A Comparison of Airborne Data Processing Methods on Single Scattering Properties of Cloud Ice Habits

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Background

- Ice induction in high altitude jets reducing thrust / extinguishing exhaust
  - “The Ice Particle Threat to Engines in Flight” (Mason, Strap, Chow; 2006)

- FAA regulations on “ice crystal icing (ICI)” conditions
  - Airworthiness Directive 2013-24-01
    - Issued and effective 2013/11/27
    - Applies to several Boeing models
    - ICI conditions must be detectable by aircraft with a notification system

- Ice habits have individual scattering and absorption properties
    - Yang et al. 2000, 2005, 2015, etc.

- Backscatter can be used for detection and/or classification of ice particles

Goal/Purpose

- “… will compare aircraft probe derived backscatter to the backscatter from a LIDAR system.”

- Method of LIDAR verification
  - Must know size distributions and habits
    - What are the uncertainty levels in sizing and habit classification?
    - Which is the dominant factor?

Methodology

- Compare 3 Optical Array Probe data processing methods
  - Reconstruction, All-In, Center-In
    - Differentiated by how they handle partially captured particles
    - “A Computational Technique for Increasing the Effective Sampling Volume…”
      - (Heymsfield and Parrish; 1978)
    - Processed using Community Packages for Airborne Science (CoPAS)
  - Each should produce at least slightly different size distributions
    - Poisson counting statistics for uncertainty in sizing
    - sqrt(# particles) / (total # particles observed)
  - Determine the resulting difference in calculated backscatter
  - Repeat the process assuming different monodispersed habit structures for habit related uncertainty

Data

Location	Year	2DC	2DS	CIP	CPI	CSI	HVPS3	NEV
Georgian Bay	2012	✓		✓	✓		✓	✓
North Carolina	2014	✓	✓		✓	✓	✓	✓
Florida	2015	✓	✓				✓	✓
North Dakota	2010	✓						
	2011	✓		✓	✓			✓
	2012	✓		✓	✓		✓	✓
	2014	✓	✓				✓	✓
	2015	✓	✓				✓	✓

Equation(?)

$$P_r(R) = \frac{h}{2}\frac{C}{R^2}\frac{\beta(R)}{4\pi}\exp[-2\int_0^R \sigma_{ext}(r')dr']$$

http://reef.atmos.colostate.edu/~odell/at652/lecture_2013/lecture8b.pdf

Need to find original source of equation

Expected Results

- Reconstruction should produce more small particles than center-in and all-in
  - More small particles should theoretically increase the amount of calculated backscattered radiation
  - Reconstruction should produce consistently higher amounts of backscatter
- Since cirrus clouds are more likely to be of a consistent habit the particle size-distribution will likely be more influential than the habit assumption.
  - Habit assumption is of secondary importance and can be disregarded