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Deep-learning based classification of ice crystals: habits and microphysical processes

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Ice crystals are an important component of clouds due to their strong impact on cloud radiative properties and precipitation formation. The shape of an ice crystal impacts its radiative effect, riming efficiency, and fall speed. The ice crystal shapes are dependent on (i) the environment (temperature and humidity) that they grow in and (ii) the microphysical processes (i.e. riming, aggregation) that they have experienced. These connections offer a great opportunity to trace back the previous in-cloud conditions and the microphysical processes in clouds. Thus, ice crystal shape classification is crucial to better understand radiation properties and precipitation formation of clouds.

Scientists have explored and developed various algorithms to automatically classify ice crystal shapes in the past decades. Among those, the machine learning algorithm Convolutional Neural Network (CNN), shows a good performance due to its ability to catch the main features that describe ice crystal habits and recognize patterns between images. However, the existing classification methods all show an overlap between physical process categories (i.e. rimed) and basic habit categories (i.e. column) of ice crystals due to the existence of compound ice (i.e. column-rimed), especially in situations conducive to light riming.

A CNN was trained using over 10’000 images of pristine and complex ice crystals recorded by a holographic imager during the NASCENT campaign (Pasquier et al., BAMS, in revision) in Fall 2019, in Ny-Ålesund, Svalbard. To avoid the overlap between physical process and basic habit categories of ice crystals, each ice label contains two properties; one of 7 basic habits property (i.e. column) and up to 3 physical process properties (aggregate, rimed, aged). The trained model gives us both the basic habit and the physical processes information, which helps us to better understand the microphysical processes in clouds.