# Sea level observations in the Korean seas by remote sensing

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**Abstract**: Sea level variations and sea surface circulations in the Korean seas were observed by Topex/Poseidon altimeter data from 1993 through 1997. In sea level variations, the West and South Sea showed relatively high variations with comparison to the East Sea. Then, the northern and southern area in the West Sea showed the range of 20～30cm and 18～24cm, and the northern west of Jeju island and the southern west of Tsushima island in the South Sea showed the range of 15～20cm and 10～15cm, respectively. High variations in the West Sea was results to the inflow in sea surface of Yellow Sea Warm Current (YSWC) and bottom topography. Sea level variations in the South Sea was due to two branch currents (Jeju Warm Current and East Korea Warm Current) originated from Kuroshio Current (KC). In sea surface circulations, there existed remarkably three eddies circulations in the East Sea that are mainly connected with North Korea Cold Current (NKCC), East Korea Warm Current (EKWC) and Tushima Warm Current (TWC). Their eddies are caused basically to the influence of currents in sea surface circulations; Cyclone (0.03 cm/sec) in the Wonsan bay off shore with NKCC, and anticyclone (0.06 cm/sec) in the southwestern area of Ulleung island with EKWC, and cyclone (0.01 cm/sec) in the northeastern area of Tushima island with TWC, respectively.
**Key words**: Sea level variations, Sea surface circulations, Altimeter

## 1. Introduction

Change of ocean due to abnormal climate contributes the increase of sea level and sea surface temperature, sea level is 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 remote sensing. In this historical background, there are many observations of satellite from space to monitor the world ocean. Especially, altimetric data from satellite give very efficient informations for the studies on dynamic phenomena (sea level variations, sea surface circulations, waves, etc). Many excellent results have been accomplished in such fields of science by using very good quality data during several years [1-5].

Altimeter measurement have to be corrected by the environmental correction factors in order to gain the exact distance because radar waves (microwaves) propagate through every the atmospheric layers and were modified on sea surface. There are 2 domains that have various environmental corrections factors: the atmospheric and oceanic factors. Here, the aim of our study is essentially to know characteristics of sea level variations and sea surface circulations in the Korean seas.

## 2. Data and method

Map of Sea Level Anomaly (MSLA) altimeter data have been generated for over 5 years using the Archiving, Validation, and Interpretation of Satellite Data in Oceanography [6] GDR-M products for Topex/ Poseidon (T/P). The study area were selected over the entire Korean seas (115°～155°E, 20°～50°N) and cycles 12 to 195 covering a period from January 1993 to December 1997 (Fig. 1), and is composed of 3 basin scale oceans, the East Sea, the South Sea and the West Sea (Yellow Sea). Especially the West Sea has a very big tide and complicated tidal system, and 7% of the total global tidal energy is lost in this area [7].

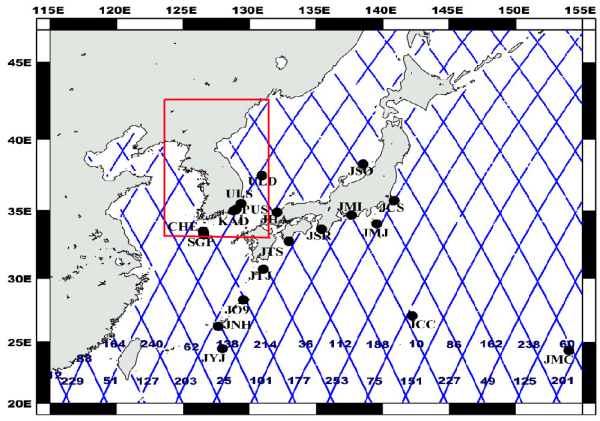


**Fig. 1. Topex/Poseidon ground tracks in the East Asian Marginal Seas. The float-operated type tide gauge location is indicated by circles. □ shows study area as the Korean seas.**

MSLA from all of the geophysical corrections and recommended editing criteria was corrected for instrumental errors, environmental perturbations, ocean wave influence, tide influence. CSR3.0 tidal model and ECMWF dry tropospheric and inverse barometer corrections are applied. MSLA are obtained using improved space/time objective analysis methods which takes into account long wave errors. The maps have resolution of 0.25 degrees by 0.25 degrees.

## 3. Results and Discussions

Fig. 2 shows sea level variations from RMS (Root Mean Square), and Fig. 3 shows distributions of sea level anomaly with the geostrophic currents and anticyclonic/ cyclonic eddies in sea surface of the Korean seas computed from T/P altimeter measurements collected over a period of 5 years. Sea level variations reveals

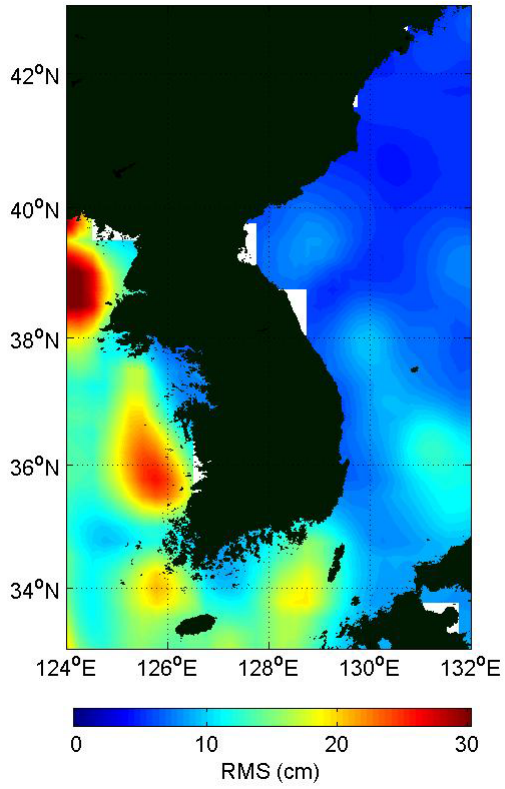


**Fig. 2. Sea level variations (cm) in the Korean seas.**

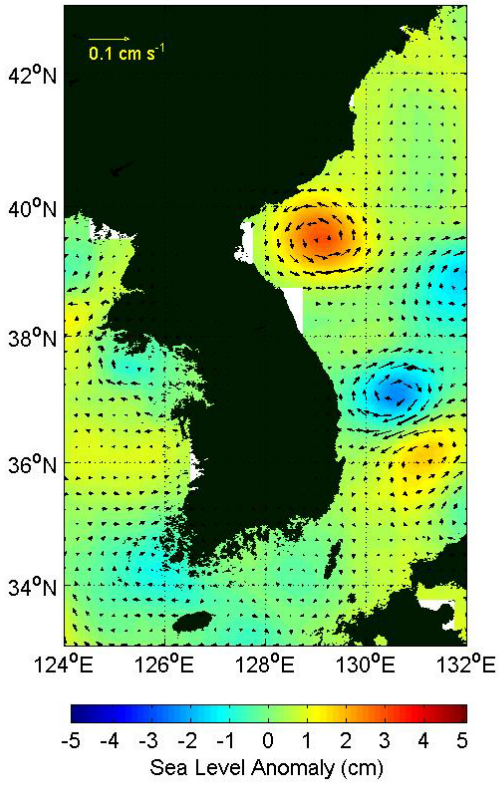


**Fig. 3. Sea level anomaly (cm) and geostrophic current (cm/sec) in the Korean seas.**

clearly the well-known, strong current-topography such as coastal current and Kuroshio Current (KC). Sea level variations, as defined here, can be considered as a statistical measure of temporal variations in major current systems. Sea level variations are totally strong in the West Sea (20～30cm in the northern part［centered to 39°N & 124°E)and 18～24cm in the southern part ［centered to 35.8°N & 125.8°E］) and the South Sea (15～20cm in the western part［centered to 34°N & 125.8°E)and the eastern part［centered to 33.9°N & 128.7°E］) for the Korean seas, excepting the East Sea (10～15cm in the southern part［centered to 36.2°N & 131.3°E)). Here, high sea level variations of the southern area in the West Sea were results to the northward current in surface of Yellow Sea Warm Current (YSWC) and influence of bottom topography. Also sea level variations of the western area as Jeju strait (the eastern area as Korean strait) in the South Sea have influenced by Jeju Warm Current (JWC), flows to clockwise along Jeju island, (East Sea Warm Current (ESWC), flows to northward along Tushima island) and bottom topography. That is say, Sea level variations in the West Sea and the South Sea were generally due to inflow in surface of three branch currents (YSWC, JWC and ESWC) originated from KC and influence of bottom topography in shallows waters. Sea level variations of the northern area shows the variation pattern of Inverted Barometric Effect (IBE) in West Sea because the gradient of IBE is a small, the other climatic effects (Monsoon, continental climate) will contribute to the sea level variations.

Sea level variations in the East Sea, mainly connected to eddies as Fig. 3 shows relatively low values with comparison to the West and South Sea. Then, sea level variations is only influenced by eddies without bottom topography. The northward Tushima current in the East Sea is divided to two branch as the northeastward extended flow in the western coast of Japan and the northward extended flow in the southeastern coast of Korea, respectively. Three eddies in the East Sea, with weak sea level variations, is confined to the northern area (Wonsan bay off shore, centered to 39.5°N & 129°E), the southern area (southwestern area in Ulleung island, centered to 37°N & 130.5°E) and the eastern area (northeastern area Tushima island, centered to 36°N & 131°E). their eddies are caused basically to the influence of currents in sea surface circulations. Cyclone (0.03 cm/sec) near the Wonsan bay was connected with North Korea Cold Current (NKCC), and anticyclone (0.06 cm/sec) near Ulleung island with East Korea Warm Current (EKWC), and cyclone (0.01 cm/sec) near Tushima island with Tushima Warm Current (TWC), respectively. Sea Level Anomaly (SLA) presents generally plus values in cyclonic eddies (divergence and upwelling) and minus values in anticyclonic eddies (convergence and downwelling) in the Korean seas. For SLA in the East Sea, the eastern area of Wansan bay (1～5cm) was higher than the southwestern area of Ulleung island (-5～-1cm) and the northeastern area of Tushima

island (0.5～1.5cm). SLA of the West Sea showed the range of 1-2cm in the middle area (35.5～36.5 °N and 124～126.5°E).

## Summary

Sea level variations in the West and South Sea was influenced generally by the inflow in sea surface of coastal currents (Yellow Sea Warm Current, Jeju Warm Current and Korea Warm Current) and the bottom topography in shallow waters (coastal area of the West Sea, Jeju strait and Korea strait). Although the East Sea presented remarkably sea surface circulations with eddies activity comparison to the West and South Sea, it showed a weak sea level variations without influenced of the bottom topography .

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