Eddies and their energetics in the Bay of Bengal

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Outline

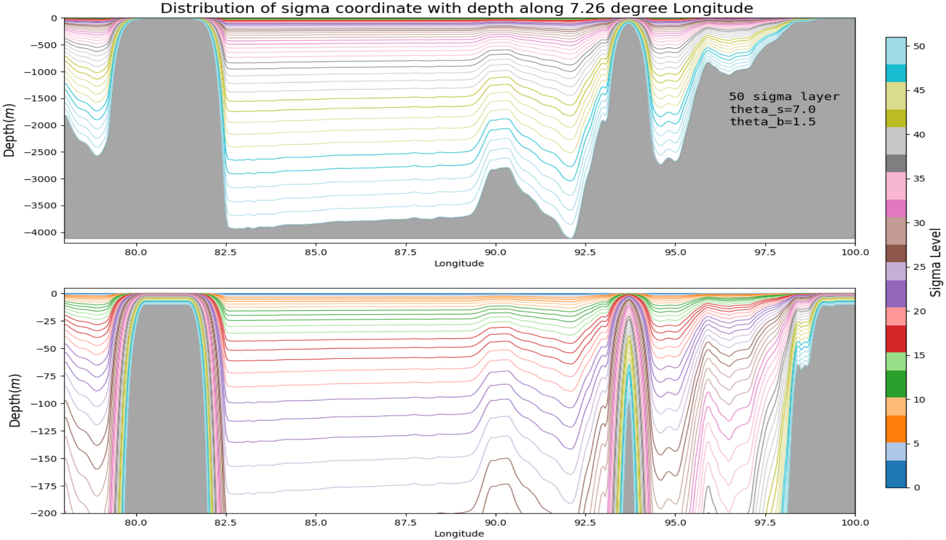
Introduction

- Oceanic motions vary abruptly in time and space and are highly energetic. This variability arises from a host of features, like rings vortices, lens, meanders, jets, filaments etc. These are referred to as eddies generally.(Robinson, 1983)
- Eddies are the integral part of ocean circulation and play an important role in the energy transfer.
- The eddy kinetic energy is several folds greater than the rest of the ocean.(Wyrtki et al., 1976)
- The causative factor for eddy generation are the barotropic and baroclinic instabilities which arise from the horizontal and vertical shear because of horizontal currents.(Pedlosky, 2013)

Model Configuration

- Domain: $78^\circ E - 100^\circ E$, $5^\circ N - 25^\circ N$
- Resolution:
  - Horizontal: $\frac{1}{18^\circ}(5.95km)$
  - Vertical: 50 sigma levels
- Grid Parameter: $\theta_s = 7.0, \theta_b = 1.5$, $T_c = 10m$
- Bathemery: ETOPO2
- Initial Condition: WOA-13
- Lateral Boundary: SODA3.3.1(Monthly Climatology)
- Atmospheric Forcing: Tropflux and ERA-Interim
- River Forcing: Dai and Trentberth Global River

Distribution of sigma levels



Eddy Detection method

To identify an eddy two different methods were applied simultaneously:-

Geometrical Method: In this method close contours of sea surface height(SSH) were identified, in which we detect the local maxima and minima of SSH is detected.(Chelton et al., 2011)

Dynamical Method: In this method we calculated the Okubo-Weiss parameter. If the modification of the flow is dominated by vorticity rather than strain then the feature is classified as eddy.(Okubo, 1970; Weiss, 1991)

Okubo-Weiss Parameter

$$W = S_\eta^2 + S_s^2 + \xi_\eta^2$$

$$S_\eta = \frac{\partial u}{\partial x} - \frac{\partial v}{\partial y}$$

$$S_s = \frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}$$

$$\xi = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$$

Where:

S_η = Normal component of strain tensor
S_s = Shear Component of strain tensor
ξ = vertical component of relative vorticity

Tracking of Eddies

To detect whether the eddy detected at two consecutive time steps were same or different, we used method described by Penven et al. (2005), where a non-dimensional space property is calculated, which should be minimum.

$$X_{e1,e2} = \sqrt{\left(\left(\frac{\Delta X}{X_\circ}\right)^2 + \left(\frac{\Delta R}{R_\circ}\right)^2 + \left(\frac{\Delta \xi}{\xi_\circ}\right)^2\right)}$$

Where:

ΔX = spatial distance between the eddy centres $e1$ and $e2$

ΔR = Diameter variation

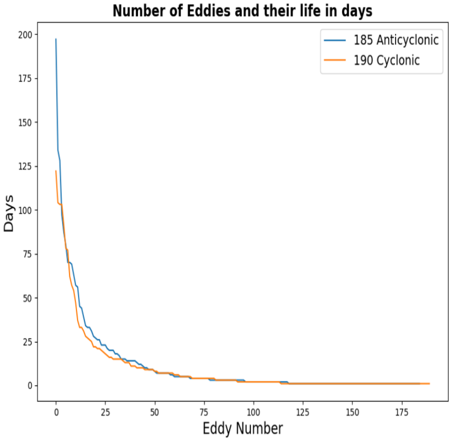
$\Delta \xi$ = Vorticity variation

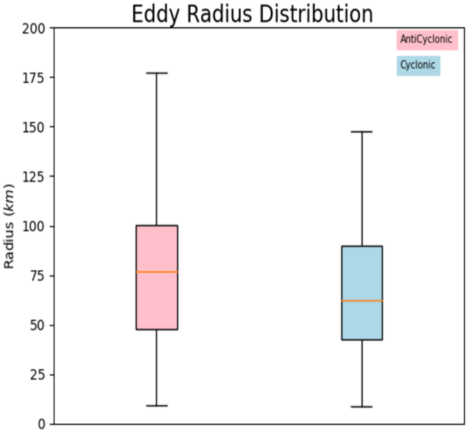
$X_\circ$ = Characteristics length scale$(100km)$

$R_\circ$ = Characteristics Radius$(50km)$

$\xi_\circ$ = Characteristics Vorticity $10^{-5}S^{-1}$.

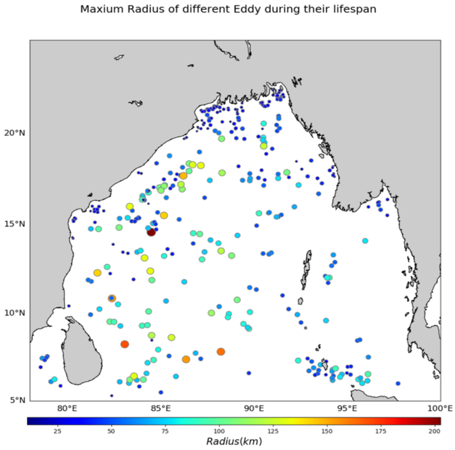
Statistical Analysis

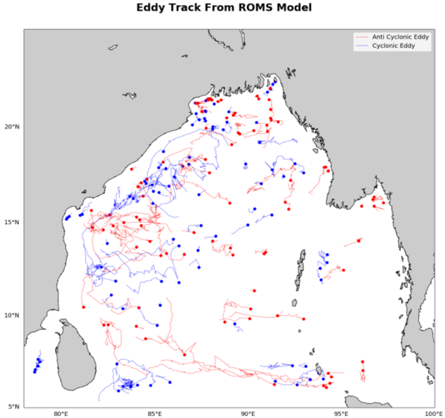




- Anticyclonic eddies have higher life span than the cyclonic eddies. Maximum life span of a anticyclonic eddy goes up to 190 days where as for cyclonic eddy it remains 120 days only.
- Average life span for anticyclonic eddies is 12 days and for cyclonic eddies it is 10 days.
- Anticyclonic eddies have mean radius of 78.35 km, where as cyclonic eddies have mean radius of 66.14 km.
- The largest eddy is of anticyclonic type whose radius is 202.7 km whereas that of a cyclonic eddy is 147.3 km.
- Anticyclonic eddies have radius within 49 km to 100 km. Cyclonic eddies have radius within 43 km to 90 km.

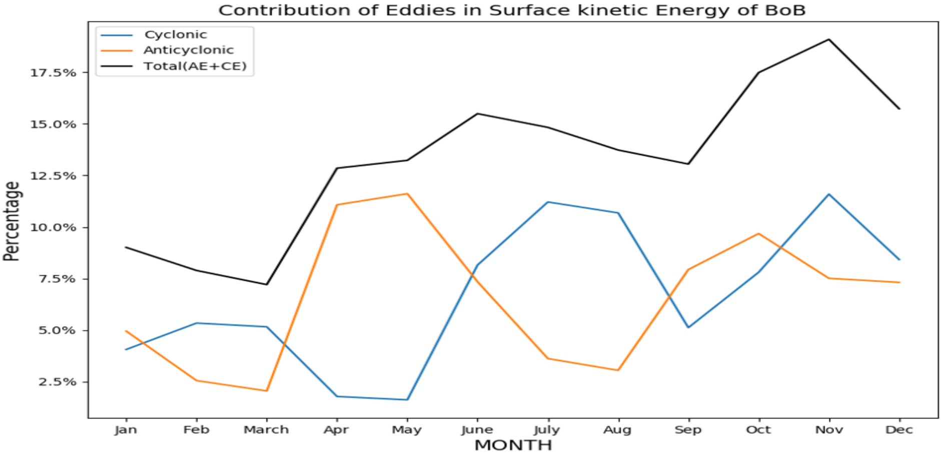
Maximum Radius and Track of Eddies





- Largest number of eddies formation takes place in the East India Coastal Current(EICC) region away from the coast and they have eddy radius in the range of 50-150km.
- Formation of biggest eddy takes place near the Vishakhapatnam, Vijayawada and Chennai region with a maximum radius for this eddy goes to 200km.
- In the northern part of Bay of Bengal (BoB) near the coast eddies with smaller radius are formed in between 10-25km. In the central region of BoB eddy radius ranges from 50 – 125 km.
- Analyzing the eddy track we can say that , most of the BoB get the presence of eddies except Andaman Sea(AS) where less number of eddies presence occur than the other parts of BoB.
- The southern BoB is mainly dominated by the anticyclonic eddy, which travels with the monsoon current system from eastern BoB to western BoB.
- Eddies originating in the southern BoB travel the longest distance in their lifespan.

Conclusion



Contribution of Eddies in Surface kinetic Energy of BoB
Cyclonic
Anticyclonic
Total(AE+CE)
17.5%
15.0%
12.5%
10.0%
7.5%
5.0%
2.5%
Percentage
Jan
Feb
March
Apr
May
June
July
Aug
Sep
Oct
Nov
Dec
MONTH

- The contribution of eddies to kinetic energy is lowest in the month of march when winds have the lowest magnitude.
- In the month of Oct-Nov contribution of eddies have largest which is 17.5% of the surface kinetic energy.
- In the month of April-May the EICC weakens and starts changing its direction due to which formation of eddies accelerate and the kinetic energy contribution due to eddies also rises.
- In the month of September retrieval phase of southwest monsoon starts and it starts stirring the sea surface due to which eddy energy starts rising and becomes highest in the month of November.

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Thank you!