The influence of the variation of oceanic precondition on the prediction of Typhoon Hai-Tang in 2005

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1. Introduction

Previous results suggest that sea surface cooling (SSC) induced by tropical cyclones (TCs) results in 'negative feedback' for TC intensification [e.g., Wada, 2009]. The ocean response to TCs occurs locally along TC track. In contrast, oceanic environments vary not only on a weather forecasting time scale (for example, above-mentioned SSC) but also on a seasonal to climate time scale (for example El Niño Southern Oscillation). Here, we are interested in how and to what extent the variations of oceanic environment affect TC predictions as pre-existing oceanic conditions, and whether or not the impact is significant. The purpose in the present study is to investigate the influence of the variation of oceanic precondition on the prediction of Typhoon Hai-Tang in 2005 during the intensification phase. We performed numerical-prediction experiments for Typhoon Hai-Tang in 2005 using a coupled atmosphere-ocean model included in an oceanic sublayer scheme for calculating diurnally-varying SST in the upper-ocean skin layer. To investigate the sensitivity of the variation of oceanic precondition to TC predictions, daily oceanic initial conditions on 12 July from 1997 to 2005 and one atmospheric initial and boundary conditions on July in 2005 are specified in this study.

2. Experiment Design

Table 1 shows a list of numerical-prediction experiments. The abbreviation 'SG' indicates numerical-prediction experiments using a coupled atmosphere-ocean model with an oceanic sublayer scheme (hereafter the model is referred to NCM), while the abbreviation 'NH' indicates those using an atmospheric (nonhydrostatic) model (hereafter NHM). In the present study, both NHM and NCM have 721 x 421 horizontal grids with a horizontal grid spacing of 6km, 40 vertical levels with variable intervals from 40m at the lowermost layer near the surface to 1180m at the uppermost layer, and a top height of nearly 23km.

Daily oceanic reanalysis data used for creating oceanic initial conditions are calculated by the Meteorological-Research-Institute Ocean Variational Estimation system [Usui et. al. 2006] with a horizontal grid spacing of 0.5°. Double digits on the left column in Table 1 indicates years from 1997 to 2005 in which daily oceanic reanalysis data on 12 July is used for creating oceanic initial conditions. Therefore, the total number of numerical-prediction experiments is 18.

There are some remarkable oceanic variations on seasonal to climate time scales during the period from 1997 to 2005. The day on 12 July 1999 corresponds to a period when the La Niña event

Table 1 Abbreviations of Numerical-Prediction Experiments, Year of Oceanic Precondition with the El Niño (E) or La Niña (L) Event, and Coupled (SG)/Noncoupled (NH) Ocean

EXPERIMENT	YEAR	SG/NO
SG97	1997(E)	SG
SG98	1998	SG
SG99	1999 (L)	SG
SG00	2000	SG
SG01	2001	SG
SG02	2002(E)	SG
SG03	2003	SG
SG04	2004	SG
SG05	2005	SG
NH97	1997(E)	NO
NH98	1998	NO
NH99	1999(L)	NO
NH00	2000	NO
NH01	2001	NO
NH02	2002(E)	NO
NH03	2003	NO
NH04	2004	NO
NH05	2005	NO

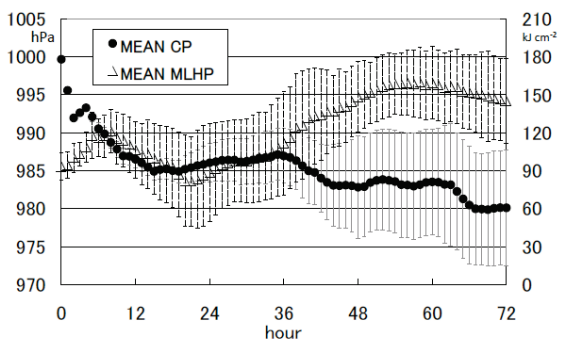

Figure.1 Time series of mean central pressures and mean mixed-layer heat potentials in SG from 1997 to 2005 and their standard deviation.

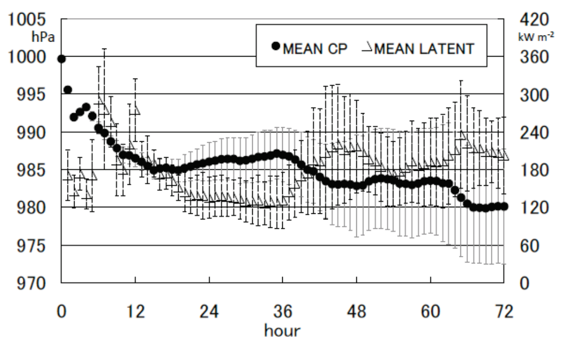

Figure.2 Time series of mean central pressures and mean latent heat fluxes in SG from 1997 to 2005 and their standard deviation.

was mature. In contrast, the day on 12 July 2002 corresponds to a period when the El Niño event was mature. Moreover, the day on 12 July 2005 corresponds to a period when the central Pacific warming event was terminated and it turned to the La Niña event. The year 2004 was a memorable year in the sense that ten typhoons extraordinarily made landfall in Japan.

To validate the results of numerical-prediction experiments, best-track positions and central pressures archived by the Regional Specialized Meteorological Center are used. The best-track data is defined as sustained 10-min mean data. In the present study, predicted central pressure is used as the reference of Hai-Tang's best-track intensity.

3. Results

Figure 1 depicts the time series of mean central pressures (CPs) and mean mixed-layer heat potentials (MLHPs) averaged from 1997 to 2005 in SG and their standard deviations. Mean values are calculated as the average of predicted CPs and MLHPs around predicted Hai-Tang's center. The definition of MLHP was described in Wada [2009]. At the early integration from 0h to 9h, mean CP rapidly falls as mean MLHP increases, while mean CP sustains its value from 12h to 36h. Mean MLHP significantly decreases from 12h to 24h due to SSC. After 36h, mean CP rapidly falls again when mean MLHP significantly increases.

Figure 2 depicts the time series of mean central pressures (CPs) and mean latent heat fluxes averaged from 1997 to 2005 in SG and their standard deviations. The variation of mean latent heat flux is similar to that of mean MLHP in the sense that mean latent heat flux us high at the early integration from 6h to 9h and increases after 36h. Therefore, mean CP is closely related to mean MLHP and mean latent heat flux, suggesting that not only sea-surface temperature but also upper ocean sea temperature and salinity are related to Hai-Tang's intensity through the variation of latent heat flux during Hai-Tang's passage. It should be noted that the result is independent of the variation of oceanic precondition.

The impact of the variation of oceanic precondition on latent heat flux is represented by the amplitude of standard deviation. In this study, we address the amplitude of standard deviation in order to investigate the impact of the variation of oceanic preconditions. Figure 3 displays the horizontal distributions of mean latent heat flux in SG (Fig.3a) and NH (Fig.3c) and those of standard deviation in SG (Fig.3b) and NH (Fig.3d). Mean latent heat flux is high west of Hai-Tang's center in SG (Fig.3a). The amplitude of standard deviation is high near Hai-Tang's center in SG (Fig.3b) and NH (Fig.3d) even though the pattern is not similar each other.

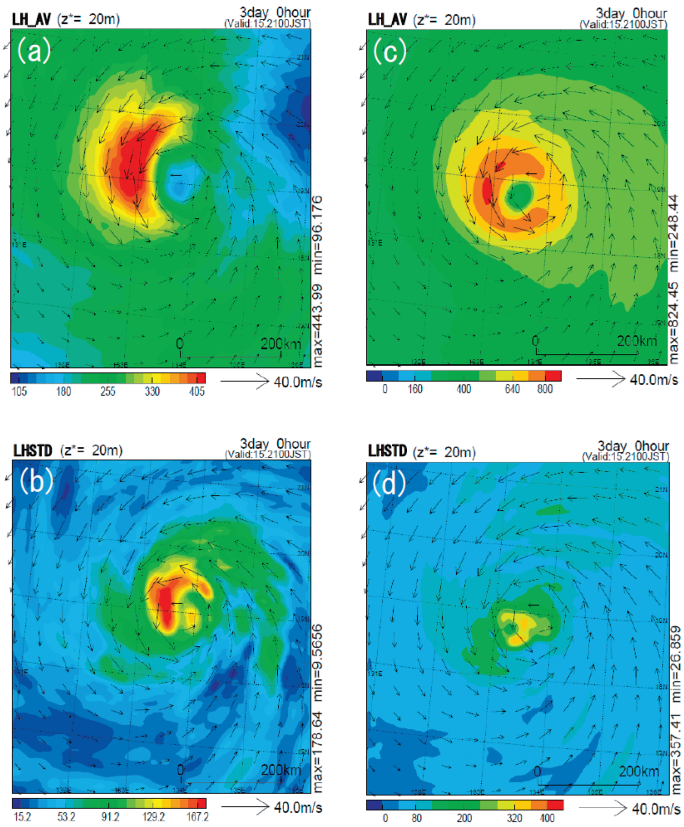

Figure 3 Horizotal distribution of (a) mean latent heat flux and mean surface wind in SG, (b) standard deviation in SG, (c) mean latent heat flux and mean surface wind in NH, and (d) standard deviation in NH at 72h.

Wave-1 asymmetry displayed in Fig. 3a is remarkable due to SSC, while its axisymmetric pattern is emphasized in Fig.3c without SSC effect. Even though the difference of horizontal distribution is salient between SSC (SG) and no SSC (NH), the impact of the variation of oceanic precondition is remarkable near Hai-Tang's center where MLHP is high. The distribution of the standard deviation of latent heat flux may demonstrate the correlation between mean MLHP and mean latent heat flux. It should be noted that the numerical-prediction experiments includes the effect of cumulus parameterization on the results of prediction. We should investigate the impact of the variation of oceanic precondition on TC prediction using cloud-resolving nonhydrostatic atmospheric model without using cumulus parameterization, coupled with the ocean model..

References

Usui, N., S. Ishizaki, Y. Fujii, H. Tsujino, T. Yasuda and M. Kamachi, 2006: Meteorological Research Institute multivariate ocean variational estimation (MOVE) system: Some early results. *J. Adv. Space Res.*, **37**, 806-822.

Wada, A., 2009: Idealized numerical experiments associated with the intensity and rapid intensification of stationary tropical cyclone-like vortex and its relation to initial sea-surface temperature and vortex-induced sea-surface cooling, *J. Geophys. Res.*, **114**, D18111