Observations of the joint variability of snow storm vertical structure and near surface snow particles

CP3g NC STATE UNIVERSITY
Clouds and Precipitation Processes and Patterns Group

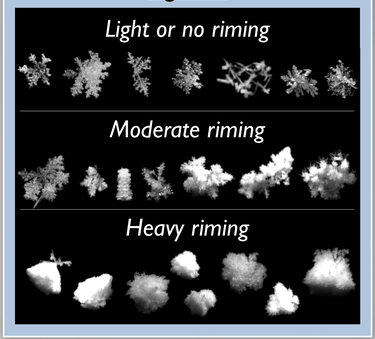
Spencer Rhodes, Sandra Yuter, and Andrew Hall
Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University

I. Introduction

Purpose

The goal of our research is to discover new relationships between vertical storm structures and the types of snow particles that form. A wide variety of snow particles can form as a result of different combinations of processes and conditions in clouds. This study investigates the formation and persistence of small snow pellets classified as graupel. Graupel forms through a process called riming. 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 discernible, the resulting ice particle is called graupel. Figure 1 to the right shows three increasing levels of riming, with the third level resulting in graupel formation.

Figure 1



Understanding the environmental conditions that form graupel is important because of the unique effects it has. On a mountain, a layer of graupel on the ground will increase the risk of avalanche because graupel does not pack as well as fresh powder snow. Furthermore, graupel contributes more to the groundwater budget than powder snow.

Study Domain

The instruments used are co-located at the Alta Ski Resort (fig. 2) in the Wasatch Mountains of Utah. A Micro Rain Radar (MRR, fig. 3) provides information about the vertical structure of storms and a Multi-Angle Snowflake Camera (MASC, fig. 4) captures digital photographs of snow while it is in free-fall. There are also temperature, wind, and precipitation gauges that supplement the MRR and MASC.

Figure 2

Figure 3

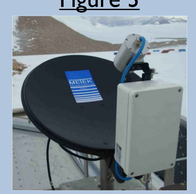
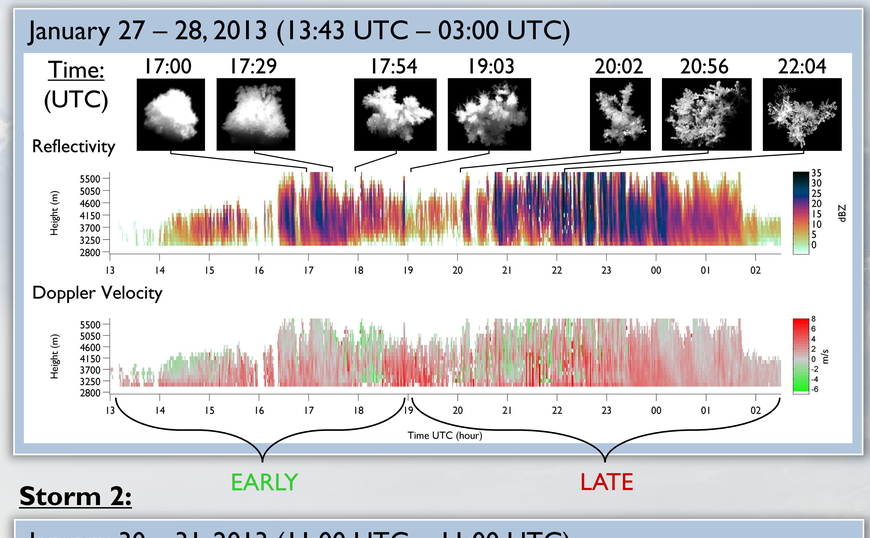


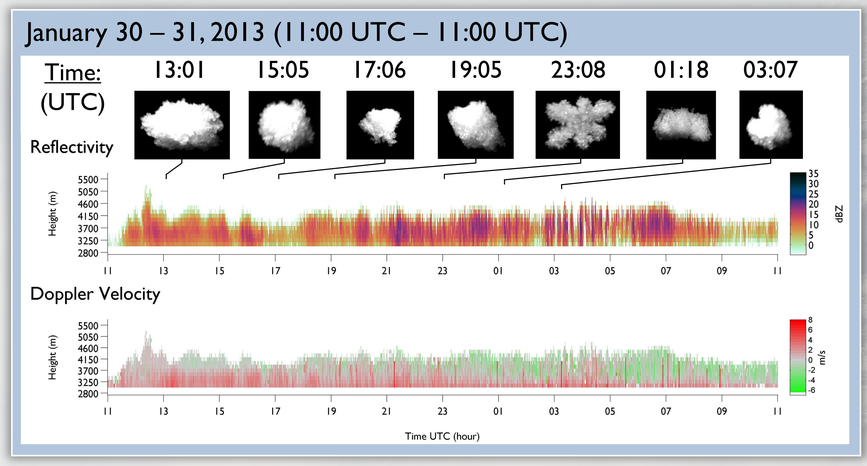
Figure 4

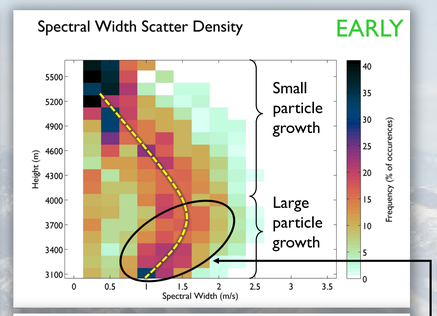
II. Observational Methodology

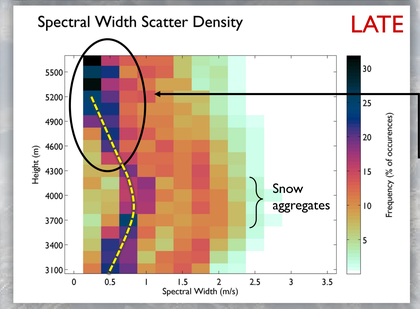
Storm 1:



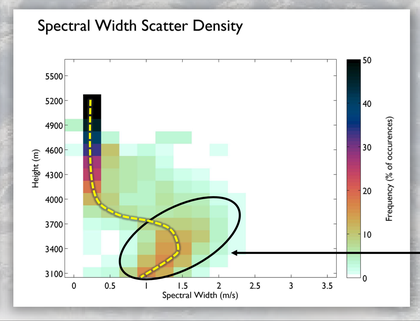
Storm 2:







Yellow line = Distribution mode



- Surface observations for Storm #1 showed that the surface temperature plummeted at the beginning of the storm, starting at -1˚C.
- Images from the MASC revealed mostly graupel reaching the surface from 15 UTC to 18 UTC, then changing to large snow aggregates.
- Separating the first storm exposes two unique signatures in the spectral width scatter density:
  - ✓ Graupel formation
  - ✓ Snow formation

Spectral Width:
The distribution of velocities within a single radar pixel.

- Storm #2 remained close to -4˚C at the surface throughout the duration of the storm.
- Storm #2 consisted of almost all graupel, verified by the MASC. A similar spectral width scatter density signature to early storm #1 was found in storm #2.

III. Summary

Overall, pristine ice crystals are the exception at Alta, Utah. The vast majority of snow has some degree of riming. The vertically-pointing radar data indicated that heavy riming typically occurred in the lower portion of the storm (less than 1 km above ground level). Graupel was produced both in taller and shorter storms. Graupel particles are associated with spectral width values greater than 1.25 m/s, consistent with turbulent air motions and/or the presence of snow particles with a wide range of sizes. The combined information from the radar and the snowflake camera will allow us to continue to document the joint variability of storm structures and snowfall in this region.

Future Work

- Better understand the atmospheric conditions in place at higher levels during graupel snow storms.
- Develop explanations of how abnormally shaped snow particles form.

Acknowledgements

- Dr. Tim Garrett, WASHARX, University of Utah.
- Funded by NSF Grant AGS-1127759.
- Special thanks to M. Miller and C. Burleyson.