Ocean Science Symposium 2015, Busan

Poster Session :

27-Oct-2015, 13:30 – 14:20

Ocean Science Symposium 2015, Busan
27-Oct-2015, 13:50-14:30, Poster Session

Observed structures and dynamics of the subsurface currents in the Philippine sea

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Abstract

This study investigate the structures and dynamics of three subsurface currents, namely the Mindanao Undercurrent (MUC), the Luzon Undercurrent (LUC) and the North Equatorial Undercurrent (NEUC), in the Philippine Sea using high-resolution observations of WOD09 and Argo floats. The three subsurface currents are confirmed below and in opposite direction to the Mindanao Current (MC), Kuroshio and the North Equatorial Current (NEC), respectively, in climatologic sense by multi-section analyses. MUC presents two velocity cores and NEUC can also be divided into two parts. The offshore part of MUC, carrying South Pacific and equatorial Pacific waters, turns east to feed the southern NEUC at 9-10°N. The inshore part of MUC flows northward near the coast and can be traced to at least 10.5°N. Water mass analyses suggest that the northern NEUC may originate from the confluence of LUC and inshore MUC. The formation mechanism of these undercurrents is also examined by testing the criterions for subsurface inversion of geostrophic velocity proposed by Wang and Hu [1999]. The emergence of subsurface countercurrents is tightly associated with the opposite horizontal gradients of sea surface height (SSH) and the depth of the thermocline (DTC) induced by basin-scale wind stress. According to the westward intensification of ocean currents, slopes of DTC and SSH are significantly strengthened near the western boundary, leading to strengthening of subsurface currents below thermocline.

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Ocean Science Symposium 2015, Busan
27-Oct-2015, 13:50-14:30, Poster Session

Distinct characteristics of East Sea Intermediate Water in response to varying western boundary current

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Abstract

The intermediate water known as 'East Sea Intermediate Water' and its coastal mode 'North Korean Cold Water' found south of the Subpolar Front (SF) is formed in the northern East (Japan) Sea, and its physical properties are known to be determined by wintertime air-sea interaction north of the SF. Hydrographic data collected off the coast bi-monthly from 1994 to 2011 show significant decadal oscillations in spiciness (π) following isopycnals of intermediate water (27.1-27.2$\sigma\theta$), which are explained by the Arctic Oscillation (AO) and consequent cold-air outbreaks. During positive AO phases over the decades, the cold-air outbreak and water formation are more active and the intermediate water having the same π reaches higher density (higher π following the same isopycnals). At interannual timescale, however, the π variability is well beyond the relationship with the AO. Especially, lower π (or both less saline and lower temperature) intermediate water was observed in spring of 2010 than 2001 under nearly the same winter condition for water mass formation in the northern area. Strong cooling with negative peaks in surface net-heat flux and common negative peaks in the AO index are prominent in winter of those two years over the past two decades. Such contrasting characteristics of intermediate water between 2001 and 2010 are consistent with the HYCOM reanalysis results which, along with the satellite altimetry-derived sea surface height maps, indicates widespread extension of low (high) π intermediate water in the southwestern East Sea in 2010 (2001). A clear contrast in circulation pattern results in the different characteristics of the intermediate water. Northward penetration of the East Korea Warm Current (EKWC) inhibits the southward extension of the intermediate water in 2001. On the other hand, the EKWC was poorly developed in 2010 due to southward shift of separation point of the Tsushima Warm Current in 2010, which allows low π intermediate water to prevail in the southwestern East Sea.

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Ocean Science Symposium 2015, Busan
27-Oct-2015, 13:50-14:30, Poster Session

Time-Depth Variations of Equatorial Currents in the Western Pacific Directly Observed by Subsurface Moorings

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Abstract

The time-depth variations of surface, subsurface and intermediate equatorial currents in the western Pacific were directly measured by two acoustic Doppler current profiler moorings at 2°N and 4.7°N, 140°E during January-August 2014. The mean structure and variability of the North Equatorial Countercurrent (NECC), northern branch of the South Equatorial Current (SEC), Equatorial Undercurrent (EUC), Equatorial Intermediate Current (EIC), North Intermediate Countercurrent (NICC) and North Equatorial Subsurface Current (NESC) are further distinguished, by giving some credit for previous studies and some new findings. The 8-month time series of velocity profiles reveal the larger vertical ranges of SEC and NESC, the deeper EIC and NICC, and much larger velocities of NICC and NESC, and capture the reversals of the EIC in May and the NESC in June from westward to eastward. Significant intra-seasonal variations of the NECC, EUC, EIC, NICC and NESC are observed and, with the help of the model and satellite data, the combined variability in current route and intensity are found to determine the observed intra-seasonal variations of the NECC, EUC and EIC. During January-April 2014, the route and intensity of the NECC are found to be almost southernmost and minimum over the past twenty years, respectively, and possibly associated with the fickle El Niño of 2014.

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The observation study of instruction process of Kuroshio Bottom Branch Current to the northeast of Taiwan in spring

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Abstract

A series of cruises were carried out to investigate the spring process of Kuroshio Bottom Branch Current to the northeast of Taiwan (KBBCNT) from February to July 2015. As indicated by the high salinity water distribution, the intrusion of the KBBCNT from the northeast of Taiwan to Changjiang river mouth has existed through the whole spring. The intrusion was enhanced from March to June but weaken since July. The weaken is also proved by the three ADCPs moorings observation out of Changjiang River mouth and north of offshore of Zhejiang in 2014. The velocity observations indicated an increase of bottom residual current from June and reach maximum in July but decrease afterward. This work indicate the instruction of KBBCNT reaches the maximum in July and clarify the instruction process in spring.

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Factors leading to the spreading of the Changjiang freshwater into the Yellow Sea interior in 2012

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Abstract

Abnormally low-salinity water originated from the Changjiang River (CR) was observed at the central Yellow Sea in 2012, which is quite unique compared to other years. Here, we have examined the intruding processes of the freshwater into the Yellow Sea interior by characterizing and quantifying the results from a regional ocean hindcast over the past 10 years with particle-tracking experiments. The particles representing the behavior of Changjiang freshwater are released continuously at the CR mouth from May to August, and then tracked.

Our model reproduces the observed low-salinity water from the CR as well as their spatial patterns, emphasizing on the freshwater intrusion into the YS interior in 2012. The particle-tracking analysis shows that the largest intrusion of the particles into the YS occurs in 2012 with 19.6% of total particles released during the four months, and second in 2008 (14.7%). In contrast, only 6% particles entered into the YS in 2003. The freshwater flowing into the YS can be explained by three leading factors tidal residual current along the Chinese coast, passage of typhoons, and transition in wind pattern. The processes and effects of each factor will be presented.

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Tropical-subtropical exchange in the Pacific Ocean based on Argo profiles and ship measurements

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Abstract

The tropical-extratropical exchange in the northwestern Pacific Ocean is studied using the absolute geostrophic currents based on Argo Profiles and the observations of the western boundary currents (WBCs) during two cruises in the winters of 2010 and 2012. The absolute geostrophic currents are calculated using the P-vector method for the period of 2004 through 2011. The transport of the geostrophic currents is compared with the Sverdrup theory and found to differ significantly in several locations. Analyses have shown that errors of wind stress estimation cannot account for all of the differences. The largest differences are found in the area, where nonlinear activities are vigorous, suggesting that the linear dynamics of the Sverdrup theory is deficient in explaining the geostrophic transport of the tropical northwestern Pacific Ocean.

Previous studies suggest recharge and discharge of the tropical Pacific Ocean heat content through the interior circulation of the North Pacific Ocean, based on the Sverdrup theory, and that the WBCs play the role opposite to the interior ocean anomalies. Using ocean observations from two cruises in a La Niña winter and a normal winter, it is suggested that the Kuroshio transport decreases significantly and the Mindanao Current transport increases significantly at the peak of 2010 La Niña, opposite to the prediction of existing understanding. The anomalies of the western boundary current transport are found much larger than those of the meridional circulation in the interior of the North Pacific Ocean. The results suggest that the WBCs play an important role in ENSO dynamics.

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Relationships between Basin Mode/Dipole Mode of SST Anomalies in the Tropical Indian Ocean and the ENSO Transition

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Abstract

Relationships between the basin mode/dipole mode of sea surface temperature anomalies (SSTA) in the Indian Ocean, after these two modes occur, and the El Niño-Southern Oscillation (ENSO) phase transition during the following year are examined in observations during the period 1958-2008. The boreal winter basin mode index/fall dipole mode index is shown to demonstrate robust negative correlations with SSTA in the equatorial central-eastern Pacific Ocean in the following summer through winter seasons. The lag teleconnections indicate that both the positive (negative) phases of the basin mode and dipole mode in the tropical Indian Ocean could lead to the El Niño (La Niña) decay and phase transition to La Niña (El Niño) during the following year. The cold (warm) SSTA in the equatorial central-eastern Pacific in the coming year originate from subsurface temperature anomalies in the equatorial eastern Indian and western Pacific Ocean, which propagate eastward and upward to meet the surface along the thermocline. And the eastward propagation of the upwelling (downwelling) Kelvin waves contributes to the thermocline displacement

Both the atmospheric bridge and oceanic channel between the tropical Indian and Pacific Ocean seem contributed to the dynamics of the lag teleconnection. The atmospheric wind anomalies in the equatorial western Pacific play an important role, especially in the relationship between the Indian Ocean basin mode and the ENSO decay and phase transition. The impact of the Indonesian throughflow transport anomalies is more significant for the lag teleconnection associated with the dipole mode.

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Atmospheric noise in the tropical Pacific and its relationship with the two types of El Nino

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Abstract

It is well known that the occurrence frequency of Central Pacific (CP) El Nino has been increased since the late- 1990s. In spite of a wealth of studies, however, the physical mechanisms to cause such a change still remain unclear. We hypothesize that the atmospheric noise plays a role to cause the increase of CP El Nino frequency since the late-1990s. To examine this issue, we analyzed the characteristics of atmospheric noise obtained from a simple statistical methodology before and after the late-1990s and we further conducted four model experiments using the Modular Ocean Model version 4 (MOM4) in which the statistics of atmospheric noise and mean state are different among model experiments. Model experiments showed that the atmospheric noise plays a major role to lead the CP-type El Nino after the late-1990s compared to the change in the mean state. We further examine the characteristics of atmospheric noise which forced the MOM4 before and after the late-1990s.

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Ocean Science Symposium 2015, Busan
27-Oct-2015, 13:50-14:30, Poster Session

Long-term variabilities of meridional geostrophic volumn transport in North Pacific Ocean

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Abstract

The meridional geostrophic volumn transport (MGVT) by the ocean plays a very important role in the climatic water mass and heat balance because of its large heat capacity which enables the oceans to store the large amount of radiation received in the summer and to release it in winter. Interactions between the oceans and the atmosphere are known to be a major cause of the climate fluctuations on interannual time scales (e.g. El Nino) and may be also a significant factor on decadal time scales (e.g. Latif 1998). Better understanding of the role of the oceans in climate variability is essential to assess the likely range of future climate fluctuations. In the last century the North Pacific Ocean experienced considerable climate variability, especially on decadal time scale. Some studies have shown that the North Pacific Ocean is the origin of North Pacific multidecadal variability (Latif and Barnett, 1994; Barnett et al., 1999). These fluctuations were associated with large anomalies in sea level, temperature, storminess and rainfall, the heat transport and other extremes are changing as well. If the MGVT of the ocean is well-determined, it can be used as a test of the validity of numerical, global climate models.

In this paper, we investigate the long-term variability of the MGVT in North Pacific ocean based on 55 years long global ocean heat and salt content data (Levitus et al., 2012). Very clear inter-decadal variations can be seen in tropical , subtropical and subpolar regions of North Pacific Ocean. There are very consistent variations between the MGVT anomalies and the inter-decadal pacific oscillation (IPO) index in the tropical gyre with cold phase of IPO corresponding to negative MGVT anomalies and warm phase corresponding to positive MGVT anomalies. The subtropical gyre shows more complex variations, and the subpolar gyre shows a negative MGVT anomaly before late 1970’s and a positive anomaly after that time. The geostrophic velocities of North Pacific Ocean show significantly different anomalies during the two IPO cold phases of 1955-1976 and 1999 to present, which suggests a different mechanism of the two cold phases. The long term variations of Sverdrup transport compares well with that of the MGVT in the basin of 8-10N and north of 35N, but the two compares poorly or even reversed in the middle part of the basin. A reduced gravity model is used to investigate the mechanisms of the above variations.

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Ocean Science Symposium 2015, Busan
27-Oct-2015, 13:50-14:30, Poster Session

Surface currents in the Northwestern Pacific Ocean observed by drifting bouys: A case study

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Abstract

Twenty six surface drifting buoys were deployed in the area 5~7°N on 165°E in June of 2014 as the MOF/Korea-NOAA JPA project and the Global Drifters Program. The drifter trajectories for one year reveal the general features of the surface circulation in the northwestern Pacific Ocean, e.g., the North Equatorial Current (NEC), the separation of the NEC into the Kuroshio and Mindanao Current (MC), the retroflection of the MC, the Kuroshio intrusion into the South and East China Seas etc. The NEC separation location was around 13°N in March and April of 2015. The fastest drifter velocity appeared in the North Equatorial Countercurrent with its estimated value of about 2 kn in June and July of 2015. Consecutive small circular structures indicating inertial motion and mesoscale eddies were observed mainly in the northern part of the NEC and the western Philippine Sea, respectively.

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Ocean Science Symposium 2015, Busan
27-Oct-2015, 13:50-14:30, Poster Session

The relationship between Pacific Meridional Mode and different flavors of ENSO

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Abstract

The Pacific Meridional Mode (PMM) is the first svd mode of surface temperatureand wind after ENSO signal is removed. Previous studies showed that PMM could act as a "trigger" of ENSO by inducing extratropical atmospheric variabilities into the central-western equator in the spring prior to ENSO events. In this study, based on NCEP CFSR reanalysis data and CCM3-RGO coupled mode results, we further explored the relationships between PMM and different flavors of ENSO, ie., Eastern Pacific (EP) and Central Pacific (CP) types of ENSO. Statistical results show that both types of ENSO events are proceeded by PMM events 3 seasons prior to peek, but evolves into different SST anomaly patterns since 7-8 months prior to peek. This discrepancy may be influenced by ocean preconditioning and local air-sea interactions in the central-western equatorial Pacific. Our results also imply that better simulation of PMM in coupled model might help improving ENSO forecasts

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Roles of ocean initialization and wind bias correction on ENSO predictability

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Abstract

El Niño and Southern Oscillation is one of the most well-known and important climate phenomena. Although the ENSO appears in the tropical Pacific, it interacts with climate variability over the world, which impacts the human life by various ways. KIOST has been developed an ENSO prediction system by applying the ocean data assimilation and wind bias correction to a fully coupled climate model, GFDL CM2.1. The ocean observation data are assimilated into its ocean component model through the data assimilation system of the KIOST (DASK) while other component models are freely integrated. Even though atmospheric observation variables are not assimilated, the wind bias of the DASK has been corrected through applying a simple wind bias correction when calculating the air-sea fluxes. We evaluated the variability of the ocean climate in the climate reanalysis by the DASK from 1947 to 2012. The DASK represents global temperature and salinity well, not only at the surface but also at intermediate depths in the ocean. The DASK's ocean climate variability also matches well with observations of the ENSO, Pacific Decadal Oscillation and Indian Ocean Dipole. The heat content of the DASK shows a good correlation with real-world observations. In this study, we use the reanalysis data from the DASK as an initial condition of our ENSO prediction system. To evaluate the ENSO prediction system, hindcast experiments have been conducted during 30 years from 1982 to 2011, which suggests that the ocean initialization and wind correction significantly improve the ENSO prediction skill. The sensitivity of the ENSO prediction skills to the ocean initialization and wind bias correction will be displayed in more detail in our study.

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Impact of Coupling and Model Resolution on Numerical Simulations of Typhoon Son-Tinh with a Regional Coupled Model

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Abstract

Numerical model is one of the main means to study typhoon process, and how to improve the precision of the simulation has become more important. Because of the insufficiency of the dynamic and thermodynamic mechanisms of typhoon process, the simulation of typhoon cases in previous numerical models is often difficult to achieve the observation. Based on the regional coupled model we developed recently, we set up a series of numerical experiments to simulate the typhoon case Son-Tinh occurred in the South China Sea in 2012. The NCEP FNL Operational Global Analysis data and HYCOM Global Analysis data are applied as initial and boundary conditions to all the experiments. The results indicate that air-sea coupling and higher resolution can improve the model capability to simulate typhoon process.

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Ocean Science Symposium 2015, Busan
27-Oct-2015, 13:50-14:30, Poster Session

Physical processes on the changes in air-sea interactions in the western tropical Pacific during boreal summer

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Abstract

It is found that the relationship between sea surface temperature (SST) and precipitation has been changed from a negative correlation to a positive correlation in the western tropical Pacific across the late-1990s. Before the late-1990s, for example, the anomalous warm SST in the eastern tropical Pacific can induce anomalous precipitation through low-level moisture convergence in the western-to-central tropical Pacific and Inter-Tropical Convergence Zone (ITCZ). Subsequently, enhanced cloudiness acts to reduce the incoming solar radiation, leading to the anomalous cold SST in the western tropical Pacific. On the other hand, after the late-1990s, the anomalous warm SST in the central tropical Pacific can also induce anomalous precipitation through low-level moisture convergence in the western-to-central tropical Pacific. However, cloudiness does not act to effectively reduce the incoming solar radiation, leading to a positive correlation of SST-Precipitation in the western tropical Pacific.

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Ocean Science Symposium 2015, Busan
27-Oct-2015, 13:50-14:30, Poster Session

Variability of temperature in Korea and its relationship with the western Pacific Ocean during boreal summer

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Abstract

This study investigates the variability of Korean temperature in South Korea on sub-seasonal timescales during boreal summer (June-July-August) and factors which have an influence on its variability. We mainly rely on the correlation analysis to examine factors affecting the summer temperature variability in Korea on sub-seasonal timescales. It is found that there exist some differences in temperature variability between early summer (June) and late summer (July-August) in terms of their temporal variability. In addition, the summer temperature variability during early summer and late summer has different connections from the tropical Pacific including the Indian Ocean. It is found that the Korean temperature variability during early summer has no significant relationship with tropical Pacific. In contrast, however, there exists remarkable influence in both the tropical Pacific and the Indian Ocean on the Korean temperature during late summer.

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Ocean Science Symposium 2015, Busan
27-Oct-2015, 13:50-14:30, Poster Session

Strengthened western boundary current overrides the effect of warming on lobster larval dispersal & survival

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Abstract

Climate change is projected to increase ocean temperatures and modify circulation patterns, with potential widespread implications on planktonic larvae of marine organisms. Understanding the impact of climate driven changes in larval dispersal is crucial to predict future species distributions, anticipate ecosystem shifts, and design effective management strategies. This study examines the effect of climate driven changes in circulation and temperature on larval dispersal in a region of rapid ocean warming. We use velocity and temperature fields from an eddy-resolving ocean model to simulate lobster larval dispersal under a contemporary and future (A1B carbon emissions) scenario. Our results show that the effect of changes in circulation and temperature can counter each other: ocean warming is favourable for the survival of lobster larvae, whereas a strengthened western boundary current reduces the total amount of larvae that reach the coast. Changes in circulation have a stronger effect on the connectivity patterns than the ocean warming, so that larval retention reduces by ~10% and the settlement peak shifts poleward by ~270km. Thus ocean circulation appears the dominant effect in climate-change-induced expansion of species ranges.

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Radioactivity in the Pacific Oceans: an overview and its potential to be tracers of ocean circulation

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Abstract

Many anthropogenic radionuclides such as ^{3}H, ^{14}C, ^{90}Sr, ^{99}Tc, ^{129}I, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Am have been released to the marine environment via for example, above ground nuclear weapon tests, the nuclear power plant accidents, or direct dumping of nuclear wastes. These man-made radionuclides have caused environmental problems of concerns on the one hand, they are on the other hand potential tracers of ocean circulation.

The Pacific Ocean have all these radionuclides with ^{3}H, ^{14}C, ^{90}Sr, ^{137}Cs, $^{239,240}Pu$ being most widely studied. For the year 2000, the estimated average ^{90}Sr, ^{137}Cs and $^{239,240}Pu$ activities in surface Pacific Ocean varied from 0.1 to 1.5 mBq/L, 0.1 to 2.8 mBq/L, and 0.1 to 5.2 mBq/L, respectively (Povinec et al., 2005). There are primarily two pathways to introduce radionuclides into the ocean. The predominant introduction is the global fallout from a series of large atmospheric nuclear weapons tests carried outat Novaya Zemlya and Marshall Islands, which released radionuclides into the stratosphere. Approximately 76% of the fallout was deposited in the Northern hemisphere. Fallout is maximal at mid-latitudes (30°-60°) and minimal at the equator and poles. The other significant contribution is local fallout originating from tests carried out at the Marshall Islands mainly in the 1950s. Due to the specific nuclear weapons design and test yields, different sources have different isotopic ratios. When these specific labeled radionuclides introduced to surface waters by wet and dry deposition or released into water from sediment that are dissolved in seawater and becomes constituents of seawater, they would be transported to different regions along with the ocean circulation. Therefore, the radionuclides can be powerful tracers providing basic insights into ocean circulation.

The Pacific Proving Grounds (local fallout) in the Marshall Islands islocated in North Equatorial Current (NEC), the branches of which form Kuroshio and Mindaneo Currents. Like animmortal machine, it continuously releases a series of tracers (^{3}H, ^{14}C, ^{90}Sr, ^{137}Cs and $^{239,240}Pu$ etc.) into water. Substantial excesses of measured inventories of ^{3}H, ^{14}C, ^{90}Sr, ^{137}Cs, and $^{239,240}Pu$ were indeed found at many locations in the Western North Pacific. The tracer data of ^{14}C and ^{3}H on a transect between Australia and Bail points to a main North Pacific origin of the waters that cross the Indonesian seaway from the Pacific to the Indian Ocean (Leboucher et al., 2004). Except for these traditional radioactive tracers to study marine processes (^{3}H, ^{3}He, ^{14}C), the plutoniumis also presentative of such kind of radionuclides. The average $^{240}Pu/^{239}Pu$ atom ratio of global fallout is 0.176 ± 0.014 (Kelley, et al., 1999), but the local fallout is characterized by higher ratio of 0.30−0.36 (Buesseler, et al., 1997; Muramatsu, et al., 2001). A case study in the South China Sea (SCS) showed that the high $^{240}Pu/^{239}Pu$ atom ratio water from the Marshall Islandscanbe still continuously

transported into SCS, along the NEC followed by the transport of the Kuroshio and its extension through the Luzon Strait (Wu, et al,. 2014). For tracing Indonesian throughflow (ITF) and South China Sea throughflow (SCSTF), plutonium can distinguish itself because one main origin of them was also NEC. Some high $^{240}Pu/^{239}Pu$ atom ratio signals have appeared in Makassar Strait, which is the main pathway of ITF (Yamada, et al., 2006). However, only depending on the plutonium isotopes, it appears tame and weak due to the complexity of the circulation. Radium isotopes may be alternatively helpful due to their higher water solubility and different half lives. It has been widely used in quantitative analysis of seawater mass and estimation of horizontal diffusion coefficients. The lower $^{228}Rn/^{226}Rn$ in the Kuroshio than that in the marginal sea makes them feasible to potentially differentiate ITF and SCSTF.

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Ocean Science Symposium 2015, Busan
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Impact of the Kuroshio intrusion on the seasonal and interannual variations of nutrient inventory in the northern South China Sea

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Abstract

We examined the seasonal and interannual variations of nutrient inventory influenced by Kuroshio intrusion in the northern South China Sea (NSCS). For the seasonal variation study, data were collected from four cruises to the NSCS, covering a full seasonal cycle in 2009-2011. The nutrient inventory showed a clear seasonal pattern with the highest value appearing in summer, while the N+N inventory in spring and winter had a reduction of ~13% and ~30%, respectively, relative to that in summer. To quantify the extent of the Kuroshio intrusion, an isopycnal mixing model was adopted to derive the proportional contribution of water masses from the Kuroshio characterized by extremely low nutrients and the SCS proper with relatively higher nutrient levels along individual isopycnal surfaces. Results showed that the nutrient inventory in the upper 100 m of the NSCS was overall negatively correlated to the Kuroshio water fraction, suggesting that the Kuroshio intrusion significantly influenced the nutrient distribution in the SCS and its seasonal variation. Based on a three dimensional Regional Ocean Model System, coupled with the isopycnal mixing approximation, the Kuroshio water fraction at the South East Asia Time Series Station (SEATS) in the basin area of the NSCS was further quantified. It showed significant interannual variations in both the Kuroshio water fraction and nutrient inventory. Upon filtering the seasonal signal, the interannual variations of Kuroshio water fraction was negatively correlated with the nutrient inventory (R2=0.68), indicating that at interannual time scale, the Kuroshio intrusion into the NSCS had also a dilution effect on the nutrient inventory in the upper NSCS. We conclude therefore that the Kuroshio intrusion plays an important role in determining the nutrient inventory in the NSCS both at seasonal and interannual timescales.

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