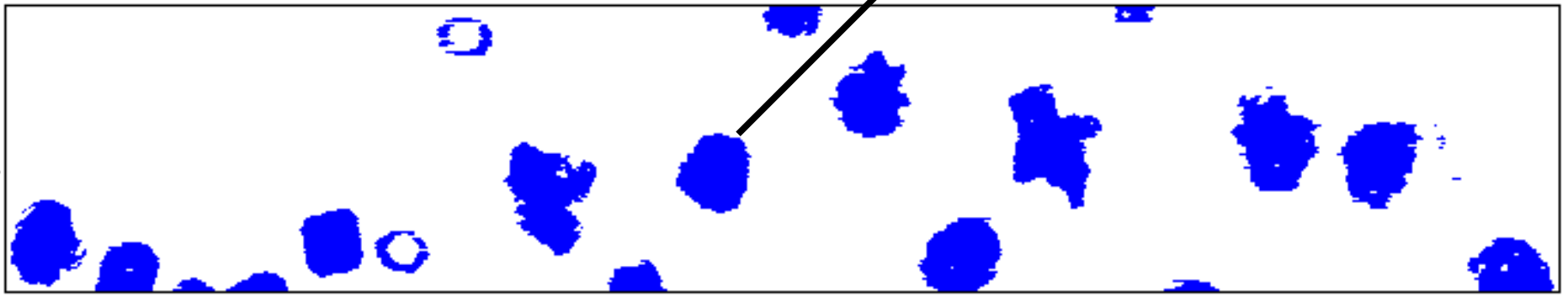
# Two-Dimensional Stereographic (2D-S) Probe

- Orthogonal laser light sheet ~ 0.793 $cm^2$.
- Arrays of 128 diodes which are 10 µm.
- Captures shadow images of particles.
  - Data post-processing uses 29 size bins, 10 to 2,000 µm in diameter.
  - Use one second-averaged data.





10 µm Shadowed Diode

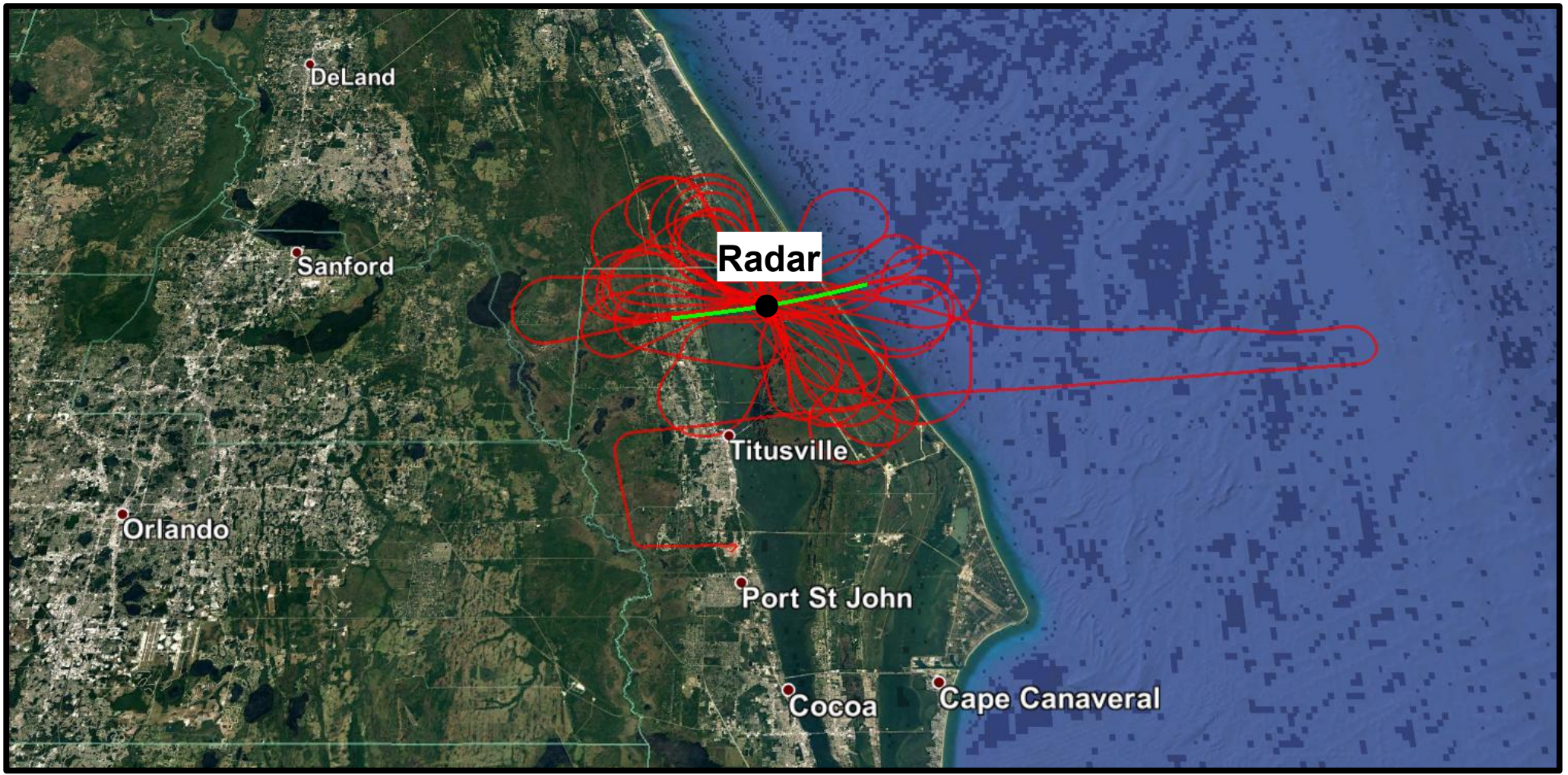


1,280 µm

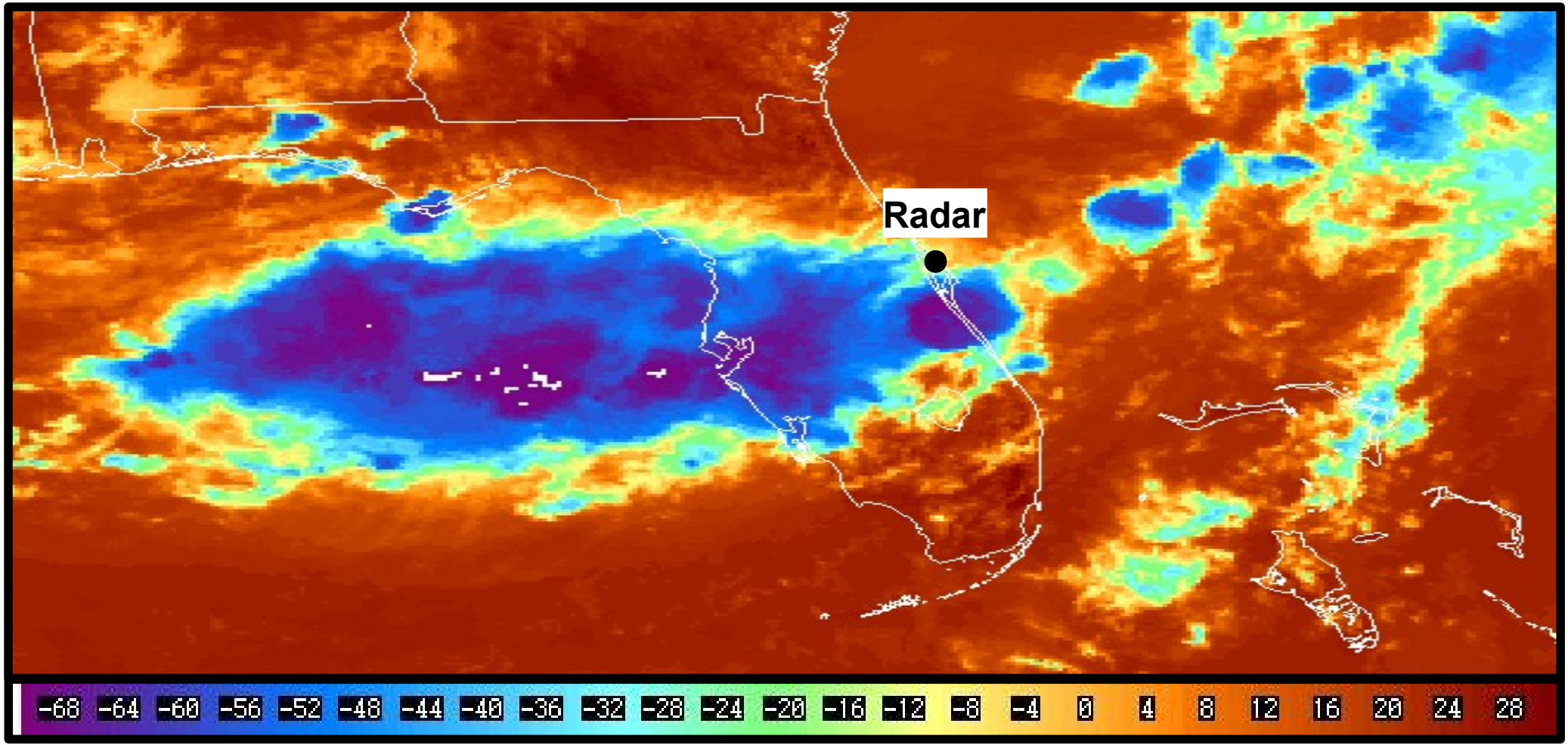
# Post-processing of Aircraft Data

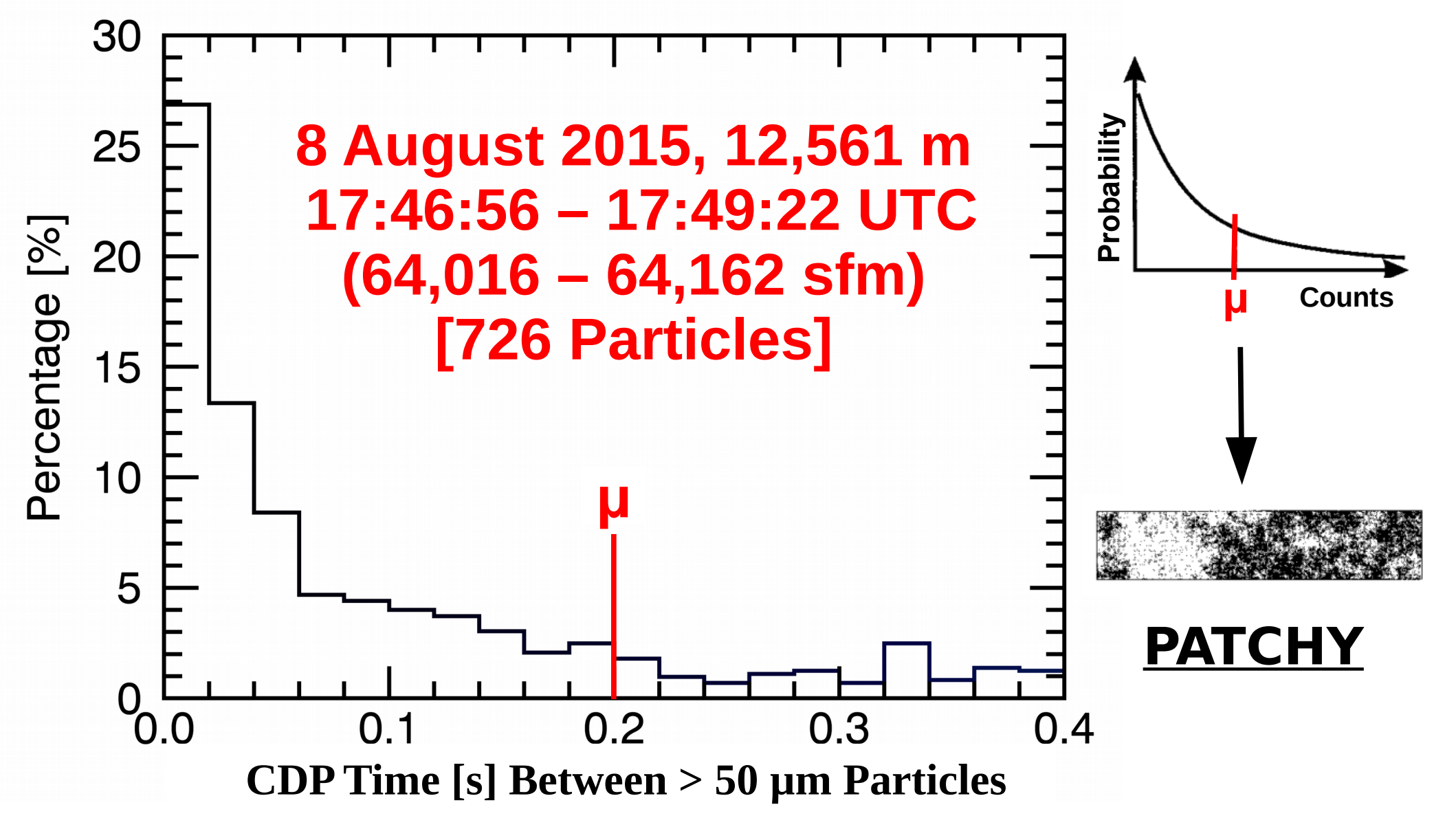
- Cloud Droplet Probe (CDP) data processed using the Airborne Data Processing and Analysis (ADPAA) software package (Delene, 2011).
- 2D-S particle spectrum calculated using SODA2 code from NCAR (https://github.com/abansemer/soda2).

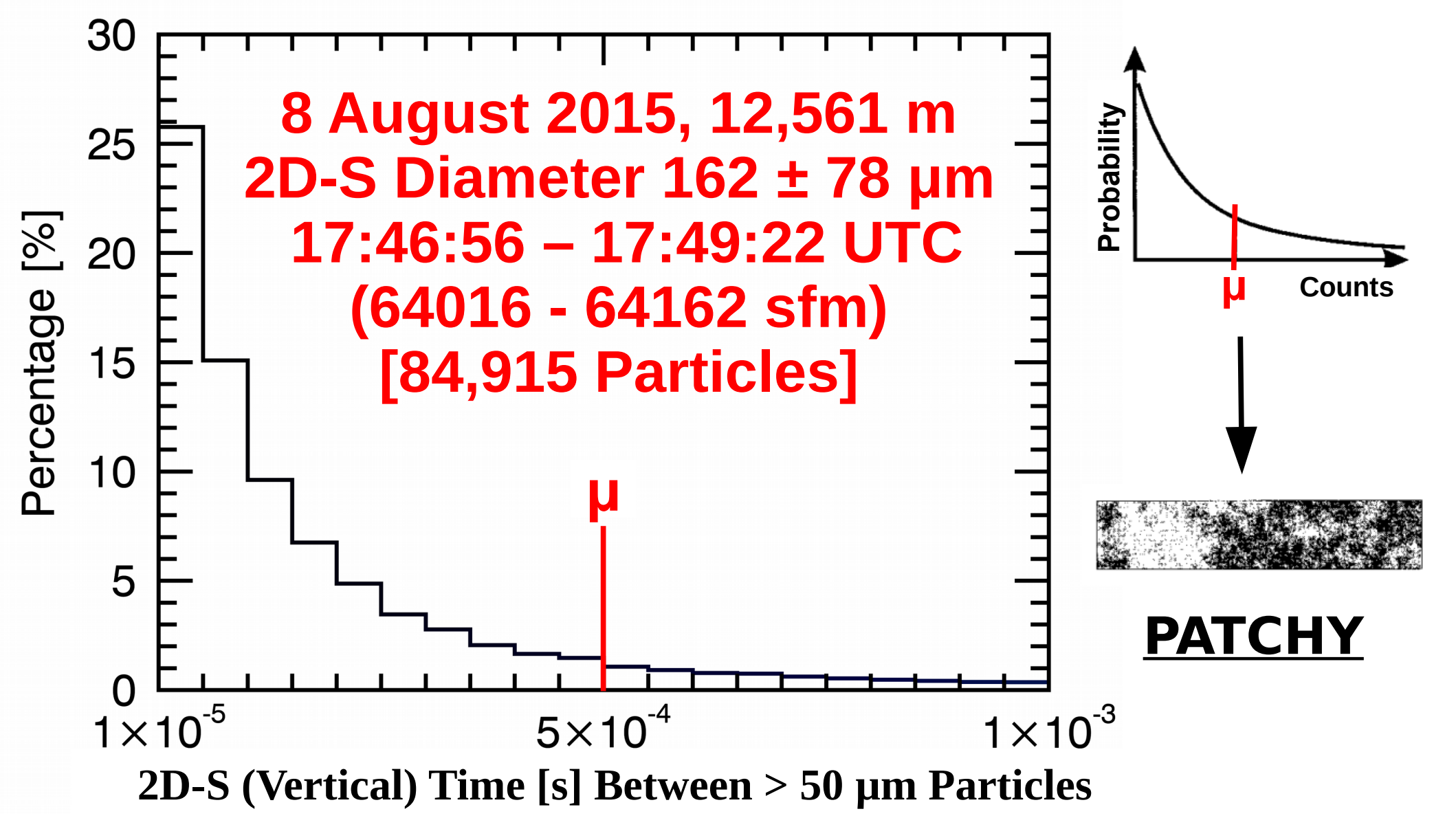
# 8 August 2015 Flight: 17:46:56 - 17:49:22



# GOES 13 IR – 8 August 2015, 17:45:00 UTC




8 August 2015, 12,561 m
17:46:56 – 17:49:22 UTC
(64,016 – 64,162 sfm)
[726 Particles]
Percentage [%]
CDP Time [s] Between > 50 µm Particles
µ
Probability
Counts
PATCHY

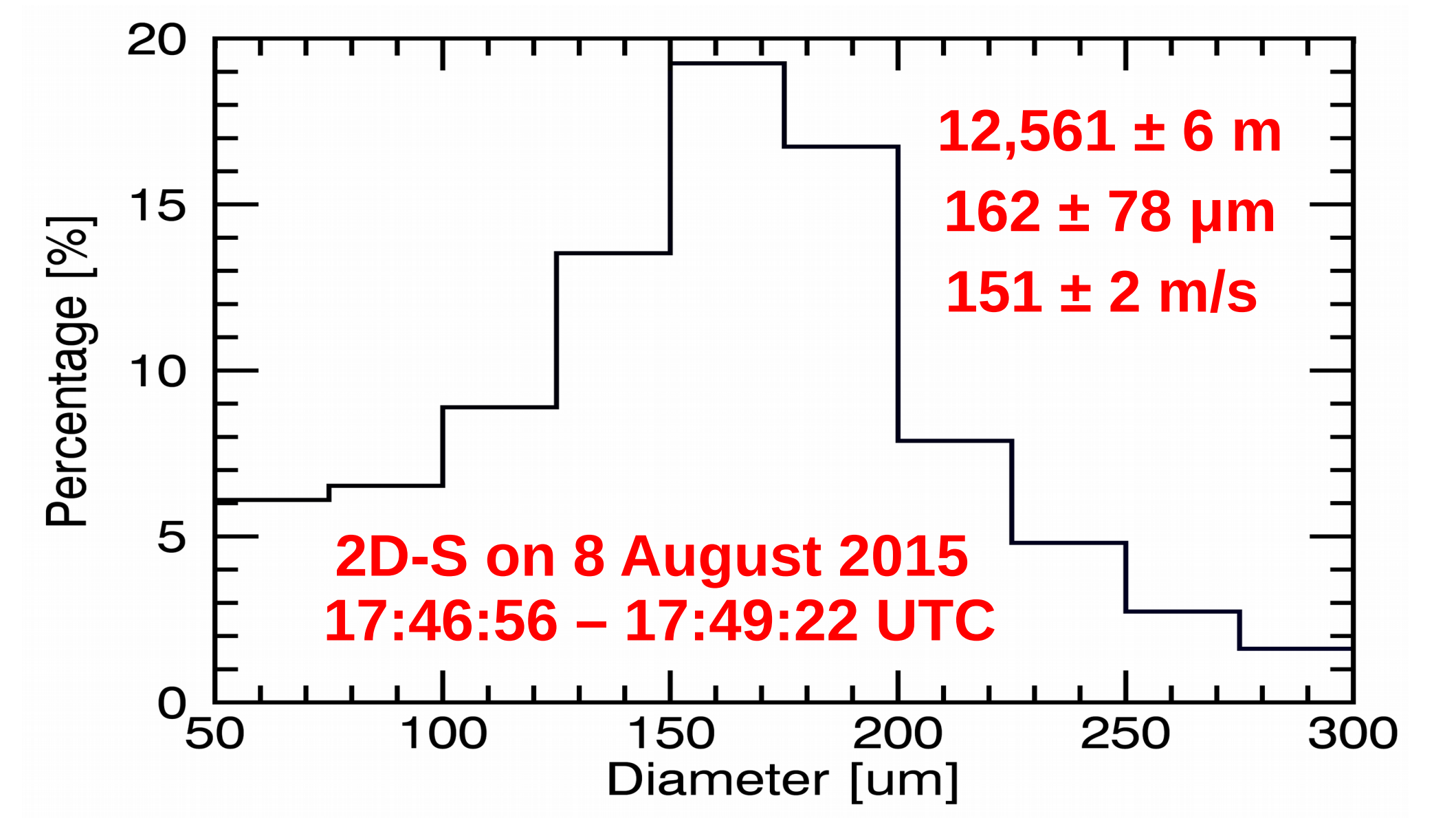

8 August 2015, 12,561 m
2D-S Diameter 162 ± 78 µm
17:46:56 – 17:49:22 UTC
(64016 - 64162 sfm)
[84,915 Particles]
µ
Percentage [%]
30
25
20
15
10
5
0
1×10-5
5×10-4
1×10-3
2D-S (Vertical) Time [s] Between > 50 µm Particles
Probability
µ
Counts
PATCHY

# Conclusion

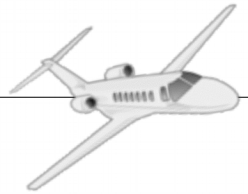
- Florida anvil cirrus with aspect ratios of 0.7 – 0.8 are observed to be patchy.

# References

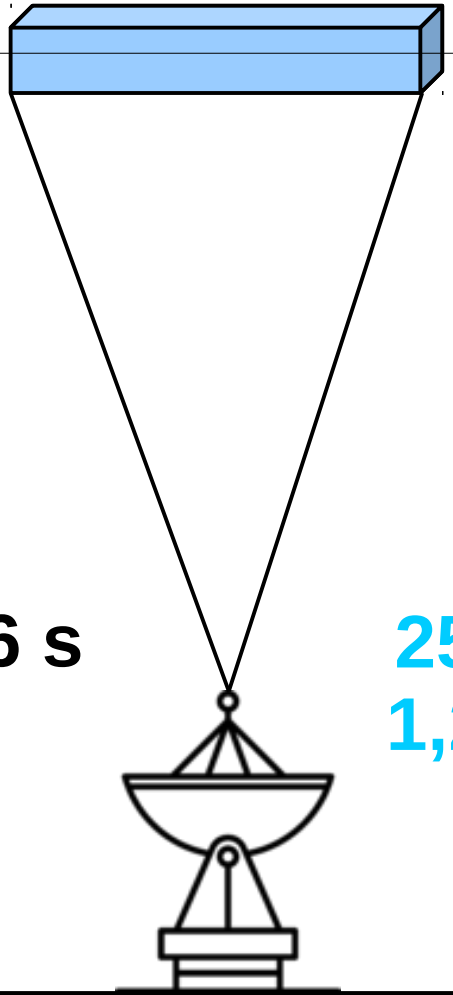

- Delene, D. J., 2011: Airborne data processing and analysis software package. Earth Sci. Inform., 4, 29–44, doi:10.1007/s12145-010-0061-4.
- Kostinski, A. B., and A. R. Jameson, 2000: On the Spatial Distribution of Cloud Particles. J. Atmos. Sci., 57, 901–915, doi:10.1175/1520-0469(2000)057<0901:OTSDOC>2.0.CO;2.
- J. M. Schmidt, and Co-Authors, 2012: Radar observations of individual rain drops in the free atmosphere. PNAS, 109, 9293-9298, doi: 10.1073/pnas.1117776109.



12,561 ± 6 m
162 ± 78 µm
151 ± 2 m/s
2D-S on 8 August 2015
17:46:56 – 17:49:22 UTC
Percentage [%]
Diameter [um]
0
5
10
15
20
50
100
150
200
250
300

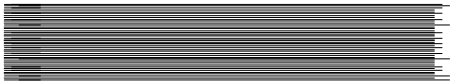
# Sample Volumes



**TAS - 151 m/s**



**Altitude – 12,561 m**



**0.793 $cm^2$ * 151 m/s * 146 s**
**1.75 $m^3$ 2D-S Volume**

**25.1 m * 25.0 m * 2.0 m**
**1,256 $m^3$ Radar Volume**