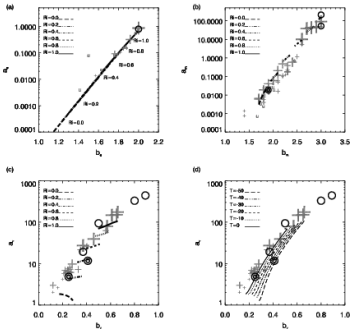
A New Bulk Microphysical Scheme That Includes Riming Intensity and Temperature Dependent Ice Ch

Research Highlight

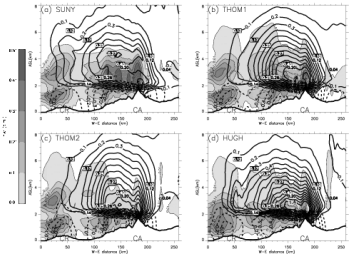
The representation of ice particle properties is important, because it has wide applications from the retrieval of ice water content using remote sensing to its parameterization in numerical models. Many empirical formulas, such as power laws, have been derived to describe irregularly shaped ice particle properties, such as relating the projected area, mass, and fall velocity to the maximum dimension. We propose a generalized description of ice particle properties considering temperature and riming intensity impact. Based on this general ice property presentation framework, a new bulk microphysical parameterization is developed to represent more of the conditions associated with ice clouds.

A new bulk microphysical parameterization (BMP) scheme is presented that includes a diagnosed riming intensity and its impact on ice characteristics. As a result, the new scheme represents a continuous spectrum from pristine ice particles to heavily rimed particles and graupel using one prognostic variable (precipitating ice, or PI) rather than two separate variables (snow and graupel). In contrast to most existing parameterization schemes that use fixed empirical relationships to describe ice particles, general formulations are proposed to consider the influences of riming intensity and temperature on the projected area, mass, and fall velocity of PI particles. The proposed formulations are able to cover the variations of empirical coefficients found in previous observational studies. The new scheme also reduces the number of parameterized microphysical processes by ~50% as compared to conventional 6-category BMPs, and thus it is more computationally efficient.

The new scheme (SBU-YLIN) has been implemented in the Weather Research and Forecasting (WRF) model and compared with three other schemes for two events during the Improvement of Microphysical Parameterization through Observational Verification Experiment (IMPROVE-2) over the central Oregon Cascades. The new scheme produces comparable surface precipitation forecasts as other more complicated BMPs. The new scheme reduces the snow amounts aloft as compared to other WRF schemes and compares better with observations, especially for an event with moderate riming aloft. Sensitivity tests suggest both reduced snow depositional growth rate and more efficient fallout due to riming contribute to the reduction of ice water content aloft in the new scheme, with the larger impact from the partially rimed snow and fallout.



(a) Coefficients of area-diameter (A-D) relationship in the new scheme. (b) Same as (a), except for the mass-diameter (M-D) relationship. (c) Same as (a), but for the velocity-diameter (V-D) relationship. (d) Same as (c), but each line shows the variation with Ri. More details of the figure are available in the journal article.



A west-east cross section across the solid line box in Fig. 5c showing north-south averaged LWC (shaded every 0.1 gm#3), IWC (the sum of snow, graupel, and ice, black solid), graupel (black dotted), and rain (black dashed) from 2300 to 0200 UTC 13-14 Dec 2001 (forecast hours 23-26) of IOP9. The boxed numbers are the Convair measured IWC (white) and NOAA P-3 measured IWC (white) and LWC (black) during the same period.

Reference(s)

Lin Y and BA Colle. 2010. "A new bulk microphysical scheme that includes riming intensity and temperature dependent ice characteristics." Monthly Weather Review, , . ACCEPTED.

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Working Group(s)

Cloud Life Cycle