Seasonal Variations in Water Column Stratification in the Gulf of Thailand

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Introduction

Water column conditions in terms of vertical well mixing and stratification are important to phases of physical and biochemical environments such as vertical material exchanges and primary productivity of phytoplankton. Water stratification plays as a barrier to nutrient mixing between surface and subsurface waters. Primary productivity in such area is then limited by nutrient availability. In contrast, the stratification in a high eutrophic area can generate hypoxia or anoxia in near bottom water due to organic material decomposition.

The objective of this study is to investigate the seasonal variations of water column stratification in the Gulf of Thailand (GoT) from the distributions of temperature and salinity profiles. Other controlling factors such as surface heat flux, freshwater discharge, rainfall, tidal and wind stirrings were also included in this study.

Methodology

The model of the rate of change of potential energy in water column (d*E*/d*t*) in this study was modified from Buranapratheprat et al. (2008). The basic of assumption of this model is that the rate of change of potential energy in water column can be considering to index of vertical stratification in the water column. When d*E*/d*t* value is higher than 0, it was consider as vertical well mixing area. In the other hand, when d*E*/d*t* value less than 0, it was consider as vertical stratification area. The model is,

$$\frac{dE}{dt} = -\frac{\alpha gQH}{2C_p} - \frac{\beta gSHR}{2A} - \frac{\beta gSHP}{2A} + \frac{4\varepsilon k_b \rho_w U_t^3}{3\pi} + \delta k_s \rho_a W^3$$

Where

Symbols	Definitions	Values	Units
α	Thermal expansion coefficient	2.3E-04	$^{o}C^{-1}$
g	Gravitational acceleration	9.8	ms^{-2}
H	Water depth		m
Q	Heat flux		Wm^{-2}
C_p	Specific heat of water	3.9767	$Ws\ g^{-1}\ {}^{o}C^{-1}$
β	Salinity contraction to density	0.001	$g\ cm^{-3}\ psu^{-1}$
S	Salinity		psu
R	River discharge		$m^3\ s^{-1}$
P	Net rain fall		$m^3\ s^{-1}$
A	Surface area under river discharge influence		m^2
ε	The efficiency of conversion from turbulenceto potential energy for tidal stirring	0.015	
k_b	Bottom drag coefficient	2.5E-03	
ρ_w	The density of seawater		$g\ cm^{-3}$

Symbols	Definitions	Values	Units
U_t	Tidal magnitude		m s^{-1}
δ	The efficiency of conversion from turbulence to potential energy for wind stirring	0.039	
C_D	Surface drag coefficient(Eq. (3a) and (3b))		
k_s	$C_D \times \gamma$		
γ	The ratio of wind-induced current to wind speed	0.0127	
ρ_a	The density of air	1.25E-03	g cm^{-3}

The surface drag coefficient (C_D) calculated from wind magnitude at 10 m above sea surface (W_{10}) by Eq. (Yelland&Taylor, 1996).

$$1000C_D = 0.29 + \frac{3.1}{W_{10}} + \frac{7.7}{W_{10}^2} \qquad (3 \le W_{10} \le 6\ ms^{-1}) \qquad \text{(a)}$$

$$1000C_D = 0.60 + 0.071W_{10} \qquad (6 \le W_{10} \le 26\ ms^{-1}) \qquad \text{(b)}$$

The data which used in this study were gather from various sources are as follow

Monthly data of salinity and temperature at water surface, 10, 20, 30, 50 and 75 m depth were downloaded from U.S. NODC World Ocean Atlas 2001 and calculated the average of weighting data. These data used to calculate sigma-t by using equation of Pond & Pickard (1983).

Monthly four heat types of surface heat flux data were downloaded from the School of Marine Science and Technology, Tokai University and were interpolated by using Gauss method in order to into the same set the coordinate with monthly salinity and temperature then calculate total surface heat flux from 4 heat types.

Monthly wind speed and direction was calculated by using average wind data during 1999 to 2009 downloaded from QuickScat and were interpolated by using Gauss method at 150 km grid size in order to set the same coordinate with other data set.

Monthly discharge data were get from Office of Water Management and Hydrology Royal Irrigation Department Thailand. They were average and interpolated data by using Gauss method at 150 km grid size, then weighting data considering to the distance from river mouth.

Net atmospheric flux calculated by volume of rainfall grid data minus volume of evaporate grid data, monthly rainfall data and monthly evaporate data during 1999 to 2009 downloaded from Ocean color and Woods Hole Oceanographic Institution, respectively.

Tidal data were from mathematic model of Yanagi and Takao (1998) (M_2 and K_1), they were calculated net amplitude each component and total amplitude and interpolated data by Gauss method.

Result

Stratification was prevalence almost all year round, except in December when mixed water column occurred in the upper gulf and along the central coast of the GoT (Fig.1). Generally during the northeast monsoon season (November – January), weak stratification occurred due to strong wind and low surface heat flux. On the other hand, during the southwest monsoon season (May – August), and the strongest stratification showed on May, strong stratification prevailed due to high surface heat flux and high rainfall (Fig.2).

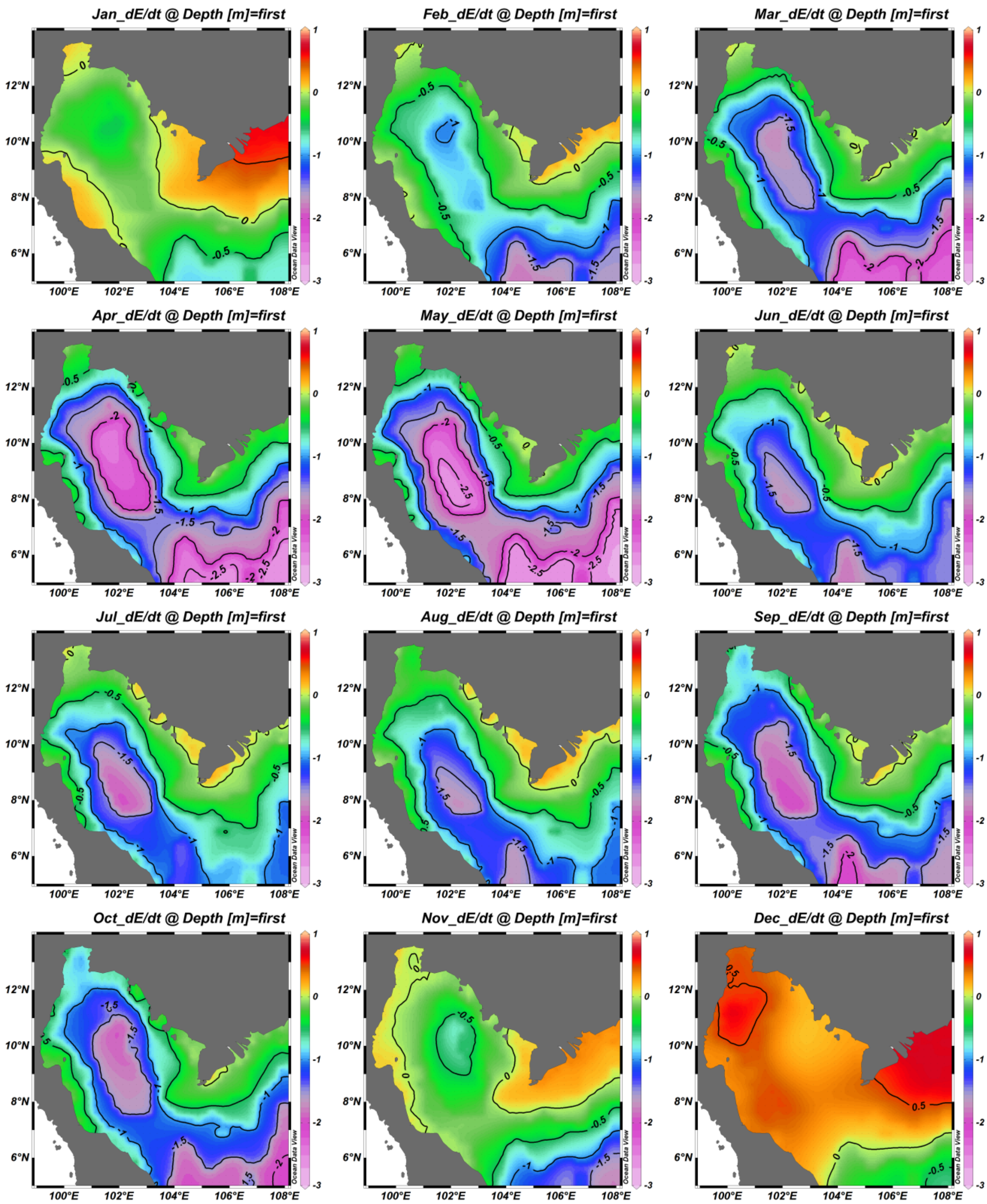

Fig.1 Monthly variations in the rate of change of potential energy in the water column in the GoT.

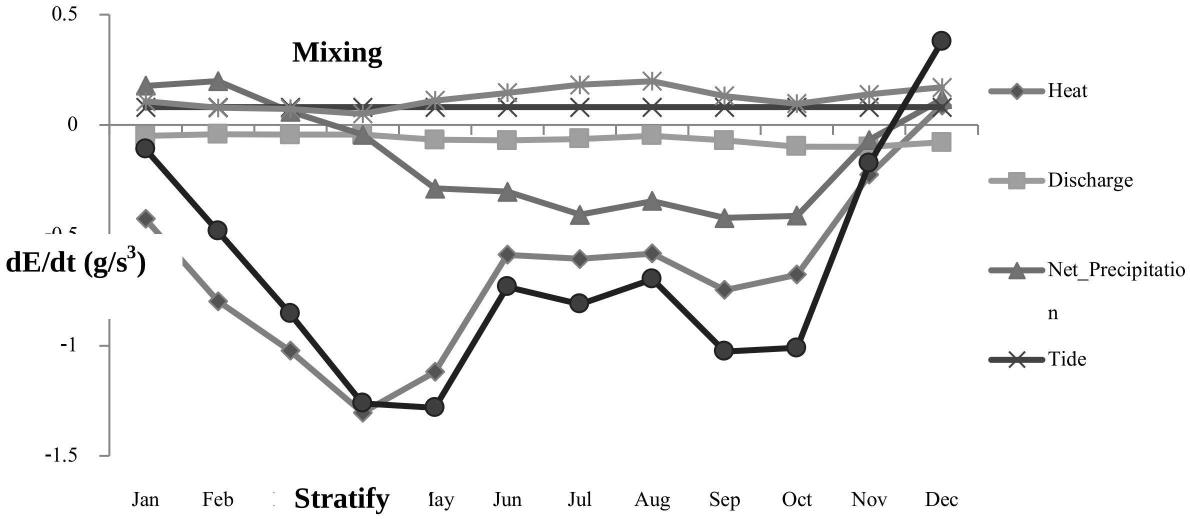

Fig. 2 Seasonal variations in the rate of change of potential energy in the water column in the GoT

Reference

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