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

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## 1. Introduction

The Global 7 km mesh nonhydrostatic Model Intercomparison Project for improving TYphoon forecast (TYMIP-G7) is designed to understand and statistically quantify the advantages of high-resolution nonhydrostatic global atmospheric models to improve tropical cyclone (TC) prediction (Nakano et al., 2017). Through TYMIP-G7, we found that the central pressure in the 7-km mesh nonhydrostatic global spectral atmospheric Double Fourier Series Model (DFSM) showed over-intensification compared with that predicted by the Global Spectral Model (GSM) with a horizontal resolution corresponding to 20 km. Because both DFSM and GSM had the same specifications except for the horizontal resolution, this result suggests that the improvement of physics schemes suitable for such high-resolution models is needed for accurate forecasts of the central pressure. The over-intensification was also found in the prediction of Typhoon Lionrock (2016). The purpose of this study is to understand the sensitivity of the prediction of Lionrock to the surface boundary scheme in DFSM, which is closely related to diabatic heating within the inner core of the storm.

## 2. Experimental design

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 first experiment name is 'DFSM_nolimevp', where 'nolimevp' means that the threshold regarding the limitation of the evaporation in the cloud scheme is not considered. The package of physical schemes incorporated into the original DFSM is the same as in GSM1403, while GSM1705 includes another package of physical schemes used in operational runs of GSM. The name of the corresponding experiment with the new physics is 'DFSM_GSM1705'.

In the original GSM1403 and GSM1705, the effect of gusts is considered to calculate air-sea momentum and turbulent heat fluxes. In the 'DFSM_nolimevp_Modify' experiment, the effect of gusts was neglected. Instead, the effect of sea spray on turbulent heat fluxes (Bao et al., 2000) was incorporated into the DFSM. In addition, the Bowen ratio (0.1) was used to limit the overestimation of sensible heat fluxes against latent heat fluxes. In other words, the upper limit of air-sea sensible heat fluxes was determined by using the Bowen ratio and latent heat fluxes. Thus, all the three sensitivity numerical prediction experiments shown in Table 1 were performed by using the DFSM incorporating the package of physical schemes used in GSM1403 / GSM1705.

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

| Experiment name | Model & Horizontal resolution | Gust | Sea spray | Limitation of Bowen ratio (0.1) |
|---|---|---|---|---|
| DFSM_nolimevp | 7km GSM1403 | ○ | × | × |
| DFSM_nolimevp_Modify | 7km GSM1403 | × | ○ | ○ |
| DFSM_GSM1705 | 7km GSM1705 | ○ | × | × |

## 3. Results

### 3.1 Track prediction

Figure 1 shows the results of track predictions in three experiments and the Regional Specialized Meteorological Center (RSMC) Tokyo best track. In the DFSM_nolimexp experiment, the predicted storm moved southwestward and changed the direction to eastward north of the best- track recurvature point. After the recurvature, the storm moved more eastward compared with the RSMC Tokyo best track. In the DFSM_nolimexp_Modify experiment, the track changed a little before arriving at the recurvature point. However, the moving direction changed after the recurvature and the predicted storm track tended to move westward compared with the RSMC best track and made landfall in Ibaraki prefecture, south of the real landfalling location of the storm. In the DFSM_GSM1705 experiment, the predicted storm track was close to the track in the DFSM_nolimexp_Modify experiment although the moving speed became slower.

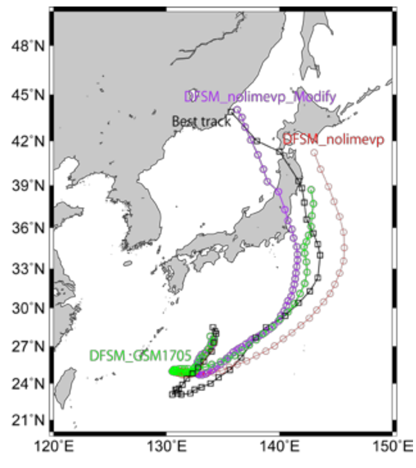


Figure 1 Results of track predictions

### 3.2 Intensity prediction

Figure 2 shows the results of intensity predictions compared with the RSMC best track intensity. In Figure 2a, the maximum wind speed at 10 m height in the DFSM_nolimevp experiment was much higher than that in the other experiments and the best track maximum wind speed at 10 m height. Unlike the simulated central pressures, the maximum wind speeds in the DFSM_nolimevp_Modify and DFSM_GSM1705 experiments were reasonably close to the best track maximum wind speed. In Figure 2b, however, predicted central pressure in the DFSM_GSM1705 experiment was much lower than that in the DFSM_nolimevp_Modify experiment and the best-track central pressure. This reveals that the wind-pressure relation in the DFSM_GSM1705 experiment strongly differed from the relation in the other two experiments and in the RSMC Tokyo best track data.

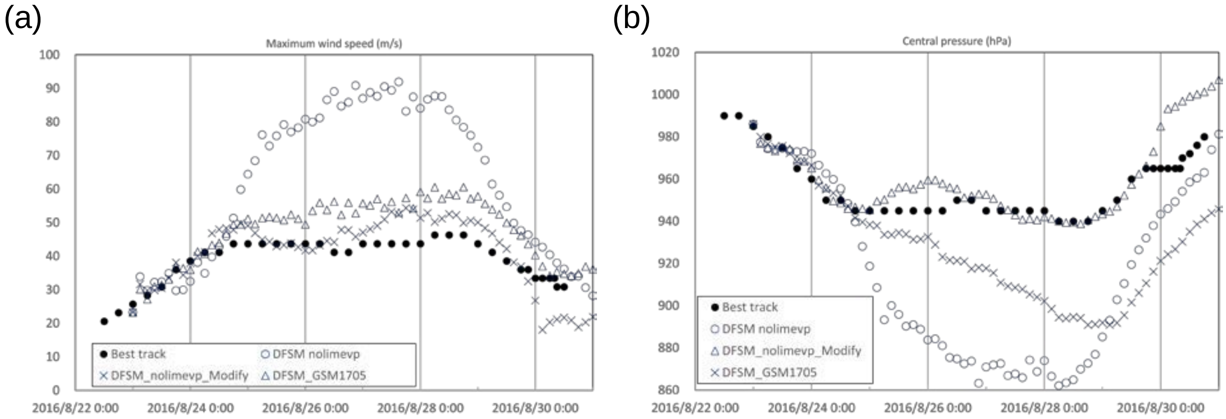


Figure 2 Time series of (a) predicted maximum wind speed at 10 m height and (b) predicted central pressure together with RSMC Tokyo best track data.

### 3.3 Sensible and latent heat fluxes

Figures 3 and 4 shows the horizontal distributions of sensible and latent heat fluxes at 0000 UTC 25 August 2016, corresponding to 48-hour integration time. In the DFSM_nolimexp experiment, the value of both sensible and latent heat fluxes within the inner core of the predicted storm was extremely high. The value of latent heat flux was relatively high, while the value of sensible heat flux within the inner core reduced clearly in the DFSM_nolimexp_Modify experiment due to the Bowen ratio limitation and the effect of sea spray scheme. In the DFSM_GSM1705, the value of latent heat flux was relatively low, while the value of sensible heat flux was relatively high.

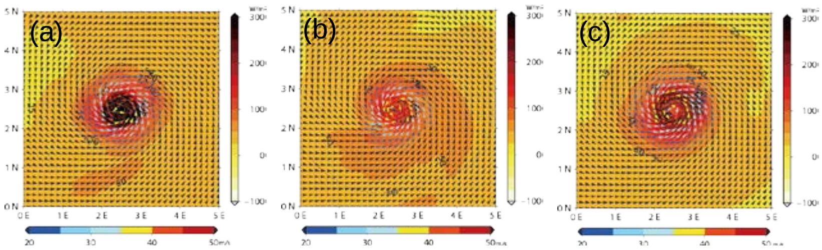


Figure 3 Horizontal distributions of sensible heat fluxes (shades) collocated at the predicted storm center in the (a) DFSM_nolimevp, (b) DFSM_nolimevp_Modify and (c) DFSM_GSM1705 experiments. Arrows with colors indicate the surface wind vectors and speeds.

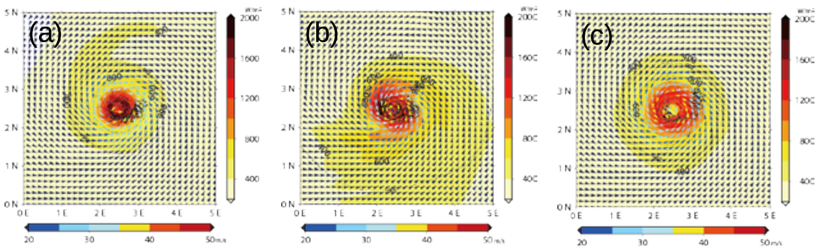


Figure 4 Same as Figure 3 except for latent heat fluxes.

### 4. Concluding remarks

The relation of the sensible and latent turbulent heat fluxes to predicted central pressures (Fig. 2b) was not straightforward. Although the latent heat flux around the inner-core of the storm was smallest, the predicted central pressure could become deeper. In other words, a large amount of turbulent latent heat flux within the inner core of the storm does not always contribute to deepen the central pressure of the storm because of the combination of physical schemes incorporated into the DFSM.

## References

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