Introduction

Snow occurs in a multitude of shapes depending on the temperature and humidity along the path it forms and falls. Current retrieval methods for snowfall rate and accumulation estimation use simplified geometries for snowflakes. This project examines thousands of snowflake images to more fully document the range of geometries of natural snow. Previous methods catch snowflakes on a flat surface, which can break delicate structures. We have documented three snowflake aggregate geometries not mentioned in previous classifications.

Methods

I: Data Collection
Images of snowflakes were obtained from a Multi-Angle Snowflake Camera (MASC) at Alta, UT and Stony Brook, NY from 2013 through 2015. The MASC takes pictures of flakes in free fall, preserving the natural orientations and 3D structures. Typically 10,000 or more flake images are obtained in a single snowstorm.

II: Example Snowstorm

III: Snowflake Geometries

- An aggregate is a jumble of snowflakes. We do not specify that the aggregate must consist of the same crystal habits.
- Rimming is a process where very tiny spheres of water stick to the surface of the aggregate and freeze.
- We examine both rimed and unrimed aggregates. Rimed aggregates were documented in Locatelli and Hobbs (1974) but their emphasis was on rimed aggregates that consisted only of dendrites (6-sided branched crystals). We commonly observed aggregates containing a mixture of crystal habits (needles, columns, plates and dendrites) which demonstrates that snowflakes that formed separately can fall out at the surface together.

Three delicate aggregate geometries were observed in free falling snow.

- A train is a chain of flakes with larger spheroids of flakes connected by much smaller ice crystals. The connectors are less than a quarter of the minimum diameter of the larger spheres in size. The connected balls of snowflakes are roughly equal in size.
- An outrigger snowflake contains a thin connection from the larger main body of flakes to a smaller group of particles. The smaller group of particles is less than half the size of the main body and the connection between the two is very thin and appear as a line.
- In a tail snowflake, an appendage of flakes is attached to the main body of particles. The tail’s width is less than half of the body’s minimum diameter and should be relatively constant. The length of the tail is equal to or greater than the body’s minimum diameter.

Preliminary Results

The 3 delicate geometries occurred in both locations. The snow at Alta is usually more rimed and more frequently includes heavily rimed graupel than at Stony Brook. More riming yields a higher water content than less rimed snow.

Conclusions

- Three types of aggregates were distinguished that were previously not documented: tails, trains, and outriggers.
- Snowflakes that matched the new classifications were observed at both Alta, UT and Stony Brook, NY.
- The results suggest that these new delicate geometries can form and reach the surface in environments with low air turbulence.
- Future work will utilize a database of derived characteristics from the snowflake images and sounding data to examine other variables that may affect the formation of these geometries.


Acknowledgements: Special thanks to Nicole Corbin, Spencer Rhodes, John Hader, and Matt Wilbanks for their assistance and advice. Research supported by National Science Foundation grants 1127759 (collaboration with T. Garrett at U. Utah) and 1347491 (collaboration with B. Colle at Stony Brook U.).