CELEBRATING 20 YEARS

April 22nd 2017

Ocean Observation Systems

1997-2017

Two Decades of Observing the Oceans

National Institute of Ocean Technology, Chennai

सत्यमेव जयते
डॉ. एम. राजीवन
DR. M. RAJEEVAN

सचिव
भारत सरकार
पृथ्वी विज्ञान मंत्रालय
पृथ्वी भवन, लोदी रोड़, नई दिल्ली-110003
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
PRITHVI BHAVAN, LODHI ROAD, NEW DELHI-110003

MESSAGE

It is my great pleasure to be part of the celebrations of two decades of National Data Buoy Programme. The achievement deserves a special remark, in view of the many challenges in sustaining the moored buoy network and ensuring the continuous monitoring of crucial meteorological and oceanographic parameters in the Indian Seas.

Observations from tropical Indian Ocean is vital for the understanding of Indian Monsoon that drastically affects the livelihoods of more than a billion people in Indian Ocean rim countries. India with a long coast line of 7500 km and 2.02 million sq. km EEZ, offers immense scope for the utilization of marine resources and coastal zones. Real-time measurements of meteorological and oceanographic parameters are also necessary for the oceanographic services, improving the predictive capability of short and long-term climatic changes, early warning of natural disasters like cyclones, tsunamis etc. Considering the importance of real-time data collection from Indian Seas, Ocean Observation Systems (OOS) under National Institute of Ocean Technology (NIOT) Chennai, erstwhile National Data Buoy Programme (NDBP), was established in 1997 by Ministry of Earth Sciences (then Department of Ocean Development).

It is significant to note that the data from moored buoys have immensely helped in providing accurate predictions of past 20 cyclones formed in the seas around India. The large number of publications using moored buoy measurements reveals the importance of the observations and improving the understanding of upper ocean dynamics. I appreciate the significant milestones in indigenisation and improving the buoy technology.

I congratulate the OOS team for its landmark contributions in sustenance of moored buoy network.

New Delhi
17-04-2017

(M. Rajeevan)

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NATIONAL INSTITUTE OF OCEAN TECHNOLOGY
पृथ्वी विज्ञान मंत्रालयं, भारत सरकार
(Ministry of Earth Sciences, Government of India)
एन आई ओ टी केम्पस, वेलच्चेरि ताम्बरम मुख्य मार्ग, नारायण पुरम, पल्लिकरणै, चेन्नै - ६०० १०० भारत.
NIOT Campus, Velachery - Tambaram Main Road, Narayanapuram, Pallikaranai, Chennai - 600 100 INDIA.

Dr. S. S. C. SHENOI
Director

MESSAGE

It is a remarkable occasion of celebrating the two decades of National Data Buoy Programme and to commemorate the achievements during this long journey. The programme started with a network of twelve moored buoys measuring surface meteorological and oceanographic parameters. Today the network has expanded remarkably with its presence in various applications including next generation buoy systems OMNI (Ocean Moored buoy Network for Northern Indian Ocean) capable of profiling the sub-surface upto 500m, tsunami buoys, CAL-VAL buoy for satellite applications and specially designed Arctic mooring-IndARC.

The moored buoy observations are widely utilised in cyclone forecast, weather prediction, port operations, monsoon studies, improving the model dynamics, validation of model/satellite data etc. These observations steered the better prediction of track, intensity and land fall of tropical cyclones leading to significant reduction in loss of life and property in cyclone hit areas. The programme has also brought out many technological developments, significantly improved the measurement capabilities and ensuring the quality and continuity of data.

The efforts to organise students session is commendable, and I am sure that it will encourage the budding researchers to bring out more results utilising the moored buoy observations. I congratulate the team for their achievements and wish great success in scientific and technological endeavours. It is to mention that this achievement would not have been possible without continued support from our Ministry.

Chennai
17-04-2017

(S. S. C. Shenoi)

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One day Workshop on
Two Decades of Observing the Oceans

April 22nd, 2017

Venue: Panikkar Hall, NIOT Campus

Inaugural Function	
09:00 - 09:03	Invocation
09:03 - 09:05	Lighting the Lamp
09:05 - 09:10	Welcome address by Director, NIOT
09:10 - 09:18	Overview of National Data Buoy Programme
09:18 - 09:20	Release of 'Souvenir' and 'Footprints'
09:20 - 09:25	Inaugural address by Secretary, MoES
09:25 - 09:30	Vote of Thanks
09:30 - 09:35	Group Photo
09:35 - 10:00	**High Tea**

Establishment and Growth of Ocean Observation Network	**Session 1**
10:00 - 10:10	Dr.B. N. Krishnamurthy, Former Advisor – DOD
10:10 - 10:20	Dr. A. E. Muthunayagam, Former Secretary - DOD
10:20 - 10:30	Dr. Shailesh Nayak, Former Secretary – MoES
10:30 - 10:40	Prof. M. Ravindran, Former Director – NIOT
10:40 - 10:50	Dr. Inger Midtkandal , Norwegian Embassy
10:50 - 11:00	Mr. K. Premkumar, Former PD – NDBP
11:00 - 11:10	Dr. M. A. Atmanand, Former Director – NIOT
11:10 - 11:20	Dr. M. Ravichandran, Director, NCAOR
11:20 - 11:30	Dr. R. Venkatesan, Group Head – OOS

Application of Moored Buoy Data – I	Session 2 Venue : Rajendra Chola Hall
Chair: Dr. L.S.Rathore, DGM (Rtd.), IMD	
11:35 - 11:50	Prof. Sulochana Gadgil, Professor (Retd.), IISc
11:50 - 12:00	Dr. K. J. Ramesh, DGM, IMD
12:00 - 12:10	Dr. E.N. Rajagopal, Head, NCMRWF
12:10 - 12:20	Dr. M.V. Ramanamurthy, Head, ICMAM
12:20 - 12:30	Dr. M. Sudhakar, Head, CMLRE
12:30 - 12:40	Dr. T.N. Prakash, Director (i/c), NCESS
12:40 - 12:50	Prof. G.S. Bhat, IISc
12:50 - 13:00	Prof. P.N. Vinayachandran, IISc
13:00 - 14:00	**Lunch Break / Evaluation of Student Posters**

Application of Moored Buoy Data – II	Session 3
Chair: Dr. Yugraj Singh Yadava , Director BOBP-IGO	
14:00 - 14:10	Dr. Rashmi Sharma, SAC-ISRO
14:10 - 14:20	Dr. G. Latha, Head, OA, NIOT
14:20 - 14:30	Dr. Balakrishnan Nair, Head, ISG, INCOIS
14:30 - 14:40	Dr. Pattabhi Rama Rao, Head, DMG, INCOIS
14:40 - 14:50	Mr. Sanjeev Afzulpurkar, NIO, Goa
14:50 - 15:00	Dr. C. Gnanaseelan , IITM Pune
15:00 - 15:10	Mr. Tata Sudhakar, Head, OE, NIOT
15:10 - 15:20	Ms. B. Amudha, RMC, IMD, Chennai

Industry Session : Prof. D. Sen	Session 4
15:20 - 15:25	M/s. Fugro-Oceanor - Norway, M/s. Norinco – Mumbai
15:25 - 15:30	M/s. Teledyne RDI - USA
15:30 - 15:35	M/s. Data Pattern, Chennai
15:30 - 15:35	M/s. Elektronik Lab, Chennai
15:35 - 16:00	**Tea Break/Poster Session**

Students Session : Prof. M. Ravindran	Session 5
16:00 - 17:00	Presentation by Students / Poster session
17:00 - 17:30	**Valedictory Function**
17:30 - 18:00	**Lab Visit**
18:00 - 20:00	**Cultural Programme followed by Dinner**

Glimpses of National Data Buoy Programme

Ministry of Earth Sciences (Erstwhile Department of Ocean Development), Government of India entrusted National Data Buoy Program (NDBP) to undertake activities to collect ocean data through moored buoy program in the year 1997, with the objectives to establish, maintain and develop moored buoy observational network in the Indian seas. Under this program the Buoy network was established with buoy systems capable of measuring surface meteorological and oceanographic parameters. The buoy network expanded with additional buoy systems such as OMNI (Ocean Moored buoy for Northern Indian Ocean) buoys with sensors measuring upto 500 m depth, tsunami buoys, polar mooring (IndARC) and Cal-Val buoy for satellite applications with a data return of more than 93%,highest among global moored buoy networks.

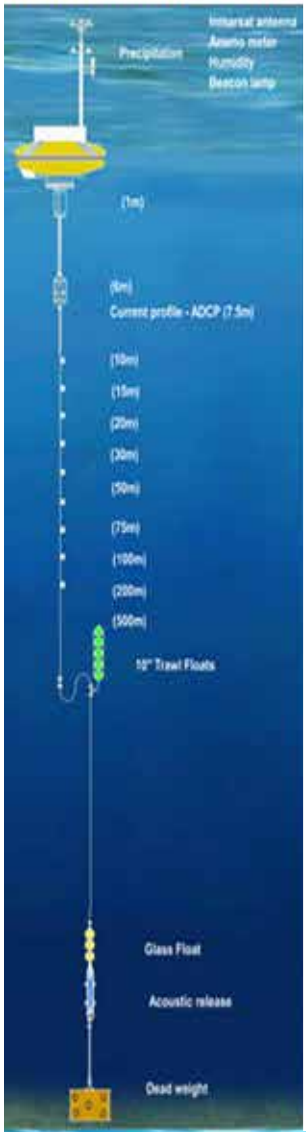
Technology development efforts at OOS are aimed at incorporating new measurement techniques, development of newer observation platforms and indigenization of buoy components. Under the make in India programme, Indigenous OMNI buoy system 'PRAKRUTI' was developed. Indigenously developed data acquisition system 'HRUDAYA' forms the core of PRAKRUTI buoy system. HRUDAYA seamlessly interface with all buoy sensors, autonomously collects, process, store and transmit the data via various satellite telemetry. The development of HRUDAYA accelerated our indigenization efforts and allowed us to successfully implement many innovative concepts. One such innovation is the Rapid Mode Data Transmission during cyclones which is implemented in the four coastal buoys enables more frequent data transmission during cyclones proved very useful in early warning. Indigenously developed tsunami buoy system and bottom pressure recorder, SAGAR BHOOMI, have successfully undergone field trial. CAL-VAL buoy system used for validation of the satellite data is operational since December 2011. Multi-sensor mooring in Kongsfjorden in the Arctic Ocean, IndARC, is providing continuous data since July 2014. The data from all moored platforms is received at shore station at NIOT, manned 24x7. Further, the data is disseminated to INCOIS in real-time and also available via mobile app IMoon.

NDBP team received three prestigious national awards in recognition of the work carried out during this period. National Geoscience award, in the year 2016, received from the honorable President of India, for the establishment of first Indian Arctic mooring near North Pole. NRDC societal Innovation award, in the year 2015, for Integrated Marine Surveillance System (IMSS) and NIGIS meritorious award, in the year 2014.

Three patents filed till date, more than 125 papers published in refereed journals with overall impact factor of 99.536 and more than 200 conference proceedings. OOS team has also organized 20 conferences/ training, participated in many training programmes in India &abroad and encouraged the staffs to upgrade the educational qualification as part of capacity building. The team has successfully collaborated with many national and international institutions such as WHOI-USA, JAMSTEC-Japan, Department of Environmental Affairs-South Africa, Peru and Norway through Ministry of Earth Sciences. Expertise gained by the team further led to imparting training to other countries like South Africa and provides guidance to academic projects for students from IIT's, NIT's & various universities.

Sustaining the observational programme and ensuring the high quality data with minimal data gap amidst multitude of challenges require enormous vision and team work. With rigorous research and technological development initiative, OOS continues to ensure that vital buoy system is robust enough to provide reliable high quality data to users and decision makers even during extreme weather events and natural disasters. We, the OOS team, are thankful for each challenge, because it strengthens us and after successfully completing two decades of services to the nation, journey continues….

Deep Sea Instrumented Mooring



IndARC Mooring

Ocean Observation Systems
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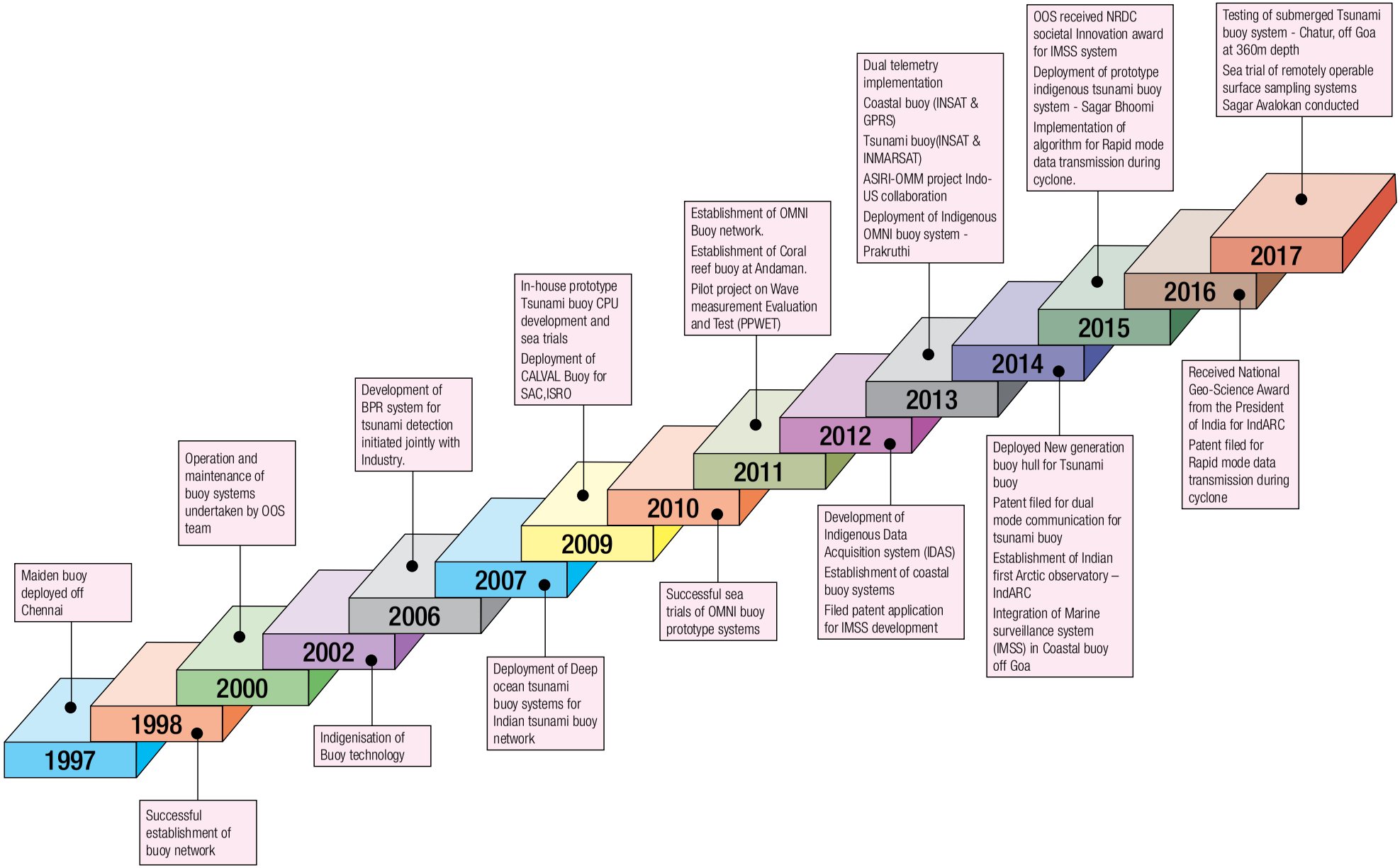

1997
Maiden buoy deployed off Chennai
1998
Successful establishment of buoy network
2000
Operation and maintenance of buoy systems undertaken by OOS team
2002
Indigenisation of Buoy technology
2006
Development of BPR system for tsunami detection initiated jointly with Industry.
2007
Deployment of Deep ocean tsunami buoy systems for Indian tsunami buoy network
2009
In-house prototype Tsunami buoy CPU development and sea trials
Deployment of CALVAL Buoy for SAC,ISRO
2010
Successful sea trials of OMNI buoy prototype systems
2011
Establishment of OMNI Buoy network.
Establishment of Coral reef buoy at Andaman.
Pilot project on Wave measurement Evaluation and Test (PPWET)
2012
Development of Indigenous Data Acquisition system (IDAS)
Establishment of coastal buoy systems
Filed patent application for IMSS development
2013
Dual telemetry implementation
Coastal buoy (INSAT & GPRS)
Tsunami buoy(INSAT & INMARSAT)
ASIRI-OMM project Indo-US collaboration
Deployment of Indigenous OMNI buoy system - Prakruthi
2014
Deployed New generation buoy hull for Tsunami buoy
Patent filed for dual mode communication for tsunami buoy
Establishment of Indian first Arctic observatory – IndARC
Integration of Marine surveillance system (IMSS) in Coastal buoy off Goa
2015
OOS received NRDC societal Innovation award for IMSS system
Deployment of prototype indigenous tsunami buoy system - Sagar Bhoomi
Implementation of algorithm for Rapid mode data transmission during cyclone.
2016
Received National Geo-Science Award from the President of India for IndARC
Patent filed for Rapid mode data transmission during cyclone
2017
Testing of submerged Tsunami buoy system - Chatur, off Goa at 360m depth
Sea trial of remotely operable surface sampling systems Sagar Avalokan conducted

Invited Talks

An Enduring Association in Protecting Indian Coastline and Scientific Research

Director General Rajendra Singh
PTM, TM
Indian Coast Guard, New Delhi

Awards & Recognition

- President's Tatrakshak Medal, 15 Aug 2007
- Tatrakshak Medal, 15 Aug 1990
- The first regular direct entry officer of the Indian Coast Guard
- An impeccable track record in the fields of operations, administration, human resources, policy and plans

It gives me immense pleasure to learn that Ocean Observation Systems (OOS) is celebrating 20 years of service to the nation. The moored buoy observation program started in 1997 and is now very well evolved. An extensive network of buoys deployed in the Bay of Bengal and Arabian Sea provides continuous near-real time observations of various parameters vital for oceanographic research and disaster management. The data based on moored buoys have proven crucial for preparedness in events of extreme weather events like cyclone. Besides, the tsunami buoy system is well equipped to ensure adequate early warning for entire Indian coastline.

I am very glad that the Indian Coast Guard is partnering OOS in protecting the vital assets deployed by OOS at sea. The Coast Guard has been providing timely assistance in reconnaissance and rapid recovery of buoy components in the event of any buoy getting adrift or suffering vandalism. Needless for me to say that the moored buoy observations have proved to be of immense utility to the Coast Guard in its surveillance and rescue efforts at sea.

I take this opportunity to congratulate the entire team at OOS for successfully maintaining the moored buoy network for the past twenty years and rendering yeoman service to the nation. I would also like to assure OOS of continued whole-hearted support of the Indian Coast Guard in all their future endeavours.

Moored Buoy Observations for Daily Weather Forecast and Early Cyclone Warning

Dr. K. J. Ramesh
Director General of Meteorology, India Meteorological Department

Education

Ph. D. from IIT Delhi (Monsoon Dynamics)

M. Sc. (Meteorology), Andhra University

Professional and Research Career

- IIT Delhi for 10-years (1984-1994)
- Group Head, Department of Science & Technology, NCMRWF
- Disaster Management Cell, Department of Science & Technology (2005-2007)
- Advisor and Scientist-'G', Ministry of Earth Sciences (2007-2016)

Member

- National Academy of Sciences, Allahabad
- National Disaster Management Authority (NDMA)
- Indian Delegation for UNFCCC Negotiations on climate change related issues

Understanding our oceans is critical to protect people from natural disasters and the impending challenges of climate variability and change. Monitoring marine environment is essential to provide information for research and services. Traditionally routine ocean measurements are carried out by ships of opportunity, which will not be available during extreme events. The introduction of moored buoy network in Indian Seas filled this gap and significantly improved the predictive capability and oceanographic services.

I am very happy to learn that the NIOT buoy data have been widely used both by operational and scientific communities to understand and predict the observed variability of monsoons, cyclones and short-term climate change through an improved approach of air–sea interaction processes. Since its inception, the time series observations from a close network of data buoys provide valuable information on important meteorological observations, particularly during the cyclone period and supported IMD to predict the track and intensity of cyclones and provide advance information to the Government agencies and warnings to public.

It is my great pleasure to acknowledge the implementation of rapid mode data transmission during cyclones. The high frequency data sets provided by the buoys during the recent cyclones greatly helped in tracking and early cyclone warning.

It is worthwhile to appreciate the customized web and app based software developed for various applications specifically for the display and operational support. The team has also achieved significant progress in indigenizing buoy components and integrated new technologies in system and measurement.

I congratulate OOS team for their remarkable achievement within a short span of 20 years.

Building Ocean Observation System for India

Dr. A. E. Muthunayagam
Former Secretary – Department of Ocean Development, Government of India.

Education

Ph.D, Purdue University, USA.
Master of Engineering, IISc Bangalore

Positions Held

- Secretary – DOD.
- Chairman, Board of Governors, IIT Madras.
- Executive Vice President, Kerala State Council for Science Technology & Environment.
- Founder Director, LPSC, ISRO, GoI.
- Founder Vice Chancellor, Karunya University.
- Pro-Vice Chancellor, Noorul Islam University.
- Chairman, State Environment Impact Assessment Authority, Kerala.
- Chairman, Expert Appraisal Committee of MoEF, GoI.

Fellowship

- Fellow, Astronautical Society of India
- Fellow, Indian National Academy of Engineering
- Foreign Member of Academy of Cosmonautics, Moscow, Russia
- Fellow, The Institution of Engineers (India)

Awards & Recognitions

- Dr. VM Ghatge award for 1989 from Aeronautical Society of India.
- Mechanical Engineering Design 1995 from Institution of Engineers (India)
- National award for Life Time Achievement in Ocean Science & Technology 2007 from MoES.
- ISRO Outstanding Achievement Award 2008
- Aryabhatta Award 2010 from Astronautical Society of India for outstanding contribution in Propulsion Technology.

He is not only the Chief architect of Rocket Propulsion of Indian space programme but also the architect in establishing the first of its kind ocean observation programme - the National Data Buoy Programme (NDBP) for India.

The past 20 years have provided us with an unprecedented ability to observe, monitor and forecast the oceans. In situ ocean observations in combination with ocean models using data assimilation from data buoys are playing vital role in weather forecast and climate applications.

This ocean observation program was the first major program which I implemented in my capacity as Secretary to GoI. For India, it is first of its kind with a goal to establish one of the best ocean observation systems in the globe by selecting the best configuration, right ocean platform, high performance sensors to suit our requirements from the best suppliers of ocean observation systems in the world.

Based on the detailed evaluation of offers from International suppliers by my colleagues from DOD, NIOT and the NDBP, we selected the best components/ subsystems from M/s Oceanor and M/s Seatex of Norway. I decided that we should procure the best from both suppliers. Challenge was to ensure compatibility among the components/ subsystems from two suppliers and evolve an integrated operational system with selected sensor system, instrumentation system and control system and platform with optimum financial outlay.

With active involvement of DOD Finance and Technical team, I identified the best component/ subsystem from among the two suppliers and succeeded in making both M/s Oceanor and M/s Seatex agree to join hands, share technologies and supply the selected components/sub systems at a price, lower of the two offers.
Subsequent to our negotiations, both M/s Oceanor and M/s Seatex merged and we were successful to get the best ocean observation system, integrated and supplied by M/s Oceanor, Norway.

I am also very happy to note the indigenous developments of this successful programme, started with 14 data points way back in 1997 has 104 data points now in 2017, which is a big leap, making significant contributions in cyclone and Tsunami early warning to the countrymen.

Congratulations for ‘Wisdom’ in ‘Action’.

Well done. Keep it up.

Ocean Observation and Oceanographic Services to the Nation

Dr. Shailesh Nayak
Former Secretary, MoES

Education

PhD - M.S. University, Baroda

Positions Held

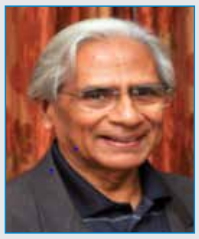
- Scientist, SAC, ISRO
- Director of Marine and water resources.
- Director, INCOIS
- Chairman, Research Advisory Committee of the National Institute of Oceanography, Goa and Defense Terrain Research Laboratory, Delhi.

Awards & Recognition

- IGU-Hari Narain Lifetime Achievement Award in Geosciences 2013.
- ISCA Vikram Sarabhai Memorial Award 2012.
- Bhaskara Award 2009.
- Indian National Remote Sensing Award 1994.
- National Mineral Award 2005

Oceans control weather, climate and hazards, provides us energy, food and mineral resources as well as an ecosystem to survive. Ocean observations help to understand various oceanic processes as well as their interaction with anthropogenic activities. The application of such knowledge helps to build services for humanity. Long-term, sustained measurements of various environmental variables which record the vital signs of the ocean, their changes and causes are essential to distinguish between the variability and changes in the oceans. During late nineties, systematic, time series observations of various ocean parameters initiated by developing network of moored buoys, both in the Arabian Sea and Bay of Bengal. During same time, the first satellite to observe ocean was launched (Oceansat-1), and provided new dimensions to observations and made dramatic change in the information on ocean and climate. These, satellite and in situ, data sets heralded era of operational oceanography in the country. The development of Cal-Val site for ocean color and indigenous tsunami buoy was major landmark achievement during last decade. Today, the capability to build and deploy such systems from the Arctic to Southern Ocean has been developed. The communication through INSAT satellite ensured reception of uninterrupted data. The large volumes of data are organized as the Ocean Data and Information System (ODIS) to provide services for ocean-state, cyclone, tsunami, coral reef alert, etc. to all stakeholders. I congratulate the leadership and the team of ESSO-NIOT for their dedication and commitment for ushering new era in Oceanography in the country.

The Genesis and Development of Data Buoy System in India



B N Krishnamurthy,
Former Deputy Commissioner,
Director and Advisor, GoI.

Education

B.Tech. in Civil Engineering, 1964

Post Graduate Diploma of IIT Mumbai in Dock and Harbor Engineering in 1967.

Positions held

- Responsible for Design and Development of Major Ports.
- Policymaking, Planning, Engineering investigations, Design and Development of Fishing Harbors and Fish Landing Centers.
- Worked in MoES, DOD, ESSO-NIOT and ESSO-INCOIS.
- Chairperson for development of coastal infrastructure for fishery in Karnataka.
- National Consultant for FAO for development of cleaner Fishing Harbors in Orissa and Gujarat
- Currently working with the World Bank on Coastal Disaster Risk Reduction Project.

In order to bring to the knowledge of younger generation the efforts involved in setting up a project like NDBP under GoI, the topic chosen is The Genesis and Development of Data Buoy System in India. On 27th January 2016, I was on The World Bank Mission, when I saw a small cabin carrying the title of NIOT at a remote place, Soothikoppam, near Cuddalore, TN. I was thrilled to see and my memories went two decades back to the days when I was pursuing with the appraisal agencies in Government of India to obtain the investment decision on NIOT. It was equally satisfying coincidence to receive an invite from NIOT to participate in the celebration of two decades of NDBP service to the Nation.

I had worked in the design of New Port of Mangalore in early part of my career, 1965, and had struggled to get reliable data on ocean parameters like waves, to design marine structures such as breakwaters and prepare master plan layout. When I had assignment in DOD, the practical Harbour engineering experience I had acquired, gave a strong conviction that NDBP was the answer to fill the crucial gaps in the data availability in India, not only for infrastructure like harbours but for developing and running models for reliable prediction of weather, monsoons, cyclones etc.

Enlisting cooperation and support from National Institute of Oceanography (NIO), CSIR and India Meteorological Department, IMD, DST, convincing Ministry of Defense (security concerns), a proposal was prepared for setting up of the Data Buoy programme, which contained the number, size, required met-ocean parameters for deciding sensors in the buoys, identification of institute for implementation, grants likely available from bilateral agency NORAD, GoI budget, manpower, etc. Unquestionable and absolute faith from Secretary I enjoyed, made the proposal sail through. The approval of Government was obtained and NIOT was chosen as the institute responsible for implementation, in consultation and with consent from the Director NIOT.

The extensive use of moored buoy data from the time of its inception, in the research and development and its existence for two decades, justified the decision to set up the NDBP. The future prospects of NDBP will be only a decisive positive slope.

National Data Buoy Programme - 2 Decades of Serving the Nation

Prof. M. Ravindran
Founder Director, NIOT

Education

Ph.D., Indian Institute of Technology (IIT) Madras.

Positions Held

- Vice Chairman of Inter-governmental Oceanographic Commission of UNESCO
- Legal and Technical Commission, International Seabed Authority, Jamaica
- Head of the Hydrodynamics panel of Naval Research Board (NRB) of DRDO

Awards & Recognition

- Prof. H. Dill gold medal of Society of Bioscience.
- Ocean Science & Technology Development Award of Ministry of Earth Sciences

I am extremely happy to congratulate the entire team of the National Data Buoy Programme (NDBP) of the National Institute of Ocean Technology, (NIOT) Chennai on the completion of 20 years of pioneering service in providing the most important ocean related data to understand the air –sea interaction and improve our nation's capability in predicting weather, rainfall and occurrence of storms and cyclones. The data from the buoys in seas around India in various water depths up to 4000 m have contributed to more accurate prediction of monsoons in India by the India Meteorological Department for the benefit of farmers in our entire country. These data also help to monitor the tracks of cyclones and predict their landfall locations in advance, which have helped to save a number of lives and minimize damages in coastal areas. The surface and subsea data given out by the buoys are used by the Indian National Centre for Ocean Information Service, Hyderabad to predict the potential fishing zones for the benefit of the fishermen community during the last two decades. These data are very useful to make the ocean state forecast and for various types of Ocean Modeling by all Ocean Scientists.

The most important contributions of the NDBP team during the last two decades have come in the areas of Indigenization of the manufacture of all components of the buoy (except the sensors), development of reliable mooring systems for shallow and deep water locations, increase in both the number of parameters and the data points in each buoy, the number of operational buoys and their safe deployment and recovery procedures. After the major tsunami attack in India in 2004, this team has constantly worked on the data buoy with Tsunami warning systems. Few buoys with Tsunami warning systems are already working successfully for the last few years. This technology up gradation in these buoys has resulted in the 8th generation of success buoys. The latest feather in the team's cap is the development and deployment of special mooring for Arctic region.

The NDBP, started in 1997, was the first major operational programme of NIOT established in 1993, under the Dept. of Ocean Development, Govt. of India. As the founder Director of NIOT I am extremely proud of the NDBP team, presently headed by Dr .R Venkatesan, for their contributions to the development of indigenous technologies for all the subsystem of the buoys, especially the central data processing unit and ensuring the safety of the buoys in deep seas. This indigenous capability developed has made NIOT, a leader in the moored buoy technology in this part of the world and brought in worldwide recognition to the team.

I whole heartedly congratulate the NDBP- NIOT team on their excellent achievements in the last two decades in enhancing the contributions of Ocean Technology to the nation.

Norway-India Collaboration in Ocean Research

Inger Midtkandal
Science and Technology Counsellor,
Royal Norwegian Embassy in
New Delhi, India
Commercial section, Innovation Norway.

Professional Experience

- European Union
- Joint Research Center
- IPTS in Sevilla (Spain)
- Research Council of Norway

The Norwegian Embassy congratulates NIOT on the 20 years anniversary of the Ocean Observation Systems. An Indian project supported by Norwegian aid in its initial phase, has grown into an impressive buoy network in the Indian Ocean and even moored observation in the Norwegian Arctic fjord, King's Bay in Ny-Ålesund, Svalbard. Along with this NIOT have built important knowledge and competence related to the Oceans.

Norway and India share a comparative advantage through closeness to the oceans, long coastlines and the curiosity and need to further explore and benefit from the Ocean Space. India is one of the few prioritized countries for research and educational collaboration for Norway, and Ocean Space is one of our prioritized areas for research, innovation and international collaboration. We hope to explore further how we can mutually benefit from joint collaboration in this field.

The Norwegian Government just presented a white paper on Oceans – a white paper for Norway in a global setting. We are now stepping up our efforts for the oceans and intend to make sustainable use of the oceans a global priority. The white paper gives special priority to three areas: sustainable use and blue growth, clean and healthy oceans, and the role of the blue economy in development policy.

The world population is expected to increase by more than two billion by 2050, increasing our need to obtain resources such as food and energy from the oceans. There are considerable opportunities for sustainable growth in ocean-based industries in the time ahead. However, there is also serious concern about environmental problems such as pollution and marine litter, climate change, and unsustainable uses of the oceans, such as overfishing.

Indo-Norwegian research collaboration has grown strong over the last 10 years in various areas, polar sciences, climate and energy being among them. Areas related to the Ocean Space; ocean technology, blue-economy and green shipping etc have nevertheless not been explored sufficiently in a bilateral, joint manner. We have an untapped area of opportunity just in front of us. In the years to come, I really hope to see a new area of joint Indo-Norwegian collaboration within Ocean Space and I would like to end by inviting you to work with us in realizing these potentials for mutual exploration and research.

Congratulations on past work over the last 20 years, and best of luck for future endeavors.

Understanding the Links of Monsoon Variability to Atmospheric Convection Over the Oceans: Role of Data Buoys

Prof (Rtd.) Sulochana Gadgil

Centre for Atmospheric & Oceanic Sciences, IISc, Bangalore

Education

Ph.D Harvard University

M.Sc. Pune University

Awards & Recognition

- Fellow of the Indian Academy of Sciences, Bangalore
- Fellow of the Indian National Science Academy
- Fellow of the Indian Meteorological Society
- UGC Career Award(1980)
- B N Desai Award of India Meteorological Society(1982)
- Vasvik Award(1986)
- Shri Hari Om Ashram Prerit Dr.Vikram Sarabhai Award(1989)
- Norman Borlaug Award(1996)
- Astronautical Society Award(1996)
- National award for Atmospheric Science and Technology, MoES, GoI 2008
- Life Time Excellence award in Earth System Science, MoES, GoI, 2016

After elucidating the nature of the relationship between convection over tropical Oceans and SST and of monsoon variability to organized convection over the oceans, Sulochana Gadgil strongly advocated systematic observations with launching of buoy programmes over the Indian seas, for better understanding of monsoon variability, served on committees to nurture the buoy programme and published the first paper on observations with the Indian buoys with scientists from NIOT and IISc.

Most of the rainfall over the Indian region during the monsoon occurs in association with cloud systems generated over the warm waters of the surrounding seas and the equatorial Indian Ocean. The variability of the monsoon is, therefore linked to the variability of convection over these oceanic regions.

For convection over the oceans, the most important oceanic variable is believed to be the sea surface temperature (SST). Studies of the relationship satellite derived convection/precipitation with SST show that it is highly nonlinear. There is a high propensity for convection when SST is above a threshold of about 27.5°C or 28°C. In fact, the large variation in convection over the equatorial central Pacific between El Nino and La Nina is directly related to the variation of the SST which goes above the threshold during El Nino events. However, if the SST is maintained above the threshold, the relationship between convection and SST is at best weak.

It so happens that generally during the Summer monsoon, Eastern Arabian Sea, the Bay of Bengal and equatorial Indian Ocean are maintained above the threshold. Consequently, the correlation of convection /rainfall over these oceanic regions with SST is poor, or sometimes even negative, for time-scales ranging from daily to seasonal, with or without lag. The first study with the data of Indian buoys over the Bay of Bengal showed that the SST, in fact, responds to the convection, cooling during convective episodes and warming under cloud-free skies. Thus, the coupling of convection with these oceanic regions is more complex that the equatorial central Pacific case. Rather than SST, we expect SST gradients to play a major role.

For understanding such coupling, analysis of only the readily available data i.e. ‘Reynolds’ or TMI is not adequate, since comparison with the buoy data has clearly shown large errors in convective conditions. We need a concerted effort with analysis of all the buoy data along with a slew of data from other platforms such as ARGO as well as satellite data, to understand the nature of the relationship of the convection over these oceanic regions with the oceanic variables.

Special Features of Air-Sea Interaction Over the North Indian Ocean Derived from NIOT's Moored Buoys

Prof. G. S. Bhat
Chairman,
Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bengaluru

Education

Ph.D. in Aerospace Engineering

Positions Held

- Professor, IISc, Bangalore

Awards & Recognition

- PRL Award for the year 2001 in the field of Earth and Planetary Sciences
- Shanti Swarup Bhatnagar Prize in earth, Atmosphere, Ocean and Planetary Sciences
- Fellow, Indian Academy of Sciences, Bangalore India
- Member, India Meteorological Society, New Delhi.

I started closely looking at data from NIOT's moored buoys while involved in planning and executing BOBMEX, ARMEX and CTCZ, the field programmes under the Indian Climate Research Program (ICRP). Prior to 1997, i.e., before NIOT's buoys were deployed and in the absence of continuous in situ SST time series, satellite derived Reynolds SST was used to understand air-sea interaction over the North Indian Ocean. These SSTs showed little intraseasonal variation except for a seasonal cooling, thus the notion that Bay and the Arabian Sea are such vast reservoirs of energy that SST is unaffected by what atmosphere does. The paper by Premkumar et al in Current Science completely changed this notion. Data collected with buoys DS1 and DS2 in the Arabian Sea, and DS3 and DS4 in the Bay of Bengal clearly brought out for the first time fundamental differences in the nature of SST variations over these two seas. In fact, one major objective each of both BOBMEX and ARMEX were based on new information revealed in the buoy data. Build up of SST from February till May are somewhat similar over these two seas, however, response to monsoon winds are very different. After the onset, SST of the Bay exhibits strong intraseasonal oscillation while that of the Arabian Sea remains nearly flat, and here the decrease in SST at the onset time is dramatic. Understanding these features formed major objectives of BOBMEX and ARMEX, respectively. NIOT buoy data also revealed that sea-air temperature difference is much smaller over the North Indian Ocean compared to Western Pacific warm pool and tropical Atlantic Ocean. This triggered detailed investigation of the mechanism responsible for the anomalous behaviour in the Indian Ocean. It turns out that something very unique happens during the summer monsoon period over the North Indian Ocean where sea-air property differences are influenced by atmospheric boundary layer dynamics at the atmospheric mixed layer top. We also demonstrated that no matter how advanced remote sensing is, there is no substitute for accurate in situ observations by comparing SSTs from ship, buoys and TRMM satellite. Thus, data from NIOT 's moored buoys have advanced understanding of air-sea interactions over the North Indian Ocean in the last 20 years. It is difficult to imagine the state of this area if NIOT buoy program was not launched. Probably we continued to apply the understanding gained and relations developed elsewhere, and that would have done more harm while giving the impression that the field has advanced!

Establishment and Growth of Moored Buoy Programme

Dr. M. A. Atmanand
Former Director and Scientist G, NIOT

Education

Ph.D : Indian Institute of Tech.-Chennai

M.Tech : Indian Institute of Tech.-Chennai

Awards & Recognition

- Received the Institute of Electrical and Electronics Engineers (IEEE) Oceanic Engineering Society Presidential Award in 2016
- National Geoscience Award, 2010
- International Society for Offshore and Polar Engineers (ISOPE) Ocean Mining Symposium awards, 2009
- Founder Chairman of IEEE Oceanic Engineering Society in India
- Associate Editor of Journal of IEEE Oceanic Engineering Society
- Currently Chair, IEEE Madras Chapter

Member

- Marine Technology Society
- Society for Underwater Technology
- The Institution of Engineers (India)
- Ocean Society of India

The moored buoy programme expanded under his directorship incorporating newer technologies and venturing into indigenizing the buoy components.

The moored buoy programme was established in the year 1997 with an objective to operate, maintain and develop moored buoy network in the Indian Seas. The systematic monitoring and real time transmission of meteorological and oceanographic parameters was a distant dream, until the establishment of the network by NIOT. Looking back after two decades, the programme has achieved its goals and added many laurels to its credit.

The programme started with a network of buoys measuring surface met-ocean parameters, presently measures various parameters up to 500m depth. It has also broadened the spectrum of measurement to tsunami buoys and polar mooring. Besides, OOS has taken initiative in indegenisation of buoys which helps in not only lowering their costs but also in customizing the buoys to meet specific requirements and troubleshooting many issues that may arise during field operations.

I am happy to mention that the moored buoy observations proved its worthiness over a wide range of applications and grown even to arctic region and continuing its efforts to provide quality data integrating new technologies and incorporating user feedback. During my Directorship and even later on, the data has been used effectively by IMD and other agencies and has assisted in predicting the land fall of cyclones like Phailin accurately.

It gives me great pleasure to congratulate Dr. Venkatesan and his efficient team leading the moored buoy programme on this momentous occasion of celebrating two decades success.

Ocean Observation Systems - A Success Story

Dr. K. Somasunder
Scientist-G/Advisor in the Ministry of Earth Sciences (MoES)

Education

Ph.D in Ocean biogeochemistry

Responsible for coordination & implementation of national projects relating to Ocean Observational Network and Ocean Information Services

Past Experience

- National Institute of Oceanography, Goa.
- National Environmental Engineering Research Institute
- Department of Ocean Development.
- Indian National Centre for Ocean Information Services.

Area of Interest

- Biogeochemical process of the Indian Ocean.
- Air-sea interaction studies and role of upper ocean circulation on atmospheric processes in the India region.

His contribution in establishing the first of its kind ocean observation programme – the National Data Buoy Programme (NDBP) for India is highly commendable

Our ability to forecast weather and climate including cyclones, storm surges and tsunamis, is largely contingent upon our capability to observe the changes in oceanic processes in real-time at spatial and temporal scales with the required resolution and accuracy. The Ocean Observation System (OOS) of National Institute of Ocean Technology under Ministry of Earth Sciences plays a major role on this perspective by maintaining Met/Ocean and Tsunami moored buoy in the Indian Ocean.

The new generation buoys provide subsurface parameters up to 500m deep.

OOS has accomplished several major milestones which include indigenization of seven variants of data loggers for Met-Ocean and Tsunami applications. Development of Bottom Pressure Recorder is also underway. Expertise and knowledge gained over the period have helped this team to develop such new instruments and technologies.

Use of INSAT telemetry has been successful, greater cost advantage and has reduced dependence on foreign satellites. The data from these buoy system are being used widely by national and international communities for both operational forecast and research purposes. Owing to persistent and diligent efforts, this programme has received international recognition.

Sustaining and continuing an observational program on a long term basis amidst challenges like vandalism and sea piracy, is a great thing. As a Programme Officer for this group, I would complement NIOT for the hard work to upkeep the buoy network.

I wish to congratulate the entire team all the very best in their endeavors.

Ocean Observation System in Indian Seas through Indigenous Buoys

Dr. M. Sudhakar
Scientist-G, Director, CMLRE

Education

Ph.D Indian School of Mines, Dhanbad

Master's degree in Law of the Sea and Marine Policy in 1990 from the London School of Economics & Political Science,UK

Member

- Legal & Technical Commission (LTC) of the International Seabed Authority (ISBA) International Association for Hydro-Environment Engineering and Research, IAHR.
- Scientific Committee on Ocean Research (SCOR), ICSU
- Visiting scientist to the Aachen University of Technology, Germany.
- National Steering Committee for Science and Astronomy Olympiads
- Scientific Committee, International Geological Congress

Past Experience

- National Institute of Oceanography (NIO) & National Centre for Antarctic and Ocean Research (NCAOR) in Goa

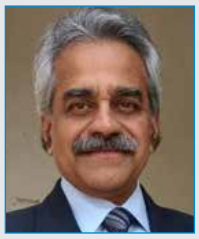
Understanding our oceans is critical to implement effective management strategies for the conservation and sustainable utilization of resources, to protect people from natural disasters and the impending challenges of climate change. Regular monitoring of marine environment is essential to supplement information for research and services but this cannot be fully met through shipboard surveys due to limitations in collecting high frequency data on long-term. The introduction of autonomous moored buoy network in Indian Seas has significantly strengthened the knowledgebase and predictive capability for providing high quality oceanographic services.

Ocean sciences in India had seen a remarkable facelift with the integration of NIOT buoy data by the researchers in addressing air-sea interaction processes, variability in monsoons, cyclones and their biological responses. The high resolution data and information have been extensively improved the models and the predictive capabilities for Tsunami warning system, Ocean State forecast system, etc., particularly during the cyclone period and supported IMD to provide advance information to the Government agencies to take necessary precautions. The team has also achieved a milestone by indigenizing buoy components and integrating new technologies in system designing and measurement.

My hearty Congratulations to the team OOS at NIOT for their commendable achievements during the last 20 years.

Applications of Moored Buoy Data at NCMRWF

E.N. Rajagopal, M. Das Gupta, V.S. Prasad and John P. George



Dr. E. N. Rajagopal
Scientist-G & Head
ESSO-NCMRWF,
Ministry of Earth Sciences,
NOIDA, INDIA

Positions Held

- Scientist-G & Head, ESSO-NCMRWF

Awards & Recognition

- Certificate of Merit for outstanding contributions in Atmospheric Science for the year 2007 by Ministry of Earth Science, Govt. of India.

Meteorological/oceanographic observations from moored buoys deployed in the Arabian Sea and Bay of Bengal are vital inputs for model initialization/verification. NCMRWF has been utilizing the Indian buoy observations since last two decades. Not only these observations are valuable for forecasting weather patterns over Indian Seas but also these served as an important source/dataset of in-situ observations for validation numerical models and satellite products.

In the first decade, only surface pressure and winds from the buoys deployed by NIOT were being ingested into the global atmospheric data assimilation system at NCMRWF. However, in the recent decade surface temperature and specific humidity are also getting assimilated though very few global buoys are reporting humidity.

In the first decade the winds at 10 meter level dirived from the moored buoy observations were extensively used at NCMRWF to validate the various scatterometer winds (QuikSCAT, OSCAT) and model analysis/predictions (e.g., Goswami and Rajagopal, 2003). During the same period, significant wave height observations were also extensively used for validation of the operational wave model products (WAM and WAVEWATCH-III) at NCMRWF. The activity of validation of 10 meter winds with subsequent scatterometer satellite missions (ASCAT, SCATSAT, etc.) have been going on regularly (Rani et al. 2013, 2014).

Few impact studies of global buoy observations using NCMRWF global data assimilation system conducted during July 2002 had shown impact buoy observations on mean monthly analyses of wind and temperature at 1000 hPa level (Das Gupta, 2006). Though the maximum impact is shown over southern hemispheric oceanic region, a small impact was also seen in mean wind analyses over Arabian Sea region along the lower level jet region.

Applications of Moored Buoys: New in-sights and Ocean Services

Dr. M. Ravichandran
Director
ESSO-NCAOR,
MoES, Goa, India

Education

Ph.D, Physics

Positions Held

- Scientist in Indian Institute of Tropical Meteorology (ESSO-IITM), Pune
- Senior Project Engineer in National Institute of Ocean Technology (ESSO-NIOT), Chennai
- Scientist at Indian National Centre for Ocean Information Services (ESSO-INCOIS), Hyderabad

Awards & Recognition

- Co-Chair, Indian Ocean Panel - CLIVAR/ IOC-GOOS

Member

- International Argo Steering Team
- SIBER (Sustained Indian Ocean Biogeochemical and Ecological Research) Scientific Steering Committee
- Indian Meteorological Society
- Indian Physics Association
- Oceanographic Society of India

Started with atmosphere and migrated to surface ocean (Buoys), dived to deep ocean (Argo) and now working on solid Ice.(e-mail : mravi@ncaor.gov.in)

Ocean Observations in general, moored buoys in particular, is essential to provide ocean services and to a variety of new in-sights about air-sea interaction and the upper ocean dynamics. NDBP buoys has been providing marine meteorological and oceanographic real-time parameters over the North Indian Ocean for the past two decades. First time in the North Indian Ocean, these buoy data provided useful information to validate satellite and model derived data, to document intra-seasonal variability of sea surface temperature and its cause, clue for the cyclone nowcast / forecast, etc. These data sets also used to assimilate in the Ocean model to provide ocean analysis for the initialization of coupled ocean-atmosphere model to predict the monsoon seasonal forecast. Without these data, it is very difficult to understand the variability of marine meteorological and ocean parameters from diurnal to seasonal timescales and beyond. Also, the deployment of moored buoy in the Arctic has provided information about the cause of glacier melt in the Arctic fjord.

Ocean Observations - NCESS Perspective

Dr.T.N.Prakash
Marine Scientist
Director (in-charge) at National Centre for Earth Science Studies, Trivandrum

Intersted in

- Beach and Coastal Processes including the Management aspects.
- Contributed in the Integrated management plan of the Athamudi estuary

Any observations/measurements in the ocean require a stable platform or can be operated through a mooring system. The most important observations which often coastal engineers required are the wave data and were initiated during the late sixties and early seventies by many coastal states due to the huge investments in the offshore oil industry and related harbor development. National Centre for Earth Science Studies (NCESS) the erstwhile CESS has initiated the coastal observation along the south-west coast of India as early as in 1980s by utilizing the available infrastructure like coastal pier and developed in-house measurement systems for the coastal observation for the first time in the country by establishing four coastal laboratories viz., Trivandrum, Alleppey, Tellichery and Calicut. The results from these long-term measurements were available from the studies of Baba et al. 1983, Thomas and Baba, 1983; Kurian et al. 1985; Baba 1985. The observations include the shallow water waves, breaker characteristics, longshore currents, littoral drifts, sediment size distribution and beach dynamics. The data were used for studying the nearshore wave climate and beach processes in addition to test the sediment transport and beach evolution models. The deep water wave measurements were made by using wave rider buoys which were used to study the deep water wave climate and to calibrate the hindcasting models.

When the Wave rider buoy operation was still in infant stage in India because of their cost involved, and for recording the shallow water waves a pressure type wave and tide telemetering system is used. The transducer is kept below water level at the end of the pier the signals are transmitted by cable laid over the pier. A wave rider buoy was operated in deep waters mainly to collect data for wave transformation studies. Beach profiles are taken from the fixed bench mark using a dumpy level and staff. Longshore currents were measured by using vane float assembly and also by neutrally buoyant floats. Sediment samples are collected from the berm, beach face and surf zone, which was analysed using standard procedures. The meteorological parameters viz. wind speed, direction, pressure and temperature were also monitored. The data analyses were carried out by adopting the standard procedures. Prediction of sediment transport and beach evolution was studied during those days which were very new to the south-west Indian coast. In addition to the statistical analysis, wave hindcasting by utilizing hybrid models, wave refraction models etc. were also successfully carried out by the NCESS team.

Presently the Coastal Processes Group (CoP) of NCESS is working on the beach and surf zone dynamics where sophisticated and calibrated instruments are being used for the investigations. The hydrodynamic measurements are being carried out by using Wave and Tide gauges (Valeport), directional Wave Rider Buoy (WRB) with acoustic current meter, Acoustic Doppler Current Profiler (ADCP), Acoustic Doppler Velocimeter (ADV), Recording Current Meter (RCM), Automatic Weather Stations (AWS), in-house developed Sediment Traps, Van Veen Grab Sampler, Piston Corer, Shallow Seismic Profiler etc. Numerical modeling of waves, currents and sediment transport was used for the better understanding of the coastal processes. Process based one-line models was also used for simulating the cross-shore profiles and shoreline evolution.

The future developments are required in the areas of Satellite observations with higher resolution and more spectral bands from satellites, Improved capability for ocean color observations in case-II waters, Improvements in ocean platforms, Improved glider technology and mooring technology, New development in ocean sensors and system, New and improved capability to measure biogeochemical variables, nutrients, and dissolved oxygen and carbon dioxide.

Significance of Moored Buoy Observations for Coastal and Marine Area Management

Dr. M.V. Ramana Murthy
Scientist-G,
Ministry of Earth Sciences heading Integrated Coastal and Marine Area Management

Education

Ph.D., Ocean Engineering, IITM, Chennai.

M.Tech in Ocean Engineering, IITM, Chennai

B.E (Civil), M.Tech (Planning), CEPT, Ahmadabad

Awards

- National Geo Science Award 2010.
- Ministry of Earth Sciences Award 2006.
- Modeling and American Bureau of Shipping Award 1997

Member

- Expert Appraisal Committee for Infrastructure Development, Coastal Regulation Zone, Building/Construction and Miscellaneous projects.
- International Association for Hydro-Environment Engineering and Research.
- BIS for Revision of IS 4651 and Tsunami code
- Pondicherry Coastal Zone Management Authority.
- Task for developing Coastal Protection strategies for Gujarat.
- CPDAC and President Ocean Society India

Coastline is subjected to geomorphic changes due to natural as well as manmade activities; the changes are at varied spatial and temporal resolutions. One of the major factors influencing the coastline is wave climate which needs to be understood in terms of its formation, propagation, near shore transformation and finally its impact on coastline or on coastal establishments. The near shore climate at the coastline can be assessed only when reliable observations are made at Deep Ocean and also along the coastal areas.

The National Data Bouy Programme (NDBP) operated by National Institute of Ocean Technology (NIOT), has helped in collection of systematic information on waves in deep sea and coastal waters. These observations were used in validation of numerical models and to derive near shore wave climate in hindcast and forecast mode. The systematic observations made by Data Buoy Programme is very useful for industries (Ports and Harbors) as well as protection of infrastructure along the coast.

Significance and Growth of National Data Buoy Programme

Mr. K. Premkumar
Former Programme Director
NDBP, NIOT, Chennai

Positions Held

- DGM in Goa Shipyard Ltd, Goa, a PSU of GoI
- Director, National Test House (Southern Region), GoI
- CEO - Win Marine Consultancy Services

Member

- Vice-Chair of International Buoy Programme of Indian Ocean (IBPIO) an action group under DBCP. 2003-2007.
- Marine Technology Society, USA.
- Was a Member Institute of Standard Engineers.
- Visiting Faculty to Indian Institute of Technology, Chennai to B.Tech. Naval Architecture students for the academic year 1994.
- Academic Council of Anna University- from 1997 to 2000

Establishment & sustaining of the National Data Buoy Programme beyond a plan period was not an ordinary task and could not have been achieved by officials of ordinary in nature. During the first decade, the programme faced many hurdles like the saying "When one climb up a step, he slips three steps down". Frequent damages/ vandalism to buoys almost wiped off the buoy network more than one occasions , buoy blast-loss of live hence scare on buoys maintenance nearly made a full stop to the programme, near fatal injuries to team during maintenance activities, less time with family members due to long working hours, frequent sailing for buoy maintenance, availability of ship time only during rough weather periods, no clear employment security/growth, exodus of people etc., did not deter the core team, who have built & rebuilt the buoy network, engineered well the buoys to world class standard in more cost effective manner and anchored the programme for the country like Army men. I, salute all those contributed in the establishment and sustaining it in the last two decades.

One of the main objectives to establish the programme was to greatly assist IMD in predicting the cyclone track and provide early warning to the country men to minimise the loss of lives. The significance and important role of the NDBP for our country is evident from precise prediction of the track of Super Cyclone Phailin by IMD utilising buoy observations, which led to zero casualty.

NIOT Buoys Augment Bay of Bengal Boundary Layer Experiment (BoBBLE)

Prof. P. N. Vinayachandran
Professor
Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bengaluru

Education

Ph.D., (Oceanography), Indian Institute of Science.

M.Sc.[Engg.], (Oceanography), Indian Institute of Science.

Positions Held

- Science Education Panel of the Indian Academy of Sciences (IASc) and editorial board of Resonance
- Current member of editorial board of Current Science and co-chair of IIOE-2 Science Theme – 2

Awards & Recognition

- Shanti Swarup Bhatnagar prize
- Fellow of the Indian Academy of Sciences, Bangalore
- National Academy of Sciences, India

BoBBLE is a joint MoES, India – NERC, UK program to study the role of air-sea interaction on the variability of south Asian monsoon. A major objective of the field programme during BoBBLE was to collect high-quality observations of ocean, atmosphere and their interface. During June- July, 2016, the BoBBLE field programme was conducted along 8°N, in the southern Bay of Bengal on board RV Sindhu Sadhana (National Institute of Oceanography, Goa). The UK aircraft FAAM flew over the ship in order to obtain simultaneous measurements of both atmosphere and ocean. Using gliders and CTD, a time – series of hydrography covering the entire cruise period was obtained along the 8°N transect. One limitation of the ship-board observation program is the limited spatial coverage. The data collected by the moored buoys deployed by NIOT under their Ocean Observing System project is useful in providing the much needed spatial linkage of the ocean features that are explored in detail by the field experiment. An example is shown here using the intrusion of high salinity water from the Arabian Sea into the Bay of Bengal. The high salinity core is a subsurface feature and is associated with the summer monsoon current. The new set of observations from multiple platforms suggest that the meandering of the monsoon current distributes the high salinity water in the southern Bay of Bengal.

Overview of Ocean Observation Systems

Dr. R Venkatesan
Scientist G & Head
Ocean Observation System (OOS),
ESSO-NIOT

Education

PhD –IISc, Bangalore.

Awards & Recognition

- National Geoscience Award
- NRDC National Award
- NIGIS Meritorious Award
- NDRF National Design Award
- MOSCOT National award
- Tamilnadu State Scientist Award
- Best PhD Thesis Award : NACE
- Member Steering Committee of Global Ocean Observation System of UNESCO IOC Asia Pacific
- Chairman International Tsunameter Partnership

It is my great pleasure to present an overview of the Ocean Observation System (OOS) during the past twenty years and to list out major achievements. The OOS has been systematically maintaining the twelve deep sea instrumented buoy systems with surface & subsurface sensors, four coastal buoys, one CALVAL Buoy and two tsunami buoy systems. The overall data return is more than 93%, which is placed at the top among global moored buoy networks.

The OOS team has integrated newer technologies, measurement techniques and significantly improved the buoy system and communication. The Indigenous OMNI buoy system **'PRAKRUTI'** was designed and developed indigenously under make in India program. The indigenous data processing unit **'HRUDAYA'** (Data Acquisition System) with seven variants is the heart of the PRAKRUTI. This unit has the facility to interface with all the buoy sensors, autonomously collects, process, store and transmit in real time via various satellite telemetries such as INMARSAT, INSAT, GPRS/GSM and UHF accelerated the indigenization efforts. Rapid mode data transmission during cyclone period is implemented in four coastal buoys, which successfully transmitted high frequency data during recent cyclones. The state-of-the-art data reception software ADDRESS developed in-house caters to data reception from buoy systems, analysis and archival of data. The data reception centre manned 24 x 7 and data being sent to INCOIS in realtime. The buoy data is also made available through mobile app IMoon along with relevant details.

The prototype Indian Tsunami Buoy system both surface buoy system and Bottom Pressure Recorder **(Sagar Bhoomi)** worked satisfactorily for 134 days at a depth of 3370m. The CALVAL buoy system combining moored data buoy and an optical buoy with INSAT satellite telemetry is operational since December 2011. The multi-sensor Indian Arctic mooring **(IndARC)** is continuously operational since its inception in July 2014 in Kongsfjorden, Arctic Ocean.

The moored buoy observations are widely utilized by scientific community and OOS team published more than 125 papers in peer reviewed journals and more than 200 papers in conference proceedings. The team has successfully collaborated with many national and international institutions such as WHOI-USA, JAMSTEC-Japan, Department of Environmental Affairs-South Africa, Peru and Norway through Ministry of Earth Sciences.

The significant efforts in improving the buoy system resulted in three patents filed related to buoy technology and recognized with prestigious National Geoscience award and NRDC National Award.

Wave Forecasting Techniques Using Moored Buoy Measurements in Indian Seas

G.Latha and K.Jossia Joseph

Dr. G. Latha
Scientist F, NIOT
Head of the Ocean Acoustics and Modeling program of NIOT.

Education

Doctorate degree in Mathematics from IIT Madras.

Masters in Mathematics from IIT Madras.

BSc in Mathematics from Madras University (University Gold Medal)

Awards

- MS Narayanan Memorial lecture award
- Member of Acoustical Society of America and IEEE Signal Processing.

Continuous data on wave parameters from in-situ measurements of moored buoys in shallow and deep waters of Indian seas are vital for various coastal and open ocean applications. It has been understood from experience that establishment and maintenance of wave buoys is challenging and expensive. Newer technologies have emerged to estimate wave parameters through numerical modeling, soft computing methods and satellite data, which are validated using moored measurements to ensure the reliability and quality of the simulated parameters.

Soft computing techniques are utilized to estimate wave parameters, which require long term continuous measurements of wind and wave. The gaps in the long term data need to be filled by secondary data before adopting soft computing techniques. In general, the gaps are filled using satellite measurements or simulated data. The estimated wave parameters compare well with measurements.

Presently well calibrated numerical models are utilized for wave forecasting, which in general agree well with the average wave parameters in open ocean. However the results exhibit a lesser correlation in coastal areas due to bathymetric effects, wave diffraction, refraction, reflection etc. Lesser correlation is also observed in swell wave parameters, which is a challenging part in numerical modeling. Wave measurements carried out at specific locations are utilized for validating the results and improving the model physics. Numerical modelling of wave parameters are carried out using WAM model, which exhibited good correlation with measured data. The assimilation of wave data exhibited further improvement. The soft computing tools as well as numerical modelling can be utilized for simulating the wave data, which has wide applications in ocean state forecasting.

Utilizing Ocean Buoy Observations for Indian Satellite Program and Data Assimilation Study

Dr. Rashmi Sharma
Scientist SG and Head, Oceanic Sciences Division
Space Applications Centre (ISRO), Ahmedabad.

Education

Ph.D, Andhra University

Positions Held

- Principal investigator for many projects under ISRO's Science Missions.

Awards & Recognition

- P. R. Pisharoty Memorial Award for the year 2008 instituted by Indian Society of Remote Sensing.
- ISRO representative of international Ocean Surface Vector Wind – Virtual Constellation.

In-situ measurements of oceanographic parameters are the key component of the satellite oceanography and ocean modeling / data assimilation activity. Reliability/accuracy of satellite derived parameters like sea surface temperature, wave height, sea surface salinity and surface currents are often compared against the buoy measurements to gain confidence and to take corrective measures. In situ measurements are also extremely vital to tune the retrieval algorithms to derive the geophysical parameters from satellites. Another very important use of in situ observations is its use in assessing the performance of numerical ocean models when satellite data are assimilated in the model.

At Space Applications Centre, we have extensively used the moored buoy measured parameters like significant wave height (SWH), swell height, ocean currents (surface & sub-surface), temperature and salinity profiles for wide range of applications ranging from validation of satellite data and value added parameters to assessment of data-assimilative ocean models. We are engaged in utilizing the satellite data in ocean wave and circulation models to demonstrate its effectiveness in generating the forecasts. Moored buoy data in the Indian Ocean are being widely used by us in validating model analyses and forecasts.

Indian Space Research Organization (ISRO) has launched several meteorological and oceanographic satellites in the recent past, namely, Oceansat-2 having Ocean Color Monitor and Scatterometer (OSCAT), SARAL/AltiKa (an altimeter mission jointly with CNES), RISAT-1 (Imaging Radar), INSAT-3D/3R (Imager & Sounder) and SCATSAT-1 (Scatterometer). Apart from Indian satellites, data from international missions are also being utilized by us for various applications. For many of these satellites, moored buoy observations have been widely used for validation of the derived parameters. AltiKa derived significant wave height and winds have been compared with the coastal wave rider and moored buoys and bottom pressure recorder measurements. Jason-2 derived coastal SWH have also been assessed with coastal buoy data. SST data from moored buoys have been used to assess merged SST product, namely, GHRSST. Multi-satellite derived ocean surface currents have been compared with the buoy measured currents.

Moored buoy measurements over north Indian Ocean are of great use in ISRO's satellite CAL-VAL and data-assimilation activity. A more detailed aspects pertaining to the usage of in situ observations for Indian Space Program will be presented in the workshop.

National Data Buoy Program: An essential Component of Indian Ocean Forecast System

Balakrishnan Nair
Scientist F.
Head of Ocean Science and Information Services at Indian National Center for Ocean Information Services (INCOIS).

Education

PhD in Marine sciences

Master degree in science (Marine Geology) from Cochin University of Science and Technology, Kerala.

Awards & Recognition

- Young scientist award from Indian association of Sedimentologists in 2001.
- Certificate of Merit for outstanding performance from the Ministry of Earth Science, Govt. of India in 2007 for developing Ocean forecast system for India.
- Best Government website award from Ministry of Information and Communication Technology
- National Geoscience Award, 2014

Member

Fellow of Telangana Academy of Sciences.

Indian National centre for Ocean Information Service (INCOIS), under Ministry of Earth Science (MoES) is the nodal agency for providing forecast and warnings for ocean areas to protect life and property and to enhance the blue economy. Short term forecasting of oceanic parameters is essential for many stakeholders for ensuring safe navigations and operations at sea. Realizing the importance of this service to the society and the lack of such a system for the Indian Ocean, INCOIS started the ocean state forecasting service by issuing forecasts of vital ocean parameters like Sea surface waves, remotely generated waves (Swell waves), ocean surface winds, mixed layer depth, Sea surface currents, depth of 20 degree isotherm etc. INCOIS also developed and operationalized customized products such as Search and Rescue Aid Tool (SARAT), online oil spill Advisories (OOSA), forecast along the shipping routes, forecast for port and harbors. Indian Ocean forecasting system has more than 16 Lakh users from various sectors such as fishermen, shipping, oil industry, state administration, Coast guard, Navy and disaster management agencies.

The data from National Data Buoy Program (NDBP) is one of the the essential component for such a end to end Ocean forecast System. The qualities of the forecasted parameters are primarily assessed using the data from NDBP and coastal buoy system of INCOIS. During extreme events the wave forecast from various numerical models are compared with moored buoy observations (BD08, BD11, BD14, AD06, AD04 and AD09) in the North Indian Ocean and error in the forecasted parameters are determined. Comparison of wave forecast with moored buoy observations during some of severe cyclones (SIDR, PHALIN, HUDHUD,VARDHA) shows the error in the forecast i.e. scatter index obtained for wind and wave parameters are in the order of (22%) and (14%) respectively with correlation (>0.9). INCOIS also developed online and real-time validation system of forecast using the data from NDBP and INCOIS coastal buoys. Recently, INCOIS developed prediction system of swell surge, which gives alerts during high surge conditions. The alerts are being issued after comparing forecast data with buoy observations.

Moored Buoy Data Reception, Processing, Quality Control and Dissemination

E. Pattabhi Rama Rao, R. V. Shesu, Suprit Kumar
Indian National Centre for Ocean Information Services, Hyderabad

Mr. E. Pattabhi Rama Rao,
Head of the Data and information Management Group (DMG) at INCOIS.

Past Experience

- Project Engineer at National Institute of Ocean Technology (NIOT), Chennai.
- Research Fellow at National Institute of Oceanography (NIO).

Awards

- Indian National Geospatial Award, 2010.
- Certificate of Merit by the Ministry of Earth Sciences, Govt. of India.

Member

- India Meteorological Society
- Indian Remote Sensing Society
- Ocean Society of India.
- IODE/IOC/UNESCO Steering Groups on Quality Management Framework (QMF)
- Ocean Biogeography Information System (OBIS)
- Co-Chair of WMO Steering Committee on Indian Ocean Data Rescue Project (INDARE-SC).

The observations from the oceans are the backbone for any kind of operational services (potential fishing zone advisory services, ocean state forecast, storm surges, cyclones, monsoon variability, tsunami etc.) and vital for research in understanding different oceanographic processes, validation of satellite sensors and model simulations as well as to undertake need based user projects for coastal and offshore applications. India established a network of Ocean Observing Systems covering both open and coastal in the Indian Ocean. The in-situ ocean observing system includes argo floats, automatic weather stations on board ships, moored buoys, drifting buoys, wave rider buoys, tide gauges, tsunami buoys, HF Radar, Current Meter Moorings, XBT/ XCTD etc.

INCOIS being the central repository for the oceanographic data, receives variety of oceanographic and surface marine meteorological data from different in-situ and remote sensing Ocean Observing Systems in real-time as well as offline. Further, INCOIS serves as the National Oceanographic Data Centre (designated by the Intergovernmental Oceanographic Exchange Programme (IODE) of IOC/UNESCO), National Argo Data Centre as well as the Regional Argo Data Centre for the Indian Ocean region. The data centre receives and processes the oceanographic and marine meteorological data, quality control and disseminate the data to operational agencies in real-time. INCOIS serves the data through web-based data services viz., Ocean Data and Information System (ODIS) and Live Access Server which facilitates the users for data search, analysis, visualization and download.

INCOIS has the major responsibility of receiving the data in real-time from moored buoy network implemented by National Institute of Ocean Technology (NIOT), data processing, quality control and dissemination to the operational agencies in real-time as well as serve the data to users. An end-to-end data management system is developed on ODIS to receive, process, quality control and disseminate the moored buoy data in real-time. A trigger based quality control was developed and embedded in ODIS for real-time quality control before disseminating the moored buoy data to the operational agencies in the country. Further, the data are converted in FM-18 format as per the WMO Manuals and transmitted to international operational agencies through Global Telecommunication System (GTS). The moored buoy data are organized into a database and metadata are generated as per the ISO 19115 schema and data products are generated in NetCDF format as per the Ocean SITES standards and quality control procedures. Various software tools are developed for quality control of the moored buoy data in delayed mode with climatology.

The met-ocean data generated by the moored buoy network are served to students, researchers, government agencies and for consultancy services. These data are being widely utilized for providing ocean information and advisory services, weather forecasting, understanding various oceanographic processes, validation of models, calibration and validation of remote sensing satellites etc.

Need for Development of New Observation Technologies

Tata Sudhakar
Head, Ocean Electronics Group

Education

M. Tech (Electronics and Control)

Achievements

- Key member of the team responsible for the establishment of National Data Buoy Programme for monitoring of oceans.
- Filed seven patents and transferred technologies like Ocean drifters and ARGO floats to Indian industry.

Awards & Recognition

- National Geo Science Award from Ministry of Mines, Govt of India in the category of Disaster management for the contributions in establishment of Indian Tsunami warning system in 2012.
- Certificate of merit for technical excellence in Ministry of Earth science, Govt of India in 2013.

The development of new Ocean observation technologies is need of the hour as the requirement for more accurate and high sampling rate systems is growing, Also for supporting national programmes such as ocean state, Tsunami, PFZ forecasting and for water quality monitoring of coastal waters. The data security of critical measurements is also important and there is need to use Indian satellites to achieve this. The performance of systems available today has limitations in tropical water. National Institute of Ocean Technology is working for development few critical technologies like Autonomous Underwater Profiling drifters (AUPD), drifting buoys and shallow water glider systems with INSAT communication. Some of the technologies developed are transferred to local industry after trail production.

Indigenous Development of Ocean Observation Platforms

Sanjeev Afzulpurkar
Scientist F.
Chief Scientist & Head of Division
Marine Instrumentation Division
CSIR - National Institute of Oceanography

Research and development

- Development of Autonomous Platform for ocean data observations.
- Developed Autonomous Underwater Vehicle, MAYA and Autonomous Vertical Profiler.
- Involved in design, development and operation of NIO research vessels namely RV Sindhu Sankalp and RV Sindhu Sadhana.

The Ocean Observations Program is one of the successful programs to run over a long period of time. The network of these buoys collect data that is very pertaining to the coastal programs that need to monitor and determine short and long term changes. In this aspect OOS has played a very key role. Be it monsoons, storms, tsunamis or cyclones, buoys based OOS programs have their contribution while routinely collecting basic data during the normal seas.

Various observation platforms such as buoys, AUV's, floats, drifters etc., play an important role in oceanography in general and coastal oceanography in particular. Here the observation platforms developed by CSIR -NIO during the last decade are presented with their capabilities towards ocean observations.

NIOT Buoy Observations in a Modelling Perspective

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ESSO-IITM
MoES, Pune, India

Education

Ph.D,IIT Kharagpur

M.Sc. from Madurai Kamaraj University

Interested Fields

- Ocean Modelling,
- Physical Oceanography,
- Ocean Variability,
- Monsoon Variability,
- Air Sea Interaction
- Data Assimilation

Awards & Recognition

- Visiting or adjunct faculty of several universities.
- Fellow of the Indian Academy of Sciences, Bangalore

Indian Ocean (IO) was considered one of the poorly sampled basins until recently. However with the advent of Array of Realtime Geostrophic Oceanography (ARGO) floats the sampling of Indian Ocean improved dramatically. However the ARGO profiling is limited to few oceanic variables. Though the modeling community benefitted a lot from the ARGO data, several issues are still not resolved in the model. The National Data Buoy Program provided most vital observations of several oceanic parameters to supplement the existing observation network. These data sets are currently being used for process studies and model validation. Even with the current observations modeling of the three dimensional state of IO is becoming a very difficult task. Several studies have shown that ocean general circulation models display large errors in simulating IO especially when they simulate the other oceans reasonably well. This is true for both ocean general circulation models (OGCMs) and coupled GCMS (CGCMs). Some of the challenging issues the current OGCMs facing are improper simulation of (a) upper ocean vertical structure of temperature and salinity, (b) currents (c) mesoscale eddies and their interaction with the boundaries along the east coast of India and the coast of Somalia etc. To overcome these challenges in-situ observations play a big role. Momentum transfer coefficient for example play vital role in estimating the transfer of momentum flux from atmosphere to ocean. This transfer is sensitive to the boundary layer conditions over the ocean. The transfer coefficients behave nonlinearly for low winds (<4 m/s), when most of the known empirical relations assumed it linear. NDBP observations helped us to develop empirical models to estimate the momentum transfer coefficient for the IO through long time series of in situ observations from the north Indian Ocean. Impact of momentum transfer coefficients on the upper ocean studies using an OGCM revealed that the Arabian Sea and Equatorial Indian Ocean are more sensitive to the momentum transfer coefficients than the Bay of Bengal and south Indian Ocean. So modeling studies help us design a better strategy for observation. Another important issue in modelling is the simulation of mixed layer depth (MLD), OGCMs as well as CGCMs overestimate MLD over the IO. This overestimation leads to unrealistic air sea interaction processes in the coupled models and produce erroneous forecast of different phenomena. Time series observations of vertical structure of temperature, salinity and horizontal currents by the OMNI buoys provided unprecedented observations to explore such processes but need more intensity and coverage. Detailed study revealed that the state of the art ocean reanalyzes, which are commonly used by researchers, underestimate upper ocean stratification in Bay of Bengal. This underestimation is not due to improper forcing of fresh water fluxes however it is due to the improper understanding of upper ocean processes associated with the upper ocean circulation. It is found that many models over estimates the vertical shear of upper ocean horizontal current in the model. This leads to the excess mixing leading to positive MLD bias. Thus observations from OMNI buoys have provided very important input for the mixing physics. Overall NDBP buoy program provided unprecedented observations to the ocean modeling community to improve model physics. It is anticipated that NDBP extend their observations list including light penetration and surface fluxes estimates to support ocean modeling activity.

Validation of QuikSCAT Wind Data Over Bay of Bengal Using Ocean Surface Winds from Moored Buoys during the Phases of Indian Northeast Monsoon, 1999-2008

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Scientist-D
Regional Meteorological Centre
India Meteorological Department
Chennai – 600006.

Education

M.Sc. in Physics, Univ. of Madras

Positions held

Served as member of World Meteorological Organization Expert Team on Regional Instruments Centres, Calibration and Traceability during 2010-14.

Awards & Recognition

Award of excellence for outstanding performance in Pune, IMD, Jan 2008

Best Employee among Group A officers, IMD Foundation day, Jan 2011.

WMO Prof. Vilho Vaisala Award-2016 for developing countries, Sep 2016, for WMO IOM-117 Report "Alternatives for dangerous and obsolete instruments".

Experience

Was Project Director for commissioning 550 Automatic Weather Stations in IMD. Experience in surface meteorological instrumentation, hydrology, research on northeast monsoon and cyclonic storms.

The Indian northeast monsoon (NEM) season from 1 Oct to 31 Dec is a smaller spatial scale monsoon covering parts of south peninsular India (SPI). The ocean surface winds (OSW) over Bay of Bengal (BoB) play a crucial role in maintaining NEM activity over land. A study was undertaken for the 10 year NEM period of 1999-2008 to extract differential patterns of OSW utilizing Quick Scatterometer (QuikSCAT, QS) data over five sectors of BoB in the region bounded by 77-100°E and 0-25°N and several new results were derived.

To validate QS OSW, in-situ wind data from nine moored buoys with call signs DS05, OB10, SW06, OB08, DS03, AN04, AN05, SW05 and OT01 deployed at specific lat./lon. coordinates over BoB by NIOT, Chennai was obtained from INCOIS, Hyderabad. The days comprising of the conventional NEM seasonal period were distributed under five phases viz. pre-NEM (C1), active and vigorous (C2), light (C3), dry (C4) and post-NEM withdrawal (C5). The mean wind vector, WV (direction and speed) and mean scalar wind speeds (WS, knots) reported by buoys during the phases of NEM activity viz. C1 to C5 were computed and visually compared with the spatial patterns of OSW derived utilising QS winds. Number of observations from each buoy during the period of study varied from 567 to 3647. The results are briefly described below:

i) For all the phases, OSW direction reported by buoys in all sectors of BoB are consistent with QS winds.

ii) Buoy winds are slightly stronger over BoB during dry and post-NEM phases compared to active phase in most of the sectors.

iii) Northerly mean OSW is reported over Gulf of Mannar during NEM which is corroborated by the data of two buoys located in the same area.

iv) Mean QS OSW speeds are higher by 10-15% than that reported by buoys with the latter varying from 5.6 – 10.9 knots during pre-NEM phase and 6.8 – 13.9 in rest of the phases. The WS from QS appears to be slight overestimation of the actual OSW.

Student Abstracts

Upper ocean response of the Bay of Bengal to the monsoonal wind from moorings

Dipanjan Chaudhuri[1], K. Jossia Joseph[2], R. Sundar[2] and Debasis Sengupta[1]

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Dipanjan Chaudhuri

K. Jossia Joseph

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Debasissengupta

Momentum transfer from surface wind stress is important in the maintenance of the quasi-steady ocean circulation. The momentum transfer takes place through a variety of physical processes acting on different timescales. Wind-driven ocean circulation consists of low frequency or quasi-geostrophic flows, intermediate scale Upper Ocean Ekman flow, and near-inertial oscillations at the local coriolis frequency. The annual reversal of winds due to monsoon makes the Bay of Bengal a natural laboratory for studying wind-driven circulation. A thin surface layer of river and rain water in the northern Bay could be rapidly accelerated by changes in wind stress, although this has not been well documented from observations. We study the upper ocean current response (Inertial and Ekman) from two NIOT (National Institute of Ocean Technology) moorings near 18°N, 89°E (BD08; BD09) in the Bay of Bengal. Our analyses are based on the velocity (one current meter at 1 m and one downward looking Acoustic Doppler Current Profiler), and surface forcing (meteorology sensors on moored buoy). Our main finding are: (i) the shallowest current at 1 m makes 55° degree angle to the right of the wind during summer monsoon (15-jun-2013 to 31-aug-2013) (ii) Observed Ekman transports agrees with theory to within 3% in magnitude and 10° in direction during the aforesaid period. (ii) Estimated Ekman depth is 31 m which is consistent with the mixed layer depth (25 m). (iv) Our simulated near-inertial currents from Pollard-Millard Model have a good agreement with the observation from NIOT mooring BD08 during 20-July-2015 to 5-Aug-2015. (v) We find near-inertial rotation in surface wind favours resonant inertial current generation in the mixed layer

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Validation and assessment of INSAT-3D retrieved Sea Surface Temperature over Indian Sub-Continent using Moored Buoy Data

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GeethikaTyagi


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H. A. Solanki

INSAT-3D level-2 (4 km) Sea Surface Temperature (SSTskin) product for day and night-time is analysed for accuracy in coastal as well as open-ocean regions of Indian sub-continent using 'Indirect Comparison Method'. Comparison has been made with collocated bulk in-situ measurements (with corresponding wind speed > 6 m/sec) of near sea surface temperature (SSTdepth) obtained from Indian moored buoy network for three years (Oct, 2013 – Oct, 2016). Statistical results show that Root Mean Square Error (RMSE) of INSAT-3D retrieved SST with buoy data over entire Indian sub-continent is in range of ~0.64-0.68°C with negative bias ranging from -0.14 to -0.29°C. Underestimation is found to be more in case of Arabian Sea with bias ranging from -0.14 to -0.35°C and RMSE ranging from 0.63 to 0.70°C as compared to Bay of Bengal region showing negligible bias in the range of 0.01 to -0.10°C with relatively less RMSE ranging between 0.61-0.66°C. INSAT-3DR retrieved SST product is also showing almost similar retrieval error with RMSE of ~0.71°C and negative bias of ~0.20°C. In addition, Indian moored buoy SST measurements are compared with iQuam (in-situ SST Quality monitor) datasets and results show that both datasets are in good agreement having RMSE of ~0.34°C and Bias less than 0.01°C respectively. Seasonal validation analysis of INSAT-3D SST for the years 2014 and 2015 reveals that RMSE is highest during monsoon (May-August) (0.65°C-0.72°C) followed by pre-monsoon (January-April) (0.61-0.65°C) and post-monsoon (September-December) (0.56-0.58°C) periods.

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Validation of the simulations by the High-resolution ROMS model for the Bay of Bengal

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Jithin

Francis P. A

Abhishek

Suprit K

Vijayan Fernando

A high-resolution (1/48°) model using Regional Ocean Modelling System (ROMS) has been set up for the Bay of Bengal (BB-HOOFS) and simulations were validated with observations from NIOT buoys, RAMA buoys and coastal ADCPs. To evaluate the effect of horizontal resolution in improving the simulations of circulation and temperature, comparison of simulations from a relatively low-resolution (1/12°) basin scale model setup (IO-HOOFS) were also carried out with the same data sets. Results suggest that BB-HOOFS is able to reproduce the observed vertical structure and variability of currents very well in this region with high correlation and reduced RMSE values compared to IO-HOOFS. Simulations of temperature fields from the high resolution model show significant improvements in the comparisons with the observations of its vertical structure at NIOT buoy locations. BB-HOOFS reproduce temperature inversions with a better accuracy in the open ocean and variability below the surface, particularly in thermocline regions compared to IO-HOOFS. Comparison of currents in the coastal regions show substantial improvements in vertical structure as well as in temporal variability in BB-HOOFS simulations, which suggest that higher horizontal resolution is necessary for the better simulation of currents, especially in the coastal regions.

The upper oceanic response of Eastern Arabian Sea to the tropical cyclone Nanauk

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Lix John

R.Sajeev

Upper oceanic and surface meteorological time series observations from a moored buoy at 15°N and 68.9°E in the eastern central Arabian Sea were used to understand the upper oceanic response to the tropical cyclone 'Nanauk' during June 2014. Nanauk initially originated at east central Arabian Sea on 9 June 2014 and it intensified on 11 June 2014 and finally weakened into a depression on 13 June 2014 over the west central Arabian Sea. The analysis shows that preconditioning of the Arabian Sea to the Nanauk with high Sea surface temperature (31.21°C) and Tropical Cyclone Heat Potential (90KJ/cm2). However, the passage of the cyclone caused for a sudden drop in both Sea surface temperatures (SST) and Tropical Cyclone Heat Potential (TCHP). The SST drop was around 2.5°C and the TCHP reduction was around 30 KJ/cm^2. The high vertical turbulent mixing associated with the cyclone leads to the deepening of both mixed layer depth and Isothermal layer depth. The increased latent heat loss associated with high wind speed and the upper ocean divergence through the Ekman pumping induced by the positive wind stress curl may be the primary reason for the observed cooling in the upper layers of the eastern Arabian Sea.

Keywords: SST, TCHP, Mixed Layer Depth, Eastern Arabian Sea.

Low frequency Internal Waves and it's variability in the Andaman Sea

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Noufal K K

Latha G

Internal waves are waves observed in the interior part of the ocean with a frequency range in between inertial and buoyancy frequency of corresponding water column. It is experienced due to the density differences between water layers and these density difference results from the variation in temperature and salinity. Generation of internal waves strongly depends up on the different forcing mechanisms such as tide, wind and non-linear interaction of other internal waves and topography of sea floor.

Andaman Sea of the Indian Ocean is known site of extra ordinary large amplitude internal wave activity (Alpers et al, 1997). The Andaman Sea is located along the eastern side of the Indian Ocean between the Malay Peninsula and the Andaman and Nicobar Islands (between approximately 6° to 14°N. latitude and 93° to 99°E. longitude). The observed internal waves shows wave characteristic such as amplitude (>60 m), wavelength (6 -15 km), and speed (> 2.0 m/s) (An Atlas of Oceanic Internal Solitary waves, 2002)

A study has been conducted on deep water low frequency internal waves and its seasonal variability present in the Andaman Sea with the help of BD12 OMNI buoy deployed at an approximate water depth of 4000 m. CTD time series at standard depths between 5-500 m of water column and wind speed has been used for this study. Presence of internal waves is confirmed by deriving density, buoyancy frequency using CTD time series and spectral analysis of temperature and salinity. Power spectral analysis and Garret-Munk spectrum unfolded the information about dominant influence of semi diurnal tide (M2). Garret-Munk spectrum is useful to describe oceanic internal wave field especially in deep ocean (Fu, 1981). Also study reveals other low frequency influence apart from tidal constituents.

Understanding the response of ocean subsurface parameters to changes in surface met-parameters using high resolution moored buoy observations in the Indian Ocean

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a School of Earth, Ocean & Climate Sciences, IIT Bhubaneswar, Bhubaneswar, Odisha
b National Institute of Ocean Technology (MoES), Chennai, TamilNadu


Samar K. Ghose


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K. Jossia Joseph


D Swain

Mixed layer and isothermal layer are the regions of the ocean which interact with the atmosphere and thus play a significant role in climate variability. Mixed layer depth (MLD) and isothermal layer depth (ILD) show significant seasonal and intra seasonal variability in the Bay of Bengal and Arabian Sea. Ocean parameters like sea surface temperature and sea surface salinity are known to vary with wind speed (WS), relative humidity and air temperature. In this study, the variability of MLD and ILD in response to changing WS has been analysed in the Indian Ocean region using high resolution hourly moored buoy observations obtained from NIOT, Chennai. Wind Speed plays an important role in density stratification given the fact that the depth of turbulent mixing at the base of the mixed layer is sensitive to thermal and density stratifications. On the other hand, the mixed layer contains the ocean's memory of air sea exchange for periods ranging a year or longer. Hence, the air-sea interaction processes are studied by deriving latent heat, sensible heat and momentum flux from various met-ocean parameters. These flux terms show both diurnal and seasonal variability with remarkable thermal stratification of the ocean which may result in mixing from deep layer to surface layer. It can be well understood from surface parameters like drag coefficient, latent heat and sensible heat transfer coefficients. An effort is made to establish the relation between these flux terms with MLD and ILD variability in the present study.

Keywords: MLD, ILD, Latent and sensible heat flux, Drag coefficient, Transfer coefficient

OMNI Buoys: A Platform for Multiscale Circulation Studies

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Samiran Mandal

Sourav Sil

The Indian moored buoy systems in the Indian Ocean have provided continuous, high resolution and highly accurate datasets to provide ample opportunities for versatile studies, viz., large-scale ocean-atmosphere interactions and oceanic dynamical features on multi-timescales, from hourly to inter-annual, from seasonality to extreme events. There are satellite and Argo observations to give the surface and sub-surface thermohaline information respectively, but the OMNI buoys are only source of the current profiles in addition to three RAMA buoys in the Bay of Bengal (BoB). The objective of this work is to present some of the applications of these buoys on the ocean circulation for tidal currents variability, meso-scale current system and extreme weather events in the BoB.

The comparisons showed good agreement for the near surface current of the buoys with an Algorithm Derived Current (ADC) from satellite observations. Tidal current has been captured effectively both at the surface and the subsurface from buoys in the BoB. The M2 tidal driven currents have been observed with clockwise circulation pattern at all the depths with significant magnitude at around 5 cm/s. The buoys help to analyse and quantify the intra-seasonal eddy properties in this domain. They also measured the current profiles during the passage of the cyclonic storm ROANU in May 2016. The observation at BD09 detects the near surface current that reaches 1.75 m/s during the cyclone event, which is generally 0.2 m/s during other time. In addition, the rotary spectral analysis showed the strong clockwise inertial currents with frequency ~2.3 days at BD11 location in the cyclone duration. Study concludes the broad importance and implications of the OMNI buoys to analysis the multi-timescale features of the BoB circulation.

Keywords: Bay of Bengal, OMNI Buoys, Tides, Eddy and Cyclone

Applications of Big data for Ocean Moored Buoy Data using Hadoop Framework

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Johnny Konjarala

V. Masilamani

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V.S.Samy

Vijaysri Lakshmanan

Big Data is a term that describes voluminous amount of data that is structural, semi-structural and sub-structural data that has potential to be mined for information. The ocean data is a typical big data, which can be seen from the data volume, velocity, variety, and value perspectives. While opportunities exist with big data, the data could overwhelm traditional technical approaches and the growth of data is outpacing scientific and technological advances in data analytics.

In view of the above, Ocean Observation System (OOS) of National Institute of Ocean Technology (NIOT) has deployed various moored buoys, which are floating platforms equipped to measure parameters such as air pressure, air temperature, humidity, radiation, wind, wave, current, salinity, and surface & subsurface water temperature at different spatial and temporal scales.

The main aim of this study is to explore the role of Big Data analytics in ocean moored buoy datasets. Big Data analytics is a powerful tool ease to manage the heterogeneous ocean moored buoy datasets. The application(s) of big data analytics will help to evaluate the ocean moored buoy datasets, finding the trend, behaviour analysis and viewing the data insights, data visualization (in 2D/3D) and ocean products (like heat way map, SSH, SST) using machine learning algorithms with the help of Hadoop frame work in effective manner. The machine learning algorithm(s) will learn the pattern among the known examples, and the learnt pattern will be used to predict measures in the future

Surface sampling system for oceanic Research

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The Surface sampling system is a data collection platform used for oceanic research. The implemented platform can be able to address the needs of various oceanic exploration activities. The platform is remotely operable and is capable of carrying customized sensor payload for different applications. The system is controlled using arduino compatible hardware and gives us an endurance time of about 3 hrs. A test is carried out with an inbuilt sensor logging shield which monitors the air quality. The availability of fish at particular places is carried out using a fish finder module which will be useful to the fisher man communities. To increase the endurance time of the platform renewable energy sources like solar energy and fuel cells are used to power the system.

Industry Associates

Fugro Oceanor AS

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Congratulate NIOT and the involved staff with 20 years successful operation of the National Data Buoy Program. We in OCEANOR, which today is included in the Fugro team, are very pleased to be a part of this story. Oceanographic Company of Norway, OCEANOR, was established in 1984, and one of our first internationalareasof focus was to extend the ongoing co-operation between Norway and India through NTH (Norwegian University of Technology in Trondheim/Norway). At that time the co-operation was with National Institute of Oceanography about institutional building and the deep sea mining project.

During the 90ies OCEANOR developed the Seawatch system. The system was one of the first realizations of the GOOS system, which was launched at the UN World Environmental Summit in 1992 in Rio/ Brazil.In May 1994 a Norwegian delegation, headed by the Norwegian Minister of Development Co-operation Mr Kari Norheim Larsen, visited India, the Seawatch system was presented at Department of Ocean Development (DOD) to an audience of approx. 30 Indian representatives. Afterwards OCEANOR was requested to submit a Seawatch proposal to DOD.13th December 1996, DOD and OCEANOR, signed an agreement to deliver 15 SeawatchWavescan buoys, including a lot of sensors, a shore station including a data receiving unit, software for data reception, data control, and data distribution to other users, a training module, and a transfer of technology module.DOD appointed NIOT to be the institution where the system should be implemented. By that decision NIOT and now Fugro started the development of NDBP, and the long term co-operation during the last 20 years, which we also celebrate today.

Very interesting results from the NDBP network are presented in many international conferences. I am really impressed by thescientific results, and the applications developed which are demonstrating the highvalue of the NDBP. In addition the Royal Norwegian Embassy, New Delhi, during the final annual meeting in Oct 2000 concluded that NDBP is an example for demonstrating the success of developmental co-operation between Government of Norway and India.

During these years a lot of people have been involved both from India and Norway. I first like to mention Dr Ole Gunnar Houmb, a Norwegian professor at NTH, and later one of the managers at OCEANOR, who loved India and Indian people and started the co-operation with India back to late 70ies, and was strongly involved in establishment of NDBP.I would also like to mention Director of NIOT, Prof. M. Ravindran, the first Director of NDBP, Mr K. Premkumar, and the today Director Dr.R. Venkatesan. Together with the involved staff at NIOT they have strongly contributed to a successful project. In addition my colleagues at OCEANOR, MrEgil Olsen and Mr. StigLyng, who both loved to work together with the staff at NIOT, have contributed to solve challenges to secure the NDBP to be a success.I would also like to mentionManaging DirectorGeorge Mathew and technical Director Mr. Rajaraman atNorinco, who both have been of great importance to develop the good relationship between NIOT staff and Fugro staff, and secure a proper service of the buoy network.

In 2004 OCEANOR established SeawatchPartnership, and NIOT has actively contributed to making this initiative to be a success. In 2010 Fugro also succeeded to be awarded the contract to deliver the buoys to the Deep Sea Moored buoys network (Indian Monsoon monitoring and forecasting), called the OMNI buoy network.

Fugroand the international community have gained a lot of experience and knowledge based on the co-operation with NIOT to develop operational oceanography globally. We are pleased to be your long term partner, and would like to do our best to maintain and develop further our good relationship in the years to come.

Elektronik Lab

T.S. Rangarajan
Vice President of Elektronik lab

I have over a decade of sailing experience on various types of Merchant vessels and as a Radio Surveyor with Directorate General of Shipping before joining Elektronik lab in 2001. Since then I have been actively involved in Classification societies Survey under SOLAS regulations for various types of vessels in India and abroad. Presently he is involved with various research organization like NIOT, NIO, NPOL, NSTL, GSI, UWR, NHO for their projects and supporting them with equipment, technical man power and system integration. I am trained in handling various scientific and oceanographicequipment by various OEMs.

The services of Elektronik Lab to OOS commenced with supply of INMARSAT terminals and airtime support and over the years have grown along with the project. The Tsunami disaster saw a major change in our role and we were able to support the Indian Government and NIOT OOS by providing a solution for early detection of the occurrence of tsunami from the sea bed and transmitting the information across to NIOT Communication centre. Sonardyne UK was brought in to provide the underwater Bottom pressure Sensor and acoustically transmit the data to the moored buoy. This enhanced the understanding of the natural occurrences and collection of large amount of such data from our oceans. Presently Elektronik Lab is associated with NIOT OOS to provide the complete technical man power in maintenance of both electronic components, sensors and mechanical items of the Data buoys, Tsunami Buoys, deploy them in deep oceans and retrieve them. Elektronik lab is also providing support for transportation of these systems from NIOT campus to the various ports for onward cruise to deploy and retrieve them. The communication centre has been handled by our dedicated staff for more than a decade now and has contributed with their uninterrupted support of receiving the data's and coordinating with INCOIS even during the Chennai floods.

Data Patterns

Mr. S. Rangarajan
Founder CEO of Data Patterns (India) Pvt. Ltd.

Data Patterns has been associated with NIOT since 2008, with early interactions on building Indigenous Data Buoys Controllers and Data Acquisition Systems at the Ocean Observation Systems Department. The challenge was to build a controller that is reliable, low cost, and suitable for battery and solar power operation. The products were to be deployed in remote offshore locations far from shore in the ocean and had to work 24/7/365 in adverse environmental conditions.

Drawing upon its background of building high reliability products for aerospace applications, and available portfolio of circuit building blocks, Data Patterns applied detailed design analysis, component derating, Structural and Thermal design, Water and corrosion protection, Design for manufacturability and testability, to ensure reliable hardware. On the software front, complete life cycle management practices, Defensive coding techniques, Code walk through, Independent verification and validation, Black box testing, ensured a reliable product. The product was subject to environmental testing, validating performance at high and low temperatures, vibration, water proofing, and corrosion resistance. Environmental Stress Screening (ESS) was applied to ensure product reliability.

The OOS team provided complete support in validating the product performance, and ensuring system requirements were met. Necessary product feature enhancements and consistent support ensured a successful program.

After initial success in the National Data Buoy program, additional challenges in Tsunami warning systems and other critical programs were entrusted to Data Patterns. These systems have successfully provided warning of Tsunamis and cyclone.

Data Patterns is proud to have participated in a Program of national importance. Together with the OOS team, Oceanography data gathering is now available consistently over the past many years, without field failures. This is a successful import substitute and “Make in India” program, implemented many years before the phrase was coined. We stand by our slogan “Made in India with Pride”.

Teledyne RD Instruments

Darryl Symonds
Director of Marine Measurements Product Lines

In 1984 I started my career at Teledyne RD Instruments (TRDI) located in San Diego, CA USA. During my career, I have worked as an assembler, technician, customer service manager, and, starting just over 16 years ago, and became the Director of the Marine Measurements Product Lines (MMPL). As a Product Line Director I am responsible for the product development, support, and planning for TRDI's Acoustic Doppler Current Profiles (ADCPs) and Conductivity, Temperature, and Depth (CTD) Sensors used to measure physical and chemical properties in sea water applications from the coast line to the open ocean. I am very excited about my 32+ years of my career at TRDI and enthusiastic about being part of the company that is committed to manufacturing products used to better understand our world.

I have been working in this industry for over 32 years and for 20 years I have been working and partnering with NIOT and many of the people there. I am proud to be able to participate in this celebration and to congratulate NIOT for 20 years of Ocean Observations!

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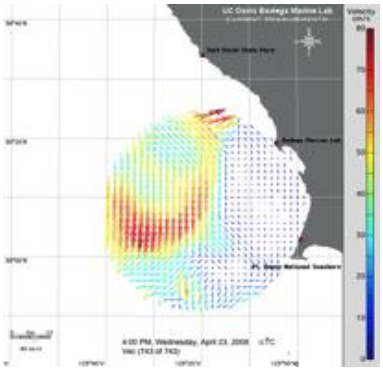

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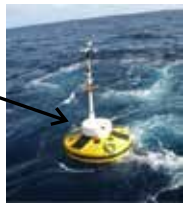

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