The wavelet analysis of satellite sea surface temperature in the South China Sea and the Pacific Ocean

TIAN Jiwei, XU Jinshan & WEI Enbo

The Physical Oceanography Laboratory, Ocean University of Qingdao, Qingdao 266003, China (e-mail: lab@mail.ouqd.edu.cn)

Abstract Using wavelet transform, the sea surface temperature (SST) during the period of 1982—1999 of the South China Sea and the equatorial Pacific, from datasets of NOAA/AVHRR, was analyzed. It is shown that there are 4- and 8-year interannual oscillations in the eastern equatorial Pacific and 8-year interannual oscillation in the western equatorial Pacific. In terms of attractive time-frequency localization and multi-scale properties of wavelet transform, as shown by the Morlet wavelet, it is found that an in-phase coupling oscillation occurs between the SCS and the equatorial Pacific. The SST changes of SCS will have echoed every event of El Niño (abnormally warm) and La Niña (abnormally cold) in the equatorial Pacific. There is a positive correlation between the SCS and the western equatorial Pacific in the 8-year time-scale. Evidence is presented that the SST anomalies of the equatorial Pacific influence the SST of the SCS.

Keywords: SST, the South China Sea, the Pacific, El Niño, wavelet transform, remote sensing.

The interannual variability is a strong signal in the climatic system. Because the relationship between the interannual variability and the anomalies of the global climate, scientists pay more and more attention to it. El Niño and La Niña are important features which influence the interannual variability in global climate. Abnormally warm sea surface temperature (SST) in the equatorial Pacific is the essential character of El Niño. SST and sea surface temperature anomaly (SSTA) are thought to be important symbols of the ocean thermodynamic parameters, so researching SST and SSTA is a very important aspect in global and local area climate change. The South China Sea (SCS) is a tropical sea located between the Asian land mass to the north and the west, the Philippine Islands to the east, Borneo to the southeast, and Indonesia to the south. It includes the shallow Gulf of Thailand and connections to the East China Sea (through the Taiwan Strait), the Pacific Ocean (through the Luzon Strait), the Sulu Sea (through the Mindoro Strait), the Java Sea (through the Gapser and Karimata Straits) and to the Indian Ocean (through the Strait of Malacca). All of these straits are shallow except the Luzon Strait where the maximum depth is 1 800 m. So, how the Pacific influences the SCS and what interrelationship is between them have been attracting increasing interest. Zhou\textsuperscript{[1,2]} has shown that the low-frequency oscillation in the SCS is one of components of the variety of the tropic Pacific by using the power spectral analysis and digital filter. Niu\textsuperscript{[3]} researched the month-average datasets of SST by power spectral analysis and found that there is common interannual variability of 3.3-year cycle in both coasts of Peru and the SCS. Xie\textsuperscript{[4]} also shows the in-phase low-frequency coupling oscillation about 16.6-year cycle between the Nansha in the SCS and the Warm Pool in the west Pacific through power spectral analysis. The Fourier transform (FT), including spectral analysis, has been a major tool for investigation of temperature structure of the SCS and the Pacific, it maps signal from time to frequency domain, providing a time-mean power spectrum. As such it fails to reveal possible changes of the oscillation characteristics with time. However, in wavelet analysis the coefficients are displayed in time-frequency frames for the entire time domain on several different time-scales, separating the
large-scale behavior from the small-scale behavior. The temporal localization of wavelet coefficients displayed in these time-frequency frames is an additional advantage of wavelet transform over FT. Since some of the meteorological phenomena, such as intra-annual oscillations, are localized in time, the WT method is highly suitable to studying these phenomena. The temperature structure itself and the processes interacting with it are multiscale, so the traditional analysis technique cannot reveal the interrelation between the SCS and the Pacific from only the time-scale. And, the routine observation data are difficult to use to show the global character of the whole SCS or the Pacific. In the present study, we use the continuous WT to analyze the time series data of weekly SST of the SCS and the Pacific averaged from a grid dataset for the period of January 1982—February 1999 derived from National Oceanic and Atmospheric Administration (NOAA)-Advanced Very High Resolution Radiometer (AVHRR). We present the information about the interrelation between the SCS and the Pacific in different scales. This is helpful to researching the air-sea interaction, and the large-scale circumfluence in SCS and the Pacific.

1 The time series of SSTA in the SCS and the Pacific

The ocean remote sensing satellites provide us a great amount of data with high quality, large scope, long periods and high resolution. The SST data used here were derived from the NOAA/AVHRR for the period of January 1982—January 1999, which are $1^\circ \times 1^\circ$ grid, weekly mean. We selected three rectangular areas, each covering an area of (105°E—125°S, 5°S—25°N), (105°W—90°W, 15°S—15°N), (130°E—180°E, 15°S—15°N), which represent the SCS, the eastern equatorial Pacific Ocean and the western equatorial Pacific Ocean, respectively. The mean temperature of every area was derived from the area average. Figs. 1(a), 2(a), 3(a) show the time series used in our analysis, namely,