Processing of In-Situ T-28 Aircraft Data for Coupling with Radar Observation of Hail Storms

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Photo provided by Tom Warner

Motivation

- Annually, hailstorms cause ~1.433 billion USD in damage to crops within the US.
- Improved understanding hailstorms improves forecasts and modeling.

Research Objectives

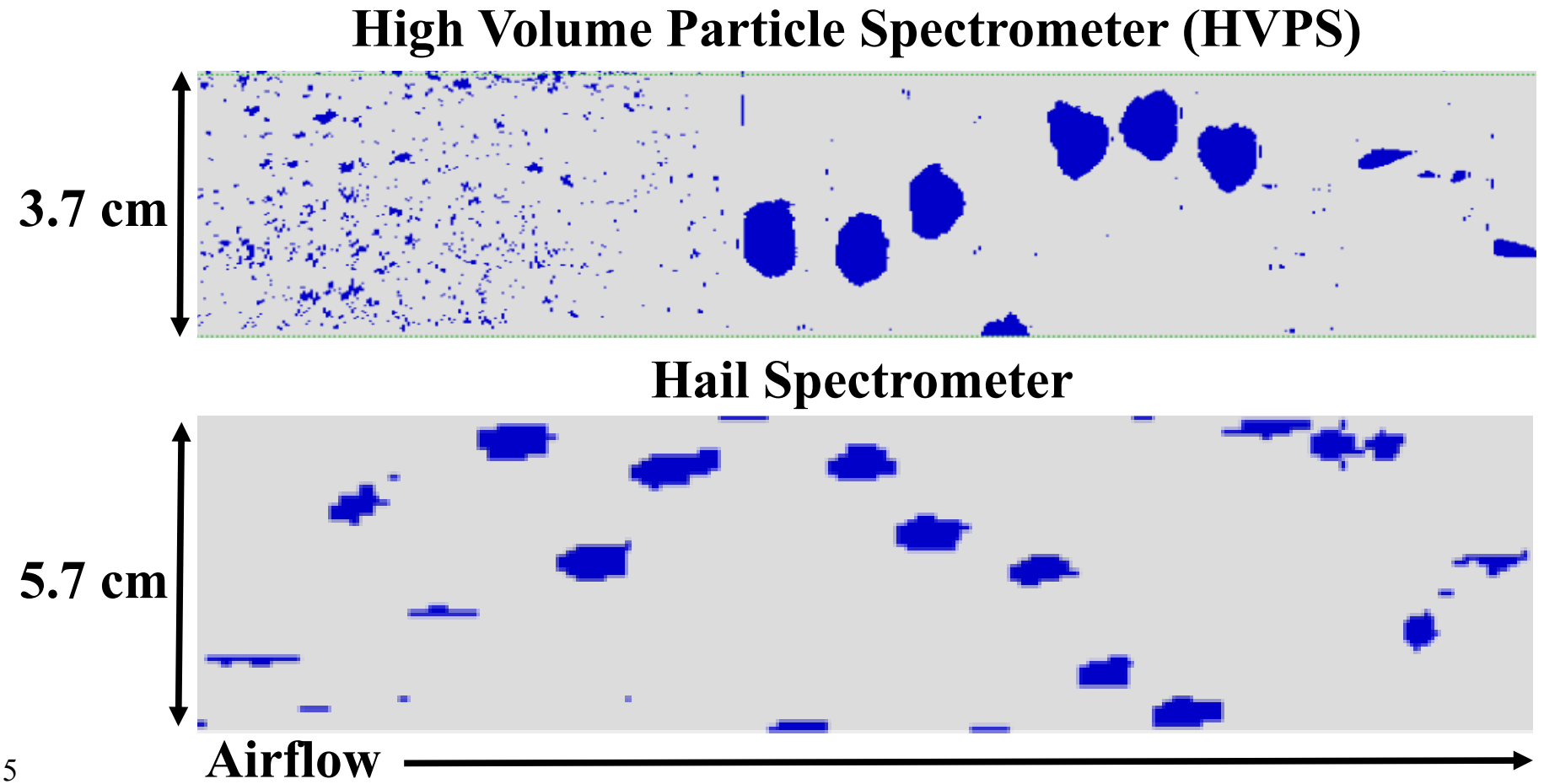
- Compare T-28 aircraft in-situ measurements of hail with CSU-CHILL radar observations.
  - Assess the data quality of Optical Array Probe (OAP) measurements.
  - Assess uncertainty in using T-28 in-situ data for calculating radar signatures such as reflectivity.

Photo of CSU-CHILL Radar by John Eisele

T-28 Aircraft

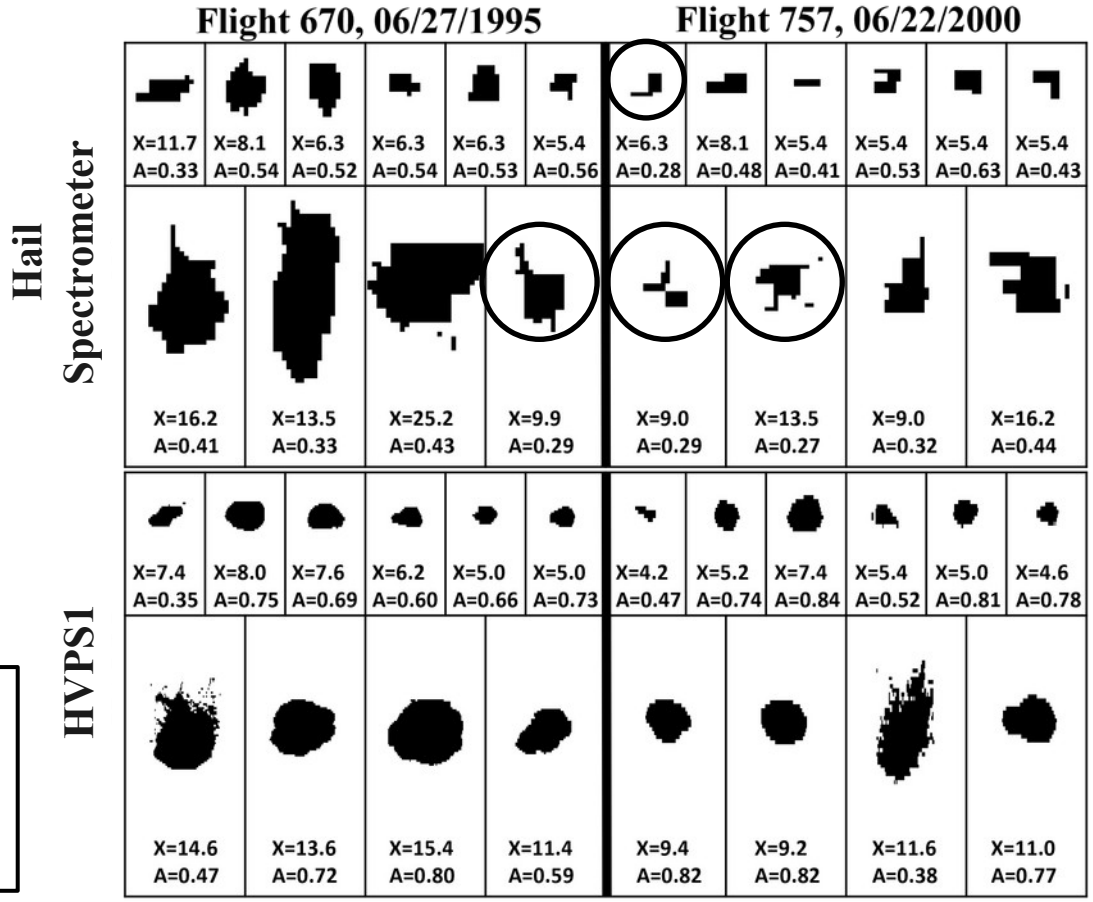
- Able to fly in hail up to 7.5 cm (3 inch)
- Analyze 14 flights.
- Deployed two optical array probes (OAP),
  - Hail Spectrometer
  - HVPS-V1

Optical Array Probe (OAP) Images



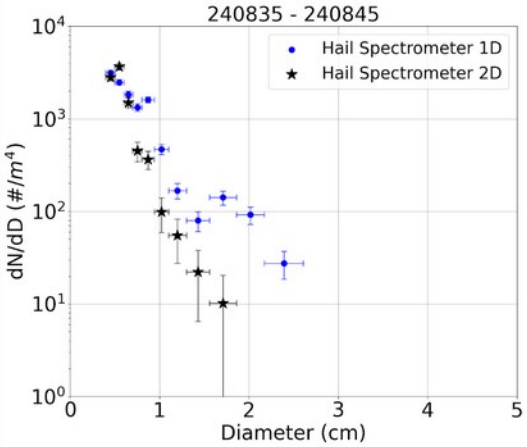
Review of Individual Particles

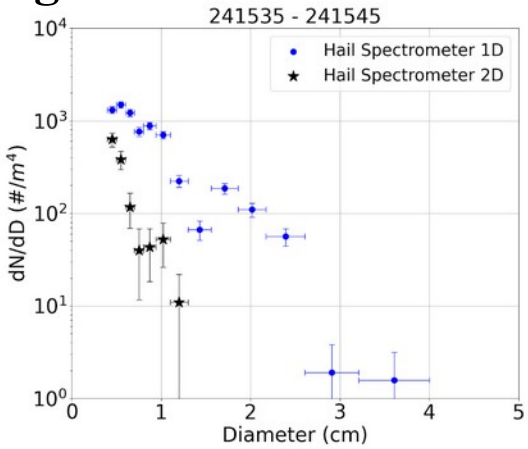
- Overall assessment of image quality.
- Provide confidence in area ratio threshold (0.3) used for particle rejection using SODA processing software.



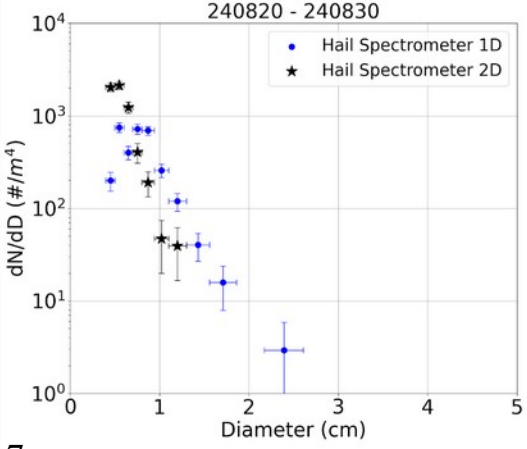
Legend:
- X = x-size diameter (mm)
- A =Area ratio

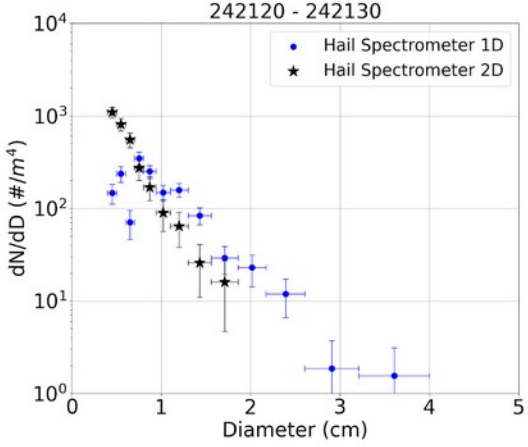
T-28 Flight 815





T-28 Flight 757

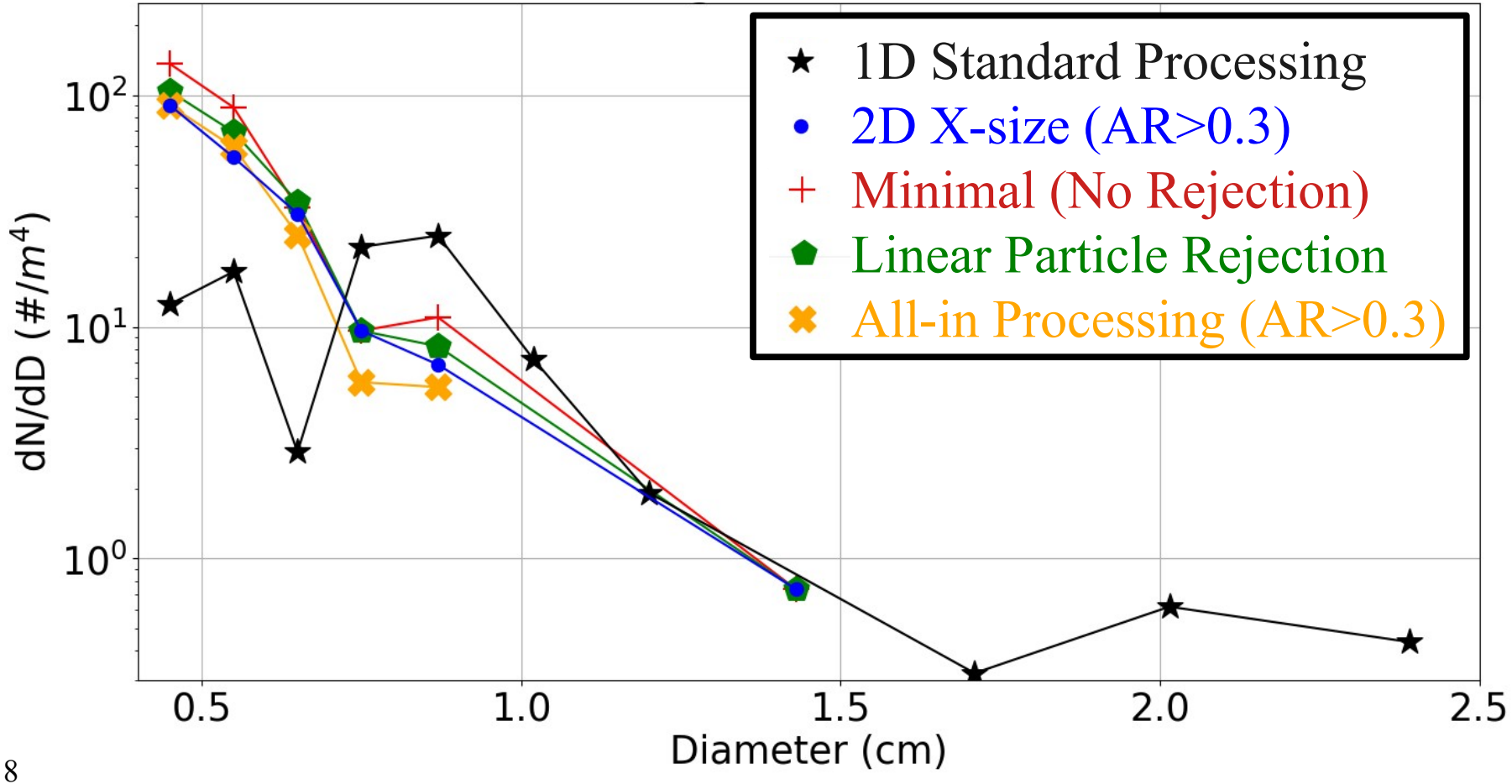




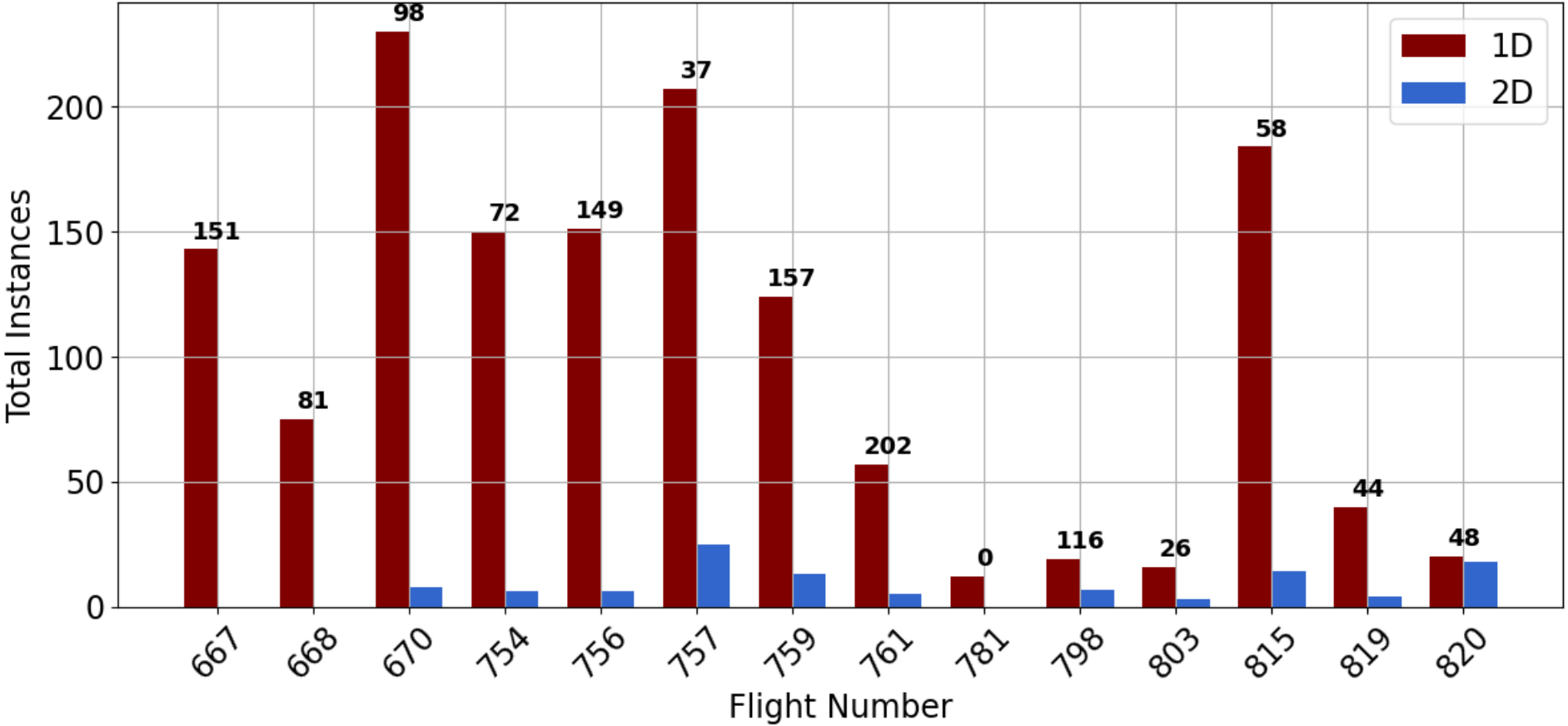
Particle Size Distributions (PSD)

- Analysis quantitatively evaluates 2D image quality.
- 1D and 2D PSDs do not agree.
- 1D PSDs have too many large particles and too few small particles.

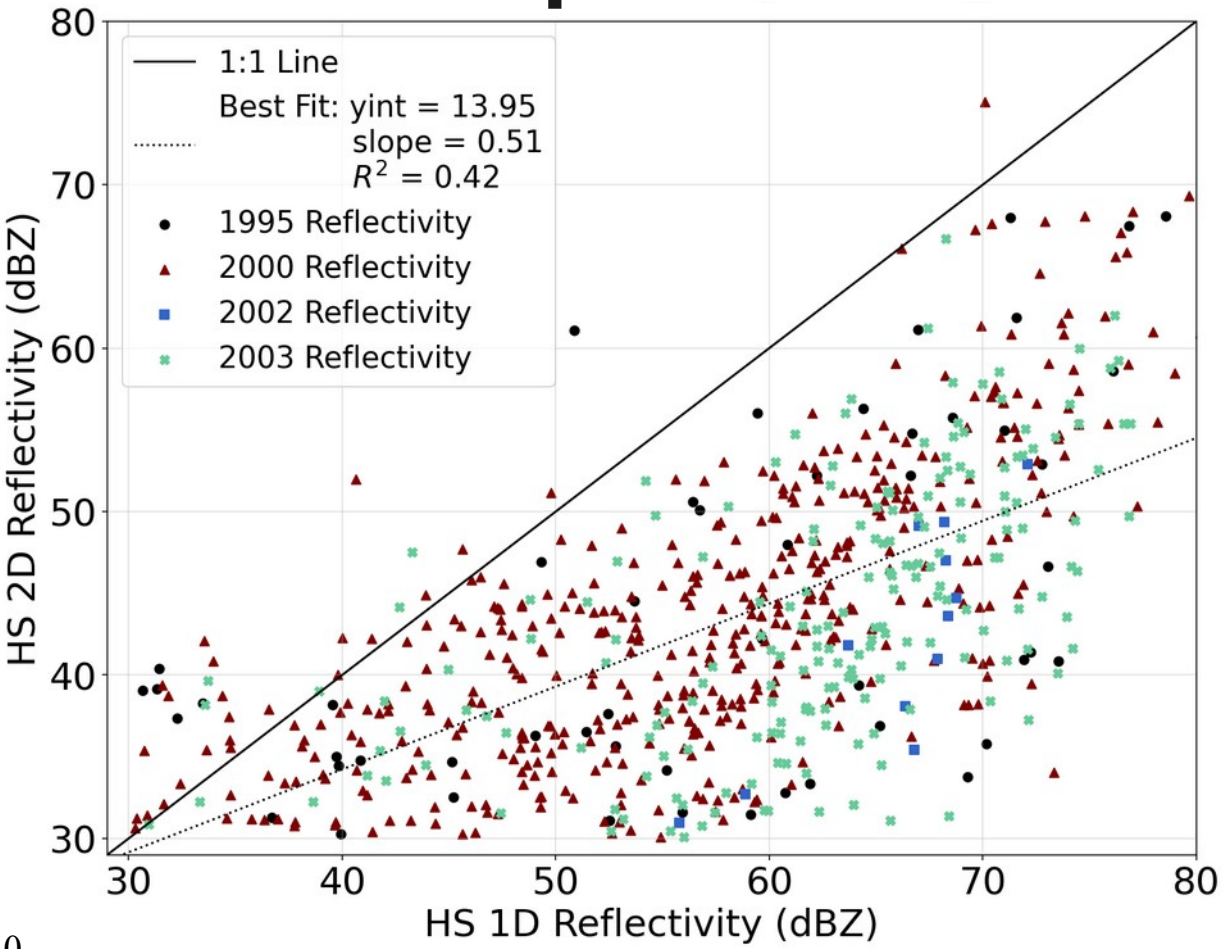
June 22, 2000 (Flight 757) 24:21:00-24:21:10 UTC)



Summary of 1D and 2D PSD Largest Particles



Impact on Reflectivity



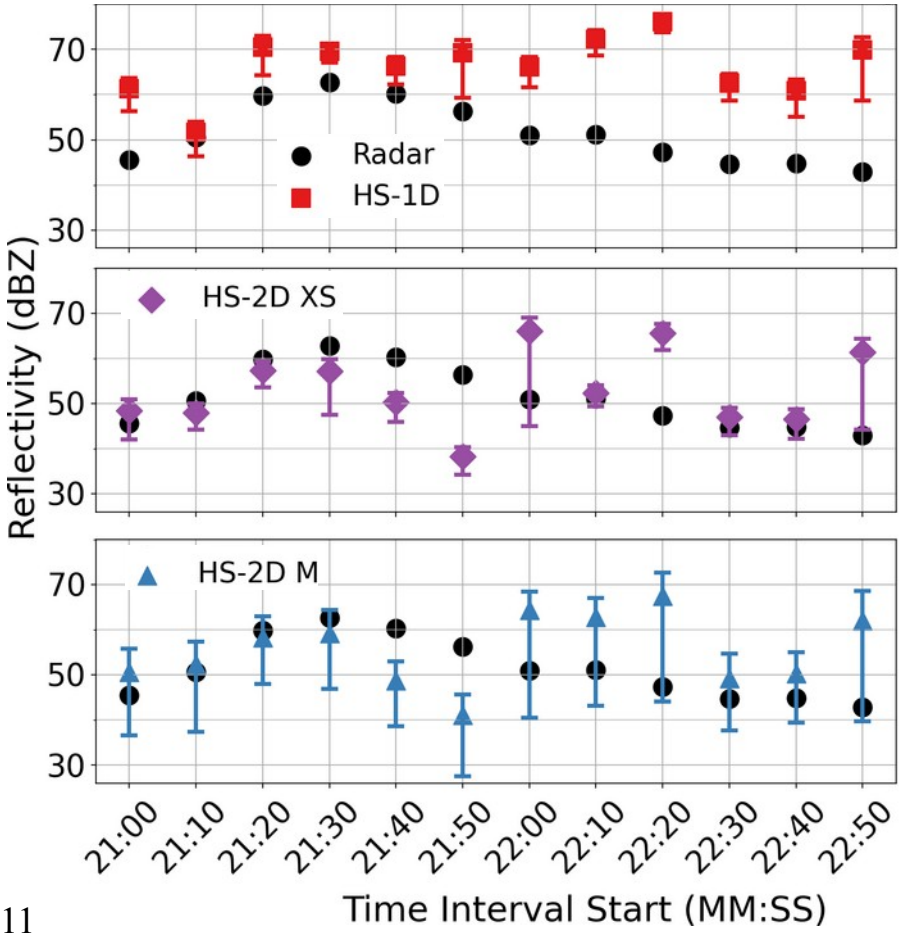
$$Z_e = 10 * log_{10}\left(\frac{0.197}{0.93}\sum_{i=1}^{14} D_i^6 * C_i\right)$$

1 Particle, 1 cm:
Z_e = 37.6 dBZ

1 Particle, 2 cm:
Z_e = 56.4 dBZ (x76)

1 Particle, 3 cm:
Z_e = 67.2 dBZ (x917)

June 22, 2000 (Flight 757): Radar Comparison

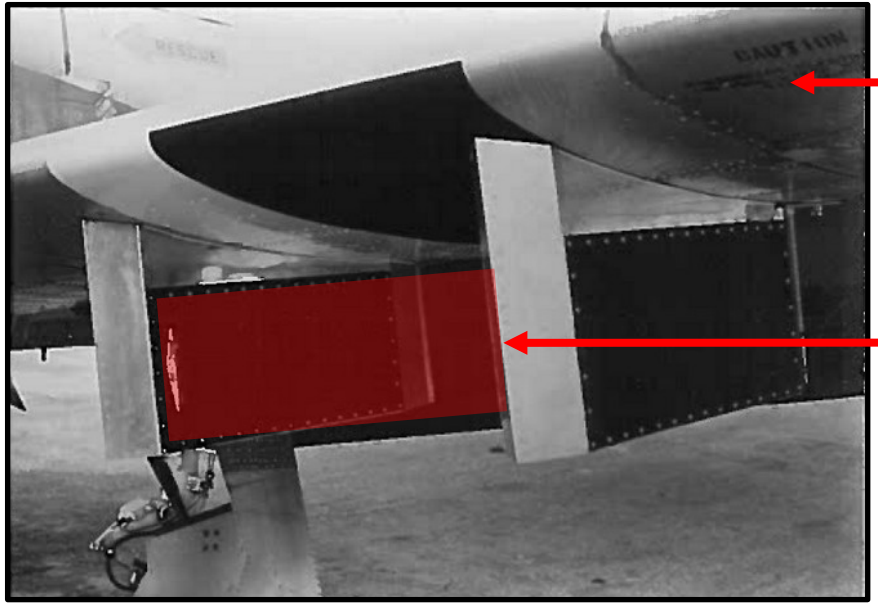


- 1D PSD has reflectivity consistently higher than the radar.
- 2D x-size (XS) PSD reflectivity has over and underestimates compared to the radar.
- 2D mean (M) of all PSD overlaps within the Uncertainty for 10 out of 12 for the 10 s intervals.

Conclusions

- 1D processing has consistently higher concentration of large particles than the 2D processing PSDs.
- The 2D processing should be used when available.
  - More consistent PSD shape.
  - More consistent with manual image analysis.
- Manuscript under development for publication.

James Klinman Thesis, “Evaluating Hail Spectrometer Data Quality and Uncertainty for Calculating Radar Reflectivity Factor”, Fall 2025, in press, 2026. (See https://commons.und.edu)



T-28 Wing

Sample Area