19th Pacific Asian Marginal Seas Meeting (PAMS 2017), Jeju, KOREA, 11-13 April 2017

Meridional transition of upper-ocean primary productivity due to diapycnal eddy mixing across the Kuroshio off Japan

Yusuke Uchiyama, Yota Suzue and Hidekatsu Yamazaki

Abstract

The Kuroshio is accompanied by intensive meso- and submesoscale eddies, which substantially affect biogeochemical processes particularly in the upper ocean. We examine primary production around the Kuroshio off Japan with a climatological ocean modeling based on ROMS (Regional Oceanic Modeling System) coupled with a nitrogen-based pelagic NPZD (nutrient, phyto- and zooplankton, and detritus) biogeochemical model in a submesoscale eddy-permitting configuration. The model results indicate significant differences in the biogeochemical responses to eddy activities in the Kuroshio region (KR, off Enshu-nada Sea) and Kuroshio Extension region (KE, off Boso Peninsula). In the KR, persisting cyclonic eddies developed between the Kuroshio and the coastline are responsible for upwelling-induced eutrophication in principle. However, the eddy-induced vertical nutrient flux counteracts to promote pronounced south- and downward diapycnal nutrient transport from the mixed layer to beneath the Kuroshio main body, which suppresses the near-surface productivity. In contrast, the KE has higher productivity by 23.5% than the KR even at comparable eddy intensity. Upward nutrient transport prevails extensively near the surface due to predominant cyclonic eddies particularly to the north of the KE, whereas the nutrient subduction barely occurs except at depth deeper than 400 m at much lesser degree than that in the KR. An eddy energy conversion analysis reveals that a combination of shear instability including topographic eddy shedding and prominent baroclinic instability near the Kuroshio front is essential to generating eddies in the KR, leading to the increase of the eddy-induced vertical nitrate transport around the Kuroshio.

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On generation and propagation of oceanic mesoscale eddies in the North Pacific analyzed with an eddy-tracking algorithm

Nobue Okada, Yusuke Uchiyama, Yu Liu, and Changming Dong

Abstract

Mesoscale eddies are ubiquitous in the world ocean that frequently collide with currents, leading to substantial alteration of the associated dynamics. For instance, the Kuroshio plays a major role in preconditioning the coastal environment around Japan through poleward heat and material transport from the subtropics, while its path is known to meander occasionally by eddy collisions. To investigate the statistical nature of mesoscale eddies and their effects on the oceanic currents, the velocity-based automated eddy detection and tracking algorism developed by Nencioli *et al*. (2010) is employed to a 20-year long dataset derived from the satellite altimetry. It enables us to determine near-surface geostrophic currents used for eddy detection in the North Pacific (NP) at a lateral resolution of 0.25^{o} and sampling intervals of a week.

In the NP, eddy kinetic energy (EKE) is highest in the Kuroshio Extension (KE) region off Boso Peninsula as a consequence of eastward release of the Kuroshio-induced eddies that interact with westward propagating eddies (WPEs). The western-most region of the subtropical zonal band (SZB) around Luzon Strait has secondarily energetic EKE due to accumulation of WPEs as baroclinic Rossby waves. In contrast, the eastern NP (ENP) off the U.S. West Coast is a major generation site where the equatorward seasonal wind causes persistent coastal upwelling fronts and resultant WPEs. In the middle of the NP, topographies are essential to prompt generation of WPEs particularly around Hawaiian Ridge. From 1993 to 2012, about 44,000 individual eddies with lifetimes longer than 8 weeks are identified in the NP. About 20% of them are detected in the SZB, while the contributions from the KE and ENP are 5% and 13%. In both the KE and SZB, counterclockwise rotating, cyclonic eddies are more intensely distributed in terms of vorticity magnitude yet with smaller sizes in their diameters than anticyclonic eddies. On the other hand, the eddy statistics in the ENP exhibit minor differences between cyclonic and anticyclonic eddies.

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Development of a coastal forecasting system with a 3DVAR assimilation for the Seto Inland Sea, Japan

Kenta Kurosawa, Yusuke Uchiyama and Takemasa Miyoshi

Abstract

By optimally combining ocean models with observation data, numerical oceanic reanalysis and forecast systems allow us to predict the ocean more precisely. In general, data assimilation is exploited to prepare the initial condition for the forecast. This technique has widely been employed in atmospheric prediction, whereas oceanic prediction lags behind weather forecast. Accurate oceanic prediction systems have been demanded for operational purposes such as for fisheries, vessel navigation, marine construction, offshore platform management, marine monitoring, etc.

The variational method is one of the major approaches in data assimilation. Based on the maximum likelihood estimation theory, it attempts to obtain ocean state estimates by minimizing a cost function defined as a sum of quadratic terms of errors in model background states and observations. Three-dimensional variational (3DVAR) data assimilation identifies the best estimate at a specific analysis time using observations obtained around the time. Several research groups have developed realistic data assimilation systems, some of which adopt the variational assimilation scheme.

In the present study, we develop an assimilation system toward coastal data prediction around Japan based on a 3DVAR assimilation scheme for Regional Oceanic Modeling Systems (ROMS). A high-resolution coastal circulation modeling encompassing the western part of the Japanese coastal region around the Seto Inland Sea (SIS), Japan, is configured to improve the representation of coastal processes. In crowded harbors and estuaries including the SIS, data assimilation has barely been adapted because data from satellites and Argo floats essential to successful oceanic predictions is desperately limited. Instead, there are a number of autonomous in-situ monitoring systems for vertical profiles of temperature and salinity, tens of tidal gages, along with continuous surface current measurement using HF radars in and around the SIS.

We first describe a theoretical framework of the 3DVAR algorithm optimal for the high resolution configuration. Subsequently, the developed 3DVAR is coupled with the SIS ROMS model to compare the model outcomes against observation. The comparison indicates that the 3DVAR ROMS model for the SIS outperforms the forward SIS model without assimilation with better model skill scores. We then demonstrate that the assimilation system is capable of successfully reproducing the complex flow field in the SIS as for the complex topography and coastlines with more than 3,000 islands.

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Model assessment of wastewater effluent on a seaweed farm in Osaka Bay, Japan

Xu Zhang, Yusuke Uchiyama, and Yota Suzue

Abstract

The Seto Inland Sea (SIS), Japan, consists of several semi-enclosed basins with complex coastlines and thousands of islands with substantial effects from the Kuroshio. Even though the water quality has been improved adequately because of enacted environmental preservation policies, Osaka Bay (OB) located at the northeastern SIS still suffers from pollution due to dense population in the hinterland. Tarumi Sewage Treatment Plant (TSTP) is the major wastewater treatment plants in OB near Akashi Strait where energetic and complex tidal flow occurs. This area is quite famous for seaweed farming (*cf*., the second largest prefectural product in the nation), while the local fishermen keep complaining possible impacts from TSTP effluent on the farm. The local government has taken an action to construct a new outfall away from the farm to mediate the impact by seasonal diversion. Therefore, a numerical modeling is needed to assess the present situation as well as to further improve the outfall design.

In the present study, we develop a quadruple-nested high-resolution ocean model based on ROMS. The outermost boundary conditions are provided by JCOPE2 oceanic reanalysis and the capability of tracking sewage effluent is implemented into the innermost ROMS-L4 model with horizontal grid spacing of 20 m as an additional Eulerian passive tracer model based on Uchiyama *et al.* (2014). The sewage effluent is applied at the locations of the two outfalls as a bottom-released freshwater plume at a constant volume rate of 180,000 m^3/day. Compared with normal sewage discharge, the western diversion works well as intended. The eastward mean and eddy-induced sewage effluent transport is decreased by about 50 % on and around the eastern shore. The tracer concentration fluctuates mostly at tidal frequency in the western area of the farm, whereas subtidal variability dominates over tidal fluctuations in the eastern area.