# The Development of Diurnally-Varying Sea-Surface Temperature Scheme. Part II. Idealized numerical experiments.

Akiyoshi Wada [1*] and Yoshimi Kawai [2]

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

2) Japan Agency for Marine-Earth Science and Technology, 2-15 Natsushima-Cho, Yokosuka, 237-0061, JAPAN.

*awada@mri-jma.go.jp

## 1. Introduction

We have developed a new scheme for precisely simulating a diurnally-varying sea-surface temperature (SST) (Wada and Kawai, 2009). In this paper, new scheme based on Schiller and Godfrey (2005) (hereafter referred to as SG) is incorporated into a nonhydrostatic atmosphere model coupled with a slab mixed-layer ocean model (hereafter NCM). In order to investigate the impact of diurnally-varying SST on the atmosphere, idealized numerical experiments were performed by the NCM.

## 2. Experiment Design

In order to perform the numerical experiments by the NCM, atmospheric and oceanic initial conditions are required. The atmospheric initial condition is provided from the Japan Meteorological Agency Regional Analysis data. The atmospheric profile is assumed to be uniform with the reference to the profile around 139°E, 29.5°N at 0000 UTC (0900 JST) on 27 June in 2004. The initial sea temperatures are 28˚C at the sea surface (SST), 27˚C at the mixed-layer base, 15 ˚C at the thermocline base and 5˚C at the bottom level. Salinity is assumed to be homogeneously 35. Layer thicknesses are 5 m in the mixed layer, 45 m in the thermocline, 450 m in the lowermost layer. The Coriolis parameter is $5 \times 10^{-5}$.

The integration time is 288 hours. During the integration from the initial time to 48h, the numerical experiments were performed by the nonhydrostatic atmosphere model (NHM). After 48 hours, the numerical experiments were performed by the NHM and the NCM. The time step is 10 seconds. The horizontal-grid number is 32 x 32 with the grid spacing of 2 km. The number of vertical layer is 40. The interval of vertical layers is changed from 40 m (near the surface) to 1180m (upper atmosphere). The top height is nearly 23 km.

In SG, solar radiation, cloud index and wind stress are provided by the NCM. The value of chlorophyll concentration is assumed to be 0.1 and 1 mg·$m^{-3}$ and has not been changed during the integration. The depth of uppermost layer (hereafter referred to as dz) is set to be 5 m, which is equal to the mixed-layer depth at the initial time in NCM. In order to investigate the impact of solar radiation on the skin-depth (hereafter zDt) and the amplitude of computed SST, sensitivity experiments are preformed: Solar radiation (Wind stress) is 1.5 (0.75) times larger than that of control experiments (CNTL). The specification and abbreviation of numerical experiments are listed in Table 1.

Table 1 Specification of numerical experiments

| | Atmospheric forcing |
|---|---|
| CNTL | From regional analysis data |
| SR15 | Solar radiation is 1.5 times only in SG. |
| WD075 | Wind stress is 0.75 times only in SG |
| SRWD | Solar radiation is 1.5 times and Wind stress is 0.75 times only in SG |

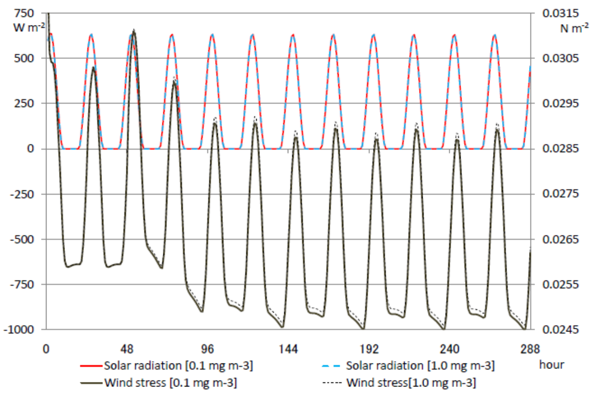


Figure 1 Time series of solar radiation and wind stress in CNTL (0.1 mg $m^{-3}$) and CNTL (1.0 mg $m^{-3}$). Each figure enclosed within parentheses indicates a chlorophyll concentration.

## 3. Results

### 3.1 Short-wave radiation and wind stress

Figure 1 depicts the time series of solar radiation and wind stress in CNTL (0.1 mg $m^{-3}$) and CNTL (1.0 mg $m^{-3}$). Solar radiation varies diurnally, while computed wind stress varies with a period of two days. The computed wind stress is reduced after NCM begins to run. A difference in solar radiation is not seen between CNTL (0.1 mg $m^{-3}$) and CNTL (1.0 mg $m^{-3}$). On the other hand, a difference in wind stress can be seen when solar radiation is nearly zero in a day.

### 3.2 Depth of skin layer and simulated SST

Figure 2 depicts the time series of zDt and SST in CNTL (0.1 mg $m^{-3}$) and CNTL (1.0 mg $m^{-3}$). After the sunrise (around 0100-0200 UTC), zDt becomes small but turns to the value of dz. This recovery of zDt is probably due to relatively small solar radiation and strong wind stress. This is the reason why a difference in zDt is not seen between CNTL (0.1 mg $m^{-3}$) and CNTL (1.0 mg $m^{-3}$). A difference in SST between CNTL (0.1 mg $m^{-3}$) and CNTL (1.0 mg $m^{-3}$) is at most 0.1 $^{o}$C. The amplitude of diurnally-varying SST is large when a chlorophyll concentration is high.

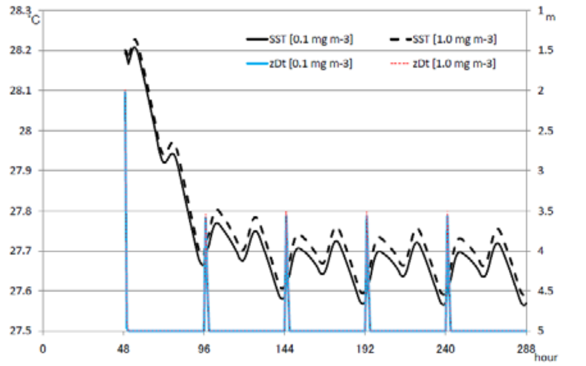


Figure 2 Time series of zDt and SST in CNTL (0.1 mg $m^{-3}$) and CNTL (1.0 mg $m^{-3}$). Each figure enclosed within parentheses is the same as figure 1

### 3.3 The impact of solar radiation

Figure 3a depicts the time series of SST and zDt in CNTL, SR15, WD075 and SRWD when the chlorophyll concentration is 0.1 mg $m^{-3}$. A difference in SST is not seen except for the SRWD. The period of shallow zDt is only three-four hours in WD075 and only 1-hour in CNTL. The period of shallow zDt in SRWD is longest in four experiments. This suggests that this scheme is sensitive only to extremely high solar radiation and extremely weak wind stress, or both conditions are needed to compute apparent peak of diurnally-varying SST. Figure 3b depicts the time series of wind stress at the lowermost, first layer. When zDt becomes shallow and SST within the depth of zDt increases, wind stress is slightly stronger. In addition, wind stress is stronger during the night even though zDt is 5 m. This suggests that a peak of SST leads to the enhancement of wind stress during the night. It should be noted that a 2-day period is seen in the evolution of wind stress. Enhanced wind stress suppresses the amplitude of diurnally-varying SST in turn and then weakens the wind stress in the next day.

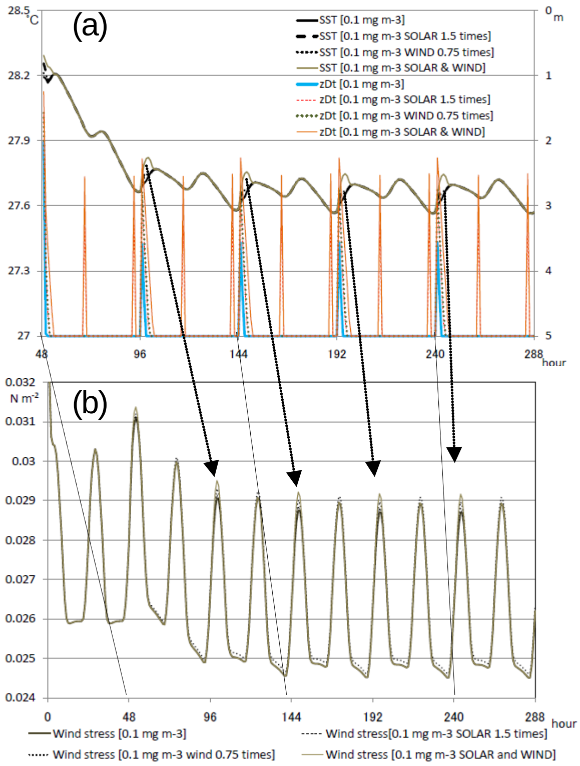


Figure 3 (a) As Fig. 1 except for CNTL (0.1 mg $m^{-3}$), SR15 (0.1 mg $m^{-3}$) and WD075 (0.1 mg $m^{-3}$). (b) As Fig. 2 except for CNTL (0.1 mg $m^{-3}$), SR15 (0.1 mg $m^{-3}$) and WD075 (0.1 mg $m^{-3}$).

### References


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

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.



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