Turbulence estimation using fast response thermistors attached to CTD frames

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Turbulence observations have been limited because of difficulty in microstructure measurements. In order to efficiently obtain more turbulence data down to the ocean floor without spending extra ship-time, we introduce a new method using a fast response thermistor attached to a CTD frame. Turbulence intensity from CTD-attached profilers is evaluated by comparing it with free-fall vertical microstructure profilers measured at the same location within 2 hours. Turbulence intensity from the CTD-attached profilers is roughly comparable with the one from the free-fall profilers. Whereas, excessively overestimated data are sometimes observed for the CTD-attached method, and regarded to be abnormal since those data are deviated from log-normal distributions and correspond to the small fall rate W ($W < 0.5$ m/s) and the large standard deviation of W ($W_{sd} > 0.1$ m/s). Temperature gradient spectra also tend to be disturbed in that case. The overestimated data are capable to be removed by the simple criterion of $W_{sd}/W > 0.2$. As a result of the data screening, thermal and energy dissipation, χ and ε, from CTD-attached and free-fall profilers are consistent within the factor of 3 in the range of $10^{-10} < \chi$ [℃^{2}/s] (ε [W/kg]) $< 10^{-7}$ (10^{-8}) for 50m-bin averaged data, respectively. Observations using CTD-attached profilers are performed covering a wide range of the northwest Pacific Ocean, and turbulence distribution from the surface to the deep ocean is estimated.

Keywords: physical oeanography, turbulence, micro temperature, oceanic observations, microstructure profiler

Estimates of eddy diffusivities using fast response thermistors

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We assess the performance of the CTD (conductivity-temperature-depth profiler) system equipped with a microstructure profiler called MicroRider (MR, manufactured by Rockland Scientific Inc.) in measuring microstructure in the deep ocean through the field observation carried out in 2017. Temperature overturns were detected by the fast response thermistor (FPO-7). The overturning scales (the Thorpe scale L_T) are converted into energy dissipation rates, which are then compared with those directly measured by Vertical Microstructure Profiler (VMP) in the same region in 2016. We find that, although the difference between the eddy diffusivities obtained by MR and VMP is large in the upper layer, it diminishes as the measuring depth increases. This motivates us to introduce the ratio R_{OT} of the Ozmidov scale L_O to the Thorpe scale L_T which depends on the density stratification. We define the value of R_{OT} as $\alpha N/N_{ave}$ (N is the buoyancy frequency, and N_{ave} is the average value of N) and estimate suitable α. It is found that, compared to the case using constant ratio $R_{OT} = 0.8$, the root mean square (rms) between the eddy diffusivities obtained by MR and VMP is decreased by an order. Thus, using the corrected factor R_{OT} obtained in this study, the eddy diffusivities estimated by MR become comparable to those directly measured by VMP, except for the layers affected by the background temperature inversions and double diffusion.

Keywords: Thorpe scale, Temperature overturn, MicroRider

Development of deep profiling floats with turbulence sensors

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A float-type repeatable microstructure profiler is developed, and tested in the ocean. The Deep NINJA float (Tsurumi Seiki) equipped with turbulence sensors (Rockland Scientific International Inc.) repeatedly measures turbulence-intensity and CTD down to 4000 m depth with shear probe and FP07 fast thermistor. A field test was conducted in the Shinsei-maru KS-16-10 cruise in August 3-11, 2016.

The profiler completed 8 dives in the Sagami Bay. At each dive, ascending speed and duration of engine operation were monitored by changing pump volume etc. to seek optimal operation for turbulence observations. We also examine to what extent CTD pump or engine operation influence on observed turbulence data. The engine generates noise which sometimes interfere shear probe measurements and might have some influence on thermistor measurements. Noise of CTD pump operation is not detected. Availability and limitation of the measurement are being investigated.

Evaluation of Mixing Coefficients in the Deep Ocean

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On the basis of an accumulation of observational results obtained mostly in the upper ocean, the mixing coefficient Γ in the Osborn's diapycnal diffusivity model is usually treated as a constant, $\Gamma = 0.2$. However, it has not been fully addressed whether Γ remains constant throughout the deep ocean. To address this issue, we estimate Γ using deep profiles of the turbulent kinetic energy dissipation rate ε and the temperature variance dissipation rate χ_T obtained in various regions such as the Izu-Ogasawara Ridge, the Emperor Seamounts, the Aleutian Ridge, and the Southern Ocean. The estimated Γ is surprisingly variable, possibly depending on the density ratio R_ρ, the buoyancy frequency N, and the buoyancy Reynolds number $Re_b = \varepsilon / (\nu N^2)$ with ν as the kinematic viscosity. While the estimated Γ remains to be around the conventional value of 0.2 in the temperature-stratified upper ocean with $R_\rho > 2$ or $R_\rho < -1$, Γ tends to increase to ~1 not only in the salinity-stratified upper ocean with $|R_\rho| << 1$ but also in the deep ocean. The increasing trend of Γ in the deep ocean appears to be related to the decreasing trend of N and/or the increasing trend of Re_b. This study thus suggests that the diapycnal diffusivity in the deep ocean might be significantly larger than ever thought.

Keywords: Mixing coefficient, Diapycnal diffusivity, Density ratio, Buoyancy frequency, Buoyancy Reynolds number

Detailed water properties of mesoscale vortex pairs in the Sea of Japan: direct observations using an underwater glider

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The Sea of Japan is a marginal sea bounded by the Asian landmass and the Japanese islands. Warm, saline Kuroshio waters enter the sea via the Tsushima Strait to form the Tsushima Warm Current. The Subpolar Front extends roughly along 40ºN to the Tsugaru Strait. Large horizontal density gradients across the front maintain a surface-intensified jet with a lateral scale of *O*(10 km) and speeds exceeding 0.5 m s^{-1}. The region offshore of Sado Island and the Noto Peninsula (i.e., along the southern margin of the central Sea of Japan) is characterized primarily by an eastward jet flows along the Subpolar Front and the Tsushima Warm Current and mesoscale eddies formed around the main currents. The anomalous intrusion of such currents and eddies into this region cause perturbations of temperature and salinity, which raise serious concerns for the set-net fisheries and aquaculturists in the region. Although earlier studies have investigated those synoptic-scale and mesoscale structures, their details remain unclear owing to insufficient in-situ data.

We successfully completed for the first time a spatially high-resolution survey with an underwater glider (Seaglider, Kongsberg Underwater Technology Inc.) along a Jason-2 satellite altimeter track #86 off Sado Island from 20 April through 2 June 2016. The Seaglider repeatedly profiled temperature and salinity from the ocean surface to roughly 900 m depth with an along-track profile separation 2–3 km, which is sufficient to resolve the mesoscale structures. A total of 257 profiles were obtained during a two-round-trip observation (four transects; referred to as “Transects 1–4”).

We applied principal component analysis using a time series of the absolute sea surface height (SSH) from 1993 to 2015 by AVISO and a correlation matrix method. Horizontal distribution of SSH of the first principal component are approximately in phase over the interested study domain with intraseasonal variations, whereas that of the second principal component (PC2) shows the existence of a vortex pair off Sado Island with primarily interannual variation.

A large variability of mesoscale frontal/eddy structures and water properties was revealed by the glider observations; Transects 1 to 4 were respectively characterized by a cyclonic eddy, a vortex pair, an anticyclonic eddy, and baroclinic jets (no eddies). We detected the vortex pair consisting of northern anticyclonic eddy and southern cyclonic eddy along Transect 2, almost corresponding to that of PC2. The paired anticyclonic and cyclonic eddies have distinct water properties and spatial structures. The anticyclonic eddy had a diffusive-convection favorable vertical structure near the surface layer (< 50 m depth) characterized by water being colder and fresher than those at the underlying subsurface layer. The counterpart of the cyclonic eddy was salt-fingering favorable which is warmer and more saline at the surface layer. In the cyclonic eddy, horizontal interleaving structures were also observed. With the horizontally high-resolution data obtained by the glider observations we will investigate the mixing processes and their spatial/temporal variability within the vortex pair system from statistical and quantitative approaches.

Keywords: underwater glider, vortex pairs, spatiotemporal change, subpolar front

Fine-scale structure and mixing across the front between the Tsugaru Warm and Oyashio Currents in summer along the Sanriku Coast, east of Japan

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High-resolution shipboard observations were made across the front between the Tsugaru Warm Current (TWC) and the Oyashio in July 2013. Fine structure in the frontal zones were successfully captured with an Underway Conductivity–Temperature–Depth (UCTD) profiler deployed with a typical horizontal interval of 2–3 nautical miles. The front characterized by marked horizontal gradients in temperature and salinity extended from the subsurface onto the shelf. Along this frontal layer, the minimum frequency for internal waves became substantially lower than the local inertial frequency, mainly due to the strong vertical shear of the geostrophic velocity. Turbulent energy dissipation rates ε (vertical diffusivity K_ρ) were frequently elevated along the front and its offshore side up to 3×10^{-8} W kg^{-1} (10^{-4} m^2 s^{-1}), which may have been caused by an “internal tide chimney”, trapping low-frequency internal waves within the band of strong shear. At the onshore side of the TWC on the shelf, strong mixing with ε (K_ρ) exceeding 10^{-6} W kg^{-1} (10^{-3} m^2 s^{-1}) was also observed. A large portion of the water columns in the frontal area provided suitable conditions for double diffusion; in some layers with moderate turbulence, temperature microstructures indicative of double diffusion were observed. The vigorous mixing processes around the front are likely to modify the properties of the TWC downstream, which could then produce a latitudinal gradient in environments along the coast.

Keywords: Tsugaru Warm Current, Oyashio, Front, Vertical mixing, Internal tide chimney

Turbulent mixing within the Kuroshio in Tokara Strait

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Strong turbulent mixing within the Kuroshio are observed using a microstructure profiler in Tokara Strait. The Kuroshio current is greatly modified at shallow seamounts. The vertical diffusivity in the Kuroshio at the lee of the seamount is enhanced nearly 100 times from the upstream site to K_{rho} ~ $O(10^{-3})$–$O(10^{-2})$ m^2 s^{-1}. In the 70-m thick shear enhanced turbulence layer, the flow is in favor of shear instability. A one-dimensional diffusion model using the observed eddy diffusivity reproduces the observed water mass transformation. However, the estimated diffusion time scale is at least 10 times longer than the advection time scale and suggests much stronger turbulence mixing in the vicinity of the seamount. Our study suggests that a better prediction of current and water mass properties of the Kuroshio requires an accurate parameterization of interactions of the Kuroshio with topography and the associated turbulent mixing.

Strong vertical turbulent nitrate flux in the Kuroshio across the Tokara Strait and the Izu Ridge

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In the oligotrophic Kuroshio / Kuroshio Extension region, vertical turbulent mixing is considered to be an important driver to supply nutrients to maintain the biological production in the euphotic zone and high fisheries productions (e.g. Kaneko et al. 2013). Besides, in the intermediate layer below the euphotic zone, vertical mixing is also thought to be an important process to transport nutrients upward from the North Pacific Intermediate Water (NPIW, e.g. Reid 1965), which provides a nutrient source to the Kuroshio as suggested by Sarmiento et al. (2004). However, due to the lack of sufficient data on turbulence and nitrate, where and how much nitrate is supplied along the Kuroshio / Kuroshio Extension from down below and what impact this nitrate flux would have on the primary production have not been fully quantified yet.
In the present study, by using observational data on turbulence intensity and nitrate, we estimate the vertical turbulent nitrate flux near the Tokara Strait and the Izu Ridge, where the Kuroshio flows over steep bottom topography. The vertical mixing within the Tokara Strait is often found 1-2 orders of magnitude larger than the background value of $K\rho = O(10^{-5})$ [m^2/s] and is intermittently enhanced to $\varepsilon = O(10^{-6})$ [W/kg] and $K\rho = O(10^{-1})$ [m^2/s] at 26 –26.5 σ_θ. The vertical turbulent nitrate flux, F_{NO3}, is thus often enhanced by 1-2 orders of magnitude from the background value of $F_{NO3} = O(10^{-3})$ [mmolN/m^2/day] and intermittently reaches $F_{NO3} = O(1)$ [mmolN/m^2/day]. The mean nitrate flux across the whole Tokara Strait $\langle F_{NO3} \rangle = O(10^{-1})$ [mmolN/m^2/day] just below the euphotic zone and at about 26.5 σ_θ. In the proximity to the Izu Ridge within the Kuroshio, the mean nitrate flux with the same order of magnitude is also observed both just below the euphotic zone and at about 26.5 σ_θ. These results suggest that these two mixing hotspots in the Kuroshio may provide large portion of the new production in the euphotic zone and may draw sufficient nitrate upward from the NPIW to impact the downstream.

Keywords: turbulent mixing, nitrate flux, Tokara Strait, Izu Ridge, Kuroshio

Long-range propagation and associated variability of internal tides in the South China Sea

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The variability of internal tides during their generation and long-range propagation in the South China Sea (SCS) is investigated by driving a high-resolution numerical model. The present study clarifies the notably different processes of generation, propagation and dissipation between diurnal and semidiurnal internal tides. Internal tides in the SCS originate from multiple source sites, among which the Luzon Strait is dominant, and contributes approximately 90% and 74% of the baroclinic energy for M_2 and K_1, respectively. The tidal beams from the Luzon Strait can travel across the deep basin and finally arrive at the Vietnam coast and Nansha Island more than 1000-1500 km away. During propagation, M_2 internal tides maintain a southwestward direction, whereas K_1 exhibit complicated wave fields because of the superposition of waves from local sources and island scattering effects. After significant dissipation within the Luzon Strait, the remaining energy travels into the SCS and reduces by more than 90% over a distance of ~1000 km. Inside the SCS, the K_1 internal tides with long crests and flat beam angles are more influenced by seafloor topographical features and thus undergo apparent dissipation along the entire path, whereas the prominent dissipation of M_2 internal tides only occurs after their arrival at Zhongsha Island.

Keywords: internal tides, energy cycle, Mixing

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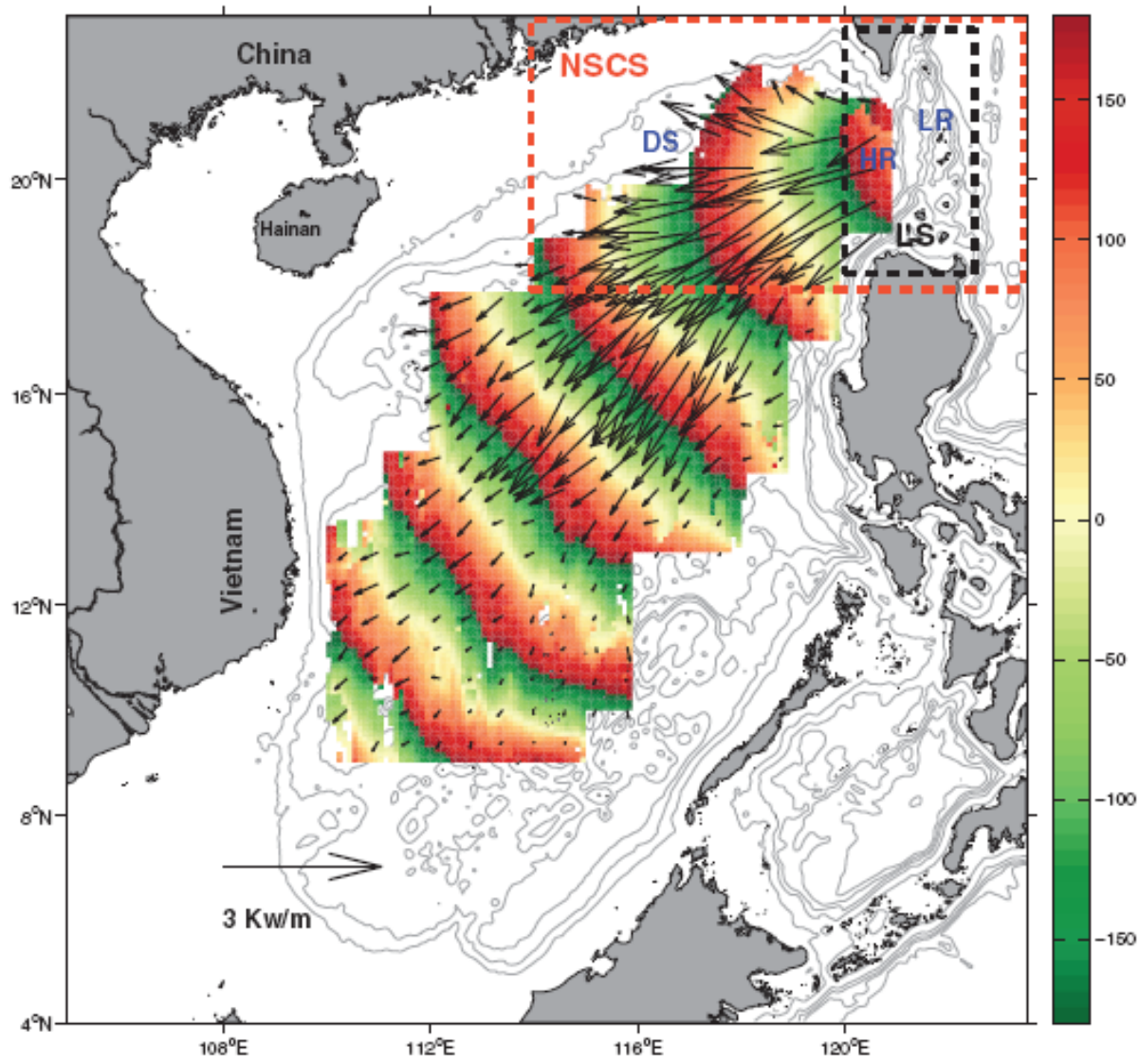

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Fission of internal solitary waves over shoaling topography cascades tidal energy to turbulence

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The tides are a major energy source of small-scale turbulence, and therefore diapycnal mixing, in the world's oceans. An understanding of the processes responsible for the cascade of energy from tides to turbulence is important in identifying when and where this mixing will take place. Internal solitary waves (ISWs) generated by tide-topography interactions are ubiquitous in the world's oceans and are thought to be important sources of mixing. Whilst the understanding of the dynamics and energetics of ISWs have been greatly advanced in the past a few decades, identification of the processes and mechanisms responsible for their dissipation is limited. Here we present velocity and turbulence measurements from the South China Sea, together with process-orientated numerical simulations, to demonstrate the key role of ISW fission, into groups of high-frequency internal waves over rough topography, in the dissipation of tidal energy. The results show that, as a result of the fission, wave-induced velocity shear is elevated over significant time periods coincident with a period of enhanced turbulent dissipation. We suggest that the enhanced dissipation is a result of instability and breaking of the high-frequency internal waves. The finding reveals an important pathway of tides-to-turbulence cascade and generation of turbulence and mixing in the ocean interior, having important implications for understanding ocean dynamics as well as its ecological and climatic impacts.

Keywords: internal solitary waves, tides, turbulence, energy cascade, fission

Seasonal Variation of M_2 internal tides and tidal surface currents of the North Atlantic

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Following the global study of Kodaira et al. (2016), a high resolution regional ocean model is used to study the M_2 internal tides of the North Atlantic with a particular focus on their seasonal variation. The regional model has a grid spacing of 1/36 degree and is based on MITgcm. The predicted tidal variation of sea surface height is shown to be in reasonable agreement with altimeter observations. Tidal surface currents are also evaluated by comparing them with estimates based on the recently available hourly drifter dataset of Elipot et al. (2016). The large scale features in the maximum speed of surface tidal current derived from the drifter observations and model predictions are in reasonable agreement, particularly in the vicinity of known generation sites for internal tides. The higher wavenumber variations, previously explained by Kodaira et al. (2016) in terms of phase locking of the barotropic tide and mode-1 baroclinic response, do not line up exactly. Possible explanations are provided. We next examine seasonal variability. Both observed and predicted surface currents change with season. We interpret this variation in terms of seasonal changes in the vertical structure of mode-2 internal tides. By way of contrast, the model predictions indicate only small seasonal changes in the vertically integrated horizontal kinetic energy and the barotropic to baroclinic energy conversion rate.
Kodaira et al., 2016. *JGR Oceans*, *121*(8), 6159–6183.
Elipot et al., 2016. *JGR Oceans*, *121*(5), 2937–2966.

Keywords: internal tide , drifter observation

Observations of small island wakes in the Kuroshio: flow-pattern evolution, shear instability and turbulent mixing

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Evolution and turbulent mixing of Green Island wake (~5 km in diameter) was investigated in the alongshore flowing Kuroshio (1-1.5 ms^{-1}) east of Taiwan with shipboard ADCP and echo sounder, Underway CTD and microstructure profiler. Repeated 12 cross-wake and 4 along-wake surveys in the lee of Green Island reveal transects of wake evolution and downstream eddy propagation, respectively. In the cross-wake section, the cyclonic and anti-cyclonic recirculation alternatively presents at a period of ~12.5 hours, in agreement with a 1-month moored measurement. A resonance effect with semidiurnal tide is the most likely explanation for the observed period. The repeated along-wake surveys depicted that a cyclonic eddy shed downstream at a speed of 0.34 ms^{-1}, 1/3 of the upstream current speed. A cross-wake microstructure survey reveals an average TKE dissipation rate of $O(10^{-7})$ WKg^{-1} and an enhanced value of $O(10^{-5})$ WKg^{-1} at the horizontal shear line, separating the mean flow and the recirculation in the leeward side of the island. The depths of enhanced turbulence are co-located with the strong vertical shear of horizontal velocity, where the Kelvin-Helmholtz billows with a vertical scale of ~30 m are observed in the echo sounder image. Presumably, the tilting of the lateral boundary-induced vorticity likely causes the strong vertical shear.

Keywords: Kuroshio, island wake, turbulent mixing

Water Mass Analysis of Tsushima Strait by Multiple Tracers and seasonal contribution of various origin.

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Tsushima strait is an important pathway for connecting the East China Sea (ECS) and the Sea of Japan. In order to monitor currents in this region, various in-situ temperature and salinity datasets were used for developing numerical simulation models. However, the water origin of currents in this region lacked of systematical understanding. Because of shallow depth and various currents pass through, the chemical properties of Tsushima Strait water changed rapidly. Multiple tracers analysis is a comprehensive method to approach detailed and instantaneous status of water mass. This study used Rare Earth Elements (REEs), $\delta^{18}O$, combing with CTD data (Temperature, Salinity, Fluorescence) and routine data (Nutrients, Dissolved Oxygen), to analyze water mass mixing of Tsushima Strait.

All samples (3 seasons, from 5 cruises) were collected at Tsushima Strait (Line 129.38E, 34.88N to 130.15E, 33.83N) from 2015 May to 2016 October used T/S Nagasaki Maru (Nagasaki University). The salinity, temperature, DO and fluorescence data were collected by CTD, the DO samples were measured on-board by automatic titration. Nutrients and $\delta^{18}O$ samples were stored for laboratory analysis. The REEs samples were filtered by 0.2μm membrane filter and acidified to pH 1.5 by hydrochloride acid in clean booth immediately, then extracted by NOBIAS PA1 chelate resin (Hitachi High-Tech) and measured by ICP-MS (Element 2, Thermo Fisher Scientific) in a cleanroom on land.

CTD and multiple tracers datasets show that: (Ⅰ)The Changjiang Diluted Water (CDW) and Kuroshio Intermediate Water (KIW) are important end members of this region, according to the temperature-salinity diagram. (Ⅱ)Fluorescence vertical profiles and horizontal sections shows unbalanced distribution. High fluorescence mainly occurred in subsurface layer of east channel in spring and fall, especially shallower than the thermocline in fall. (Ⅲ)Post-Archean Average Australian Shale (PAAS) normalized REEs patterns show similar water mass mixing in this region in different season, and high Ce/Ce* suggests the particle influence. These results suggest the nutrients origin of Tsushima Strait water might be CDW. Further, to understand the dominant water mass, we calculated the mixing ratios by least square method with five parameters, including salinity, Dy/Ho, Ho/Er, Er/Tm and Tm/Yb. End member dataset included Yellow Sea Cold Water (YSCW), Taiwan Warm Current (TWC), KIW and CDW (Private communication, Hongliang Ma, Ocean University of China). Calculation result suggests the two sides of Tsushima Strait water were dominated by different origin over 3 seasons. The west channel show clear stratification. YSCW and CDW influenced the surface and the subsurface layer in spring and fall, however, the layer deeper than 100 m was dominated by KIW. The east channel was mainly controlled by CDW throughout the year. Results also suggests CDW is the vital water origin of Tsushima Strait, according to the collaboration of CDW domination region and high fluorescence layer. The water mass distribution and seasonal changes in Tsushima Strait were revealed in this study, and multiple tracers are efficient method for the water origin analysis. Our results and method will provide evidence for improving current simulation models.

Keywords: Water mass analysis, Rare Earth Elements, Tsushima Strait

Dynamics of Water mass in the East Japan Basin using Multiple Chemical Tracers

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The Sea of Japan is a semi-closed ocean area, which results to an independent circulatory system. Especially in the East Japan Basin, various previous reports of deep circulation were established (Senjyu et al., 2005; Hatta and Zhang, 2006). However, the details of water masses were not clarified, because of limited observation stations. This study used multiple chemical tracers to analyze the dynamics of the deep water in East Japan Basin, and to clarify the existence of water advection in this region. Samples were collected from GEOTRACES JAPAN KH-10-02 cruise (Leg 2, June 21 to July 6, 2010). Dissolved oxygen (DO) and nutrients of seawater were analyzed on board. Rare earth elements (REEs) were extracted by chelate resin (NOBIAS Chelate PA-1) and measured by HR-ICP-MS on land.

The results of the four observation stations CR34 (140.00E, 45.67N), CR41 (138.93E, 44.20N), CR47 (138.21E, 42.82N), CR58 (135.92E, 40.43N), which located from northern to central region of East Japan Basin, were shown as follow. With comparing the DO and PO_4-P vertical profiles of CR41 and CR47, PO_4-P shows excess refer to the Redfield ratio, suggests the influence of particles. According to the REEs data, the CR41 and CR47 showed the same HREEs (Heavy REEs) patterns, indicates the advection from CR47 to CR41. Meanwhile, the same HREEs patterns also showed by CR41 500m and CR34 bottom water, suggests the advection from CR34 to CR41. Further, CR34 bottom water is influenced by resuspended particles or water masses out of East Japan Basin, which inferred by the higher LREEs (Light REEs) in CR34 bottom. In future, it is important to clarify the wide regional deep circulation with the biogeochemical observation in the northern part of Japan Sea and Okhotsk Sea.

Keywords: Water mass analysis, Rare Earth Elements, East Japan Basin

Small scale structure in temperature and salinity over the Mindanao Dome

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In June-July 2011, Japan Meteorological Agency carried out the regular observation in the Pacific Northwest along the longitude line of 137 E. Continuous observation data were obtained every minute from a Thermo Salino Graph. Small scale spikes in both temperature and salinity are found between the latitude 5 N and 10 N over the Mindanao Dome, where cold-salty waters are upwelled. It should be noted that the area where the small scale structure was observed correspond to warm pool.

Soundings of temperature and salinity from the Conductivity Temperature Depth profiler showed that upwelled water are present up to 50 dbar in 8 N. The sharpest spike structures in temperature and salinity is found in 7N and 9N, where Dissolved Oxygen is supersaturated; These data indicate that the active mixing occurs.

Thermohaline staircase, extending vertically for a few of dbars, are found in some latitudes.
In case of 5 N, the height of staircase is about 4 dbar and the roughly estimated buoyancy frequency is about 0.007 (1/sec). The horizontal scale of the spike is about 1 km.

What causes the small scale structure of temperature and salinity over the Mindanao Dome? It is well known that thermohaline staircases are often observed when salt finger convection occur. However, the observed horizontal scale is about 1km and the vertical scale is about 10 m; The shape of the cell is not "finger".

Second, it is possible that internal gravity wave is generated by convection (Michael Le Bars at al.,2015). They experimentally investigate the dynamics of a turbulent convective layer adjacent to a stable stratified layer. This condition is very similar to the vertical profile of Mindanao Dome area. They find that the convectively excited internal waves propagate in the stratified zone. I will describe the comparison between the ship observation and the results of their experiment.

Keywords: internal gravity wave, salt finger, Mindanao Dome

An observed variability of Chlorophyll-a during 2015-2016 El Nino event in Mindanao Dome

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The 2015-2016 El Nino was considered as one of the strongest on record, comparable to the 1982-1983 and 1997-1998 events that triggered widespread climate and ecosystem changes in the Pacific and in regions beyond. Mindanao Dome area is an important upwelling system of the Western Philippine Sea. This study aims in examining the variability of Chlorophyll-a and related physical parameters of the Mindanao Dome to assess the impact of the recent 2015-2016 El Nino event. This assessment was based on the data derived from observed satellite data and available data from underwater sensors on Triangle Trans-Ocean Buoy Network (TRITON) buoys. Results indicate that the Mindanao Dome region has been chronically enriched in Chlorophyll-a levels during this event. This increased primary productivity may influence the overall ocean productivity of the area.

Keywords: El Nino, primary productivity, western Philippine Sea, satellite data, TRITON buoy

