A Numerical Model Study Of The Deep Circulation In The South China Sea

Ching-sheng Chern, Joe Wang and Mei-Ying Lin
Institute of Oceanography, National Taiwan University, Taipei, Taiwan, R.O.C.

Abstract

The South China Sea (SCS) is a fairly enclosed basin with the Luzon Strait as the only deep channel connecting to the Pacific ocean. Field observations at the entrance of the Bashi Channel to the Luzon Strait indicated that there is a persistent southwestward flow of the western Philippine Sea deep water into the northern SCS. We regard this inflow as a major source for the upwelled water in the SCS and use a three-dimensional primitive equation model to simulate the flow and the associated upwelling in the lower portion of the SCS. The model predicts that the deep circulation in the SCS forms a cyclonic pattern and there is an anticyclonic circulation at the northwestern portion of the SCS in the surface layer.

1 Introduction

The South China Sea (SCS) is a fairly closed basin with Luzon strait as the only deep channel connecting to the open ocean. Previous hydrographic observations in the SCS indicated that the water properties in the SCS are quite different from that of the Kuroshio water to the east of the Luzon strait (Wang and Chern, 1996). The SCS water is characterized by the presence of a very shallow mixed layer and a strong thermocline. A possible cause for this difference may be due to the mixing between the surface water and the strongly upwelled lower layer water in the SCS. Therefore there must be a steady source of deep water flowing into the SCS to maintain a mass balance.

Figure 1 shows a stick diagram of the current observed near bottom in the Luzon strait. It clearly depicts that there is a steady southwestward flow with a mean strength about 15 cm/s and temperature around 2 C over the whole year. Since the observation site is in the only passage for the exchange of deep water between the SCS and western Philippine Sea. This flow may be regarded as the main source for the upwelling water in the SCS. In this paper, we adopt a three-dimensional primitive equation model to simulate the flow in the SCS driven by the inflow of deep water in the Luzon strait.

2 Numerical model

Our model domain covers a region between 108-122 E and 3-23 N. The horizontal

resolution is 20 km. There are 18 layers in the vertical direction with a maximum model basin depth 4000 m. Initially, there is no motion in the model basin and the temperature is horizontal homogeneous, its vertical profile is derived from the averaged value of Levitus (1982). The salinity is constant during the numerical computation, chosen to be 35 psu.

The cold deep water flows into the model basin through a channel of 20 km wide at depth between 1500 m and 2500 m near the northern open boundary. The velocity of the inflow is 15 cm/s. Hence there is a total 3 Sv deep water flowing into the SCS. In order to maintain a mass balance, we withdraw 3 Sv water from the upper 1000 m from the northern open boundary to the east of Taiwan. Since the inflow deep water has a temperature much less than the surface water flowing out the model domain. We impose a constant surface temperature, 27.4 C, to provide a downward heat flux to balance the heat loss associated with the upwelling. We integrate the model 1600 days. Although the temperature field still has weak variations, the flow pattern reaches a quasi-steady state.

3. Model Results

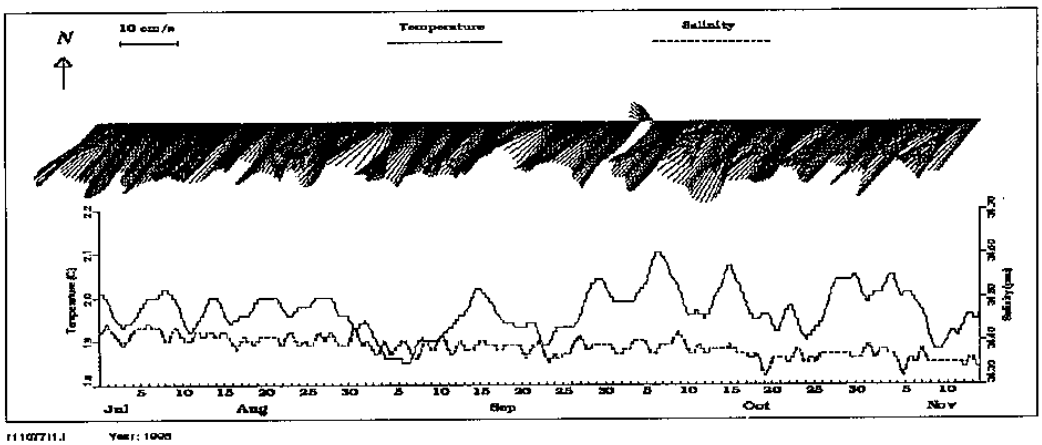
Figure 2 depicts the velocity distribution at depth 2000 m. It is clear that most of the inflow water follows the continental slope of the northwestern SCS and forms a cyclonic pattern. And a portion of the inflow water follows the western coast of Luzon and then flows westward to join the southward flowing water along the western bank of the deep basin. Figure 3 depicts the velocity at 37 m and surface elevation distribution. There is an anti-cyclonic circulation at the northwestern part of the SCS and the velocity in the deep water region is generally weak. Chao and Shaw (1996) also studied the deep circulation in the SCS. They found that the deep circulation in the SCS depends on the surface forcing and has strong seasonal variation. The permanent deep upwelling in their model only occurs at the southwestern offshore of Taiwan. However the inflow of the deep water into the SCS has no apparent seasonal change, Fig.1. Therefore the flow pattern shown in Fig. 2 should be a steady feature and the associated upwelling also occurs in the deep region in the southern SCS. Whether this deep flow will be affected by the surface monsoon winds needs further study.

4. References

Chao, S.Y., P.T. Shaw and S.Y. Wu (1996) Deep water ventilation in the South China Sea. Deep Sea Res., 43, 4, 445-466.

Levitus (1982) Climatological atlas of the world ocean. NOAA Professional paper No. 13, 173pp.

Wang, J. and C.S. Chern (1996) Some aspects on the circulation in the northern South China Sea. La mer, 34, 3, 246-257.



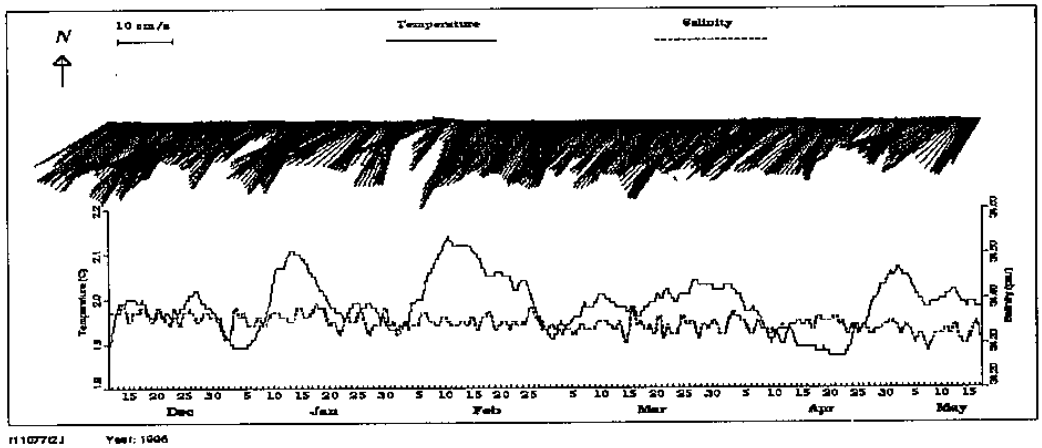


Fig. 1 Deep current observation in the Luzon Strait during July 1995-May 1996

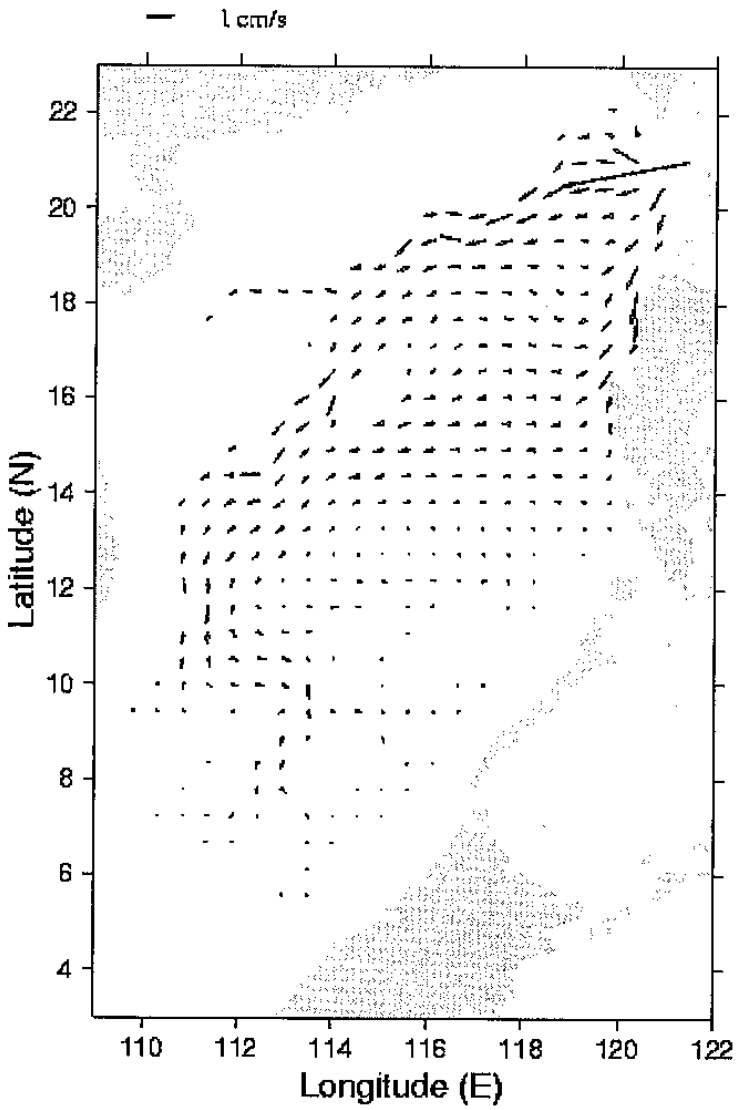


Fig. 2 The velocity distribution at 2000 m on day 1600

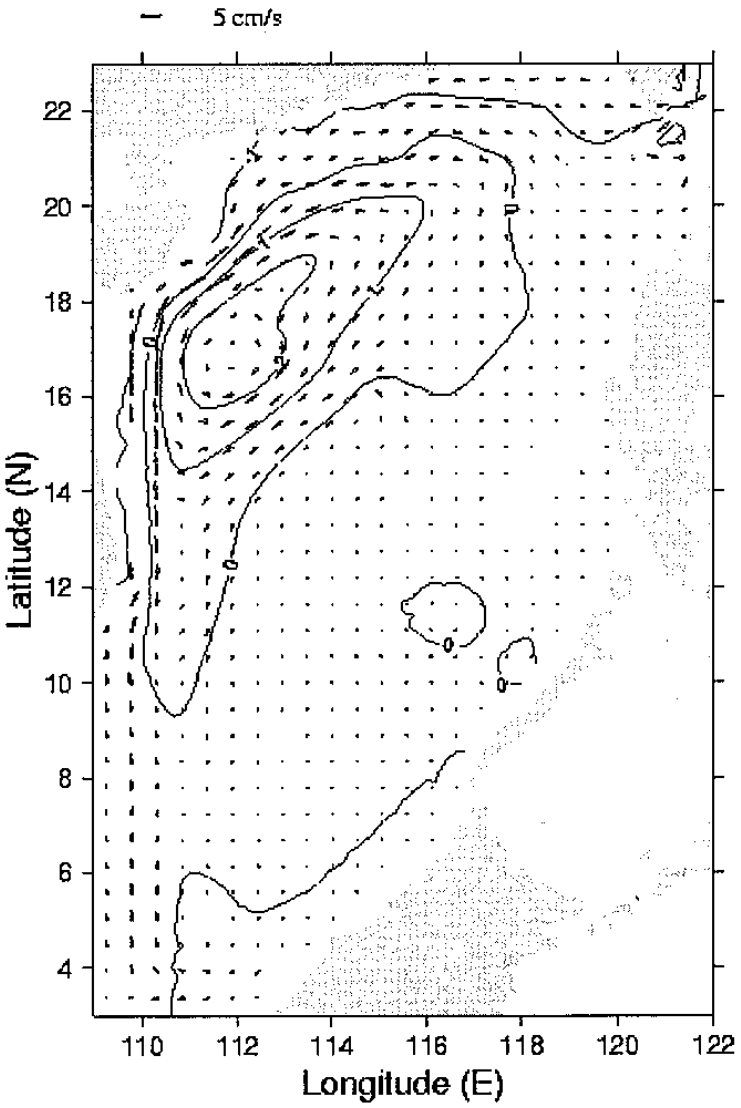


Fig. 3 The distribution of velocity at 50 m and surface elevation (in cm) on day 1600.