Development of a Cumulus Parameterization Scheme of the Operational Global Model at JMA

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The cumulus parameterization scheme implemented in the Japan Meteorological Agency (JMA) Global Spectral Model (GSM) follows the scheme proposed by Arakawa and Schubert (1974) with modifications by Moorthi and Suarez (1992), Randall and Pan (1993) and Pan and Randall (1998). JMA revised the cumulus parameterization scheme of operational GSM in March 2001 to include reevapolation effect of the convective precipitation (GSM0103). The aim of this revision is to improve performance in the medium- and long-range predictions of tropical precipitation and associated circulation. However, this revision produced a systematic negative error in temperature and geopotential height fields at lower troposphere over the western portion of the North Pacific high in early forecast days. The main reason for this error is the excessive cooling by the evaporation of convective precipitation. At the same time, it is known from a forecast experiment that the GSM can not maintain the atmospheric general circulation over a long period without cooling and moistening effects of the reevapolation.

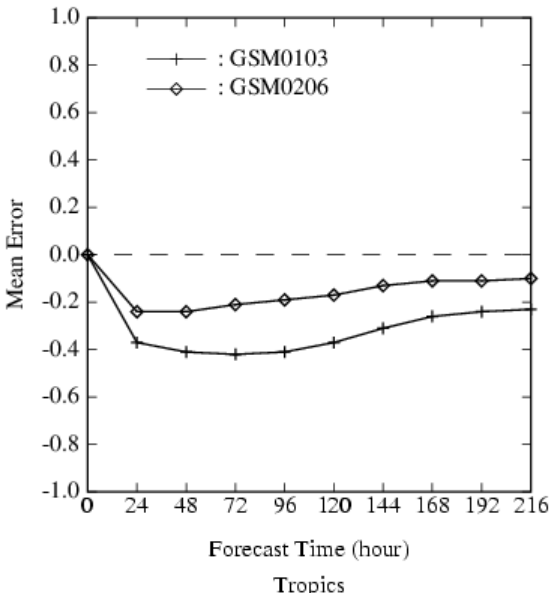

Fig. 1. Mean forecast error of 850 hPa temperature (K) over the tropics (20S-20N) averaged for the 15 cases. +: GSM0103, o: GSM0206.

JMA has been developing a new cumulus parameterization scheme which includes the entrainment and detrainment effects between the cloud top and the cloud base in convective downdraft instead of reevapolation of convective precipitation (GSM0206). To test the impact of the new scheme, two data assimilation experiments using GSM0103 and GSM0206 were conducted for the period 1-31 July 2001. Nine days forecasts were performed for 15 cases starting from 12UTC 8-22 July 2001. The results were compared with each other.

Figure 1 shows the mean forecast error of 850 hPa temperature over the tropics (20S-20N) averaged for the 15 cases with respect to the forecast time. It is seen that

the GSM0103 forecast shows systematic negative bias throughout the forecast period up to -0.42 K. The bias of the GSM0206 forecast is about half as much as that of the GSM0103 forecast. This difference is caused by the change of the cumulus parameterization scheme. Root mean square errors for the both experiments were also calculated and found to be comparable (not shown).

The 24-hour forecast and its mean error for 500 hPa geopotential height field are shown in Fig. 2. The field simulated by GSM0103 is systematically lower than the analysis field in wide area extending from the North Pacific high to the Asian monsoon region. GSM0206 makes much better forecast than GSM0103 due to the smaller temperature bias at lower troposphere.

In conclusion, the new cumulus parameterization scheme suppresses the systematic errors of GSM0103 in temperature and geopotential height fields at lower troposphere. JMA plans to implement this scheme in operational GSM in April 2003.

References.

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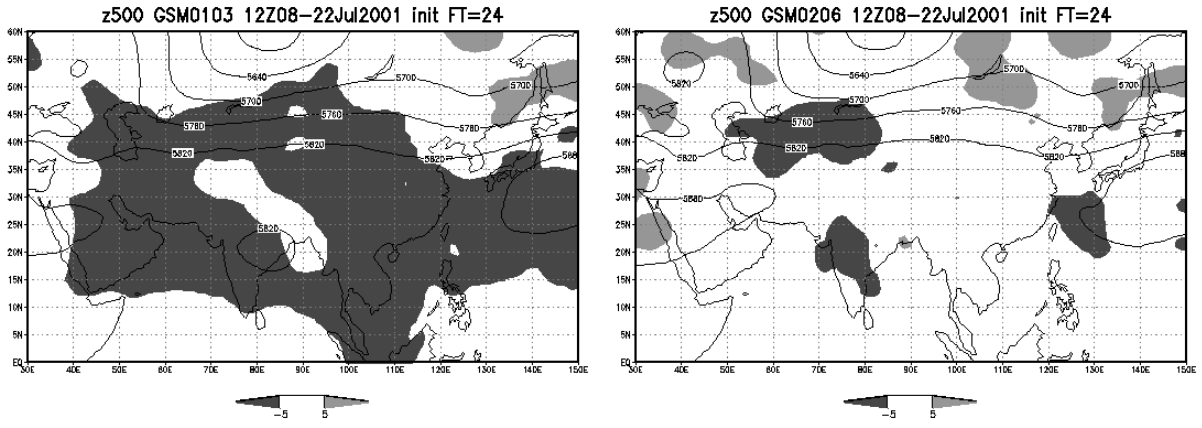

Fig. 2. Twenty four-hour forecast (contour) and mean forecast error (shade) of 500 hPa geopotential height (m) averaged for the 15 cases by GSM0103 (left) and GSM0206 (right). The contour interval is 60 m. Areas with mean forecast errors larger than 5 m are shaded.