Variations of Sea Level and Sea Surface Temperature in Korean Seas by Topex/Poseidon and NOAA

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ABSTRACT : Altimeter(Topex/Poseidon) and AVHRR(NOAA) data were used to study the variations and correlations of Sea Level(SL) and Sea Surface Temperature (SST) in the North East Asian Seas from November 1993 to May 1998. This region is influenced simultaneously to continental and oceanic climate as the border of the East Sea(Japan Sea). SL and SST have increased gradually every year because the global warming, and presented usually a strong annual variations in Kuroshio extension region with the influence of bottom topography.

Key word: EOF Analysis, Sea Level, Sea Surface Temperature

1. INTRODUCTION

Change of ocean with abnormal climate contributes the increase of SL and SST, the change of ocean surface circulation and the variation of sea level. SL and SST are the fundamental index for oceanography and climatology. In order to predict to change of ocean, it is necessary to monitor and predict the oceans in the long time by satellite data. Several studies (Carnes,1990), Cheney (1982) have found that SL derived from altimeter and subsurface temperature are highly correlated. The correlation between SL and SST is 0.6 (Nerem,1997). Coupled Pattern Analysis (CPA) between global SL and SST presented annual cycle accounts for nearly all (95.3%) of the covariance. The spatial and temporal coefficients of the primary mode of a nonseasonal CPA are correlated with ENSO events (Eric,1999). Here, we estimated characteristics on the variations and the correlations of SL and SST, and examined Empirical Orthogonal Function (EOF) analysis in the North East Asian Seas (Fig.1).

2. DATA AND METHOD

Map of Sea Level Anomaly (MSLA) altimeter data have been generated for over 5.4 years, from October 1992 to May 1998, using AVISO GDR-M products for Topex / Poseidon (T/P), cycles 3 to 210. MSLA was corrected for instrumental errors, environmental perturbations, ocean wave influence, tide influence. CSR3.0 tidal model and ECMWF dry troposhperic and inverse barometer corrections are applied. MSLA are obtained using improved space/time objective analysis methods which takes into account long wave errors(Le,1998). The maps have resolution of 0.25 degrees by 0.25 degrees. The MSLA data temporally low-passed at 140 days cut off in order to remove tidal aliasing errors in shallow water. The Optimum Interpolation (OI) Sea Surface Temperature (SST) is produced weekly on a one-degree grid. It was removed the tidal aliasing errors from SSH data, and EOF analysis is applied to the 67 months of SL and SST data.

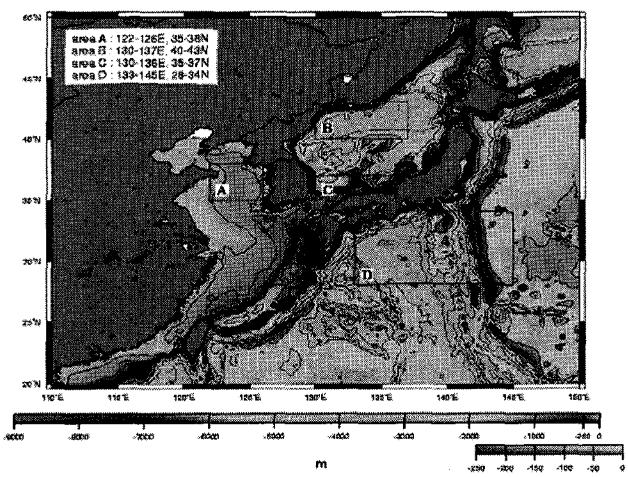


Fig. 1. Schematic map shows bottom topography in the North East Asian Seas. Area A presents the Yellow Sea, Area B the East Sea, Area C the Japan Sea and Area D the North Pacific Sea, respectively.

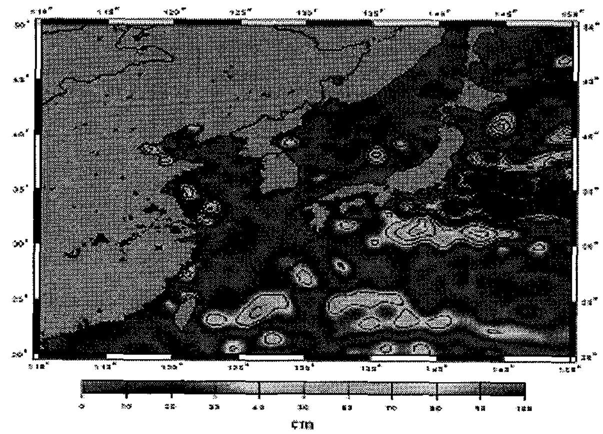
3. RESULTS AND DISSCUSION

In the eastern sea of Japan, SL showed a strong variations of 50-100cm in the region of Kuroshio extension with eddy activity and meandering (Fig. 2a). SST presented a small variations of 0.0-0.1℃ because of the continuous heat compensation of Kuroshio Warm Current (Fig. 2b). This region maintained the characteristics of oceanic climate. In the eastern sea of China, SL presented a small variations of 0-10cm in the Yellow Sea and the Southeast China sea (Fig. 2a).

But SL showed a strong variations of 50-90cm in the coastal areas of the Yellow and Yangtze river with eddy activity because of the confluence area between the China Continental Coast Waters and the huge freshwater. SST presented a strong variations of 0.3-0.6℃ (Fig. 2b).

Here, the high deviation of SST between Summer and Winter means a distinct seasonal variations. This region maintained the characteristics of continental climate. For variations and correlation of SL & SST (Fig. 3), they showed a remarkable seasonal variations and correlation coefficient was 65%, and then RMS was 5.1cm for SL and 3.9℃ for SST. The trends of SL and SST increased gradually in all periods as SL is 0.8cm/year and SST is 0.29℃/year.

(a)



(b)

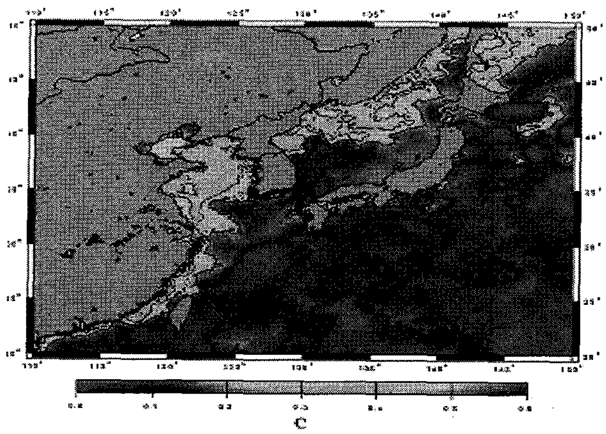


Fig. 2. Variations of (a) sea level and (b) sea surface temperature from 1993 to 1998.

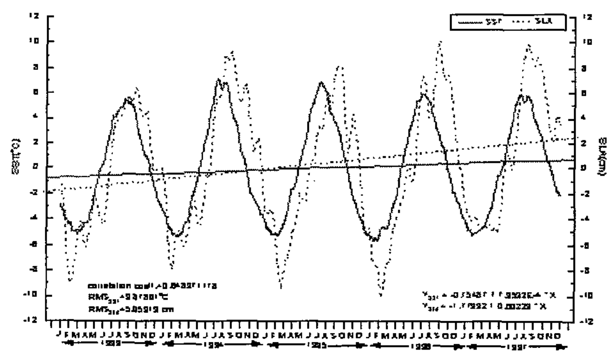
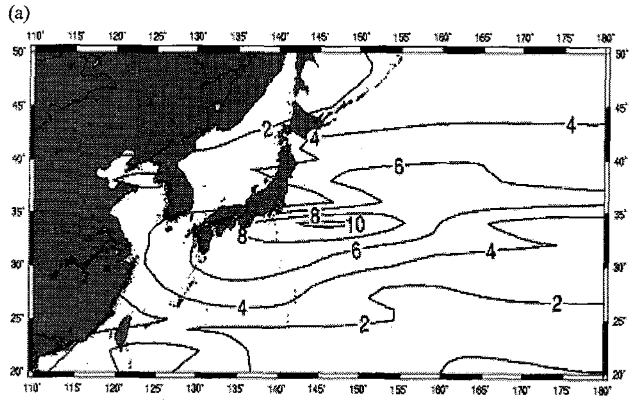


Fig.3. Trends of mean sea level anomaly and sea surface temperature anomaly from 1993 to 1998.

For the annual mode of EOF analysis (Fig. 4 and 5), the variance of original data of SL was 57% (first mode: 40%, second mode: 17%) and those of SST was 97% (first mode: 94%, second mode: 3%). In spatial structure for first mode(Fig. 4a and 5a), SL showed strong annual variation in the region of Kuroshio extension and bottom topography, and SST presented annual variation in the northern part of Yellow Sea and East Sea. In temporal structure for first mode (Fig. 4b and 5b), SL and SST showed dominant annual variation in the Kuroshio region.

(a)



(b)

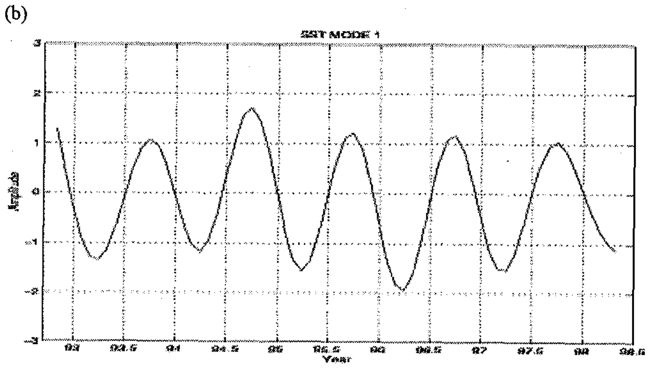


Fig. 4. (a) spatial field and (b) temporal amplitude of the first mode(40%) for SL.

(a)

(b)

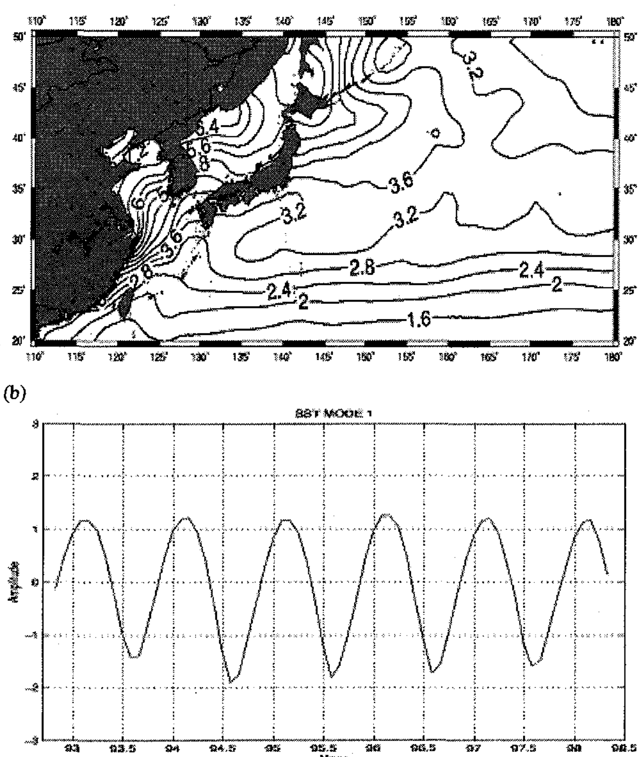


Fig. 5. (a) spatial field and (b) temporal amplitude of the first mode(94%) for SST.

Fig. 6 and 7 show (a) cross spectral density and (b) phase between SST and SL in Area A and B in the North Asian Seas, respectively. Here, Area A is the Yellow Sea that is influenced by the continental climate and Area D is the East Sea that is influenced by the oceanic climate. In the distributions of energy on cross spectral density, Area A and D showed simultaneously a remarkable peaks at the annual and semi-annual period. Area D had a high energy levels in all periods against to Area A because of a strong variations due to the Kuroshio Current. In the differences of phase, plus (minus) value means that variations of SST (SL) leading to those of SL (SST). In the annual period of phase, all Area A and D presented minus values with the leading of variations of SL. But in the semi-annual period of phase, Area A and D presented the mutual reverse values. That is say, the characteristics of plus value in Area A (minus value in Area D) is mainly decided by seasonal variations (influence of currents).

(a)

(b)

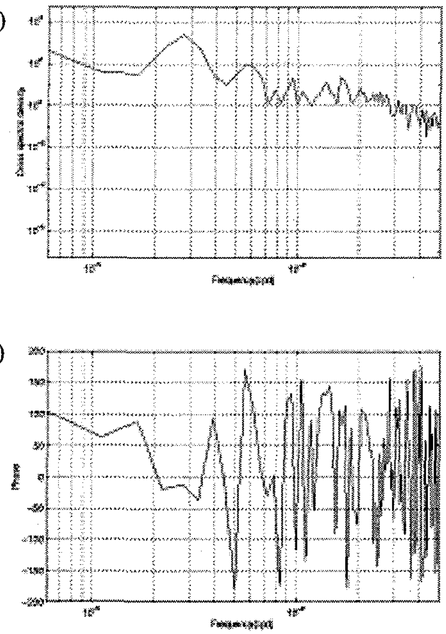


Fig. 6. (a) Cross spectral density and (b) phase between SST and SL in Area A in the North East Asian Seas.

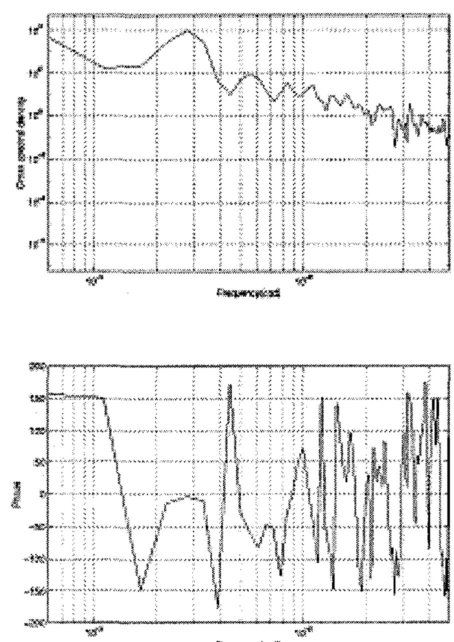


Fig. 7. (a) Cross spectral density and (b) phase between SST and SL in Area D in the North East Asian Seas.

4. CONCLUSIONS

The eastern sea of Japan maintained the characteristics of oceanic climate by Kuroshion current, and the eastern sea of China maintained the characteristics of continental climate by Monsoon. SL and SST increased gradually in all periods and then the slopes of SL and SST presented 0.84 cm/year and 0.29℃/year, respectively. Their correlation coefficient showed 65 %. It should be considered that the increment of SST and SL is caused by the global warming. In EOF analysis for SST and SL, 97% and 57% of the variance are represented by the first two modes with a strong annual variations expected for steric changes. The correlated annual variations of SST and SL was dominant in the region of Kuroshio. The second mode of SST shows 3～4 month offset, but that of SL presented a long-term variations.

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