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Study of the Temporal and Spatial Analysis by using SST Satellite Data

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Abstract

It is studied the sea surface temperature(SST) variation around Korean Peninsula by using Group for High Resolution Sea Surface Temperature(GHRSST) images for 22-year data from 1993 January 1 to 2014 December 31. For the accuracy of GHRSST data, near observation station were collected to correlate GHRSST and water temperature data. Mean correlation in Yellow Sea was 0.968, mean correlation in South Sea was 0.963, and mean correlation in East Sea was 0.962. The result of harmonic analysis showed that the amplitude of SST in Yellow Sea was 10~16℃ and the amplitude of SST in East Sea and South Sea was 8~12℃. The phase of SST in Yellow Sea was 230~235°, and the phase of SST in South Sea and East Sea was 240~244. EOF analysis resulted that the first mode of coefficient was 97.59%. When it is used with various climate data, for example, sea level, wind, air temperature, it will be represented the specific variation of SST.

***Keywords**: Sea Surface Temperature (SST), Remote Sensing, Harmonic Analysis, EOF (Empirical orthogonal function)*

1. Introduction

Ocean and atmosphere interaction is the main cause of the climate change, and sea surface temperature (SST) is a basis of many oceanographic and meteorological applications in the dynamic interaction [1-2]. Ocean warming is the largest near the surface on the global scale in the climate system, more than 60% of the net energy was stored in upper ocean(0~700m) between 1971 and 2010 [3]. Therefore, SST is steady increasing on the global scale. East Asian Marginal Seas including Korea is influenced by mesoscale phenomena such as vortex, coastal upwelling, water mass, global scale phenomena such as monsoons, the Pacific Decadal Oscillation (PDO), El Nino-Southern Oscillation (ENSO), and Arctic Oscillation (AO) [4]. However, even though SST variation is not globally uniform, most of studies analyzed the global scale of SST variation.

Satellite image is able to acquire the data for the wide area without physical contact on sea surface to measure SST [5]. The accuracy of SST satellite images was validated by Kwak, it was highest in East Sea of Korea [6]. Therefore, this study is analyzed the temporal and spatial SST variation around Korea by using satellite images.

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2. Data and Method

SST data were used Group for High Resolution Sea Surface Temperature (GHRSST). GHRSST is high resolution SST data in near real time by using various satellite sensors. Its products are L2, L3 and L4, L2 product is only used input SST data without adjustments. L3 product is not processed the analysis or interpolation to fill the no observations. L4 product is gridded data which is interpolated the gap by analyzing the lower data [7]. In this study, L4 GHRSST daily data were used 22-year data from 1993 January 1 to 2014 December 31. The resolution of GHRSST images were 1/4°.

Water temperature used from Korea Oceanographic Data Center (KODC) which provides the daily observations at 34 coastal stations. Water temperature data from 1993 January 1 to 2014 December 31 were observed 26 stations (South Sea: 10 stations, East Sea: 8 stations, Yellow Sea: 8 stations). For the accuracy of GHRSST data, near observation station were collected to correlate GHRSST and water temperature data.

Study area is showed Figure 1, it is 117~142℃E and 25~45℃N around Korea and near China and Japan.

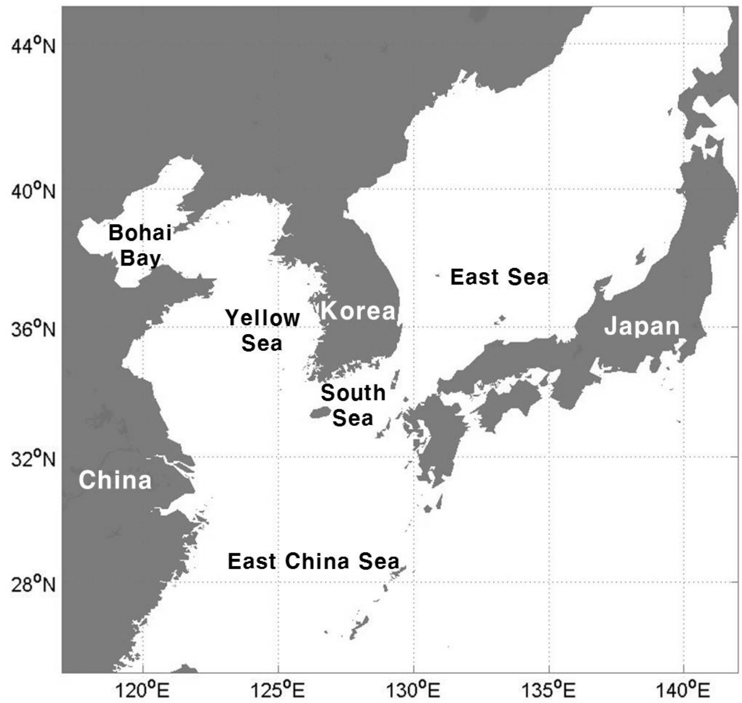


Figure 1. Study Area

Harmonic analysis is used to see SST distribution of variation around the Korean Peninsula. It represents the amplitude and the phase with sine wave from time series data with complex wave [8]. It is used to analyze the spatial analysis of SST variation around Korea. Also, empirical orthogonal function (EOF) analysis is used to find the time series and spatial patterns of SST variation. It uses singular value decomposition (SVD) to analyze SST which is associated with an orthogonal spatial mode and time series amplitude [9].

3. Results

Table 1 shows the correlation between monthly SST and monthly water temperature. Mean correlation in Yellow Sea was 0.968, mean correlation in South Sea was 0.963, and mean correlation in East Sea was 0.962. Correlation in Sokcho was 0.985, which was the highest in stations. Figure 2 indicates correlation with mean satellite SST and mean water temperature. Correlation coefficient was 0.99.

Table 1. Correlation between Monthly SST and Monthly Water Temperature

No.	Waters	Station	Correlation
1	East Sea	Jeju	0.982
2		Udo	0.981
3		Sorido	0.977
4		Geomundo	0.977
5		Marado	0.976
6		Gadeokdo	0.957
7		Busan	0.955
8		Wando	0.951
9	South Sea	Jukdo	0.943
10		Dangsado	0.931
11		Sokcho	0.985
12		Ulleungdo	0.984
13		Jukbyeon	0.971
14		Gampo	0.955
15		Homigot	0.955
16		Gijang	0.952
17		Pohang	0.949
18		Ulgi	0.945
19	Yellow Sea	Maldo	0.984
20		Budo	0.984
21		Eocheongdo	0.979
22		Hongdo	0.971
23		Sohuksando	0.971
24		Socheongdo	0.963
25		Gunsan	0.945
26		Mokpo	0.945

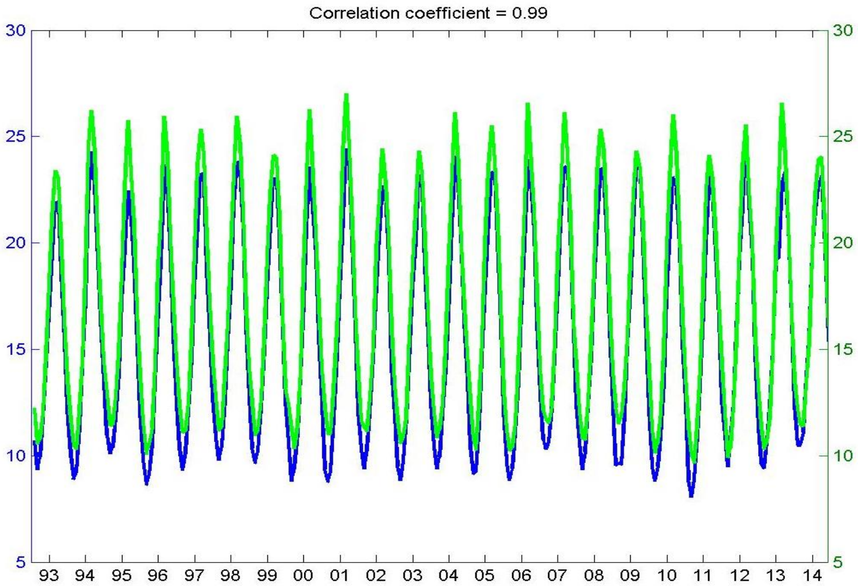


Figure 2. Correlation between Mean SST and Water Temperature (Green: SST, Blue: Water Temperature)

Figure 3 shows the correlation with satellite SST and water temperature in South Sea, correlation coefficient in Jeju(a) was 0.982, and Udo(b) was 0.981, which is the highest within South Sea stations.

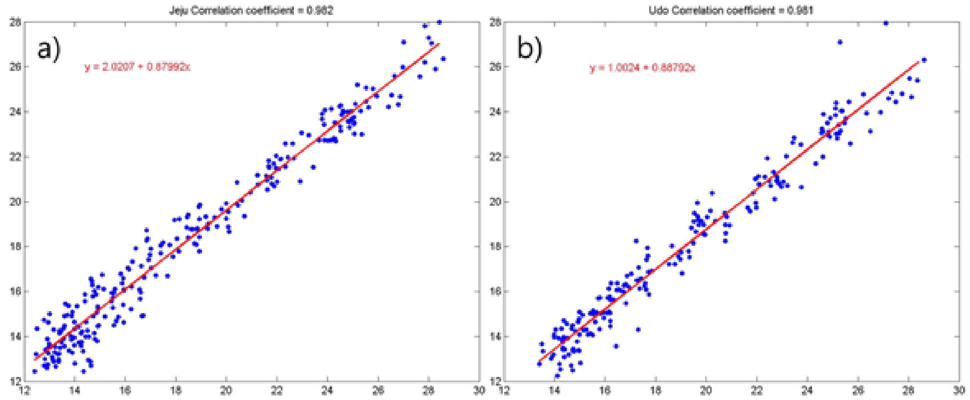


Figure 3. Correlation Coefficient in Jeju(a) and Udo(b)

Figure 4 shows the correlation with satellite SST and water temperature in East Sea, correlation coefficient in (a) Sokcho was 0.985, and (b) Ulleungdo was 0.984, which is the highest within East Sea stations.

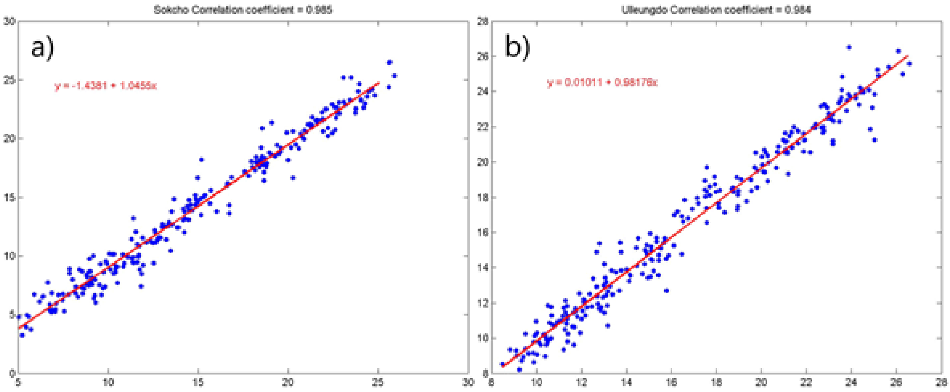


Figure 4. Correlation Coefficient in Sokcho(a) and Ulleungdo(b)

Figure 5 shows the correlation with satellite SST and water temperature in Yellow Sea, correlation coefficient in (a) Maldo and (b) Budo was 0.984, which is the highest within Yellow Sea stations.

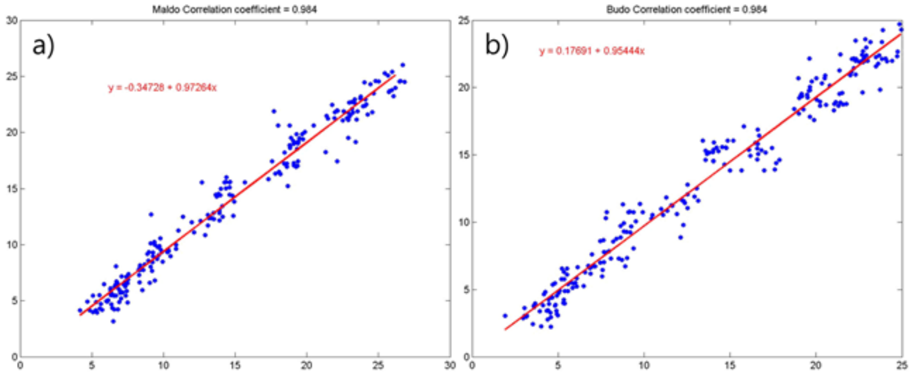


Figure 5. Correlation Coefficient in Maldo(a) and Budo(b)

Figure 6 is mean SST between 1993 and 2014. The highest mean SST was about 27℃ around East China Sea. It is considered that the Kuroshio warm current is strong. The lowest mean SST was about 14~15℃ near northern East Sea, which is supposed that the Liman cold current is affected. In Korea, mean SST in Yellow Sea shows 20~23℃, mean SST in East Sea was about 22~24℃ and mean SST in South Sea is about 22~25℃. There were mean SST difference between Yellow Sea and East Sea where is the similar latitude. Because it is expected that Tsushima warm current moves up to East Sea of Korea.

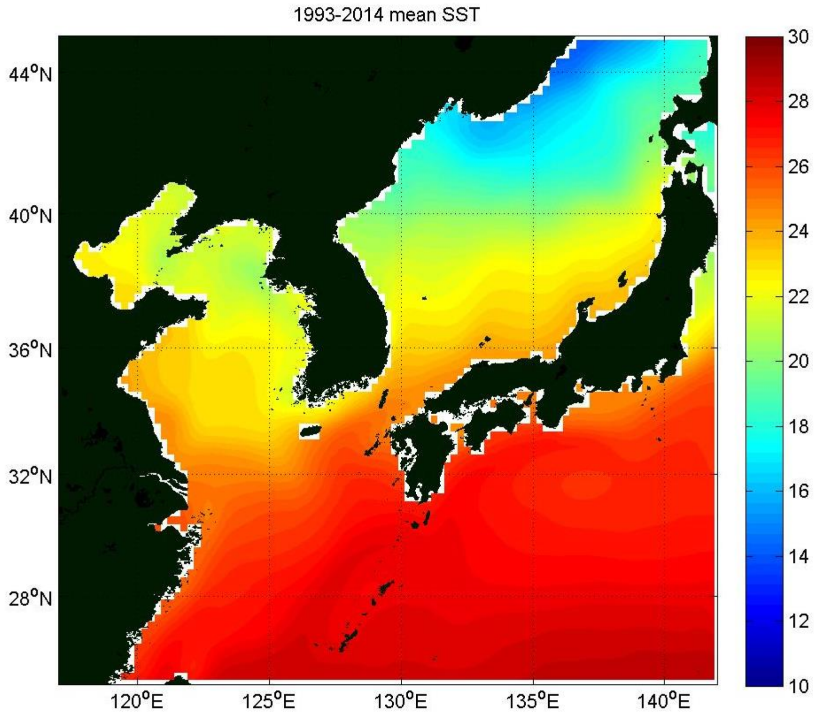


Figure 6. Mean SST (℃) between 1993 and 2014

Figure 7 and Figure 8 showed the harmonic analysis results that represented the amplitude and phase. Figure 7 shows the annual amplitude of SST. The highest annual amplitude SST was 16~18℃ near Bohai Bay in China, it is considered that the monsoon affects the big difference of SST. The lowest annual amplitude SST was 5~6℃ near East China Sea where is the highest mean SST(Figure 6). The annual amplitude SST in Yellow Sea was 10~16℃ and the annual amplitude SST in South Sea and East Sea were 8~12℃. Annual amplitude in South Sea and East Sea were lower than in Yellow Sea because it is considered there is less affected the monsoon.

The result of annual phase of SST between 1993 and 2014 is Figure 8. Near East China Sea was the lowest annual phase between 225° and 230°, which is the middle of August. Near East Sea of Japan showed the highest annual phase between 250° and 252°, which is the beginning of September. The annual phase of Yellow sea was 230~235°, which is the middle of August. The annual phase of East Sea and South Sea showed 240~244°, which is the end of August.

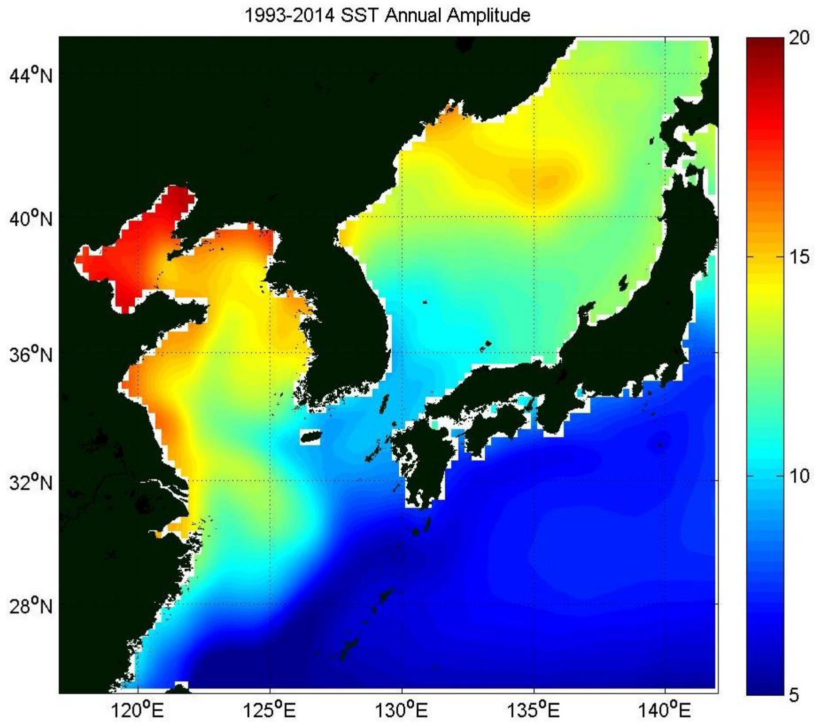


Figure 7. Annual Amplitude of SST between 1993 and 2014

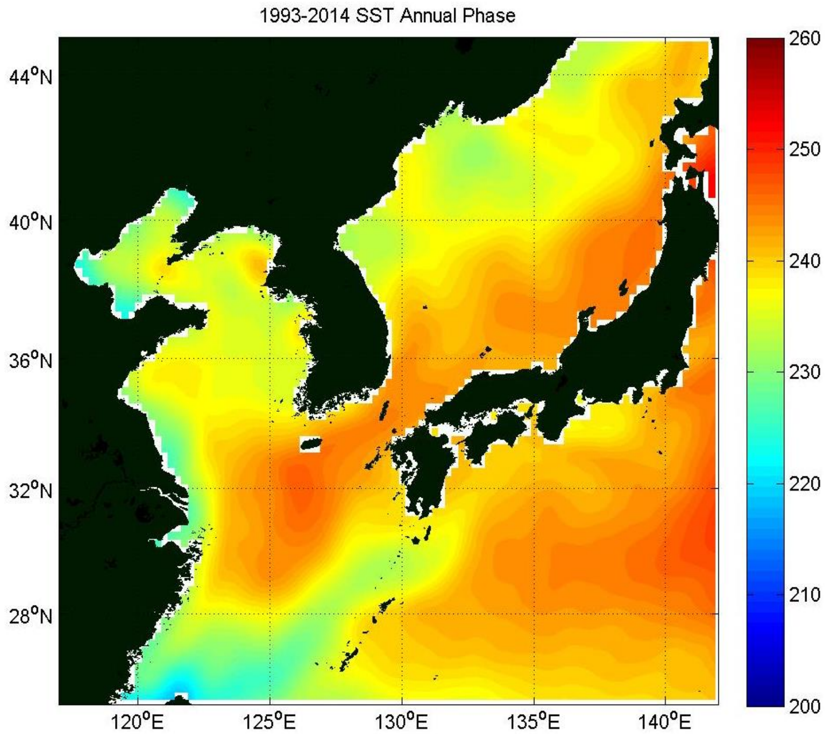
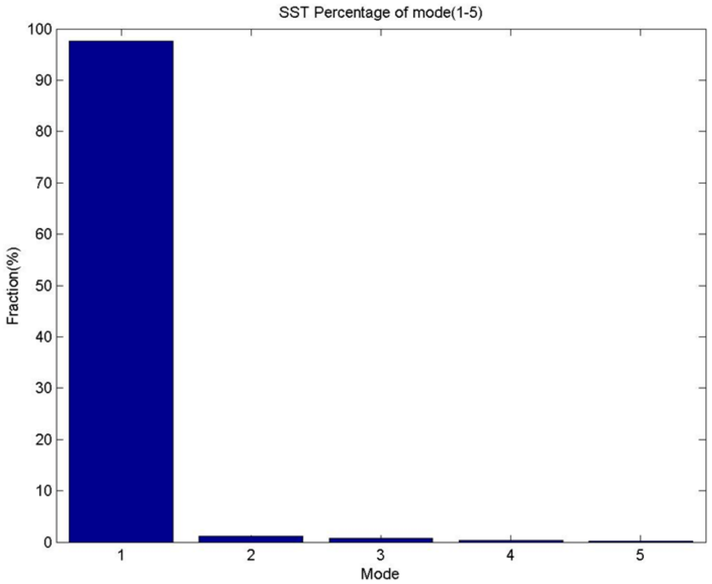


Figure 8. Annual Phase of SST between 1993 and 2014

To find the spatial patterns and time series, EOF was analyzed. It calculated 5 modes. Figure 9 shows the SST percentage of mode. The first mode of coefficients was 97.59%, the second mode was 1.16%, the third mode was 0.70%, the forth mode was 0.34%, the fifth mode was 0.21%. The first mode is considered that it represented the temporal and spatial variations of SST well. The first mode of amplitude time series showed annual cycle in Figure 10. The first mode of time series of power spectrum density (PSD) indicated annual cycle in Figure 11. The peak of PSD was about 365 day frequency, which was also considered that SST was affected the annual cycle round Korea.



Mode	1	2	3	4	5
(%)	97.59	1.16	0.70	0.34	0.21

Figure 9. SST Percentage of Mode(1~5)

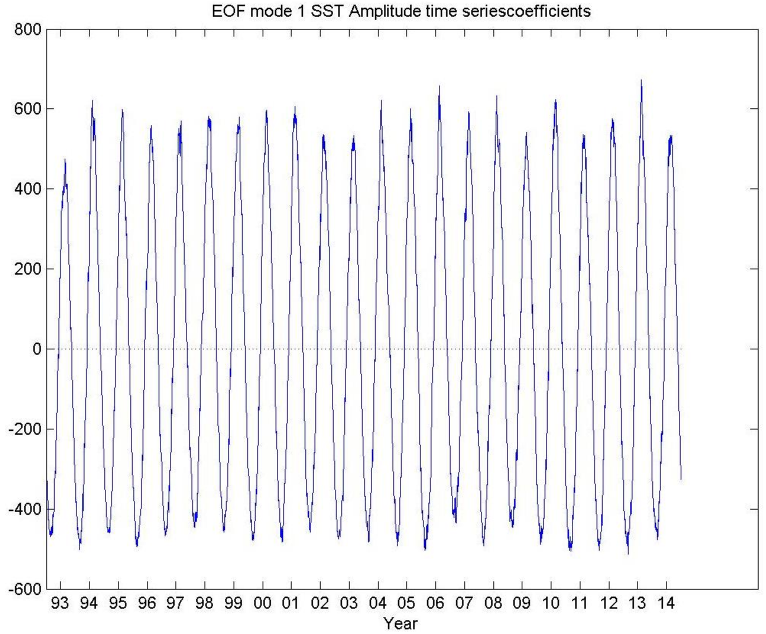


Figure 10. EOF First Mode of SST Amplitude Time Series Coefficients

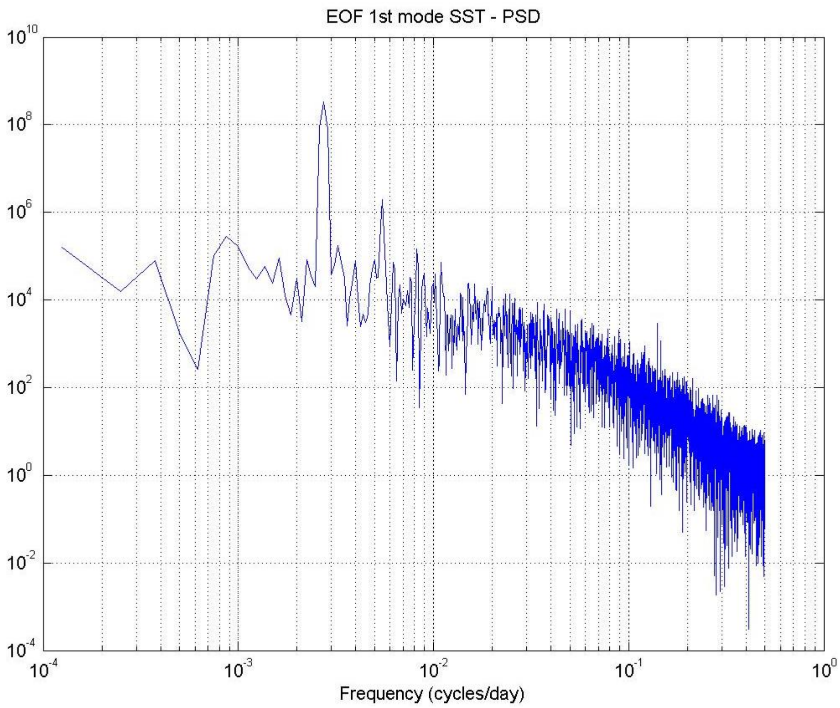


Figure 11. PSD of EOF First Mode of SST

The first mode of spatial distribution patterns showed Figure 12, these patterns were similar to annual amplitude SST in Figure 7. The highest coefficient was near Bohai Bay, the lowest coefficient was near East China Sea. In Korea, Yellow Sea showed the highest coefficient, the coefficient in South Sea were between 0.012~0.014 and the coefficient in East Sea were 0.014~0.016.

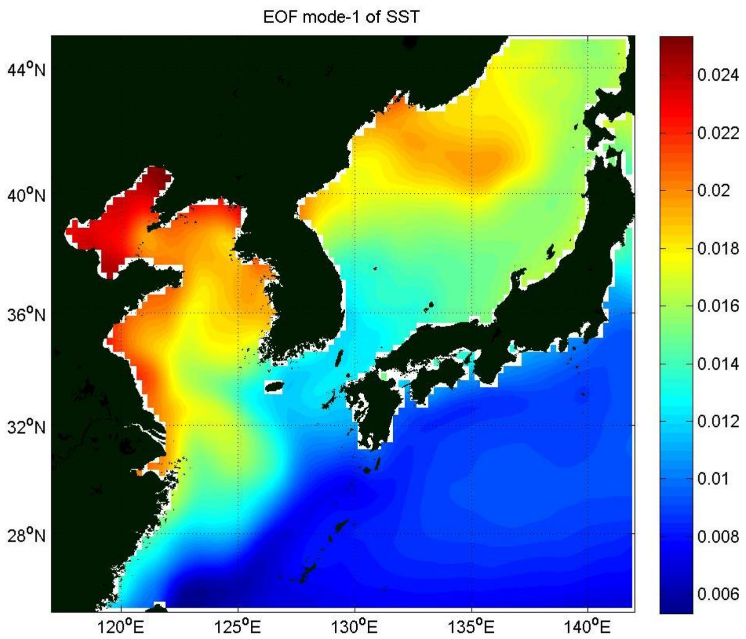


Figure 12. EOF First Mode of SST Spatial Distribution

4. Conclusion

Harmonic analysis and EOF figured out the SST variation around Korean Peninsula by using GHRSST images. The mean SST in Yellow Sea w/as 20~23℃, the mean SST in South Sea was 22~25℃ and the mean SST in East Sea was 22~24℃. The result of harmonic analysis showed that the amplitude of SST in Yellow Sea was 10~16℃ and the amplitude of SST in East Sea and South Sea was 8~12℃, which is considered that around Yellow Sea was affected the monsoon. The phase of SST in Yellow Sea was 230~235° which is the middle of August, and the phase of SST in South Sea and East Sea was 240~244° which is the end of August. EOF analysis resulted that the first mode of coefficient was 97.59%. It is affected the annual cycle to refer the first mode of time series coefficient and PSD results. When it is used with the air temperature, sea level and current data like climate data, it will be represented the specific variation of SST.

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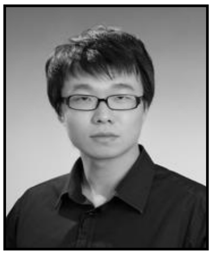

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