NC STATE UNIVERSITY

Department of Marine, Earth, and Atmospheric Sciences

Determining Snowflake Characteristics and Geometries using Computer Vision

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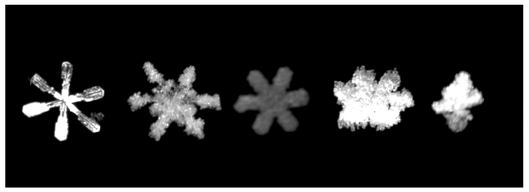
ENVIRONMENT ANALYTICS

Introduction

Riming is the process by which super-cooled water droplets attach and freeze onto ice crystals. As snow particles accumulate more droplets, their **degree of riming** increases, and the particle becomes more dense and rounded.



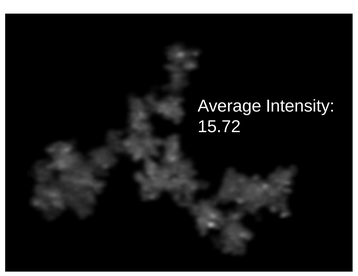
Credit to URL: http://goo.gl/b3DIQz

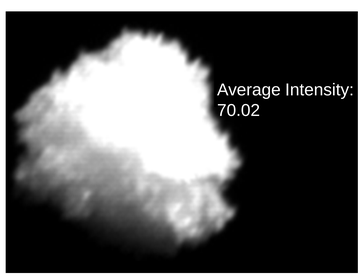
Light ⟶ Heavy

Degree of riming affects a snowflake's geometry. Using **machine learning**, computers can be trained to automatically classify snowflakes into three categories: low, medium, and high degrees of riming. We use **computer vision** to analyze several extracted feature characteristics of each snow particle.

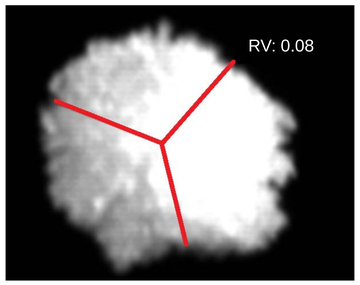
Extracted Features

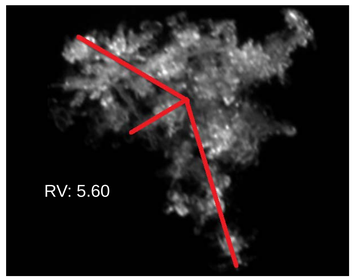
Average Intensity is determined by summing the intensity (brightness) of an image and dividing by the area of the snowflake. Rimed snowflakes tend to have higher average intensity than unrimed ones. The snowflake on the left has a low degree of riming and the snowflake on the right is heavily rimed.





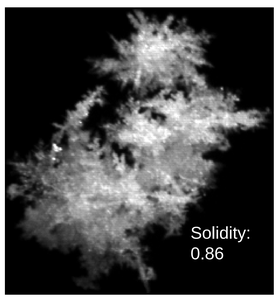
Radial Variance (RV) is the standard deviation of distances from the centroid of the snowflake to each pixel on the boundary. This provides a measure of how "round" a snowflake is. Round snowflakes are usually more heavily rimed.

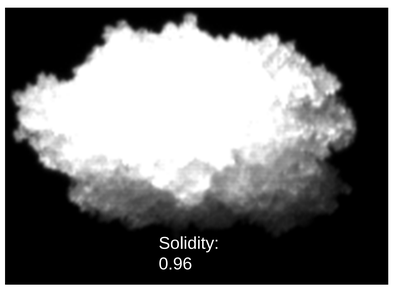




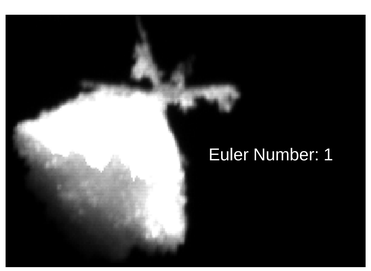
(Red lines represent distance from center)

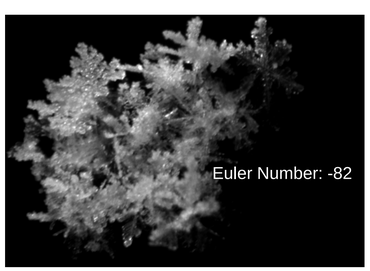
Solidity is the ratio between the snowflake area and the area bounded by a convex polygon fit to the outer edge of the snowflake. It describes the relative area of the holes in the snow particle.



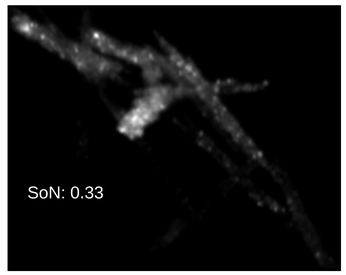


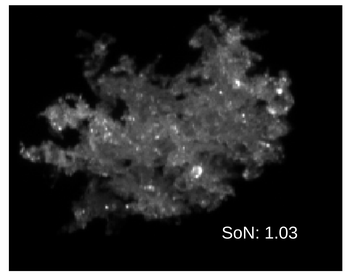
Euler Number describes the number of holes in the image. Rimed snowflakes have fewer holes than unrimed snowflakes on average.





Sonic number (SoN) is defined by the average minimum distance to the closest black pixel. This number helps identify needle-like snowflake structures. A lower SoN indicates that a structure is more needle-like.

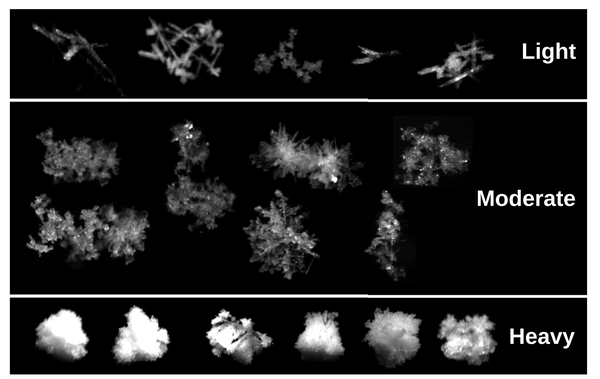




Classification Results

We used the Support Vector machine learning method and the 5 features described above to determine low, moderate and high degree of riming for individual snowflake photographs. We used a 200 snowflake image training set. The machine learning was then applied to an independent sample of 120 snowflakes. Compared to classification by eye, the analytic model had ~80% accuracy rate. No lightly rimed flakes were misclassified as heavy nor were any heavily rimed flakes classified as light. Future work will expand the training data set with the goal of automating the processing of millions of snow images.

Example of classified snowflakes



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