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Simulations of ice pellets and freezing rain using an explicit parameterization of the bulk liquid fraction of ice particles

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During the cold season, storms can often be associated with the favorable vertical temperature structure for the formation of several winter precipitation types, such as snow, wet snow, freezing rain, ice pellets and rain. The types of precipitation reaching the surface depend on the degree of melting and re-freezing of particles as they fall through the atmosphere. For example, when a warm layer is overlaying a refreezing layer, ice particles can melt partially or completely in the warm layer to produce either ice pellets, freezing rain or a combination of the two at the surface. In this study, an explicit prognostic liquid fraction is implemented in a bulk microphysical scheme to predict freezing rain and ice pellets, and to evaluate their interactions with the environmental conditions. The approach is to modify the Predicted Particle Properties (P3) microphysics scheme by adding a prognostic variable for the liquid water mass-mixing ratio of the solid precipitation category in order to predict its bulk liquid fraction. This predicted liquid fraction is the key variable to differentiate the surface precipitation type occurring when temperatures are near 0°C. First, using a one-dimensional cloud model, it will be shown that the explicit simulation of mixed-phase particles improves the representation of the surface precipitation types with respect to the original scheme. Second, the impact of the partial melting of ice will be studied by simulating the 1998 Ice Storm over eastern North America using a full 3D mesoscale model. Overall, the prediction of the bulk liquid fraction allows a more accurate differentiation of surface winter precipitation types, which contributes to improve their forecasts.