Impacts of diurnally-varying sea-surface temperature on the predictions of Typhoon Hai-Tang in 2005. Part II. The impact on the thermodynamics field around Hai-Tang's center.

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1. Introduction

Wada et al. [2010] reported that the impacts of diurnally-varying sea-surface temperature (SST) on central pressure prediction could not be distinguished from those of the random noises in the case of the numerical prediction of Typhoon Hai-Tang in 2005 using the nonhydrostatic model (NHM) and the NHM coupled with a mixed-layer ocean model (NCM). However, the impacts of diurnally-varying SST might be significant on Hai-Tang's thermodynamics field such as the distribution of hourly precipitation even though the impact of diurnally-varying SST on central pressures and maximum wind speeds could be regarded as that of random noises. This paper investigates the impact of diurnally-varying SST on thermodynamics fields such as specific humidity within a radius of 300km, liquid water (specific cloud plus specific rain) within a radius of 300km from the surface to nearly 6.5km, and an hourly trend of temperature due to radiation within a radius of 300km from nearly 6.5km to nearly 14km, regarded as a warm-core temperature trend.

2. Methods

The specification of numerical experiments for Hai-Tang's predictions 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.

A series of numerical experiments is listed in Table 1. The experiment design was described in Wada et al. [2010]. On the basis of the results of Hai-Tang's predictions, we determine the horizontal area within a radius of 300km from Hai-Tang's center determined by minimum sea-surface pressure. The ranges of layers vertically averaged are from the lowermost layer to 32 (nearly 14km) in specific humidity, from the lowermost layer to 22 (nearly 6.5km) in liquid water, and from 22 to 32 in hourly trend of temperature due to radiation.

We investigate the average of the deviations from the central pressures in seven experiments (SG05, NEA05-NEF05) to the central pressures in NO05 and their standard deviations. If the average in SG05 ranges within the standard deviations, the impact of diurnally-varying SST on the intensity prediction is regarded as the impact of randoms noise on a weather-forecasting scale. Here we show the result of numerical experiments when the oceanic initial condition in 2005 is used.

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) & Couple
NEC05	2005	NOISE(-0.1~0 overall the area) & Couple
NED05	2005	NOISE(+0~0.1 where diurnal amplitude > 0.1)
NEE05	2005	NOISE(-0.05~0.05 where diurnal amplitude >
NEF05	2005	NOISE(-0.1~0 where diurnal amplitude > 0.1)

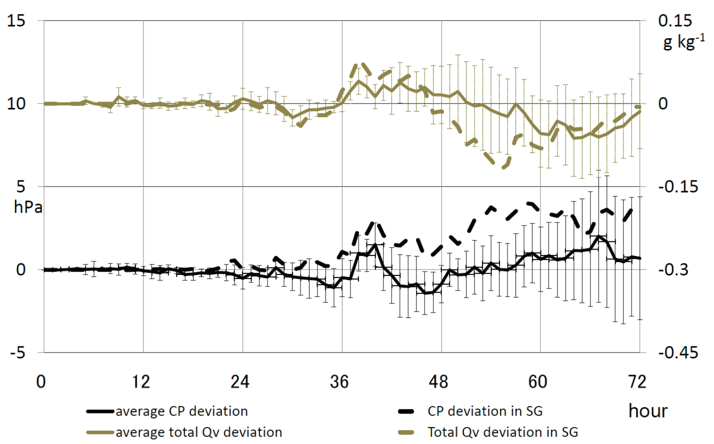

Fig.1 Solid lines indicate the averages of central pressure (black) and specific humidity (gray). Dashed lines indicate the results of central pressure (black) and specific humidity (gray) in SG05.

3. Results

Figure 1 depicts the evolution of the average of the deviations of central pressure and specific humidity from that in NO05 among seven numerical experiments except for NO05 and the evolution of the deviations of central pressure and specific humidity between SG05 and NO05. Central pressure in SG05 tends to be higher than that in NO05. However, the deviation excesses the standard deviation only from 36h to 60h when the amplitude of diurnally-varying SST is high [Wada et al., 2010]. During the period, the specific humidity in SG05 is higher than the average value around 38h and turns to be lower than the average value around 56h. After the change in the trend of specific humidity around 46h, the impact of diurnally-varying SST on central pressure prediction in SG05 becomes significant and continues until 62h.

Figure 2 depicts the evolution of the average of the deviations of central pressure and liquid water from that in NO05 among seven numerical experiments except for NO05 and the evolution of the deviations of central pressure and liquid water between SG05 and NO05. During the period, the liquid water in SG05 is significantly lower than the average value around 38h and turns to be higher than the average value from 42h to 56h. A decrease in liquid water precedes an increase in specific humidity.

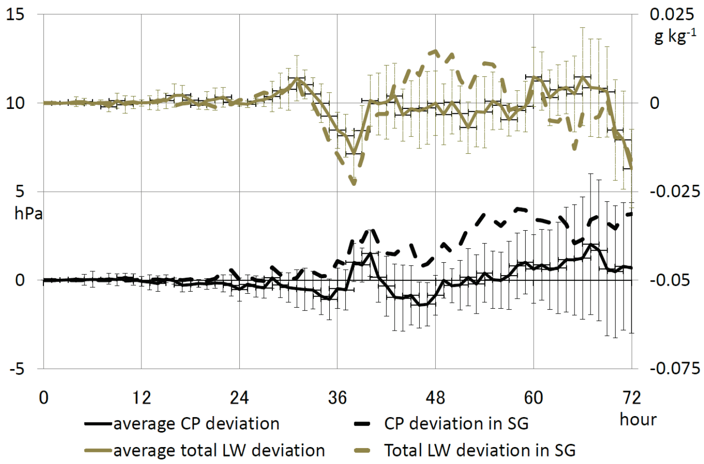

Fig.2 Solid lines indicate the averages of central pressure (black) and liquid water (gray). Dashed lines indicate the results of central pressure (black) and liquid water (gray) in SG05.

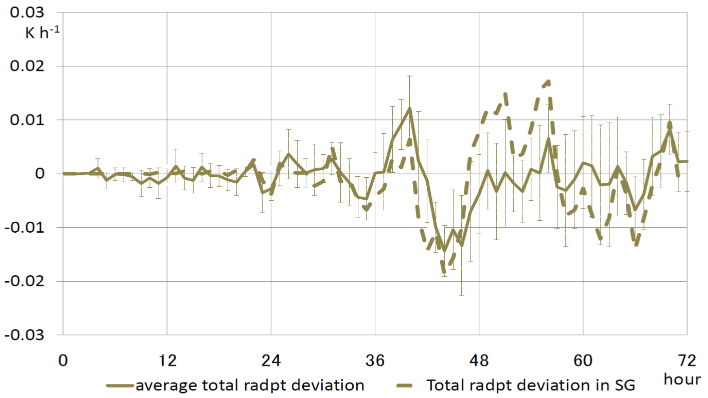

Fig.3 Solid lines indicate the averages of hourly trend of temperature due to radiation. Dashed lines indicate the results of hourly trend of temperature due to radiation in SG05.

Figure 3 depicts the evolution of the average of the deviation of hourly trend of temperature due to radiation from that in NO05 among seven numerical experiments except for NO05 and the evolution of the deviation of hourly trend of temperature due to radiation between SG05 and NO05. The deviations are significant after 36h when the deviations of specific humidity (Fig. 1) and liquid water (Fig. 2) become salient. However, the deviation exceeds the standard deviation only from 48h to 56h. This implies that the impact of diurnally-varying SST on warm-core temperature trend is only significant from 48h to 56h, probably because of a significantly increase in liquid water. The period from 48h to 56h corresponds to the period shortly after the amplitude of diurnally-varying SST is high (~3°C, see Table 2 in Wada et al. [2010]). Differently from the deviations of specific humidity and liquid waters, the amplitude of the deviation of hourly trend of temperature due to radiation between SG05 and NO05 varies on a shorter time scale, implying that the variation is affected not only by diurnally-varying SST but also by atmospheric radiation. This result indicates that the impact of diurnally-varying SST on Hai-Tang's prediction is non-lineally influenced by atmospheric thermodynamics.

4. Concluding remarks

From the sensitivity experiments, we conclude that the impact of diurnally-varying SST on the prediction of Typhoon Hai-Tang in 2005 cannot be distinguished from the impact of a noise for SST when the amplitude of diurnally-varying SST is smaller than 3°C. We need to explore the non-lineally atmospheric-oceanic processes after the impact of diurnally-varying SST on atmospheric ingredients exceeds the standard deviation.

References

Wada, A., Y. Kawai and N. Usui, 2010: Impacts of diurnally-varying sea-surface temperature on the predictions of Typhoon Hai-Tang in 2005. Part II. Intensity prediction. CAS/JSC WGNE Research Activities in Atmosphere and Oceanic Modelling, Submitted.

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