Variation of the Sea Level in the Korean seas Using Altimeter Data (TOPEX/POSEIDON)

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Abstract -- A merged altimeter data products are used to estimate sea level variation in the East Sea between 1993 and 2006. The altimeter data show a high correlation coefficient (0.85) after applying gaussian low pass filter for 180days at Ulleung island. The both of Mukho coast and Ulleung island are minimal sea level in March to May and maximal in September to November. Sea level of Mukho coast is higher than that of Ulleung island during March to May, while Mukho coast is lower during September to November because the North Korea Cold Current flows along the coast line of Mukho. Generally sea level variation at Mukho coast and Ulleung island associated with seasonal variations.

Index Terms -- Sea Level, Altimeter Data, East Sea, Filtering

I. INTRODUCTION

Sea level is one of the most significant parameter as describing the ocean dynamics. The phenomena in the ocean, such as the ocean circulations in the middle and large scales, the energy exchange in the ocean-atmosphere interface, the climatic fluctuations, EL Nnio, etc. are strongly related to sea level changes. Satellite altimeter data have contributed to very well understand various oceanic phenomena in the world ocean. The East Korean Warm Current (EKWC) flows northward and meets the North Korea Cold Current at 38~39°N near Korean coasts. Meandering of EKWC and a large warm water mass near Ulleung island are permanent features off the east coast. Some eastward flows are observed along the Subpolar Front and a large meander often forms in the around of Ulleung island. The interior of the meander crest forms the Ulleung Warm Eddy (UWE) [1], [2], [3]. This warm water is referred to as the Ulleung warm lens [4]. The large variance of monthly mean sea level at Ulleung island might be associated with the path variability of EKWC [5].

This study mainly focused on estimating variation of sea level around Korean coasts by using altimeter data, and to find connections among oceanographic phenomena such as TWC, EKWC and UWE.

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II. DATA

We used gridded delayed time products (DT-MSLA : Delayed Time Map of Sea Level Anomaly) for estimating the characteristic of sea level at the Korean coasts. In delayed time, it is to maintain a consistent and user-friendly altimeter database by SSALTO/ DUACS system using the state-of-the-art recommendations from the altimetry community. The Korean peninsula is surrounded by the East Sea, the Yellow Sea and the South Sea, and they have the very different environmental characteristics. In this study, we studied sea level variations about each sea, especially the East Sea, after dividing four area near Korean coasts based on Oceanographic Atlas of Korean Waters of Korea Ocean Research & Development Institute (KORDI) (Fig. 1).

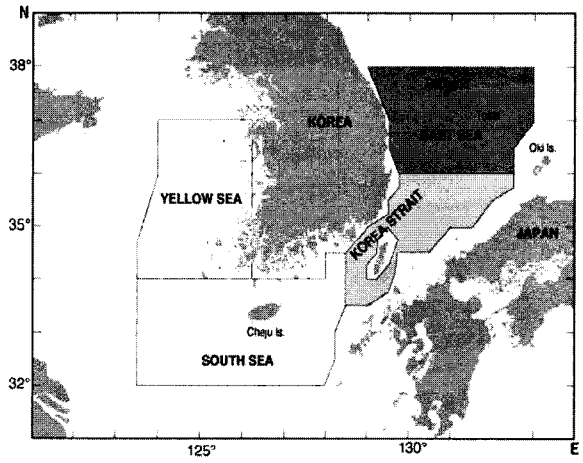


Fig. 1 Oceanographic atlas of the Korean waters (KORDI).

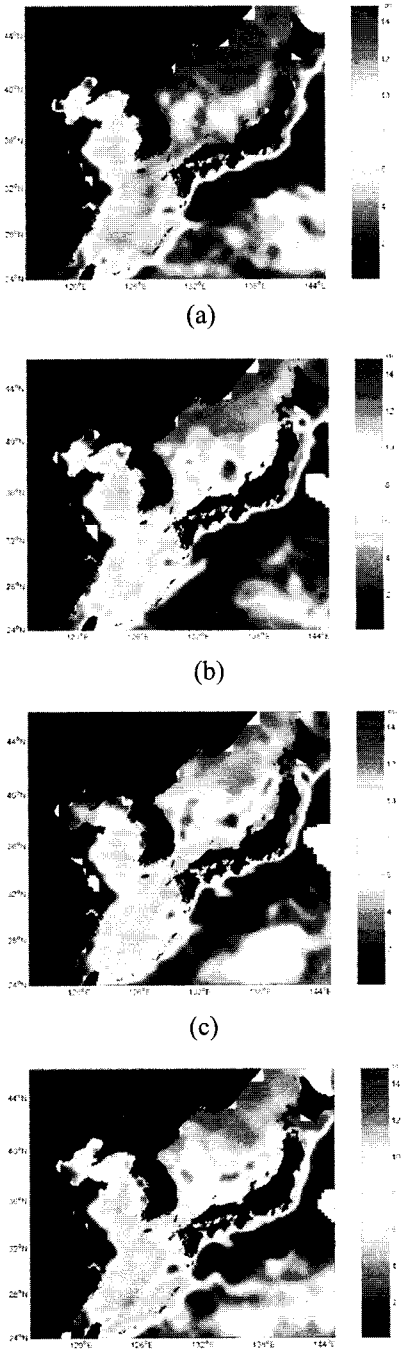
III. RESULTS AND CONSIDERATION

3.1 Seasonal variability of sea level

We used RMS (Root Mean Square) in order to estimate sea level variability and eddy at the surrounding seas of Korea. RMS explains dynamic phenomena in the ocean such as meander, mixing turbulence, eddy and sea level variability and mass transport, etc.

Fig. 2 shows the seasonal characteristics of sea level variability. The sea level variability near Ulleung island (37.49E, 130.91N) presents high values all over the season by 9~12cm. This high value (9~12cm) in this area correspond to warm eddies. The separated EKWC from

TWC meets the southward flowing North Korean Cold Current. Some branches that flow eastward is observed along the Subpolar Front and a large meander often forms in the near of Ulleung island. The interior of the meander crest generates the Ulleung Warm Eddy (UWE). Moreover, EKWC splits into two branches with the main branch meandering around Ulleung island and a minor branch flowing northeastward to contribute to the Subpolar Front [6], [7]. This main branch meandering will affect on this areas where RMS is high.



(a) (b) (c) (d)

Fig. 2 Distribution of RMS variability of sea level from 1993 to 2006, (a) Spring, (b) Summer, (c) Autumn and (d) Winter.

3.2 Harmonic analysis

Annual-amplitude variation shows about 7~13cm (Fig. 3a) in the surrounding seas of Korea. The annual-amplitudes in the East Sea are 6~8 expect the southeastern of Ulleung island, where the annual-amplitudes are 9~10. The Yellow Sea has 8~9 and the South Se indicates 9~11. The annual-amplitudes of 11~13 in the Korea Strait are much higher than other areas. As shown in Fig. 3(b), the annual-phase variability presents that the maximum annual sea level in the surrounding seas of Korea occurs between on the early August (240°) and the early of September (280°). The phase of annual sea level variation in the East Sea is reached the maximum between the middle of September (290°) and the middle of October (320°). The annual-phase of the early of July (220°) to the early of August (250°) in the Yellow Sea is the fastest in other areas. The phase of the South Sea is from the end of August (260°) to the early of September (280°). The Korea Strait is almost similar to the South Sea.

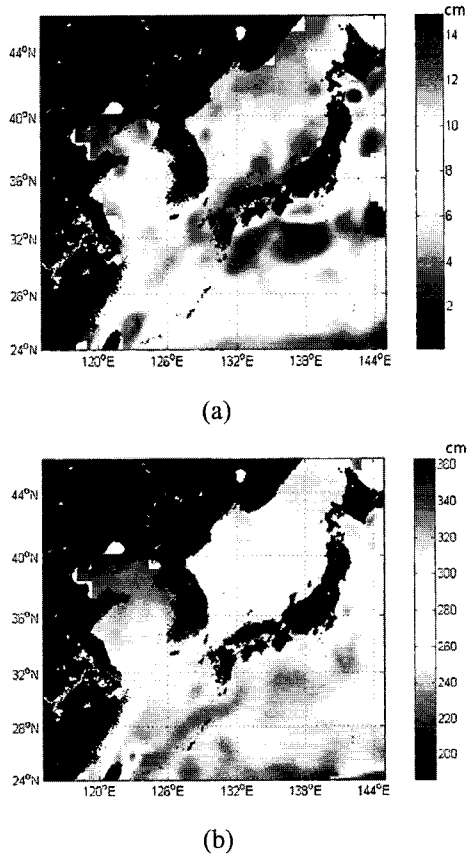
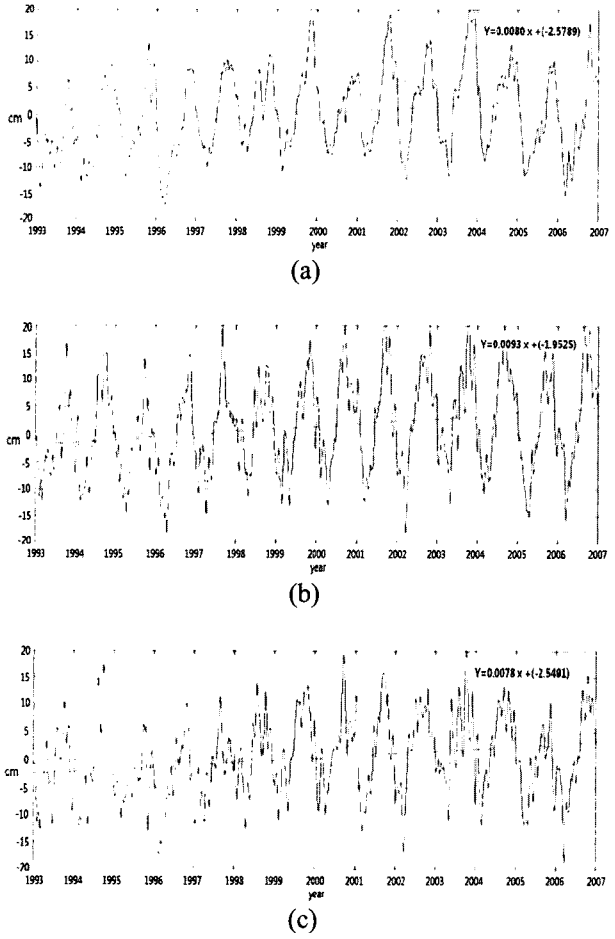


Fig. 3 (a) Annual-amplitude and (b) annual-phase in the harmonic analysis of sea level

3.3 Comparison among the East Sea, the South Sea and the Yellow Sea

We averaged spatially altimeter data to estimate sea level variations in the long term and the trend of the sea level among the East Sea, the South Sea and the Yellow Sea from 1993 to 2006(Fig. 4).

The trend of sea level in the East Sea is rising 4.16/yr and indicate that it rose 5.82 cm in 2006 against to 1993. The South Sea is the fastest in the study areas (4.89/yr, 6.84cm) and the Yellow Sea is 4.10 mm/yr and 5.75cm, respectively.



(a)

(b)

(c)

Fig. 4 Sea level variation in the long term and the trend of sea level in (a) the East Sea, (b) the South Sea and (c) the Yellow Sea during 14 years

3.4 Monthly mean sea levels at Mukho coast and Ulleung island

The monthly mean sea levels are shown in Fig. 5. The both of Mokho coast and Ulleung island are minimal sea level in March to May and maximal sea level in September to November. Sea level at Mukho coast is higher than Ulleung island during March to May, while Mukho coast is lower during September to November because influence of the North Korea Cold Current which flows along the coast line near Mukho.

Therefore, annual amplitude is low during spring season. On the other hand, Ulleung island is influenced on seasonal variation because it is located on the open sea. Thus, sea level between September and November is high and is low from March to May. Especially, sea level at Ulleung island shows minimal value at the early of spring due to strong cooling effects during winter season. As a result, sea level variation of the east coast near Mukho is dominant by the influence of the North Korea Cold Current, and those of Ulleung island is usually decided by the characteristics of seasonal variation.

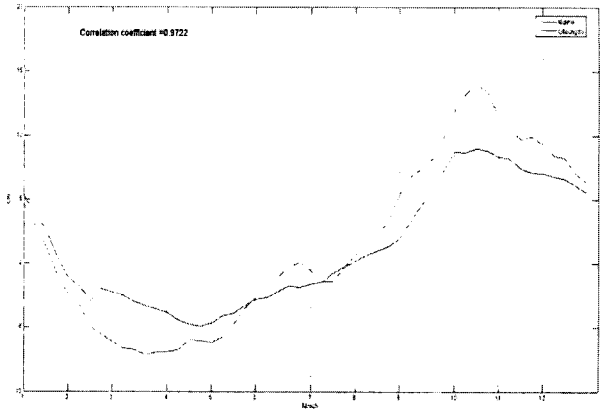
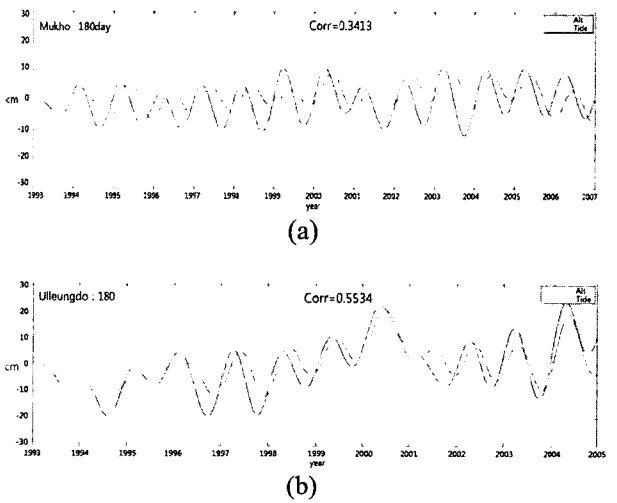


Fig. 5 Monthly mean sea levels at Mukho coast (blue line) and Ulleung island (red line)

3.5 Comparison of altimeter data (T/P) with tide gauge data (TG) in the long term

Fig. 6 shows the result of filtering for 180days at Mukho coast and Ulleung island between altimeter data (T/P) and tide gauge data (TG). Eight major tidal constituents (M2, S2, K1, O1, P1, Sa, N2 and K2) as signal noises influence strongly on the sea level variation in the long term and Discordance of interval both T/P and TG brings aliasing in the signal processing. And in order to know the sea level variations in long term and the change of oceanic climate in Korean Peninsula, Gaussian low pass filter used for 180 days.



(a)

(b)

Fig. 6 Low-pass filtered for 180 days in sea level between altimeter data (red line) and tide gauge data (blue line) at (a) Mukho coast and (b) Ulleung island

At Ulleung island where is located far from the coast, we can obtain a much higher correlation coefficient for 180days than for 30days after applying Gaussian filter for 30, 90 and 180days. The results of correlation coefficient showed high value in the period of 180days against to the period of 30, 90 days. Correlation coefficient presents high value because Ulleung island is comparatively located off the east coast. On the contrary, when we compared with Mukho coast, it presents different aspect with Ulleung island. Mukho where is adjacent the coast doesn't show a good correlation coefficient after filtering for 30, 90, 180 days, respectively. This reason is because Mukho is strongly influenced by coastal topography and coastal current, etc. than Ulleung island in the open sea.

IV. CONCLUSION

The sea level variability near Ulleung island (37.49E, 130.91N) presents high values all over the season. The sea level variations in the long term and the trend of sea level in the East Sea is rising 4.89 ㎜/yr and indicates that it rose 6.84cm in 2006 against to 1993. The both of Mokho coast and Ulleung island are minimal sea level in March to May and maximal in September to November. Sea level at Mukho coast is higher than Ulleung island during March to May, while Mokho coast is lower during September to November because influence of the North Korea Cold Current which flows along the coast of Mukho. Ulleung island where is located far from the coast, presented much higher correlation coefficient in the sea level variation of long term than Mukho where is located the coast.

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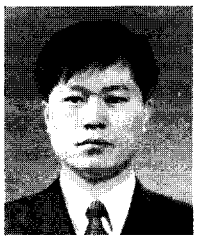

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