The impact of pre-existing oceanic condition on the ocean response to Typhoon Hai-Tang in 2005

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1. Introduction

Sea surface cooling (SSC) by the passage of tropical cyclones is known to be mainly caused by the Ekman pumping and vertical turbulent mixing. The impact of pre-existing oceanic condition (for examples, mixed-layer depth and temperature gradient in the thermocline) on SSC is thought to be relatively small compared with the Ekman pumping and vertical turbulent mixing. Recently, Zheng et al. (2008) suggested the importance of pre-existing oceanic condition on SSC caused by the passage of Typhoon Hai-Tang in 2005. They concluded that SSC caused by the Ekman pumping was not significant due to fast translation of Hai-Tang (5-8 m s^{-1}). Although the impact of pre-existing oceanic condition on SSC underlying Hai-Tang is significant, SSC caused by the passage of Hai-Tang may be influenced by the Ekman pumping to some extent because cyclonic wind stress results in the divergent flow at the sea surface which enables the water beneath the typhoon to transport outside and to raise the seasonal thermocline. In order to confirm the above-mentioned typhoon-induced dynamics during the passage of Hai-Tang, we investigated the impact of pre-existing oceanic condition on the ocean response to Hai-Tang using the Meteorological Research Institute Community Ocean Model (MRI.COM).

2. Experiment Design

First, we perform a numerical simulation using the North Pacific version of MRI.COM. The integration time is 2 months with nudging daily data of sea temperature and salinity on 11 August 2005, obtained from the oceanic reanalysis data. Second, we perform a numerical simulation by the same version except that the integration time is 11 days and the run is performed without nudging daily data of sea temperature and salinity on 11 August 2005. The purpose of the second run is to make initial and lateral boundary conditions for the third run. Third, we perform a numerical simulation using the regional version of MRI.COM. The integration time is 11 days. The computational domain for the regional model is 120-160°E, 10-50°N. The horizontal resolution is 0.25° and the number of vertical levels is 54. The time step is 10 minutes. The mixed-layer scheme of Noh and Kim (1999) is used in the present study. These three procedures are the same as those of Wada et al., (2009).

NCEP R2 atmospheric reanalysis dataset with a grid spacing of 1.875° is used for making atmospheric forcings such as short-wave and long-wave radiation, sensible and latent heat fluxes, water flux and wind stress. In addition, the Rankine vortex created by using the RSMC best track data is used for the third run (see Wada et al., 2009). Short-eave radiation is diurnally varied based on the formulas of Danabagoslu et al. (2006). The input of short-wave radiation lessens by 10% when the precipitation data is significant. Not only NCEP R2 data but also hourly GsMAP data (http://www.radar.aero.osakafu-u.ac.jp/~gsmap/pdf/gsmap_mwr_j_web.pdf) are used for estimating hourly precipitation data. When there is no precipitation data, the precipitation is expressed as a function of wind speed (Jacob and Koblinsky, 2007): P (mm $hour^{-1}$) =0.0016 x (v – 25) where P indicates precipitation and v wind speed.

3. Results

Figure 1 shows horizontal distributions of simulated sea surface temperature (SST: °C) and sea surface height (SSH: cm) at 120h. Around 21-22°N, 126°E where Hai-Tang passed, SSH was low in 2005 (Fig.1a), while that was relatively high in 1999 (Fig. 1b). The difference in SSH between 1999 and 2005 was independent of the ocean response to Hai-Tang because Hai-Tang was positioned around 20°N, 130°E at 120h. Figure 2 shows latitude-depth sections of sea temperature from the surface to 100 m depth at 120h. In 2005, the seasonal thermocline is shallow around 21-22°N (Fig. 2a), while the seasonal thermocline is relatively deep in 1999 (Fig. 2b). Figure 3 shows the latitude-depth sections of sea temperature at

196h. Salient upwelling occurs at 21° and 22°N in 2005, resulting in salient SSC after the passage of Hai-Tang (Fig. 3a). However, SSC is not salient in 1999 (Fig. 3b). Therefore, pre-existing oceanic condition affects the formation of SSC caused by the typhoon-induced upwelling (mainly caused by the Ekman pumping).

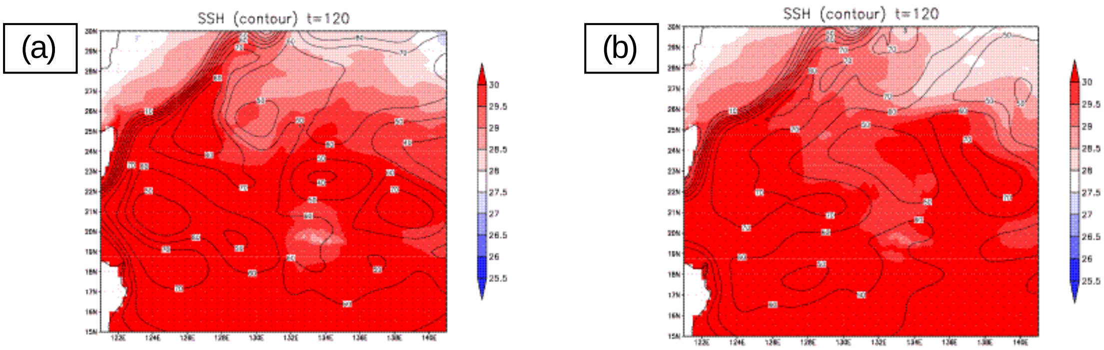

Figure 1 Simulated sea surface temperature and sea surface height at 120h (a) in the 2005 and (b) in the 1999 fields.

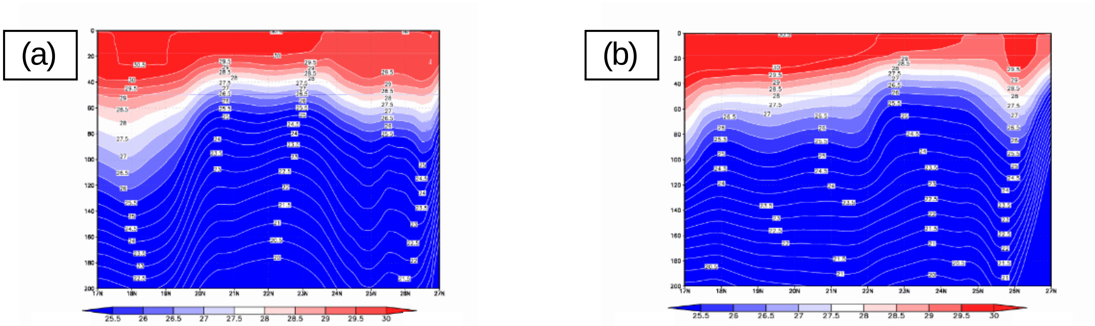

Figure 2 Latitude-depth section of simulated sea temperature across 126°E at 120h (a) in the 2005 and (b) in the 1999 fields.

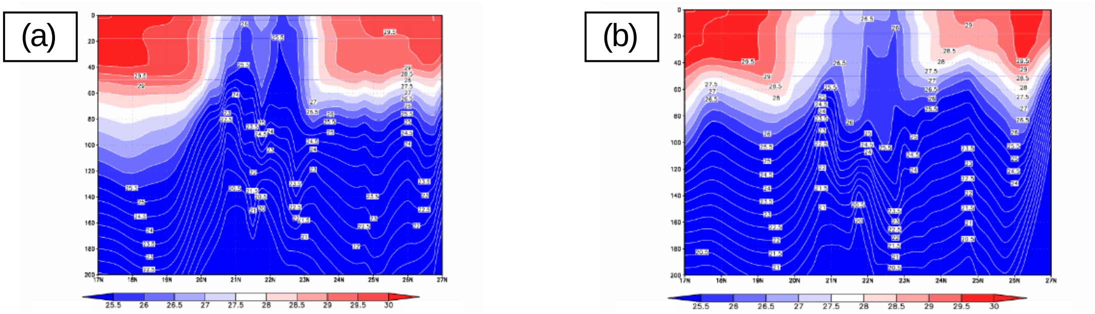

Figure 3 Same as Figure 2 except at 196h.

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