Atmosphere-wave-ocean coupled-model simulation on the effect of Himawari-8 all-sky infrared radiances assimilation on the track simulation of Typhoon Jongdari (2018)

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1. Introduction

Typhoon Jongdari was generated around 19.7°N, 136.7°E at 12 UTC on July 24 in 2018. First, the typhoon moved northward and then moved counterclockwise over the ocean south of Japan, and made landfall in Ise City, Mie Prefecture, with a central pressure of 970 hPa and a maximum sustained surface wind speed of 35 m s^{-1}. The Jongdari's track was unusual when compared with the typical typhoon track in July because the unusual track could be influenced by the cut-off of upper cold low. The improvement of the quality of global objective analysis data may serve as understanding of the interaction between the upper cold low and the typhoon vortex and the dynamics of the unusual typhoon track in the framework of the atmosphere-ocean coupled system. Therefore, we applied Himawari-8 all-sky infrared radiances assimilation data for atmospheric initial conditions and numerical simulations were performed by a coupled atmosphere-wave-ocean model and various atmospheric initial and boundary conditions created by different global objective analysis data at different initial times.

2. Experimental design

Numerical simulations were performed by using a nonhydrostatic atmospheric model (NHM) and coupled atmospheric-wave-ocean model (CPL). The list of numerical simulations is shown in Table 1. The horizontal resolution was 3 km and the domain was 3000 x 3000 km. The number of the vertical layer was 55. The top height was approximately 27 km.

Table1 List of numerical simulations

Atmospheric condition	*Model*	*Initial time*
NAPS10 (JMA, 2019)	NHM / CPL	12 UTC on July 25 to 12 UTC on July 28 (6-hour interval)
CNT（Geer et al. 2018）	NHM / CPL	
ASR (New product)	NHM / CPL	

The atmospheric initial and lateral boundary conditions of the atmospheric model were created by the following three global analysis data, respectively. The experiment ‘NAPS10’ used the global objective analysis data based on the Japan Meteorological Agency (2019). The data is currently available in the operational system in the Japan Meteorological Agency (JMA). The experiment ‘CNT’ used the global objective analysis data calculated based on Geer et al. (2018). The experiment ‘ASR’ used the improved version from the ‘CNT’ global objective analysis data and the assimilation system is under development.

The JMA North Pacific Ocean analysis data with horizontal resolution of 0.5° were used for creating oceanic initial conditions. The initial time is set every 6 hours from 12 UTC on July 25 to 12 UTC on July 28. The integration time was 144 hours. The time step was 3 seconds for NHM, 18 seconds for the ocean model, and 6 minutes for the ocean surface wave model. The physical components were exchanged between NHM, the ocean model, and the ocean surface-wave model every time step of a model with a longer time step. Detail information is described in Wada et al. (2018).

3. Results

3.1 Track simulations

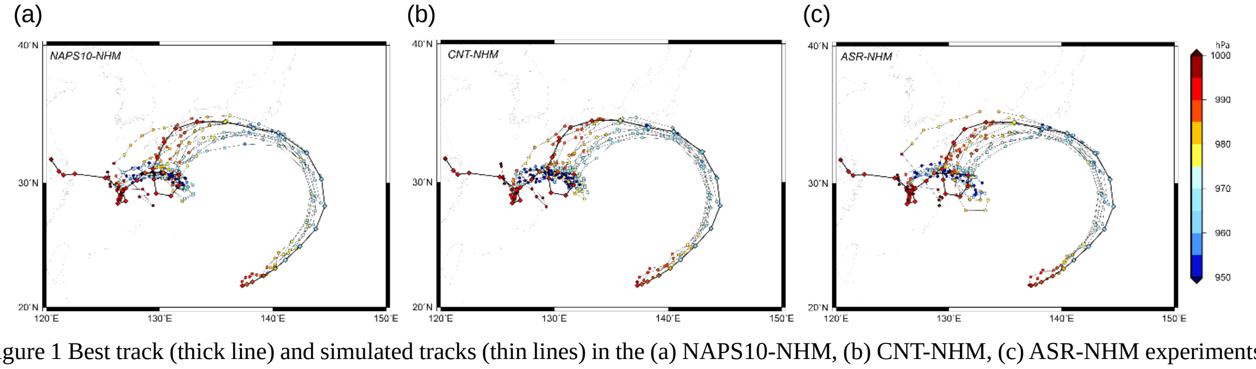

Figure 1 Best track (thick line) and simulated tracks (thin lines) in the (a) NAPS10-NHM, (b) CNT-NHM, (c) ASR-NHM experiments. Colors indicate the best-track central pressure and simulated central pressures plotted every 6 hours.

Figure 1 shows the simulated tracks in the NAPS10-NHM, CNT-NHM, and ASR-NHM experiments together with the Regional Specialized Meteorological Center Tokyo best track data. In almost all the experiments, when compared with the best track data, the overall tendency of simulated tracks was a westward deviation at the early integration, a southern deviation while moving westward, and an eastern deviation of the counterclockwise track south of Kyushu. This tendency was also found in the results of numerical simulations by the CPL. The impact of the difference between NAPS10, CNT and ASR on the typhoon simulation performed by the NHM and the CPL was found in the difference in simulated tracks and simulated central pressure to some extent but did not lead to the improvement of track simulations significantly.

3.2 Predictability of typhoon track and central pressure

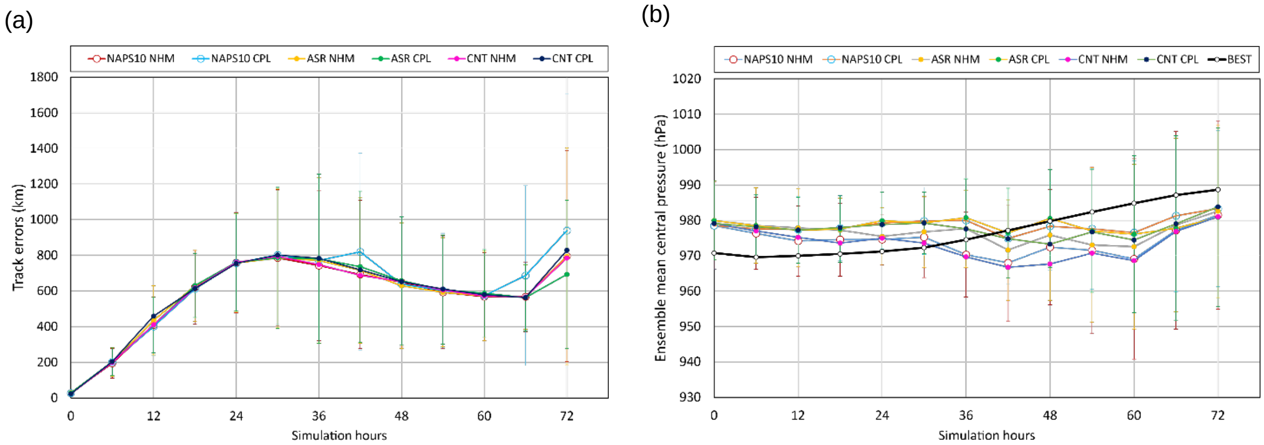

Figure 2 Time series of (a) mean track errors at each integration time (6-hour interval) in each experiment (Table 1) with reference to the best track data and (b) mean best track (thick black line with open circles) and mean simulated central pressure at each integration time (6-hour interval) in each experiment (Table 1). The error bar indicates the standard deviation at each integration time. The mean value is calculated using all simulation results from the initial time every 6 hours from 12 UTC on July 25 to 12 UTC on July 28.

Figure 2 shows the time series of mean simulated track errors and mean simulated central pressures in all the experiments (Table 1). When compared with the best track data, the simulated track errors did not significantly differ between the six experiments, but rather the standard deviation resulted from the difference of the initial time becomes large in the latter of the integration. However, at the 72-h integration time, the simulated track was improved in the ASR-CPL experiment, while the simulated track in the NAPS-CPL experiment became worst.

Regarding the simulated central pressure, the NHM experiment shows a systematic tendency to lower the central pressure in the latter half of the integration. Although the central pressure at the initial time did not match that of the best track data, simulated central pressure by the NHM was relatively low even at the early integration, which affected the relatively low value of simulated center pressure even in the latter half of the integration. The standard deviation of simulated central pressure resulted from the difference of the initial time became large in the latter of the integration. The result suggests that both the effect of ocean coupling and the difference of the atmospheric initial condition between initial times had a greater effect on Jongdari's simulation than the difference of the methodology to create global objective analysis data.

4. Concluding remarks

This study investigated the impacts of the methodology to create the global objective analysis data on the simulation of Typhoon Jongdari (2018) by using a nonhydrostatic atmosphere model and its coupled atmosphere-wave ocean model with three kinds of global objective analysis data at different initial times. Both ocean coupling and differences in atmospheric initial and boundary conditions between initial times had a greater impact on simulated tracks and central pressures than the difference of the global atmospheric data assimilation method. It should be noted that Himawari-8 all-sky infrared radiances assimilation is currently under development. In order to understand the dynamics of unusual Jongdari's track, it is necessary to evaluate the steering flow and the interaction between the upper cold low and the typhoon vortex by using the different global objective analysis data and its simulation results. This is a subject in the future.

References

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