Operational Implementation of Modification to Stratocumulus Parameterization Scheme in JMA's Global Spectral Model

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Stratocumulus parameterization is implemented in the operational Global Spectral Model (GSM) of the Japan Meteorological Agency (JMA) to represent subtropical marine stratocumulus clouds off the western coast of continents. This parameterization is designed to work under the conditions of a strong inversion layer, and diagnoses the cloud fraction as a function of inversion strength. It normally has a positive effect that makes the radiation budget in regions of subtropical marine stratocumulus cloud more consistent with observed values (Kawai and Inoue, 2006). However, it eventually causes spurious clouds over dry regions (such as the Sahara and inland North America) and in dry conditions over the Sea of Japan because no information on water vapor is considered in the conditions under which the scheme is operated. Shimokobe (2012) showed that the addition of a new relative humidity threshold to the conditions reduces the incidence of spurious clouds and mitigates low-temperature bias in the lower troposphere with the low-resolution (TL319L60) global data assimilation and forecast system. In this study, the effects of the modification (in which a relative humidity threshold of more than 80% is added to the conditions) were investigated in a high-resolution (TL959L60) experiment. The threshold value of 80% was selected so that necessary subtropical marine stratocumulus clouds are maintained as much as possible and spurious clouds are eliminated as appropriate. Here, the previous model is referred to as CNTL, and the modified model is referred to as TEST.

Figure 1 shows cloud forecasts in CNTL and TEST around Japan. The spurious cloud by the stratocumulus scheme over the Sea of Japan seen in CNTL correctly disappears in TEST in comparison with visible image of MTSAT.

Figures 2 to 4 show the results obtained from global data assimilation and the forecast system with the same implementation as operational. Figure 2 indicates differences at a forecast time of 12 hours between TEST and CNTL averaged for August 2011 at 00 UTC. It can be seen that the frequency of stratocumulus scheme operation in TEST decreases in dry regions as intended. In addition, surface downwelling shortwave radiation grows and the temperature in the lower troposphere increases in areas where the stratocumulus scheme operation is suppressed. Figure 3 shows monthly average temperature differences at 850 hPa between radiosonde observations and the 12-hour forecast for August 2011 at 00 UTC. For CNTL, the model temperatures at 850 hPa are lower than the radiosonde observations at many stations. For TEST, however, the model temperatures are close to the observed values as per the differences seen in Figure 2.

Figure 4 shows the improvement ratio of TEST compared to CNTL in terms of the root mean square error (RMSE) of forecast values against analysis for forecasts covering periods from one to eleven days in August 2011 and January 2012. Significant positive impacts are seen on temperature at 850 hPa for all regions in forecast periods exceeding three-days forecast time during both periods. The RMSEs of other variables are also improved or neutral. These results are consistent with those of the low-resolution experiment conducted by Shimokobe (2012). This modified model has been in operation since December 18, 2012.

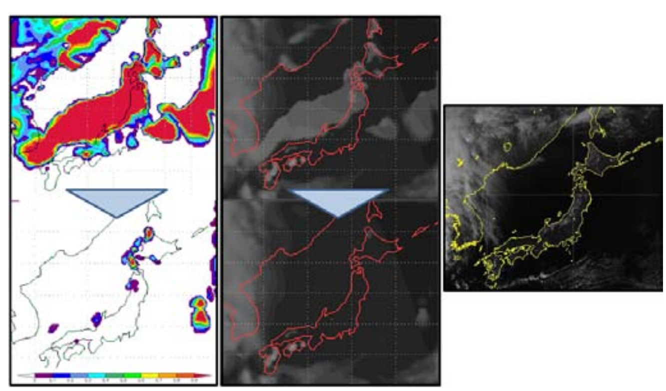

Figure 1: Cloud at a forecast time of 18 hours in TEST (top) and CNTL (bottom) around Japan on April 6, 2011 at 06 UTC. The panels on the left show the frequency of stratocumulus scheme operation in integration time steps from the previous six hours, those in the center show simulated visible cloud images of the GSM and that on the right shows MTSAT visible imagery.

References

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

Shimokobe, A., 2012: Improvement of the Stratocumulus Parameterization Scheme in JMA's Operational Global Spectral Model. CAS/JSC WGNE Research Activities in Atmospheric and Oceanic Modelling, **42**, 4.17 – 4.18.

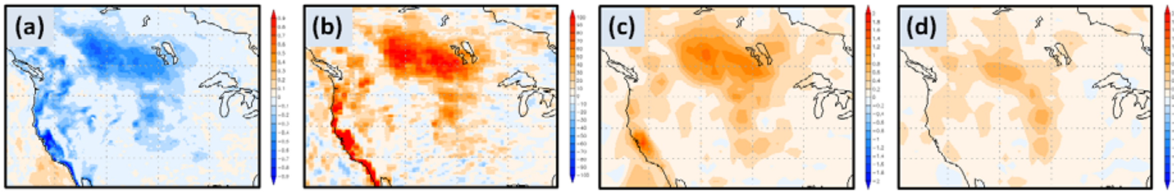

Figure 2: Differences between TEST and CNTL (TEST-CNTL) at a forecast time of 12 hours in North America for August 2011 at 00 UTC. (a) Frequency of stratocumulus scheme operation in integration time steps from the previous six hours, (b) surface downwelling shortwave radiation [W/m^2], (c) temperature [K] at 925 hPa, (d) temperature [K] at 850 hPa.

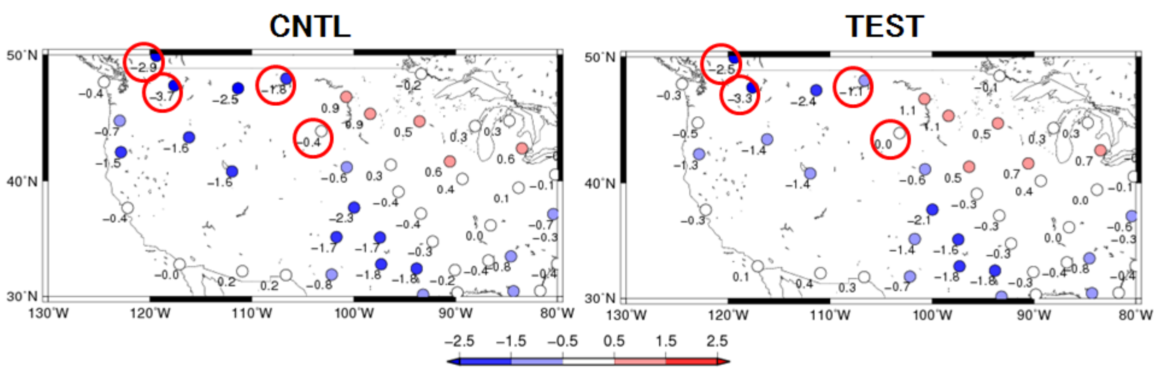

Figure 3: Monthly average bias of temperature [K] at 850 hPa against radiosonde observations for a forecast time of 12 hours in North America for August 2011 at 00 UTC. Observation stations with a bias difference between TEST and CNTL exceeding 0.4 K are circled in red.

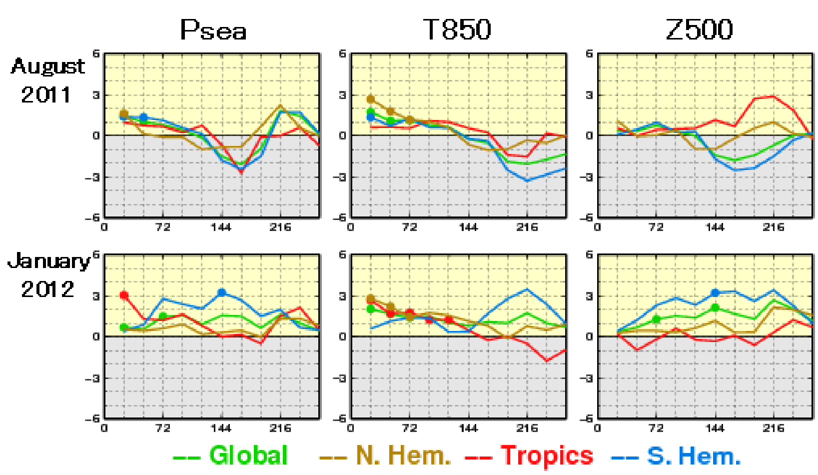

Figure 4: Improvement ratios (%) of TEST to CNTL in the RMSEs of forecasts against analysis for 1-11 day forecasts in August 2011 (top) and January 2012 (bottom). The horizontal axis represents the number of forecast hours. The graph labeled “Psea” shows surface pressure, “T850” shows temperature at 850 hPa and “Z500” shows 500 hPa geopotential heights. The green, brown, red and blue lines show the forecast improvement ratio for the global, Northern Hemisphere, tropical and Southern Hemisphere regions, respectively. Lines appearing in the upper (yellow) area indicate reduced RMSEs. The dots on the score lines represent statistical significance.