DYNAMIC FEATURES AND FOMATION MECHANISM OF THE UPPER MIXED LAYER IN THE SOUTH CHINA SEA DURING 1998 SUMMER MONSOON ONSET

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1. INTRODUCTION

Because there is only few observations with long time at a point, the variation feature and mechanism of the upper mixed layer with longer time in the South China Sea (SCS) hardly been studied. In the IOP of the South China Sea Monsoon Experiment (SCSMEX), the cruise of KEXUE #1 located at $6^0$15'N,110^0E during 6~25th May and 6~20th June 1998. The cruise of SHIYAN #3 located at 20° N，116°E during 8~21 may and 4~23th. The observation data included: surface meteorology variables (SST, air temperature, pressure, humidity, wind, solar radiation, downward longwave radiation) taken every 30s, every 1 m mean temperature and salinity taken by CTD every 3 hours et al.

The variation of the SST may results from variability of the surface heat flux, horizontal currents, vertical motions and the mixing process.

The dynamic features of the upper mixed layer will be described in section 2. In section 3 the one dimensional turbulence kinetic (TKE) model will used to simulate and to do some experiment to discuss formation mechanism of the mixed layer in the SCS.

2. DYNAMIC FEATURE OF THE UPPER MIXED LAYER

Based on the Monin Obukhov similarity theory and codes made by Launiainen and T. Vihma (1990), the flux between air and sea is calculated.

Based on data observed during South China Sea Monsoon Experiment (SCSMEX), the depth of upper mixed layer, the upper boundary of thermocline and the thickness of the barrier layer were discussed. The thermal and dynamical features of the mixed layer and its relation with the onset of the summer monsoon of the South China Sea (SCS) were also analyzed. It is found that the variations of temperature and depth of the mixed layer could be divided into three sub-periods on both observation point during the onset period of 1998 summer monsoon:

In the north observation point (20^0N, 116^0E), before the onset of the southwest monsoon the wind is weak and the sun radiation is strong, mixed layer temperature is higher (28^0C or more) and mixed layer depth is shallow (about 10m). During the onset of the southwest monsoon, the wind is strong, the radiation from the sun is weak, the temperature of the mixed layer is low (28^0C or less), and the depth of the mixed layer is increased to 20m. After the onset of the southwest monsoon, the depth of the mixed layer is decreases to 10m, and the temperature reverted to the value of 28^0C or more.

Besides, the depth of the mixed layer in the south observation point ($6^0$15'N, 110^0E) is twice as deep as in the north point of the SCS. Its average value is 27.3m, the temperature of the mixed layer is 29^0C or more all the time; Before the onset of the southwest monsoon, the temperature of the mixed layer is low(29^0C or so), and the depth increased gradually by the forcing of stronger Northeast or Northwest wind; during the onset period of the southwest monsoon, the temperature of the mixed layer increased to reach 31^0C, and the depth of the mixed layer reduced to 10m or less; After the onset of the southwest monsoon, the depth of the mixed layer increased to 40m, the temperature reduced to 30^oC. During summer monsoon onset the thermal and dynamical features of the mixed layer were different between the North and South of the SCS

3. NUMERICAL SIMULATION AND EXPERIMENTS

The one dimensional turbulence kinetic (TKE) model is used to simulate and do some experiments on the SST and the upper mixed layer in the South China Sea (SCS), and to discuss the formation mechanism of the SST and the mixed layer by the examinations.

The results show that: the TKE model can simulate the main features of the time variable of the SST and mixed layer depth in the north of the SCS (Fig.1a,b Fig.2a,b). In May and June, the daily oscillation of the SST is mainly determined by daily variation of the sun short-wave radiation, which maintains the SST mainly and it can make the SST increases 1~4^oC ; The mixed effect of the wind restrains the daily oscillation of the SST. To comparison with sun short-wave radiation and the wind stress, the latent heat and sensible heat flux are a minor factor to control the variable of the SST in spring. In May, both the wind stress and sun short-wave radiation control the depth of upper mixed layer, and the effect of the wind stress can make the mixed layer grow on 5~10m, the short-wave radiation can make the mixed layer to shallow 5~10m. But in June, the sun short-wave radiation is smaller after summer monsoon onset, the short-wave radiation can only make the mixed layer to shallow 1~2m, and the latent heat and sensible heat flux make the mixed layer depth become more intensify about 1~2m, the depth of mixed layer is controlled mainly by wind stress

In the South of the SCS, the TKE model can also simulate the main features of the time variation of the SST and mixed layer depth except in the middle period of May(Fig.3a, Fig4a,b). In May and June, the diurnal oscillation of the SST is mainly determined by diurnal variation of the solar short-wave radiation, and the mixing effect of the wind restrains the diurnal oscillation of the SST in the South of the SCS. Compared with solar short-wave radiation and the wind stress, the latent heat and sensible heat fluxes are a minor factor in controlling the variation of the SST and the mixed layer during summer monsoon onset in the SCS. Solar short wave radiation is the main heat source to maintain the SST. In spring, the effect of short-wave radiation

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could make the SST in the south of the SCS to increase 4^0C or less; and latent heat and sensible heat flux could make the SST to decrease in 3^0C. The wind controls the depth of the upper mixed layer, and its effect could make the mixed layer depth grows on 20~30m; The short-wave radiation could make the mixed layer depth to shallow 2~3m and the latent heat and sensible heat flux make the mixed layer to become more depth about 2~3m. In the south of the SCS the effect of heat flux on the mixed layer depth is smaller than the effect of wind in spring.

4. DISCUSSION

We have used the newly observation data in IOP of the SCSMEX in 1998 spring to study the mixed layer in the South China Sea and have studied the dynamic feature of the SST and mixed layer depth during summer monsoon onset. We fund the TKE model can describe the response of the upper mixed layer to flux between air and sea, but the high frequency oscillation of the mixed layer depth by internal tide or internal wave can not been simulation in the one dimension TKE model. In the two observation points the high frequency oscillation of the mixed layer depth is very markedly. Then the effect of internal tide or internal wave on the mixed layer need be study in future.

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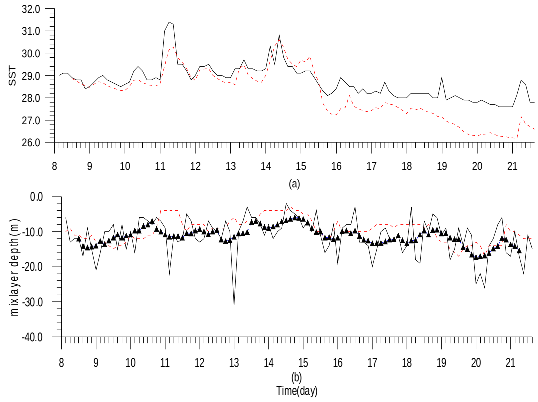

Fig. 1 The SST (a) and depths of mixed layer In May at the North point (20° N , 116°E), the solid line is obseavation data and the dashed line is simulation data.

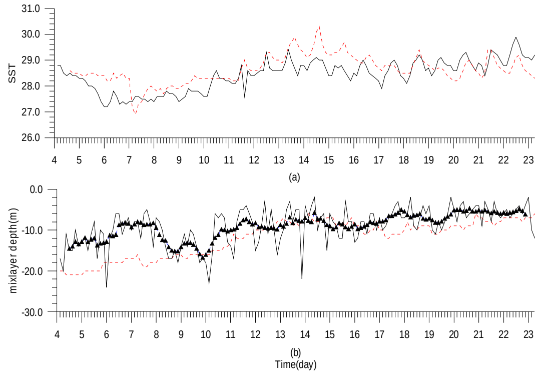

Fig. 2. The SST (a) and depths of mixed layer In June at the North point (20° N , 116°E), the solid line is obseavation data and the dashed line is simulation data.

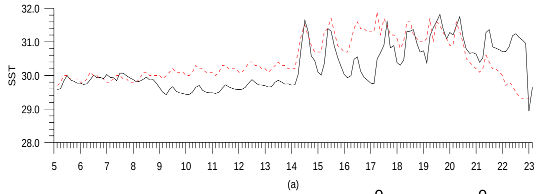

Fig.3. As Fig1(a), except at point ($6^0$15'N,110^0E)

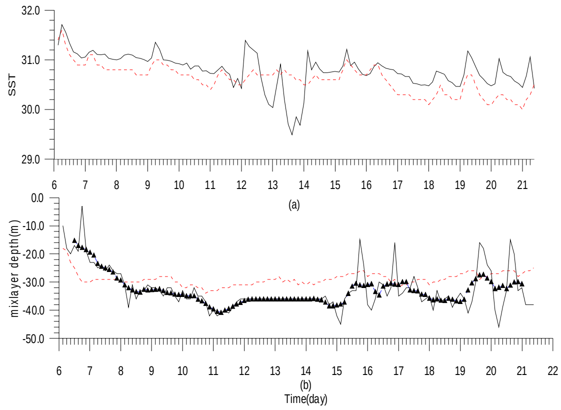

Fig. 4 As Fig.2 , except at point ($6^0$15'N,110^0E). during 12^{th}-15^{th} there is not observation data of mixed layer.