Modification of the Kain-Fritsch convective parameterization scheme in the Meso Scale Model

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The Japan Meteorological Agency has been operating the Meso Scale Model (MSM) – a nonhydrostatic model with a horizontal grid size of 5 km – to support the mitigation of meteorological disasters since March 2006. The MSM adopts the Kain-Fritsch convective parameterization scheme (KF scheme: Kain and Fritsch 1990; Kain 2004) along with a cloud microphysics scheme to estimate sub-grid scale convection. Previously, the KF scheme in the MSM often predicted false precipitation along coastlines due to its oversensitivity to topography and differences in roughness between sea and land in conditions with highly moist incoming air (Fig. 1 (b)) compared to the results of actual observation (Fig. 1 (a)). Narita (2010) showed that a higher mixing rate between sub-grid convective updrafts and their environmental air was effective in suppressing this type of false precipitation prediction. We have now modified the KF scheme to introduce the variable radius of the sub-grid updraft in order to increase the mixing rate.

The KF scheme was originally developed on a model with coarser grid spacing, and it was assumed that the radius of the sub-grid scale updraft was limited to between 1,000 m and 2,000 m as a function of its upward velocity. Accordingly, we implemented modification to adopt a more suitable radius for the sub-grid scale updraft in the 5-km grid size model. The modified radius depends on the lifted condensation level (LCL), i.e., the radius becomes gradually smaller as the LCL decreases. The mixing rate is formulated to be inversely proportional to the radius of the updraft in the scheme, and the modified radius therefore brings about enhanced mixing. This modification causes damping of excessively developed convection, resulting in a reduction of false precipitation (Fig. 1 (c)).

Using the modified KF scheme, we tested the operational MSM and verified precipitation predictions in an experiment conducted between 7th and 26th July, 2009 (during the highly moist rainy season). The statistical verification results for accumulated precipitation every three hours are shown in Fig. 2. The equitable threat score shown in Fig. 2 (a) indicates an improvement in the range between 10 mm/3h and 25 mm/3h, while the bias score indicates a slightly decreasing trend for the predictive frequency of relatively weak precipitation and an increasing one for that of heavy precipitation (Fig. 2 (b)).

The modified KF scheme successfully suppresses false precipitation predictions along the coast and contributes to the improvement of quantitative precipitation forecasts. The modification was incorporated into the operational MSM in November 2010.

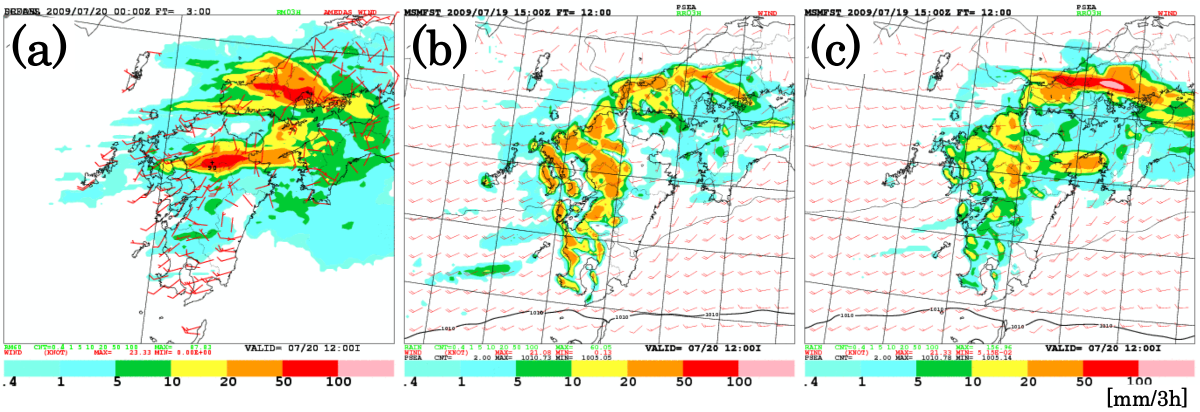

Fig. 1 Improvement of suppression for false precipitation prediction along coastlines: accumulated precipitation [mm/3h] of: (a) observed (radar-raingauge analyzed precipitation); (b) MSM forecasts using the original KF scheme; and (c) MSM forecasts using the modified KF scheme

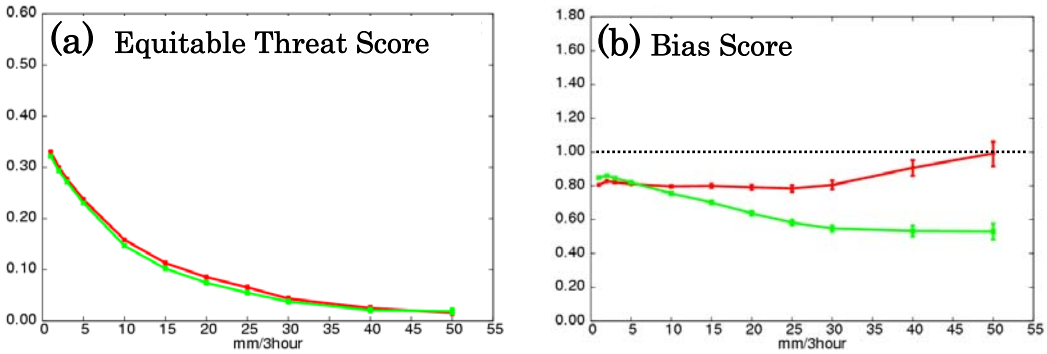

Fig. 2 Statistical verification results for three-hourly accumulated precipitation of MSM forecasts against radar-raingauge analyzed precipitation based on the contingency table in the term between 7th and 26th July, 2009: (a) equitable threat score; (b) bias score. The scores for MSM forecasts using the modified KF scheme are indicated by the red line, while the original ones are indicated by the green line, with error bars showing a 95% confidence interval.

References

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