Improvement of the Stratocumulus Parameterization Scheme in JMA's Operational Global Spectral Model

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1. Introduction and objectives

In JMA's operational global analysis, a negative analysis increment in SLP (sea level pressure) is often seen around North America for 00UTC (Fig. 1). This increment is given by radiosonde temperature observations. Monitoring of cloud cover over this area has shown that the stratocumulus scheme (Kawai and Inoue, 2006) of the Global Spectral Model (GSM) creates afternoon pseudo-clouds, which causes the model's temperature to fall below the observation value in the lower troposphere.

This stratocumulus scheme is designed to represent subtropical marine stratocumulus clouds off the west coast mainly as a function of inversion strength. However, it has been revealed that the scheme works even in dry conditions, which causes the appearance of the pseudo-clouds and the low temperature bias. Accordingly, JMA added a new relative humidity threshold to the conditions in which the scheme works to reduce the occurrence of pseudo-clouds over the continent.

In this report, the operational GSM is referred to as CNTL, and the GSM with the modified stratocumulus scheme is referred to as TEST.

2. Evaluation for North America

Figures 2, 3 and 4 show the results of a Tl319 analysis/forecast cycle experiment (low resolution version of the operational global data assimilation system) in October 2010 for North America. Figure 2 shows that there is pseudo-cloud in CNTL in comparison with the visible image for GOES-WEST, but the stratocumulus scheme modification in TEST reduced the amount over North America. Figure 3 shows temperature differences at 850 hPa between radiosonde observations and the first guess of the GSM. For CNTL, the radiosonde temperature observations in the lower troposphere are higher than the model temperatures, but for TEST the model temperatures are close to the observation values. Figure 4 shows the monthly average analysis increment of SLP. For CNTL, negative values are seen for North America, but the negative analysis increment decreases for TEST.

Figure 5 shows a scatter plot of downwelling solar radiation at Fort Peck between the observation and the GSM forecast from 12 UTC October 1st to 12 UTC November 1st. For CNTL, it can be seen that the downwelling shortwave radiation of the GSM forecast is statistically much smaller than that of the observation. However, the GSM forecast for TEST resembles the observation values due to the reduction of pseudo-cloud. The definition of downwelling solar radiation in the GSM forecast differs slightly from that of observation, but its effect is much smaller than the difference between CNTL and TEST.

3. Global evaluation

Figures 6 and 7 also show the results of a Tl319 analysis/forecast cycle experiment in October 2010. Figure 6 shows the mean error (ME) and root mean square error (RMSE) of temperature at 850 hPa for a two-day forecast against the values for radiosonde observation. It can be seen that the negative ME bias is alleviated and the RMSE decreased. Figure 7 shows the rate of improvement defined by ($RMSE_{cntl}$ - $RMSE_{test}$) / $RMSE_{cntl}$. Positive growth is observed, especially in temperature at 850 hPa.

4. Summary

Adding a new relative humidity threshold to the stratocumulus scheme of the GSM reduces the appearance of pseudo-cloud over North America, and this leads to a reduction in the SLP analysis increment. Excess low cloud cover over the continent was found from daily analysis increment monitoring, which is considered effective in improving moist processes in numerical models.

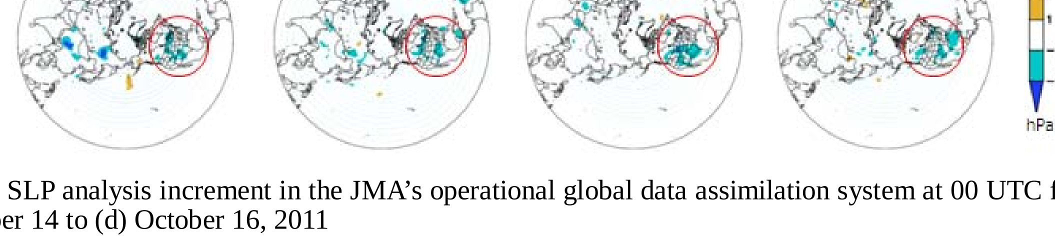
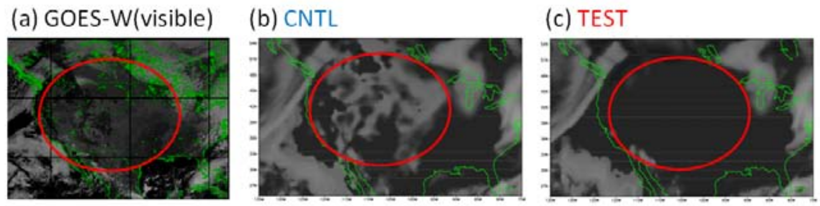
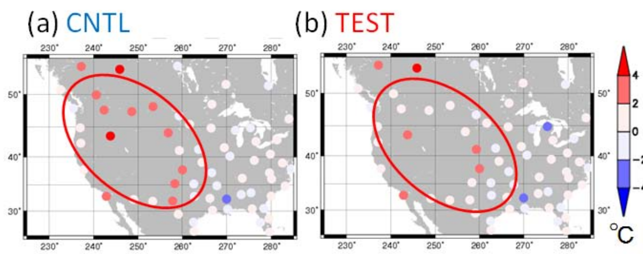


Fig. 1 SLP analysis increment in the JMA's operational global data assimilation system at 00 UTC from (a) October 14 to (d) October 16, 2011

Fig. 2 (a) Visible image of GOES-WEST, and simulated visible cloud images of the GSM for (b) CNTL and (c) TEST at 18 UTC on 14 October 2010





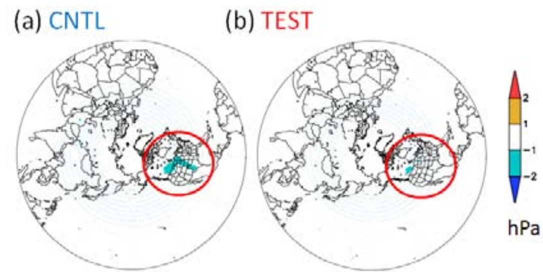
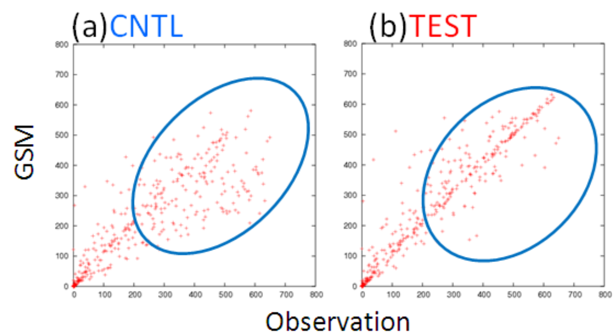


Fig. 3 Temperature differences at 850 hPa between radiosonde observations and the first guess of the GSM at 00 UTC October 15, 2010 for (a) CNTL and (b) TEST.

Fig. 4 Average monthly SLP analysis increment at 00 UTC in October 2010 for (a) CNTL and (b) TEST.

Fig. 5 Scatter plot showing downwelling solar radiation [W/m^2] at Fort Peck between the observation (horizontal axis) and the GSM forecast (vertical axis) for (a) CNTL and (b) TEST



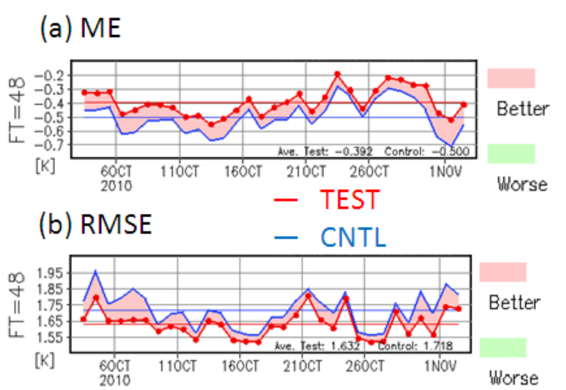


Fig. 6 Verification of temperature at 850 hPa for a two-day forecast against radiosonde observations. (a) ME and (b) RMSE

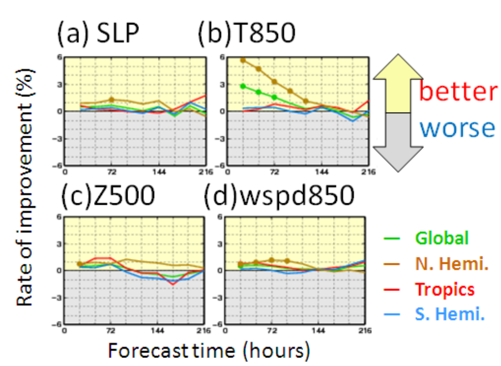


Fig. 7 Verification against the analysis (rate of improvement)

References

Kawai, H. and T. Inoue, 2006: A simple parameterization scheme for subtropical marine stratocumulus. *SOLA*, 2, 17 –20.

Acknowledgement

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The downwelling solar data for Fort Peck are reproduced courtesy of the SURFRAD project.