Sensitivity of tuning parameters in a mixed-layer scheme to simulated sea surface cooling caused by a passage of a typhoon

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1. Introduction

Tuning parameters in the mixed-layer scheme of Noh and Kim (1999) are usually selected to match each observation every numerical experiment. For example, a data assimilation system developed in Meteorological Research Institute/ Japan Meteorological Agency (e.g. Usui et al., 2006) has not used 'recommended values' of the parameters described in Noh and Kim (1999). If sea surface cooling (SSC) by a passage of a typhoon is affected by these tuning parameters, we need to know the sensitivity of tuning parameters to simulated SSC. Using an oceanic general circulation model, we investigated the sensitivity in the case of Typhoon Rex (1998).

2. Mixed-layer scheme and experiment design

We employed the Japan Meteorological Agency Meteorological Research Institute Community Ocean Model (MRI.COM: Ishikawa et. al., 2005) to simulate SSC caused by a passage of Rex. The MRI.COM includes a mixed-layer scheme developed by Noh and Kim (1999).

There are two arbitrary tuning parameters in Noh and Kim's mixed-layer scheme. One is a proportional coefficient associated with viscous and diffusion coefficients. The eddy viscosity K is modeled as

$$K = Sq\ell , \tag{1}$$

where q is the root mean square velocity of turbulence, ℓ is the length scale of turbulence, and S is a constant which is a function of a turbulent Richardson number defined by

$$R_{it} = \left(N\ell/q\right)^2 . \tag{2}$$

In Eq. (2), N is the Brunt-Väisälä frequency.

When the turbulent Richardson number R_{it} is relatively large, S is modeled as

$$S = S_0\left(1+\alpha R_{it}\right)^{-1/2} , \tag{3}$$

where S_0=0.39 is the value at a neutral stratification and α is one of tuning parameters.

The other tuning parameter is associated with a surface boundary condition that gives a turbulent kinetic energy (TKE) flux caused by breaking surface waves. The TKE flux may be given by

$$K_E \frac{\partial E}{\partial z} = mu_*^{\,3} , \tag{4}$$

where K_E is the eddy diffusivity, E is the mean TKE, and u_* is the frictional velocity. Here, m is one of tuning parameters.

The experiment design and atmospheric forcing has been already described in Wada et al., (2007) except that the diurnal cycle of solar radiation is taken into consideration. The pairs of tuning parameters used in the present study are shown in Table 1. The result in EXP1 was compared with the result in CNTL to investigate the sensitivity of m, while the results in EXP2 and EXP3 were compared with the result in EXP1 to investigate the sensitivity of α. The sea surface temperature (SST) observed by R/V Keifu Maru was used to evaluate the reproduction of SSC caused by a passage of Typhoon Rex (1998). The time series of SST calculated by the MRI.COM were compared with that of SST observed by R/V

Keifu Maru.

3. Results

The SST observed by R/V Keifu Maru gradually decreased accompanied with negligibly small diurnal-cycle variations, while the SSTs calculated by the MRI.COM showed more salient diurnal-cycle variations from 24 to 27 August in 1998 (Fig. 1). During the period, the sensitivity of tuning parameters to simulated SSTs was not clear among the four numerical experiments probably due to low wind speeds and small vertical turbulent mixing at the observational stationary point.

After 27 August, the SST observed by R/V Keifu Maru suddenly decreased by nearly 3°C by a passage of Rex (Fig. 1). The difference in calculated SSCs was salient from 28 to 29 August among the four numerical experiments. This reveals that calculated SSC largely depended on the value of two tuning parameters (Fig. 1). Weak surface-wave breaking (small m) and stable stratification (large α) more strongly suppressed the vertical eddy diffusion, resulting in weak SSC.

The dependency of SSC on tuning parameters is closely related to atmospheric forcing, which is necessary to run the ocean model. In the present numerical experiments, a Rankin vortex was merged into the atmospheric objective analysis dataset. Without a Rankin vortex, SSC could not be successfully calculated by the MRI.COM because wind speeds in the original atmospheric objective analysis dataset was considerably weak due to its coarse horizontal resolution. However, we show here that we need to pay attention to the values of tuning parameters even if a Rankin vortex or with a realistic wind field is introduced to atmospheric forcing.

Table 1 Experiment design of tuning parameters

experiments	α	m
CNTL	5	175
EXP1	5	100
EXP2	15	100
EXP3	2	100

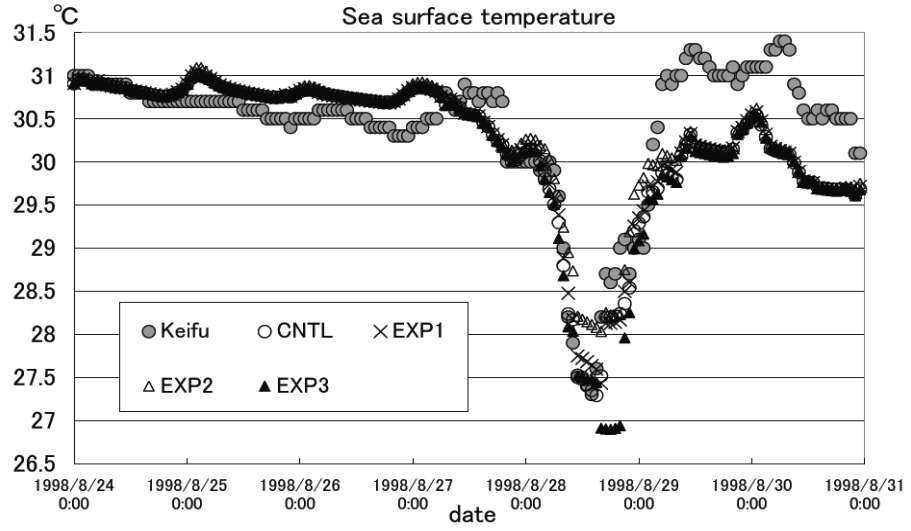

Figure 1 Time series of observed (Keifu) and simulated (CNTL, EXP1, EXP2, EXP3) sea surface temperature from 24th to 30th August in 1998 when Typhoon Rex passed around the observation area.

References

Ishikawa et al., (2005): Technical Reports of the Meteorological Research Institute, 47, 189pp. (in Japanese).
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