Utilization of Convolutional Neural Networks in Classification of Snowflakes Based on Images by a Multi-Angle Snowflake Camera

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This paper presents an extension of research covered by the MASCRAD (MASC + Radar) project located at a field site in Easton Valley View Airport, outside of Greeley, Colorado. The MASCRAD project is in-depth study of the microphysical and scattering properties of winter precipitation, employing several advanced disdrometers under the umbrella of the dual-polarization CSU-CHILL Radar. The in-situ surface instruments include a 2D-video disdrometer and a multi-angle snowflake camera (MASC) deployed within a 2/3-scaled double fence intercomparison reference (DFIR) wind shield. The MASC system modified by Colorado State University utilizes five high-resolution cameras in known positions with a common focus point to capture images of winter precipitation in free fall. These images can then be used in a three-dimensional (3D) reconstruction method called Visual Hull and for classification of hydrometeors based on their observed physical parameters. Here we focus on the application of machine learning algorithms to aid in the classification of snow data captured by the MASC system.

Over the course of the MASCRAD project, the MASC system has captured several hundred thousand individual snowflake images. Extensive research has been done into the characteristics of snow particles when cross-referenced with the polarimetric radar. The snowflake geometry, degree of riming, and other physical parameters have been shown to have a direct correlation to backscattering measurements taken by the CSU-CHILL Radar. The snow particle's physical parameters also are related to the environmental conditions present during their formation. An automated MASC-based hydrometeor classification procedure is fundamental to establish quantitative precipitation estimation in terms of the dominant particle types. This task is uniquely suited to machine learning algorithms, specifically the use of Convolutional Neural Networks (CNNs).

We present a discussion of the results of a CNN trained on random snowflake data sampled from several previous MASCRAD events dating back to 2014. We analyze the results of a CNN on geometric classification and automatic feature extraction used in cascade with a Support Vector Machine (SVM) for classification and compare these results with previous studies. The results over the five views of the same particle are correlated to improve the classification for each hydrometeor. We discuss the use of CNNs in gauging degree of riming for each class of snowflakes and their relation to supporting data.