The effects of oceanic initial conditions created from different reanalysis datasets on the intensity prediction of Typhoon Trami (2018)

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1. Introduction

Wada (2019) showed the results of numerical simulations on Typhoon Trami (2018) to investigate roles of a mesoscale cold eddy centered at around (21˚N, 129 ˚E) in the rapidly weakening of the intensity from 915 hPa at 06 UTC on 25 September to 950 hPa at 00 UTC on 26 September according to the Regional Specialized Meteorological Center (RSMC) Tokyo best track analysis (https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/besttrack.html). From the results of ensemble simulations on different oceanic initial conditions, the setting of an unrealistic artificial mesoscale cold eddy was needed to simulate the rapid weakening even when a coupled atmosphere-wave-ocean coupled model was used (Wada, 2021). In the supplement of Wada (2021), the timeseries of tropical cyclone heat potential (TCHP) averaged in a 2˚×2˚ squared area centered at (21˚N, 129˚E) from 19 September to 5 October 2018 showed that the value of TCHP varied depending on the analysis/reanalysis data set although all data sets showed that the TCHP did decrease from 25 September. To understand the difference of the oceanic initial condition attributed to the difference in the oceanic analysis/reanalysis data set on the simulation of Trami, numerical simulations were conducted by using a nonhydrostatic atmosphere model (NHM) and the coupled atmosphere-wave-ocean model (CPL).

2. Experimental design

The list of numerical simulations is shown in Table 1. The initial time of all experiment was 0000 UTC on 23 September in 2018. The computational domain was 2280 x 3120 km with a grid spacing of 2 km (Fig. 1a). The number of the vertical layer was 55 for the NHM and CPL. The top height was approximately 27 km for both NHM and CPL. The integration time in all simulations was 180 hours.

The oceanic reanalysis datasets used in this study were the Four-dimensional variational Ocean ReAnalysis (FORA) dataset (Usui et al. 2017) with a 0.5° horizontal resolution, new data set with a 0.1° horizontal resolution for operational use in Japan Meteorological Agency (JPN), and the Copernicus Marine Environment Monitoring Service GLOBAL_ANALYSISFORECAST_PHY_CPL_001_015 dataset (Lea et al. 2015) with a 0.25° horizontal resolution (ORA5).

It should be noted that an artificial cold eddy (Wada, 2021) was not embedded in the oceanic initial condition in all experiments shown in Table 1. This implies that simulated Trami would overly develop after the rapidly weakening from 25 to 26 September in the NP05_CPL experiment like the result in Wada (2021).

Table1 List of numerical simulations

Name	*Model*	*Oneanic initial data*
NP05_NHM	NHM	FORA
NP05_CPL	Coupled NHM-wave-ocean	FORA
NP01_NHM	NHM	JPN
NP01_CPL	Coupled NHM-wave-ocean	JPN
ORA5_NHM	NHM	ORA5
ORA5_CPL	Coupled NHM-wave-ocean	ORA5

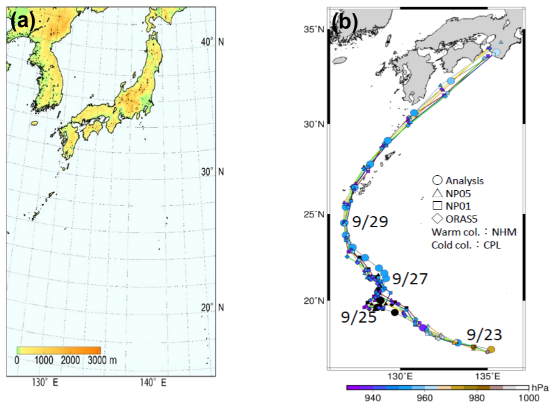

Figure 1. (a) Computational domain. (b) Results of track simulations along with the RSMC Tokyo best track positions.

3. Results

Figure 1b shows the results of simulated central pressure positions along with the RSMC best track positions. The effect of the difference in oceanic initial conditions on the track simulation was not significant. This result was also found in the comparison of the simulation results between NHM and CPL. All simulation results clearly show the irregularity of the storm track from 25 to 27 September where Trami-induced sea surface cooling occurred (Wada, 2021). Except the northeastward shift of the simulated track on 27 September, the simulated tracks in all experiments were reasonable to the RSMC best track.

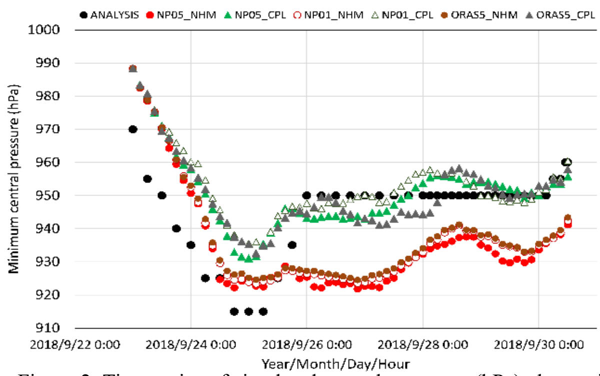

Figure 2. Time series of simulated central pressures (hPa) along with the RSMC best track central pressures.

Figure 2 shows the timeseries of simulated central pressure along with the RSMC best track central pressure. The increase in simulated central pressures due to ocean coupling was clearly found in all the experiments with the three oceanic reanalysis data sets (FORA, JPN, and ORA5). The difference in simulated central pressures between NHM and CPL became constant after the rapidly weakening of simulated Trami. At that time, the simulated central pressure became low again probably due to poor simulation of the mesoscale cold eddy around (21˚N, 129˚E). After 27 September, the simulated central pressure increased again in all the experiments, which was not found in the RSMC best track analysis.

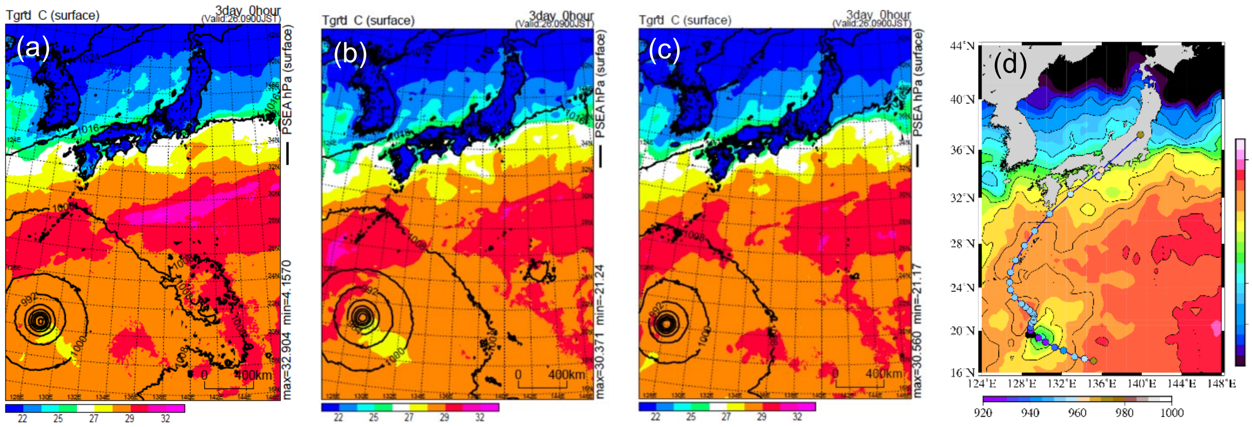

Figure 3. Horizontal distribution of simulated sea surface temperature and ground temperature in (a) NP05_CPL, (b) NP01_CPL, and (c) ORA5 experiments and (d) that of daily sea surface temperature (v05.0) obtained from the Remote Sensing Systems website (https://www.remss.com/measurements/sea-surface-temperature/).

Figures 3a-c show the horizontal distributions of simulated sea surface temperature and ground temperature in the NP05_CPL (Fig. 3a), NP01_CPL (Fig. 3b), and ORA5_CPL (Fig.3c) experiments. Compared with the horizontal distribution of daily sea surface temperature shown in Fig. 3d, Trami-induced sea surface cooling formed before the arrival of the stagnant area of Trami was poorly simulated in all the experiments. This may be caused by insufficient simulated peak intensity of Trami as well as uncertainty of the upper oceanic condition.

As for the insufficient peak simulated intensity, the central pressure at the initial time was relatively high in all the simulations compared with the RSMC best track central pressure (Fig. 2). This resulted in relatively high simulated central pressure during the intensification phase compared with the best track central pressure although the intensification rate was reasonably simulated particularly in the CPL simulations. This also means that the peak intensity in all the simulations calculated by the CPL was weaker than the best track analysis due to the relatively weak intensity at the initial time. Therefore, the ocean response to simulated wind stress of Trami continued to be relatively weak so that Trami-induced simulated sea surface cooling was not remarkable in the simulations shown in Figs. 3a-c. Nevertheless, this does not explain why Trami-induced sea surface cooling was least noticeable in the ORAS5_CPL experiment. On 27 September, simulated central pressure in the ORAS5_CPL experiment was lower than that in the other two experiments (NP01_CPL and NP05_CPL).

4. Concluding remarks

Sensitivity numerical experiments on the oceanic initial condition were conducted by the NHM and CPL with three different ocean reanalysis products. The use of the coupled model is important in predicting the intensity of Trami. In addition, the importance is independent of a kind of oceanic reanalysis datasets that is needed to create oceanic initial condition. However, any oceanic initial condition did not realize the improvement of the simulation of Trami's peak intensity. This may be in part due to unrealistic initial central pressure. Therefore, another numerical experiments using a different atmospheric analysis data different from the objective analysis in the Japan Meteorological Agency are needed. This will be a subject in the future.

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