Article ID: 1006-8775(2007) 02-0177-04

STUDY ON VARIATION CHARACTERISTICS OF SST OBSERVED IN THE PAST 40 YEARS IN THE COASTAL REGION OF SOUTH CHINA

PAN Wei-juan (潘蔚娟)[1], QIAN Guang-ming (钱光明)[1], YU Ke-fu (余克服)[2], CHEN Te-gu (陈特固)[2]

(1. Guangdong Climate and Agrometeorology Center, Guangzhou 510080 China; 2. South China Sea Institute of Oceanology, CMA, Guangzhou 510301 China)

Abstract: To study the variation characteristics of SST in coastal south China, observed SST was analyzed for the past 44 years. The results show that the monthly and yearly averaged SST have rising trends, the yearly averaged SST's linearity rising rate is 0.12－0.19 °C/decade in the years, the rising extents in winter are higher than those in summer. The variability in winter is larger than that in summer, with the largest in February and March. A majority of significant cold or warm events occurred in winter. A wavelet multi-resolution method was used to analyze periodical characteristics of SST in coastal south China, all time-scale decomposition series are very similar, and high-frequency decompositions within the year are dominant. Low-frequency decompositions show rising trends since the mid-1970.

Key words: coastal south China; observed SST; variation characteristics

CLC number: P434.5 **Document code:** A

1 INTRODUCTION

The anomalous variation of regional climate has been an increasingly focused point. The rise of sea level in the background of global warming is posing serious threats to sustainable development of coastal regions, making the study on the variation of sea level temperature in these regions very realistic. SST on the coast of North America is divided into three main spatial patterns using the methods of primary analysis and wave spectra and their variations are discussed [1]. Warming trends have been shown to exist in four offshore regions of the Bohai Sea, Yellow Sea, East China Sea and South China Sea over the past 100 years, especially since the 1980s, and by 0.2°C in the 1980s and 0.3°C in the 1990s in northern South China Sea[2]. 24 – 30 months are the significant periods of SST in the SCS and the SST variation on the interannual scale takes place as a whole across the region[3]. The variation of SST is discussed of the Weizhou Island from 1960 to 2001[4]. Most of these previous studies are about the variation in the whole or parts of South China Sea while no attempts have ever been made in systematic study of SST in coastal south China. In this work, the observed SST data from the region will be used to discuss the long-term variation trends and multi-scale periodic characteristics of the yearly and monthly mean SST in the region.

2 DATA

The data used in this work include the observed monthly mean SST from January to December in the 44 years of 1960 – 2003 at seven maritime observation stations. They are, from west to east, Beihai, Weizhou Island, Luzhou Island, Zhapo, Zhelang, Yun'ao and Xiam1en.

3 TRENDS OF SST VARIATION IN COASTAL SOUTH CHINA

From the computed coefficients of linear trends of SST at individual stations from January to December in the 44 years[5], it is found that the variation of SST with time mainly shows an ascending trend, reaching a significance level with 5% confidence for all stations in January, June and October. The rising trend is particularly obvious in the summer of the Beibu Bay. With the exception of April, May and November, the

Received date: 2006-08-06; **revised date:** 2007-08-27
Foundation item: Key project for Natural Science Foundation of China (40231009)
Biography: PAN Wei-juan (1976-), female, native from Guangdong province, engineer, M.S., mainly undertaking the research on short-term climate prediction.
E-mail: wjpan@grmc.gov.cn

increasing trend in the northern stations, especially Xiamen, attains the significance level with 5% confidence.

As for the annual mean SST (Tab.1), the increasing trend is stronger in the north than in the south, with the significance level with 5% confidence in Beihai, Weizhou Island and Luzhou Island and the remaining four stations even having a significance level in 1% confidence.

Tab.1 Statistical characteristics of yearly averaged SST for individual stations in coastal south China

	Beihai(1)	Weizhou Island(2)	Luzhou Island(3)	Zhapo(4)	Zhelang(5)	Yun'ao(6)	Xiamen(7)
Coefficients of trends	0.33	0.32	0.31	0.37	0.38	0.36	0.52
Coefficients of linear regression	0.014	0.012	0.012	0.013	0.012	0.013	0.019
Variance	0.20	0.23	0.24	0.20	0.16	0.21	0.22
Multi-year mean temperature (°C)	23.92	24.57	24.26	23.52	22.0	21.18	21.37

To study its rate of linear growth, linear tendency estimates are made of the monthly and annual SST at the stations in the 44 years. It is known that Xiamen has the largest annual growth of SST, 0.19°C / 10a, followed by all the rest ranging from 0.12°C to 0.14°C (Tab.1). For the linear growth rates of SST in individual months, they are generally higher in the winter half of the year (November – April) than the summer half (May – October). It is known that the warming trends in winter have more important contribution to the increase of yearly averaged temperature.

From the computed variance of monthly SST for January – December at the stations, it is known that the SST variability is smaller in wintertime at Zhelang and Yun'ao in the east than the Beibu Bay and waters off western Guangdong but it is larger in summertime in the waters off eastern Guangdong. It is also noted that the SST variability is much larger in the winter half of the year than in the summer half, being the largest in February and March. From the monthly series of SSTA of the stations, it is also found that significant cold and warm episodes usually happen in the winter half of the year in coastal south China, which is consistent with the conclusion by Wang et al.[3]

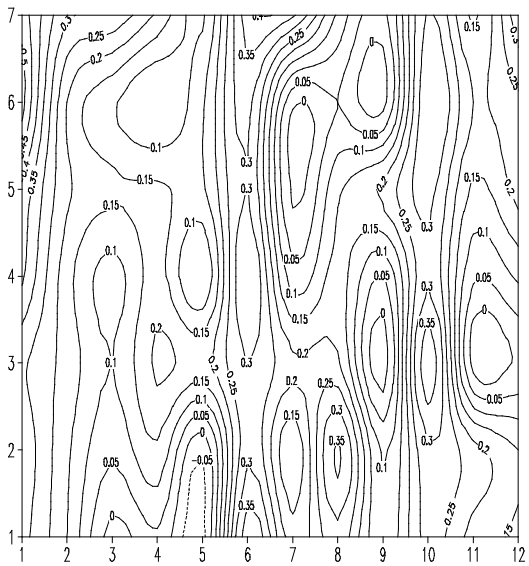

Fig.1 Coefficients of SST tendency for the stations in coastal south China from Jan. To Dec. The abscissa is for the month, the ordinate for the serial number of the stations, which are listed in Tab.1.

4 PERIODS OF SST IN COASTAL SOUTH CHINA

With the DB16 wavelet of the compactly supported orthogonality, the series of SSTA in the seven measuring stations whose length n＝528 (44× 12) are studied for their characteristics of the periods using the method of wavelet analysis with multiple resolution. Series with a length of 528 are decomposed into eight sections of frequency, consisting of seven high-frequency components (d1 - d7) and one low-frequency component (a7).

From the wavelet analysis of SSTA with multiple resolution, it is known that component series of individual stations on different scales, especially those with long scales, are similar to each other. Here, only

the coefficients for Beihai are reconstructed (Fig.1). The smoothed component (a7) shows that beginning from the mid-1970s, SST kept increasing and most pronounced warming began from the 1990s and is still present today.

Tab.2 Rates of contribution by variance on different time scales for the seven stations (%) and their correlation with the original series

components		a7	d7	d6	d5	d4	d3	d2	d1
Period(months)		>224 months	112-224	56-112	28-56	14-28	7.0-14	3.5-7.0	<3.5
years		>19 years	9.2-19	4.6-9.2	2.3-4.6	1.1-2.3	0.6-1.1	0.3-0.6	<0.3
Variance contribution rates	Beihai	0.024	0.01	0.048	0.059	0.084	0.175	0.252	0.345
	Weizhou Is.	0.037	0.019	0.061	0.098	0.119	0.248	0.223	0.179
	Luzhou Is.	0.062	0.017	0.063	0.089	0.116	0.195	0.256	0.209
	Zhapo	0.044	0.007	0.043	0.068	0.104	0.191	0.26	0.272
	Zhelang	0.063	0.013	0.023	0.082	0.112	0.165	0.283	0.239
	Yun'ao	0.048	0.022	0.034	0.084	0.114	0.165	0.271	0.223
	Xiamen	0.087	0.024	0.015	0. 065	0.151	0.174	0.254	0.195
Correlation coefficients	Beihai	0.156	0.101	0.22	0.247	0.288	0.417	0.507	0.588
	Weizhou Is.	0.233	0.18	0.254	0.318	0.345	0.496	0.474	0.422
	Luzhou Is.	0.202	0.086	0.245	0.325	0.349	0.441	0.509	0.457
	Zhapo	0.225	0.108	0.217	0.271	0.322	0.435	0.513	0.521
	Zhelang	0.283	0.161	0.172	0.298	0.336	0.408	0.531	0.488
	Yun'ao	0.297	0.243	0.22	0.299	0.339	0.405	0.521	0.471
	Xiamen	0.353	0.249	0.148	0.26	0.39	0.415	0.505	0.441

By extracting the wavelet coefficients for individual layers and determining the rates of contribution by variance on different time scales at the seven stations (%) and their correlation with the original series, one finds that the variance contribution rates show a general tendency of decrease with the growth of time scales. The maximum time scale of the rates is 1 year or less; the sum of the rates for three annual or intraannual scales can be as high as in the range from 65% to 75%; the coefficients are all larger than 0.4 of the correlation between the components on three annual or intraannual scales and the original series. In other words, the variation of SSTA in coastal south China is mainly on the intraannual scale.

The annual variation is the most significant for SST in the South China Sea, followed by the interannual variation and then the intraseasonal variation and the intraseasonal oscillation of SST is mostly resulted from the interactions with low-level atmosphere; the significant annual variation contained in the South China Sea SST is mainly reflecting on the air-sea coupling oscillation in the monsoon region[8]. The intraseasonal oscillation of the South China Sea is resulted from the mutual effect of atmospheric dynamic forcing and thermodynamic forcing, which is closely related with monsoon activity[9]. It is generally consistent with the conclusion drawn in this work of periodic characteristics of coastal south China.

For analyses of other aspects, refer to the Chinese edition of the journal.

5 CONCLUSIONS

(1) As shown in the low-frequency components determined with wavelet multiple resolution analysis, the SSTA is mainly of intraseasonal variation in coastal south China, which began its current rising trend from the mid-1970s.

(2) Monthly SST is mainly increasing in the region, with the amplitude generally larger in the winter half of the year than the summer half. For the yearly averaged SST, the rising trend in Beihai, Zhapo and Yun'ao has reached the significance level of 1% confidence and Weizhou Is. and Luzhou Is. are also at the level of 5% confidence. The linear growth rate is 0.12 – 0.19°C / 10a. The variability is much larger in the winter half than the summer half with the maximum in February and March. The variability in Zhelang and Yun'ao in the east is smaller in the winter half than the Beibu Bay and waters off the western Guangdong while it is larger in the eastern waters in the summer half.

REFERENCES:

[1] Daniel B Lluch-Cota， Warren S Wooster. Principal Modes and Related Frequencies of Sea Surface Temperature Variability in Pacific Coast of North America [J]. Journal of Oceanography，2003, 59: 477-488.

[2] ZHANG Xiu-zhi, QIU Yue-fang, WU Xun-ying. The long-term change for sea surface temperature in the last 100 years in the offshore sea of China [J]. Climatic and Environmental Research, 2005, 10(4): 799-807.

[3] WANG Dong-xiao. Basic characteristics of the interannual oceanic variation of the South China Sea[C]// Proceedings of the oceanographic and climatic variation and their effects on the environment and resources. Beijing: Ocean Press, 2001: 123-131.

[4] YU Ke-fu, JIANG Ming-xing, CHENG Zhi-qiang, et al. Latest forty two years' sea surface temperature change of Weizhou Island and its influence on coral reef ecosystem [J]. Chinese Journal of Applied Ecology, 2004, 15(3): 506-510.

[5] SHI Neng, CHEN Jia-qi, TU Qi-pu. 4-phase climate change features in the last 100 years over China [J]. , 1995, 53(4): 531-539.

[6] YAN Hua-sheng, WAN Yun-xia, DENG Zi-wang, et al. Orthogonal wavelet analysis of the variations of the recent 100-years precipitation in China [J]. Chinese Journal of Atmospheric Sciences, 2004, 28(1): 151-157.

[7] HU Chang-hua, ZHANG Jun-bo, XIA Jun, et al. System Analysis and Design Based on MATLAB – Wavelet Analysis [M]. Xi'an: Electronic Science and Technology University Press, 2000: 2-223.

[8] GAO Rong-zhen, ZHOU Fa-xiu. The coupled spectrum features of the SST system of the SCS and its neighboring sea areas [J]. Journal of Ocean University of Qingdao, 1999, 29(3): 415-420.

[9] ZHOU Fa-xiu, DING Jie, YU Shen-yu. The intraseasonal oscillation of sea surface temperature in the South China Sea [J]. Journal of Ocean University of Qingdao, 1995, 25(1): 1-6.