

Improved Accuracy of Snowflake Characterizations Using the Snowflake Measurement and Analysis System

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Snowflake Measurement and Analysis System, also denoted as SMAS, is a camera-based snowflake observation and analysis instrument. This instrument has seven cameras with a laser plane triggering system that triggers the cameras and the flashes. A highspeed camera, mounted on the horizontal plane, then subsequently captures a long exposure shot of the snowflake to provide the system with the ability to estimate particle fall speed. Each camera view, then, by counting the pixels, can give us an estimate cross sectional area of the snowflake. Additionally, the system is also capable of the automatic classification based on the geometry of the snowflakes and 3D reconstructions and volume estimations of the snowflakes. The focus of this paper is on the improvements of fall speed and cross-section area estimations based on SMAS observations.

The simple procedure is to measure the conversion from pixels to World coordinates (distance in mm) that each pixel represents. This can be simply done by intrinsic calibration of the cameras by any means. The intrinsic calibration then, with how far away the focus plane is, can be used to calculate the conversion. With this, we multiply the conversion coefficients with the area of snowflakes in pixels or the streaks measured by the high-speed SMAS camera.

However, all these cameras are toggled at a very high f-stop, resulting in a larger depth of field around the camera. Therefore, we have an imaging volume that is approximately a sphere of 10 cm diameter. Having a larger volume naturally also means that we need to estimate depth. Without depth estimation, our speed and area measurements, will have an added error of $\pm 20\%$, and this is before interference from other errors. With the aid of epipolar geometry and triangulation between a pair of cameras, we can optimally find the 3D location of the snowflakes. However, there is still a minimal reprojection error caused by the limitations of the cameras. The error also becomes larger as the snowflakes get to the further end of the imaging volume.

Our techniques can successfully recover – using computer vision and image processing techniques – the depth of the snowflakes to improve estimations of fall speed and cross-section area of observed snowflakes using the SMAS. Our approach can also provide a heat map based on the 3D positioning of the cameras and their calibration information, which is another useful general feature.