Observations of Convective Storm Anvils in Florida

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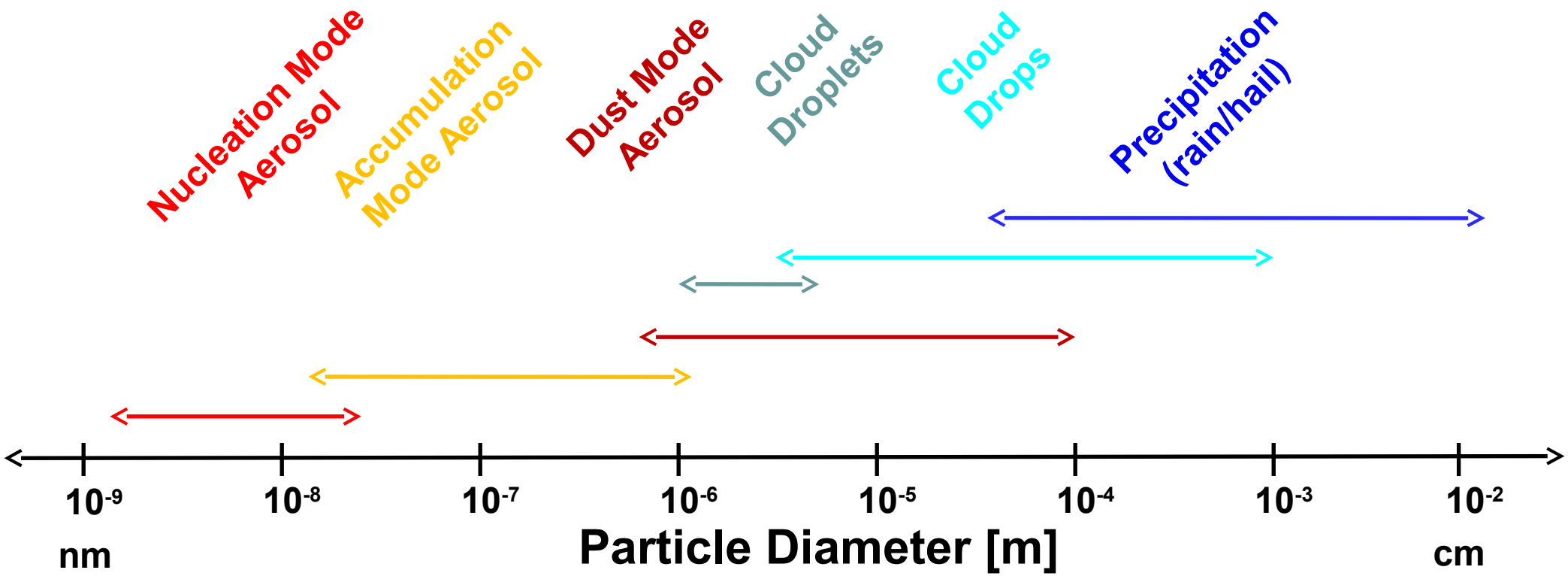
Atmospheric Particle Background

Atmosphere contains particles of all sizes.

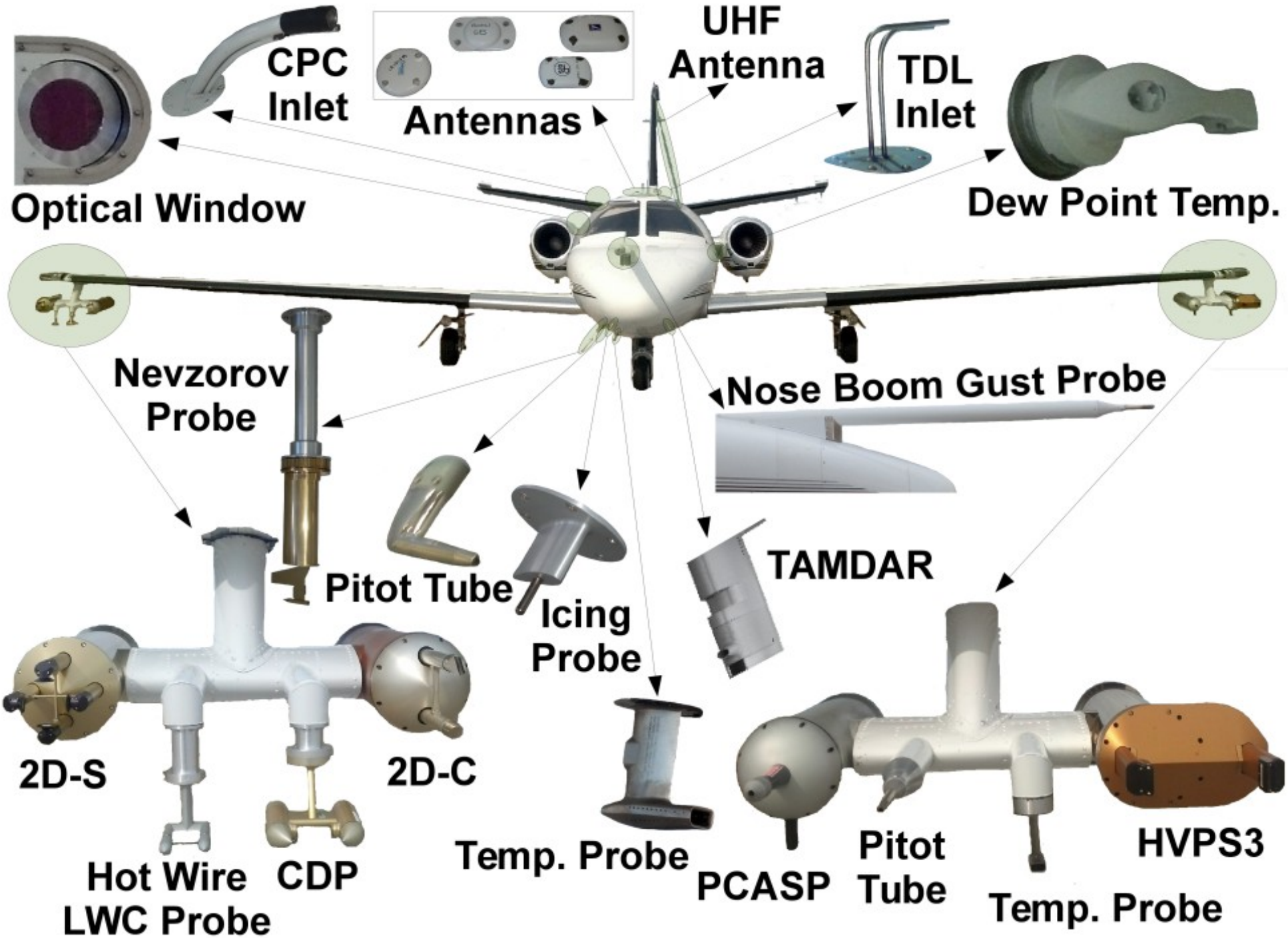
- Suspended particles (aerosols) move with the average flow of gas molecules (atmospheric wind).
- Large particles (dust/drops/rain) have sufficient inertia to move independently of the wind.



Objectives

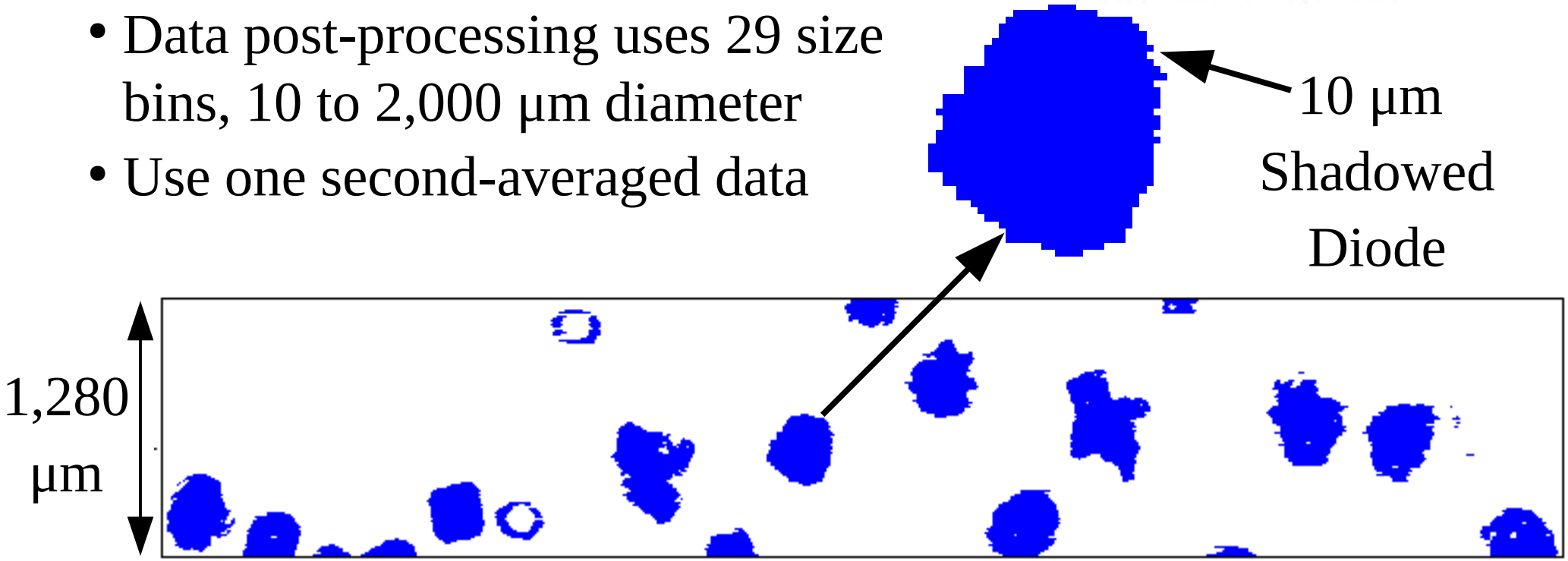
- Compare in-situ measurements with the Mid-Course Radar (MCR) observations.
- Improvements of MCR.
- **Model improvement of ice clouds (anvils).**

CAPE2015 – Florida, 8 Flights, 21.9 hrs



Two-Dimensional Stereographic (2D-S) Probe

- Horizontal and vertically oriented laser.
- 128 Diodes, 10 µm each.
- Captures images of shadows from cloud particles.
  - Data post-processing uses 29 size bins, 10 to 2,000 µm diameter
  - Use one second-averaged data



Nevzorov Probe - Water Content

- Measurement of total (ice and liquid) and liquid water content measurement.
- Maintain constant temperature on a hot (125 C) wire sensor head.
- Measure power required to maintain constant temperature.
- Direct measurements to compare 2D-S derived measurements with.
- High altitude clouds so total ice water is used for ice water content measurements.
- Comparison at frequency of up to one second.

Mid-Course Radar (MCR)

- C-band, Dual-polarization Doppler Radar
- 3 MW Operating Power, 0.22 Degree Beam Width
  - Pulse Volume of 504 m^3 at 12,000 m
  - Box around Citation Research Aircraft has a volume of 1,050 m^3

Reflectivity Calculations

- Calculate reflective to compare with MCR using 2D-S number size distribution.

$$z = \sum_{i=1}^{n} N_i D_i^6 \, |K|^2$$

  - Ice Dielectric constant of 0.197 (Rinehart, 2010).
  - Summed over all 29 size bins.
  - Convert to logarithmic units (dBZ).

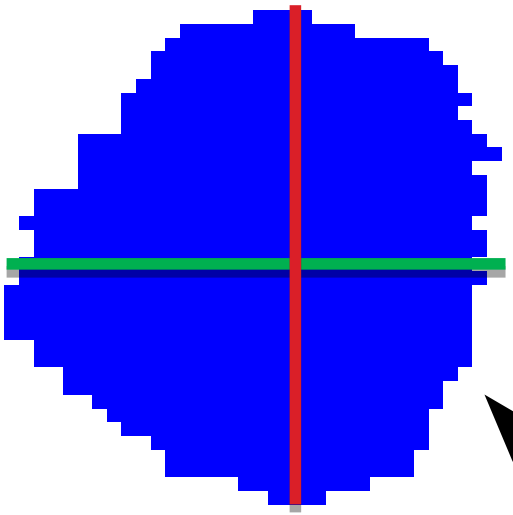
$$Z = 10 \log_{10} \left(\frac{z}{1 \, mm^6/m^3} \right)$$

Processing Codes:

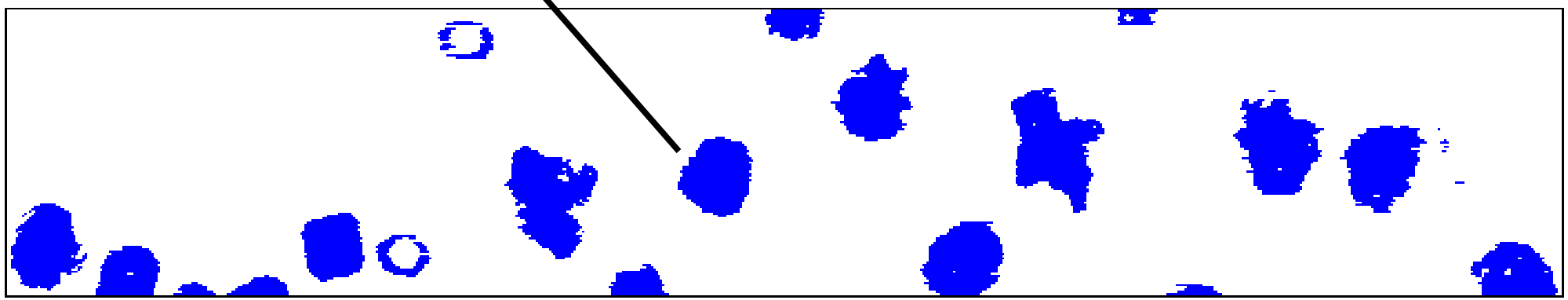
- twods_conc2bulk_ice.py
- twods_conc2bulk_liquid.py

Diameter Size Calculation (Aspect Ratio)

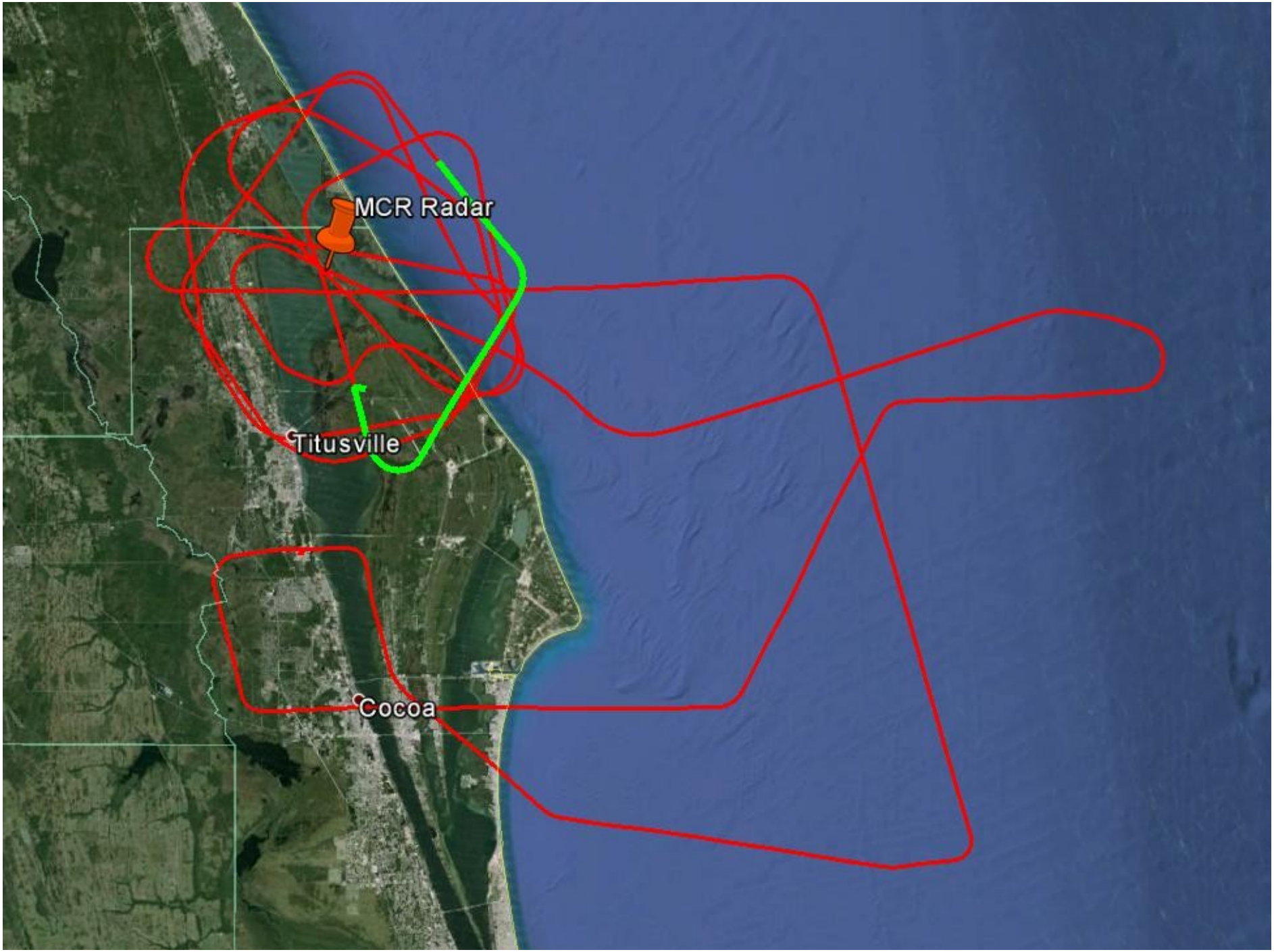
- Calculated during data post-processing using the SODA code from NCAR.
- How circular (spherical) are particles?



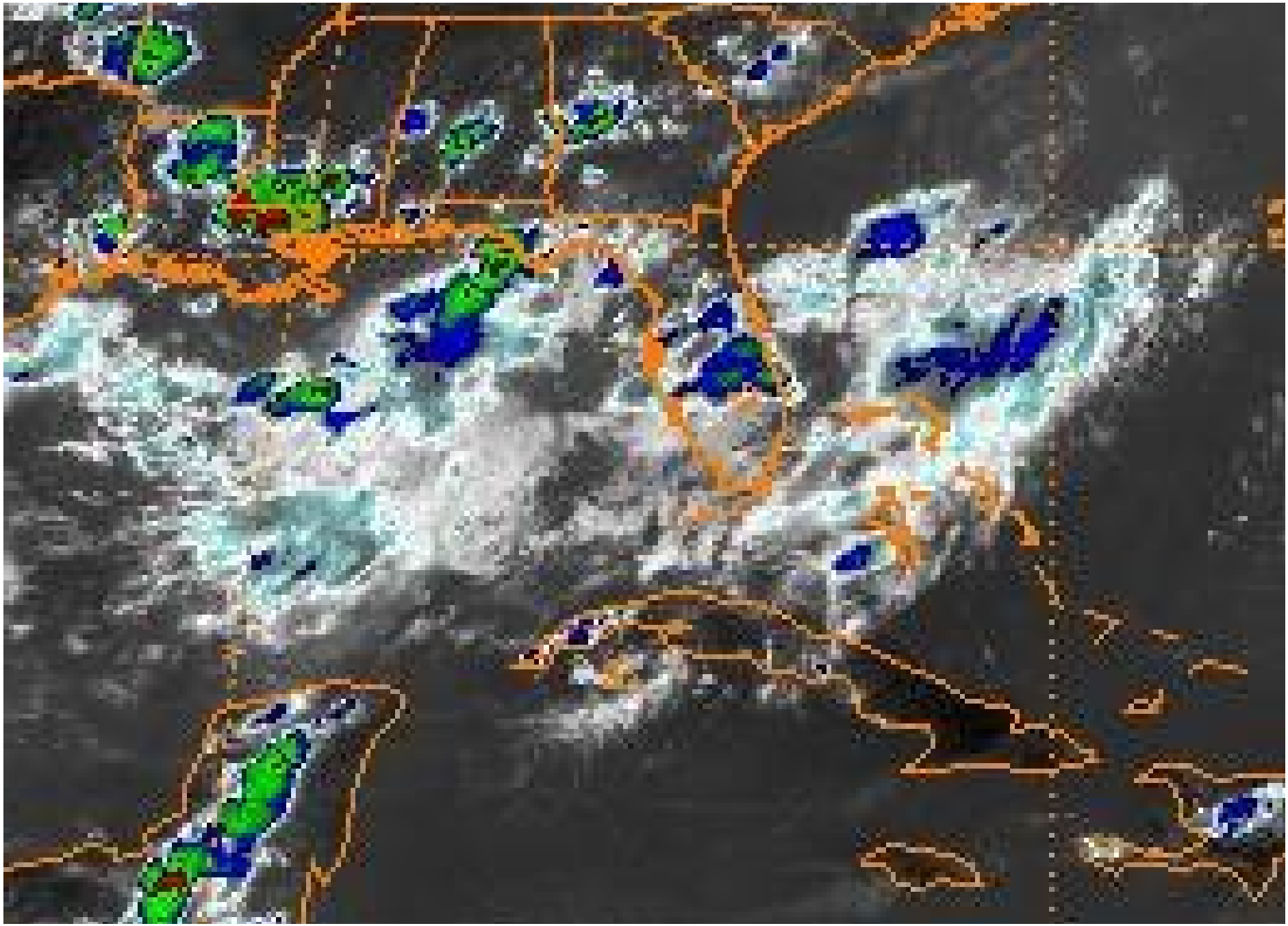
$$\text{Aspect Ratio} = \frac{\text{Horizontal Width}}{\text{Vertical Width}}$$



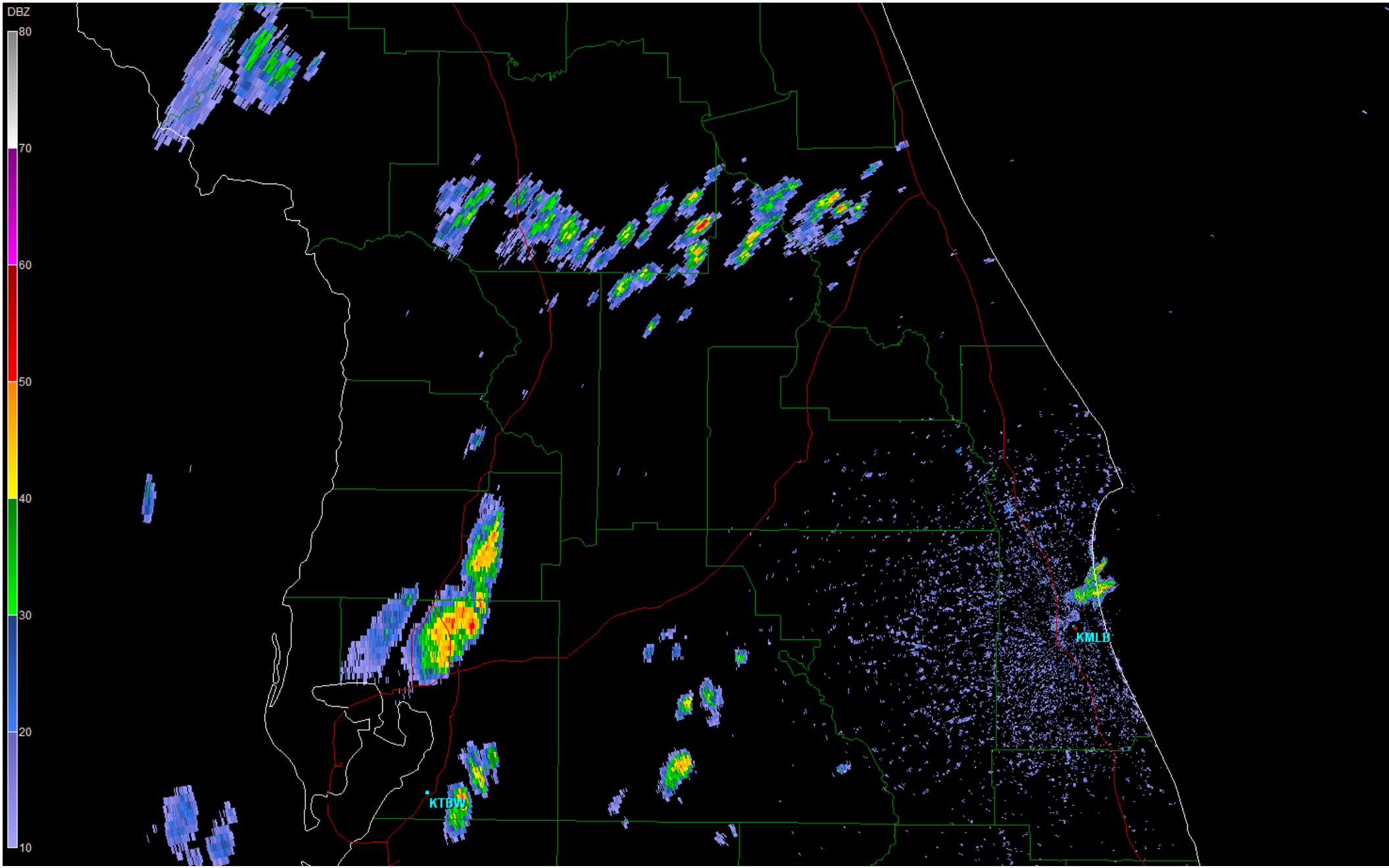
July 30, 2015 Flight: 66,000-66,360 sfm



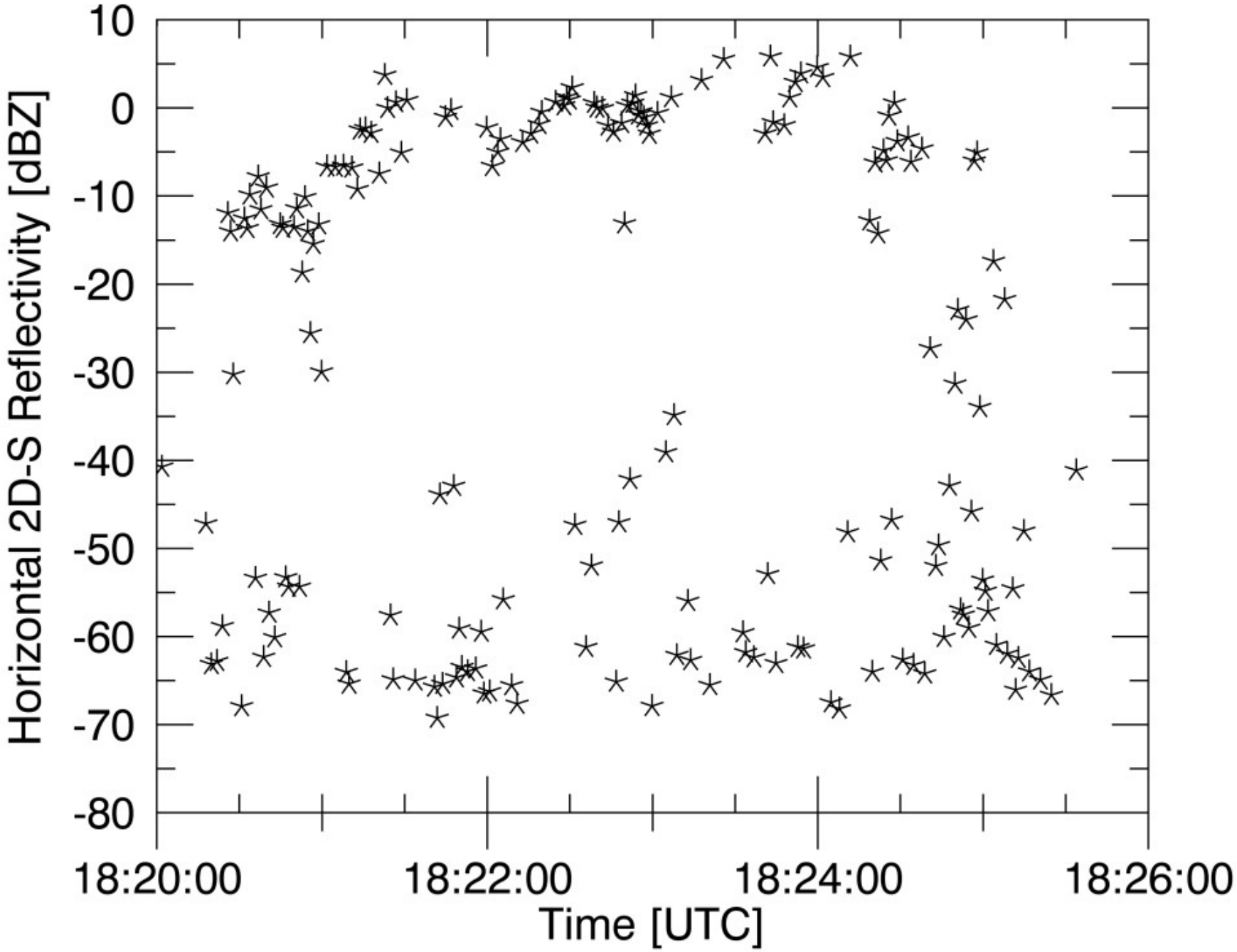
July 30, 2015 GOES 13: 18:30 UTC



July 30, 2015 Melbourne Radar



July 30, 2015: 9,400 m (31,000 ft)



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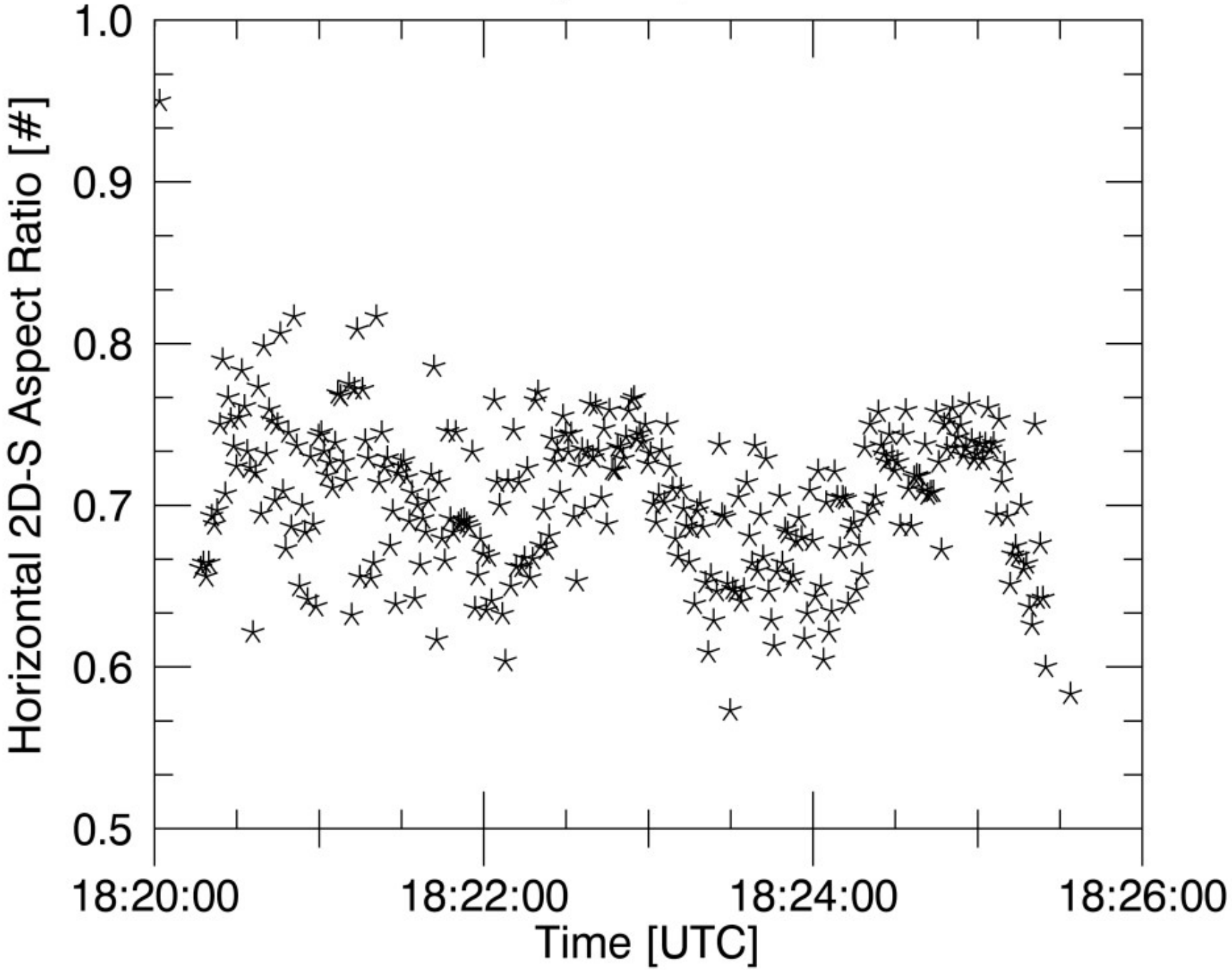

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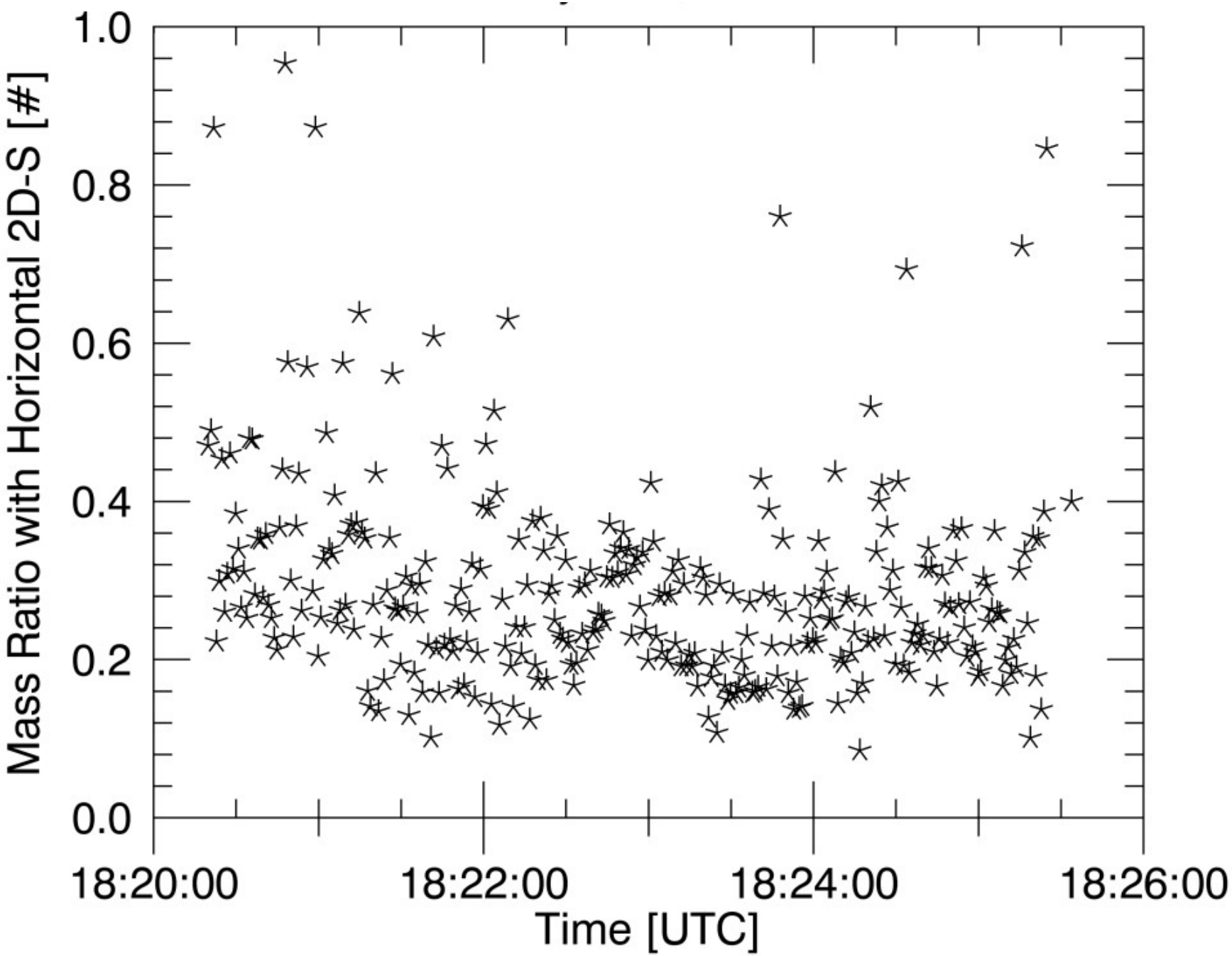

Conclusion

- The assumptions are likely insufficient. Aspect ratios not close to 1.0, spherical?
- How will calculated and observe reflectivity compare?
- Mass ratios very low, 0.1 to 0.4.

Future Work

- Comparison with MCR reflectivity.
- More complex equations for reflectivity calculations.
- Vertical Velocity Comparison.

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.
- Heymsfield, A. J., A. Bansemer, C. Schmitt, C. Twohy, and M. R. Poellot, 2004: Effective ice particle densities derived from aircraft data. J. Atmospheric Sci., 61, 982–1003, doi:10.1175/1520-0469(2004)061<0982:EIPDDF>2.0.CO;2.
- Rinehart, R. E., 2010: Radar for Meteorologists. Rinehart Publications, 482 pp.
- 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.More complex equations for reflectivity calculations.