Seasonal variability of surface circulation in the northern Bay of Bengal

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Abstract

Circulation patterns in the northern Bay of Bengal (BoB) were studied using satellite tracked drifter trajectories. Circulation patterns and the sea surface temperature in the Bay of Bengal are affected by the monsoonal dynamics in the Indian Ocean (IO). Characteristics of the water and sediments in the Bay of Bengal are determined by the fresh water influx from the large Indian rivers specially Ganges and Brahmaputra and high saline water from Arabian Sea (AS). East Indian Coastal Currents (EICC), which flows along the western boundary of the BOB reverses direction twice a year. The northeastward flows from March to September with a strong peak in April (June-September; summer monsoon), and southwestward from October to February with strongest flow in November (December-February; winter monsoon). This phenomenon seems to be more complex than developed models based on observations.

General characteristics of surface currents in tropical Indian Ocean were analyzed for the period of 2012 to 2014. Colour maps derived from insitu data and Ocean color images from satellites showlow salinity cold water transport from BOB to AS along the east coast of India and Sri Lanka during winter monsoon and it reversed during summer monsoon with high salinity warm water from AS to the BOB.

The findings of this research can be applied socio-economically for the determination of upwelling regimes, chlorophyll distributions, potential fishing grounds, whale aggregating areas, predicting weather conditions and navigation. Also, results can be applied during disaster mitigations such as oil-spills by, ship wrecks to determine possible path ways to identify impact areas.

Keywords: Bay of Bengal, Winter/Summer monsoon, EICC, SST, SVP drifters

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Introduction

Circulation patterns and the sea surface temperature in the Bay of Bengal (BOB) are affected by the seasonal variations (monsoon) in Indian Ocean (IO). The specifics of the water and sediments in the Bay of Bengal are determined by the fresh water influx from the large Indian rivers such as Ganges and Brahmaputra, and high saline water from Arabian Sea. Western boundary currents (East Indian Coastal Currents (EICC)) in

the BOB reverse direction twice a year. EICC flows northeastward from February to September with strong peak in March and April and southwestward from October to January with strongest flow in November [Schott and McCreary, 2001]. But the surface circulation in Northern Indian Ocean seems to be more complex than developed circulation models based on observations.

There are two pathways of low salinity water from the Bay of Bengal into the southeastern Arabian Sea [Vinayachandran et al., 2005]. One is along the coast around Sri Lanka and the southern tip of India during October – November and the other is through the winter monsoon current during December – March which is fed by the EICC [Shanker et al., 2002]. Low saline water observed in the southeastern Arabian Sea during November – December [Boyer et al., 2002] and numerical models which show that the EICC flows around India and Sri Lanka in to the Arabian Sea [Han and McCreary, 2001; Vinayachandran and Yamagata, 1998] suggest that the EICC is a definite conduit [Vinayachandran, 2005]. We have observed the variation of the monsoon activation time when analyzing data from the RAMA (The Research Moored Array for African–Asian–Australian Monsoon Analysis and Prediction) buoys. For 2013 northeast monsoon seems to be activated in the mid-December while southwest monsoon in mid-June (Fig. 4). The seasons shifts in 2014 as northeast monsoon activated in mid-November while southwest in early June (Fig. 4). Based on wind data analysis we have used December-February as the winter monsoon season, while June-September as the summer monsoon season.

Study onseasonal variation of circulation in the Bay of Bengal is important for the identification of formation of eddies, changing wind patterns, cyclones, weather and climate prediction in the BOB region. Lack of reliable data is a major challenge for understanding Indian Ocean circulation and hence the prediction of monsoon.

Current study describes seasonal variability of near-surface flow paths, currents, and temperature in the Bay of Bengal, especially boundary currents off Sri Lanka using satellite-tracked drifter observationscollected during 2012 to 2014.

Materials and Methods

Set of satellite-tracked SVP drifters were deployed by National Aquatic Resources Research and Development Agency (NARA) jointly with Scripps Institution of Oceanography (SIO)in the Bay of Bengal. Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imageries of sea surface height anomaly (SSH) and sea surface temperature anomaly (SST) were analyzed for confirmation of

theresults.MATLAB scientific software was used for the analysisof drifter data and to produce ocean current maps around Sri Lanka.

Results and Discussion

The trajectory of satellite tracked SVP drifters indicated the variation of winter monsoon currents (WMC) patterns around Sri Lanka(Fig. 1 and 2). During winter monsoon, EICC flows along the Sri Lanka coast, around Maldives Islands to the Arabian Sea. During summer monsoon, EICC flows away from the Sri Lankan coast towards east of BOB. The results indicated that monsoon patterns influence to change the direction of EICC and its responses and changes with the development of the monsoon.

Sea Surface Temperature (SST) in the BOB fluctuates in a contrasting manner (Fig. 3), especially during winter (Blue) and summer monsoon (Green) periods where water currents reverses its direction between BOB (with high fresh water influx) and Arabian Sea (with high evaporation rates). SST data obtained from drifters shows SST drops around east coast of India and coastline around Sri Lanka along the western boundary currents of the BOB during November to Februaryand then indicated gradual increase of SST along the path when current comes to the Arabian Sea

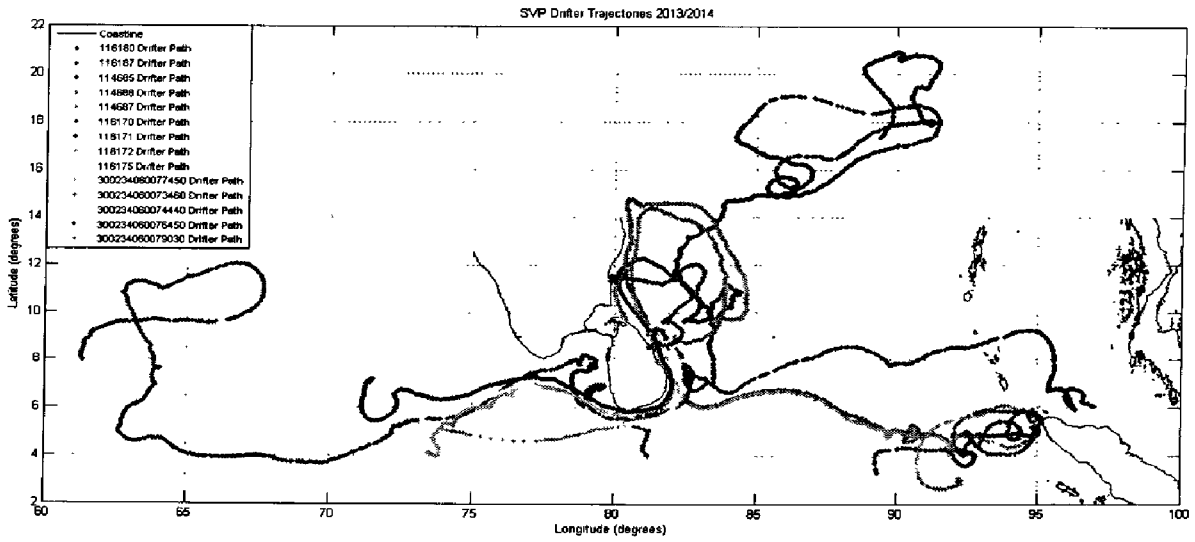

Figure 1 : Trajectories of 15 SVP drifters deployed during 2013 – 2014 period.

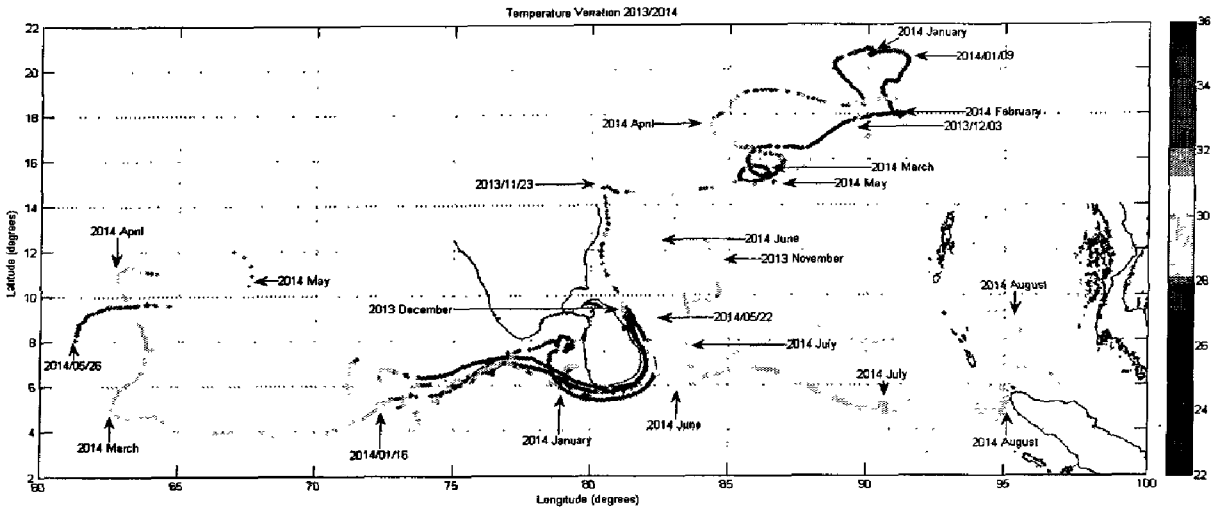

Figure 2: Temperature variation along the drifter trajectories during winter and summer monsoon period. More cold water current is observed close to Sri Lanka coast between December and January.

Conclusion

Currents in the Indian Ocean reverse due to the Impact of monsoonal winds. EICC flows along the east coast of India and Sri Lanka during winter monsoon (WM) with decreases of SST. Shrinkage of sea surface temperature around southern coast of Sri Lanka occurs during both monsoons indicating an upwelling event due to the divergent currents. Anticlockwise eddies are formed closer to Sumatra in between July to August indicating a trend of travelling north during inter-monsoon and disappears with the onset of winter monsoon where currents started to flow southward of BOB.The most ofeddies are formed associated with ninety East Ridge (90°E) which indicated morphological influence onCurrent patterns.

Trajectories of SVP drifters which were deployed in the east of Sri Lanka in December 2013, flow southward along the coast and turn northwest near southern tip of SL around080°E.Later, those turn southwest around077°E and flows toward Maldives Islands instead of travelling north to connect with the West Indian Coastal Current (WICC). It is somewhat differ from the mechanism illustrated by Schott and McCreary in 2001, where they suggest that the EICC connects with the WICC through Laccadive High (LH) during winter monsoon.The time period of the drifters came to077°E is in January which represents the winter monsoon peaks. Monsoon winds (Easterlies) become strength as the monsoon progresses, surface currents are driven by wind and those may be the reasons to the change the current direction.

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