Atmospheric Conditions and Processes Associated With Different Degrees of Snowflake Riming

CP3g NC STATE UNIVERSITY
Clouds and Precipitation Processes and Patterns Group

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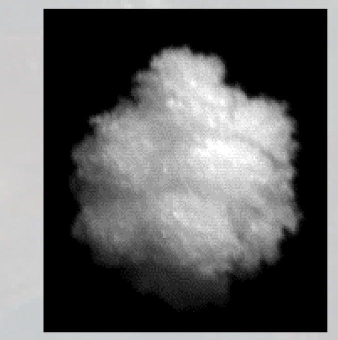
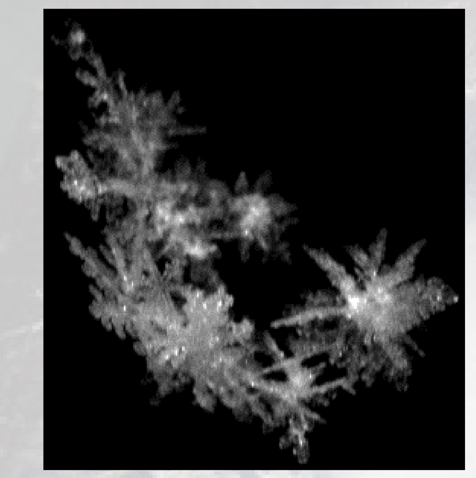


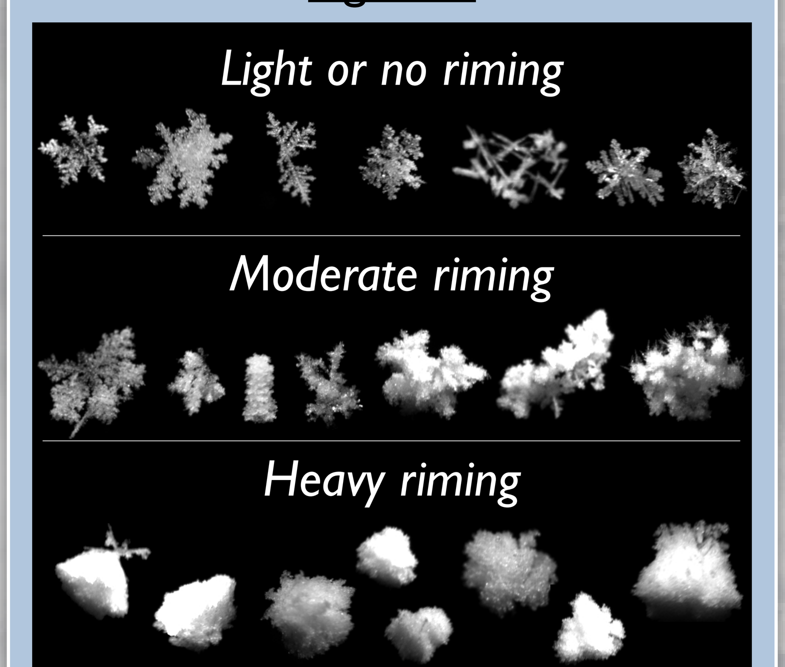


I. Introduction

Purpose

A wide variety of snow particles can form as a result of different combinations of processes and conditions in clouds. This study investigates the relationships between internal storm structures and snow particles at the surface. Riming occurs when an ice crystal collides with supercooled rain droplets in a cloud. When riming occurs to such an extent that the original ice crystal is no longer discernable, the resulting ice particle is called graupel. Figure 1 shows three increasing levels of riming, with the third level showing examples of graupel particles.

Figure 1



Snowfall accumulation is affected by riming since less riming means a lower density and therefore more accumulation. Furthermore, a layer of graupel on a mountain will increase the risk of avalanche because graupel does not pack as well as fresh powder snow. Our goal is to improve the understanding of storm structures associated with the various degrees of riming.

Study Domain

During the WASHARX experiment, several instruments were located at the Alta Ski Resort (Fig. 2) in the Wasatch Mountains of Utah. A Micro Rain Radar (MRR, Fig. 3) provided information about the vertical structure of storms such as reflectivity and spectral width (a proxy for turbulence). Meanwhile, a Multi-Angle Snowflake Camera (MASC, Fig. 4) captured digital photographs of snow while it is in free-fall. Meteorological sensors recorded data at various altitudes within the ski resort.

Figure 2

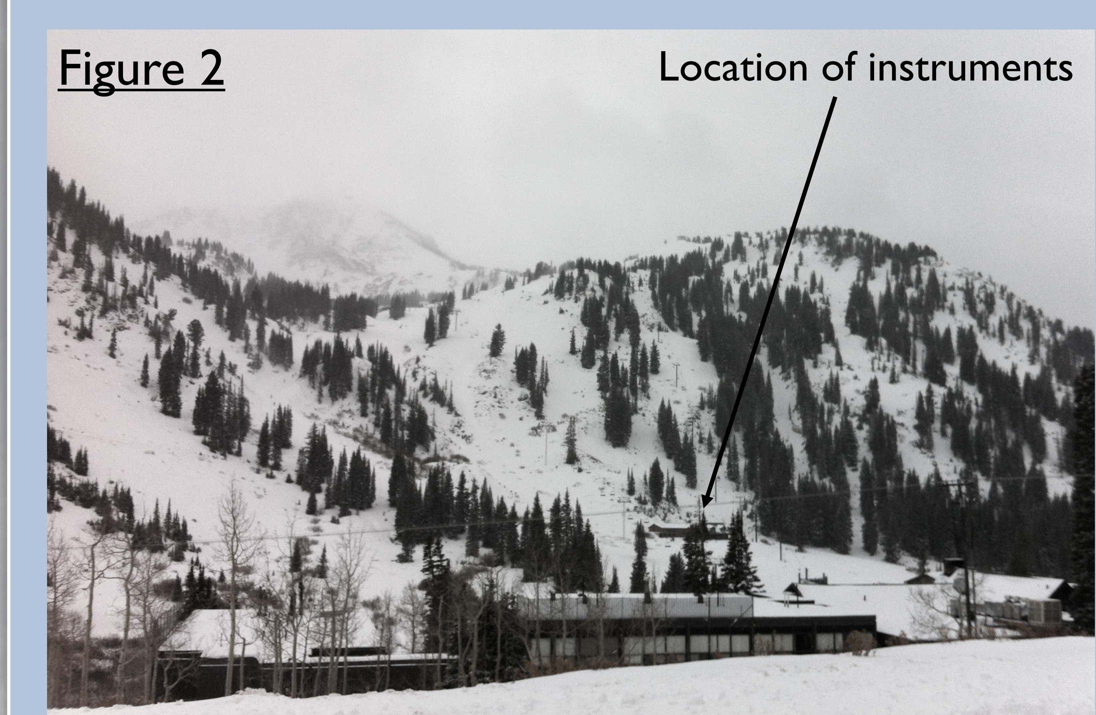
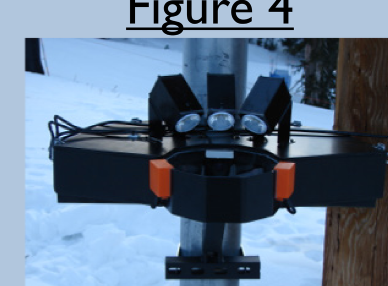


Figure 3

Figure 4



II. Observations from February 10, 2014

Figure 5a

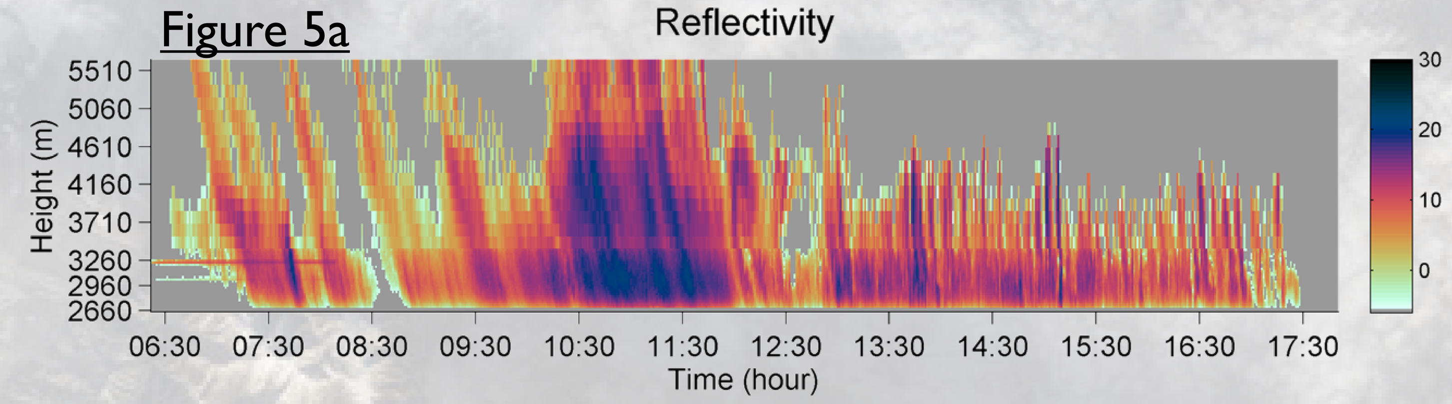
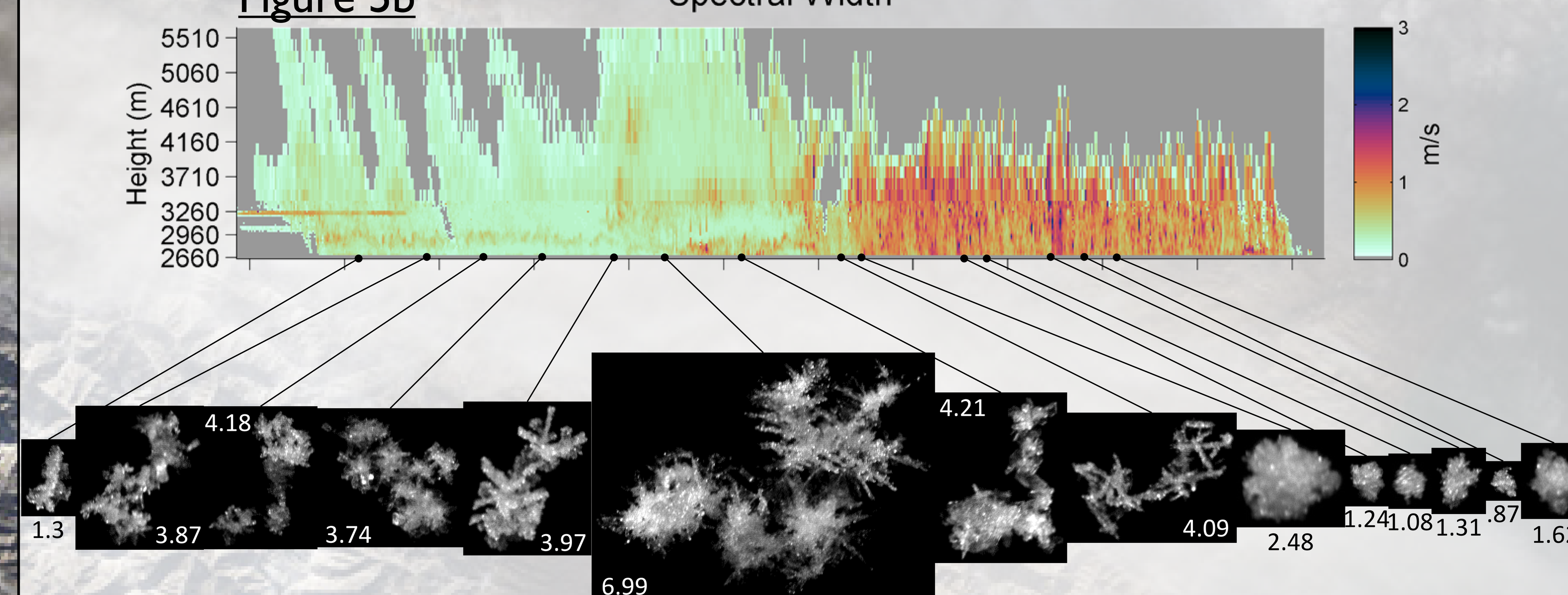


Figure 5b



Numbers indicate the maximum diameter in mm

This event illustrates a transition from low to high spectral width (turbulence) during a storm (Fig. 5). Surface air temperature ranged from -3.86°C at 7:30UTC to -0.98°C at 17:00UTC. The sample images from the MASC above show how lightly rimed aggregates dominated during the first part of the storm when spectral width was low. In conditions of higher turbulence in the column during the latter part of the storm, mainly graupel was observed. Figures 6a and 6b depict time series of characteristics of individual snowflakes over the course of the storm. Fall speeds become more variable and particle size decreases during the transition from aggregates to graupel.

Figure 6a

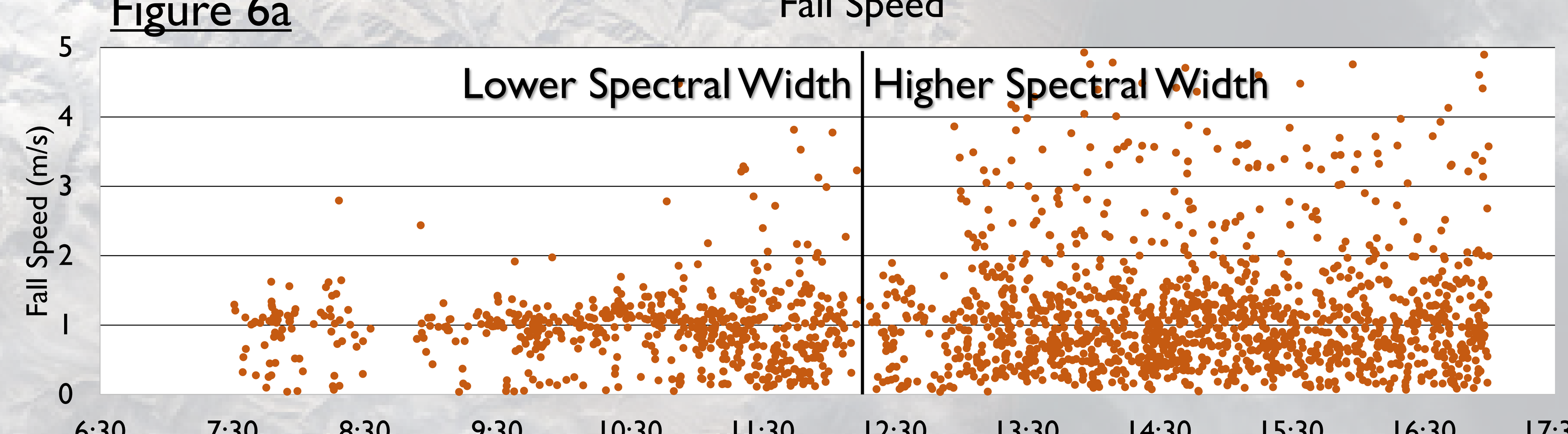


Figure 6b

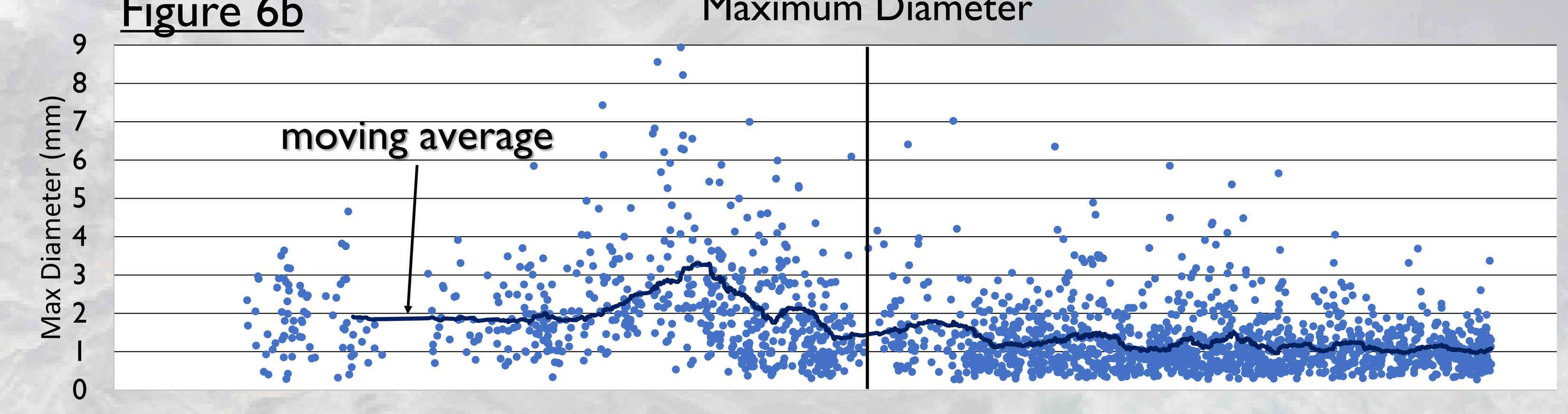
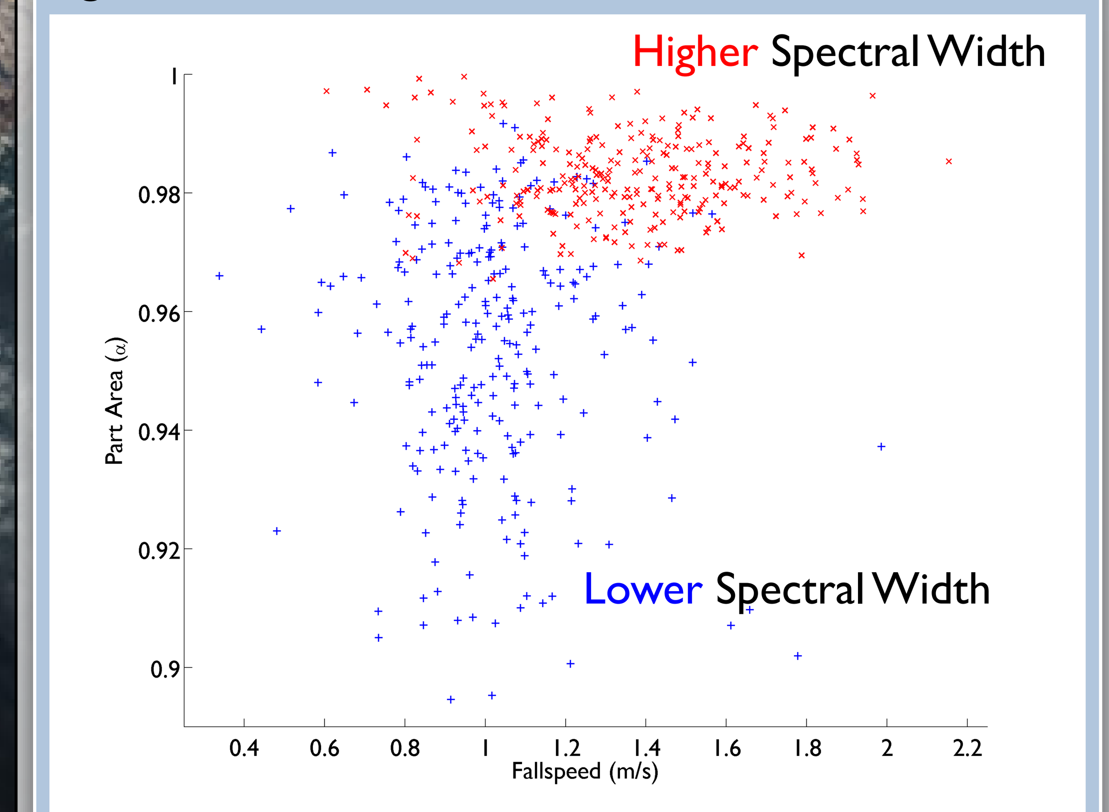
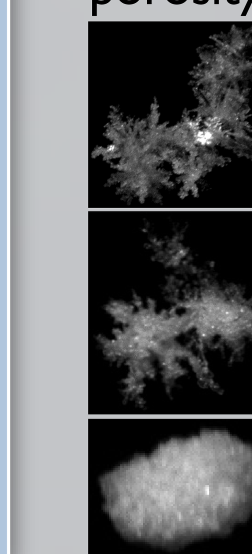


Figure 7



- Particle ratio area (α) is a measure of an ice particle's porosity.
- Values of particle ratio close to 1.0 indicate low porosity (i.e. graupel)



$\alpha < 0.9$

$0.9 < \alpha < 1.0$

$\alpha = 1.0$

Figure 8a

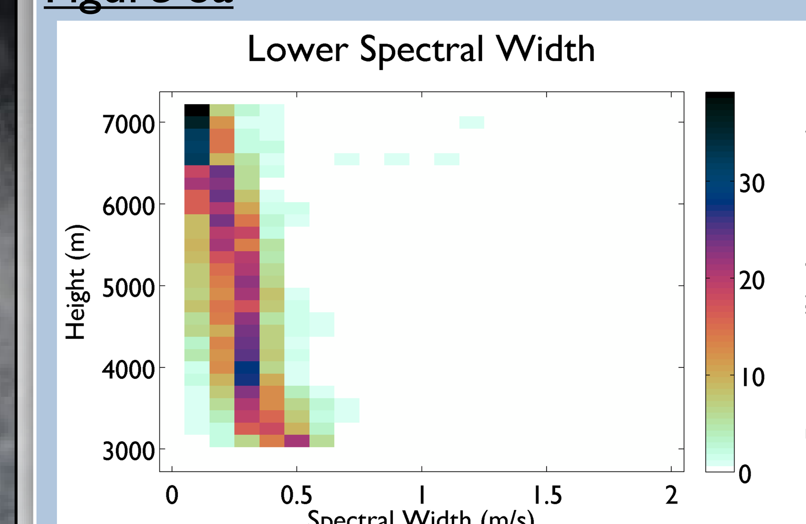
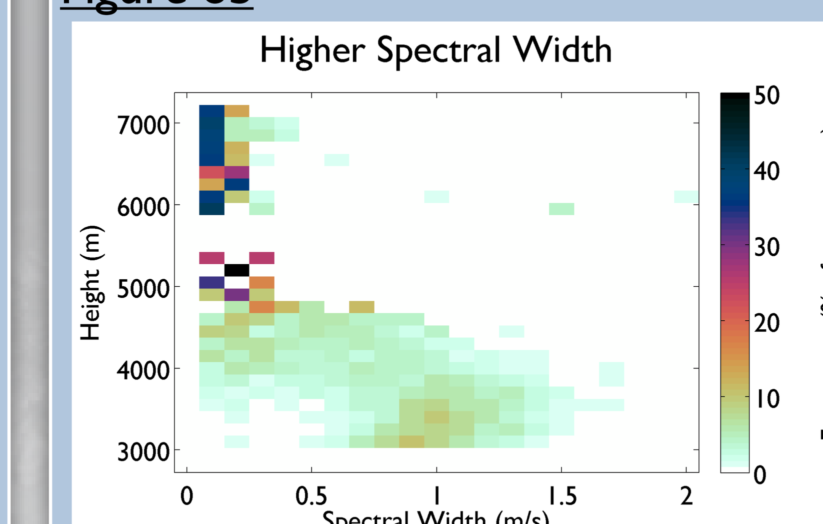


Figure 8b



Figures 8a and 8b are joint frequency distribution (CFAD) plots showing the percentage of spectral width values binned every 0.1 m/s at a given height for 5.5 hours (a) and 4.5 hours (b), where the percentage is normalized by the height.

III. Summary

An increase in the degree of riming and the formation of graupel coincided with an increase in the Doppler spectral width in the lowest 2 km of the storm. Graupel particles are associated with supercooled droplets and upward air motions and are therefore more likely to coincide with more turbulence. Figures 8a and 8b exemplify the increase in low-level turbulence in the latter part of the storm. Figure 7 illustrates the more variable fall speeds of low porosity graupel as compared to high porosity aggregates. The combined information from the MRR and the snowflake camera will allow us to document the joint variability of storm structures and snowfall in this region.

Acknowledgements

- Dr. Tim Garrett, WASHARX, University of Utah.
- Special thanks to Daniel Horn for snowflake database software.
- Funded by NSF Grant AGS-1127759.