J. Ind. Geophys. Union (January 2019)
v.23, no.1, pp: 101-105

TECHNICAL NOTE

OMNI (Ocean Moored buoy Network for northern Indian Ocean) Buoy System—a critical component of ocean observational programme of ESSO (Earth System Science Organization), Ministry of Earth Sciences, Government of India

Raja Acharya* and Suman Chattopadhyay

India Meteorological Department, Regional Meteorological Centre, Ministry of Earth Sciences, 4, Duel Avenue, Alipore, Kolkata-700027

*Corresponding Author: raja.acharya2011@gmail.com

ABSTRACT

The NIOT (National Institute of Ocean Technology) Chennai deployed moored bouys attached with sensors to collect subsurface oceanographic parameters on real time basis at selected locations in Eastern Arabian Sea and Bay of Bengal and named it as the OMNI (Ocean Moored Bouy Network for Northern Indian Ocean) bouy system. This paper presents the usefulness of OMNI Bouy programme, in terms of technical advancements and met-ocean data quality and future strategies related to the programme.

Keywords: OMNI Bouy, Ocean Observational programme, ESSO

INTRODUCTION

The National Institute of Ocean Technology (NIOT), Chennai, the nodal agency for ocean technology, deployed instrumented moored buoys in Eastern Arabian Sea and selected locations of the Bay of Bengal since 1997, to provide continuous time-series measurements of surface meteorological and oceanographic parameters at such locations. In the recent years, several studies have shown the important role of variability of heat storage in the near-surface layers on the intra-seasonal and inter-annual evolution of monsoons and cyclones. Hence, a strong need was felt to augment some of these buoys with subsurface temperature, salinity and current sensors to continuously record the temporal evolution of their vertical structures. Under a new initiative, NIOT has deployed six moored buoys, attached with sensors, to collect subsurface oceanographic parameters on real-time basis in at selected locations. These are coded as the OMNI (Ocean Moored buoy Network for Northern Indian Ocean) buoy system. The OMNI buoys are Moored Buoy Network in Northern Indian Ocean having the capability to Measure Ocean current, conductivity and temperature up to 500 m depth and transmit hourly data through satellite. Moreover, these buoys are also equipped with radiation sensors and rain gauges too (Venkatesan et al., 2013).

SIGNIFICANCE

The primary objective of this mooring is to understand the complex near surface thermohaline structure in the northern Bay of Bengal and understand the phenomenon of the mean seasonal cycle of the Indian monsoon, the intra-seasonal to intra-decadal oscillations of air–sea interactions, trends that are related to tropical cyclones and the annual cycle balance in the exchange of waters between the two limbs of North Indian Ocean, i.e. the Arabian Sea and the Bay of Bengal.

SYSTEM DESCRIPTION

The moored bouys are floating platforms, which consist of discuss shaped bouys, 3 m in diameter, with an aluminium instrument vessel to which sensors are attached for measuring meteorological parameters. These bouys are equipped with GPS, beacon light and satellite transceiver. The OMNI bouys are powered by lithium batteries and equipped with data acquisition and processing unit. The sensors are programmed to acquire data samples of specific duration of time and frequency. The performance of the data bouy depends upon the type of bouy, location and the water depth. The data bouy carries out sampling process for 30 minutes and at the end of sampling, the averaged data are transmitted to NIOT (National Institute of Ocean Technology) Chennai, every 3 hours, via IMMARSAT satellite telemetry (Venkatesan et al., 2013). The data is placed in the global telecommunication system for weather and forecasting purposes. The data are disseminated to ESSO INCOIS (Indian National Centre for Ocean Information Services) after necessary quality control checks.

Table 1. Details of sensors used for measuring the aforesaid parameters in OMNI bouy system.

Parameter	Sensor Type	Resolution	Accuracy	Range	Data Recorded
Wind Speed	Cup Anaemometer	01.m/s	±2%	0–35 m/s	1 h
Wind Direction	Vane+flux gate compass	0.1°	1.5– 4° ±	0–359° –30–	1 h
Air temperature	Pt/100 RTD	0.0015°C	0.3°C	70°C	1 h
Relative humidity	Capacitance	0.47	± 1%	0–100% RH	1 h
Air pressure	Pressure transducer	0.01 hPa	± 0.15 hPa	500–1100 hPa	1 h
Rainfall	Capacitance	0.058		0–50 mm	2min
Downwelling long-Wave radiation	Pyrgeometer	1.27 W/m2	± 1 mm 5%	0–700 W/m2	1h
Downwelling Short wave radiation	Pyranometer	0.488 W/m2	3%	0–2800 W/m2	1h
Water temperature	Thermistor	T: 0.0001°C	0.002°C	–5–35°C	1h
Conductivity	Conductivity cell	C: 0.0001mS/cm	0.002°C	0–70 mS/cm	1h
Water pressure	Strain gauge	P: 0.002%	0.003mS/cm	0–70 mS/cm	1h
Directional wave Spectra	Accelerometer, angular ratesensor, magnetometer	Pitch and roll: < 0.001°	Heave: 5 cm pitch and roll: 0.05° Heading: 1.2°	Heave: ± 50 m Heading: ± 180°	1h
Ocean current Profile	Accoustic Doppler Current Profiler	Velocity: 0.1 cm/s Dir: 0.01°	Velocity :± 5 mm/s Dir: ± 2°	0–256 cm/s	1h
Single point	Doppler Volume Sampler	Velocity: 0.1 cm/s Dir: 0.01°	Velocity 1% Dir: ± 2°	0–600 cm/s	1h

(Source: Venkatesan et al., 2013)

The meteorological sensors

They are assembled and fitted on the top of the bouy assembly. The meteorological sensors fixed on the sensor arm include air temperature, relative humidity, wind speed and direction at 3 m amsl. The Radiation and rainfall sensors are placed on the sensor arm at 2 m and 1m amsl respectively. The surface temperature and conductivity (to yield salinity) are measured from the bouy at a nominal depth of 1m. Subsurface CT (conductivity temperature) sensors are mounted on the inductive cable of the mooring system to measure temperature and conductivity at 10 different levels. The Accoustic Doppler Current Profiler (ADCP) is attached to the inline mooring for measuring subsurface currents. The depth at which the moorings are anchored to the seabed is 5000 m. (http://www.incois.gov.in/documents/ITCOocean/Suprit_MBD.pdf).The bouy system rely on lithium battery, using compact low power satellite communication system.

Parameters measured by OMNI Bouy system

The OMNI Bouys (Figure 1) measure the following meteorological and oceanographic parameters:

***Surface meteorological*:** Wind speed and direction, air temperature, air pressure, humidity, short wave radiation, incoming long wave radiation and precipitation.

Surface Ocean parameters: Sea surface temperature, conductivity, wave, current speed and direction

Sub surface parameters: Temperature and salinity at depths starting from 5 m, 10 m, 15 m, 20 m, 30 m, 50 m, 75 m, 100 m, 200 m and 500 m. Currents at the depth levels of 10 m, 20 m, 30 m, 50 m and 100 m. Details of sensors and measuring parameters are given in Table 1**.**

OMNI BOUY SYSTEM STRUCTURE

The OMNI Bouy consists of the upper mast fitted with to the top of the bouy assembly, to which various meteorological sensors are attached and the antennas are mounted. A keel with counterweight is mounted under the hull to prevent capsizing of the buoy. The instrumentation cylinder is attached in the middle of the buoy hull which contains all electronic modules, the power package and the wave sensors. There are 3 sections of the OMNI Bouy Structure (https://www.niot.res.in/uploads/Mooring%20 Design.pdf):

Figure 1. OMNI (Ocean Moored buoy Network for northern Indian Ocean) Buoy System (https://www.niot.res.in/index.php/node/index/129/

Upper section

The Upper section has an alloy long link chain and an induction cable of about 16 mm diameter and 500 m length and the sub – surface sensors are attached in it. The link chain of 5 m in length is connected at the keel frame. Diameter of the chain is about 19 mm. It also has to absorb the rotational energy of the mooring, induced by the buoy rotating around its axis. The link chain ends at the Accoustic Doppler Current Profiler (ADCP) frame and the inductive cable is attached to the ADCP frame and extends up to the nylone rope below.The inductive cable has a diameter of 16 mm and has a maximum breaking load of 9000 kg. This section is designed to protect the mooring from fish bite and to enable the safe deployment and retrieval of the buoys.

Middle Section

The Middle section has a nylon rope, having diameter 18 mm, Length 500 m, depths below 2500 m , 750 m and above 2500 m. This section gives S–shape to the mooring. During high current, the nylon rope stretches and keeps the buoy always surfaced. The length of the nylon rope is chosen carefully to provide sufficient stretch to the mooring line. The maximum breaking load of the nylon rope is 5500 kg and it can stretch to about 20% of its initial length, when stretched to its working load limit. The nylone rope is fitted to the trawl floats, which help to keep the mooring in position.

Lower Section

This section consists of a polypropylene rope of 18 mm diameter and 4000 m in length, besides an anchor chain of 16 mm diameter and 1m in length .The polypropylene rope has a working load limit of 5500 kg. The polypropylene rope can stretch upto 15% of its original length. The ground chain connects the polypropylene rope with the sinker having weight of 1900 kg. In order to avoid the rubbing of chain with the sinker weight, subsurface floats consisting of 3 glass spheres with net buoyancy 25.4 kg, are mounted on the link chain with shackles that keeps the chain in upright position. The sinker weight and the drag anchor of the mooring, keeps the buoy in its position. The acoustic release is used for the recovery of bouy system. The release will hold onto the anchor of a buoy system until it is commanded to release it by signal from ships etc. An acoustic release has the ability to both receive and transmit signals to a surface instrument.

TECHNICAL ADVANCEMENTS AND DATA UTILITY

The sensors used in the OMNI Bouys have been selected based on performance history of similar systems at sea and due recommendations of an national expert committee comprising of eminent meteorologists and ocean scientists. The sensor is chosen on the basis of its withstanding hostile weather conditions and data stability. High correlation has been observed during inter-comparsion of conductivity and temperature data of OMNI Bouy with insitu, ship based measurement (**Mathew et al., 2016**).The analysis of OMNI bouy data have contributed in better prediction of monsoons and cyclones in the Bay of Bengal (**Venkatesan et al., 2014**). Moreover, data collected from the OMNI Bouy system are utilized in the validation of remote sensing data. Validation of retrieved and corrected SST(K-SST) from Kalpana satellite has been carried out, using near simultaneous observations of NIOT moored bouy data in E. Arabian sea and Bay of Bengal regions. A significant improvement in Root Mean Square Deviation (RMSD) of K-SST with respect to buoy (1.50–1.02 K),

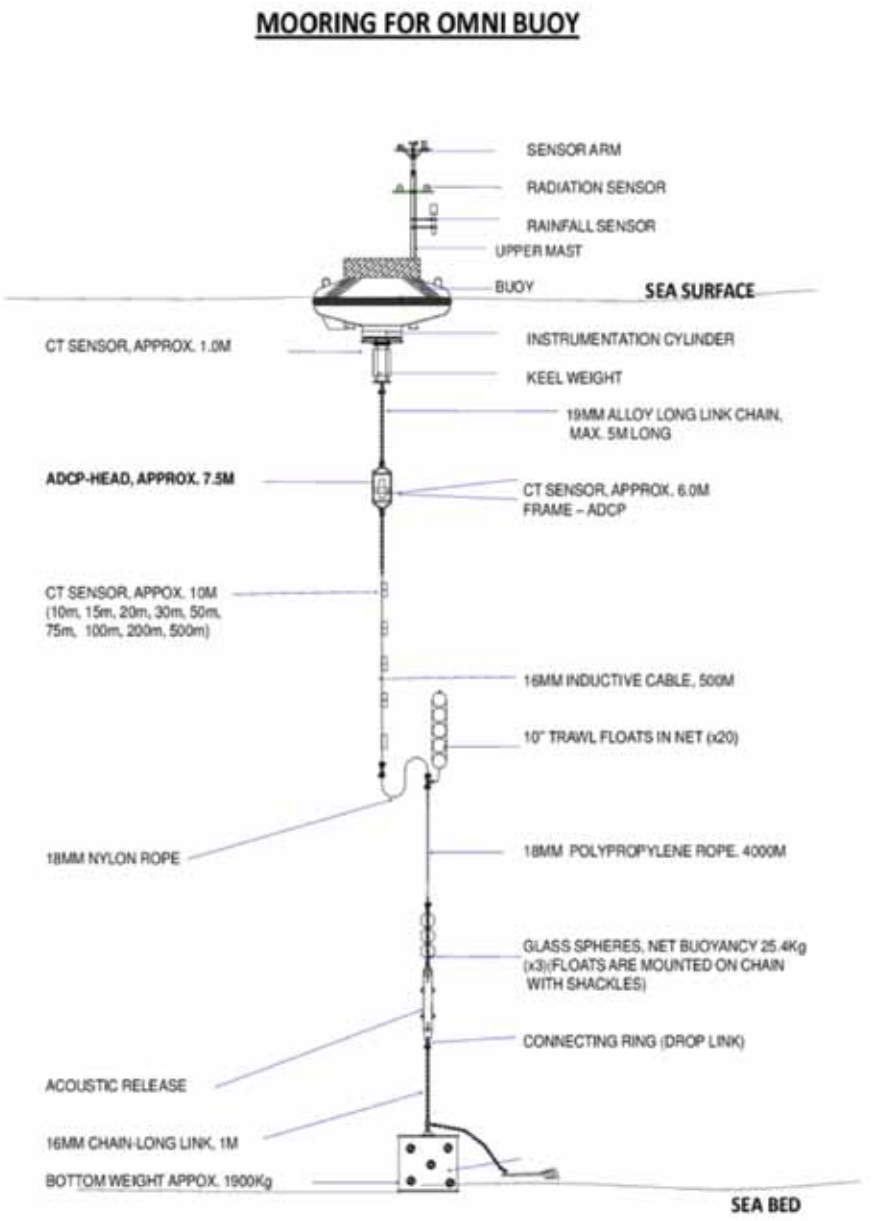

Figure 2. Mooring Configuration of the OMNI Bouy System (**Venkatesan et al., 2013**).

has been observed with the use of near real-time water vapour fields of TMI (**Shahi et al., 2011**).Data from NIOT moored data bouy are also used in the validation of Ocean Generation Circulation Model (OGCM) and Coupled Ocean Atmospheric Model (Thompson et al., 2008). The bouy data available on surface waves and currents can be effectively used for optimum ship routing to save time and fuel costs. Specially designed mooring system with induction mooring cable, acoustic release and anchors are used to keep the system in position in deep sea bed, as mentioned before. The huge voluminous data generated through OMNI Bouy network require proper data management and to overcome the manual mode of data management quality control, Advanced Data Reception and Analysis System(ADDRESS), has further been been developed, specially for data inventory, cruise and operations management(Venkatesan et al., 2015a).

LIMITATIONS

Maintenance of the OMNI bouy system is expensive, specially in view of the challenges posed by increase in vandalism and piracy in Arabian Sea and Bay of Bengal. The availability of ship time according to planned schedule, is another challenge to maintain the bouy network for its optimum performance. Uninterrupted data transmission

through satellites is another challenge. To overcome the problems of data reliability caused due to sensor fouling, anti fouling paint/anti foulant device is applied to bouycomponent (Venkatesan et al., 2015b).

FUTURE STRATEGIES

Permanent maritime security arrangements to be considered on prority basis to address the problem of vandalism and privacy. Specialised ships with deep sea mooring capabilities are required for retrieval and deployment operations to ensure high standard of bouy data quality (Venkatesan et al., 2016). There is a growing interest in continous multidisciplinary observations of oceans from regional scale to global scale and thus, bio-geochemical sensors and bio-optical sensors are highly needed. Bio-geochemical sensors are needed to monitor causes and effects of global climate change and ocean's capabaility to act as a sink for CO_2 and other green house gases and heat. Bio-optical sensors are required for measuring parameters to indicate occurrence of water turbidity, harmful algal booms and near surface trapping of heat. The O-SCOPE (Ocean Systems for Chemical, Optical and Physical Experiment) project sponsored by the NOPP (National Oceanographic Partnership Program), USA have taken a leading role in development and testing of advanced interdisciplinary ocean sensors (Dickey and Moore, 2003).The Ocean Obseving System (OOS) is presently collaborating with ESSO-NCAOR (National Centre for Antarctic and Ocean Research) in the design and deployment of surface and subsurface mooring systems in the southern Indian ocean, to collect data on various parameters such as ocean currents, temperature, partial pressure of CO_2 gas dissolved in water, dissolved oxygen etc to measure the quantity of sinking particulate organic material (Venkatesan et al., 2016).

CONCLUSIONS

The longstanding need for comprehensive and continous measurements on surface met. Ocean parameters along with subsurface ocean measurements have been fulfilled with the deployment of OMNI Bouy Network. These bouy data are assimilated into models by various operational forecasting agencies all over the world, leading to improved forecasts. Moreover, the moored bouy data are used to validate the performance of ocean atmospheric and coupled models and provide various measurement of ocean surface parameters viz SST, wave height etc. to validate satellite measurements and numerical model outputs.

ACKNOWLEDGEMENTS

This technical note has been compiled using internet and other sources basically to propagate the importance of OMNI Bouy network systems. We unequivocally state that the technical details given above have not been developed by us either directly or indirectly. We are grateful to the Ministry of Earth Sciences, Govt of India and NIOT for introducing this state of art Bouy technology and placing various resources relating to the same online. We are thankful to the Dy. Director General of Meteorology, Regional Meteorological Centre, and Kolkata for encouragement for preparing this note. We are also grateful to the Chief Editor of JIGU, for editing and publishing this technical note. The views expressed in the article are solely the views of ours and not our employing organisation and our employing organisation has no financial liability in the matter.

Compliance with Ethical Standards

The authors declare that they have no conflict of interest and adhere to copyright norms.

REFERENCES

Dickey, T. and Moore, C., 2003. New sensors monitor bio-optical/ bio geochemical ocean changes. Sea Tech, 44, 17-24.

Mathew, S., Shamji, V.R., Vengatesan, G., ArulMuthiah, M. and Venkatesan, R., 2016. Systematic Validation of conductivity and Temperature from Ocean Moored Bouy data in northern India Ocean with *insitu* ship based measurement. Indian .J.Geo-marine Sci., 45(2), 224-229.

Shahi, N.R., Agarwal, N., Mathur, A.K. and Abhijit Sarkar, A., 2011.Atmospheric correction from sea surface temperature retrieval from single thermal channel radiometer data onboard Kalpana satellite.J.Earth Sys.Sci., 120, 337-345

Thompson, B.,Gnanaseelan, C., Parekh, A. and Slavekar, P.S., 2008. North Indian Ocean warming and sea level rise in an OGCM. J.Earth Syst. Sci., 117,169-178.

Venkatesan,R., Shamji, V. R., Latha, G. and Mathew, S., 2013. Insitu ocean subsurface time series measurement from OMNI bouy network in the Bay of Bengal. Current Sci., 104, 1166-1177

Venkatesan, R.,Mathew, S., Vimala, J., Latha. G., et al., 2014. Significance of bouy observatories for accurate prediction of Phalin Cyclone in the Bay of Bengalduring Oct. Current Sci., 107, 589-595

Venkatesan, R., Ramasundaram, R., Ranganathan, S., Vedachalam, N., et al., 2015a.Reliability assessment of state- of – the- art reat time data reception and analysis system for the Indian seas. Marine Techno. Soc. J., 49, 127-134

Venkatesan, R., Muthiah, M.A., Kesavakumar, B., 2015b. Study of performance of sensors in Indian Moored Bouys, Data Bouy Cooperation Panel (DBCP), JCOMM 31st Scientific and Technical Workshop, WMO Geneva, 19th Oct 2015.

Venkatesan, R., Lix, J.K., Phanindra Reddy, A., Arul Muthiah, M. and Atmanand, M.A., 2016. Two decades of operating the Indian moored bouy network: significance and impact, J. Operational Oceanography, 9, 45-54.

Received on: 17.10.18; Revised on: 22.10.18; Accepted on: 29.10.18