PCES 2020, VS5-S5 (BIO/POC), ID: 14964

Horizontal scale of chlorophyll a variability affected by eddy activities in the midlatitudes of global oceans

Hitoshi Kaneko[1] and Shin-ichi Ito[2]

1. Mutsu Institute for Oceanography, Japan Agency for Marine-Earth Science and Technology
2. Atmosphere and Ocean Research Institute, The University of Tokyo

E-mail: h_kaneko@jamstec.go.jp

1. Introduction

Ocean eddies are ubiquitous and crucially important for the distribution of heat and other properties such as nutrient in the whole ocean. Eddies also contributes to the distribution of chlorophyll *a* (CHL) concentration through various processes including eddy pumping associated with isopycnal heaving caused by cyclonic eddy [*McGilicuddy et al.*, 1998], local Ekman pumping through interaction with surface wind (convergence in cyclonic eddies and divergence in anticyclonic eddies; [*Siegel et al.*, 2011]), horizontal advection of ambient CHL distribution along the periphery [*Abraham*, 1998; *Siegel et al.*, 2007, 2011; *Chelton et al.*, 2011b, Science]. In addition, vertical fluxes of nutrient occurred within eddy during development and decay could also affect the CHL concentration [*Folkowski et al.*, 1991].

Because importance of nonlinearity of eddies have been pointed out in the recent studies [e.g., Chelton et al., 2007], a view of eddy pursuit (Lagrangian perspective) has been addressed. In addition, wider geophysical approach (Eulerian perspective) concerning eddy variability is also important in order to understand roles of eddies on biogeographical function.

In the present study, we attempt to elucidate relationship of the global distribution of horizontal characteristic scale of CHL distribution, its relationship to especially horizontal scale of it to eddy activity, and basin specific features of the relationship in comparing each basins such as the North/South Pacific & Atlantic globally using with long-term data of CHL and geostrophic velocity provided by satellites.

2. Data & Method

Velocity: Ocean Surface Current Analysis Real-time (OSCAR, https://doi.org/10.5067/OSCAR-03D01.) [*Bonjean and Lagerloef*, 2002].

CHL: GlobColour (http://globcolour.info), [*Maritorena et al.*, 2010; *d'Andon et al.*, 2009].

8-days averaged, GSM01 (Garver-Siegel-Maritoren) merged model [Maritorena and Siegel, 2005]

Climatological time series of CHL at each grid point were calculated at each ~10 day, using data from January 2001 to December 2019. Then, anomalies of CHL from the climatology were estimated.

Correlation coefficients of each time-series and distance among all grids were calculated (Fig. 1). Statistical mean of the correlation coefficient in each 10-km-bin, and horizontal scale *D*, was estimated.

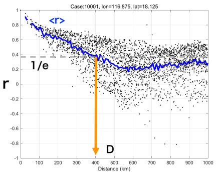

Fig. 1
An example of plot of correlation coefficient to horizontal scale of CHL, *D*.

Five regions (North/South Pacific & Atlantic, Indian Ocean; Fig. 2) were selected focusing mid-latitude (from 15 degree to 60 degrees in latitude).

3. Results

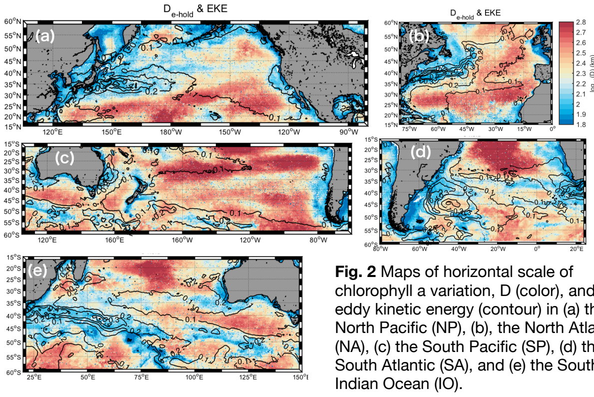

Fig. 2 Maps of horizontal scale of chlorophyll a variation, D (color), and eddy kinetic energy (contour) in (a) the North Pacific (NP), (b), the North Atlantic (NA), (c) the South Pacific (SP), (d) the South Atlantic (SA), and (e) the South Indian Ocean (IO).

Using horizontal scale in the four directions of east (D_E), west (D_W), north (D_N), and south (D_S) from the each referenced point, we estimated ratio of the horizontal scales, R_D, as follows;

$$R_D = (D_E + D_W)/(D_S + D_N)$$

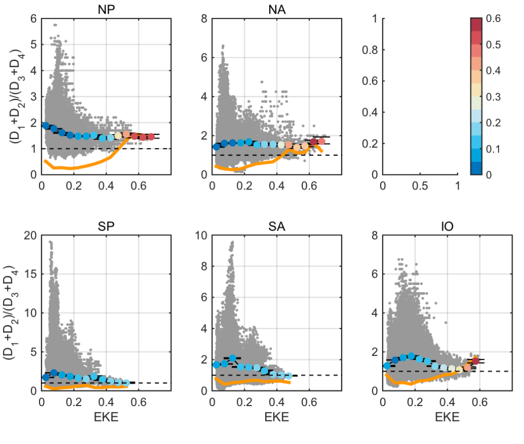

Fig. 4 Plots of the ratio of the zonal scale to the meridional scale, R_D (y-axis) to EKE (x-axis) in (a) NP, (b) NA, (c) SP, (d) SA, and (e) IO.

Colored circles denote the mean of R_D in each 0.05 $m^2 s^{-2}$ bin of EKE, and color itself means mean velocity of each bin.

Error bars denote 95% confidence interval.

Orange lines show the index of time scale I_t.

The horizontal scale decreased with increase of the eddy kinetic energy (EKE) and converged to 80–100 km in the EKE range of 0.6 $m^2 s^{-2}$. In contrast, in the lower range of EKE, the scale varied from 180–210 km in the NP, the NA, and the IO, to > 280 km in the SP and the SA. Higher sensitivity of *D* to EKE was indicated in the SA, showing rapid convergence with increasing of EKE (Fig.3).

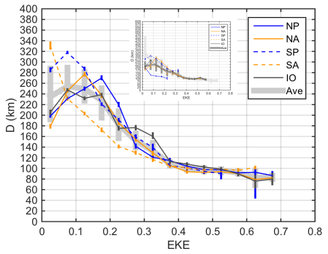

Fig. 3 Plots of mean horizontal scale of chlorophyll a variation, D, to EKE in each basin with 95 % confidence interval. The small inbox indicates that in the region higher latitude than 40°.

Similar convergence pattern of SP was shown in the higher latitude of NP where iron limitation and eddy transport of CHL were well known.

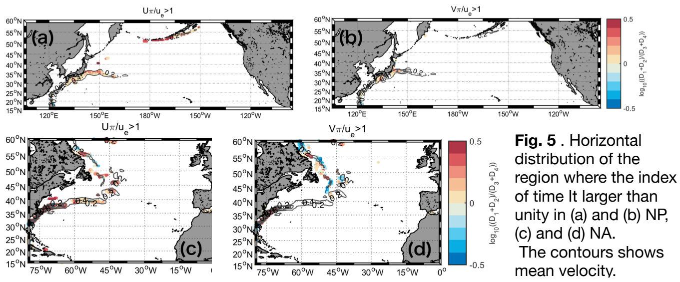

Fig. 5 . Horizontal distribution of the region where the index of time It larger than unity in (a) and (b) NP, (c) and (d) NA.
The contours shows mean velocity.

Left (right) column denotes in the case of $I_t > \pi U/u_e$ ($\pi V/u_e$). *U* and *V* are mean zonal and meridional velocity, respectively. u_e denotes mean eddy velocity. $I_t \gg 1$, means that timescale due to eddy motion would be far longer than that caused by the mean flow, thus, it would be expected that horizontal scale of CHL would be stretched in the direction along the mean flow.

R_D also converged to unity with increase of EKE except for the regions where intense mean flows such as the Kuroshio and the Gulf Stream occur (Figs. 4, and 5).

The results suggested uniformization of CHL within eddies in the high eddy activity regions, and interaction such CHL distribution with mean flows.