A modified Kain-Fritsch scheme and its application for the simulation of an extreme precipitation event in Vietnam

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Abstract: From 24 to 26 November 2004, an extreme heavy rainfall event occurred in the mountainous provinces of central Vietnam, resulting in severe flooding along local rivers. The Regional Atmospheric Modeling System, version 4.4, is used to simulate this event. In the present study, the convective parameterization scheme includes the original Kain-Fritsch scheme and a modified one in which a new diagnostic equation to compute updraft velocity, closure assumption, and trigger function are developed. These modifications take the vertical gradient of the Exner function perturbation into account, with an on-off coefficient to account for the role of the advective terms. According to the event simulations, the simulated precipitation shows that the modified scheme with the new trigger function gives much better results than the original one. Moreover, the interaction between convection and the larger-scale environment is much stronger near the midtroposphere where the return flow associated with lower-level winter monsoon originates. As a result, the modified scheme produces larger and deeper stratiform clouds and leads to a significant amount of resolvable precipitation. On the contrary, the resolvable precipitation is small when the original scheme is used. The improvement in the simulated precipitation is caused by a more explicit physical mechanism of the new trigger function and suggests that the trigger function needs to be developed along with other components of the scheme, such as closure assumption and cloud model, as a whole. The formalistic inclusion of the advective terms in the new equation gives almost no additional improvement of the simulated precipitation.

Index Keywords: Closure assumptions; Cloud models; Convective parameterization schemes; Event simulation; Extreme precipitation; Heavy rainfall; Midtroposphere; Modified scheme; Physical mechanism; Regional atmospheric modeling systems; Return flow; Stratiform clouds; Trigger functions; Vertical gradients; Viet Nam; Winter monsoon; Rain; atmospheric modeling; extreme event; numerical model; parameterization; precipitation (climatology); rainfall

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