Signature of Eddy-Wind interactions in the formation of thermocline bulge in the Bay of Bengal during Winter

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AGU FALL MEETING

SCIENCE LEADS THE FUTURE

INTRODUCTION

- Surface circulation is well known in the Bay of Bengal.
- Very little is known about the subsurface circulation in the bay.
- A few available studies report active subsurface eddy fields (Babu et al., 1991; Madhusudan and James, 2003; Gordon et al., 2017; Jithin and Francis 2021 etc.)
- Knowledge of the subsurface circulation is crucial to understand the salt and heat budget.
- The mechanisms that control the evolution of the warming and cooling cycle of the sea surface.
- We started our research by looking at RAMA buoy subsurface data.

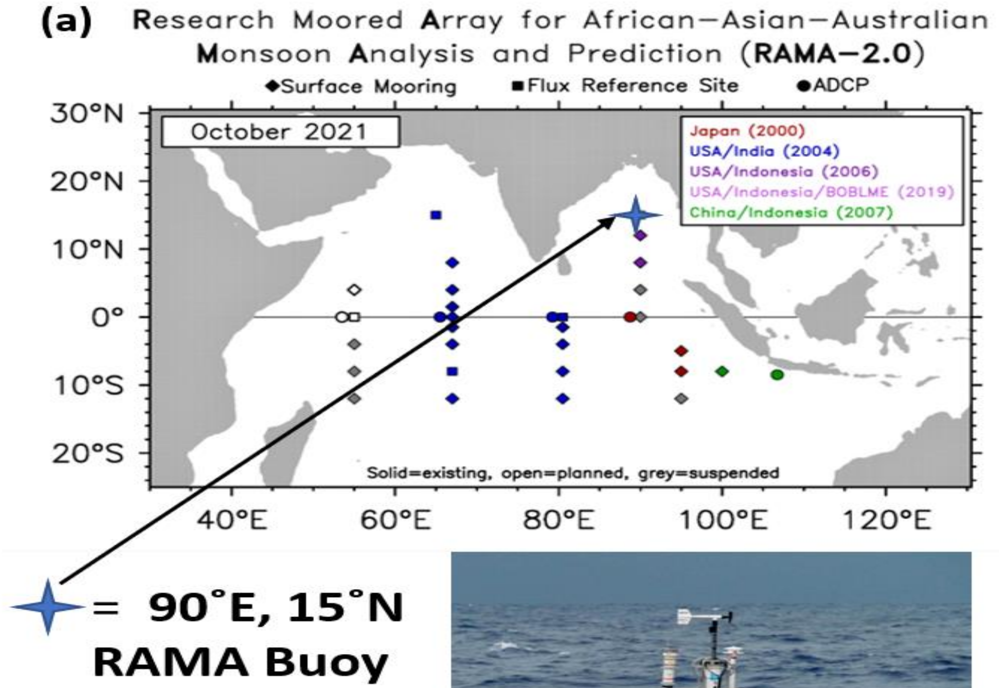
DATA AND METHODS

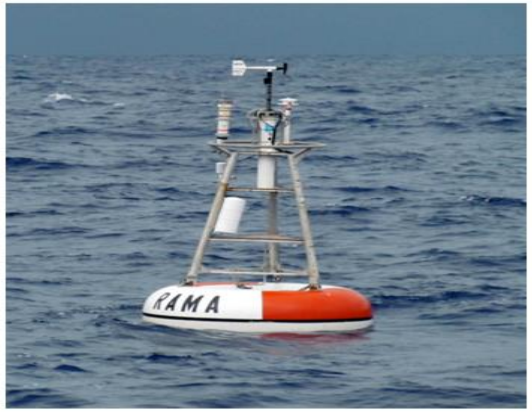
- In-situ **NOAA's RAMA buoy (at 90˚E, 15˚N)** surface to subsurface (T, S) data
- Satellite derived surface AVISO SLA and Ug data, surface OSCAR current data, near surface ASCAT atmospheric wind data.
- HYCOM re-analysis model subsurface data to understand the possible dynamics.
- We have used PyFerret, CDO, NCO and Python tool in Linux environment to analysis and visualize the data products.

Acronym used

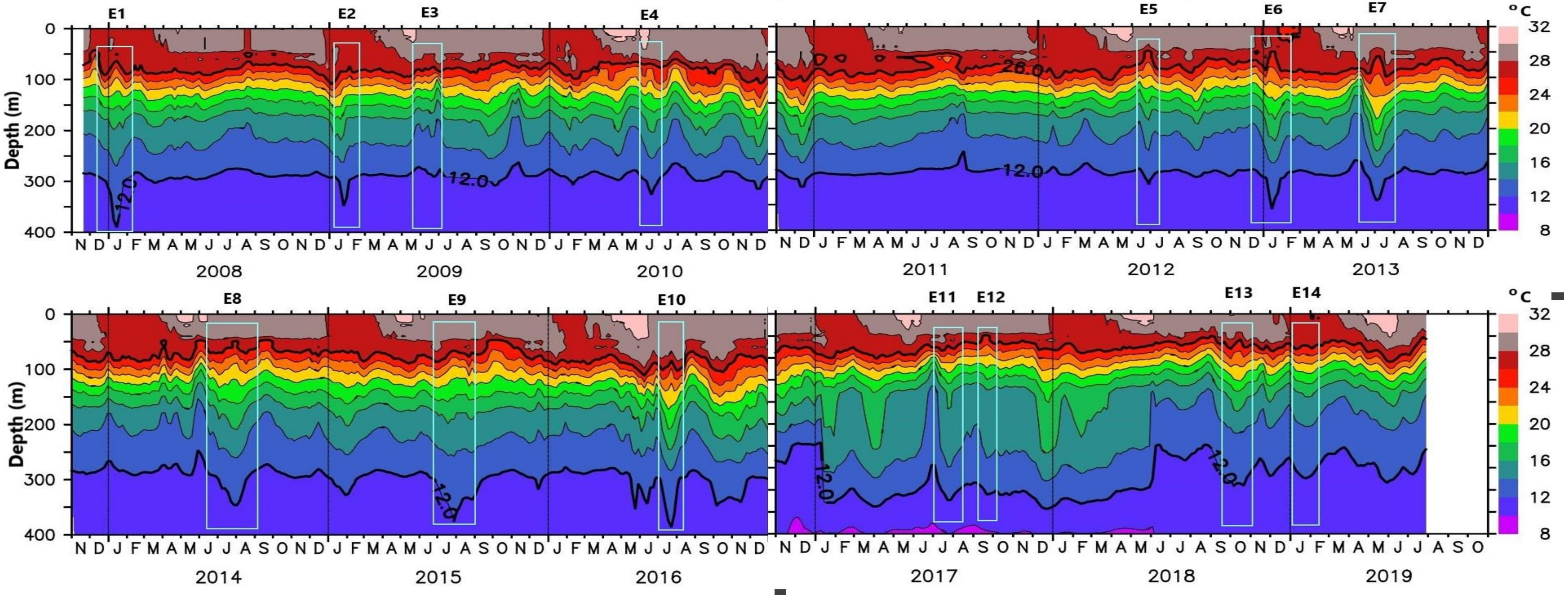
T = Temperature; S = Salinity; SLA = Sea Level Anomaly
Ug = (ug, vg) = Geostrophic ocean surface current
NOAA = National Ocean and Atmospheric Administration
AVISO = Achieving Validation and Interpretation of Satellite Oceanography
OSCAR = Ocean Surface Current Analysis Real-time
ASCAT = Advanced Scattero-meter

RAMA Array Map



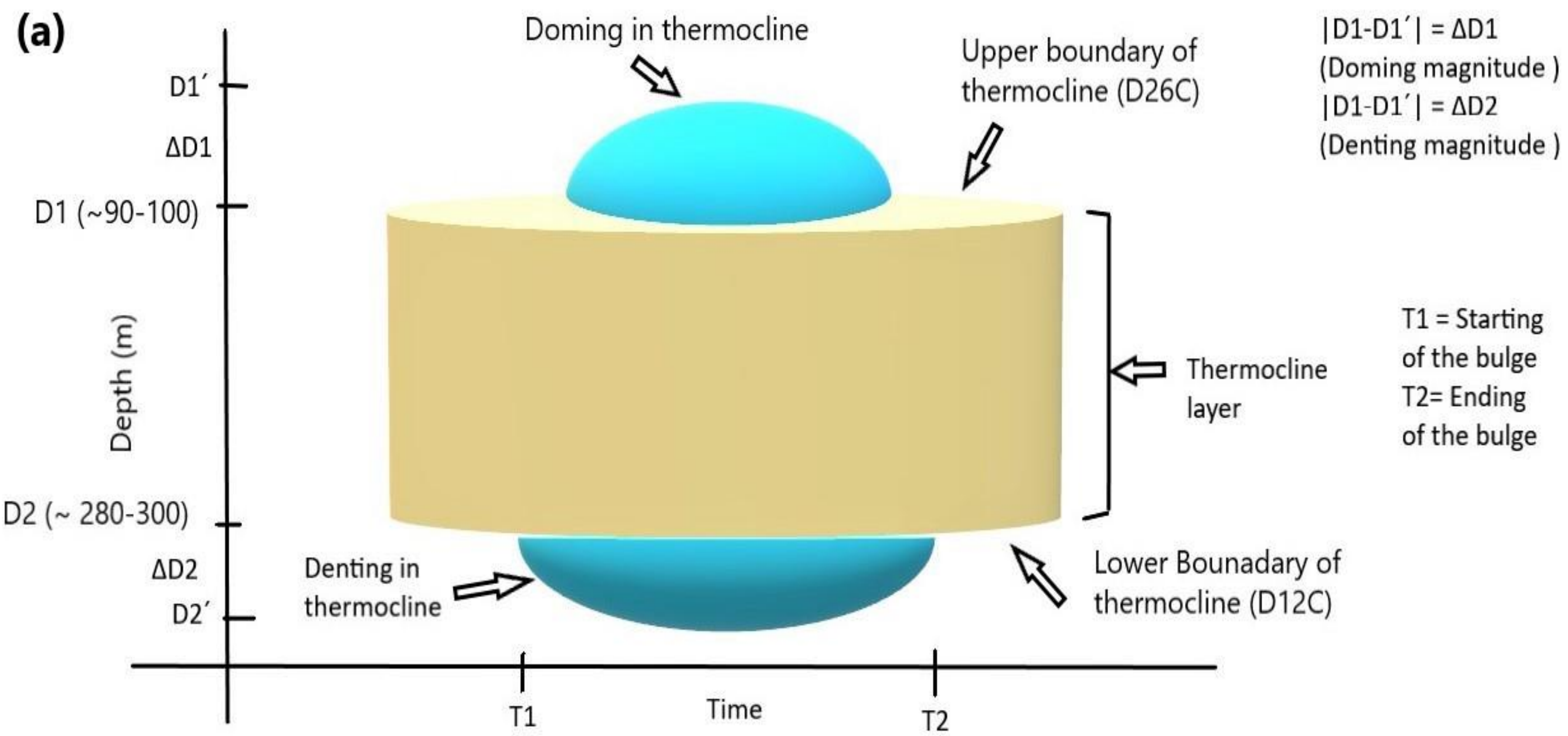


RESULTS: THERMOCLINE BULGE (2007-19)

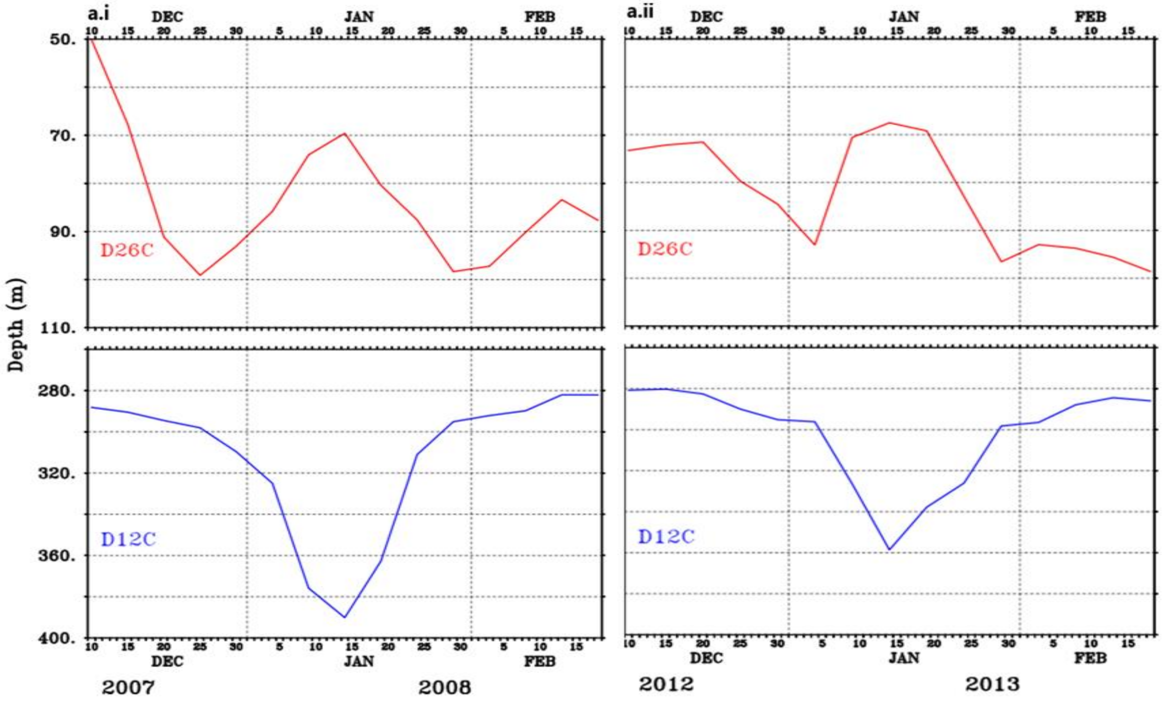


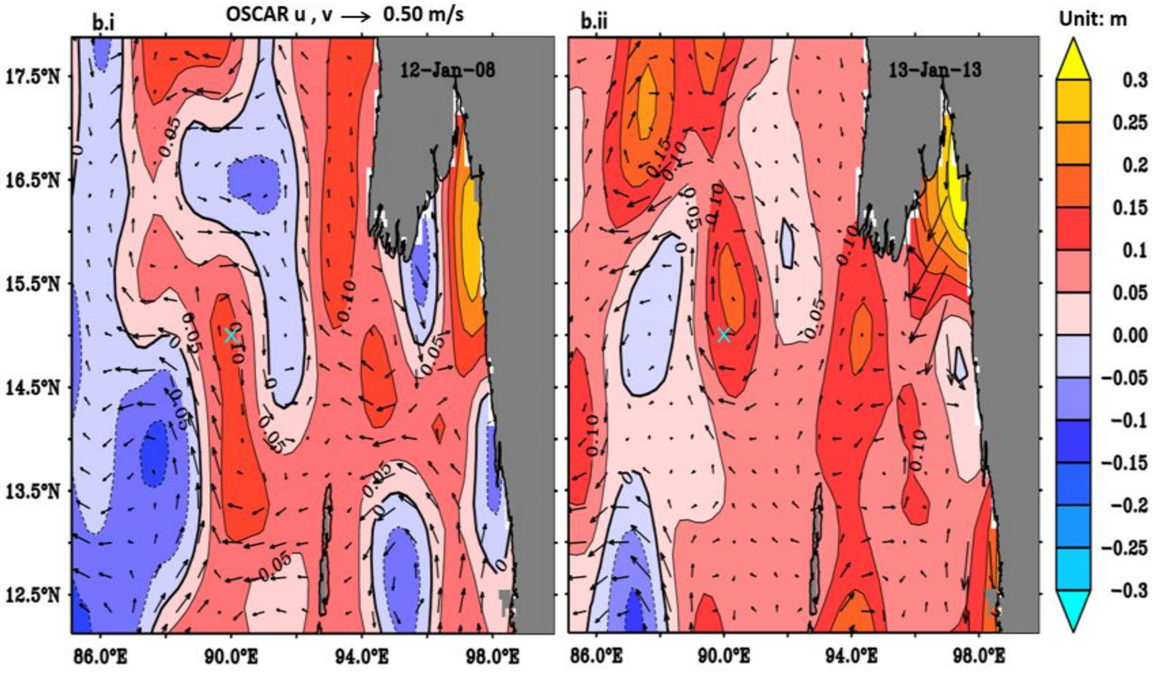
<u>Thermocline bulge:</u> When seasonal TC (D26) shoals and permanent TC (D12) dents under the influence of external forcing.

SCHEMATIC OF THERMOCLINE BULGE



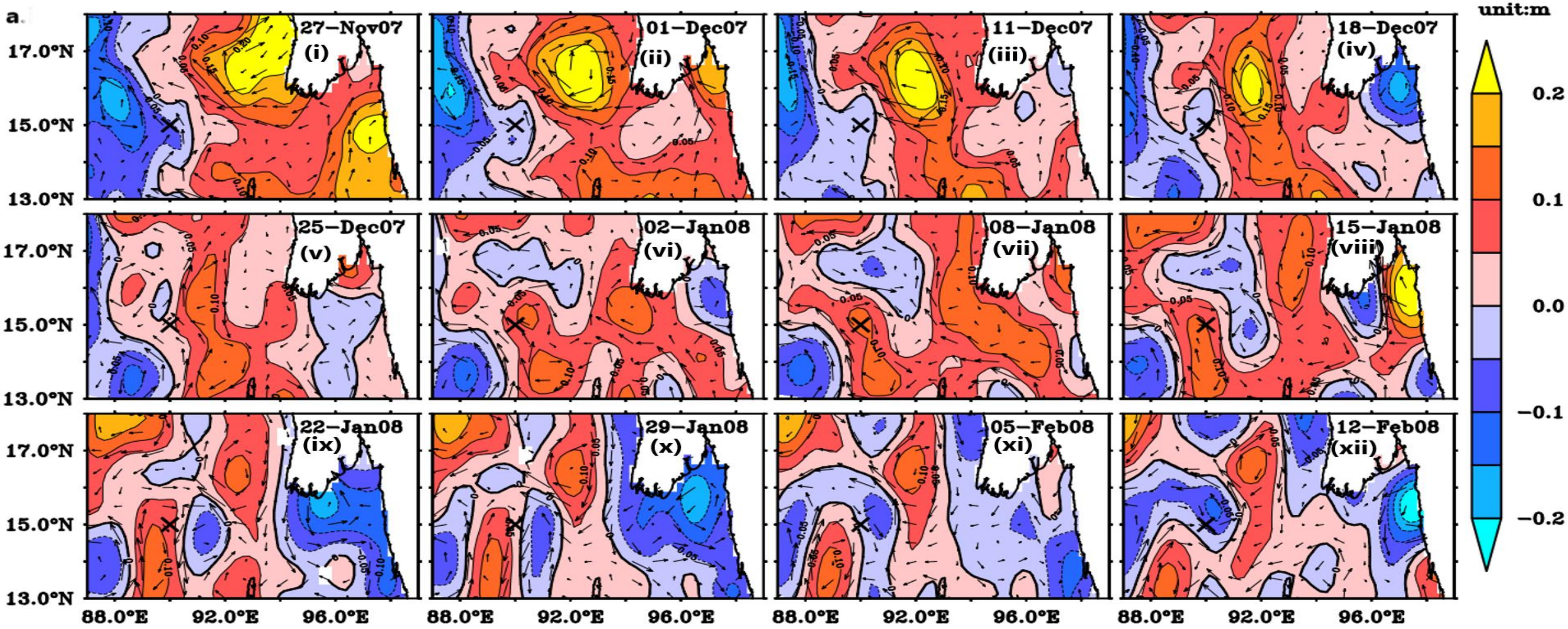
TC BULGE IN WINTER (2007-08 & 2012-13)





Right: Seasonal bulge in thermocline layer in both winters . Left: Both bulge events correspond to the presence of an anticyclonic eddy (ACE). The buoy (cyan cross) was at the north/west-south edges of the ACEs in both seasons.

GENESIS AND PROPAGATION OF ACE



From surface current vector and SLA analysis, ACE is generated off-Myanmar and propagate south-west direction due to Rossby wave forcing and crosses the buoy location during Dec to next Jan.

WHY IS TC-BULGE RELATED TO ACE?

Answer: "Eddy-wind" interaction (*Stern, 1987; Seo et al., 2019; Gaube et al, 2014; McGillicudy et al., 2014, 2015*):

1. Eddy current effect on local relative wind-stress (linear)
2. Eddy current vorticity gradient effect on local wind-stress (non-linear)
3. Eddy-induced SST gradient effect on local wind-stress (less contribution in most of the basins)

$$|\vec{\omega}_{tot}| = \frac{|\vec{\nabla} \times \vec{\tau}_{rel}|}{\rho_o(f+\zeta)} + \frac{1}{\rho_o(f+\zeta)^2}\left(\tau^x_{rel}\frac{\partial \zeta}{\partial y} - \tau^y_{rel}\frac{\partial \zeta}{\partial x}\right) + \frac{\beta \tau^x_{rel}}{f^2 \rho_o} \quad (1)$$

$$f = f_o + \beta \Delta y \quad (2)$$

$$\tilde{\boldsymbol{\tau}} = \rho_a C_D(\mathbf{u}_{bg} - \mathbf{u}_o)|\mathbf{u}_{bg} - \mathbf{u}_o|,$$

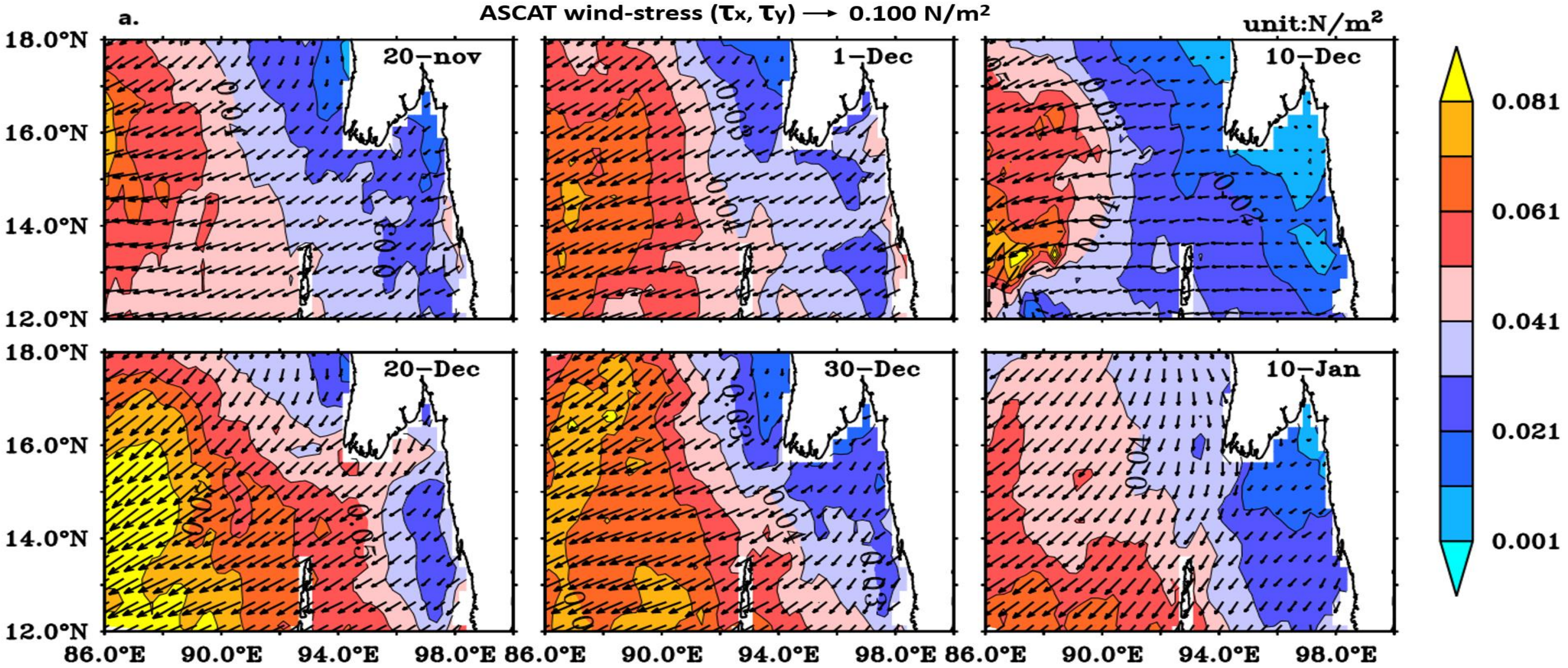
$$\tilde{W}_{tot} = W_c + W_\zeta + W_{SST},$$

$$W_c = \frac{\nabla \times \tilde{\boldsymbol{\tau}}}{\rho_o(f+\zeta)},$$

$$W_\zeta = \frac{1}{\rho_o(f+\zeta)^2}\left(\tilde{\tau}^x\frac{\partial \zeta}{\partial y} - \tilde{\tau}^y\frac{\partial \zeta}{\partial x}\right),$$

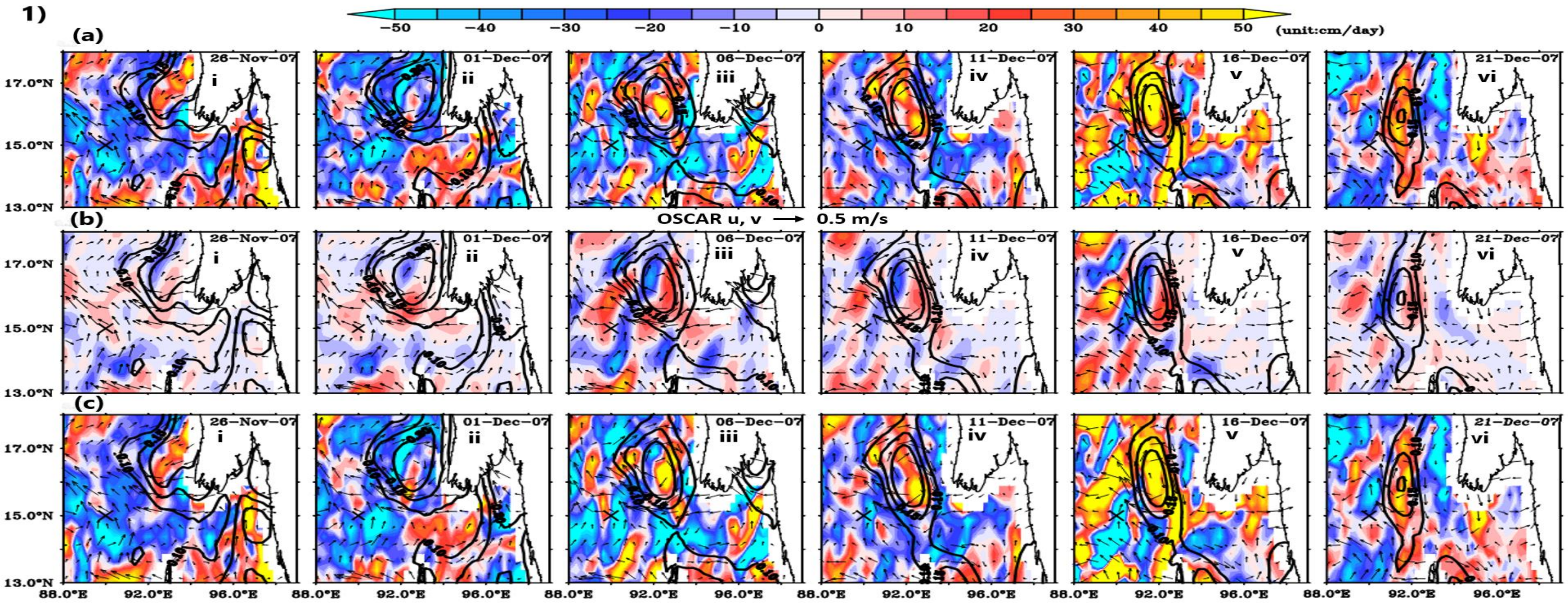
$$W_{SST} = \frac{\nabla \times \boldsymbol{\tau}'_{SST}}{\rho_o(f+\zeta)}.$$

WIND FIELD OFF-MYANMAR IN WINTER



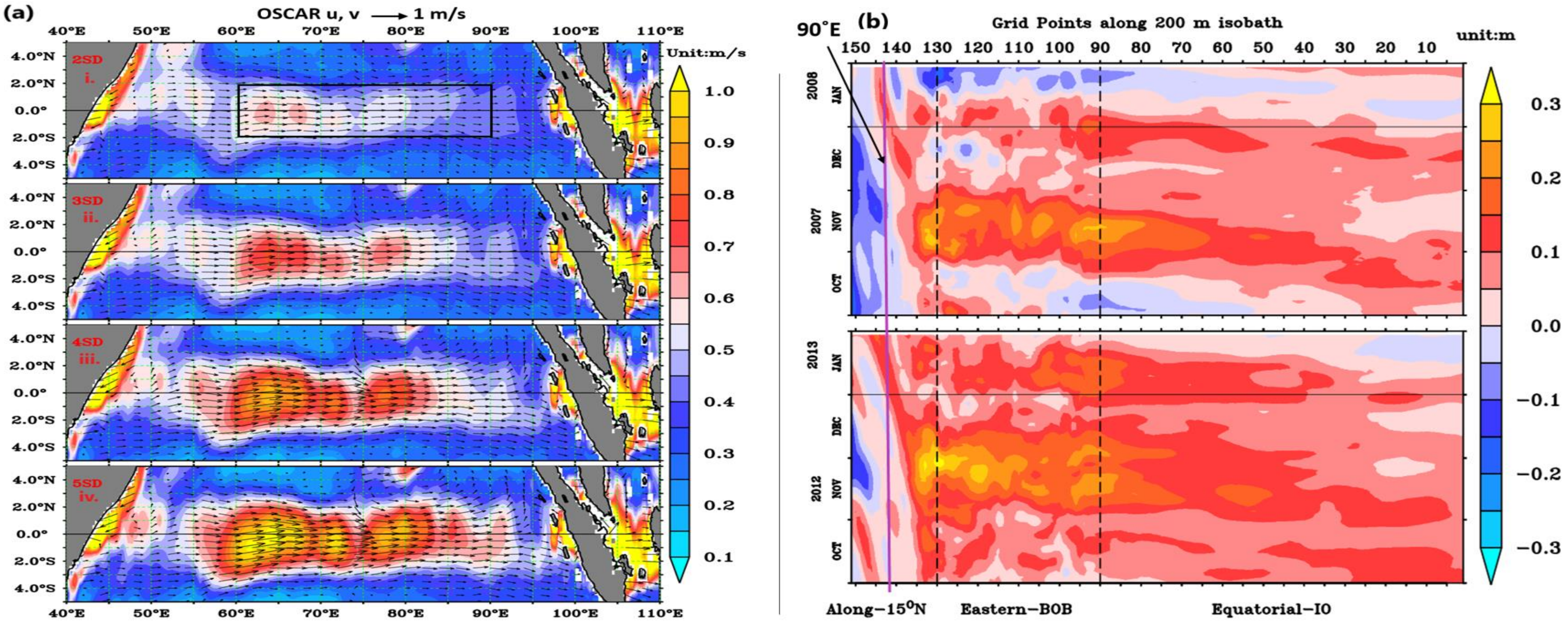
Upwelling favorable winter monsoon wind-stress off-Myanmar.

EDDY-WIND INTERACTION IN WINTER



Eddy-Wind interaction leads to upwelling (or shoaling in seasonal TC) at the center of ACE and propagates south-west direction.

CONNECTION TO EQUATORIAL DYNAMICS



Coastally trapped downwelling Kelvin waves due to equatorial Wrytki jet helps in genesis of ACE off-Myanmar. Then local upwelling favorable winds act of ACE. Thus, TC-bulge forms and propagates with ACE to RAMA location.