Upgrade of JMA’s operational global NWP system

Hitoshi Yonehara, Ryouhei Sekiguchi, Takafumi Kanehama, Kei Saitou, Teppei Kinami,
Akira Shimokobe, Daisuke Hotta, Ryoji Nagasawa, Hitoshi Sato, Masashi Ujiie,
Takashi Kadowaki, Syoukichi Yabu, Kazutaka Yamada, Masayuki Nakagawa,
Takayuki Tokuhiro
Japan Meteorological Agency, Tokyo, Japan
(email: yonehara@met.kishou.go.jp)

1. Introduction

In May 2017, the Japan Meteorological Agency (JMA) upgraded its operational global NWP system by introducing a revised version of its Global Spectral Model (GSM: JMA 2013). The revision involved the refinement of various parametrized processes, including cloud, convection, surface, and radiation schemes, which collectively resulted in forecast improvement. This report outlines each component of the upgrade.

2. Major updates

2.1 Cloud and convection

Melting and re-evaporation processes were revised to address inadequate cooling caused by the artificial limiters applied to evaporation/condensation heating rates in order to ensure stable time integration. The new schemes consist of a rain evaporation scheme (Kessler 1969) with an implicit time discretization method and simple relaxation parameterization to account for melting of snow that falls across the freezing level. These changes induced another cooling bias in the lower troposphere, which was mitigated by refining the convective downdraft treatment to suppress excessive evaporation.

2.2 Land model

The leaf area index (LAI), vegetation cover ratio and soil parameters were updated using more accurate reference sources. The soil moisture content climatology used to initialize the land model is now produced using atmospheric forcing datasets from the Global Soil Wetness Project Phase 3. The LAI data were also updated from more recent satellite observations (Myneni et al. 2002). These updates resulted in reduction of the excessive sensible heat flux seen in the previous model.

2.3 Radiation

Aerosol radiation treatment was refined for separate consideration of the radiative properties of five types of aerosols (sulfate, black carbon, organic carbon, sea salt and mineral dust) to improve representation of their radiative effects (Yabu et al. 2017). A deep cumulus diagnostic scheme was incorporated into the radiation scheme to reduce excessive biases seen in downward short-wave flux at the surface.

2.4 Other changes

A new sea-ice estimation method, updated sea surface temperature climatology data, a revised discretization technique for pressure gradient force, and a stratospheric methane oxidation parameterization based on Untch and Simmons (1999) were adopted. The background error covariance in 4D-Var data assimilation was updated to ensure consistency with the error characteristics of the first guess.

3. Verification results

Twin examinations were conducted to compare forecast scores of the previous and updated systems for two separate periods of July to September (JAS) 2015 and December to February (DJF) 2015/2016. Forecasts were improved overall, with particular enhancement in temperature and wind fields. Figure 1 shows vertical profiles of root mean square errors (RMSEs) for temperature forecasts up to 11 days ahead verified against analysis averaged over the Northern Hemisphere (20 – 90°N) for the JAS period. The upgraded system exhibits reduced RMSEs for most pressure levels and forecast lead times as compared to the previous version (Yonehara et al. 2017). Other forecast elements such as geopotential height and winds were similarly improved.

References

Japan Meteorological Agency, 2013: Outline of Operational Numerical Weather Prediction at JMA. Japan Meteorological Agency, Tokyo, Japan.

Kessler, E., 1969: On the distribution and continuity of water substance in atmospheric circulation. Meteorological Monographs, Vol. 10. Am. Meteorol. Soc., Boston, MA.

Myneni, R. B., S. Hoffman, Y. Knyazikhin, J. L. Privette, J. Glassy, Y. Tian, Y. Wang, X. Song, Y. Zhang, G. R. Smith, A. Lotsch, M. Friedl, J. T. Morisette, P. Votava, R. R. Nemani and S. W. Running, 2002: Global products of vegetation leaf area and fraction absorbed PAR from year one of MODIS data. Remote Sens. Environ., 83, 214 – 231.

Untch, A. and A. J. Simmons, 1999: Increased stratospheric resolution in the ECMWF forecasting system. ECMWF Newsletter, No. 82, 2 – 8.

Yabu, S., T. Y. Tanaka and N. Oshima, 2017: Development of a multi-species aerosol-radiation scheme in JMA's global model. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell., 4.15 – 4.16.

Yonehara, H., T. Tokuhiro, R. Nagasawa, M. Ujiie, A. Shimokobe, M. Nakagawa, R. Sekiguchi, T. Kanehama, H. Sato and K. Saitou, 2017: Upgrade of parameterization schemes in JMA's operational global NWP model. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell., 4.17 – 4.18.

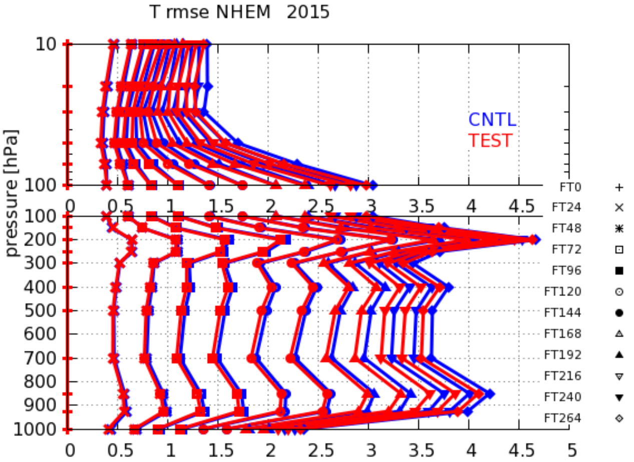

Fig. 1: Profiles of RMSE (CNTL(old)/TEST(new)) for temperature [K]. The reference values are the respective analysis results, and the verification region is the Northern Hemisphere (20 – 90°N). The trial period was 2015JAS. The lines show results for a forecast lead time from FT = 0h to FT = 264h at 24-hour intervals.