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Progress in Representing Microphysical Processes in a Snow Growth Model

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A steady-state snow growth model (SGM) has been developed based on the microphysical growth processes of vapor deposition, aggregation and riming. Climate models use mass-dimension (m-D) and area-dimension (A-D) power laws (e.g. m = αD^{β}) to formulate ice particle growth rates, however it is well known that the m-D and A-D power laws for the smallest ice particles differ considerably from the power laws for the largest particles. To overcome this problem, β and α are predicted as a function of diameter where the m-D expression is a 2^{nd}-order polynomial in log-log space. By tailoring these m-D and A-D relationships to the SGM, ice particle growth rates and fall speeds are represented more accurately and realistically. The predicted size spectra by SGM are in good agreement with observed spectra from Colorado Airborne Mixed-Phase Cloud Study (CAMPS).

Although ice particle riming often has little impact on ice particle size, its impact on ice particle mass and projected area can be considerable. A method is introduced to calculate rimed mass and area from unrimed mass and area, and from maximum mass and area that can be achieved by riming. The treatment for riming is explicit, accounting for the dependence of collision efficiency on droplet and ice particle size using both hydrodynamic theory and experimental measurements. It appears that the riming process is essential in characterizing the snowfall rates. Moreover, increase in cloud condensation nuclei (CCN), due to aerosols, can modify cloud droplet SD (size distribution) and therefore decrease the snowfall rate. So, snowfall rate is sensitive to the shape of cloud droplet SD. It is speculated that by implementing the new m-D and A-D treatment, and riming growth in any climate model, the ice particle growth rates will become more accurate.