Sensitivity of the prediction of Typhoon Lionrock (2016) to the parameter in the cloud scheme using the 7-km mesh nonhydrostatic global spectral atmospheric Double Fourier Series Model (DFSM)

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1. Introduction

This report is similar to Wada et al. (2018) except that this examination addresses the sensitivity of the prediction of a storm to the parameter in the cloud scheme of the 7-km mesh nonhydrostatic global spectral atmospheric Double Fourier Series Model (DFSM). As described in Wada et al. (2018), the over-intensification was found in the prediction of the intensity of Typhoon Lionrock (2016). The purpose of this study is to understand the sensitivity of the prediction of Lionrock to the parameter associated with the cloud diagnosis in DFSM. This process is considered to be as important as surface boundary processes because it is closely related to diabatic heating within the inner core of the storm.

2. Experimental design

The experimental design is almost the same as in Wada et al. (2018) except for the kind of sensitivity experiments. That is, the initial time of the prediction of Lionrock is set to 0000 UTC 23 August 2016. The prediction period is from this initial time to 0000 UTC 31 August 2016. The integration time is 8 days. The specification of the original DFSM is the same as in Table 4 of Nakano et al. (2017). The experiment name 'DFSM' represents 'DFSM_nolimevp' in Wada et al. (2018): The threshold regarding the limitation of the evaporation in the cloud scheme is not considered. The package of physical schemes incorporated into the DFSM is based on GSM1403. The cloud parameter 'cwcadd' represented the supplement amount of cloud water content, which was originally adjusted to mitigate the time step dependence of predicted precipitation due to large scale condensation in GSM1403 with the horizontal resolution corresponding to 20 km. 'Qs' indicates saturated specific humidity. In a series of the experiments 'Modify', the effect of the gust was removed. Instead, the effect of sea spray on turbulent heat fluxes (Bao et al., 2000) was incorporated into the DFSM. The inclusion of the Bowen ratio (0.1) as estimating the upper limit of sensible heat fluxes against latent heat fluxes is the same as in Wada et al. (2018). Thus, all the four numerical prediction experiments shown in Table 1 were performed using the DFSM.

Table 1 List of sensitivity numerical prediction experiments for the prediction of Lionrock

Experiment name	Cloud parameter	Gust	Sea spray	Limitation of Bowen ratio (0.1)
DFSM	Min(cwcadd, 0.3*Qs)	○	×	×
DFSM_Modify_03	Min(cwcadd, 0.3*Qs)	×	○	○
DFSM_Modify_02	Min(cwcadd, 0.2*Qs)	×	○	○
DFSM_Modify_01	Min(cwcadd, 0.1*Qs)	×	○	○

3. Results

3.1 Track prediction

Figure 1 shows the results of track predictions in four experiments (Table 1) and the Regional Specialized Meteorological Center (RSMC) Tokyo best track. In the DFSM experiment, the predicted storm moved southwestward and changed the direction to eastward north of the best-track recurvature point (Wada et al., 2018). After the recurvature, the storm moved more eastward compared with the RSMC Tokyo best track. The cloud parameter 'cwcadd' did affect the track prediction clearly. When the effect of saturated specific humidity on the supplement amount of cloud water content reduced, the predicted storm tended to move more slowly after the recurvature. However, the moving direction of the predicted storm was not simply explained by the value of the cloud parameter. This suggests that atmospheric environments associated with the steering flow did change due to the cloud parameter. In the following subsection, we will show the results of intensity predictions and predicted precipitation patterns to examine the effect on the track prediction.

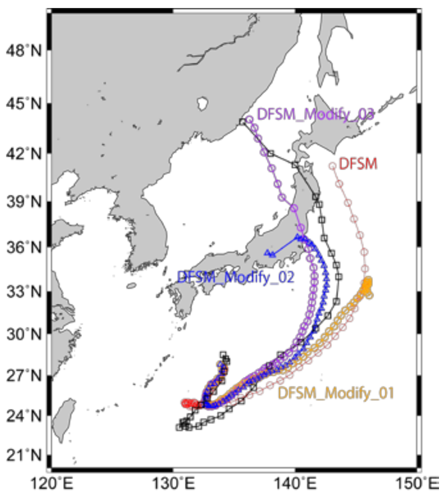

Figure 1 Results of track predictions

3.2 Intensity prediction

Figure 2 shows the results of intensity predictions compared with the RSMC best track intensity. Unlike the results in Wada et al. (2018), there was only a little difference in predicted central pressures and maximum wind speeds at 20 m height among the DFSM_Modify_01, DFSM_Modify_02 and DFSM_Modify_03 experiments. This implies that the difference of the intensity predictions was not crucial for explaining the difference of the track predictions among the three experiments. On the other hand, the difference of the intensity predictions found in the latter integration can be explained by the difference of the track predictions: In the DFSM_Modify_01 experiment, the intensity tended to be strong because the predicted storm was over the ocean during the integration, while the storm intensity tended to weaken due to making landfall in the main island of Japan.

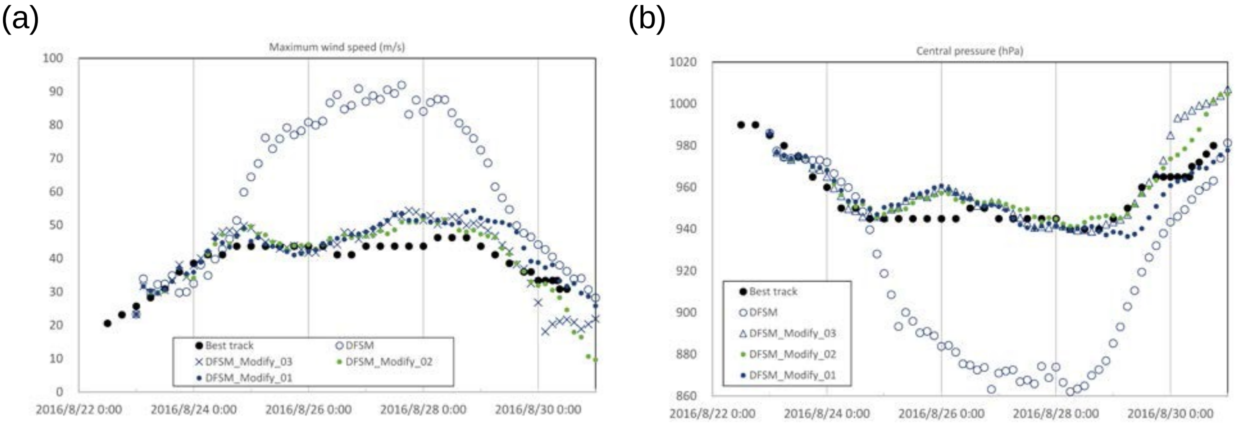

Figure 2 Time series of (a) predicted maximum wind speed at 10 m height and (b) predicted central pressure together with RSMC Tokyo best track data.

3.3 Precipitation pattern

Figures 3 and 4 show the horizontal distributions of precipitation rate and total precipitable water at 0000 UTC 27 August 2016, corresponding to 96-hour integration time. The wave-1 asymmetric pattern of precipitation rate (Fig. 3) was commonly found in the DFSM_Modify_03, DFSM_Modify_02 and DFSM_Modify_01 experiments. The horizontal distribution of total precipitable water, however, showed axisymmetric (Fig. 4) although the total precipitable water was locally high on the right side from the storm center in the DFSM_Modify_01 experiment. The similarity of the inner core structure of simulated storm was consistent with the results of intensity predictions.

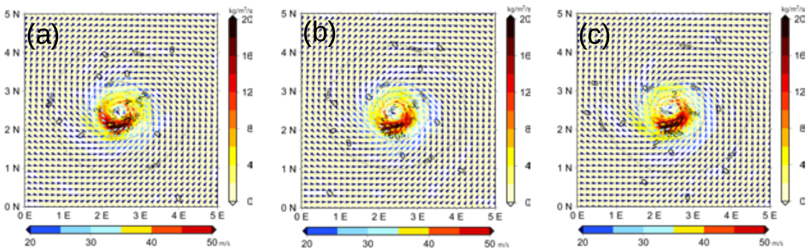

Figure 3 Horizontal distributions of precipitation rate (shades) collocated at the predicted storm center in the (a) DFSM_Modify_03, (b) DFSM_Modify_02 and (c) DFSM_Modify_01 experiments at 96 h. Arrows with colors indicate the surface wind vectors and speeds.

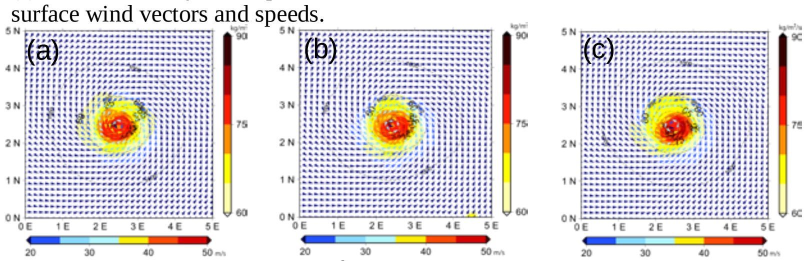

Figure 4 Same as Figure 3 except for total precipitable water.

4. Concluding remarks

The cloud parameter 'cwcadd' affected the track predictions of Lionrock (2016). However, this is a result of a single tropical cyclone case. Thus, we need to do sensitivity experiments for more tropical cyclone cases. In addition, we need to study how the atmospheric environments change due to the tuning of the cloud parameter.

References

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