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Review

Indigenous drifting buoys for the Indian Ocean observations

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ABSTRACT

Drifting buoys are widely deployed to measure near surface ocean currents and temperature. The Global Ocean Observation System program designed a global array of 1250 drifter buoys to cover oceans at resolution of one per $5^\circ \times 5^\circ$ grids spatially. The National Institute of Ocean Technology, India indigenized drifting buoy in 2012 with geostationary satellite communication to have near real-time data at every hour. The drifting buoy technology is applied for intellectual property right and transferred to Industries. The measurement scheme in the drifting buoys is capable to measure variability in sea surface temperature and small mesoscale surface eddies. This article describes case studies of indigenous drifting buoys in the Indian Ocean from 2012 onwards. The sea surface temperature and drifting speed measured with indigenous drifting buoy is compared with market available drifting buoy (Marlin-Yug), moored data buoy (BD11) and remote sensed data. We also report results from a drifting buoy with General Packet Radio Service (GPRS) telemetry in the coastal region.

1. Introduction

Measurement and knowledge on Sea Surface Temperature (SST) is important to understand atmospheric convection, amount of heat exchange between ocean and atmosphere, high productive ocean regions and climatic state. Ocean currents transfer heat from lower latitude to higher latitude. Hence SST and ocean currents have significant impact on world's climate. The Lagrangian drifting floats are widely deployed to measure near surface ocean currents (Smith et al., 1984; Lanza, 1984). A significant development of drifting buoys for measuring SST and current took place under surface velocity program (SVP) of the Tropical Ocean Global Atmosphere (TOGA) experiment and the World Ocean Circulation Experiment (Woce). The Global Ocean Observation System (GOOS) program designed a global array of 1250 drifter buoys (DB) to cover oceans at resolution of one per $5^\circ \times 5^\circ$ (Ioc-goos; Soreide et al., 2001). In general DB is powered with internal battery and communicates over short range radio frequency or through low orbit satellites.

The National Institute of Ocean Technology (NIOT), India indigenized DB in 2012 (Srinivasan et al., 2013; Sudhakar et al., 2013; Zacharia et al., 2015). The DB technology is applied for intellectual property right and transferred to Industries (Srinivasan et al., 2013). The industries are produced the DB at a very competitive price. This paper describes case studies of indigenous drifting buoys in the Indian Ocean from 2012 onwards. The sea surface temperature and drifting speed measured with indigenous drifting buoy is compared with market available drifting buoy (Marlin-Yug), moored data buoy (BD11) and remote sensed data. We also report results from a drifting buoy with General Packet Radio Service (GPRS) telemetry in the coastal region.

2. Means and methods

2.1. Drifting buoy description

The DB is made of a flanged two part spherical float of 0.4 m diameter made of acrylonitrile butadiene styrene. The bottom half of the float houses battery, embedded system, power control switch, power controller and satellite modem or a General Packet Radio Service (GPRS) modem (Fig. 1). The bottom half of the sphere is coated with antifouling paint. The upper half portion of the float is coated with ultra violet protective coating. A 12 m stainless steel tether wire is connected to an eye bolt at bottom center of the float. The bottom center of the float is strengthened internally. The bottom end of the tether is attached to a disc type frame on windowed cylindrical holy sock drogue.

The battery (11–15 V, 56 Ah) is made of 32 alkaline cells. It is connected to the circuits through an external switch and power controller. The power controller is controlled by embedded controller and enables the power to the sub systems and sensors. The DB is instrumented with SST sensor at 0.16 m depth, atmospheric pressure sensor and a GPS

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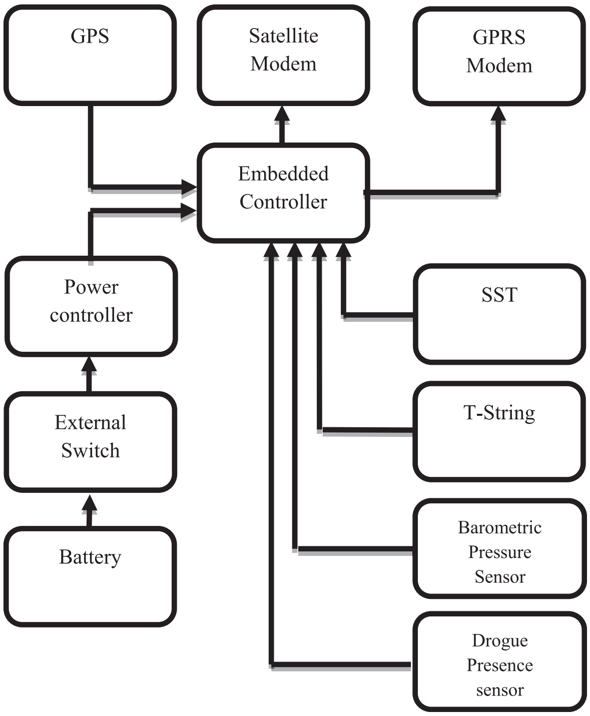

Fig. 1. System Block diagram.

Table 1
Specifications of drifter buoy sensors.

Sensor	Barometric Pressure (m bar)	Sea water Temperature (° C)	Depth (bar)
Measurement Range	800 to 1100	Sensor Range: −10 to 70 Calibrated Range: 25 to 35	0 to 2
Resolution	0.1	0.01	0.1
Accuracy	±0.3	±0.05	1% of reading

Fig. 2. A photograph the drifting buoy.

(Table 1). A strain gauge based load cell monitors the presence of drogue and it acts as the drogue presence sensor (DPS). Six numbers of temperature and pressure sensor modules (T-String) are attached at 1–15 m depth on an underwater cable. The sensors are installed on the DB according to the application. A photograph the DB with T-String is shown in Fig. 2. The unique attempt with 96 temperature measurements and 24 GPS position acquisitions per day enables the DB to measure fluctuations in SST and smaller surface eddies. The geostationary satellite communication (Indian Satellite Telemetry) provides near real-time data at every hour.

2.2. Deployments

The indigenous DB with satellite modem is deployed in the deep Ocean for long duration (2–9 months) measurement and DB with GPRS modem is deployed for short duration (1–2 days) in the coastal regions. The deployment positions of the drifter buoys are shown in Table 2.

3. Results and discussion

The trajectories of the indigenous drifting buoys deployed from 2012 onwards are shown in Fig. 3. The field test results of P2 drifting buoy is validated with the data from a commercially available drifting buoy (Marlin-Yug) deployed along with it, data from a nearby moored data buoy (BD11, at the location Lat. 14.203 ºN, Lon. 82.93 ºE) and data from Advanced Very High Resolution Radiometer (AVHRR) satellite data.

3.1. Comparison of SST and drifting speed measured by P2 and marlin-yug drifting buoys

The trajectories of the P2 drifting buoy Marlin-Yug drifting buoy from 9th March 2013 to 12th April 2013 are shown in Fig. 4 (Zacharia et al., 2015). Even though they are deployed in the same position and time, initially they followed dissimilar trajectories in the same direction. The Marlin-Yug drifting buoy followed a clockwise north-south elliptical eddy on 16–17 March 2013 with a major and minor axis of 4.2 km and 2.7 km respectively. The Marlin-Yug drifting buoy mapped in a second similar eddy on 17–19 March 2013 with a major and minor axis of 2.6 km and 1 km respectively. The P2 drifting buoy is drifted to position 11.8716 °N, 81.106 °E on 20th March 2013 at 18:37:00 h, but Merlin-Yug drifting buoy arrived there only on 24th March 2013 at 15:03:42 h. The drifting buoys followed a similar trajectory from the above position, except a north-south clockwise elliptical eddy with major axis 2.6 km and minor axis 2.3 km made by P2 drifting buoy during 23–24 March 2013. In this section of Marlin-Yug drifting buoy followed trajectory of P2 within 1–4 h. The maximum observed distance between the trajectories is 73.7 km and the minimum is 0.4 km. Even though both the buoys are drifted in a neighboring distinct trajectories with 1–4 h delay, they intersected at location 14.16 °N, 83.78 ºE on 4th April 2013 and at location 13.51 ºN, 83.91 ºE on 6th April 2013. The drifting buoys had undergone a clockwise eastern-south semicircular trajectory of 146 km diameter from 29th March 2013 to 12th April 2013.

The scatter plot SST measured by P2 and Marlin-Yug drifting buoys from 28th March 2013 to 12th April 2013 is presented in Fig. 5. Their trajectories are separated less than 25 km during this period. It is observed that the measurements are strongly correlated with coefficient of determination R^2 value of 0.80.

A scatter plot of current derived from drifting buoys position from 25th March 2013 to 12th April 2013 are shown in Fig. 6. A strong agreement of current measurements is seen with coefficient of determination R^2 value of 0.88 when their separation is less than 40 km distance.

Table 2
Deployment positions of drifter buoys.

Drifting buoy name	Lat. (°N)	Lon (°E)	Deployment duration
P1 (Sudhakar et al., 2013)	6.94	82.97	21 April to 19 June 2012
P2 (Zacharia et al., 2015)	11.0	82.51	09 March to 17 April 2013
CDB (Srinivasan et al., 2016)	17.01	73.24	21–23 February 2014
P4	13.14	83.5	01 May to 04 Nov 2015
P5	14.03	84.1	08 March to 12 May 2015
P6	8.699	83.6	02 October to 03 November 2015
P25 (Srinivasan et al.,)	11.96	72.1	21 March to 01 May 2016
P30	11.92	74.0	25 June to 01 July 2016