IMPROVEMENT OF SST PREDICTION BY DIUNAL CYCLING ALGORITHM IN THE MRI MIXED LAYER OCEAN MODEL

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1. Introduction

Recently, many researchers have recognized the importance of the sea surface temperature (SST) particularly local SST cooling for intensities of tropical cyclones (TCs), and have studied the relationship between the SST and the intensities of TCs by various methods. It is necessary to estimate the SST more accurate in order to improve forecasts of intensities of TCs. A SST is usually determined by sea surface heat fluxes, horizontal and vertical advection, and entrainment process and so on. With regard to sea surface heat fluxes, solar insolation is considered to be the most important among surface heat fluxes to determine the SST because solar heating warms and stabilizes the upper ocean at midday. However, the contribution of sea surface heat fluxes for the SST variation will be underestimated in a mixed layer ocean model owing to its deep mixed layer if we simply formulate the net heat flux as the sum of sensible, latent, long-wave and short-wave radiative heat fluxes. Solar insolation is absorbed in the water column at most O (10m), while the heat loss calculated by sensible, latent, and long-wave radiative heat fluxes is presumed to leave directly from only sea surface. Here, the algorithm of Price et al. (1986) (diurnal cycling algorithm) is partly applied within the mixed layer in the Meteorological Research Institute (MRI) mixed layer ocean model. We state the detail of this MRI mixed layer ocean model (updated MRI mixed layer ocean model), and then we indicate the model performance for maritime observation data obtained by Keifu-Maru, which is the research vessel and belongs to Japan Meteorological Agency, through the cruise on August 1998. After some inspections including this paper, we will plan to apply this model to Typhoon-ocean coupled model.

2 Numerical models

The construction of the MRI mixed layer ocean model is referred to Wada (2002). Beyond this, we include the processes of horizontal viscosity for ocean currents and diurnal cycling algorithm in the MRI mixed layer ocean model. As for the diurnal cycling algorithm, we set to 1m as the vertical grid resolution within the mixed layer (30m). At a top layer, a SST is affected by net heat flux (sensible, latent, and long-wave radiative heat fluxes) and solar insolation. Absorption or transmission rates of solar insolation depend on the depth and are estimated by formulas of Price et al. (1986). Except the top layer, only solar insolation affects the SST within the mixed layer at midday. If the density inversion occurs at each layer within the mixed layer, the layer is stirred and stabilized. At last, the SST in the updated MRI mixed layer ocean model is determined as an average of second and third layer (equivalent to 2.5m depth). After this diurnal cycling algorithm is completed, the advection term and the entrainment term in thermodynamics equations are estimated. Absorption rates at the top layer are also used to estimate the part of natural convection by entrainment.

3. The numerical experiment in case of the field observation

We conducted a numerical experiment in order to inspect the performance of the diurnal cycling algorithm. The CTD data acquired by Keifu-Maru on August 23 around 130° E, 20° N were used to determine the oceanic vertical profiles of sea temperature and salinity, which are assumed to be horizontally constant, however the SST was determined by maritime data. We also used maritime data (air temperatures and winds) by Keifu-Maru as the atmospheric initial and boundary conditions from August 23, 1998 to August 26, 1998. Maritime data by Keifu-Maru were obtained every 10 minutes except the total cloud cover in tenths by visual observation in every three hours. The time step of the MRI mixed layer ocean model was set to 20 minutes so that atmospheric boundary conditions changed in every time step. The long-wave radiative flux and solar insolation were respectively determined by bulk formulas included the total cloud cover. According to Figure 1, the SST variation in the updated MRI mixed layer ocean model is similar to that of the SST observed by Keifu-Maru. During the periods of the experiment, diurnal cycling appeared from August 25, 1998 to August 26, 1998 and this period agreed with the time when the total cloud cover was less. In addition, the decreasing slope of predicted SST in the updated MRI mixed layer ocean model was suitable for that of observed SST during the nighttime particularly when the wind speed was over 10m/s.

4.The numerical experiment in case of moving typhoon (Typhoon Rex in 1998).

We inspected the model performance by applying the case of Typhoon Rex shown by Wada (2002). Wada (2002) realized a local 3℃ cooling of SST by passage of Typhoon Rex using the MRI mixed layer ocean model, however SST cooling tended to be underestimated with the model. The underestimation of SST cooling seemed to be caused by errors of bulk coefficients. In this report, the SST cooling by passage of Typhoon Rex is better expressed with the updated mixed layer ocean model (Figure 2). The prominent results shown in Figure 2 are the following:

1) A gentle decrease of SST is well simulated from August 24, 1998 to August 27, 1998.

2) The amount of the maximum SST cooling is well simulated under the same modification of bulk coefficients as introduced to Wada (2002).

It is convinced that the variance of SST is better simulated by diurnal cycling algorithm, however model-computed SST seems to be lower than SST observed by Keifu-Maru at a region of the Kuroshio after August 29, 1998, which is one of the future problem in developing the mixed layer ocean model.

References

Price, J. F., and Weller, R. A. 1986: Diurnal Cycling: Observations and models of the upper ocean response to diurnal heating, cooling, and wind mixing. J. Geophys. Res., 91, 8411-8427.

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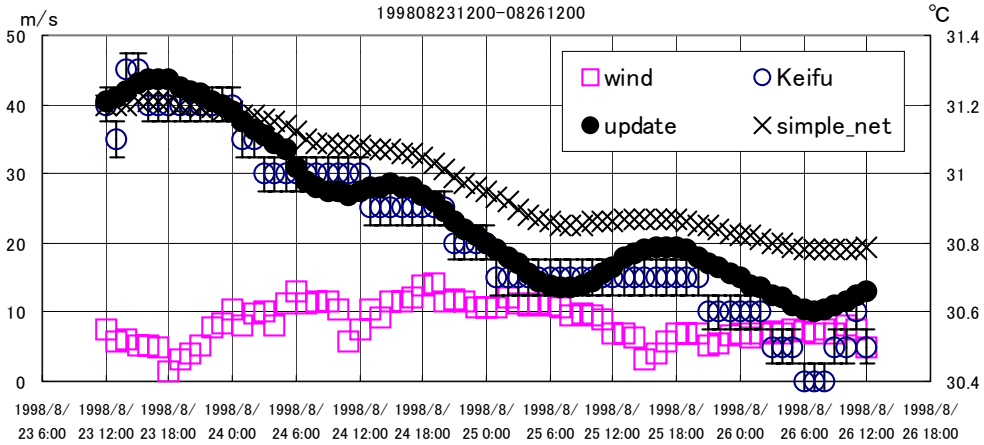

Figure 1 Time series of the observational SST by R/V Keifu-Maru, the SST by simply surface net flux, and the SST by updated mixed layer ocean model from August 23, 1998 to August 26, 1998.

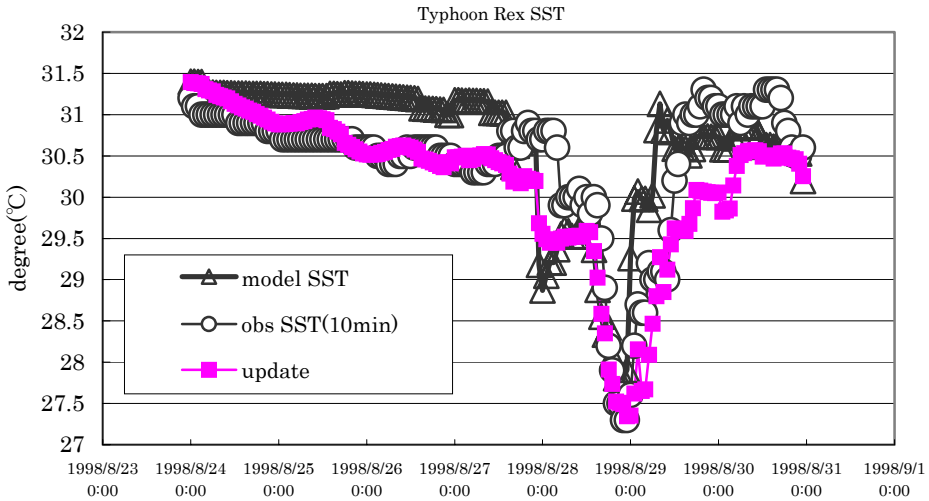

Figure 2 Time series of the observational SST by R/V Keifu-Maru, the SST by Wada (2002), and the SST by updated mixed layer ocean model. from August 24, 1998 to August 31, 1998.