Using the Multi-Angle Snowflake Camera, MASC, to Look at Complex Snowflake Characteristics

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Abstract

Microphysical processes and hydrometeor forms are important when it comes to precipitation rates, storm lifetimes, avalanche predictions and radar measurements. But they are difficult to imitate in models. I want to know if flatter snowflakes are more likely to fall with a tilt. The Multi-Angle Snowflake Camera, MASC, was created to obtain high-resolution images of falling hydrometeors as well as measure fall speeds and other variables. It was found that snowflakes with a shorter maximum diameter fall the most frequently in Alta. Less of a correlation is seen between the aspect ratio and fall orientation of snowflakes with larger aspect ratios.

Objective

Run a program created in MATLAB, to analyze frozen hydrometeor data captured by the MASC. Diagnostic and statistical variables produced from the program will then be analyzed to better understand properties of individual hydrometeors.

Introduction

- The MASC, Multi-Angle Snowflake Camera, is an instrument consisting of 3 cameras separated by 36-degree angles, with one common focus point. Two infrared detectors trigger the cameras when falling hydrometeors pass through the field of view.[5]
- Fall speeds are measured during the passage between the infrared detectors. Hydrometeor size, shape, and aspect ratio are obtained from the photographs.[6]
- Masclab is a program designed for use in MATLAB, by Tim Garrett and edited by Karlie Rees, for the purpose of analyzing data and snowflake images produced by the MASC.

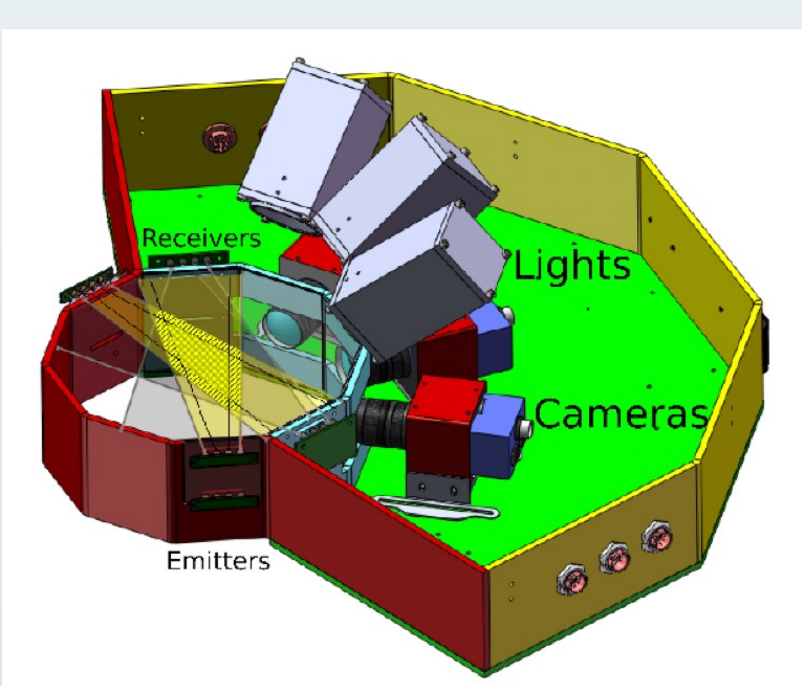


Diagram of the MASC, Multi-Angle Snowflake Camera[5]

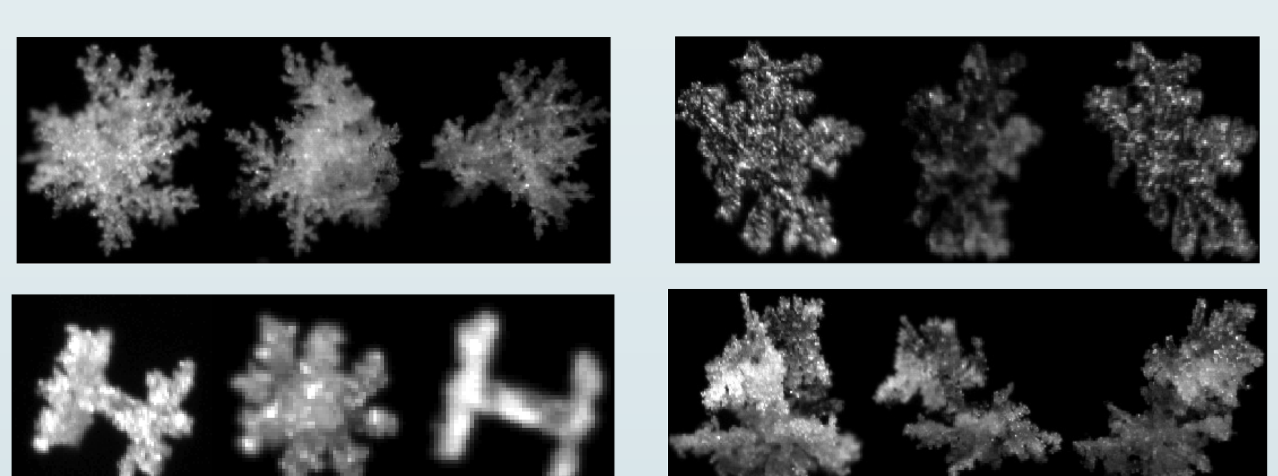
Methodology

- The data used is from the MASC stationed at Alta Ski Area, Utah during the 2020-2021 winter season. Dates ranged from October 22nd to April 25th with the majority coming from the months of March and April. Thousands of images were captured during this time period.
- The MASC program goes through a multi-step operation to sort and analyze images.
- It starts by sorting through the images and rejecting those that are of poor quality. The images that make it through are then cropped and diagnostics data is recorded for each snowflake.

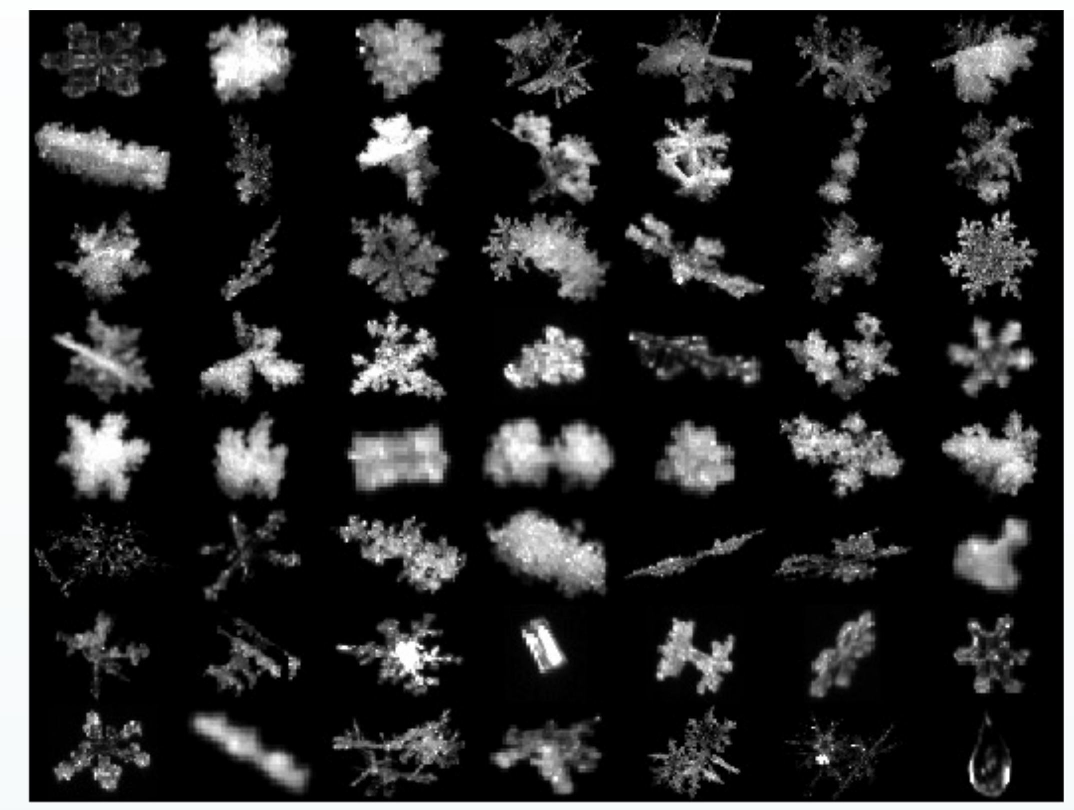
The deployed MASC stationed at Alta Ski Area

MASC Snowflake Imagery

- Data from 70,547 snowflakes was retrieved from this period.
- The following figures show images of a single snowflake from three different angles captured from the MASC.
- Complexity data was analyzed to obtain the snowflake habit. Of those snowflakes, 41,002 were graupel, 5,132 were aggregates, and 2,441 were densely rimed snowflakes.



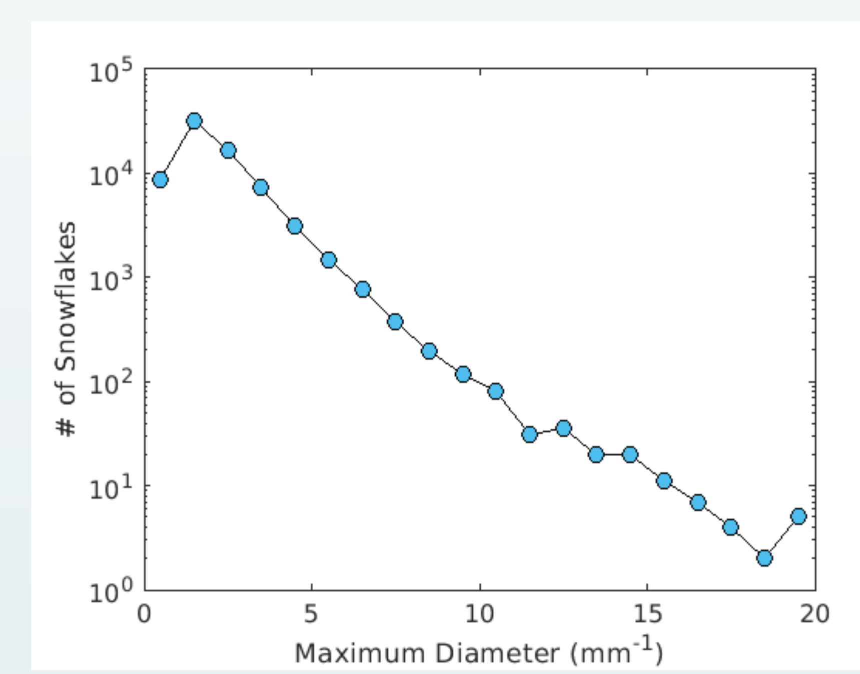
Triplet snowflake images: images of the same snowflake from 3 different angles captured by the MASC.



MASC snowflake imagery from the month of April.

Maximum Diameter

- The maximum diameter is the measure of the hydrometeors longest axis observed from the image[4].
- Knowing the maximum diameter allows us to have a better understanding of the size of the snowflake.

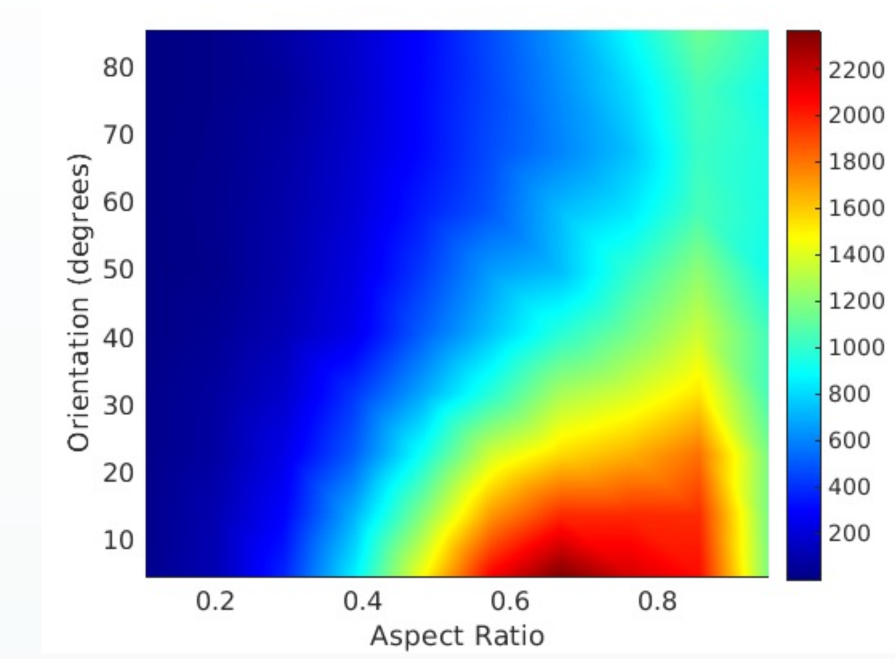


Distribution of the maximum diameter of snowflakes recorded at Alta.

- The results show that snowflakes with smaller maximum diameters occur most often at Alta.

Orientation & Aspect Ratio Relationship

- The aspect ratio is the ratio of the hydrometeor's shortest axis to the longest axis.
- The orientation describes the angle at which snowflakes fall.
- The average aspect ratio for all observed hydrometeors was 0.707 and the average orientation was 35.2 degrees.
- It is observed that there is less of a correlation between the aspect ratio and the fall orientation as the aspect ratio increases.



Relationship between observed aspect ratios and falling orientation.

- The average orientation for snowflakes with an aspect ratio greater than 0.8 and less than 0.8 are 40.3 degrees and 32.2 degrees, respectively.
- This relationship shows us that flakes with smaller aspect ratios are less likely to fall with a tilt while flakes with larger aspect ratios are more likely.

Future Direction

- To continue this work, I want to take a deeper look into the processes that occur during the formation of our most seen snowflake sizes/types.
- I would also like to investigate the reasoning behind why we see flatter snowflakes falling at less of an angle that other snowflakes.

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