

Ocean current mapping with indigenous drifting buoys

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Ocean current transports mass and energy around the world and it is the driving force of climate and it regulates local weather. Drifting buoy plays an important role in mapping world's ocean water circulations and its study. The National Institute of Ocean Technology (NIOT), MoES, Chennai has indigenized drifting buoy with the Indian Satellite (INSAT) telemetry and global positioning system receiver to acquire geo-positional updates to precisely calculate ocean's mixed layer surface current. The drifting buoy acquires hourly positional data (24 data/day) compared to ARGOS drifters which has limited pass in Indian tropical regions. The NIOT deployed drifting buoy in the Bay of Bengal and the Arabian Sea during monsoon seasons of 2012–2019 to study the Indian Ocean currents. This article reports about the mixed layer surface currents mapped by the indigenous drifting buoy in the Bay of Bengal.

Keywords: Drifting buoy, GPS receiver, mixed layer surface currents, mesoscale eddies.

Introduction

DEBRIS and messages in bottles have contributed towards an understanding of the ocean's surface currents during the 19th century^{1,2}. The National Oceanic and Atmospheric Administration (NOAA) has collected ocean surface current using more than 100,000 traceable drifter units deployed around the globe until 2014 (ref. 3). The Global Drifter Program (GDP) reached a significant milestone of deployment of 25,000 drifters since 1979. Internationally deployments of drifters are coordinated by the Global Drifter Center, NOAA in collaboration with national and international partners. A drifter consists of surface float, drogue and tether wire. Generally, the length of the tether wire determines the depth at which the mixed layer surface current (MLC) is measured. Drifting buoy (DB) measures ocean currents, sea surface temperature and barometric pressure and these observations improve weather forecasts, ocean state estimation and are used for validation of satellite measurements of SST. Apart from satellite-based surface current measure-

ments, ocean current measurement by drifter is the main source of surface current mapping and it is mainly used for studying ocean tidal currents⁴.

Indigenous development of drifting buoys

Drifters built with ARGOS satellite receivers has limited pass per day in the Indian tropical regions and the positional accuracy is around ± 350 to 1000 m. The Ministry of Earth Sciences (MoES), Government of India, implemented a national drifting buoy programme and funded for development and deployment of self-powered automated ocean observation system⁵. There are 16 DBs deployed by various Indian institutions in Indian waters and reporting data sets to the global data centre⁶. The National Institute of Ocean Technology (NIOT), MoES indigenized DBs using INSAT (Indian satellite) transmitter for telemetry ensure daily 24 set of positional information on every hour basis. Hourly based geo-positional information's enables to map occurrences of sub-meso scale eddies in ocean and to study regional ocean water circulation patterns. The DBs operated in coastal areas can utilize inexpensive general packet radio service (GPRS)⁷ for communication. Hence, NIOT incorporated both INSAT and GPRS telemetry options. The GPRS supports for a two-way communication wherein data downloads and system programming is possible. The NIOT also indigenized technology of drifting buoys with INSAT communication with high-resolution SST measurement technique and GPS receiver by RF Solutions^{8,9}. The NIOT produced seven DBs (P1–P7) with various sensor configurations during 2011–2017 and carried out deployments in Bay of Bengal (BoB) during 2012 to 2017 and validated their field performances^{10,11}. The DB systems P1–P6 observed mesoscale eddies in BoB, which found to be energetic, and swirling, having time-dependent circulations for about 100 km in width¹².

Measurements of ocean current using DBs

The Lagrangian drifters are not affected by Doppler shifting through background currents and it provides good spatial coverage to track ocean eddies. The DBs are used to examine the meridional structure of inertial variability

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in BoB. The rotary velocity is directly calculated from drifter tracks to estimate the tidal amplitudes and phases and the wire walkers are used to study the cyclonic flow. The DB is mounted with a GPS¹³ receiver module, SST sensor and an INSAT telemetry device as listed in Table 1. The main objective of GPS receiver is to provide drifter's position on hourly basis¹⁴. Thus the indigenized DB is used to measure MLC on real time basis and it has good water following characteristics¹⁵. DBs deployed by NIOT at various seasons to map ocean current are indicated in Table 2. The first prototype, P1, with SST, was deployed (off Panama, Sri Lanka) in BoB during 2012 using *Sagar Manjusha* at 10°00.035'N, 88°30.165'E (Figure 1). Drift track of P1 is superimposed using Google Map on 6–8 May 2012. The drifter data was captured every 15 min and it is observed that the drifter whirled in a steady location (7°N–83°E) for about a month (21 April–25 May 2012) may be due to reversal wind speed and surface current (Figure 2).

Deployment of cluster of drifting buoys

The DB-P2 was built during November 2012 and deployed off Tamil Nadu coast in BoB using the vessel *Sindhu Sankalp* on 8 March 2013 with a cluster⁸ of two drifters including the imported DB from Marlin-Yug, Ukraine. Figure 3 illustrates the drift rate of both drifters considered for comparison and evaluation. The red and blue column represent drift rate of P2 and the imported drifter respectively. The mixed layer surface (MLC)

current following the characteristics of indigenous drifter is matching as that of imported drifter. The DB attains more velocity in the shallow water region than in the deep sea. It also provides information on eddy current circulations that occurs due to the reversal of surface current in response to strong winds at deep sea surface. The field test result of DB-P2 is validated with a commercially available DB (Marlin-Yug). Drift rate comparison of these drifters indicates a strong agreement of current measurements.

Table 2. Deployment position of drifters

Drifting buoy ID	Latitude	Longitude	Deployment details
DB-P1 ²¹	6.94	82.97	21/4/2012
DB-P2 ¹⁹	11.0	82.51	09/3/2013
CDB ²⁵	17.01	73.24	21/4/2014
DB-P4	13.14	83.5	01/5/2015
DB-P5	14.03	84.1	08/3/2015
DB-P6	8.699	83.6	02/10/2015
DB-P25 ²⁰	11.96	72.1	21/3/2016
DB-P30	11.92	74.0	25/6/2016

Table 1. Accuracy of sensors

Sensor	Accuracy
GPS	±10 m
High resolution sea-surface temperature sensor	± 0.05°C



Figure 2. Mixed layer surface current mapped using DB-P1 drifter.

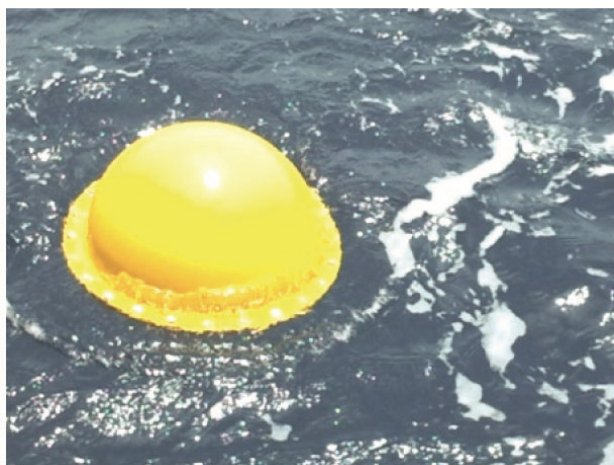


Figure 1. Drifter deployed at ocean.

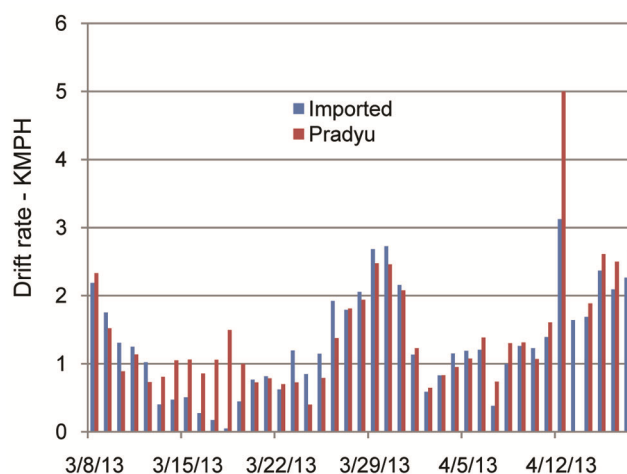


Figure 3. Drifter's drift rate comparison (km/h).

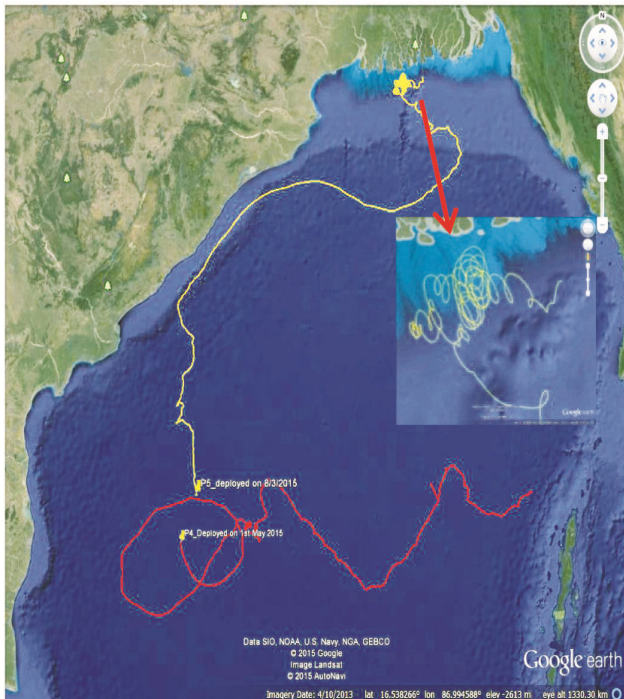


Figure 4. Current pattern in shallow water and deep sea during March–September 2015.

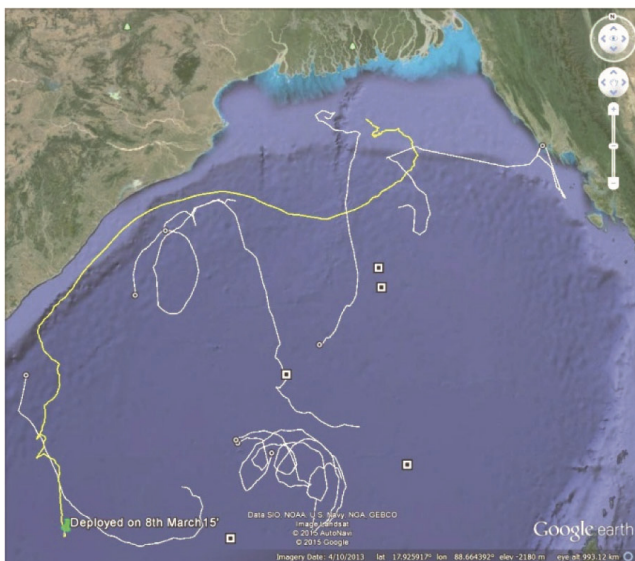


Figure 5. Ocean current mapped using drifters deployed by NIOT (yellow) and NOAA (white) during March–June 2015.

P4 and P5 systems

The DB-P5 was deployed on the west of central BoB at position 14.3°N, 84.1°E on 8 March 2015 using *Sagar Manjusha* around 50 km off Chennai. It was carried by the strong East India Coastal Current (EICC) and reached the shallow basin near the world's largest tidal mangroves and delta system, Sundarbans and Bengal delta¹⁶.

It strongly coincided with the northeastward EICC during February to April¹⁷. Figure 4 indicates the DB P5's current map along the EICC and longer stay at Sundarbans regions due to shallow and muddy waters. The DB-P4 was deployed at position 13.14°N, 83.5°E in the BoB on 1 May 2015 using *Sagar Manjusha* around 120 km off Chennai. It mapped the pre southwest monsoon current during May to June and northeast monsoon current and it got held up off the Indonesian coast for more than 20 days. It followed southwest monsoon current during June to August and drifts from BoB central eye section towards northward and due to freshwater runoff it returned back in to central eye and further drifts towards Andaman Islands during the northeast monsoon season (NEM). The network of drifters deployed by NOAA-6 Nos and NIOT-1 No in BoB during March–May 2015 and their MLC current maps are shown in Figure 5. It is observed that most of functional drifters follow northeast-ward EICC directions during the period March–May 2015.

Conclusions

This article reports the results of indigenous drifting buoys deployed in Indian waters since 2012. The mixed layer surface currents measured using indigenous DB-P2 is compared with imported drifter (Marlin-Yug) and the advantage of using Indian geostationary satellite over polar satellite for data communication which can provide near real time data has been explained.

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