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Impact of the El Nino on the Variability of the Antarctic Sea Ice Extent

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Abstract In this paper, the spreading way in the southern hemisphere that anomalous warm water piled in tropical eastern Pacific is analysed and then impact of El Nino on the variability of the Antarctic sea ice extent is investigated by using a dataset from 1970 to 2002. The analysis result show that in El Nino event the anomalous warm water piled in tropical eastern Pacific is poleward propagation yet the westward propagation along southern equator current hasn't been discovered. The poleward propagation time of the anomalous warm water is about 1 year or so. El Nino event has a close relationship with the sea ice extent in the Amundsen sea, Bellingshausen sea and Antarctic peninsula. After El Nino appears, there is a lag of two years that the sea ice in the Amundsen sea, Bellingshausea sea, especially in the Antarctic peninsula decreases obviously. The processes that El Nino has influence with Antarctic sea ice extent is the warm water piled in tropical eastern Pacific poleward propagation along off the coast of southern America and cause the anomalous temperature raise in near pole and then lead the sea ice in Amundsen sea, Bellingshausen sea and Antarctic peninsula to decrease where the obvious decrease of the sea ice since 80' decade has close relation to the frequently appearance of El Nino.

Key words El Nino, equator Pacific, anomalous temperature, Antarctic sea ice extent.

1 Introduction

Many meteorologists and oceanographers paid much attention to the study of the mechanism of ENSO for many years, such as Bjerknes(1966), Wyrtki(1975), McCreary(1983), Philander(1984), Zhang and Chao(1993) and McCPhaden(1998) have made great development in the study of ENSO. Especially in the 1990's, with the increasing of the data in the deep ocean, the someone argued that the ENSO episode had close relation-

ship with the eastern transportation of the anomalous sea surface temperature in the west Pacific(Li and Mu 1999; Huang 2000) , which has been known by the meteorologists and oceanographers. By studying the relationship between the anomalous temperature field in the west Pacific especially in the warm pool and the ENSO episode, the author has suggested that there is an the important mechanism that the anomalous sea temperature of North Equatorial Current transport westward to lead to the anomalous sea temperature variation in the west Pacific (Chen *et al*. 2002a; Chen *et al*. 2002b) . The anomalous sea temperature of North Equatorial Current transporting westward and the anomalous sea temperature of the warm pool in the west Pacific transporting eastward format a circle way of the anomalous sea temperature signal(Chen *et al*. 2003) . The position of circle lies in the Equatorial Current and the North Equatorial Current, however the signal in the South Equatorial is not obvious.

In order to explain such phenomena further and give evidence that there is not the obvious process of the western transportation in the South Equatorial Current. The article study the anomalous warm water in the east Pacific of Equatorial area during the episode of El Nino and try to find out the transporting characteristic of the warm water in the south hemisphere during the episode of El Nino. In the same time, the article study the relationship between the episode of El Nino and the Antarctic ice and try to find out the relation between them.

2 Data

The indexes of the NINO and Southern Oscillation are gained from the National Centers for Climate Prediction(Climate Prediction Center 2002) , the data of Antarctic sea ice gained from the Antarctic Bureau of Australia(Jacka 2002) . The sea temperature data of the Pacific (0-360°E; 60°S-60°N) obtained from the Meteorology Department of University of Maryland USA(Carton 2002) .

3 The Transportation of the Anomalous Warm Water in the East Pacifc

By analyzing the episode of El Nino and La Nina happened from the 1980' s till now, Chen Jinnian etc. have point out that when the episode of El Nino happened, the anomalous warm water piling on the sub-surface ocean in the east Pacific would transport to the warm pool of the west Pacific along the North Equatorial Current, which supplies energy for the next episode of El Nino. Also, when the episode of La Nina happens, the anomalous cold water piling on the sub-surface ocean of the east Pacific would transport the warm pool of the west Pacific along the North Equatorial Current, which supplies energy

for the next episode of La Nina. However, it should be paid attention to that the warm and cold water of the east Pacific in the equatorial area do not transport westward obviously in the south hemisphere.

In order to analyze such phenomena further, we study the transporting passway of the anomalous sea temperature in the south hemisphere during the episode of El Nino. Fig 1 and Fig 2 respectively are the transporting process of the anomalous warm water in the East Pacific of the Equatorial area during the 1982-1983 and 1986-1987 episode of El Nino. The figures show clearly that with the development of the episode of El Nino the anomalous warm water area of the East Pacific in the Equatorial area becomes wider and wider, and the anomalous warm water enlarge to the coast of Peru, and then it transport toward the Antarctic along the coast of Chlie. The process of the transportation last almost one year, and it could transport to 60°S of the South Ocean.

Above result shows that the anomalous warm water which piles in the east Pacific during the El Nino transports by two way: the first, it transports westward along the North Equatorial Current; the second, it transports towards the Antarctic along the coast of Peru and Chlie. the result also showed an evidence , that there is not anomalous sea temperature transporting westward in the South Equatorial Current.

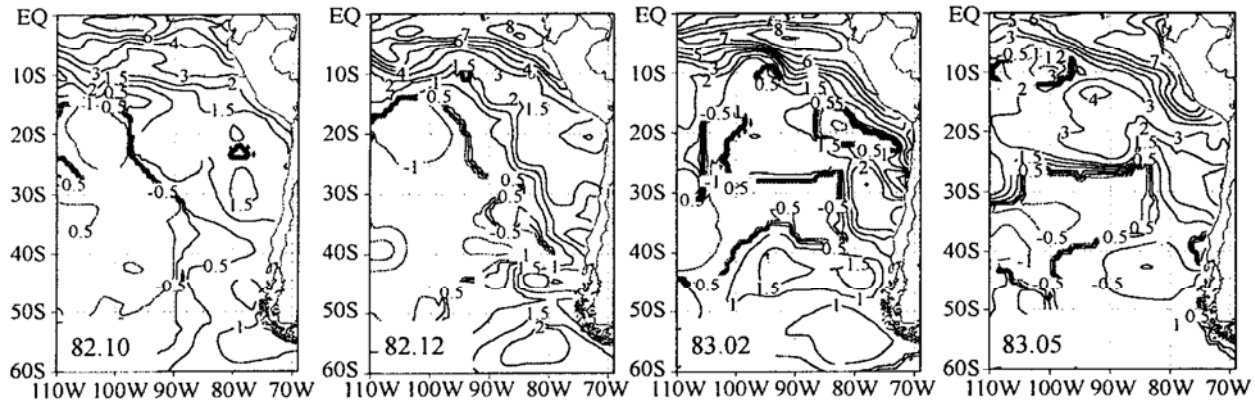

Fig. 1. The propagate way of the anomalous warm water in the Equatorial East Pacific during 1982-1983.

4 The Episode of El Nino and the Variation of the Antarctic Sea Ice

The analysis result from above shows that the anomalous warm water piling on the Equatorial East Pacific transport towards the Antarctic along the coast of Peru and Chlie during the El Nino. The transporting process has an effect on the field of the sea temperature of the South Ocean and the Antarctic sea ice. Therefore, we analyze the correlation

between the indexes of NINO and the Antarctic sea ice and try to find out the affect on the variation of the Antarctic ice.

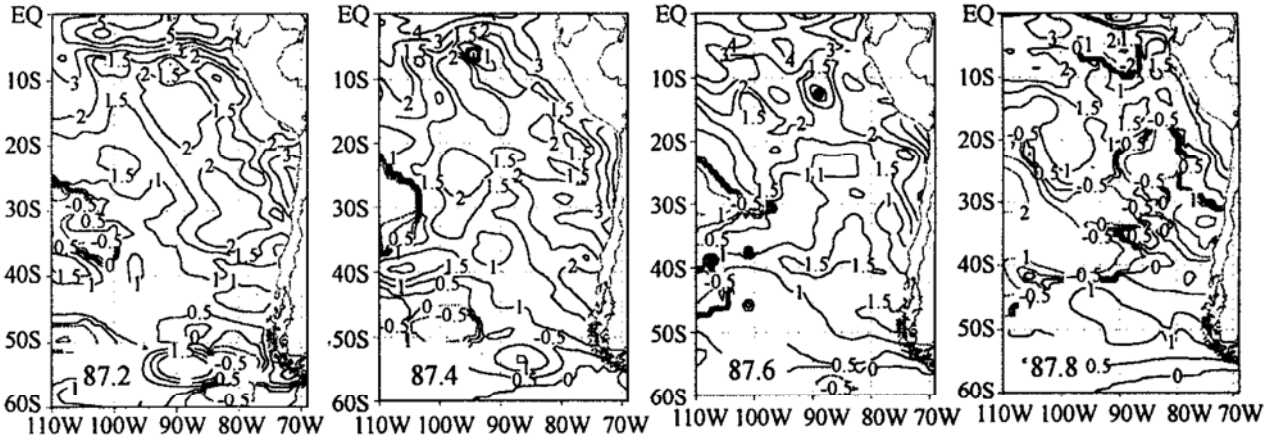

Fig. 2. The propagate way of the anomalous warm water in the Equatorial East Pacific in 1987.

According to the past studying, the sea ice in the Antarctic has an obviously seasonal and annual variation, and the sea ice variation in different longitude differs greatly(Chen *et al*. 1998; Chen and Qin 2000). So, we would analyze the relation between the area of the Antarctica sea ice and the indexes of NINO.

The analysis result shows, the variation of the Antarctica sea ice has an obvious relationship with the indexes of NINO. There are two notable correlation zones among their time-lag correlation. The first is about 30 months ahead of the indexes of NINO in the South-east Antarctica; the second is about 24 months lagging the indexes of NINO in the Amundsen-Bellingshausen Sea and Antarctica peninsula. The former correlation shows that the variation of the Antarctic ice has a promoting effect on the El Nino and La Nina; the later shows that the variation of the Antarctic ice responds to the episode of El Nino and La Nina. In order to explain the phenomenon, we only give the correlation between NINO3 and the variation of the Antarctic ice (Fig. 3).

Fig. 3 also shows that the correlation between the sea ice of the other longitude except two place and the indexes of NINO4 is very low, the correlation of some place is even plus . This phenomenon has a close relationship with the variation of the Antarctica sea ice in different longitude.

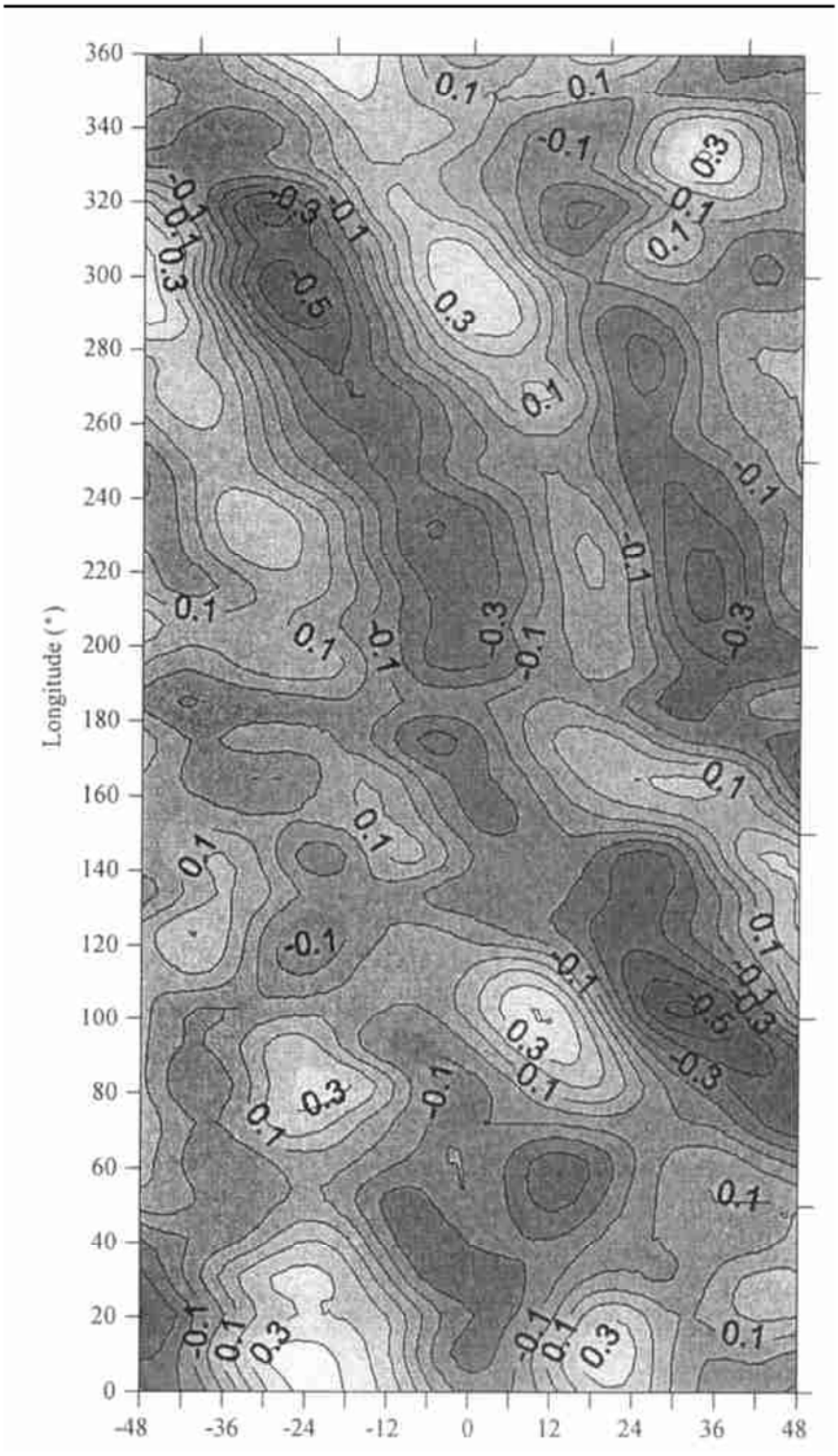

Fig. 3. The correlation field between NINO and the Antarctic ice.

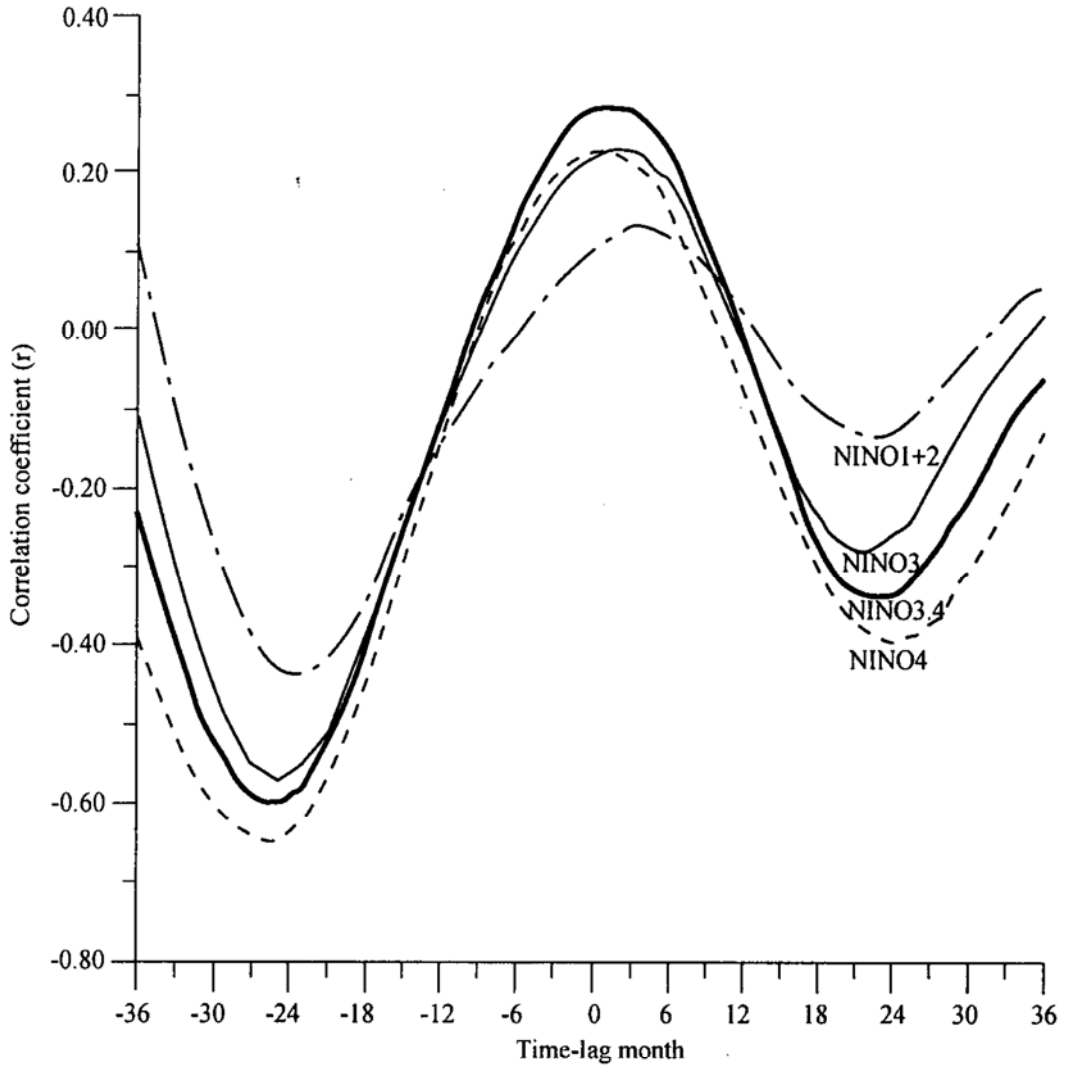

Fig. 4 the correlation between the NINO indexes and the variation of the sea ice of the Antarctic peninsula.

Among the correlation between the episode of El Nino and La Nina and the Antarctic sea ice, this article only analyze the relation between the episode of El Nino and La Nina and Amundsen-Bellingshausen Sea and Antarctica Peninsula. Fig. 4 is the curve of time-lag correlation between the area variations of the sea ice in the Antarctica peninsula (80°-40°W) and the each indexes of NINO. As shown ahead, the notable correlation between the sea ice of Antarctica and the index of NINO occurs between 24 months and 26 months, variation the later proceed the former. Among the correlation between NINO1+ 2, NINO3, NINO3. 4 and NINO4 and the sea ice of Antarctic Peninsula, the notable correlation between the sea ice of Antarctica and NINO1+ 2 occurs 24 months ahead. The notable correlation between the other indexes of NINO and the sea ice of the Antarctic Peninsula occur ahead between 25 months and 26 months, the later lags the former. Such notable correlation shows that the time-lag between the Antarctic sea ice and each of the NINO indexes has a close relationship with the west-east position of the SST in the tropical ocean.

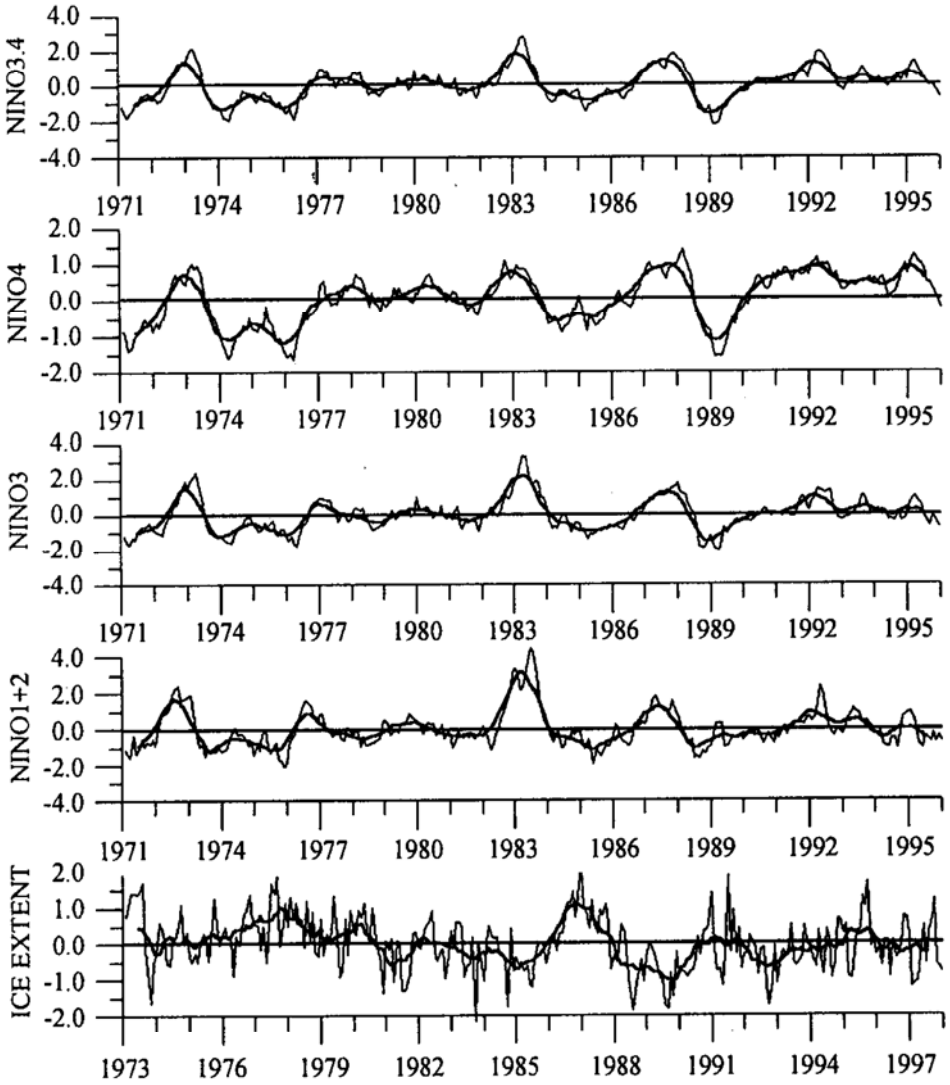

Fig. 5. The annual variation of the sea ice in the Antarctic peninsula and the indexes of NINO.

In order to directly understand the relation between the sea ice in the Antarctic peninsula and the NINO indexes, it is used that data of the anomalous variation of the sea ice in the South-East polar from January 1973 to December 1997 and each of the NINO indexes which occurred then and that lag 26 months to draw the curve (Fig. 5). As seen in Fig. 5, the annual variation of the sea ice in the Antarctic Peninsula has anti-phase relationship with the NINO indexes. This indicates that the area of the sea ice in the Antarctic peninsula should increase or decrease which lagging 24-26 months when the episodes of La Nina or El Nino occurred.

5 The possible mechanism that the episode of El Nino influences the Antarctic sea ice

The results given above indicate that the episodes of El Nino and La Nina have some relationship with the Antarctic sea ice, and the latter is evidently laggard. Now the ques-

tion is whether El Nino and La Nina can influence the Antarctic sea ice or not, if can, what is the way that they influence the Antarctic sea ice? We know from the third section analysis results (Fig. 1 and Fig. 2) that during El Nino the anomalous warm water piled in tropical eastern Pacific propagate poleward along Peru and Chile. The process of anomalous ocean temperature poleward propagation is the possible important mechanics of the change of the Antarctic sea ice.

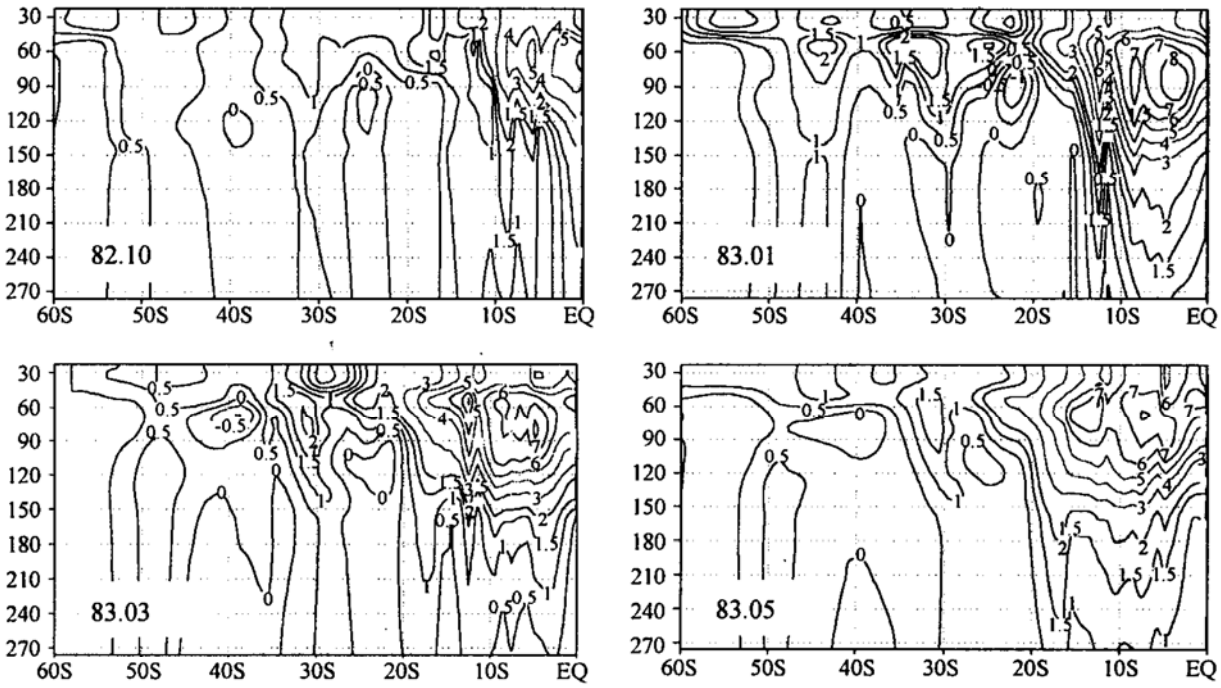

Fig. 6. Process of anomalous sea temperature poleward propagation in tropical eastern Pacific during 1982 to 1983.

In order to find the process of anomalous warm water poleward propagation, we give the depth-latitude section figure of the east-south Pacific sea temperature anomaly which are twice most intense El Nino episode in 1980s, Figure 6 is the characteristic that the sea temperature anomaly changed during the El Nino year 1982/83. As seen from the figure, in October 1982 the anomalous warm water in tropical eastern Pacific propagates southward along South America to 35°S, in January 1983 the anomalous warm temperature has propagated to 60°S, after March 1983 the anomalous warm temperature propagates poleward continued. This propagate process has continued to July, 1983.

Above same, after El Nino took place in 1986-1987, the anomalous warm water piled in tropical eastern Pacific propagate poleward along Peru and Chile. But its intensity is weaker than that in 1982-1983. So we will conclude that the process that the anomalous warm water in tropical eastern Pacific propagates southward along South America is the important reason that leads the decrease of the Antarctic sea ice.

6 Discussion

According to the analysis of data this article has studied the propagation way of the anomalous warm water which piling on the tropical east Pacific and finds out the fact that the anomalous sea temperature of the tropical Pacific in the South Hemisphere propagate towards the Antarctica along the coast of South America. Such analysis result further gives the proof that the anomalous sea temperature of the South Equatorial Current does not transport westward evidently.

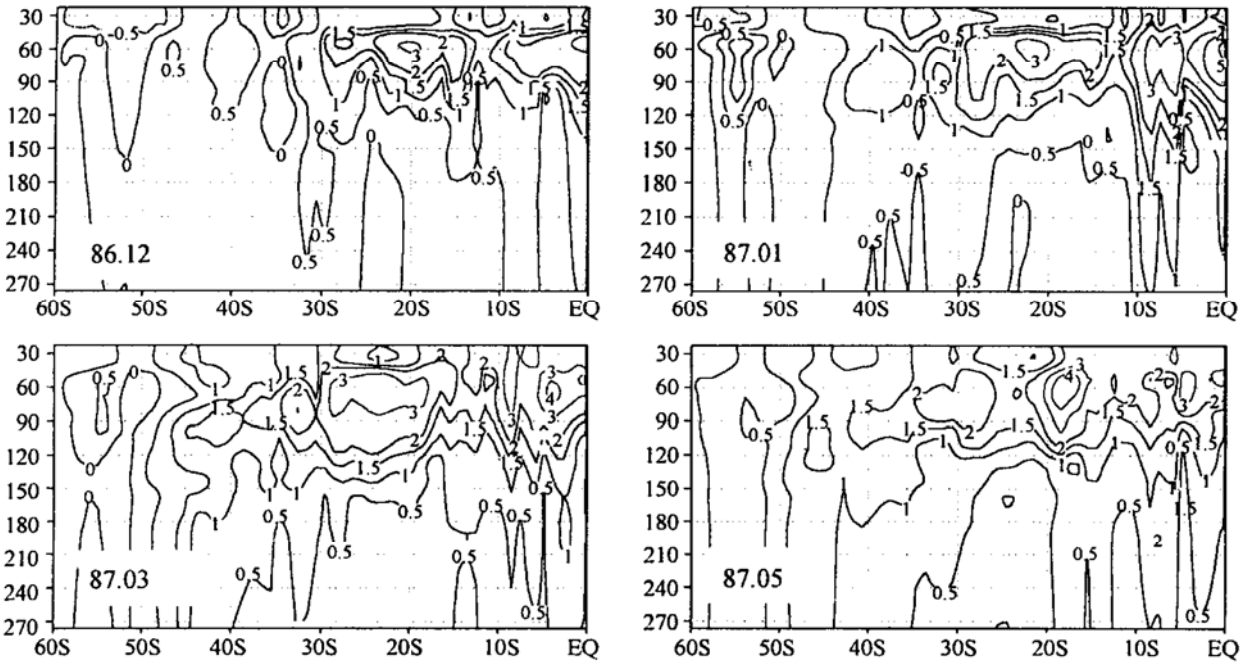

Fig. 7. Process of anomalous ocean temperature poleward propagation in tropical eastern Pacific during 1986 to 1987.

The episodes of El Nino and La Nina have some effect on the variation of the Antarctic sea ice especially when the episode of El Nino happens. After about two years when the episode of El Nino happens the sea ice of the Amundsen-Bellingshausen Sea and Antarctic peninsula will decrease especially the sea ice of the Antarctic peninsula.

After the episode of El Nino happens the anomalous warm water which piling on the tropical east Pacific will propagate towards the Antarctica along the coast of Peru and Chlie (90°-75°W) and lead to the anomalous variation of the sea temperature in the temperature in Antarctica, finally it has an effect on the sea ice of the Amundsen-Bellingshausen Sea and Antarctic peninsula and makes the sea ice decrease.

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