Improved representation of super-cooled liquid water cloud in JMA's next-generation coupled seasonal prediction system

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1 Introduction

The Japan Meteorological Agency (JMA) is developing the next-generational seasonal ensemble prediction system (JMA/MRI-CPS3; CPS3) for the purpose of supporting three-month, warm-/cold-season and El Niño forecasts. Some investigations have shown that a lack of supercooled liquid water (SLW) at the low-level cloud top causes radiation biases associated with underestimation of cloud amount and optical thickness (Kay et al., 2015) in CPS3. Accordingly, the authors tackled this issue via a pragmatic approach as an operational center to provide better forecasts. This report outlines the method and results.

2 Method

To represent the effects of SLW near the top of low-level cloud, the cloud ice ratio is calculated using an alternative diagnostic function of temperature that enables SLW presence down to a temperature of 238.15 (K)[1], and the deposition rate is reduced over the 500 (m) depth near the cloud top following the formulation of ECMWF (2018). The former change is also applied to the radiation scheme in calculating cloud optical thickness.

3 Results

The results of one-day experiments using the atmospheric component of CPS3 (TL319L100) with and without the modified cloud and radiation schemes were compared with the DARDAR-MASK product (Delanoë and Hogan, 2010), which contains vertical profiles of cloud phase extracted from the CALIPSO and CLOUDSAT satellite products. Along the satellite orbit on 8th Feb. 2010 (the red line in Figure 1), results from the TEST experiment with the modified schemes represent SLW near the cloud top from 160 to 165°E better than CNTL with the original schemes (Figure 2). Upward shortwave radiative flux at the top of the atmosphere is increased, and related error is smaller since lower-cloud cover and SLW increase (not shown).

Radiative biases were also evaluated through one-year experiments with observation data on sea surface temperature and sea ice concentration. Consistent with previous research, the most remarkable change is the wintertime improvement of shortwave radiation in the Southern Ocean, where low-level cloud with SLW near the top is commonly present (Figure 3). Overall, the revision of the schemes demonstrates significant improvement.

Reference

Delanoë, J., and R. J. Hogan, 2010: Combined CloudSat-CALIPSO-MODIS retrievals of the properties of ice clouds. J. Geophys. Res., 115, D00H29, doi:10.1029/2009JD012346.

European Centre for Medium-Range Weather Forecasts, 2018: IFS Documentation CY45R1, Part IV:Physical Processes, Chapter 7: Clouds and large-scale precipitation.

Kay, J. E., L. Bourdages, N. Miller, A. Morrison, V. Yettella, H. Chepfer, and Eaton, B., 2015: Evaluating and improving cloud phase in the Community Atmosphere Model version 5 using spaceborne lidar observations. J. Geophys. Res. Atmos., 121, 4162-4176.

[1] The current function cannot generate SLW at temperatures lower than 258.15 (K).

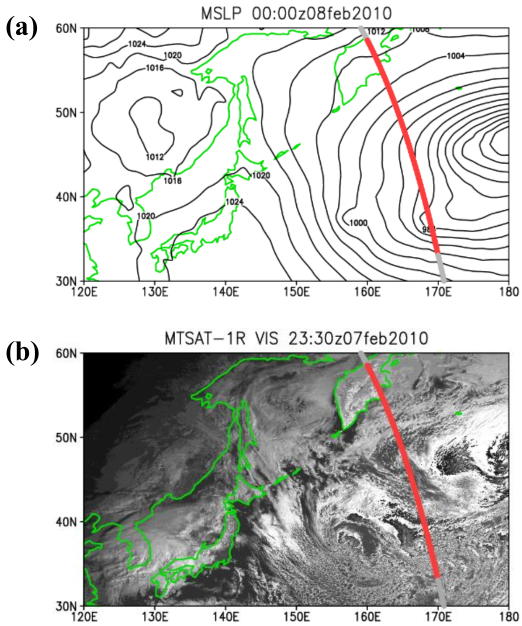

Figure 1 Satellite orbit in the DARDAR product (red line) and **(a)** Sea level pressure from JRA-55 reanalysis (contours) **(b)** Himawari-6 visible image

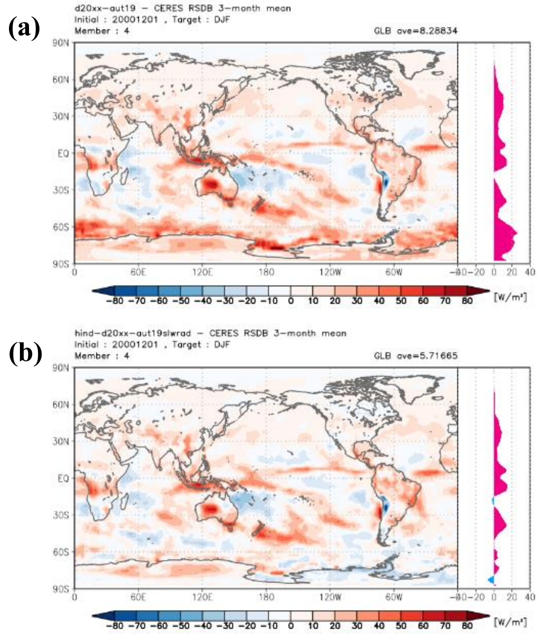

Figure 3 Bias of surface downward shortwave radiation flux against CERES-EBAF v2.8 in winter (DJF) from the **(a)** CNTL and **(b)** TEST experiments

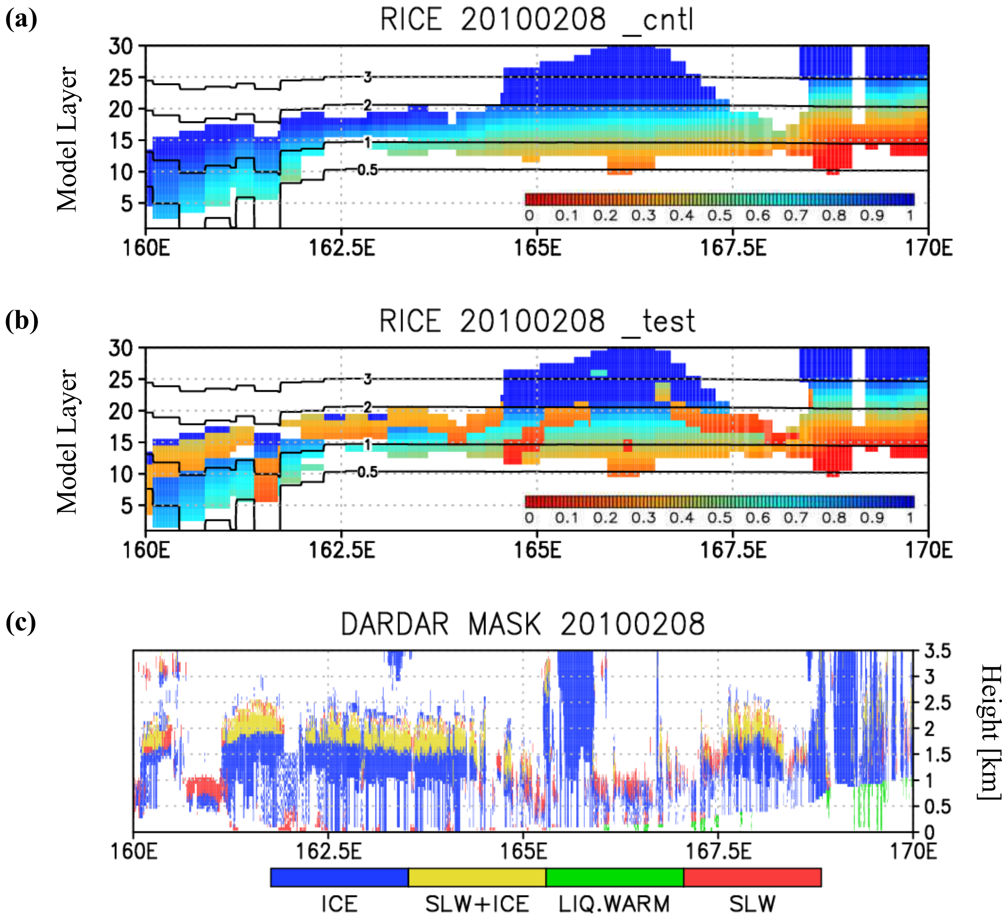

Figure 2 Cloud ice ratio (shading) and geopotential height [km] (contours) for the **(a)** CNTL and **(b)** TEST experiments. Cloud/precipitation phase categorization (shading) of the DARDAR-MASK product is shown in **(c)**.