The impacts of preexisting oceanic cold eddies on the intensity forecast of Typhoon Trami (2018) during the mature phase

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1. Introduction

Typhoon Trami (2018) is one of the typhoons that made landfall in Japan. According to the Regional Specialized Meteorological Center (RSMC) Tokyo best track analysis, the central pressure reached 915 hPa at 18 UTC on 24 September around 20˚N and then rapidly increased up to 950 hPa in 18 hours. After the rapid increases in the central pressure, intensity forecasts announced further intensification to 935 hPa, but the typhoon couldn't intensify again. In order to clarify the impact of the cold eddies over the ocean on this forecast error, we conducted numerical simulations with different oceanic initial conditions (daily oceanic analysis data from 19 to 25 September were used and the number of ensemble members is seven) using a 2 km-mesh nonhydrostatic atmosphere model coupled with ocean surface wave and multilayer ocean models (Wada et al., 2010, 2018) with the Japan Meteorological Agency (JMA) global objective analysis with horizontal resolution of 20 km and the JMA North Pacific Ocean analysis with horizontal resolution of 0.5°. In addition, a sensitivity numerical experiment was conducted with the oceanic initial condition on 23 September merged with an artificial cold vortex centered at 21˚N, 129 ˚E where both a mixed layer and thermocline were 50 m shallower than the initial field on 23 September used the control experiment. Moreover, ensemble simulations with a 2 km-mesh nonhydrostatic atmosphere model and seven different oceanic initial conditions were performed to compare the results with the ensemble simulations by the coupled model. The initial time, corresponding to the time of atmospheric initial condition, and the integration period are 00 UTC on 23 September and 180 hours with the time interval of 3 seconds.

2. Experimental design

The list of numerical simulations is shown in Table 1. Fifteen numerical simulations were performed in this study. The model physics in the coupled model includes an explicit three-ice bulk microphysics scheme, turbulent closure model in the atmospheric boundary layer, a radiation scheme, roughness lengths based on the third-generation ocean surface wave model and a sea spray parameterization. These are the same as in Wada et al. (2018). No cumulus parameterization was used in this study.

Figure 1 shows the computational domain and Figure 2 shows the horizontal distribution of tropical cyclone heat potential (Wada et al., 2012) in the AWO_0923 (Fig. 2a) and AWO_cold (Fig. 2b) experiments. A cold-eddy region in the AWO_cold experiment was better reproduced than the region in the AWO_0923 experiment around 21˚N, 129 ˚E.

Table1 List of numerical simulations

Name	***Model***	***Oceanic initial data***	***Additional information***
[A/AWO]_0919	NHM/Coupled NHM-wave-ocean	19 September	[Noncouple/Couple]
[A/AWO]_0920	NHM/Coupled NHM-wave-ocean	20 September	Ensemble experiments
[A/AWO]_0921	NHM/Coupled NHM-wave-ocean	21 September	
[A/AWO]_0922	NHM/Coupled NHM-wave-ocean	22 September	
[A/AWO]_0923	NHM/Coupled NHM-wave-ocean	23 September	
[A/AWO]_0924	NHM/Coupled NHM-wave-ocean	24 September	
[A/AWO]_0925	NHM/Coupled NHM-wave-ocean	25 September	
AWO_cold	Coupled NHM-wave-ocean	23 September	+Artificial cold eddy

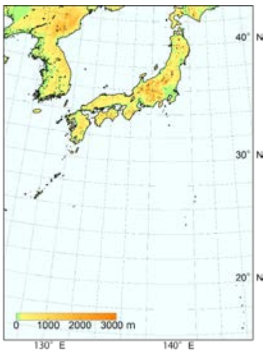

Figure 1. Computational domain.

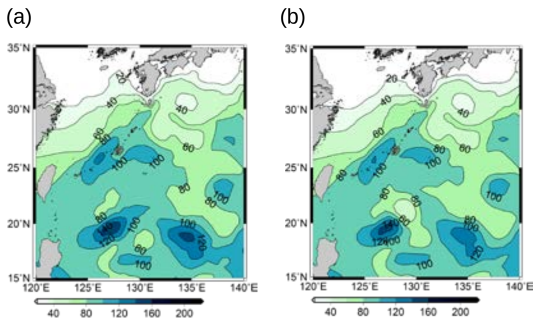

Figure 2. Horizontal distribution of tropical cyclone heat potential (a) in the AWO_0923 experiment and (b) in the AWO_cold experiment.

3. Results

Figure 3 shows the results of track simulations in the A_0923, AWO_0923 and AWO_cold experiments together with the best-track analysis. The model used in this study reasonably simulated the track of Trami although the track excessively moved westward around 20˚N, 130 ˚E. The effect of ocean coupling on the track simulation was negligibly small. In addition, the effect of oceanic cold eddy on the track simulation was also small. Compared with the operational forecast based on the results of the numerical prediction by the global atmospheric spectral model in the Japan Meteorological Agency, the track simulation was much improved due to the improvement of the objective analysis with in situ observations by GPS dropsondes during the aircraft missions of the Tropical Cyclones-Pacific Asian Research Campaign for the Improvement of Intensity Estimations/Forecasts (T-PARCII, Ito et al., 2018).

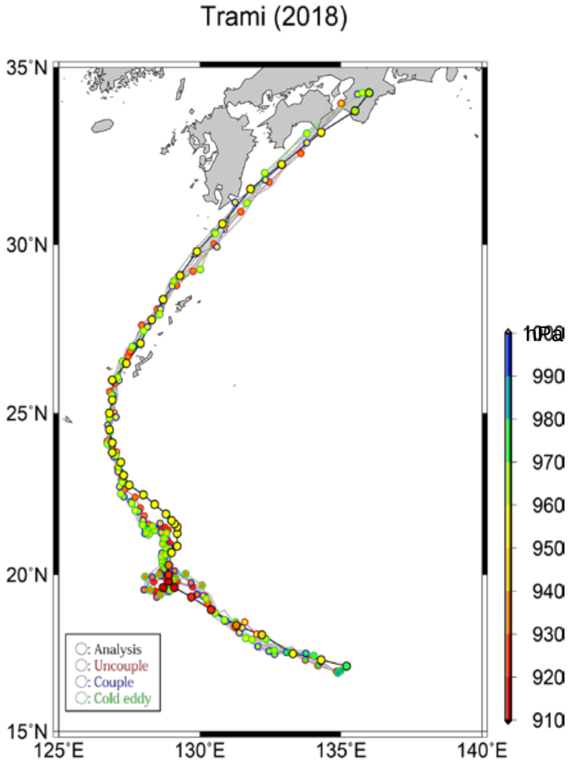

Figure 3. Results of track simulations in the A_0923 (Uncouple), AWO_0923 (Couple) and AWO_cold (Cold_eddy) experiments together with the best-track analysis.

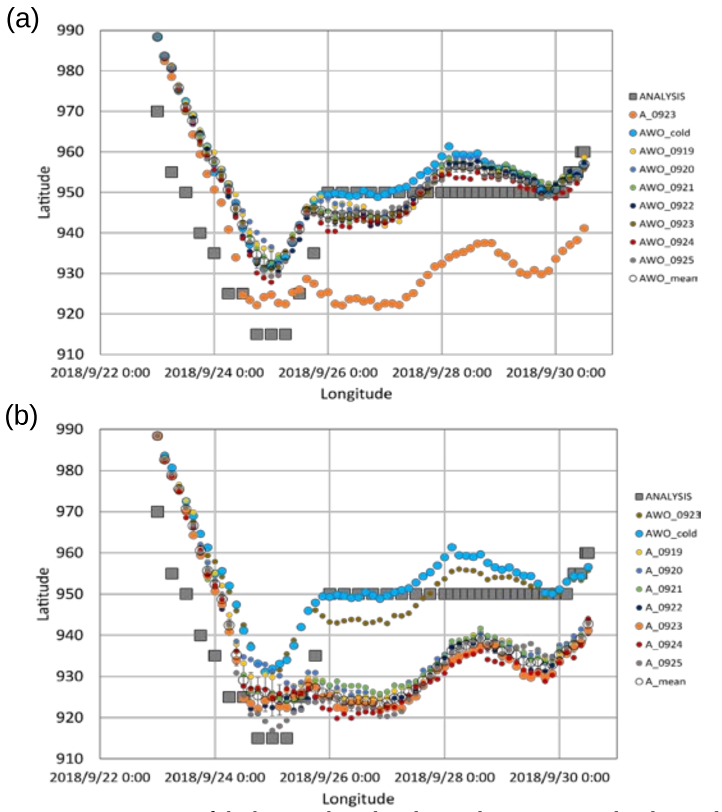

Figure 4. Time series of the best-track analyzed central pressure, simulated central pressure in the A_0923, AWO_0923 and AWO_cold experiments together with (a) the simulated central pressures in the AWO series ensemble experiments and (b) those in the A series ensemble experiments.

The rapid decrease in the central pressure could not be simulated due to a large difference in central pressure at the initial time (Fig. 4). The simulated minimum central pressure was higher than the best track central pressure. The variation in the simulated central pressures in the AWO (Fig. 4a) and A (Fig. 4b) series experiments was smaller than the difference in the simulated central pressures between AWO_0923 and A_0923 experiments. In addition, the difference in the simulated central pressures between AWO_0923 and AWO_cold became large after 12UTC on 25 September due to the effect of artificial cold eddy. This suggests that the intensity forecast could be improved when the oceanic cold eddy was embedded in the initial oceanic condition. In other words, the intensity forecast errors resulted from errors in ocean analysis data currently used in this study.

4. Concluding remarks

While the number of sea surface temperature observations from satellites is increasing, in situ observations in the upper ocean are still extremely sparse, particularly in storm areas. When a storm passes over oceanic cold eddies, the amount of storm-induced decreases in sea surface temperature becomes larger and thereby the development of the storm is suppressed. Without the effects of oceanic cold eddies and ocean coupling, the errors in typhoon intensity forecast will increase due to the overdevelopment of the intensity particularly when the moving speed of the typhoon is slow. Also, it is necessary to analyze storm-induced sea surface cooling more accurately in the sea surface temperature analysis. In this study, the Merged Satellite and In-situ Data Global Daily Sea Surface Temperatures (MGDSST) dataset (Kurihara et al., 2006) was used. The improvement of MGDSST is desirable to improve the typhoon intensity forecast.

References

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Acknowledgement

This work was supported by JSPS KAKENHI Grant Number JP15K05292 and JP17H02964.