Effect of Down-Gradient Turbulent Liquid Water Flux Parameterization On Condensation in Mesoscale Models

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Abstract

The down-gradient turbulence mixing parameterization has been used not only for the conserved variables, but also for those that are not conserved during cloud processes in mesoscale models. It is shown that when being applied to non-conservative variables (such as potential temperature, water vapor and liquid water), the down-gradient scheme produces unrealistic condensation profile for stratocumulus clouds in the boundary layer. It occurs because the scheme does not account for condensation, and therefore introduces unphysical turbulent heating and moistening profiles. The errors in the fluxes, however, are canceled out when they are linearly combined to obtain the fluxes of the conserved variables. Consequently, the predicted liquid water from this type of mixing schemes is almost the same as that based on the mixing of the conserved variables and physically based liquid water flux despite the fact that the turbulence mixing and condensation are erroneously represented. The condensation profile resulting from the down-gradient mixing of the non-conserved variables should not be used in any analyses or diagnostic studies, particularly if they are for stratocumulus clouds in the boundary layer where turbulent motion is dominant in producing condensation and evaporation.