Impacts of diurnally-varying sea-surface temperature on the predictions of Typhoon Hai-Tang in 2005. Part I. Intensity prediction.

Akiyoshi Wada [1*], Yoshimi Kawai[2] and Norihisa Usui[1]

1) Meteorological Research Institute, Tsukuba, Ibaraki, 305-0052, JAPAN

2) Japan Agency for Marine-Earth Science and Technology, Yokosuka, Kanagawa, 237-0061, JAPAN.

1. Introduction

Wada and Kawai [2009a, 2009b] described the formulation on the basis of Schiller and Godfrey [2005] and Ohlmann and Siegel [2000] for calculating skin temperature in the ocean and showed the results of 1-D numerical experiments using an atmosphere-ocean coupled model. The impact of diurnally-varying sea-surface temperature (SST) on the atmosphere was relatively small and interestingly wind stress increases on alternative days. In the present study, we extend the scheme for the prediction of Typhoon Hai-Tang in 2005. We investigate the impacts of diurnally-varying SST on Hai-Tang's predictions using both the nonhydrostatic model (NHM) and the NHM coupled with a mixed-layer ocean model (NCM). We perform the numerical experiments for checking the sensitivity of skin temperature to TC intensity predictions. In the Part I, we focus on whether or not the impact of diurnally-varying SST is distinguished from the impact of random noise.

2. Experiment Design

The specification of numerical-prediction experiments is as follows. The NHM and NCM have 721 x 421 horizontal grids with a horizontal grid spacing of 6km, 40 vertical levels with variable and stretch intervals from 40m at the lowermost layer near the surface to 1180m at the uppermost layer and the top height of nearly 23km.

Oceanic initial conditions are obtained from daily oceanic reanalysis data with a horizontal resolution of 0.5° calculated by the Meteorological Research Institute Ocean Variational Estimation system [Usui et. al. 2006]. Oceanic reanalysis data used in the present study is daily output in 1999 and 2005.

Table 1 lists numerical-prediction experiments in the present study. Here, the abbreviation 'SG' indicates the experiments by the coupled atmosphere-ocean model with a diurnally-varying SST scheme, the abbreviation 'NO' indicates the experiments by the coupled atmosphere-ocean model without a diurnally-varying SST scheme, and the abbreviation 'NH' indicates the experiments by the atmosphere model.

Uniform random real numbers in the interval (0,0.1] are generated using the multiplicative congruence method. In experiments A, B, and C, the random numbers are added instead of the skin temperature overall the computational domain, while the random numbers are added instead of the skin temperature where the amplitude of skin temperature is higher than 0.1°C in experiments D, E, F. The random numbers are regarded as random noises in this study.

To validate the results of numerical-prediction experiments, best-track positions and central pressures archived by the Regional Specialized Meteorological Center are used. In the present study, central pressures are regarded as a reference of Hai-Tang's intensity.

Table 1 Abbreviations of Numerical-Prediction Experiments, Year of Oceanic Precondition, and Coupled / Noncoupled Ocean Model with (SG) or without (NO) an oceanic sublayer scheme or Noise Patterns and its Areas

EXP.	YEAR	SG/NO/NOISE & Couple/Noncouple
SG05	2005	SG & Couple
NO05	2005	NO & Couple
NH05	2005	NO &Noncouple
NEA05	2005	NOISE (+0~0.1 overall the area)& Couple
NEB05	2005	NOISE(-0.05~0.05 overall the area) &
NEC05	2005	NOISE(-0.1~0 overall the area) & Couple
NED05	2005	NOISE(+0~0.1 where diurnal amplitude >
NEE05	2005	NOISE(-0.05~0.05 where diurnal
NEF05	2005	NOISE(-0.1~0 where diurnal amplitude >
SG99	1999	SG & Couple
NO99	1999	NO & Couple
NH99	1999	NO &Noncouple
NEA99	1999	NOISE (+0~0.1 overall the area)& Couple
NEB99	1999	NOISE(-0.05~0.05 overall the area) &
NEC99	1999	NOISE(-0.1~0 overall the area) & Couple
NED99	1999	NOISE(+0~0.1 where diurnal amplitude >
NEE99	1999	NOISE(-0.05~0.05 where diurnal
NEF99	1999	NOISE(-0.1~0 where diurnal amplitude >

Table 2 Diurnal Amplitude of Sea-Surface Temperature Calculated in the domain around 10-30°N, 120-160°E.

	0-24h (°C)	25-48h (°C)	49-72h (°C)
SG05	1.39	3.07	0.82
NO05	0.71	0.60	0.51
SG99	2.64	3.82	1.49
NO99	0.63	0.59	0.65

3. Results

Table 2 shows the amplitude of diurnally-varying SST every 24h. The amplitude of diurnally-varying SST is notable from 25h to 48h. Figure1 displays horizontal distributions of the amplitude of diurnally-varying SST from 25h to 48h when the amplitude is notable (Table2). The amplitude of diurnally-varying SST is close to zero around Hai-Tang and is relatively low along Hai-Tang's track. In contrast, the amplitude of diurnally-varying SST is relatively high where the area is far from Hai-Tang's track. The effect of new scheme for calculating the skin temperature is remarkable around the area. This indicates that new scheme hardly affect the calculation of sea-surface cooling induced by Hai-Tang.

Figure 2 depicts the time series of predicted central pressures listed in Table 1. All predicted central pressures are higher than best-track central pressures after 24h. A difference in predicted central pressures between Fig. 2a and Fig. 2b indicates that predicted central pressures are influenced by oceanic precondition, not diurnally-varying SST and random noises. There seems to be no difference between random noises overall the domain and over the limited domain where the amplitude of diurnally-varying SST is higher than 0.1˚C.

However, the impact of random noises overall the domain on central pressure prediction is less that 1 hPa from 6h to 24h (Fig.2c). The random noises around Hai-Tang's track directly affect central pressure prediction. Figure 2c indicates that we cannot distinguish the impacts of diurnally-varying SST on central pressure prediction from those of the random noises even though a difference between SG and NO becomes salient at certain integration times. The impact of diurnally-varying SST and the random noises far from Hai-Tang's track on central pressure prediction is significant after 24h in the present study.

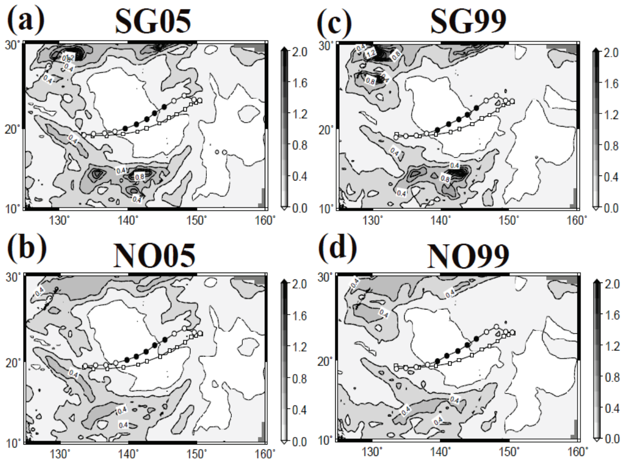

Fig.1 Horizontal distribution of the amplitude of diurnally-varying SST (˚C) from 25h to 48h in (a) SG05, (b) NO05, (c) SG99, and (d) NO99.

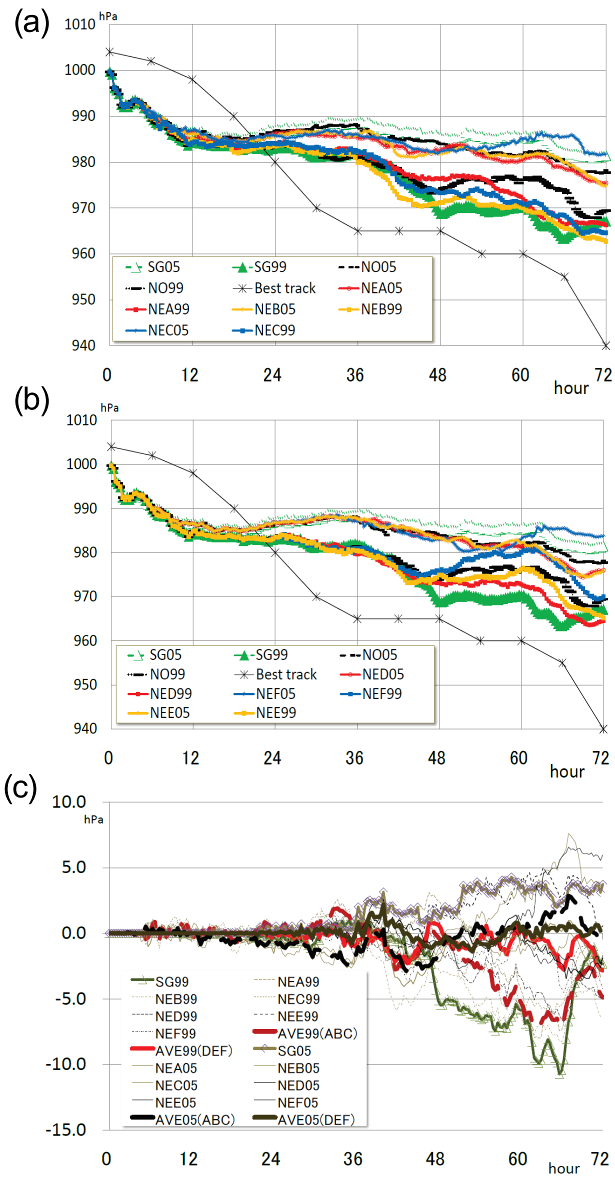

Fig.2 Time series of predicted central pressure in (a) experiments A, B, and C, (b) experiments D, E, and F, and (c) deviations from SG to NO and their averages.

References

Ohlmann, J.C., and D.A. Siegel, 2000: Ocean Radiant Heating. Part II: Parameterizing Solar Radiation Transmission through the Upper Ocean. J. Phys. Oceanogr., 30, 1849–1865.

Schiller, A., and J. S. Godfrey, 2005: A diagnostic model of the diurnal cycle of sea surface temperature for use in coupled ocean-atmosphere models, J. Geophys. Res., 110, C11014, doi:10.1029/2005JC002975.

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., and Y. Kawai, 2009a: The development of diurnally-varying sea-surface temperature scheme. Part I. Preliminary numerical experiments. CAS/JSC WGNE Research Activities in Atmosphere and Oceanic Modelling, 0907-0908.

Wada, A., and Y. Kawai, 2009a: The development of diurnally-varying sea-surface temperature scheme. Part II. Idealized numerical experiments.CAS/JSC WGNE Research Activities in Atmosphere and Oceanic Modelling, 0909-0910.

This work was supported by Japan Society for the Promotion of Science (JSPS), Grant-in-Aid for Scientific Research (C) (19612005).