Retrieving Vertical Motions in Arctic Mixed-phase Clouds

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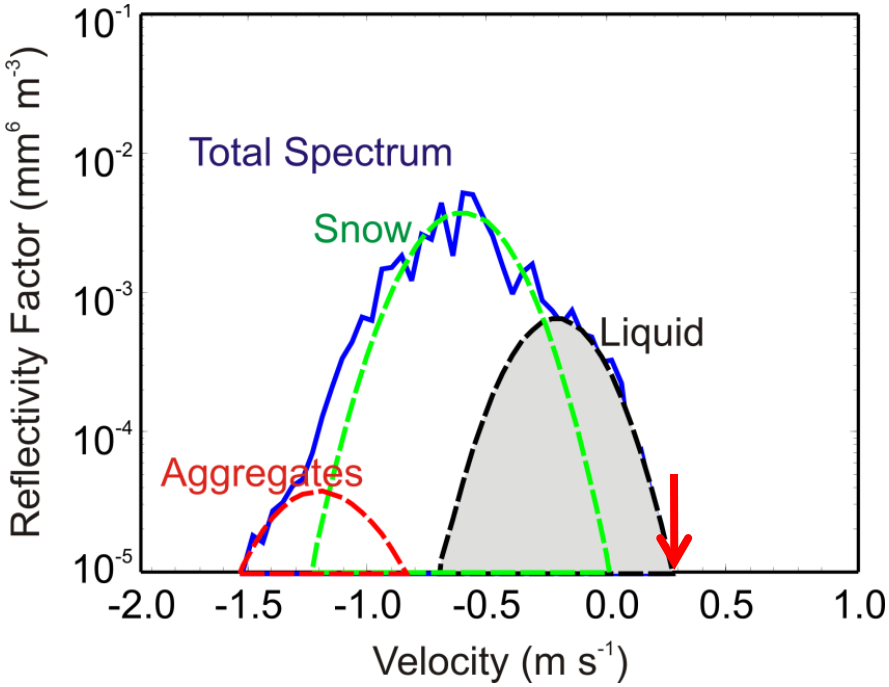
Motivation and Objectives

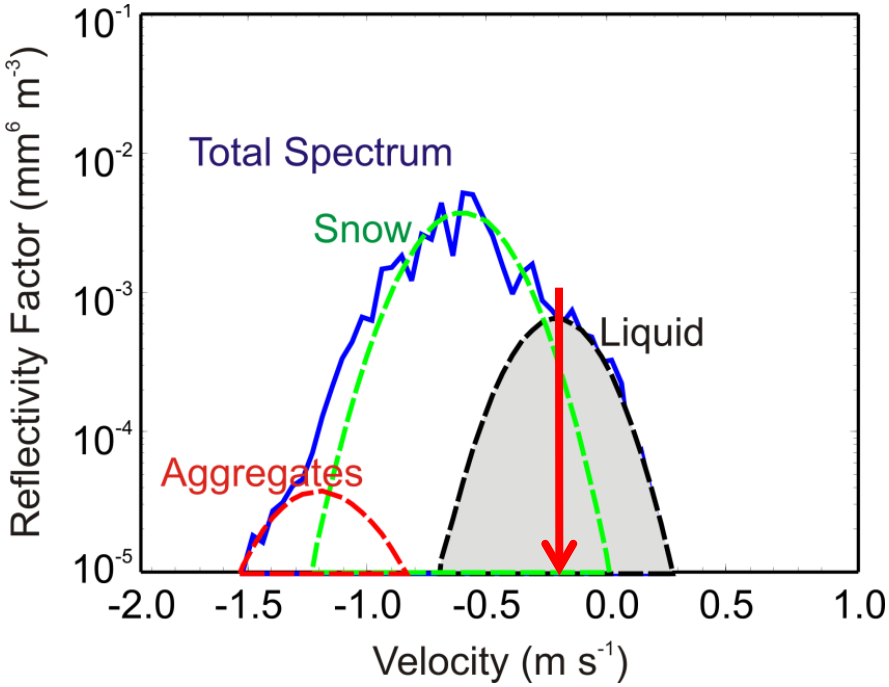
- Cloud droplets are good tracers of air motion
  - Difficult to separate from Doppler spectra
  - Current technique identifies the velocity at the edge of the spectra
  - Then adjust from there
- Develop an alternative method



Positive velocities represent upward motion.

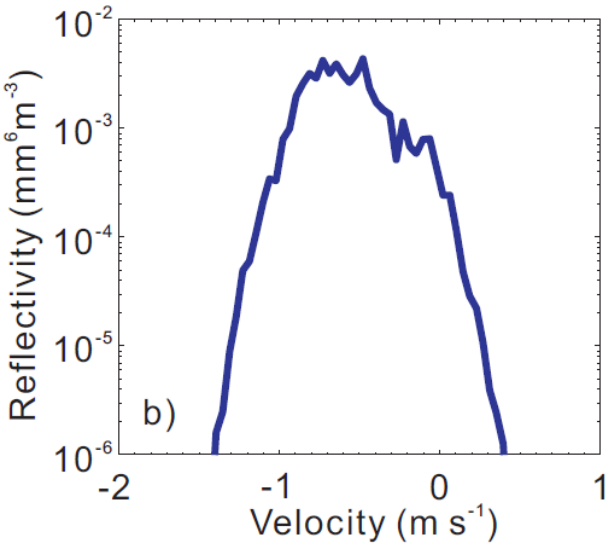
Method: Assumptions

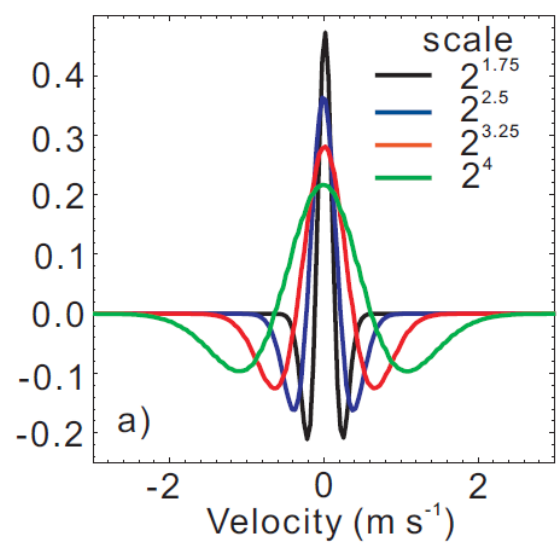
- Cloud liquid peak
  - Gaussian distribution
  - Centered approximately at the vertical velocity
  - Always furthest to the positive

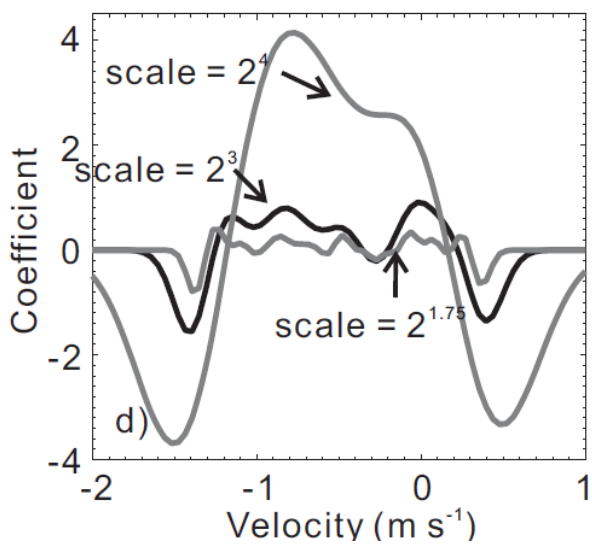


Positive velocities represent upward motion.

Method: Wavelet Analysis







2nd derivative of Gaussian

Method: Wavelet Analysis

- Identify three peak location candidates
- Fit the Gaussian distribution associated with each of them

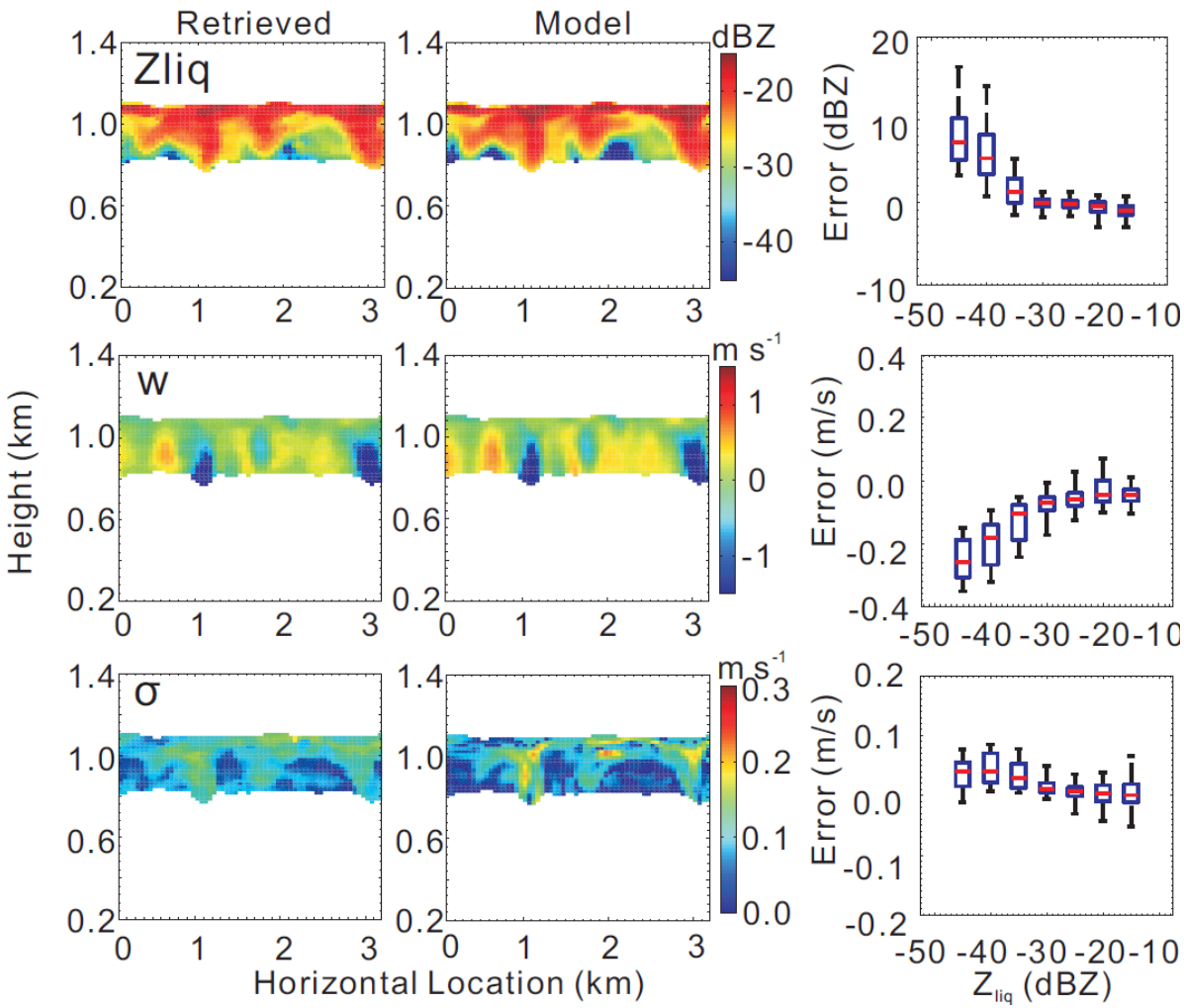
Method: Fuzzy Logic

- Use fuzzy logic to pick the most likely distribution from candidates
  - Classify each spectrum
    - pure liquid, liquid-dominated, and precip.-dominated
  - Different fuzzy logic membership functions for each class
  - From cloud top to cloud base
    - Liquid signal dominates near cloud top (McFarquhar *et. al*., 2011)

Validation: against Model Data

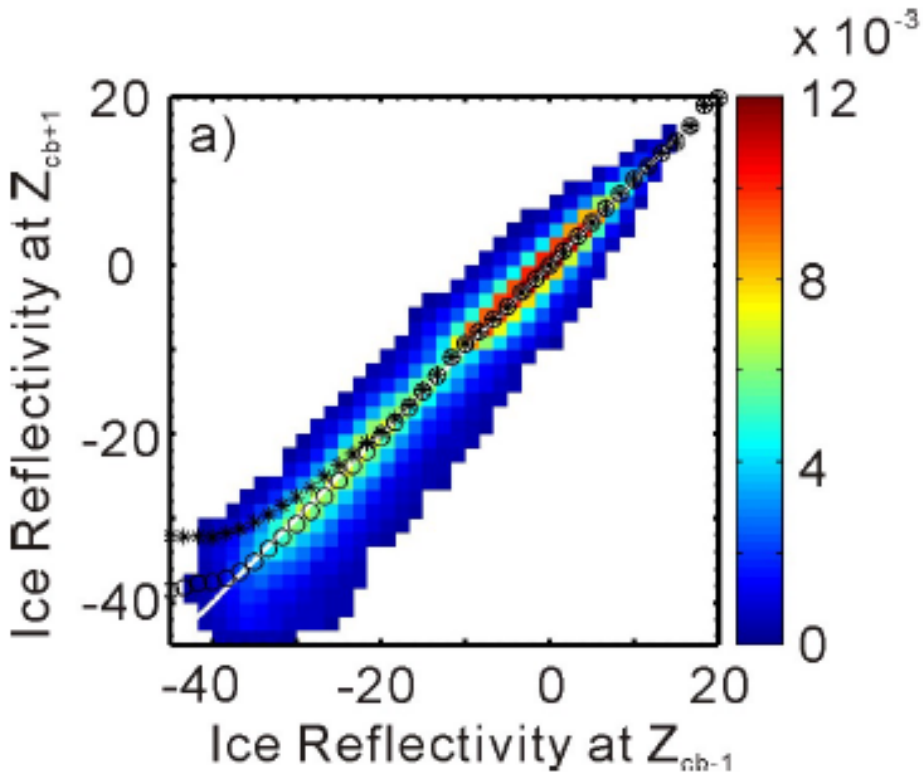
- Generate Doppler spectra from model data
  - Cloud resolving model data (Avramov *et al.*, 2011)
  - Radar spectrum simulator (Yu *et al.*, 2013)
  - Ice backscattering (Botta *et al.*, 2010)
- Apply the algorithm to the simulated Doppler spectra and compare with model data

Validation: against Model Data

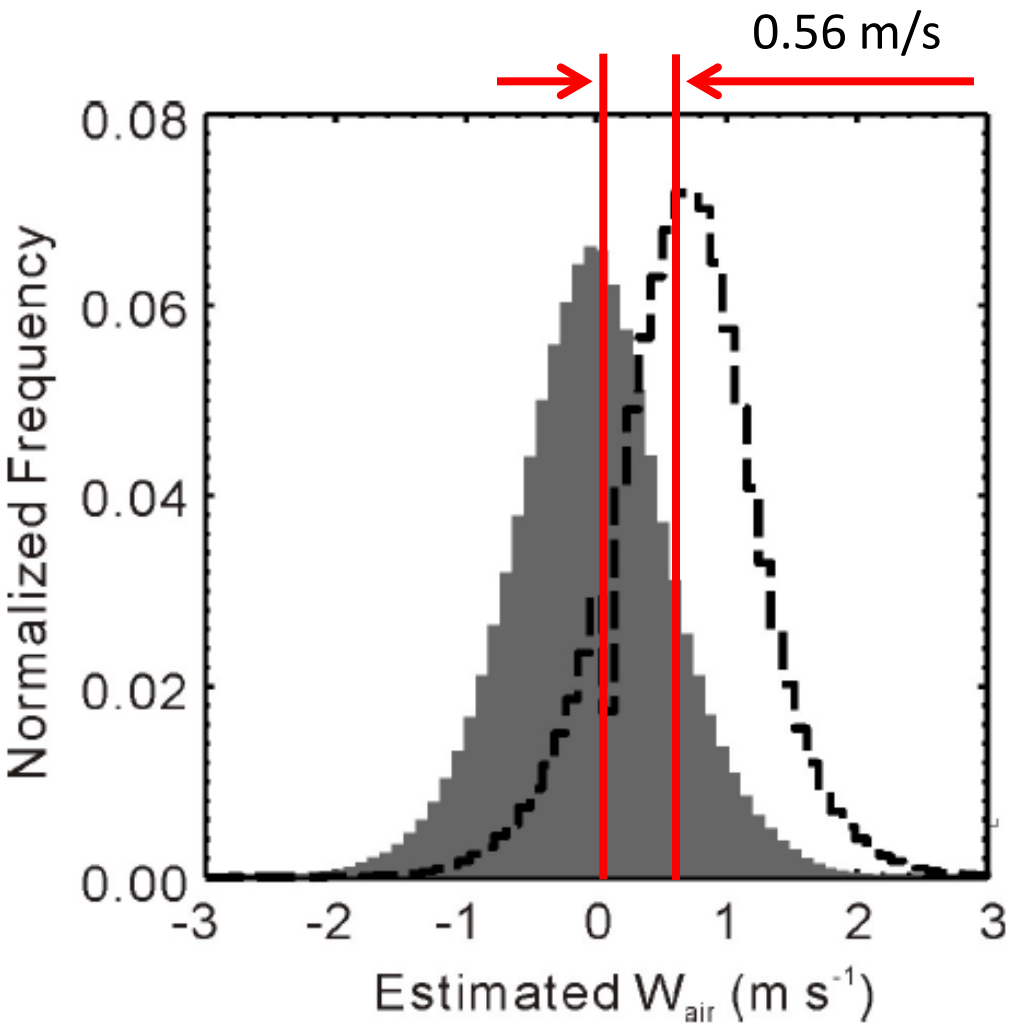


Validation: Self-consistency

- Single-layer mixed-phase clouds, 185 hr KAZR data from NSA, Oct., 2011
- Radar volumes one gate above and below cloud base



Results: Vertical Motion



Shaded: Retrieved vertical air motions

Dash: First-bin velocities

Single-layer mixed-phase clouds
185 hr KAZR data from NSA
Oct., 2011

Summary

- An algorithm for retrieving vertical motions
  - Based on wavelet analysis and fuzzy logic
  - Validated against model data
  - Applied to single-layer, mixed-phase clouds
  - KAZR Doppler spectra measured at NSA, Oct., 2011
- Results
  - Mean vertical velocity in clouds is close to zero
  - Mean overestimation with first-bin velocities is about 0.56 m/s