Snowflake Mixtures in Coastal Northeast United States Winter Storms

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Introduction

Heavy snow and ice from cold-season extratropical cyclones in the northeastern United States can shut down cities for extended periods. Snow and mixed-phase precipitation accumulation are influenced by many characteristics including the number and size of particles, particle crystal shape, degree of riming, and density. Prior research has shown that denser, more rimed snow is expected close to the cyclone low-pressure center while less dense, less rimed snow occurs along the northwest edge of the storms. Riming occurs when a snowflake falls through a cloud with supercooled water droplets, which adhere to the snowflake and freeze. Improved understanding of snowfall characteristics can yield better estimates of snow from radar since reflectivity alone is too unconstrained.

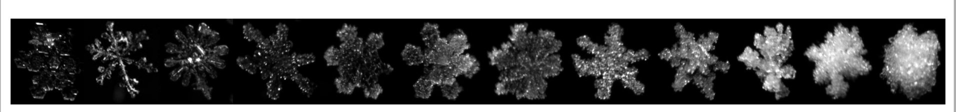


Figure 1. Degrees of riming – light to moderate to heavy – from left to right

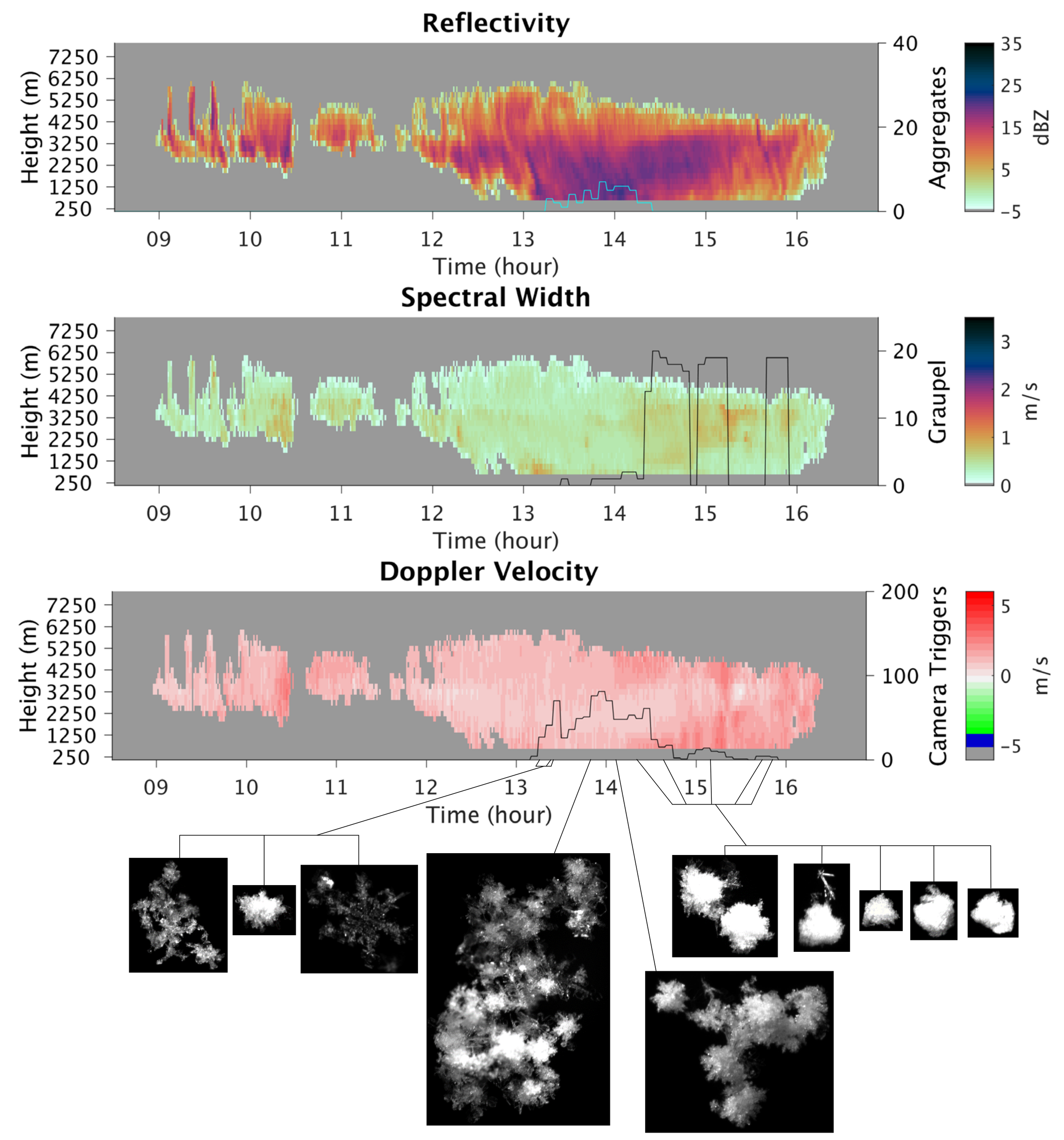
Methods

Our dataset is comprised of vertically pointing radar data from a Micro Rain Radar (MRR) and snowflake data from a Multi-Angle Snowflake Camera (MASC). The data have been collected together at Stony Brook University (SBU) on Long Island in New York since December 2014. The radar data is visualized using time-height plots of reflectivity, spectral width (a proxy for turbulence), and Doppler velocity (related to vertical motion). Embedded in the MRR plots are 5-minute totals for large aggregates, graupel, and the total number of snowflakes captured by the MASC. Four storms are analyzed as part of this project.

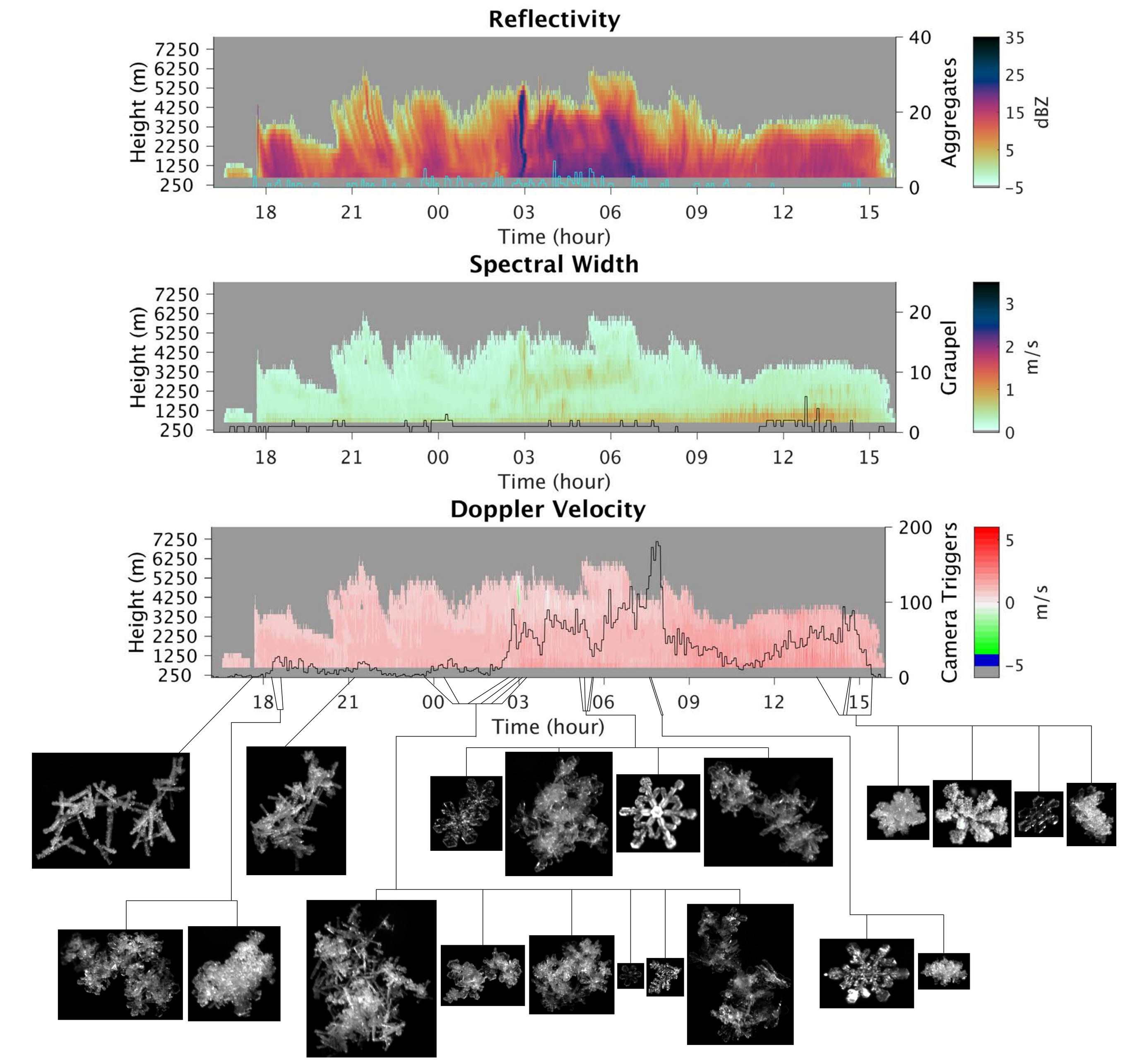
Figure 2. Map indicating location of SBU

Figure 3. MASC (foreground) and MRR (background)

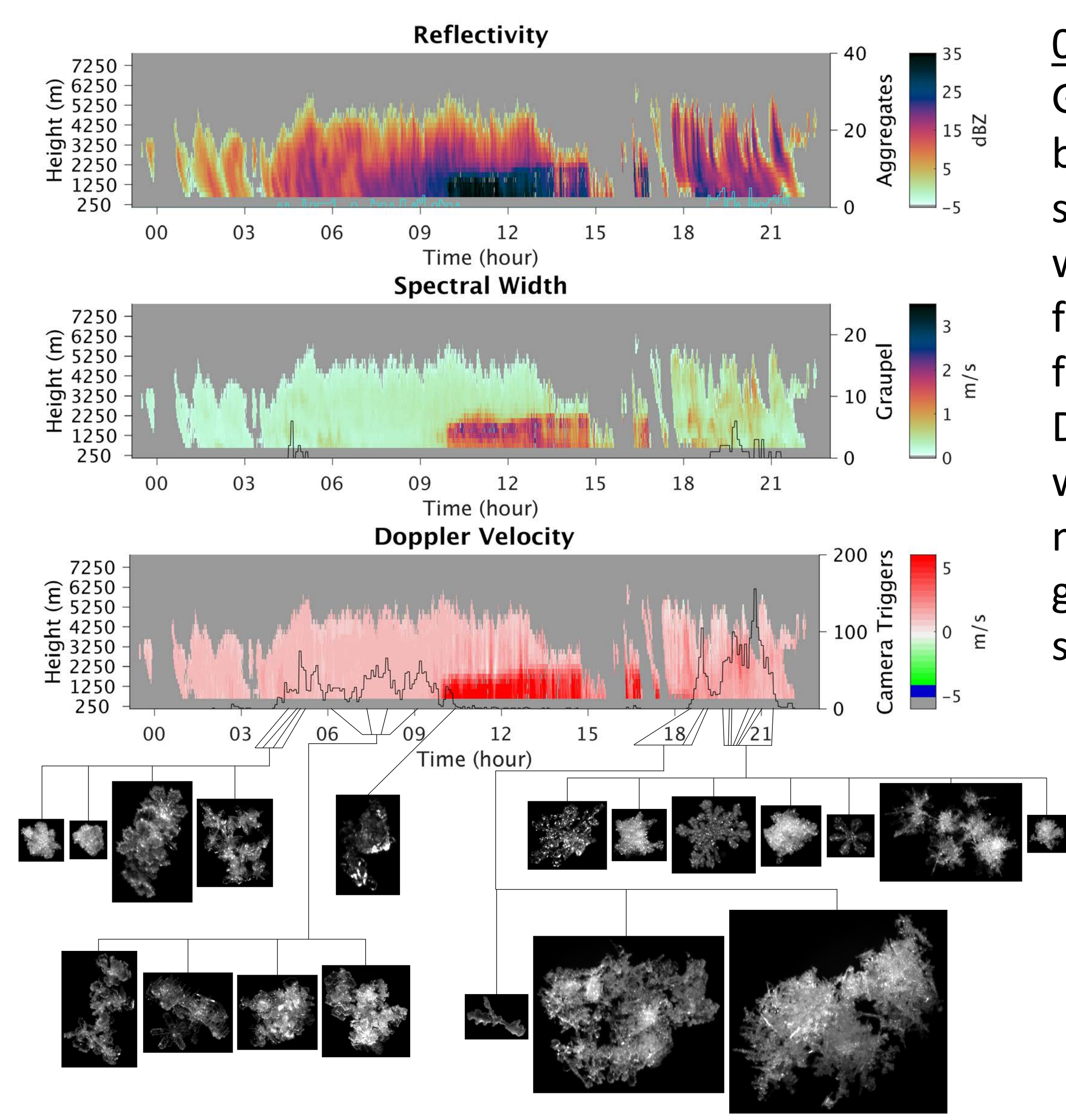
Data Analysis & Results



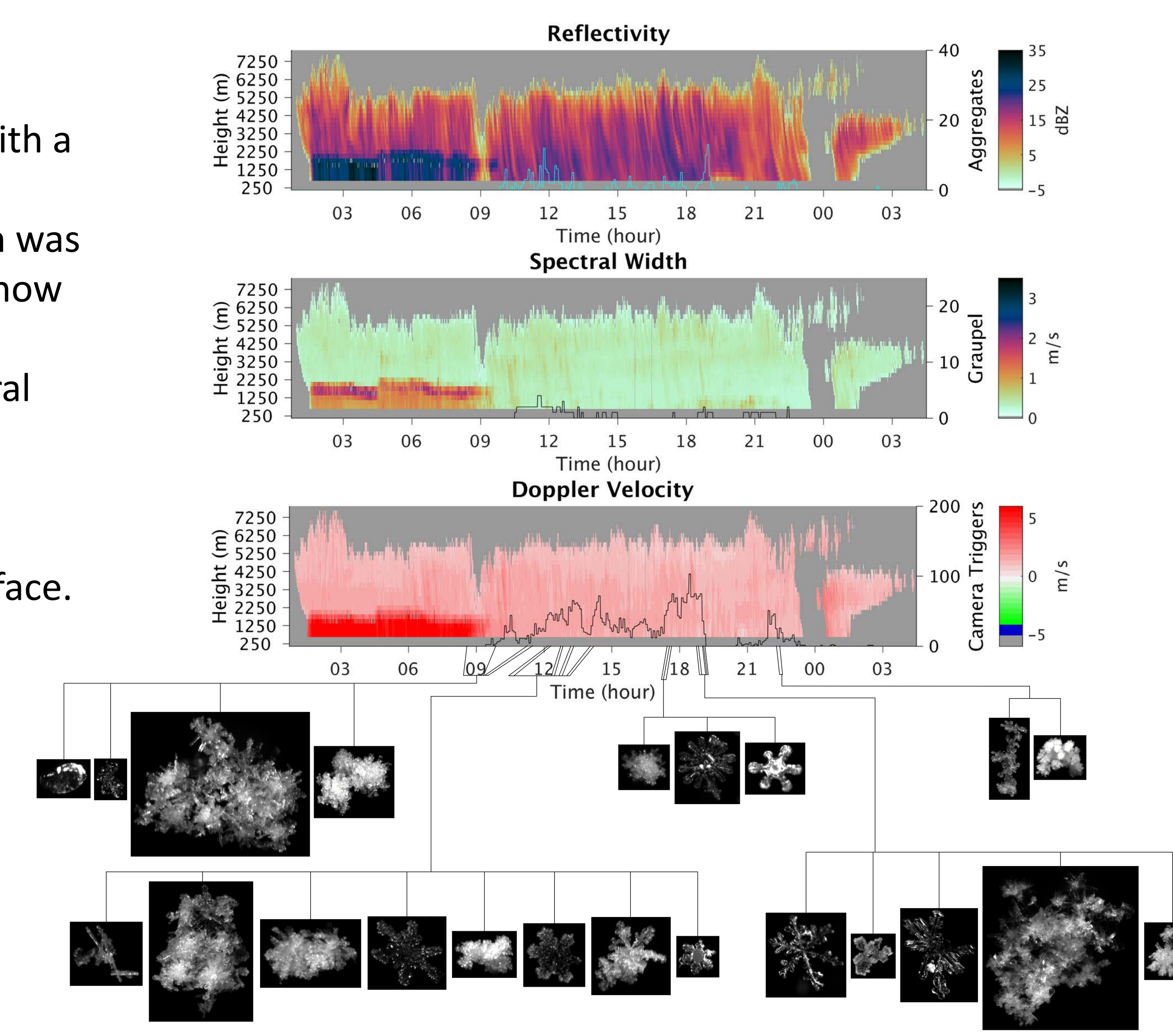
09 January 2015:
Snowflake mixture with predominately aggregates (jumbles of snowflakes) occurred when surface reflectivity was higher from 13:15Z to 14:30Z. Surface reflectivity decreased after 14:30Z while spectral width increased aloft and Doppler velocity increased near the surface. Exclusively graupel (heavily rimed snow particles) fell during this period. Multiple fall streaks can be noted between 15:00Z and 16:00Z.



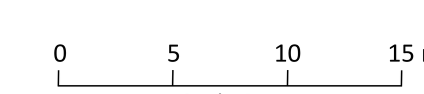
26-27 January 2015:
Snow band evident at 03Z with predominately aggregates and individual snowflakes observed at the surface. Surface reflectivity increased as another snow band neared the observation site around 07:00Z. Mostly aggregates fell at this time. The peak number of camera triggers occurred after the peak in surface reflectivity. Increasing near-surface spectral width at the end of the storm corresponded to an increase in degree of riming.



02 February 2015:
Graupel occurred at the beginning of the storm with a slight increase in spectral width. A transition to rain was followed by a period of snow from 18:30Z to 22:00Z. During this period, spectral width increased while a mixture of aggregates, graupel, and individual snowflakes fell at the surface.



05-06 March 2015:
Rain occurred at the beginning of the storm, but transitioned to snow at 09:40Z. At around 12:00Z, needle aggregates fell concurrently with dendrite aggregates. At times during the storm, lightly rimed individual snowflakes fell simultaneously with graupel-like particles. Many fall streaks can also be noted throughout the storm.



Conclusions

Our data show that snowfall within winter storms in the coastal northeastern United States is complicated and frequently nonhomogeneous in nature. For example, heavily rimed particles like graupel can occur exclusively at times in weakly forced environments as in the 09 January 2015 storm while heterogeneous mixtures of multiple particle types fall at times during all of the analyzed storms. Higher spectral width values (>1) are associated with heavily rimed particles like graupel (excluding periods of rain). Increased spectral width is an indicator of greater turbulence in the atmosphere, which is conducive to riming. Fall streaks (narrow bands of locally increased reflectivity) can correspond to periods of falling graupel, but are not exclusively associated with graupel-like particles.

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