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Consistency between the cloud and radiation processes in a numerical forecasting model

Rae Seol Park and Soo Ya Bae

Korea Institute of Atmospheric Prediction Systems, Environmental Science & Engineering, SEOUL, Korea, Republic Of (rspark28@gmail.com)

For consistency between clouds and radiation, two modifications in the radiation scheme of the KIM physics package: applying the hydrometeor-based effective radii and considering the subgrid-scale hydrometeor are carried out and their impact on radiation and precipitation are investigated. The hydrometeor-based effective radii increase mostly over the ocean except for the convective region, so the increase of the surface downward solar radiation improves its systematic bias when compared to those in the CTL simulations. Over the convective region, the cloud radiative forcing increases and the surface downward solar radiation decreases in a direction that improves their systematic bias when the subgrid-scale hydrometeor is considered. The skill scores of the precipitation in the MOD simulations are also improved and this is especially distinct over the convective region. The change in convective precipitation over the ocean is in contrast with that over land because the convection in the MOD simulations for the latter is suppressed by a decrease in the surface fluxes while that over the ocean is enhanced by an increase in longwave heating.
We modulated the radiation scheme to be consistent with the microphysics, convection, and cloudiness schemes, which resulted in an improvement in the radiation and precipitation performances. On the other hand, this study is influential in that the consideration of the subgrid-scale hydrometeor in the radiation process is a unique approach and may be further considered in other subgrid parameterization schemes (e.g. the shallow convection scheme). Based on this, the consistency among other physical schemes should be further examined in the future to improve atmospheric model performance.