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Comparison of two Centennial-scale Sea Surface Temperature Datasets in the Regional Climate Change Studies of the China Seas

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Abstract. Two widely used sea surface temperature (SST) datasets are compared in this article. We examine characteristics in the climate variability of SST in the China Seas.Two series yielded almost the same warming trend for 1890-2013 (0.7-0.8°C/100 years). However, HadISST1 series shows much stronger warming trends during 1961-2013 and 1981-2013 than that of COBE SST2 series. The disagreement between data sets was marked after 1981. For the hiatus period 1998-2013, the cooling trends of HadISST1 series is much lower than that of COBE SST2. These differences between the two datasets are possibly caused by the different observations which are incorporated to fill with data-sparse regions since 1982. Those findings illustrate that there are some uncertainties in the estimate of SST warming patterns in certain regions. The results also indicate that the temporal and spatial deficiency of observed data is still the biggest handicap for analyzing multi-scale SST characteristics in regional area.

1. Introduction

Sea surface temperature (SST) is one of the most fundamental and important elements used to quantify climate change. The China Seas are located on the largest continental shelf of the world and exhibit significant geographical diversities. Investigations of the SST variability over the China Seas, especially the offshore areas, are important for the study of regional climate change [1-4].

In recent years a number of extended historical observed SST products have been produced for use in climate studies [5]. Different SST datasets are used to study the SST change and variability in the China Seas [6-9]. But the evaluations of SST between different SST products in the China Seas have not been analyzed in detail. Researchers [7, 10] used several different datasets, including the reconstructed and un-interpolated datasets, to study the tropical SST trends and the China Seas. They found that there are larger uncertainties in the estimate of SST warming patterns using Hadley Centre Sea Ice and SST dataset [13]. It is important to reduce the biases and uncertainties in regional SST warming patterns in studying the long-term climate change. So, we focus on two centennial-scale SST products: HadISST1 and Centennial Observation-Based Estimates of SST version 2 [12]. Both of the two products are reconstructed data. The aim of this paper is to assess the comparability of the two publicly available gridded SST data sources. This comparison will allow the assessment of which one of these SST data sources describes more accurately the regional SST of the China Seas.

Following the introduction, Section 2 shows the study region, data and methods. Section 3 describes the results. Further discussion and a summary are given in Section 4.

2. Study region, data and methods

2.1 Study region
In this paper, the China Seas are defined as the offshore region of 15-45°N, 105-135°E.

2.2 Data and methods
(1) Monthly Hadley Centre Sea Ice and Sea Surface Temperature (HadISST1) data with the resolution of 1°x1° during 1870-2014 are from Hadley Centre, UK (http://www.metoffice.gov.uk/hadobs/hadisst/data/download. html). This data is based on in situ observations from the Met Office Marine Data Bank and ICOADS and monthly satellite SST data from January 1982 onwards.

(2) Monthly COBE SST2 data with the resolution of 1°x1° during 1891-2013 are from Japan Meteorology Agency (http://www.ds.data.jma.go.jp/tcc/products/elnino/cobesst/cobe-sst.html)[12].

In our study, the SST period is confined to the period of 1891 to 2013. Here, we calculated a monthly climatology for each grid cell based on the period of 1960 to 1990.

3. Results and comparisons

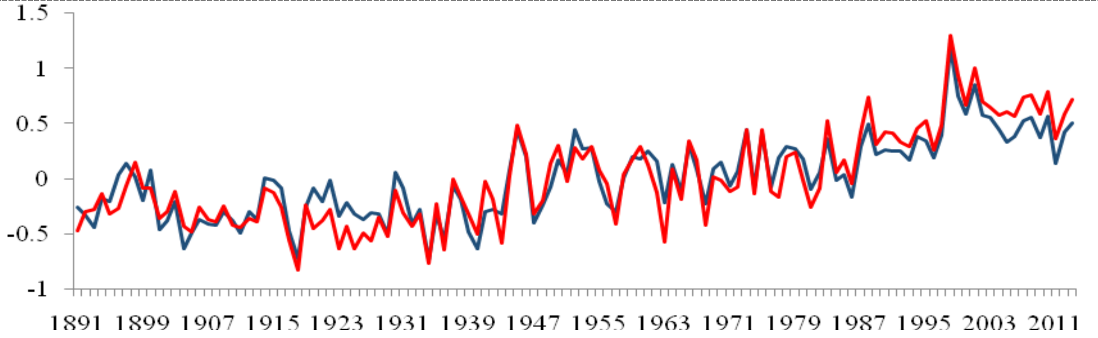

Figure 1. Regional mean annual SST anomalies time series for the China Seas during 1891-2013 relative to 1961-1990 (red line: HadISST1, blue line: COBE SST2)

Table 1. SST anomalies of annual mean decadal average during 1891-2013 (relative to 1961-1990) (°C)

Period	HadISST1	COBE SST2
1890s	-0.19	-0.14
1900s	-0.34	-0.41
1910s	-0.38	-0.28
1920s	-0.44	-0.25
1930s	-0.37	-0.38
1940s	-0.02	-0.07
1950s	0.08	0.08
1960s	0.06	0.06
1970s	0.18	0.16
1980s	**0.22**	**0.14**
1990s	**0.56**	**0.45**
2000s	**0.69**	**0.52**

Table 2. Linear trends of annual mean SST anomalies of the whole China Seas during 1891-2013, 1961-2013, 1981-2013 and 1998-2013 (Unit:ºC/10 yr)

	1891-2013	1961-2013	1981-2013	1998-2013
HadISST1	0.08	0.19	0.20	-0.27
COBE SST2	0.07	0.11	0.14	-0.34

The time series of regional mean annual SST anomalies time series for the China Seas during 1891-2013 relative to 1961-1990 are shown in Figure 1. We further calculated the 10-year averaged temperature anomalies also relative to 1961-1990 in Table 1. Besides, the 100-year warming trend from 1891 to 2013 is calculated in Table 3. From Figure 1 and Table 2, we can see the two time series are very close, with the similar warming trend from 1891 to 2013, 0.08 ºC/10 yr for HadISST1, 0.07 ºC/10 yr for COBE SST2, and all of the trends are significant at the 99% confidence level. All of the two time series reflect the similarinterannual variability. There exist decadal to multi-decadal variations in the SST anomalies series, with a general cool period from 1890s to 1930s and a significant warm period from 1980s to present. Bao and Ren [14] also reported the same decadal variations in the HadISST1 series.

However, there are still discrepancies in the amplitudes of the SSTA. The differences are noticeable in 1910s and 1920s, when the COBE SST2data exhibitshigher anomalies and the HadISST1 data exhibitslower anomalies. The differences are also much significant from 1980s to 2000s, when the COBE SST2 data exhibit slower anomalies and the HadISST1 data exhibitshigher anomalies. An interesting issue can be found by comparing the two time series in details (Figure 2). Obviously, HadISST series has been much higher than COBE SST2 since 1981. The number of SST observations increases with time, and 100-1000 times more observations are available after 1950 than in the earlier times [12]. Since 1960s, more SST data from bucket measurements, satellite observations are incorporated.So, in the next study, the time period is focused on 1961 to 2013. Then, in term of the previous studies, the time period from 1961 to 2013 can be divided into accelerated warming period (1961 to 1998) and hiatus period (1981 to 2013) [15-16]. The trend of each period is shown in table. It can be found that the trends of annual mean HadISST1 in the China Seas (0.19 ºC/10 yr for 1961-2013; 0.19 ºC/10 yr for 1981-2013; -0.27 ºC/10 yr for 1998-2013) are generally much higher than these of annual mean COBE SST2 in the same area (0.11 ºC/10 yr for 1961-2013; 0.20 ºC/10 yr for 1981-2013; -0.34 ºC/10 yr for 1998-2013).

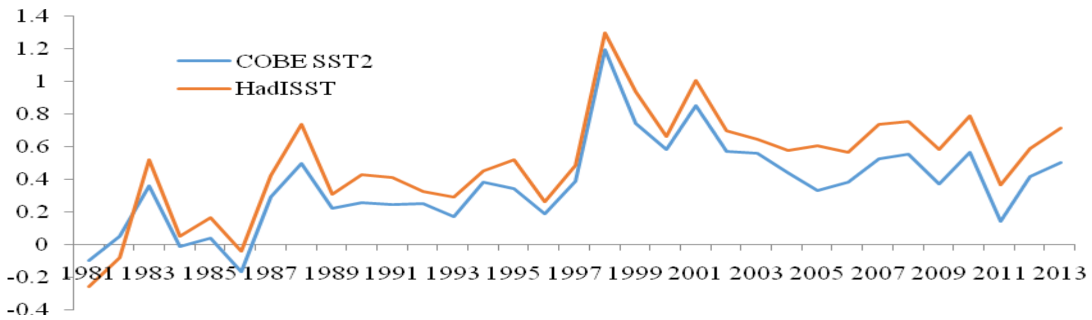

Figure 2. Regional mean annual SST anomalies time series for the China Seas during 1981-2013 relative to 1961-1990 (red line: HadISST1, blue line: COBE SST2)

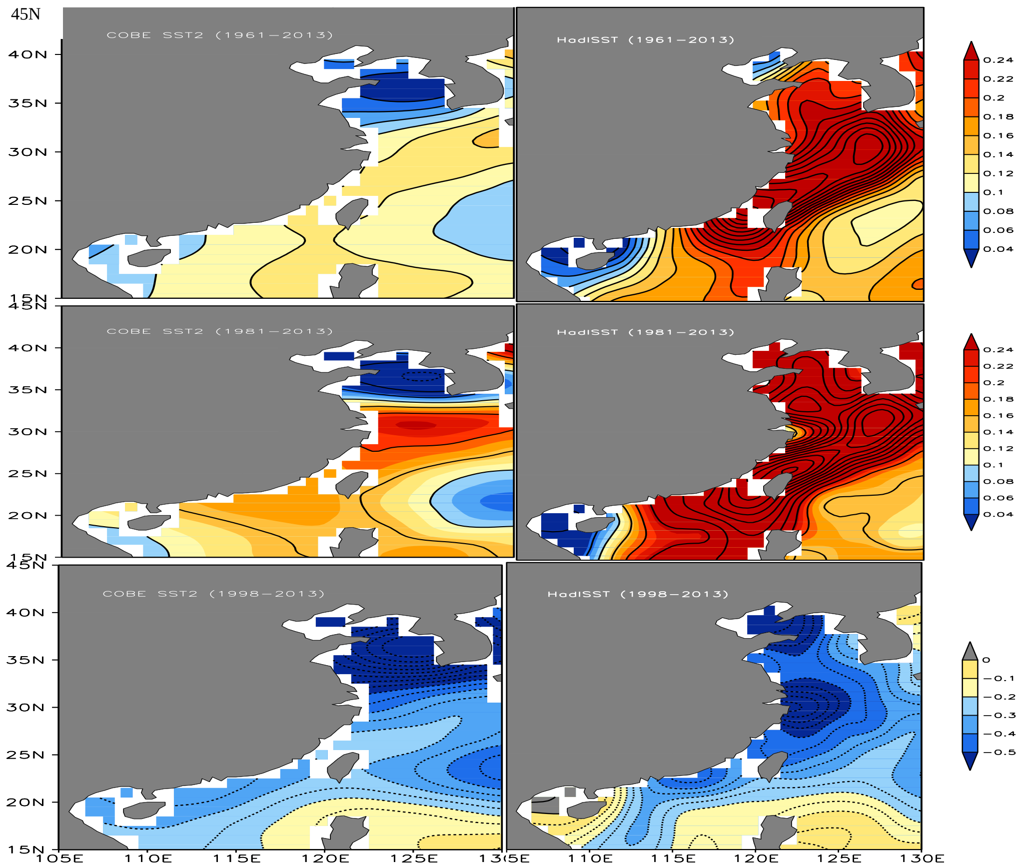

Figure 3. Spatial distribution of the trends of annual mean SST from 1961-2013; 1981-2013 and 1998-2013 over the China Seas (COBE SST2(left); HadISST1 (right)) (Unit: ºC /10 yr)

Figure 3 shows the linear trend distributions of annual mean SST anomalies given by HadISST1 and COBE SST2 during 1961-2013, 1981-2013 and 1998-2013at each grid point in the China Seas. The two datasets show the consistent SST warming trends pattern during 1961-2013 and 1981-2013. For the two reconstructed SST, largest warming trend appears at the East China Seas (Figure 3). However, the linear warming trend estimated from HadISST1 during 1961-2013 and 1981-2013 is much stronger than that from COBE SST2, especially in the East China Sea and the east of Taiwan Island. According to Figure4 the annual mean difference in the SST warming trends between HadISST1 and COBE SST2 is nearly 1°C/100yrs in the East China Sea and 1.5°C/10 yr in the Yellow Sea. However, during the hiatus period (1998-2013), the linear warming trendsfrom HadISST1 during 1998-2013 are lower than that from COBE SST2 over the China Seas, about 0.7 °C/100yr difference. The maximum cooling rate given by HadISST1 exceeds 4°C/100yr in the Yangtze River and the offshore region of the East China Sea. The maximum cooling rate given by COBE SST2 exceeds 4°C/100yr is located in the Yellow Sea. The annual mean SST trends as obtained by the respective use of HadISST1 and COBE SST2 have much difference which shows the uncertainties involved studying these warming trends.

4. Discussion and Conclusions

Information from SST series is an important basis for detecting climate change and finding their causes. In this paper, we reviewed and compared two reconstructed and centennial-scale SST datasets which are widely used by the international research community. Our analyses indicated that, in general the two series are highly correlated in the long-time series. But, there are some differences among the decadal mean SST anomalies, especially from 1910s to 1920s, from 1980s to 2000s.These reconstructions indicate wide divergences in linear trends of regional averaged SST during 1961-2013, 1981-2013 and 1998-2013. It can be found that the trends of annual mean HadISST1 in the China Seas (0.19 ºC/10 yr for 1961-2013; 0.19 ºC/10 yr for 1981-2013; -0.27 ºC/10 yr for 1998-2013) are generally much higher than these of annual mean COBE SST2 in the same area (0.11 ºC/10 yr for 1961-2013; 0.20 ºC/10 yr for 1981-2013; -0.34 ºC/10 yr for 1998-2013). The maximum warming rates of 1961-2013 and 1981-2013 from HadISST1 and COBE SST2 is both located at the East China Sea and Taiwan Strait as shown in Figure 4, while the rates are much different. The maximum cooling rate given by HadISST1 suits in the Yangtze River and the offshore region of the East China Sea, while the maximum cooling rate given by COBE SST2 is located in the Yellow Sea. The different results obtained from the two datasets may be due to the reconstruction technique or the incorporation of satellite observations since 1980s. The comparisons of the SST linear trends obtained respectively from the HadISST1 and COBE SST2 datasets can show the uncertainties in studying the warming trends.

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