Sea level observations at Kerguelen island in the South Indian Ocean by ARGOS satellite data

H.-J. Yoon, Y.-S. Kim*, A.-S. Suh, H.-S. Chung**, M.-H. Ahn****
Dep. of Ocean Engineering, Division of Ocean System, Yosu National University
Dep. of Satellite Information Science, Division of Earth Environments, Pukyong National University
Remote Sensing Research Laboratory, Meteorological Research Institute, KMA

ARGOS 위성 자료를 이용한 남인도양 케르겔른섬의 해수면 조사

윤홍주, 김영섭*, 서애숙**, 정효상**, 안명환**
여수대학교 해양시스템학부 해양공학과
*부경대학교 지구환경학부 위성정보학과
**기상청 기상연구소 원격탐사연구실
yoonhj@yosu.ac.kr

Abstract

We observed sea level variation of the long time term at Kerguelen island in the South Indian Ocean with ARGOS data and meteorological data during about 1 year(May 1993~March 1994) through using filter, spectral analysis, coherency and phase, and found characteristics for the two oceanic signal levels(detided oceanic signal level, $h_{detided}$ and seasonal oceanic level, $h_{corr.ib}$). The forms of variations are very well agreed to between ARGOS data and meteorological data for atmospheric pressure in the observed periods. The seasonal difference of sea level between Summer and Winter is about 1.6cm. Both the detided oceanic signal level($h_{detided}$) variation and the inverted barometer level(h_{ib}) variation have a strong correlation for T>1day period bands. Characteristics of $h_{detided}$ variation are decided not by the influence of any meteorological distributions (pressure, winds, etc.), but the influence of another factors(temperature, salinity, etc.) for T>2days periods bands. $h_{corr.ib}$ plays an very important role of sea level variation of the long time term(especially T>about 180days period bands).

Key Words : ARGOS satellite, Sea level, Inverted barometer

1. Introduction

Sea level variation with the lapse of time shows the spatial and temperal scales in the ocean. This presents many various phenomena with hourly, dialy, seasonal, annual and centurial, and the range from 10km to several 1000km. A regular tidal phenomena, a remarkable and frequent upwelling according to the meteorological distributions and a wave due to a typhoon in small-scale, a wind and pressure in relation to circulation of the ocean in meso-scales, a wave which is occurring to extend over all the space in sea level variation, a phenomena of El Nino in connection with the evolution of climat in annual sea level variation of water temperature(the steric variation) and of water variation(the eustatic variation) due to a freezing or melting of continetal glaciers in sea level variation of the long term, and a geometric variation of the basin of ocean in sea level variation of the very long term. Several sea level variation due to various phenomena as mentioned above becomes oceanic signal levels which have directly or indirectly an influence on sea level variation in the oceans.

A striking climatological characteristics is occurred at Kerguelen island in the South Indian Ocean and a huge continental Self is located in the northern area of this island. This area presents a Sea Surface Temperature(SST) of minus anomalies, a high heat losses of -200W/m2 in the Austral Winter, and a wind stress and its curl of maximal values(Taljaard and Von Loon, 1984). having a bearing the oceanic environments of this area, several hydrological and dynamical studies had concretely and in detail carried out by Park et al.(1992, 1993).

The essential main point of our study gains a better understanding on characteristics both of detided oceanic signal level($h_{detided}$) and of seasonal oceanic signal($h_{corr.ib}$) among oceanic signal levels which contributing to sea level variations in this area.

2. Oceanic signal levels

The absolue sea level which is measured from the reference of geodetic surface gives generally expression to the sum of various kinds of oceanic signal levels as following as(Chelton and Enfield, 1986);

$$h_{sl} = h_t + h_p + h_w + h_e + h_s + h_c + h_g + r \quad (1)$$

Thus from various obvious facts of the above in our study, equation(1) can be simply presented as followings as;

$$h_{sl} = h_t + h_{ib} + h_s \quad (2)$$

$$h_{detided} = h_{sl} - h_t \quad (3)$$

$$= h_{ib} + h_s \quad (4)$$

$$\text{with } h_{ib} = h_p - \overline{h_p} \quad (5)$$

also equation(3) and (4) can be again written as followings as;

$$h_{corr.ib} = h_{detide} - h_{ib} \tag{6}$$

$$= h_s \tag{7}$$

here, $h_{detided}$ is detided oceanic signal level when h_t is only removed from h_{sl}, h_{ib} is inverted barometer level, that is say, this is anomaly of atmospheric pressure, and $h_{corr.ib}$ is seasonal oceanic signal level when h_t and h_p are removed from h_{sl}, respectively.

3. Data and Processing method

Atmospheric and bottom pressure, bottom water temperature(ARGOS data with dt = 1hour at ARGOS satation; 70°13′E and 49°20′S), and atmospheric pressure and winds(METEO FRANCE data with dt = 3hours at Port Aux Francais station; 70°14′E and 49°21′S) were used in our study during May 1993~March 1994. Sea level was computed and processed by hydrostatic equation and harmonic analysis.

4. Results and Consideration

Their shapes with the time changes are very well agreed between ARGOS data and meteorological data for atmospheric pressure during the observed periods. $dP = (P_{ARGOS} - P_{METEO})$ appears the differences of between atmospheric pressure at ARGOS(satellite data) and atmospheric pressure at METEO(in situ data), here dP does not shows the parallel line as a constant form at the observed periods. It should be considered that the irregular shaps of dP is cause to the seasonal and meteorological influences in this area. Bottom water temperature seasonally varies with a range of about 0~10°C.

A equation of regression of between bottom water temperature and dP is $Y_{mbar} = -0.53X_{℃} + 5.8558$ with X=4.856℃ and Y=3.219mbar for all data in the observed periods. As comparing bottom water temperature and dP after using the low-pass filter(gaussian filter) with T= 3day-period cut-off, they represent completely a anti-correlation with a correlation coefficient of r=-0.8229. It could be devided by the seasonal characteristics from the concentration as group 1 and group 2; group 1 represents the Spring and Summer in Southern Hemisphere(October~December 1993 and January~March 1994) and group 2 the Autumn and Winter in Southern Hemisphere(June~September 1993). Then two equation of regression for both group 1 and group 2 are $Y_{mbar} = -0.4518X_{℃} + 5.2045$ in Summer and $Y_{mbar} = -0.4325X_{℃} + 5.7230$ in Winter, respectively.

In power spectrum density for (a) h_{sl}, (b) h_t, (c) $h_{detided}$ and (d) BWT. When setting on the basis of T=3days period, h_{sl} variation shows a high values of energy in all the band and h_t variation a very low values of energy in all the band excepting several stronger peaks of energy in T<3days period bands. Thus these phenomena mean that tides(high frequency tides) do not greatly contribute to h_{sl} variation of the long term changes as compared with $h_{detided}$ variation in distributions of energy of all the period bands. So to speak, this should be explained that BWT with the seasonal and annual time scales contributes to h_{sl} variation of the long time term.

The results of the above show an important bearing on the relations of detided oceanic signal level, $h_{detided}$ to inverted barometer effects, h_{ib}. Thus giving attention to both $h_{detided}$ and h_{ib} this two oceanic signal levels appear almostly a smilar form with the lapse od time. So that, this two oceanic signal levels had dealed with gaussian's the low-pass filter method(T=3days period cut-off) in order to know exactly periodicity or regulation of their mutal relation. Here we can know that there is a strong correlation between $h_{detided}$ variations and h_{ib} variations with r=0.87. This means that oceanic signal level by inverted barometer effects is the most superior among all the oceanic signal levels for contributions of sea level variations.

As comparing with $h_{detided}$ and h_{ib} through spectral analysis, *cm*, coherency, r^2 and phase, θ . $h_{detided}$ appears sea level of both about 4.8cm in T=about 10days period and about 5.6cm in T=about 180days period and h_{ib} appears sea level of about 6.6cm in T=about 10days period in spectral analysis, and these two levels($h_{detided}$ and h_{ib}) shows a good relation with r^2=0.46(here, confidence level is 95%) for T>1days period bands in coherency squard. $h_{detided}$ response to atmospheric forcing distributions is advanced than h_{ib} response in the high frequency(T<2days period bands) but contrastly $h_{detided}$ response to atmospheric forcing distributions id slower than h_{ib} response in the low frequency variation(T>2days period bands) in phase. The results of the above means that characteristic of variation of $h_{detided}$ are decided not by the influence of any atmospheric forcing distributions(pressure, wind, etc) but by the influence of another factors(temperature, salinity, etc) as having the turning point of T>2days period bands in the long term variations.

Sea level variations present usually a range of a distinct variation of about semi-annual or annual seasonal characteristics(six or twelve months periods) with amplitudes of 2~3cm in low latitude and of about 10cm in high latitude in monthly and annual time scales. Seasonal oceanic signal level, $h_{corr.ib}$, variations are basically caused by simutaneously seasonal modulation of meteorological effects and thermal structure of sea surface(warming up or cooling down by seasonal variations in sea surface). As thinking over $h_{corr.ib}$ variations in sea level variations, there are a necessity for knowing their relationship between seasonal oceanic signal level, $h_{corr.ib}$ and variation of BWT. In the low-pass filtering with a cut-off at 3day period for both $h_{corr.ib}$ and BWT, and the power spectrum density of $h_{corr.ib}$ of T>3days period bands. here we can know that $h_{corr.ib}$ varies approximately with a form of sine function in relation to seasonal variations of BWT with a certain regulation during this observed periods, and that then $h_{corr.ib}$ has generally a high peak of energy in the long term. that is say, it should be explained that seasonal oceanic signal level($h_{corr.ib} \cong 6.2\sin(\frac{\pi}{2}t+\frac{\pi}{6})$, unit: cm) due to steric changes by seasonal water temperature variations contributing to sra level variations of the long term in monthly and annual time scales.

For the presents of energy(PSD/total PSD) in T>10days period bands for both $h_{detided}$ and $h_{corr.ib}$, then $h_{detided}$ and $h_{corr.ib}$ have about 12.3884cm and 7.4268cm for RMS, and about 30% and 80% for the percents of energy, respectively. This means that a contribution of $h_{corr.ib}$ is superio to that of $h_{detided}$ in sea level variations of the long term(T>100days period bands).

5. Conclusions

Many human activities, both agricultural and industrial, are causing the emission of increasing quantities of ploy-atomatic molecules into the atmosphere. We know that the green effects causes a general warming of the lower atmosphere and earth surface, and a compensation cooling of the upper atmosphere. The augmentation of temperature brings about on a global rise in mean sea level resulting of meltwater from glaciers and polar ice caps and to the thermal expension of sea water. generally an upper limit of 60cm be estimated for the rise in global sea level by the end of the next century(Welander, 1990), but this estimate is fraugt with large incertains. But whatever parameters contribute to sea level rise, our deep interests should have to be paid attention to sea level variations as a global warning for the Earth's environments.

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